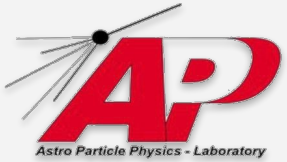
Il modulo LEM per la missione spaziale NUSES.

108° Congresso Nazionale SIF
Milano 2022/09/16

Riccardo Nicolaidis
On behalf of the NUSES collaboration

Trento Institute for
Fundamental Physics
and Applications



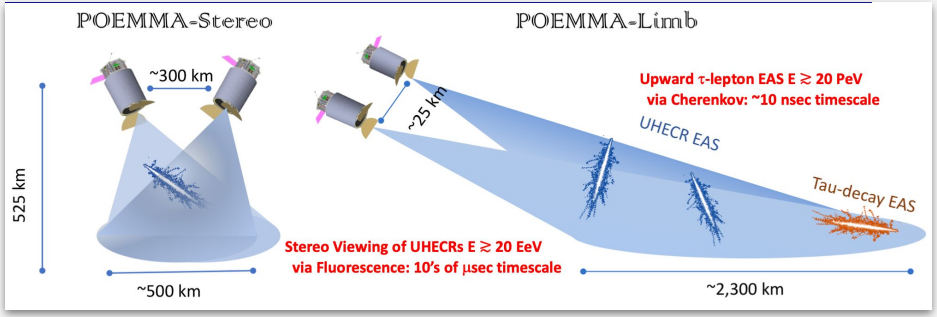
NUSES mission: two payloads...

GSSI - Thales Alenia Space Italy (TAS-I) project

Next talks (This session) :
- Panzarini G. The NUSES fiber tracker
- Lorusso L. The NUSES mission

TERZINA

- Telescope pointing Earth's limb
- CRs - EHS - UAS
  (Same detection technique of POEMMA)



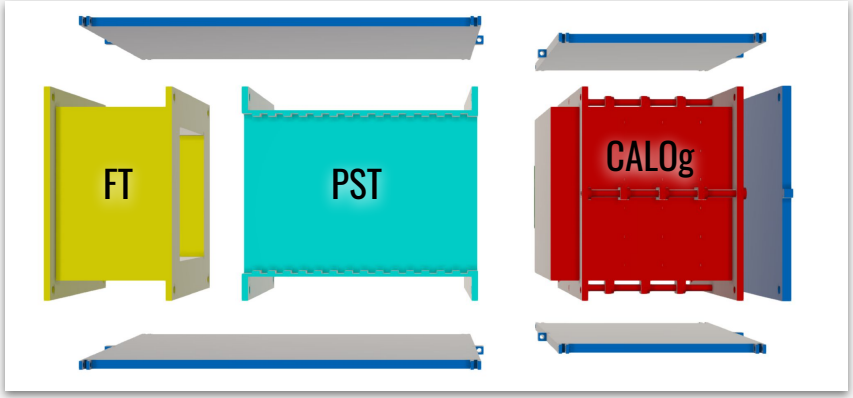
Teresa Montaruli 1st NUSES Collaboration Meeting

ZIRE

- Fiber tracker (FT)
- Plastic Scintillatior Tower (PST)
- LYSO CALOg

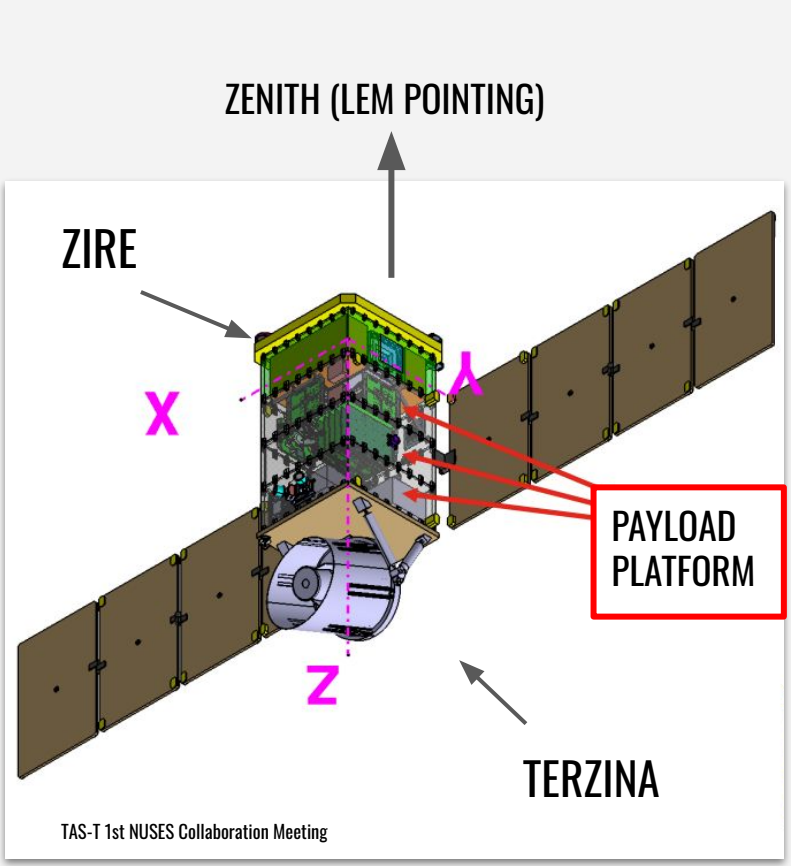
- Counting rates **electron** (E > 5 MeV) and **p/nuclei**
- Solar activity monitoring
- Experimental test of MILC model

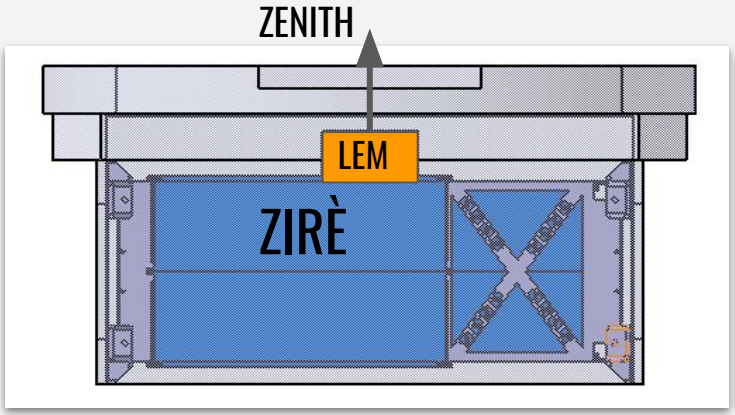
(Magnetospheric Ionospheric Lithospheric Coupling)

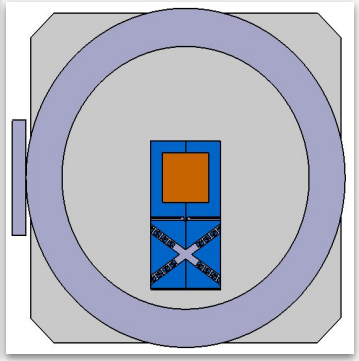


Felicia Barbato 1st NUSES Collaboration Meeting

The Low Energy Module LEM : Electrons (0.1 - 7 MeV)



