Active Tissue Equivalent Dosimeter (ATED): a tissue equivalent proportional counter currently operating aboard ISS

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Active Tissue Equivalent Dosimeter Scientific Objectives

- Continuously measure the Linear Energy Transfer (LET) spectra, absorbed dose and dose equivalent as functions of time with ~30 second resolution for a total duration of 6 months.
- Demonstrate the operational capability of the Active Tissue Equivalent Dosimeter
- Correlate time resolved data with ISS orbital position, altitude and orientation.
- Determine average dose and dose equivalent rates from galactic cosmic rays, trapped protons in the South Atlantic Anomaly, and trapped electrons at high latitudes.
- Compare results with measurements made using other radiation detectors deployed throughout ISS (IV-TEPC, REMs, RAMs, Liulin-4, etc.).
- Compare results with model calculations (HZETRN/OLTARIS).
- Analyze operational performance of instrument and identify problems and lessons learned for improvement in next generation.

Active Tissue Equivalent Dosimeter Physics Specifications

- External Dimensions: 25.5 cm × 15.8 cm × 13.0 cm
- Mass: 3.22 kg (1 kg is just the power chord!)
- Power: 7.6 Watts
- Power Source: 120 Vac from ISS inverter
- Maximum internal voltage: +900 Vdc
- Operational Period: Continuous for 6 months, with short interruption for sample data download to ground via ISS laptop
- 3″ diameter acrylic spherical chamber simulating ~2 μm diameter cell volume.
- 8K channel spectrum every 30 seconds.
- Data: 32 Gbyte SDRAM card, compatible with ISS laptop

NASA EPSCoR

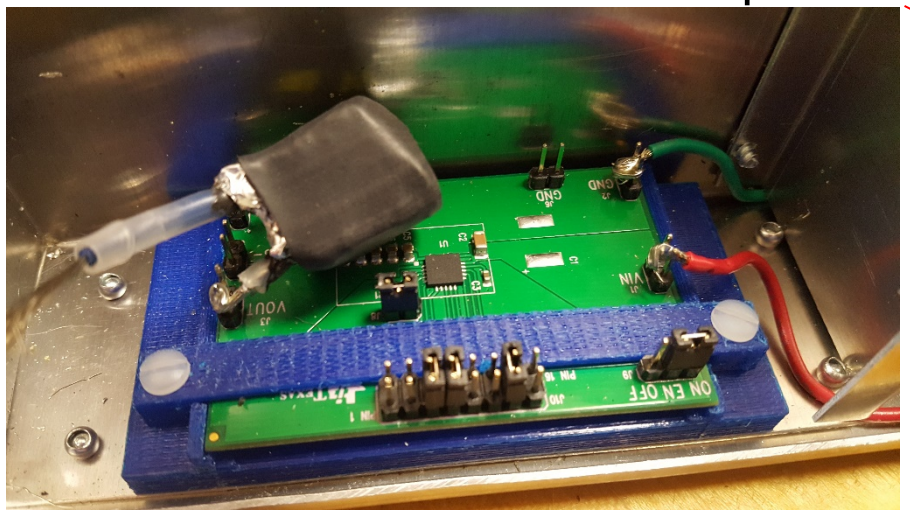
OSU EVB RPL

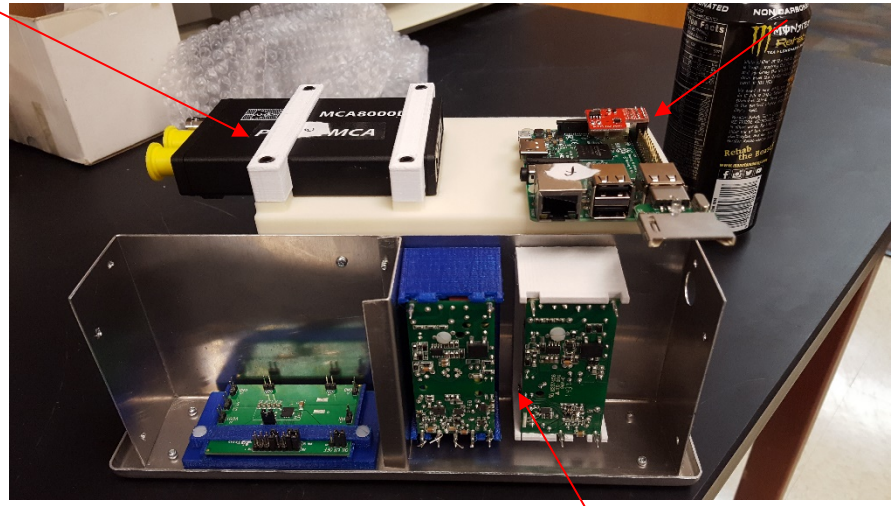
Spaceflight Version
Active Tissue Equivalent Dosimeter (ATED)

