HARPO
A gas detector concept for photon detection and polarimetry in the MeV-GeV range

LLR/Irfu project
funded by ANR and P2IO

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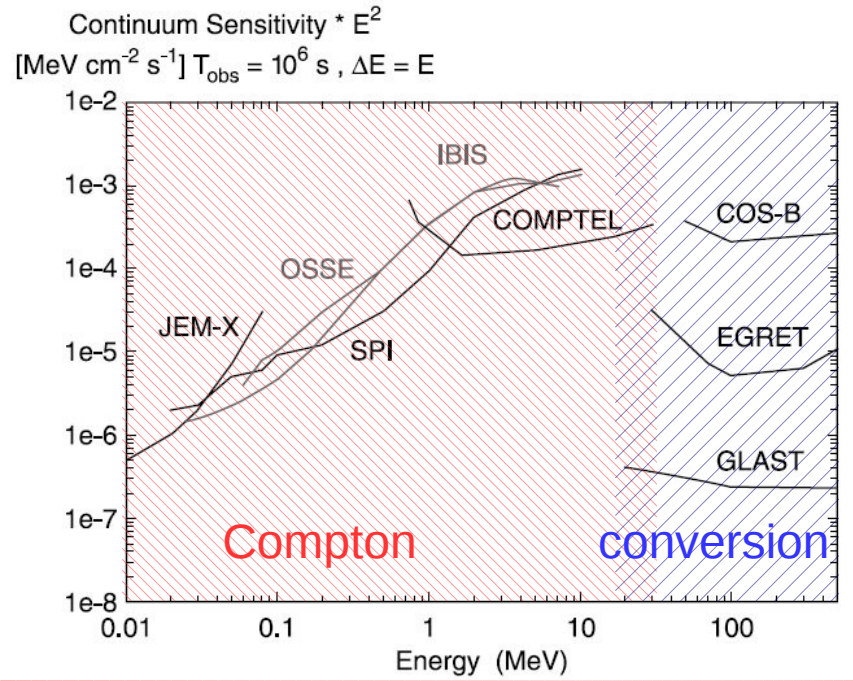
Outline

- Science case
  - angular resolution for photons in the MeV-GeV range
  - gamma ray polarimetry above 1MeV
- Proposed detector: TPC
  - active target gas detector
  - photon conversion to e+e-
- Expected performance
- Status and outlook

Science case

- Sensitivity/resolution gap in the MeV-GeV region
  - High Compton, low conversion
- No polarimetry above 1MeV

