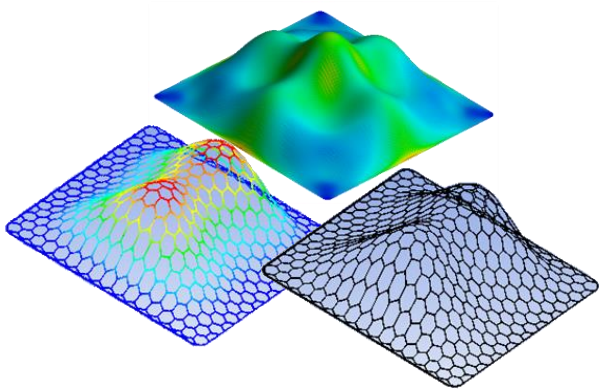
Mechanical Design and Characterization of Thin Film Structures



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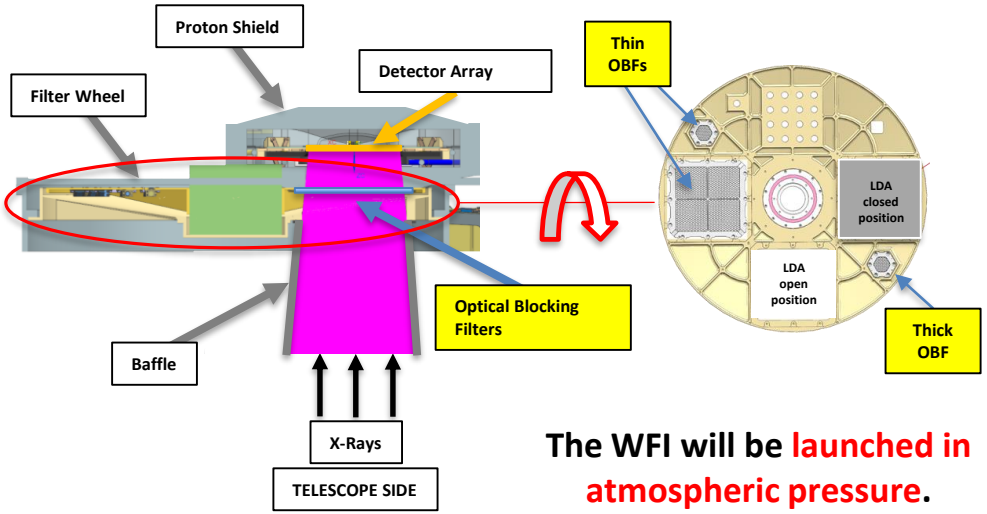
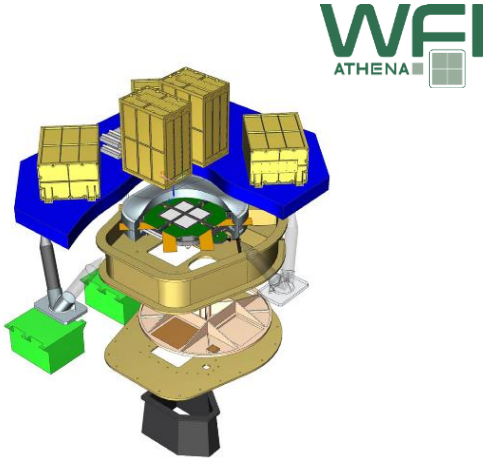
Outline

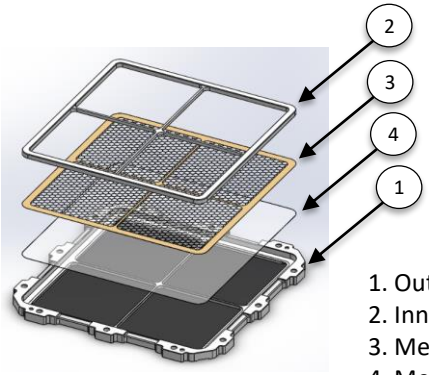
- **Mechanical Design and Finite Element Analysis**
  - Structural
  - Thermal
- **Prototyping**
- **Testing and Characterization**
  - Differential pressure and Thermo-Vacuum
  - Acoustic and Vibration Tests

Thin Film Structures in the Instrument Context





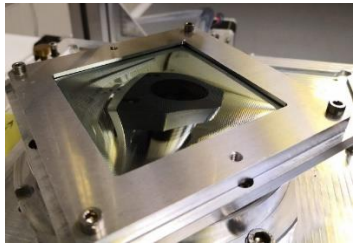
The WFI will be launched in atmospheric pressure.



