

# **ASTROMech**

## **Advanced Space Technological Research center for OptoMechanics**

Nicola La Palombara (IASF Milano)  
on behalf of a large collaboration

### **Proposing team:**

- **IASF-Mi:** S. D'Angelo, M. Fiorini, S. Incorvaia, N. La Palombara, L. Schettini, S. Scuderi, G. Toso, M. Uslenghi,
- **OABrera:** S. Basso, M. Civitani, G. Pareschi, E. Redaelli, M. Riva

# Scope of the project

Consolidation of the INAF technological hub in the Milano Area for research and development in the field of optomechanics for astronomical space instrumentation

⇒ to serve the entire community through participation in ASI & INAF-funded space projects

⇒ to improve the cooperation with national and international industries

⇒ to seek for technology synergies with astronomical ground-based projects

**Strengthening the IASF – Mi and OABrera (@Merate) labs with state-of-the-art optomechanical instrumentation**

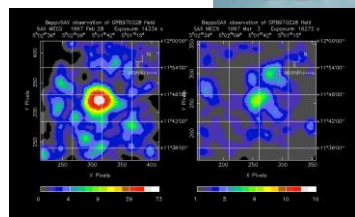
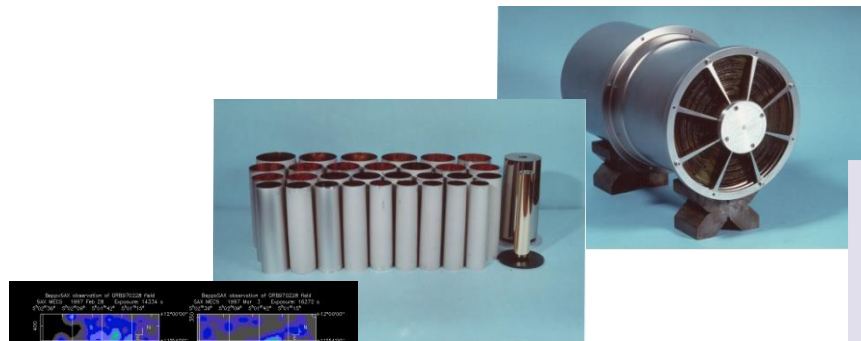
**Complementarity with other ongoing programs with similar goals, in particular STILES**

# IASF Milano and OABrera: a long heritage of successful projects (space + ground based)

- Development of the [Ni electroforming replica technology](#) (Citterio and collaborators @IASF-Mi and OABrera) for monolithic X-ray optics:
  - already used technology for several X-ray missions (*Beppo-SAX, JET-X/Swift XMM-Newton, eRosita, Einstein Probe*) and hard X-ray imaging prototypes (*Simbol-X/NHXM*)
  - ready *off-the-shelf* technology for other under development missions (*eXTP, HEX-P, Escape-EUV*)
- AGILE payload
- VIRMOS
- ESPRESSO
- X-Shooter
- BEaTriX and Vert-X X-ray calibration facilities for ESA
- ASTRI and CTAO (telescopes and optical cameras, Project Management)
- Glass innovative X-ray optics for Lynx and BabyIAXO

**several performed in close collaboration**

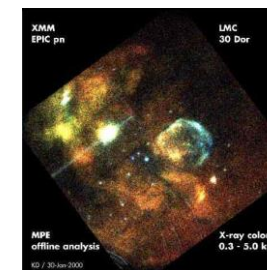
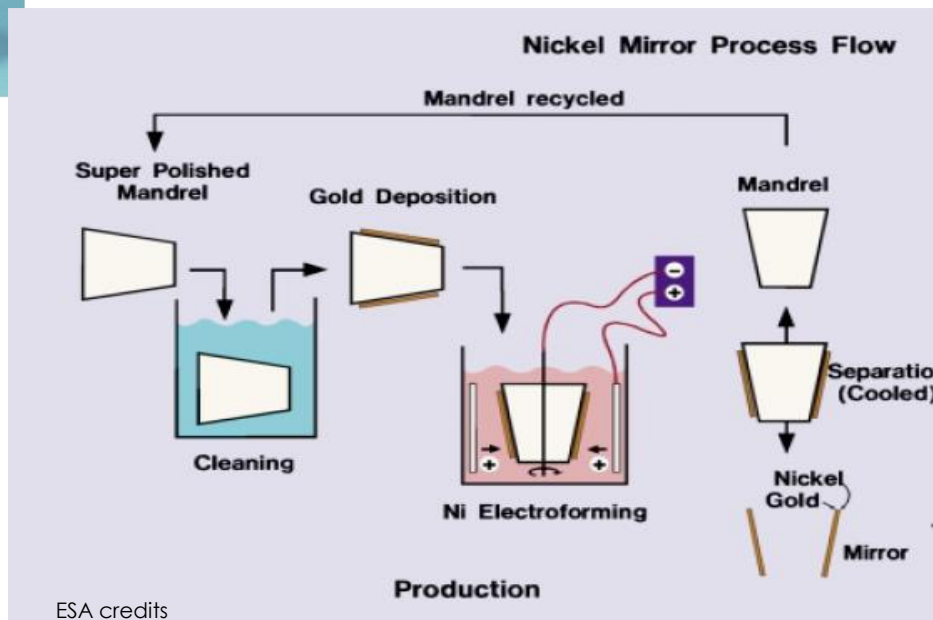
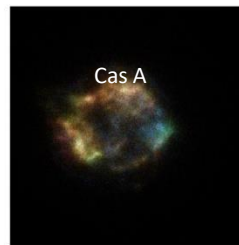
# X-ray optics by Ni electroforming replication



