



European Solar Telescope

The European Solar Telescope: Status and Perspectives

M. Collados and the EST Team

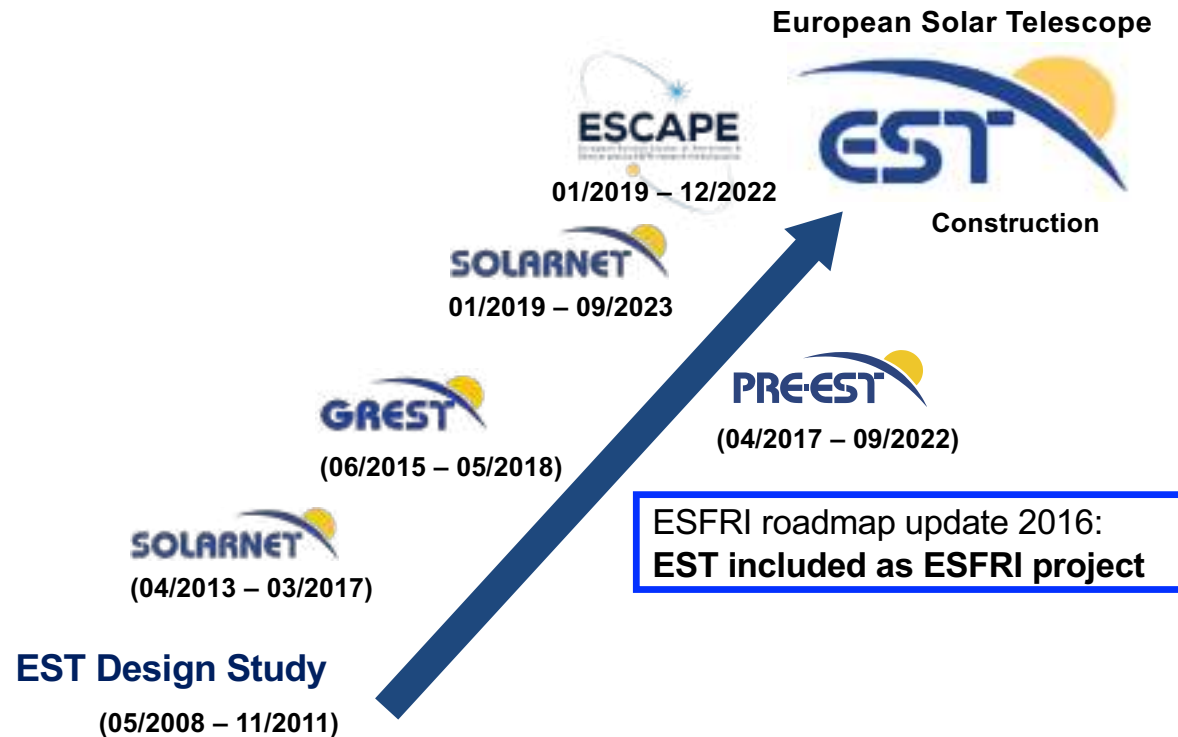


EST Consortium and trajectory



29 Institutions

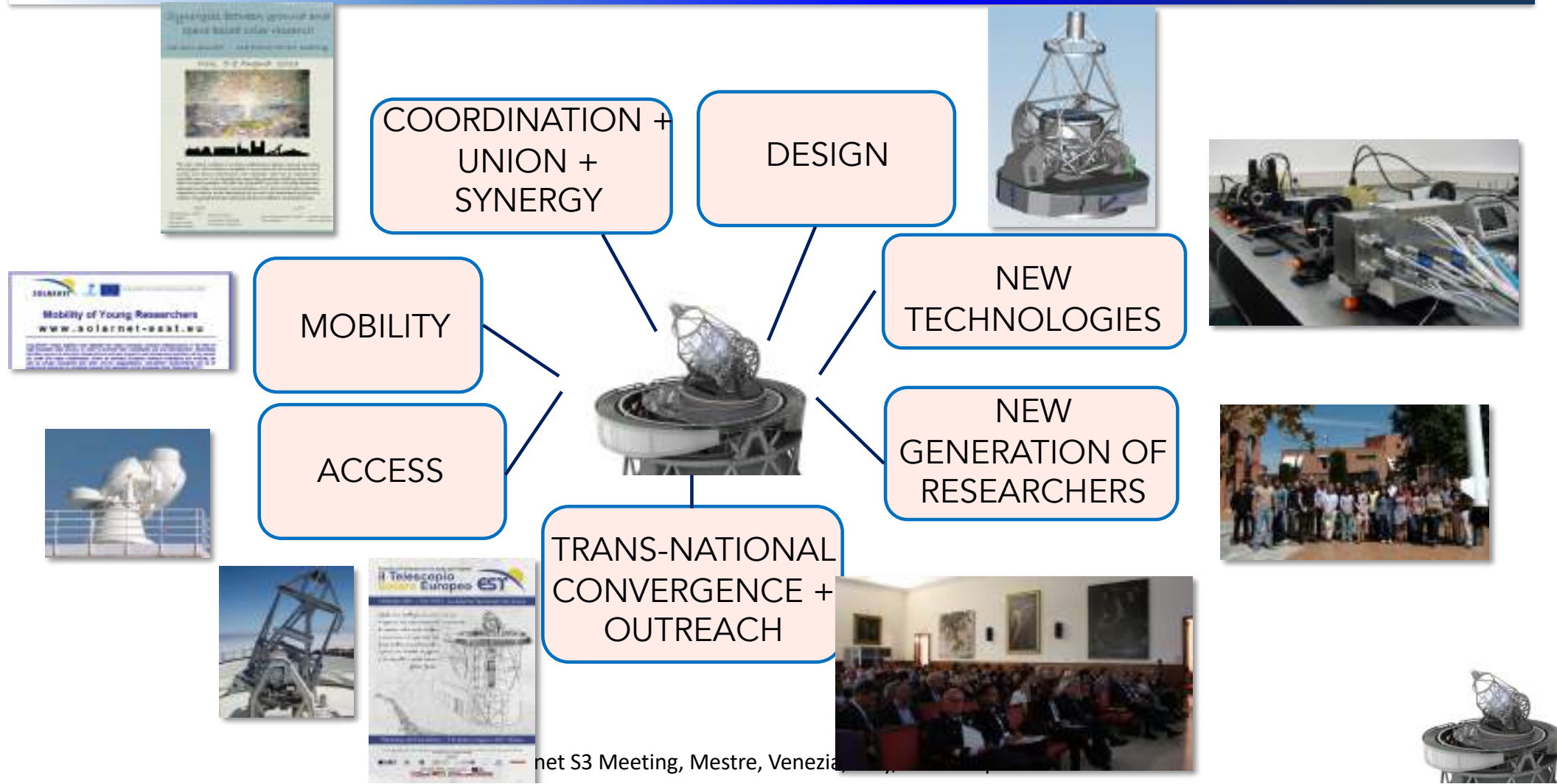
18 European countries



ESFRI roadmap update 2016:
EST included as ESFRI project



Creating synergies across Europe



ASTRONET Roadmap (2022-2035)



Ground-based facilities

Completion of the construction and commissioning of the ESO Extremely Large Telescope (ELT) and its first generation instruments, as well as that of the Square Kilometre Array (SKA) Phase 1 and its Regional Centres are of key strategic importance. Amongst new ground-based infrastructure projects requiring major funding decisions, three emerge as priorities: two of those (CTA, EST) have unique capabilities and receive strong support from their respective communities, with the third (wide-field spectroscopic facility for a 8-10m class telescope) being a more general facility with applications from planetary systems to cosmology.

