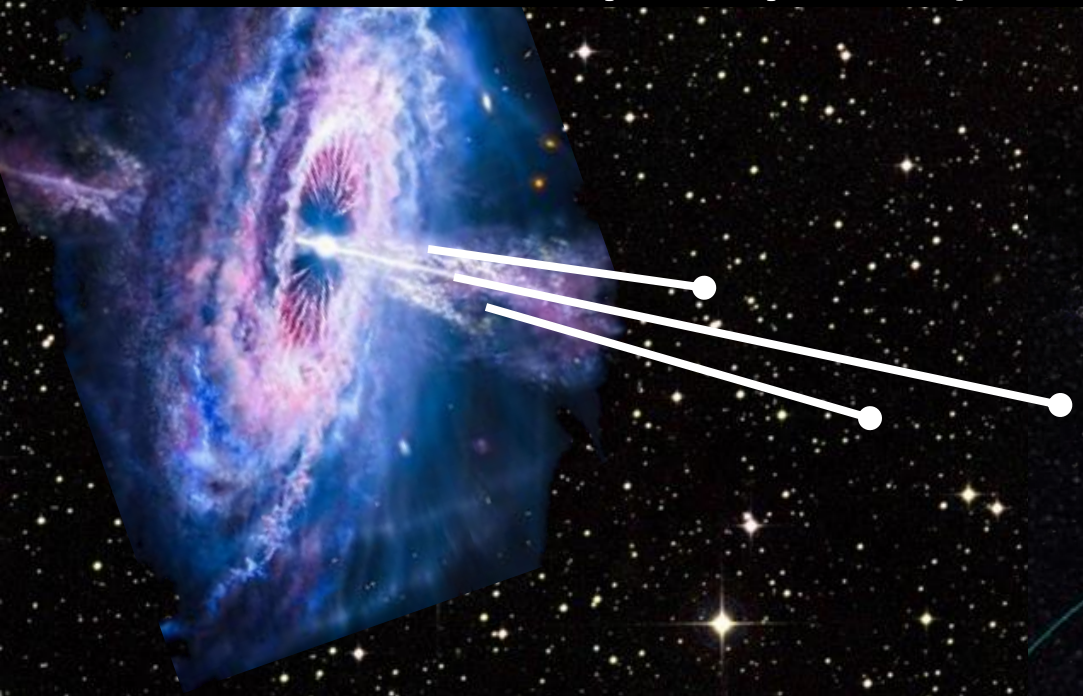
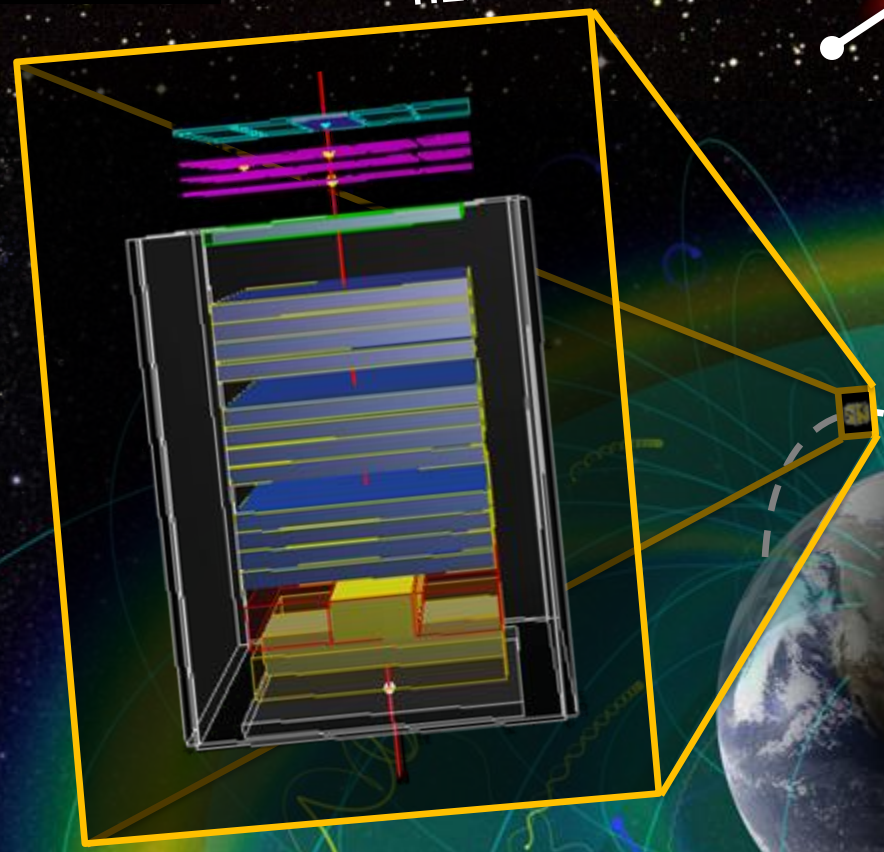
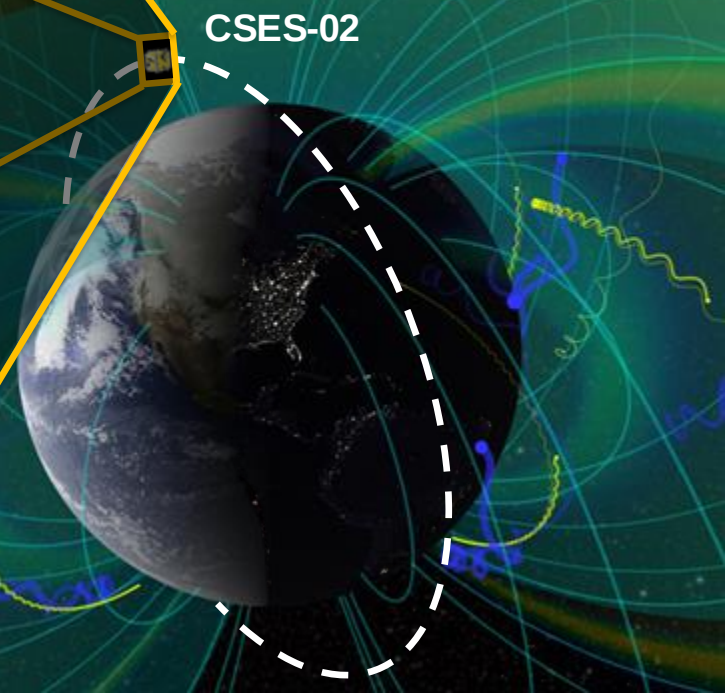
First Physics Results of the High Energy Particle Detector aboard the CSES-02 Satellite

