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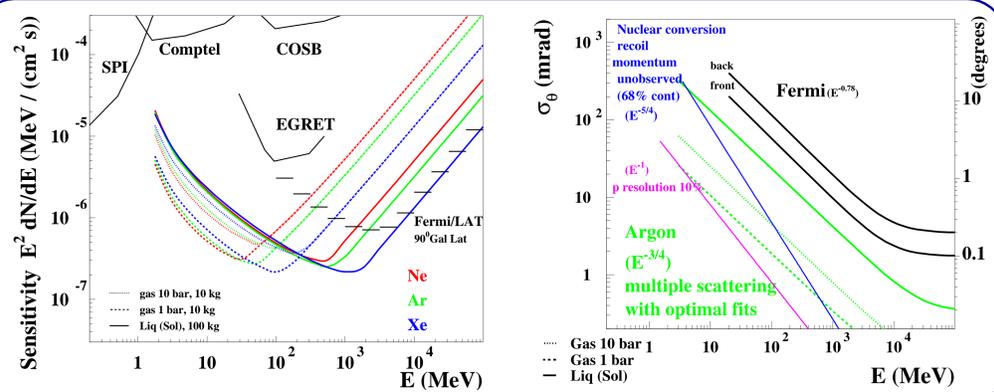
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## Physics motivations

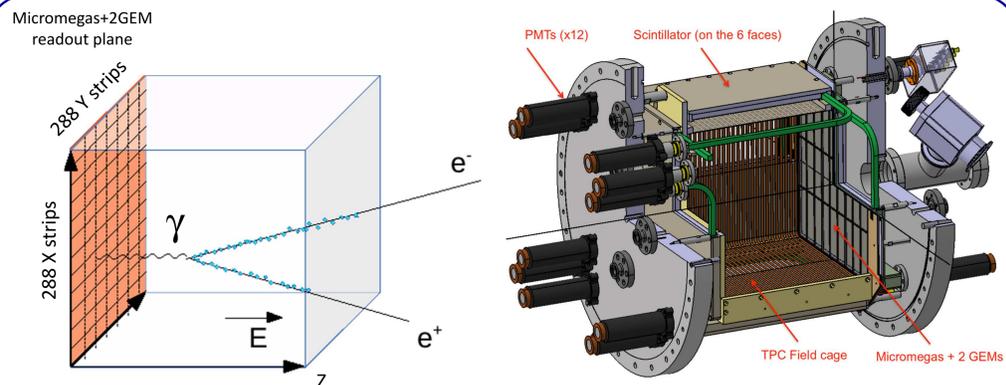
**HARPO** (Hermetic ARGon Polarimeter) is a demonstrator for a new type of  $\gamma$ -telescope and polarimeter which uses a high-pressure gaseous Time Projection Chamber (TPC) to :

- ✓ Fill the 1-100 MeV sensitivity gap between Compton & pair telescopes.
- ✓ Improve the angular resolution by an order of magnitude w/r to FERMI/LAT.
- ✓ Make use of the unique tracking capabilities of a gaseous TPC to derive the  $\gamma$  polarisation from the azimuthal angle derived from the  $e^-$  and  $e^+$  tracks. A precision of 1.4% would be reached with a  $1\text{m}^3$  5 bar TPC exposed for 1 year with 100% exposure fraction to a Crab-like source. *D. Bernard, NIM A729 (2013) 765*



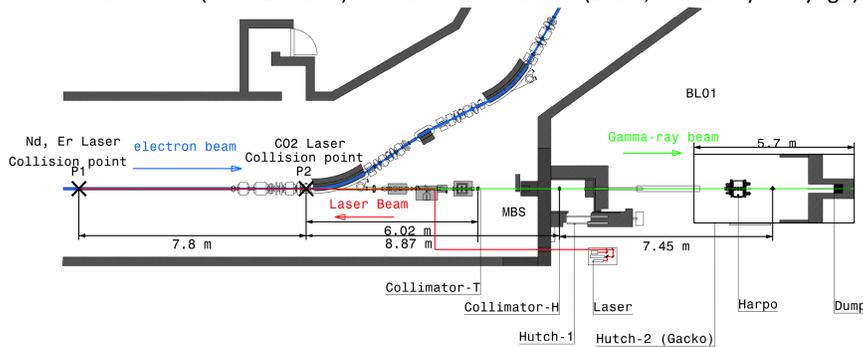
## HARPO : The Hermetic ARGon Polarimeter demonstrator

- ✓ The HARPO demonstrator is a  $30\text{cm}^3$  TPC surrounded by 6 scintillators for trigger purposes. It can be filled at up to 5 bar with a mixture of Argon + 5%  $i\text{C}_4\text{H}_{10}$
- ✓ The TPC is readout with a « hybrid » MicroPattern Gaseous Detector (MPGD), composed of 2 Gas Electron Multipliers (GEM) stacked with 2 mm spacing above a MICRO MESH Gaseous Structure (Micromegas).
- ✓ The  $2 \times 288$  orthogonal anode strips are spaced with 1 mm pitch and readout with an electronic chain composed of two T2K/TPC Front-End cards (AFTER ASIC), two FEMINOS back-end cards, a Trigger Clock Module and a modified PMm2 card whose FPGA handles a custom Fully Automated Switched Trigger (FAST)
- ✓ The performances of the demonstrator with an  $^{55}\text{Fe}$  5.9 keV x-ray source and cosmics are reported in *S. Wang, arXiv:1503.03772 & P. Gros, POS(TIPP2014)133*

