The 4m International Liquid Mirror Telescope (ILMT): status report (8/11/2019)

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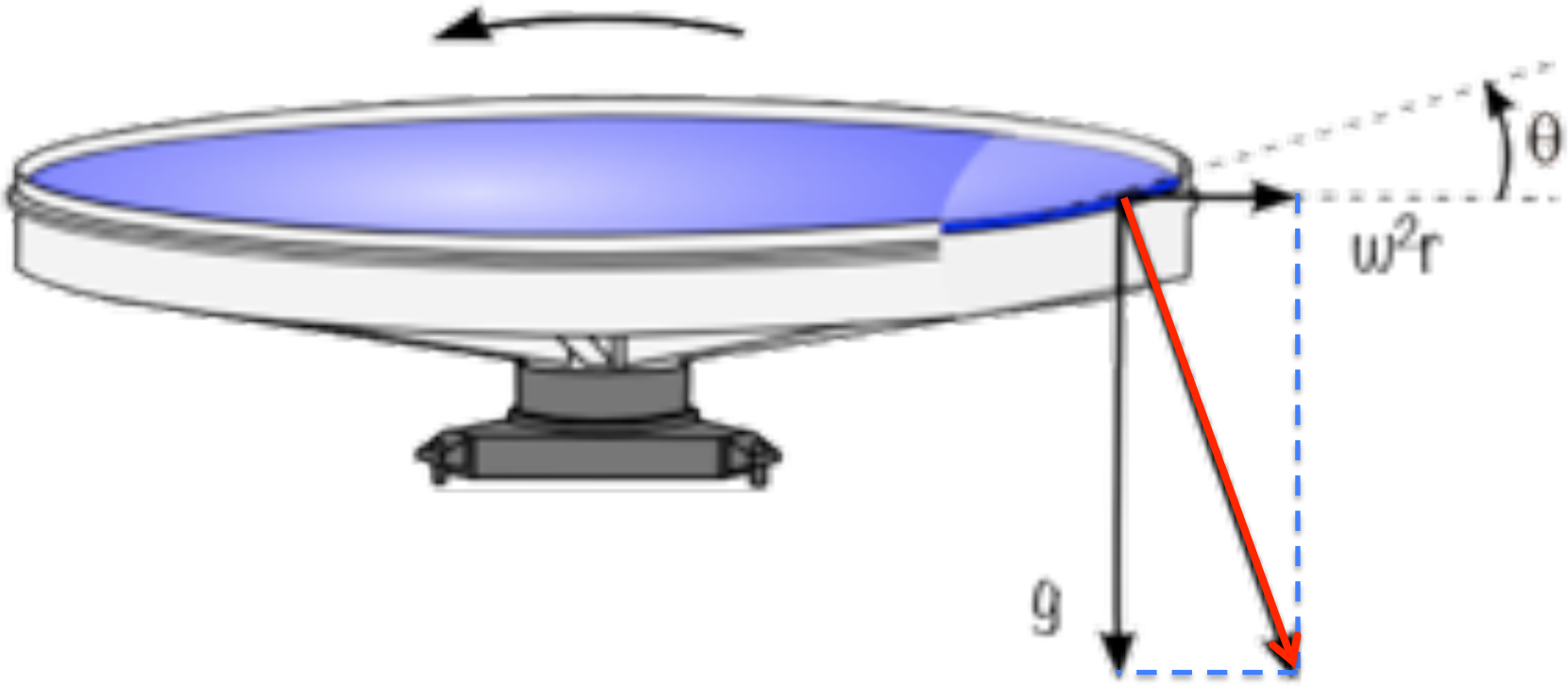
Outline

- The liquid mirror telescope principles
- The TDI mode of observation
- Science with LMTs
- The 4m International Liquid Mirror Telescope (ILMT)
- Present status report
- Conclusions
- General discussion (data reduction, analysis, archiving and Science)

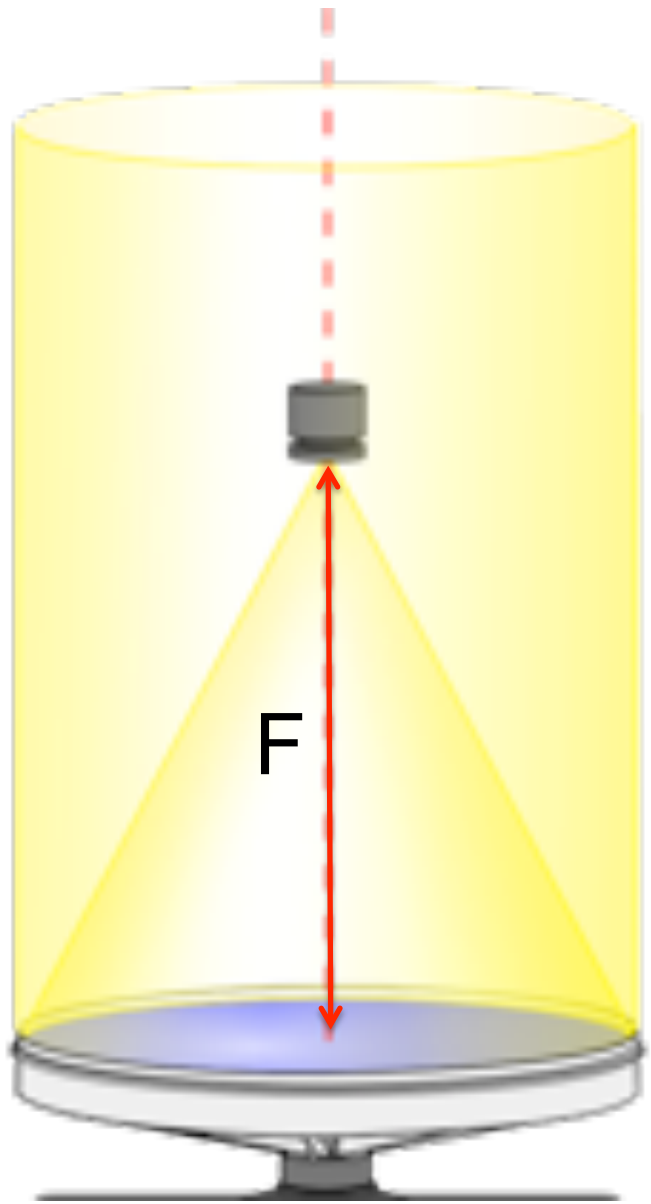
The Liquid Mirror Telescope principles

The Liquid Mirror Telescope principles



The Liquid Mirror Telescope principles

A paraboloid is an ideal optical system

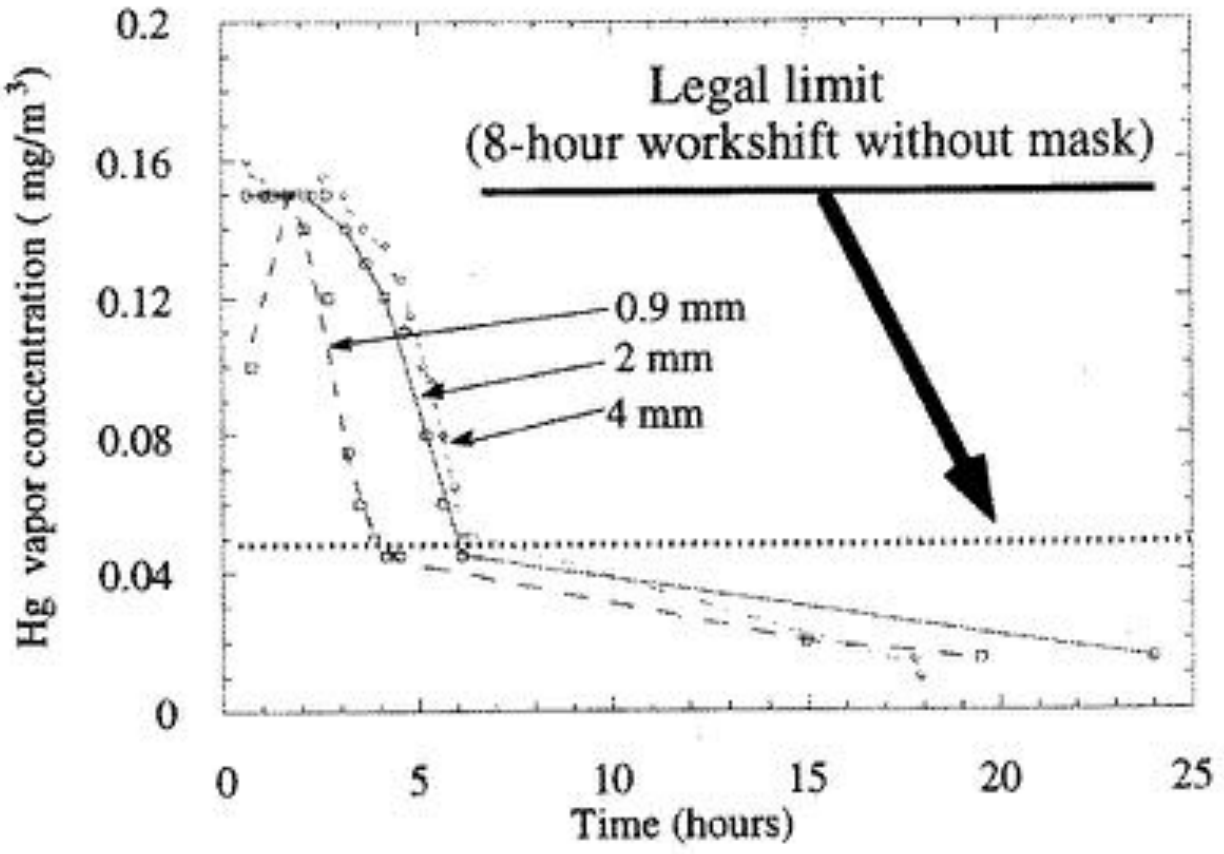


$F = g / 2\omega^2$

The Liquid Mirror Telescope principles

Mercury as a reflective liquid

- Reflectivity : 85 %
- Thin layer : 2-3 mm
- Quantity : ~ 500 kg
- Oxidation
- Toxicity



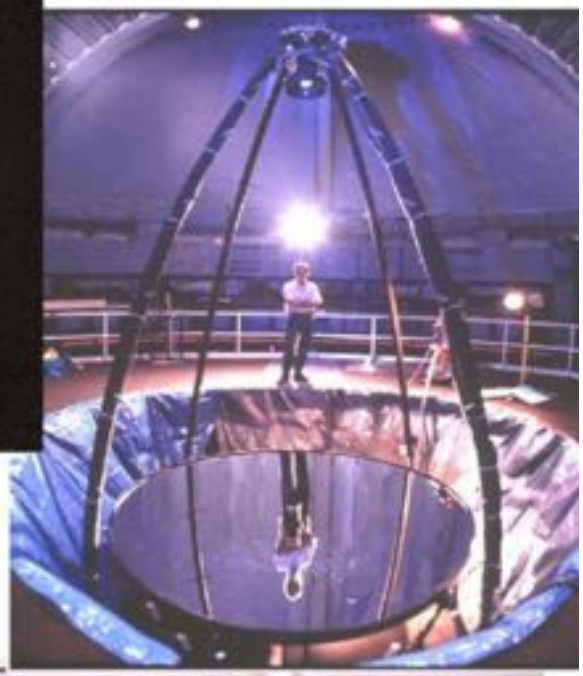
Ignorance always provides a bad answer to a thrilling question!

Same applies to Hg …

The Liquid Mirror Telescope principles

Some LMT :

- 2.7m UBC/Laval
- 3m NODO
- 6m UBC LZT
- 3.7m Lab. LMT



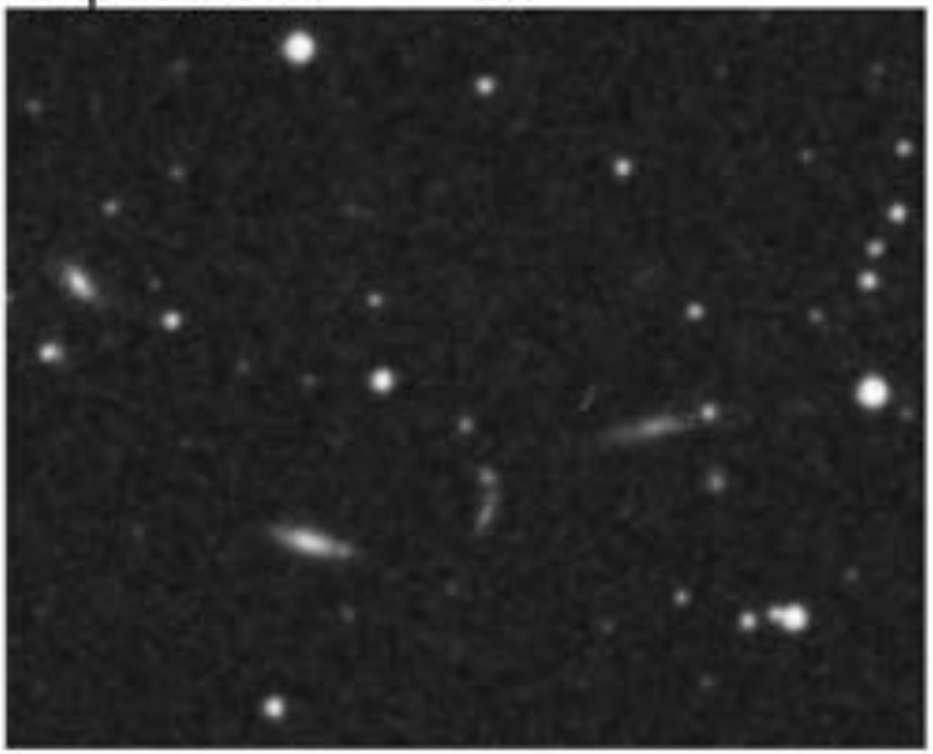
The Liquid Mirror Telescope principles

Large Zenith Telescope image

The Liquid Mirror Telescope principles

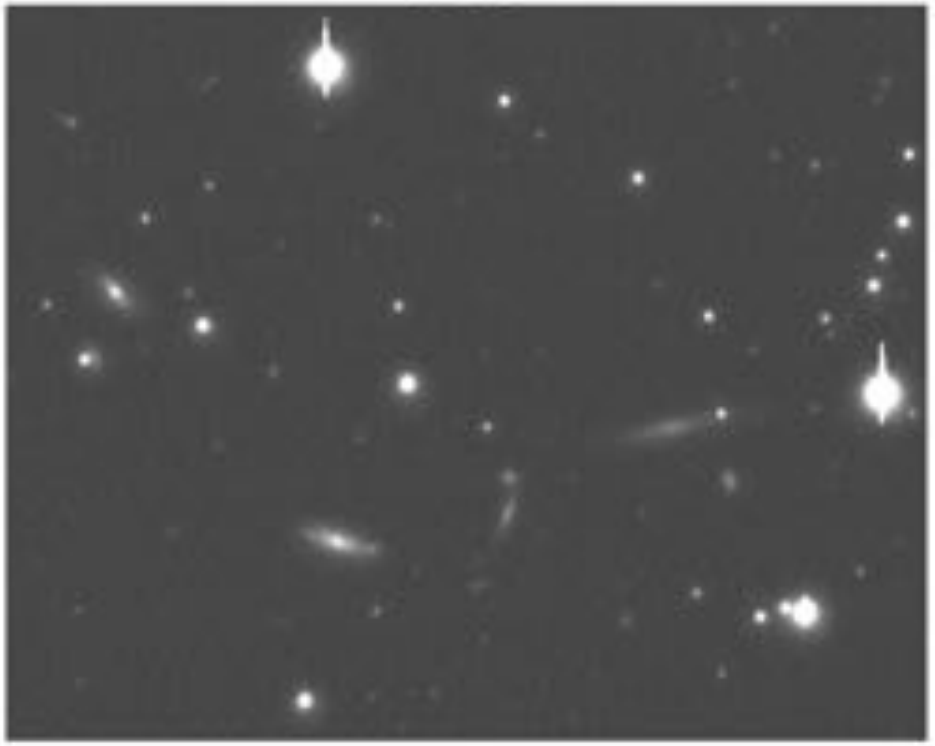
Palomar Schmidt Telescope (1.2m)

Exposition : 1h

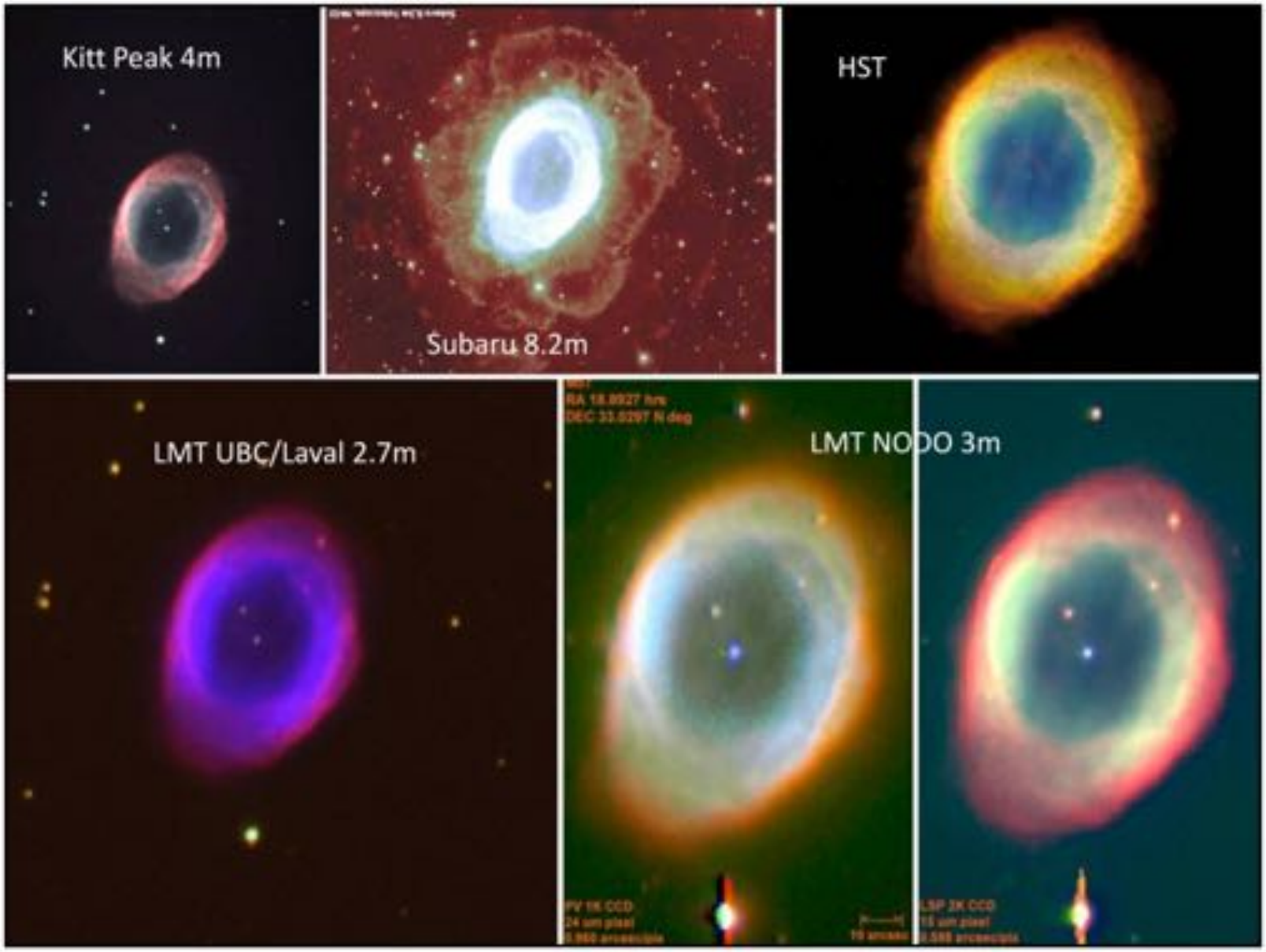


NODO (3m)

