OPTICAL MANUFACTURING FACILITIES IN THE INAF-BRERA ASTRONOMICAL OBSERVATORY

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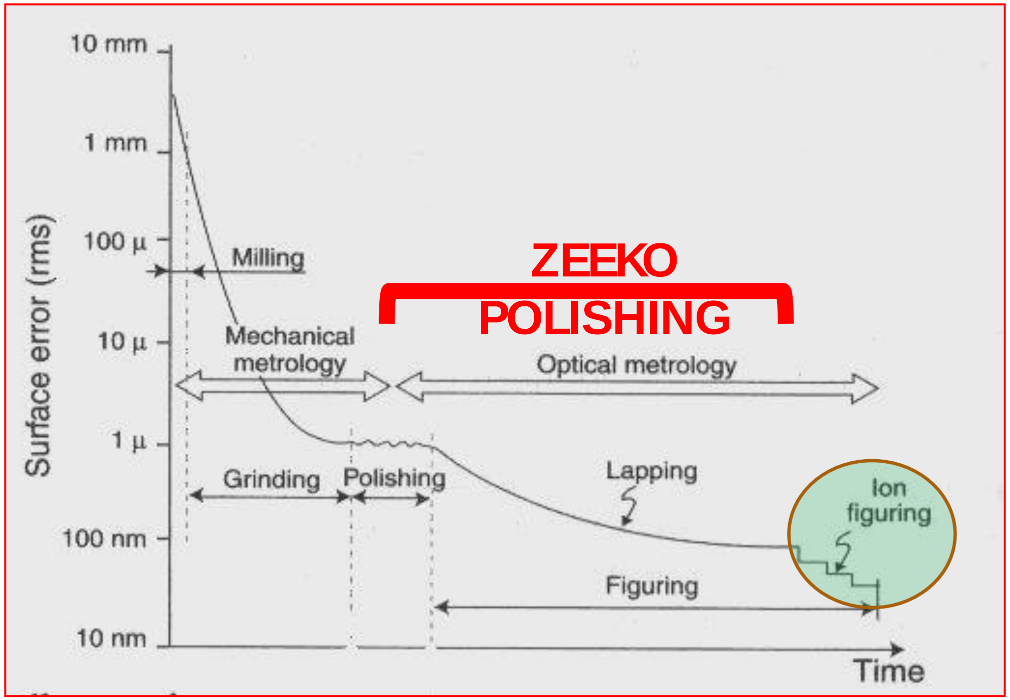
Firenze, 13-04-2016

OPTICAL MANUFACTURING CHAIN



Surface error *vs* time

The Polishing brings the workpiece from ground quality to optical quality.

In traditional optical polishing the tool is forced against the workpiece in presence of abrasive fluid. There is no active control on tool-workpiece distance.

In CNC polishing the tool position is actively controlled to follow the surface of the workpiece.

IRP MACHINE BY ZEEKO LTD

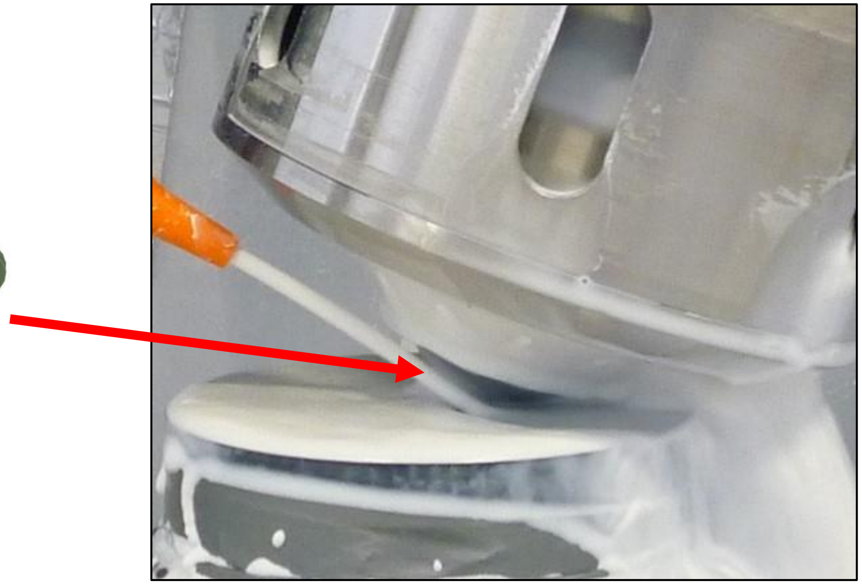
The IRP is a 7 axis CNC optical polishing/forming machine capable of producing ultra-precise surfaces on a variety of materials and shapes.

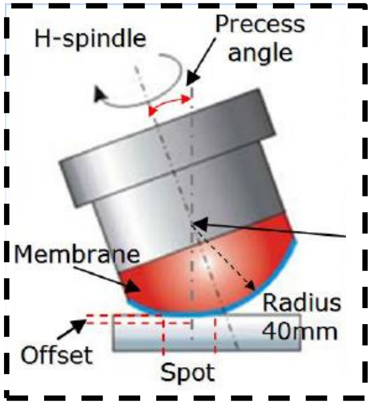
- IRP1200 model. Nominal max part size = 1200 mm.
- Three machines of this kind in Italy (two are in Media Lario).
- Footprint: 4,3m x 4,3m x 3m (including console, chiller and abrasive slurry unit).
- Load capacity = 500 Kg.
- Clean room ISO7, 49m^2 area.
- Required temperature variations within 2°C over 24h.