- First, the **Cherenkov Telescope Array (CTA)** is an array of telescopes located across two sites on both hemispheres to detect very high energy gamma rays from black holes and other extreme phenomena. As the first true large-scale observatory targeting these energies, it is expected to lead to breakthroughs in our understanding of the origins and production of non-thermal particles in the Universe. The construction of CTA is expected to start soon and the recommendation is to bring it to completion in a timely fashion.

The other two recommendations correspond to two additional, equally ranked, priorities:

The **European Solar Telescope (EST)**, a 4m solar telescope to be built in the Canary Islands with first light expected by 2030. The EST will significantly increase our understanding of the solar magnetic field and its relations with the heliosphere and the Earth. Its completion and scientific exploitation in synergy with the US-based DKIST is a priority.

- A **general-purpose, wide-field, high multiplex spectroscopic facility**, for a telescope of the 8-10m class. Such a facility will enable a broad range of science investigations and help capitalise on other large investments by providing follow-up capabilities for facilities such as JWST, VRO and Euclid.

nature

[nature](#) > [news](#) > article

NEWS | 03 May 2023

'Einstein' telescope high on Europe's astronomy wish list

A massive gravitational-wave detector and the new solar telescope are among the priorities on funders' latest roadmap.

Among the recommended projects are a new wide-field spectroscopic telescope, support for the Einstein Telescope – a gravitational-wave detector still in development – and the European Solar Telescope, which will study the Sun's magnetic field. Space-based missions include a follow-up to the Gaia spacecraft that is mapping billions of stars.



European Solar Telescope (EST)
Credit: Gabriel Pérez (IAC)

...e, Venezia, Italy, 11-15 Sep 2023



EST main scientific goals



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

2nd edition, December 2019

Written by: Schlichenmaier, R.¹; Bellot Rubio, L.R.²; Collados, M.^{3,4}; Erdelyi, R.^{5,6}; Feller, A.⁷; Fletcher, L.^{8,13}; Jurčák, J.⁹; Khomenko, E.³; Leenaarts, J.¹⁰; Matthews, S.¹¹; Belluzzi, L.^{12,1}; Carlsson, M.^{13,14}; Dalmasse, K.¹⁵; Danilovic, S.¹⁶; Gömöry, P.¹⁶; Kuckein, Ch.¹⁷; Manso Sainz, R.⁷; Martínez González, M.⁷; Mathioudakis, M.¹⁸; Ortiz, A.^{13,14}; Rietmüller, T.L.⁷; Rouppe van der Voort, L.^{13,14}; Simoes, P.J.A.¹⁹; Trujillo Bueno, J.^{3,20}; Utz, D.^{2,21}; Zuccarello, F.²²

(Author affiliations given on page 3.)

<https://arxiv.org/pdf/1912.08650.pdf>

Discussed and approved by the EST Science Advisory Group (SAG)

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Solarnet S3 Meeting, Mestre, Venezia, Italy, 11-15 Sep 2023



EST main scientific goals



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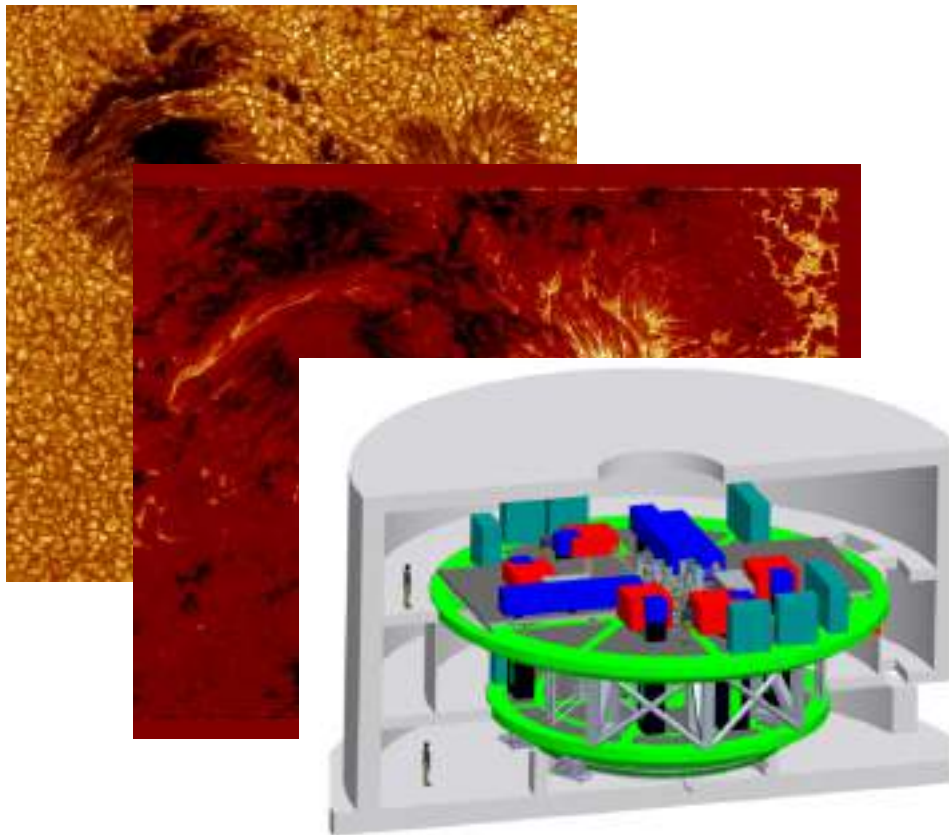
Discussed and approved by the EST Science Advisory Group (SAG)

Magnetic coupling of the solar atmosphere: from the deep photosphere up to the upper chromosphere

- Magnetic field emergence
- Energy transport and release
- Heating of the chromosphere
- Wave propagation, reconnection, ...
- Large-scale magnetic structures
- Polar magnetic fields
-



