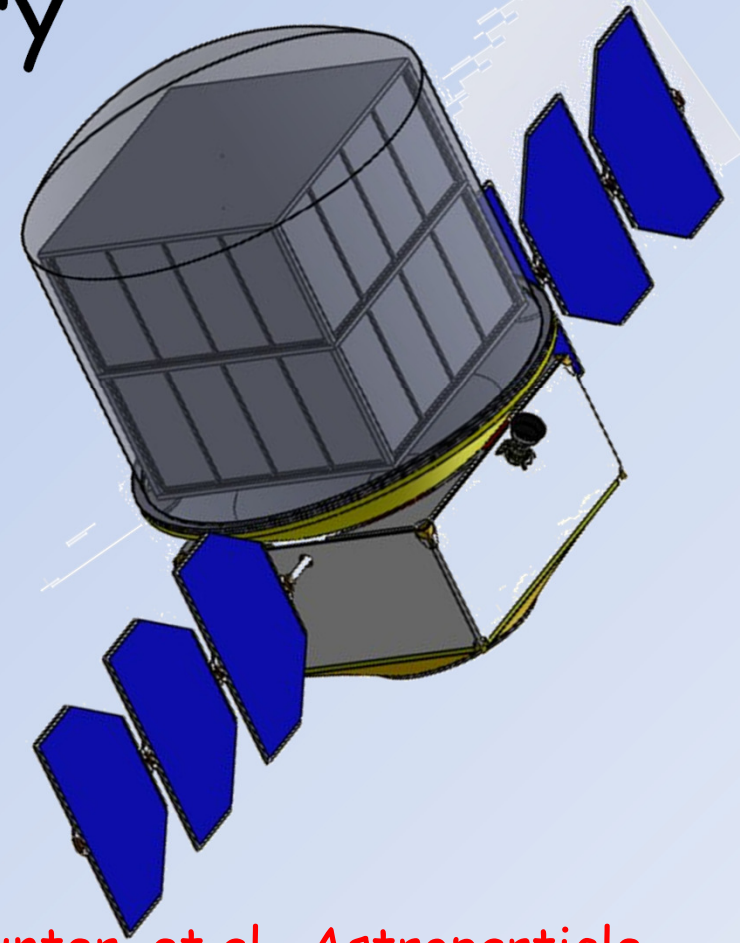


Advanced Energetic Pair Telescope for Medium-Energy Gamma-Ray Polarimetry

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Hunter, et al., *Astroparticle
Physics*, 59, 18-28 (2014)

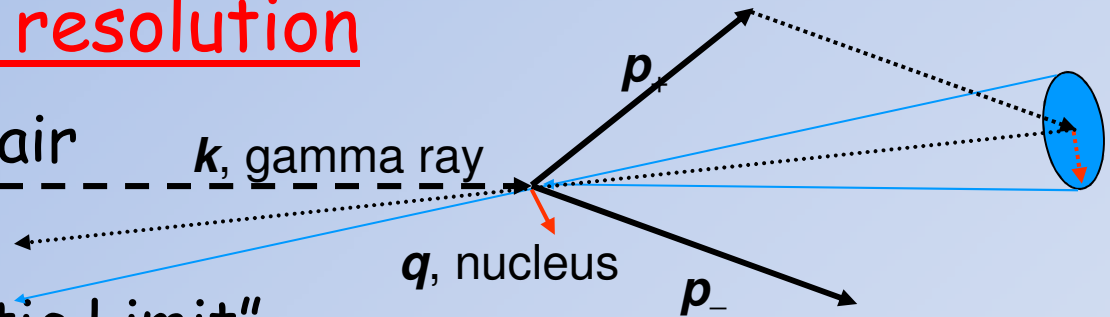
AdEPT Science, 5-200 MeV

- AdEPT will reveal the configuration of the most energetic accelerators in the Universe
- Explore fundamental processes of particle acceleration in active astrophysical objects
 - Pulsars, pulsar nebulae, supernova remnants, active galactic nuclei, magnetars, accreting binaries, gamma-ray bursts, ...
- Map the transition from electron to hadronic processes in the Galactic diffuse emission
- Probe the universe for exotic processes

AdEPT Design Philosophy

- Optimize for angular resolution

- Angular resolution of pair telescope limited by nuclear recoil, "Kinematic Limit"

