

SOLAR ORBITER DATA PRODUCTS

Input to JHelioviewer meeting - 2-3 July 2014

REQUIREMENTS (DERIVED FROM SIRD)

A **Visual Data Browsing and Context Tool (VDBC)** will be developed, which interactively displays and overlays the following quantities in an integrated tool:

- Synoptic observations from all Solar Orbiter (SolO) instruments
- Synoptic data from near-Earth assets (images in FITS with WCS-compliant headers)
- Solar Orbiter's trajectory
- Models of coronal and heliospheric magnetic fields & HCS to connect IS and RS measurements
- Coronal hole maps
- Solar event markers

More specific reqs:

- Zoom function for appropriate view of both large coronal FOVs (HI, METIS) and high-resolution data
- 3D-view to handle images taken from different viewpoints.
- Visualization of time series (IS instruments) in combination with RS instrument data products, clearly specifying acquisition times
- Accessible by the Instrument Teams and all other parties involved in the instrument science operations.
- Usable on standard Linux, Windows, and Mac computer platforms.
- Retrieval of input data from the Solar Orbiter Archive. Sources for non Solar Orbiter data specified by PS.
- World Coordinate System enables the user to switch between relevant coordinate systems.
- Shall be tested with representative instrument commissioning/characterization data during the NECP and CP.

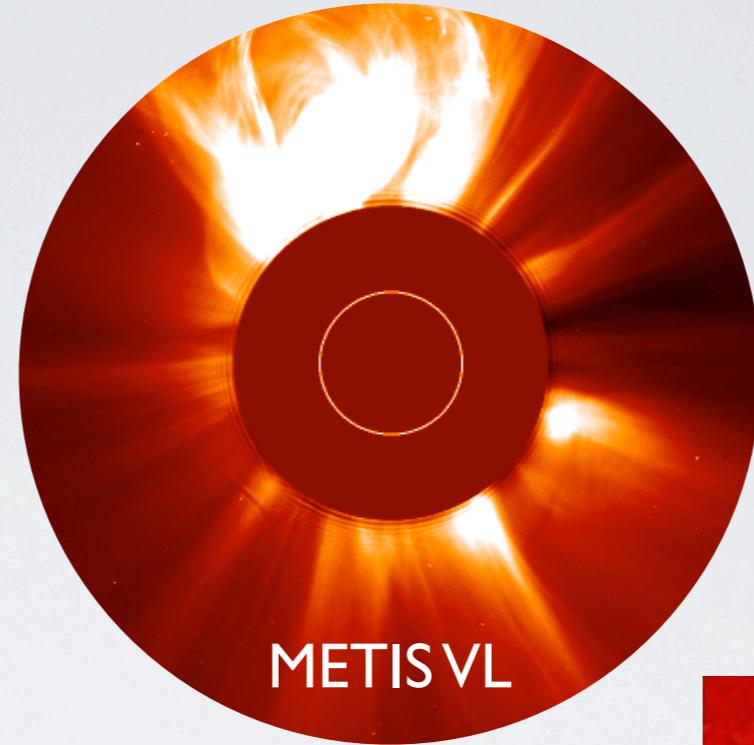
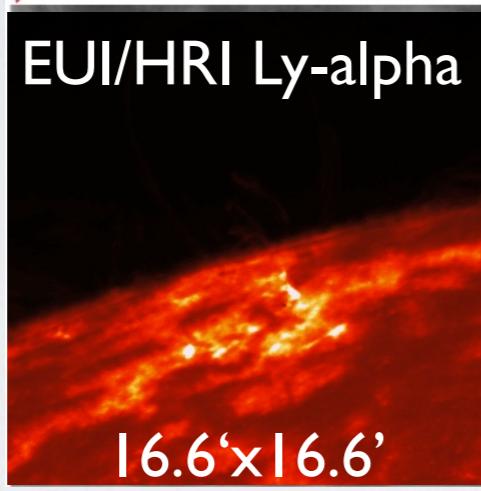
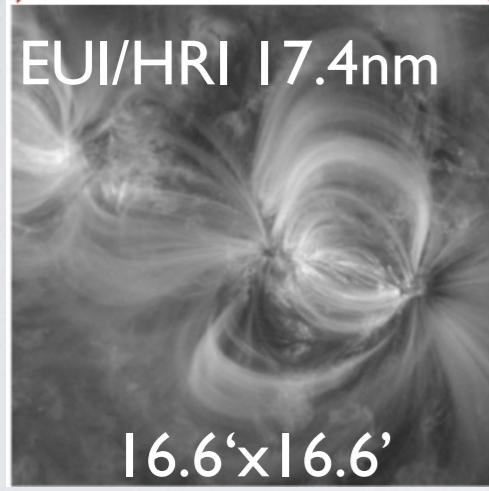
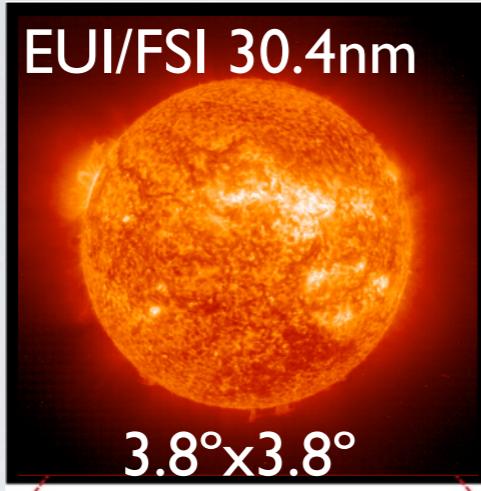
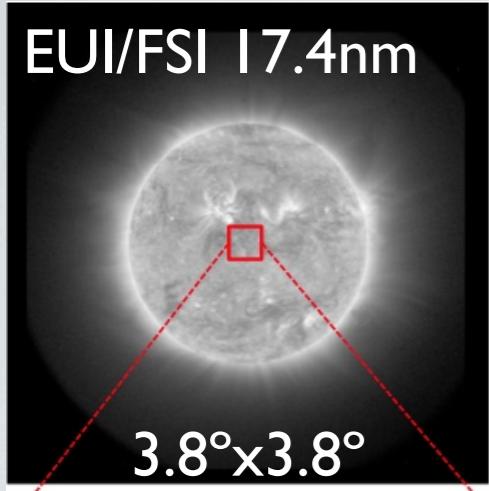
REMOTE-SENSING PAYLOAD

	<u>Wavelengths</u>	<u>Field of views</u>
• EUI: EUV Imager		
• FSI: Full Disk Imager	30.4nm or 17.4nm	3.8°×3.8°
• HRI_EUV: High-res. Imager	17.4nm	16.6'×16.6'
• HRI_Lyalpha: High-res. Imager	121.6nm	16.6'×16.6'
• METIS: coronagraph		
• VL	580-640nm	5.8°×5.8° + circular
• Ly-alpha	121.6nm	occulter radius 1.5°
• PHI: Polarimetric & helioseismic imager		
• FDT full disk telescope	613.3nm (6w×4p)	2°×2°
• HDT high-resolution telescope	613.3nm (6w×4p)	16.8'×16.8'
• SoloHI: Heliospheric imager	VL	40°×38.5° (5.5° off)
• SPICE: spectrograph	70-79 / 97-105nm	16'×11'-14'
• STIX: X-ray imager	X-rays	1.9°×2.1°

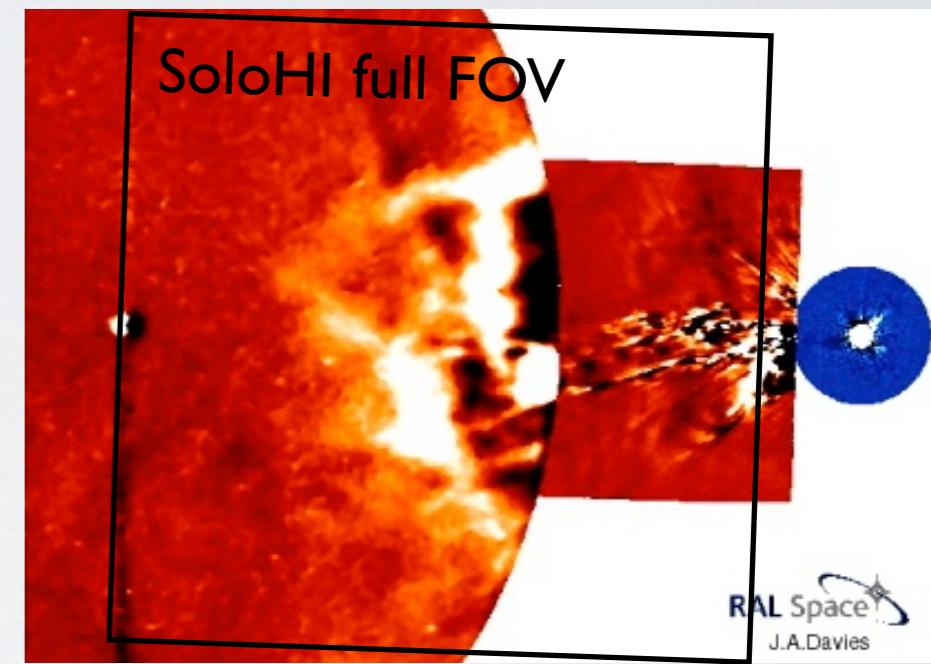
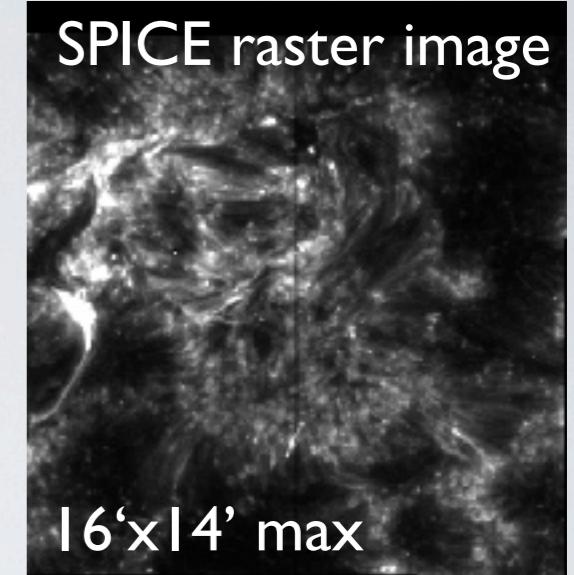
REMOTE-SENSING PAYLOAD

