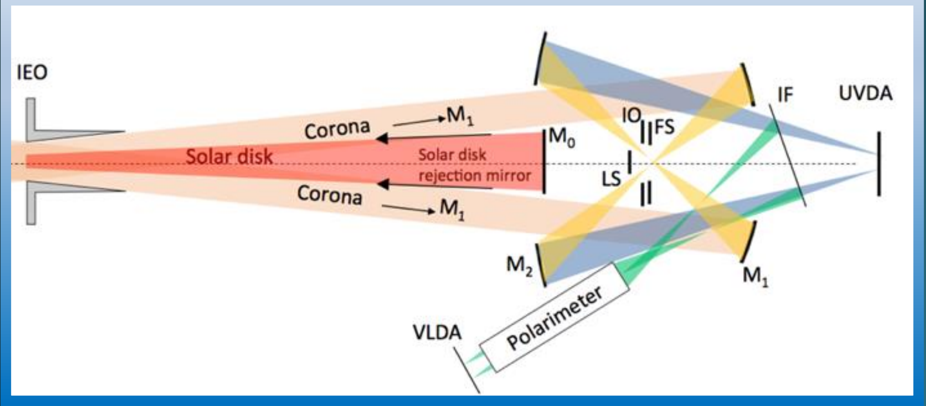
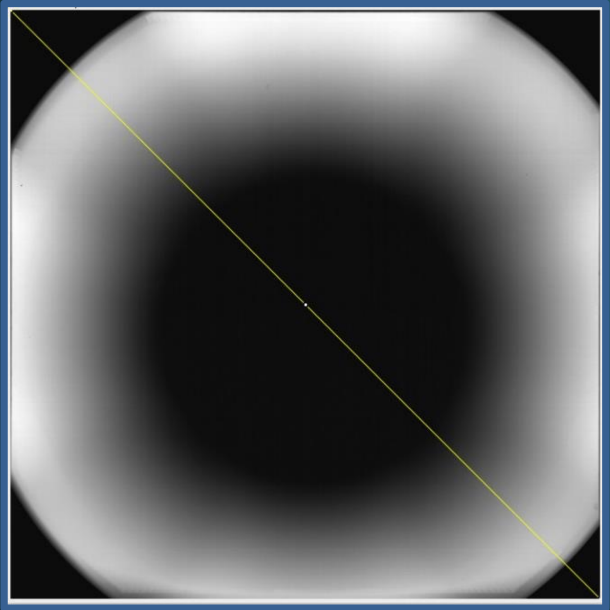
In-flight radiometric calibration of Metis using stars

Y. De Leo, L. Teriaca, V. Andretta, M. Romoli, D. Spadaro and the Metis Core Team

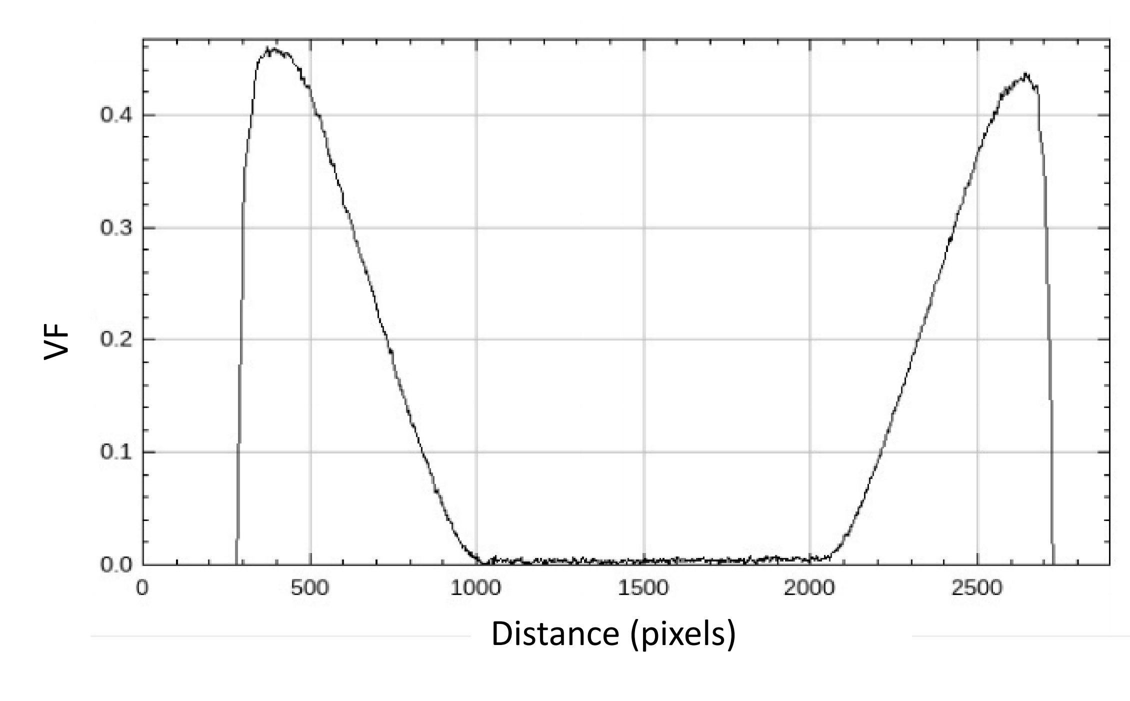
What is Metis?



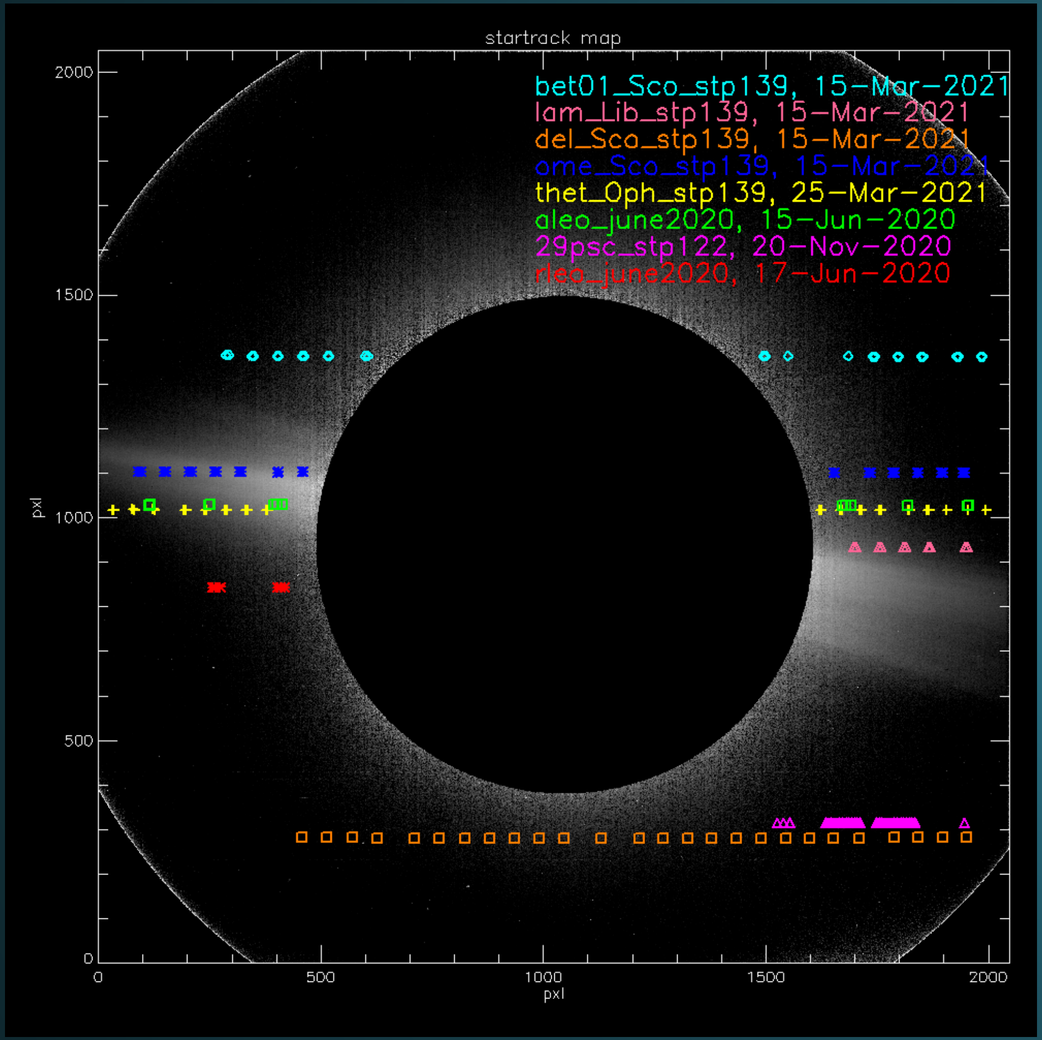
Metis is an imaging externally occulted coronagraph that provides full Imaging of the extended corona in UV, and visible light in pB and tB, with different spatial resolution and detector exposure time (*Antonucci et al. 2019).*



Visible light channel vignetting function as measured on ground



Radiometric calibration with stars

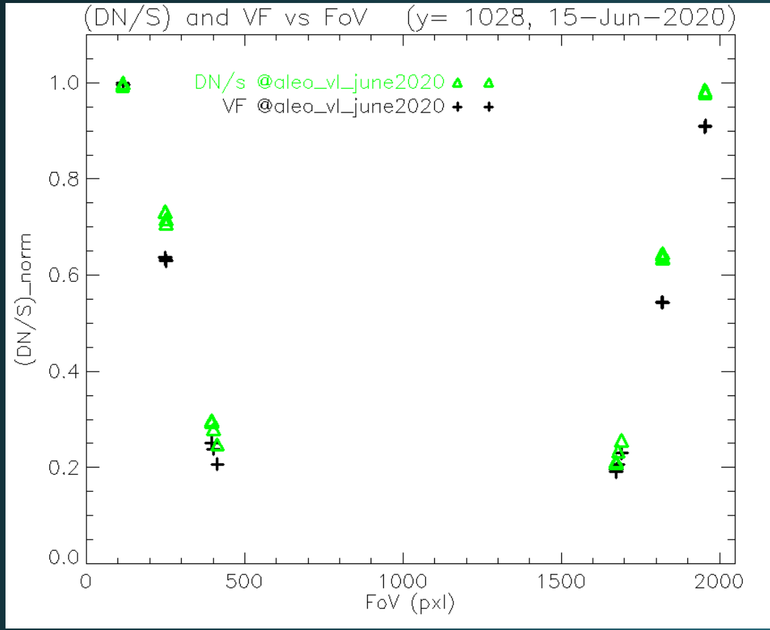


Tracks of the analysed stars in the field of view of the Metis VL channel (2048 pxl x 2048 pxl).

