Progress on Tissue Equivalent Dosimeters being developed at Oklahoma State University



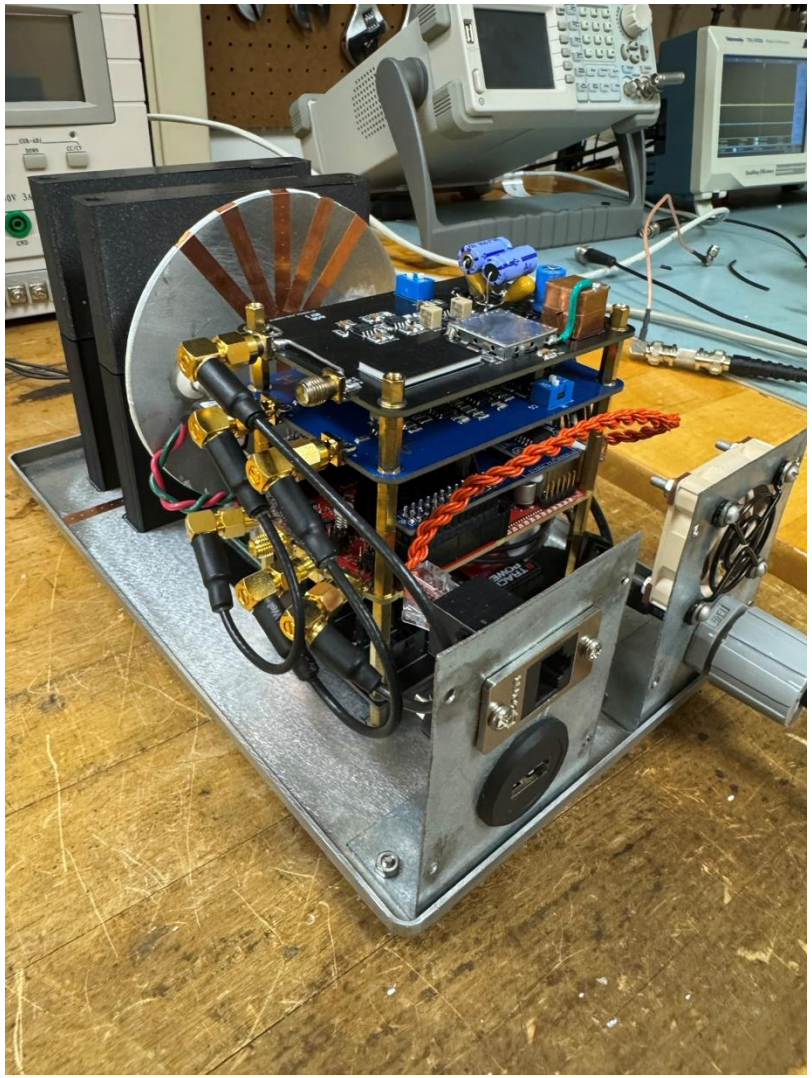
Eric Benton, Conner Heffernan, Garrett Thornton, and Buddy Gersey

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

WRMISS-29, Prague, Czechia
1-3 September 2026

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



Blue Origin New Shepard NS 5.5



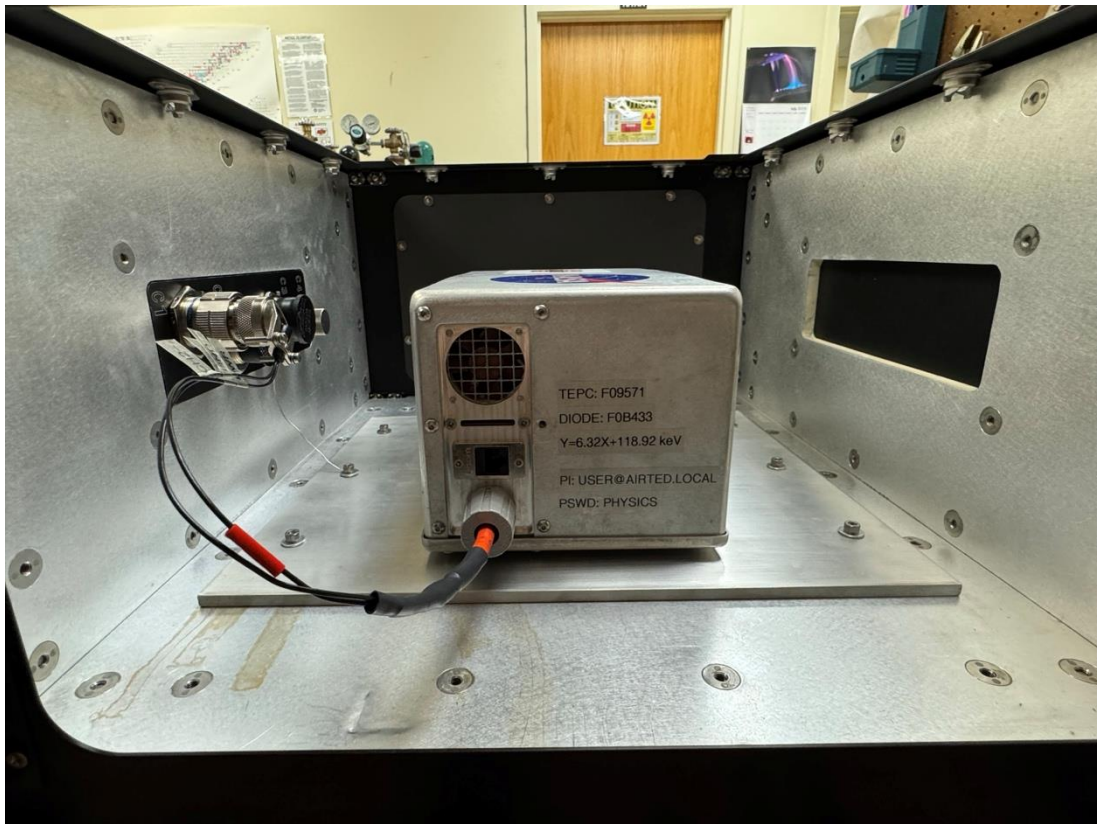
- Flew on 18 September 2025
- Capsule Maximum Altitude: 105.3 km
- Flight Duration: ~11 minutes



