# Occulter optimization tests at OPSys


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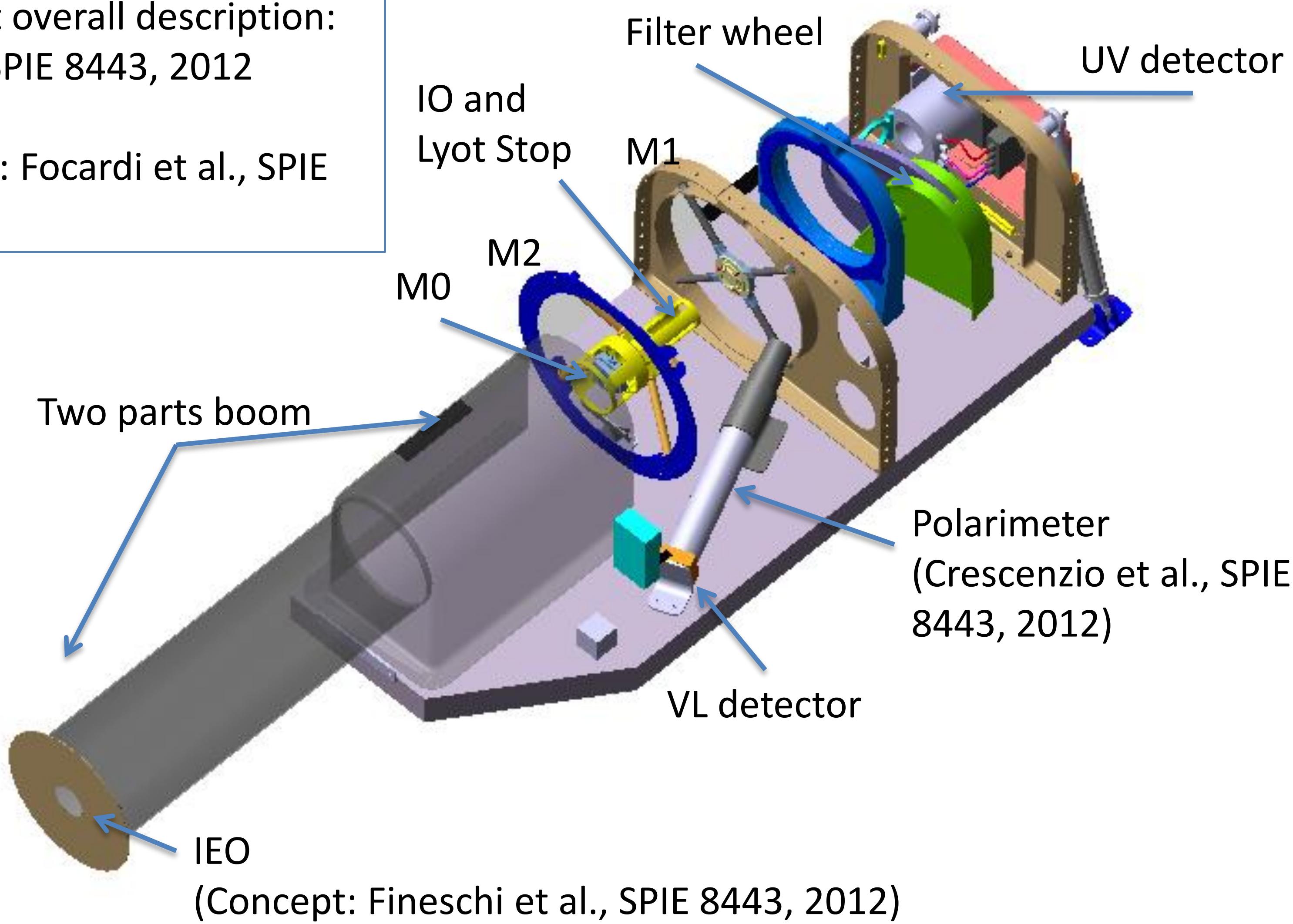
# Outline

- METIS and its occulting system
- Theoretical estimate of the diffraction pattern on the primary mirror plane
- Occulter optimization concept
- The prototypes:
  - BOA (Breadboard of the Occulting Assembly)
  - ANACONDA (AN Alternative COnfiguration for the Occulting Native Design Assembly)
- Preliminary results from LAM measurements
- Set-up modifications to be introduced at the OPSys facility
- Preliminary activity schedule

# METIS occulting system design

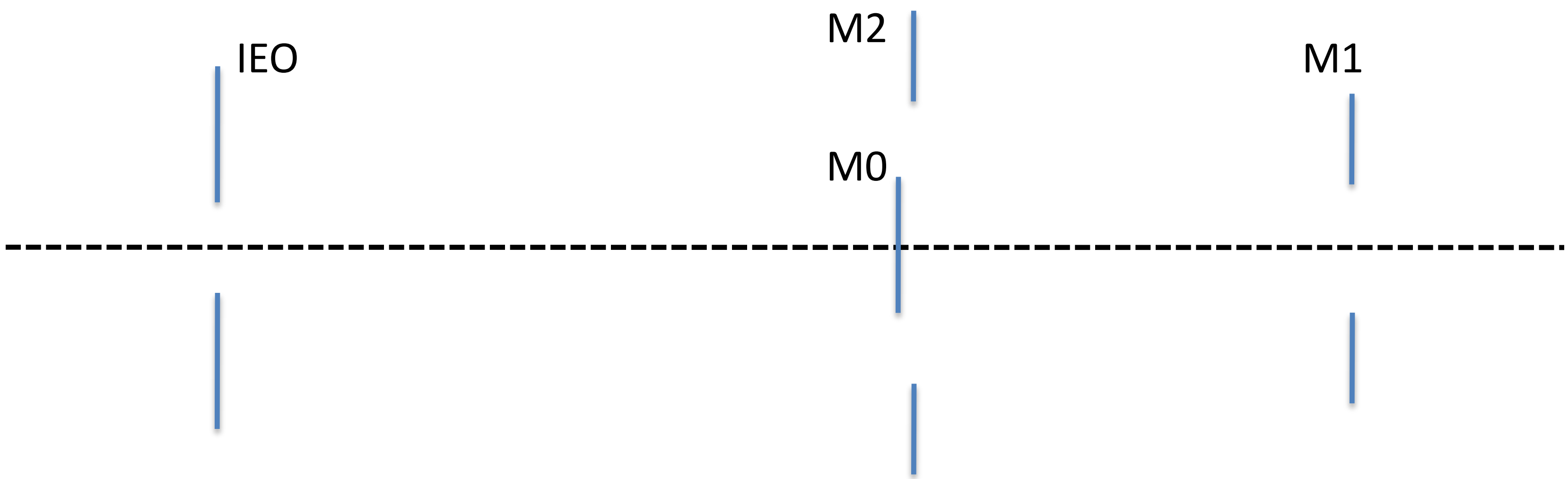
METIS instrument overall description: Antonucci et al., SPIE 8443, 2012

