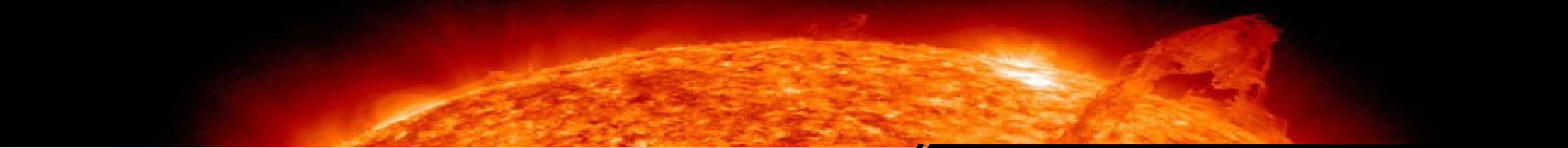
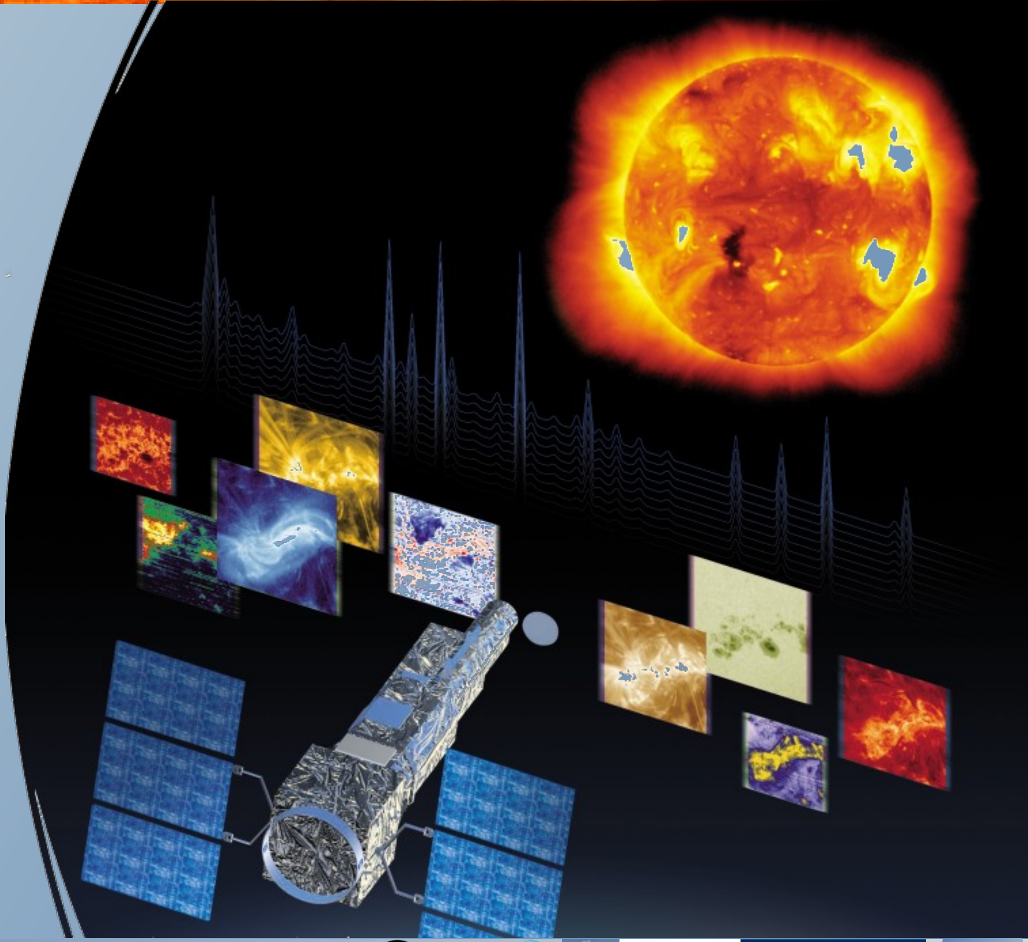


The SOLAR-C Mission

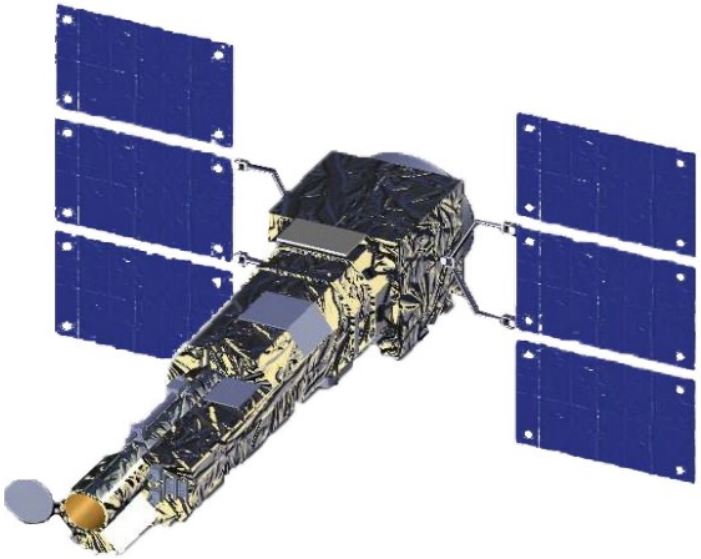
V. Andretta

INAF, Osservatorio Astronomico di Capodimonte, Naples, Italy



The SOLAR-C mission at glance

- **Key observations**
  - ✓ How the mass and energy is transferred through the whole atmosphere



(Source: T. Shimizu)

- **Mission instruments**
  - ✓ EUV high-throughput Spectroscopic Telescope (EUVST)
  - ✓ With Solar EUV Spectral Irradiance Monitor (SoSpIM)

- **Much advanced EUV spectroscopy**
  - ✓ Temp coverage: 10^4-10^7 K
  - ✓ Spatial resolution: 0.4”
  - ✓ High throughput: x10 ~ x40 higher (Temporal resolution: 0.5-sec cad.)
  - ✓ Strategic coordination with MUSE and ground-based observatories

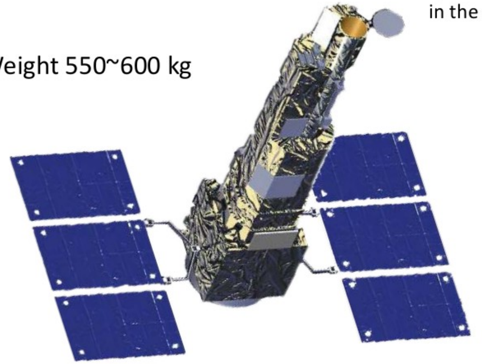
- **Latest status and launch date**
  - ✓ In transition to Phase B (development test phase)
  - ✓ ~~July 2028 (JFY 2028)~~ **November 2028**

The SOLAR-C mission: The spacecraft

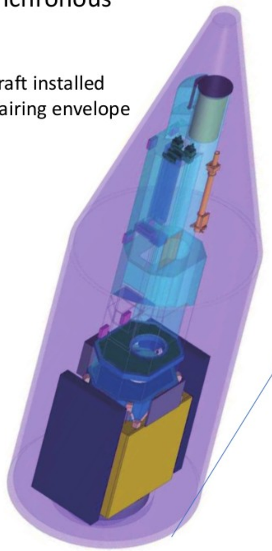
Spacecraft system

- EUVST mounted on a spacecraft bus, to be launched aboard an Epsilon-S rocket into a sun synchronous polar orbit (>600 km).

