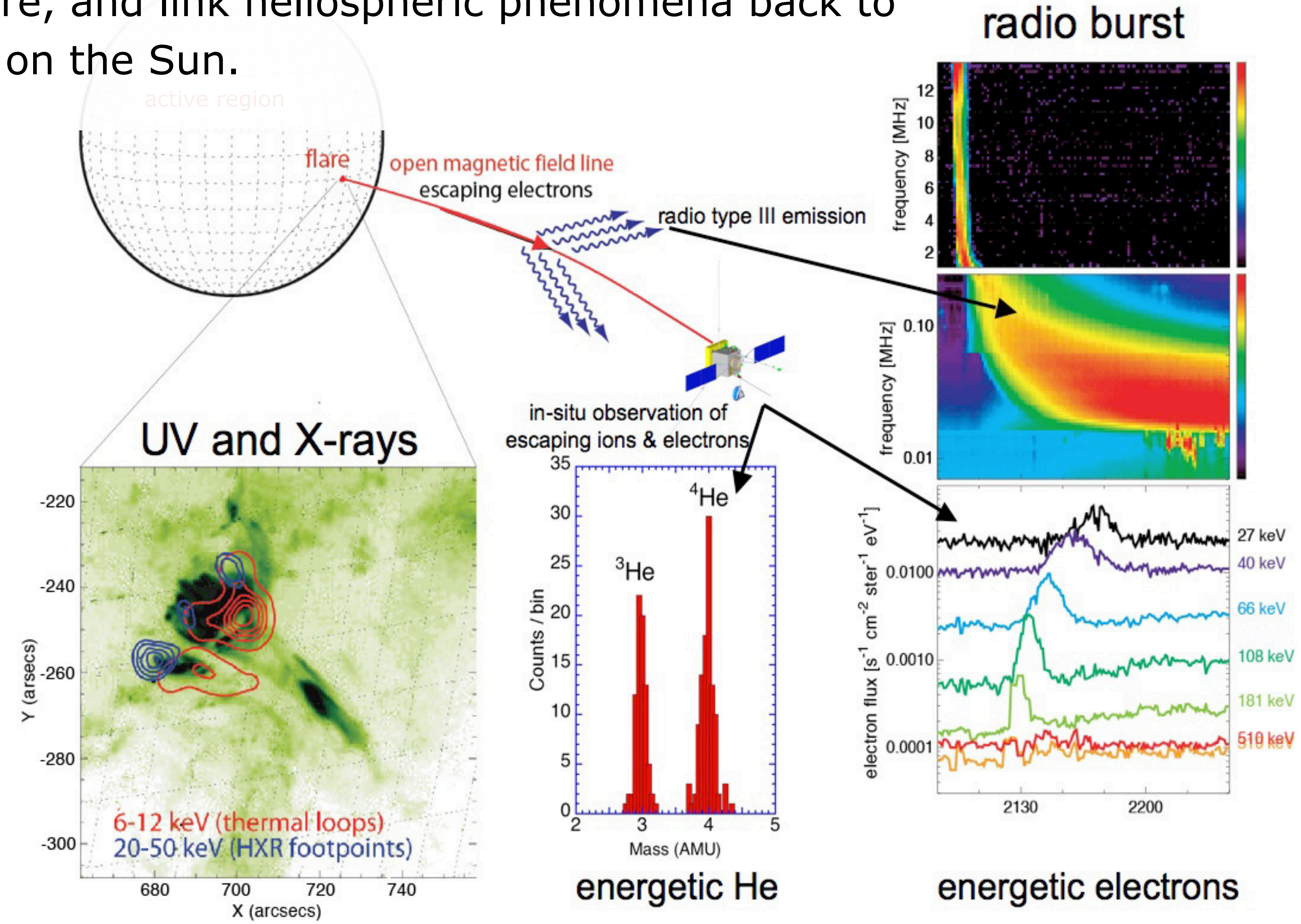

esa
NASA
Solar Orbiter
Exploring the Sun-Heliosphere Connection
Getting involved
Louise Harra (EUI co-PI)
Daniel Müller (ESA PS) -> slides on SO.
A.Fludra (SPICE)-> slides for SPICE
www.esa.int
European Space Agency

What will Solar Orbiter do?

Solar Orbiter is a mission designed to observe the Sun and the heliosphere, and link heliospheric phenomena back to their sources on the Sun.



