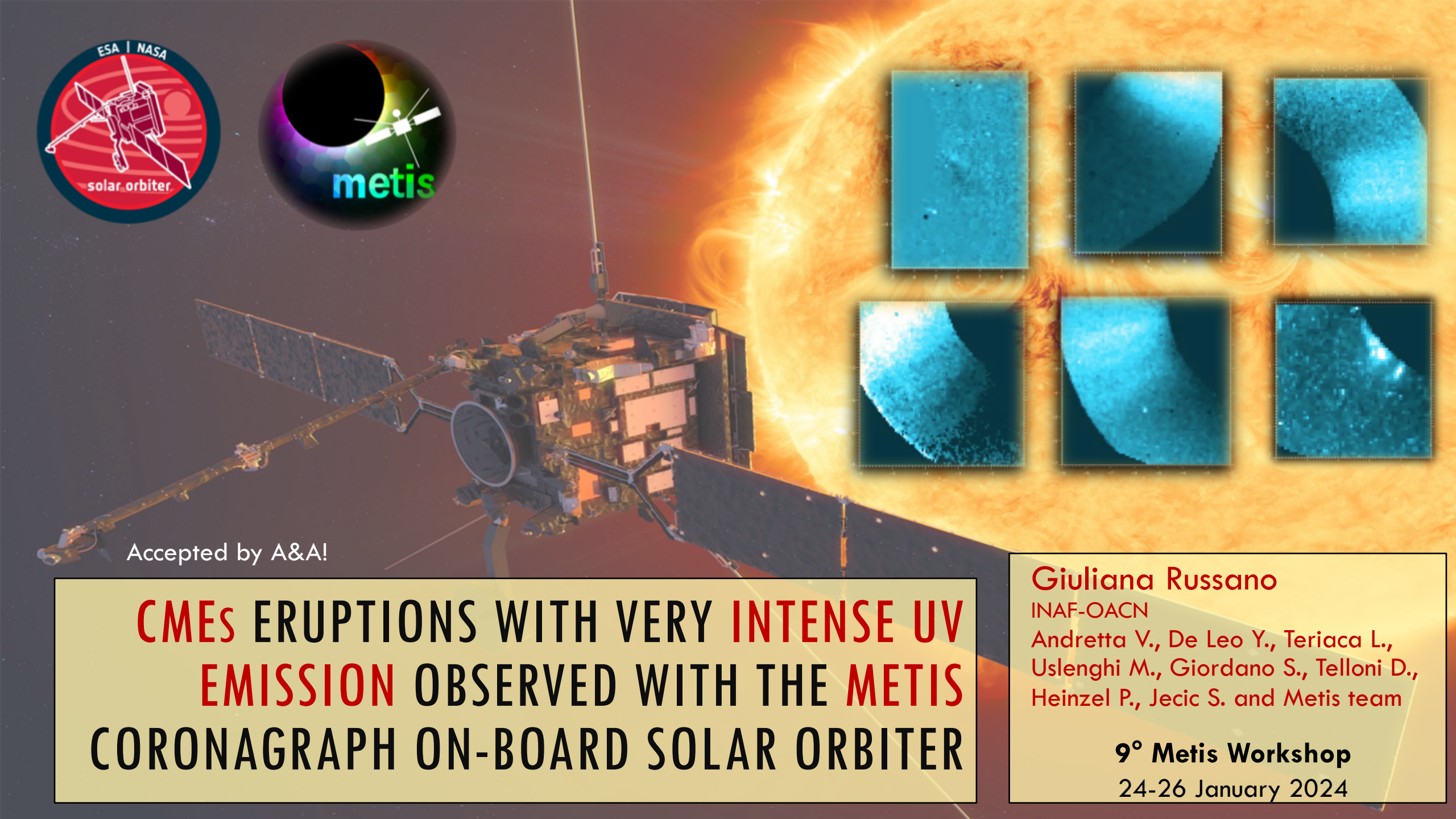


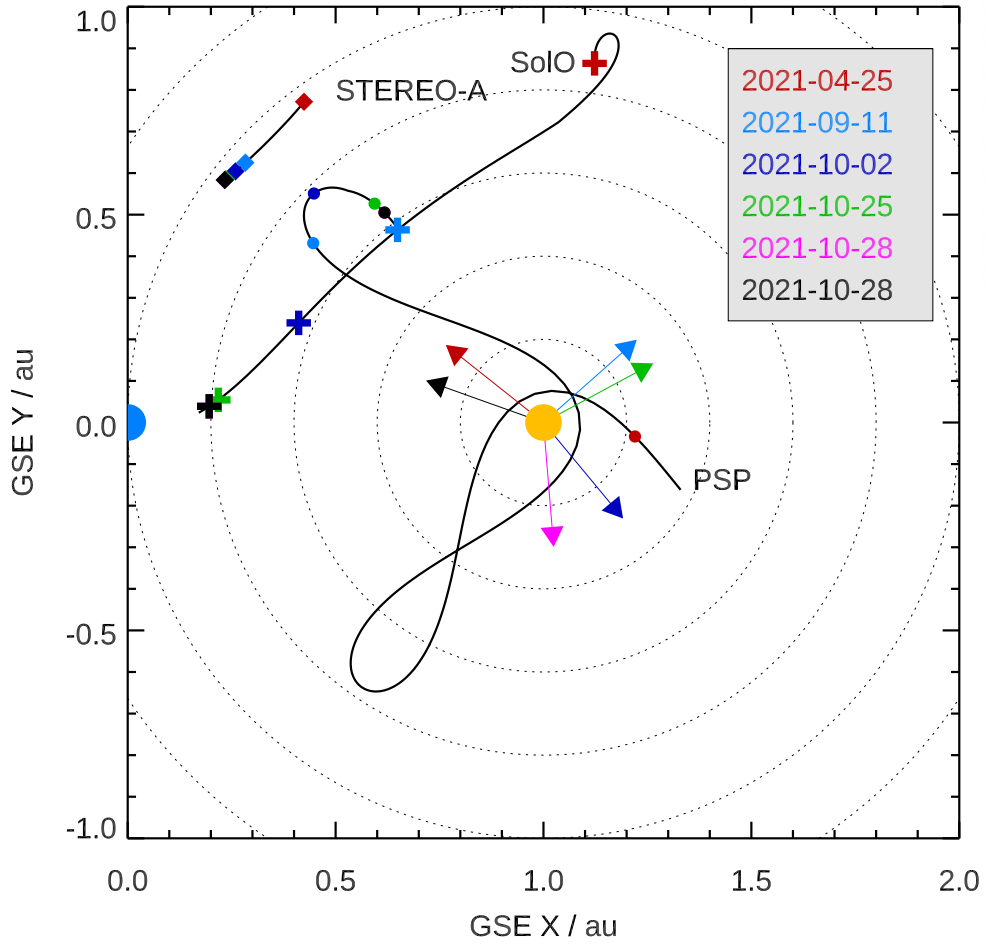
Accepted by A&A!

CMEs ERUPTIONS WITH VERY INTENSE UV EMISSION OBSERVED WITH THE METIS CORONAGRAPH ON-BOARD SOLAR ORBITER

Giuliana Russano
INAF-OACN
Andretta V., De Leo Y., Teriaca L., Uslenghi M., Giordano S., Telloni D., Heinzel P., Jecic S. and Metis team

9° Metis Workshop
24-26 January 2024

SIX ERUPTIVE EVENTS, APRIL - OCTOBER 2021



Accepted by A&A, in press!

