CHARACTERIZATION OF THE OPTICAL PERFORMANCE OF LASER RETROREFLECTORS FOR SATELLITE AND LUNAR LASER RANGING TECHNIQUES

LNF - 02.04.19 | INSPYRE school

Chiara Mondaini

A little bit of me..

- Born & raised in Rome
- Wonderful family
- American mother

- Operating mechanisms of things
- Classical-Linguistic High School

History of Art or Aerospace Engineering?

The Space &... The National Laboratories of Frascati..

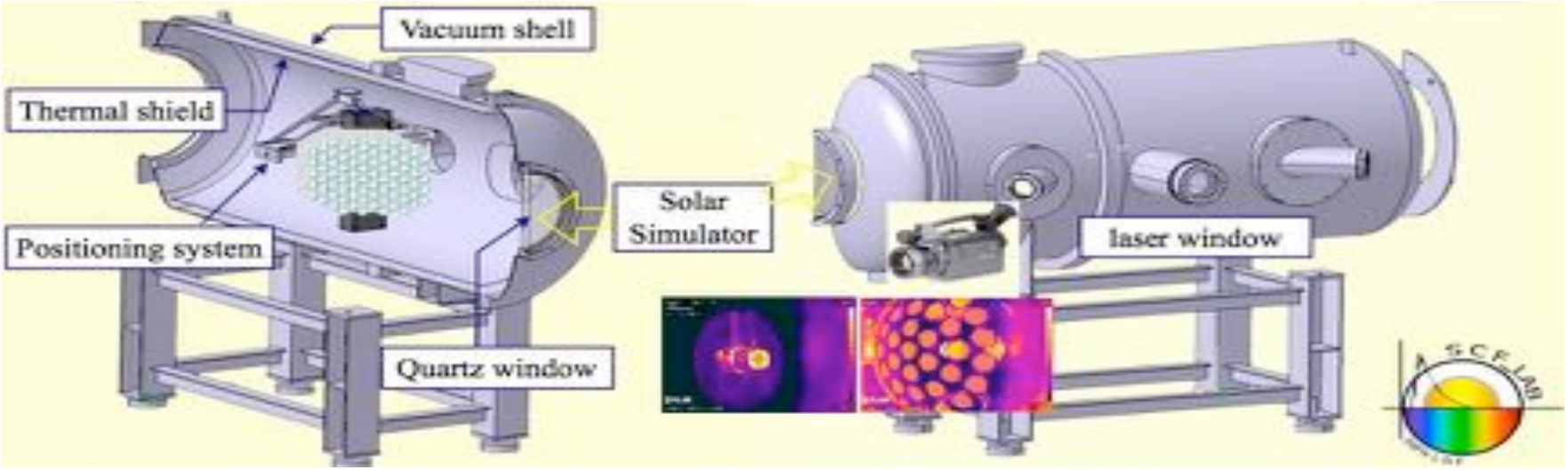
My work at LNF in the SCF_Lab

SCF_Lab

Satellite/Lunar/GNSS

laser ranging/altimetry and Cube/microsat

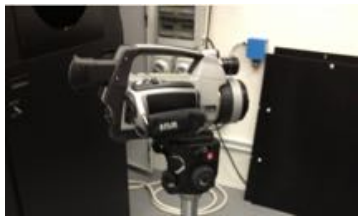
Characterization **F**acilities **Lab**oratory