BeppoSAX



Jet-X/Swift



XMM-Newton

# Equipment and facilities already available or under implementation @ IASF-Mi and OABrera

## OABrera

- Advanced instrumentation for optical processing: *Ion Beam Figuring* and *Zeeko–Bonnet Polishing*
- Advanced instrumentation for surface and optical metrology: AFM, microscopy, profilometry, interferometry
- Mechanical workshop, including ultrasonic-assisted milling machine (*recent acquisition thanks to PNRR STILES funds*)
- New X-Y-Z large profilometer (*2024-2025 acquisition thanks to PNRR STILES+ Space infrastructural funds*)
- *BEaTriX* X-ray testing expansive beam facility, Bede X-ray reflectometer
- 3D Optical holographic lab for spectrometers (*under expansion thanks to STILES funds*)

## IASF-Mi

- Mechanical workshop with classical machines (lathes, grinding and drilling machines, to be renewed)
- Mechanical design
- Electronics lab and service
- UV optical testing lab (*supported with INAF Space Infrastructural funds*)

# ASTROMech program

## GOAL

- **Renewal of IASF-Mi** mechanical workshop, in an ad hoc climatized room, with a new generation **5-axis machining centre** and a state-of-the-art **diamond-turning lathe**
- **Strengthening of the OAB-Merate** workshop with a **metal 3D printer** for the fabrication of lightweight opto-mechanical interface parts

## TARGET

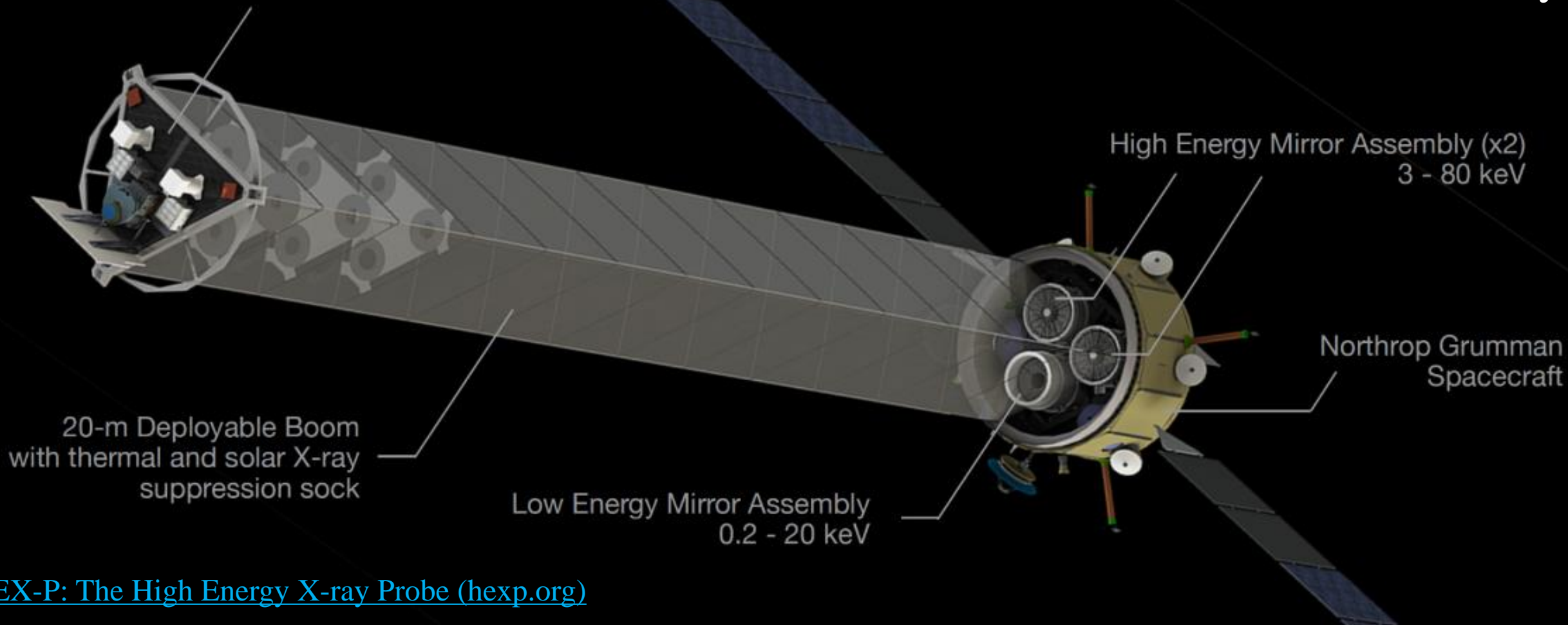
*Facilities useful for different applications, but proposed specifically for the following space programs of ASI and INAF interest:*