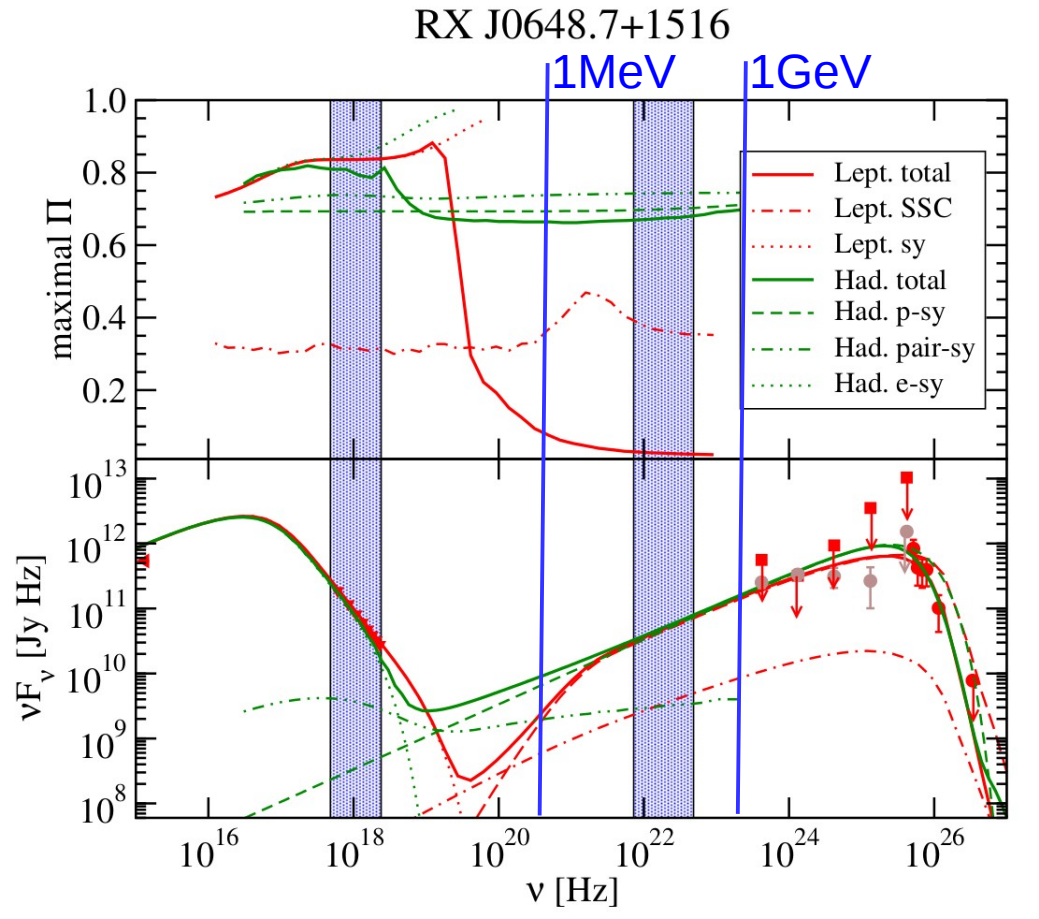


V. Schönfelder,
New Astr. Rev. 48 (2004) 193

- Astrophysics:
  - Understand mechanisms of gamma sources
  - Pulsars, AGN, GRB
- Cosmology
  - Search for Lorentz invariance violation

Science case example: Blazars

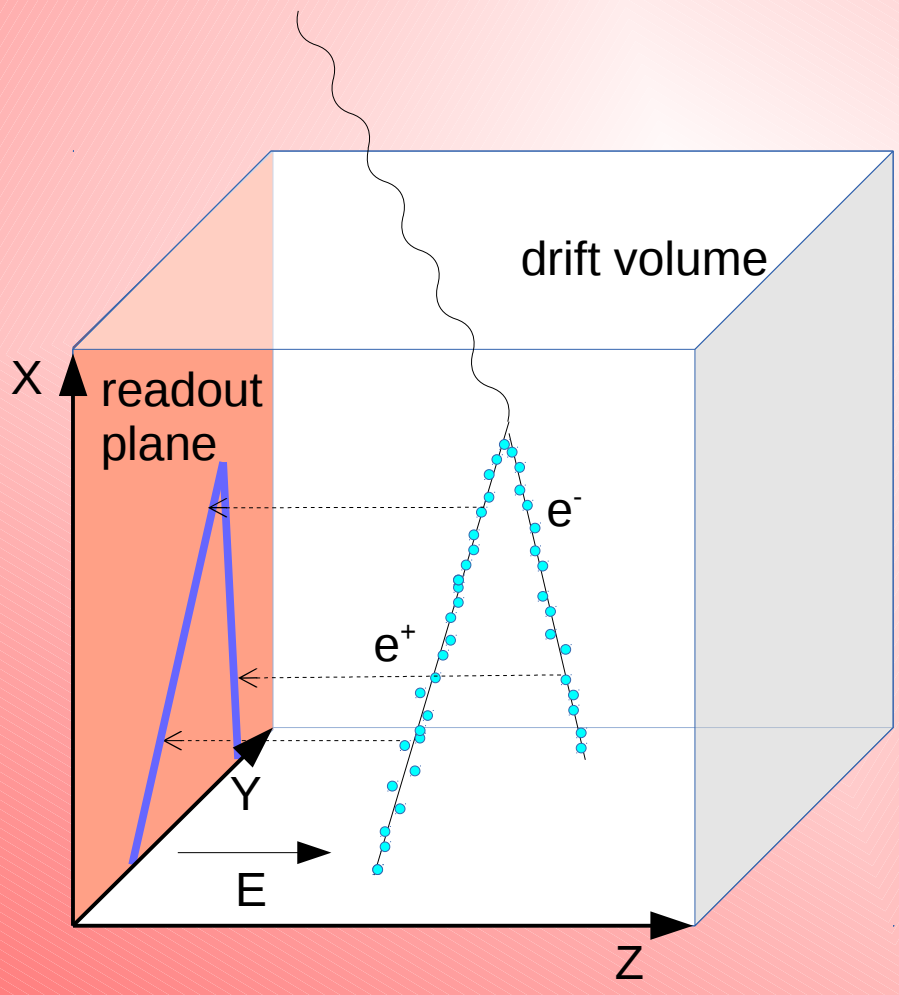
- Separating processes
  - Leptonic synchrotron self Compton (SSC)
  - Hadronic proton synchrotron
- Polarisation can give the answer
  - no difference in X
  - visible in gamma



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

Time Projection Chamber (TPC)

