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Observations from Analysis of Alpha/Beta Radionuclides in Food Using Quantulus 1220, Quantulus GCT, and Hidex 300 SL Liquid Scintillation Spectrometers

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Presentation Outline

- Motivations
- Objectives
- Experimental Approach
- Sample Preparation
- Instrument Calibrations & Optimizations
- Observations & Discussions
- Summary

Motivations

- Increasing challenges in safeguard FDA-regulated products from radioactive contamination call for a broad range of complementary radioanalytical techniques
- Detection and quantification of alpha and beta radioactivity are essential parts of FDA food safety compliance and emergency response programs
- Advancement of FDA radioanalytical capability and surge capacity hinges on comprehensive metrology knowledge
- Development of scientific collaborations and partnerships to promote and advance regulatory science

Objectives

- To adapt the current FDA radioanalytical capability and surge capacity to more novel, efficient, and sensitive instrument technologies
- To identify the detection techniques that simplifies and expedites analysis of alpha and beta radionuclides in foods
- To ascertain performance characteristics of novel technology based liquid scintillation spectrometers
- To make effective use of instrumentations for different radioanalytical needs

Experimental Approach

- Three liquid scintillation spectrometers different in detector designs and pulse analysis techniques were used
- The following performance characteristics were studied:
  - ✓ Background
  - ✓ Cerenkov Counting
  - ✓ Simultaneous α/β Analysis
- The following α/β radionuclides were analyzed:
  - ✓ ^{3}H
  - ✓ ^{89}Sr and ^{90}Y
  - ✓ $^{90}Sr/^{241}Am$ and $^{90}Sr/^{239}Pu$

Detector Assembly & α/β Pulse Analyzer

Quantulus GCT

- ✓ Low background Pb shield
- ✓ Pulse amplitude comparison (PAC)
- ✓ α/β discrimination based on pulse shape (PSA)
- ✓ Bismuth germanium oxide (BGO) detector guard
- ✓ Guard compensation technology (GCT) algorithm