Solar Orbiter
Exploring the Sun-Heliosphere Connection

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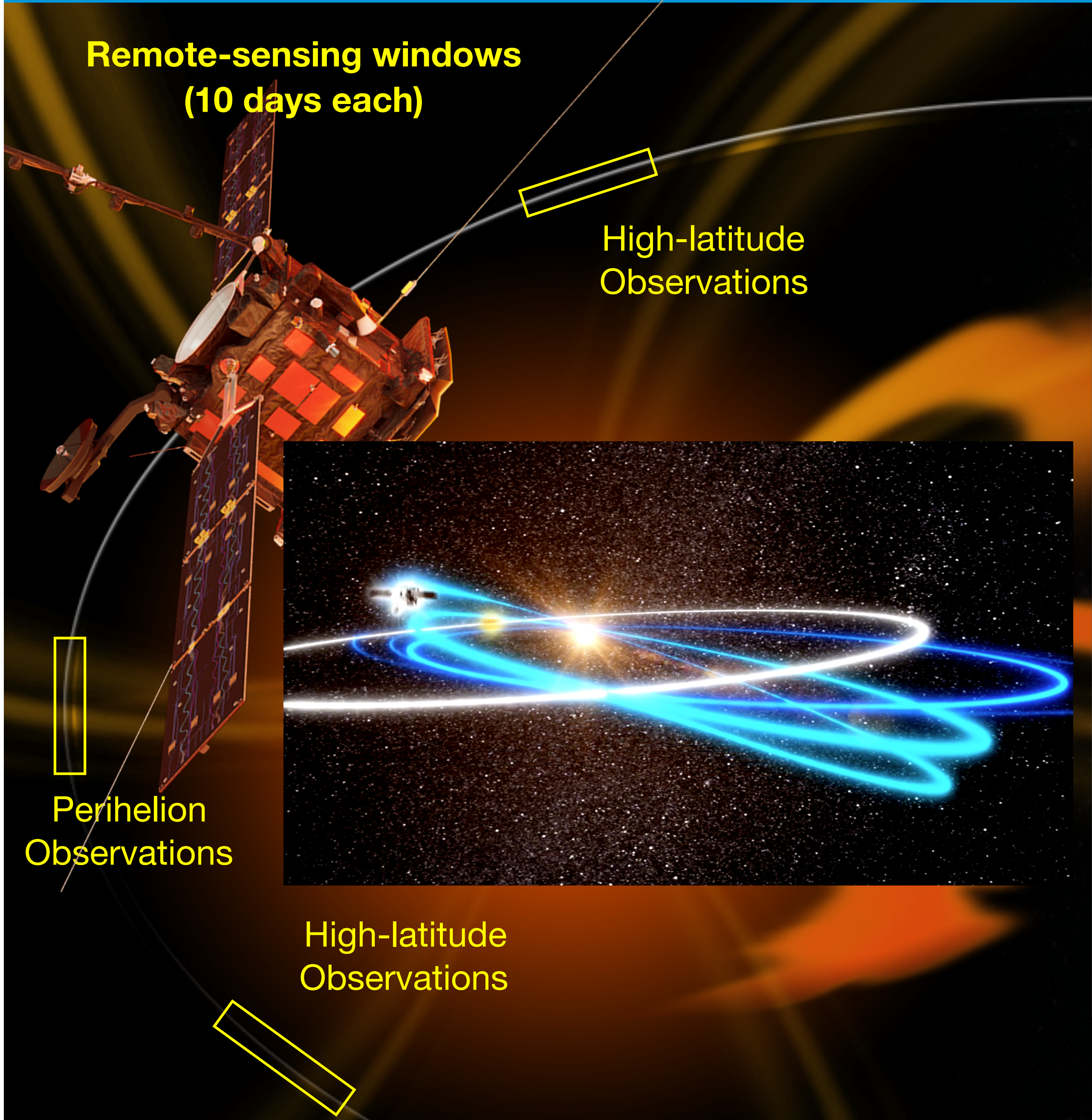
Science Objectives

How does the Sun create and control the Heliosphere – and why does solar activity change with time ?

1. What drives the solar wind and where does the coronal magnetic field originate?
2. How do solar transients drive heliospheric variability?
3. How do solar eruptions produce energetic particle radiation that fills the heliosphere?
4. How does the solar dynamo work and drive connections between the Sun and the heliosphere?

