The ComPair Balloon Instrument and Flight

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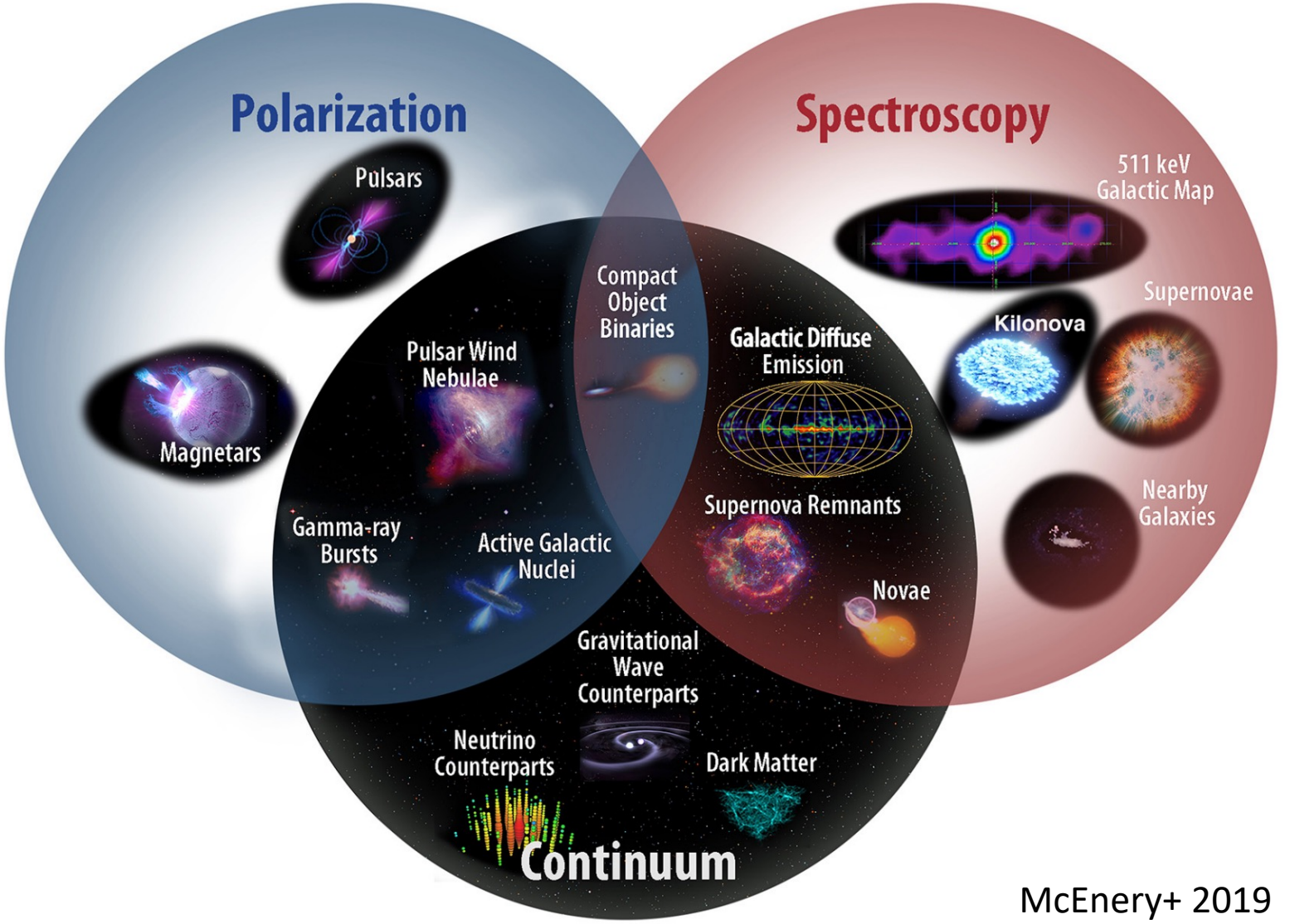
for ComPair Team

The ComPair Balloon Instrument and Flight

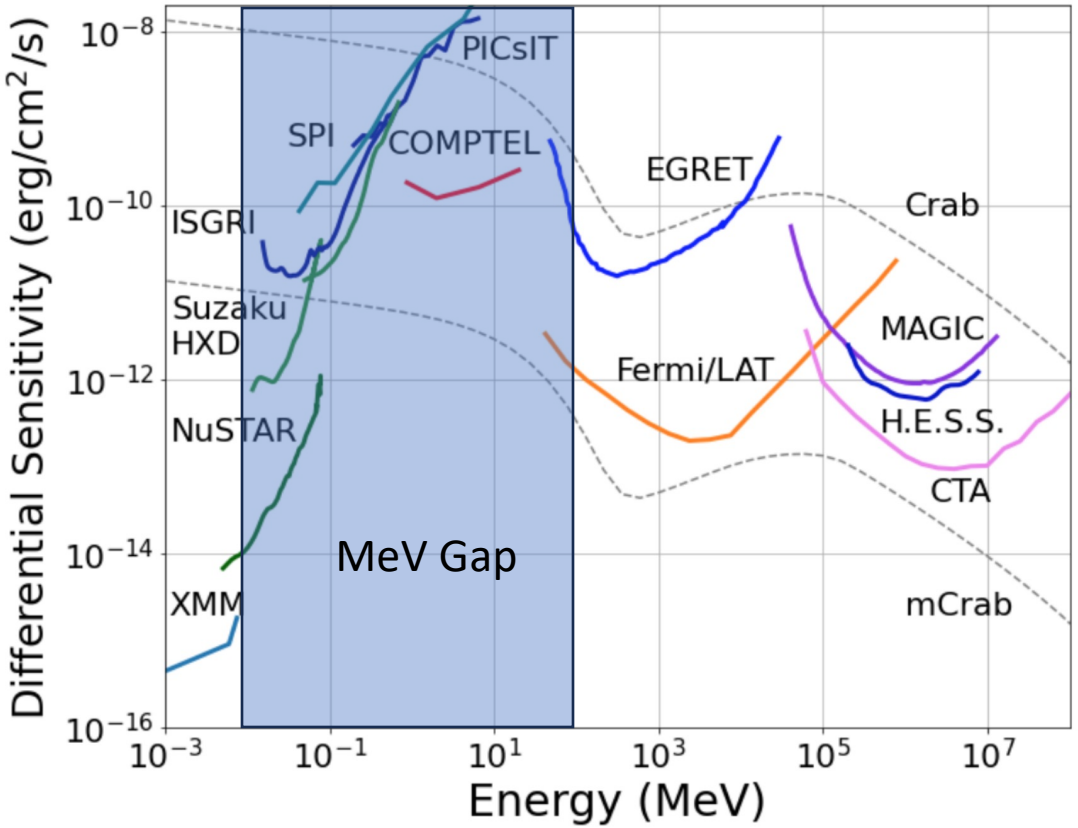
1. Intro to MeV astronomy
2. ComPair and its instruments
3. The balloon flight
4. What's next

MeV Astronomy Science Cases



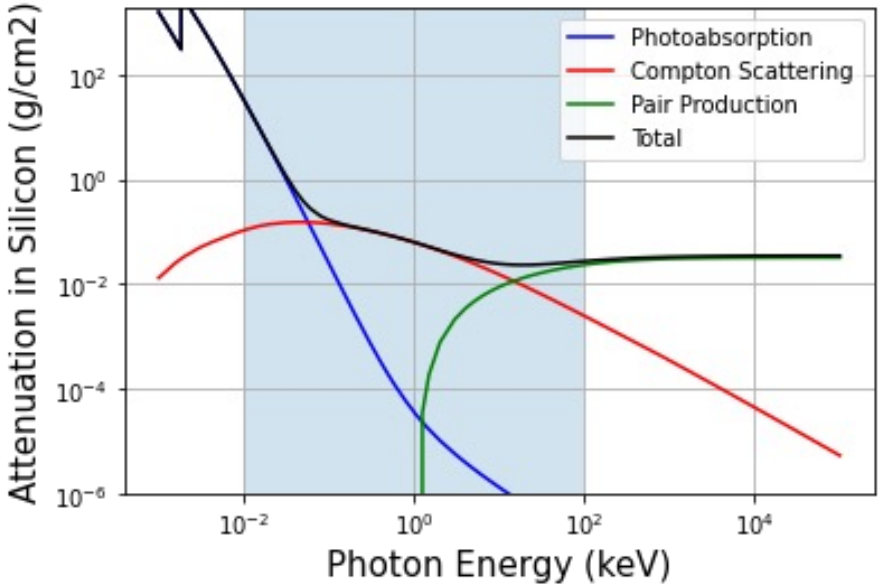
McEnery+ 2019
(AMEGO White Paper)