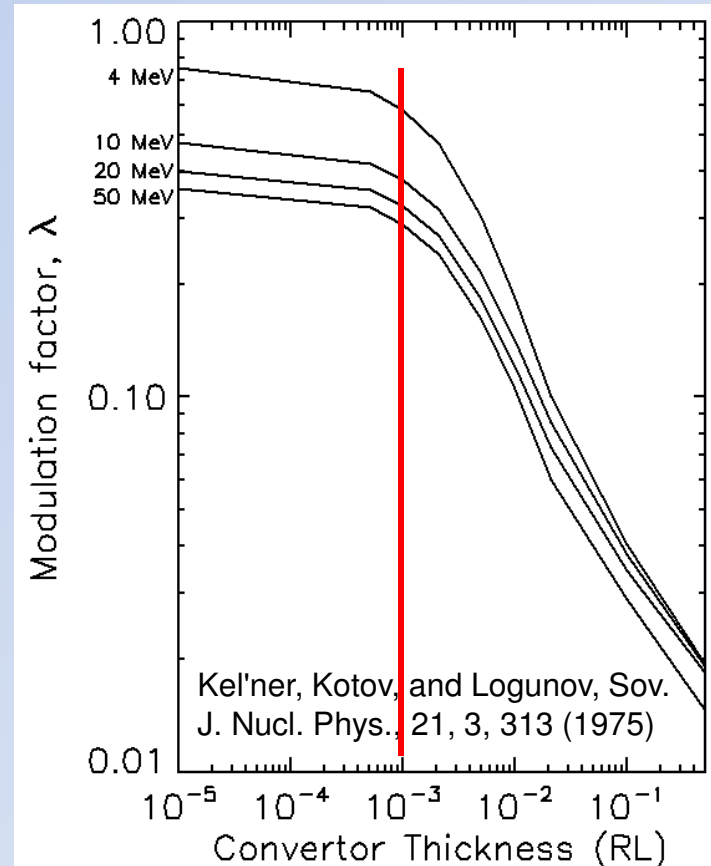


- Optimize for polarization sensitivity

- Modulation factor, λ , decreases exponentially with thickness of tracking medium above ~ 1 mRL

$$\sigma(\Psi_+) = \frac{\sigma_0}{2\pi} [1 + P\lambda \cos^2(\Psi_+ - \Psi_0)]$$

- Measure e^- and e^+ directions in $\lesssim 1$ mRL
 - $\sim 100 \mu\text{m}$ of Si, ~ 8 cm of Ar at 1.5 atm

