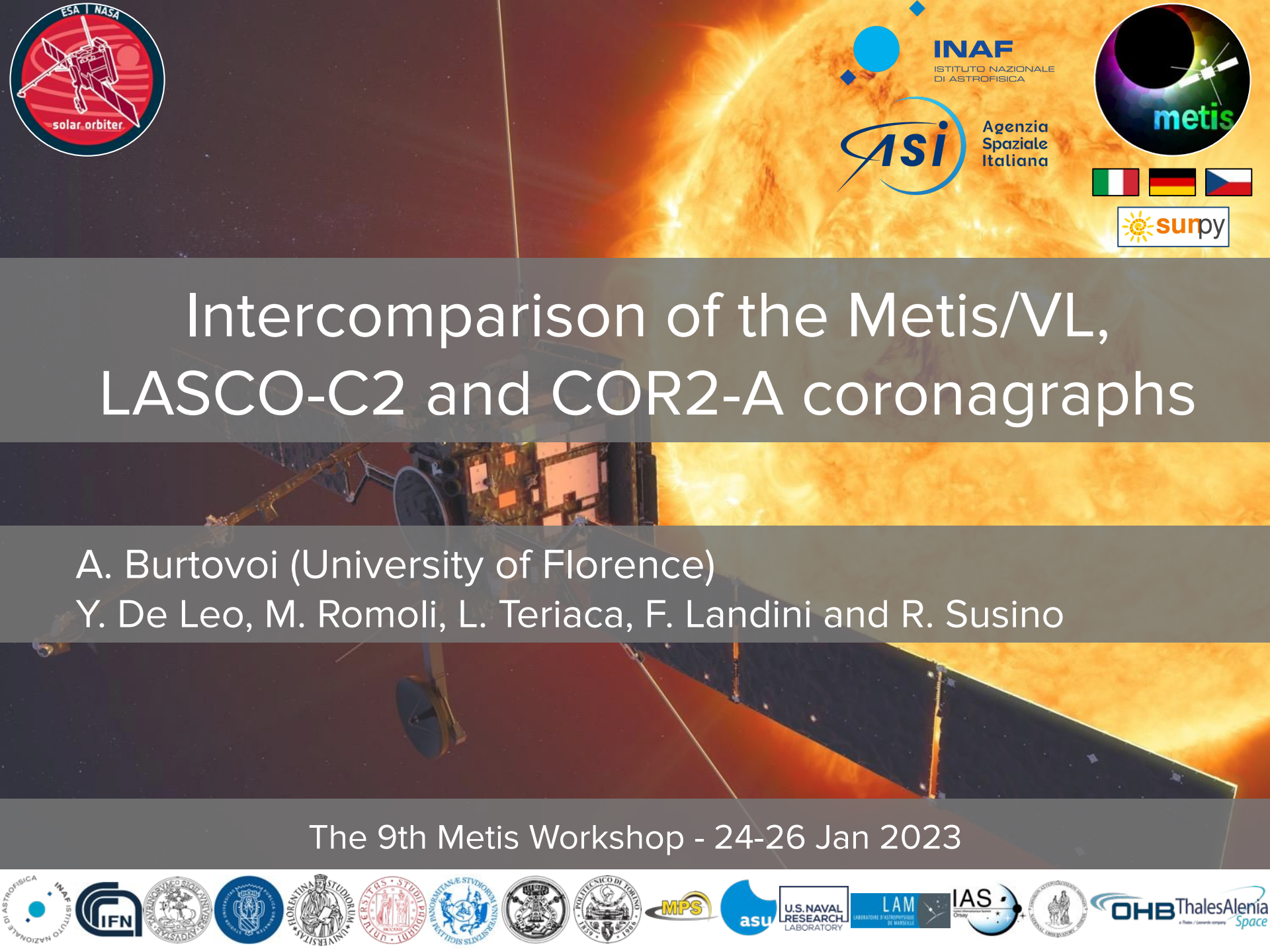


Intercomparison of the Metis/VL, LASCO-C2 and COR2-A coronagraphs

A. Burtovoi (University of Florence)
Y. De Leo, M. Romoli, L. Teriaca, F. Landini and R. Susino

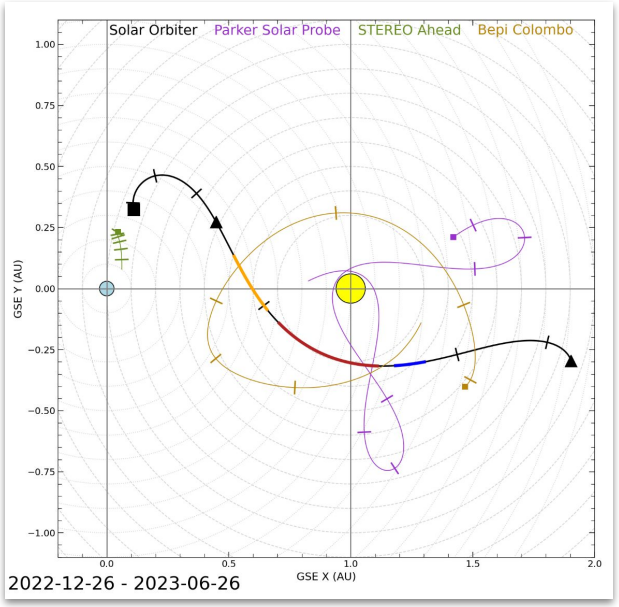
The 9th Metis Workshop - 24-26 Jan 2023

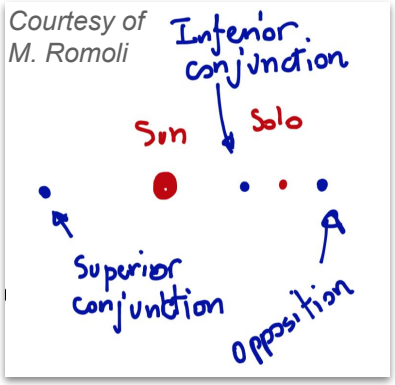
Introduction

- Three currently operating visible light (VL) space coronagraphs: Metis/Solar Orbiter, LASCO/SOHO and COR2/STEREO-A
- Peculiar orbit of Solar Orbiter is an advantage ⇒ numerous conjunctions/oppositions

Our goal:

❓ To compare the coronal VL data of these instruments





Dataset

- Instrument parameters:
  - Metis:
    - distance to Sun: variable (from 0.28 au)
    - field of view (FoV): variable (spanning from 1.7 $R_\odot$ to ~9 $R_\odot$)
  - LASCO-C2:
    - distance to Sun: ~1 AU (L1 point)
    - FoV: 2.5 - 6.2 $R_\odot$
  - COR2-A:
    - distance to Sun: ~1 AU
    - FoV: 3 - 14 $R_\odot$
- Orbital parameters:
  - $|\Delta l|$ and $|\Delta b| < 5$ deg

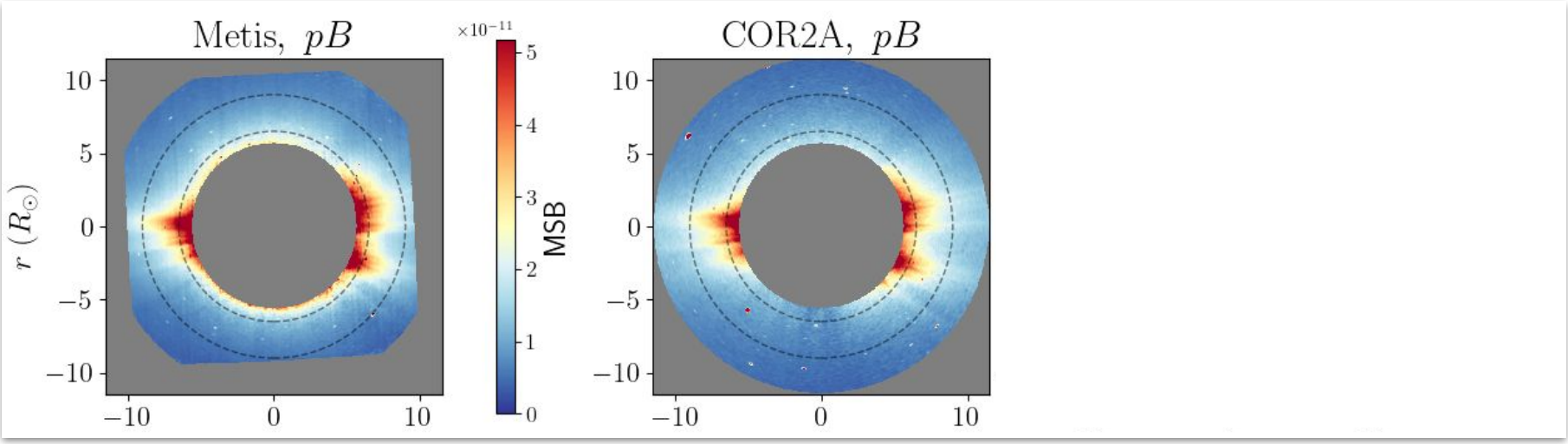
Dataset

- 12 available conjunctions/oppositions in 2020 (2007) - 2023
- 828 pairs of images in total

Date	Instruments	Conj./Opp. parameters					N_{img}	
		type	Δd [au]	Δl [°]	Δb [°]	FoV [$R_\odot$]	pB	B
Apr 16-18, 2007	COR2-A + C2	opp	0.031	-2.98	0.007	3.0 - 6.2	2	4
Nov 18-21, 2020	Metis + COR2-A	sup	0.038	-0.34	-1.06	5.55 - 9.4	81	81
Sep 21-22, 2021	Metis + COR2-A	opp	0.358	-3.85	5.18	3.61 - 6.1	26	26
Nov 16-21, 2021	Metis + C2	opp	0.042	-0.31	0.73	5.85 - 6.2	67	72
Dec 2-3, 2021	Metis + C2	inf	-0.02	2.07	-0.21	6.03 - 6.2	1	2
Mar 7-8, 2022	Metis + C2	opp	0.487	-0.50	-3.00	3.0 - 5.1	2	4
Apr 15-17, 2022	Metis + COR2-A	sup	0.448	1 → -1	2.76	3.1 - 5.2	25	25
Sep 20-22, 2022	Metis + COR2-A	sup	0.436	1 → -1	-0.72	3.3 - 5.7	54	54
Sep 29-30, 2022	Metis + C2	sup	0.580	0.86	0.95	2.51 - 4.2	6	12
Nov 17 - Dec 2, 2022	Metis + COR2-A	opp	0.168	1.82	-3.61	4.9 - 8.1	63	63
Mar 23, 2023	Metis + COR2-A	opp	0.485	2.24	-0.35	3.0 - 5.0	1	1
Jul 19 - Sep 01, 2023	COR2-A + C2	opp	0.05	-2 → 2	-0.12	3.0 - 6.2	52	104

