Unlocking coronal plasma diagnostics with Solar-C/EUVST : nanometer-level optical metrology of the grating assembly

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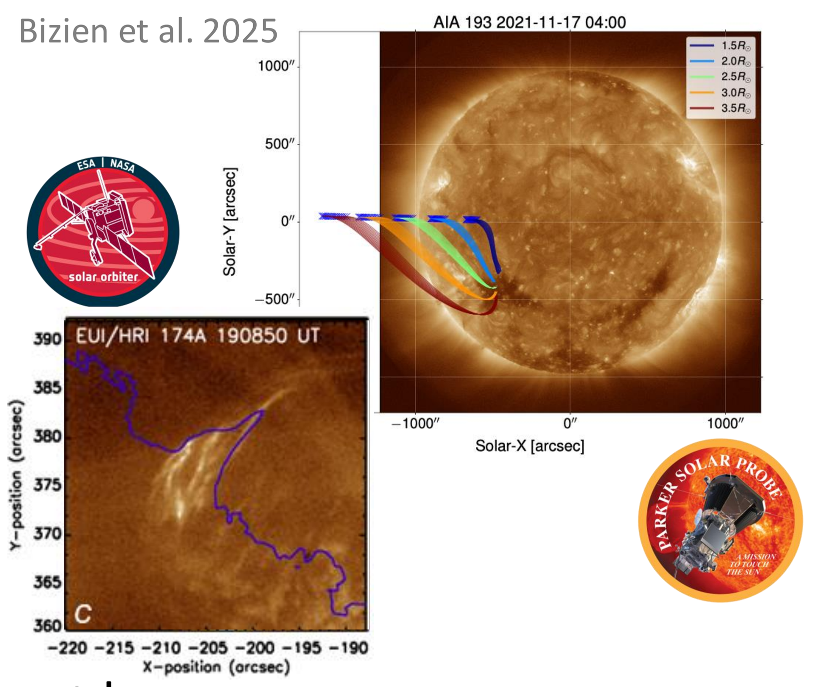
Context: Coronal dynamics: an open question

Jets and small-scale eruptions are thought to play a key role in coronal heating and solar wind loading, through energy and mass transfer between the corona and the heliosphere.

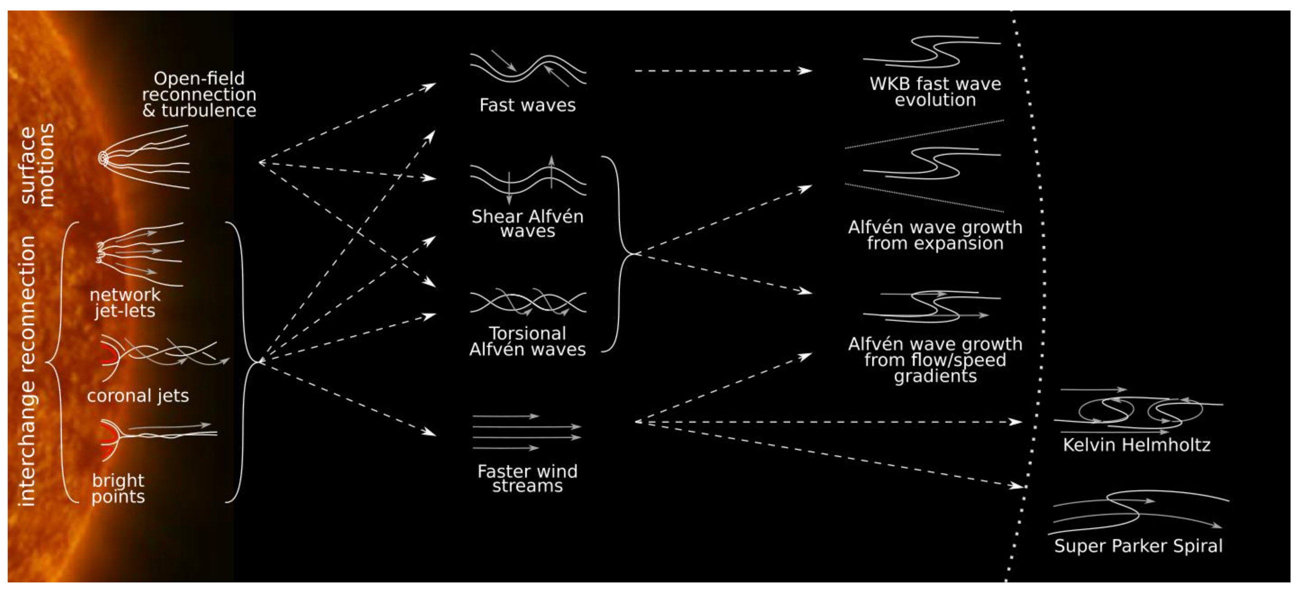
Recent advances from Parker Solar Probe and Solar Orbiter have opened a new window on these processes, yet establishing causal links between coronal transients and heliospheric structures remains highly debated (Bizien et al. 2025, Tripathi et al. in prep.).