- Clean Room
- Space Environment
- Test
- Laser Retroreflectors

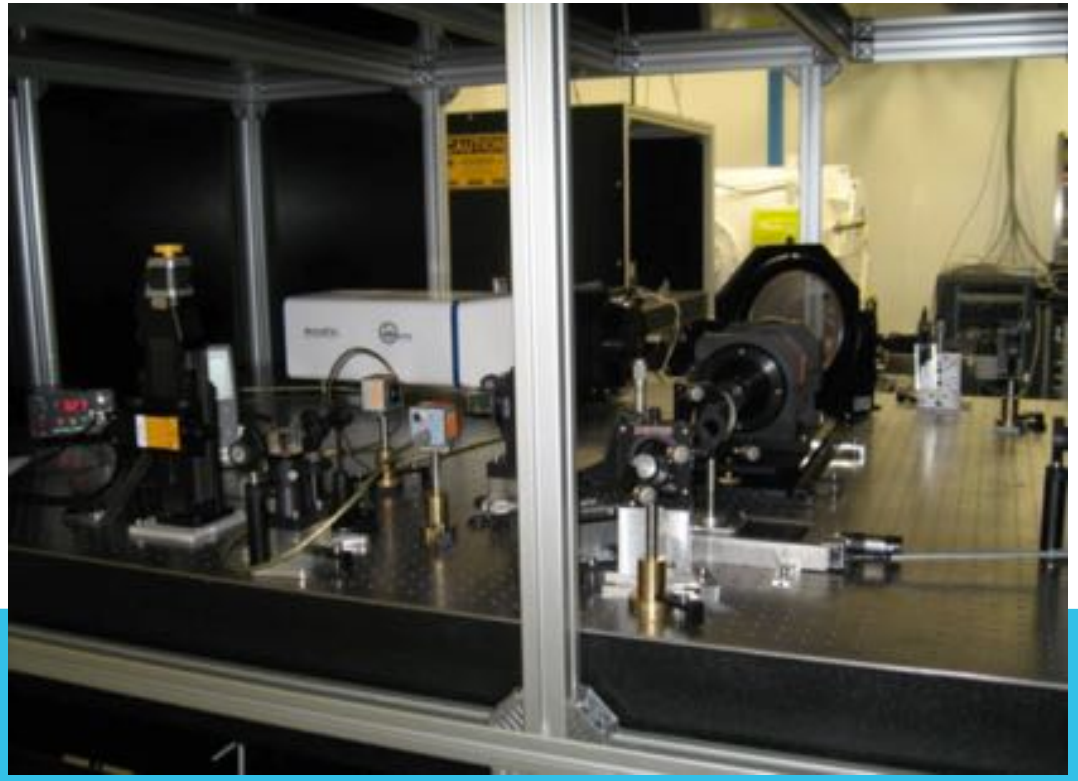
The SCF_Lab at INFN-LNF

Sun Simulator



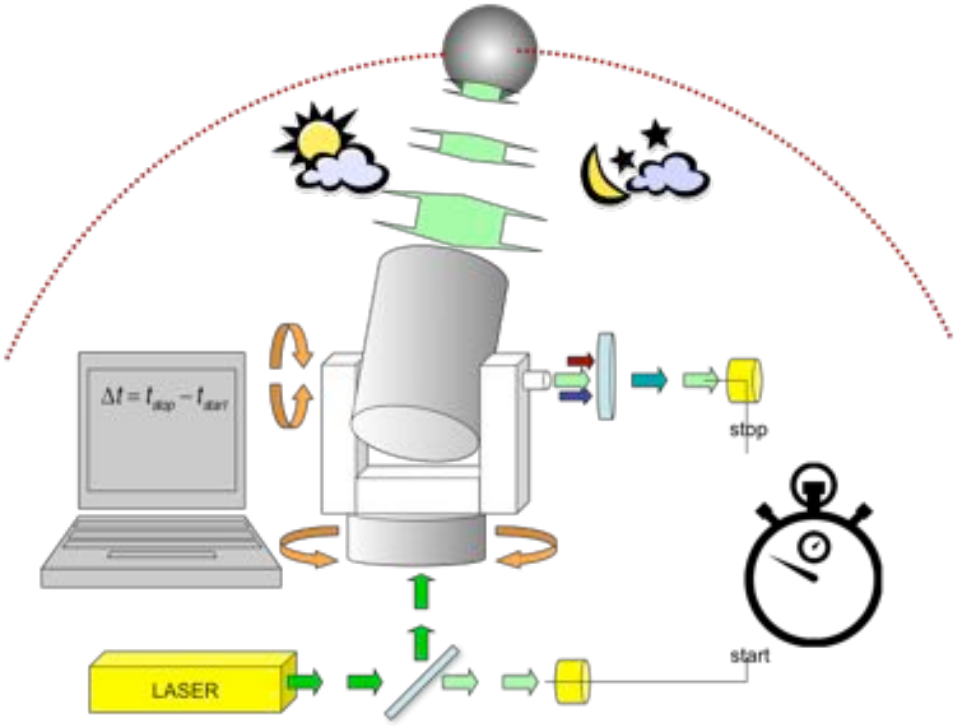
← IR Camera

Optical bench



What is Laser Ranging?

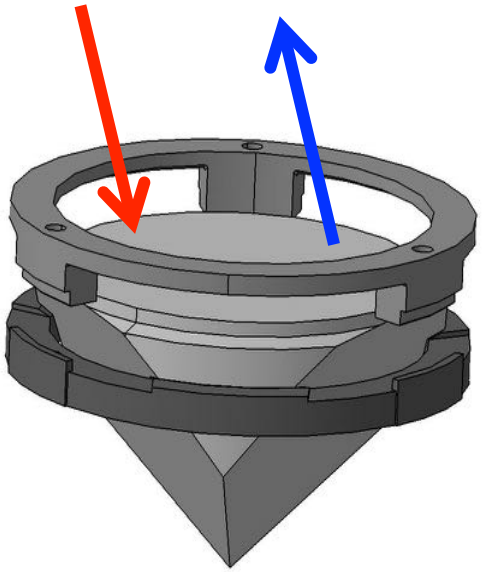
LLR/SLR concept: Laser ➔ receiving telescope ➔ time of flight