IMAPP Internship Proposal (UniBo-INFN)







Alberto Oliva
INFN Section of Bologna, Italy

Astroparticle Physics

Separation between **astroparticle physics** and **astrophysics** is somehow artificial. It refers mainly to the fact that the measurement are carried out using **high-energy particle-physics detection techniques**. Two main categories:

- **Charged (or Cosmic Rays)**: e^-, e^+, p, $\bar{p}$, nuclei and anti-nuclei with |Z|>1.
- **Neutral**: γ-rays (photons with E>MeV) and neutrinos.

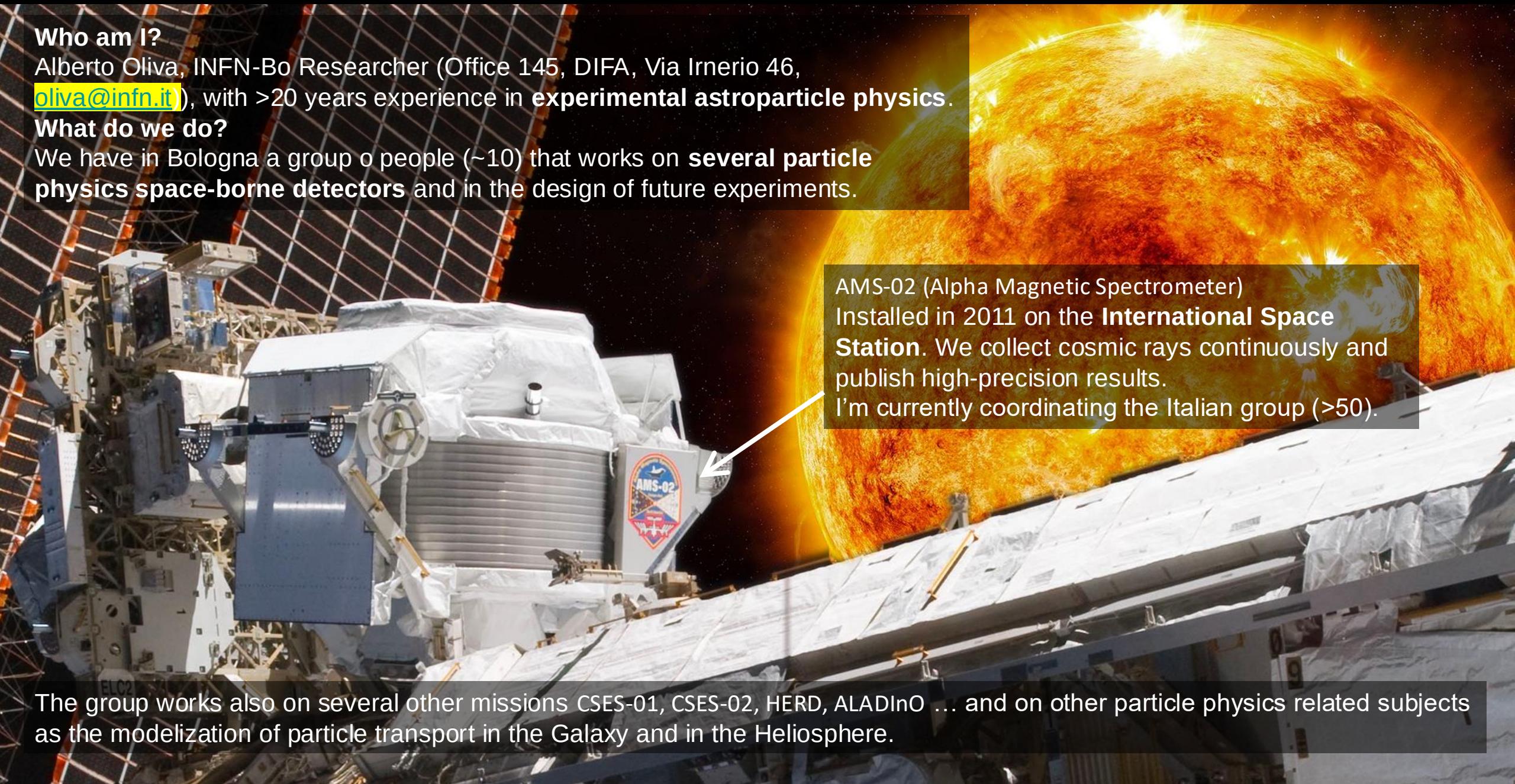
γ-ray: high energy photons (>MeV), point to their source.

