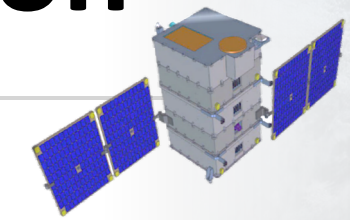
GRAN SASSO SCIENCE INSTITUTE
SCHOOL OF ADVANCED STUDIES
Scuola Universitaria Superiore

INFN
Istituto Nazionale di Fisica Nucleare

The NUSES space mission



Margherita Di Santo

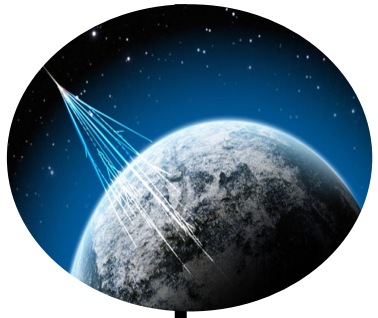
8th GSSI Astroparticle Physics Science Fair
L'Aquila, Feb. 15th, 2022
www.gssi.it

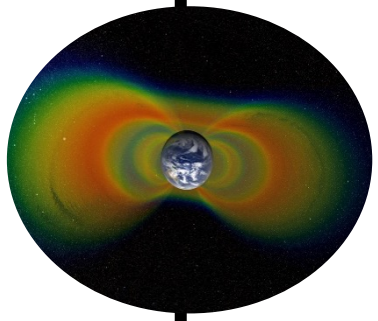
THE PROJECT

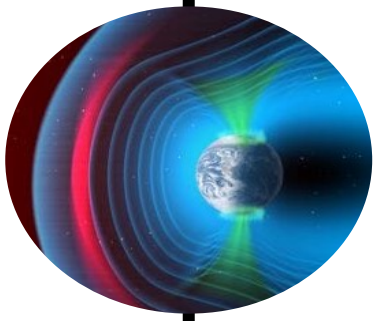
- ✓ approved by the Italian government as a flagship initiative to relaunch the economy of **L'Aquila (AQ)** area.
- ✓ funded by the Italian government and the Italian Minister for economic development.
- ✓ industrial partnership with Thales Alenia Space Italy (TAS-I).

- **Gran Sasso Science Institute (GSSI)**
- **INFN – Laboratori Nazionali del Gran Sasso**
- **Università dell'Aquila (UnivAQ)**
- **Università di Roma "Tor Vergata" & INFN-Roma2**
- **Università di Torino & INFN Torino**
- **Università di Trento & INFN-TIFPA**
- **Università di Bari & INFN**
- **Università di Padova & INFN**
- **Università di Napoli & INFN**
- **(Università del Salento & INFN)**

MISSION GOALS







TECHNOLOGICAL PATHFINDER

exploring and testing innovative technological and observational approaches for satellite-borne particle detectors

- **COSMIC RADIATION**

variability (fundamental for the effects on space missions with/without crew)

- **ASTROPHYSICAL NEUTRINOS**

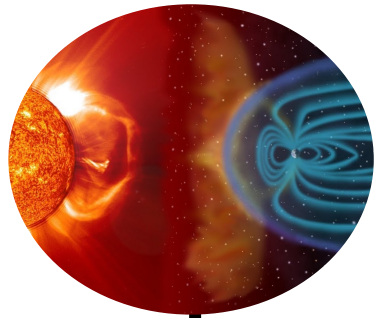
as probes of the deep universe of extreme astrophysical phenomena

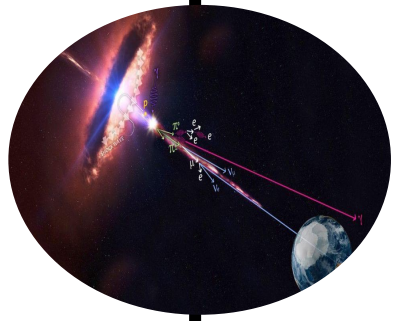
- **MAGNETOSPHERE-IONOSPHERE-LITOSPHERE COUPLING (MILC)**