90 s

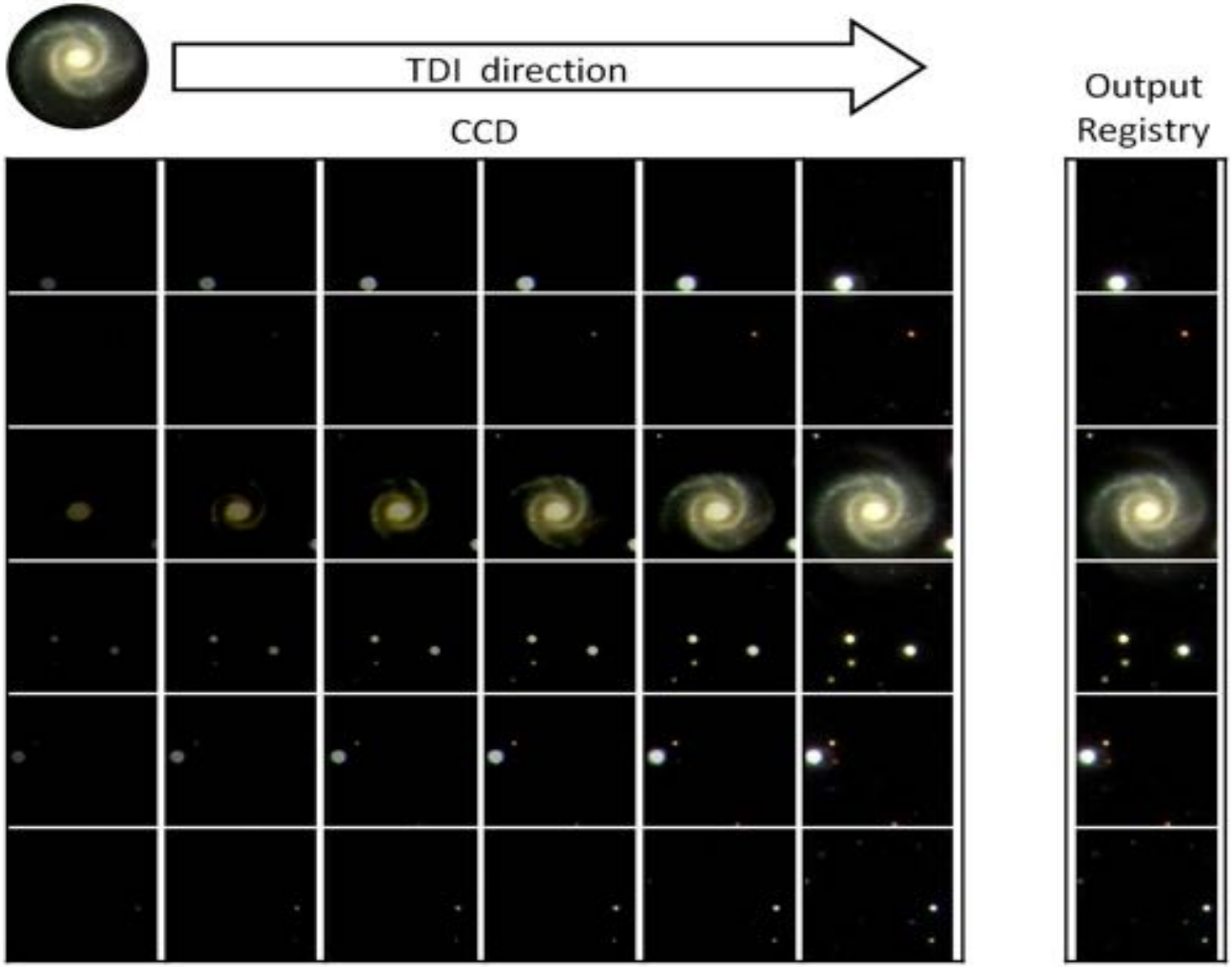


The Liquid Mirror Telescope principles

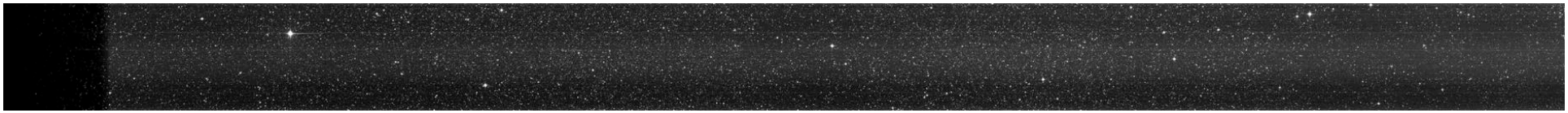


The TDI mode

The TDI mode



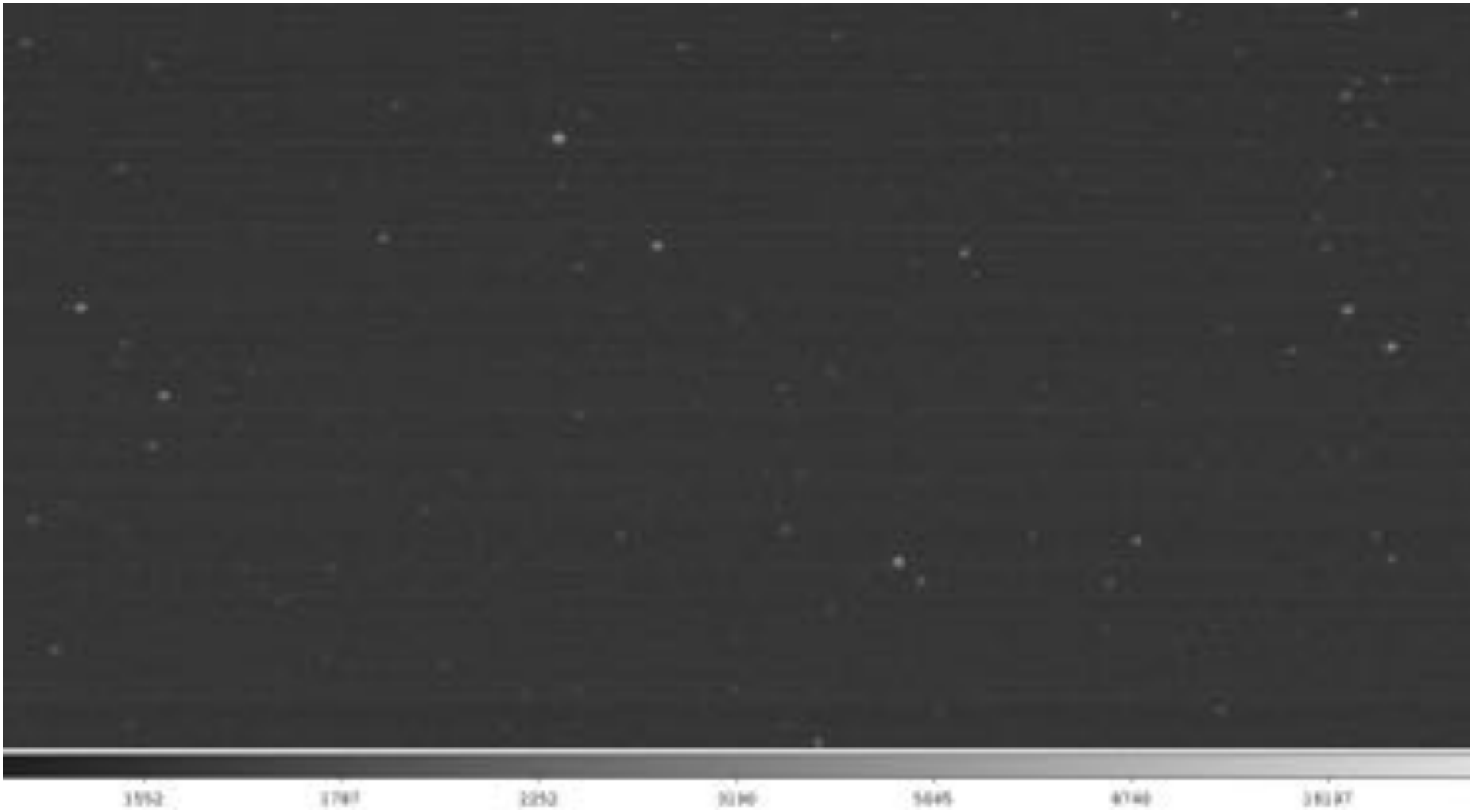
The TDI mode



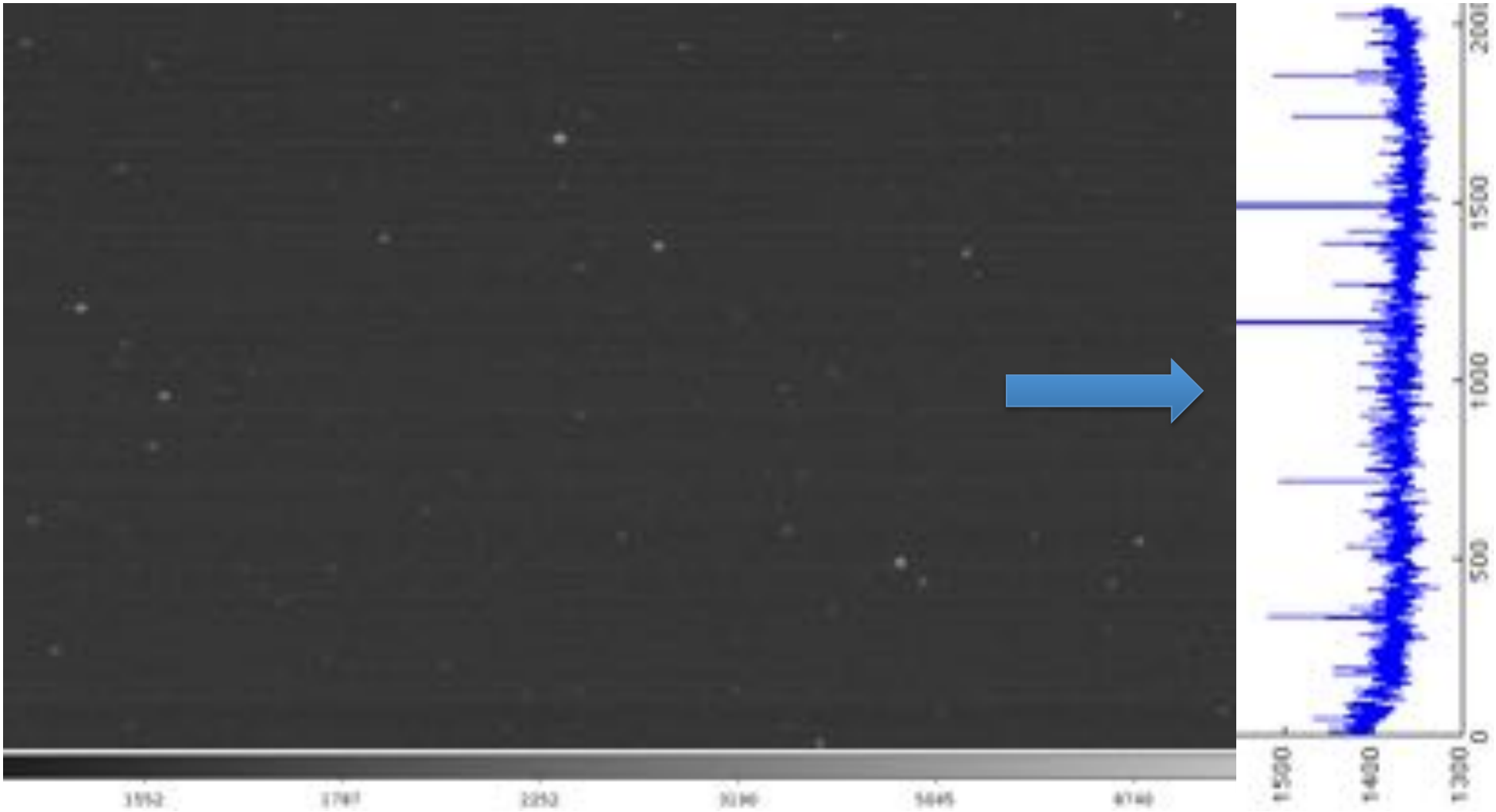
- TDI images have a limited exposure time
  - but the latter can be increased by co-adding images

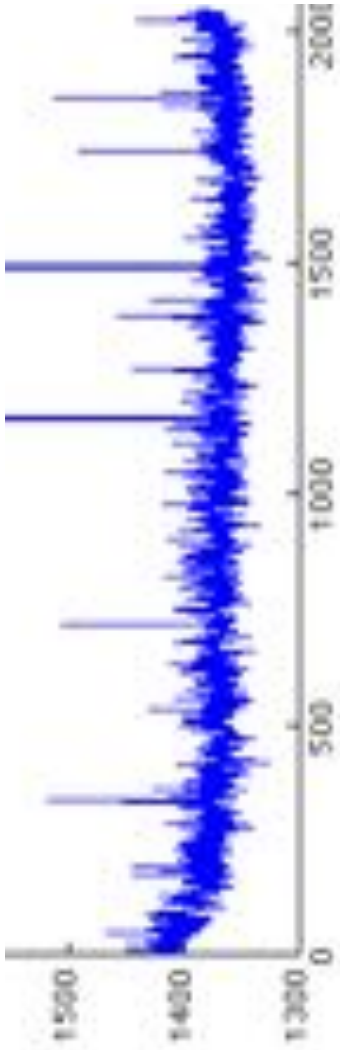
Number of scans	3	6	12	60 (~1 year)	240
Δm	0.6	1.0	1.35	2.22	2.98

Raw image (unprocessed)

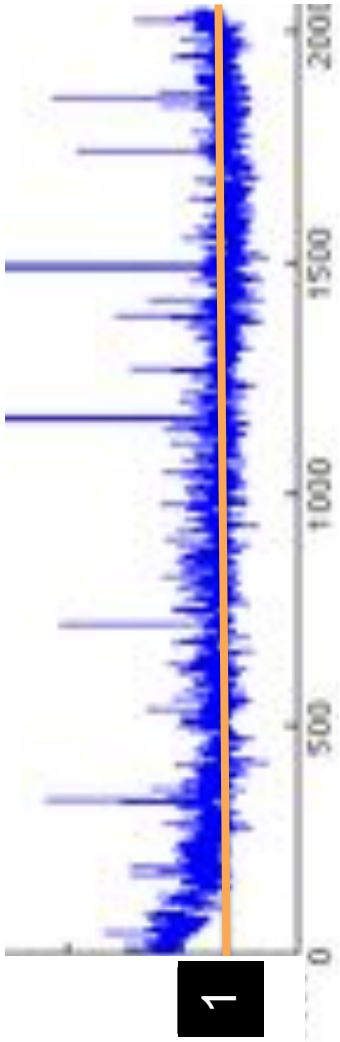


1D Flatfield



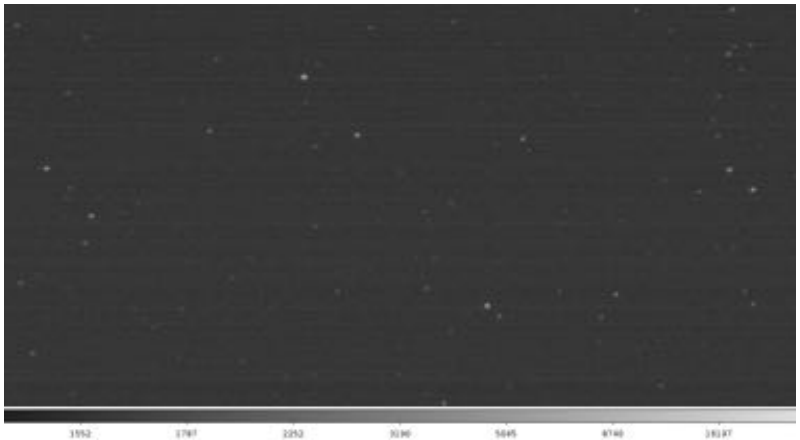


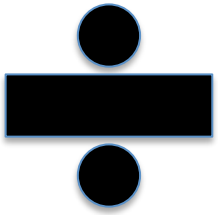
Normalization



2-D Flatfield

Pre-processing

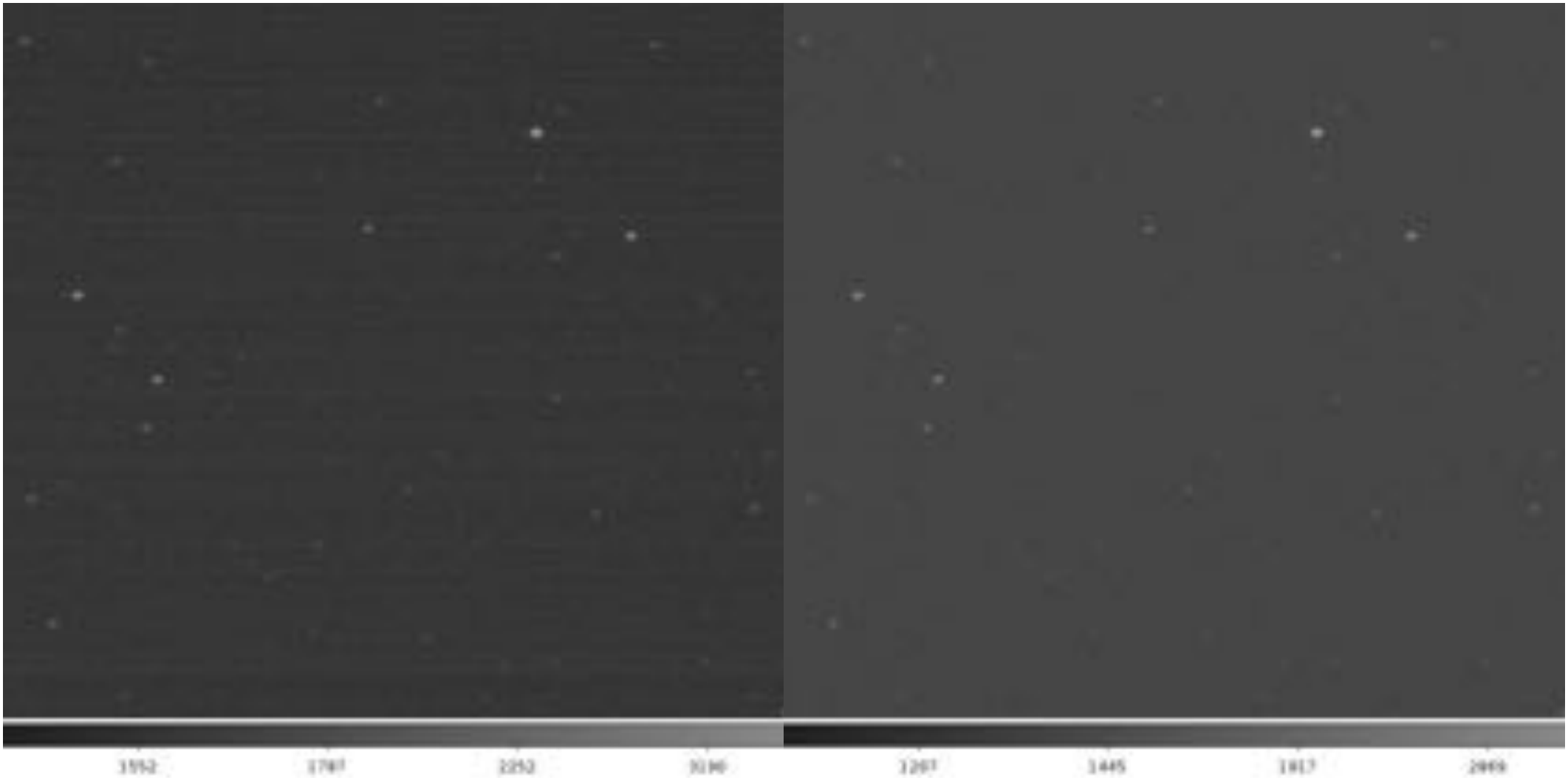




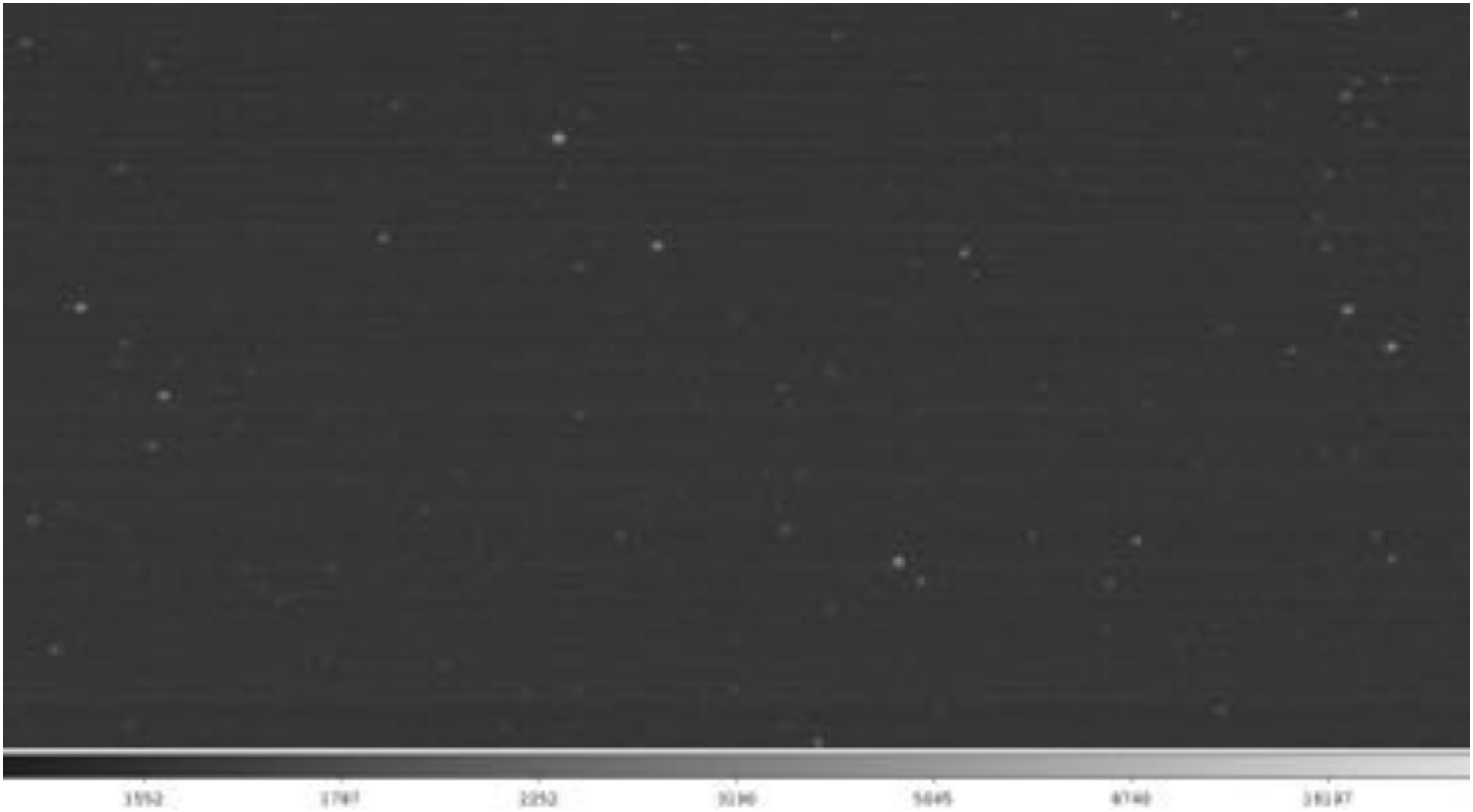
Flatfield corrected image

Unprocessed image

Processed image



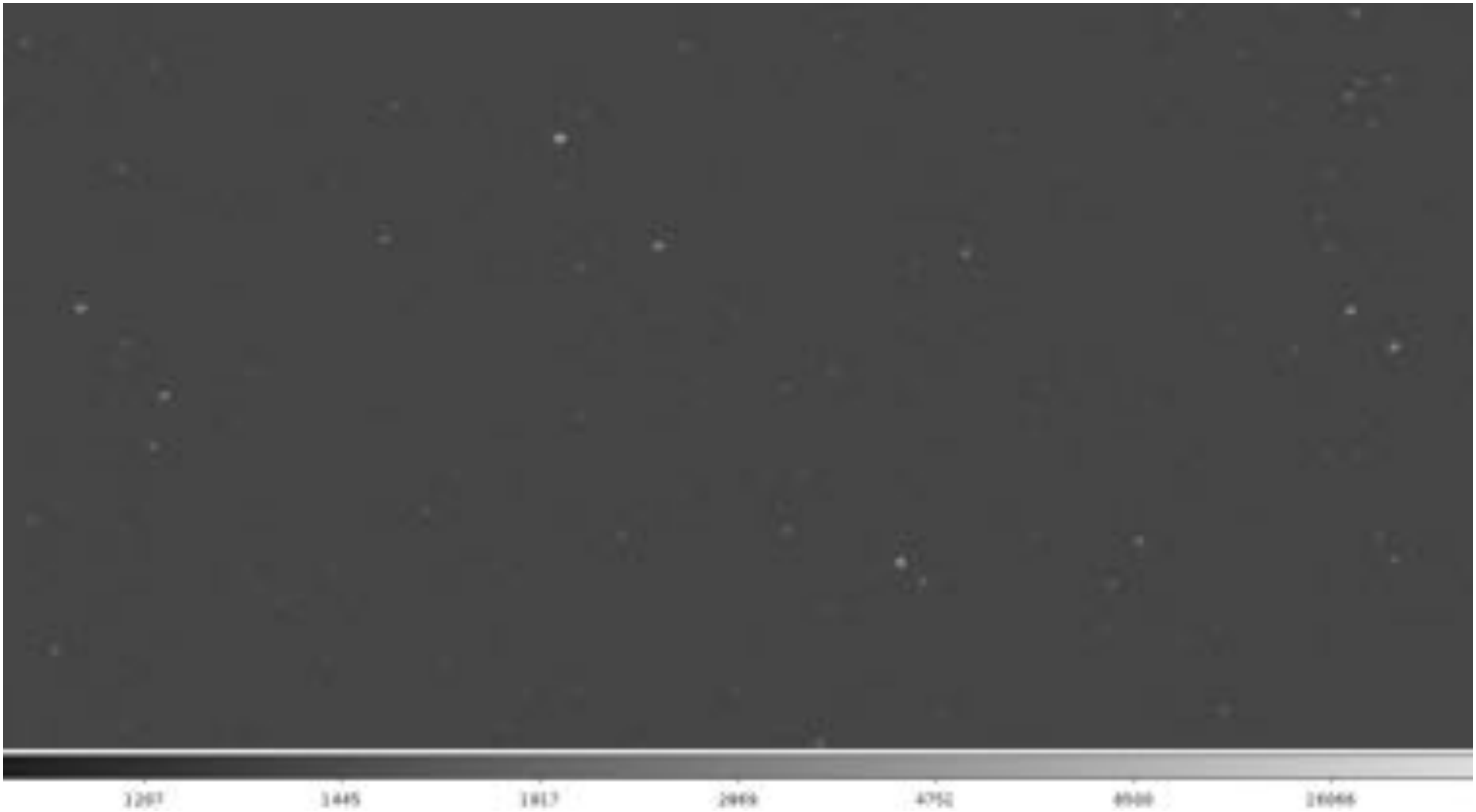
Raw image (unprocessed)



