Measurement of a polarised gamma ray beam from 1.7 to 74 MeV with the HARPO TPC

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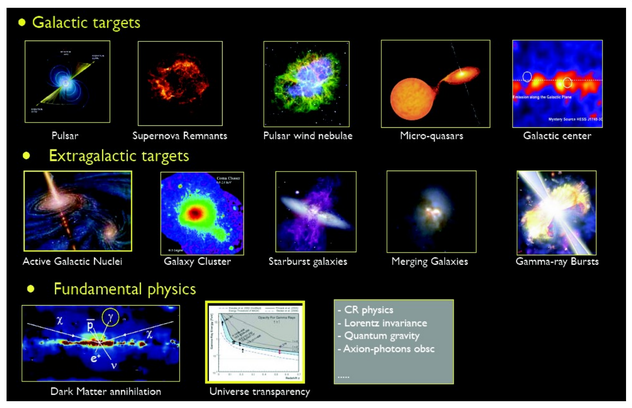
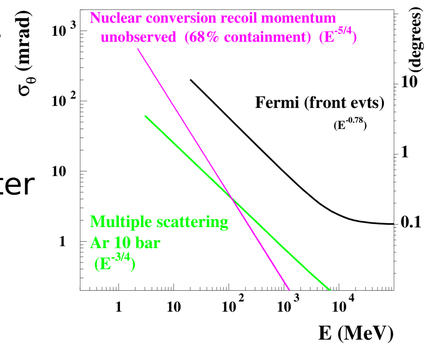
A Gaseous detector for gamma-ray detection: motivation and performance

- Rich physics in gamma astronomy
  - Understanding acceleration processes
  - Potential for new physics (Dark Matter, Lorentz Invariance Violation, ...)
- Polarimetry powerful at lower energies
  - never measured above 1MeV



- Sensitivity gap around 1-100MeV
  - Too high for Compton scattering, too low for pair conversion
  - limited by angular resolution
  - Pair tracking limited by scattering in converter
- Gas detector necessary below 100MeV
  - 0.4° at 100MeV:10x better resolution than Fermi-LAT
  - limited by nucleus recoil at low energy



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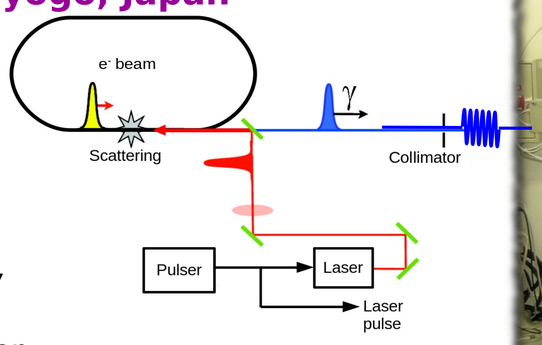
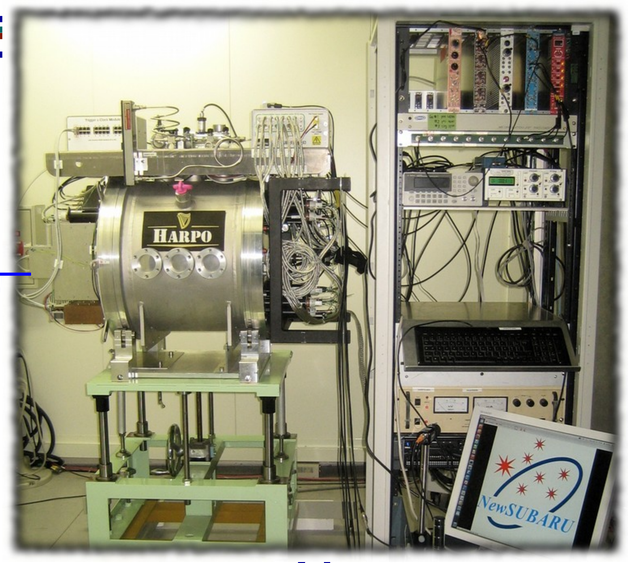
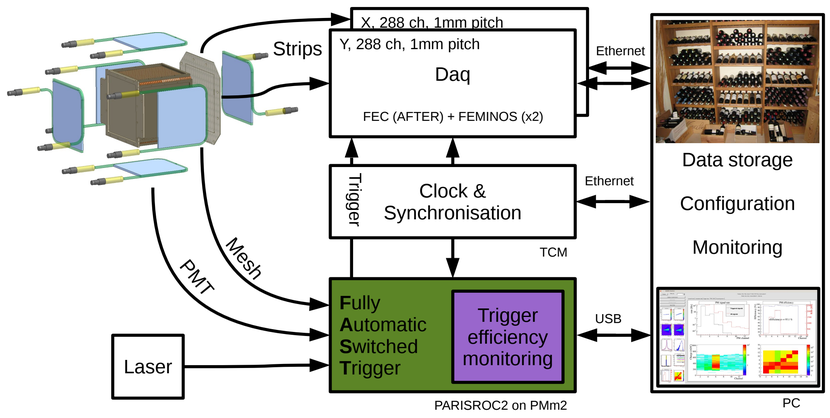
The NewSUBARU beam
LASTI, U. Hyôgo, Japan

