Advanced Exploration Systems
RadWorks - Radiation Protection Technologies

Advanced Neutron Spectrometer on the International Space Station (ANS-ISS)

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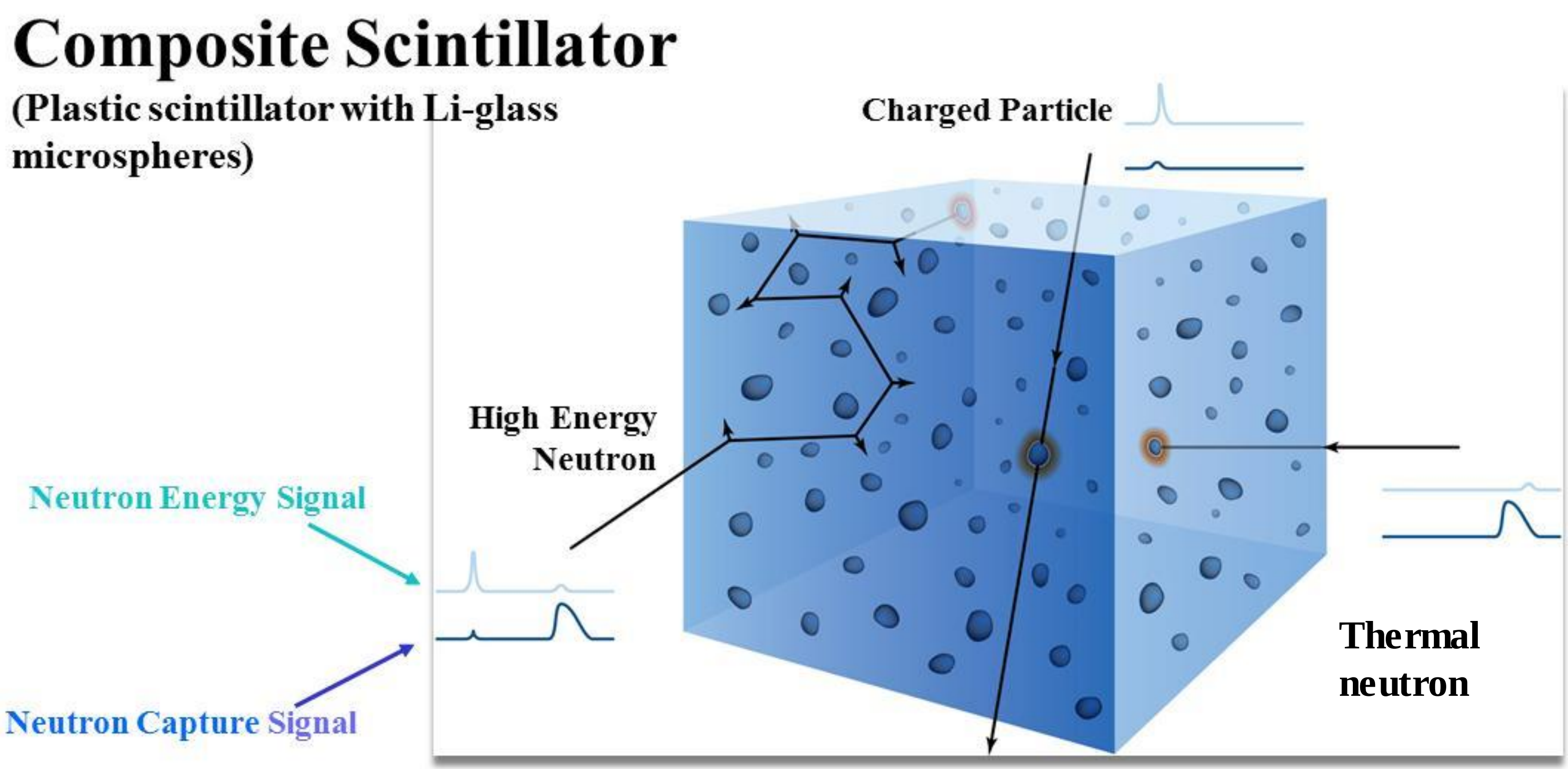
ANS Technology Demonstration

- Element of the Dosimetry Project/Advanced Exploration System Program
- Objective: Develop candidate neutron spectrometer for exploration missions
- Conduct ground-based testing and spaceflight technology demonstration to evaluate performance
  - Launch to ISS: Oct 2016
  - Primary operations: Dec 2016-June 2017:

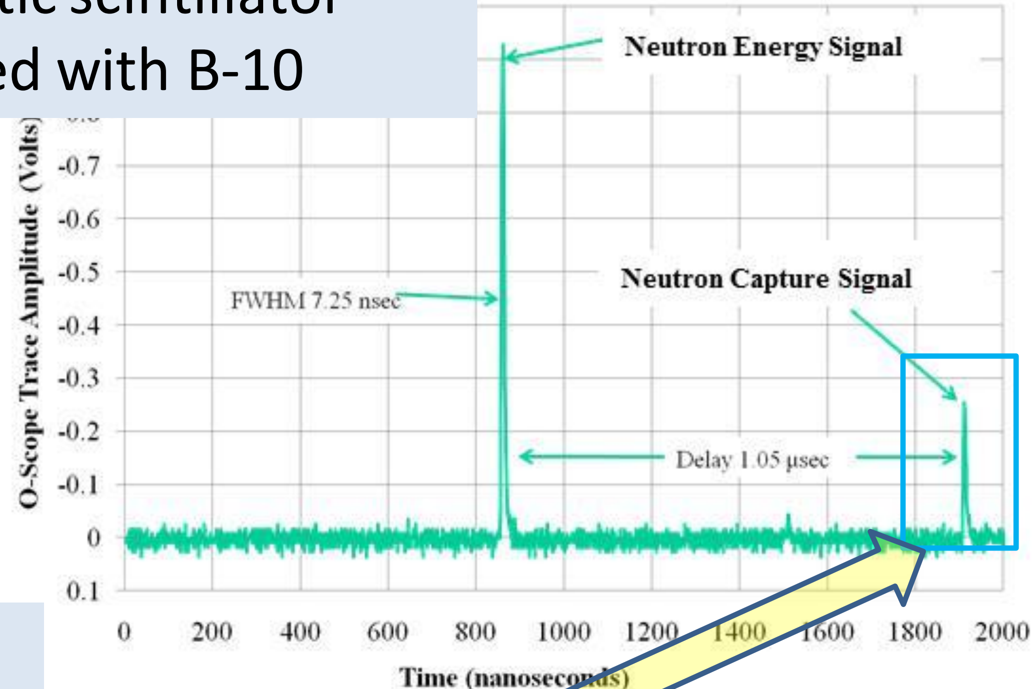
    location: USLab, Node1, Node2
- Extended operations: Sept 2017 - present
- Data analysis: On going

