

# QUANTULUS™

## Measuring Extremely Low Levels of Environmental Alpha and Beta Radiation



Life Sciences

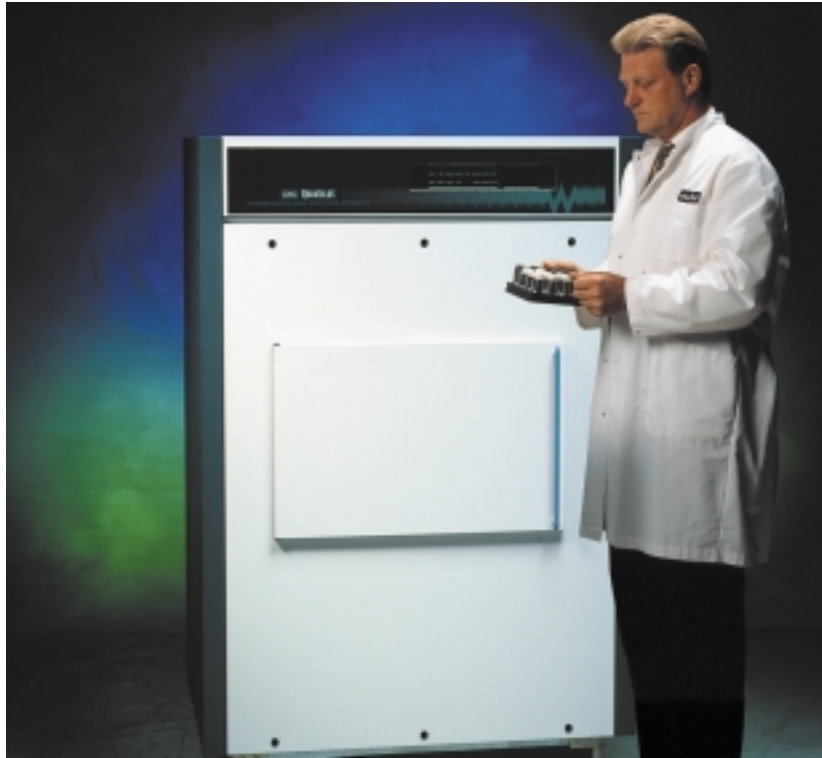
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NEN

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# QUANTULUS-The Best Ultra Scintillation Counter



1220 QUANTULUS has established its position as the best ultra-low level liquid scintillation spectrometer, a reference counter with unsurpassed performance for measurement of extreme low concentrations of both man-made, cosmogenic and other natural radionuclides.

- Unsurpassed stability, an absolute must when using long counting times.
- Reliable technology Wallac QUANTULUS counters are built to withstand heavy use, day after day. They are built to last.
- Reliable technology to provide best results all day long and every day of the year.
- Superior alpha/beta separation is based on amplitude independent classification of pulses by their length.
- Passive attenuation of environmental radiation is achieved by using sufficient low radioactivity lead shielding. Active shielding of cosmic and other environmental radiation causes no counting efficiency loss.

# -Low Level Liquid

## A Liquid Scintillation Spectrometer to Detect Extremely Low Radioactivity

QUANTULUS is a liquid scintillation spectrometer for detection of beta and alpha radiation, Cerenkov radiation, X-rays, Auger electrons, luminescence and gamma radiation. Maximum physical sample volume is 20 mL, but in extraction and enrichment techniques radiation may originate from larger volumes and sensitivity improved accordingly.

## Selected Phototubes

First step into low background liquid scintillation counting is to disable thermal noise of photomultiplier tubes (PMT). As this signal is random and not timely correlated, acceptance of coincidence events from the tubes removes this noise, which would interfere with low energy beta spectra, as  $^3\text{H}$ .

QUANTULUS phototubes are selected for low inherent background and spectral stability and meet with the strict specification of high quantum efficiency.

## Passive Attenuation of External Radiation

The asymmetric passive radiation shield attenuates most of the environmental gamma radiation and is made of low radioactivity Boliden lead around detector assembly, maximum thickness of 200 mm on top, 100 mm on side walls and 150 mm below the counting chamber. The head of the piston is made of massive OFHC copper and is a part of passive shielding.

