Space Tissue Equivalent Dosimeter (SpaceTED) and Atmospheric ionizing radiation Tissue Equivalent Dosimeter (AirTED)

Eric Benton, Tristen Lee, Conner Heffernan, Martin Yang,
Garrett Thornton and Buddy Gersey

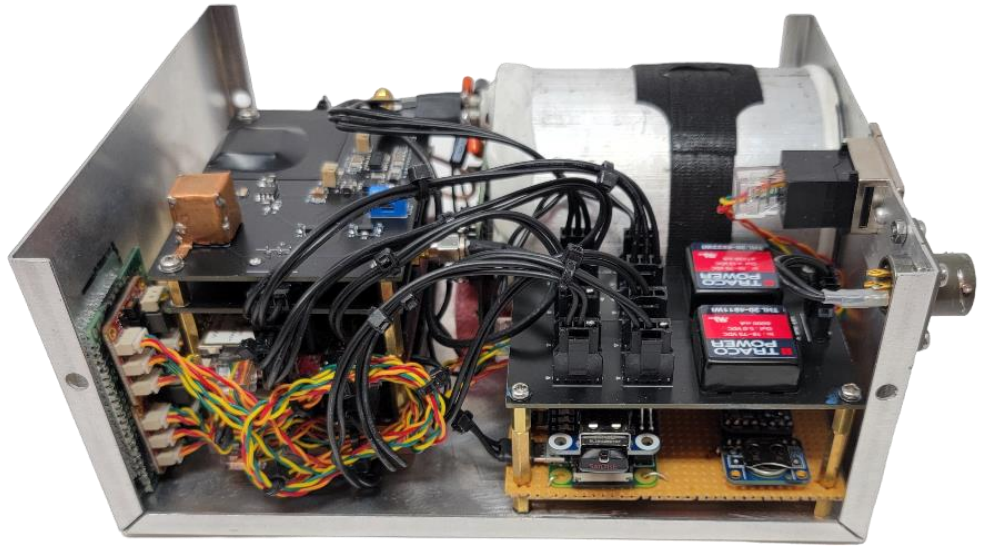
Oklahoma State University, Radiation Physics Laboratory,
Stillwater, Oklahoma USA

WRMISS-27, Boulder, CO

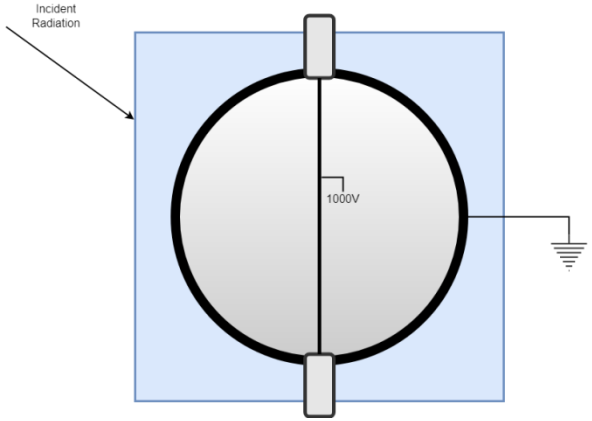
3 September 2024

AirTED/SpaceTED Overview

- Measures absorbed dose and dose equivalent received from ionizing radiation during flight.
- Size of shoebox, weighs ~2 kg
- 10-Watt power draw
- Two detectors to better cover expected particle species and energy ranges at aviation altitudes
  - Tissue Equivalent Proportional Counter (TEPC) for high-LET particles (neutrons)
  - Silicon PIN diode for low-LET (electrons, photons)
- Environmental sensor suite including RTC
- AirTED time-resolved data can be interpreted spatially and temporally with services such as FlightAware



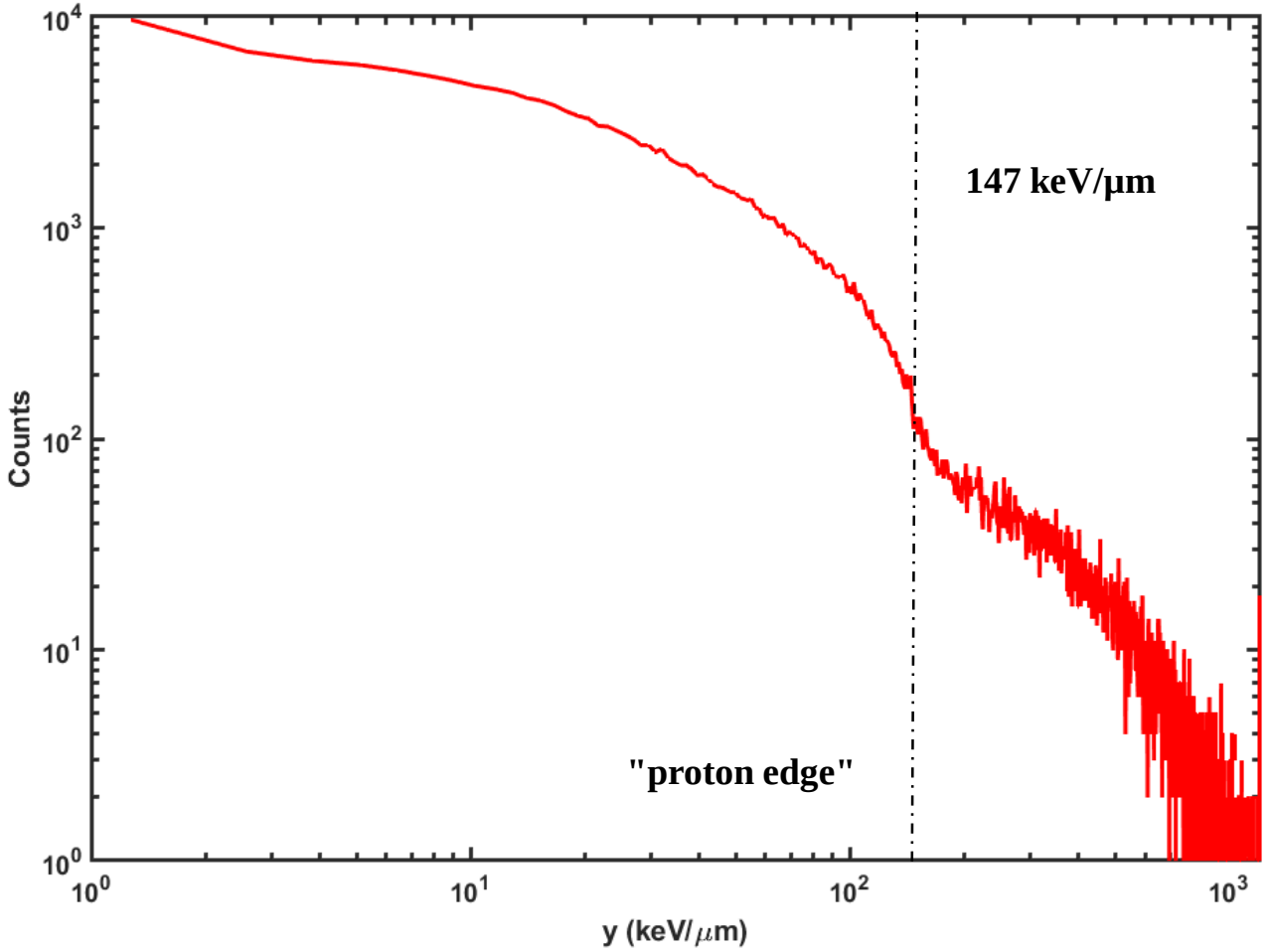
Tissue Equivalent Proportional Counter (TEPC)



