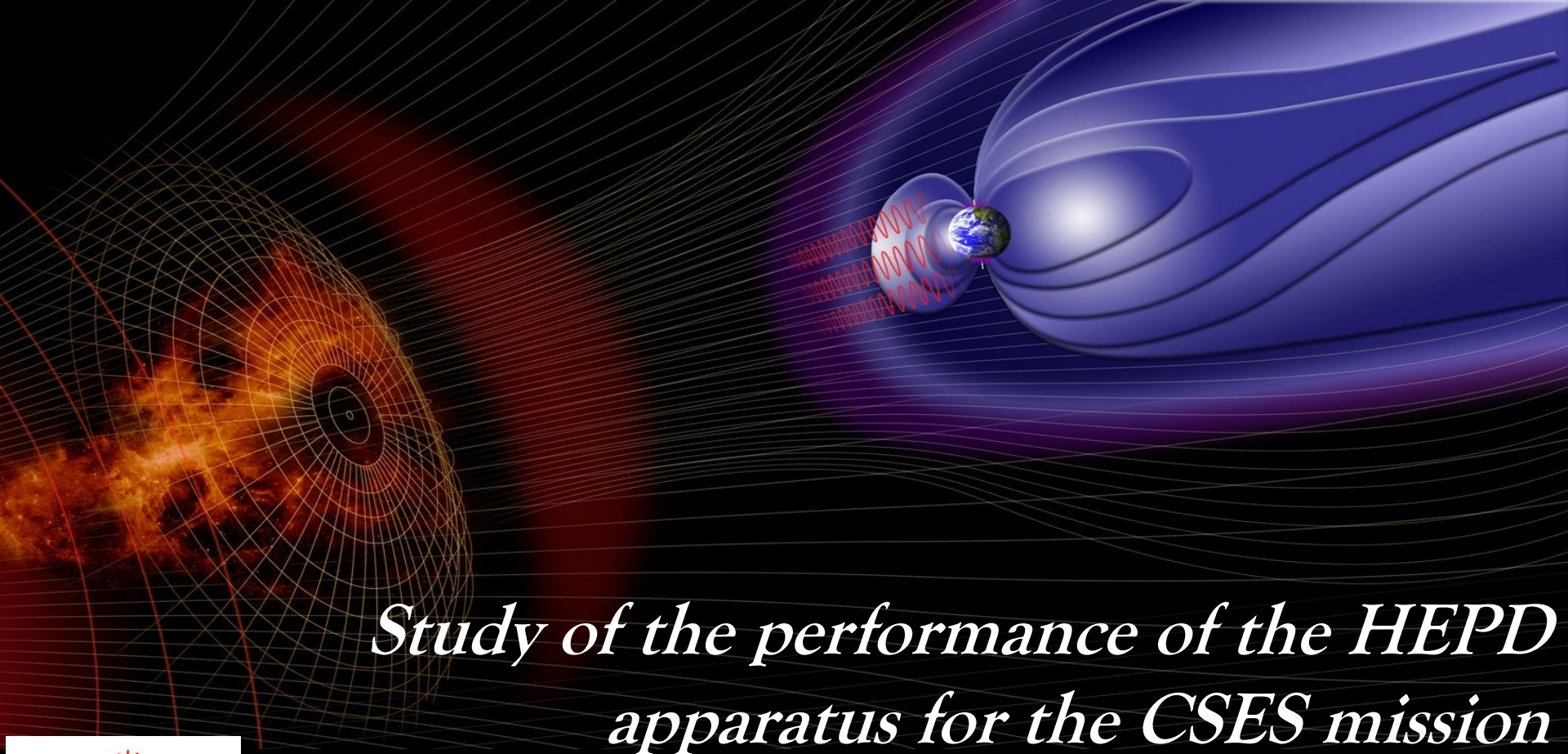
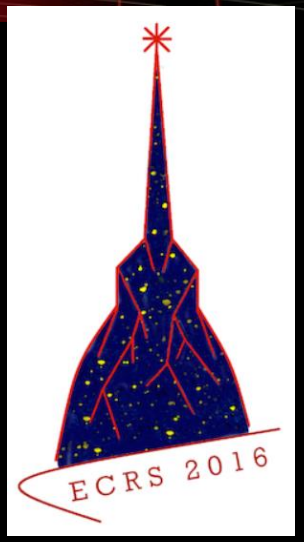


Study of the performance of the HEPD apparatus for the CSES mission

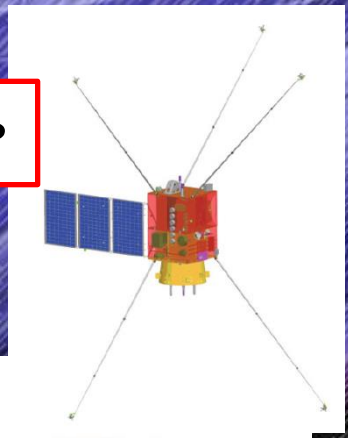
Beatrice Panico

INFN Naples

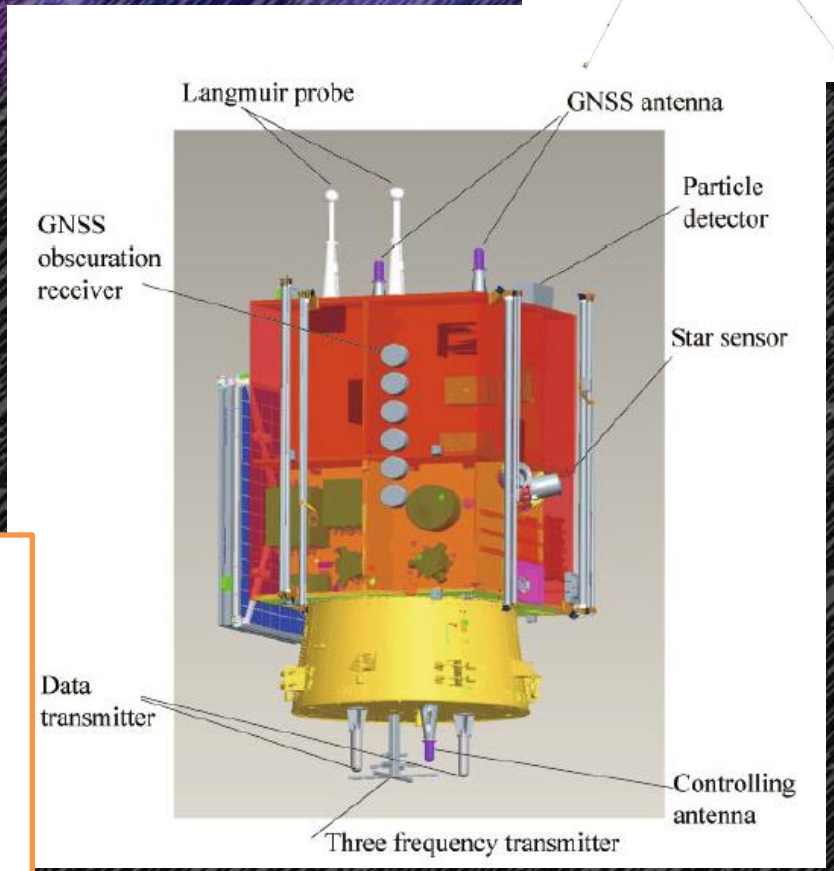


THE CSES MISSION

CSES: *China Seismo-Electromagnetic Satellite*



- Space mission with different goals
- Collaboration China National Space Administration (CNSA) - Italian Space Agency (ASI)
- Developed by:
  - China Earthquake Administration (CEA)
  - Italian National Institute for Nuclear Physics (INFN)
  - Chinese and Italian Universities



- 98° inclination Sunsynchronous circular orbit
- Altitude ~500 km
- Expected lifetime ~5 years
- Launch scheduled for the first half of 2017