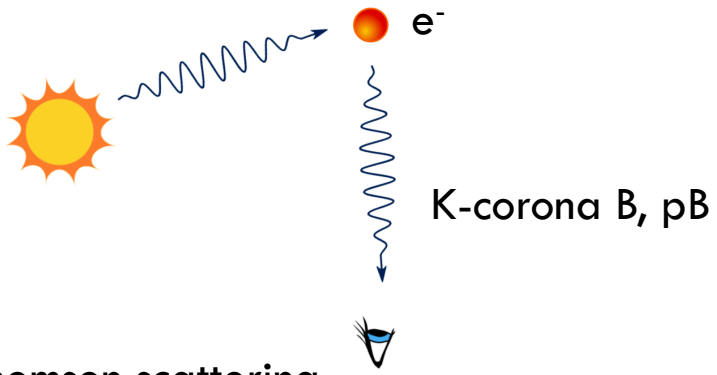
Eruptive events with exceptionally bright emission in H I Ly-α observed by the Metis coronagraph

G. Russano[1], V. Andretta[1], Y. De Leo[2,3], L. Teriaca[2], M. Uslenghi[4], S. Giordano[5], D. Telloni[5], P. Heinzel[6,7], S. Jejčič[6,8,9], L. Abbo[5], A. Bemporad[5], A. Burtovoi[10], G. E. Capuano[3,11,12], F. Frassati[5], S. Guglielmino[11], G. Jerse[13], F. Landini[5], A. Liberatore[14], G. Nicolini[5], M. Pancrazzi[5], P. Romano[11], C. Sasso[1], R. Susino[5], L. Zangrilli[5], V. Da Deppo[15,16], S. Fineschi[5], C. Grimani[17,18], J.D. Moses[19], G. Naletto[20], M. Romoli[21], D. Spadaro[11], and M. Stangalini[22]

- Characterization of six UV bright eruptions during Solar Orbiter cruise phase
  - 25-26 April 2021
  - 11 September 2021
  - 2 October 2021
  - 25 October 2021
  - 28 October 2021 NW and SE

- Study on morphology, kinematics and discussion on general features of pB and UV emissions

SOLAR CORONA EMISSION WITH METIS



Thomson scattering

Polarized Visible-Light emission:

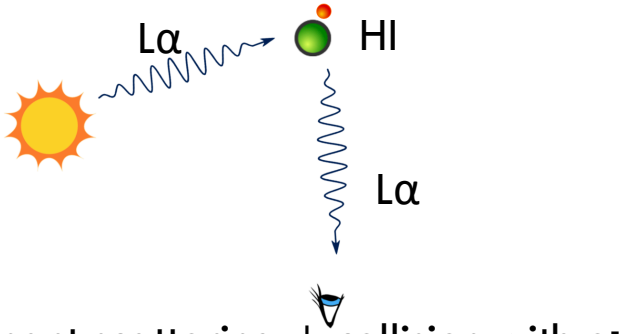
- evolution of plasma electron density
- kinematic properties

(e.g. white light imaging with STEREO and SOHO/LASCO)

UV emission:

- plasma temperatures
- inflow velocity
- elemental composition variations

(e.g. Coronagraph Spectrometer SOHO/UVCS)

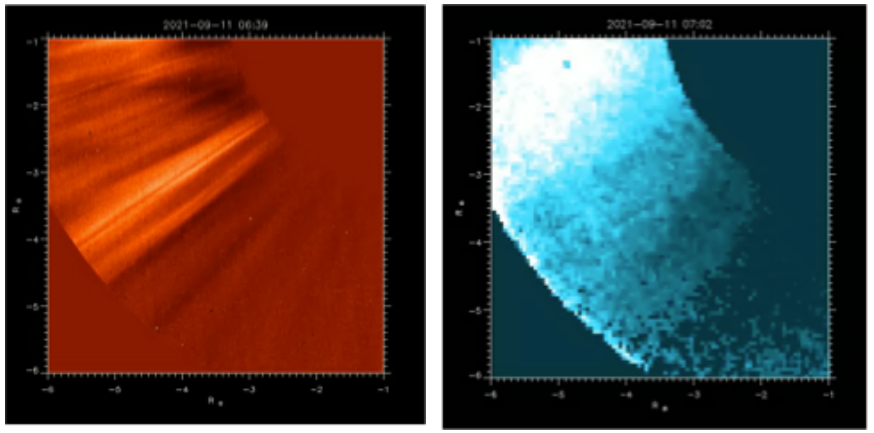


Resonant scattering + collision with e-

Metis provides direct imaging in UV HI Ly-α

Unprecedent spatial and temporal resolution

VL UV



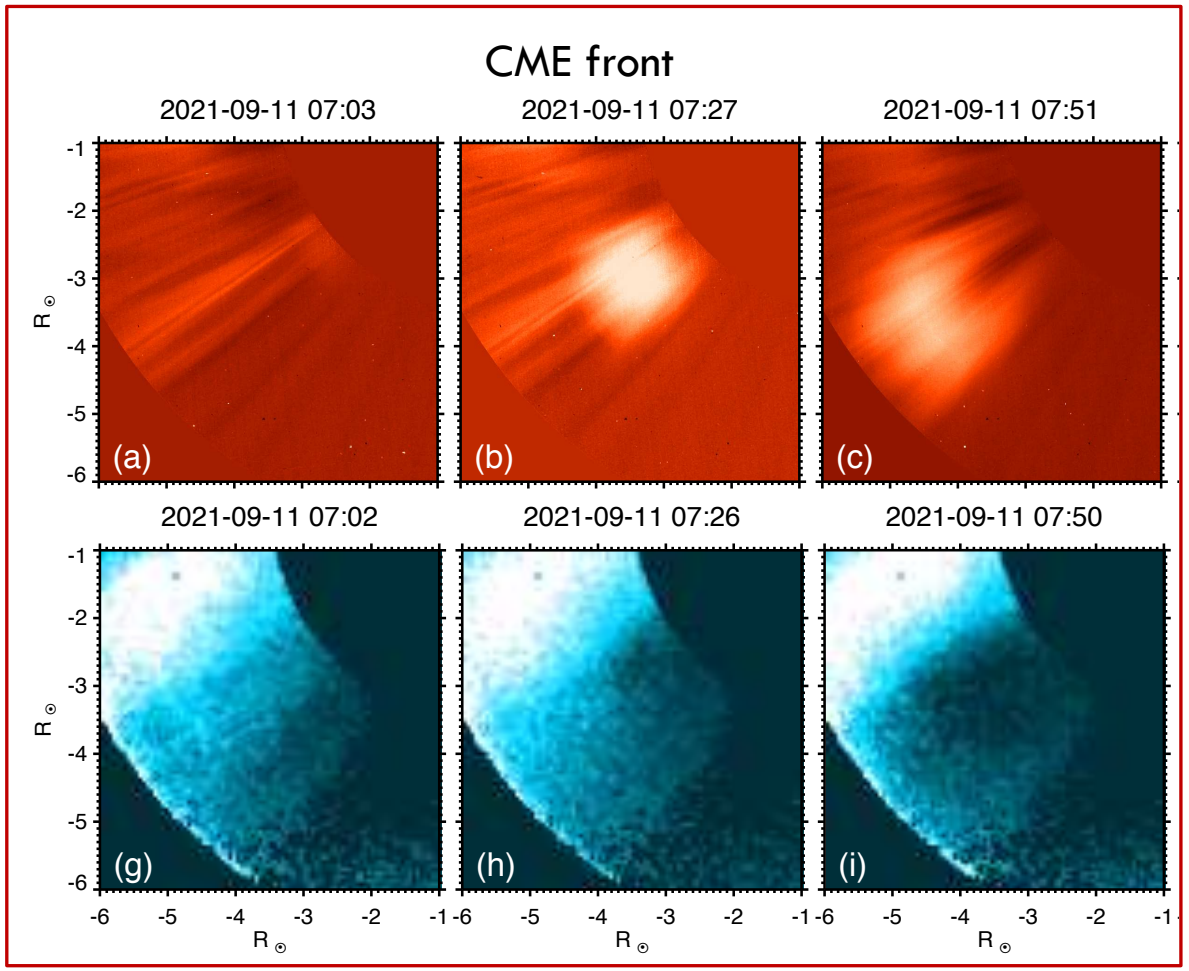
September 11, 2021

Russano et al. A&A, in press (2024)