- photons are converted in the gas
- produced electrons ionise the gas
- ionisation electrons drift along E field
- electrons are amplified and mesured on the xy-readout plane
- time gives a measure of the z coordinate

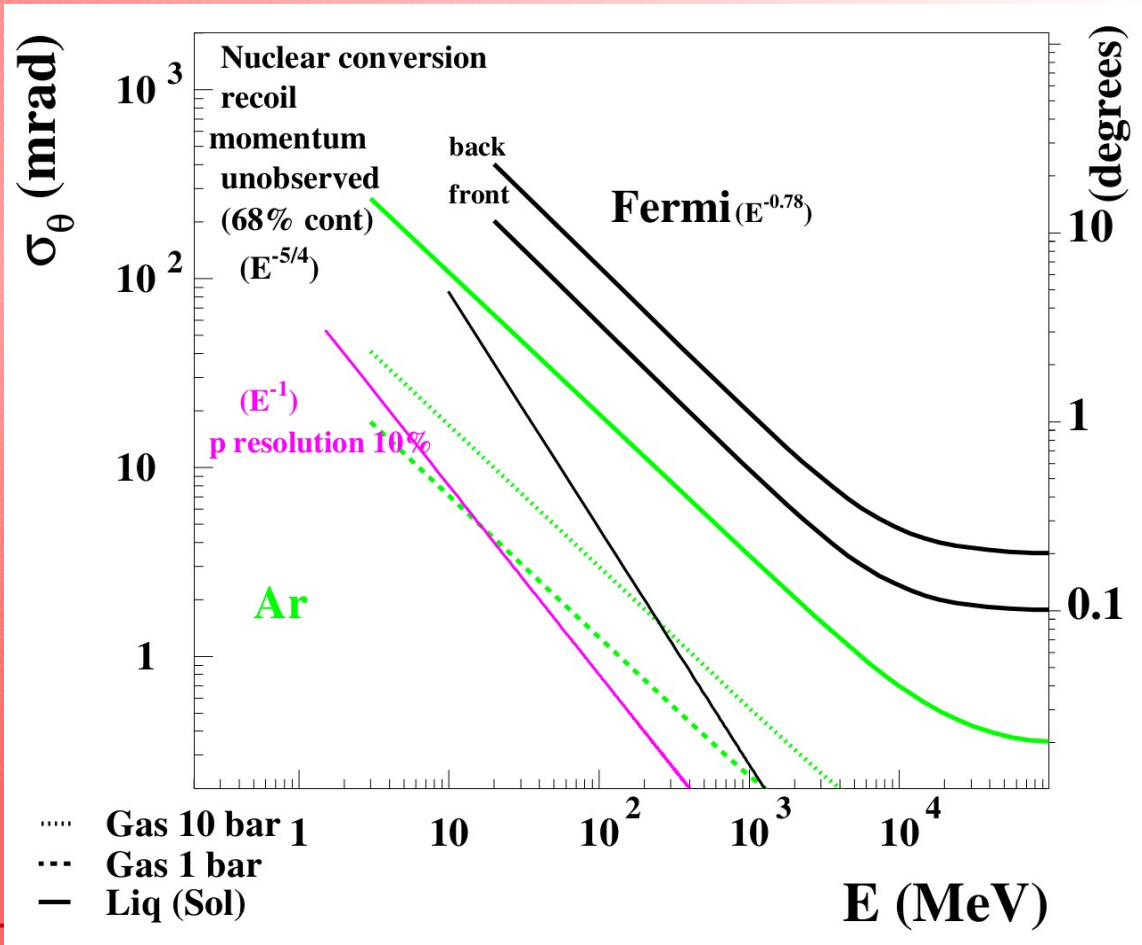


TPC characteristics

- A gaseous 3D tracking detector
  - Often used in particle physics
  - High resolution, excellent tracking
  - Low multiple scattering => tracking even for low momentum tracks
- “Thin” active target
  - sensitivity proportional to mass, not surface
  - Polarisation information accessible (thick detector, e.g. W/Si excluded)