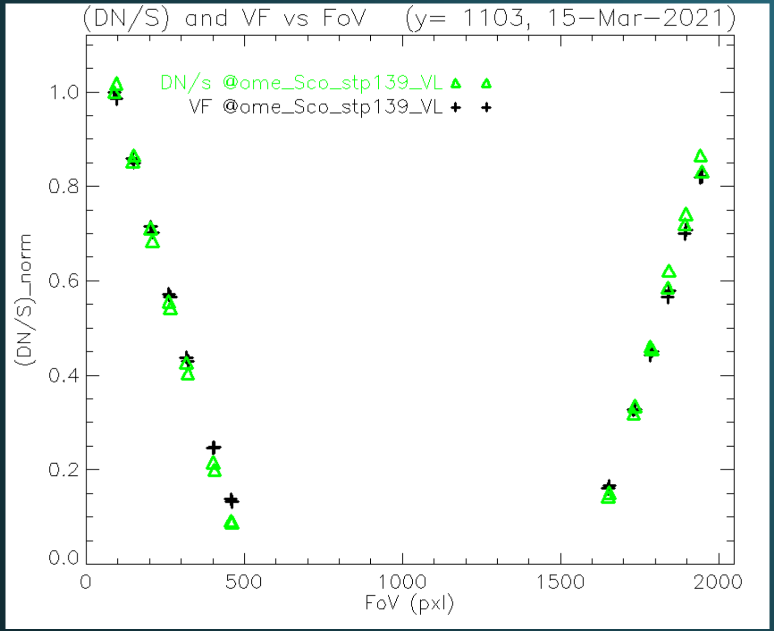
The stellar target opportunity is very rich for the VL channel

It is important to consider that the available targets for the UV channel are relevantly less

VL channel calibration



α Leonis



ω Scorpii

Starting from the star signal N_*(counts per second), it is necessary to invert the data in order to find the channel efficiency ε_{ch}:

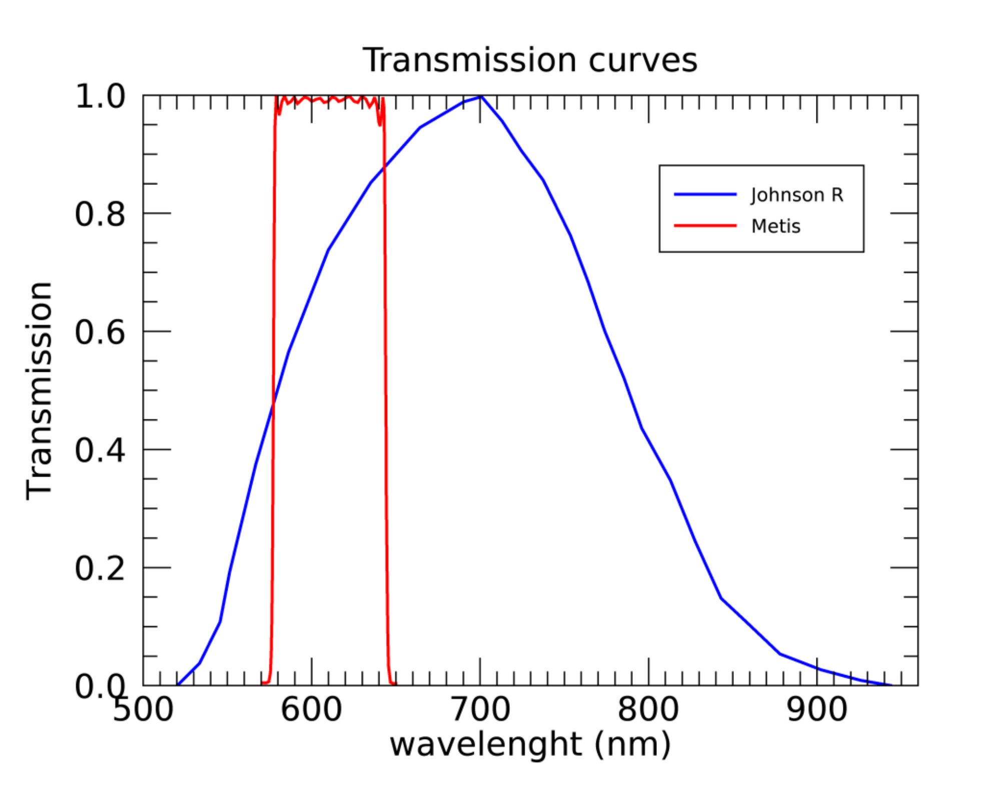
- $N_*(FoV) = \bar{f}_* \cdot \varepsilon_{ch} \cdot A_{pup} \cdot VF(FoV)$

- $\varepsilon_{ch} = \frac{N_*(FoV)}{\bar{f}_* \cdot A_{pup} \cdot VF(FoV)}$

Metis VL bandpass (580-640 nm)

The Metis VL channel peculiar photometric system

The VL channel is comparable to a non-standard red filter so it is necessary to adapt the calibration of a non-standard photometric system to a standard one.



$$R = \frac{\bar{f}_{Metis}}{\bar{f}_R}$$

$$\bar{f}_{Metis} = \frac{\int F_\lambda T_{Metis} d\lambda}{\int T_{Metis} d\lambda} \quad \text{and} \quad \bar{f}_R = \frac{\int F_\lambda T_R d\lambda}{\int T_R d\lambda}$$

and from the magnitude relation

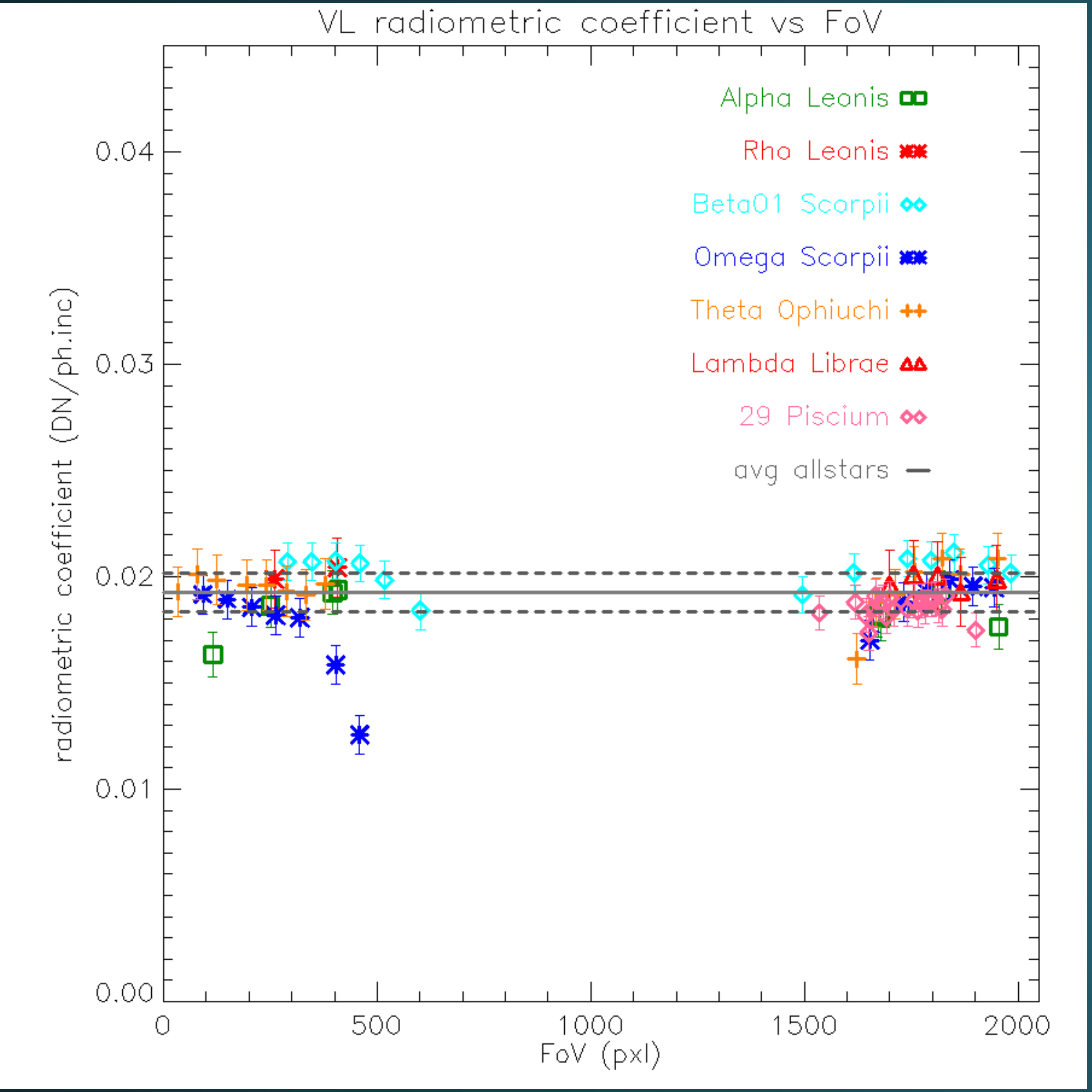
$$m_R - m_{R0} = -2.5 \log \frac{\bar{f}_R}{f_{R0}}$$

