

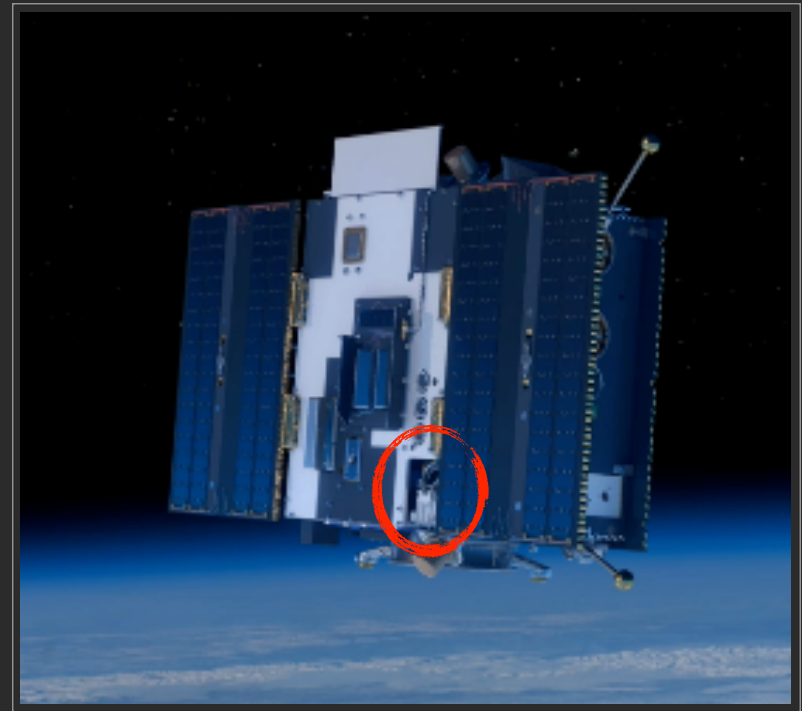
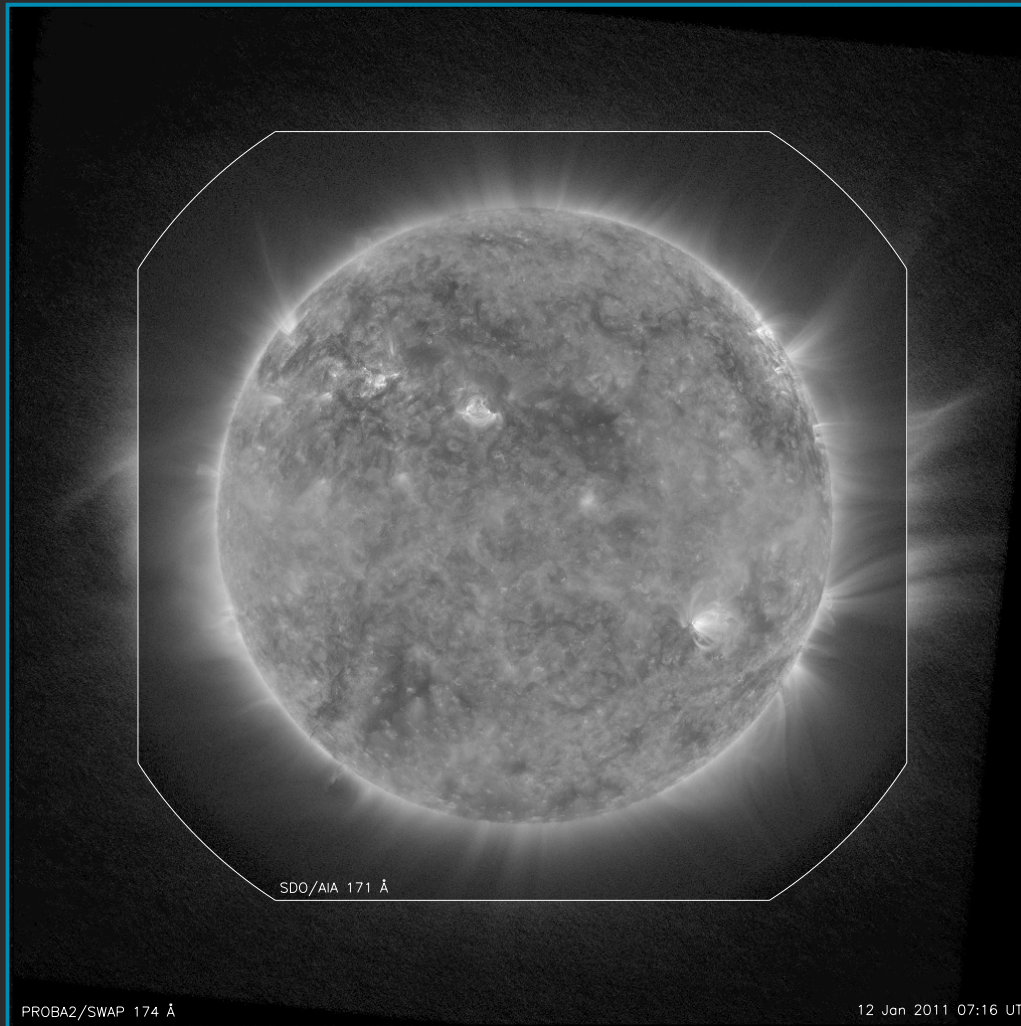
PROBA2/SWAP OBSERVATIONS OF THE LARGE-SCALE, LONG-TERM EVOLUTION OF THE EUV CORONA

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**ESA, **Royal Observatory of Belgium*

