

# Measuring and Modeling Solar and Galactic Cosmic Radiation in the Atmosphere for Space Weather Applications



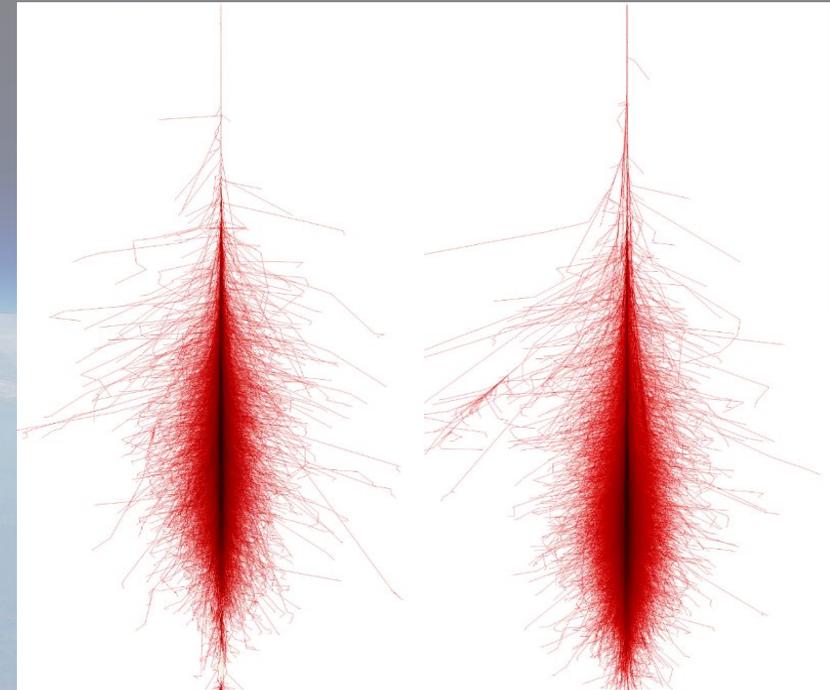
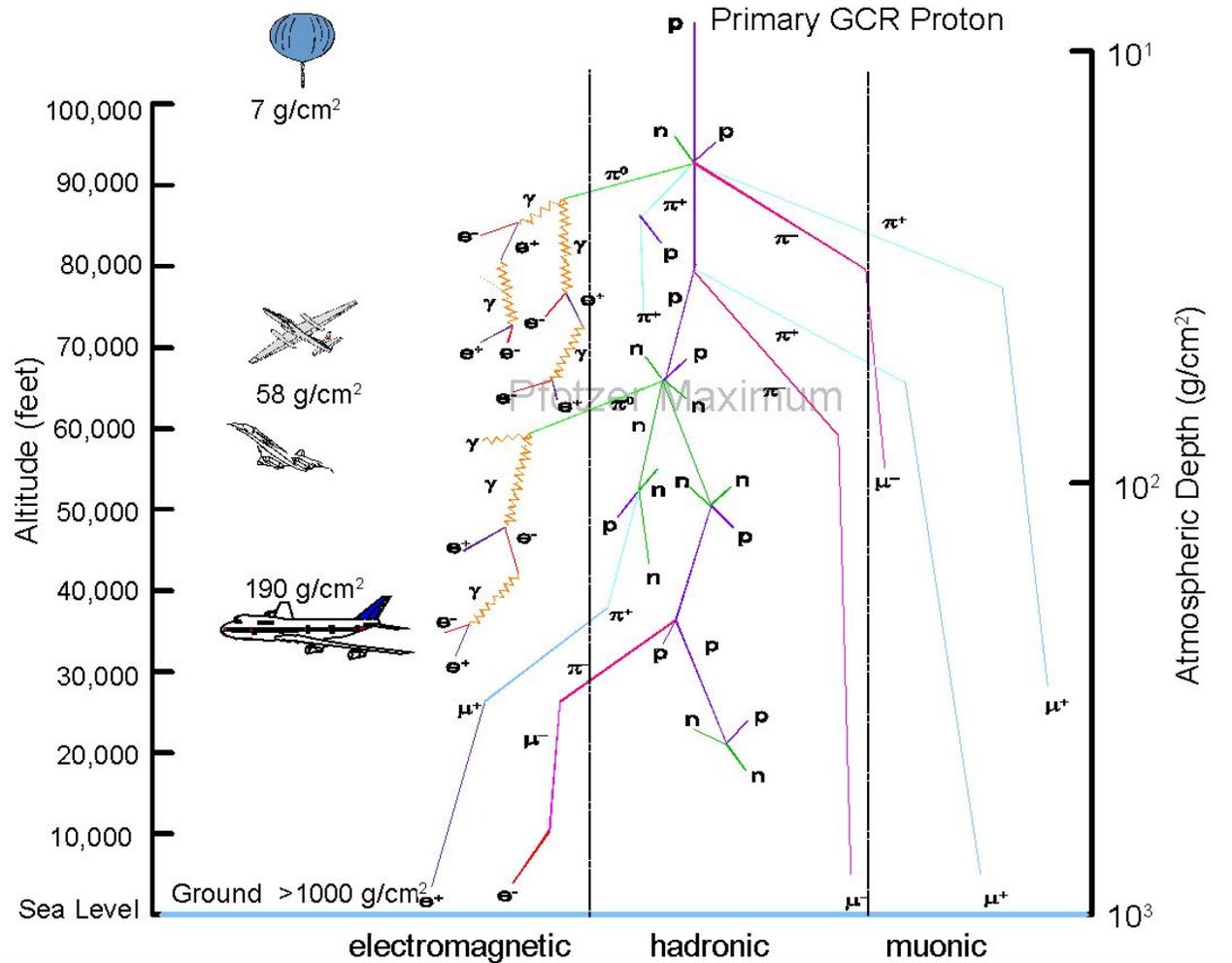
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# Cosmic Ray Air Showers



