INSTRUMENT MANUAL

1220-931-06
September 2002

WALLAC 1220 Quantulus™

Ultra Low Level Liquid Scintillation Spectrometer

PerkinElmer™
life sciences.

Wallac 1220

Quantulus™

Ultra Low Level Liquid Scintillation Spectrometer

Internal software version 1.D

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Warning

This equipment must be installed and used in accordance with the manufacturer's recommendations. Installation and service must be performed by personnel properly trained and authorized by PerkinElmer Life Sciences.

Failure to follow these instructions may invalidate your warranty and/or impair the safe functioning of your equipment.

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Introduction

Introduction to the instrument manual

The Instrument manual forms the second level of the Quantulus Operating System:

The first level is the built-in HELP feature which is a constantly available aid to the operator and can be called on at any point where a decision has to be made to clarify the possibilities.

Then secondly there is this instrument manual. This describes the basic operational details of the instrument as they are visible to the user via direct control of the instrument, either with DOS based data acquisition software (using a line editor or menu driven Queue Manager) or with the Windows user interface WinQ via the Term key.

However, it is recommended that instead of the approach described above, you use the Windows user interface. You can use the protocol editor define a protocol on the three editor pages. This protocol is then queued to the instrument and started with Start button. WinQ usage is described in the user manual 1220-924.

Data can be processed with the off-line spectrum analysis program called EASY View. This runs under Windows. See its user manual 1224-945 for more details

In this Instrument manual the material is arranged in subject blocks e.g. Chemiluminescence, Clock etc., and these blocks are in alphabetical order. The key section is entitled Parameters: this describes briefly all the Mode 1 parameters in the order they are found in the parameter listing. Where a parameter requires a fuller treatment it is then described in its own section.

Introduction to the instrument operation

For a specific measurement the counting parameters, such as count time, counting windows, MCA configuration, printout etc., can be set by the user. Eight such protocols can be stored in the instrument. Counting of samples can be interrupted for editing of counting protocols or adding protocols to the queue which consists of counting protocols waiting to be executed. The instrument will continue with the next protocols in the queue after the previous one has been finished .

The multiple MCA technology allows an MCA configuration to be specified for each counting protocol. An MCA configuration comprises parameters such as analogue signal to be converted, anticoincidence conditions spectrum split signals etc. A detailed discussion of MCA configurations can be found in the chapter "Program modes".

Start-up

Power requirements
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Switch on

Start-up

Power Requirements

Two electrical outlets each with a protective earth should be available, if possible with a separate power line (having an isolation switch and a fuse box) for the instrument itself. The power requirements are 200 VA for the instrument and 350 VA for the cooling unit. If excessive disturbances to the mains voltage are anticipated, a mains stabilizer may be necessary.

Note: the cooling unit may be left connected to the normal power line, because Quantulus' great thermal inertia allows fairly long power shortages without major changes in temperature.

Cooling unit

The cooling unit allows the temperature to be set to a maximum of 12°C below room temperature. The temperature setting can be set by the potentiometer which is on the left side of the cooling unit. The actual temperature set is twice the number on the potentiometer, i.e. the allowed temperature setting is from 5°C to 25°C whereas the potentiometer reading is from 2.5 to 12.5.

The cooling unit contains copper tubing to circulate the cooling water. By cooling Quantulus it boosts the performance. In this case the reference is the water temperature instead of air temperature. At the rear of the instrument is an outlet for condenser water. Take care when putting the cover on the instrument because it is necessary to prevent leakage of warm air into it.

Switch on procedure

1. Switch on the computer (or video terminal), check that it is 'on-line' (shown by the red light on the keyboard). If you have a video terminal, check that the CAPS LOCK key is down.

2. Switch on the printer. In the case of the video terminal, if you do not want printout press CTRL/PRINT.

3. Switch on Quantulus. When the instrument is turned on the first time or when the duration of the power failure is too long (more than 100 hours for one memory board and half that time for 2 boards etc.) the software types:

```
MASTER CLEAR

1220 QUANTULUS
MAIN PROGRAM V 1.D

Copyright (C) 1986 by LKB-Wallac

OPTION PROGRAMS:

PSA V 1.C

TUE  10 APR 1984   0:00   (NOT SET)
TYPE C RETURN TO SET THE CORRECT TIME

*** MAKE SURE THAT THE POSITION OF THE TRAY ONE
      IS EMPTY -  AND AFTER THAT TYPE RETURN    ->

*** CONVEYOR CLEARING ***

  READY ->
```

4. If power has been off but not long enough to drain the standby power supply, the message POWER FAILURE will be displayed 2 mins. after power is switched on. Press / to go to the READY state.

5. Set the clock, see the section entitled Clock.

Instrument description

The concept of total optimization
Detector shielding
Multiple multichannel analyser technology
Pulse shape analysis
Pulse amplitude comparison
Program modes

The concept of total optimization

Introduction

To enhance the accuracy of low level counting, all factors which affect the counting have to be considered. This can be defined as "total optimization". The design and construction of Quantulus enable the optimization of the counting conditions and data validation for various applications. This is achieved by:

- optimized design for background reduction
- measurements based on multiple multichannel analyzer (MCA) technology
- random access, variable time base counting
- electronic noise suppression and a high capacity personal computer for storage and post assay validation and optimization

In addition the special teflon counting vials give a choice of the most suitable vials for different sample volumes.

Shielding

As the detection limit is determined by the signal to background ratio, or, more specifically, by the error in the background determination, this places the following demands on instrument performance:

- the background must be minimized
- the instrument must be stable during the long counting times needed for low level samples

The low background is achieved by the massive, asymmetrical lead shield and the active shield. The active shield can be used to give anticoincidence signals to the analogue to digital converter or to give a multichannel analyser "split" signal. The "split" signal guides the converted pulse to the second half of the dual multichannel analyser.

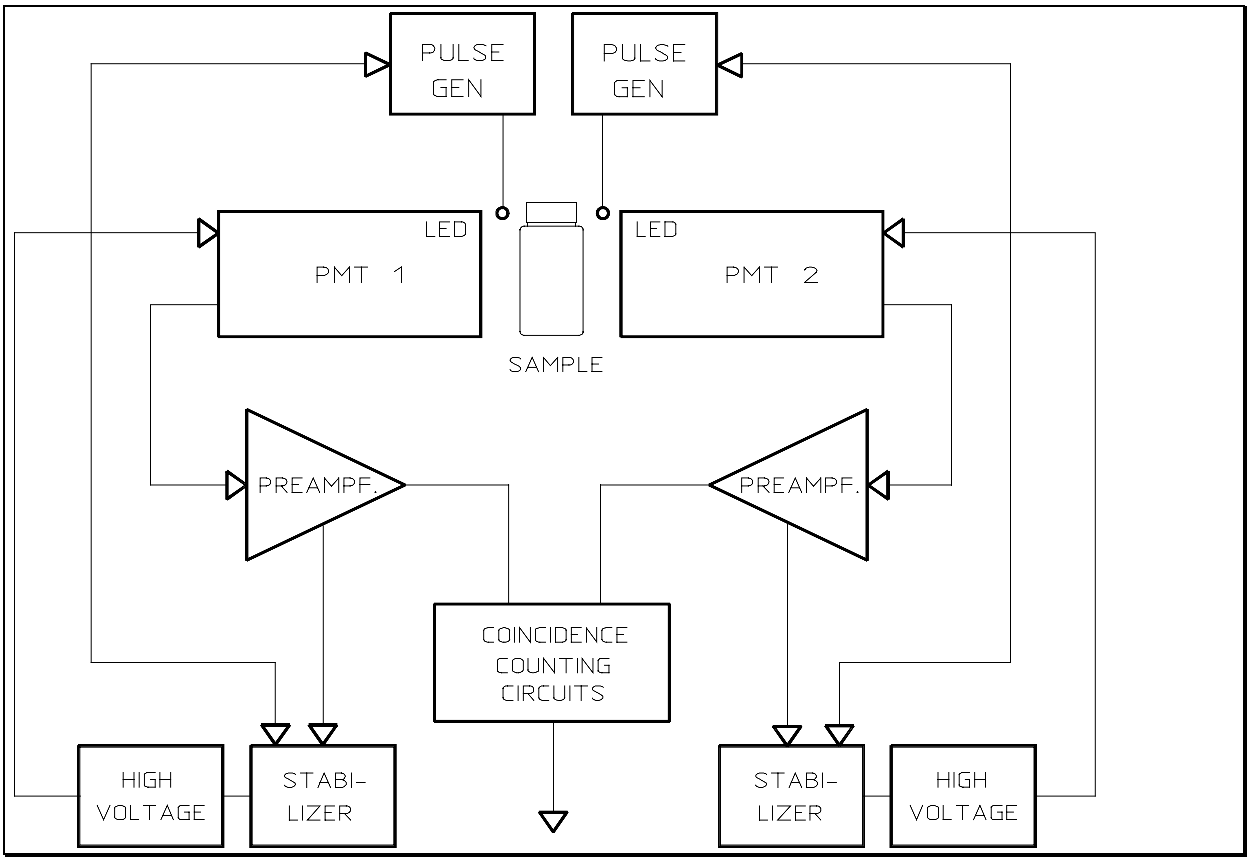
Multichannel analyser

The dual multichannel analyser mentioned above is a part of the multiple multichannel analyser technology. Quantulus incorporates two dual multichannel analysers. They are programmable in the sense that logical signals from the coincidence unit, pulse analyser electronics, active shield or guard pulses, to mention just a few, can be selected to trigger or inhibit analogue to digital conversion or to select the MCA memory half.

For ease of use preset MCA configurations can be selected for ^{3}H and ^{14}C analysis which gives optimized information about the samples with maximized shielding.

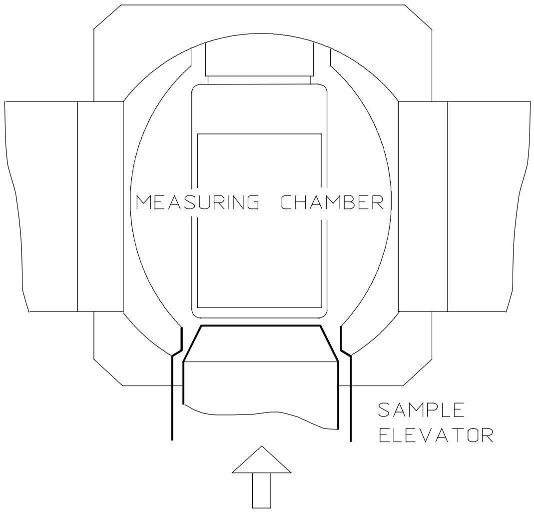
Automatic continuous spectrum stabilization

The Automatic Continuous Spectrum Stabilizer is a unique patented feature of Wallac instruments. It comprises a GaAsP LED and a feedback loop to the HV supply for the photomultipliers; the LED flashes 60 times per second. The output from the photomultiplier is compared with a preset reference level and the HV is adjusted if any drift has occurred, see the figure. In this way changes in both the light detection and the electrical parts of the photomultiplier are corrected for, giving a guaranteed stability in the CPM from a sample of 0.2% per 24 hours (having allowed for the normal statistical variation in the CPM value due to the nature of radioactive processes).



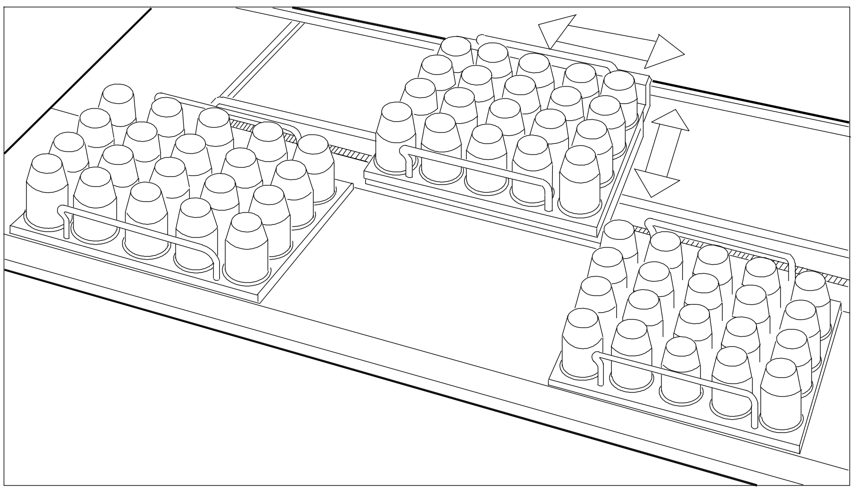
As the HV is automatically adjusted to the correct value it is possible to switch it off when not needed. In Quantulus the HV is only switched on when the sample is in the measuring chamber, which increases the photomultipler life time and performance.

A further benefit is that there is no need for a complicated double light shutter to protect the detectors when the sample is being lifted into the chamber because the detector HV is off at that time. The sample elevator acts as the light shutter when the sample is in the measuring chamber, see the figure. This makes the system mechanically much simpler and more reliable.



Random access counting

Low level counting generally includes the counting of standard and background samples together with unknown samples. The counting time is divided into several parts so that the samples are circulated and counted several times; the average results are then used. Traditional LSC counters have the limitation that the order in which samples are counted is fixed once the samples are loaded on to the counter. This is not the case for the Quantulus. The unique sample changer mechanism and the counting protocol give total freedom to determine in which order samples are counted.



In addition the counting time can be individually determined for each sample. This random access counting with a variable time base has advantages when reaching for the extreme limits of counter performance. The fact that the efficiency and the background count rate are determined several times during the counting of the unknowns enables the monitoring of sample stability, instrument stability and possible background variations.

Electronic noise suppression

The modern laboratory has many types of electrical and electronic equipment. Deep freezes, refrigerators, heating equipment equipped with thermostats and similar equipment switch on and off throughout the day. This switching can cause disturbances to an LSC counter both as radio-frequency noise picked up by the electronics or noise on the mains power lines. The disturbances can be seen as short bursts of high count rates. The use of polyethene vials can cause problems with static electricity because, the vials are charged during sample preparation or during the movement in the counter. Static electricity is also seen as random bursts of high count rates. The lower the activity levels the more clearly even small disturbances can be seen in the results. This has been taken into account in the construction of the Quantulus as follows:

- the cooling device is a noise free Peltier cooling unit. The lower temperature reduces thermal noise in phototubes.

- the pulse electronics, preamplifier and pulse amplifier are designed to maximize the signal to noise ratio. High bias, pulse amplitude comparison and pulse shape analysis can be used to boost the signal to noise ratio.
- a radio-frequency noise suppressor unit detects disturbances of this kind and inhibits the counting while they last .

- an AC HV ionizer neutralizes static charge on the vial surface while it is raised into the counting chamber.

- the sample changer mechanism is constructed so as to cause minimal friction between the samples and their trays and the changing mechanism. Vials are contained in metal light shutters, which further assists in elimination of static charge.

- high coincidence bias can be selected for improved background and figure of merit for counting ^{14}C or other high energy beta emitters in glass vials.

Pulse shape analysis (PSA)

Pulse shape analysis allows identification of the particle which caused it and enables simultaneous recording of pure alpha and beta spectra and counting of very small alpha activity in the presence of high beta activity. It also allows a great reduction in beta background particularly in glass vials, further reducing the already low background achieved by the active anticoincidence guard detector. In this software the PSA level can also be set based on the figure of merit. For more details of this feature see the separate chapter on PSA.

Pulse amplitude comparison (PAC)

Another feature of Quantulus is the Pulse Amplitude Comparator. This provides a means for decreasing the background component produced by optical crosstalk in liquid scintillation counting. See the separate chapter for more details.

Computer

The data output from the instrument can be large. For each sample measurement CPM from up to 8 counting windows, up to 5 x 1024 channel spectra and position, count time, sample ID, or other selected information regarding the sample. To be able to fully use all possible data validation, a computer is necessary. Quantulus is combined with a personal computer with a hard drive, a floppy disc drive and a printer. Separate manuals exist for additional computer software such as the user interface and spectrum analysis program.

The computer can also act as a terminal, then the Quantulus is operated using the computer keyboard.

The concept of total optimization, realized as it is in the design and construction of the Quantulus, enables the accurate measurement of the low levels of radioactivity found, for example, in radiocarbon dating and in the analysis of environmental radioactivity.

Detector shielding

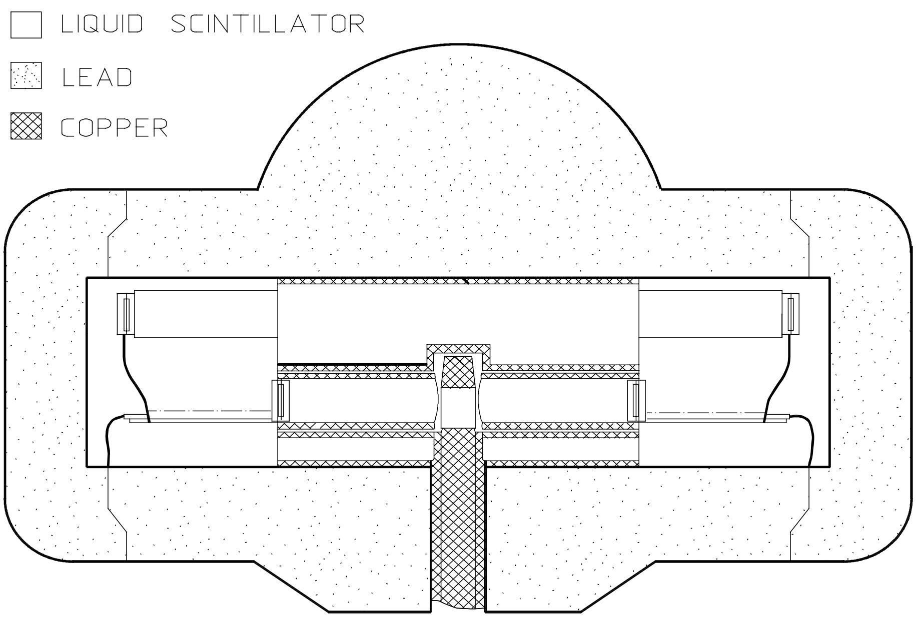
The low background levels obtained with the Quantulus are comparable with those obtained with installations made underground in special laboratories. This is achieved by the unique detector shielding which consists of a passive and an active shield.

Passive shield

The Passive shield is graded: first the asymmetric lead shield, and a layer of copper of the active liquid scintillation guard container.

The lead shield, total weight 630 kg is asymmetric which means that it is thickest, (20 cm) above the measuring position. Shielding is needed most above the measuring chamber because the intensity of cosmic radiation is higher from above; the earth attenuates radiation coming from below. The thickness of the shielding to other directions is 7-11 cm which is sufficient for attenuation of the gamma radiation in the instrument surroundings. The asymmetrical shape gives improved shielding against both cosmic radiation and radiation resulting from interactions between cosmic radiation and the shielding material.

The lead X-rays induced by cosmic radiation are partly absorbed by the copper wall of the container of the liquid scintillator guard. The signal threshold is adjusted below the thermal noise of the phototubes, thus allowing the detection of the smallest signals triggered by external radiation in the guard detector.



Active Shield

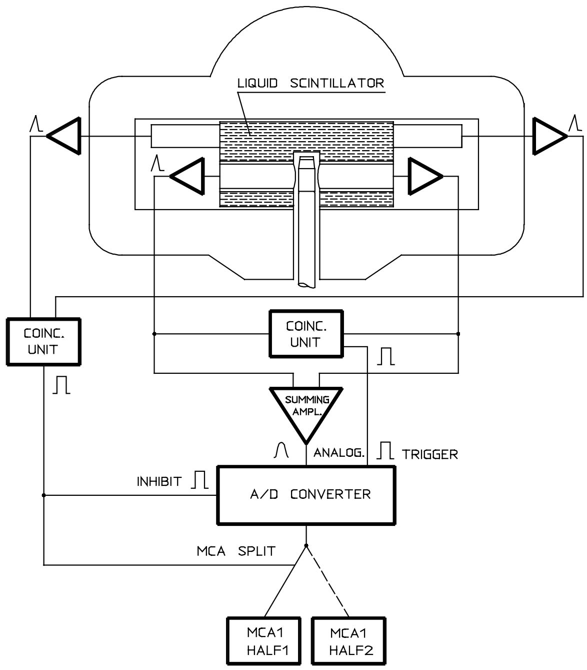
The active shielding is the asymmetric liquid scintillator guard. The guard is a cylinder in which the beta detector is fitted in a tube. This tube is off axis, thus the scintillator thickness is greatest above the measuring chamber and the photomultiplier tubes. The active element in the guard is a mineral oil based scintillator. Two photomultiplier tubes are used to detect scintillation in the guard.
Fast cosmic particles can cause Cerenkov radiation in the glass of the PM tubes. To avoid this being accepted by the instrument and contributing to the background the active guard also covers the PM tubes so these pulses are inhibited.

The function of the active shield is the following:

Ionizing radiation, i. e . gamma and cosmic radiation, which moves through material leaves a trace behind; this is in the form of excited atoms and molecules. In the active guard the excitation creates scintillations. which are detected by the photomultiplier tubes of the guard detector . The pulse in the guard detector activates a logical signal. If this signal is coincident with a pulse in the beta detector it can be used to inhibit the analogue to digital conversion of the pulse or to cause the converted pulse to be stored in Half 2 of the MCA (^{14}C counting mode).

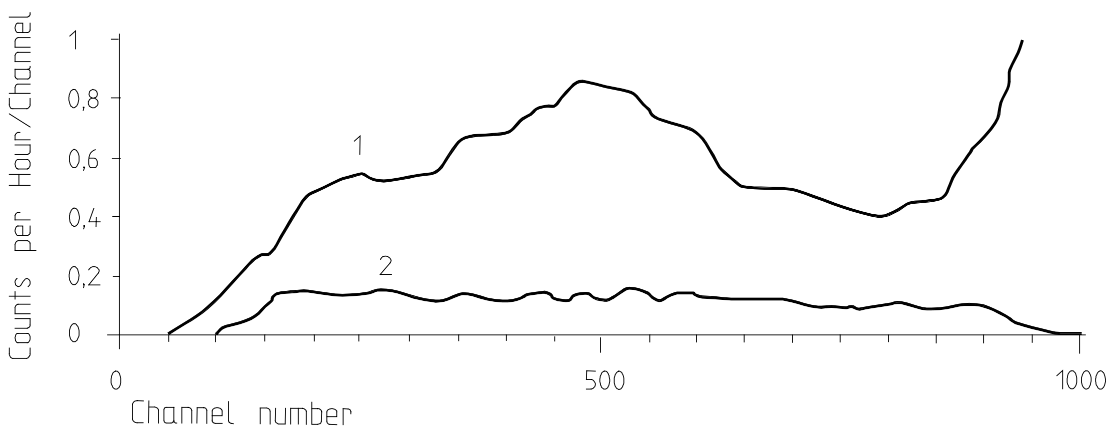
The active guard performance and the intensity of the background can be monitored during counting by the following two methods.

1. MCA 2 is used for measuring the spectrum of the guard. As the guard detector electronics is similar to that of the beta detector, the energy spectrum caused by the background radiation in the guard can be measured. Also the MCA configuration for MCA 2 can be selected so that in the second half the guard pulses coincident with pulses in the beta detector are measured and in the first half all the other or anti-coincident pulses are measured. The latter pulse rate is not to be expected to stay stable because it is affected by the variable cosmic flux, which is dependent on the Sun's activity and on the atmospheric pressure, or amount of air mass above the instrument.



2. If the logical guard signal is used as a memory split signal for MCA 1, then MCA 1, half 1 will contain the sample spectrum in anticoincidence with the guard, and MCA 1 half 2 will contain the spectrum of the pulses in the beta detector coincident with the guard. MCA1 half 1 contains therefore accepted counts from the sample, half 2 contains rejected counts. More details on the MCA configuration are given later in the Multichannel Analyser Technology.

The following figure is the background spectrum of Quantulus. It shows the high efficiency of the active anticoincidence shield. Plot 1 shows the count rate with the shield inactive and plot 2 shows the much reduced background with the shield active.



Multiple multichannel analyser technology

Why multiple multichannel analyser technology?

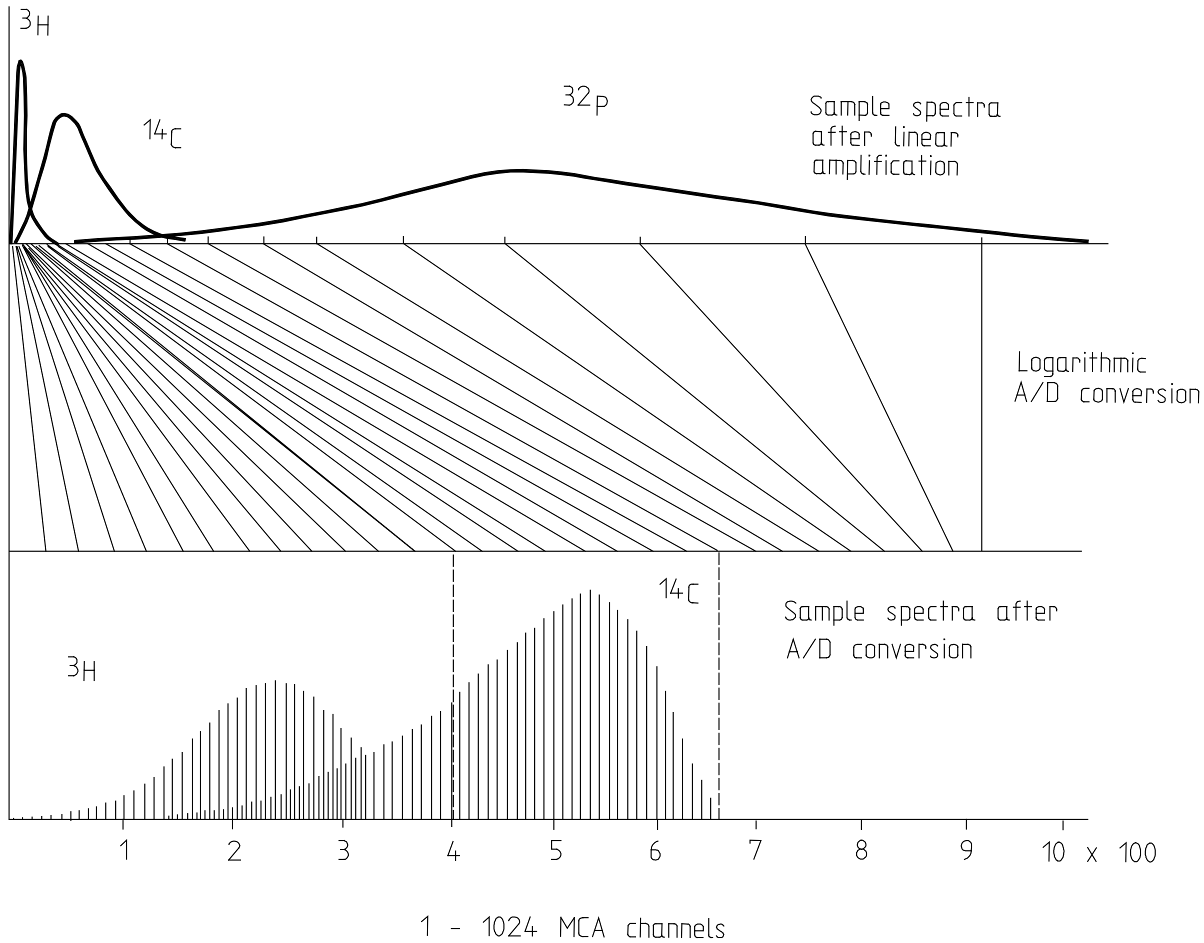
To achieve such high accuracy as in the Quantulus a "rigorous approach" to data evaluation is necessary. Such an approach must encompass not only parameters relating to counting statistics but also those relating to the environment of the instrument, such as variations in the cosmic flux, contamination due to sample handling or radon build-up. During the long counting times needed for low level counting, sample stability and counting efficiency variations must be monitored. Disturbing phenomena such as chemiluminescence and static electricity must be detected and corrected for. The active shielding adds to the instrument one more unit whose efficiency will affect the results, consequently the active shielding performance must be monitored.

How is it achieved?

To accomplish this rigorous approach it is necessary to abandon pulse height discrimination based counting or the single "static" multichannel analyser technology. The only way to be able to monitor and control the above mentioned factors is to use a technology based on multiple "programmable" multichannel analysers. The term "programmable" means that the user can select the analogue pulses which will be converted by the analogue to digital converter. The logical signals, trigger, inhibit etc. which guide the conversion can also be user selected by simple software commands. The use of a programmable multichannel analyser gives possibilities for enhanced data validation not possible with a traditional static multichannel analyser.

The multichannel analysers

Quantulus incorporates 2 dual programmable MCAs. This enables simultaneous measurement of 4 spectra, each with 1024 channel resolution. The pulse amplifiers yield a linear pulse height spectrum. The analogue to digital conversion is logarithmic. The logarithmic presentation of the spectra gives the benefits of constant relative energy resolution and for low energy isotopes (^{3}H) enhanced possibilities for the optimization of the signal to noise ratio.



The user interface software WinQ includes a function called auto scaling, the vertical scale is automatically adjusted according to the number of counts collected during the counting. The counting window limits for Windows 1 and 2 are marked by cursors. You can change these limits in WinQ.

The logarithmic presentation "spreads" the spectra out over a larger channel range than the linear MCA spectra, thus, when the optimization of the measuring conditions are done, the counting window limits can be set in smaller steps giving better resolution.

The setting of the MCA configuration is done by simple Boolean logic commands in the counter software. For easy use, preset configurations can be selected. See the WinQ user manual for further information.

Pulse shape analysis (PSA)

Introduction

Pulse Shape Analysis (PSA) was introduced first by Wallac for 1220 Quantulus in 1986 and since then it has been a standard feature in many Wallac liquid scintillation counters.

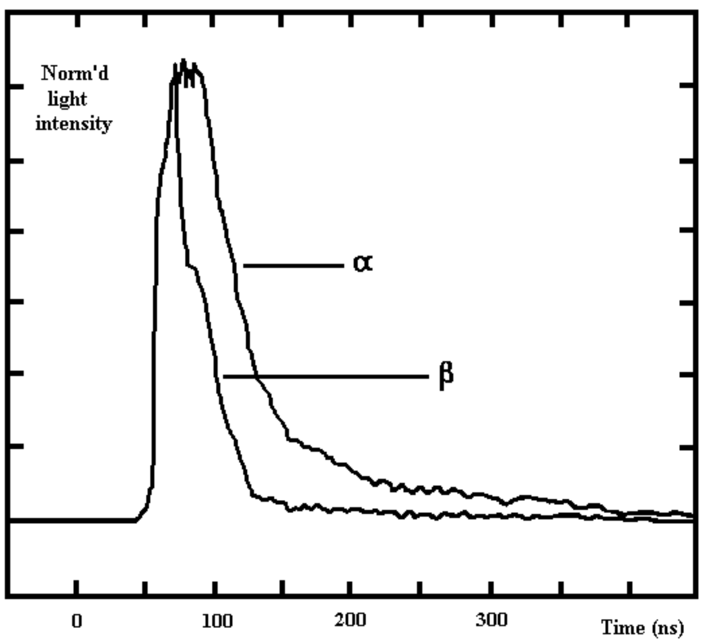
Physical background

Alpha particles emit 5 MeV or more energy which is able to create triplet states in solvent which de-excite to ground state slower than singlet states produced by beta particles. Measurement of the pulse decay time or length allows identification of the particle which caused it and enables simultaneous recording of pure alpha and beta spectra, respectively.

Pulse length depends also on the solvent and fluors used. There are fast cocktails containing volatile solvents such as xylene, pseudocumene, toluene and dioxane. Safe, biodegradable cocktails are slow as those based on di-isopropylnaphthalene (DIN).

Wallac PSA principle

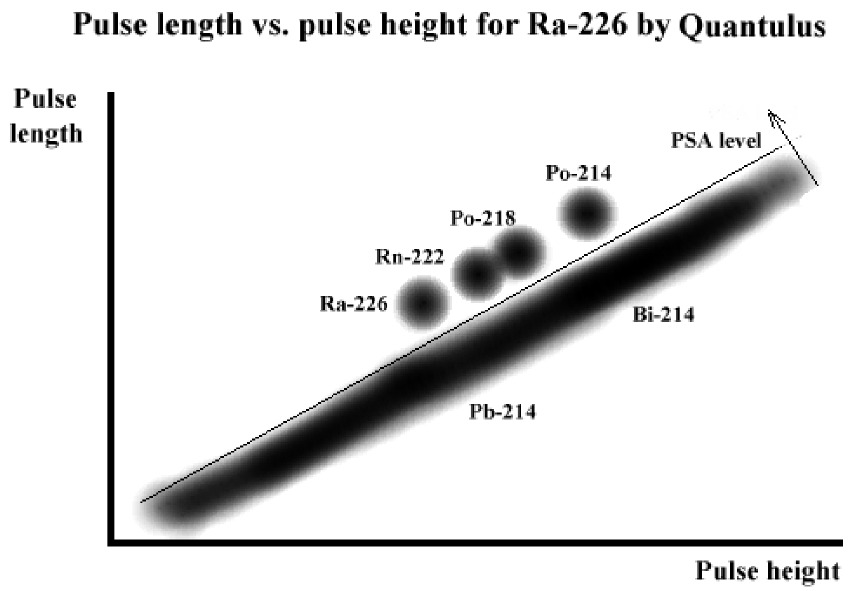
- Integrates the tail of the pulse for long enough time to enable differentiation between short and long pulses see the figure below.



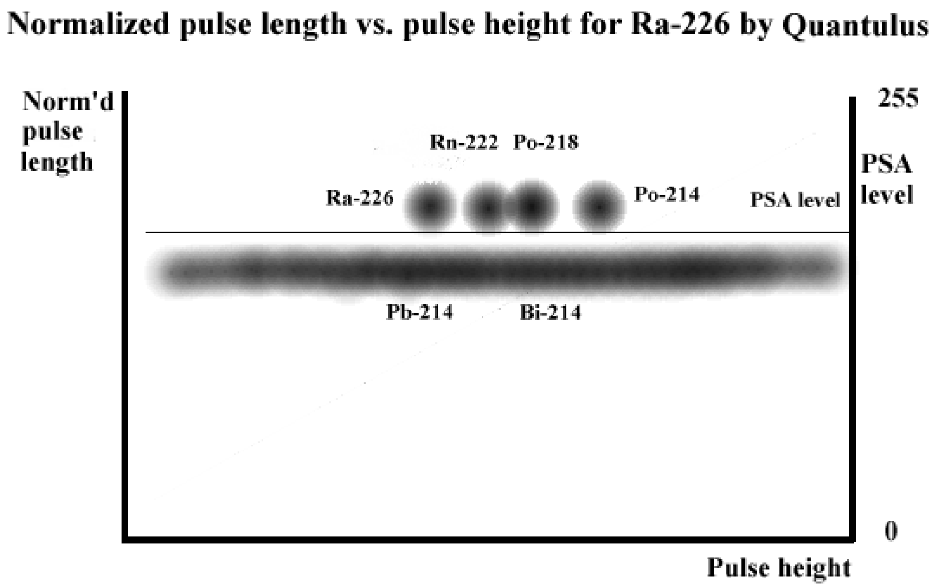
Pulse shape for events caused by beta and alpha particles.

- Normalizes the pulse length information to the pulse height to achieve amplitude independence.

The alpha/beta pulse amplitude (energy) spectrum is transformed in the process to a three dimensional counts vs. pulse amplitude and pulse spectrum (see the following two figures). Electronic division of pulses into alpha and beta spectra is carried out by dividing the pulse amplitude/length plane in two parts by a straight, user adjustable line: pulses above it are directed into the long pulse spectrum, pulses below it into a short pulse spectrum. When the dividing line is correctly set, the former spectrum is the pure alpha spectrum and the latter one is the beta spectrum. The position of the dividing line is controlled by PSA level adjustment. This feature allows setting to conform with various solvents, fluors and quench levels.



3-D spectrum of Ra-226 vs. Pulse amplitude (total signal) and pulse length (tail signal).



3-D spectrum of Ra-226 vs. pulse amplitude and pulse length normalized to pulse amplitude.

Wallac PSA excellency

- Operates simultaneously with and independently of the anticoincidence guard detector from which sample detector is optically isolated. Ultra low level counting mode is thus enabled in the presence of PSA.

- Wallac PSA works well in a large variety of cocktails without need to lengthen the pulse with any additives such as naphthalene.

- Spill-over of alphas and betas into each others' spectra is typically less than 0.2 % in 8 ml water mixed with 12 ml safe cocktail samples.

- Wallac PSA works very well with both fast and slow cocktails without the need to add naphthalene to make the pulse slower.

- Wallac PSA saves alpha and beta spectra. Automatic scanning can be carried out with this software package to test for the optimum division of events. Scanning can be made using any pure alpha and beta samples or by using a mixed alpha/beta and background sample.

Usage of pulse shape analysis

a) for alpha/beta separation and b) extra background reduction in alpha and beta counting.

a) Most of the LSC background is composed of short pulses and thus falls into the beta spectrum while alpha background remains very small, typically much less than 0.1 CPM. One may therefore count natural decay series radionuclides with greater sensitivity by measuring their alpha emissions only than by counting the total alpha/beta activity. Another application is to count very small alpha activity in the presence of high beta activity. Wallac counters can detect less than 1 DPM of alpha activity in the presence of 60000 times more beta activity.

b) One may set the PSA to cut beta counting efficiency by 5 % for instance, resulting in a great reduction in the of beta background particularly in glass vials, further reducing the already low background achieved by the active anticoincidence guard detector. In this software the PSA level can also be set based on the figure of merit.

Alpha background may be reduced analogously by cutting some alpha counting efficiency.

Advantages of alpha counting by LSC

1) 4π counting geometry (equivalent to geometrical factor = 1)
2) No sample self-absorption (as in the case of planchet counting)
3) Virtually 100 % counting efficiency (less than 50 % in planchet counting and solid state alpha spectrometry)
4) Simple sample preparation by mixing with a commercial cocktail
5) High throughput - automatic, multiple sample counting
6) Large sample capacity
7) Simultaneous alpha/beta counting (with separation of each spectrum using pulse shape analysis)
8) Low backgrounds and great sensitivity for alpha counting

Pulse shape analysis and quench

Pulse length

Pulse length is a function of sample quench - the higher the quench, the shorter the pulse length. This is a physical phenomenon, not introduced by the instrument. When the sample quench level is fairly consistent, there is no need to adjust the PSA level from sample to sample (the counting efficiency remains constant). If the quench variation is large (50 Ch or more), there may be need to readjust the level for variable quench or leave the PSA level at the optimum value for the lowest quench sample and let alpha efficiency drop at higher quench. Compensation for quench can be carried out by using a linear fit to the efficiency vs. external quench parameter SQP(E) programmed as an output function.