Flatfield corrected image

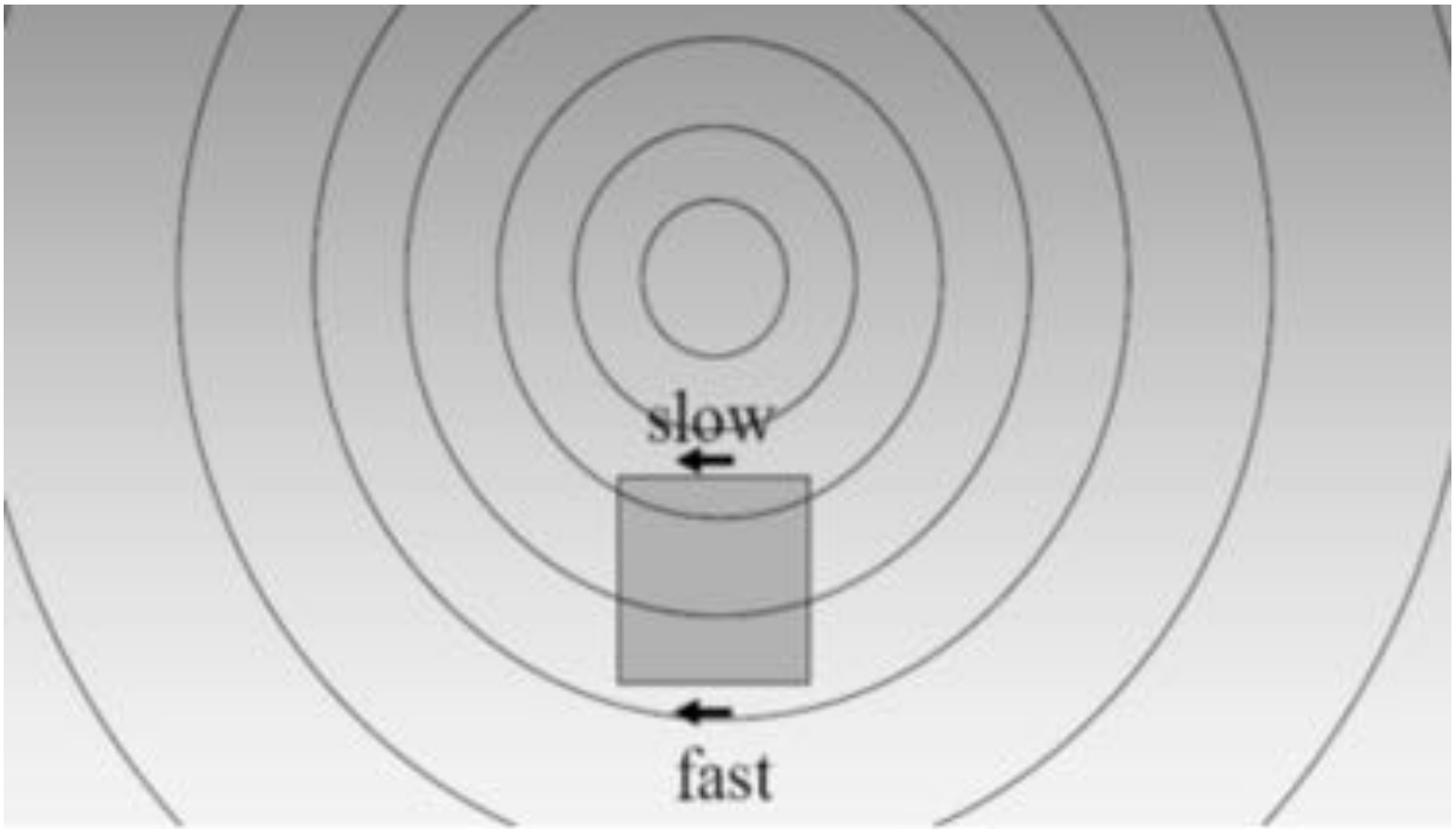
Unprocessed image

Processed image



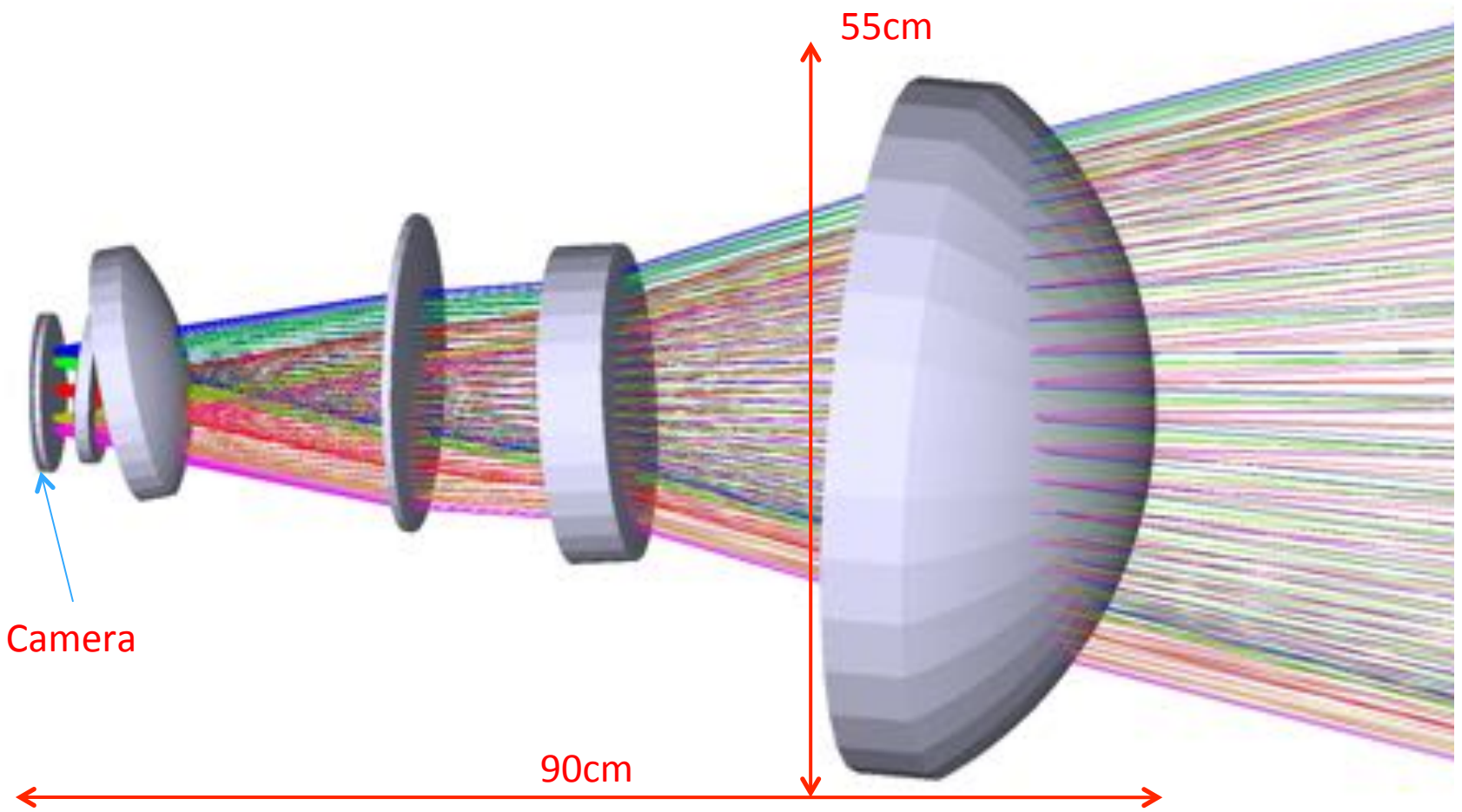
The TDI mode

The TDI mode



The TDI mode

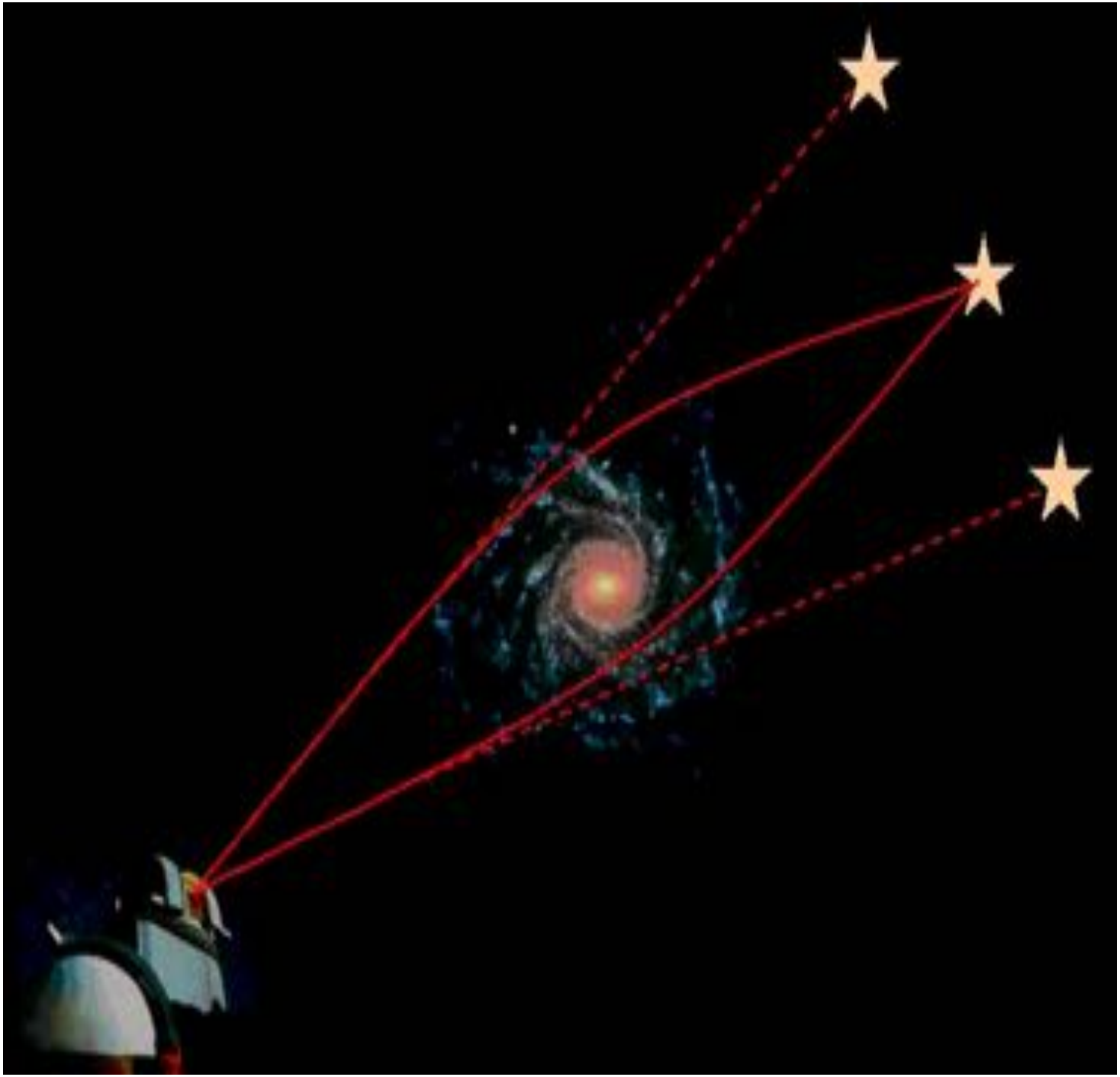
- The corrector



Science with LMTs

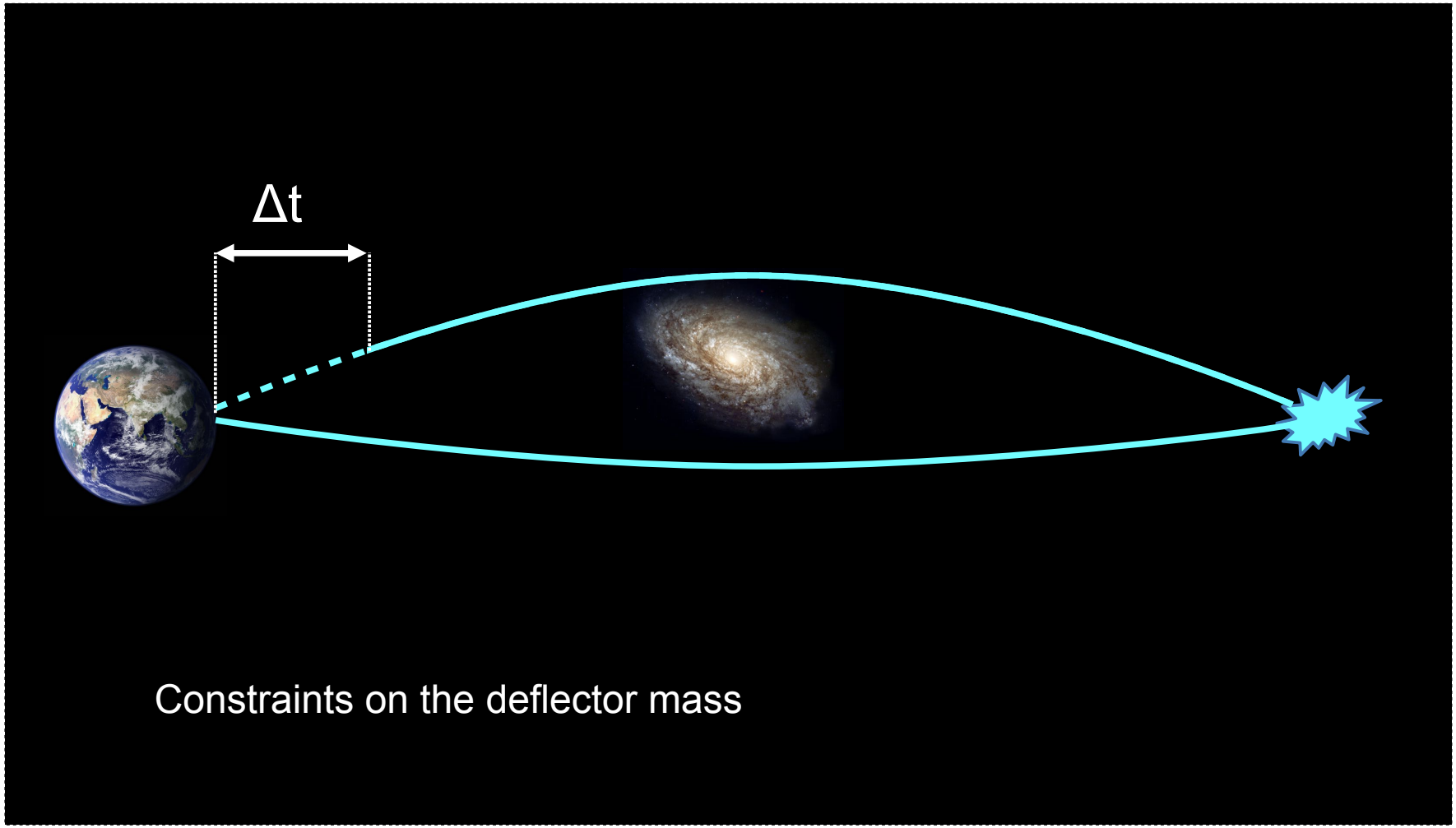
Science with LMTs

Gravitational lenses



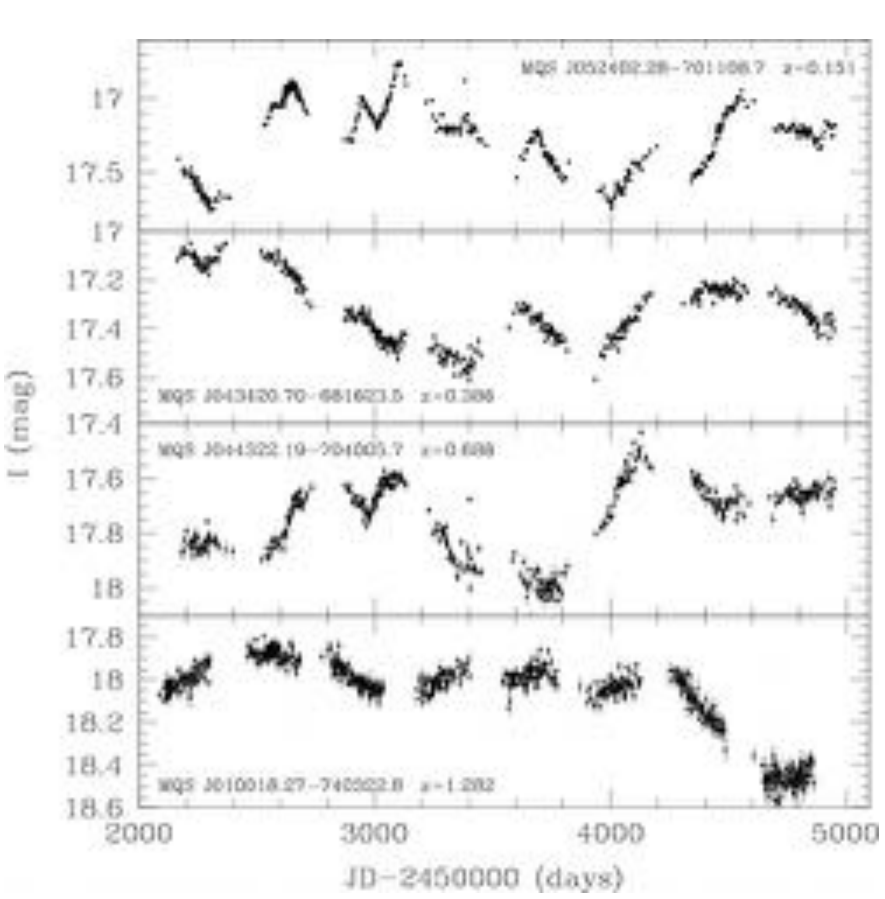
Science with LMTs

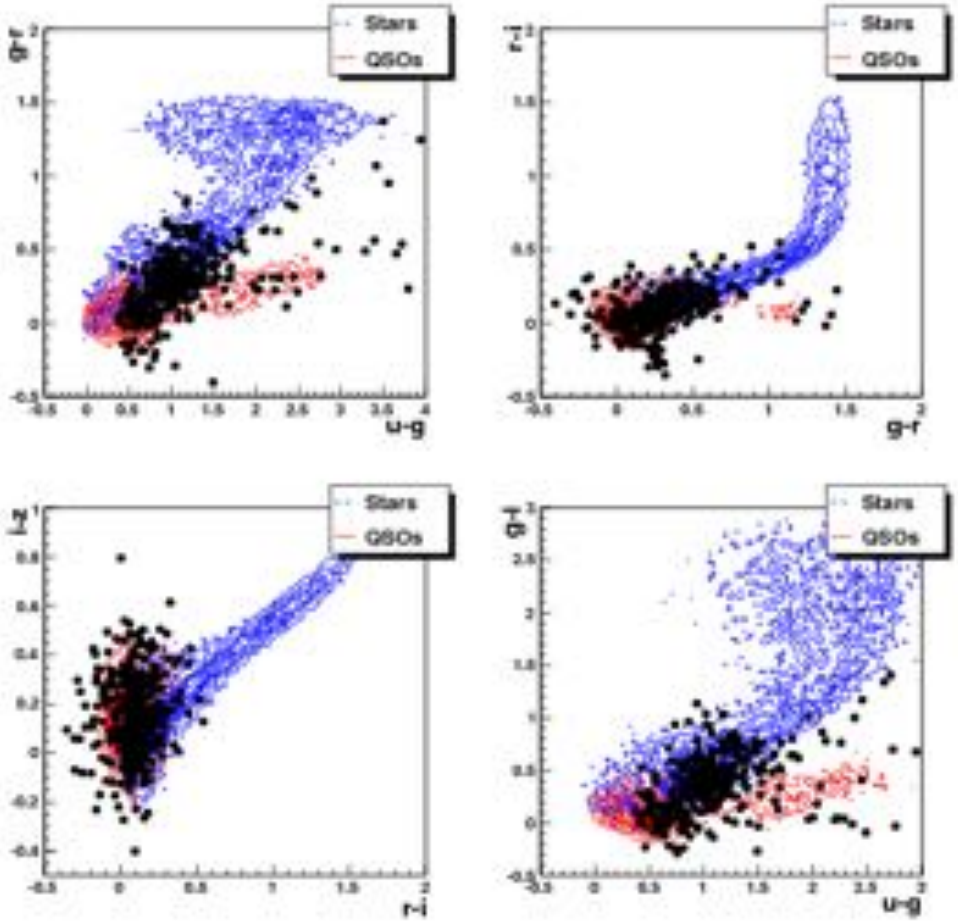
Gravitational lenses



Science with LMTs

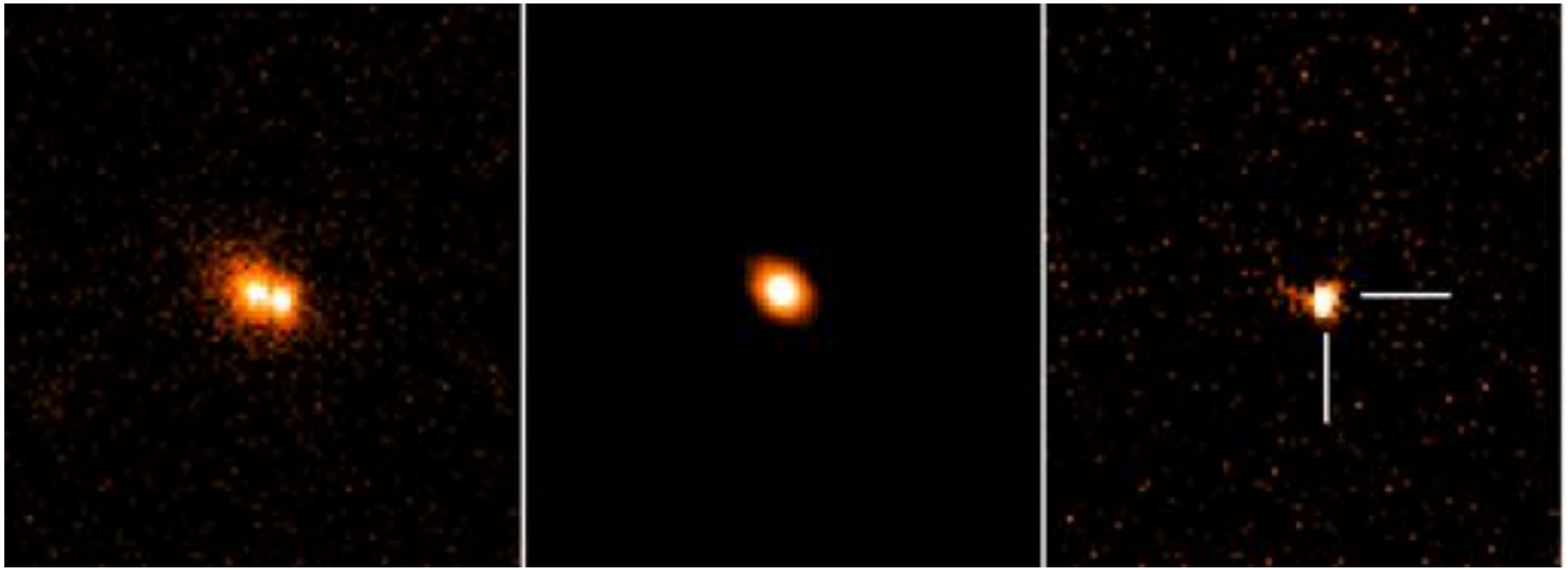
Quasar detections (variability + color)





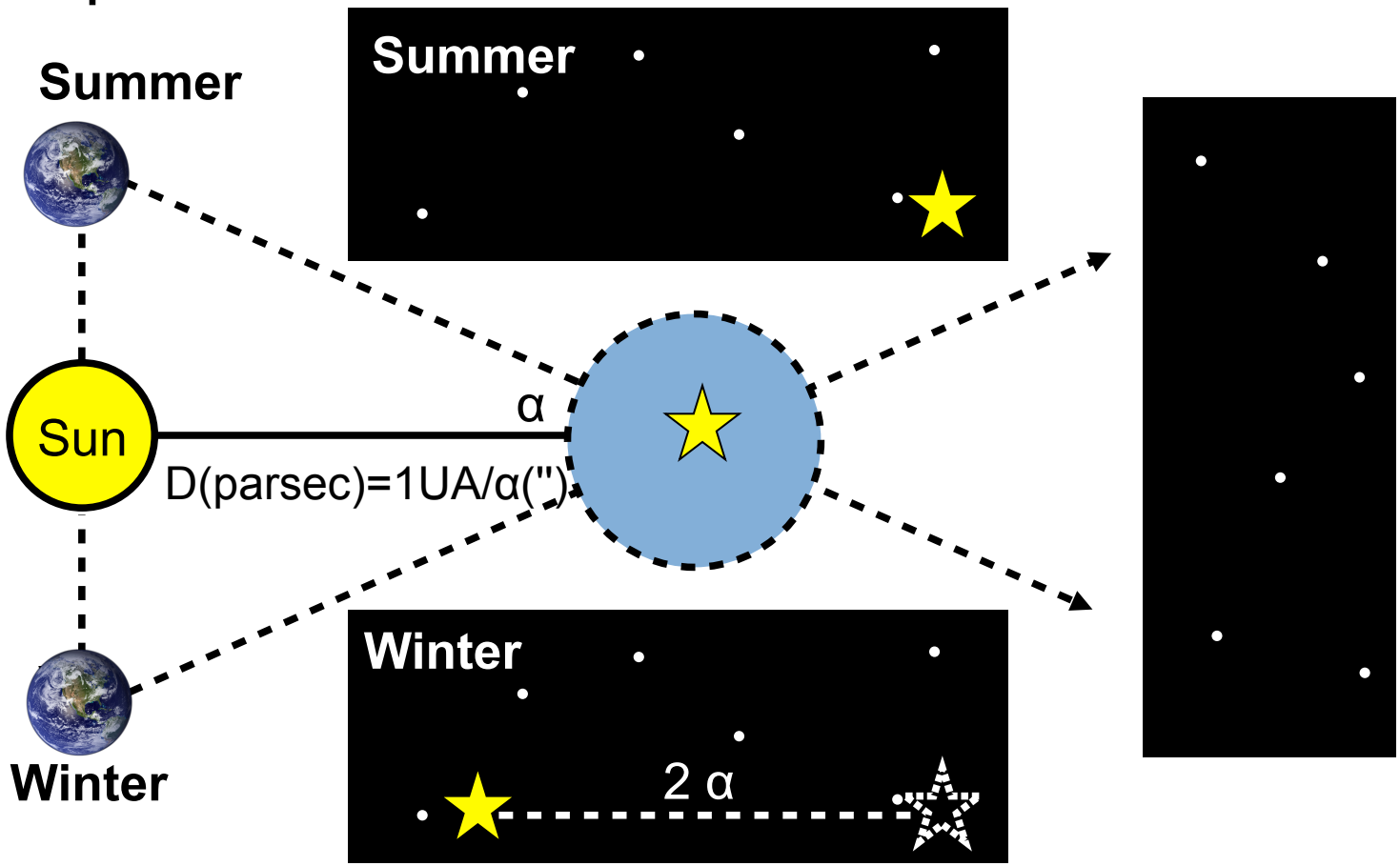
Science with LMTs

Supernova detection



Science with LMTs

Stellar parallaxes



Science with LMTs

But also...

- Space debris detection & follow up
- Brown/white dwarf detection
- Asteroids study
- Dark matter study in very low surface brightness galaxies
- Survey targets for other detailed studies (3.6m DOT, VLT, ...)
- Transient objects
- ...