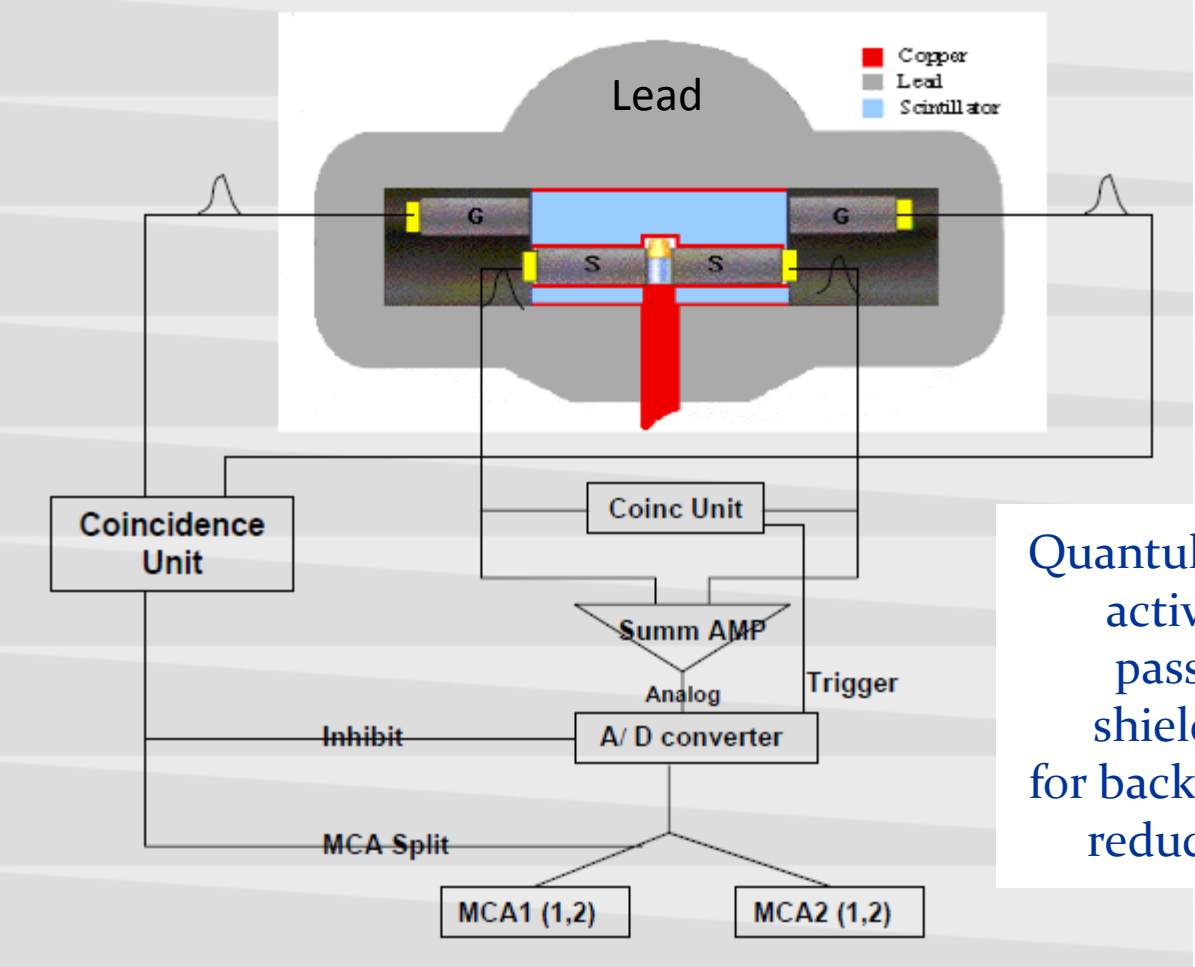
Quantulus 1220

- ✓ Low background Pb shield
- ✓ Guard detectors
- ✓ Pulse amplitude comparison (PAC)
- ✓ α/β discrimination based on pulse shape (PSA)

Hidex 300 SL

