

# European Solar Telescope for space weather

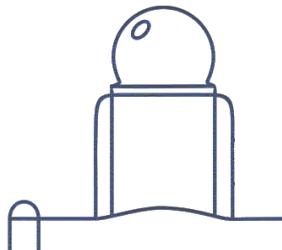


OFRAIME Space Weather Days 2026 ; Grenoble, Fr ; Feb. 10<sup>th</sup> 2026



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# Major ground-based solar telescopes & projects



Facility	Aperture	1st light	Country
DST	0.8 m	1969	USA
VTT	0.7 m	1989	Germany
THEMIS	0.9 m	1996	France (form. Italy)
SST	1.0 m	2002	Sweden (& Norway)
GST	1.6 m	2008	USA
NVST	1.0 m	2010	China
GREGOR	1.5 m	2012	Germany
DKIST	4.0 m	2022	USA
CLST	1.8 m	?	China

Facility	Aperture	Status	Country
WeHoST	2.5 m	Construction	China
EST	4.2 m	Project	EU
NST	2.0 m	Project	India
GCST	8.0 m	Project	China

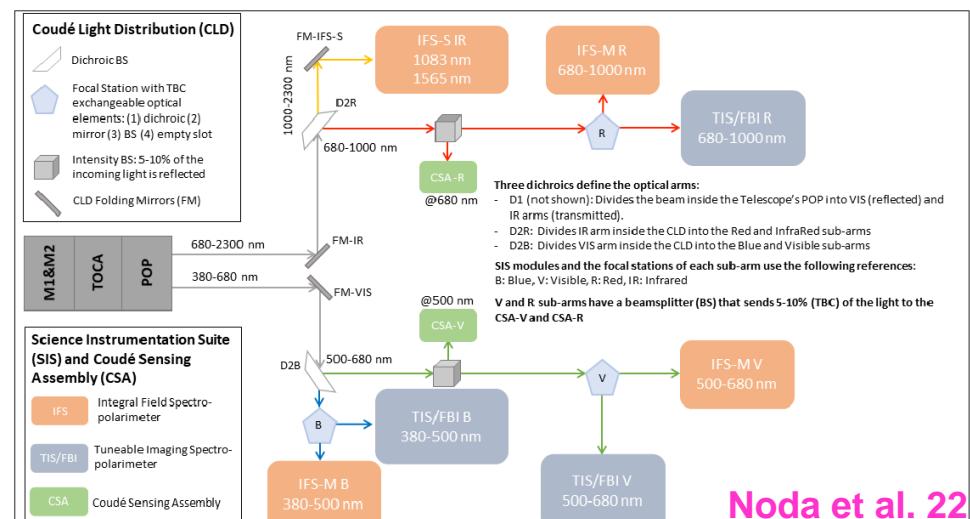
- **European ground-based solar telescope landscape presently dominated by aging national facilities.**
- Strategic risks :
  - Lost of expertise in historic leadership in visible-IR in high-resolution solar physics → impact on space instrumentation developments in spectropolarimetry, driven by ground-based
  - Reliance on non-EU high quality magnetic field measurements

# The European Solar Telescope (EST)

- **EST is the unique European project of the next-generation telescope for solar physics in the 21<sup>st</sup> century**
- Site: RQM observatory @ La Palma, Canarias, ES
- 4.2-m aperture
- State-of-the-art multi-conjugated adaptive optics
- Perform world-best multi-layer spectropolarimetry
  - On-axis design & simultaneous observations in IR, blue-, & red-white-light spectral ranges
- Seven innovative 1st-light instruments
  - State of the art Fabry-Perot spectro-imagers
  - Next-generation integral field units:
    - micro-lenses & optical fiber



Courtesy Socas-Navarro & EST foundation



Noda et al. 22

# Unique scientific opportunities offered by EST



- EST paper: **Noda et al. 22**
- Science Requirement Document (v3): **Schliechenmaier et al. 25**
- Highest-resolution solar physics
  - Resolving structure at 0.02";  
~ 20km on the sun
- **Highest-quality B field estimation**
  - World best spectropolarimetric measurements
- Simultaneous multi-layer observations in low-solar atmosphere
  - Suited to study energy transfers through the most complex layers of the solar atmosphere.
- **Sustain space weather research (this talk)**



Science Requirement Document (SRD)  
for the  
European Solar Telescope (EST)

