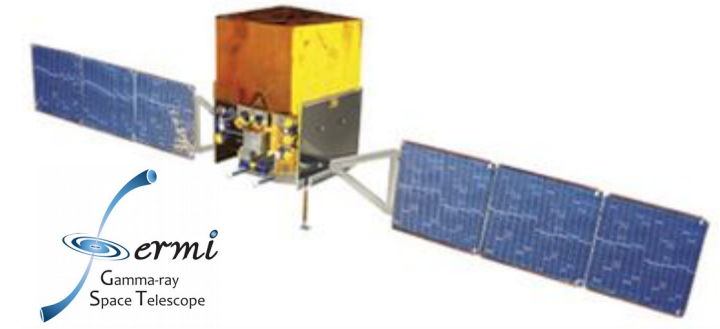
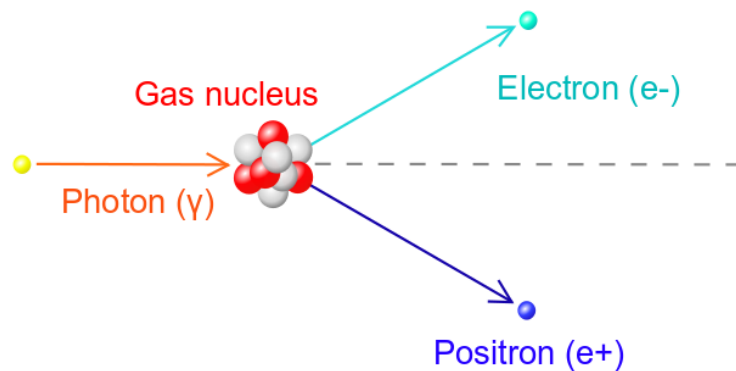




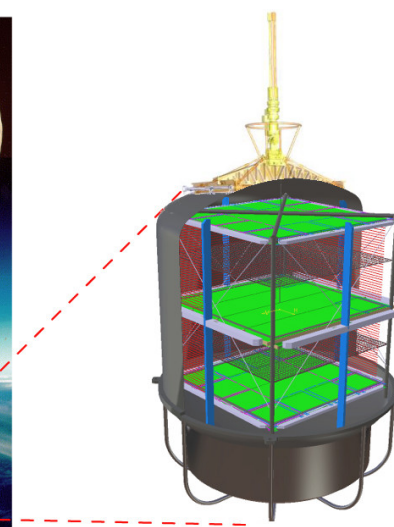
# A multi-m<sup>3</sup> gas detector as a high-precision 3D tracker for a future gamma-ray space telescope



**Challenging :**  
**Low power consumption**  
**Reduce number of sensors**  
**High background (20 kHz/m<sup>2</sup>)**

# Ground characterisation towards a space mission

## Electronics for the HARPO (Hermetic ARgon POLarimeter) TPC (Time Projection Chamber)



Today



Technological validation of a  
gas detector as  
gamma-ray polarimeter

Next proposal:  
Balloon-borne

# Poster

**ELECTRONICS for HARPO**  
Design, development and validation of electronics for a high performance polarized  $\gamma$ -ray detector

**Electron amplification**

- Multi-stage amplification: Two GEM + Micromegas
- Gas:  $\text{Ar/C}_2\text{H}_2$  95/5% up to 5 bar
- High dynamic range, low spark rate
- Gain: ~ 2500 ( $5 \times 5 \times 100$ )

**Electronics global view**

- themet DAQ
- two FEMINOS + FEC (4 AFTER)
- ARISROC2 on PMm2 (trigger)
- synchronization with TCM

**Trigger**

Combination of signals from

- Scintillators (PMT)
- Mesh
- Laser (when available)

**Drift & amplification  $\vec{E}$  fields**

Trigger time related between:

- main line (50 ns)
- trigger efficiency specific lines
- Veto on upstream events (signal in upstream scintillator ready (<1 $\mu$ s) in mesh)
- Inhibit & disable capability

**Data Taking at NewsUBARU LASTI University of Hyogo, Japan**

- November 2014
- 1.7 - 74MeV photons from inverse Compton scattering of IRVisible laser pulse on 0.6 to 1.5GeV  $e^-$  bunches
- photon beam pseudo-monochromatic and high polarization by on-axis collimation
- 60MeVts on disk, 13 energy points, P=0 or 100%, 4 TPC angles