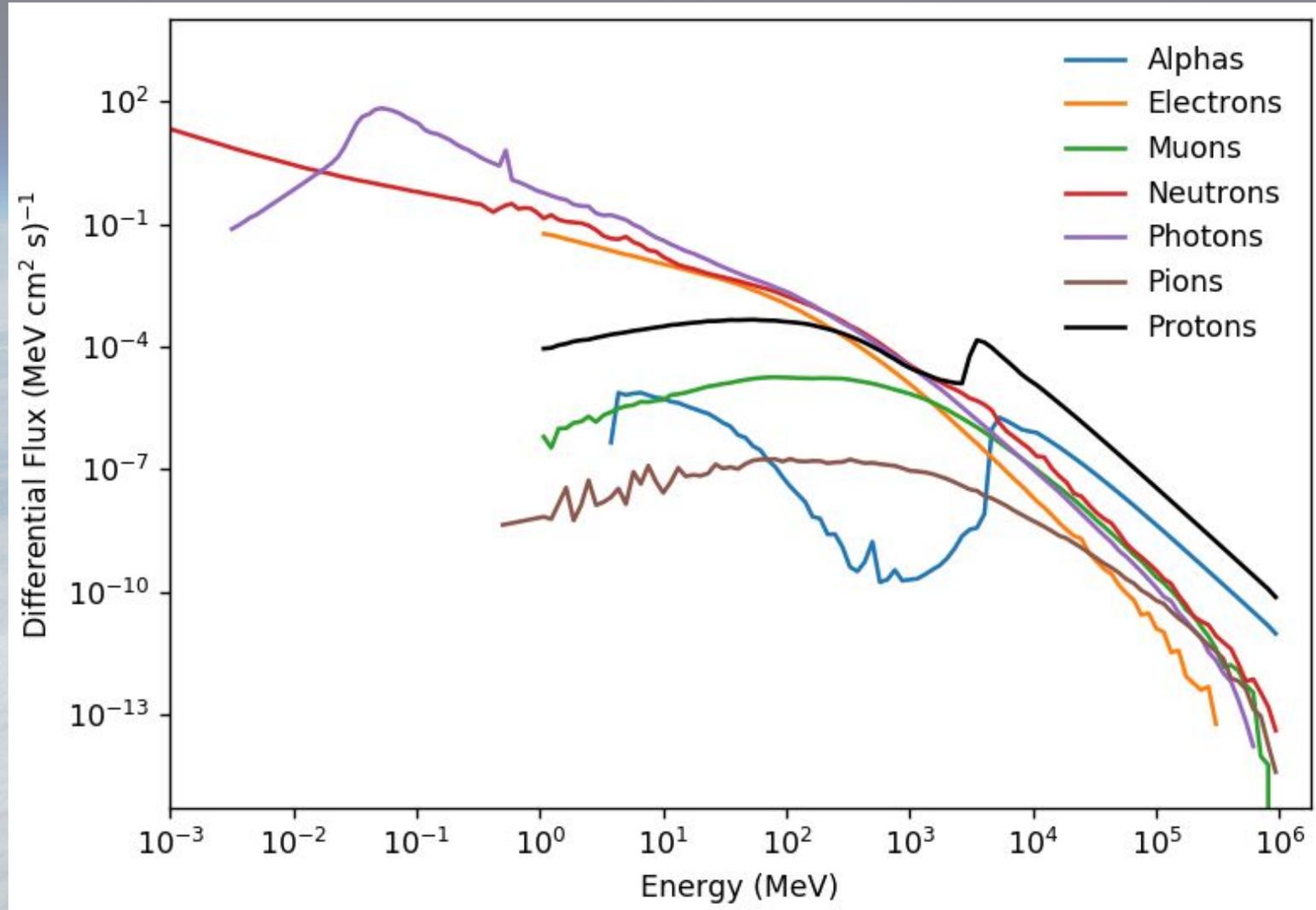
50 GeV proton

1 TeV proton

CORSIKA MC code simulations of proton-initiated air showers [CORSIKA website].

A diagram of a cosmic ray air shower illustrating the hadronic, electromagnetic and muonic cascades.

# GCR secondary particle energy spectra produced by AIREC for use in modeling the 2005 DSTB high altitude balloon flight.



Latitude: 34.47° North  
Longitude: 255.75° East  
Altitude: 36.576 km  
Date: November 2005  
Multiple Secondary Particles