Image comparison procedure

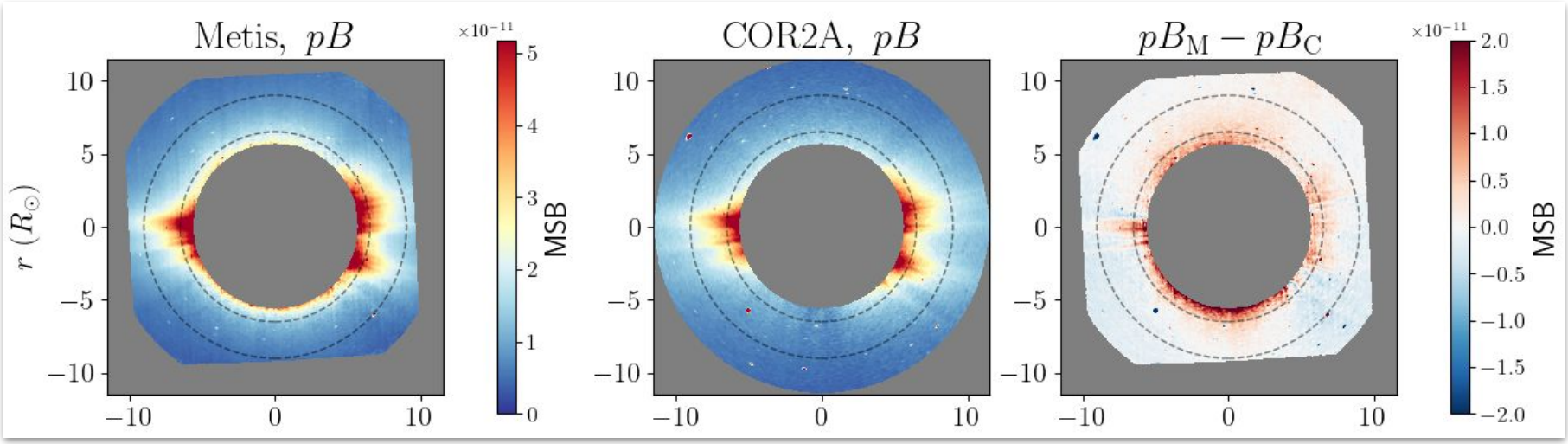
- We compare two images with $t_{obs} < 2$ h



Nov 2020, superior conjunction
De Leo et al. (2023)

Image comparison procedure

- We compare two images with $t_{obs} < 2$ h



Nov 2020, superior conjunction
De Leo et al. (2023)

Image comparison procedure

- We compare latitudinal profiles extracted for different heliocentric distances
- If they are correlated their regression follows the linear function $f(x) = ax + b$
- We find the best-fitting a and b
  - a - scaling factor
  - b - background

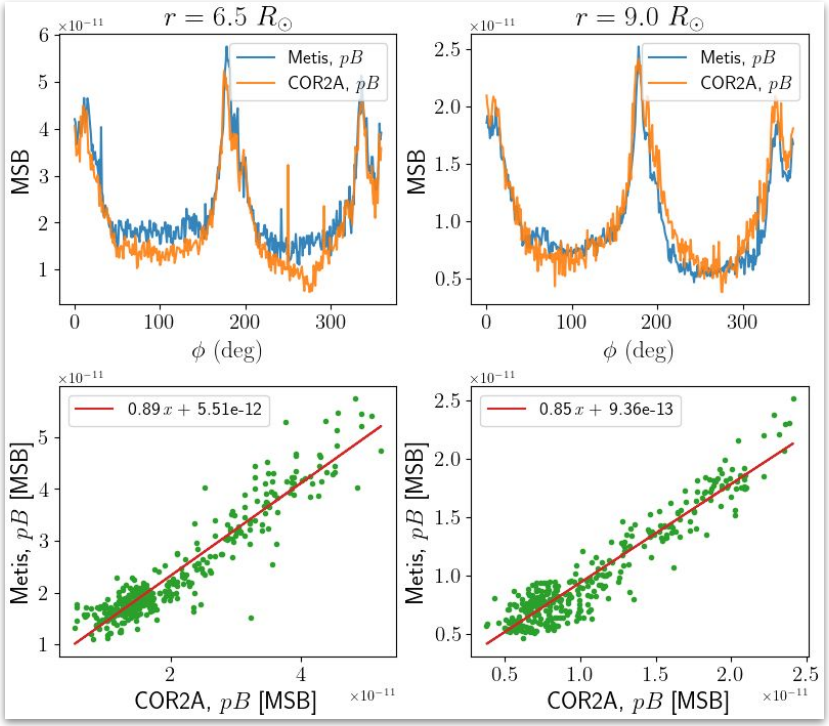


Image comparison procedure

We repeat these calculations for all heliocentric distances ($dr = 0.01\ R_\odot$), ...

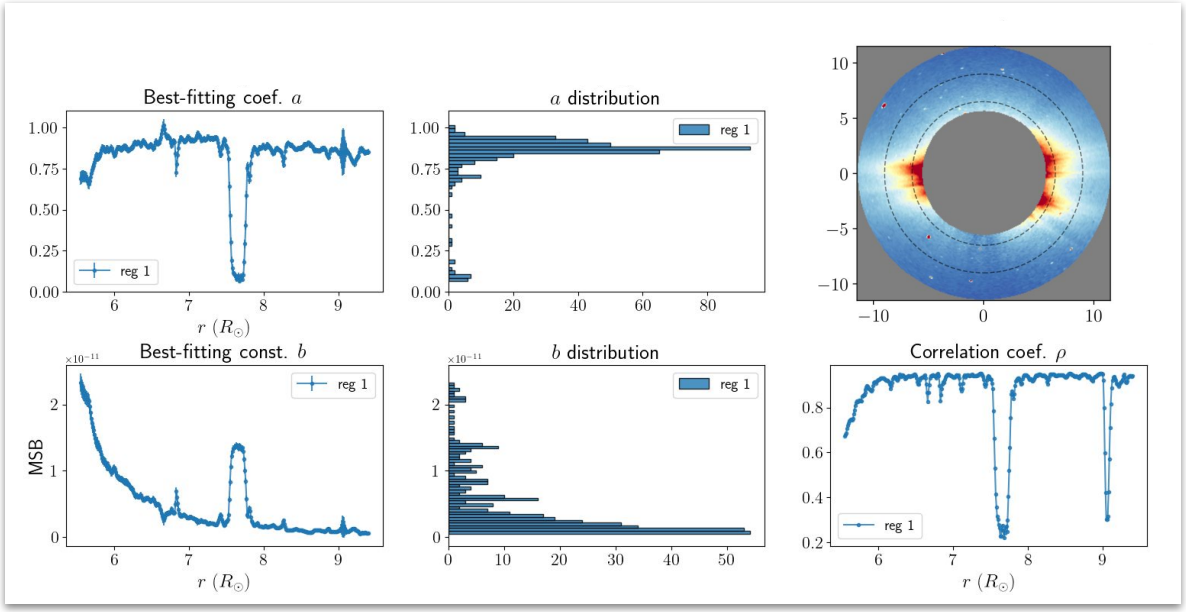


Image comparison procedure

... dividing the images on four regions ...

Equatorial regions (**blue** & **green**):
- are much more correlated
- best-fitting a is much more stable along FoV

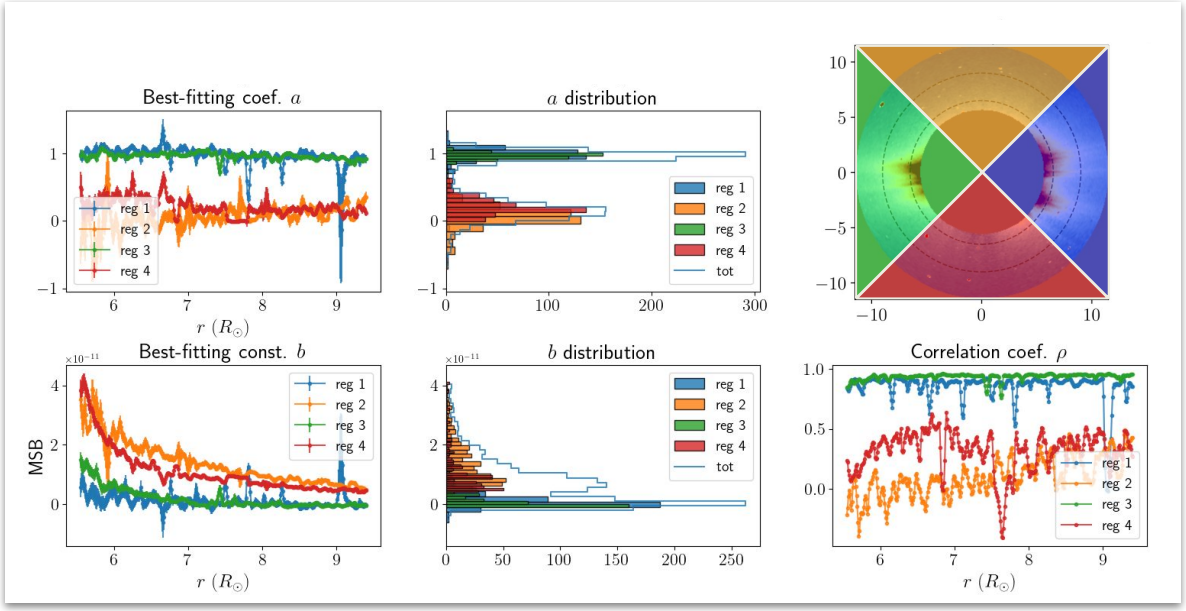
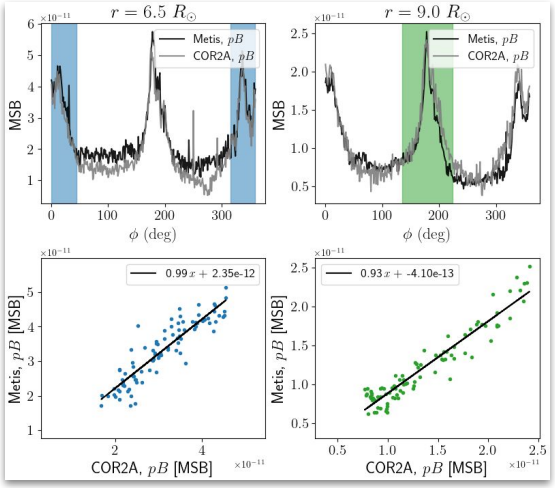


Image comparison procedure

... dividing the images on four regions ...