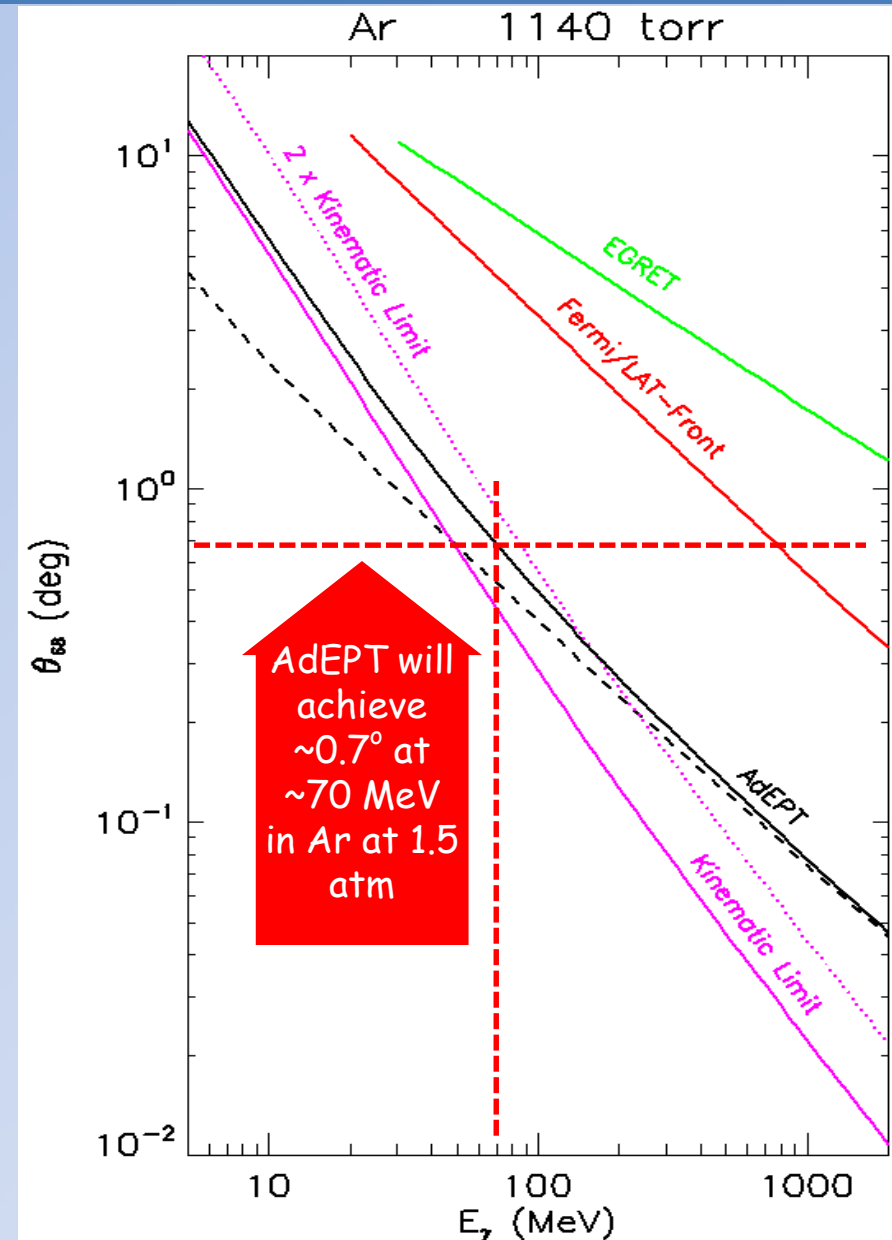


AdEPT Angular Resolution

Achieving angular resolution near the Kinematic Limit

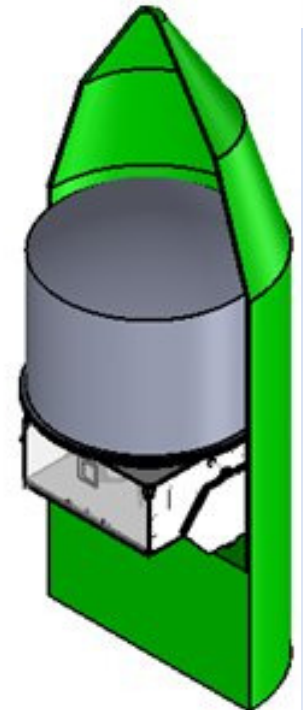
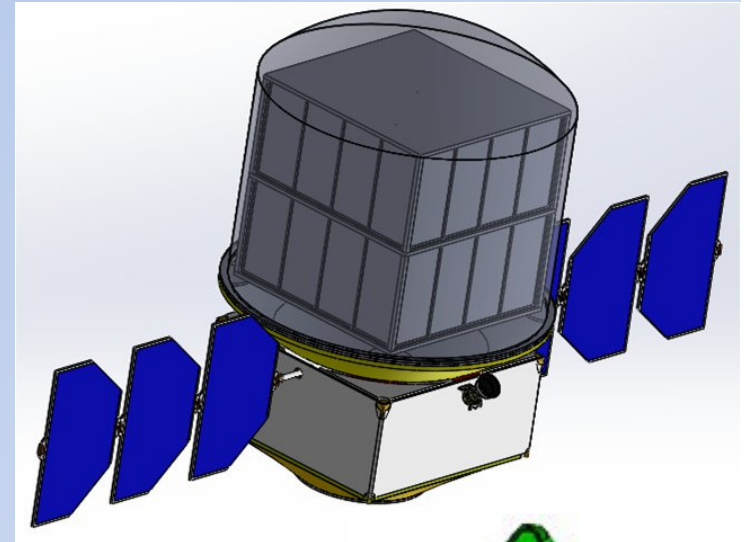
Continuous medium track imager density must be $< \sim 5 \text{ mg/cm}^3$
i.e. a Gaseous medium

Hunter et al., Astroparticle Physics 59, 18-28 (2014)



AdEPT is a Viable Gaseous γ -ray Polarimeter!

