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Beyond HERMES

Toward a multipurpose interplanetary X and gamma-ray spectrometer instrument

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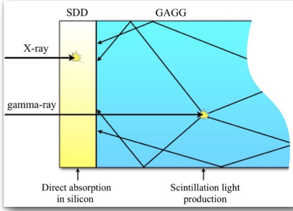
In a nutshell...

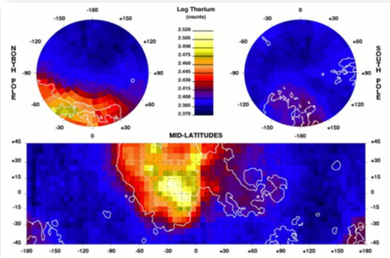
The context → HERMES Pathfinder: ASI/INAF/PoliMI project involving a constellation of six 3U CubeSats with a sensitive X and gamma-ray detector for GRB observation and localization
Very compact (10x10x10 cm³), lightweight (1.5 kg), low-power (<2.8 W) with huge sensitivity band (2 keV to 2 MeV) with ~50 cm² area.
The project → study of the application of this detector in other scenarios beyond Low Earth Orbit (Moon, Mars, interplanetary/cis-translunar space or Lagrangian points) **for long-baseline GRB localization and spectroscopy of planetary surfaces**

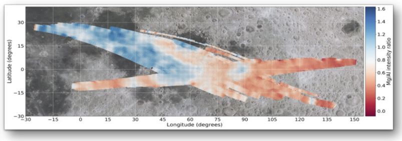
HERMES Pathfinder (*High Energy Rapid Modular Ensemble of Satellites*)
- Constellation of **six 3U CubeSats** in a LEO. General constellation launch foreseen in **early 2025** (ASI+H2020 funding)
- Detection of **Gamma Ray Bursts** and other transients with localization through triangulation
- A seventh identical payload onboard the Australian mission SpIRIT launched 1st **December 2023** in a Sun-synchronous orbit and working nominally (→ TRL 9)



Siswich principle:
Use the Silicon Drift Detector both as a direct X-ray detector and as a photodetector for scintillation photons → **Huge sensitivity band in a compact and segmented design**

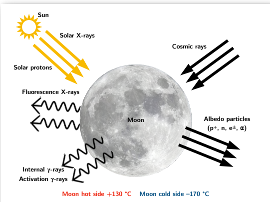
The HERMES detector is also suitable as a X and gamma-ray spectrometer for **studies of planetary surfaces**
- **Fluorescent X-ray emission** (in the range 1–20 keV) produced by solar irradiation allows to **map chemical compositions**
- Spectroscopy of **nuclear lines** (in the range 100 keV–a few MeV) allows to assess **chemical abundances of elements in planetary surfaces** down to a depth of several centimeters





Left: Thorium measurements by Lunar Prospector (Lawrence et al. 1998)
Above: Mg/Al intensity ratio as measured by Apollo 16/XRF (Gloudemans, Kuulkers, Campana et al. 2021)

Both kinds of measurements are **simultaneous** and **complementary** and allow to obtain a **multi-faceted** picture of the celestial body composition and formation.
The sensitive area of X-ray and gamma-ray spectrometers flown up to now for planetary observations is **quite small** (or comparable with the HERMES one).



Beyond low-Earth orbits, radiative environment is rather complex:
- Full, unshielded cosmic ray fluxes
- Solar flares, energetic particles
- Radiation damage of the detectors
- (possibly) complex thermal environment, active/passive cooling issues
- Shielding → mass!
- SEE on on-board electronics

Aim of the proposal is to study design improvements on the basic HERMES payload design to cope with these challenges:
- Anticoincidence (active) shielding
- Passive shielding
- Active/passive detector cooling
- Study of the required modifications on the FEE ASICs
- Study and Monte Carlo simulation of possible scenarios

Synergies with LEM-X and TASTE projects

Status

Milestone 1 – Study of radiative environment in the various scenarios (HEO, cis/trans-Lunar space, Lagrangian points, Mars)
✓→ BH-INAF-REPORT-001 technical note

Milestone 2 – Design of possible mitigation strategies
Impact of environment on detector performance
→ **In progress**: study and development of shielding designs.
→ **In progress**: thermal simulations of possible designs.
Monte-Carlo simulations
✓→ Simulator available, GDML-based mass-modelling allowing for fast iteration, analysis tools available.

Milestone 3 – Baseline design of a "planetary HERMES" payload
→ **In progress**

Milestone 4 – Optimisation of front and back-end electronics
✓→ Hardware: PCB with improved front-end ASIC + SDD + scintillator produced
→ **In progress:** dedicated laboratory testing

Bandi Ricerca Fondamentale...

- The RF program is potentially great (annual call cadence, budget available, "light" management)
- Research programs **over 3 years** could have added value (especially for Techno and Large grants), as already proposed by the community.

Include the possibility to propose projects on a 2-year and 3-year scale within the same budget!
- Nice to have firm timeframes and deadlines for **availability of funds and KO** of projects

For example: know that with the 2024 call for proposals, funds will be available to awardees as of Dec. 1, 2024 (but: in the case of multiple RUs, how to manage the timing of fund transfers between structures?)
- Guidelines for project management (financial and non-financial) available since the call for proposals
- How much freedom in remodulation between budget items is allowed?
- Periodic and final reporting? Format/content?
- Possibility of cost-free extensions of projects?

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