5th Solar Orbiter Workshop ☀ Brugge, Belgium ☀ September 10-14, 2012





ESA microsatellite PROBA2
sun-synchronous orbit since Nov '09

Seaton et al. 2012, Sol.Phys. online
Halain et al. 2010, SPIE 7732

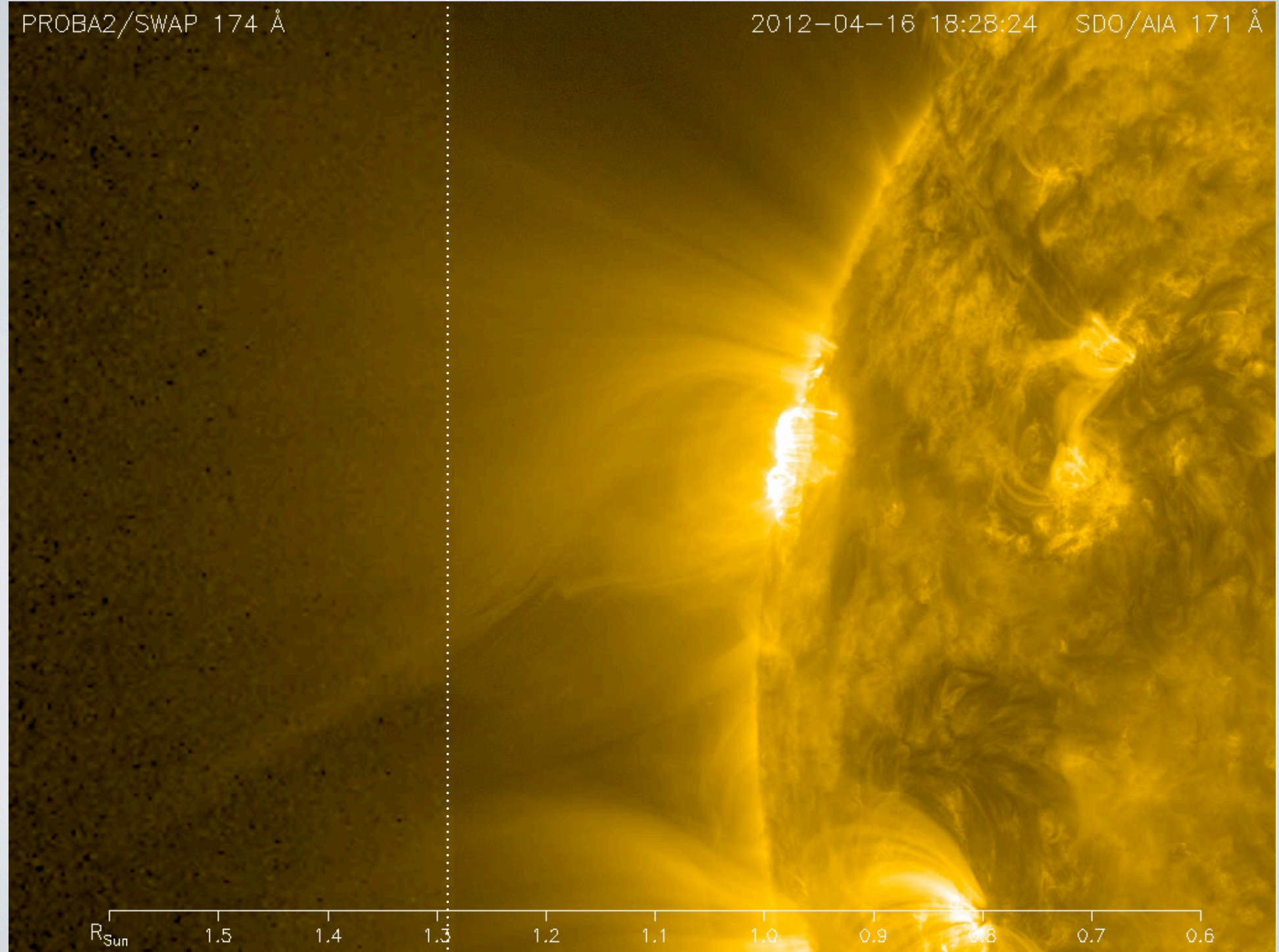
SWAP EUV IMAGER

1 million° corona in EUV 17.4nm ☼ ~2 mins cadence (upto 20s)

large FOV ☼ 1Kx1K CMOS APS (~EUI, PHI, SoloHI)