$f_{R0} = 2190 \cdot 10^{-12}\ \mathrm{erg}/cm^2/\mathrm{s}/\text{Å}$ *zero point flux*

m_{R0} =0.07

$$\bar{f}_{Metis} = R \cdot \bar{f}_R = R \cdot f_{R0} \cdot 10^{-\frac{m_R - m_{R0}}{2.5}}$$

VL channel calibration

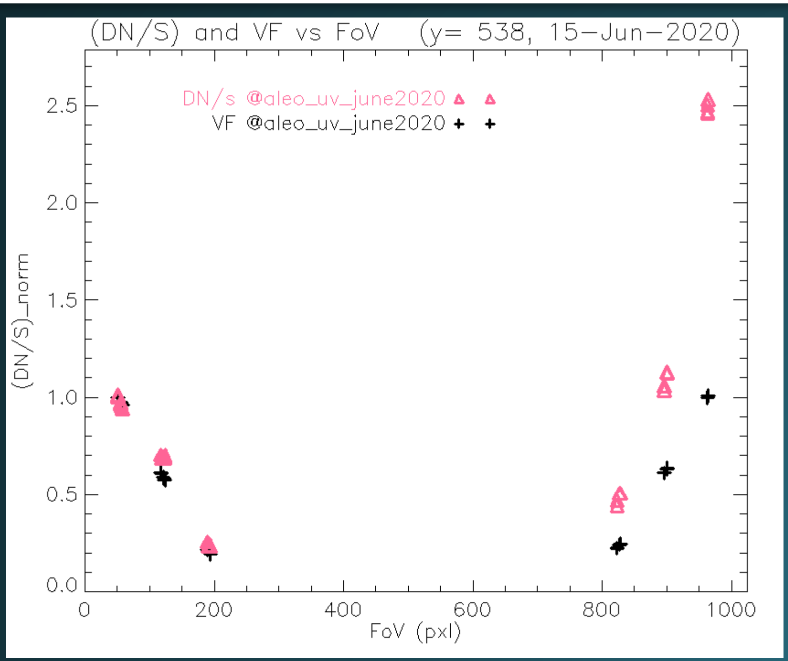


In this plot the first results of the data inversion

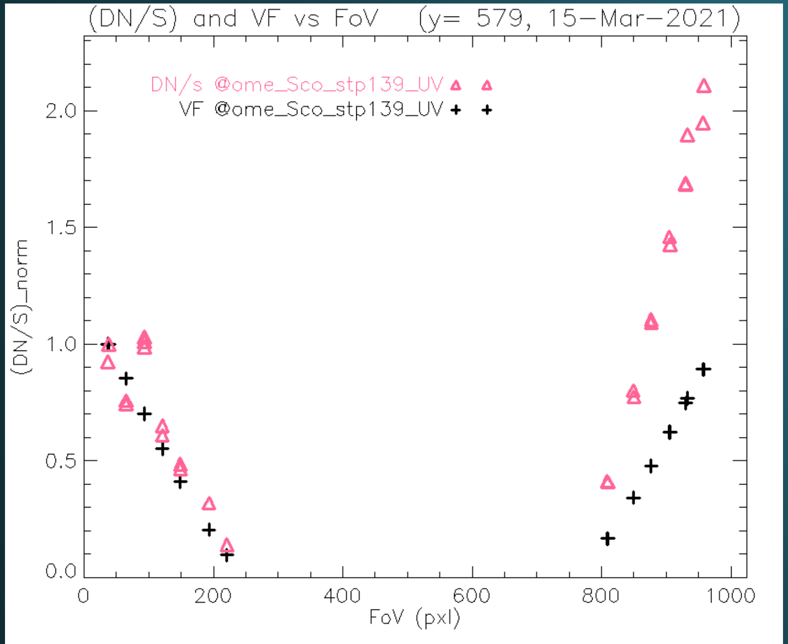
The values are consistent between the several stars.

This analysis provides the radiometric coefficient to pass from L0 data (in digital units) to L2 data (in physical units)

UV channel calibration



α Leonis

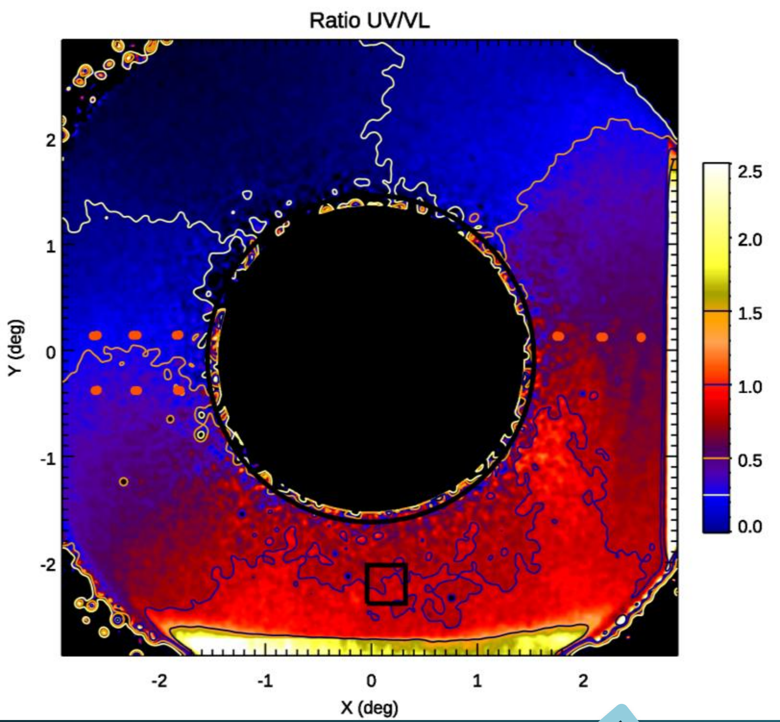


ω Scorpii

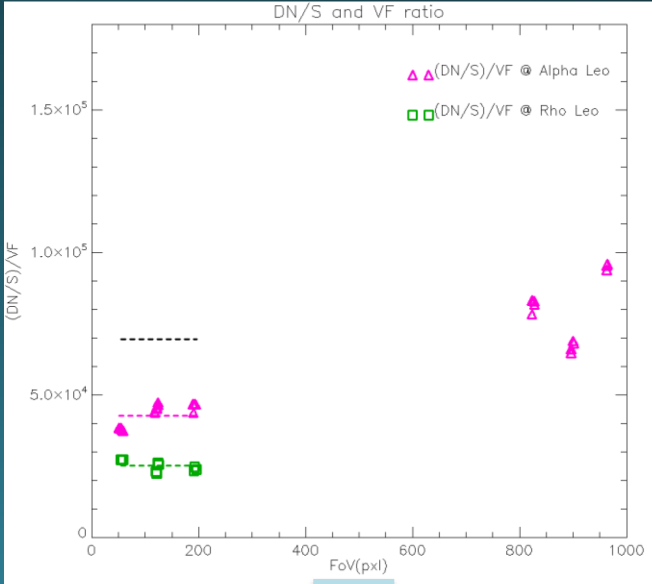
Comparison between the star signal and the VF trend along the field of view of the UV channel

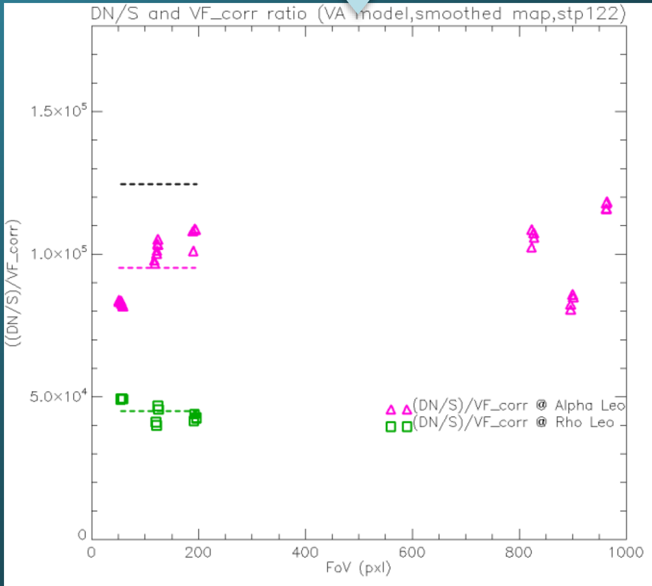
In this case the two trends present an evident discrepancy <u>on the west side</u> of FoV

Back-illumination door frames



Working hypothesis:
Assuming that at each point of the door the reflectance ratio for the 2 channels is the same, we can try to use UV2VL ratio to correct the data.





Using the UV2VL ratio maps was helpful to reduce the discrepancy

Conclusions

- The study of the stars transits, since the beginning of the *commissioning phase*, has proven to be very useful in order to optimize the radiometric calibration of the two channels of the instrument.

- This preliminary analysis already shows that the VL channel response is substantially as expected.

- For the UV channel we noticed a discrepancy between star data and the VF measured on ground, and this requires more work in order to fix the response of this channel.

References

Antonucci E. et al., (2020), “Metis: the Solar Orbiter visible light and ultraviolet coronal imager”, A&A, 642, A10.

