Neutron Measurements with the ISS-RAD.

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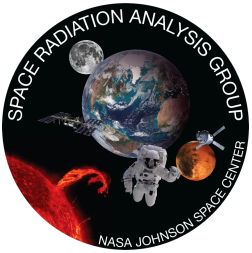


RAD Overview

Neutron Identification and Background Subtraction

Dose and Flux

Q4 2020 ISS Data w/ Oltaris comparisons

FND ANS Comparisson

Conclusion and Outlook

RAD Overview

RAD

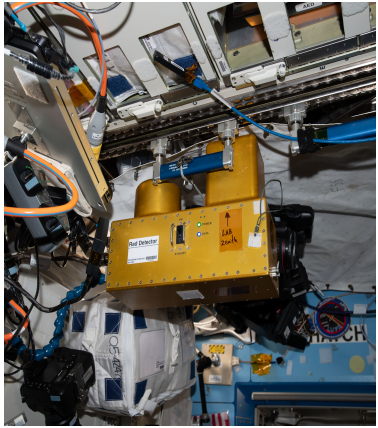


Figure: Radiation Assessment Detector

- Deployed in early 2016.
- Built by SwRI. Flight software by Big Head Endian.
- Used for Caution and Warning alarm.
- Three main components: CPD, FND, and RIB.
- Currently in U.S. Lab, but deployed to other locations in past.

FND Overview

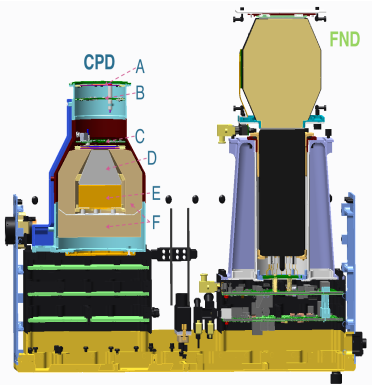


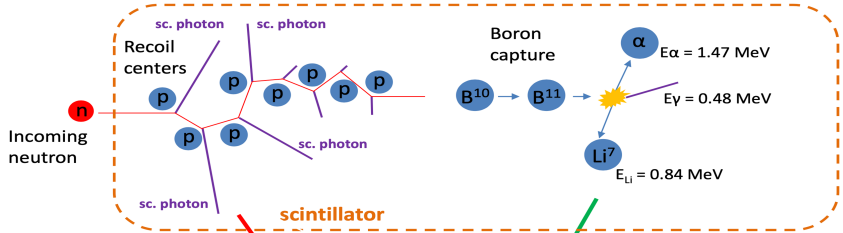
Figure: Fast Neutron Detector

- FND: Boron doped plastic scintillator. Double pulse method for n.
- CPD: Silicon telescope, identical to MSL-RAD. Anti-coincidence E,F for n.
- Neutron sensitivity; FND $\in$ [0.5, 8-10] MeV. CPD $\in$ [5,100] MeV.

Neutron Identification and Background Subtraction

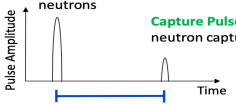
Neutron Capture

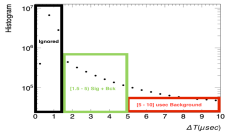
- Neutrons deposit energy in plastic scintillator, some captured by ^{10}B atoms:



Recoil Pulse: sum of light signals produced during deceleration of neutrons

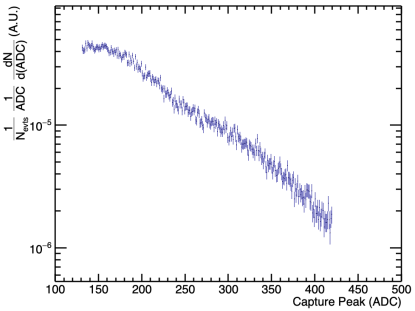
Capture Pulse: light produced by neutron capture on boron



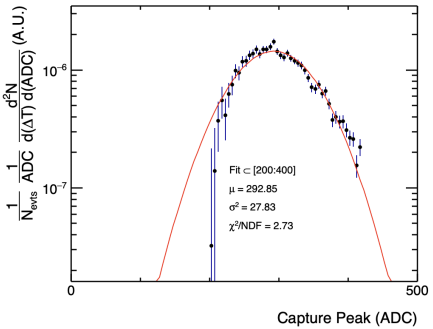


- Measurements of **recoil** and **capture** photon signals and:

Background Subtraction Method



(a) Capture Amplitude histogram with AmBe source.



(b) Capture peak recovered after background subtract to remove cc.