# AirTED

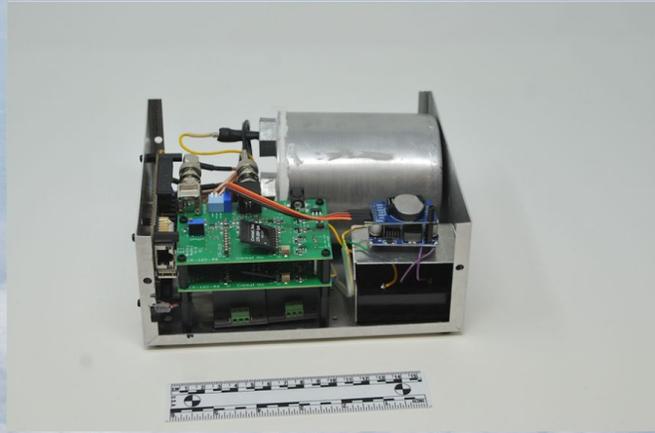
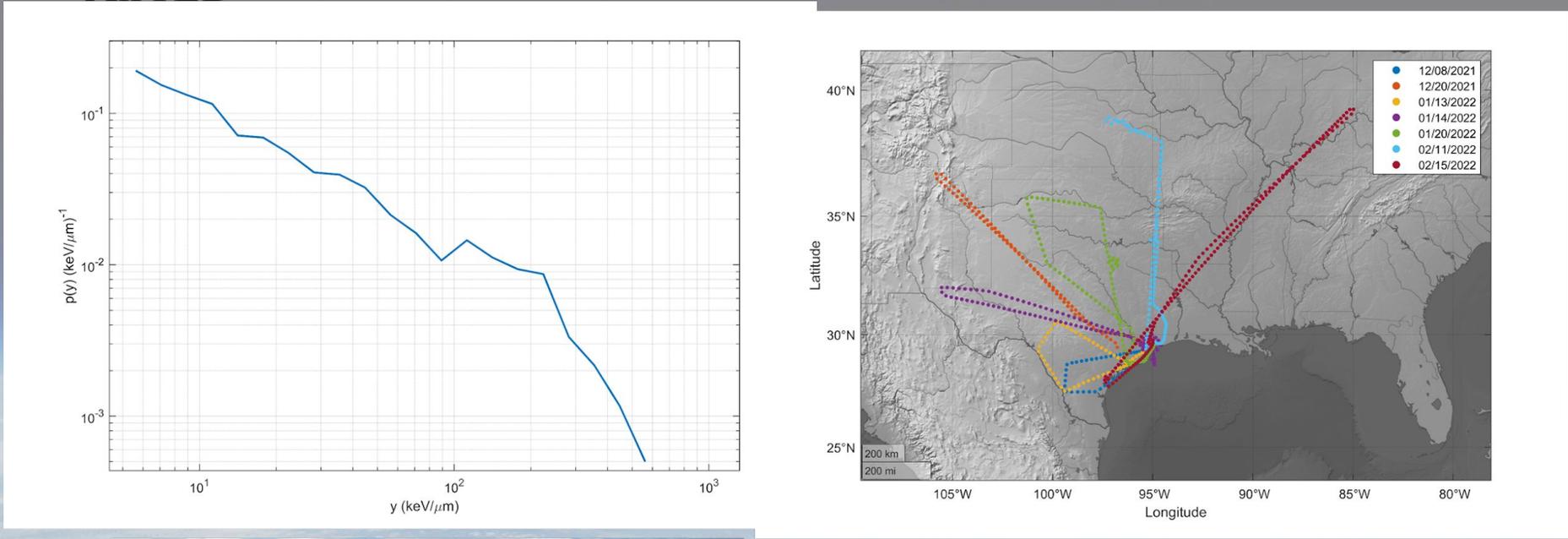
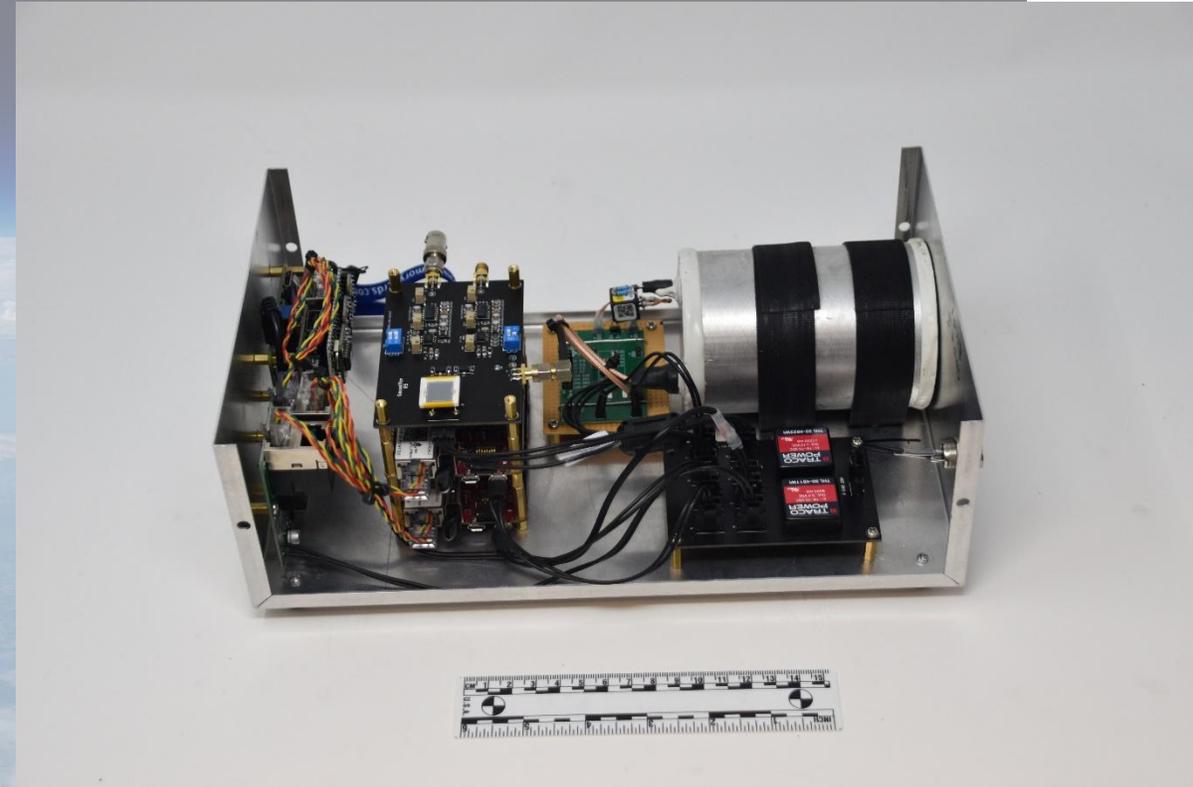
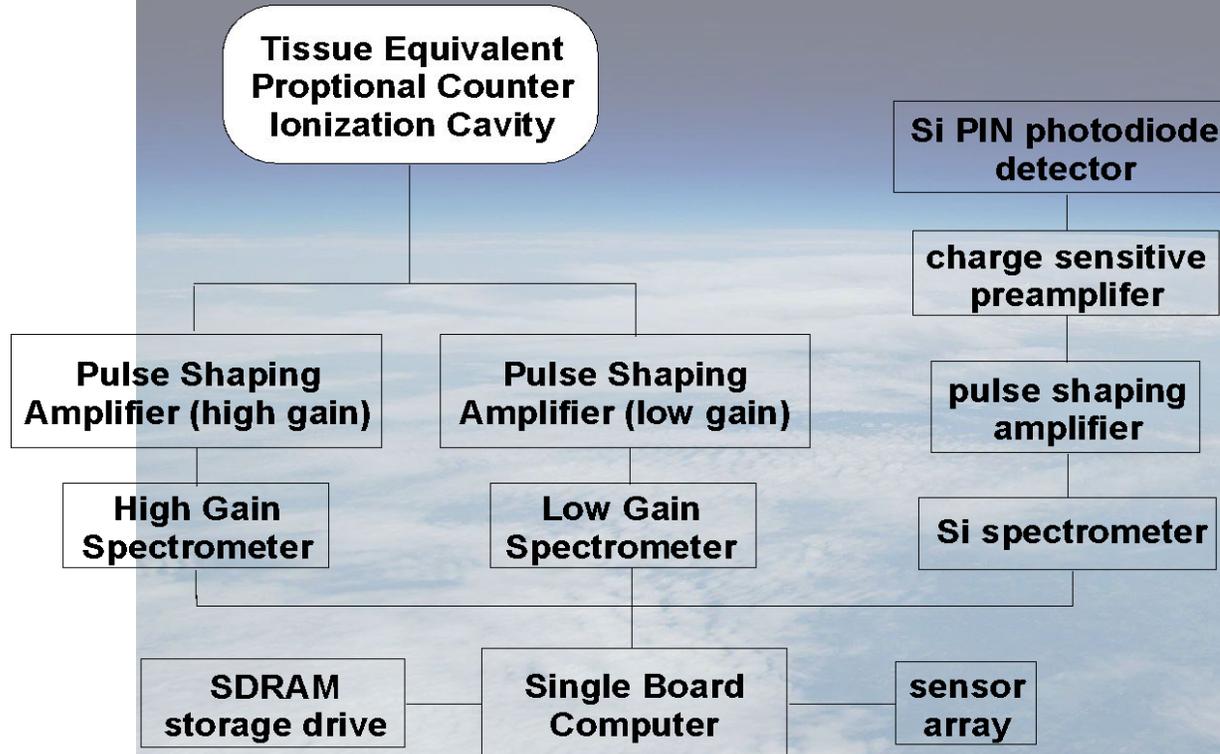