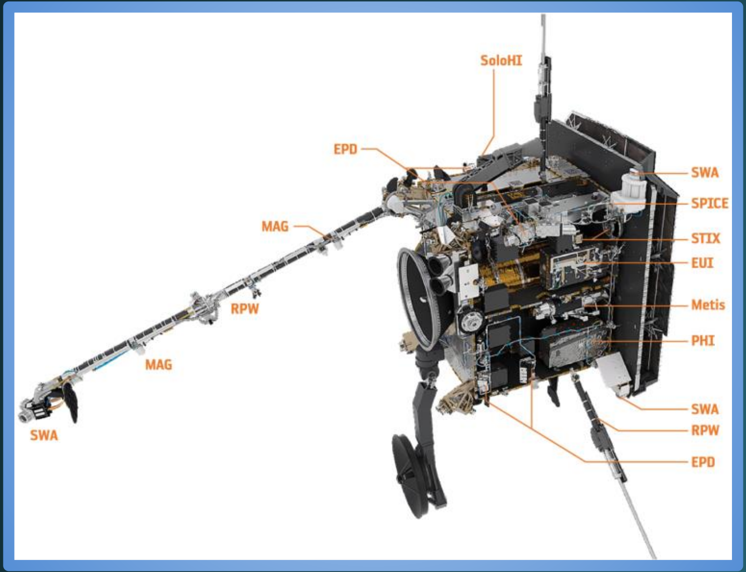
SCAN ME

Contact: Yara De Leo deleo@mps.mpg.de

Thanks for your kind attention!

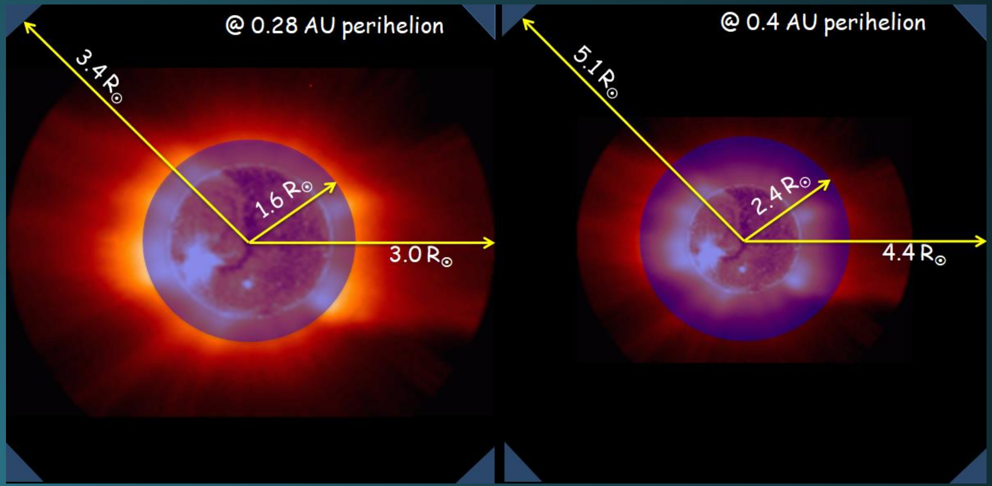
Back-up slides

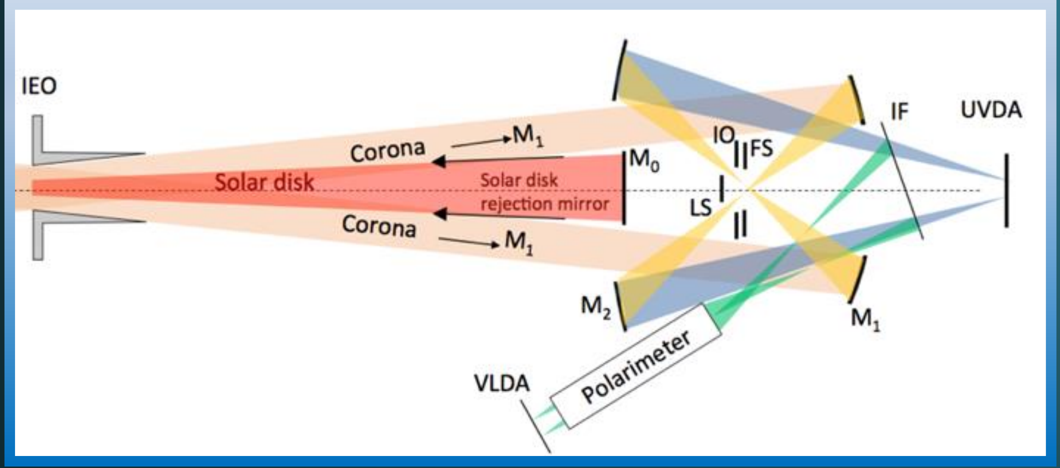
What is Metis?



Field of view:
annular, 1.5° - 2.9°

- 1.6 $R_\odot$ to 3.0 $R_\odot$ @ 0.28 UA
- 2.4 $R_\odot$ to 4.4 $R_\odot$ @ 0.40 UA





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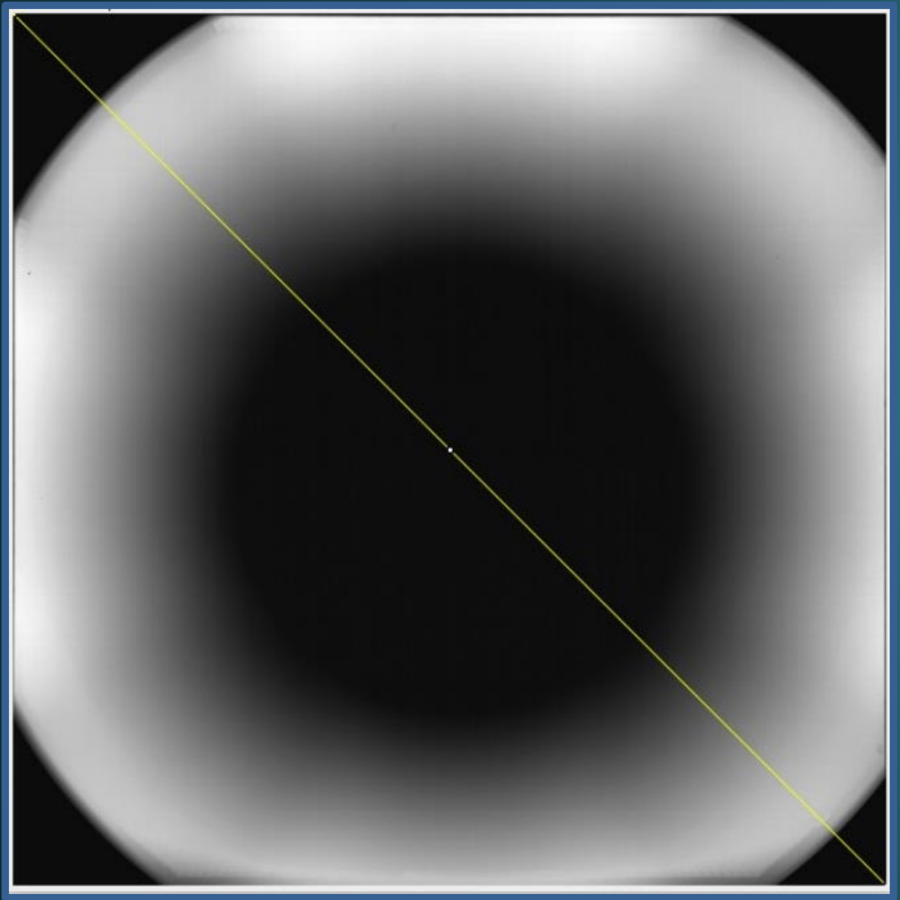
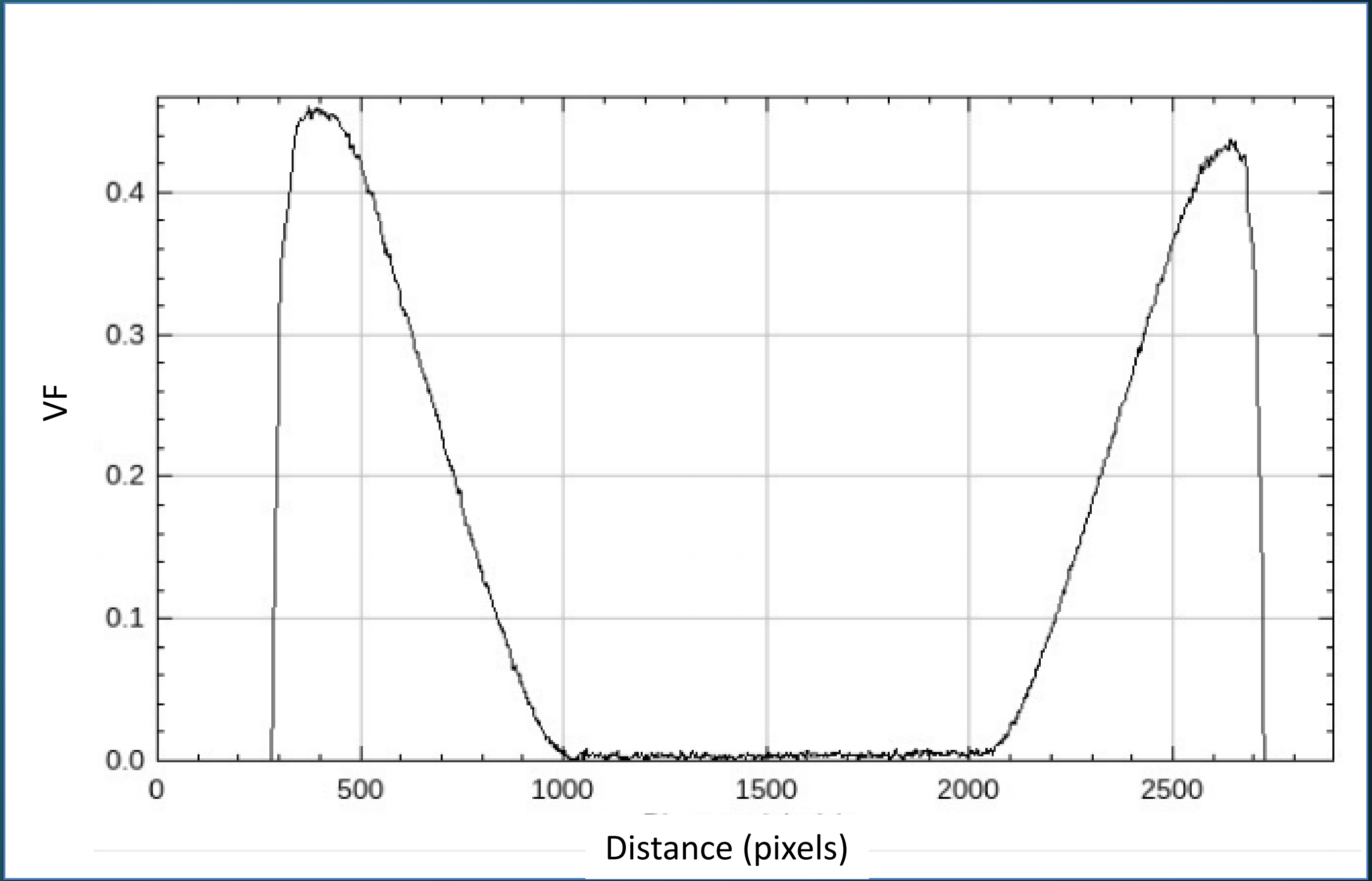
Antonucci et al. 2019