Equatorial regions (**blue** & **green**):
- are much more correlated
- best-fitting a is much more stable along FoV



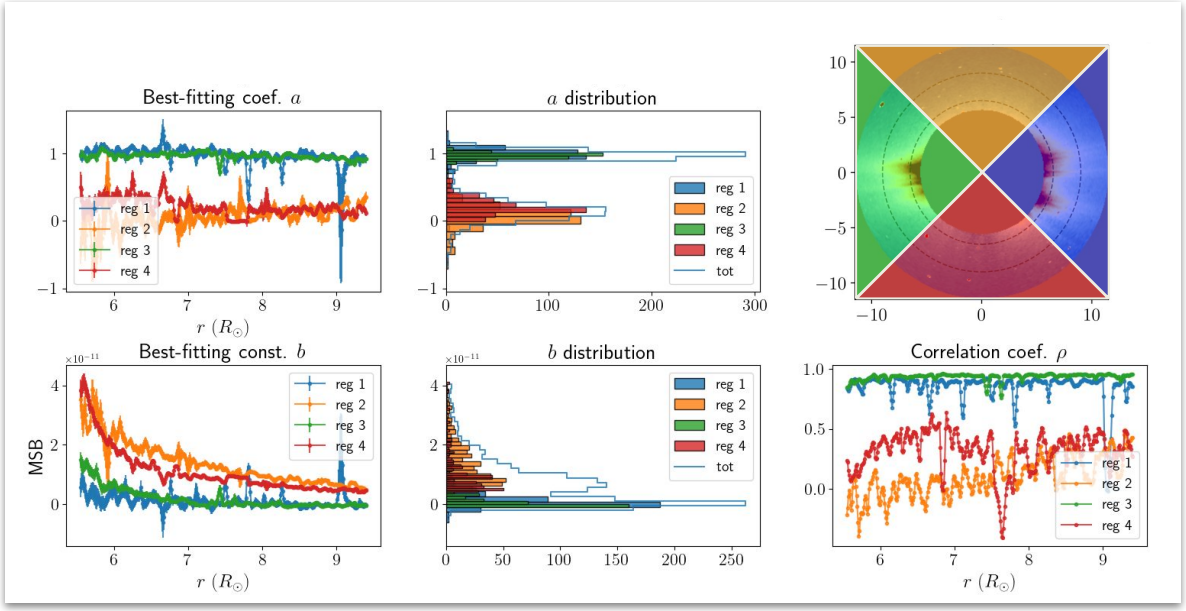


Image comparison procedure

... dividing the images on four regions ...

Polar regions (**orange** & **red**):
- are not-correlated
bg-dominated oscillations
- best-fitting a close to 0

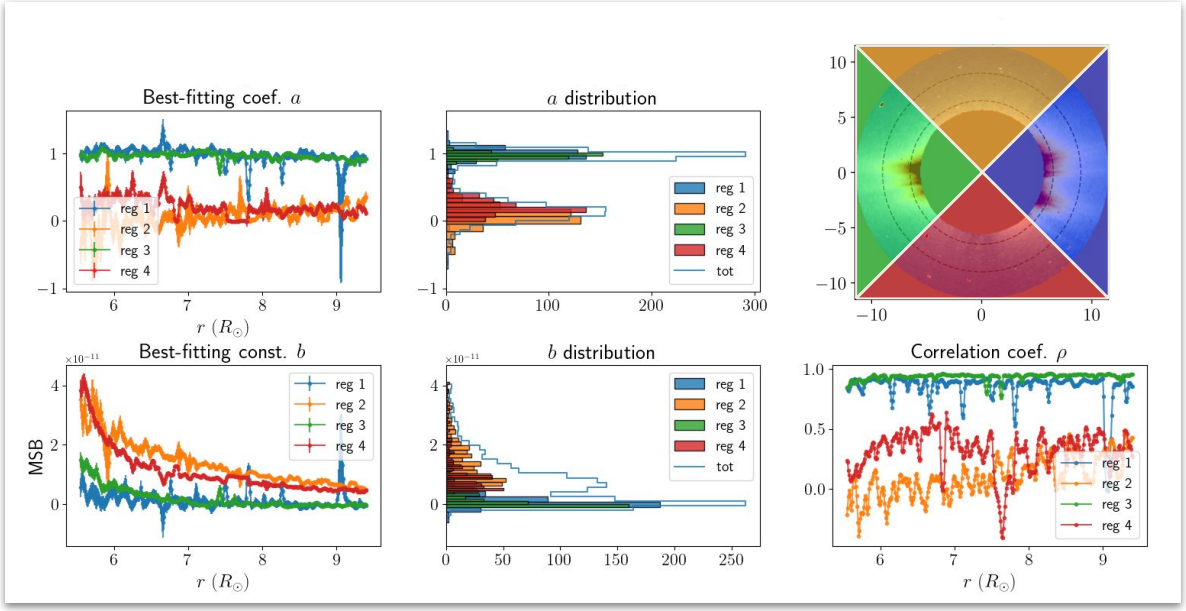
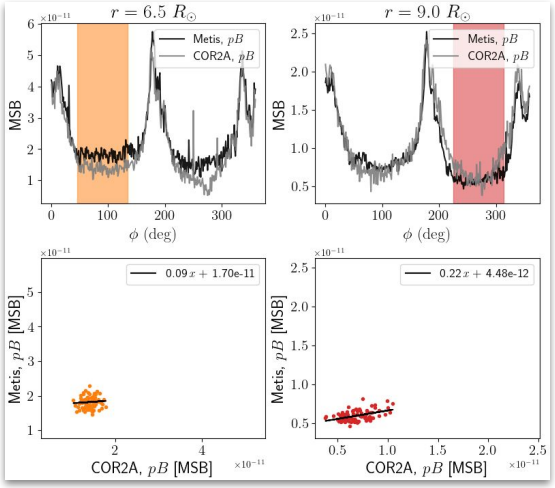


Image comparison procedure

... dividing the images on four regions ...

Polar regions (**orange** & **red**):
- are not-correlated
bg-dominated oscillations
- best-fitting a close to 0



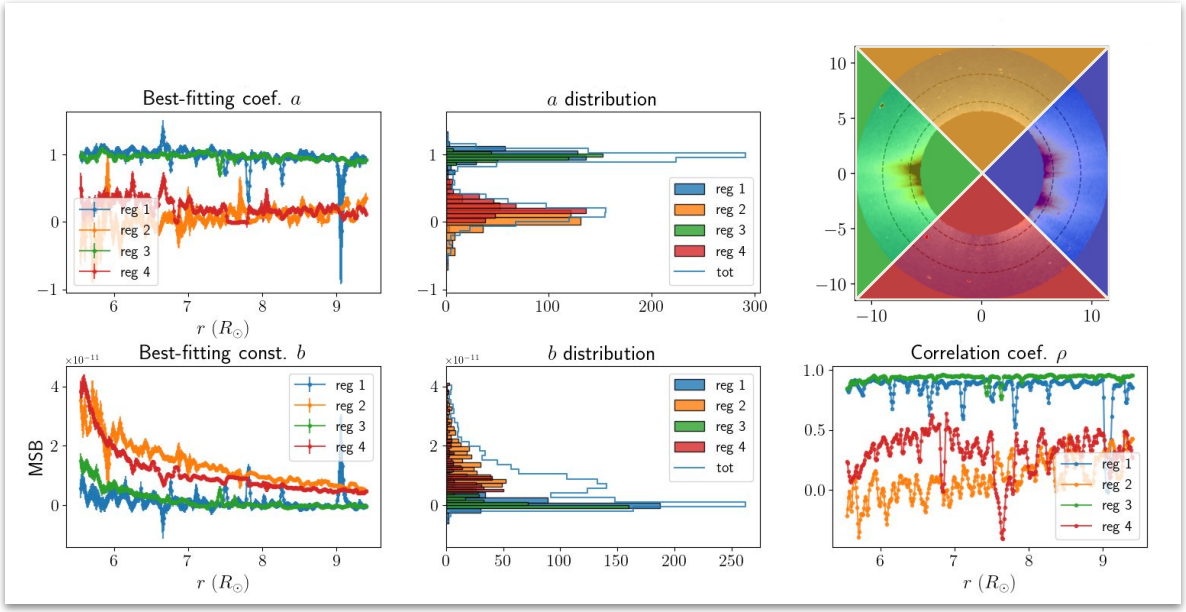
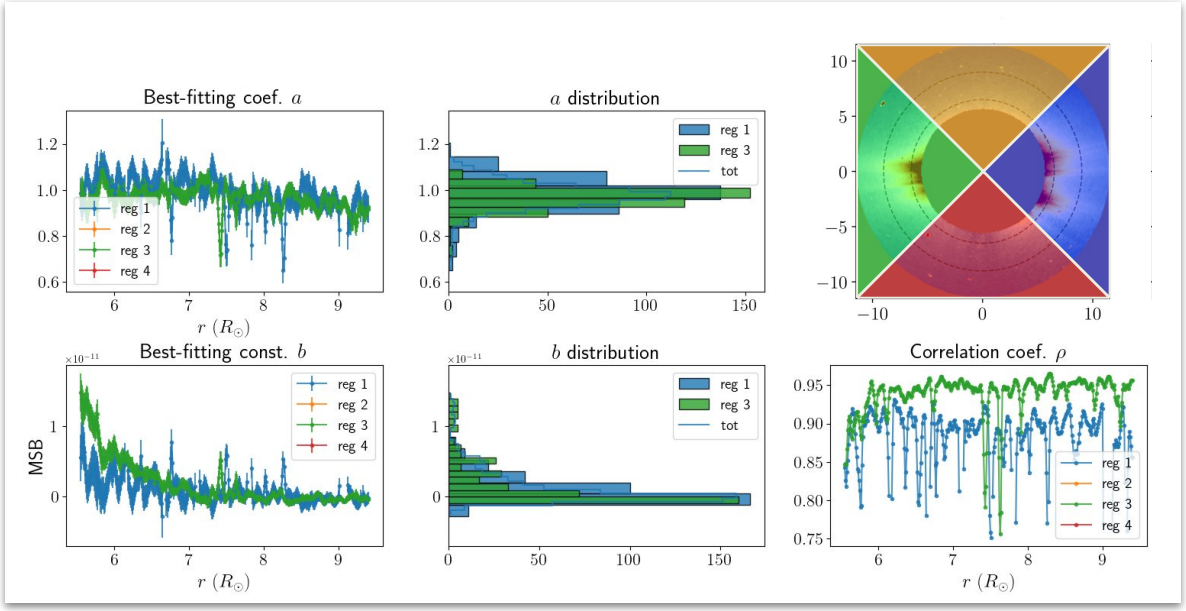


