Labex UnivEarthS

Instrumental issues for detection in the MeV energy range

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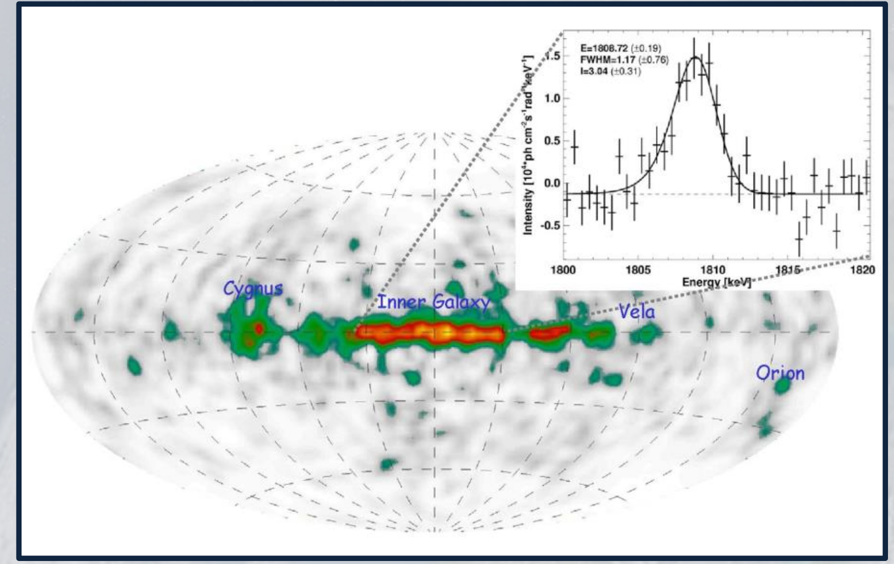
THE MEV RANGE : IDEAL FOR NUCLEOSYNTHESIS

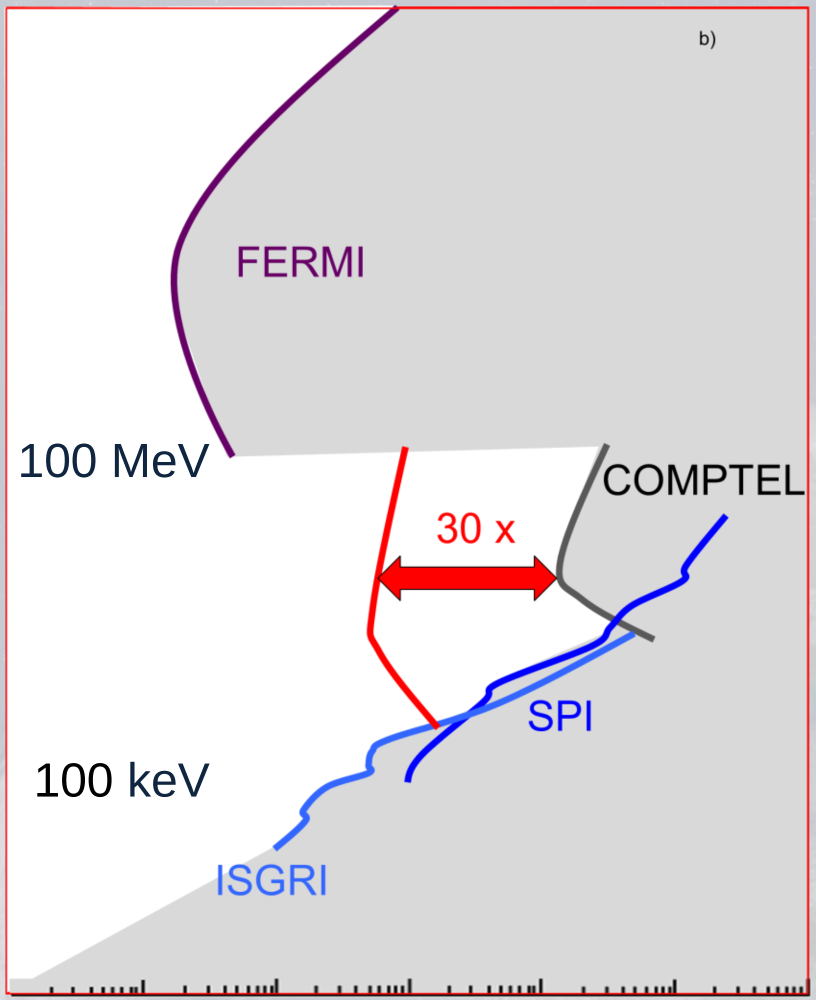
- ✓ The 1 – 30 MeV range is the ideal energy range to map the nucleosynthesis sites in our Universe.
- ✓ It was pioneered by the CGRO/Comptel telescope observations in the nineties,
- ✓ and followed up by the INTEGRAL/SPI telescope, but only up to a few MeV.