ATED Flight Unit

Spectrometer

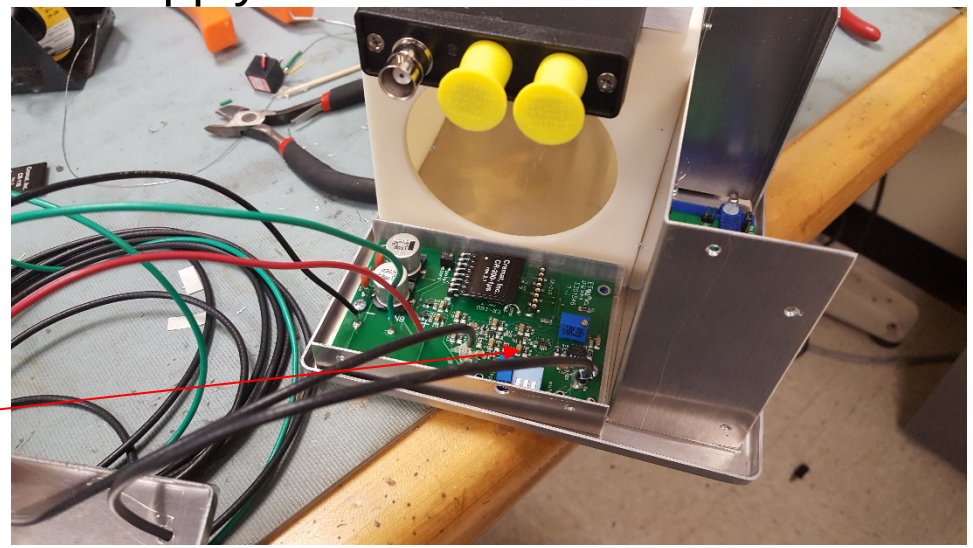
CPU & Data Storage





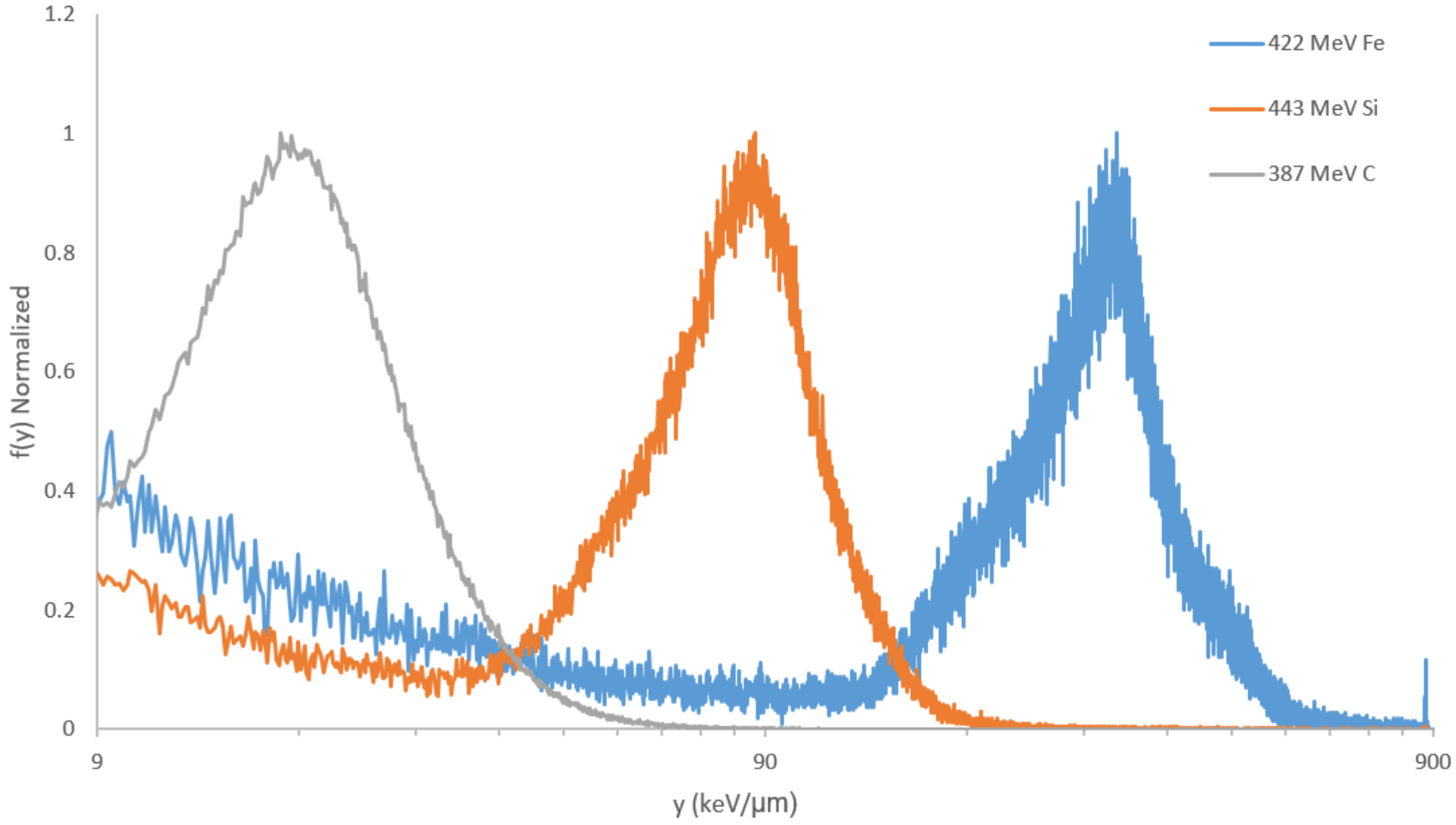
High Voltage Power Supply

AC to DC Power Supplies



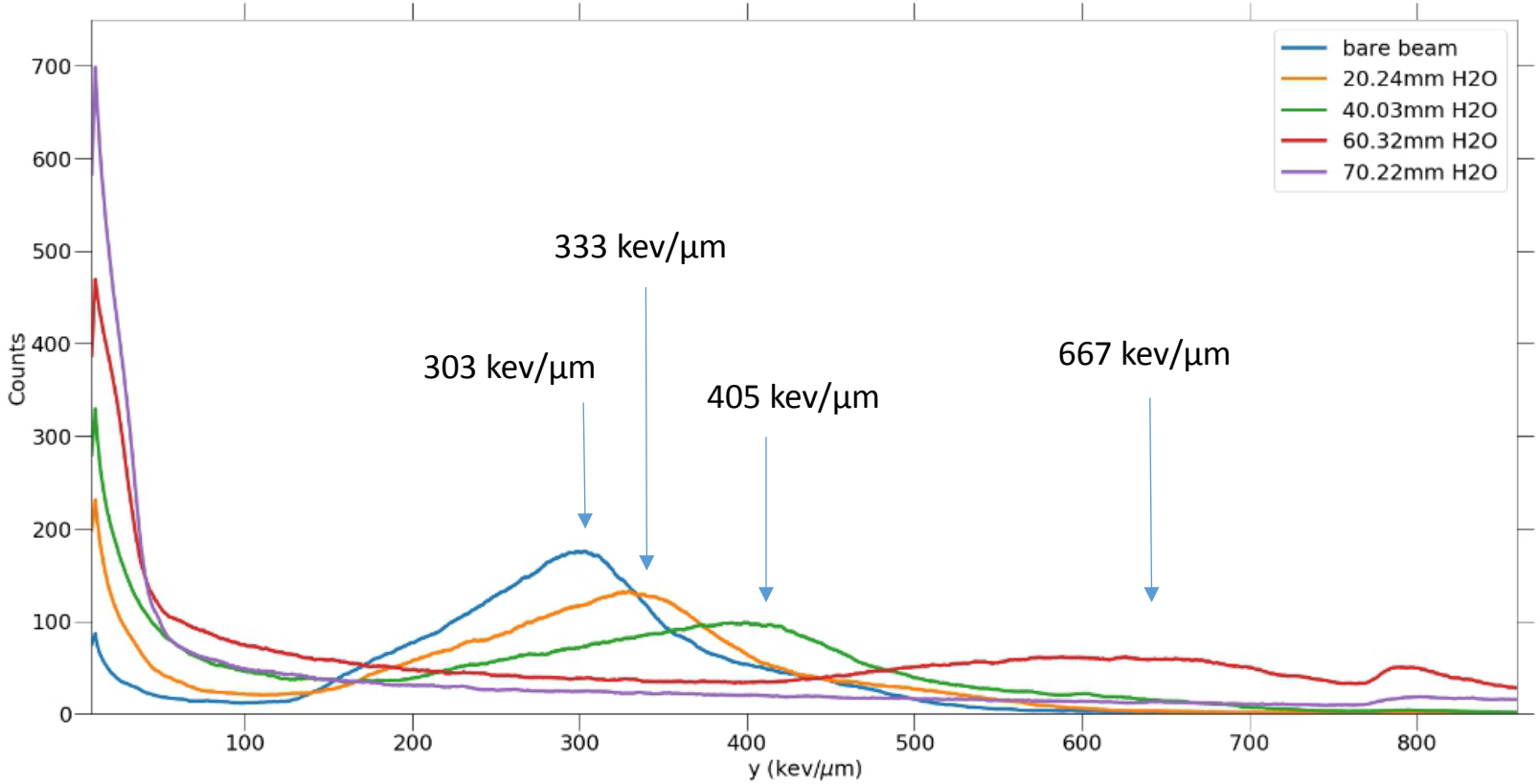