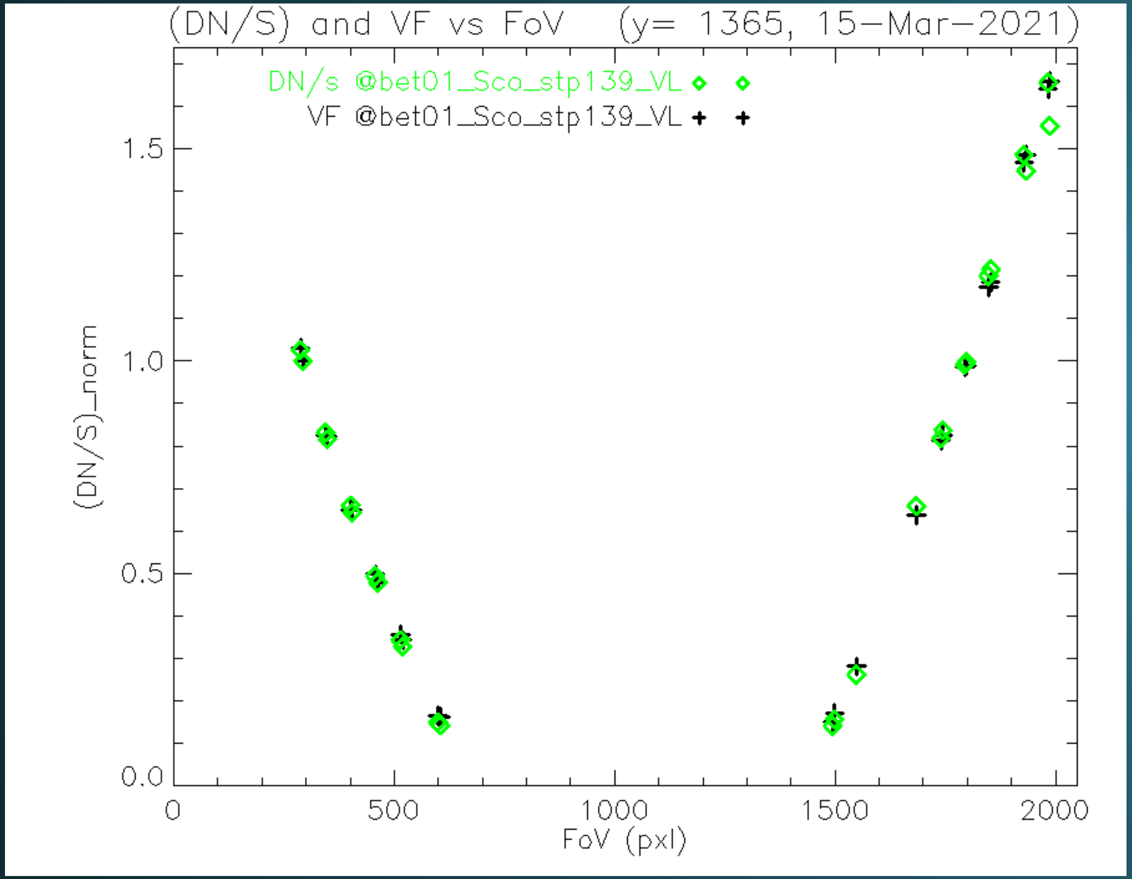
Coronagraph peculiarities: the Vignetting Function

