Optical FFDP and Interferometry measurement and modeling of GNSS retroreflector payloads at SCF_Lab

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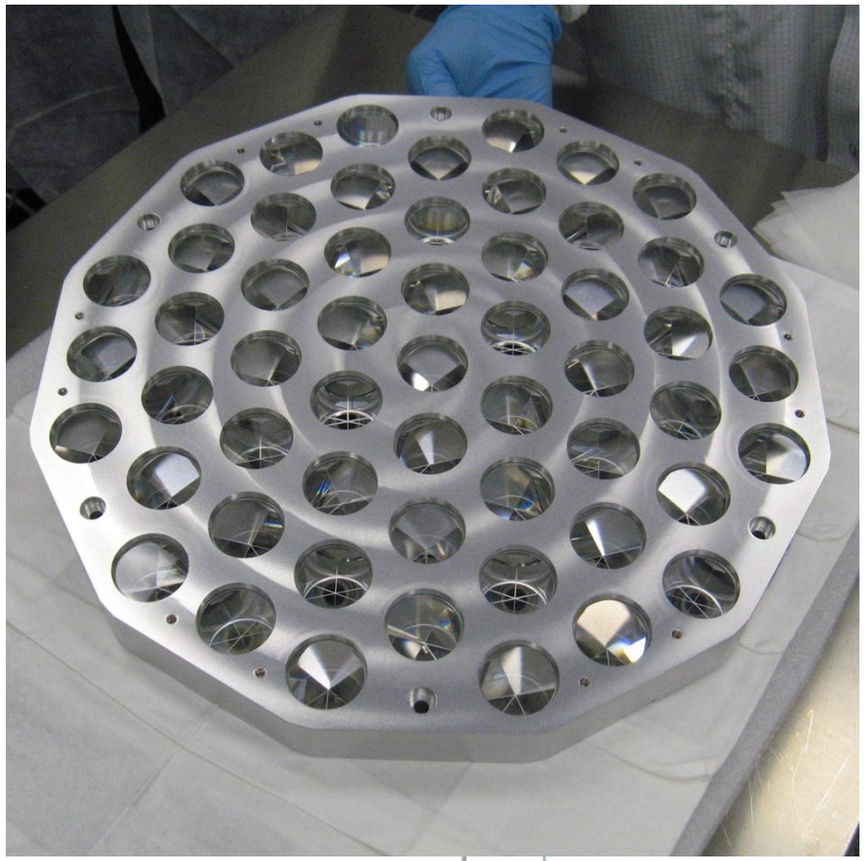
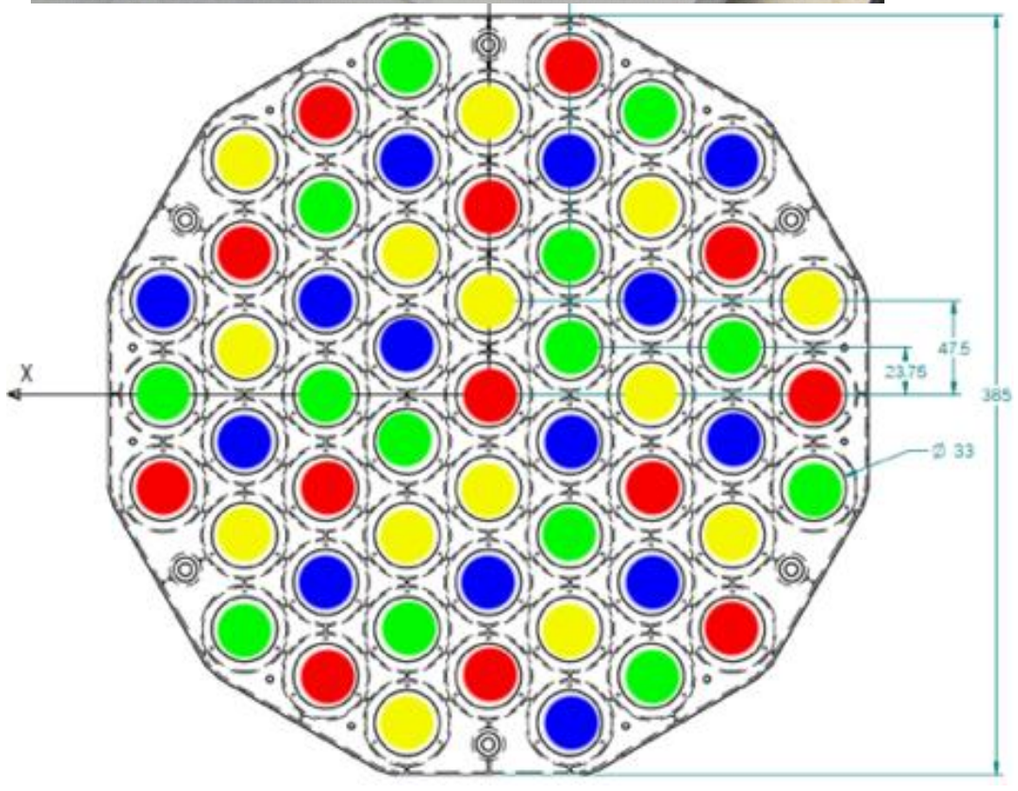
Outline

- GRA optical and mechanical design
- Orbital measurement at the SCF_Lab
- Galileo simulated orbit (GCO)
- ThermaOptiSim WP for ETRUSCO-2
- Optical simulations and comparison with measurements
- Comparison of linear and circular polarization
- Conclusions and future work

GNSS Retroreflector Array: GRA

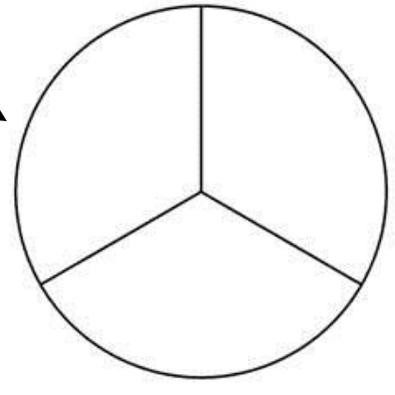




- 55 uncoated retroreflectors
- Fused Silica (Suprasil 1) CCRs with 33 mm front face diameter with DAO = 3 × (0.0’’ ±0.5’’)
- Aluminum base
- Quasi circular shape
- Four azimuth orientations