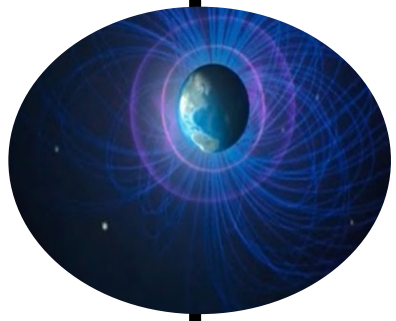
monitoring of the variations in the EM field and the particle flux both in the ionosphere and in the induced by natural sources, (seismic activities or anthropogenic emitters)

- **SUN-EARTH ENVIRONMENT**

- **SPACE WEATHER**







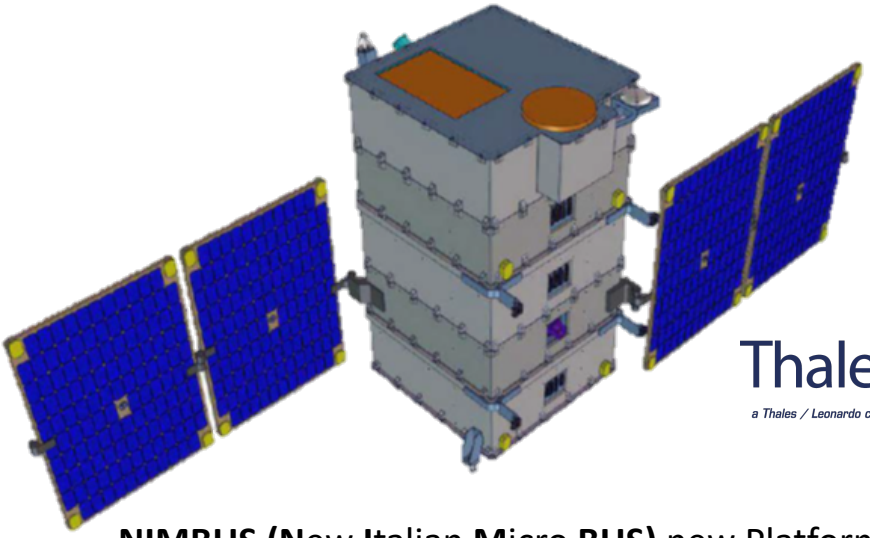
PAYLOADS

TERZINA

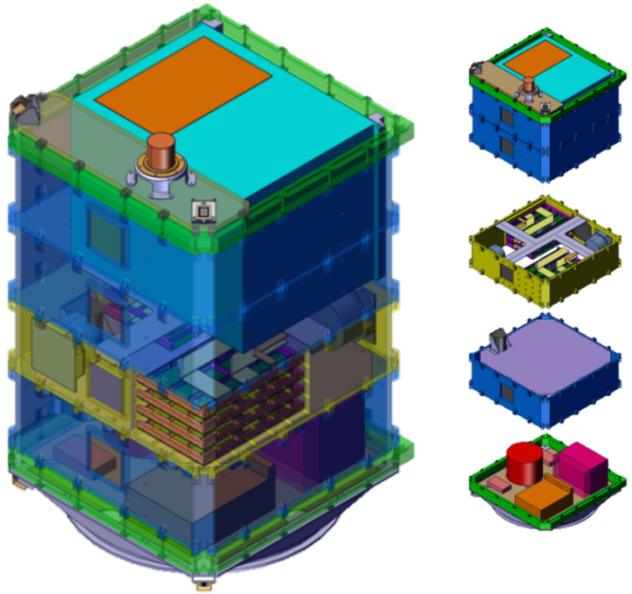
ZIRÈ

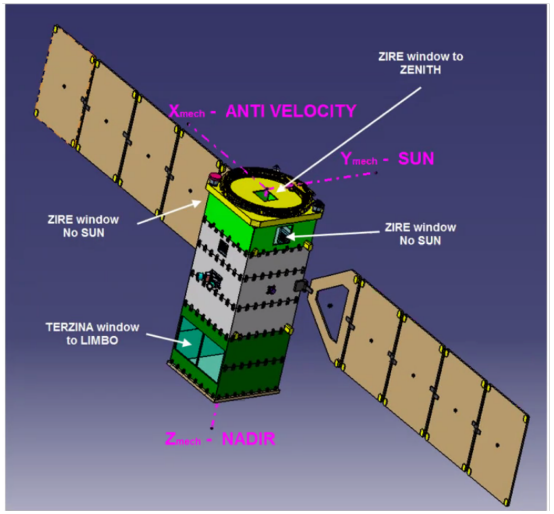
Pathfinder for future missions devoted to UHE cosmic ray and neutrino astronomy throught space-based atmospheric Cherenkov light detection. Characterization of the expected background in the observation of astrophysical neutrinos with energies higher than 100 PeV by employing the Cherenkov observation technique.