BONNET POLISHING MODE

- The bonnet is pressed against (offset) the part defining the spot size.
- Removal is proportional to the dwell time and to the product of relative surface speed and pressure (Preston model). Removal depends also on the type of tool, abrasive slurry and material

Bonnet





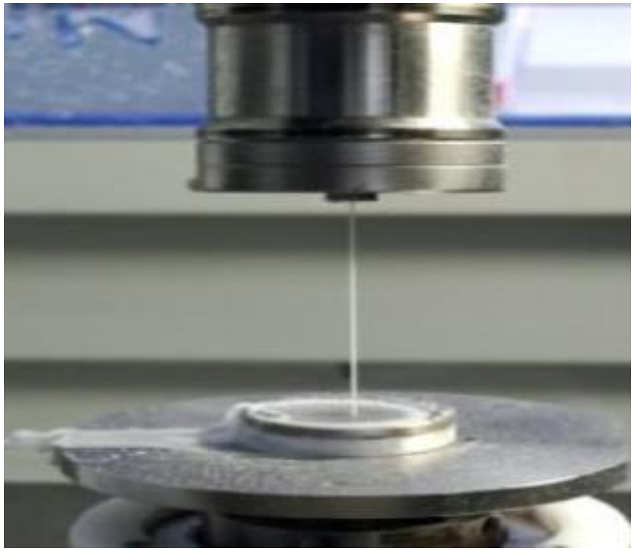
- Different size tools (bonnets) are available
- The min tool spot size sets the shortest form wavelength correctable.

FLUID JET POLISHING MODE (FJP)

A slurry of abrasive particles is pressurized and projected through a nozzle towards the surface. Removal rate is directly proportional to specific gravity of the slurry.

FJP resembles Ion Beam Figuring as both are kinetic machining techniques with no tool contact.

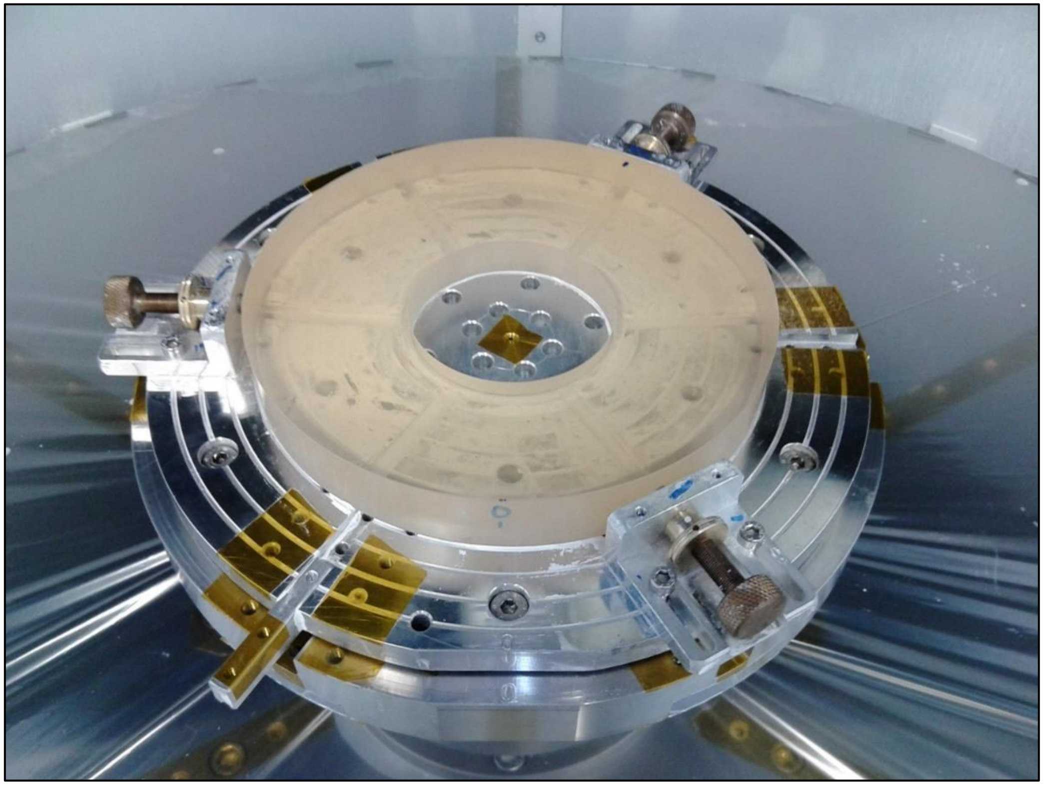
It holds the potential to address mid-spatials and edges.



