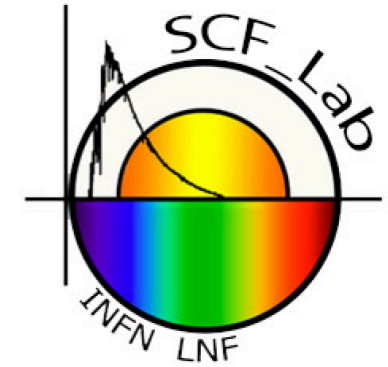


# SCF\_Lab

Satellite/Lunar/GNSS

laser ranging and altimetry

Characterization Facilities Laboratory



# SCF\_Lab, 1st part: Introduction, solar simulator and space optics technological services

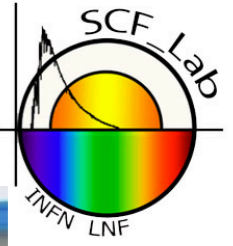
Luca Porcelli

on behalf of SCF\_Lab Group @ INFN-LNF

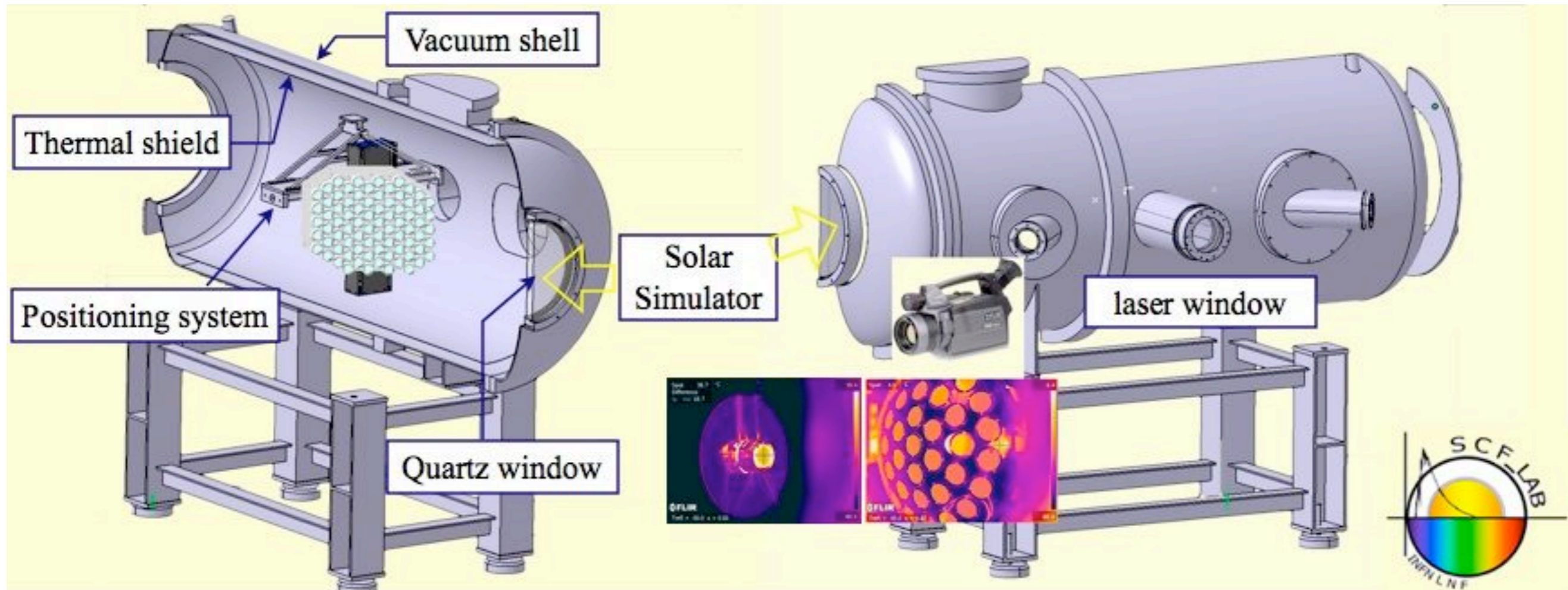
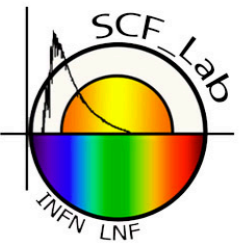
[www.inf.infn.it/esperimenti/etrusco](http://www.inf.infn.it/esperimenti/etrusco)

1st Synergy LNF-OAR Workshop - 16-17/04/2014

# The SCF\_Lab and its innovative activity



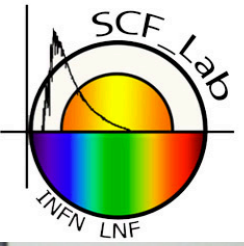
# SCF and SCF-G



## Vacuum + Cold + Sun = Space (at 1 AU from the Sun)

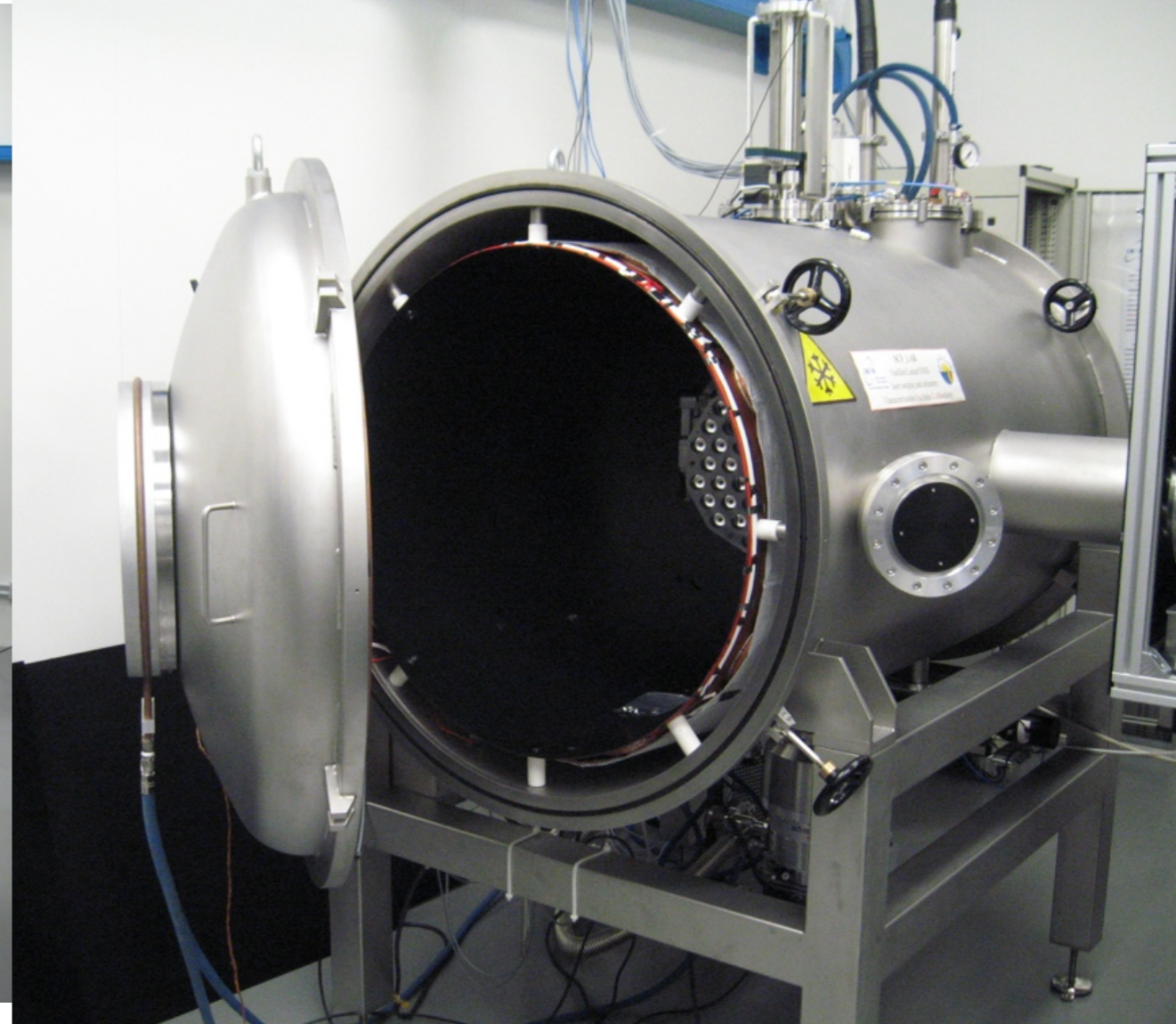
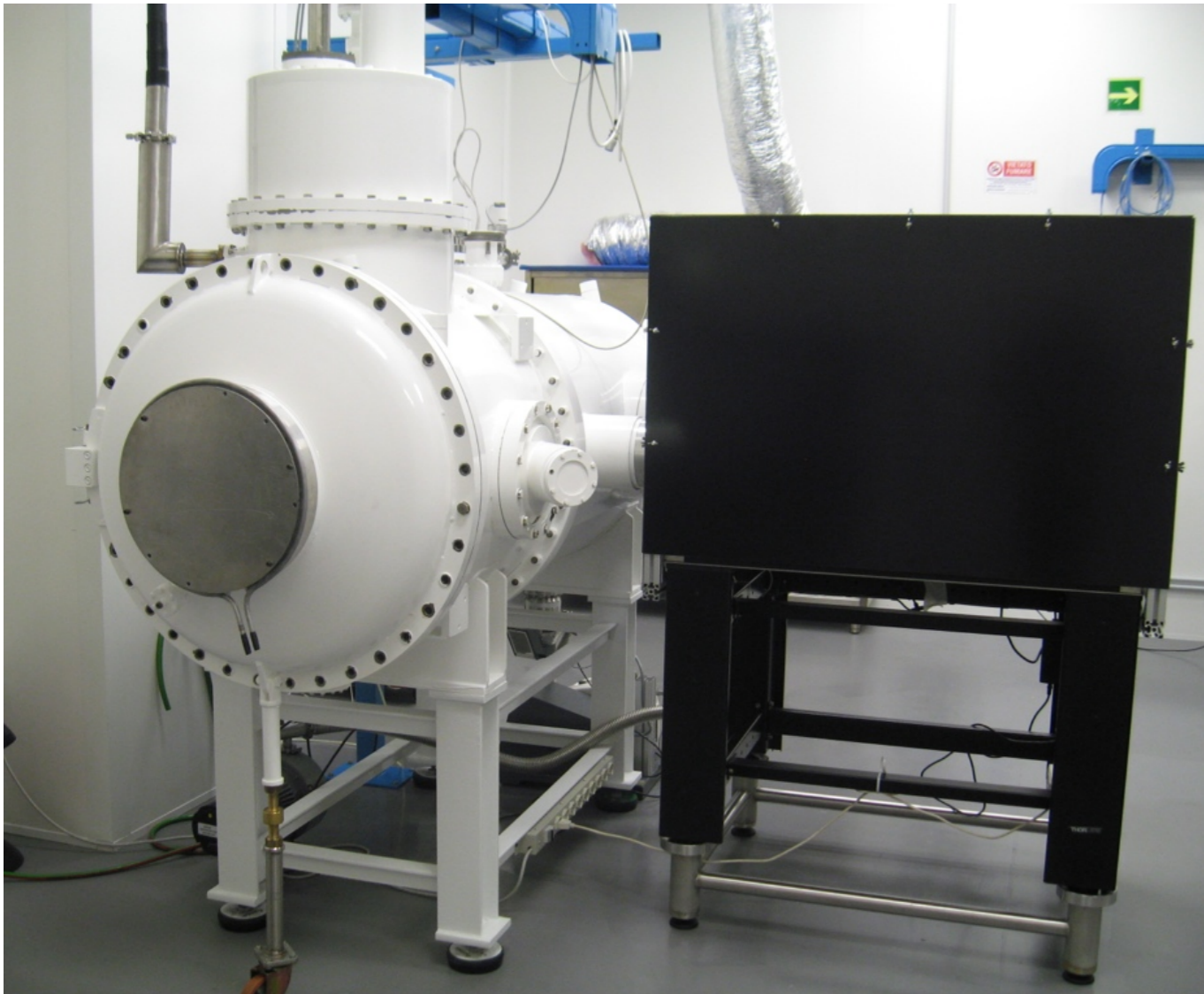
- Cryostat (environment pressure down to  $\sim 10^{-7}$  mbar, temperature of the chamber at  $\sim 80$  K, high emissivity cold shield)
- AM0 Solar Simulator
- FFDP Optical table
- Vacuum pump system, control electronics and computers