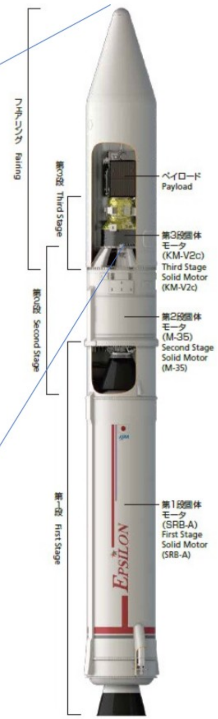
Weight 550~600 kg



Spacecraft installed in the fairing envelope



JAXA Epsilon-S rocket
(→ IHI Aerospace after 2025)



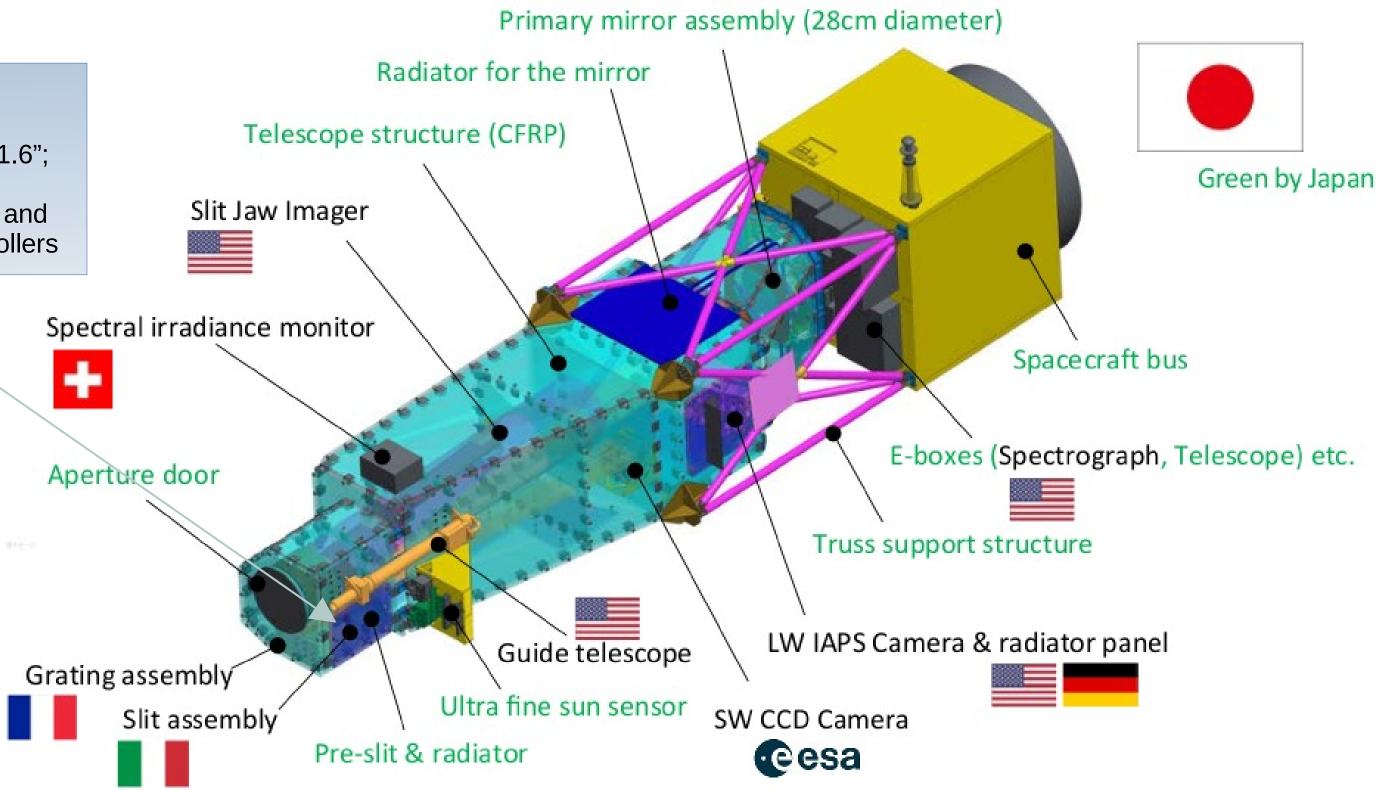
Sun synchronous polar orbit (>600 km)

High pointing stability, based on Hinode knowledge

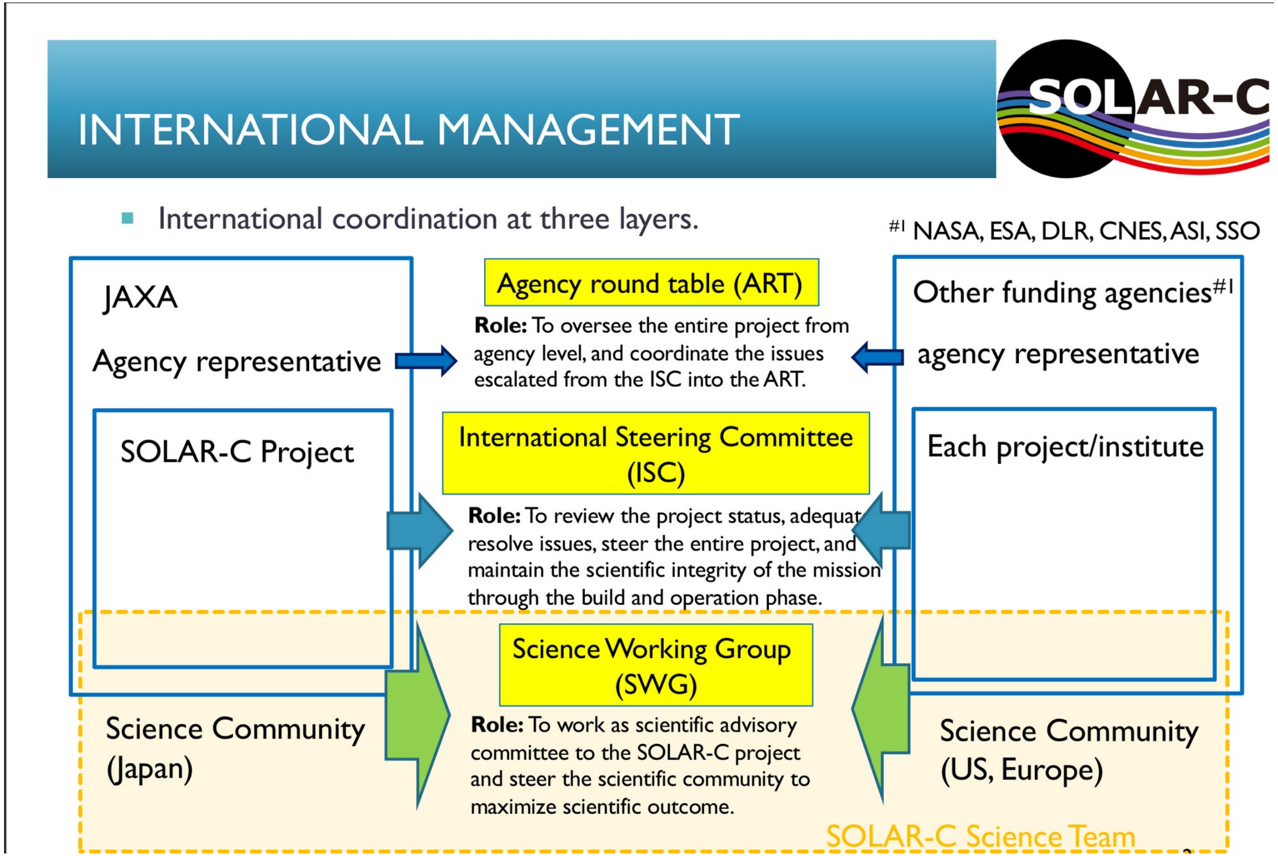
(Source: T. Shimizu)

Contributions to the SOLAR-C Mission

Slit assembly:
1) Set of 5, 280” long slits:
   - Science slits: 0.2”, 0.4”, 0.8”, 1.6”;
   - Calibration (wide) slit.
2) Slit exchange mechanisms (main and redundant), and associated controllers



SOLAR-C International Management



SOLAR-C International Management

T. Shimizu (ISAS/JAXA) 2022.2.7
T. Shimizu (ISAS/JAXA) 2022.6.15 Rev.D

ISC'S MEMBERS

SOLAR-C

- To review the project status, adequately resolve issues, steer the entire project, and maintain the scientific integrity of the mission through the build phase.
- Proposed members
  - JAXA SOLAR-C project and their counterparts at each partner (institute for hardware development)

Country	Position	Name	Primary function
Japan	JAXA Project Manager	Toshifumi Shimizu	Managing the entire project, Chair
Japan	JAXA Principal Scientist	Hirohisa Hara	Responsible for telescope development
Japan	JAXA Project Scientist	Shinsuke Imada	Responsible for assessing science values, Bridge to SWG
US	NASA Program Scientist	Simon Plunkett	Coordinating for the whole heliophysics
US	NASA Mission Scientist	Sabrina Savage	For EUVST
US	US Principal Investigator	Harry Warren	Responsible for the US components (NRL+LMSAL)
US	US LM Lead	Bart De Pontieu	Responsible for LM components, coordinating with MUSE
Europe	ESA Project Manager	Brian Shortt	Responsible for UK SW CCD
Italy	Italian Principal Investigator	Vincenzo Andretta	Responsible for Slits Assembly
France	French Principal Investigator	Frédéric Auchère	Responsible for Grating Assembly
Germany	German Principal Investigator	Luca Teriaca	Responsible for MMC, PSHV, and TV calibration
Switzerland	Swiss Principal Investigator	Louise Harra	Responsible for Irradiance Monitor (SoSpIM)