Monitoring of low energy (<250 MeV) CR fluxes, mainly electrons and protons, to study Van Allen belts, space weather and lithosphere-ionosphere-magnetosphere couplings.
Detection of 0.1 MeV – 10 MeV photons for the study of transient (GRB, e.m. followup of GW events, SN emission lines,…) and steady gamma sources.



ThalesAlenia Space
a Thales / Leonardo company



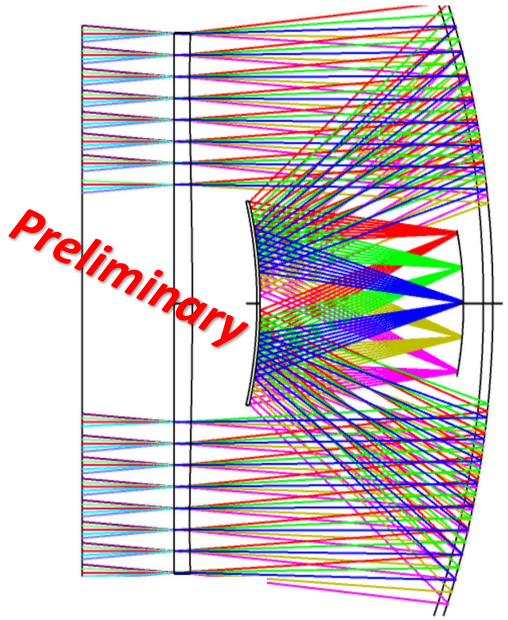


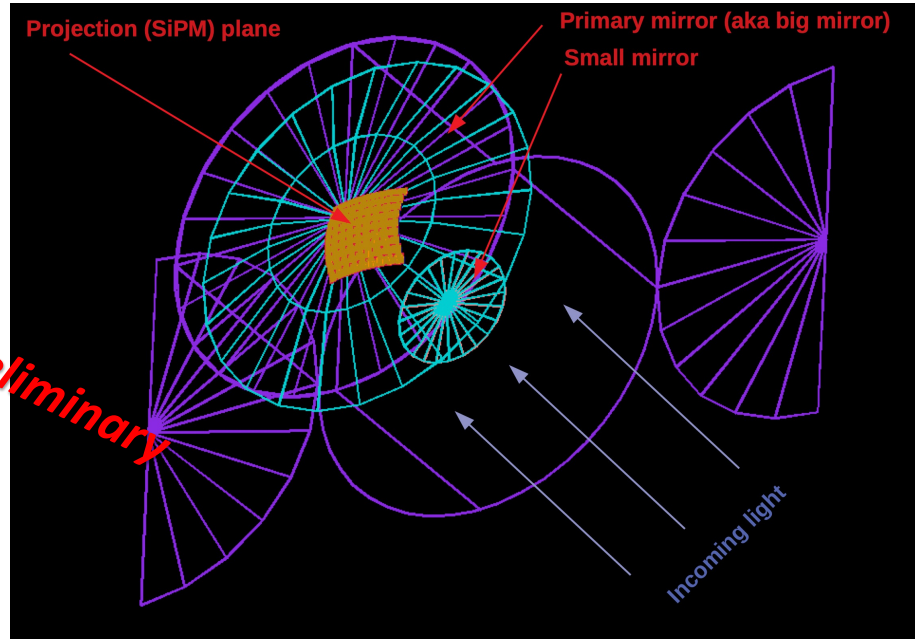
NIMBUS (New Italian Micro BUS) new Platform concept for low orbit microsatellites (LEO) which foresees a modular approach relying on standard trays.