# SCF and SCF-G



## SCF

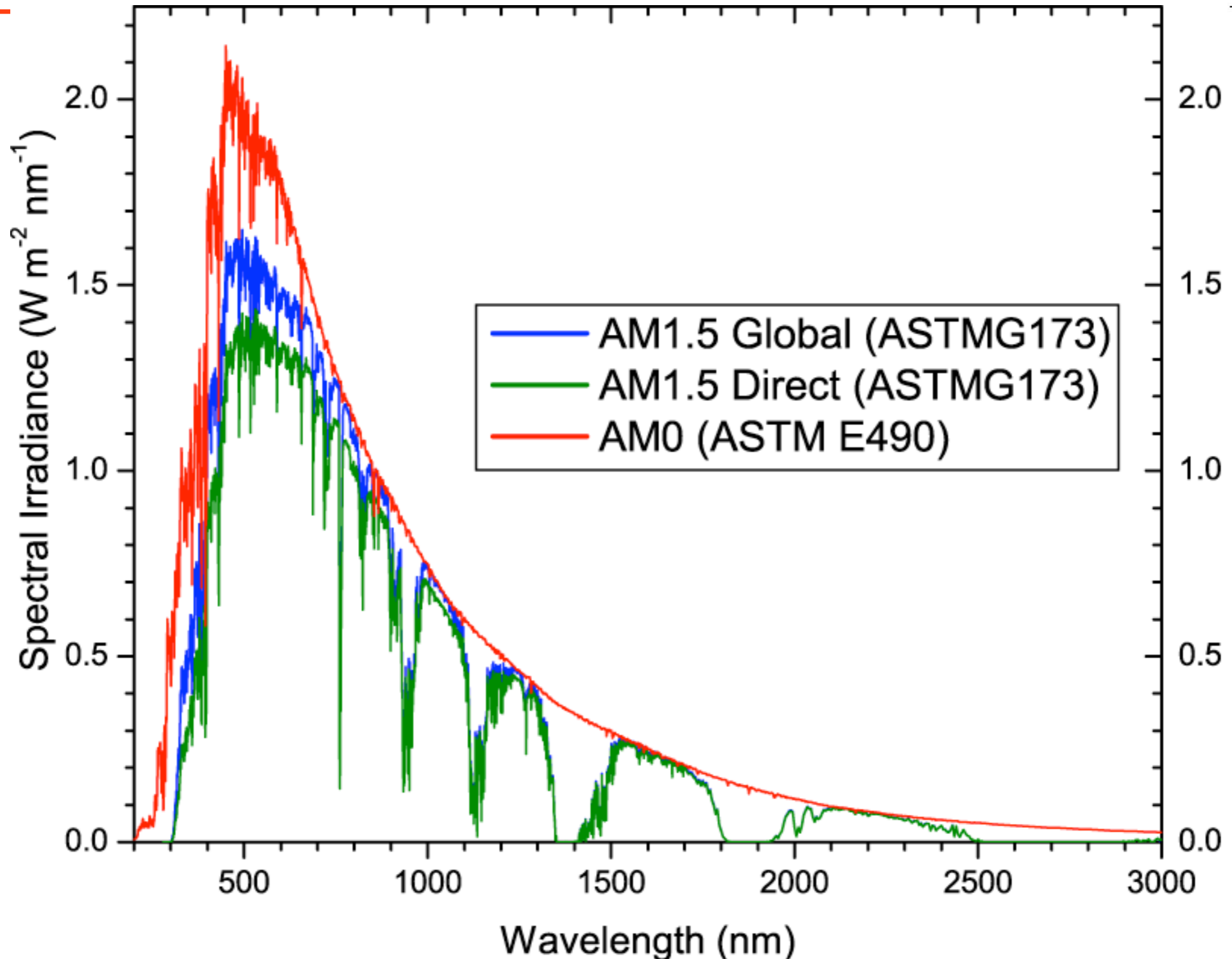
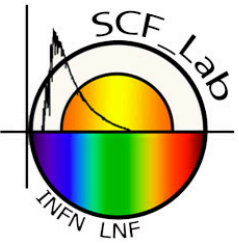
## SCF-G



### Vacuum + Cold + Sun = Space (at 1 AU from the Sun)

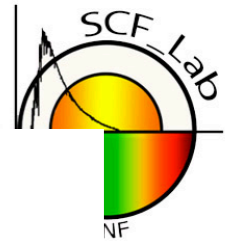
- Cryostat (environment pressure down to  $\sim 10^{-7}$  mbar, temperature of the chamber at  $\sim 80$  K, high emissivity cold shield)
- AM0 Solar Simulator
- FFDP Optical table
- Vacuum pump system, control electronics and computers

