# SCF-Test of the NASA-GSFC "LAGEOS Sector" and of a Hollow Retroreflector

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# Outline

- ETRUSCO INFN experiment
- SCF (SLR/LLR Characterization Facility)
- SCF-Test of the NASA-GSFC LAGEOS engineering model
  - measurement layout
  - integrated thermal and optical analysis
- SCF-Test of the NASA-GSFC Hollow CCR
  - measurement layout
  - integrated thermal and optical analysis
- Conclusions

# ETRUSCO (INFN) and ETRUSCO-2 (ASI-INFN)

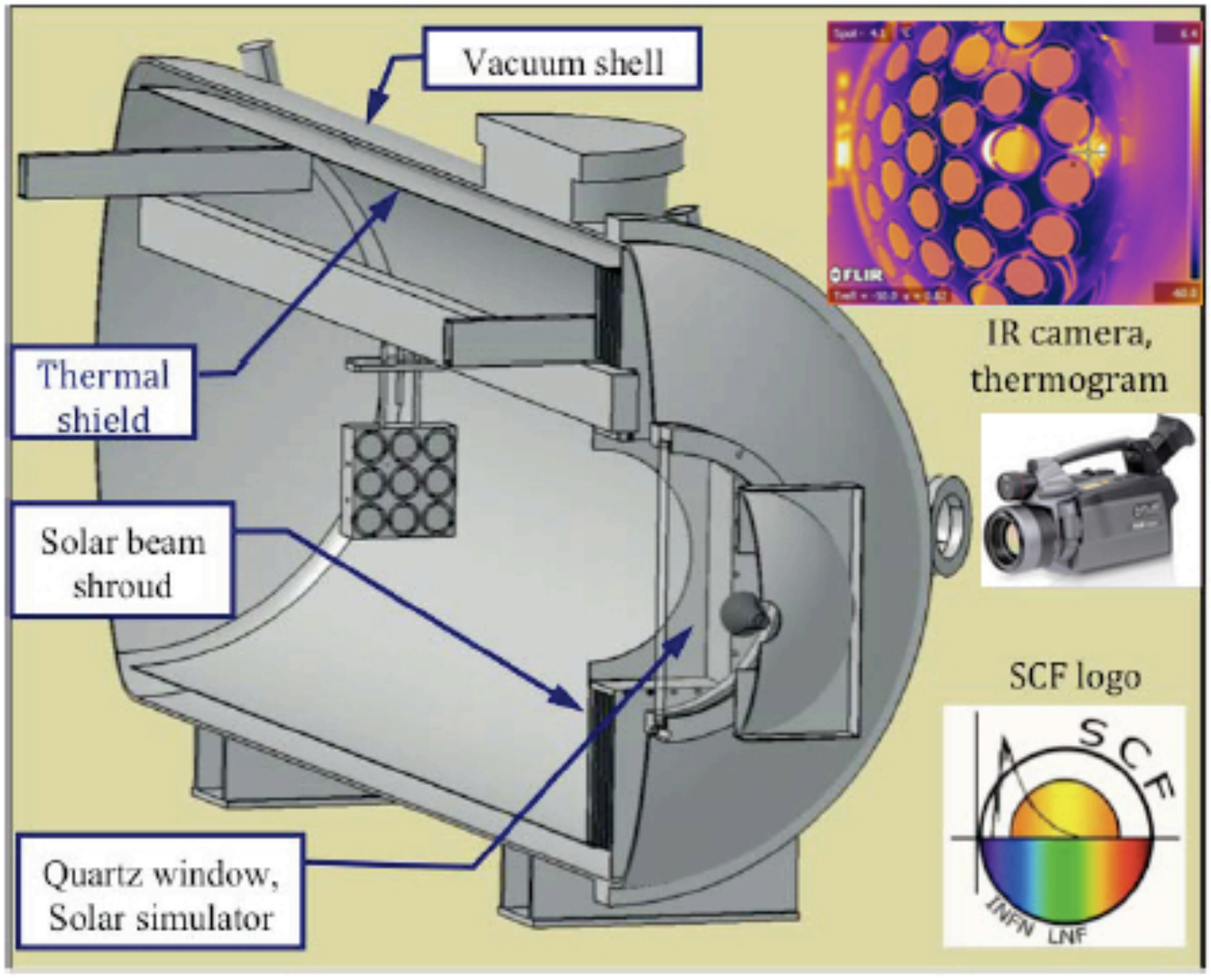
Activity started in 2005

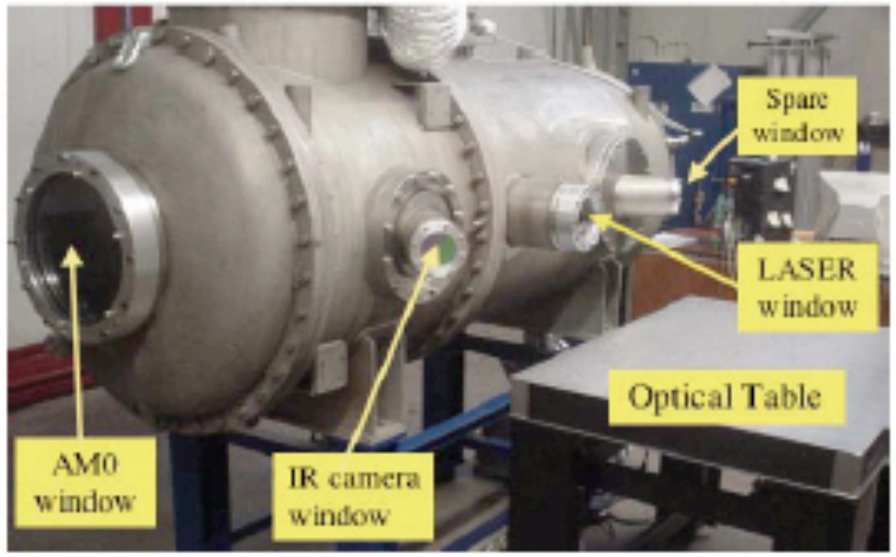

ETRUSCO developed within ILRS

# ETRUSCO program

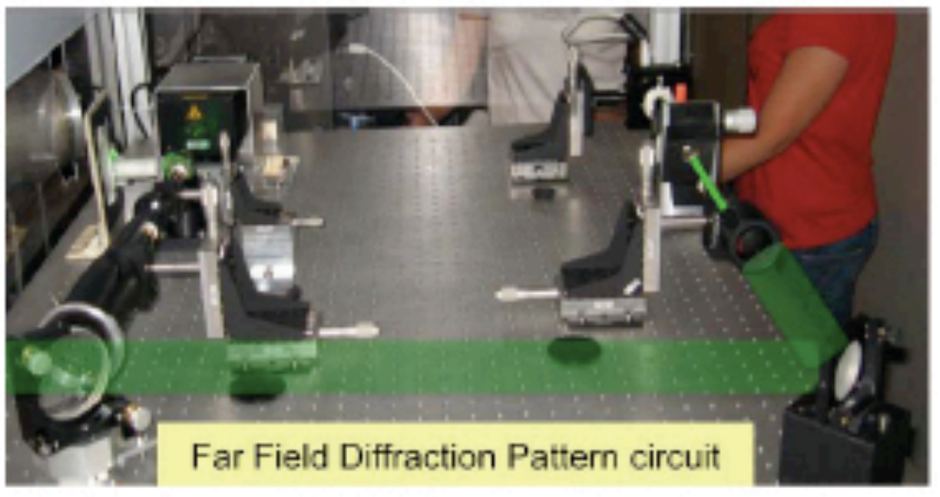
- 2005-2006: construction of SCF
- 2007-2008: development of a new industry-standard space test characterization of laser retroreflectors, the SCF-Test
- 2007-2008: SCF-Test of GPS-2 flight model and of Glonass prototypes
- GPS-3: R&D with NASA-GSFC on innovative hollow CCRs
- 2009: SCF-Test of the NASA-GSFC LAGEOS engineering prototype ("Sector")
- 2010: SCF-Test of the NASA-GSFC hollow CCR

# SCF(SLR/LLR Characterization Facility)




Optical circuit




Integrated and concurrent thermal and optical measurements in space like environment

# LAGEOS engineering model SCF-Test

# Measurement layout

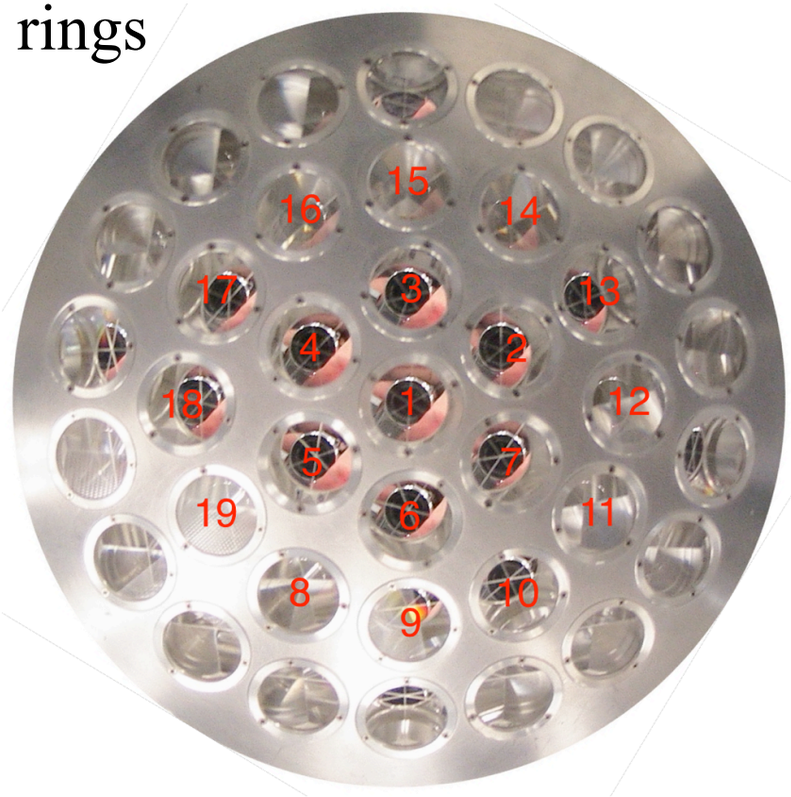
LAGEOS sector was installed inside the SCF, on the rotation+tilt positioning system, controlled in temperature by an interface copper plate. Temperature sensors recorded sector temperature, while the IR camera measured CCRs' front face temperatures.

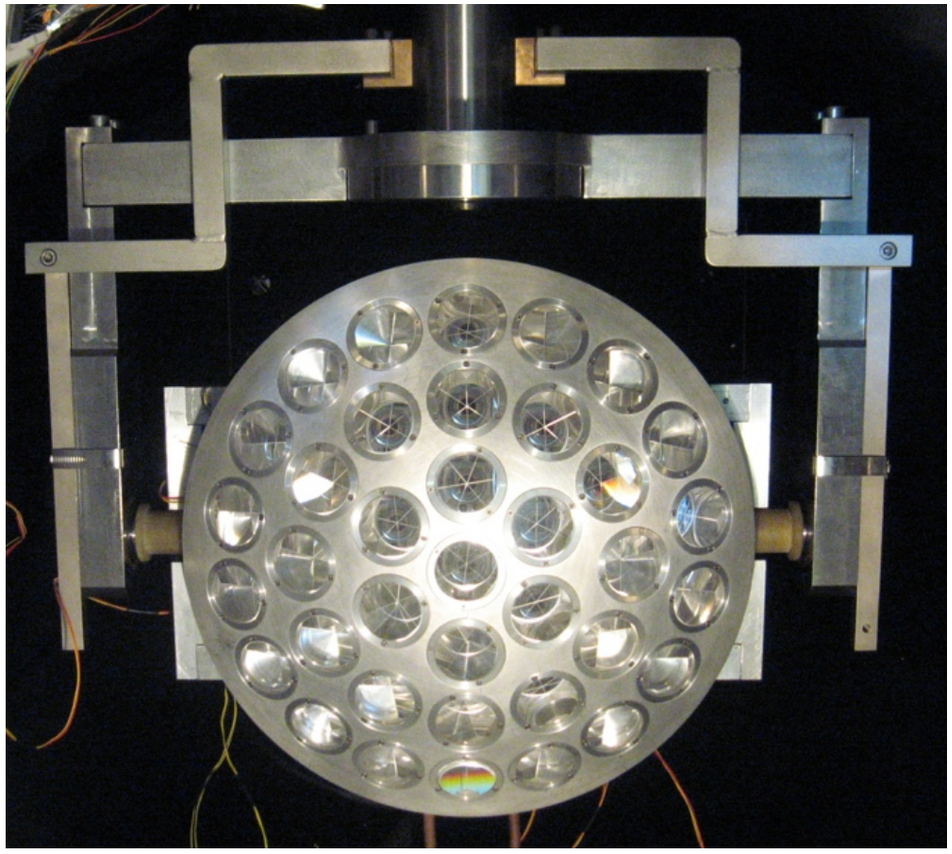
Measurements were performed in several conditions:

- Sector @ 300K. Polar CCR inside its housing at two different torques of the screws of the aluminum retainer ring: 0.135 N·m (LAGEOS nominal value) and 0.2 N·m
- Screw torque=0.2 N·m. Sector held at different temperatures: 280K, 300K and 320K

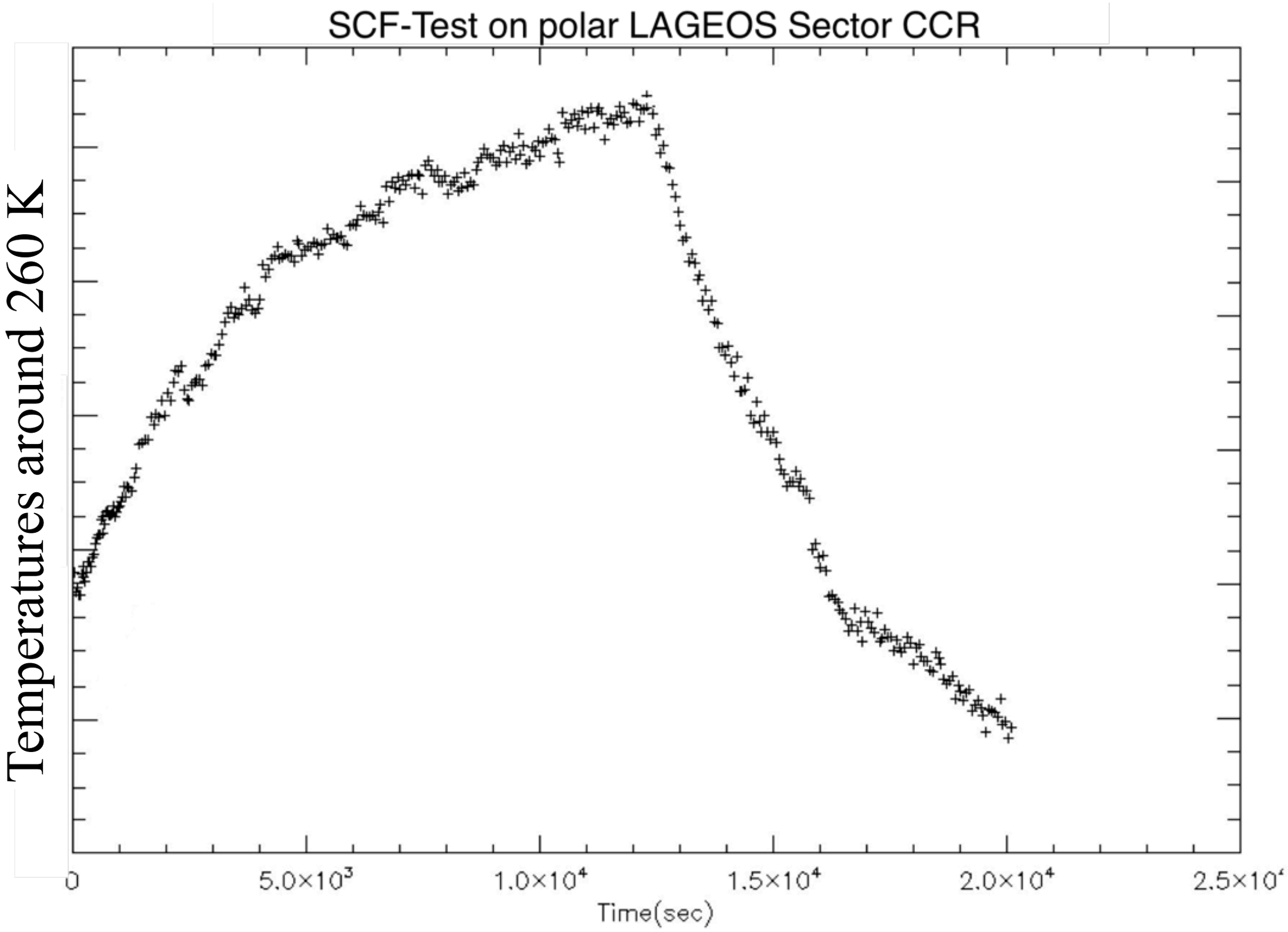
Concurrent thermal/optical measurements only on polar CCR