SPI observation of the Galactic ^{26}Al 1.8 MeV emission (Diehl et al., 2006)

MeV range sensitivity gap

- ✓ So, our Galaxy is not known at higher key energies for nucleosynthesis studies …
- ✓ … as there is a large sensitivity gap in the MeV range !

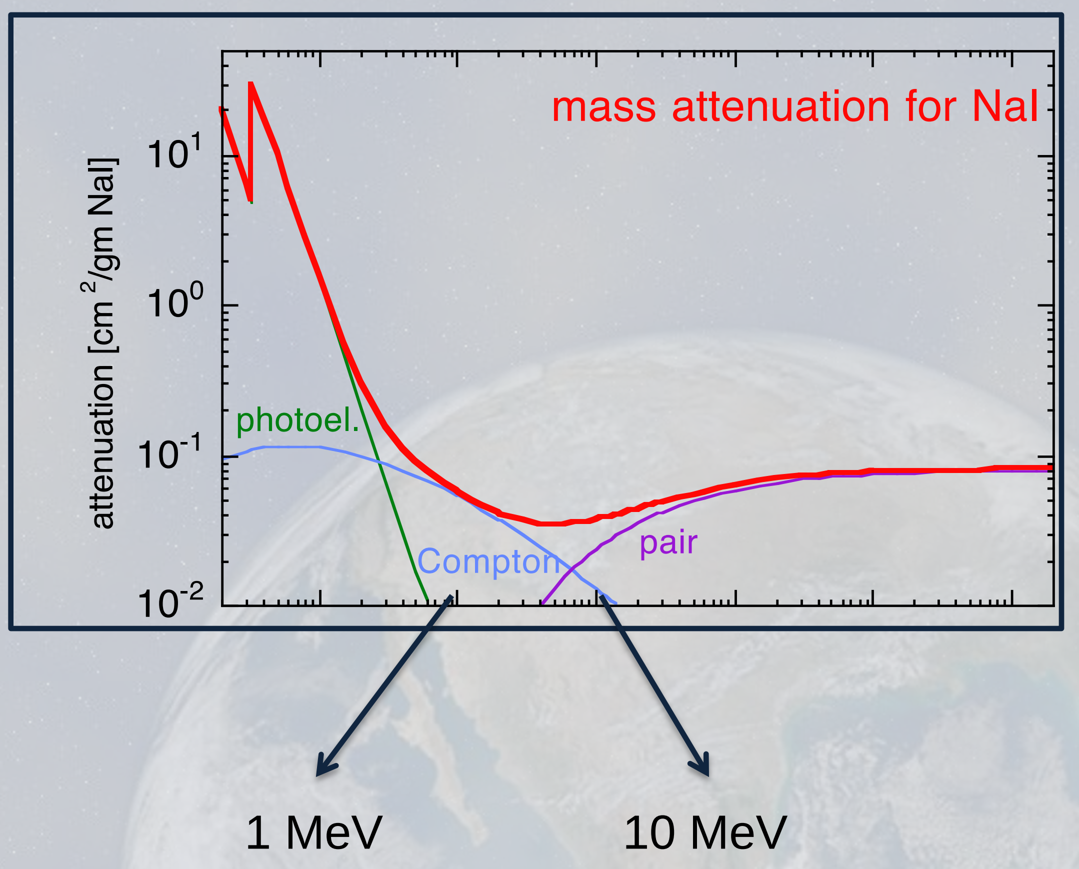


astronomy in the transition region : the "impossible" MeV range (1/2)