Expected angular resolution

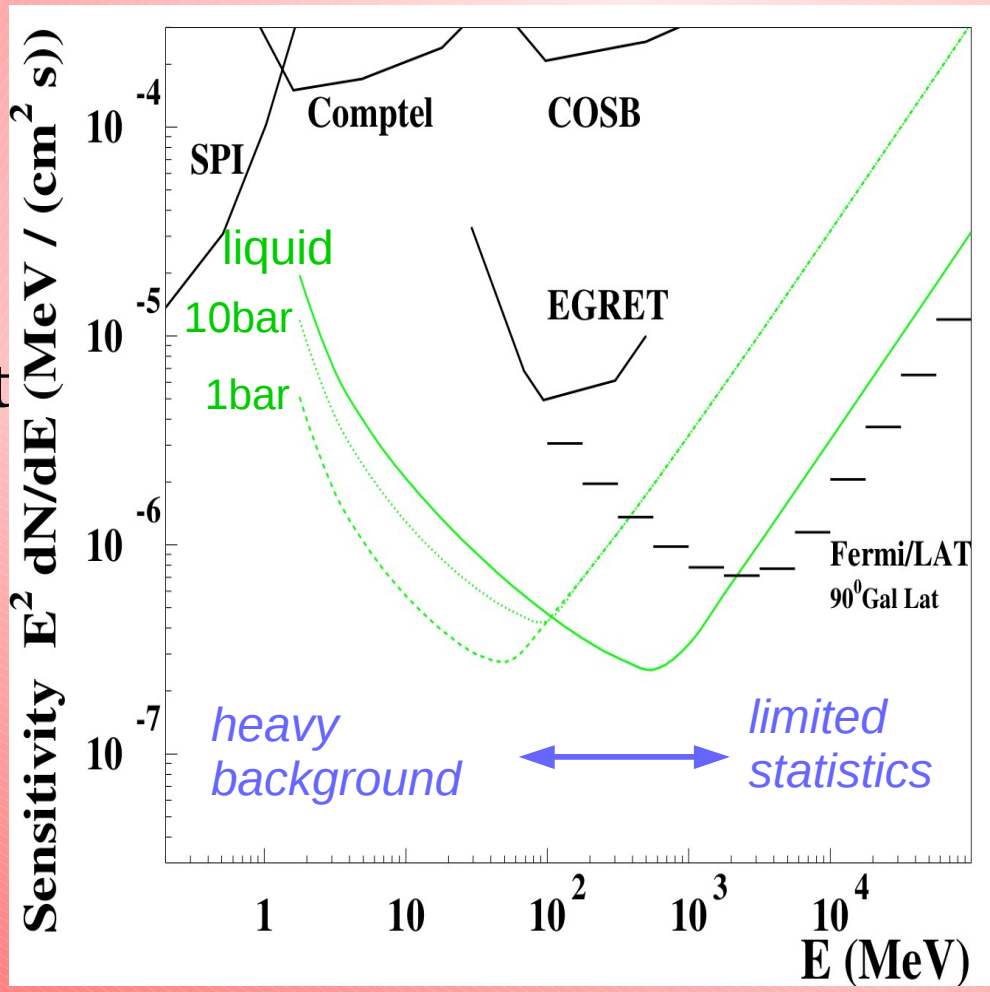
- Up to 1 order of magnitude improvement compared to FERMI



D. Bernard,
NIM A 701 (2013) 225

Expected sensitivity

- At lower energies
  - E<~100MeV
  - up to 2 orders of magnitude improvement
- Higher energy
  - E>100MeV
  - Limited by low cross-section
  - still better than FERMI up to 400MeV