	<u>Field of views</u>	<u>MaxResolut./format</u>
• EUI: EUV Imager		
• FSI: Full Disk Imager	3.8°×3.8°	3072×3072 FITS
• HRI_EUV: High-res. Imager	16.6'×16.6'	2048×2048 FITS
• HRI_Lyalpha: High-res. Imager	16.6'×16.6'	2048×2048 FITS
• METIS: coronagraph		
• VL	5.8°×5.8° + circular occultor radius 1.5°	2048×2048 FITS
• Ly-alpha		1024×1024 FITS
• PHI: Polarimetric & helioseismic imager		
• FDT full disk telescope	2°×2°	5x(2048×2048 FITS)
• HDT high-resolution telescope	16.8'×16.8'	5x(2048×2048 FITS)
• SoloHI: Heliospheric imager	40°×38.5° (5.5° off)	3968×3968 FITS
• SPICE: spectrograph	16' × 11'-14'	4D FITS (x,y,λ,index)
• STIX: X-ray imager	1.9°×2.1°	~7''(1024×1024)

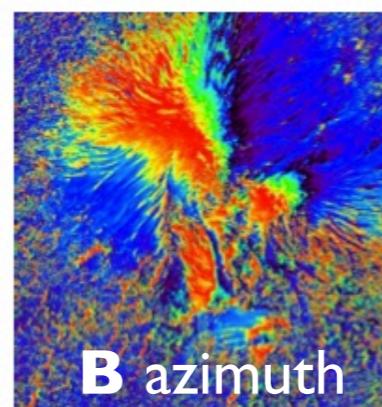
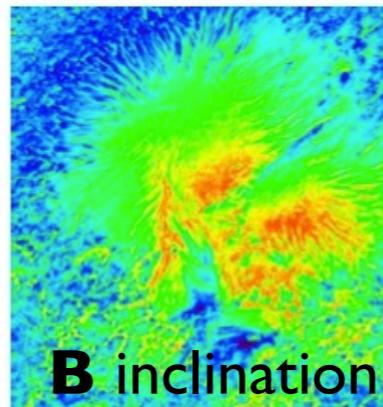
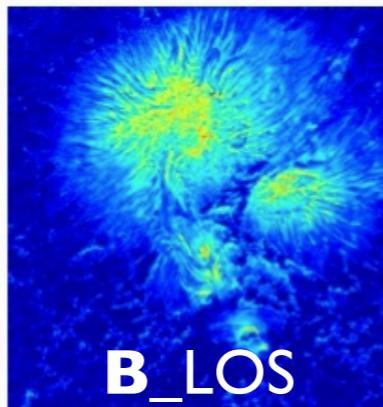
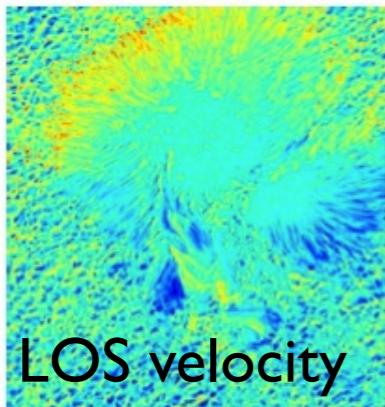
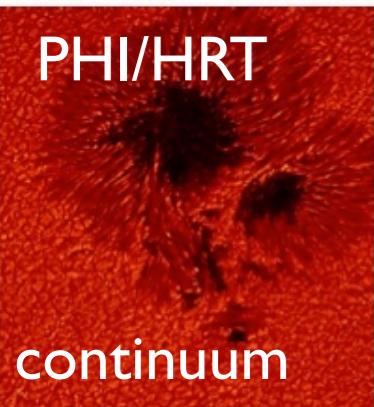
REMOTE-SENSING IMAGERY



+ similar for
Ly-alpha



All images in FITS format + WCS
Resolution varies along the orbit



+ similar images
for PHI/FDT

REMOTE-SENSING SPECTRA

SPICE spectra:

- Level 1: 4D FITS files, calibrated in space, wavelength and intensity
- Level 2: Synthesized image data products: Dopplergrams, thermograms, ...
- Level 2 QL: Spectral image products generated from the Level 0 data

TBD which products need visualisation by Data Browser

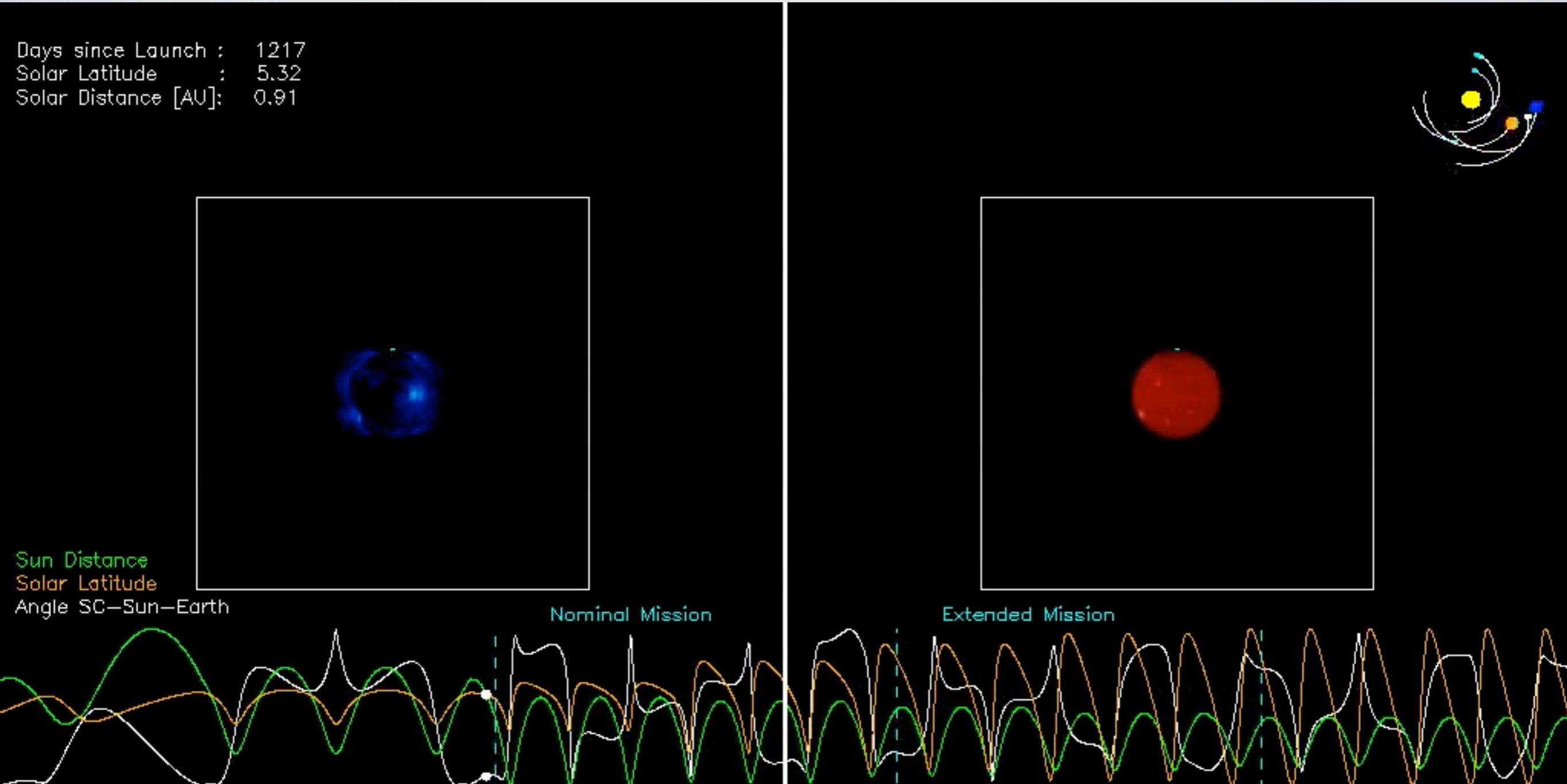
STIX:

LowLatency data: Light curves + X-ray spectra at 4s cadence, disk-integrated & in 5 energy bins, but covering whole time period.