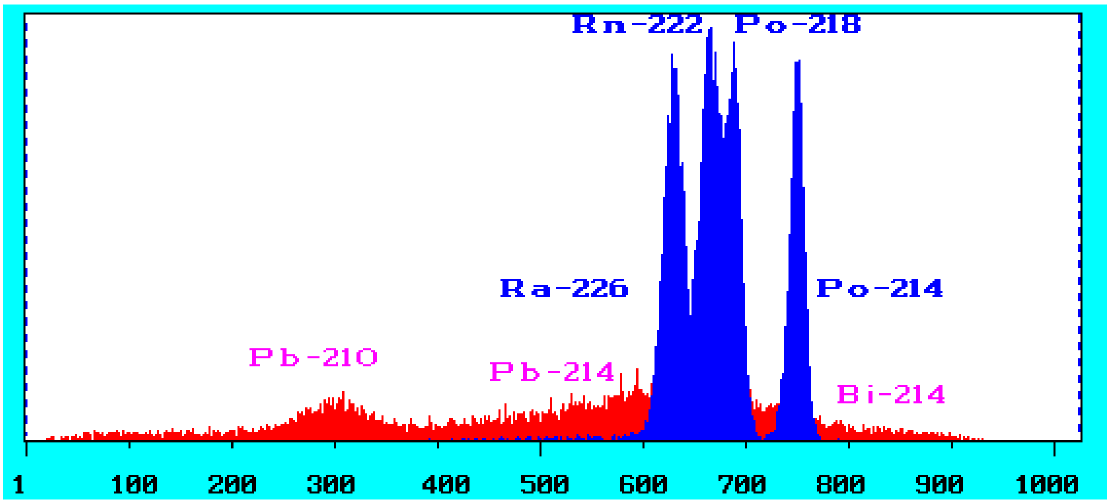
In Quantulus, the PSA level for the optimum alpha/beta separation is the lower, the higher the quench.

Counting efficiency

Alpha particle counting efficiency remains close to 100 % up to very high quench levels, provided that the PSA level is set accordingly. This is due to the fact that the number of emitted photons per decay is several thousands and there is thus room for loss of photons and decay events are still observed. The alpha spectrum will shift to a lower channel at increasing quench and therefore the counting window needs to cover the range of alpha channels under variable quench.

Energy resolution for alpha particles

Alpha energy resolution is about 300 keV FWHM at best in liquid scintillation counting (see the figure below). The higher the sample quench is, the poorer the resolution. High quench, as in 8 ml water mixed with 12 ml cocktail, effectively merges the ^{226}Ra, ^{222}Rn and ^{218}Po peaks into a single, broader one. The high energy, ^{214}Po peak remains separated.



Alpha and beta particle spectrum of Ra-226 measured in a Wallac liquid scintillation counter.

Resolution is also affected by the vial choice: translucent vials scatter light and offer better resolution (Teflon is the best), standard glass vials give poorer energy resolution (ref. 1).

During long storage of a sample, deterioration of energy resolution may occur because of the accumulation of alpha emitters on the surface of vial. This leads to a smaller geometrical factor than unity for decays occurring on the surface. The alpha particles may also be partly absorbed in the wall. Poorer energy resolution and counting efficiency will result, alpha peaks creating a low energy tail. The aging effect can be avoided by adding acid, e.g. HCl in 0.1 - 0.5 M concentrations.

Pulse shape analysis and plastic vial effect

Fast cocktails, such as the ones containing toluene, xylene and pseudocumene will penetrate into the plastic vial wall resulting in deterioration of the alpha spectrum and instability of the alpha count rate. Plastic vials are not recommended for counting using these cocktails, instead teflon coated plastic vials, glass vials or teflon vials should be used.

Identification of alpha emitters

Identification is always based on comparison with known samples. It is possible to create calibration curves for various alpha emitters by measuring the external standard quench parameter SQP(E) and emission peak position. Various alpha emitters will set on different lines and can then be identified by measuring the quench parameter.

References:

[1] Product News Letter: Pulse Shape Analysis, Wallac Oy, February 1987, November 1991.

[2] Oikari, T., Kojola, H., Nurmi, J. and Kaihola, L., Simultaneous counting of low alpha- and beta-particle activities with liquid-scintillation spectrometry and pulse-shape analysis. Int. J. Appl. Radiat. Isot. 38, 875 (1987)

[3] Kaihola, L., Oikari, T. and Suontausta, J., Ultra sensitive alpha particle detection in the presence of high beta activity by low level liquid scintillation spectrometry. Int. Conf. on Advances in Liquid Scintillation Spectrometry, LSC94, Glasgow, Scotland, Aug 8-12, 1994.

[4] Suontausta, J., Oikari, T. and Kaihola, L., Liquid scintillation counting with high water content cocktails. Int. Conf. on Advances in Liquid Scintillation Spectrometry, LSC94, Glasgow, Scotland, Aug 8-12, 1994.

[5] DeVol, T.A., Brown, D.D., Leyba, J.D. and Fjeld, R.A., A Comparison of Four Aqueous-Miscible Liquid Scintillation Cocktails with an Alpha/Beta Discriminating Wallac 1415 Liquid Scintillation Counter. Health Physics Journal 70(1), 41-46 (1996).

Pulse amplitude comparison (PAC)

Introduction

The Pulse Amplitude Comparator provides a means for decreasing the background component produced by optical crosstalk in liquid scintillation counting.

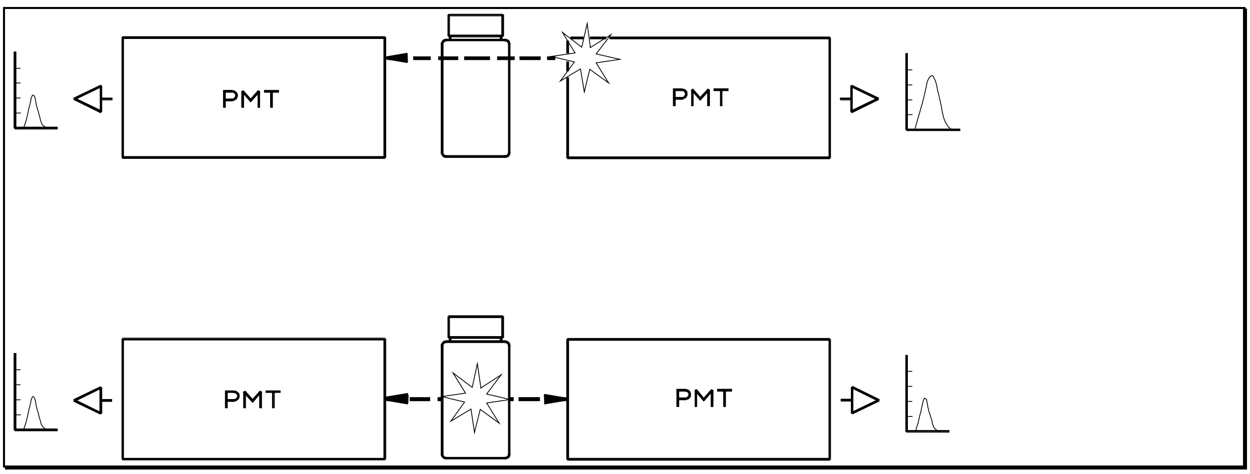
Physical background

A considerable amount of the background in liquid scintillation counting is produced by fluorescence and Cerenkov phenomena in the photomultiplier tubes due to cosmic rays, environmental gamma radiation and residual radioactive impurities in the materials of the detectors themselves. Typically the corresponding coincidence pulse comprises a relatively large amplitude component from the affected tube and a small amplitude from the other tube which may also detect some of the photons emitted (so called crosstalk). The sample scintillations in the vial, on the other hand, produce coincidences with a much smaller relative difference between the component amplitudes from the individual photomultipliers.

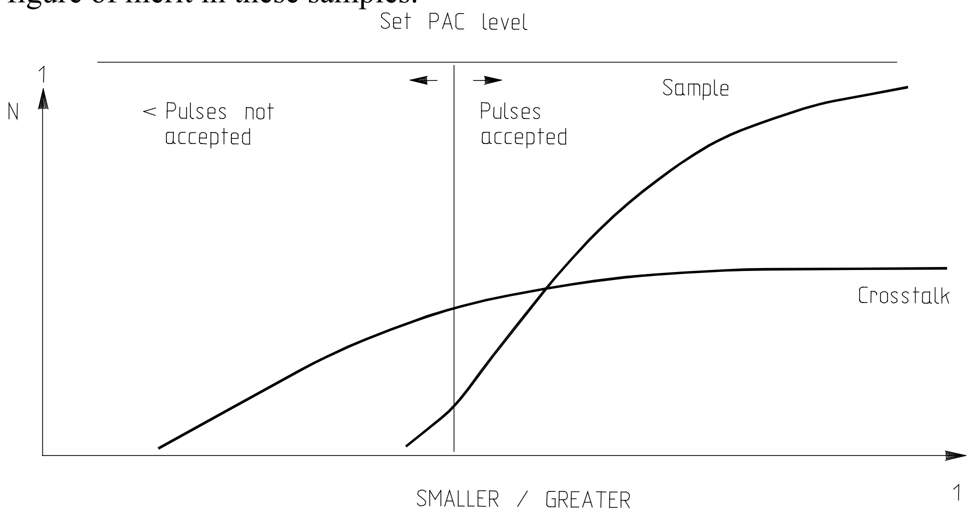
How PAC works

Pulse amplitude comparison can be explained as follows. The coincidence pulse consists of an output component from both individual photomultipliers. Obviously then the smaller/greater ratio between the amplitudes of the two components has a value ranging from nearly zero (the amplitudes are highly different) to unity (the amplitudes are equal). Due to the above reasons, smaller/greater ratios of sample coincidences are distributed closer to unity than those of crosstalk coincidences.

This is the basis of the PAC operation. The user adjustable PAC level, from 1 to 256, corresponds to the smaller/greater ratios, ranging from nearly zero to about 0.8.



Access to the PAC is in counting mode 6 after selection of PAC as a part of the trigger, inhibit or MCA split condition. Software then asks for a PAC level, which can be set by the user (1 - 255, 1 = no PAC). PAC acts as a discriminator so that the higher the level, the closer the amplitudes from the individual photomultipliers must be for the detected coincidence pulse to be accepted (see the figure). An optimum setting is found by measuring an isotopic standard and a background sample at different PAC levels. The best settings may be e.g. that which gives the maximum figure of merit in the counting window. PAC is particularly effective in glass vials when low quench ^{14}C sample is measured. PAC levels above 180 have effect on the figure of merit in these samples.



Program modes

Introduction

The instrument software is organized in three program modes having the numbers 1, 2 and 6. Program mode 1 gives access to the CPM/ DPM program and program mode 2 is a spectrum printer plot program (80 character resolution). Program mode 6 is also called the Quasi Simultaneous (QS) counting mode.

The QS mode enables the full use of the possibilities the Quantulus gives for data validation. The QS mode enables random access to the sample changer, individual time base for samples, free setup of the multichannel analysers and most important of all Windowless Counting based on spectrum analysis. The term windowless counting means that spectra are measured and then sent to a computer. Even rejected count spectra can be saved if needed. Optimization of the counting window can be done off-line based on the information of the total spectral content.

Quantulus can store 8 counting protocols or parameter groups in non-volatile EEPROM memory. A counting protocol can be any of the three program modes, modified so that it suits the application in question. If CPM to DPM conversion is used, the quench curve is also stored in the EEPROM together with the counting protocol. The counting protocols are run in the order determined by the user by setting up a queue in which the order is specified.

A virtually unlimited number of mode 6 protocols (parameter groups) can be saved and sent to Quantulus with newer user interfaces such as Queue Manager.

Program mode 1 - CPM/DPM

Program mode 1 gives the CPM results for up to 8 counting windows which can be freely set to cover any part of the spectrum. In addition CPM to DPM conversion, average of repeat counts or replicate samples, percentage of reference sample etc. is enabled for two windows or two isotopes simultaneously.

When the program mode 1 is used the spectrum is measured in one half of MCA 1. The other half of MCA 1 can be used to measure the Random Coincidence spectrum which is used to correct the CPM values for chemiluminescence. The Active Guard is used in anticoincidence with the analogue to digital converter (A/D converter) for MCA 1. This means that if the guard registers a signal simultaneously with a coincidence signal in the beta detector the guard detector will inhibit the A/D conversion.

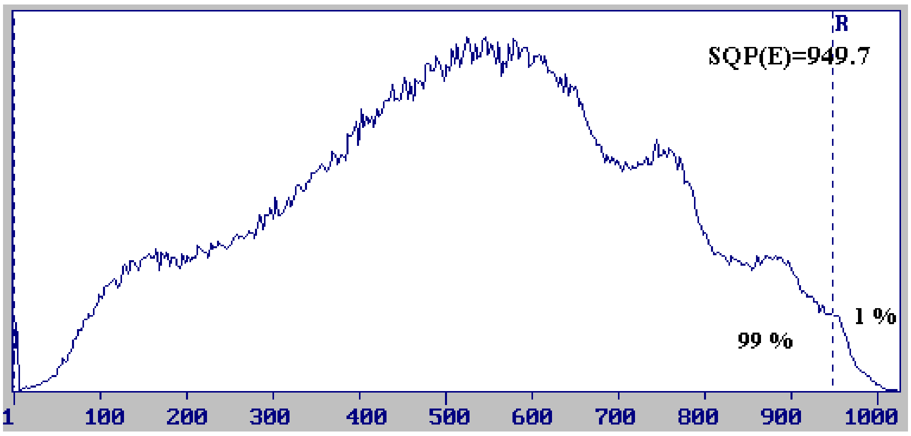
The sample detector with one phototube pair and the guard detector with another one are two entities which are independent of each other. Therefore, background caused by external radiation is rejected by true event detection, which guarantees sample independent, improved sensitivity in the measurement.

Due to the construction of the sample changer it is necessary to specify which position is used in the measurement. This enables also the positions to be measured in a random fashion, the positions do not necessarily have to be in numerical order.

Program mode 1 enables:

- CPM results for 8 counting windows
- DPM results for 2 counting windows or two isotopes
- chemiluminescence correction
- background correction by measurement of a background sample or by typing in background CPM
  value CPM results for two isotopes given as a percentage of reference samples
- half life correction
- calculations of averages of repeat measurements or replicate samples
- calculations of standard deviation, observed and theoretical error and probability test for results of
  repeat or replicate counts.
- user selectable printout
- factorization of results: by multiplying the result with a factor they can be transformed from
  CPM/DPM to wished units, for example to Becquerels.

The quench calibration curve can be made by using the external standard or a quench parameter calculated from the sample spectrum. The external standard is ^{226}Ra in Quantulus models up to #2200166 after which ^{152}Eu is used. This source is located in its own storage shield and is moved by compressed air along a stainless steel tube to the measuring position when a measurement is to be made. Full details of the external standard system are given in the Quality Control Report. The Spectral Quench Parameter of the External Standard, SQP(E), is then calculated from the external standard spectrum. The SQP(E) is the endpoint of the net external standard spectrum, i.e. a channel below which reside 99 % of the counts generated by the gamma radiation from the external standard. Usage of an external standard provides a non-destructive, fast method to measure sample quench - no addition of known extra activity in the sample is needed.



SQP(E) based on Ra-226 external standard
(unquenched sample)

If the quench parameter is calculated from the sample spectrum, the quench parameter is called Spectral Quench Parameter of isotope, SQP(I). The SQP (I) is the centre of gravity of the measured isotope spectrum.

Quantulus includes a special program which measures the standard samples, calculates efficiencies and quench parameter, calculates the quench curve and assigns the curve to the specified counting parameter group.

The Quench curve can the be edited if needed and used to convert the CPM results to DPM results.

Program mode 2 - Spectrum plot program

The spectrum plot program plots the contents of the MCA on the printer. The same MCA configuration is used as for program mode 1. It is possible to plot the sample spectrum or the external standard spectrum. To modify the plot the following is possible:

- determine the channel region which will be plotted
- add MCA channels together for the plot to select smoothing of the plot

The spectrum plot program can be used for window optimization if Quantulus is used without the personal computer and the Quantulus PC software. Then the spectrum plot program should be used to measure and plot spectra of standard and background samples from which the window which gives the best counting conditions can be selected. For the actual measurement of the assay program mode 1 or 6 can be used.

Spectrum Analysis Program gives access to high resolution printouts in mode 6 (see the software manual).

Program mode 6 - Quasi-simultaneous program mode

Program mode 6 is the main program mode in the Quantulus. This allows optimization and measurement of all factors which affect the validation of the results. Program mode 6 is also supported by PC software for off line data analysis, spectrum storage, communication with the Quantulus and "windowless" counting based on spectrum analysis, see the software manual.

Program mode 6 offers:

- free access to the sample conveyor, the samples can be counted in any order
- individual time base for each sample position, if wished the counting time and count terminator can be determined separately for each sample position
- user selectable printout for both output ports
- 8 counting windows
- program control of coincidence bias, bias can be selected low or high, high bias will reduce the background for high energy isotopes
- programmable control of the multichannel analysers by Boolean logic commands
- spectra output on output port 2 to computer, for off-line evaluation
- the external standard quench parameter, the SQP(E) value can be determined for specified samples

Unique for the quasi simultaneous counting mode is the possibility to set the MCA configurations. Quantulus comprises 2 dual MCAs which enable the measurement of 4 spectra with 1024 channel resolution simultaneously. It is possible to select the configuration to be one of two preset configurations or to be freely set. The preset configurations are given below. To set the MCA configuration means the following:

- the analogue signal can be selected, this is the pulse which will be converted
- the logic trigger pulse for conversion can be selected
- the anticoincidence pulse or inhibit pulse can be selected
- the MCA split pulse can be selected, this is the pulse which determines in which half of the dual MCA the converted analogue signal is stored.

Both MCAs are programmable in the way described above. An MCA configuration is then the combination of the selected analogue and logical signals which are determined for the assay. As the MCA configurations are set by the counter software and not by hardware the configuration can vary between the 8 counting parameter groups. When a new parameter group in the queue is started, the MCA configuration specified in the parameter group is set and counting is started.

The possibility to freely set the MCA configuration enables total monitoring of the instrument performance and measuring conditions to be set so that maximal data validation can be obtained. The two preset conditions will however offer a powerful choice for most applications . Configuration 1 for low energy isotopes (^{3}H) and configuration 2 for high energy isotopes (^{14}C).

A third configuration is available as the default in the windowed workstation, the Queue Manager: alpha/beta separation or usage of the Pulse Shape Analyser (PSA).

The combination of Quantulus and the computer supplied with the low level dedicated software offers unequalled possibilities for both measurements and data validation. The most important feature of the QS counting mode is that it supports the PC software. The spectra can, after the measurement, be sent to the PC together with the sample related information such as measuring time, CPM and all other information selected to be sent to output port 2. The numerical data are stored in a REGISTRY.TXT file in the directory specified for the assay.

For the spectra a unique file name for each sample is generated by the system based on the order number, position, repeat and the number of the cycle for the assay. This file name convention enables convenient and easy file manipulations for the off line spectrum analysis.

Preset MCA configurations

Quantulus MCA can be controlled by logic commands which are listed by ? on line 4 in Quantulus terminal communication (see also help screen on SPECTRA).

There are two default modes in Quantulus' internal software:

1. CARBON CONFIGURATION, Carbon-14 counting mode which may be used for any other higher spectrum that does not interfere with chemiluminescence
2. TRITIUM CONFIGURATION, a counting mode which may be used for any other low energy beta emitter, whose spectrum interferes with chemiluminescence
3. FREE SETUP, for low level alpha particle counting and other special problems

Pulse selection and additional conditions of analysis are set by logic commands in MCA INPUT, TRIGGER, INHIBIT and MEMORY SPLIT.

In MCA INPUT the analogue pulse is selected, this is normally, the combined total pulse train from left and right PMT's (L+R).

The trigger condition is normally coincidence condition L*R, which eliminates the random noise of phototubes and is the first requisite for low level counting. A/D conversion can further be inhibited with a logic condition which quite often activates the anti-coincidence guard counter for more background reduction.

Finally, the pulses may be directed into two separate MCA halves by using logic split condition. If the condition is true, the pulse will end up in the second half, else in the first one.

The configurations are the following:

1. C-14 or other high energy beta emitters

MCA INPUT	TRIGG.	INHIBIT	MEMORY SPLIT
1 LRSUM	L*R	PAC+G+EG	
2 GSUM	G	L*R	

MCA1 is used for analysis of the combined left and right PM tube pulses. Using the Coincidence condition as a trigger select, reduces random coincidence of thermal noise. Split by pulse amplitude comparator, guard and external guard leaves, in SP11, all events which were detected by the guard or external guard or were not accepted by the comparator (or by any combination of these). Detection by the guard means that the event was caused by an external source (cosmic or other environmental). The rest of the events are from the sample, its true activity or residual background (SP11). By leaving the main background reduction device, the guard in the memory split state, one is able to record both the rejected events and the net signal.

2. H-3 or other low energy beta emitters

MCA INPUT	TRIGG.	INHIBIT	MEMORY SPLIT
1 LRSUM	DCOS	G+EG	L*R
2 GSUM	G	L*R	

Here a delayed coincidence circuitry combines another pulse stream with the prompt coincidence one (see the logic below). The aim is to monitor the random coincidence signal which may create problems in the energy range of e.g. ^{3}H. Using the guard as inhibit rejects pulses from external sources. SP12 will contain the prompt coincidence events, i.e. sample +

background + random coincidence (like chemiluminescence). SP11 contains only delayed coincidence events, i.e. random coincidence.

3. Free setup allows free configuration of MCA's by user selection of any control signal.

4. Separation of alpha and beta particle spectra (available as default in the newest, windowed Quantulus workstations)

MCA INPUT	TRIGG.	INHIBIT	MEMORY SPLIT
1 LRSUM	L*R	G	PSA
2 GSUM	G	L*R	

Here only true coincidence events from the sample are analysed and the pulse stream is divided by the pulse shape analyser (see below). The pulses that are longer than the PSA level set by the user, will be directed into the second half of MCA1, SP12. The shorter pulses are directed into SP11. When the PSA level is correctly set, SP12 contains pure alpha events and SP11 contains beta events (see also help on PSA and PSASETUP in the Spectrum analysis program).

In the above configurations MCA2 has been dedicated for monitoring the guard performance. The SP22 contains the counts from the guard detector which are in coincidence with the signal from the sample detector, typically of the order of 20 CPM, most from cosmic muon passage through the lead and guard. SP21 contains the rest of the guard pulses, the ones in anticoincidence with the sample. This spectrum shows clearly a high energy muon peak, of the order of 300-400 CPM. It also shows a Compton recoil electron continuum from 100 to 800 channels, scattered by gamma photons which entered the guard through the lead. The low energy end of the spectrum is the phototube noise spectrum (see instrument performance data).

MCA2 may, however, be used for other types of analyses of the sample input signal LRSUM by combining the conditions (for instance in alpha counting mode one could set the MCA2 to monitor chemiluminescence by adding there the ^3H counting mode).

* and + denote Boolean AND and OR, respectively.

Logic signals and their combinations:

Help: Analogue pulse select (=INPUT signal)
L = Left detector analogue pulse
R = Right detector analogue pulse
LRSUM = Left and right pulses summed (=L+R)
GSUM = Left and right guard detector pulses summed (=GL+GR)
GL = Left guard detector pulse
GR = Right guard detector pulse
EG = External guard pulse (optional)

Help: Digital pulse select (A/D conversion TRIGGER pulse)
L*R = Left and right detectors in coincidence
(L+R) = either left or right pulse or both exist
L = Only left detector pulse
R = Only right detector pulse
DCOS = Left and right in coincidence or delayed left in coincidence with right (L*R+DL*R)
G*EG = Guard pulse in coincidence with external guard pulse
(G+EG) = Guard pulse or external guard pulse
G = Left and right guard pulses in coincidence
GL = Left guard detector pulse
GR = Right guard detector pulse
EG = External guard pulse (optional)

Help: INHIBIT SELECT (conversion inhibit pulse)
N = No inhibit pulse
PAC = Pulse amplitude comparison met
NPAC = Pulse amplitude comparison not met
G = Guard pulse
G*EG = Guard pulse in coincidence with external guard pulse
EG = External guard pulse (optional)
L*R = Left and right detectors in coincidence
PSA = Pulse Shape Analyzer
and combinations of the above. For example: EG+G+PAC means any of external guard, guard or PAC or any two or three of them. When the criterion is met, it causes an inhibit pulse. This pulse prevents a digital pulse from being sent to MCA.

Help: MEMORY SPLIT SELECT (Selection of MCA half for converted pulse)
N = Half 1 always
PAC = Pulse amplitude comparison met
NPAC = Pulse amplitude comparison not met
G = Guard pulse
G*EG = Guard pulse in coincidence with external guard pulse
EG = External guard pulse (optional)
L*R = Left and right detectors in coincidence
PSA = Pulse Shape Analyzer
and combinations of the above. For example: EG+G+PAC means any of external guard, guard or PAC or any two or three of them. When the criterion is met, the digital pulse goes to half 2 of the MCA.

Note: for PAC, LRC (left-right comparator) and for PSA, PSD (pulse shape discriminator) and PSM (pulse shape monitor) have been used in earlier versions of the Quantulus internal software.

A high coincidence bias can be selected for improved background and figure of merit for counting ^{14}C or other high energy beta emitters in glass vials. A pulse below the bias threshold cannot trigger the coincidence unit. Additional glass vial background in Ch 1 - 300 is caused by beta particles from 40K such as Cerenkov and fluorescence and is thus cut off by high bias with only a small loss of true events from ^{14}C.

External standard

Under certain conditions the MCA configuration is locked. This is when the external standard is counted or when program mode one or two is used. Program mode one is the DPM program and mode two is the spectrum plot program. The locked configuration is the following:

- MCA 1 half 2 is used for the beta spectrum
- The guard is active as an inhibitor
- When counting the external standard guard is off the guard is off and the spectrum is stored in MCA1 half 1.

SQP(E) evaluation is done in two phases:
1) the external standard is present and the sum of sample and Compton recoil electrons from gamma interaction is recorded and saved.
2) the external standard is removed and only sample is counted at the same time as in phase 1). Net external standard spectrum and SQP(E) are calculated from the difference of the recorded spectra.

General features

Output devices
Commands in the READY state
Information control command
Calendar clock
Help function
Sample handling
Starting counting
Display and multichannel analyser
Interrupting Counting
Error messages

General features

Output devices

Output Ports

The Quantulus has two output ports called Terminal 1 (or A) and Terminal 2 (or B). Simultaneous use of both terminals is not possible, if one terminal is used, the instrument will ignore all commands typed in on the other terminal.

The data output is freely selectable for both ports. Also any or all of the possible 4 measured sample spectra and the external standard spectrum can be sent to the PC via port 2.

Using the Video Terminal (Optional)

When operated via a video terminal connected to Terminal 1, the following points must be observed:

The on line light must be on; the light is situated on the upper left corner of the keyboard.

The caps lock key must be pressed down .

The video terminal printer can be on-line or off-line, the latter is often used during editing of a counting protocol.

The backspace key can be used for correcting typing errors before the return key is pressed.

The printer must be on line. Take care that there is sufficient paper and that the paper runs freely.

Using the computer

If Quantulus is operated with the computer connected to Terminal 2 the following must be observed:

The computer will automatically boot up the Quantulus software after power up. Take care that the caps-lock key is pressed down, this is indicated by the signal on the caps-lock key (newer user interfaces do not require CAPS LOCK on, see the software manual).

For communication with the counter the communication program must be selected by pressing function key 3. When the computer is in communication with Quantulus the READY prompt will appear on the screen in response to the RETURN key (for newer user interfaces, see the software manual).

Commands in the READY state

When the instrument is idle, or when the power has been connected, the message READY followed by an arrow

```
READY ->
```

can be seen on the screen. The instrument is now ready to be operated. By typing a question mark (?), the HELP function will give a listing of possible actions.

```
READY ->?
Help: Commands in the READY-state (press RETURN after a command):
C - set date and time
D - display date and time
I - display program version numbers
L - display information about parameter groups
? - display this information
P - edit parameters
A - start counting
S - enter the standardization program

Commands while editing parameters (on any line):
? - display more information about the parameter
/ - (no RETURN) save parameters and go to the READY-state
In program mode 6 on main parameter lines only
Lx- jump to line number x
RETURN - jump to the next line
BACKSPACE - correct typing errors

Press RETURN for more information or type any READY-state command ->

Commands while counting:
E - edit (while counting going on)
O - stop counting and go to the READY-state
Dx- (no RETURN) display function, x is from 1 to 8, type D9 to scan
again (Note: this command is no longer available)


READY ->
```

Information control command

When the Quantulus is in the READY state, control command I can be typed and RETURN pressed to give a printout of software version number and application software present in the instrument. This also tests that the CPU can read the software stored in ROM memory. Failure to obtain a printout after typing I indicates software error.

```
READY ->I

1220 QUANTULUS
MAIN PROGRAM V 1.D

Copyright (C) 1986 by LKB-Wallac

OPTION PROGRAMS:

PSA V 1.C

READY ->
```

Calendar clock

Quantulus includes a calendar clock, which gives a printout of date and time at the beginning of each batch of samples. In the READY state the date and time can be displayed using the command D. The time can also be selected as a part of the printout; using printout code TIME will cause a printout of the current time for each sample. The clock is a 24 hour clock. The memorized calendar clock is valid up to year 2099 taking into account the leap years. The date can be printed out by selecting DATE in printout selection.

The calendar clock is set in the Ready state by typing the command C and pressing Return. The date and time is requested and should be entered as shown in the printout example. The clock is started after typing Y and pressing Return in response to the instruction `"TYPE Y RETURN TO START CALENDAR CLOCK".`

The clock has to be reset after a power failure or a Master Clear. If the clock is not set after Master Clear the text "NOT SET" is printed out after the time printout.

```
READY ->C

ENTER DAY:MONTH:YEAR  10 APR 1984 ->?
Help: Enter day, month and year separated with a space and press
RETURN.
Range: 1 JAN 1901 - 31 DEC 2099.
ENTER DAY:MONTH:YEAR  10 APR 1984 ->18 SEP 1996

ENTER HOUR:MIN   0:08 ->13:35

TYPE Y RETURN TO START CALENDAR CLOCK -> Y

WED  18 SEP 1996  13:35


READY ->
```

Help function

Quantulus incorporates a HELP function. This is a facility by which extra information can be obtained from the instrument to help in operating it. At any point where a user instruction is needed the HELP function can be activated by typing ? and pressing Return. An explanation of what the possibilities are, including the range of values allowed for a parameter if it is a parameter help in question, will appear on the display and then again the command line or parameter line will be presented for the user's choice to be entered.

Sample handling

Quantulus takes up to three sample trays each with a maximum of twenty samples. Sample positions 1-20 are found on tray 1, 21-40 on tray 2 and 41-60 on tray 3.

The following table shows the order of samples:

1	2	3	4	5	21	22	23	24	25	41	42	43	44	45
6	7	8	9	10	26	27	28	29	30	46	47	48	49	50
11	12	13	14	15	31	32	33	34	35	51	52	53	54	55
16	17	18	19	20	36	37	38	39	40	56	57	58	59	60

When trays are loaded, tray 1 occupies the leftmost position, tray 2 the middle and tray 3 the rightmost position. If possible, samples should be loaded so as to fill one tray before putting samples into the next. This releases the other trays for others to use. When trays are loaded onto the counter, check that the tray is not placed in the position of a tray under measurement as it will be returned to the empty space.

Above each loading position there are two LEDs one red and one green. If the red LED is on it shows that during parameter setting samples from the tray in that position were specified for counting. If the green LED is on then no samples from that tray have been specified and the tray can be removed for loading other samples.

Example. If sample positions 1-25 are specified then the red LEDs will be on above tray loading positions 1 and 2 but above position 3 will be the green LED. If positions 1 and 2 are specified then there will be a red LED only above tray loading position 1.

Starting counting

The Counting Protocol Queue

Quantulus activates the counting protocols in the order they are specified in a queue. The setting of the queue is based on the use of a command line which allows

D (isplay) of the queue
M (odification) of the queue
R (emove) to remove items from the queue
I (nsert) a parameter group into the queue
S (tart) counting

The queue determines in which order the parameter groups are counted. When command A with RETURN is typed in READY state the setting of the queue is started

The first question is

```
Data to be filed in PC? (Y/N) Y ->
```

If this is answered Y(es) the Quantulus will check if the computer is ready to accept data.

If the computer is using a dedicated communication routine, Quantulus then asks for the first parameter group to be counted by printing on the screen:

```
1. assay in queue
PARAMETER GROUP NUMBER 0 ->
```

If a slash (/) is typed in it will return to the command line.

If there is no queue present, type in the parameter group number which is to be counted.

(If a terminal program is used, such as GENTERM, ULTROTERM or Windows Terminal, an error will result if there is an attempt to save spectral data that would be printed on screen instead:

```
Data to be filed in PC? (Y/N) Y ->Y

PC not on line!
```

With terminal programs one should select N at this point.)

If DATA TO PC is selected Yes then the next question is the directory path. The name of the directory where the results are to be stored should now be typed in. Quantulus will then cause the PC to make the directory. If the directory already exists a warning is given

```
Are you sure ?  Directory Exists !
```

It is also possible to make a sub-directory, i.e.

```
DIRECTORY PATH - MYDIR\ASSAY1
```

causes a sub directory ASSAY1 to be established under the directory MYDIR.

If the DATA TO PC is selected as No the directory question is omitted.

When the last parameter group to be counted is typed in, the slash returns to the command line. If counting is started by typing S the queue is memorized and can be edited later. If the command line is left by typing slash, the instrument returns to the READY state and the queue is cleared.

The queue can take a maximum of 8 parameter groups.

```
READY ->A

Data to be filed in PC? (Y/N) Y ->Y

1. assay in queue
PARAMETER GROUP NUMBER 0 ->3
MYDIR\ASSAY1

2. assay in queue
PARAMETER GROUP NUMBER 0 ->5
MYDIR\ASSAY2

3. assay in queue
PARAMETER GROUP NUMBER 0 ->7
YOURDIR\ASSAY1
4. assay in queue
PARAMETER GROUP NUMBER 0 ->/

COMMAND: Display,Modify,Remove,Insert,List groups,Start counting ->D
ORDER  PGROUP   DIRECTORY PATH
1       3       MYDIR\ASSAY1
2       5       MYDIR\ASSAY2
3       7       YOURDIR\ASSAY1
```

Display and multichannel analyser

Quantulus includes two dual multichannel analysers providing logarithmic analogue to digital conversion to four 1024 channel spectra simultaneously. This process can be described as follows.

The analogue pulses from the PM tubes are of different pulse heights depending on the energy of the beta decay. The analogue to digital converter "measures" the pulse heights and compares them against a "scale" which is the maximum pulse possible divided by the number of channels in the multichannel analyser.

The multichannel analyser is in practice a memory space with as many positions as the MCA channel number, so that position one corresponds to "scale" interval one, position two corresponds to "scale" interval two etc.

When the A/D converter has "measured" a pulse height and found the "scale" interval corresponding to the pulse height, the respective memory position or multichannel analyser channel content is incremented. Thus the multichannel analyser shows both the count rate and the energy distribution of the isotope being counted; the count rate is the total number of counts in all channels, the energy distribution is shown by the content of each channel.

The multichannel analyser opens new possibilities, the spectra can be stored and analysed, possibilities for spectrum analysis and spectrum display are enhanced. With the whole spectrum stored the number of counting windows can easily be increased. Quantulus offers 8 independently usable counting windows, e.g. for optimization of windows in low level counting.

As a consequence of the MCA approach Quantulus offers two alternatives for visualizing the counted spectra. With the spectrum display it is possible to follow the growth of the spectrum during counting, after the end of counting a hard copy of the spectrum can be obtained with the Spectrum Plot, program mode 2.

Indicator lights

There are two LEDs on the upper front panel:

Stable - spectrum stabilizer working correctly

ON/OFF - shows the status of the instrument, whether it is ON or OFF.

Error messages

Power Failure

If the mains power goes off during operation, stored parameters will remain in the EEPROM indefinitely and the standby power supply comes into operation. If a power failure occurs there will be a delay of 2 mins. after which POWER FAILURE will be printed Use of the following commands (without RETURN) is possible during the delay period:

C this enters the Master Clear program

/ the instrument returns to the READY state, parameters are retained in the EEPROM

RETURN bypasses the delay and continues program execution

After about ten minutes delay the program automatically goes back to the READY state if the program was in the READY state, EDIT state, listing parameters or editing. If the instrument was counting a sample then the same sample will be recounted.

Mechanical Obstruction

If the conveyor is mechanically obstructed, after a period of one minute the instrument will stop and CONVEYOR ERROR will be printed followed by READY. The obstruction should be removed and operation can then continue.

High Voltage Failure

If the high voltage to the detectors goes off during counting, the message COUNTING ERROR will be printed.

File Error

If a parameter group is not properly initialized when the Ax command is used, then the message FILE ERROR will be printed and the instrument returns to the READY state. If this continues after repeating the Ax command then a fault in the EEPROMs is indicated.

Memory Storage Fault

The error message PARAMETER SAVING FAILURE is printed out and the instrument returns to the READY state if the memorization procedure fails during any operation that requires transfer of information into the EEPROMs for storage. This indicates a fault in the EEPROMs.

Too few counts The error message NOT ENOUGH COUNTS FOR SQP(E)! will appear if too few counts are accumulated to allow a meaningful SQP(E) calculation. SQP(E) and SQP(E)% values will not be printed out for the sample.

Mode 1 - CPM/ DPM

Mode 1 Parameters
Chemiluminescence monitoring and subtraction
Standard curve fitting
DPMl measurements
Half-life correction
Printout selection
Repeat and replicates
Results
Sample quality monitor
Standardization parameter setting
Window setting

Mode 1 - CPM/DPM

Parameter setting

Note: In newer user interfaces such as Queue Manager and WinQ, the Term(inal) door must be used to access the following commands.