Blue Origin New Shepard NS 5.5

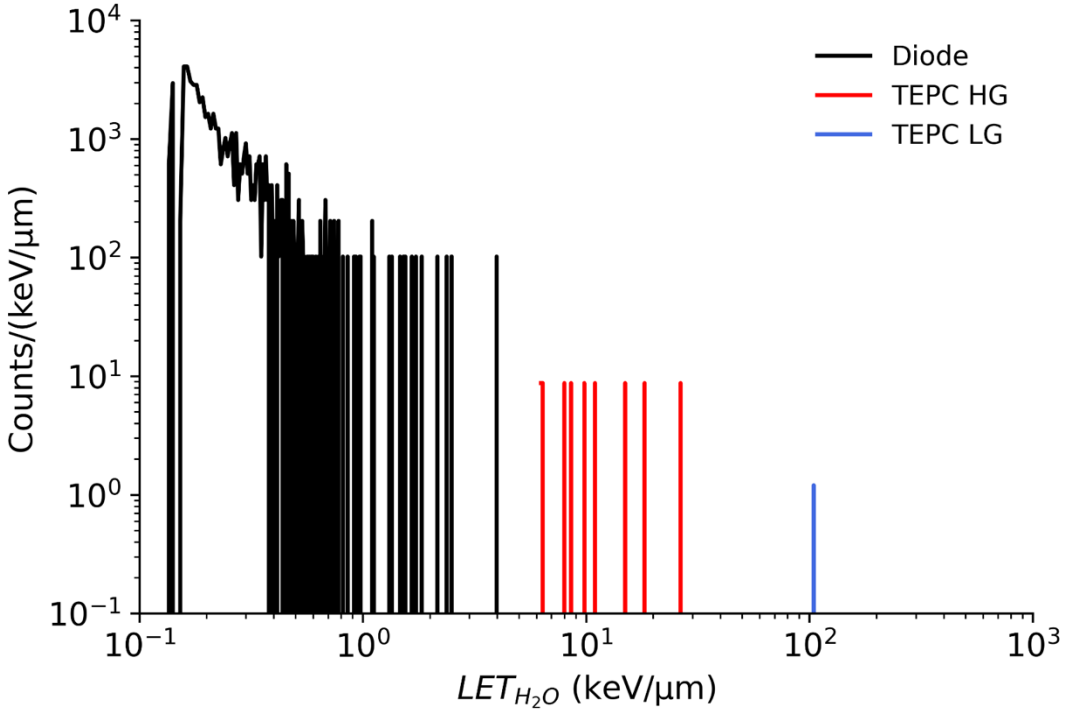


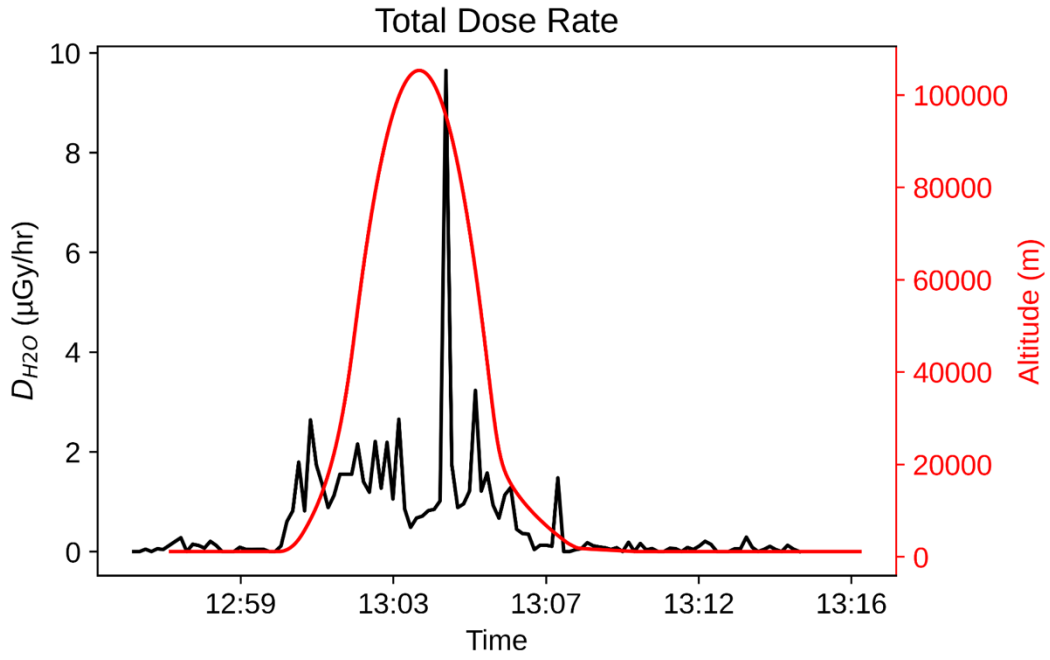
Poor mans' 30 g acceleration test

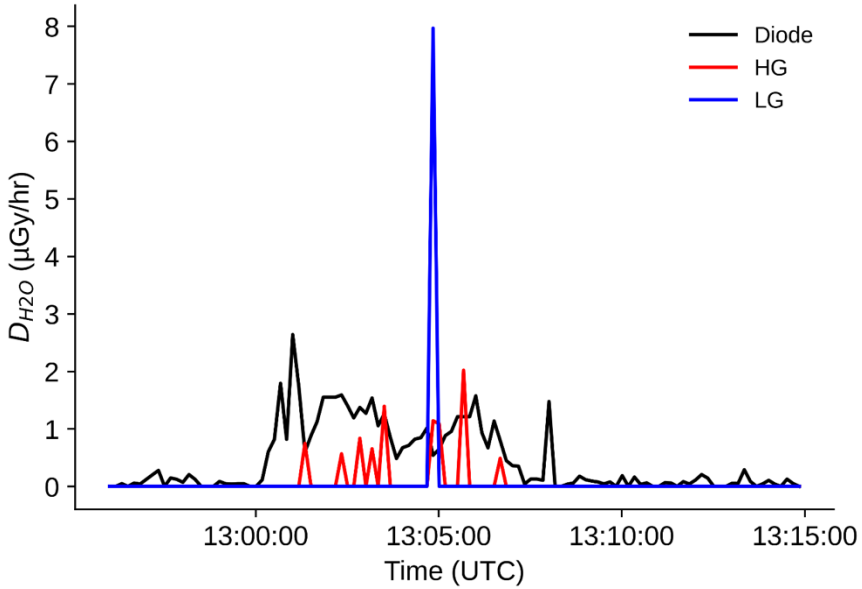


SpaceTED in New Shepard equipment locker.

Blue Origin New Shepard NS 5.5
Total Absorbed Dose: 0.19 µGy*



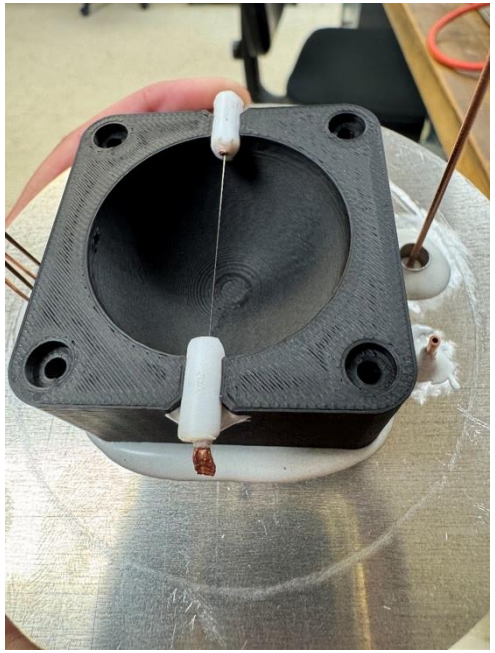


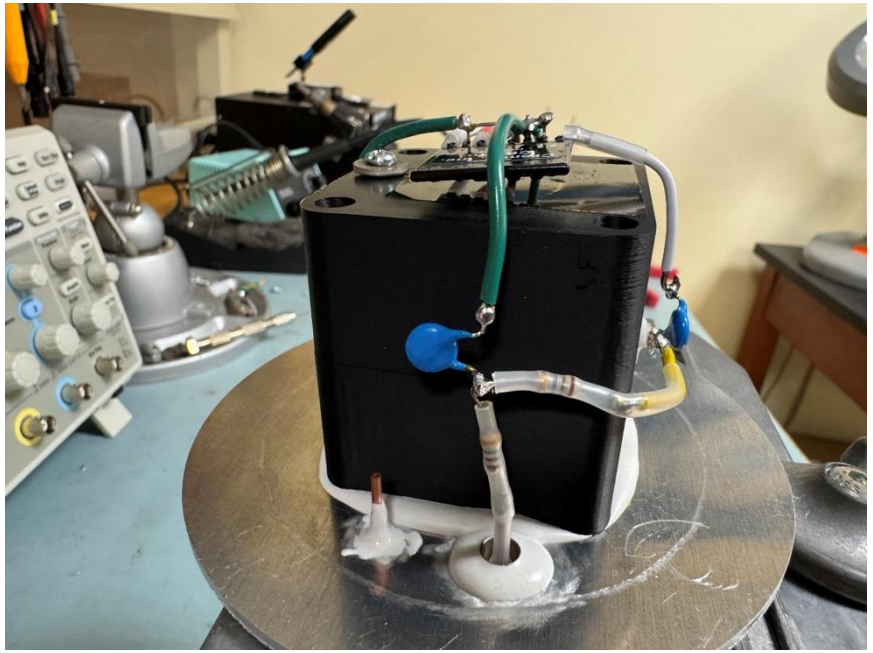


Lesson Learned: Our SpaceTED detector can operate continuously during launch, ascent, capsule separation, descent and landing.