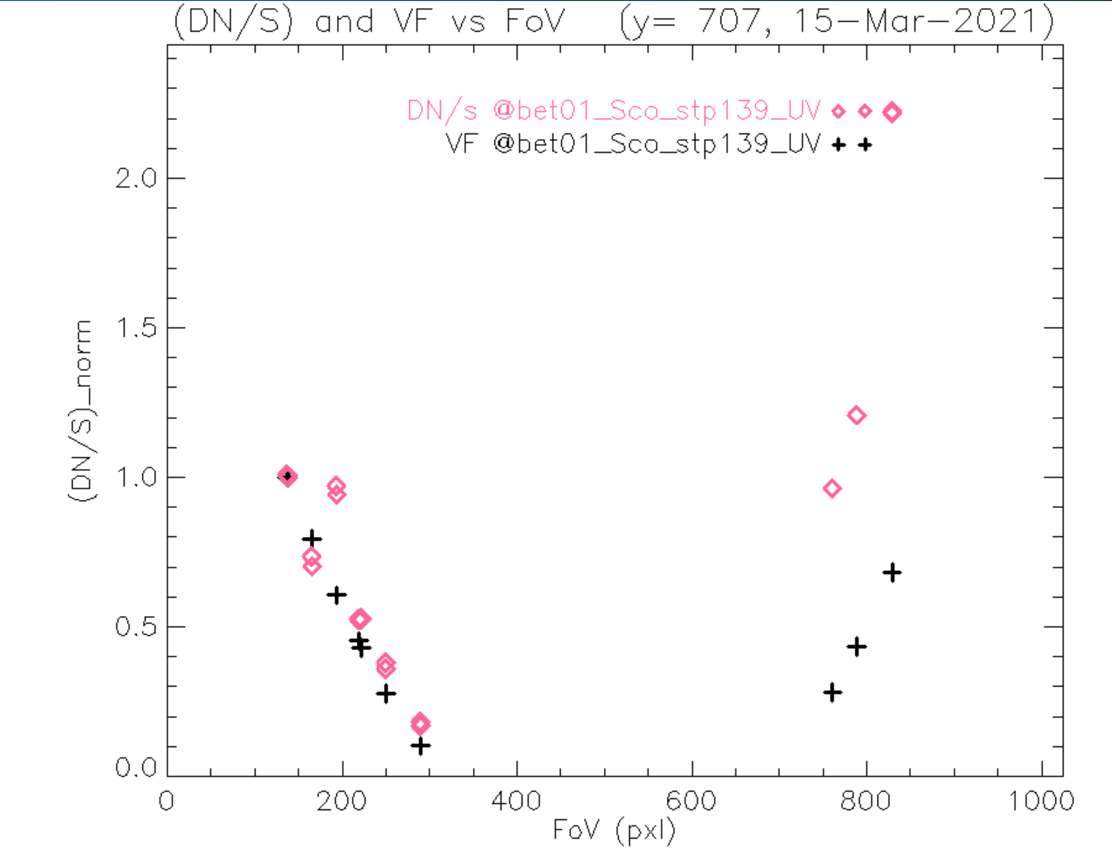




Beta01 Scorpii

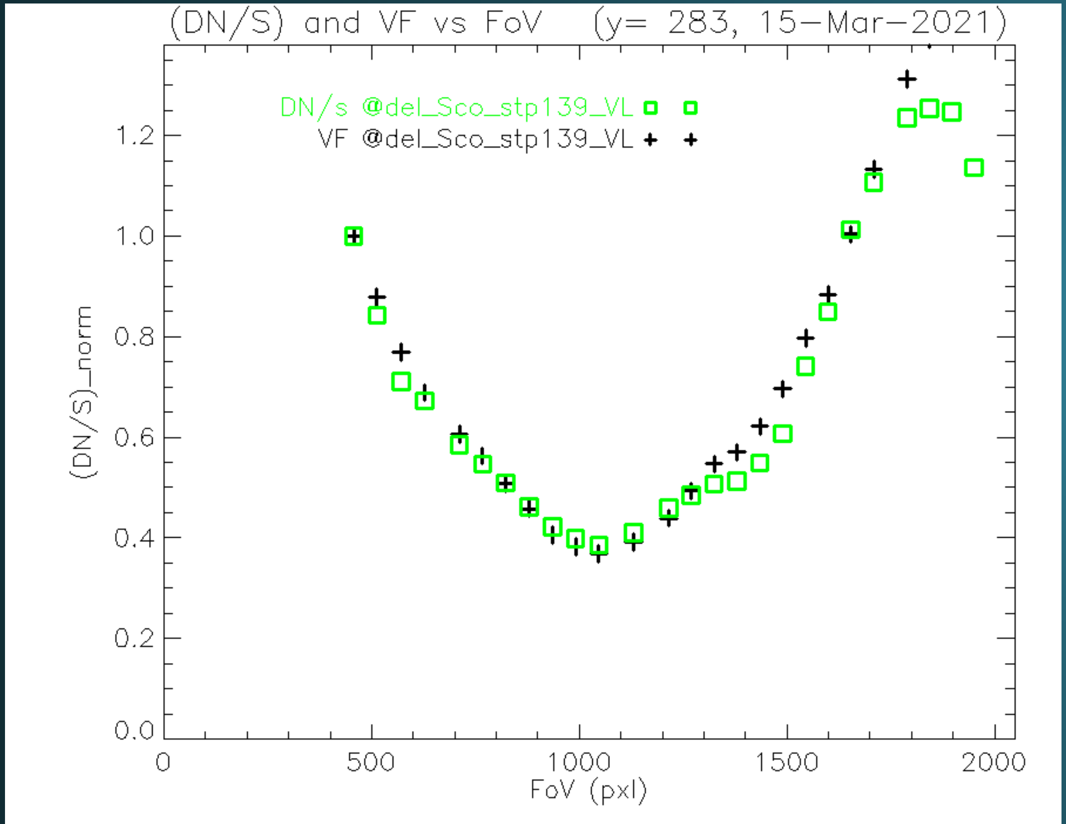
RC activity: STP-139/140/141

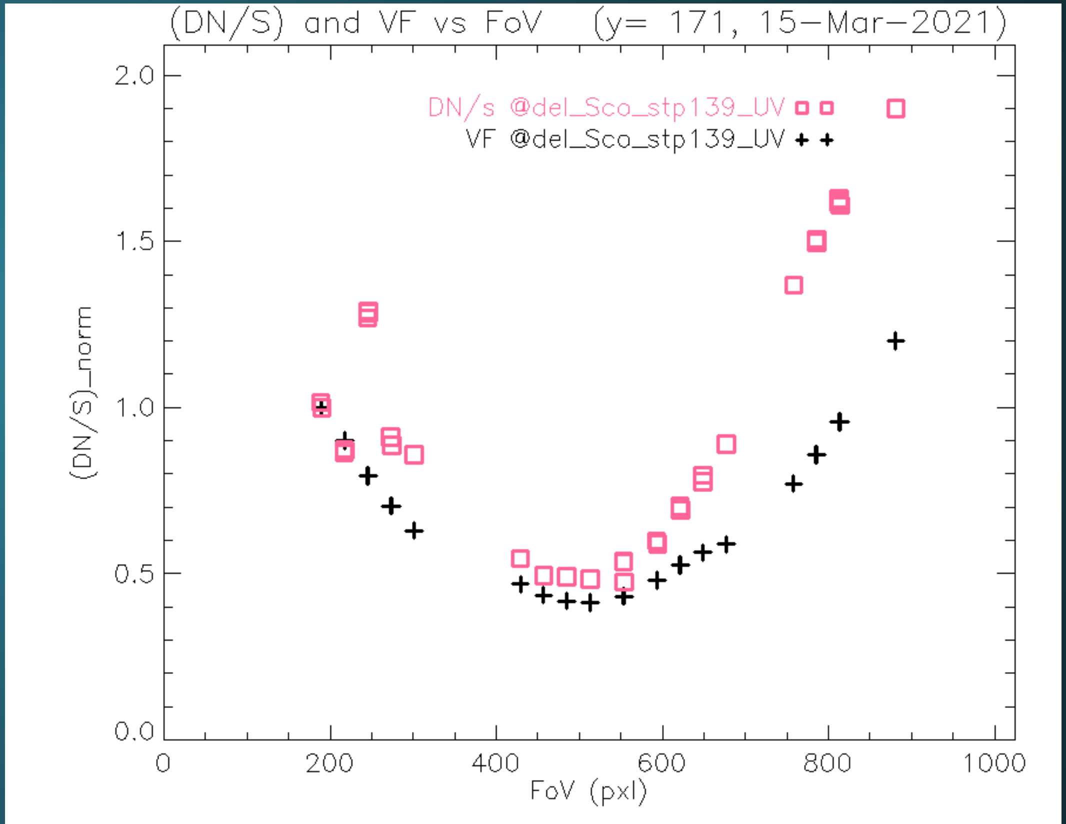




RC activity: STP-139/140/141

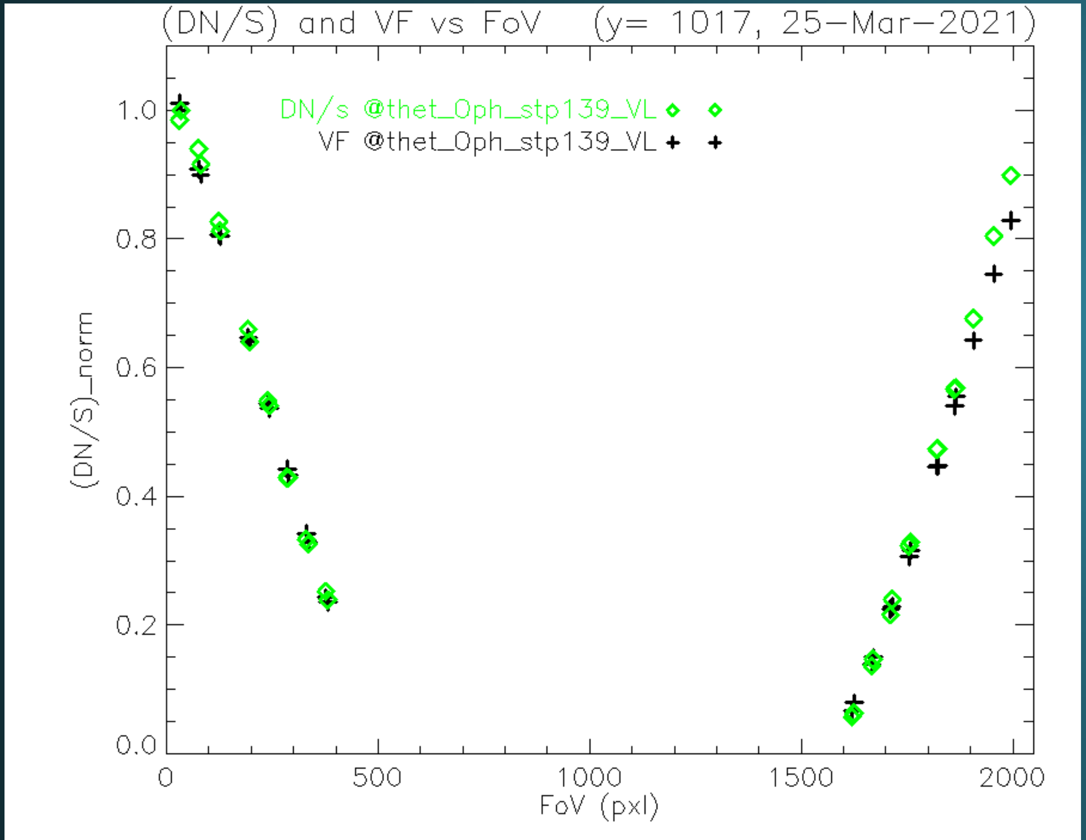
Delta Scorpii

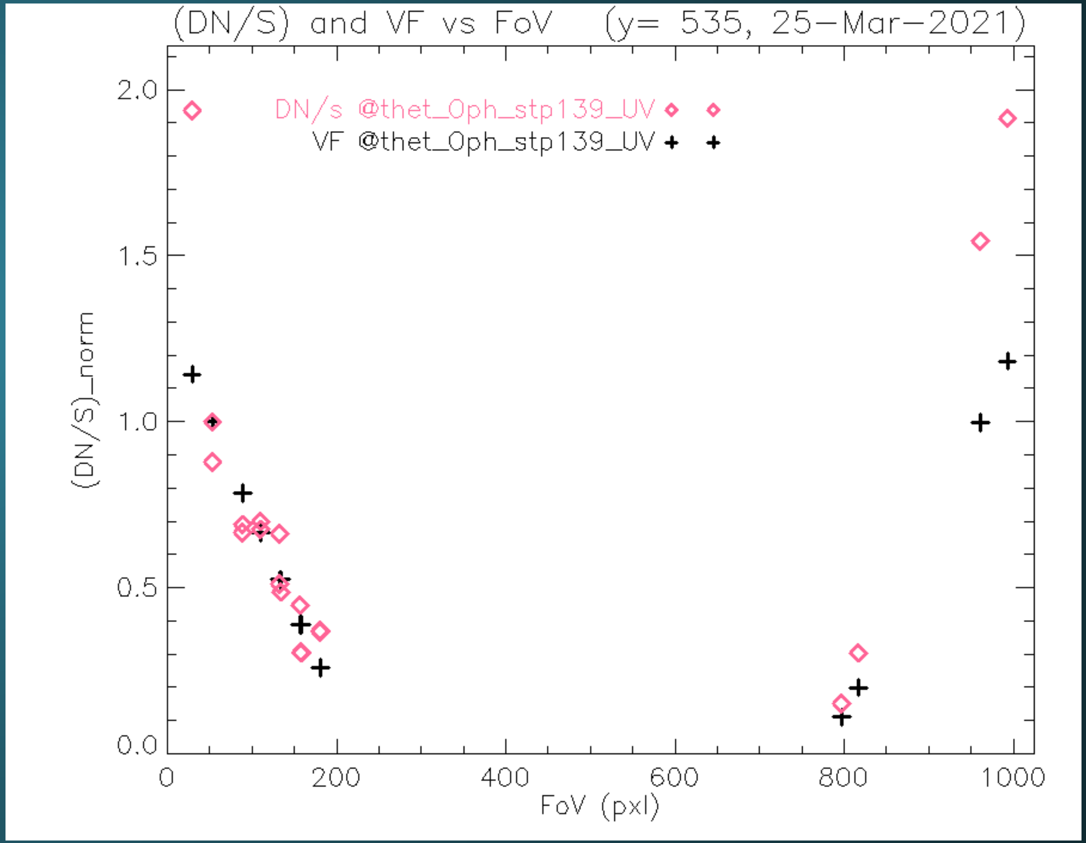




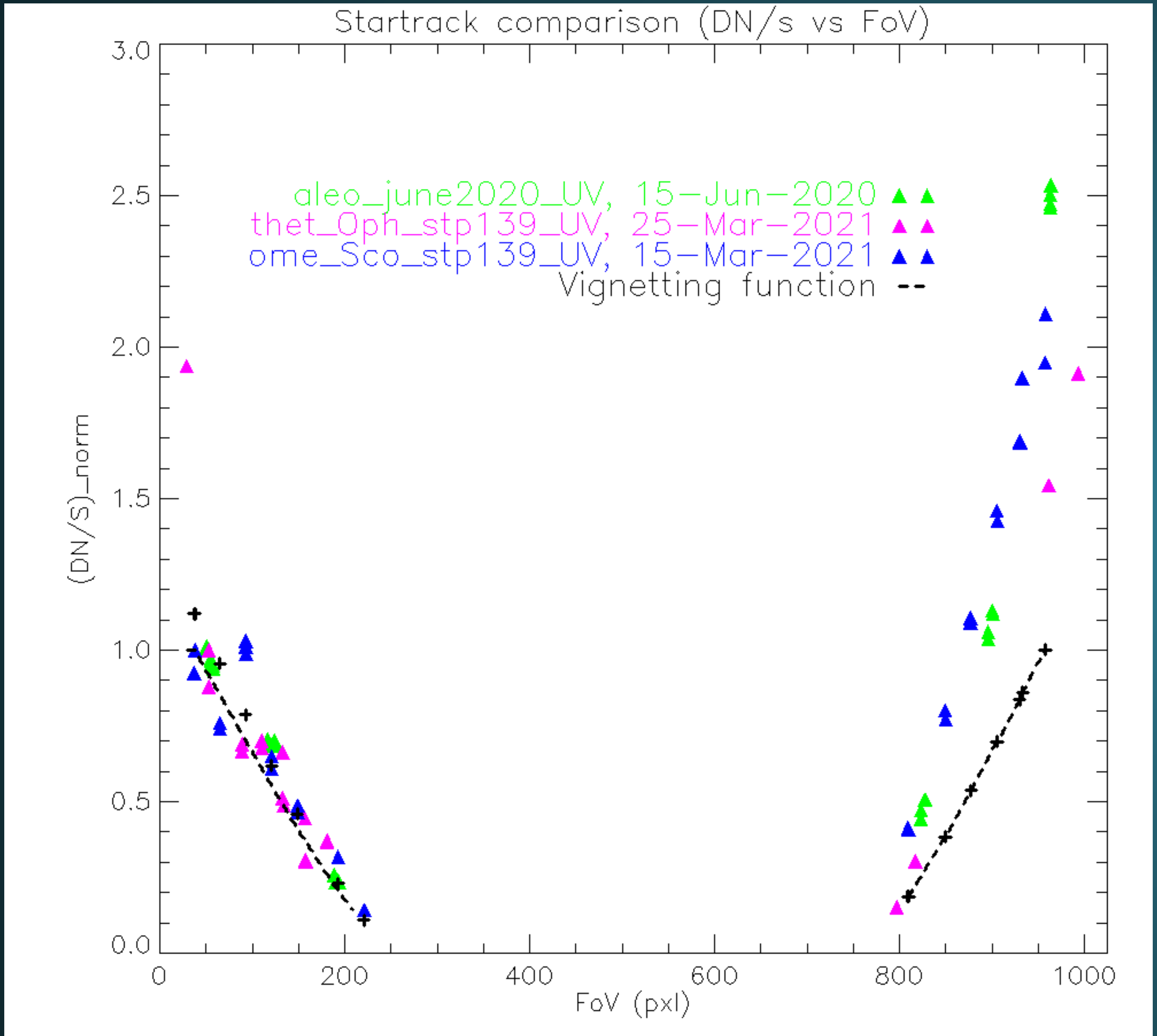
RC activity: STP-139/140/141