IR thermal measurements on polar CCR and first two rings



# CCR SCF-Test (Sector @ 300K)



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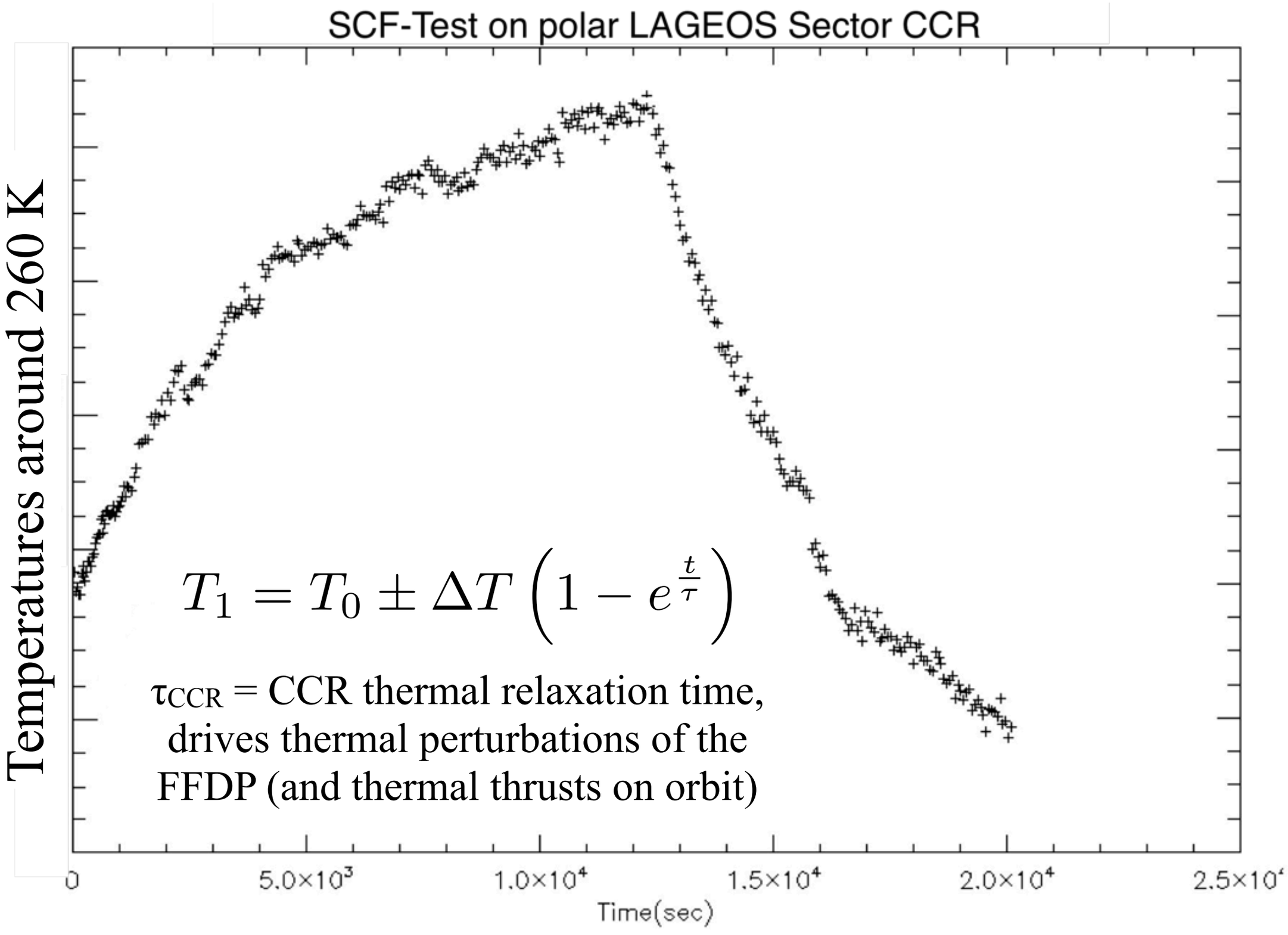
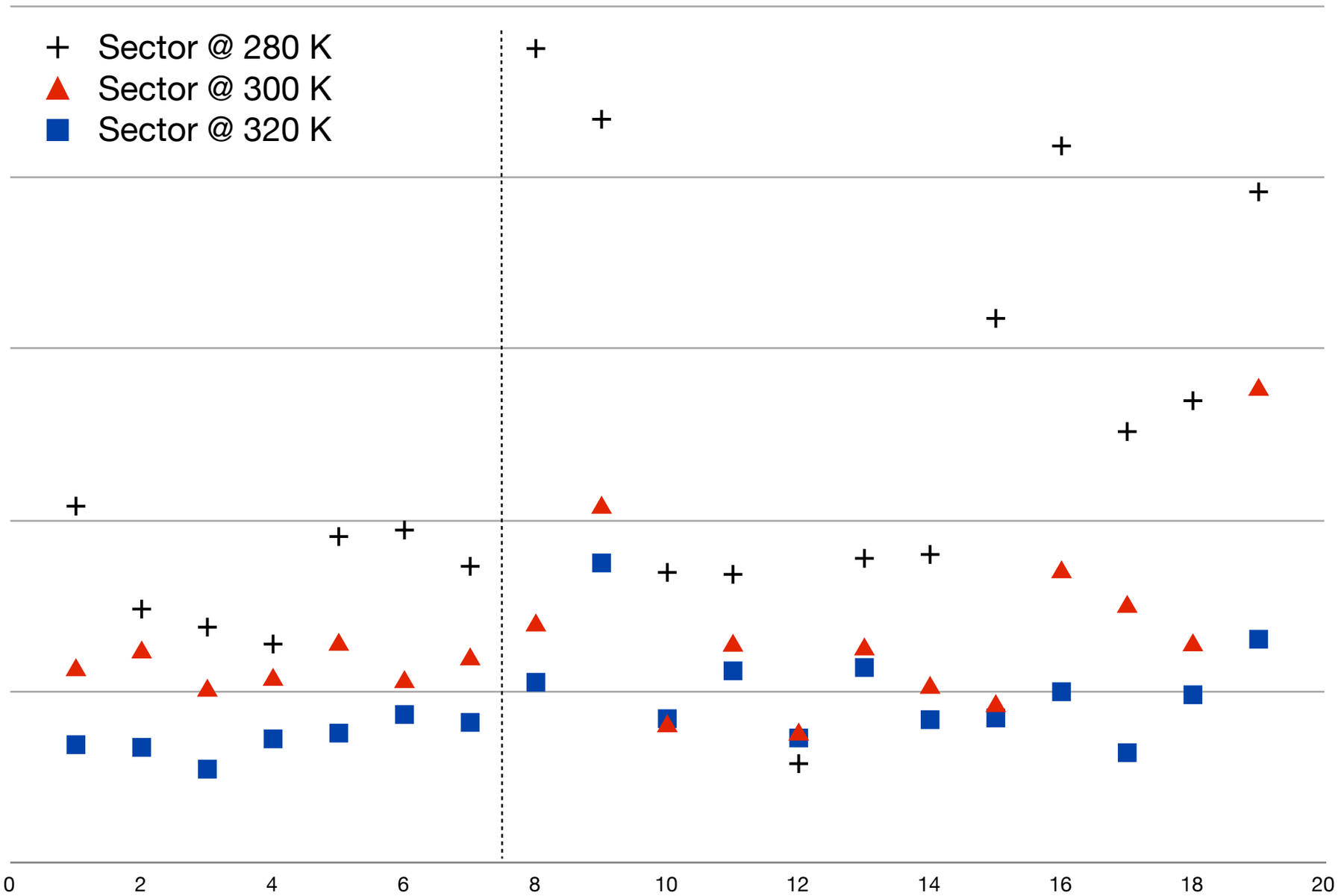


# Thermal analysis (varying Sector temperatures)



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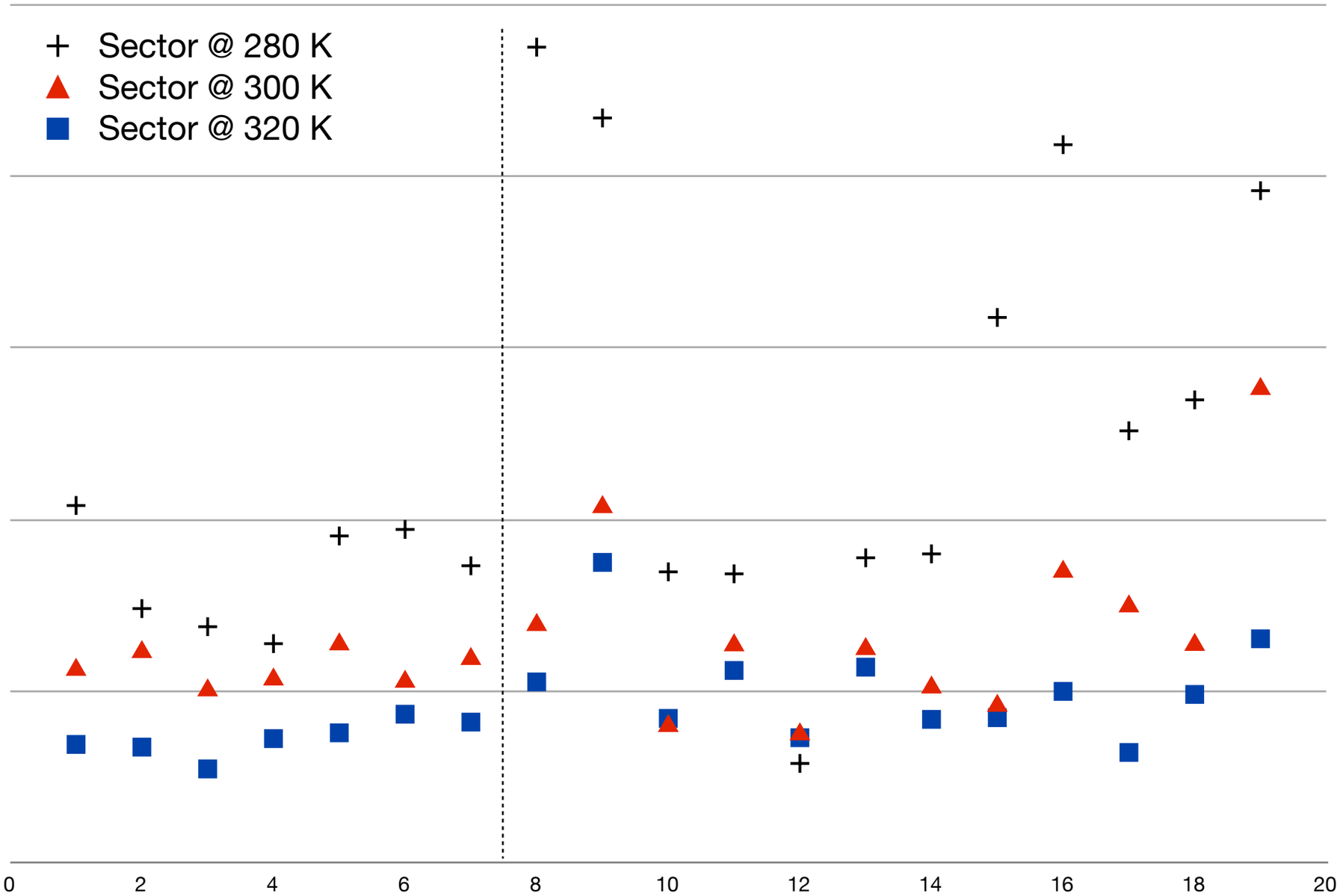


Characteristic heating and cooling time constants ($\tau_{CCR}$) decrease with temperature.

$$\frac{\tau_{T_1}}{\tau_{T_2}} \approx \left(\frac{T_2}{T_1}\right)^3$$

# CCR average intensity vs time

For each FFDP, average intensity at 35 μrad velocity aberration is plotted.

Screw torque, nominal value= 0.135 N·m, Sector @ 300 K

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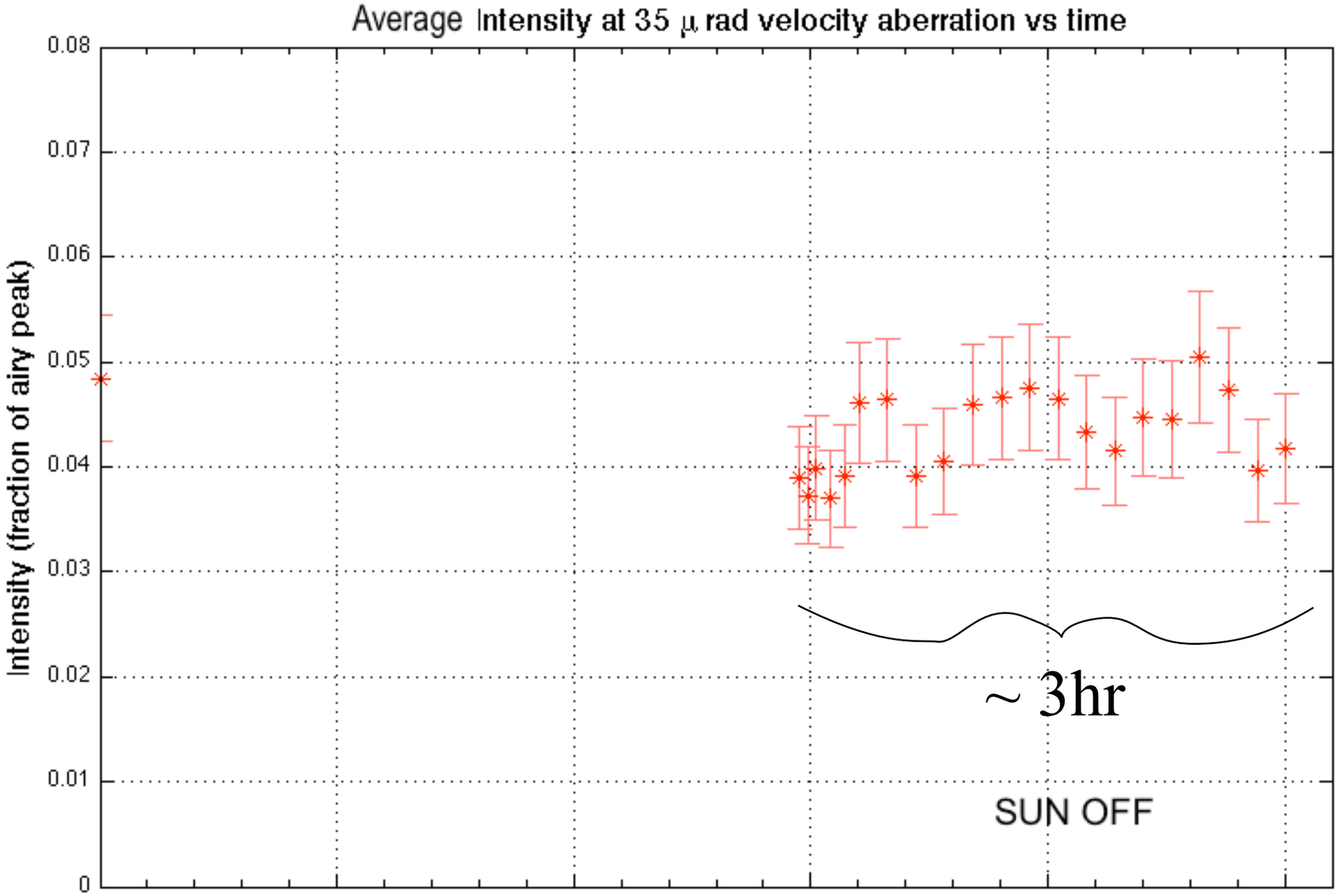