The International Liquid Mirror Telescope (ILMT)

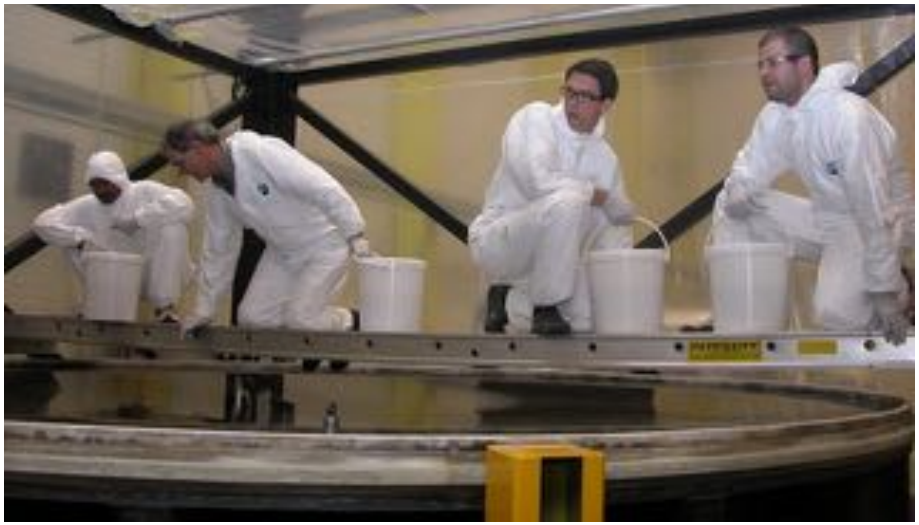
The International Liquid Mirror Telescope

P.I.: J. Surdej (ULg) + AEOS, ARIES P.I.: H. Chand
Project managers: S. Habraken & J.-P. Swings (ULg)
in collaboration with:
- AMOS (Adv. Mech. Opt. Syst.) & CSL (Centre Spatial de Liège)
- ROB (Royal Observatory of Belgium),
- Canada (Univ. of British Columbia, Laval Univ., Montreal Univ., Toronto Univ., Yorke Univ.; Prof. Paul Hickson, Prof. Ermanno Borra)
- ARIES (Aryabhatta Research Institute of Observational Sciences, India; Prof. Ram Sagar, Dr Brajesh Kumar ➔ Dr Hum Chand, Bikram Pradhan)
- UAM Poznan Observatory (Poland, Dr Przemo Bartczak)

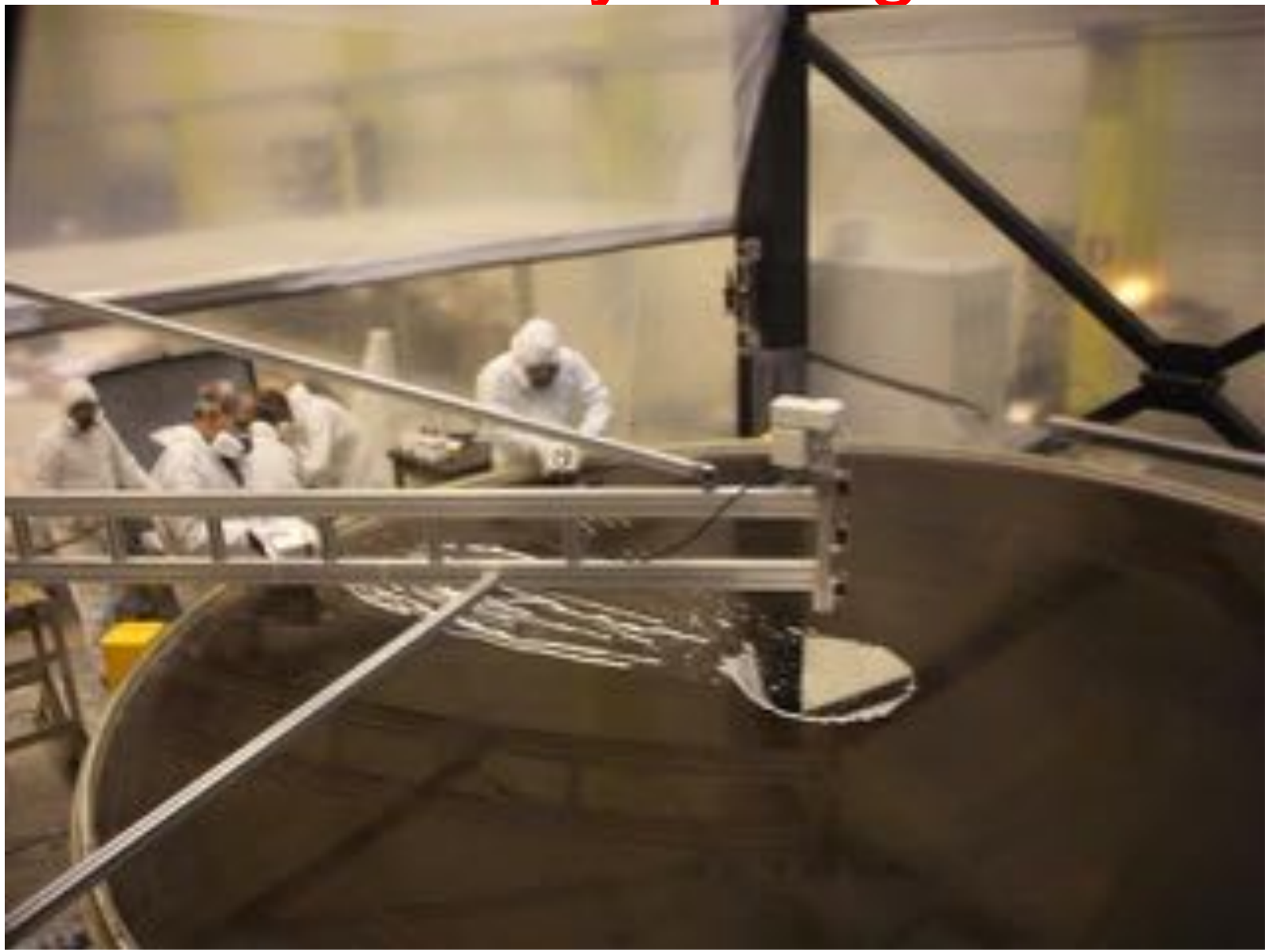
The International Liquid Mirror Telescope

The International Liquid Mirror Telescope

Spin-Casting

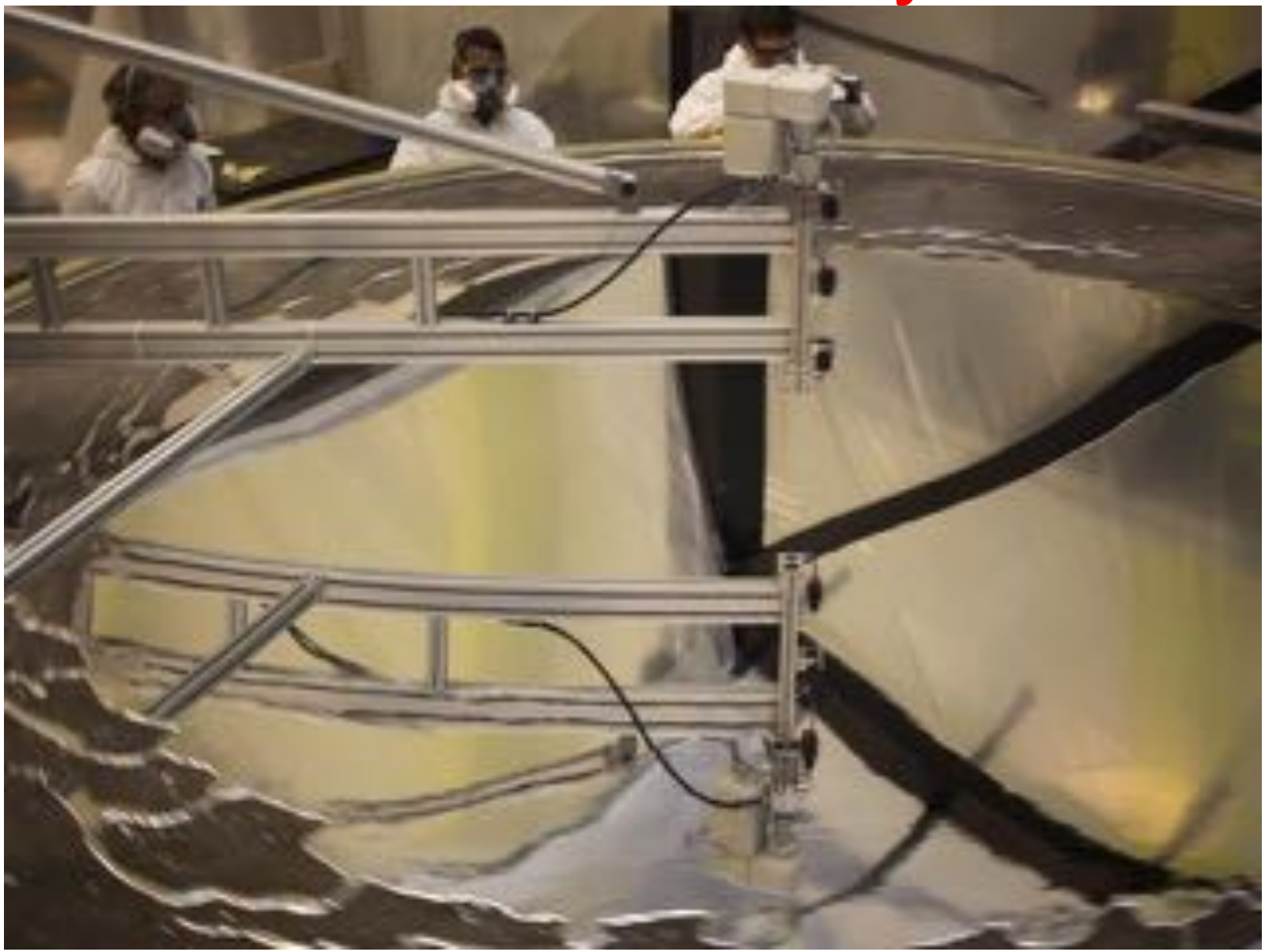


Mercury spillage



Optical tests carried out from the 14th to the 16th of January 2011 in AMOS workshops, Liège