Analysis Steps:

1. Parse out relevant data packets and fnd candidate events
2. Correlate prescale packet to FND neutron candidate
3. Fill histos, weight by prescale. Perform delta time background subtraction and cuts for SAA/GCR.
4. Unfold Recoil histogram.
5. Normalize Recoil to fluence and differential flux, apply efficiencies and corrections.
6. Use ICRP 74 H*(10) values to get dose equivalent, convert to μSv/day

cuts: SAA = L$\leq$3 and B$\leq$23 μT, GCR != SAA

Dose and Flux

Input for Response Matrix

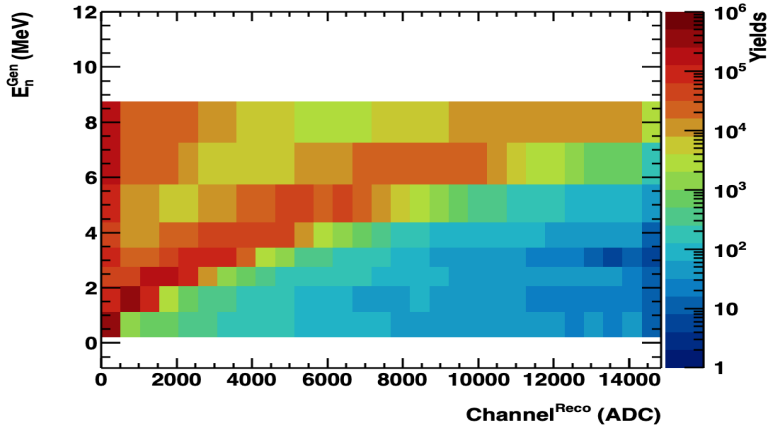


Figure: PTB delivered energies and the measured recoil distribution, 8 monoenergetic runs used.

Diff. Flux comparison JPM and US Lab

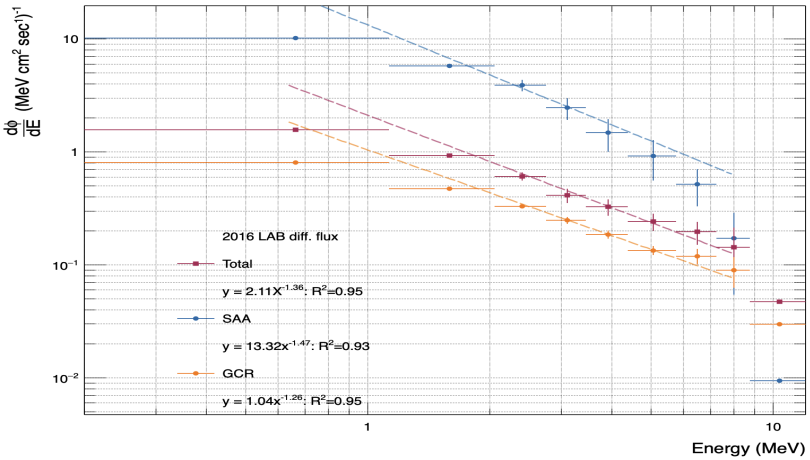


Figure: Diff. Flux in US Lab (Feb 1, 2016 - Dec 31, 2016)

Diff. Flux comparison JPM and US Lab

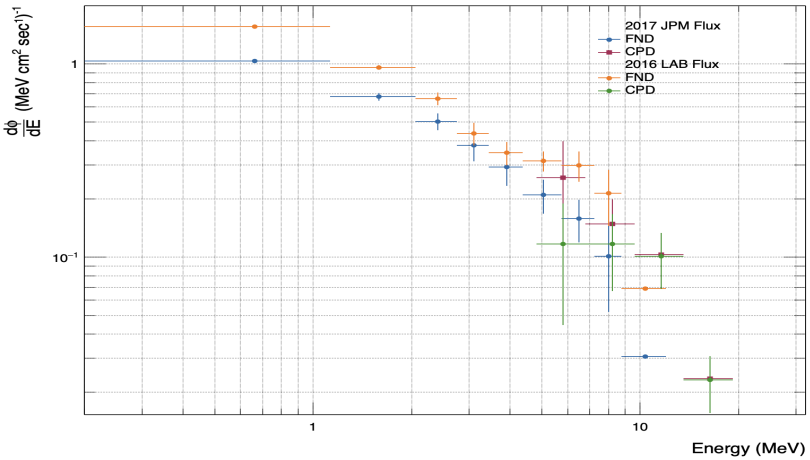


Figure: Diff Flux. US LAB (Early 2017) and JPM (Mid 2017)