## True Background Reduction by Coincidence Event Detection

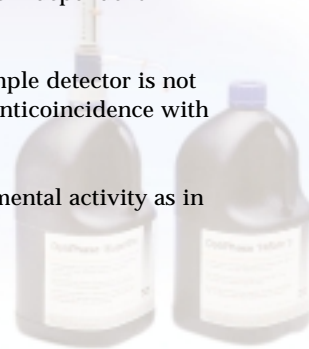
In ultra-low level environmental liquid scintillation counting, an active guard is necessary to remove the natural background fluctuations. Wallac's active coincidence event detection principle originally developed for the highly regarded QUANTULUS, is based on established active anti-Compton guard technologies in physical sciences. It is able to remove much of the sample signal from low energy environmental gamma radiation and almost 100% of the GeV muon particles, whose flux varies due to changes in atmospheric pressure and humidity. There is no need for atmospheric pressure correction in QUANTULUS during long counting periods.

In QUANTULUS two photomultiplier tubes are used for background event detection and two separate ones for coincident sample counting. The sample chamber is fully enclosed inside the guard detector and sample and guard detectors are optically isolated from each other to provide background reduction, which is independent on sample quench level and pulse length.

Any event observed with this detector simultaneously with the sample detector is not accepted as a sample event. The sample detector thus operates in anticoincidence with the guard detector.

Guard enables high performance even in areas of elevated environmental activity as in Chernobyl.

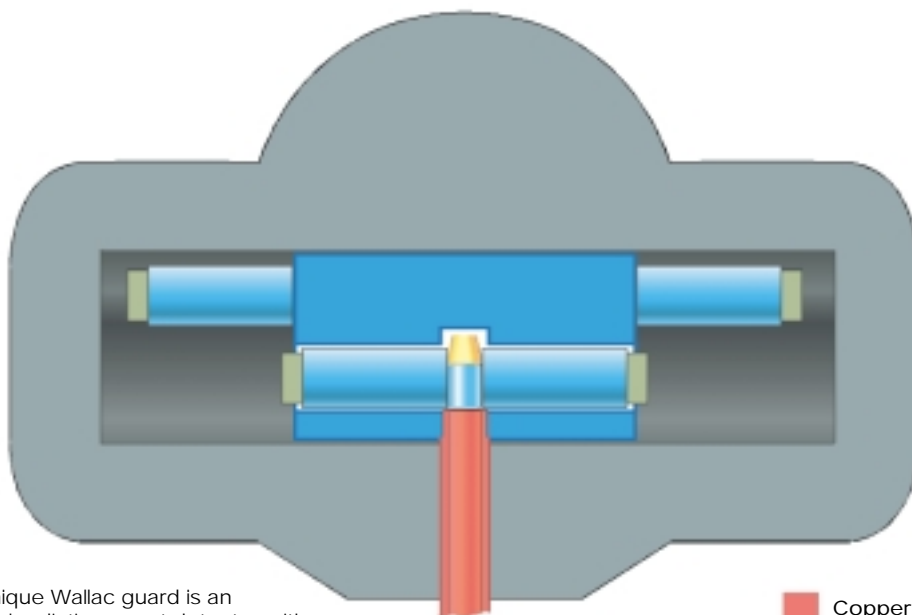
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## Guard – Optical isolation assures no misclassifications

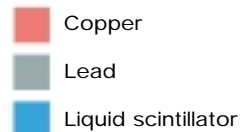
The true excellence of Wallac's coincidence event detection stems from optical isolation of the sample detector and the guard detector. This means that the sample quality and fluors do not affect the background reduction performance. Sample light does not penetrate into the guard detector.

The method is unique because it performs background reduction without efficiency losses i.e. without errors in interpretation of the origin of sample events.



Anticoincidence guard detector and lead shield in 1220 QUANTULUS

The unique Wallac guard is an external radiation event detector with its own phototubes. QUANTULUS™ also features extensive passive shielding.



## Logarithmic MCA's for resolution where you really need it

Two dual multi-channel analyzers in QUANTULUS ensure storage of full spectral information – even rejected counts can be saved when necessary. Five spectra for each sample can be saved in both instruments. The QUANTULUS MCA is user controlled by logic commands that allow hundreds of tailored configurations in addition to 3 default ones. Original spectra can be saved on hard disk in ASCII format and are accessible also by users' own programs and spreadsheet software.

