HARPO
A thin homogeneous telescope and polarimeter as the post-Fermi mission?

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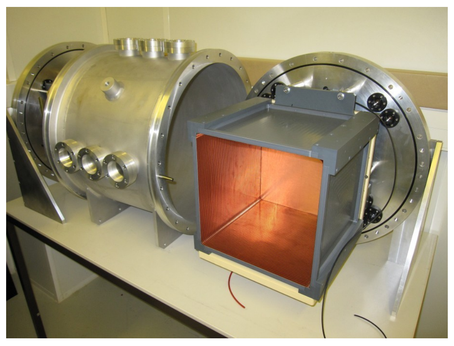
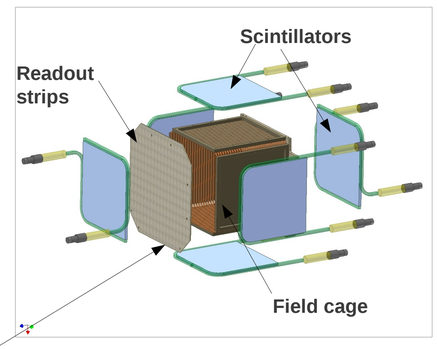
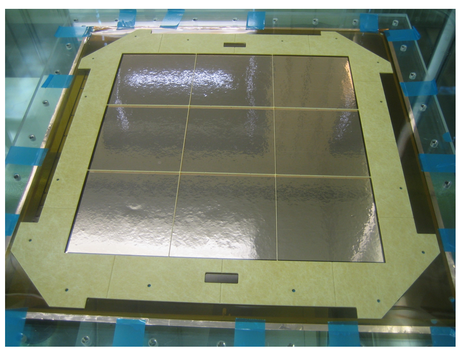
The HARPO Detector Prototype

- 30 cm cubic TPC
- Amplification made by Micromegas+2GEM
- Gas: Ar/iC_4H10 95/5 up to 5bar
- 2x288 strips readout (X&Y), ~0.5mm wide
- Readout electronics based on AFTER chips (511 time bins up to 50 MHz)
- Trigger: 6 scintillators in coincidence







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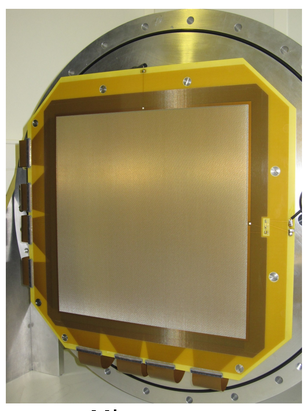
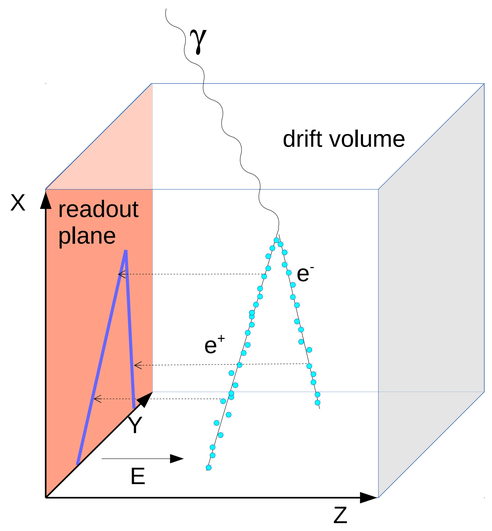


GEM
(Gas Electron Multiplier)

Micromegas
(Micro-Mesh Gaseous Structure)

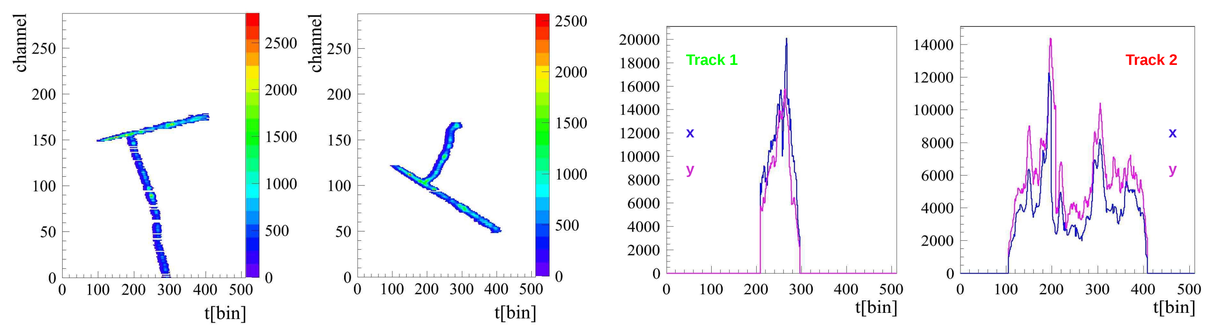
TPC (Time Projection Chamber)



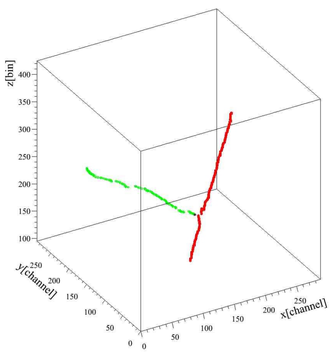
- Nuclear conversion of γ in the gas
- Produced e^+e^- ionize the gas along their trajectories
- e^- from ionization drift along the E field and are amplified and measured on the x-y readout plane
- Drift time gives a measure of the z coordinate
- Excellent tracking allows good background suppression

Reconstruction and track matching

- Cosmic-ray event leaving a lower energy electron (δ-ray)