EST main performance

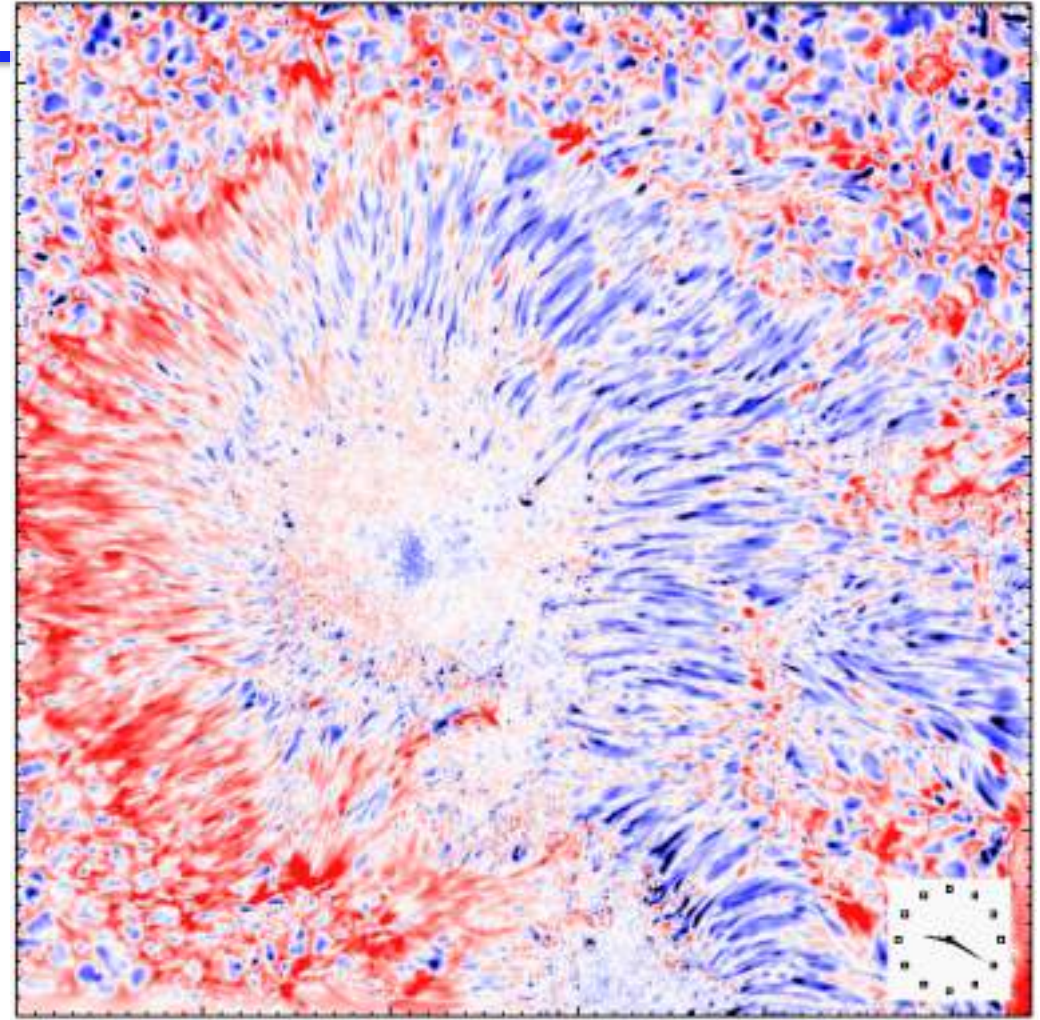
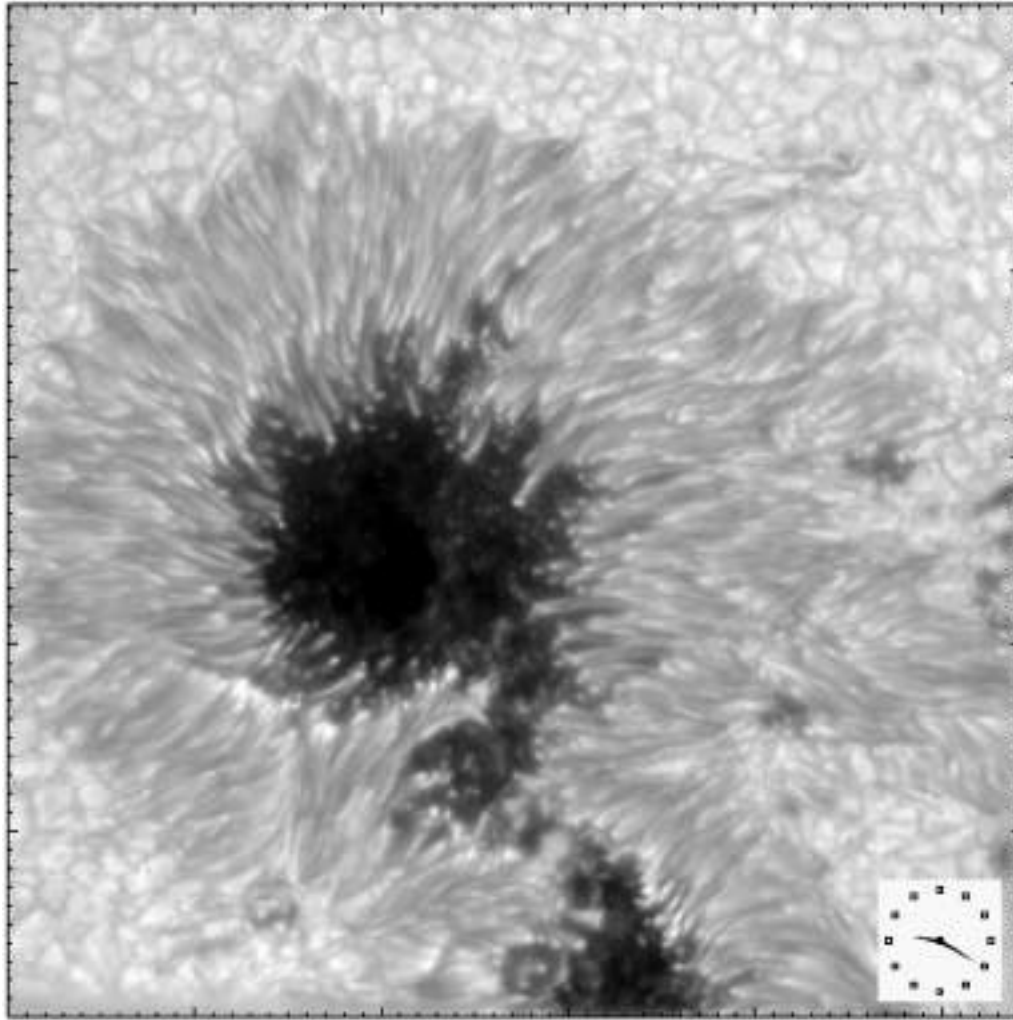


- Superb spatial resolution
- Excellent polarimetric performance
- Advanced set of instruments for multiwavelength imaging and spectropolarimetry