Acrylic:
$(C_5O_2H_8)_n$
1.18 g/cm³

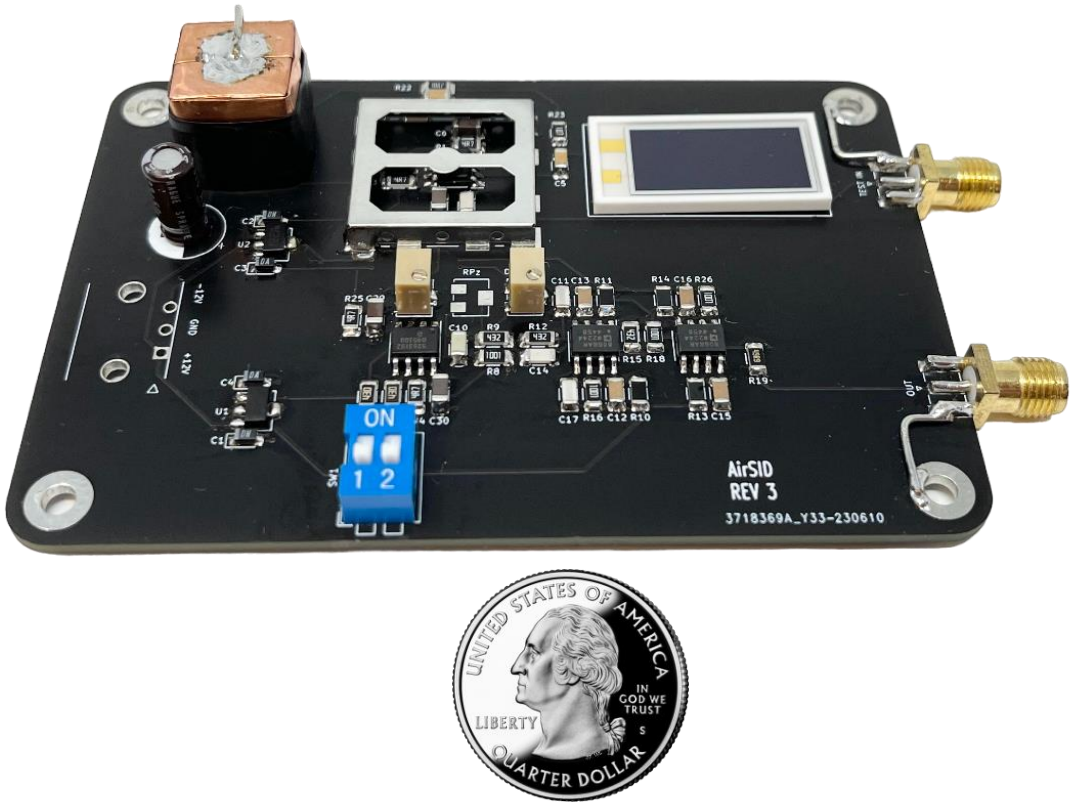
- Low pressure gas-filled detector
- Acrylic wall simulates living tissue
- Detects neutrons through elastic (n,p) interactions with hydrogen in the wall
  - Secondary proton penetrates gas volume, ionizes gas and induces current in anode proportional to energy deposited in the gas
- Most sensitive to the high-LET component of air showers
- Calibrated with neutron source
- Yields lineal energy spectra, absorbed dose, and dose equivalent

Tissue Equivalent Proportional Counter (TEPC)



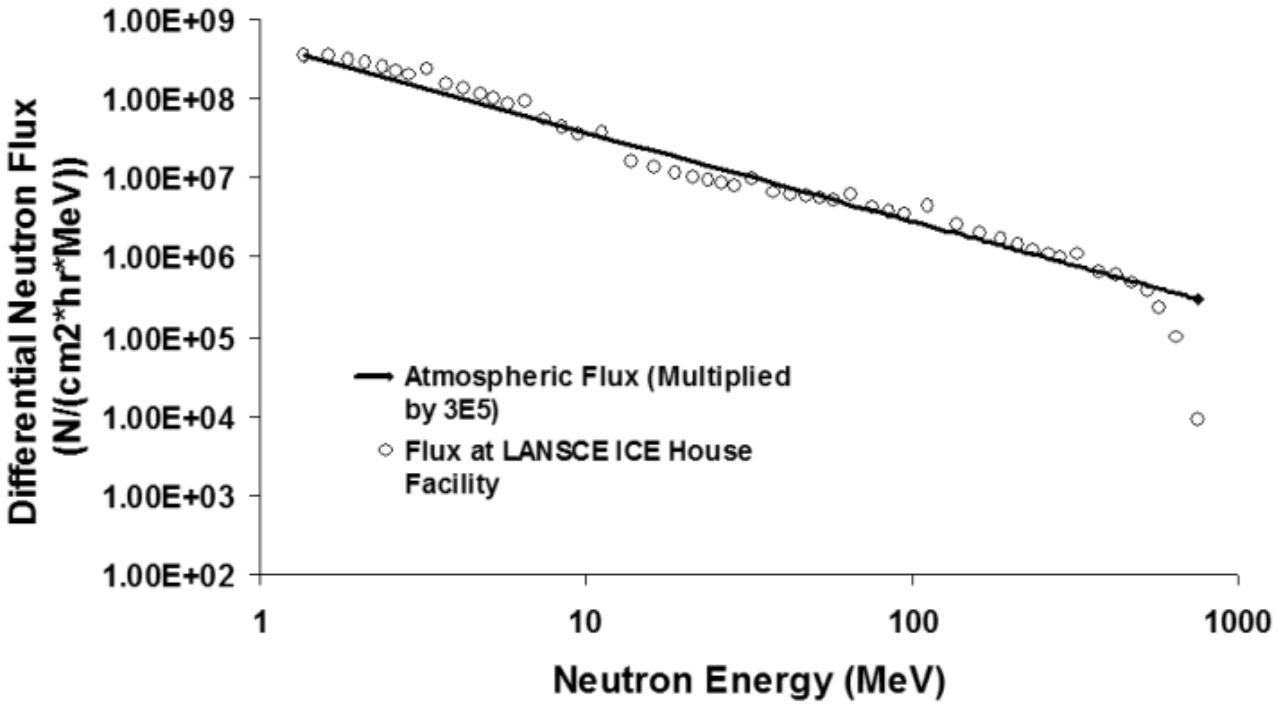
- Plutonium-beryllium (PuBe) neutron source
- Proton edge corresponds to stopping protons crossing the diameter of the spherical active volume
- These protons have a maximum lineal energy – 147 keV/µm

