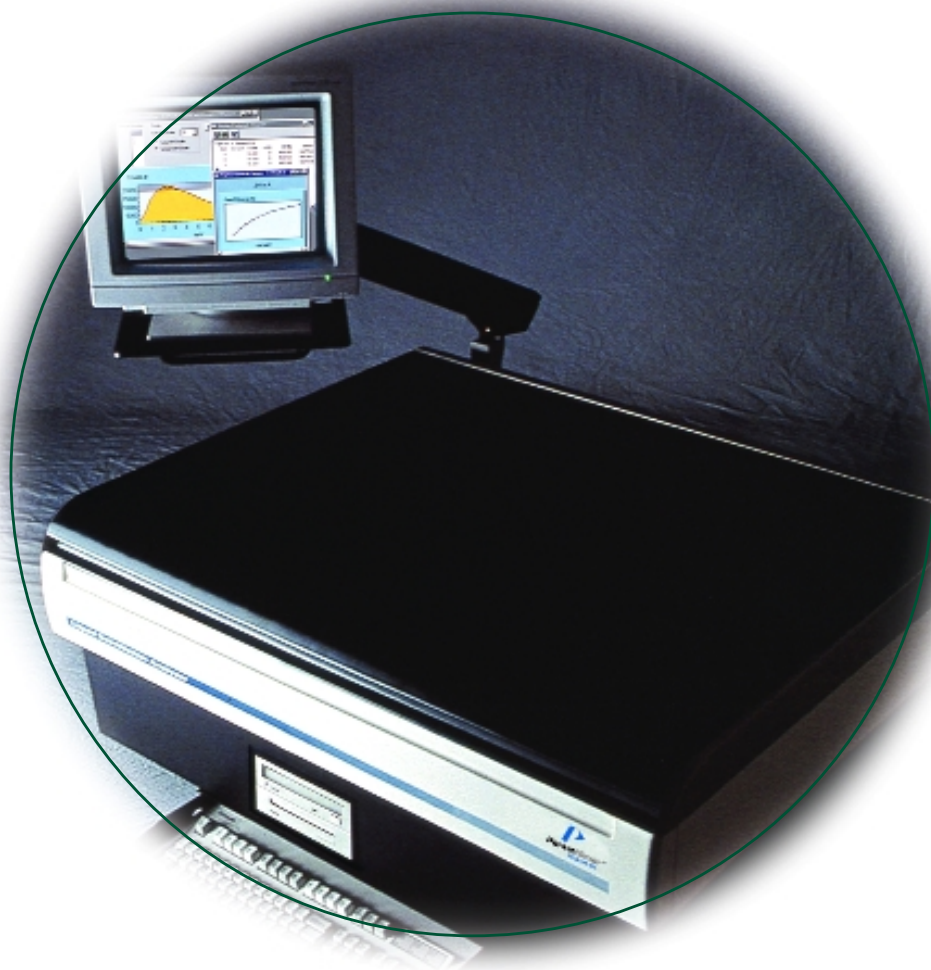


Features and Benefits Guide

for Tri-Carb[®] Liquid Scintillation Analyzers



Life Sciences

Table of Contents

TR-LSC® (Time-Resolved Liquid Scintillation Analysis)	2
Integrated Computer Control with Tandem Processing	4
IPA™ (Instrument Performance Assessment)	7
tSIE (Transformed Spectral Index of the External Standard)	9
AEC (Automatic Efficiency Control)	12
Direct DPM (Disintegrations Per Minute)	14
Dynamic Color Quench Corrected DPM	15
Luminescence Detection and Correction	16
Replay Sample Post-Processing	18
Live SpectraView™ and Enhanced Live SpectraView	19
Built-In DataStore	21
High Sensitivity Solid Scintillator Counting	22
Downloading Sample Changer with Double Light Seal and Complete Access to All Samples	23
Group PrioStat, Priority Counting Mode	24
Sample PrioStat, Priority Counting Mode	25
Worklisting with Extended Positive Sample ID	26
TR-PDA™ (Time-Resolved Pulse Decay Analysis) for Alpha/Beta Separation	28

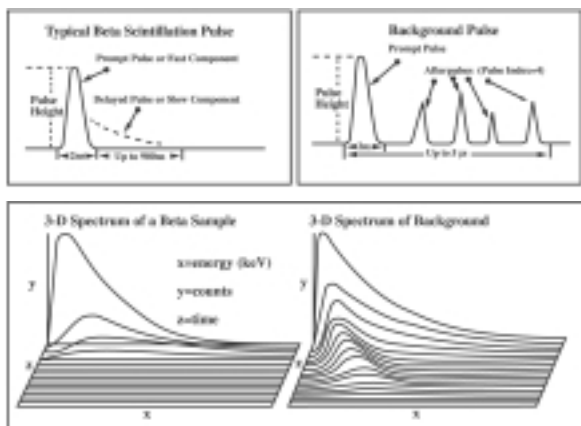
TR-LSC (Time-Resolved Liquid Scintillation Analysis)

Introduction

Liquid scintillation counting sensitivity is a function of sample counting efficiency and background. High efficiency and low backgrounds yield greater sensitivity. Since most modern liquid scintillation counters operate at the technological limit of counting efficiency, the most direct way to improve sensitivity is to lower background. TR-LSC reduces background by as much as 97%, thereby greatly increasing sensitivity for all LSC (Liquid Scintillation Counting) applications.

Beta decay and background pulses consist of a primary or fast component. This is the pulse which is detected by the coincidence circuit of all liquid scintillation counters. Background pulses come from sources other than the actual sample. They have a fast component, but many are also followed by a series of low intensity afterpulses which remain undetected in conventional systems. These afterpulses provide a characteristic fingerprint for discriminating between beta and background events.

The patented TR-LSC circuitry employs a multiparameter multichannel analyzer, and three dimensional analysis of both the prompt and afterpulses to discriminate between true beta events and background pulses. TR-LSC can even distinguish between beta and background pulses throughout the entire 0-2,000 keV energy range when the fast components are virtually identical.



There are four counting modes of TR-LSC which provide increasing degrees of sensitivity:

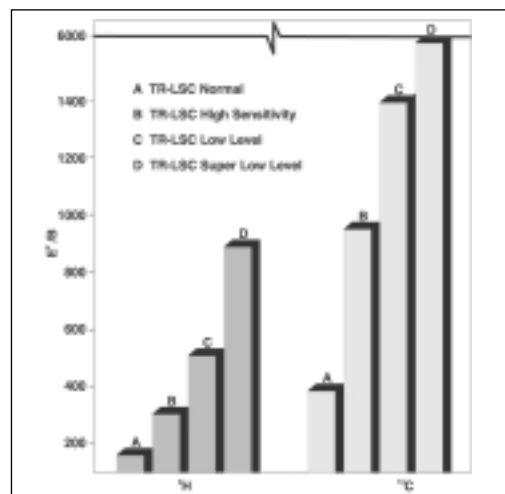
- NCM (Normal Count Mode)
- HSCM (Low Activity/High Sensitivity Count Mode)
- ULLCM (Ultra Low Level Count Mode)
- SLLCM (Super Low Level Count Mode)

The Normal Count Mode is standard on all Tri-Carb liquid scintillation analyzers and reduces background by 30% to 40% compared to conventional liquid scintillation counters. NCM is typically recommended for LSC samples above 750 DPM.

The Low Activity/High Sensitivity Count Mode is recommended for lower sample activities extending down to the level of 50 DPM. In HSCM, the background is reduced by 50% to 60%.

The Ultra Low Level Count Mode reduces background by 80% or more, and is used when sample activity approaches background levels. The ULLCM is used for extremely low activity counting situations, such as environmental samples, radiocarbon age dating, and drug and chemical distribution studies in animals and plants.

The Super Low Level Count Mode employs a BGO (bismuth germanium oxide) detector guard to lower backgrounds for ^3H to less than 1.5 CPM, and ^{14}C backgrounds to below 0.3 CPM. This mode is the most sensitive for environmental analysis, water monitoring, and radiocarbon age dating.



▲ Minimum acceptable factory performance using sealed large glass vial standards.

Benefits

TR-LSC background reduction improves counting performance by providing:

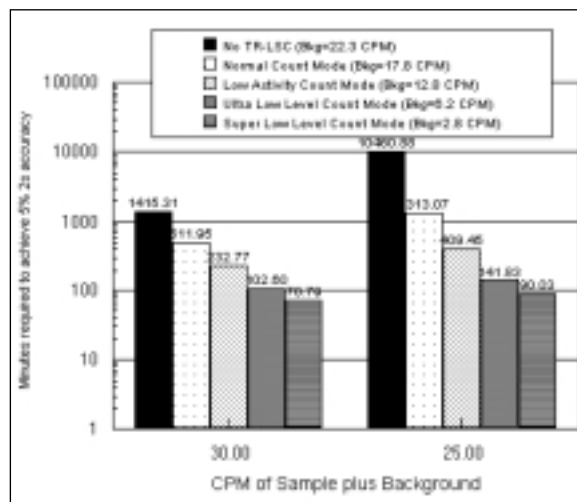
- **Lowest backgrounds** — As much as 80% to 97% of the background is removed with TR-LSC to permit counting lower activity samples.
- **Highest sensitivity** — Limits of detectability are greatly reduced. Less than 2 Bq/L of tritium can be measured in water samples in 500 minutes without enrichment.
- **Faster throughput** — Samples may be counted to the same statistical precision in less time, because of reduced background.
- **Less chemical and radioactive waste** — Greater sensitivity means that less radioactivity and cocktail may be used, thereby reducing waste. As little as 25 microliters of sample can be counted accurately.

Normal Count Mode is standard on all Tri-Carb liquid scintillation analyzers. This includes models 2100TR, 2900TR, 3100TR and 3170TR/SL.

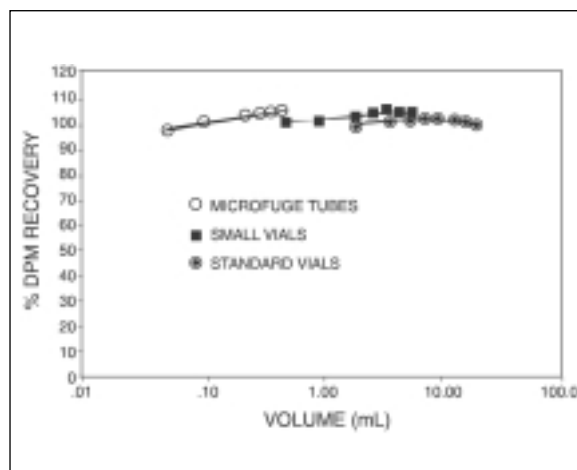
Low Activity/High Sensitivity Count Mode is standard on model 3100TR, and is optional on models 2100TR and 2900TR.

Ultra Low Level Count Mode is optional on models 2900TR and 3100TR.

The Super Low Level Count Mode is standard on the Tri-Carb 3170TR/SL.



