Short review of activities on optical and geometrical characterization of OMSoP dish

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OMSoP demonstrative plant: INNOVA dish @ ENEA-Casaccia

- **Structure: revamping of an old McDonnell Douglas dish**
- **Mirrors: new facets based on ALMIRR 303**
- **Receiver: original!**
- **Microturbine: original!**
- **Control system: original!**

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Receiver design needs of the solar Flux profile!!!

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Solar Flux profile necessary for its design!!!

Focus position nesessary for the rigth position of the components!!!

Dish OMSoP in numbers

⌀outer ≈ 12 m

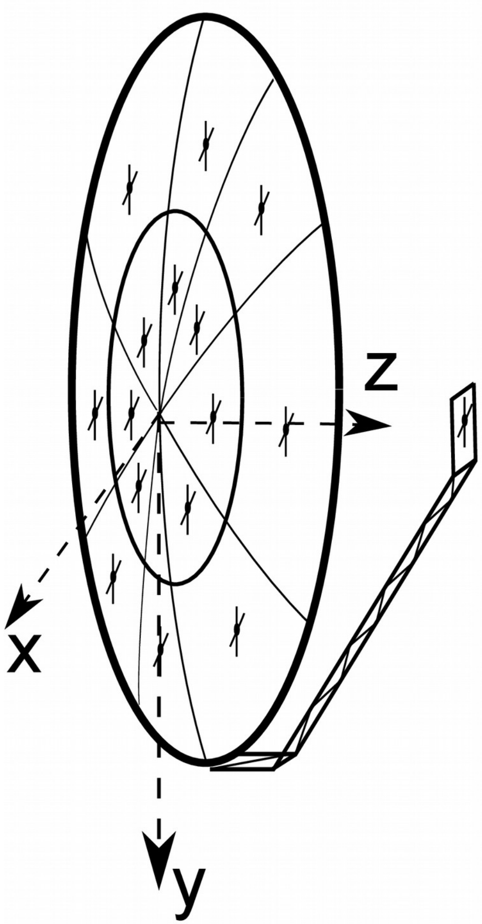
⌀inner ≈ 2 m

$A \approx 88\ m^2$

$P_0 = A \times DNI \approx 70.4\ kW$ @ $0.8\ kW/m^2$

$z = 0.25(x^2+y^2)/f$ con $f \approx 7\ m$

Preliminary geometrical characterization of the dish - I



Photogrammetry

- 1 target per facet
- 4 targets on boom
- Best fit of points

$\{(x_k,y_k,z_k)\}_{facet}$ with paraboloide equation

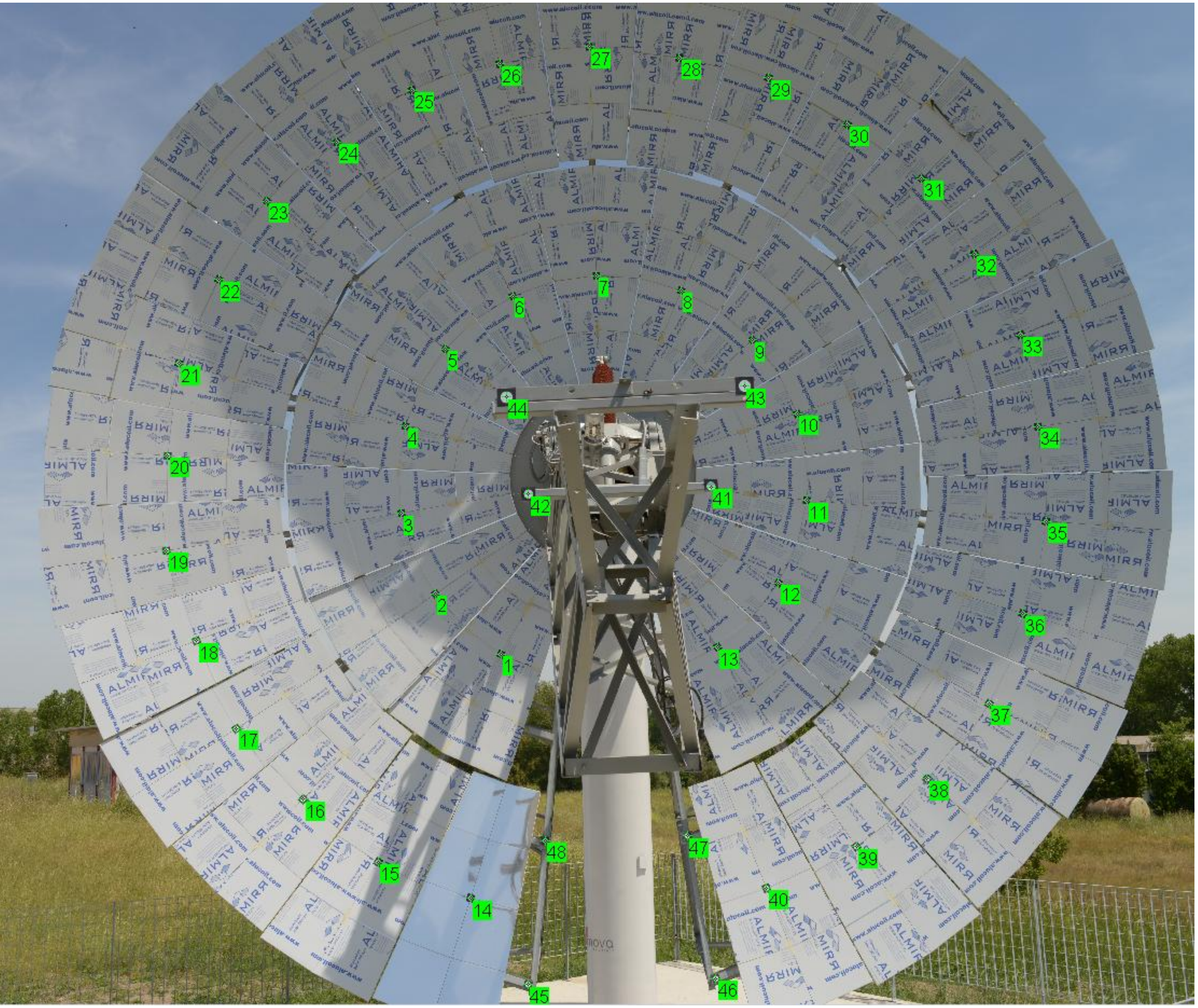
➔ *axis & vertex*

Totale Station

permanent points:
4 low facet supports
2 boom

For anytime measure

Preliminary geometrical characterization of the dish - II

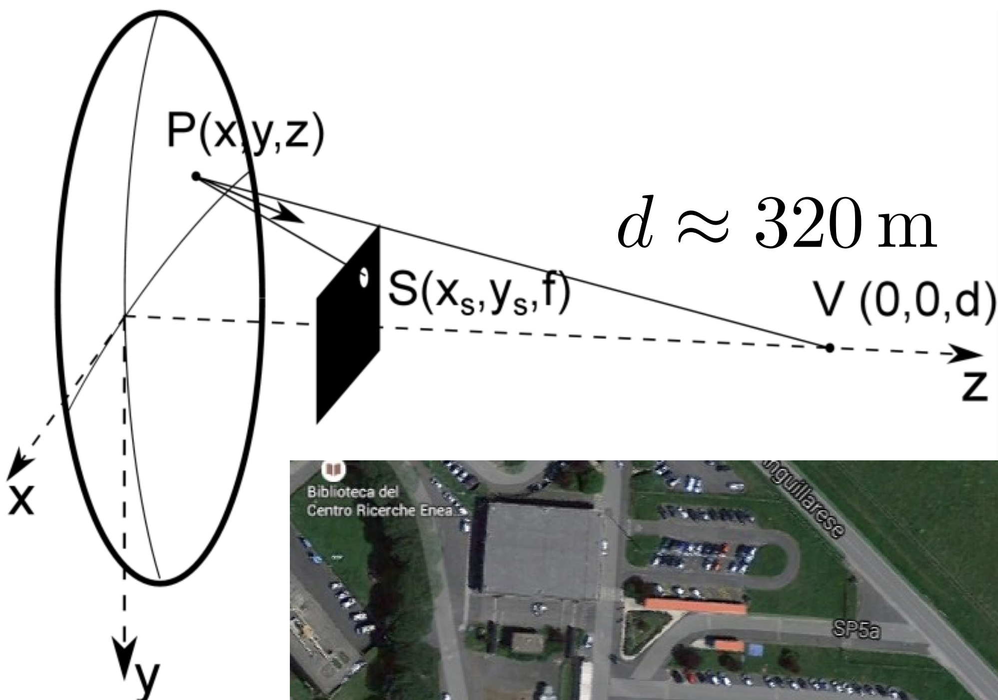


- **paraboloide axis**
- **vertex point**

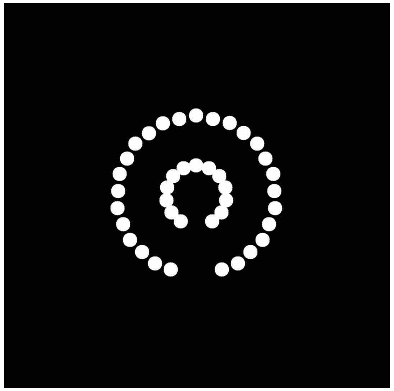
by assuming

$$f = 7040\,\mathrm{mm}$$

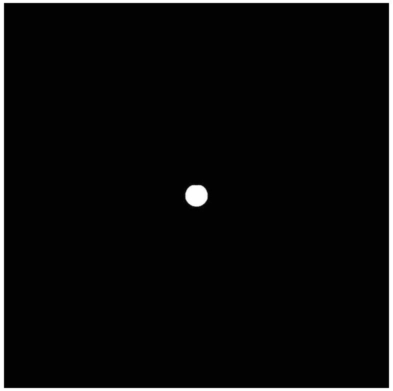
Facet canting by means the new instrument *VISdish* Rev. Sci. Instrum. 2017 (88) 065107



$$d \approx 320\,\mathrm{m}$$



$$z = 7040\,\mathrm{mm}$$

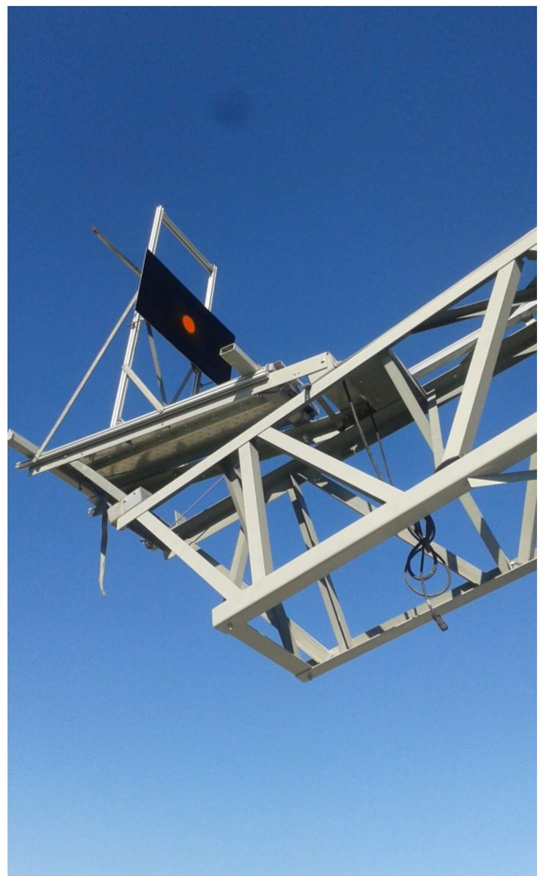


$$z = 7230\,\mathrm{mm}$$

VISdish – facet canting

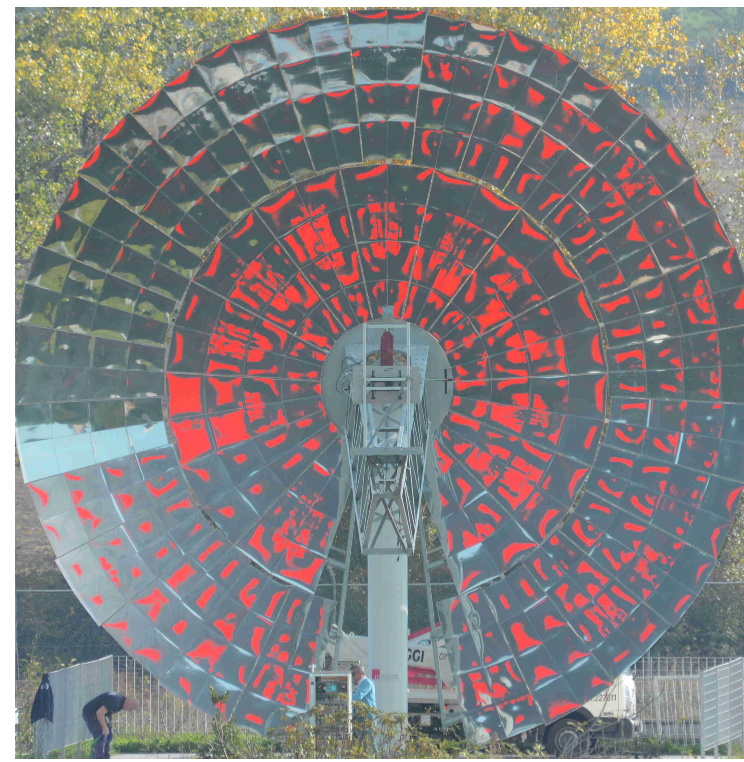
Aiming

fake-monitor



⊘ red dot = 120 mm

Alignment at mid way



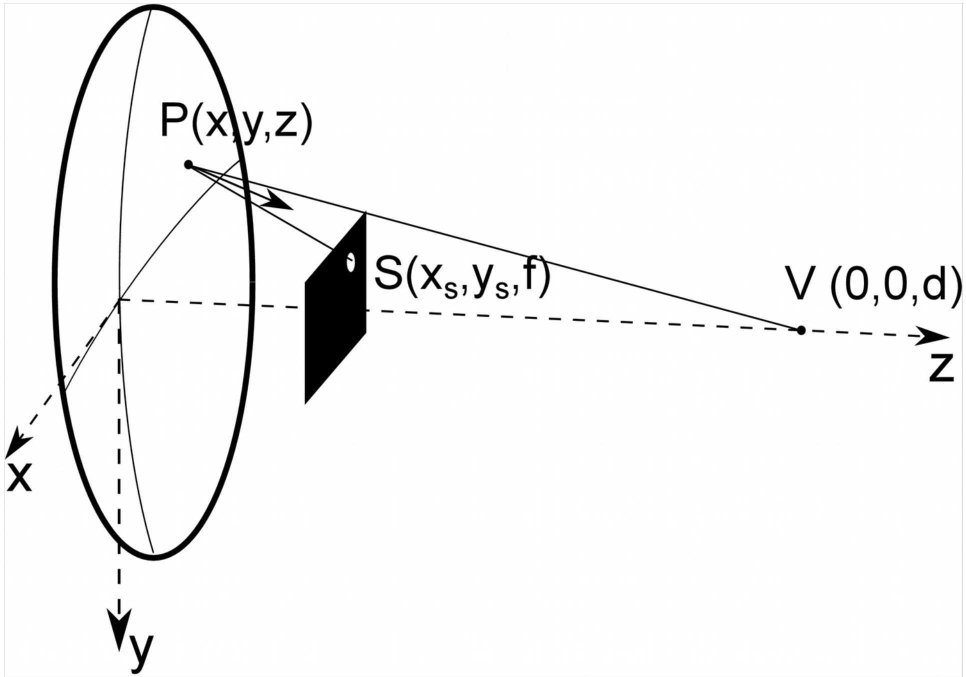
VISdish: the observer

Components of VISdish-canting:

1) Fake monitor
2) Telescope
3) Binocular
4) Walkie-Talkie

Simple & Chip !!!