Closure of the mercury surface



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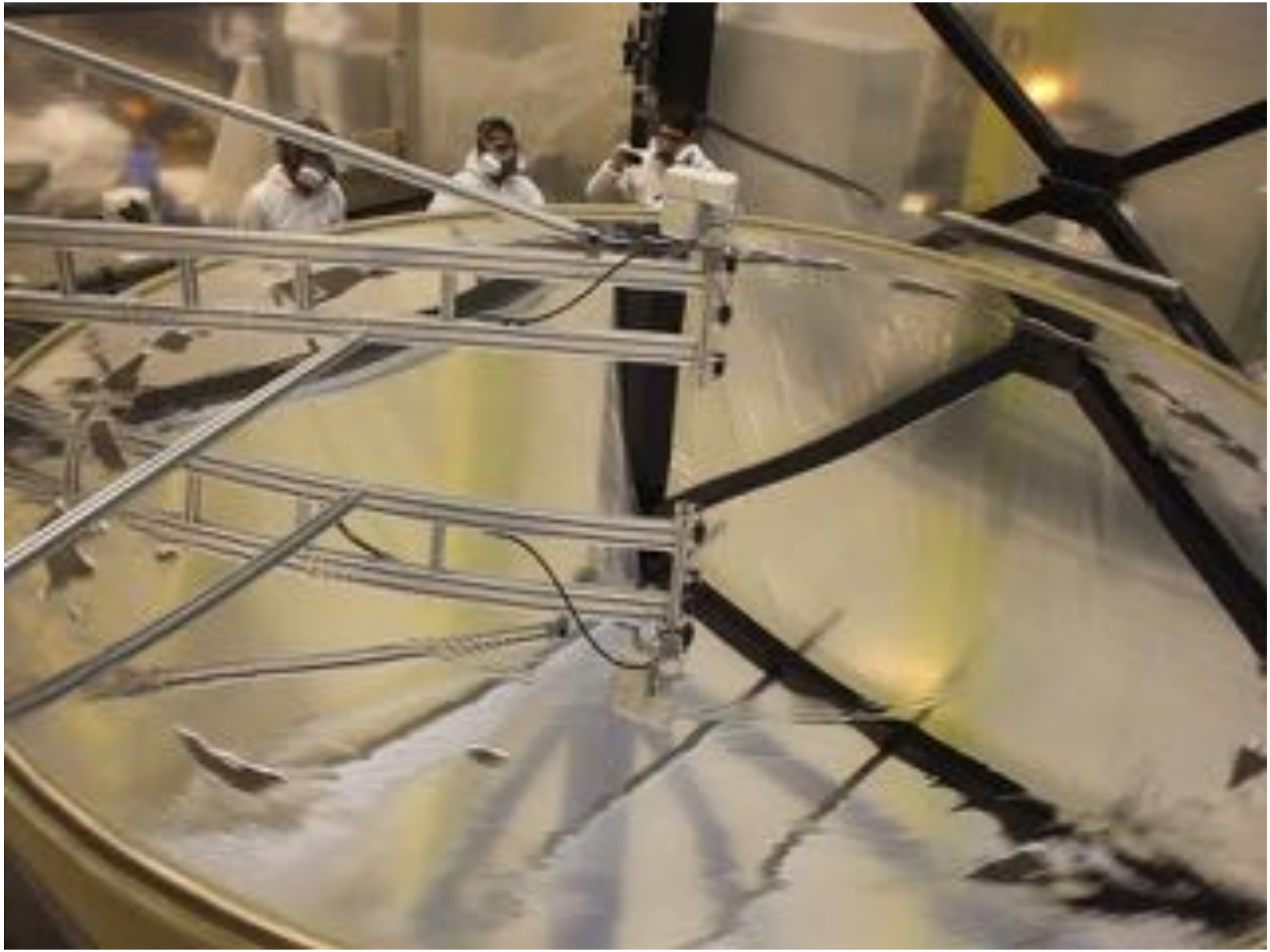
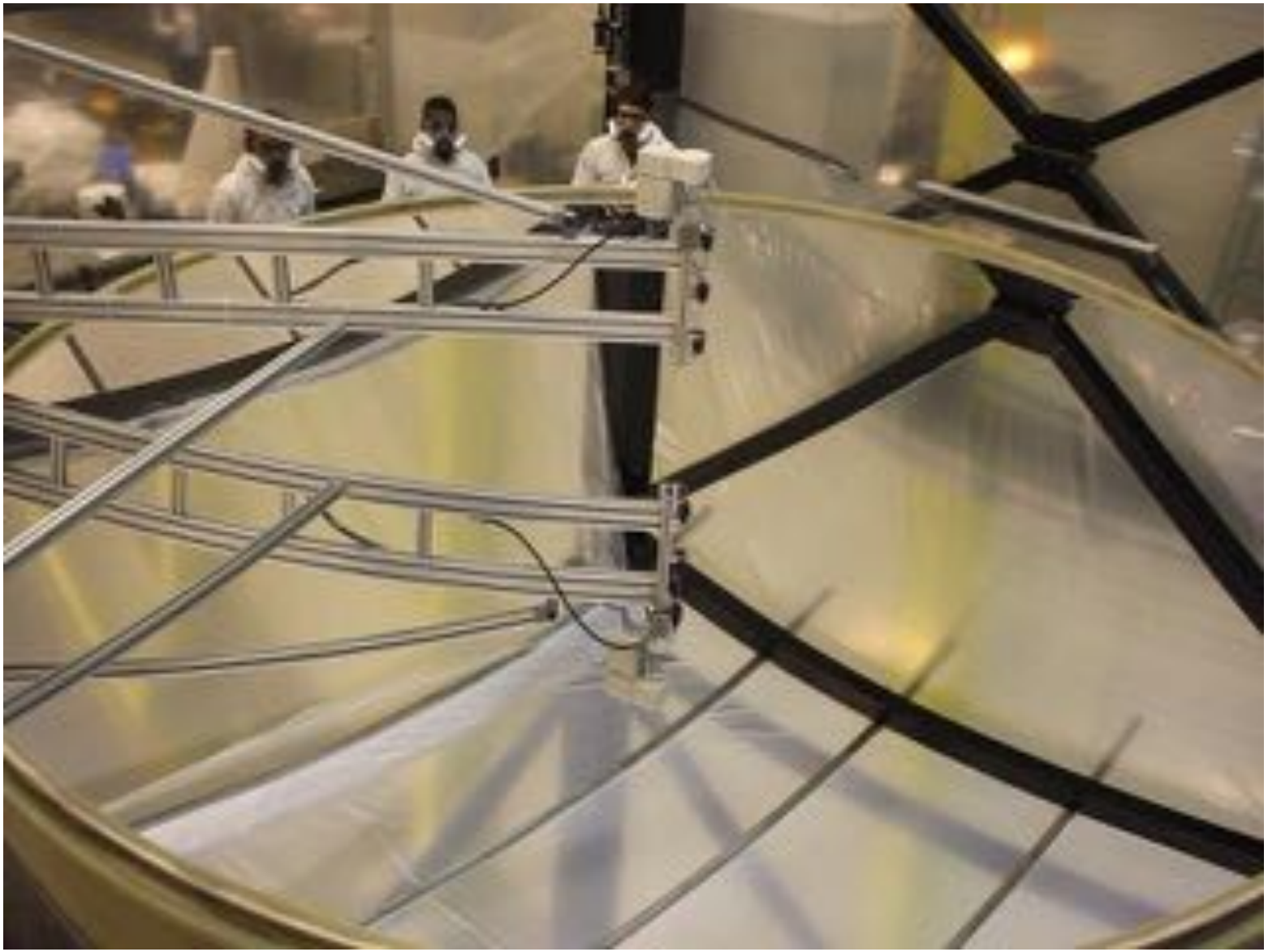
Closure of the mercury surface



Optical tests carried out from the 14th to the 16th of January 2011 in AMOS workshops, Liège

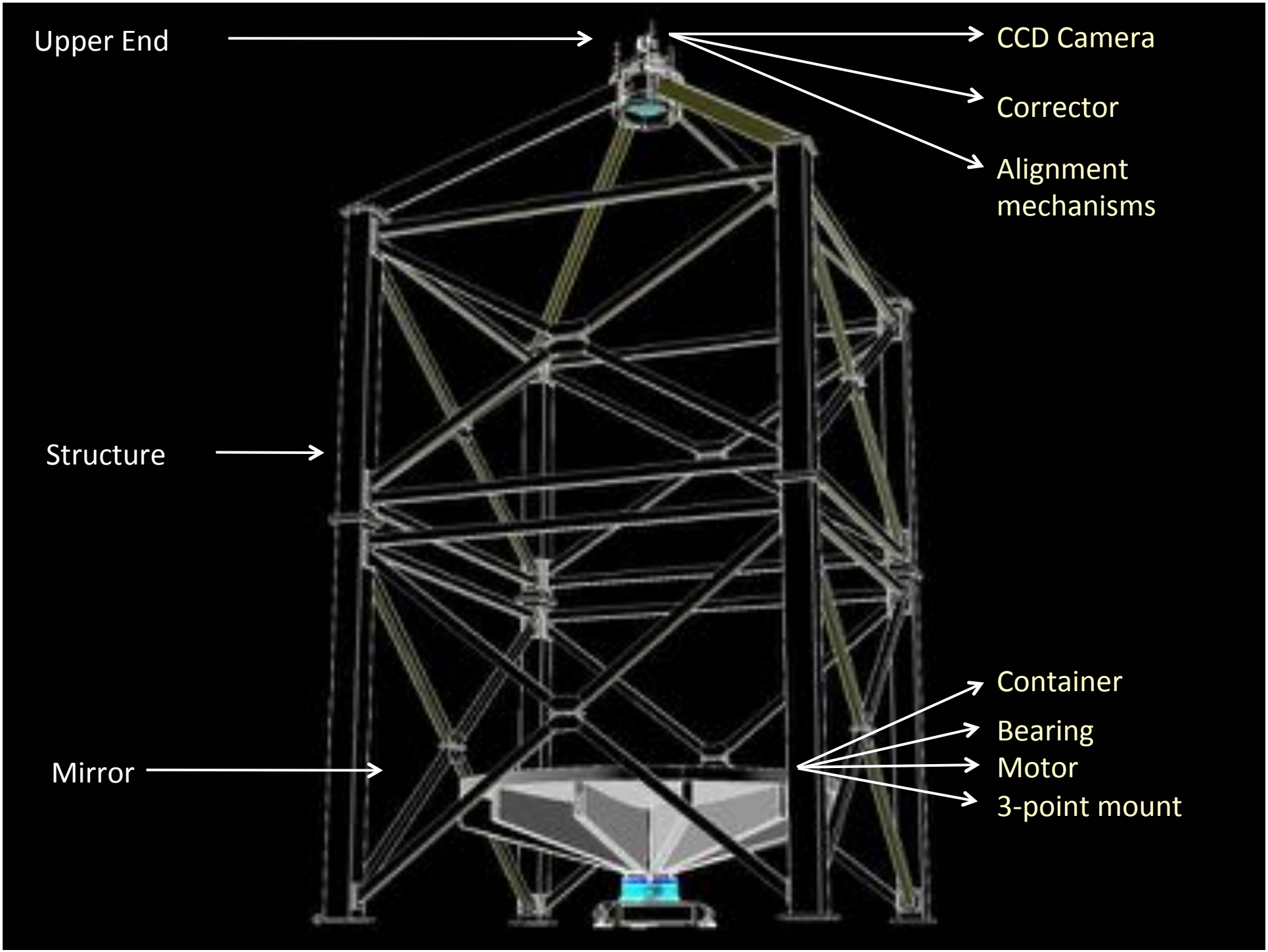
Closure of the mercury surface



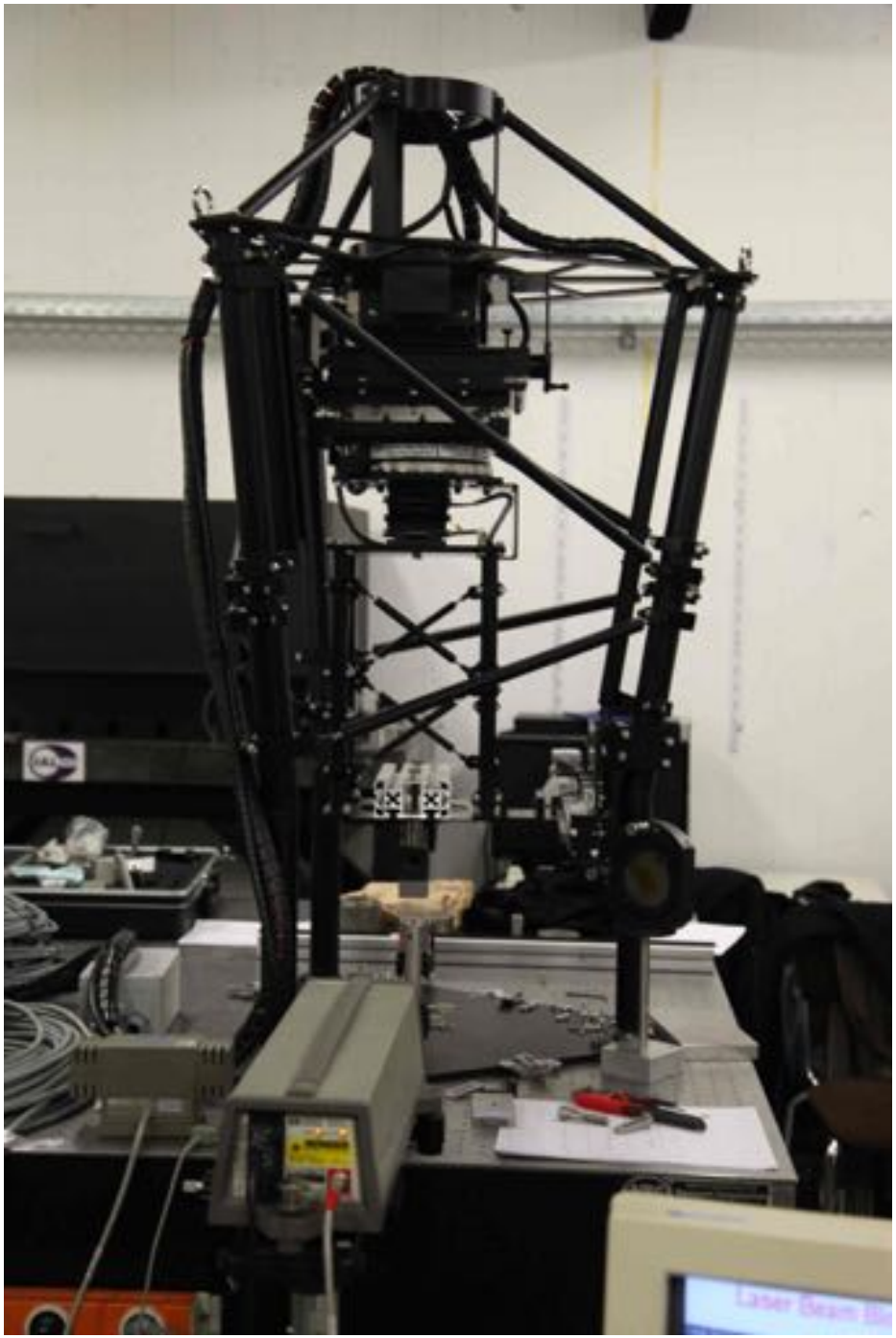
Optical tests carried out from the 14th to the 16th of January 2011 in AMOS workshops, Liège

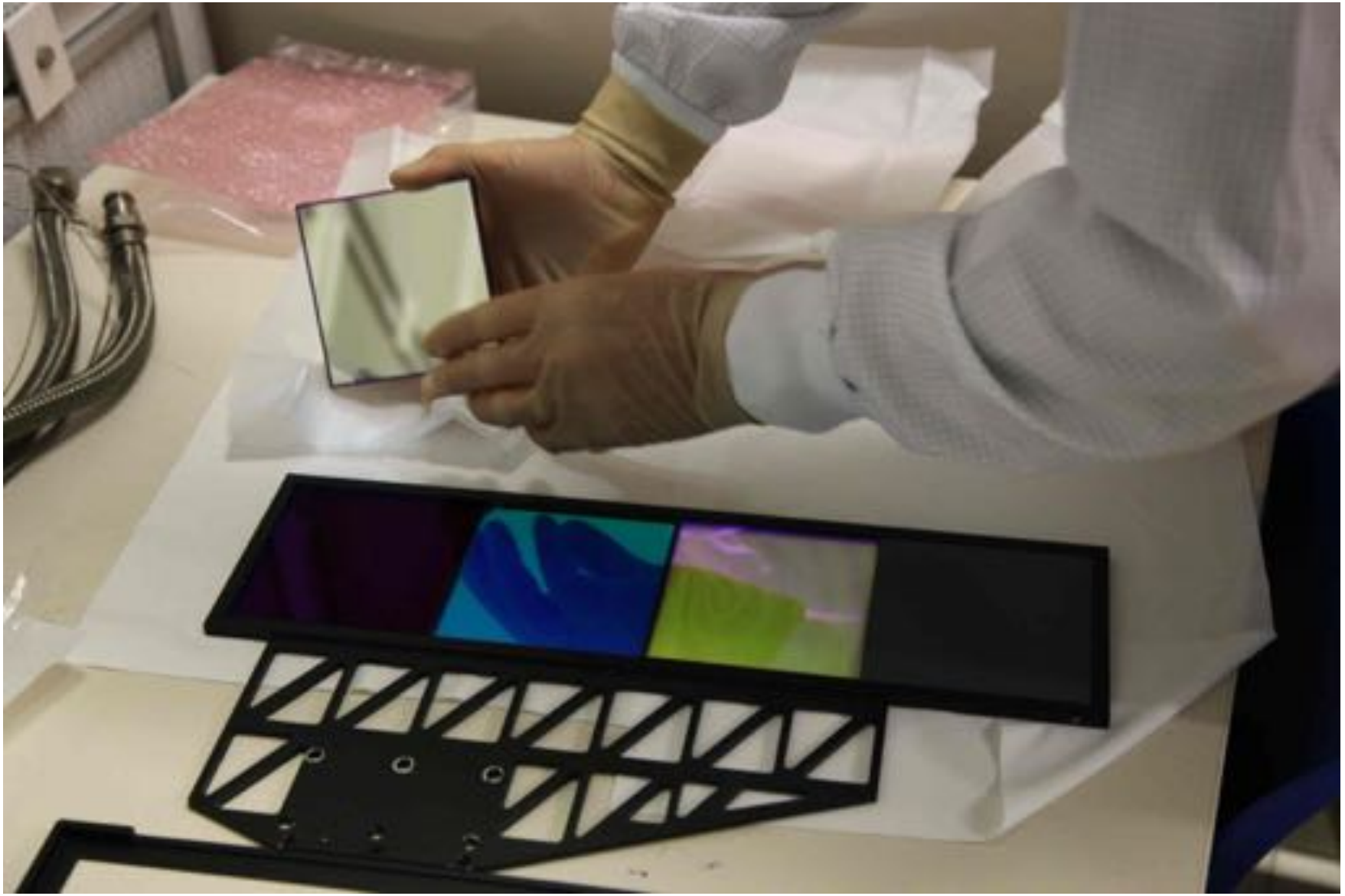
Laser beam testing

Optical tests carried out from the 14th to the 16th of January 2011 in AMOS workshops, Liège

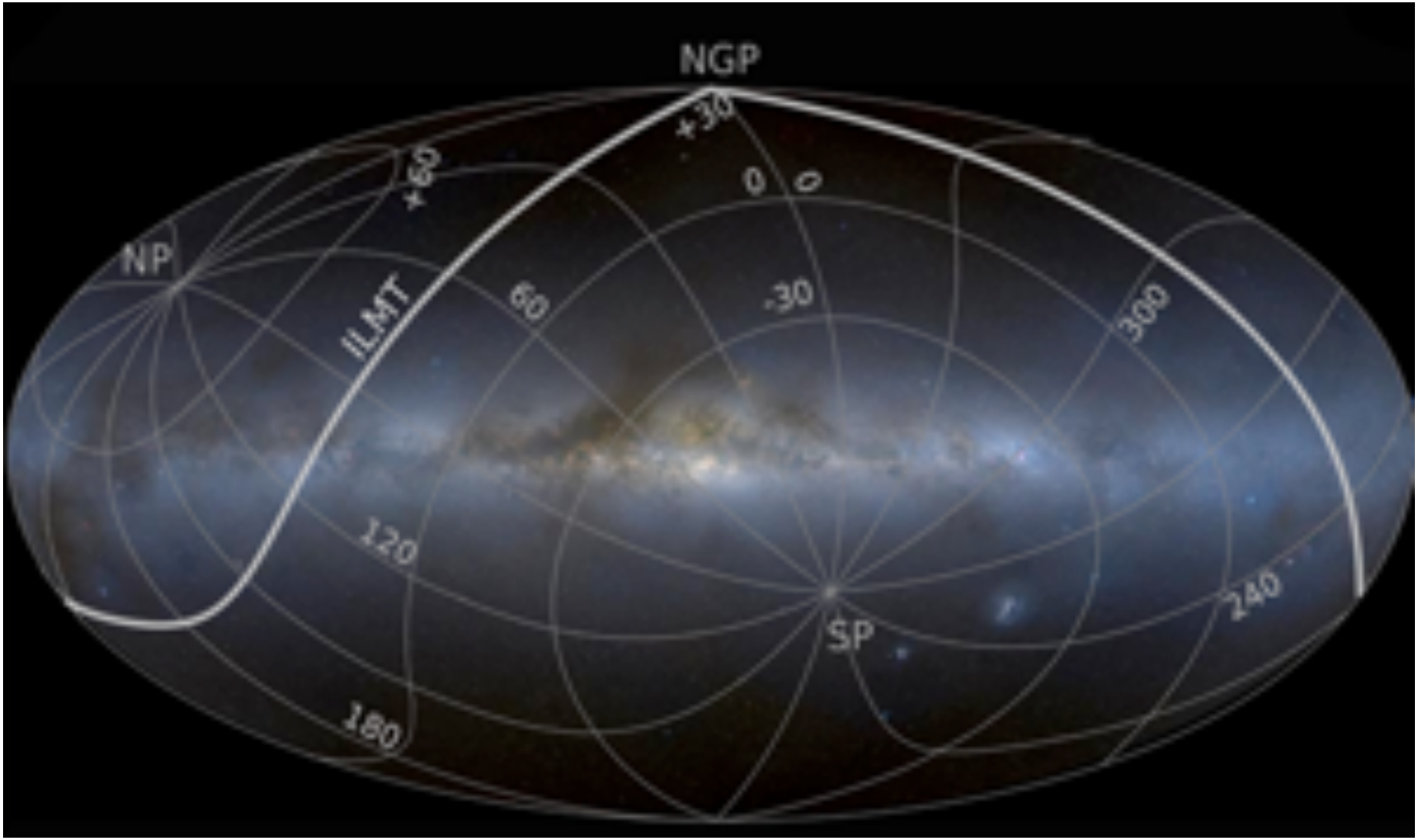

Upper End
CCD Camera
Corrector
Alignment mechanisms
Structure
Container
Bearing
Motor
3-point mount
Mirror

SOCABELEC interface between the ILMT CCD camera and the optical corrector (tests at CSL, 18 November 2013)





One of the two drawers with 3 Sloan filters plus one dark frame which will be used as a shutter in the ILMT CCD camera (tests at CSL, 18 November 2013)


NGP
+30
+60
0
0
NP
ILMT
60
-30
300
120
SP
240
180

Shipping of the ILMT (22nd of December 2011)

Packing of the mirror with foam, carbon fiber and polyurethane at AMOS, before shipping from Liège to ARIES observatory (Devasthal, India) on the 22nd of December 2011.