- November 2014
- Associated to the SPring8 facility
- 0.6 to 1.5 GeV electron storage ring
- 1.7 to 74MeV polarised γ from inverse Compton scattering of optical laser
- 60Mevts, 13 energy points, P=0 or 100%, 4 TPC rotations



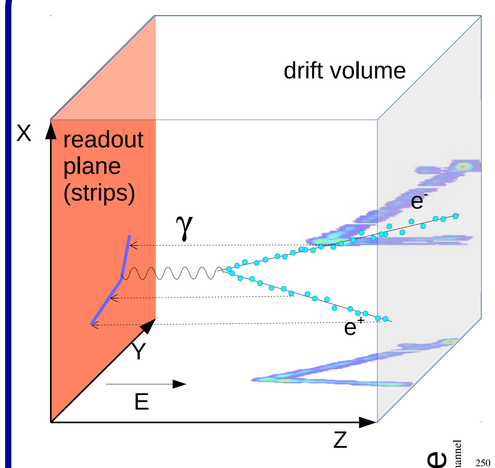


Electronics global view



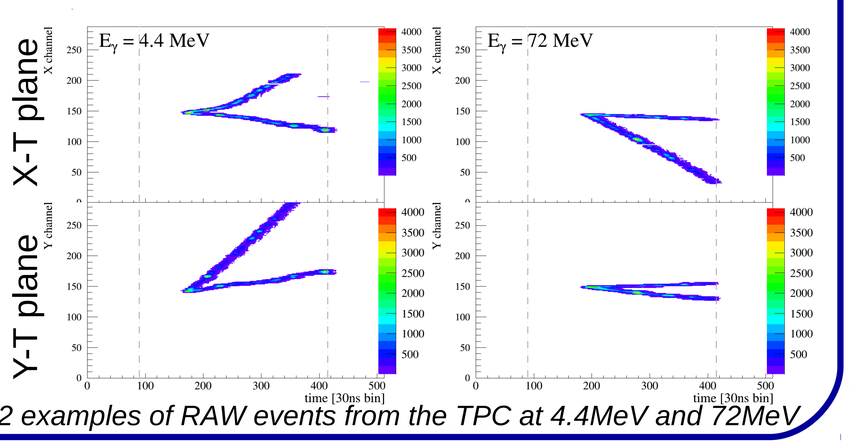
- 2FEMINOS+FEC (4 AFTER) => 576 12bit channels
- 33MHz sampling (up to 100MHz)
- trigger: 12PMT (PARISROC2+FPGA)
- Synchronization with TCM

Event Geometry in the TPC



- Pair conversion of γ in the gas
  $\gamma A \rightarrow e^+e^-A$
- e^+e^- ionize gas along their trajectory
- 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