METIS electronics: Focardi et al., SPIE 8442, 2012

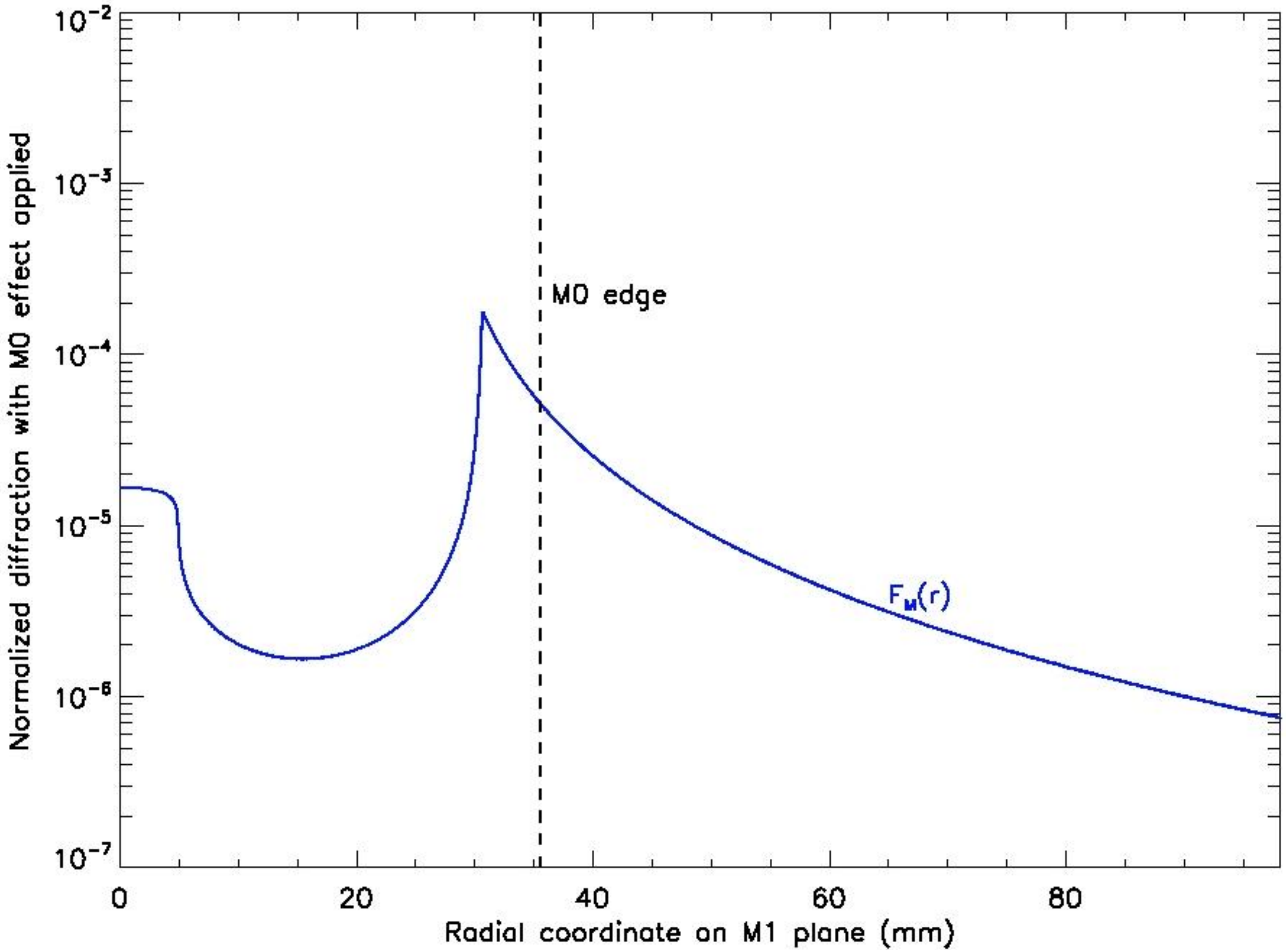


# Inverted External Occulter

- smaller external occulter diameter
- thermal load on M0 greatly reduced
- on-axis telescope configuration
- more compact, cylindrical structure

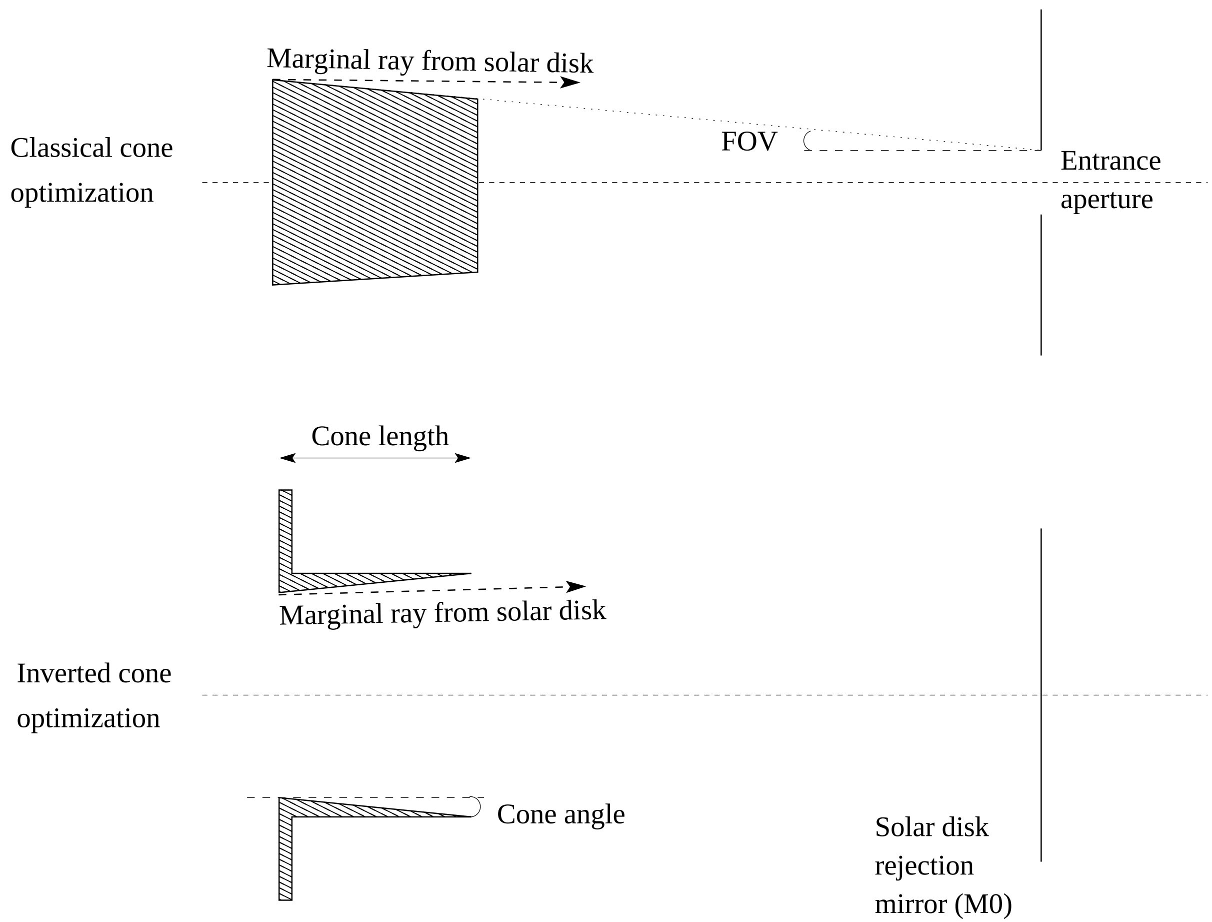


# Theoretical diffraction estimate



# IEO optimization concept

The experience of past space-borne solar coronagraphs teaches that an optimization of the geometry of the occulter is needed in order to lower the stray light level behind the occulter itself.




METIS innovative occultation system requires a dedicated study to determine the most suitable occulter optimization technique.

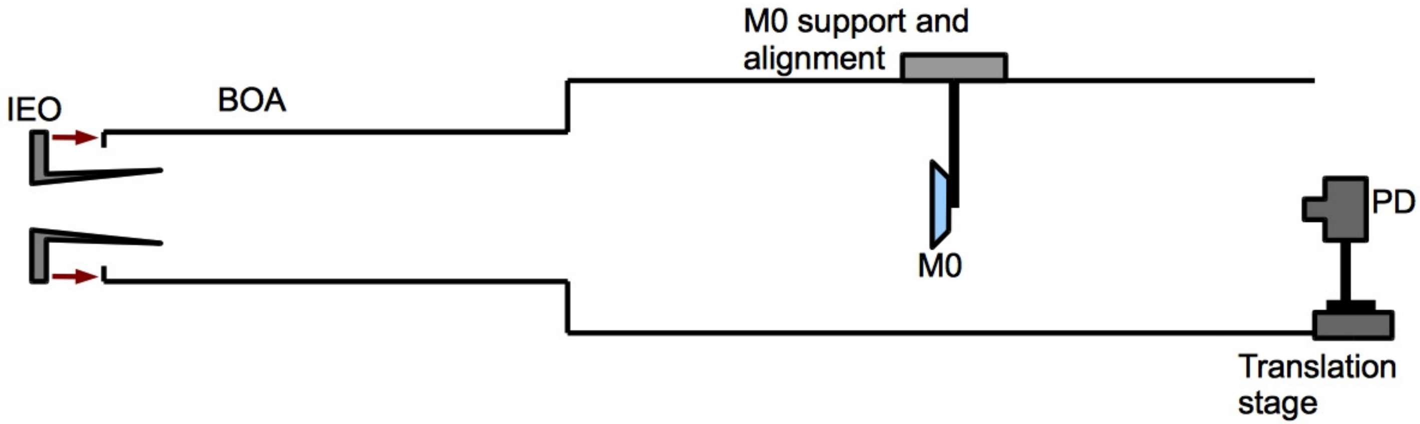
# Two prototypes

The boom is the most critical interface, subject to likely structural modifications throughout the mission's phases

Two prototypes in order to span the widest possible range of geometries:

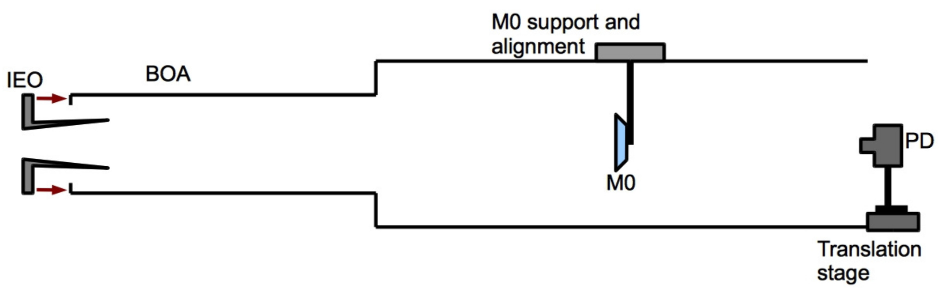
- BOA (Breadboard of the Occulting Assembly)
- ANACONDA (AN Alternative COnfiguration for the Occulting Native Design Assembly)