Instrument control commands

Instrument control commands are available by typing ? in the READY state (refer to Ch. 3).

Parameter Groups

A parameter group comprises all the parameter values needed to count a set of samples. Eight parameter groups are stored in the memory of Quantulus, each with an identifying number in the range 1-8. Normally a group consists of preset parameters but these can be edited to produce a group of parameters just suited to the need of the user.

Listing Stored Parameter Groups

Type L and press RETURN to see the parameter groups. A list will be printed out showing the group number, as well as the program mode, count mode and name (identifier) of each group. The list also shows if a quench calibration curve is stored with the group of parameters.

```
READY ->L -  Type L and press RETURN to get a list of the stored groups

                                        WED  18 SEP 1996  14:44

 GROUP  PROGRAM MODE   COUNT MODE                    ID

  1     CPM / DPM      FIXED, SQP(E), C-14          CARBON STD CURVE
  2     CPM / DPM      FIXED, SQP(E), I-125          DUAL LABEL
  3     CPM / DPM      FIXED, SQP(I), H-3            MECHANICAL TEST
  4     CPM / DPM      AUTO,  SQP(E), I-125          DUAL
  5     CPM / DPM      FIXED, SQP(E), H-3            KOE
  6     CPM / DPM      FIXED, SQP(E), H-3            OTHER
  7     QUASI SIMULTANEOUS COUNTING PROGRAM          CERENKOV
  8     QUASI SIMULTANEOUS COUNTING PROGRAM          test

  READY ->
```

Parameter group editing

Quantulus is designed to present to the user only those parameters which need to be set for the particular mode of operation selected by the user. In what follows a description is given of all the possible parameters that can be set by the user in the CPM/DPM counting mode.

Sometimes where the description of a parameter requires more background information it is described in its own section as can be seen by looking at the subject index.

Parameter Setting Selection - P

Parameter setting is started from the READY state by typing control letter P and pressing Return. The current date and time is then printed out automatically. The section entitled Clock describes how this date and time can be set or adjusted.

Parameter Group Selection

After the date and time have been printed out the question PARAMETER GROUP will appear. A parameter group comprises all the parameter values needed to count a set of samples. Eight parameter groups are stored in the memory of Quantulus, each with an identifying number in the range 1-8. Normally a group consists of preset parameters but these can be edited to produce a group of parameters just suited to the need of the user. The response required is to give the number of the group of parameters to be listed and, if required, edited. Select one of these groups by typing the number and pressing Return.

There are a number of other possible responses to the Parameter Group question:
Copying Parameters - Mx,y

This command copies parameters in one parameter group (represented here by x) into another group (represented here by y). The parameters in group x remain unchanged whereas those in group y are overwritten by the ones from group x.

```
READY ->P             - Select parameter setting

                                        WED  18 SEP 1996  14:45

    PARAMETER GROUP ->M3,4   - Copy values from group 3 to group 4
SAVING PARAMETER GROUP  4      Press RETURN to end the line


  READY ->                   - The program goes to the READY state
```

Copy can be helpful if a user wants a parameter group similar to an existing one without changing the existing one and without having to enter all the parameters one by one in a new group (especially if a standard curve is stored in the first group). Once parameters have been copied to the new group any changes can be made to that second group without affecting the first group. After the copy operation the program returns to the READY state.

Clearing Parameters- Cx

Parameters in a group can be cleared and reset, that is returned to the default values which are built into the program. The command C followed by the group number is used to perform this operation. To avoid accidental clearing of a group the user is asked to confirm the choice both to clear and the number of the group to be cleared. If the choice is confirmed by typing Y (Yes) the clearing will occur but if N (No) is selected the group will not be cleared.

This command is useful if, for example, the user only wants to use the short list of parameters but is not sure if any of the extended list parameters have been changed by a previous user of the group. Instead of checking every single parameter the Cx command can be given and then only those parameters the user is interested in need be selected.
After the clearing operation the program goes to edit the next parameter line, identifier.

```
READY ->P

                                        WED  18 SEP 1996  14:49

    PARAMETER GROUP ->?
Help: Type x or Ex RETURN to edit a parameter group number x. Range:
1 - 8.
Ex allows extended parameter listing in program mode 1.
Type Mx,y RETURN to copy a parameter group number x to group number
y.
Type Cx RETURN to clear a parameter group number x.
Type / to go to the READY-state.
    PARAMETER GROUP ->C4  - This sets the default parameters
    CONFIRM: CLEAR PARAMETER GROUP  4    N ->Y - Confirm your choice with Yes
    CLEARING PARAMETER GROUP  4

    ID:  ->TRITIUM - Parameters can be edited as normal with the default values
```

Identifier

The identifier is an identifying name for the group which can be set by the user if required. It is purely optional but helps to identify the group in parameter group listing and can be used to give an idea of the function of the group. Up to 20 alphanumeric characters can be used. If no identifier is to be given or if the existing one is not to be changed, only Return need be pressed.

Line Selection

The next parameter gives the user a choice of starting at any particular parameter line by giving the line number (0-32), or of only listing the existing parameters by typing L and pressing Return. The program returns to the READY state after the listing. If however a line number was given then the parameter line selected will be displayed next.

Line 00A - Program Modes

There are three standard program modes. The program mode determines the type of data reduction intended to be used. The program modes are:
1. CPM/DPM counting

2. Spectrum plot
6. Quasi-simultaneous counting mode

The rest of this section describes the Mode 1 parameter. Mode 2 and Mode 6 are described in their own sections.

Line 00B - Count modes

A count mode determines the general details of the counting protocols such as windows, quench indicating parameter, single or dual label and isotopes. One count mode is the combination chosen in each specific case.

The selection of the count mode automatically determines which parameters can be set. Some of the main types of parameter list are shown at the end of the 'Parameters section'. The first time a count mode is selected parameters will be assigned preset values; the count mode will select counting windows limits and determine the printout selection , preset values for the sample and external standard count times. This will also occur if the Clear command is given. If the mode has been previously selected and parameters edited then other values than the default ones will be shown. -Whichever is the case the used can edit the parameters until they are what is required.

If any parameter line is changed which would mean a fundamental change to the parameter group, invalidating the results if used as such, a warning is given. If such a change is made a hard copy of standard points dedicated to the parameter group is printed out then these points are deleted.

Window selection

This choice assumes that option 1220-114 is included in the instrument. If it is not then only Fixed window can be used. For a full discussion on window setting see the section entitled Windows.

Spectral Quench Parameter

If Fixed window has been selected there are three choices of Spectral Quench parameter: two for single label and one for dual label. In the former the SQP can be based either on the isotope spectrum (SQP(I) or on the external standard spectrum (SQP(E)). In the latter only SQP(E) can be selected. SQP is described further in its own section. If option 1220-114 is selected only SQP(E) can be used.

Isotope selection

The are six single label isotopes and fourteen dual label preset isotope counting windows. These are shown in the following table.

```
Single label
    H-3   (1), I-125 (2)
    C-14  (3), S-35  (4)
    Ca-45 (5), P-32  (6)
Dual label
    H-3   / I-125  (1)
    H-3   / C-14   (2)
    H-3   / S-35   (3)
    H-3   / Ca-45  (4)
    H-3   / P-32   (5)
    I-125 / C-14   (6)
    I-125 / S-35   (7)
    I-125 / Ca-45  (8)
    I-125 / P-32   (9)
    C-14  / Ca-45 (10)
    C-14  / P-32  (11)
    S-35  / Ca-45 (12)
    S-35  / P-32  (13)
    Ca-45 / P-32  (14)
```

When the isotope has been selected, the count mode specification is complete. Quantulus displays a summary of the mode giving the type of window, the window setting, the SQP selected, the number of labels and the name of the isotope (s).

If an isotope is required which is not in the list, select fixed window and an isotope with the closest window setting to that required then give the correct window on line 8 in parameter setting .

Line 01 - Position

Quantulus allows free ordering of every sample in all of the three trays. Each sample is specified by its position number, 1-60, so each sample will be counted in the order in which its position number is specified on parameter line 1. Each position number is separated from the next by a comma. If several samples are to be counted in numeric order they can be specified by giving the first and last numbers of the sequence separated by a hyphen . E.g.

```
POSITIONS
-> 2,41-50,22,23,5
```

means that first sample 2 (on tray 1) is counted, then samples 41 to 50 (on tray 3) are counted, followed by samples 22 and 23 on tray 2 and finally sample 5 on tray 1.

Line 02 - Listing

If a listing of the parameters in this group is required before results are printed out when measurements are taking place then answer Y (Yes) to this question otherwise answer N (No).

Line 03 - Counting Time

Give here the length of time for which each sample is to be counted. The normal units are minutes and the default is 1 min. The range is 1 - 900 000 counts (999 999 means no limitation). However the units can be given in seconds or hours by following the number by S or H respectively e. g . 30S or 5H. It is important that the time given here is long enough for enough counts to be accumulated even for the most quenched sample so that the statistical error (square root of the number of counts) is within the range required for the measurement.

Lines 04 & 05 - Maximum Counts

The maximum number of counts to be accumulated can be set on these two lines. For fixed window single label counting maximum counts for window 1 need to be specified on line 04. For fixed window dual label, maximum counts for both window 1 and 2 need to be given using lines 04 and 05 and then during counting when both of the two maximum values are exceeded counting stops.

This parameter enables the user to decide on the uncertainty (error) level required. Providing the count time is then long enough so that the counting of every sample is terminated by this maximum count parameter the count error for every sample will be the same.

If there is the danger of chemiluminescence in samples causing abnormally high count rates and thus hiding the isotope contribution making it useless to continue counting the sample, this parameter can be used to terminate the counting of such samples. For further discussion on Chemiluminescence, see the section with that name.

Line 07 - Sample Quality Monitor

This allows DPM results to be monitored to make sure that within the limits of expected uncertainty the results from the sample agree with the quench curve. If the DPMl value is outside the expected limits then a change has most likely happened to the sample quality. This function is describe in the section entitled Sample Quality Monitor. It can only be used if SQP (E) is selected. The default setting is No.

Line 08 - Number of Windows

This line only appears if Fixed Window is selected. The number of simultaneous windows from 1 to 8 can be selected here.

Lines 09, 10 & 11A to 11F - Windows 1 to 8

These lines only appear if Fixed Window selected. The number of lines that appear depends on the number of windows specified on line 8. The preset value for the windows will be 1-1024 unless changed by the user.

Line 12 - External Standard Counting Time

This and the next two lines do not appear if SQP(I) is selected. The external standard has an activity of 37 KBq; it is normally sufficient to count it for 2 min. to get adequate statistics. However other counting times can be set if required by entering the value in minutes (or seconds using S or hours using H) here. The range is 1 to 9999 sec (2 hours).

Line 13 - External Standard Maximum Counts

This acts like the maximum counts for samples on line 4 except that it is now for the external standard.

Line 14 - Printout Selection

Printout selection determines what will be printed out, the heading of each printout column and the order of columns. There are 48 printout codes each of which is a number specifying one type of printout. Up to 33 codes can be selected for print out. Text can also be included as described in the section entitled Printout.

```
14  PRINT 1,2,5,7,21,22,8,10
    ->?
Help: Current coding:
POS    CTIME  CPM1  CPM1%  SQP(E)  SQP(E)%  DPM1  DPM1%
Printout codes:
 1 POS        11 EFF1       21 SQP(E)     31 DPS2       41 CPM6
 2 CTIME      12 COUNTS2    22 SQP(E)%    32 %REF1      42 CPM7
 3 STIM       13 CPM2       23 CLM%       33 %REF2      43 CPM8
 4 COUNTS1    14 FCCPM2     24 CPM3       34 DATE       44 CPM1/CPM2
 5 CPM1       15 CPM2%      25 CPM4       35 TIME       45 CPM2/CPM1
 6 FCCPM1     16 DPM2       26 CPM5       36 ETIME1     46 DPM1/DPM2
 7 CPM1%      17 FDPM2      27 CCPM1      37 ETIME2     47 DPM2/DPM1
 8 DPM1       18 DPM2%      28 CCPM2      38 SCR        48 DTIME%
 9 FDPM1      19 EFF2       29 SQP(I)%    39 ESR        ,"TEXT",
10 DPM1%      20 SQP(I)     30 DPS1       40 NEW LINE
Range: 1 - 33 codes.
Type +x,y,-z,t to add codes x and y and to subtract codes z and t.
Type / to go to the READY-state. Type Lx RETURN to jump to line
number x.
```

Note: printout codes are explained in Ch 4 in Printout Selection.

Extended List Selection

Line 14 is the last line of the short parameter list. The user is given the opportunity to continue with the rest of the parameters in the extended list or to return to the Ready state. If N (No) is answered to the Extended Parameter List question the parameter setting will be terminated the parameter group updated with the parameter values set by the user and the word READY will be displayed. If Y (Yes) is answered to the Extended List question the remaining parameters will be listed for editing starting with line 15.

If this is answered with Y (yes) then the standard points (if any) will be listed one by one to allow editing (or if there are no points, data entry). See Curve Edit for more details.

Line 16 - Curve Fitting Method

This allows selection of one of the three curve fitting methods: Smoothing Spline, Interpolation Spline or Linear Interpolation. See Curve Edit for more details.

Line 16A - Replot with Auto Run

There are two types of curve plot which differ in their scales. One is a so called full size plot designed for printout and the other a reduced size scale designed to fit the display. Answering Y (Yes) to this first question on line 16A means that a full size plot will be printed out before the results during an automatic run i.e. normal sample measurement.

Replot with Curve Edit

This is the second question on line 16A. If it is answered Y (Yes) then a small scale plot of the stored curve will be displayed immediately after Return is pressed. Then another parameter line will appear with the question:

Lines 17 & 18, 19 - Background Sample and Background Subtraction

The CPM in the counting window(s) can be corrected for the background contribution. This contribution can be an experimental background and/or the natural background in the laboratory .

The experimental background can be, for example, background radiation from the counter lane when counting samples are labelled with both a beta and a gamma emitter.

The natural background is cosmic radiation and naturally occurring radiation in the laboratory building material. The contribution of this background has to be corrected for when counting low activity samples.

Quantulus automatically corrects the CPM in the counting windows using either a measured background for background samples, or estimated background CPM values; these can also be experimental values.

In both cases it should be remembered that the background is dependent on the sample and cocktail volume, and the background counting efficiency.

If background samples are used, the position of these samples are coded in answer to line number 17. The average background CPM in the counting windows is automatically used to correct the unknown sample CPMs.

If background samples are not coded background the CPM, line 18 (and 19 if more than 2 windows have been selected), will be asked for each of the counting windows given on line 8.

Note: Background sample only applies to Window 1 (for single and dual label) and Window 2 (for dual label) but not any other windows whereas background subtraction applies to the windows for which it is set.

Line 20 - Repeat

Each sample can be counted as many times as specified by this parameter. See the Repeat and Replicate section for more details about this parameter and the next.

Line 21 - Replicate Samples

The number of replicate samples can be specified with this parameter.

Line 22 - Sample Preparation Error %

When samples are prepared, a certain error is involved which contributes to the total error in the final result. An estimate of this uncertainty can be obtained from the differences between replicates, but this parameter allows the user make sure that this uncertainty is taken into account even if only single samples are being measured.

Lines 26 & 27 Multiplying by a factor

The CPM or DPM for windows one and two can be multiplied with the factors typed in as answers to lines 26 and 27.

The corrected CPM or the DPM results for windows one and two are multiplied with the respective factors, and the results are obtained by selecting the factorized CPM or DPM FCCPM 1,2 or FDPM 1,2 in the printout selection. The factor limits are 0.00001 E-9 - 0.9999E9 or 0.00001 to 999999. Results are given in decimal or exponential form.

Lines 28 & 29 Half-Life

For fast decaying isotopes it is necessary to correct for the reduction in sample activity over the period of measurement of a batch of samples. The half-life in hours can be entered on these lines for both single or dual labelled samples (the range is 0.1 to 99000 hr). See the Half-Life section for more information.

Line 30 - Number of Cycles

Samples on the conveyor will be passed through the counting position for the number of times specified by this parameter (range 1 to 99). This parameter acts as a sort of repeat count for a batch of samples. This process will continue until the number of cycles has been completed then counting of the next batch will begin.

Lines 31 & 32 - Reference Samples

The results for the samples in a batch can be compared to reference samples, and the result of the comparison is printed out as a percentage of the reference. The positions of the reference samples are coded by giving the lowest and highest positions. One set of reference samples can be given for each isotope if dual labelled. Reference 1 samples must be measured after background samples and before reference 2 samples. The average of the results for the reference samples is calculated and used for the comparison. When counting repeats or replicates, if %REF1 (and %REF2) have been selected, the average percentage is calculated when the statistical analysis is made. If reference samples for two isotopes are coded, the question Dual Label CPM counting will be asked and needs to be replied Y or N. By answering Y (Yes) to this question, coefficients will be calculated using the reference samples which enables spillover corrections to be made for the two isotopes in the respective counting windows.

Saving Parameters

After the Return has been pressed on line 31 (or 32 if it appears) the program will show the message:

```
SAVING PARAMETER GROUP x
```

where x is the group number selected at the beginning of parameter setting. This message will also appear after line 14 if only the shorter list has been selected or if parameter setting is terminated using the slash (/) command. This means that all the changes made to the parameters will be stored under group number x and the values there previously will be lost.

After parameters have been stored the program will return to the Ready state.

Parameter editing functions

There are three instructions (in addition to the Help function) which simplify parameter setting and editing:

Jump to another line: Lx
To jump to another parameter line before or after the one you are on type L then the line number you want to go to and press RETURN, e.g. if you are on line 10 and want to go to line 5 type L5 and press RETURN.

Jump to READY: /
Anytime you want to leave parameter setting and go to the READY state type /.

Correct the character typed: BACKSPACE
If you want to change what you have just typed you can do this as long as you have not pressed RETURN by using the BACKSPACE key on the keyboard . Each time you press it, one character will be deleted. When you have got rid of all the characters you want, type the new ones and then press RETURN. If you have pressed RETURN and then notice something needs to be changed in the parameter value, use the Lx instruction to go back to the line and give the whole parameter value again.

```
READY -> P
    PARAMETER GROUP ->5
    ID:      ->
    LINE             ->

00A PROGRAM MODE             1 ->
00B COUNT MODE SELECTION
    FIXED WINDOW (1)         1 ->
    SQP(I) SINGLE LABEL (1)
    SQP(E) SINGLE LABEL (2)
    SQP(E) DUAL LABEL   (3)  2 ->
    H-3   (1), I-125 (2)
    C-14  (3), S-35  (4)
    Ca-45 (5), P-32  (6)     1 ->
    COUNT MODE: FIXED WINDOW
                SQP(E) SINGLE LABEL
                H-3
01  POSITIONS 5
  ->5
02  LISTING                  Y ->
03  TIME                100:00 ->1
04  COUNTS 1            900000 ->
07  SAMPLE QUALITY MONITOR   N ->
08  NUMBER OF WINDOWS        1 ->
09  WINDOW 1            5- 320 ->
12  EXTERNAL STD TIME     0:15 ->
13  EXTERNAL STD COUNTS 900000 ->
14  PRINT 1,2,5,7,21,22,8,10
    ->
    EXTENDED PARAMETER LIST  N ->Y  - Extended list has been selected
15  CURVE EDIT               N ->
16  CURVE FIT               SS ->
16A REPLOT WITH AUTO RUN     N ->
    REPLOT WITH CURVE EDIT   N ->
17  BACKGROUND SAMPLE     0- 0 ->
18A BACKGROUND SUB. 1       .0 ->
20  REPEAT                   1 ->
21  REPLICATE                1 ->
22  SAMPLE PREP. ERROR %    .0 ->
26  FACTOR 1        1.00000E 0 ->
28  HALF LIFE 1             .0 ->
30  NUMBER OF CYCLES         1 ->
31  REFERENCE 1           0- 0 ->

SAVING PARAMETER GROUP  5
```

```
READY ->P
    PARAMETER GROUP ->5
    ID:       ->
    LINE             ->

00A PROGRAM MODE             1 ->
00B COUNT MODE SELECTION
    FIXED WINDOW (1)         1 ->
    SQP(I) SINGLE LABEL (1)
    SQP(E) SINGLE LABEL (2)
    SQP(E) DUAL LABEL   (3)  2 ->1
    CONFIRM: CHANGE C-MODE   N ->
    SQP(I) SINGLE LABEL (1)
    SQP(E) SINGLE LABEL (2)
    SQP(E) DUAL LABEL   (3)  2 ->
    H-3   (1), I-125 (2)
    C-14  (3), S-35  (4)
    Ca-45 (5), P-32  (6)     1 ->
    COUNT MODE: FIXED WINDOW
                SQP(E) SINGLE LABEL
                H-3
01  POSITIONS 5
  ->
02  LISTING                  Y ->
03  TIME                  1:00 ->
04  COUNTS 1            900000 ->
07  SAMPLE QUALITY MONITOR   N ->
08  NUMBER OF WINDOWS        1 ->
09  WINDOW 1            5- 320 ->
12  EXTERNAL STD TIME     0:15 ->
13  EXTERNAL STD COUNTS 900000 ->
14  PRINT 1,2,5,7,21,22,8,10
    ->
    EXTENDED PARAMETER LIST  N ->Y
15  CURVE EDIT               N ->
16  CURVE FIT               SS ->
16A REPLOT WITH AUTO RUN     N ->
    REPLOT WITH CURVE EDIT   N ->
17  BACKGROUND SAMPLE     0- 0 ->
18A BACKGROUND SUB. 1       .0 ->
20  REPEAT                   1 ->
21  REPLICATE                1 ->
22  SAMPLE PREP. ERROR %    .0 ->
26  FACTOR 1        1.00000E 0 ->
28  HALF LIFE 1             .0 ->
30  NUMBER OF CYCLES         1 ->
31  REFERENCE 1           0- 0 ->

SAVING PARAMETER GROUP  5
```

```
READY -> P
    PARAMETER GROUP ->5
    ID:      ->
    LINE            ->
00A PROGRAM MODE             1 ->
00B COUNT MODE SELECTION
    FIXED WINDOW (1)         1 ->
    SQP(I) SINGLE LABEL (1)
    SQP(E) SINGLE LABEL (2)
    SQP(E) DUAL LABEL   (3)  2 ->2
    H-3   (1), I-125 (2)
    C-14  (3), S-35  (4)
    Ca-45 (5), P-32  (6)     1 ->
    COUNT MODE: FIXED WINDOW
                SQP(E) SINGLE LABEL
                H-3
01  POSITIONS 5
  ->
02  LISTING                  Y ->
03  TIME                  1:00 ->
04  COUNTS 1            900000 ->
07  SAMPLE QUALITY MONITOR   N ->
08  NUMBER OF WINDOWS        1 ->8
09  WINDOW 1            5- 320 ->
10  WINDOW 2            1-1024 ->
11A WINDOW 3            1-1024 ->
11B WINDOW 4            1-1024 ->
11C WINDOW 5            1-1024 ->
11D WINDOW 6            1-1024 ->
11E WINDOW 7            1-1024 ->
11F WINDOW 8            1-1024 ->
12  EXTERNAL STD TIME     0:15 ->
13  EXTERNAL STD COUNTS 900000 ->
14  PRINT 1,2,5,7,21,22,8,10
    ->
    EXTENDED PARAMETER LIST  N ->Y
15  CURVE EDIT               N ->
16  CURVE FIT               SS ->
16A REPLOT WITH AUTO RUN     N ->
    REPLOT WITH CURVE EDIT   N ->
17  BACKGROUND SAMPLE     0- 0 ->
18A BACKGROUND SUB. 1       .0 ->
18B BACKGROUND SUB. 2       .0 ->
19A BACKGROUND SUB. 3       .0 ->
19B BACKGROUND SUB. 4       .0 ->
19C BACKGROUND SUB. 5       .0 ->
19D BACKGROUND SUB. 6       .0 ->
19E BACKGROUND SUB. 7       .0 ->
19F BACKGROUND SUB. 8       .0 ->
20  REPEAT                   1 ->
21  REPLICATE                1 ->
22  SAMPLE PREP. ERROR %    .0 ->
26  FACTOR 1        1.00000E 0 ->
28  HALF LIFE 1             .0 ->
30  NUMBER OF CYCLES         1 ->
31  REFERENCE 1           0- 0 ->
SAVING PARAMETER GROUP  5
READY -> P
```

```
PARAMETER GROUP ->5
    ID:       ->
    LINE             ->

00A PROGRAM MODE             1 ->
00B COUNT MODE SELECTION
    FIXED WINDOW (1)         1 ->
    SQP(I) SINGLE LABEL (1)
    SQP(E) SINGLE LABEL (2)
    SQP(E) DUAL LABEL   (3)  2 ->3
    CONFIRM: CHANGE C-MODE   N ->Y
    H-3   / I-125  (1)
    H-3   / C-14   (2)
    H-3   / S-35   (3)
    H-3   / Ca-45  (4)
    H-3   / P-32   (5)
    I-125 / C-14   (6)
    I-125 / S-35   (7)
    I-125 / Ca-45  (8)
    I-125 / P-32   (9)
    C-14  / Ca-45 (10)
    C-14  / P-32  (11)
    S-35  / Ca-45 (12)
    S-35  / P-32  (13)
    Ca-45 / P-32  (14)       2 ->
    COUNT MODE: FIXED WINDOWS
                SQP(E) DUAL LABEL
                H-3 / C-14
01  POSITIONS 5
  ->
02  LISTING                  Y ->
03  TIME                  1:00 ->
04  COUNTS 1            900000 ->
05  COUNTS 2            900000 ->
07  SAMPLE QUALITY MONITOR   N ->
08  NUMBER OF WINDOWS        2 ->
09  WINDOW 1            5- 240 ->
10  WINDOW 2          200- 650 ->
12  EXTERNAL STD TIME     0:15 ->
13  EXTERNAL STD COUNTS 900000 ->
14  PRINT 1,2,5,7,13,15,21,22,8,10,16,18
    ->
    EXTENDED PARAMETER LIST  N ->Y
15  CURVE EDIT               N ->
16  CURVE FIT               SS ->
16A REPLOT WITH AUTO RUN     N ->
    REPLOT WITH CURVE EDIT   N ->
17  BACKGROUND SAMPLE     0- 0 ->
18A BACKGROUND SUB. 1       .0 ->
18B BACKGROUND SUB. 2       .0 ->
20  REPEAT                   1 ->
21  REPLICATE                1 ->
22  SAMPLE PREP. ERROR %    .0 ->
26  FACTOR 1        1.00000E 0 ->
27  FACTOR 2        1.00000E 0 ->
28  HALF LIFE 1             .0 ->
29  HALF LIFE 2             .0 ->
30  NUMBER OF CYCLES         1 ->
31  REFERENCE 1           0- 0 ->
32  REFERENCE 2           0- 0 ->

SAVING PARAMETER GROUP  5
```

Chemiluminescence monitoring and subtraction

Chemical reactions can result in the emission of photons under certain conditions, e. g . when during sample preparation solubilizers or H_2O_2 have been used.

Several types of sample have to be solubilized before counting. Generally some quaternary ammonium hydroxide compounds are used as solubilizers. H_2O_2 is added as a bleaching agent for sample types which are strongly coloured. The sample preparation then results in an alkaline solution which, because it is water based, is counted in a liquid scintillation cocktail of emulsifying type. The emulsifier chemicals combined with the alkaline oxygen rich compound can result in a high rate of chemiluminescence reactions.

Chemiluminescence is a single photon reaction, consequently one chemiluminescence reaction is not enough to trigger the fast coincidence discriminator of Quantulus, but the higher the chemiluminescence reaction rate the bigger the probability that two reactions happen so close to each other that the fast coincidence discriminator is triggered and they will be accepted as a pulse and counted. At very high count rates the contributions of these random coincidences can make a considerable contribution to the counted spectra. As the random coincidence is the sum of two single photons the chemiluminescence spectrum is in the low energy end in channels 5-100 and a problem only when counting ^3H or some other low energy isotope.

The chemiluminescence reaction rate decays with time, so that after keeping the samples in a dark cupboard at room temperature overnight the rate is so low that it does not normally disturb the counting.

The reaction rate can be speeded up by increasing the temperature of the samples or by stirring. Other methods to reduce chemiluminescence are to add some acid, HCl or ascorbic acid, to the samples to return the pH value to below 7.

Quantulus has a built-in monitor for the detection of random coincidences, this is called the chemiluminescence monitor. Its function is the following: the radioactive decay gives rise to multiple photon reactions, as one disintegration releases energy sufficient for many photons to be produced in the scintillation cocktail. Characteristic for a multi-photon event is that both PM tubes "see" the scintillations inside a very short time, a few nanoseconds. If the signal from one of the PM tubes is delayed longer than the time of the scintillations then there will be no signal from the tube whose signal was delayed and the condition for coincidence will not be fulfilled. For chemiluminescence reactions there exists no time correlation between the scintillations. Thus the probability for random coincidence is the same even if one of the signals is delayed. In Quantulus when the chemiluminescence correction is selected the delayed coincidence spectrum is measured in MCA1 Halfl.

The normal or prompt coincidence spectrum consists of both true coincidence events and random coincidence events whereas the delayed coincidence spectrum consists of random coincidences due to chemiluminescence tube noise and, depending on the sample activity, random coincidences between beta decay events.

The delayed coincidence spectrum is used to correct the normal coincidence spectrum by subtracting it channel by channel. The CLM %, chemiluminescence percentage, is also calculated based on the delayed coincidence spectrum. CLM % can be printed out by selecting printout code 36 on line 14 in the parameter program. If CLM % is not selected and the chemiluminescence percentage is higher than l0 % the instrument will give a flag warning CLM % 10!

Note: Chemiluminescence is only subtracted if the CLM% printout is selected .

```
READY  >A6         Counting started with parameters from group 6

                                     WED  24 OCT 1984  15:31

PARAMETER GROUP:  6
ID: CHEM.LUM. TRIAL
***STD CURVE FITTING***   - Standardization has already been made
Thirty repeat counts of the same sample are shown below with chemiluminescence decaying from
70% to 2%
POS CTIME        CPM1      DPM1 DPM1%   CLM%  SaP(E)
001 00030    88270 97 192121.1  .905 71.271  455.85 -  Chemiluminescence
is
CLM% > 10 !                                             very high and the
001 00030    83119 37 180979.4  .923 63.108  455 76    detectors are close to
CLM% > 10 !                                             saturation
001 00030    78762.72 171567.3  .946 52.408  455.67
CLM% > 10 !
001 00030    74617.76 162490.9  .920 41.598  455.73
CLM% > 10 !
001 00030    72369.14 159032.9  .932 30.524  453.76 -  Chemiluminescence
CLM% > 10 !                                             corrected DPMs are
001 00030    71908 83 158775,3  .954 20.813  452.75    now stable
CLM% > 10 !
001 00030    70525.52 155580.2  .918 12.257  452.94 -  CPMs are now also
CLM% > 10 !                                             stable with over 10%
001 00030    68681.13 152256 6  .930  5.816  451.91    chemiluminescence
001 00030    69831.55 156230.0  .938  5.693  450.00
001 00030    69400.49 155398.8  .910  9.354  449.82
001 00030    69681.34 155609.8  .930  9.330  450.38
001 00030    69477.33 155789.7  .941  8.677  449.54
001 00030    70341.29 158175.9  .923  8.229  448.95
001 00030    70472.37 158134.6  .918  7.466  449.39
001 00030    70257.01 158049.6  .906  6.619  448.87
001 00030    69587.18 156732.4  .939  5.650  448.63
001 00030    69087.17 156251.2  .943  5.565  447.79
001 00030    69751.96 157538.9  .919  4.762  448.06
001 00030    69244.46 157861.3  .945  4.331  446.19
001 00030    69437.73 158140 2  .929  4.052  446.39
001 00030    67869.88 155927.5  .933  3.819  444.66
001 00030    68379.46 156185.7  .932  3.335  445.81
001 00030    69171 09 158099.2  .946  3.297  445.68
001 00030    68552.33 156651.4  .951  2.937  445.72
001 00030    68671 98 158938.2  .950  2.770  443.22
001 00030    68447.05 158335.9  .941  2.540  443.32
001 00030    68065.10 157278.1  .949  2.376  443.54
001 00030    67805.88 157175.6  .980  2.341  442.93
001 00030    68059.95 156889.5  .947  2.120  444.01
001 00030    67488 47 156493 0  .959  2.090  442.86
```

Curve

Standard curve fitting

In the standardization program, the standard points can be plotted out and fitted automatically by curves based on three different calculation methods:

Linear Interpolation LI
Smoothing Spline SS
Interpolation Spline IS

Smoothing Spline is the standard method; it fits a continuous curve to all the standard points using a different third degree polynomial to fit each pair of points. It also imposes the additional restrictions that the curve has only one turning point and is as smooth as possible.

Interpolation Spline is similar to the smoothing spline except that no restriction is placed on the shape of the curve other than that it must be continuous.

Linear Interpolation fits a straight line between each pair of points.

In the case of dual label operation the symbols used on the quench curves are listed in the efficiency listing before the curves are plotted out.

Two types of curve plots are possible. A full scale curve is plotted out:

i) during a standardization run after the curve fitting information has been printed out,
ii) when Ax is typed when the instrument has returned to the READY state after curve editing, provided that the following parameter of the extended list has been answered thus: -

```
16A REPLOT WITH AUTO RUN -> Y
```

After curve edit a small scale curve is plotted out after Y is answered to the second part of this parameter line:

```
16A REPLOT WITH CURVE EDIT -> Y
```

Due to the limitations of the matrix printer and the small area involved, several asterisks may appear on one line. A small scale curve can be converted to a full scale curve by following procedure ii) given above. This parameter reverts back to N after a curve has been plotted.

In the FITTING TABLE printed prior to curve plotting, the WEIGHT(%) means the initial uncertainty of each standard point. The larger the weight, the bigger the uncertainty.

If Smoothing Spline is chosen, the following list is an explanation of the characters printed prior to the fitting table:

N = number of curve fitting attempts (1-6) .
S = smoothing factor measures the ease of smoothing the fitted curve. The larger this is, the more difficult it is to make the curve fit smooth.
E = the number of maxima and minima values of the curve (these should be eliminated during curve fitting).
TP = number of turning points of the curve .
F = fitting factor (the lower the value, the better the fit).
T = quench level value (SQP(I) or SQP(E) where the curvature of the curve changes (= turning or inflection point).

Curve edit

When the standard points information is being printed out after Y and RETURN have been typed in response to line 15 CURVE EDIT there are three ways of altering the points. These are:

Adding standard points

Type the letter I after any of the standard point information lines and press RETURN. An additional point can be added at the end of the table for each I typed. Only one I can be typed per line. After all the standard points have been listed, blank lines are printed corresponding to the number of additional points chosen.

Changing points

Type in the necessary information at the end of the relevant line and press RETURN. Leave a space (by pressing the space bar), comma or dashed line between the figures typed in for the SQP, EFF.(%), and WEIGHT.

Deleting points

Type a hatch mark (#) at the end of the line you want to delete and press RETURN.

Note: A maximum of 10 standard points is allowed.

Editing dual label curves

When editing dual label quench curves it must be remembered that four fitting tables are printed out. These are for:

Isotope 1, Window 1.
Isotope 1, Window 2.
Isotope 2, Window 1.
Isotope 2, Window 2.