# Solar Simulators @ SCF\_Lab

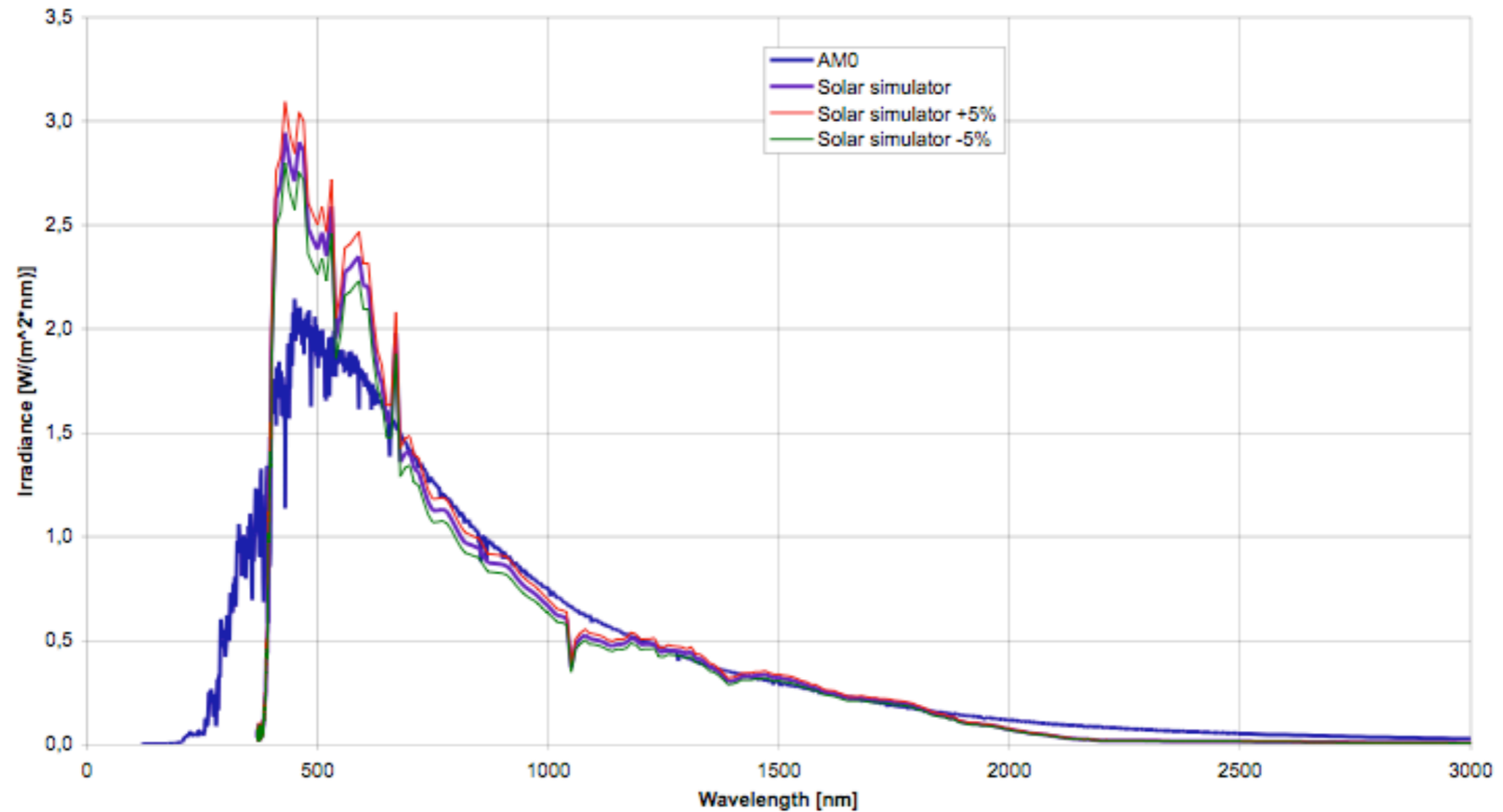


[www.astm.org/Standards/E490.htm](http://www.astm.org/Standards/E490.htm) (for AM0) and [www.astm.org/Standards/G173.htm](http://www.astm.org/Standards/G173.htm) (for AM1.5)

# Solar Simulators @ SCF\_Lab

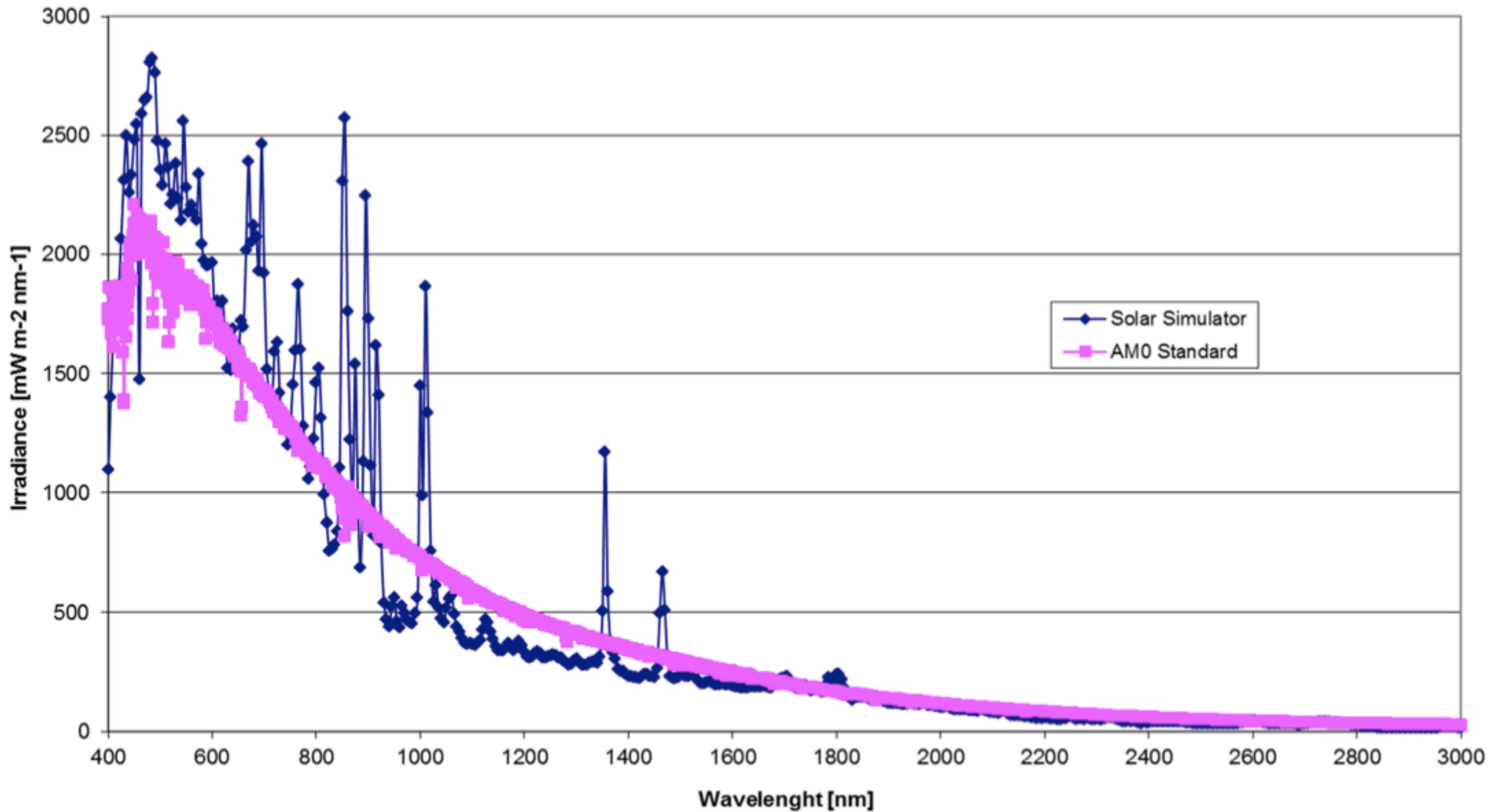
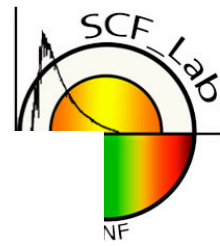


Case: no window - no mask. Comparison between solar simulator and AM0 standard.



[www.astm.org/Standards/E490.htm](http://www.astm.org/Standards/E490.htm) (for AM0) and [www.astm.org/Standards/G173.htm](http://www.astm.org/Standards/G173.htm) (for AM1.5)

