EUI onboard Solar Orbiter: unique data for high resolution, far corona and connection science

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Abstract

The Extreme Ultraviolet Imager (EUI) onboard Solar Orbiter is composed of three telescopes, the Full Sun Imager (FSI), and two High Resolution Imagers observing in EUV (HRI EUV) and Lyman-alpha (HRI Lya). EUI observes the Sun from the smallest features at the base of the corona and in the chromosphere up to the largest s cales in the extended corona.

EUI observations are indispensable for heliospheric connection science as they provide essential information about coronal source regions of eruptive events and solar wind. FSI reveals structure and evolution of the corona to unprecedented distances from the Sun (to a distance of more than 6 solar radii).

EUI's unparalleled spatial and temporal resolution at perihelion naturally leads to discovery of new structures at previously inaccessible scales such as campfires, picojets, and the smallest decayless kink waves observed to date.

This poster aims to show interested scientists the way to EUI observations and data analysis. The reader is directed to the latest EUI Data Release, tools and overviews, and kindly invited to become part of the EUI community, facilitated by EUI's open data policy and fast data availability. A particularly effective way to join the EUI community is the Guest Investigator Program of the Royal Observatory of Belgium (ROB), which allows selected applicants to spend a few weeks with the EUI, PROBA2/SWAP or PROBA2/LYRA PI team in Brussels to obtain expert knowledge on the instruments, to participate in observation planning according to the needs of their proposal, and to conduct their research in collaboration with ROB scientists.

Enhanced[4] high res movie M2.4 2024-03-23

EUI telescopes and abilities

EUI is the Extreme Ultraviolet Imager[1] onboard Solar Orbiter (SolO). It consists of three telescopes – Full Sun imager (FSI); EUV High Resolution Imager (HRI EUV) and Lyman-alpha High Resolution Imager (HRI Lya) – which together image the solar atmosphere from the largest scales in the extended corona to the smallest features in the corona and chromosphere.

FSI

FOV: 3.8°×3.8° = [14.3×14.3] Rs @ 1 au;
[4×4] Rs @ perihelion
Angular resolution: 9"
Passbands: 30.4 nm (transition region, ~80 000 K) and 17.4 nm (EUV corona, ~1 MK)
Typical exposure time: 10 seconds
Typical cadence: 10 seconds to 60 minutes
Detector: CMOS-APS, 3072×3072 pixels

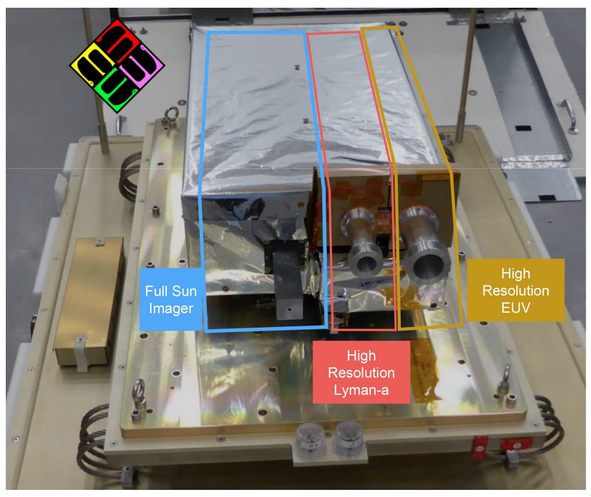

Figure 1. The Extreme Ultraviolet Imager.