# BOA vs ANACONDA

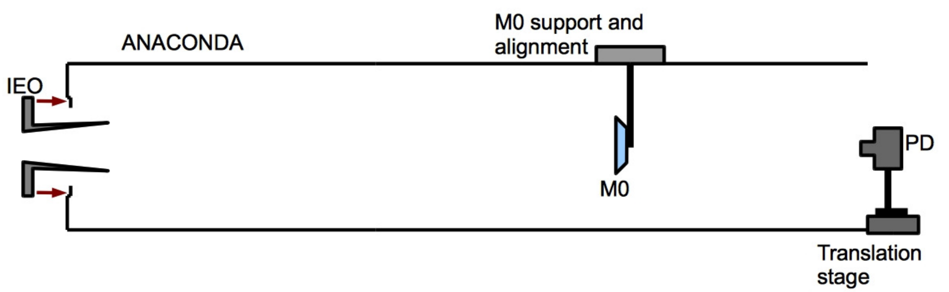



# Common characteristics

- Vanes can be easily implemented and removed
- The front part includes a sliding adjusted hole H7/g6 to host several types of cone different angles and lengths) without affecting the alignment

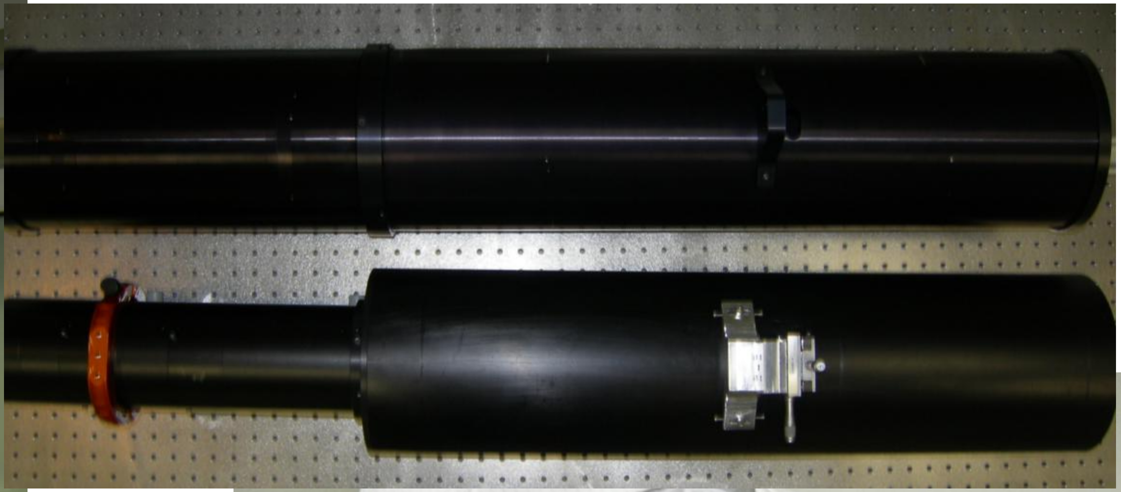


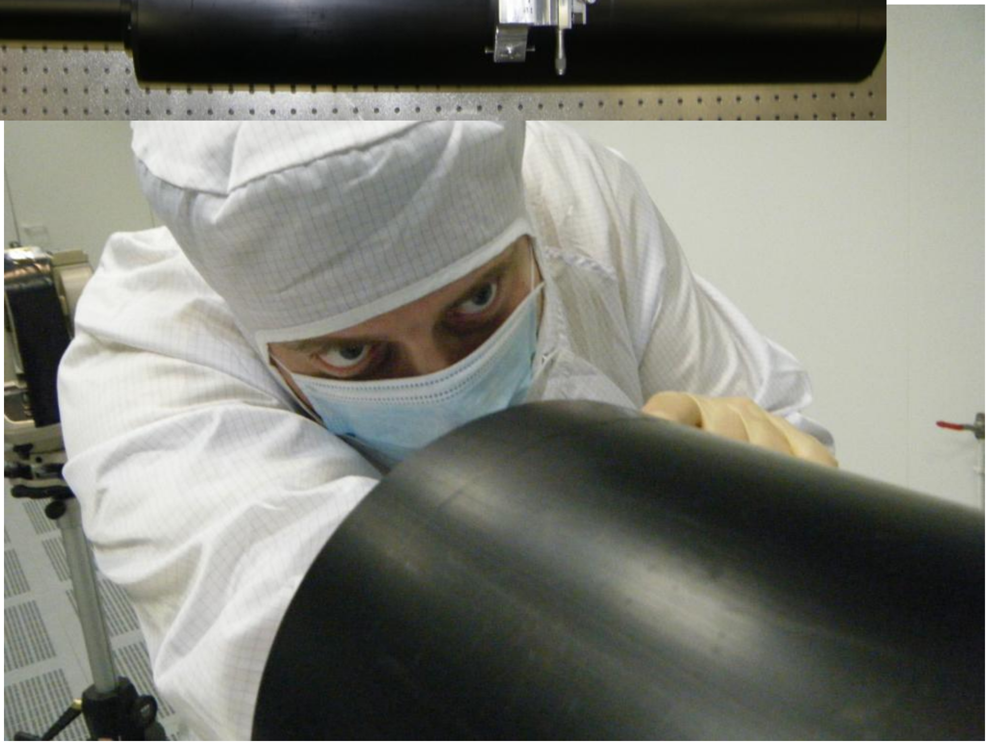

- The back part is equipped with a motorized translation stage carrying a calibrated photodiode (CPD) that scans one diameter of M1