3rd edition, December 2025

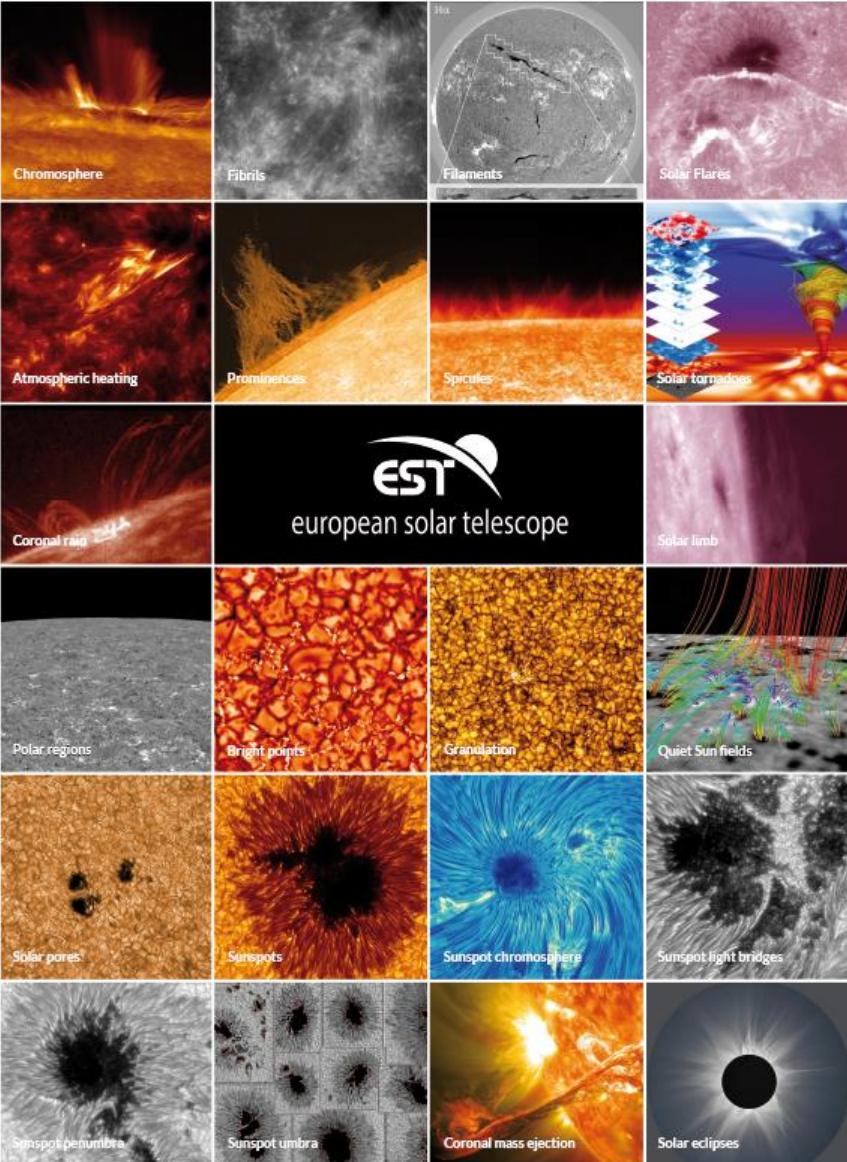
Schliechenmaier, R.<sup>1</sup>; Bellot Rubio, L.R.<sup>2</sup>; Collados, M.<sup>3,4</sup>; Erdelyi, R.<sup>5,6,27</sup>; Feller, A.<sup>7</sup>; Fletcher, L.<sup>8,13</sup>; Jurčák, J.<sup>9</sup>; Khomenko, E.<sup>10</sup>; Leenaarts, J.<sup>10</sup>; Mathews, S.<sup>11</sup>; Belluzzi, L.<sup>12,1</sup>; Carlsson, M.<sup>13,14</sup>; Danilovic, S.<sup>10</sup>; Gömöry, P.<sup>16</sup>; Kuckein, C.<sup>13</sup>; Manso Sainz, R.<sup>17</sup>; Martínez González, M.<sup>13</sup>; Mathioudakis, M.<sup>18</sup>; Ortiz, A.<sup>24,25</sup>; Riehmüller, T.L.<sup>7</sup>; Rouppe van der Voort, L.<sup>13,14</sup>; Simoes, P.J.A.<sup>19</sup>; Trujillo Bueno, J.<sup>3,20</sup>; Utz, D.<sup>21</sup>; Zuccarello, F.<sup>22</sup>; de la Cruz Rodriguez, J.<sup>10</sup>; Giovanelli, L.<sup>23</sup>; Jafarzadeh, S.<sup>18</sup>; Jess, D.B.<sup>18</sup>; Milic, I.<sup>1</sup>; Nelson, G.<sup>26</sup>; van Noort, M.<sup>7</sup>; Ruiz de Garreta, C.<sup>3</sup>; Zeuner, F.<sup>12</sup>

(Author affiliations given on page 2.)

