Bologna, 22-24/06/2022 – Forum della Ricerca Sperimentale e Tecnologica in INAF

Ottica, Metrologia e Termomeccanica

INAF ISTITUTO NAZIONALE DI ASTROFISICA

IAPS ISTITUTO DI ASTROFISICA E PLANETOLOGIA SPAZIALI

IAPS - Roma

Carlo Lefevre

in rappresentanza di tutto il personale coinvolto nelle attività

ƒISPEx Integral Field Imager and Spectrometer for Planetary Exploration

FILACCHIONE, G.[1], Tarabini, M. [2], Mazzotta Epifani, E.[3], Ciarniello, M. [1], Piccioni, G. [1], Raponi, A. [1], I. Di Varano [1], Saggin, B.[2], Kanuchova, Z.[2], Palumbo[1,4], P., Guerri, I.[5], Taiti, A.[5],, Barilli, M.[5], Zambelli, M. [1], Biondi, D. [1], Boccaccini, A. [1], Nuccilli, F. [1], Giusti, M[1], S. Pelli[6], F. Cosi[6].

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ƒISPEx Integral Field Imager and Spectrometer for Planetary Exploration

The ƒISPEx study has been selected in 2018 through the competitive call ASI-INAF *«Attività di studio per la comunità scientifica per Sistema Solare ed Eso-Pianeti»* ASI - INAF Agreement N.2018-16-HH.O. End of activities: December 2022.
Project funding: **652 k€**

ƒISPEx), an highly innovative instrument in which **a single front-optics is used to feed light to a camera and imaging spectrometer**, both coaligned on the same Field of View. **The camera is capable to acquire images at different visible wavelengths by means of a Liquid Crystal Tunable Filter (LCFT)** whereas a **0.4-5 µm integral field imaging spectrometer records a hyperspectral cube with a single acquisition (snapshot mode) through a Coded-Mask Optical Reformatter (CMOR)**.

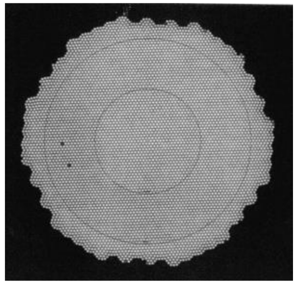
The implementation of the ƒISPEx concept will result in great advantages in terms of **payload integration**, instrument operations and scientific return with respect to current cameras-spectrometers configurations

The ƒISPEx instrument is designed for the **exploration of small bodies** (asteroids, NEA, comets) from orbit but can be easily adapted for other targets. By operating with fast readout detectors, an Integral Field spectrometer can adequately resolve the **four dimensions** of data (2D spatial, spectral and temporal) opening the possibility to perform **time-resolved hyperspectral movies.**