Mission overview: Müller et al., Solar Physics ***285*** *(2013)*

Solar Orbiter
Exploring the Sun-Heliosphere Connection



Mission Summary

Launch: Feb 2020 TBC

Cruise Phase: 1.8 years

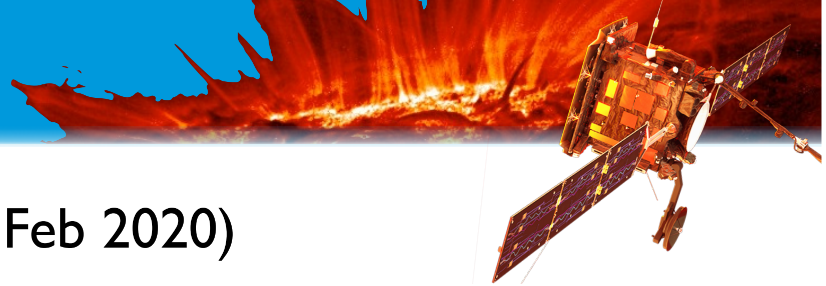
Nominal Mission: 4 years

Extended Mission: 3.5 years

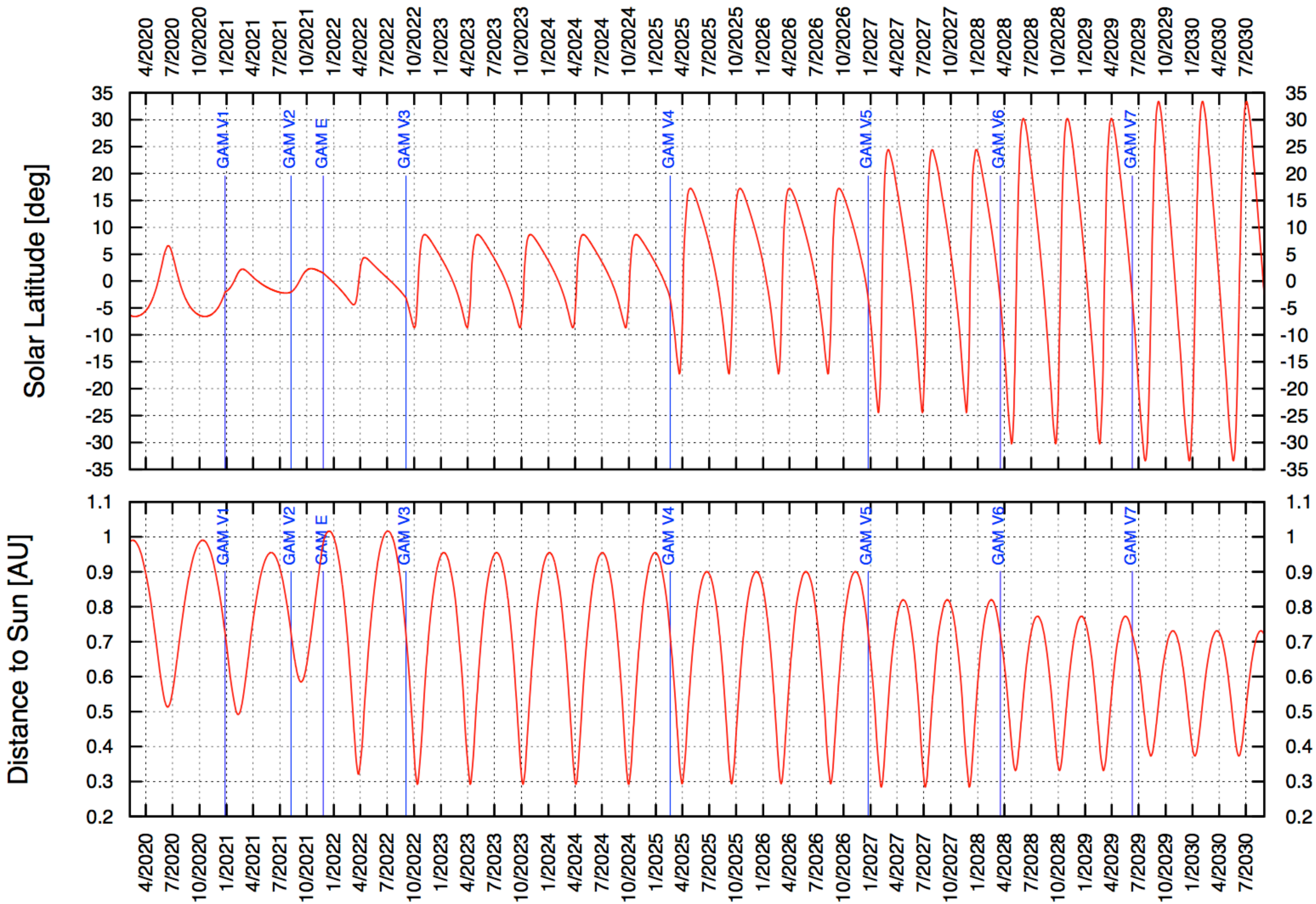
Orbit: 0.28–0.91 AU (P=150-180 days)

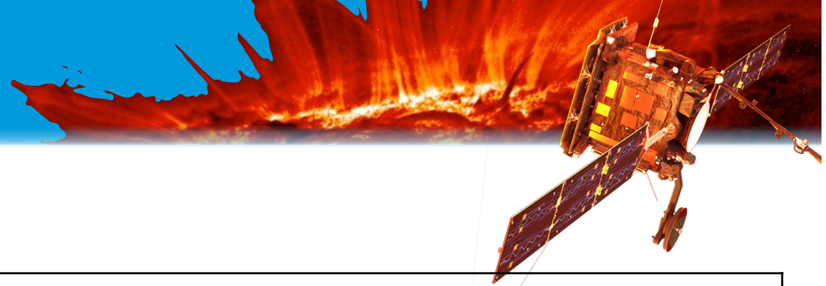
Out-of-Ecliptic View:
Multiple gravity assists with Venus to increase inclination out of the ecliptic to >24° (nominal mission), >33° (extended mission)

Reduced relative rotation:
Observations of evolving structures on solar surface & in heliosphere for almost a complete solar rotation



Solar Latitude & Distance (for launch in Feb 2020)