The effect of TR-LSC on the time required to achieve 5% 2Sigma accuracy. Background sample = 12 mL Ultima Gold™ LLT, 8 mL “dead” water; ³H (0-18.6 keV region of interest).



DPM Recovery vs. Sample Volume in various size vials.

Effect of TR-LSC Discrimination on Background, Efficiency and E²/B

³H performance*; 8 mL water; 12 mL Ultima Gold LLT; ³H (0-18.6) keV region.

Amount of TR-LSC Discrimination	Vial Type	% ³ H Efficiency	Background CPM	E ² /B
None	Glass	34.2	22.3	52
Normal	Glass	33.8	17.8	64
Low Activity	Glass	33.9	12.8	90
Ultra Low Level	Glass	29.4	6.2	139
Super Low Level	Glass	26.7	2.8	255
None	Plastic	33.7	11.1	102
Normal	Plastic	33.9	11.1	104
Low Activity	Plastic	33.4	10.2	109
Ultra Low Level	Plastic	28.7	4.9	168
Super Low Level	Plastic	27.7	2.0	384

¹⁴C performance** comparison of ultra low level and super low level count modes. 4 gm benzene in 7 mL glass vials with brass caps. Optimized windows.

Count Mode	% ¹⁴ C Efficiency	Background CPM	E ² /B
Ultra Low Level	67.20	1.63	2,770
Super Low Level	63.00	0.41	9,680

* Data acquired at Scottish Universities Research and Reactor Center, East Kilbride, Scotland and at Packard Instrument Company, Meriden, CT, U.S.A.

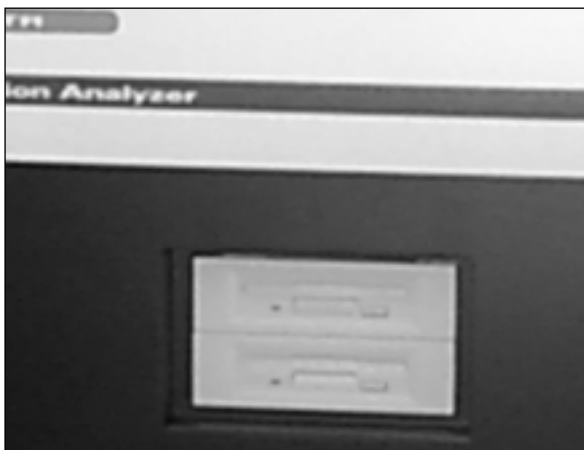
** Data acquired at Scottish Universities Research and Reactor Center, East Kilbride, Scotland.

Integrated Computer Control with Tandem Processing

Introduction

The Tri-Carb TR series of liquid scintillation analyzers features fully integrated computer control of all instrument functions. In most systems, the computer control may also be utilized for unattended, automatic data processing, and instrument performance validation and verification (IPA), as well as direct linking to networks.

The Tri-Carb 2100TR includes a built-in computer (586 or better) which controls all system functions including sample changer, CRT display, and data output. The built-in computer also facilitates storing count data directly on disk via an optional built-in 3.5 inch DataStore disk drive, or an optional hard disk.

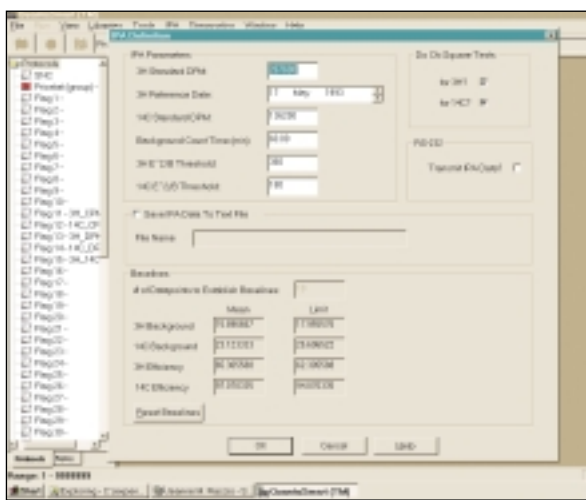


▲ *DataStore disk drive option*

Benefits

- Provides rapid and simple disk updates of system operating software. This overcomes expensive and time consuming hardware updates with their associated down time.
- Disk based operating software assures up-to-date improvements and enhancements, regardless of the age of the counting system.
- On-board data storage with the DataStore floppy or hard disk eliminates permanent hard-wired transmission links to outboard computers, and the uncertainty and inconvenience of hand-carrying data disks to other workstations. It provides complete flexibility to directly process data on any computer capable of reading MS-DOS compatible disk files. The optional built-in hard disk overcomes the limitations of manually downloading to floppy disks.
- On-board data storage assures data integrity of the stored results. Automatic power failure recovery of both the LSC and the integrated computer prevent any data loss even under adverse conditions.
- IPA validates instrument performance without requiring user intervention.

The Tri-Carb 2900TR, 3100TR, and 3170TR/SL with the powerful built-in computer and the QuantaSmart™ user interface for the Windows NT® operating system provide true multitasking in a secure 32 bit environment. Additional applications can be run on the internal PC and data can be transferred automatically to the application for additional data reduction or the data can be transmitted over a network supported by the Windows NT operating system. The powerful built-in computer provides the capacity to store IPA data and postrun reprocessing of historical, sample data (excluding Direct DPM data) via Replay for the life of the instrument. IPA and Replay are optional on the Tri-Carb 2900TR.



▲ IPA Definition Screen

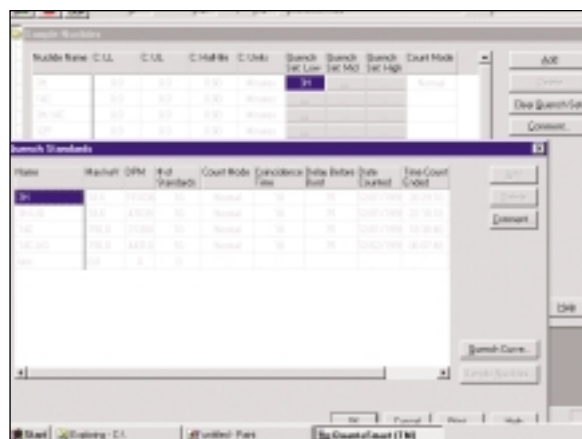
Benefits

- Uninterrupted IPA and sample data storage (Replay) for the life of the instrument. (Replay not available for Direct DPM assays).
- SpectraBase storage of all standard and most sample spectra for later recall and reprocessing.
- SpectraBase storage of all quench curves for use with any assay regardless of count regions or other assay parameters.
- Ample capacity, flexible data storage and easy networking.
- Unattended automatic execution of user application software.

QuantaSmart™ Software

QuantaSmart instrument software for the Windows NT operating system is featured on the Tri-Carb 2900TR, 3100TR and 3170TR/SL. QuantaSmart is a true 32 bit application that uses a simple and logical tabbed dialogue conversation. Designed for ease of use and compliance with GLP, QuantaSmart is the latest in LSC software technology.

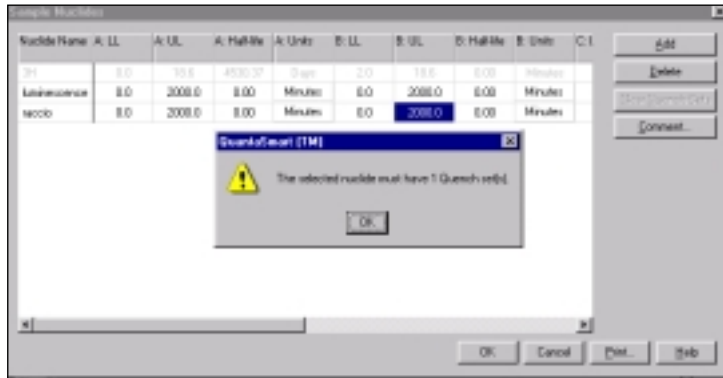
QuantaSmart software is based on an intuitive dialogue that reduces the chances of assay setup errors. In addition, cautions are issued for incompletely defined assays, missing standards, or incorrect count modes. Designed for compliance with GLP, sample data (excluding Direct DPM assays) are stored for the life of the instrument in an incorruptible form with the Replay feature. IPA (Instrument Performance Assessment) data are stored historically as well. QuantaSmart also reports all acquisition parameters, including drive and path of electronically stored data, instrument serial and model number, software version number, and calibration data. IPA and Replay are optional features on the Tri-Carb 2900TR.



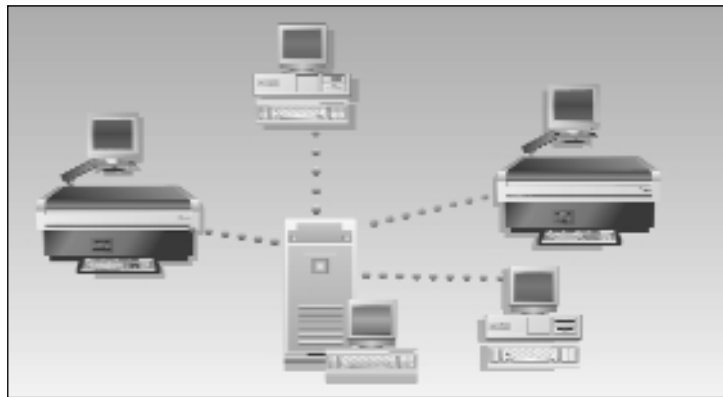
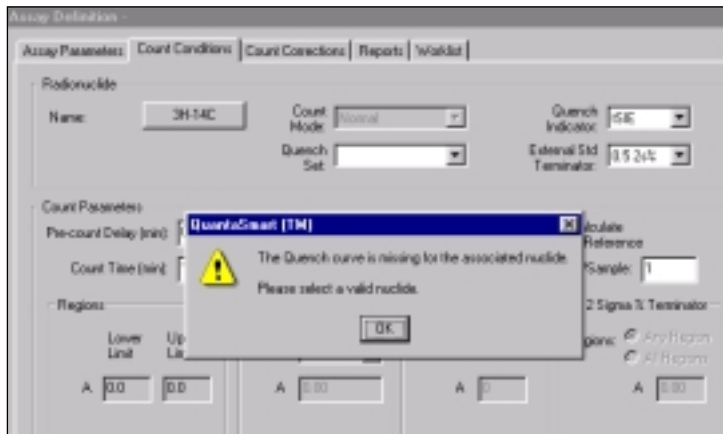
▲ The SpectraBase library allows the use of a single quench curve with any assay.

Benefits

- QuantaSmart software provides an easy, multi-tasking operating environment.
- Easy networking under the Windows NT operating system.
- Reduces operator error to a minimum with cautions and prompts.
- Data Reporting complies with GLP (Good Laboratory Practices).



Caution is issued to warn of incorrect or incomplete assay set up.



Direct linking to networks is possible with all Tri-Carb liquid scintillation analyzers.