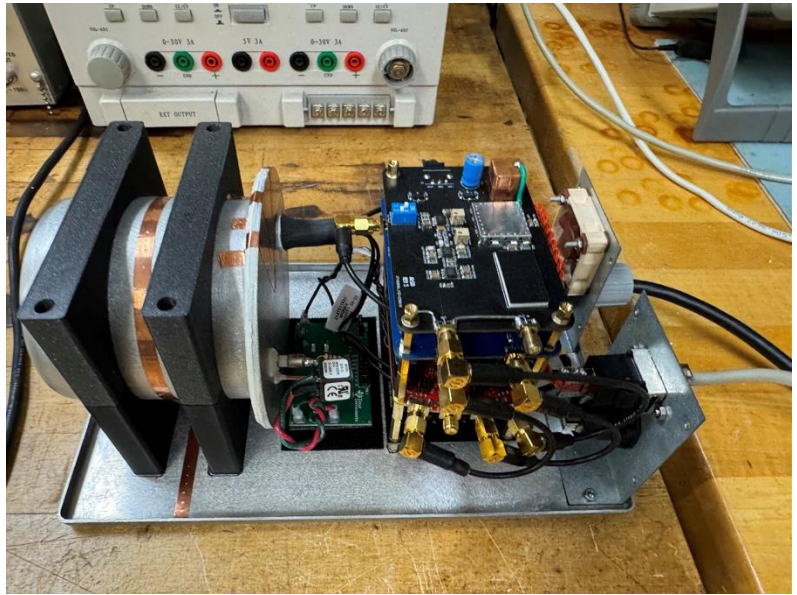
*CARI-7A Estimate: 0.29 µGy

Latest version of AirTED

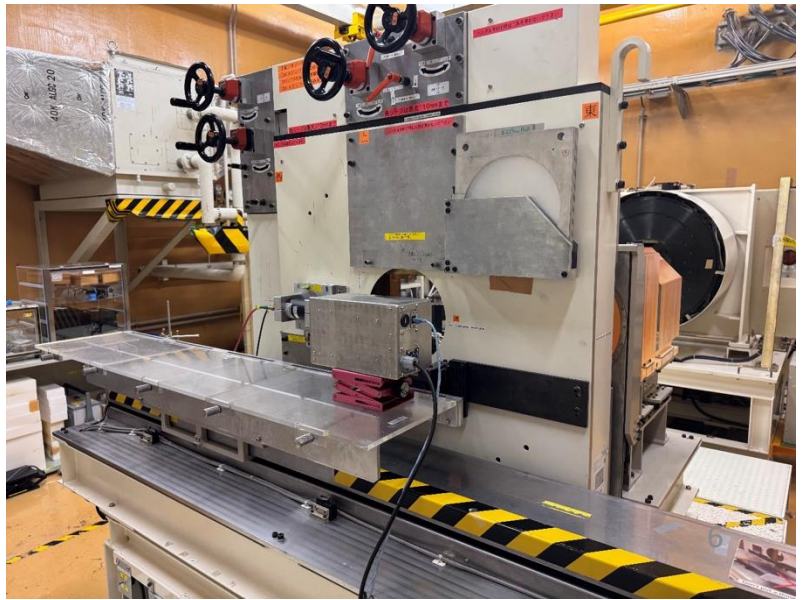












USAF Compass Call Flights over southwest USA

- Collaboration with US Air Force Institute of Technology, Wright Patterson AFB
- USAF team flew variety of radiation detectors including NaI scintillators and Si-based personal dosimeters
- Two flights from US Army's Fort Huachuca, Arizona in June 2026
- Additional flights are planned in Alaska.
- The EA-37B Compass Call is an electronics warfare aircraft based on a Gulfstream G550 business jet.

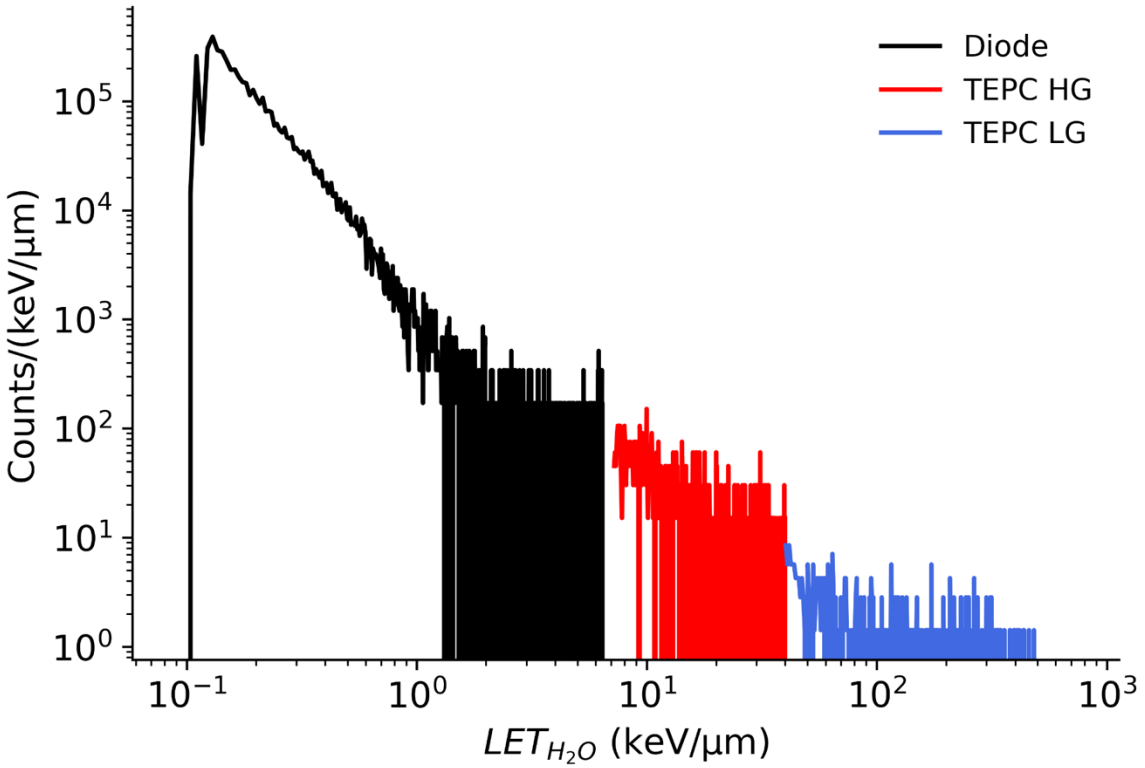


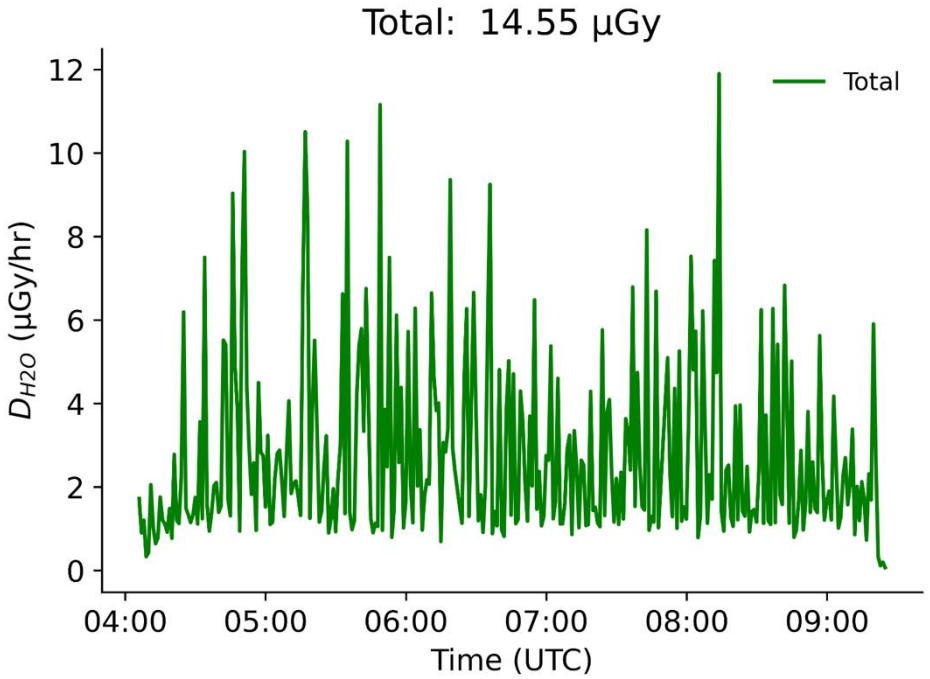
First Compass Call Flight

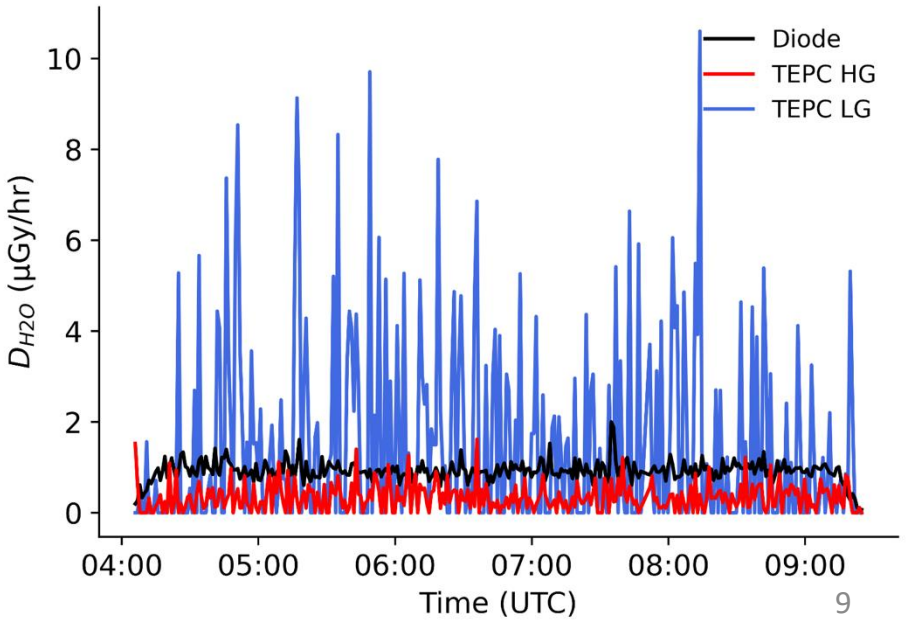
- 17 June 2026
- Average altitude: 41,000 Ft (12.5 km)
- Duration: 5.65 hours
- Measured AirTED absorbed dose: 14.6 μGy
- CARI-7A estimated absorbed dose: 11.9 μGy
- Percent difference: +22.3