If points are altered for one of the isotopes then the appropriate values must be given in both fitting tables relevant to that isotope. The SQP value must be the same in both tables for the same point but the efficiency, deviation, and weight percentage values can differ. The number of standards can differ between isotopes but must remain the same for one of the isotopes in both windows.

```
READY ->P                                 - Parameter setting selected

                                          TUE  24 SEP 1996  14:11

    PARAMETER GROUP ->2
    ID: C14 ->
        LINE              ->15          - Jump to line 15
15  CURVE EDIT                 N ->
16  CURVE FIT                 SS ->
16A REPLOT WITH AUTO RUN       N ->Y  - Replot curve before counting unknowns
    REPLOT WITH CURVE EDIT     N ->Y  - Printout small scale curve

   ISOTOPE 1, WINDOW 1                - Curve fitting using the smoothing spline method
   SMOOTHING SPLINE                     selected on line 16

 BUSY CALCULATING
 N    S    E  TP
 1   .00  0  2
 2  1.50  0  0

 N =   2
 S =   1.50
 F =    .25

              FITTING TABLE                    - Table of SQP(E) values versus
 STD  SQP(E)  EFF.(%)  DEV.(%)  WEIGHT(%)        Efficiency % for each standard
  1   903.95   95.95     -.06     1.14
  2   785.43   88.37     -.63     1.17
  3   690.23   81.37      .41     1.22
  4   583.43   62.75     1.33     1.38
  5   509.29   40.34     -.64     1.73
  6   459.73   24.74     -.45     2.29

EFFICIENCY%
      I-----+------+------+------+-----+------+------+------+-----+--
      I                                                      *****OI
  90.0+                                           =**********      +
      I                                   ********O                I
      I                             *O****                         I
      I                        *****                               I
  70.0+                     ***                                    +
      I                  ***                                       I
      I               *O*                                          I
      I             **                                             I
      I           **                                               I
  50.0+         **                                                 +
      I       **                                                   I
      I    **O                                                     I
      I  **                                                        I
  30.0+ **                                                         +
      IO                                                           I
      I-----+------+------+------+-----+------+------+------+-----+--SQP(E)
           500    550    600    650   700    750    800    850   900

                 USEFUL SQP(E) RANGE:  460 - 904

    CALCULATE UNKNOWNS         N ->L15       - Jump to line 15

15  CURVE EDIT                 N ->Y         - Line 15 selected to allow curve to be edited
```

```
ISOTOPE 1, WINDOW 1
   SMOOTHING SPLINE

 BUSY CALCULATING
 N    S   E  TP
 1   .00  0  1
 2  1.25  0  0


 N =   2
 S =   1.25
 F =    .25


              FITTING TABLE
 STD  SQP(E)  EFF.(%)  DEV.(%)  WEIGHT(%)
  1   903.95   95.95     -.02     1.14
  2   785.43   88.37     -.49     1.17
  3   690.23   81.37      .31     1.22
  4   583.43   62.75     1.16     1.38
  5   509.29   40.34     -.97     1.73
Curve replotted with five points only

EFFICIENCY%
      I------+-------+------+-------+-------+------+-------+------+--
      I                                                        ****OI
      I                                              **********     I
  90.0+                                      ****O***               +
      I                                *******                      I
      I                           **O**                             I
      I                       ****                                  I
      I                    ***                                      I
  70.0+                 ***                                         +
      I              ***                                            I
      I           O*                                                I
      I         **                                                  I
      I       **                                                    I
  50.0+     **                                                      +
      I   **                                                        I
      I **                                                          I
      IO                                                            I
      I------+-------+------+-------+-------+------+-------+------+--
SQP(E)
            550     600    650     700     750    800     850    900

                  USEFUL SQP(E) RANGE:  509 -  904

    CALCULATE UNKNOWNS       N ->L16     - Jump to line 16 to change fitting method

16  CURVE FIT               SS ->LI      - Smoothing Spline changed to Linear Interpolation
16A REPLOT WITH AUTO RUN     Y ->        - Curve replotted with new method
    REPLOT WITH CURVE EDIT   N ->Y
```

```
ISOTOPE 1, WINDOW 1
   LINEAR INTERPOLATION

              FITTING TABLE
 STD  SQP(E)  EFF.(%)  DEV.(%)  WEIGHT(%)  - There is no deviation shown in this
  1   903.95   95.95      .00      1.14       table because linear interpolation goes
  2   785.43   88.37      .00      1.17       through all the points
  3   690.23   81.37      .00      1.22
  4   583.43   62.75      .00      1.38
  5   509.29   40.34      .00      1.73
This curve is replotted using linear interpolation to fit the points
EFFICIENCY%
      I------+-------+------+-------+-------+------+-------+------+--
      I                                                       ****OI
      I                                               *********    I
  90.0+                                       ***O****             +
      I                               ********                     I
      I                          **O**                             I
      I                       ***                                  I
      I                    ***                                     I
  70.0+                ****                                        +
      I             ***                                            I
      I           O*                                               I
      I         **                                                 I
      I       **                                                   I
  50.0+     **                                                     +
      I   **                                                       I
      I **                                                         I
      IO                                                           I
      I------+-------+------+-------+-------+------+-------+------+--
SQP(E)
            550     600    650     700     750    800     850    900

                  USEFUL SQP(E) RANGE:  509 -  904

    CALCULATE UNKNOWNS        N ->L15     - Jump to line 15 again for further editing

15  CURVE EDIT                Y ->

   ISOTOPE 1

   SQP(E)  EFF1(%) WEIGHT(%)
   903.95   95.95     1.14 ->
   785.43   88.37     1.17 ->
   690.23   81.37     1.22 ->700. 81.37 1.5  - This point and the next are moved
   583.43   62.75     1.38 ->594. 62.75 1.5
   509.29   40.34     1.73 ->

16  CURVE FIT                LI ->
16A REPLOT WITH AUTO RUN      Y ->
    REPLOT WITH CURVE EDIT    N ->Y          - Curve replotted with points moved
```

```
ISOTOPE 1, WINDOW 1
   LINEAR INTERPOLATION


              FITTING TABLE
 STD  SQP(E)  EFF.(%)  DEV.(%)  WEIGHT(%)
  1   903.95   95.95      .00     1.14
  2   785.43   88.37      .00     1.17
  3   700.00   81.37      .00     1.50
  4   594.00   62.75      .00     1.50
  5   509.29   40.34      .00     1.73
```

Curve plotted with points saved

```
EFFICIENCY%
      I------+-------+------+-------+-------+------+-------+------+--
      I                                                        ****OI
      I                                               *********     I
  90.0+                                       ***O****              +
      I                                *******                      I
      I                            *O**                             I
      I                        ****                                 I
      I                     ***                                     I
  70.0+                  ***                                        +
      I               ***                                           I
      I            *O*                                              I
      I          **                                                 I
      I        **                                                   I
  50.0+      **                                                     +
      I    **                                                       I
      I  **                                                         I
      IO*                                                           I
      I------+-------+------+-------+-------+------+-------+------+--
SQP(E)
            550     600    650     700     750    800     850    900

                  USEFUL SQP(E) RANGE:  509 -  904
```

`CALCULATE UNKNOWNS       N ->Y`	- Unknown values to be entered manually
`NUMBER OF REPLICATES ->2`	- Number of replicates given
`REPLICATE =   1`	- Values for first replicate required
`SQP(E)             ->650`	- SQP(Q) for first replicate
`SQP(E) ERROR %     ->0.1`	- Error in SQP value
`CPM1               ->1500`	- CPM value
`CPM1 ERROR %       ->0.5`	- Error in CPM value
`EFF.(ISOTOPE 1, WINDOW 1) % = 72.59`	- Calculated efficiency using the curve printed out previously
`DPM1                        = 2066.5`	- Calculated DPM
`DPM1 ERROR %                = 1.7`	- Calculated DPM error
`REPLICATE =   2`	- Values for second replicate required
`SQP(E)             ->`	- Etc.

DPM

DPM measurements

Quantulus includes the DPM program, which enables efficiency corrected results to be obtained.

The DPM program automatically calculates an efficiency correction curve or quench curve for single labelled samples and the two efficiency curves and spillover correction curves needed for dual labelled samples. Each of the 8 parameter groups can be supplied with quench curves. A maximum of 10 standard points can be used to calculate the quench curve.

There are three methods of quench curve calculation:

Method 1 - Single sample, incremental quench
Quenching agent is added progressively after each measurement. The sample may be measured up to ten times. Each quenched sample can be counted when START COUNTING is printed.

Method 2 - Single sample using HatTrick calibration
Quenching agent, $CC1_4$, is diffused into the cocktail from a special cap. Eleven measurements are made automatically (when using external standardization), and the mean values of each pair of measurements are calculated and stored giving ten calibration points. The starting SQP(I) or SQP(E) may be used to define the starting quench level for which quench points are stored.

Note: the HatTrick kit has been discontinued in 1996.

Method 3 - Standard Series
A series of up to ten quenched samples per isotope is made up and measured automatically.

Note: For single labelled samples, calibration is carried out once for the single isotope. For double labelled samples calibration is carried out automatically twice, once for each isotope, the low energy isotope being counted first.

For each quench or efficiency level the counting efficiency and the quench parameter value is recorded.

Quantulus uses two parameters:

1) SQP(E), spectral quench parameter of the external standard
2) SQP(I), spectral quench parameter of the isotope, this is the centre of gravity of the spectrum

Both parameters are based on spectrum analysis, the SQP (E) on analysis of the external standard spectrum, the SQP (I) on analysis of the isotope spectrum. Characteristic for both is the good dynamic range and small statistical error.

A curve is fitted to the standard points using either linear interpolation, interpolation spline or smoothing spline. Linear interpolation fits straight lines between the standard points, the interpolation spline fits a third degree polynomial function between each point subject to the condition that the curve must be continuous. The smoothing spline has an additional smoothing function which decreases the influence on the curve of bad points (outliers). The curve fit method is specific to the parameter group to which the quench curve will be dedicated.

The information concerning the standards such as activity and calibration method is given in the Standardization program which is activated with the S command.

The quench calibration results in a plot of the quench curve. The standard points are saved in EEPROM (non-volatile memory) together with the other parameter group information and are thereafter called into use when the parameter group is selected.

Note: SQP(I) can only be used for single label samples. SQP(I) is not well-defined for low activity samples for which SQP(E) is always recommended.

The DPM program offers additional benefits: quench curves can be edited and replotted, thus different curve fitting methods can be tested to see which will give the best result. The questions concerning editing and plot are in the extended parameter list.

A complete set of standard points can manually be typed in, thus if the standard points are deleted by mistake the standards need not be counted anew.

Quantulus can be used as a DPM calculator, DPM results can be manually counted. The CPM value and quench indicator value can then be manually typed in.

Half-life correction

One of the characteristics of radioactive decay is the half-life, that is the time in which the activity has decayed to half of the original. The decrease in activity is exponential and each isotope has its specific half-life.

If the decrease in activity is noticeable when compared with the time between the first and last sample in a batch a considerable error is introduced and the results within the batch can not be directly compared with each other, e.g. a count of ^{32}P lasting 24 hours gives results 5% too low by the end of the batch.

Quantulus makes automatic half-life correction for single or dual labelled samples if required by the user.

Half-life corrected CPM values are obtained by giving the half-life (in hours) and zero time for the isotope or isotopes and selecting the corrected CPM (CCPM l, 2) printouts.

The half-life correction for DPM values is automatically done for DPM l, 2 if half-life and zero time are given.

If a half-life value differing from 0 is given, the counter will ask for zero date and zero time. This is the time back to which the activity is corrected. This means also that if the batch is counted anew after e. g. one week, the DPM results are directly comparable as they are half-life corrected back to the same date and time.

If the half-life is set to 0 or ZERO TIME is not set when half-life is a non-zero value, the time of the start of counting will be used as the zero time.

If the Zero time is set in advance of the present date then the CCPM will be negative. Instead of a number, the text "NEG.ETIME" will be printed, and instead of the ETIME the text "NEG" will be printed.

```
28  HALF LIFE 1             .0 ->340.8
28A ZERO TIME 1 SET          Y ->
28B ZERO DATE 1    19 SEP 1996 ->15 SEP 1996
28C ZERO TIME 1           8:35 ->11:51
    ZERO DATE/TIME 1   15 SEP 1996  11:51
30  NUMBER OF CYCLES         1 ->
31  REFERENCE 1           0- 0 ->

SAVING PARAMETER GROUP  5
```

Printout

Printout selection

There are 48 standard printouts available with Quantulus. Each printout is identified by a number in the range 1-48 called a printout code. Printout codes are set on parameter line 14. Each code is separated by a comma (,) and after the last code RETURN must be pressed. Each count mode has its own preset list of printout codes but these can be changed by the user like any other parameter. A maximum of 33 codes or characters can be set.

Each printout code set on line 14 causes a preset column heading to be printed out when count results are being printed out. Then the numerical values for the items selected are printed out row by row, each under its own column heading.

Two symbols + and - allow the user to edit the printout selection line without retyping the whole line. If printout codes are to be added the + should be typed followed by the codes to be added.

```
14 PRINT 1,2,40,6
   -> +4,32
```

would add codes 4 and 32 to the existing list so that it becomes:

```
14 PRINT 1,2,40,6,4,32
->
```

Similarly the symbol - allows printouts to be deleted so:

```
14 PRINT 1,2,40,6,4,32
   -> -6,32
```

leads to the printout selection list:

```
14 PRINT 1,2,40,6
->
```

Both these symbols can be used on the same line e.g.

```
14 PRINT 1,2,4,5
-> +12,13,-4,5
```

which gives:

```
14 PRINT 1,2,12,13
```

The order does not matter so

```
-> -4,5,+12,13
```

would give the same result.

Text can be added to the printout in the form of one or more extra columns. E.g. the text "%" could be added to the printout selection; during actual printout the text "%" would appear on every line in the position specified.

The effect of the printout editing can be checked by jumping back to line 14 using the L14 command.

Printout

```
1 POS         Sample position number
2 CTIME       Sample count time
3 STIM        External standard count time
4 COUNTS1     Counts in window 1
5 CPM1        Counts per minute in window 1 (background subtracted)
6 FCCPM1      CPM1 corrected for half-life (if set) and spillover (if
              set and dual label) multiplied by factor 1
7 CPM1%       Percentage error in CPM1
8 DPM1        Disintegrations per minute
9 FDPM1       DPM in window 1 multiplied by factor 1
10 DPM1%      Percentage error in DPM1
11 EFF1       Efficiency in window 1
12 COUNTS2    Counts in window 2
13 CPM2       Counts per minute in window 2 (background subtracted)
14 FCCPM2     CPM2 corrected for half-life (if set) and spillover (if
              set and dual label) multiplied by factor 2
15 CPM2%      Percentage error in CPM 2
16 DPM2       Disintegrations per minute in window 2
17 FDPM2      DPM in window 2 multiplied by factor 2
18 DPM2%      Percentage error in DPM2
19 EFF2       Efficiency in window 2
20 SQP(I)     Isotope spectral quench parameter
21 SQP(E)     External standard spectral quench parameter
22 SQP(E)%    Percentage error in SQP(E)
23 CLM%       Chemiluminescence as a percentage of window 1 CPM
24 CPM3       CPM in window 3
25 CPM4       CPM in window 4
26 CPM5       CPM in window 5
27 CCPM1      Corrected CPM in window 1
28 CCPM2      Corrected CPM in window 2
29 SQP(I)%    Percentage error in SQP(I)
30 DPS1       Disintegrations per second in window 1
31 DPS2       Disintegrations per second in window 2
32 %REF1      Sample CCPM (or DPM if selected) in window 1 as
              a percentage of Reference 1 CCPM (or DPM)
33 %REF2      Sample CCPM (or DPM if selected) in window 2 as
              a percentage of Reference 2 CCPM (or DPM)
34 DATE       Date of sample measurement
35 TIME       Time of sample measurement
36 ETIME1     Elapsed time since A or Q Return pressed unless Zero
              Time 1 set in which case this defines start time for ETIME1
              (see Half-life section)
37 ETIME2     Elapsed time since A or Q Return pressed unless Zero
              Time 2 set in which case this defines start time for ETIME2
              (see Half-life section)
38 SCR        Sample channels ratio
39 ESR        External standard channels ratio
40 NEW LINE   Start remaining printout on a new line
41 CPM6       CPM in window 6
42 CPM7       CPM in window 7
43 CPM8       CPM in window 8
44 CPM1/CPM2  Ratio of CPM in window 1 to that in window 2
45 CPM2/CPM1  Ratio of CPM in window 2 to that in window 1
46 DPM1/DPM2  Ratio of isotope 1 activity to isotope 2 activity
47 DPM2/DPM1  Ratio of isotope 2 activity to isotope 1 activity
48 DTIMEX     Ratio of isotope 2 activity to isotope 1 activity
"TEXT"        Text can be added between quotation marks " "
```

Repeats and replicates

Repeat

Samples can be counted repeatedly (maximum 99 times) to check sample stability or instrument performance, or to see the possible effect of chemiluminescence on the result.

Replicate samples can be used as a method to evaluate sample preparation errors, e.g. standards can be counted as replicates before quenching for the evaluation of the spread and error in the standard DPM.

The number of repeats or replicate samples should be typed in on lines 20 or 21. The counter will count and print out the results. After the last repeat or replicate the average values of various quantities (see example) are calculated. The following statistical evaluations are made.

The theoretical and observed errors are calculated.

The theoretical error is the total error expected due to the statistical nature of nuclear radiation for each sample plus the sample preparation error. The theoretical error is given as a percentage of the mean.

The observed error is the standard deviation of the mean as a percentage of the average for repeats and replicates.

The chi-square test is done for the observed and theoretical error. The reduced chi-square value is printed out for n observations:

$$\chi^2 / (n-1) = (\text{Observed error})^2 / (\text{Theoretical error})^2$$

If the results obtained have a statistical spread which can be expected for the radioactive decay, the theoretical and observed error should be about the same, and the chi-square value should be close to one (refer to the chi-square table).

Additional information about the quality of the results is obtained by the probability factor, which is calculated. This gives the percentage probability, that a random sample from a true Poisson distribution of the same number of samples as the number of repeats or replicates will have a greater chi-square value than the observed. For example if the probability is low (2%) it can be concluded that the observed deviation is abnormally large because there is only a 2% probability that a random sample from a correct distribution would have a larger chi-square value. If the probability is high (98%) the observed deviation is abnormally small because there is then a 98% probability that a random sample from a correct distribution would have a larger chi-square value. The probability should be between 5% and 95% for a good fit of the observed distribution and the theoretical one. The number of observations (cycles, repeats) must be 30 or greater before any definite conclusions can be drawn about the fit.

If the number of repeats or replicates is equal to or greater than 5 the additional questions REPEAT PLOT or REPLICATE PLOT are asked. If answered Yes the instrument will, after printing out the results, print out a trend plot showing the distribution of the results around the average value; in the plot the 90% and 99% confidence limits and the confidence intervals are indicated.

After the distribution plot a frequency plot is obtained. The range between the highest and lowest result is divided in to a number of intervals depending on the number of repeats or replicates. The number of results in each interval is then plotted.

```
READY ->A
Data to be filed in PC? (Y/N) Y ->

 1. assay in queue
PARAMETER GROUP NUMBER  0 ->5
DIRECTORY PATH   ->USR1\H3TEST

 2. assay in queue
PARAMETER GROUP NUMBER  0 ->/
COMMAND: Display,Modify,Remove,Insert,List groups,Start counting  -
>S


                                        THU  19 SEP 1996  10:40



    PARAMETER GROUP:  5
    ID:REPEAT

00A PROGRAM MODE             1 ->
    COUNT MODE: FIXED WINDOW
                SQP(E) SINGLE LABEL
                H-3
01  POSITIONS 5
  ->
02  LISTING                  Y ->
03  TIME                 60:00 ->
04  COUNTS 1            900000 ->
07  SAMPLE QUALITY MONITOR   N ->
08  NUMBER OF WINDOWS        1 ->
09  WINDOW 1            5- 320 ->
12  EXTERNAL STD TIME     0:15 ->
13  EXTERNAL STD COUNTS 900000 ->
14  PRINT 1,2,5,7,21,22,8,10
    ->
15  CURVE EDIT               N ->
16  CURVE FIT               SS ->
16A REPLOT WITH AUTO RUN     N ->
    REPLOT WITH CURVE EDIT   N ->
17  BACKGROUND SAMPLE     0- 0 ->
18A BACKGROUND SUB. 1       .0 ->
20  REPEAT                  30 ->
20A REPEAT PLOT              Y ->
21  REPLICATE                1 ->
22  SAMPLE PREP. ERROR %    .0 ->
26  FACTOR 1        1.00000E 0 ->
28  HALF LIFE 1             .0 ->
30  NUMBER OF CYCLES         1 ->
31  REFERENCE 1           0- 0 ->
```

Results

Automatic Counting

Start the instrument counting by typing A followed by the correct parameter group number and then press RETURN.

To stop automatic counting, type letter O and press RETURN. The instrument then returns to the READY state.

Radiation Safety Protocol

The total sum of CPM or DPM counted in a batch is summed together and printed out at the end of the batch. If DPMs are counted the printout of total DPM will also include the DPM value transformed to nanocuries and kilo Becquerels. Thus a record of the activity handled can be kept by collecting these printouts in a binder, or by giving them to the person responsible for the records of radioactivity in the laboratory.

Result reliability

The long term stability of the counter is of utmost importance when counting large amounts of samples or when results which are counted at different times are compared. In a Liquid Scintillation Counter the most important part is the photomultiplier tube section, including the pulse amplifiers, the instability of whose components can be seen immediately as a spread in the results.

Factors such as:

- temperature variations
- drift in the high voltage
- aging of the PM tubes

can cause errors if not corrected for.

Quantulus, as all Wallac counters incorporates the Automatic Continuous Spectrum Stabilizer, which will check counter performance automatically 63 times per second and correct if any drift is observed.

The basic principle for the ACSS is the following.

Reference light sources, light emitting diodes, emit a light pulse of constant intensity. The responses of the PM tubes and amplifiers to the light pulses are compared to a reference voltage and if they differ from it the high voltage is corrected.

The light emitting diodes of the ACSS unit are used at a very low intensity, thus the life time of the LEDs are ensured to be longer than the life time of the PM tubes. The temperature dependence of the circuitry driving the LEDs is made to be the same as that of the counter so that the LED output and thus counter stability is independent of temperature variations in the range 15-35°C.

Sample quality monitor

One problem in liquid scintillation counting is inhomogeneity of the mixture composed of the sample being analysed and the liquid scintillation cocktail. If sample and cocktail are not adequately mixed some of the beta particles will be absorbed in the sample phase and thus not reach the scintillation liquid phase, This will appear as a reduced counting efficiency for the sample.

This happens because the external standard spectrum which is produced by the Compton electrons resulting from the gamma radiation from the external standard, is not affected by the inhomogeneity of the sample and cocktail mixture. This is because the Compton electrons are generated throughout the whole volume and thus will effectively produce scintillations. The counting efficiency might even be improved for the external standard as the quenching agents are in the sample phase.

Thus the counting efficiency obtained from the measurement of the external standard is not correct if sample and cocktail mixture is two phased.

The sample and liquid scintillator mixture can be homogeneous when the counting starts, but as time goes the last samples can be inhomogeneous if the samples are close to the sample holding capacity of the cocktail. When using an emulsifying cocktail, the sample is suspended in "drops", micelles, in the cocktail. The micelles are small compared to the range of the beta particle energy so that absorption in the micelles is minimized. However if the sample amount is big, close to the sample holding capacity, the micelle will start to grow which will affect the counting efficiency.

The Sample Quality Monitor will detect this type of changes in the samples when DPM data reduction is used. If inhomogeneity is detected, the information

```
CHECK SAMPLE
```

will be printed out after the results. The same warning can be obtained for some other reason, for example due to large volume differences between standards and unknown samples.

The Sample Quality Monitor functions as follows:

If this function is to be used, a standard curve must first be obtained. During standardization a relationship is established between the SQP(E) value and the isotope spectrum endpoint. This will automatically be stored together with the standard points. It is assumed that the standards making up the standard curve are homogeneous and that these define the envelope of acceptable homogeneity. If the Sample Quality Monitor prompt is answered Y (yes) then when the parameter group is used the SQP(E) and isotope spectrum endpoint are calculated for each sample. The values obtained are compared against the stored Sample Quality curve. If it is found that the values fall outside the standard homogeneity envelope then the sample is flagged as inhomogeneous.

As the Sample Quality Monitor is based on a relationship between the isotope spectrum and the quench indicating parameter, a blank sample will naturally be flagged as inhomogeneous. However the homogeneity of a background sample is of lesser importance.

Standardization parameter setting

Selecting standardization - S

To select the standardization parameters, control letter S must be typed and Return pressed. The current date and time will be printed out and the title Standardization Program.

Parameter Group Selection

The results of a standardization measurement i.e. the quench curve, become part of a parameter group therefore it is necessary to specify what this group is before beginning the standardization routine. Once the group number is given and Return pressed the summary of the group count mode will be printed out and then parameter setting can begin. Two lines appear for parameter lines 1, 4 and 5 if the dual label counting mode is selected. The standard samples can be placed in any order; the instrument automatically records the results in decreasing order of quench level.

Line 01 - Positions of Standards

The number of standard points to be obtained for the quench curve must be given by giving the positions of the standards; a maximum of ten is allowed. If correction has been selected in the P-program then the vial type, glass or plastic will be asked after the positions of standards.

Line 02 - Automatic Run Selection

There are two modes - manual and automatic. The latter mode allows a quench standard to be measured and then unknowns evaluated using the resulting quench curve without any further user intervention. It also place restrictions on the methods of quench measurement. Only the two automatic methods, 2 and 3, can be used. Automatic run is selected by answering Y (Yes) on the parameter line. If N (No) is answered there will be no automatic plot of quench curve and measurement of unknowns, these are subject to user control and thus allow the possibility of curve editing before unknowns are measured. It also means that any of the three quench standard measurement methods, including the manual one, can be used.

When using the standardization program, only certain combinations of automatic run and automatic window are allowed with particular quench calibration methods. These are shown in the following table.

Line 03 - Standardization Method

There are three methods as described in the DPM section of this manual. If the fixed window manual run has been selected, any of these can be chosen, i.e. Manual, HatTrick or Series but if an automatic run has been chosen, then only HatTrick and Series are allowed.

Note: 1210-126 HatTrick kit is not available any more from Wallac.

Line 04 - Isotope DPM

The DPM(s) for the isotope (or isotopes) being used in the quench standard measurement must be given on this line.

Line 05 - DPM percentage error

The uncertainty in the DPM value given on line 04 can be given as a percentage of the isotope DPM.

Line 06 - Starting SQP value

A quench curve establishes a relationship between the efficiency of measurement of a standard and the spectral quench parameter (SQP(I) or SQP(E)). This parameter allows maximum SQP value to be given thus eliminating the plotting of points outside the range that is significant for the unknown samples to be measured.

When the Repeat or Replicate mode is in operation (when using the extended list), if some of the repeat or replicate values of the unknown samples are outside the limits of the standard curve then ! OUT OF RANGE ! is printed if a single sample is out of range.

Line 07 - Time Factor

The time factor multiplies both standard parameters line 03, Time and line 11, External Standard Time. A time factor of 1 means that the counting time will be the same as that for the unknowns, 2 means twice as long etc.

Line 08 - Start Counting

Counting is started by typing Y (Yes) and pressing Return. The name of the method of producing the quench curve is printed out then the title Standardization after which counting begins.

The example shown on the following pages is of a dual label standardization. First the parameters are set for counting dual label samples, then the standardization parameters. One quench series for each isotope is measured and two standard curves plotted.

```
READY ->P
                                        TUE  24 SEP 1996  10:24
    PARAMETER GROUP ->1
    ID: DUAL ->
    LINE           ->
00A PROGRAM MODE             1 ->
00B COUNT MODE SELECTION
    FIXED WINDOW (1)         1 ->
    SQP(I) SINGLE LABEL (1)
    SQP(E) SINGLE LABEL (2)
    SQP(E) DUAL LABEL   (3)  3 ->
    H-3   / I-125  (1)
    H-3   / C-14   (2)
    H-3   / S-35   (3)
    H-3   / Ca-45  (4)
    H-3   / P-32   (5)
    I-125 / C-14   (6)
    I-125 / S-35   (7)
    I-125 / Ca-45  (8)
    I-125 / P-32   (9)
    C-14  / Ca-45 (10)
    C-14  / P-32  (11)
    S-35  / Ca-45 (12)
    S-35  / P-32  (13)
    Ca-45 / P-32  (14)       2 ->
    COUNT MODE: FIXED WINDOWS
                SQP(E) DUAL LABEL
                H-3 / C-14
01  POSITIONS 13-16
  ->
02  LISTING                  Y ->
03  TIME                 10:00 ->
04  COUNTS 1             50000 ->
05  COUNTS 2             50000 ->
07  SAMPLE QUALITY MONITOR   N ->
08  NUMBER OF WINDOWS        2 ->
09  WINDOW 1            5- 240 ->5-300
10  WINDOW 2          200- 650 ->100-600
12  EXTERNAL STD TIME     0:15 ->
13  EXTERNAL STD COUNTS 900000 ->
14  PRINT 1,2,5,7,13,15,21,22,8,10,16,18
    ->-7,15
    EXTENDED PARAMETER LIST  N ->Y
15  CURVE EDIT               N ->
16  CURVE FIT               SS ->
16A REPLOT WITH AUTO RUN     N ->
    REPLOT WITH CURVE EDIT   N ->
17  BACKGROUND SAMPLE     0- 0 ->
18A BACKGROUND SUB. 1       .0 ->
18B BACKGROUND SUB. 2       .0 ->
20  REPEAT                   1 ->
21  REPLICATE                1 ->
22  SAMPLE PREP. ERROR %    .0 ->
26  FACTOR 1        1.00000E 0 ->
27  FACTOR 2        1.00000E 0 ->
28  HALF LIFE 1             .0 ->
29  HALF LIFE 2             .0 ->
30  NUMBER OF CYCLES         1 ->
31  REFERENCE 1           0- 0 ->
32  REFERENCE 2           0- 0 ->
SAVING PARAMETER GROUP  1
```

```
READY ->S
                                        TUE  24 SEP 1996  10:26

*** STANDARDIZATION PROGRAM ***

    PARAMETER GROUP            ->1
    COUNT MODE: FIXED WINDOWS
                SQP(E) DUAL LABEL
                H-3 / C-14
01A NO. OF STAN. ISOTOPE 1  10 ->5
    POSITION OF FIRST STAND  1 ->
01B NO. OF STAN. ISOTOPE 2  10 ->5
    POSITION OF FIRST STAND 11 ->7
02  AUTOMATIC RUN            Y ->
03A METHOD 2,3               3 ->
04A ISOTOPE 1 DPM           .0 ->8500
04B ISOTOPE 2 DPM           .0 ->9900
05A ISOTOPE 1 DPM ERROR%    .0 ->.5
05B ISOTOPE 2 DPM ERROR%    .0 ->.5
06B START SQP(E)          1024 ->
07  TIME FACTOR            1.0 ->3
08  START COUNTING           Y ->  SERIES

Data to be filed in PC? (Y/N) Y ->N

ISOTOPE 1 STANDARDIZATION

     CPM1  EFF1%  ERR1%        CPM2  EFF2%  ERR2%   SQP(E) SQP(E)%
  5751.93  67.67    .65     4430.81  52.13    .69   906.36     .06
  3014.48  35.46    .76     1534.33  18.05    .95   783.02     .08
  1486.92  17.49    .96      475.63   5.60   1.53   692.62     .10
   520.43   6.12   1.47       91.98   1.08   3.33   593.58     .11
   159.96   1.88   2.55       22.36    .26   6.70   508.53     .13

*** CONVEYOR CLEARING ***

   ISOTOPE 1, WINDOW 1
   SMOOTHING SPLINE

 BUSY CALCULATING
 N    S   E  TP
 1   .00  0  0

 N =   1
 S =    .00
 F =    .00
```

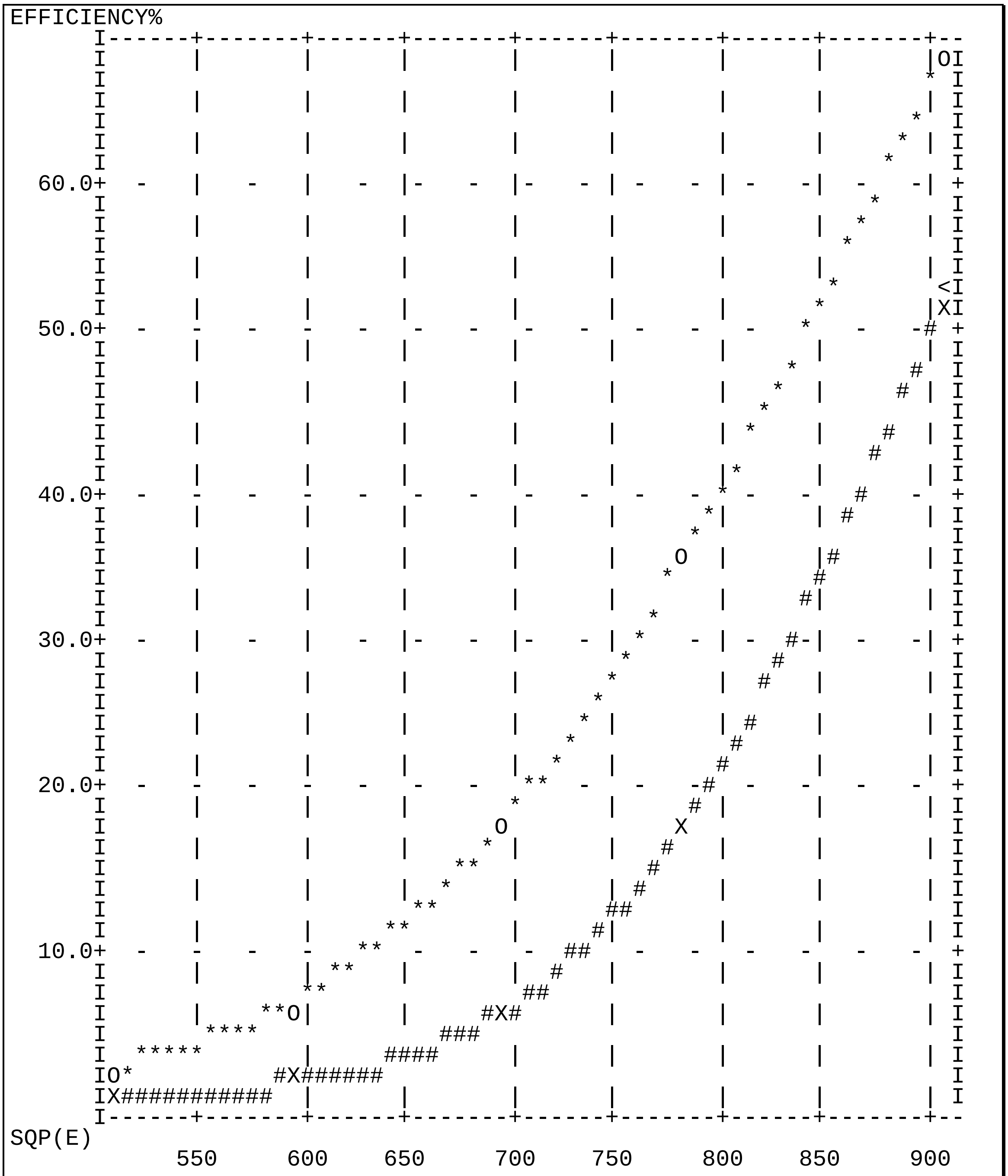
The last three columns in the fitting table explain the symbols used in the plots

```
                           FITTING TABLE
 STD   SQP(E)  EFF.(%)  DEV.(%)  WEIGHT(%)  POINT  CURVE  ERR.LIMIT
  1    906.36   67.67      .00       .69      O      *        =
  2    783.01   35.46      .00       .87      O      *        =
  3    692.62   17.49      .00      1.15      O      *        =
  4    593.58    6.12      .00      1.70      O      *        =
  5    508.53    1.88      .00      3.07      O      *        =
```

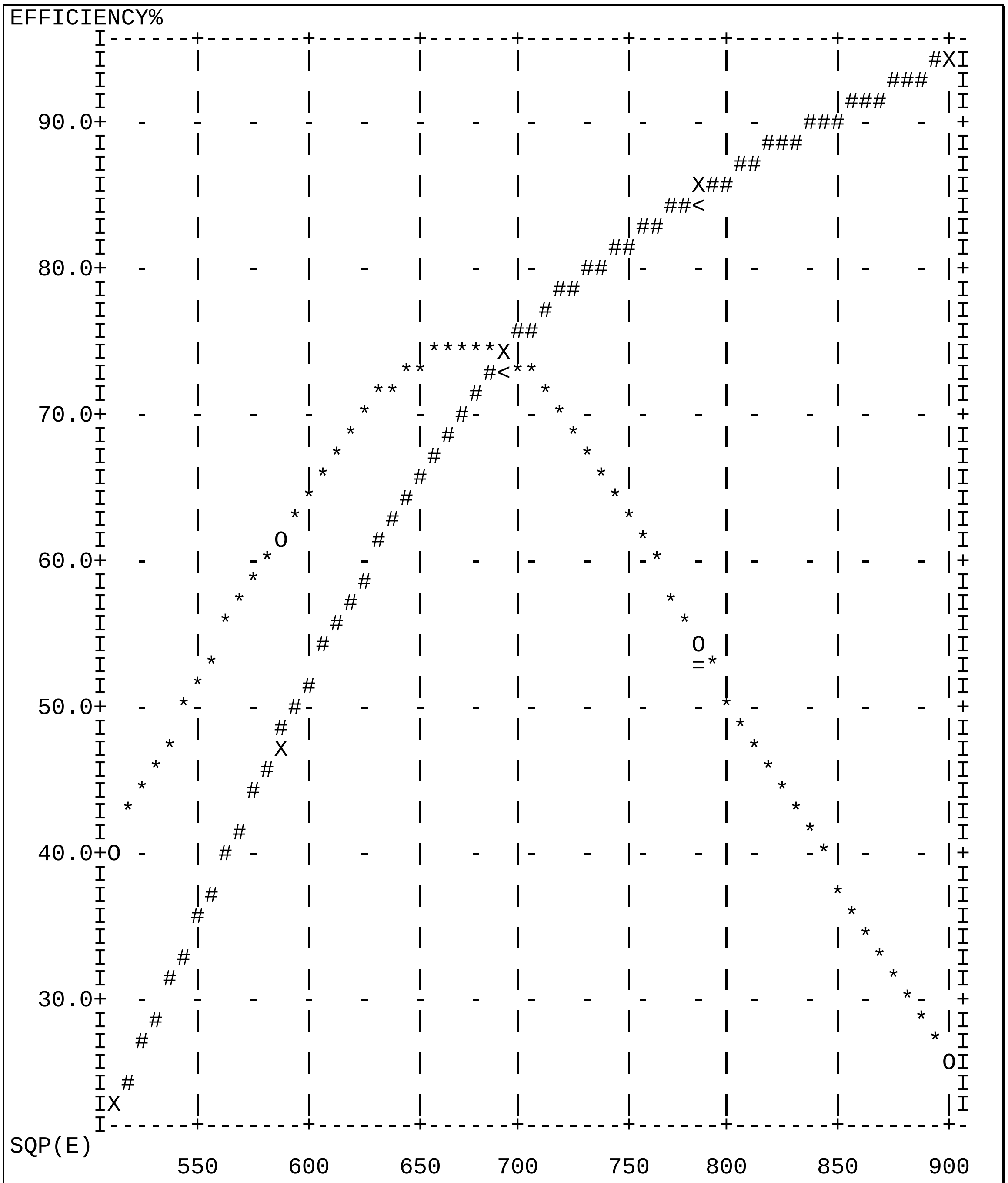
```
ISOTOPE 1, WINDOW 2
   SMOOTHING SPLINE

 BUSY CALCULATING
 N     S    E   TP
 1   .00  0   0


 N =    1
 S =     .00
 F =     .00


                          FITTING TABLE
 STD  SQP(E)  EFF.(%)  DEV.(%)  WEIGHT(%)  POINT  CURVE  ERR.LIMIT
  1   906.36   52.13      .00        .75     X      #        <
  2   783.01   18.05      .00       1.21     X      #        <
  3   692.62    5.60      .00       1.91     X      #        <
  4   593.58    1.08      .00       3.71     X      #        <
  5   508.53     .26      .00       7.11     X      #        <
```

Standard curve showing results for isotope 1 in tritium and carbon windows

```
ISOTOPE 2 STANDARDIZATION

      CPM1  EFF1%  ERR1%        CPM2  EFF2%  ERR2%   SQP(E) SQP(E)%
   2641.81  26.68    .79     9330.95  94.25    .60   902.83     .06
   5362.95  54.17    .67     8444.93  85.30    .61   785.07     .08
   7350.60  74.25    .67     7307.73  73.82    .67   689.20     .10
   6109.55  61.71    .64     4739.50  47.87    .68   585.11     .12
   4040.92  40.82    .71     2331.83  23.55    .82   507.77     .13

*** CONVEYOR CLEARING ***

   ISOTOPE 2, WINDOW 1
   SMOOTHING SPLINE

 BUSY CALCULATING
 N    S   E  TP
 1   .00  1  1

 N =   1
 S =    .00
 T =   772.21
 F =    .00

                           FITTING TABLE
 STD   SQP(E)  EFF.(%)  DEV.(%)  WEIGHT(%)  POINT  CURVE  ERR.LIMIT
  1    902.83   26.68      .00       .91      O      *        =
  2    785.07   54.17      .00       .71      O      *        =
  3    689.20   74.25      .00       .67      O      *        =
  4    585.11   61.71      .00       .68      O      *        =
  5    507.76   40.82      .00       .83      O      *        =

   ISOTOPE 2, WINDOW 2
   SMOOTHING SPLINE

 BUSY CALCULATING
 N    S   E  TP
 1   .00  0  0

 N =   1
 S =    .00
 F =    .00

                           FITTING TABLE
 STD   SQP(E)  EFF.(%)  DEV.(%)  WEIGHT(%)  POINT  CURVE  ERR.LIMIT
  1    902.83   94.25      .00       .60      X      #        <
  2    785.07   85.30      .00       .62      X      #        <
  3    689.20   73.82      .00       .69      X      #        <
  4    585.11   47.87      .00       .79      X      #        <
  5    507.76   23.55      .00      1.21      X      #        <
```




```
SAVING PARAMETER GROUP  1

POINTS STORED
```




```
                USEFUL SQP(E) RANGE:  509 -  903

SAVING PARAMETER GROUP  1

POINTS STORED
```

```
TUE  24 SEP 1996  12:21

    PARAMETER GROUP:  1
    ID: DUAL

00A PROGRAM MODE             1 ->
    COUNT MODE: FIXED WINDOWS
                SQP(E) DUAL LABEL
                H-3 / C-14
01  POSITIONS 13-16
  ->
02  LISTING                  Y ->
03  TIME                 10:00 ->
04  COUNTS 1             50000 ->
05  COUNTS 2             50000 ->
07  SAMPLE QUALITY MONITOR   N ->
08  NUMBER OF WINDOWS        2 ->
09  WINDOW 1            5- 300 ->
10  WINDOW 2          100- 600 ->
12  EXTERNAL STD TIME     0:15 ->
13  EXTERNAL STD COUNTS 900000 ->
14  PRINT 1,2,5,13,21,22,8,10,16,18
    ->
15  CURVE EDIT               N ->
16  CURVE FIT               SS ->
16A REPLOT WITH AUTO RUN     N ->
    REPLOT WITH CURVE EDIT   N ->
***STD.CURVE FITTING***

17  BACKGROUND SAMPLE     0- 0 ->
18A BACKGROUND SUB. 1       .0 ->
18B BACKGROUND SUB. 2       .0 ->
20  REPEAT                   1 ->
21  REPLICATE                1 ->
22  SAMPLE PREP. ERROR %    .0 ->
26  FACTOR 1        1.00000E 0 ->
27  FACTOR 2        1.00000E 0 ->
28  HALF LIFE 1             .0 ->
29  HALF LIFE 2             .0 ->
30  NUMBER OF CYCLES         1 ->
31  REFERENCE 1           0- 0 ->
32  REFERENCE 2           0- 0 ->
```

Unknown dual label samples are counted

```
POS CTIME    CPM1    CPM2  SQP(E)  SQP(E)%  DPM1  DPM1%   DPM2  DPM2%
013 10:01   39.95   98.14  868.27     .115   7.8 71.900  103.5  5.302
014 10:01   80.53  195.99  866.43     .111  15.2 54.117  207.3  4.016
015 10:01  157.26  372.95  856.55     .126  14.9 86.207  404.2  3.300
016 10:01  166.54  374.29  850.82     .122  22.5 61.071  404.9  3.352

TOTAL COUNT RATE:      1485.7 CPM
TOTAL ACTIVITY:        1180.3 DPM =        .5 nCi =       .0 kBq

*** CONVEYOR CLEARING ***

  READY ->
```

Window setting

The Quantulus has built-in window setting for six common isotopes in both single and dual label combinations. These settings give the optimal windows for unquenched samples. If there is quenching the isotope spectrum will be shifted to lower energies. In order to keep the spectrum within the counting window you should adjust the window to fit the spectrum. Quantulus allows you to do this in two ways:

Using the spectrum display to help you adjust your window settings until the spectrum falls visually within the windows.