Neutrinos (υ): weakly interacting, carry information from very far away.

Cosmic Ray (CRs): charged particles. They are deflected by magnetic fields and may generate the υ and γ backgrounds.

Astroparticle Physics from Space in INFN-Bo

Who am I?
Alberto Oliva, INFN-Bo Researcher (Office 145, DIFA, Via Irnerio 46, oliva@infn.it), with >20 years experience in **experimental astroparticle physics**.
What do we do?
We have in Bologna a group o people (~10) that works on **several particle physics space-borne detectors** and in the design of future experiments.

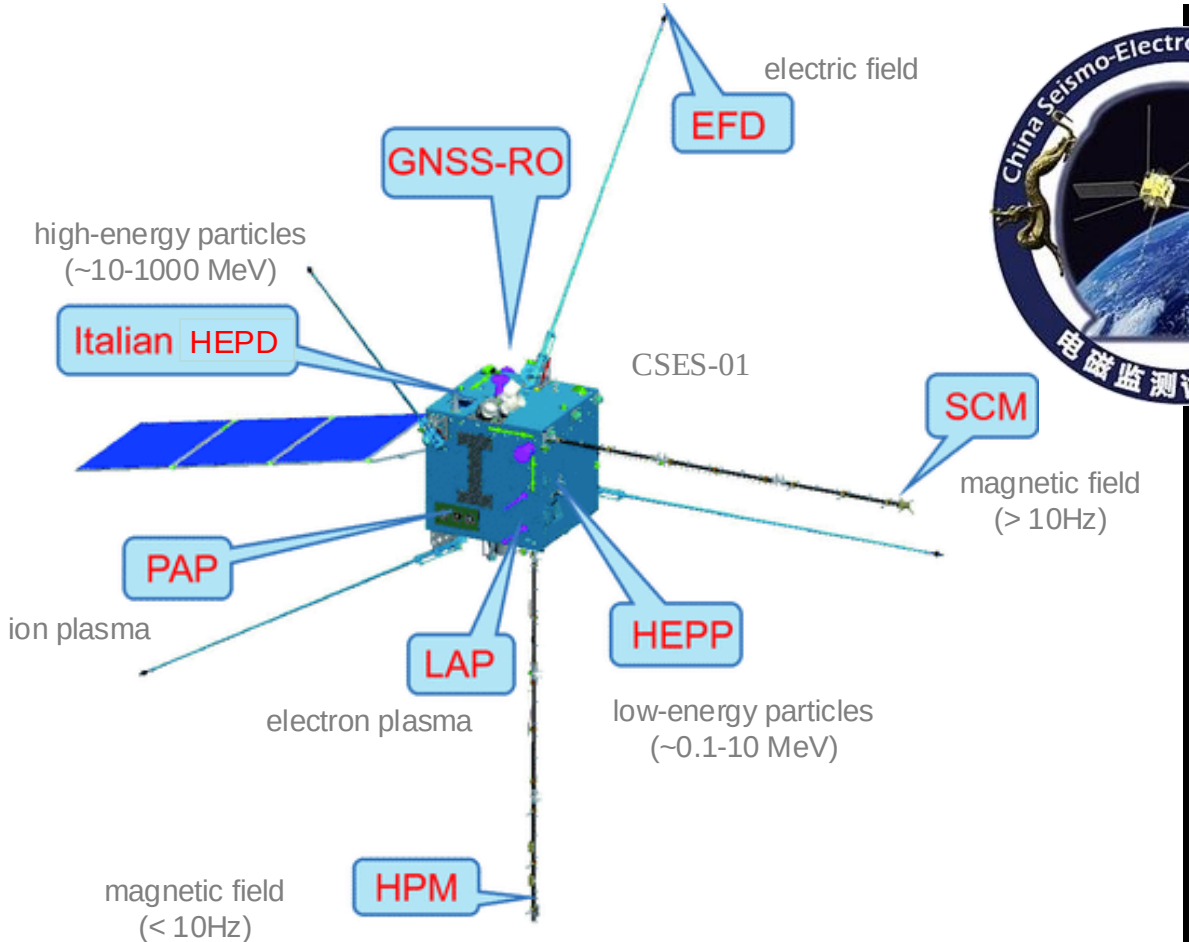


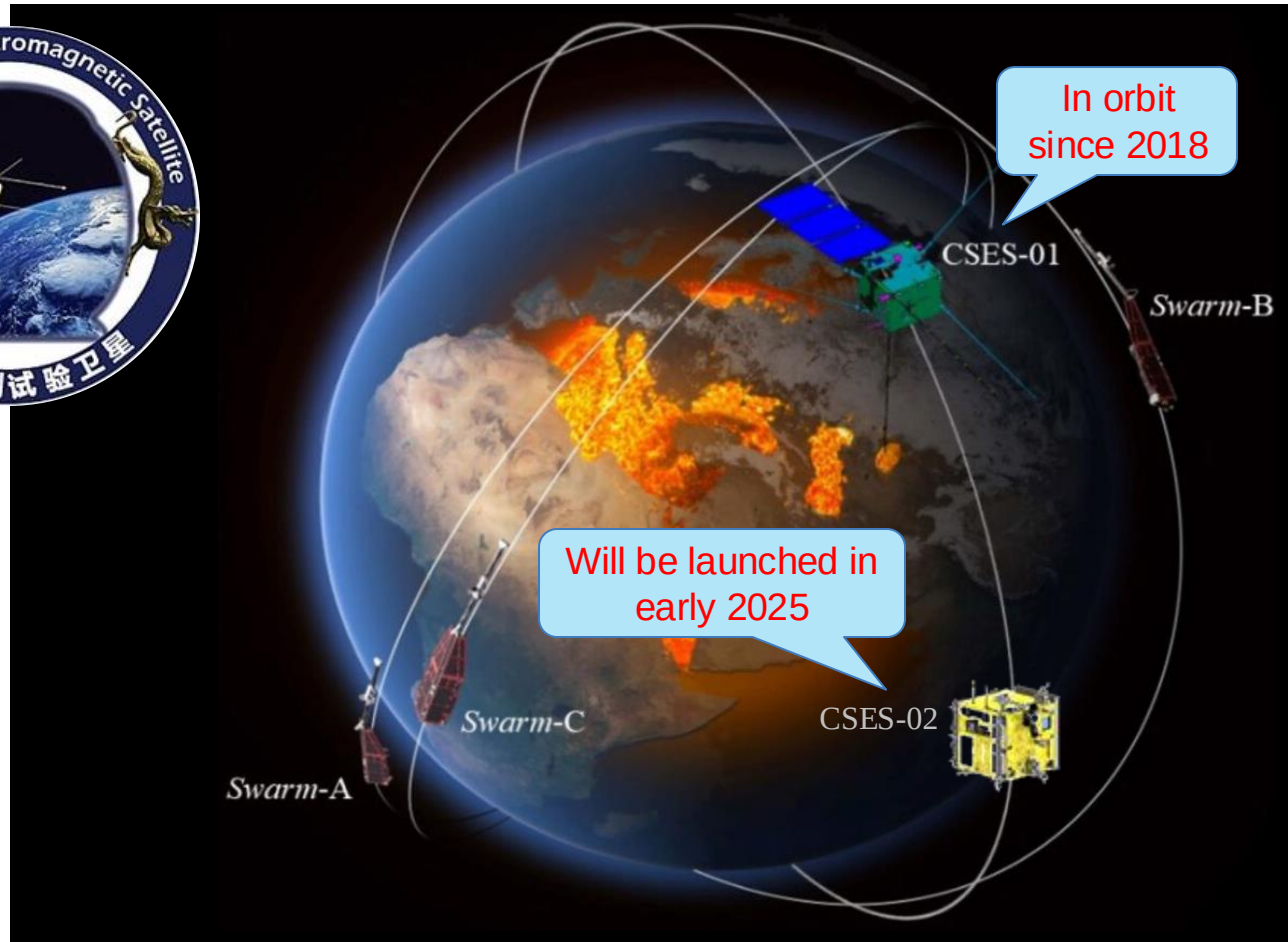
AMS-02 (Alpha Magnetic Spectrometer)
Installed in 2011 on the **International Space Station**. We collect cosmic rays continuously and publish high-precision results.
I'm currently coordinating the Italian group (>50).

The group works also on several other missions CSES-01, CSES-02, HERD, ALADInO … and on other particle physics related subjects as the modelization of particle transport in the Galaxy and in the Heliosphere.