- The mechanics that is used to hold and align M0 is the same

# Some pictures

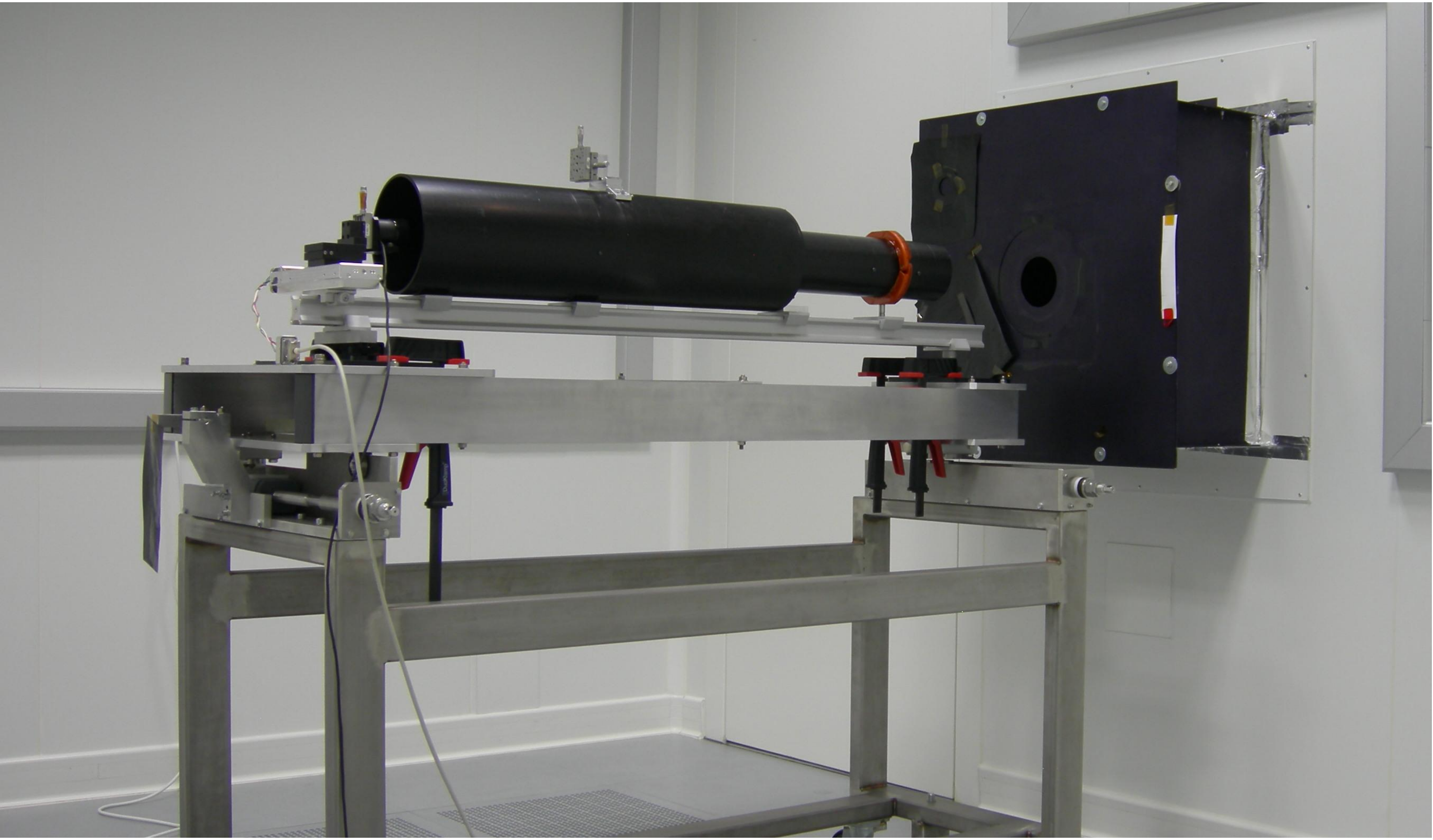




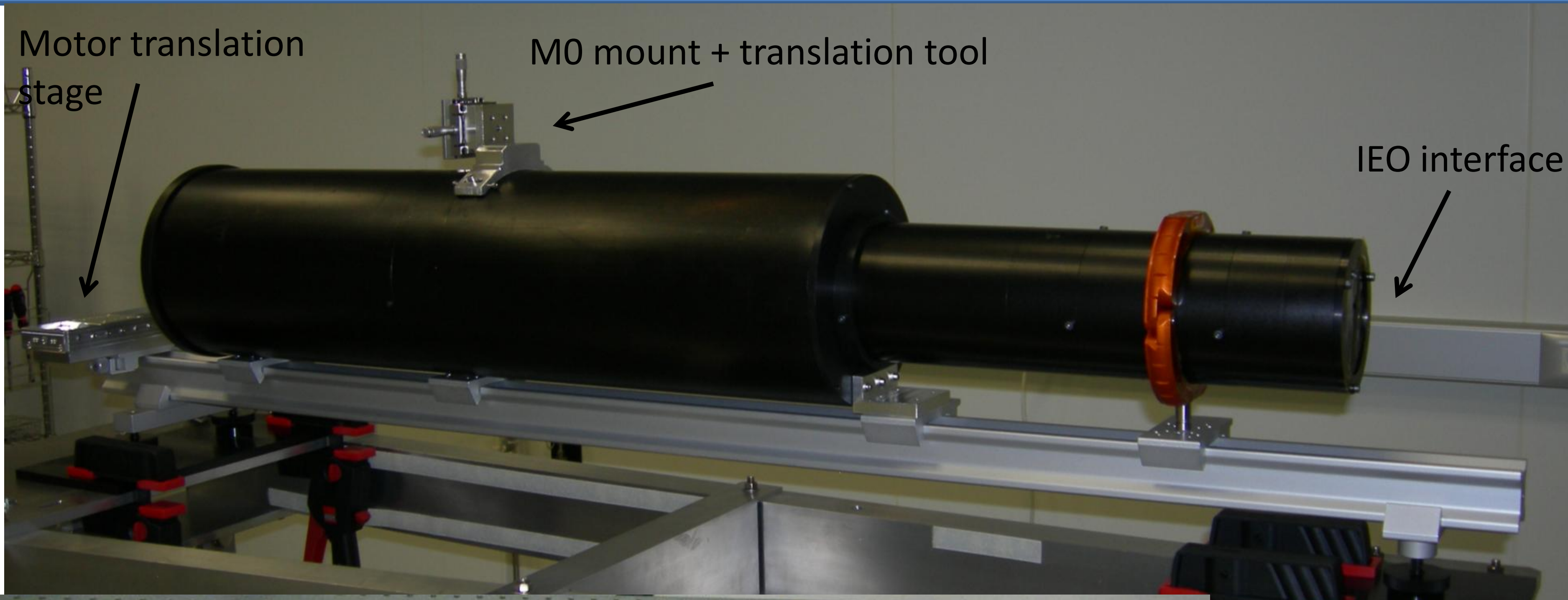
# Preliminary tests

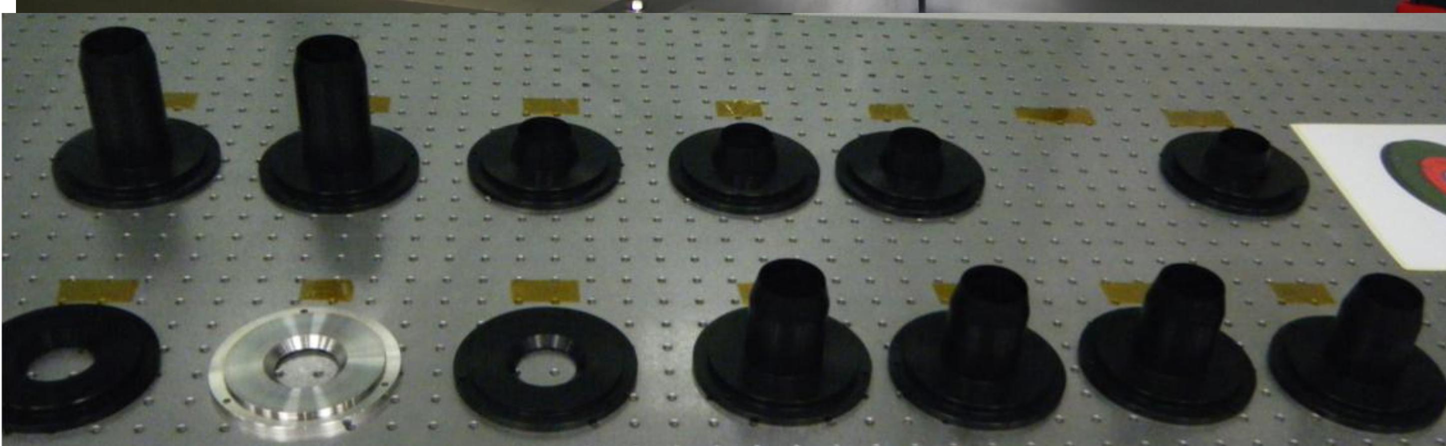
- A first measurements campaign has been run at the Laboratoire d'Astrophysique de Marseille (LAM), France, in front of a solar disk simulator (~32 arcmin→ ~1 AU) and in a class 100 clean room.
- The simple knife edge aperture was taken as a reference.
- All the measurements have been normalized to the unobstructed solar disk light from the solar simulator.

# The whole view



# The whole view

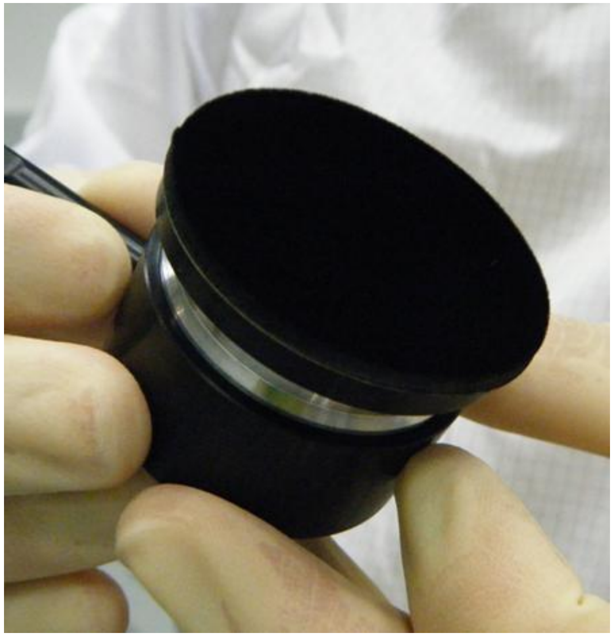


The manufactured IEOs

# LAM tests peculiarities

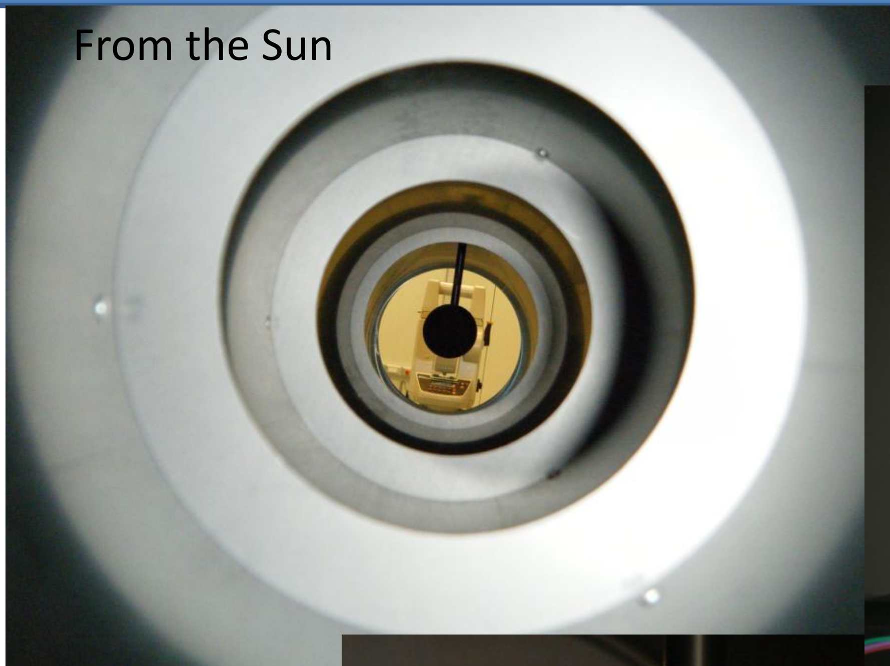
- Only knife edge apertures and inverted cone solutions have been compared.
- In place of M0 a Vel Black® (Esli) coating has been applied.