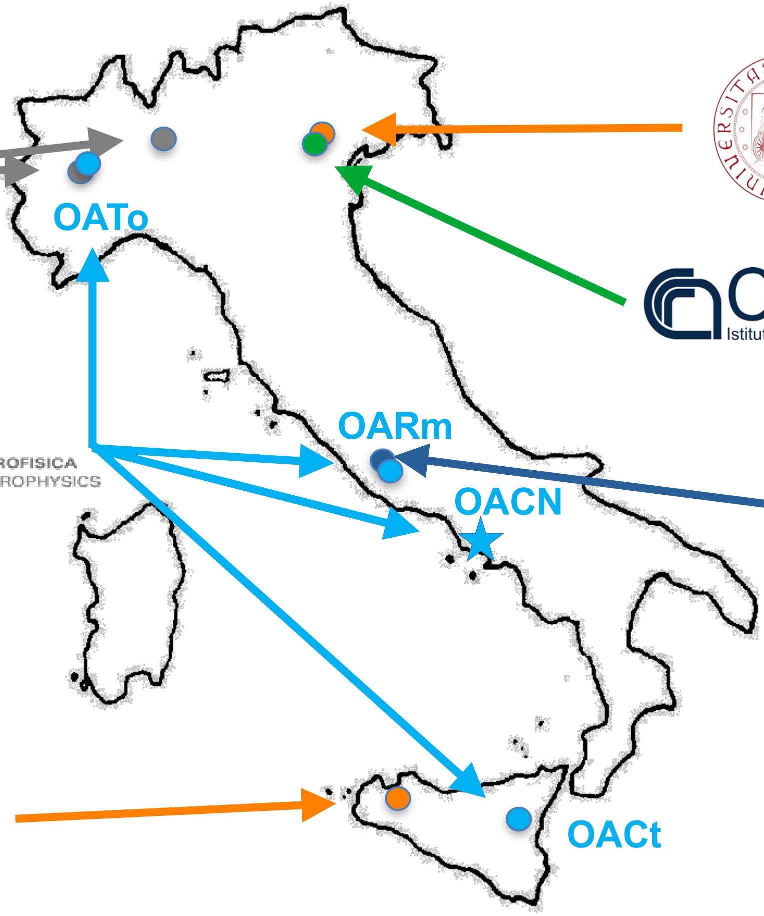
  - Secretary (Japan): One young scientist (Shin Toriumi) from JAXA for meeting arrangement and minutes
- Closed meeting, invited only for guests.

SWG members

Country	Name	Position/Role
Japan (5):	Shinsuke Imada (Chair), Univ. Tokyo	Project Scientist ISAS, SWG Chair
	Yukio Katsukawa, NAOJ	Data Calibration (Instrument point of view)
	Ayumi Asai, Kyoto Univ.	Coordinated observation with GBO and other satellites
	Shin Toriumi, ISAS	Mission Operation and Data Analysis
	Satoshi Masuda, ISEE Nagoya Univ.	Solar-C Science Center
Secretary	Yusuke Kawabata, NAOJ	Young Scientist from Japan (Ready for the next generation)
Country	**Name**	**Position/Role**
US (5):	Ignacio Ugarte-Urra, NRL	Scientific Leadership from US-side
	Bart DePontieu, LMSAL	Coordinated observation with MUSE SJI Scientific Leadership
	Sabrina Savage, NASA	Coordinated observation with GBO and other satellites
	Viggo Hansteen, LMSAL	Collaboration with numerical simulation research
	David Brooks, NRL	EUVST Scientific data analysis tools
Country	**Name**	**Position/Role**
ESA (3):	Krzysztof Barczynski, ETH / PMOD	SoSPIM Scientific Leadership
	Sarah Matthew, MSSL	Data Calibration (Instrument point of view)
	Tiago Pereira, Univ. Oslo	Collaboration with numerical simulation research
	Marie Dominique, Royal Observatory of Belgium	SoSPIM Scientific Leadership
	Clara Froment, CNRS/LPC2E	Scientific data analysis tools

The Italian contribution to SOLAR-C

ThalesAlenia Space
a Thales / Leonardo company



UNIVERSITAS STUDII PADUANI MCCXXII

CNR IFN
Istituto di Fotonica e Nanotecnologie

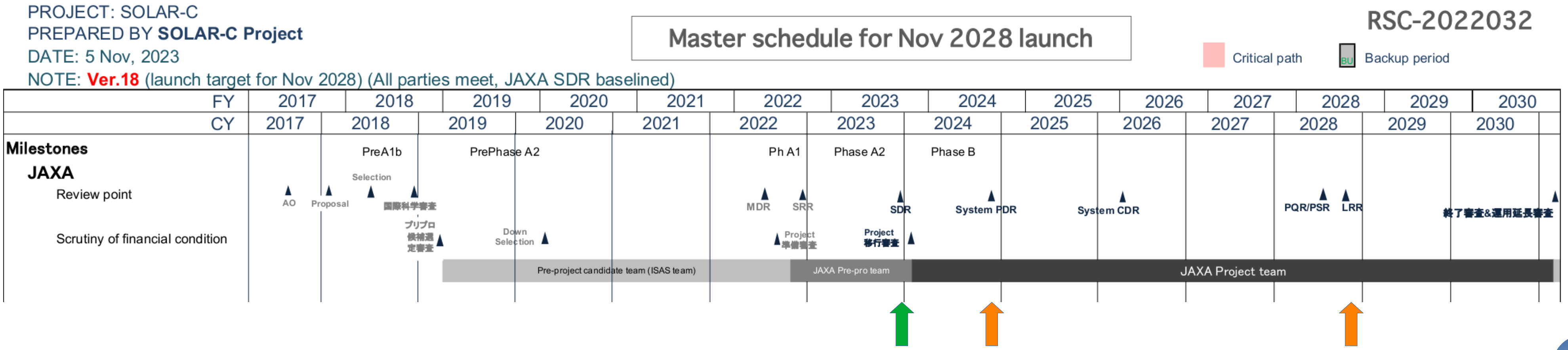
INAF
ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS

ASI Agenzia Spaziale Italiana

UNIVERSITÀ DEGLI STUDI DI PALERMO

Latest project schedule

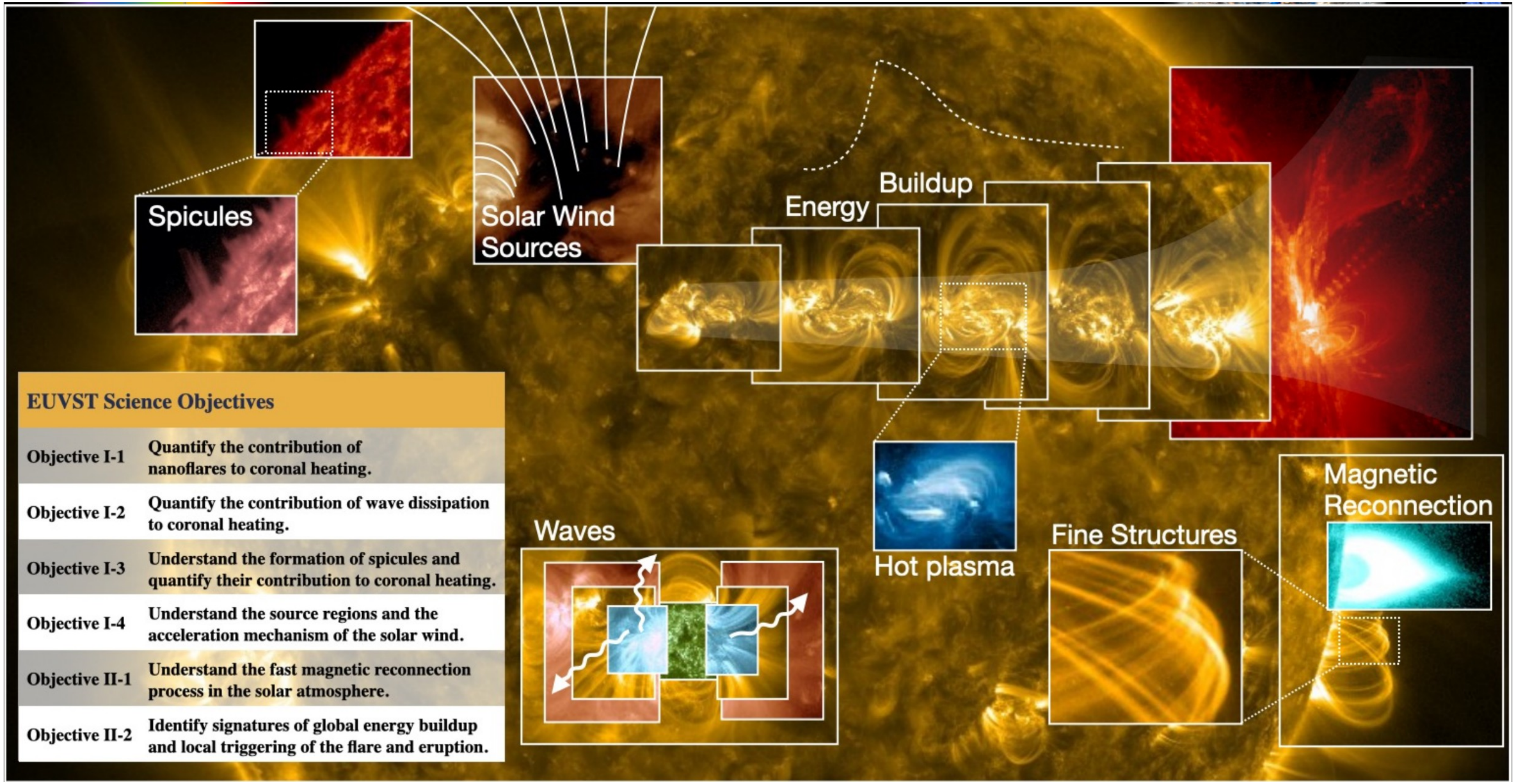
- **JAXA System Definition Review (SDR) completed in November 2023**
- **Working towards system PDR later this year**
- **Launch currently scheduled for November 2028**
- **Mission duration: 2 years (nominal mission) + 4 months (commissioning)**