The CSES Scientific Mission

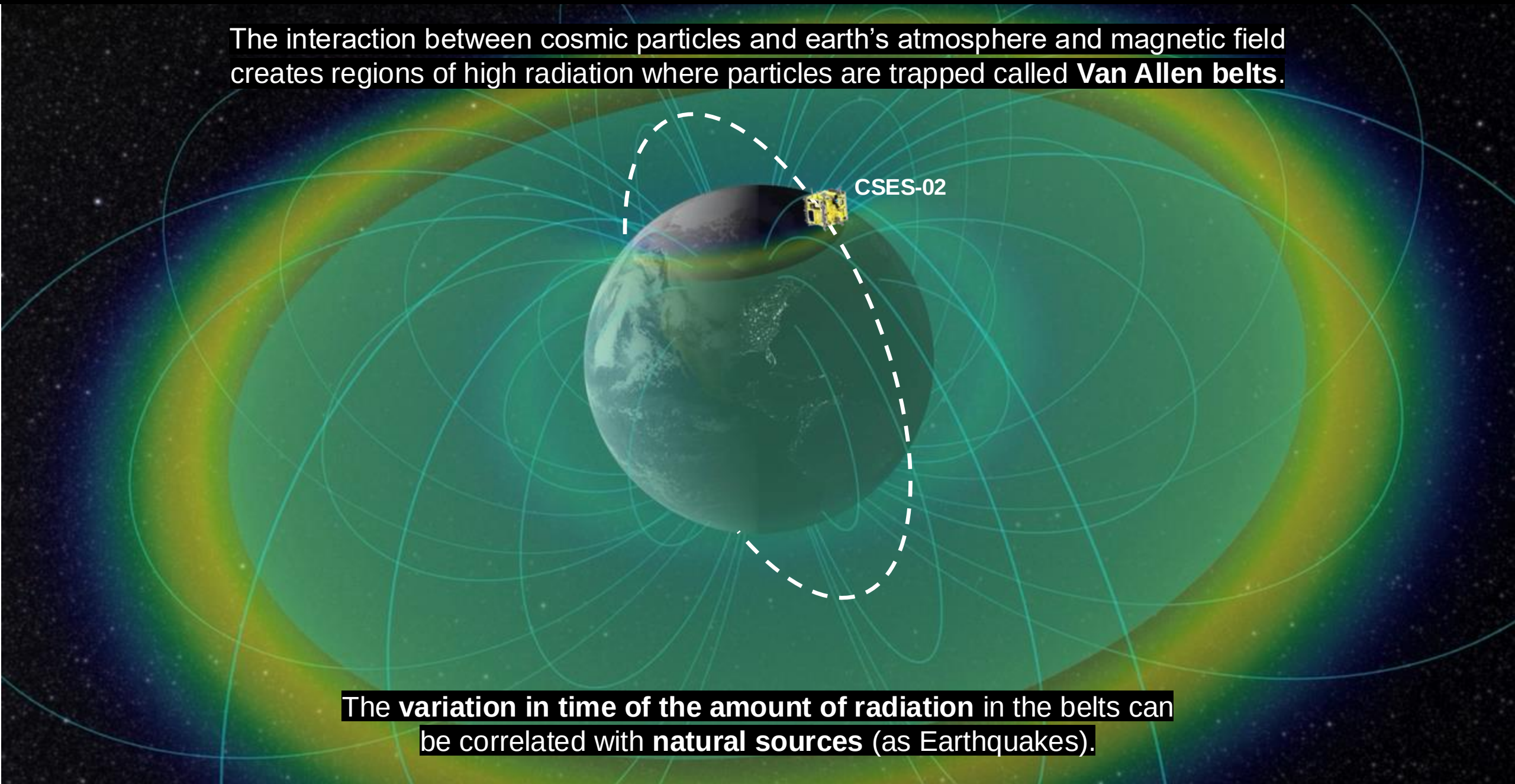
- The CSES (China Seismo-Electromagnetic Satellite) is a space mission in collaboration between Universities and research institutes of Italy and China (including UniBo and INFN-Bo).
- It consists in a constellation of satellites characterizing the **near-Earth environment** and its **time variation**.
- The first satellite, CSES-01, was launched the 2nd Feb. **2018**, and is on a polar sun-synchronous orbit at an altitude of ~500 km.
- The second one, CSES-02, is almost ready, and will be launched in **early 2025**.
- On each satellite several detectors measure with high resolution and continuously in time **particles** (protons, electrons, high-Z ions) in a wide energy range, **plasma**, **electromagnetic waves**, **magnetic** and **electric fields**.





The CSES Scientific Mission Goals

The interaction between cosmic particles and earth's atmosphere and magnetic field creates regions of high radiation where particles are trapped called **Van Allen belts**.



The **variation in time of the amount of radiation** in the belts can be correlated with **natural sources** (as Earthquakes).

The HEPD/CSES Scientific Mission Goals

SUN

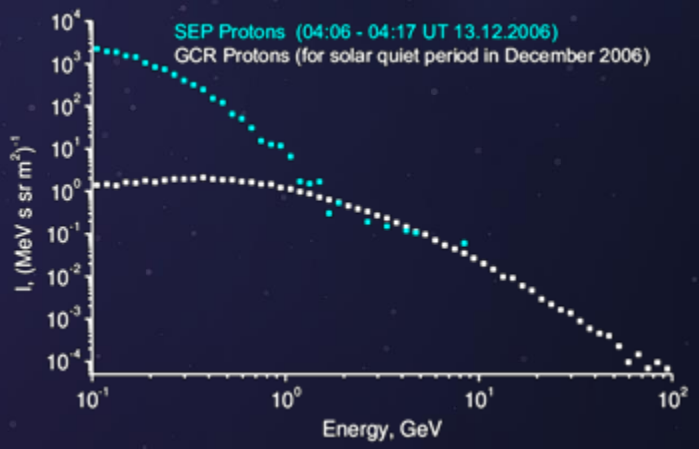
SOLAR RADIATION

Monitor the Earth's ionosphere with high precision and study the correlation between near-Earth environment to look for correlation with natural events, or anthropic emitters.

MAGNETOSPHERE

EARTH

Study the effect of the Sun on the near-Earth environment, as the effect of solar wind on cosmic rays, acceleration of particles due to the Sun, …



GALACTIC RADIATION

Study the low-energy origin and propagation of galactic cosmic rays.