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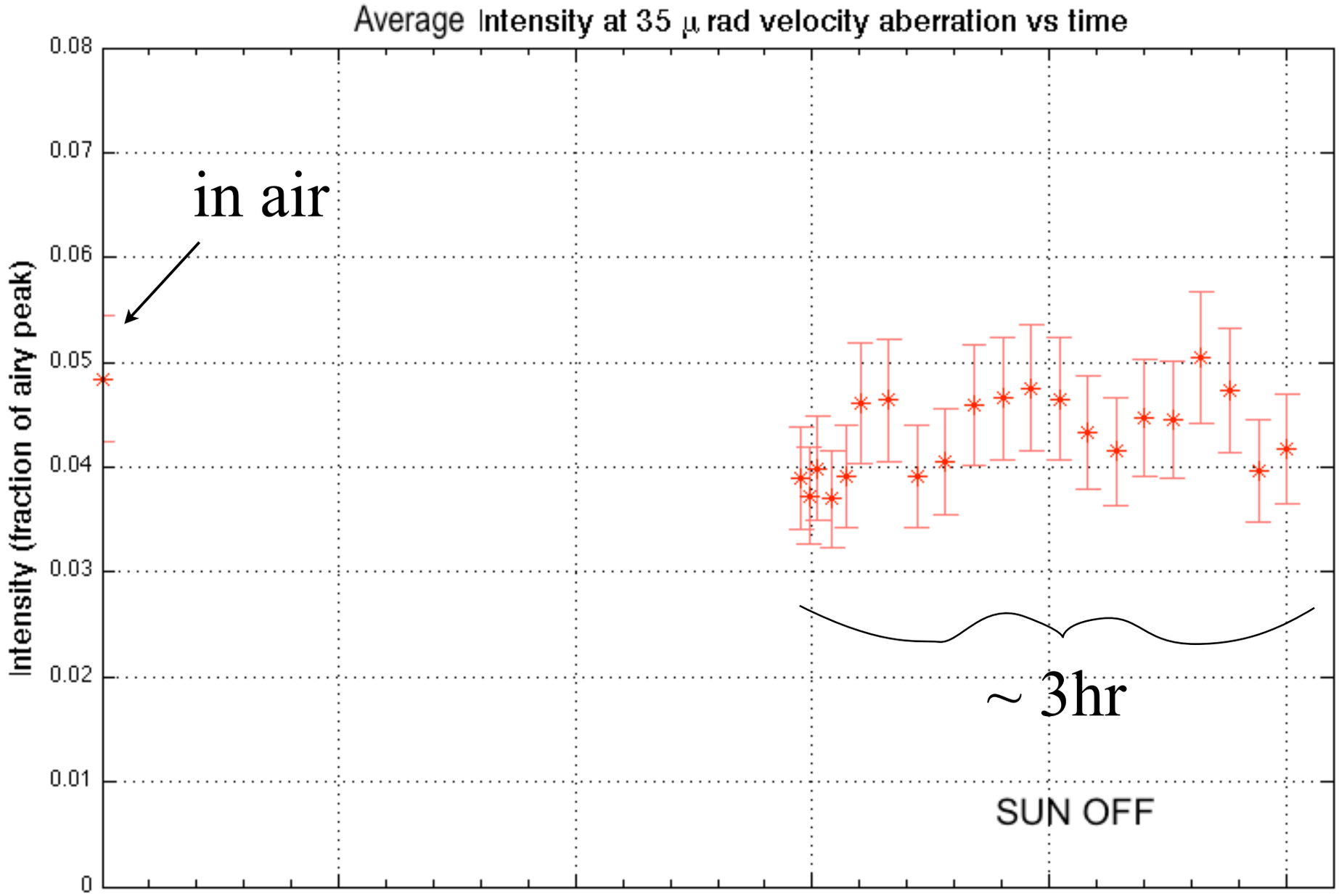
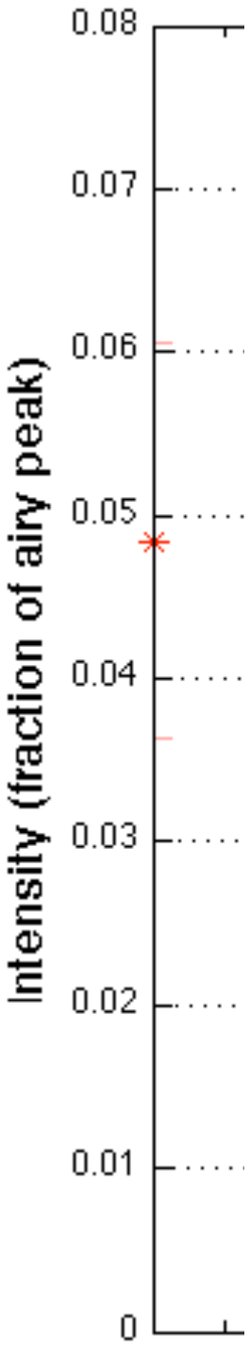
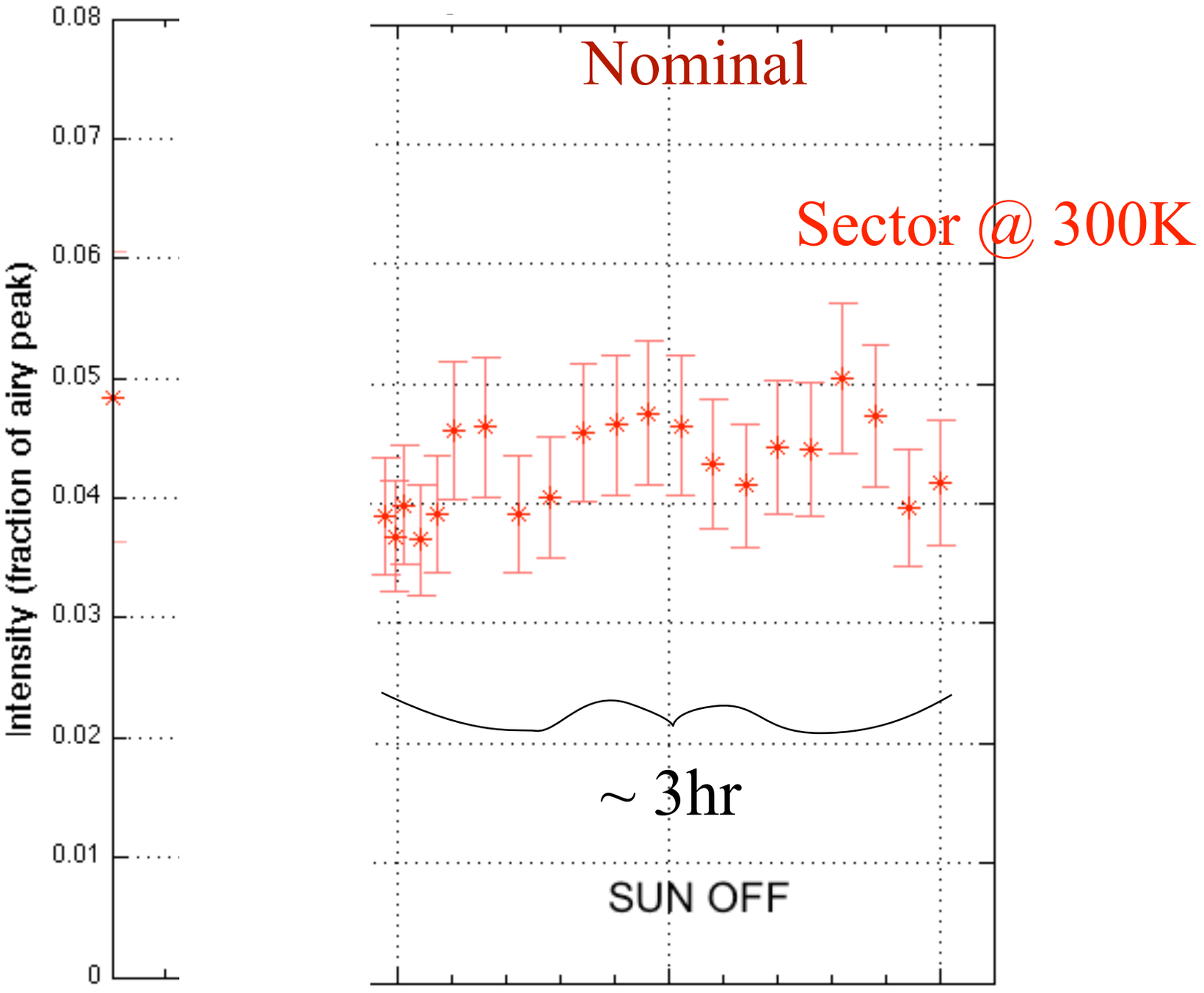


# Ave Intensity change with screw torque




Sector @ 300K

# Ave Intensity change with screw torque



# Ave Intensity change with screw torque


0.135 N·m

0.2 N·m

Nominal

Sector @ 300K

Intensity (fraction of airy peak)

0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0

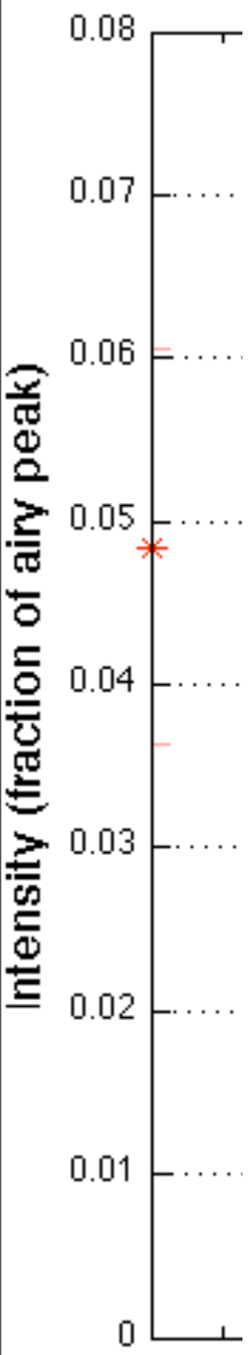
~ 3hr

SUN OFF

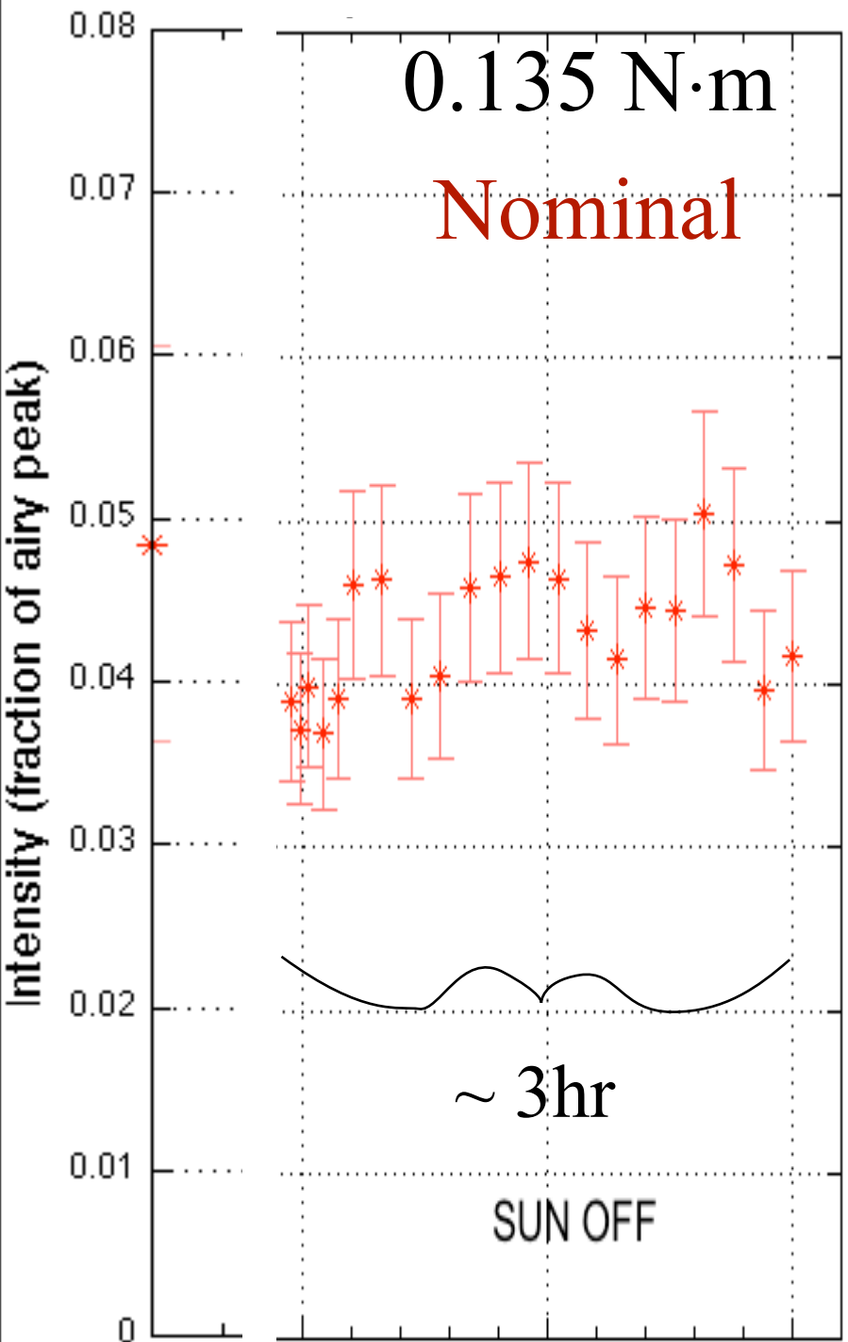
~ 2hr

SUN OFF

# FFDP perturbation after 3hr of Sun on



# FFDP perturbation after 3hr of Sun on



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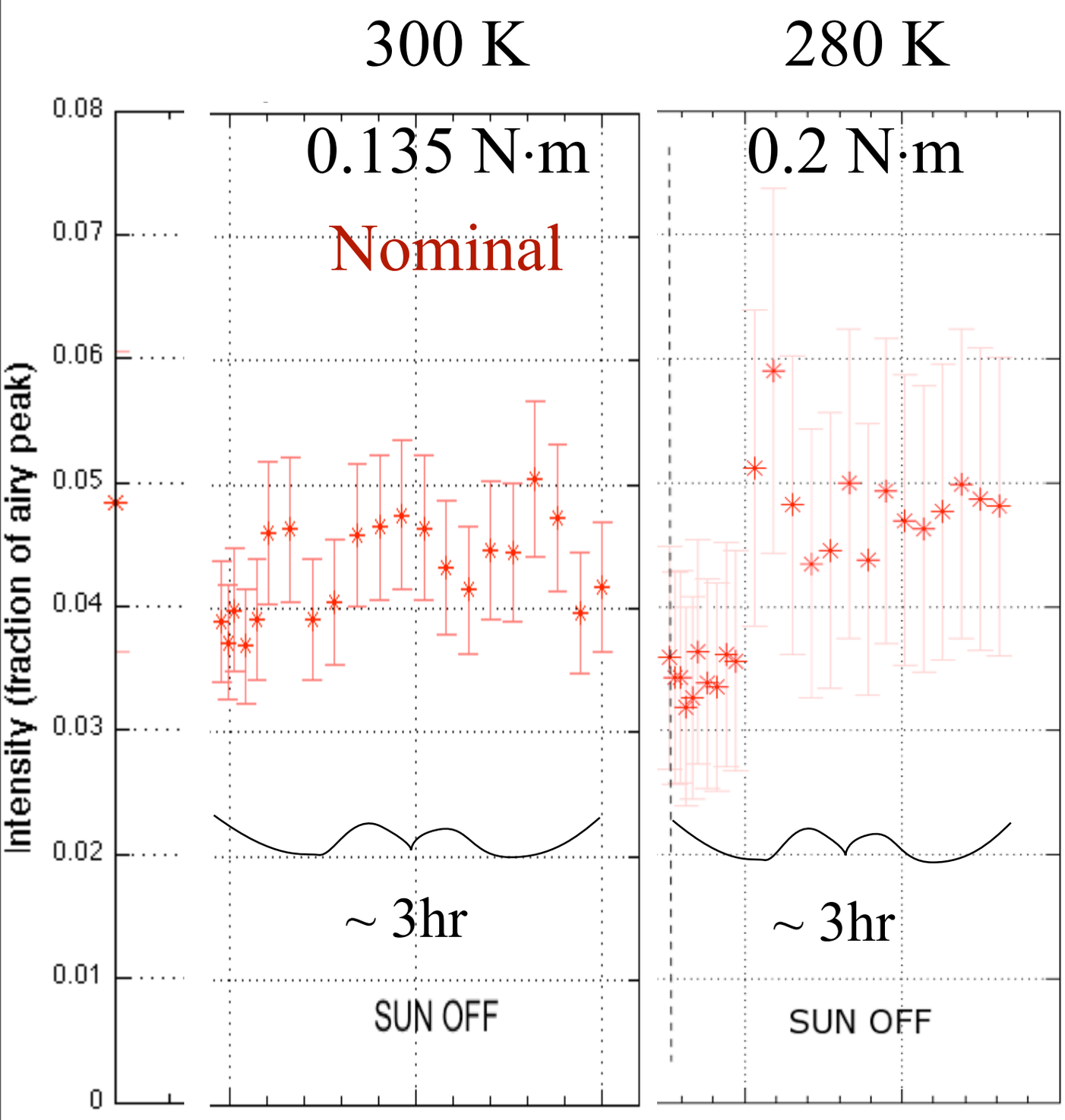