MeV Astronomy Challenges



Kierans+ 2022

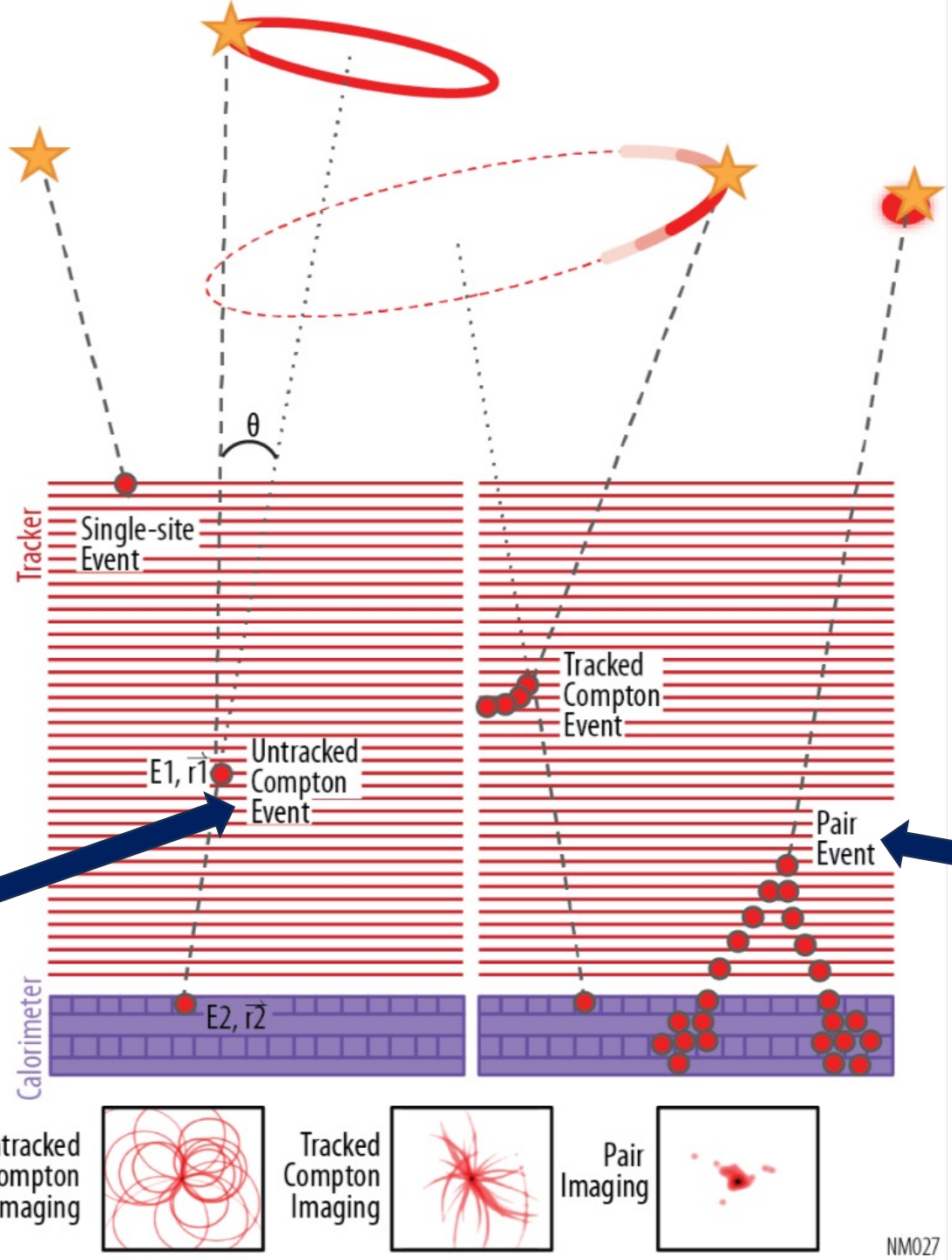
NIST XCOM



- Crossover between interactions
  - Photoabsorption
  - Compton Scattering
  - Pair Production
- Hard to optimize detector design for different interaction mechanisms
- Charged particle background dominates

MeV Imaging

Compton Scattering Events
- < 10 MeV
- Energy + position measure scattering angle, which defines a ring in the sky
- Overlap multiple events' rings to localize the source



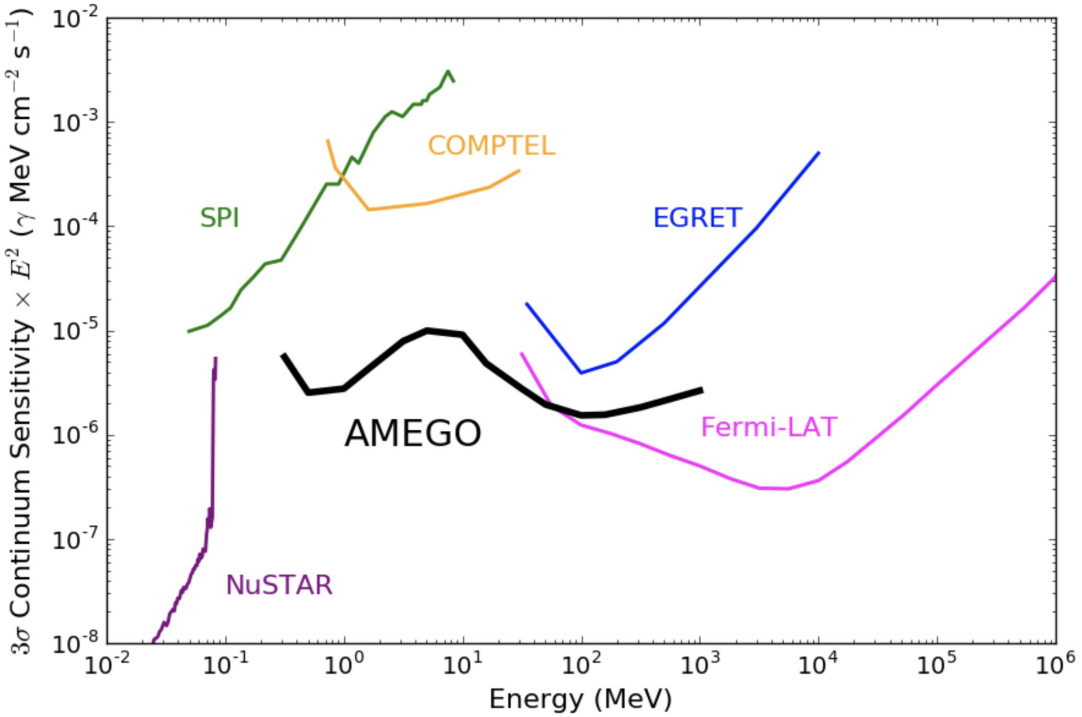
COSI-like

Fermi LAT-like

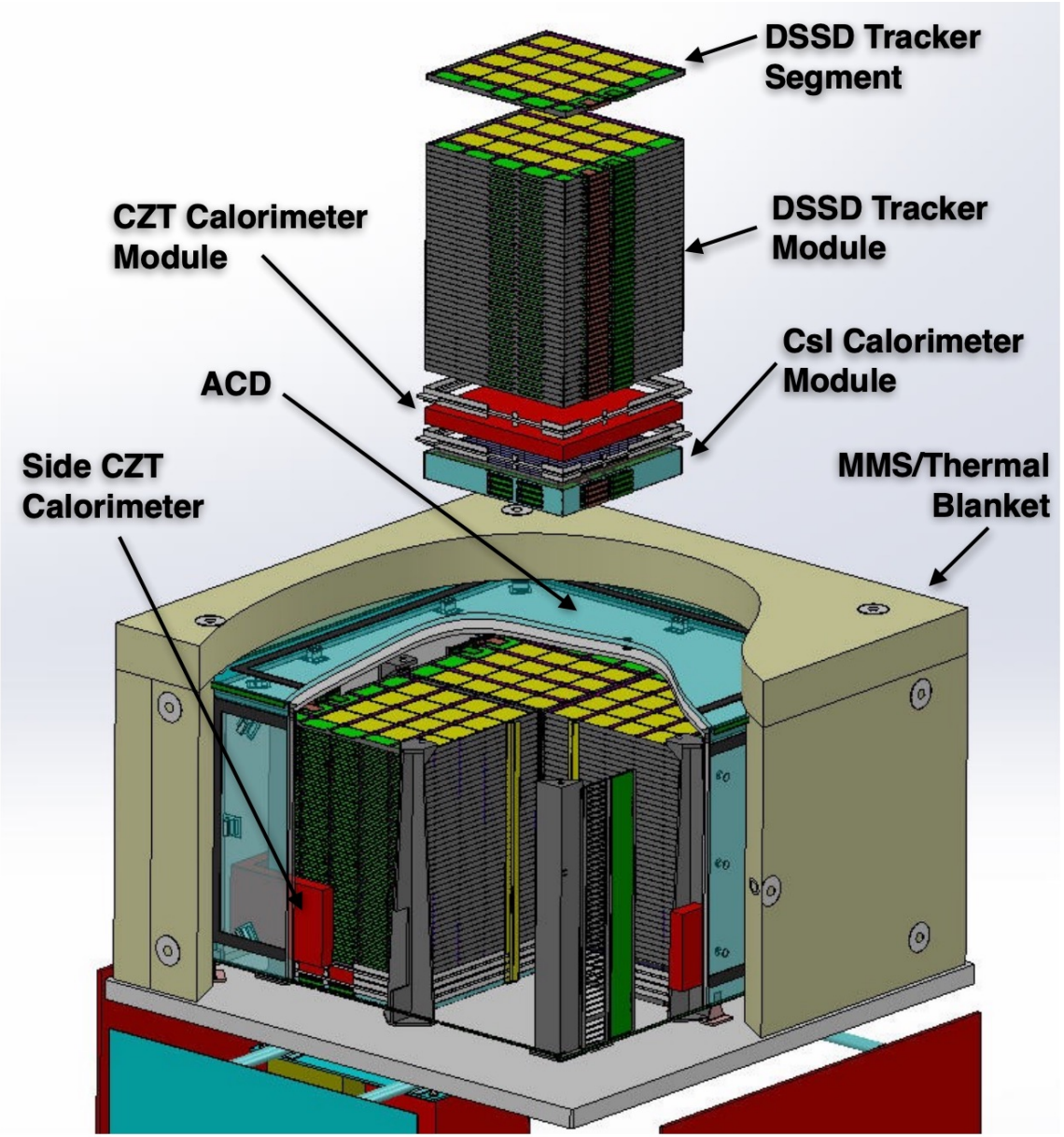
Pair Production Events
- > 10 MeV
- Track electron/positron pairs
- Each event points to a single spot in the sky