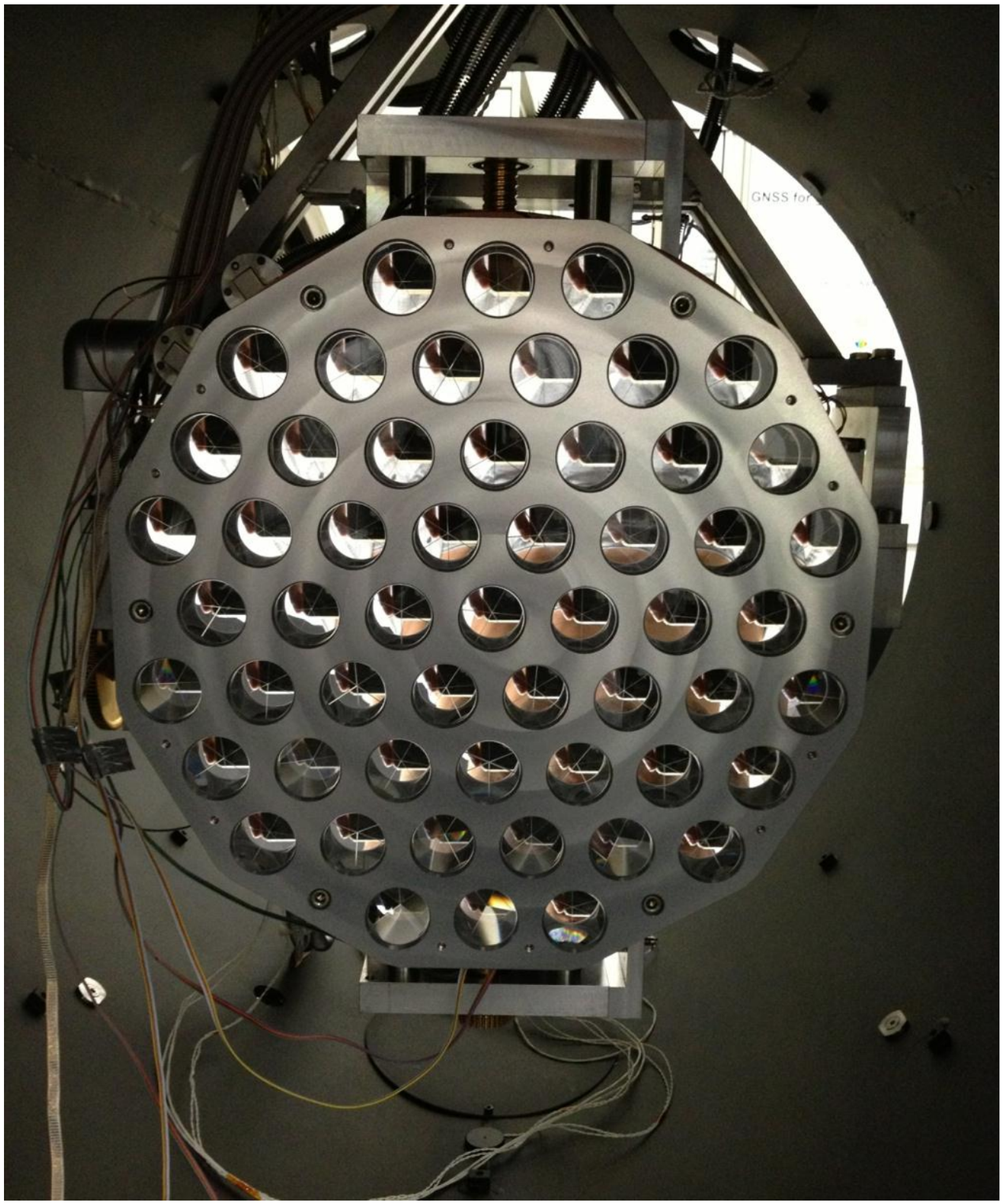
Clocking of CCRs orientation:

red=0º, green=30º, blue=60º, yellow=90º



DAO: Dihedral angle offset

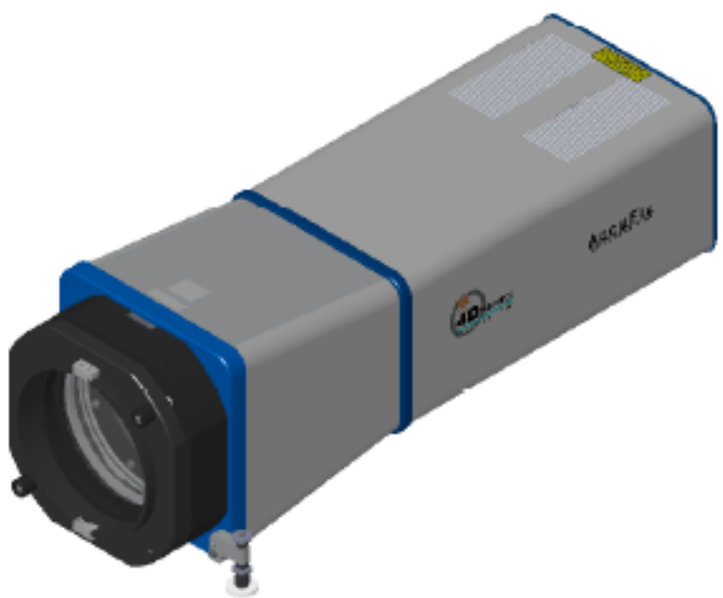
SCF-Test of the GRA at the SCF_Lab



SCF_Lab measurements

- Far Field Diffraction Pattern (FFDP) measurement in Air of all 55 CCR
- SCF-Test
- Simulated orbital measurement

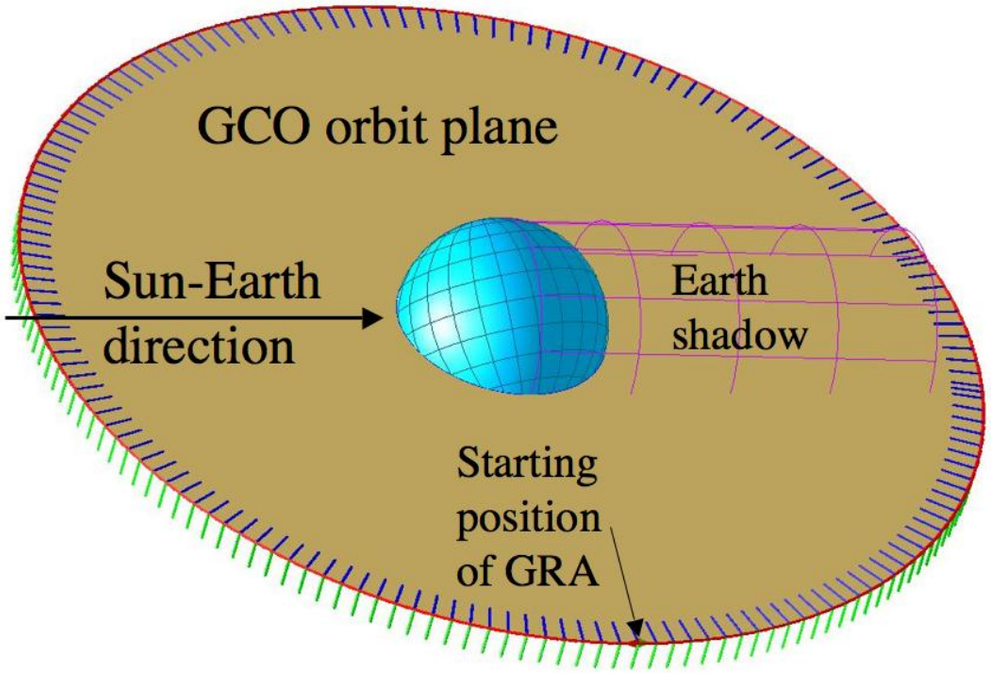
Introduced interferometric measurements from a commercial fizeau interferometer