The "Extreme Ultraviolet Imager" (EUI)
Centre Spatial de Liège
Institut d'Astrophysique Spatiale
Laboratoire Charles Fabry, Institut d'Optique
Max Planck Institute for Solar System Research
Physikalisch-Meteorologisches Observatorium Davos
UCL-Mullard Space Science Laboratory
Royal Observatory of Belgium

HRI EUV

FOV: 1000"×1000" = [1×1] Rs @ 1 au;
[0.3×0.3] Rs @ perihelion
Angular resolution: 1"
Passband: 17.4 nm (EUV corona, ~1 MK)
Typical exposure time: a few seconds
Typical cadence: from 1 second to 1 minute
Detector: CMOS-APS, 2048×2048 pixels

HRI Lya

FOV: 1000"x1000" = [1×1] Rs @ 1 au;
[0.3×0.3] Rs @ perihelion
Angular resolution: >9", variable
Passband: 121.6 nm (lower chromosphere/upper transition region, ~30 000 K)
Typical exposure time: a few seconds
Typical cadence: from 1 second to 1 minute
Detector: intensified CMOS-APS, 2048×2048 pixels

High resolution

- HRI EUV: unparalleled high resolution images; cadences as fast as 1 second
- HRI EUV discovered/observes smallest scale phenomena ever:
  - ➢ Discovery of very small EUV brightenings in the quiet Sun, nicknamed "campfires"[2]
  - ➢ Discovery of "picoflare jets"[3]
  - ➢ Identification of small-amplitude decayless kink oscillations
  - ➢ Active regions observed in unsurpassed detail

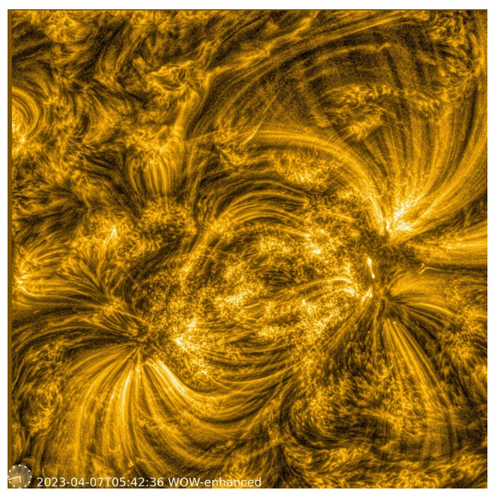

Figure 2. Detailed HRI EUV observations of an active region, 2023-04-07 (0.31 au from the Sun). Image enhanced using the WOW algorithm[4].

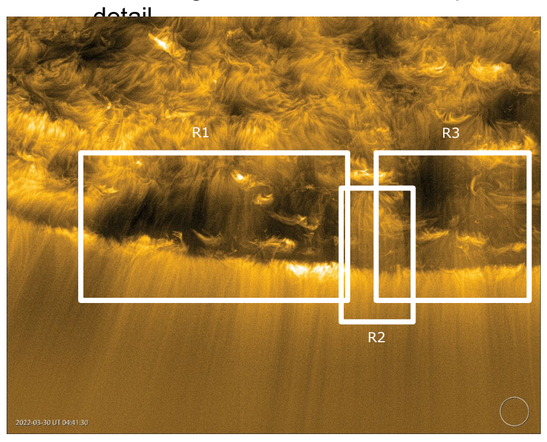

Figure 3. Polar coronal hole, 2022-03-30 (0.33 au from the Sun), featuring picoflare jets[3].

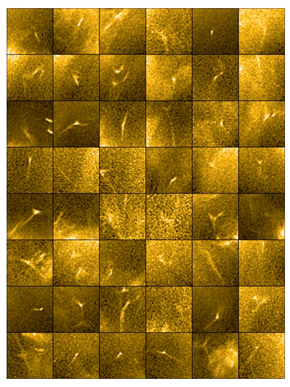

Figure 4 (left). Ubiquitous and intermittent picoflare jets identified in regions R1, R2 and R3 in Figure 3. Time scale ~60 s, speed ~100 km/s, kinetic energy in picoflare range.