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Photosphere

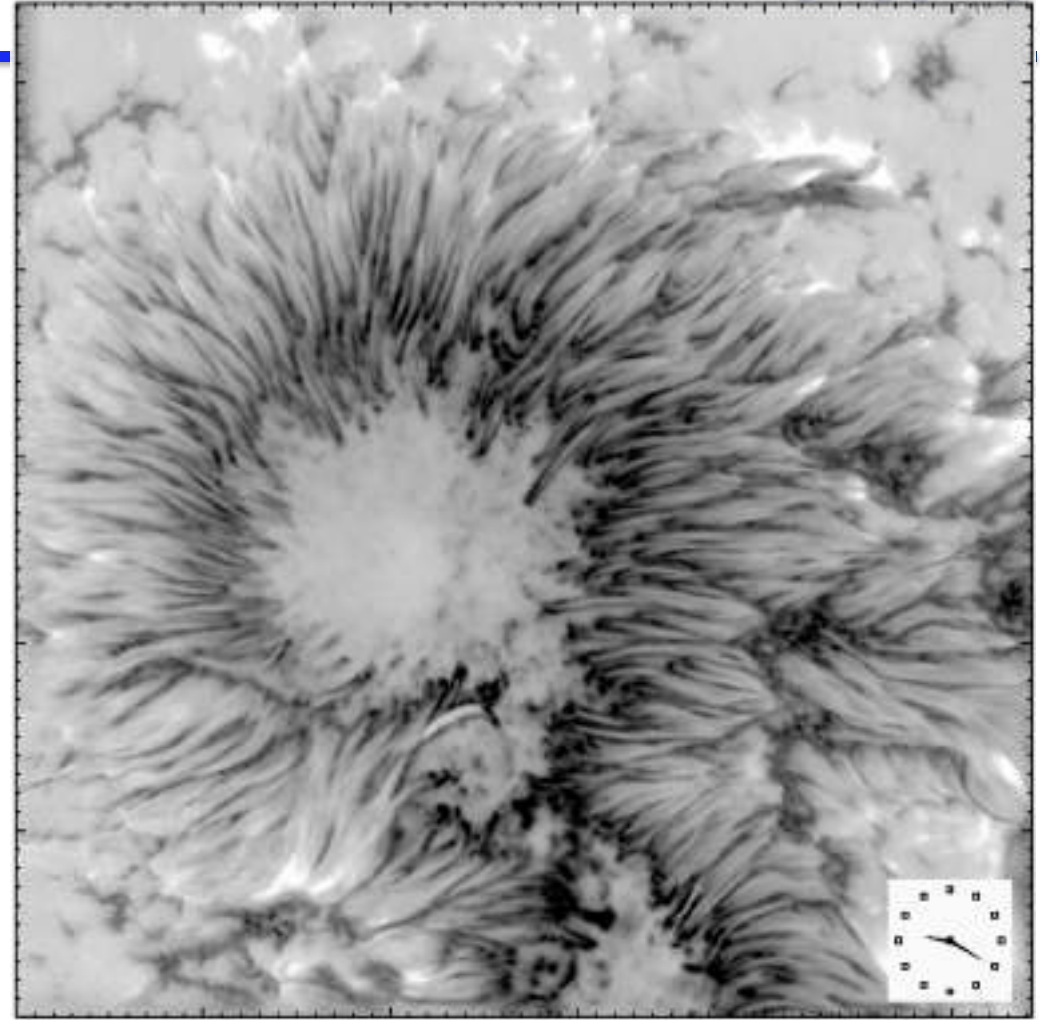
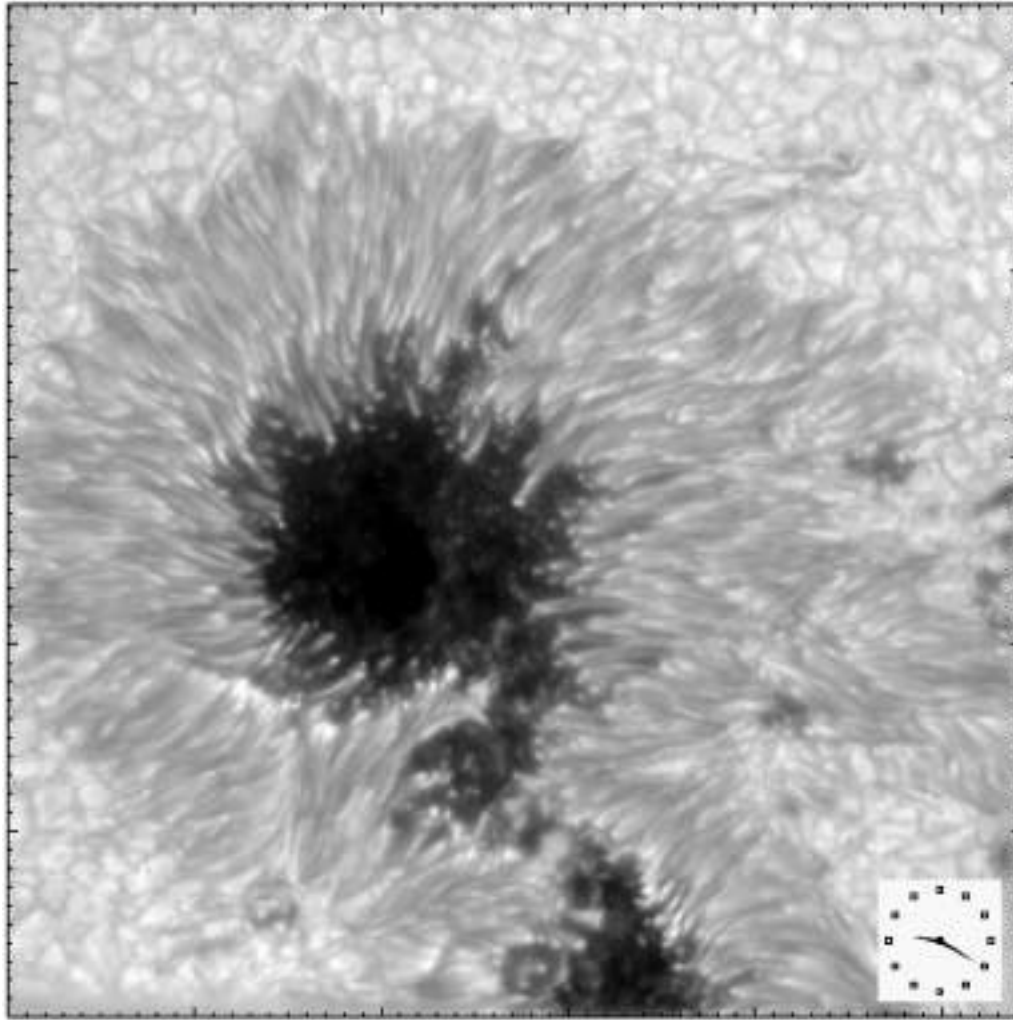


SST, Esteban Pozuelo et al (2015)

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Photosphere



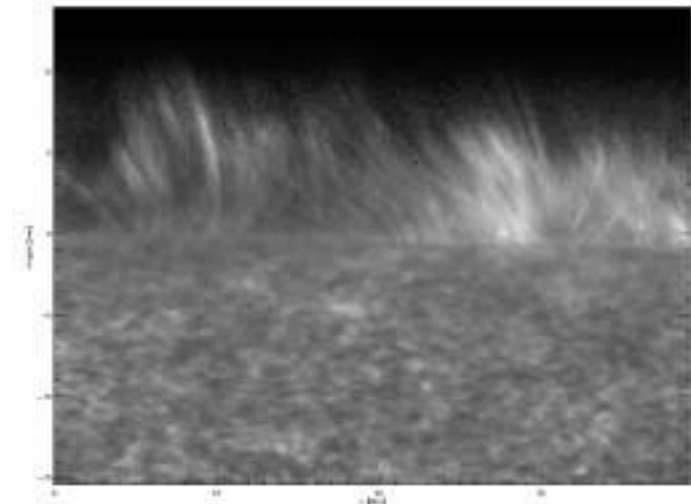
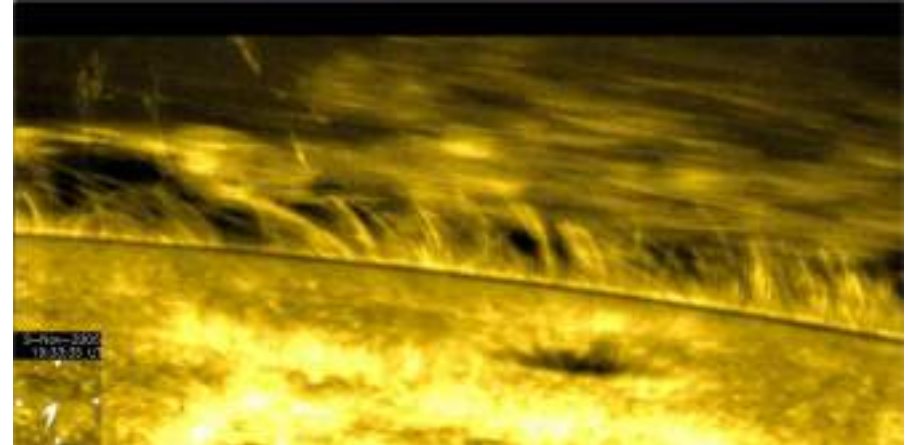
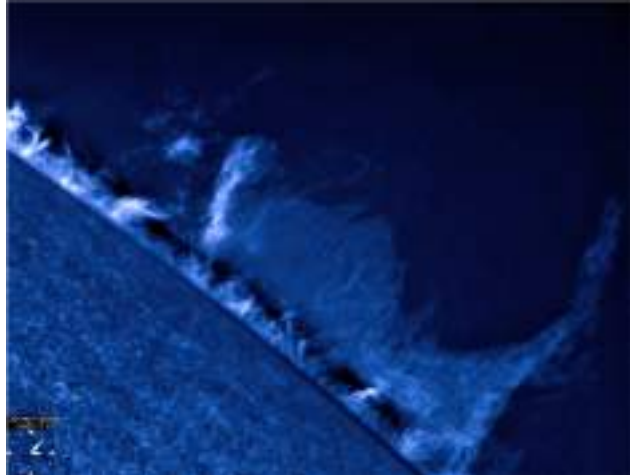
SST, Esteban Pozuelo et al (2015)