Wallac's advanced logarithmic multi-channel analyzer provides resolution unmatched by any competitive system. It is based on 12-bit linear analog-digital conversion and offers 0.0038 keV resolution in the lowest range (corresponding to tritium).

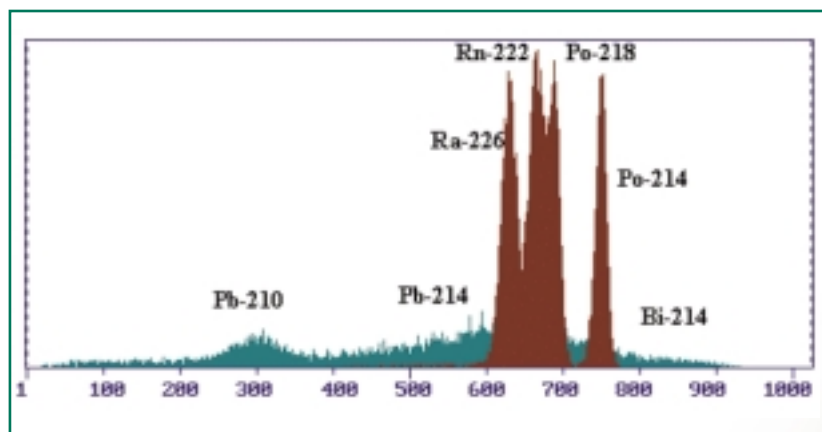
Delayed coincidence circuitry is present for  $^3\text{H}$  and other low energy beta emitters to detect interfering random coincidence signal, as chemiluminescence.

## Pulse Shape Analysis

Pulse Shape Analyzer (PSA), standard feature in QUANTULUS, allows simultaneous acquisition of pure alpha and beta spectra from mixed radiations of a sample. Pioneered by Wallac, PSA is a necessary condition for sensitive liquid scintillation alpha counting. Alpha backgrounds are greatly reduced by PSA when compared with the total sample background, which is composed mostly of short, beta type pulses.

Clear separation of alphas and betas is achieved in Wallac counters with both fast and slow cocktails without additives. Pulse Shape Analysis can also be used for background reduction in beta counting to cut slow fluorescence event background, which interferes, particularly in the  $^3\text{H}$  energy region in glass vials.

The anti-coincidence guard is active during Pulse Shape Analysis allowing alpha/beta separation in ultra low level mode. QUANTULUS discovers alpha emitters even in 100,000 excess of beta radiation.



*Ra-226 alpha and beta particle spectra by pulse shape analysis representative of the best energy resolution at lowest quench levels.*

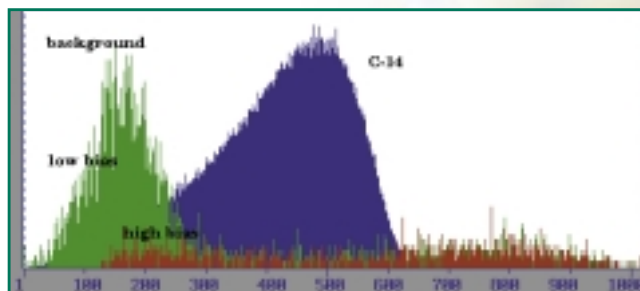
## Pulse Amplitude Comparison

Another feature in Wallac counters is Pulse Amplitude Comparison (PAC), which is used to reject crosstalk between phototubes. This type of background, where pulses are in great disparity, is created in phototubes by their inherent radioactivity and by external radiation. Improved figure of merit is achieved since true sample events have very much less variation in amplitude ratio and are not rejected by the comparator.

## Bias Threshold

High bias threshold is available for elimination of low energy glass vial background below Ch 300 and improving background and figure of merit for high energy beta emitters, as for  $^{14}\text{C}$ .

