New instrumentation at the Laboratorio di Astrofisica Sperimentale (LASp)

INAF ISTITUTO NAZIONALE DI ASTROFISICA

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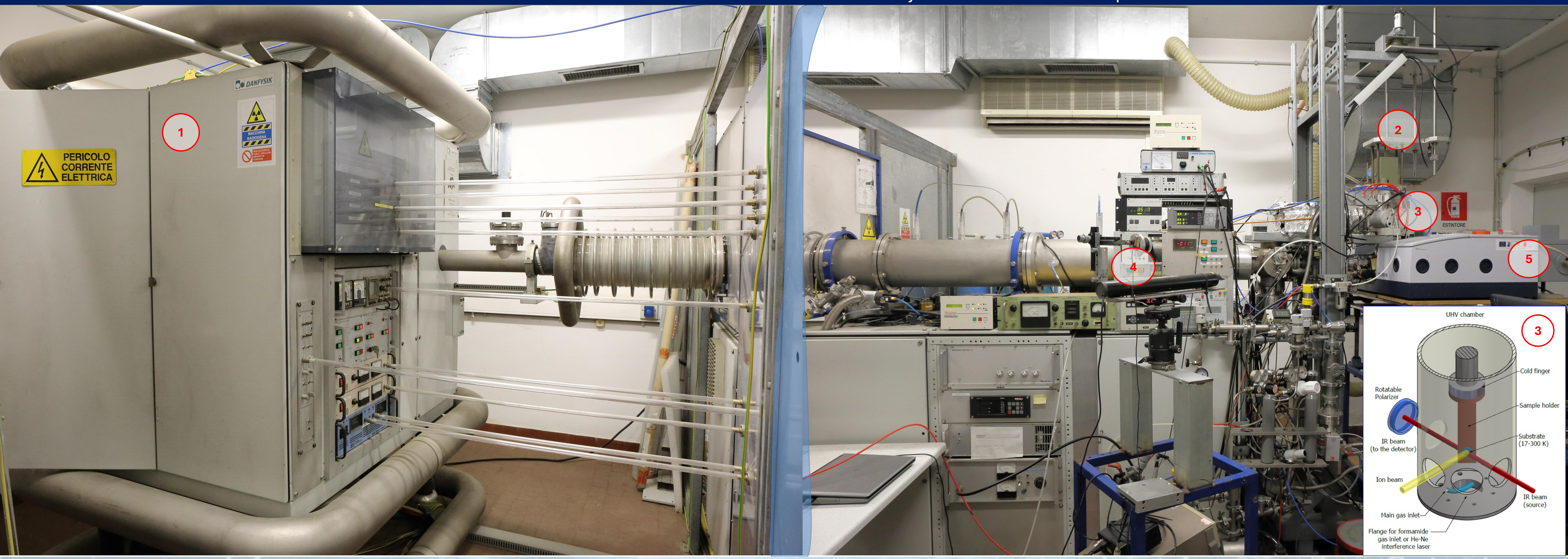
The LASp is a unique facility in INAF and in Italy dedicated to the study of solid materials and extraterrestrial samples subjected to typical space conditions such as vacuum, low temperature and irradiation with UV photons and fast ions (200-400 keV) that simulate the effects of the solar wind, Solar Energetic Particles (SEP) and low-energy cosmic rays.

Main expertise/activities:

* Study of the effects of ion irradiation and UV photolysis on solid samples
* In situ IR and Raman spectroscopy
* Analysis of extraterrestrial samples



Ion bombardment and photon irradiation facility

- Ion implanter Danfysik 1080 200 kV (H^+, He^+, N^+, C^+, Ar^+, etc…) **(1)**
- Hydrogen generator for proton bombardment
- Microwave powered Lyman-alpha resonance lamp (Opthos) and system for in-situ measurement of UV photon flux
- Closed-cycle He cryocooler (CTA) operating at 18-300 K **(2)**
- Ultra High Vacuum (UHV) scattering chamber (P <= 10^{-9} mbar) **(3)**
- He-Ne laser for ice thickness measurement **(4)**