**Trigger timing**

- Laser pulse
- Veto upstream scintillator
- Signal in, at least, one downstream scintillator
- Veto early (<1 $\mu$ s) signal on Mesh
- Late (>1 $\mu$ s) signal on Mesh

**TPC principle & Outlook**

- Pair conversion of  $\gamma$  in the gas  $\gamma \rightarrow e^+e^-$
- $e^+e^-$  ionize gas along their trajectory
- $e^-$  from ionization drift along the  $\vec{E}$  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

**Outlook: Balloon flight**

- 2bar
- Scintillator-free trigger (weight)  $\Rightarrow$  Multiples modules "à la HARPO"
- $\Rightarrow$  AGET chips (real time multiplicity signal)
- Embedded low power electronics

TPC design

Beam configuration & Trigger performance

TPC principle & Outlook

Presented Tuesday by Denis Calvet

DAQ & Trigger design

## Electronics for HARPO: Design, Development and Validation of Electronics for a High Performance Polarised-Gamma-Ray Detector

Yannick Geerebaert, Denis Benard, Philippe Bruel, Mickael Focin, Boris Gicels, Philippe Gos, Danyel Horan, Marc Lounis, Patrick Pollock, Igor Semenov, Shao Wu, David Anzi, Denis Calvet, Paul Cole, Alain Dulhry, Patrick Sten, Eksp Goto, Sho Amuro, Satoshi Hashimoto, Takuro Kouda, Yusaku Minamiyama, Shuji Miyamoto, Akimori Takemoto, Masashi Yamaguchi, Shin Dae, Haruo Okuma

**Abstract**—We designed and built an experimental apparatus based on a new prototype chamber (TPC). The present detector is aimed at ground-validation tests, but we have designed it taking into account the constraints of space operation. Indeed,  $\gamma$ -ray past telescopes currently in orbit suffer from a lack of sensitivity in the lower part of the  $\gamma$ -ray energy spectrum due to the technological noise in the detector /  $\gamma$ -ray conversion background events.

**Introduction**—The present paper details the design, the integration and the validation of the electronic components of the HARPO TPC from the drift volume where conversion occurs in the data being recorded on a PC. The electron amplification system and the trigger were identified as the challenging and critical functions and are therefore presented in more detail. The multi-stage electron amplification system is based on an innovative combination of two techniques: MICROMEGAS (Micro-Mesh Gaseous Structure) [1], [2] and GEM-Gas Electron Multiplier [3]. Furthermore, the trigger has real-time analysis capabilities. It is able to switch between multiple configurations while taking into account that it is possible to analyse its performance in real-time for each run of data taking.

**Reliability** is performed by the analysis of the angular properties of pair conversion events that are reconstructed in the TPC. The detector requires that the subdetectors related to the TPC are located in space operation to not affect the angular resolution of the TPC.

**II. TIME PROJECTION CHAMBER**

As shown in Fig. 1, HARPO tracks pair creation events which follow from the interaction of a photon with the nucleus of a gas atom from the active volume of the detector. The