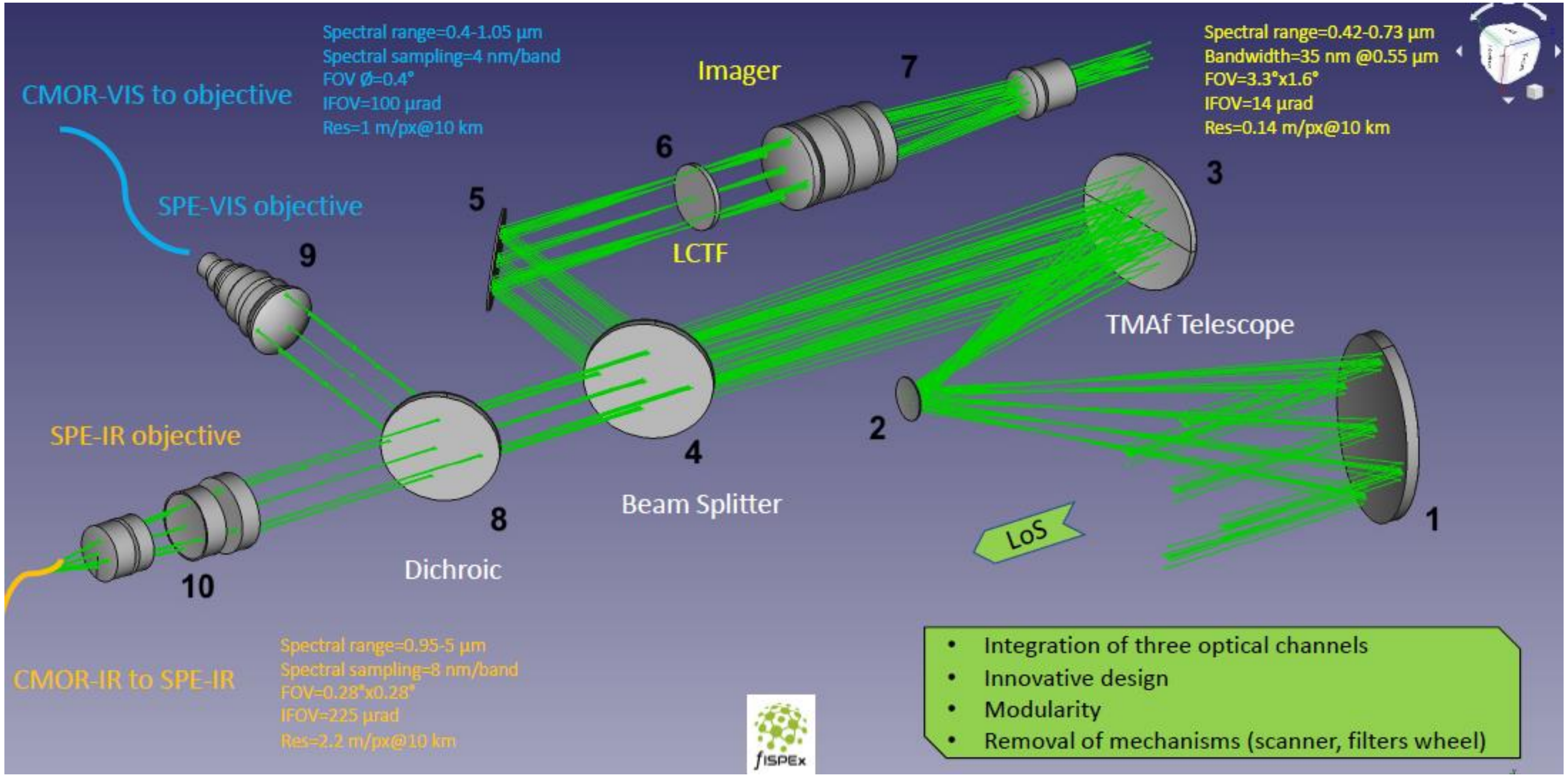
ƒISPEx Integral Field Imager and Spectrometer for Planetary Exploration

Spectrometer: Coded-Mask Optical Reformatter

Schott Wound Glass bundle
4000 fibers, fiber ø=6.4 µm, bundle Ø=0.45 mm



4500 spectra with a single acquisition



Imager: Liquid Crystal Tunable Filter

High flexibility in wavelength selection (1 nm resolution)

-Wide Spectral Range: 420 to 730 nm
-Short switching time (<40 ms)

-Removal of filter wheel mechanism/mass saving

-Many possible Nematic LC/Polarizer/Lyot Filter combinations

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DORA, Deployable Optics for Remote sensing Application

Fabrizio Capaccioni[1] , Giancarlo Bellucci[1] , Giovanna Rinaldi[1] , Bortolino Saggin[2] , Pietro Valnegri [2], Gianrico Filacchione[1] , Vincenzo Della Corte[1] , Demetrio Magrin[3] , Matteo Angarano[4] , Daniele Filippetto[4] , Giampaolo Ferraioli[5] , Elena Martellato[5] , Pasquale Palumbo[5] , and Alessandra Rotundi[5]