First Compass Call Flight







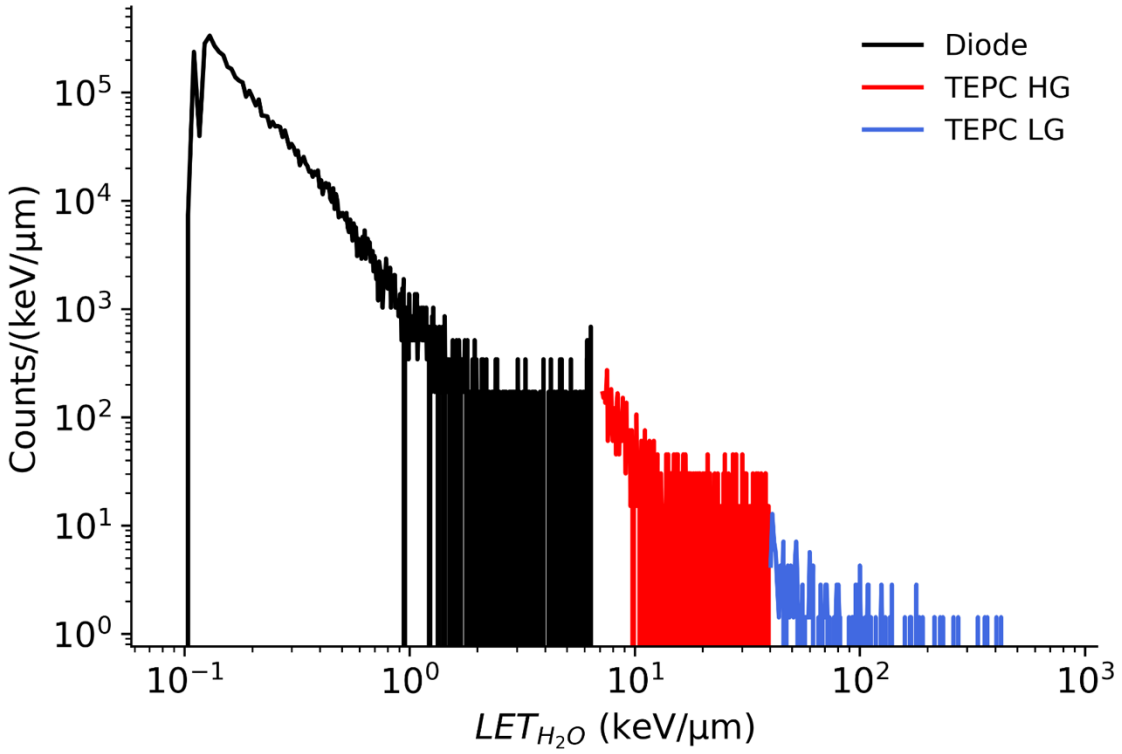
	Absorbed dose (µGy)	% Contribution
Si Diode	4.83	33.2
TEPC High Gain	1.80	12.37
TEPC Low Gain	7.92	54.4
Total	14.55	

Second Compass Call Flight

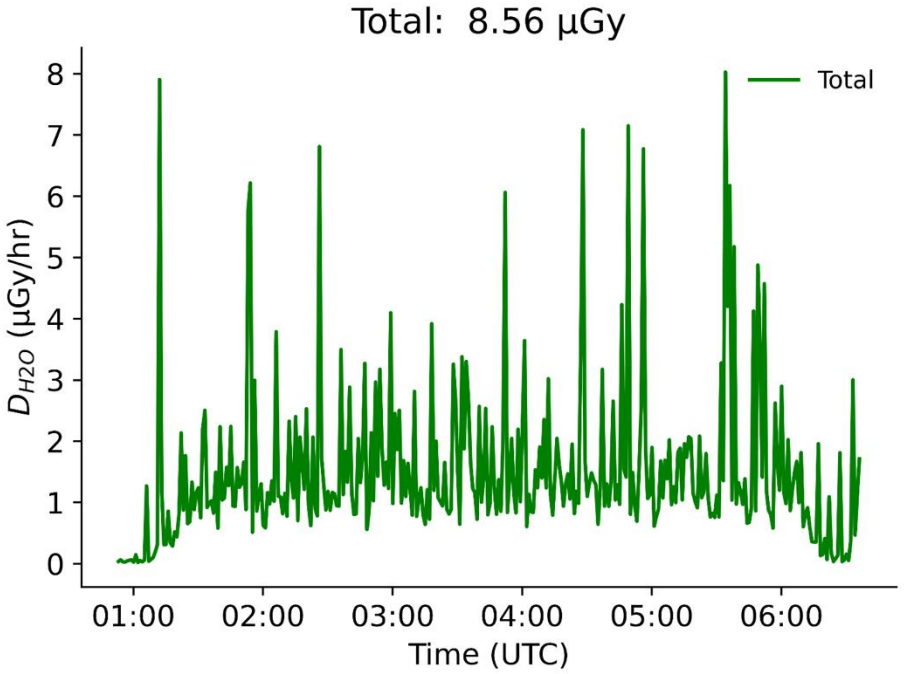
- 19 June 2026
- Average altitude: 40,000 Ft (12.2 km)
- Duration: 5.52 hours
- Measured AirTED absorbed dose: 8.5 µGy
- CARI-7A estimated absorbed dose: 11.5 µGy
- Percent difference: -22.5

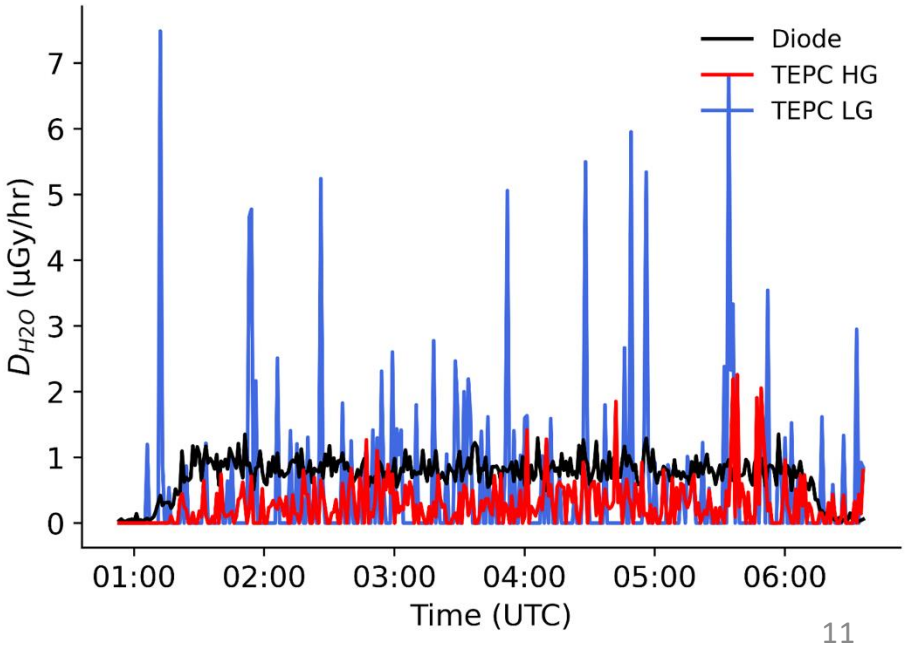


Second Compass Call Flight



	Absorbed dose (µGy)	% Contribution
Si Diode	4.14	48.36
TEPC High Gain	1.59	18.57
TEPC Low Gain	2.83	33.06
Total	8.56	