Credit: A. Beaucamp et al. SPIE 8838 (2013)

WORK IN PROGRESS: COSMOS MIRROR ON ZEEKO

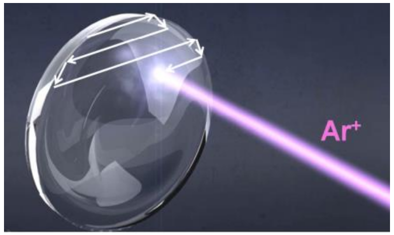
COSMOS – Multispectral Imaging for Terrestrial Observation with remote Sensing



Aspherical surface
External diameter 200mm
Hole diameter 80mm
Center thickness 15mm
Edge thickness 26.5 mm
Material Zerodur
Weight 1440 grams
RoC: 422 mm

This work has been financed by Cariplo Foundation and Regione Lombardia

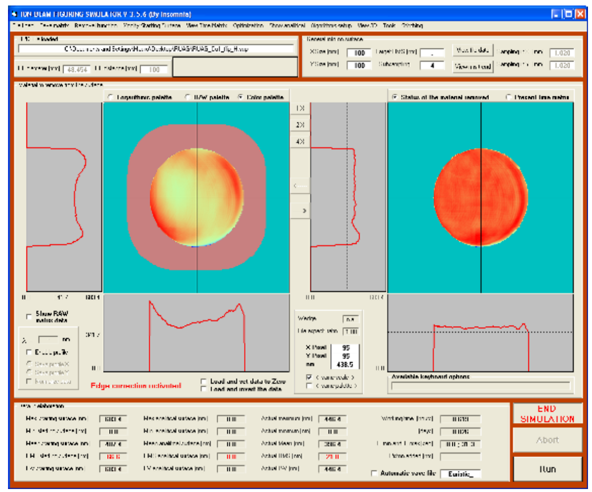
IBF TECHNOLOGY IN INAF-OAB



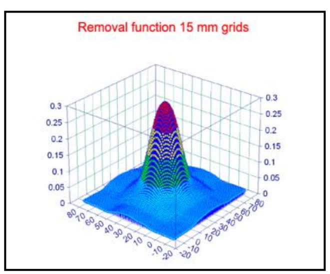
Optic to be corrected

- Deterministic process
- Pressurless technique (good edges correction)

Interferometric measure

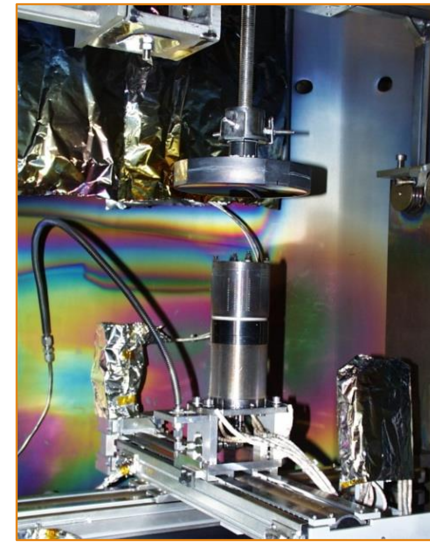


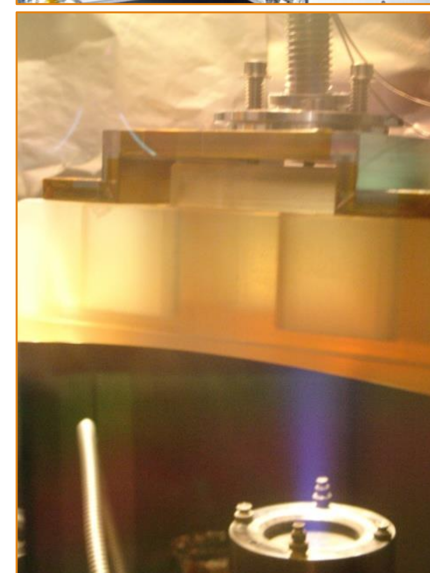
Time matrix computation



Removal function

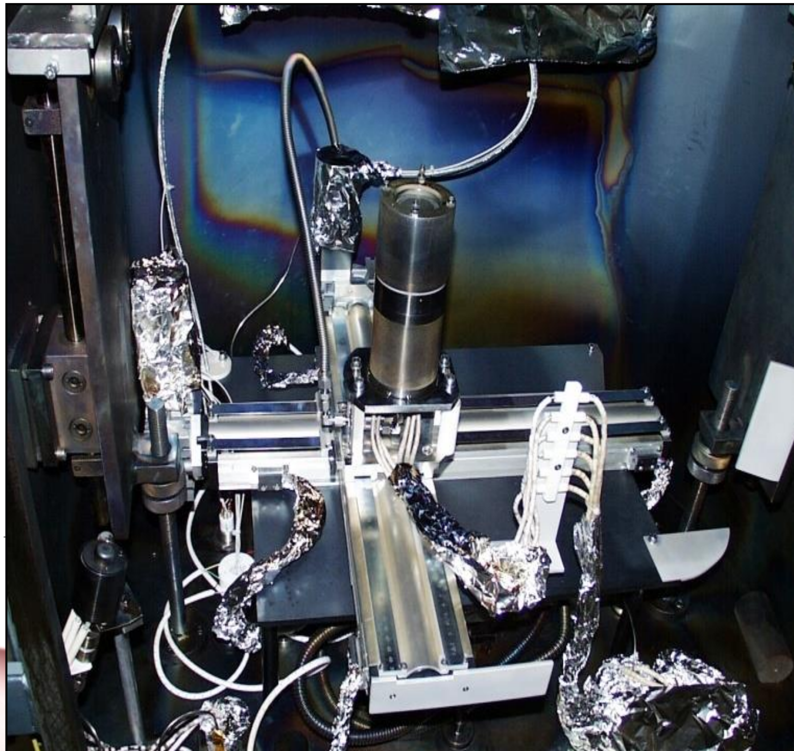
- Figuring possible on optics already assembled. Stable removal rate (50/100 nm min.)