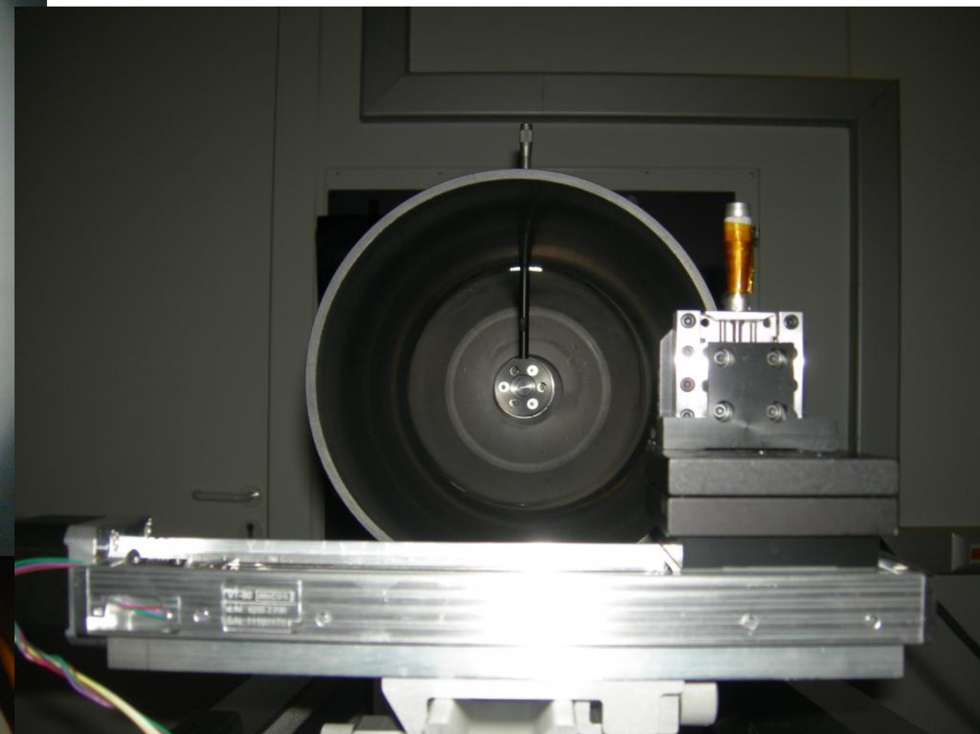
- All the measurements were performed with a fixed Sun dimension.
- M0 has been resized to reproduce with the LAM Sun the same over-occultation of METIS at perihelion.