SUPERNOVA

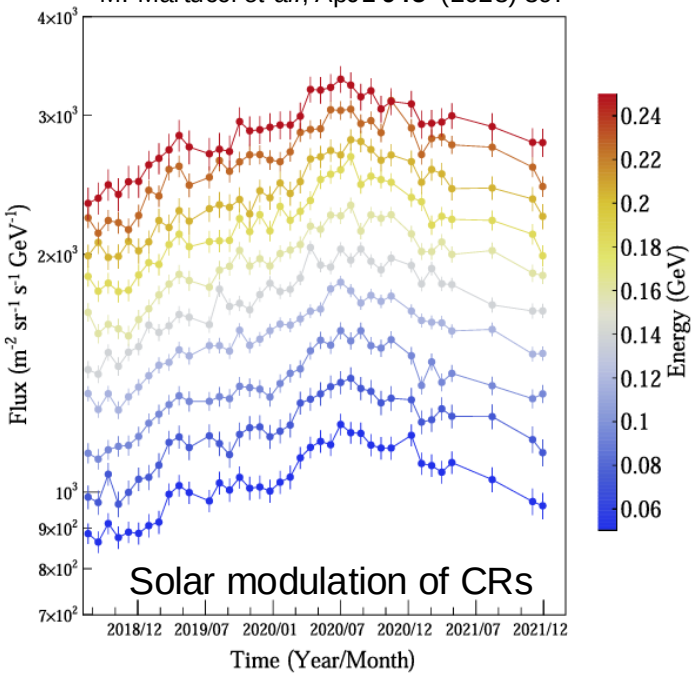
The High Energy Particle Detectors (HEPDs) of CSES

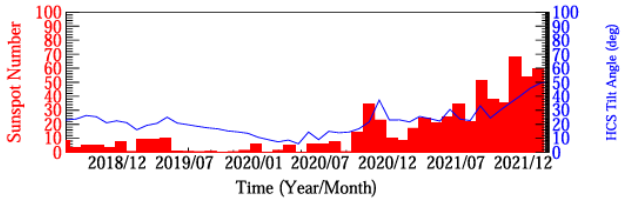
HEPD-01/CSES-01

A calorimeter measuring electrons in the range between 3 and 100 MeV, protons and nuclei between 30 and 200 MeV/n.

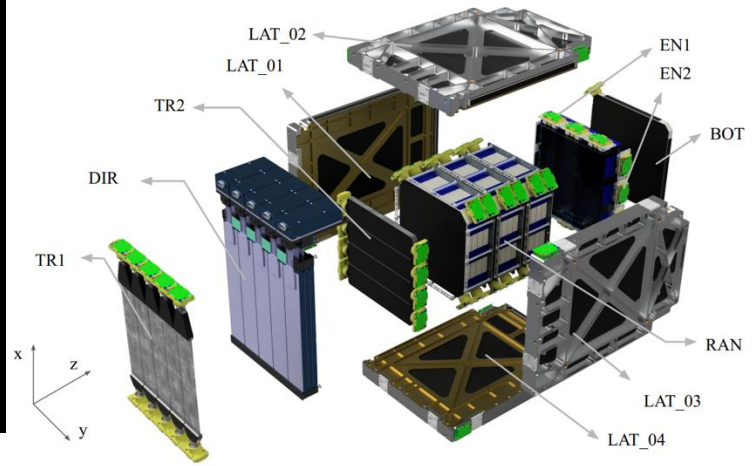
Launched in 2018 in geosynchronous orbit, monitors the Earth's radiation environment.

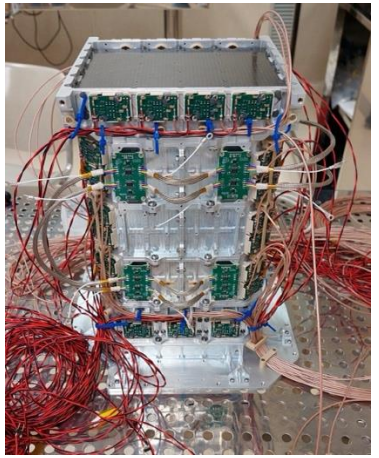
M. Martucci *et al.*, ApJL **945** (2023) 39.



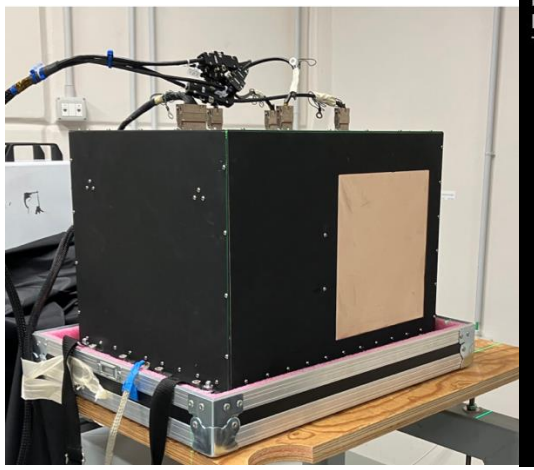


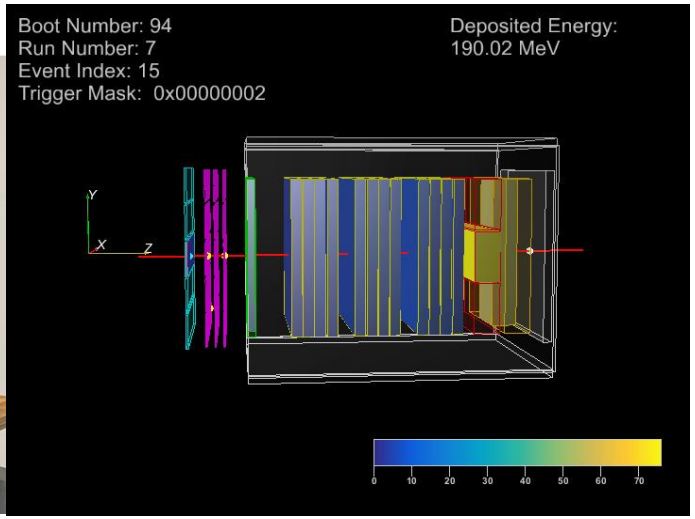
HEPD-02/CSES-02





Major upgrade in the design of HEPD-01, extending to lower energies, reducing passive materials in the detection volume, and adding pixel detector.