1. Outer frame
2. Inner frame
3. Mesh
4. Membrane: polyimide (Detector side)/aluminum (Telescope side)

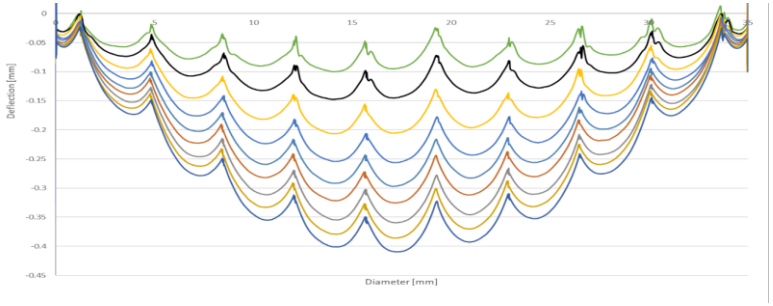
LDA OBF
Clean aperture: 159 mm x 159 mm
Membrane material: Polyimide ($C_{22}H_{10}N_2O_4$) 150 nm thick + Al coating 30 nm thick
Mesh - **material:** SS (AISI304) + Au plating 5 µm thick
- **Pattern**: honeycomb with pitch **4.8 +/- 0.05 mm**
- **Wires: 75 +/- 4 µm x 150 +/- 15 µm**
- **Blocking Factor: ~ 4%**

Mechanical Design and FEM: Static Pressure Load

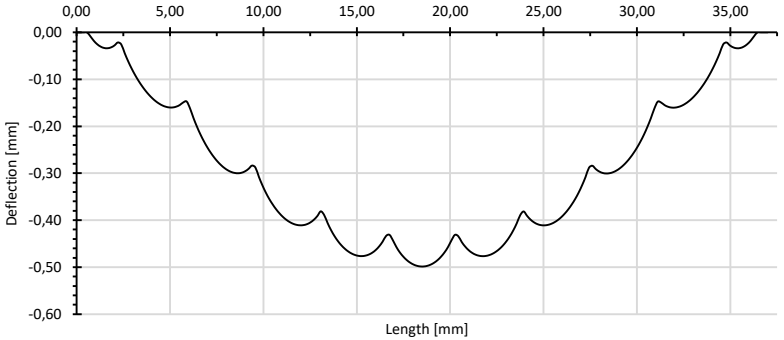


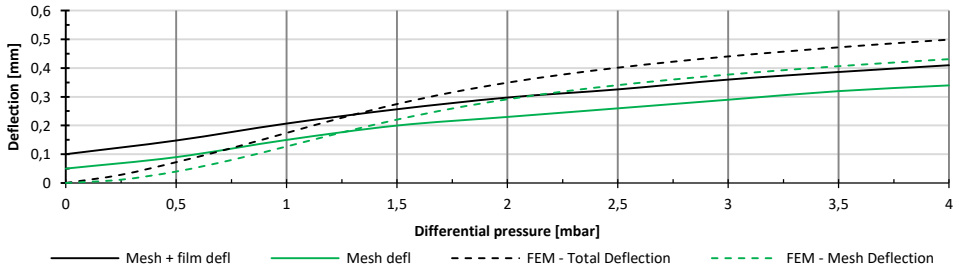
- Membrane 200 nm polyimide/30 nm aluminum;
- Stainless steel mesh with 5 µm gold plating;
- Hexagonal with a pitch of 3.6 mm (+/-0.05);
- Wire width 40 (+/-2) µm, thickness 80 (+/-8) µm.

Filter deflection measurements (0-4 mbar).