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Chromosphere

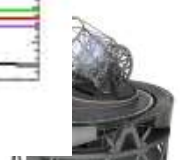
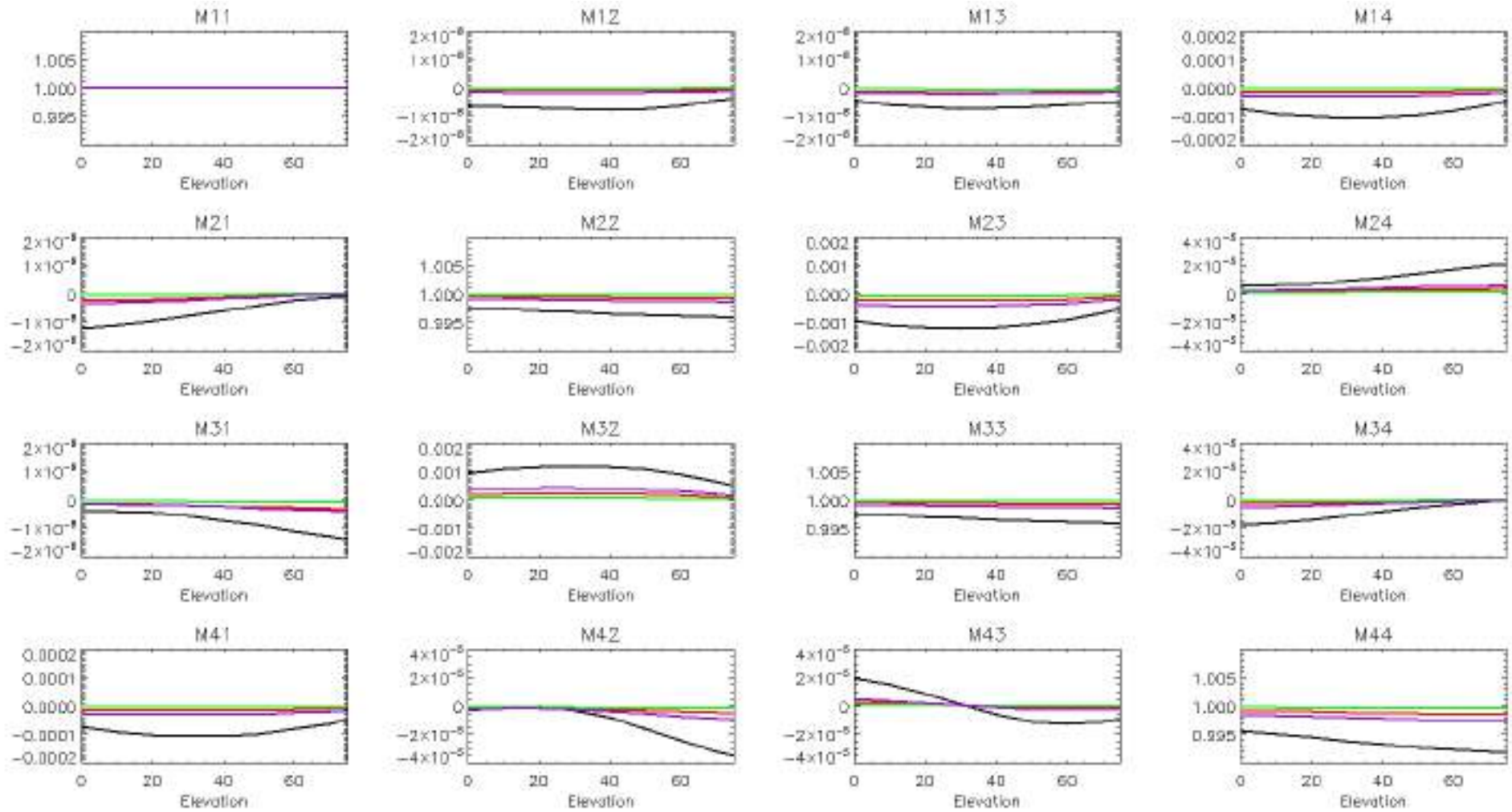
van Noort (this meeting)



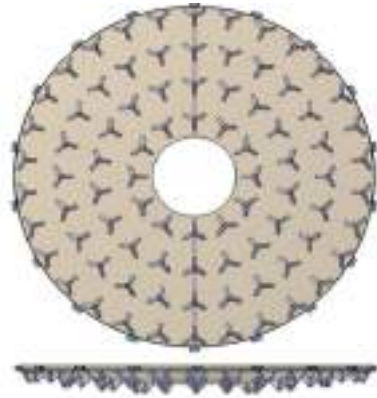
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Telescope Polarimetric Behaviour



Technological challenges

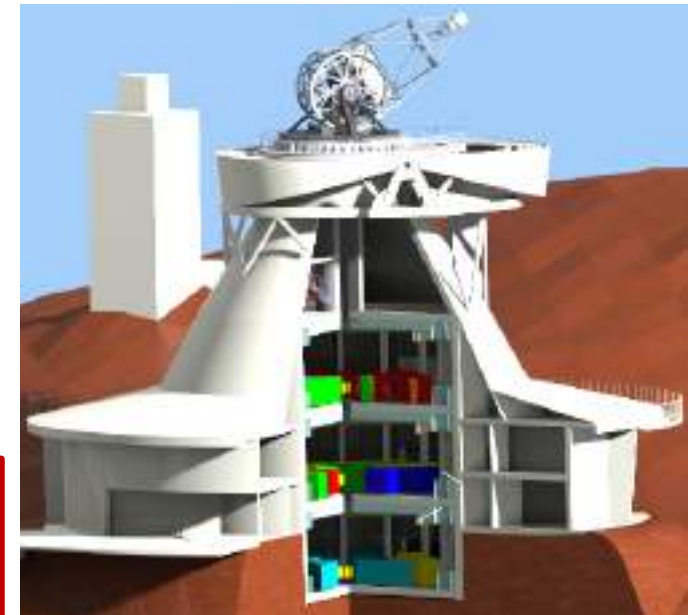


Primary Mirror:
70 mm thick Solid Meniscus 4Rings

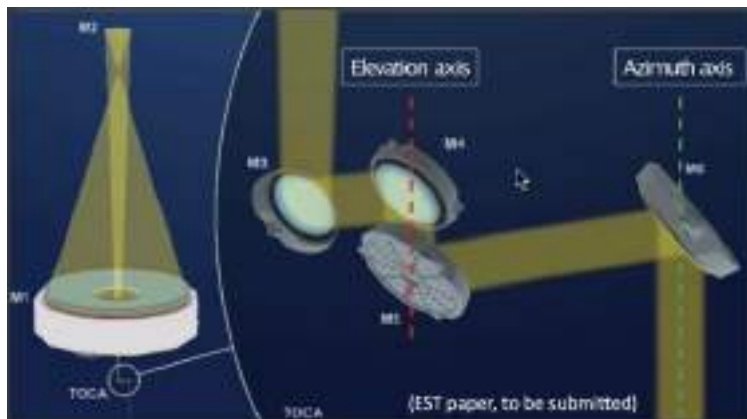


Adaptive secondary mirror

*Belio et al., Cozar Castellano et al.,
Feijoo et al., Gallieni et al. (this meeting)*