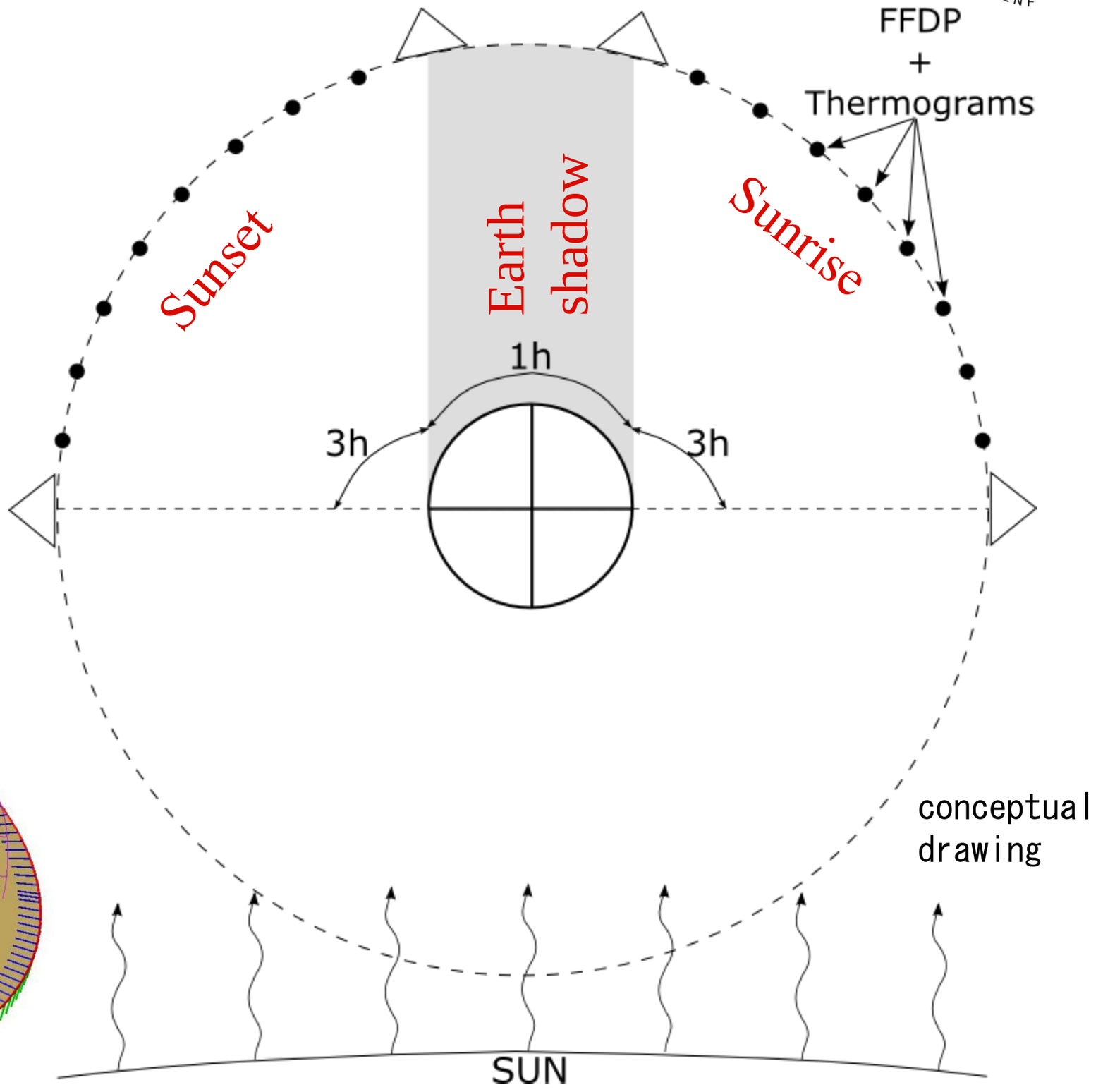


Lab-simulated GCO SCF-Test

SCF-testing of GNSS Critical half-Orbit (**GCO**) Sunrise-Eclipse-Sunrise probes critical features of the thermal and optical behaviour of the CCR

Galileo orbit:
- altitude = 23222km
- period ~ 14 h
- shadow time duration ~1h (cylindrical approximation)



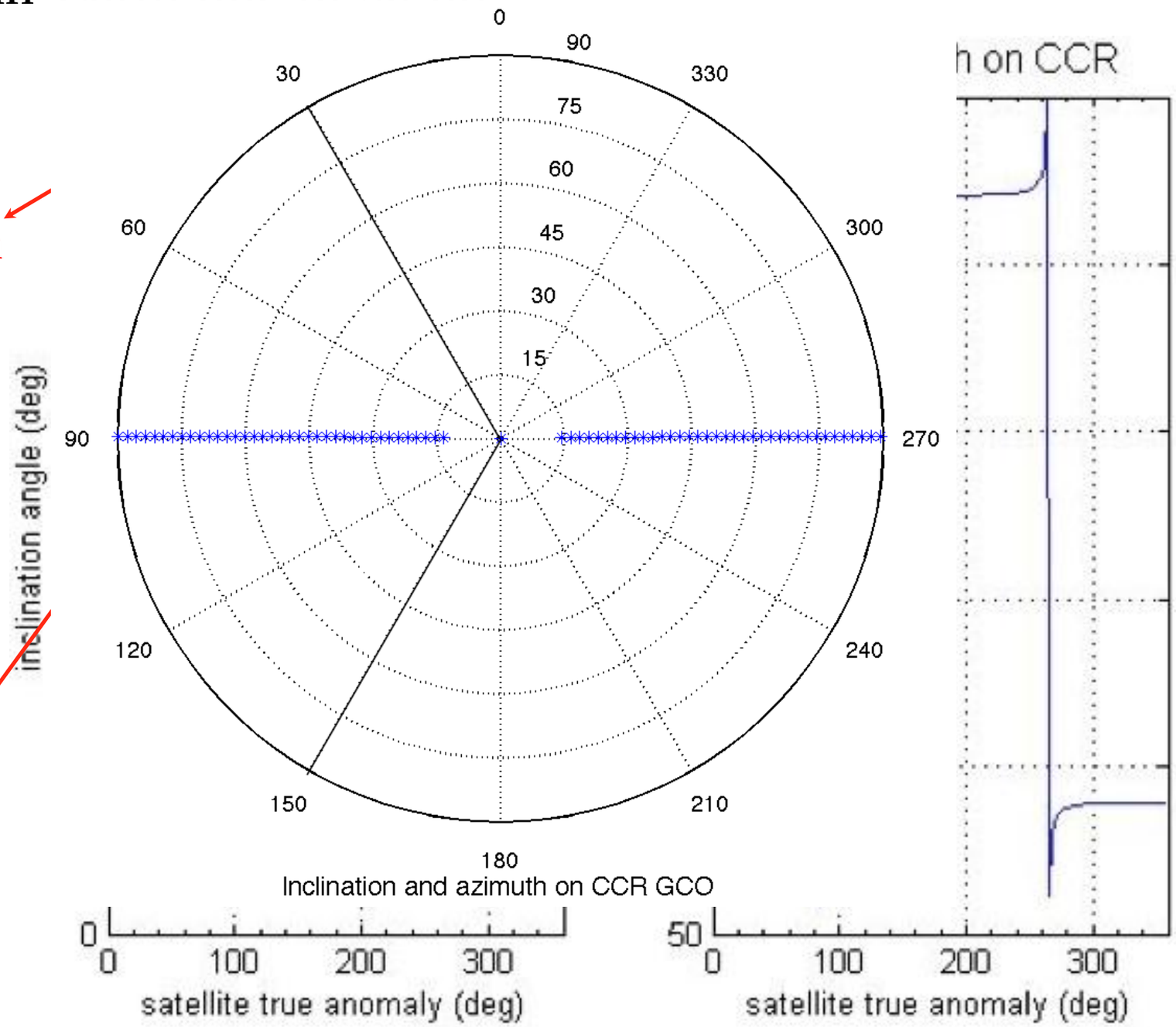


GCO trace on CCR front face

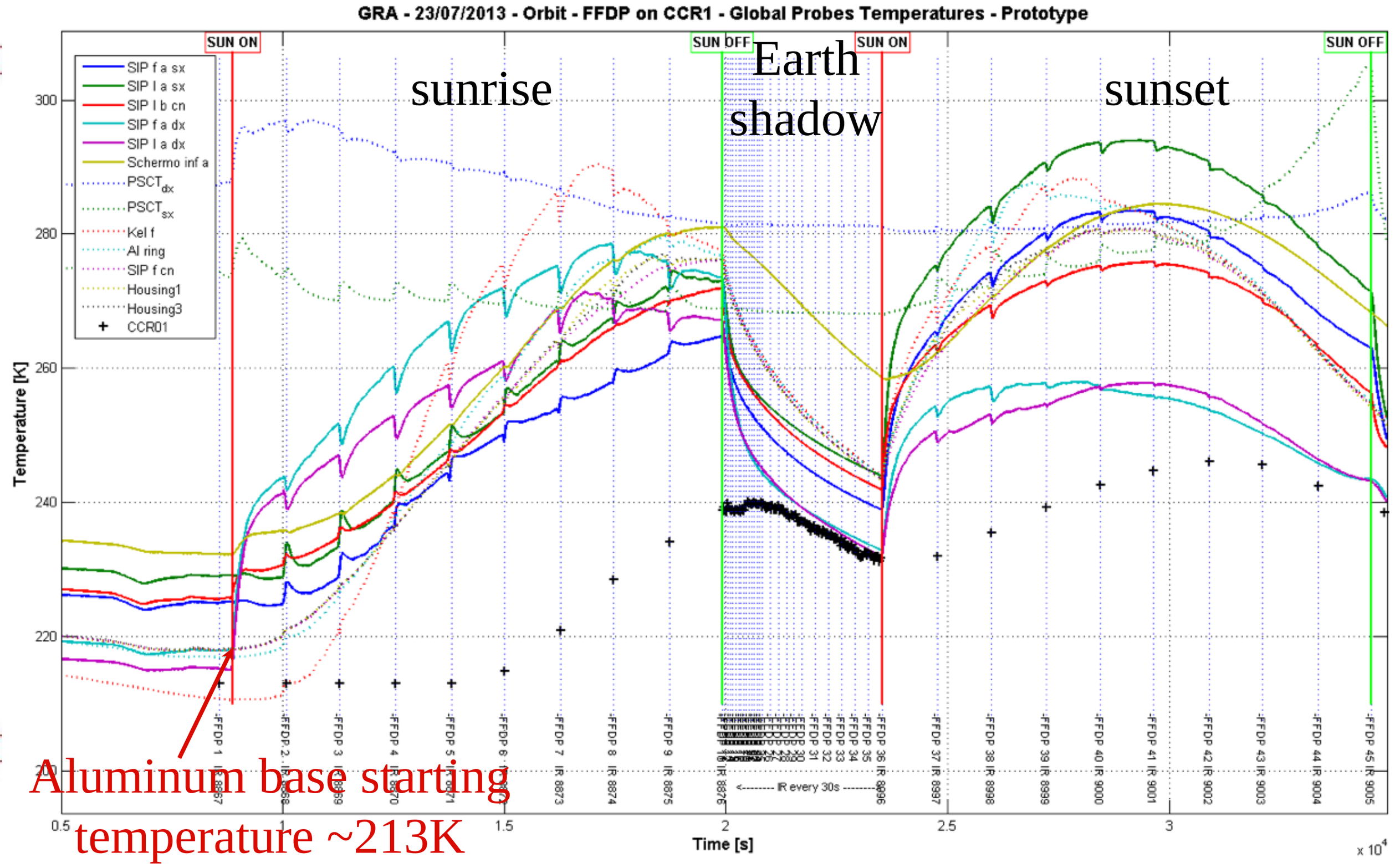
GCO (GNSS Critical Orbit) is the orbit whose angular momentum is orthogonal to the Sun-Earth line of sight