Bizien et al. 2025



The plasma dynamics of these events cannot be directly measured without spectroscopic diagnostics:

- Plasma outflow velocities → mass and energy injection
- Thermal structure → reconnection and heating signatures
- Transient tracking→ causal links to heliospheric structures



Wyper et al. 2026

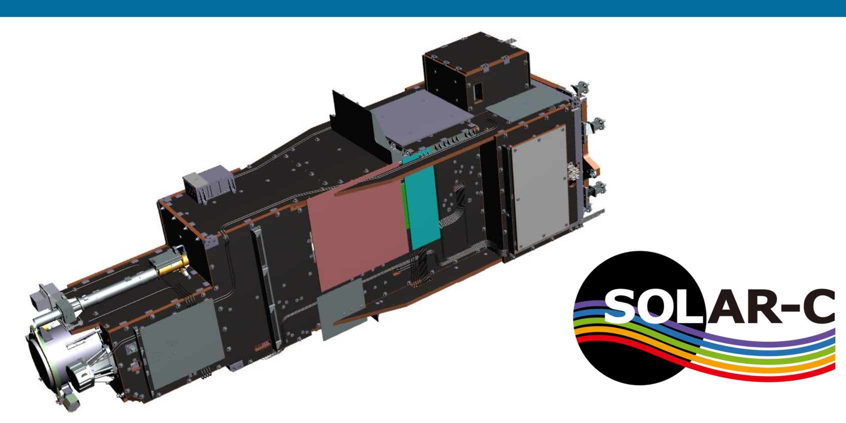
Multiple pathways to solar wind structures, rooted in coronal source regions

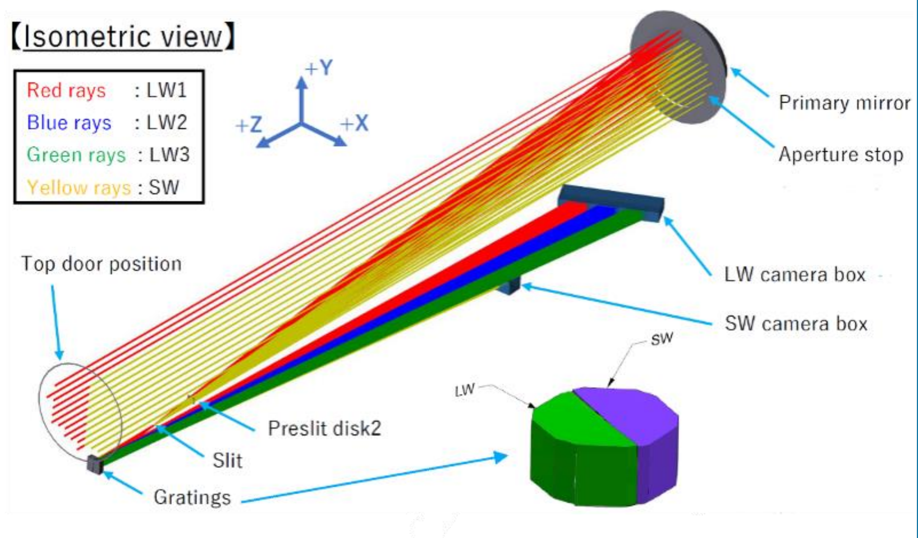
High-resolution EUV spectroscopy is the missing key.