IPA (Instrument Performance Assessment)

Introduction

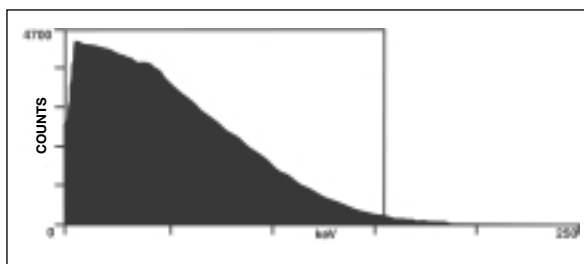
The IPA (Instrument Performance Assessment) feature automatically measures and records efficiency, background, E²/B (figure of merit, sensitivity), and Chi-square (precision) values for the ³H and ¹⁴C counting regions each time the Tri-Carb is calibrated. IPA data are stored and can be viewed for the life of the instrument on the Tri-Carb 2900TR (option) and the Tri-Carb 3100TR series. Data are stored in both running mean menu and fixed baseline chart formats. The most recent 100 values for each parameter are available for the Tri-Carb 2100TR.

IPA is a built-in quality control monitor of instrument performance to support the validity of experimental data. It employs highly sensitive counting conditions to detect even the smallest changes in system performance.

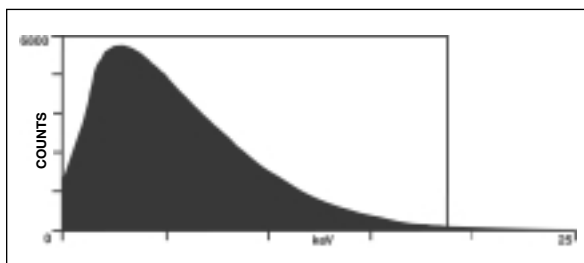
IPA Counting Regions

Efficiency:

¹⁴C 0-156 keV



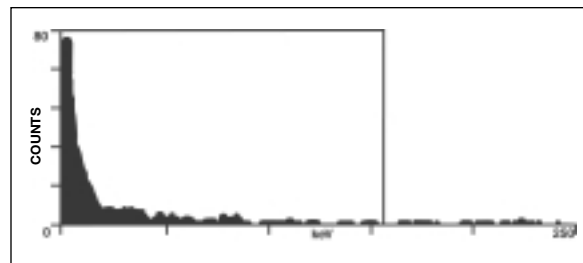
³H 0-18.6 keV



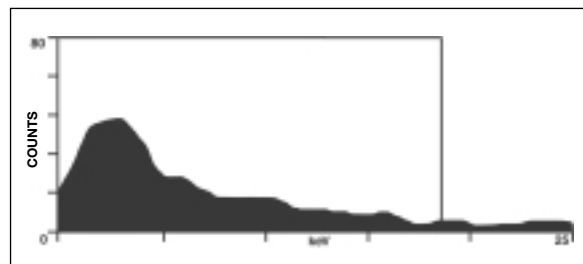
▲ The full spectrum efficiency is monitored for the unquenched ¹⁴C and ³H standards to a precision of 0.5% 2S error. Efficiency falling below 90% for ¹⁴C and 58% for ³H is flagged.

Background:

¹⁴C 0-156 keV



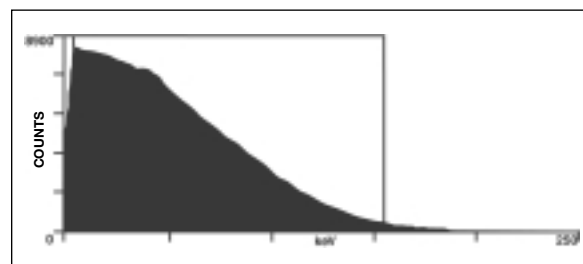
³H 0-18.6 keV



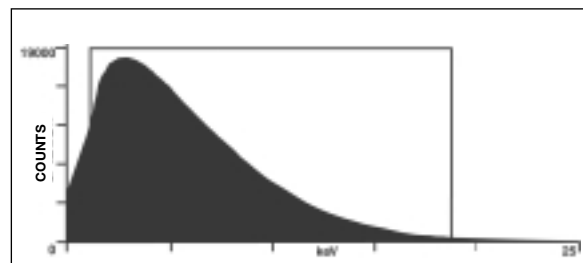
▲ The full spectrum background is monitored for both the ¹⁴C and ³H counting regions for a minimum count time of 60 minutes. Backgrounds deviating from the established base line ± 4 S.D. are flagged.

E²/B:

¹⁴C 4-156 keV



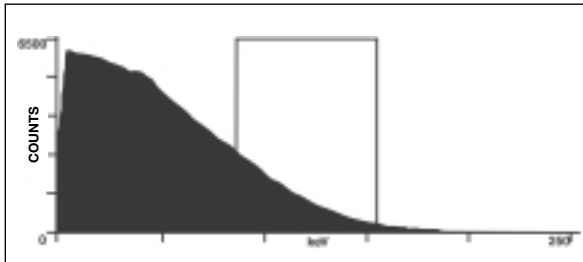
³H 1-18.6 keV



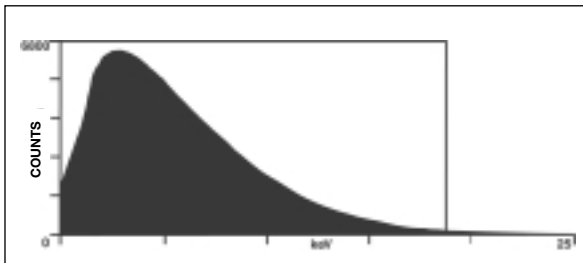
▲ Narrower counting regions are selected to detect even the smallest changes in efficiency or background. Values falling below operator selected thresholds are flagged.

Chi-square:

¹⁴C 87-156 keV

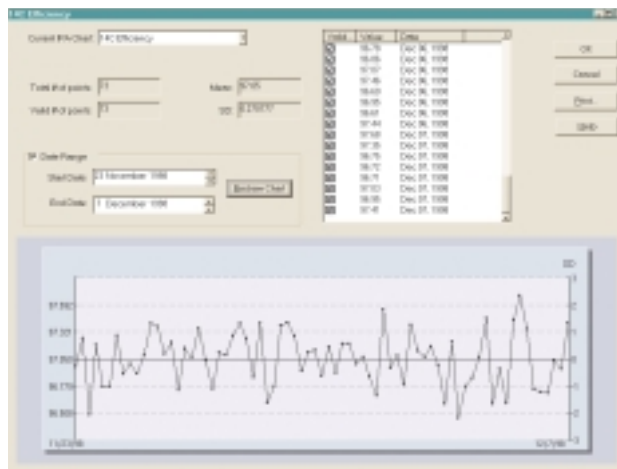


³H 0-18.6 keV



▲ The ¹⁴C and ³H regions selected provide the most sensitive measure of repeatability. Twenty individual 0.5 minute counts are accumulated, and Chi-square values outside $7.63 < X^2 > 36.19$ are flagged.

¹⁴C efficiency chart for Tri-Carb 2900TR and 3100TR series.



Benefits

- IPA automates LSC performance monitoring. It overcomes the need to setup special procedures for monitoring LSC instrument performance. IPA is automatically initiated each time the calibration cassette is identified if 23 hours have elapsed since the last calibration. The Tri-Carb 3170TR/SL initiates IPA each time the calibration cassette is identified. The instrument operator can initiate IPA any time on-demand by simply activating the SNC/IPA protocol flag.
- Instrument performance record-keeping is as simple as printing out IPA files or saving IPA data electronically. The calibration and reference sources are supplied with each Tri-Carb, so no additional calibration standards need to be purchased.
- Good laboratory practice requires routine testing and documentation of all instruments used in analytical procedures. Only Tri-Carb liquid scintillation analyzers provide the built-in, automatic IPA performance monitor. IPA is the only incorruptible LSC early warning system to alert you of any changes in your counter's performance before your results are affected.

The IPA feature, which includes a database containing tables and charts, is standard on Tri-Carb models 2100TR, 3100TR and 3170TR/SL, and optional on the 2900TR.

IPA tests all eight IPA parameters and provides a printout of results on all Tri-Carb models.

tSIE (Transformed Spectral Index of the External Standard)

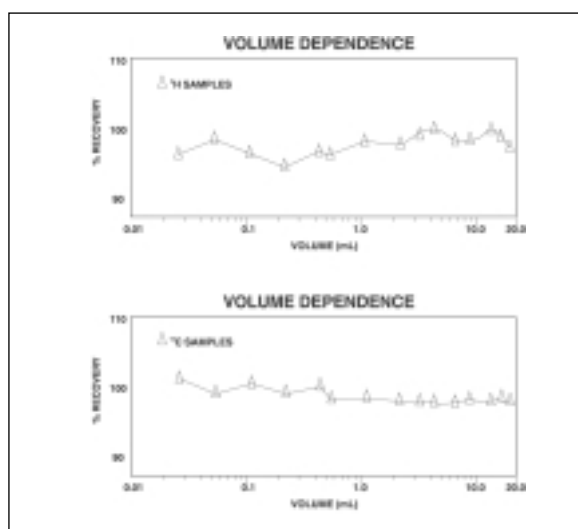
Introduction

The patented tSIE (Transformed Spectral Index of the External Standard) provides fast, sensitive, and accurate sample quench measurements for single, dual, and triple label LS (Liquid Scintillation) samples for a wide range of volumes and sample types.

All real life LS samples exhibit some degree of quenching which will affect sample count rate (CPM). Therefore, CPM results may be invalidated due to the unknown effect of quench, which varies from sample to sample. It is, therefore, necessary in many cases to correct CPM results for quench to produce DPM results. External standardization is an accepted method of quench correction, and is independent of sample count rates.

The tSIE quench indicating parameter is determined by evaluating the spectrum of the sample, and the Compton electron spectrum of the ^{133}Ba external standard source with the Spectralyzer MCA (Multichannel Analyzer). First, the spectrum of the sample and external standard is accumulated and stored in the MCA, followed by the spectrum of the sample only. The net external standard spectrum is then generated by subtracting the sample spectrum.

The net external standard spectrum is then transformed by a reverse channel-by-channel summation technique. The total counts (S1) of the highest energy channel remain stored in that channel. Then, the value of the total counts (S1) is added to the counts (C1) of the next lower energy channel, to yield a new sum (S2) which replaces the stored counts in that channel. This new sum (S2) is added to the counts (C2) in the next lower energy channel to yield a new sum (S3), which replaces the counts stored in that channel. This process continues until all MCA channels have been transformed by the reverse summation technique.



Two points are strategically located on the transformed external standard spectrum such that spectral interferences are eliminated, and a line is fitted between them which extends across the X-axis (abscissa). This intercept point is used to measure the quench of the sample. In other words, the maximum energy of the transformed external standard spectrum is proportional to the degree of quench in the unknown sample.