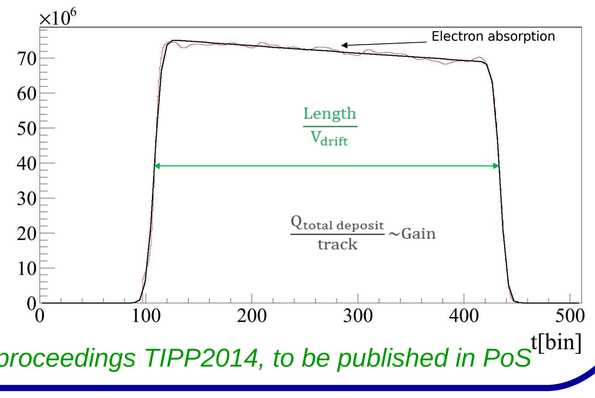
- Pattern recognition (Hough method) identifies tracks on each plane projection (XZ and YZ)
- dE/dx distribution along each track are matched to build 3D tracks



D. Bernard, Proc. SPIE 9144, Space Telescopes and Instrumentation 2014: Ultraviolet to Gamma Ray, 91441M (July 24, 2014) arXiv:1406.4830

Characterization with cosmic-rays

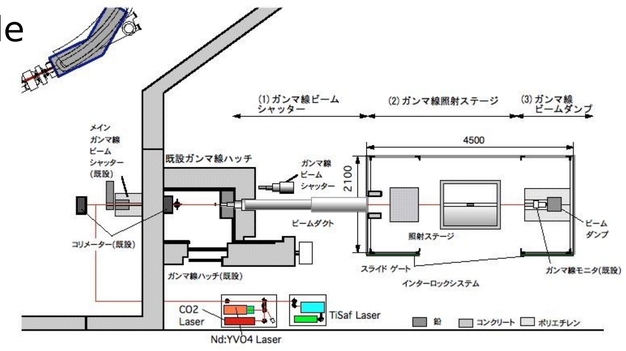
- High momentum cosmic muon perpendicular to the readout plane can be used to characte and monitor the gas propertie
  - Electron absorption along the track
  - Drift velocity (drift time)
  - Gain (total charge)



PG, proceedings TIPP2014, to be published in PoS

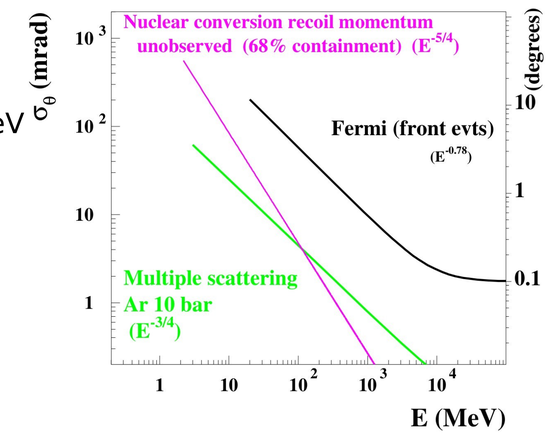
Data Taking at NewSUBARU, Japan

- ~100% linearly polarized gamma beam, by on axis collision of optical /UV laser pulse on GeV e-
- 2-76MeV energy range available
- Data taking in November 2014

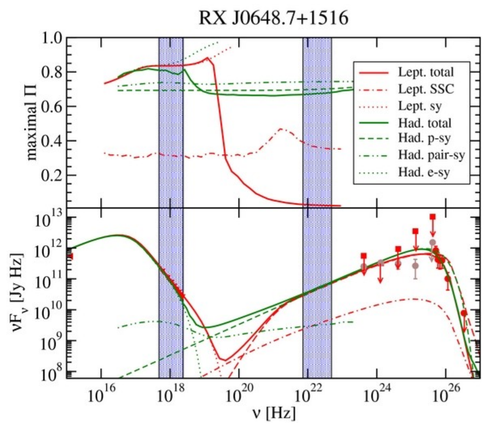


Expected performance

- Angular resolution:
  - limited by multiple scattering above 100MeV
  - limited by the unknown recoil nucleus momentum below 100MeV
  - only multiple scattering for triplet conversion, but very low efficiency
- Up to 1 order of magnitude better than Fermi!



*D. Bernard, NIM A **701**, 225 (2013)*

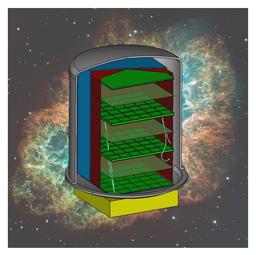


*H. Zhang and M. Böttcher, A.P.J. **774**, 18 (2013)*

- Polarimetry
  - possible from nuclear conversion
  - limited by the unknown recoil nucleus
  - very low background
- Can distinguish emission models for AGN
  - leptonic and hadronic models give very different polarisation
  - about 1 year of data...

Challenges of a TPC in space

- Maintain gas quality over a long mission
  - satisfying performance after 3 month in seal vessel, without material optimization
  - promising results from GEMS project
    J. Hill et al., Lifetime estimation of a time projection chamber x-ray polarimeter, Proc. SPIE 8859, UV, X-Ray,
  - and Gamma-Ray Space Instrumentation for Astronomy XVIII, 25 - 29 August 2013, San Diego USA.
- Trigger on gamma events
  - TPC produces very large amount of data
  - timing information need as reference for 3D tracking
- Mass and volume
  - mass of vessel proportional to mass of gas (and sensitivity)
  - volume inverse proportional to gas pressure (and multiple scattering)



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