Science data (light curves + X-ray spectra) cover only flare periods, but at higher resolution (in E, time and space).

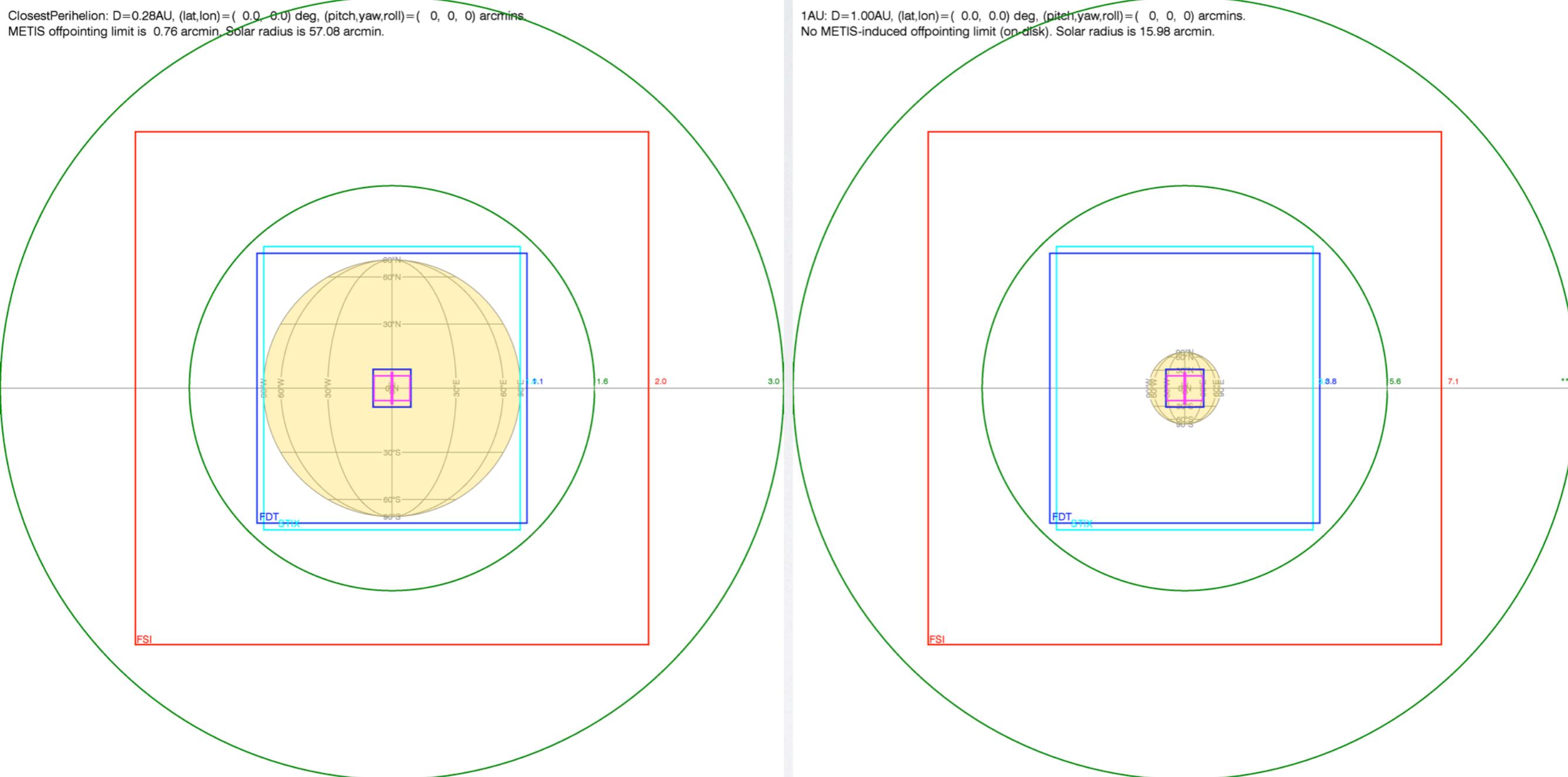
Light curves could be visualised as time series, in combination with the in-situ science data.