THE CSES MISSION

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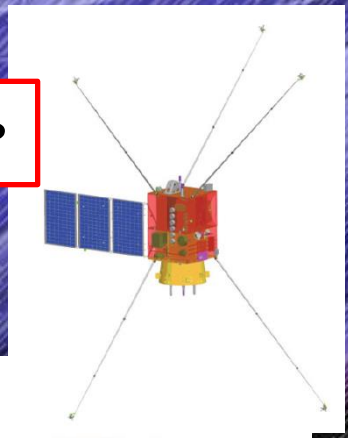
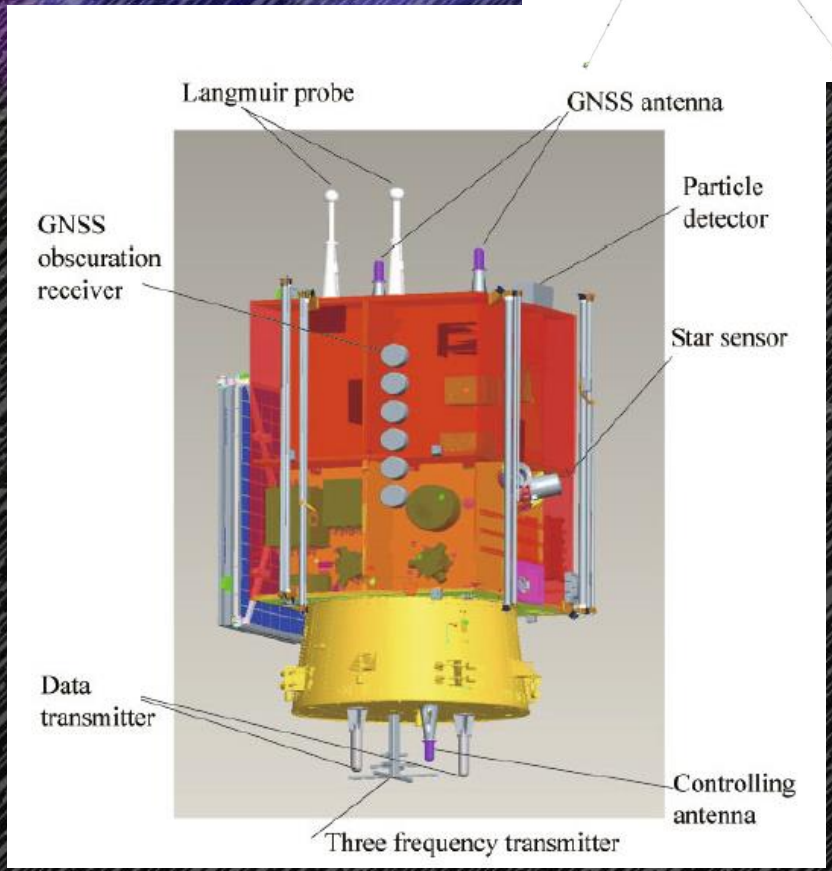


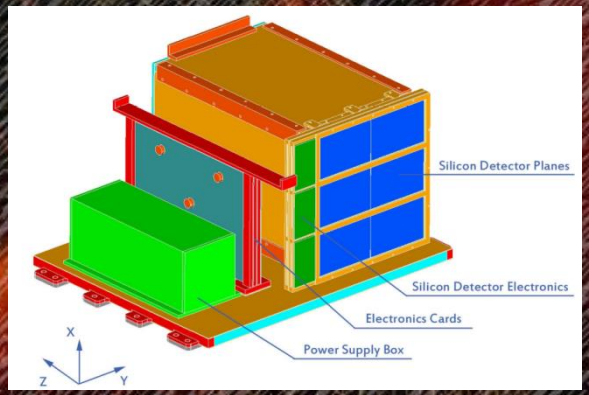
Several instruments on board:

- a Search-Coil Magnetometer, a High-Precision Magnetometer and Electric Field Detector for measuring the *magnetic and electric fields*
- a Plasma Analyser Package and a Langmuir Probe for *measurements of local plasma disturbances*
- a GNSS Occultation Receiver and a three frequency (VHF/UHF) Transmitter for the *study of profile disturbance of plasma*
- **the High-Energy Particle Package and High-Energy Particle Detector for the *measurement of the flux and spectrum of energetic particles***



THE HEPD DETECTOR

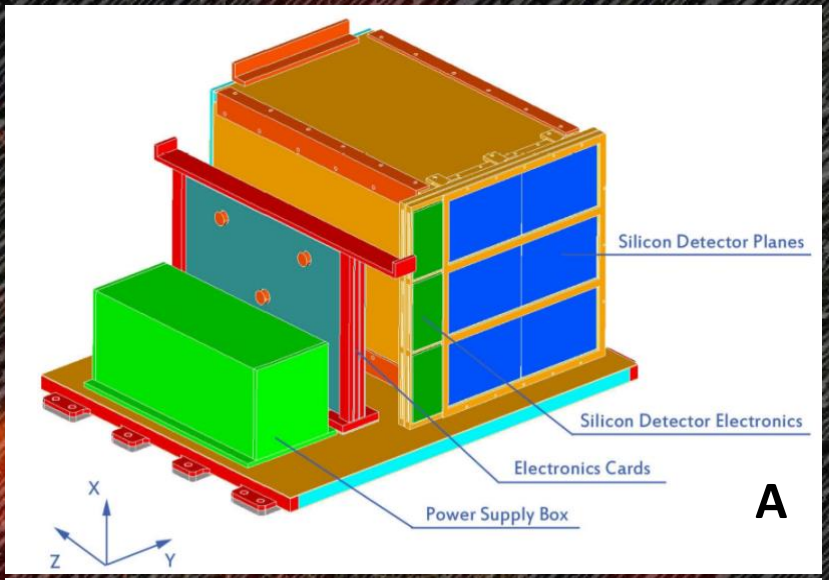
HEPD: High Energy Particle Detector

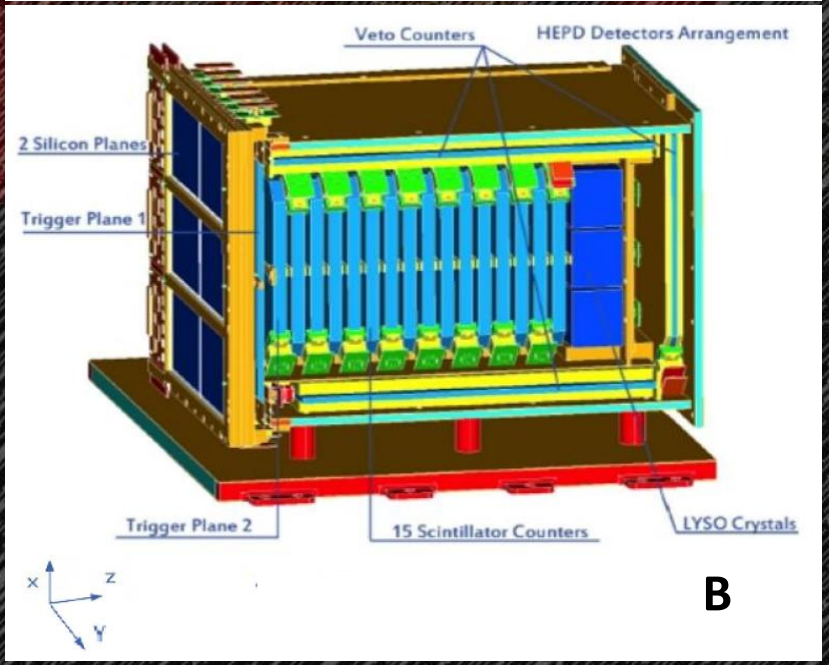


The High-Energy Particle Detector (HEPD) is developed by the Italian members of the CSES mission

Parameter	Value
Energy range	Electron: 3-100 MeV
	Proton: 30-200 MeV
Angular resolution	<8°@ 5 MeV
Energy resolution	<10% @ 5 MeV
Particle Identification	>90%
Maximum Omni-directional Flux	10^7 cm^{-2}s^{-1}sr^{-1} (accepted by trigger before pre-scaling)
Operating temperature	-10 °C - + 35 °C
Mass (including electronics)	< 43 kg
Power Consumption	< 43 W
Scientific Data Bus	RS-422
Data Handling Bus	CAN 2.0
Operation mode	Event by Event
Life span	> 5 Years

THE HEPD DETECTOR





- The **tracker**, made of two planes of double-side silicon micro-strip sensors; each tracker plane includes 3 ladders made of 2 modules
- The **trigger system**, made of one layer of plastic scintillator, divided into 6 segments; different trigger combinations can be used
- The **range calorimeter**, which consists of two parts:
  - The first part is made with 16 plastic scintillator planes, 1cm thick
  - The bottom part of the calorimeter consists of a layer with 9 LYSO crystals
- The **veto system**, five plastic scintillator counters, 5 mm thick
- The **electronics sub-system**