arXiv:1912.08650v2 [astro-ph.SR] 18 Dec 2025

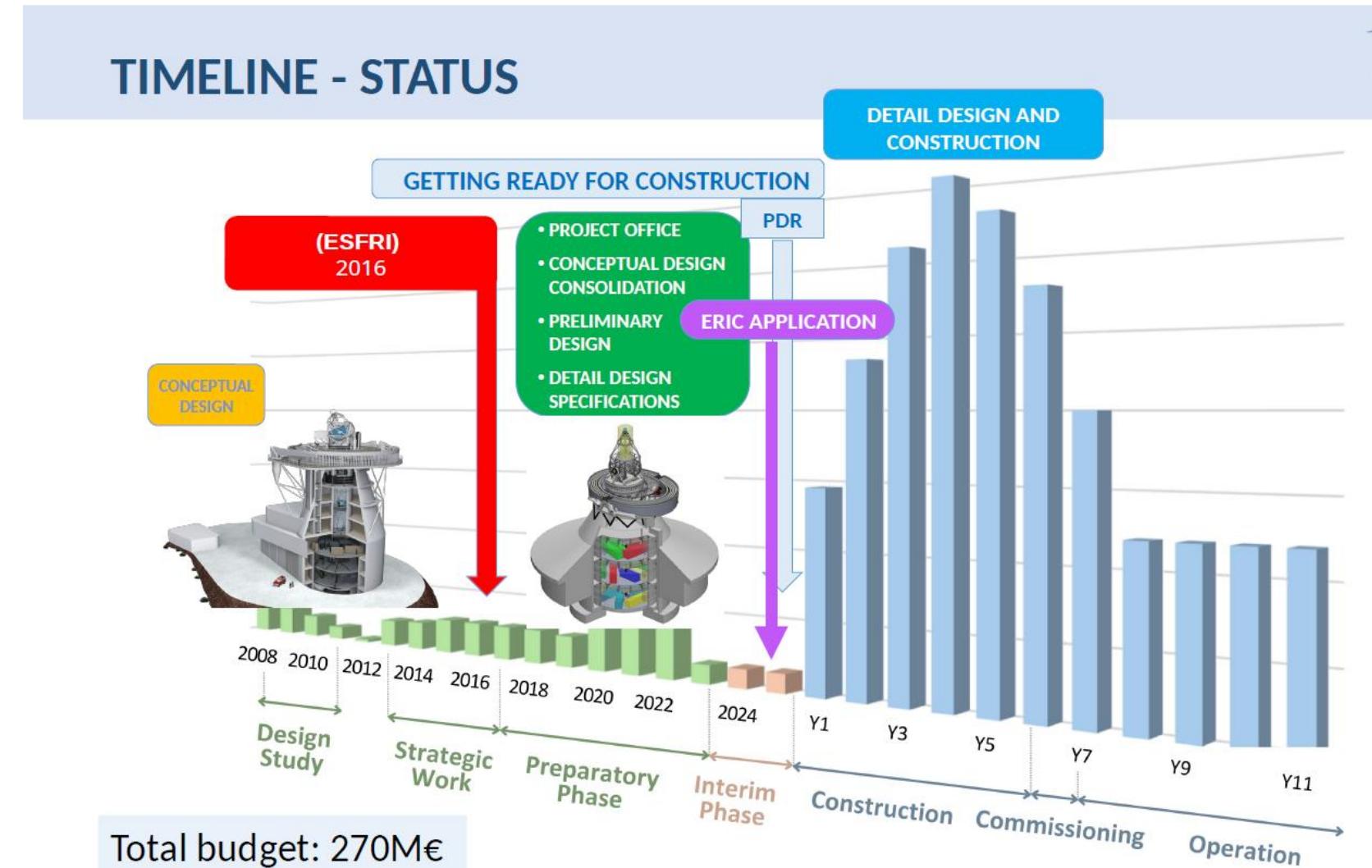


"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 739 500"



# EST Timeline

- EST is in the list of the ESFRI (European Strategy Forum on Research Infrastructures) since 2016
  - **ESFRI review in 2026!**
- EST listed as a high priority for ground-based observations by ASTRONET.
- **Creation of EST ERIC (European Research Infrastructure Consortium) presently being discussed**
  - 3 committed nations: Spain, Slovakia and Czech Republic.
  - ~40% of budget



# EST & France



- **French researchers from diverse laboratories (IRAP, LIRA, LPP, THEMIS, UNIDIA) have continuously been associated with the development of the EST project**
  - represented in the European Association for Solar Telescopes (EAST) since its creation 2006
  - MSDP concept proposed as 1<sup>st</sup> light instrument (**Malherbe et al. 2023**)
  - EST Conceptual Design
  - co-authors of EST main paper & EST SRD
- 2 EST-France workshops: 2010 & 2025
- **Strong interest of several French high-tech industry** (in optics): key expertise for EST construction  
→ guarantee return to investment for France
- **White paper**, largely written by young French scientists, **highlighting how EST will uniquely advance French research in solar physics and space weather.**

**Atelier EST France 2025**  
11-12 juin 2025 Paris (France)

Connexion

FR EN

**NAVIGATION**

- Accueil
- Annonce
- Inscription
- Nouveau dépôt
- Programme
- Plan d'accès
- Liste des participants

**SUPPORT**

- Contact

**OBJECTIFS**

L'European Solar Telescope (EST ; <https://est-east.eu/>) est un télescope solaire de nouvelle génération à grande ouverture. Avec un miroir primaire de 45 mètres, il sera possible d'obtenir des images de haute résolution spatiale et temporelle, en utilisant plusieurs instruments simultanément pour produire efficacement des informations spectrales en 2D. EST sera situé aux îles Canaries, un site de premier ordre pour les observations astronomiques. Ce projet, inscrit dans la feuille de route de l'European Strategic Forum for Research Infrastructure (ESFRI), est actuellement dans une phase cruciale de consolidation.

L'atelier EST France 2025, organisé avec le soutien de l'action thématique Soleil-Terre (ATST ; <https://atst.osugr.universite-paris-saclay.fr/>) de l'INSU/CNRS, vise à réunir les cadres européens d'EST avec les communautés françaises, scientifique et industrielle, intéressées par la mise en place du projet. L'atelier permettra la présentation du projet, son intérêt et son utilisation par la communauté française et des discussions sur la stratégie d'implémentation de la France dans le consortium scientifique d'EST.

Plusieurs présentations données lors de l'atelier sont publiquement disponibles ([Creative Commons CC BY-NC 4.0 license](#)) sur le site de dépôts de fichier dédié ([cliquez sur le lien](#)).