Greenbelt (MD) SLR station

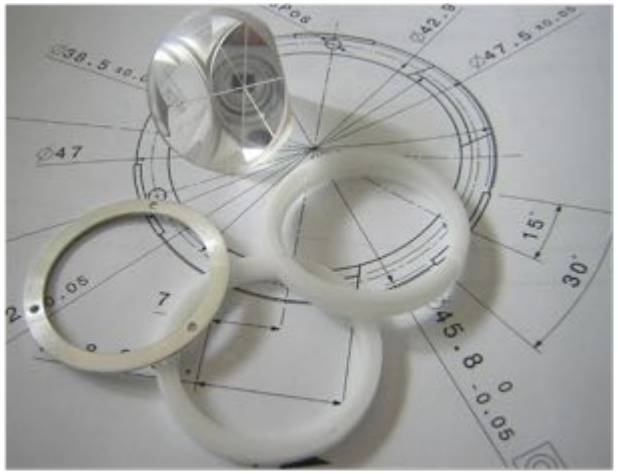
Accurate technique to measure the position of objects in space

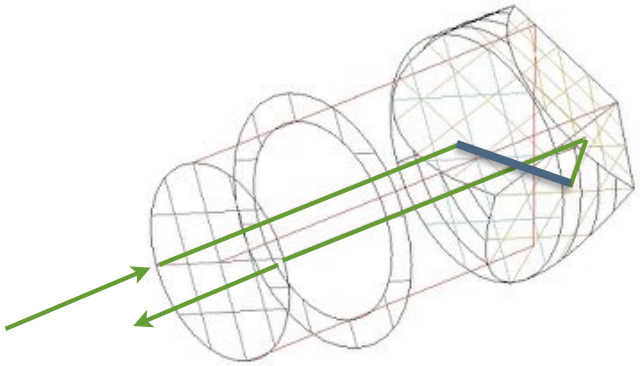
What are the Retroreflectors?

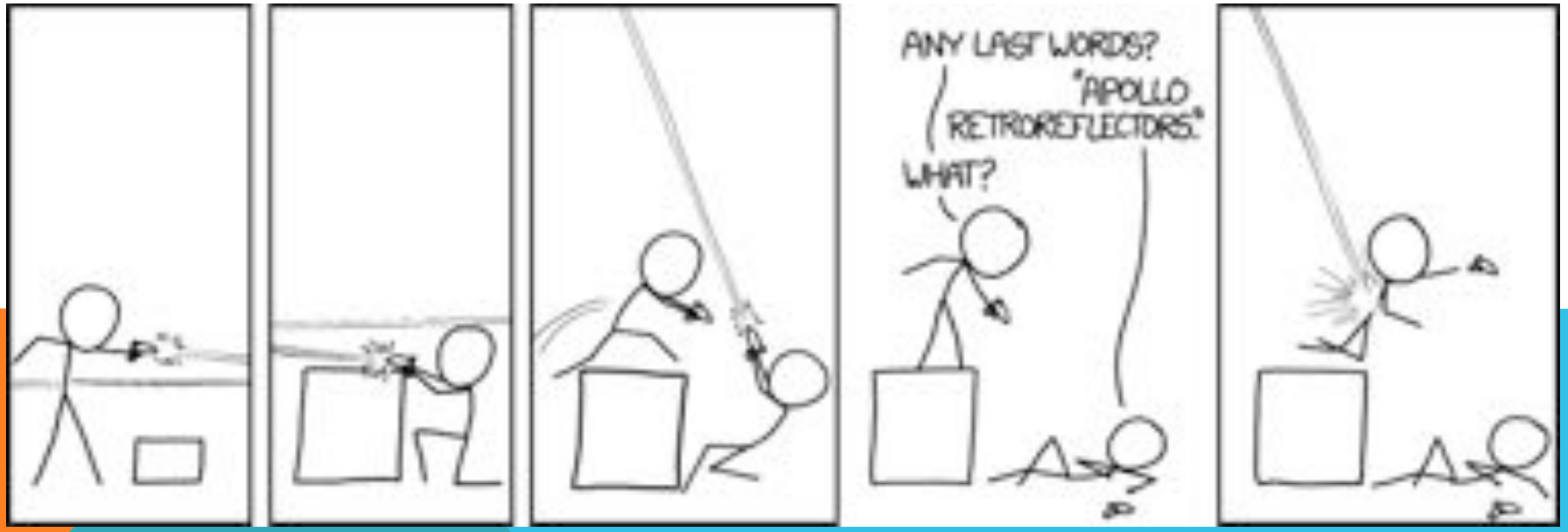


- Fused silica prisms cut as a corner of a cube (or hollow manufacturing).
- They reflect light goes back to the same incident direction.
- Every CCR back face forms and angle of 90° with the two other faces.
- Back faces may be "naked" or metal coated.
- Can be arranged in "arrays".
- The diffraction patterns are analyzed to study their optical performances in Space.