VISdish: shape-measurement



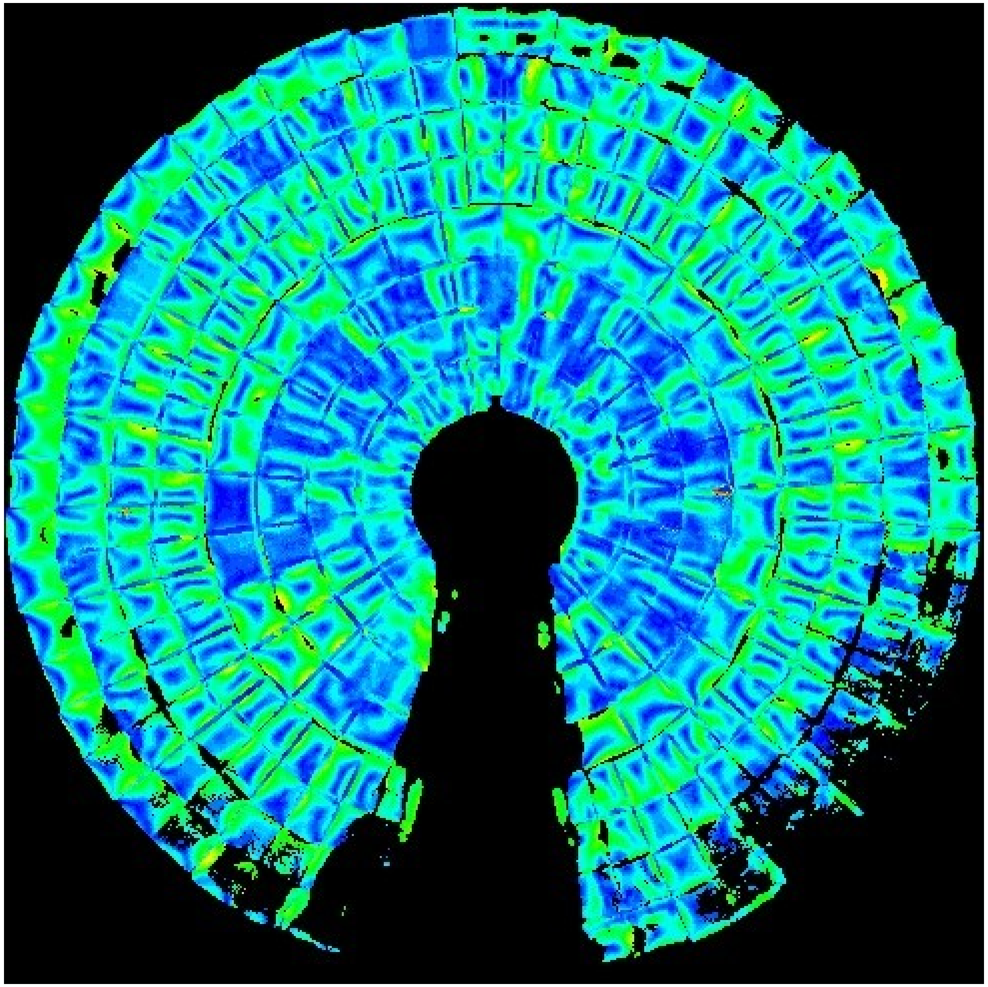
- **S is moved at step.**
- **For each position, one image is acquired by V**
- ***Point*, N^2 step**
- ***Linee horizontal and vertical*, 2N step !!!!**
- **Determination of the unit vector normal to the mirrored surface by image processing**

Results dish shape

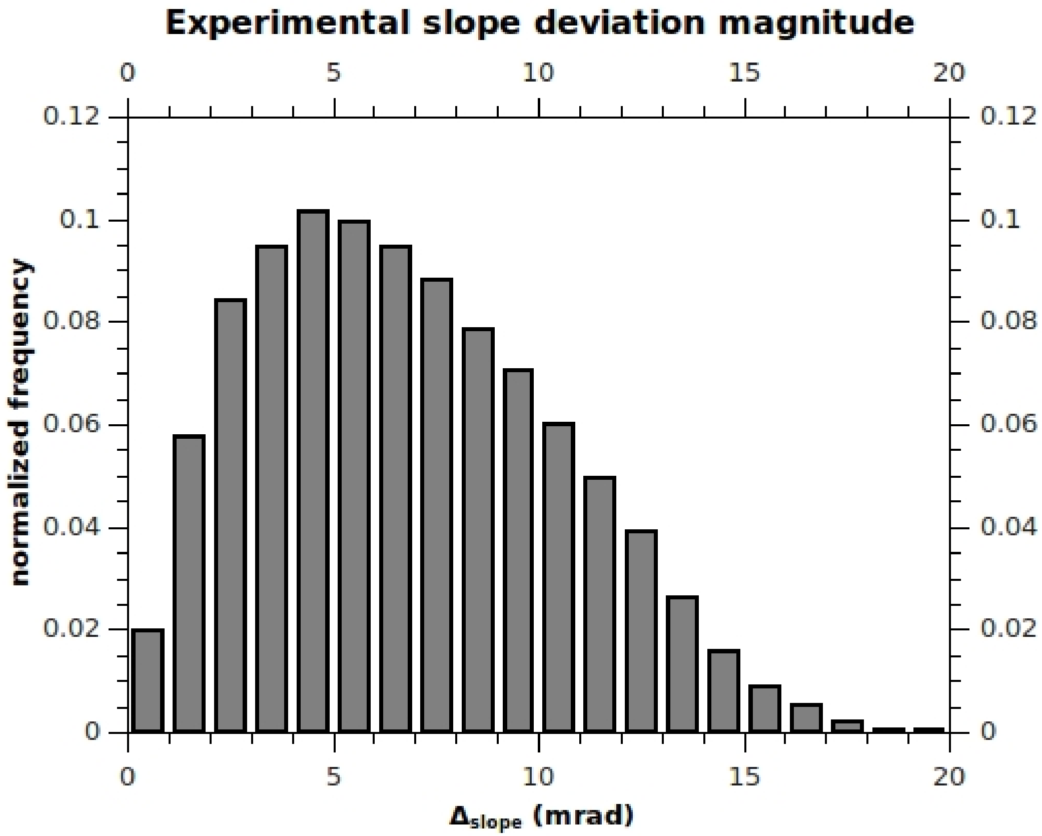
Sample surface: 83.25 m^2 of 88 m^2

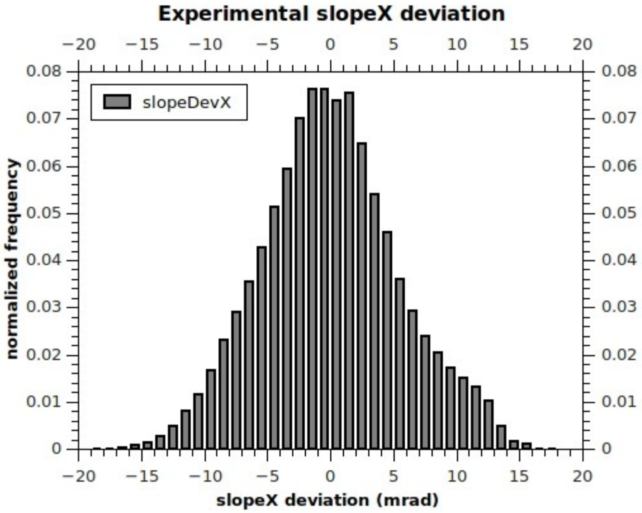
- The used TV LCD was too much small
- Frost on the mirrors

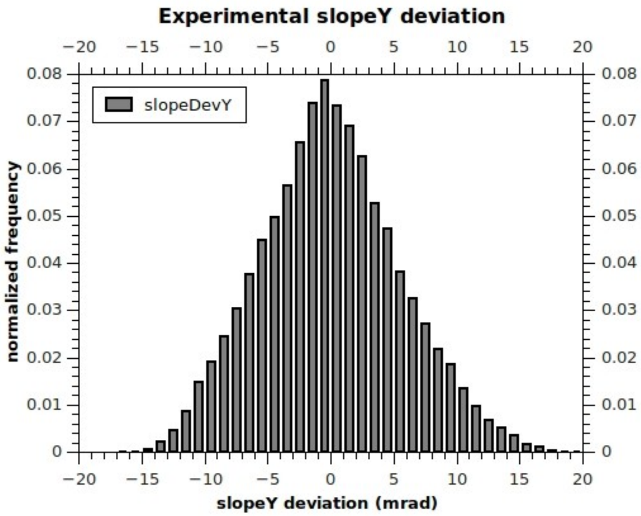
Slope deviation contour map



Slope deviation dish OMSoP

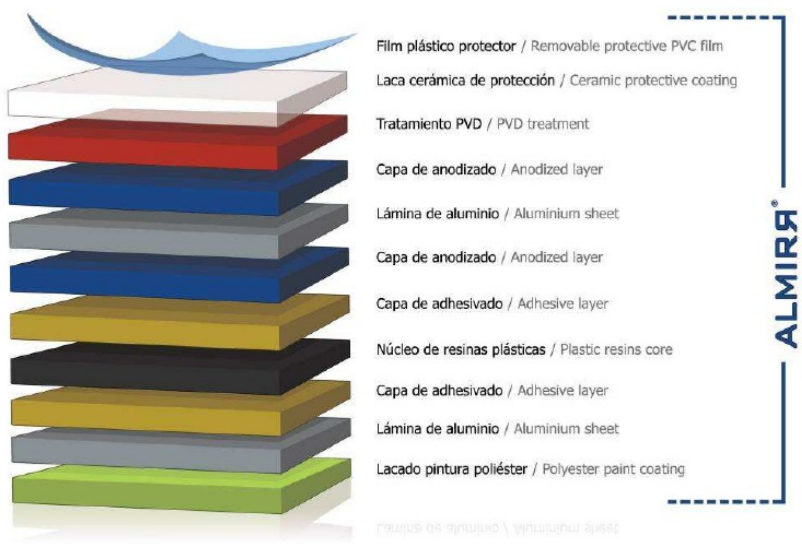


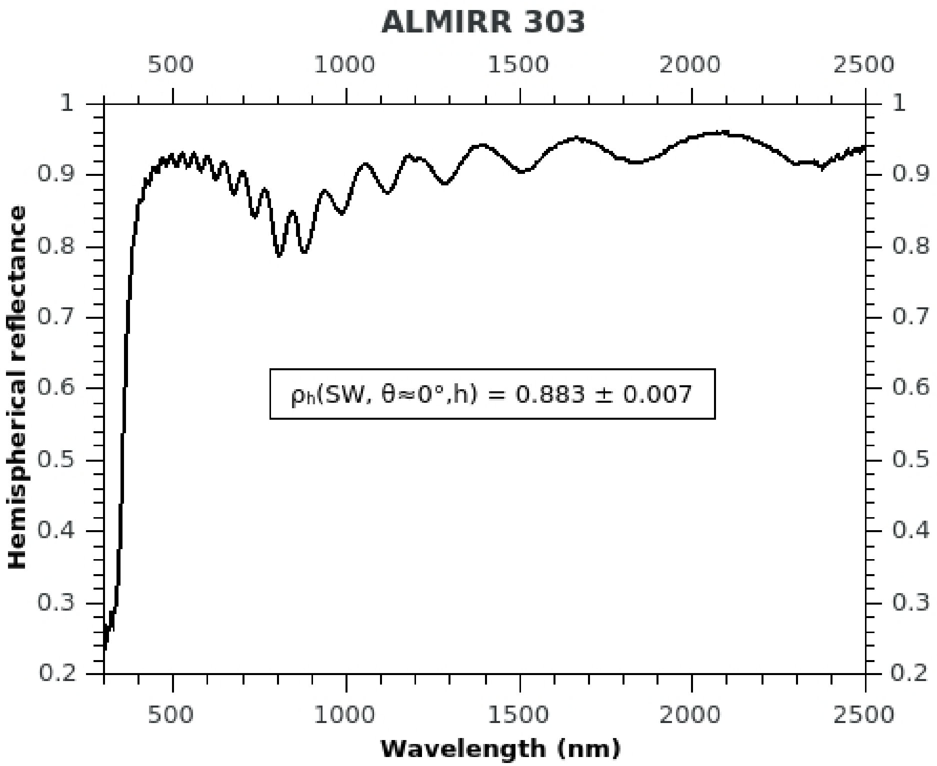




ALMIRR 303 solar mirror

Multilaminar Aluminium Mirrors, Almirr®, consist of two aluminium sheets and a plastic resin core.



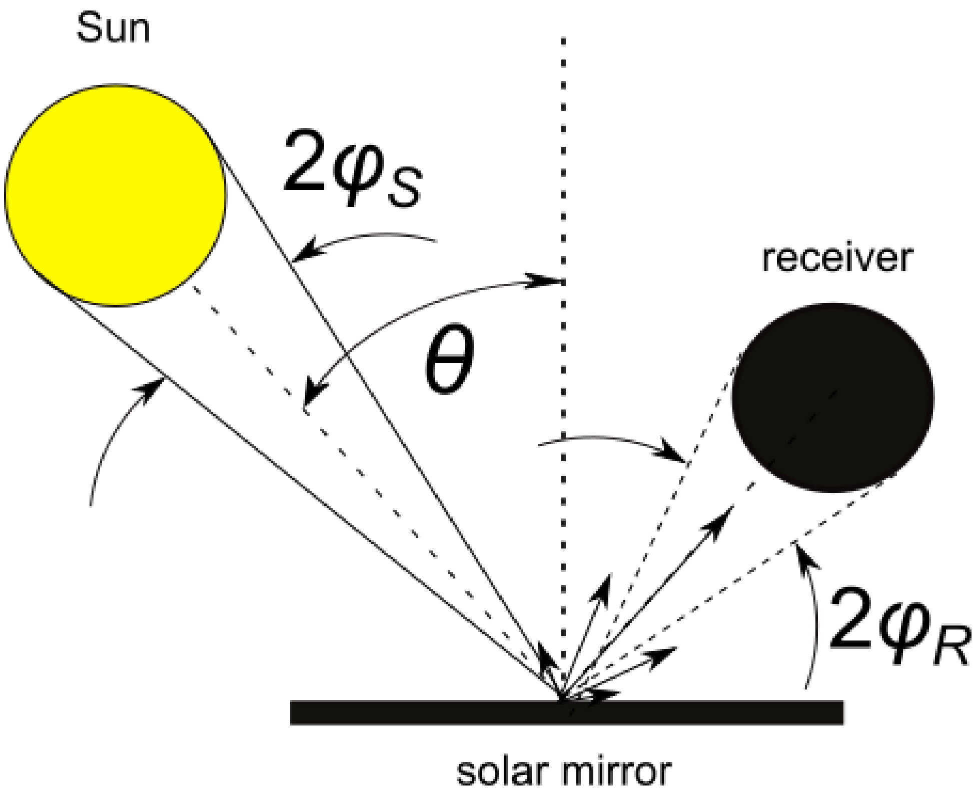


Perkin Elmer L950, integrating sphere 15 cm, first surface Al reference mirror

$$\rho_h(SW, \theta \approx 0^\circ, h) = 0.883 \pm 0.007$$

$$A = 0.117$$

MIRRORS IN CSP and SCR(θ,φ)



Sun is not a point source infinitely far.

Solar radiation does not travels as plane wave: $2\varphi_s$ = 9.46 mrad in a clear-sky day.

Then *reflectance* concept does not properly fit the typical CSP conditions!!!

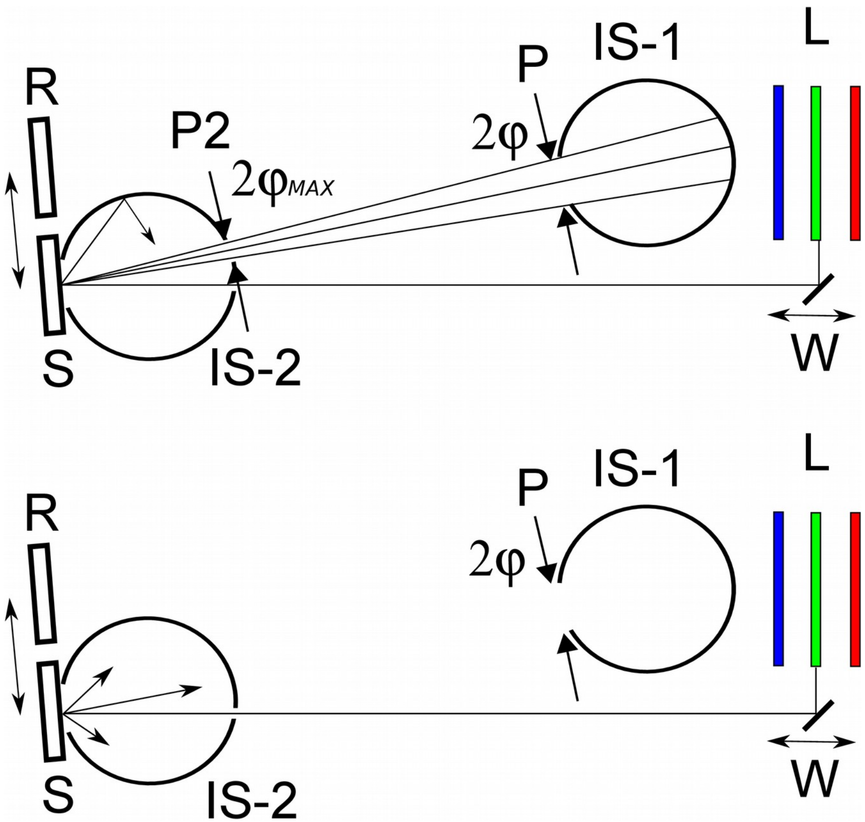
This is the first reason for introducing the new parameter:

Sun-radiation Conic Reflectance (SCR)

i.e. rate of solar energy reflected by the mirror and intercepted by the receiver viewed under $2\varphi_R$ from the reflection point.

SMQ set-up (ENEA)

Designed to measure the near-specular reflectance (no deconvolution)!



Main features:

- low divergent laser beams (< 1 mrad)
- no lenses
- small beam size (< 1 mm)
- ⇒ spatial selection of φ (3-20 mrad)
- data processing based on TIS and EMA returning the solar near-specular reflectance

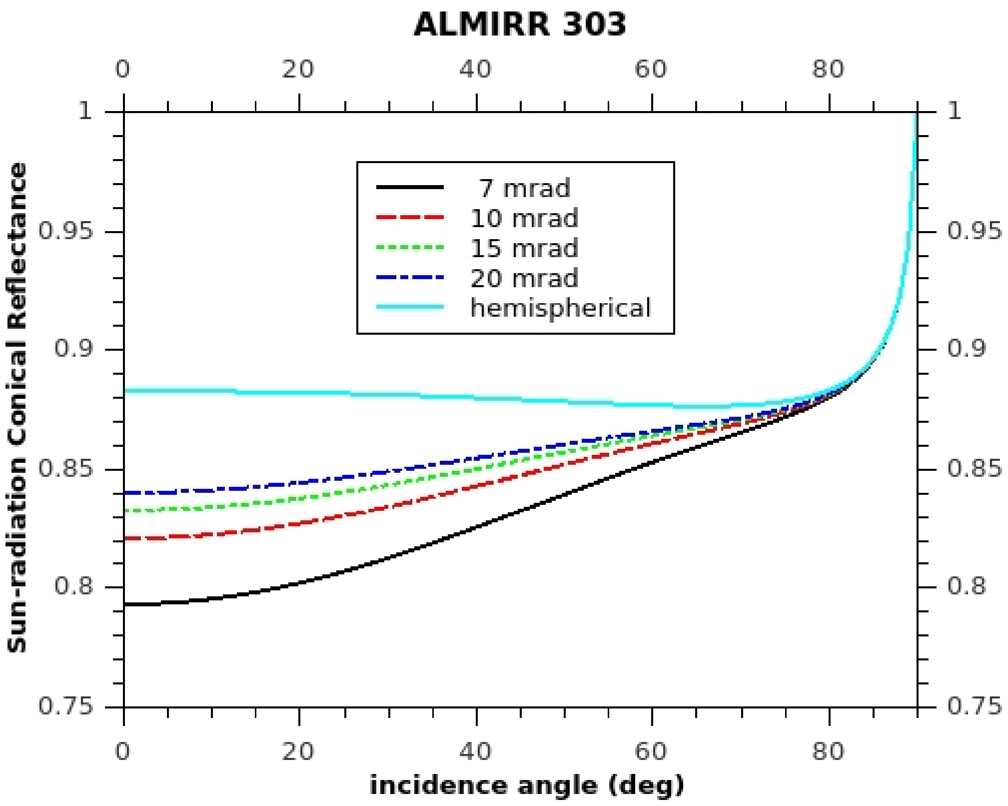
$$\rho_s(SW, \theta, \varphi)$$

given

$$\rho_h(\lambda, 0^\circ, h)$$

The continuous spectral measurement can not achieved by SMQ because the beam must have *low divergence* (< 1mrad) and *small spot* (<1 mm) ⇒ **laser beam!!!**

SCR of ALMIRR 303



Low performance

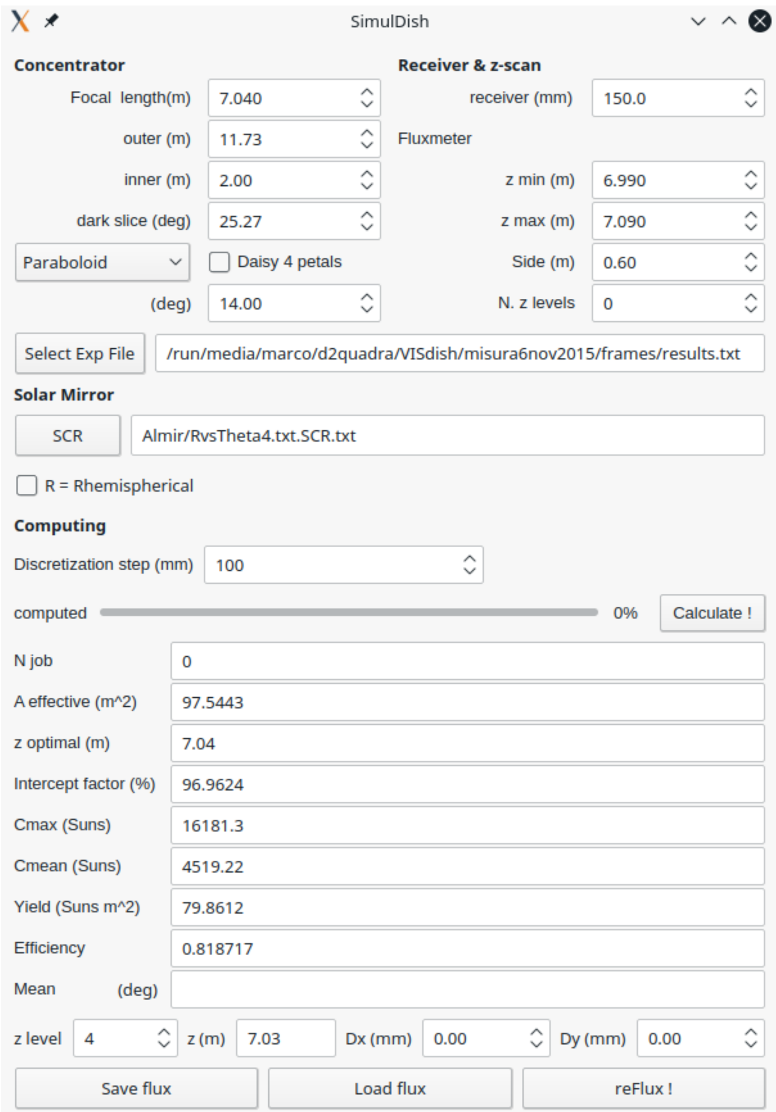
SCR(15 mrad)≈83%

(thin glass Ag > 95 %)

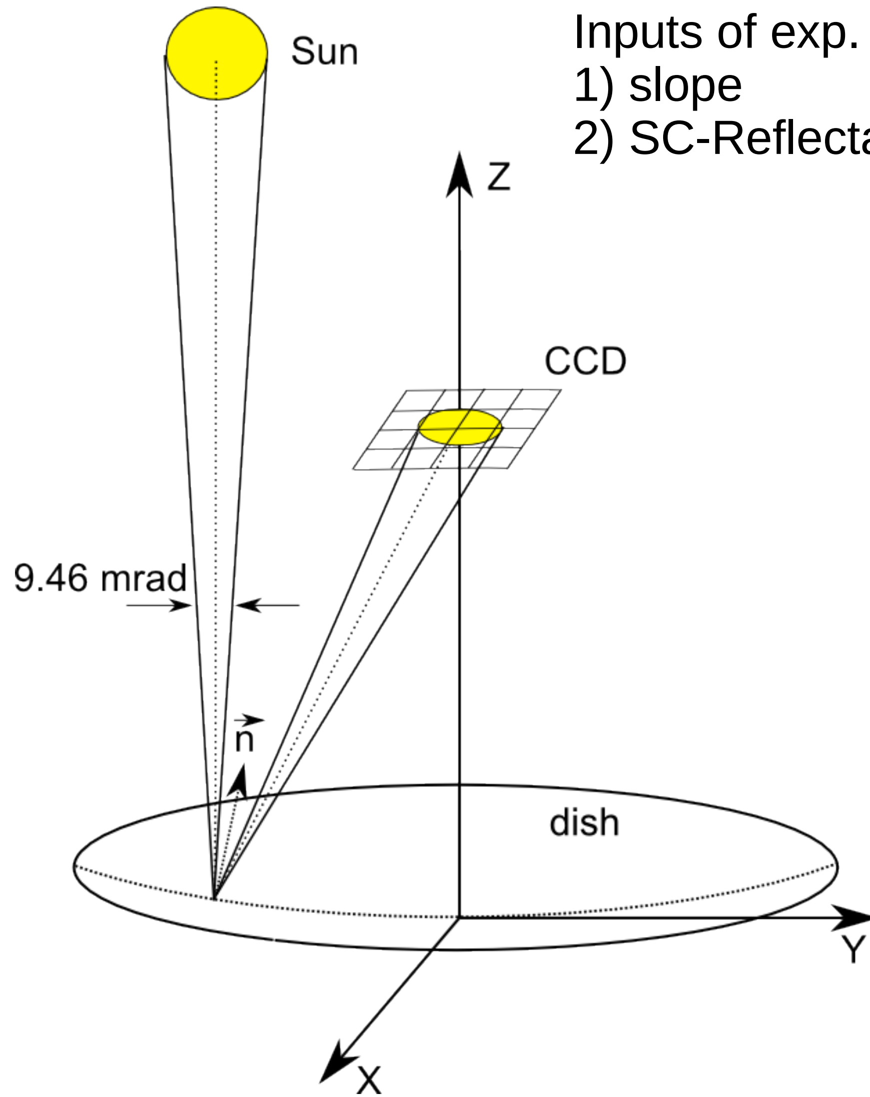
Large diffuse portion

4.3% beyond 20 mrad

SIMUL-DISH: simulation software



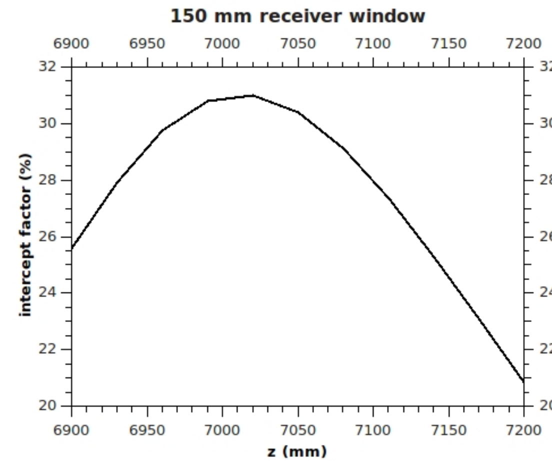
Inputs of exp. data:
1) slope
2) SC-Reflectance

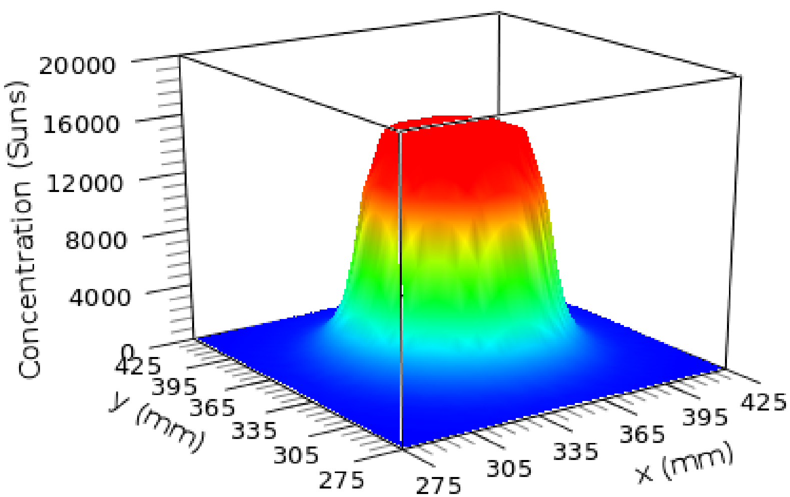


Results

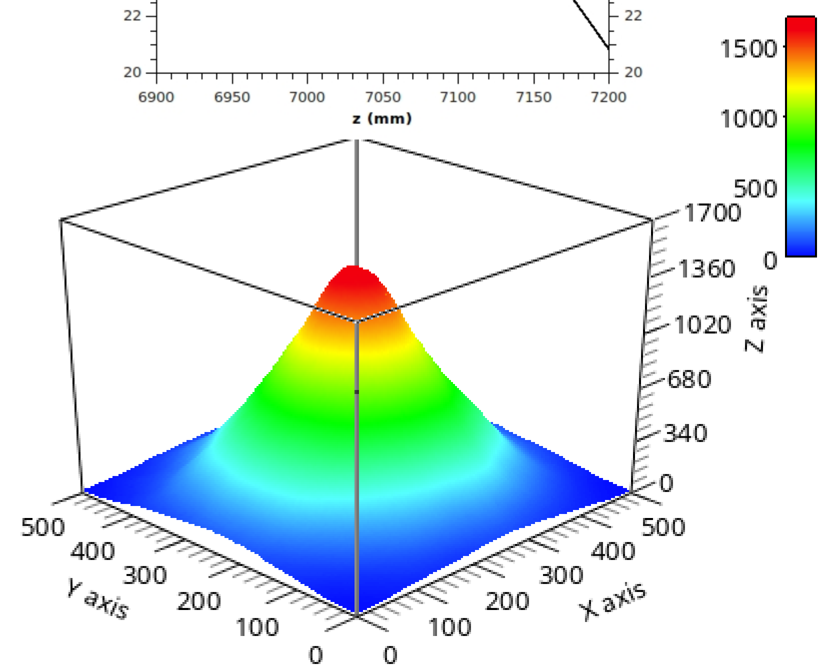
$$f = 7020 \pm 10\,\mathrm{mm}$$

$$IF_{150\,\mathrm{mm}} = 31.0\%$$





ALMIRR & **ideal shape**
Cmax ≈ 16˙000 Suns



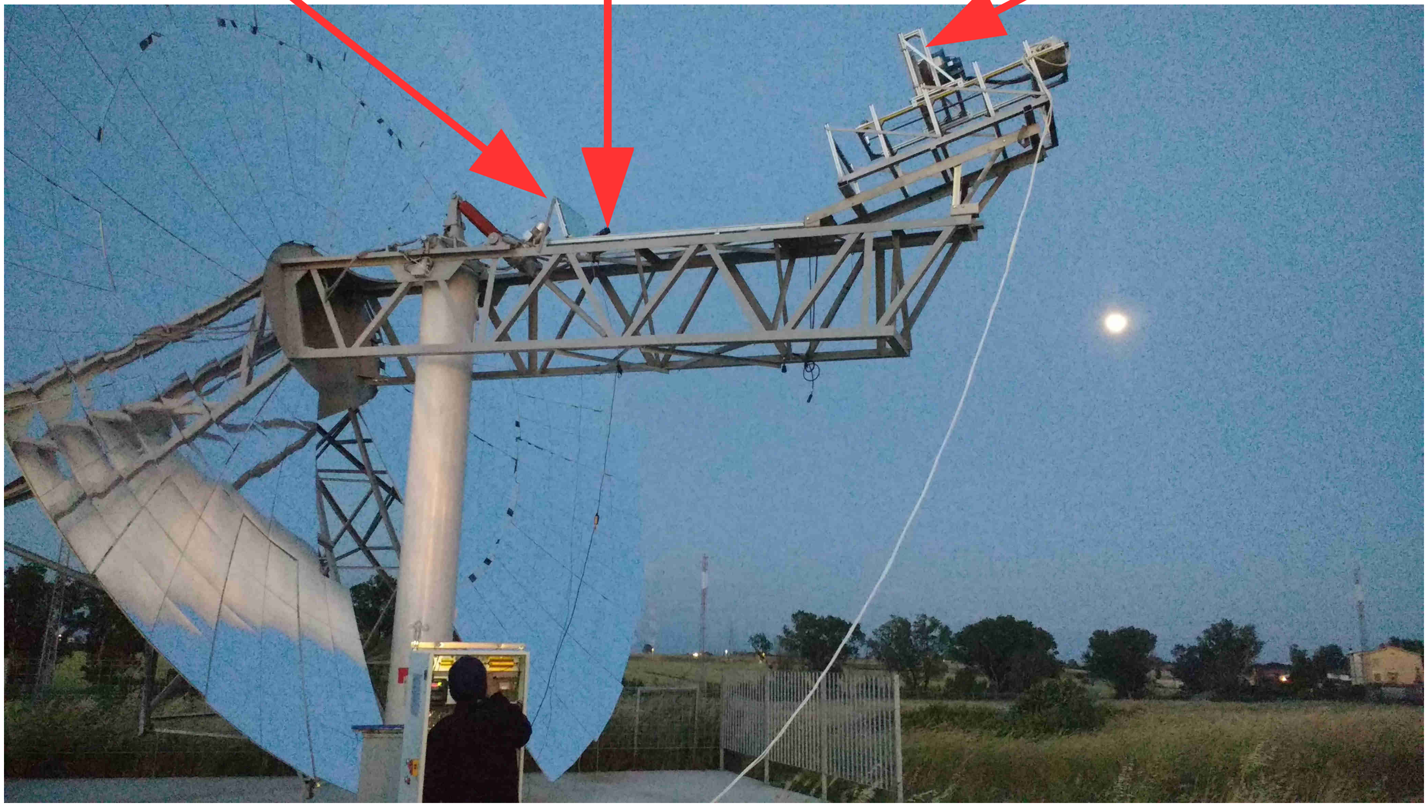
ALMIRR & **exp .slope by VISdish**
Cmax ≈ 1˙680 Suns

FluxMapper: experimental measurement of flux profile

Flat mirror (reference)
1 Sun

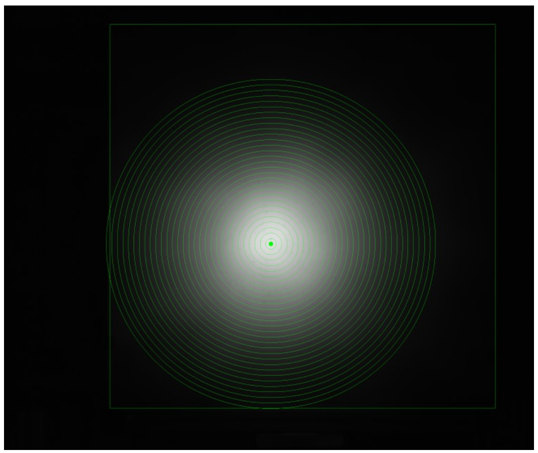
Camera Prosilica GT Allied Vision
2448×2050 pixels
14 bit depth
Nikkor 28 mm

Diffusive screen
Alumined copper
cooler
motorized

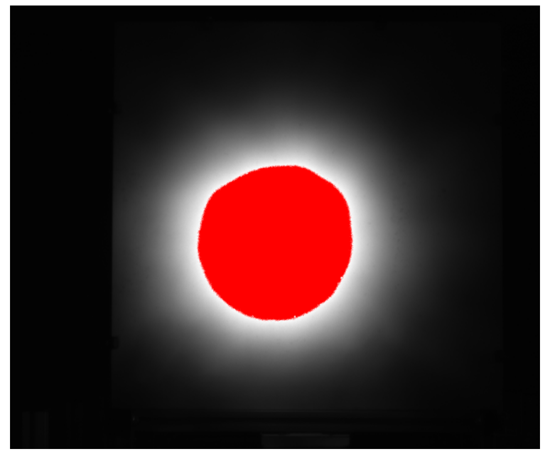


FluxMapper: Moon-tracking
20th May 2016 (99% lunar disc)

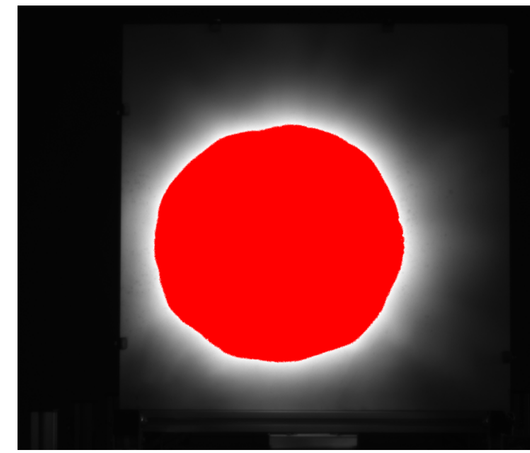
$$z = 7016 \pm 5\,\mathrm{mm}$$



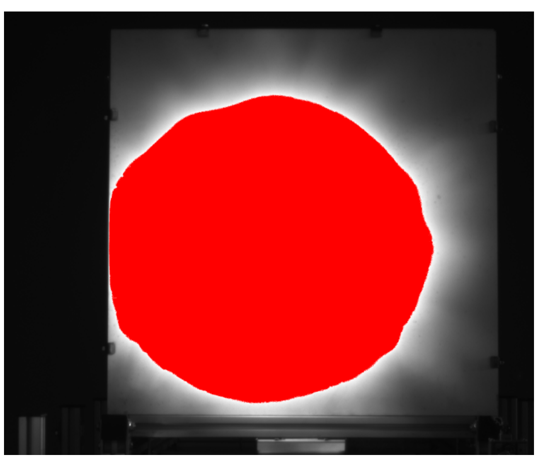
10 ms



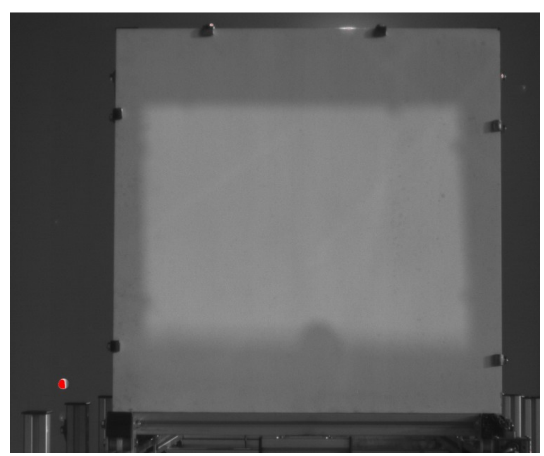
30 ms



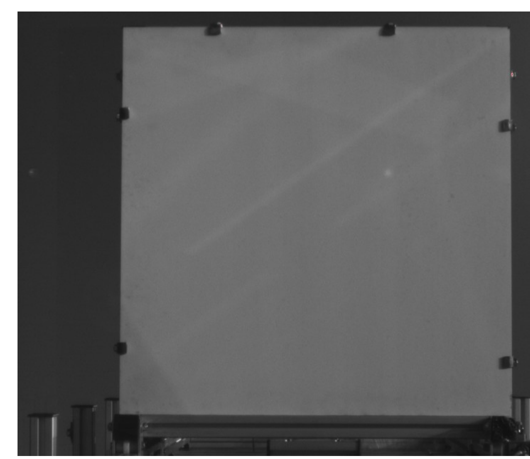
90 ms



270 ms



1 Sun at 270 ms



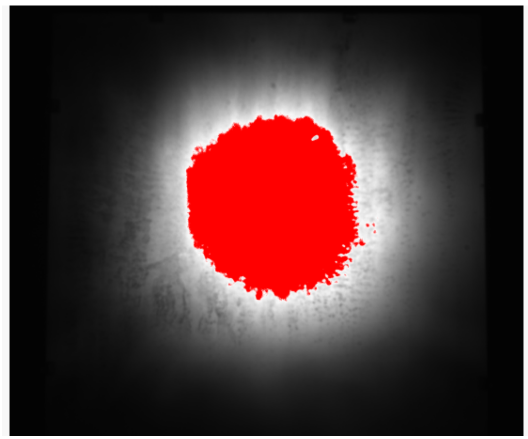
Background at 270 ms

FluxMapper + 10 Big stop Lee filter: Sun-tracking 17th May 2017

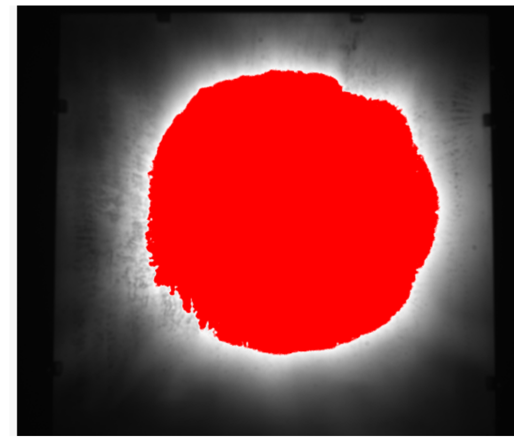
$$z = 7016 \pm 5\,\mathrm{mm}$$

Confirmed!!!!