## White paper on the relevance of the European Solar Telescope (EST) for the French heliophysics community.

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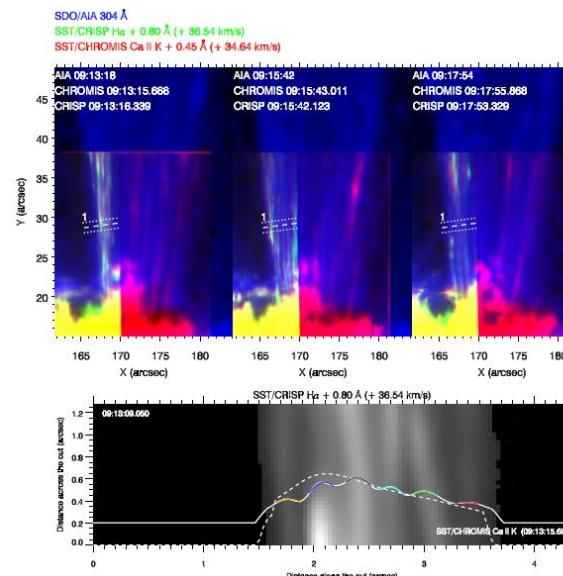
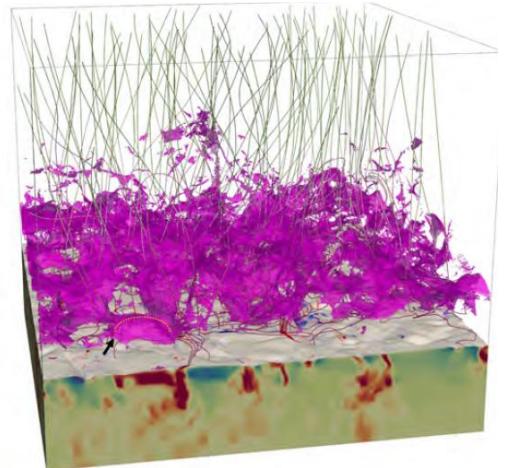
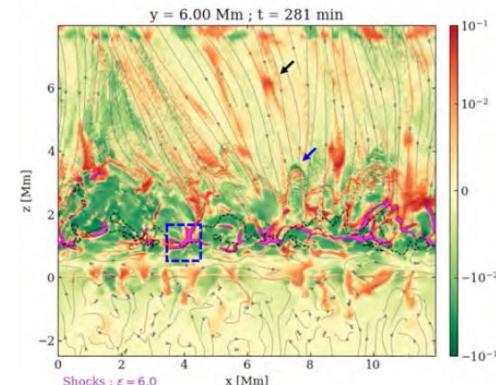
# EST science for French astrophysics community



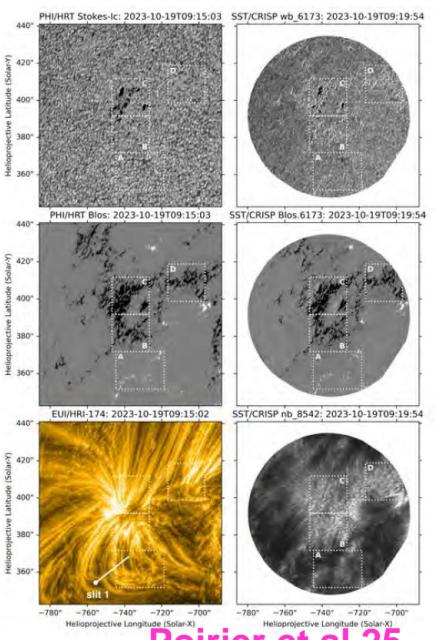
## • Solar Physics

- Observation & modelling of the granulation scales
- Magnetism of the Quiet-Sun
- High-fidelity measurements of electric currents
- Small-scale dynamics & heating of the chromosphere
- The photosphere-corona connection
- Coronal rain and its relationship with coronal heating mechanisms
- Low atmospheric signature of coronal eruptive phenomena
- Modulation of the helium abundance in the wind
- Transfer of heavy ions into the solar corona & wind

Noraz et al 26



Froment et al 20



Poirier et al 25

# EST science for French heliophysics community



- EST for space weathers applications

Main cons:

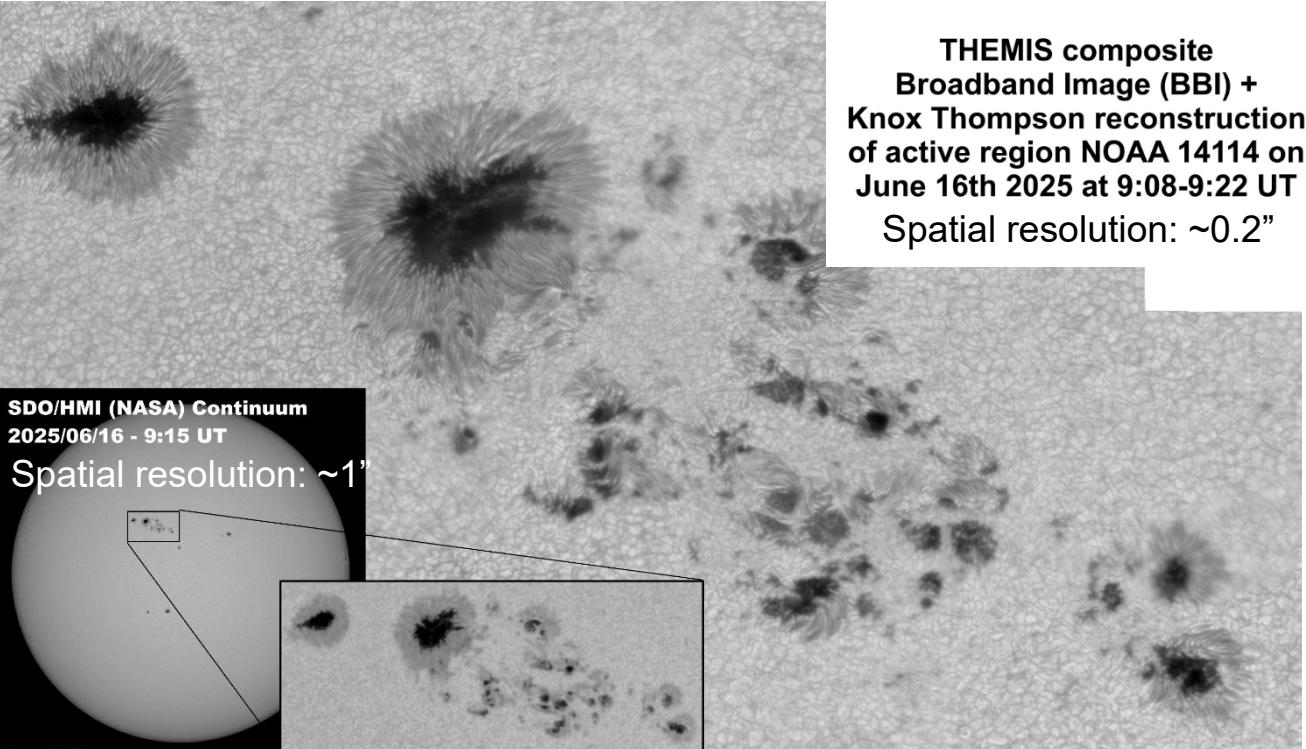
- Observation limited to daylight and quality affected by seeing
- FOV very limited: 1'-2': ~ 50-100 Mm on Sun

Main pro:

- High spatial res.: 0.02"-0.03"~20 km on Sun
- **Ground-based instruments can reach unrivaled resolution, in particular in region prone to solar eruptions**
- high-spectral & high-temporal resolution high-polarimetric sensitivity → high quality measurements.

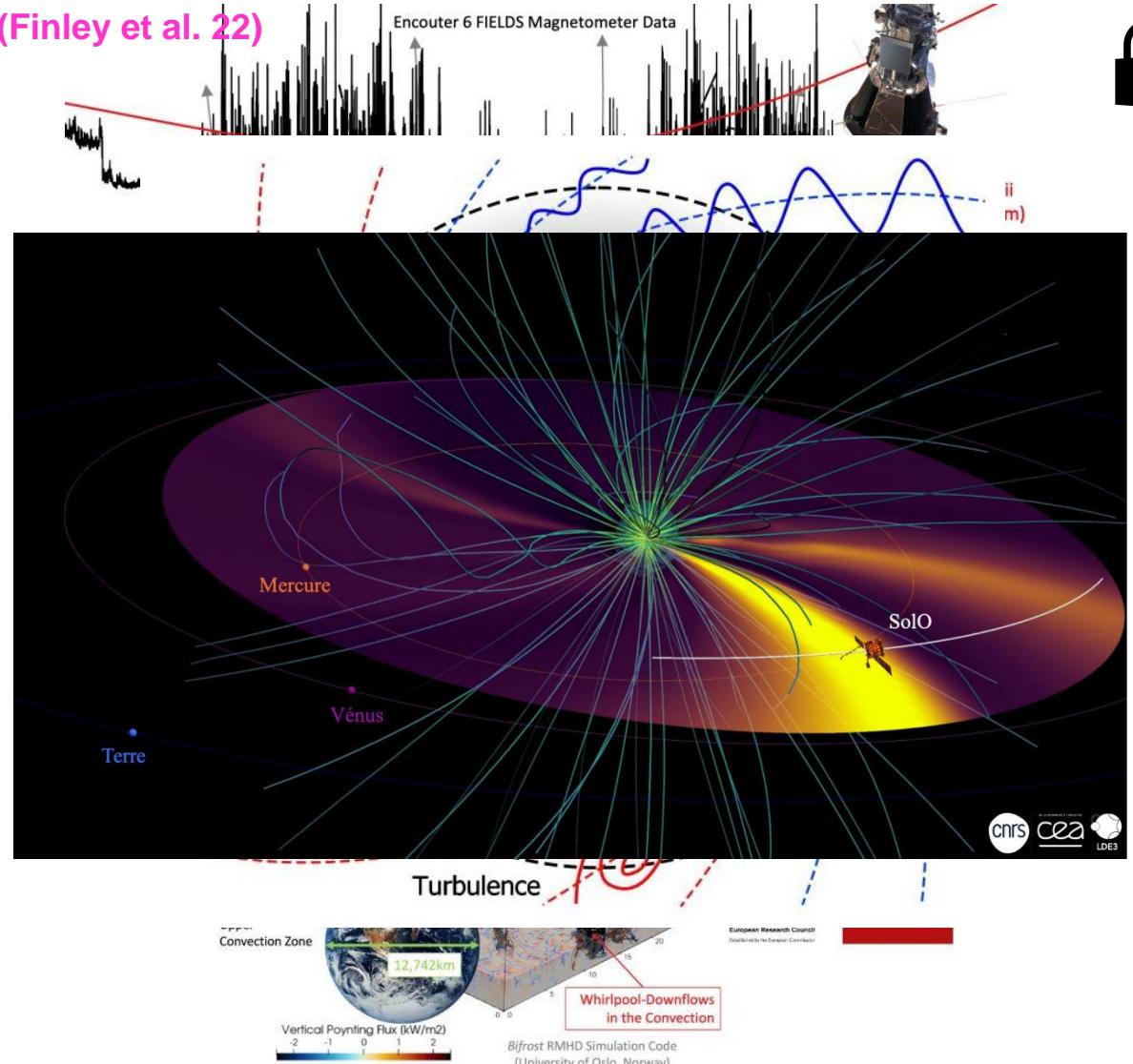
- **Unique SW topic addressed by EST**

- **Pariat et al. 2026**
- **See also presentation of B. Perri at the EST France 2025 Workshop**