What are the Retroreflectors?







SCF-Test at INFN-LNF

1. New thermal-optical-vacuum test procedure for retroreflectors
2. Space conditions accurately simulated in the laboratory

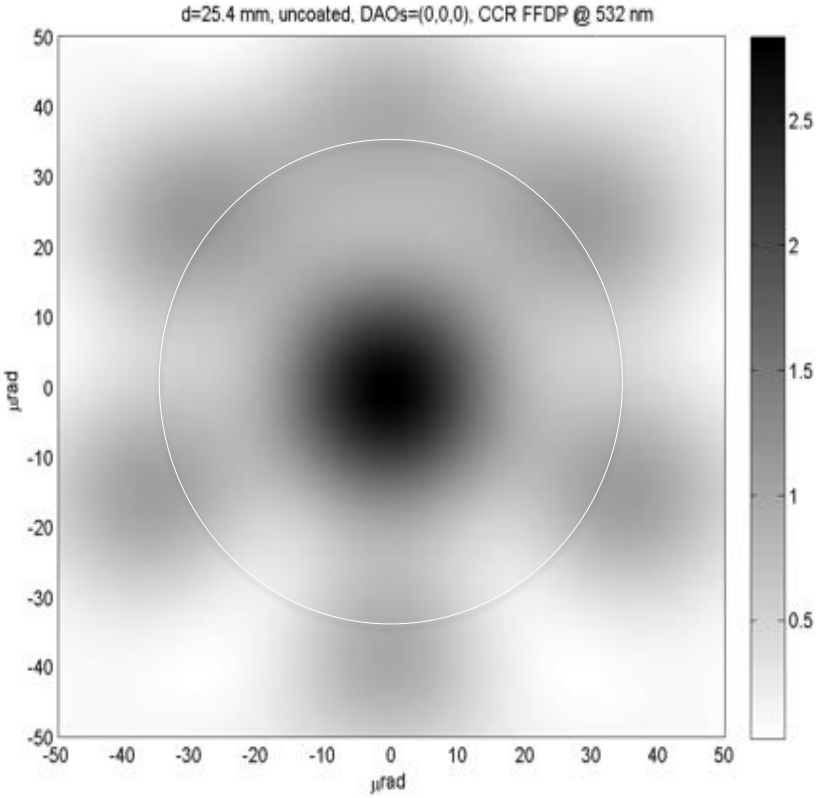
The payload is subject to:

- Thermal control of the reflector aluminum housing (300K)
- Vacuum (10-6 mbar)
- Sun illumination (several h SUN ON, several h SUN OFF)
- Laser interrogation during SUN OFF
  - FFDP & Fizeau Interferograms
- Non-invasive IR Thermometry (FLIR Thermacam 640...)
  - (CCR Thermal relaxation constant ...)

SCF-Test at INFN-LNF

FFDP: optical response of laser return to ground surface.

Diffraction patterns are analyzed to study their optical performances in Space.