TERZINA PRELIMINARY DESIGN

Preliminary optical design :

- a **Primary mirror** with an oblate spheroidal geometry characterized by a diameter of 0.56 m and a radius of curvature (RoC) of ~ 0.8 m:
- an oblate spheroidal **Secondary mirror** with a 0.2 m diameter and RoC of ~ 0.36 m;
- multi-pixel focal surface detector based on **Silicon Photo Multiplier (SiPM)** technology;
- a PMMA made planar surface adopted as **Corrector** for the incident photon angles.





TERZINA will point to the dark side of the earth's limb by detecting the expected background for a large area Cherenkov telescope in Space.
By orienting it at the limb, where CRs can produce cascades of particles into the atmosphere (EAS),
it will be possible to test the detection technique of tau neutrinos producing EAS resulting in Cherenkov light emission.

EARTH'S OBSERVATIONS

Observations on ground and with satellites at Low Earth Orbit altitudes have revealed:

- anomalies in the ionosphere (electromagnetic and plasma density perturbations,…)

French micro-satellite dedicated to the study of ionospheric perturbations (measurement of electromagnetic waves and their effects), caused by natural phenomena, such earthquakes and volcanic eruptions, or resulting from human activities

ANNALS OF GEOPHYSICS, 55, 1, 2012; doi: 10.4401/ag-5356

Special Issue: EARTHQUAKE PRECURSORS

Extremely low frequency plasma turbulence recorded by the DEMETER satellite in the ionosphere over the Abruzzi region prior to the April 6, 2009, L'Aquila earthquake

Jan Błęcki[1,*], Małgorzata Kościesza[1], Michel Parrot[2], Sergey Savin[3], Roman Wronowski[1]

[1] *Space Research Centre PAS, Warsaw, Poland*

[2] *Laboratoire de Physique et Chimie de l'Environnement et de l'Espace, Université d'Orléans, CNRS, Orléans, France*

[3] *Space Research Institute, Russian Academy of Sciences, Moscow, Russia*

Possible correlation with earthquakes or eruptions?

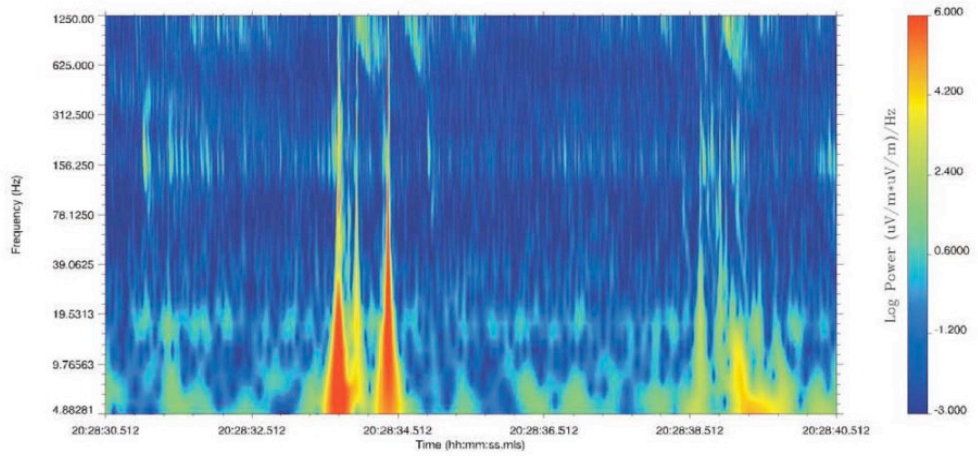


Figure 7a. Wavelet spectrogram of the broad-band emission in the ELF range recorded on April 4, 2009. The distance of the footprint of the satellite to the epicenter was about 280 km. The color scale is as in Figure 2.