✓ Domain for inelastic Compton scattering :

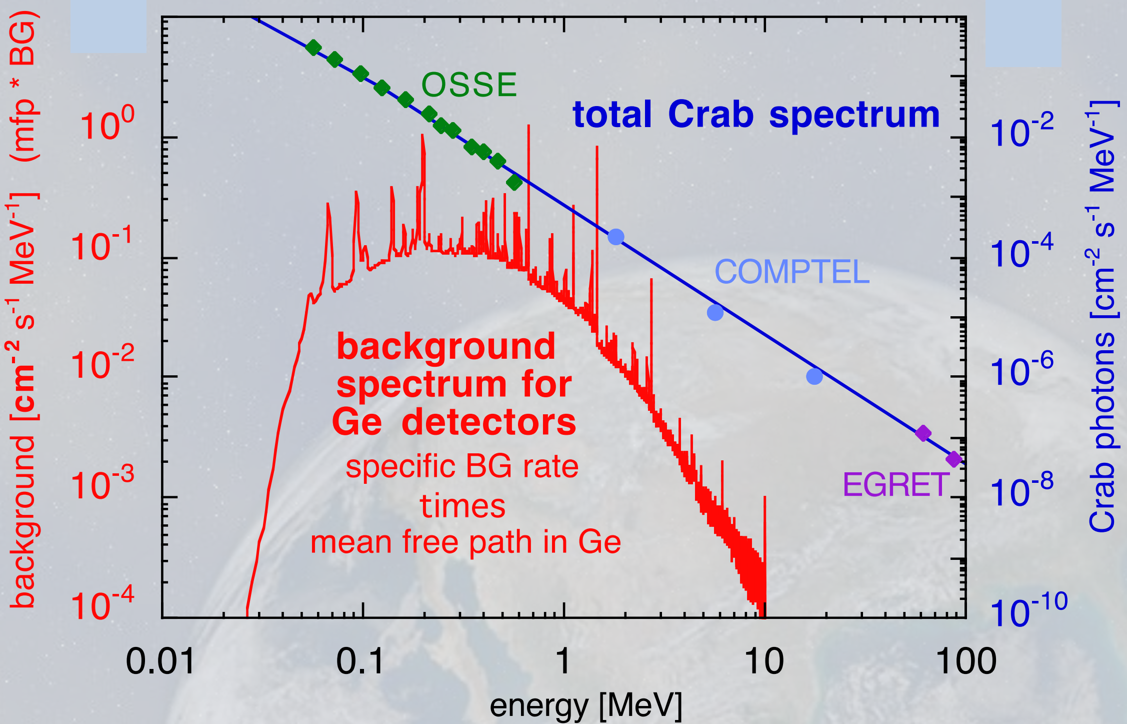
⇒ minimal cross section of interaction

⇒ Determination of the incident photon energy and direction not straight forward.



astronomy in the transition region : the "impossible" MeV range (2/2)

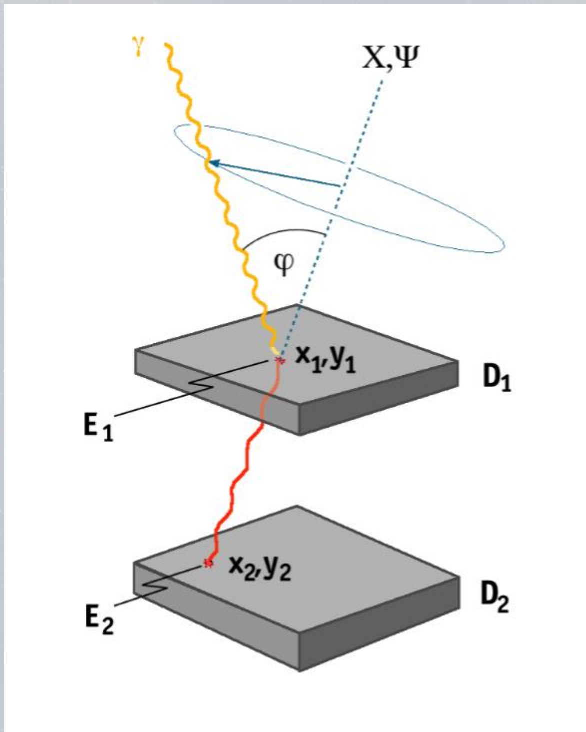
- ✓ Due to the cosmic protons, the telescope becomes also radioactive so …
- ✓ … Observations of the sky are polluted by a strong background induced in the telescope itself !