Silicon PIN Diode



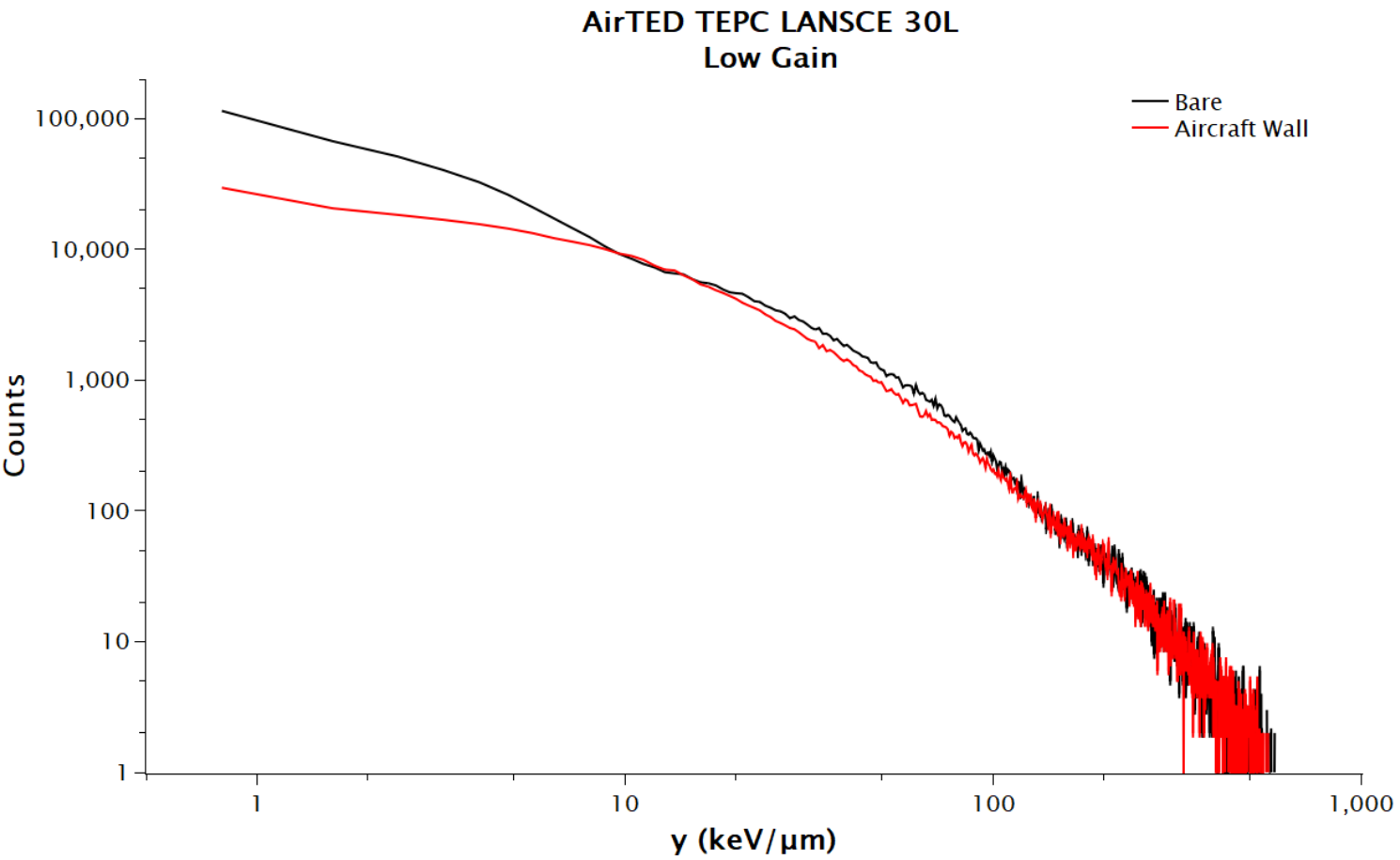
- Detects radiation through production of electron-hole pairs in silicon
- Sensitive to low-LET component of air showers (electrons, photons, etc.)
- Yields energy deposition spectra

Los Alamos Neutron Science Center (LANSCE) spallation neutron source, 30L beam line



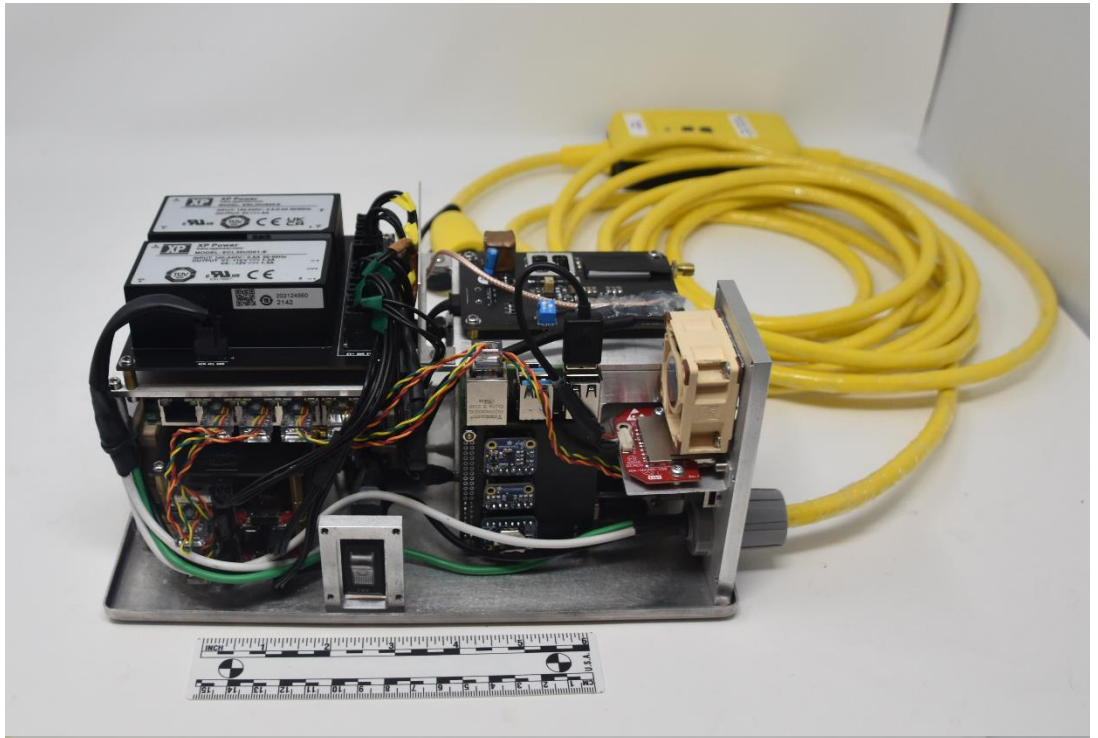
- Produces neutron flux similar to atmospheric flux
- Allows us to quickly and efficiently characterize our detectors.
- 1 hour in the beam is ~300,000 flight hours
- LANSCE is an invaluable resource in the development of AirTED