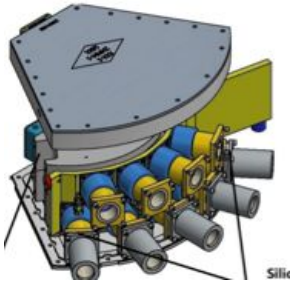




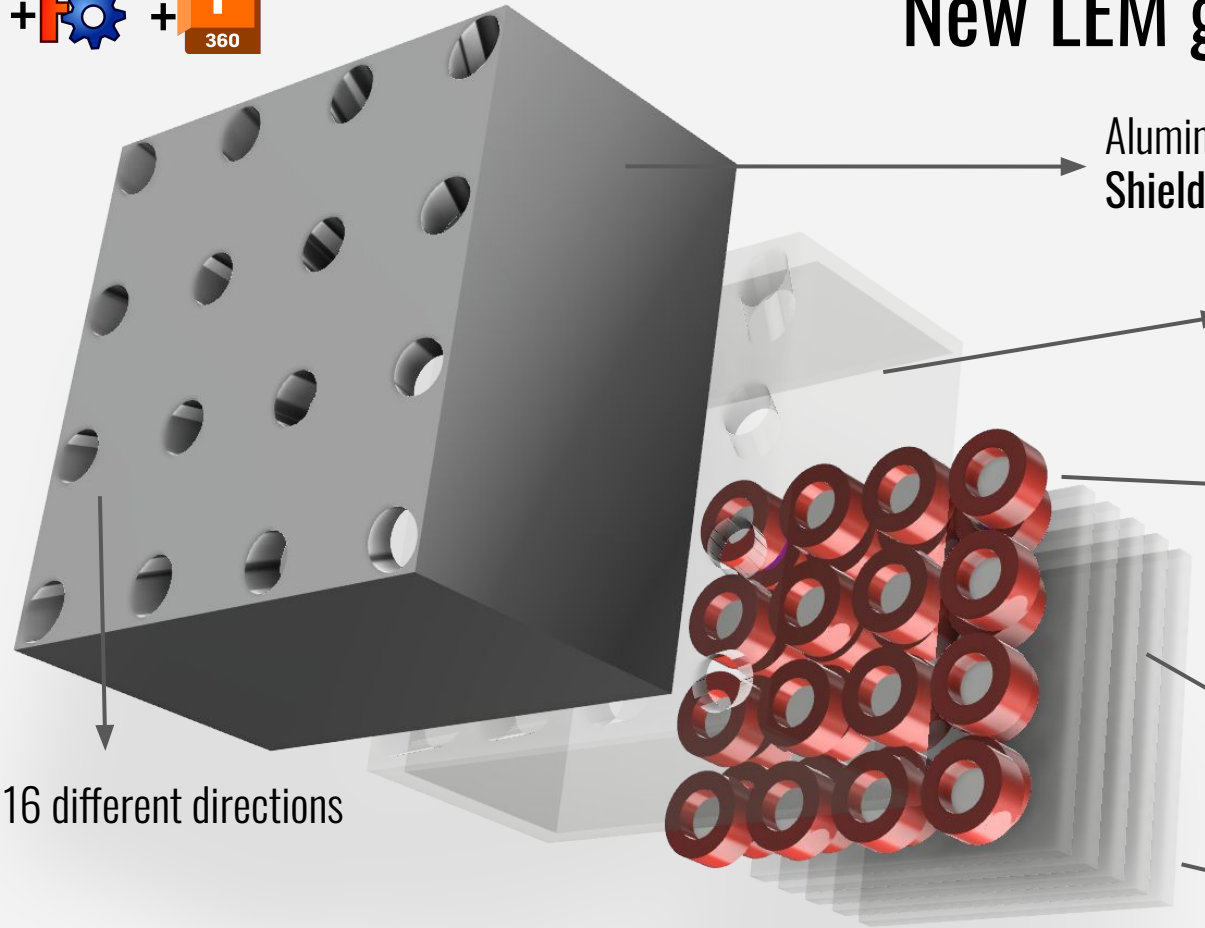
Design a Low Energy Module (LEM):

- Compact (10 x 10 x 5 cm^3)
- Light (~ 1 kg)
- Good angular resolution (< 10°)
- Large FOV / # of directions
- Good PID

Design of previous detectors not suitable (e.g. HEPP-L)



New LEM geometry concept



Aluminium mask (Thickness 0.8 cm)
Shielding of Trapped Electrons **BKG**

Active collimator (plastic scintillator, about 1 cm thick)

Passivated Implanted Planar Silicon detectors **PID**
- **100 um** ΔE
- **500 um** E

4 plastic scintillator layers (**extend to higher energies**)

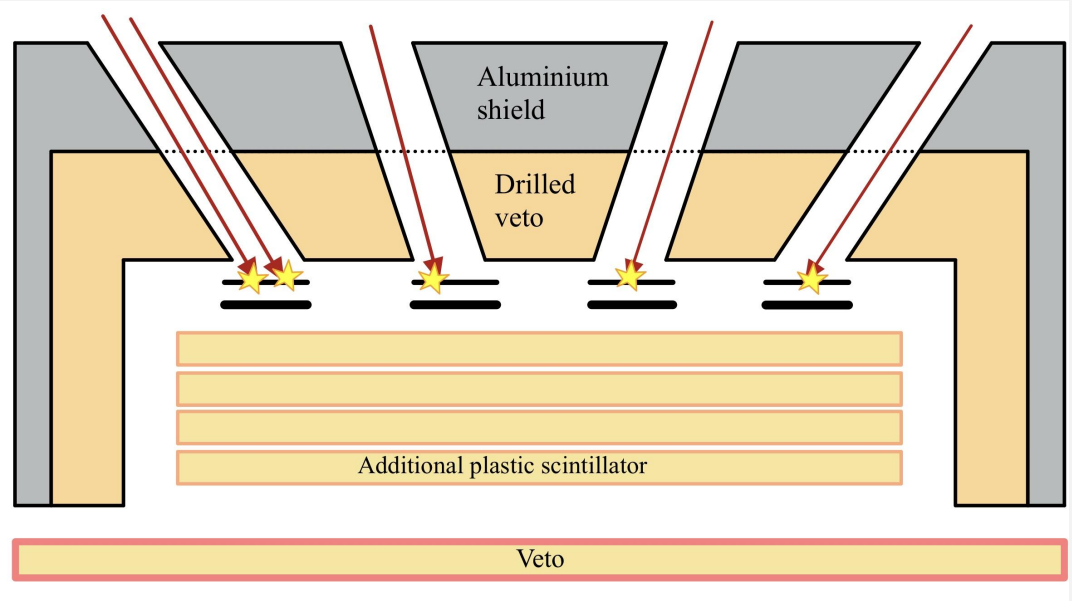
1 plastic scintillator **veto**

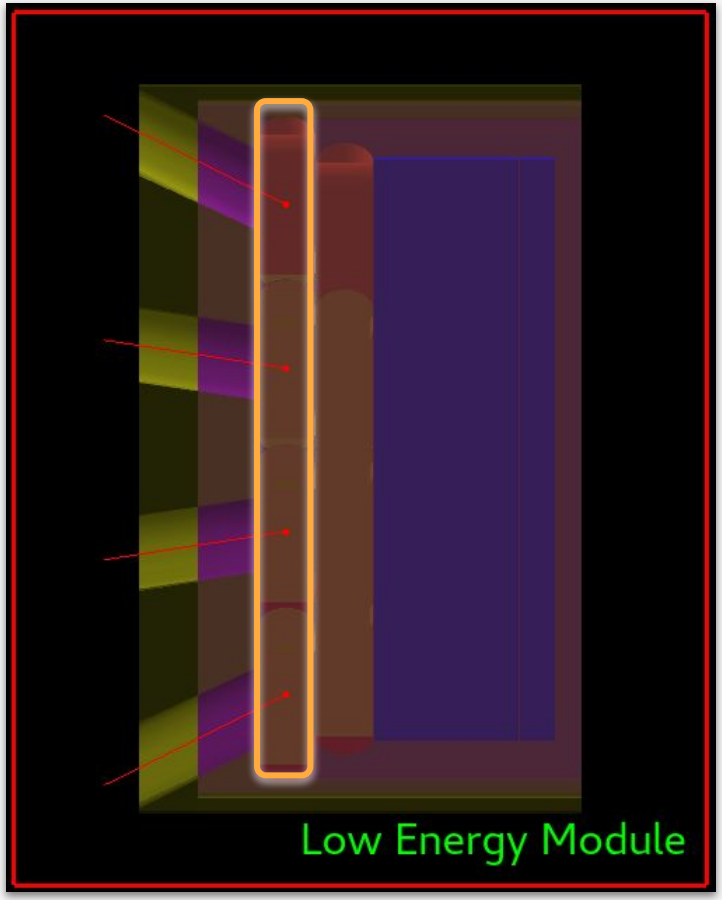
16 different directions

The detection concept

- Energy is too low
- No PID
- **Rejected**

Event:

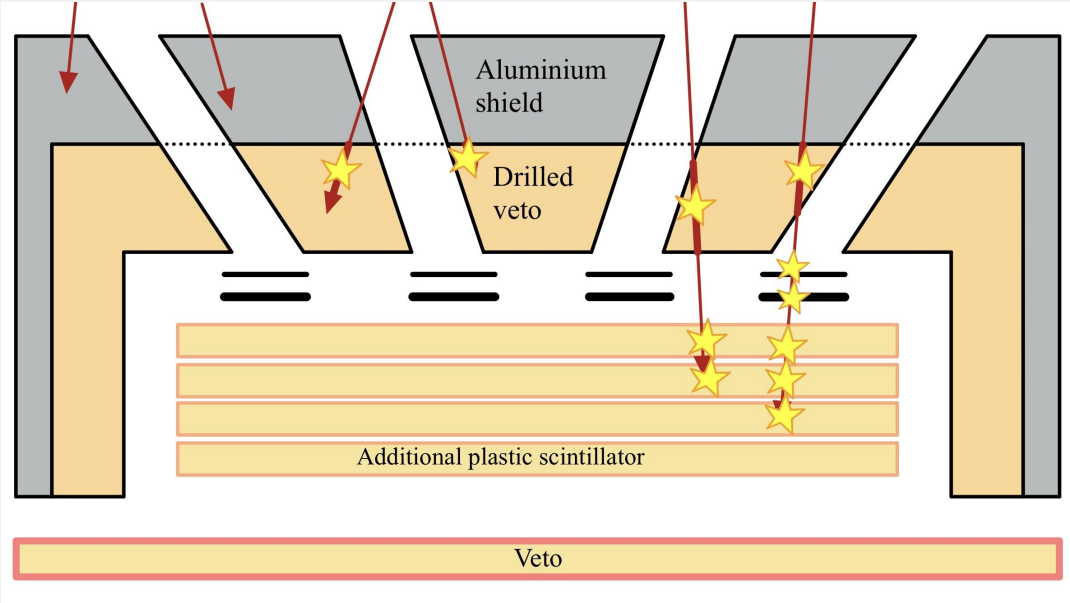


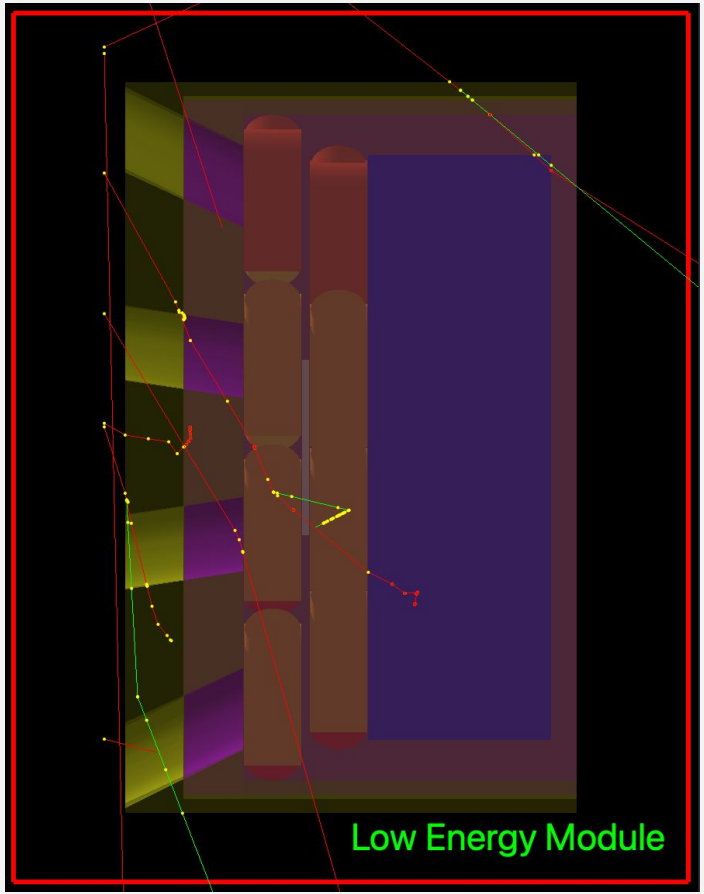


The detection concept

- Shielded by Aluminium
- Wrong direction
- **Rejected**

Event:

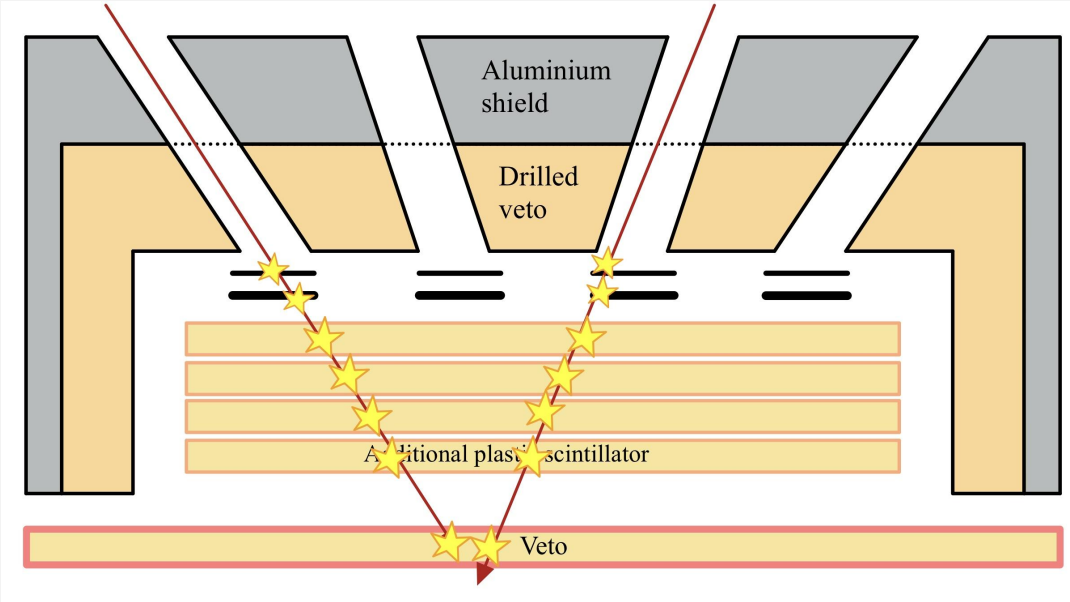


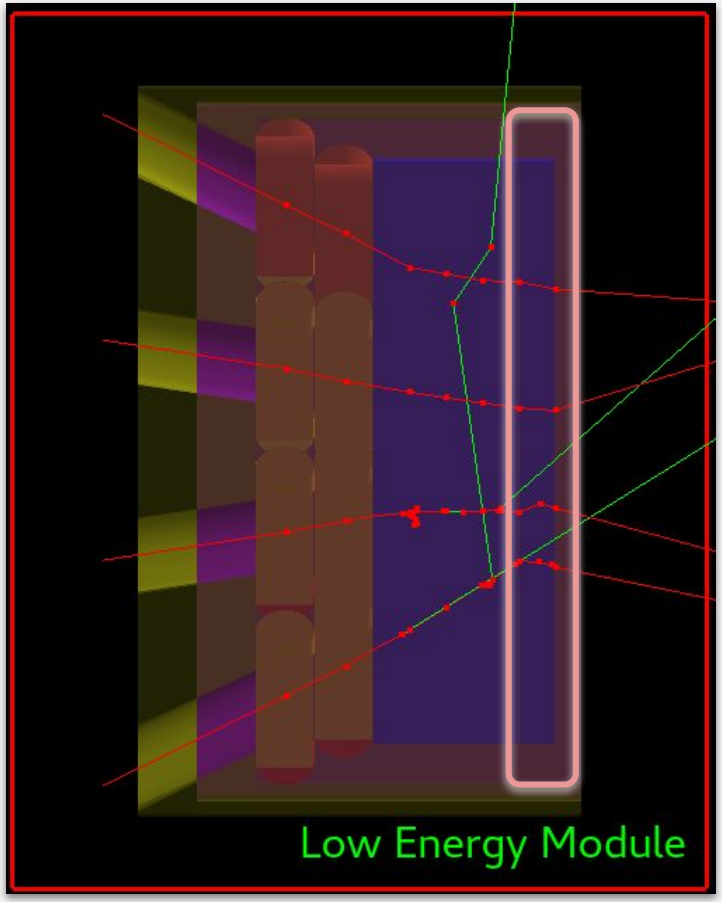


The detection concept

- Energy is too high (Difficult PID)
- Veto activated
- **Rejected**

Event: ✕

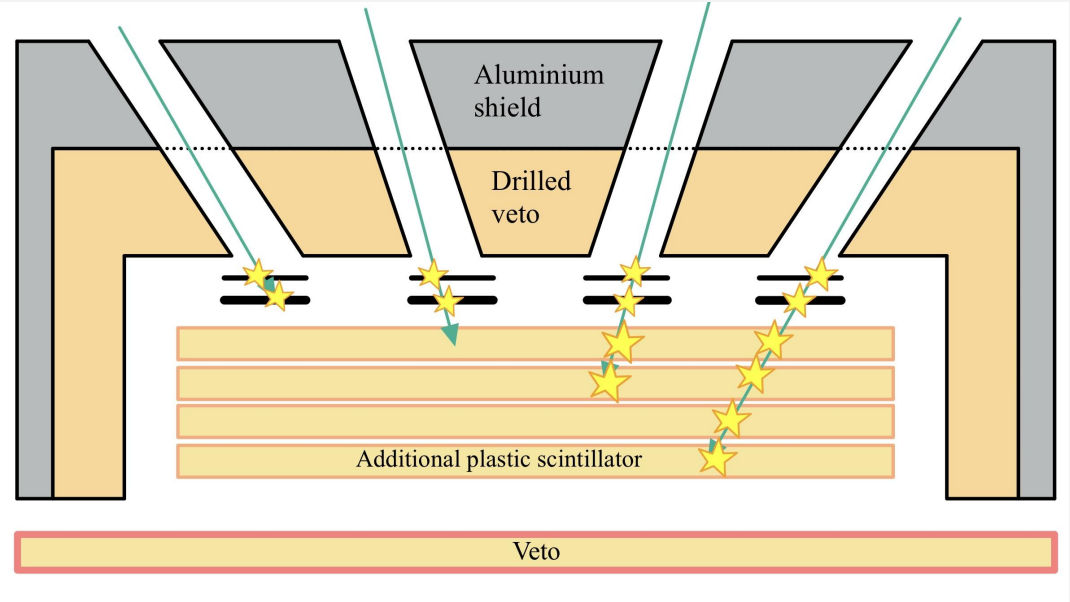


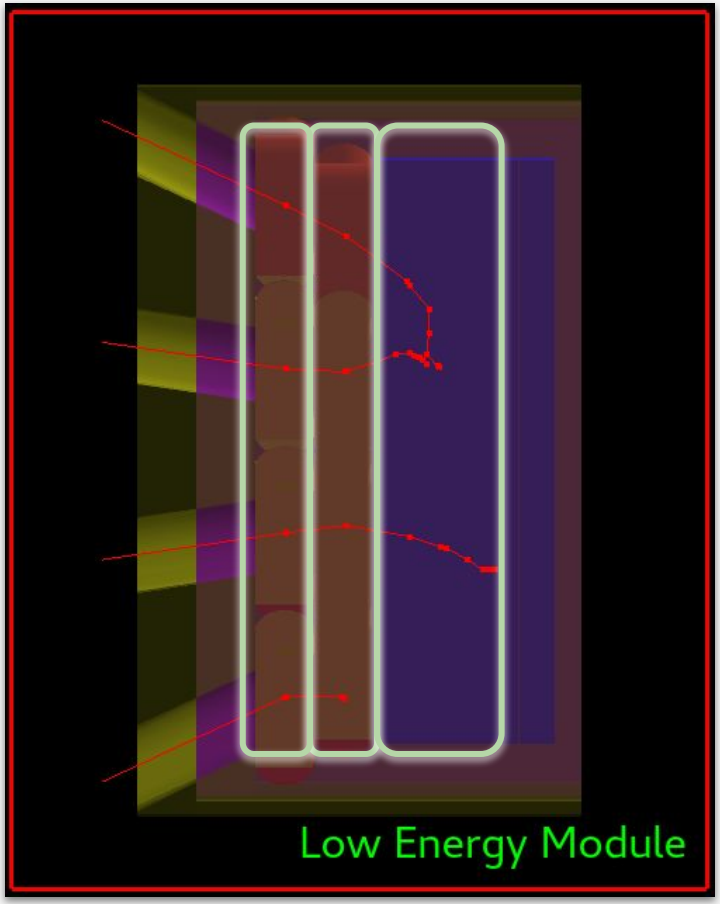


The detection concept

- Particle **confined** within the thin layer and the veto
- **Good events**

Event:





Aluminium shielding of trapped electrons

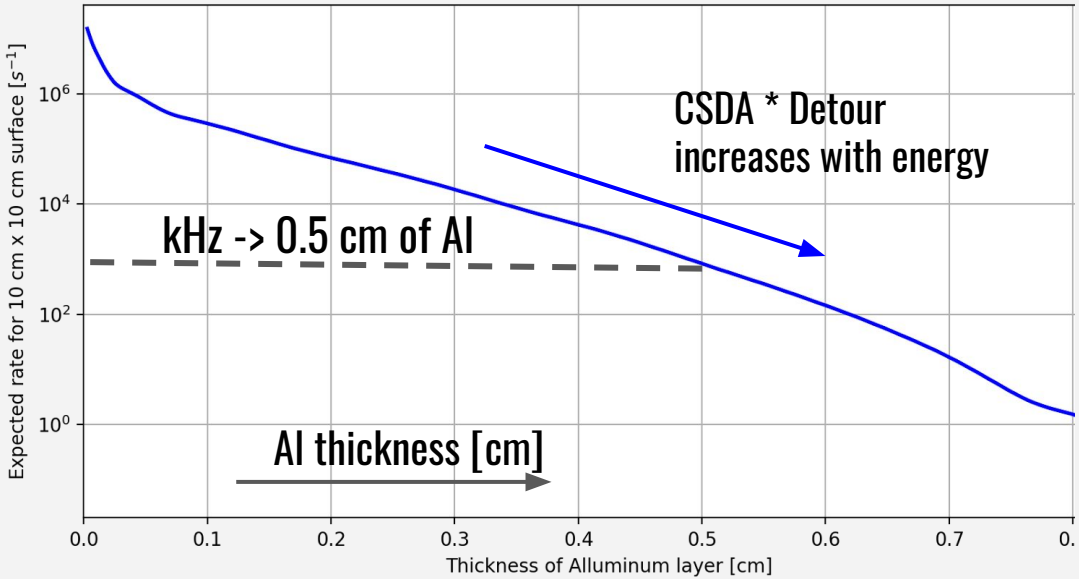
Energy [MeV]	Differential flux [MeV^{-1} cm^{-2} s^{-1}]	Integral flux [cm^{-2} s^{-1}]
0,04	1,96E+06	2,44E+05
0,1	1,25E+06	1,51E+05
0,25	3,20E+05	4,48E+04
0,5	4,35E+04	1,15E+04
0,75	1,32E+04	5,56E+03
1	6,21E+03	3,38E+03
1,5	2,44E+03	1,46E+03
2	1,03E+03	6,29E+02
2,5	4,99E+02	2,82E+02
3	2,09E+02	1,09E+02
3,5	8,56E+01	4,19E+01
4	3,23E+01	1,41E+01
4,5	1,05E+01	4,17E+00
5	3,06E+00	1,14E+00
5,5	6,87E-01	2,41E-01
6	1,09E-01	3,17E-02
6,5	1,57E-02	0,00E+00

