SPACEWEATHER

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Participant Institutions:

ITALY: INFN Bologna, LNF, Napoli, Perugia and Roma 2-Tor Vergata; ASI (Italian Space Agency);
RUSSIA: MePhi, IBMP, Roscosmos
CHINA:CNSA (Chinese Space Agency), CEA (Chinese Earthquake Administration)

1 Introduction

The SPACEWEATHER experimental program is devoted to the exploration - through dedicated space missions - of three main research fields:

1. Interaction between terrestrial geophysical events and Earth radiation belts.
2. Physics of the space environment in Earth orbits.
3. Biomedical effects of space radiation on human body.

These tasks will be achieved by:

1. The study of the correlation between seismic events and perturbation of the Van Allen belts.
2. Monitoring of the radioactive environment and of the nuclear abundances inside and outside the ISS (International Space Station).
3. Measurements of passive shielding to reduce the dose on astronauts.
4. Study of the "light flashes" phenomenon observed by astronauts in space.

This program is a continuation and an extension of the activities carried out for the experiments SIEYE1 and SIEYE2 on board the Russian Space Station MIR in the years 1995-2002 and for the experiment SIEYE3/ALTEINO on board the International Space Station (ISS), still running [1) 2) 3)].

2 The Experimental Program

In 2011, the SPACEWEATHER experiment received the approval for the development and the realization of a series of detectors (mini-magnetic spectrometer, electric field detector, magnetic field detector, low frequency e.m. wave detector), under the acronym CSES (Chinese Seismo-Electromagnetic Satellite), to study the fast variations of the fluxes of protons and electrons trapped in the radiation belts due to pertrbations caused by seismic events. In the Sections of Roma Tor Vergata and in the LNF an executive project to set up the sensors for the measurement of the electric field and of the first level data acquisition system has been carried out. Laboratory tests are in progress. The Section of Perugia is developing the design of the magnetic spectrometer and is carrying out laboratory tests as well. The mechanics of the experiment is being designed in Bologna. Roma Tor Vergata is also in charge of the general system of data acquisition, storage and telemetry of the italian portion of the experiment. Agreements between the Space Agencies ASI and CSNA have started and are in progress. In Fig.1, a sketch of the CSES Satellite and the Payload instruments is shown.

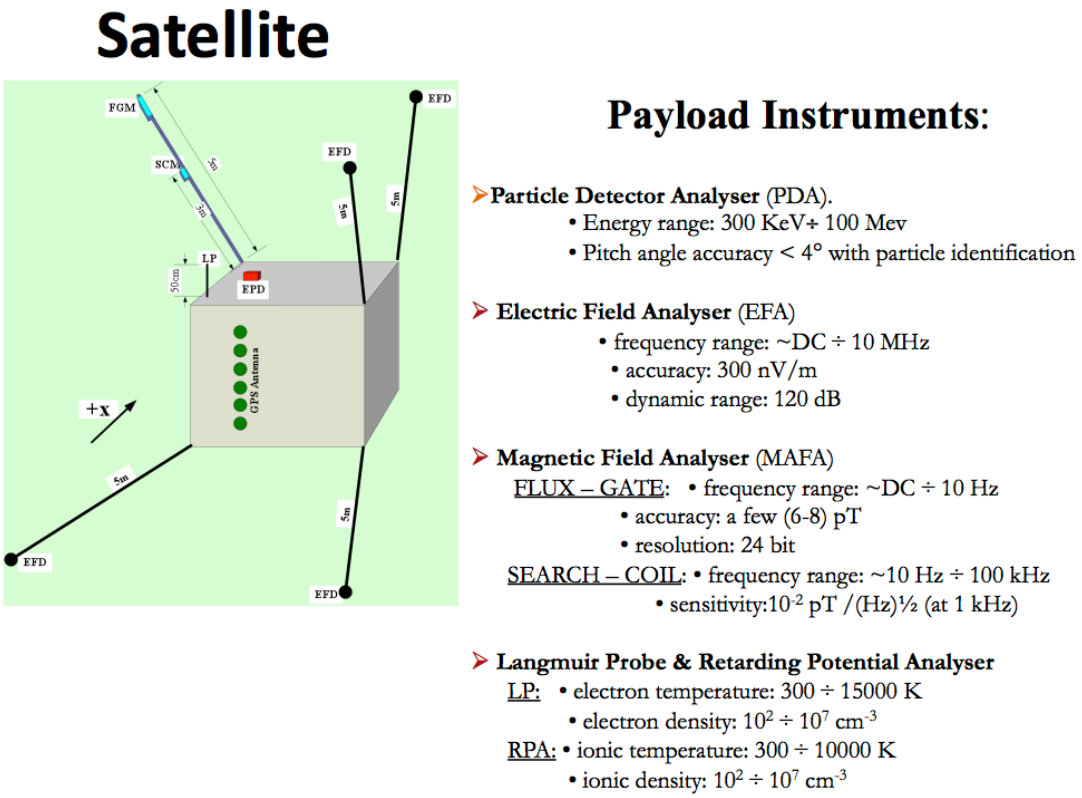

Figure 1: Sketch of the CSES Satellite with the Payload Instruments.

The task of the SI-RAD-ALTCRISS experiment (approved by ESA and ASI in Phase A) was to develop a detector to be placed on the external part of the ISS. The detector will be used to monitor cosmic rays and radiation environment in Low Earth Orbit. Long term (Solar modulation) and short term (coronal mass ejections, orbit dependence) effects on the particle flux will be monitored as well as the dose absorbed by the astronauts. In addition, data will be compared with measurements taken inside the ISS with ALTEA [4], ALTEINO and LAZIO/SIRAD [5] detectors to validate radiation transport and dose estimation codes. At the same time, the investigation, with a more sophisticated instrument, of the "Light Flashes" phenomenon [6], will be conducted to improve and refine the results obtained with the previous SIEYE experiments.