AMEGO

- Probe Concept to close MeV gap
- Addresses all science cases from earlier

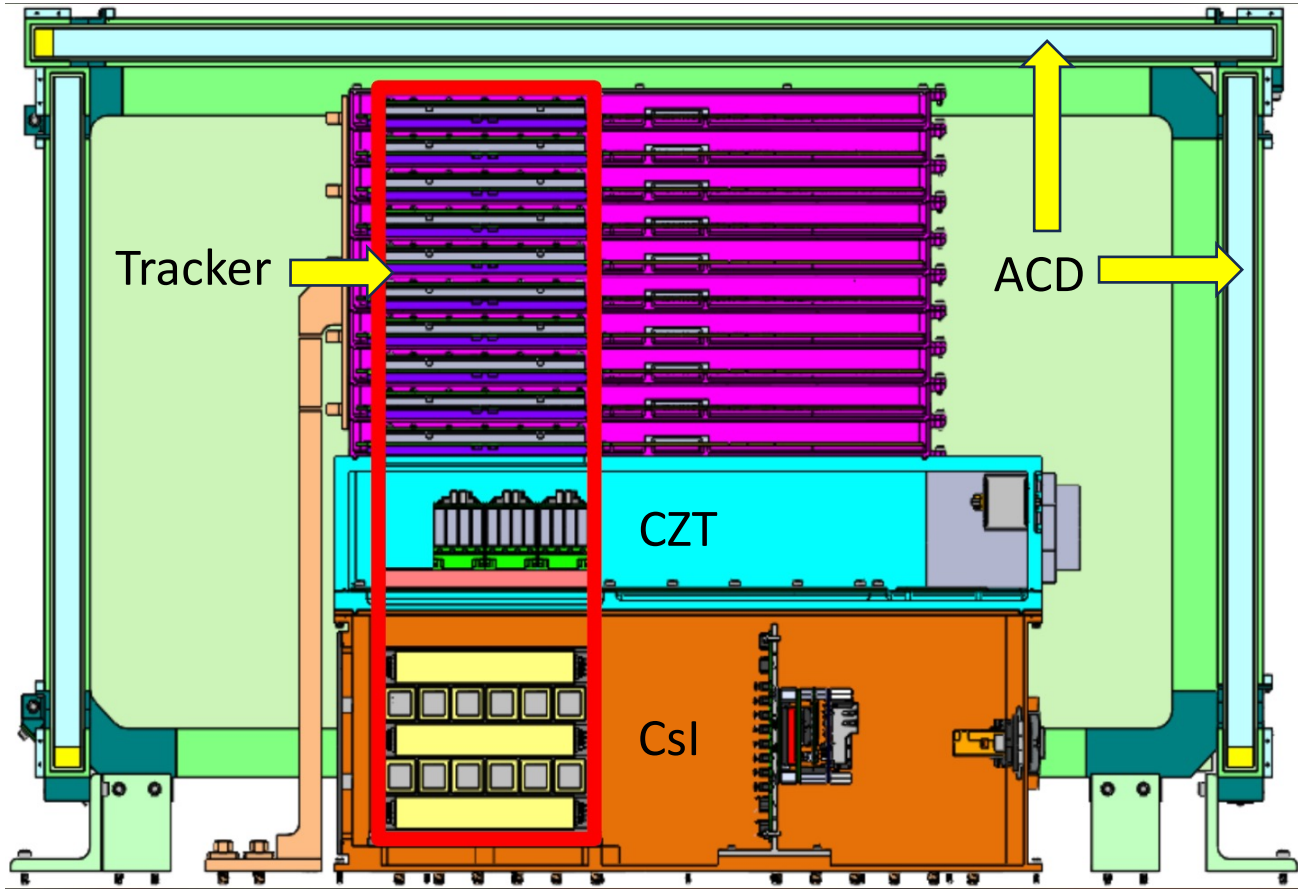


McEnery+ 2019



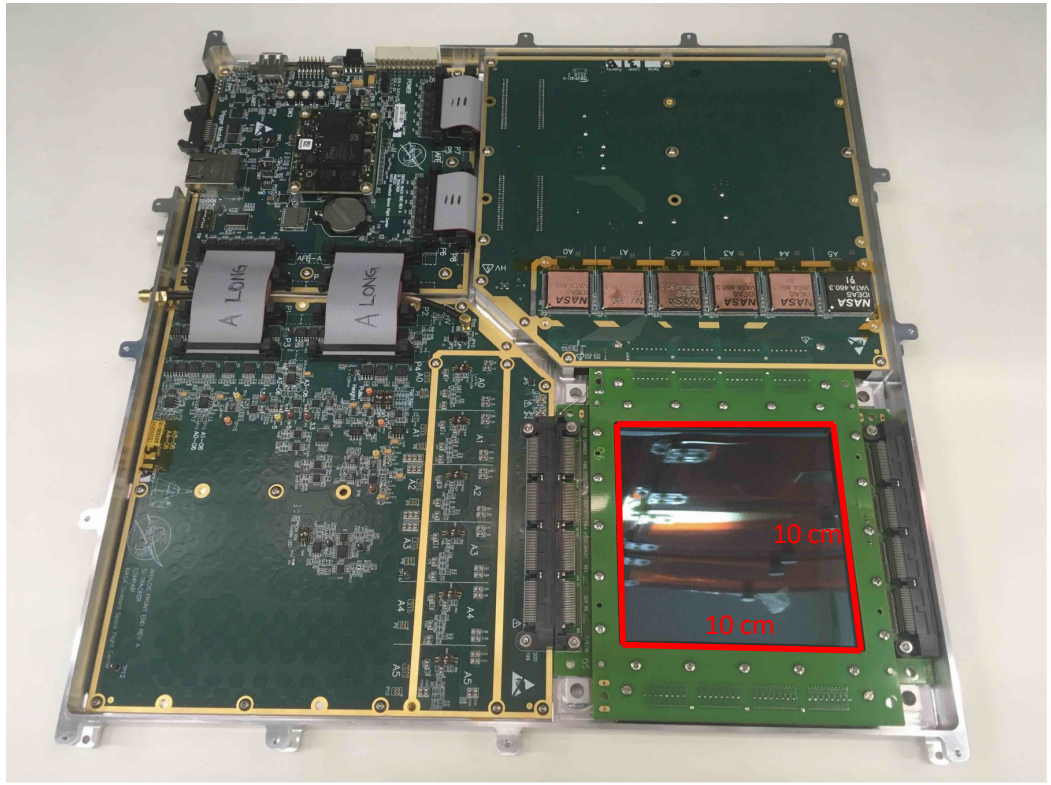
ComPair: A prototype for AMEGO

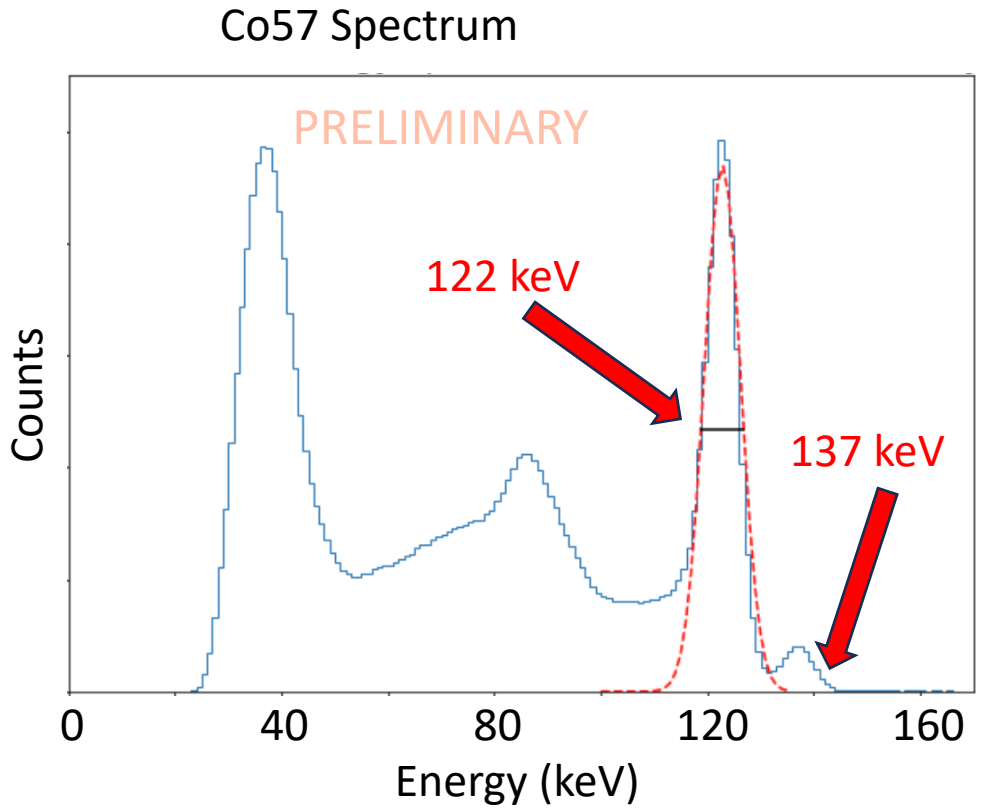
- 4 detector subsystems
  - Double-sided Silicon Strip Detector Tracker
  - CZT Calorimeter
  - CsI Calorimeter
  - Plastic Scintillator Anti-Coincidence Detector