Table 3.1-1 Trapped electron spectrum

TAS-I report

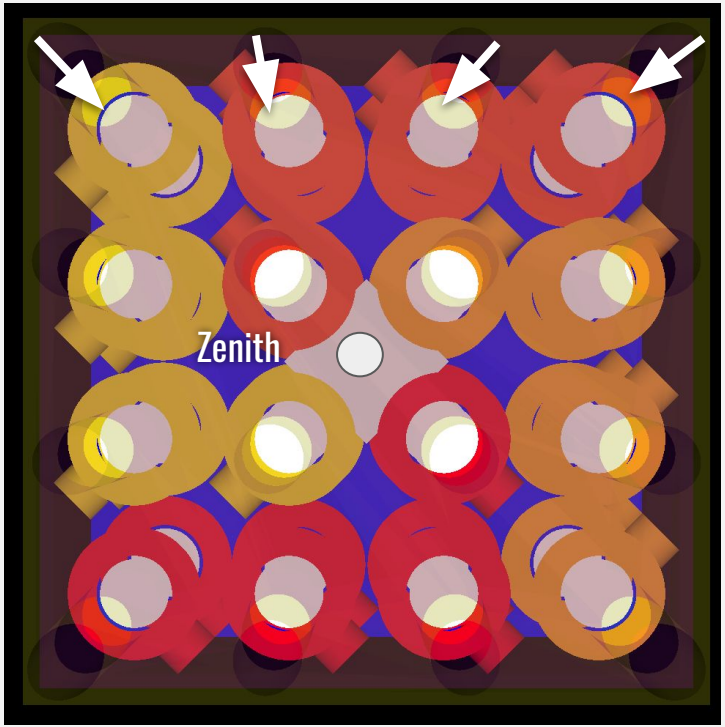
- **~0.5 cm** of **Aluminium will** stop e- with energy below **3.5 MeV**
- Surviving flux **~20 cm^2 s^{-1}**
- Expected **Veto rate ~10 kHz**
- Expected **Event rate ~1-10 kHz** (trapped electrons)

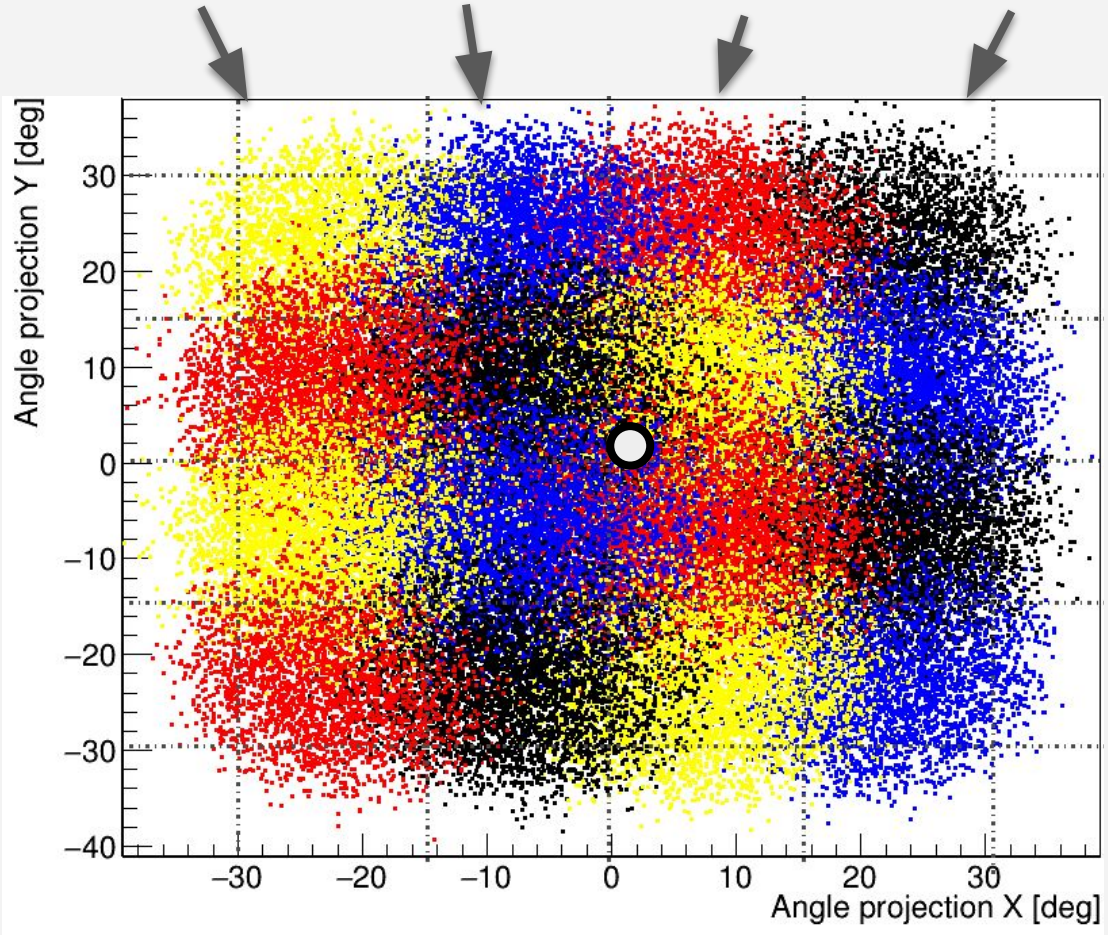
Al -> Shielding trapped electrons



Angular resolution

- Large FOV (60° x 60°)
- Resolution of about **~7 degs (rms)**





Study of the energy deposition

Some definitions:

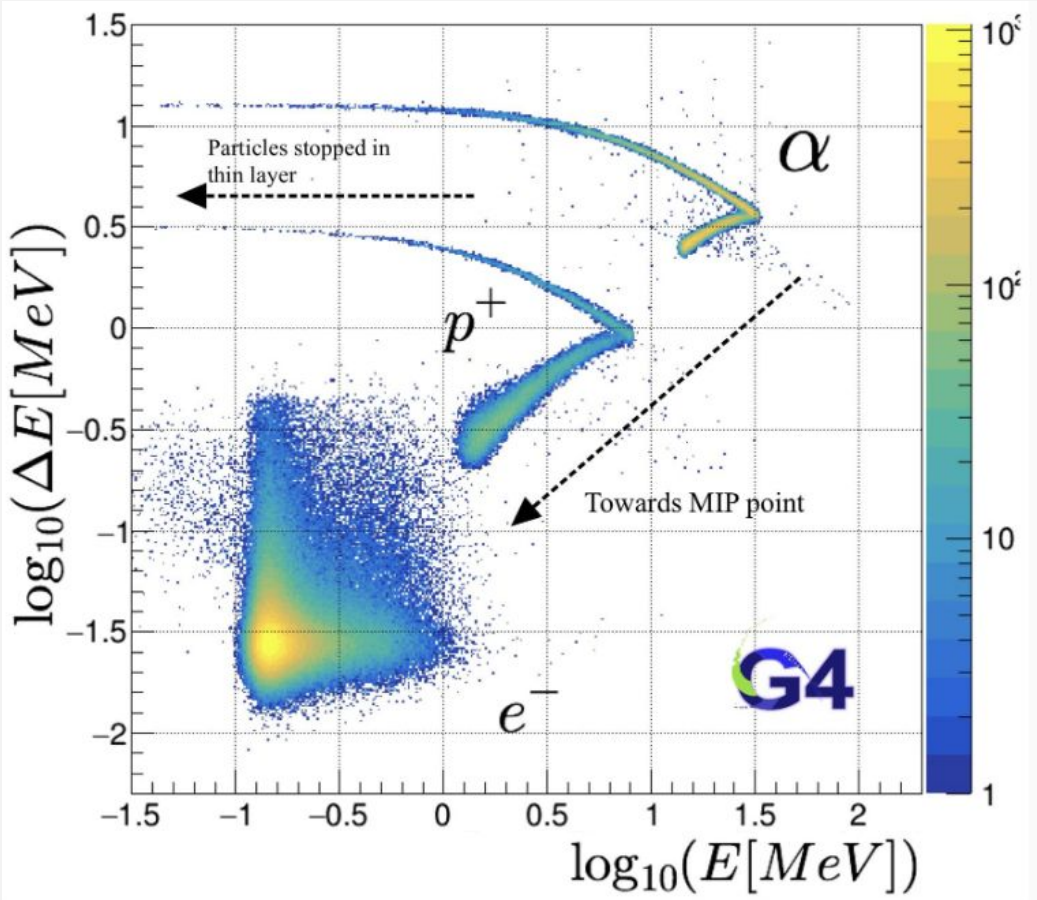
ΔE Energy in 100 um (Thin)