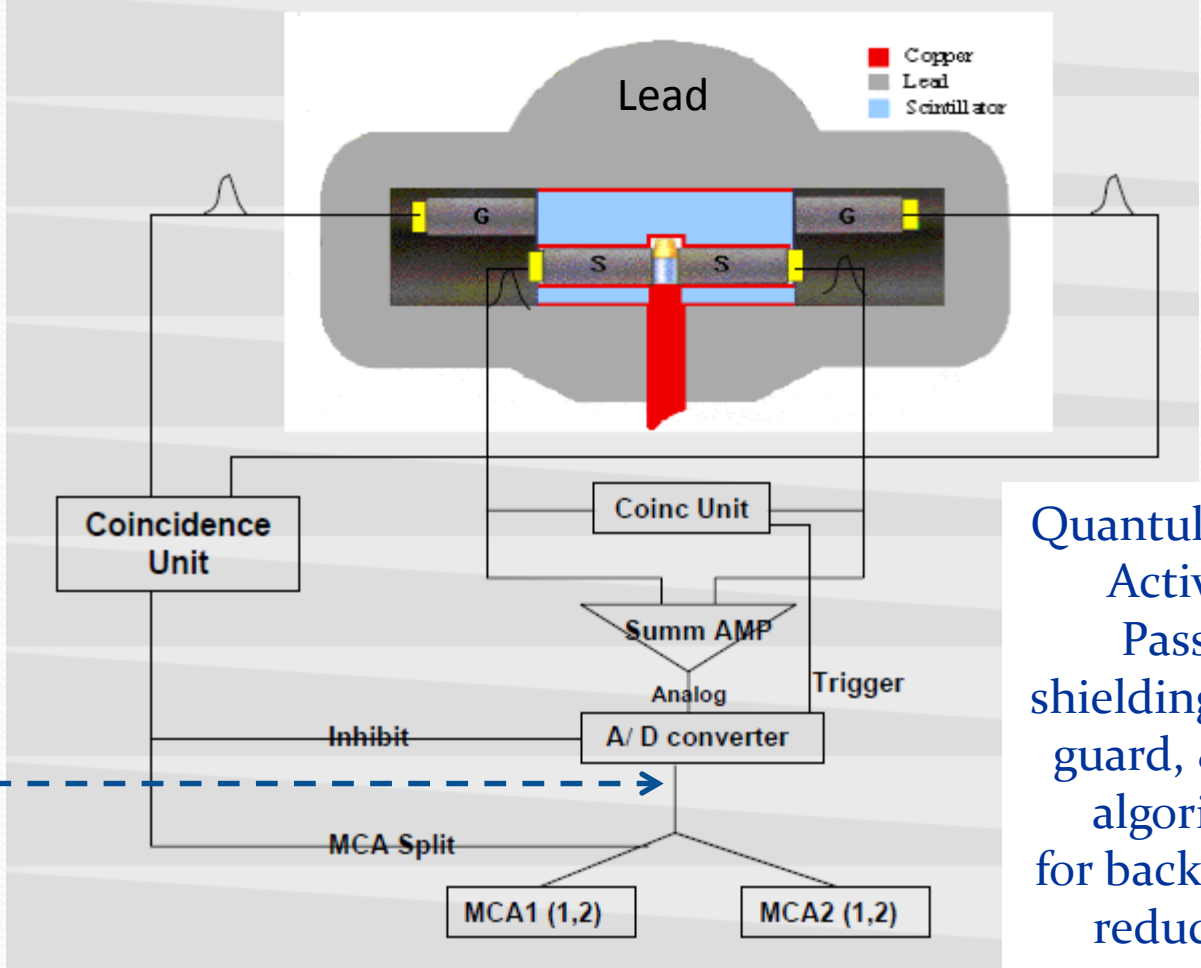
- ✓ Low background Pb shield
- ✓ Guard detector
- ✓ Triple PMT coincidence counting
- ✓ α/β discrimination based on pulse length index (PLI)
- ✓ Triple-to-Double Coincidence Ratio (TDCR)

