

### The HEPD apparatus for the CSES mission

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# 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 2017, August



# THE CSES MISSION

### **CSES**: China Seismo-Electromagnetic Satellite

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 – LIMADOU 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 <sup>7</sup> cm <sup>-2</sup> s <sup>-1</sup> sr <sup>-1</sup> (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 doubleside 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, 7<sup>th</sup> – November, 30<sup>th</sup> 2006 (142 Days) December 13<sup>th</sup> : Solar flares is excluded Latitude: [-60°;+60°] Altitude: [490 – 520] km Geometric factor PAMELA/HEPD ~ 6



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





## THE HEPD MODELS

4 HEPD versions must be produced:

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

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



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





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

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

Electrons and positrons from 30 to 150 MeV

The HEPD FM during the beam test at the BTF

Electrons 30 MeV ~10<sup>4</sup> events





#### **Electrons 30 MeV**





#### **Electrons 30 MeV**

Event selection: NoLateral Veto hit No Bottom veto hit More than 12 crossed planes

Total charge measured in the Calo for different impact point of the beam





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#### Electrons 30 – 120 MeV

Event selection: NoLateral Veto hit No Bottom veto hit More than 12 crossed planes



## TEST BEAM @Trento

Beam test @Proton Cyclotron of Trento

Protons from 51 to 300 MeV

Number of hit Calo planes 51 MeV 25000 70 MeV 100 MeV 154 MeV 125 MeV 20000 174 MeV 15000 10000 5000 0 13 14 5 6 8 9 10 11 12 15 16 Number of hit counters The HEPD FM during the beam test at Trento



### **TEST BEAM @Trento**

#### **Energy loss in the Calo**



## TEST BEAMS

#### Fully contained protons



## **TEST BEAM @Trento**

nice

#### **Energy loss in the LYSO**





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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 Flight Model has been tested

✓ Beam test @BTF of the "Laboratori Nazionali di Frascati" of INFN
✓ Beam test @Proton Cyclotron of Trento
*Data under study*

✓ HEPD Flight on August, 16<sup>th</sup> 2017