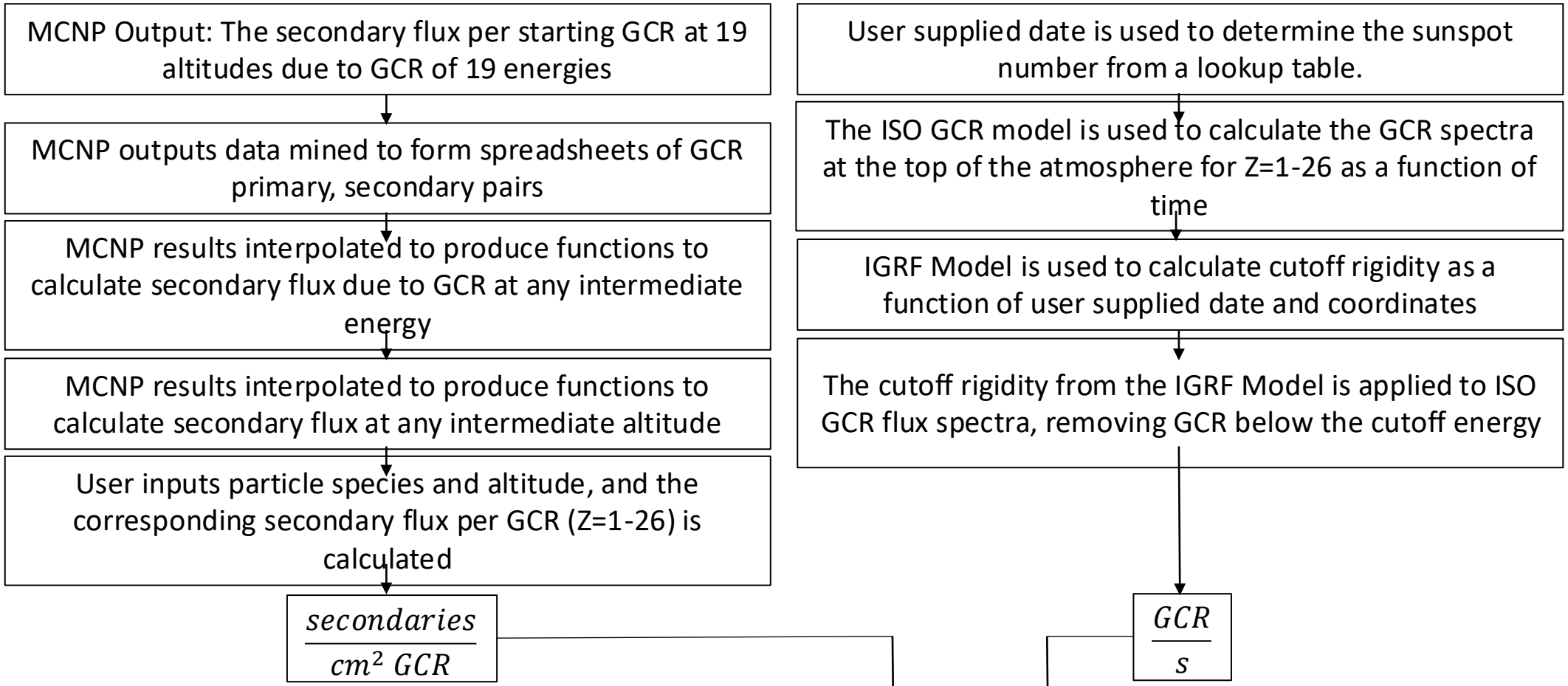
Comparison of two Compass Call Flights

	Flight 1 (μGy)	Flight 2 (μGy)	Ratio (Flight 1/Flight 2)
Si Diode	4.83	4.14	1.17
TEPC High Gain	1.80	1.59	1.13
TEPC Low Gain	7.92	2.83	2.80
Total	14.55	8.56	1.70

Atmospheric Ionizing Radiation Environment Code (AIREC)

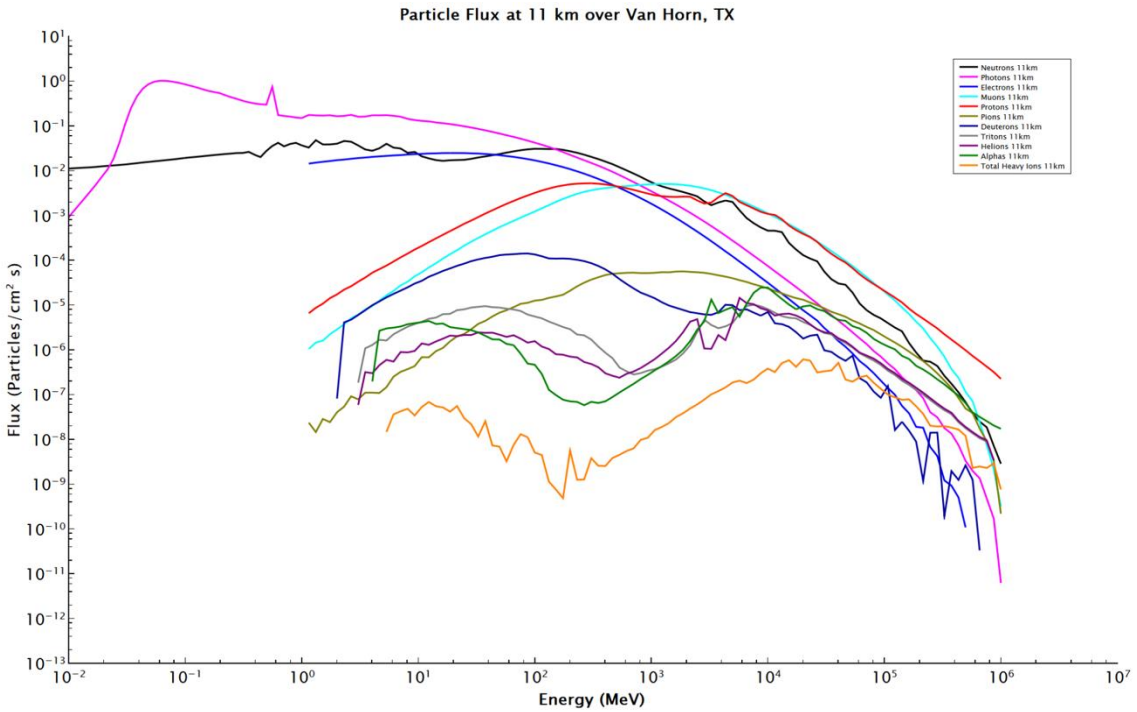
- Based on same MCNPX GCR simulations used in development of the CARI-7 model.
- Instead of Effective Dose, Ambient Dose Equivalent or Absorbed Dose, estimates primary and secondary particle flux and energy spectra as functions of altitude, geographic location and time.
- Altitudes from sea level to 100 km.
- Primary particles of Z = 1 to 26, energies from 1 MeV to 1 TeV.
- Secondary particles including photons, protons, neutrons, ±electrons, ±muons, protons, ±pions, deuterons, tritons, helions, and alpha particles.
- Ported code from Python to C++ (AIREC++)…runs faster, improvement.
- Used in conjunction with MCNP6 to simulate Solar Balloon and Compass Call flights.

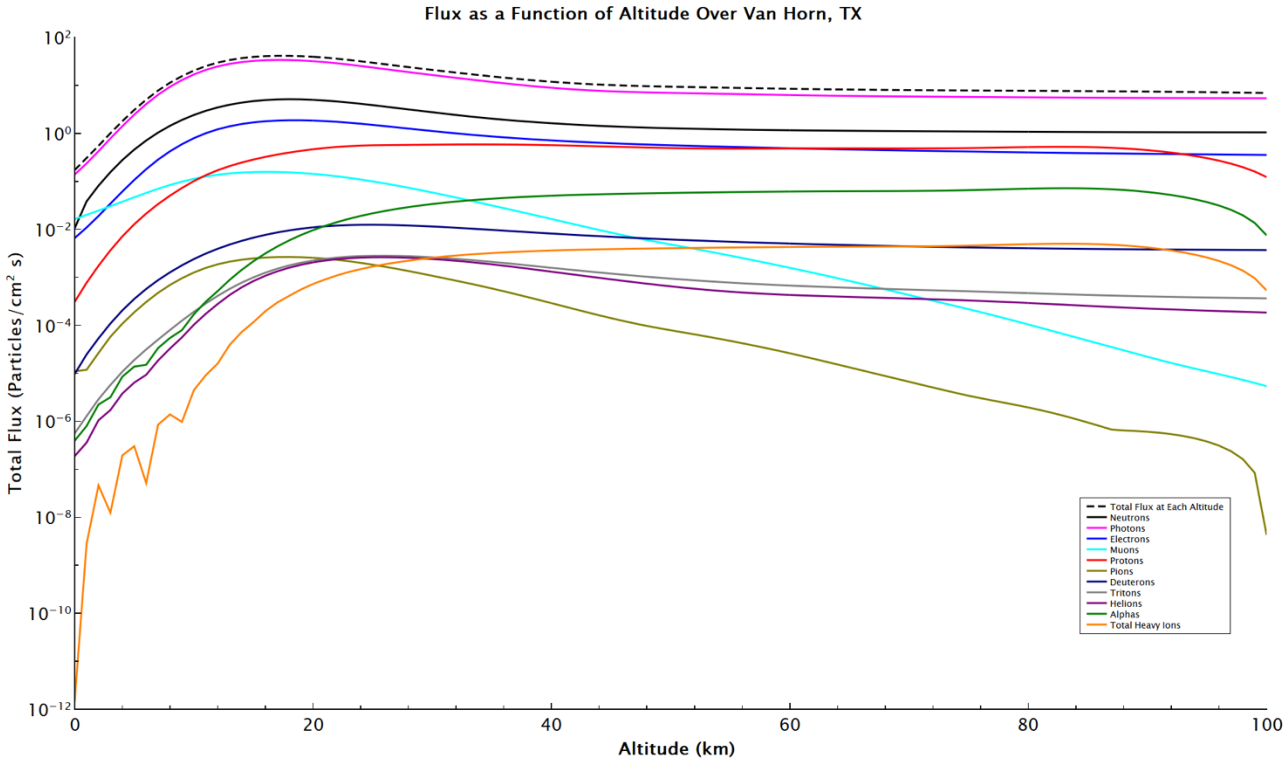
Flowchart illustrating operation of the AIREC code to determine GCR secondary particle energy spectra in the atmosphere as functions of altitude, time and geographic (geomagnetic) location.