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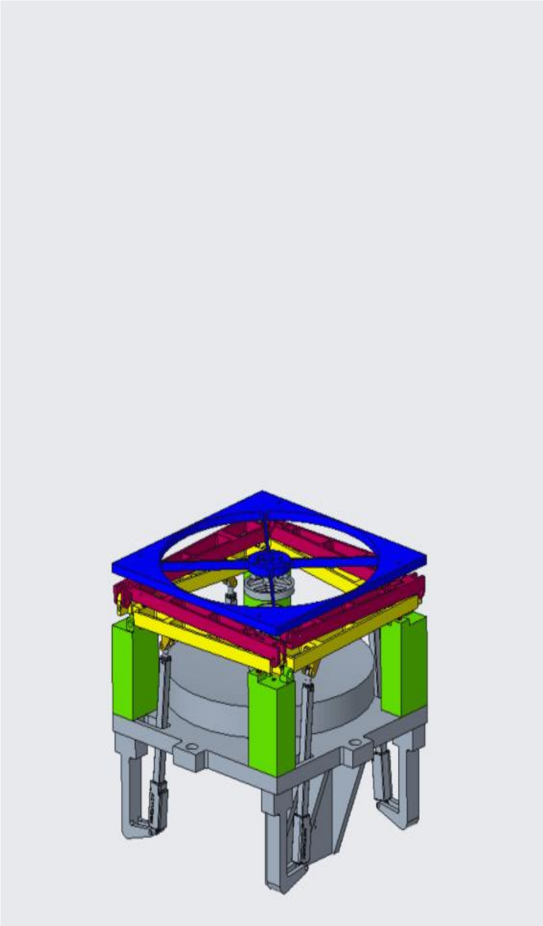
4 SITAEL s.p.a., Mola di Bari, Italy 5DiST - Università Parthenope, Napoli, Italy Osservatorio Astronomico di Padova, INAF, Italy 4SITAEL s.p.a., Mola di Bari, Italy
5 DiST - Università Parthenope, Napoli, Italy

DORA, Deployable Optics for Remote sensing Application



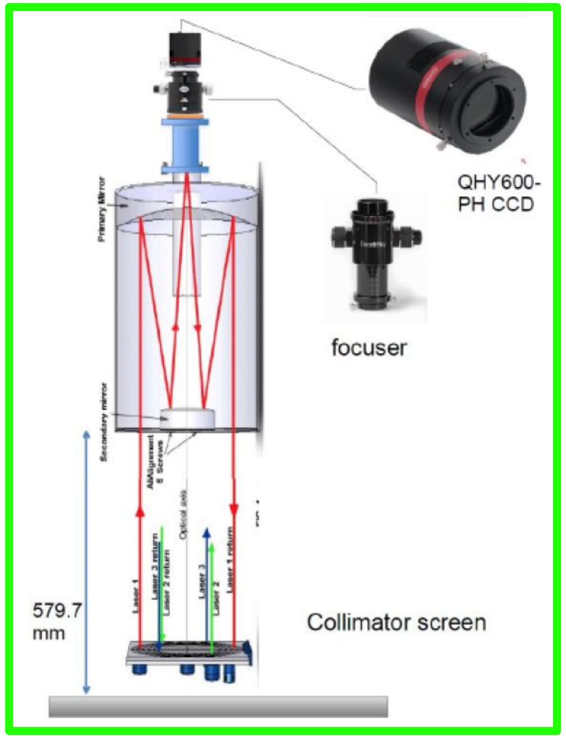
IAPS and OaPd) and major partners SITAEL, Università Parthenope and Politecnico di Milano.

The **DORA** Project is funded by MUR (National Research Plan 2015-2020);The major objective is the design, realisation and test of the prototype of a telescope with deployable optics, coupled to a Fourier infrared spectrometer (MIMA), both configured to be embarked on a micro-satellite (Sitael PLATINO <100 kg).

A breadboard of the final design of the telescope has been built, tested at PoliMi and found within tolerances (circa 100μ).

Optical performances will be verified at IAPS (July-September) using a CCD camera instead of MIMA to guarantee optical measurements accuracy

For Additional details see poster by Igor Di Varano et al.



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Piezoelectric Crystal Microbalance for Space Mission and Laboratory applications

Ernesto Palomba, Fabrizio Dirri, Andrea Longobardo, Chiara Gisellu, David Biondi e Angelo Boccaccini.