CCR enters the Earth shadow

Sun behind the satellite

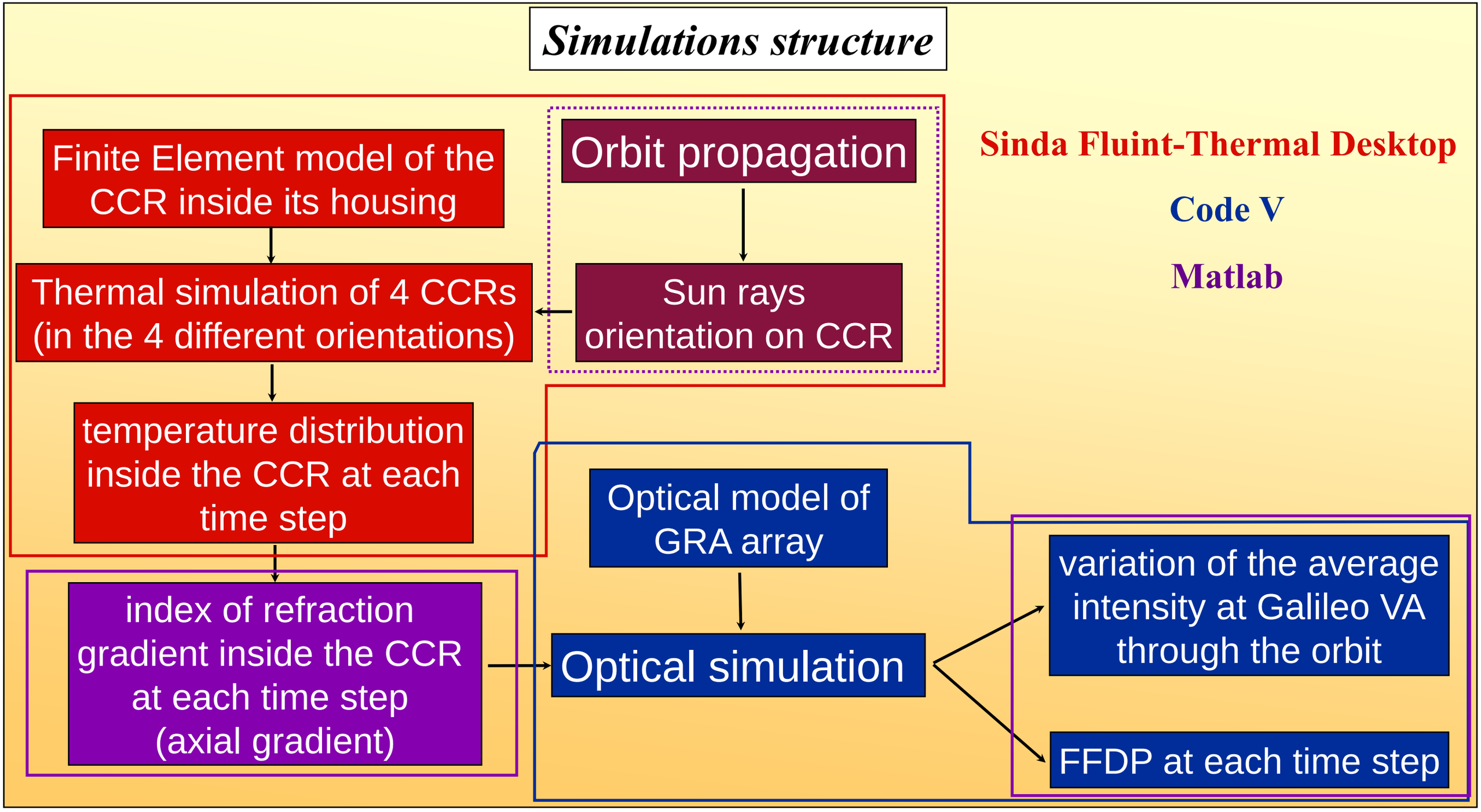


GCO SCF-Test

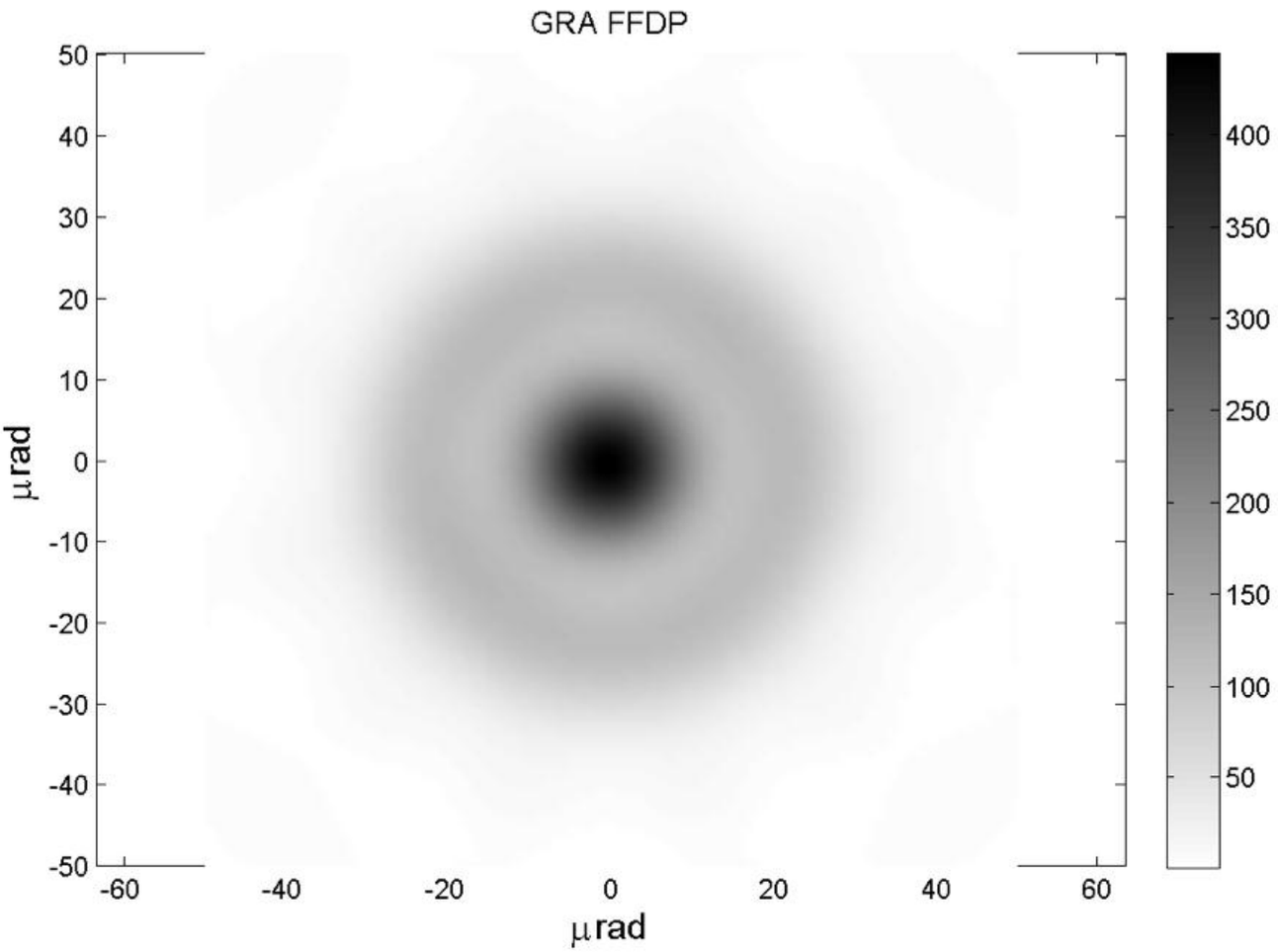

GRA - 23/07/2013 - Orbit - FFDP on CCR1 - Global Probes Temperatures - Prototype
SUN ON
SUN OFF
SUN ON
SUN OFF
sunrise
Earth shadow
sunset
SIP f a sx
SIP l a sx
SIP l b cn
SIP f a dx
SIP l a dx
Schermo inf a
PSCT dx
PSCT sx
Kel f
Al ring
SIP f cn
Housing1
Housing3
CCR01
Temperature [K]
300
280
260
240
220
200
0.5
1
1.5
2
2.5
3
Time [s]
x 10^4
IR every 30s
Aluminum base starting temperature ~213K