E Energy in 500 um and (eventually) the 4 plastic scintillators

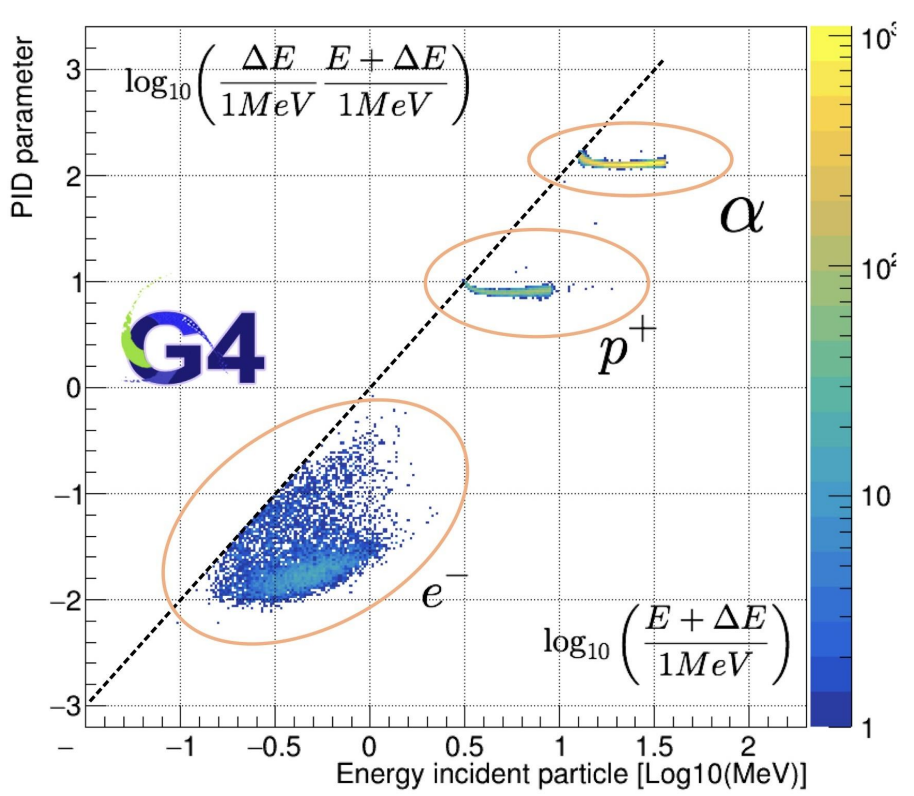
$$\Delta E \propto \frac{z^2}{\beta^2} \qquad E_{tot} \propto A\beta^2$$

$$E_{tot} = E + \Delta E$$

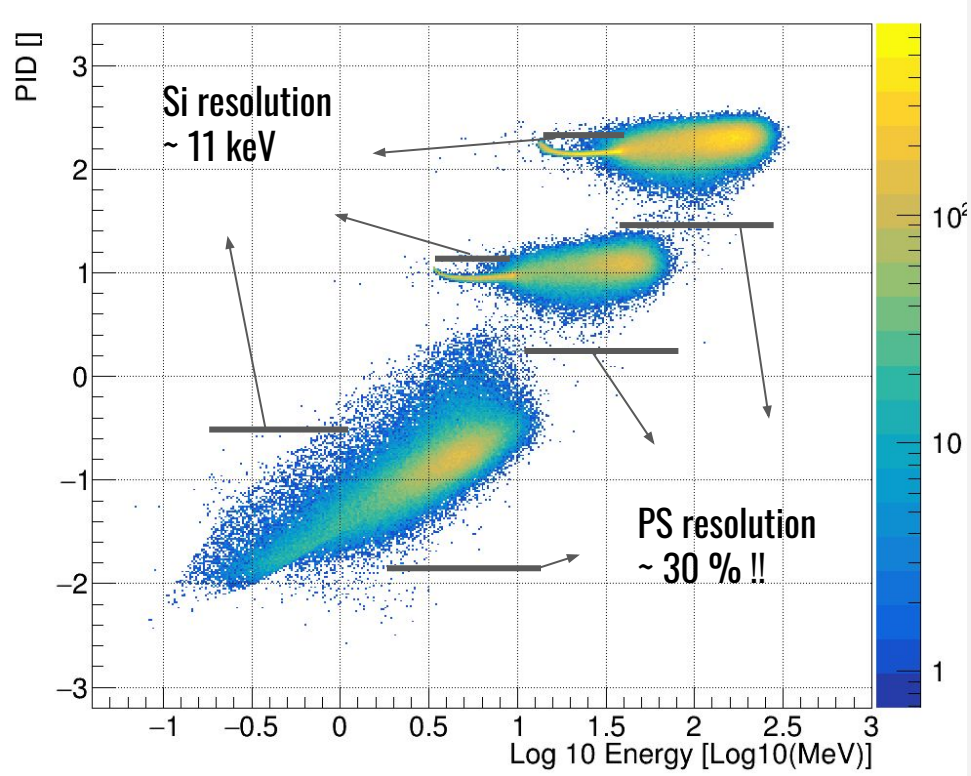
$$PID_{\text{proxy}} = \log_{10}\left(\frac{\Delta E}{1\ \text{MeV}}\,\frac{E_{tot}}{1\ \text{MeV}}\right)$$



Energy deposition

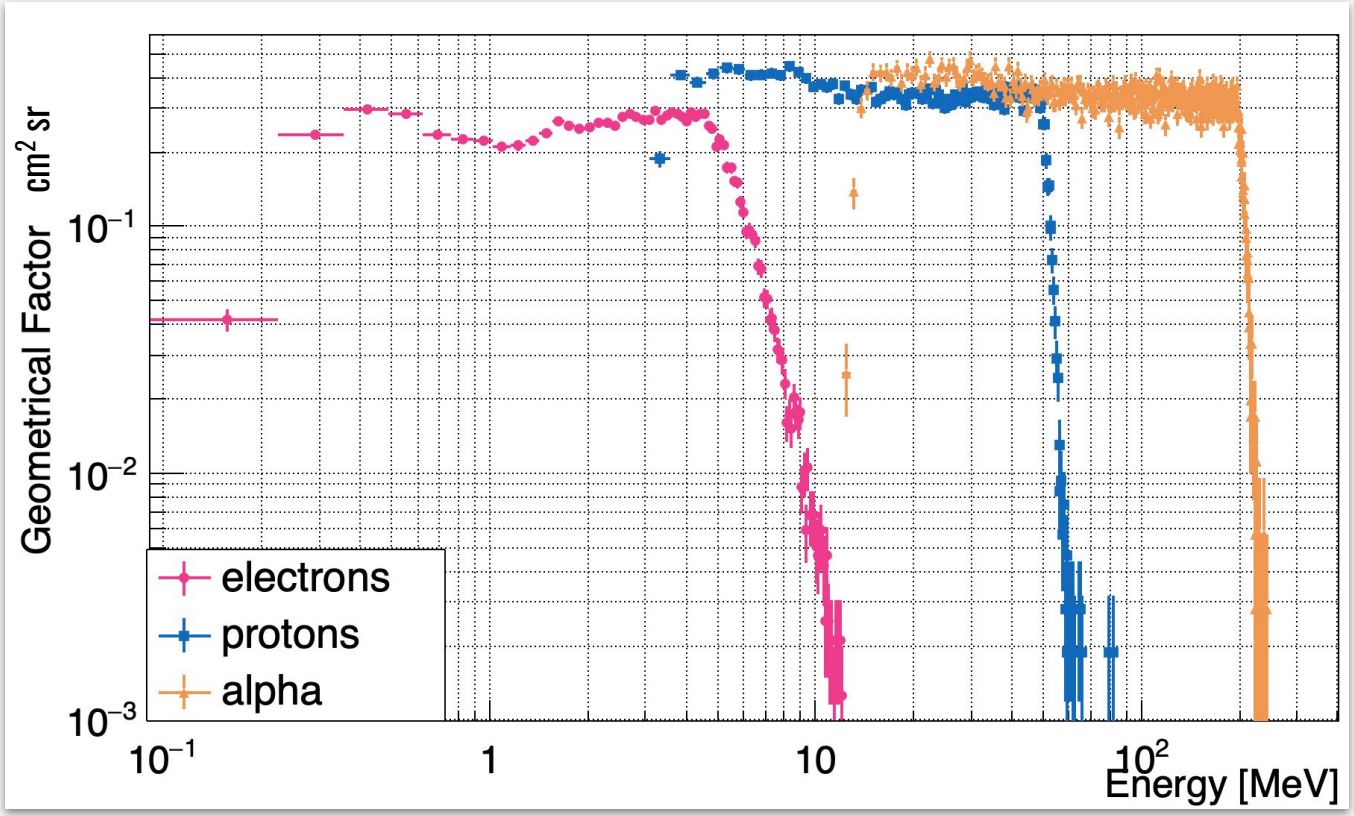


Si 100 um - Si 500 um (No PS)