Double-Sided Silicon Strip Detector Tracker

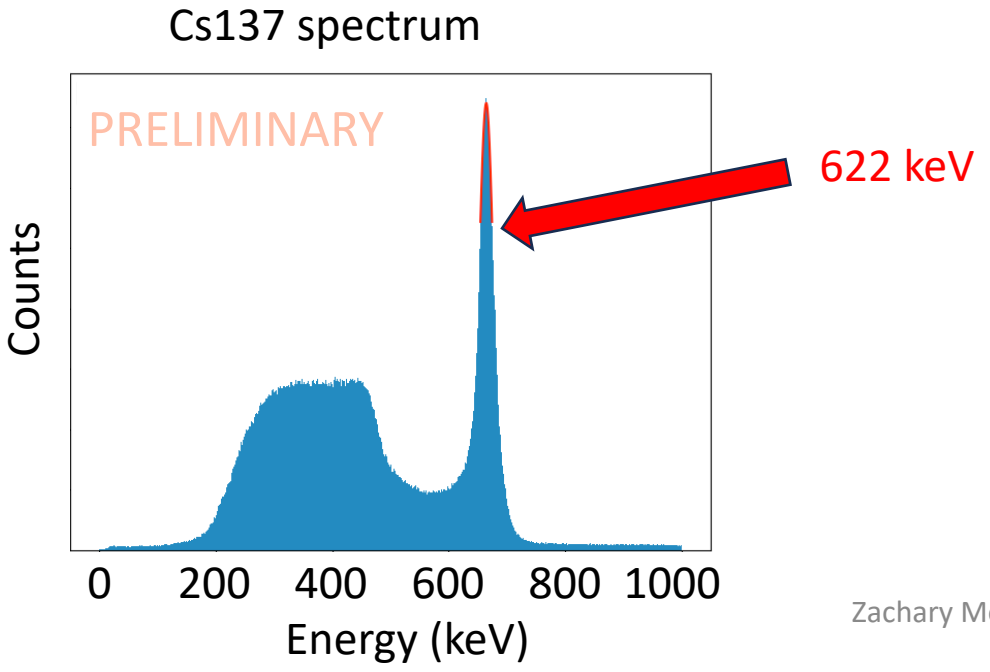
- Compton Scatterer & Pair converter
- 10 layers
- 6.5% FWHM at 122 keV
- 300 µm FWHM position resolution

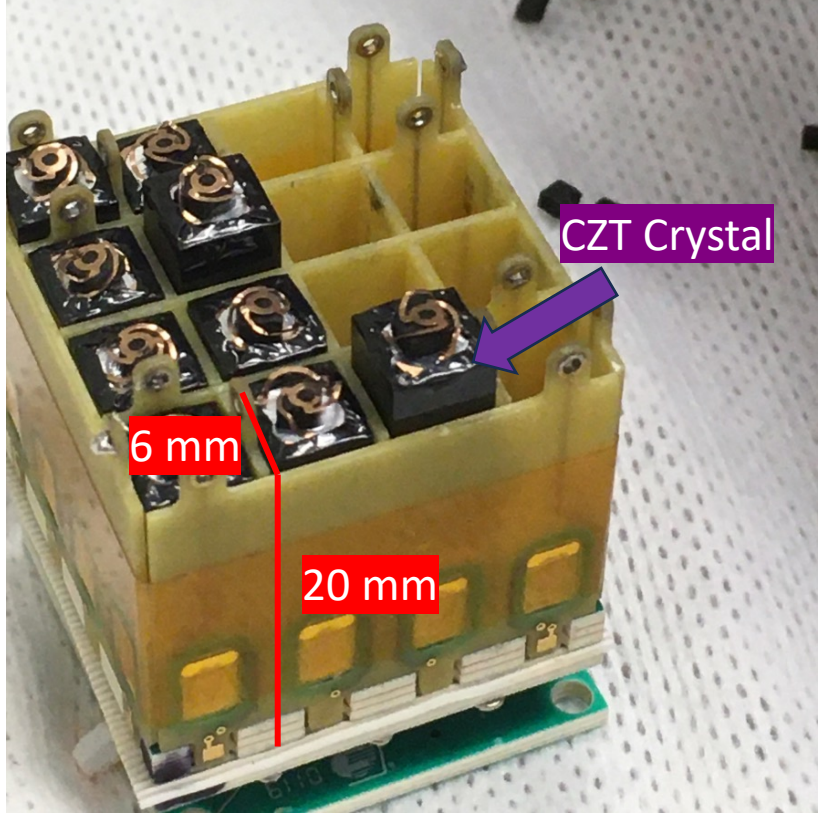


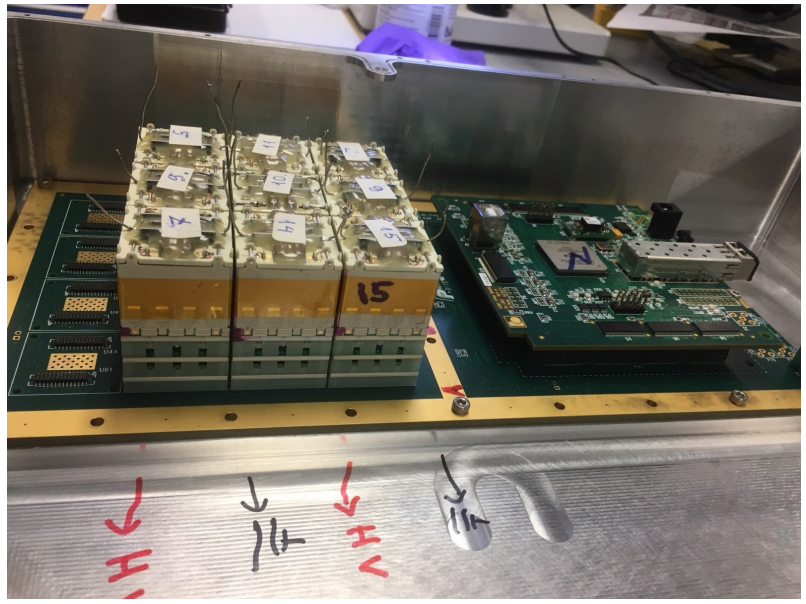


CZT Calorimeter

- Enhances Compton efficiency
- 9 crates with 16 crystals each
- 4.5% FWHM at 662 keV
- 2mm FWHM position resolution