The intercept point value is then adjusted during calibration to yield a tSIE value of 1000 to normalize the system. As quench increases, the tSIE value decreases proportionally for each quench sample or standard.

tSIE Dynamic Range

Sample	%EFF	%Rec	%CV	tSIE
1	58.47	99.94	0.362	815.2
2	55.78	99.77	0.200	725.9
3	44.49	100.23	0.224	472.2
4	24.77	99.82	0.304	231.1
5	18.07	99.42	0.303	177.1
6	10.81	99.60	0.318	119.8
7	6.15	99.29	0.640	83.59
8	3.32	99.00	0.381	58.75

Sample	%EFF	%CV/EFF	tSIE
1	1.388	0.922	39.00
2	0.617	0.868	26.99
3	0.311	0.476	21.08
4	0.166	1.072	18.15
5	0.096	2.876	15.41
6	0.060	1.587	14.88
7	0.038	3.990	12.70
8	0.023	2.410	12.30
9	0.016	2.740	10.20
10	0.011	3.310	9.956

Benefits

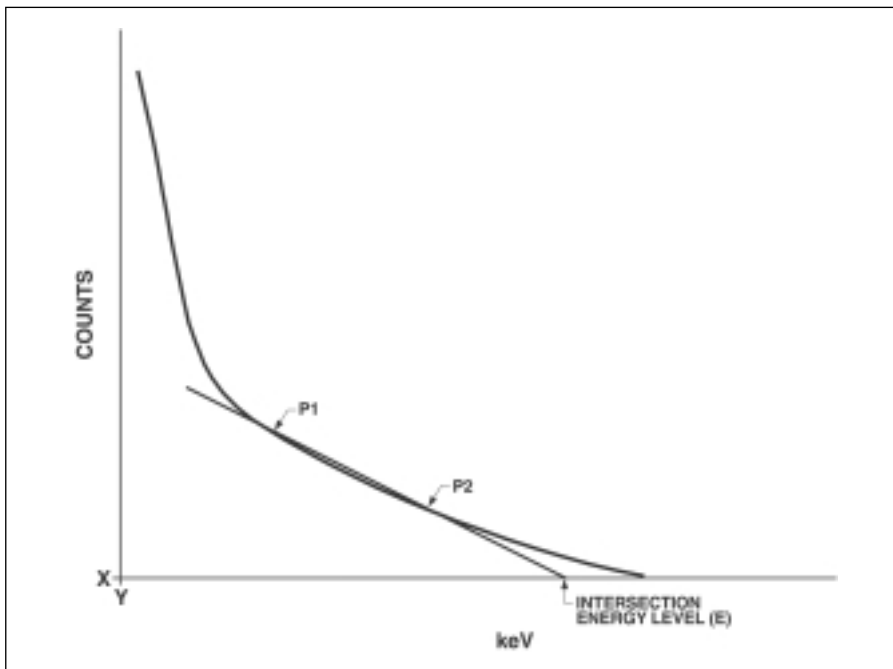
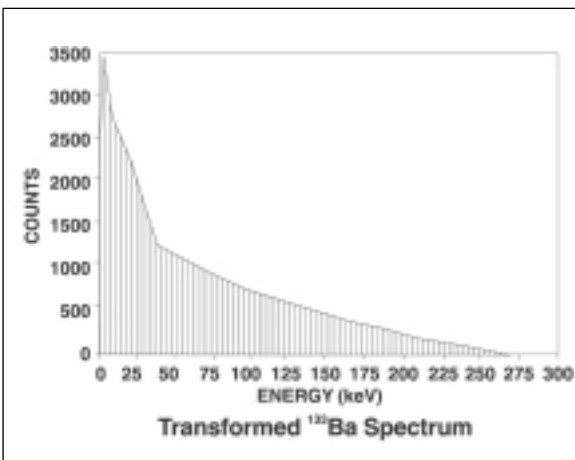
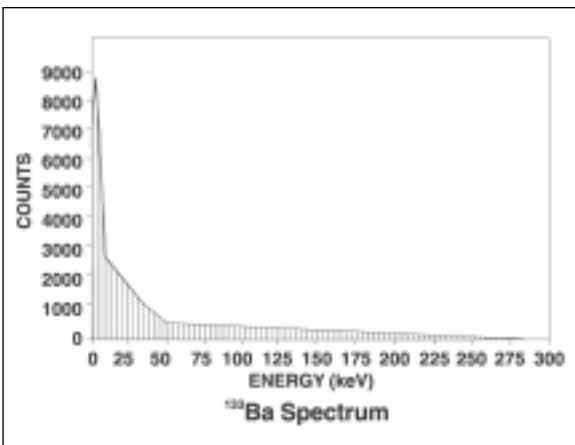
The tSIE quench indicating parameter overcomes the interferences which affect external standard quench measurements to yield the highest accuracy in the shortest time, without requiring repeat measurements.

- The low energy of the ^{133}Ba external standard source is the most *sensitive* means of tracking quench in samples containing low energy nuclides such as ^3H and ^{14}C and will not need replacement for the life of the instrument. High energy external standard sources such as ^{137}Cs , ^{226}Ra , and ^{152}Eu are much more difficult to quench, and do not track subtle quench changes in low energy samples. Using high energy sources for external standardization of ^3H and ^{14}C is very much like using ^{32}P as an internal standard to monitor quench of these nuclides.
- Bottom positioning of the ^{133}Ba source provides optimal geometry, and *volume independence*. Quench in samples as small as 25 microliters is accurately determined due to the low energy of the ^{133}Ba external standard. High energy external standard sources require much longer counting times because the high energy gamma rays do not interact as efficiently with LS cocktails.
- The tSIE method assures exceptionally *high reproducibility* by measuring the entire external standard spectrum, rather than a small portion of it. Only a single tSIE measurement is required for any sample.
- The tSIE reverse transformation method *overcomes the plastic vial wall effect*.
- The tSIE method provides the *highest dynamic range*. Accurate DPM results are possible at ^3H efficiencies below 1%.

The tSIE feature is standard on Tri-Carb models 2100TR, 2900TR, 3100TR, and 3170TR/SL.

DPM in Plastic Scintillation Vials

Time (hrs.)	Volume (mL)	DPM	% DPM Recovery
0	5	43.567	100.2
0	15	132.759	100.2
12	5	44.009	101.1
12	15	133.693	100.9
24	5	43.657	100.3
24	15	132.639	100.1
36	5	43.466	100.4
36	15	132.487	99.9
48	5	43.692	100.4
48	15	132.419	99.9
60	5	43.595	100.2
60	15	132.387	99.9
72	5	43.568	100.1
72	15	133.120	100.5
84	5	42.984	98.8
84	15	132.570	100.0
Mean	43.567 (5 mL)	132.795 (15 mL)	
SD	308.21	479.72	
%CV	0.71	0.36	



The tSIE is the intersection energy level (E) multiplied by the instrument calibration factor.

AEC (Automatic Efficiency Control)

Introduction

The AEC (Automatic Efficiency Control) feature provides automatic counting region adjustments for single and dual label samples to improve counting sensitivity and DPM results accuracy.

Dynamic quench-controlled spillover correction is an essential element of dual label sample DPM analysis. Radionuclides of different energies such as ^3H and ^{14}C quench at different rates, and fixed counting regions greatly limit the quench range and accuracy of dual label assays. The degree of spill-down from the high energy nuclide into the low energy nuclide counting region increases with quench when regions are fixed. This can cause an excess contribution of the high energy nuclide in the low energy region, resulting in inaccurate DPM results, particularly for the low energy nuclide. The problem is even greater in triple label assays when fixed counting regions are used.

AEC tracks quench via the tSIE quench indicating parameter, and automatically adjusts counting regions to maintain spillover at a nearly constant rate. This maintains low spillover levels and increases the dynamic range of dual label assays. The degree of adjustment for each counting region is dependent on the initial unquenched counting region energy level, thereby compensating the adjustment for different nuclide energies.

In single label assays, the AEC feature improves sensitivity by reducing the counting region as a function of quench. This is particularly important when the sample count rate is low relative to background.

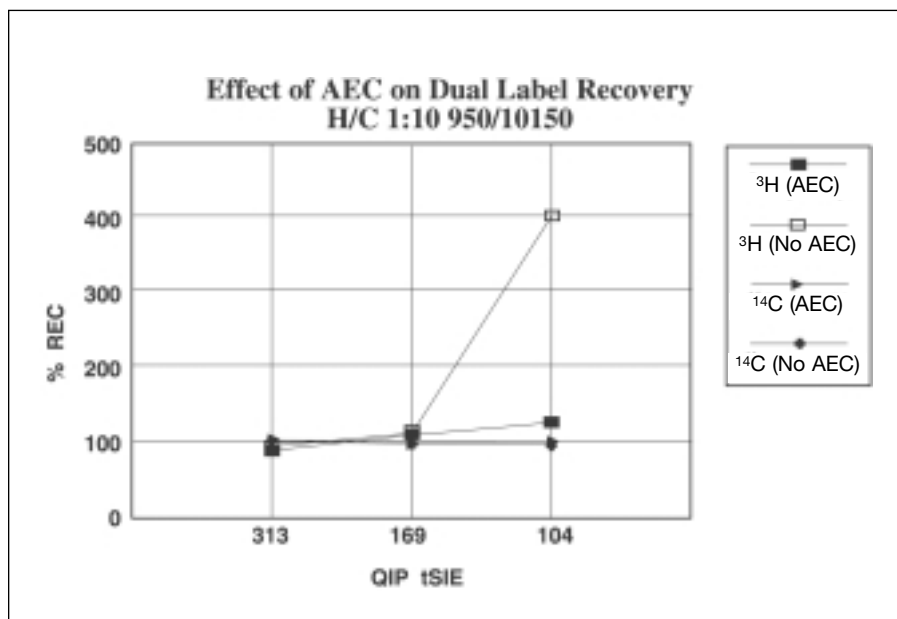
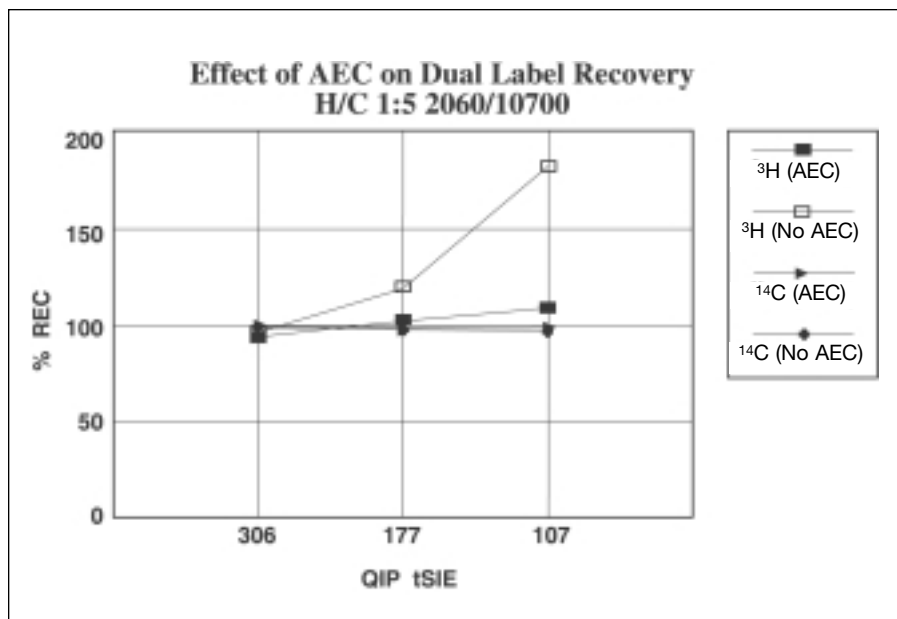
Dual Label Separation at various quench levels and equal activity ratios

^3H % Recovery	^{14}C % Recovery	tSIE
99.7	100.9	780
101.3	100.5	674
101.7	100.1	584
99.8	100.5	448
99.8	100.4	364
101.3	100.7	307
99.5	100.9	166
Mean	100.510	100.600
SD	0.894	0.278
% CV	0.889	0.276

Benefits

- AEC assures low and predictable nuclide spillover rates for dual and triple label assays, and increases the usable quench range without requiring additional quench libraries.
- AEC increases the statistical accuracy of dual and triple label assays.
- AEC increases sensitivity for single label assays by minimizing background.
- The accuracy of AEC is unaffected by sample count rate. It tracks quench and adjusts counting regions by using the tSIE quench indicating parameter. Even extremely low count rate samples are accurately measured.

AEC is standard on all Tri-Carb models.



Direct DPM (Disintegrations Per Minute)

Introduction

The Direct DPM (Disintegrations Per Minute) feature provides a fast, simple, and easy means of determining DPM for single label samples, such as ^3H , ^{14}C , ^{35}S , ^{32}P , and ^{45}Ca . With Direct DPM, there is no need to store quench correction data.

Differing quench levels among LSC samples often invalidate CPM results, since samples are counted at different efficiencies. Therefore, sample counting efficiencies and DPM values must be determined to overcome the effect of quench. Normally this requires storing quench curves for each nuclide to be counted using calibrated quenched standards for each nuclide. However, with Direct DPM, single label samples may be counted directly without storing quench curves. This is particularly useful for short-lived or frequently used radionuclides.

It is difficult and quite expensive to obtain accurately calibrated standards for short-lived nuclides, such as ^{32}P , ^{33}P , and ^{35}S . With Direct DPM these nuclides may be accurately calibrated for subsequent use in other single, dual, and triple label experiments.

Direct DPM uses a proprietary technique to determine the counting efficiency and DPM for each sample. This automatic feature even permits the counting and DPM calculation of different nuclides within the same cassette without changing the program if half-life correction is not used. The Direct DPM program is installed at the factory; all the operator needs to specify is the counting time (and the nuclide if half-life correction is to be applied). Any number of samples can be counted with Direct DPM in one or more cassettes. Direct DPM is best used for sample activity in excess of 500 CPM.

Benefits

- Eliminates need to define counting conditions.
- Eliminates storing of quench curves.
- Eliminates the preparation of calibrated standards.
- Allows random sample counting with intermixed nuclides in the same cassette.
- Accurate for heavily quenched ^3H .
- Calibrates short-lived nuclides (i.e., ^{32}P , ^{33}P , ^{35}S).

Direct DPM is standard on all Tri-Carb models.

Direct DPM Recovery Data

Radionuclide	tSIE	Direct DPM	Actual DPM	% Recovery
^{14}C toluene Large glass vials	691	120,701	120,300	100.33
	422	120,999	120,330	100.58
	255	123,389	120,300	102.75
^{14}C Ultima Gold Small glass vials	535	37,259	38,100	97.79
	277	38,419	38,100	100.84
^3H toluene Large glass vials	705	245,390	247,009	99.34
	428	246,980	247,009	99.99
	152	248,408	247,009	100.57
^3H Ultima Gold Small glass vials	509	46,299	45,536	101.67
	253	47,251	45,536	103.87
^3H Ultima Gold Small plastic vials	592	45,907	45,536	100.81
	258	44,782	45,536	98.34



Direct DPM feature is standard on all Tri-Carb LSCs.

Dynamic Color Quench Corrected DPM

Introduction

The dynamic color quench correction feature automatically corrects results for the optical quenching effects of highly colored single and dual label samples, without requiring storage of special color quench correction curves or libraries.

The degree of correction is proportional to the amount of color quench in each sample. Therefore, non-colored samples receive no color correction, while samples with increasing color quench receive proportionally increased correction.

Dynamic color quench correction is based on the fact that color and chemical quenching yield different characteristics in the sample and external standard spectra. These differences are detected by comparing the normal coincidence counting spectrum with that of a single phototube spectrum. As the degree of color quenching increases relative to that of chemical quenching, the differences between the coincidence spectrum and the single phototube spectrum increase. The fractional difference between chemical and color quench is then determined, and a proportional correction is employed to correct the counting efficiency to yield accurate DPM values.

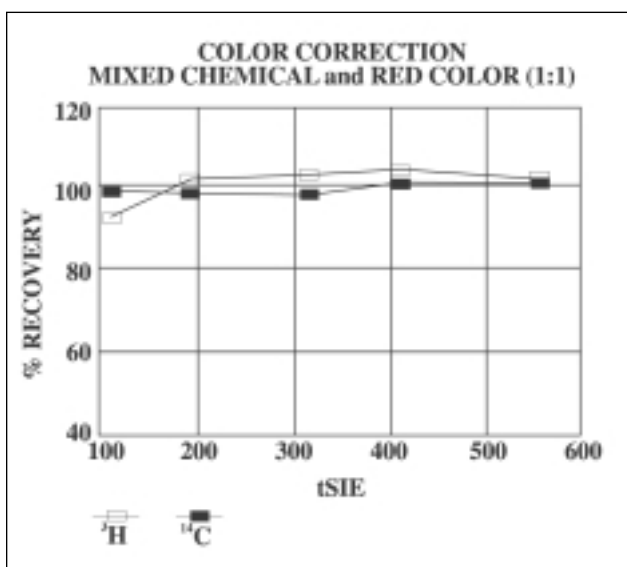
Many types of LSC samples contain some color. These include whole blood, urine, tissue digests from plants or animals, extracts, or even culture media. Decolorizing with bleaching agents may introduce unwanted chemiluminescence, and greatly increases sample preparation time and labor. Dynamic color correction is fully automatic, and each sample is evaluated independently.

Benefits

Automatic Dynamic Color Correction overcomes the need to decolorize samples, or to prepare special color correction standard curves, before counting, to achieve accurate single and dual DPM results for ^3H and ^{14}C . Since the correction is proportional to the degree of color in each sample, the color correction feature will only correct samples which exhibit color quenching. Therefore, colored and non-colored chemical quenched samples may be intermixed in the same sample batch.

This unique feature works for both single and dual labeled ^3H and ^{14}C samples.

Dynamic color corrected DPM is standard on Tri-Carb models 2900TR, 3100TR, and 3170TR/SL. It is included with the DPM option on model 2100TR.



DPM Recovery vs. Quench with color correction.

Luminescence Detection and Correction

Introduction

The luminescence detection and correction feature automatically detects, quantitates and corrects for unwanted or unexpected luminescence in liquid scintillation samples. Corrected sample results may be reported along with the percent luminescence occurring in each sample.

Liquid scintillation samples may produce unwanted luminescence as a result of sample preparation or exposure to intense short wavelength light. Strong alkaline conditions commonly found with the use of tissue solubilizers, NaOH and KOH, produce intense luminescence. Peroxides used for bleaching color quenched samples and digesting acrylamide gels also produce luminescence.

Typically, the number of unwanted luminescence events occurring in liquid scintillation samples is quite small, and is prevented from contributing to the sample count rate by the coincidence circuit. However, when the number of luminescence events is sufficiently high, the coincidence circuit is overwhelmed, and chance luminescence events are recorded as legitimate events. PerkinElmer developed a method of luminescence detection and correction which corrects the problem.

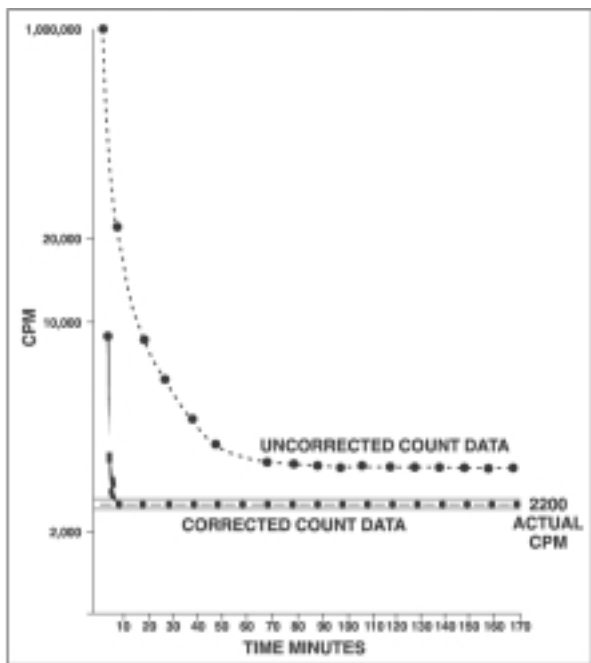
Chance coincident events are detected by adding a second coincidence circuit (B) which delays the signal of one of the photomultiplier tubes by a period of time equal to the coincidence resolving time. This circuit detects and records only the chance coincidence (unwanted luminescence) events. The chance events are then subtracted from the total coincidence events (A) to yield the net sample counts. The percentage of luminescence events as compared to the total events is also calculated and reported.

Benefits

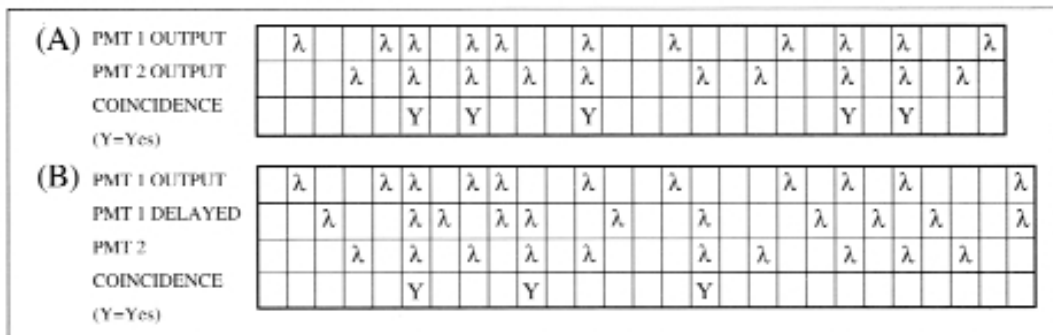
- The luminescence detection feature identifies and records the presence and relative amount of luminescence in liquid scintillation samples. This alerts the investigator to possible problems with sample results accuracy.
- The luminescence detection *and* correction feature automatically overcomes the interference of unwanted luminescence to allow counting samples without waiting for the samples to stabilize. Therefore, *results can be obtained faster*.
- Luminescence detection *and* correction allows counting samples without the need for special chemical treatment to eliminate the luminescence to *simplify sample preparation*.
- Luminescence detection *and* correction increases *sample accuracy* by eliminating even small amounts of unwanted luminescence, which may otherwise go undetected.