1.4 ms

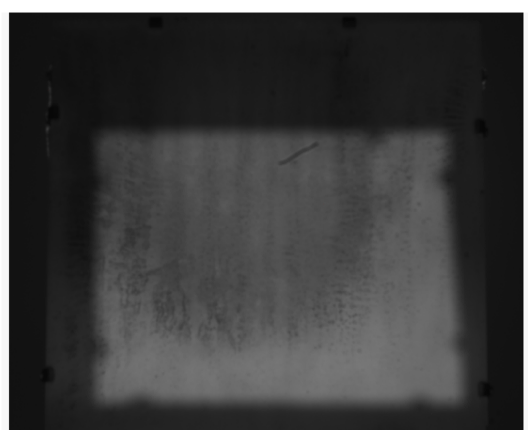


4.2 ms

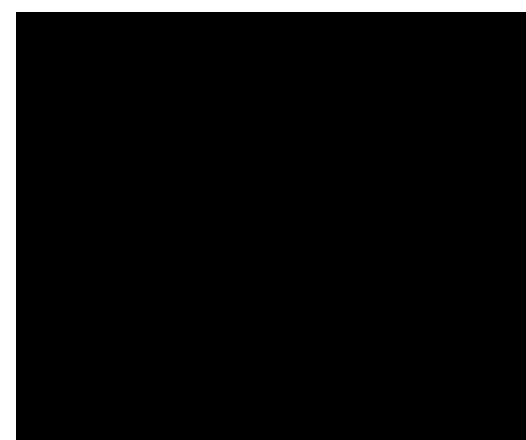


12.6 ms

37.8 ms

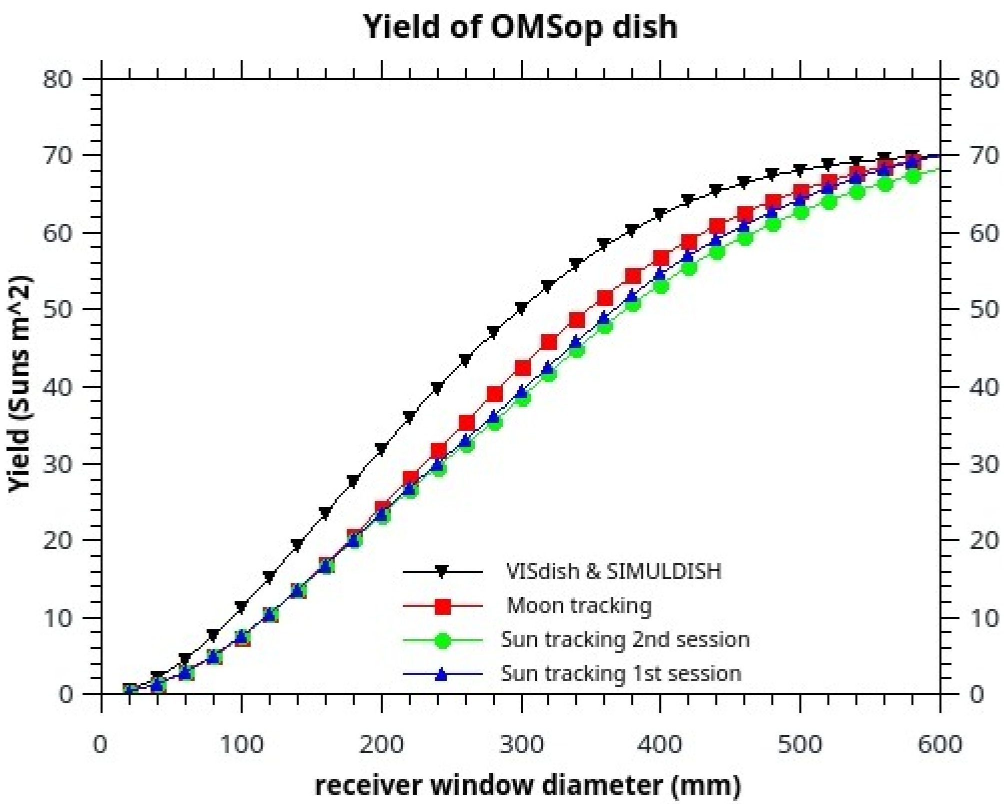


1 Sun at 340 ms



Background at 340 ms

Dish-yield from different methods



Experimental measurements with *Flux-mapper* give flux profile more spread than the simulated one based on *VISdish & SCReflectance*!

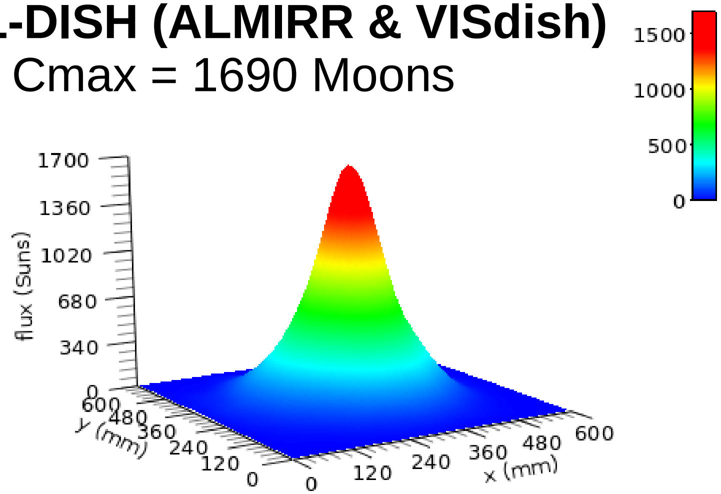
With DNI 800 Wm^{-2} , in a window of diameter 220 mm

Pin = 22.4 kW

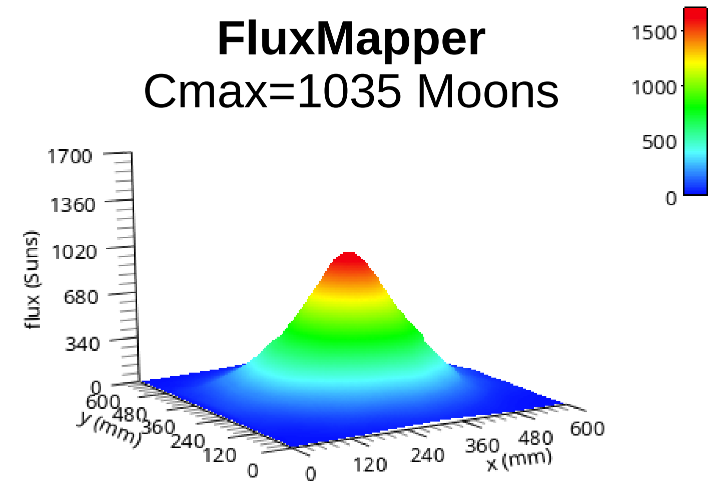
Pout = 33.6 kW

Flux profile comparison

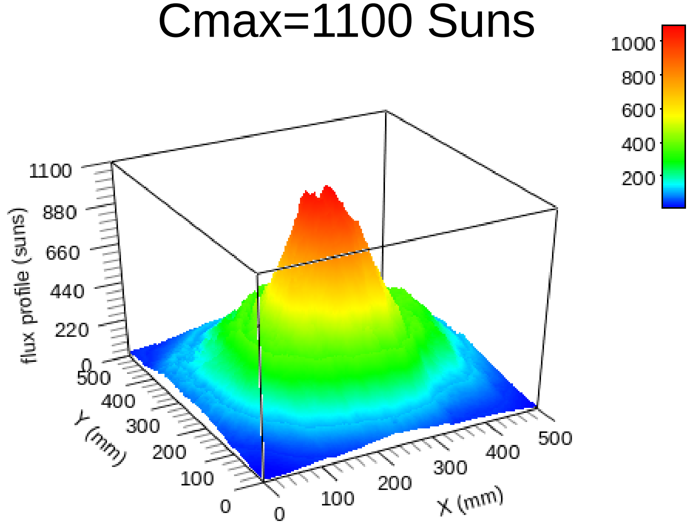
SIMUL-DISH (ALMIRR & VISdish)
Cmax = 1690 Moons



FluxMapper
Cmax=1035 Moons



FluxMapper
Cmax=1100 Suns



Results & Conclusions

- ✔ **<u>Optical axis</u> z e <u>focal length</u> (7020 mm) have been determined**
- ✔ **ALMIRR 303 SCReflectance was measured: SCR(15 mrad) ≈ 83%**
- ✔ **Facet-shape deviation was measured: $\sigma \approx 5.4$ mrad**
- ✔ **Flux-profile by simulation (VISdish&SCR&SIMUL-DISH): in 220 mm 28.9 kW**
- ✔ **Flux-profile by FluxMapper: in 220 mm 22.4 kW**
- **The low quality of facets of SCReflectance and <u>mainly of shape</u> greatly reduces the concentration performance of the OMSoP dish**
- **33.6 kW goes out 220 mm ⇒ shielding is needed**