- ✓ Our idea is, anyway, to take advantages of the Compton scattering process to design the telescope.

Optimizing a Compton telescope : Compton principles

- ✓ In principle, a Compton telescope is composed of a stack of “scatterers” + “calorimeters” :
- ✓ Scatterer : spectro-imager optimized for the Compton scattering
- ✓ Calorimeter : spectro-imager optimized for photo-absorption



2 interactions with absorption
$\cos\theta = 1 - m_e c^2 \left(\frac{1}{E_\gamma - E_1} - \frac{1}{E_\gamma} \right)$
$E_\gamma = E_1 + E_2$

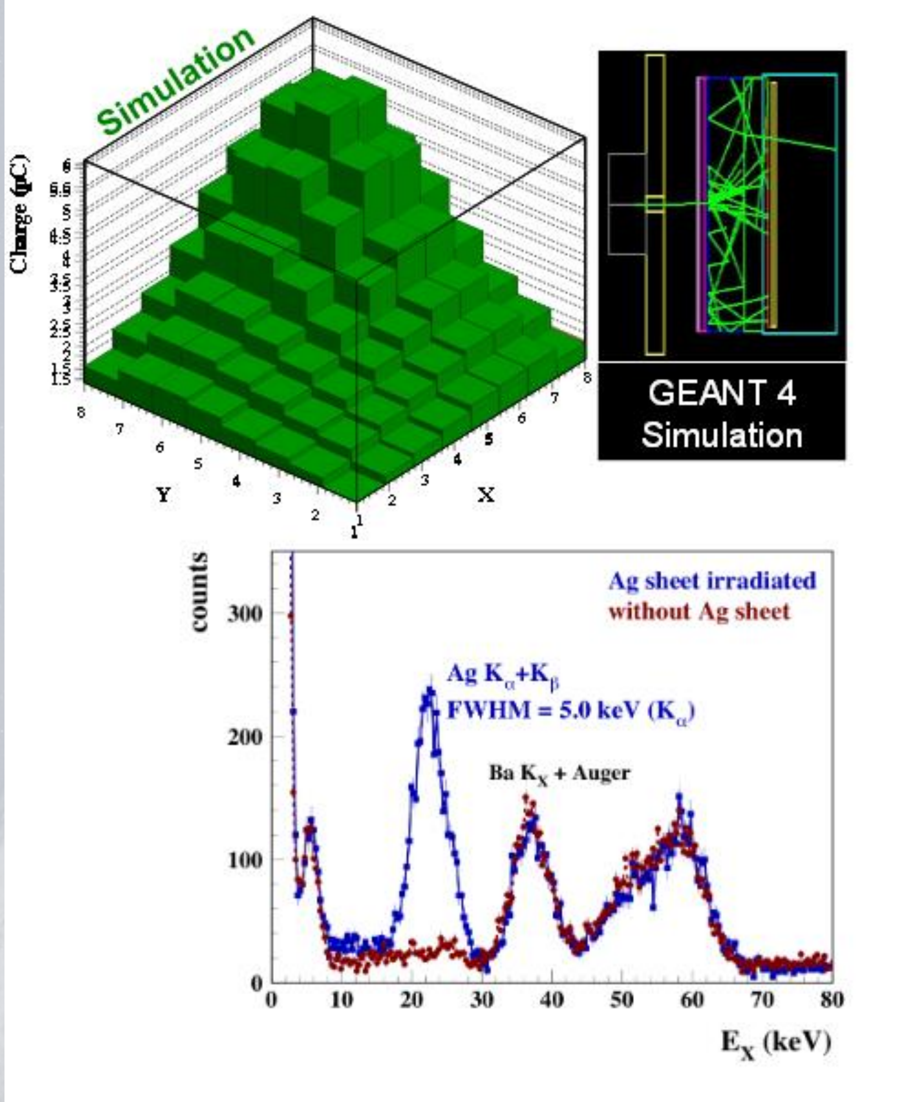
Optimizing a Compton telescope : requirements