Pulse Shaping
Amplifier Module

HIMAC Calibration



ATED: Calibration (422 MeV/amu Fe spectra)

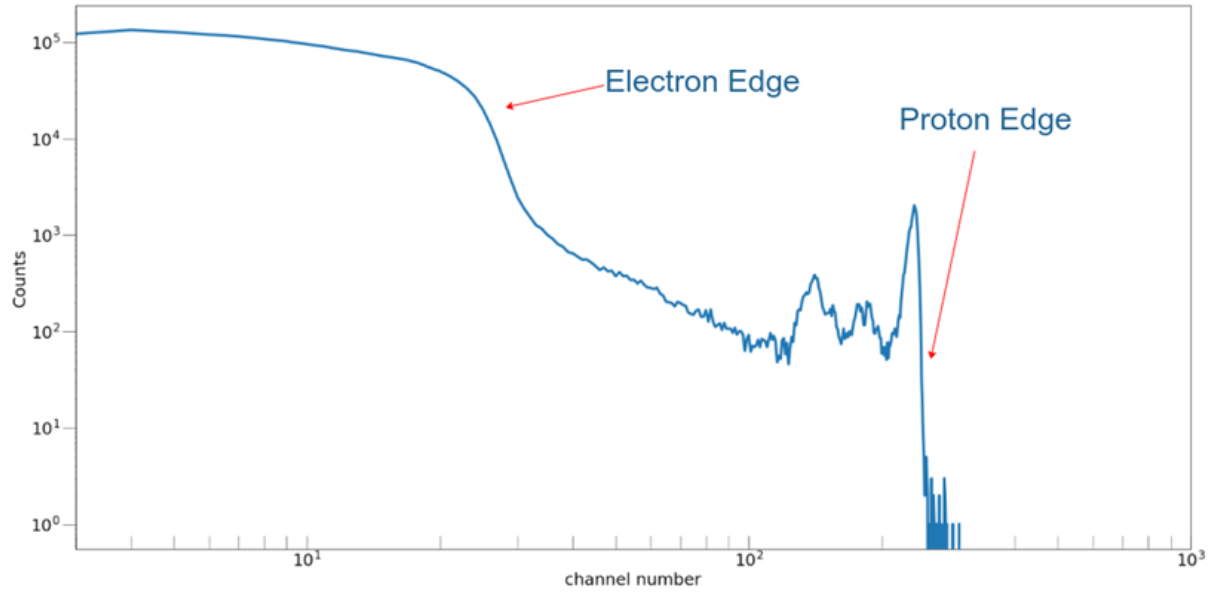
- Measurements is taken of a nearly mono-energetic 422 MeV/amu iron ion beam at HIMAC.
- The peak from the bare-beam is used to calibrate the rest of the x-axis energy values.
- Increasing thicknesses of a water equivalent plastic is placed between the bare-beam and ATED's detector head to simulate different shielding environments in space.