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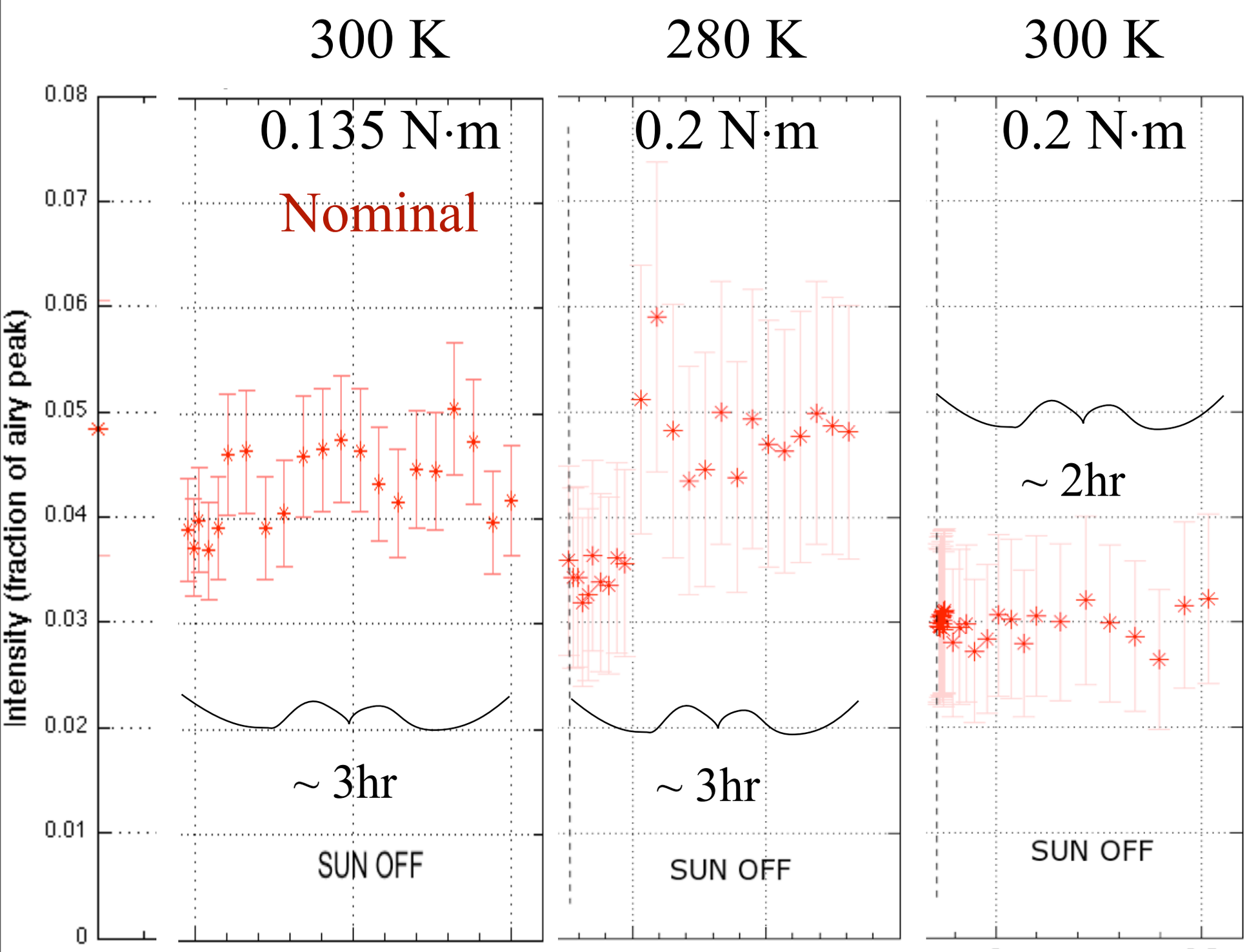

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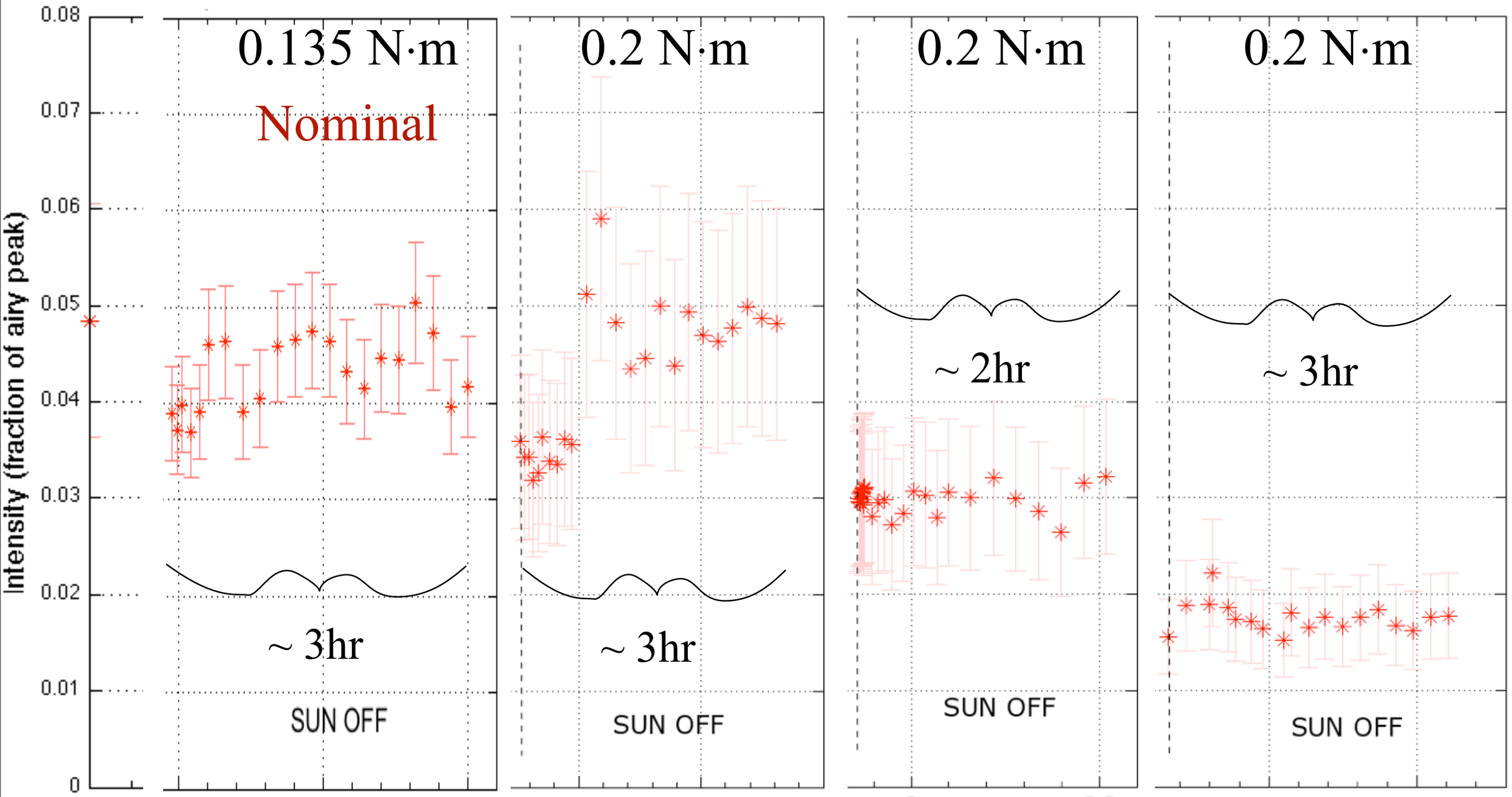
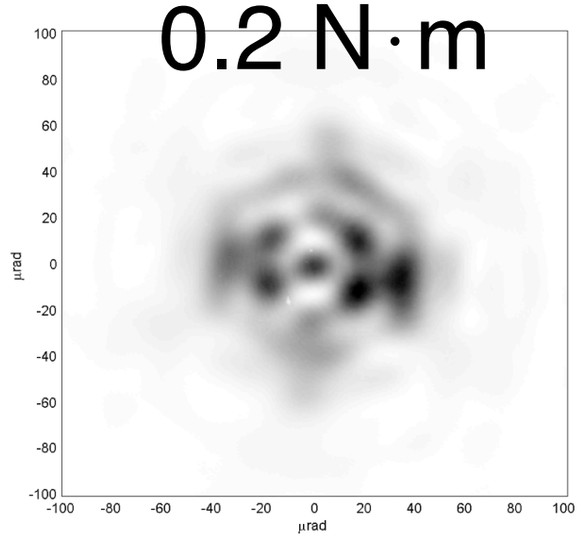
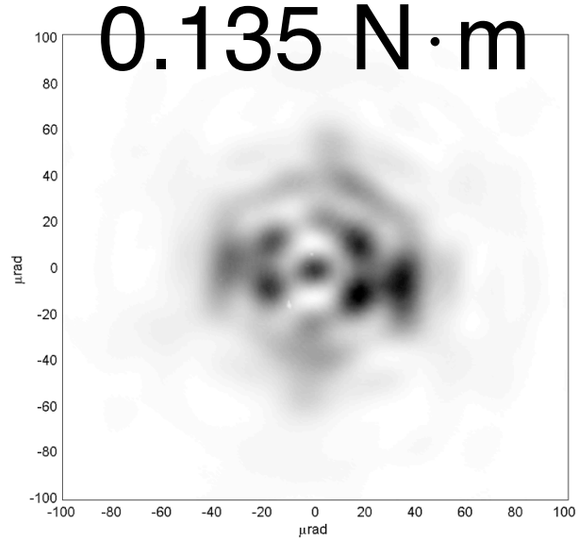
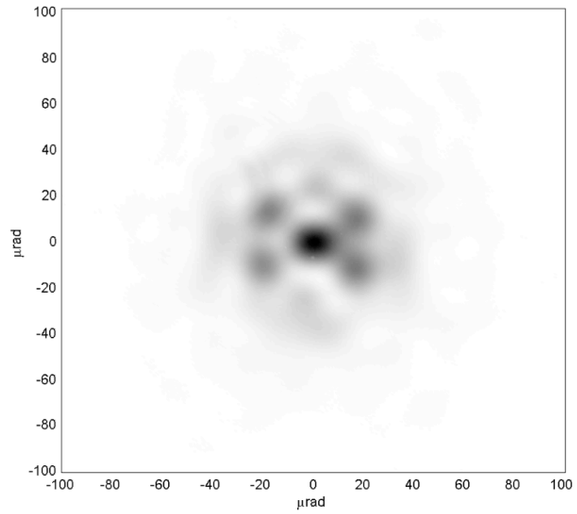
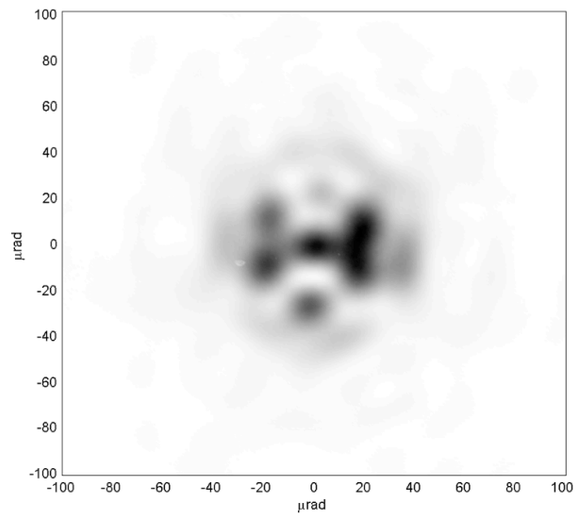
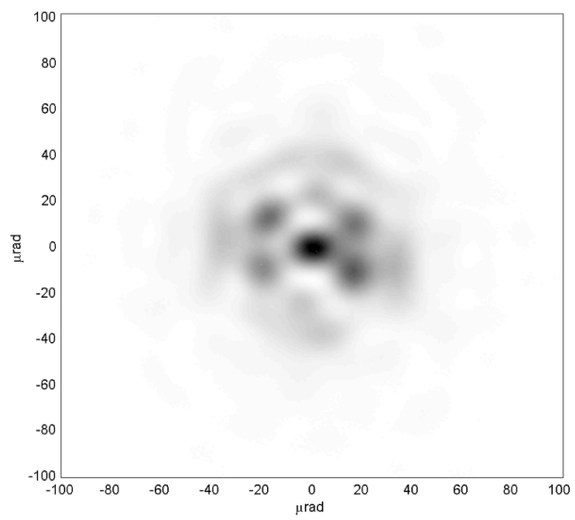
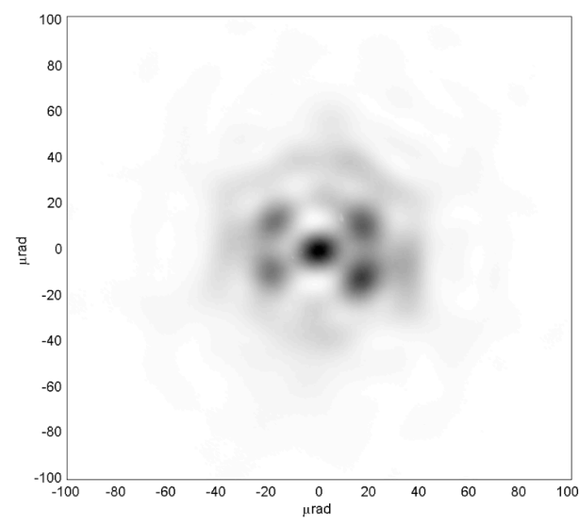


# FFDP vs screw torque (Sector @ 300K)

| | 0.2 N·m | 0.135 N·m |
|---|---|---|
| in Air |  |  |
| After ~3 hr of SUN ON |  |  |
| End SCF-Test 2-3 hr after Sun off |  |  |

