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Title: High-dose neutron detector project update

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Report

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High-dose neutron detector project update

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MPACT Working Group Meeting at
Wash. DC, Aug 9-10, 2016

Outline

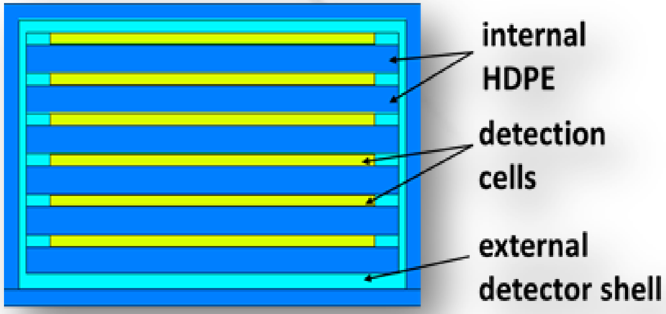
- Background - Update
- B-10 parallel-plate technology for high radiation dose application
- PDT corrugated sealed cell design and fabrication
- Boron coating method and efficiency improvements
  - Gamma-ray resistance from HV plateau shape
- Detector test results
  - Detector stability tests
- Path Forward

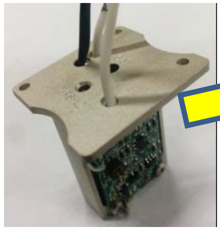
Focus Areas for Gamma Resistance

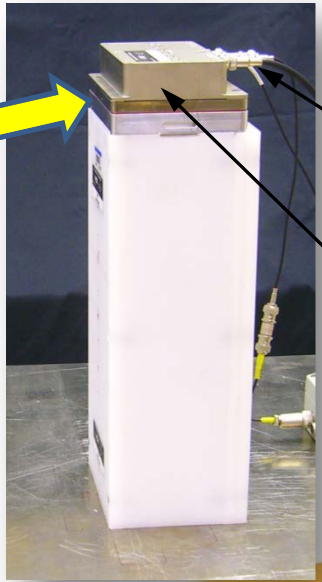
- Detector ^{10}B materials and coating improvements
- Detector design improvements for better neutron/gamma discrimination performance
- Fast amplifiers for rejection of the slower gamma pileup
- Amplifiers on each cell with list-mode readout
- Parallel readout to shift register modules (eg. JSR-15)
- High counting rates capability > 10 MHz

^{10}B-lined Parallel Plate Technology Description (devloped with NNSA/NA-241 funding)

- System of boron-lined parallel proportional chambers developed by Precision Data Technology, Inc. (PDT)
- Plates coated with ^{10}B metal particles for the neutron capture reaction
- HDPE layer between each cell for neutron thermalization to reduce neutron self-shielding in the B coatings
- Fast time constant amplifiers on each of the 6 counting cells to allow MHz counting rates

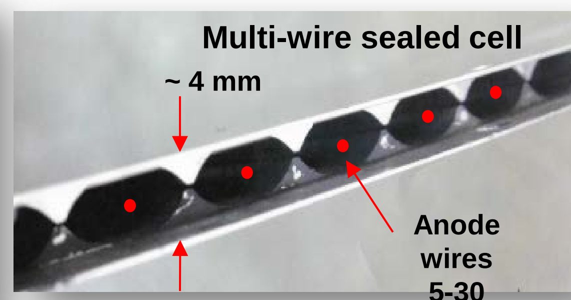



Fast-amp.