- Constraints for solar wind modeling
- Monitoring of active nests
- High-resolution characterization of CME filaments
- Improving active region **B** reconstructions
- Anticipation of solar eruptions

# EST and solar wind modelling



**Need to understand solar wind structure and heating in order to predict correctly the trajectory of transients**

Magnetic transfers between the various solar layers affect the **structure of the large-scale interplanetary magnetic field + heating** that leads to the final **speed**

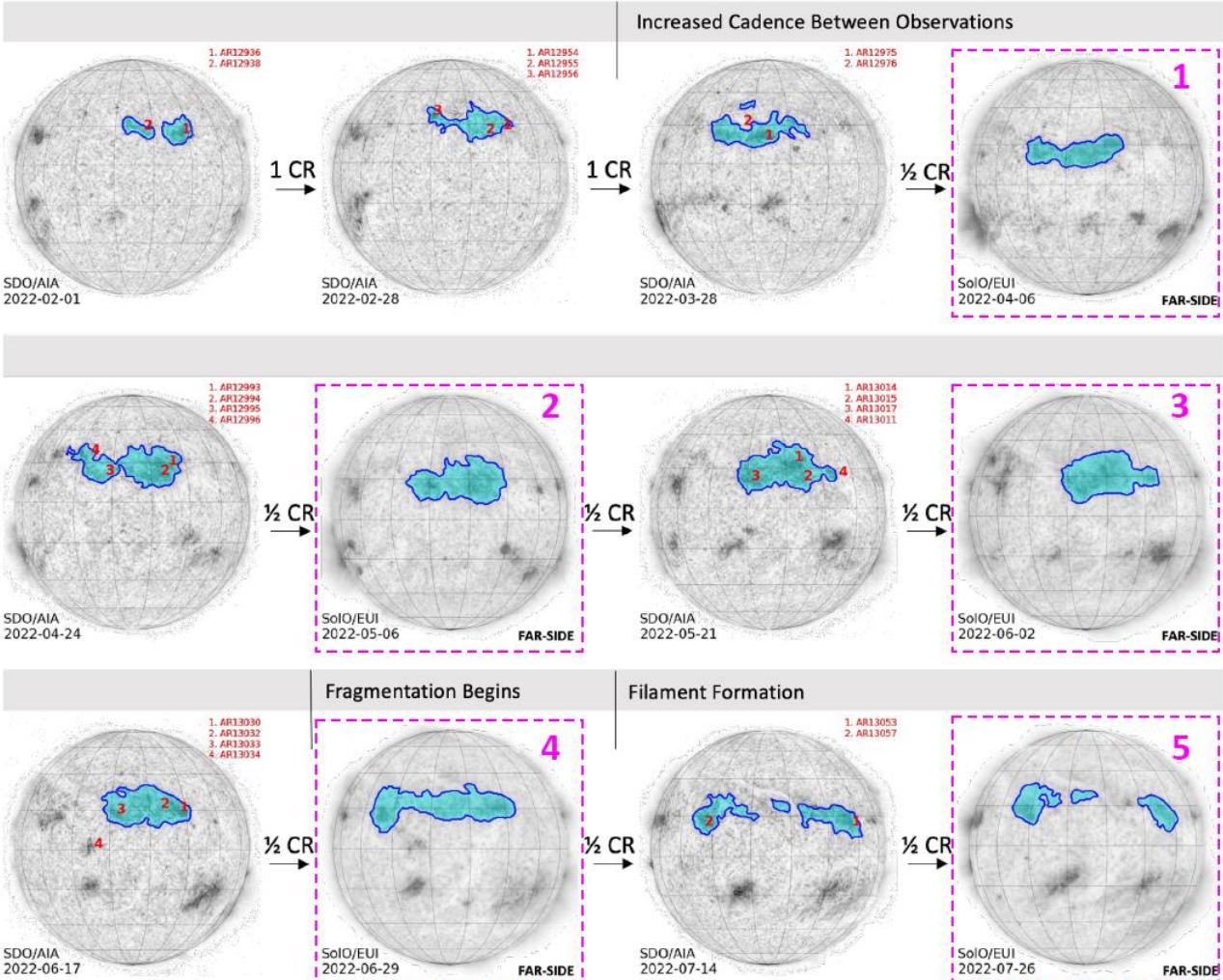
→ Need to couple **small to large spatial scales** in the solar atmosphere (with codes such as **Wind Predict** and **Wind Predict-AW**)

(Réville et al. 2015, 2020, Perri et al. 18)

**By providing high-resolution measurements of the photospheric magnetic field, especially at the borders of active structures, EST will help the French community to improve their previsions of solar connectivity.**