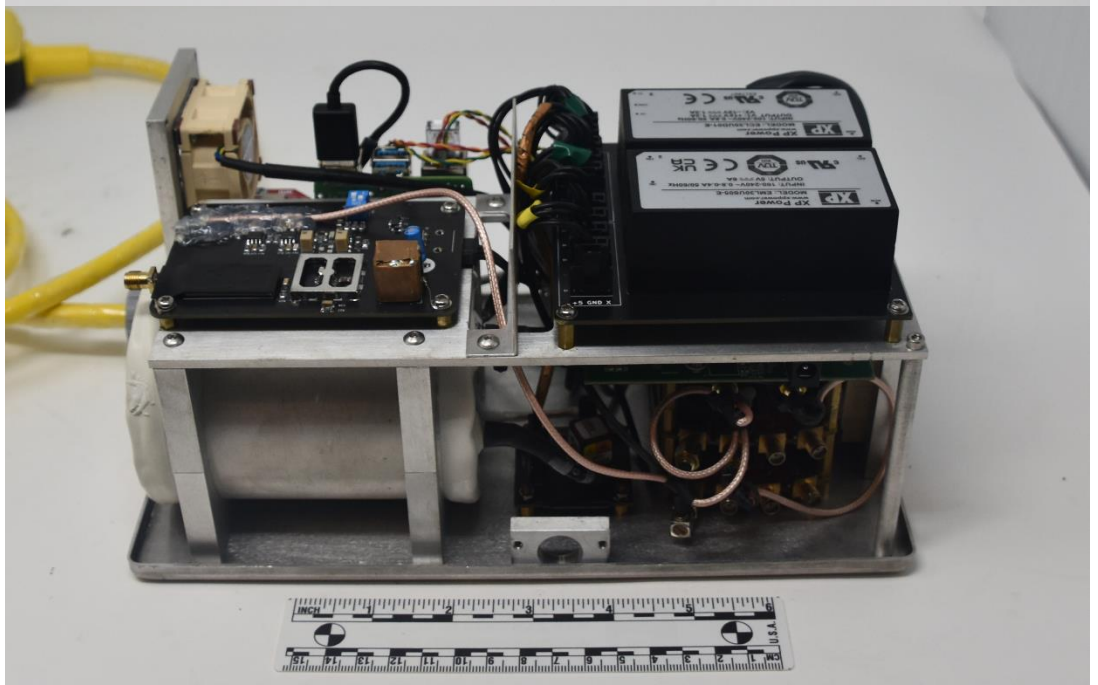
LANSCE 30L



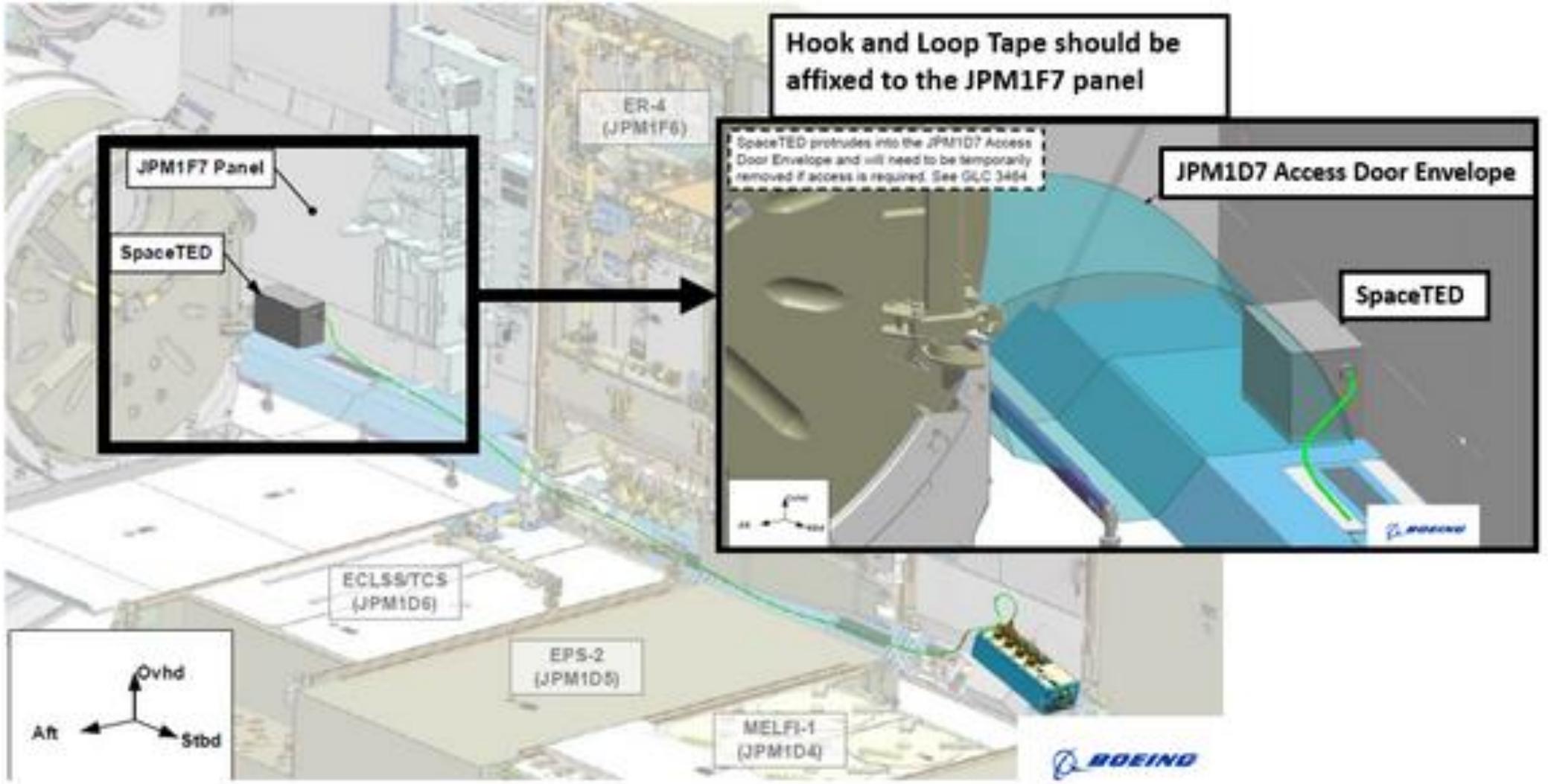
- 2-hour exposures
- Simulated aircraft wall (Al/polyethylene)
- Aircraft wall scatters neutrons out of the beam, resulting in fewer (n,p) interactions in TEPC
- The aircraft wall has minimal effect on the overall spectrum