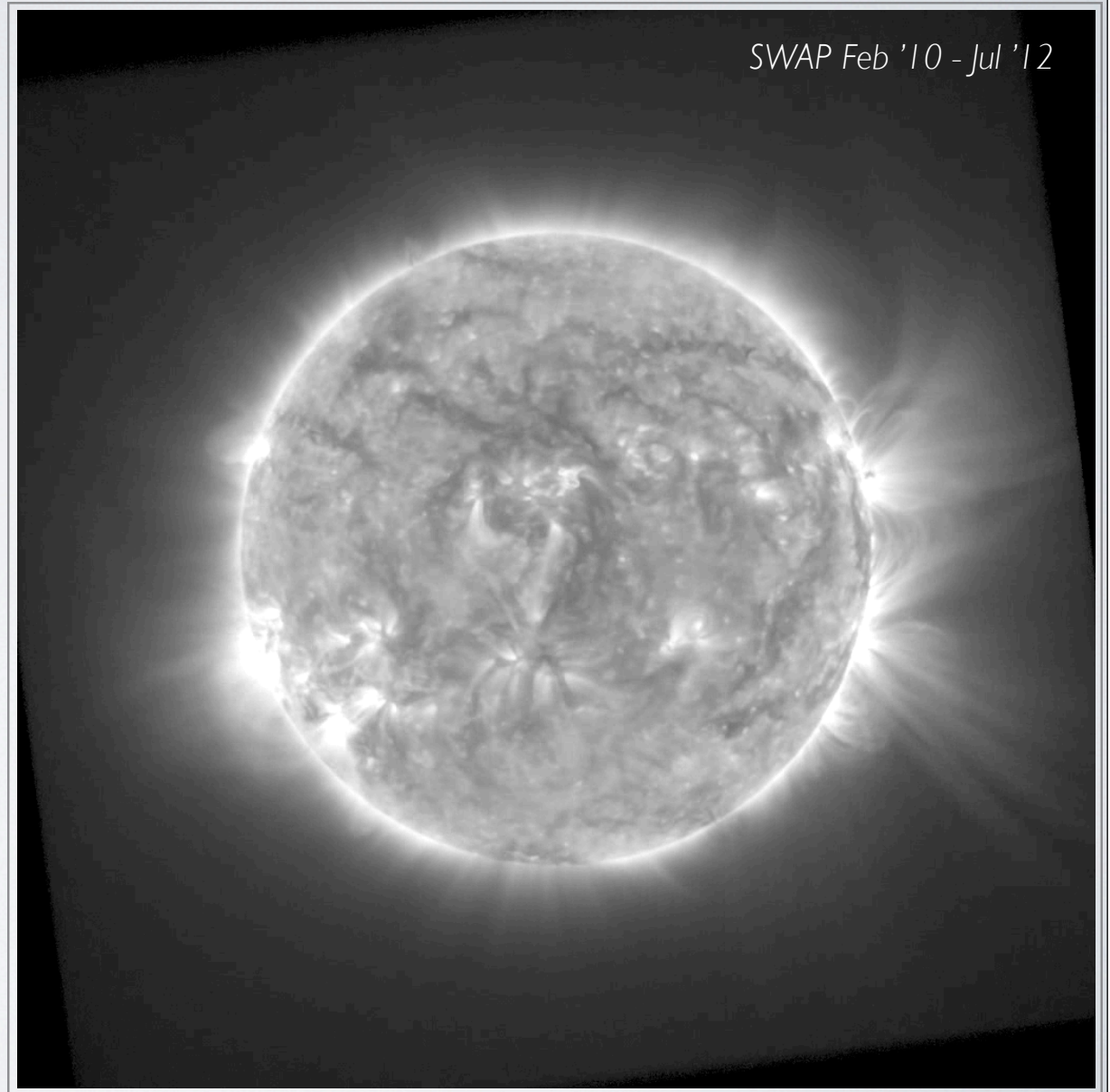
PROBA2/SWAP 174 Å

2012-04-16 18:28:24 SDO/AIA 171 Å

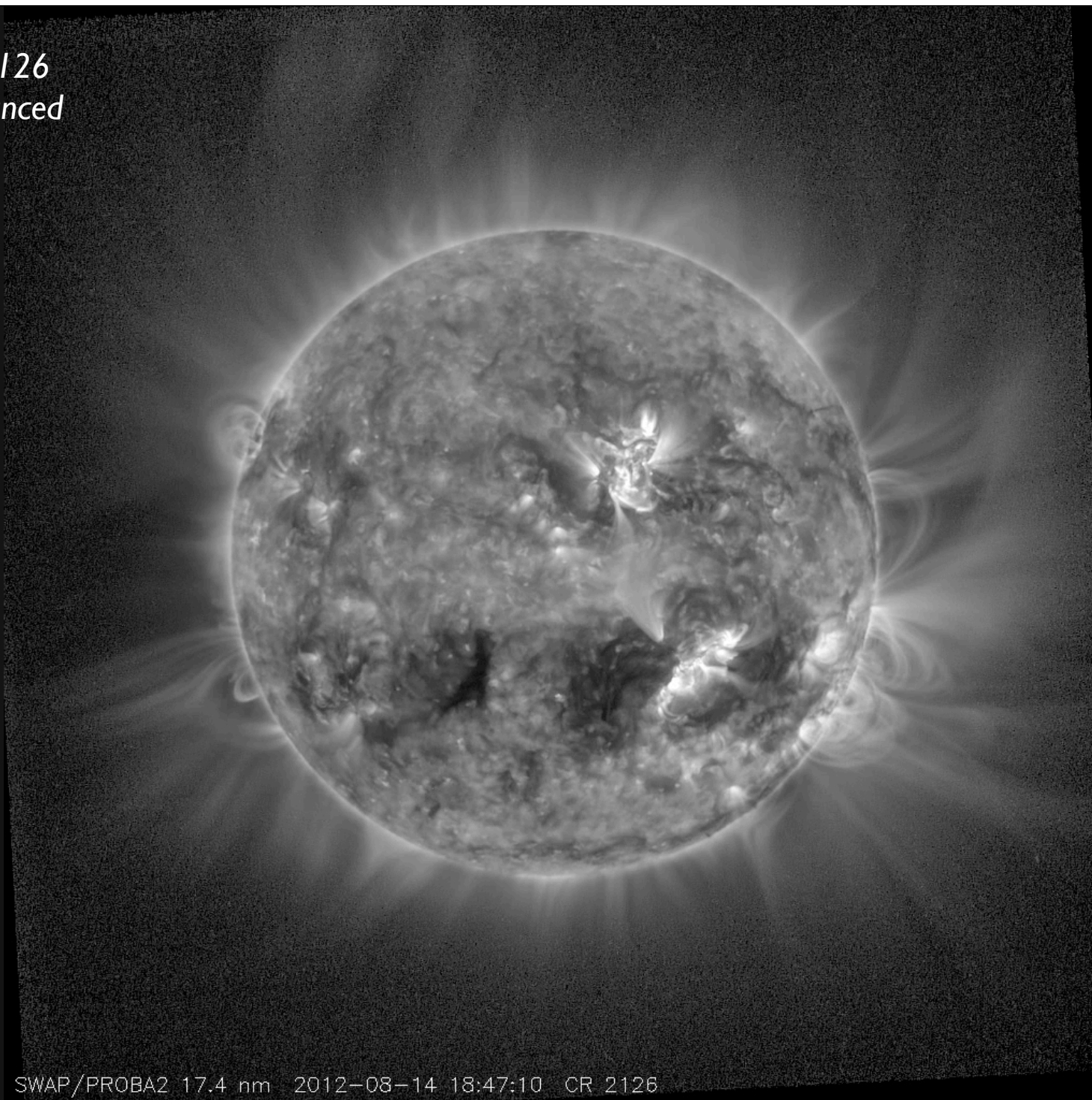


EVOLUTION EXTENDED CORONA

- high-quality, deep-exposure SWAP images by stacking up many individual images
- Carrington rotation movies
<http://proba2.oma.be/swap/movies>
- SWAP monitored the extended corona ($< 2 R_{\text{sun}}$) over 2,5 years (rising phase)
- **Aim of this presentation:**
present preliminary results,
inspire new research on
extended EUV corona
above $1.3 R_{\text{sun}}$



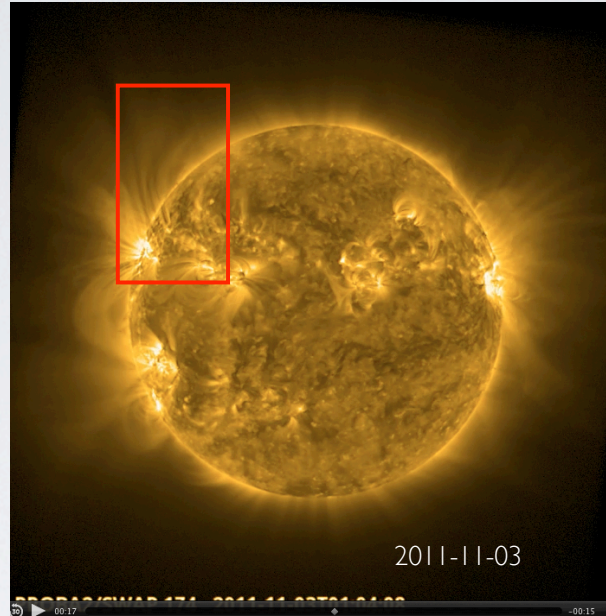
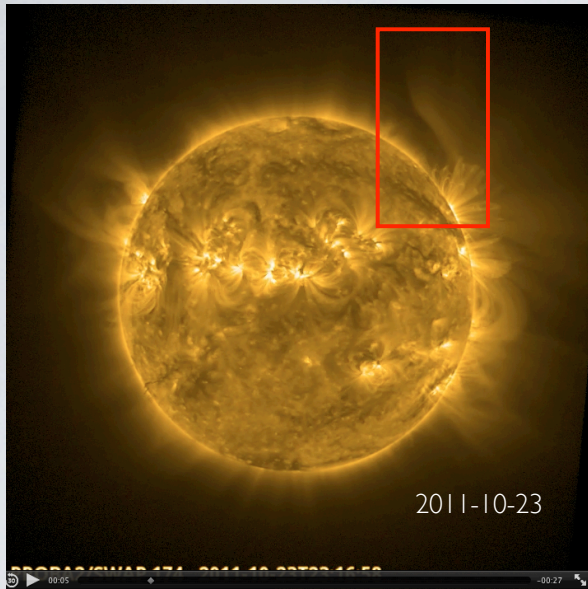
CR 2125-2126
radially enhanced



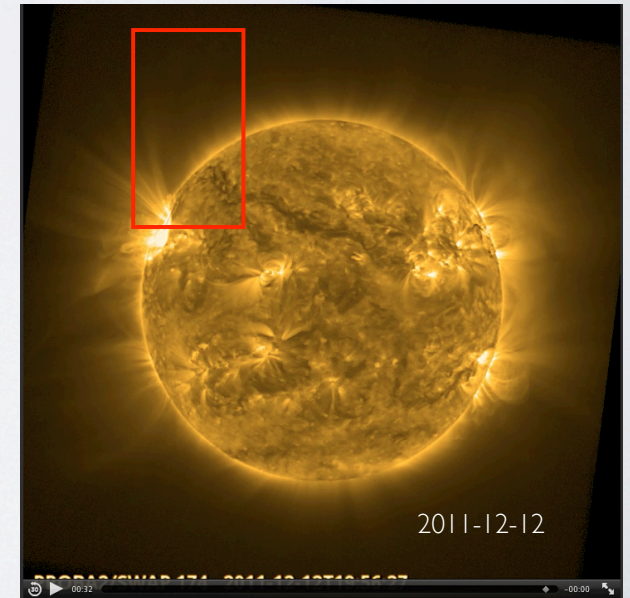
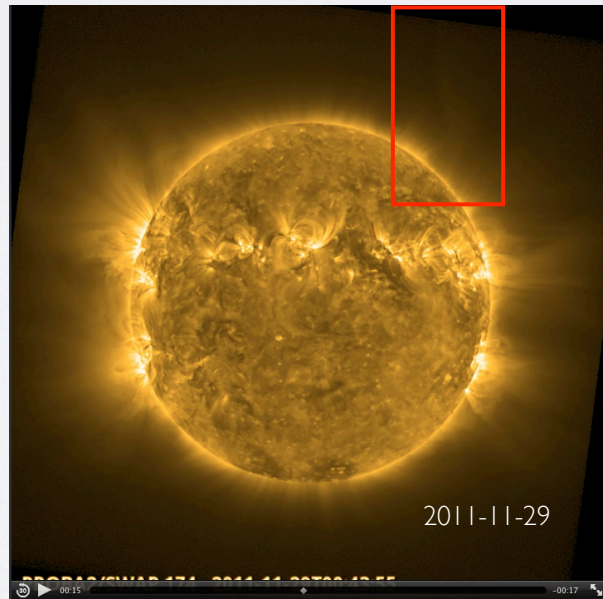
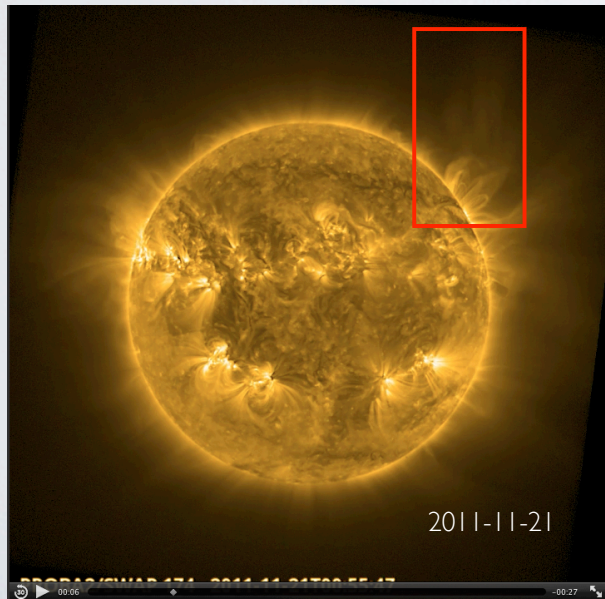
SWAP/PROBA2 17.4 nm 2012-08-14 18:47:10 CR 2126