Solar C/EUVST

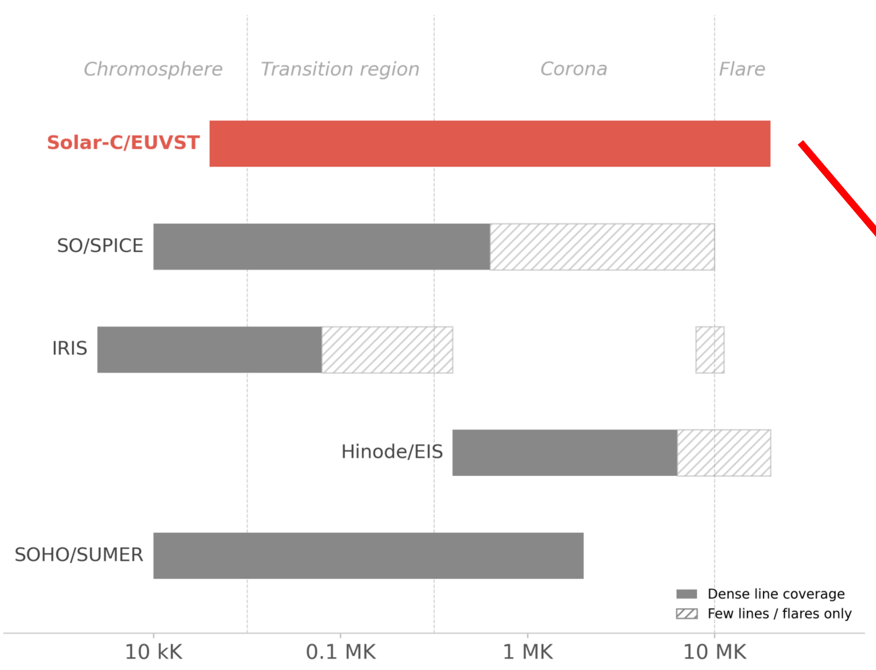
EUVST key capabilities:

- Spectral resolution : λ/Δλ ~ 10 000
- Spatial resolution : ~0.4 arcsec
- Wavelength range : 170 - 215 Å and 690 - 1270 Å
- Temporal resolution : ~0.5s/2 s (different observation modes)
- Doppler velocity sensitivity : down to ~3 km/s → direct measurement of plasma outflows in coronal jets





EUVST Optical design with grating



EUVST will trace the flow of energy from chromosphere to corona

Compared to existing EUV spectrographs, EUVST represents a leap forward in all key observational parameters:

Instrument	λ/Δλ	Spatial res.	Temporal res.
SOHO/SUMER	19000-40000	~1.5”	Minutes
Hinode/EIS	3000-4000	~3”	Minutes
IRIS	4000	0.35”	2s
Solar Orbiter/SPICE	2000	4”	5s
Solar-C/EUVST	10000	0.4”/0.8”	2s/0.5s

EUVST is the first EUV spectrograph to combine high spectral resolution with sub-arcsecond spatial resolution, enabling direct Doppler diagnostics of coronal plasma at the scale of elementary structures.

Instrumentation: Optical metrology at IAS

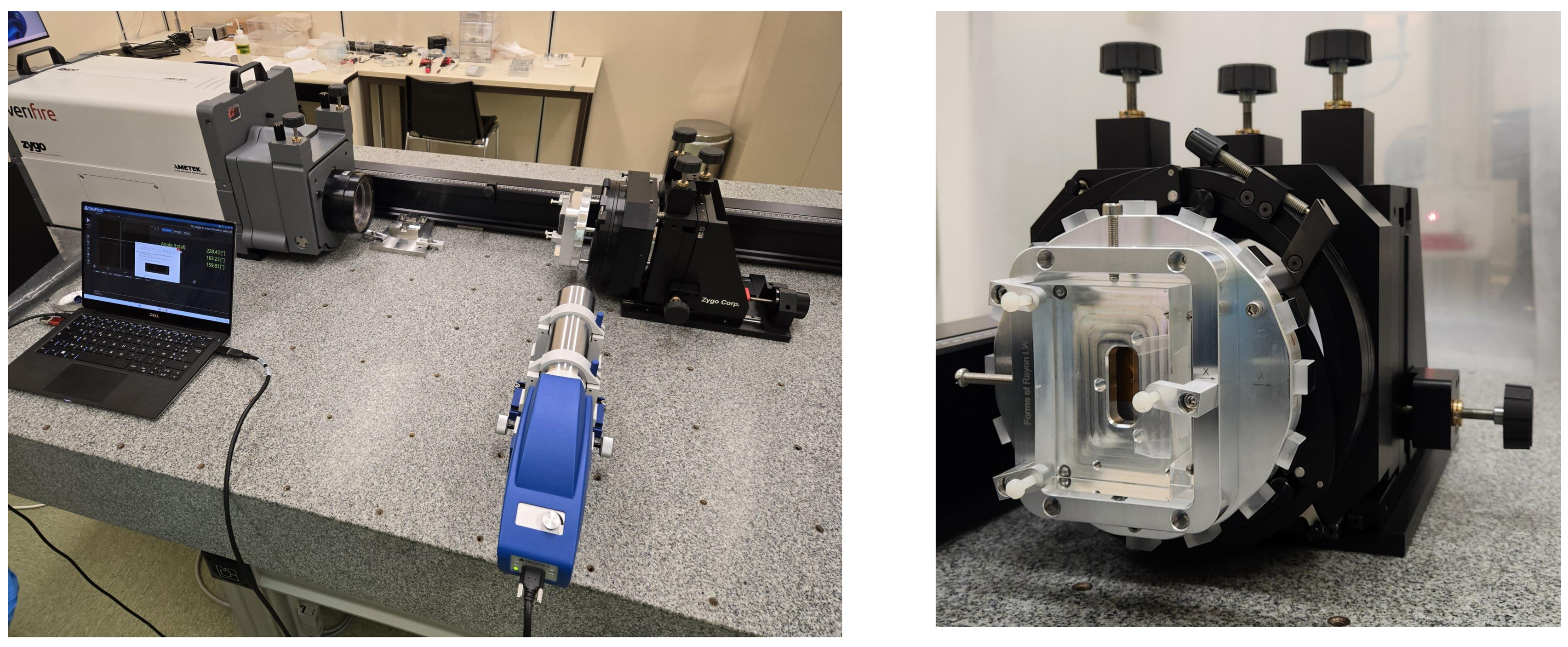
Achieving this spectral resolution requires nanometer-level surface quality on the grating substrates. Figure errors and slope errors directly degrade the wavefront, broadening spectral lines and reducing Doppler sensitivity.