Using option 1220-114. This works by measuring first the sample with the external standard in place. Then the sample spectrum alone is measured over the complete energy range. The two spectra are subtracted to give the external standard spectrum. From this the spectral quench parameter is obtained. This is then used to calculate the optimum window setting for the sample. This optimum setting is then imposed on the stored spectrum and the amount of the sample spectrum in that window is calculated and the final result printed out. The spectral quench parameter guarantees a precise window setting.

If the status of this mode is changed, e.g. going from fixed to automatic or vice versa the quench curve must be rerun.

If BATCH WINDOW is selected, the results of counting the first sample of the batch are used by the instrument to select the window setting for the remaining samples. This should only be used for counting a batch of samples that are similarly quenched.

Note: The Batch Window parameter only appears if option 1220-114 is included.

```
READY ->A

Data to be filed in PC? (Y/N) Y ->N

 1. assay in queue
PARAMETER GROUP NUMBER  0 ->5

 2. assay in queue
PARAMETER GROUP NUMBER  0 ->/
COMMAND: Display,Modify,Remove,Insert,List groups,Start counting  -
>S

                                        THU  19 SEP 1996  11:30



    PARAMETER GROUP:  5
    ID: C14

00A PROGRAM MODE             1 ->
    COUNT MODE: FIXED WINDOW
                SQP(I) SINGLE LABEL
                C-14
01  POSITIONS 1-10
  ->
02  LISTING                  Y ->
03  TIME                  1:00 ->
04  COUNTS 1            900000 ->
08  NUMBER OF WINDOWS        1 ->
09  WINDOW 1          195- 645 ->
14  PRINT 1,2,5,7,20,29
    ->


POS   CTIME        CPM1    CPM1%   SQP(I)  SQP(I)%

001    1:01    36553.10     .519   169.54     .113


*** CONVEYOR CLEARING ***



TOTAL COUNT RATE:     36553.1 CPM


*** COUNTING INTERRUPTED ***

     PARAMETER GROUP 05
     POS  002

  READY ->
```

Mode 2 - Spectrum plot

Mode 2 Parameters

Mode 2 - Spectrum plot

A copy of the spectrum accumulated in the multichannel analyser memory can be printed in 57 characters resolution using the spectrum plot program which is obtained by selecting Program Mode 2 in parameter setting. This mode has its own set of parameters beginning with line 40. Both the isotope spectrum and the external standard spectrum can be plotted. The plot can be formatted using the window width and step functions. Window width determines the number of channels which are summed together for the plot. The step function determines how many channels there are between the lower limits of two successive windows. If the number of step channels is less than window channels the spectrum will be smoothed.

By choosing window = 4 and step = 4 the plotted spectrum will be a copy of the displayed spectrum. The interesting channel area can be specified.

When mode 2 is selected the heading SPECTRUM PLOT PARAMETERS will be printed out followed by the parameters themselves.

Line 01 - Position

As in Mode 1 the free ordering of every sample in all of the three trays is allowed. Each sample is specified by its position number, 1-60, so each sample will be counted in the order in which its position number is specified on parameter line 1. Each position number is separated from the next by a comma. If several samples are to be counted in numeric order they can be specified by giving the first and last numbers of the sequence separated by a hyphen.

Line 40 - Parameter Listing

If answered Y (Yes) it provides a printout of the Spectrum plot parameters before results are printed.

Line 41 - Spectrum Selection

The user can select either to have the sample spectrum or the external standard spectrum.

Line 42 - Counting time

The time in minutes, seconds (S) or hours (H) for which the spectrum is to be accumulated is specified on this line.

Line 43 - Maximum Counts

The maximum number of counts in the area of interest is specified here.

Line 45 - Area of Interest

The number of channels to be plotted out should be given on this line. The range is from 1 to 1024.

Line 46 - Window Width

This parameter allows the user to specify how many channels are to be summed together to produce one line on the printout plot. If the window width is very small i.e. one or two channels then the number of counts accumulated per channel could be quite small producing a "ragged" plot due to statistical variation. A reasonable window width produces a clearer spectrum. A width of 4 produces an identical spectrum to that on the display. If the window width is too great, the peaks in the spectrum can be lost. A good idea of what width to select can be obtained by looking at the spectrum display.

Line 47 - Step

This parameter specifies how many channels one window starts after the start of the previous one. If the step number is the same as the width then the windows follow exactly one after each other. If the step is less than the width, the windows overlap and if it is greater, there will be channels not included in the printout.

Line 48 - Repeat

The number of times a sample is to be counted and hence the number of plots for each sample is specified here.

Line 49 - Width of printer output

This parameter allows the user to make the best use of the printer output by adjusting the size of the plot to the best width for the printer paper (or display). The units are printer characters.

Note: the printout includes 23 characters of information before the plot line. If 80 is selected for the print width the plot will be 57 characters wide.

Note: Spectrum Analysis Program gives access to high resolution printouts in mode 6 (see the software manual).

```
READY ->P
                                        THU  19 SEP 1996  11:50



    PARAMETER GROUP ->3
    ID: PLOT ->
    LINE            ->

00A PROGRAM MODE             1 ->2  - Program Mode 2, Spectrum plot, selected
    CONFIRM: CHANGE P-MODE   N ->Y

    *** SPECTRUM PLOT PARAMETERS *** - Sample positions specified
01  POSITIONS
  ->1-3
40  PARAMETER LISTING        Y ->  - Parameter listing before plots
41  SPECTRUM SELECTION
    SAMPLE            (1)
    EXTERNAL STANDARD (2)    1 ->   - Only sample spectrum required
42  TIME                  1:00 ->2  - Count time 2 mins.
44  COUNTS              900000 ->
45  AREA OF INTEREST    5-1024 ->
46  WINDOW WIDTH            20 ->
47  STEP                    20 ->   Other parameters unchanged
48  REPEAT                   1 ->
49  PRINT WIDTH             80 ->

SAVING PARAMETER GROUP  3
```

```
READY ->A
Data to be filed in PC? (Y/N) Y ->N

 1. assay in queue
PARAMETER GROUP NUMBER  0 ->3

 2. assay in queue
PARAMETER GROUP NUMBER  0 ->/
COMMAND: Display,Modify,Remove,Insert,List groups,Start counting->S
                                        THU  19 SEP 1996  11:52



    PARAMETER GROUP:  3      - Parameters listed before results plotted
    ID: PLOT

00A PROGRAM MODE             2 ->

    *** SPECTRUM PLOT PARAMETERS ***

01  POSITIONS 1-3
  ->
40  PARAMETER LISTING        Y ->
41  SPECTRUM SELECTION
    SAMPLE             (1)
    EXTERNAL STANDARD (2)    1 ->
42  TIME                  2:00 ->
44  COUNTS              900000 ->
45  AREA OF INTEREST    5-1024 ->
46  WINDOW WIDTH            20 ->
47  STEP                    20 ->
48  REPEAT                   1 ->
49  PRINT WIDTH             80 ->
```

```
SAMPLE SPECTRUM  Spectrum plot for Tritium sample
POSITION: 001
TIME:   2:01       WINDOW WIDTH:   20       STEP:   20

  CHANNEL       CPM   0.0     2.0     4.0     6.0     8.0    10.0    12.0
E3
                       +-------+-------+-------+-------+-------+-------+---
-
   5 -   24     215.24 I*
  25 -   44     973.29 I===*
  45 -   64    2832.45 I==========*
  65 -   84    5515.37 I=====================*
  85 -  104    7883.17 I===============================*
 105 -  124    9873.75 I======================================*
 125 -  144   11226.34 I============================================*
 145 -  164   11920.74 I===============================================*
 165 -  184   11850.37 I==============================================*
 185 -  204   11309.65 I============================================*
 205 -  224    9856.16 I======================================*
 225 -  244    8046.68 I===============================*
 245 -  264    5888.44 I=======================*
 265 -  284    3802.13 I==============*
 285 -  304    2025.76 I=======*
 305 -  324     845.49 I==*
 325 -  344     227.67 I*
 345 -  364      44.49 *
 365 -  384       7.76 *
 385 -  404       3.10 *
 405 -  424       3.62 *
 425 -  444       2.59 *
 445 -  464       2.59 *
 465 -  484       2.07 *
 485 -  504       2.59 *
 505 -  524        .52 *
 525 -  544       1.55 *
 545 -  564       2.59 *
 565 -  584       1.55 *
 585 -  604        .52 *
 605 -  624        .52 *
 625 -  644        .00 *
 645 -  664        .00 *
 665 -  684        .00 *
 685 -  704        .00 *
 705 -  724        .52 *
 725 -  744        .00 *
 745 -  764        .00 *
 765 -  784        .00 *
 785 -  804        .52 *
 805 -  824       1.03 *
 825 -  844        .00 *
 845 -  864        .00 *
 865 -  884        .52 *
 885 -  904        .00 *
 905 -  924        .00 *
 925 -  944        .00 *
 945 -  964        .00 *
 965 -  984        .00 *
 985 - 1004        .00 *
1005 - 1024        .00 *
-----------------------
   5 - 1024  104371.29
```

Spectrum plot for ^{14}C sample

```
SAMPLE SPECTRUM
POSITION: 002
TIME:   2:01       WINDOW WIDTH:   20       STEP:   20

  CHANNEL       CPM   0.0    1.0    2.0    3.0    4.0    5.0    6.0    7.0E3
                       +------+------+------+------+------+------+------+---
   5 -   24      14.99 *
  25 -   44      59.46 *
  45 -   64     198.55 I*
  65 -   84     385.21 I==*
  85 -  104     621.00 I===*
 105 -  124     841.79 I=====*
 125 -  144    1027.42 I======*
 145 -  164    1225.97 I========*
 165 -  184    1380.58 I=========*
 185 -  204    1585.86 I==========*
 205 -  224    1759.08 I===========*
 225 -  244    2071.39 I=============*
 245 -  264    2341.30 I===============*
 265 -  284    2646.89 I==================*
 285 -  304    3105.54 I=====================*
 305 -  324    3444.22 I=======================*
 325 -  344    3915.27 I==========================*
 345 -  364    4422.01 I==============================*
 365 -  384    4858.94 I=================================*
 385 -  404    5411.69 I=====================================*
 405 -  424    5897.22 I========================================*
 425 -  444    6332.08 I===========================================*
 445 -  464    6782.45 I==============================================*
 465 -  484    7040.99 I================================================*
 485 -  504    6984.11 I================================================*
 505 -  524    6835.71 I===============================================*
 525 -  544    6058.55 I=========================================*
 545 -  564    4962.87 I==================================*
 565 -  584    3405.96 I=======================*
 585 -  604    1776.66 I===========*
 605 -  624     621.51 I===*
 625 -  644     117.89 I*
 645 -  664      13.96 *
 665 -  684       2.07 *
 685 -  704        .00 *
 705 -  724        .00 *
 725 -  744        .00 *
 745 -  764        .00 *
 765 -  784        .00 *
 785 -  804        .00 *
 805 -  824        .00 *
 825 -  844        .00 *
 845 -  864        .00 *
 865 -  884       1.03 *
 885 -  904        .00 *
 905 -  924        .52 *
 925 -  944        .00 *
 945 -  964        .00 *
 965 -  984        .00 *
 985 - 1004        .00 *
1005 - 1024        .00 *
-----------------------
   5 - 1024   98150.71
```

Spectrum plot for ^{36}Cl sample

```
SAMPLE SPECTRUM
POSITION: 031
TIME:   2:34       WINDOW WIDTH:   20       STEP:   20

  CHANNEL       CPM   0.0    5.0   10.0   15.0   20.0   25.0   30.0   35.0E3
                       +------+------+------+------+------+------+------+---
   5 -   24      31.14 *
  25 -   44     116.70 *
  45 -   64     339.15 *
  65 -   84     635.31 I*
  85 -  104     917.87 I*
 105 -  124    1160.07 I=*
 125 -  144    1479.04 I=*
 145 -  164    1724.31 I=*
 165 -  184    2032.76 I==*
 185 -  204    2397.36 I==*
 205 -  224    2635.17 I===*
 225 -  244    3151.15 I===*
 245 -  264    3754.88 I====*
 265 -  284    4208.56 I=====*
 285 -  304    4853.53 I======*
 305 -  324    5654.70 I=======*
 325 -  344    6616.02 I========*
 345 -  364    7549.70 I==========*
 365 -  384    8907.65 I===========*
 385 -  404   10535.00 I==============*
 405 -  424   12279.94 I================*
 425 -  444   14383.35 I===================*
 445 -  464   16665.33 I======================*
 465 -  484   19774.37 I===========================*
 485 -  504   22803.99 I===============================*
 505 -  524   26432.52 I====================================*
 525 -  544   29943.90 I=========================================*
 545 -  564   33351.73 I==============================================*
 565 -  584   35289.28 I================================================*
 585 -  604   35542.44 I=================================================*
 605 -  624   33074.87 I=============================================*
 625 -  644   26350.03 I====================================*
 645 -  664   15691.72 I=====================*
 665 -  684    6013.61 I=======*
 685 -  704    1156.99 I=*
 705 -  724     234.73 *
 725 -  744     106.61 *
 745 -  764      25.00 *
 765 -  784       4.38 *
 785 -  804        .44 *
 805 -  824        .88 *
 825 -  844        .00 *
 845 -  864        .00 *
 865 -  884        .00 *
 885 -  904        .00 *
 905 -  924        .00 *
 925 -  944        .00 *
 945 -  964        .00 *
 965 -  984        .00 *
 985 - 1004        .00 *
1005 - 1024        .00 *
-----------------------
   5 - 1024  397826.16
```

Spectrum plot of ^{241}Am sample

```
SAMPLE SPECTRUM
POSITION: 032
TIME:  39:60       WINDOW WIDTH:   20       STEP:   20

  CHANNEL       CPM   0.0   1.0   2.0   3.0   4.0   5.0   6.0   7.0   8.0 E3
                       +-----+-----+-----+-----+-----+-----+-----+-----+----
   5 -   24       .83 *
  25 -   44      3.17 *
  45 -   64      8.35 *
  65 -   84     13.27 *
  85 -  104     13.50 *
 105 -  124     16.33 *
 125 -  144     23.88 *
 145 -  164     31.15 *
 165 -  184     42.09 *
 185 -  204     55.04 *
 205 -  224     63.89 *
 225 -  244     73.91 *
 245 -  264     78.12 *
 265 -  284     82.37 *
 285 -  304     92.60 I*
 305 -  324    107.98 I*
 325 -  344    133.42 I*
 345 -  364    159.02 I*
 365 -  384    207.29 I*
 385 -  404    276.77 I=*
 405 -  424    581.09 I==*
 425 -  444   2066.01 I===========*
 445 -  464   5634.01 I=================================*
 465 -  484   7831.47 I==============================================*
 485 -  504   4369.77 I=========================*
 505 -  524    915.44 I====*
 525 -  544     70.39 *
 545 -  564      8.50 *
 565 -  584      4.22 *
 585 -  604      1.52 *
 605 -  624       .28 *
 625 -  644       .03 *
 645 -  664       .00 *
 665 -  684       .05 *
 685 -  704       .03 *
 705 -  724       .00 *
 725 -  744       .00 *
 745 -  764       .00 *
 765 -  784       .00 *
 785 -  804       .00 *
 805 -  824       .00 *
 825 -  844       .00 *
 845 -  864       .00 *
 865 -  884       .00 *
 885 -  904       .00 *
 905 -  924       .00 *
 925 -  944       .00 *
 945 -  964       .00 *
 965 -  984       .00 *
 985 - 1004       .00 *
1005 - 1024       .00 *
-----------------------
   5 - 1024   22965.76
```

Spectrum plot of a background sample

```
SAMPLE SPECTRUM
POSITION: 021
TIME: 900:01       WINDOW WIDTH:   20       STEP:   20

CHANNEL       CPM   0.0       5.0      10.0      15.0      20.0      25.0E-2
                     +---------+---------+---------+---------+---------+----
   5 -   24       .03 I======*
  25 -   44       .06 I===========*
  45 -   64       .09 I=================*
  65 -   84       .10 I===================*
  85 -  104       .10 I==================*
 105 -  124       .10 I===================*
 125 -  144       .07 I============*
 145 -  164       .11 I=====================*
 165 -  184       .11 I======================*
 185 -  204       .13 I========================*
 205 -  224       .11 I======================*
 225 -  244       .13 I=========================*
 245 -  264       .16 I===============================*
 265 -  284       .14 I===========================*
 285 -  304       .13 I=========================*
 305 -  324       .15 I=============================*
 325 -  344       .14 I===========================*
 345 -  364       .13 I=========================*
 365 -  384       .16 I==============================*
 385 -  404       .15 I============================*
 405 -  424       .13 I========================*
 425 -  444       .13 I========================*
 445 -  464       .14 I===========================*
 465 -  484       .13 I=======================*
 485 -  504       .11 I=====================*
 505 -  524       .10 I====================*
 525 -  544       .10 I====================*
 545 -  564       .08 I===============*
 565 -  584       .05 I==========*
 585 -  604       .07 I=============*
 605 -  624       .07 I=============*
 625 -  644       .06 I============*
 645 -  664       .06 I===========*
 665 -  684       .07 I============*
 685 -  704       .07 I=============*
 705 -  724       .08 I==============*
 725 -  744       .07 I==============*
 745 -  764       .09 I==================*
 765 -  784       .09 I================*
 785 -  804       .08 I================*
 805 -  824       .07 I=============*
 825 -  844       .08 I===============*
 845 -  864       .07 I=============*
 865 -  884       .04 I======*
 885 -  904       .01 I==*
 905 -  924       .01 I=*
 925 -  944       .01 I=*
 945 -  964       .01 I*
 965 -  984       .00 I*
 985 - 1004       .00 *
1005 - 1024       .01 I=*
---------------------
   5 - 1024     4.39
```

Mode 6 - Quasi-simultaneous counting

Mode 6 - Quasi-simultaneous counting program

Introduction

Note: This counting mode is supported by the Quantulus workstations such as Queue Manager and WinQ, allowing creation and saving of virtually unlimited number of parameter groups on computer disk. The following applies to direct control of Quantulus using the old user interfaces and Quantulus' internal command language, using eight parameter groups on Quantulus RAM. (refer to Chapter 4). These commands are accessible in Queue Manager and WinQ via the Term(inal) command.

In counting mode 6 each sample or position can have its own counting conditions, the MCA configuration can be different for each parameter group and in the setting of count windows it is necessary to determine from which spectrum, MCA and MCA Half, the CPMs are collected. The printouts from output ports "Terminal 1" and "Terminal 2" are determined independently from each other and are customized for each counting program by selecting the necessary items from a printout code list. The measured spectra can also be transmitted via the Terminal 2 output port to the computer.

```
READY ->P
                                        THU  19 SEP 1996  13:23



    PARAMETER GROUP ->7
    ID: CERENKOV ->
    LINE            ->

00A PROGRAM MODE             6 ->?
Help: Program modes:
1 = CPM / DPM
2 = spectrum plot
6 = quasi simultaneous counting
Type / to go to the READY-state. Type Lx RETURN to jump to line
number x.
00A PROGRAM MODE             6 ->
```

Program mode 6 is built up in 4 main blocks:

Block 1 - sample or position related data
Block 2 - MCA configuration
Block 3 - window settings
Block 4 - printout for both output terminals.

Counting program editing is started by pressing P when the instrument is in the READY state. When the parameter group number has been typed in, editing can be started. The HELP function is activated at any point by the ? (question) mark and RETURN.

Setting standard parameters

If the parameter group number is preceded by the letter C, i.e. C2, the parameter of this counting program will be set to the default values.

Parameter Editing

The instrument will ask for the needed data line by line. New input data is entered by typing the new data and RETURN. If no change is needed only RETURN need be typed to give the next question.

It is possible to jump from one line to any other, backwards or forwards, by typing in L and the line number, i.e. L9 causes a jump to line 9.

A slash (/) given on a main command line terminates editing and returns the instrument to the Ready state after saving the parameter group.

Program Block Structure

The main program blocks have a common structure as far as editing is concerned. If the settings in any of the 4 blocks are modified the steps are the following.

Answer the line Y(ES), i.e.

```
04 set MCA configuration N -> Y
```

the instrument responds with a listing of current settings and prints out the command line. The command line gives the following possibilities:

- by typing D, the settings are displayed
- by typing M, the settings can be modified. M is generally followed by an index showing which item can be specified.
- by typing R, items can be removed, i.e. printout codes or counting windows
- by typing I, items can be inserted
- by typing C, items can be copied

Pressing only RETURN will cause a jump to the following item in the block. Typing slash '/' will return the program to the command line. Inside a block the steps in editing are only in one direction. To go back to some item inside a block it is necessary to return to the command line and start again. The item in question is quickly reached by advancing through the questions by pressing RETURN.

Identifier

The first information to be given in Mode 6 is the parameter group identifier. In response to the prompt ID -> type in an identification for the parameter group with a maximum of 20 characters.

Line selection

By typing in a line number, the program will jump directly to the line specified. By typing L a listing of the program is obtained. By typing RETURN the program goes to the first line, zero.

BLOCK 1

Line 1 - Set position parameters

In this block it is possible to specify the sample positions to be counted, the order in which they are counted, the counting time and counts termination limits for each position. Further position specific parameters are the external standard and position repeat counts but in this program version external standard is not used for automatic quench correction, however, its value can be generated.

The command line gives possibilities to display, modify, remove, insert and copy. The format and use of these functions can be learned from the HELP for the command line.

```
01  SET POSITION PARAMETERS  Y ->
ORDER  POS  ID   CTIME COUNTS CUCNTS MCW  REP  STD STMS  STIME
```

This is the order line when the block has been cleared.

Note: there must be a sample defined before proceeding beyond this point.

If you answer Y(es) the present state of the block will be printed out. If the block has been cleared, then only the headings will appear. If parameters have been set then the value will appear beneath the heading.

```
ORDER  POS  ID          CTIME COUNTS CUCNTS MCW  REP  STD STMS STIME
   1     6  CL36        30:00 NO LIM NO LIM   1    1    N
```

The headings are defined as follows:

The position parameter program block has the following parameters:

ORDER = The running line number of the sample information. The increasing order is set by the instrument. The instrument counts the positions following the order number. A maximum of 24 order numbers is allowed.

POSITION = Sample position to be counted. If several positions are counted with the same counting time; the first and last positions can be typed in. I.e. 2 - 10 means that positions 2 to 10 can be counted with the same settings. The positions can be typed in in any order. A maximum of 60 positions is allowed.

ID = An identification can be given to the sample(s) or the position using up to 16 characters.

CTIME = Counting time for the positions. Time is given in minutes. It is also possible to give time in hours or seconds by following the value by space then H or S respectively.

COUNTS = Stops counting when the number of counts set here has been reached.

Note: this parameter and the next one require a numerical input not using exponential notation although the program will show the number in exponential notation.

CUCNTS = Cumulative counts. When the cumulative counts limit is exceeded the position will not be counted any more during the remaining cycles or repeats. One cycle is defined as the time during which the counting of all positions programmed takes place.

MCW = (Maximum counts window) If the COUNTS terminator or CUCNTS terminator are used, the window whose counts are used for termination must be specified.

REP = Number of repeats of the order per cycle.

STD = Control of the external standard: N = no external standard, Y = external standard. If the external standard is counted, a quench parameter value can be obtained by selecting the SQP printout.

STMS = Format 1/x . Determines how often the external standard is counted. E.g. 1/4 means that the external standard is counted every fourth cycle: the 1st cycle then the 5th cycle then the 9th etc.

STIME = Count time for the external standard. Time in minutes, hours or seconds. See CTIME.

Note: for these last two parameters only appear if STD is selected.

After the existing parameter values have been listed the command line will appear.

Pressing ? cause the Help information to be displayed as the example shows.

```
COMMAND: Display,Modify,Remove,Insert,Copy,Path,<ret>(=continue)  -
>?
Help:
Dx-y = Display orders from x to y
    If -y omitted, order x displayed
    If x-y omitted, all displayed
Mx-y = Modify orders from x to y
Ix = Insert order before x
    If x omitted, insert at the end
Rx-y = Remove orders x to y
Cx,y = Copy order x and insert copy before y
P = Path on/off. If path is on, sample ID is added to directory
    path and spectra of each order will be in own directory
RETURN or / = exit to next line
```

Inserting an Order into the sequence of Orders

This command allows a new order to be created. This command must come first if the group has been cleared because then there is no Order. Here order number 4 is inserted in the sequence and the parameter values are set:

```
COMMAND: Display,Modify,Remove,Insert,Copy,Path,<ret>(=continue) ->I

Modifying order  4
POSITION(s)             0 ->3-6
ID                        ->TESTRUN
COUNTING TIME       60:00 ->2
COUNTS             NO LIM ->
CUMULATIVE COUNTS  NO LIM ->360000
WINDOW OF COUNT LIMIT   1 ->?
Help: Window which counts terminates counting. Range 1-8.
Type / to exit to command line
WINDOW OF COUNT LIMIT   1 ->
REPEATS                 1 ->2
EXTERNAL STANDARD       N ->

Modifying order  5
POSITION(s)             0 ->/
COMMAND: Display,Modify,Remove,Insert,Copy,Path,<ret>(=continue)  ->
```

Creating a Copy of an existing order

If an Order exists then a further copy of it can be created using the Copy command in the form Cx,y where x is the number of the order to be copied and y is the order before which the copy is to be inserted. All the order numbers after the new order will increase by one. In the example here a copy of Order 4 becomes Order 5.

COMMAND: Display,Modify,Remove,Insert,Copy,Path,<ret>(=continue) ->C4,5

Modifying an existing order

The parameters in an existing order can be modified using the Modify command in the form Mx where x is the order number to be modified. Here Order 5 is modified.

```
COMMAND: Display,Modify,Remove,Insert,Copy,Path,<ret>(=continue)->M5
Modifying order  5
POSITION(s)          3- 6 ->1-2
ID                TESTRUN ->FIRST
COUNTING TIME        2:00 ->5
COUNTS             NO LIM ->1E5
COUNTS             NO LIM ->100000
CUMULATIVE COUNTS  3.6E05 ->
WINDOW OF COUNT LIMIT   1 ->2
REPEATS                 2 ->
EXTERNAL STANDARD       N ->
```

Displaying the parameter values in an order

Type Dx where x is the number of an Order. This will cause the contents of an Order, i.e. the parameter values to be printed out as the example shows:

```
COMMAND: Display,Modify,Remove,Insert,Copy,Path,<ret>(=continue)->D4
ORDER  POS  ID          CTIME COUNTS CUCNTS MCW  REP  STD STMS STIME
   4  3- 6  TESTRUN      2:00 NO LIM 3.6E05   1    2    N
```

Removing an Order from the sequence

Any existing order can be deleted using the R command in the form Rx where x is the Order number to be removed from the sequence. In the following example the orders are displayed to show that there are three of them, then number 3 is deleted. Display is used again to show there are only two of them.

Note: When an order is deleted the others are renumbered.

```
COMMAND: Display,Modify,Remove,Insert,Copy,Path,<ret>(=continue) ->D
ORDER  POS  ID          CTIME COUNTS CUCNTS MCW  REP  STD STMS STIME
   1     5  CL36        30:00 NO LIM NO LIM   1    1   N
   2     7  H2O-BKG     60:00 NO LIM NO LIM   1    1   N
   3     8  RN          60:00 NO LIM NO LIM   1    1   N
   4  3- 6  TESTRUN      2:00 NO LIM 3.6E05   1    2   N
   5  1- 2  FIRST        5:00 1.0E05 3.6E05   2    2   N
COMMAND: Display,Modify,Remove,Insert,Copy,Path,<ret>(=continue)->R3
COMMAND: Display,Modify,Remove,Insert,Copy,Path,<ret>(=continue)->D
ORDER  POS  ID          CTIME COUNTS CUCNTS MCW  REP  STD STMS STIME
   1     5  CL36        30:00 NO LIM NO LIM   1    1    N
   2     7  H2O-BKG     60:00 NO LIM NO LIM   1    1    N
   3  3- 6  TESTRUN      2:00 NO LIM 3.6E05   1    2    N
   4  1- 2  FIRST        5:00 1.0E05 3.6E05   2    2    N
COMMAND: Display,Modify,Remove,Insert,Copy,Path,<ret>(=continue)->
```

Line 2 - Number of Cycles

One Cycle is the counting of all the programmed positions. Number of cycles determines how many times the sample sequence are to be counted. For data evaluation it is more beneficial to divide a long counting time in shorter cycles, whose summed time equals the total counting time. The statistical reliability is the same, but the instrument performance during the counting can be monitored by comparing the individual results for the cycles. The sample stability can also be monitored by looking at spectrum shifts or variations in SQP values.

```
02  NUMBER OF CYCLES         1 ->?
Help: Number of cycles. Range: 1-999.
Type / to go to the READY-state. Type Lx RETURN to jump to line x.
02  NUMBER OF CYCLES         1 ->2
```

Line 3 - Coincidence Bias (L/H)

This allows the adjustment of the coincidence trigger threshold level. Low bias is suitable for low energy isotopes i.e. Tritium. High bias is suitable for high energy isotopes i. e. ^{14}C. The high bias prevents a low pulse and a high pulse from being accepted and summed together.

Such pulses can contribute to the background in the low energy channels below Ch 300, particularly in glass vials where Cerenkov radiation and fluorescence signal induced mainly by inherent ^{40}K activity reside. A small loss results in ^{14}C signal from high bias but an improved background and figure of merit is achieved. Since high bias threshold is applied to both phototube signals, it has in principle the same effect in low energy region as the Pulse Amplitude Comparator has in the higher energy range.

```
03  COINCIDENCE BIAS (L/H)   L ->?
Help: Discrimination level. L=low,H=high.
Type / to go to the READY-state. Type Lx RETURN to jump to line x.
03  COINCIDENCE BIAS (L/H)   L ->H
```

BLOCK 2

Line 4 - Set MCA Configuration

Line 4 is the beginning of the second program block in which the MCA configuration is set. This determines which analogue signal is converted in MCA1 and which is converted in MCA2. It also includes ADC trigger conditions, inhibit and MCA memory split conditions.

The command line enables display, modification and removing or disabling of an MCA.

For convenient use there is a selection of 2 preset MCA configurations
configuration 1 for ^{14}C counting
configuration 2 for ^{3}H counting

Configuration 3 enables free set up of the MCAs.

Parameters when modifying the MCA configurations are:

ADC INPUT = Analogue pulse to be converted by the ADC. A list of the choices can be obtained by the HELP function.

ADC TRIGGER = Logical signal which enables conversion of the analogue pulse. The list can be obtained by the HELP function.

INHIBIT = Logical signal which inhibits the conversion. This is usually a signal from the active guard.

MEMORY SPLIT = Logical condition which guides the converted pulse to the first or second half of the MCA. If the condition is true the pulse is guided to Half 2 otherwise to Half 1.

For MCA 2 modifications the same principles apply.

Print MCA configurations and control order are given under Instrument description/program modes.

```
02  NUMBER OF CYCLES         2 ->
03  COINCIDENCE BIAS (L/H)   H ->
04  SET MCA CONFIGURATION    Y ->
    CARBON CONFIG.    (1)
    TRITIUM CONFIG.   (2)
    FREE SETUP        (3)    1 ->
    PULSE COMPARATOR LEVEL     1 ->
05  SET WINDOW CONFIGURATION Y ->L4

04  SET MCA CONFIGURATION    Y ->
    CARBON CONFIG.    (1)
    TRITIUM CONFIG.   (2)
    FREE SETUP        (3)    1 ->3
MCA INPUT  TRIGG. INHIBIT                       MEMORY SPLIT
 1  LRSUM  L*R                                  PAC+G+EG
 2  GSUM   G                                    L*R
COMMAND: Display,Modify,Remove,<ret>(=continue)  ->?
Help:
D  = Display MCA configuration
DW = Display window configuration
DM = Display MCA configuration
DA = Summary of all
Mx = Set MCA x
Rx = Disable MCA x
RETURN or / = exit to next line
COMMAND: Display,Modify,Remove,<ret>(=continue)  ->
```

BLOCK 3

Line 5 - Set Window configuration

Window settings are done in Block 3. A total of 8 fixed counting windows can be specified. For each window the window limits, MCA and MCA Half have to be specified.

The command line enables the user to select what windows are displayed, modified or removed.

Parameters are:

WINDOW = order number for the window 1-8

CHANNELS = lower and upper channel limit for the window

MCA = MCA from which the window data is collected

HALF = the half of the MCA from which the data is collected

Note: If a default MCA configuration 1 or 2 is selected the preset windows will be set automatically.

```
05  SET WINDOW CONFIGURATION Y ->
WINDOW    CHANNELS    MCA  HALF
  1       50-  650     1     1
  2       70-  500     1     1
  3      300-  640     1     1
  4       50-  650     1     2
  5       70-  500     1     2
  6      300-  640     1     2
  7        1- 1024     2     1
  8        1- 1024     2     2
COMMAND: Display,Modify,Remove,<ret>(=continue)  ->?
Help:
D  = Display window configuration
DW = Display window configuration
DM = Display MCA configuration
DA = Summary of all
Mx-y = Set window(s) from x to y
Rx = Disable window x
RETURN or / = exit to next line
COMMAND: Display,Modify,Remove,<ret>(=continue)  ->
```

BLOCK 4

Line 6 - Set Printout

Line 6 starts the fourth major program block. Here the printout selection is set for both terminal 1 (optional VDU Terminal and/or printer) and terminal 2.

The data sent out to terminal 2 is for a computer and will accompany the spectra which are also sent out.