Powerful suite of instruments



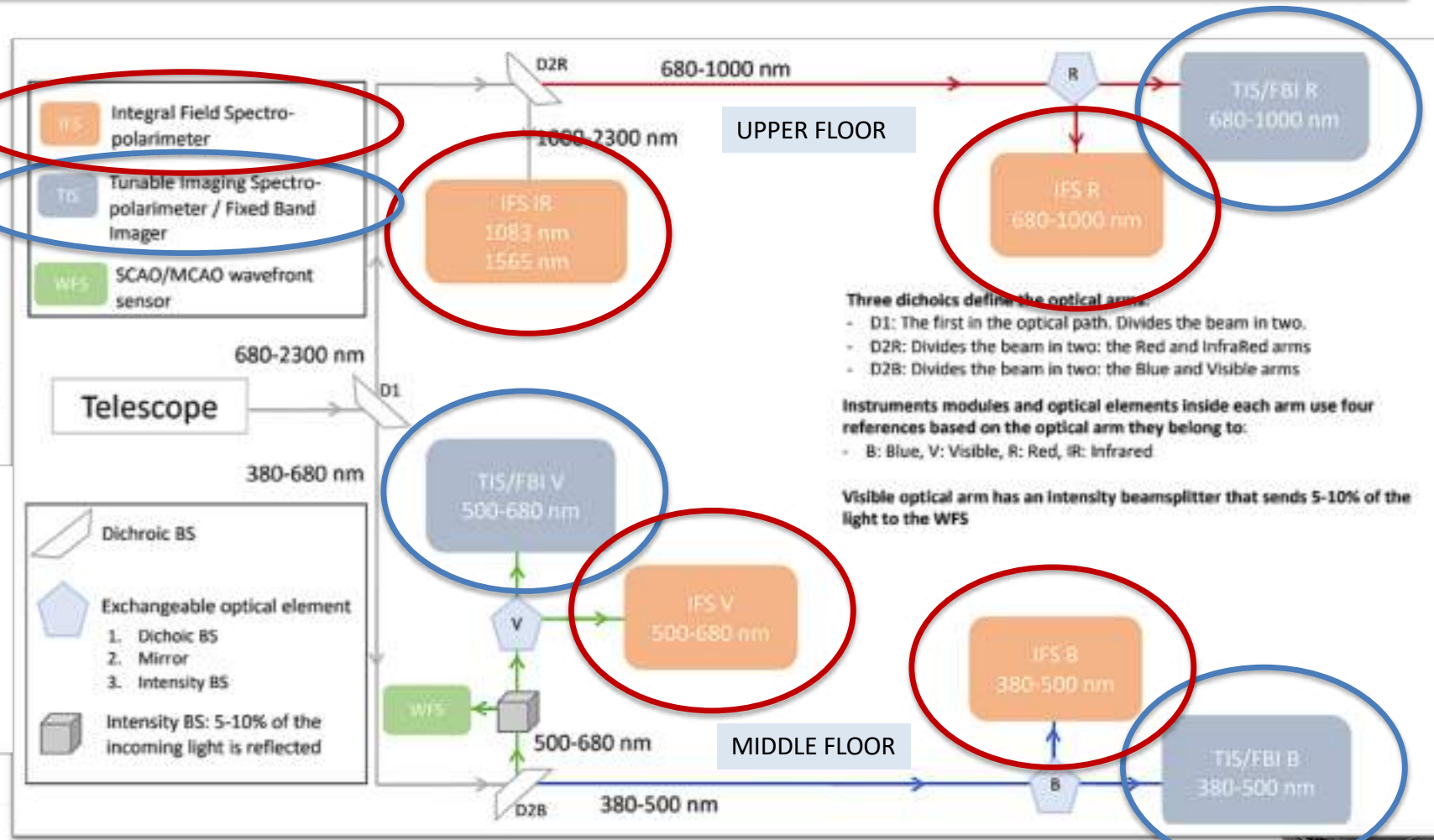
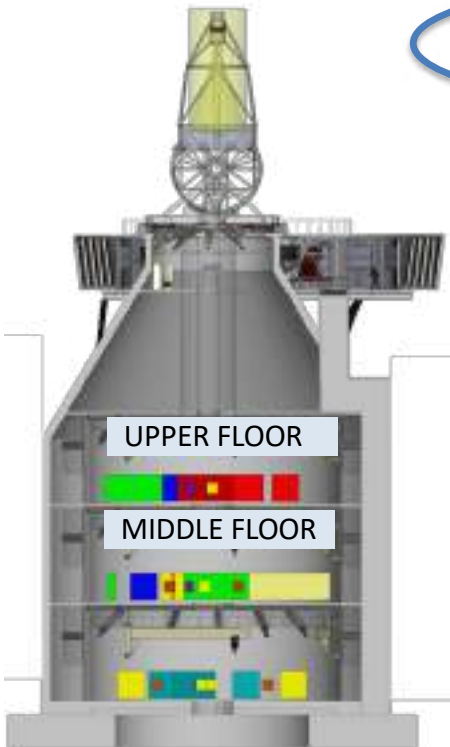
Embedded MCAO system

M3+M4+M5+M6:

- Elevation + azimuth axes
- Polarimetric compensation
- MCAO DMs



Instruments



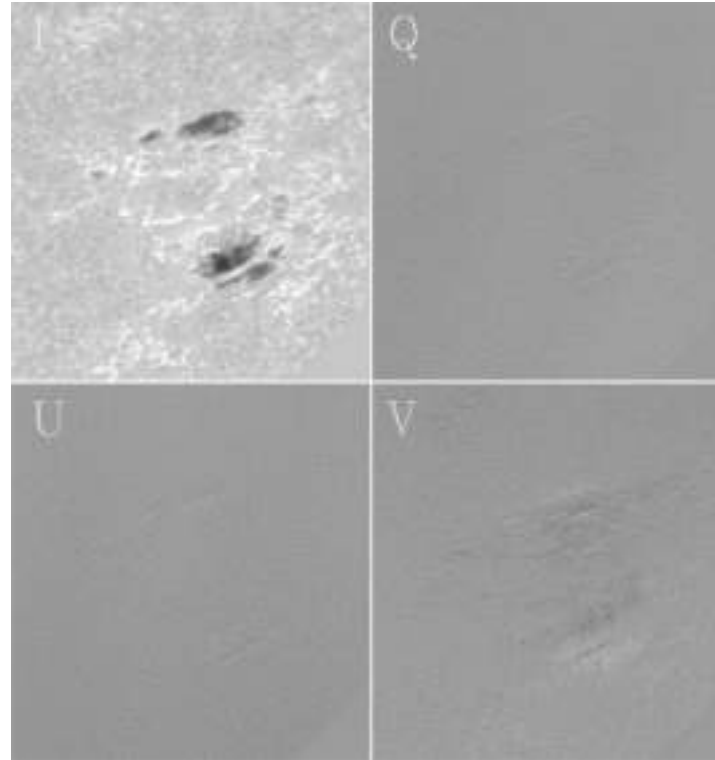
Tunable Imaging Spectropolarimeter (TIS)



FOV: 60" × 60" Diffraction limited
Spectral Resolution > 50 000
 $\sigma_{Q,U,V} \sim 10^{-3} I_c$ with $t_{int} \sim 15-30$ s

