A Novel Calibration Scheme of Effective Volume in a Large Segmented Liquid Scintillator Antineutrino Detector

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For the PROSPECT Collaboration

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Talk CN.00003

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第5回 日米物理学会 合同核物理分科会
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Hilton Waikoloa Village,
Hawaii Island

PROSPECT: Two Goals

See M. Mendenall, Talk LA.00001, Saturday morning

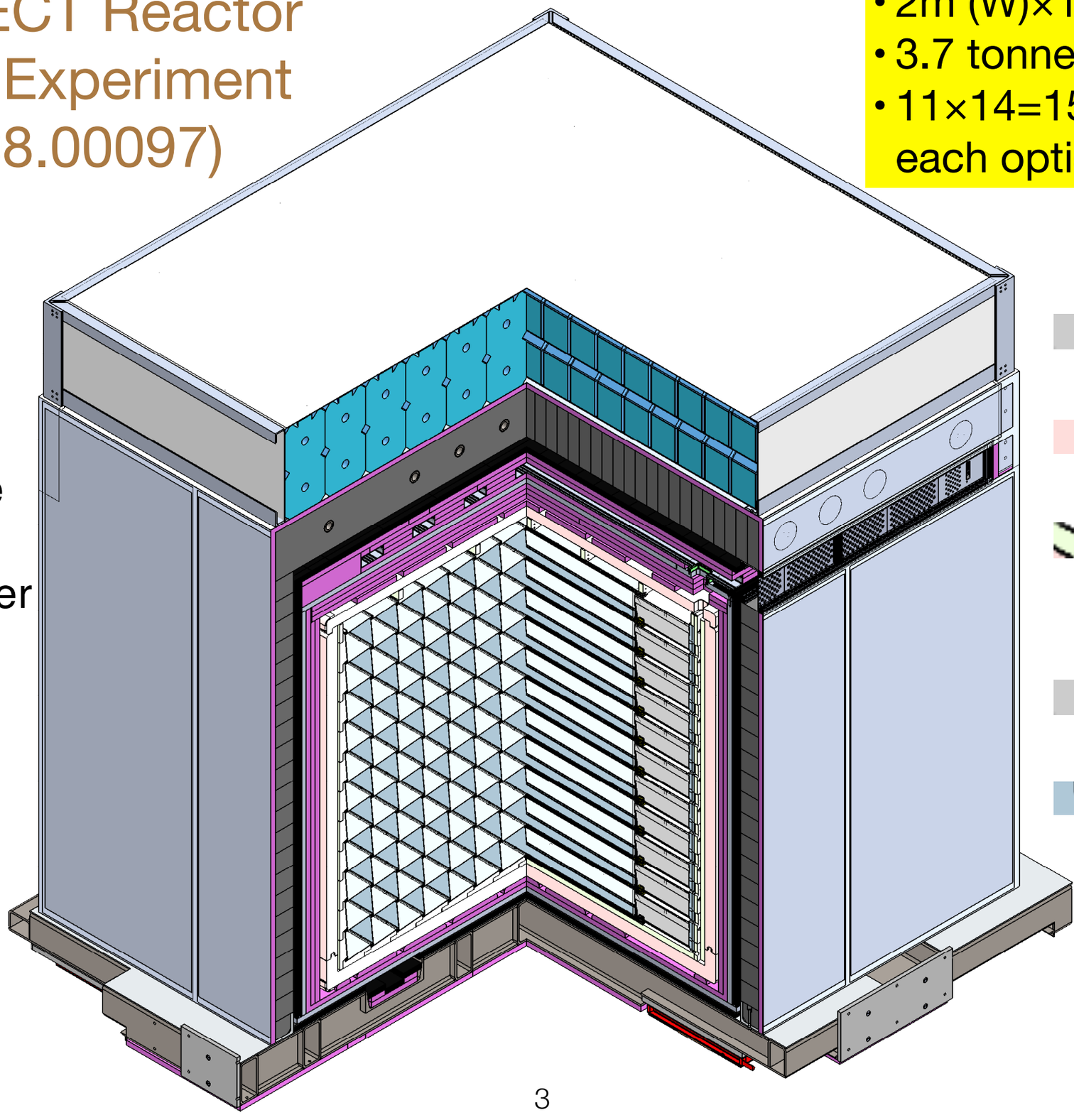
(1) Search for sterile neutrino oscillations in with Δm^2_{14} near $1 eV^2$ near a reactor core and a highly segmented detector

(2) Perform a precision measurement of the neutrino spectrum from a reactor core made of highly enriched in ^{235}U

PROSPECT@HFIR

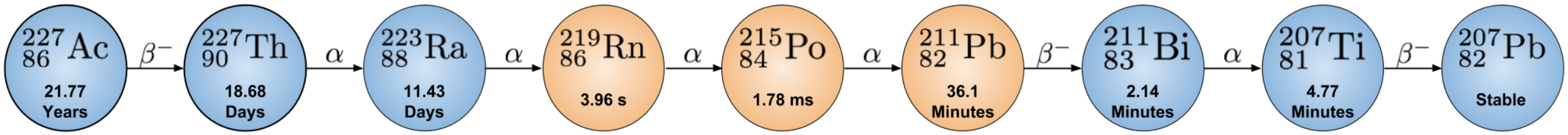
The PROSPECT Reactor Antineutrino Experiment (arXiv:1808.00097)

- 2m (W)×1.6m (H)×1.2m (L)
- 3.7 tonnes ^{6}Li-loaded LS
- 11×14=154 segments, each optically isolated



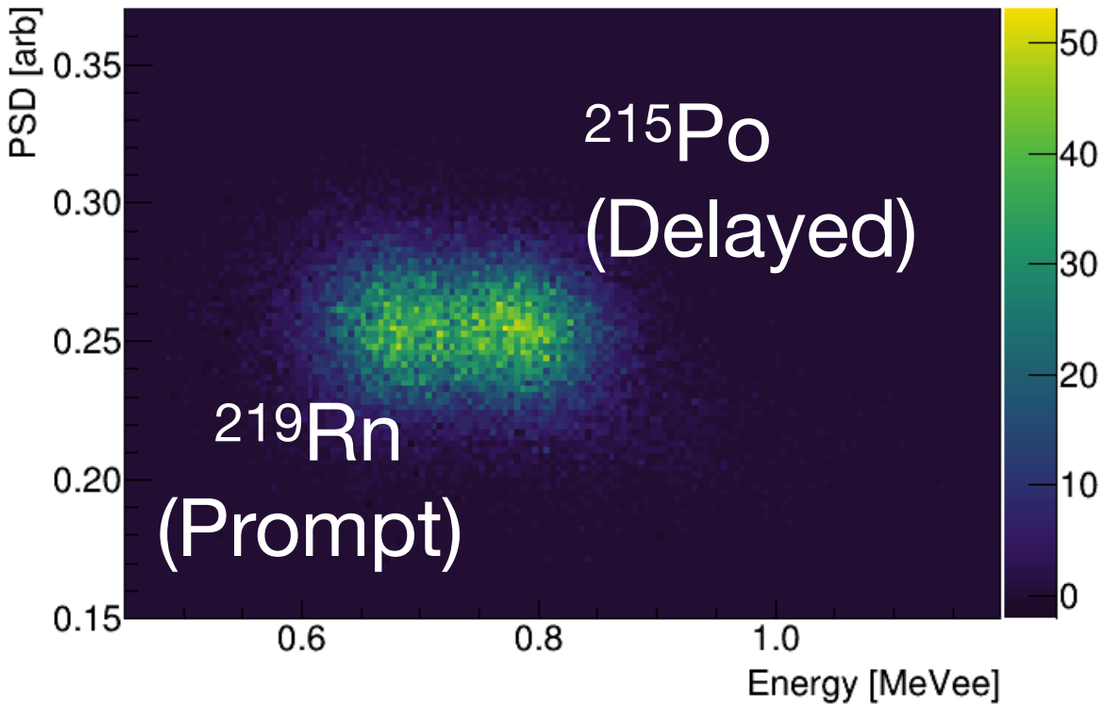
^{227}Ac Calibration Scheme

D. Berish, D. Jones (Temple), D. Jaffe (BNL)

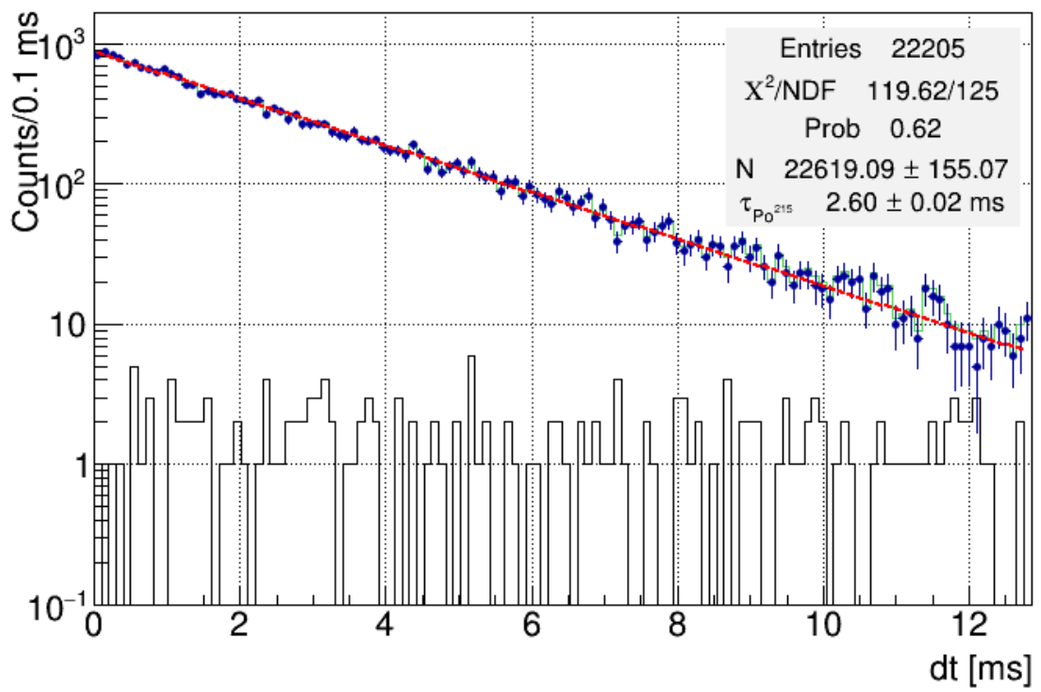


<u>The idea</u>: Spike the LiLS with a tiny amount of ^{227}Ac and monitor each segment separately with ^{219}Rn→^{215}Po+α→^{211}Pb+α decays

Easy to identify RnPo's



Observe Rn→Po lifetime



Prototype Measurements

Discussed by D. Berish at DNP 2017; NIM paper in progress

Does actinium dissolved into the LiLS…

- … adsorb onto materials into the neutrino detector?
- … produce an intolerably high background?
- … degrade the performance of the scintillator?

All answers are “No”, based on two extended studies:

Controlled adsorption w/high ^{227}Ac concentration

Glass vials containing samples of all materials in contact with LiLS in full scale detector

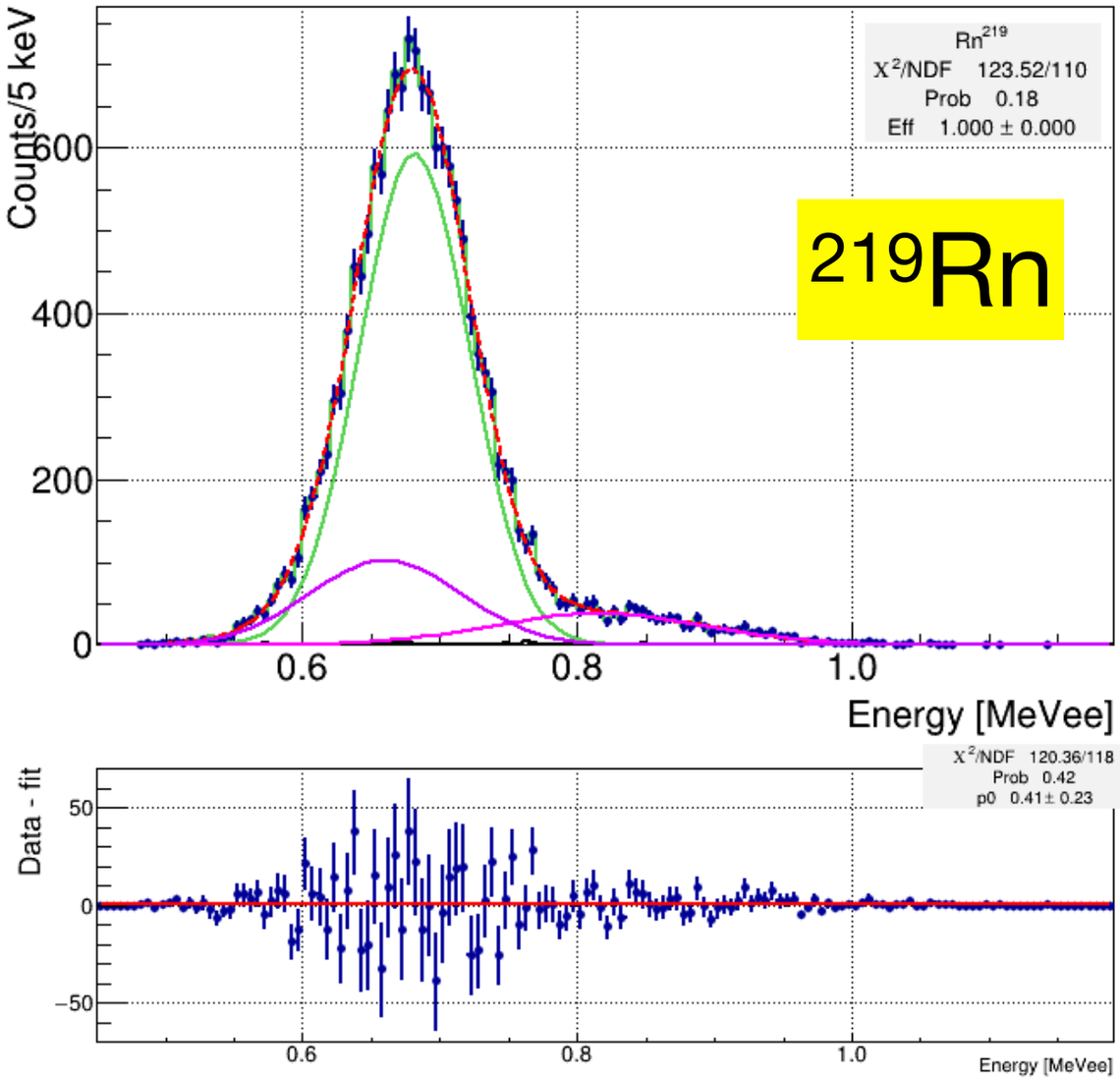
Spike in the P50* PROSPECT prototype

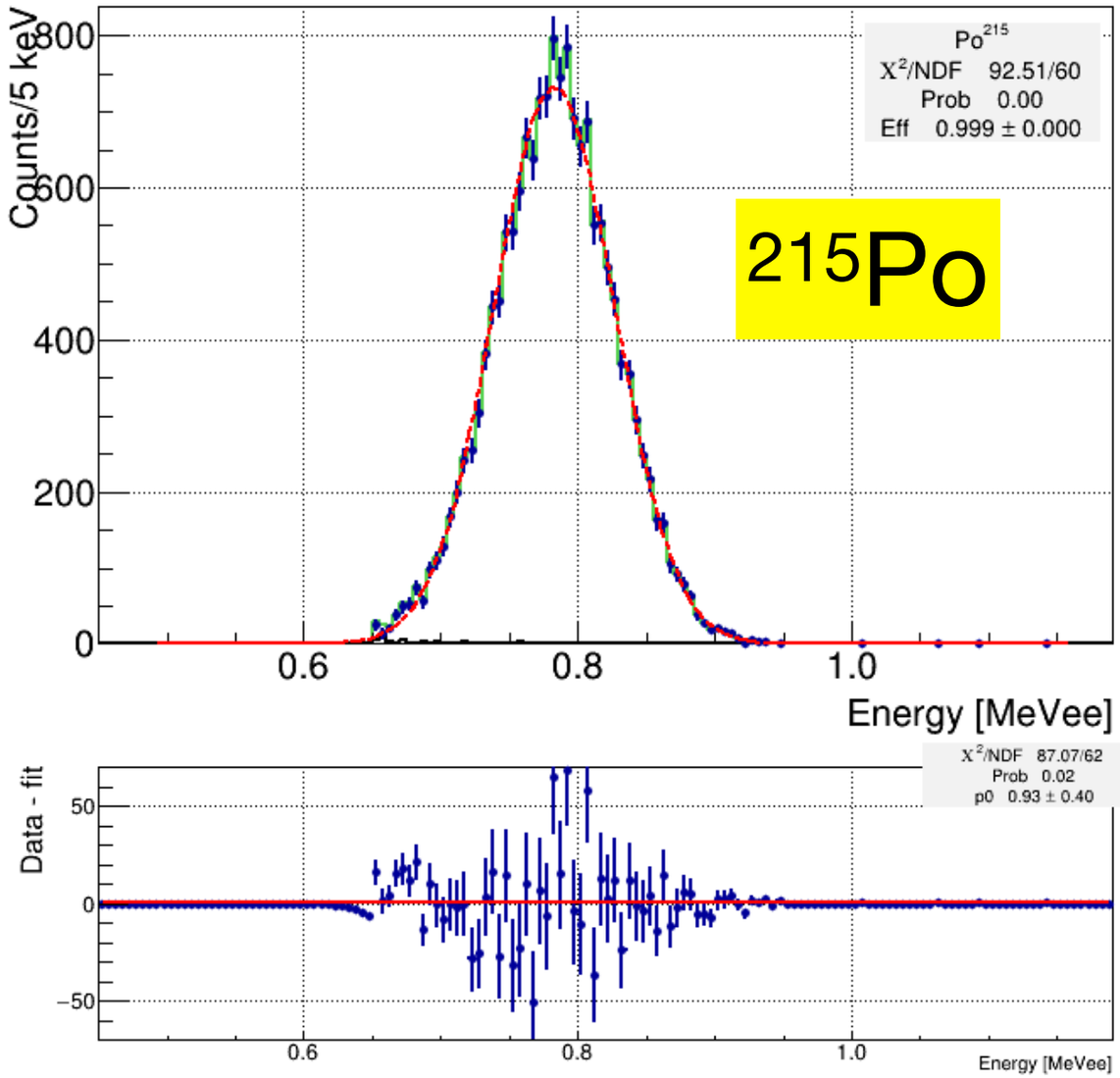
Measured activity over several months in two-segment detector, also allowing us to test relative rate stability

* See JINST 13 (2018) no.06, P06023

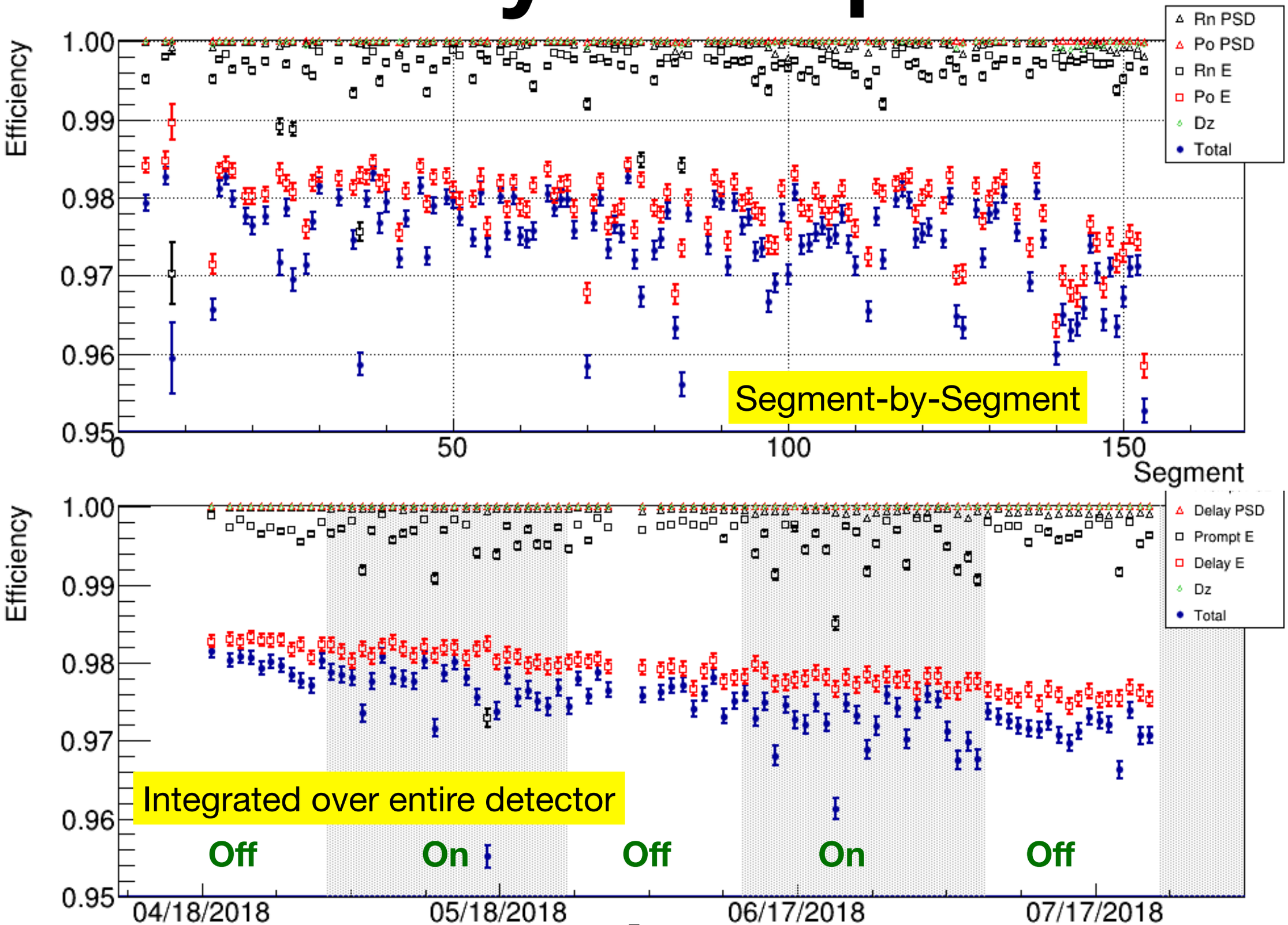
^{227}Ac Detection Efficiency

- Cuts are made in Energy, PSD, Δz, and Δt in each segment
- Fits are performed on sample to determine what is missed
- Example: Energy distribution for “prompt” and “delayed”:

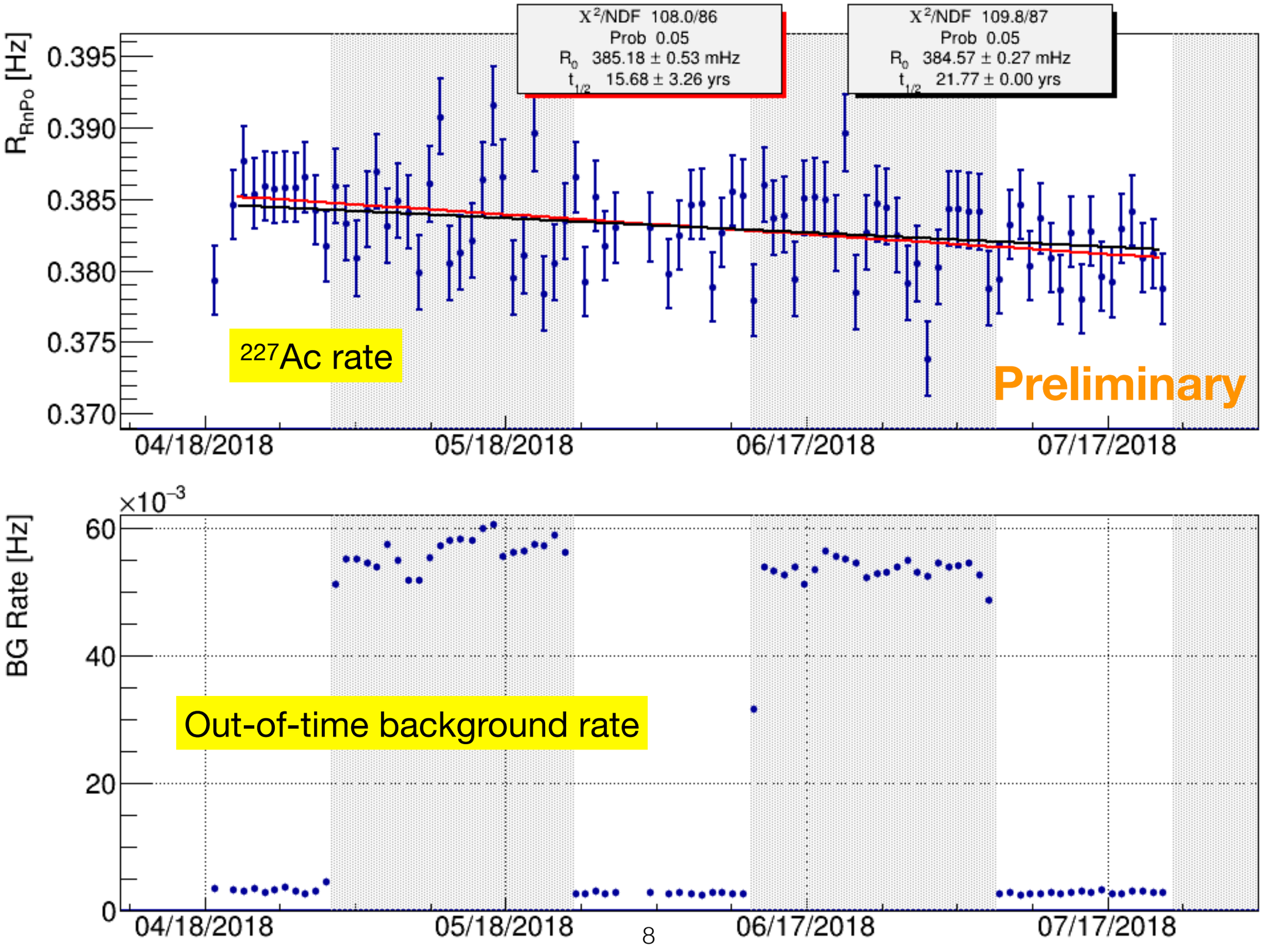




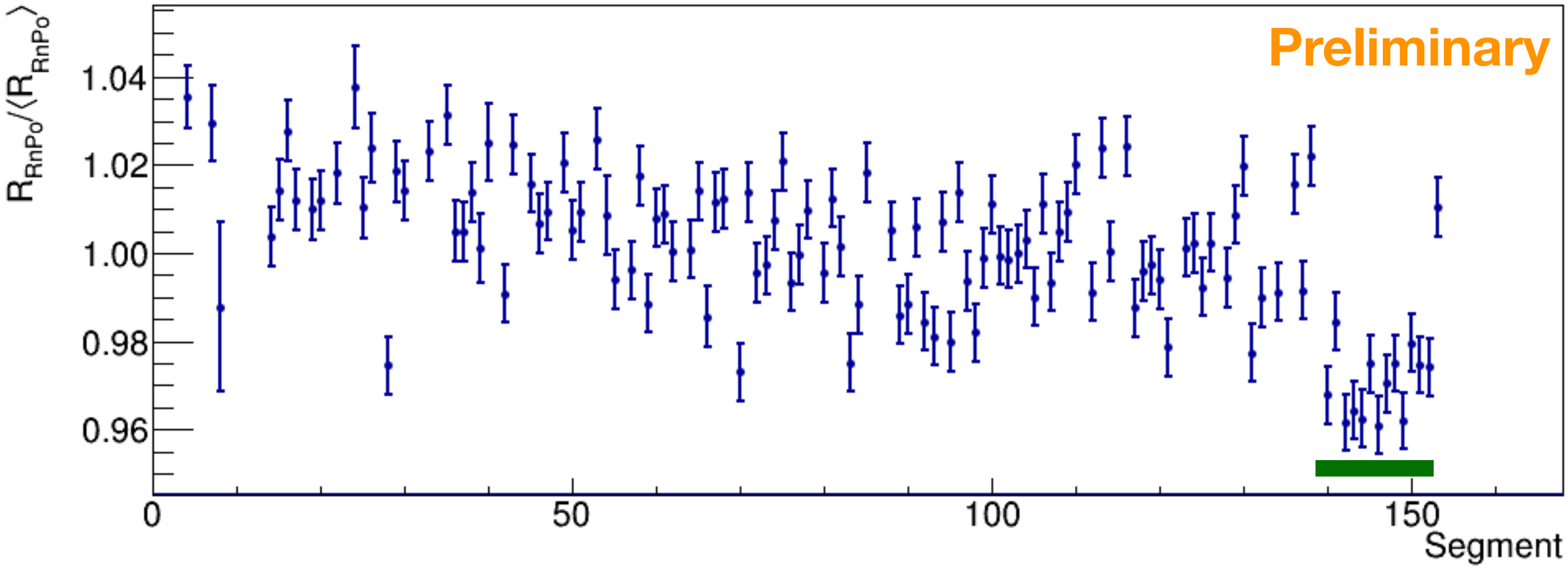
Efficiency Compilation

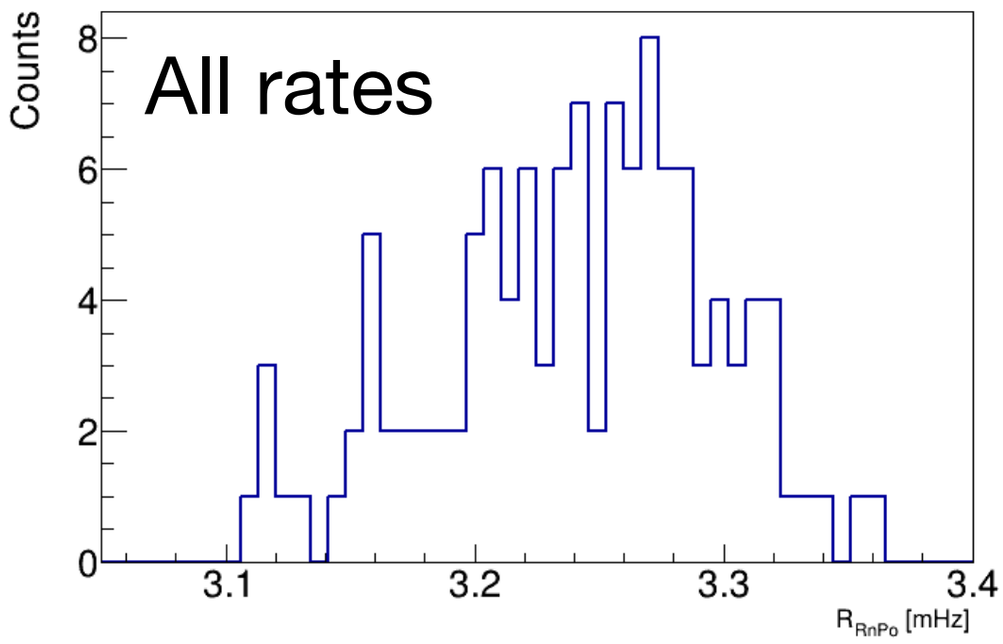


Integrated Rates over Time



Results: Segment Rate



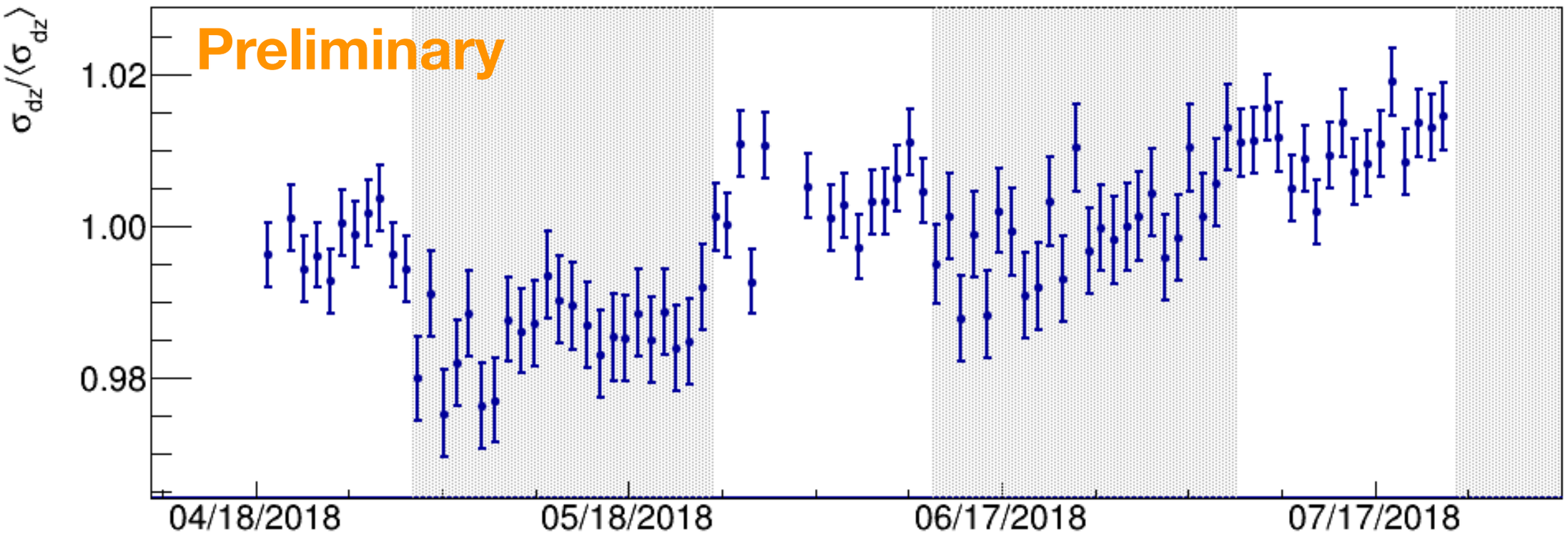


- Segment to segment variations in volume × efficiency
- Small downward trend towards the top of the detector
- Top row is systematically low

Results: Stability monitor

The ^{227}Ac spike provides some unique opportunities to monitor the detector over time.

For example, both alpha particles are at the same place, so we can use this to monitor position resolution:



Other performance monitors (eg calibrations and resolution for energy and pulse shape) are being studied.

Conclusions

Dispersing ^{227}Ac through the scintillator provides a useful monitor of segment volume × detector efficiencies.

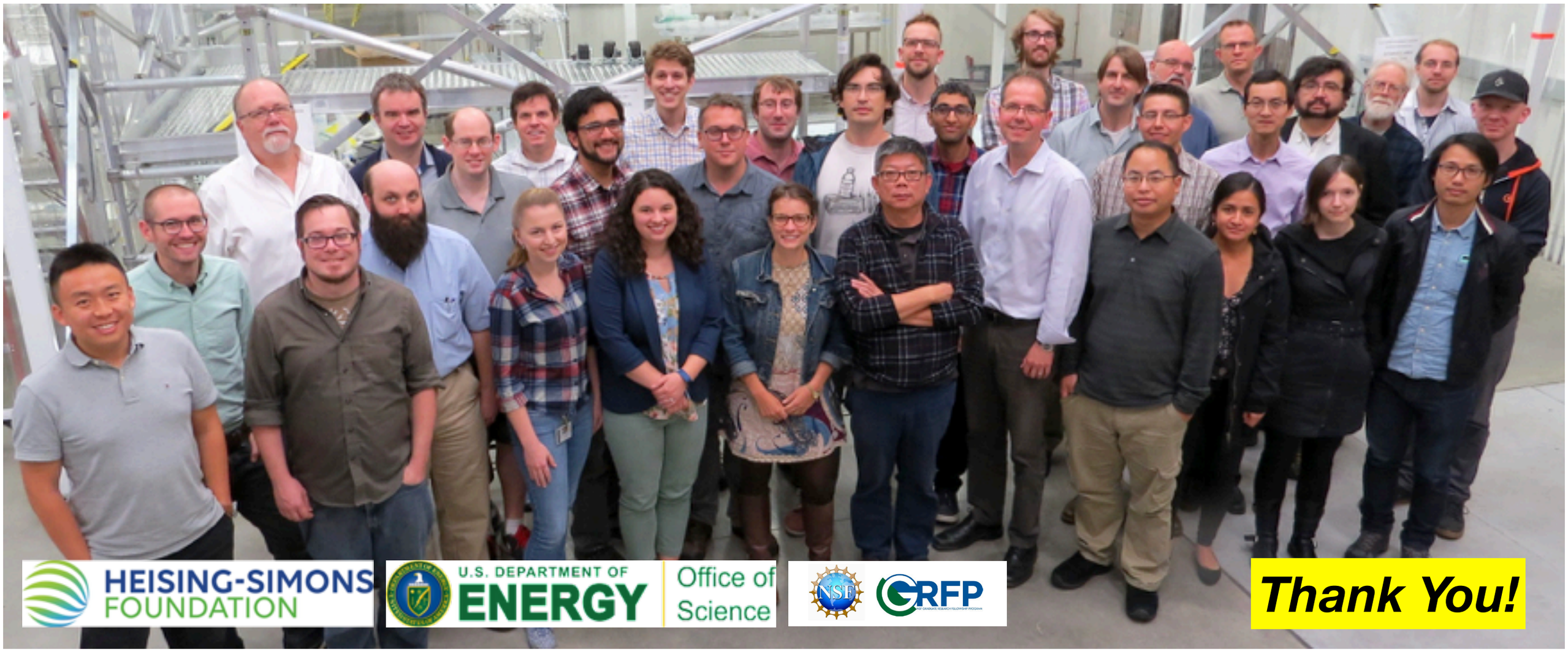
The ^{227}Ac rate decreases over time at a rate consistent with the ^{227}Ac lifetime. This analysis is continuing.

Additional benefits of this scheme are identified, including a monitor over time of important scintillator parameters.

The PROSPECT Collaboration

Ten Universities, Four National Laboratories, ≈70 Collaborators

BROOKHAVEN NATIONAL LABORATORY · Drexel University · Georgia Tech · HFIR · Lawrence Livermore National Laboratory · NIST · Oak Ridge National Laboratory · Temple University · UT · University of Waterloo · Yale · Le Moyne College



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Thank You!