Science with EUVST

Objective I: Understand how fundamental processes lead to the formation of the solar atmosphere and the solar wind

Objective II: Understand how the solar atmosphere becomes unstable, releasing the energy that drives solar flares and eruptions



EUVST Science Objectives	
Objective I-1	Quantify the contribution of nanoflares to coronal heating.
Objective I-2	Quantify the contribution of wave dissipation to coronal heating.
Objective I-3	Understand the formation of spicules and quantify their contribution to coronal heating.
Objective I-4	Understand the source regions and the acceleration mechanism of the solar wind.
Objective II-1	Understand the fast magnetic reconnection process in the solar atmosphere.
Objective II-2	Identify signatures of global energy buildup and local triggering of the flare and eruption.

EUVST requirements

A) Seamlessly observe all the temperature regimes of the atmosphere from the chromosphere to the corona, simultaneously and at the same spatial resolution.

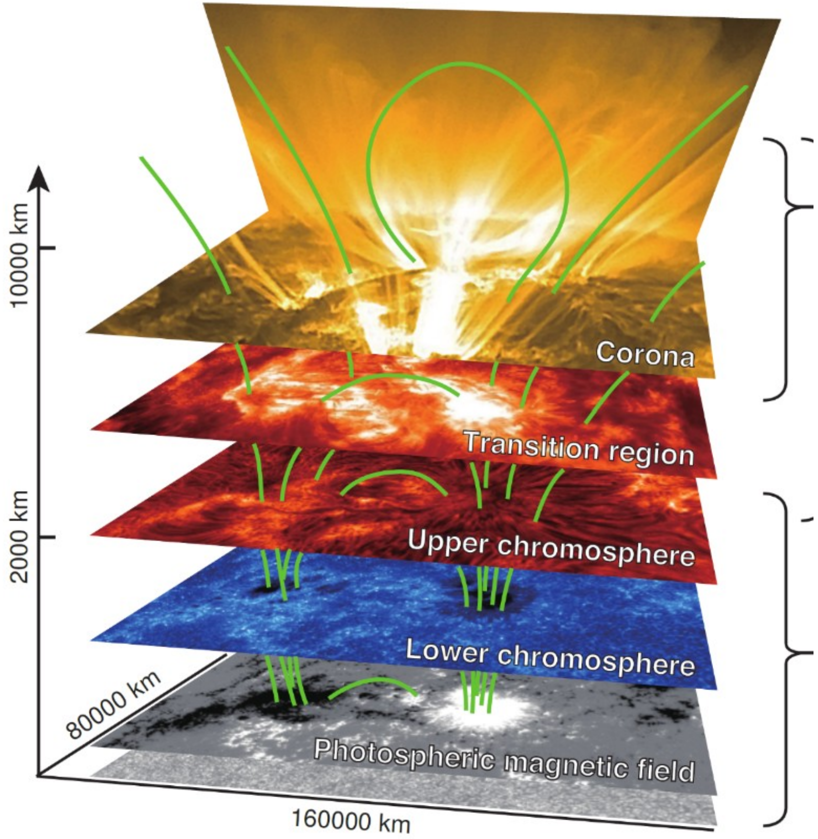
(Temperature range: 10^4 - 10^7 K)

B) Resolve elemental structures of the solar atmosphere and track their changes with sufficient cadence.

(Spatial resolution: 0.4” (300 Mm) at < 1 s exposure

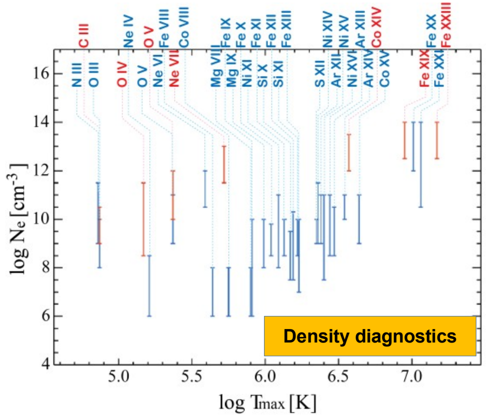
C) Obtain spectroscopic information on dynamics of elementary processes taking place in the solar atmosphere.

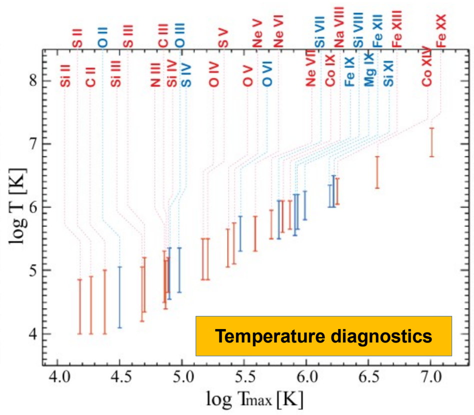
(Velocity, density, temperature, composition, ionization, etc)

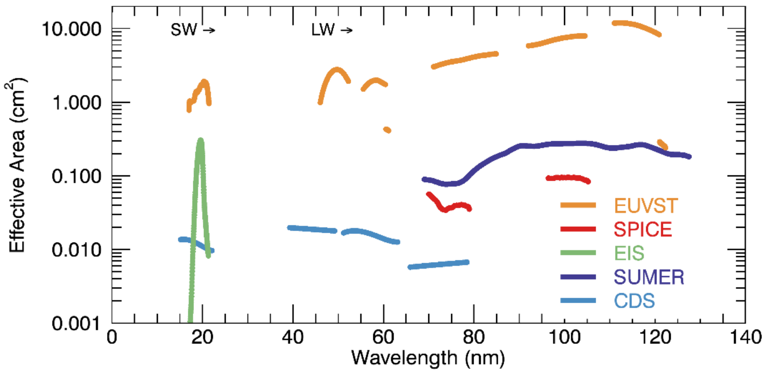


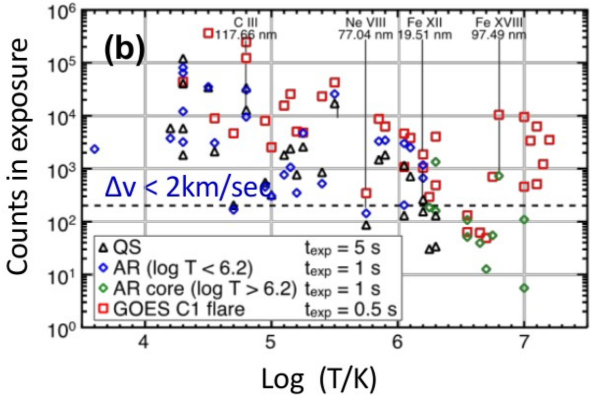
The EUVST spectrograph: Performance requirements