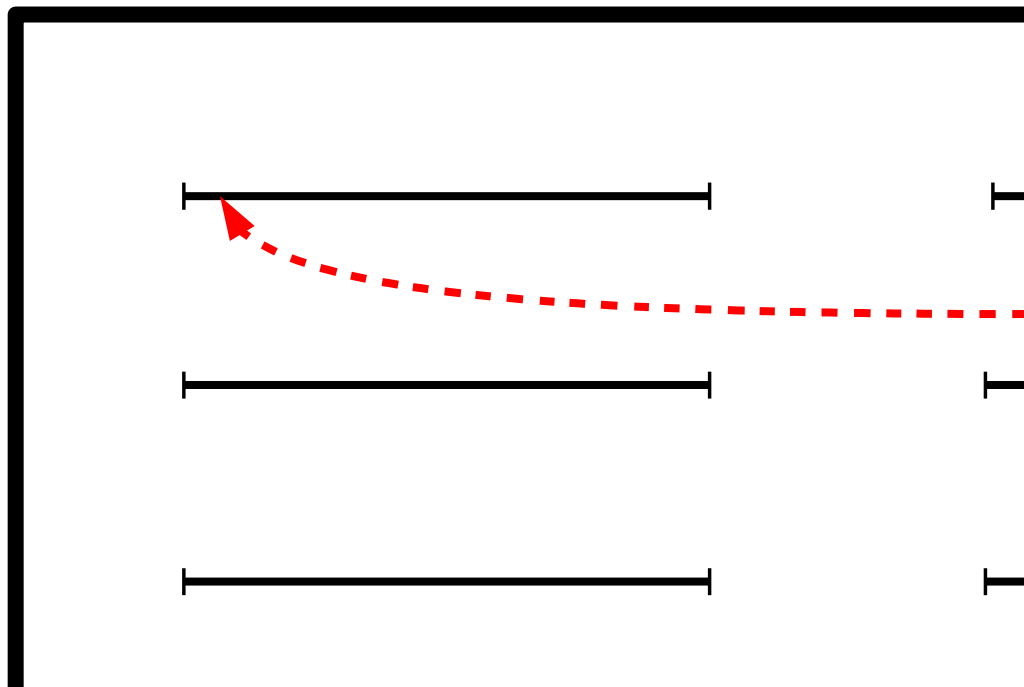


# Poster location

## Session n° 2, Friday morning

## Poster ID n°47

## Place: E01



Poster area



## Coffee area

**HARPO**  
**ELECTRONICS for HARPO**  
 Design, development and validation of electronics for a high performance polarized  $\gamma$ -ray detector

**Electron amplification**

- Multi-stage amplification: Two GEM + Microegas
- Gas:  $\text{Ar/C}_2\text{H}_2$  95/5% up to 5 bar
- High dynamic range, low spark rate
- Gain:  $\sim 2500$  ( $5 \times 5 \times 100$ )

**Electronics global view**

- Ethernet DAQ
- Two FEMINOS + FEC (4 AFTER)
- PARISROC2 on PMM2 (trigger)
- Synchronization with TCM

**AFTER chip**

- 72 channels
- 511 time bins
- Input: 120C to 600C
- Up to 100MHz sampling

**Drift & amplification  $\vec{E}$  fields**

**Data Taking at NewSUBARU**  
 LASTI University of Hyogo, Japan

- November 2014
- 1.7 - 74MeV photons from inverse Compton scattering of IR/Visible laser pulse on 0.6 to 1.5GeV  $e^-$  bunches
- photon beam pseudo-monochromatic and high polarization by on-axis collimation
- 60MeVs on disk, 13 energy points, P=0 or 100%, 4 TPC angles

**Trigger**

Combination of signals from:

- Scintillators (PMT)
- Mesh
- Laser (when available)

Trigger time shared between:

- main line (90% time)
- trigger efficiency specific lines
- Veto on upstream events (signal in upstream scintillator or early ( $< 1\mu\text{s}$ ) in mesh)
- Inhibit & downscale capability

**Trigger timing**

- Laser pulse
- Veto upstream scintillator
- Signal in, at least, one downstream scintillator
- Veto early ( $< 1\mu\text{s}$ ) signal on Mesh
- Late ( $> 1\mu\text{s}$ ) signal on Mesh

**Performance:**

- 99% noise rejection
- Good events
- >50% of triggered events
- 50Hz Acq rate

**Time Projection Chamber (TPC)**

- Pair conversion of  $\gamma$  in the gas  $\gamma \rightarrow e^+e^-$
- $e^-$  ionize gas along their trajectory
- $e^+$  from ionization drift along the  $\vec{E}$  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

**Outlook: Balloon flight**

- $\sim 1\text{m}^3$  active gas, 2bar
- Scintillator-free trigger (weight)
- $\Rightarrow$  Multiplies modules "à la HARPO"
- $\Rightarrow$  AGET chips (real time multiplicity signal)
- Embedded low power electronics

**Time Projection Chamber (TPC) Diagram:** A 3D diagram showing a cylindrical chamber with a central axis (z) and readout planes (x-y). It illustrates the drift of ionization electrons and the resulting signal.

**Trigger Timing Diagram:** A graph showing the timing of various signals: Laser, Veto upstream scintillator, Signal in downstream scintillator, Veto early signal on Mesh, and Late signal on Mesh. The x-axis is time in ns, and the y-axis is signal level.

**TPC Performance Graph:** A graph showing the relationship between drift velocity (cm/μs) and drift time (ns) for different gas conditions.