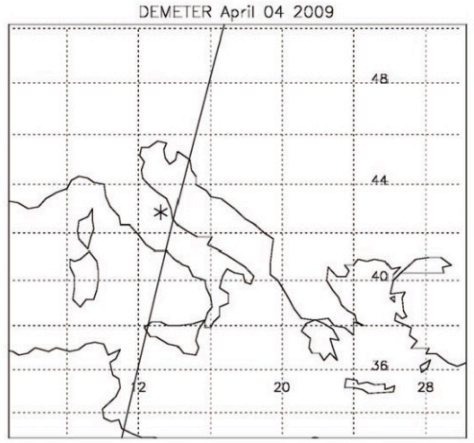


Figure 6. Map showing the epicenter of the April 6 L'Aquila earthquake (*) and the orbit of the DEMETER satellite on April 4, 2009. The point of closest approach from the epicenter was 125 km.

A POSSIBLE MODEL

remote sensing

MDPI

Article

Magnetospheric–Ionospheric–Lithospheric Coupling Model. 1: Observations during the 5 August 2018 Bayan Earthquake

Mirko Piersanti [1,*,†], Massimo Materassi [2,†], Roberto Battiston [3,†], Vincenzo Carbone [4,†], Antonio Cicone [5,†], Giulia D'Angelo [5,†], Piero Diego [5,†] and Pietro Ubertini [5,†]

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† These authors contributed equally to this work.

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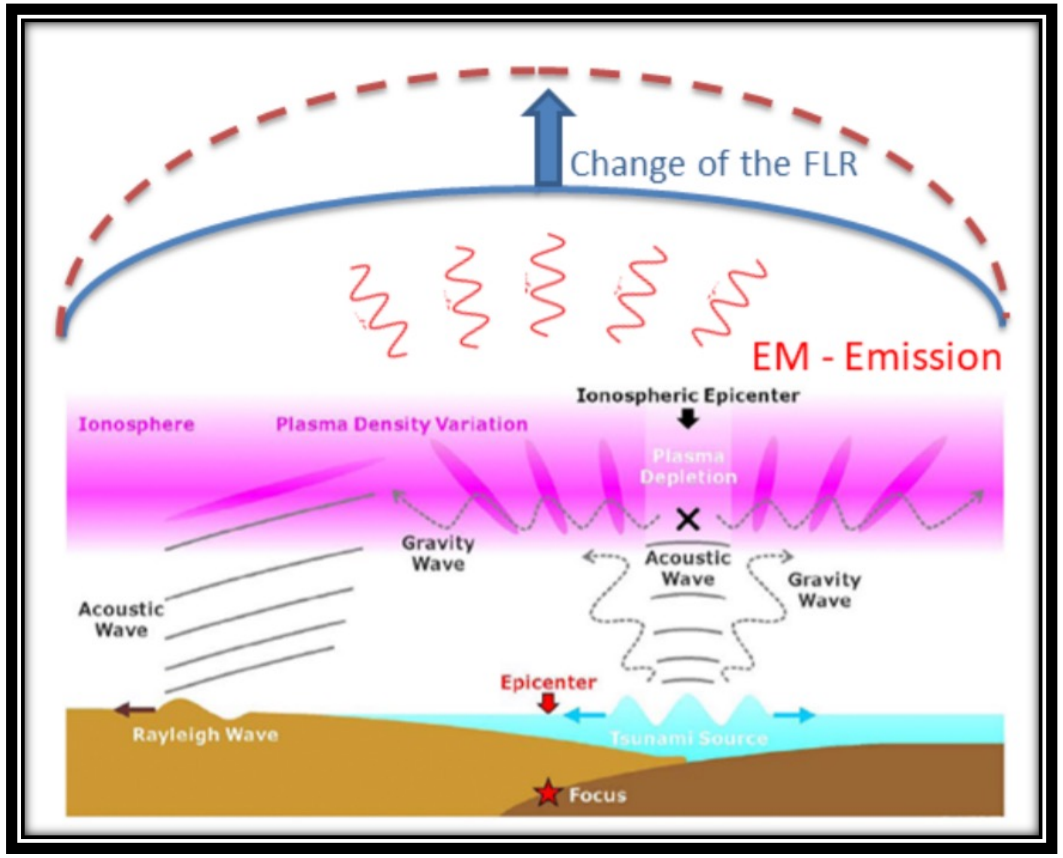
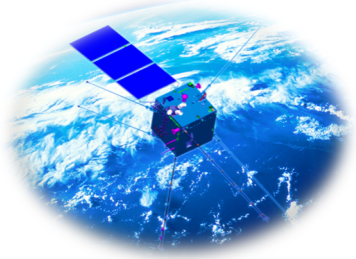
Abstract: The short-term prediction of earthquakes is an essential issue connected with human life protection and related social and economic matters. Recent papers have provided some evidence of the link between the lithosphere, lower atmosphere, and ionosphere, even though with marginal statistical evidence. The basic coupling is hypothesized as being via the atmospheric gravity wave (AGW)/acoustic wave (AW) channel. In this paper we analyze a scenario of the low latitude earthquake (Mw = 6.9) which occurred in Indonesia on 5 August 2018, through a multi-instrumental approach, using ground and satellites high quality data. As a result, we derive a new analytical lithospheric–atmospheric–ionospheric–magnetospheric coupling model with the aim to provide quantitative indicators to interpret the observations around 6 h before and at the moment of the earthquake occurrence.