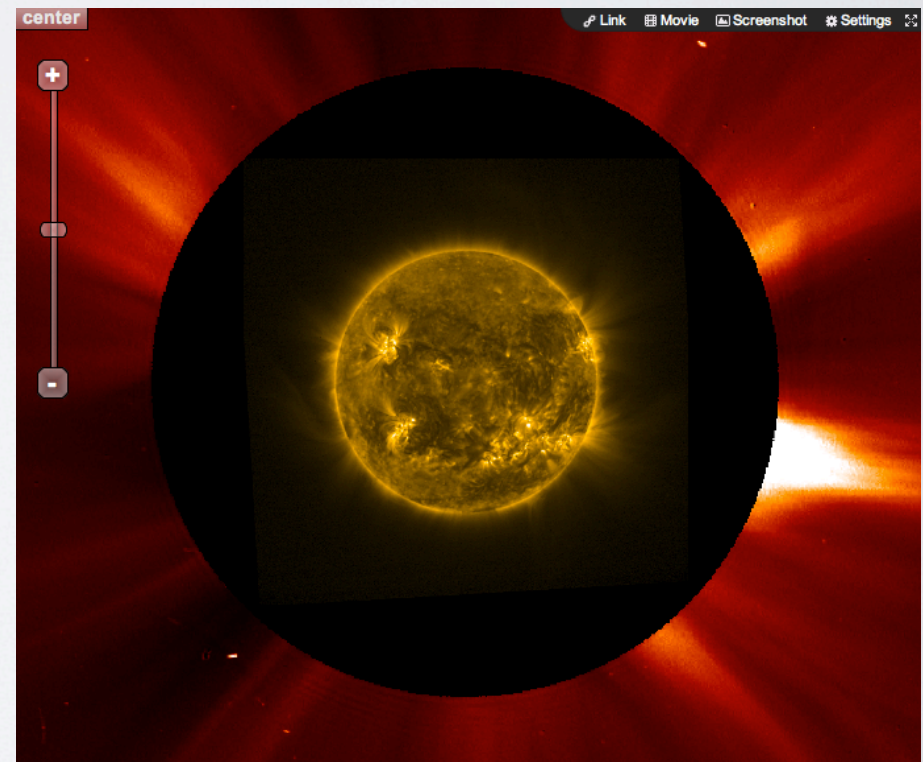
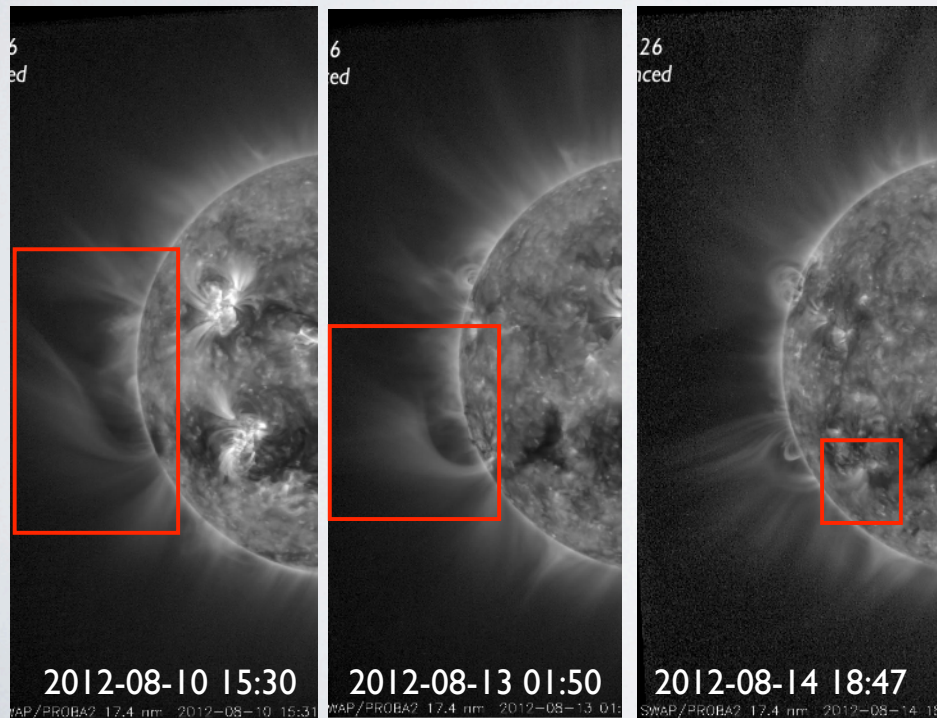
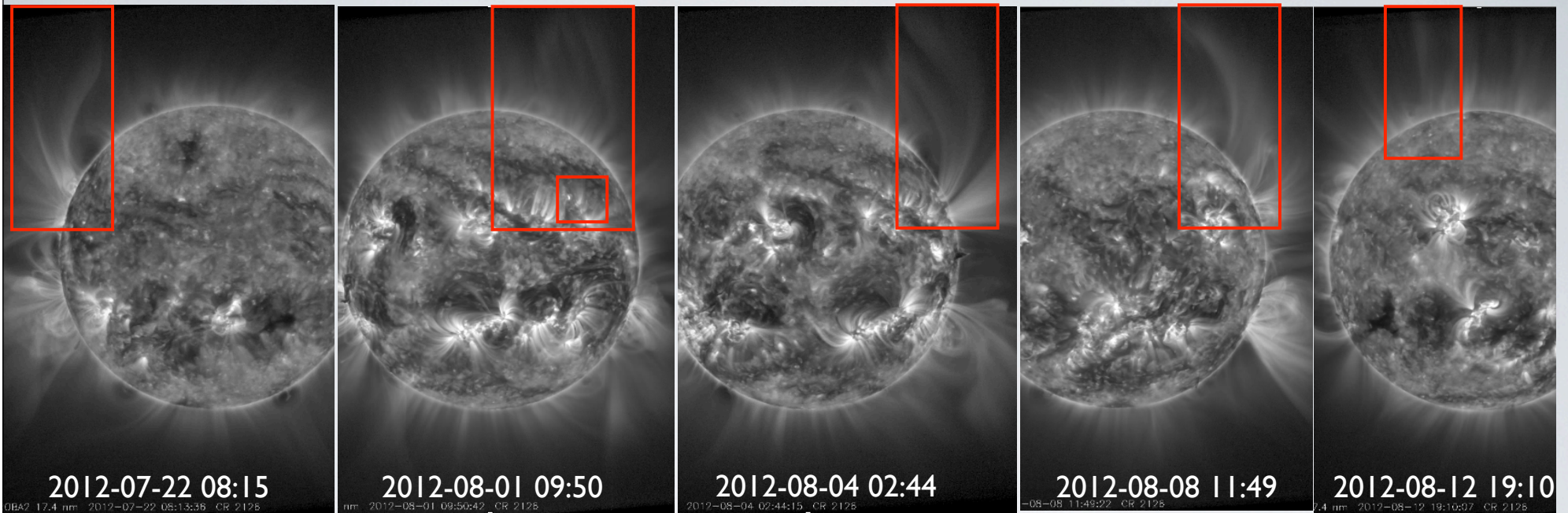
CORONAL 'FAN RAYS'

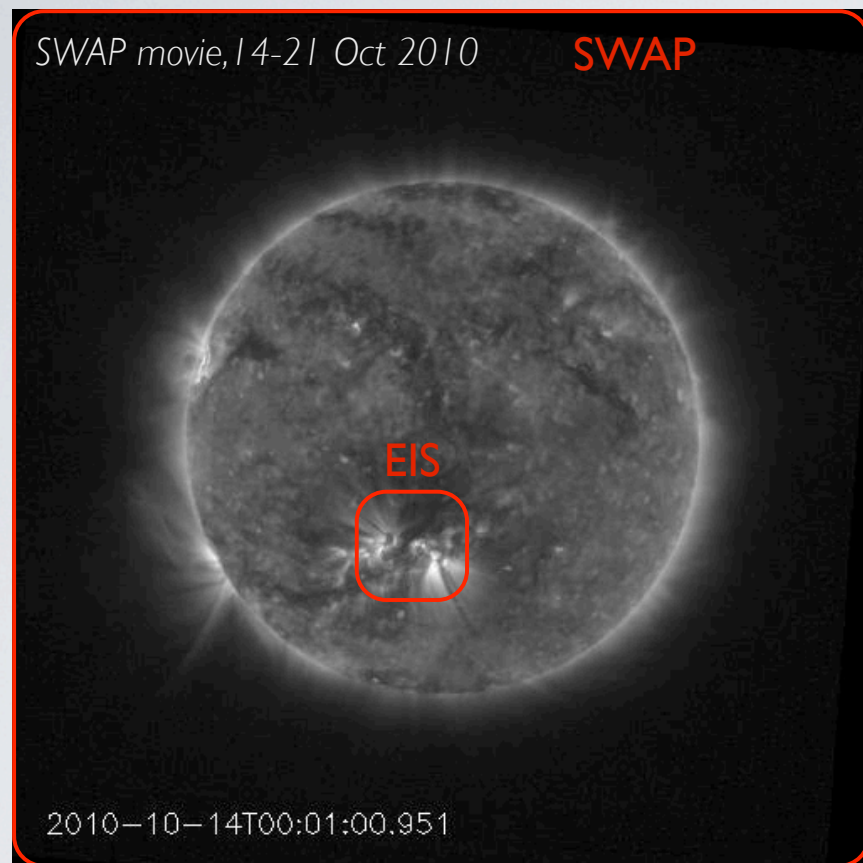
- Extended, EUV bright structures
- Raise along open field lines
- Seem rooted in the fan loops close to the edges of the AR
- Stable & persistent over several rotations - despite AR closeby
- Often bending above closed field