SpaceTED Flight Unit

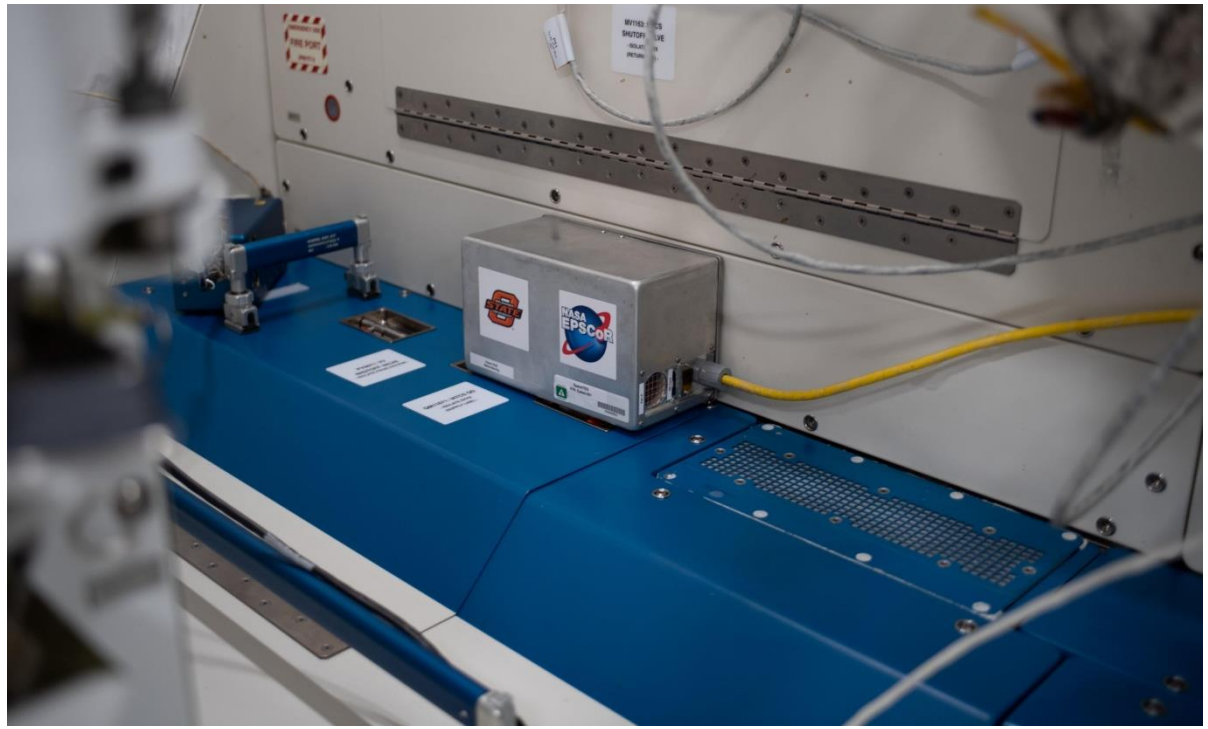


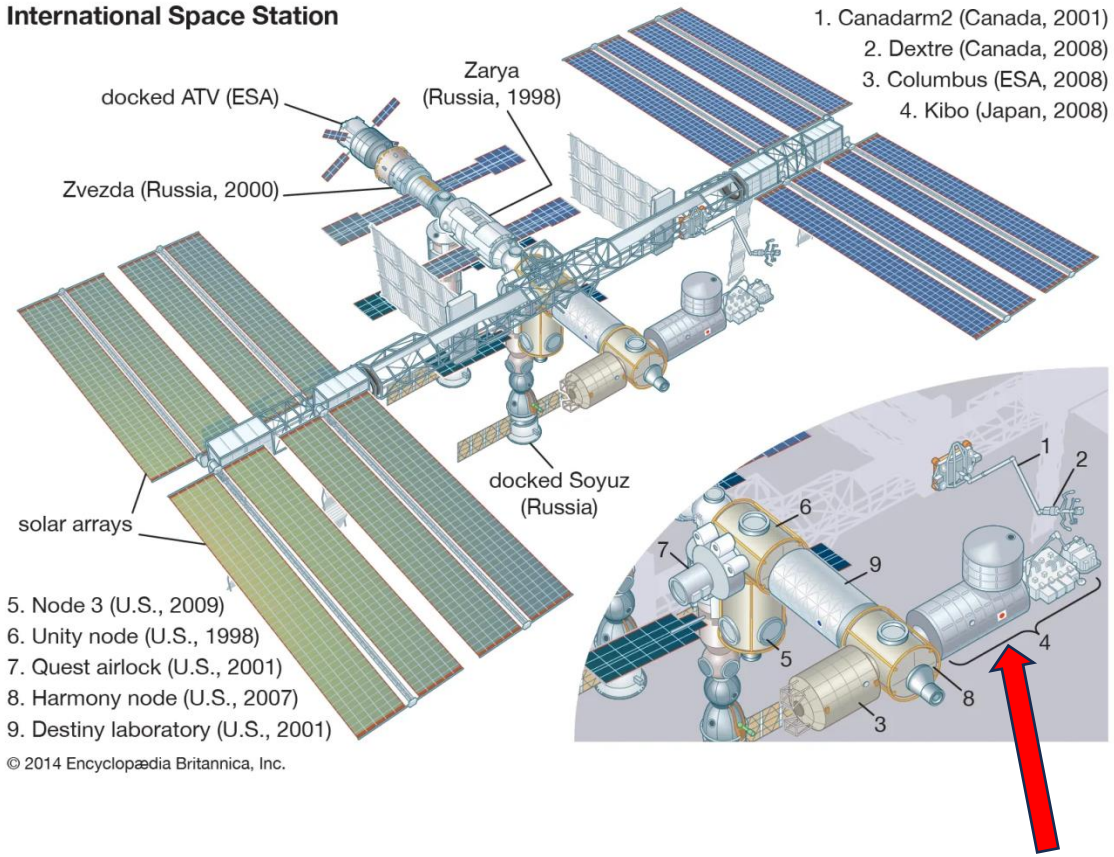


SpaceTED Exposure Location in ISS JEM

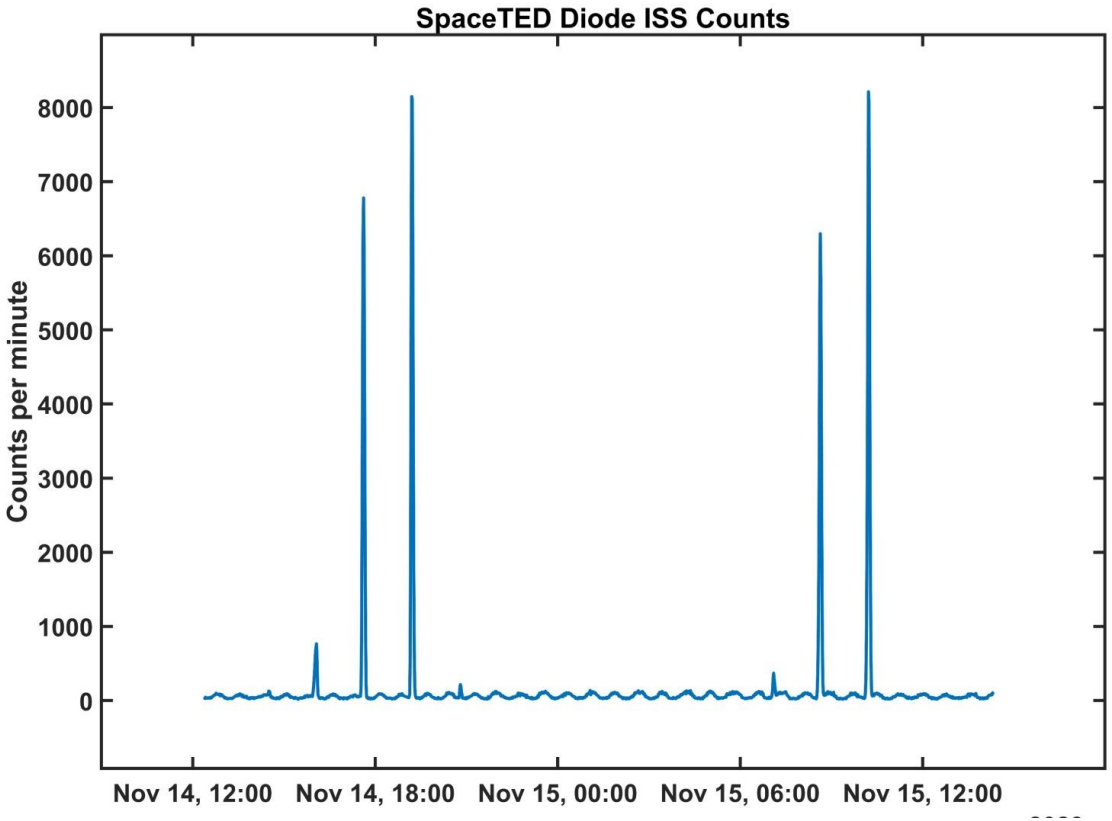


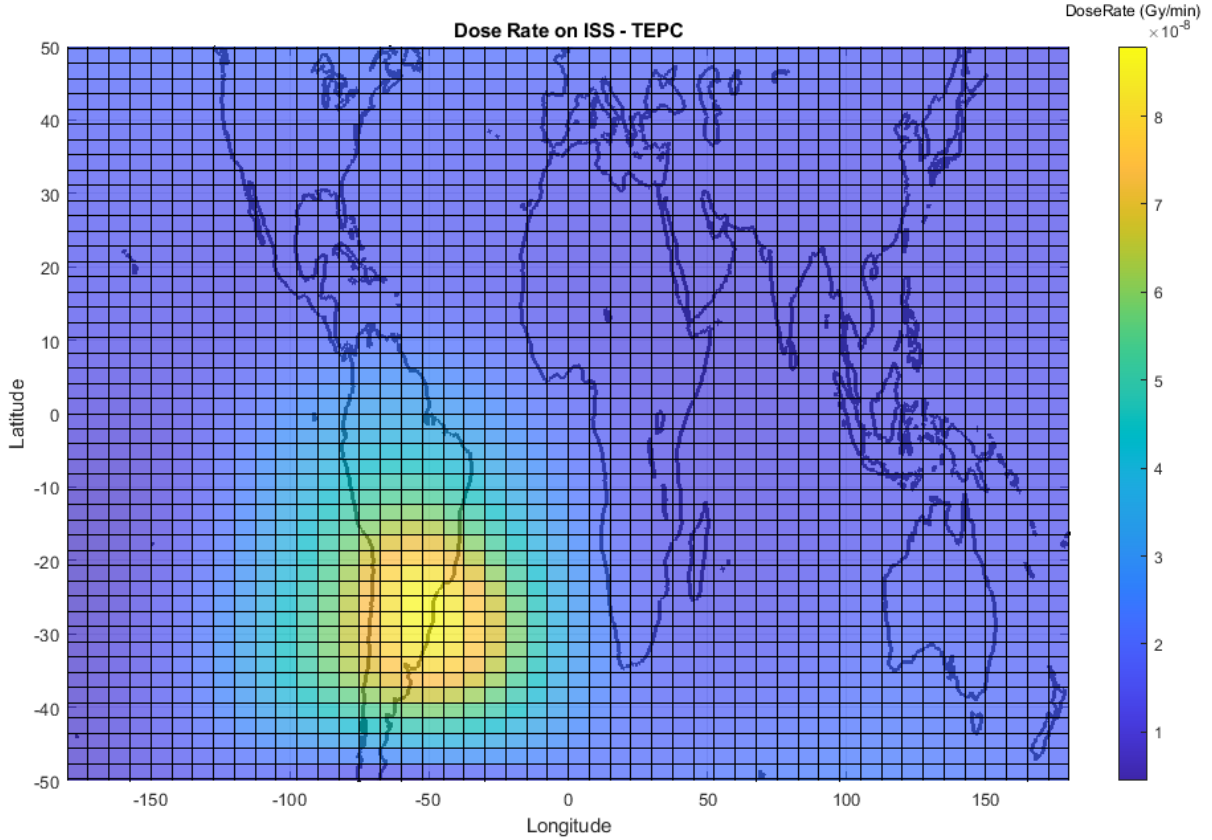
SpaceTED Aboard the ISS





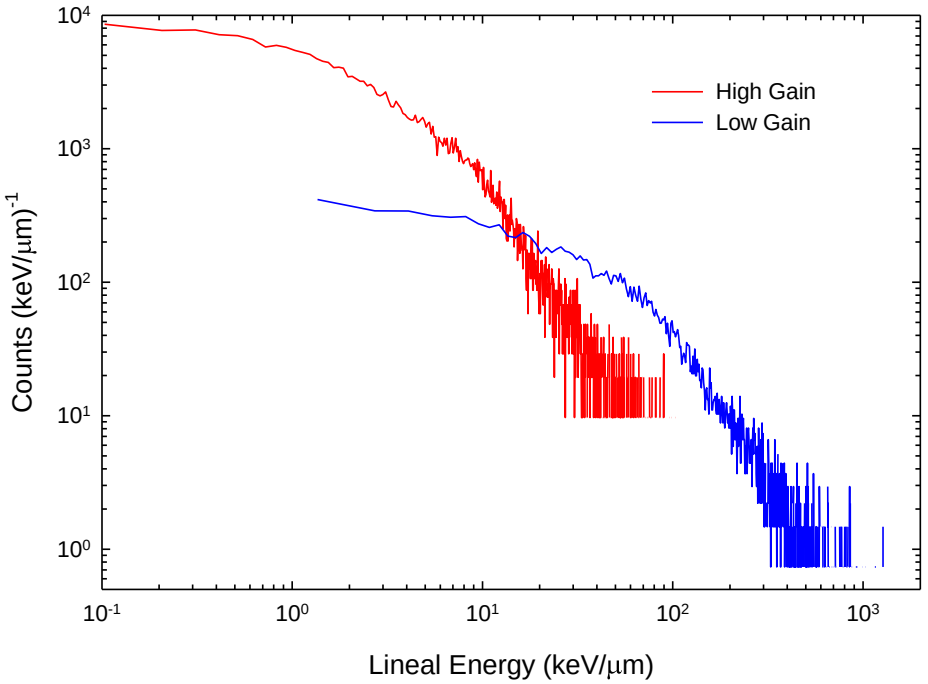
SpaceTED Aboard the ISS



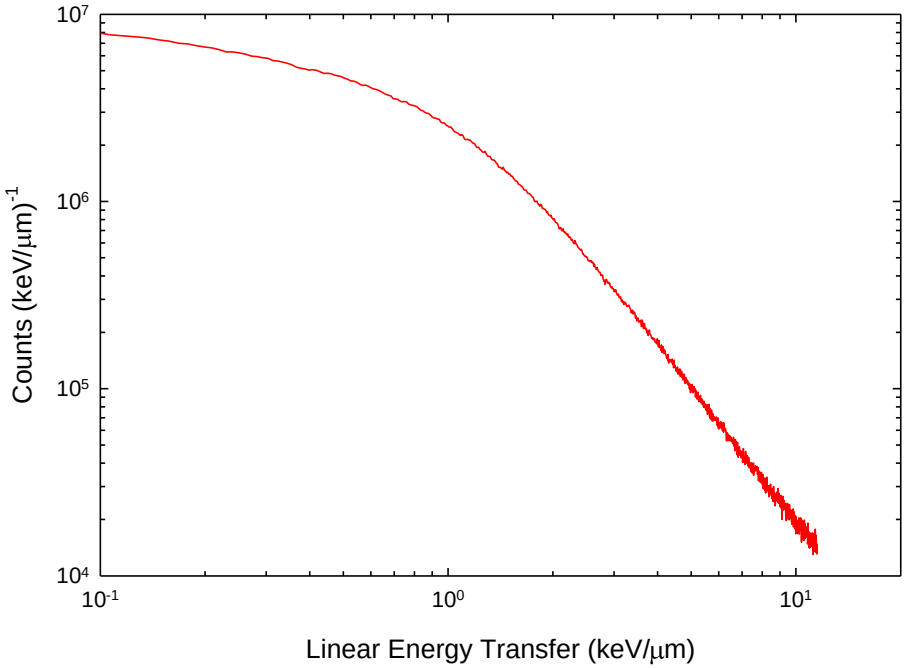


SpaceTED Aboard the ISS