In-situ analysis during simulated space weathering experiments

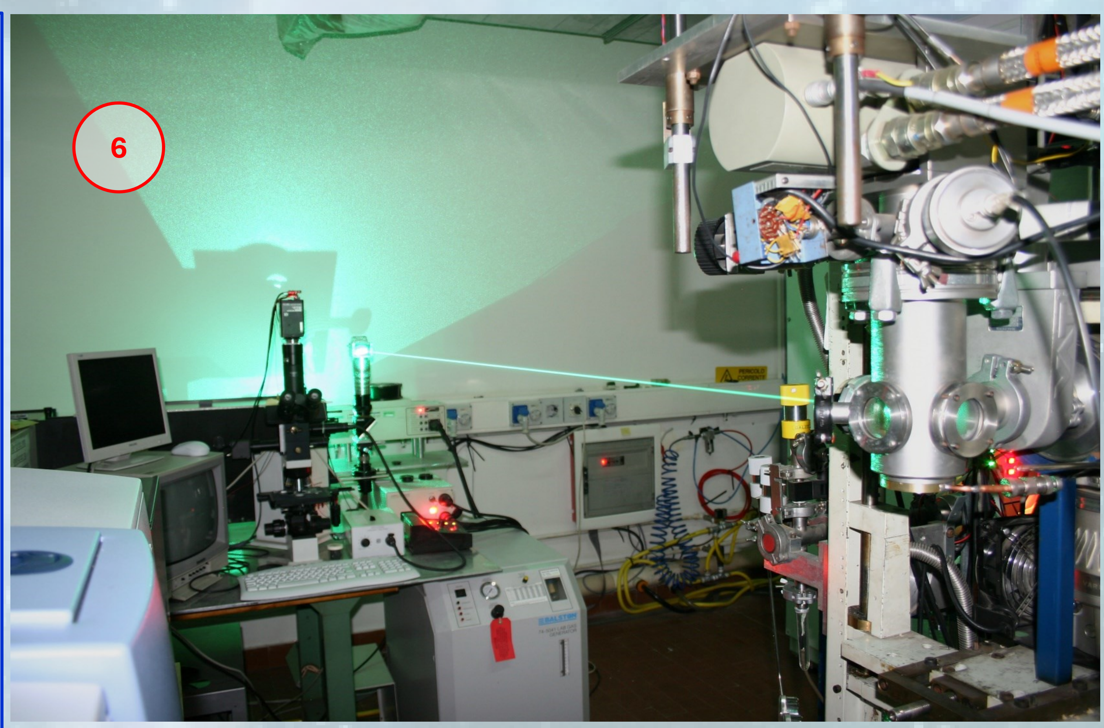
- FT-IR spectrometer Bruker Vertex 70 (12500-400 cm^{-1}) **(5)**
- FT-IR spectrometer Bruker Invenio (8000-350 cm^{-1})
- Raman spectrometer Triplemate 1877 SPEX equipped with a CCD detector and confocal illuminator (DILOR, macro+microscope, 400-950 nm) **(6)**
- mini Raman spectrometer He-785 (HORIBA, 200-3300 cm^{-1}) equipped with a CCD detector, optical fiber and 300 mW 785 laser diode
- other laser (He-Ne 35 mW; Nd-YAG 266 nm 20 kHz, 30 mW)
- UV-Vis-NIR Perkin Elmer Lambda 19 spectrometer (190-2500 nm)