The command line allows items to be removed and inserted into the printout list. Alternatively preset printout can then be chosen.

```
06  SET PRINTOUT             Y ->
Selected printout for terminal 1 (A)
 1.      2.     3.         4.       5.     6.         7.      8. 9.
REP   CTIME DTIME1     DTIME2   CUCNTS    SQP        SQP%   STIME <
     10.       11.        12.      13.     14.        15.     16. 17.
      ID      CPM1    COUNTS1   CPM1%    CPM2    COUNTS2   CPM2% <
      18.       19.        20.      21.     22.        23.     24. 25.
              CPM3    COUNTS3   CPM3%    CPM4    COUNTS4   CPM4% <
      26.       27.        28.      29.     30.        31.     32. 33.
              CPM5    COUNTS5   CPM5%    CPM6    COUNTS6   CPM6% <
      34.       35.        36.      37.     38.        39.     40.
              CPM7    COUNTS7   CPM7%    CPM8    COUNTS8   CPM8%

Selected printout for terminal 2 (B)
 1.  2.  3.     4.      5.      6.       7.     8.       9.    10. 11.
CYC POS REP  TIME   DTIME1  DTIME2  CUCNTS     SQP     SQP%  STIME <
  12.      13.        14.      15.      16.   17.       18.     19.
             ID       CPM1  COUNTS1    CPM1%  CPM2  COUNTS2   CPM2% <
```

The printout for a particular output port can be inserted selecting control character I followed by a number 1 or 2. If both output ports are selected then I alone is sufficient. Selecting this control command causes the parameter line:

`WRITE MNEMONIC PRINTOUT CODES`

The printout codes are typed in in mnemonic form separated by spaces. A list of the printout codes is obtained with the HELP function for the line.

```
COMMAND: Display,Remove,Insert,Preset,<ret>(=continue)  ->I
WRITE MNEMONIC PRINTOUT CODES ->
?Help: Selectable printout codes
POSITION    ID          CTIME       CYCLE       DATE
TIME        REPEAT      STIME       CPM1        CPM2
CPM3        CPM4        CPM5        CPM6        CPM7
CPM8        COUNTS1     COUNTS2     COUNTS3     COUNTS4
COUNTS5     COUNTS6     COUNTS7     COUNTS8     DTIME1
DTIME2      CUCNTS      INSTR#      SQP         SQP%
CPM1%       CPM2%       CPM3%       CPM4%       CPM5%
CPM6%       CPM7%       CPM8%       8SPACES     17SPACES
<
< = New line
Type in required codes separated by space
RETURN only = no insert
WRITE MNEMONIC PRINTOUT CODES ->

COMMAND: Display,Remove,Insert,Preset,<ret>(=continue)  ->
```

Printout codes are added to the list using the I(nsert) command. It is possible to specify which printout, which terminal (1 or 2) and the place in the printout of the inserted items.

By typing IB3, the codes typed in after the "write mnemonic printout codes" question are inserted before item number 3 in the printout list for terminal 2 (B terminal).

The number given in the printout code is the order number for the item in the printouts set by the instrument. The order number is used when inserting or removing printout codes.

Line 7 - Send Spectra

It is possible to send the spectra together with the printout to the computer on terminal 2. The spectra can then be stored together with the other information of the sample given by the printout. Thus an off-line data analysis of the total measured data is later possible using the Spectrum Analysis program. If the Quantulus is used together with the Laboratory Computer the four spectra are sent together and stored under a unique file name created by the system.

The transferred spectra are determined by the following codes:
A = All 4 spectra
N = No spectrum output
11 = MCA 1 HALF 1
12 = MCA 1 HALF 2
21 = MCA 2 HALF 1
22 = MCA 2 HALF 2
S = External standard spectrum

The spectra output can be combinations of these, i.e. 11, 21, S gives MCA 1 HALF 1, MCA 2 HALF 1 and the external standard spectrum. The preset value is all spectra sent.

```
07  SEND SPECTRA   11,12,21,22 ->?
Help: Select spectra for output on terminal 2
Alternatives: Any combination of 11,12,21,22 and S (=stand.). A =
all, N = none
For example 11 means spectrum of MCA 1 half 1
Type / to go to the READY-state. Type Lx RETURN to jump to line x.
```

Further the resolution of the spectra has to be determined. This is done when answering the question.

```
RESOLUTION OF SPECTRA ->
```

The resolution can be 16, 32, 64, 128, 256, 512 or 1024 channels. The resolution during the measurement is always 1024 channels.

```
07  SEND SPECTRA   11,12,21,22 ->
    RESOLUTION OF SPECTRA  512 ->?
Help: Resolution of spectra sent to terminal 2.
Alternatives: 16,32,64,128,256,512 or 1024 channels.
Type / to go to the READY-state. Type Lx RETURN to jump to line x.
    RESOLUTION OF SPECTRA  512 ->1024
```

Line 8 - Listing

If answered Y(ES) a list of the counting program parameters is printed and/or saved before the results.

```
08  LISTING                  Y ->?
Help: List parameters before counting. Y = yes, N = no.
Type / to go to the READY-state. Type Lx RETURN to jump to line x.
```

Line 9 - Instrument Number

This information is printed/saved in the parameter list.

This is useful when several instruments send the same type of information to the same computer.

```
09  INSTRUMENT NUMBER        1 ->?
Help: Number of instrument. Range: 1-9.
Type / to go to the READY-state. Type Lx RETURN to jump to line x.
```

Storing the parameter group

Line 9 is the final line. After the following message the instrument automatically stores the program and is ready for use.

```
SAVING PARAMETER GROUP  7


  READY ->
```

Editing while counting

If control command E followed by Return are pressed during counting, editing can be started as described below. In the meantime counting of the sample in the measuring chamber will continue but no data is sent out. When this sample has been counted, the next one will be counted also. While these two samples are being counted, editing can be done without disturbing the counting. Only if the duration of editing exceeds the time when the counting of the second sample ends will counting actually be suspended.

As the example shows, either parameters or the queue can be edited by electing P or Q respectively. After the end of editing, R must be pressed to resume counting.

During editing you may not edit certain parameters. These are indicated in the parameter listing by the text `CANNOT BE EDITED`.

Note: the control character E will not be printed out when it is pressed but the bell will sound to show the command has been accepted.

Editing has been selected by pressing E although this does not show on the printout.
The first printout item is the command line shown next.

```
E

      *** EDIT while COUNTING ***

EDIT Command: Parameters,Queue,List groups,Clock,Resume ->P
Parameter editing selecting

                                        THU  19 SEP 1996  14:34

    PARAMETER GROUP ->7 Group 7 is to be edited
    ID: L7 ->
    LINE            ->

01  SET POSITION PARAMETERS  Y ->
ORDER  POS  ID         CTIME COUNTS CUCNTS MCW  REP  STD STMS
STIME
   1  3- 5             30:00 NO LIM NO LIM   1    1    N
COMMAND: Display,Modify,Remove,Back,Insert,<ret>(=continue)  ->M1

Modifying order  1
COUNTING TIME       30:00 ->
COUNTS             NO LIM ->
CUMULATIVE COUNTS  NO LIM ->      These parameters can be edited
REPEATS                 1 ->

COMMAND: Display,Modify,Remove,Back,Insert,<ret>(=continue)  ->
02  NUMBER OF CYCLES         2 ->    This parameter can be edited
03  COINCIDENCE BIAS (L/H)   L    WARNING! If changed only restart
allowed
                               ->  This parameter should not be edited
04  SET MCA CONFIGURATION    Y    WARNING! If changed only restart
allowed
                               ->  This parameter should not be edited
    CARBON CONFIG.     (1)
    TRITIUM CONFIG.   (2)
    FREE SETUP        (3)    3 ->
MCA INPUT  TRIGG. INHIBIT                  MEMORY SPLIT
 1  LRSUM  L*R                             PAC+G+EG
 2  GSUM   G                               L*R
COMMAND: Display,Modify,Remove,<ret>(=continue)  ->
    PULSE COMPARATOR LEVEL     1 ->
05  SET WINDOW CONFIGURATION Y ->
WINDOW    CHANNELS    MCA  HALF
  1        50-  650     1     1
  2        70-  500     1     1
  3       300-  640     1     1
  4        50-  650     1     2
  5        70-  500     1     2
  6       300-  640     1     2
  7         1- 1024     2     1
  8         1- 1024     2     2
```

```
COMMAND: Display,Modify,Remove,<ret>(=continue)  ->
06  SET PRINTOUT             Y ->
Selected printout for terminal 1 (A)
  1.       2.        3.        4.        5.       6.       7.      8. 9.
 REP    CTIME    DTIME1    DTIME2   CUCNTS     SQP     SQP%  STIME  <
  10.        11.        12.      13.      14.     15.       16. 17.
   ID        CPM1    COUNTS1   CPM1%     CPM2 COUNTS2    CPM2%  <
  18.        19.      20.      21.        22.     23.  24.25.
  PM3    COUNTS3   CPM3%    CPM4    COUNTS4   CPM4%  <
  26.        27.      28.      29.        30.     31.      32.33.
  PM5    COUNTS5   CPM5%    CPM6    COUNTS6   CPM6%  <
     34.        35.      36.      37.        38.     39.      40.
    CPM7    COUNTS7   CPM7%    CPM8    COUNTS8   CPM8%

Selected printout for terminal 2 (B)
  1.  2.  3.     4.      5.        6.       7.     8.      9.   10.11.
 CYC POS REP  CTIME  DTIME1    DTIME2  CUCNTS   SQP    SQP% STIME  <
 12.        13.        14.      15.        16.        17.      18.19.
  ID        CPM1    COUNTS1   CPM1%       CPM2    COUNTS2   CPM2%  <

COMMAND: Display,Remove,Insert,Preset,<ret>(=continue)  ->
07  SPECTRA SENDING CANNOT BE EDITED - This parameter cannot be edited
08  LISTING                  Y ->      - This parameter and the next can be edited
09  INSTRUMENT NUMBER        1 ->

SAVING PARAMETER GROUP  7

EDIT Command: Parameters,Queue,List groups,Clock,Resume ->R  Editing is ended by pressing R

    *** COUNTING RESUMED ***
```

Specifications
and
Routine maintenance

Specifications

Physical dimensions

Width 1010 mm Height 1560 mm Depth 920 mm Weight approx. 1000 kg

Stands on four feet (each 28 square cm, 90 cm apart)

Power

Mains voltage selectable 100, 115, 120, 220, 240 V, +-10 %, 50/60 Hz. In the case of the mains voltage being 230V select 220 V on Quantulus.

Power consumption 200 VA.

Cooling unit consumes approximately 350 VA, voltage rating as above.

Connections/ input output

Serial ASCII interface RS-232C, two output terminals: terminal 1 for data input/output to a display/printer and terminal 2 for data input/output to an external microcomputer. Also temperature sensor connector in cooling unit.

Radiation shield

Asymmetric passive radiation shield made of low radioactivity lead around the detector assembly, maximum thickness of 200 mm on top, 100 mm on side walls and 150 mm below the counting chamber. Head of the piston made of copper and is part of passive shielding.

Active shielding against cosmic particles and environmental gamma radiation is enforced by an asymmetric guard counter which operates in anticoincidence with the sample detector. The guard's OFHC copper container offers extra passive attenuation against environmental radiation, i.e. is part of the so-called graded shield. The guard length is 350 mm, diameter 160 mm and it is monitored with two 2" PMTs operating in summed coincidence. Filling is scintillation liquid. Space is provided above the shield for an optional flat cosmic counter, external guard, to act as a cosmic umbrella.

Guard operation is sample independent, i.e. light from the sample and guard do not pass through each other and are detected with their dedicated PM tubes.

External standard source is enclosed in an asymmetric lead shield with maximum attenuation towards the counting chamber.

Operating conditions

Temperature +15 to +35° C.

Humidity max. 75 %.

Air conditioning of the counting laboratory with stabilized temperature is recommended in conditions where temperature rises above 30° C and/or humidity is above 75 %.

Electrical safety - The design of the instrument is based on the following electrical safety requirements:

EN61010-1

CAN/CSA -C22.2 No.1010-1-92

Electrical compatibility - the instrument fulfils EMC standards EN 50082-1 (1992) and EN50081-1 (1992).

Temperature control

Four Peltier elements of the cooling unit are able to maintain the temperature of the main instrument body 12° C below the ambient temperature (electronics is not cooled). The cooling unit fins contain a water inlet to boost cooling so that 12º C below water temperature may be reached for the instrument temperature.

The large amount of lead provides effective inertia for temperature changes and therefore several hours of power failure will not cause major temperature increase of the instrument.

The cooling unit is always recommended for Quantulus.

Sample changer and conveyor

60 samples in 3 racks, 20 each, can be accessed in random, pre-programmed order. Standard 20 ml vials as well as copper teflon vials may be used. Other sizes can be measured in adapters of 20 ml vial size (0.3 ml teflon for instance). Lift piston may be modified on request for adapters that do not allow axial rotation. The modification does not prevent counting of normal vials.

Rack transport is by friction belt drive system, transverse movement by toothed chain driven by electric motors. Sample lifted up to measuring chamber by elevator driven by electric motor. Vial holder act as light shutter. Sample change time is 45 s for the first sample and 20 s for samples in the same rack. Rack and sample position and movements are controlled by electro-optical sensors.

Vials

Maximum acceptable sample vial diameter is 28 mm and maximum height 62 mm. Special Wallac copper-teflon vials are available in sizes 20, 15, 7 and 3 ml. The body of the vial has been raised to the centre of the PM tube and environmental radiation is attenuated by copper tops and bases, which also reduce cross-talk. Any other sizes can be counted in adapters of 20 ml vial size.

Detector assembly

There are two low noise selected PM tubes working in the detector assembly. Assembly includes also light emitting diodes for the automatic spectrum stabilizer. Coincidence resolution time 15 ns. The PM tube high voltage is switched off between sample changes.

Performance

Typical counting efficiency for sealed, nitrogen flushed organic samples:
3H = 66 %
14C = 95 %

Stability

Count variation less than 0.2 %/24 hours (not including random statistics).

Electronic hardware

Microprocessor controlled counting and data reduction. Separate microprocessor control of display functions. Memory configuration, ROM 128 k, RAM 642 k and EEPROM 16 k. Logarithmic A/D converter, energy range 1-2000 keV (beta). Two dual 2 x 1024 channel programmable multichannel analyzers enable acquisition of up to 5 spectra per sample. Built-in dead time correction compensates for lost counts to high activity samples. Up to 8 preprogrammable counting windows.

Display

Any of the four spectra produced by the two MCAs can be selected for display on external computer screen using user interface software (1220-305 Queue Manager or 1220-307 WinQ).

Automatic continuous spectrum stabilizer

The performance of the PM tubes and pulse amplifiers is automatically checked 62 times/second using green GaP LEDs as reference light sources, and the high voltage is adjusted automatically to keep the signal output constant.

Stand-by power supply

Battery support for RAM memory, to give automatic restart after power failure, maximum 50 h. Parameter group data stored indefinitely in EEPROM memory.

Static electricity eliminator

Ionizer unit to protect against static electricity created during sample preparation and rack movement on the conveyor lane. Conveyor base and vial holders are metal for reduction of static electricity.

Electromagnetic interference eliminator

An antenna operates in anticoincidence with the sample detector to reject electromagnetic noise interference from power lines and radiofrequency sources.

Multiuser/ counting conditions

User interface is a menu driven software package, called WinQ (1220-307). It also provides live display of selected spectra on computer screen. Number of parameter groups or protocols is limited by the hard disk size of the computer. Each user has their own area for the protocols. WinQ can control four Quantuluses simultaneously.

External standard

1 μCi (37 kBq) Eu-152 source in sealed stainless steel capsule. Source is pneumatically transported to the vicinity of the sample vial for standardization.

Counting conditions:

Mode 1 - CPM/DPM:

Count mode selection of preset time, counting windows, quench monitor (SQP) and printout selection for 3H, 14C, 35S, 45Ca, 32P, 125I single labels and in dual label combinations.

All parameters are user programmable:

Sample position 1-60

Count time, 1-999999 s (approx. 277 h) or no limit

Ext. standard time 1-9999 s (approx. 2.7 hrs)

Ext. standard count limit 900 000 or no limit

8 counting windows, 1-1024 in one channel steps

Count termination after reached preset counts, range 1-900000. This enables counting with same statistical error, e.g. counts limit = 10 000 gives 2 standard deviations = 2 %. Sample preparation error 0-99.5 %

Sample quality monitor: quench curve validity for samples is monitored when counting in DPM mode

Full user selectable printout format. Printout can be formatted using the printout edit function and printout codes.

Automatic background correction using a preset background CPM or background sample.

Factorization of results in counting windows 1 and 2, multiplying the count rates with an input factor, range 0.00001E-9 - 9.99999E9. Factor input in decimal or exponential form.

Automatic half-life correction. For dual label both results for both isotopes are corrected to their respective zero time.

Sample repeat 1-99.

Sample batch cycling (cycle repeat), range 1-99.

Sample replicates 1-99.

Comparison of results in counting windows 1 and 2 to reference sample. Results are given as percent of reference 1 and reference 2.

Sum of batch activity; CPM or DPM are summed for all samples in the counted batch. Sum is printed out at the end of the batch.

DPM program enables efficiency corrected results.

Automatic calculation of quench curves using spectral quench parameter of the isotope SQP(I) or spectral quench parameter of external standard SQP(E) as quench indicators.

Two methods for counting of standard points, Hat-Trick and standard series.

Quench curve fit using Linear Interpolation, Interpolating Spline or Smoothing Spline.

Maximum number of standard points is 10.

Plot of standard curve and edit possibility.

DMP results for single and dual labelled samples.

Chemiluminescence monitor (based on delayed coincidence)

The random coincidence spectrum is measured in one half of the MCA and subtracted from normal beta coincidence spectrum. The contribution as percent of result CPM is given. CLM % > 10 causes a warning to be printed.

Calendar clock

Instrument contains calendar clock giving date and time. Printout of time in READY state. Printout of time in count result is also possible using printout code for time. The instrument software is Y2K compliant.

Help function

Ease of instrument operation is ensured by the Help Function, giving information about operating possibilities in READY state and in parameter editing.

Mode 2: spectrum plot program

Plot of the isotope spectrum or ext. std. spectrum from multichannel memory. High resolution graphics plots are available in mode 6 with the aid of Spectrum Analyzer Software (see below).

Mode 6: quasi-simultaneous or low background counting mode

This count mode offers the full control of two MCAs by Boolean logic commands. There are hundreds of combinations to control measurement.

MCA is a sophisticated device capable of collecting up to four spectra + external std. spectrum from the sample simultaneously. The four spectra may all be from sample under different conditions. The spectra can be saved on hard disk or diskette (see SPA below).

Modes available are for instance:

- default 3H and 14C MCA modes

- coincidence sample counts with guard counter active or low background counting (sample in anticoincidence with the guard)

- coincidence sample counts with guard counter inactive (can be used for high activity samples)

- Cerenkov counting in noncoincident mode with/without guard

- monitoring facilities are available for the user to look at any PMT noise; random coincidence signal, guard performance vs. time can be monitored, i.e. coincident (active) and anticoincident (inactive) guard pulses can be saved

- pulse amplitude comparison (PAC) can be forced with user adjustable level of rejection to reduce cross-talk

- pulse shape analyser (PSA) is user adjustable to allow optimum separation of alpha particle spectra from other kinds of radiation in environmental samples, like 222Rn or 226Ra water samples. PSA leads to extremely low background count rates in liquid scintillation counting of alpha particles, which is not achievable in standard LSC.

- guard, PAC, PSA rejected sample pulses can be saved

- two state (High/Low) coincidence bias operating before left/right pulse summation. High is tuned for low background 14C counting, Low enables low energy beta counting

Counting parameters:

- 24 sample input lines/parameter group

- each line may contain one position or a range of positions (max. 1-60)

- sample(s) ID, max. 16 characters

- preset counting time 1 s to 277 hrs

- count limit/cycle 1-9.9E99 counts or no limit

- cumulative limit 1-9.9E99 counts or no limit

- count limit for window definition

- repeats for a sample 1-99

- external standard yes/no (SQP(E))

- ext. std. on each sample cycle or every Nth cycle, N=1-99

- ext. std. counting time 1 s - 2 hrs
- cycles of batch 1-999
- preset windows 1-8
- printout selection and definition for 2 printers
- spectrum save selection (max. 4 spectra + ext. std.)
- spectrum resolution on save 16, 32, 64, 128, 256, 512, 1024

Routine maintenance

Keeping the instrument clean

The conveyor surface should be kept clean to avoid dust and dirt entering into the optics at the measuring position. The conveyor surface should be cleaned using a soft cloth or tissue paper soaked in a mild detergent solution or alcohol.

Power supply fan

Check that the cooling fan in the power supply unit is working by listening for its sound.

Cables

Check that the power cable and the cables to the peripherals are tightly connected and that the cables and connectors are not damaged. Any damaged cable should be replaced immediately!

Quality control information

QC Contents

1099 0209
November 1995

Evaluation of the safety of the Eu-152 external standard source in Wallac 1220 Quantulus ultra low level spectrometer

Isotope

Europium 152.

Maximum activity

37 kilo Becquerels (1 microcurie) (half-life 13.5 years).

Origin of radioactive material

The Eu-152 radioactive material is made by the Radiochemical Centre, Amersham, England.

Manufacturer of the standard capsules

The Eu-152 standard capsules are manufactured by Wallac Oy, Finland.

Manufacturing process

The manufacturing process by which the radioactive standards are produced involves two steps: the preparation of the radioactive material and the encapsulation of this material with a metal cover.

In the manufacturing process the active Eu-152 solution is absorbed homogeneously into crystalline synthetic zeolites in such a way that the activity of each active source is 1 μCi.

The construction principles of the capsule are described in document 1036 0835.

ISO-test

The capsule has been tested by the Quality Assurance department of Wallac Oy according to the ISO 2919 standard. The rating C43334 has been achieved.

External standard transport system

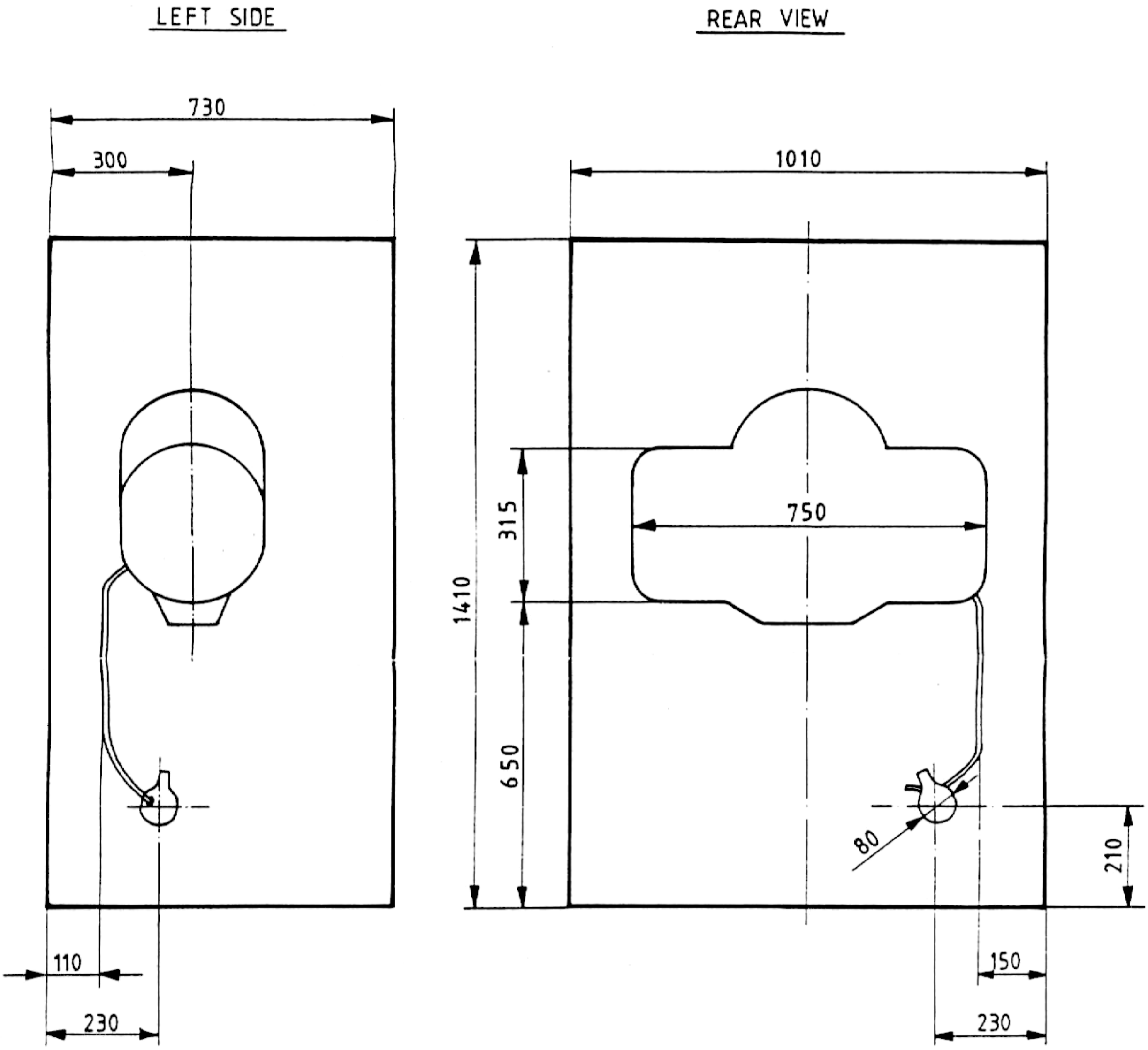
The transport system is illustrated in document 1036 0835.

The construction with dimensions is illustrated in document 1036 0841.

Disposal of the capsule

When the instrument is no longer in use, the Eu-152 standard capsule must be removed and sent to the appropriate radiation safety authorities or to Wallac for disposal. This procedure must be performed only by a qualified PerkinElmer Life Sciences service engineer.

CORR. NO.	DATE	DRWN.					
					wallac oy TURKU - FINLAND	NAME QUANTULUS 1220 EXTERNAL STANDARD SYSTEM, CONSTRUCTION WITH DIMENSIONS	NO. 10 36 0841
					DRWN. 940930 AS	CHKD. 940930 HKY	APPR. 941003 KLOU



MORE DETAILED INFORMATION ON THE DOC. NO. 10 36 0835

PerkinElmer
life sciences.

1096 1061

Quality Control Report

Name of Product:	Quantulus
Product Type No.:	1220
Manufacturer:	Wallac Oy, Turku, Finland
Function Tested:	Classification of External Standard Capsule Eu-152 according to ISO 2919.
Activity of the capsule:	37 kBq

CERTIFICATION

Eu-152 External standard source has been tested according to ISO 2919 - 'Sealed Radioactive Sources - Classification'.

The tests are:

Test	Class	Short definition
Temperature	4	- 40 °C (20 min) + 400 °C (1 h) and thermal shock to 20 °C
Ext. pressure	3	25 kPa abs. to 2 MPa abs.
Impact	3	200 g from 1 m
Vibration	3	2 times 10 min, two axes 25 Hz to 50 Hz/5G, 50 Hz to 90 Hz/0.635 mm amplitude, 90 Hz to 400 Hz/10G
Puncture	4	50 g from 1 m

Leakage tests according to ISO TR 4826 have been performed after the classification tests. The tests show no significant leakage.

The source fullfils ISO 2919 tests and is therefore classified as C43334.

Date: 26 Oct. 1994

Signature of controller

Raimo Kananen

Raimo Kananen, M.Sc.
Physicist
Quality Assurance Department, Instruments

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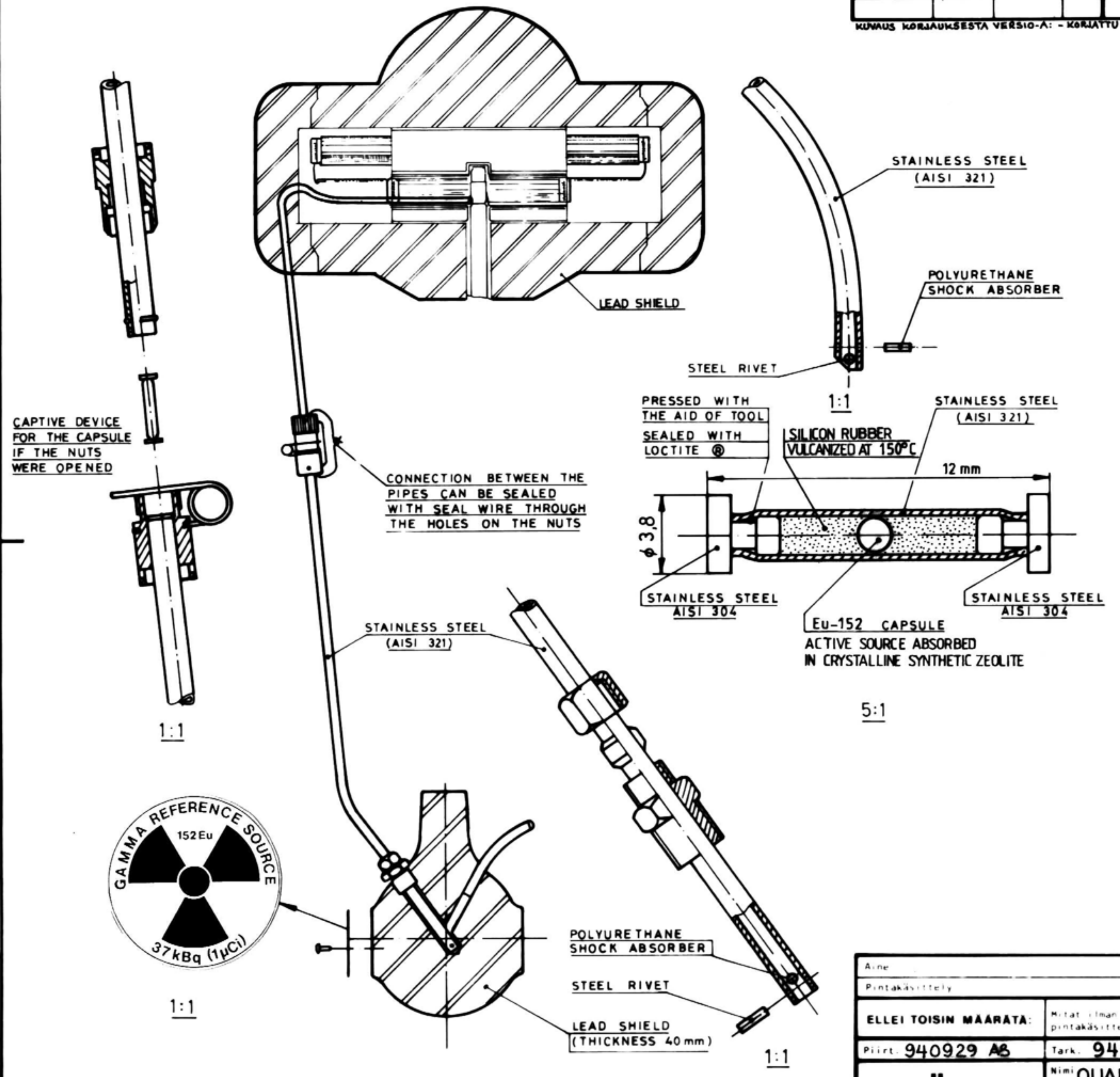
Asema	MT n:o	Päiväm.	Piirt.
VERSIO-A		960422	AS

KUVAUS KORJAUKSESTA VERSIO-A: - KORJATTU (3X) TEKSTI STEINLESS → STAINLESS.



CAUTION
RADIOACTIVE
MATERIAL

SÄTEILYVAARA

When this instrument is no longer in use the Eu-152 standard capsule must be removed and sent to the appropriate radiation safety authorities or to the instrument manufacturer for safe disposal.

Kun tämä laite poistetaan lopullisesti käytöstä, on Eu-152 standardi kapseli irroitettava ja toimitettava säteilyturvallisuusviranomaisille tai laitteen valmistajalle.

THE ABOVE LABELS ARE PERMANENTLY ATTACHED TO THE EXTERIOR REAR PLATE OF THE INSTRUMENT

Aine

Pintakäsittely

ELLEI TOISIN MÄÄRÄTÄ:	Mitat ilman pintakäsittelyä	Ra √	Yleis-toleranssi	Reiät ØH13	Suhde 1:2,5 (1:1, 5:1)
Piirt. 940929 AS	Tark. 940929 HKY	Hyv. 941003 KLOU			Osal. n:o

wallac oy
TURKU - FINLAND

Nimi / Name: QUANTULUS 1220 EXTERNAL STANDARD TRANSPORT SYSTEM

Piir.n:o 10 36 0835-A

1390 3693

PerkinElmer life sciences.

DECLARATION OF CONFORMITY FOR CE-MARKING
INSTRUMENTS

We

Supplier's name
WALLAC OY
Address
PL 10, 20101 TURKU, FINLAND

declare under our sole responsibility that the product

Name, type or model, lot, batch or serial number, possibly sources and numbers of items
1220 QUANTULUS, LIQUID SCINTILLATION COUNTER Valid from serial number 2200195

to which this declaration relates is in conformity with the following standard(s) or other normative document(s)

Title and/or number and date of issue of the standard(s) or other normative document(s)
EN 50082-1:1992; EN 50081-1: 1992 EN 61000-3-2 :1995 + A1 :1998 + A14 :2000; EN 61000-3-3 :1995 EN 61010-1 :1993

(if applicable) following the provisions of the following directives

Electromagnetic compatibility (EMC), 89/336/EEC Low voltage (LV), 73/23/EEC

Date and place of issue
16 August 2001 TURKU, FINLAND
Name and signature or equivalent marking of authorized person
Pekka Mäkinen, Quality Assurance Manager

Installation

Low background counting requirements
Installation instructions

Low background counting requirements

Achieving stability

The most important factor for the low level counting procedures is the stability of the counter background. Thus, an elevated, stable background is far better than a low variable background. To achieve stability, one must have a stable instrument, environment and sample.

The sample should not change its composition as a function of time, such as separating into two phases (this can be monitored visually, looking at the spectra and their statistics and by SQP(E)). Generally it is recommended to let the samples cool down before counting.

Quantulus is stable in stable environmental conditions. Below some hints are given about how to achieve as good a laboratory environment as possible.

Sources of background

The background count rate of an instrument is a function of several environmental conditions. Background is introduced by the inherent radioactivity of the instrument and sample containers, cosmic particles and their secondaries and by environmental gamma radiation.

Wallac 1220 Quantulus is carefully constructed by using ultra low activity materials to minimize the inherent background of the instrument. Selected phototubes are the only radioactive components in the close vicinity of the counting chamber. The 40K of glass presents a stable background contribution and is reduced by using quartz in the tubes.

In liquid scintillation counting, considerable background increase is introduced especially in the low energy region (3H) if glass vials (always containing some 40K) are used. Plastic and teflon vials can very well be used for this purpose today since modern biodegradable cocktails will not create a plastic vial effect. If a glass vial is preferred, one has a means of electronic background reduction in Quantulus, the so-called Pulse Shape Analyser.

A major background component in liquid scintillation counting is the high energy cosmic radiation, whose intensity varies with the atmospheric pressure and humidity. Quantulus contains, however, an extra detector to identify external radiation and block its background contribution. The detector, anticoicident guard counter is external to the counting chamber and very effectively detects the high energy cosmic particles and most of other environmental radiation, leading to stable sample background.

It is an advantage to have the laboratory built underground where cosmic radiation is attenuated by floor masses on top. It is not, however, a necessary requirement.

The most important factor in terms of Quantulus background is the gamma photon flux from the counting environment.

Wallac low level background room

The Wallac low background counting room is an example of an inexpensive room with considerably reduced gamma background. It has 1 m thick walls, the inner halves of which are low activity concrete composed of iron ore pellets from the Finnish Outokumpu mine to replace sand (not available any more) plus white cement, Aalborg Portland from Denmark. Quartz sand can serve as a replacement for normal sand. The ceiling and the floor are also of the low activity material. In this environment the gamma flux is about 1/20th of the flux in our normal environment resulting in halving of background count rate.

We maintain overpressure in the room to flush out radon underneath the door, air exchange is about 3 times/ hr. The outside air inlet should be located well above the ground level since otherwise a small variation of radon concentration will result due to diurnal variation close to ground level. Filters in the air inlet maintain dust free air - no dust nor cigarette smoke should be allowed in the counting room.

It is also important to avoid great temperature changes in the counting room, air conditioning and temperature control is recommended to reduce humidity as well. The instrument cooling unit is able to maintain a 12 degree (centigrade) difference between the instrument interior and ambient air temperature. If cooling is boosted by running water through the cooling fringes, a 12 degree difference is maintained between the water and interior. The mass of the instrument presents a thermal inertia, which considerably slows down the temperature variation due to power failure.

The Wallac low level room is a Faraday cage. When the power line is dependable and not noisy, it is not necessary to have Faraday cage. Quantulus contains an aerial in anticoincidence to filter electromagnetic interference. With noisy power lines it may be necessary to use an uninterruptable power supply. The cooling unit may be left connected directly to power line but the computer has to be fed through the uninterruptable supply if Quantulus is connected there in order to ensure continuous operation.

Addition of lead or low activity steel plates around the Quantulus is another way to improve the background but leads certainly to a significant mass of material (see below for surface loads).

The anticoincidence guard counter spectrum in its Compton continuum region reflects the changes in the environmental gamma flux, although attenuated by the additional shielding effect of the lead, e.g. in the Wallac low level laboratory the continuum drops only to one half of the one seen in the normal environment.

Incandescent lighting is recommended and sunlight should not have access to the counting room.

It is recommended that only background samples are prepared and stored in the counting room. One should check for the background changes of high activity gamma sources outside the counting room caused by moving the sources, for instance. A pulsed accelerator in the distance may be source of variable background, too.

Other factors

Humidity

Quantulus is able to run in a high humidity environment but then a container should be placed under the condensed water outlet. In extremely dry atmosphere (less than 10 % rel. humidity) there is a danger of static electricity building up with some plastic vials - in the most cases Quantulus' deionizer and metal vial holders/light shutters will remove the problem.

Static loading

The maximum (static) load by the instrument is 1 tn/sq meter. One may distribute the load on a larger surface. A 2x2 meter reinforcement would reduce the load by the instrument to 250 kp/sq meter. On steel reinforced concrete floors only small plates under the feet are normally necessary, there is little advantage in using e.g. steel plate since a 200x200x2 cm plate would weigh some 600 kg by itself. One might consider a thick plywood plate instead.

Anticoincidence guard

Quantulus is run with an anticoincidence guard counter activated for low activity samples. The minimum requirements to be considered for samples and counting room are then the ones printed in italics above.

Literature

Numerous low level counting labs have been introduced in the Proc. of the 3rd Int. Conf. on Low-Level Counting, Bratislava, Czechoslovakia, 21-25 Oct, 1985, Nucl. Instr. & Methods in Phys. Res. B17 (5,6) 1986.

L. Kaihola, H. Kojola and R. Kananen, Low Level Liquid Scintillation Counter Performance in a Low Level Surface Laboratory. Nucl. Instr. Meth. Phys. Res. B17 (5,6), 509 (1986).