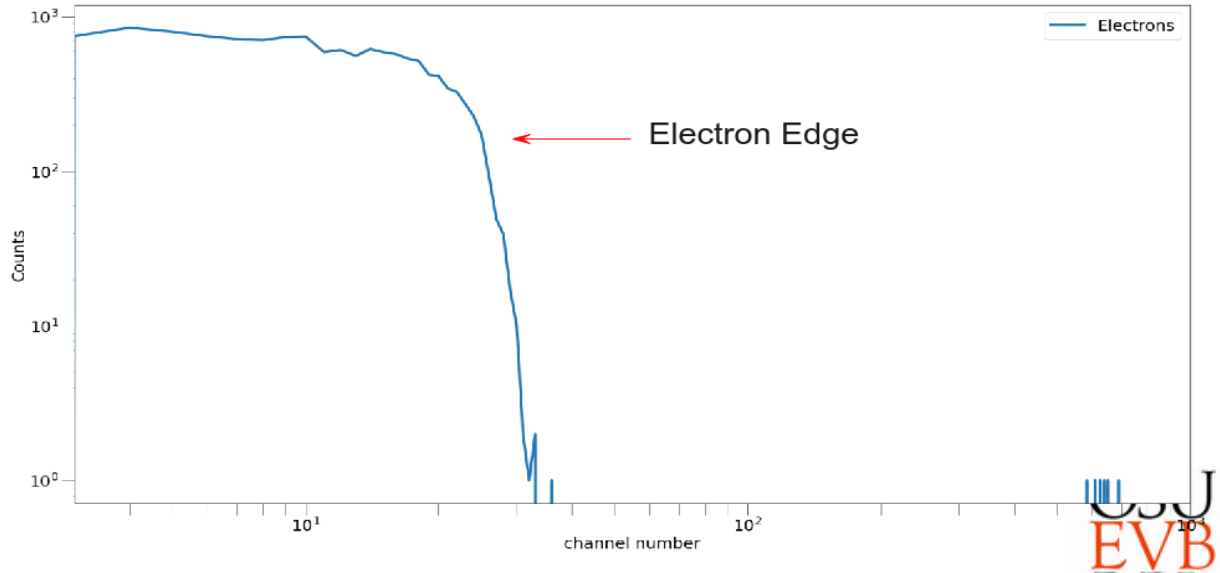
Alternative Calibration Method

lineal energy spectrum from PuBe neutron source

Proton edge at ~147 keV/μm
Electron edge at ~ 12 keV/μm



lineal energy spectrum from ^{137}Cs gamma ray source



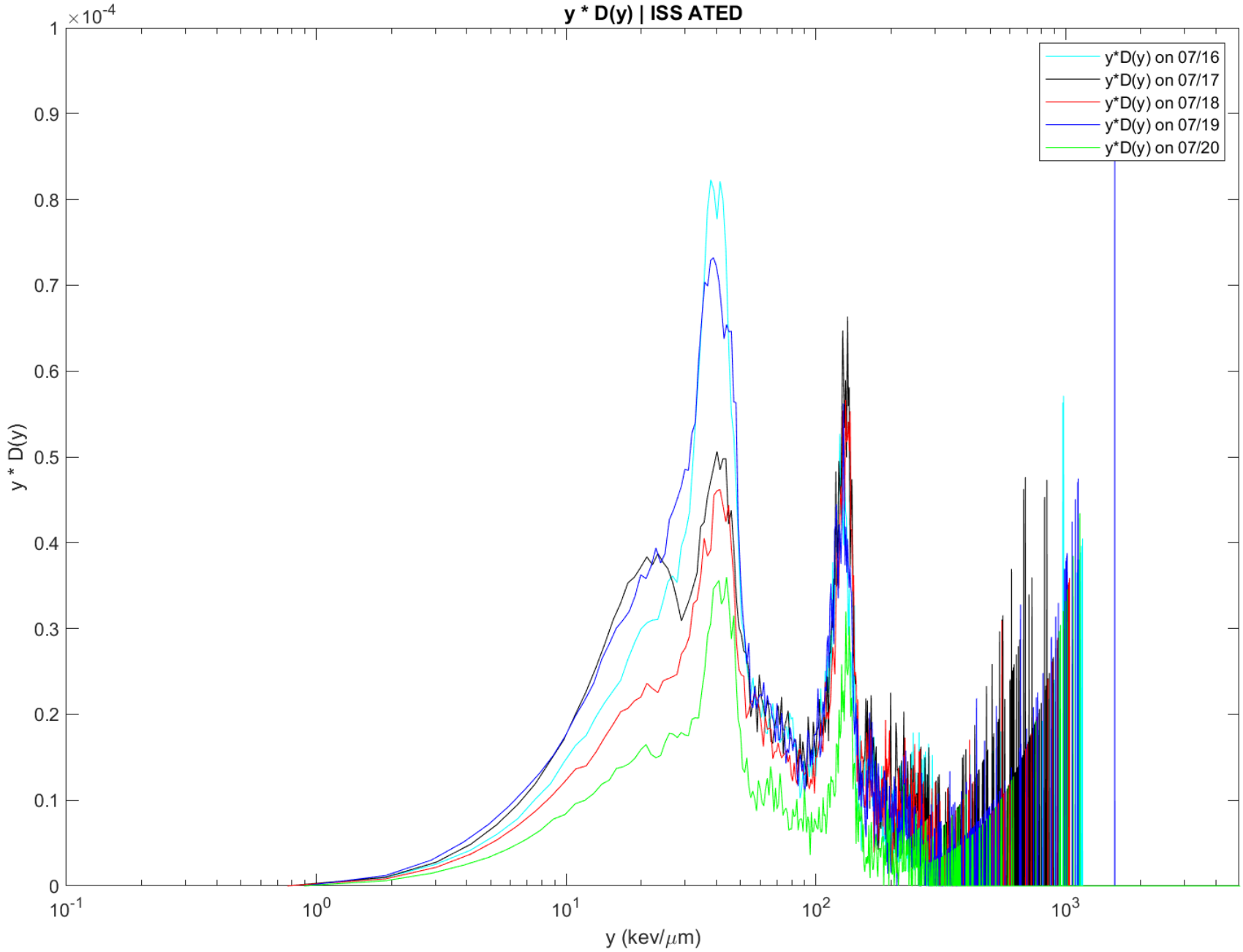
Loss of first ATED Flight Unit