Grating metrology at IAS:

Surface maps are acquired using a Fizeau interferometer (Zygo), providing nanometer-level height maps of the aspherical substrate surface.

IAS dedicated test benches achieve:

- 0,005% precision on radii of curvature
- 5’’ precision on the surface tilt
- <1 nm precision on the surface figure error



Fizeau interferometer setup (Zygo)

Surface characterization:

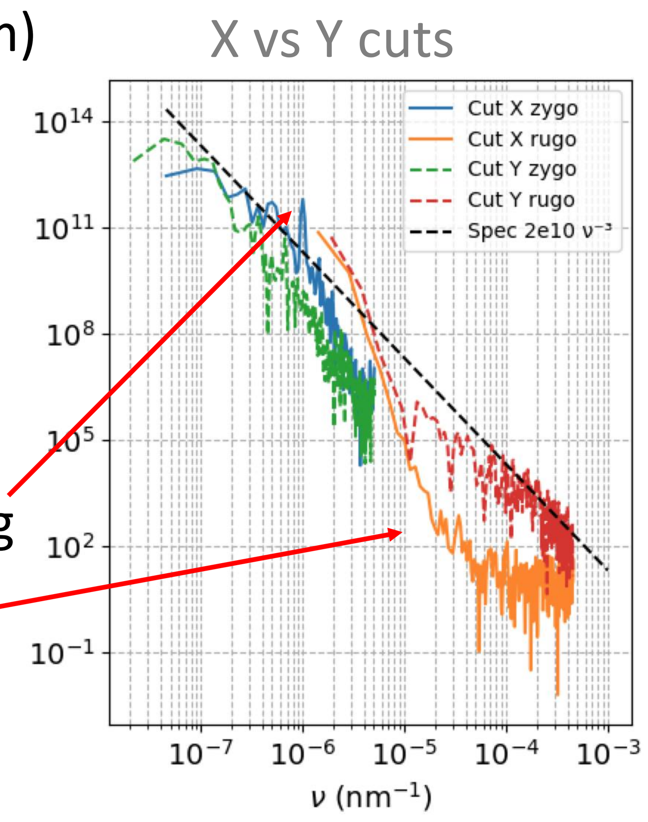
- Full surface map → global figure error, tilt, curvature
- Useful area map → RMS figure error directly comparable to spec

Results:

- Surface Figure Error: 6-8 nm RMS (spec: < 5 nm)
  - →Iterative polishing ongoing and converging
  - → IAS setup detects bias in provider SFE measurements
- Roughness: 0.62 nm RMS (spec: <0.4 nm)
  - →Known limitations of the polishing
- PSD analysis reveals:
  - → Periodic structures caused by the polishing technique
  - → Anisotropy at high frequencies

Power Spectral Density (PSD)