RS PRODUCTS: EXAMPLES



http://eui.sidc.be/movies/eui_fsi.mp4

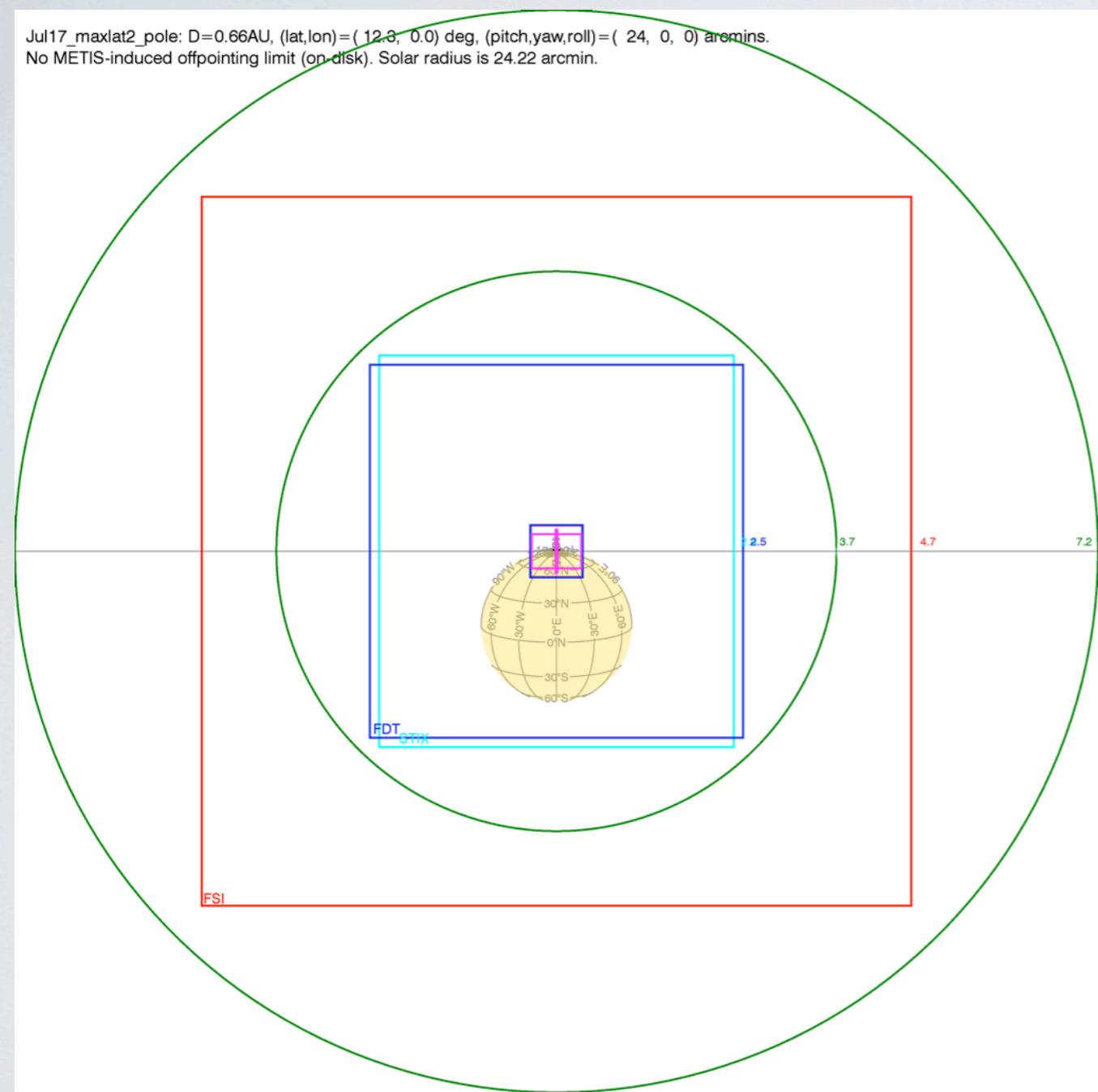
RELATIVE FOVS



Closest Perihelion

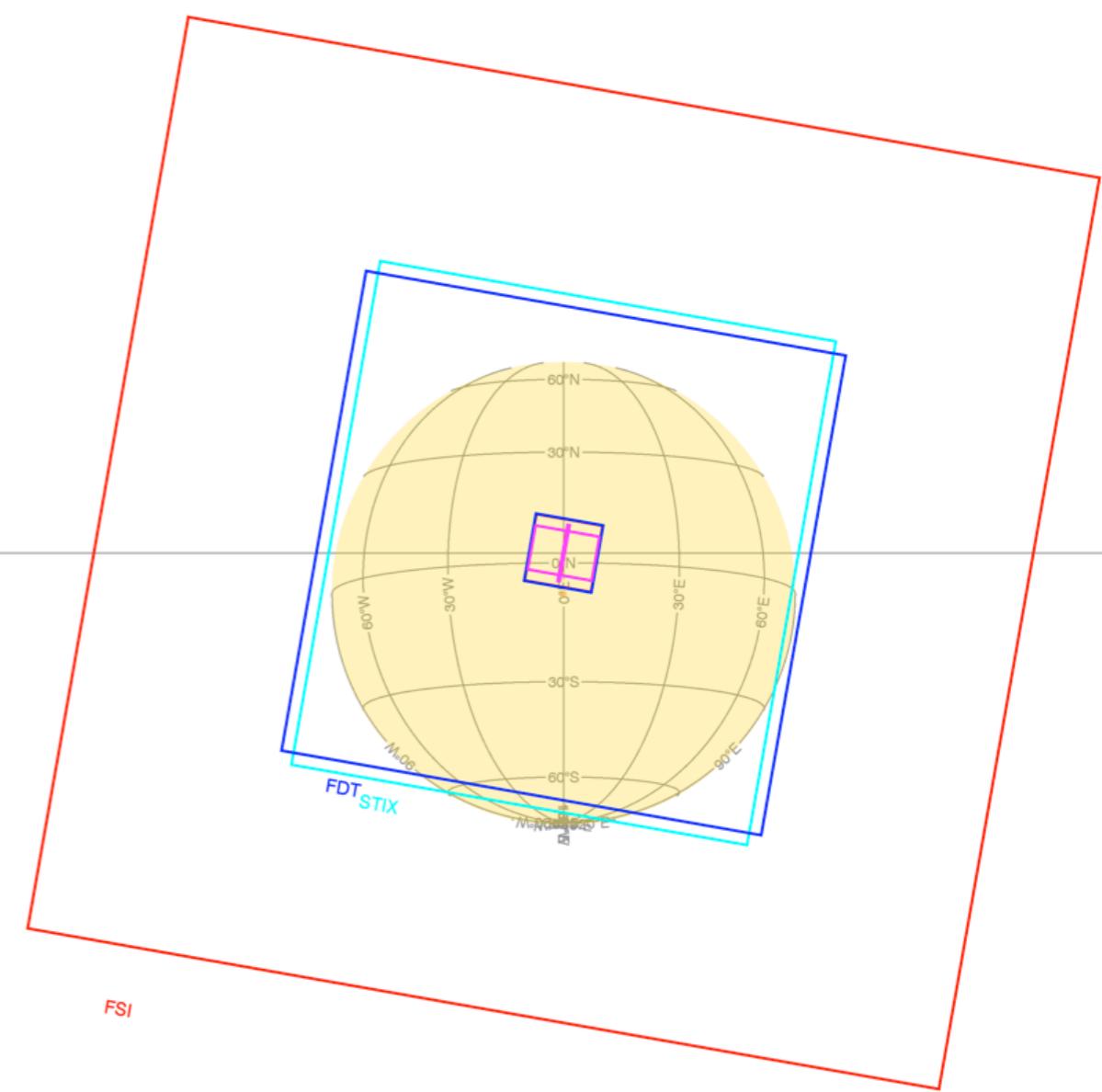
1 AU

RELATIVE FOVS (2)



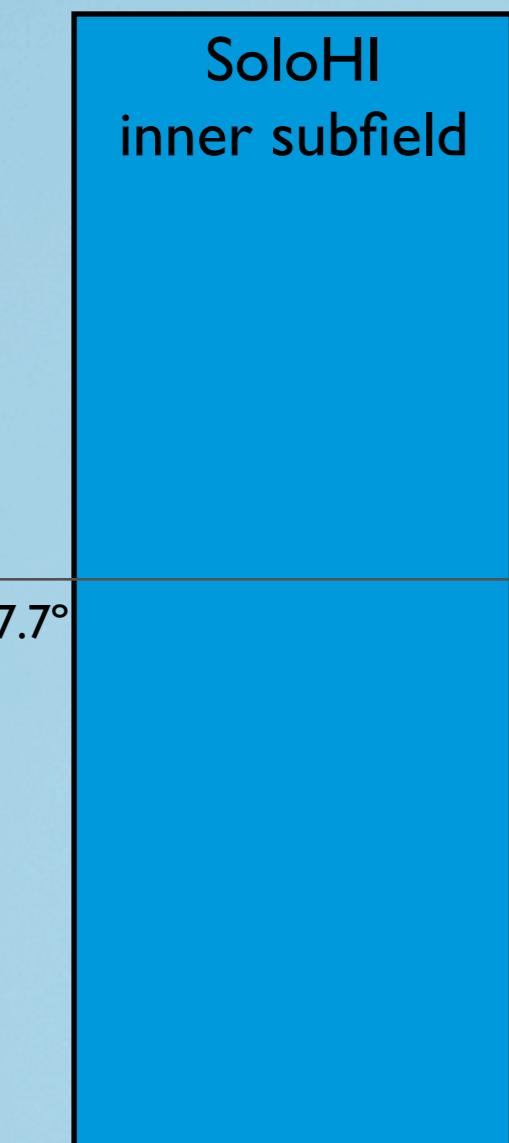
Offpointing @ 0.66AU
(July17 max latitude 2)

Jul17_perihel2_pitch+roll: D=0.28AU, (lat,lon)=(-7.6, 0.0) deg, S/C (pitch,yaw)=(10, 0) arcmins, S/C roll= 10 deg.
METIS offpointing limit is 0.76 arcmin. Solar radius is 57.08 arcmin.
METIS performance limit is violated!

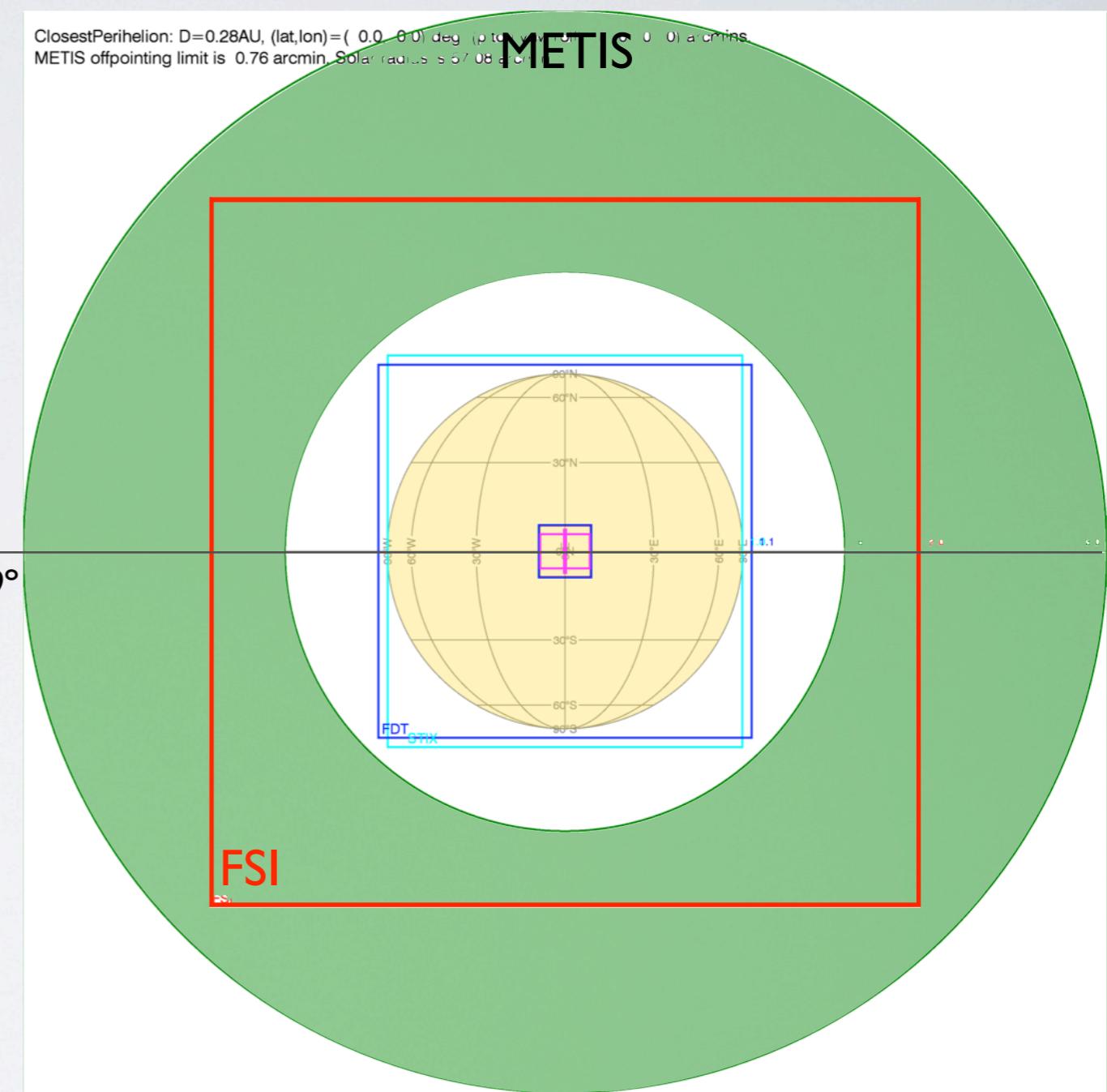


S/C roll @ 0.28AU
(July17 perihelion 2)