ANS neutron detection concept

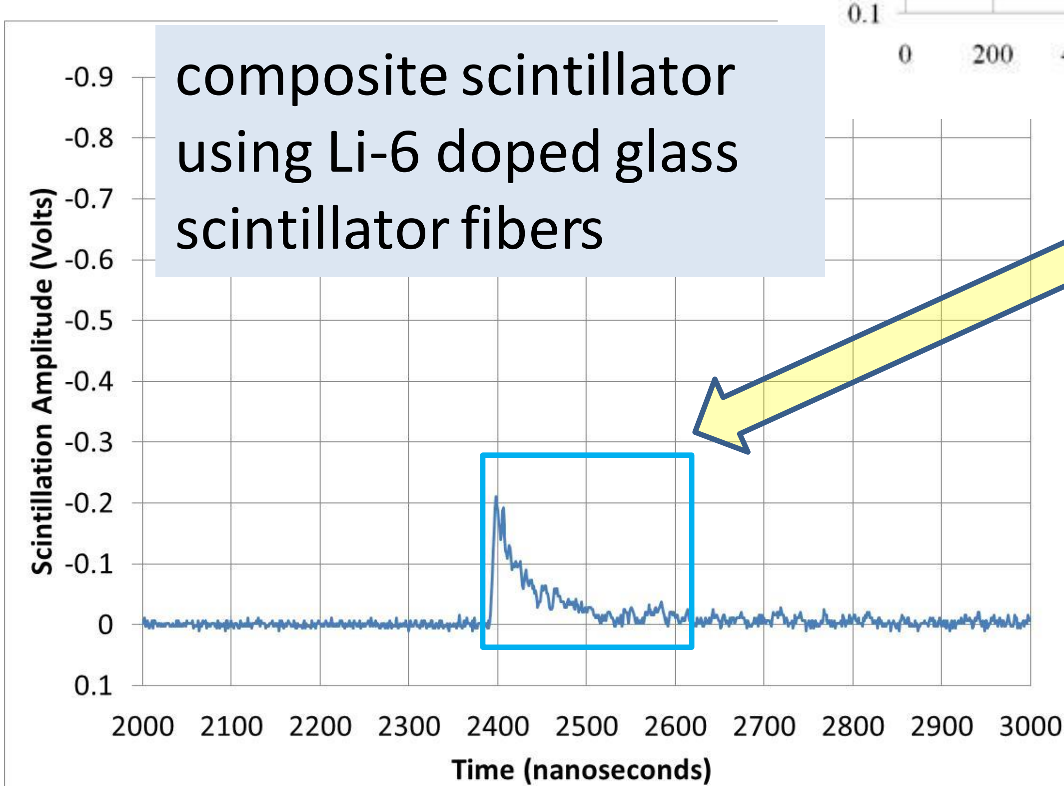


Capture-Gated Technique

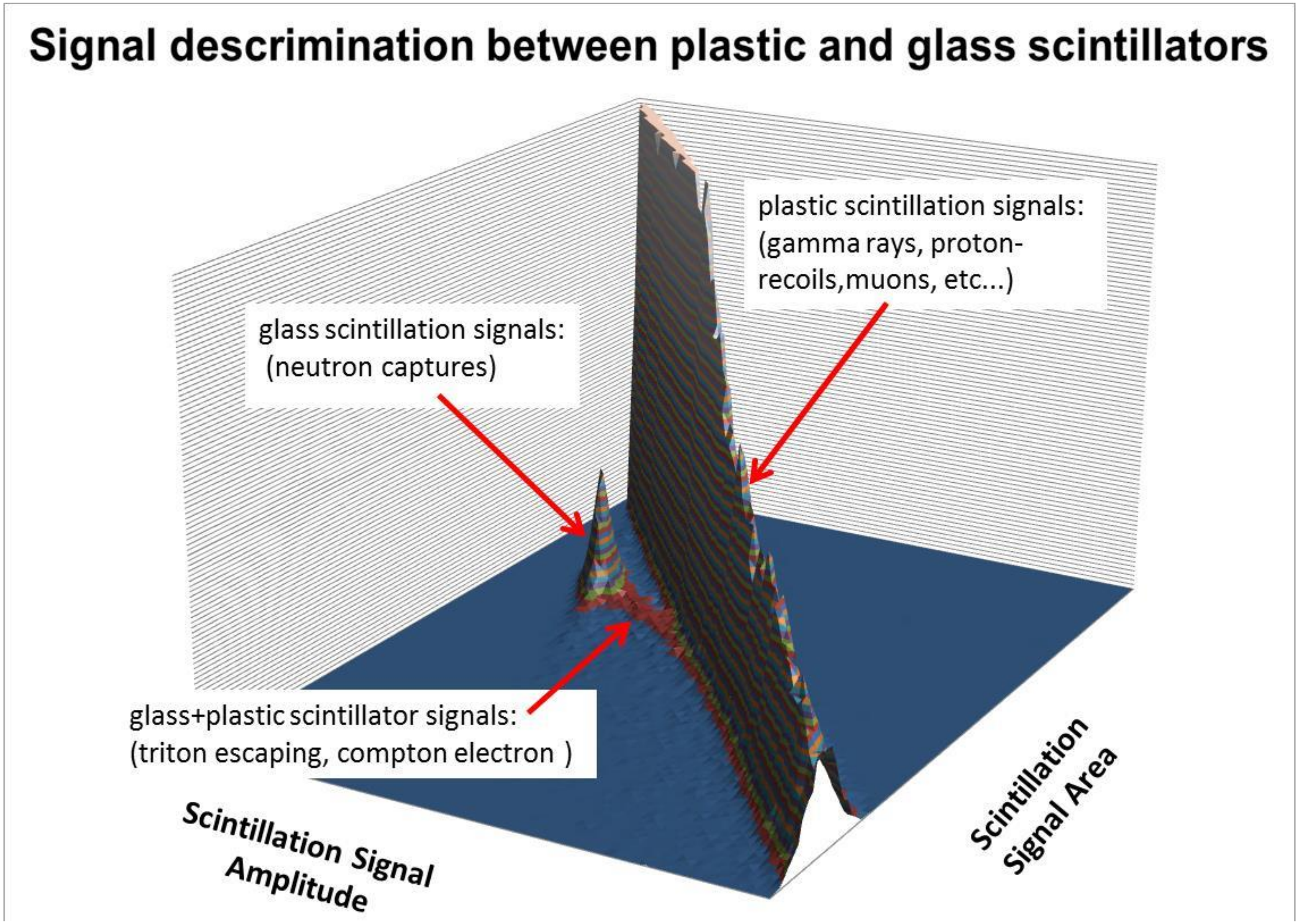
plastic scintillator doped with B-10



composite scintillator using Li-6 doped glass scintillator fibers

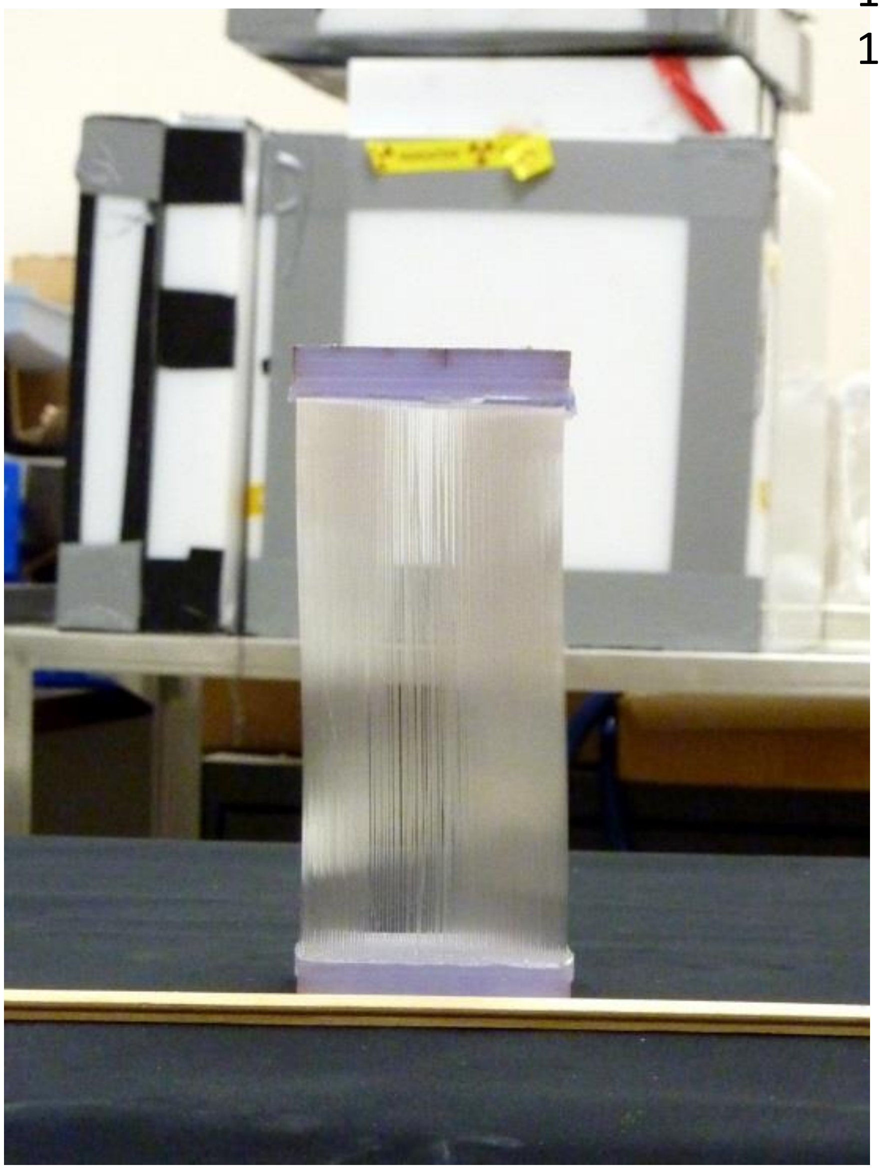


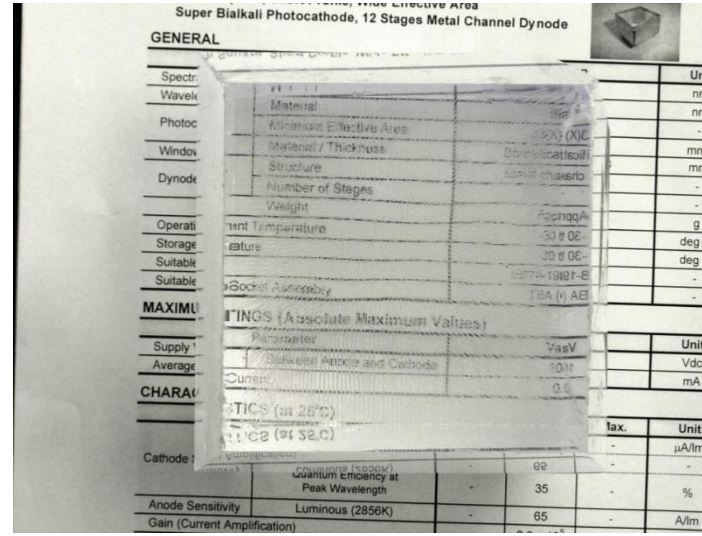
Clear neutron identification

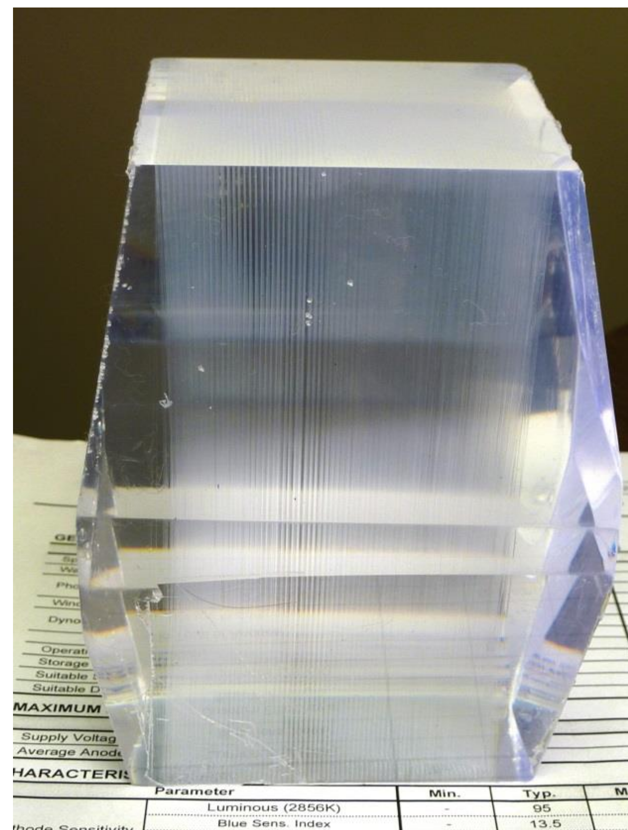


Fabrication

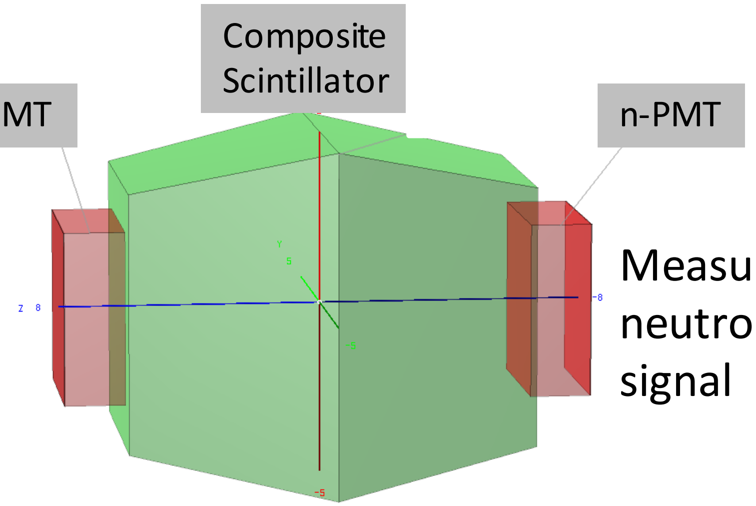
Fiber array:
72×73 fibers
120 um dia.
1 mm spacing
15 cm length