EXPECTED RATE

Expected rate of cosmic rays along the satellite orbit

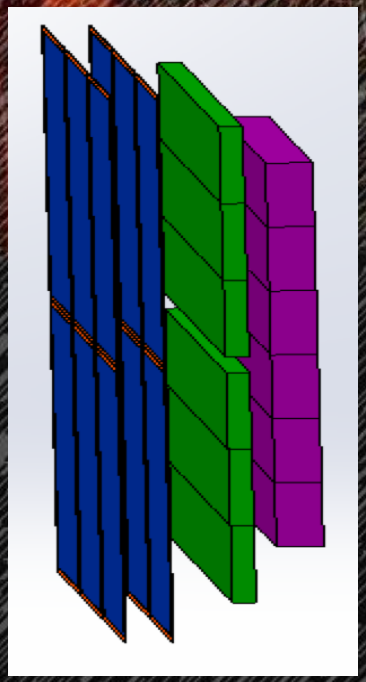
Data from PAMELA experiment

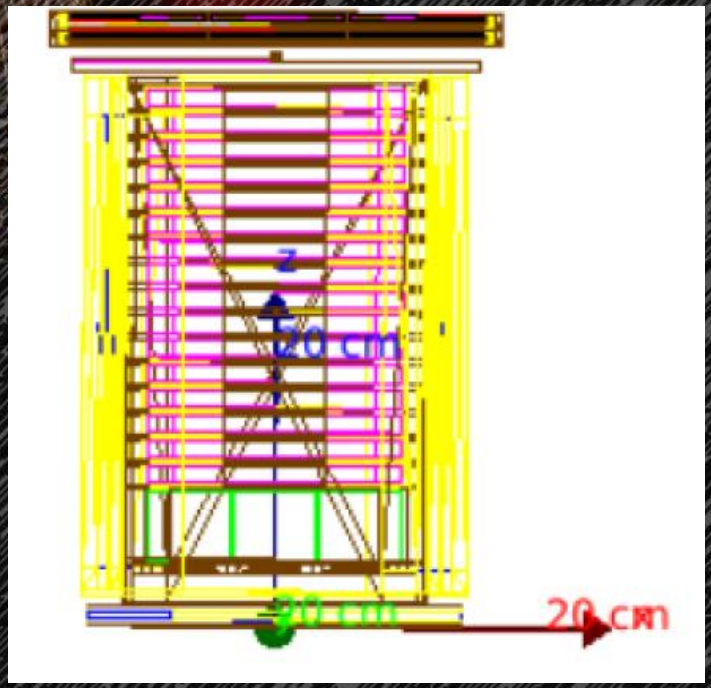
Period: July, 7th – November, 30th 2006 (142 Days)
December 13th : Solar flares is excluded

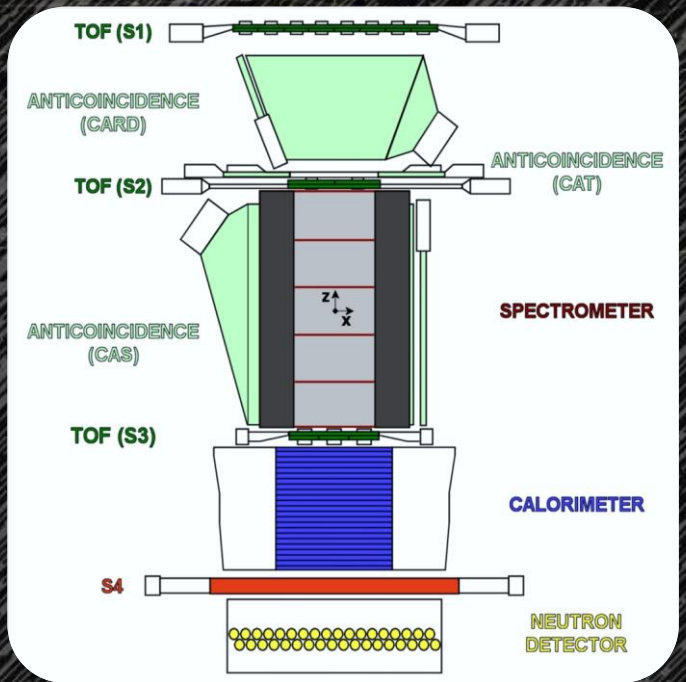
Latitude: [-60°;+60°]

Altitude: [490 – 520] km

Geometric factor PAMELA/HEPD ~ 6







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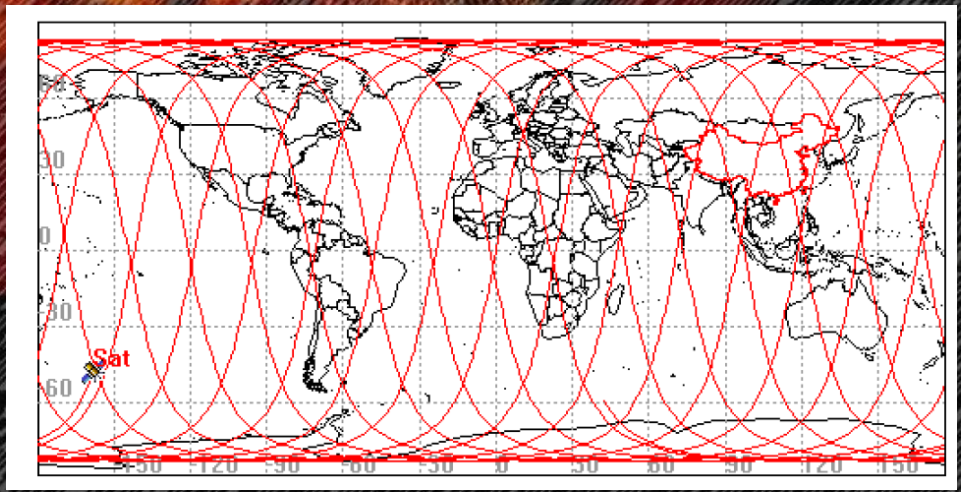
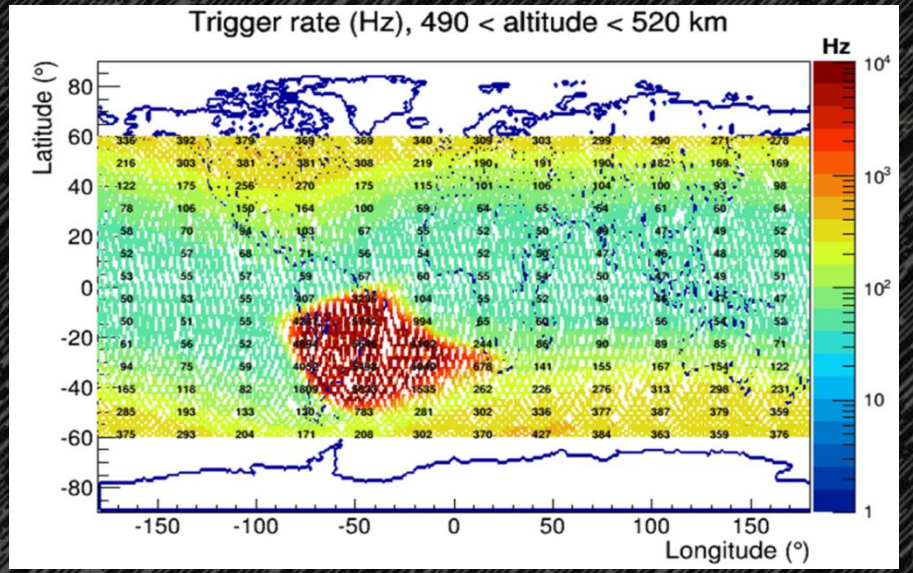


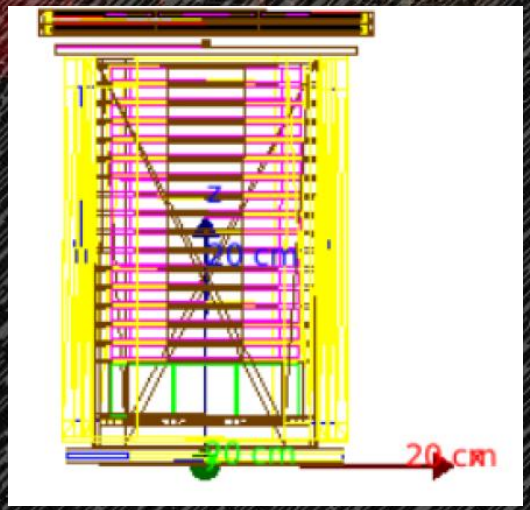


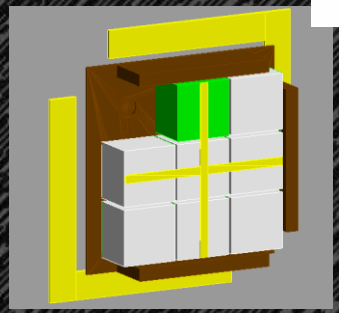
Different trigger masks depending on the orbital zone!