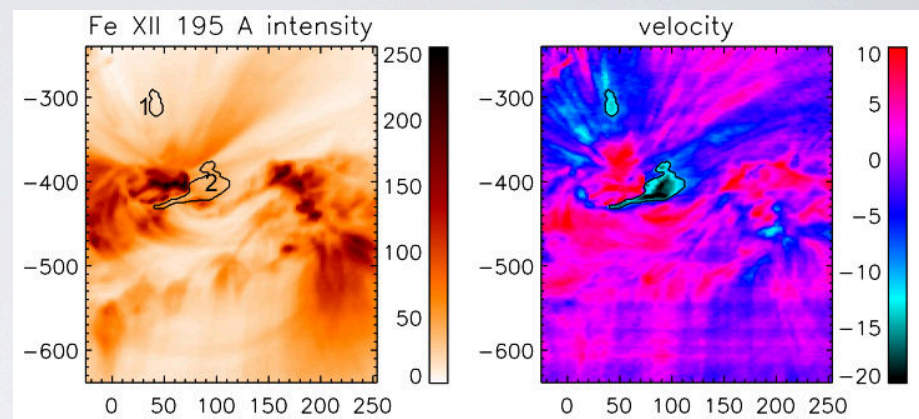
Persistence:
same structure visible
over at least 2 CRs



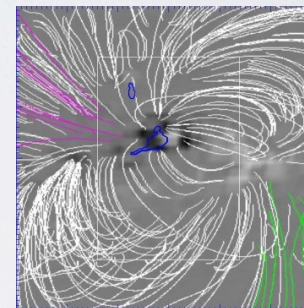




Outflows in AR 11112 detected by EIS 14/10/10



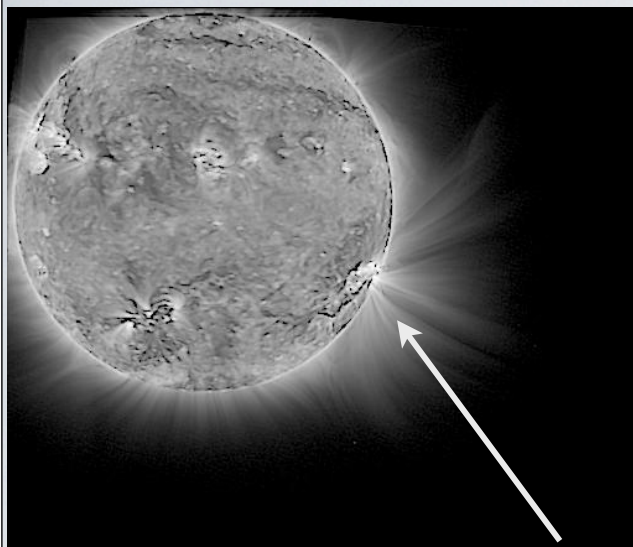
PFSS magnetic field



FAN RAY CASE STUDY (SWAP+EIS+ACE)

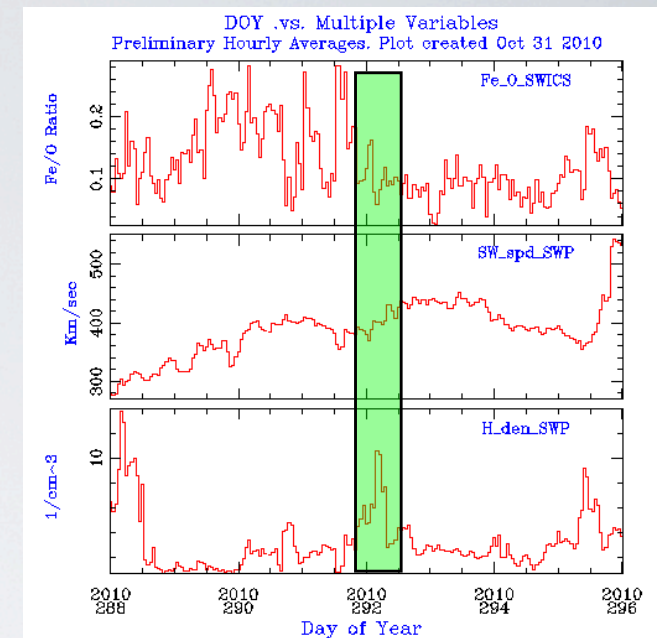
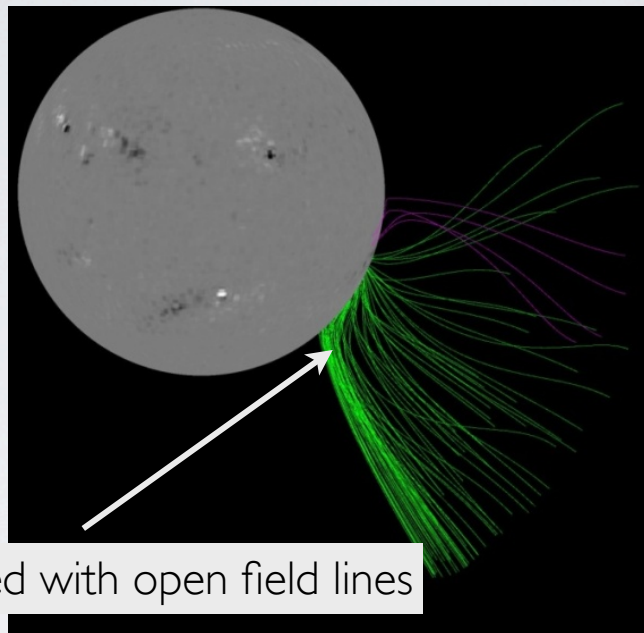
Hinode/EIS detects outflows in AR on-disk

7 days later, SWAP points West to observe flows at high cadence
outflows are linked to solar wind data