# Solar Simulators @ SCF\_Lab

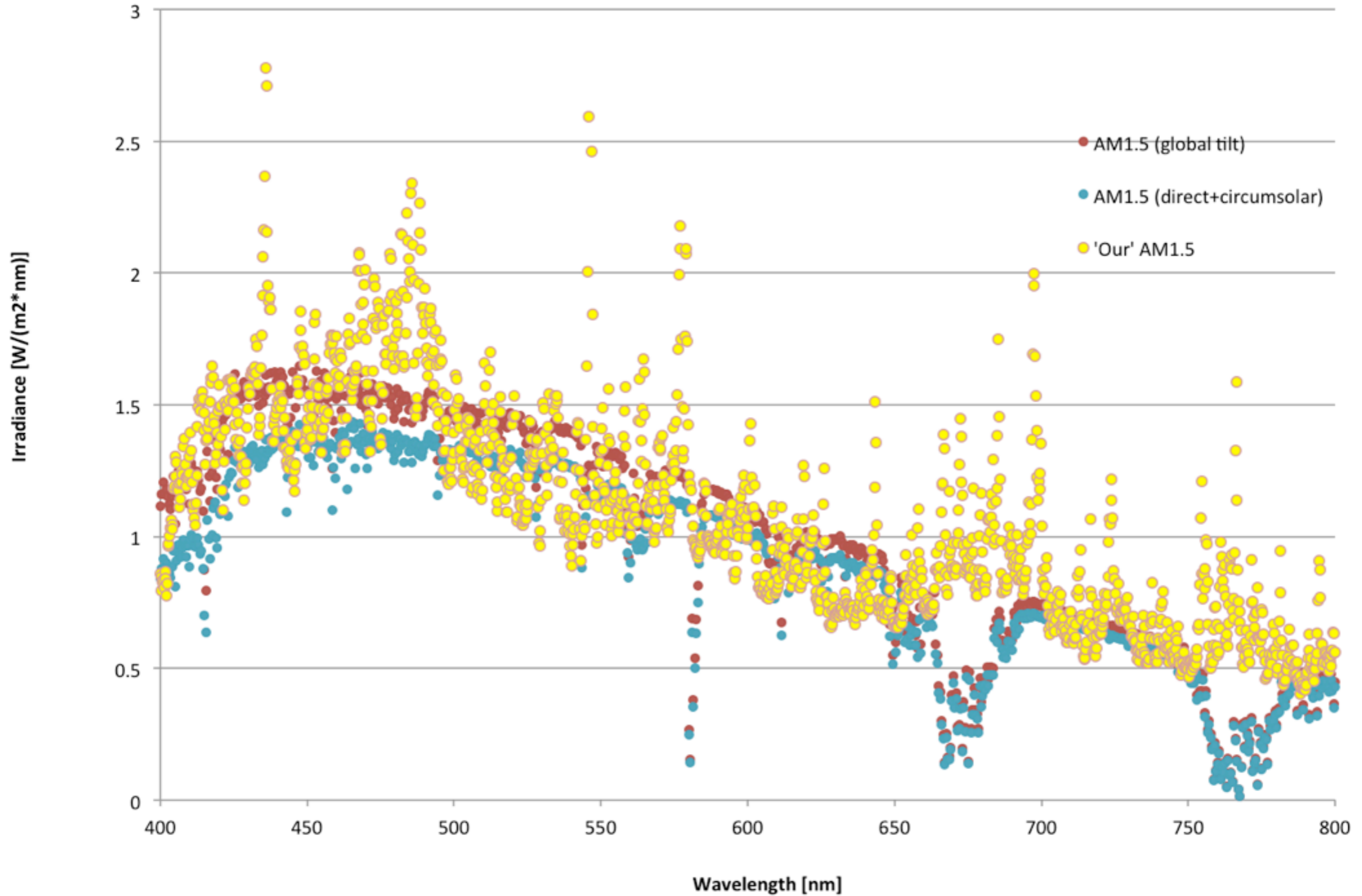


[www.astm.org/Standards/E490.htm](http://www.astm.org/Standards/E490.htm) (for AM0) and [www.astm.org/Standards/G173.htm](http://www.astm.org/Standards/G173.htm) (for AM1.5)

# Solar Simulators @ SCF Lab



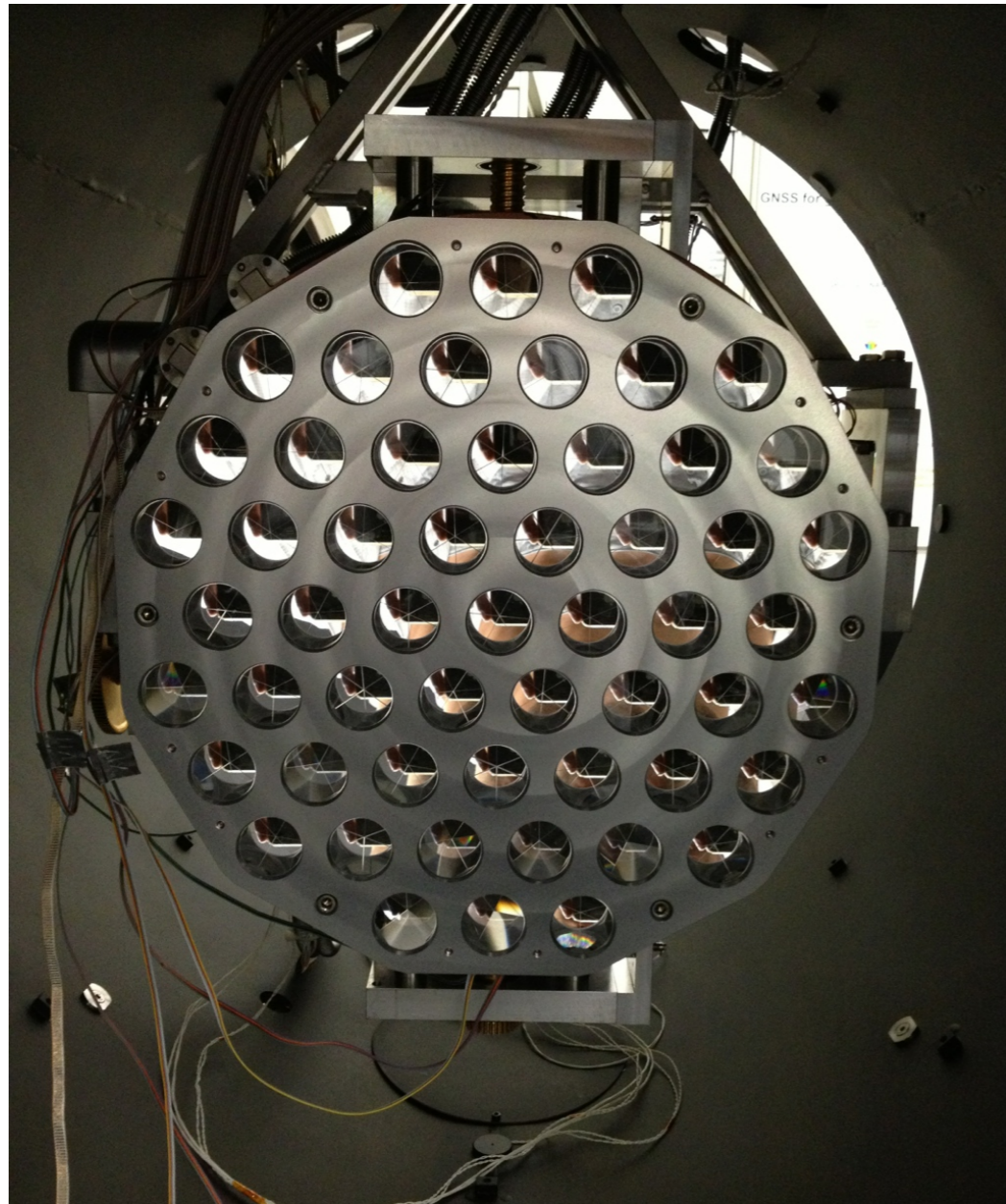
### AM1.5 compared with SCF-G SS



[www.astm.org/standards/E470.html](http://www.astm.org/standards/E470.html) (for AM1.0) and [www.astm.org/standards/G173.html](http://www.astm.org/standards/G173.html) (for AM1.5)



The purpose of the SCF\_Lab measurements is to characterize the whole payload, retroreflectors and their supporting structure under realistic space conditions, in order to determine their compliance to design specification and variation of performance in space.

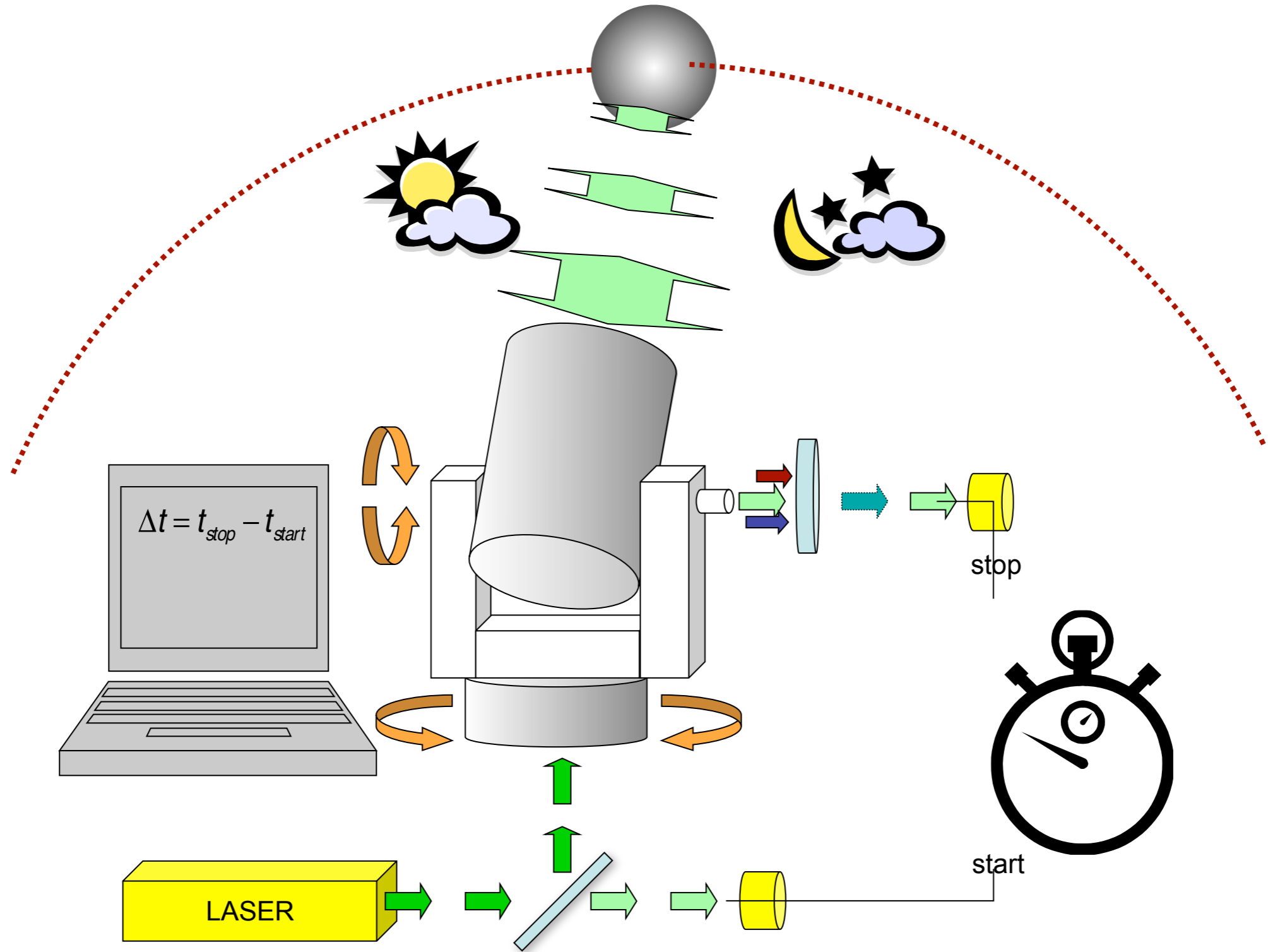
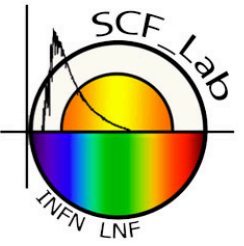