- ✔ Four wavelength bands in the FUV/EUV, covering the ranges 170 - 215 Å and 460 - 1280 Å, with sufficient signal to allow full plasma diagnostics throughout that range
- ✔ Spatial resolution: 0.4”
- ✔ Field of view (through scanning): 300” x 280”
- ✔ Esposure times: as low as 0.5 s
- ✔ Slit-jaw imaging of the photosphere and chromosphere (as done in the IRIS mission)

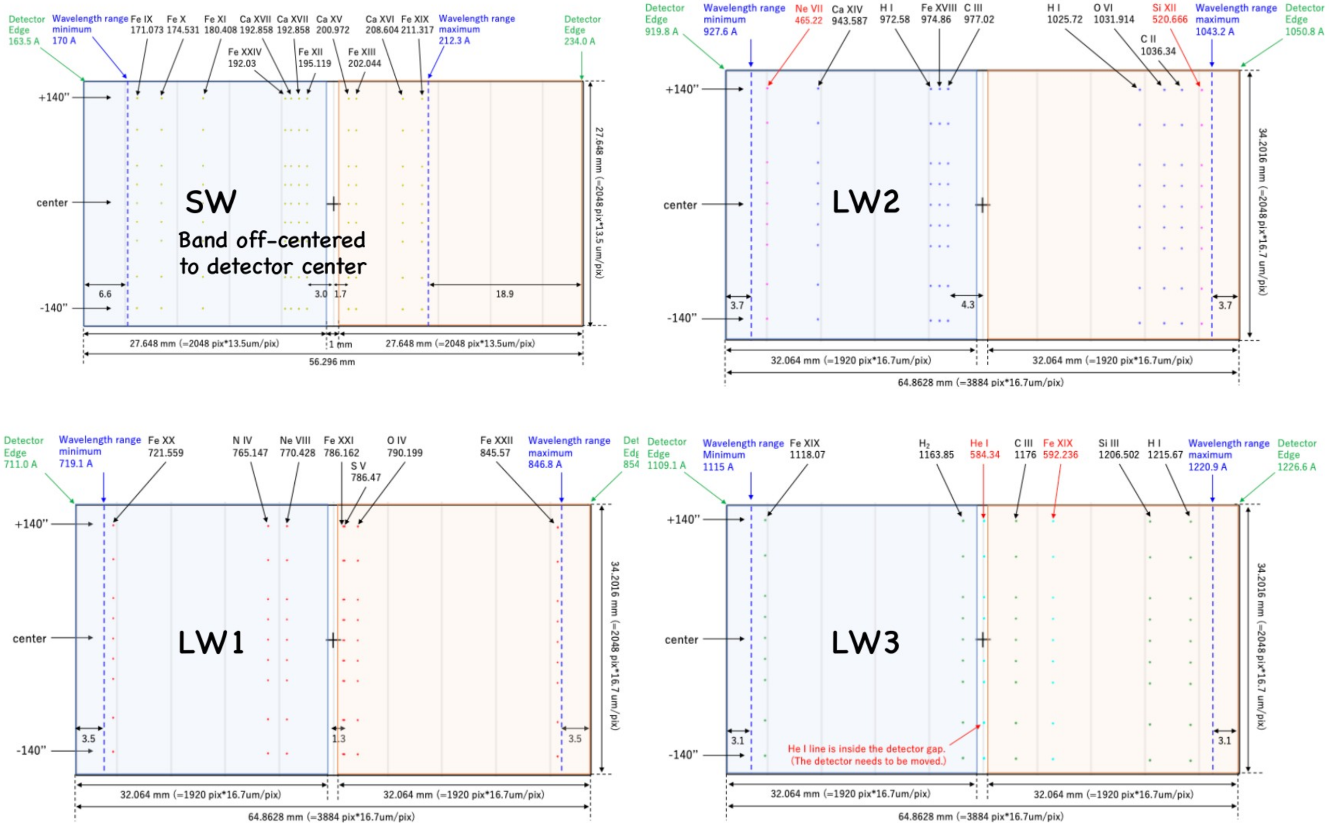




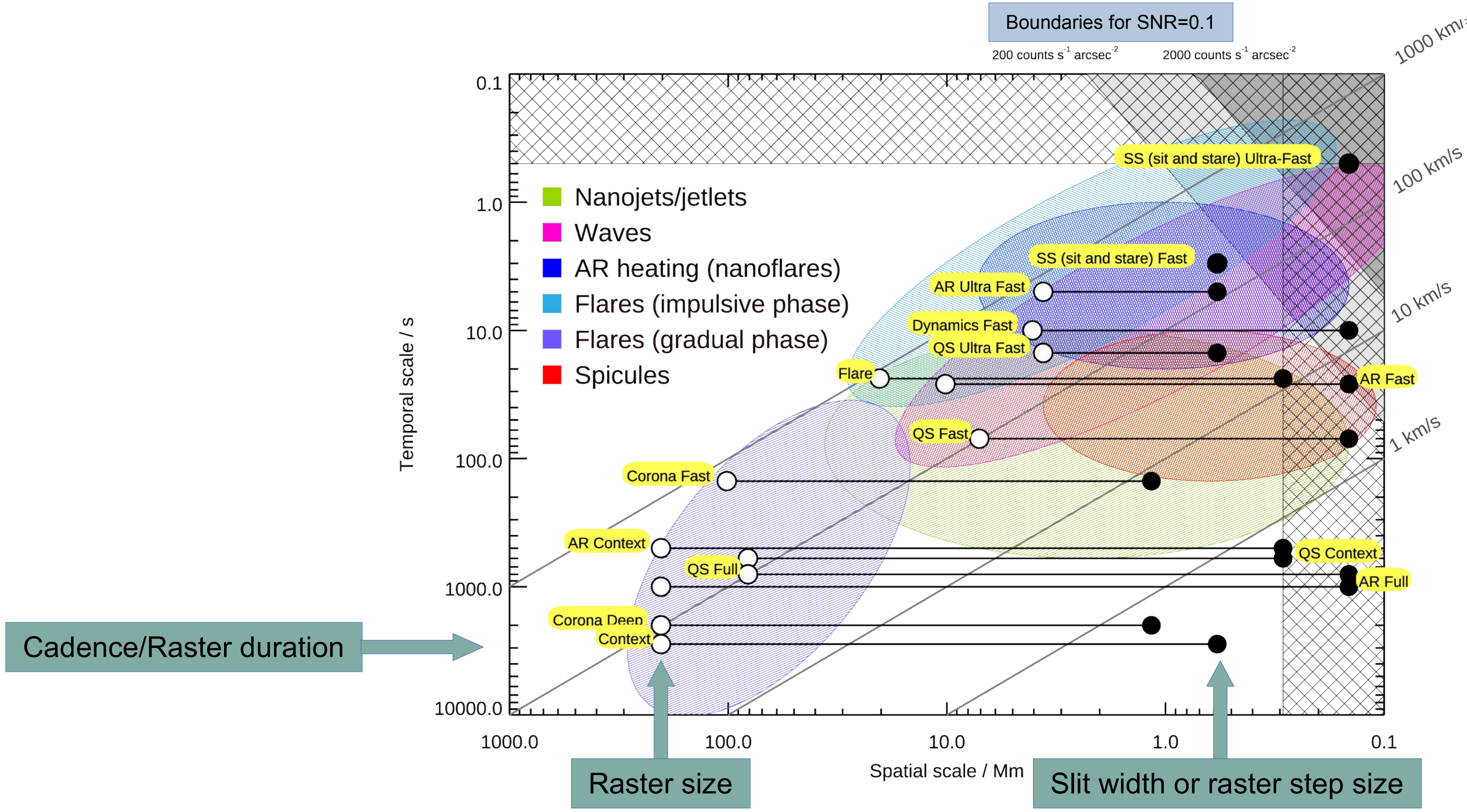




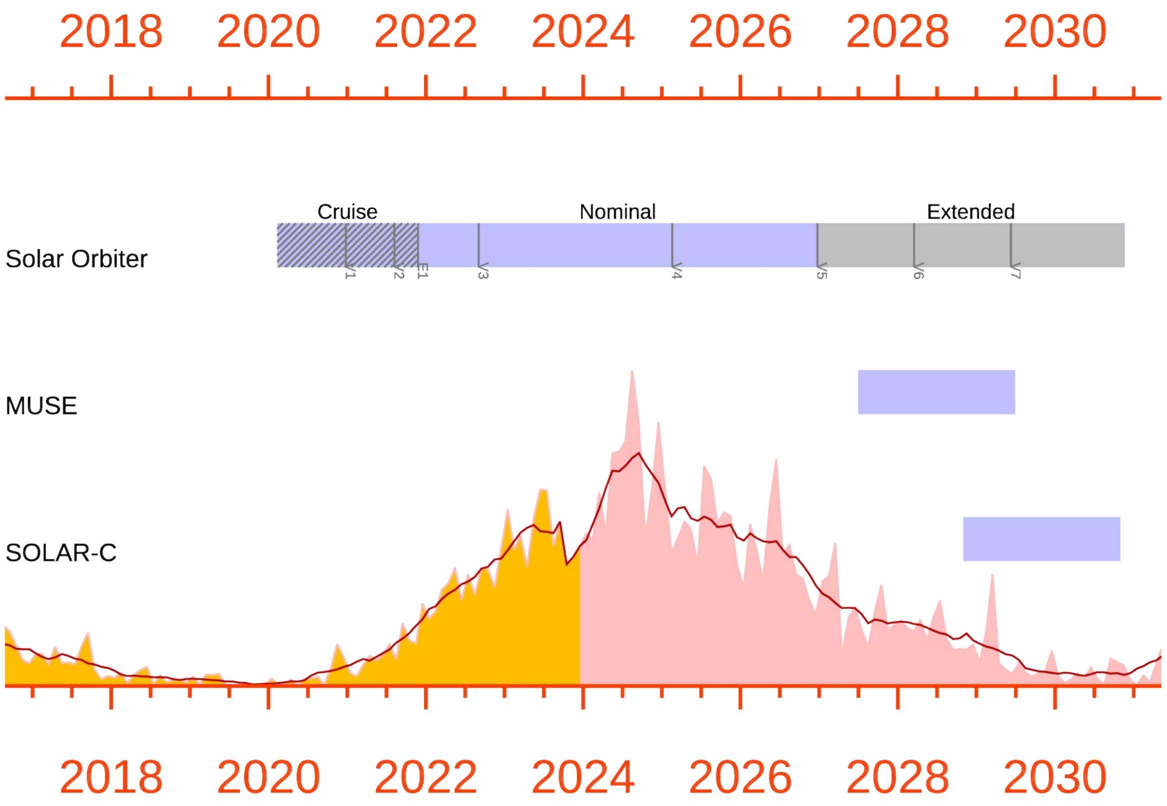
The EUVST spectrograph: Wavebands



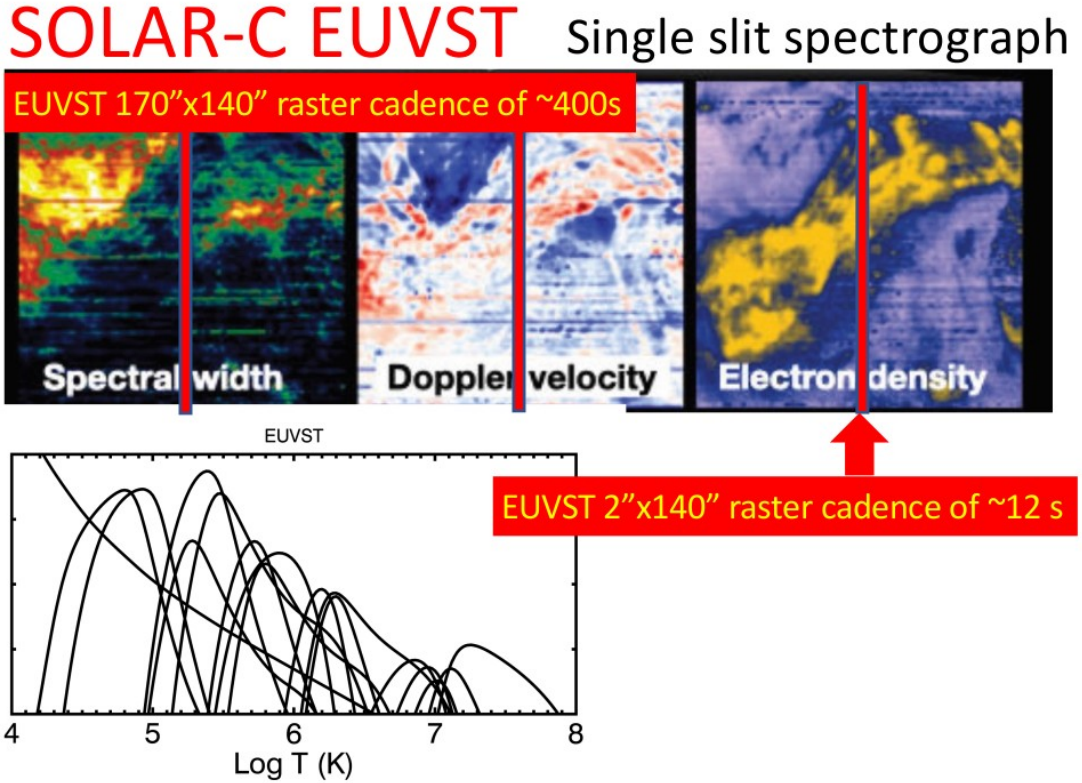
Designing observing modes with EUVST

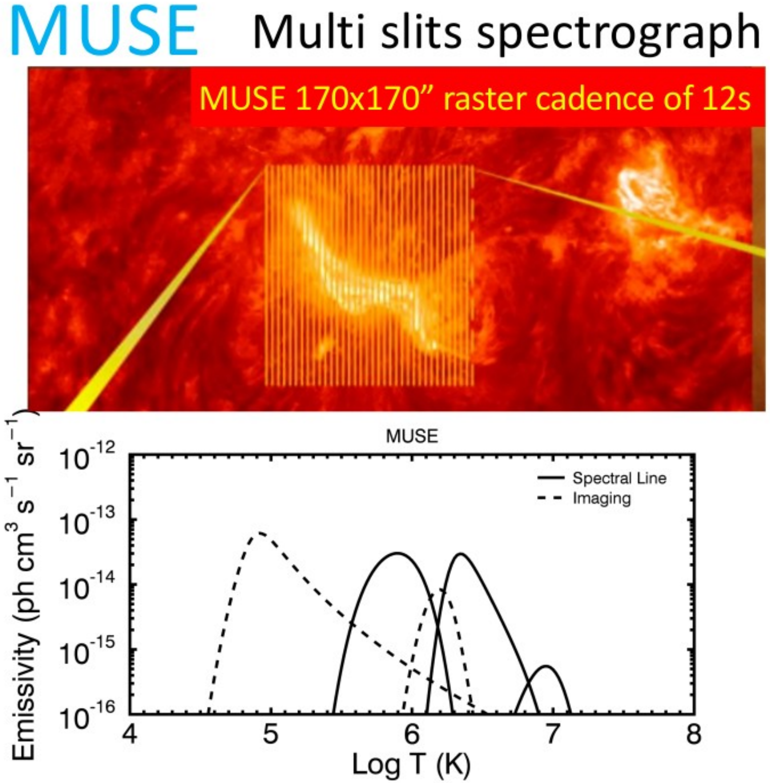


Synergies with other space missions



Synergies with MUSE

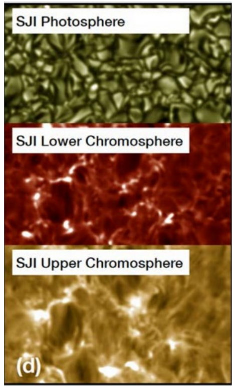




(Source: T. Shimizu)