# Track & monitor early emergence in active nests

- AR emergence is driven by the underlying solar dynamo
- Almost 50% of ARs appear close to another AR (Schrijver & Zwaan 2008), in magnetically active zones, called **active nests, that can survive several solar rotations**.
- **Finley et al. 25**: 6 months tracking of an active nest that contributed up to 70% of the total solar flaring activity.
- Magnetic flux emergence starts at small scale and is difficult to capture with low-spatial resolution instrument
  - → **needs of long term monitoring of active region, at high resolution, in synergy with space observations**
  - **EST can fill such observation needs**

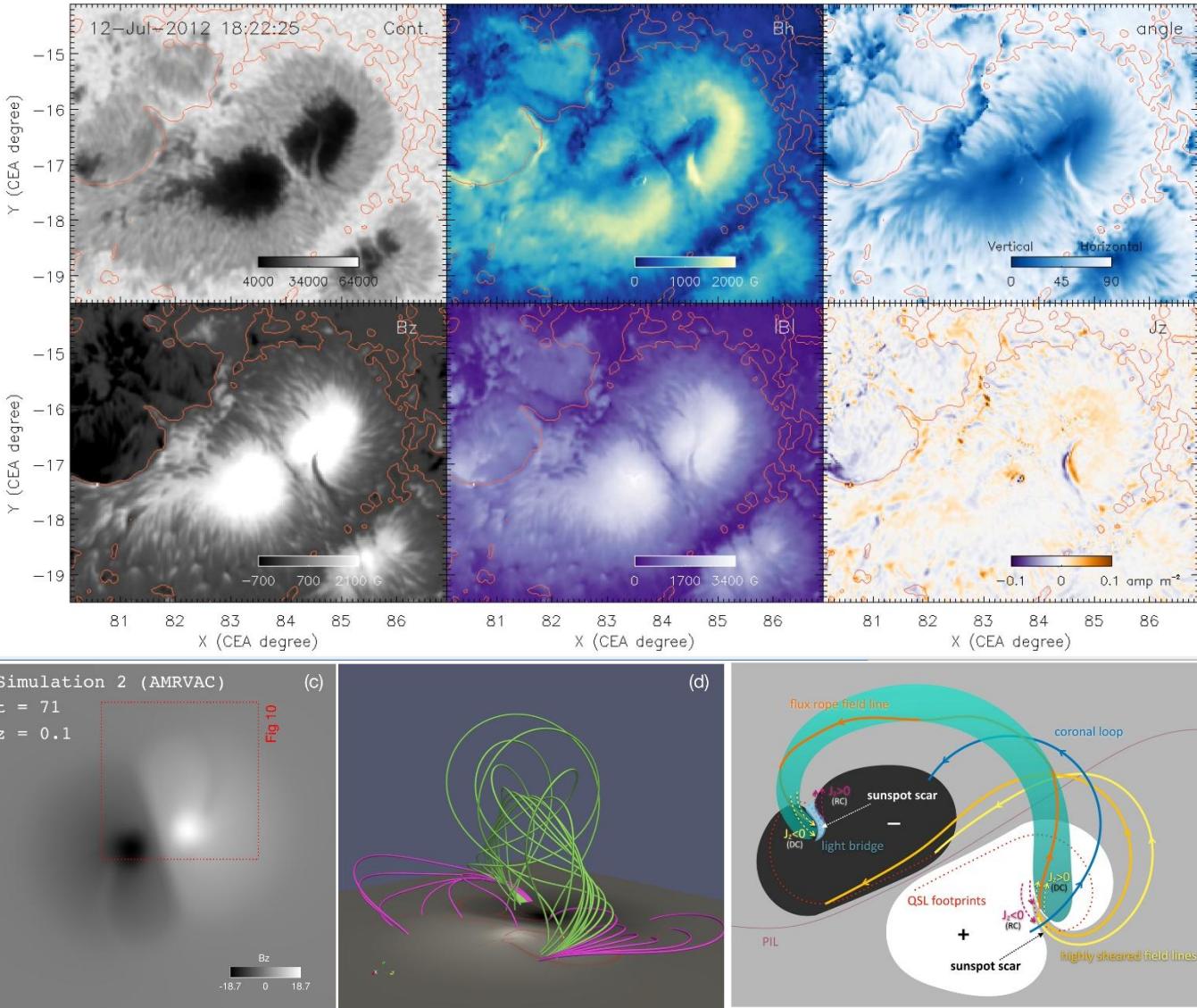


(Finley et al. 25)

# Active region « scars » as flux rope indicators



- Flux rope in active region are key pre-eruptive magnetic structure
  - Determining their presence has been very elusive so far
- **Xing, Aulanier, et al. 24** : « Sunspot scar », arc-shaped structure wedges into a sunspot, marks the edge of the pre-eruptive flux rope footpoint
  - Usually difficult to observe
- **EST will possess the quality and precision to detect this strong pre-eruption indicators**
- **→ EST will improve early prevision of solar eruptions**