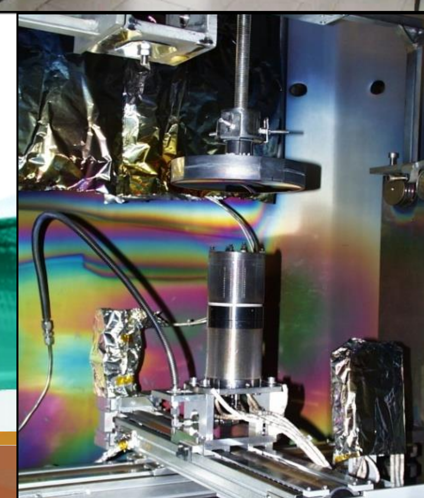


FIRST ION BEAM FIGURING FACILITY

System able to figure optics up to 350 mm in diameter

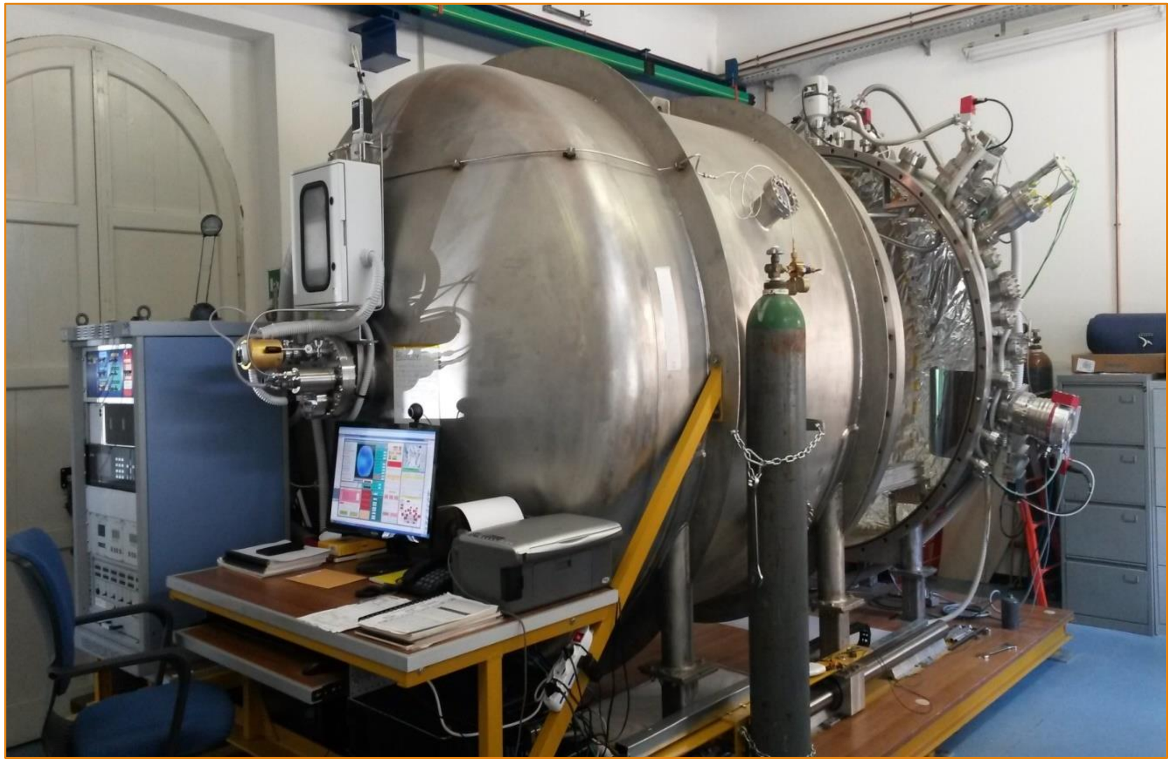


Internal view of the facility



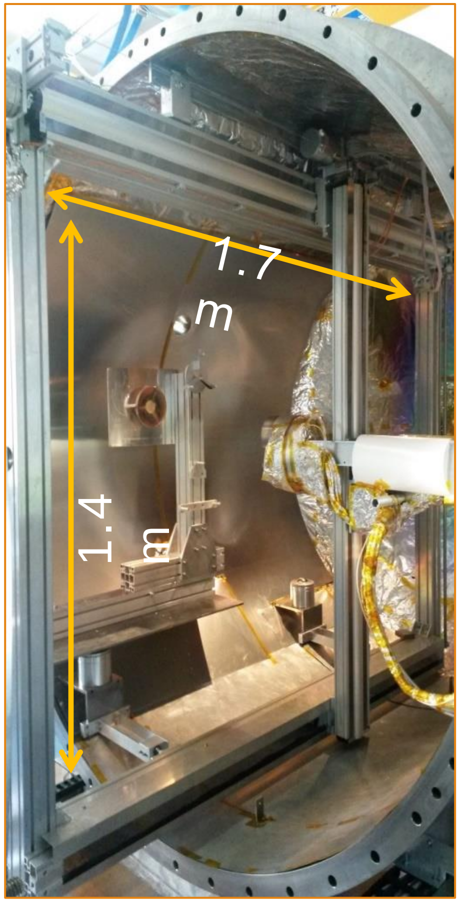
SECOND IBF FACILITY IN INAF-OAB

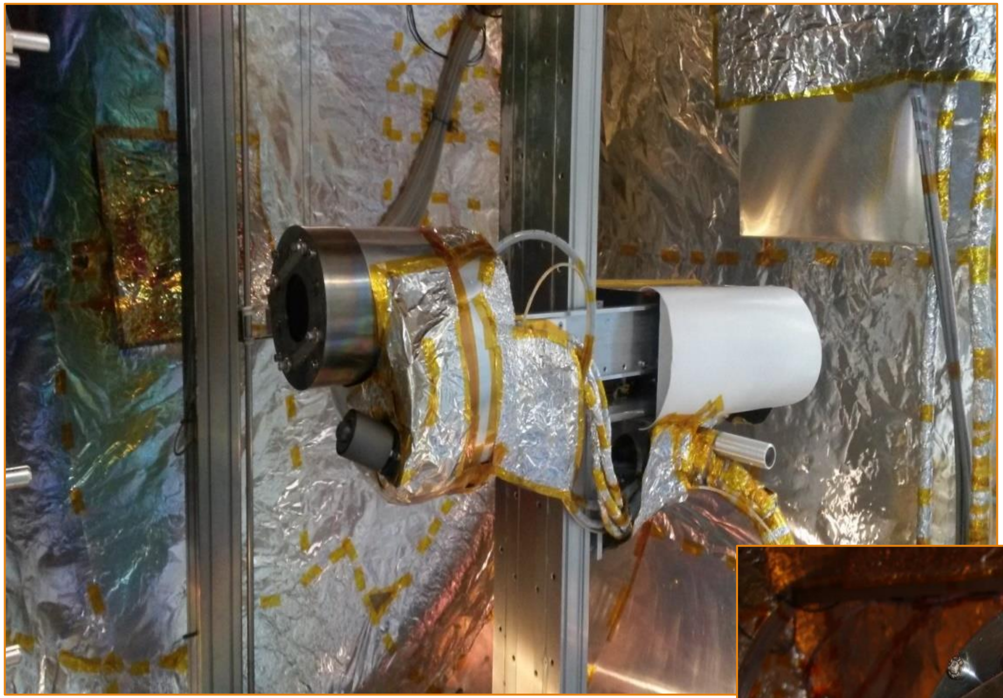
Used mainly (but not only) for R&D studies



Vacuum chamber size 2 m x 3 m. – 2 mech. pumps + 4 turbopumps - IBF working pressure 2*10-4 mBar 4 hours pumping down time – MKS Argon flux controller – Veeco Ion source & Power supply -

IBF FACILITY IN INAF-OAB





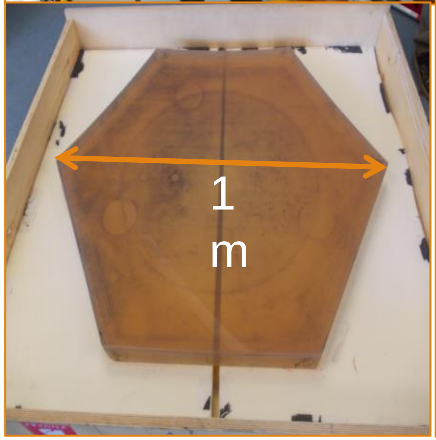
The optic to be figured is mounted in vertical position

Working area of 1.7 x 1.4 m
Three axis system xyz with two gridset

- 50 mm collimated grids
- 15 mm focused grids
- Hollow cathode ion source
- Beam Power from 6 to 240 watts
- Raster scan path