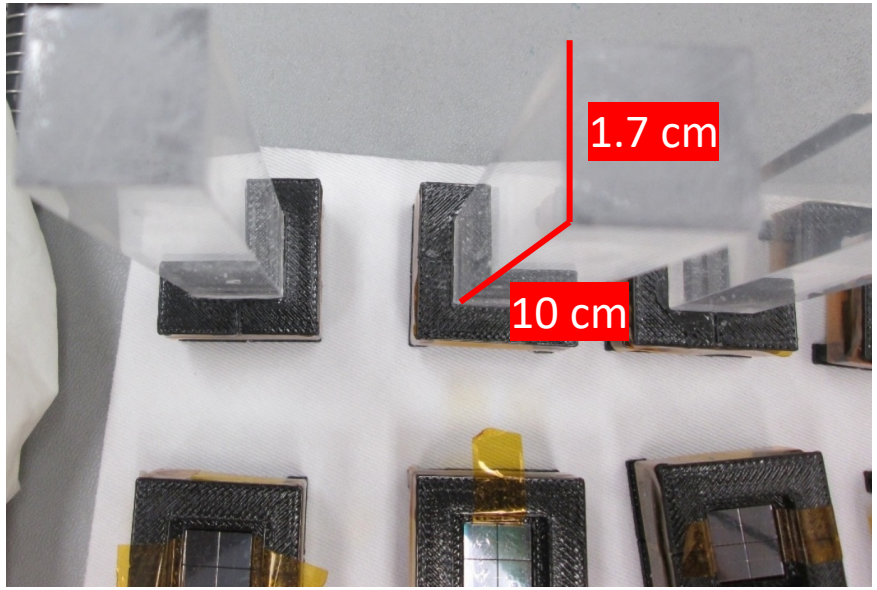


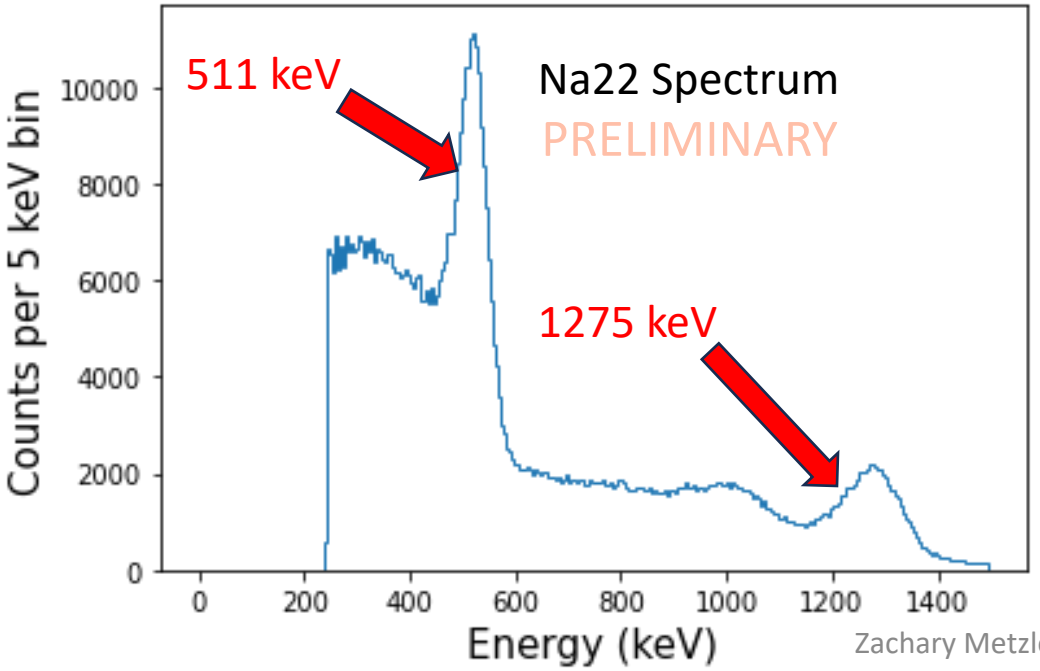


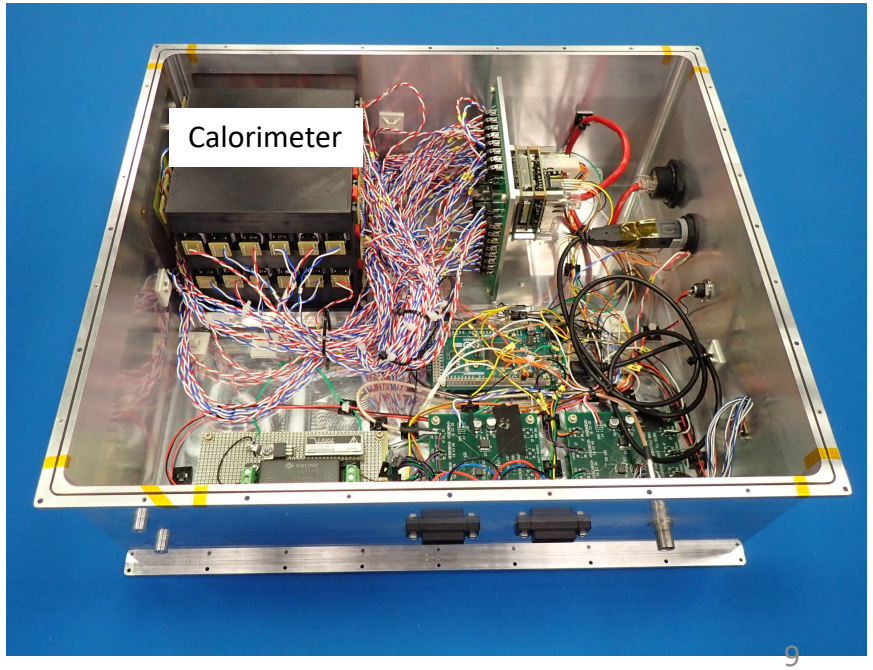


CsI Calorimeter

- Enhances pair efficiency
- Low-Energy version of LAT Calorimeter
  - Hodoscopic design
  - APDs -> SiPMs
- 30 bars in 5 layers w/ 2 SiPM arrays per bar
- 6.8% FWHM at 1275 keV
- 1 cm FWHM position resolution

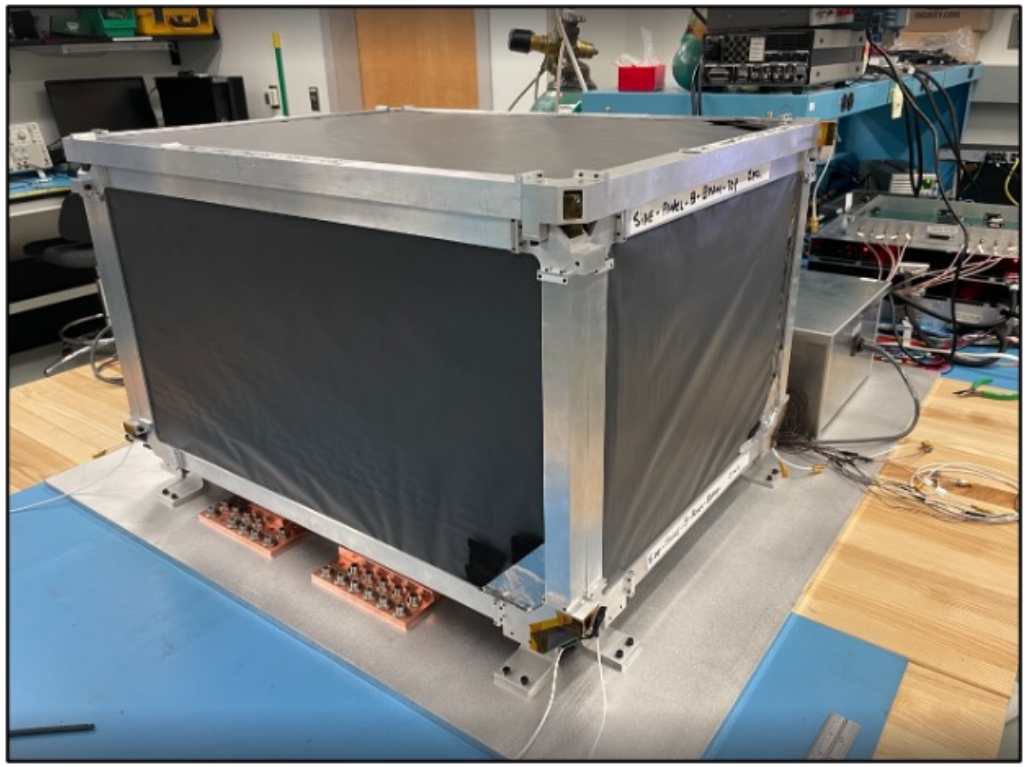


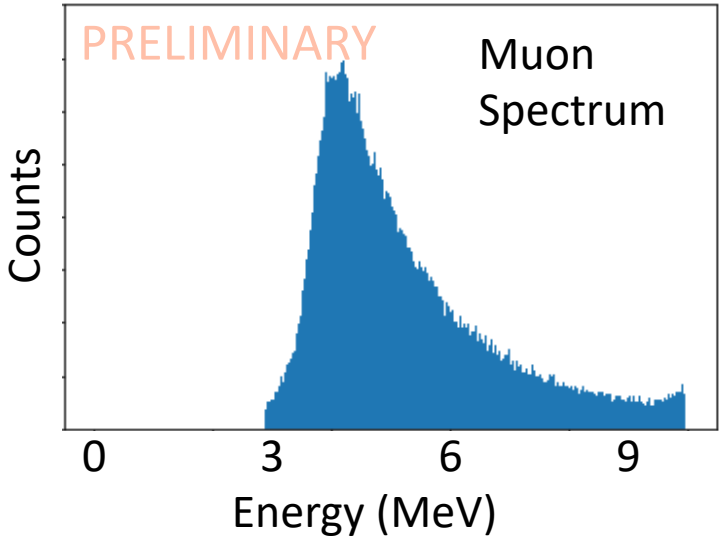


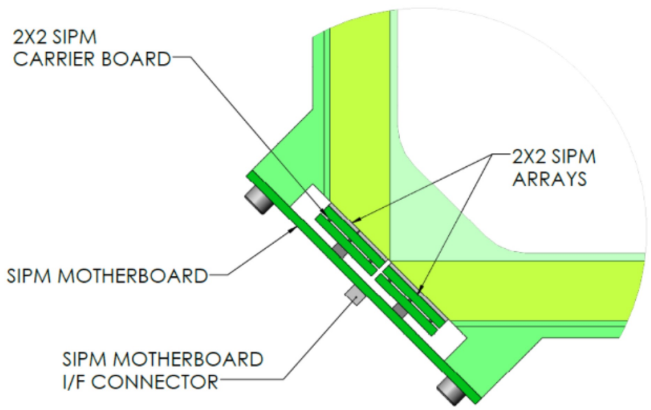


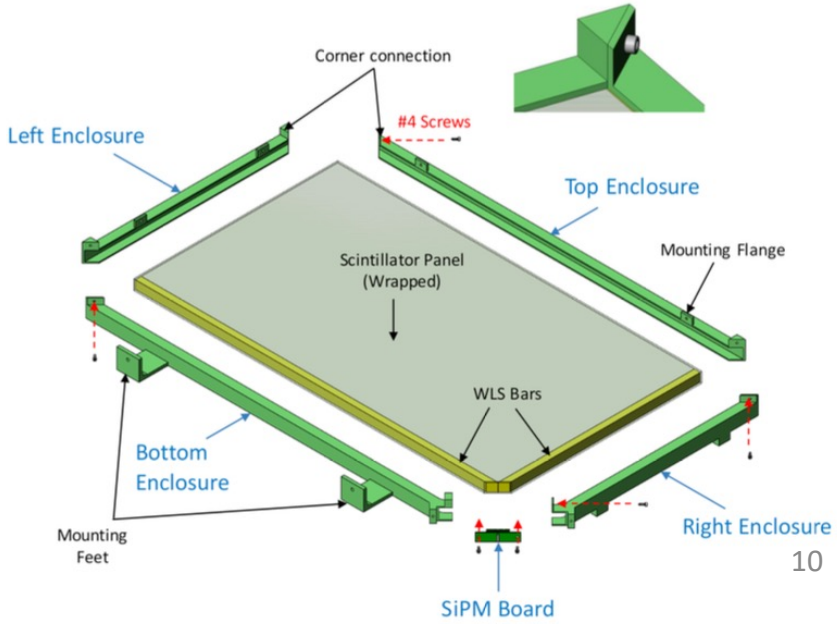
Anti-Coincidence Detector

- 5 panels
- Each panel:
  - 2 wavelength shifting bars
  - 2 SiPM arrays
- Charged particle veto >3 MeV