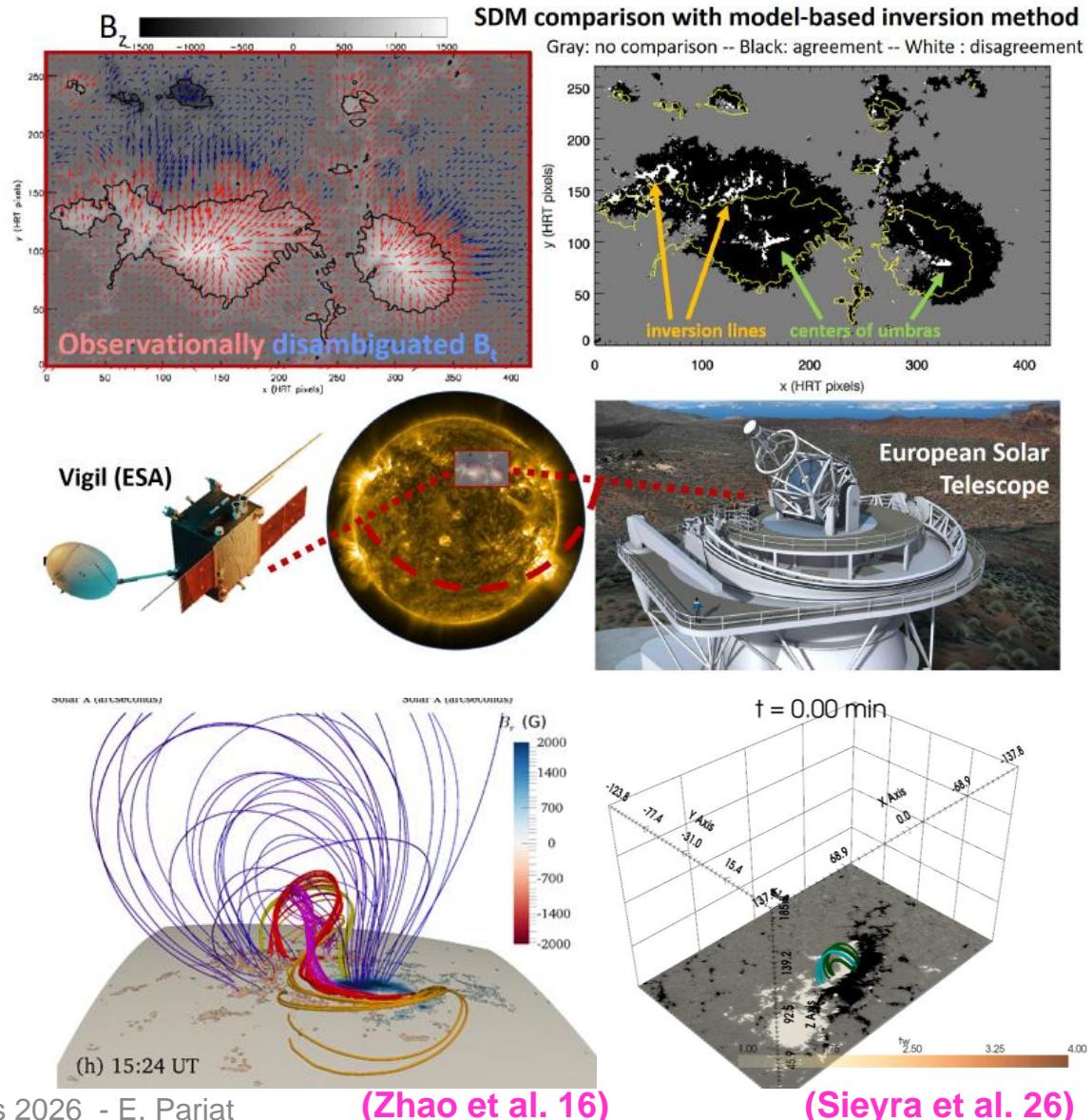
# Improve coronal magnetic field reconstructions



- **EST will provide B maps of the highest quality**

- Excellent polarimetric sensitivity
- High-spatial resolution
- Extensive sampling of spectral lines
- Synergic stereoscopic observation of EST & VIGIL will provide disambiguated  $B_{\text{trans}}$ 
  - SDM method (**Valori et al. 22, 23**)
- New generation of fast and efficient magnetic field inversion methods, relying on AI (**e.g. Asensio Ramos et al. 25, Diaz Baso et al. 25**)
- **EST will enable:**

- **ground breaking improvements in 3D reconstruction of the coronal B field from 2D photo. & chromo. magnetograms.**
- **High-fidelity representation of the magnetic structure & energy content of active centers**
- **Improved modelling of solar eruptions**



# Conclusions

## Relevance of EST observations for space weather activities:

### Anticipation

- **Monitoring of ARs nests & flux emergence**
- **High-resolution monitoring of ARs**  
→ Identification of «scars », e.g. flux rope markers
- High-res. & high-quality **B** field measurements  
→ **next generation coronal B reconstruction of eruption source regions**

### Geo-effectiveness

- High-resolution obs. & **B** field measurements at filaments  
→  **$B_z$  of CMEs**
- Studies of magnetic perturbations transferred between solar layers  
→ **improve magnetic connectivity modeling**

### Impact

- **Next-generation magnetic reconstruction**  
→ High-fidelity energy budget of eruption source regions
- Studies of **energy transfers** from inner layers to the corona

# Conclusion : your support matters!

## White paper on the relevance of the European Solar Telescope (EST) for the French heliophysics community.

Contributing authors:

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Co-signing authors:

**! Your name here !**



- EST project at a crucial step: creation of an ERIC
  - Unlike with ESO & ESA, no specific EU agencies to finance directly such project
  - Funding is complex and results from states-by-states contribution
- **Call for support to a French participation to EST !** (cf. ATST newsletter)
  - Comments welcomed ; Not an engagement to personally use the data ;
  - Beneficial for whole heliophysics community
- **Support by co-signing the white paper:** <https://sdrive.cnrs.fr/s/g9qgFAESoiqXSeq>