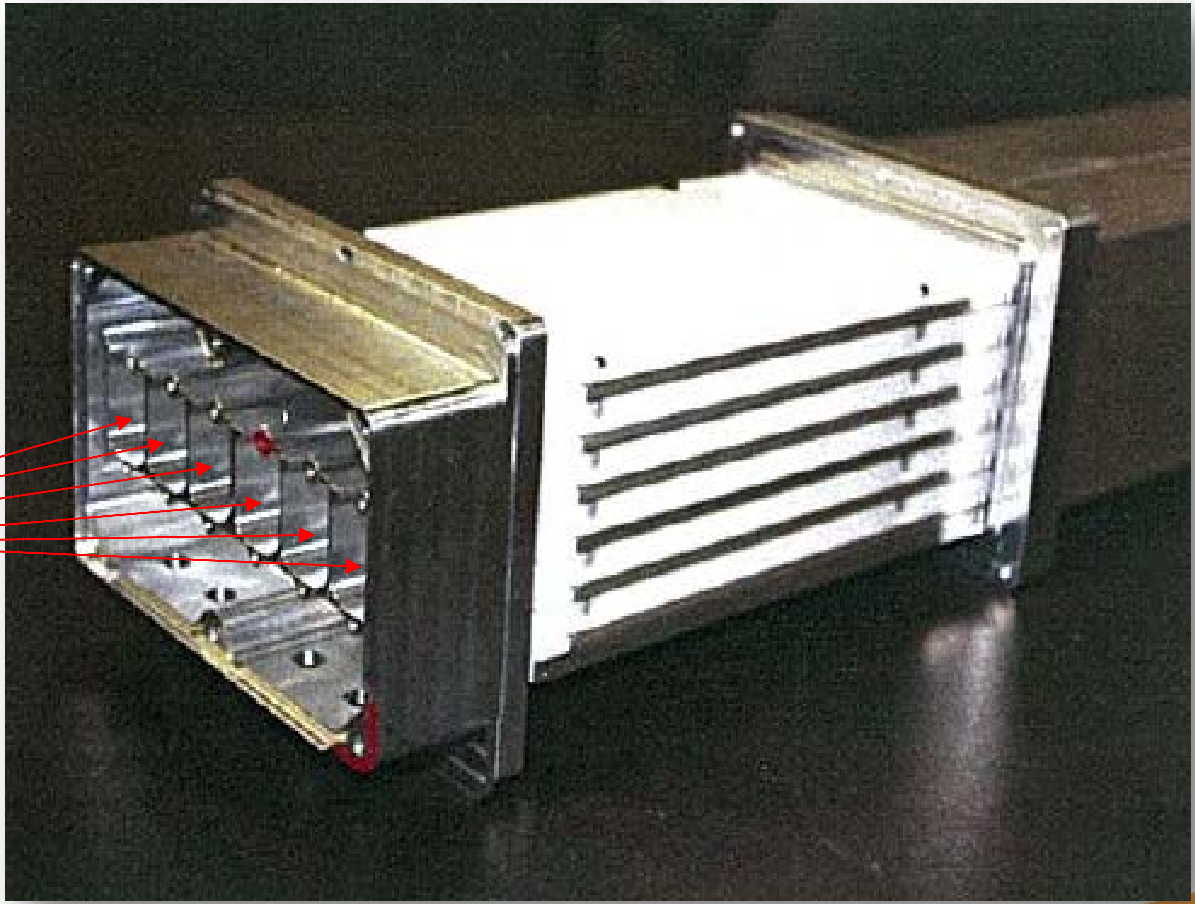
PDT sealed-cell concept with corrugated boron coated cells

- Each cell individually sealed
- No organic materials inside sealed cell
- High temperature cleaning treatment possible for high gas purity
- Stability equal to 3He tube system