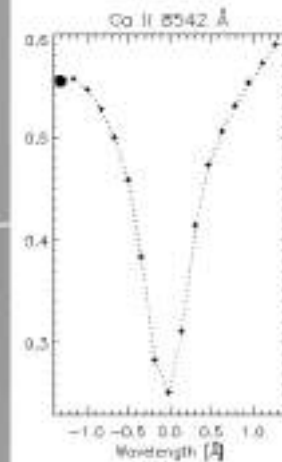


Etalon diameter ~ 180 mm



*Bailen Martínez et al., Munari et al.,
Scharmer et al. (this meeting)*

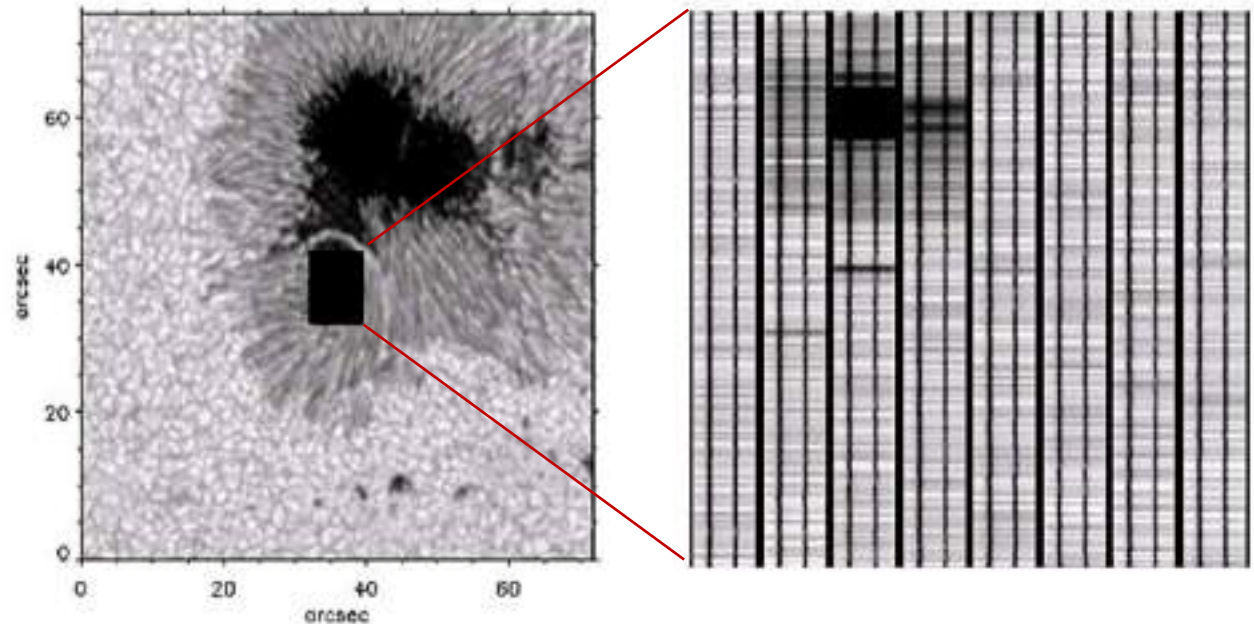
Courtesy of
J. de la Cruz Rodriguez



Integral Field Spectropolarimeters



FOV: $10'' \times 10''$ Diffraction limited
Spectral Resolution $> 150\,000$
 $\sigma_{Q,U,V} \sim 10^{-3} I_C$ with $t_{int} \sim 1-2$ s

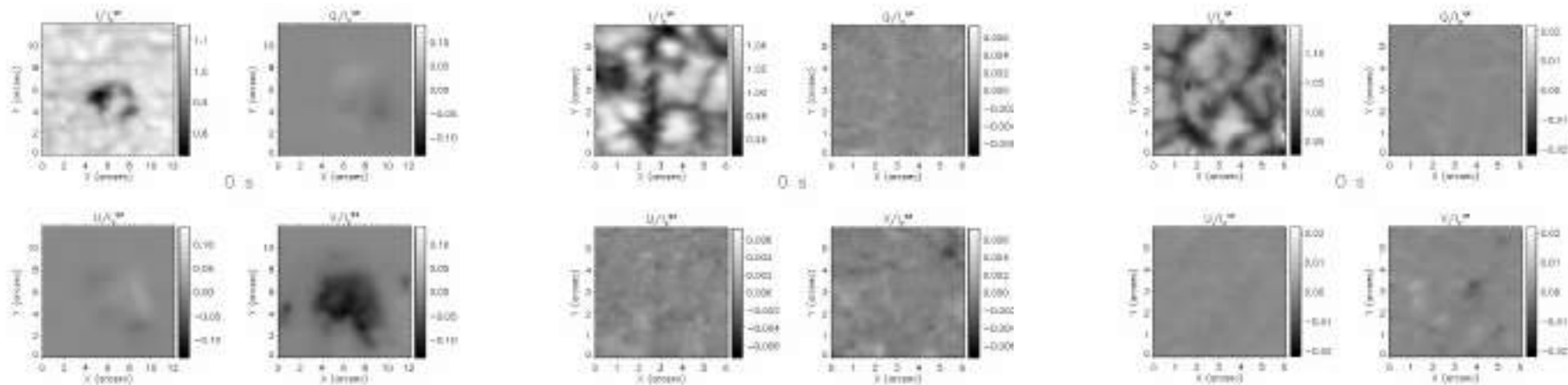


2D spectroscopy is essential for EST

IFS better suited to avoid scanning (2D $10'' \times 10''$ evolution with high cadence)

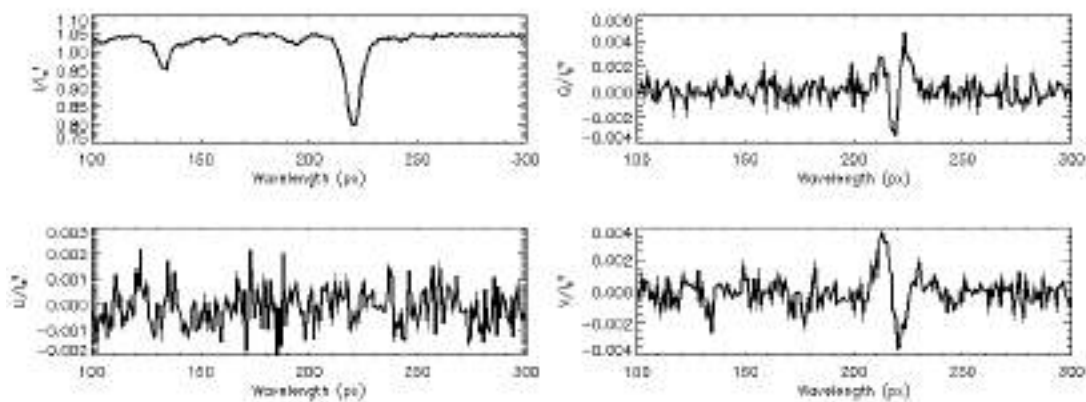


Integral Field Spectropolarimeters: Slicers



Regalado Olivares et al. (this meeting)