Night shipping of the 4m-telescope and its mirror in India (23rd of March 2012)

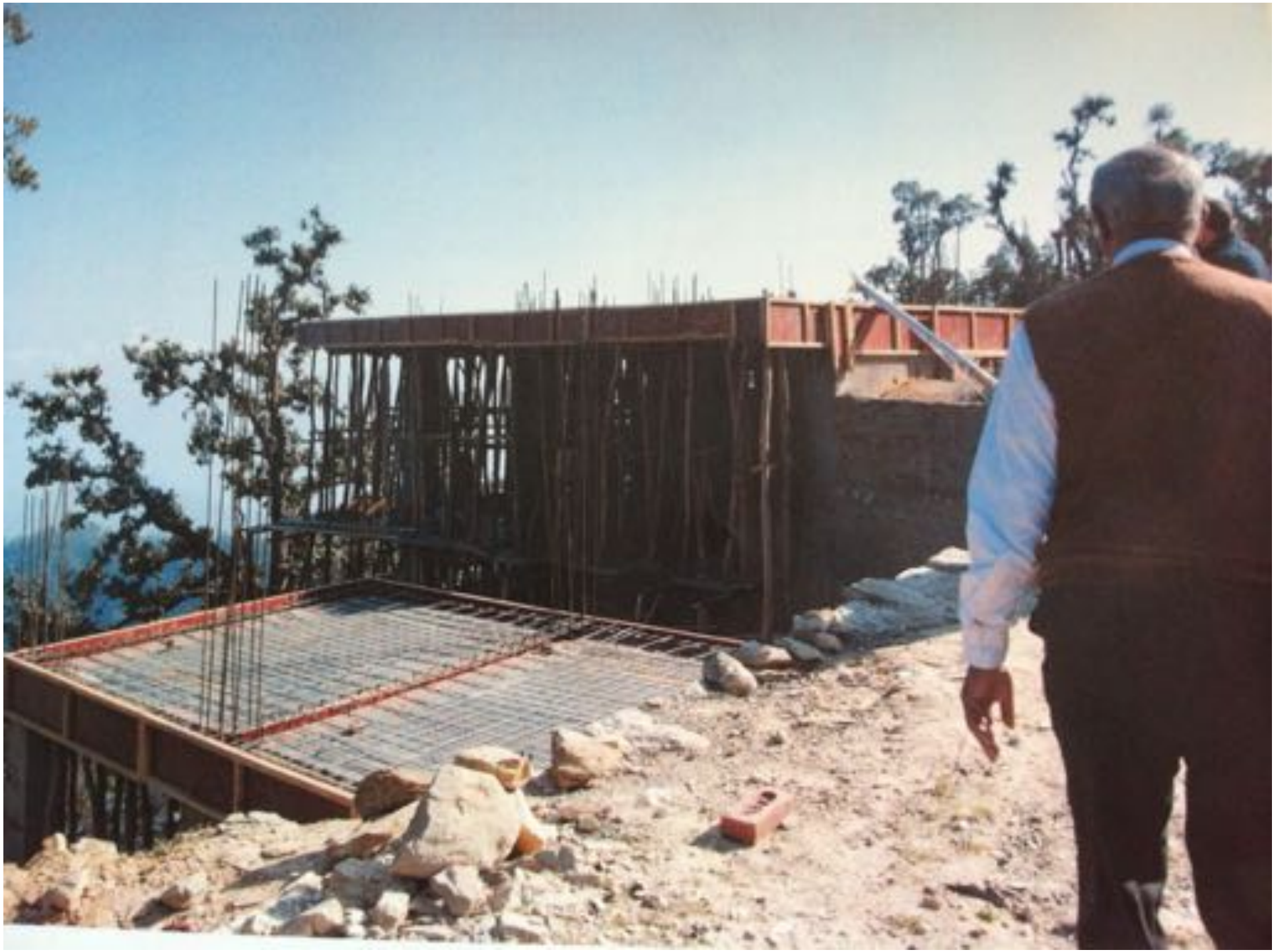
Arrival of the truck carrying the 4m-mirror at the site of Devasthal (India) (23rd of March 2012)

Crane dropping off the 4m-mirror at the site of Devasthal (India)
(23rd of March 2012)

Transportation of the ILMT primary mirror between the entrance and the summit of the Devasthal Observatory (24 May 2013)

Civil engineering construction of the ILMT dome

ILMT dome construction on the Devasthal site (7 February 2013)



ILMT dome construction on the Devasthal site (23 April 2013)

ILMT dome construction on the Devasthal site (24 May 2013)

Construction of the 3.6m Devasthal Optical Telescope (DOT)

Construction of the 3.6m DOT on the Devasthal site (19 May 2013)

Construction of the 3.6m DOT on the Devasthal site (14 June 2013)

Present status report

Present status report (11/3 – 24/4/2019)

Lifting the Socabelec interface from the flight case and setting it on a wooden pallet.

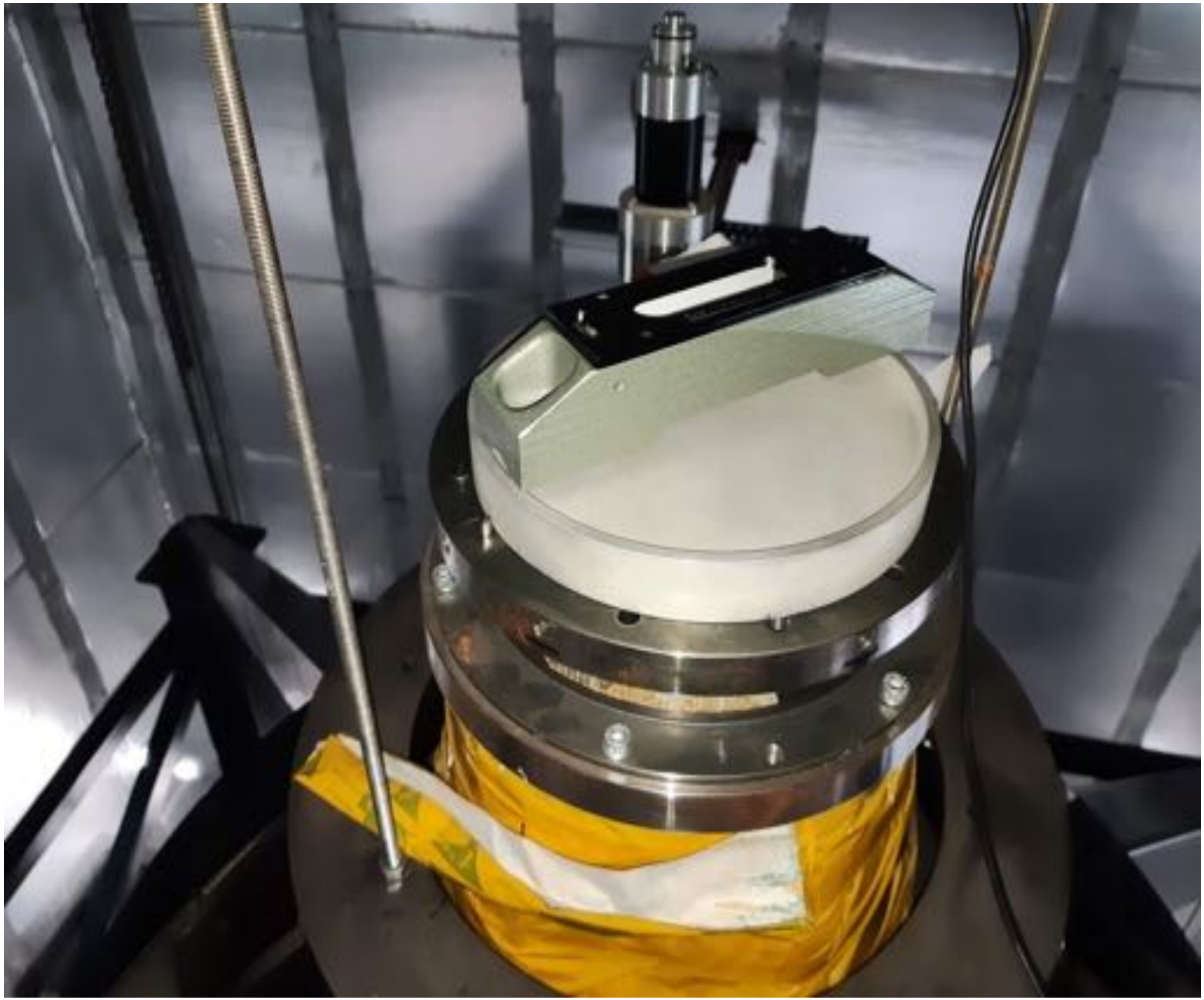
Present status report

The fully assembled mechanical interface (image at left) and electric connections to the interface’s control panel (image at right).

Present status report

The folding platform ready to be fixed to the telescope structure.

Present status report



Present status report

NF-50 cylinder containing the explosive gas (on the right) and intermediate hose to connect a big cylinder of cooling gas to the CCD compressor recharge valve. The latter hose could not be attached to the NF-50 gas cylinder because of a missing adapter.

Present status report

Upper left: a spirit level (black) was set on a flat aluminium plate close to the mirror center.

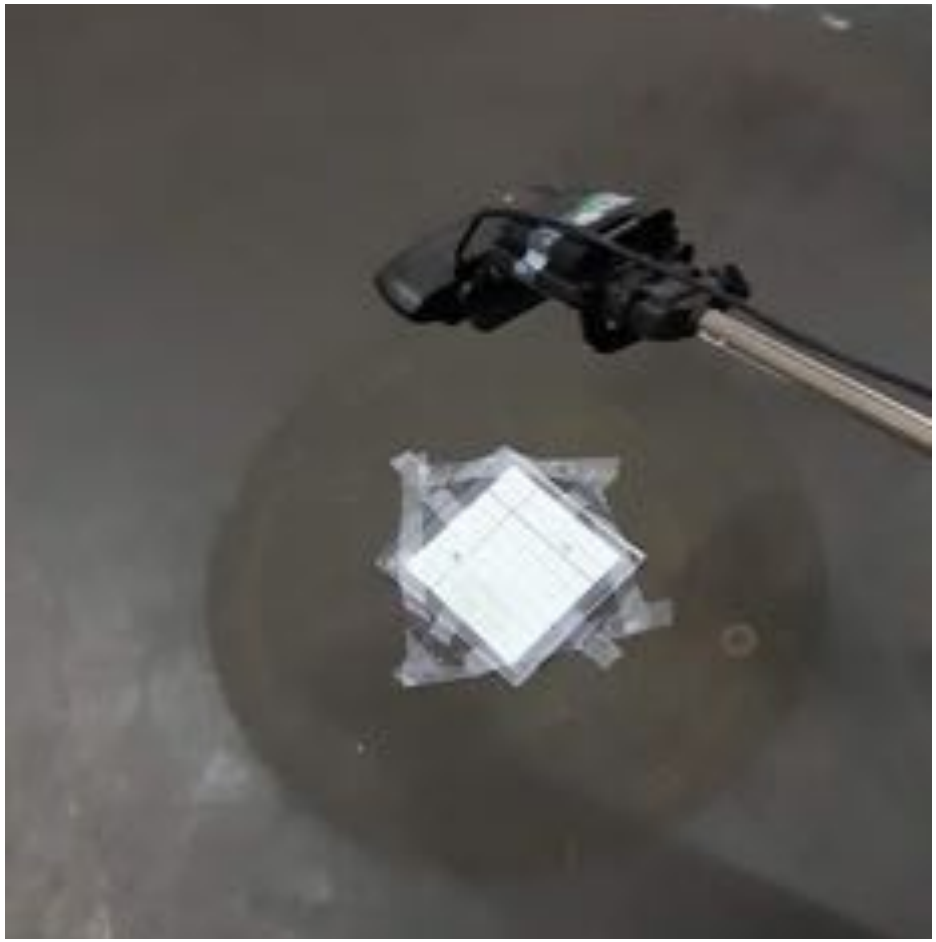
Right: Adjusting the tilt of the air-bearing by means of three screws separated by 120° with respect to its center.

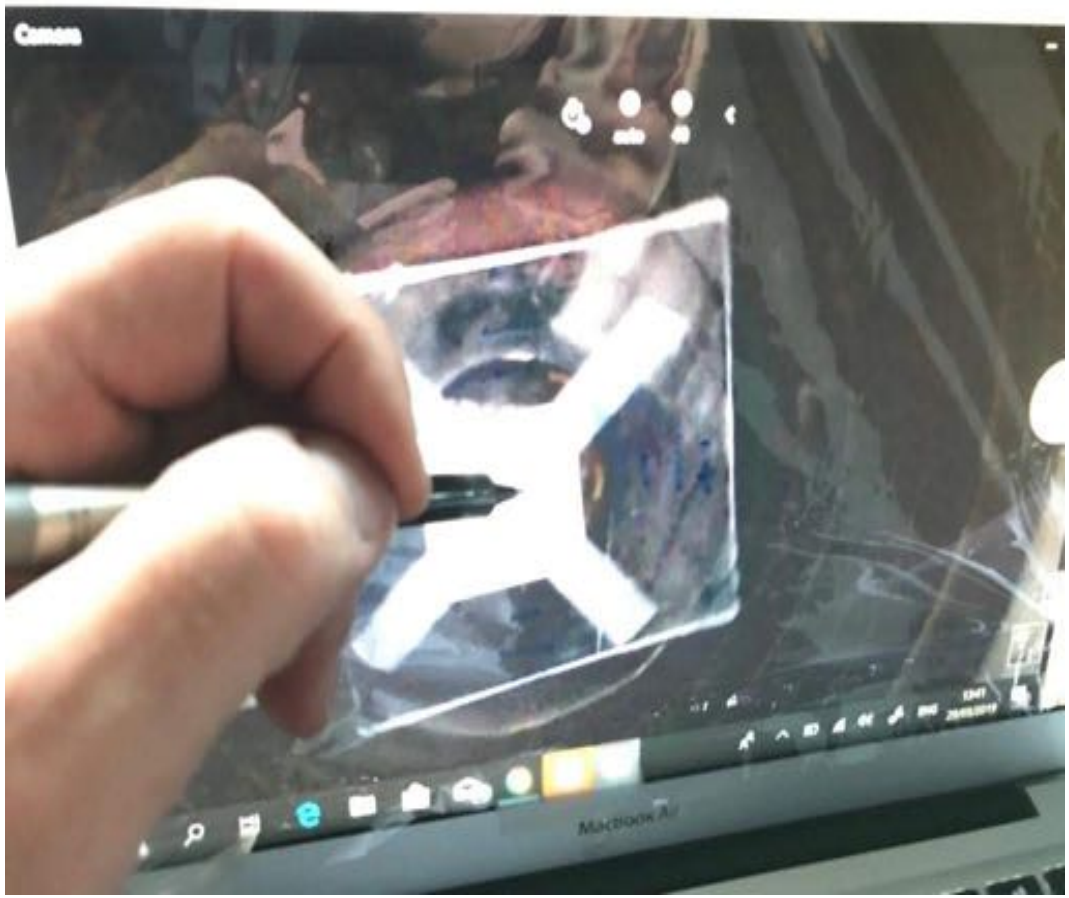
Present status report

Plexiglass casing around the pneumatic modules inside the compressor room.

The pneumatic modules surrounded by the plexiglass casing inside the ILMT data room.

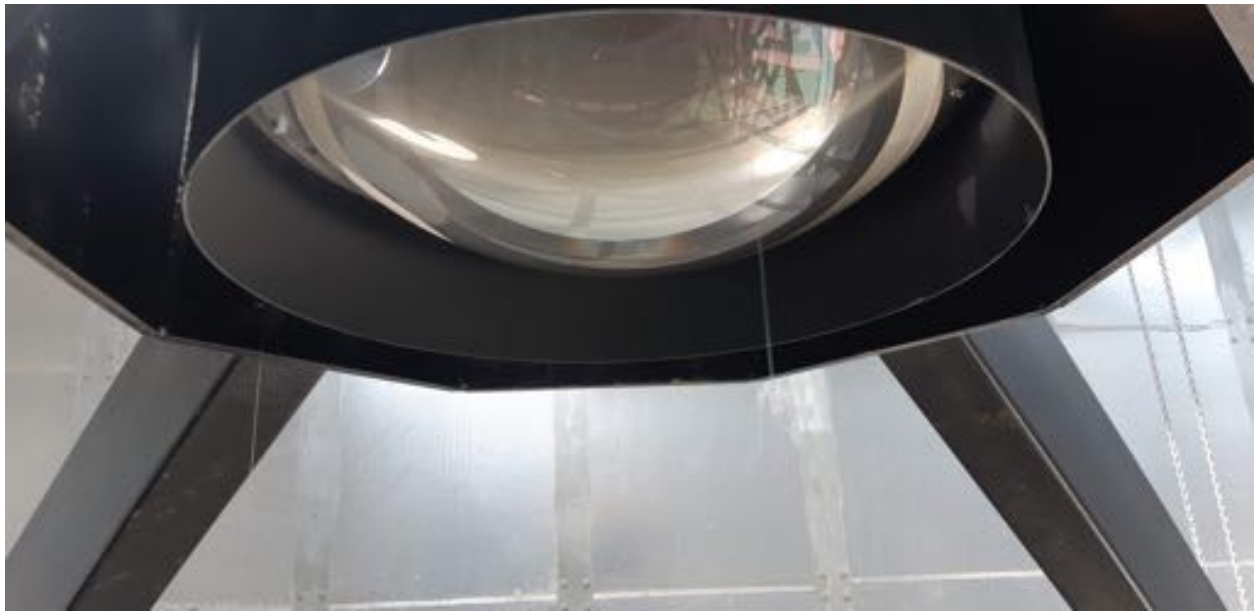
Present status report: mirror & corrector centering



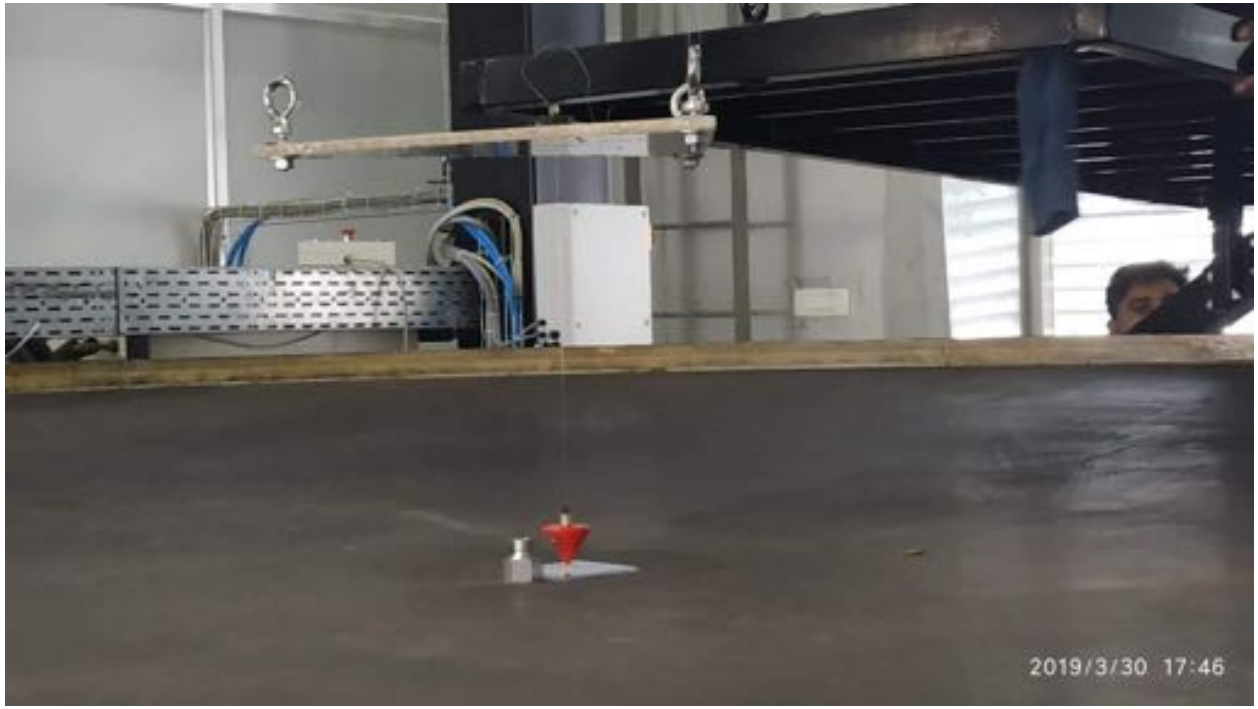


The left image shows the point mark placed near the center of the bowl and the image on the right shows how we estimated the required shifts to put the mark over the center of the bowl.

Present status report: mirror & corrector centering

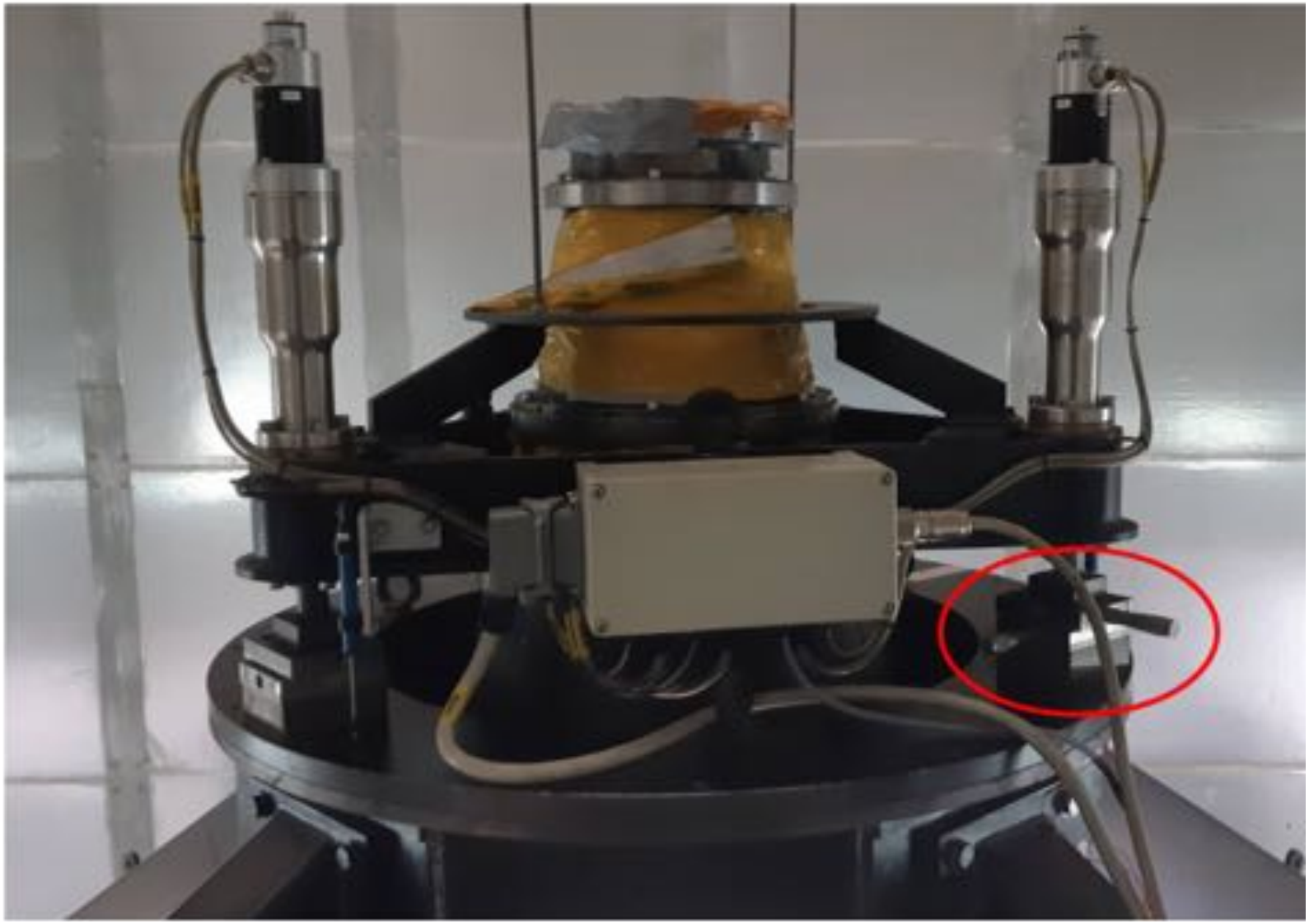


Nylon wires hanging along the corrector lens with an angular separation of 120°.