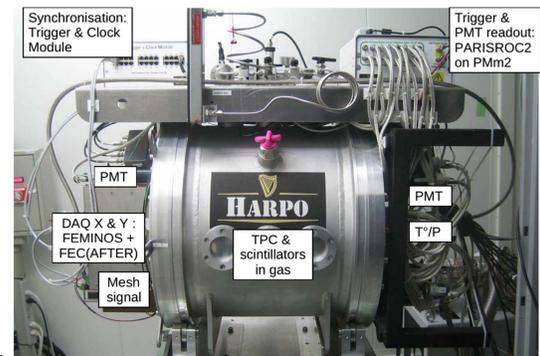
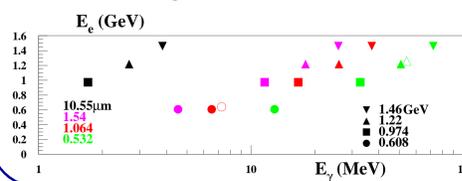


## Tests with a polarised photon beam at NewSubaru (Spring-8, Hyôgo, Japan)

The  $\gamma$ -ray beam is produced by the inverse Compton scattering of laser photons on the relativistic electrons (0.6 – 1.5 GeV) stored in NewSUBARU (LASTI, University of Hyôgo).

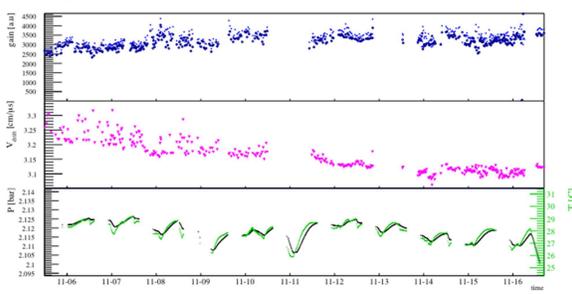


- ✓ 23 days of data taking with  $\approx 100\%$  linearly polarised  $\gamma$  of 13 energies.
- ✓ Specific runs with unpolarised  $\gamma$  and for 4 different azimuthal angles of the TPC for systematic errors and background studies.



## The TPC gas stability

- ✓ TPC was filled at 2 bar after successive pumpings & rinsing
- ✓ 23 days of data taking with the same gas (sealed mode).
- ✓ Evidence of low  $e^-$  capture.
- ✓ Less than 5% variations in gas gain and drift electron velocity.
- ✓ Monitoring of gas properties is still going-on after 6 months.
- ✓ A gas recirculation & purification system is under development for decade-long space mission.

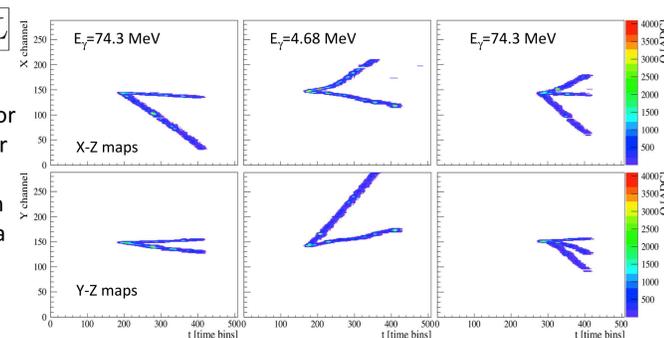


## Examples of $\gamma$ conversions in the gas volume

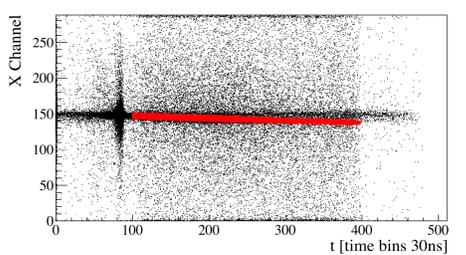
$$T_\gamma \equiv \bar{S}_{up} \cap O \cap M_{slow} \cap L$$

Main  $\gamma$  trigger line with :

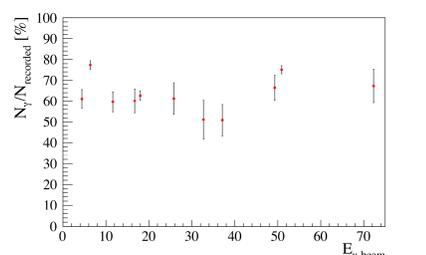
- $\bar{S}_{up}$  : veto on upstream scintillator
- $O$  : 1/5 downstream scintillator
- $L$  : pulsed laser trigger signal
- $M_{slow}$  : signal on the micromesh of the micromegas detector with a veto for  $\gamma$ -rays converted between the upstream scintillator and the active TPC gas volume.



## Estimation of the rate of $\gamma$ conversions in the TPC



Distribution of the position of the first signal in the TPC for each event in one run. Beam position is in red.



Fraction of recorded events which contains  $\gamma$ -ray events converted in the TPC gas.

## Conclusion & perspectives

- ✓ The HARPO TPC demonstrator was exposed to polarised gamma photons with energies between 1.74 MeV and 74.3 MeV with nearly 60 millions recorded events.
- ✓ The data taking was efficient with more than 50% of high quality events coming from  $\gamma$  conversion to  $e^+e^-$  pairs inside the TPC gas volume.
- ✓ A complete reconstruction and characterisation of these events is on-going to measure the angular resolution of the detector, as well as its sensitivity to the photon polarisation.
- ✓ R&D programs in the perspective of a stratospheric balloon flight test :
  - Rad-hard electronics, optimization of the MPGD (thin gap micromegas) and the development of an advanced trigger and a gas recirculation-purification system.