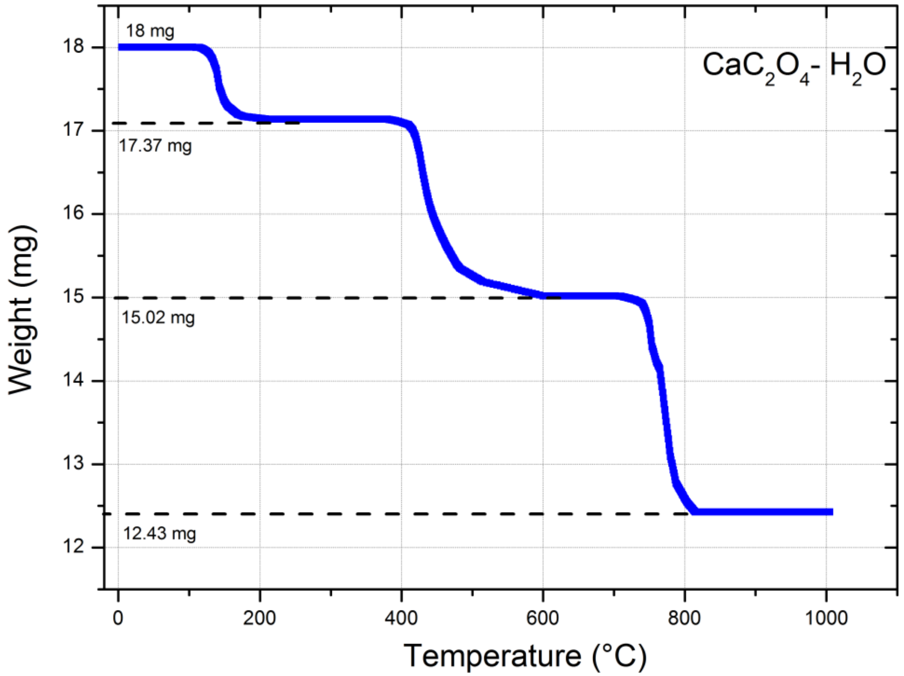
Piezoelectric Crystal Microbalance for Space Mission and Laboratory applications

The sensor core is the crystal, oscillating at a frequency linearly depending on the mass deposited on its sensible area, according to the Sauerbrey equation (Sauerbrey 1959).

$$\Delta f = -\frac{f^2 \Delta m}{N\rho}$$

Thermogravimetry is a technique to study absorption/desorption, sublimation/condensation processes. The crystal temperature can be increased by means of built-in heater and measure the amount of weight change as a function of increasing temperature, due to the release of more volatile species.

Units	CAM, VISTA
Sensor type	*Quartz Crystal Microbalance*
Resonant Frequency	*10MHz*
Mass [g]	*90*
Volume [mm]	*50×50×38*
Power [W]	*1.5 W (peak); 0.9 (mean)*
Data rate	*66 bit/ measurement*
Operating Temperatures [°C]	*from -80 to +100*
Measurable mass	*4.4 ng/cm2 to 700µg/cm2*
TRL	*6*
Application	*Moon, Mars, small bodies, molecular contamination monitoring in space (Spacecraft, CubeSat, etc.)*



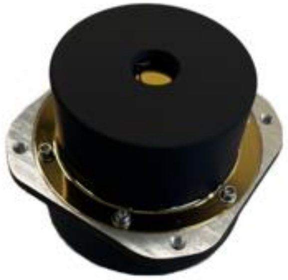
Piezoelectric Crystal Microbalance for Space Mission and Laboratory applications

HERITAGE and Projects on-going at Space Materials Laboratory (IAPS)

- **ESA-ITT project: CAM** (Contamination Assessment Microbalance) – Spacecraft applications
- **ESA-ITT projects: CAMLAB** and **CAMLAB 2.0** – Laboratory applications (2019-2022)
- **VISTA** (Volatile In Situ Thermogravimeter Analyser), selected and under development for:
  - **- ESA HERA** mission, on board Milani CubeSat (2020-2023)
  - **- CNSA Tianwen-2 Mission** (2021-2025)

- **MOVIDA** (Moon Volatile Ice and Dust Analyser) instrument
  - Under evaluation by ESA for the call Lunar Exploration Campaign Science and Technology Payloads (2018)

CAM - 2016



VISTA for HERA-2021

CAMLAB - 2019

CAMLAB 2.0 - 2022

Team: Ernesto Palomba, Fabrizio Dirri, Andrea Longobardo, Chiara Gisellu

Small displacements measure

•*Emiliano Fiorenza, Carlo Lefevre, Pasqualino Loffredo, David Massimo Lucchesi, Umberto DeFilippis, Marco Lucente, Carmelo Magnafico, Alfredo Morbidini, Roberto Peron , Francesco Santoli, Valerio Iafolla*