## SCF\_Lab measurements

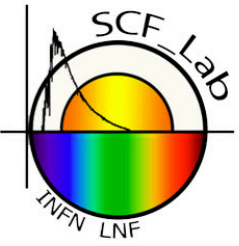
- Far Field Diffraction Pattern (FFDP) measurement of CCRs
- SCF-Test = Integrated thermo-optic characterization of laser retroreflector (arrays) prototypes before eventual space launch
- Orbit Test = Simulated orbital measurement

**Comprehensive literature available  
online at  
[www.lnf.infn.it/esperimenti/etrusco](http://www.lnf.infn.it/esperimenti/etrusco)**

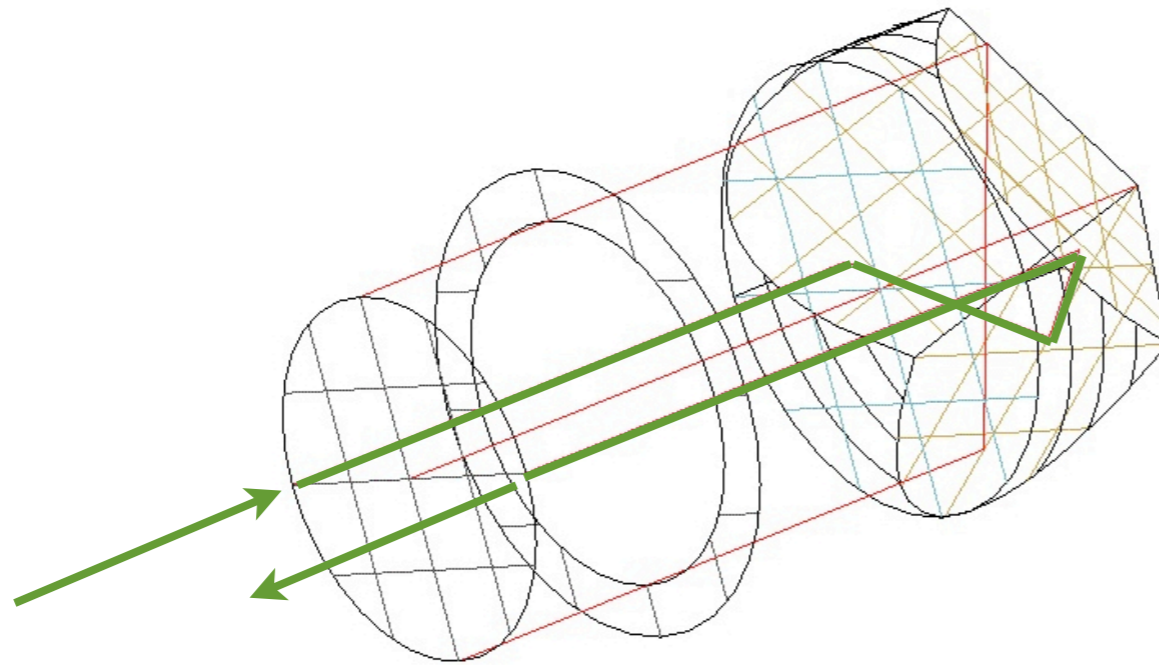
# Ranging technique



# Cube Corner Reflector

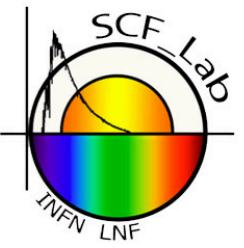


- A CCR is a prism, usually made of Fused Silica, whose vertex is the corner of a cube
- Every CCR back face has an angle of  $90^\circ$  with the two remaining faces
- A ray entering the CCR is retroreflected along the very same incidence path
- A ray entering the CCR comes out in a point opposite to the origin



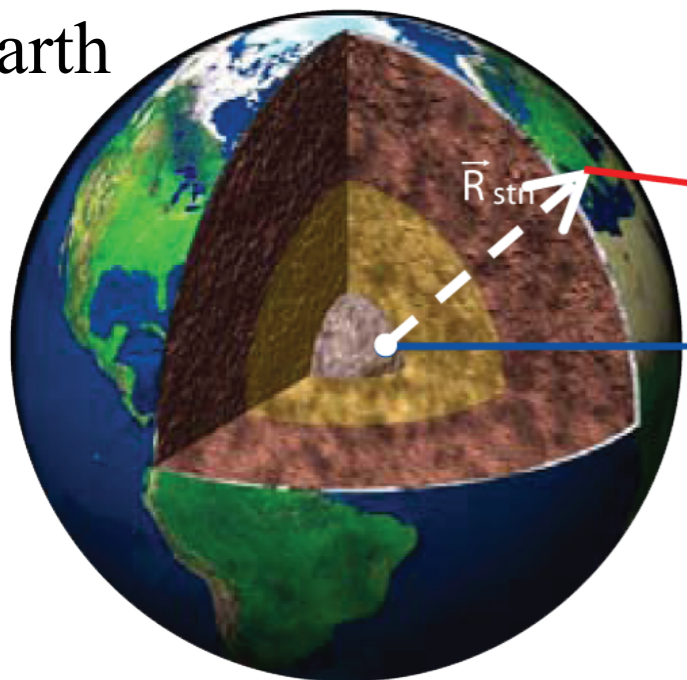
reflection on the three back surfaces through total internal reflection

# Satellite/Lunar Laser Ranging (SLR/LRR)



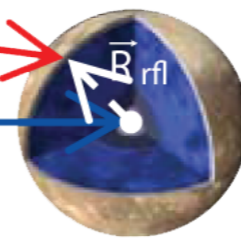
SLR and LLR are precise time-of-flight (ToF) measurements  
short laser pulses fired from ground stations to Cube Corner Retroreflectors  
coordinate by the ILRS = International Laser Ranging Service

Earth

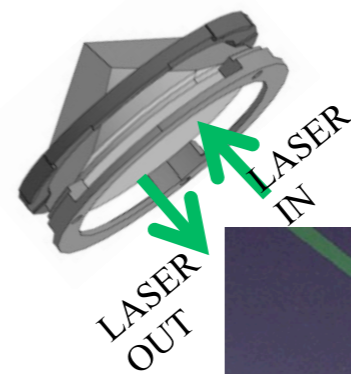


$\bar{\rho}$

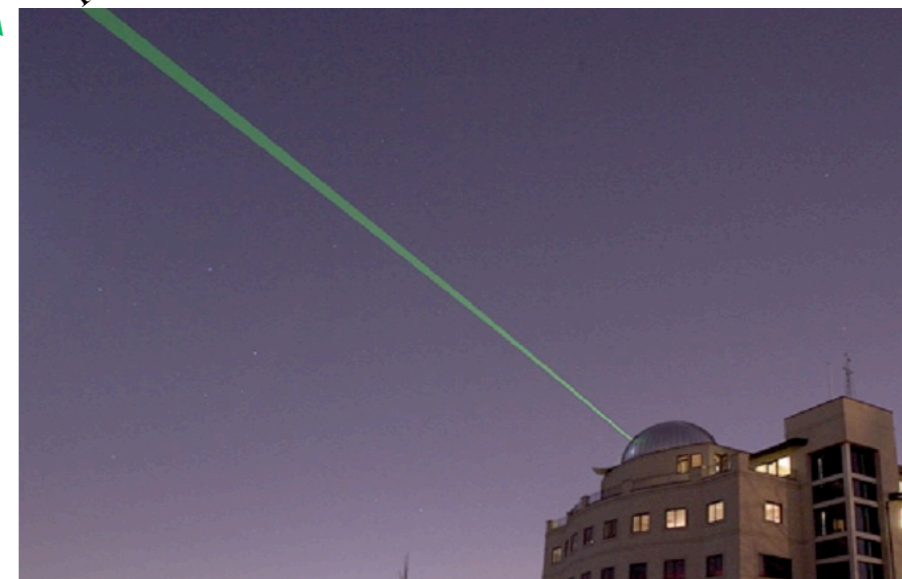
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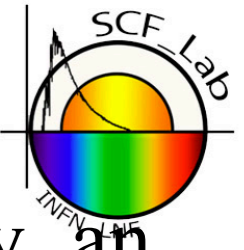
Moon