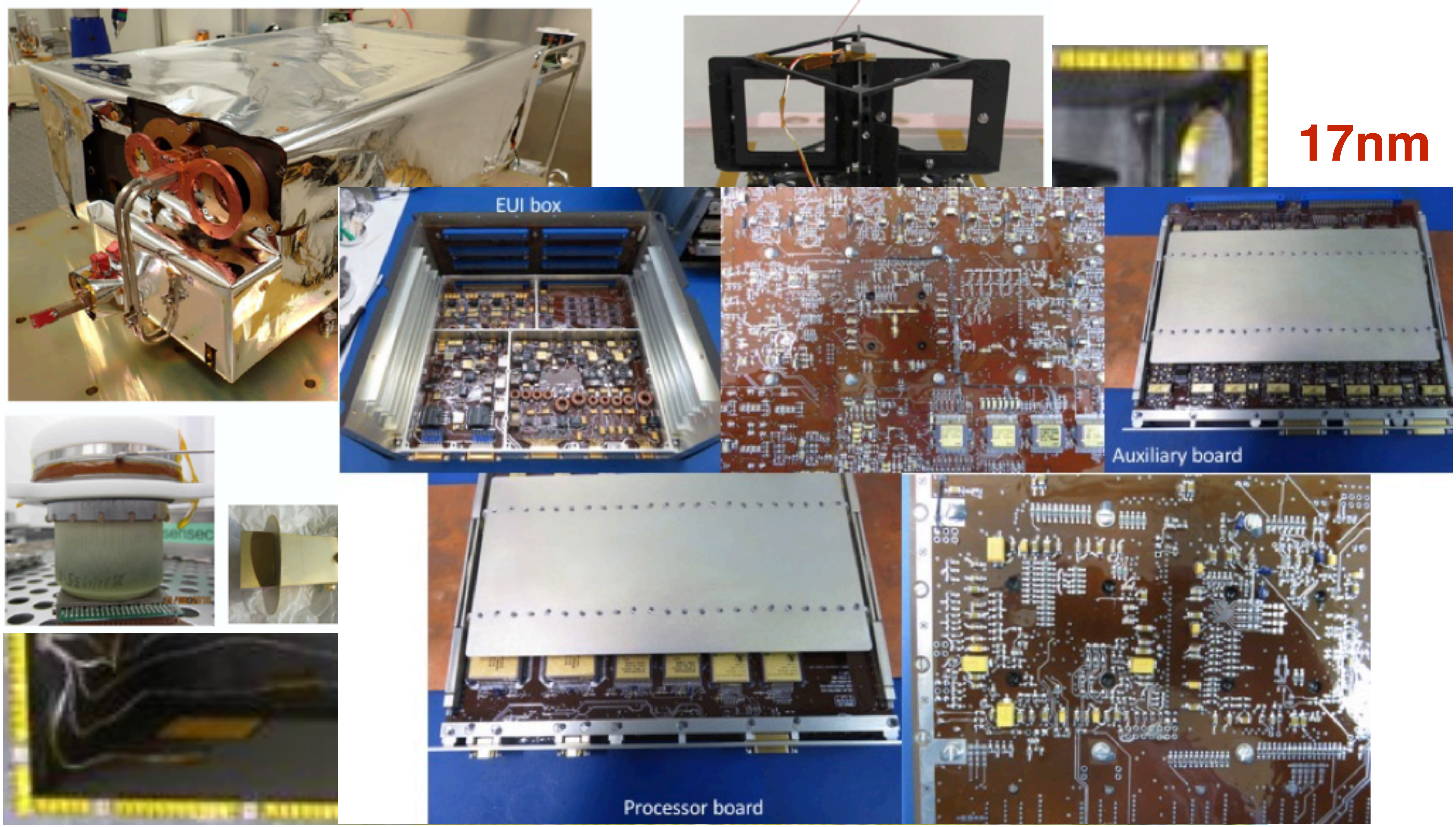




Payload

In-Situ Instruments			
EPD	Energetic Particle Detector	J. Rodríguez-Pacheco	Composition, timing and distribution functions of energetic particles
MAG	Magnetometer	T. Horbury	High-precision measurements of the heliospheric magnetic field
RPW	Radio & Plasma Waves	M. Maksimovic	Electromagnetic and electrostatic waves, magnetic and electric fields at high time resolution
SWA	Solar Wind Analyser	C. Owen	Sampling protons, electrons and heavy ions in the solar wind
Remote-Sensing Instruments			
EUI	Extreme Ultraviolet Imager	P. Rochus	High-resolution and full-disk (E)UV imaging of the on-disk corona
METIS	Coronagraph	E. Antonucci	Visible and UV Imaging of the off-disk corona
PHI	Polarimetric & Helioseismic Imager	S. Solanki	High-resolution vector magnetic field, line-of-sight velocity in photosphere, visible imaging
SoloHI	Heliospheric Imager	R. Howard	Wide-field visible imaging of the solar off-disk corona
SPICE	Spectral Imaging of the Coronal Environment	ESA facility instrument	EUV imaging spectroscopy of the solar disk and near-Sun corona
STIX	Spectrometer/Telescope for Imaging X-rays	S. Krucker	Imaging spectroscopy of solar X-ray emission

