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

INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

IAPS ISTITUTO DI ASTROFISICA
E PLANETOLOGIA SPAZIALI

Elettronica e Rivelatori

Claudio Macculi

in rappresentanza di tutto il personale coinvolto nelle attività

Some information

- **IAPS** is an institute deeply involved in Design, Integration and Test of detectors and electronics for high energy and planetology from R&D to Scientific mission oriented items
- There is a production chain starting from the test in lab and subsequent testing in controlled environment (e.g., Clean Rooms) and/or specific facilities tailored for Space Applications
- Activities usually adopt the ECSS standards, as well as NASA, JAXA or Chinese standards, as required by the specific project
- “Detectors and Electronics” is an important activity of the institute featured by a rather regular funding

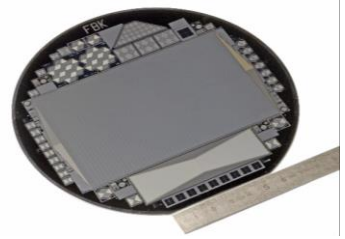
- **We are going to present:**
  - Silicon Detecors Lab
  - X-ray polarimetry
  - Experimental Plasma Physics
  - ENA instruments
  - Cryogenic Microcalorimetry for Particle Detection and X-ray Spectroscopy

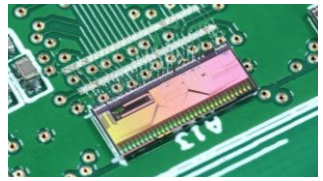
Silicon Detecors Lab

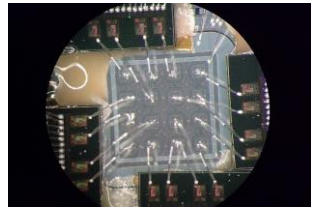
M. Feroci, Y. Evangelista, E. Del Monte, A. Argan (INAF HQ), F. Ceraudo, G. Dilillo, G. Lombardi, A. Nuti

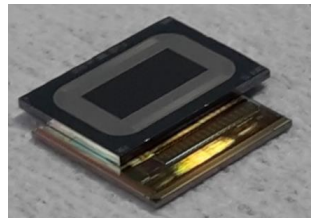
DRIVER: Spectral-Timing and Imaging in X-rays
Silicon Detectors
ASICs, Front-End Electronics

Skills	Facilities	Comments
Test and calibration of X-ray detectors	• X-ray irradiation facility (2-30 keV) and radioactive sources • Micrometric linear and rotary stages • Lab electronics and data acquisition systems • Climatic & vacuum chambers	In collaboration with INAF/OAS and IASF-Mi, INFN Trieste and Trento, Polytechnic of Milan, University of Pavia, Fondazione Bruno Kessler. Currently funded projects: **eXTP, ADAM, HERMES**
Radiation and Micrometeoroids Tests	• GEANT modelling and simulation tools • SPENVIS tool • Set-up and DAQ for tests at external facilities	Tests of both sensor and ASICs: NIEL, TID, SEE. Facilities used so far: PSI (Villigen), MPIK (Heidelberg), RADEF (Finland), Calliope (Casaccia)
Space Missions	• Design, development and management • Small, Medium size, Cubesats	AGILE, LOFT, eXTP, HERMES, STROBE-X
Thermo-mechanical Design, Analysis & Tests	• SolidWorks • Ansys • Thermica	Tests at SERMS (Terni) and PoliMi







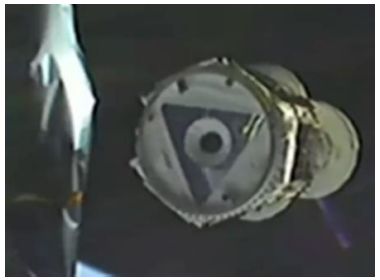


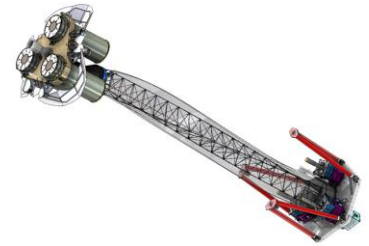
X-ray polarimetry

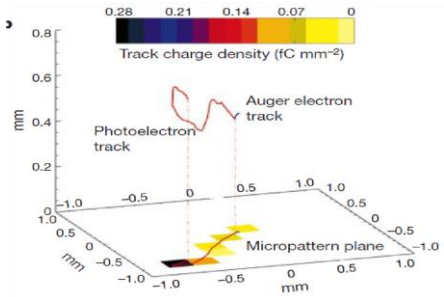
P. Soffitta, E. Costa, F. Muleri, E. Del Monte, S. Fabiani, A. Di Marco, A. Rubini, P. Loffredo, F. La Monaca, J. Rankin, L. Pacciani, A. Ratheesh, R. Ferrazzoli, D. E. Kim, G. Lombardi