Luminescence detection is a standard feature on Tri-Carb models 2100TR, 2900TR, 3100TR, and 3170TR/SL

Luminescence detection and correction is standard on models 3100TR, and 3170TR/SL. It is optional on models 2100TR and 2900TR.



▲ Effect of Luminescence Correction Performance.



▲ Diagram showing the effect of Luminescence Correction Circuit on Coincident Events.

Replay Sample Post-Processing

Introduction

Replay is a unique user-interactive program for the complete reprocessing of stored LSC sample data to correct mistakes, and to overcome unexpected counting interferences.

This exclusive PerkinElmer Life Sciences feature provides complete recall and reprocessing of previously counted sample spectral data*. During counting, the raw spectrum for each standard, unknown sample, background and reference is stored in the computer controlled SpectraBase multichannel analyzer. These complete spectra are then stored on the system hard disk for recall and reprocessing via Replay.

Because the complete raw spectrum is stored for each standard in the libraries, and for each unknown sample and background, any sample or sample batch may be reprocessed using different counting conditions to yield new CPM or DPM results. The many Replay operations include:

- Selection of different stored quenched standards.
- Changing from single to dual label DPM or from dual to single label DPM.
- Changing counting regions.
- Changing from fixed regions to AEC controlled regions.
- Changing technique for DPM calculation.
- Recalling, reprocessing, and validating data from samples run weeks, months, or years earlier, which are stored on floppy disks.
- Fine-tuning spillover in difficult dual label samples.
- Elimination of counting interferences introduced by static electricity, chemiluminescence, sample self-absorption, etc.
- Redefining data storage and reprocessing application programs.

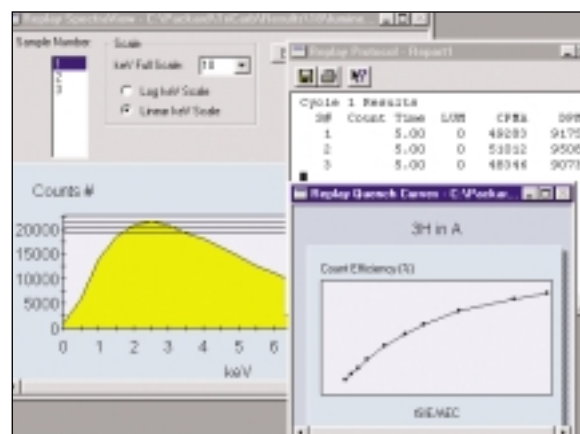
*Replay data are not available for Direct DPM assays.

Benefits

- Replay saves time by providing the capability to review and change counting conditions even after samples have been counted. Setup mistakes are easily corrected. Sample recounting is virtually eliminated. Counting interferences can be eliminated.
- Replay helps assure validation and verification of experimental results. Even when samples have been discarded, the stored spectra may be recalled for review and reprocessing.
- Replay helps isolate and characterize radionuclide contamination.
- Only Replay lets you change DPM methods, and even change the quenched standard libraries without recounting samples.

Replay is a standard feature on Tri-Carb models 3100TR and 3170TR/SL. Replay is an option on model 2900TR.

Replay is not available on model 2100TR.



Replay screens showing SpectraView display, count results and quench curve data.

Live SpectraView and Enhanced Live SpectraView

Introduction

The Live SpectraView and Enhanced Live SpectraView features provide continually updated high resolution spectrum displays of the sample currently being counted. Spectra are displayed in linear or logarithmic modes with energy reported as keV, rather than arbitrary units. The energy scale may be expanded to provide more detail of spectra with lower energy endpoints, and discriminator settings for all three counting regions are displayed to provide visual reference points.

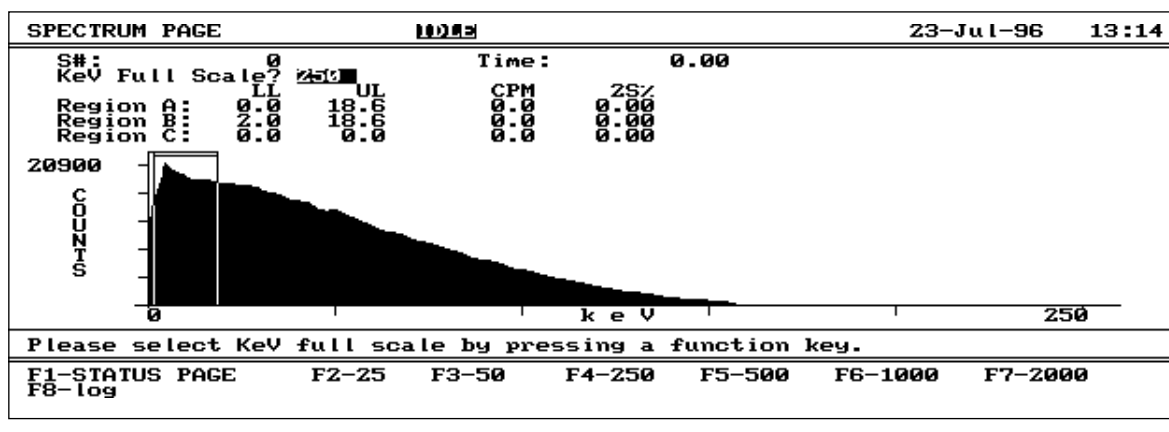
Live SpectraView is a standard feature on the Tri-Carb model 2100TR with the standard color CRT monitor. Systems with the color monitor display spectra in color. Regions of interest are displayed in different colors.

Benefits

Real time visualization and plotting of sample spectra saves time, and can even save experiments. Live SpectraView helps:

- Fine-tune regions for single, dual, and triple label assays.
- Confirm the presence of unwanted luminescence.
- Detect contaminants in radionuclides.
- Provide early confirmation of quenching problems.
- Demonstrate principles of LSC.

Live SpectraView lets you see what you are counting, while you are counting, in a full-size high resolution CRT format. There is no need to wait until the entire experiment has been counted to analyze samples. A single keystroke provides a hard copy plot of the spectrum. Multiple spectra of the same sample can be plotted over a period of time to confirm suspected changes in a spectral distribution. The instant feedback of Live SpectraView helps get the job done faster.

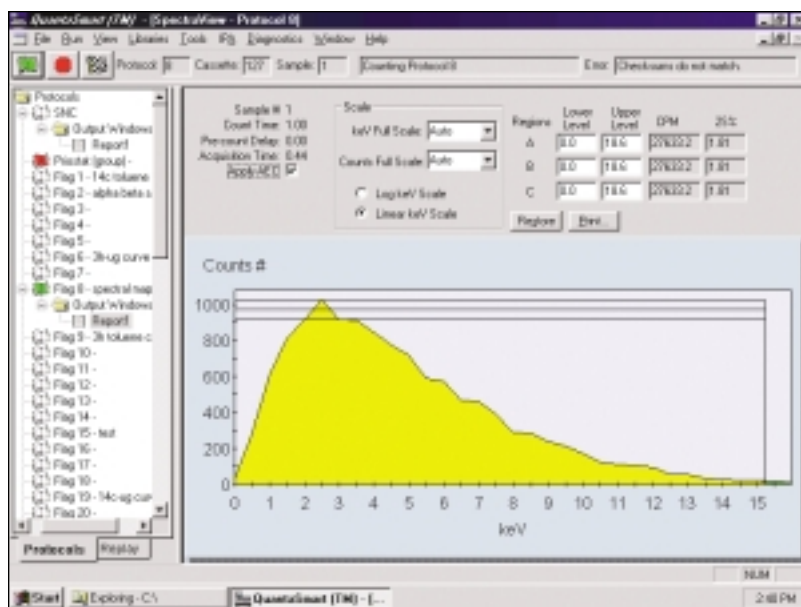


▲ SpectraView display on the Tri-Carb 2100TR.

Enhanced Live SpectraView is standard on Tri-Carb models 2900TR, 3100TR and 3170TR/SL. Enhanced Live SpectraView includes all of the features of Live SpectraView plus added capability. Enhanced Live SpectraView allows adjustment of Y-axis full scale counts, on-screen adjustable counting regions, and the ability to turn AEC (Automatic Efficiency Control) on or off. Enhanced Live SpectraView also provides greater use of color for spectrum analysis by assigning different colors to each region.

Benefits

- Adjustment of full scale counts on the Y-axis provides the means for detecting small amounts of contaminants in an otherwise normal looking spectrum. This is particularly useful if the nuclide of interest has a very low count rate relative to the potential contaminant.
- On-screen adjustable counting regions provide the flexibility to adjust counting regions and view count rate changes within those regions, without interfering with sample counting. This is accomplished via the SpectraBase regionless counting and spectrum storage. The sample spectrum data and the count rates for each designated counting region are displayed independently of the parameters set in the counting protocol. Regions to establish optimum dual label cross-over settings, spectrum interrogation, and the removal of interferences are easily and quickly determined.
- Automatic Efficiency Control, used to dynamically shift counting regions, may be turned on or off in Enhanced Live SpectraView. This allows the operator to visualize the effect of AEC on actual sample counts for optimizing starting regions for sample batches with varying quench.
- A single mouse click plots the current spectrum. Subsequent spectra of the same sample or different samples may also be displayed and plotted to demonstrate changes. This is extremely helpful for analyzing samples containing more than one radionuclide with different half-lives.
- The advantage of Enhanced Live SpectraView is that it facilitates real time sample spectrum analysis, without requiring downloading of spectra for postrun analysis on nonintegrated computers.



◀ SpectraView display on the Tri-Carb 2900TR and 3100TR series.

Built-In DataStore

Introduction

The DataStore feature provides IBM® compatible 3.5 inch disk or hard disk storage of LSC sample data and spectrum files. DataStore provides easy access to all sample data and spectrum files through protocol or assay specific file identification.

It is sometimes necessary to transfer LSC sample and spectrum data to floppy disks for additional data processing, or to provide a permanent record of critical sample information. The built-in DataStore feature is available for all Tri-Carb models, and simplifies data capture and retrieval.

All files on DataStore disks are easily read by a unique file identification code. Each file also has a unique time and date stamp to positively identify the data or spectrum file, and to link it to a printout or batch.