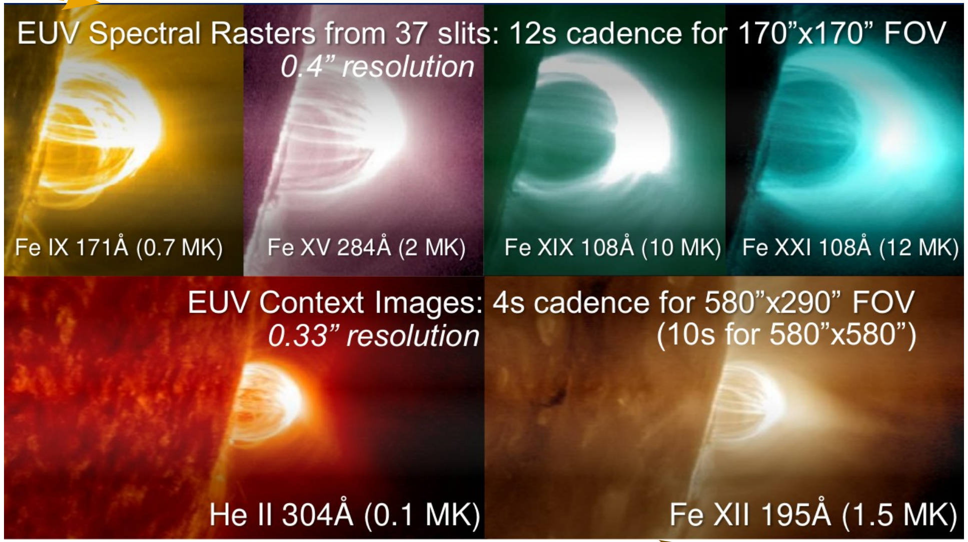
Synergies with MUSE

Slit-jaw imager



Spectrograph

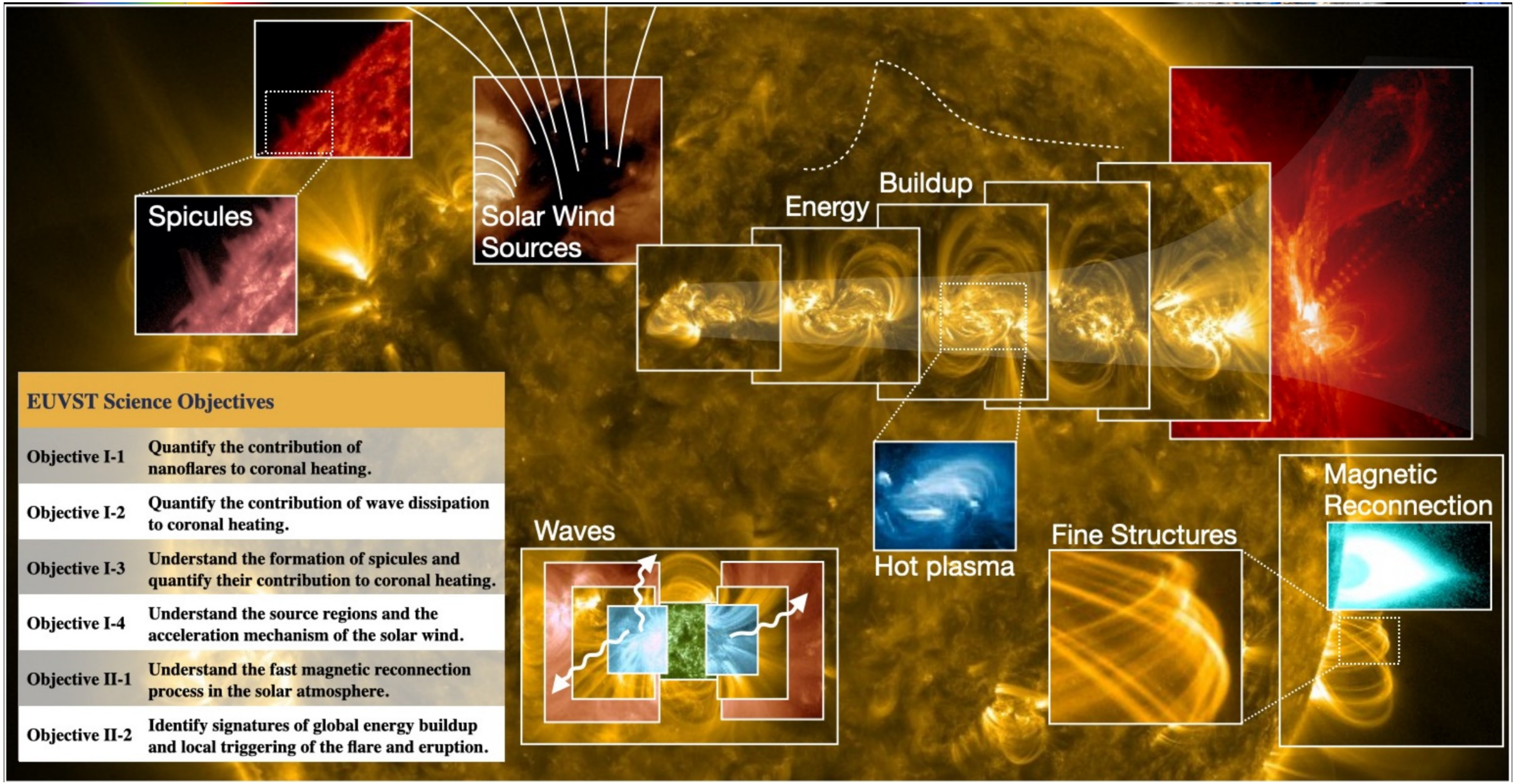
Ion	Wavelength [Å]	Log T [K]	Radiance [erg/s·cm²·sr] QS	AR	Flare (GOES C1.1)	Channel (order)
H_2	1163.85	3.60	—	193[a]	—	LW-3
H I	1215.67	4.30	65000[b]	220000[b]	>AR	LW-3
H I	1025.72	4.30	793[a]	6253[b]	>AR	LW-2
H I	972.58	4.30	139[a]	1452[b]	>AR	LW-2
He I	584.34	4.30	580[b]	5080[b]	140000[g]	LW-3 (2)
Si III	1206.502	4.50	695[b]	[illegible]	74000[h]	LW-3
C II	1036.340	4.55	40[a]	290[b]	1690[h]	LW-2
C III	977.020	4.80	[illegible]	3666[b]	58700[h]	LW-2
C III	1176.0 (6 lines)	4.80	221[c]	823[d]	21310[h]	LW-3
N IV	765.147	5.10	67[a]	142[a]	5750[h]	LW-1
O IV	790.199 (2 lines)	[illegible]	83[b]	184[b]	8900[h]	LW-1
S V	786.470	5.20	27[c]	61[d]	1760[h]	LW-1
O VI	1031.914	5.50	328[a]	2460[b]	8110[h]	LW-2
Ne VII	465.22	5.75	120[b]	989[b]	4760[h]	LW-2 (2)
Ne VIII	770.428	5.85	54[b]	600[b]	3170[h]	LW-1
Fe IX	171.073	5.90	892[c]	8400[d]	30600[h]	SW
Fe X	174.531	6.05	406[c]	5320[d]	16300[h]	SW
Fe XI	180.408	6.15	251[c]	4380[d]	13300[h]	SW
Fe XII	195.119	6.20	174[c]	3890[d]	12300[h]	SW
Fe XIII	202.044	6.25	41[c]	1248[e]	3960[h]	SW
Si XII	520.666	6.25	22[c]	1130[f]	6790[h]	LW-2 (2)
Fe XIV	211.317	6.30	73[c]	1720[f]	10500[h]	SW
Ca XIV	193.974	6.55	—	312[e]	766[h]	SW
Ca XIV	943.587	6.55	—	7.3[f]	18[h]	LW-2
Ca XV	200.972	6.65	—	239[e]	751[h]	SW
Ca XVI	208.604	6.70	—	122[e]	946[h]	SW
Ca XVII	192.858	6.75	—	147[e]	3780[h]	SW
Fe XVIII	974.860	6.80	—	88[f]	[illegible]	LW-2
Fe XIX	592.236	7.00	—	9.3[f]	1530[h]	[illegible]
Fe XIX	1118.07	7.00	—	8.6[f]	1500[h]	LW-3
Fe XX	721.559	7.05	—	—	1580[h]	LW-1
Fe XXI	786.162	7.10	—	—	178[h]	LW-1
Fe XXII	845.57	7.10	—	—	2180[h]	LW-1
Fe XXIV	192.03	7.20	—	—	18100[h]	SW



Synergies with Solar Orbiter and Metis

Objective I: Understand how fundamental processes lead to the formation of the solar atmosphere and the solar wind

Objective II: Understand how the solar atmosphere becomes unstable, releasing the energy that drives solar flares and eruptions