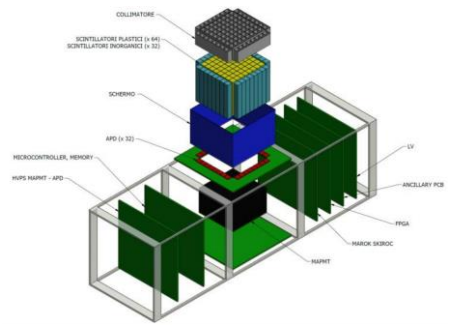
DRIVER: 1) Gas cell detectors for photoelectric X-ray polarimetry 2) Compton polarimetry with PMT and SiPM for scintillators readout 3) Detector simulation with GEANT4 4) Project Office of space projects (IXPE, CUSP)

Skills	Facilities and tools	Comments
• Detector characterization and calibration (gas and solid state)	• X-ray facility in laboratory in shielded room • Flight detector calibration facility in clean room • Climatic & vacuum chambers • Gas mixer for three mixtures flowing system (1-3 bar) to fill gas detectors (under construction)	• Polarized and unpolarized X-ray sources (≲2-30 keV) based on X-ray tubes, radionuclides, Bragg diffraction and fluorescence (Calibration of IXPE Detector Units). • He flowing for low energies.
• Detectors, payloads and mission design, • Detector simulation	• CAD and engineering software, project management software, GEANT4 Toolkit (C++)	• Simulation of: 1) IXPE instrument background, instrument performance, 2) CUSP Compton X-ray polarimeter (Cubesat Phase A mission for solar flares and space weather), 3) Hype-X new photoelectric gas polarimeter development exploiting 3D track imaging in gas cell
• Development of python analysis software	• Python and ftools Mission data analysis software (IXPE)	• IXPE scientific data analysis









Experimental Plasma Physics

P. Diego, E. Fiorenza, A. Morbidini, F. Nuccilli, E. Papini, A. Parmentier, R. Rispoli, N. Vertolli

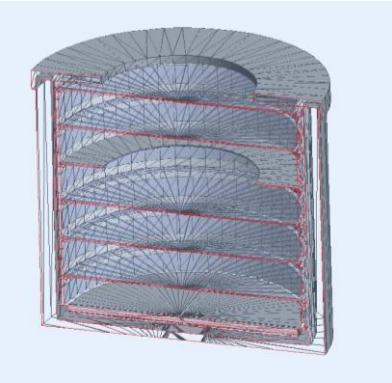
Electric Field Detector for CSES-02

Developed in collaboration with INFN, the EFD (Electric Field Detector) has been **designed to measure the ionospheric electric field components** as a voltage difference between multiple probe pairs.

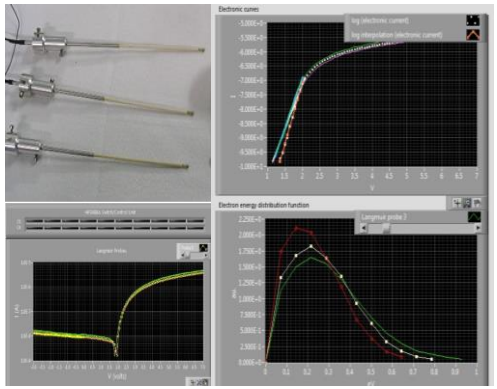
The state-of-the-art design of the front-end electronics and analog acquisition board enables a sensitivity in the order of V/m across the range from DC to 3.5 MHz. The instrument provides sensor potential in the ULF band (< 3 Hz), electric field components in the ELF (3-3000 Hz) and VLF (3-30 kHz) bands, and FFT in the HF band.

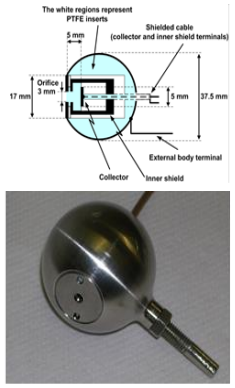
Plasma Analyzer

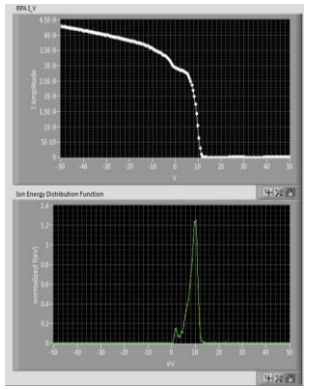
Innovative concept fit for cubesat constraints.
The segmented electrode allows for detection of plasma velocity direction as an Ion Drift Meter.