- Low multiple scattering
- Excellent tracking
- Good background suppression

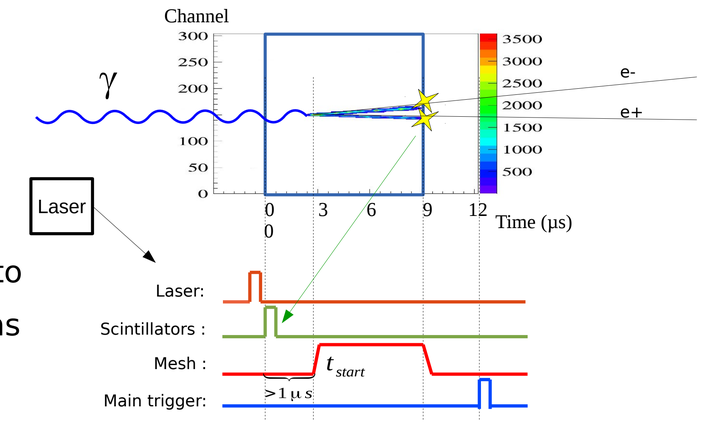


2 examples of RAW events from the TPC at 4.4MeV and 72MeV

Trigger system

Trigger using
- 6 surrounding scintillators
- signal from the laser
- timing of the micromegas mesh direct signal

The main goal of the trigger is to
- reject tracks from interactions of the beam with upstream material (>99% of events)
- Select as many conversion in the gas volume as possible (up to 50Hz Acq. rate)
- Extra trigger lines for efficiency studies

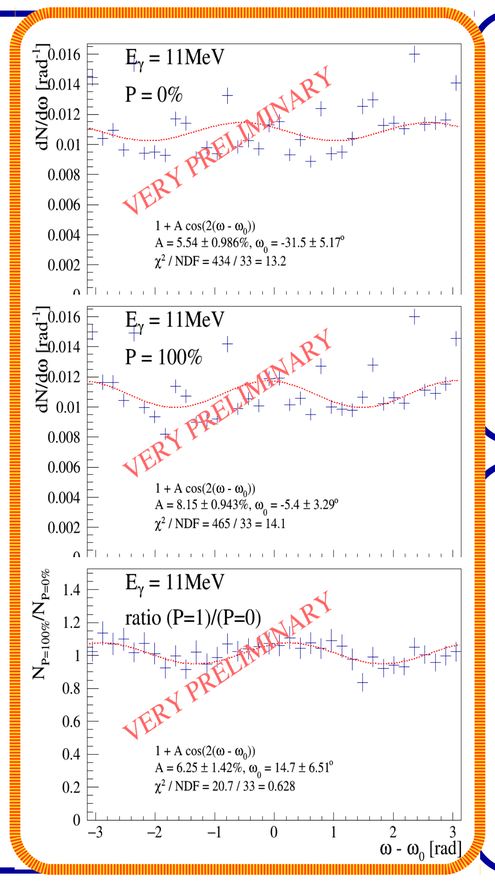


Signals constituting the trigger:
- laser starting pulse defines t_0 (when available)
- downstream scintillators (define t_0 if no laser)
- veto on upstream scintillator
- veto on mesh signal less than 1μs after t_0

First Results and Perspectives

First observation of polarisation asymmetry for 11MeV photons

- A preliminary reconstruction has been applied on the data and the azimuthal angle could be extracted for about 10% of the events identified as photon conversion
- There are large systematic errors for which we compensated by combining data with different polarisation orientation
- The effect of the polarisation asymmetry is already visible down to 11MeV, although it cannot be quantitatively measured due to systematic uncertainties
- We can cancel the systematic effects by taking a ratio with unpolarised data, when it is available



Ongoing developments

- Advanced reconstruction
  - Improved track finding and fitting with multiple scattering below 10MeV
  - Robust X-Y maps matching for 3D event reconstruction
- Geant4 simulations
  - Test of reconstruction performance
  - Study of systematic effects

Perspectives

- Development of a self triggered TPC
  - Multiple HARPO size modules
  - Balloon flight module with gas volume >1m³
- Studies towards spatialisation
  - Radiation hardened AGET electronics
  - Long term gas stability

M. Frotin, PG, et al, arXiv:1512.03248