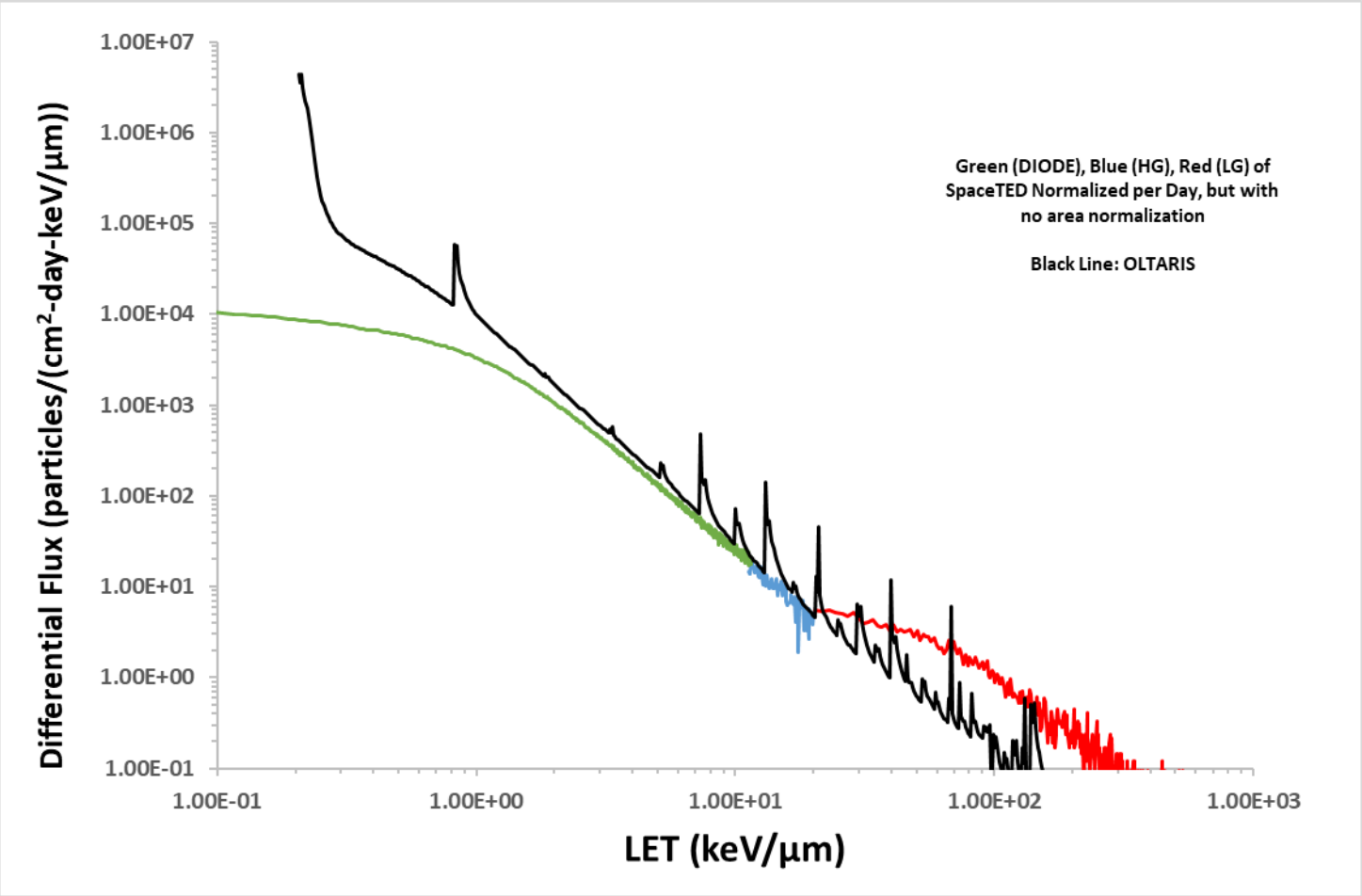
Tissue Equiavlent Proportional Counter



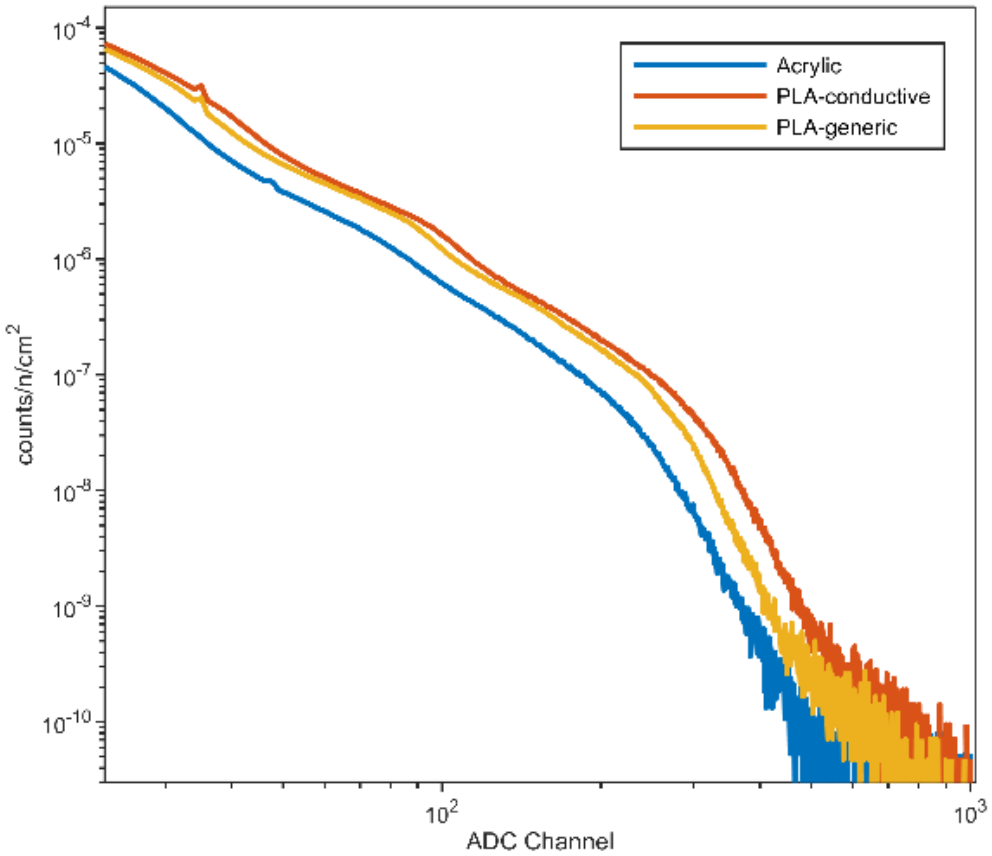
Si PIN Diode



SpaceTED Aboard the ISS



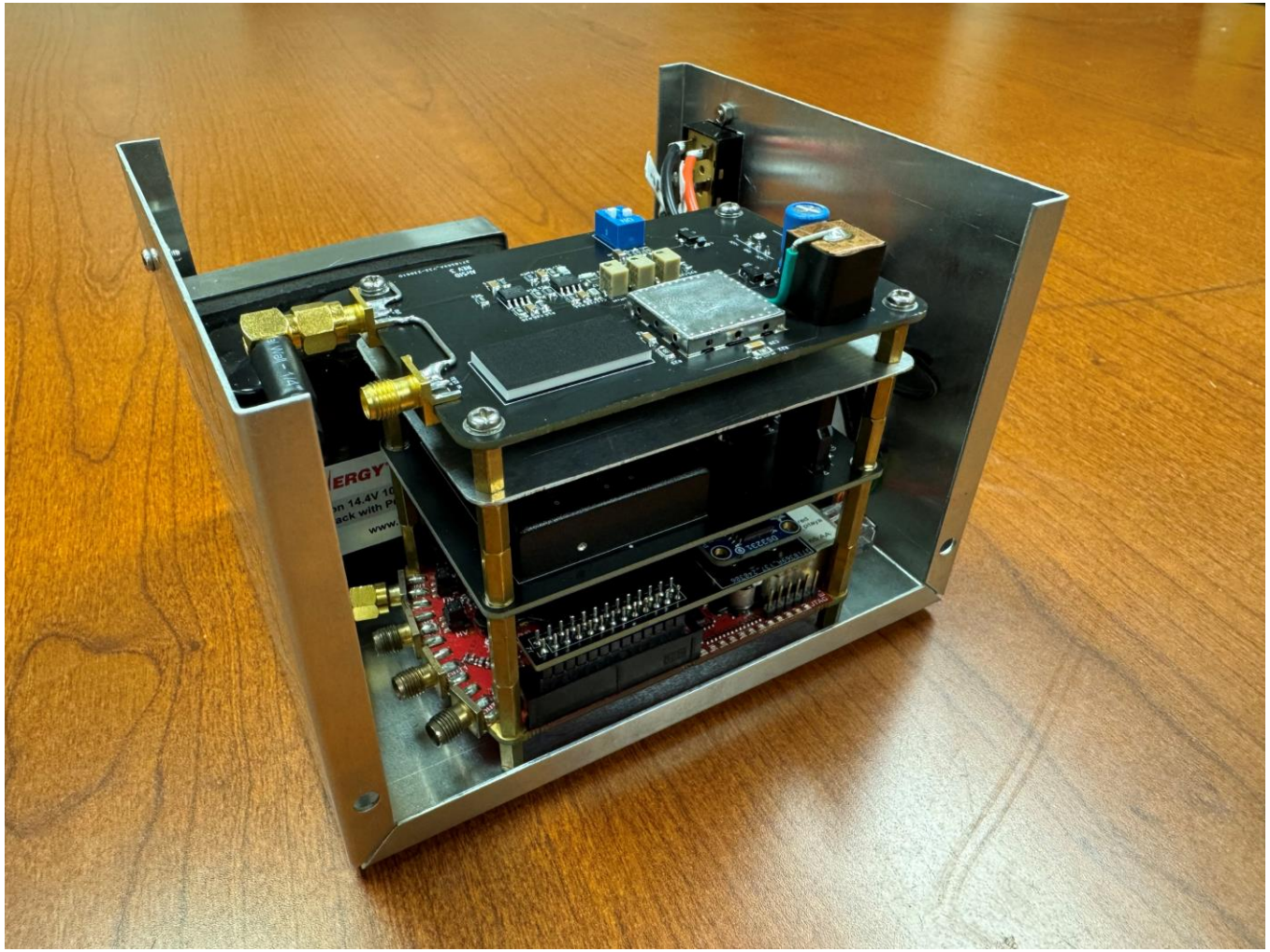
3-D Printed TEPC Detector Heads



AirSiD Heliotrope Flights

- Heliotrope (Solar Balloon) flights launched from OSU Unmanned Aircraft Flight Station
- Balloons made of painters drop plastic, clear packing tape and C black.
- 3 kg max payload, including transponder, cut down mechanism.
- AirSiD contains Si PIN diode, 3-d accelerometer, tempterature and pressure sensors, Red Pitaya spectrometer.
- Payload automatically cut down when balloon reaches programmed longidue or after specified flight duration.
- Two flights this summer (July 24 and August 27)
- Plan to develop technology so can launch during SPE.