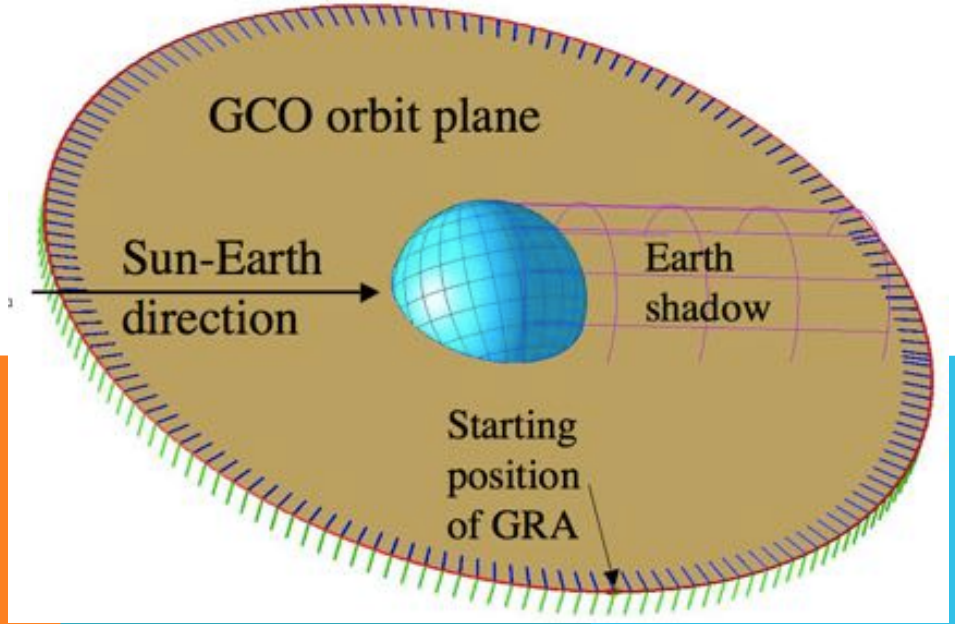
Example of FFDP

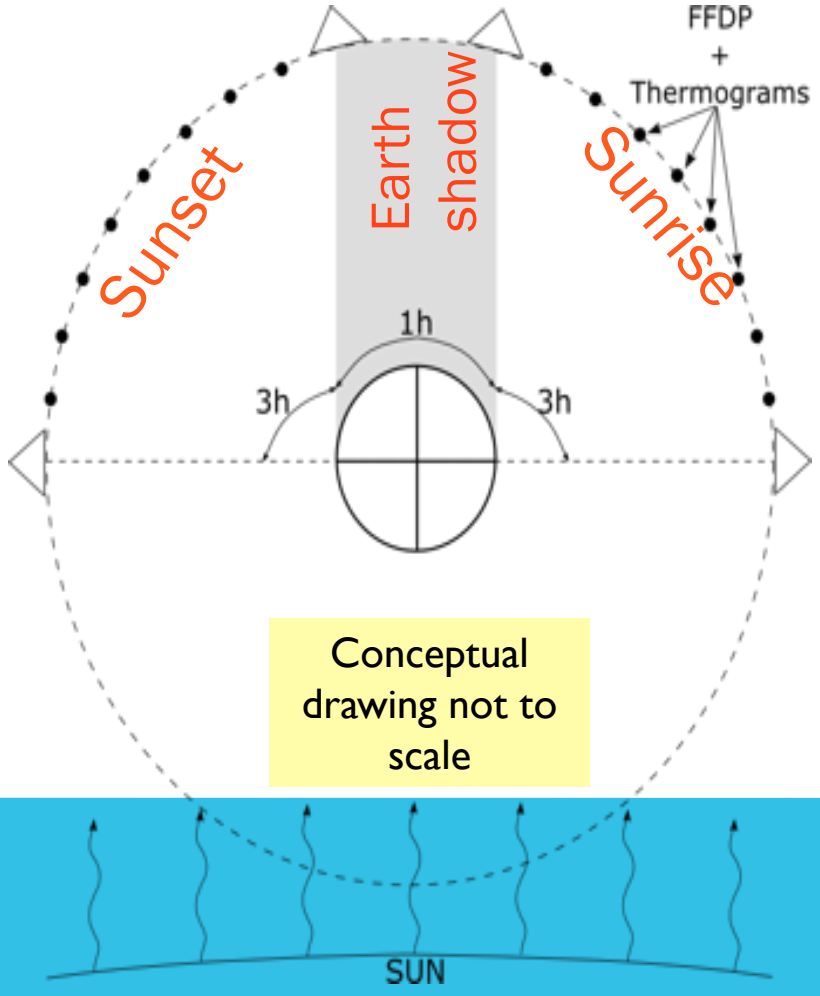
SINGLE-REFLECTOR GNSS 'CRITICAL' ORBIT SCF-TEST

GNSS Critical Orbit (GCO): GNSS orbit with nodes parallel to Sun-Earth direction. Sunrise-Eclipse-Sunset probes critical features of CCR thermal and optical behavior, including optical breakthrough.

Galileo orbit:

- Altitude = 23.222 km; Period ~ 14 hr, shadow ~ 1hr



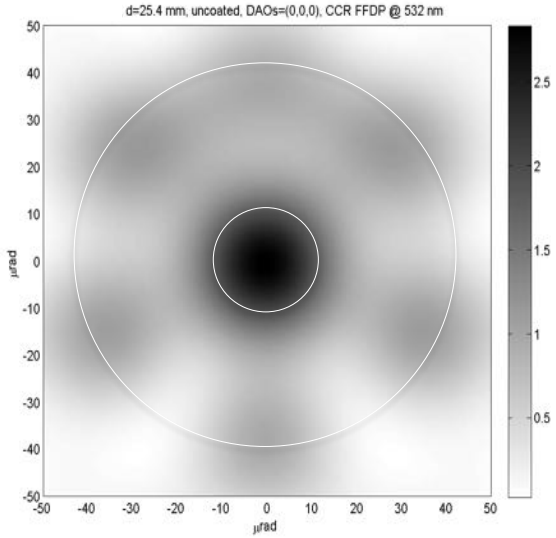


Conceptual drawing not to scale

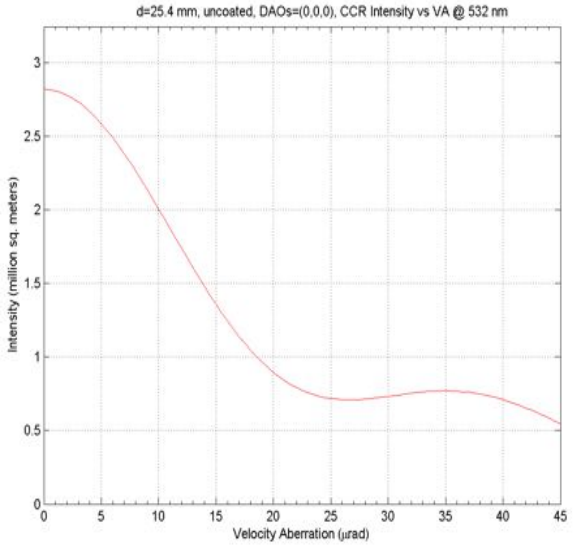
CODE V Simulations of Optical Cross Section (OCS) 'intensity

CODE V is a software for optical design, analysis and model of optical systems for diverse applications.

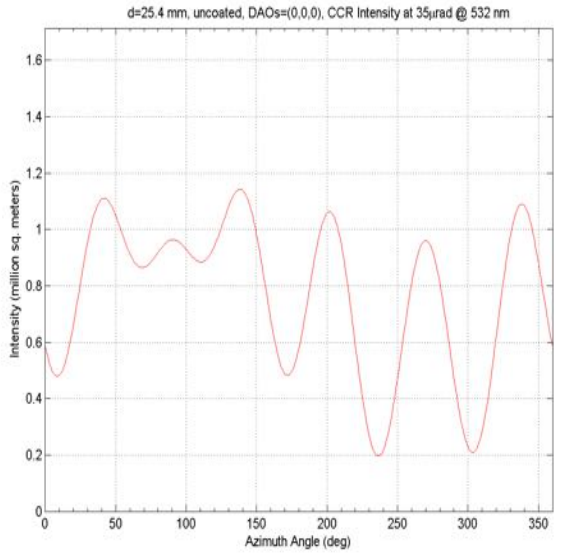
Simulations for nominal COTS DAO centered around 0.0 arcsec



Simulated FFDP of a COTS CCR

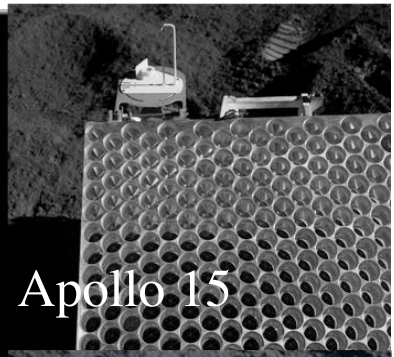


Simulated OCS intensity (averaged over the azimuth in the FFDP plane) vs. VA (Velocity Aberration) of a COTS CCR



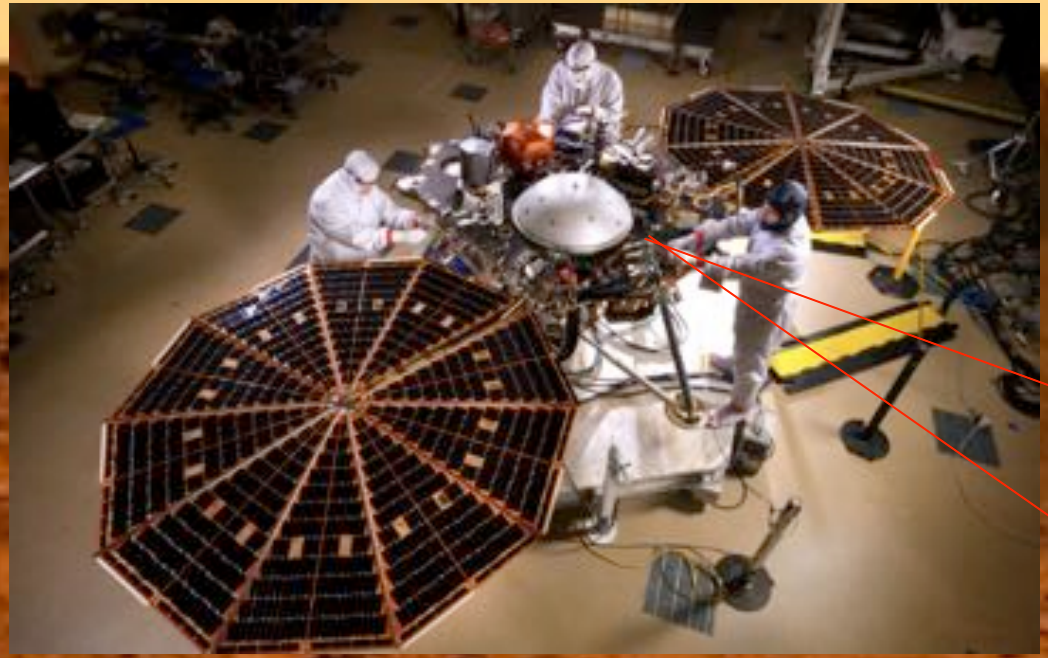
Simulated OCS intensity at a specific **VA = 35 µrad**

Lunar Laser Ranging

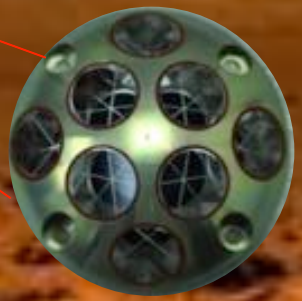


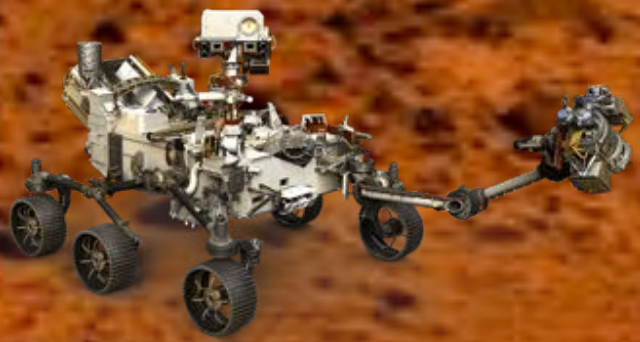
Laser Ranging on Mars & beyond..

Insight



INRRI





Mars 2020

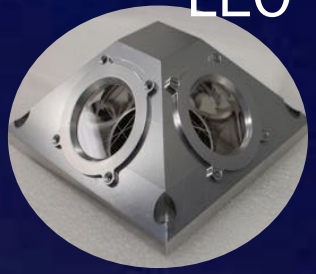
ExoMars 2020

Schiaparelli

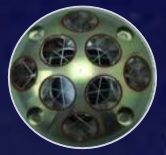
Satellite/GNSS and Lunar LASER RANGING

Matera Laser
Ranging Observatory
1.5 m telescope
@ASI - CGS

LEO

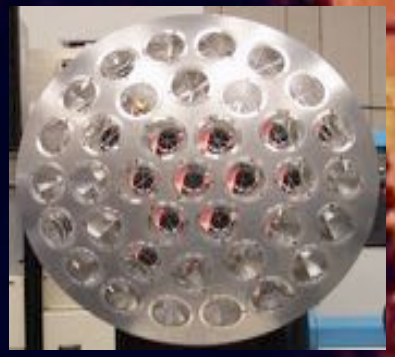


Mars
μ–reflector

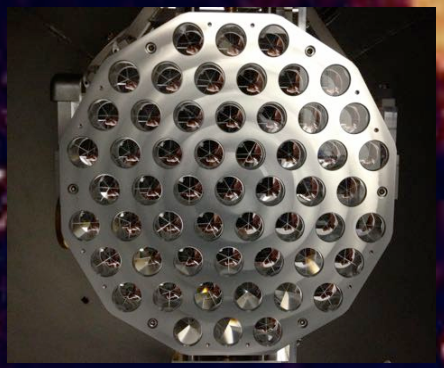


Moon

LAGEOS



GNSS



Team work...

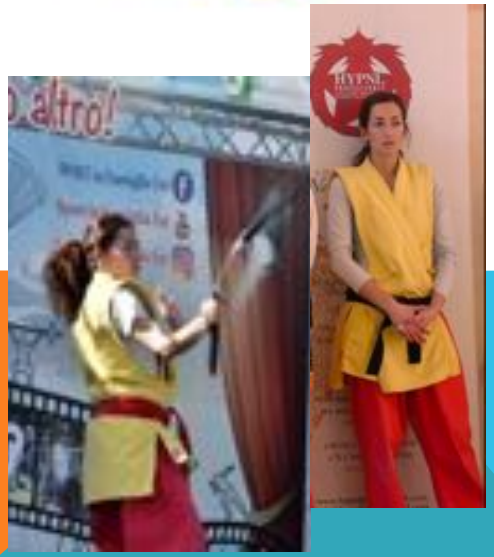

GROWTH
TOGETHER
HELP!
TEAMWORK
SUCCESS
Vision
PARTNER
Ideas!
Brainstorm
30%
10%

Thank you for your attention..

Coming together is a BEGINNING,
Keeping together is PROGRESS,
Working together is SUCCESS..

Henry Ford

Searching for the the deepest mechanisms...



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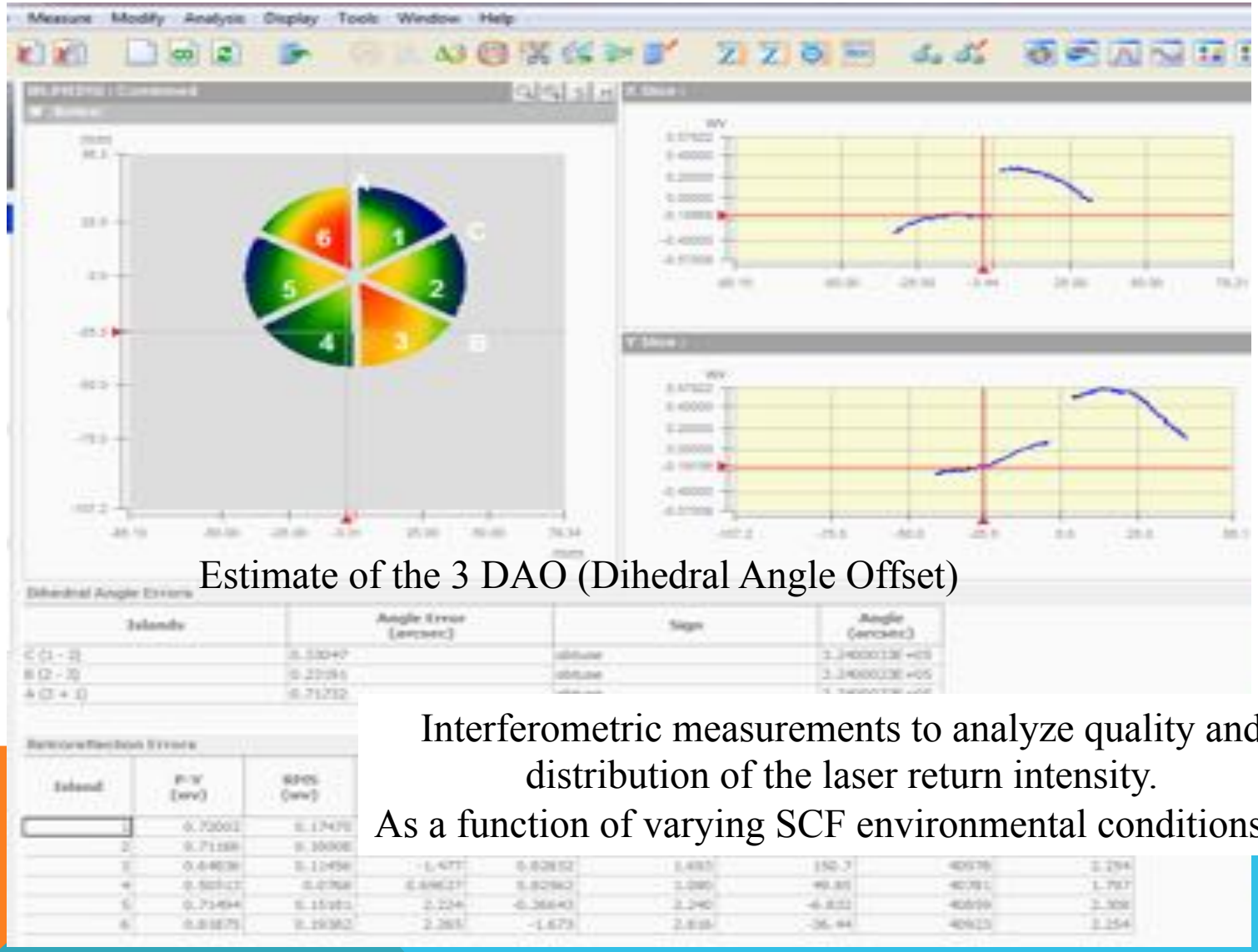
Results through Fizeau Interferometry



Estimate of the 3 DAO (Dihedral Angle Offset)

Interferometric measurements to analyze quality and distribution of the laser return intensity.
As a function of varying SCF environmental conditions