RELATIVE FOVs + SoloHI

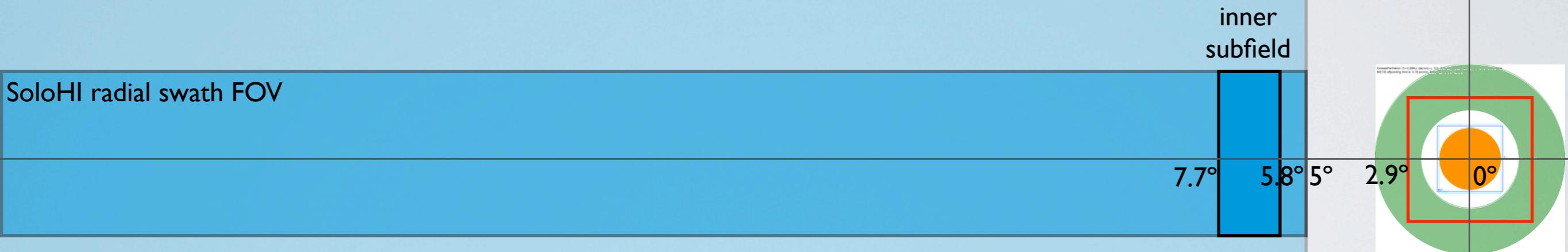


SoloHI Full FOV



Closest Perihelion

RELATIVE FOVs + SoloHI AT PERIHELION (0.28AU)



SoloHI Full FOV

SOLAR ORBITER BROWSER

1. Difficult to display all FOVs at all times (e.g. SoloHI)
2. RS imagery is only available during RS windows (as baseline)
Don't build science browser highly depending on Solar Orbiter images.
3. In general, Solar Orbiter science data will NOT be available soon after acquisition. Latencies vary and can reach ~6months.

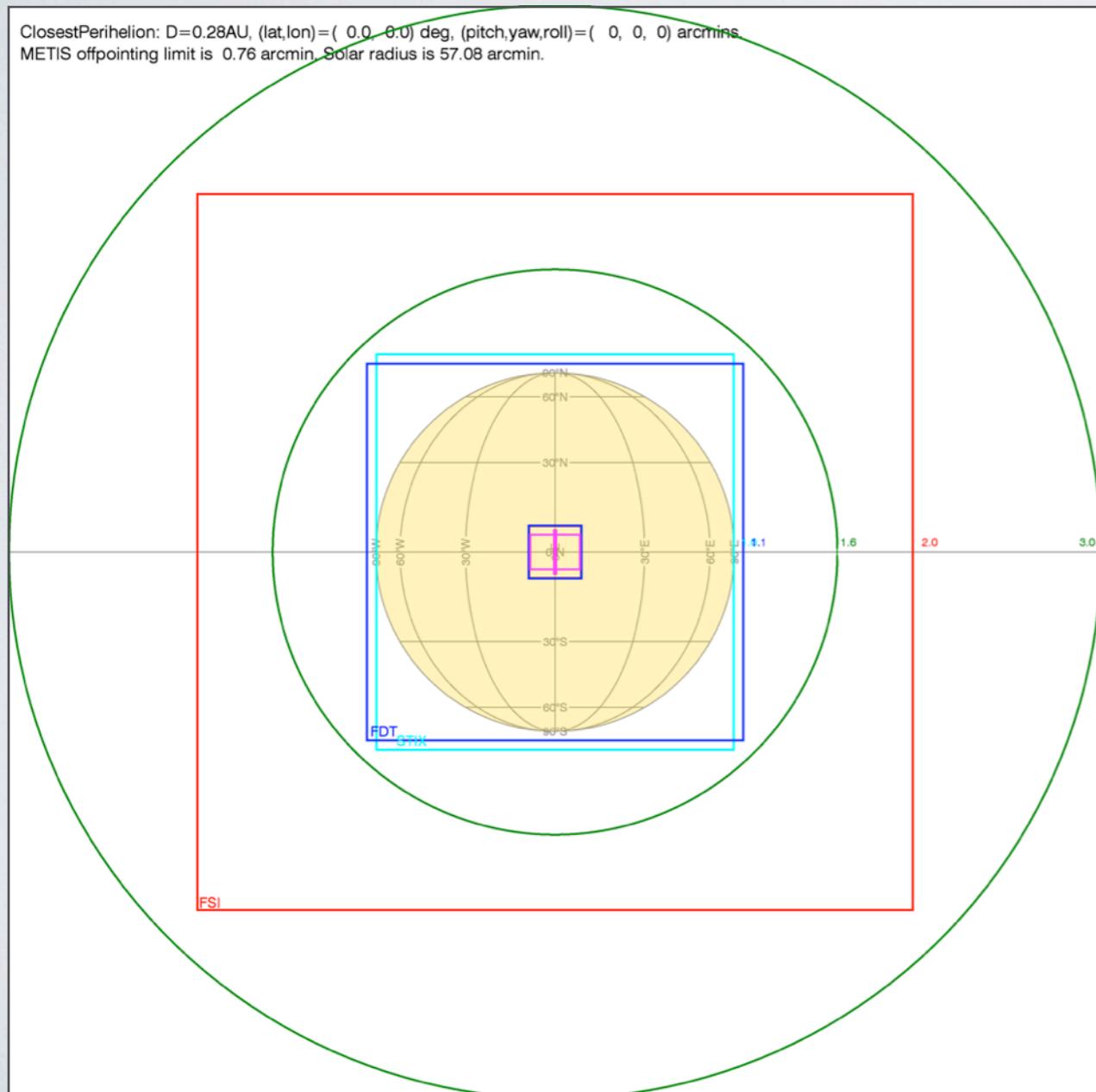
Low-Latency data will be available daily, but low-resolution, subfields, highly-compressed, ...

→ LL data will (also) be displayed in Solar Orbiter LL display tool for operational purposes

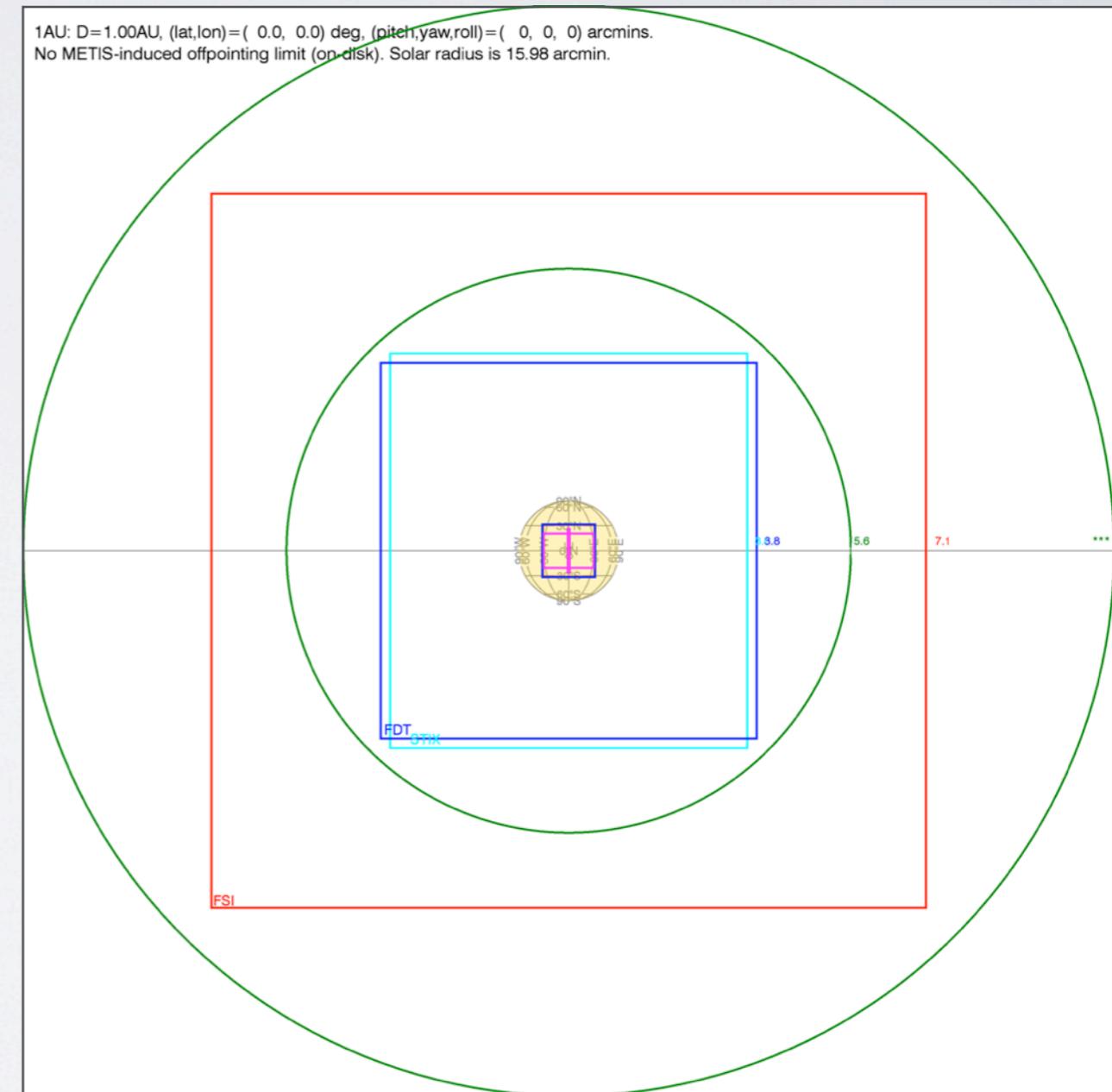
SOLAR ORBITER BROWSER

3. FOVs vary significantly relative to the Sun.

For science browser: keep Sun size constant, vary FOVs accordingly.