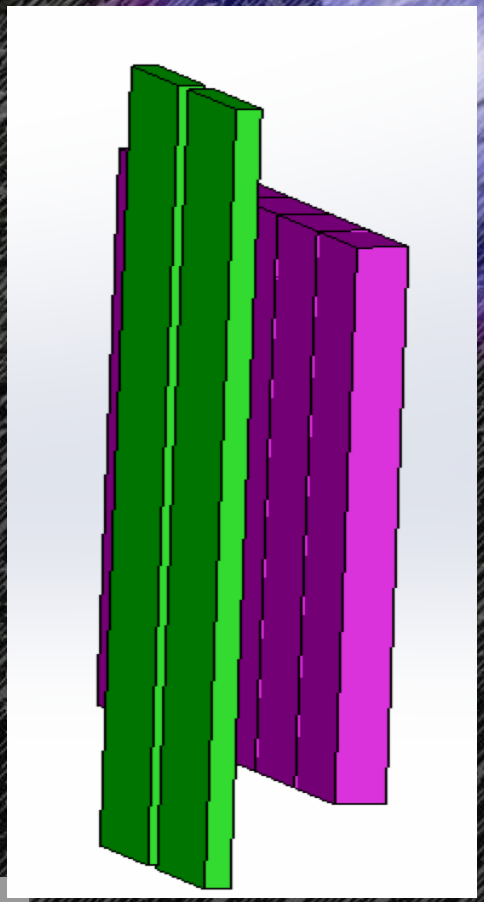
TRIGGER CONFIGURATIONS

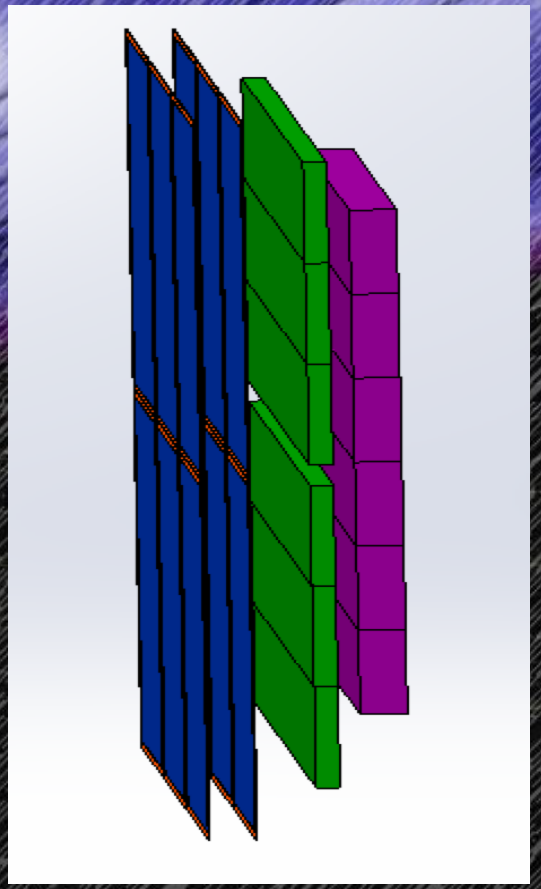
Different trigger masks depending on the orbital zone!

1. T1 & P1
2. T1 & P1 & P2
3. T1 & P1 & P2 &P3
4. T1 & (P1 || P2)
5. (T1,3 || T1,4) & (P1)
6. T1 & (P1 || P2) & (P16 || P15)
7. T1 & (P1 || P2) & P17

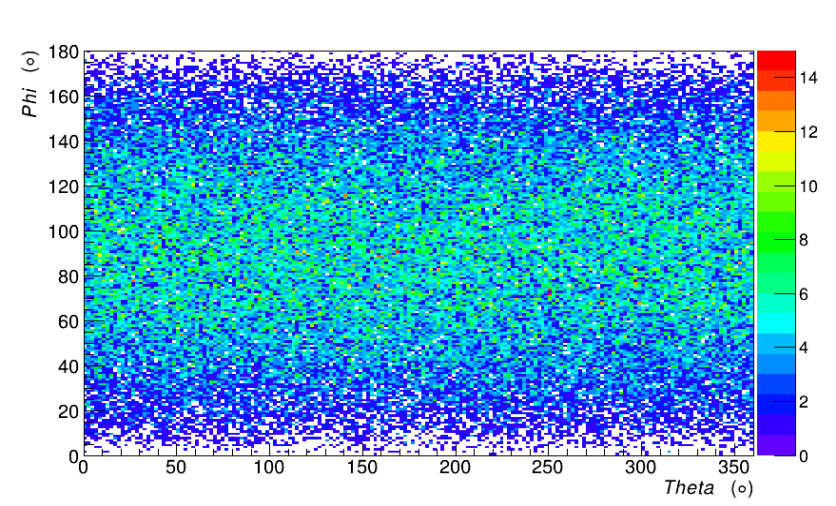


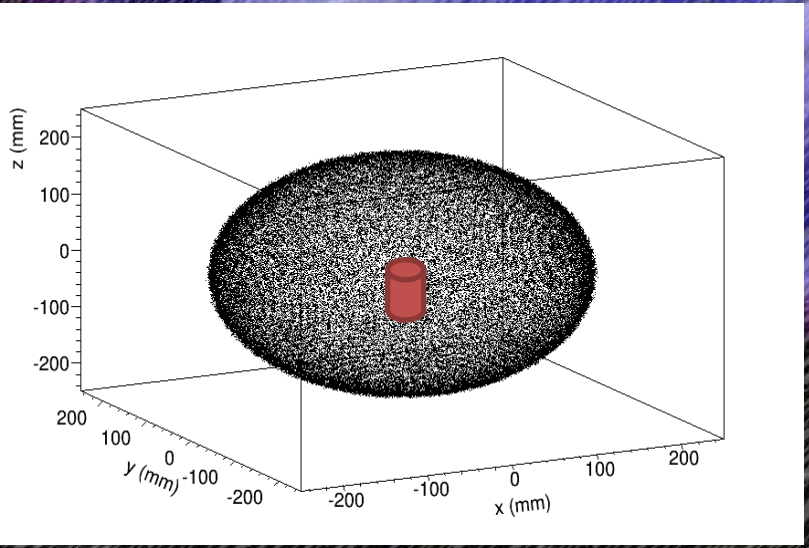






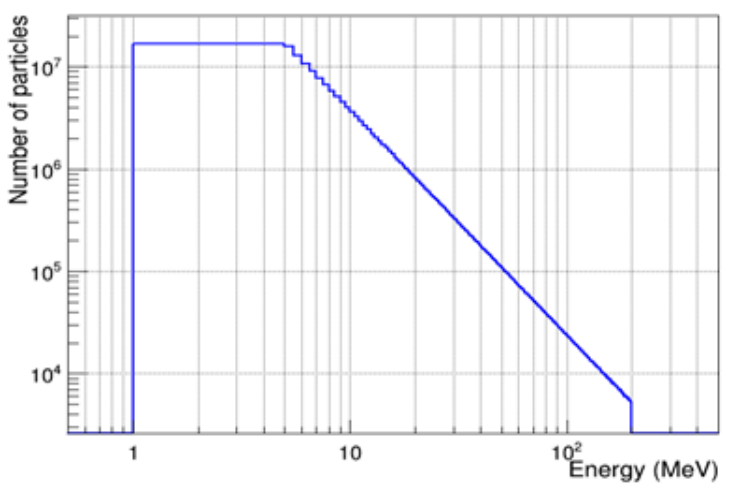
MC SIMULATION

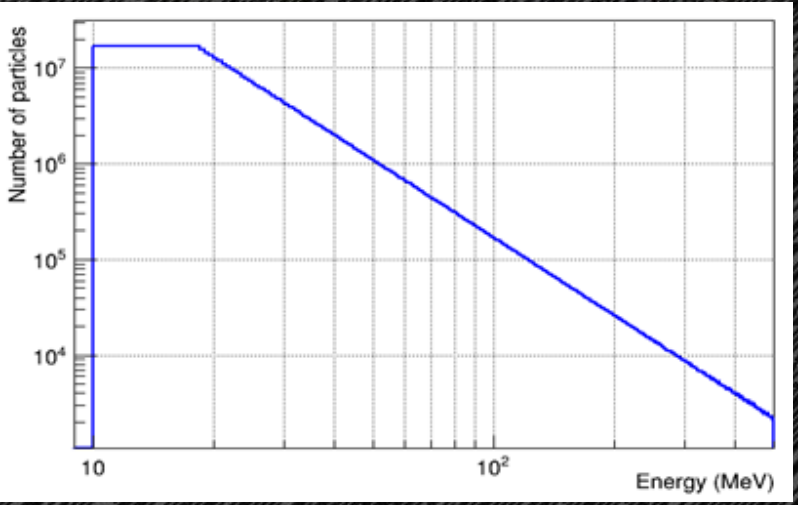




ELECTRONS 1-200 MeV
10^9 Events

PROTONS 10-500 MeV
10^9 Events





TRIGGER CONFIGURATIONS

Different trigger masks depending on the orbital zone!