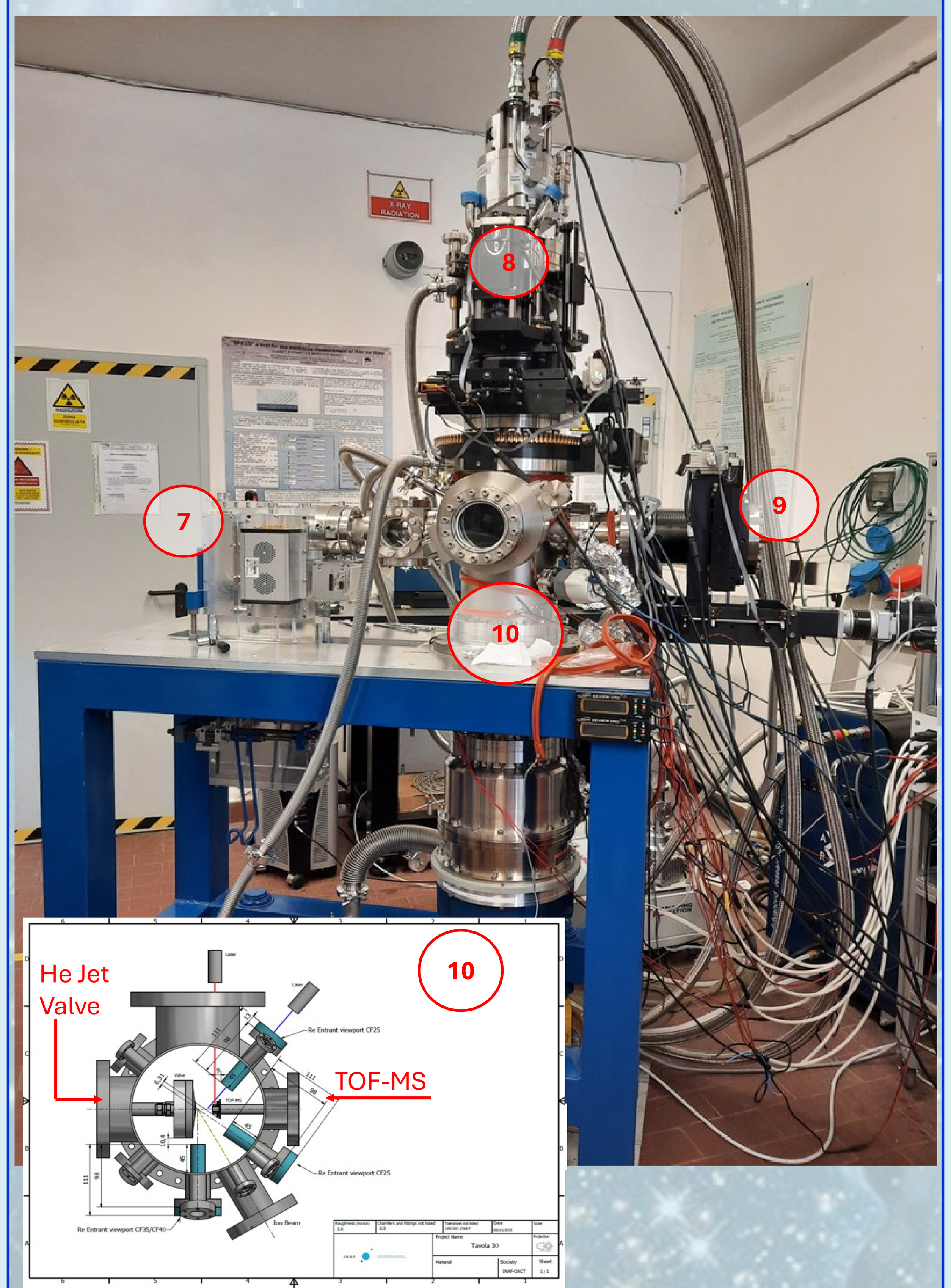
New setup for Laser-stimulated desorption and Time-of-flight Mass Spectrometry

- TOF-MS with reflectron (Tofwerk) **(7)**
- Photoionization Laser (Q-SMART Nd-YAG 355 nm, Peak OPO energy > 3 mJ)
- Desorption laser (RADIANT SE 2731 Nd:YAG 2700-3100 nm, Peak OPO energy 12 mJ)
- VUV Laser Cell (Tripling Xe-Ar gas cell to generate VUV 118-2 nm from the 355 nm Nd-YAG Laser)
- Closed-cycle He cryocooler 4-300 K (ARS) **(8)**
- He-jet valve (Velocitas VMI) **(9)**
- Custom made UHV chamber (P<=10^{-9} mbar) **(10)**

New instrumentation recently acquired and in the process of being acquired

- NIR-MIR module (temperature controller + accessories)
- UV-Vis-NIR optical fiber module (spectrometer+integrating sphere+accessories)
- Raman Laser 532 nm, 160 mW (Cobolt 08-01 series with integrated optical isolator and heatsink)
- VUV Laser Cell (Tripling Xe-Ar gas cell in order to generate the VUV 9th harmonic (118.2 nm) from the 3rd harmonic (355 nm) of a Nd-YAG laser **(11)**
- UV-Vis-NIR Perkin-Elmer Lambda 1050+ spectrometer
- NLIR fiber spectrometer 2.0 - 5.0 µm (in-situ IR reflectance)





Studied sample

Astrochemistry and Astrobiology

- Analogs (interstellar medium and solar system)
- Ices (H_2O, CO, CO_2, CH_4, CH_3OH, OCS, H_2S, N_2, NH_3 and some of their isotopologues, etc…)
- Silicates (quartz, olivine, forsterite, pyroxene, serpentine, Etnean soils, etc…)
- Carbonaceous materials (amorphous carbon, graphite, diamond, fullerene, asphaltite, pentacene, etc…)
- Bacteria (Deinococcus radiodurans)