AirSiD = AirTED – TEPC + battery power

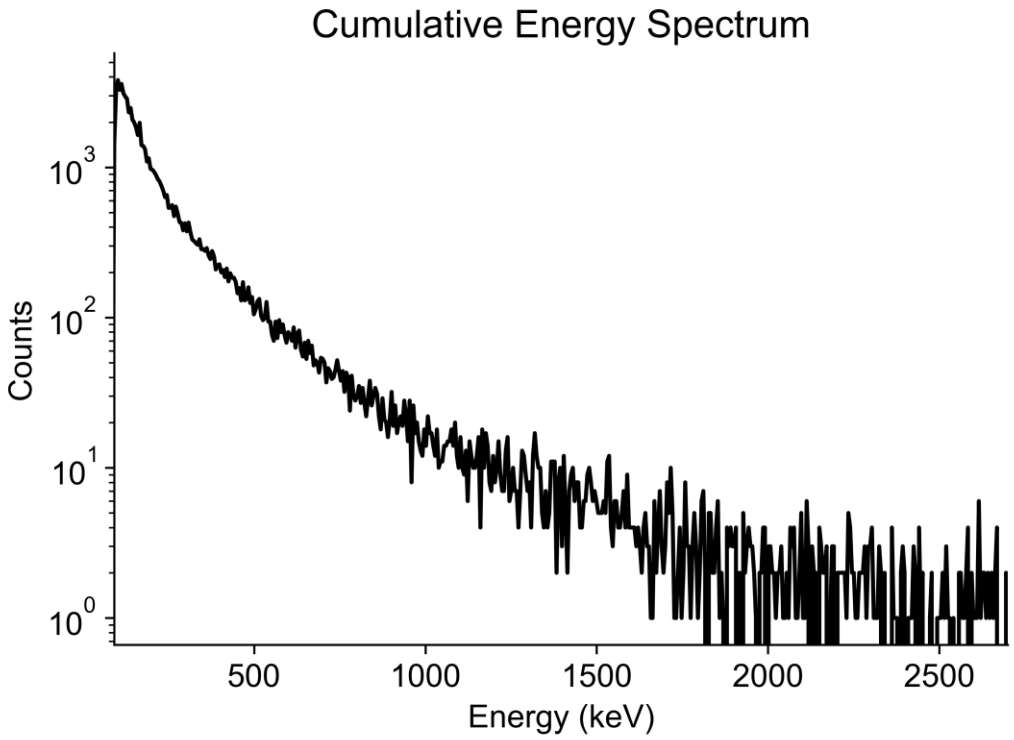


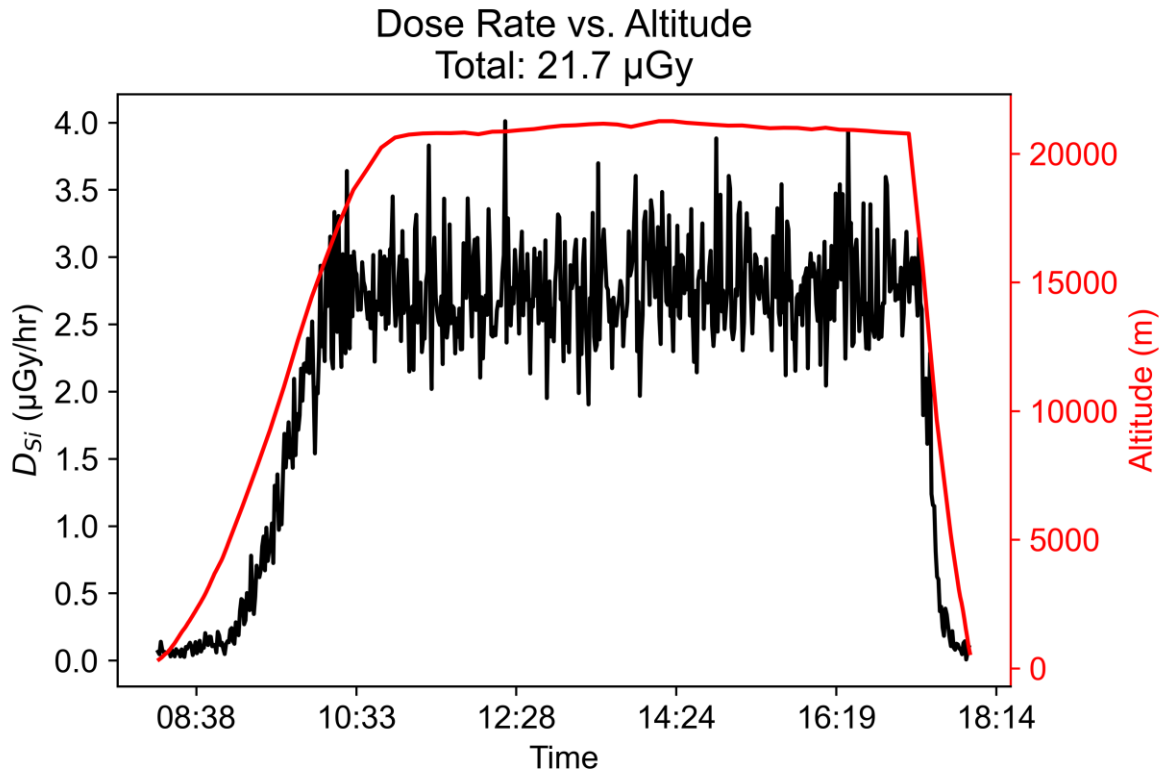
Preliminary Results from 28 August 2024 AirSiD Heliotrope Flight

Float Altiude: ~21 km, Distance: ~127 km

Float Duration: ~6 hours

Preliminary Results from 28 August 2024
AirSiD Heliotrope Flight





Measured Absorbed Dose (Si): 21.7 µGy

CARI-7A calculation (Si): 26.2 µGy

Conclusions

- SpaceTED scheduled to be returned to ground on next SpaceX flight (October) after nearly 1 year operation on ISS
- AirTED scheduled to fly on NASA WB-57 again and on USAF 45 km altitude test aircraft … and just maybe on Blue Origin New Shepard.
- Hope to adapt AirTED for smaller, lower mass, battery powered operation so can fly on high altitude balloons
  - new 4 input Red Pitaya spectrometer board greatly simplifies electronics
  - 3-D printed TEPC heads simplifies construction and reduces size.
- Develop Heliotrope technology so that we can fly AirTED at short notice whenever SWPC gives indication of likely SPE.

Collaborators

- Kyle Copeland, U.S. FAA, Civil Aerospace Medical Institute
- Brad “Buddy” Gersey, OSU Adjunct Prof.

Current Grad. Students

- Tristen Lee,
- Mingzheng (Martin) Yang,
- Conner Heffernan,
- Garrett Thornton,

Former Students

- Bryan Hayes, (graduated 2021)
- Paul Inman, (graduated 2021)