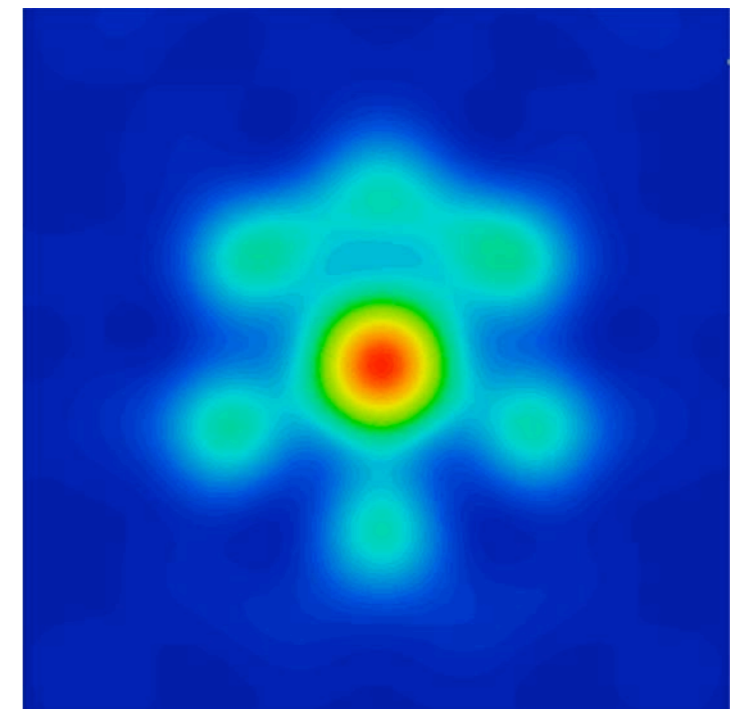
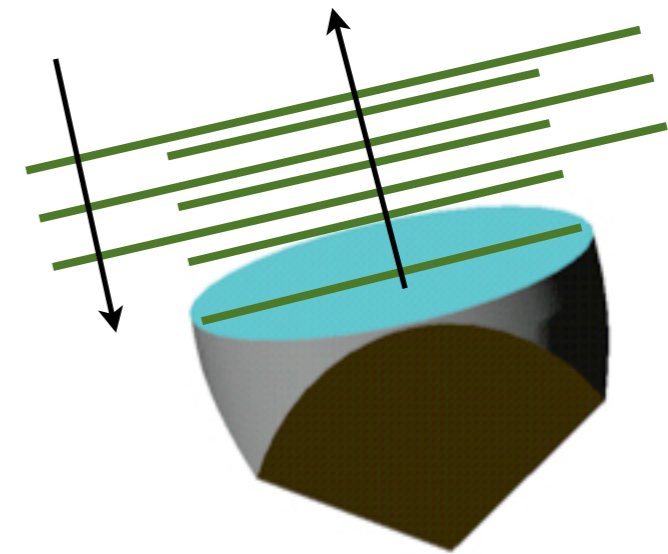
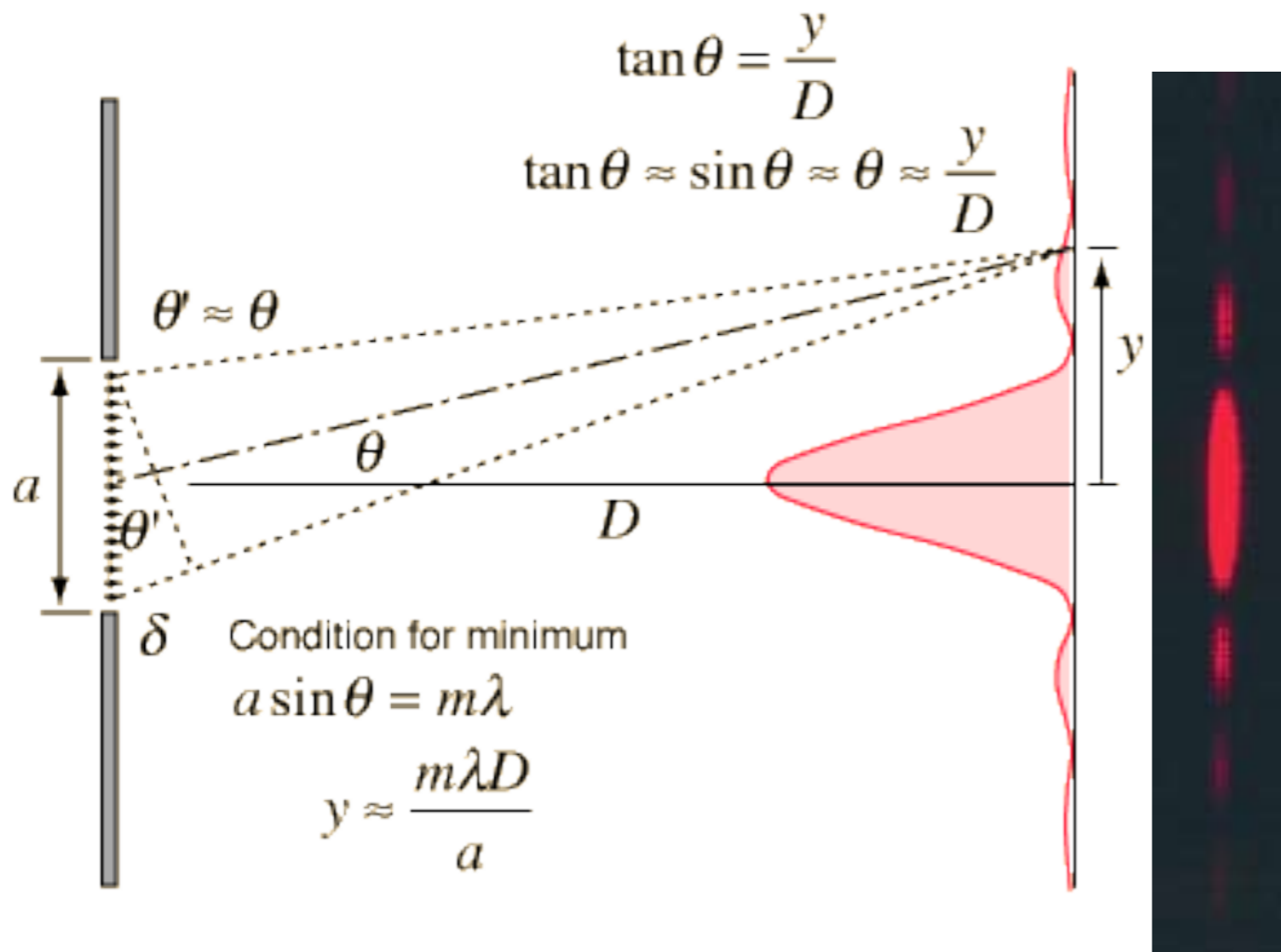
**Precise positioning**  
(normal points at mm  
level, orbits at cm  
level)



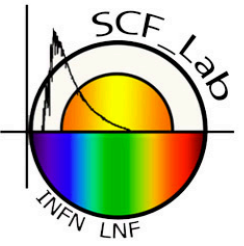
# Far Field Diffraction Pattern



Diffraction is a phenomenon that occurs when a wave passes by an obstacle or thru an aperture. On a distant screen the resulting wave will have a known intensity variation, which takes with it fingerprints of the interacting obstacle/aperture.