Figure 1. Combined Lineal energy ( $y$ ) spectrum measured with AirTED TEPC and trajectories of seven flights of a NASA WB-57 high altitude research aircraft in late 2021/early 2022. Mean altitude of all flights was  $\sim 60,000$  feet. Also shown is the NASA WB-57 aircraft and the prototype AirTED currently installed behind the cockpit.

# Block diagram of the combined AirTED/AirSiD instrument (r) and prototype for ground-based testing (l)

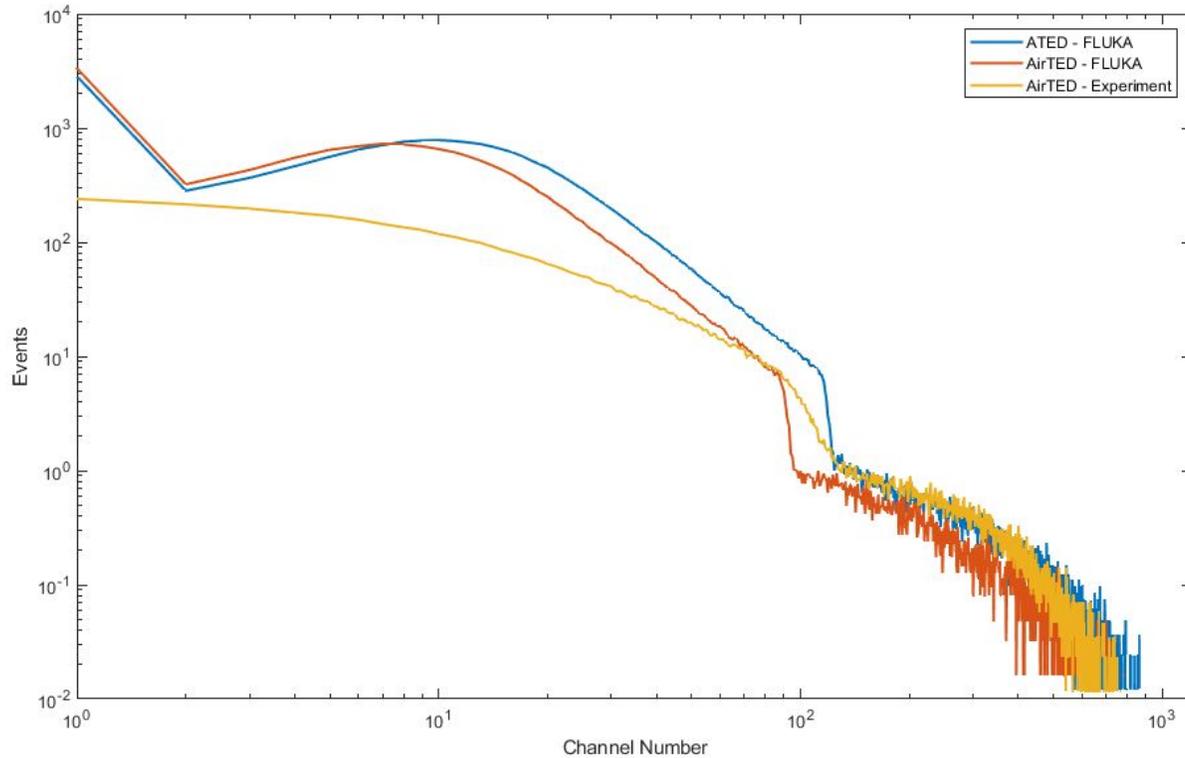


- AirTED: TEPC for high LET radiation (especially high energy neutrons that dominate dose equivalent at aviation altitudes).
- AirSiD: Si PIN diode detector for low LET radiation ( $e^{\pm}$ , x/g-rays, relativistic protons)