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2. T1 & P1 & P2
3. T1 & P1 &P2 &P3
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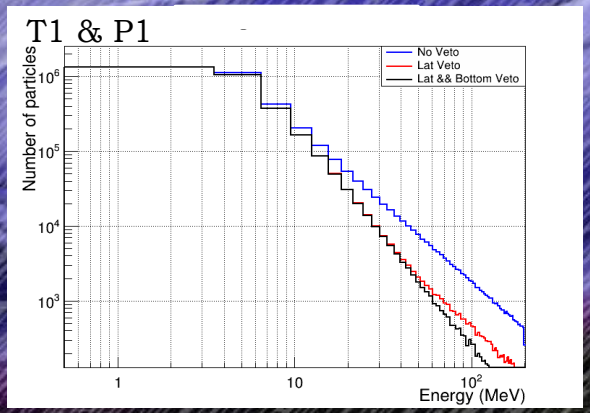
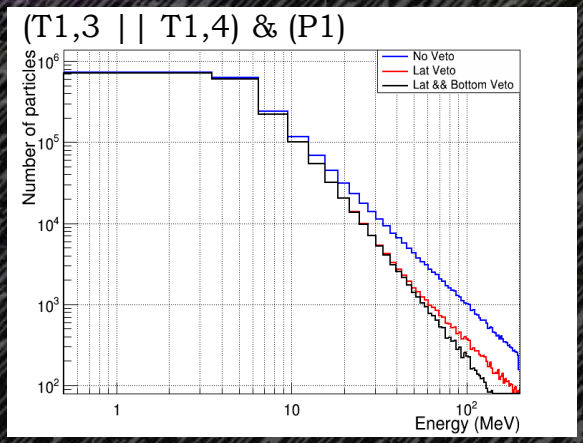
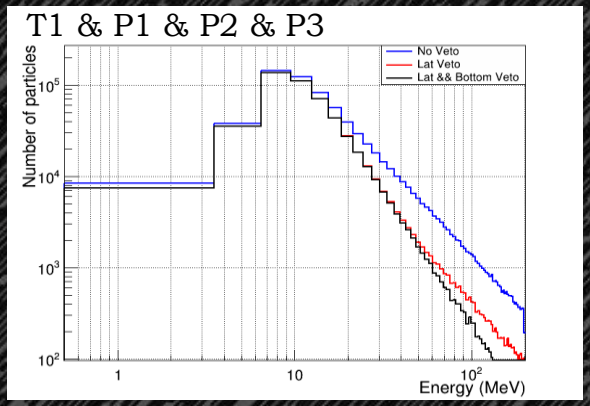
6. T1 & (P1 || P2) & (P16 || P15)
7. T1 & (P1 || P2) & P17

Each of these configurations have to be considered:

- without veto
- with lateral veto
- with the whole veto (lateral+bottom)