# High-Energy X-ray Probe (HEX-P)

Proposed by JPL & Caltech to NASA in the context of the **Probe-class** program

⇓  
short-term selection of three missions for Phase-A study

Low Energy Detector Assembly  
High Energy Detector Assembly (x2)  
Metrology Detectors



## TEAM

### HEX-P Leadership

**Principal Investigator (PI):** Daniel Stern (JPL/ Caltech)

**Deputy PI:** Kristin K. Madsen (GSFC)

**Associate PI:** Javier Garcia (GSFC)

### JPL Capture Team

**Capture Lead:** Miles Smith

**Deputy Capture Lead:** Sharon Kedar

**Payload Systems Engineer:** Patrick Morrisey

**Mission Systems Engineer:** Rashied Amini

### Key Partners

**Managing Center:** [Jet Propulsion Laboratory](#)

**LET optics:** [Goddard Space Flight Center](#)

**LET detectors:** [Max Planck Institute for Extraterrestrial Physics](#)

**HET optics:** [Italian Space Agency](#)

**HET detectors:** [Caltech](#)

**SIXTE simulations:** [Dr. Karl Remeis-Observatory](#)

**Spacecraft + Structures:** [Northrop Grumman](#)

### ITALIAN PARTICIPATION @Co-I level

Alberto Moretti (OAB):

- Co-I and PI for Italian effort
- Responsible for Mission Calibrations

Giorgio Lanzuisi (OAS)

Gabrielle Ponti (OAB)

- Galactic Surveys

Simonetta Pucetti (ASI):

- Pipeline Lead

Melania Del Santo (IASF Pa):

- Galactic binaries and the physics of accretion

Matteo Bacchetti (OA Ca):

- ULXs

**ASI with INAF** responsible for the optics of the HE telescope:  
~ 60 Wolter-I shells coated with Pt/C and W/Si multilayers



# Extreme-ultraviolet Stellar Characterization for Atmospheric Physics and Evolution (ESCAPE)

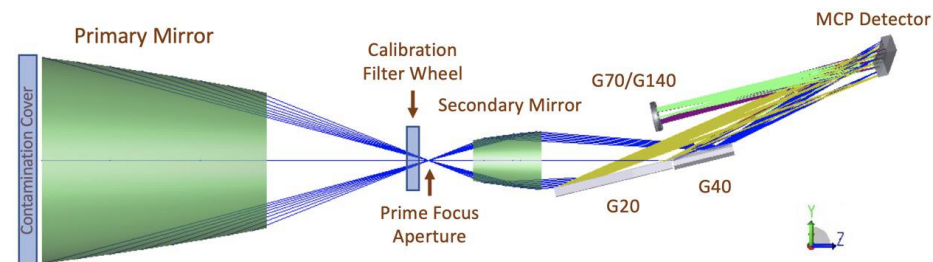
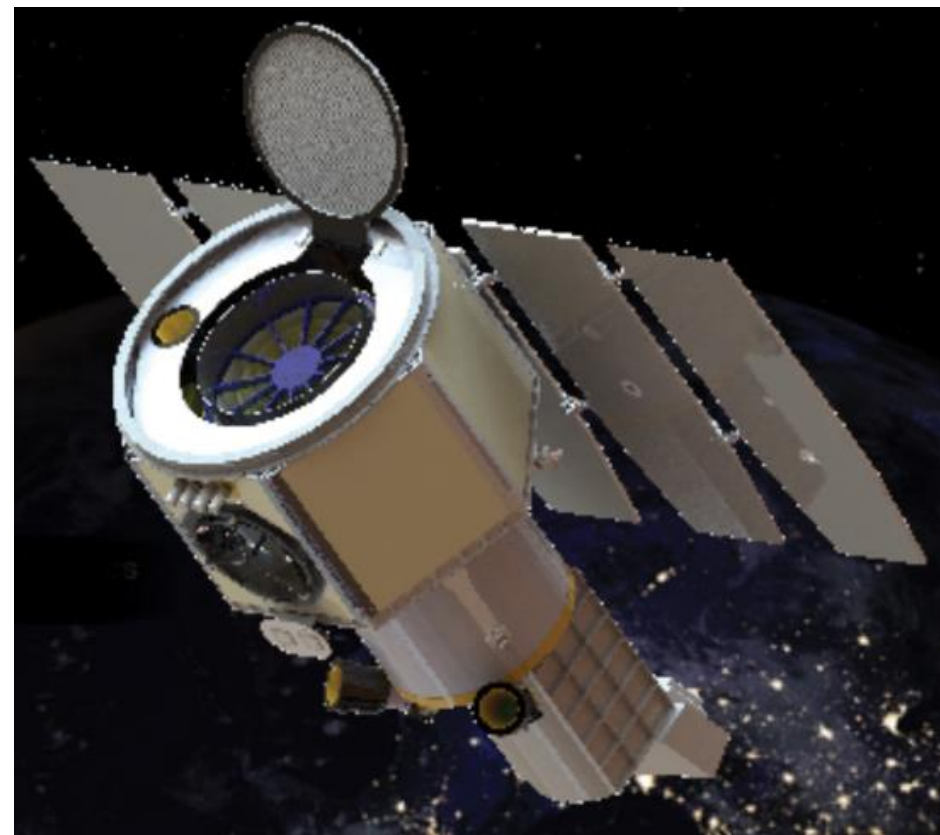
<https://lasp.colorado.edu/cusp/escape/>