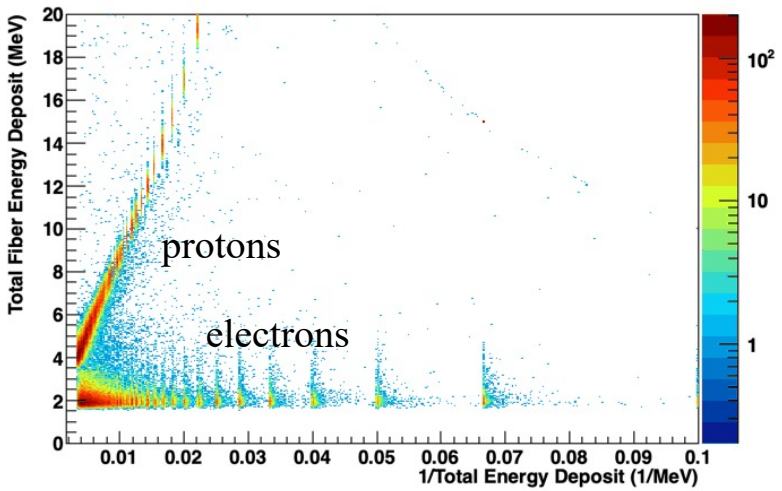


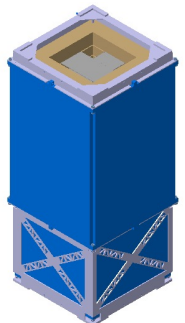


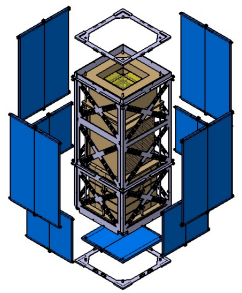
China Seismic Electromagnetic Satellite
CSES-01 on orbit since February 2018