Quantulus 1220 LSC



Quantulus 1220 active & passive shielding for background reduction

Quantulus GCT LSC



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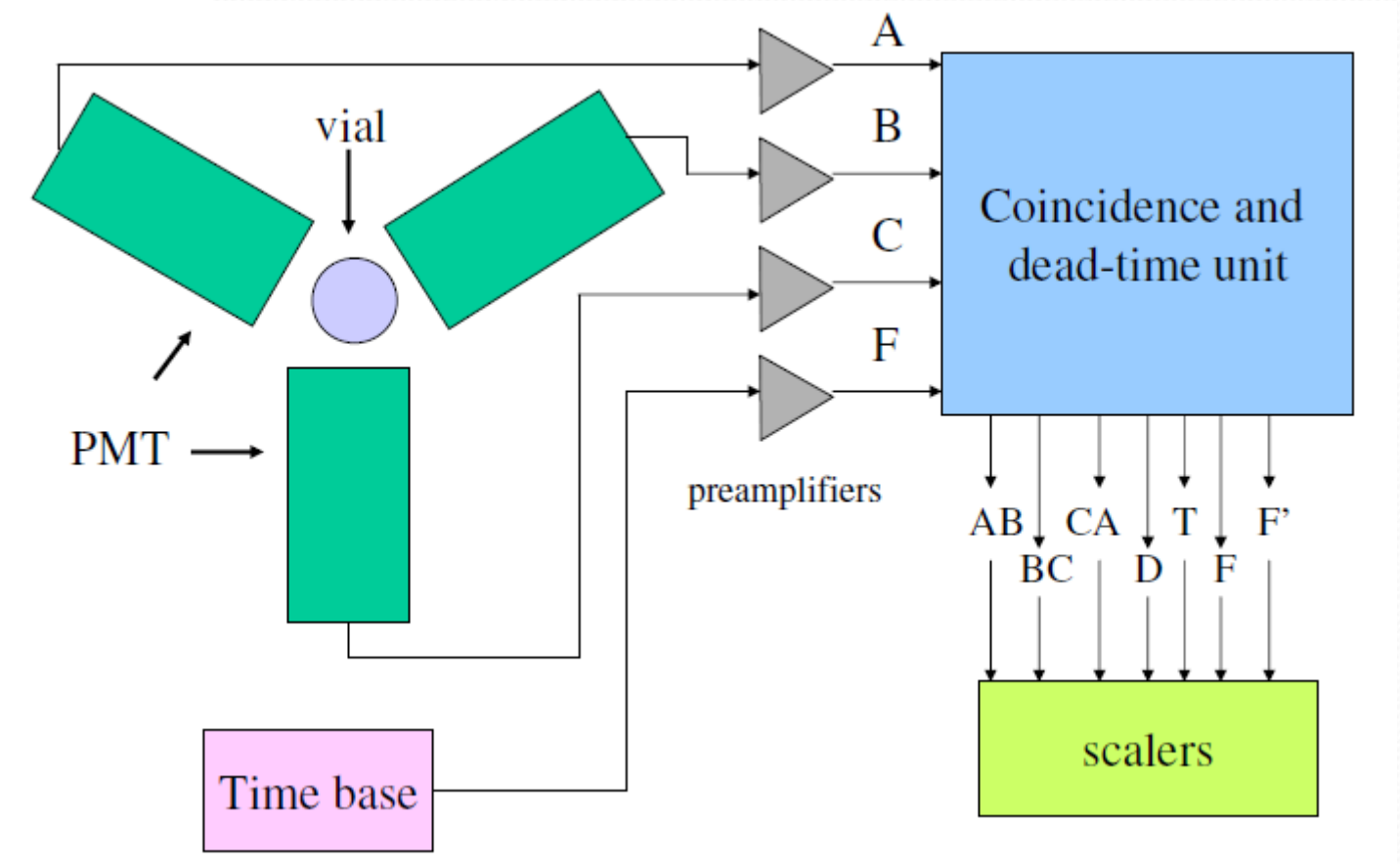
GCT Algorithm