- Proposed by University of Colorado and GSFC to NASA in the context of the SMEX-class program
- FUV/EUV spectroscopy to characterize the high-energy radiation environment in the habitable zones (HZs) around nearby stars
- grazing incidence optics and an advanced spectrometer



*selected by NASA for a 9-month Phase A study*

participation of ASI and INAF officially requested by CU

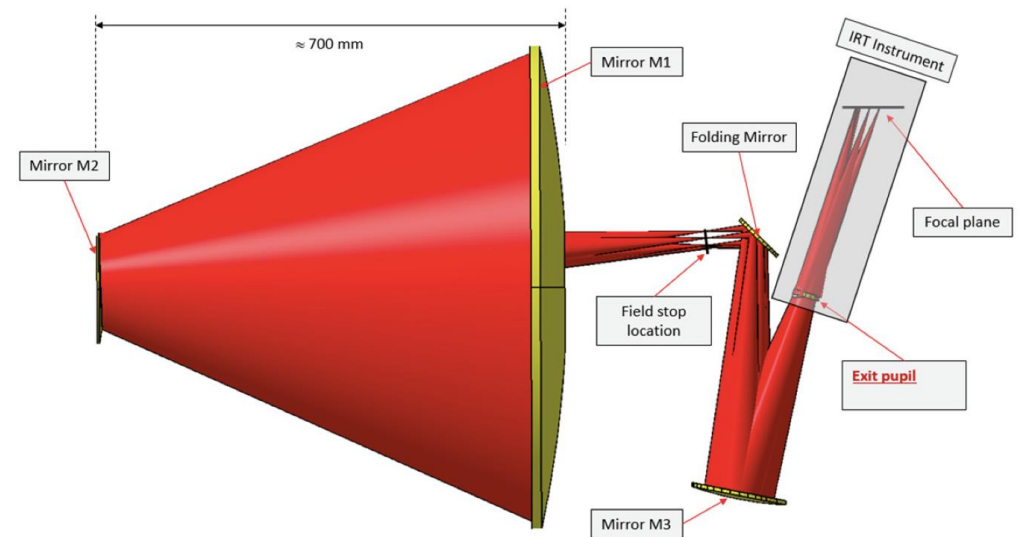


# ...and further projects:

Development of **glass-based grazing incidence optics** for the helioscope *BabyIAXO* (mandrels) and the *LYNX* NASA X-ray telescope (precise grinding and bonnet polishing of thin glass shells)



IR telescope aboard the *THESEUS* mission for GRB studies (under Phase-A study by ESA as M7), to be provided by ASI and INAF



# Single Point Diamond Turning (SPDT): High-precision mechanical processing of astronomical metal optics

## Performance:

- micro-roughness levels  $< 1.5$  nm
- shape accuracies  $< 150$  nm
- intrinsic high-precision metrology