# LAM tests peculiarities

From the Sun

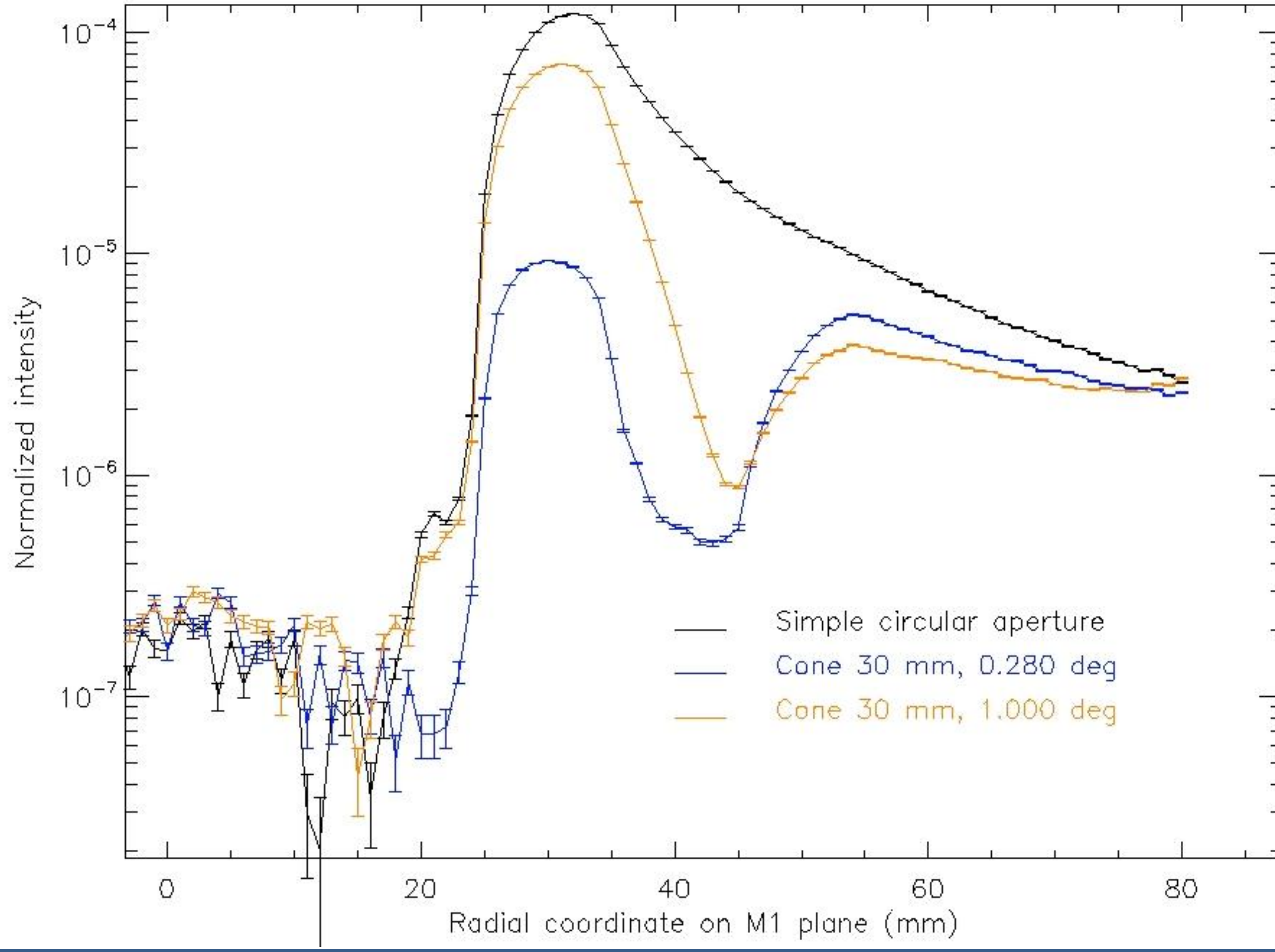


From the PD

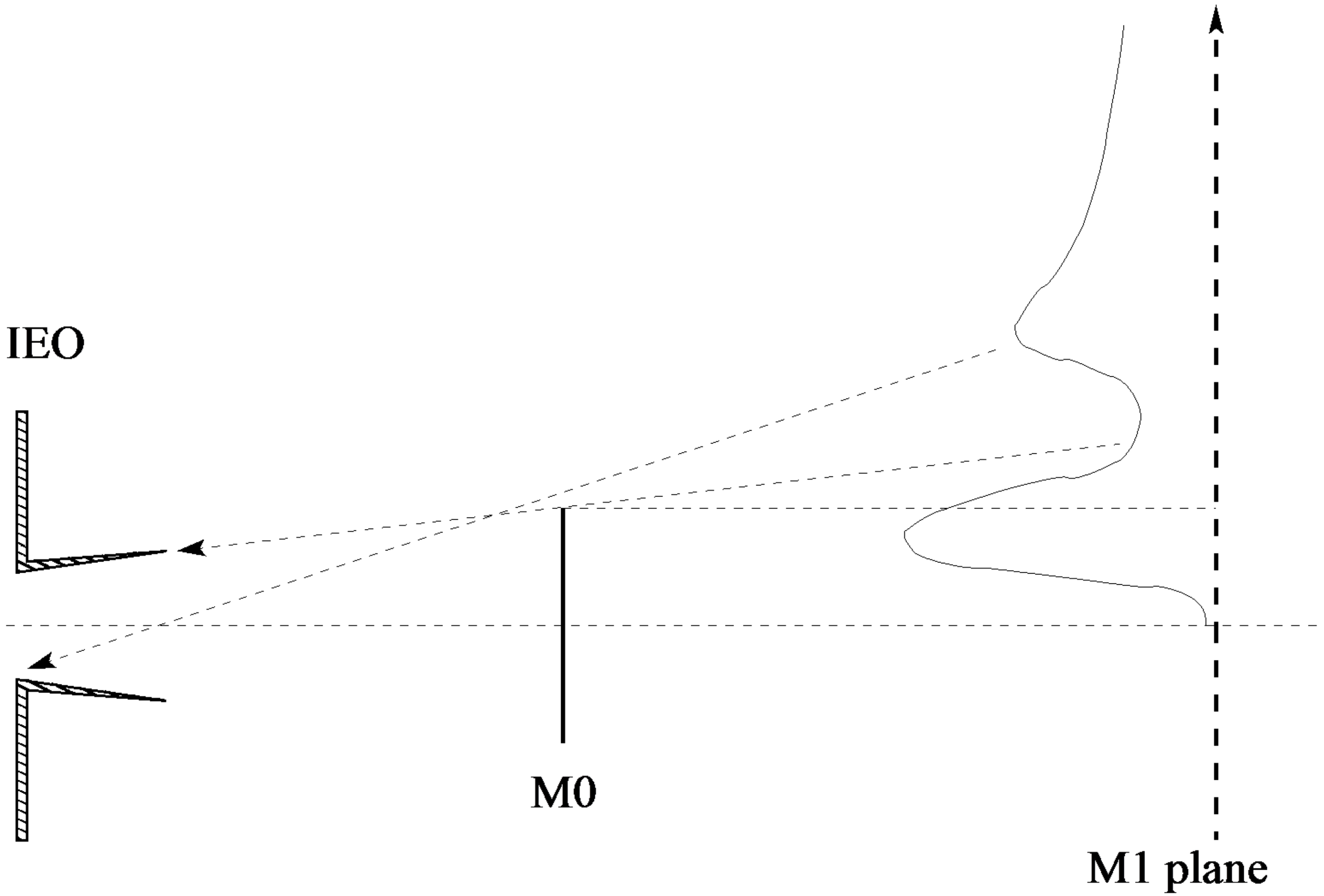


M0 custom kinematic mount

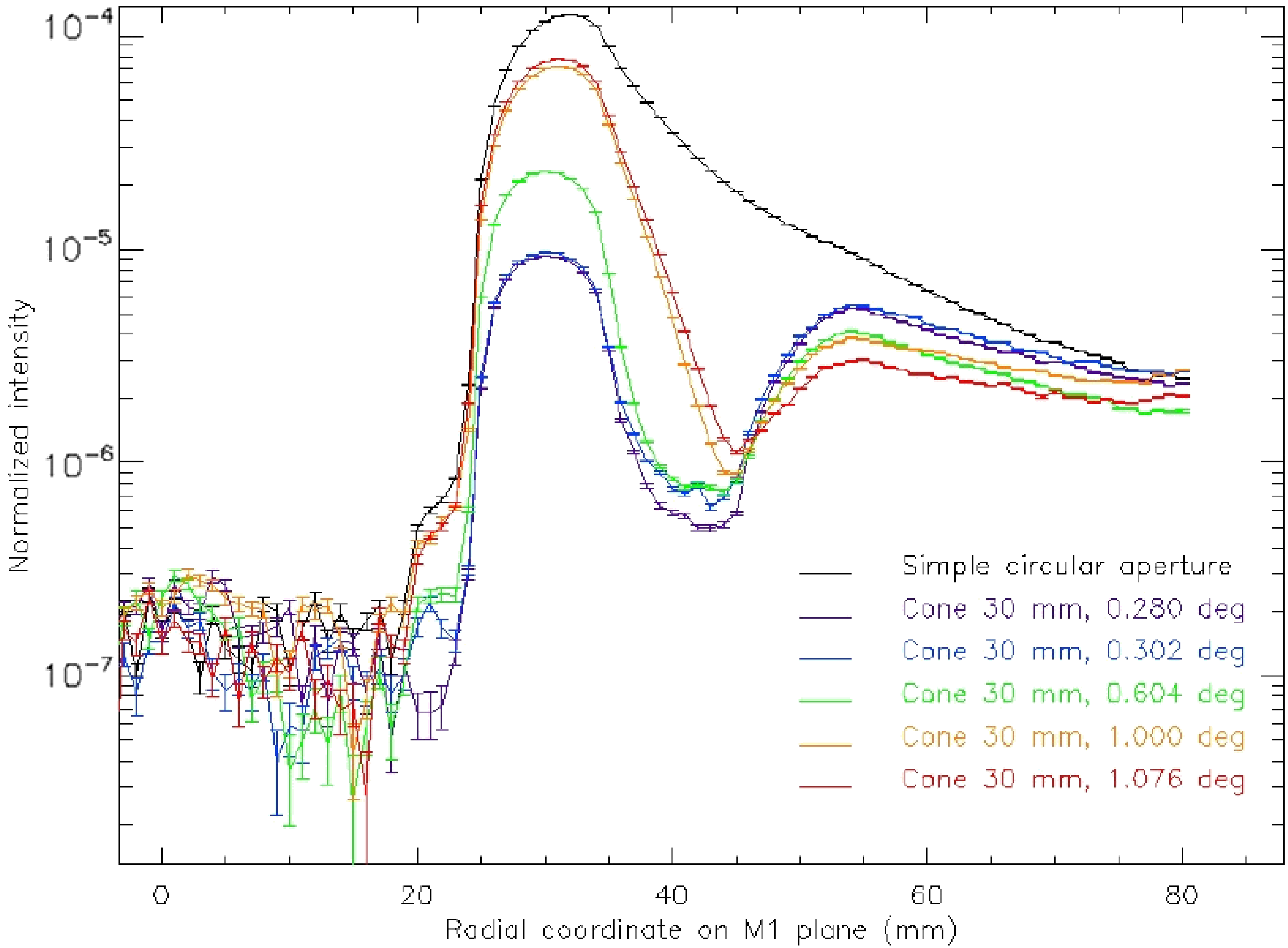
# Fixed length



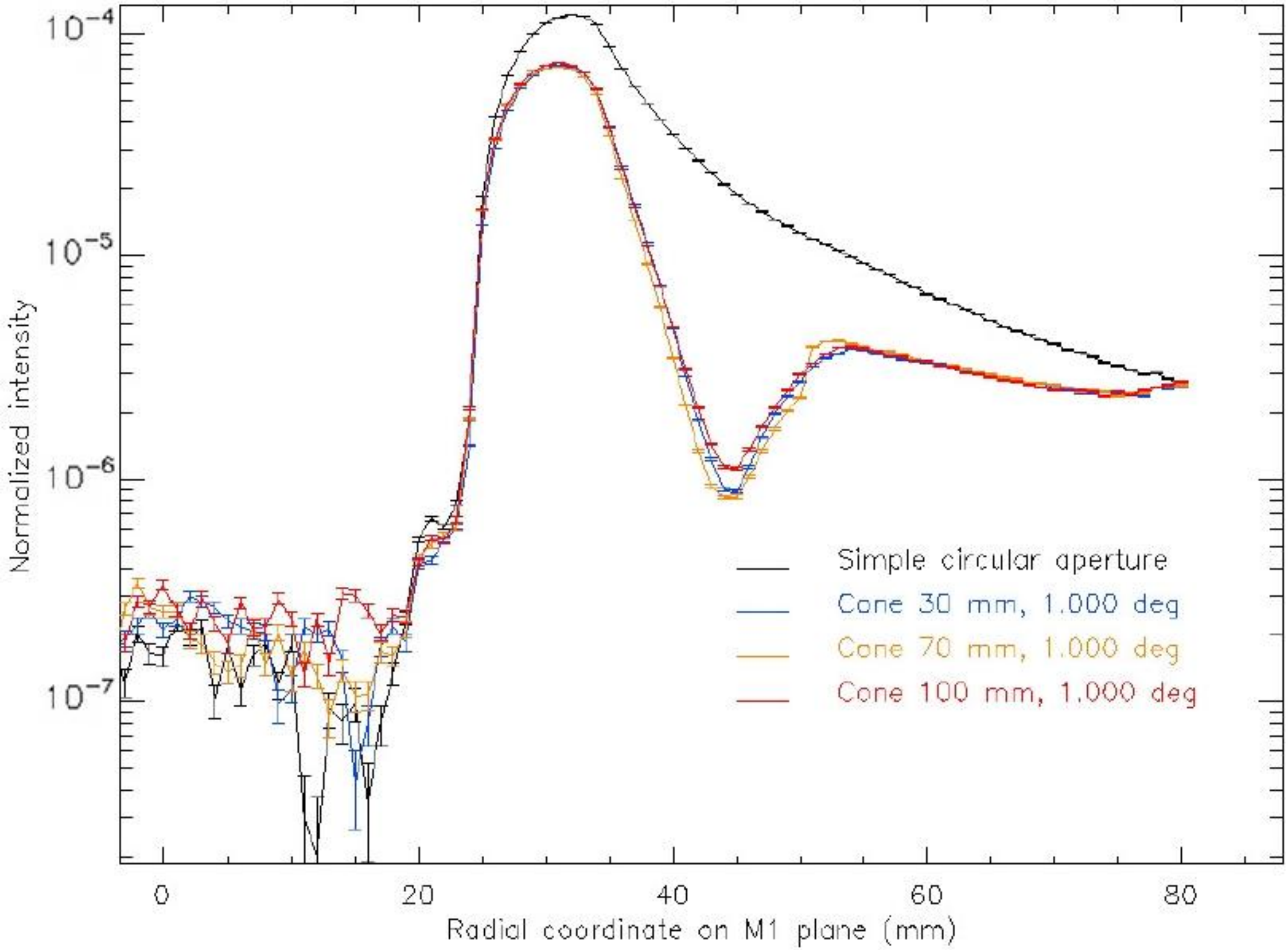