11/09/2021 OVERVIEW

Metis pB
Base
difference

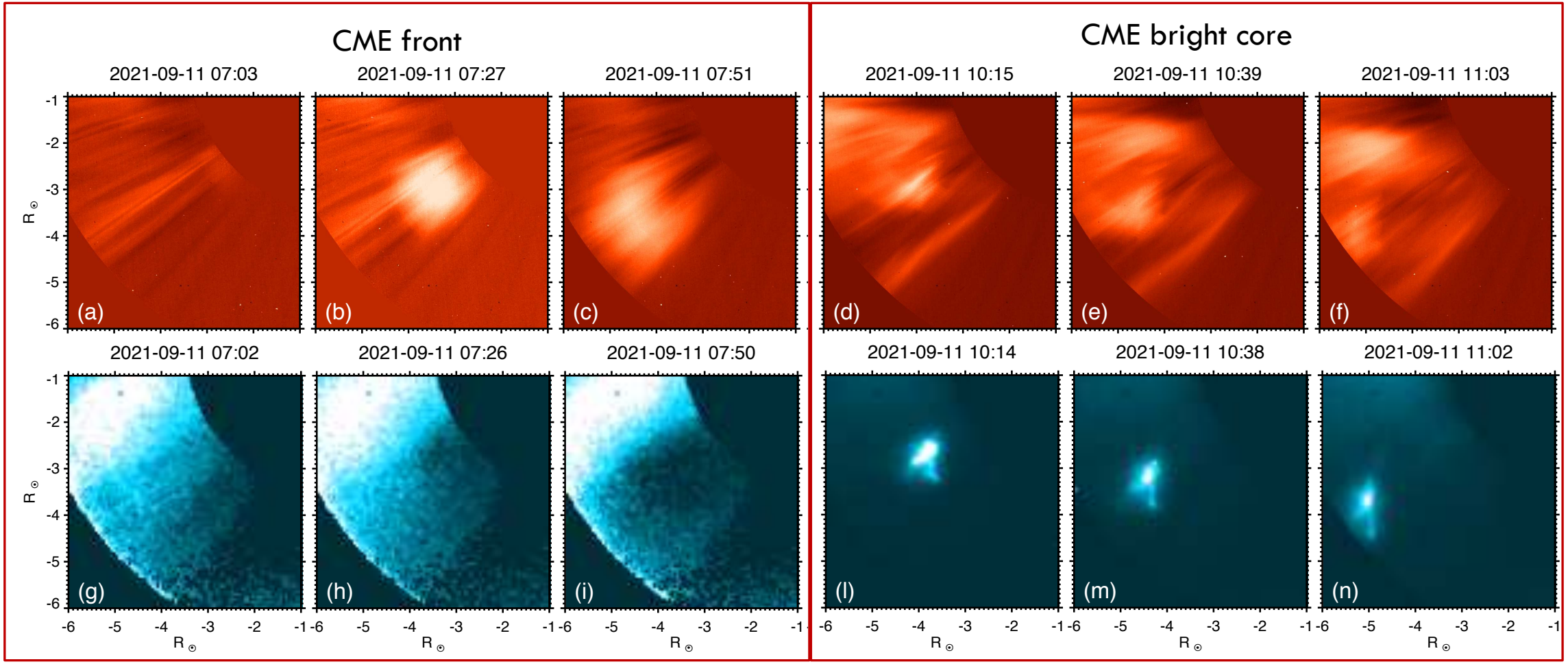
Metis UV



11/09/2021 OVERVIEW

Metis pB Base difference

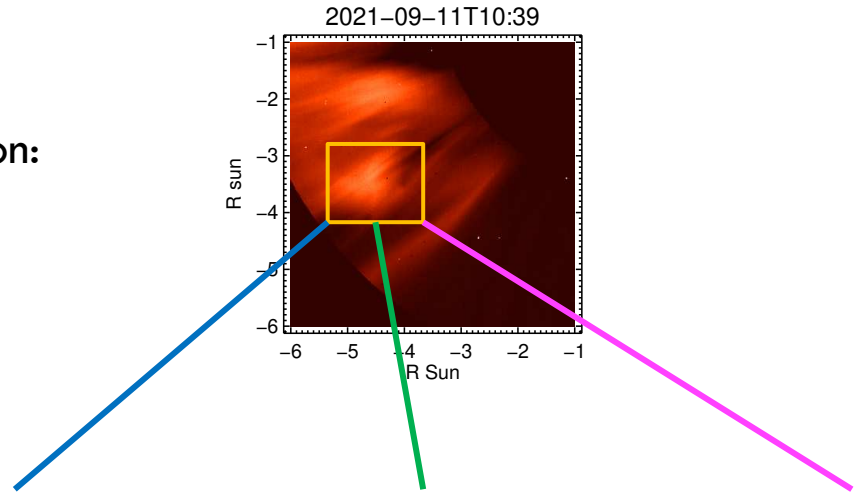
Metis UV

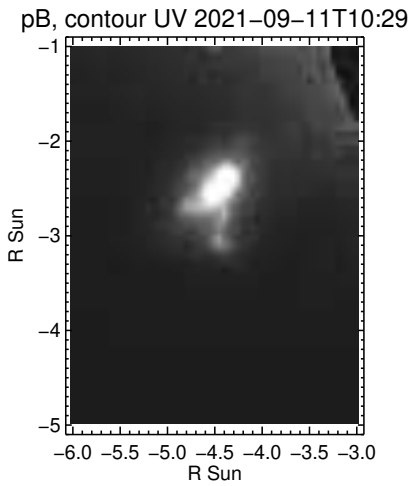


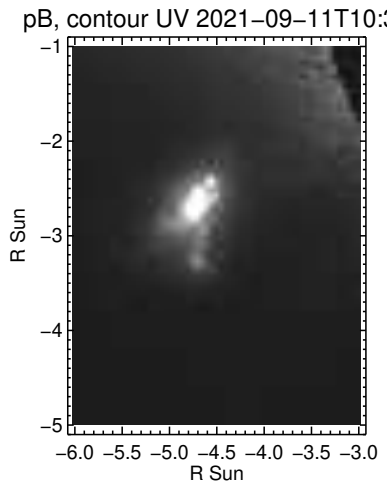
TIME AND SPACE RESOLUTION

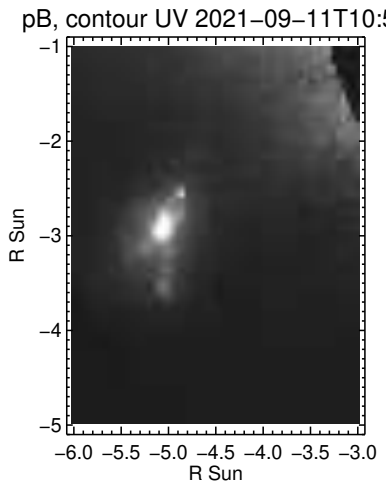
Different time resolution:

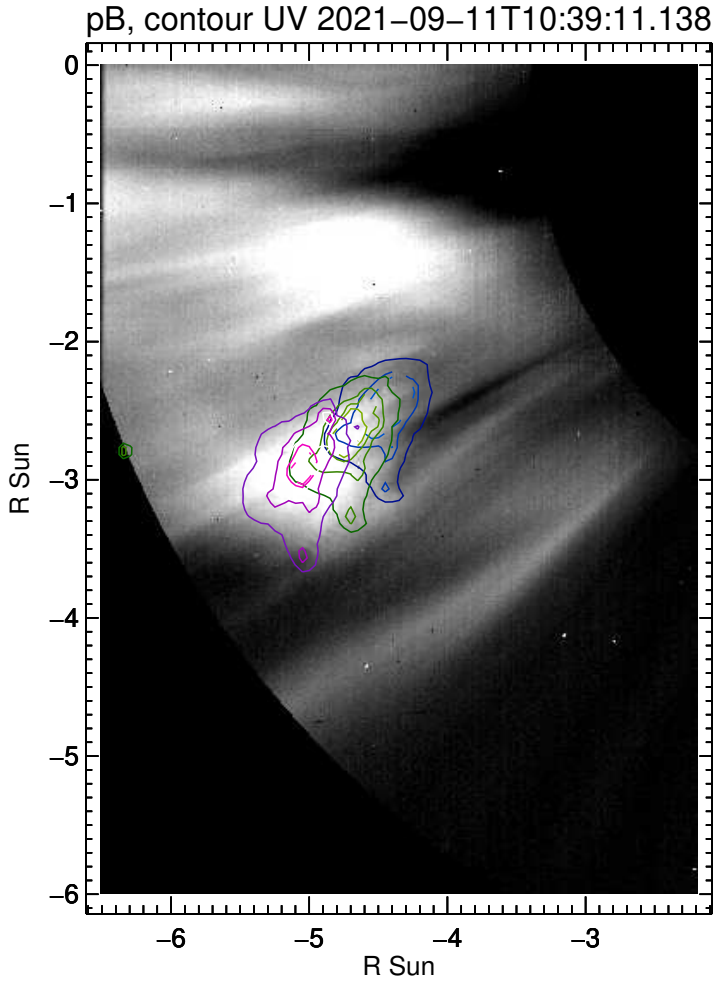
- VL cadence 24 min
- UV cadence 3 min



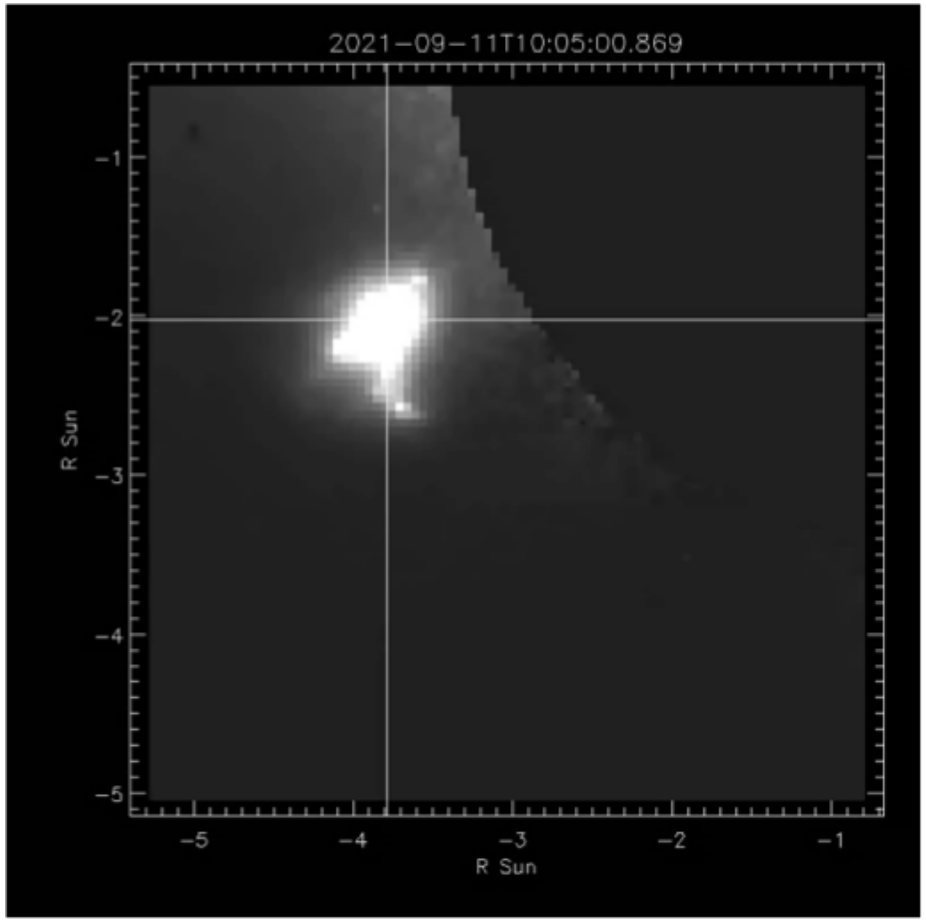


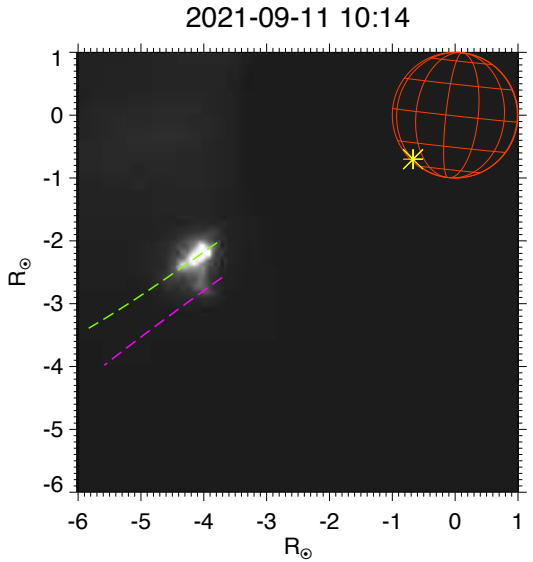




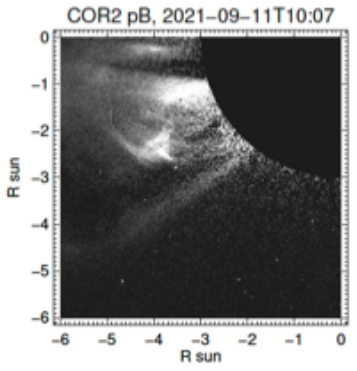


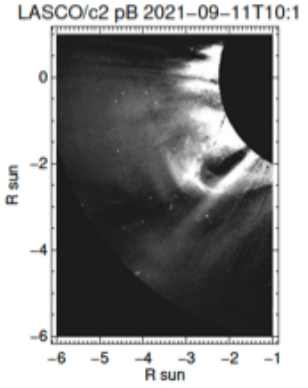
KINEMATICS OF THE EVENT

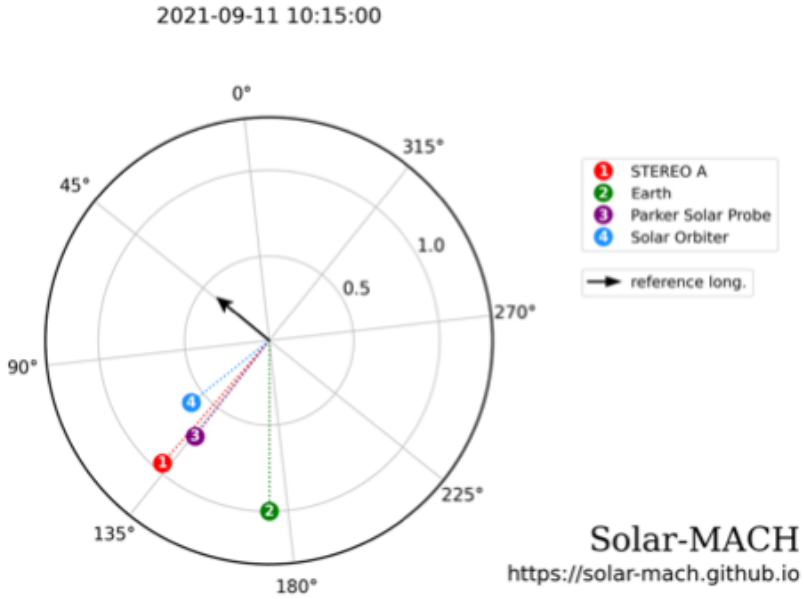




- POS velocity: 375 +/- 5 km/s
- Radial velocity: 377 +/- 5 km/s
- Residual Acceleration: 7 +/- 1 m/s^2