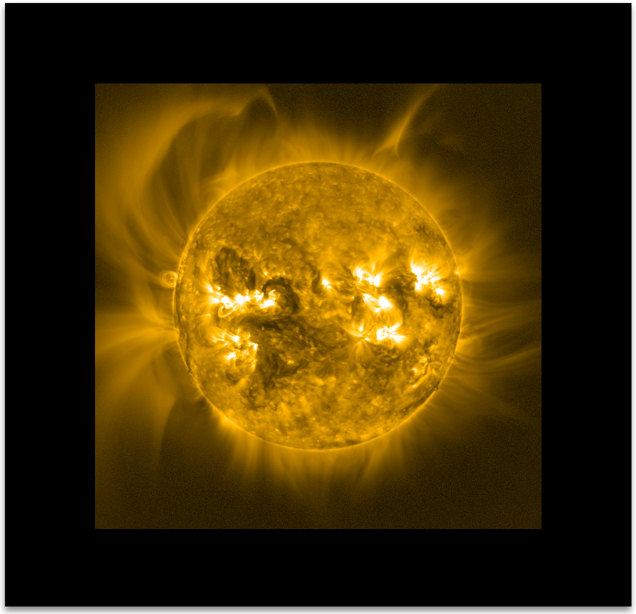
EUI = 3 telescopes

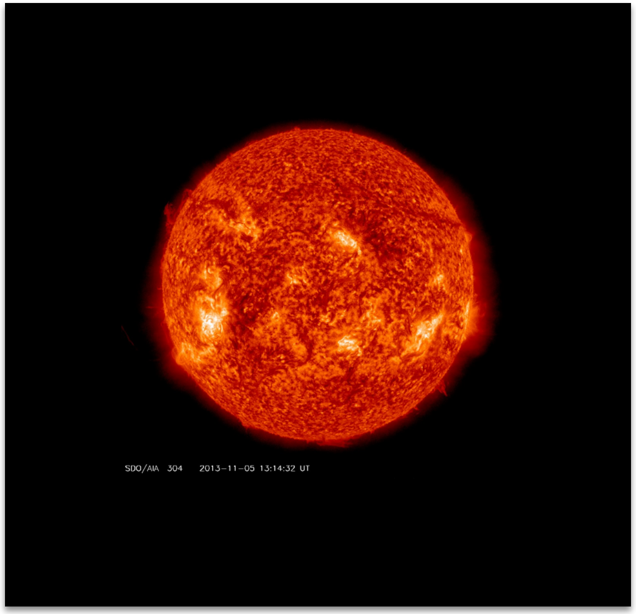


FSI: Full Sun Imager

FOV: 3.8°x3.8°, @ 0.28 AU: 4 Rsun x 4 Rsun

17nm

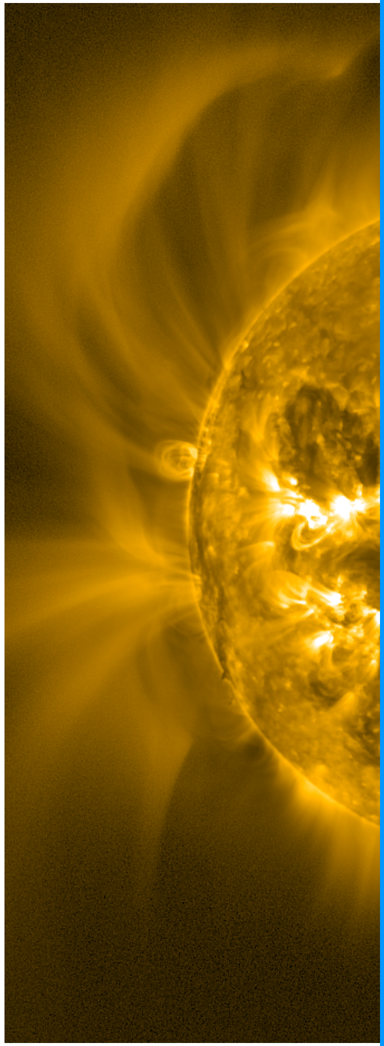




30.4nm

resolution: 9 arcsec on 2 pixels
@ 0.28 AU =1830 km on 2 pixels

HRI:H... ...agers



UK co-PI Louise Harra

UK co-Is

Deb Baker

Giulio Del Zanna

Lucie Green

Nicolas Labrosse

David Long

Duncan MacKay

Sarah Matthews

Lidia van Driel-Gesztleyi

(0.16 R)^2

2 pixels

200km

SPICE Spectrometer (built at RAL)

2 spectral bands: 70.4 - 79.0 nm, 97.3 – 104.9 nm

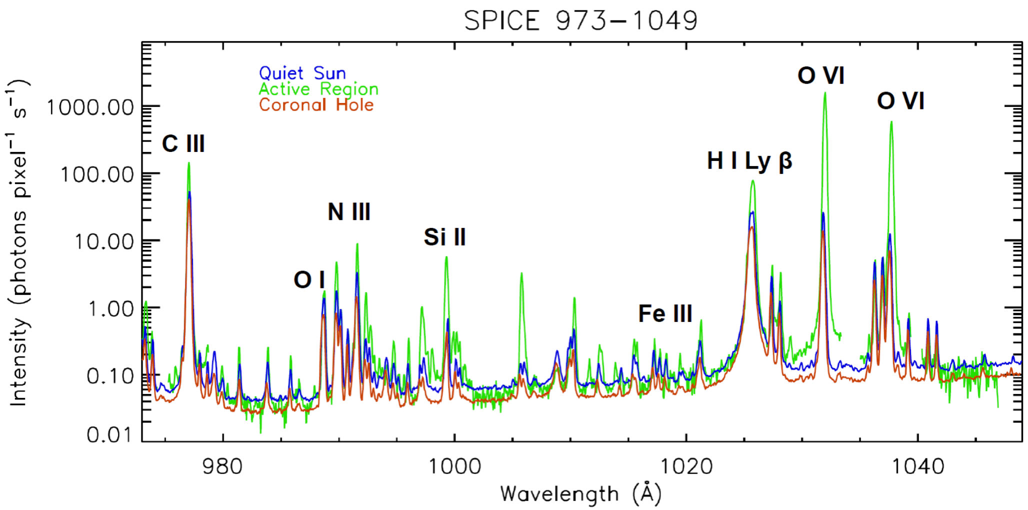
Slits: 2'', 4'', 6'', 30'' width

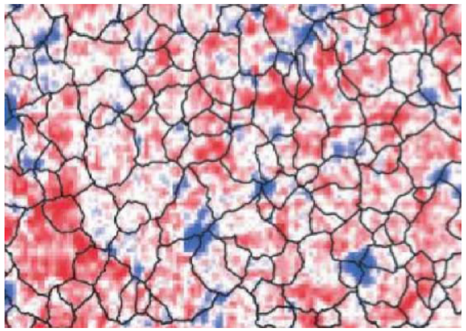
Spatial extent along the slit: **11'** + two 30''x30'' windows ("dumbbell") for narrow slits, **14'** for 30'' slit.

Horizontal field of view: up to 16'

Nominal pointing – disk centre. Needs s/c repointing.