Installation

Environment

Although normal clean laboratory conditions are usually quite satisfactory as an operational environment it is useful to take the following points into consideration.

If possible a separate room should be provided for Quantulus as this allows the best control over the immediate environment. Ventilation in the room should be adequate for all conditions of use, the temperature should be reasonably constant at about 22oC, relative humidity should not be excessive, and direct sunlight should not be able to reach the instrument. It is also important that the various isotopes are stored well away from the instrument in another room. Only those radioactive samples that are actually measured should be in the laboratory at any time in order to keep the background at a low level.

Electric power

Three electrical outlets each with a protective earth should be available, with, if possible, a separate power line for the instrument itself having an isolation switch and a fuse box. If excessive fluctuations in the mains voltage are anticipated, a mains stabilizer may be necessary.

Checking the mains voltage setting

Measure and note the mains voltage at the outlets to be used.

Note: the instrument is provided with two mains electrical inlets, the instrument itself and the cooling unit.

Fuses:
T4A: Mains 100 - 120 V
T2A: Mains 220 - 240 V

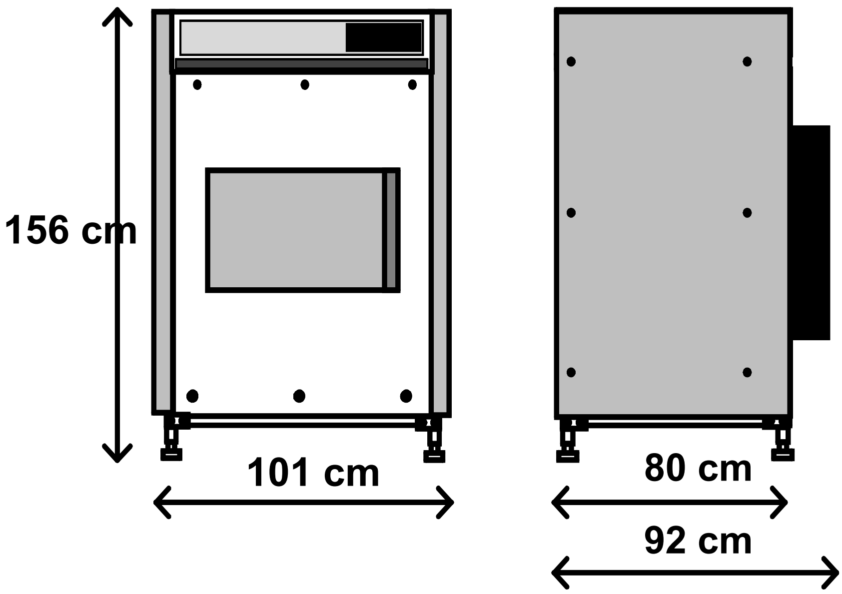
More than one live circuit, see the diagram. Locate the mains selector switches. If necessary adjust the mains selector switches to correspond with the measured supply. For supplies with a nominal voltage of 230 V it is recommended that the selector be set to 220 V.

Check that the fuses fitted in the fuse carriers on the back panel are of the correct rating for the local supply, and according to the label.

Connect the battery cable.

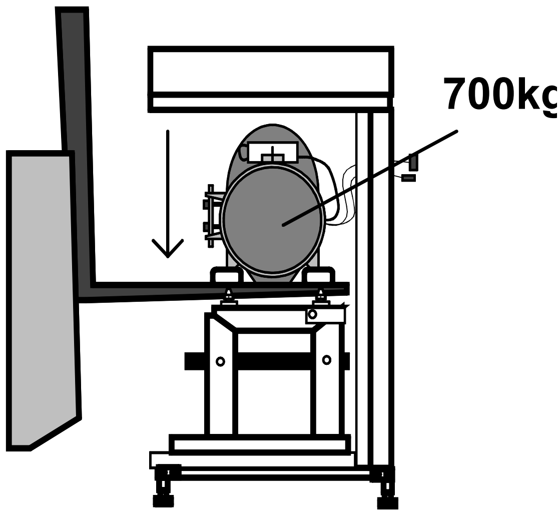
Preparing Installation of Quantulus

The weight of the lead shielding is almost 700 kg and is transported separately from the main instrument and has to be installed on the customers place. Before the actual installation there are some points to be done.
Look for a place where the installation of the lead shielding can be done (depended of lifting equipment). The closer to the final position the better.
Check that the corridors and doors are wide enough and that there are no barriers on the route.
If an elevator is used, check that it can handle the weight of the instrument and that there is space enough.
Check also that the floor of the operation room is strong enough for an instrument, with a total weight of about 1000kg and that there is enough space for the instrument. Note that there has to be at least 50 cm of empty space around the instrument for service purposes !!



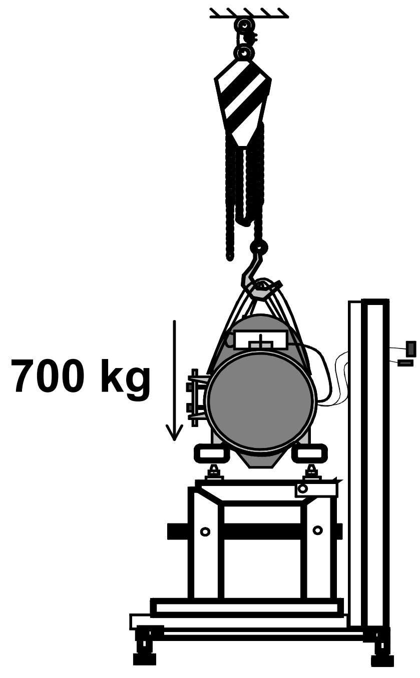
Check what kind of lifting equipment is available. Remember that there has to be enough of space for doing the installation and if the installation is made in a different place than the operating room, that the route for an already installed instrument is clear.

- the easiest is to use a fork lift truck !!



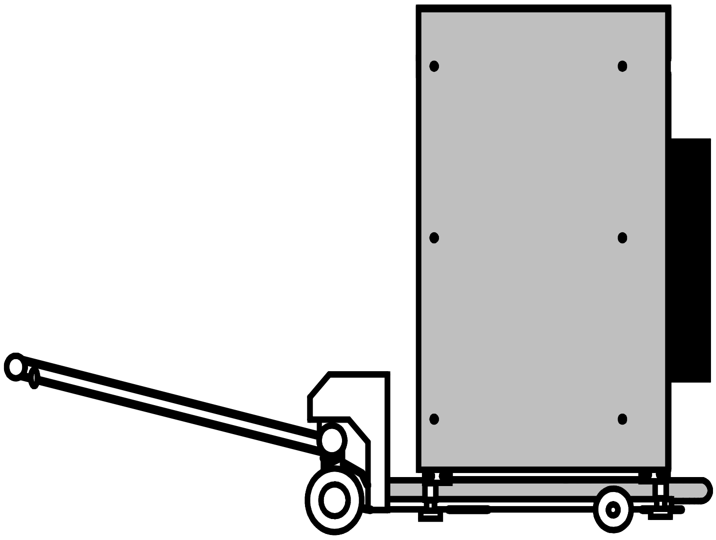
Total 1000kg

- if a truck is not possible the second alternative is to disassemble the upper part of the instrument and to use a lifting pulley. Check where to hook it.



Total 1000kg

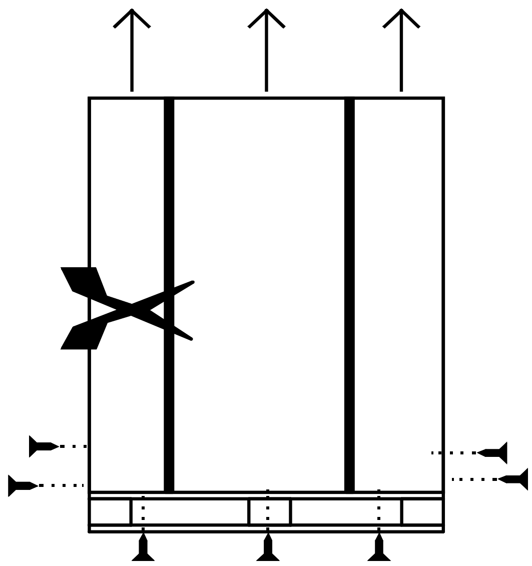
When the lead shielding is installed, it is easiest to move the instrument to the operation place with a jack.



Normal service tools are needed and it would be good from service training point of view for the local service engineer to be present all the time.
The installation and the checking of the instrument takes in normal condition about 4 .. 5 days including the training of the local service engineer and the basic training of the customer.

Note: *The instrument has to be connected to a mains / circuit having a protective earth. Installation*

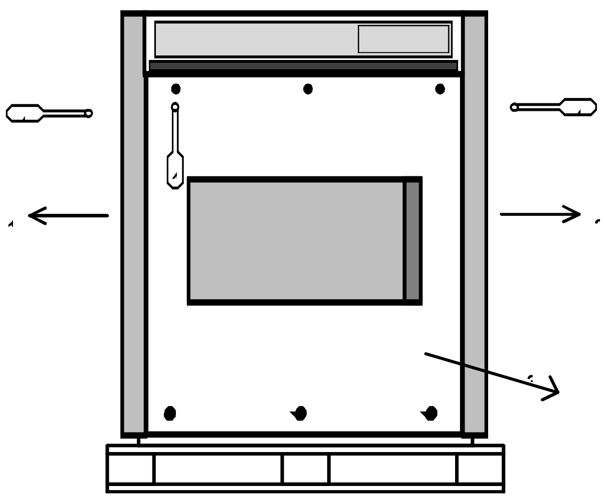
Unpacking the Main Instrument



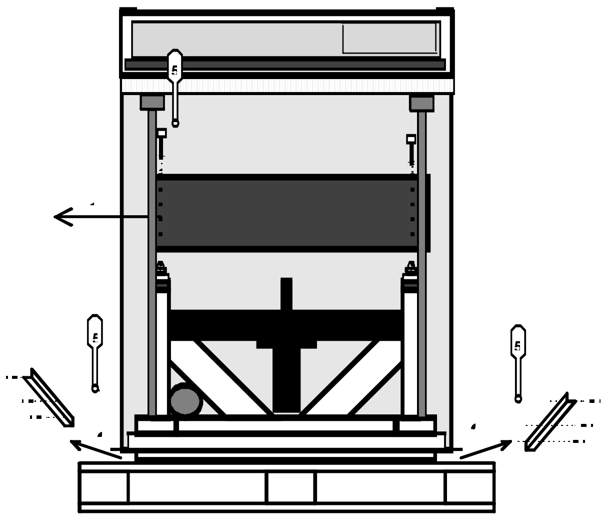
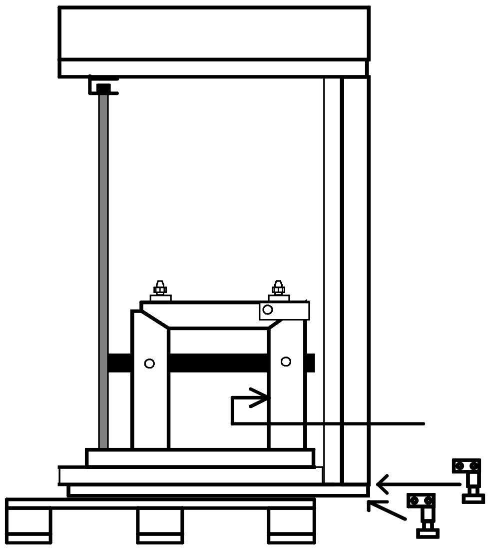
- cut the stripes
- open the Phillips screws down on the box
- lift the box carefully over the instrument
- remove the plastic around the instrument

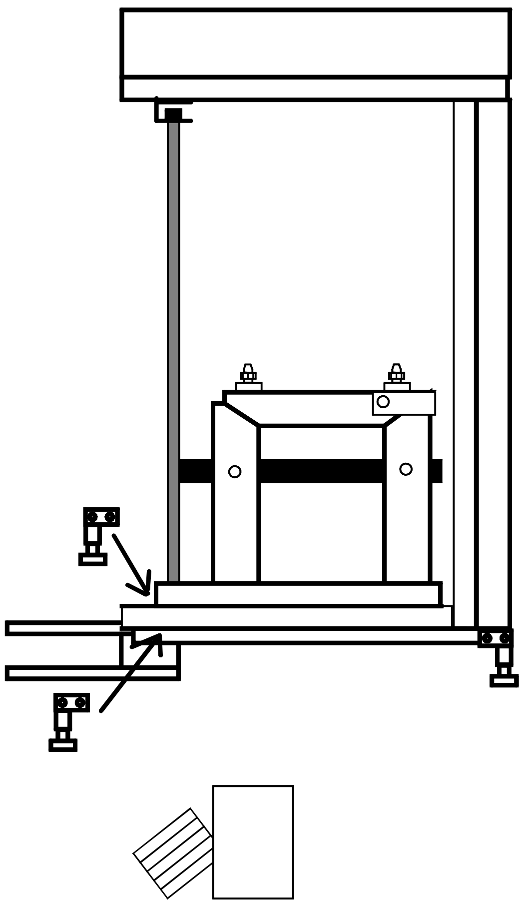
Note!

Break the box if there is not enough of space to lift the box!!



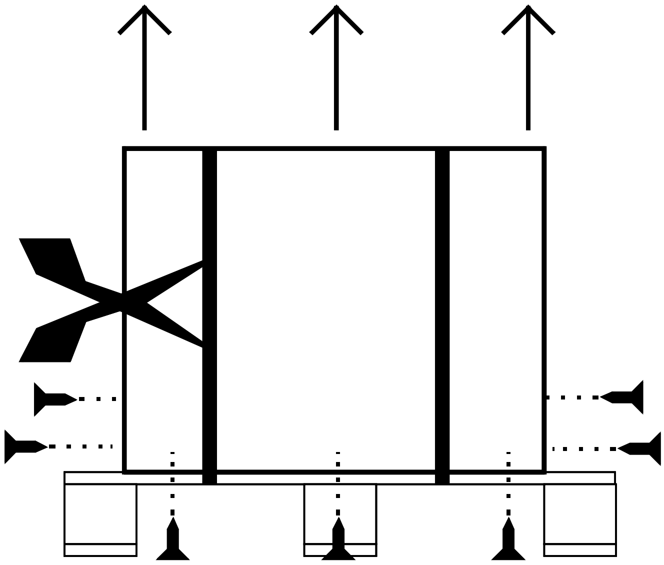
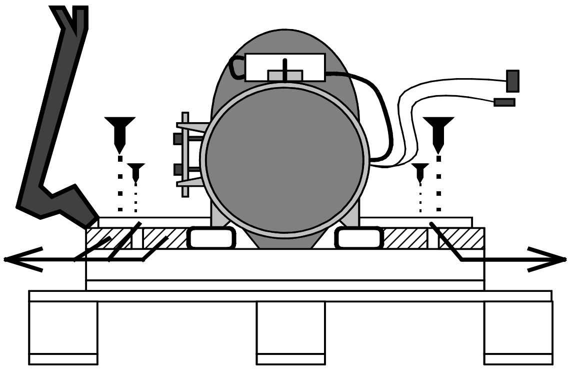
- Disassemble first the side lids and then the front lid

	– Disassemble the cooling unit – Disassemble the rails with which the instrument is attached to the stand
	– Pull the instrument (see arrow) about 20 cm over the stand – install the legs (the legs are in the lead shielding box) Note!! The legs are numbered and the according numbers are typed on the instrument

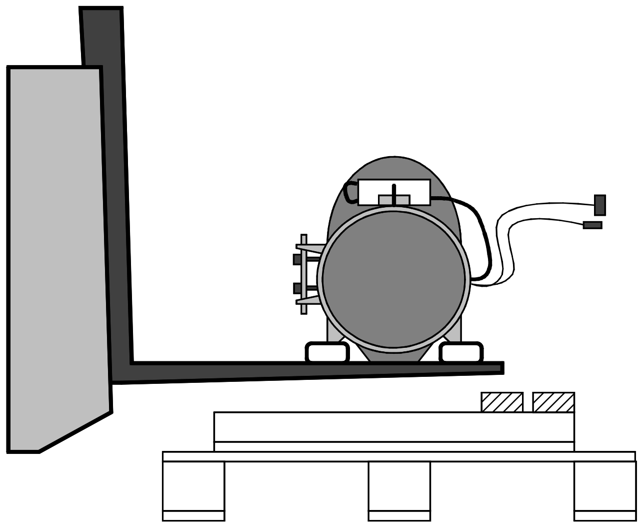


- put the corner of the stand in the centre of the front of the instrument (see picture)
- assemble the two resting legs according to the numbers on the leg and instrument

Unpacking the Lead Shielding

	– cut the stripes – open the Phillips screws down on the box – lift the box carefully over the lead
	– remove the wooden plates and the planks with which the lead shielding is attached to the stand

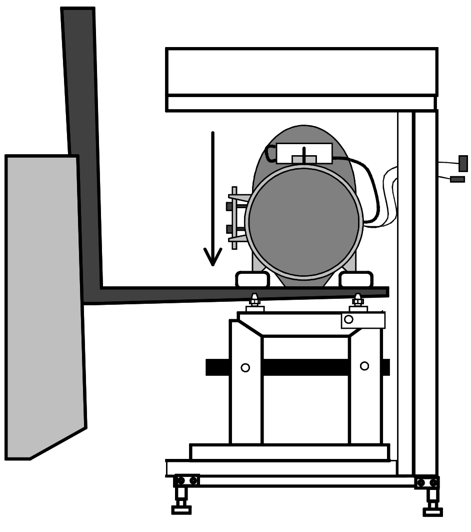
Installation with a fork-lift truck



- lift the lead shielding up with the truck so that the forks are only 2-5cm over the edge of the lead

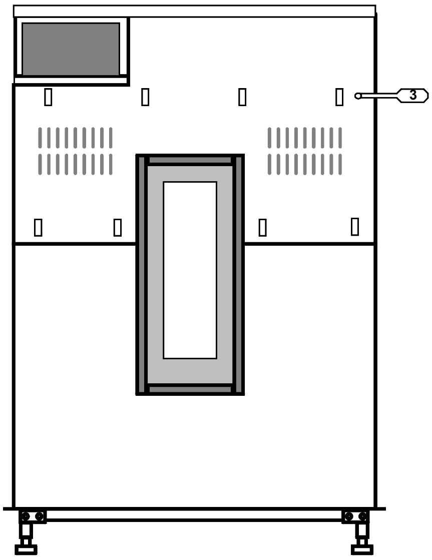
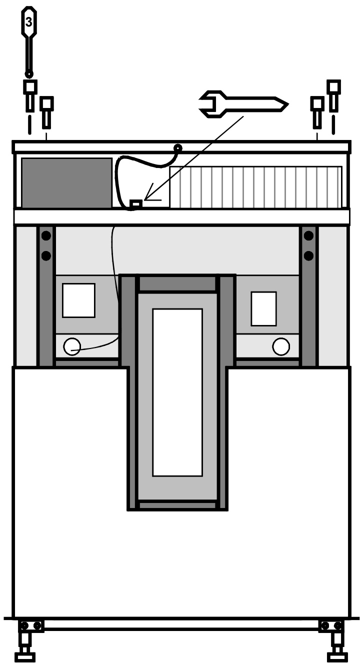
Note!!

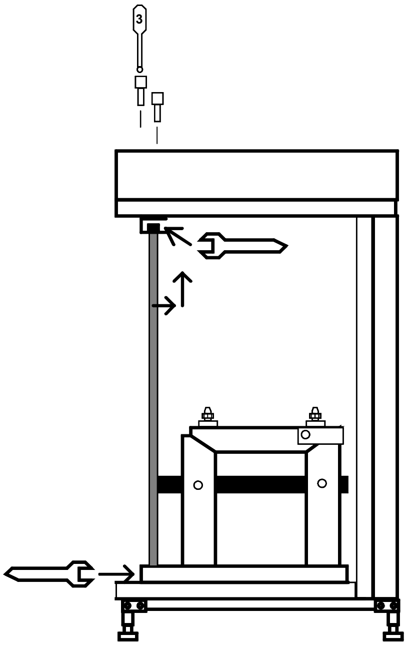
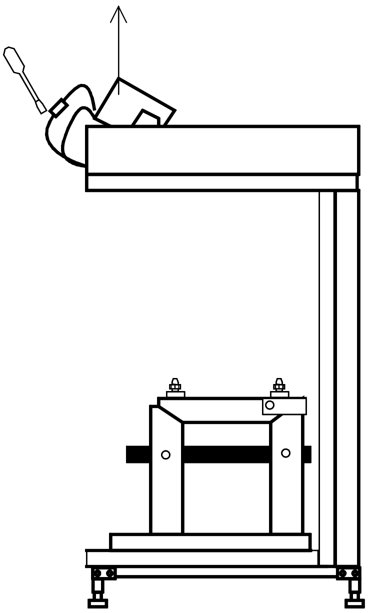
On the front of the lead shielding are the hinges for the doors and at the rear are the cables!

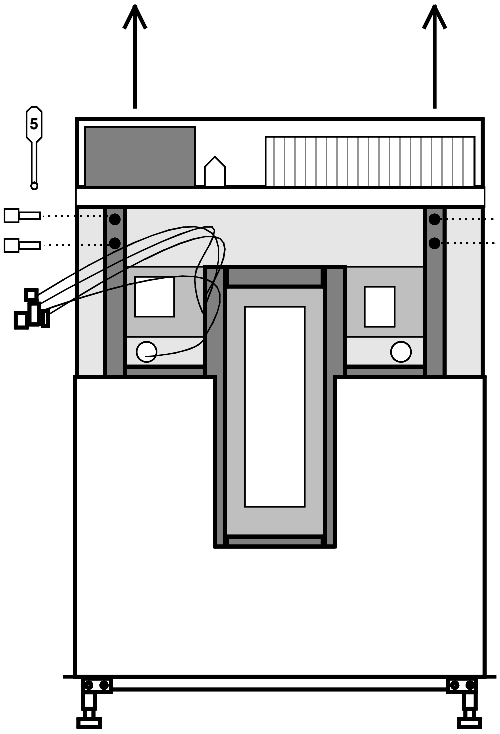
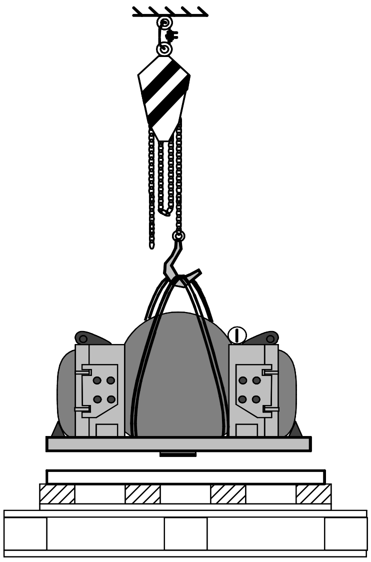


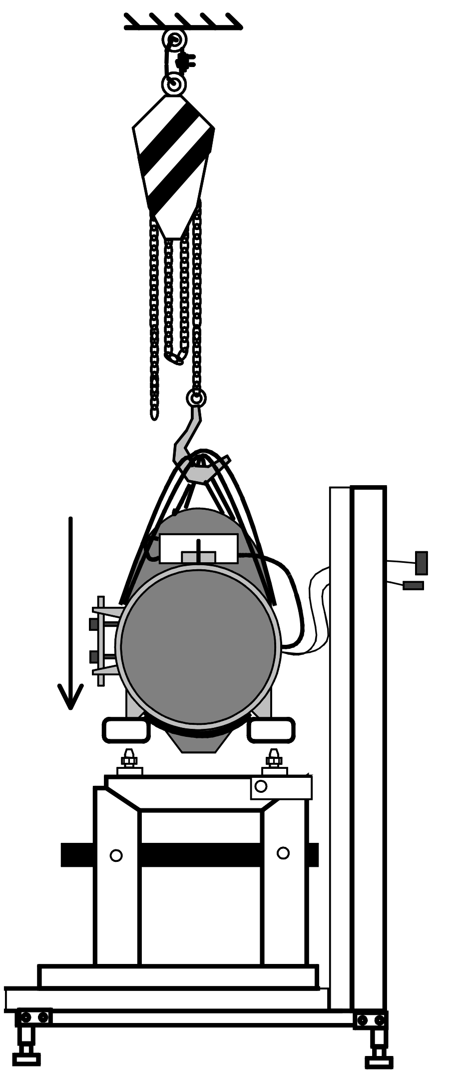
- push the instrument base under the lead
- let the lead shielding slowly down and guide the instrument so the lead goes on the four guide pins

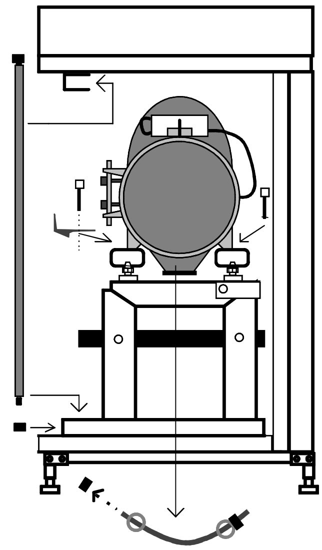
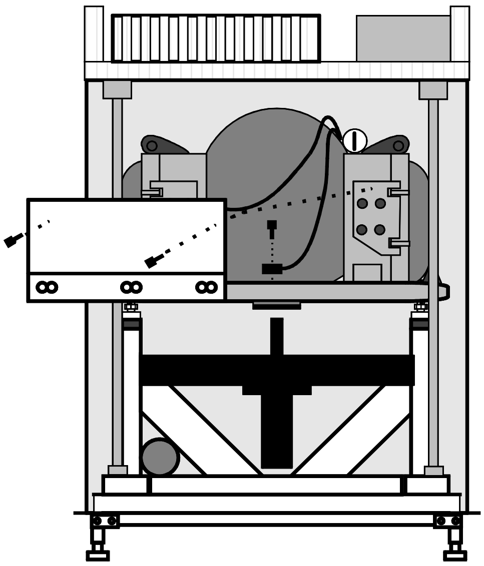
Installation with Lifting Pulley

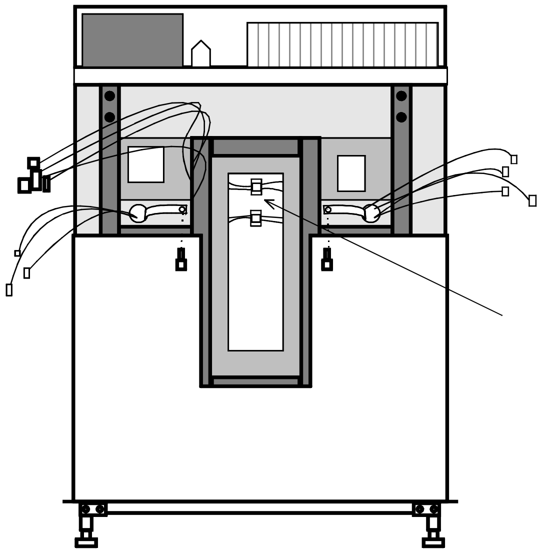
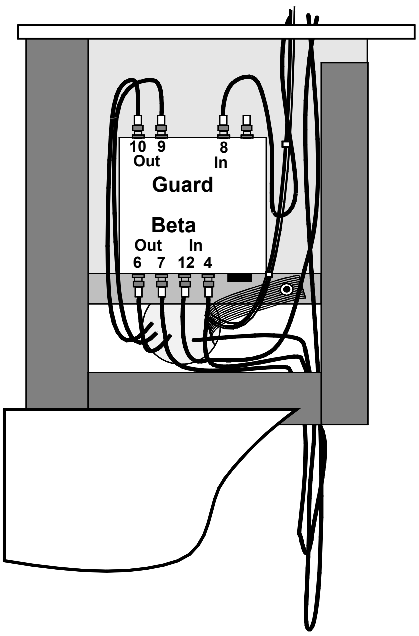
<table>
<tr><td>
</td><td>– disassemble the back panel</td></tr>
<tr><td>
</td><td>– Disconnect the ground cable
– disassemble the top cover</td></tr>
</table>

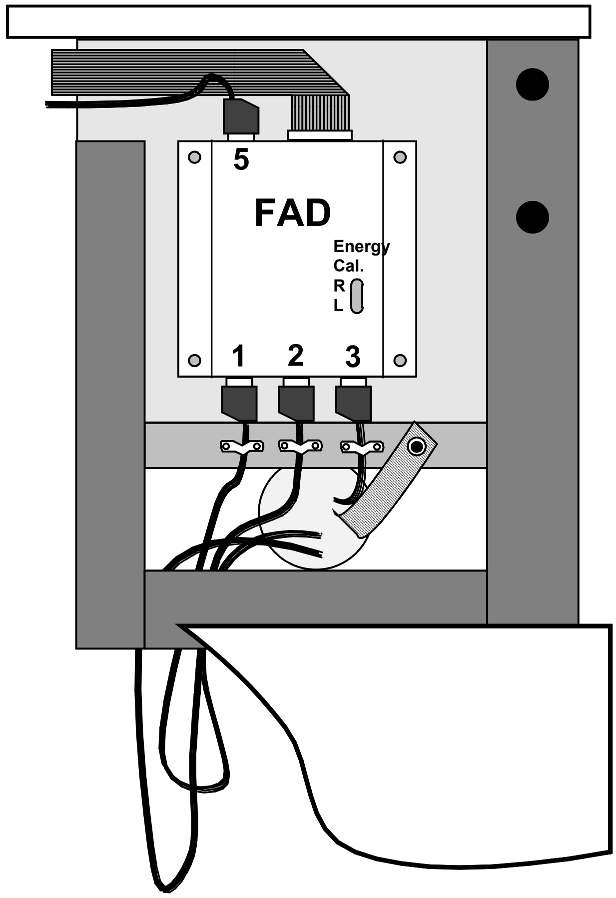
	– open the screws of the upper front panel – disassemble the support pillars (note the numbering when assembling back)
	– lift the upper front panel up on the instrument – disconnect the cables (numbered) – lift the upper front panel carefully on the floor

	– disconnect all cables which goes from the lower part to the upper part – disassemble the upper part by opening the four screw which attach the upper part to the lower (see picture) and then lift the upper part up – put the upper part carefully down on the floor
	– wrap a strong rope (lead shielding is about 700kg) around the lead like in the picture – lift the lead shielding up

	– push the instrument base under the lead – let the lead shielding slowly down and guide the instrument so the lead goes on the four guide pins

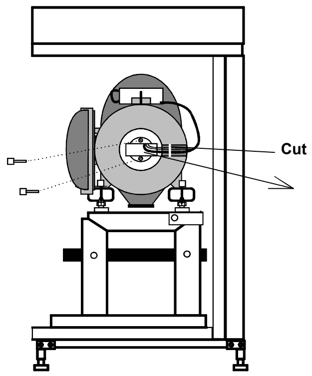
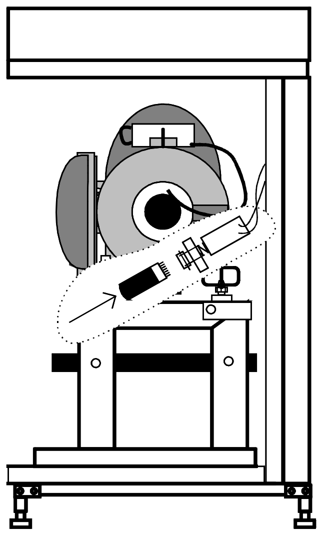
	– remove the support pieces for the lead shielding doors – assemble the blocking piece that prevents the door from opening too much (note numbers) – tight the screws for the lead shielding – install the removed support pieces (note numbers)
	– assemble the temperature sensing unit for the cooling unit according to the picture – assemble the "traffic lights" according to the picture Note the cables!!!

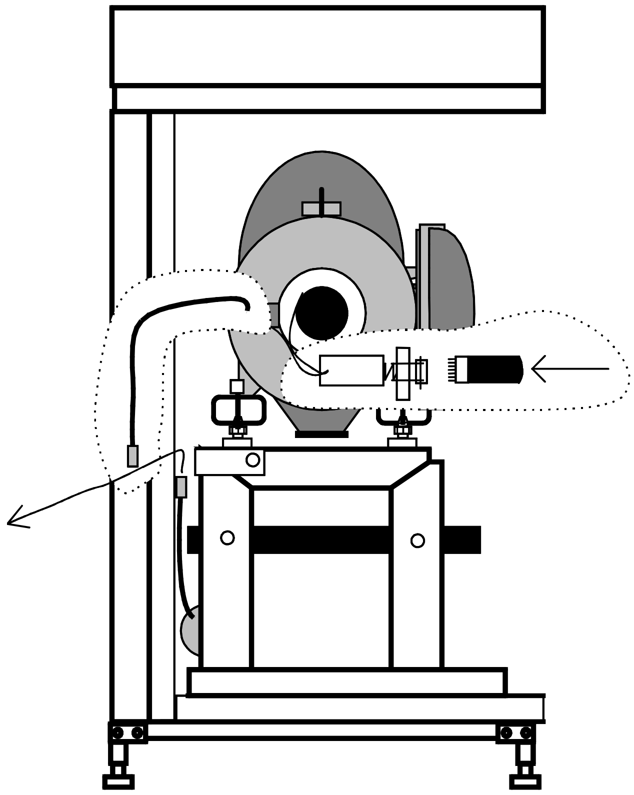
	– guide the HV cables and ionizer and cooling unit cable through the left hole seen from the back (see picture) – guide the analogue cables through the right hole – separate the HV and analogue cables at the rear of the lead shielding
	– connect the cables according to the picture – assemble the cables so the extra length goes like in the picture



– connect the cables according to the picture

Installation of the PMTs and External Standard

	– open the lead shielding door – cut the bunch holders – remove the preampilfier – check the serial number of the PMT on the door of the lead shielding – take the same numbered PMT from the box
	– assemble the PMT to the socket of the preamplifier (only one possible position to assemble) – assemble the preamplifier carefully with PMT back into the instrument (keep the PMT angled up 10-15 degrees when inserted into the instrument – tight the screws and insert new bunch holders – close the lead shielding door carefully (check that no cables between) – push on the ear of the door when tightening the screw (door gets tight against the lead)



- install the pmt as on the right side (install upper part of the external standard pipe before inserting bunch holders and closing door)
- pull the stripe out from the lower part of the external standard pipe (prevents the capsule from moving during the transportation)
- push the upper half upper end into the bottom of the hole of the guard container
- joint the pipes together by tightening the joint screw
- push on the rubber part of the external standard pump and listen that the external standard capsule moves freely inside the pipe

Reassemble the lids and connect the instrument to the mains / circuit **having a protective earth.**

Installation of the PC

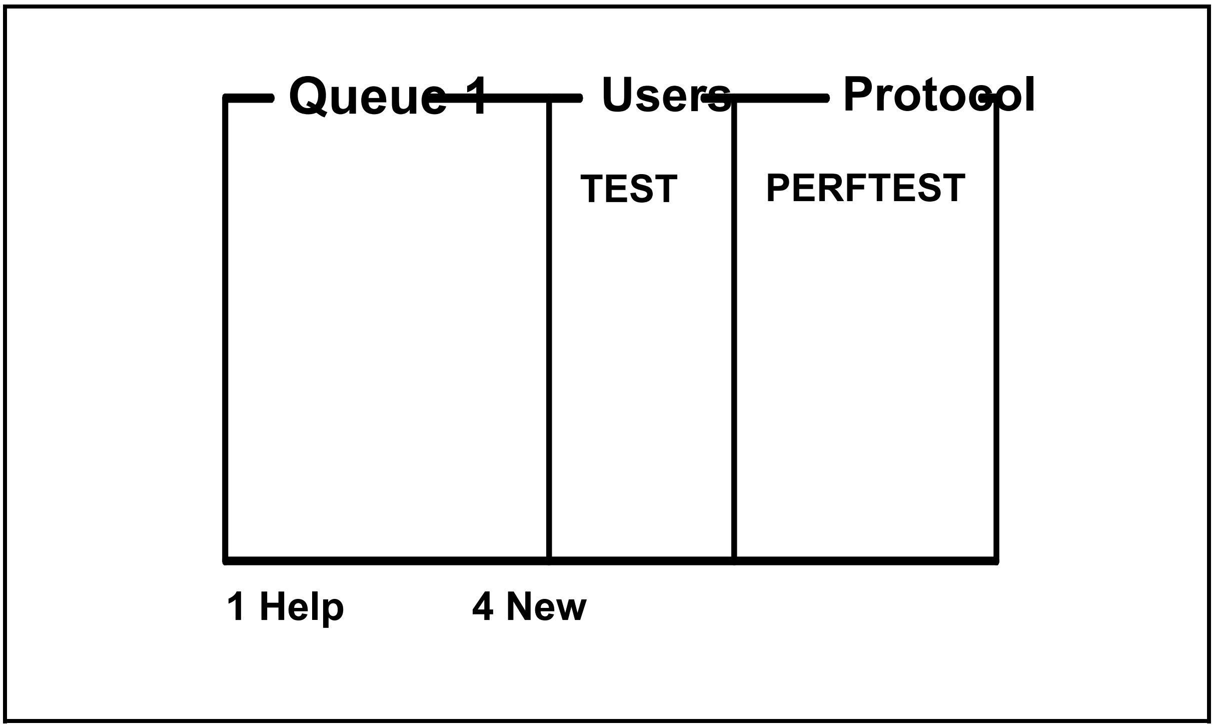
Install the SPA (Spectrum Analysis Program) and the QMGR (QueueManaGeR) to the computer according to the instructions followed with the programs.

Connect the cable (1221-459 for 25 pin or 1221-470 / -503 with shielding for 9 pin) to COM1 of the computer and to port 2 of the instrument and switch it on.

General Information of the SPA and QMGR program

QMGR

In the QMGR different users can edit and save different protocols for the 1220. When the measurement is started the protocol(s) are queued and the one being measured is sent to the instrument.
During the measurement the live spectrum can be displayed on the screen of the monitor.



The programming is done by jumping between **Queue 1** the **Users** and the **Protocol** with the arrows keys on the keyboard.

For creating a protocol you have to create a new user and a new protocol for that user:
Use the arrows and highlight **Users** on the screen. Push F4 and type a user name, i.e. **TEST** and then press enter.