SWAP 101020

Coronal rays co-aligned with open field lines

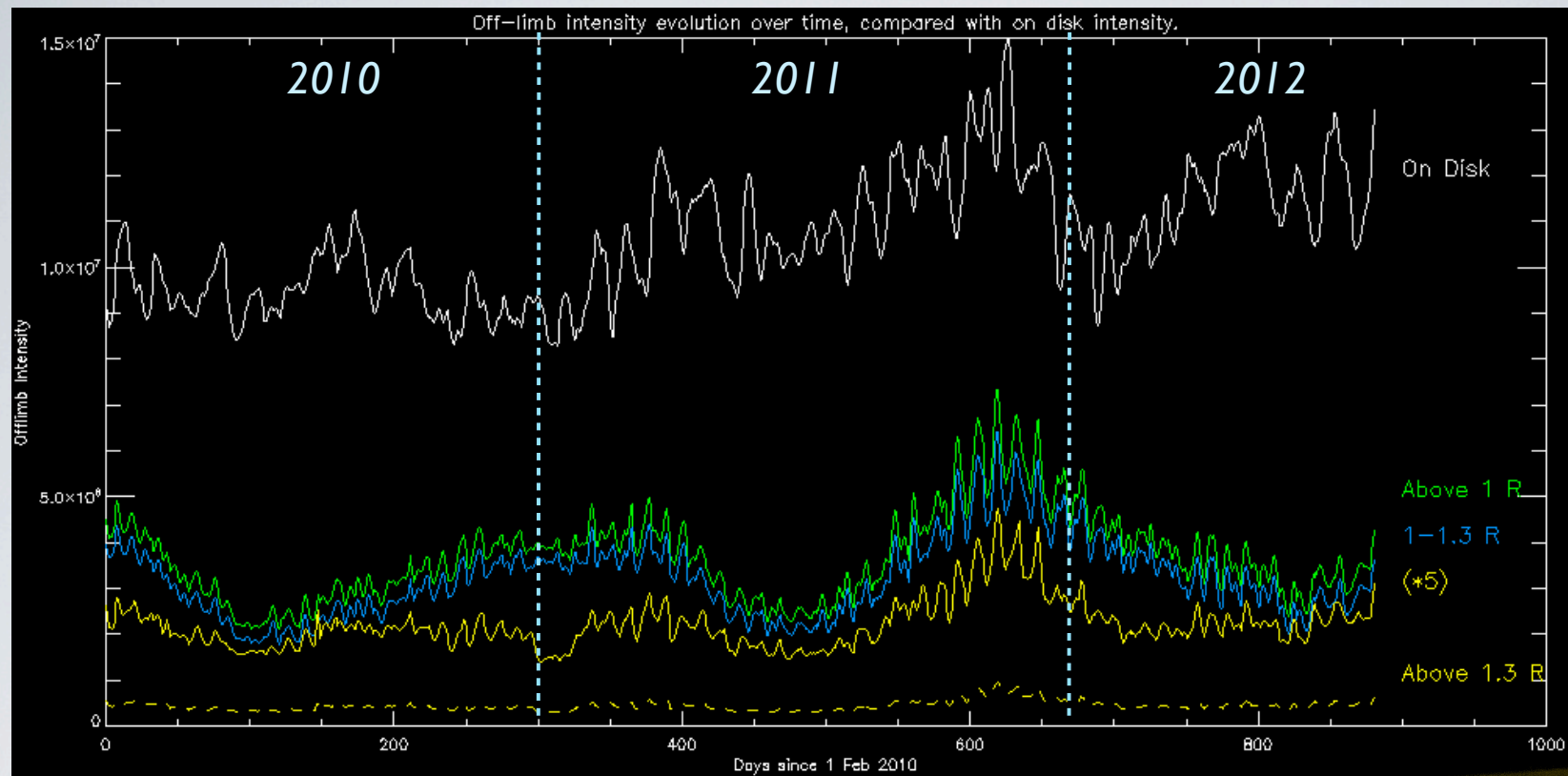


Impact of outflows on ACE solar wind data

FAN RAY CASE STUDY (SWAP+EIS+ACE)

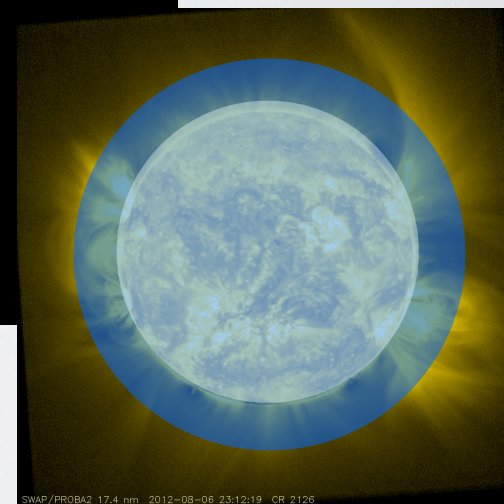
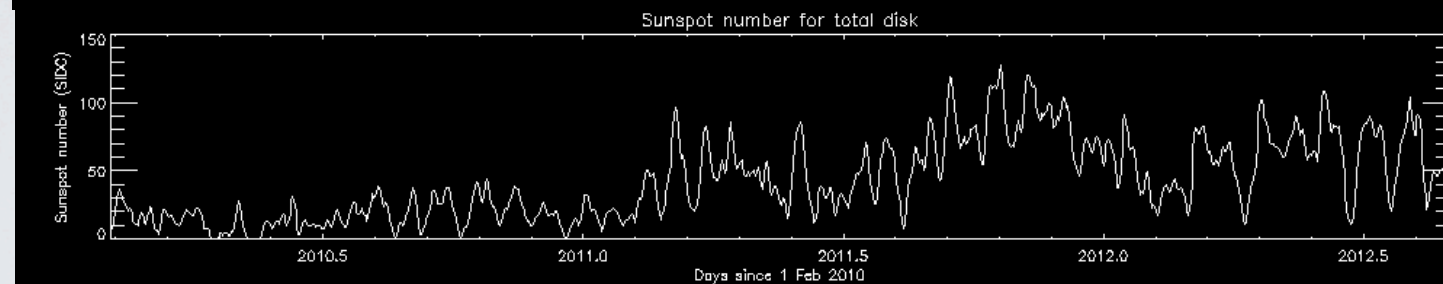
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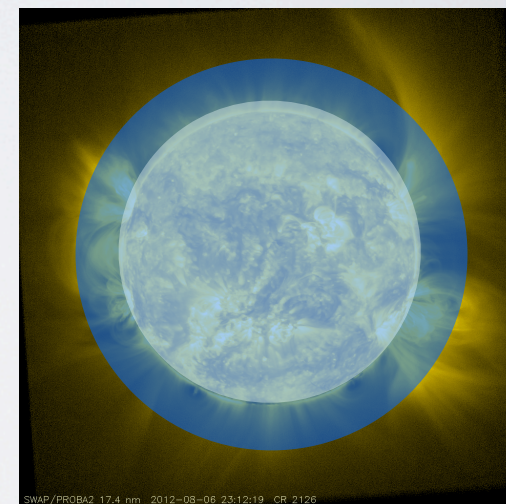
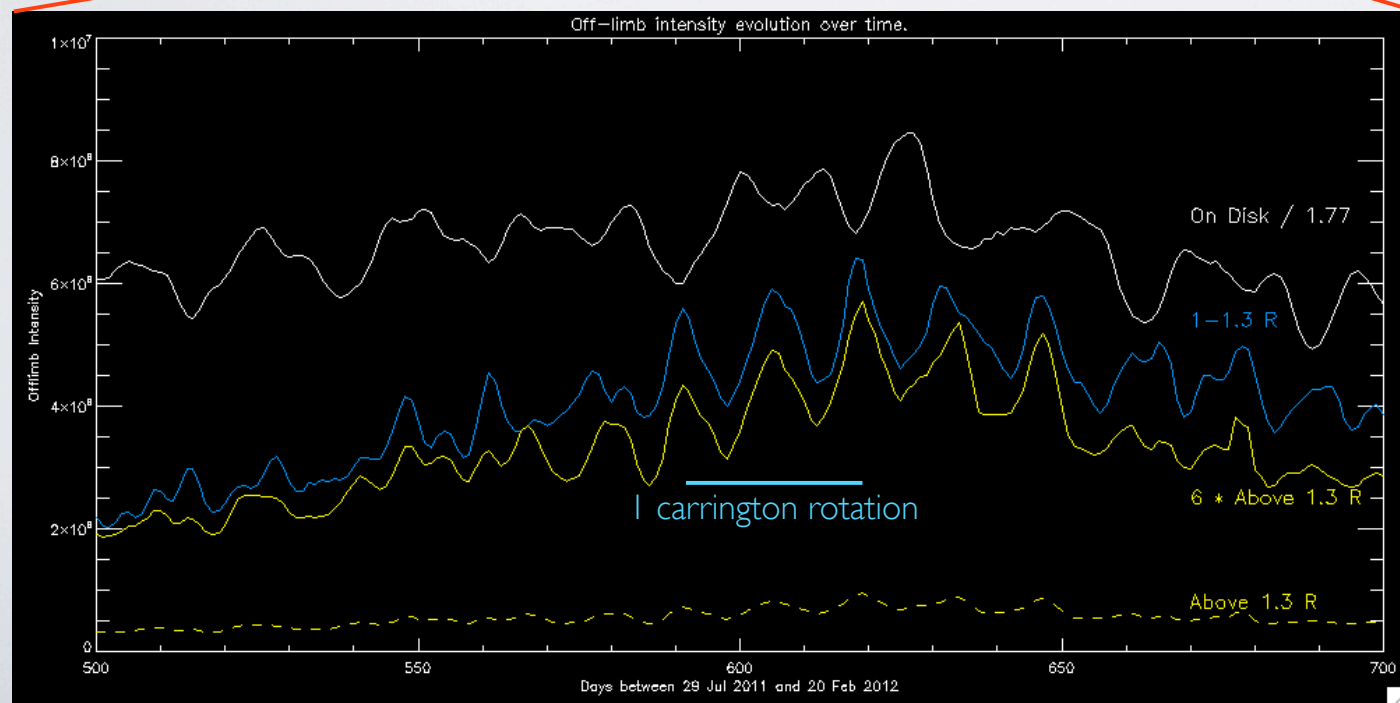
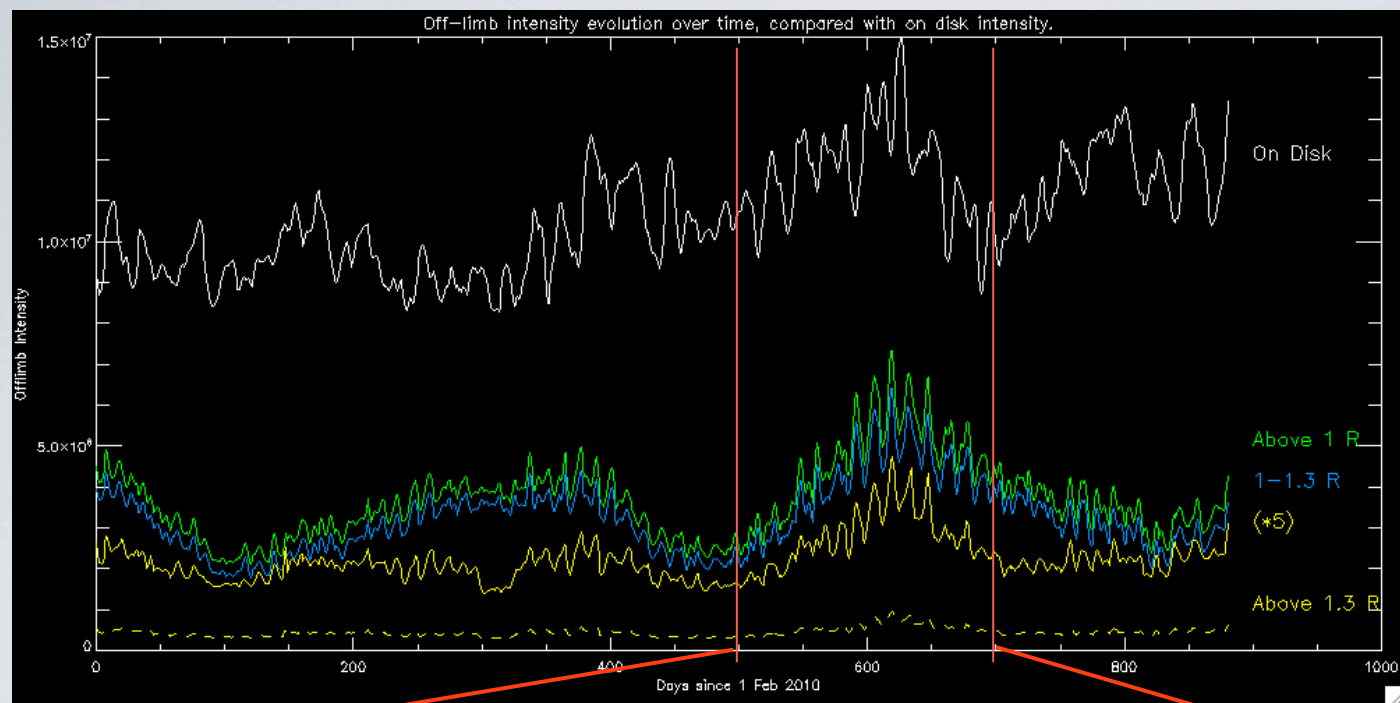