ZIRÈ PRELIMINARY DESIGN

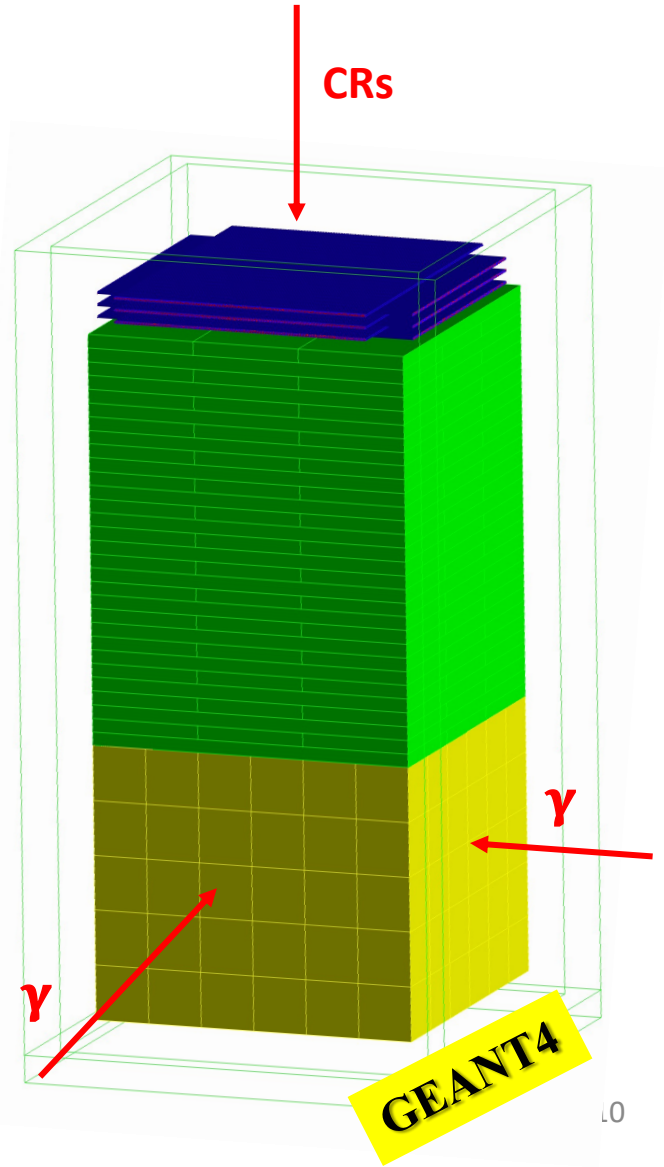
- **Fiber TracKer (FTK)** : three X-Y double-layer modules with 10 × 10 cm^2 of cross section and 2.5 cm of spacing. Fibers consisting of a polystyrene core (inner side) with a fluorescent agent and a cladding of Polymethylmethacrylate (PMMA)
- **Plastic Scintillator Tower (PST) :** 30 Plastic Scintillator (PS) layers (12 × 12 × 0.5 cm^3), each one composed by three PS X-Y bars (12 × 4 × 0.5 cm^3);
- **CALOg** : a 5x6x6 matrix of LYSO cubes with a resulting 10 × 12 × 12 cm^3 layer;
- **VETO**: 5 PS layers with 0.5 cm of thickness working as VETO system surrounding the instrument.