Solar Orbiter @ perihelion

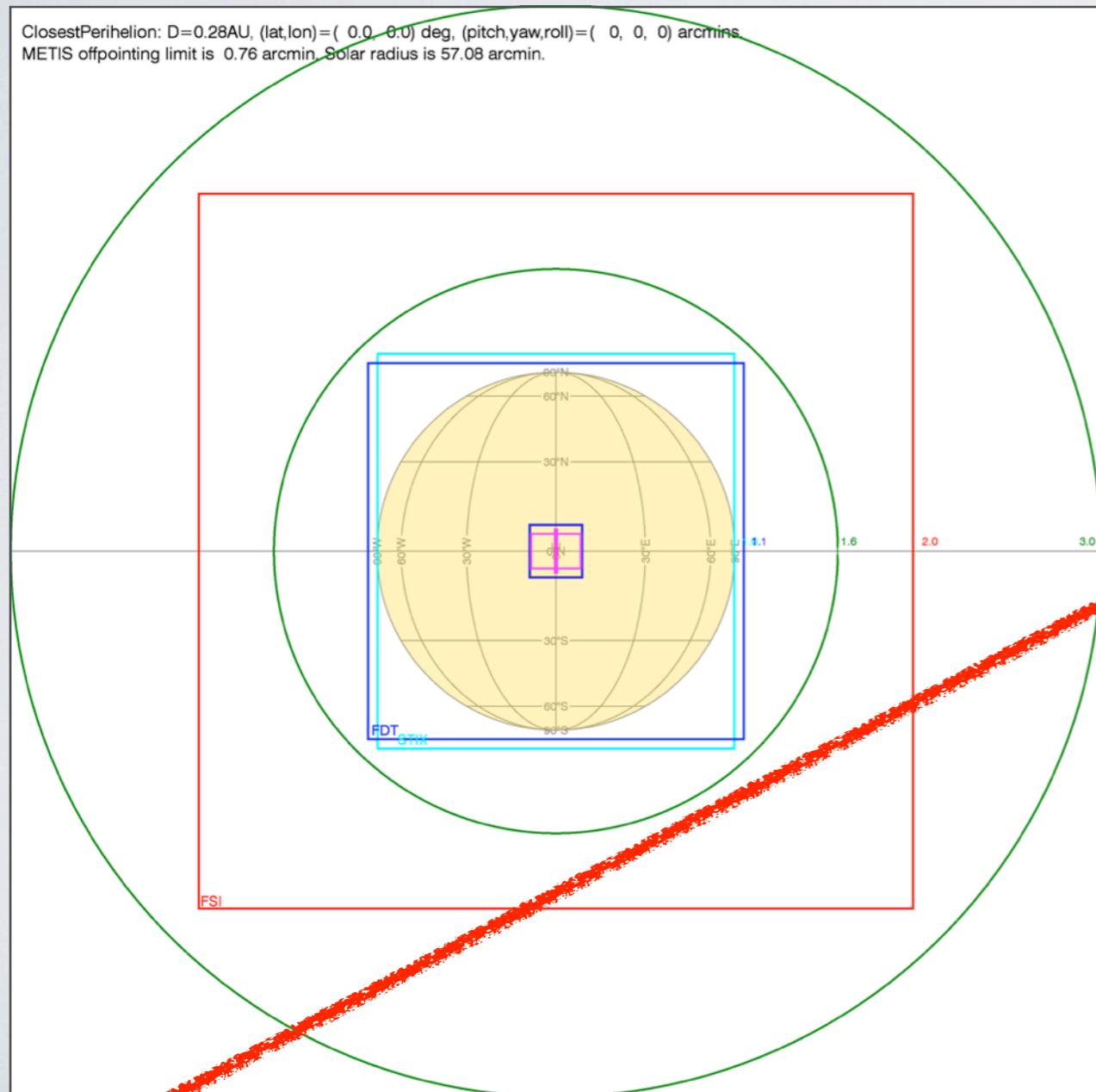


Solar Orbiter @ 1AU

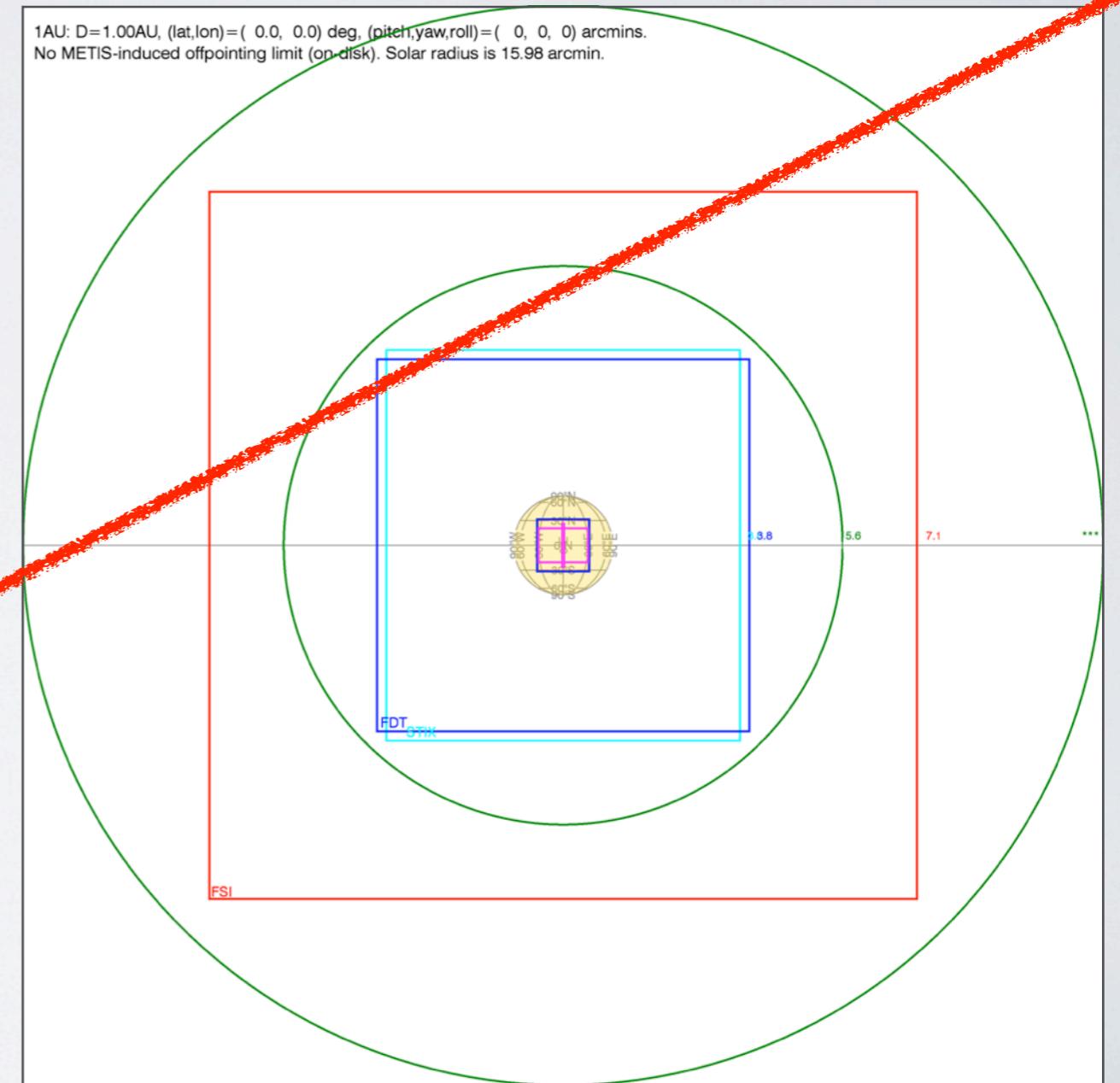
SOLAR ORBITER BROWSER

3. FOVs vary significantly relative to the Sun.

For science browser: keep Sun size constant, vary FOVs accordingly.