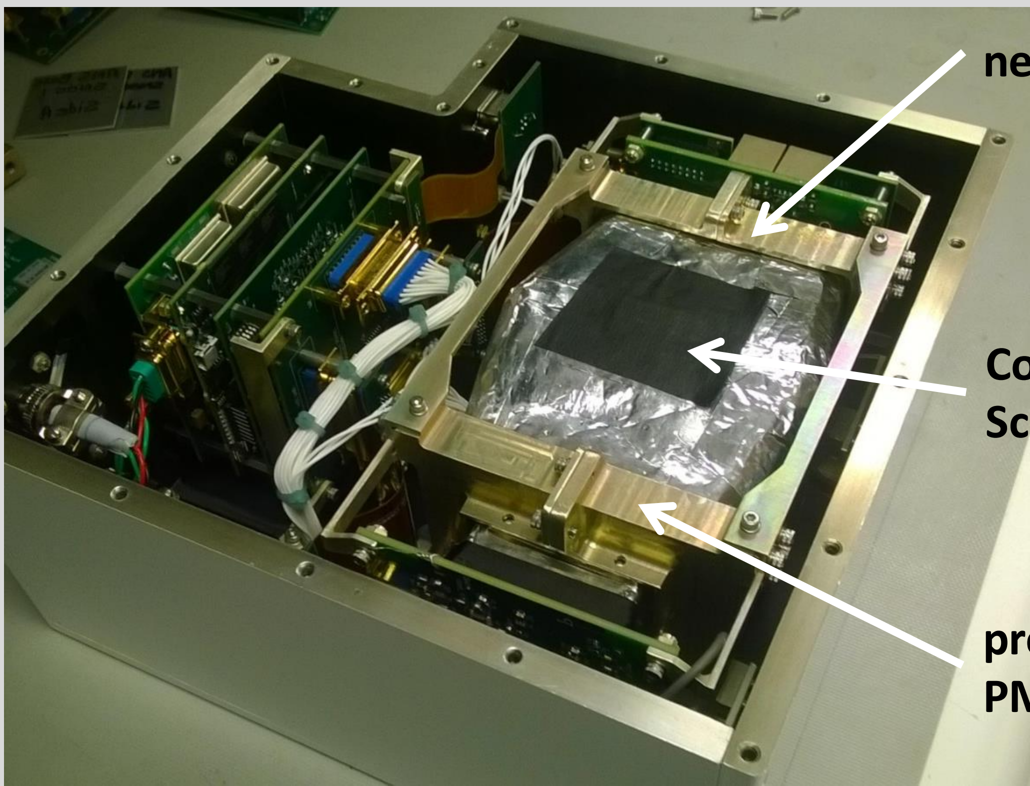




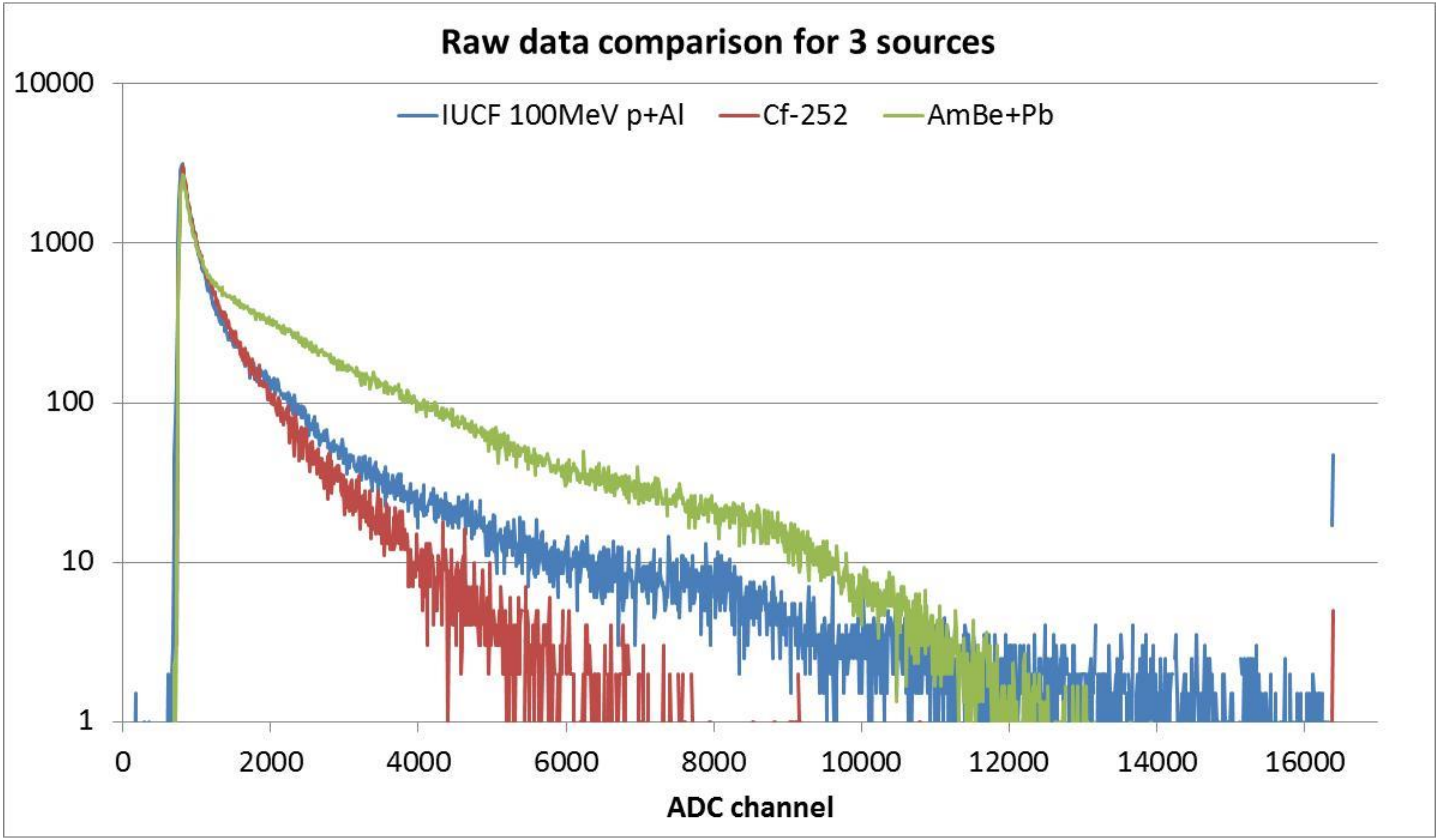
ANS-ISS



ANS Simulation Model

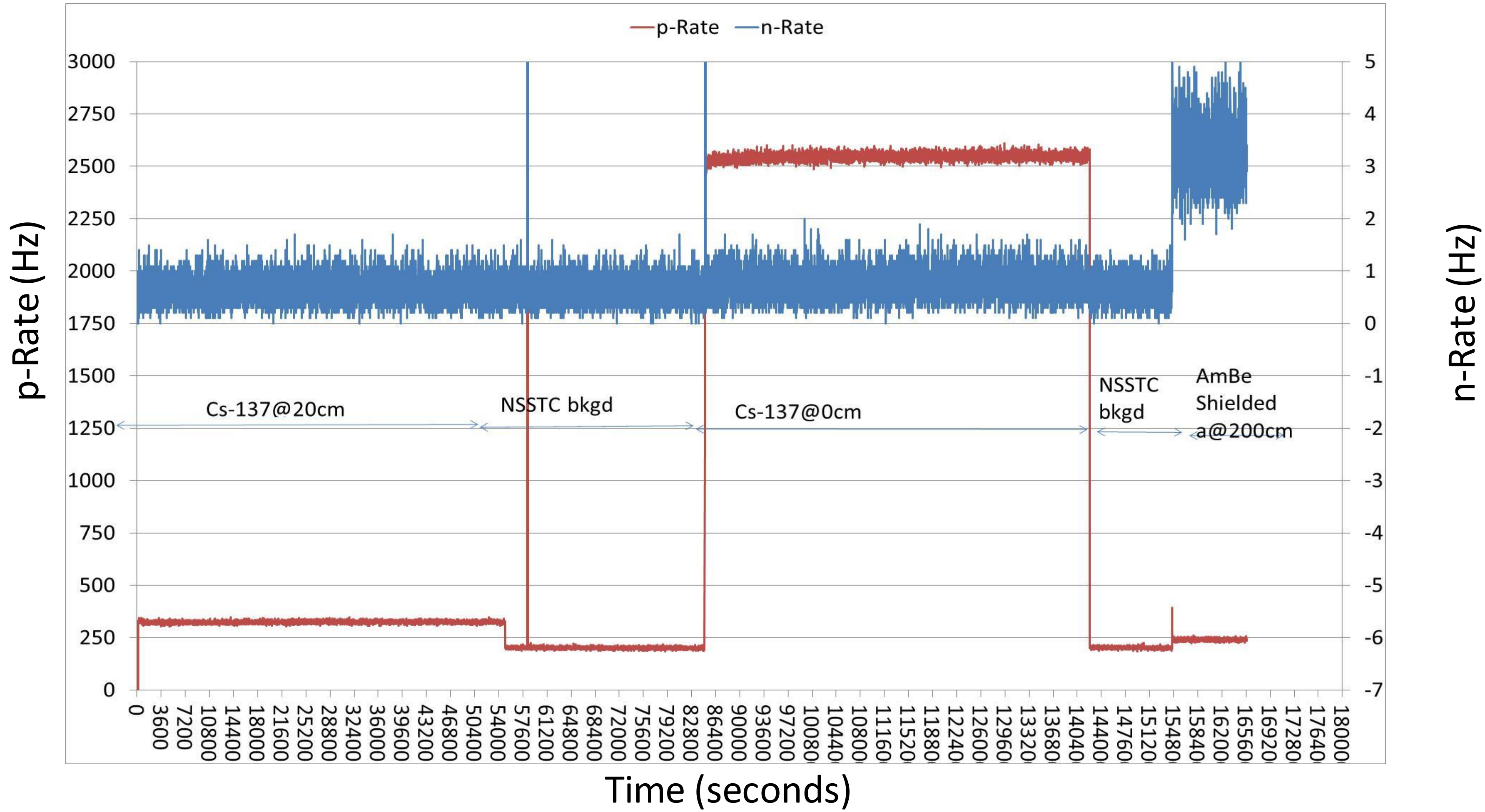


Ground based evaluation

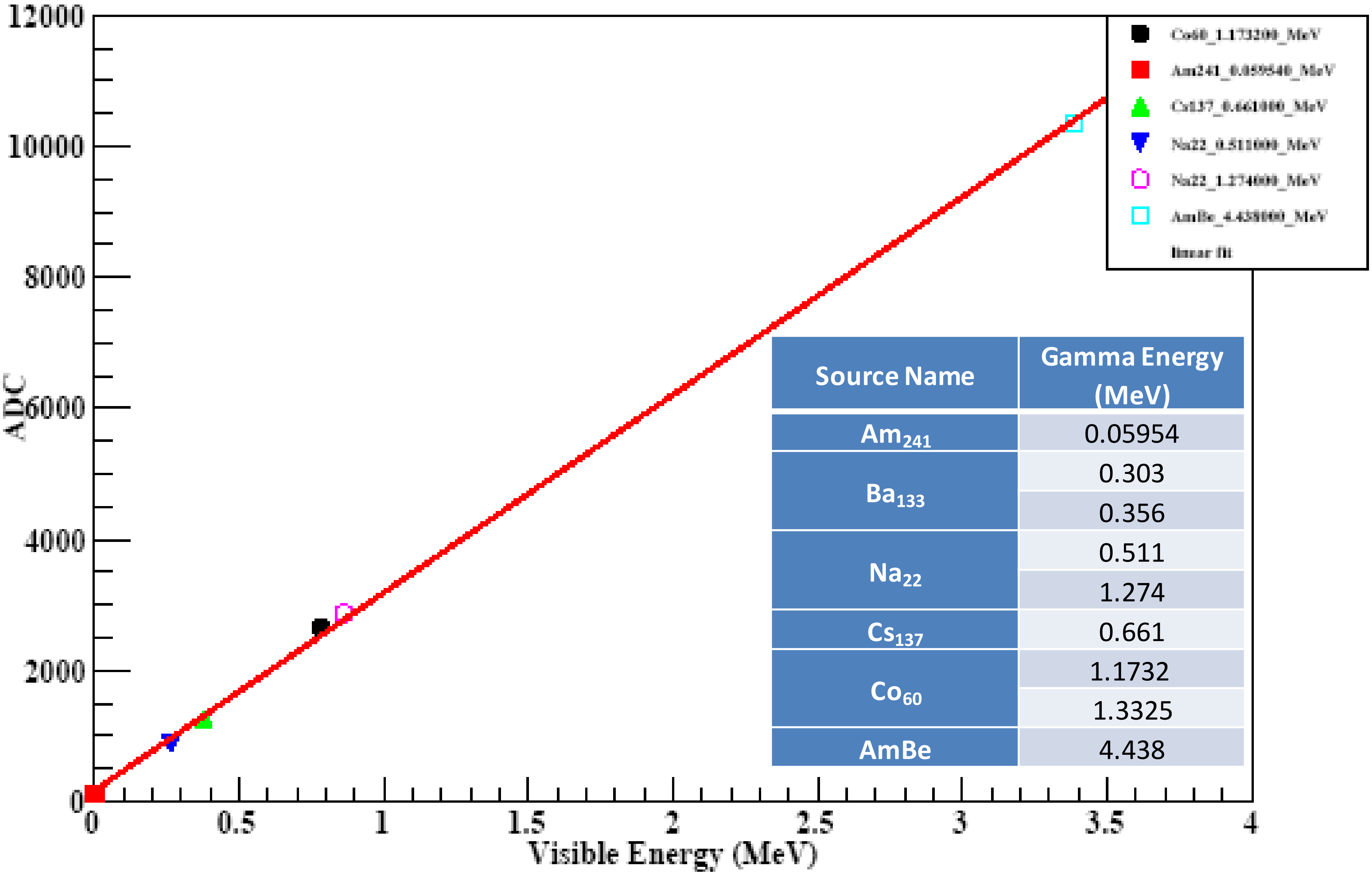


Gamma-ray induced trigger

Test			False CPS
20 cm	(.638-.620)/290		6.20E-05
0 cm	(.746-.615)/4933		2.70E-05



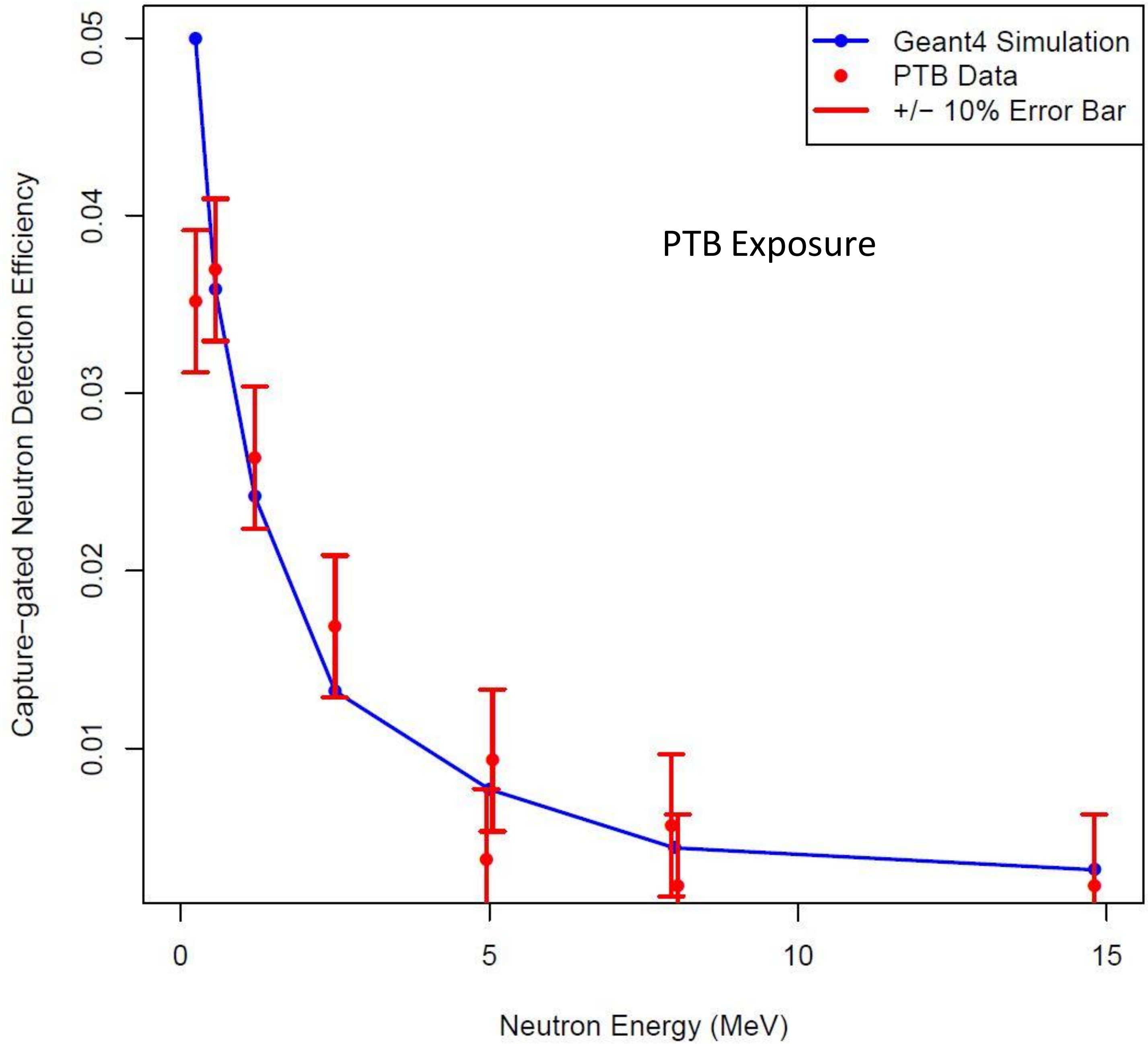