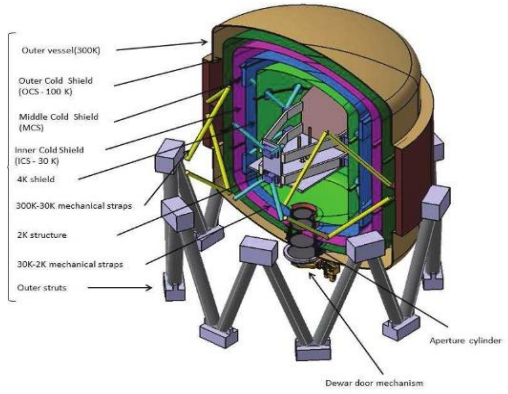
Finite Element Modelling @ 4 mbar



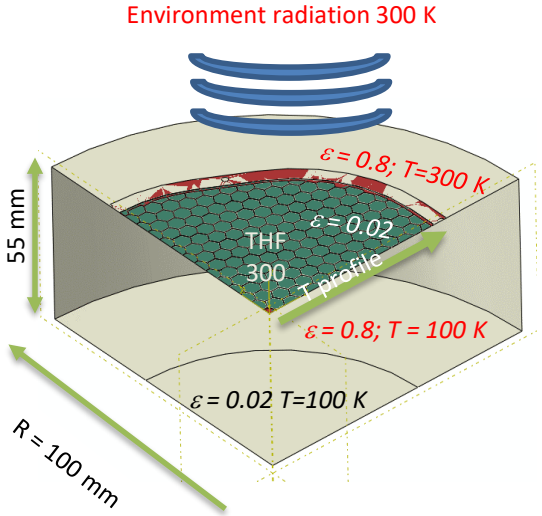


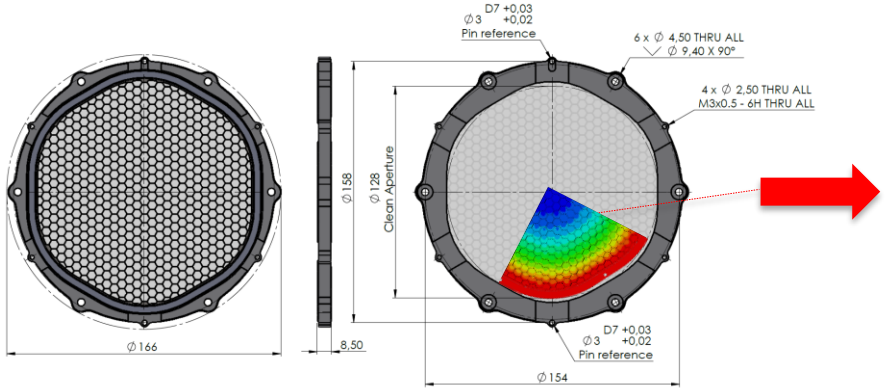
20 % estimated error between FEM and measurement

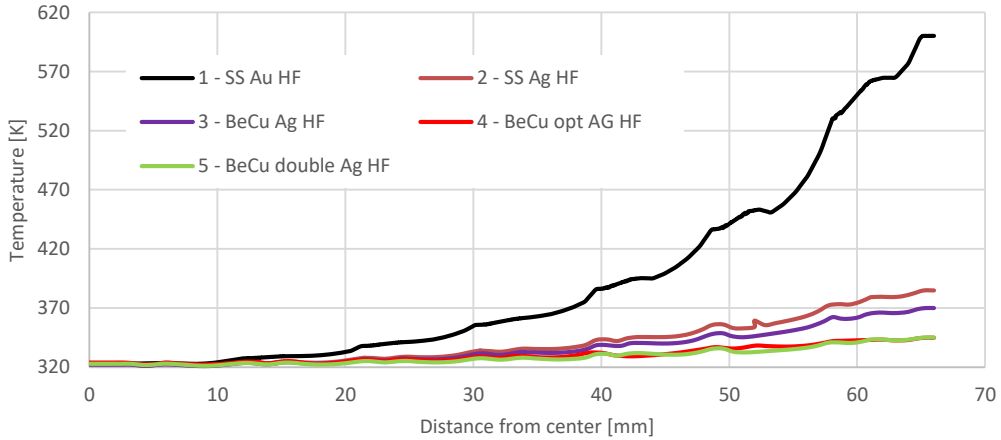
Mechanical Design and FEM: Thermal analysis



- Steady state heat transfer FEM has been used to calculate the radial temperature profile of the X-IFU THF 300 filter
- A 3D FEM is adopted to retrieve the temperature of the film inside each hex cell of the mesh
- On the upper face the filter is loaded with the environment radiation (@ 300K)
- The bottom face of the filter is considered part of a closed cavity