Image comparison procedure

... and applying correlation coefficient cut ($\rho \geq 0.75$)



Parameter space is big

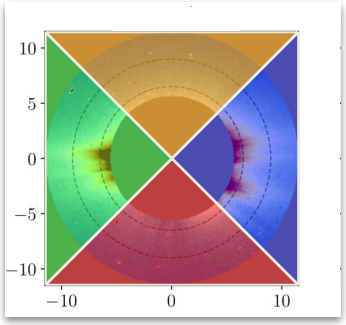
- 828 pairs of images in total
- FoV sampling with $dr = 0.01\ R_{\odot}$
- 2 fitting parameters (a, b) + correlation coefficient (ρ)
- 5 parameters of conjunction/opposition: type, Δd, Δl, Δb, FoV
- Polarized brightness + total brightness images
- Two currently available calibrations for LASCO-C2: from NRL/SolarSoft and from Legacy Archive (Lamy+2020, labeled as “C2_L2020”)

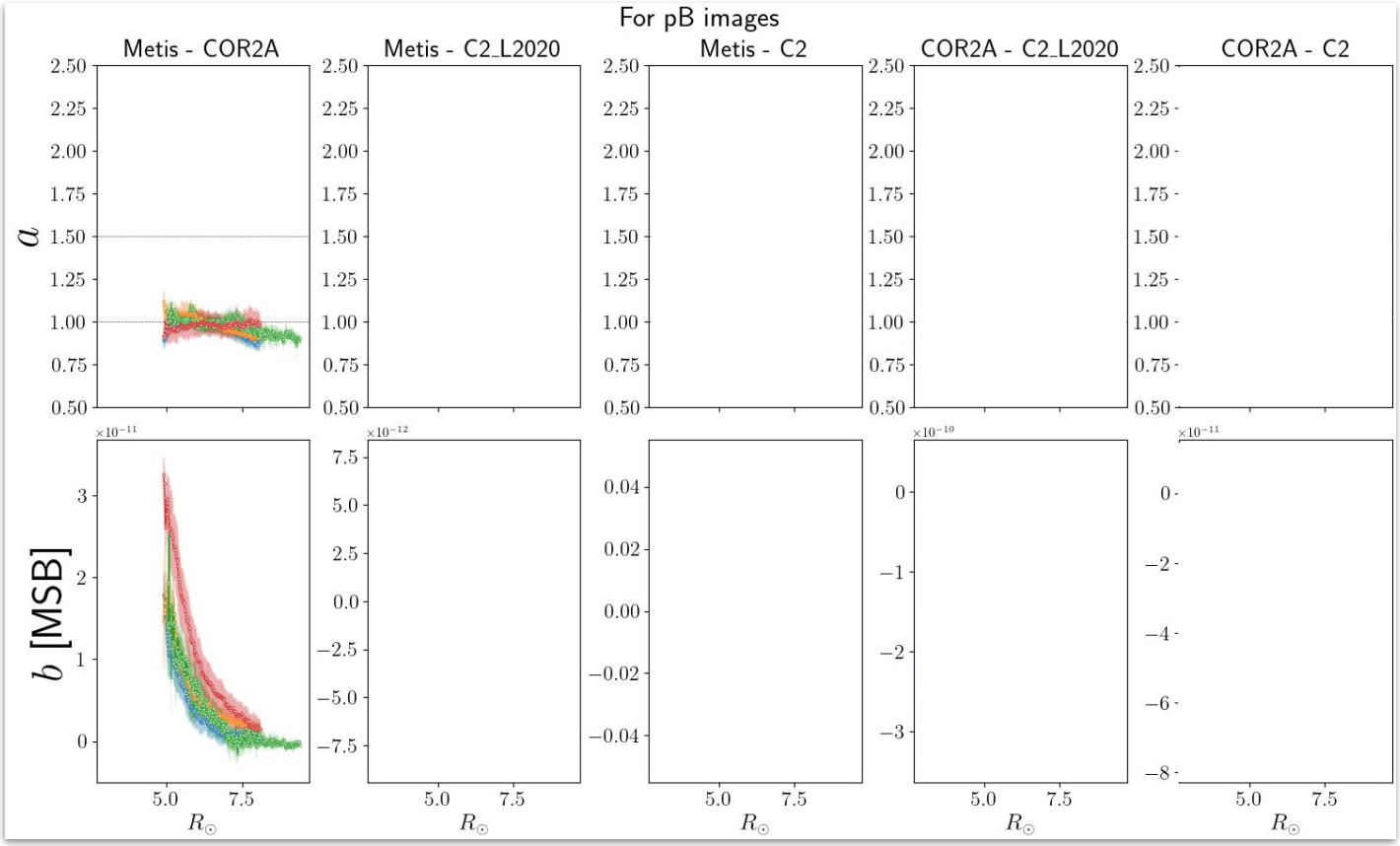
PB-Results for $\langle a(r) \rangle_t$ and $\langle b(r) \rangle_t$: COR2-A

PRELIMINARY

Data selection:

- $\rho \geq 0.95$
- $\Delta d \leq 0.2$ au



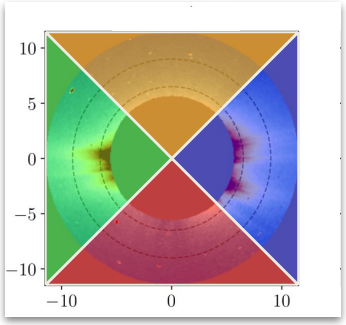


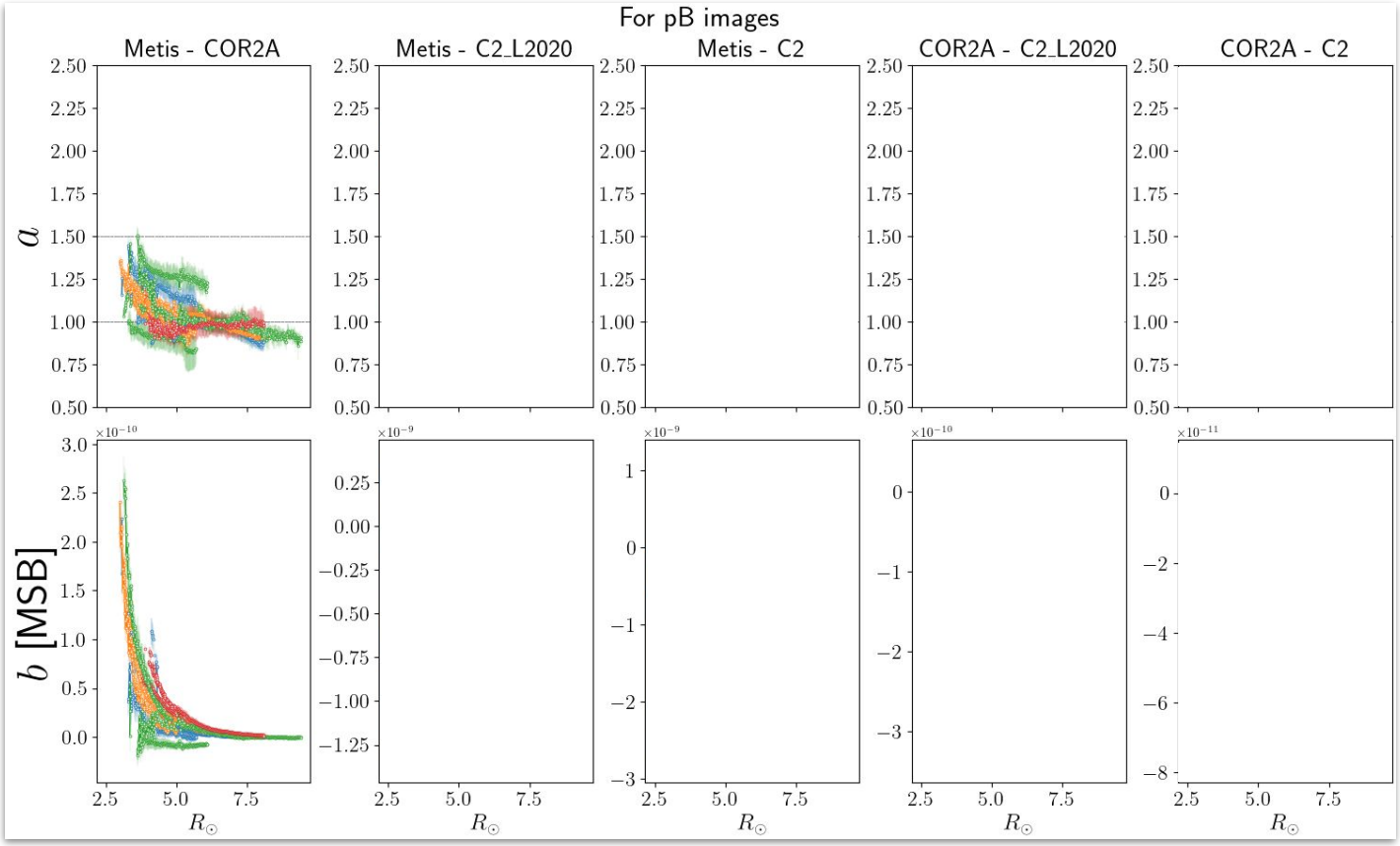
PB-Results for $\langle a(r) \rangle_t$ and $\langle b(r) \rangle_t$: COR2-A

PRELIMINARY

Data selection:

- $\rho \geq 0.95$
- all distances

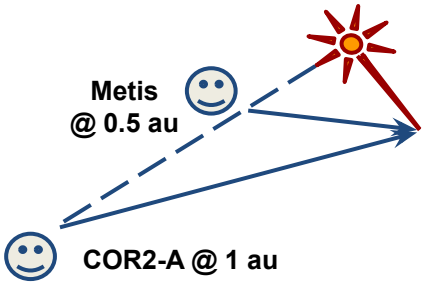


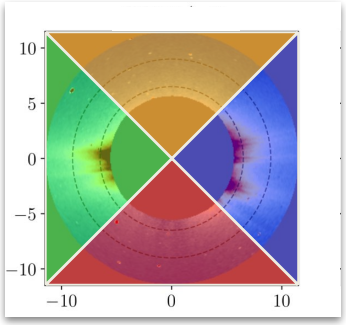


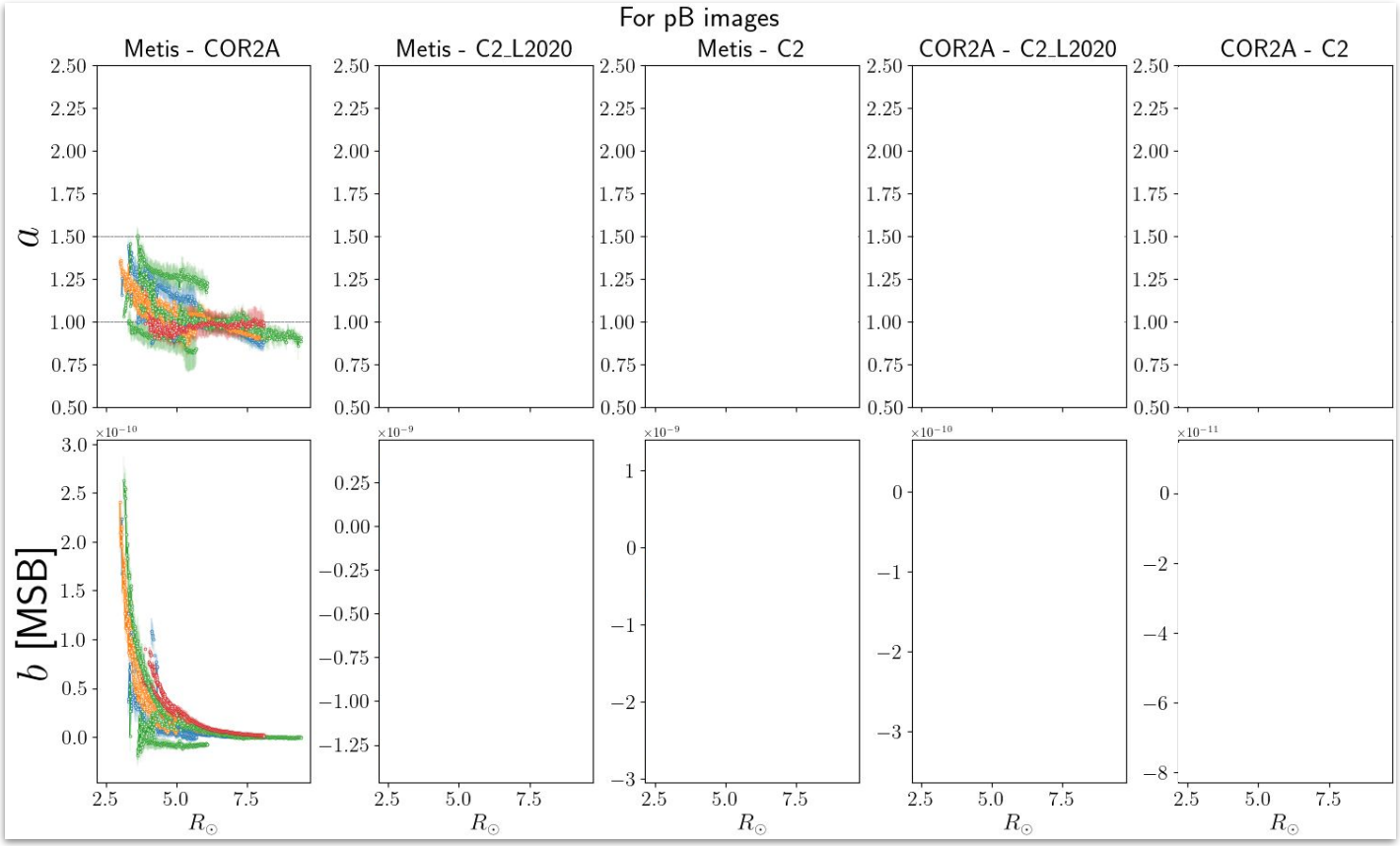
PB-Results for $<a(r)>_t$ and $<b(r)>_t$: COR2-A

PRELIMINARY

Data selection:
- $\rho \geq 0.95$
- all distances



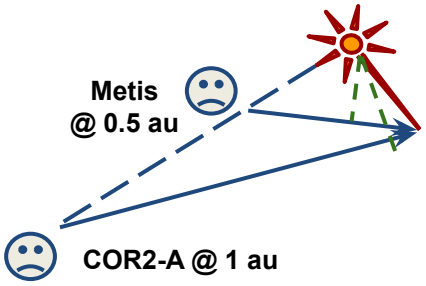


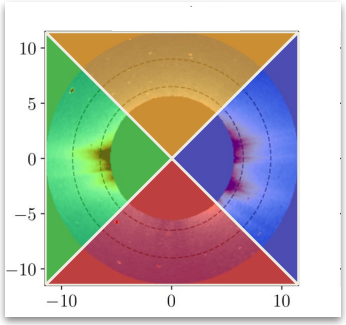


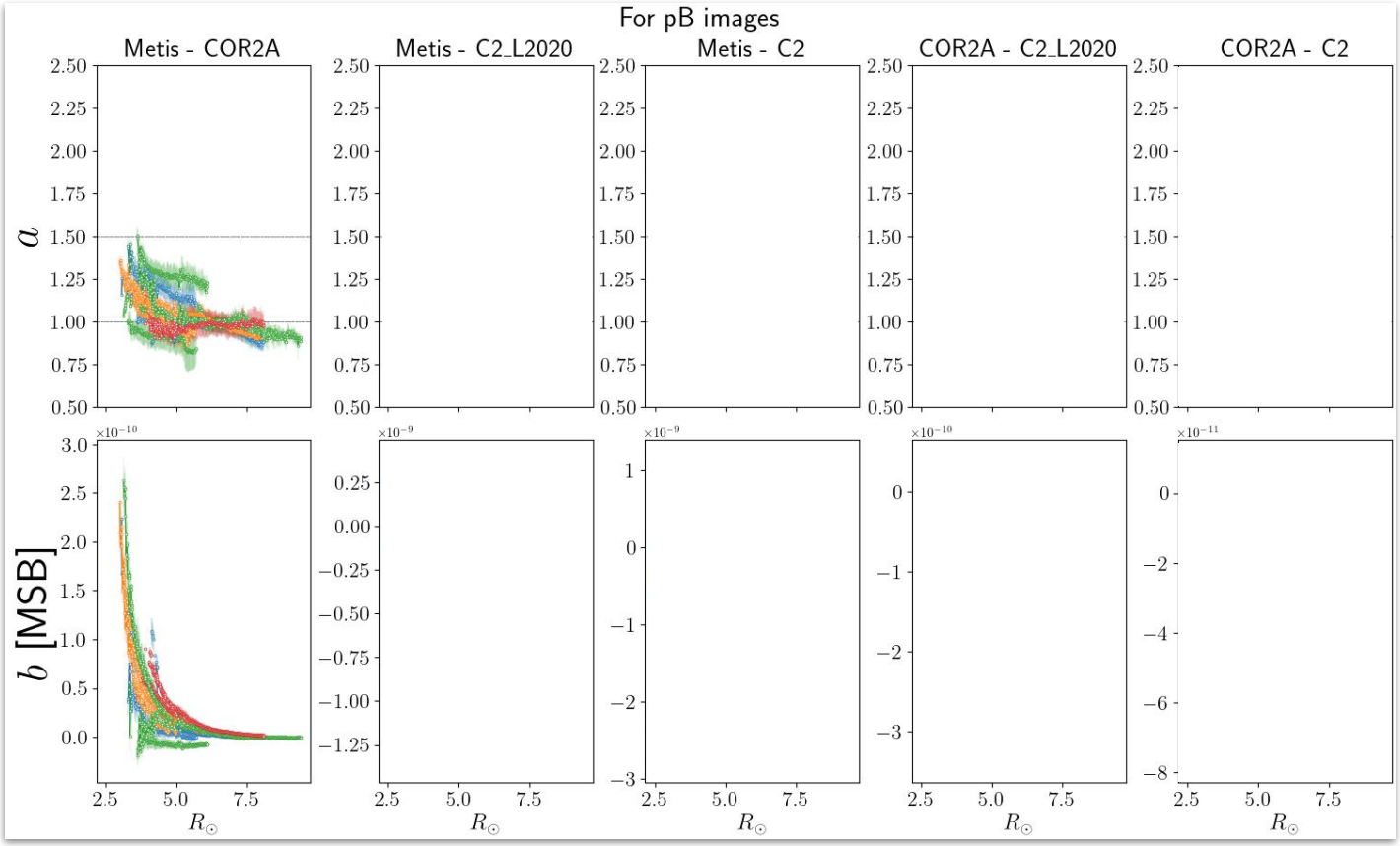
PB-Results for $<a(r)>_t$ and $<b(r)>_t$: COR2-A