Quantulus GCT Active & Passive shielding , BGO guard, & GCT algorithm for background reduction

TDCR Based LSC – Hidex 300 SL

Triple to Double Coincidence Ratio Counting (TDCR)



Sample Preparation

- Standard Preparation

For Analysis of ^{3}H:

10 mL H_2O
10 mL of Ultima Gold LLT
Teflon-coated plastic vial

For Cerenkov Counting of ^{89}Sr, ^{90}Y:

10 mL 0.1M HCl
Teflon-coated plastic vial

For Simultaneous Counting of $^{90}Sr/^{241}Am$, $^{90}Sr/^{239}Pu$:

3 mL of 0.5M HCl
17 mL of Ultima Gold AB
Low ^{40}K glass vial

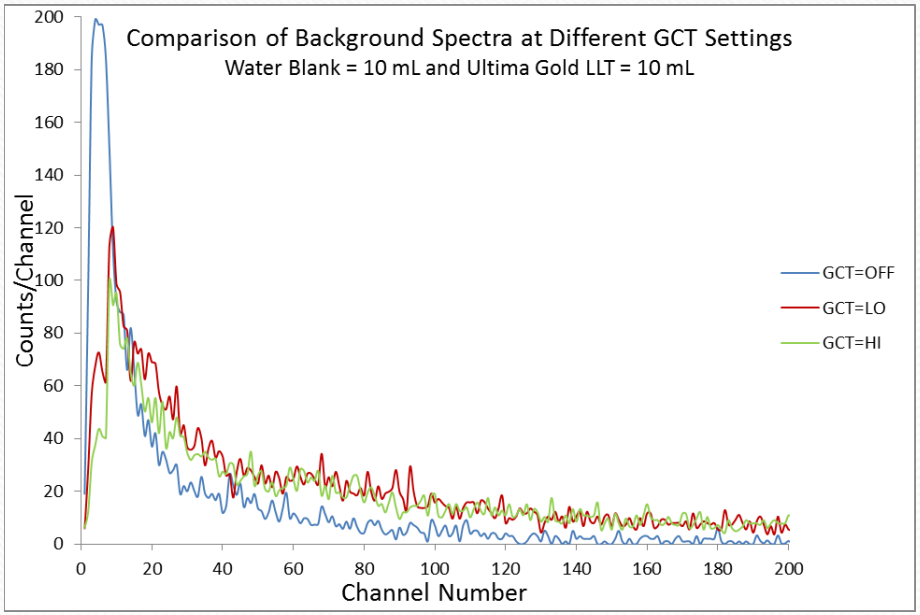
Instrument Calibrations & Optimizations

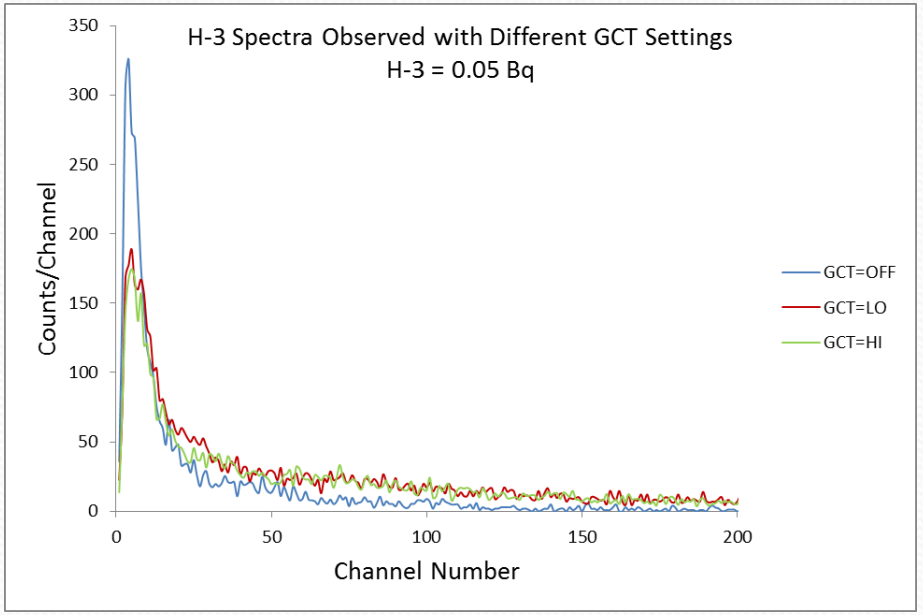
	^{3}H Efficiency %	Background CPM	E^2/B	^{89}Sr Efficiency %	Background CPM	E^2/B
Quantulus GCT (^{3}H window = 0 – 18.6 keV, ^{89}Sr window = 0 – 20 keV)						
GCT=Off*	19.04	1.50	242	32.04	1.95	526
GCT=Low	22.40	0.68	738	na	na	na
GCT=High	22.43	0.50	1006	31.82	1.0	1013
Quantulus 1220 (^{3}H window = 5 – 320 channel, ^{89}Sr window = 20 – 350 channel)						
	21.55	2.57	180	41.64	1.56	1111
Hidex 300 SL (^{3}H window = 5 – 250 channel, 5 – 350 channel)						
TDCR	12.71	3.43	47	na	na	na
TDCR	13.06	6.56	26	na	na	na

* All GCT=Off data shown uses Low Level Count Mode (LLCM)

Observations & Discussions

A significant background reduction was observed in the spectral region most critical for ^{3}H analysis.





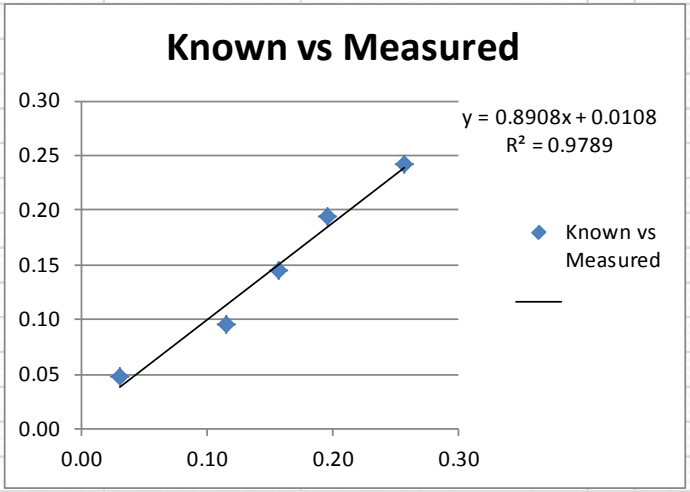
Benefited by lower background, the measurement accuracy for low level ^{3}H analysis was noticeably improved with Quantulus GCT when the GCT algorithm was applied.