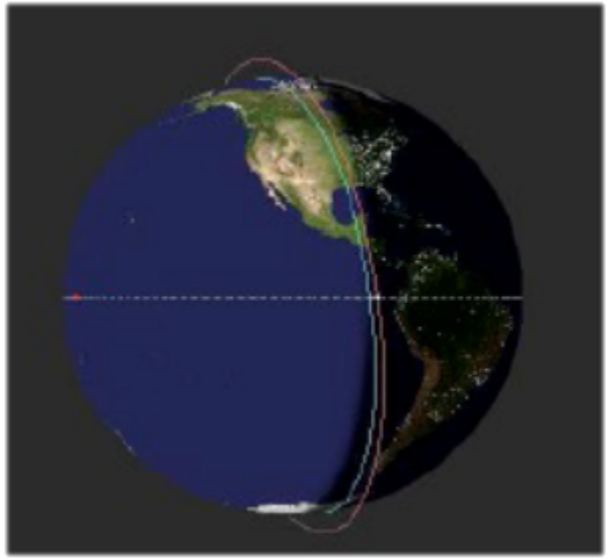


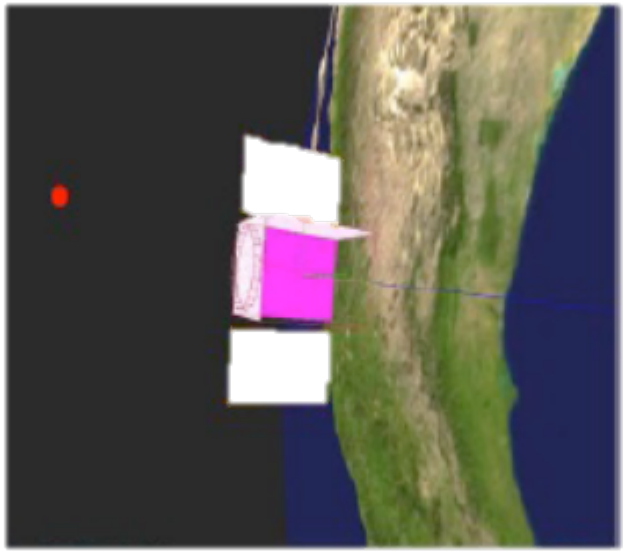


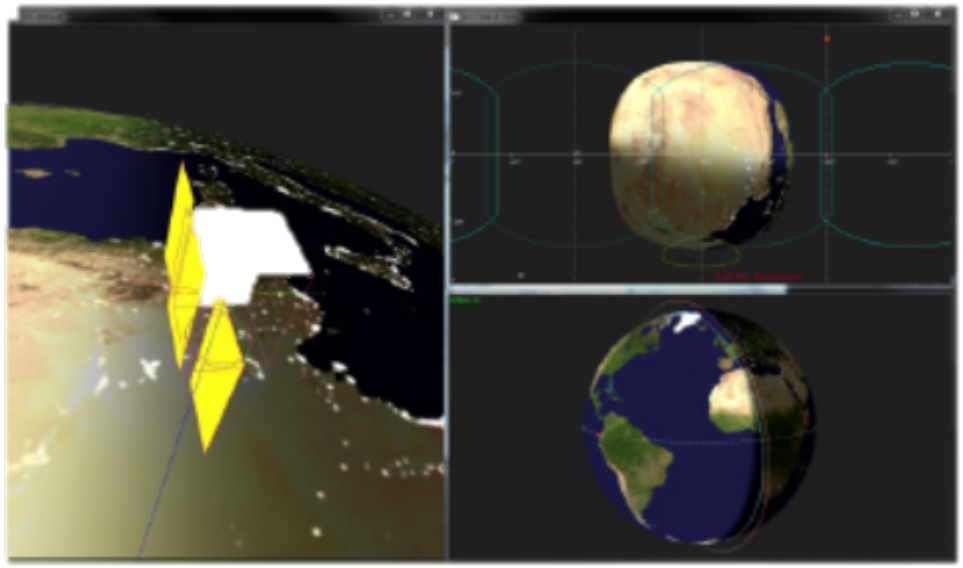
- ✓ The whole ZIRÈ detector will be devoted to the measurement of Cosmic Rays (mainly electrons and protons) in the energy range from few MeVs to hundred of MeVs.
- ✓ The CALOg will be also used as gamma detector in the energy range 50 keV -100 MeV
- ✓ Innovative SiPM technology will be adopted
- ✓ GEANT4 simulations of proton and electron events have started with the preliminary design of the ZIRÈ detector
- ✓ Preliminary CAD design of the instrument ready
- ✓ Current data suggest larger sensitivity for MILC studies using very low energy electrons (< 5 MeV) from the zenith . A specific Zirè payload extension **LEM** is being designed for the detection of such electrons.



THE ORBIT







- Low Earth Orbit (LEO) with high inclination, sunsynchronous orbit on the day-night border (mean altitude = 550 Km, inclination = 97.8°, LTAN = 18:00);
- Orbit optimization under discussion because of the interplay between Terzina-Zirè orbit requirements;
- Ballistic mission (no propulsion for orbital control);
- Terzina will point to the Limbo, while Zirè to the zenith.

CONCLUSIONS

- The NUSES project will play a key role in the development and testing of advanced technologies and innovative observational approaches for future space missions devoted to operate as MILC signal hunters and/or as observatories for astrophysical neutrino signals from the Earth's atmosphere

- Preliminary designs of the TERZINA and ZIRE` detectors have been proposed and used for dedicated MC simulations

- Many activities are in progress concerning detector design, technological development and testing

0% WORK IN PROGESS… **100%**


Thank you!