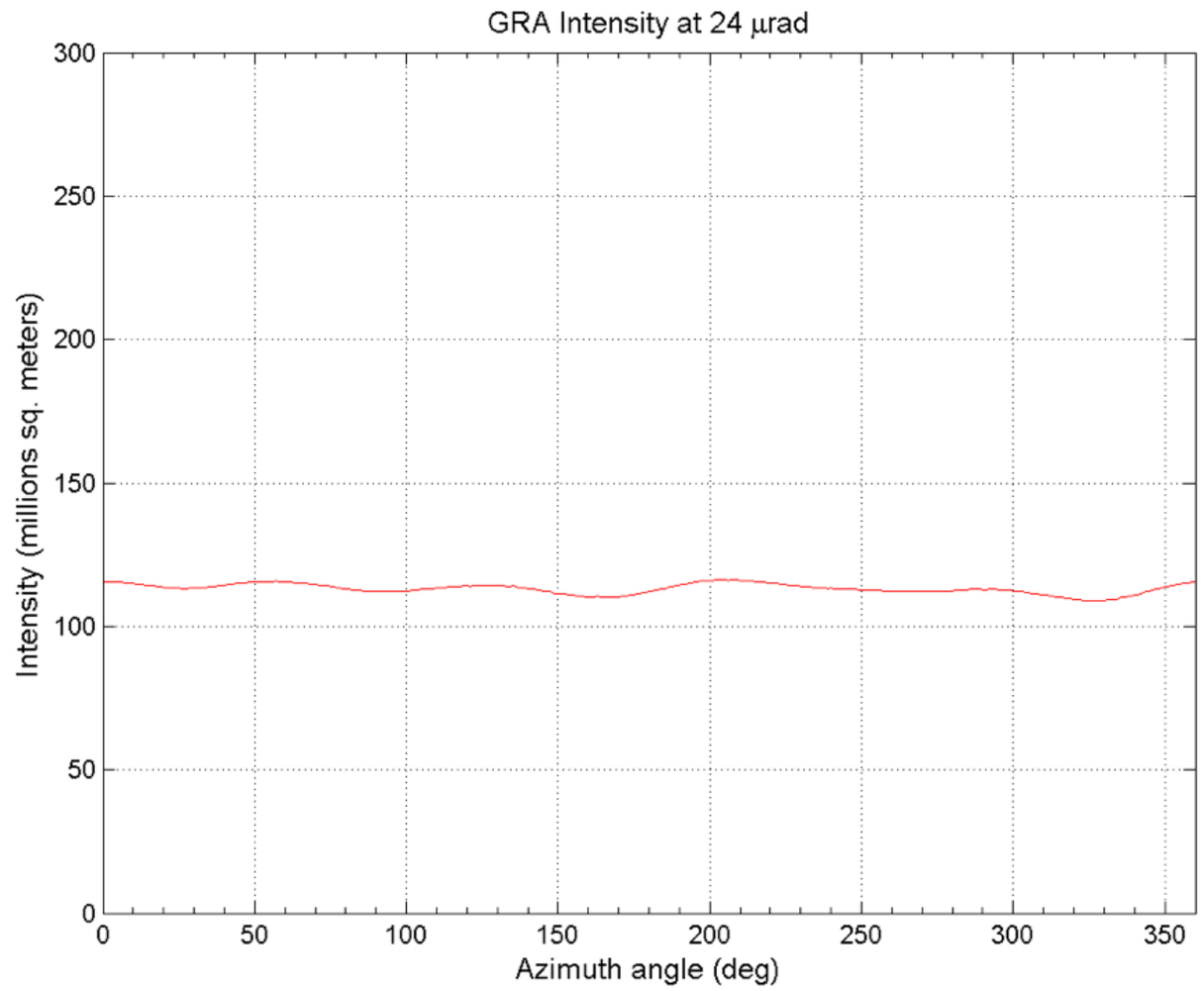
ThermaOptiSim

Thermal and optical properties are closely connected in the analysis of CCRs performance.



GRA FFDP simulation



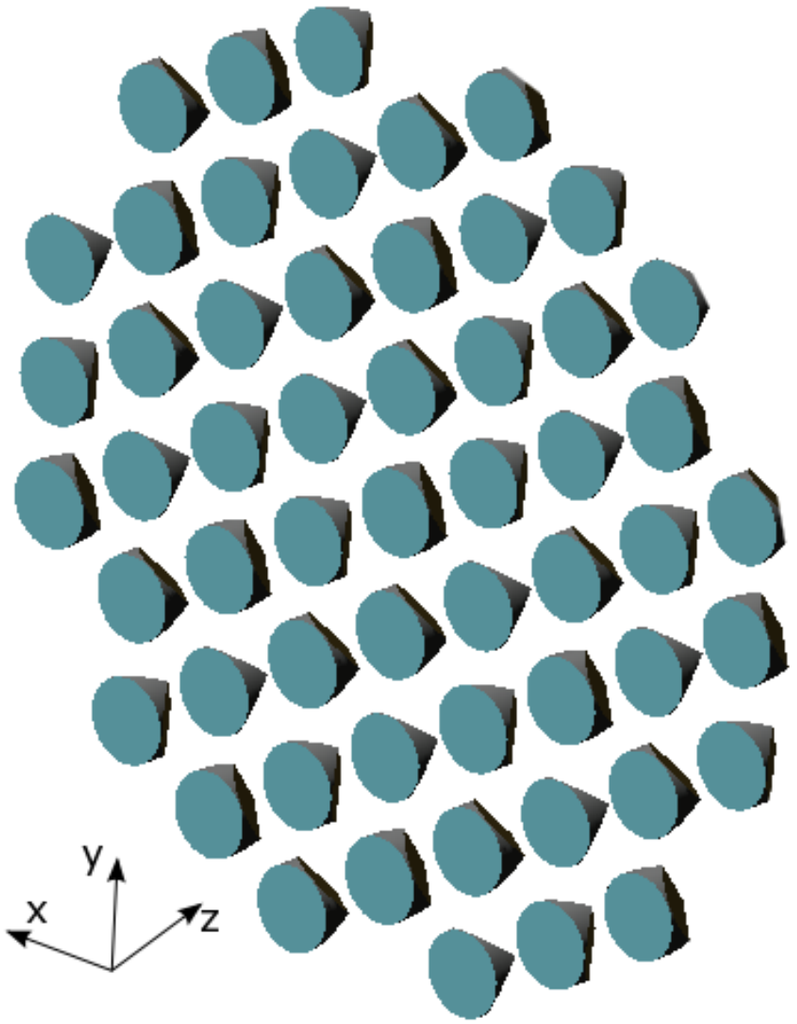


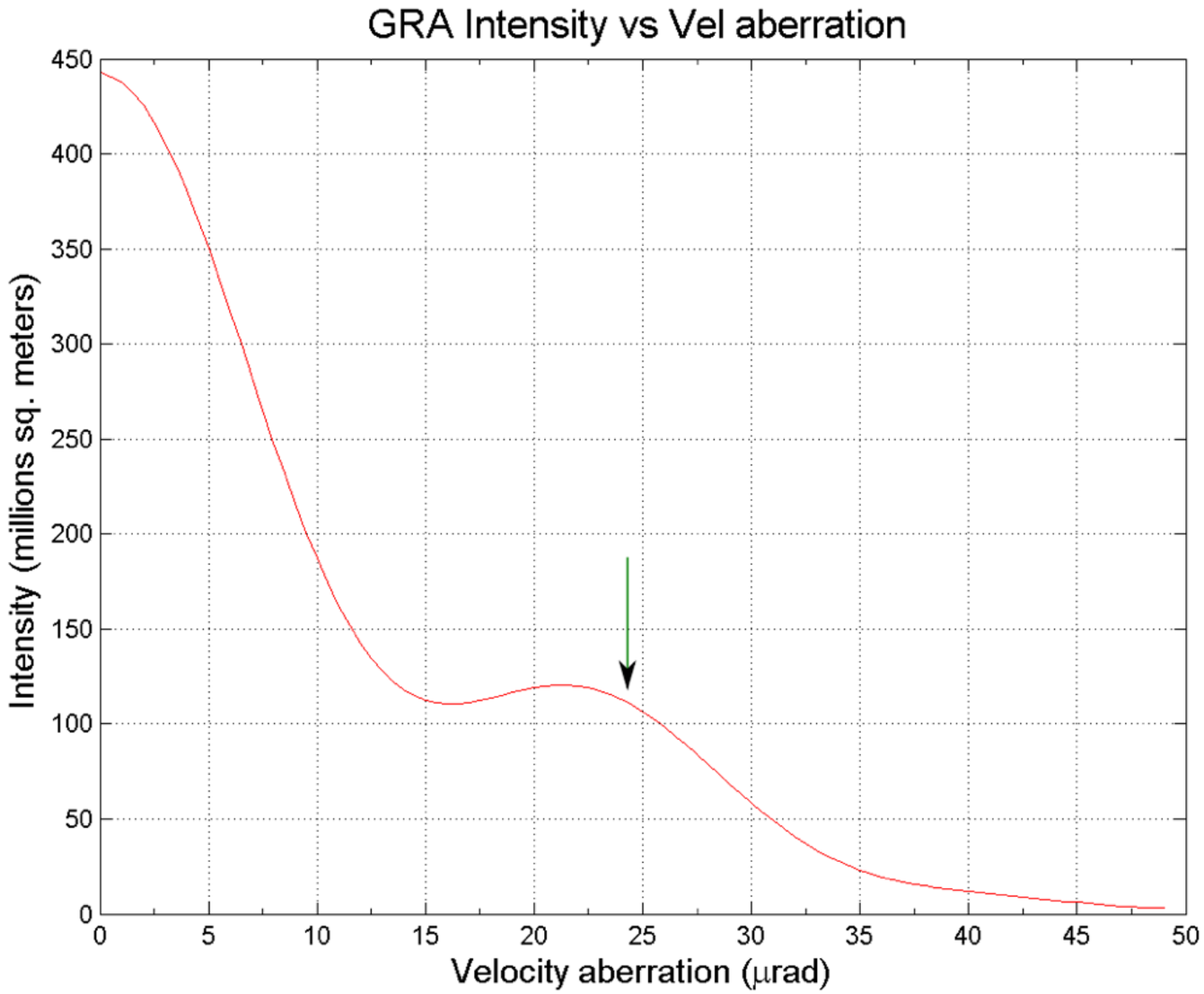
- 33 mm circular front face aperture
- CCR with DAO = 3 × (0.0’’ ±0.5’’)
- velocity aberration ~24 μrad (Galileo IOV value)
- λ=532 nm
- horizontal polarization
- Intensity (Optical Cross Section) in 10^6 m^2 units