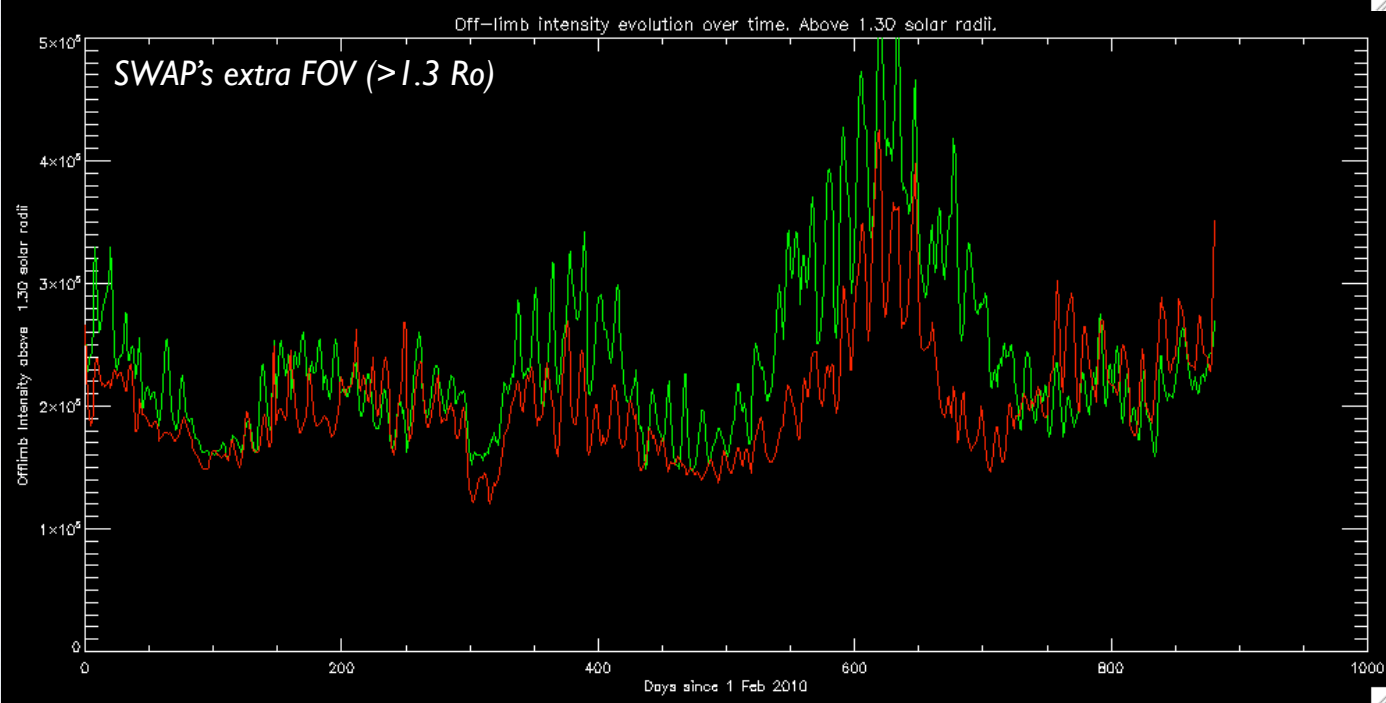
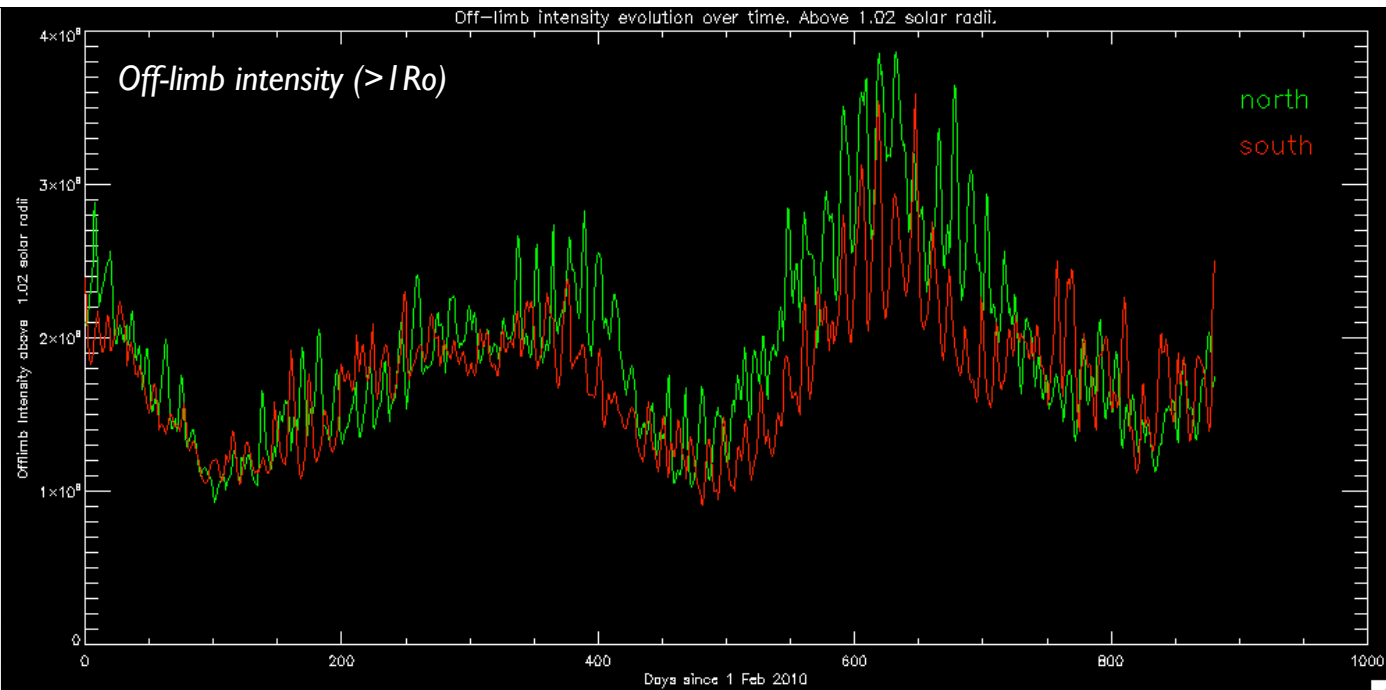
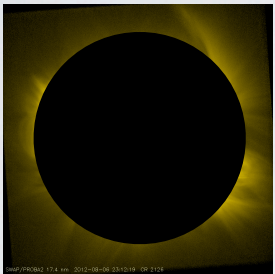
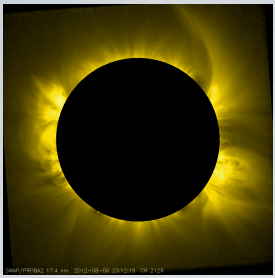
On disk