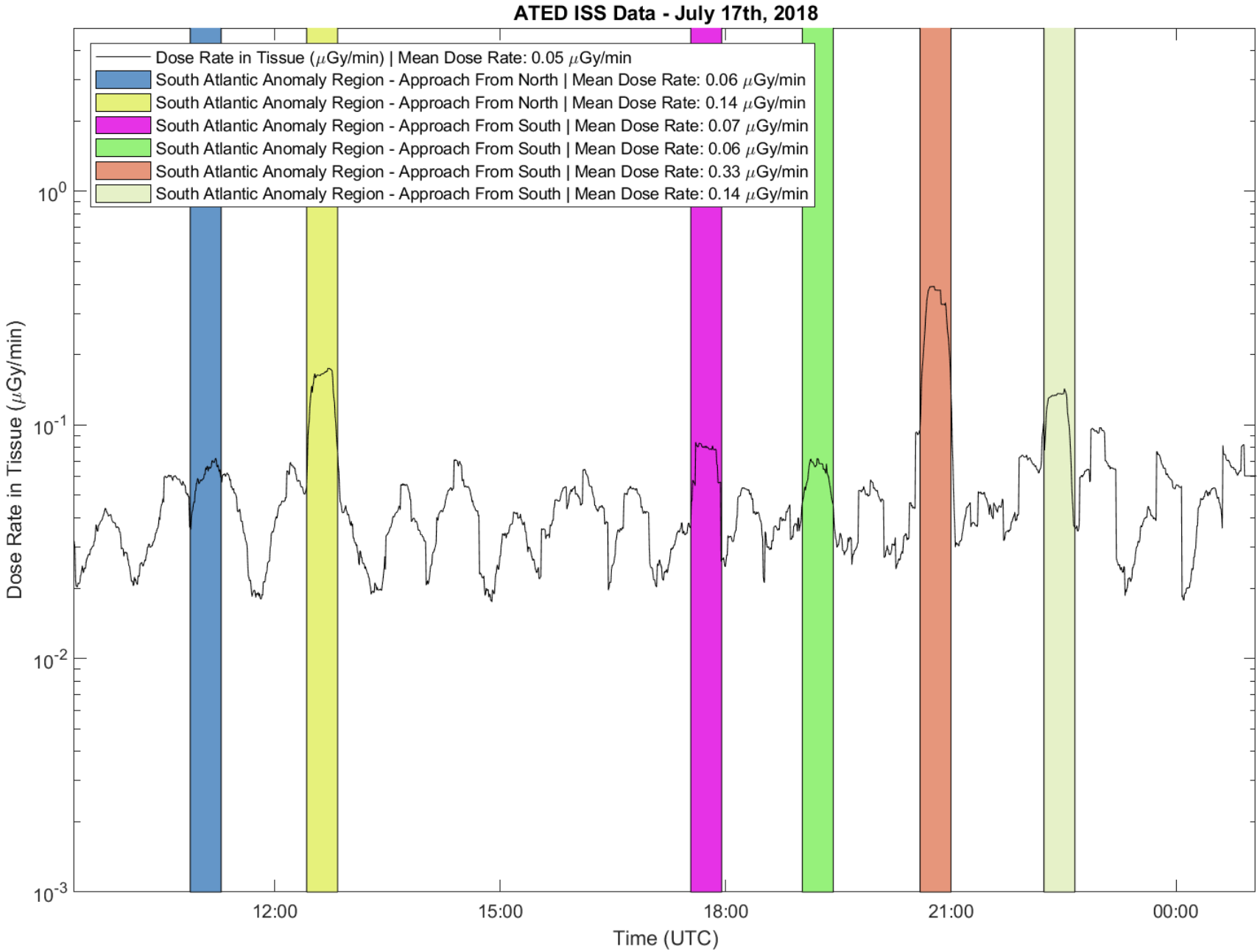
On Monday, 5 February 2018, while en route from Tulsa to Stillwater, Oklahoma, the Federal Express vehicle carrying the ATED flight hardware was involved in a fatal accident and all cargo on the vehicle, including the ATED flight hardware, was completely destroyed by fire.