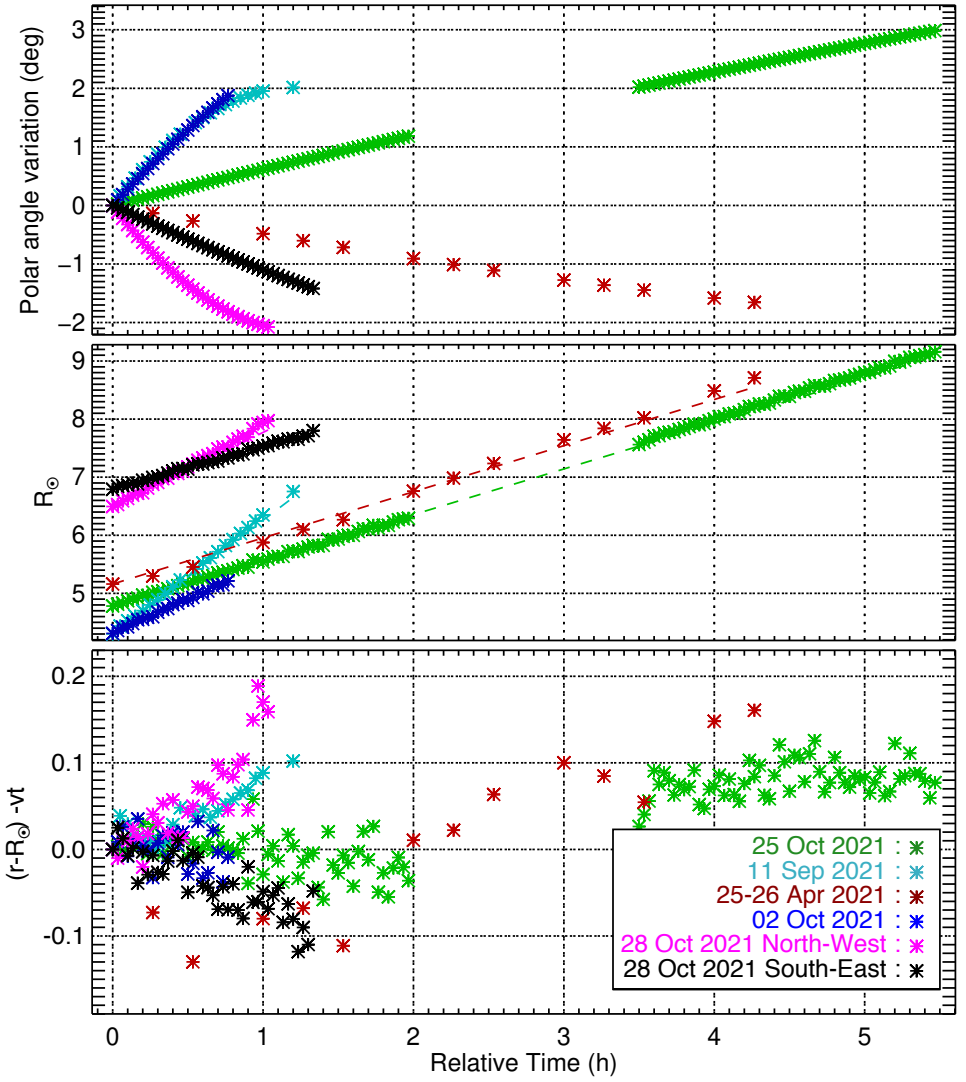


KINEMATICS OVERVIEW

Event date	PoS velocity [km/s]	Radial Velocity [km/s]	Residual Acceleration [m/s^2]	Doppler Dimming coefficients*
25-26 April	152 +/- 6	177 +/- 7	1.7 +/- 0.4	0.29
11 September	375 +/- 5	377 +/- 5	7 +/- 1	0.006
2 October	228 +/-13	367 +/- 22	~ 0	0.004
25 October	150 +/- 1	265 +/- 3	0.7 +/- 0.1	0.04
28 October NW	244 +/- 10	246 +/- 10	15 +/- 3	0.08
28 October SW	152 +/- 1	437 +/- 4	-8.5 +/- 0.1	$5.2 \cdot 10^{-4}$

*Gibson electron temperature profile

- Radial Velocity ranging 170 – 450 km/s
- Dimming of resonantly scattered component by more then 70% due to high velocity



RADIAL PROFILES

- UV radial emissivity

$$j_c \sim n_{\rm H}\, n_{\rm e} G(T_{\rm e})$$ collisional

$$j_r \sim n_{\rm H}\, D(v, T_{\rm e})\, W(r)\, \bar{I}_{\rm disk,Ly\text{-}\alpha}$$ radiative

Doppler dimming coefficients

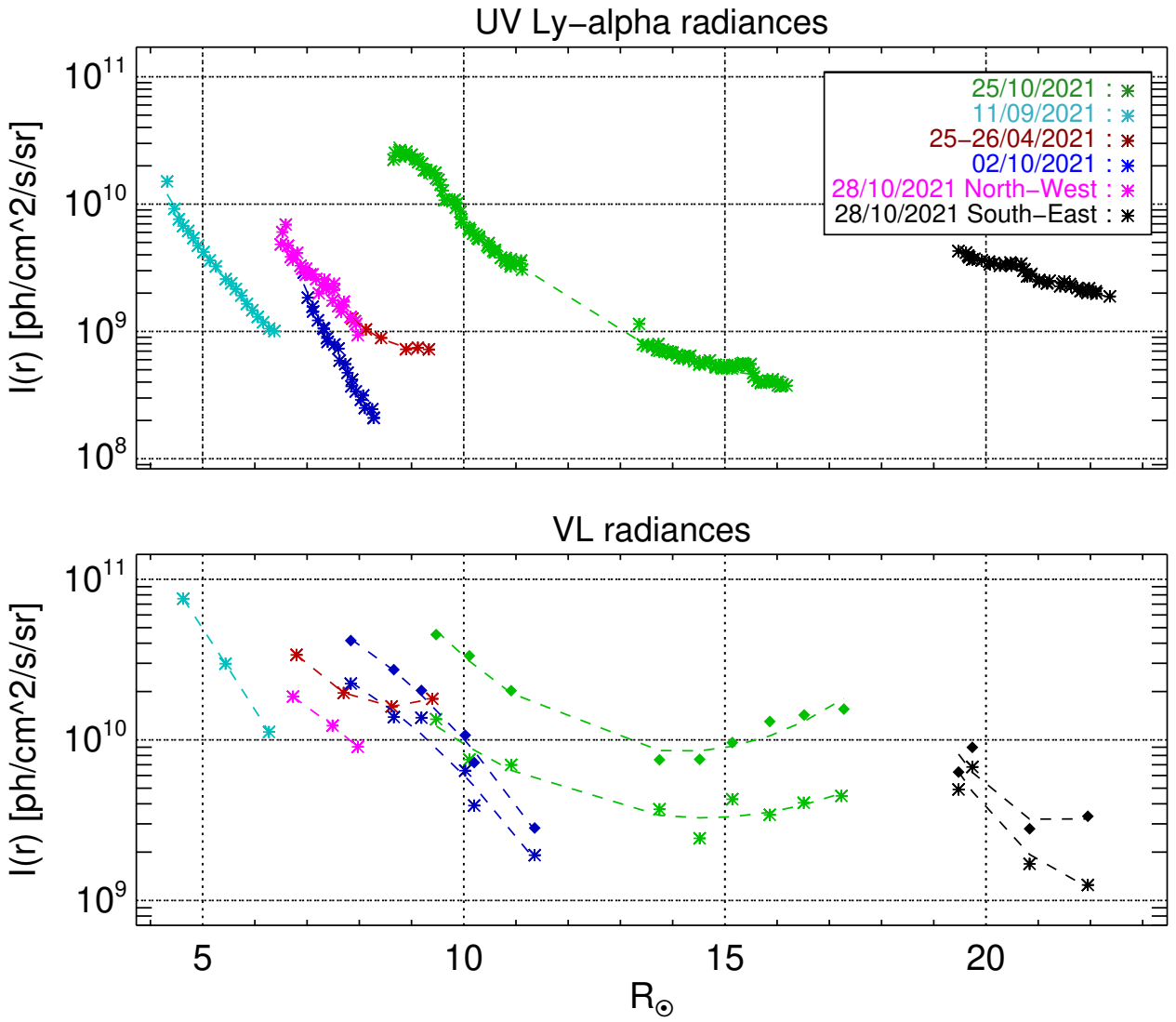
$$\mathcal{D}(\Gamma, T_{\rm HI}, v_{\rm w}) = \frac{I(v_{\rm w})}{I(v_{\rm w}=0)}$$