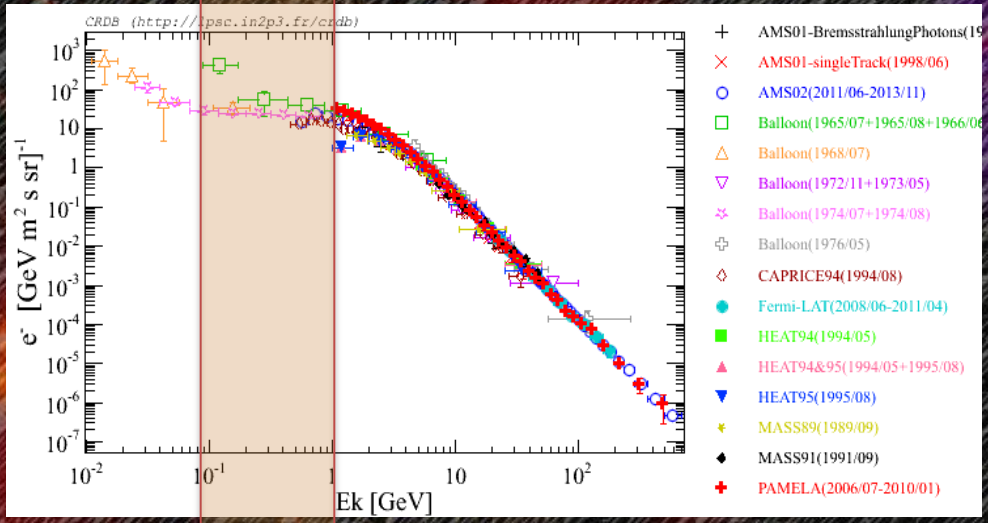


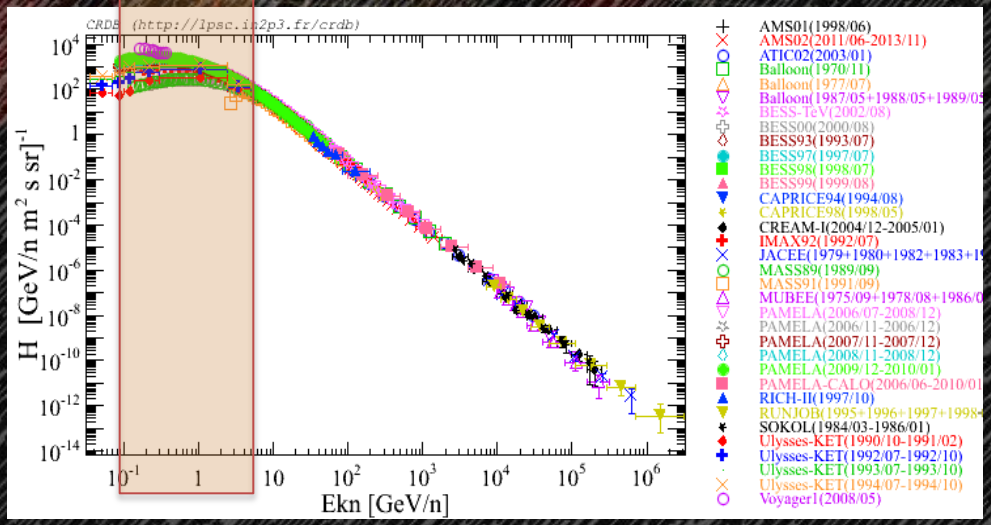


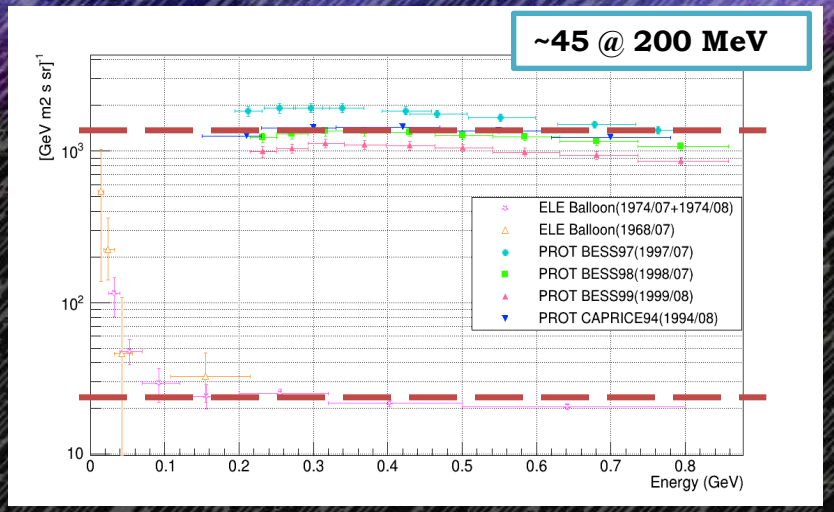


ELECTRON/PROTON DISCRIMINATION

Estimates of the electron discrimination power against protons





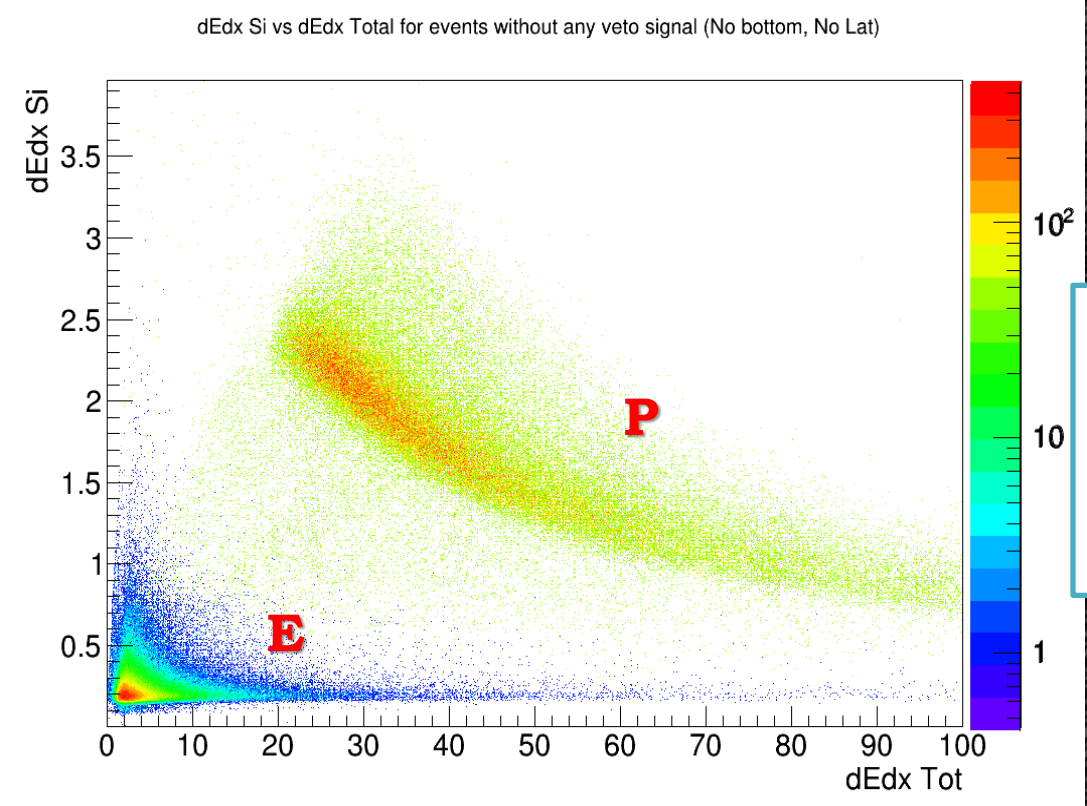


dE vs E method for discriminating electrons against protons

ELECTRON/PROTON DISCRIMINATION

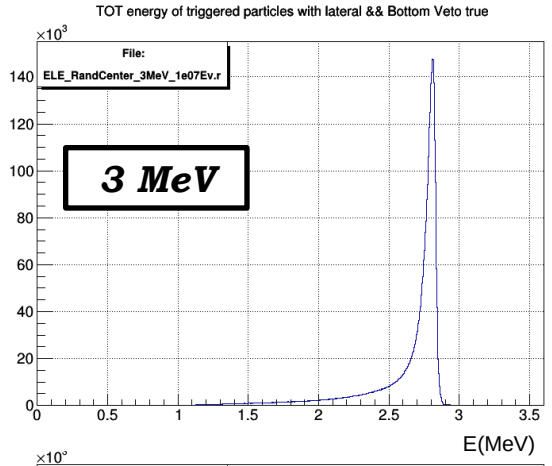
dE vs E method for discriminating electrons against protons

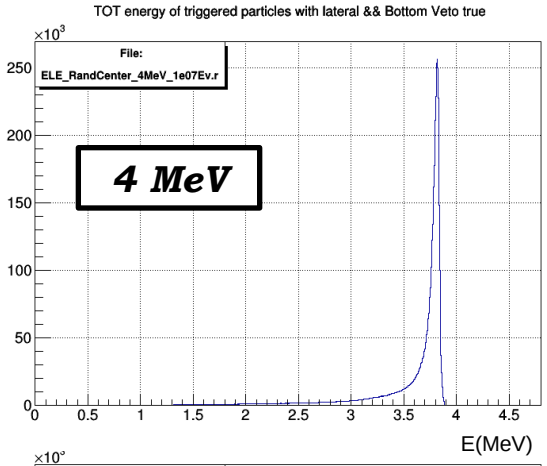
- *dE:* is the particle energy loss within the two layers of the silicon tracker
- *E:* is the energy released in the whole detector.

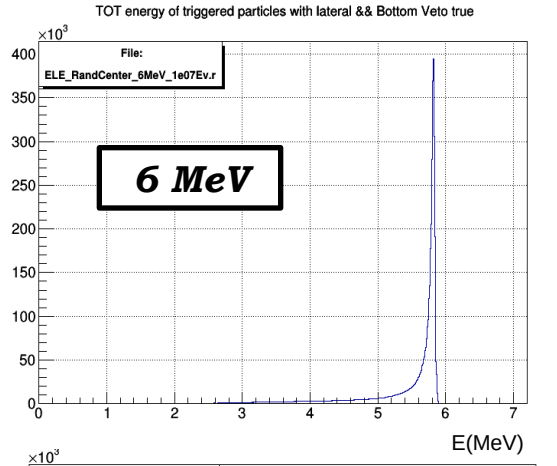


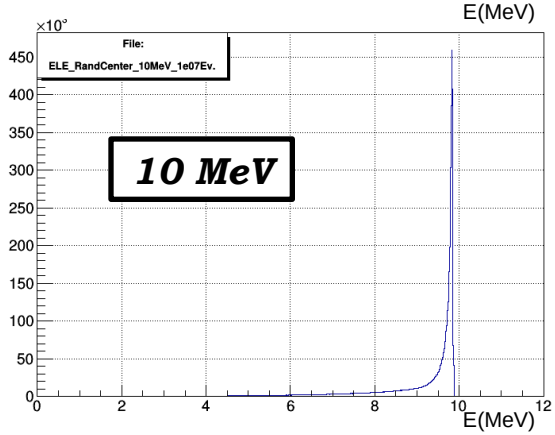
- Electron and proton distributions are very different
- Proton contamination into electron sample is negligible