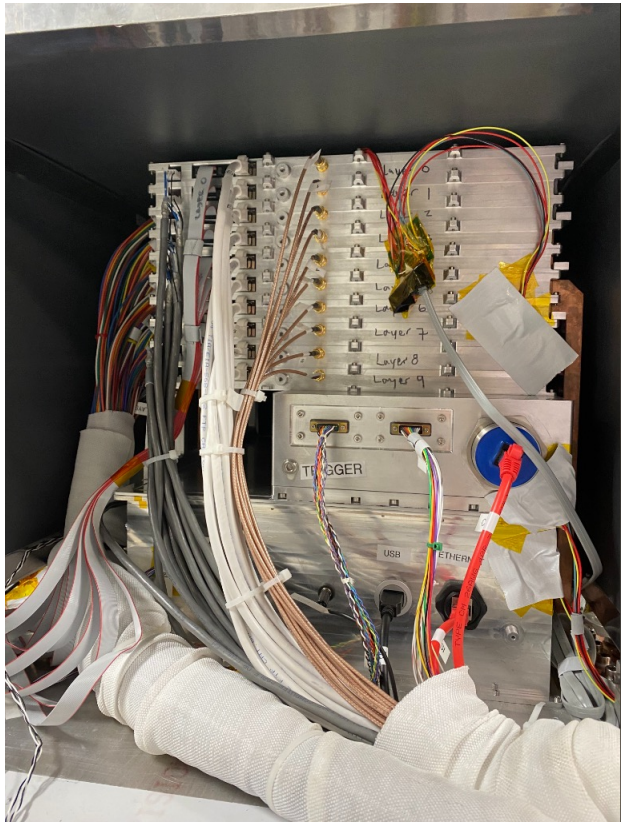


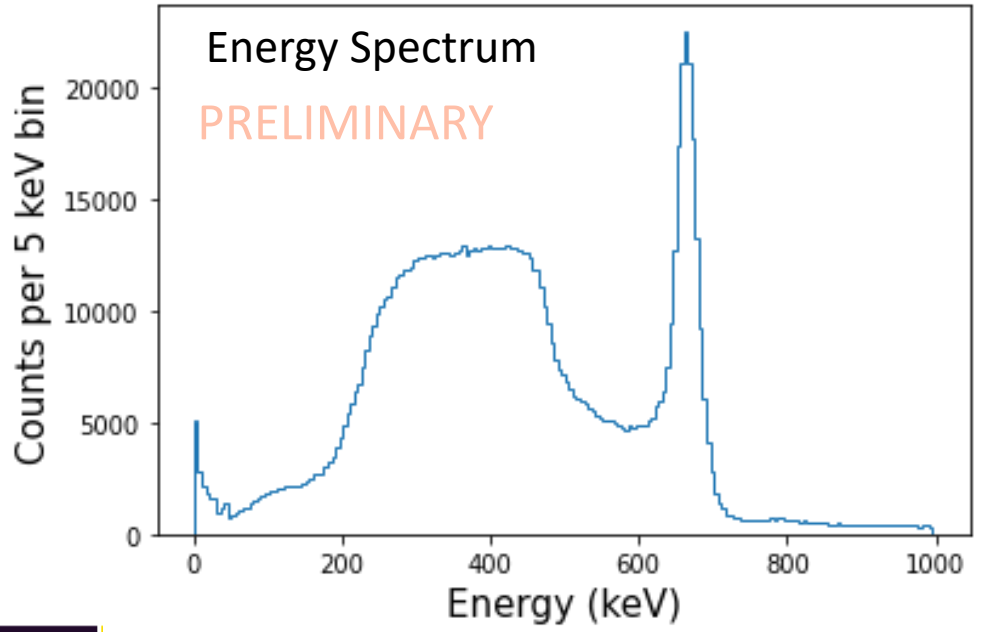


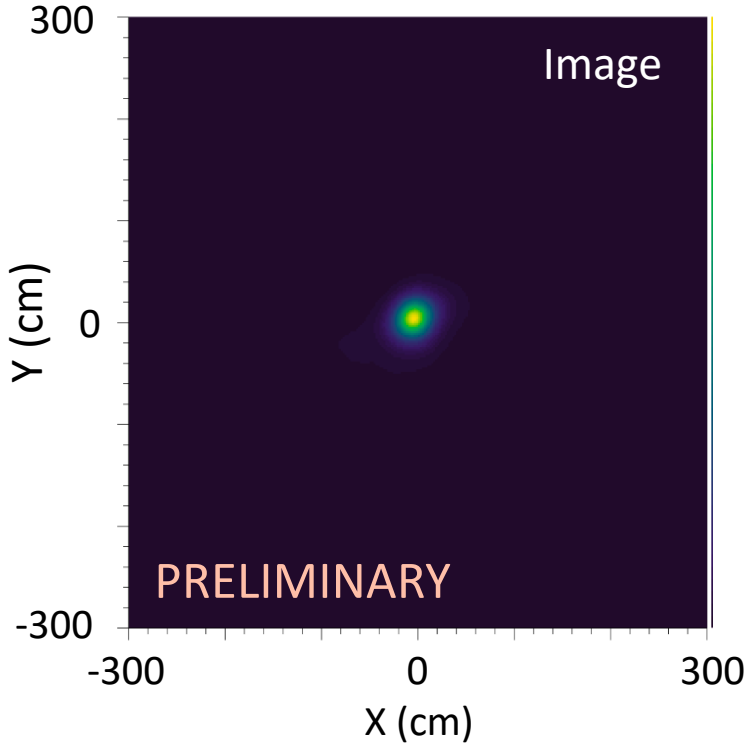


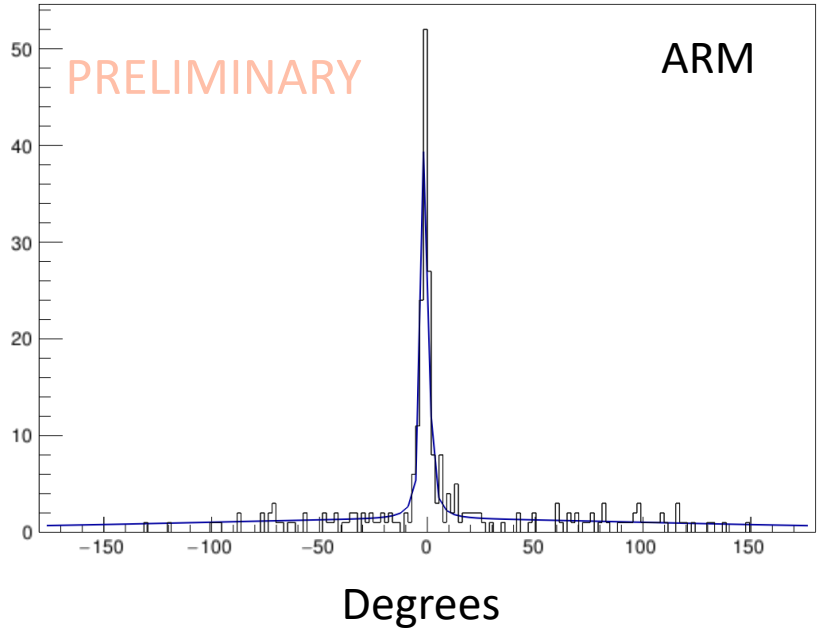
ComPair Performance

- Cs137 calibration source
- 4.5% FWHM at 662 keV
- 2.5° angular resolution

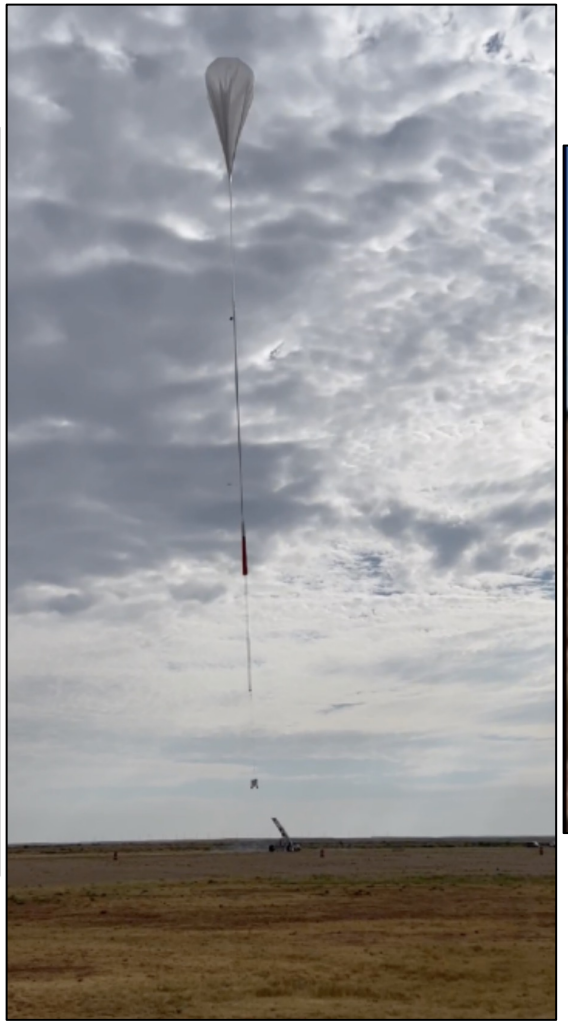