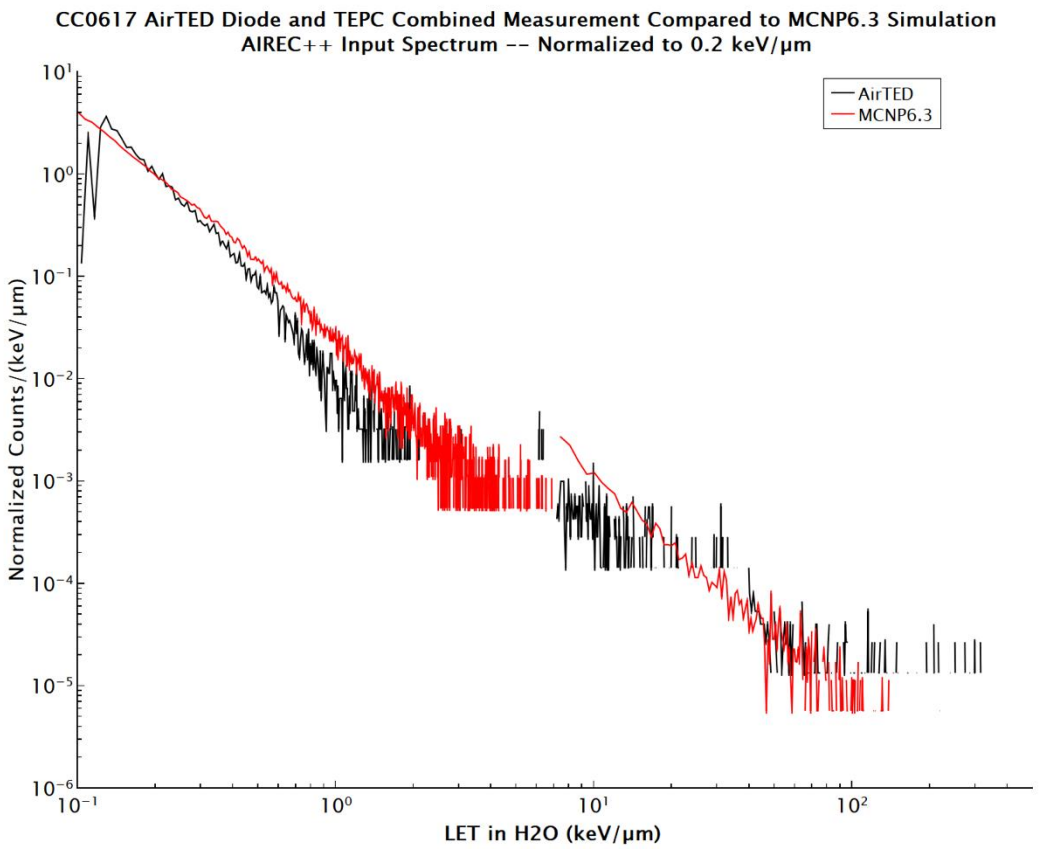
$$\Phi = \sum_{GCR\ Species} \left(\sum_{GCR\ Energy} \left(\frac{secondaries}{cm^2\ GCR} \times \frac{GCR}{s} \right) \right)$$

AIREC++ simulations of particle spectra and fluxes for the SpaceTED New Shepard flight