Solar Orbiter @ perihelion

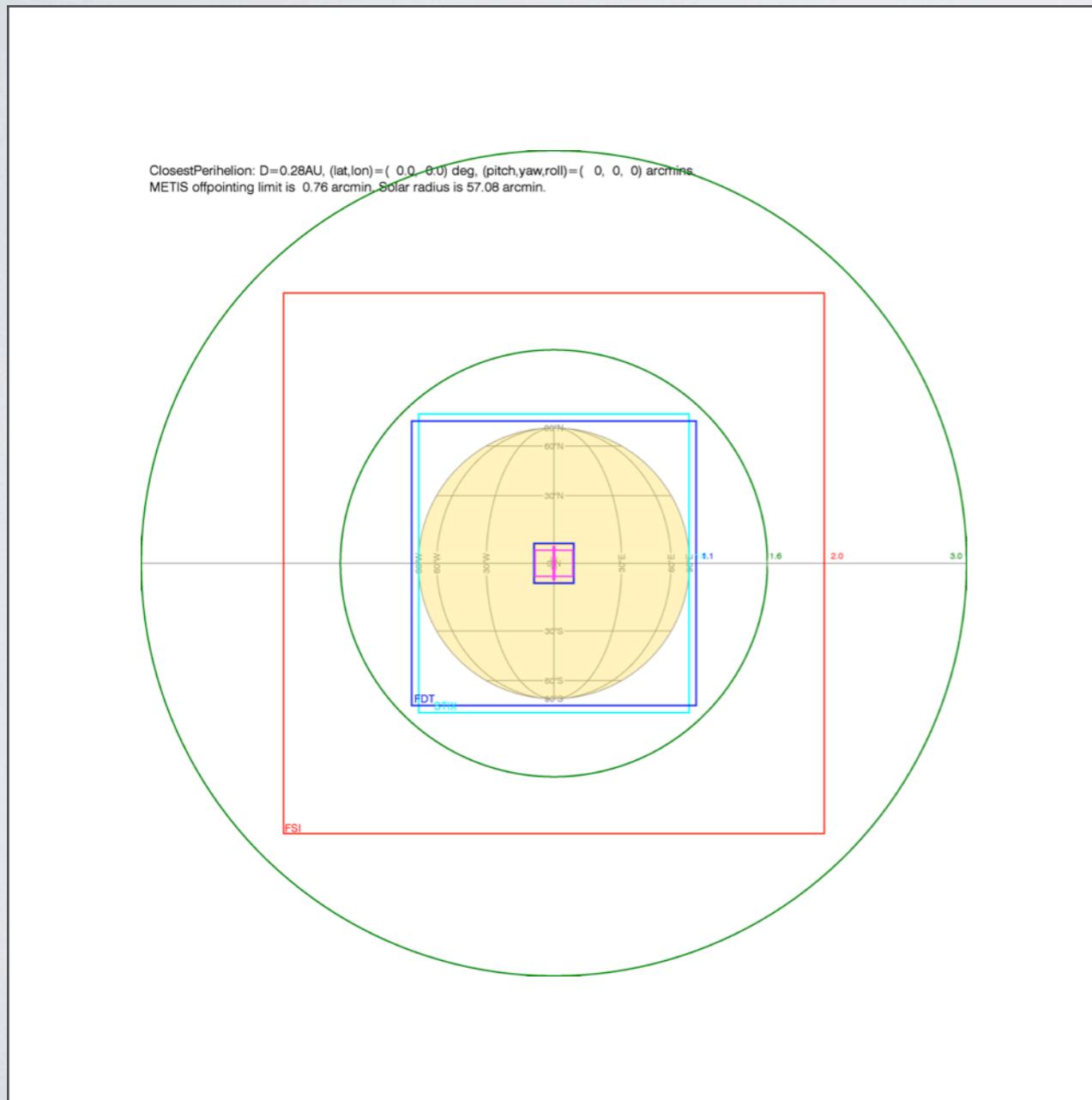


Solar Orbiter @ 1AU

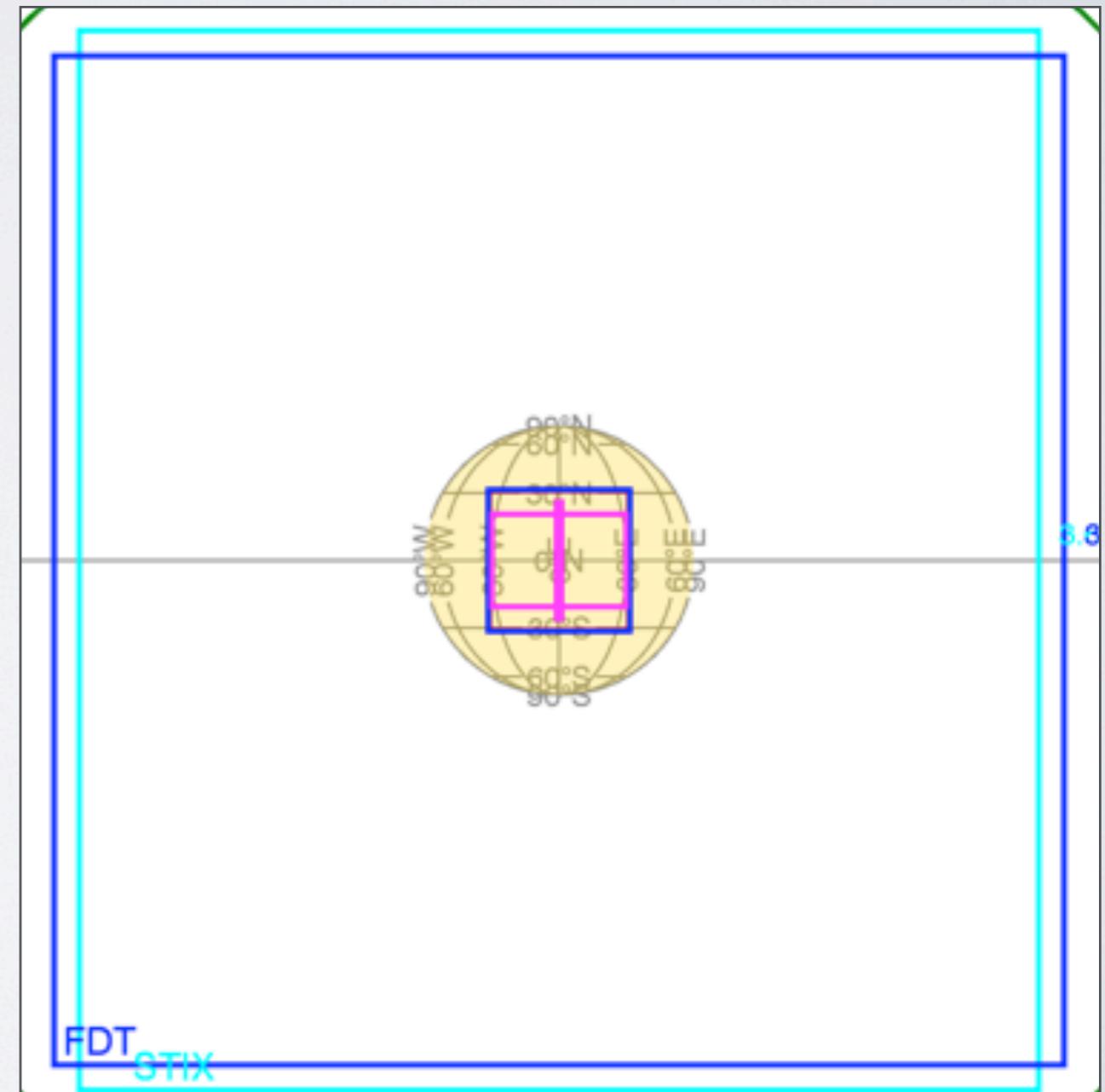
SOLAR ORBITER BROWSER

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Solar Orbiter @ perihelion



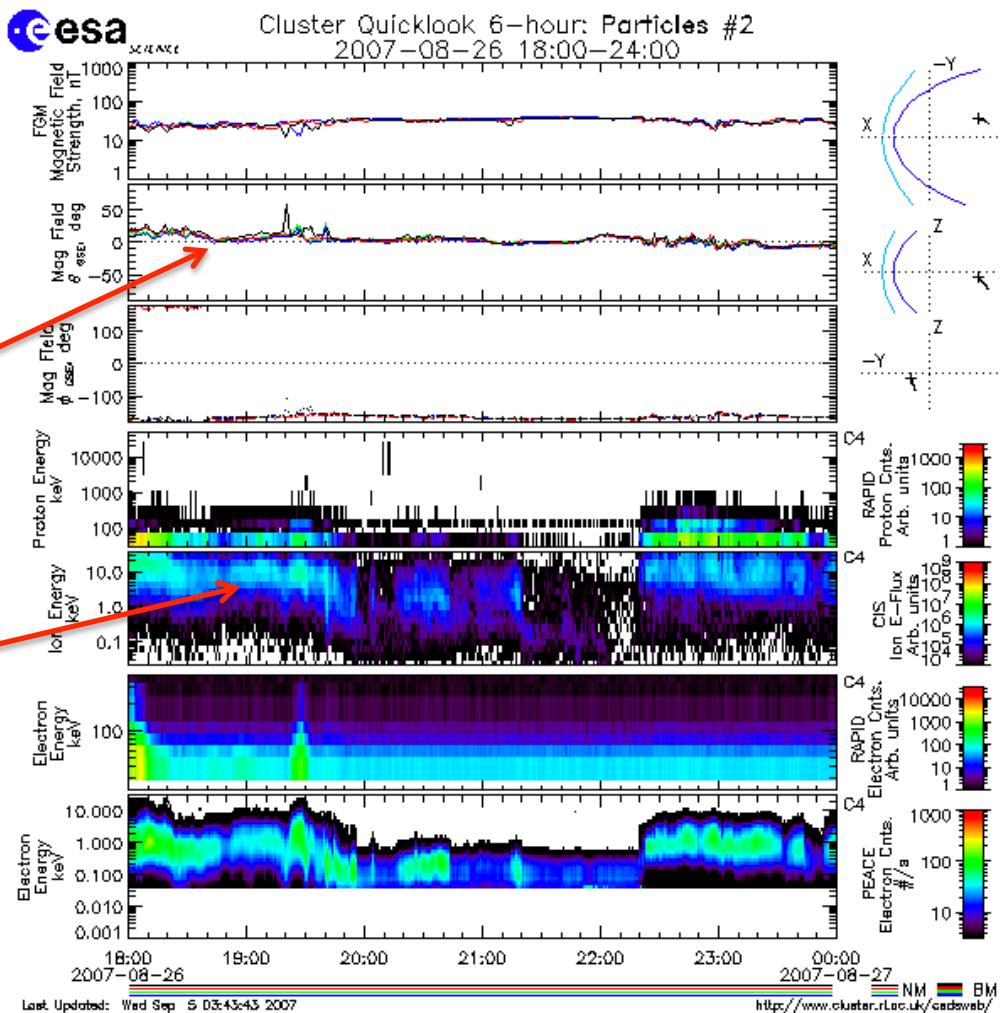
Solar Orbiter @ 1AU

In Situ Payload

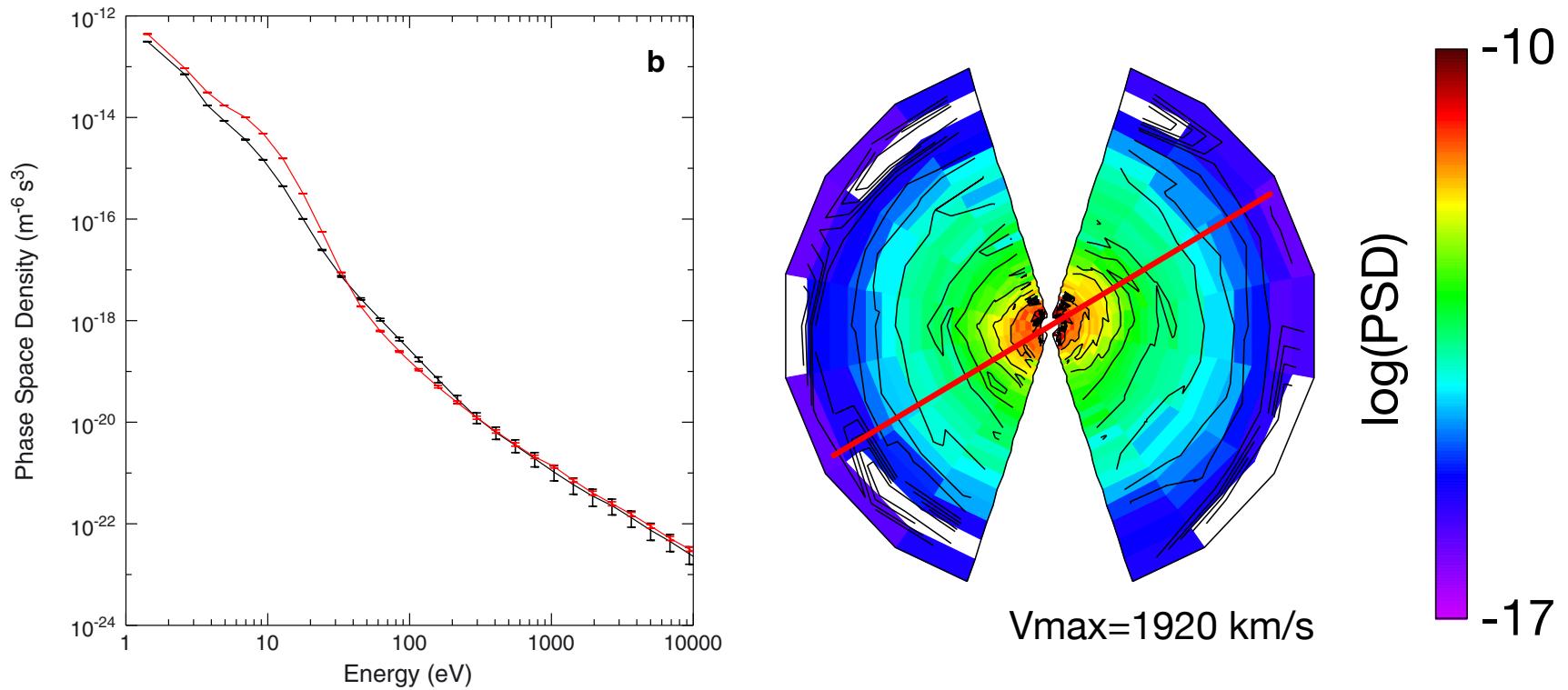
Instrument	Name	Measurements
EPD	Energetic Particle Detector	Energetic Particle Spectra: Flux as a function of time, energy, 2 angles, and species. (scalar time series, 3D & 4D datacubes)
	Suprathermal Electrons & Protons	
	Suprathermal Ion Spectrograph	
	Electron & Proton Telescope	
	High Energy Telescope	
MAG	Magnetometer	DC magnetic field (vector time series)
RPW	Radio and Plasma Waves	AC electric and magnetic fields. (scalar time series, wave power spectra as a function of time)
SWA	Solar Wind Analyser	Solar wind electron and ion distribution functions (scalar and vector time series, 3D and 4D datacubes)
PAS HIS EAS	Proton Alpha Sensor	
	Heavy Ion Sensor	
	Electron Analyser System	

Example Visualisations 1: Time Series

- To be useful we need to display several parameters (from different instruments) simultaneously.