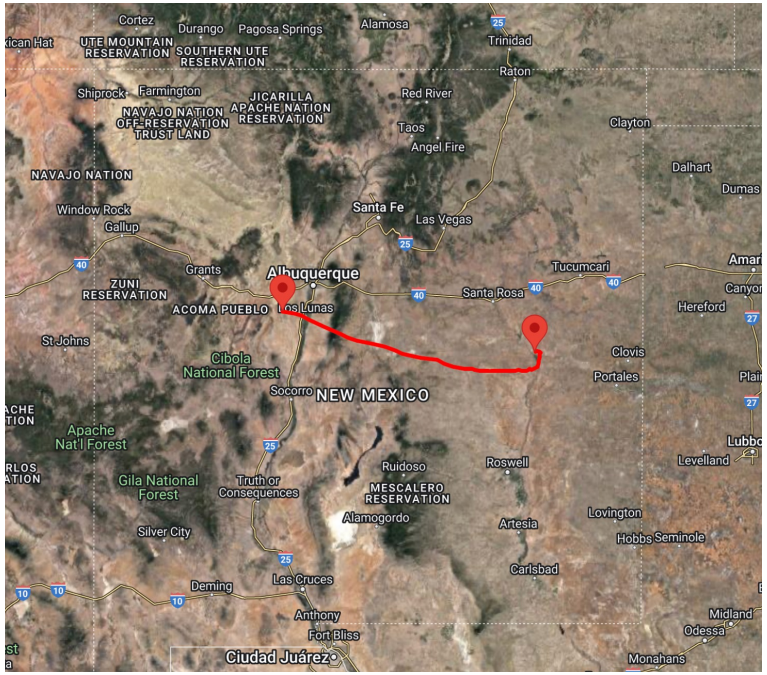


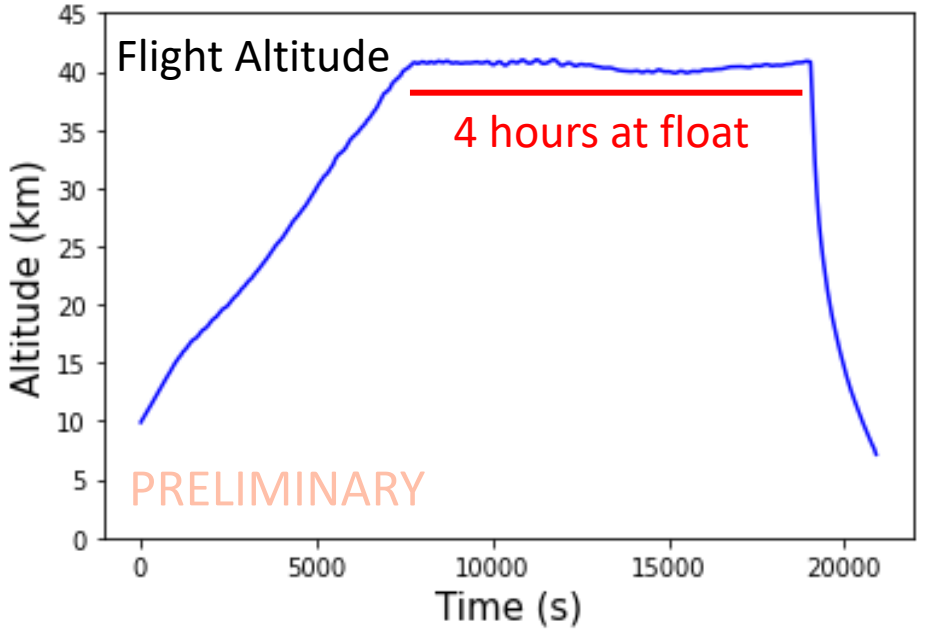
Balloon Flight

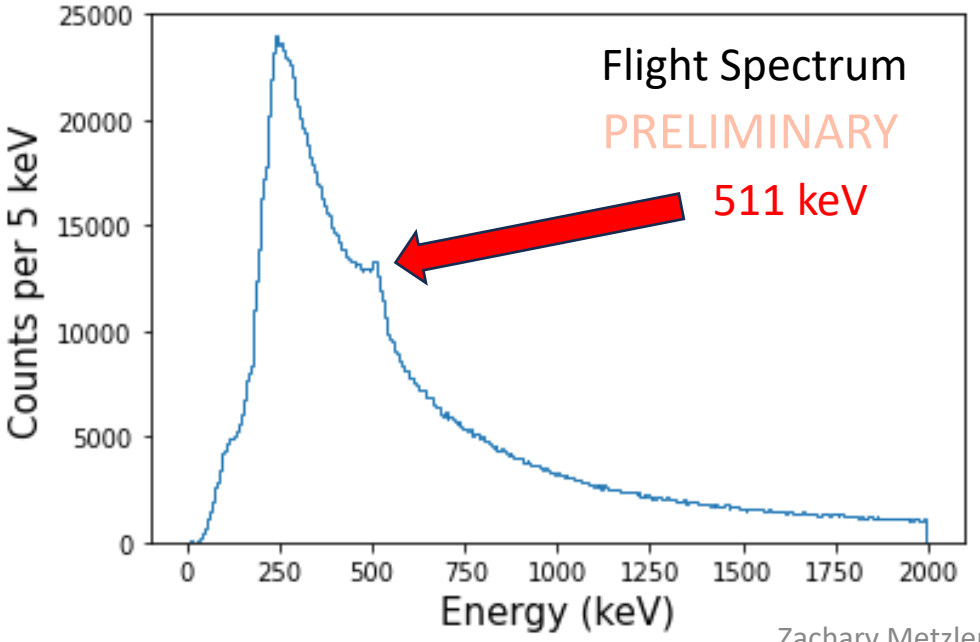


Balloon Flight

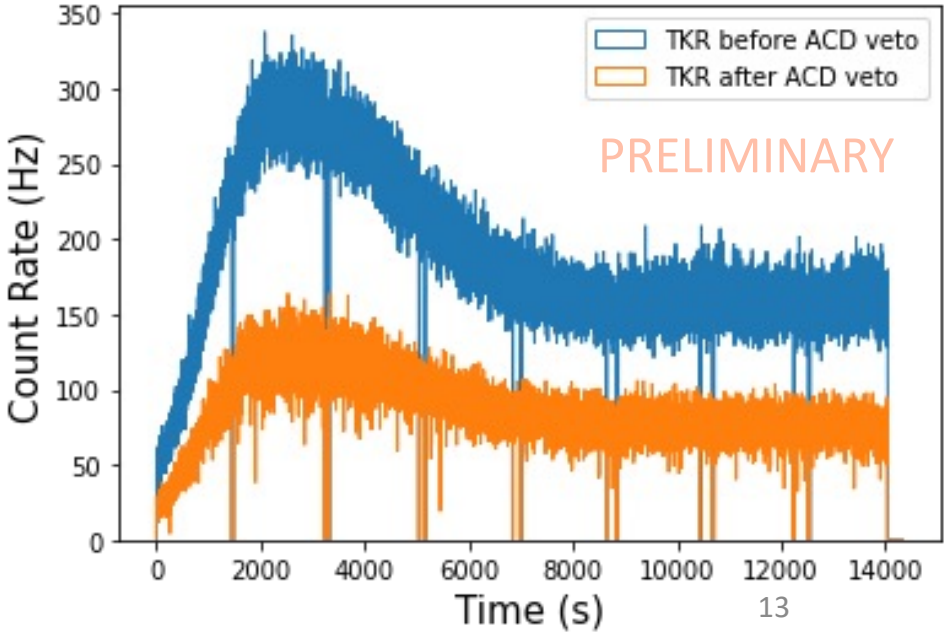
- Success!
- All instruments collected data for 4 hours at float altitude
- Instrument safely recovered!