PRELIMINARY

Data selection:
- $\rho \geq 0.95$
- all distances





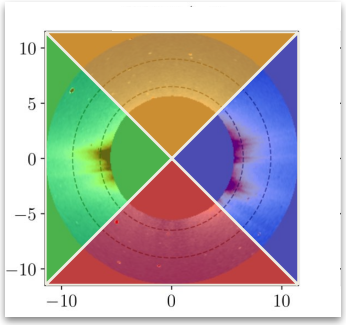


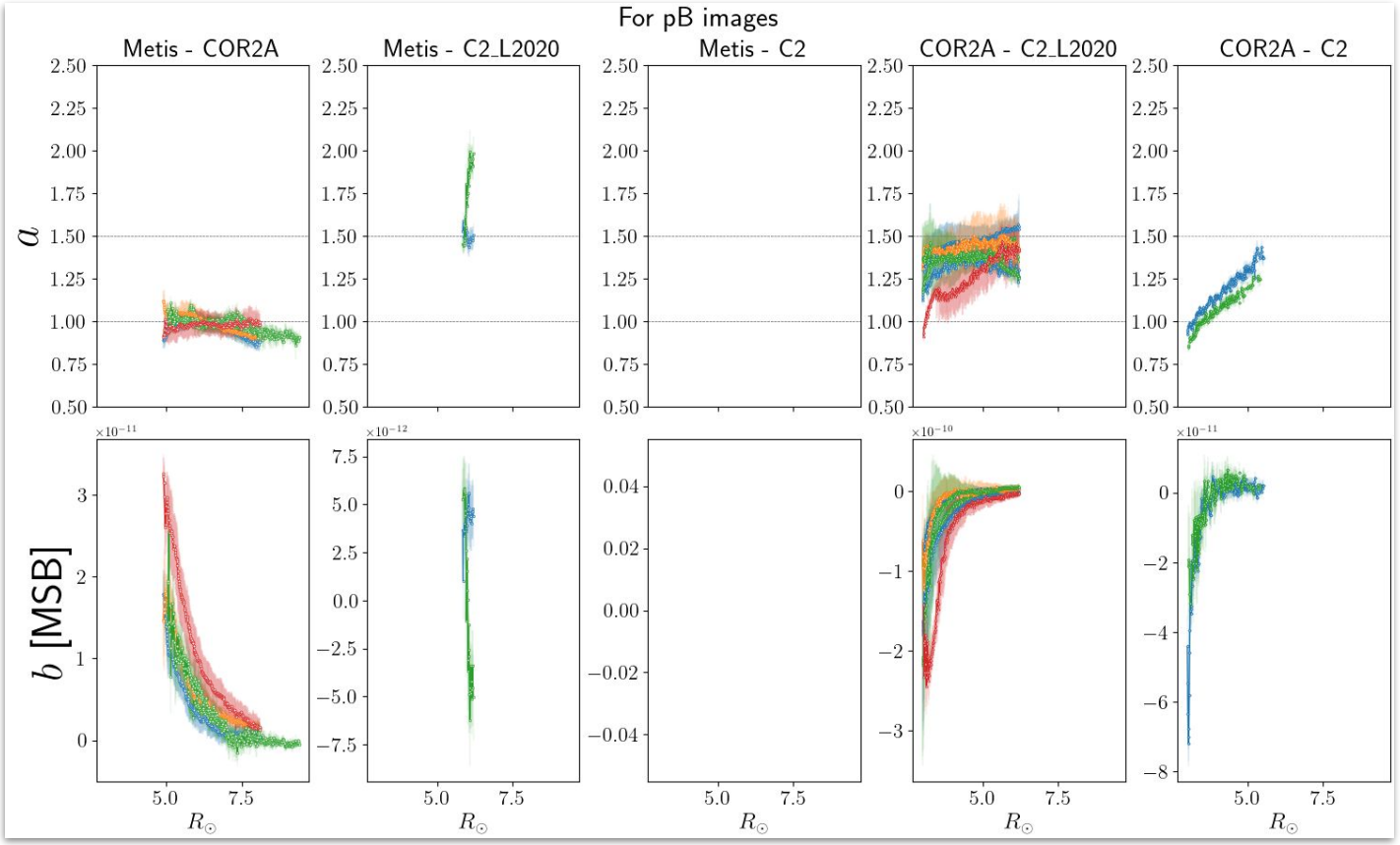
PB-Results for $<a(r)>_t$ and $<b(r)>_t$: COR2-A & C2

PRELIMINARY

Data selection:

- $\rho \geq 0.95$
- $\Delta d \leq 0.2$ au

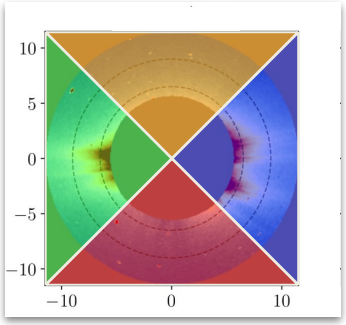


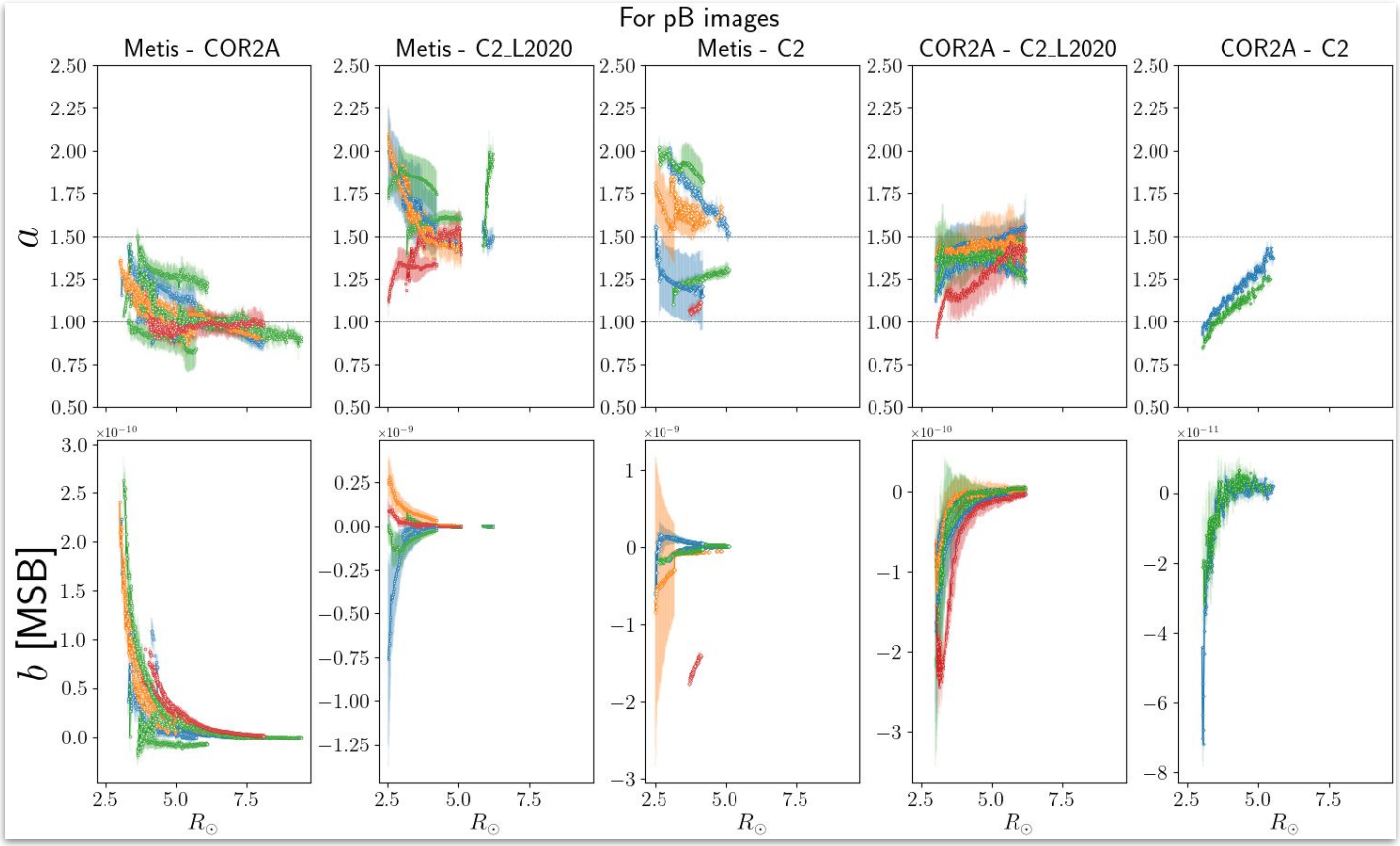


PB-Results for $<a(r)>_t$ and $<b(r)>_t$: COR2-A & C2

PRELIMINARY

Data selection:
- $\rho \geq 0.95$
- all distances

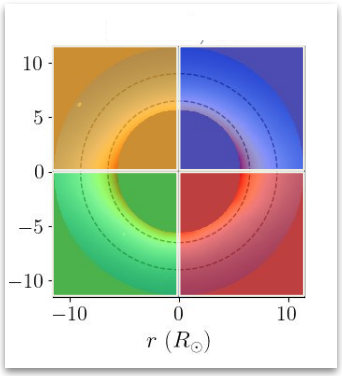




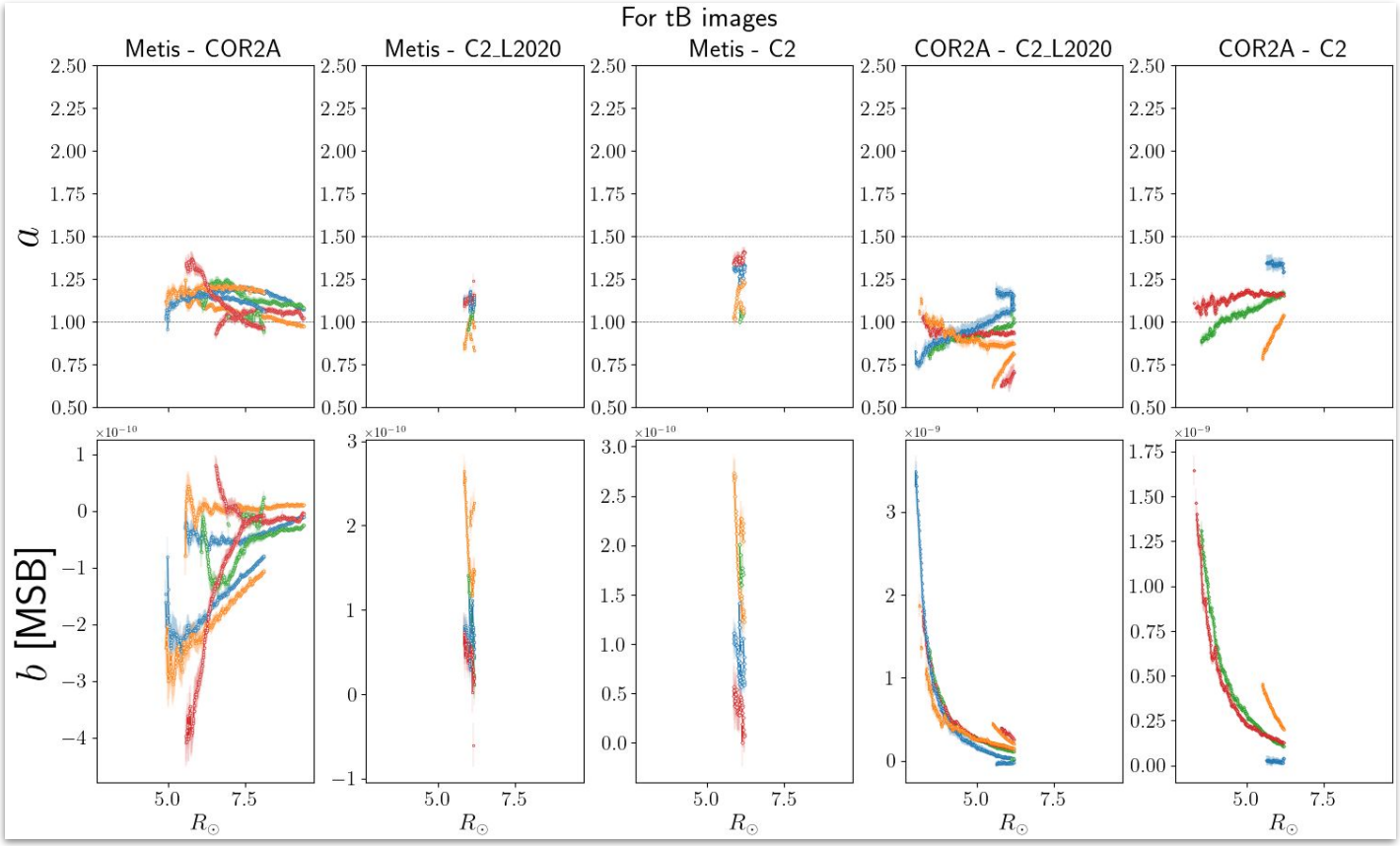
TB-Results for $<a(r)>_t$ and $<b(r)>_t$: COR2-A & C2