Theta Ophiuchi





3 central stars comparison

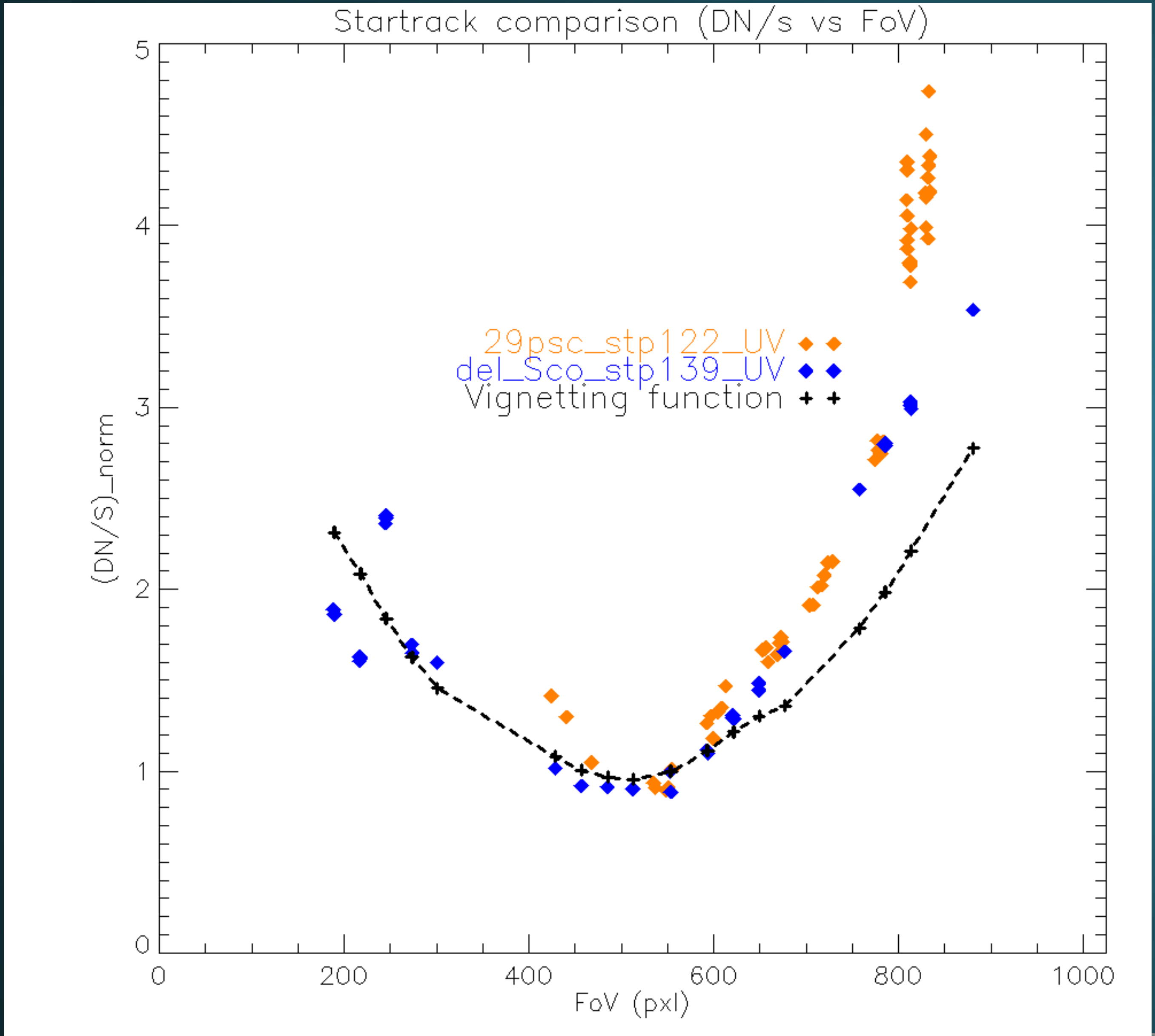


Alpha Leonis y= 538

Theta Ophiuchi y= 535

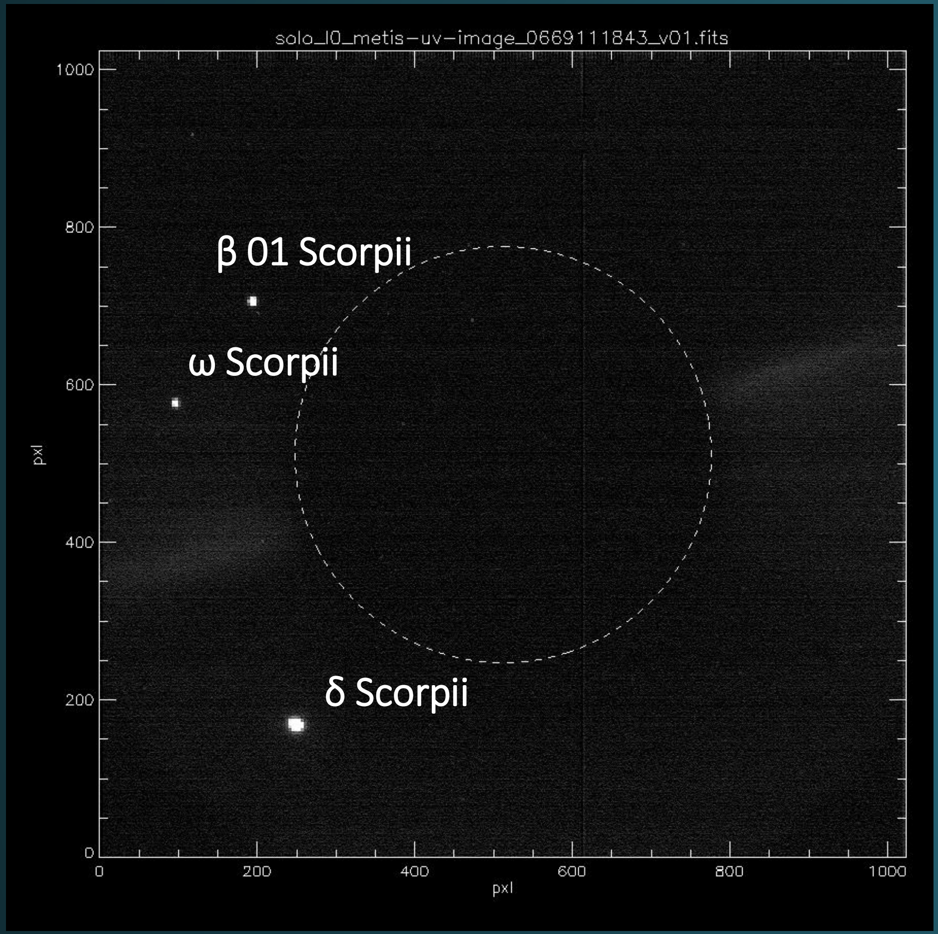
Omega Scorpii y= 579

2 bottom stars comparison

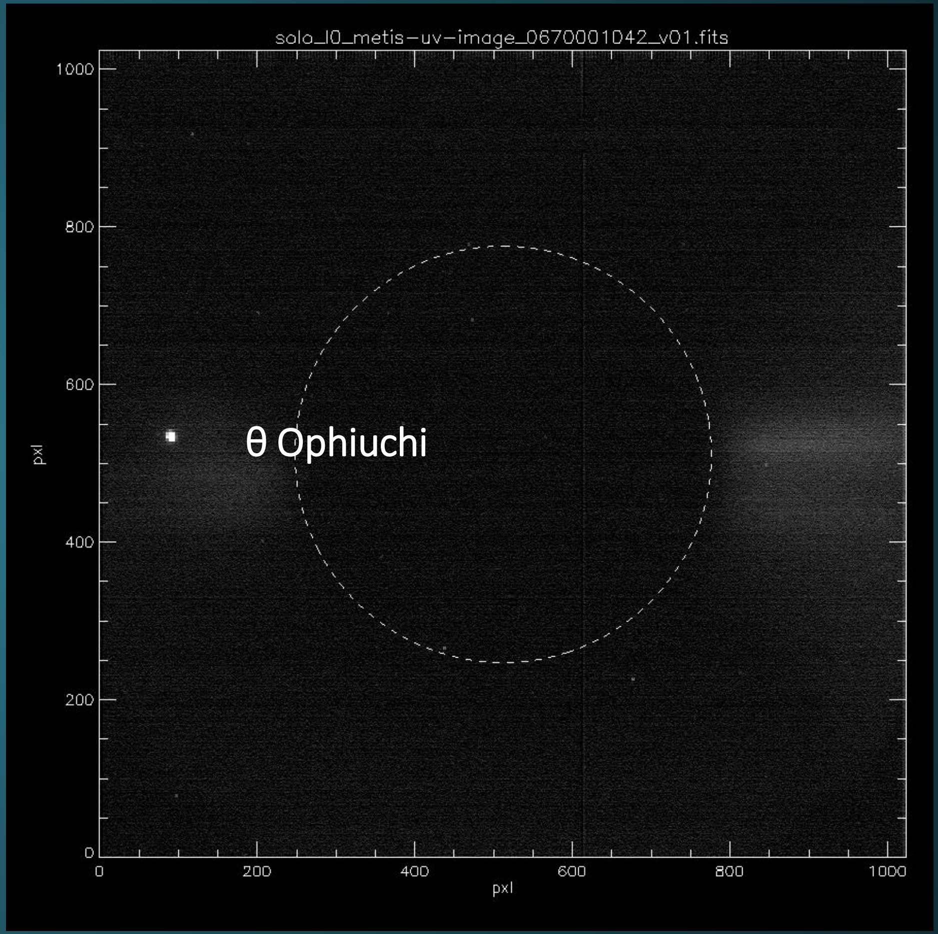


29 Piscium y= 181
Delta Scorpii y= 171

RC activity: STP-139/140

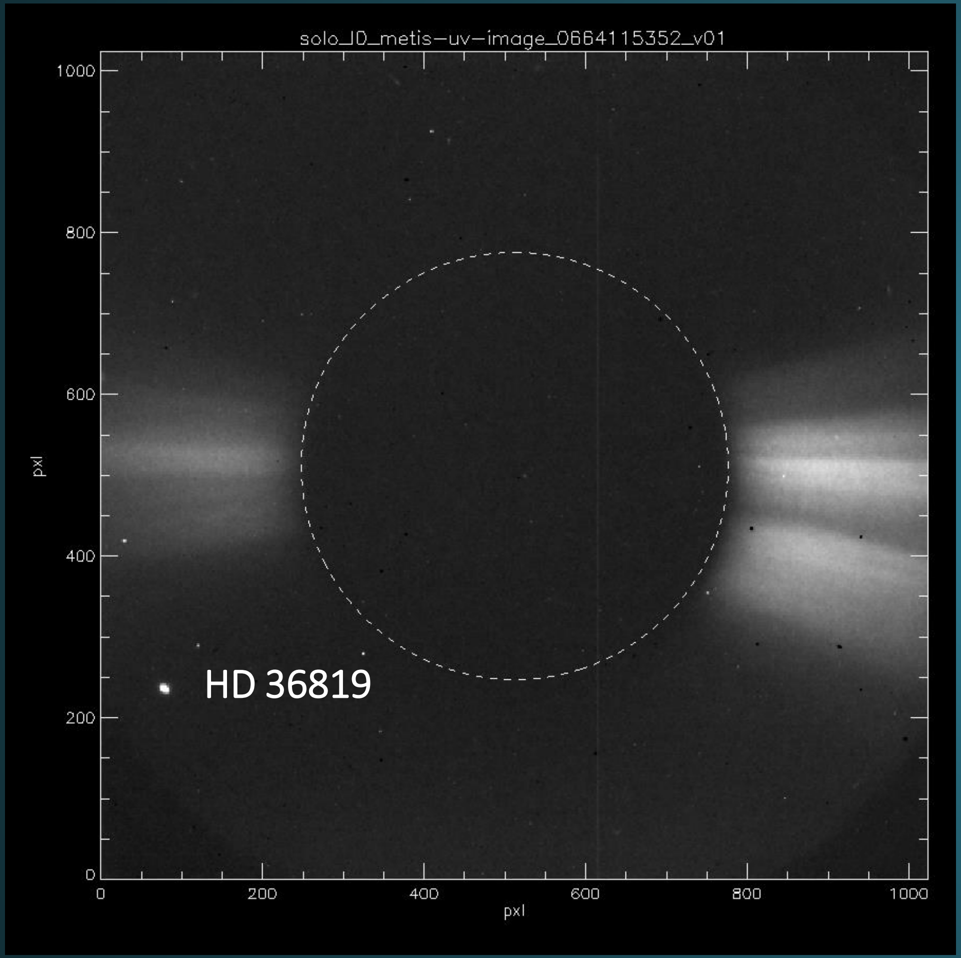