$$GRA\ FFDP\ Intensity = 113 \cdot 10^6 m^2$$

IOV: In Orbit Validation

GRA optical model in CodeV

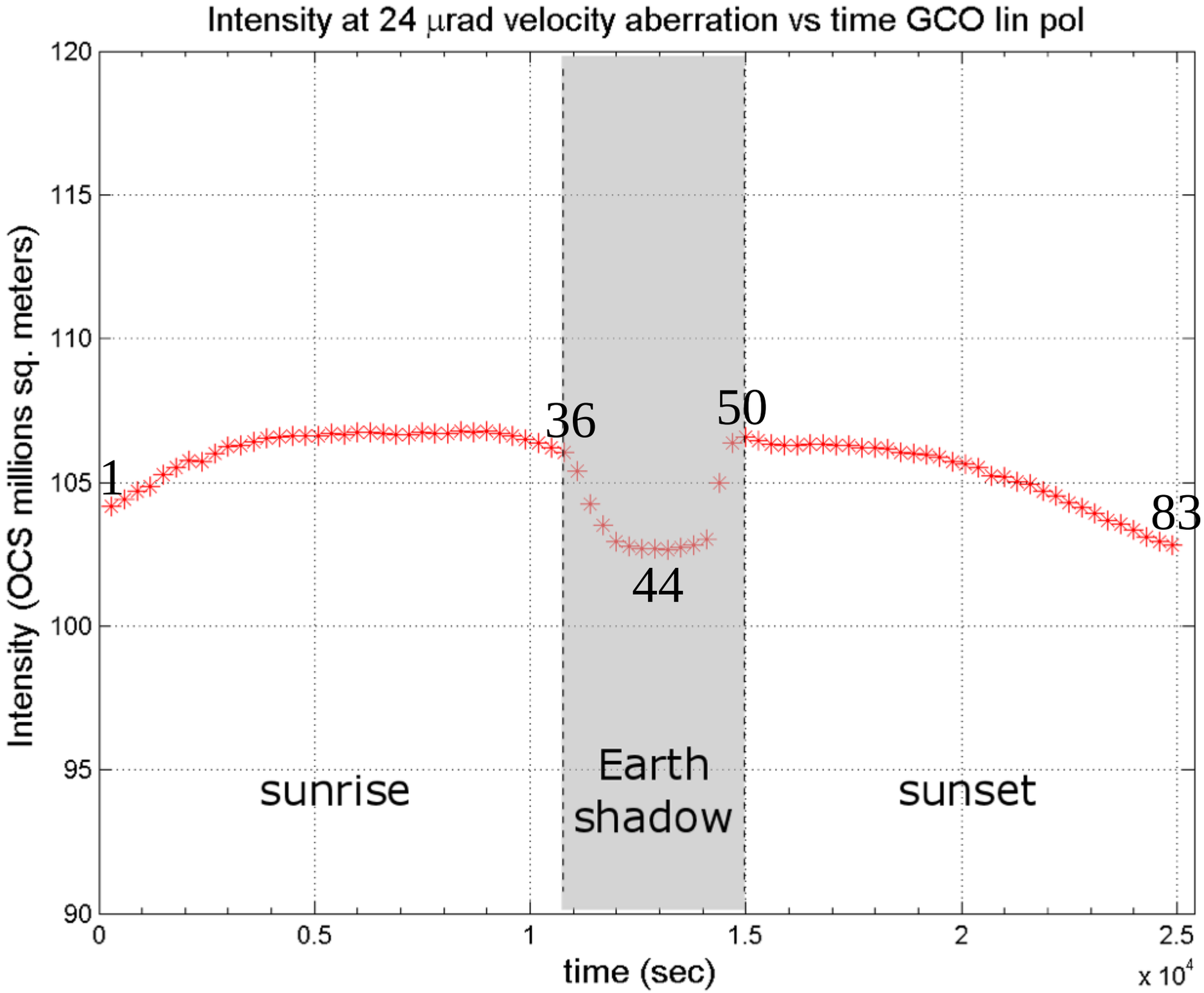




$$n(z) = a_0 + a_1 z^4 + a_2 z^3 + a_3 z^2 + a_4 z$$

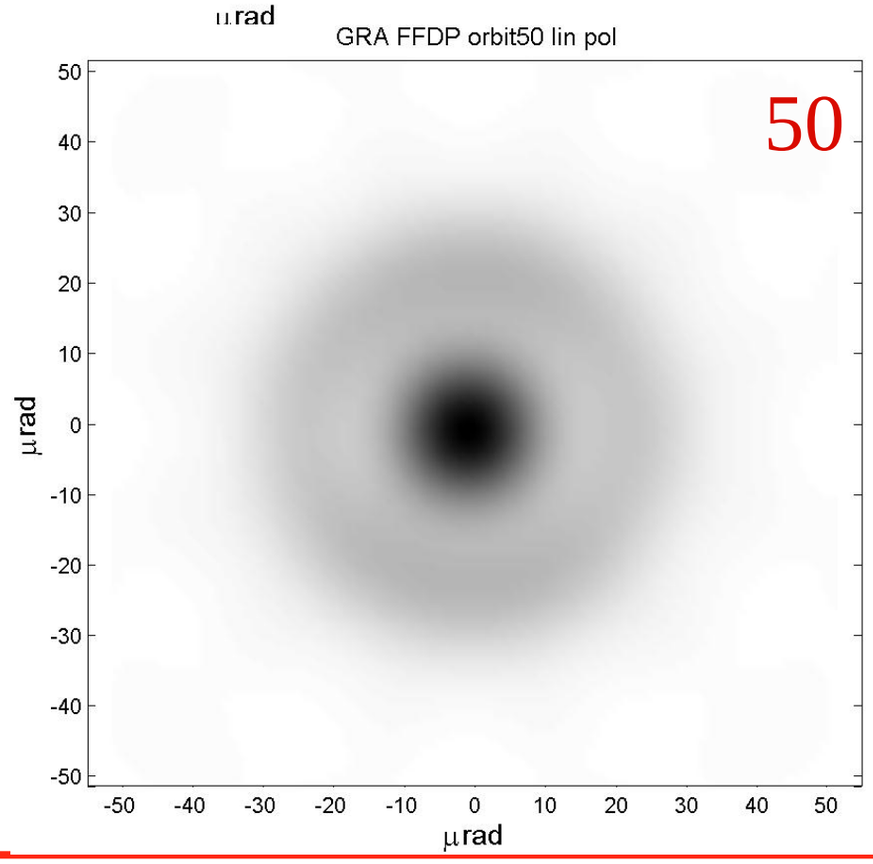
Introduced in each CCR the thermal perturbation and simulated the FFDP for each time step. Output is the evolution of average intensity over the orbit.