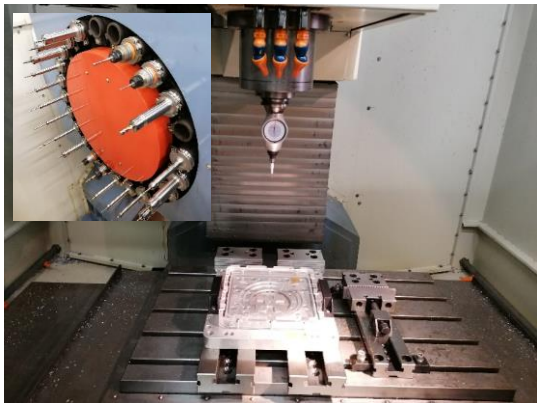




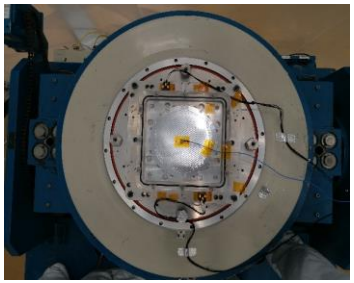
Mechanical Design and Prototyping

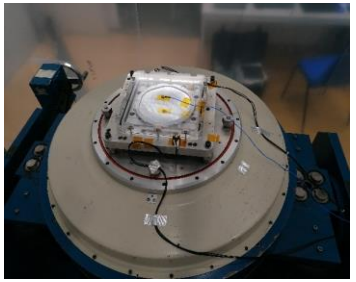
Mechanical Workshop

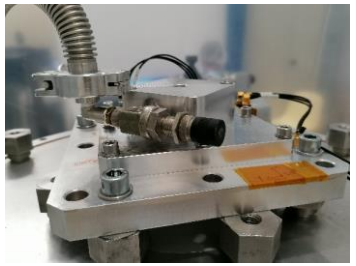
- Numerical control **milling machine FAMUP MCX 700**
- Numerical control **lathe CMT URSUS TC**
- **3 x Conventional lathe BOMAC**
- **Conventional milling machine BOMAC**
- **CAD-CAM**
  - SOLIDWORKS
  - ESPRIT



Filter breadboards, mechanical interfaces, storage and handling tools.