- **Sources of the fast solar wind (velocity maps in polar coronal holes)**
- **Composition of plasma**
- **Connectivity to in-situ observations**
- **Understanding of energetic particles – their source and acceleration in magnetic reconnection regions**
- **Heating of TR plasma**
- **Waves, jets, microflares**
- **Filament eruptions, Coronal Mass Ejections onsets and early propagation**





Ne VIII 77.0 nm velocity maps

RAL Space

SPICE spectrometer (2)

Primary modes of SPICE observation:

(a) dynamics studies: short exposure, rapid on-disk scans over smaller areas a few arcminutes wide, recording profiles of a small number of bright transition region lines,

(b) composition scans: longer exposure times, covering large areas up to 16’ wide and recording intensities of a larger number of lines and some line profiles

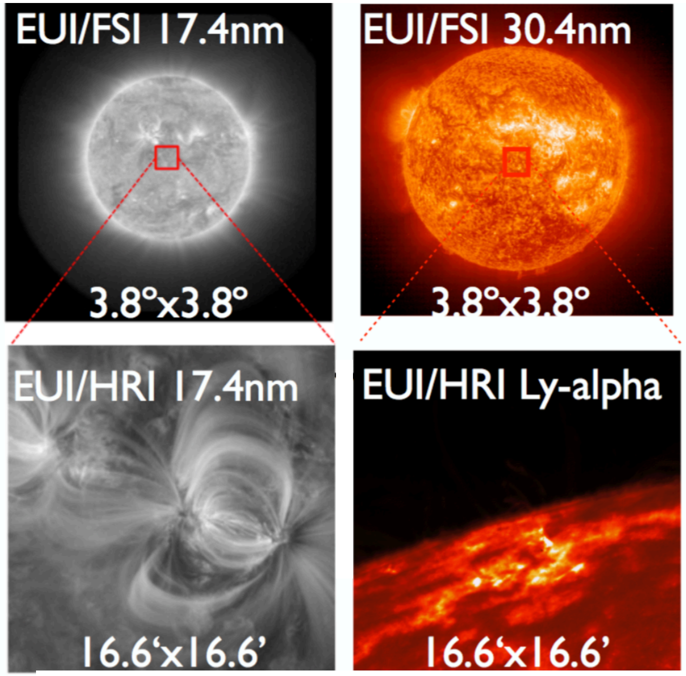
Study variations with different FOV, exposures, lines. Other modes possible (e.g., full spectral atlas, sit & stare time series)

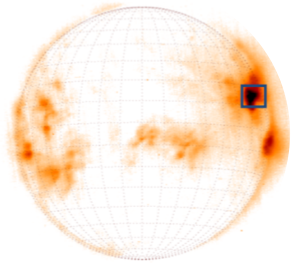
Operating mostly as part of the Science Activity Plan and SOOPs (details on ESA pages). Basic studies defined by the SPICE team. Additional SPICE observing ideas and requests are welcome:

Contact: **Andrzej Fludra (UK Co-PI), andrzej.fludra@stfc.ac.uk**

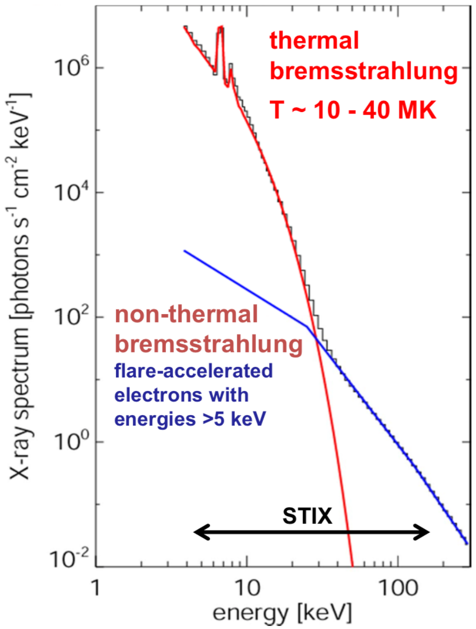
More information http://www.orbiter.rl.ac.uk/