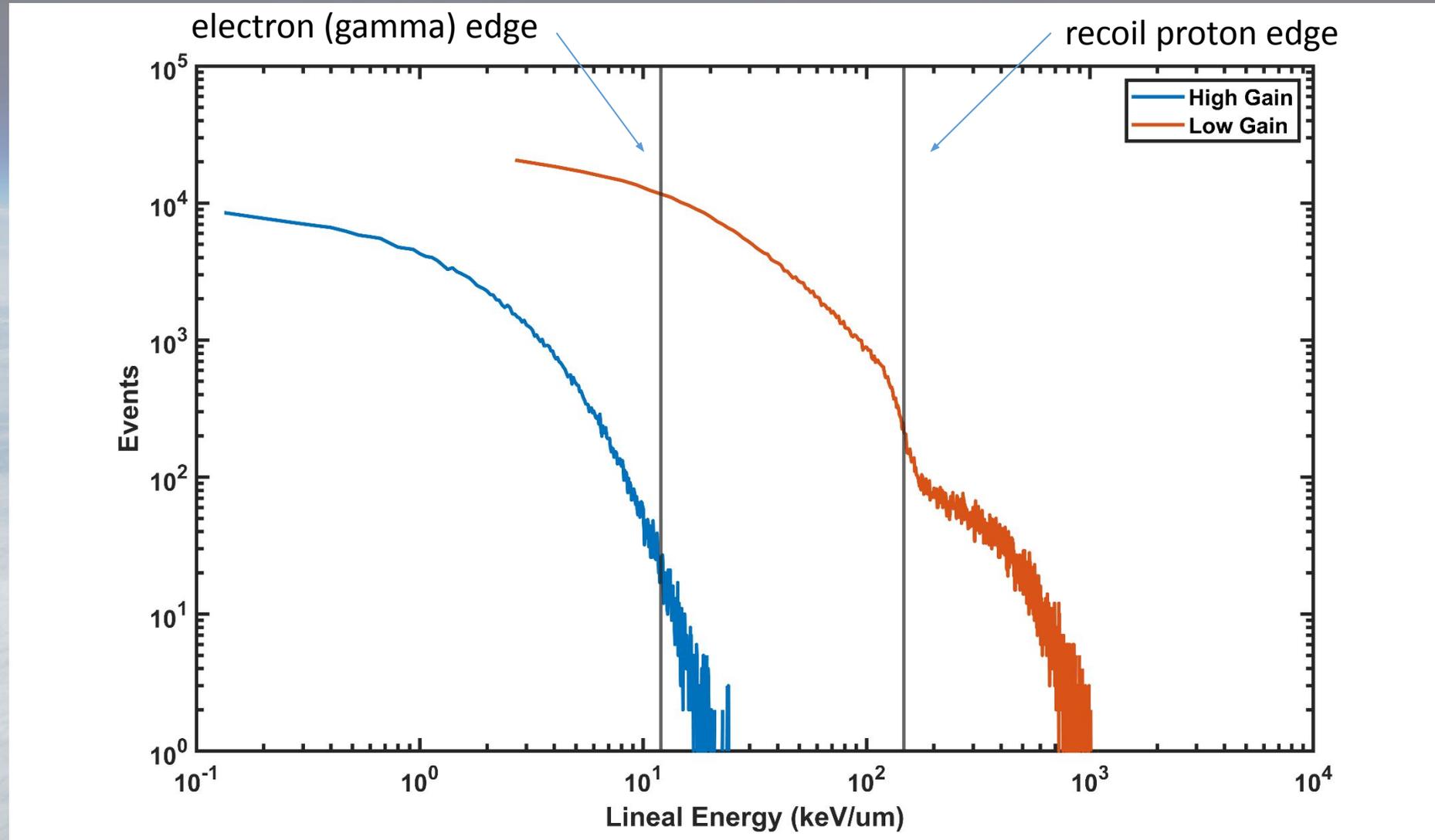
# Monte Carlo Simulation and Vs. Measurement