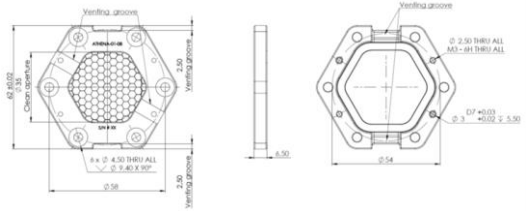


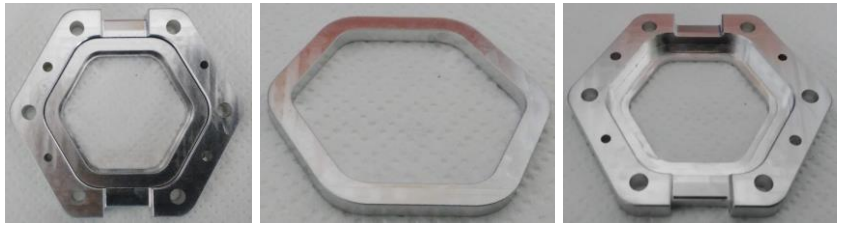


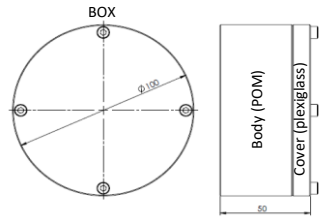


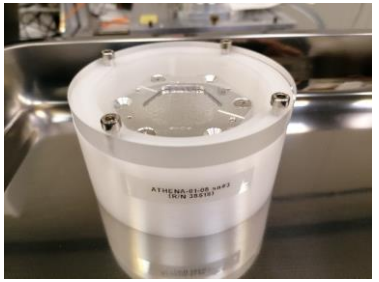
Examples of Manufactured Components

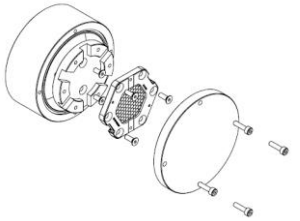
case study: WFI OBFs

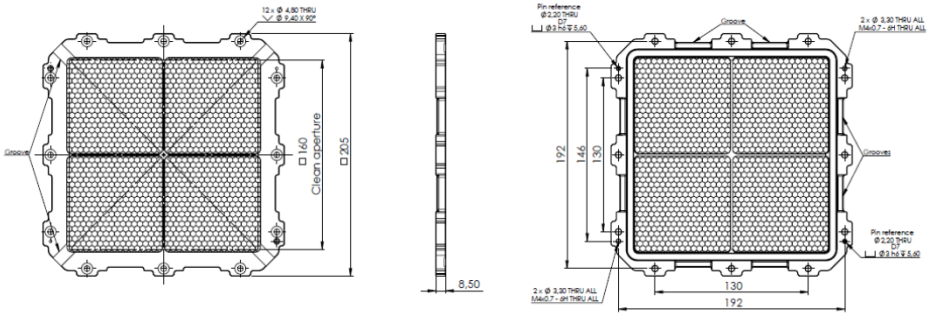


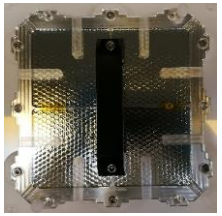


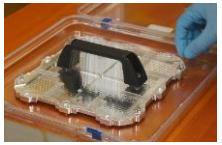


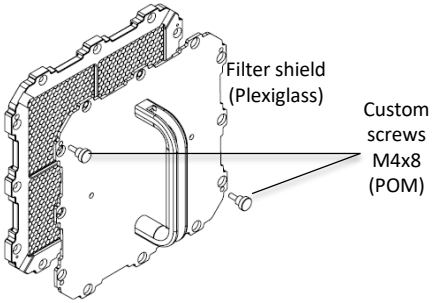


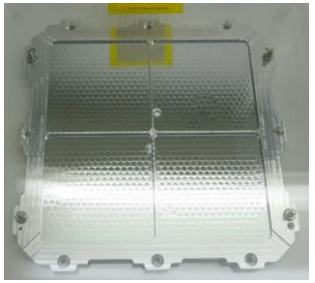








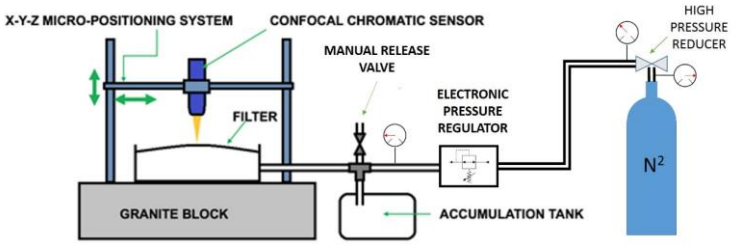


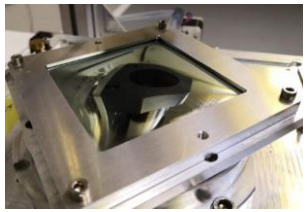


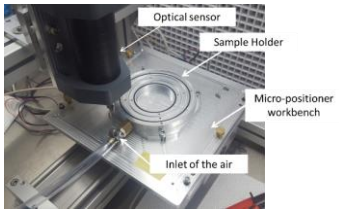
Characterization Tests: Static Pressure Load And Thermo-vacuum

Static Pressure Test @ INAF-OAPA

- X-Y-Z micro-positioner,
- Pressurization device,
- Optical confocal sensor micro-epsilon® DT 2421/2422





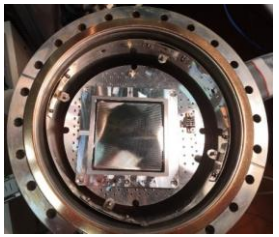


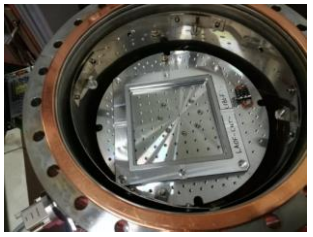
MAIN GOALS

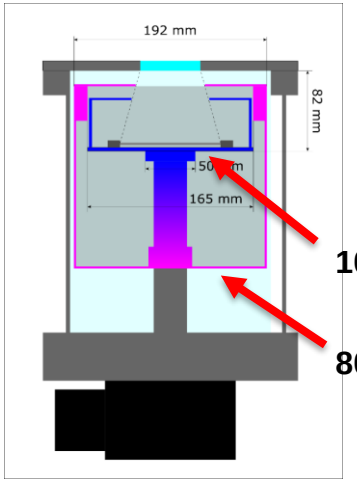
- Analyze the global and local deformation of mesh reinforced thin films.
- Investigate the stress on mesh and membranes by comparison with numerical simulations (FEA).
- Derive material parameters.