# Double peak behaviour



# Fixed length – all angles

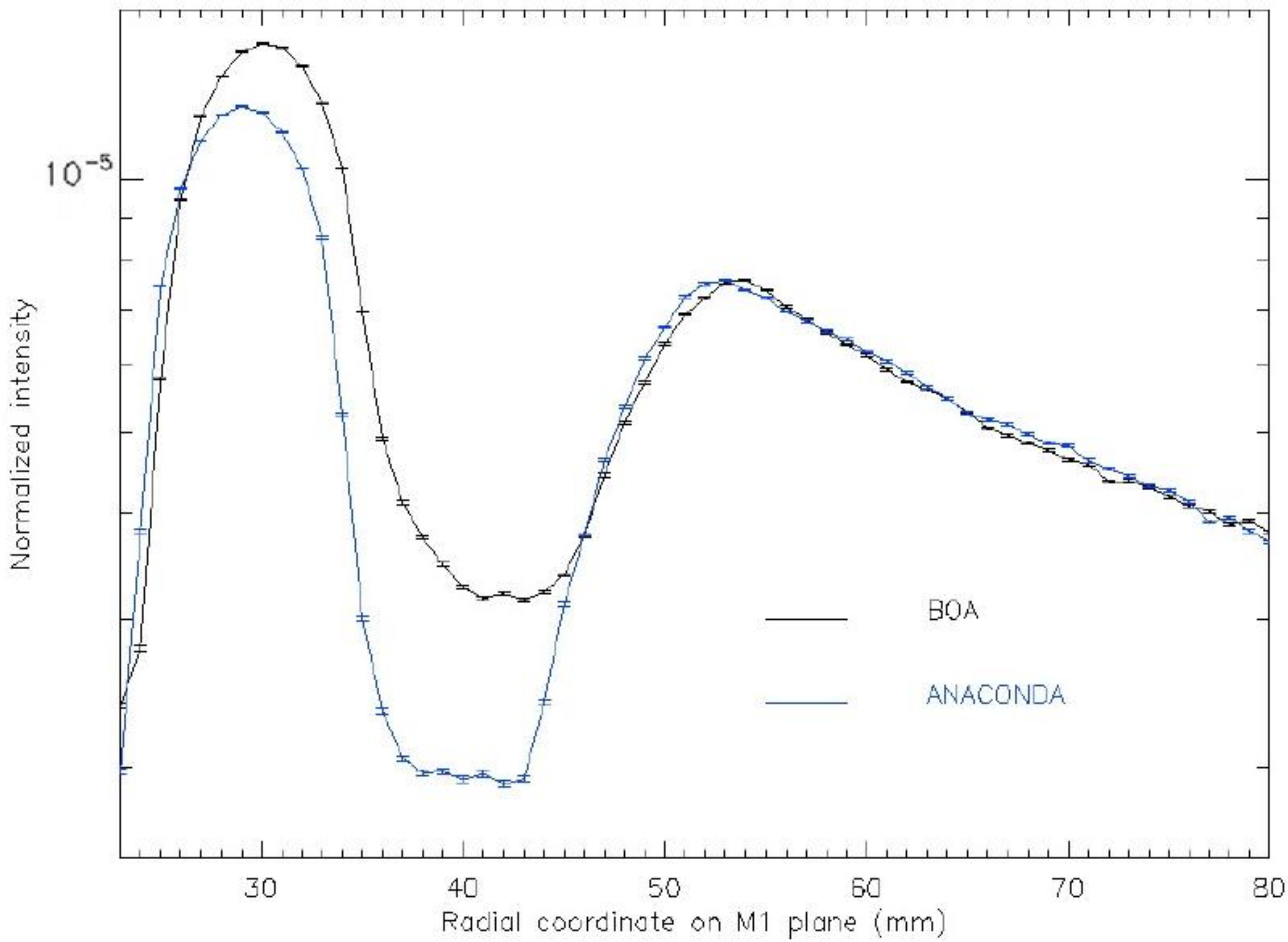


# Fixed Angle

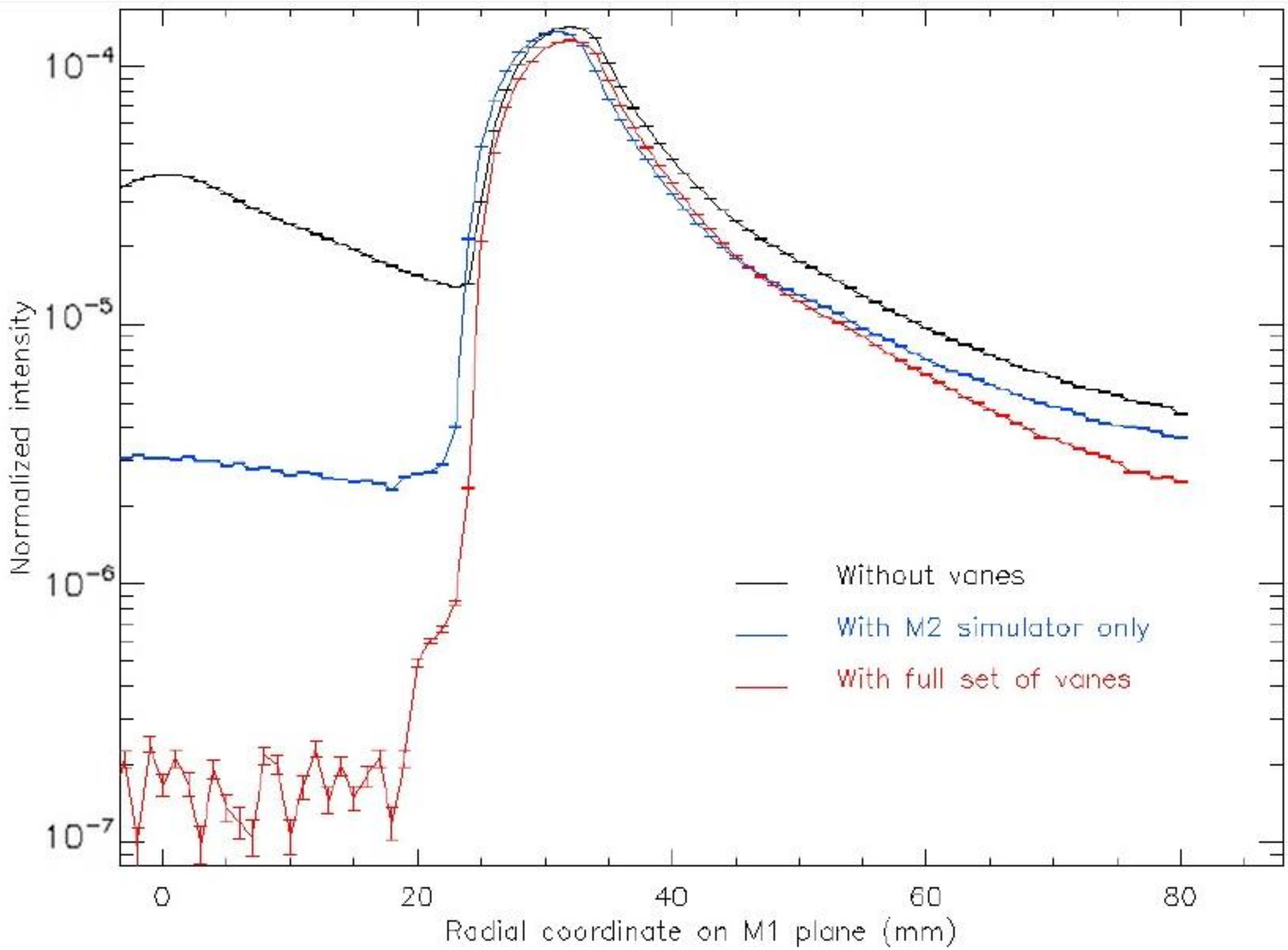


Normalized intensity
10^-4
10^-5
10^-6
10^-7
0
20
40
60
80
Radial coordinate on M1 plane (mm)
Simple circular aperture
Cone 30 mm, 1.000 deg
Cone 70 mm, 1.000 deg
Cone 100 mm, 1.000 deg