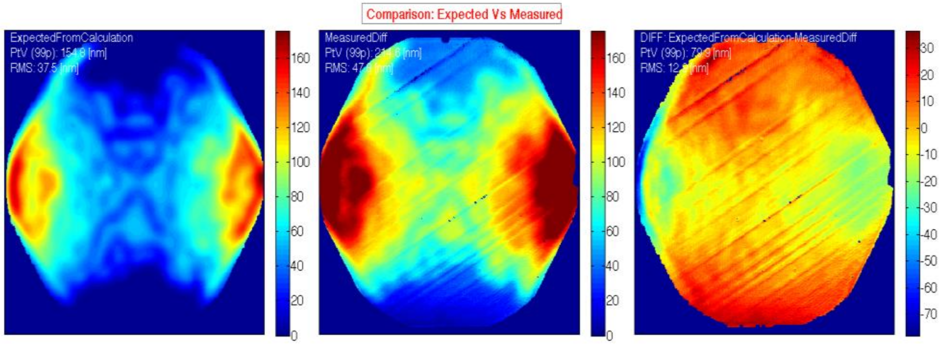
HEXAGONAL MIRROR HANDLING AND FIGURING

Glyndŵr University, N. Wales, has provided to INAF-OAB an hexagonal Zerodur mirror 1m corner to corner for initial test purposes related to the IBF process. It is spherical with a RoC of 3 m so to permit its easy interferometric measure. This mirror has been used as bench work for IBF tests and to investigate the problems (mainly thermal) related to the Zerodur when ion figured



IBF TESTS ON HEX SEGMENT

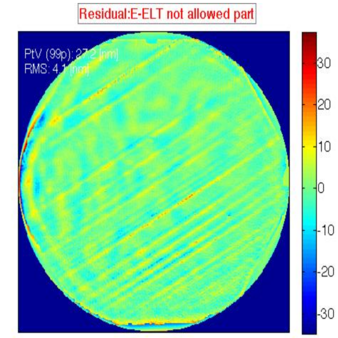
Last figuring iteration at low power level, 12 W, 19 hours figuring time



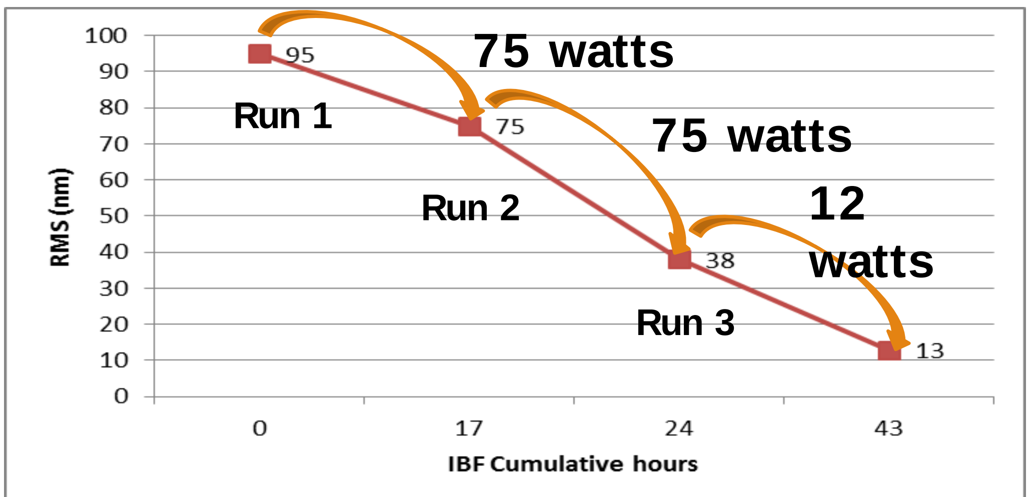
Theoretical material to be removed

Measured material removed

Difference



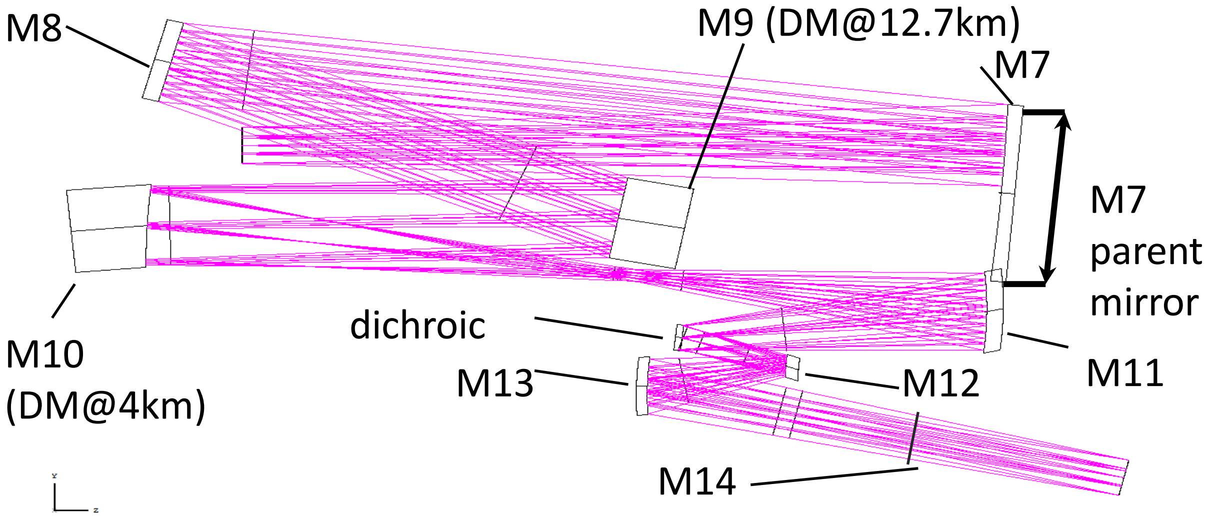
After removal of E-ELT permitted terms



Final residual error of 13 nm rms. No thermal distortions using this power level (T max: 68 °C). **After removal of E-ELT permitted terms residual error is 4 nm rms, below the goal specification (5 nm surface rms) assumed for the mean primary E-ELT segment.**