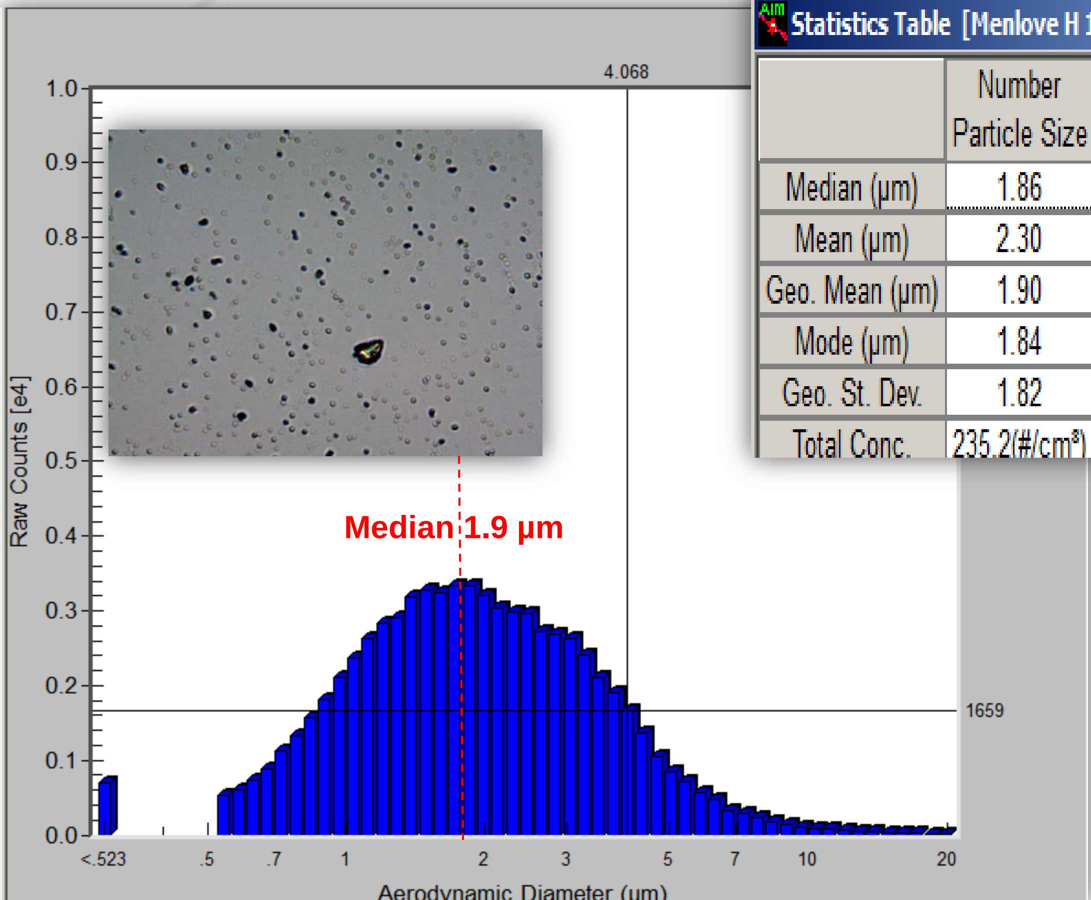
Electronics Improvements for High Radiation Dose Applications

6-cell PDT fast rise-time amplifiers (6) for high rate counting (> 10MHz)



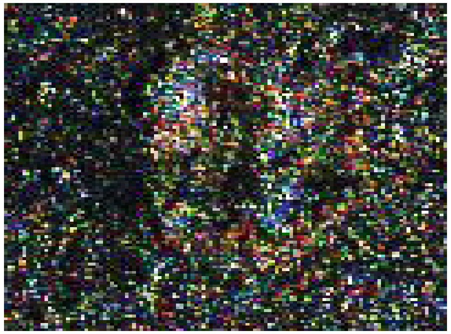
Pulse rise time < 200 ns

Boron Particle Size Distribution via Aerodynamic Separation Analysis



Statistics Table [Menlove H 11-16-2015 Boron B1.A21]

	Number Particle Size	Surface Particle Size	Mass Particle Size
Median (µm)	1.86	4.17	7.12
Mean (µm)	2.30	5.52	8.54
Geo. Mean (µm)	1.90	4.36	6.96
Mode (µm)	1.84	4.07	17.2
Geo. St. Dev.	1.82	1.98	1.95
Total Conc.	235.2(#/cm³)	2.39e+03(um²/cm³)	3.33(mg/m³)



3-D surface layer

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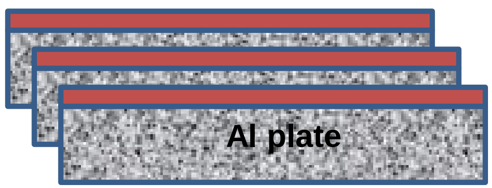
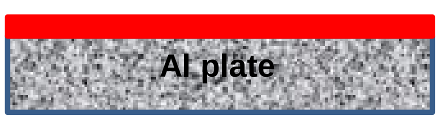
Improvements in Coating Method for Better Gamma Resistance