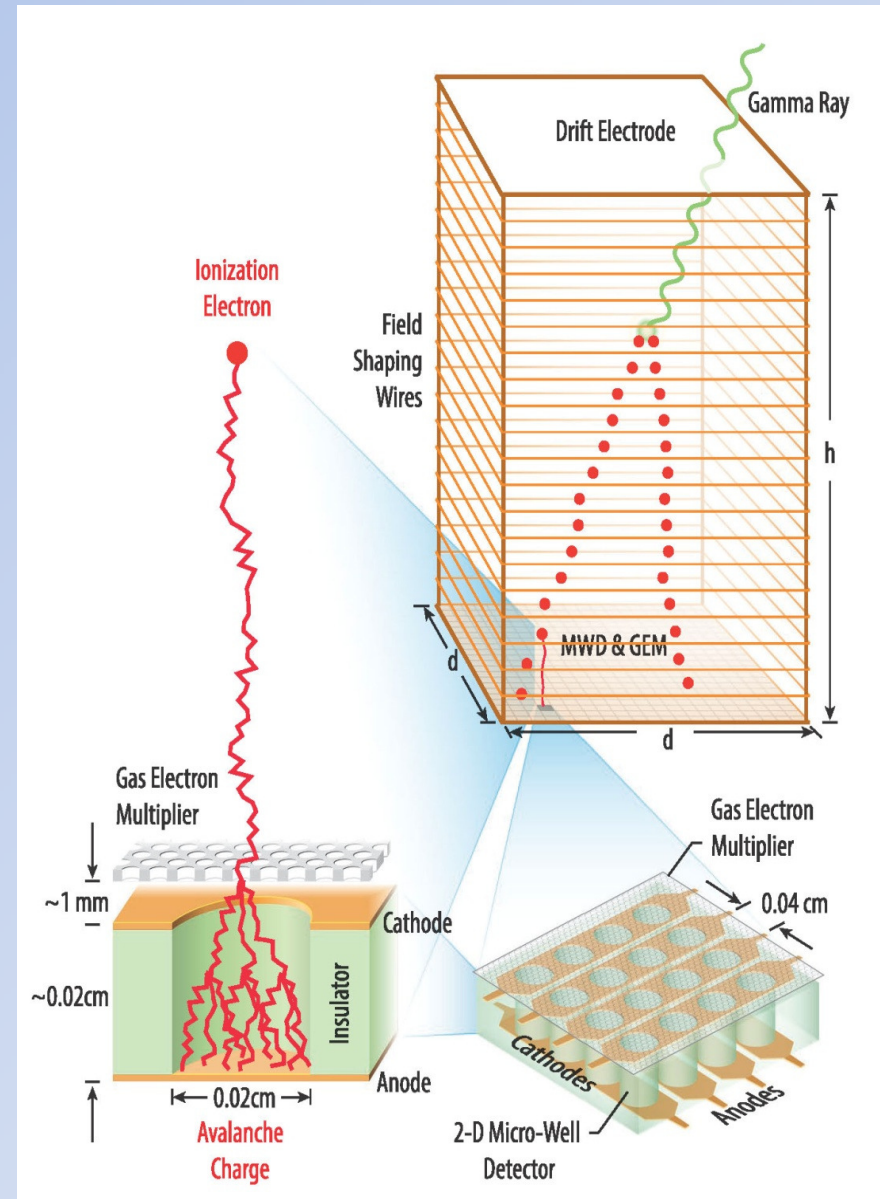
- **Baseline design studied in GSFC IDL/MDL**
- $2 \times 2 \times 2$ array of 1 m^3 3-DTI modules
 - A_{geom} : 4 m^2 , $\sim 40,000$ channels
- Ar (1100 torr) + CS_2 (40 torr), 25° C
- Pressure vessel: Al, 4 mm thick, $\sim 300 \text{ cm}$ diameter, $\sim 530 \text{ kg}$
- Instrument power: $\sim 500 \text{ W}$,
mass: $\sim 320 \text{ kg}$ w/o s/c, pv
- Spacecraft: zenith pointed, 3-axis stabilized, scanning mode
- Orbit: near equatorial, $\sim 550 \text{ km}$ altitude
- Athena launch vehicle
- Fits within mission constraints:
Mass, power, & cost