Dilution factor

$$W(r) = \frac{1}{2}\{1 - [1 - (R_\odot/r)^2]^{1/2}\}$$

- pB radial emissivity

$$j_{\rm pB} \sim n_{\rm e}\, W(r)\, \bar{I}_{\rm disk,pB}$$

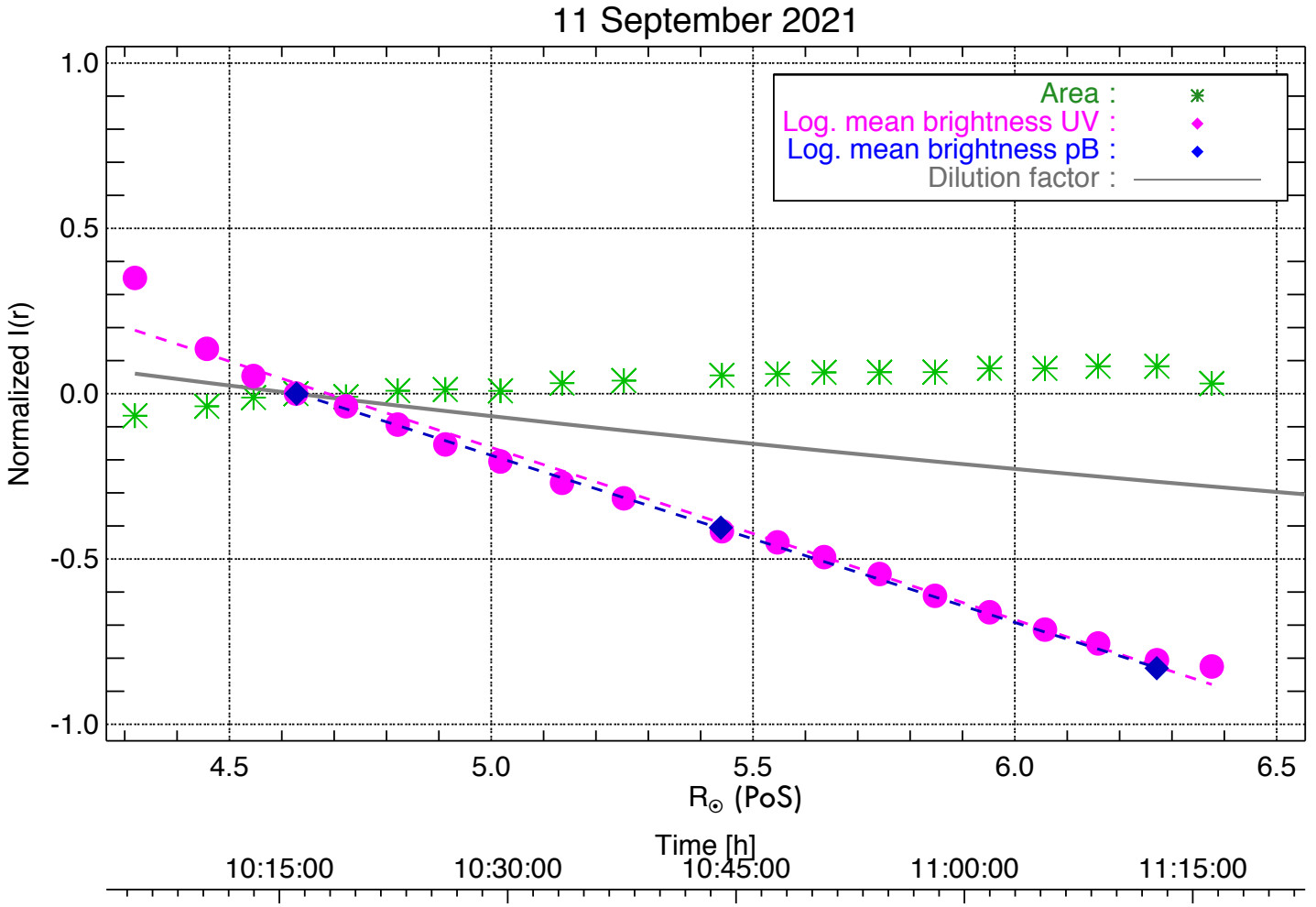


RADIAL PROFILES

- UV radial profile
- pB radial profile
- Area of the features as visible from UV frames
  - ➢ $n_e \approx N_e A^{-1/2} \sim 2.8 \cdot 10^5$ cm^{-3} electron column density

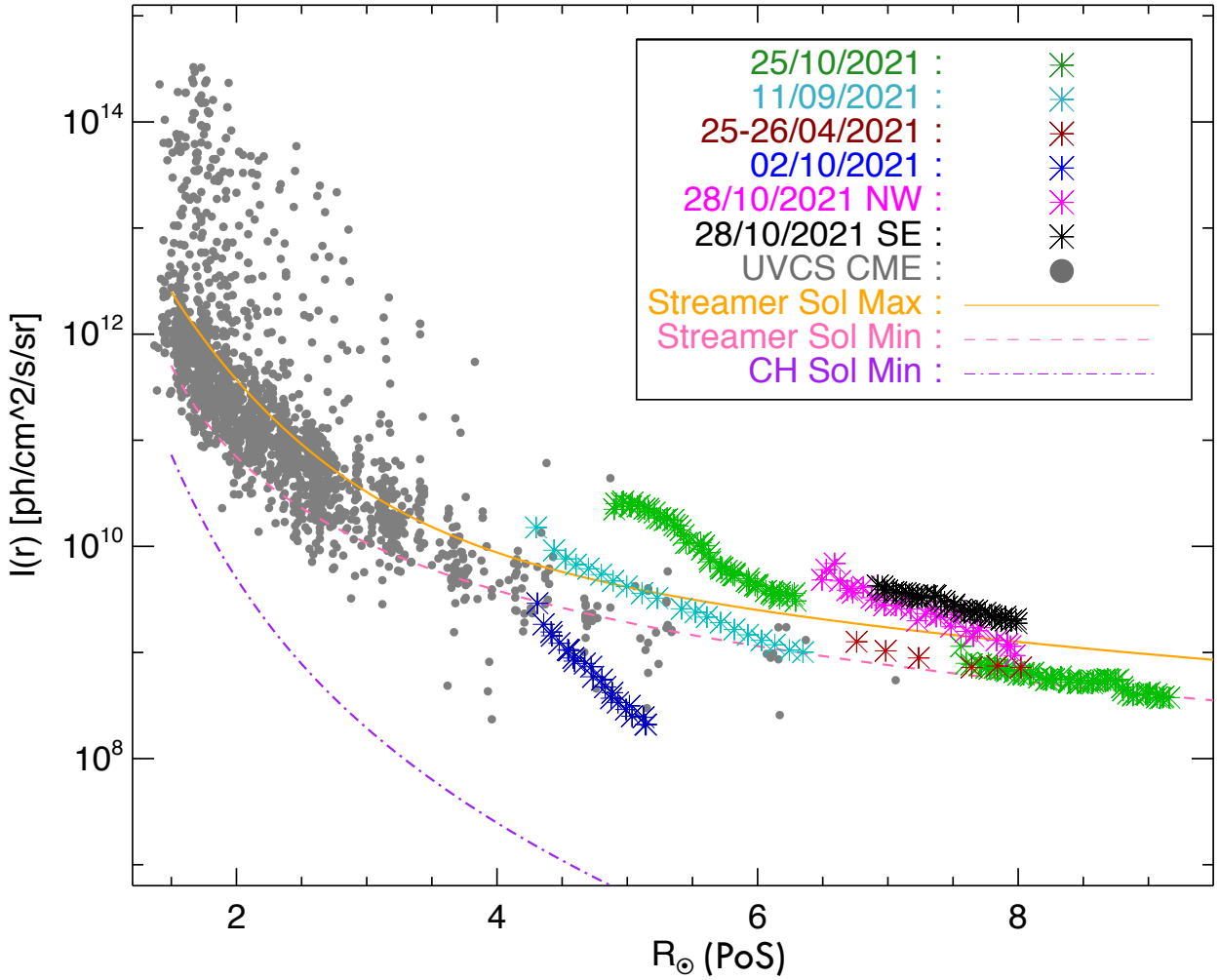
- Dilution factor, which marks the photoexcitation term

➢ Ly-alpha emission due to neutral hydrogen densities in cool plasma $\sim 10^5$ K or less



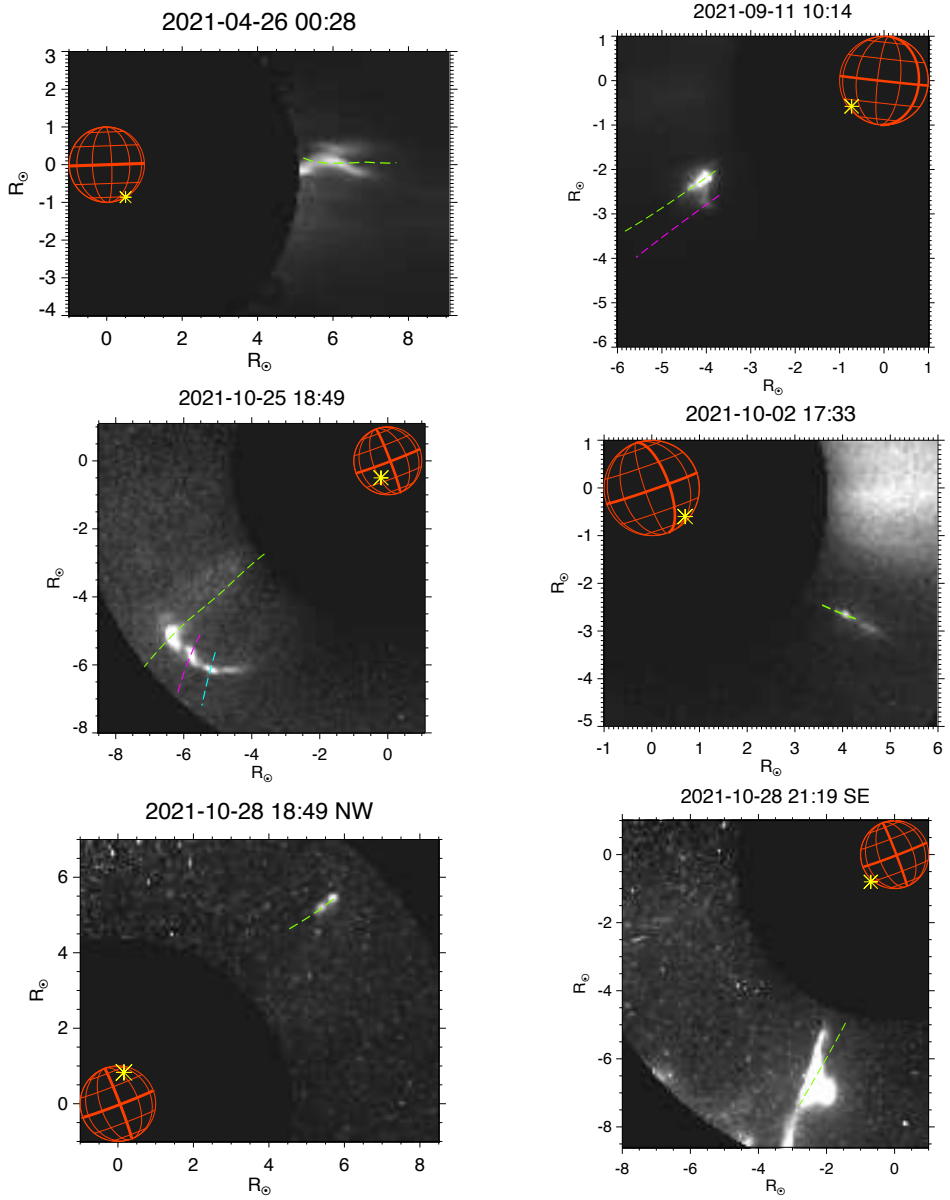
RADIAL PROFILES

- UVCS observed relatively cool plasma temperatures in core of erupting prominences ~10^5 K
- Comparison with observed line intensity distribution of the CMEs present in the UVCS catalog (Giordano et al 2013)
- General trend comparable to the streamers above 4 $R_\odot$