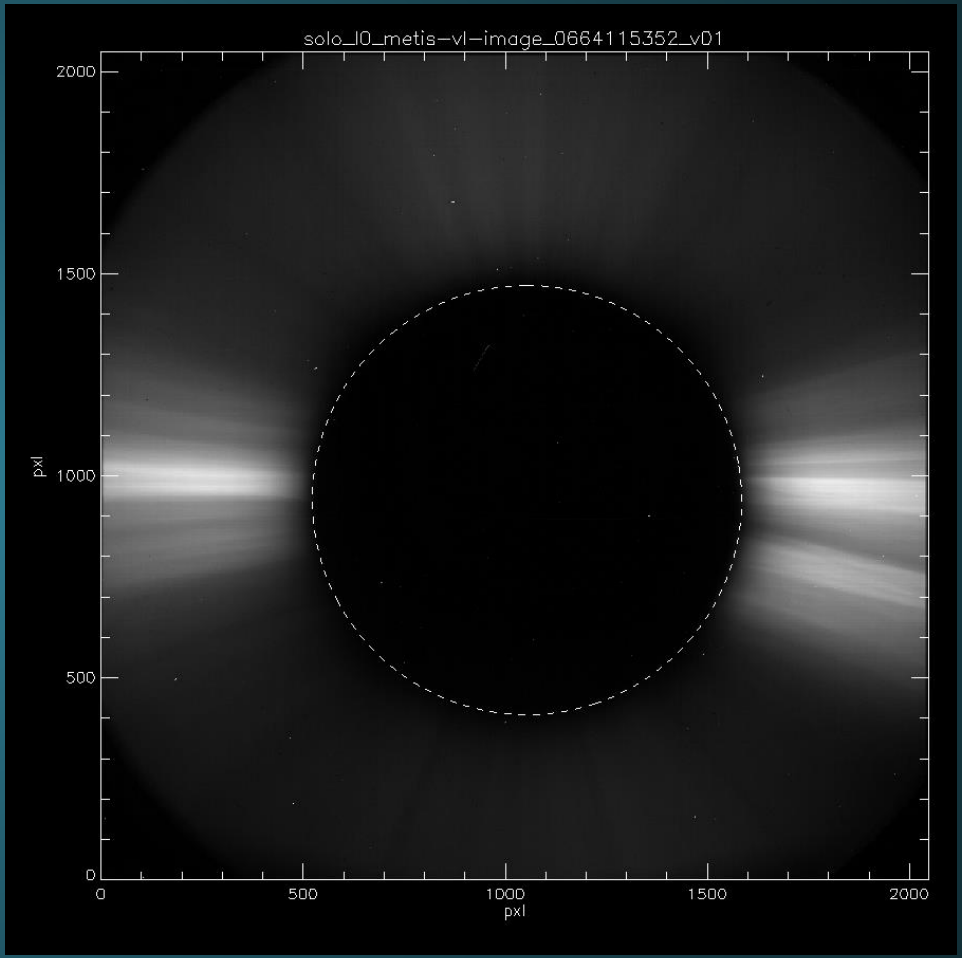
UV frame from STP-139:
On board average of 8 frames exposed 16 s



UV frame from STP-140:
On board average of 8 frames exposed 16 s

Activity: STP-130





UV frame from STP-130:
On board average of 15 frames exposed 60 s

VL pB frame from STP-130:
On board average of 15 frames exposed 30 s

Activity: STP-130