## ATED and AirTED TEPCs to PuBe neutrons

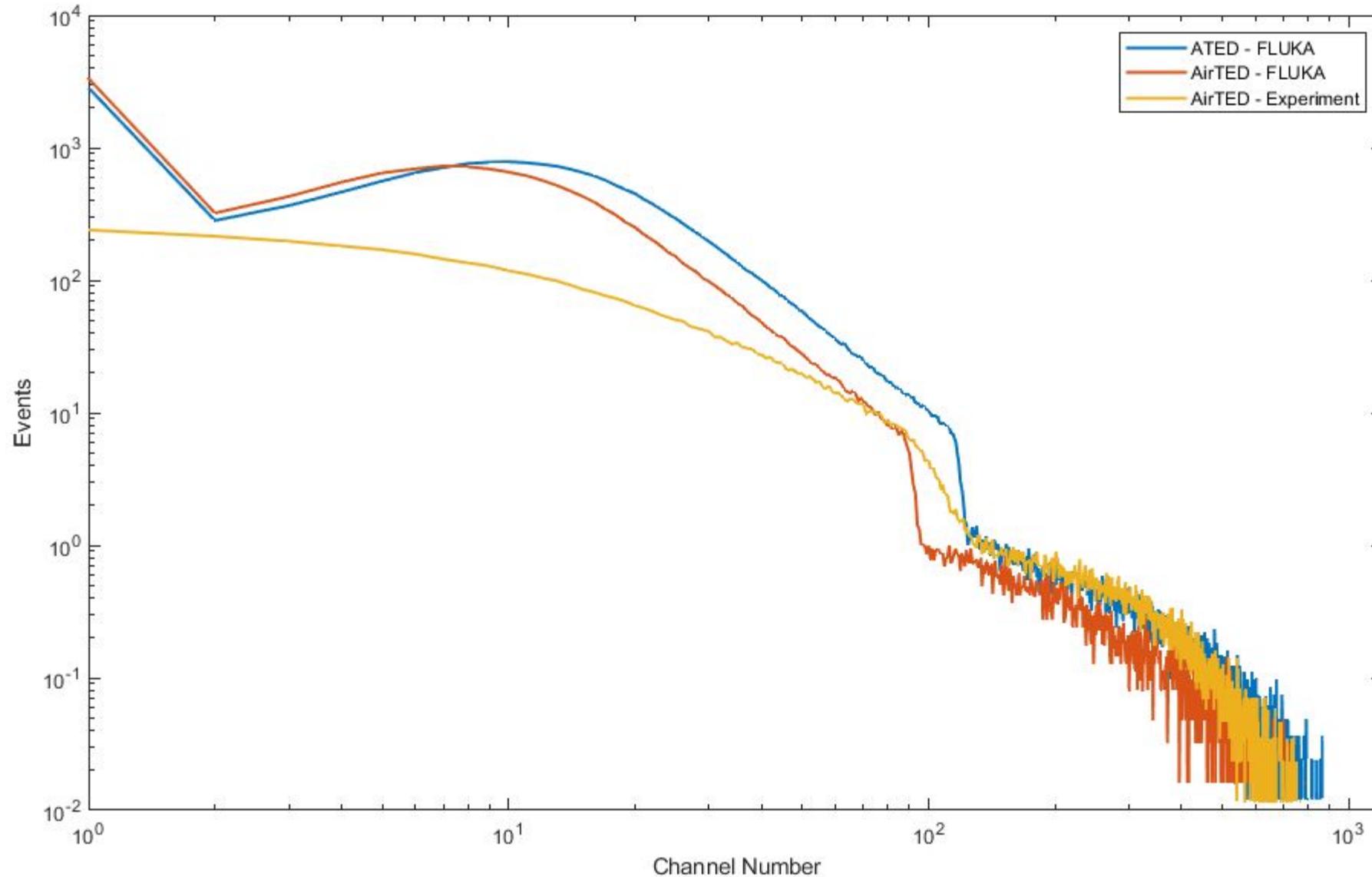
New design is the sphere-in-cylinder AirTED design (r), Old design is the spherical shell ATED design (l)



# Radioisotope Calibration of AirTED TEPC

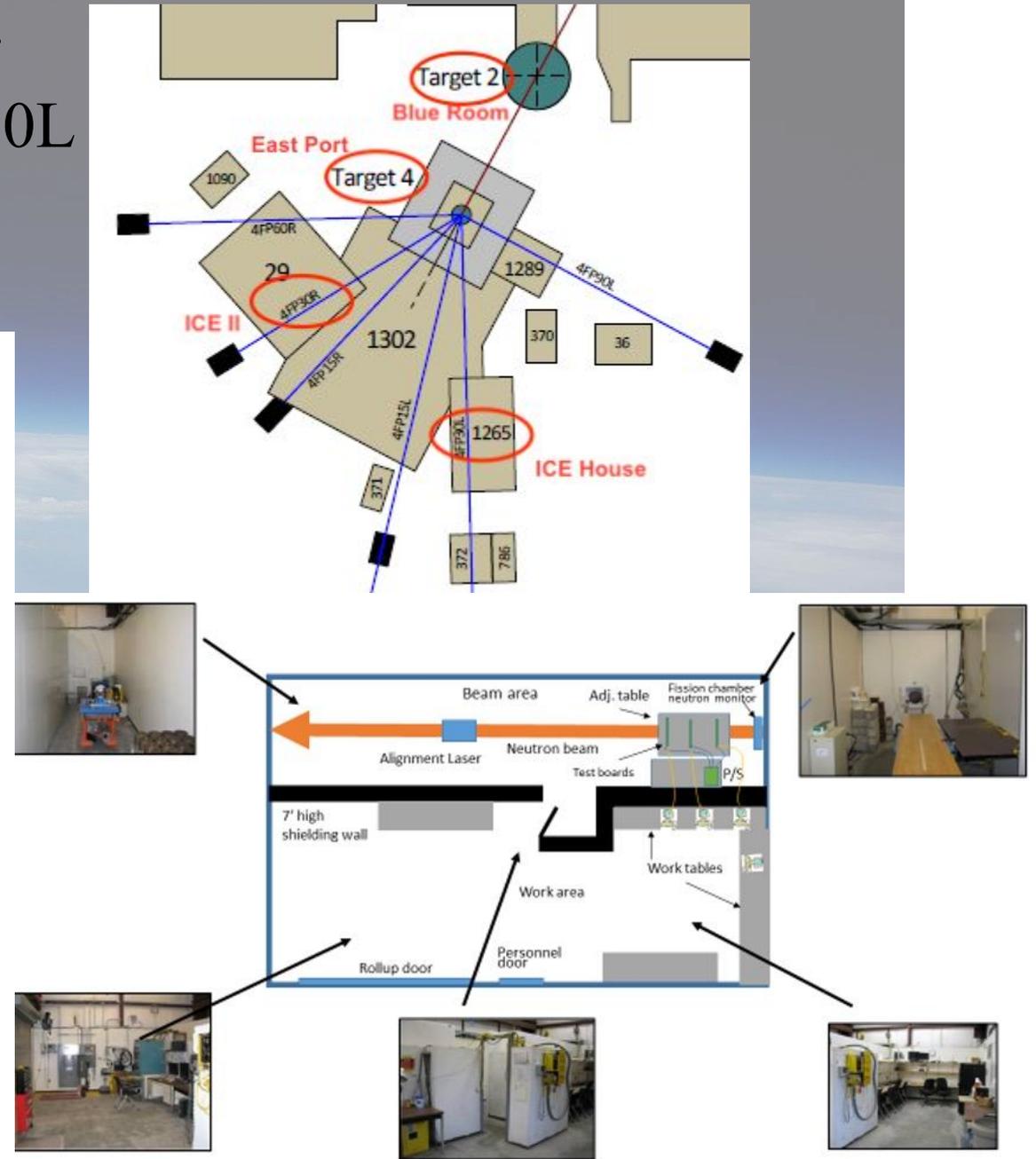
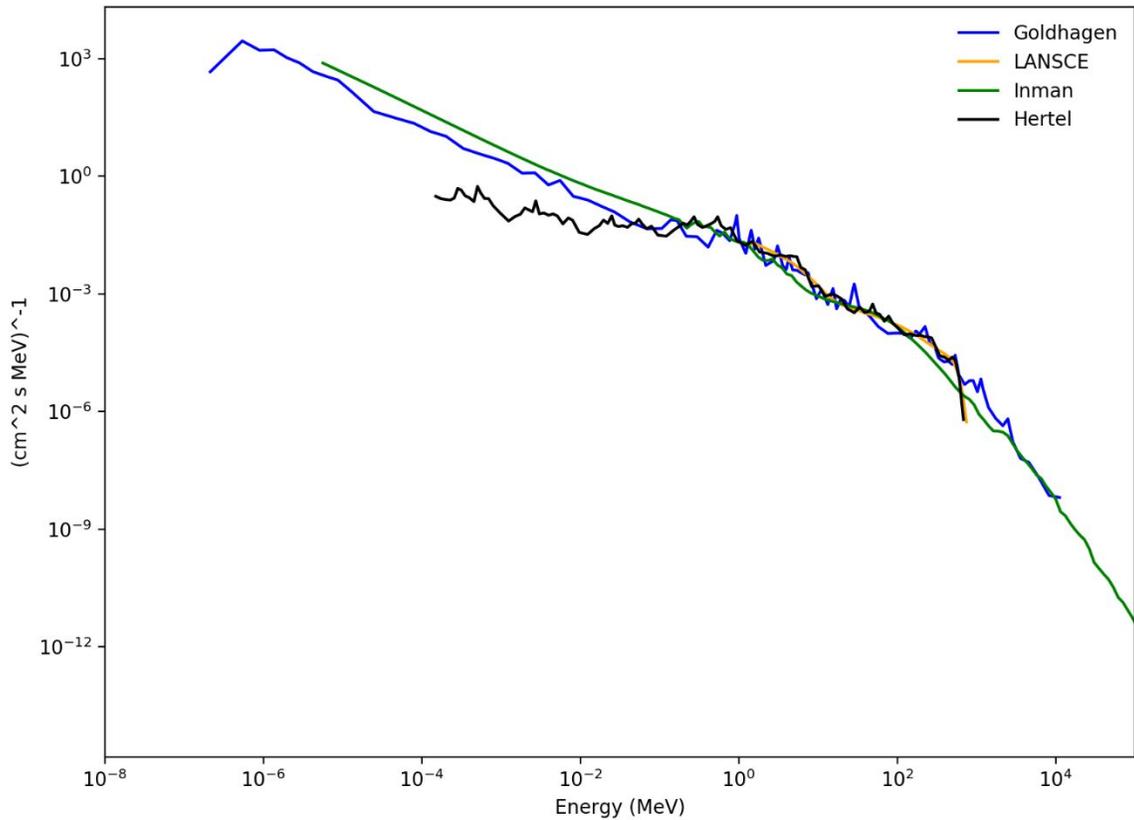


# Monte Carlo Simulation and Vs. Measurement ATED and AirTED TEPCs to PuBe neutrons

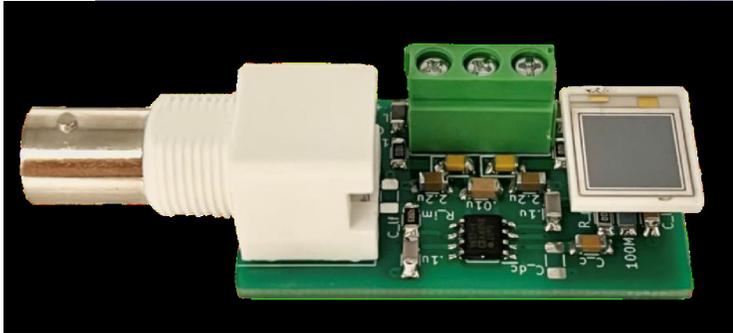


# Los Alamos Neutron Science Center (LANSCE) ICE House Flight Path 30L

- similar neutron energy spectrum  $\leq 800$  MeV.
- $10^6$ x higher flux than actual environment.