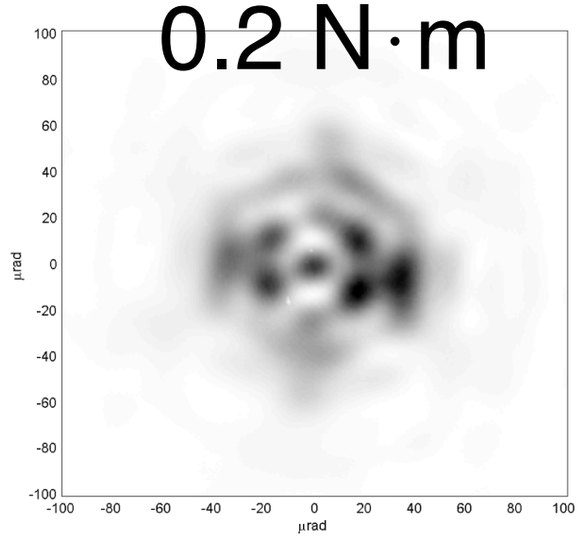
# FFDP vs screw torque (Sector @ 300K)

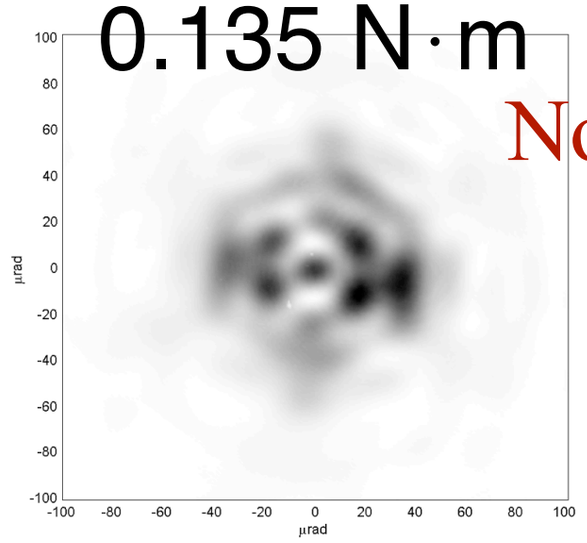
0.2 N·m

0.135 N·m

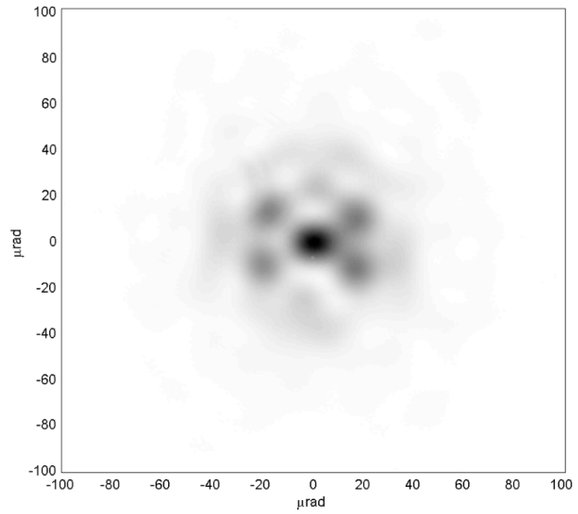
Nominal

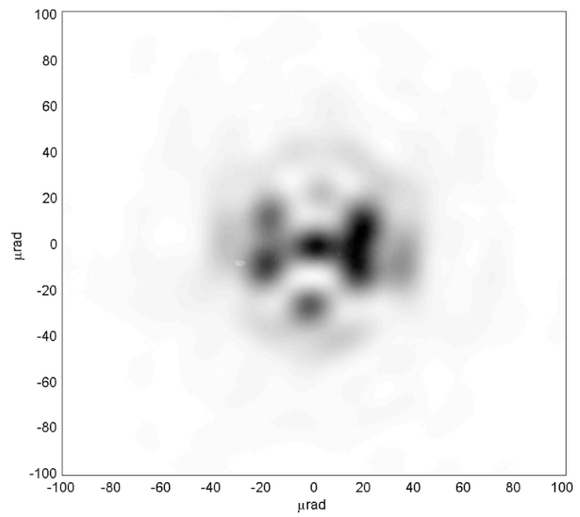
in Air



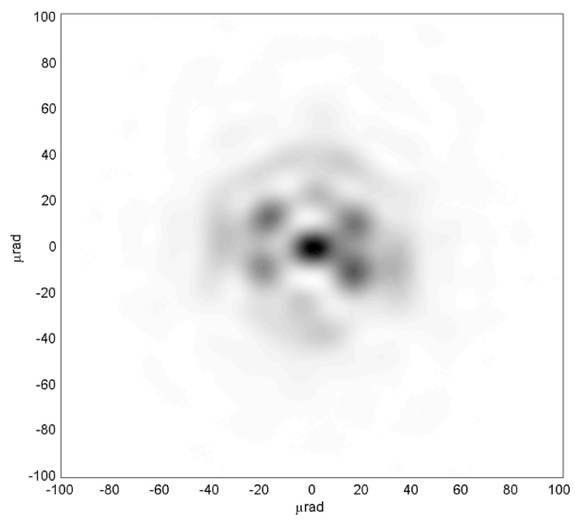



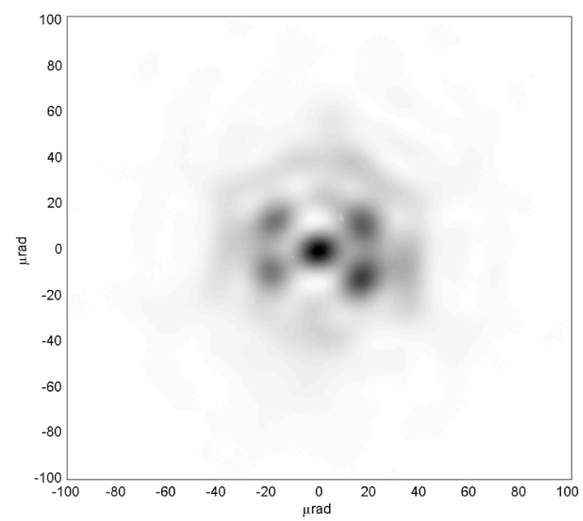

After ~3 hr of SUN ON



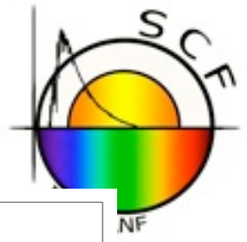




End SCF-Test 2-3 hr after Sun off



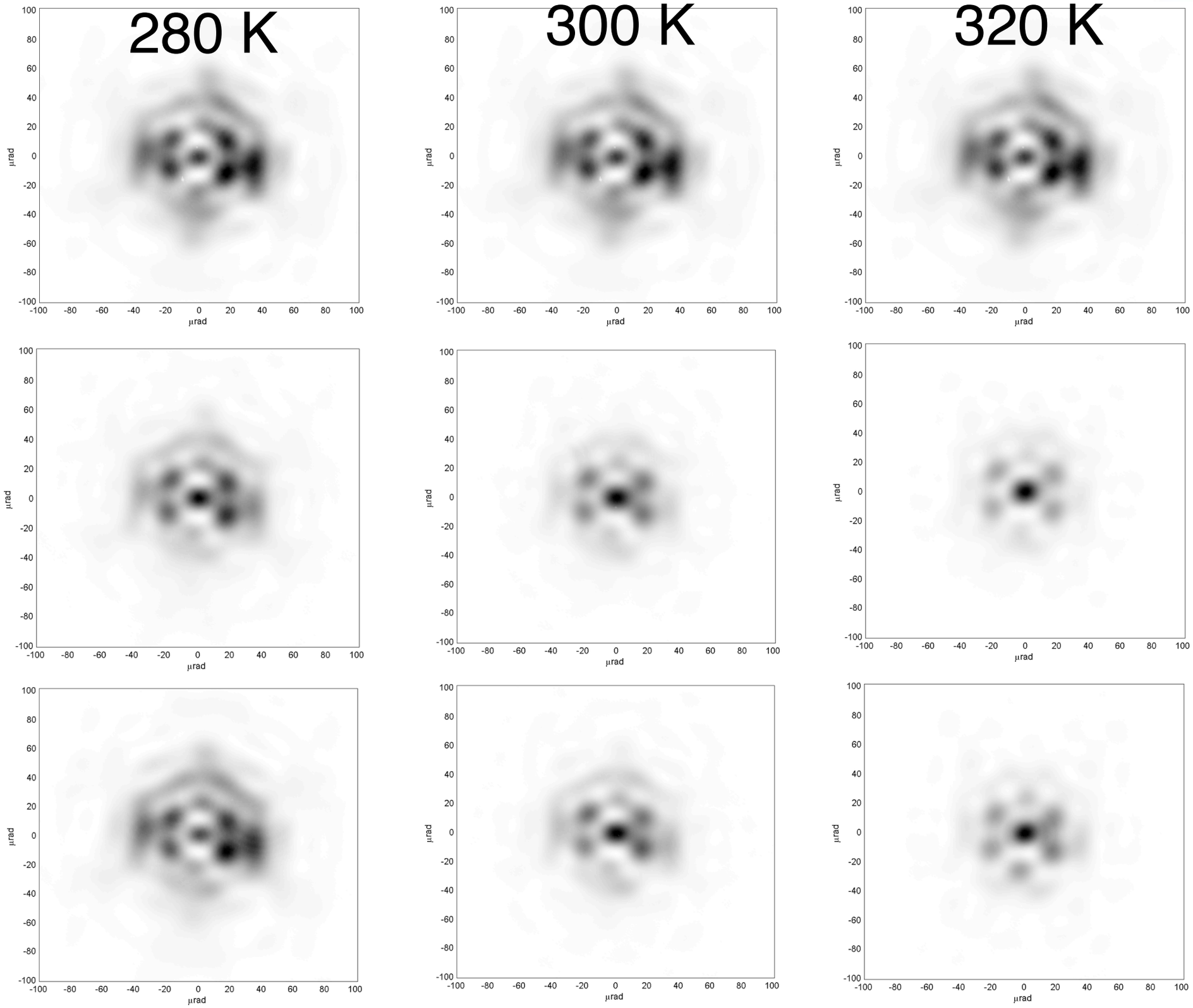
# FFDP vs Sector temperature (screw torque 0.2 N·m)




in Air

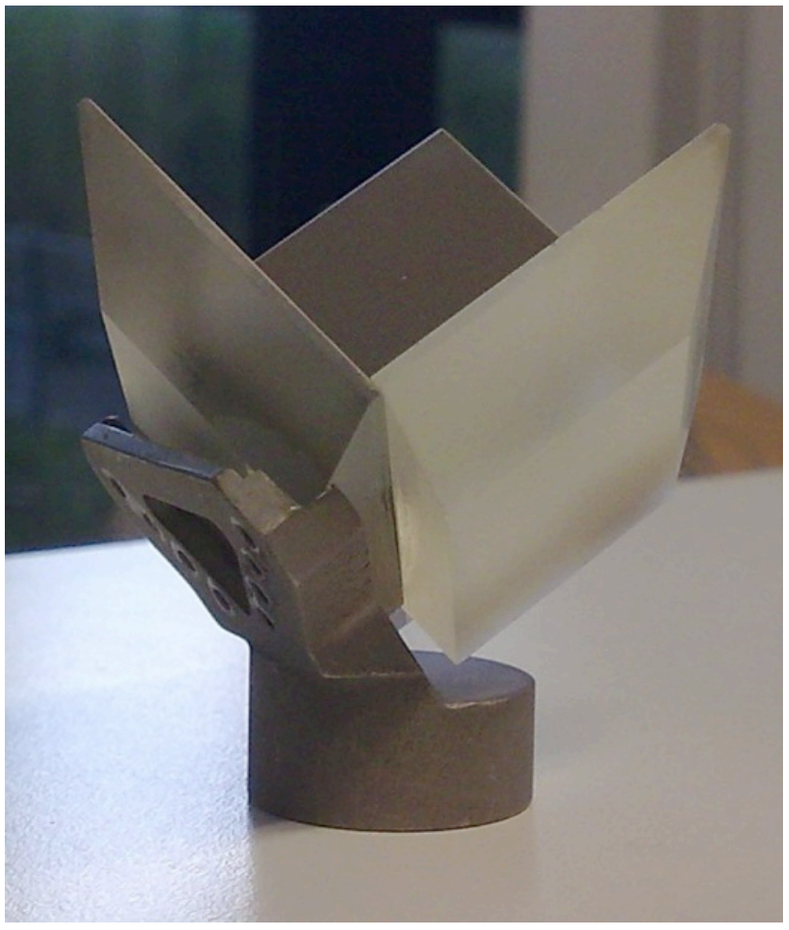
After ~3 hr of SUN ON

End SCF-Test 3-2-3 hr after Sun off



# NASA-GSFC Hollow corner cube SCF-Test

# Measurement layout



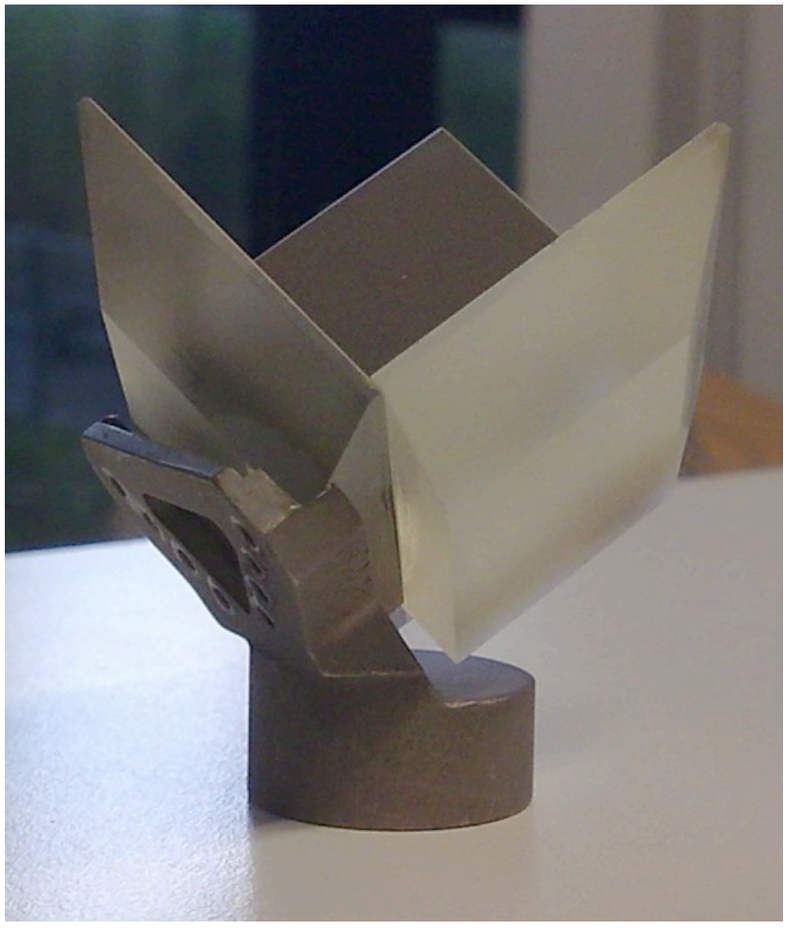
# Measurement layout

CCR with invar foot in thermal contact inside an Aluminum housing.

One physical edge horizontal (the edge between the two faces not in contact with the housing), opposite to the face in contact with the foot.

Three Platinum RTD probes measured the temperature of each of the three reflecting surface. Each one was put in contact with aluminum tape to the back of each face.

The housing was controlled in temperature (@ 300K) with a Peltier cell on the back



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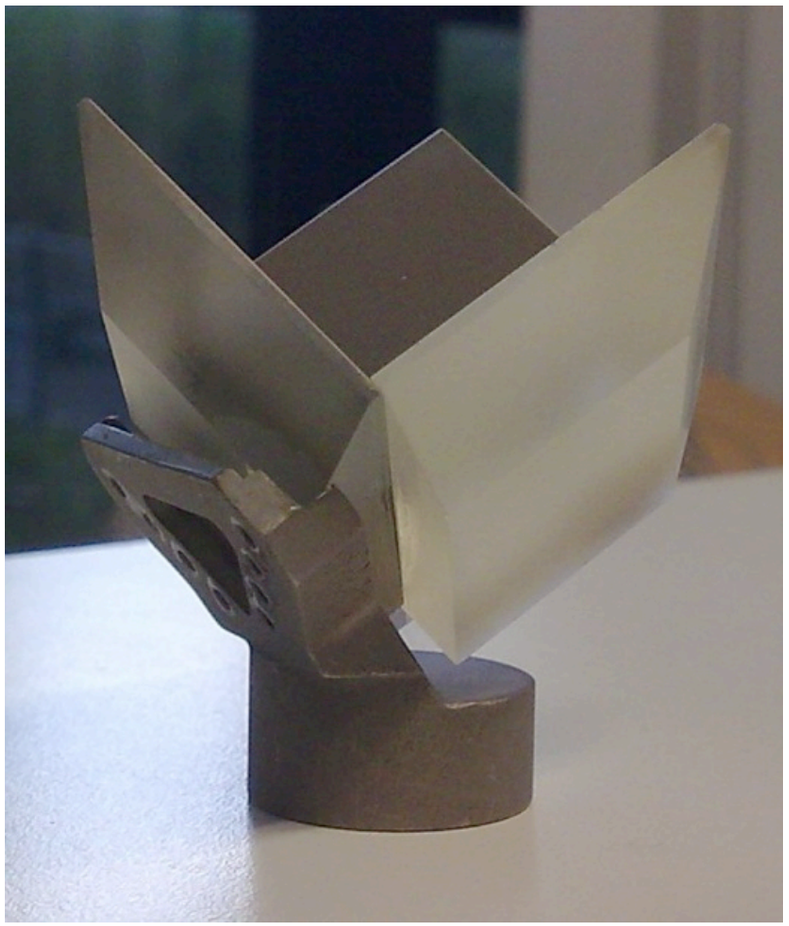
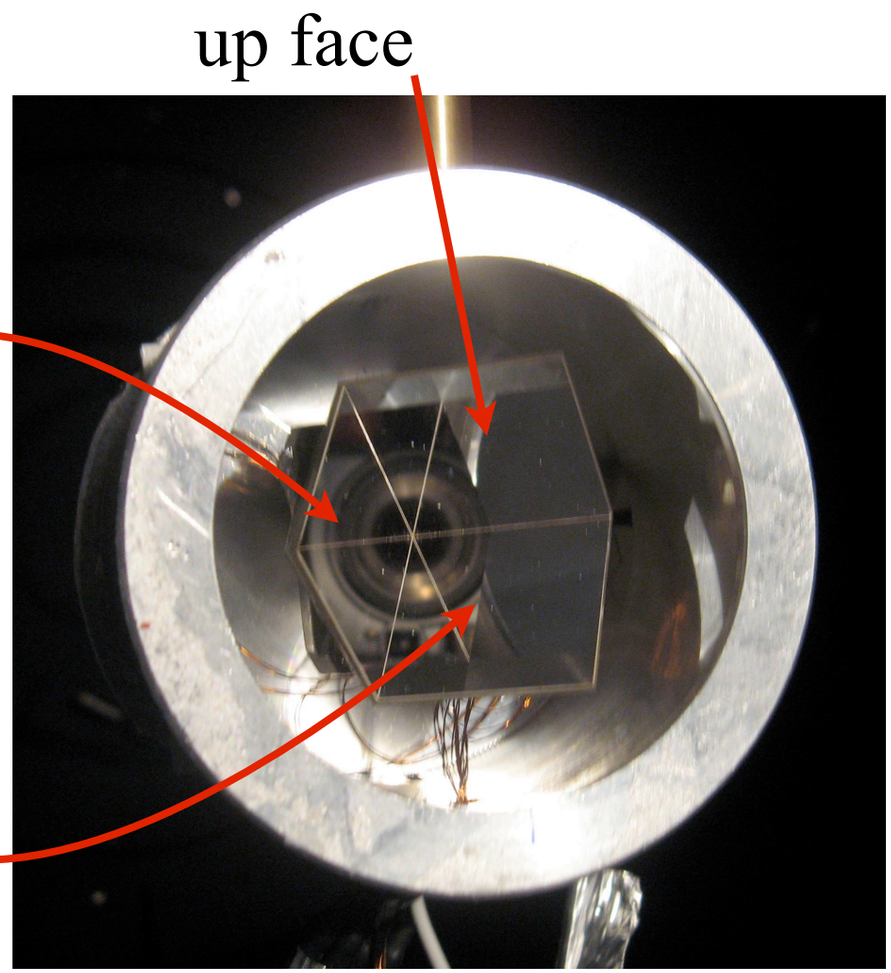
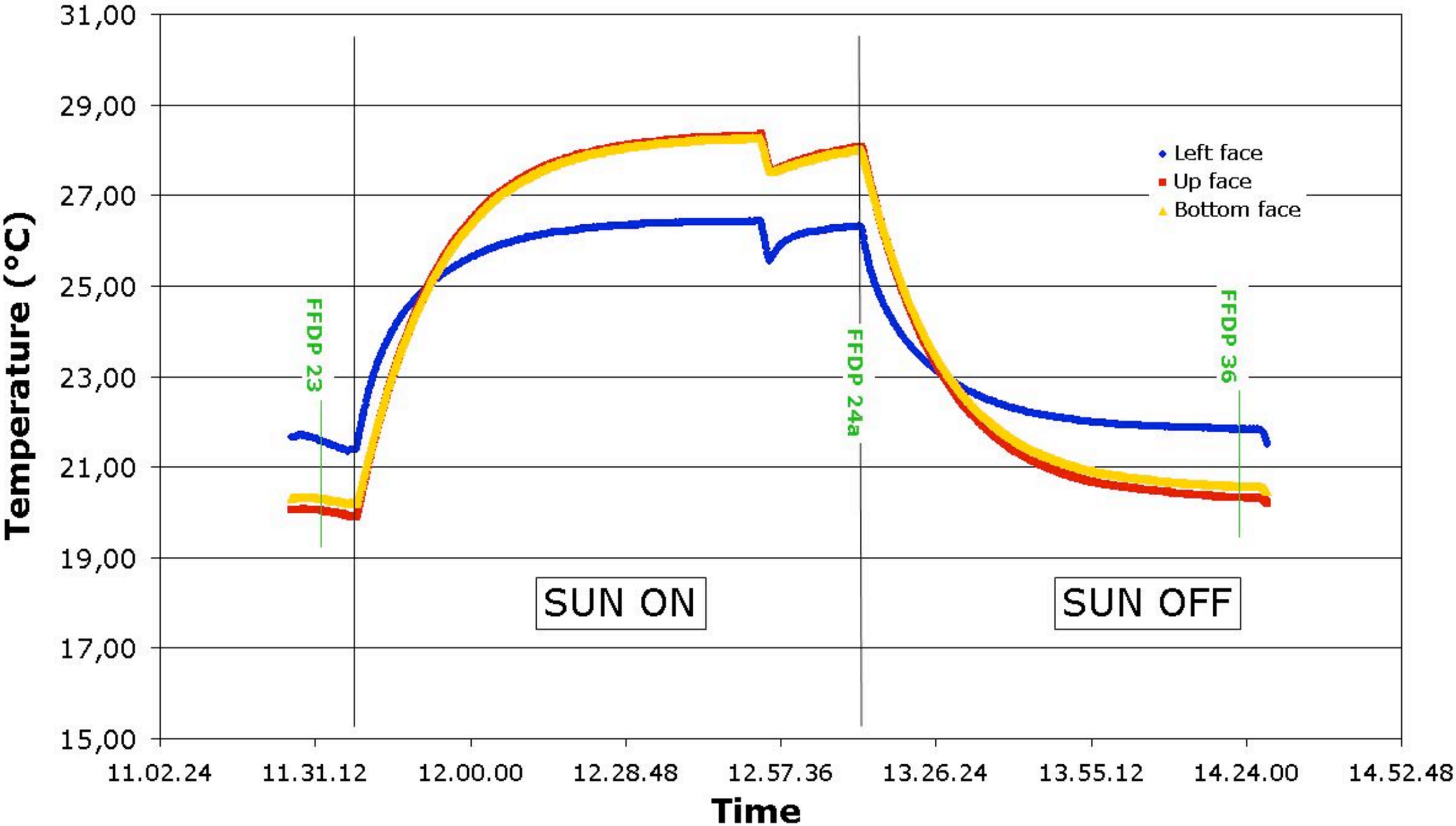


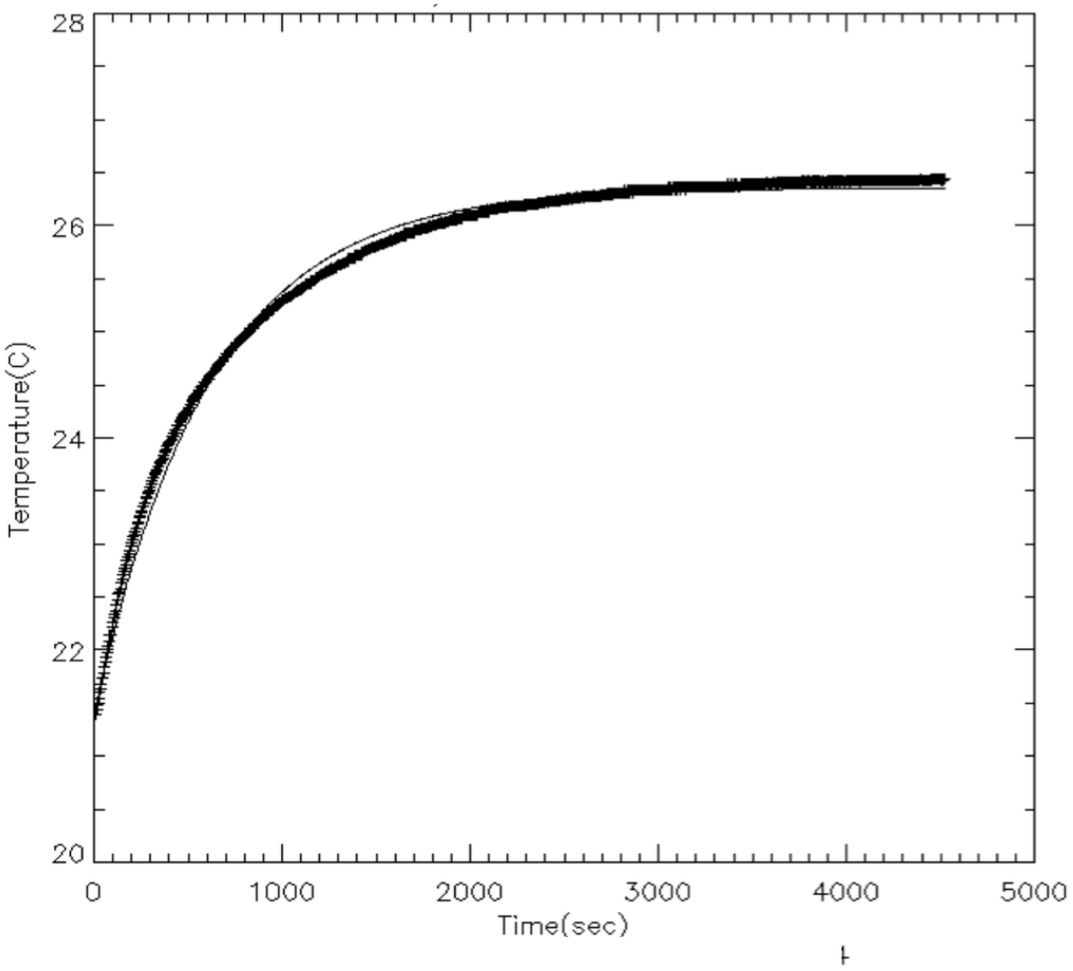


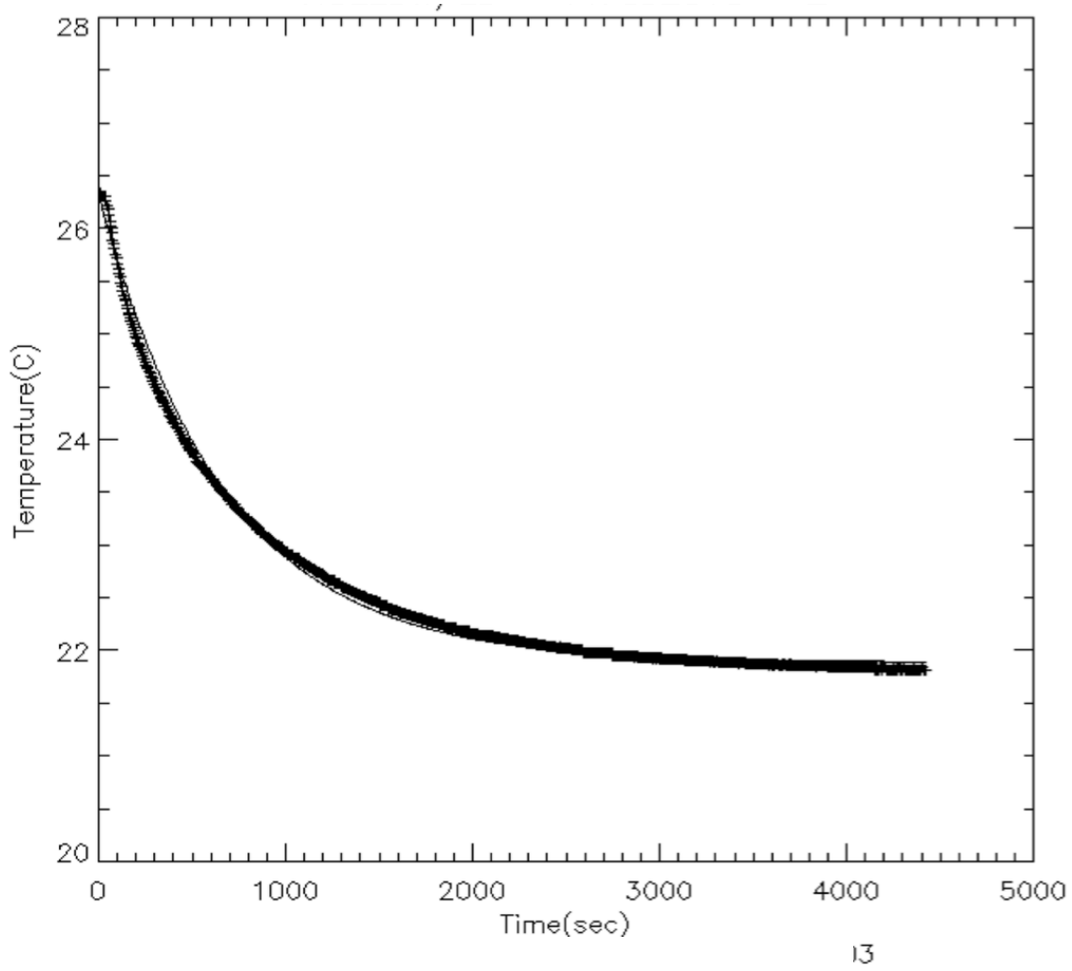
# Hollow CCR SCF-Test



# Thermal analysis

## Left face



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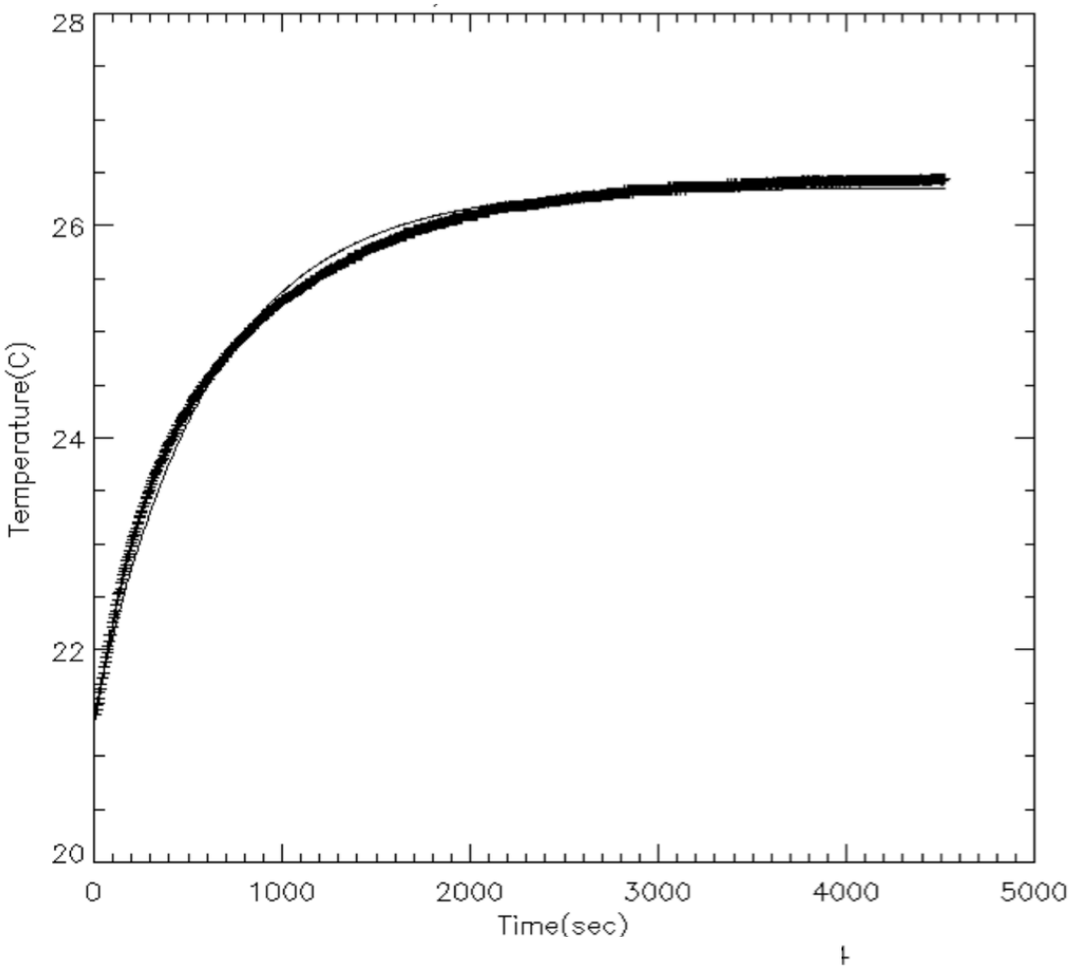


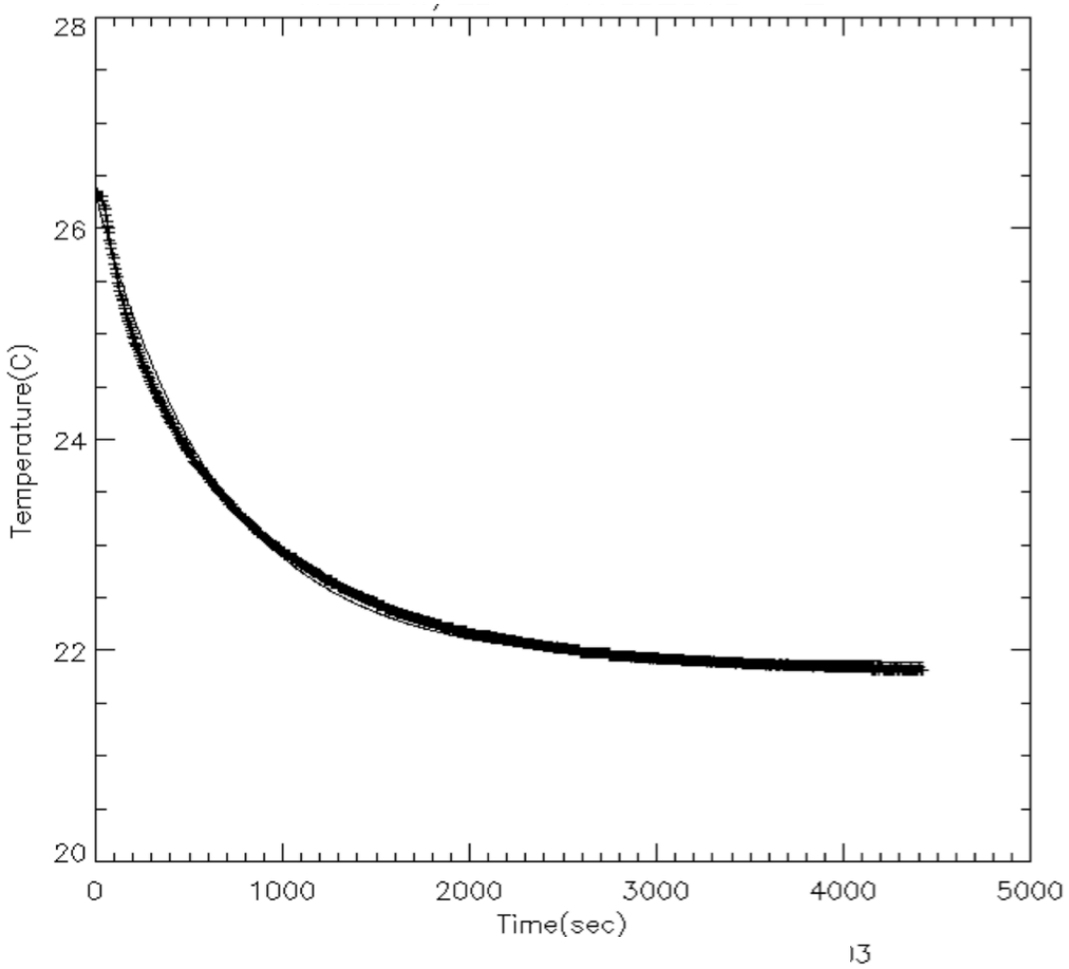


## τ hollow cube faces

| | left face | up face | bottom face |
|---|---|---|---|
| $\tau_{heating}$ (sec) | 617 | 871 | 889 |
| $\tau_{cooling}$ (sec) | 671 | 879 | 897 |

$\sigma(\tau) \approx 80$ s

# Key FFDPs

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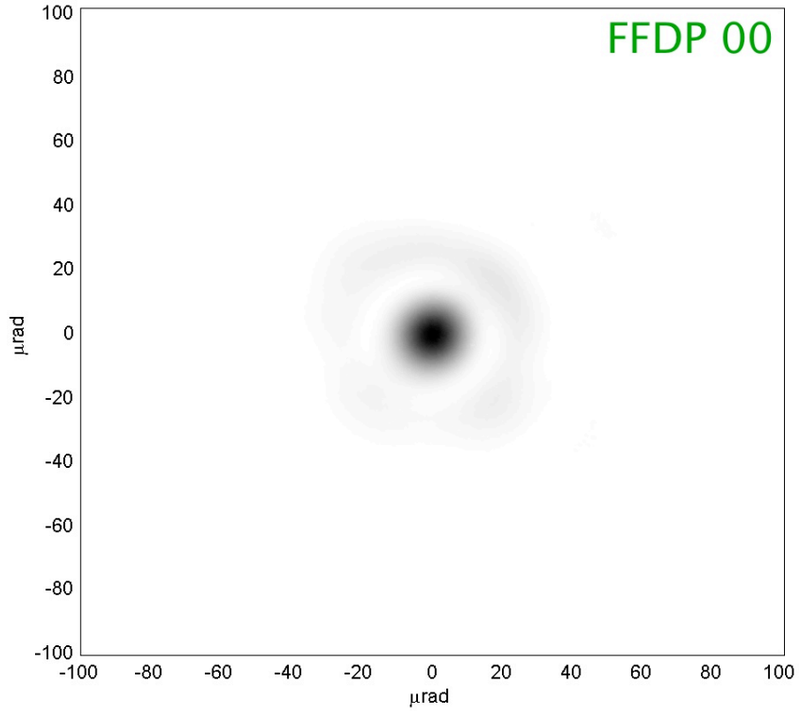
In air FFDP



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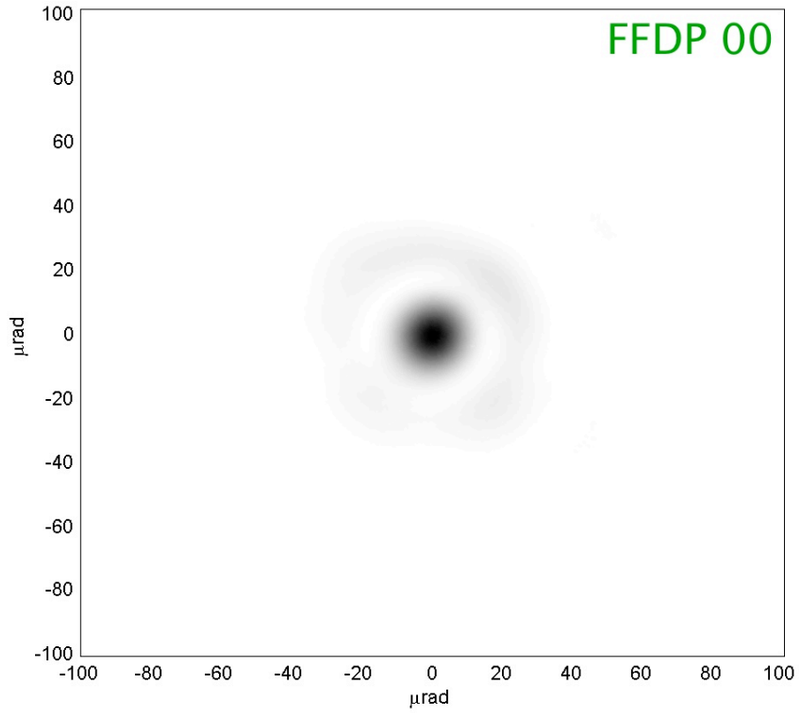
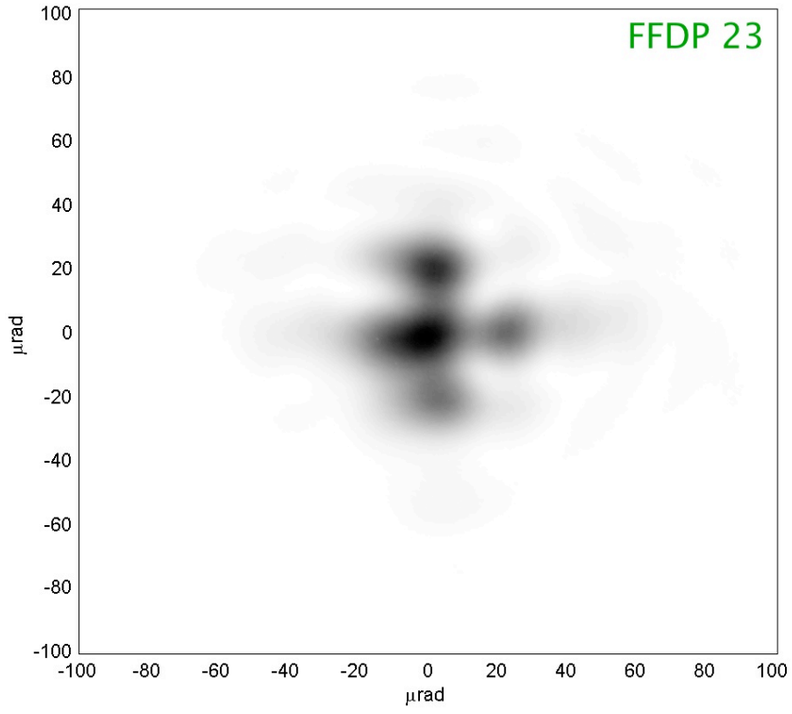
In air FFDP

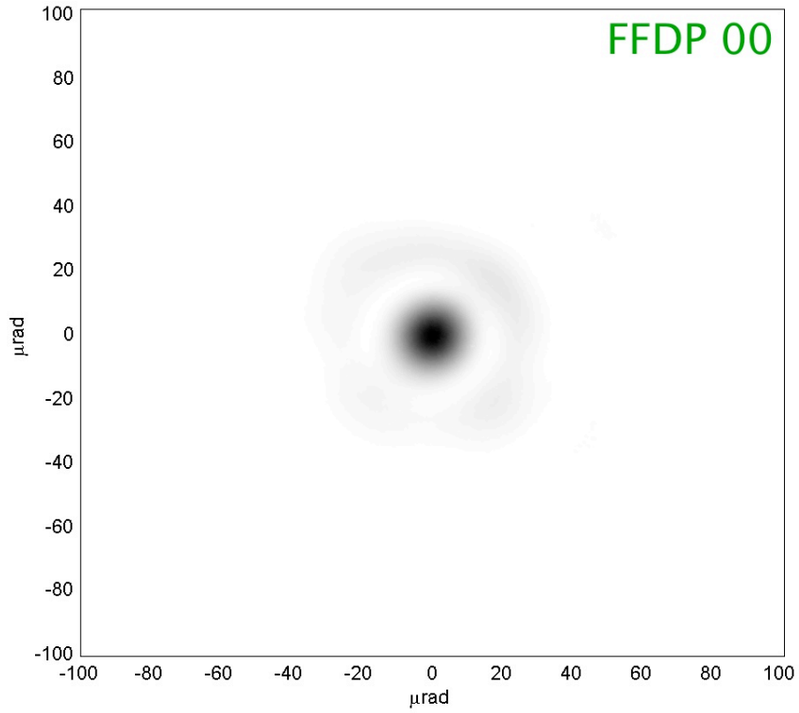


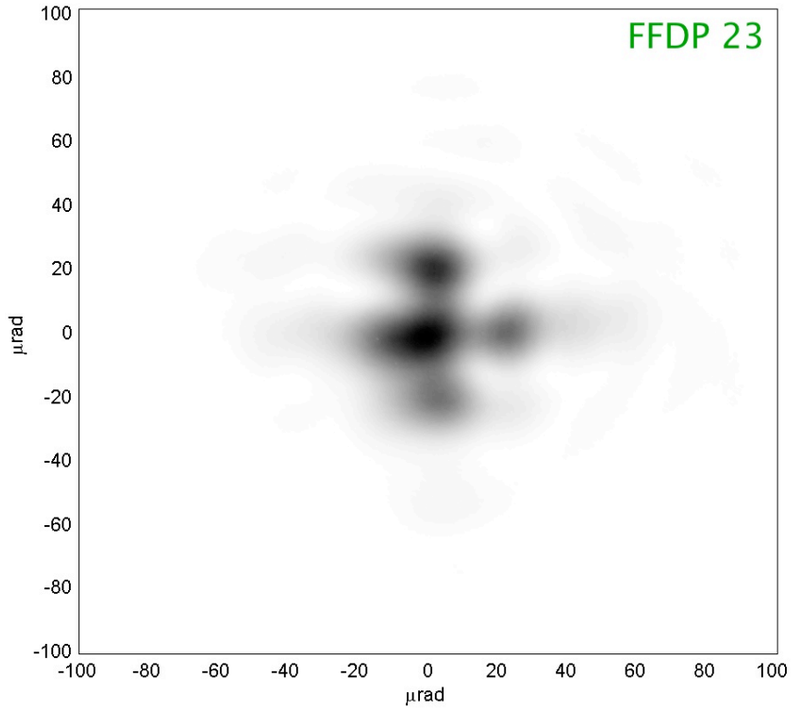




Stationary state. Before Sun on

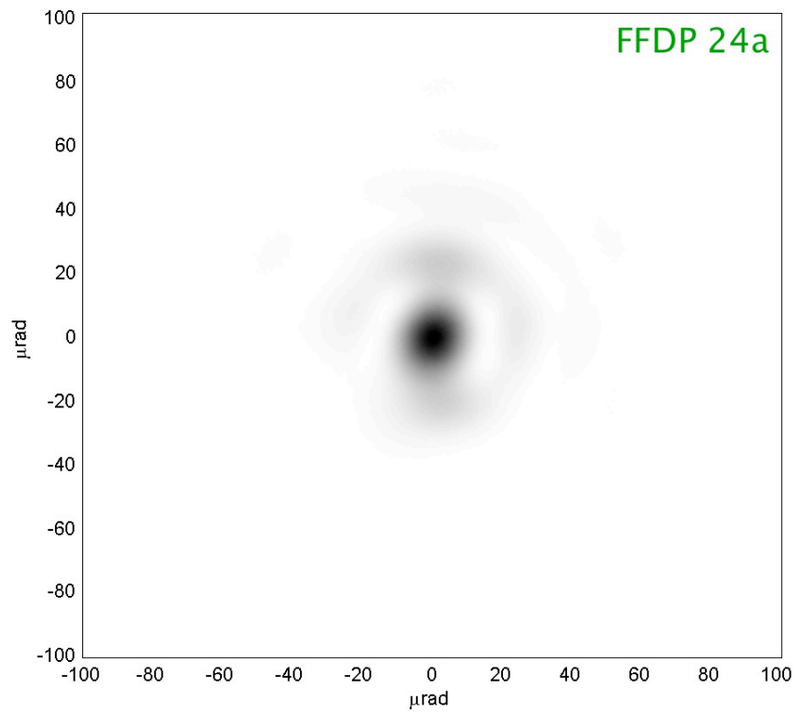
# Key FFDPs

In air FFDP



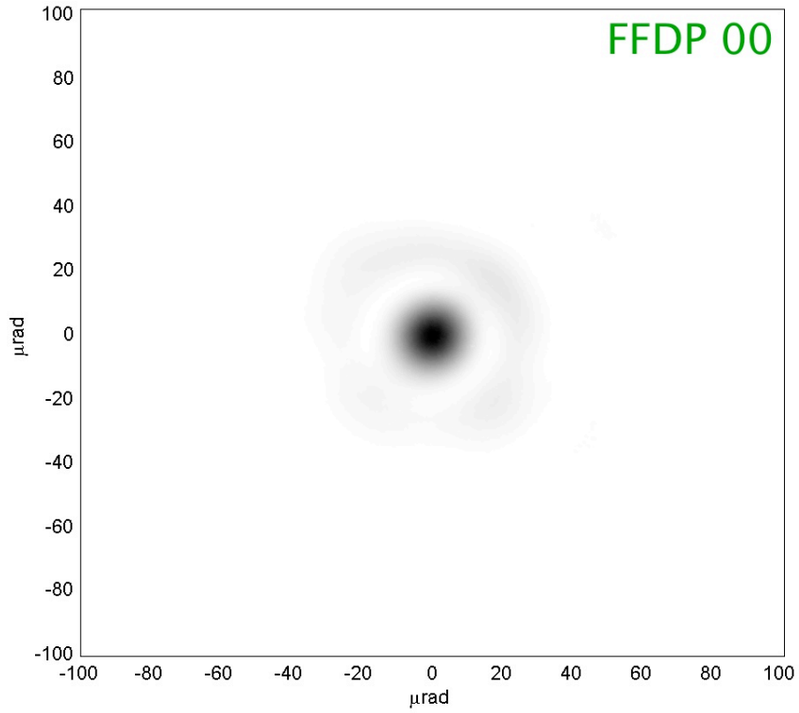

Stationary state. Before Sun on

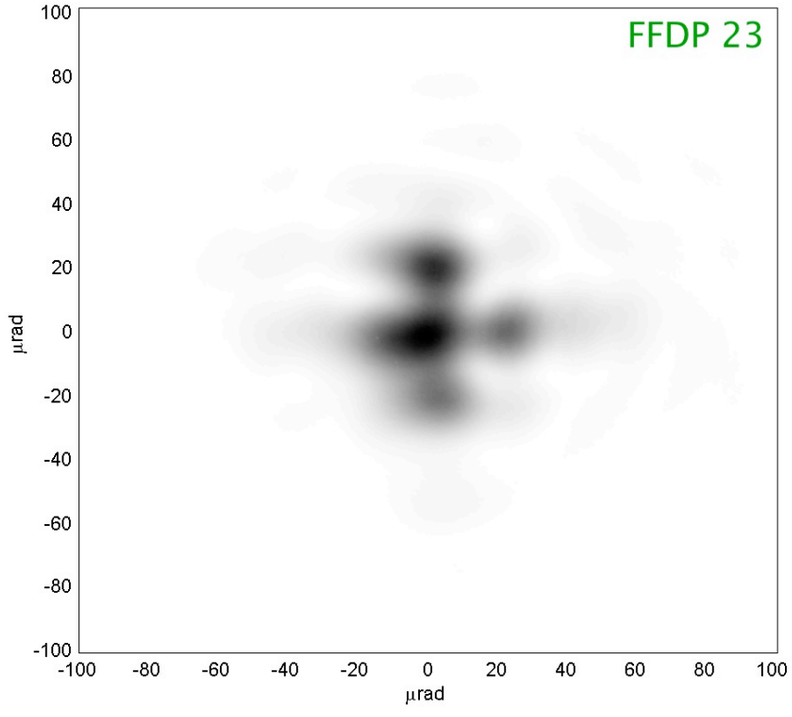



End of Sun ON

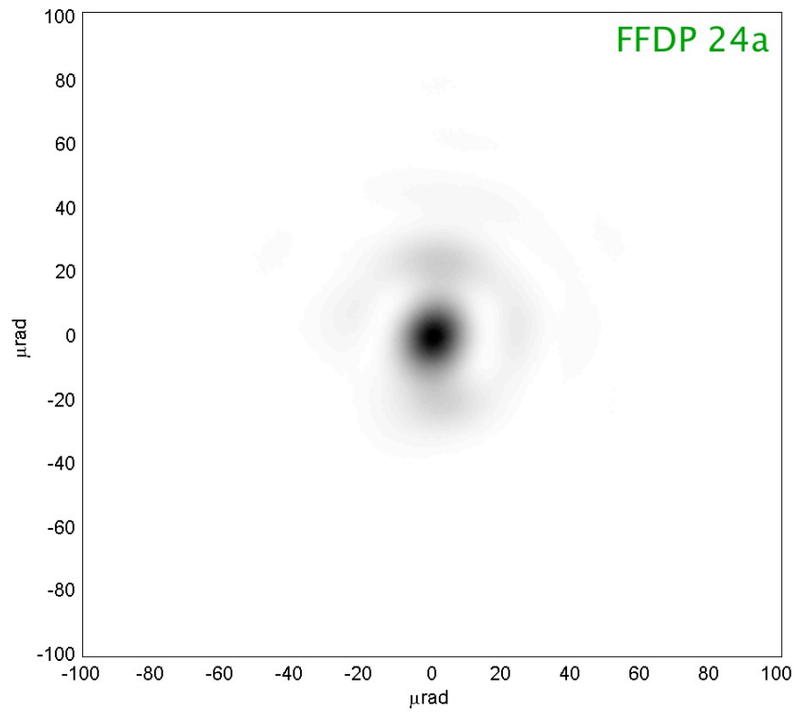
# Key FFDPs

In air FFDP

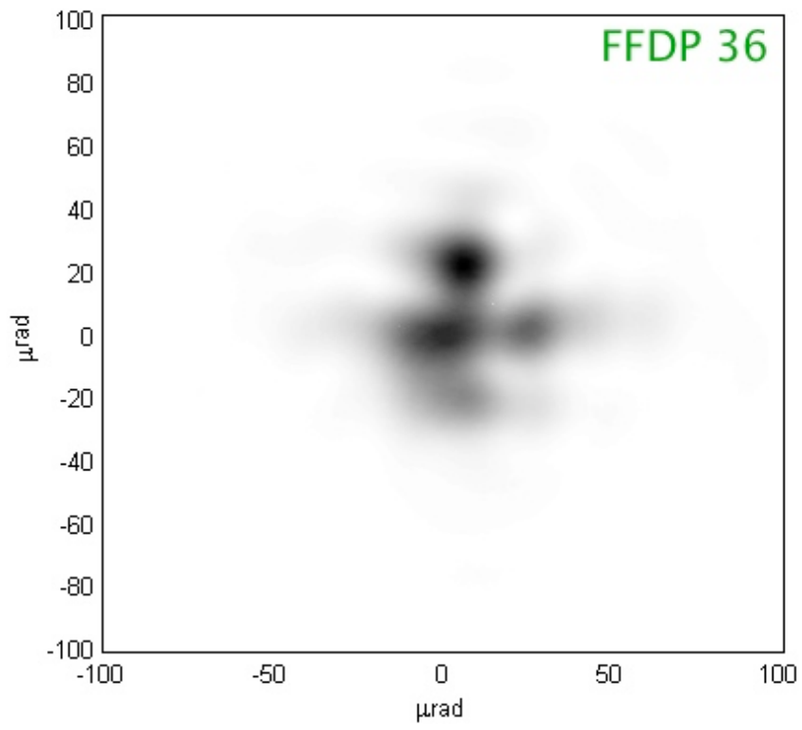



Stationary state. Before Sun on

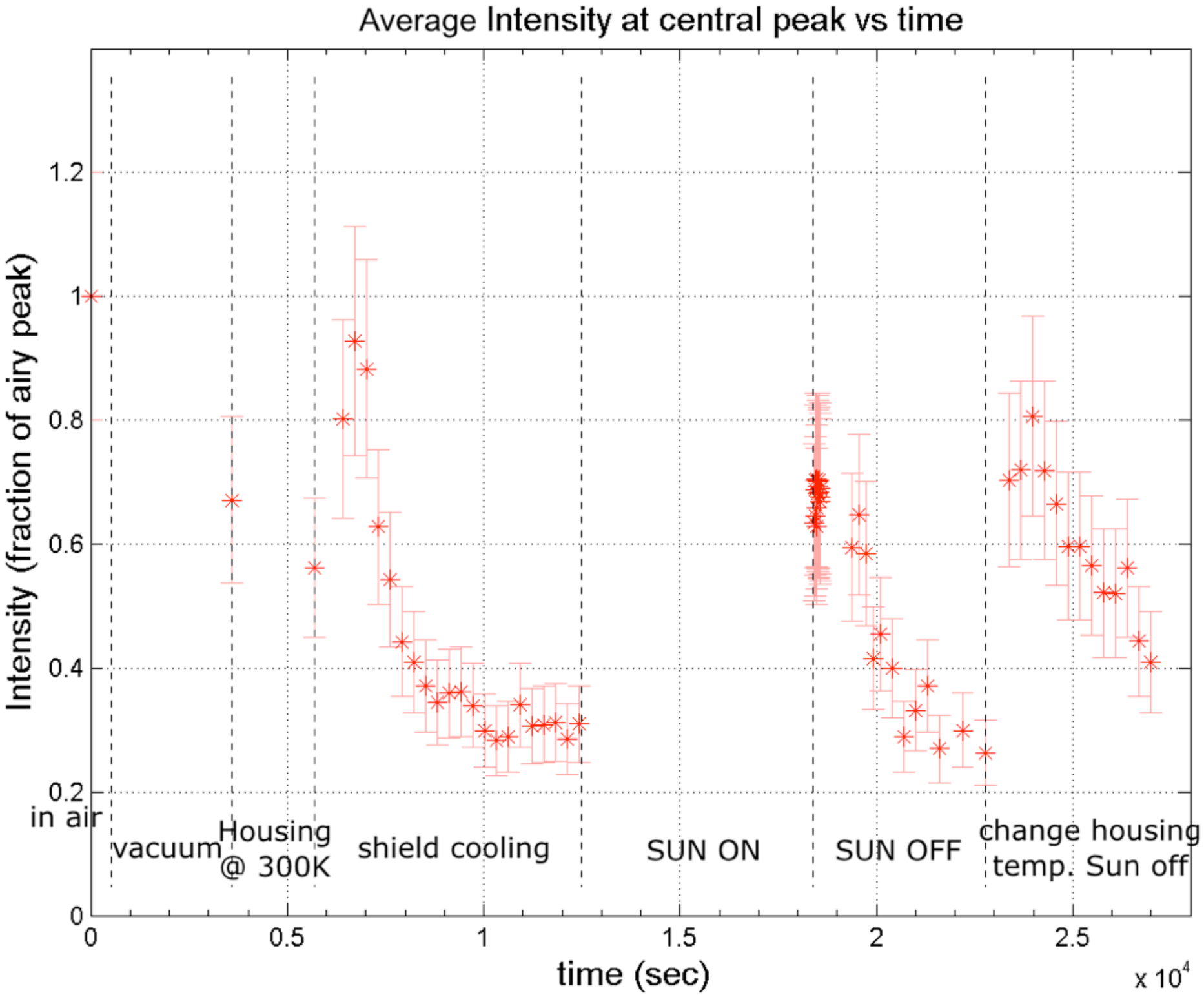



End of Sun ON

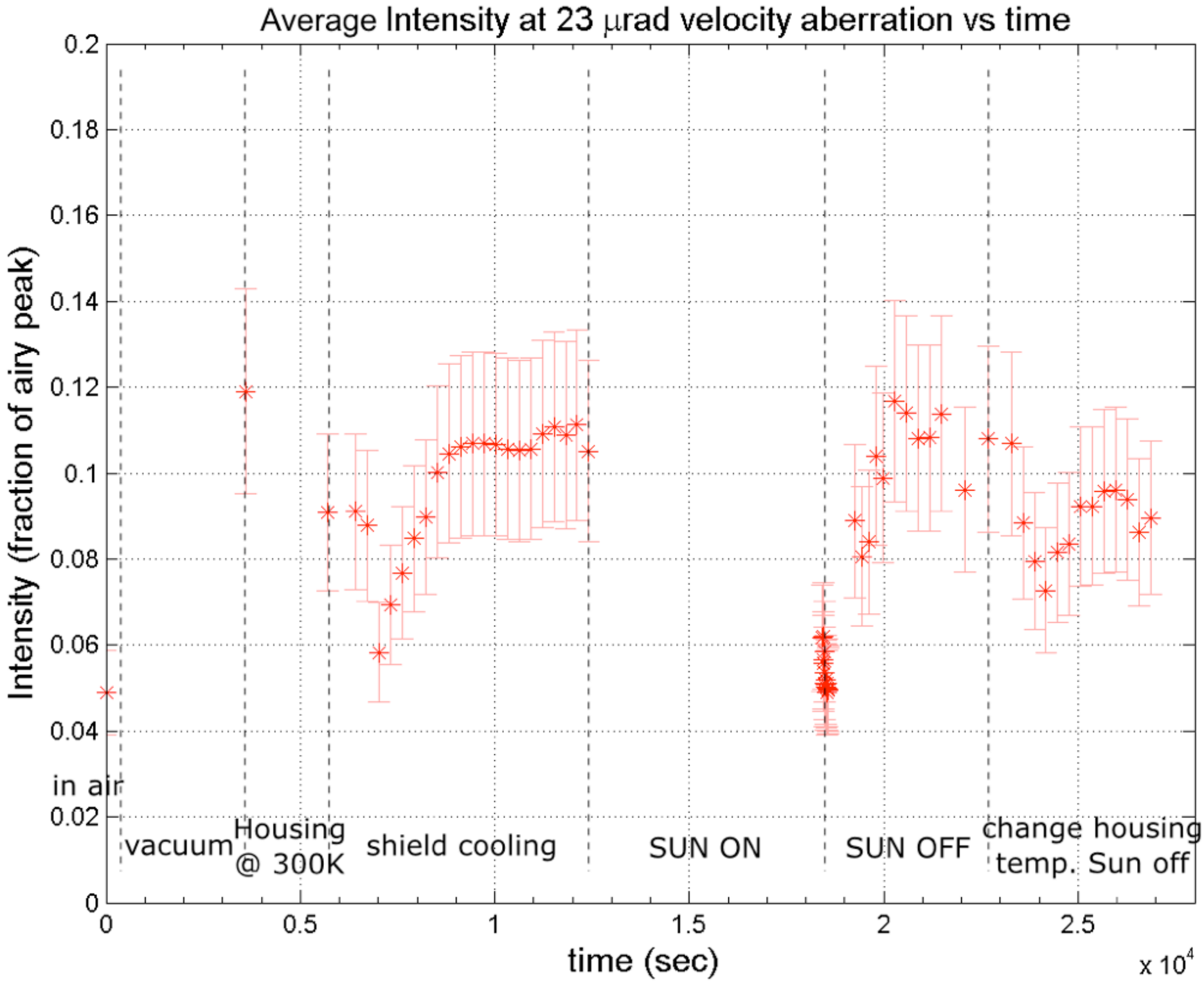



End of SCF-Test. Sun off

# FFDP Intensity change at central peak



# FFDP average Intensity change at 23 μrad



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- Hollow CCR has a short heating/cooling time constant relative to LAGEOS

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# THANK YOU FOR YOUR ATTENTION

# ANY QUESTION?