- Vector time series
- Particle Flux as a function of time and energy (could equally be angle), or wave power as a function of frequency.



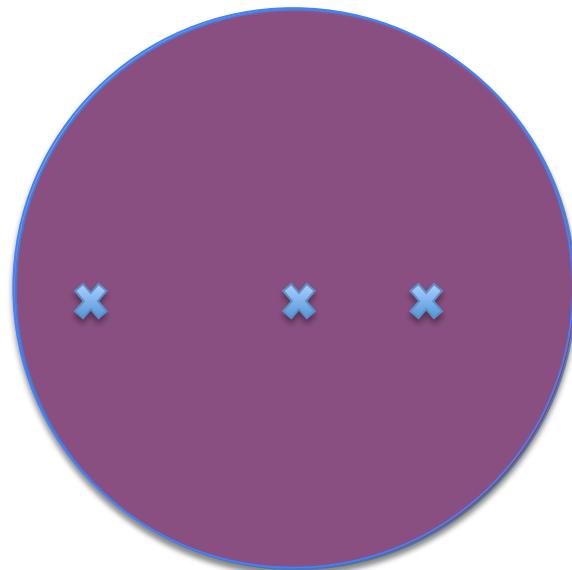
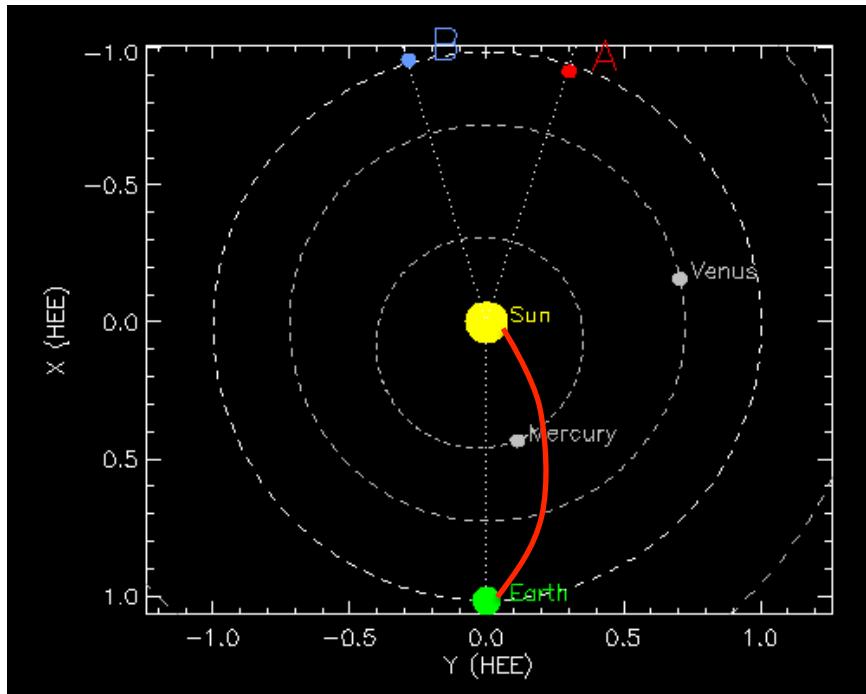
Example Visualisations 2: Spectra And Particle Distributions



Cuts of a datacube in various directions (often in Magnetic Field Aligned Coordinates)

Other Useful Information to Display

- Ephemeris
 - Including Model Parker Spiral connecting Sun & SC?
- Overlay on Solar Disk
 - Sub-SC point, Sub-Earth Point, SC Magnetic footpoint.



Coordinate Systems

- Likely to be RTN coordinates:
 - Spacecraft Centric
 - R: Sun to Spacecraft Unit Vector
 - T: Solar Rotation Axis X R
 - N: Completes the RH set (roughly // to solar north for an ecliptic orbiting spacecraft)
- Spherical polar and Cartesian representations would be useful.

Data Formats

- Several Options, still TBC:
 - CDF format with ISTP metadata (current proposal before DAWG).
 - CDF format with SPASE compliant metadata.
 - Flat ASCII
 - Cluster CEF format (Self-described ASCII with specific metadata)
 - Self-described ASCII with SPASE compliant metadata.
- There are pros & cons of each...