2017 Unfolded Daily Dose Eq.

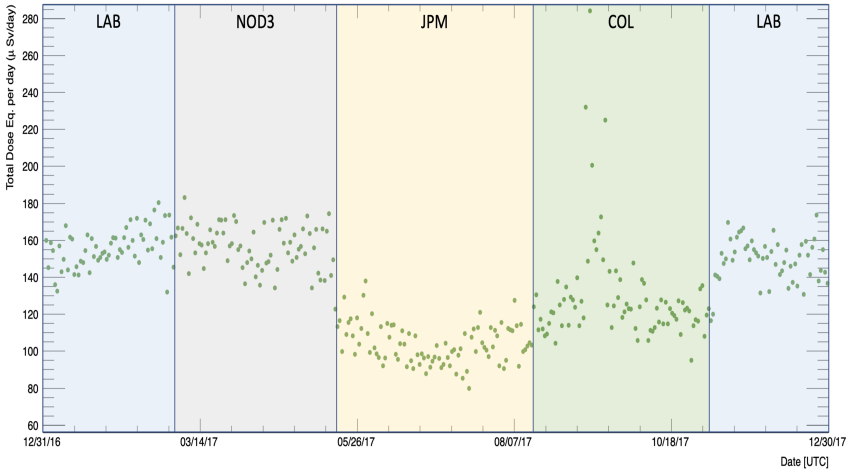


Figure: Average: Lab 147 uSv/day, 148 uSv/day NOD3, 97 uSv/day JPM, 117 uSv/day COL

Daily Unfolded Integrated Flux

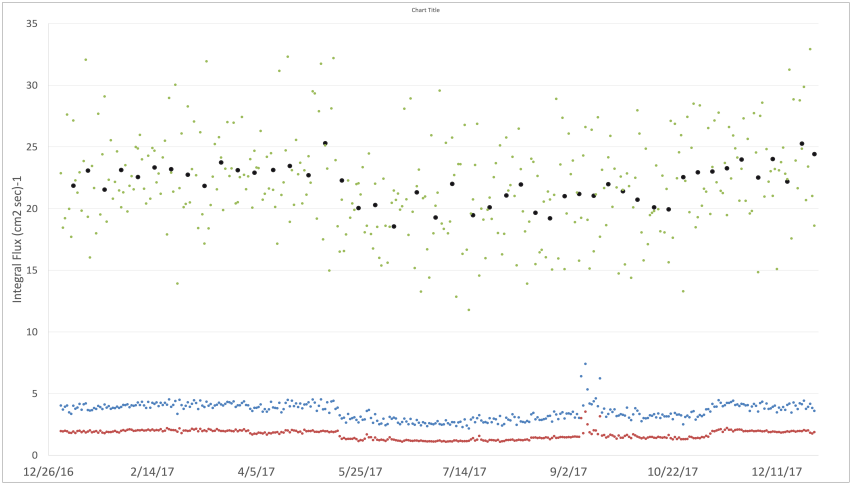


Figure: Total Daily Flux 2017. (SAA Weekly Avg in Black)

2017 Dose Eq. Comparisons

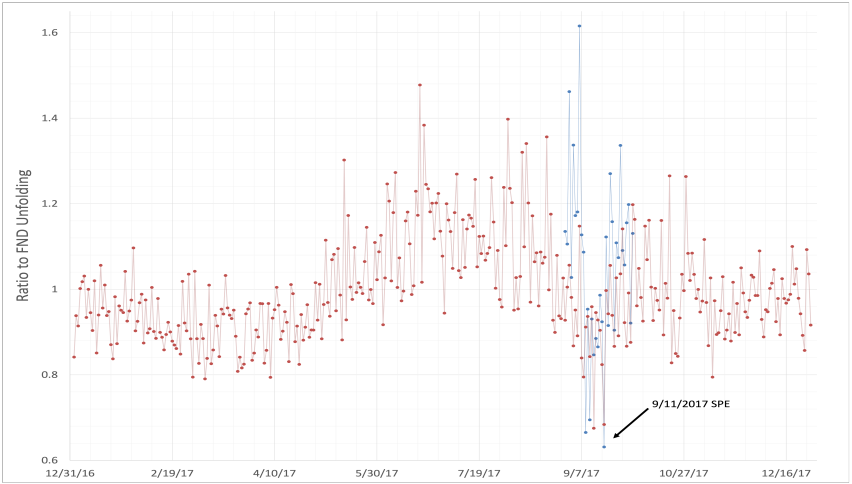


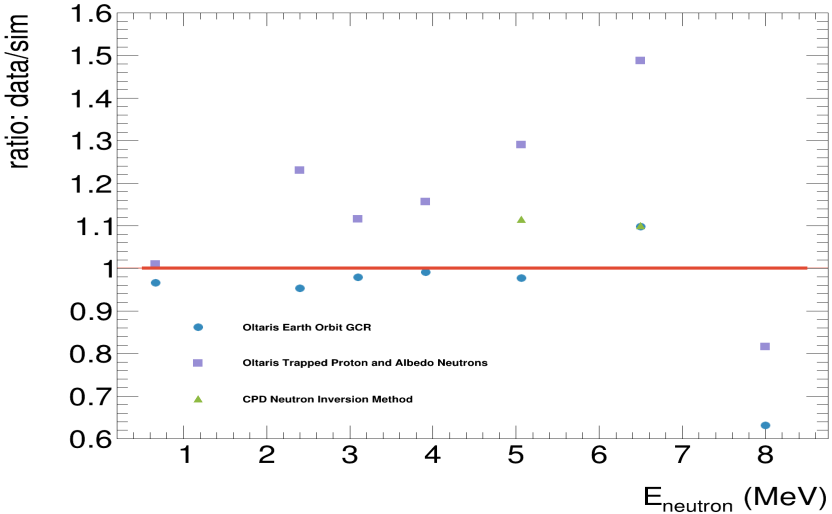
Figure: Red: Ratio of FND Analytic to Unfolding, PD 5%. Blue: Ratio CPD Inv to Unfolding

Q4 2020 ISS Data w/ Oltaris comparisons

Comparisons Inclusive data to OLTARIS and CPD [1/2]

- use trajectory input from SGP4 trajectory files
- include: Badhwar-O'Neil 2020 GCR model, AP8 trapped protons, and albedo neutrons
- 10K ray shield thickness distribution

Comparisons Inclusive data to OLTARIS and CPD [2/2]



FND ANS Comparisson

Overview

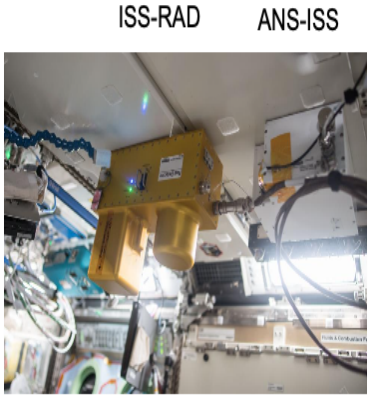


Figure: ANS and RAD in US Lab

- Boron doped scintilator fibers in glass matrix.
- Collocated with RAD 4 months in US LAB. Variety of orientations for RAD during time period.
- Comparing [0.5 - 10 MeV] similar kinematic region

Comparisons for each orientation

Date	10/2/2018 - 10/29/2018			11/02/2018 - 11/23/2018			11/27/2018 - 12/20/2018			12/25/2018 - 01/25/2019		
Orientation	Nadir			Forward			Aft			Port		
Dose [uSv/day]	Total	GCR	SAA	Total	GCR	SAA	Total	GCR	SAA	Total	GCR	SAA
FND	145	69	932	149	70	953	146	69	942	148	71	921
ANS	139	78	1010	155	80	1030	154	78	1050	135	75	1000
P.D. %	4%	12%	8%	4%	13%	7%	5%	12%	10%	10%	5%	8%

Figure: ** Preliminary ** FND measures a slightly lower Dose Eq. but both agree within 15%

Conclusion and Outlook

Outlook

- Two papers coming out soon on CPD and FND. "Life Sciences in Space Research".
- Another paper or two in the next year.... ANS and Simulations comparisons focused...
- 2D histogram may clean up the SAA daily values.
- RISK

Conclusion

- We see that unfolding does a very good job of reconstruction doses and fluxes for neutrons.
- Unfolding compares very well to analytic results, CPD, and ANS.
- Expected power law fit to flux is found with unfolding. Results very consistent with what was previously shown at WRMISS 2019 (M.Leitgab).
- Unfolding can extract the sensitivity to shielding in the ISS.
- Initial OLTARIS results consistent with unfolding.

Special thanks to Rad Science Team!! Kevin Beard, Cary Zeitlin, Mena Abdelmelek, Nic Stoffle, and Bryan Hayes!

References (I)

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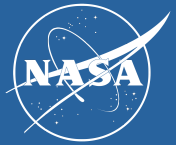
- M. Lefebvre, R.K. Keeler, R. Sobie, and J. White, *Propagation of errors for matrix inversion*, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment **451** (2000), no. 2, 520 – 528.


NASA