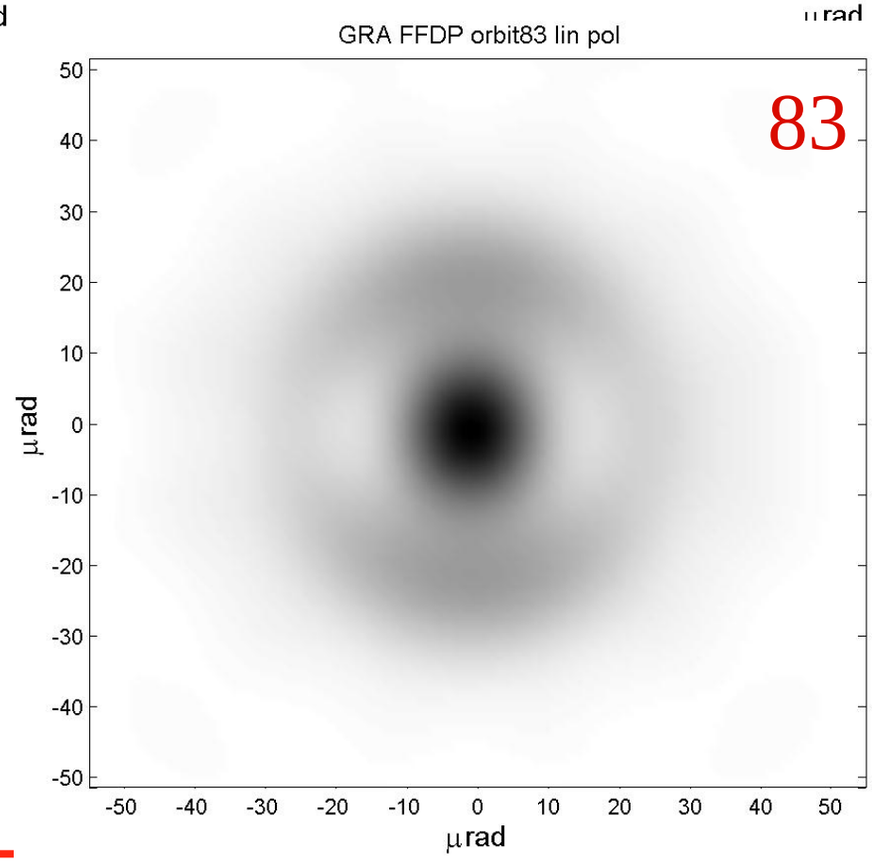
GRA GCO simulated optical behaviour



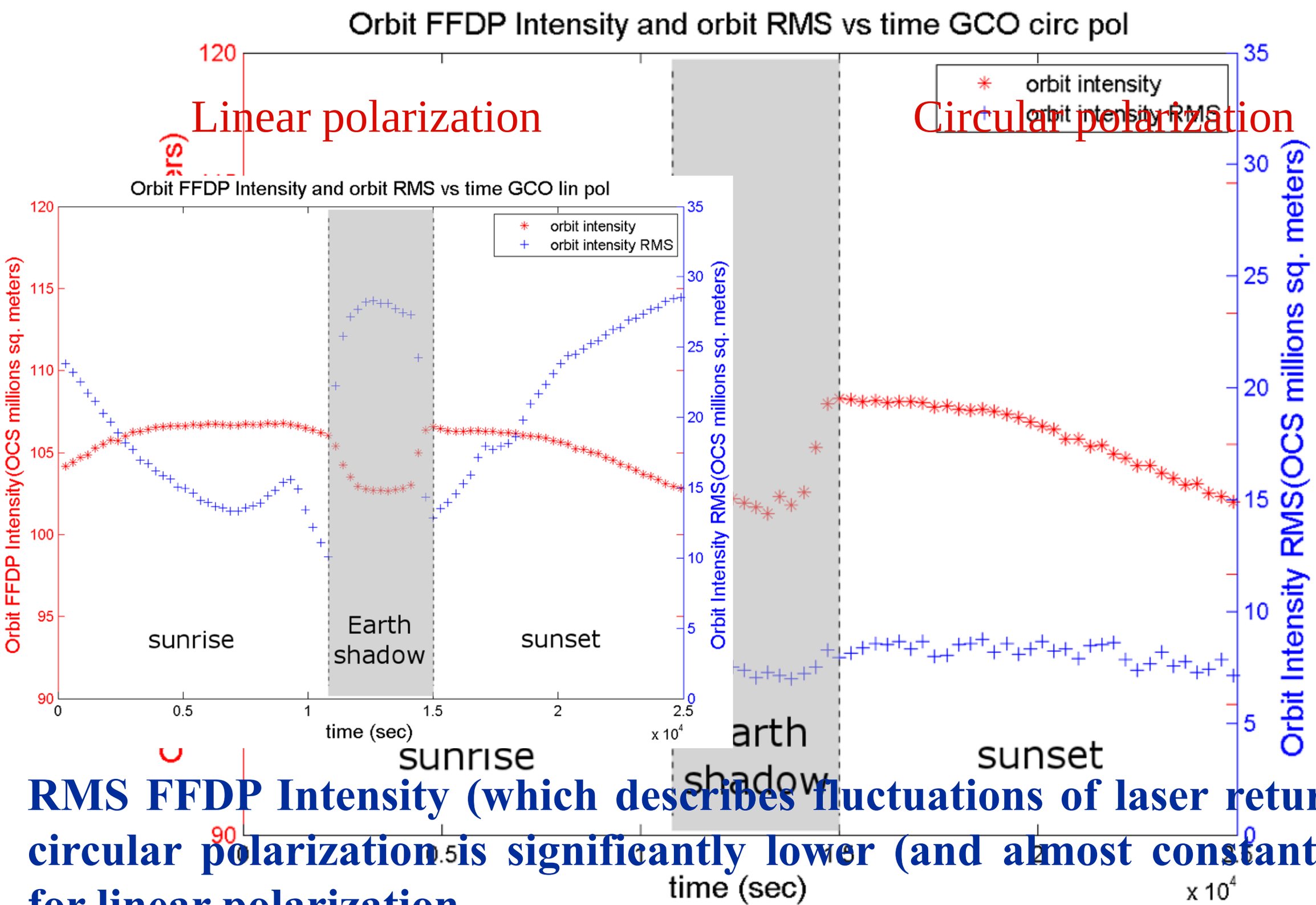
green laser, orthogonal to CCRs front face, linear polarization

GRA simulated FFDP variation





Linear vs Circular polarization



RMS FFDP Intensity (which describes fluctuations of laser return) for circular polarization is significantly lower (and almost constant) than for linear polarization

Conclusions and future work

• Completed a full SCF-Test campaign of the GRA.

• Integrated thermal/optical simulations describe single-CCR and GRA behaviours in orbit. Preliminary model in good progress.

• Laboratory measurements drive a fine tuning of thermal-optical simulations.

• Enhancements of modeling.
- GRA finite element model.
- Introduction of a more general thermal gradient in CodeV model
- Test the effect of different laser inclinations
- Different orbits other than GCO (no Earth shadow, low Sun rays inclination..)

• Simulations show a benefit, in terms of intensity RMS, of a circular polarized laser beam.

Thank you for your attention.

Any question?

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