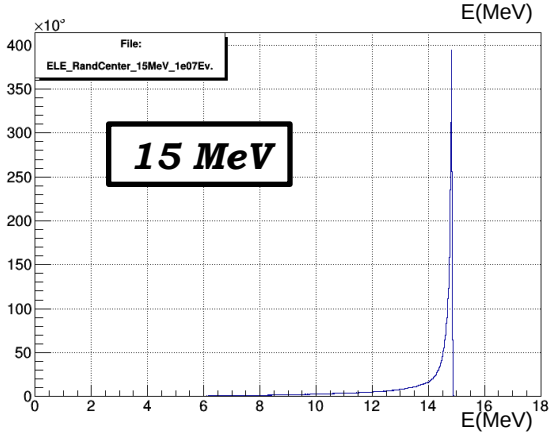
ELE - ENERGY RESOLUTION

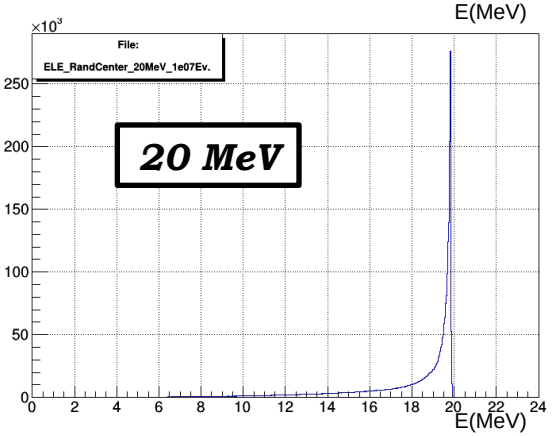


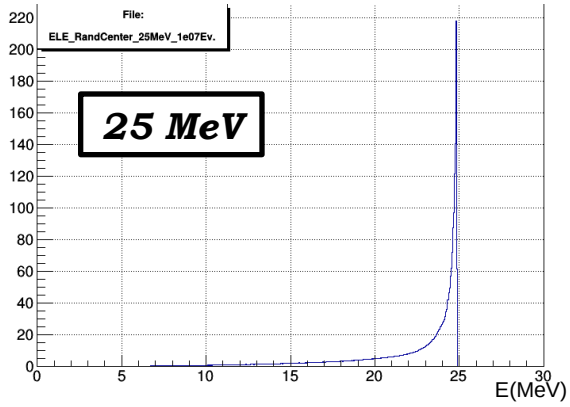


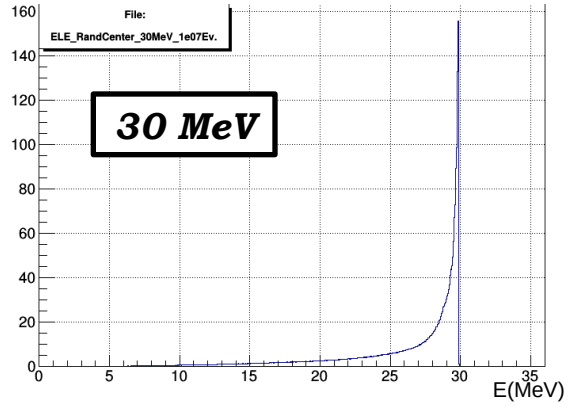


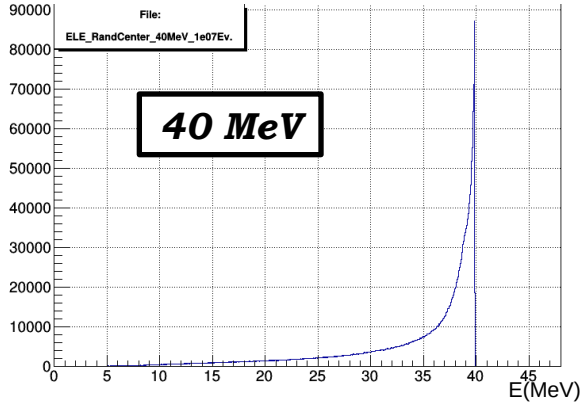




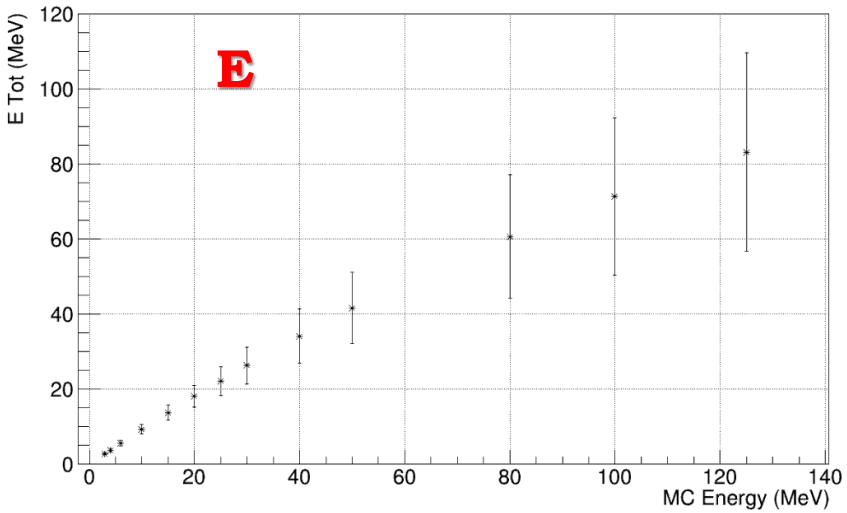








ENERGY RESOLUTION



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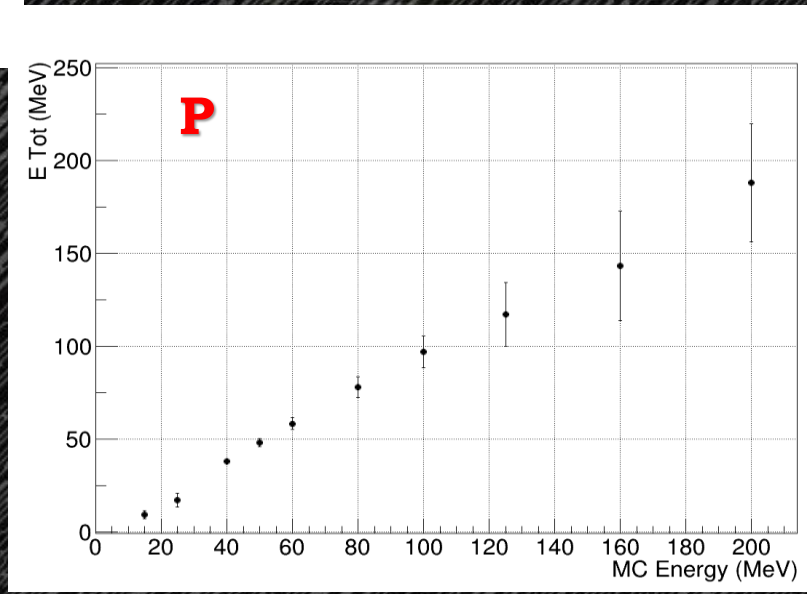


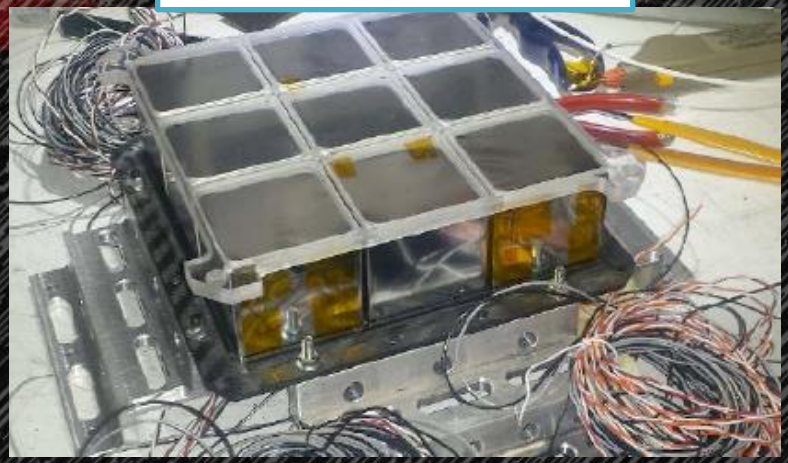
THE QUALIFICATION MODEL

4 HEPD versions must be produced:

- Electrical Model, EM (2014)
- Structural and Thermal Model, STM (2015)
- Qualification Model, QM (2016)
- Flight Model (FM) (under construction)

Front view: The trigger system with its six segments is visible

The bottom part of the HEPD QM calorimeter. The 9 LYSO crystals are shown

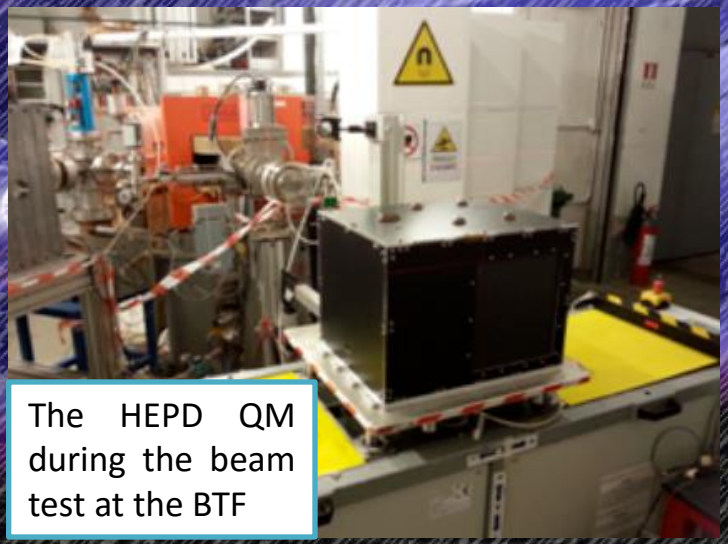


Side view: The 16 plastic scintillator planes can be seen. The PMTs are at the corners of each calorimeter plane

TEST BEAM @BTF

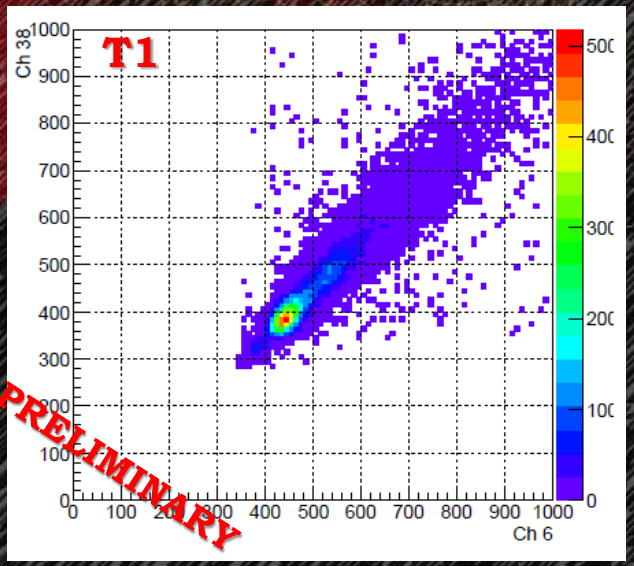
Beam test @BTF of the "Laboratori Nazionali di Frascati" of INFN