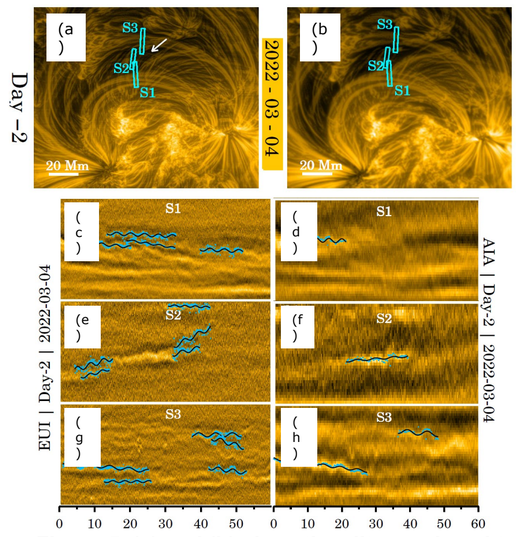

Figure 5. (a) and (b) show the slits employed to study oscillations in active region loops, 2022-03-04 (0.54 au from the Sun). (c)–(h) show the identification of small-amplitude decayless kink oscillations[5] in time-distance diagrams.

Multi-instrument science

- FSI: immense asset for multi-instrument science
  - ➢ reveals coronal configuration and evolution in almost continuous synoptic observations
  - ➢ images source regions of heliospheric events
- Combining FSI and HRI EUV reveals source regions in high resolution and high cadence

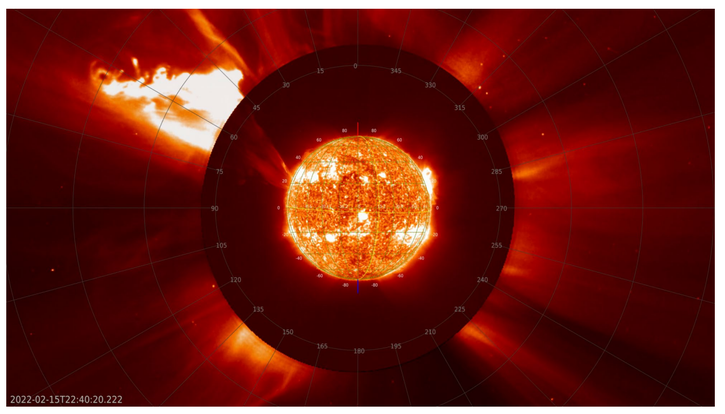

Figure 8. This JHelioviewer[7] image combines an FSI 30.4 nm image of the 2022-02-15 filament eruption with a SOHO/LASCO/C2 image. Careful analysis[6] allowed to derive 3D reconstruction and kinematics of the erupting prominence and the associated coronal mass ejection.

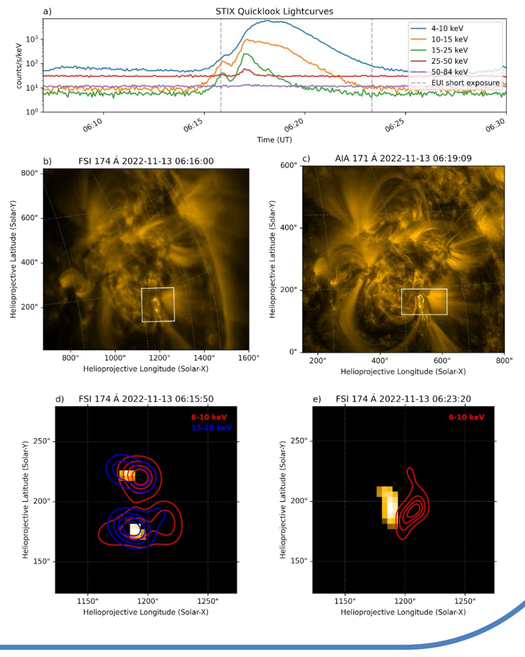

Figure 9. A "simple" flare observed by STIX and EUI/FSI[8]. The times of the FSI 17.4 nm short exposure frames are denoted by the dashed lines in panel a). Panels b) and c) compare observations from FSI and the Earth based SDO/AIA 17.1 nm channel, with panel b) showing a composite short exposure and normal exposure FSI map. Panels d) and e) show the thermal (red contours) and non-thermal (blue contours) HXR emission observed by STIX at the time of the corresponding short exposure frames.