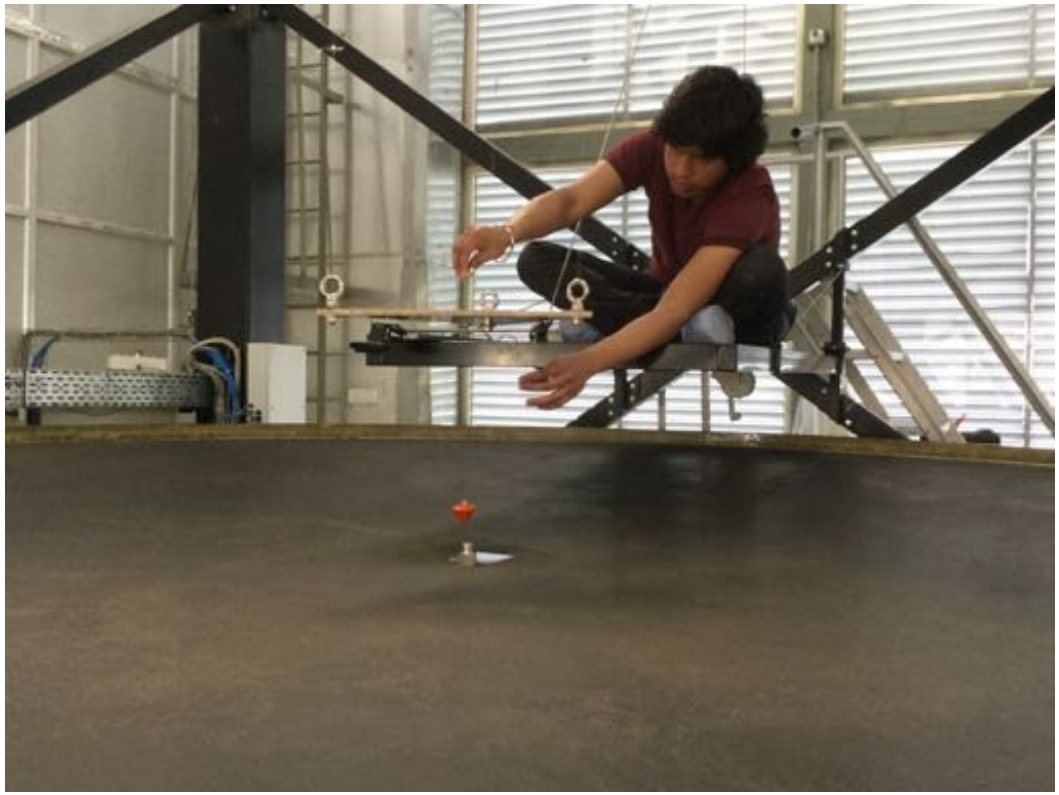
Three nylon wires attached to a wooden frame (equilateral triangle shape) over the bowl and the plumb bob extending from the centre of the triangle towards the centre of the bowl.

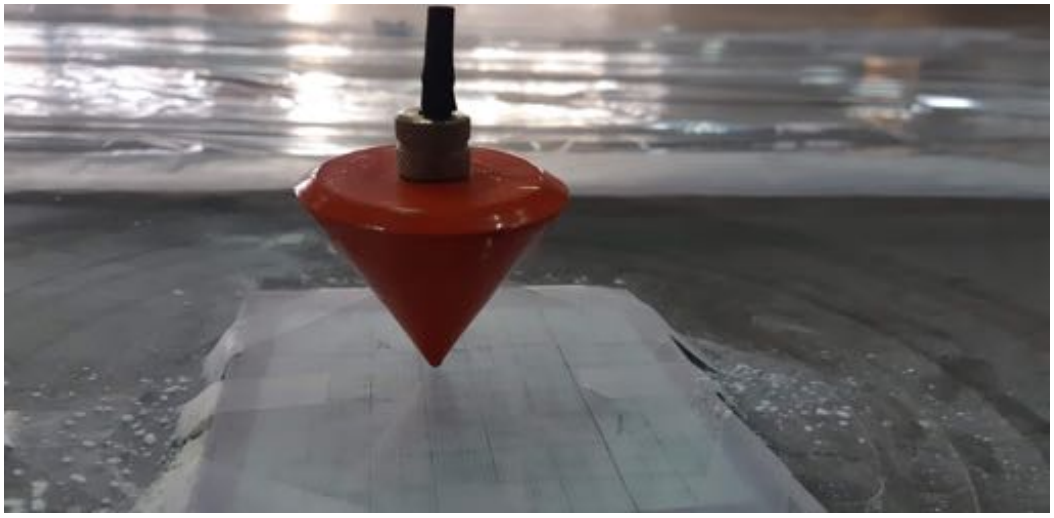
Present status report



Two orthogonal sliders on the corrector lens setup for inducing a linear translation of its center.

Present status report





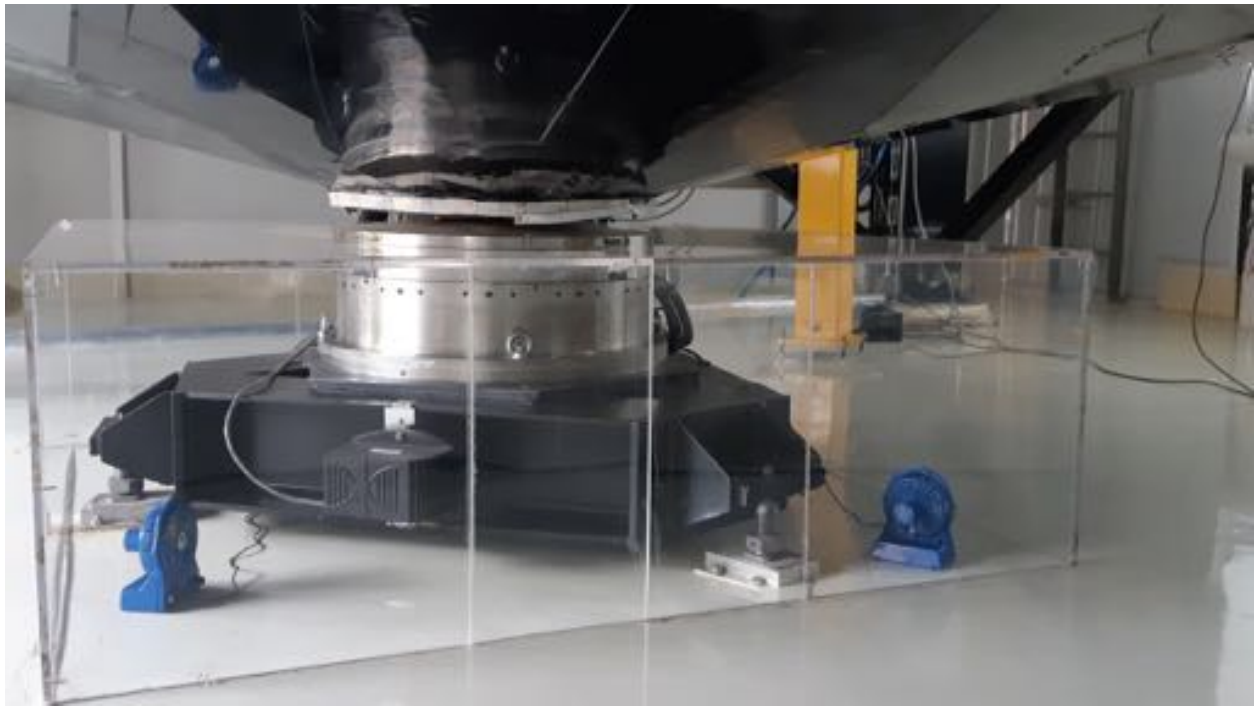
Present status report

Image on the left shows a laser pointer kept on the primary mirror. The other image shows the green laser dot at the edge of the corrector lens.

Present status report

Temperature sensor attached
at the prime focus.

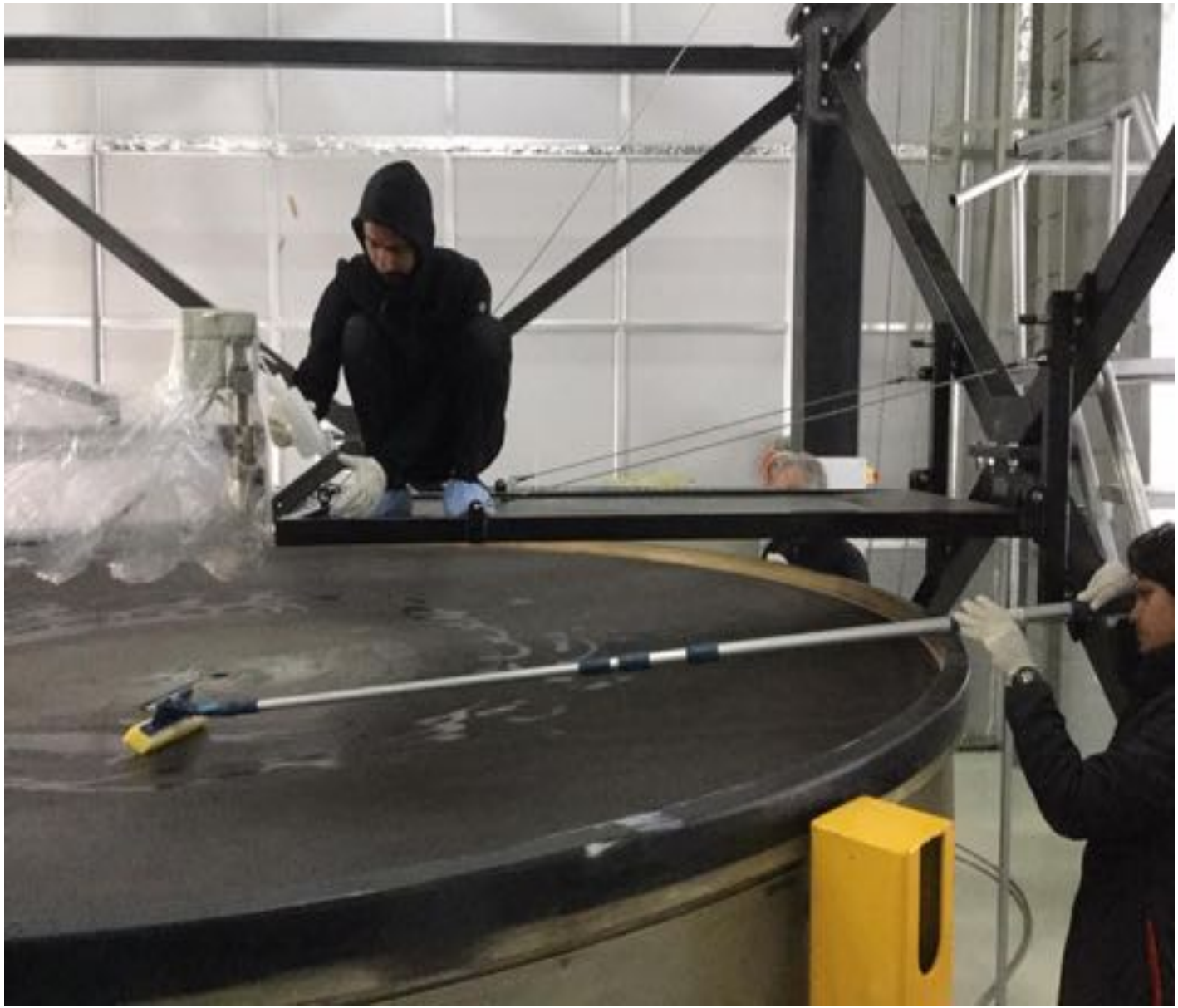
Present status report



Fans set around the air-bearing to render more uniform the temperature distribution.

Height adjustment between the primary mirror center and the first lens of the optical corrector

Present status report



Cleaning the surface of the primary mirror using isopropanol.

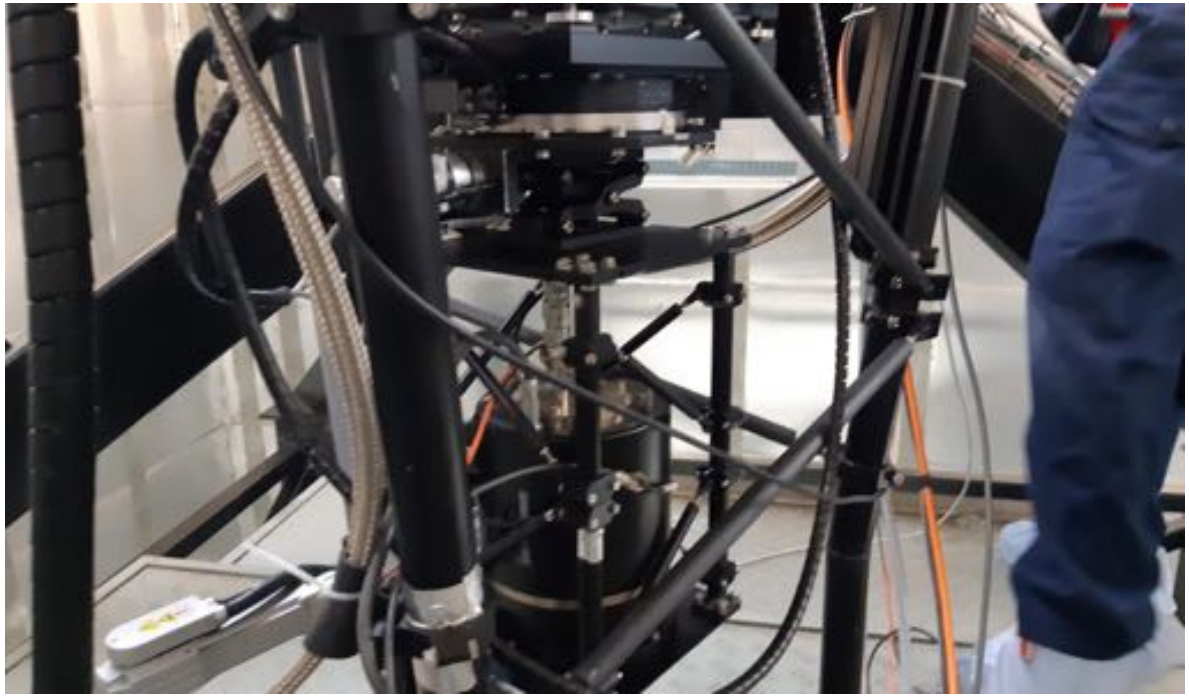
Present status report

Attachment of a mylar sheet along its edge to another one.

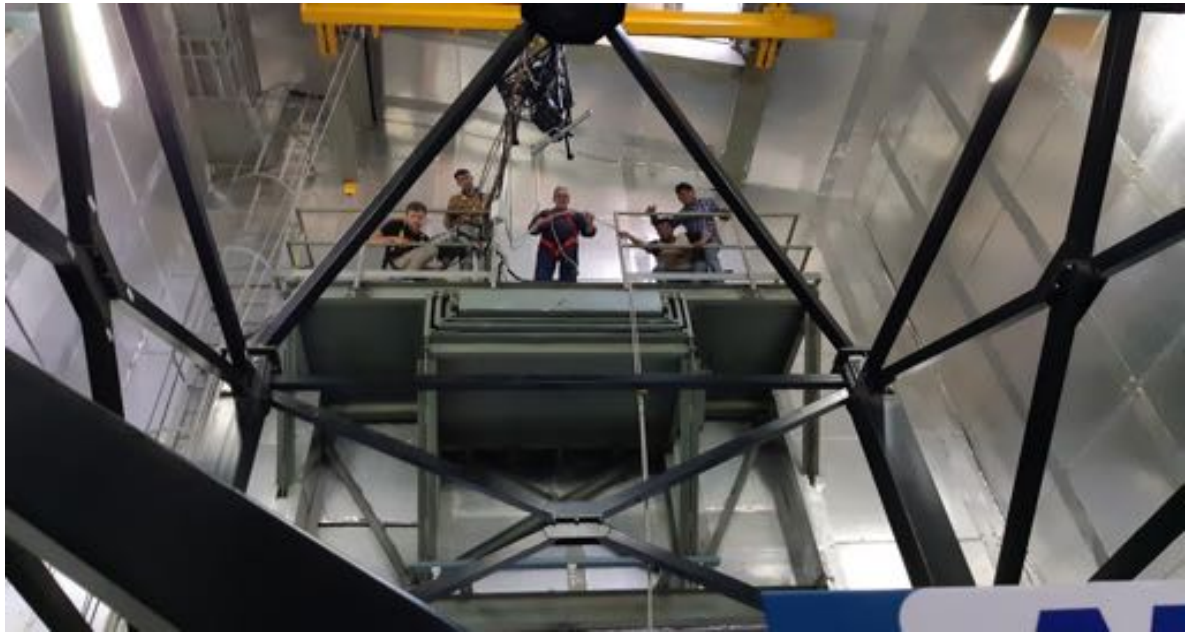
Present status report

Top view of the mylar insulation over the primary mirror.

Present status report

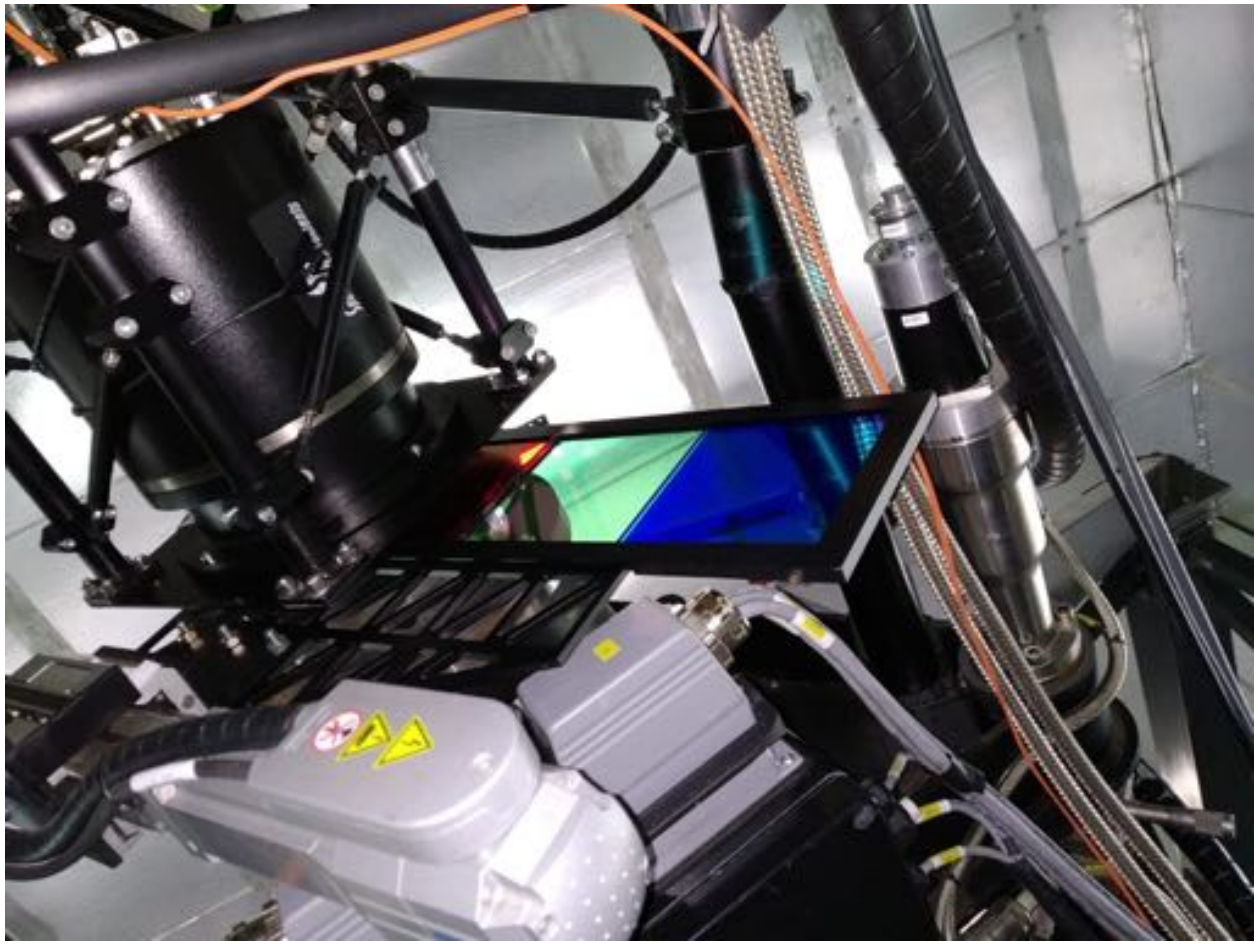


ILMT CCD imager placed inside the Socabelec mechanical interface.



The Socabelec mechanical interface is lifted up close to the prime focus.

Present status report



Installation of the tray with the SDSS broadband filters on the Socabelec mechanical interface at the prime focus.

Present status report

Hg vapour extractor located on a brown platform at right. One end of the black pipe is connected to the extractor and the other end goes near the center of the primary mirror.