Detector signal calibration to gamma-rays



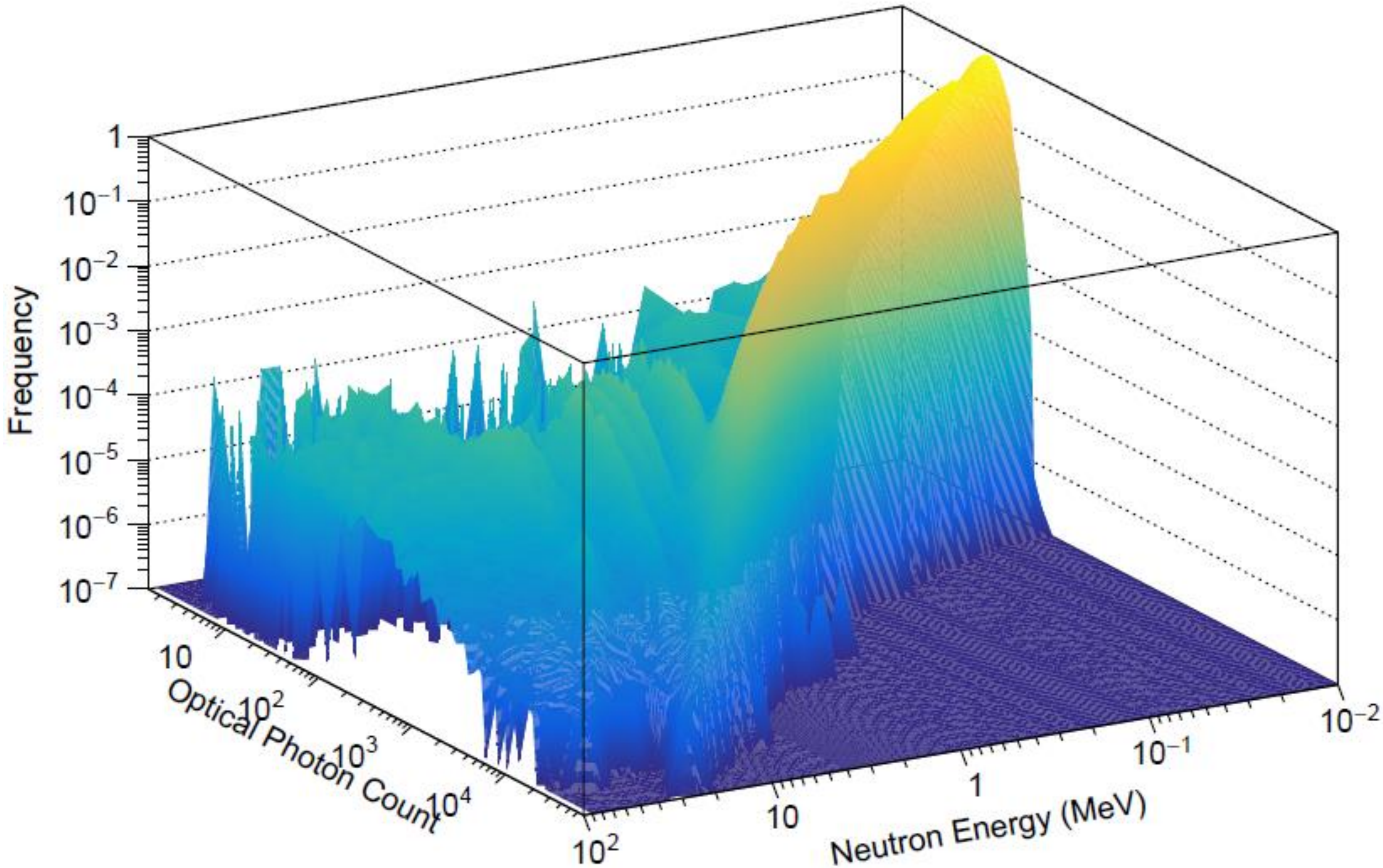
Source Name	Gamma Energy (MeV)
Am_{241}	0.05954
Ba_{133}	0.303
	0.356
Na_{22}	0.511
	1.274
Cs_{137}	0.661
Co_{60}	1.1732
	1.3325
AmBe	4.438

Compton edge corrected for scintillation saturation

ANS Efficiency Determination (with random coinc. correct.)



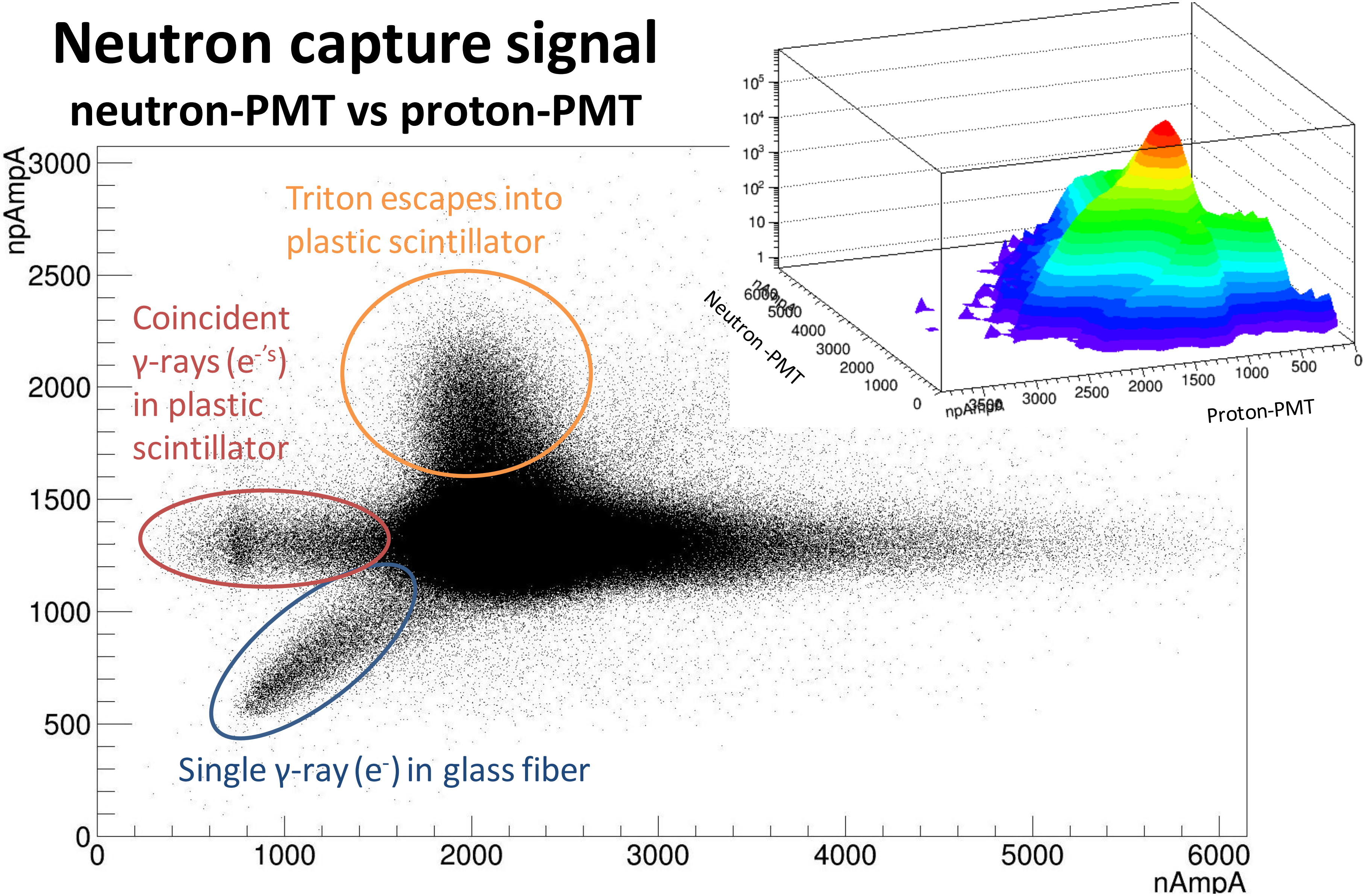
ANS response
Neutron Energy vs Scintillation Photons



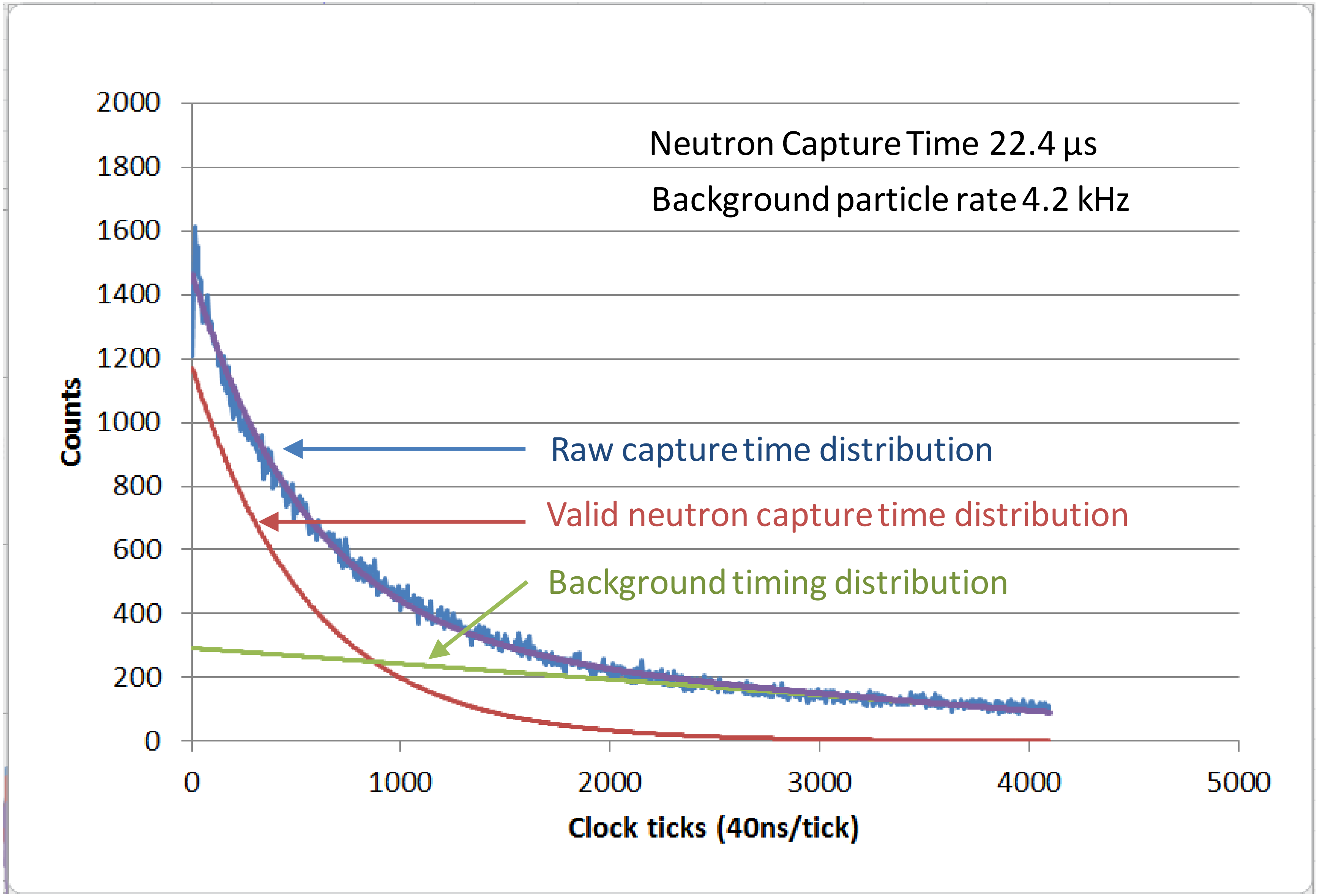
Flight data evaluation

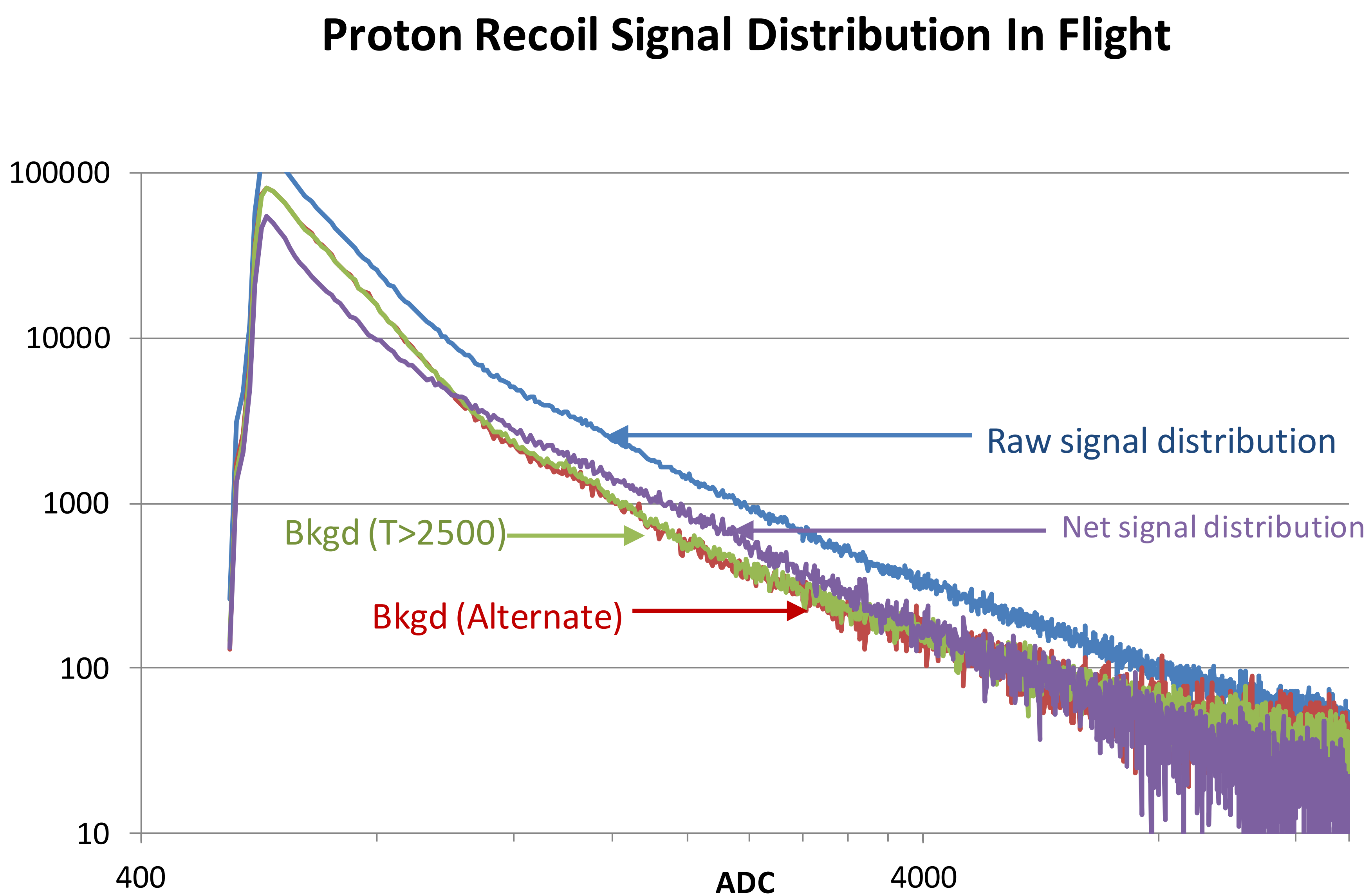
Neutron capture signal

neutron-PMT vs proton-PMT

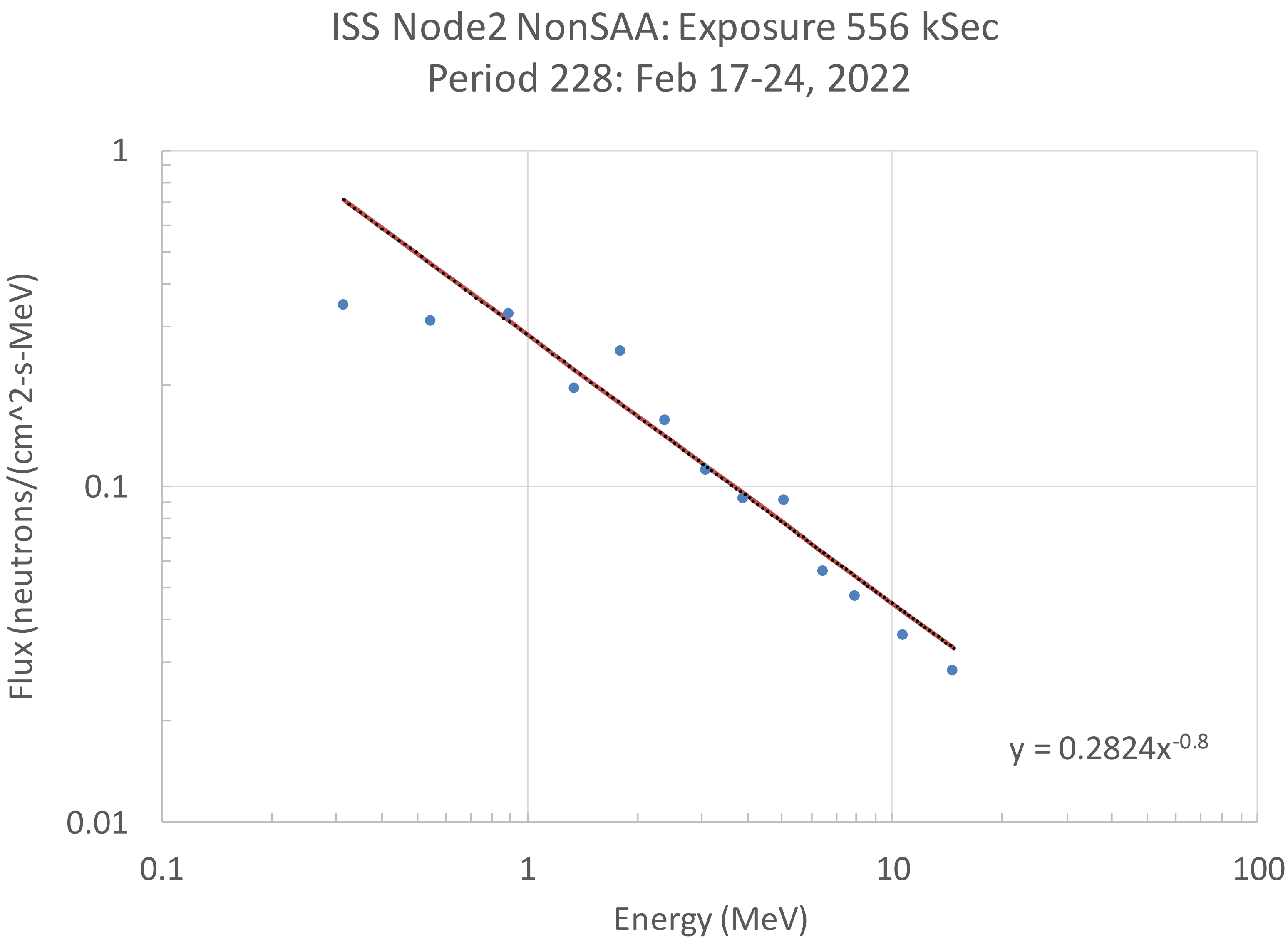


Neutron Capture Time Distribution In Flight

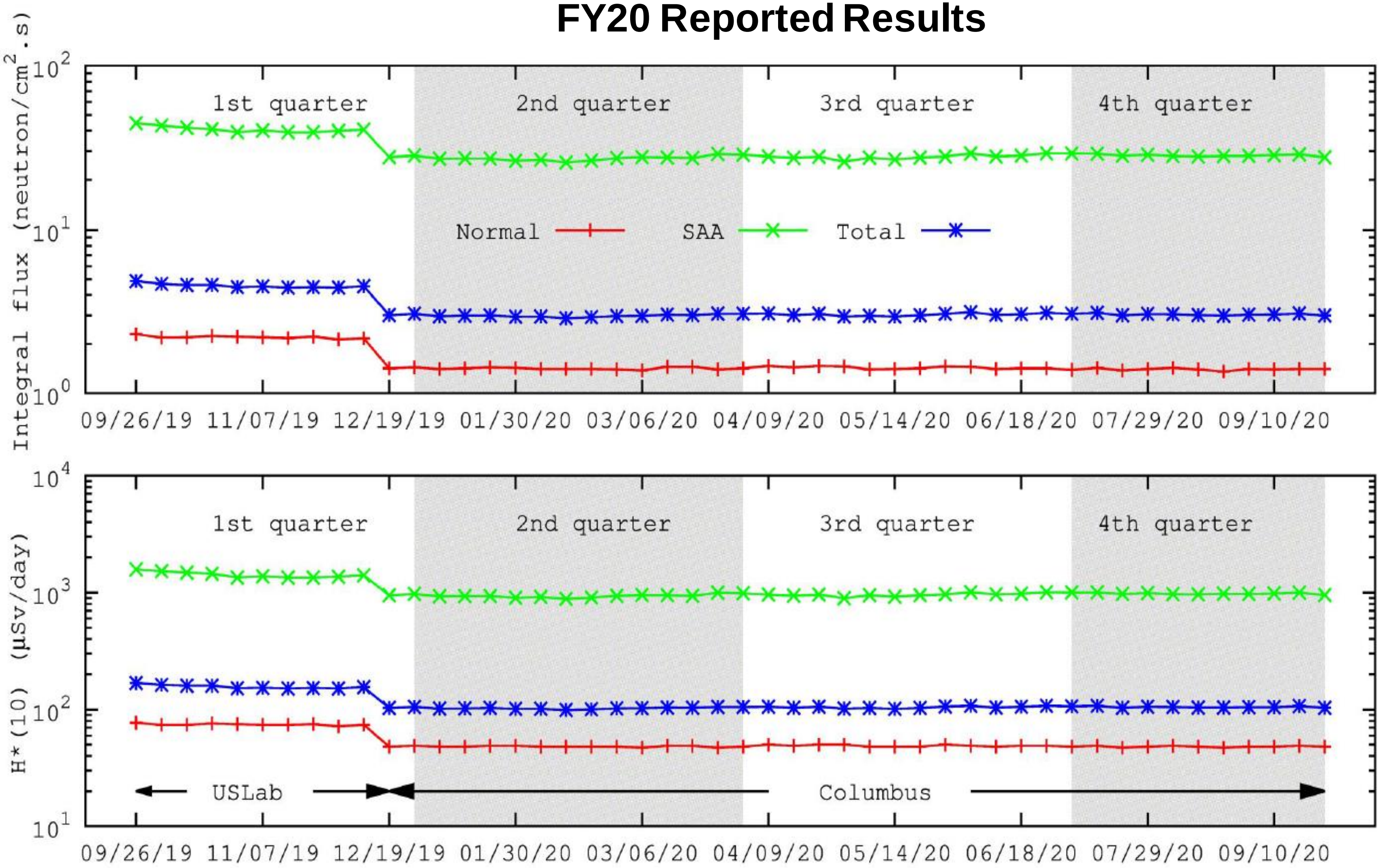



Proton Recoil Signal Distribution In Flight
100000
10000
1000
100
10
400
ADC
4000
Raw signal distribution
Net signal distribution
Bkgd (T>2500)
Bkgd (Alternate)

Neutron Spectra In Flight

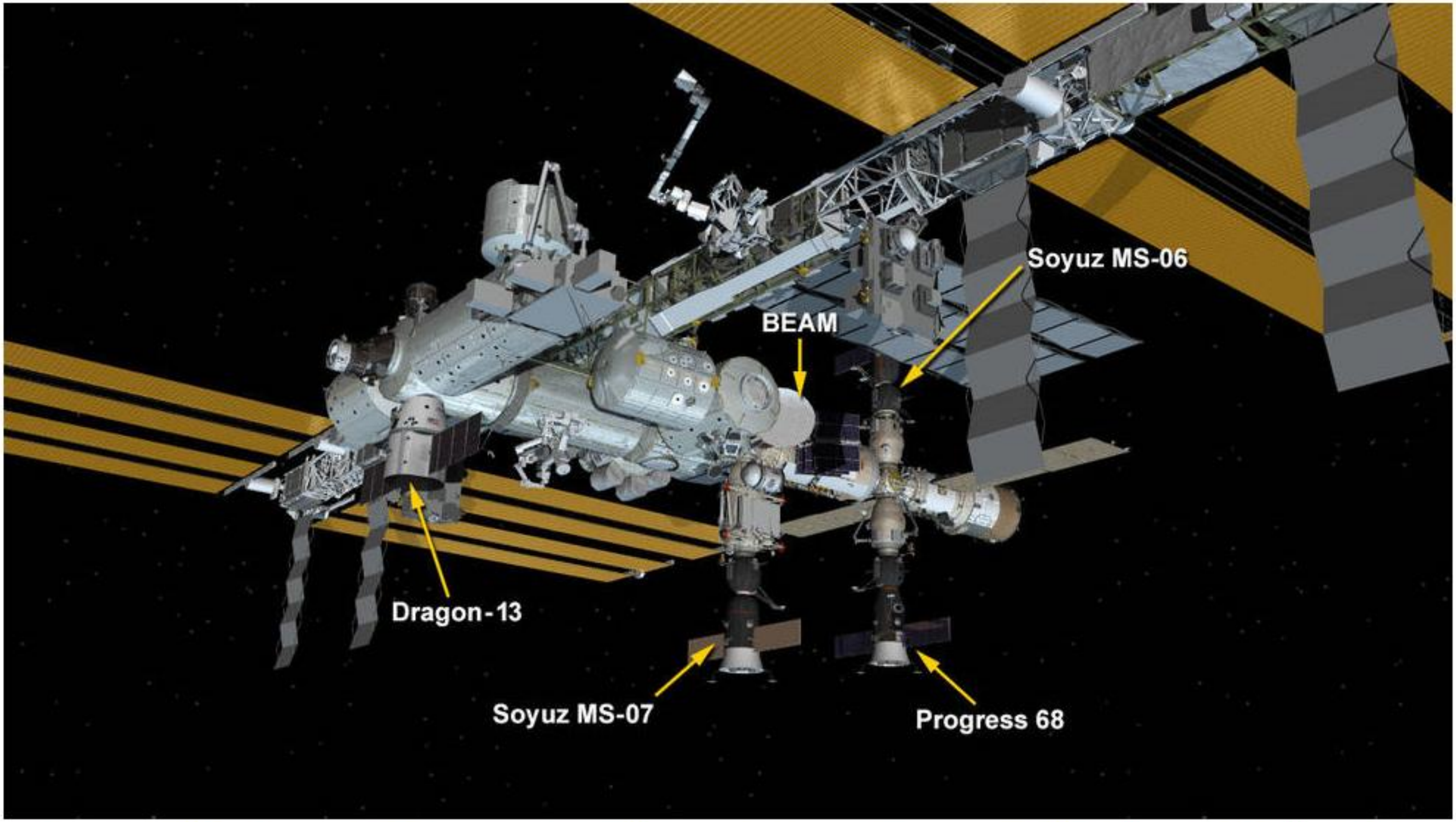


FY20 Reported Results



The SAA region contributes 6% of the exposure

Exposure onboard the ISS

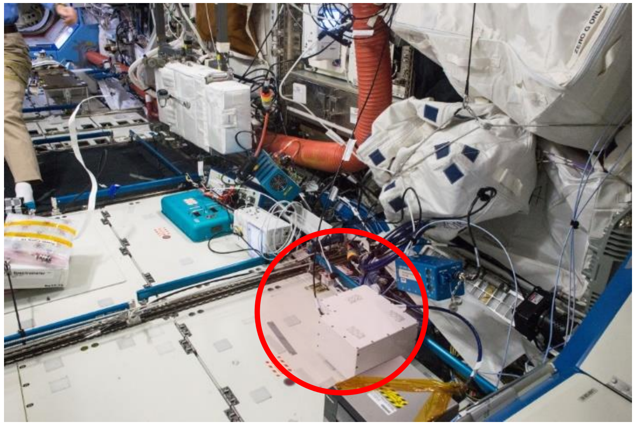


Dec. 27, 2017: International Space Station Configuration. Four spaceships are parked at the space station including the SpaceX Dragon space freighter, the Progress 68 resupply ship and the Soyuz MS-06 and MS-07 crew ships.

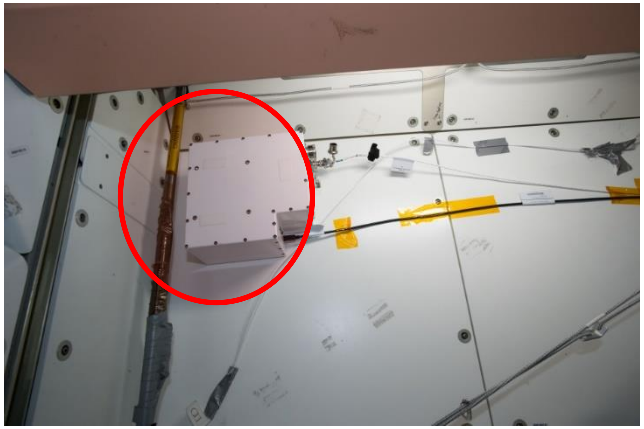
Altitude 254 mi.; Inclination 51.6°; Orbit period 90 min.

ANS-ISS Deployments

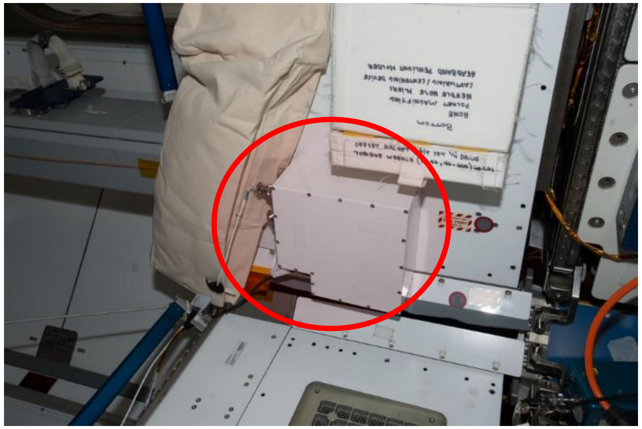
USLab Dec 2016- Feb 2017



Node 1 Feb-April 2017



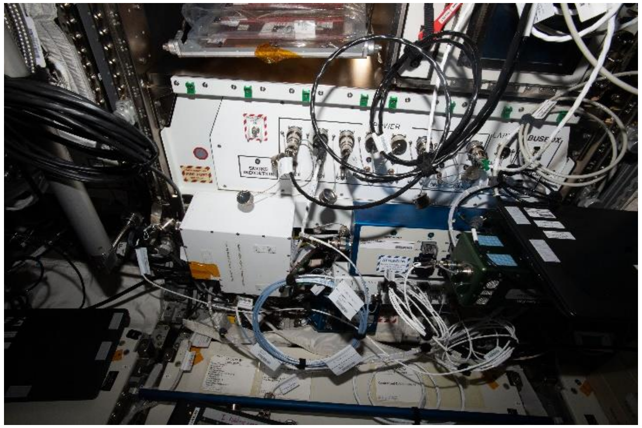
Node 2 April-June 2017



Node 1 Sept 2017-18

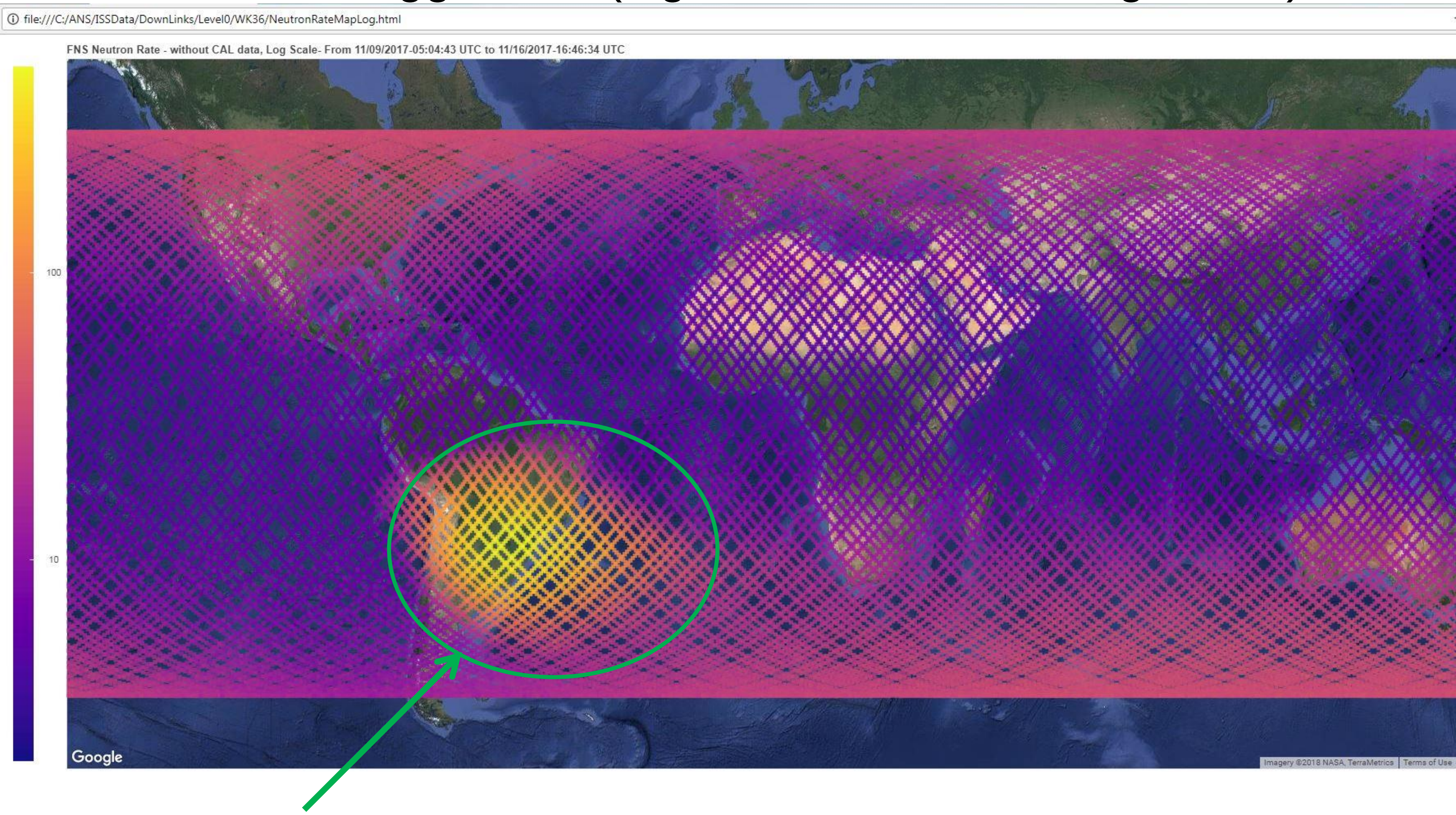
USLab Sept 2018- 2019

Columbus April 2021-22



ANS-ISS Nov 9-16, 2017

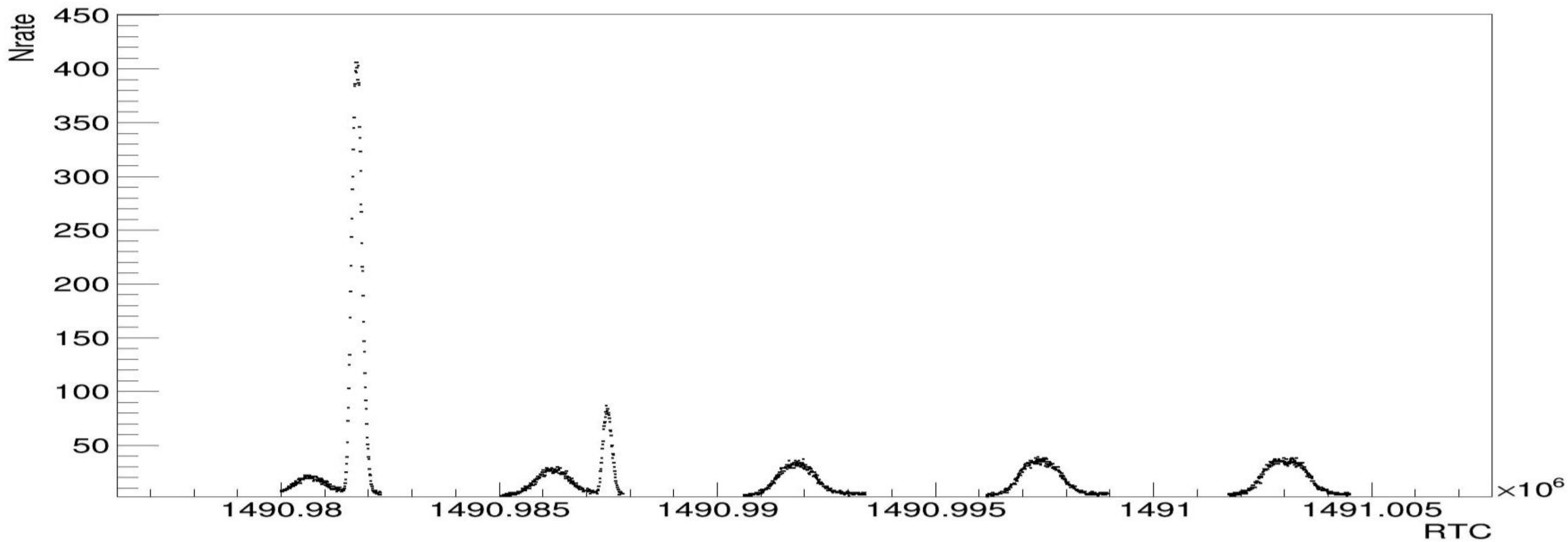
Neutron trigger rate (log scale, 10-sec averages, Hz)



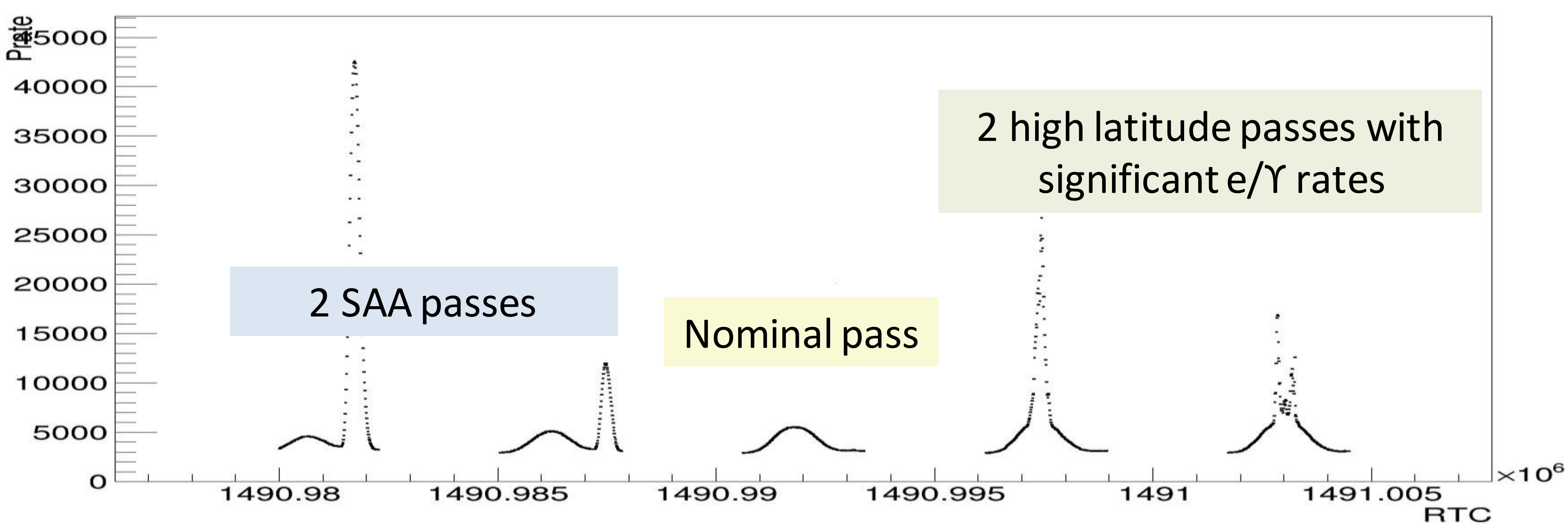
South Atlantic Anomaly (SAA)

5 consecutive orbits at Southern Latitudes (Node1)

Neutron-PMT trigger rate (Hz)

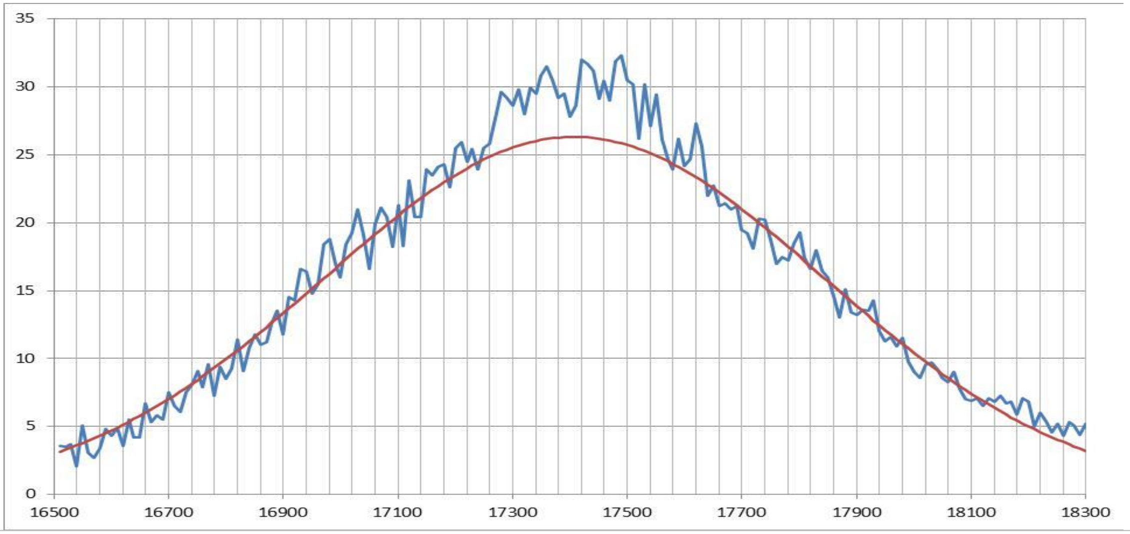


proton-PMT trigger rate(Hz)



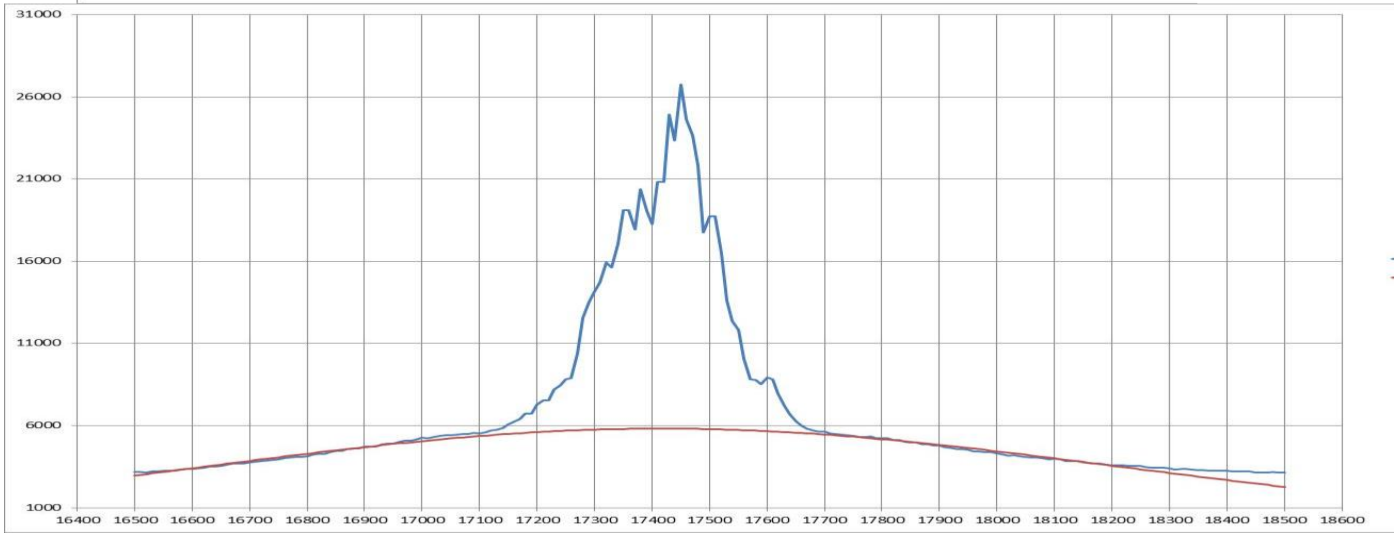
Estimation of false trigger susceptibility (high latitude region)

neutron-PMT trigger rate (Hz)



~130 excess neutron triggers

proton-PMT trigger rate (Hz)



406000 excess triggers

130/406000 = 3.2x10^-4 susceptibility

Cs 343/7,524,080= 4.56x10^-5 estimated (lab)

Note: no obvious way to assess susceptibility in normal or SAA portion of orbit

Forward

- Continue ANS exposures on the ISS for ~1 more year, covers 50% of the solar cycle then stow for future needs

- Extend energy reach beyond 20 MeV to cover higher energies: Time-of-Flight seems to be amenable to ~100 MeV using somewhat modest resources and current technologies, requiring 1 ns timing resolution at 50 cm pathlength

  Mitchell, J.G., et al., “Performance Characteristics of the Ionosphere Neutron Content Analyzer (INCA) “, 36th ICRC, Madison, WI, 2019

  note: unfortunately ElaNa 41 suffered a catastrophic event deployment