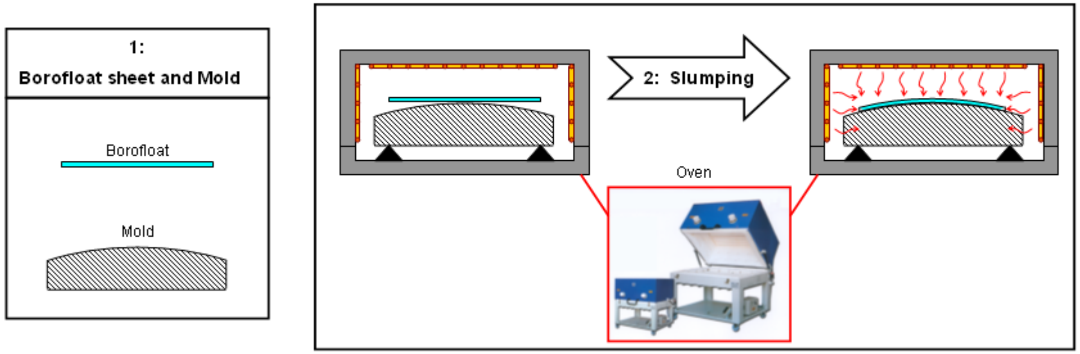
POTENTIAL USE FOR MAORY-MCAO OPTICS

- These optics have adequate size for the two facilities in INAF



- Some optics may be produced by INAF in order to reduce costs and exploit the know-how
- It would be desirable the involvement of italian industries, coordinated by INAF, like for example Selex-ES or Medialario (which has two other similar Zeeko machines)
- INAF-OAB in the coming months plans to figure the Zerodur primary 1.2m of FLYEYE that is a ground telescope funded by ESA for NEO monitoring. It's an optic similar to those of Maory

STUDY FINANCED BY ESO (FP6-2006) FOR THE SLUMPING OF BOROFLOAT33 GLASS SHEETS FOR ADAPTIVE OPTICS



Slumping principle

A study aimed to investigate the possibility to produce thin glass foils for adaptive optics to replace the present manufacturing technique. The goal was to produce a 50 cm concave spherical mirror, 1.6 mm thick, with the full size oven