$> 1 R_{\text{SUN}}$
 $1-1.3 R_{\text{SUN}}$
 $> 1.3 R_{\text{SUN}}$



OFF-LIMB INTENSITY EVOLUTION





North

South

INTENSITY PER HEMISPHERE

QUESTIONS

- Link with WL streamers? Link with solar wind?
- Why are they so persistent? Continuous heating?
- How can they stay so stable?
- Where exactly are the footpoints?
- ▶ 3D reconstruction using SWAP only or with STEREO/EUVI
- ▶ Comparison EUV rays with WL (SWAP vs MLSO)
- ▶ Apply tomographic techniques on SWAP at $\sim 1.7 R_{\text{SUN}}$

LINK WITH STREAMERS

Morgan & Habbal 2010, ApJ 710, 1

Streamers (WL)	Coronal Fan Rays (EUV)
high-density structures <i>Intensity $\sim r^{-1}$</i>	high-temperature structures <i>Intensity $\sim r^{-2}$</i>
rise radially	fan out, bend over closed loops?
same latitude as filaments & AR belts	higher latitudes? footpoints at polar edge of ARs
not necessarily associated with polar reversal	??

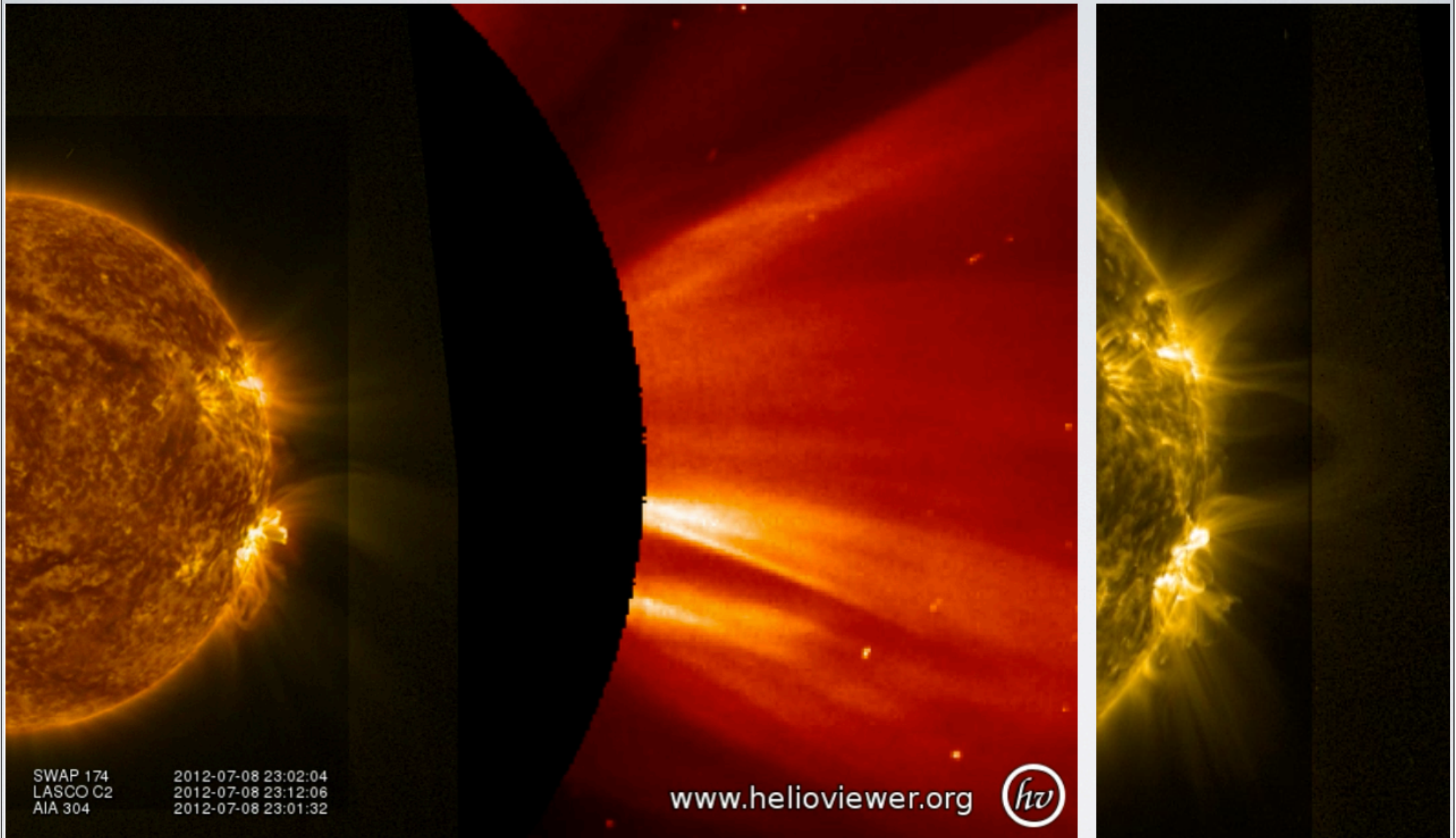


results of tomography on full solar cycle of LASCO data 4 R_{SUN}

OPPORTUNITIES SOLAR ORBITER

- FSI's broad FOV can observe extended rays
first 3 years of SolO comparable PROBA2's first 3 years
(rising phase solar cycle)
- When SolO moves out of ecliptic, link FSI/EUI information to
in-situ measurements
- METIS coronagraph: WL, (E)UV observations from 1.4 to 4
solar radii
- SPICE: EUV imaging spectroscopy of the solar disk and low
corona

a few more beautiful examples to end with



SWAP data available from <http://proba2.oma.be>