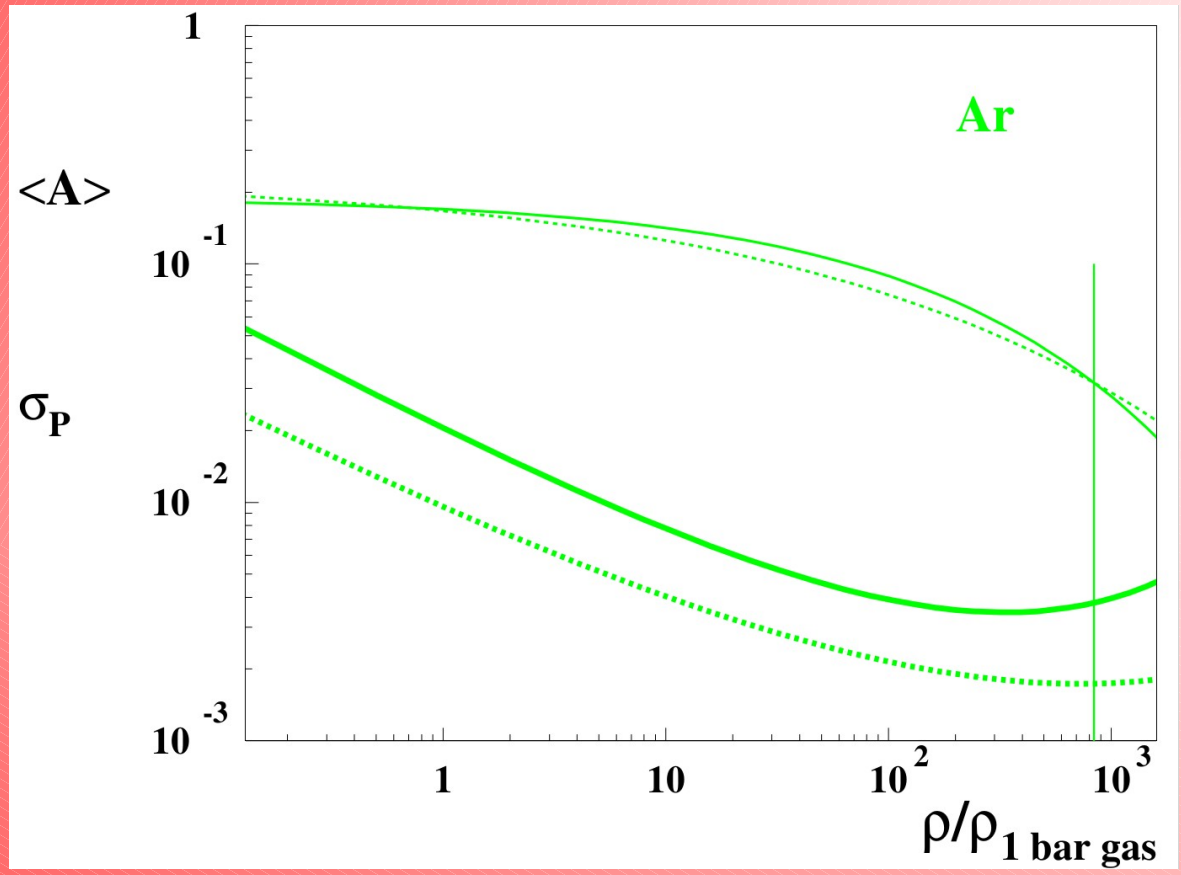
D. Bernard, NIM A 701 (2013) 225

FERMI pass7

Polarimetry

- Polarimetry capabilities depend on many parameters
  - energy, exposure, detector size, gas pressure…
- A simple example was used
  - Crab-like source, 1 year
  - size=1m^3, resolution=1mm
  - exposure fraction=1, efficiency=1

Polarimetry



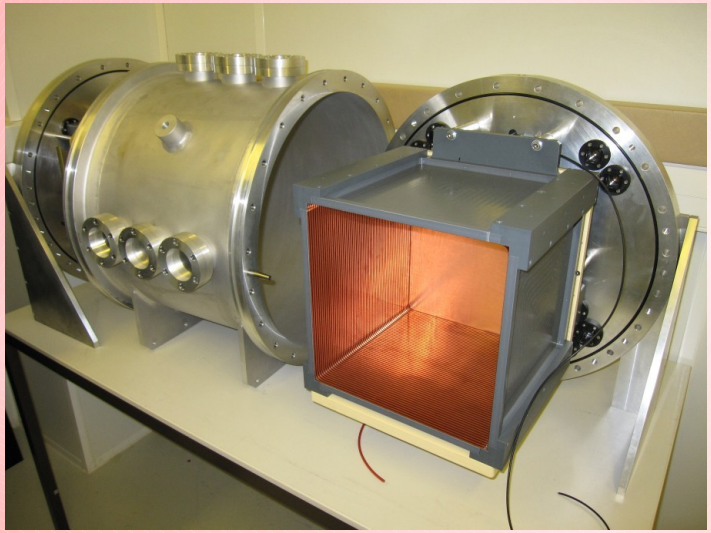
D. Bernard,
NIM A 701 (2013) 225

=> Polarisation asymmetry ~ 15%

Polarisation resolution ~ 1% at 5 bar

Status and outlook

- A TPC prototype has been built
  - 30cm cubic TPC with Ar/isobutane 95/5
  - micromegas+GEM amplification



- Tested with radioactive sources and cosmic rays
- Beam test scheduled in Japan
  - NewSUBARU: polarised photons 2MeV<E<76MeV
  - November 2014

Challenges

- Main challenges
  - triggering
  - operation in space
  - guaranteed gas quality over years
- Other challenges
  - electron amplification at high pressure
  - tracking efficiency in all directions

Conclusion

- There is a great interest for high performance gamma ray measurement and polarimetry in the MeV-GeV range
- A gas detector like a TPC is an excellent candidate to fill this gap
- Preliminary developments have been done, and a beam test will validate the performance projections

- A cosmic muon + delta electron measured with HARPO