*High bias removes glass vial Cerenkov and fluorescence peak.*



## Rejection of EM Interference

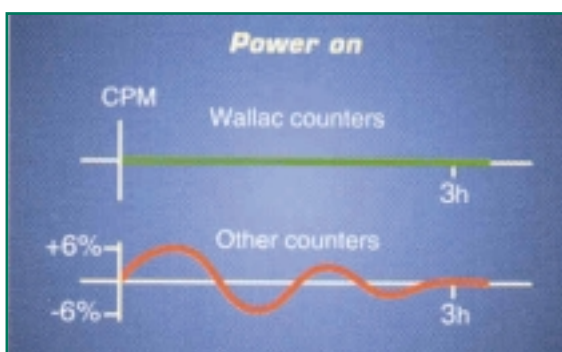
To ultimate stability requires rejection of any electromagnetic interferences, that could creep into the sample spectra. This is carried out with an aerial, which temporarily inhibits sample counting in the presence of such interferences.

## Rejection of Static Electricity

Static electricity is removed by metallic cylinders, that act as sample holders in cassettes and light shutters, when the sample is raised into the counting chamber – in this process high voltage discharge deionizes the residual static charge from vials.

## ACSS for Immediate Self Stabilization

The sound design and construction of Wallac liquid scintillation counters is based on the experience gained from four generations of counters, each ahead of its time. Automatic Continuous Spectrum Stabilization (ACSS) ensures gain stability with no loss of counting time, and with no warm-up time, for example after power failure. A double feedback system checks 100 times per minute and, if necessary adjusts PMT response. ACSS puts QUANTULUS ahead of other counters, which rely on the measurement of reference samples.

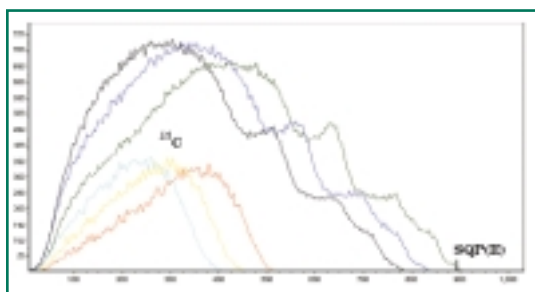


Unlike traditional counter, QUANTULUS with ACSS provides stability directly from power up.

## Low Activity External Standard for Fast Quench Correction

High energy, low activity gamma source ( $^{152}\text{Eu}$ , 37 kBq) ensures good quench index also for low energies and high quench levels. Logarithmic spectrum end point is well defined and therefore used in QUANTULUS as an index of quench, SQP(E) or External Standard Quench Parameter. The advantages of the Compton electron spectrum based quench index are:

- Fast evaluation of quench
- Nondestructive evaluation of quench
- Easy evaluation of quench even with low activity and background samples



End point of external standard Compton electron spectrum is an excellent measure of sample quench level.

## Random Access Sample Change

Highly flexible sample handling, now familiar from modern plate counters, is achieved by means of the three software-controlled 4 x 5 matrix sample trays. Their design allows totally *random access* to any sample, which, when used in conjunction with the possibility of individually programming up to 60 sequential samples in any order, allows the user to choose the combination of counting time, sequence and repeat measurements best suited to a particular application.

## Cooling - Noiseless Peltier Units

For operation under extreme or variable conditions, the sample chamber and interior of the instrument are maintained at a constant temperature within 12°C of ambient. The cooling of four electronic noise-free Peltier elements can be boosted using water circulation.

## Vials

QUANTULUS allows routine usage of ordinary plastic and glass vials. When volatile solvents are used, it is recommended that glass, teflon coated plastic or teflon vials are used, as the solvents may penetrate into through ordinary plastic vials and be a potential hazard to the sensitive instrument. Glass vials can well be used for high-energy beta emitters as pulse amplitude comparison and high bias can remove much of the extra background from small radioactivity in the vials (<sup>40</sup>K). In <sup>3</sup>H counting pulse shape analyzer removes part of the fluorescent and Cerenkov background but most of the samples are aqueous in this case and can well be counted with non-radioactive plastic vials and safe cocktails. High precision applications, as radiocarbon dating, may require special optimized copper-teflon, teflon, selected glass or silica vials (<http://www.c14dating.com/>). Reuse of selected vials is normal routine in these cases.

## Cocktails

Any commercial cocktail is acceptable in QUANTULUS but comments about selection of vial given above should be complied with.