Data selection:
- $\rho \geq 0.95$
- $\Delta d \leq 0.2$ au

For Total Brightness:
- Stray Light
- F-corona



PRELIMINARY



Conclusions and Future steps

Conclusions and preliminary results

- pB:
  - $pB(\text{Metis}) = (1.0 \pm 0.1) \cdot pB(\text{COR2-A}) + Const$
  - $pB(\text{Metis}) = (1.59 \pm 0.18) \cdot pB(\text{C2_L2020}) + Const$
    - $pB(\text{Metis}) = (1.5 \pm 0.3) \cdot pB(\text{C2}) + Const$
  - $pB(\text{COR2-A}) = (1.4 \pm 0.1) \cdot pB(\text{C2_L2020}) + Const$
    - $pB(\text{COR2-A}) = (1.13 \pm 0.12) \cdot pB(\text{C2_L2020}) + Const$

Future Steps

- Investigate the pB scaling factors a between Metis, LASCO-C2 and COR2-A
- Estimate the systematic effects due to different distance and viewing angle to the coronal structures seen with different instruments

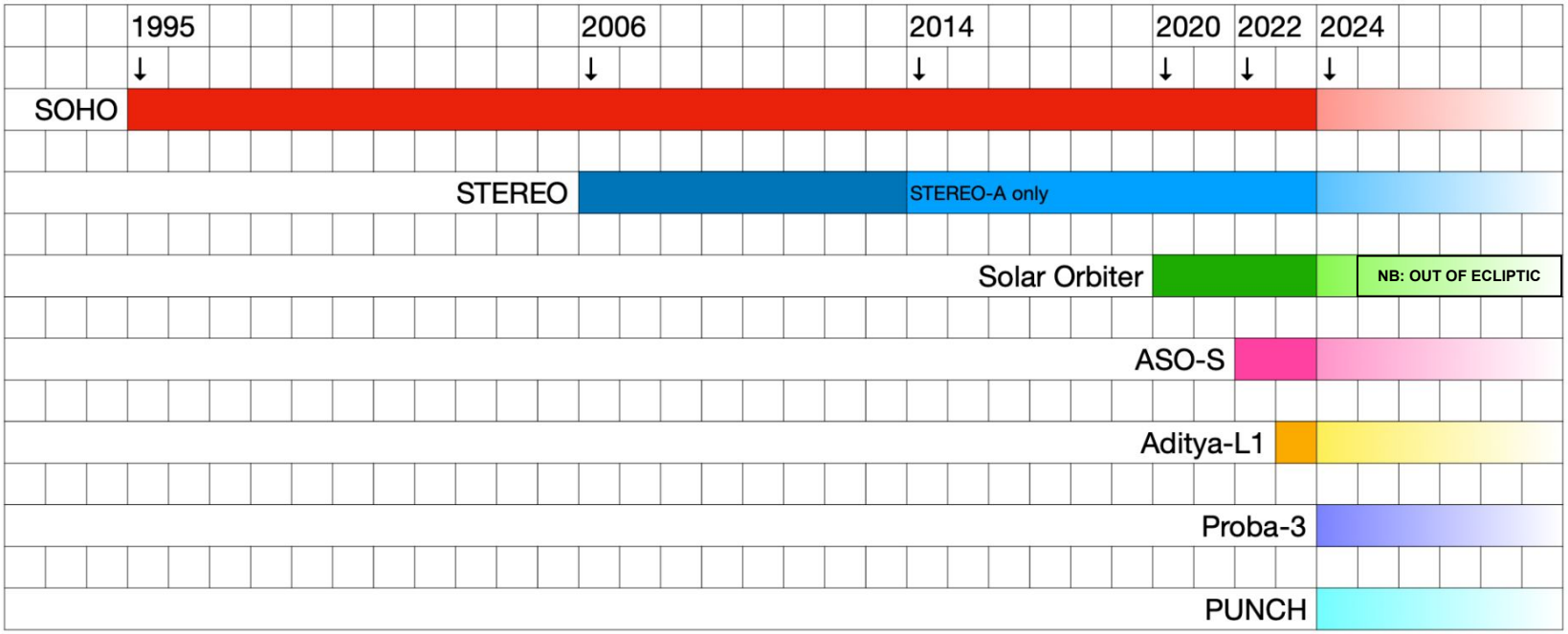
Conclusions and Future steps

Future Steps for *B* images

- Estimate the systematic effects due to
  - (as for *pB*) different distance and viewing angle to the coronal structures seen with different instruments
  - different contribution of the F-corona
  - different contribution of the stray light
- Check the expected fluxes of the field stars seen with the instruments

Any contribution is welcome!