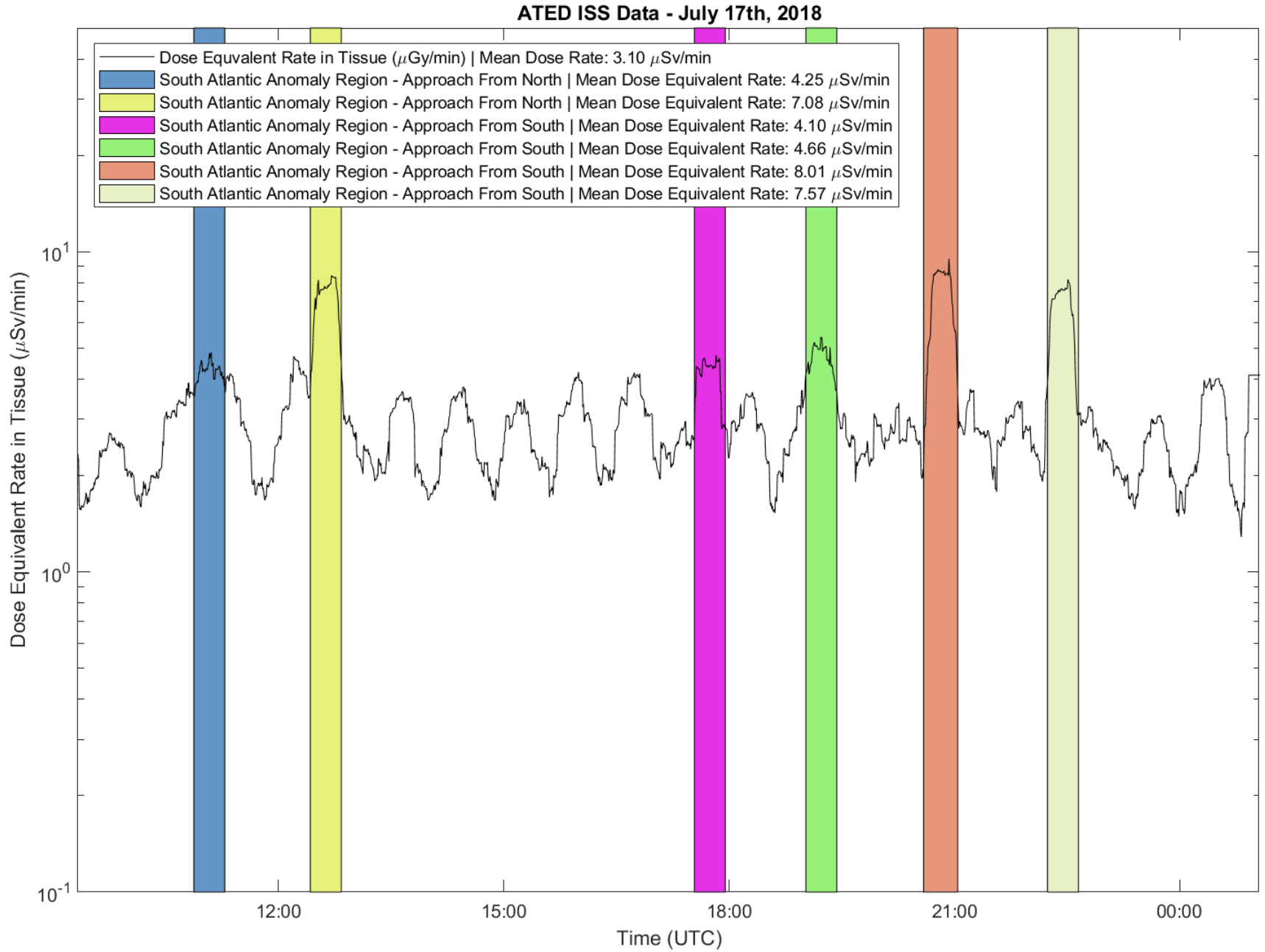
- Left: previous model detector head with traditional coaxial BNC feedthroughs that allow slow diffusion of atmosphere into the detector head.
- Right: Detector head with new vacuum-rated electrical feedthroughs.

ATED launched to ISS on OA-9 on 21 May 2018


EMERGENCY USE
FIRE PORT
NOD3F3
Active Tissue Equivalent Dosimeter
P/N ATED-001
OKLAHOMA STATE UNIVERSITY
EMERGENCY USE
FIRE PORT
NOD3 FD3
EMERGENCY USE
FIRE PORT
NOD3FD3
F 4


y * D(y) | ISS ATED
×10^-4
y*D(y) on 07/16
y*D(y) on 07/17
y*D(y) on 07/18
y*D(y) on 07/19
y*D(y) on 07/20
y * D(y)
y (kev/μm)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
10^-1
10^0
10^1
10^2
10^3


ATED ISS Data - July 17th, 2018
Dose Rate in Tissue (μGy/min) | Mean Dose Rate: 0.05 μGy/min
South Atlantic Anomaly Region - Approach From North | Mean Dose Rate: 0.06 μGy/min
South Atlantic Anomaly Region - Approach From North | Mean Dose Rate: 0.14 μGy/min
South Atlantic Anomaly Region - Approach From South | Mean Dose Rate: 0.07 μGy/min
South Atlantic Anomaly Region - Approach From South | Mean Dose Rate: 0.06 μGy/min
South Atlantic Anomaly Region - Approach From South | Mean Dose Rate: 0.33 μGy/min
South Atlantic Anomaly Region - Approach From South | Mean Dose Rate: 0.14 μGy/min
Dose Rate in Tissue (μGy/min)
10^0
10^-1
10^-2
10^-3
12:00
15:00
18:00
21:00
00:00
Time (UTC)


ATED ISS Data - July 17th, 2018
Dose Equvalent Rate in Tissue (μGy/min) | Mean Dose Rate: 3.10 μSv/min
South Atlantic Anomaly Region - Approach From North | Mean Dose Equivalent Rate: 4.25 μSv/min
South Atlantic Anomaly Region - Approach From North | Mean Dose Equivalent Rate: 7.08 μSv/min
South Atlantic Anomaly Region - Approach From South | Mean Dose Equivalent Rate: 4.10 μSv/min
South Atlantic Anomaly Region - Approach From South | Mean Dose Equivalent Rate: 4.66 μSv/min
South Atlantic Anomaly Region - Approach From South | Mean Dose Equivalent Rate: 8.01 μSv/min
South Atlantic Anomaly Region - Approach From South | Mean Dose Equivalent Rate: 7.57 μSv/min
Dose Equivalent Rate in Tissue (μSv/min)
10^1
10^0
10^{-1}
12:00
15:00
18:00
21:00
00:00
Time (UTC)

Conclusions

It WORKS!!!

More Useful Conclusions

- Still some problems with the data that need to be worked out.
- Most of the data analysis is still to be done (we only have a few days of data so far).
- Replacing the two 1K spectrometers with one 8K spectrometer didn't really work very well. Next version has two pulse shaping amplifiers with different gains feed a two input 1K spectrometer.
- Need to push down to lower lineal energy.
- Need to add data transfer/telemetry capability.
- Plan to fly on 1 month long, 24 km altitude balloon flight (Worldview)
- Already using it in place of CR-39 PNTDs in shielding materials experiments at HIMAC.