Si 100 um - Si 500 um + **4 PS layer**

Geometrical factor



Alpha
[15 - 200] MeV
~ 0.35 cm^2 sr

Protons
[3.5 - 50] MeV
~ 0.35 cm^2 sr

Electrons
[0.2 - 5] MeV
~ 0.25 cm^2 sr

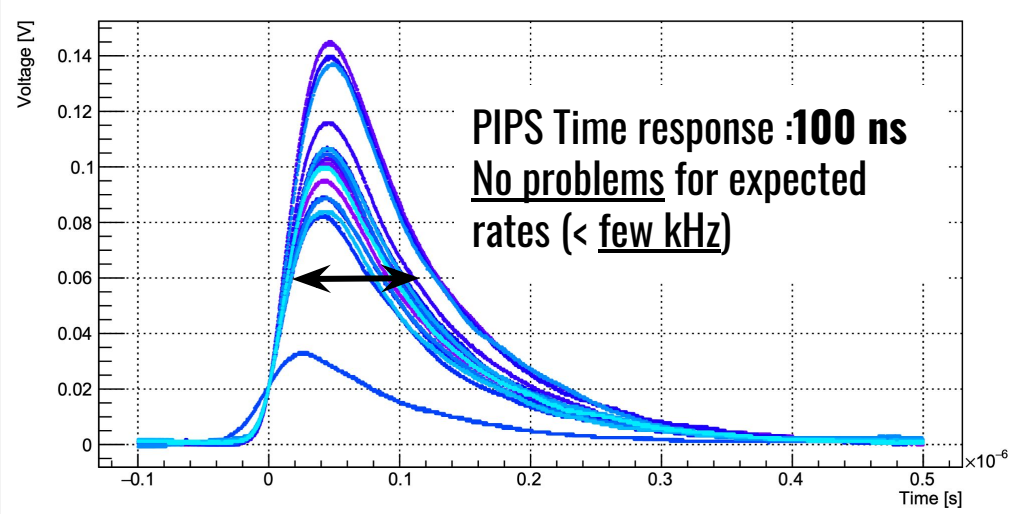
Signal rate expected (trapped electrons) : 1 - 10 kHz

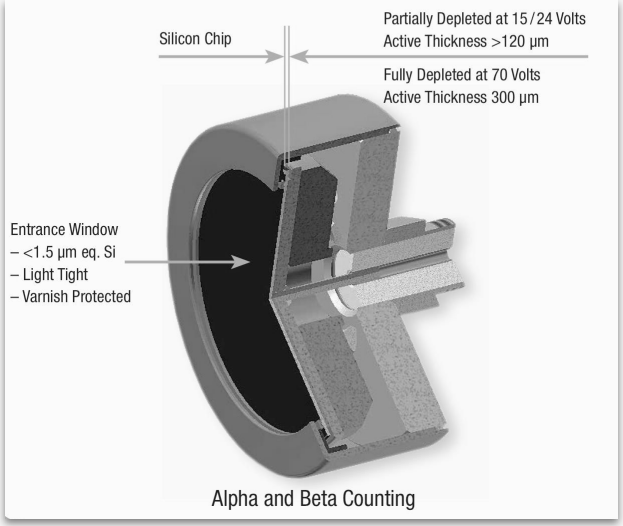
Silicon Detector Characterisation at TIFPA (Trento INFN)

Passivated Implanted Planar Silicon (PIPS)

Characterisation 500 um PIPS at TIFPA

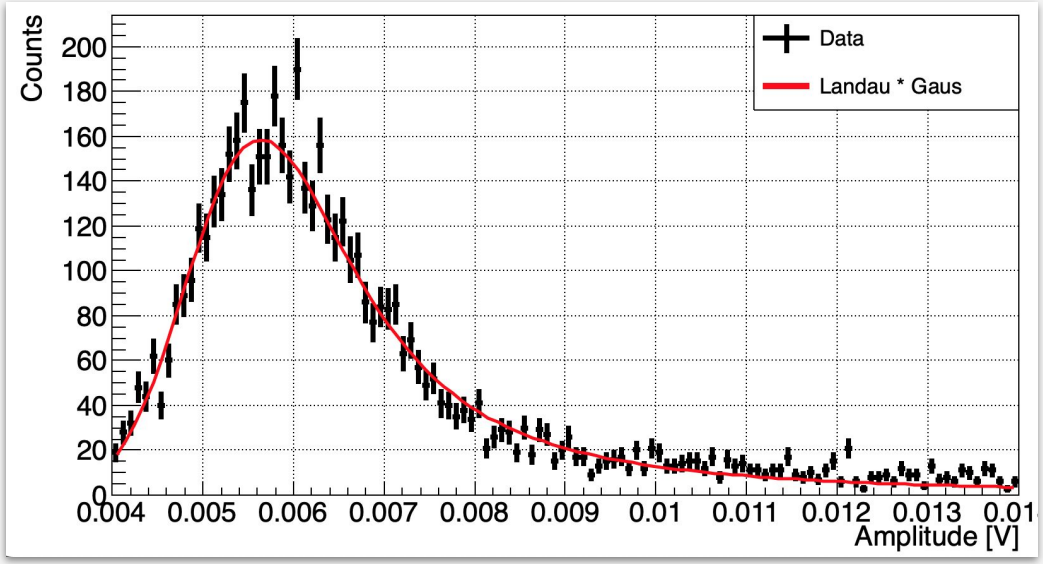
- Particle generates **electron-hole** pairs
- Electron - hole pairs separated by **electric field**
- **Charge** collected **proportional** to **energy**

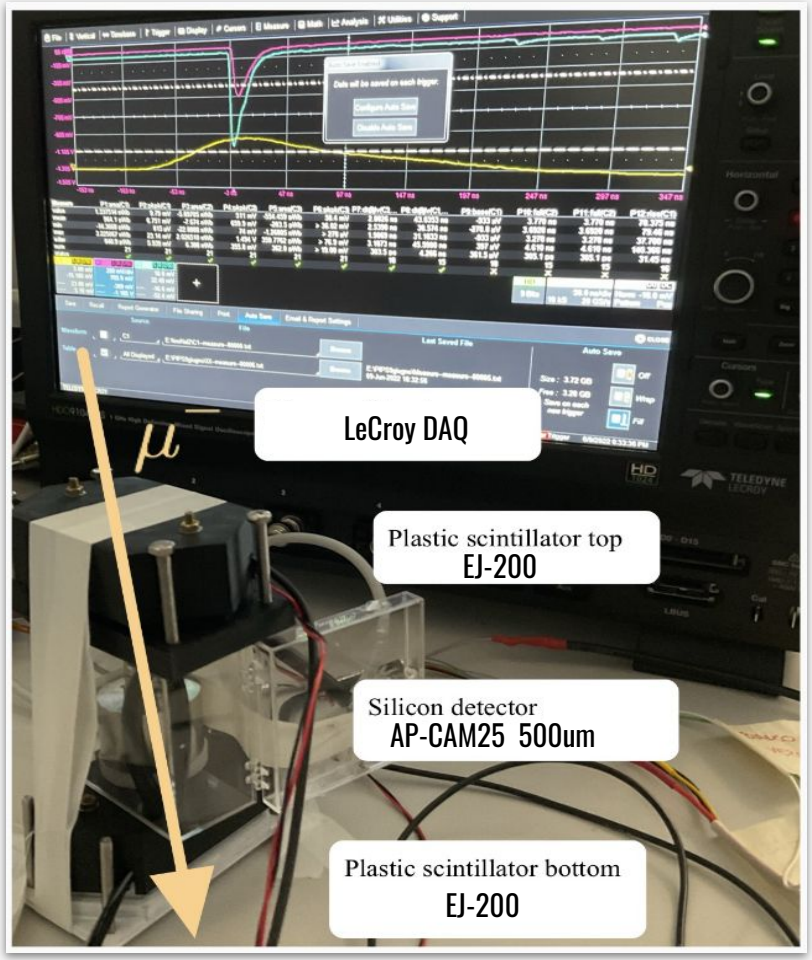




Muon calibration

- MPV measurement : **~35mV/MeV**
- Resolution **11 keV**
- Design performance is verified