Then highlight **Protocol, push F4 and type the saving path: (i.e. C:\perftest).** Jump through the protocol with the keyboard arrows and set the protocol you want to run i.e.:

General Parameters	MCA&Counter Window Settings
Saving path: C:\TEST Protocol name: PERFTEST Number of cycles: 30 Parameter listing: YES Edit notes	Configuration: 14C (high energy ß) Send spectra: All PAC 1 Number of channels: 1024 PSA N/A Coincidence bias: LOW Windows 1 2 3 4 5 6 7 8

Sample Parameters

ORD	POS	ID (PATH IS OFF)	CTIME	COUNTS	CUCNTS	MCW	REP	ST	STMS	STIME
1	1	14C	2:00	No lim	No lim	1	1	Y	1/10	1:00
2	2	3H	2:00	No lim	No lim	1	1	Y	1/10	1:00
3	5	BKG	30:00	No lim	No lim	1	1	Y	1/10	1:00

Once the settings are the way they should be, press F10 and enter for saving the protocol. Highlight Queue 1 and press F4 fur running the protocol. The protocol will be sent to the instrument and the measurement is started. For getting the live spectrum push Alt - F3 simultaneously.

When the measurement is finished the results and the selected spectra will be sent to the PC and can then be analyzed by the SPA program.

SPA

The SPA program is activated with F9 from the QMGR program and with F10->F1 for the "Old program".
When calculating and plotting spectra GRAPH F8 or statistical plots STAT F6 or F7 the program suggests for example:

C:\ (up on screen)

ORD=01 POS=01 STD=N REP=01 CYC=001 SP# = 11 ->

The path for where the files are as well as the name of the files comes from the protocol used:

Saving path: C:\TEST*) *) running number for each time Protocol name:
PERFTEST this protocol is started

The name of the files:

Q : Quantulus
O1- 99 : Order number
P1 - 60 : Position number
01 - 99 : Repeat number
N / S : Normal / External Standard
001 - 999 : Cycle number (000 = cumulative file)

In this case: 14C = C: \ TEST1\ PERFTEST \ QO1P101N.001
3H = C: \ TEST1\ PERFTEST \ QO2P201N.001
BKG = C: \ TEST1\ PERFTEST \ Q03P501N.001

The SP# = xx (spectra) value comes from the MCA configuration. In this case 14-C configuration is used:

MCA	INPUT	TRIGG.	INHIBIT	MEMORY SPLIT
1	LRSUM	L*R		PAC+G
2	GSUM	G		L*R

This means that the normal beta coincidence (LRSUM & L*R) goes into SP11 (MCA 1 / half one) and when the PAC (pulse amplitude comparator) and G (guard) is activated the pulses goes into SP12 (MCA 1 / half 2).

The guard pulses (GSUM & G) goes into SP21 (MCA 2 / half 1) and when L*R coincidence is activated the pulses goes into SP22 (MCA 2 / hold 2).

For changing an order or a position :

ORD=01 POS=01 STD=N REP=01 CYC=001 SP# = 11 -> ***O2P2 enter***
ORD=**02** POS=**02** STD=N REP=01 CYC=001 SP# = 11 ->

Type H or ? for help or see Quantulus PC Spectrum Analysis Program User Manual for more specific information!!

Mechanical check

Enter with F8 the terminal mode of the QMGR program and type:

Ready>	T and enter	: entering service mode
Service>	MO	: motor and sensor test

At this point the conveyor can be controlled with the following commands: XL, XR, YI, and YO.

Conveyor table check

Disconnect the HV cables!!!

Insert a tray and pick it up with the transporter with the commands: xl and yi
Run the tray into measuring position and switch the instrument off. Run the elevator up manually by rotating the cogwheels. Check that the elevator shaft goes smoothly up and that the light shield core does not hit against the lead shielding on the way up and that it does not hit against the sample tray on the way down.
If this is the case, the conveyor table has to be aligned: see mechanical adjustments in service manual!!!
When o.k. switch instrument on and re enter the motor and sensor test and run pos 1, 5, 16, and 20 to be sure the mechanical alignments are o.k.

For the final mechanical test make a protocol with 1s measuring time and for the positions:
1,21,41,5,25,45,16,36,56,20,40,60
Insert a sample tray in each position and push the tray as much as possible to the left. Check that the sample tray is picked up smoothly and that the elevator goes up and down smoothly without the core hitting against the lead or the tray. Push the tray each time it is returned from the instrument to the left. This is done for all corner positions.
Make a rerun of the protocol and now with the sample tray to the most right position.

If problems, check alignments!!

When o.k. reconnect the HV cables and reassemble the lids except for the back panel Assemble the cooling unit and set the temperature to be about 5 degrees of Celsius below the room temperature: 18 degrees of Celsius is normal temperature.

Electronic check

First step is to run a short performance test similar to the one on the final test data sheet, but with shorter counting time for the background. With this test the following circuits will be tested:

A) Analyzer: -background
-efficiency
B). Gain stabilizer
C). Guard detector

Make the following protocol and measure the sealed standards.

General Parameters	MCA&Counter Window Settings
Saving path: C:\TEST	Configuration: 14C (high energy ß)
Protocol name: PERFTEST	Send spectra: All PAC 1
Number of cycles: 1	Number of channels: 1024 PSA N/A
Parameter listing: YES	Coincidence bias: LOW
Edit notes	Windows 1 2 3 4 5 6 7 8

Sample Parameters

ORD	POS	ID (PATH IS OFF)	CTIME	COUNTS	CUCNTS	MCW	REP	ST	STMS	STIME
1	1	14C	1:00	No lim	No lim	1	1	Y	1/1	0:15
2	2	3H	1:00	No lim	No lim	1	1	Y	1/1	0:15
3	5	BKG	5:00	No lim	No lim	1	1	Y	1/1	0:15

Check the performance and compare them to the results on the final test data sheet in the instrument manual. Calculate also the efficiency for 3H (SPA program 4SPCalc->E%->DPM->DECAY CORRECTION Y ...).

Because the PMTs has been disassembled and exposed to light during the transportation it will take 2-3 days before they are stabilized. The spectrum calibration has to be checked according to the instruction on next page. The same check should be done after 2-3 days.

Spectrum Adjustment

Enter terminal mode and make the following protocol:

```
     Parameter Group:       1
     Id:                    Spectrum Adj
   00A  Program mode:       1
     Count Mode:   Fixed Window
                   SQP(E) Single Label
                   3-H
   01 Positions             1
   02 Listing               Y
   03 Time                  0:30
   04 Counts 1              900 000
   07 Sample Quality Monitor  N
   08 Number of Windows     1
   09 Window 1              5-320
   12 External Std time     0:15
   14 Print    1,2,5,20,21

   15 Curve Edit            N
   16 Curve Fit             SS
   16A  Replot with Auto Run  N
     Replot with Curve Edit  N
   17 Background sample     0-0
   18A  Background Sub. 1   .0
   20 Repeat                99
   20A  Repeat Plot         N
   21 Replicate             1
   22 Sample Prep. Error%   .0
   26 Factor 1              1.00000E0
   28 Half Life 1           .0
   30 Number Cycles         1
   31 Reference 1           0-0

POS  CTIME  CPM1   SQP(I) SQP(E)
```

Change the following memory locations (see 1220 service manual: section 5 / EJJ MCA interface measurement configuration table):

READY>	**T**			**:** **T**est / service mode	
SERVICE>	**PR**	**2A03**		**:** **P**rogram **R**am memory location 2A03....	
		2A03	**01**	**:** 01 = other memory changes will be valid	
		2A04	/	**:** back to service prompt	
SERVICE>	**PR**	**2180**		**:** **P**rogram **R**am memory location 2180....	
		2180	**03**	**:** digital pulse select	03 => L*R
		2181	**00**	**:** inhibit pulse select	00 => OFF
		2182	**03**	**:** LSB select	03 => LSB = 1

	2183	**0D**	: analogue pulse select *)	0D =>L+R
		0E		0E =>R
		0F		0F =>L
	2184	/	: back to service prompt	
SERVICE>	RE		: back to ready prompt	

*) depended of which side is calibrated

Select the spectrum of the left side (2183 = 0F) and start the measurement with the unquenched H-3 glass vial, which is supplied with the instrument. Use the parameter group edited on previous page. Adjust using trimmer R89 EL on FAD the SQP(I) to be according to the table subtracted with 4 channels on next page:

Select the spectrum of the right side (2183 = 0E) and resume counting. Adjust using trimmer R86 ER on FAD the SQP(I) to be according to the table subtracted with 4 channels.

Select the spectrum of both sides (2183 = 0D) and resume counting. Check that the SQP(I) is according to the table.

CAUTION! DO NOT ADJUST TEMPERATURE COMPENSATION TRIMMERS R1 AND R3 ON THE FAD-BOARD.

After the calibration go to the SERVICE PROGRAM by pressing T when in the READY state and in the service program press MC to make MASTER CLEAR to restore the original MCA configuration.

E%	SPQ(I)	SQP(E)	E%	SPQ(I)	SQP(E)	E%	SPQ(I)	SQP(E)
75	203	1002	71	187	976	67	173	951
74,5	201	999	70,5	185	973	66,5	171	948
74	199	995	70	183	970	66	170	945
73,5	197	992	69,5	181	966	65,5	168	942
73	195	989	69	179	963	65	167	939
72,5	193	985	68,5	177	960	64,5	166	936
72	191	982	68	176	957	64	165	933
71,5	189	979	67,5	174	954	63,5	163	930

SQP(E) table for EU-152

E(%)	SQP(I)	SQP(E)		E(%)	SQP(I)	SQP(E)
71.0	187	932		67.0	173	913
70.5	185	929		66.5	171	910
70.0	183	927		66.0	170	908
69.5	181	925		65.5	168	906
69.0	179	922		65.0	167	903
68.5	177	920		64.5	166	901
68.0	176	918		64.0	165	899
67.5	174	915				

(SQP(E) within +/- 25 channels)

SERVICE> PR 2A03 01

PR 2180 03
2181 00
2182 03
2183 0D L+R = table value +/-1 channel
0FL = table value - 4ch +/-1 channel
0ER = table value - 4ch +/-1 channel

To be sure that the external standard capsule moves properly check that the SQP(E) values are close the table values +/- 8 channels!!

PSA & PAC Check

Enter terminal mode and make the following protocol:

	PARAMETER GROUP:	1
	ID: PSA \ PAC	
00A	PROGRAM MODE:	6

ORDER	POS	ID	CTIME	COUNTS	CUCNTS	MCW	REP	STD	STMS	STIME
1	1	PSA/PAC	0:30	NO LIM	NO LIM	1	99	N		

NUMBER OF CYCLES	1
COINCIDENCE BIAS (L/H)	L

MCA	INPUT	TRIGG.	INHIBIT	MEMORY SPLIT
1	LRSUM	L*R		PSA
2	LRSUM	L*R		PAC
	PSA LEVEL	*)		
	PAC	*)		

WINDOW	CHANNELS	MCA	HALF
1	1-1024	1	1
2	1-1024	1	2
3	1-1024	2	1
4	1-1024	2	2

Selected Printout for terminal 1 (A)

1.	2.	3.	4.	5.	6.
CTIME	CPM1	CPM2		CPM3	CPM4

Selected Printout for terminal 2 (B)

1.	2.	3.	4.	5.	6.
CTIME	CPM1	CPM2		CPM3	CPM4

SEND SPECTRA	None
LISTING	Y
INSTRUMENT NUMBER	1

CTIME CPM1 CPM2 CPM3 CPM4

*) depends on what is checked (see the next page)

PAC Check & Adjustment

Set the PAC value to 256 and measure 14-C

Check that the ratio of CPM3 / CPM4 is 75% / 25% of the total CPMs (CPM3+CPM4) and adjust with trimmer R44 on EBL board if needed.

PSA Check & Adjustment

Upper part of the spectra

Set the PSA value to 190 and measure 241-Am

Check that the ratio of CPM1 / CPM2 is 50% / 50% of the total CPMs (CPM1+CPM2) and adjust with trimmer M3 (R90) on FAD board if needed.

Note! If no 241-Am available:

Set the PSA value to 10 and measure 14-C

Check that the ratio of CPM1 / CPM2 50% / 50% of the total CPMs (CPM1+CPM2) and adjust with trimmer M3 (R90) on FAD board if needed.

Lower part of the spectra

Set the PSA value to 1 and measure 3-H

Check that the ratio of CPM1 / CPM2 is 70% / 30% of the total CPMs (CPM1+CPM2) and adjust with trimmer ZC4 on FAD board if needed.

Performance test

Measurement

Make an over night run with the following protocol and measure the sealed standards:

General Parameters		MCA&Counter Window Settings		
Saving path:	C:\TEST	Configuration:	14C (high energy ß)	
Protocol name:	PERFTEST	Send spectra:	All	PAC 1
Number of cycles:	30	Number of channels:	1024	PSA N/A
Parameter listing:	YES	Coincidence bias:	LOW	
Edit notes		Windows	1 2 3 4 5 6 7 8	

Sample Parameters

ORD	POS STMS	ID (PATH IS OFF) STIME		CTIME	COUNTS		CUCNTS	MCW	REP	ST
1	1	14C	2:00	No lim	No lim	1	1	Y	1/10	1:00
2	2	3H	2:00	No lim	No lim	1	1	Y	1/10	1:00
3	5	BKG	30:00	No lim	No lim	1	1	Y	1/10	1:00

Note! The amount of cycles is depended on how much time is available. Minimum is 20 cycles which takes about 13 hours and the more the better. The cumulative counting time is visible at the bottom of the screen when using QMGR.

Analyzing

When the counting is finished check the following things:

A) Instrument Stability

B) Background & Efficiency

C) Guard

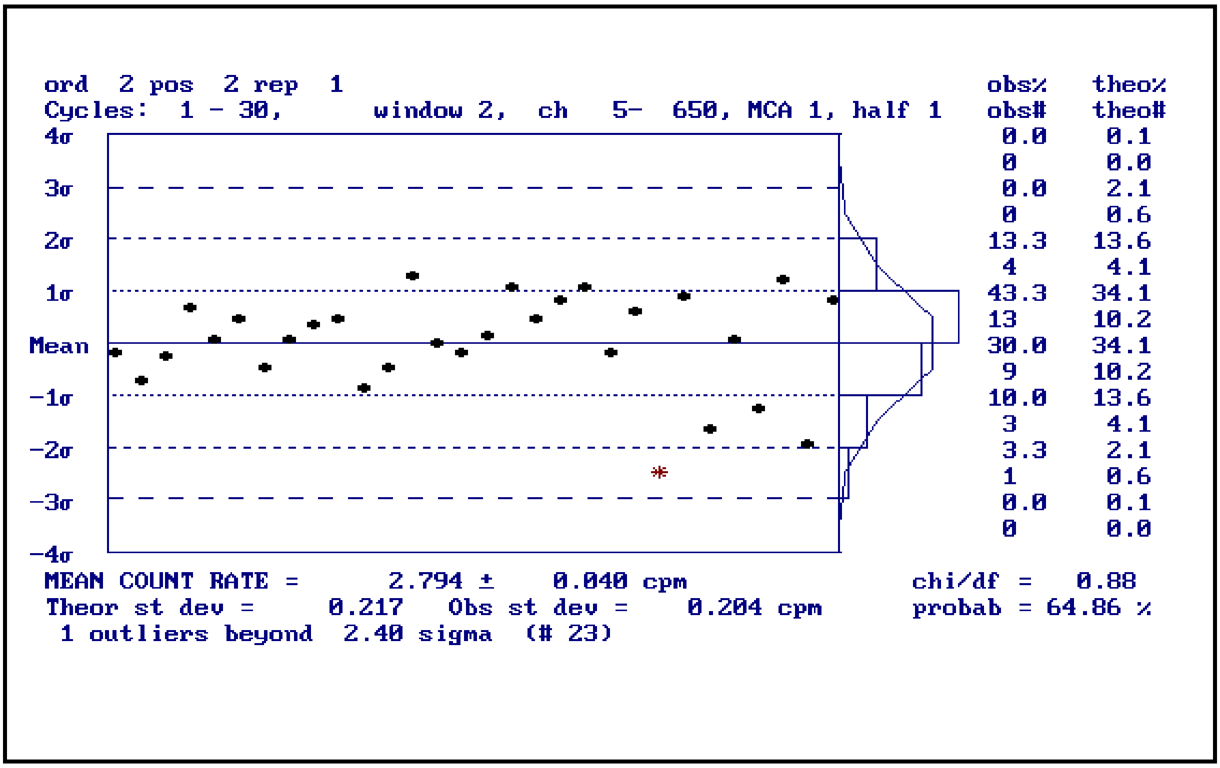
A) Stability

Activate the SPA program and check the instrument stability by entering the SWSTA (F7) of the STAT program.

Check SP11 of 14-C, 3-H and BKG.

The program suggests some windows and asks if o.k.? Answer N and type 5-320 for W1 and 5-650 for W2 and then enter until the statistic plot is plotted.

Check from the plot that there are ≤ 1 outliers and that the probability is between 5%-95%.



B) Background & Efficiency

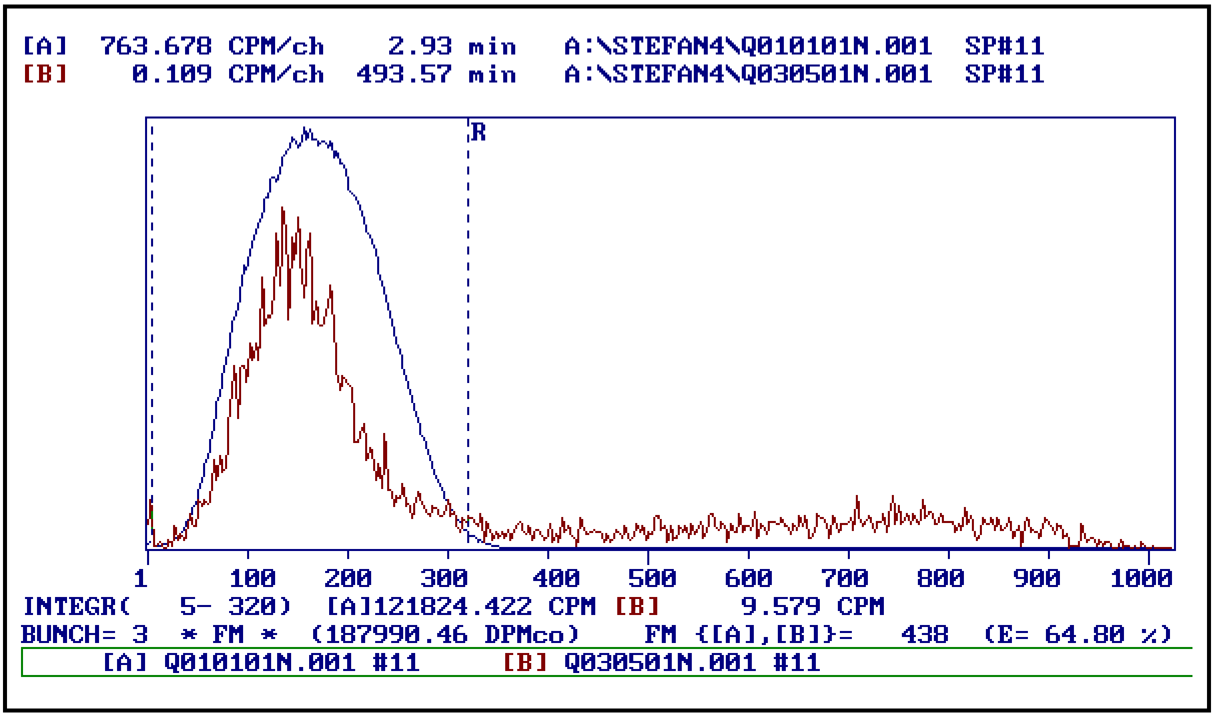
Read the 3-H spectra into array A and the background into array B:
ORD=02 POS=02 STD=N REP=01 CYC=001 SP# = 11 -> enter
Name of the array to read in (A,B,C) A -> A
ORD=02 POS=02 STD=N REP=01 CYC=001 SP# = 11 ->O3P5
Name of the array to read in (A,B,C) A -> B
ORD=03 POS=05 STD=N REP=01 CYC=001 SP# = 11 -> /

F6 (PLOT SPECTRA) / Name of the array to plot-> AB / Auto scale-> Y /
Set windows to 5-320 with the arrows and push F4 for spectrum calculations:

Calculate FM and type 3-H dpms (on the sample and in the instrument manual) / enable decay correction 12,43y / type sample preparation date and measuring date

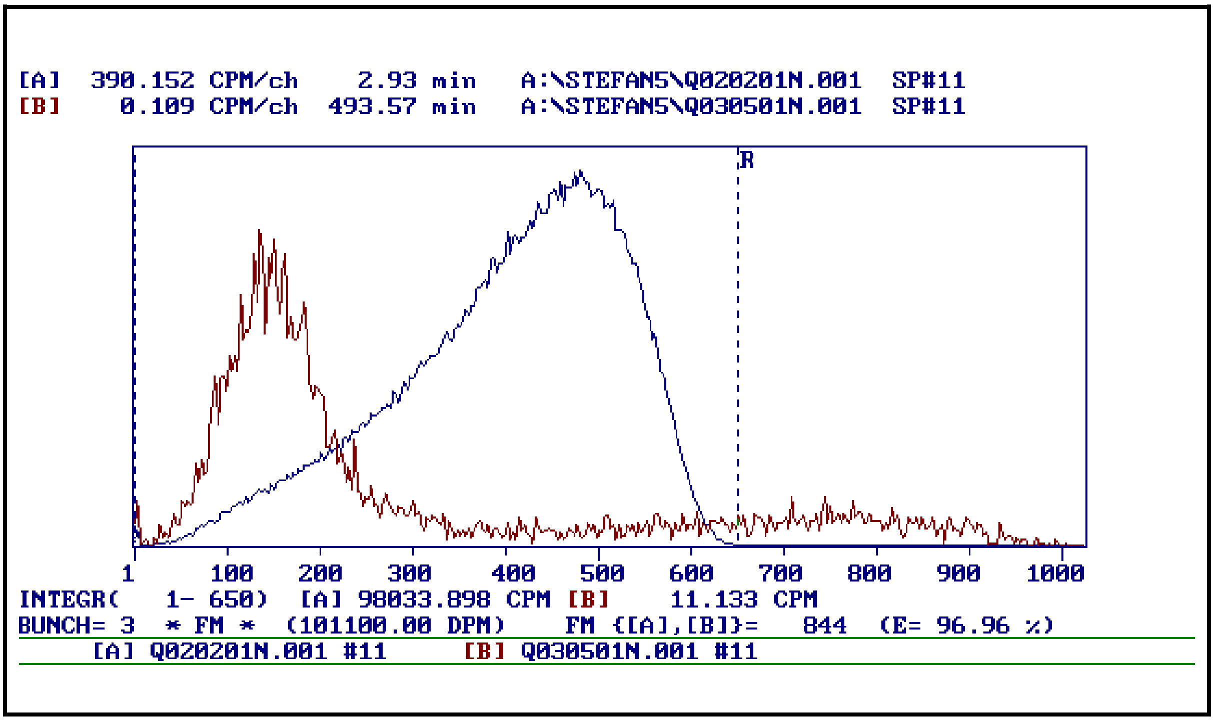
Compare the results to the results on the final test data sheet in instrument manual:

Max deviation **= E%+/-1% unit**
= BKG +/- 3cpm



Read 14-C into array A / plot A and B (bkg) / calculate FM (dpms / no decay correction) and set the window to 5-650

Max deviation **= E%+/-1%unit**
= BKG +/- 3cpm



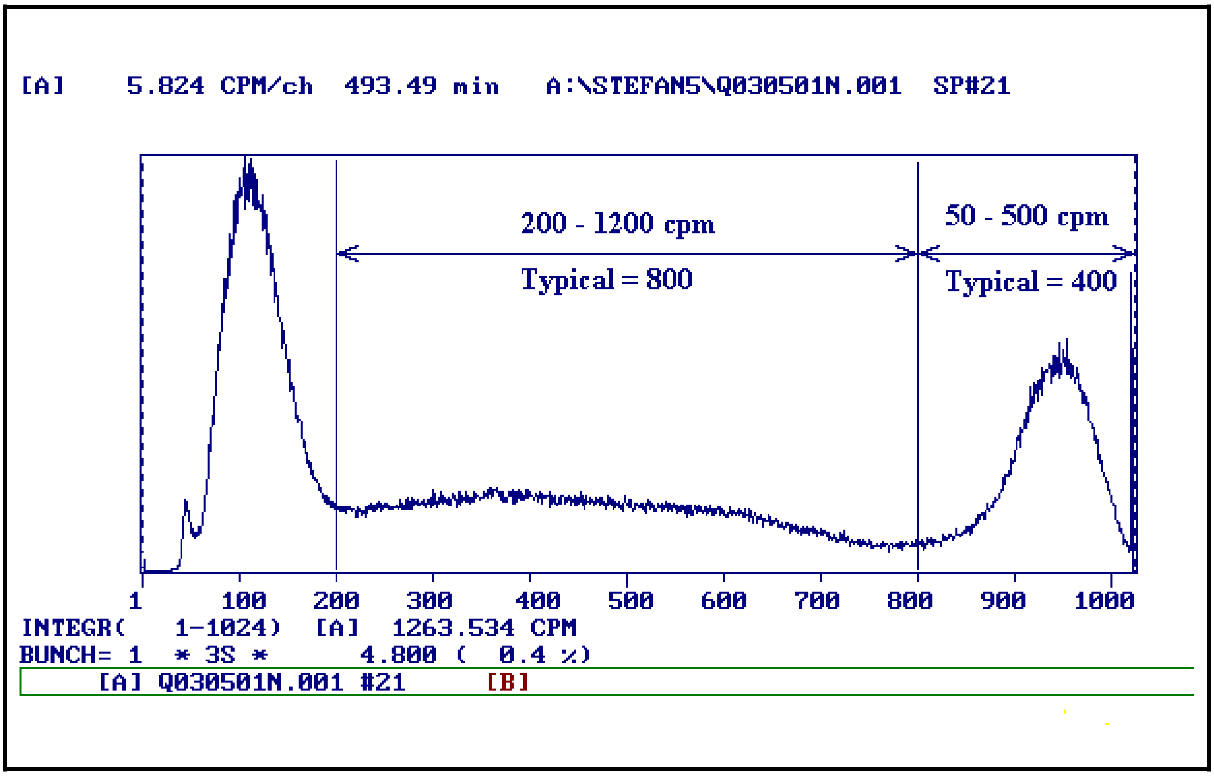
C) Guard

Plot the background spectra of SP#21 and SP#22 (SP#21-> Pulse = GSUM, trigger = G / SP#22-> memory split = L*R).
SP#21 are the guard pulses:

Window 1 - 200 shows the coincidence tube noise, which could be decreased by adjusting the threshold level higher, but then the cosmic peak and the detection of the environmental radiation would also decrease. The noise peak is usually quite high in the beginning of the installation. This is because the scintillation liquid in the guard container is unstable after of the transportation.

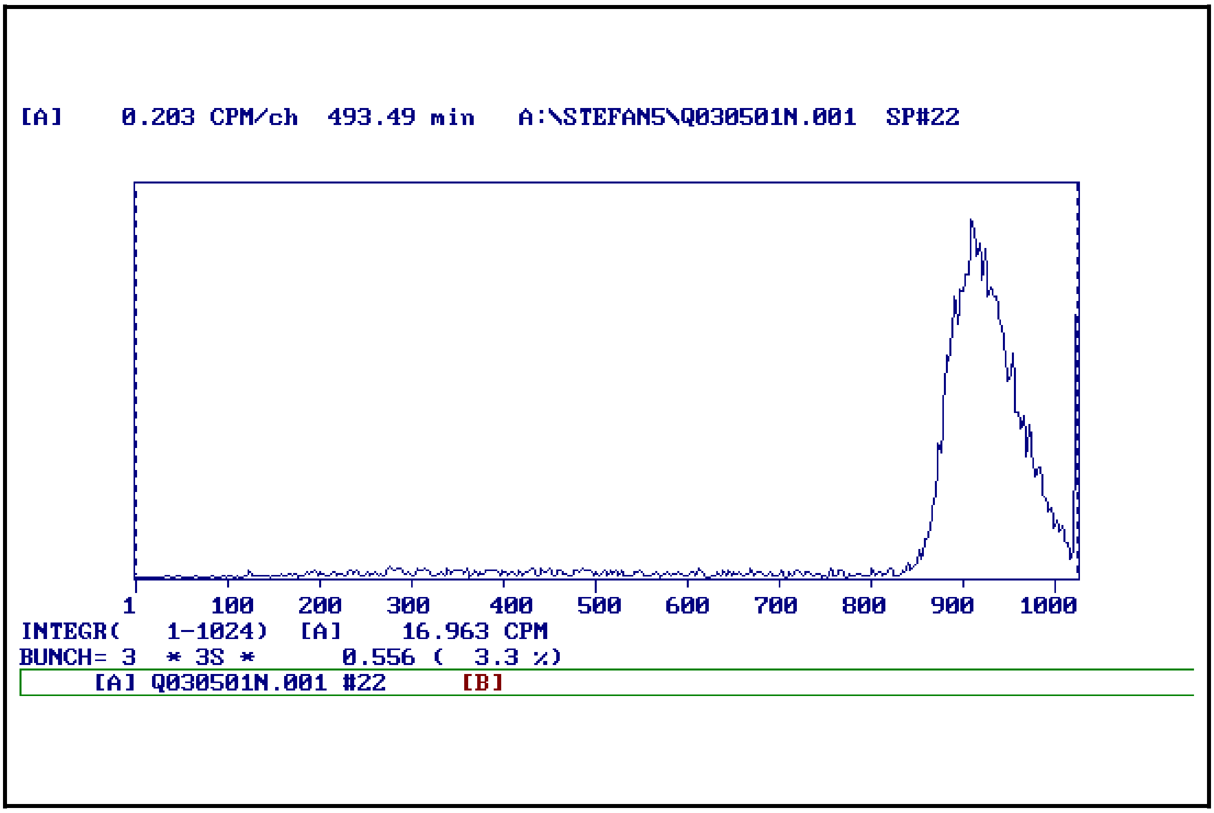
Window 200 - 800 is the background radiation from the environment. This varies between 200 - 1200 cpm depended on the building material around the instrument. Typical value is around 800 cpm. Window 800 - 1024 is the cosmic peak. This varies between 50 -500 cpm depended on the location of the instrument. The more material above the instrument, the more it is protected against the cosmic radiation.

Note! The cosmic peak is not stable. It varies depended on the weather conditions (air pressure and humidity).



SP#22 is the guard in coincidence with the sample. In other words these are the events subtracted from the actual sample.

Depending on the intensity of the cosmic peak and the sample volume, the value varies between 5 -25 cpm. Typical value is 20 -25 cpm.


[A] 0.203 CPM/ch 493.49 min A:\STEFAN5\Q030501N.001 SP#22
1
100
200
300
400
500
600
700
800
900
1000
INTEGR(1-1024) [A] 16.963 CPM
BUNCH= 3 * 3S * 0.556 (3.3 %)
[A] Q030501N.001 #22 [B]

x	**MATERIAL SAFETY DATA SHEET**		**INFORMATION FORM FOR CHEMICALS DATA**

Date*: 30.06.1996 **Former date*:**

1. IDENTIFICATION OF THE CHEMICAL AND OF THE MANUFACTURER, IMPORTER OR OTHER UNDERTAKING

1.1 Identification of the substance or preparation*

Trade name* Quantulus Guard Scintillation Liquid
Code of the preparation

1.2 Identification of the manufacturer, importer or other undertaking*

1.2.1 Manufacturer, importer, other undertaking* Wallac Oy
1.2.2 Street address# Mustionkatu 6
Postcode and post office# FIN 20750 Turku, Finland
Post-office box# 10
Postcode and post office* FIN 20101 Turku, Finland
Telephone number* + 358 2 2678 111
Telefax + 358 2 2678 357
LY code* 0937168-4
1.2.3 Name and address of the informant in emergency cases#
Emergency telephone number#
1.2.4 Information on foreign manufacturer

2. COMPOSITION AND INFORMATION ON INGREDIENTS

2.1 Description# Liquid containing alkylbenzene

2.2 Hazardous ingredients#

2.2.1 CAS number or other code#	2.2.2 Name of the ingredient#	2.2.3 Concentra-tion#	2.2.4 Warning symbol, R phrases and other data on the ingredient#
95-63-6	1,2,4-Trimethylbenzene	< 30%	X_n, R: 10-20-36/37/38 LD_{50} = 5000 mg/kg (orl-rat)
8012-95-1	Mineral oil	> 70%	LD_{50} = 22 g/kg (orl-rat)

2.2.5 Full chemical name of the ingredient (CAS number:name) ☐ **Confidential**

2.2.6 Other information

Product also contains other fluorescent compounds < 0,3%.

3. HAZARDS IDENTIFICATION

Product is irritating.

4. FIRST AID MEASURES

4.1 Special instructions# -

4.2 Inhalation# If inhaled, remove to fresh air. If breathing is difficult, give oxygen and seek medical advice.
4.3 Skin# Rinse immediately with copious amount of water and wash with mild soap solution.
4.4 Splashes in eyes# Rinse immediately with copious amount of water at least 15 minutes and seek medical advice.
4.5 Ingestion# If swallowed, do not induce vomiting. Give patient milk or water to drink, keep warm. Call a physician.
4.6 Information to doctor or other trained persons giving first aid -

5. FIRE-FIGHTING MEASURES

5.1 Suitable extinguishing media* Foam, carbon dioxide
5.2 Extinguishing media which must not be used for safety reasons
5.3 Special exposure hazards in a fire
5.4 Special protective equipment for a fire
5.5 Other instructions

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions# See section 7.1.
6.2 Environmental precautions# Do not allow run off to sewer, waterway or ground.
6.3 Methods for cleaning up* Absorb on sand, paper, vermiculite or other appropriate material and place in a closed container for disposal. Wash the area with water and detergent.
6.4 Other instructions

7. HANDLING AND STORAGE

7.1 Handling# Wear splash-proof eye goggles and gloves. Avoid contact with the product. NOTICE! These measures are not normally needed as the liquid is in a sealed place inside the device.
7.2 Storage# Store at moderate temperatures in dry, well ventilated place. Keep tightly closed.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Technical measures for exposure controls# Proper ventilation in working areas. Take precautionary measures against static discharge. NOTICE! Empty containers may contain reactive residues. Handle with care.
8.2 Limit values for workplace air
8.2.1 Limit values
8.2.2 Other information on limit values
8.3 Personal protective equipment#
8.3.1 Special instructions for protection and hygiene -
8.3.2 Respiratory protection -
8.3.3 Hand protection Rubber or plastic gloves
8.3.4 Eye protection Safety goggles
8.3.5 Skin protection Protective clothing

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Physical state, colour and odour* Clear, bluish liquid, fluorescent. Faint, hydrocarbon odour.
9.2 pH# -
9.3 Information on changes in the physical state
9.3.1 Boiling point/boiling range# > 208°C
9.3.2 Melting point/melting range# -

9.3.3 Decomposition temperature
9.4 Flash point# 81,1°C
9.5 Flammability (solid/gas)
9.6 Autoflammability
9.7 Explosion hazard
9.8 Explosive limits a) lower#
b) upper#
9.9 Oxidizing properties
9.10 Vapour pressure# < 133 Pa (20°C)
9.11 Relative density# 0,86 kg/dm3 (20°C)
9.12 Solubility a) water solubility# Insoluble
b) fat solubility# -
9.13 Partition coefficient (for ingredients): n-octanol/water#
9.14 Viscosity
9.15 Other information

10. STABILITY AND REACTIVITY

10.1 Conditions to avoid
10.2 Materials to avoid The product may react with strong oxidizers.
10.3 Hazardous decomposition products# Thermal decomposition may include hazardous gases, for example carbon monoxide and carbon dioxide.

11. TOXICOLOGICAL INFORMATION

11.1 Acute toxicity# Breathing vapour may cause headache, nausea and dizziness.
11.2 Irritancy and corrosiveness# Solution may cause severe irritation, redness and blurred vision.
11.3 Sensitization# No data available
11.4 Subacute, subchronic and prolonged toxicity
11.5 Empirical data on effects on humans# No data available
11.6 Other information on health effects

12. ECOLOGICAL INFORMATION

12.1 Persistence in the environment#
12.1.1 Biodegradation
12.1.2 Chemical degradation
12.2 Bioaccumulation#
12.3 Mobility#
12.4 Toxic effects on organisms#
12.4.1 Aquatic toxicity
12.4.2 Other toxicity
12.5 Other information No data available

13. DISPOSAL CONSIDERATIONS

Burning in a chemical incinerator. Disposal of all waste shall be in accordance with local regulations.

14. TRANSPORT INFORMATION

14.1 UN number
14.2 Packaging category

14.3 Land transport#
14.3.1 Transport class
14.3.2 Risk code
14.3.3 Name according to bill of freight
14.3.4 Other information
14.4 Sea transport#
14.4.1 IMDG class
14.4.2 Correct technical name
14.4.3 Other information
14.5 Air transport#
14.5.1 IDAO/IATA class
14.5.2 Correct technical name
14.5.3 Other information This product is not a subject to transport regulations.

15. REGULATORY INFORMATION

15.1 Information on the warning label#
15.1.1 Letter code of the warning symbol and indications of danger for the preparation X_i, irritating
15.1.2 Names of the ingredients given on the warning label
1,2,4-Trimethylbenzene
15.1.3 R phrases
36/37/38 Irritating to eyes, respiratory system and skin.
20 Harmful by inhalation.
15.1.4 S phrases
36 Wear suitable protective clothing.
15.1.5 Special regulations on certain preparations
15.2 National regulations

16. OTHER INFORMATION

16.1 Purpose of use*
16.1.1 Expressed in writing* Scintillation liquid for liquid scintillation counting.
16.1.2 Code for the purpose of use#
SIC1: KT1:
SIC2: KT2:
SIC3: KT3:
SIC4: KT4:
SIC (TOL) - Standard industrial classification
KT - Desired effect of the chemical
16.2 Directions for use
16.3 Other information The above information is believed to be correct, but does not purport to be all inclusive and shall be used only as a guide. Wallac shall not be held liable for any damage resulting from handling or from contact with the above product.
16.4 Additional information available from
16.5 Sources of information used in the compilation of the safety data sheet
Information given by manufacturer
Hazardous Substances Databank
The Sigma-Aldrich MSDS on CD-ROM
Reasons for the confidentiality of the information: