Dual PSA discriminators to categorize marginal events for optimal alpha beta separation and improved quality metric.

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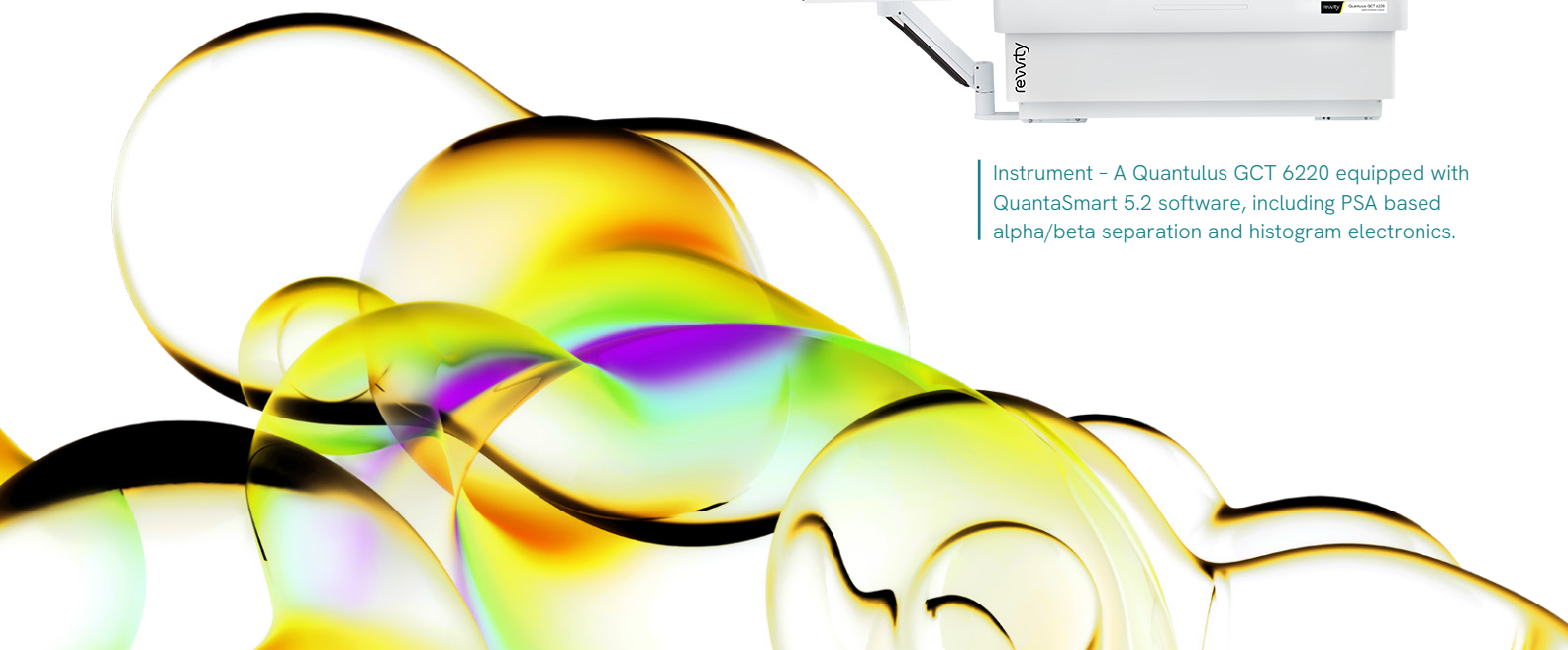
Introduction

In unknown samples that may contain a mixture of alpha and beta nuclides, a Pulse Shape Analyzer (PSA) technique is used to evaluate the pulse shape vs. pulse height of scintillation events, categorizing them as alpha (longer event tail) or beta (shorter event tail). Optimizing this process for the least amount of misclassification, or spillover, is desirable because spillover increases the noise or background levels in the opposing spectrum. In pulse shape analysis methods, some events will potentially spill-over to the opposing spectrum, particularly those events that are near the discrimination threshold. The introduction of dual PSA discriminators allows a chosen range of these marginal events to remain unclassified and be rejected from both the alpha and beta spectra. This dynamically reduces spillover, resulting in an improved Quality Metric and reduced Minimum Detectable Activity. Additionally, the advent of a PSA Histogram mode significantly reduces the counting time of alpha/beta standards by storing the PSA value for every scintillation event. This eliminates the need to count standards at a series of discrete PSA values to automatically and accurately determine the optimal PSA discriminator settings.

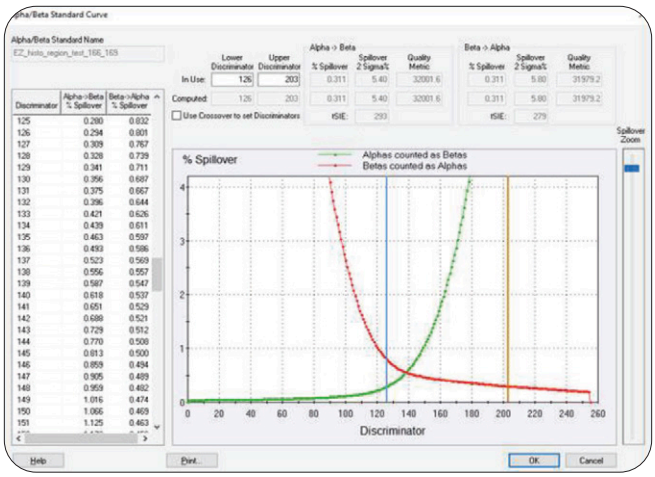
Instrument – A Quantulus GCT 6220 equipped with QuantaSmart 5.2 software, including PSA based alpha/beta separation and histogram electronics.



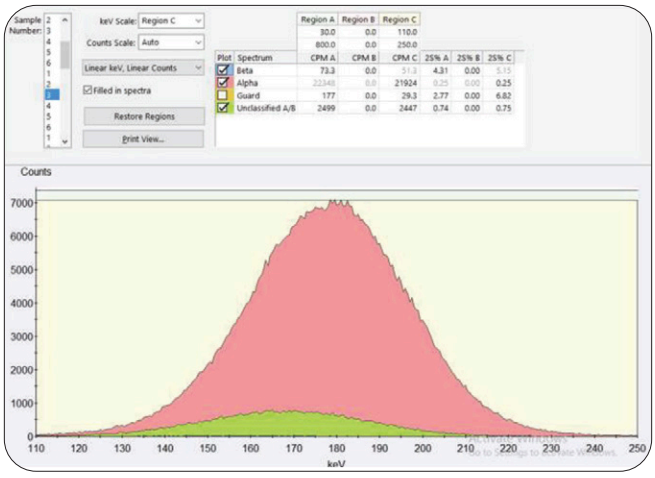
PSA histogram* and dual PSA discriminators*

A histogram of the PSA values from alpha/beta standards may be generated in order to find the optimal PSA discriminator value. The PSA histogram method requires that each standard only be counted once to find an optimal single PSA discriminator value, which can greatly decrease the counting time required.

The PSA histogram technique also allows a method for computing dual PSA discriminator values. Using dual PSA discriminator values, the instrument identifies events which may be difficult to correctly classify as alpha or beta, and sorts them as unclassified alpha/beta events. In doing so, percent spill is reduced and Quality Metrics are increased.



Spill curve with software optimized dual PSA discriminators.



Auxiliary spectrum memory (in green) into which unclassified alpha/beta events may be stored for further analysis.

Dual PSA Discriminator Performance Comparison

Table 1: A 90% reduction in alpha/beta standards run time is possible when using Histogram mode.

	Legacy mode - single PSA discriminator	Histogram mode - single PSA discriminator
Alpha/Beta standards run time	32 minutes	3 minutes

Table 2: Differences in percent spill and Quality Metric when counting 241Am and 90Sr standards in Ultima Gold LLT+ H2O. The Quality Metric is a figure of merit for alpha/beta standards where the relative efficiency of the standard is used as the "signal" in the calculation, and spill from the opposing radionuclide is used as the "noise". The use of dual discriminators can reduce spill and increase the Quality Metric by 50% when compared to single phase discriminators. The use of dual discriminators with optimized energy regions can greatly reduce spill and can increase the Quality Metric by almost an order of magnitude.

	Single PSA discriminator	Dual PSA discriminators	Dual PSA discriminators and optimized energy regions
Alpha into Beta spill	2.3%	1.2%	0.3%
Beta into Alpha spill	2.2%	1.5%	0.3%
Alpha standard quality metric	4254	6325	32002
Beta standard quality metric	4192	8322	31979

Replay and Reporting

Before and after changing from wide energy window regions to optimized energy regions using Replay. Alpha backgrounds are greatly reduced after Replay, while spill corrected CPMs remain accurate.

	Wide Window Energy Regions (before Replay)	Optimized Energy Regions (after Replay)
Alpha Background CPM	2.3	0.4
241Am CPM (no spill correction)	1190	544
241Am Spill Corrected CPM	434	429

Cycle 1 Results

Example report of recovered DPMs for 50K/500 DPM mixed 241Am/90Sr sample, and 25K/25K DPM mixed 241Am/90Sr sample. Sample #1 is first vial BKG.

S#	Count Time	CPMA	CPMA	DPM Beta	DPM Alpha
1	180.00	1.66	0.38	0.00	0.00
5	16.71	38415.75	543.97	50435.42	490.50
6	29.28	19106.06	21880.39	24987.87	25054.13

Low level Alpha/Beta DPM recovery

Automatic alpha/beta spill correction of CPM for unknown samples is now possible. Also, entering the DPMs of the alpha/beta standards into a user defined alpha/beta standards library before counting the standards assay allows the software to automatically recover DPMs of unknown alpha/beta samples.

Table 2: Count data from a 5 DPM 90Sr and 5 DPM 241Am mixed source using Ultima Gold LLT + H_2O. DPM recovery was consistently within 1 DPM from the actual amount of radioactivity in the sample for both isotopes.

	Optimized dual PSA discriminators and E regions
Alpha DPM (recovered)	4.4
Alpha efficiency	87%
Alpha background CPM	0.4
Beta DPM (recovered)	5.3
Beta efficiency	76%
Beta background CPM	1.7

Summary

When counting low level alpha/beta samples, low percent spill, low background, and good counting efficiencies are important factors in achieving accurate results. The PSA histogram method of optimizing a PSA discriminator value saves time since the alpha/beta standards do not need to be counted as many times as when using legacy methods. The use of dual PSA discriminators and optimized energy regions reduces percent spill and backgrounds to even lower levels while still providing good counting efficiency, which combine to provide excellent quality metrics and improved lower limits of detection. The ability to use Replay to modify energy regions and automatic spill correction and DPM recovery save time and simplify the data analysis process. The result is a system that is easier to use and can provide faster, more accurate results, even when low levels of alpha and beta activity are counted.

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