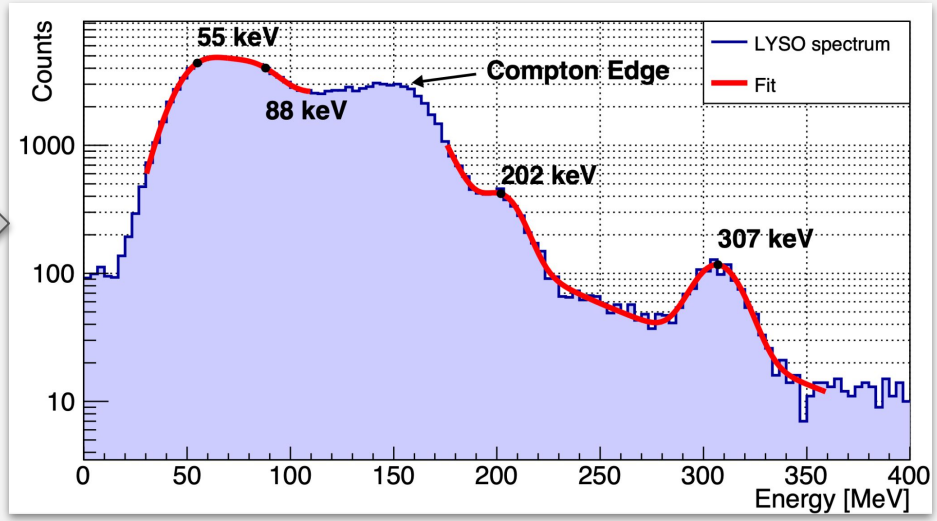
Calibration with γ sources

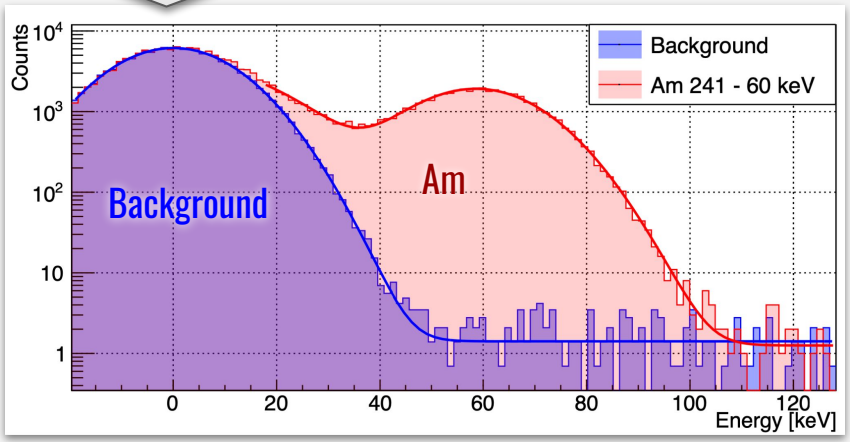
$$36.7(3)\ \text{mV/MeV}$$
$$\sigma = 11.1(4)\ \text{keV}$$

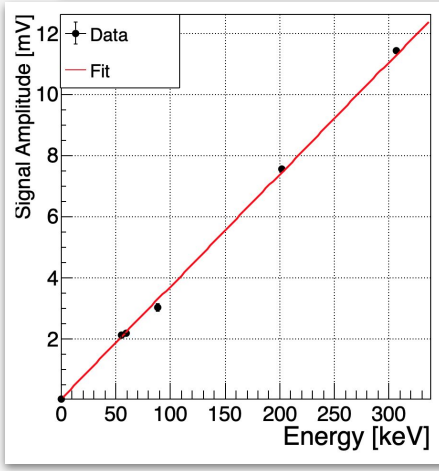
Lu 176 → In PIPS

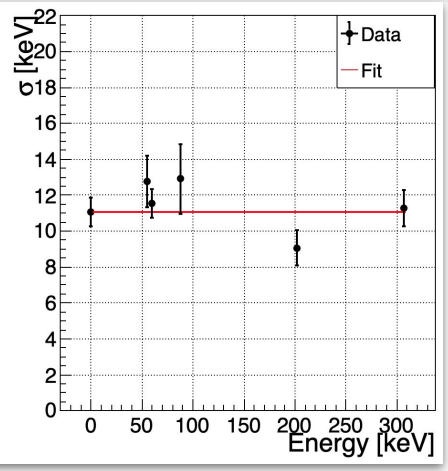
Am 241 → In PIPS

Calibration Resolution









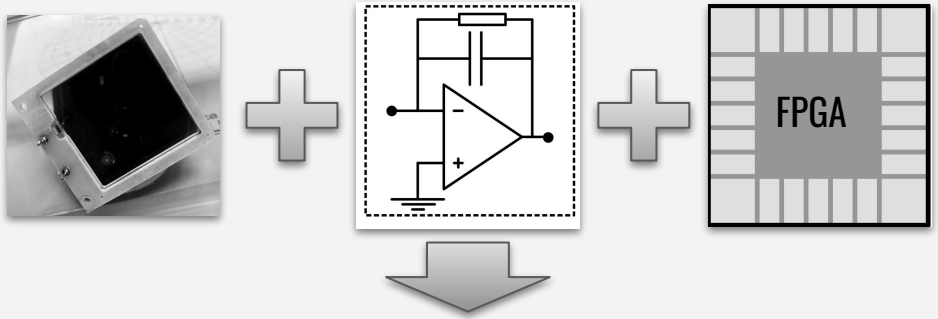
Summary and To do list

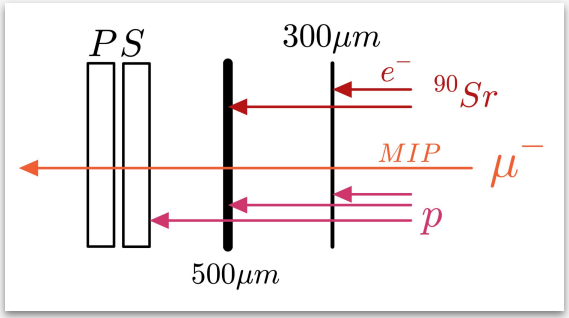
GEANT4 platform for LEM available

500 um PIPS tested and calibrated

To Do List

- Test 100 um PIPS detector
- Interface SD with suitable electronics
- Build a first $\Delta E - E$ module
- Development of the digital electronics
- Characterisation with proton beam in Trento





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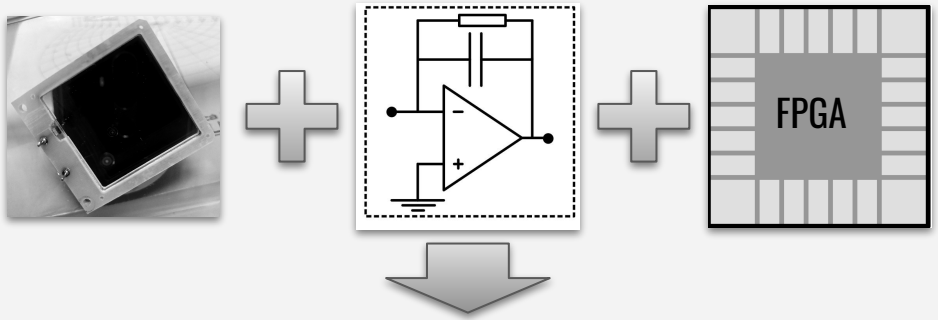

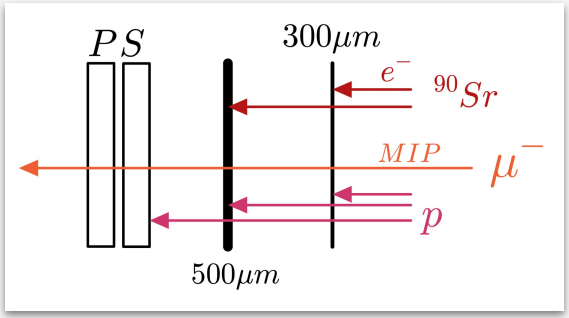

Thank you for the attention