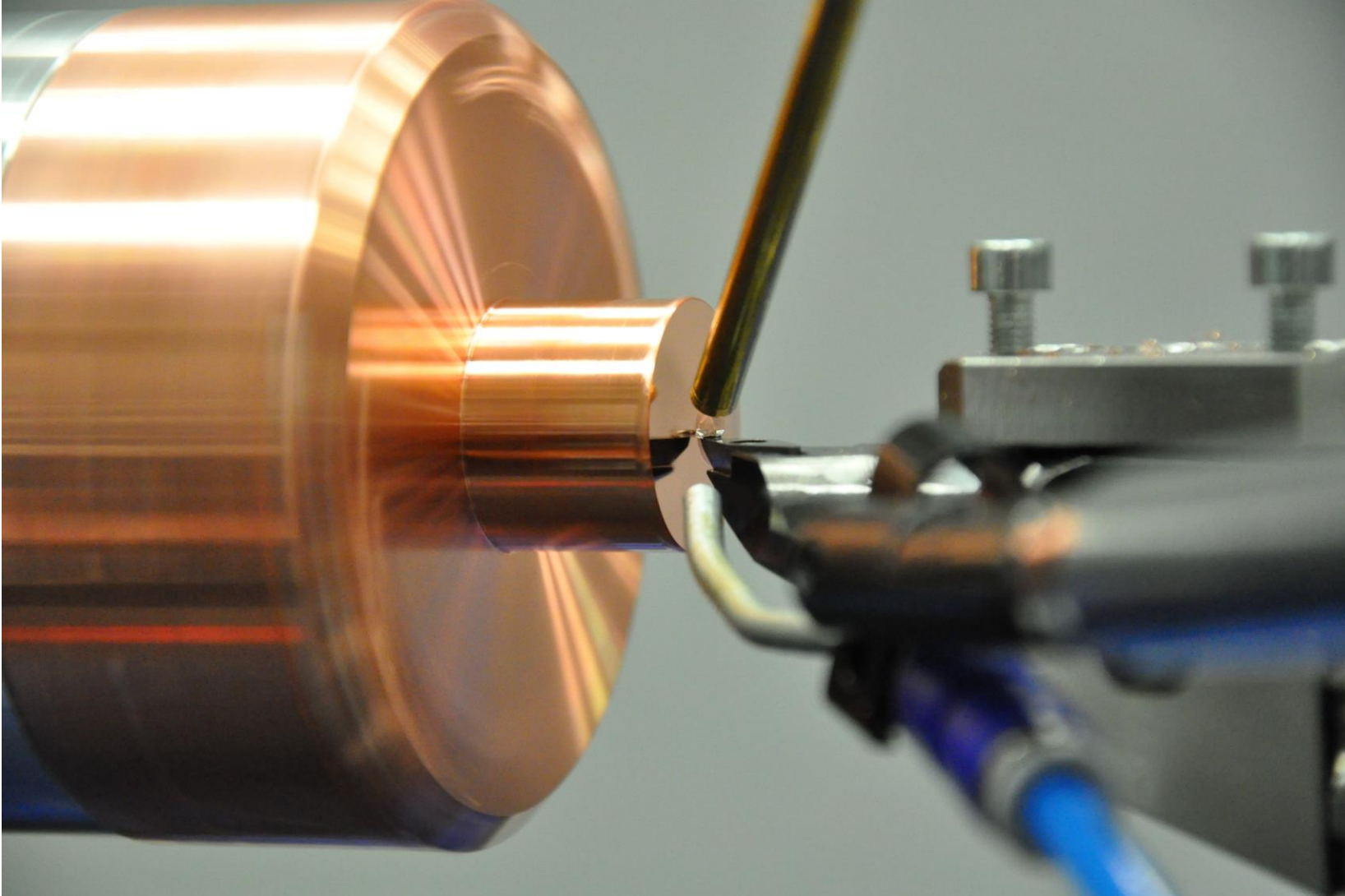
## Application examples

- shaping of **replica mandrels** in Al + Ni/P cladding necessary for the electroforming of shells
- production of **mirrors entirely made of Aluminum**
- adding on specific tools for:
  - polishing and measuring/characterization of the mandrel itself directly on the lathe
  - processing of monolithic shells in thin glass

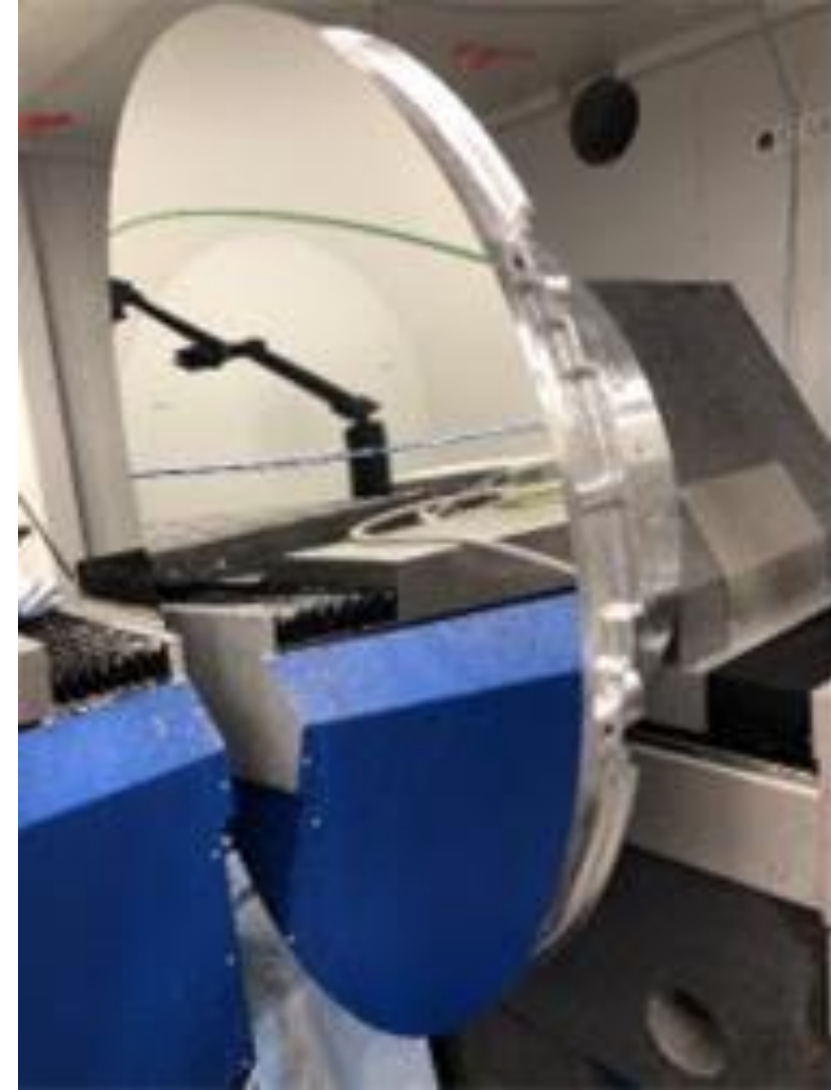
## Objectives:

- processing on **diameters  $> 50$  cm** and **lengths  $> 70$  cm**
- useful tool **strokes  $> 40$  cm**

# Single Point Diamond Turning (SPDT)



Credits: LT Ultra



Credits: ASI, INAF, LT Ultra, Media Lario

# Single Point Diamond Turning (SPDT)



Single Crystal  
diamond tool

Credits: Nanotech

# Numerically controlled vertical machining center (CDL)

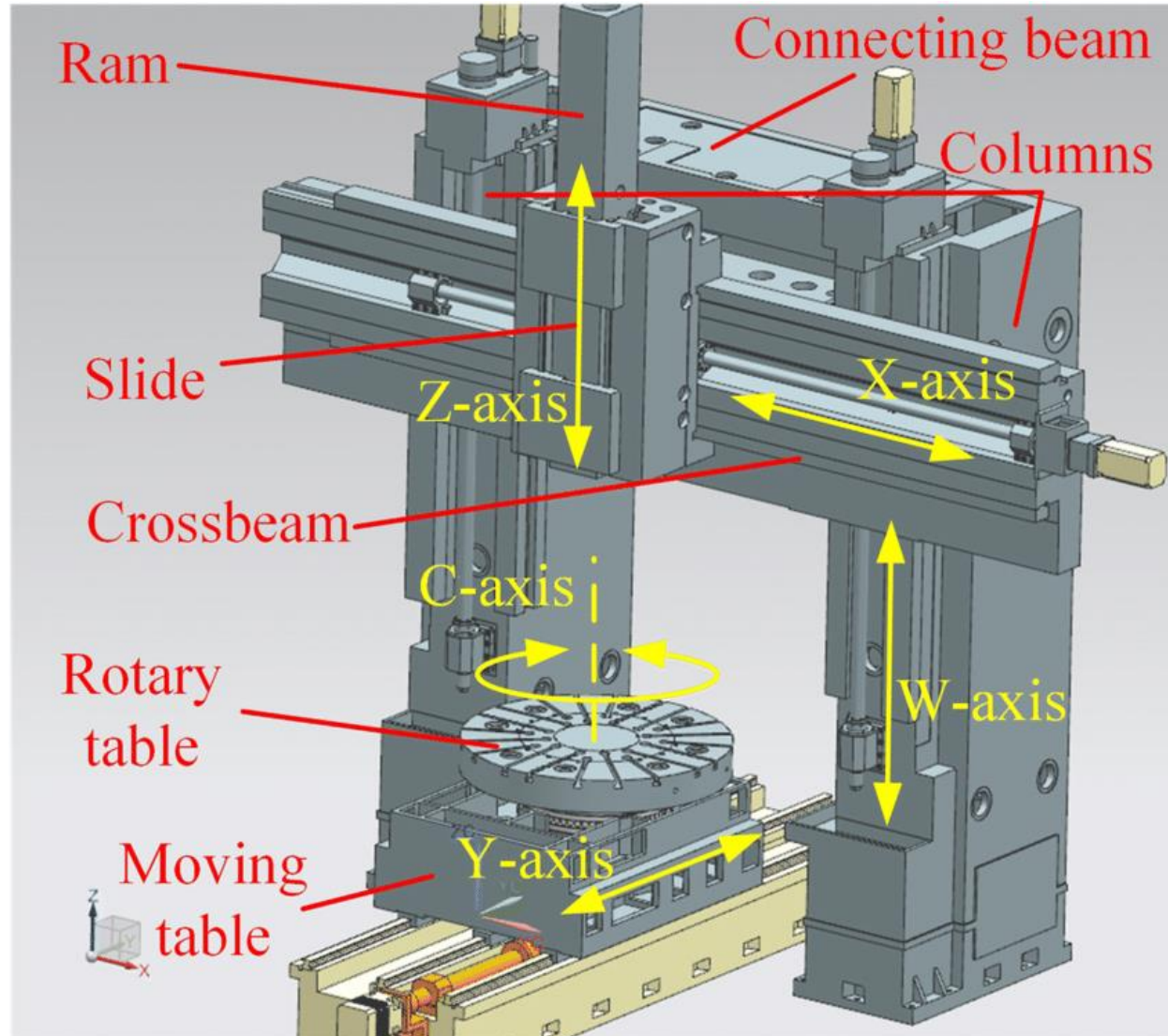
Machine characterized by:

- *high degree of accuracy* in the processing of components (a few tens of microns)
- *high level of surface finishing*
- *constant level of precision* over a high number of repetitions of the same type of processing



tool needed to:

- perform some preliminary operations on the objects to be turned
- create the interfaces needed to mount the objects themselves on the lathe



# 3D printer for metals

Tool necessary to obtain a remarkable customization and efficiency in the design and production of opto-mechanical components:

- creation of components with complex geometries and light but resistant internal structures

*⇒ increased functionality and precision of the components*

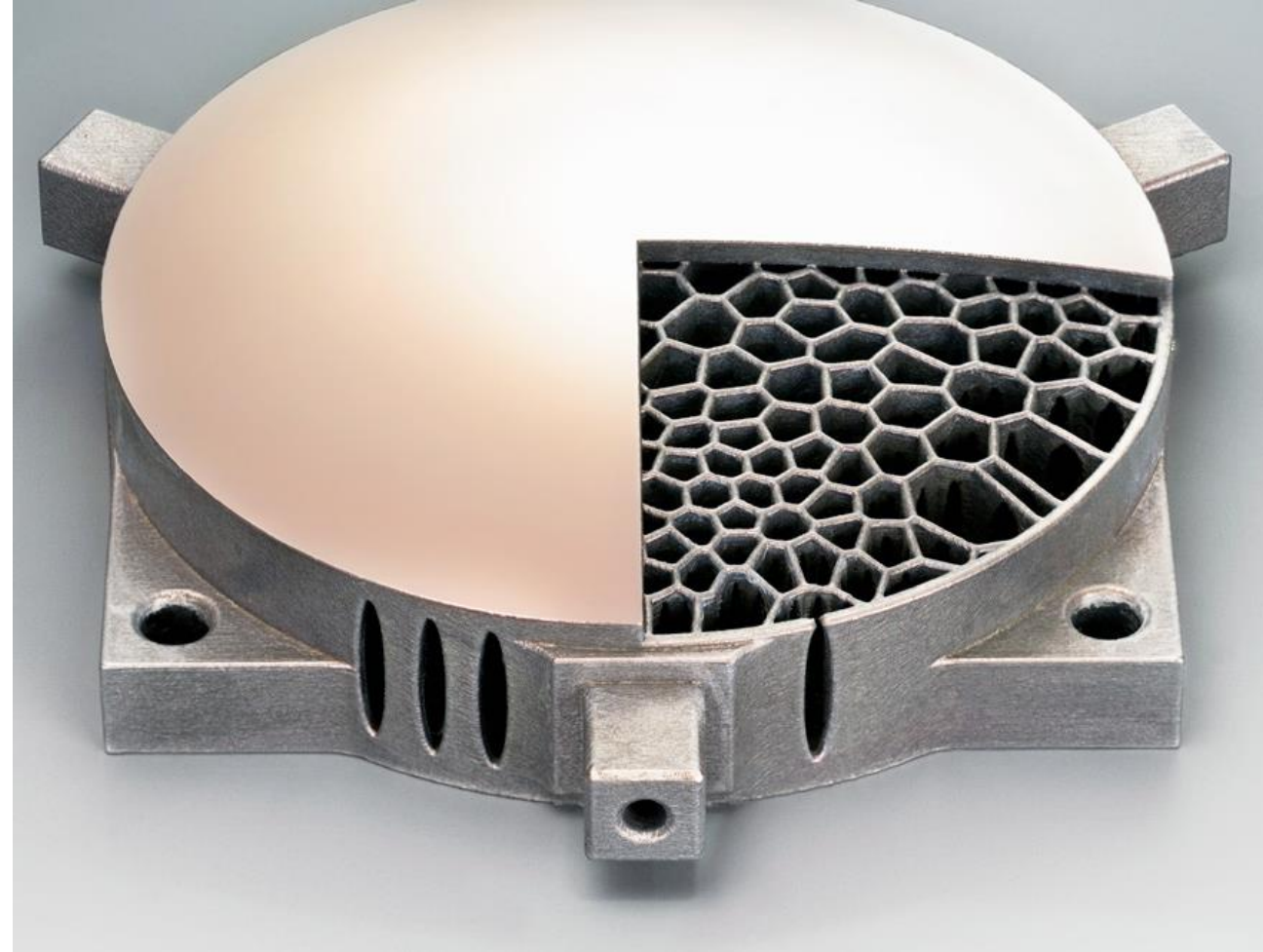
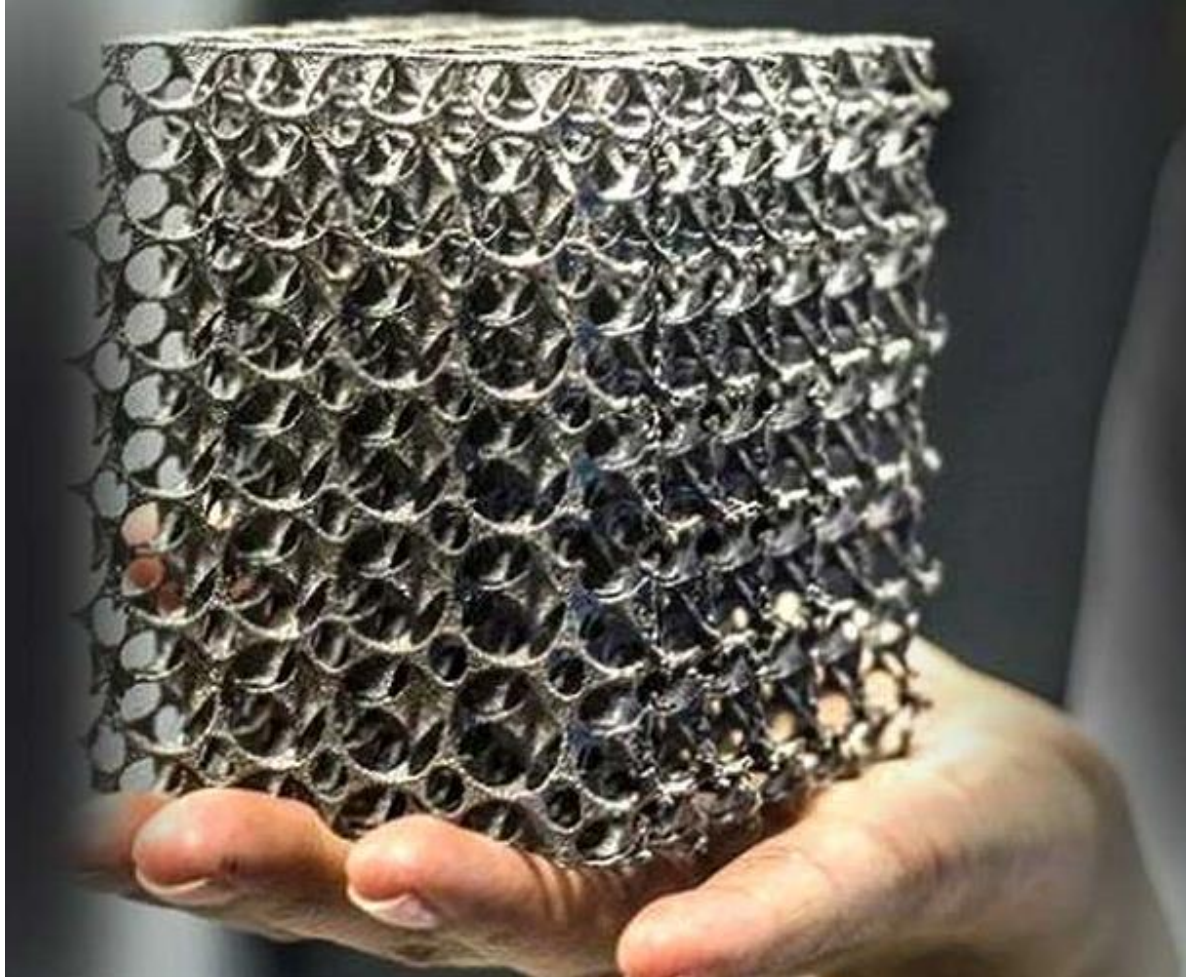
- possibility of avoiding couplings between different materials (such as glass and metal)