## Environmental - Natural and Man-made Radioactivity

Because of the enhanced sophistication of Wallac low-level spectrometers, liquid scintillation counting is now an ideal method for many areas of environmental control and monitoring of radioactivity. Simply mixing your sample with an aqueous cocktail provides the basis for highly efficient counting of alpha activities from radon, radium or uranium in drinking water. Detailed, rapid methods have already been developed for these radionuclides as well as for strontium analyses.

Achieving high sample throughput necessitates easy sample preparation, low background and high counting efficiency. Wallac liquid scintillation counters provide the optimal balance for these needs.

Direct measurement of very low radioactivities often requires large sample volumes. When, for example, measuring <sup>3</sup>H in groundwater, sensitive measurement requires 20 mL volume and maximized ratio of water to scintillant. Wallac counters allow you to use large sample volumes and eliminate background events without compromise.

Small volume samples are also counted with the best counting efficiency in Wallac low-level spectrometers. External background detection combined with pulse amplitude comparison provides optimal counting conditions for tracer studies, etc.

Alternatively, smaller amounts of radioactivity may be used in tracer studies and results still acquired in a reasonable counting time with a low-level spectrometer.

## Waste Management and Health Physics

Laboratories of radiochemical institutes, hospitals, medical and pharmaceutical industry, nuclear power and nuclear fuel reprocessing plants can make use of modern liquid scintillation spectrometers in analyzing alpha and beta particle waste. Gross alpha/beta counting can be conveniently carried using pulse shape analysis for separation of the activities.

Liquid scintillation counting can also be used for wipe tests in laboratories, thus expanding the area of application. MeltiLex Wallac's solid, meltable scintillant is convenient for this application.

Measurement of  $^3\text{H}$  in urine can be carried out directly by mixing 1 mL sample into 10 mL cocktails without additional sample preparation.

## Food control

QUANTULUS is widely used in monitoring beta activity in food products of the natural radioactivity, contamination by nuclear fallouts (Sr/Y) and contaminants from nuclear power stations or fuel reprocessing plants. It also provides means for surveying the forbidden synthetic additives in food on the basis of the cosmogenic  $^{14}\text{C}$  to be found in the products made from natural raw materials.

## Radiocarbon Dating

The answer to 'How old is it' is of paramount importance in a wide variety of disciplines including archaeology, anthropology, geology, ecology and civil engineering. Organic matter such as wood, charcoal and bone can be used, for example, to estimate the transition of man from being a hunter-gatherer to a farmer, to follow technological changes in society and to study the origin and spread of cultures throughout different parts of the world. Age can also be used to investigate the forgery of art objects or archaeological artifacts.

$^{14}\text{C}$  is a cosmogenic radionuclide which was in equilibrium within the biosphere before the industrial revolution and nuclear age. The burning of coal and oil and atmospheric nuclear explosions have led to changes in the  $^{14}\text{C}$  content in the biosphere. Dating of archaeological samples back to 65,000 years is a routine application of QUANTULUS.

Archaeological carboneous samples are converted into benzene, which is an aromatic molecule, whose scintillation is enhanced by the addition of primary solvent, butyl-PBD – secondary solvent is not necessary in QUANTULUS.

Top radiocarbon labs in the world have chosen QUANTULUS as their liquid scintillation spectrometer – <http://www.radiocarbon.org/Info.index.html.com/>.

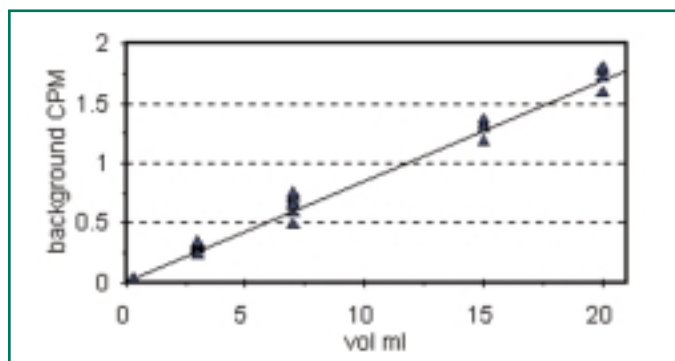


## $^{14}\text{C}$ and $^3\text{H}$ Cycles

'Where does it come from? Where does it go?' The answers to these questions regarding  $^{14}\text{C}$  and  $^3\text{H}$  are constantly being sought to increase our knowledge about such phenomena as the impact on nature of increased fossil fuel combustion, pollution, radioactive fallout, earthquake prediction and  $\text{CO}_2$  distribution between the atmosphere and the oceans. Low level  $^{14}\text{C}$  and  $^3\text{H}$  measurements can also make important contributions to hydrological studies of underground water reserves, and meteorological investigations on the origin of rain and the effect of irrigation and various crops in relation to soil management in semi-arid areas.