Material Science

- Polymers (Polystyrene, Polyethylene, Polymethyl methacrylate (PMMA))
- Silicon carbide
- Crystalline silicon
- HOPG, diamond and fullerenes

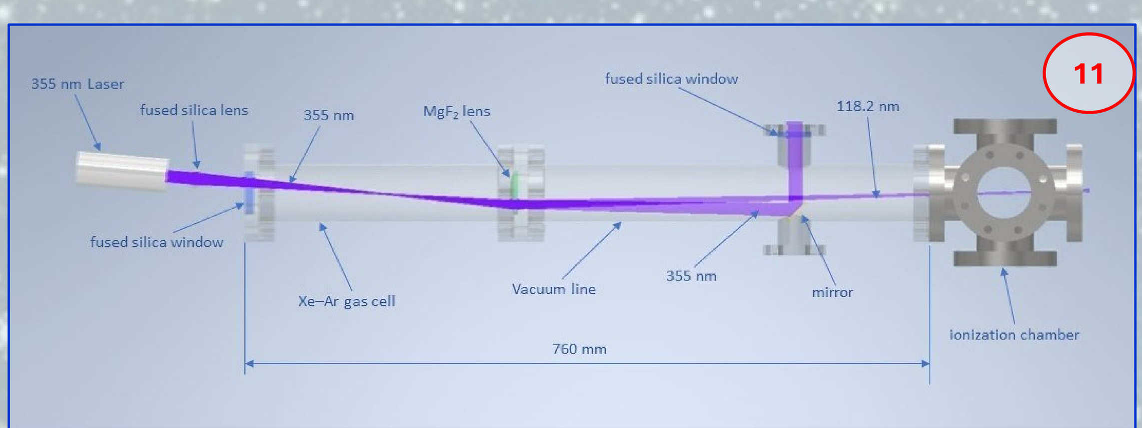
Extraterrestrial samples

- Meteorites (Orgueil, Tagish Lake, Eifel, Epinal, Bereba, Dar Al Gani 684, Tatahouine, Eagle, Vaca Muerta, etc…)
- Interplanetary Dust Particles (IDPs)
- Cometary dust particles (NASA/Stardust space mission)

Some of our works

- Spectra produced to support JWST observations (ERS IceAge, PI M. McClure; Sturm et al. 2023, A&A 679, id.A138, pp.15; Noble et al. 2024, Nature Astronomy 8, pp.1169–1180; Nisini et al. 2024, ApJ 967, Issue 2, id.168, pp.17)
- Experiments on the presence of organics on atmosphere less surfaces (the Moon, Dalla Pria et al. 2024, Icarus 415, id.116077; Ceres, De Sanctis et al. 2024, Science Advances, *In press*)
- Astrochemistry & astrobiology (origin of organics, Urso et al. 2022, A&A 668, id.A169, pp.10; Baratta et al. 2019, Astrobiology 19, Issue 8, pp.1018-1036)
- Physical properties of surfaces (e.g. Scirè et al. 2019, Spectrochimica Acta Part A 219, pp.288-296; Urso et al. 2016, A&A 594, id.A80, pp.9)
- Characterization of cometary dust particles returned to Earth by NASA/Stardust mission (e.g. Sandford et al. 2006, Science 314, 1720; Rotundi et al. 2008, MAPS 43, 367)

The facility is used by INAF researchers and other Italian and foreign institutions to develop research projects in the field of the effects of space weathering by cosmic rays and solar particles on surfaces in space.



Recent projects, collaborations & fundings

Cerere (PRIN INAF 2017) • PRESTIGE (Ricerca Fondamentale INAF 2022• Terrae (Ricerca Fondamentale INAF 2023) • Juice (ACCORDO ASI-INAF n. 2023-6-HH.0) • JWST (Ice Age Early Release Science program) • STILES (PNRR Activity #4202 - OptSpectrLab) • BRAVE NEW WORLDS (PRIN 2022 PNRR) • Minigrants INAF 2022 • Minigrants INAF 2023 • PSS (Photochemistry on the Space Station)

PSS Photochemistry on the Space Station · LASSIE · Genesis - SKA · MUR PRIN 2022 PNRR

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