Observations on ^{3}H Analysis

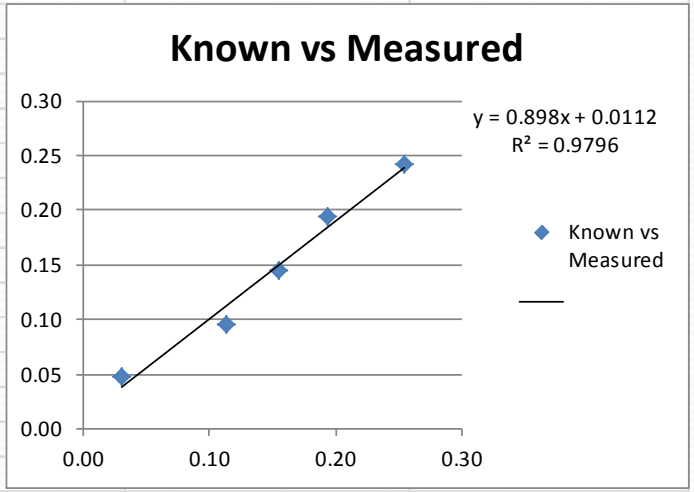
Quantulus GCT Water Results:

	0-18 kev	
Sample ID	Known	Measured
3H100215A	0.0483	0.0304
3H100215B	0.0964	0.1145
3H100215C	0.1446	0.1566
3H100215D	0.1936	0.1952
3H100215E	0.2423	0.2566
	2-18 kev	
Sample ID	Known	Measured
3H100215A	0.0483	0.0299
3H100215B	0.0964	0.1126
3H100215C	0.1446	0.1553
3H100215D	0.1936	0.1931
3H100215E	0.2423	0.2544

Window Range 0 – 18 keV



Window Range 2 – 18 keV



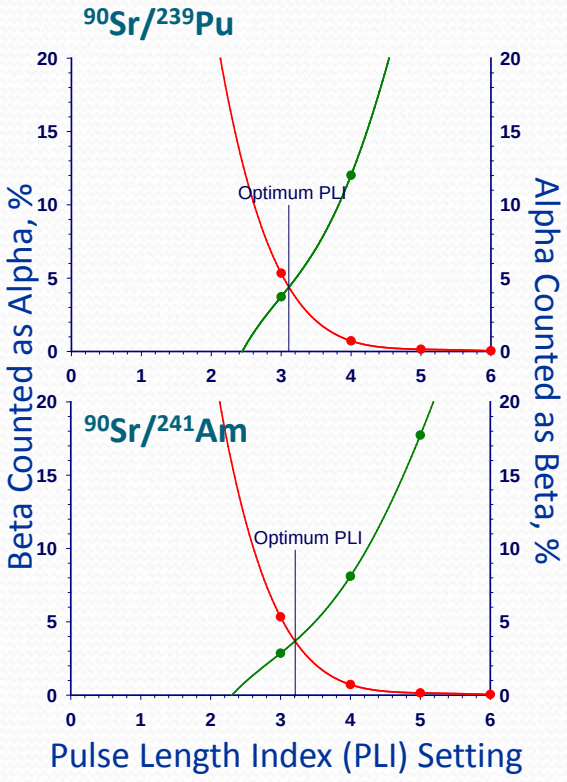
Known Sample Activity, Bq

Measured Sample Activity, Bq

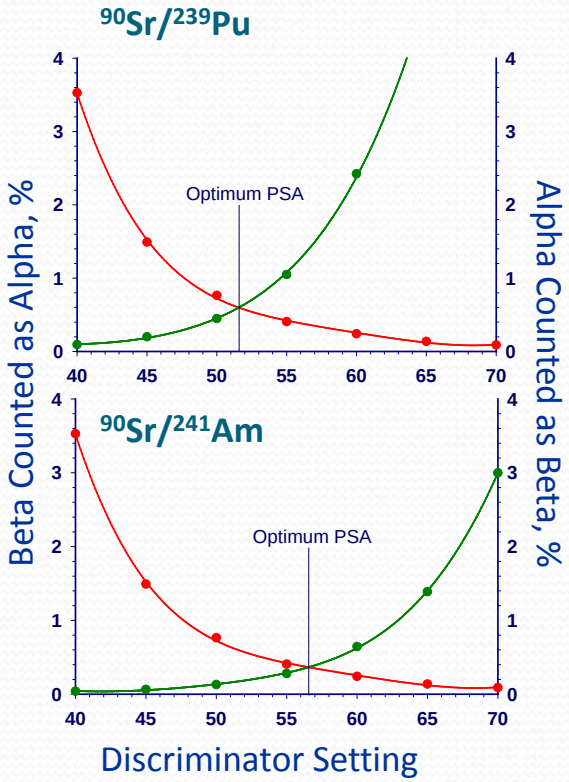
Quantulus GCT Food Results:

Food Matrix	Known, Bq/g	Measured Bq/g
Spiked Whole Milk	13.72 ± 0.44 (2s)	13.42 ± 0.51 (2s)
Spiked Fat-Free Milk	13.72 ± 0.44 (2s)	13.62 ± 0.50 (2s)

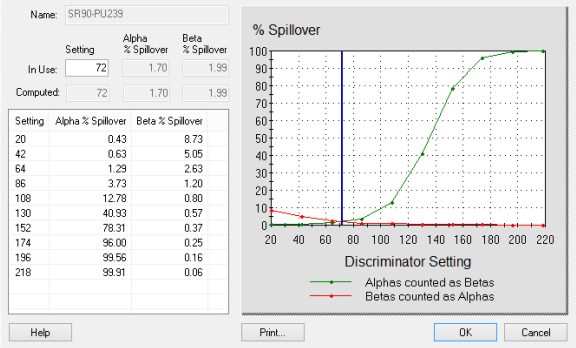
Observations on Alpha/Beta Spillover

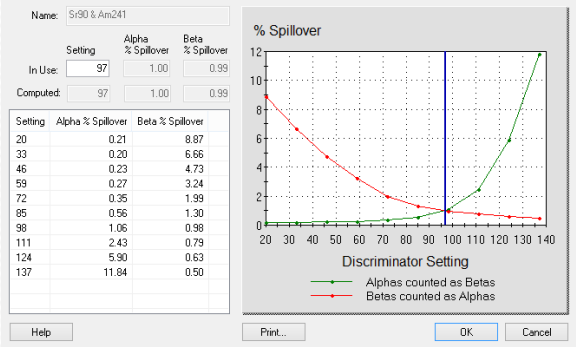


Hidex 300 SL



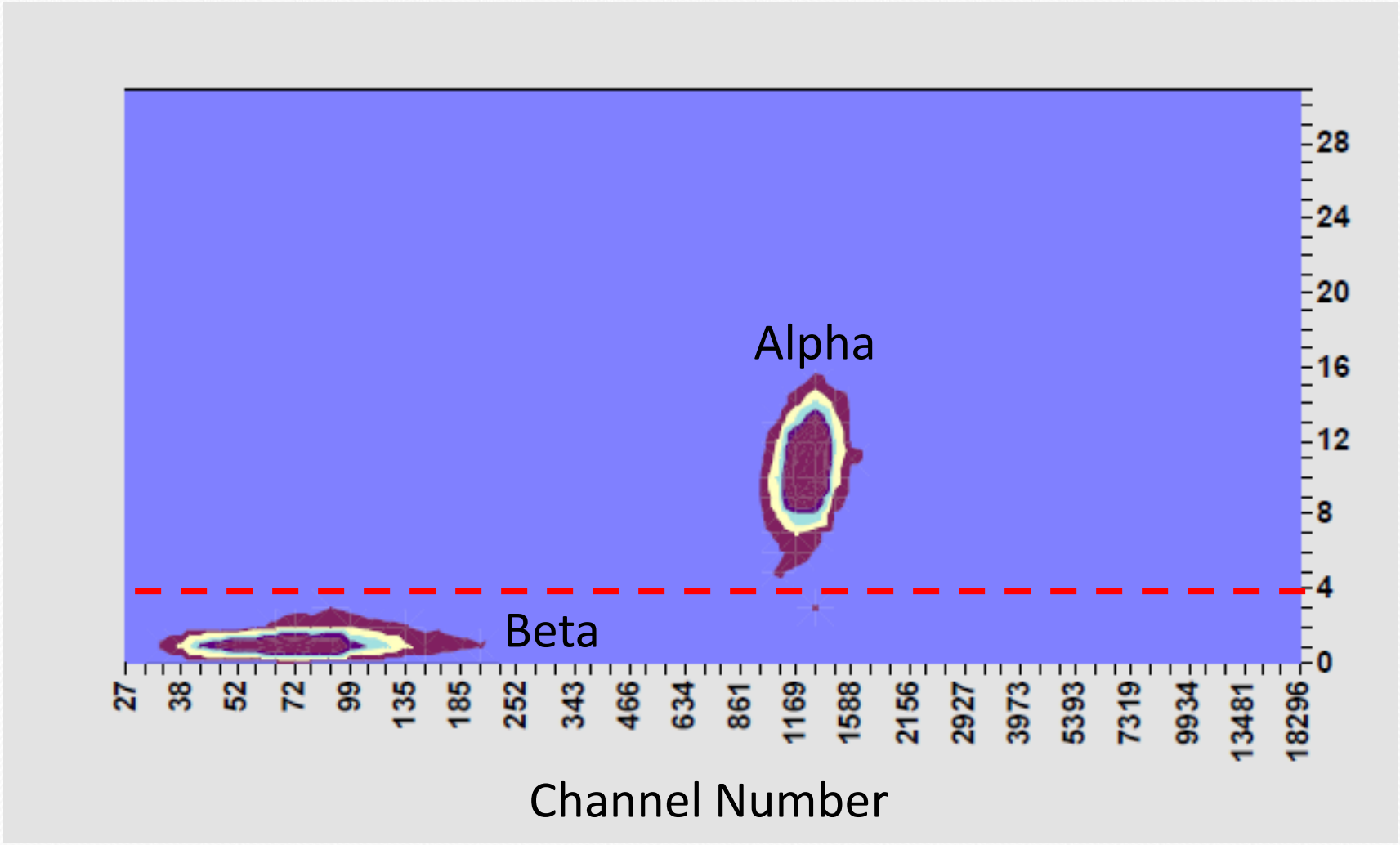
Quantulus 1220





Quantulus GCT

Visual Presentation of α/β Puls Separation with Hidex 300 SL



Observations on Alpha/Beta Spillover (con't)

LSC Counter	Alpha Counted as Beta, %	Beta Counted as Alpha, %	α/β Discriminator Setting
	$^{90}Sr/^{239}Pu$		
Quantulus GCT	1.70	1.99	72
Quantulus 1220	0.65	0.57	52
Hidex 300 SL	3.73	5.34	3
	$^{90}Sr/^{241}Am$		
Quantulus GCT	1.00	0.99	97
Quantulus 1220	0.34	0.38	56
Hidex 300 SL	2.85	5.34	3

^{90}Sr E_{max}= 0.546 MeV
^{90}Y E_{max}= 2.28 MeV

^{241}Am E_{α}= 5.49 MeV
^{239}Pu E_{α}= 5.15 MeV

Observations on Cerenkov Counting ^{89}Sr, ^{90}Y

Sample ID	Measured, Bq	Known, Bq	Difference, %
	Quantulus GCT		
SR89A1	0.948	0.948	0.02
SR89B2	1.882	1.896	-0.73
SR89C3	2.847	2.844	0.12
SR89D4	3.844	3.791	1.39
SR89E1	0.082	0.095	-13.6
	Quantulus 1220		
SR89A1	0.946	0.948	-0.15
SR89B2	1.918	1.896	1.18
SR89C3	2.828	2.844	-0.55
SR89D4	3.777	3.791	-0.37
SR89E1	0.107	0.095	12.4

Summary

- The GCT algorithm works reliably for analyzing low-level ^{3}H when Quantulus GCT spectrometer is calibrated and adapted to local environment.
- Quantulus 1220 still holds the benchmark α/β separation in simultaneous α/β analysis but its superiority in background reduction is surpassed by the GCT technology.
- Hidex TDCR-based LSC provides unique advantage over traditional LSC in sample quench determinations.
- Lack of an option for fine-tuning α/β discriminator excludes user from using the optimum discriminator setting

Summary (con't)

- Quantulus GCT LSC allows user to reprocess the spectrum that had already been collected with a new set of parameters without recounting the samples
- Hidex 300 SL uses Excel-based data file which can be easily used by user's Excel spreadsheet for automated sample activity calculation
- The application software for Quantulus GCT LSC was found to be easy to use. The entire well-known TriCab's menu layout is kept as it was with a few new add-on options
- Hidex 300 SL allow almost quantitative activity concentration determinations without standardization

Acknowledgment

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Questions?