Past, present, and future missions

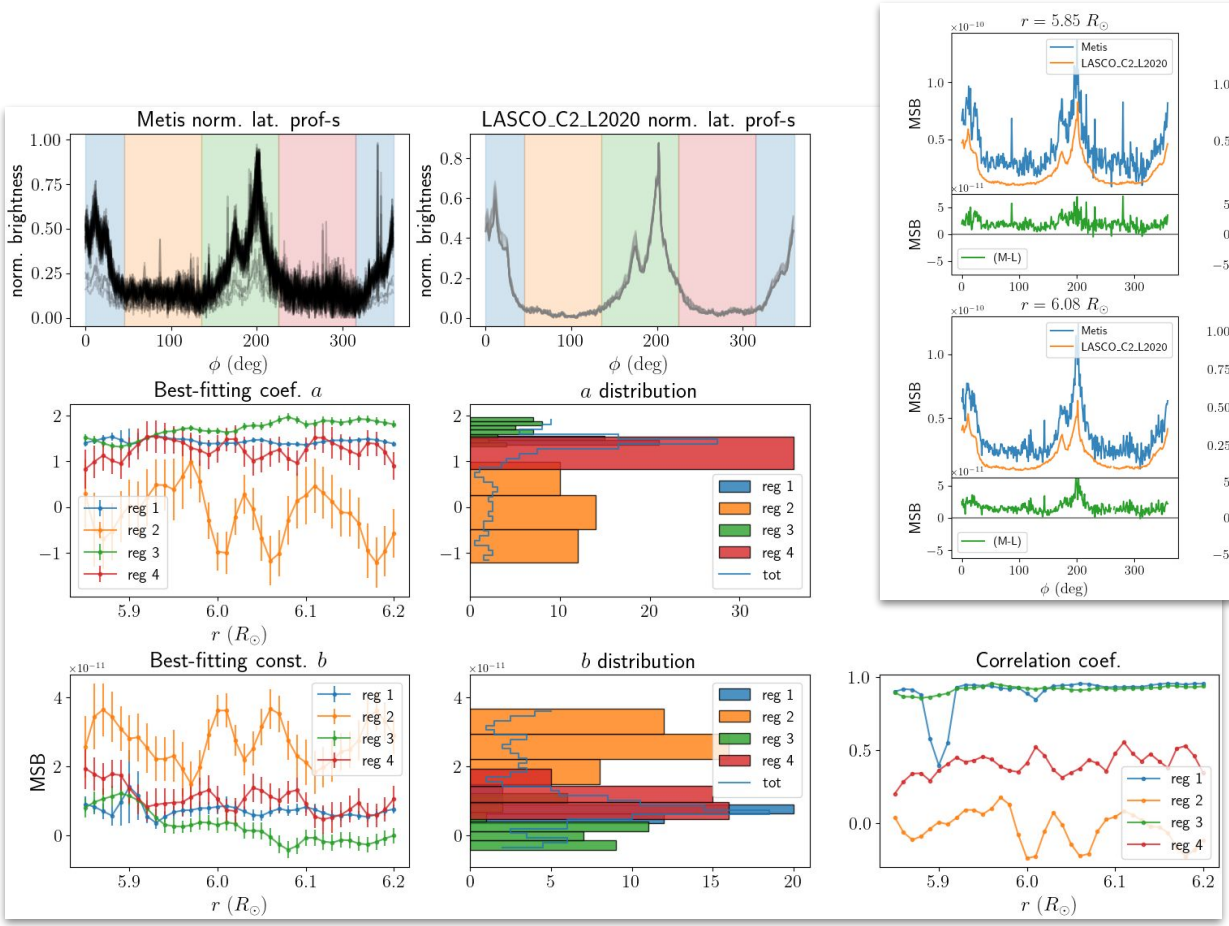


Courtesy of R. Susino

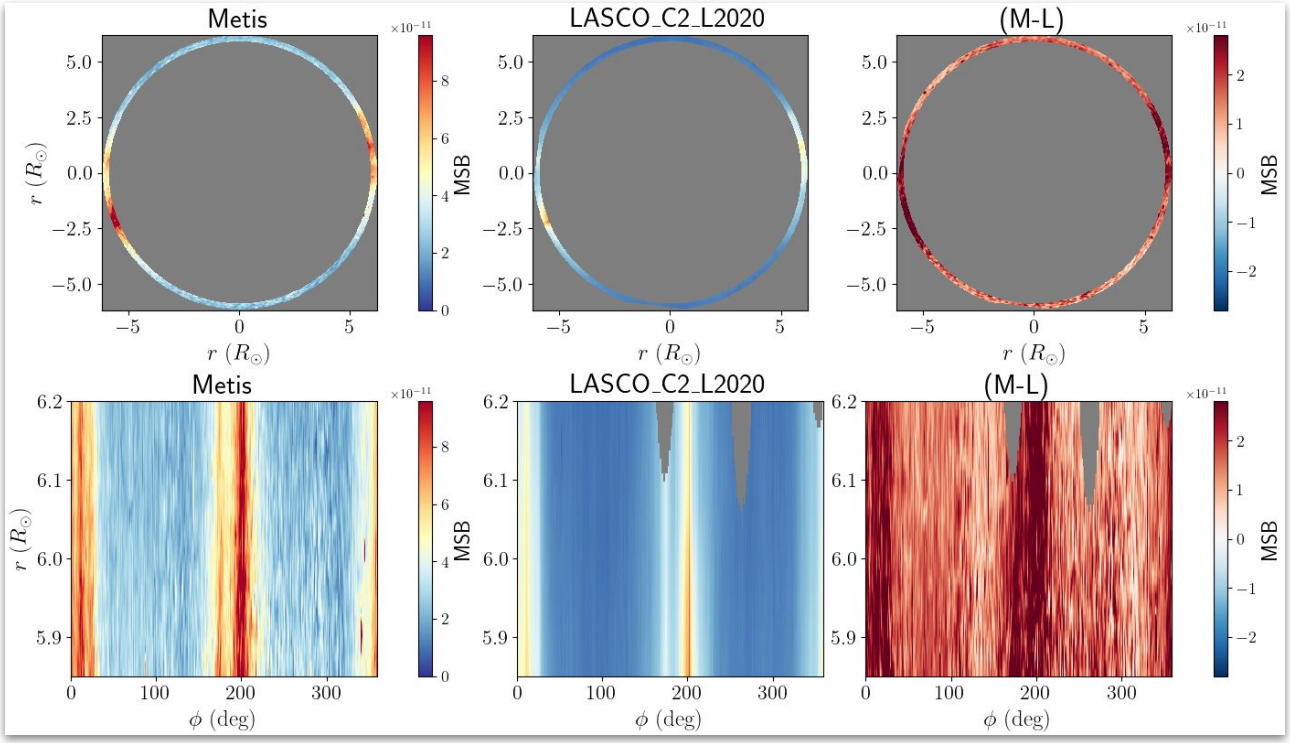
Backup slides

Introduction

Metis - C2 opposition (Nov 2021)



Metis - C2 opposition (Nov 2021)

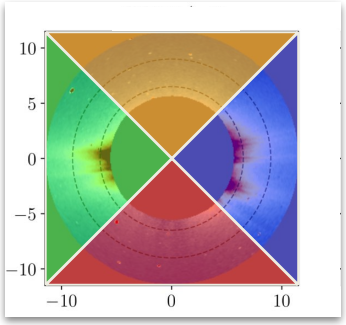


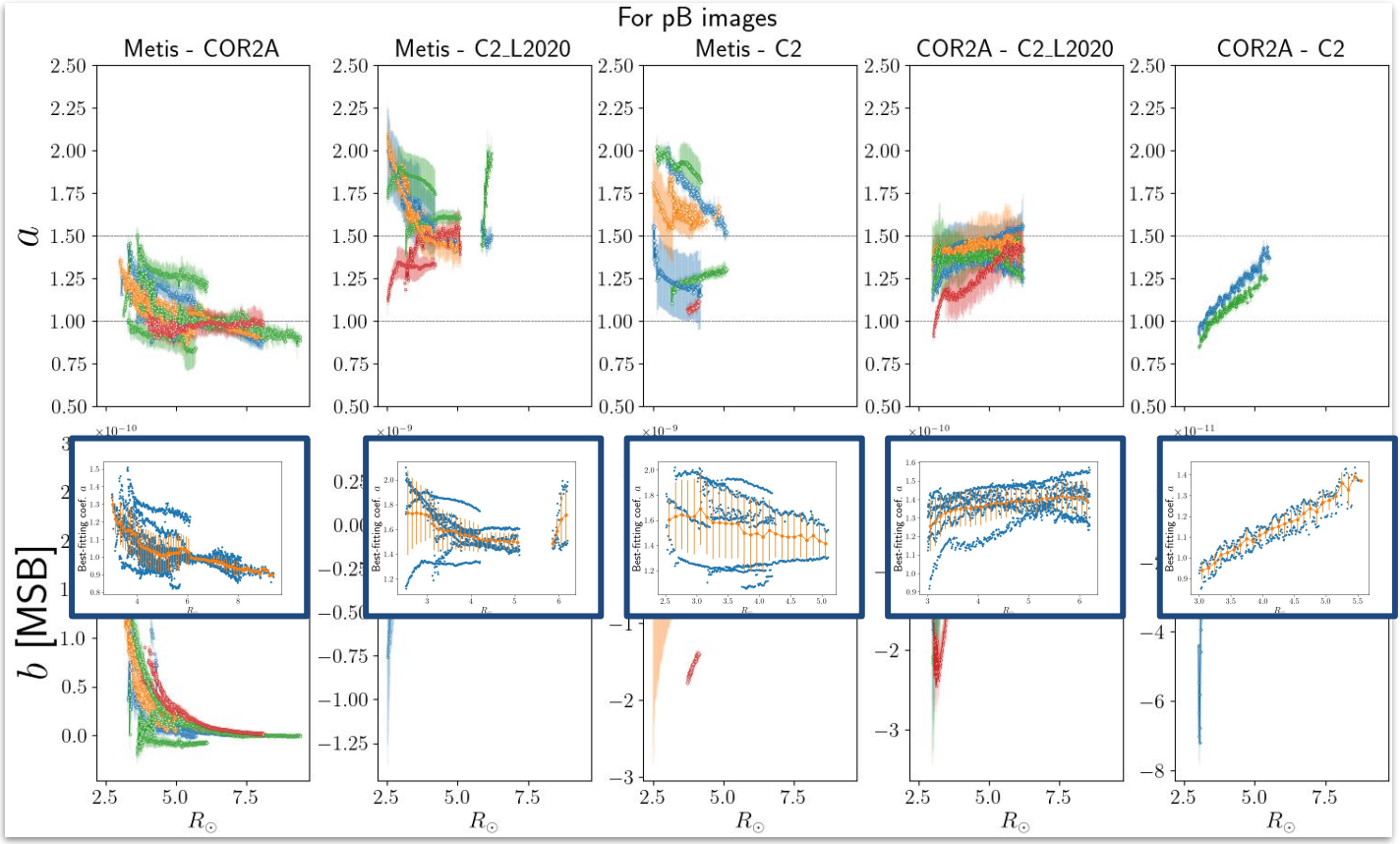
PB-Results for $\langle a(r) \rangle_t$ and $\langle b(r) \rangle_t$: COR2-A & C2

PRELIMINARY

Data selection:

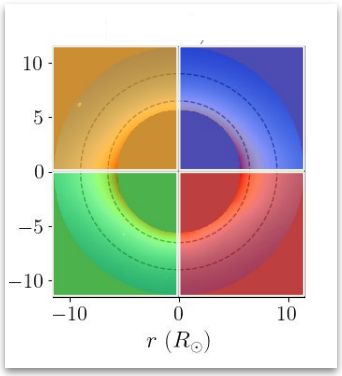
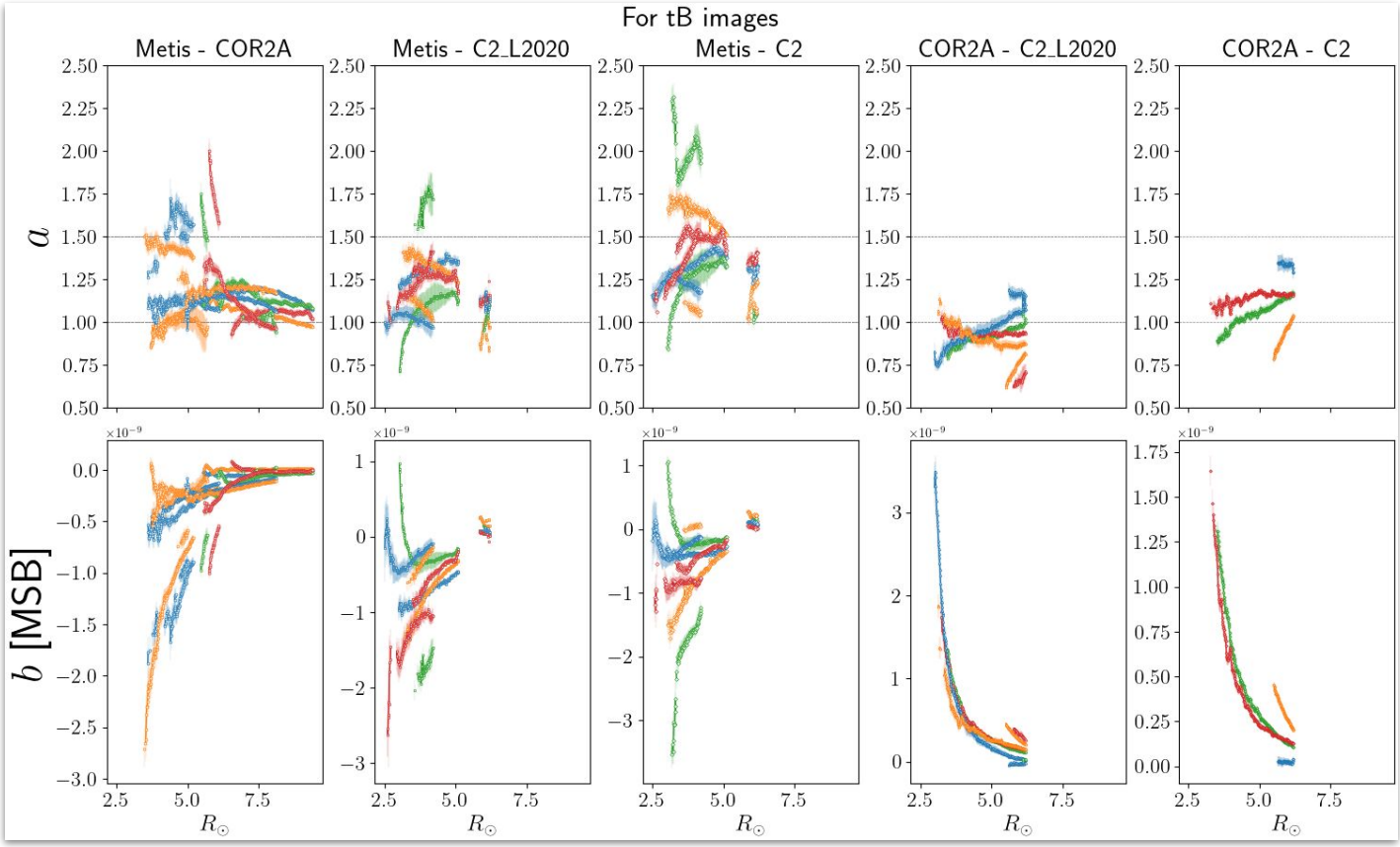
- $\rho \geq 0.95$
- all distances





TB-Results for $<a(r)>_t$ and $<b(r)>_t$: COR2-A & C2

PRELIMINARY

Data selection:
- $\rho \geq 0.95$
- all distances

For Total Brightness:
- Stray Light
- F-corona