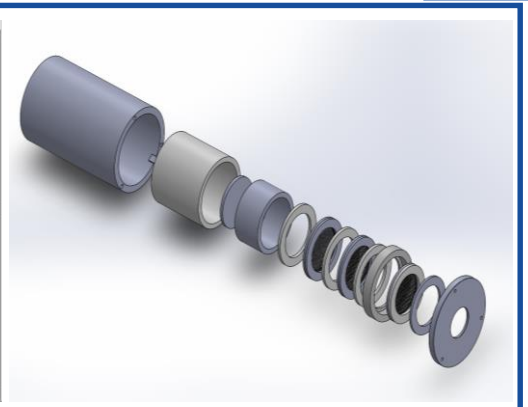


The polarization of the external grids prevents electrons from entering the sensor cavity, while inner grids allow the measurement of energy and fluxes for different ion species.









Langmuir probes to measure plasma density and temperature (left figs.), **RPA** (i.e. analyzer) to measure ionospheric plasma energy (central figs.), and solar wind energy (right fig.)

Plasma Diagnostic for Laboratories

Sensors and acquisition systems are being developed by the team to monitor plasma parameters inside the SWIPS chamber at INAF/IAPS (follow “Laboratori e Facilities” session).
This monitoring is needed to characterize other instruments, prototypes, and various kinds of space borne technologies.

ENA (Energetic Neutral Atoms) sensors

E. De Angelis, R. Rispoli, L. Colasanti, N. Vertolli, F. Nuccilli, M. Moroni

Innovative instrument developments for ENA detection to measure Mass, Energy and Direction of particles (mainly H,He O atoms in the range 1-100keV). Specific detector upgrades for ENA application:

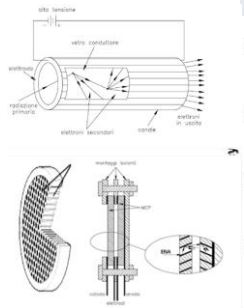
- instrument concept based on **MCP detectors** (MicroChannel Plate)

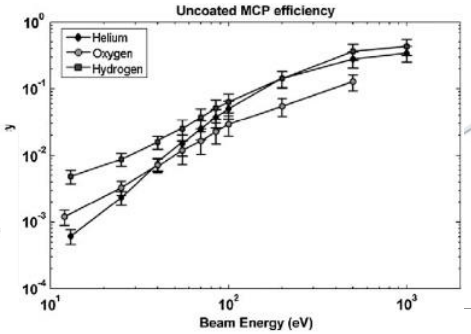
i.e. ELENA/SERENA instrument on board BepiColombo mission:
first ENA direct detection technique with 2-stage MCPs, discrete anode system, read-out eletronics (FPGA,ASIC….)

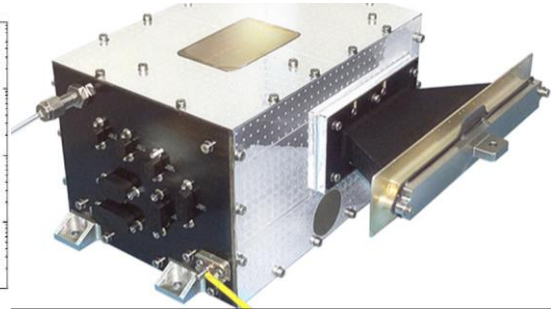
- instrument concept based on **MPGD detector** (MicroPattern Gas Detector)

i.e. SWEATERS project to realize first compact gas sensor to detect ENA

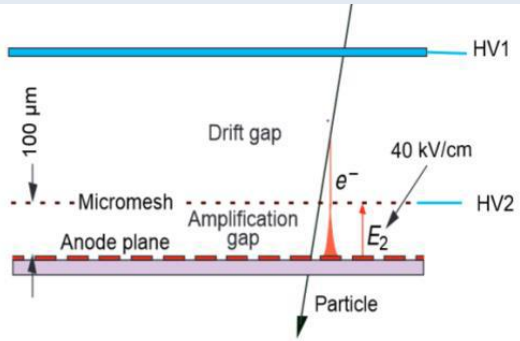
1st **MCP detector** efficiency at Low Energy