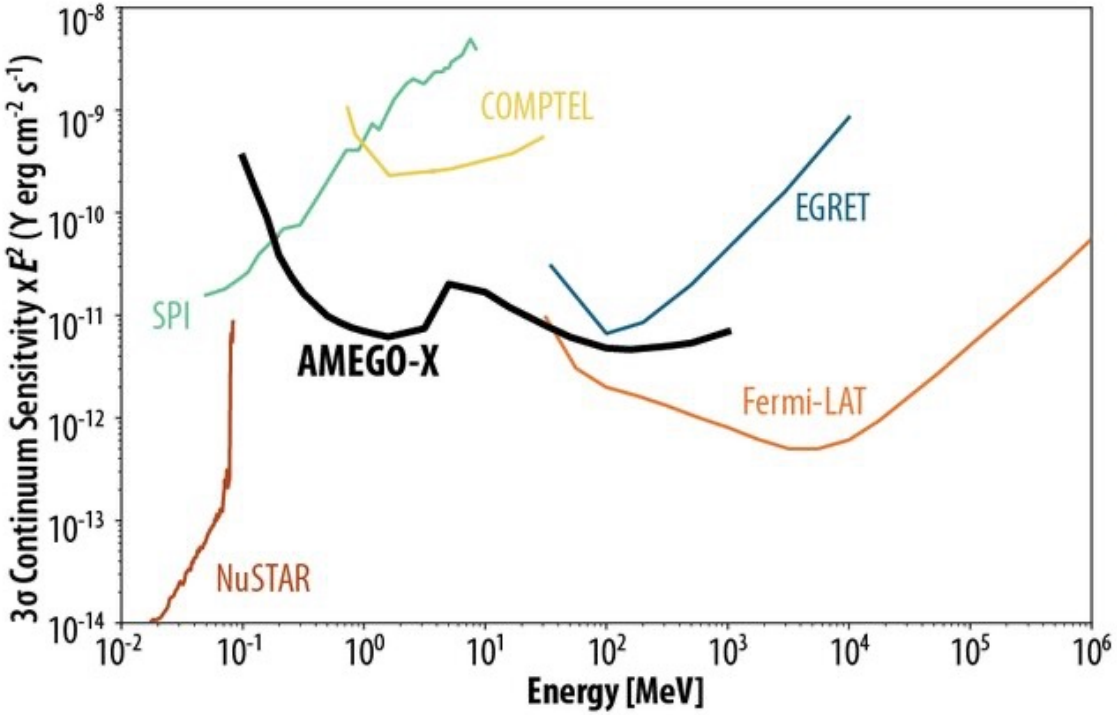


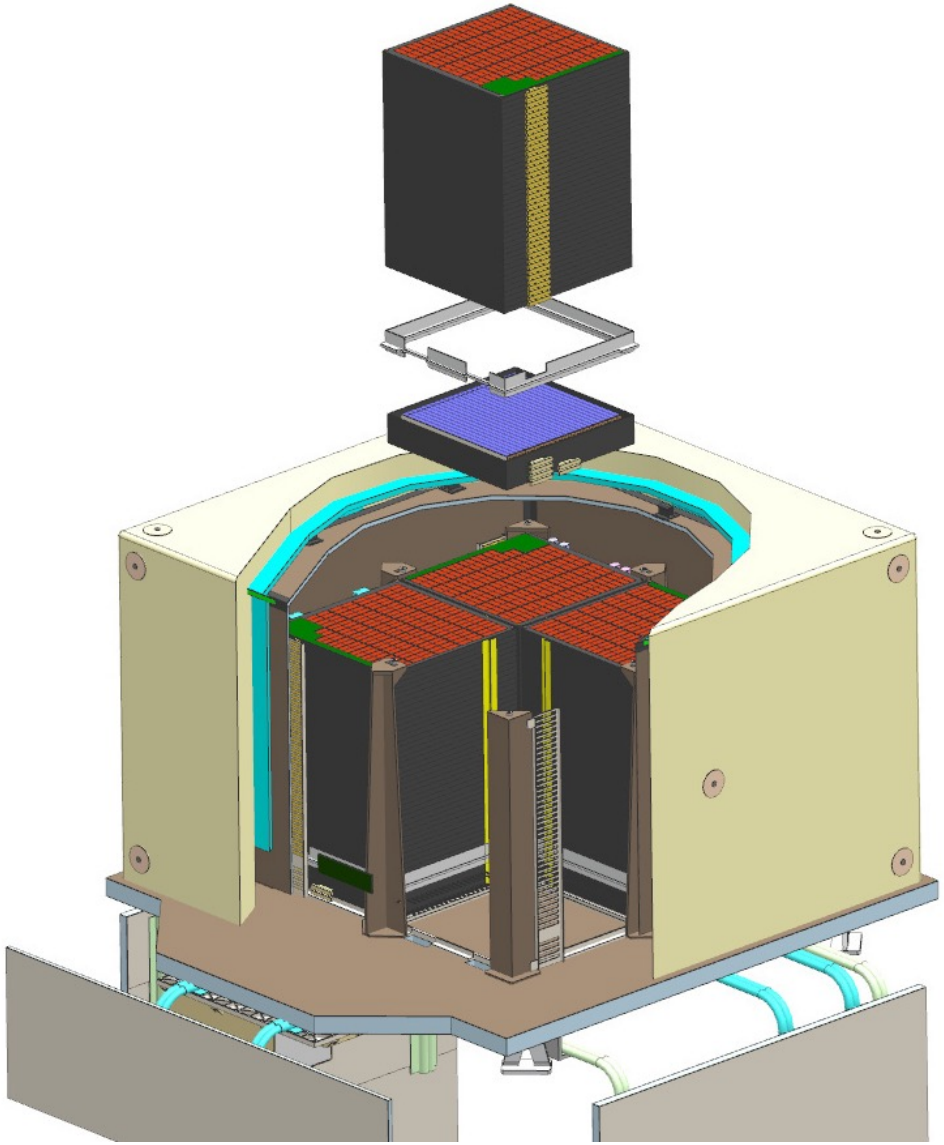
ACD Veto Performance



What's next for ComPair?

- Testing technologies for AMEGO-X
  - Pixelated silicon tracker
  - Dual gain SiPM readout
- Long duration balloon flight of ComPair 2



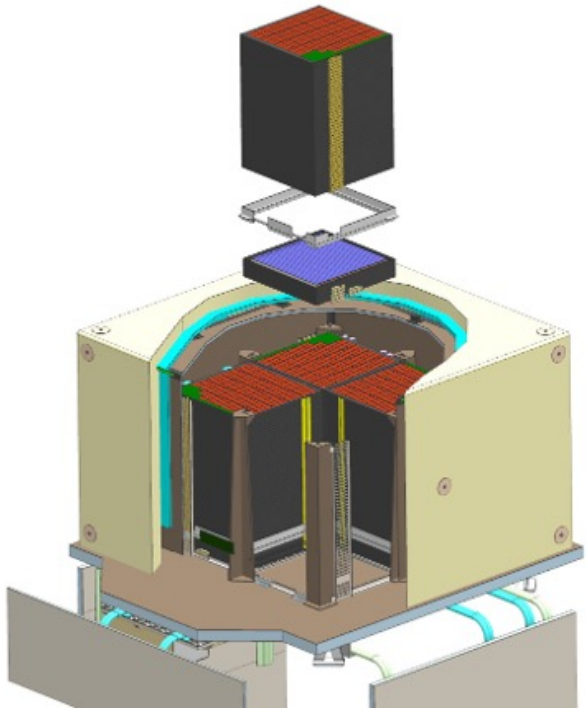


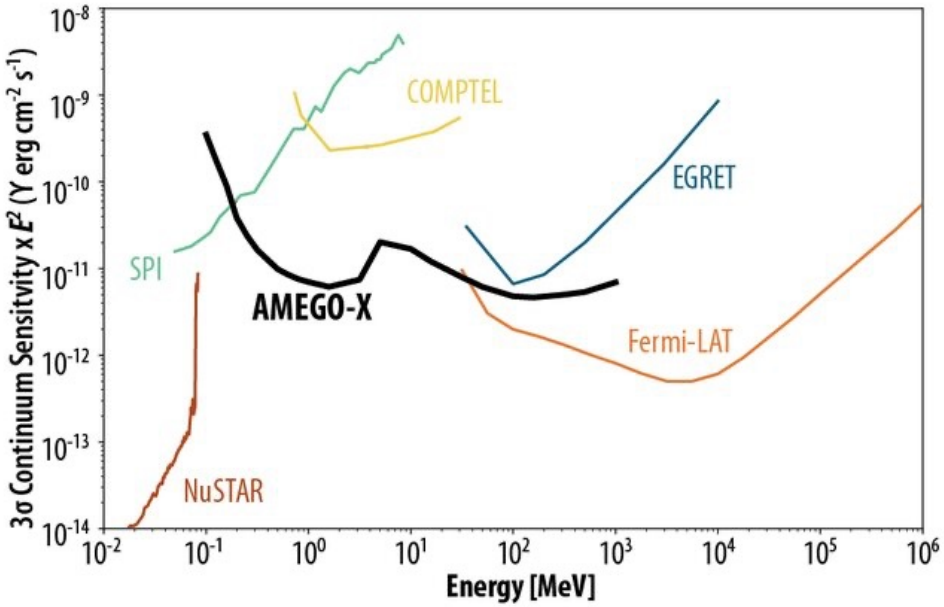
Conclusions

- The ComPair was successful with all systems operational for a 6 hour balloon flight
- ComPair met its resolution goals
  - Energy: 4.5% FWHM at 662 keV
  - Angular: 2.5° FWHM at 662 keV
- ComPair 2 will increase active area >4x and low energy sensitivity for a long duration balloon flight

AMEGO-X

- A medium explorer class mission concept to fill the MeV Gap
- 20% of sky FoV
- 25 keV – 1 GeV
- 0.6 deg persistent source localization
- 5% FWHM at 1 MeV
- Heritage from Fermi LAT





A Steinhebel 2023
R Caputo 2022