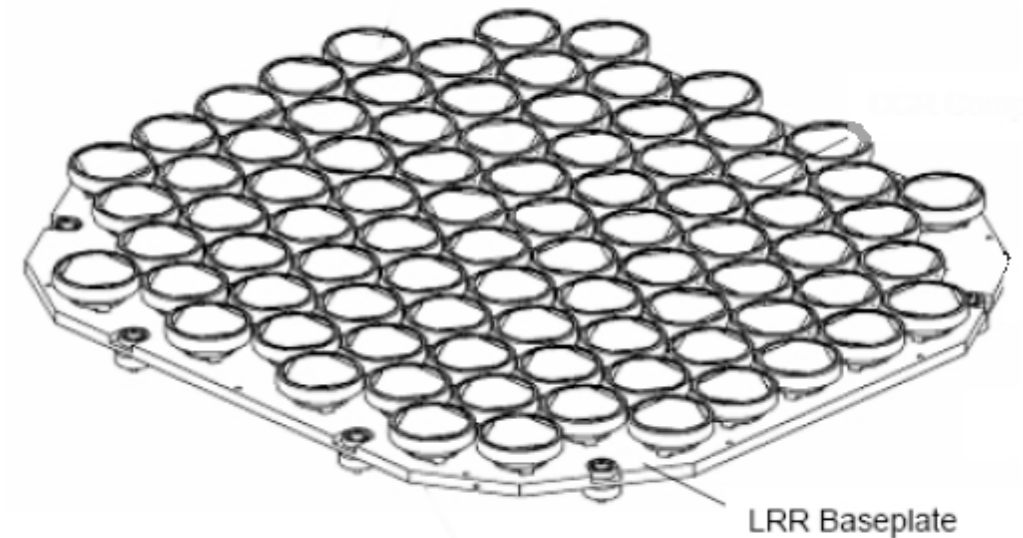
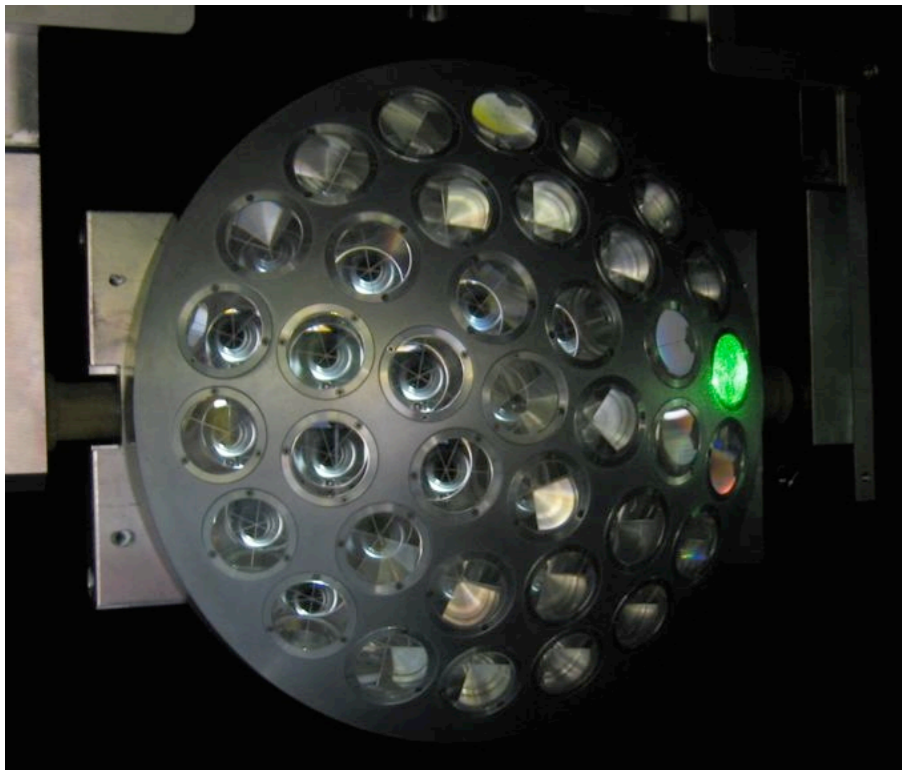
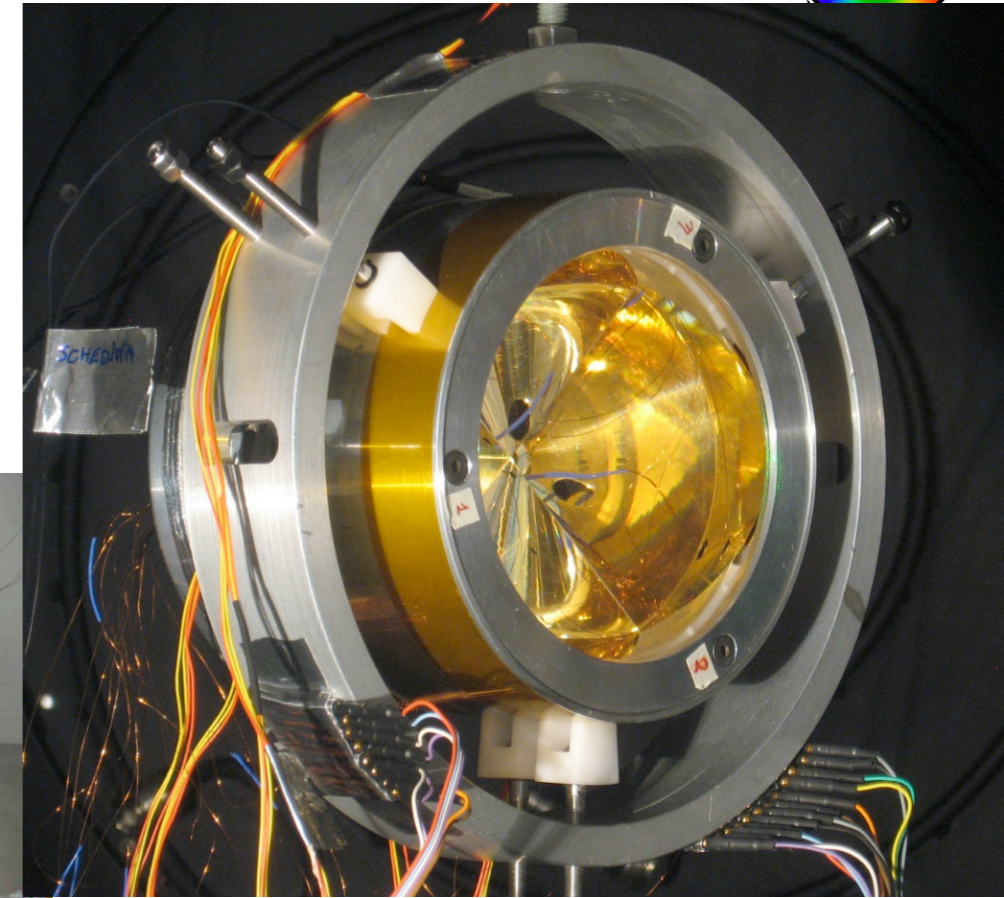
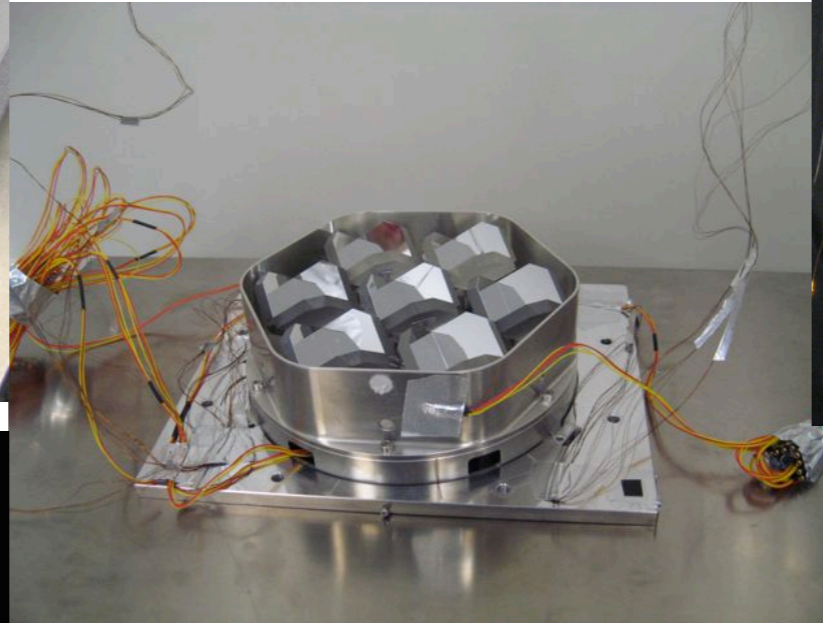
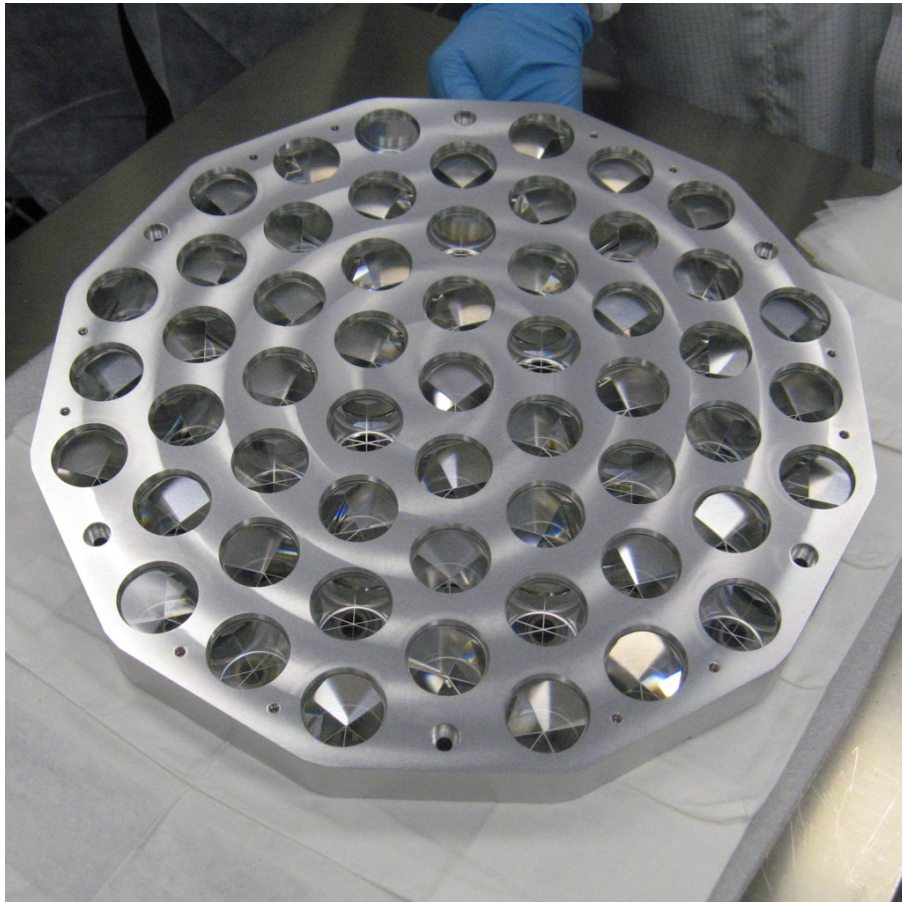