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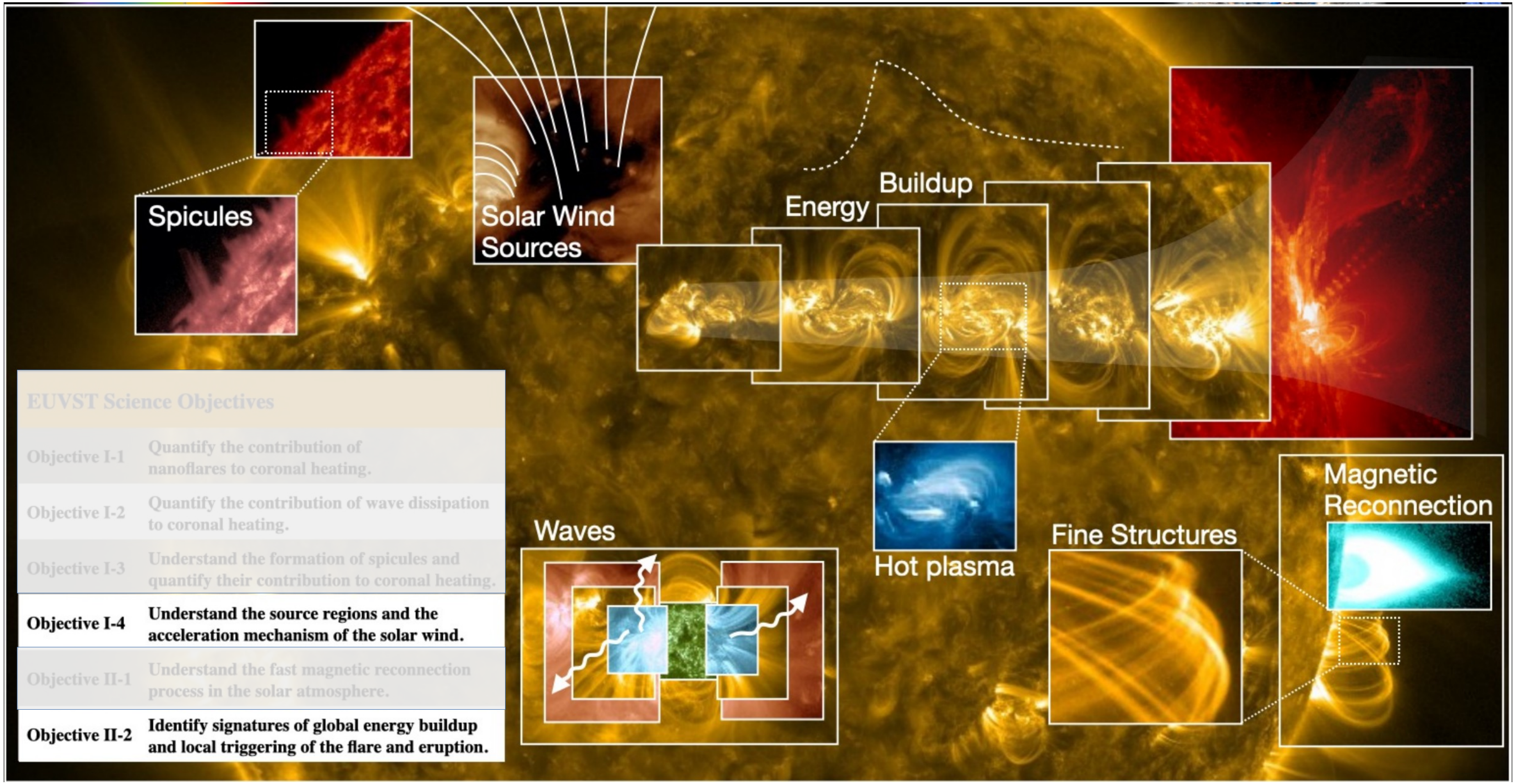

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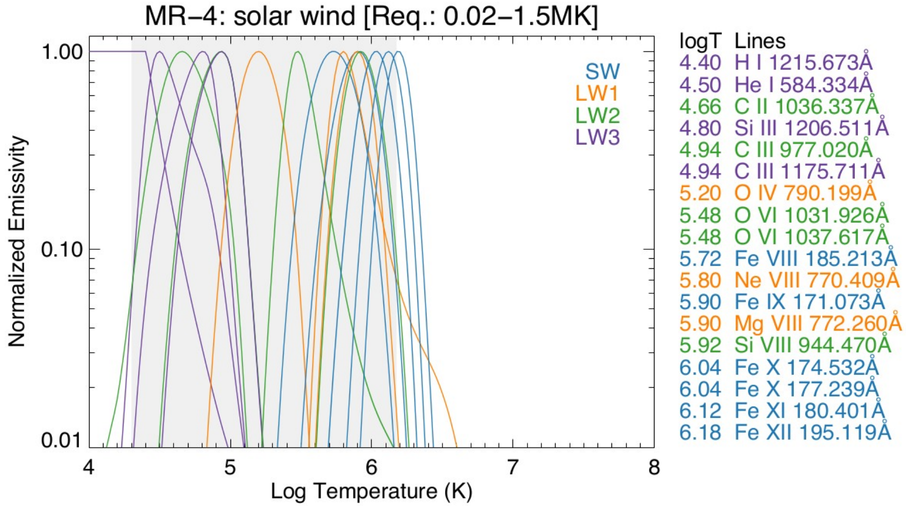
Objective II-2	**Identify signatures of global energy buildup and local triggering of the flare and eruption.**

Synergies: Objective I-4 (Solar Wind)

- The source regions of the fast and slow solar wind are still under debate.
- Scenarios: plumes, inter-plumes, jets (fast wind), interchange reconn., ARs, streamers (slow wind).
- Challenge: very long exposures needed to observe faint, open-field structures.
- Task 1: Observe v, T, N_e, and composition of source regions ⇔ magnetic field structures
- Task 2a: Detect signatures of propagating coronal Alfvén waves in plume and inter-plume region
- Task 2b: Measure energy fluxes with height



KEY FACTORS

- Comprehensive temperature evolution
- Throughput (x10) ⇒ weak sources
- Synergy with Solar Orbiter and Parker

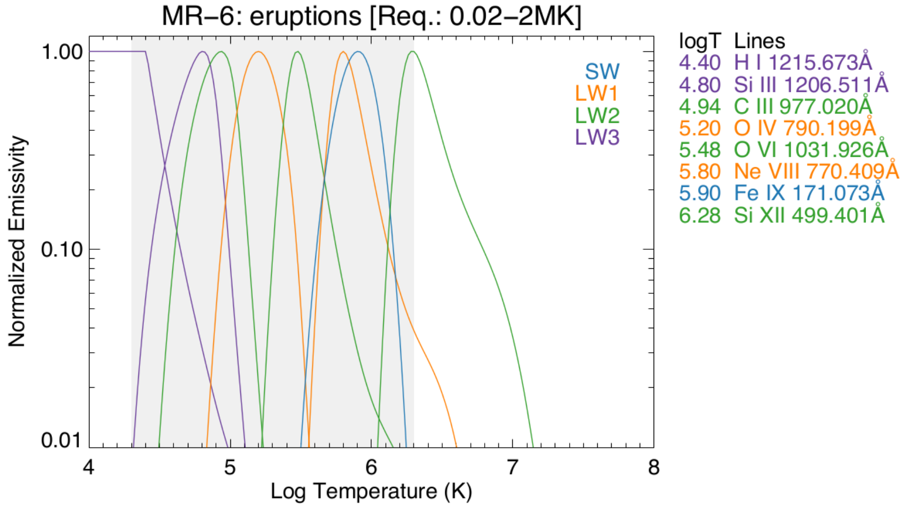
(Source: I. Ugarte)

Synergies: Objective I-6 (Energy Buildup)

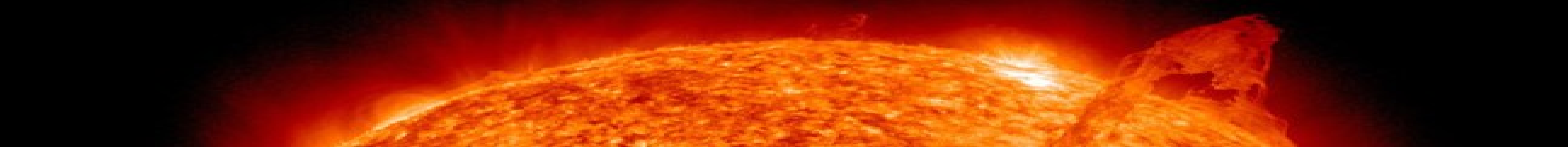
- Lack of spectroscopic monitoring of active regions in timescales of minutes over full T range.
- Flare predictions based on magnetic field!, but spectroscopy mostly untried due to the absence of suitable data-sets.
- Task 1: Monitor long-term, large-scale evolution of ARS ⇒ spectroscopic signatures of E buildup.
- Task 2: Characterize the dynamics of small-scale magnetic structures that trigger eruptions

KEY FACTORS

- Comprehensive temperature evolution
- Throughput (x10) ⇒ fast cadence (0.5s)
- 0.4” resolution ⇒ fine structure
- Slit-jaw imaging ⇒ morphology + alignment



(Source: I. Ugarte)



Thank you for your attention