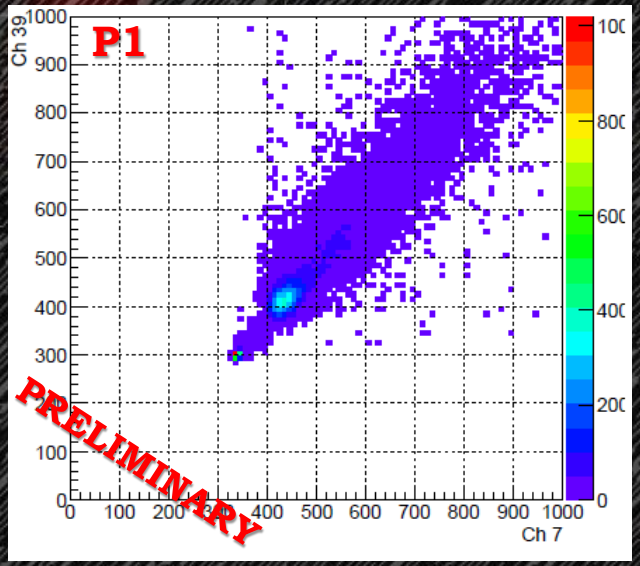
- Electrons and positrons from 30 to 150 MeV

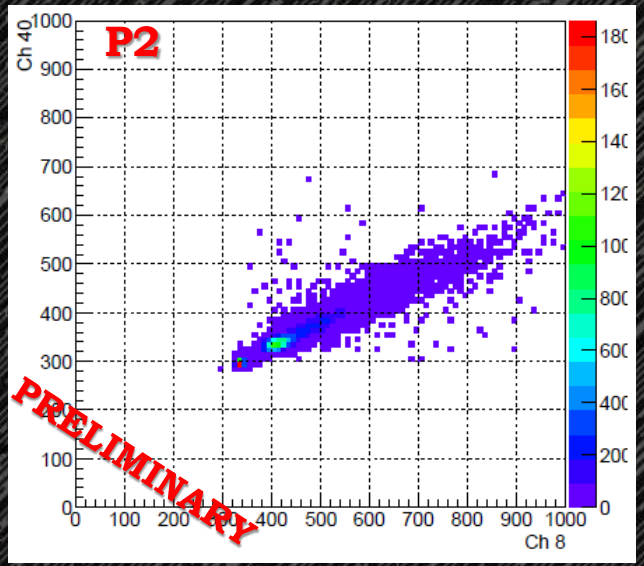


The HEPD QM during the beam test at the BTF

Electrons 30 MeV
~10^4 events







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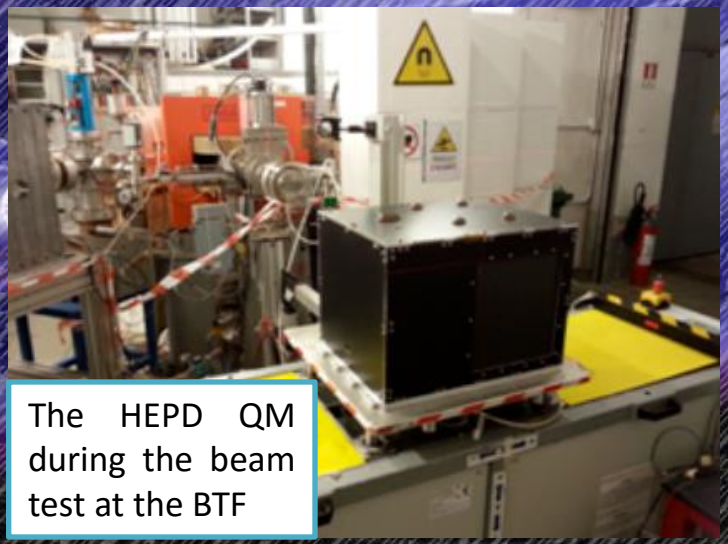

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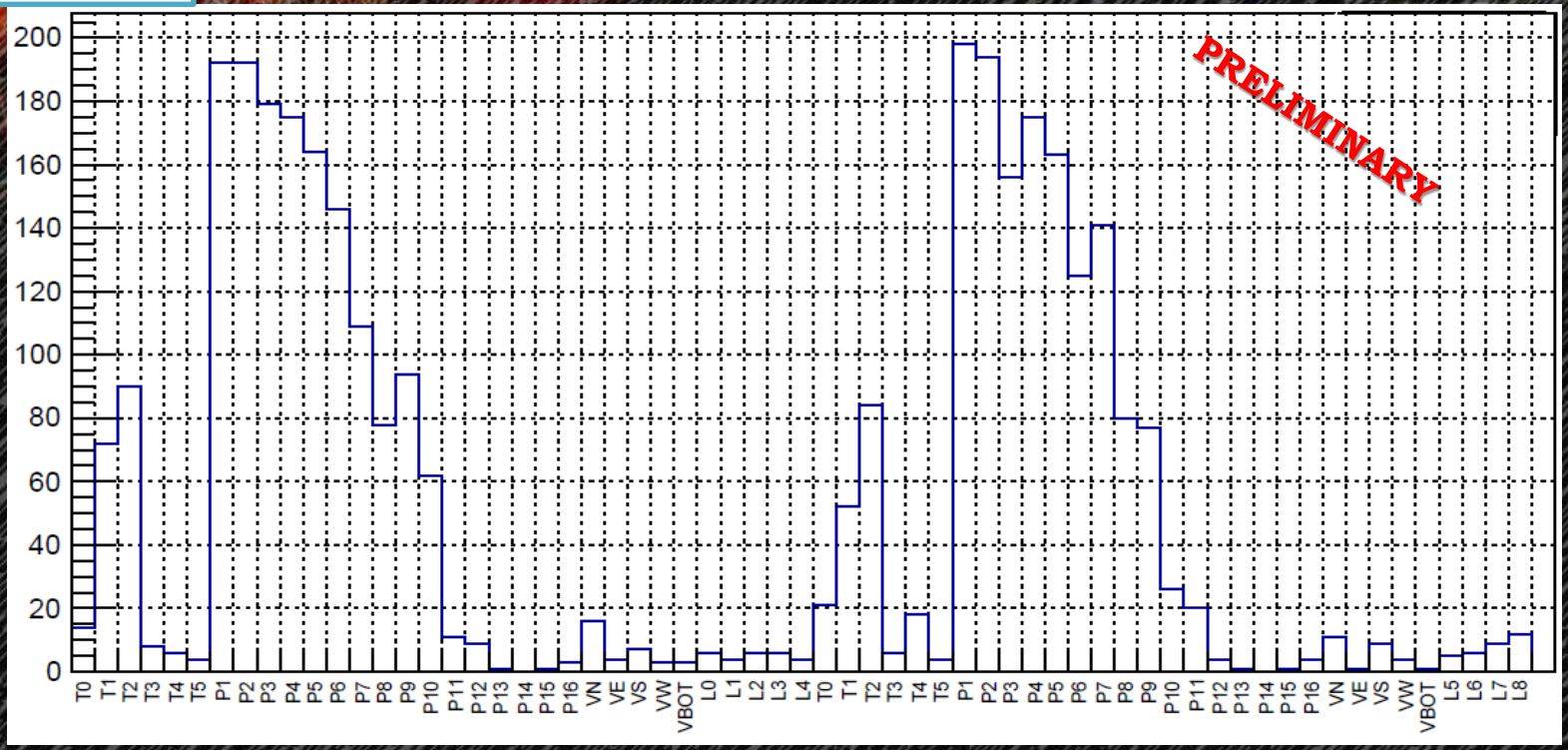

CONCLUSIONS

- ✓ Trigger configurations have been chosen according to the available bandwidth for the data transfer
  - ✓ It is changed depending on the orbital zones crossed by the satellite
- ✓ Requests on energy resolution and electron/proton discrimination have been answered
- ✓ HEPD Qualification Model has been tested
  - ✓ Beam test @BTF of the "Laboratori Nazionali di Frascati" of INFN
    Data under study
- ✓ HEPD Flight Model under construction
  - ✓ Delivery on September/October 2016