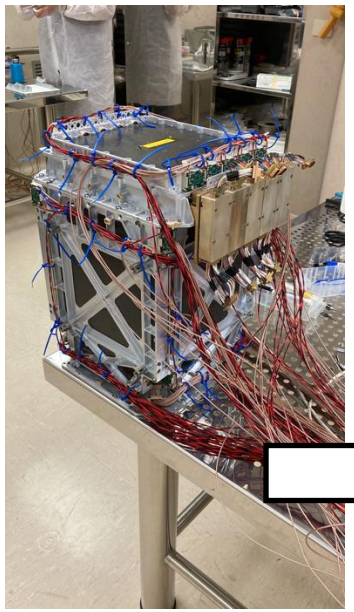


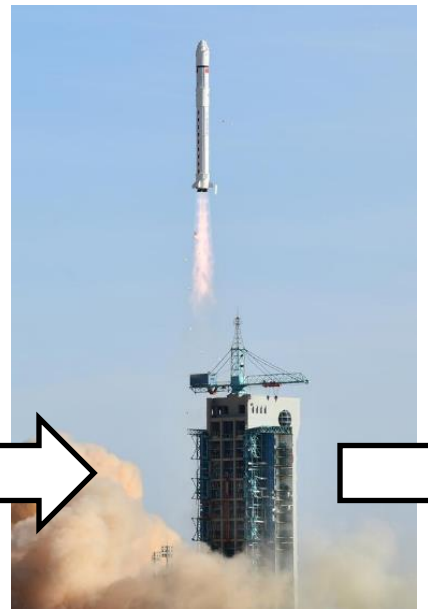


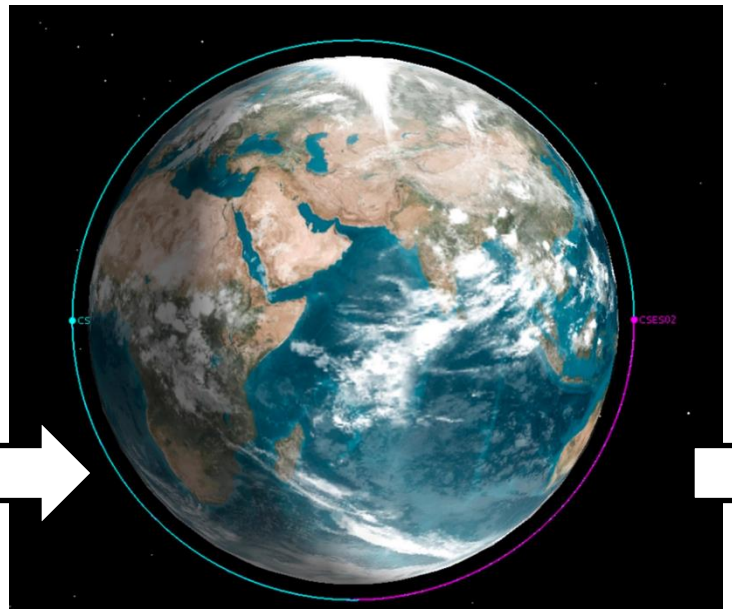
Fully constructed and space qualified, integrated in CSES-02, we are waiting for the launch.