Small displacements measure

ISA

Italian Spring Accelerometer

- ✓ ISA (BepiColombo/ESA/ASI)
- ✓ Electro-mechanical accelerometer
- ✓ launch 2018 - arrival to Mercury 2025
- ✓ Resonance: $\nu_0 = 3.5$ Hz
- ✓ Bandwidth: $3 \cdot 10^{-5} - 10^{-1} Hz$
- ✓ Noise Floor: $10^{-9} \frac{\frac{m}{s^2}}{\sqrt{Hz}}$
- ✓ Gap Proof-mass/plates: 100 µm

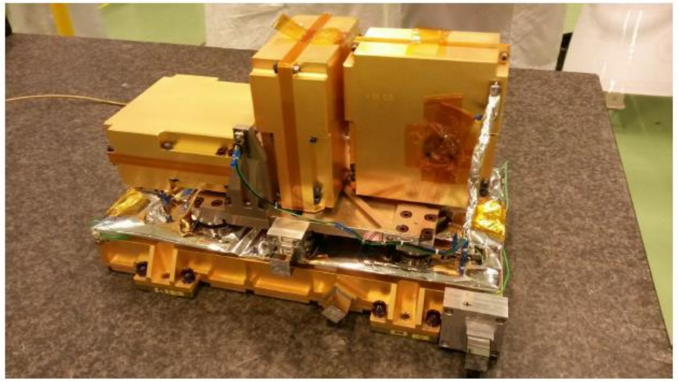
HAA

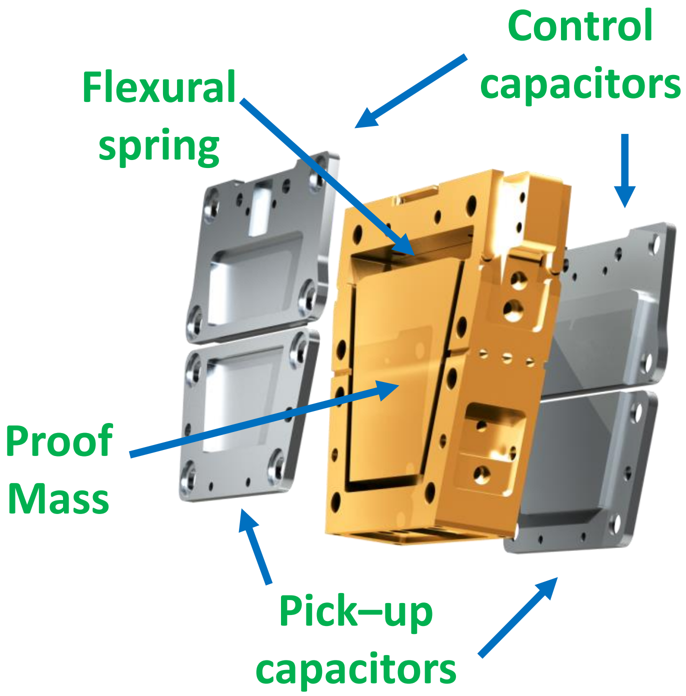
High Accuracy Accelerometer

- ✓ HAA (JUICE/ESA)
- ✓ Electro-mechanical accelerometer
- ✓ launch 2023 - arrival to Jupiter 2031
- ✓ Resonance: 3.5 Hz
- ✓ Bandwidth: $10^{-4} - 10^{-1} Hz$
- ✓ Noise Floor: $< 10^{-9} \frac{\frac{m}{s^2}}{\sqrt{Hz}}$
- ✓ Gap Proof-mass/plates: 100 µm
- ✓ Rad-hard enhancement