## Ideal for Research where Minimization of Tracer and/or Dose is Searched

QUANTULUS allows sensitive detection of alpha and beta radiation for applications where minimal usage of radioactive material is searched. Minivials down to 0.3 mL have been used in special adapters to optimize the counting conditions and provide the highest sensitivity (<http://www.c14dating.com>). An adapter is built to match the small vial size, as then air luminescence is eliminated in the empty vial volume. At the same time the cross talk between phototubes is removed by applying pulse amplitude comparison. The background signal is then in direct proportion to the sample volume for high-energy beta emitters, as  $^{14}\text{C}$ . In this scheme QUANTULUS competes with accelerator mass spectrometry in  $^{14}\text{C}$  dating.



← The best sensitivity is achieved with a masked minivial, whose volume matches the sample size which is available.

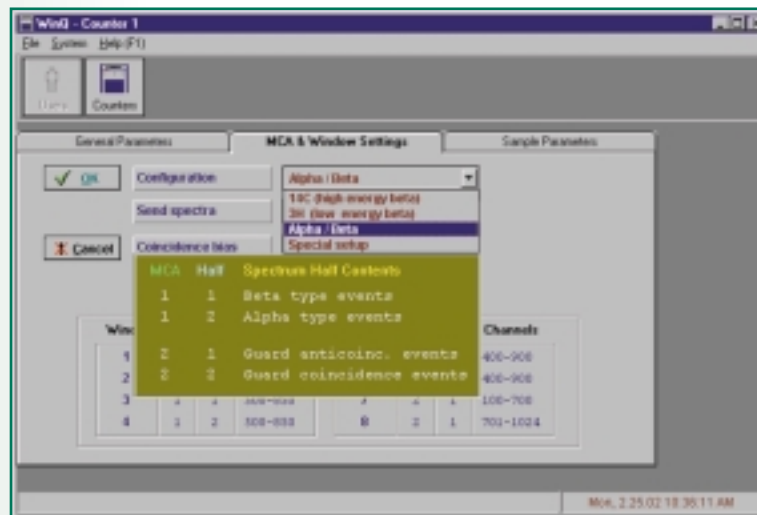
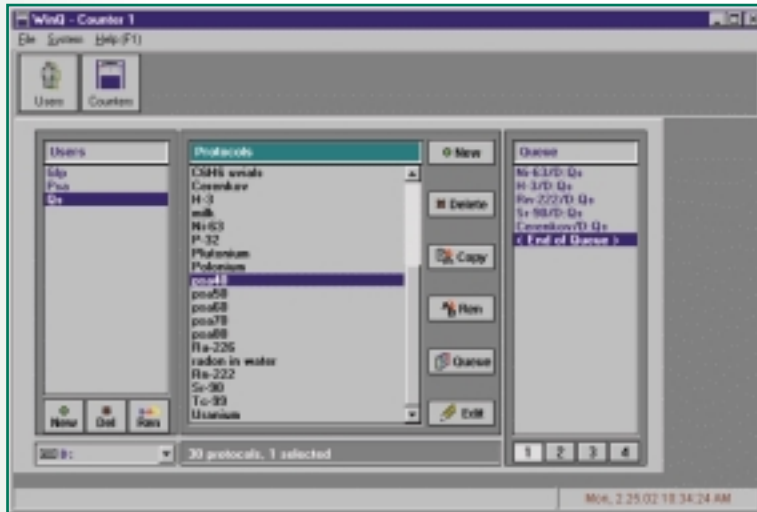
## Software

### User Interface, Protocol Editor and Data Acquisition Software

Windows user interface 1224-307 WinQ, spectrum analysis program and 1224-534 EASY View are included in the 1220-003 QUANTULUS configuration. Software runs in Windows 95, 98 and NT.