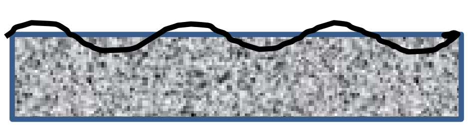
Boron coating



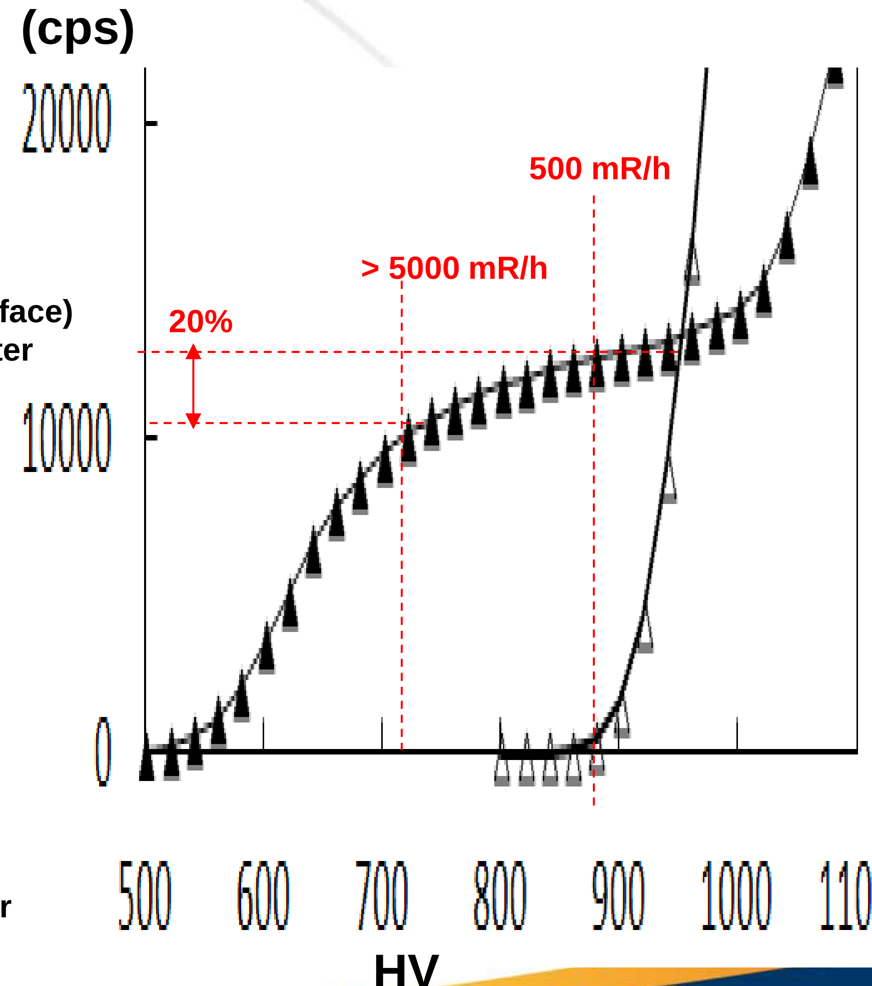
- More plates (more surface)
- Gamma increases faster than neutron



- Better ^{10}B surface coating
- No gamma increase but neutron increase



- Corrugated surface
- gamma increase greater than neutron increase

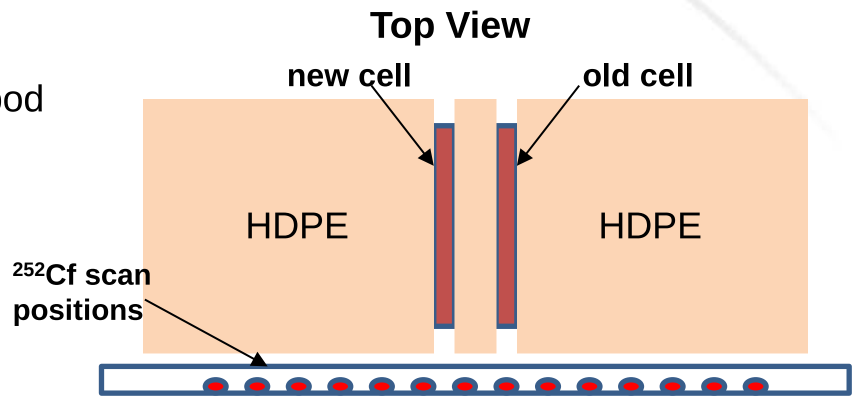


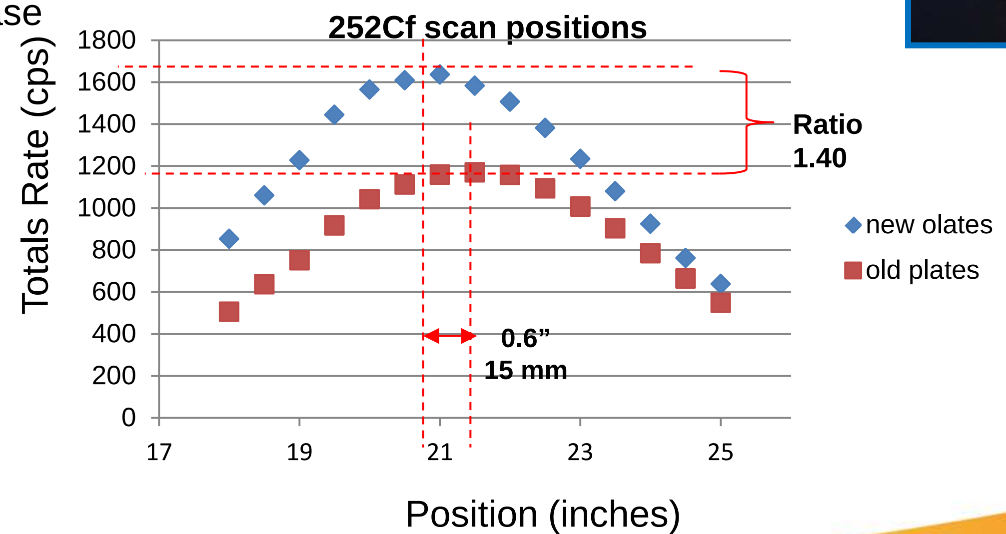
Improvements in Boron Coating Methods

- 2-cell tests (old vs. new)
  - Original cell from 2013 pod
  - New cell with advanced coating materials

  Results gave a 30-40% increase in efficiency for new coating method

  Gamma pileup has no increase





New surface coating

Better neutron/gamma ratio

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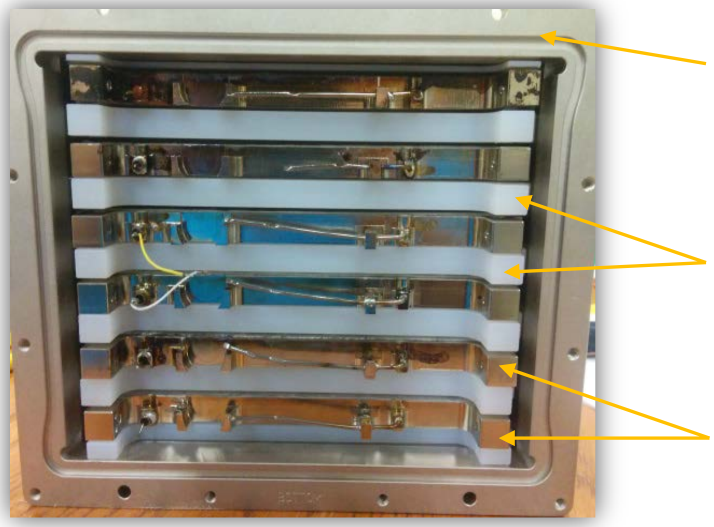
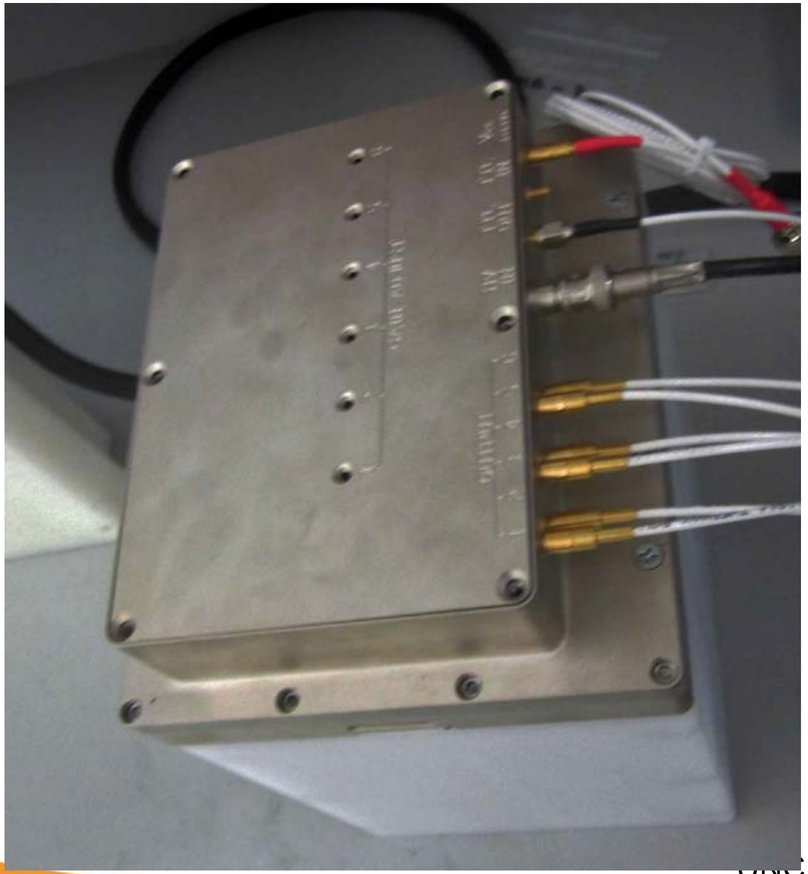
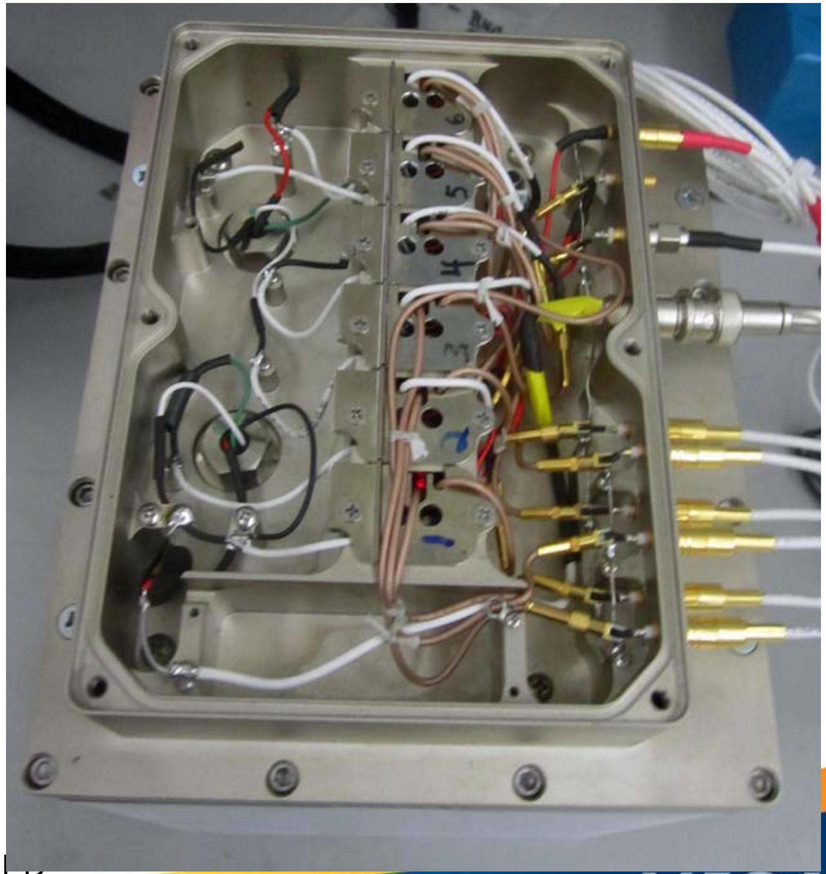
New 8” PDT boron plate detector (6 sealed cells)



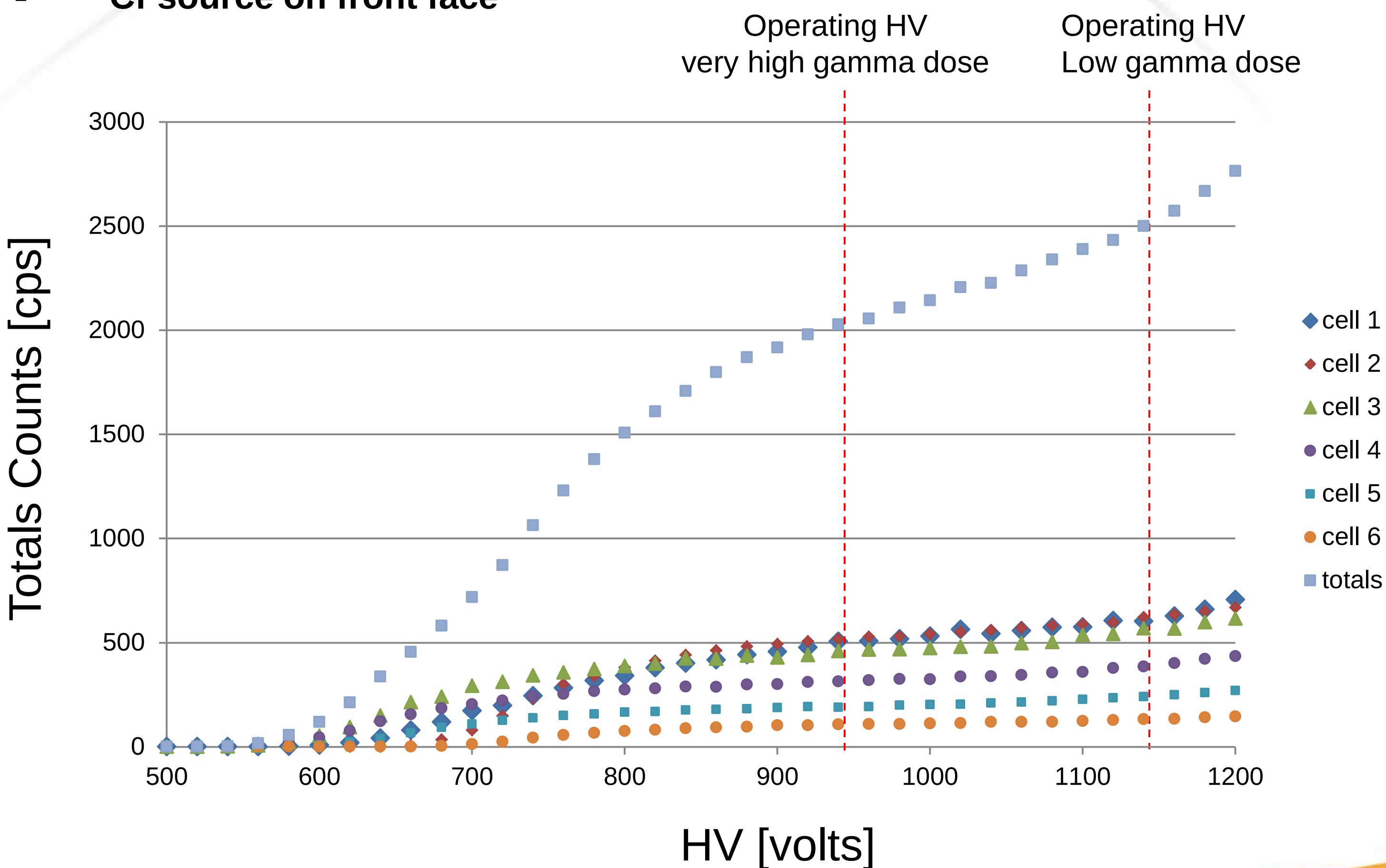
6 Cell PDT 8” Pod with TTL in and out plus 6 List mode outputs





Plateau curves for new 8” PDT boron plate detector (6 sealed cells)

- **List mode readout for 6 amplifiers**
- **^{252}Cf source on front face**



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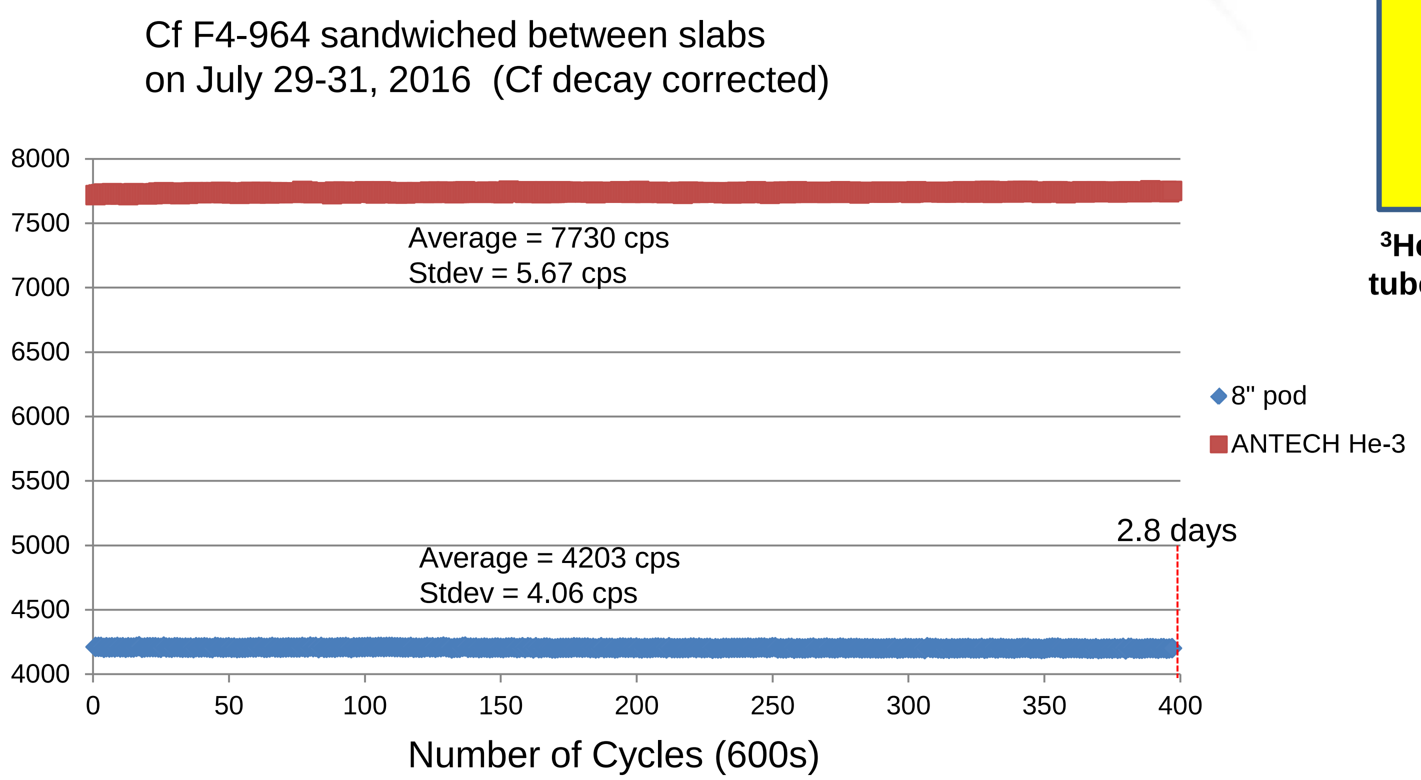
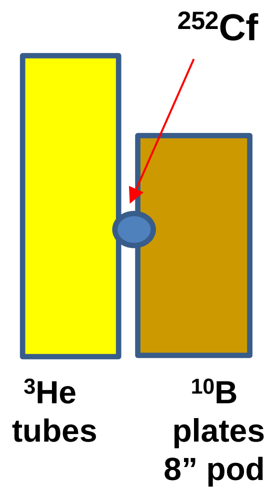
Stability measurements for boron-10 plates and He-3 tubes





Amplifier Improvements for high Counting Rates and Gamma Rejection

- An amplifier on every cell to reduce dead-time related counting losses to provide counting rates > 10 MHz
- Compact package with anti cross-talk shielding and moisture sealing
- List mode readout to give the time and cell location of every pulse
- Neutron energy information via cell position vs. poly moderator for (front/back ratios)

Summary

- Improvements in both boron coating and signal amplification have been achieved
- Improved boron coating materials and procedures have increase efficiency by ~ 30-40% without the corresponding increase in the detector plate area
- Low dead-time via thin cell design (~ 4 mm gas gaps) and fast amplifiers
- Prototype PDT 8" pod has been received and testing is in progress
- Significant improvements in efficiency and stability have been verified
- Use commercial PDT ^{10}B design and fabrication to obtain a faster path from the research to practical high-dose neutron detector

Path forward

- Fabrication of sealed-cell detector pod based on MCNP optimized design with 6 fast amplifiers and list mode readout completed
- Neutron and gamma sensitivity tests in progress
- List mode and pulse train timing for amplifiers in progress
- In-house evaluation of optimized design using LANL shielded cell capability (1-100 R/h) for high gamma dose applications
- Planning discussions with INL planed for field trial during FY17