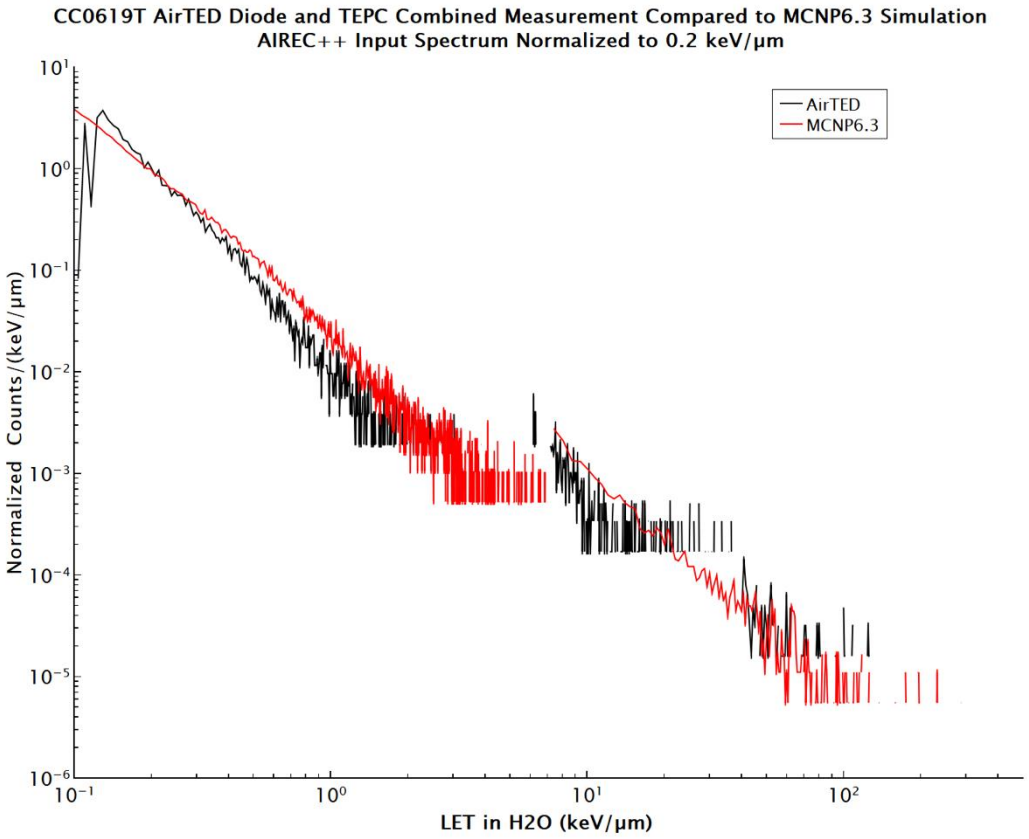




AIREC++/MCNP6 simulations of two Compass Call flights



Flight 1



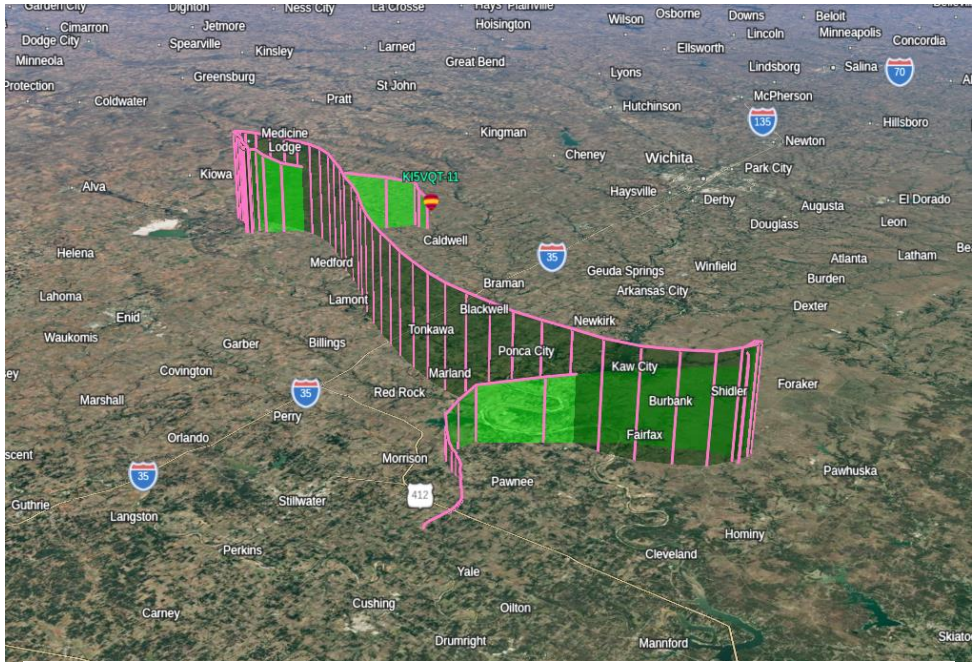
Flight 2

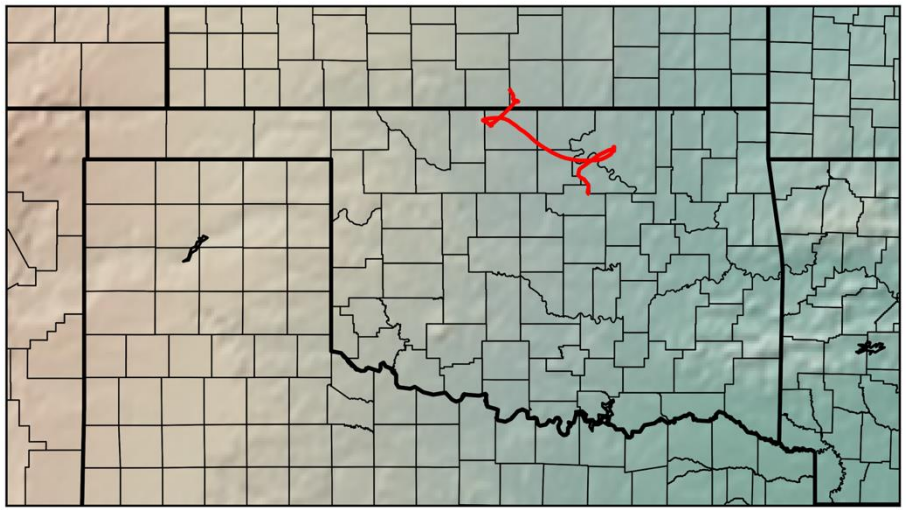
AIREC++/MCNP6 simulations of two Compass Call flights

	Flight 1 (μGy)	Flight 2 (μGy)
Measurement	14.55	8.56
AIREC++/MCNP6	15.17	12.26
CARI-7A	11.90	11.49