RESULTS SUMMARY

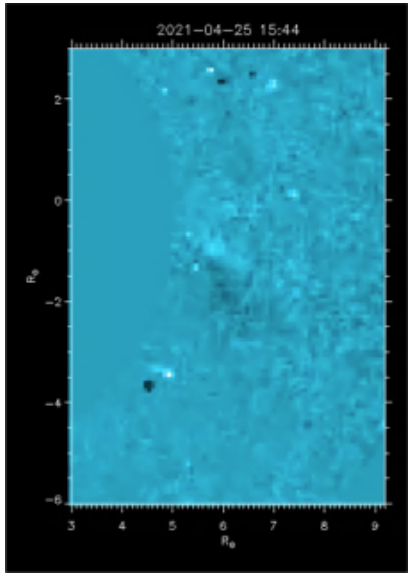
- Very UV bright events, at radial distances from the Sun as high as ~20 $R_\odot$ in the case of a halo CME
- Clear CME three-part stucture, bright UV features assimilated to the core of the CME (4 of 6 events)
- Eruption source region on the solar disk (3 of 6 events)
- Nearly constant shape and apparent lack of rotation (3 of 6 events)



ON GOING FOLLOW-UP WORKS

- **First Metis Detection of the Helium D3 Line Polarisation in a Large Eruptive Prominence (Heinzel et al. 2023)**

  See P. Heinzel's talk today



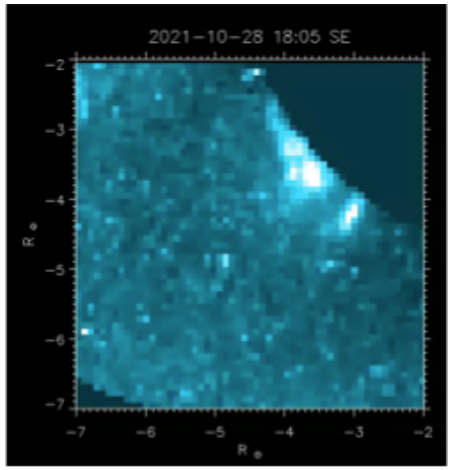
April 25, 2021

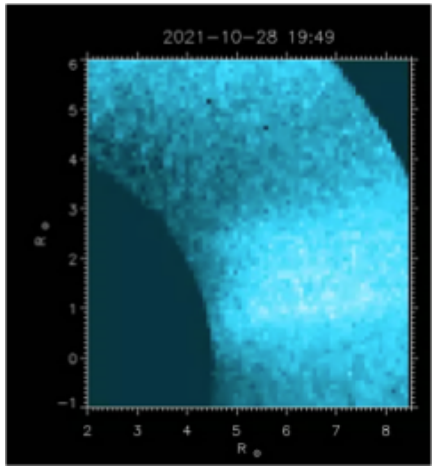
- **A 3D MHD Model for Metis CMEs**

  See P. Pagano's talk tomorrow

- **Revealing the differences between two eruptive events observed by Metis on October 28, 2021**

  See Y. De Leo's talk today





October 28, 2021

OPEN TO QUESTIONS AND COLLABORATIONS FOR POSSIBLE FOLLOW-UP!

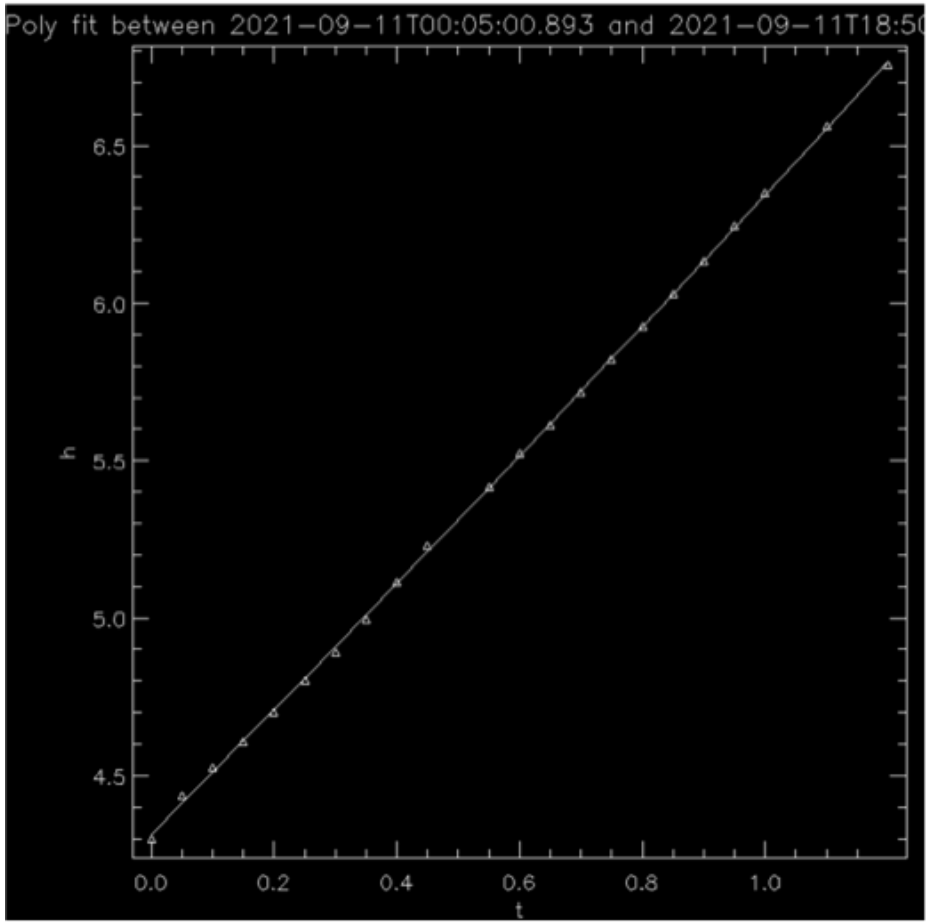
GIULIANA.RUSSANO@INAF.IT

INAF - OSSERVATORIO ASTRONOMICO DI CAPODIMONTE DI NAPOLI

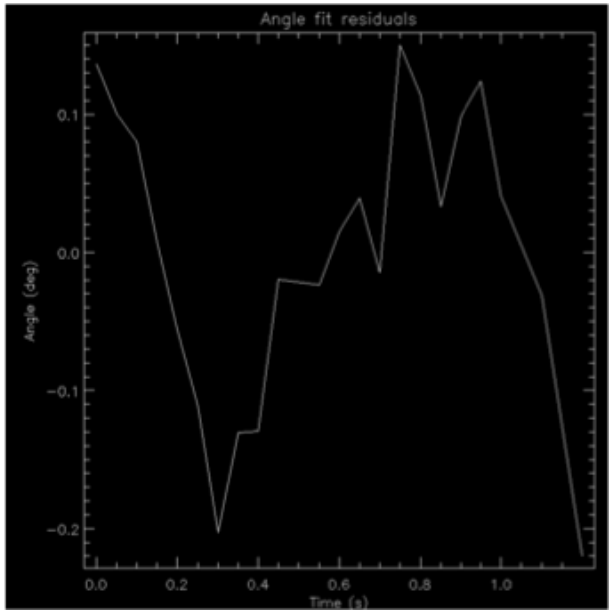
AUTHORS:
Andretta V., De Leo Y., Teriaca L., Uslenghi M., Giordano S., Telloni D., Heinzel P., Jecic S. and Metis team