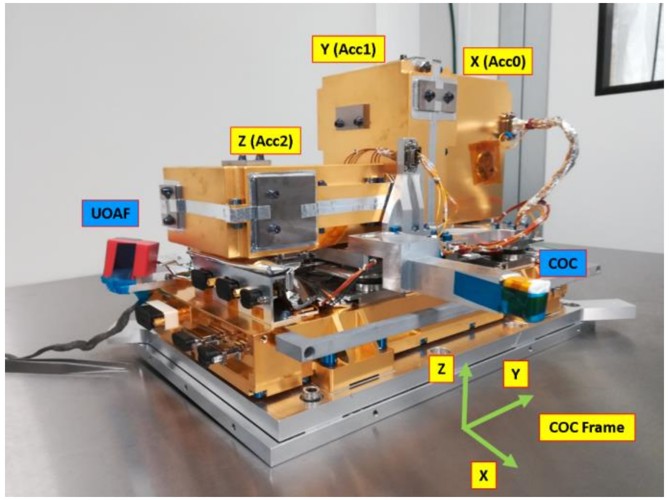
Spring- mass system based on a capacitive signal detection between proof-mass and pick-up (displacement x):

$$a_{out} = \omega_0^2 \cdot x$$





Second Order Oscillator able to detect $10^{-11} m$ displacements

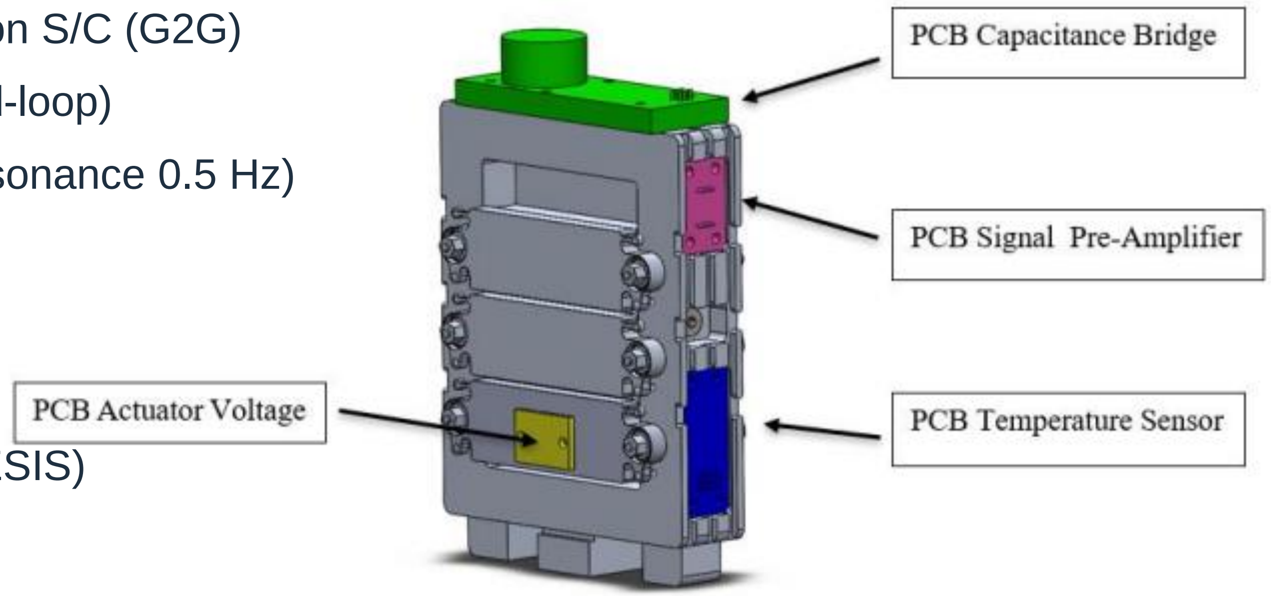


Small displacements measure

AGES

Accelerometry for Galileo Enhancement and Science

- ✓ AGES - H2020-ESA-038 GNSS Evolutions Experimental Payloads and Science Activities
- ✓ Prototype development of an accelerometer devoted to measure the Non-Gravitational Perturbations on Galileo second generation S/C (G2G)
- ✓ Electro-mechanical accelerometer (closed-loop)
- ✓ Improvement of overall sensitivity x60 (resonance 0.5 Hz)
- ✓ Improvement of thermal sensitivity (x8)
- ✓ Bandwidth: $10^{-5} - 10^{-1} Hz$
- ✓ Gap Proof-mass/plates: 75 μm
- ✓ Flight opportunity (2025/2026, ESA GENESIS)