- ✓ So to design an optimal Compton telescope, we need to:

- ✓ Have scatterers optimized for the Compton scattering, so with a low Z materials (Silicium).
- ✓ Have calorimeters optimized for photo-absorption, so with a high Z materials (crystal).
- ✓ Have a large thickness of materials to compensate the low cross sections (16 mm Si @ 10 MeV, stacked detectors).
- ✓ Mapping the sky as precisely as possible $\Rightarrow$
  - Perform long observations (10^6 s)
  - Precisely measure interaction points position
  - Precisely measure energy deposits

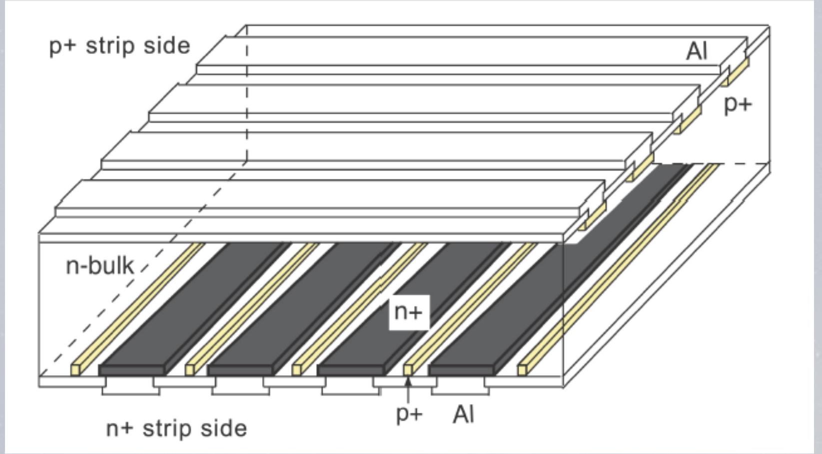
Our choice for calorimeters: thick scintillating crystal

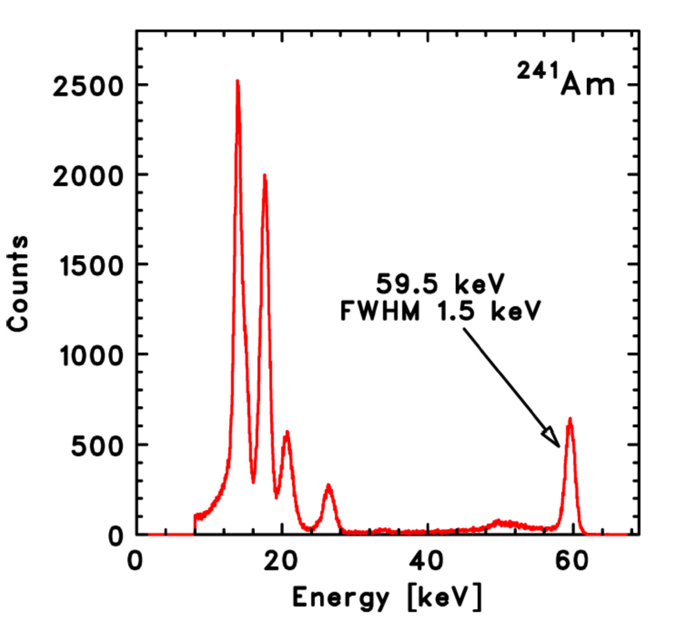
- ✓ Scintillating crystal are high Z elements, so well adapted to photoelectric absorption.
- ✓ They could have a nice position 3D resolution
- ✓ They could also have a good energy resolution if the detection chain is carefully designed



Our choice for scatterers : thick Double-Sided Strip Silicon detector (DSSSD)

- ✓ Silicon is well adapted to Compton scattering
- ✓ Stripped detectors allow us to have a nice position resolution
- ✓ They could also have a good energy resolution if the detection chain is carefully designed
- ✓ High thickness detectors implies less electronic channels, lower cost, more robust configuration.





NEXT STEP : R&D program on Double Sided Silicon Stripped Detectors !