Photons 1

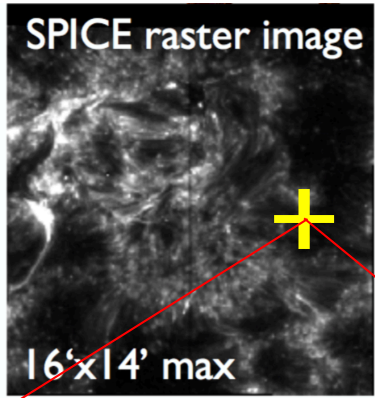


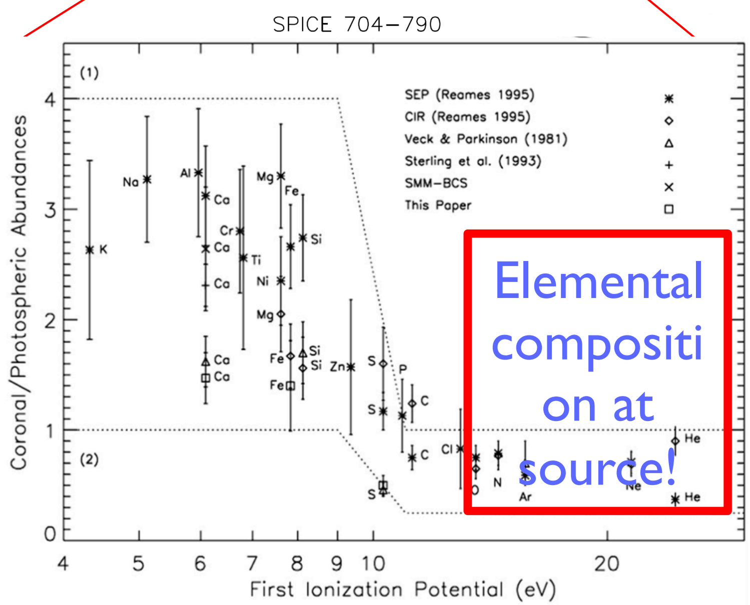


STIX imaging



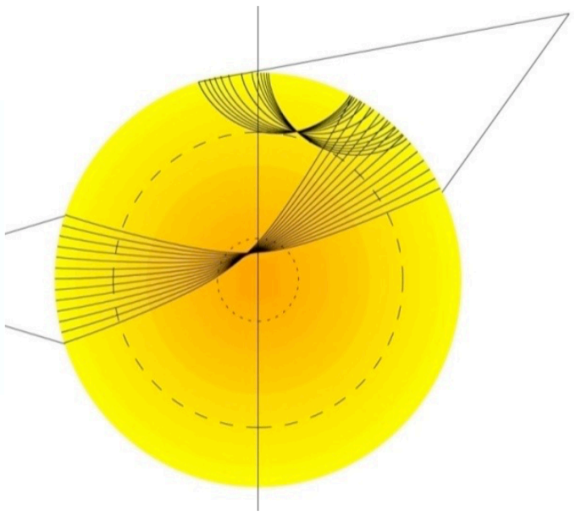
STIX spectra





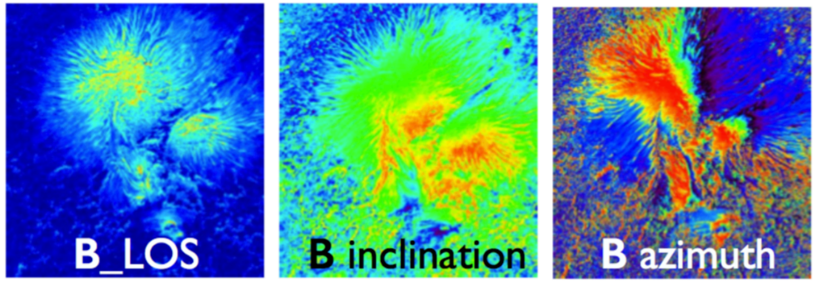
Photons 2

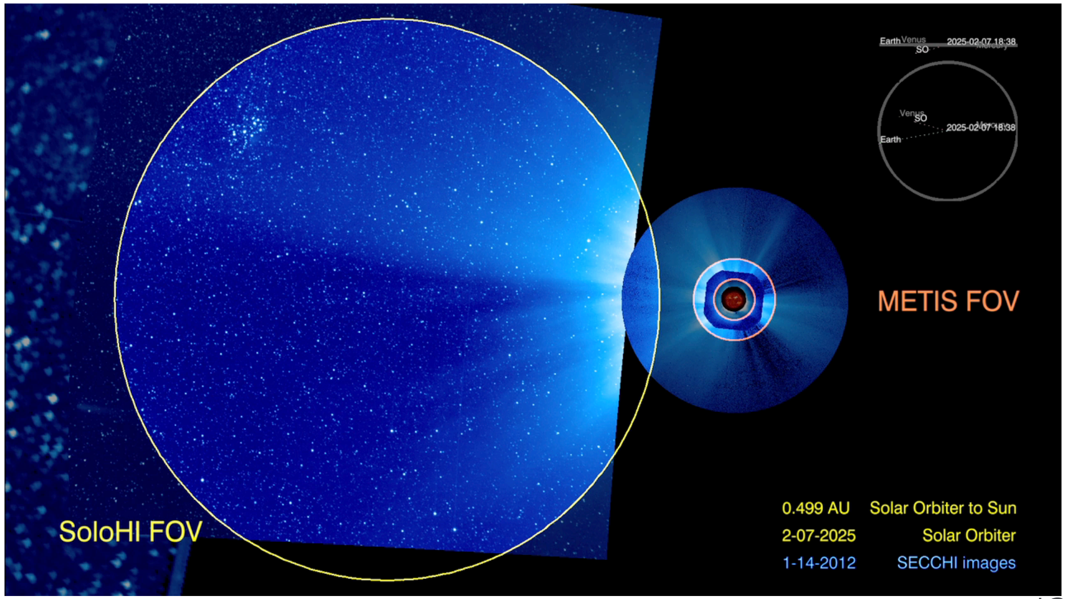
Earth view

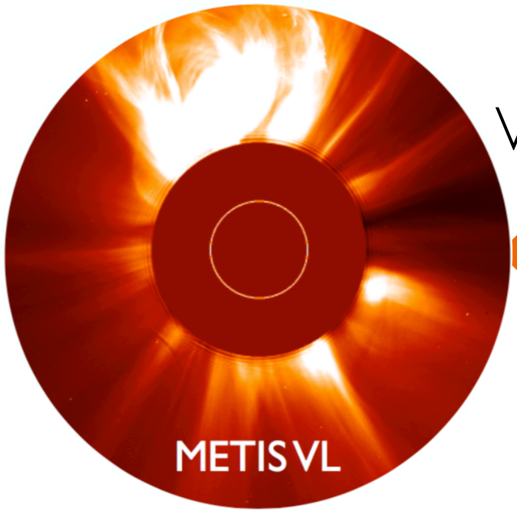


Solar Orbiter view

\+ similar images across the entire visible hemisphere







UV (HI 121.6 ± 5 nm
VL (580 – 640 nm) polarised light

Combination also gives solar wind speed *via* Doppler dimming

The Science Activity Plan (SAP)

- Strategic plan covering the science we're going to do and when over the whole mission, written by the Science Working Team (Lead: Y. Zouganelis)
- How?
    1. Definition of detailed science objectives.
    2. Group sub-objectives that require similar observations together. Define a SOOP (Solar Orbiter Observing Plan) that includes a collection of instruments and modes.
    3. Examine the trajectories to find the best opportunities for each SOOP. Define the SOOP scheduling strategy.
    4. Schedule all SOOPs within a given trajectory and simulate the high-level plan against mission constraints.