AirSiD Solar Balloon Flight, 11 Sept. 2024

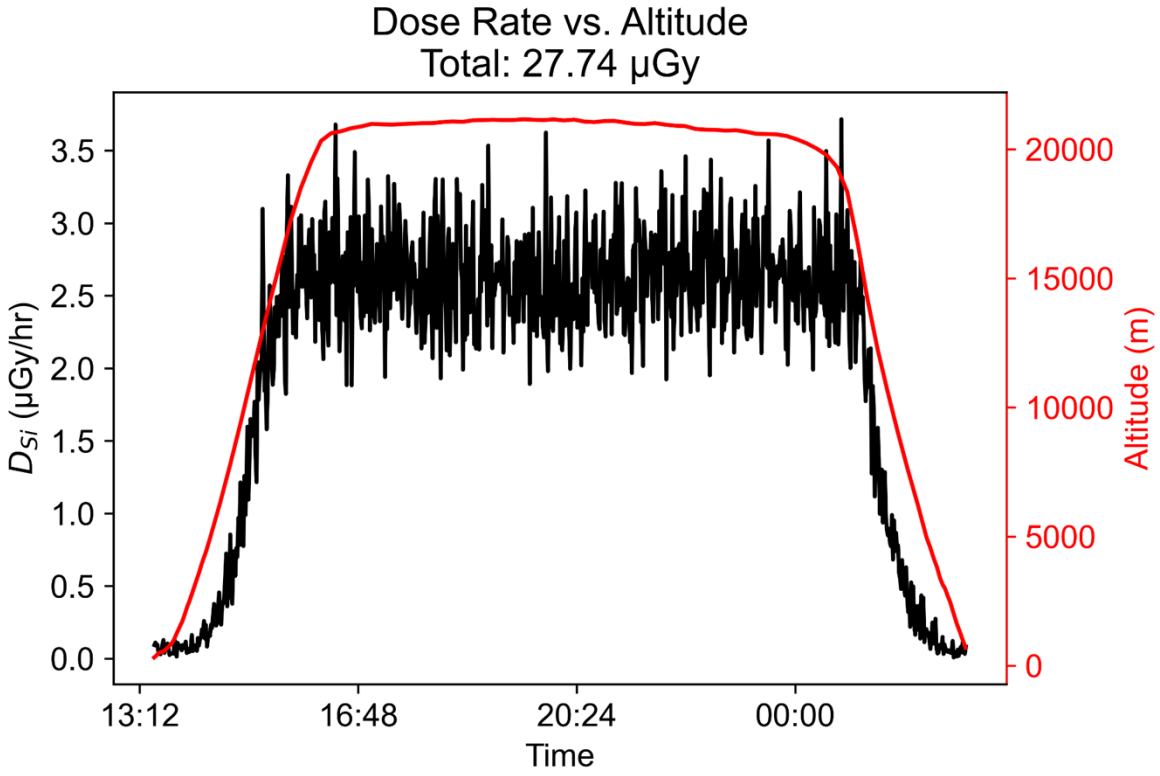


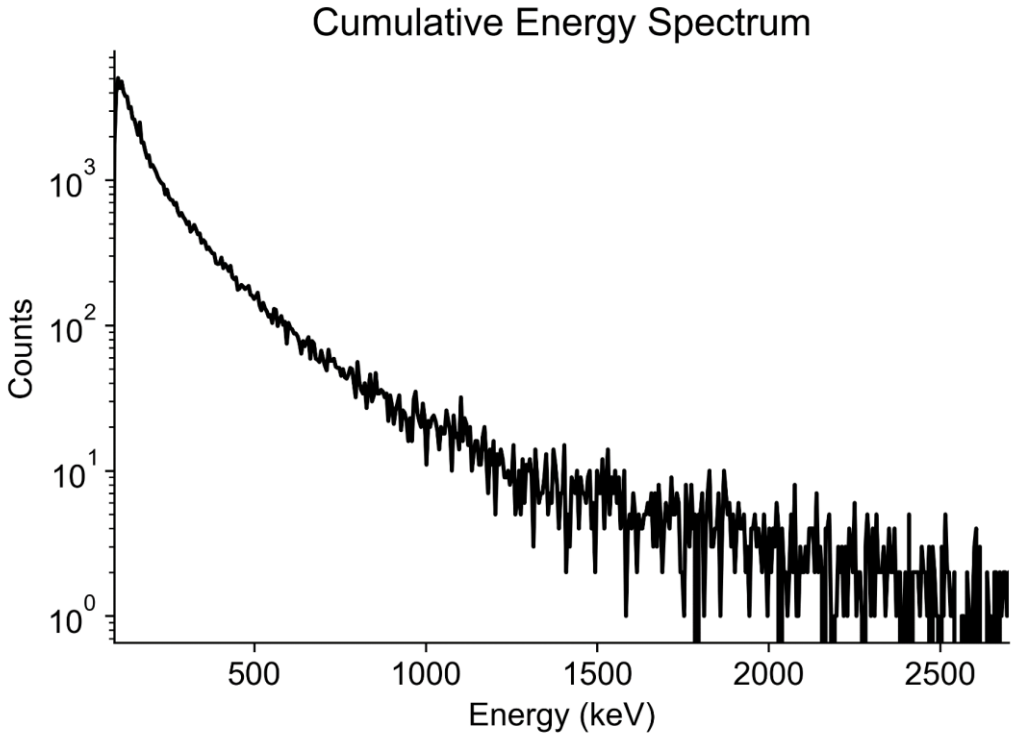




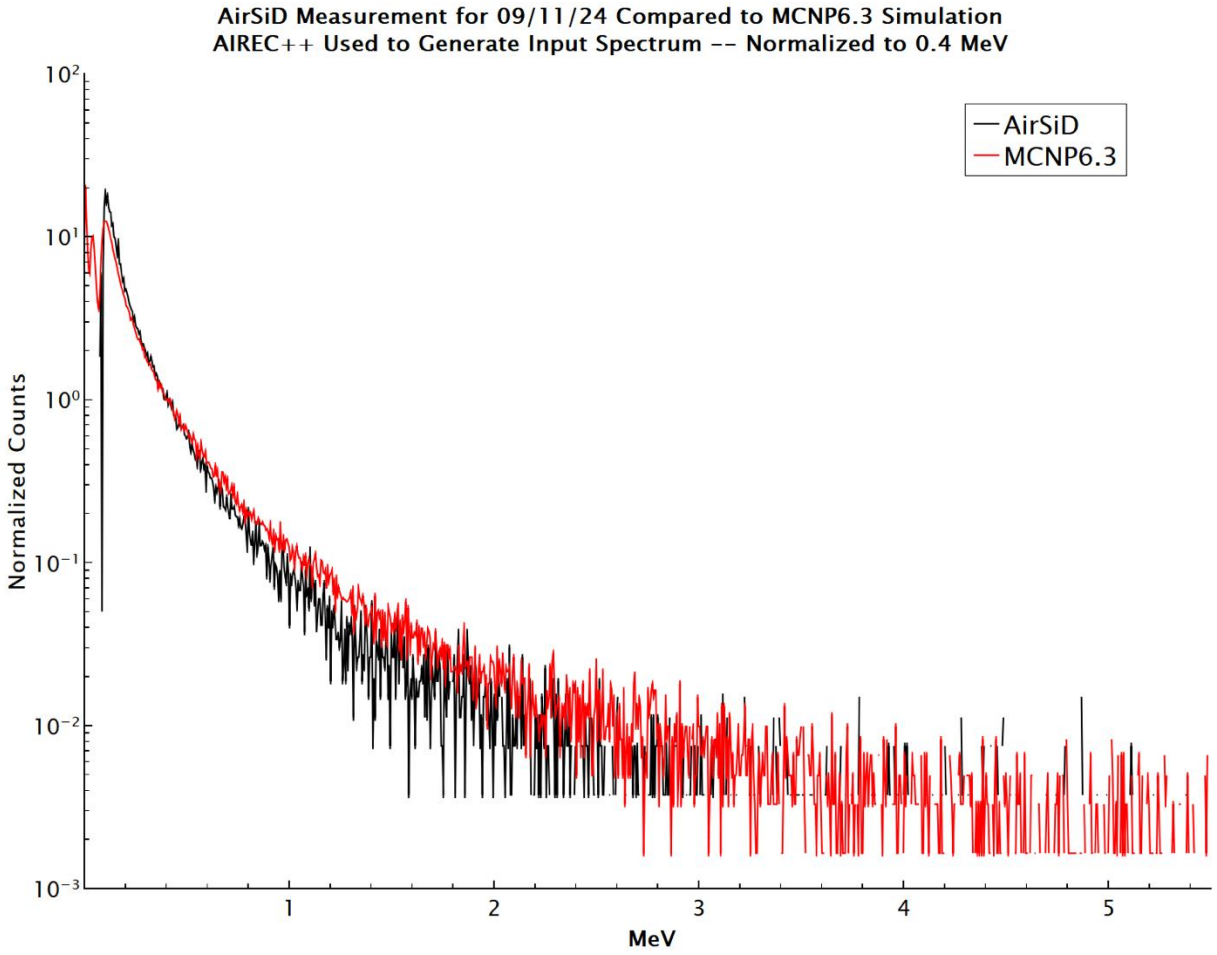


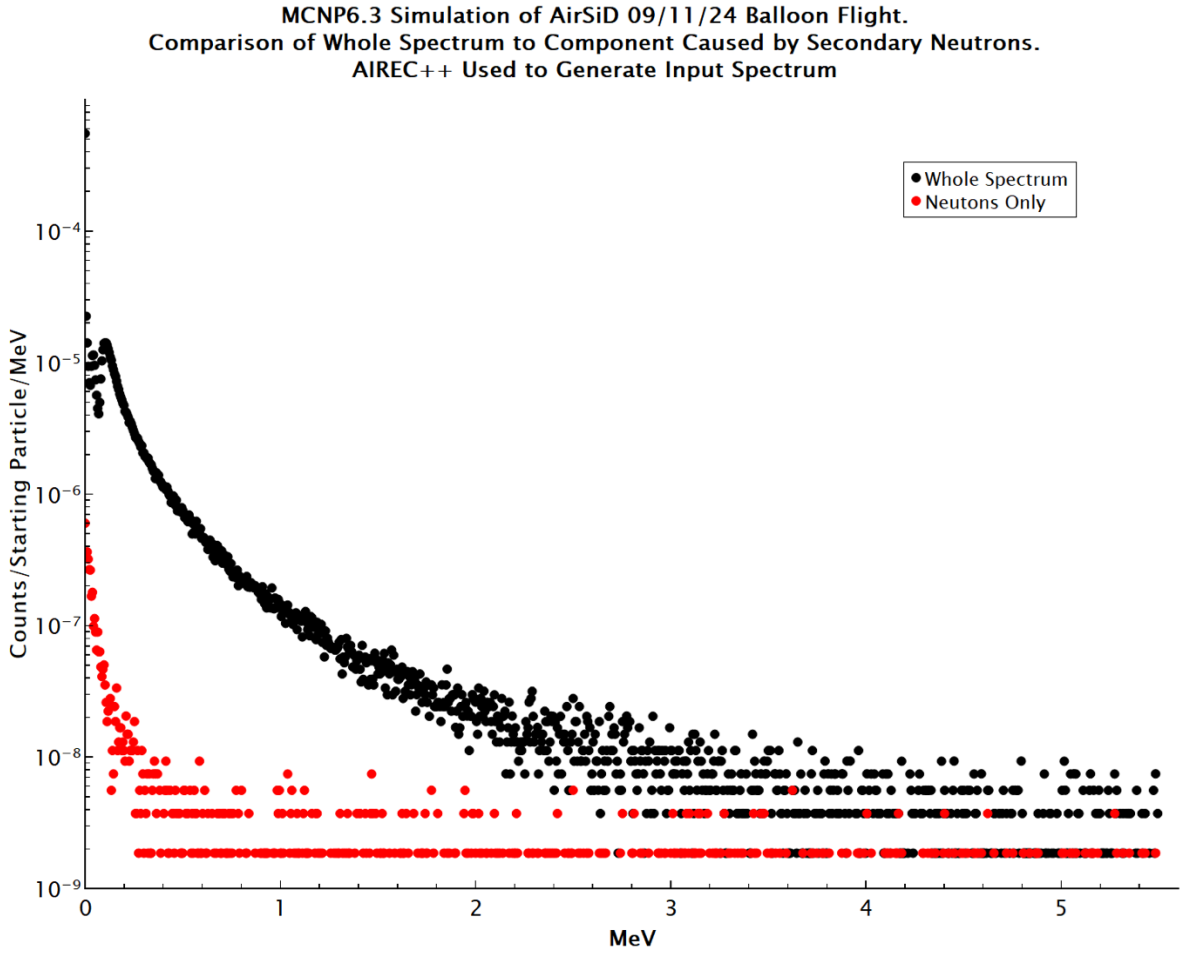
AirSiD Solar Balloon Flight, 11 Sept. 2024
Measured Results





AirSiD Solar Balloon Flight, 11 Sept. 2024
AIREC++/MCNP6 Simulations





Conclusions

- Flew SpaceTED engineering unit on Blue Origin New Shepard suborbital flight (for a whole 11 minutes!) and demonstrated the instrument can operate successfully through all phases of the flight.
- Latest version of AirTED based on four input Red Pitaya spectrometer and 3D printed TEPC ionization cavity flew on two USAF Compass Call missions over southwest US and operated successfully. Alaska flights later this year.
- Continuing Development of AIREC++ model of atmospheric radiation environment:
  - Applied to previous Solar Balloon flights,
  - Applied to Compass Call flights.
- Automated analysis of 2024 SpaceTED ISS data in ongoing.
- Developing reduced-mass AirTED for use on Solar Balloon.
- Expanding Solar Balloon program for use in undergraduate research projects.

Current Graduate Students:

- Conner Heffernan,
- Garrett Thornton,

Undergraduate Students

- Nicholette DuCom,
- Lydia Moore,
- Jack Massar,
- Amelia Frisbee,

Former Students:

- Tristen Lee, (graduated 2024)
- Martin Yang, (graduated 2024)
- Bryan Hayes, (graduated 2021)
- Paul Inman, (graduated 2021)



Collaborators and Special thanks to:

- Kyle Copeland, U.S. FAA, Civil Aerospace Medical Institute
- Brad “Buddy” Gersey, OSU Adjunct Prof.
- Satoshi Kodaira and staff at NIRS/QST