Within each ASCII data file, commas are used to separate data fields to facilitate downloading data files into other software programs, such as Lotus 1-2-3, or other commercial or custom programs. Data may also be stored directly in Lotus® and Microsoft® Excel formats on the Tri-Carb 2900TR, 3100TR, and 3170TR/SL. File search is easy, since all data and spectrum files are either numbered according to protocol and sample number (Tri-Carb 2100TR) or uniquely identified by the user.

The chart on this page is a summary of DataStore capabilities for different Tri-Carbs.

Benefits

- The built-in DataStore simplifies data and spectrum storage by integrating the DataStore disk drive into the counting system. This eliminates clumsy external storage devices, such as battery supported storage modules, expensive stand-alone disk drives, and nonintegrated computers.
- DataStore uses standard 3.5 inch floppy disks which work with any IBM compatible computer, and conventional DOS formatting.
- DataStore permits setting up protocols or assays in advance for unattended storage of sample data and spectra. Files are easily copied into software programs or onto other disks for permanent storage.

	2100TR	2900TR, 3100TR and 3170TR/SL
DataStore, 3.5 inch floppy	Optional	Standard
DataStore, hard disk	Optional	Standard
Protocol or assay specific storage	Yes	Yes
Drive and path control	Yes	Yes
Spectrum storage	Optional	Yes
Short, fixed and long format	Yes	N/A
Custom data output format	No	Yes
File drive and paths indicated on reports	No	Yes
Data stored in ASCII, Lotus or Microsoft Excel formats	ASCII Only	Yes

N/A = Not applicable

High Sensitivity Solid Scintillator Counting

Introduction

All PerkinElmer Life Sciences Tri-Carb TR liquid scintillation analyzers accurately count solid scintillators, such as YS (yttrium silicate), without instrument modification or the need for special options. By selecting a slightly wider counting window, Tri-Carb TR-LSC can achieve more counting sensitivity than other LSCs equipped with special solid scintillator counting options.

Solid scintillators, such as YS, are available for a limited number of assays. Samples employing these scintillators may be in a liquid form with the solid particles settled on the bottom of the vial. Alternatively, samples may be in a completely dry form in short caps (LumaCap™) or on filter disks.

Dry counting of solid scintillators assumes constant chemical quench, since there is no means of correcting for variable quench. However, counting efficiency from such scintillators may be affected by variations in energy and light self-absorption caused by chemical constituent differences among samples, including color. Also, sample geometry differences must be minimized by positioning samples uniformly.

Liquid counting of solid scintillators may also be impaired by color quench, but color quench correction curves may be constructed to correct for differences in sample color. Quench correction for liquid samples must utilize the quench indicating parameter based on the sample spectrum, since external standardization is not possible due to the absence of a liquid scintillator in the sample.

The counting efficiency of solid scintillators may be easily optimized on Tri-Carbs by adjusting the sample counting window to include the entire sample energy spectrum. The sample spectrum with solid scintillators generally has a higher endpoint. This is easily determined on the Tri-Carb system by measuring the SIS (Spectral Index of the Sample) of an unquenched sample, or by viewing the sample spectrum on the Live SpectraView spectrum display. Once the endpoint is determined, the upper discriminator may be set, and used for all samples using that radionuclide.

The results shown below are from ³H thymidine labeled samples and demonstrate the counting efficiencies and E²/B in two different window settings. The background of an unlabeled sample was 58 CPM in the 0-19 keV window, and 65 CPM in the 0-30 keV window using the Normal Count Mode*.

Benefits

- All standard Tri-Carb liquid scintillation analyzers provide high sensitivity counting for YS solid scintillators without requiring modifications or special options. By opening the window to the endpoint of the isotope, counting sensitivity equal or better than on dedicated counting equipment is obtained.
- The SIS energy endpoint determination provides the optimum window upper limit. SpectraView helps confirm settings and any changes in sample spectra.

Solid Scintillation Counting (³H Thymidine)*

DPM	Vol (μL)	0-19 keV			0-30 keV		
		Net CPM	EFF	E ² /B	Net CPM	EFF	E ² /B
1,000	13.7	261	26.1	11.7	280	28.0	12.1
5,000	68.5	1,225	24.5	10.4	1,297	25.9	10.3
10,000	13.7	3,042	30.4	15.9	3,223	32.2	16.0
50,000	68.5	12,771	25.5	11.2	13,561	27.1	11.3
100,000	13.7	31,634	31.6	17.2	33,540	33.5	17.3
500,000	68.5	127,192	25.4	11.1	133,518	26.7	11.0

*All data as measured at the factory in Downers Grove, IL, U.S.A.

Downloading Sample Changer with Double Light Seal and Complete Access to All Samples

Introduction

Laboratories require LSCs (Liquid Scintillation Counters) which provide stable performance and are easy to use. Because of this, all PerkinElmer's Tri-Carb systems are designed with a downloading, Varisette™ sample changer which ensures maximum counting stability and provides complete access to all samples.

The Tri-Carb's unique sample conveyor and changer design overcomes the limitations inherent to uploading systems. First of all, the downloading, Varisette changer employs a double light seal to ensure constant PMT (photomultiplier tube) response. In uploading LSCs, the high voltage to the PMTs is typically shut off, or considerably reduced, when changing samples. This causes short-term instability of the PMTs and can severely degrade the sample result, especially for low count rate samples. In the Tri-Carb systems, the high voltage is maintained at the normal operating level at all times, because the double light seal prevent light from striking the PMTs, even during sample changing. Therefore, the PMT response of Tri-Carb systems is the most stable of all commercial LSCs, and it does not require frequent adjustment.

Second, the Tri-Carb's downloading, Varisette sample changer permits complete access to all samples in the counter. This makes the Tri-Carb LSC the easiest sample changer to load and unload. The sample cassettes are always in full view.

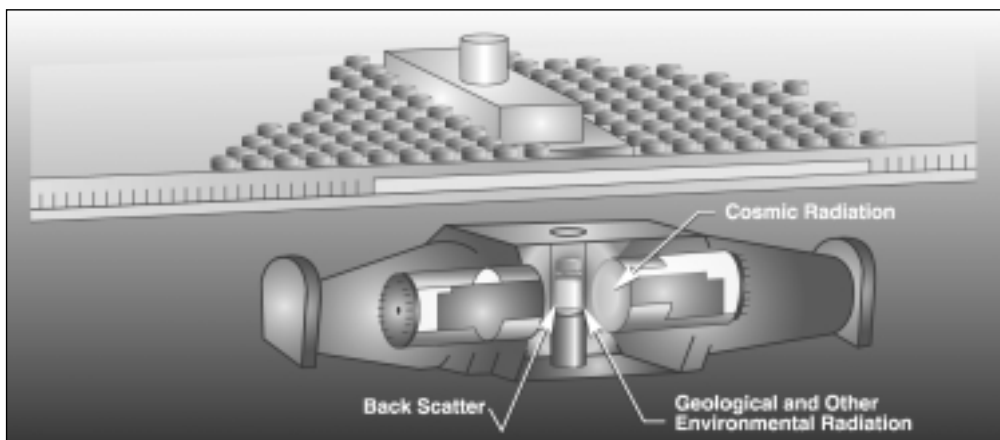
Furthermore, the complete visual access also ensures that you can see the number of every cassette (permanently placed on the top of each cassette) and the number and status of every protocol plug. This is not possible in uploading systems, because the detector resides above part of the sample changer and blocks access to as many as five racks of samples.

Third, downloading uses gravity rather than mechanical force to lower the samples. Therefore, there is much less chance of sample jamming or breakage. Uploading sample changers force the sample up into the detector, and if there is an obstruction the sample could jam or break.

Benefits

- Full access to all samples for loading and unloading.
- Full view of all cassette IDs and protocol plugs to monitor counting status.
- Constant PMT response for accurate results.
- Safer sample changing; less potential for jamming.

The downloading, Varisette sample changer is standard on all Tri-Carb liquid scintillation analyzers.



◀ *Cut away view of sample vial loaded in the detector.*

Group PrioStat, Priority Counting Mode

Introduction

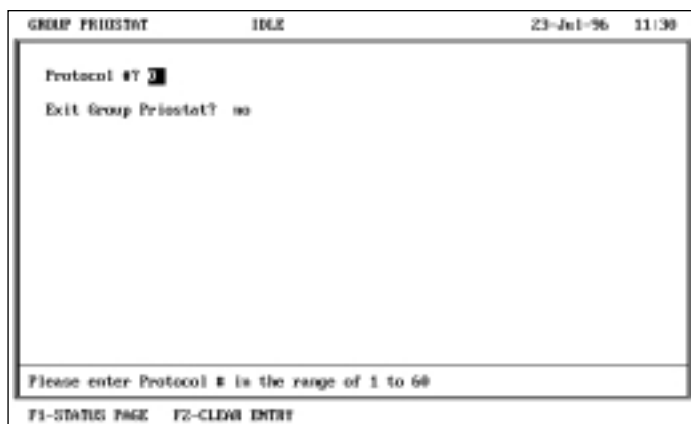
In busy laboratories, it is sometimes necessary to count samples immediately. Some LSCs require interruption or completion of a batch counting protocol before allowing priority sample counting, followed by manual restoration of the original batch counting protocol. Such systems are difficult to use, and can cause duplicate counting or missed counts. PerkinElmer Life Sciences' PrioStat feature allows the automatic interruption of currently counting protocol for a cassette of priority samples, and the automatic restoration of counting of the interrupted sample batch.

The unique PrioStat protocol plug of the Tri-Carb Varisette cassette system lets you interrupt the currently counting sample batch, count up to one full cassette of priority samples using any protocol, and automatically restore counting of the interrupted batch.

PrioStat is accessed from the instrument keyboard. In Tri-Carb models 2100TR, the PrioStat screen lets you enter the number of the protocol you plan to use for the priority samples. In the Tri-Carb 2900TR and 3100TR series models, the Run Menu lets you access either the Group PrioStat or the Sample PrioStat (see Sample PrioStat) feature. The instrument will use the shortest path to find and resume counting of the interrupted sample.

Benefits

- Group PrioStat lets you count priority samples fast, without waiting until the LSC is idle.
- Group PrioStat automatically finds the priority samples. You do not have to manually position them to count.
- Group PrioStat lets you walk away after your priority samples have counted, knowing that the Tri-Carb will automatically restore counting of the interrupted batch.