# AirSiD (Atmospheric Ionizing Radiation Silicon Detector)



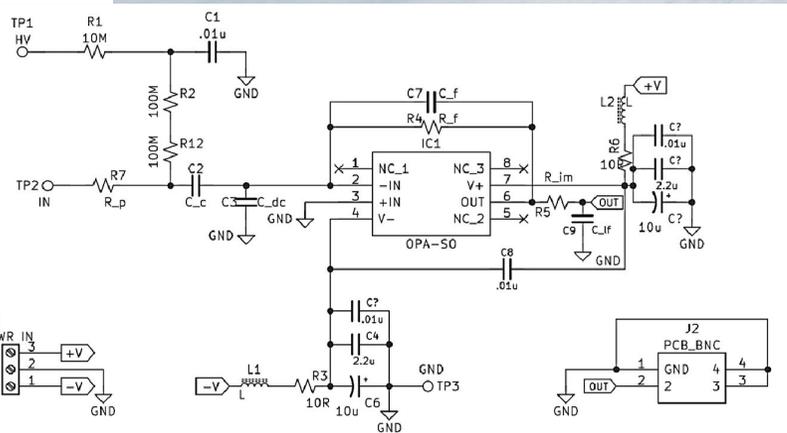
Charge Amplifiers

Shaping Amplifiers

External Trigger

DC-DC  
Converters

Battery Mount

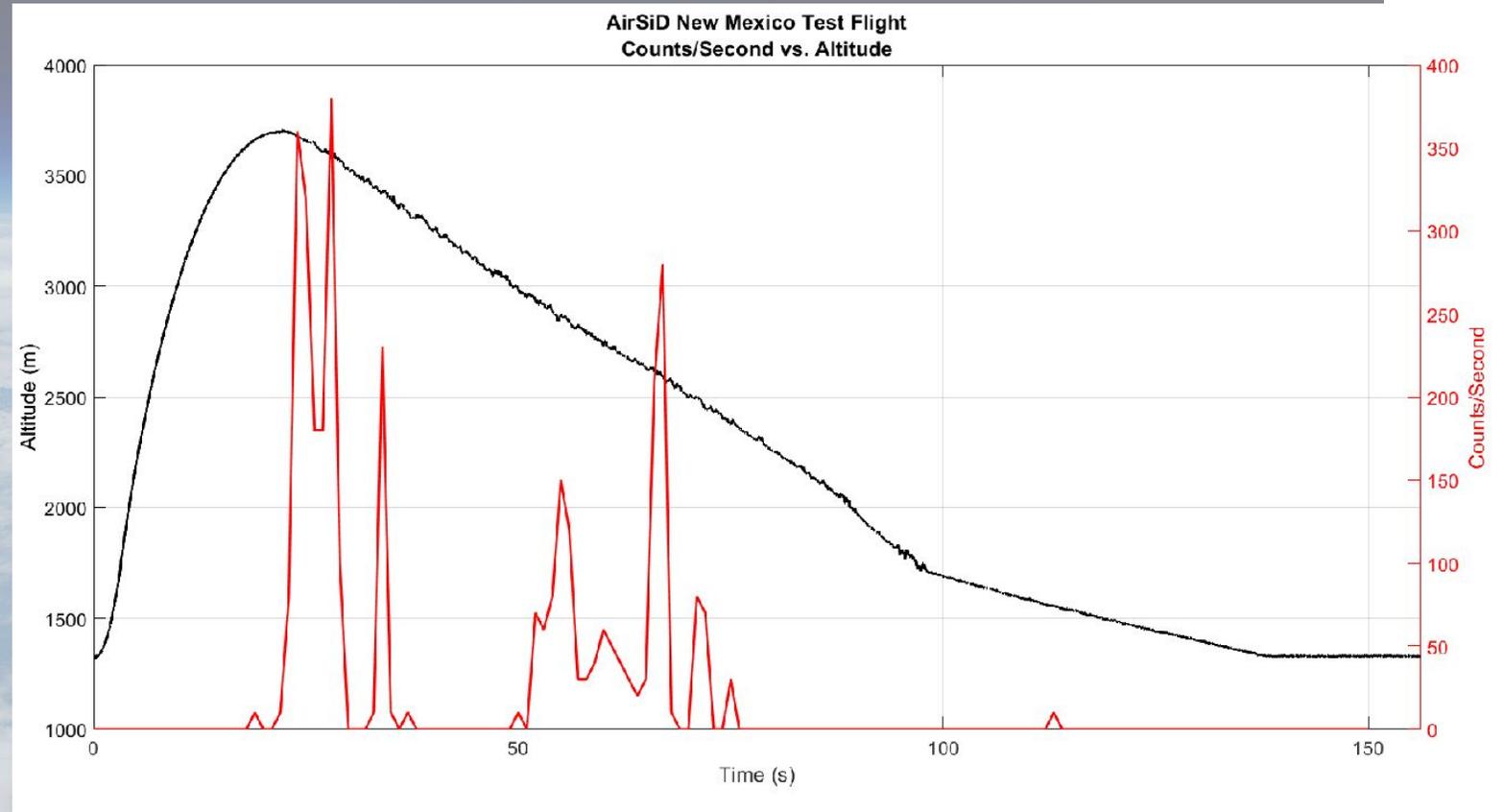


Tahoma Photography 2022



# AirSiD Spaceport America Rocket Flight

- Collaboration with OSU High-Power Rocketry Team
- 23 June 2022, Truth or Consequences, NM
- Apogee: 3702 m (12,145 ft) ASL
- Maximum Acceleration: 14 g ( $137.29 \text{ m/s}^2$ )
- Maximum internal payload temperature:  $60 \text{ }^\circ\text{C}$  ( $140 \text{ }^\circ\text{F}$ )
- Flight Duration: 138 s



# Solar Balloons to measure SSAIRE and SPE at 15-25 km altitude



## Conclusions:

# Measuring and Modeling Solar and Galactic Cosmic Radiation in the Atmosphere for Space Weather Applications Projects

- NASA WB-57 ongoing flights:
  - upgraded AirTED + AirSiD, waiting first data from Alaska campaign;
- AirTED/AirSiD experiment on Blue Origin New Shepard suborbital flight:
  - 4th Quarter 2023,
  - dosimetry for space tourism.
- SpaceATED experiment on ISS:
  - launch of SpaceX-29 in December 2023,
  - 6 months duration,
  - to be located in Japanese Experiment Module.
- Solar Balloon flights over Oklahoma starting summer 2023.