# BOA vs ANACONDA

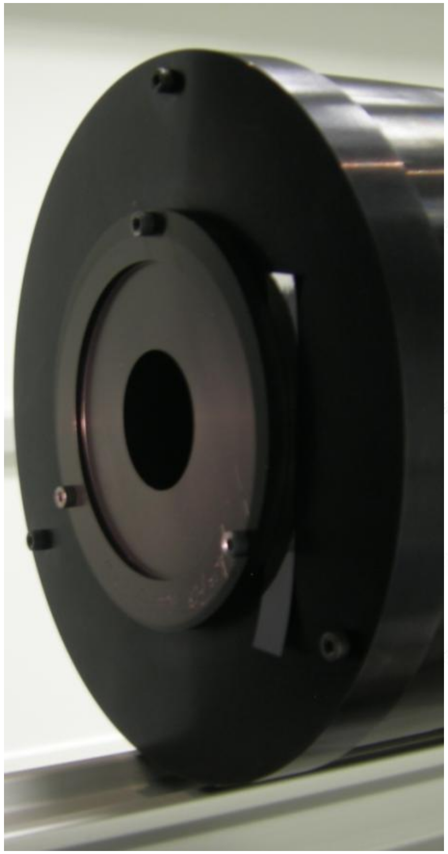


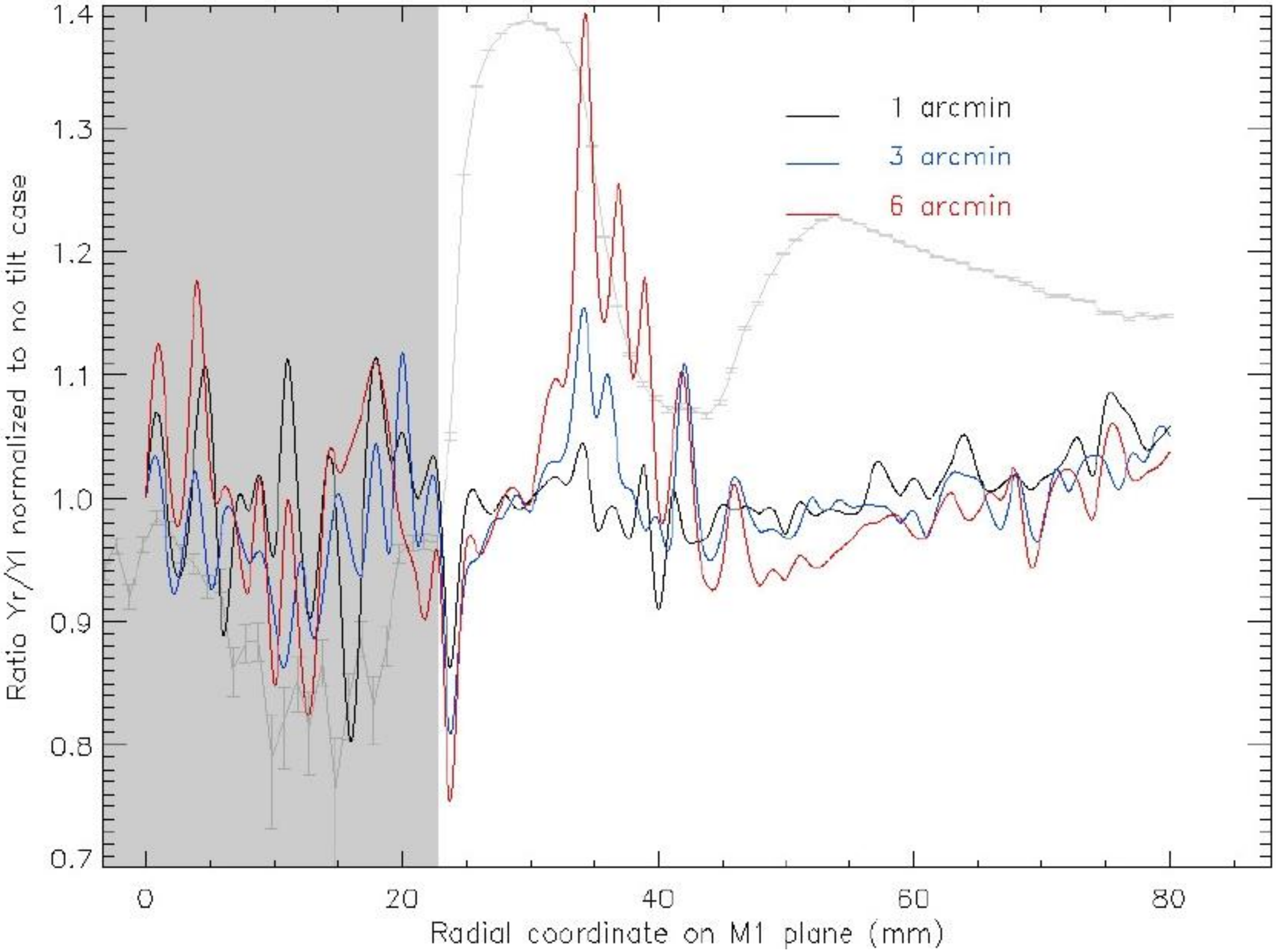
# Vanes



Normalized intensity
$10^{-4}$
$10^{-5}$
$10^{-6}$
$10^{-7}$
0
20
40
60
80
Radial coordinate on M1 plane (mm)
Without vanes
With M2 simulator only
With full set of vanes

# Tilts





1 arcmin
3 arcmin
6 arcmin
Ratio Yr/Yl normalized to no tilt case
Radial coordinate on M1 plane (mm)
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0
20
40
60
80

# Preliminary conclusions

- As expected, the optimization of the occulter reduces the stray light level on the primary mirror plane.
- The cone angle has a great impact on the performance.
- The cone length has not such a big impact.
- With the cone, no special requirements are needed for the outer edge (Landini et al., Ap Opt. 50, 2011).
- The boom diameter must be designed as large as the S/C thermal shield constraints may allow
- An optimized set of vanes is absolutely necessary.

# OPSys activity

- The OPSys (Optical Payload Systems) facility in Torino (Italy) can dynamically simulate a solar disk of bigger dimensions than the LAM one.
- Experiments can be carried on also in vacuum (to investigate the UV part of the spectrum).



# Scheduled activities

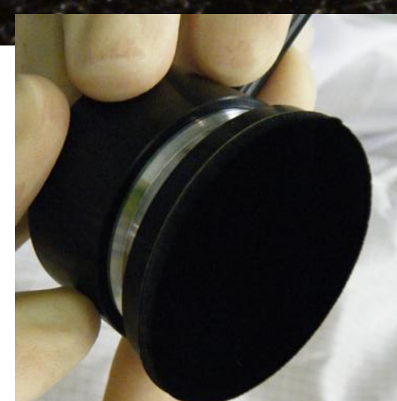
- Different roughnesses and coatings will be applied to the cone surface.

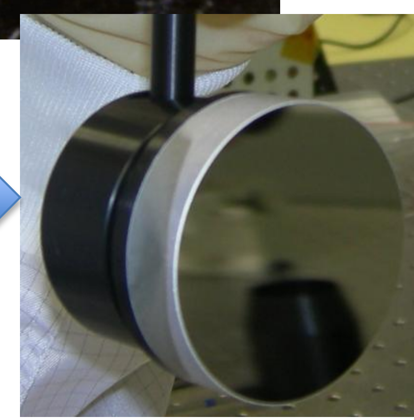
- A different (though in principle less effective) optimization concept will be tested as well: the serrated edge aperture.

Diaphragms are being manufactured from a 0.12 thick mm steel plate

- A real mirror will be installed

in place of Vel Black®.





# Scheduled activities

- Alignment procedure definition (1.5 weeks)
- LAM tests repetition and results comparison: Sun at 1 AU, VB on M0 (1.5 weeks) + data analysis (0.5 weeks)
- Same set-up, with mirror instead of VB (1 week)
- Same set-up, with Sun at 0.8 AU (0.5 week)
- Solar disk dimension change (1 week)
- Tests repetition: Sun at 0.58 AU, mirror on M0 (1.5 weeks)
- Tests by off-pointing the BOA (0.5 week)