Optical sims realized by ORA's Code V



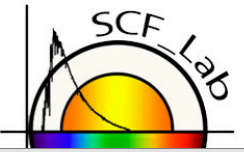
- Collaboration with NASA to characterize **LAGEOS** satellite CCRs.
- Characterization of a **Galileo-IOV retroreflector** for ESA.
- **ETRUSCO-2** project for design and characterization of a retroreflector payload for the GNSS (GRA)
- Design and characterization of a retroreflector payload for the **next generation Lunar Laser Ranging**, in collaboration with University of Maryland.
- SCF\_Lab measurements of current GNSS retroreflector payloads (**IRNSS** and **Galileo**).
- Design of payloads for next generation **Earth observation satellites** with Italian Ministry of Defense.
- Design of payloads for **laser altimetry** on solar system planets and moons (Mars and Moon)

# SCF\_Lab Laser Retroreflectors



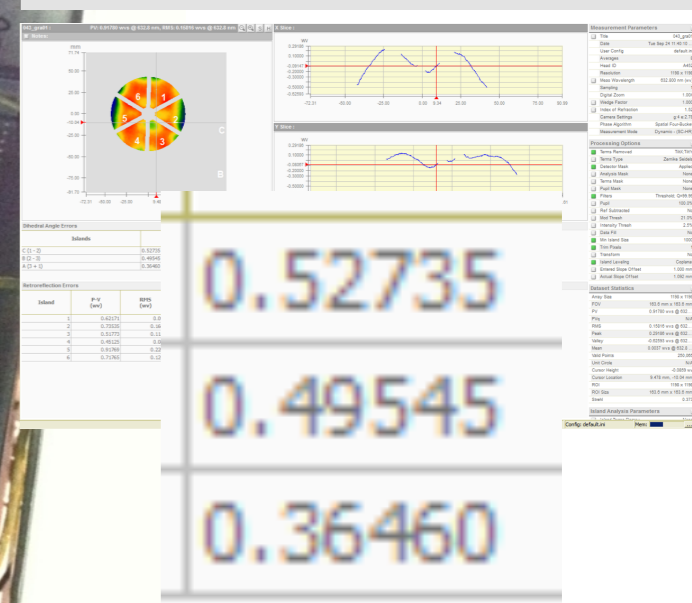
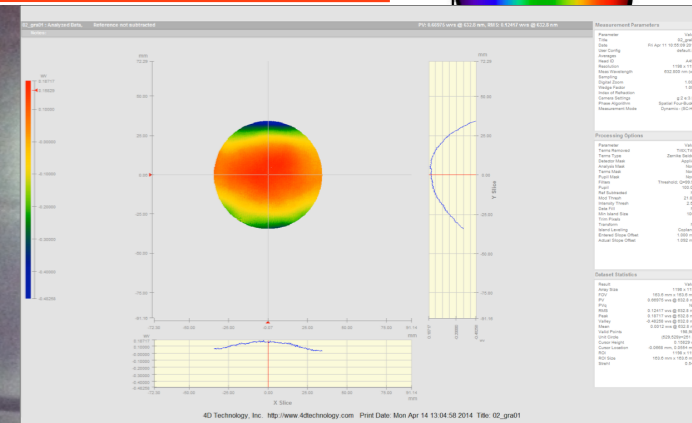
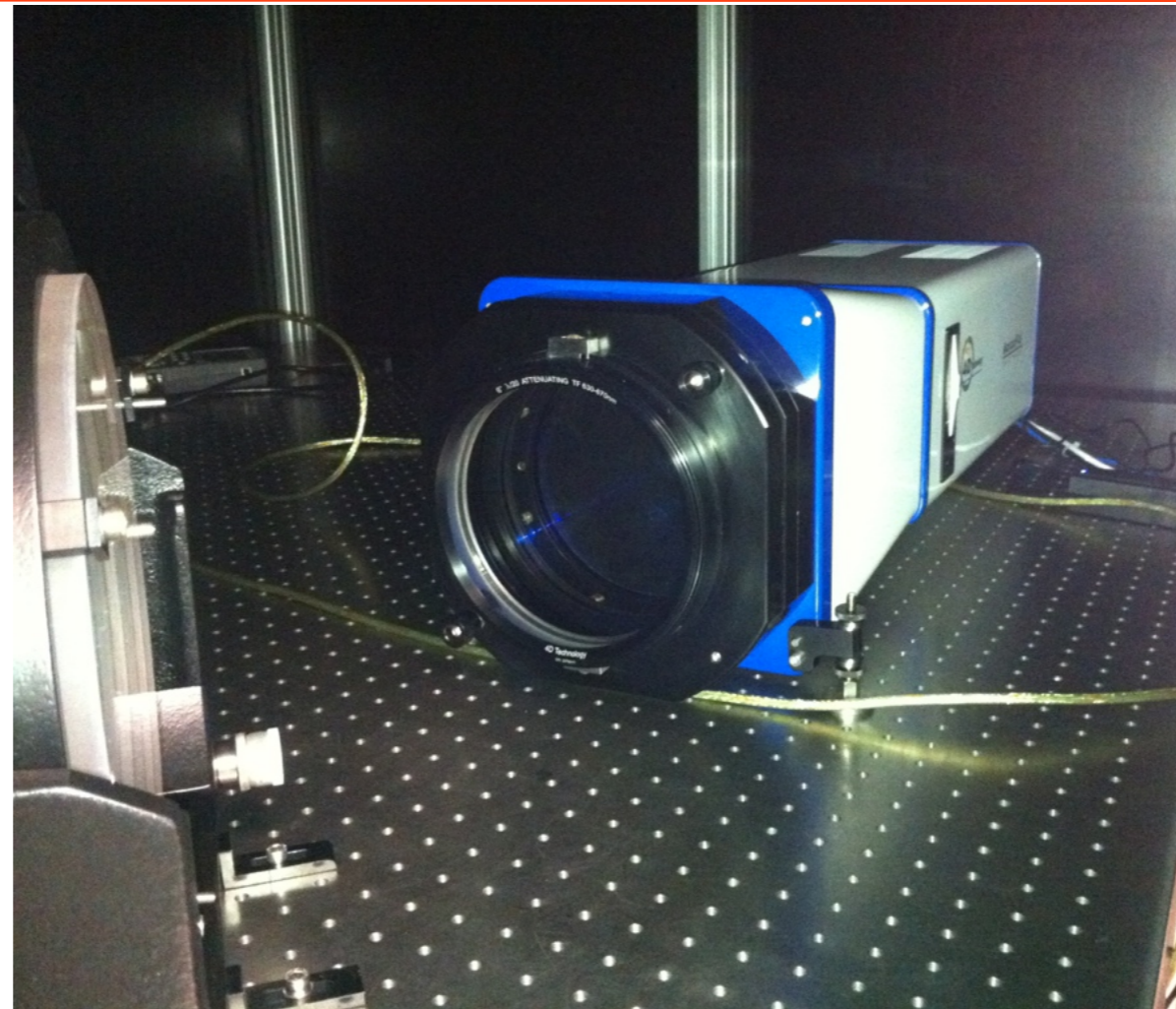
LRR Baseplate

# Interferometry @ SCF\_Lab

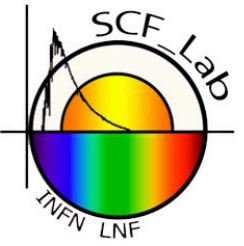


Fizeau laser interferometer for high accuracy shape and transmitted wavefront measurements (e.g., flatness testing, shape measurement, thickness uniformity, ...)

Thanks to 'Premiale' MIUR (Laser Ranging to Galileo) we shall get a 45-cm beam expander to comprehensively test whole payloads!







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**THANKS!**