SAPs

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https://issues.cosmos.esa.int/solarorbiterwiki/display/SOSP

Solar Orbiter Confluence   Spaces   Log in

- File lists
- Getting started
- MOC Documents
- SOC Documents
- SOC Presentations
- Solar Orbiter SPICE Kernels
- SOWG
- Modelling and Data Analysis Working
- Low Latency Pipeline Engineering
- EMC
- Orbit Plots
- Instruments: observables, modes anc
- **SAP-related work**
  - Solar Orbiter detailed science obje
  - SOOP pages
  - General Planning strategy for first
  - Planning periods Option E (LTP/M
- In Situ Working Group
- Remote Sensing Working Group
- Instrument-Specific Pages
- Software Development Collaboration
- Meeting notes

Pages / Solar Orbiter SOC Public

SAP-related work

Created by Anik De Groof, last modified by Yannis Zouganelis on Jul 10, 2017

The latest version (v0.1, 10 July 2017) of the full SAP document can be downloaded here.

N.B.: The individual Confluence pages might contain more recent information than the full SAP document.

- Solar Orbiter detailed science objectives
  - Objective 1: What drives the solar wind and where does the heliospheric magnetic field originate?
    - 1.1 What are the source regions of the solar wind and heliospheric magnetic field?
      - 1.1.1 Source regions of the fast solar wind
        - 1.1.1.1 Low FIP fast wind origins
        - 1.1.1.2 Origin of the small-scale X-ray and UV jets in polar coronal holes
      - 1.1.2 Source regions of the slow solar wind
        - 1.1.2.1 Does slow wind originate from the over-expanded edges of coronal holes?
        - 1.1.2.2 Does slow and intermediate solar wind originate from coronal loops outside of coronal holes?
        - 1.1.2.3 Abundance of minor ions as a function of height in the corona as indicator of slow or fast wind
        - 1.1.2.4 Study of density fluctuations in the extended corona as a function of the outflow velocity of the solar wind while evolving in the heliosphere
        - 1.1.2.5 Structure and evolution of streamers
        - 1.1.2.6 Disentangle the spatial and temporal variability of the slow wind
        - 1.1.2.7 Trace streamer blobs and other structures through the outer corona and the heliosphere.
        - 1.1.2.8 Determine the velocity, acceleration profile and the mass of the transient slow wind flows
      - 1.1.3 Source regions of the heliospheric magnetic field
        - 1.1.3.1 Full characterization of photospheric magnetic fields and find structures
        - 1.1.3.2 How does the Sun's magnetic field link into space?
          - 1.1.3.2.1 How does the Sun's magnetic field change over time?
          - 1.1.3.2.2 How is the heliospheric current sheet (HCS) related to coronal structure?
          - 1.1.3.2.3 How does the heliospheric magnetic field disconnect from the Sun?
        - 1.1.3.3 What is the distribution of the open magnetic flux?
      - 1.1.4 Transverse themes
        - 1.1.4.1 Reconnection
          - 1.1.4.1.1 Interchange reconnection between open and closed field lines and its role in slow wind generation

EUI SOOP for Filament Observations

Having examined the currently proposed Solar Orbiter Observing Proposals (SOOPs) there does not appear to have been much consideration for observations of filaments. Therefore the following draft SOOP has been created to try and fill this gap.

Proposed SOOP Coordinators

Name: R_BOTH_HRES_HCAD_Filaments
Jack Jenkins, Lidia van Driel-Gesztelyi, David Long, Susanna Parenti

Description

High resolution observations of Filaments (AR or QS) to study structure and dynamics. SOOP supports both high and low cadence, depending on structural or dynamic aims. Perihelion preferred. Can potentially be used in quadrature with Earth for coordinated observations with DKIST and other Earth-based observatories/instruments.
Pointing requirements: Preferably run on disk center, may be pointed off-limb (without Metis)
Default SOOP duration: 1 hour (TBC)
Triggers: Disabled

Instrument	Mode	Comment
EUI	HRI in highest spatial resolution. EUV & LYA Quiet Sun modes (Q) or EUV & LYA Active Region modes (A), HIGH-MID CADENCE: 10-60 second. FOV: Full (no rebinning). FSI Synoptic observations.	Will limit telemetry for entire orbit, therefore recommended to only run for 1 hour.
PHI	PHI science mode 2 (FDT or HRT)	Observations used for context and extrapolations. In event that DKIST co-observations are unavailable, PHI HRT will be required.
SPICE	A modified SPICE Dynamics mode, exposure times should be adapted for good S/N ratio in quiet Sun. H-Ly beta line, with additional lines both above and below the Ly-alpha head.	Centre of raster at centre of EUI provided that filament is at centre of EUI FOV

input by Jack Jenkins

Community Involvement

Solar Orbiter will be discussed at the annual missions forum.

Gherardo starts in January to be the link between modelling and the mission. This role will last 10 months. Please interact! This will prepare modelling for the first science phases.

Anyone interested in joining in instrument consortia meetings or the MADAWG, please contact any of the team (myself (EUI), Andrjez (SPICE), Chris Owen (SWA), Tom Horbury (MAG).

UCL-MSSL will be advertising a SO CG PDRA position very soon. Please advertise the post to likely candidates! Contact Louise Harra/Chris Owen. There is also likely to be an ops post for SWA at MSSL.

The next SO international science meeting will be in Belfast ~spring 2021.