1st **MPGD detector** application to ENA

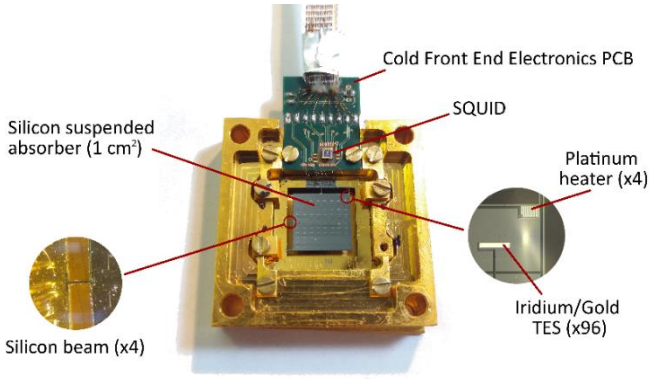


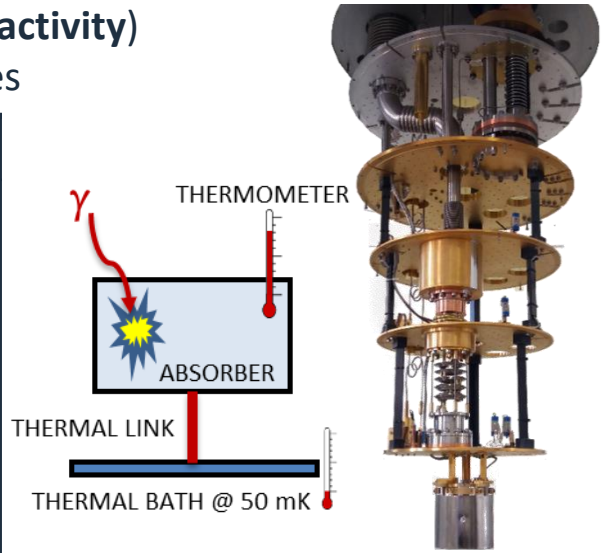
Cryogenic Microcalorimetry for Particle Detection and X-ray Spectroscopy

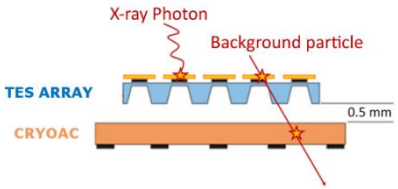
L. Piro, C. Macculi, M. D'Andrea, S. Lotti✪

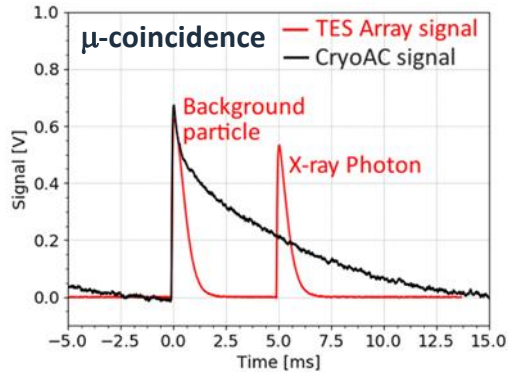
DRIVER: - Cryogenic Anticoincidence particle detectors for Low particle background applications (**main** present **activity**)
- High resolution X-ray spectroscopy (ΔE of few eV@6keV) for Astrophysics and Cultural heritage studies

Skills	Facilities and tools	Comments
Design, integration and test of • Cryogenic Microcalorimeters based on Transition Edge Sensors (TES) • Cryogenic and warm low-noise electronics based on SQUID magnetometers	• Cryogenic facilities (see "Laboratori e Facilities" session) to work at the following temperatures to be inserted in a Clean Room Class ISO7 and ISO5: ○ ~ 50 mK for TES ○ ~ 4 K for SQUID electronics • EMI filtering & magnetic shielding (down to ~ 50 mK) to enable TES + SQUID performances	• Italian collaboration with Phys. dep. Genoa Univ. (chip design and manufacturing), CNR/IFN and TAS-I (electronics) • Involved in ESA CTP programs (OptiTES) • Financial support from: ASI, ESA, INAF, UE, IAPS • CoPI-ship (L. Piro) of **ATHENA X-IFU**; we are responsible for the development and delivery of its **Cryogenic AntiCoincidence Detector (CryoAC)** to the prime
✪ Advanced Modelling of particle detectors to address design and guide data analysis	• Geant4 Toolkit (C++) (see "Tecnologie informatiche" session)	
Basic Mechanical, Thermal and Magnetic design	• SolidWorks + Comsol	
Development of Data Acquisition, Measurements Automation and Data Analysis software	• Labview + Python languages • Data analysis routines (Optimal filtering, PCA)	









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Ciao