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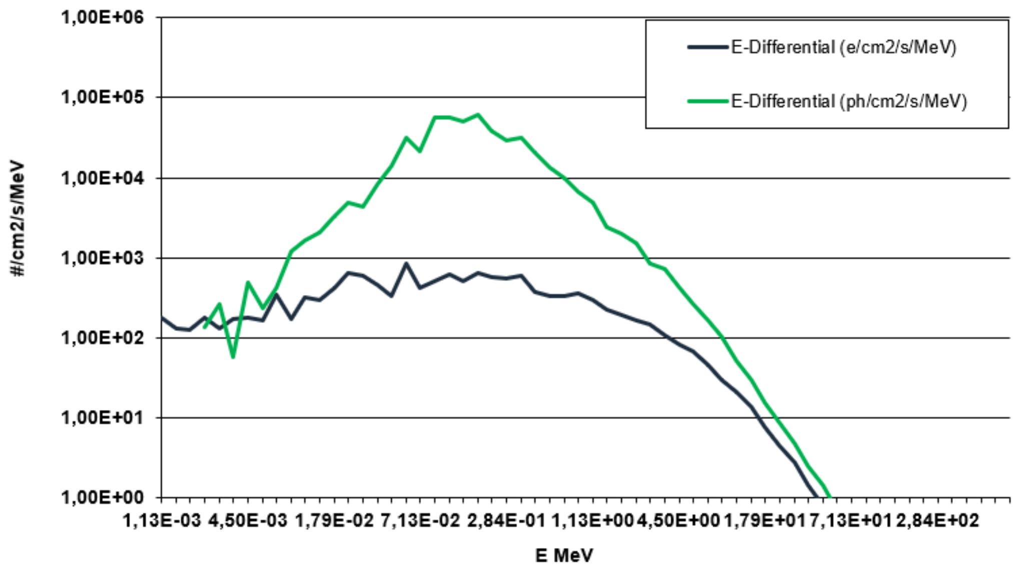
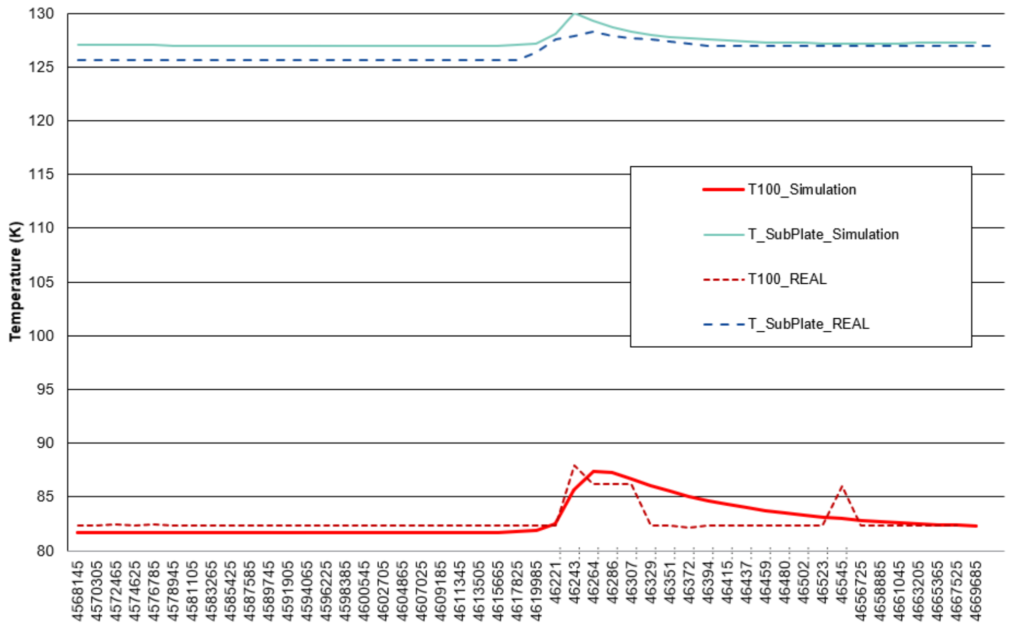
Thermal and Radiation Simulation

Massimo Zambelli

Thermal and Radiation Simulation





VEX (Venus Express) – VIRTIS; JUNO – JIRAM;JUICE – MAJIS