Thermo Vacuum @ INAF-OAPA

- Liquid Free Cryostat (10 - 320 K);
- 160 mm diameter cold plate;
- Thermometers, heaters and PID Temperature control.







MAIN GOAL

Investigate the thermomechanical compatibility between components made with different materials.

Characterization Tests: Acoustic and Vibration

Acoustic Facility

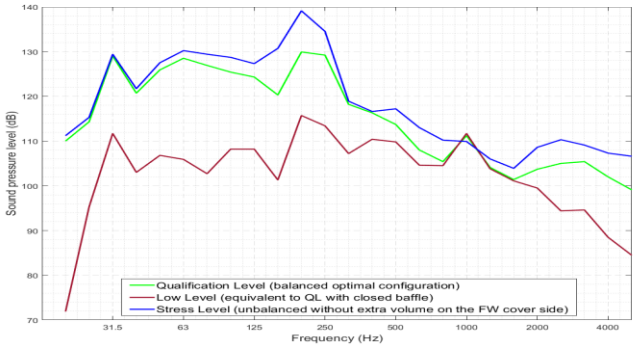
AGH University of Science and Technology (Krakow, Poland)

Reverberation chamber

Maxi Level

Differential pressure [mbar]		SPL [dB]
RMS	PEAK	TOTAL
0.8	7.9	142.0

Sound Pressure Level Spectra

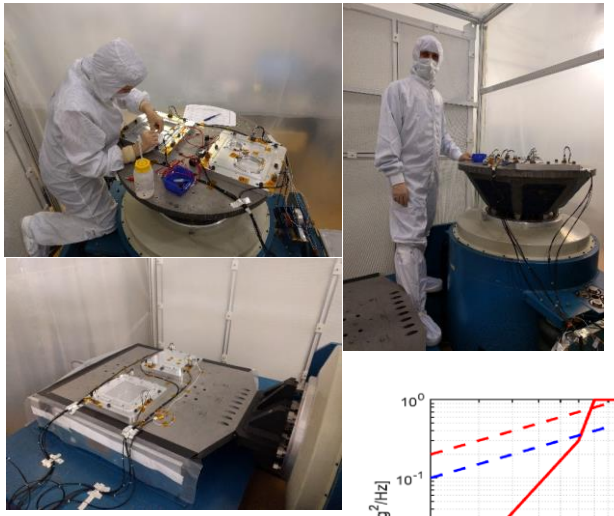


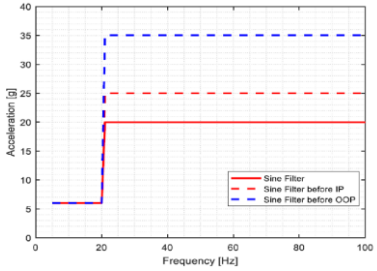
MAIN GOAL

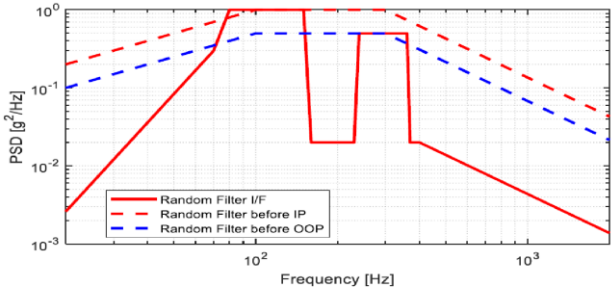
Test the resistance of components in air environment.

Vibration Facilities

- Centre Spatial de Liège – CSL (Liège- BE)
- Max Planck Institute for Extraterrestrial Physics – MPE (Garching, GE)
- Laboratory SERMS, UMBRA Group (Terni, IT)







MAIN GOALS

- Test mechanical strength of components under dynamic conditions.
- Investigate the dynamic response of components such as resonances and displacements in air and vacuum environment.

People

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