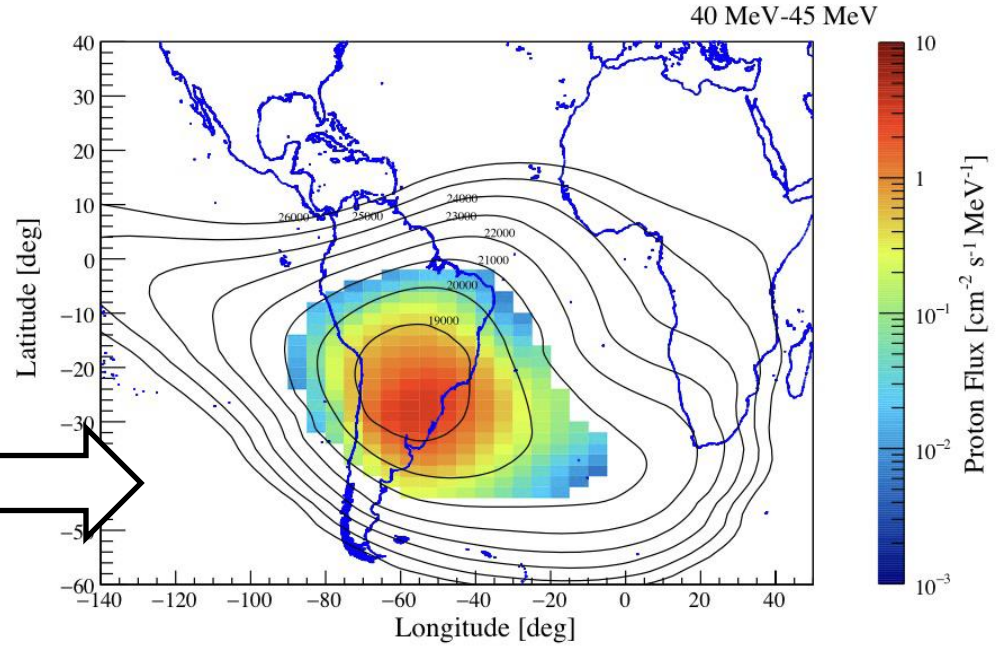
What the Training Will Be About

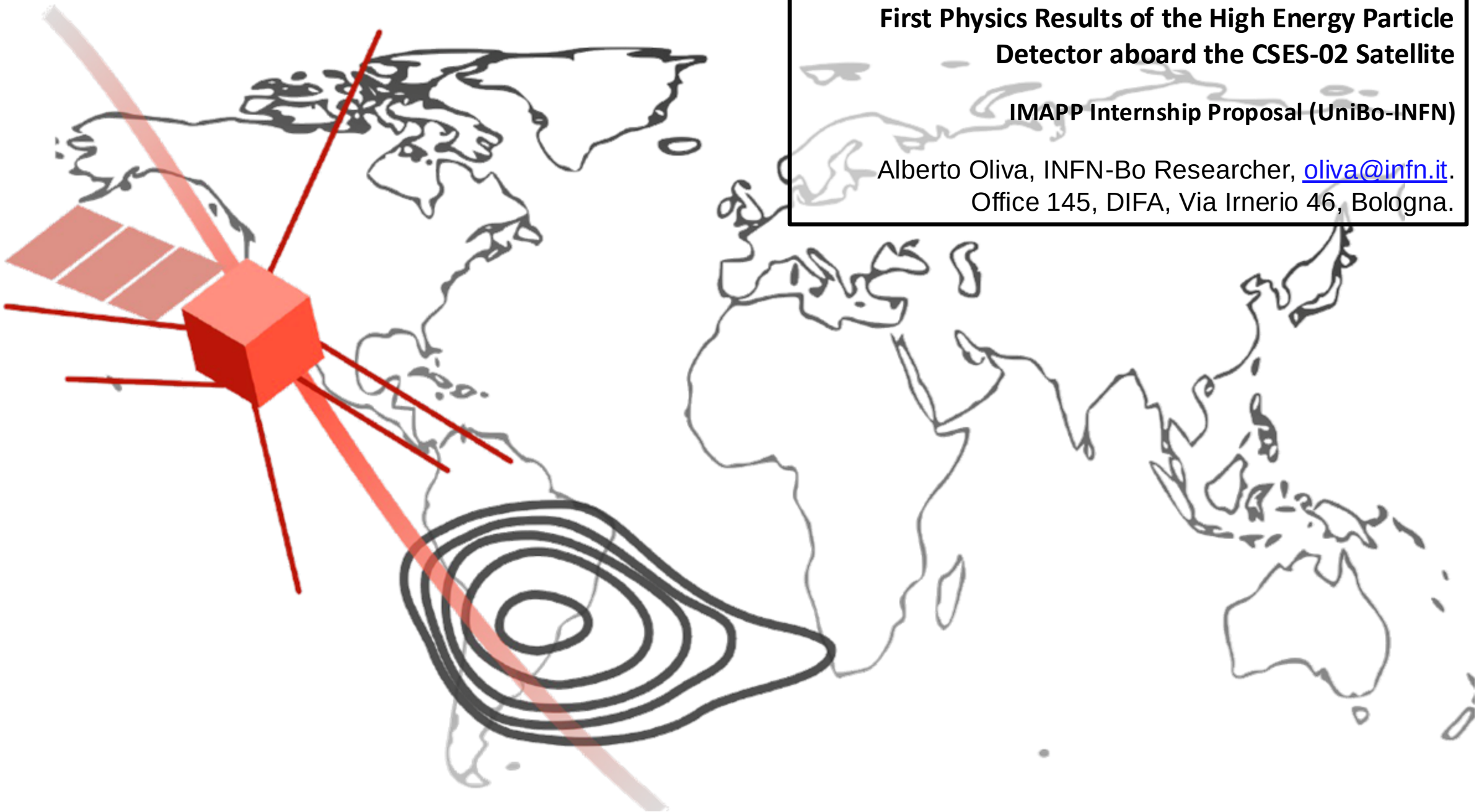
- Acquire a **background about cosmic ray physics** in the magnetosphere, in the heliosphere and in the Galaxy.
- Acquire a **background on the CSES mission** and its goals.
- Acquire an **understanding of the HEPD-02 detector**, what is measuring and how.
- Participate in the **analysis of the HEPD-02 data acquired on ground** in the last year to develop an analysis chain that can be readily used for the study of performances in orbit.
- During the launch in 2025, **participate in the commissioning** of the experiment.
- Study the performances and **get first physics results with HEPD-02** in space.











First Physics Results of the High Energy Particle Detector aboard the CSES-02 Satellite

IMAPP Internship Proposal (UniBo-INFN)

Alberto Oliva, INFN-Bo Researcher, oliva@infn.it.
Office 145, DIFA, Via Irnerio 46, Bologna.