▲ *Group PrioStat model 2100TR.*



▲ *Group PrioStat is one of several special protocols available.*

Sample PrioStat, Priority Counting Mode

Introduction

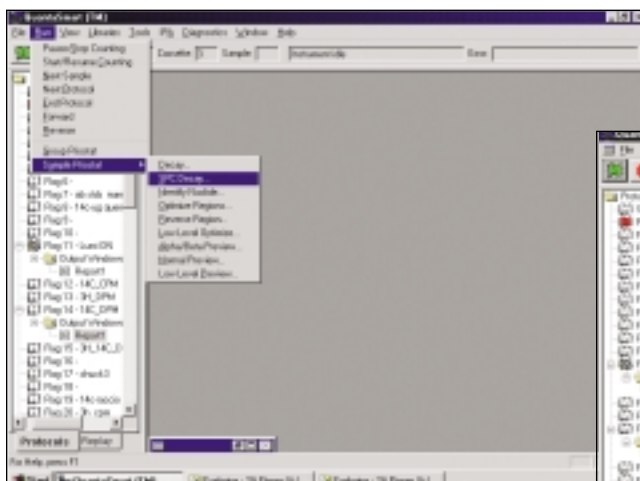
It is sometimes necessary to optimize counting conditions for unusual LSC samples, determine luminescence decay time, or even identify unknown radionuclides. The Sample PrioStat mode enables you to accomplish all of these tasks.

Sample PrioStat permits operation of your Tri-Carb in a completely manual mode. In Sample PrioStat you can select any available counting mode, preview sample count rates, define regions of interest or specific radionuclide settings, and even use automatic region optimization to optimize Efficiency²/Background for low activity samples. You can use reverse region optimization to determine the unquenched energy settings for single and dual label samples. You can select a nuclide ID mode which will identify single labeled ³H, ¹⁴C or ³⁵S, ³⁶Cl, ⁵⁵Fe, ⁶³Ni, and ³²P samples. With instruments equipped with the alpha/beta separation option, you can use Sample PrioStat to fine-tune the degree of misclassification of beta into alpha and alpha into beta. Sample PrioStat can be accessed at any time via the system menu.

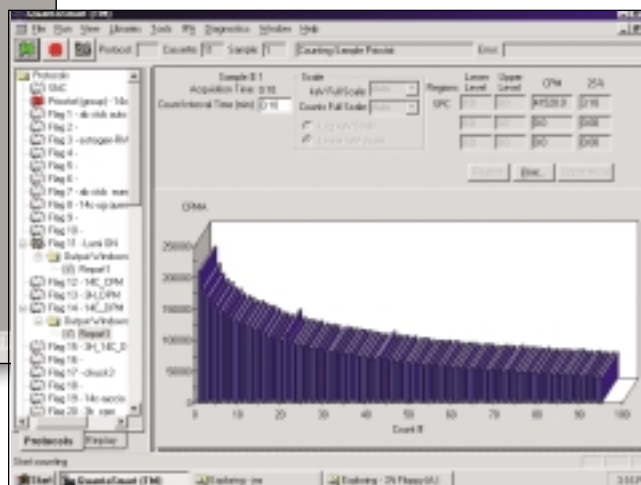
Benefits

- Sample PrioStat simplifies and speeds optimization of sample counting conditions by allowing manual operation of the Tri-Carb.
- Sample PrioStat lets you count and recount samples without having to define and count sample protocols.
- Sample PrioStat takes the guesswork out of dual label counting.
- Sample PrioStat may be accessed any time, even while other samples are counting. When you finish with Sample PrioStat, normal counting resumes without further operator intervention.

Sample PrioStat is a standard feature of Tri-Carb models 2900TR, 3100TR and 3170TR/SL. Sample PrioStat is available as an option for the Tri-Carb model 2100TR.



▲ Menu choices for Sample PrioStat (Tri-Carb models 2900TR, 3100TR and 3170TR).



▲ Luminescence Decay display in Sample PrioStat (Tri-Carb models 2900TR, 3100TR and 3170TR).

Worklisting with Extended Positive Sample ID

Introduction

With the growing need for GLP (Good Laboratory Practice) compliance, positive sample identification has become more important for virtually every type of laboratory. Now, using the PerkinElmer Life Sciences Tri-Carb worklisting feature, you can track your samples with more detailed information than you can get with the typical sample number on a printout or disk file. Worklisting actually lets you enter a detailed description of each and every sample you count. The detailed description is then printed out with the sample count result, and may be included in the disk file or RS-232 data string.

Worklisting with the Tri-Carb is easy. You create worklists by entering sample descriptions through the keyboard of the Tri-Carb while in the Worklist Application window, or you can create worklists on other computers and import the files into the Tri-Carb computer. Each sample may be described using up to 25 alpha/numeric characters, including the number of the cassette in which the samples were counted. You may also select to print the time and date each sample is counted.

You can create libraries of worklists for commonly performed assays, and recall them any time into the counting protocol. Worklists may also be exported to printers, and to disk storage through any available drive and path, including networks with the networking option.

The worklist feature provides automatic numerical incrementing for consecutively numbered samples of the same type. This greatly reduces the time required to create worklists for batches of samples from the same source, location or type. Individual sample descriptions, or entire worklists may be edited or deleted as required.

Benefits

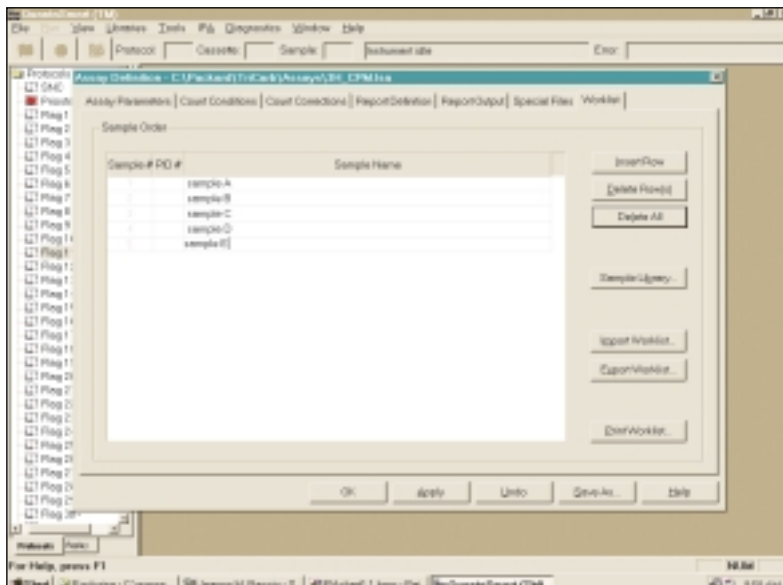
- Tri-Carb worklisting provides the most positive sample identification available for liquid scintillation samples.
- Worklisting helps you meet GLP requirements for sample identification.
- Worklisting is integrated into the system software; there is nothing extra to purchase.
- Worklisting provides a convenient means for you to use bar codes to label your sample vials.

Worklisting is a standard feature on Tri-Carb models 3100TR and 3170TR/SL.

Worklisting is an option on model 2900TR.

Positive cassette ID and date and time of sample counting are standard on all Tri-Carb systems with automatic sample changers.

Not available on model 2100TR.



Worklist screen for defining Sample IDs.



Assay printout showing Sample IDs.

TR-PDA (Time Resolved Pulse Decay Analysis) for Alpha Beta Separation

Introduction

Many samples for environmental analysis, nuclear power station monitoring, drinking water monitoring, oceanographic analysis, and nuclear waste cleanup require analysis of total beta and alpha radionuclides. However, in liquid scintillation counters, alpha radionuclide pulse height spectra overlap the pulse height spectra of higher energy beta spectra, such as ^{137}Cs , ^{89}Sr , and $^{90}\text{Sr}/^{90}\text{Y}$, due to the fact that beta radionuclides produce about ten photons of light per keV of energy, while the alpha radionuclides produce only about one photon of light per keV of energy. Therefore, it is necessary to employ a form of pulse discrimination that will differentiate alpha and beta pulses.

PerkinElmer Life Sciences' TR-PDA differentiates alpha and beta pulses according to their pulse decay characteristics. The pulse duration for alphas is typically longer than for betas, and depending on the cocktail and quench characteristics of samples, TR-PDA can achieve extremely low misclassification of betas as alphas, and alphas as betas. Misclassification can be less than 0.2% for samples with moderate quench.

TR-PDA provides sensitive automatic or manual adjustment of the PDD (pulse decay discriminator). The automatic alpha/beta standards mode scans the range of possible PDDs for both alpha and beta pulses, and determines the optimum cross-over without operator intervention.

In the manual alpha/beta standards mode, the range and number of PDD values are set by the operator to allow concentration of the PDD points within a specific range of values.

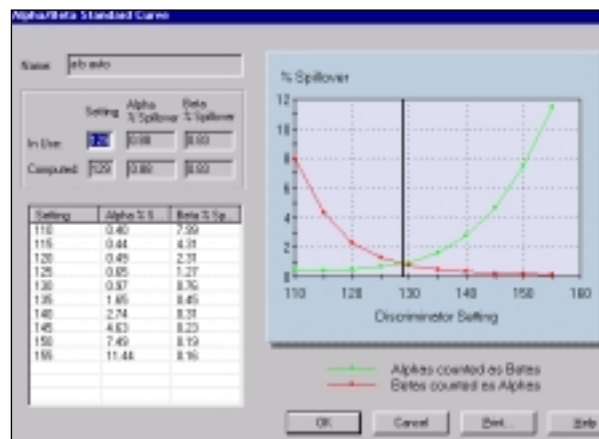
Once the optimum PDD is determined, it is stored, and can be used for any protocol in the instrument when using the alpha/beta counting mode.

Benefits

- TR-PDA enables automatic total alpha and total beta analysis of a variety of LSC samples.
- TR-PDA allows automatic optimization of alpha/beta separation and counting of samples with minimum misclassification.
- In Tri-Carb models configured with both TR-PDA and low level options, the low level mode and alpha/beta separation can operate simultaneously.
- The TR-PDA settings can be configured independently for each protocol.

The alpha/beta separation feature (TR-PDA) is optional for Tri-Carb models 2900TR, 3100TR and 3170TR/SL.

Not available on model 2100TR.



Alpha/Beta misclassification curve.



Worldwide Headquarters: PerkinElmer Life Sciences, Inc., 549 Albany Street, Boston, MA 02118-2512 USA (800) 551-2121

European Headquarters: PerkinElmer Life Sciences, Inc., Imperiastraat 8, BE-1930 Zaventem Belgium

Technical Support: in Europe: techsupport.europe@perkinelmer.com in US and Rest of World: techsupport@perkinelmer.com

Belgium: Tel: 0800 94 540 • **France:** Tel: 0800 90 77 62 • **Netherlands:** Tel: 0800 02 23 042 • **Germany:** Tel: 0800 1 81 00 32 • **United Kingdom:** Tel: 0800 89 60 46
Switzerland: Tel: 0800 55 50 27 • **Italy:** Tel: 800 79 03 10 • **Sweden:** Tel: 020 79 07 35 • **Norway:** Tel: 800 11 947 • **Denmark:** Tel: 80 88 3477 • **Spain:** Tel: 900 973 255

Windows, Windows NT and Excel are registered trademarks of Microsoft Corporation. Lotus is a registered trademark of Lotus Corporation.
All other trademarks or registered trademarks are the property of PerkinElmer Life Sciences, Inc.