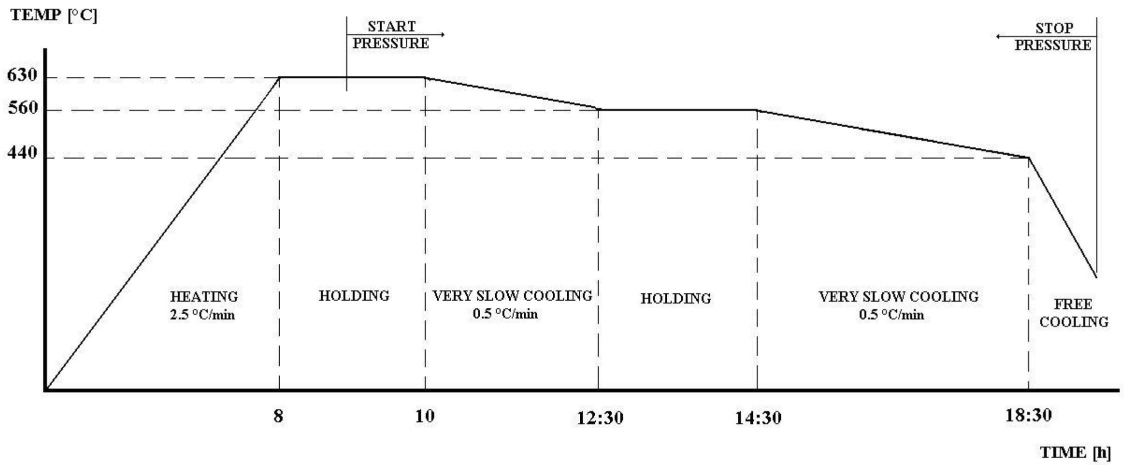
Oven for the tests

Full size Oven

MUFFLE FOR SLUMPING AND THERMAL CYCLE FOR BOROFLOAT33 GLASS SHEETS

Muffle inside the large oven

Example of thermal cycle

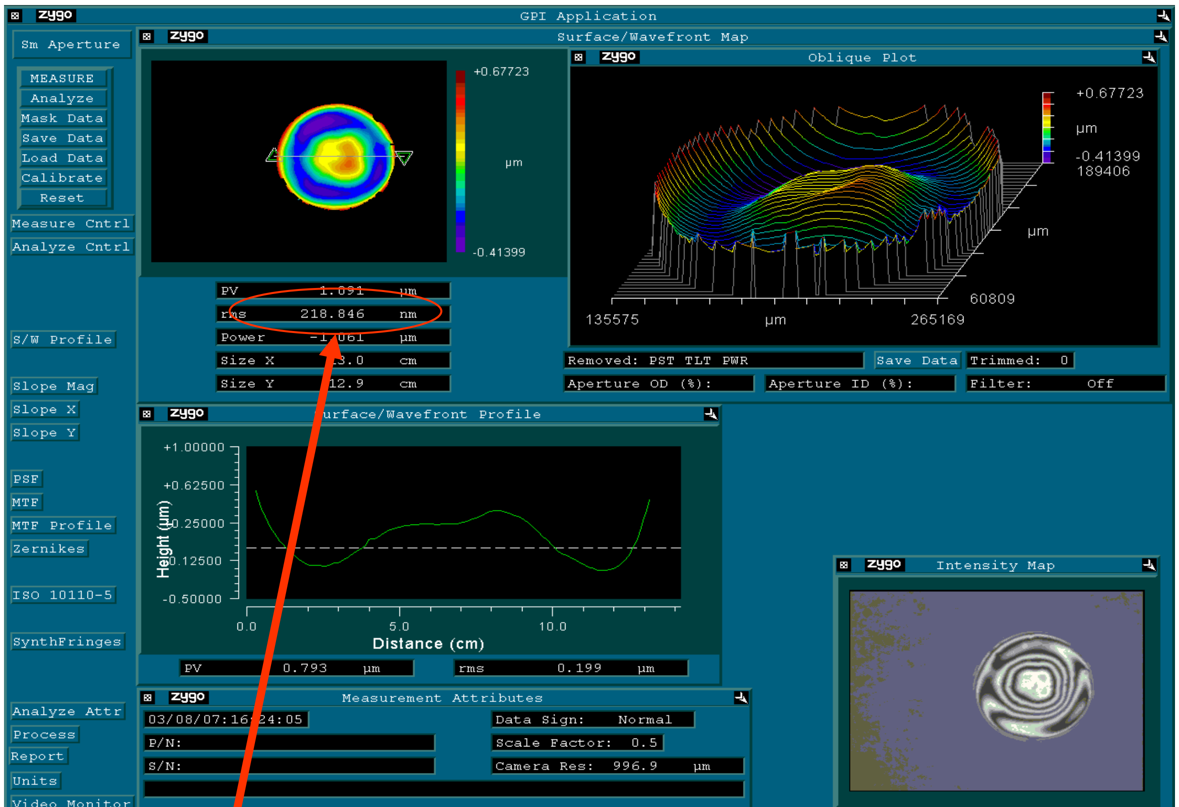


Stainless steel AISI 310
Weight= 190 Kg
External Diam= 816 mm
Height = 516 mm
Vacuum seal at about 650 °C

Thermal cycle employing a vacuum muffle with the capability to apply on the glass a uniform controlled pressure (~150 g/cm^2). The pressure was applied using a stainless steel foil 25 micron thick dividing in two the muffle cavity and introducing a controlled amount of air in the upper cavity.

SLUMPING TESTS ON SMALL DIAMETERS GLASS SHEETS

Interferometric measurement on astatic support of a slumped glass shell having <u>diameter of 150 mm and 1.7 mm thickness</u>



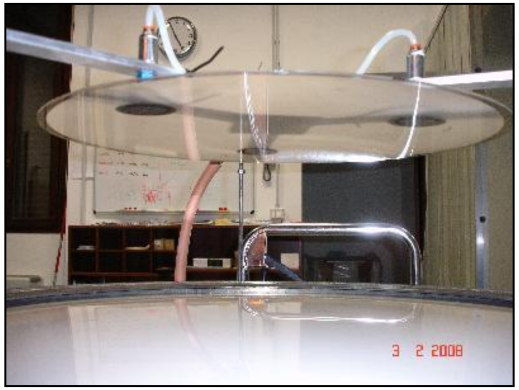
218 nm rms → λ/3 rms over 150 mm diam.

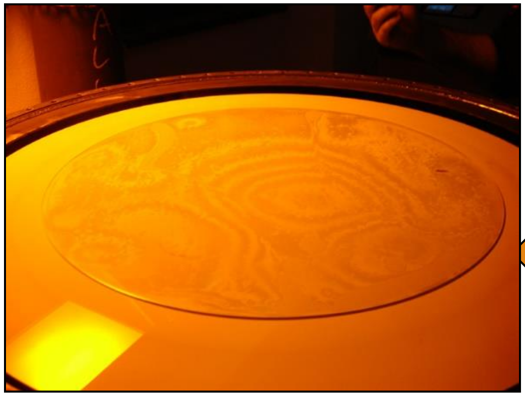
Fringes between mould and glass very circular and without dust contamination

SLUMPING STEPS

Mould into the muffle

Segment suspended above the mould before the slumping





After the slumping, lift of the glass

Segment on the mould and under sodium light

In the light of the modifications to the process developed in these 10 years for the slumping of x-ray mirrors, it would be appropriate to revisit this technique.

Thanks for your attention