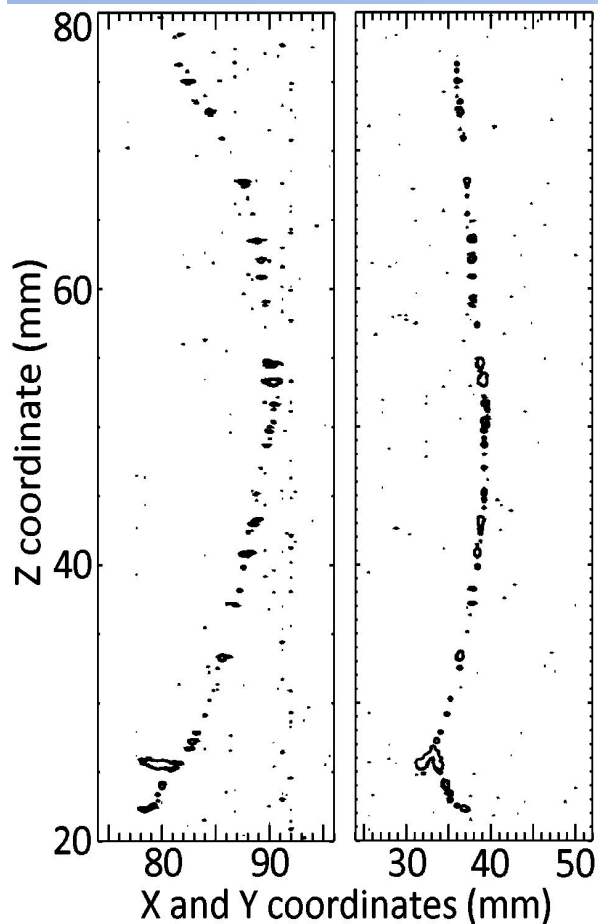
3-Dimensional Track Imager (3-DTI)

• AdEPT Enabling Technology

- Large-volume gas **time projection chamber (TPC)**
 - Low density, homogenous, 100% active particle tracking
 - Thermal diffusion achieved with negative ion drift
- **2-D readout, 2-D micro-well detector (MWD) + GEM**
 - Active detector, 0.4 mm pitch
 - GEM provides additional gain lost to negative ion drift
- Scalable to large area