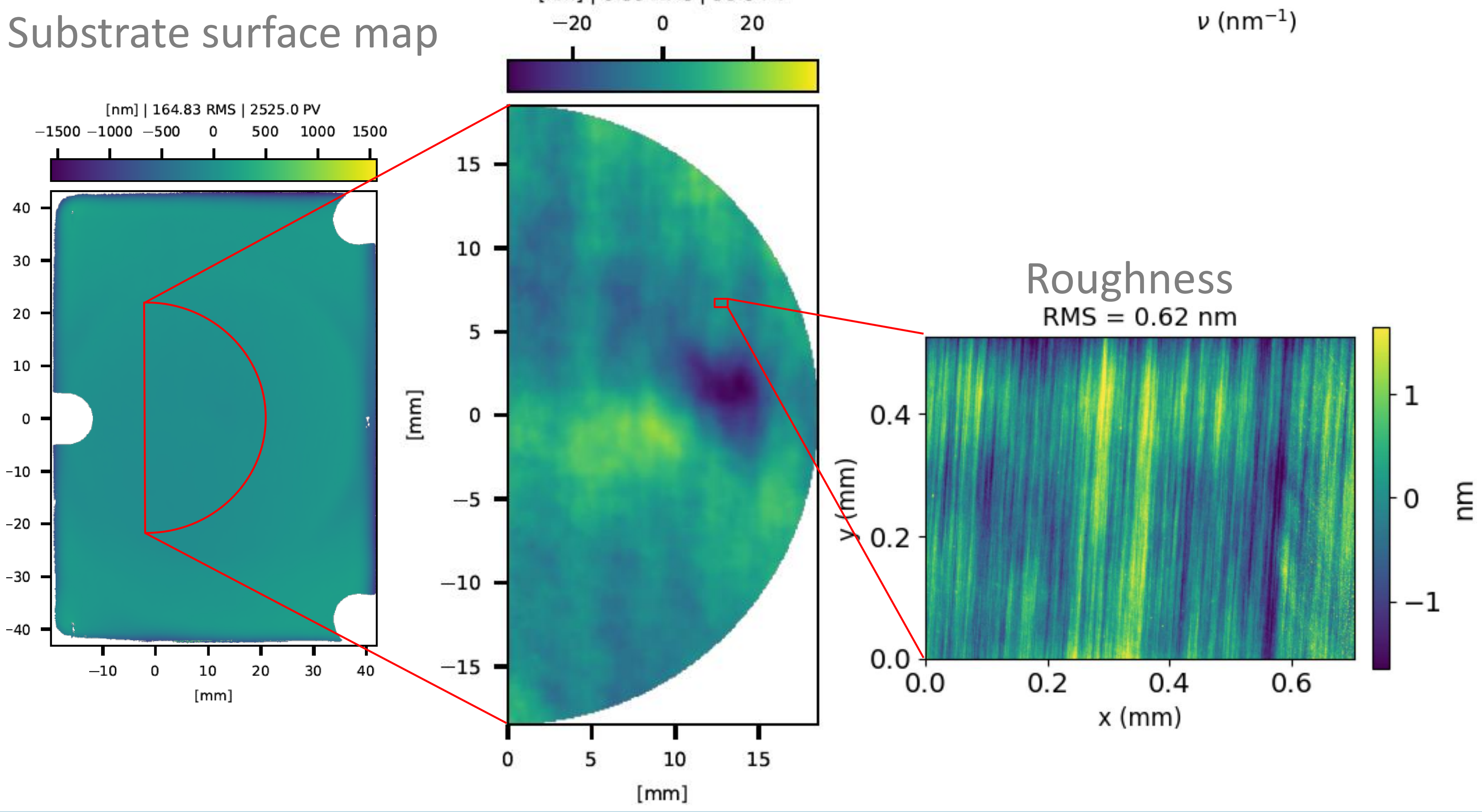
X vs Y cuts



Substrate surface map

Useful area map

Roughness



Coming next

Do coronal jets drive the switchbacks observed by Parker Solar Probe?

EUVST will enable a direct test of this hypothesis, by measuring ejection velocities and thermal signatures in coronal source regions, and investigating a statistically robust causal link between coronal transients and heliospheric structures.

Before launch, statistical study of coronal jet / switchback associations using Solar Orbiter and PSP data, in preparation for EUVST observations.

EGA Grating Assembly:

The EGA mechanical mount enables precise alignment on ground and in-flight active control.

Launch: June 2031