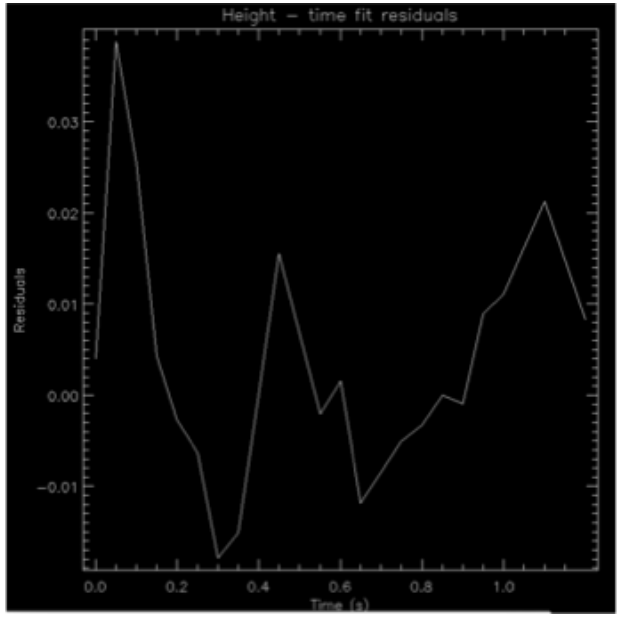
BACKUP SLIDES

POS VELOCITY ESTIMATION

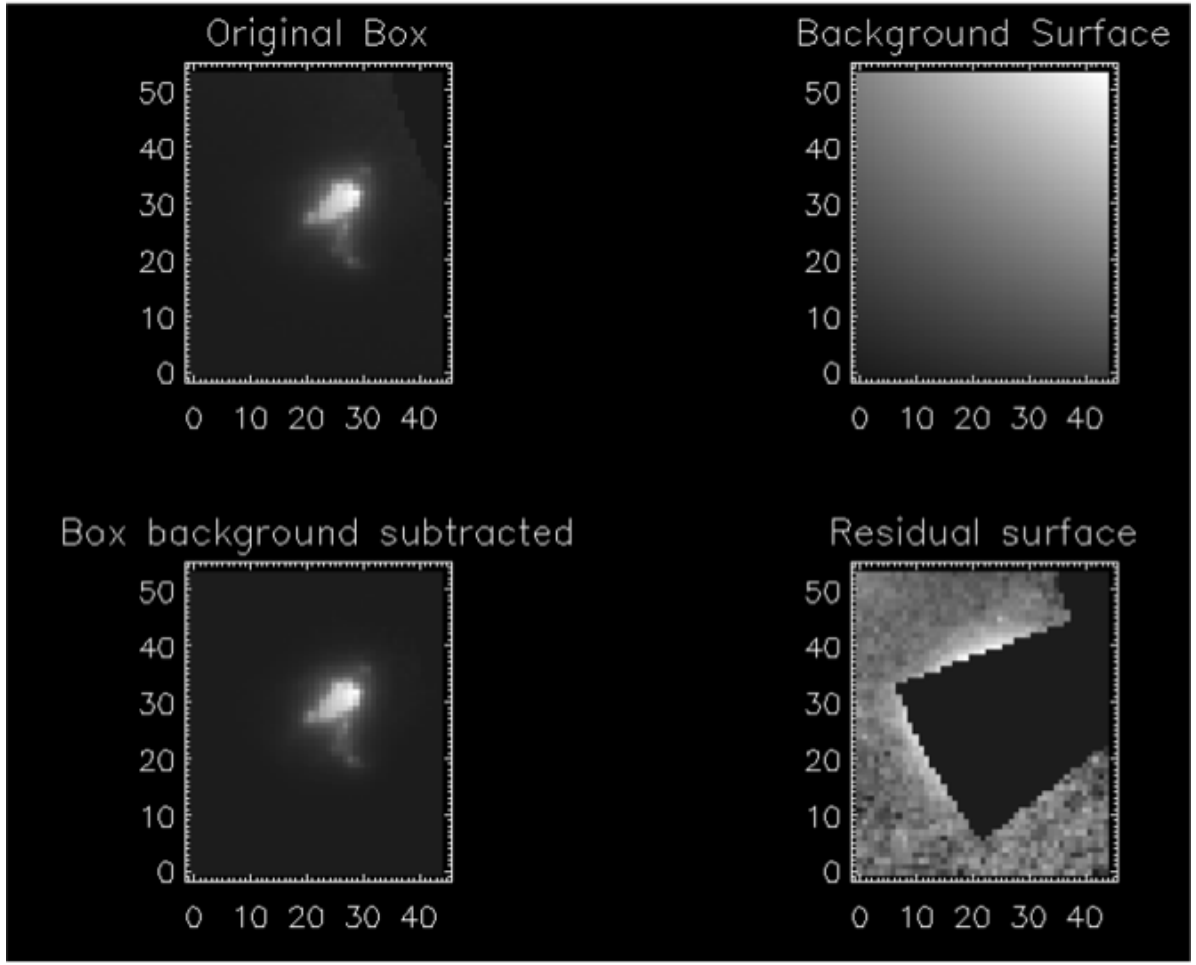


- Three methods to detect maximum intensity position: max pixel, centroid and barycenter
- Polynomial fit height VS time (residual trend due to precision in determining the maximum
- Angle trends subtracted
- Acceleration term negligible





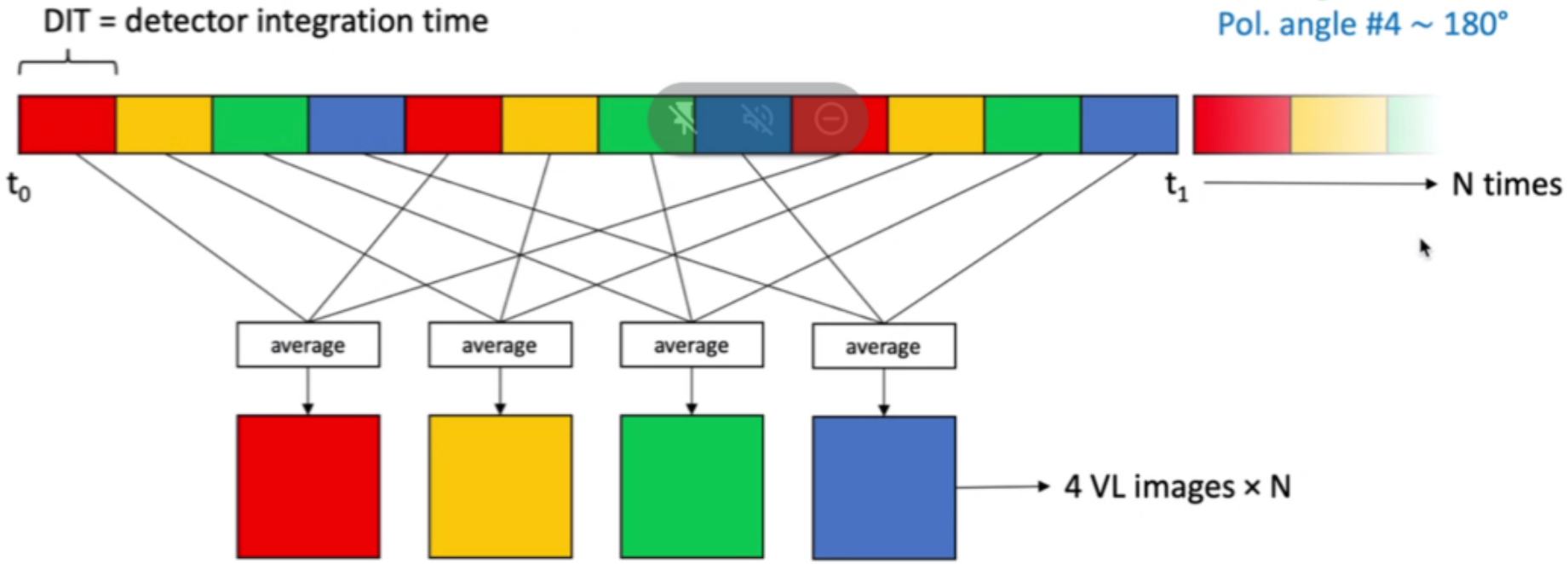
BACKGROUND SUBTRACTION



VISIBLE LIGHT ACQUISITION SCHEME

- Polarised brightness (DIT ≥ 15 s, cadence ≥ 1 min.)

Pol. angle #1 ~ 45°
Pol. angle #2 ~ 90°
Pol. angle #3 ~ 135°
Pol. angle #4 ~ 180°



UV ACQUISITION SCHEMES

- Analogue mode (DIT ≥ 1 s, cadence ≥ 1 s)