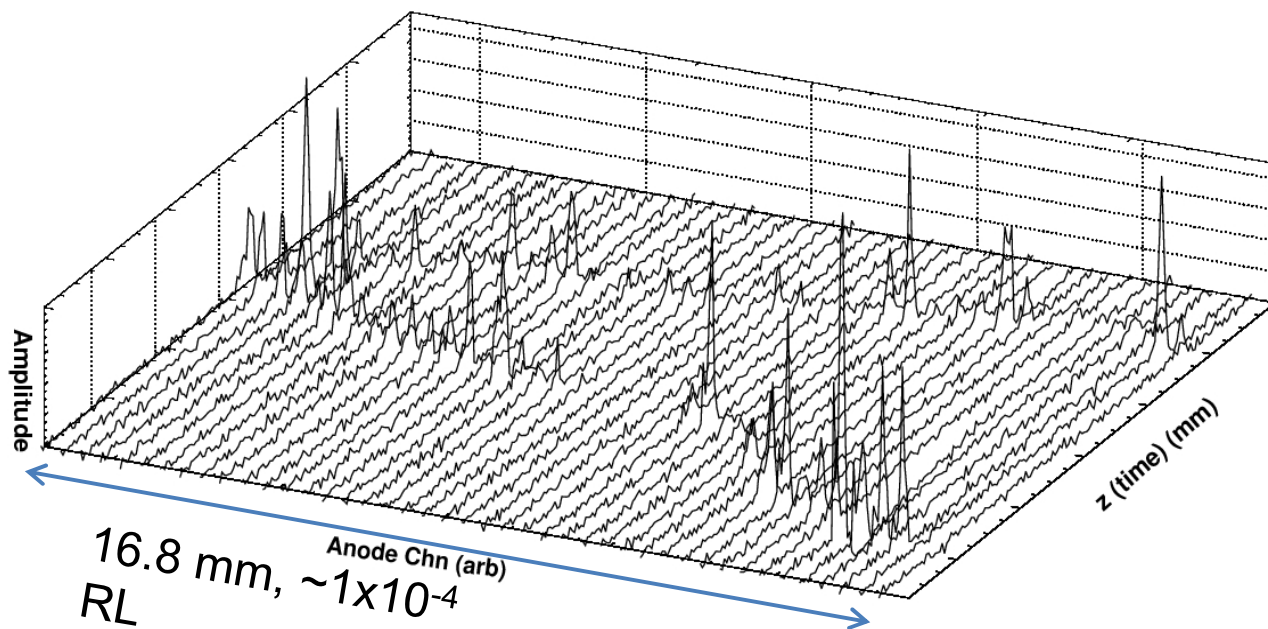


Electron Tracking in 3-DTI

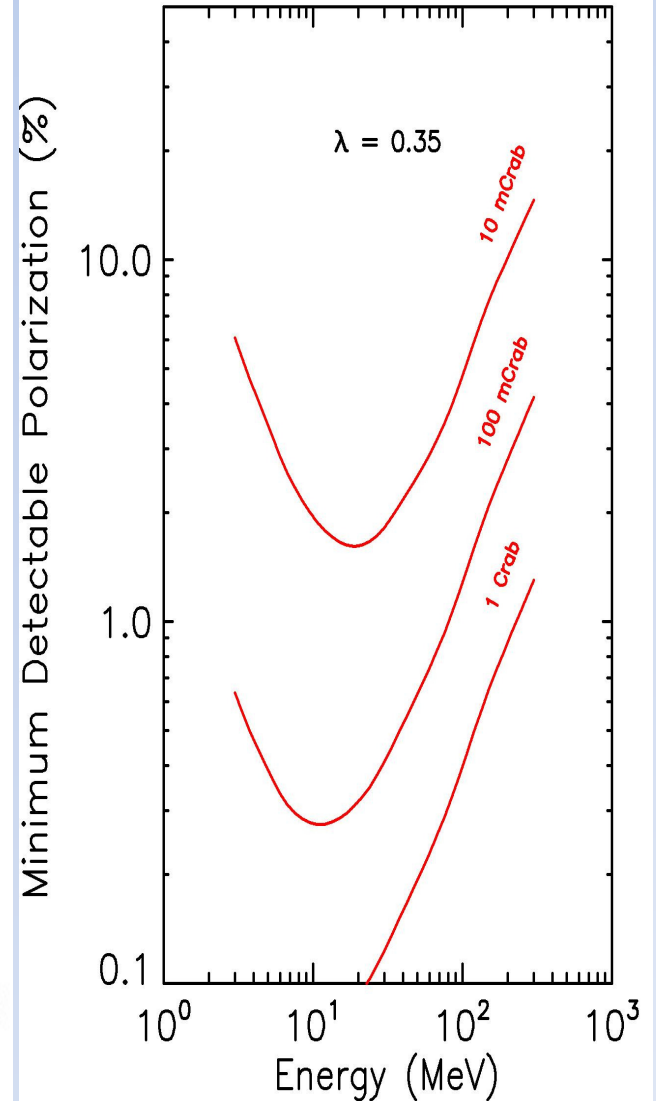
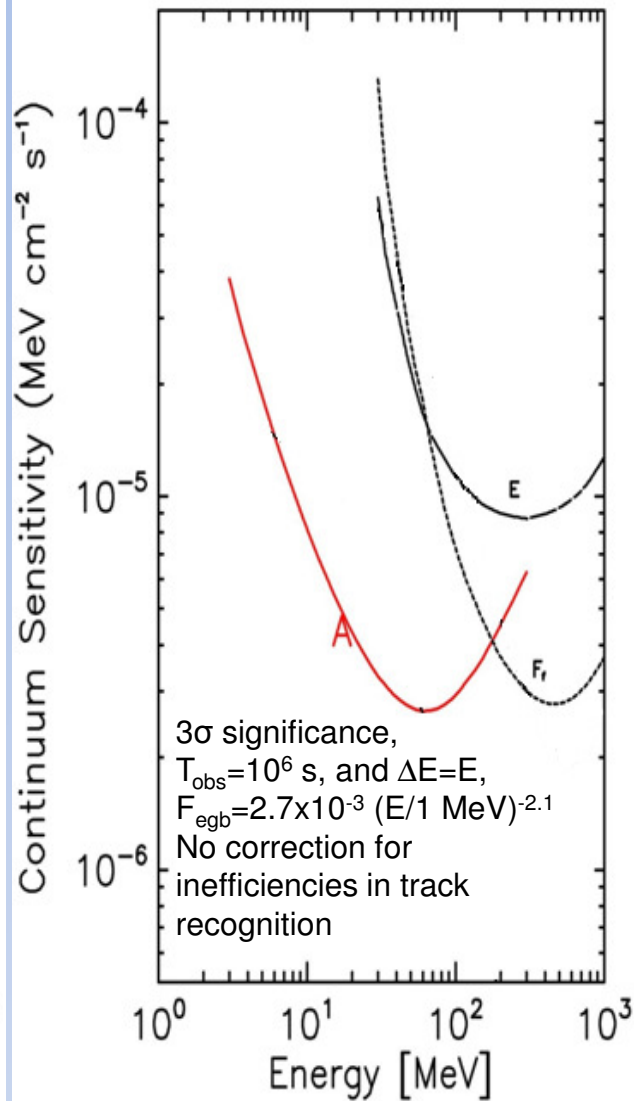
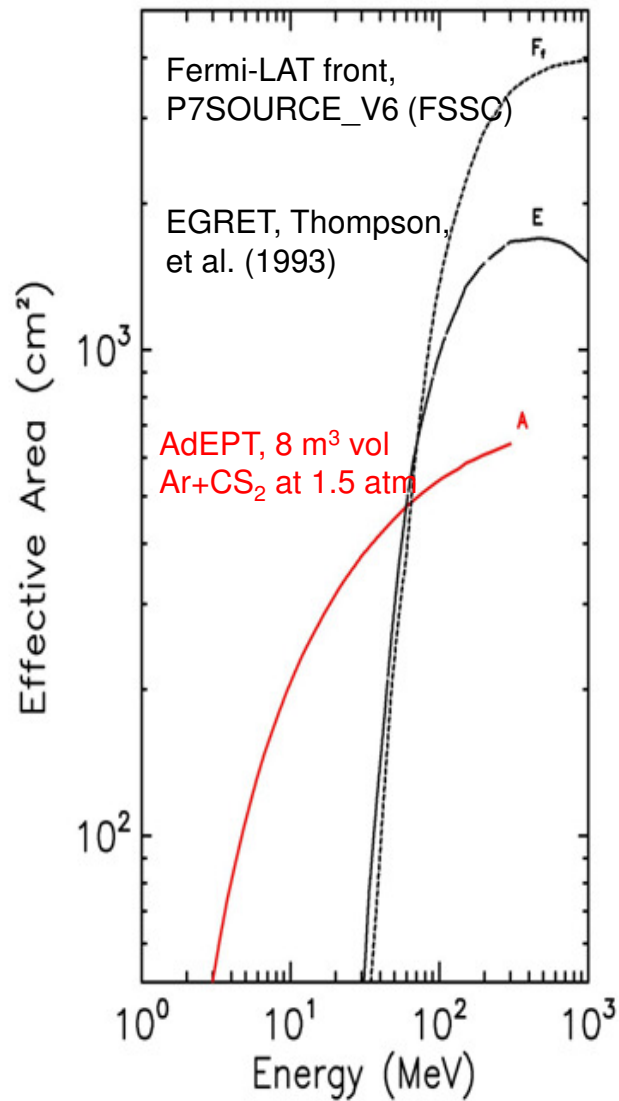


X-Z, & Y-Z projections of single electrons from ^{90}Sr in Ar + CS_2 with 0.4 mm resolution

X-Z projection of 6.129 MeV gamma interaction in 80% P-10 + 20% CS_2



AdEPT Baseline Performance



AdEPT Instrument Development

- 2015-18 ROSES-APRA
 - 50 x 50 x 100 cm³ AdEPT prototype
 - Multi-core processor to discriminate gamma-rays from background
 - Determine gamma-ray direction, energy, polarization, and time of arrival
 - Large area MWD integration
 - FEE ASIC
 - Calibrate at accelerator with polarized gamma rays, 5 - ~90 MeV
 - Determine electron energy from Coulomb scattering
 - Measure angular resolution
 - Polarization sensitivity
- Future NASA mission!