Imaging the full corona

- FSI: largest EUV FOV ever, [14.3×14.3] Rs at 1 au
- FSI door has intermediate "occulter position" and can act as an EUV coronagraph in 17.4 nm and 30.4 nm

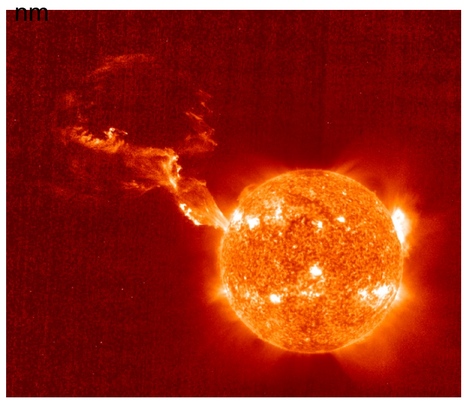

Figure 6. FSI 30.4 nm observed the 2022-02-15 filament eruption to a distance of more than 6 solar radii[6]. Image enhanced with radial filter.

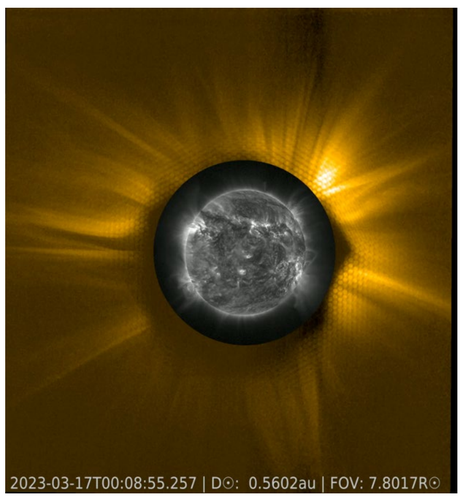

Figure 7. FSI 17.4 nm occulter image in yellow, overlaid with corresponding on-disk PROBA2/SWAP 17.4 nm image in grey, 2023-03-17.

Start analyzing EUI data today! https://www.sidc.be/EUI

- **Open Access to EUI data**: https://www.sidc.be/EUI/**data-analysis**
  - ➢ All EUI data are open and available when the Level 2 FITS files have been produced
  - ➢ **Data Release 6**: https://doi.org/10.24414/z818-4163; time range [2020-03-03, open]
  - ➢ **Data Release 7 expected October 2024** (including recalibration & pixel quality map)
- **EUI movie gallery:** https://www.sidc.be/EUI/data/**movie**/
- **List of FSI eruptions:** https://www.sidc.be/EUI/**solar-eruptions**/
- https://www.sidc.be/EUI/data/**lastDayFSI**/ & https://www.sidc.be/EUI/data/**lastWeekFSI**/
- **JHelioviewer**[7]: combine EUI and other instrument data in elaborate movies
- The EUI team invites all researchers to use EUI data and is happy to provide technical assistance on request (contact **eui@sidc.be**)
- Become **ROB Guest Investigator in 2025** (deadline November 1, 2024)
  - ➢ https://www.sidc.be/**GuestInvestigator/GI_call_2025**
  - ➢ Selected applicants are funded to **spend a few weeks with the PI team** to obtain expert instrument knowledge, plan observations if needed, and conduct their research

[1]*Rochus et al. 2019, A&A, 642, A8*
[2]*Berghmans et al. 2021, A&A, 656, L4*
[3]*Chitta et al. 2023, Science, 381, 867*
[4]*Auchère et al. 2023, A&A, 670, A66*
[5]*Mandal et al. 2022, A&A, 666, L2*
[6]*Mierla et al. 2022, A&A, 662, L5*
[7]*https://www.jhelioviewer.org/*
[8]*Collier et al. 2024, submitted to A&A*