Present status report

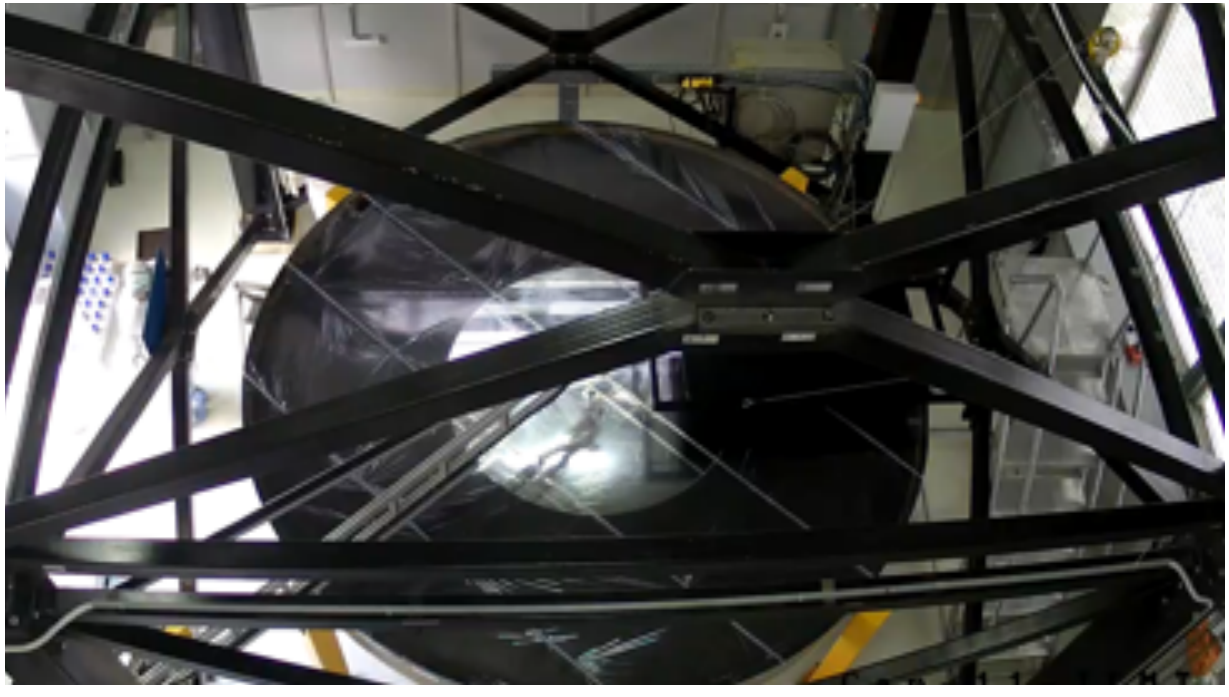
Outlet of the Hg vapour extractor (wider black pipe) reaching the exhaust fan at the farthest end.

Present status report

Picture on the left shows the hydra crane lifting the heavy mercury container and on the left the container getting on to the truck on its way to the ILMT building.

Present status report

One of the 70 bottles carrying mercury is ready to be opened and poured through a small opening near the periphery of the mylar insulation.

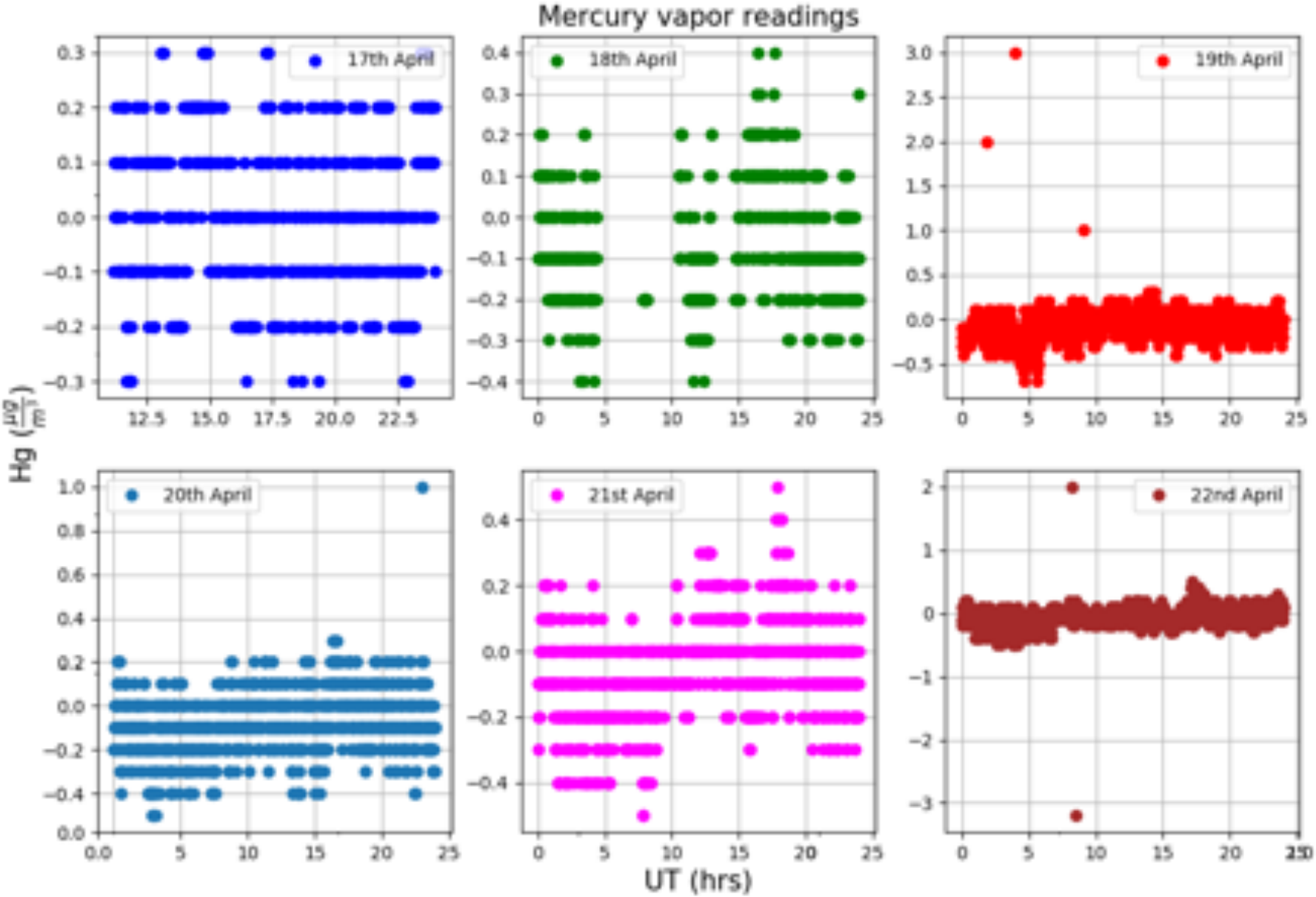


Top view of the primary mirror after mercury pouring is completed

Present status report

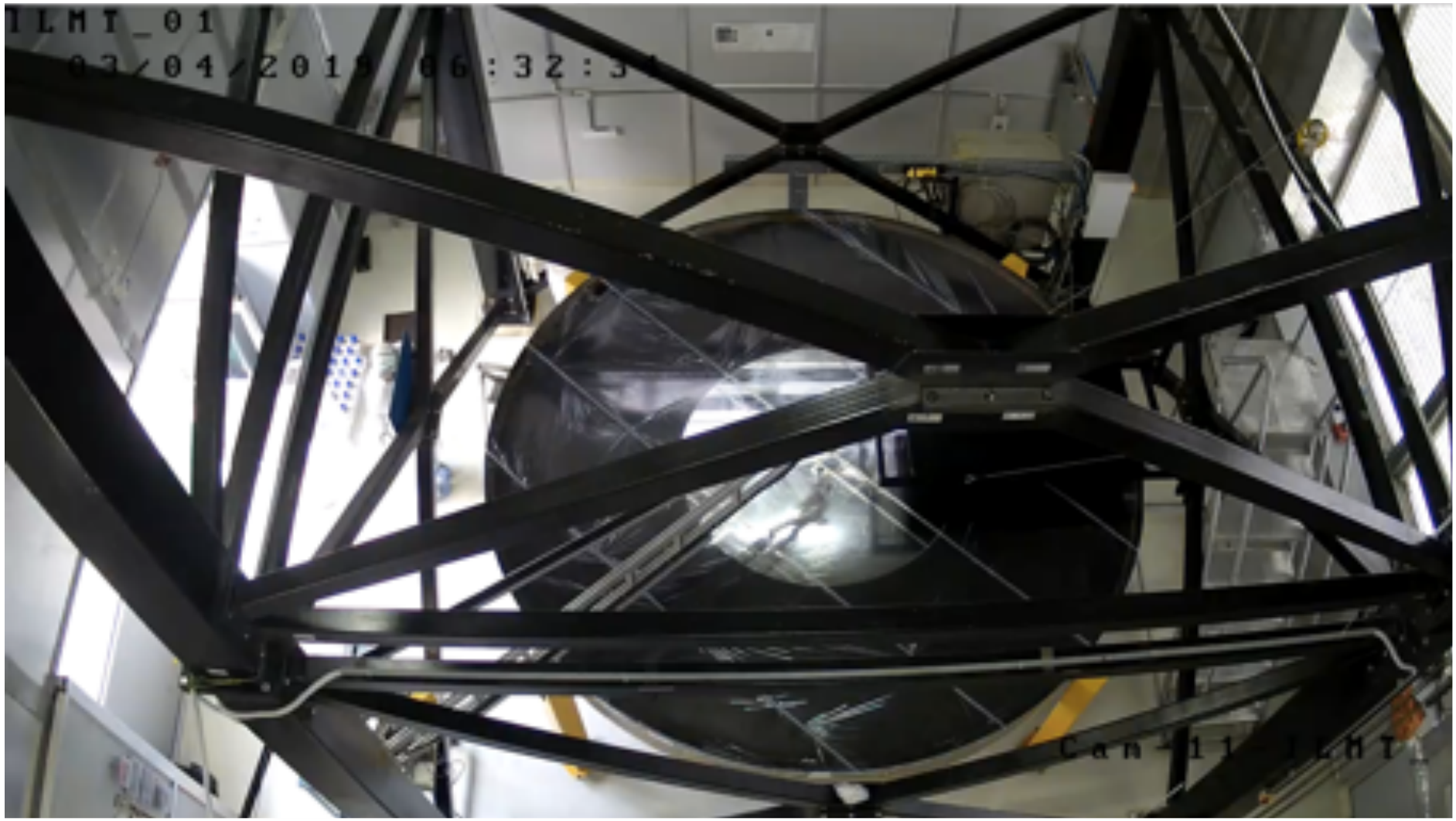
Panoramic view of the stainless steel tank (on the right), cylindrical peristaltic pump (close to the tank), pump controller (in front of the tank), and a black hose running through the metallic arm down to the center of the primary mirror.

Present status report

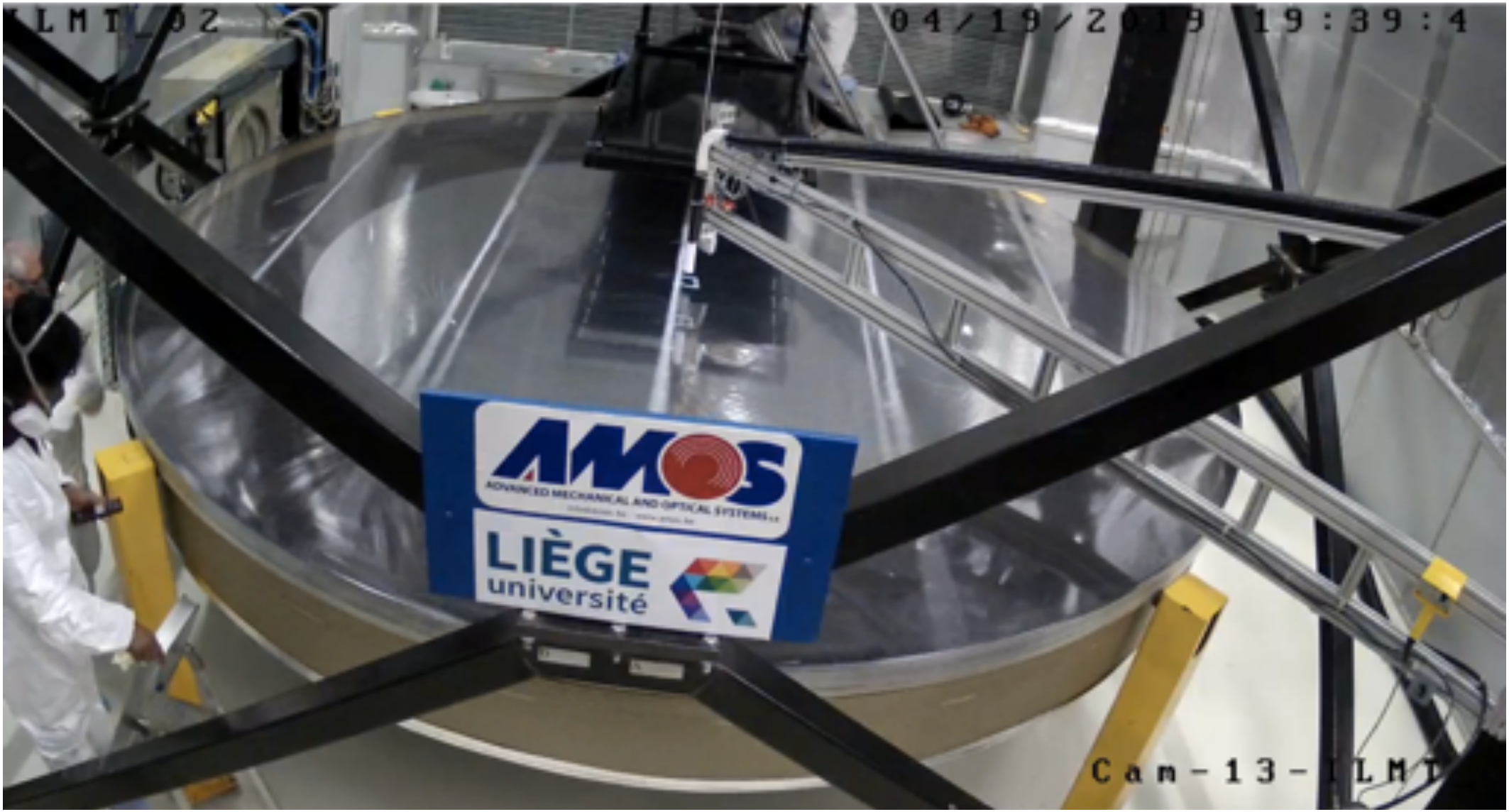


Hg vapour monitoring from 17th to 22nd of April, 2019, inside telescope building.

Present status report



Present status report



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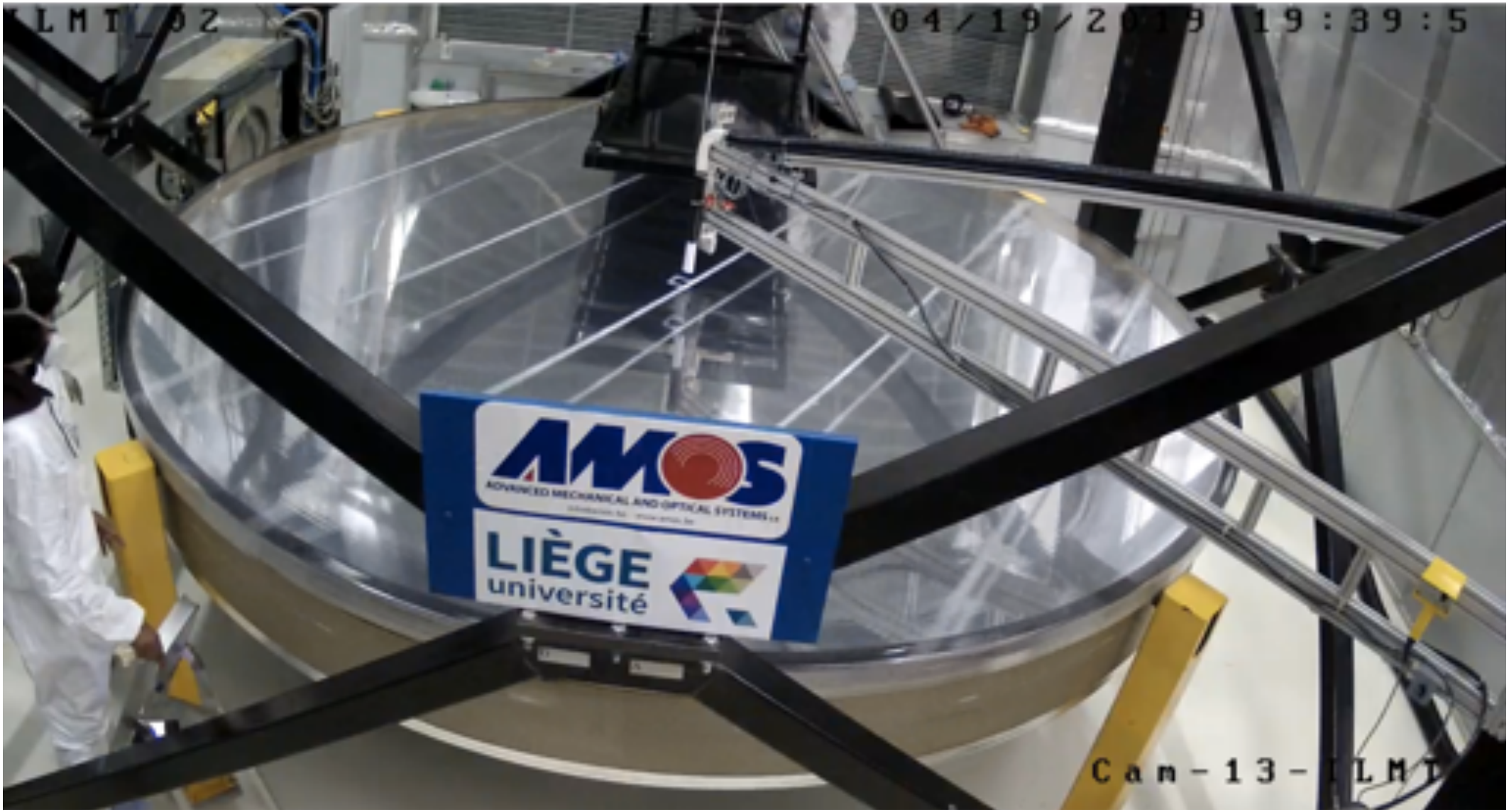

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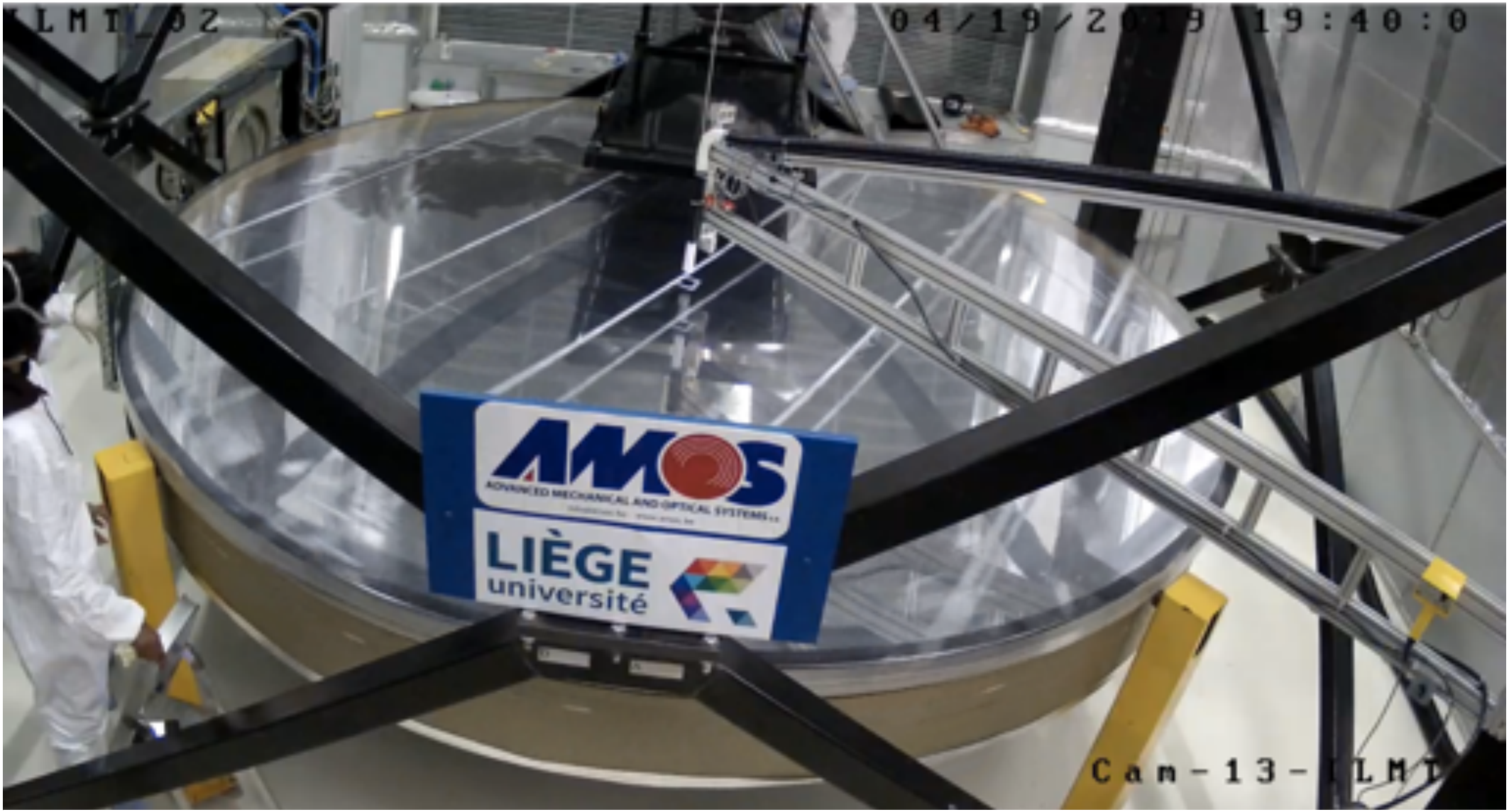

Conclusions

- **The ILMT is an instrument that may be entirely dedicated to a photometric and astrometric variability survey**
- **In principle, the mirror quality is limited by the diffraction (atmospheric seeing)**
- **Plus: continuous zenith observations (best image quality, smallest atmospheric extinction, 1D flat field: higher photometric quality, image subtraction, image addition, …)**
- **Relatively cheap**
- **Several institutes are involved at the international level**
- **Cons: non steerable telescope, 90 sec. integration, …**
- **Need for more Hg**
- **Need for powerful image subtraction algorithms**

References : **http://www.aeos.ulg.ac.be/LMT**

Thanks

Your questions are welcome …

… General discussion (data reduction, analysis, archiving and science)