The preparation of the next SI-RAD extended mission is advancing towards the completion and test of the full flight instrument consisting of a 16-plane tower of double-sided silicon detectors (8x8 cm^2 area) equipped with trigger and anticoincidence counters, as shown in Fig.2. The total weight is about 15 kg and the total power consumption should not exceed 30 W. The hardware set-up is accomplished through three steps by the construction of a laboratory prototype model, an engineering model and the final flight, space qualified model.

The activity has been mainly focused on the development of the following systems of the engineering model:

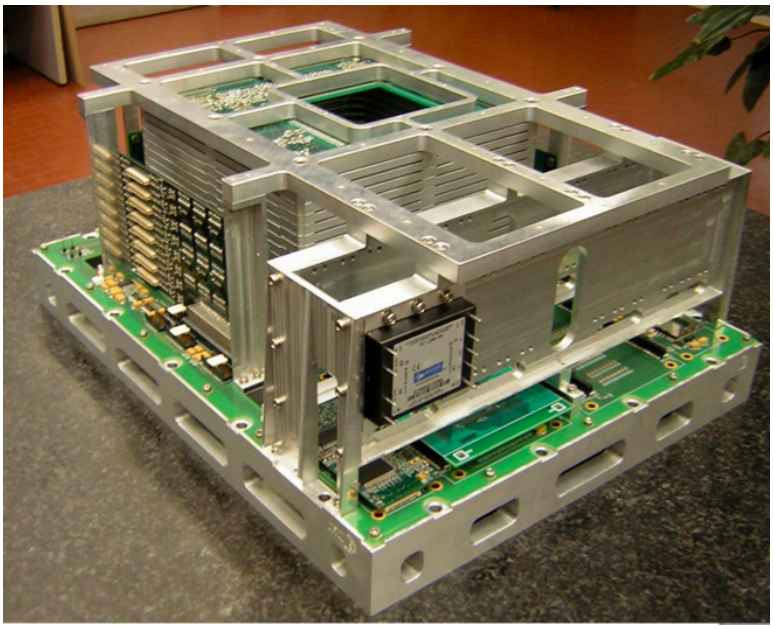

Figure 2: The SI-RAD detector.

- Trigger system.
- Development of Silicon Photomultiplier (SI-PM) technology for space applications and test of different SI-PM configurations.
- Completion and test of a highly integrated silicon board (16 cm x 16 cm).
- Production and test of a low-power, low-mass Digital Processing Unit (DPU).

For the year 2013, the planned activity includes the completion of the engineering unit and the set-up of the flight configuration equipped with autotrigger capabilities for heavy nuclei and a trigger for crossing protons and nuclei. The interface with the ISS Space Station will be realized with an intermediate CPU to manage the telecommands from ground and the download of the data. Beam tests at the LNF-BTF, GSI/Darmstadt and other facilities are also planned together with the continuation of the R&D on the SI-PM technology.

3 Activity of the LNF group

The LNF group has taken the responsibility of the design, construction and test of the mechanical structures and interfaces of the three models of the SI-RAD detector also contributing to the integration of the mechanical support for the DAQ. This activity is carried out with the support and the participation of the LNF Service for Design and Mechanical Costructions (SPCM). The activity in 2012 has been mainly devoted to the completion of the mechanical support of the engineering model and to the interfaces of the front-end and DAQ with the detector, ready to be tested on beams. These systems are being developed for the final space-qualified flight configuration. The LNF group participates as well in the beam test activities at the above mentioned facilities having the responsibility of the beam trigger counters and of the general arrangement and set-up.

Finally, the LNF is actively participating in the definition studies and first executive designs of CSES prototypes of the sensors for the measurement of the electric field and for the DAQ of the experiment.

4 Selection of recent publications

1. L. Di Fino *et al.*, "Heavy-Ion anisotropy measured by ALTEA in the International Space Station", Radiat. Res. **176**, 397 (2011).
2. M. Larosa *et al.*, "Ion rates in the International Space Station during the December 2006 Solar Particle Event", J. Phys. G. Nucl. Part.. **38**, 095102 (2011).
3. V. Zaconte *et al.*, "The radiation environment in the ISS-USLab measured by ALTEA", Adv. Sp. Res. **46**, 797 (2010).
4. V. Zaconte *et al.*, "High Energy Radiation fluences in the ISS-USLab: ion discrimination and particle abundances", Rad. Meas. **45**, 168 (2010).

References

1. V.Bidoli *et al.*,"In-flight performances of SilEye-2 Experiment and cosmic ray abundances inside space station MIR"; Journal of Physics G: Nuclear and Particle Physics **27**, 2051(2001).
2. M.Casolino *et al.*,"The Sileye/3-Alteino experiment on board the International Space Station"; Nucl.Phys. **113B**, 88 (2002).
3. V.Bidoli *et al.*, "Dual origin of light flashes in space", Nature **422**, 680 (2003).
4. L.Narici *et al.*,"ALTEA: Anomalous long term effects in astronauts. A probe on the influence of cosmic radiation and microgravity on the central nervous system during long flights", Adv. Space Res. **31**, 141 (2003).
5. F.Altamura *et al.*,"Preliminary results from the LAZIO-Sirad experiment on board the International Space Station", Proc. XXIX ICRC, Pune (2005), SH35 p.101.
6. G. Horneck, "Radiobiological experiments in space: a review", Nucl. Tracks Radiat. Meas., **20**, 185 (1992).