*⇒ increased efficiency of the systems*

*⇒ reduction of problems related to integration*

- reduction of mass and number of components to assemble, maintaining the necessary rigidity

# 3D printer for metals





# ASTROMech

a technologically advanced infrastructure  
capable of supporting the **key role** of **ASI** and **INAF** in several projects  
with regards to **opto-mechanical systems**

*significant activities of research, development and consolidation of production processes*

Manufacturing of optomechanical prototypes and thermal-structural models

- to demonstrate the full feasibility of the proposed equipment
- to control the manufacturing by industrial suppliers

Some specific programs already targeted: HEX-P, ESCAPE, LYNX, THESEUS IR telescope

*Parallel projects with possible mutual benefit presented in this workshop: **BEaTriX+** (B. Salmaso), **Elforms** (M. Civitani), **STILES - Laboratori per astronomia ottica** (V. Viotto)*

## Other on-going activities

- execution of building and thermal adaptation works of the IASF-Mi workshop premises (necessary to obtain the suitable installation of the new machinery)
- hiring of a TD technician (necessary to integrate the current team of 2 TI mechanical technicians)
- training of personnel responsible for using the systems
- organizing funds for supporting general management costs (electricity, system maintenance, transport of materials between the two workshops, ...)

Grazie  
Bianca