WinQ is easy to use with features such as drop down menus and context sensitive help messages. It allows you to control one or four QUANTULUS instruments and gives you live display of spectra on screen. You can use it to queue up an unlimited number of jobs, and it keeps a log of all the jobs that have been run. WinQ allows you automatic or manual storage path naming and you can copy protocols to other users. The program can be operated and data can be stored through LAN. Access via Internet is possible with additional networking software. There are default MCA settings for  $^3\text{H}$  (or any other low energy beta emitter),  $^{14}\text{C}$  (or any other high-energy emitter) and for alpha/beta spectrum separation. An unlimited number of parameter groups can be stored permanently on hard disk. During protocol editing, comment texts can be added to the final results printout file. Also, if you need to, can easily access the QUANTULUS internal line editor.

If, while QUANTULUS is counting, you wish to leave the program, you can do so. When you return to WinQ there is automatic recovery of data transmission. While Spectrum Analysis software is being used, WinQ operates as resident.



## Spectrum Analysis Software

1224-534 EASY View is a Windows 95, 98 NT 4.0 spectrum analysis software for QUANTULUS raw spectrum display and processing works also for old instruments.

- The program works in the selected high resolution color graphics mode and can be used simultaneously with data acquisition
- Displays up to 6 spectra simultaneously
- Also rejected count spectra can be displayed
- Manual scaling or auto scaling
- Spectrum noise filtering weighted least squares fit
- Zoom energy range
- $^{14}\text{C}$  age calculation routine
- Eff, figure of merit, sample activity in Bq and pCi,  $^3\text{H}$  activity in Bq, pCi and TU



## Instrument

1220-003	Floor standing, Low level LSC, 20 mL vials, 60 samples, detector and guard detector included
1220-307	WinQ, user interface, protocol editor and data acquisition software
1224-534	EASY View Spectrum Analysis Program
1220-102	Pulse Shape Analyzer

## Optional Items

1220-103	Cooling Unit
AAAJA-0002	Uninterruptable Power Supply
1003-0010	Dell OptiPlex GX240, small desktop SD chassis, NT4.0 17" CRT monitor, or
1003-0020	Dell OptiPlex GX240, small desktop SD chassis, NT4.0 15" Flat LCD screen, or
1003-0040	Dell OptiPlex GX240, mini tower SMT chassis, NT4.0, 17" Flat LCD screen
2011-0030	Laser printer Lexmark E320 220V 50/60 Hz, or
2011-0040	Laser printer Lexmark E320 110V 50/60 Hz
1224-122	Centronics printer cable
1220-201	QUANTULUS spare parts kit Computer, printer (ask for current models)
1220-500	Copper-teflon vials, volume 3 mL, pkg of 10
1220-501	Copper-teflon vials, volume 7 mL, pkg of 10
1220-502	Copper-teflon vials, volume 15 mL, pkg of 10
1220-503	Copper-teflon vials, volume 20 mL, pkg of 10
1200-422	Super low diffusion polyvials 20 mL, teflon coated polyethylene, pkg of 100 (caps included)
1200-420	Plastic vials 20 mL with caps, pkg of 1,000
1210-131	Glass vials 20 mL, low K-40 content, pkg of 500
1200-437	Optiphase HiSafe 3, water miscible cocktail 5 L
1200-436	Optiphase HiSafe 2, water miscible cocktail 5 L
1200-440	Optiphase TriSafe, water miscible cocktail 5 L
1205-440	Betaplate Scint, for organic samples 5 L
1210-120	Internal std kit, <sup>3</sup> H for organic solvents, 40 capsules
1210-121	Internal std kit, <sup>3</sup> H for aqueous solvents, 40 capsules
1210-122	Internal std kit, <sup>14</sup> C for organic solvents, 40 capsules
1210-123	Internal std kit, <sup>14</sup> C for aqueous solvents, 40 capsules
1210-124	Internal std kit, combination pkg; <sup>3</sup> H -O; <sup>3</sup> H -W; <sup>14</sup> C -O; <sup>14</sup> C -W, 10 capsules each

## Optional Software for MSDOS Environment

1220-305	Queue Manager, v. 1.2, user interface, protocol editor and data acquisition software, y2k compatible
1220-302	Spectrum Analysis Software, v. 3.2, y2k compatible



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