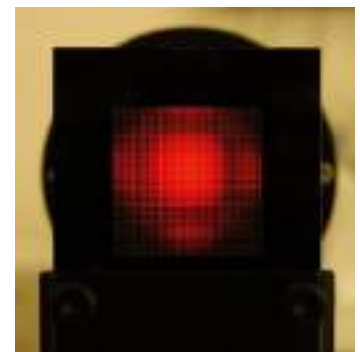
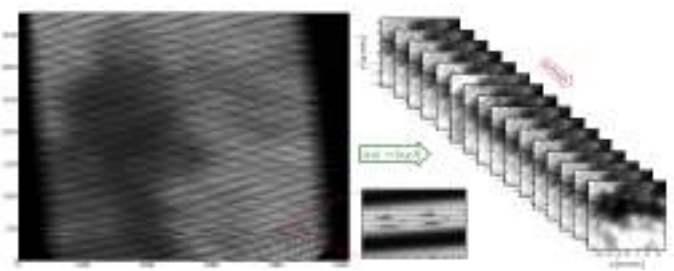
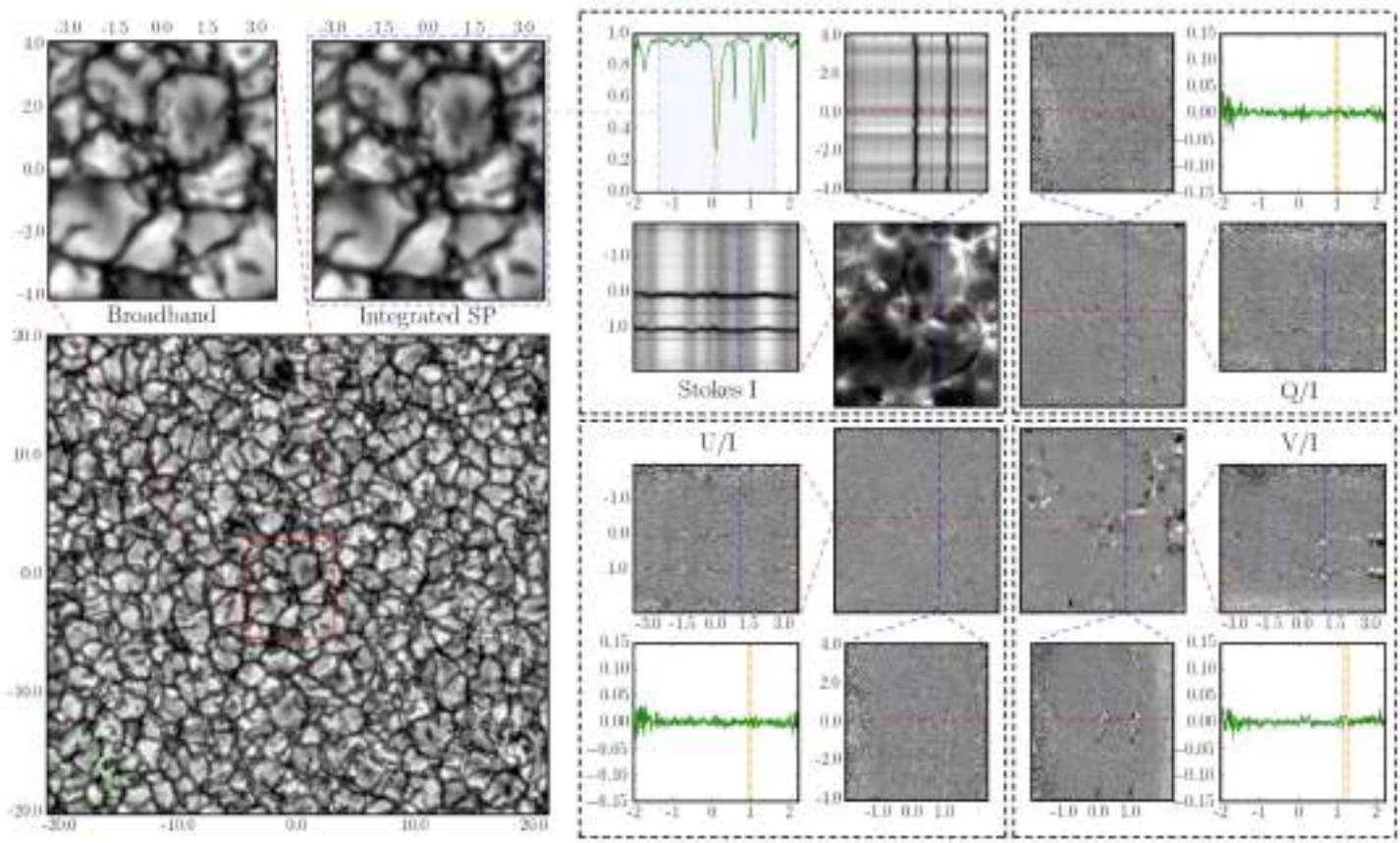
2D FoV and Spectrum
simultaneous:
IAC Slicer IFU (Gregor)



Integral Field Spectropolarimeters: Microlenses



Fe I 630.1 - 603.2 nm - MIHI (SST, Courtesy of Michiel van Noort)



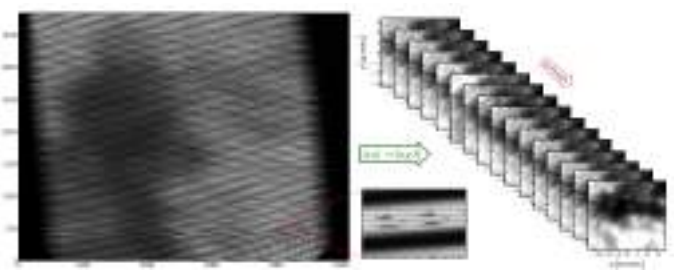
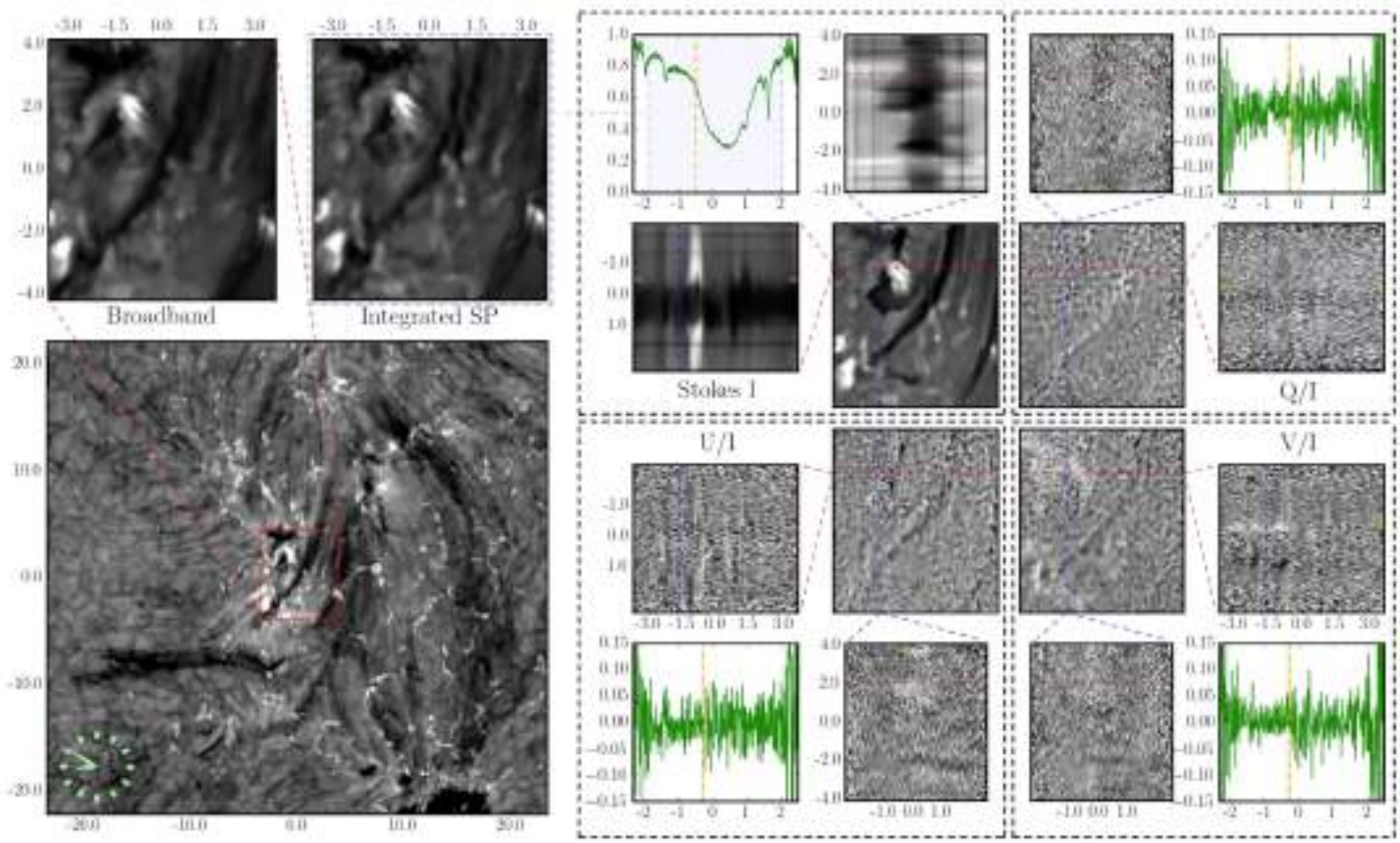
van Noort (this meeting)



Integral Field Spectropolarimeters: Microlenses



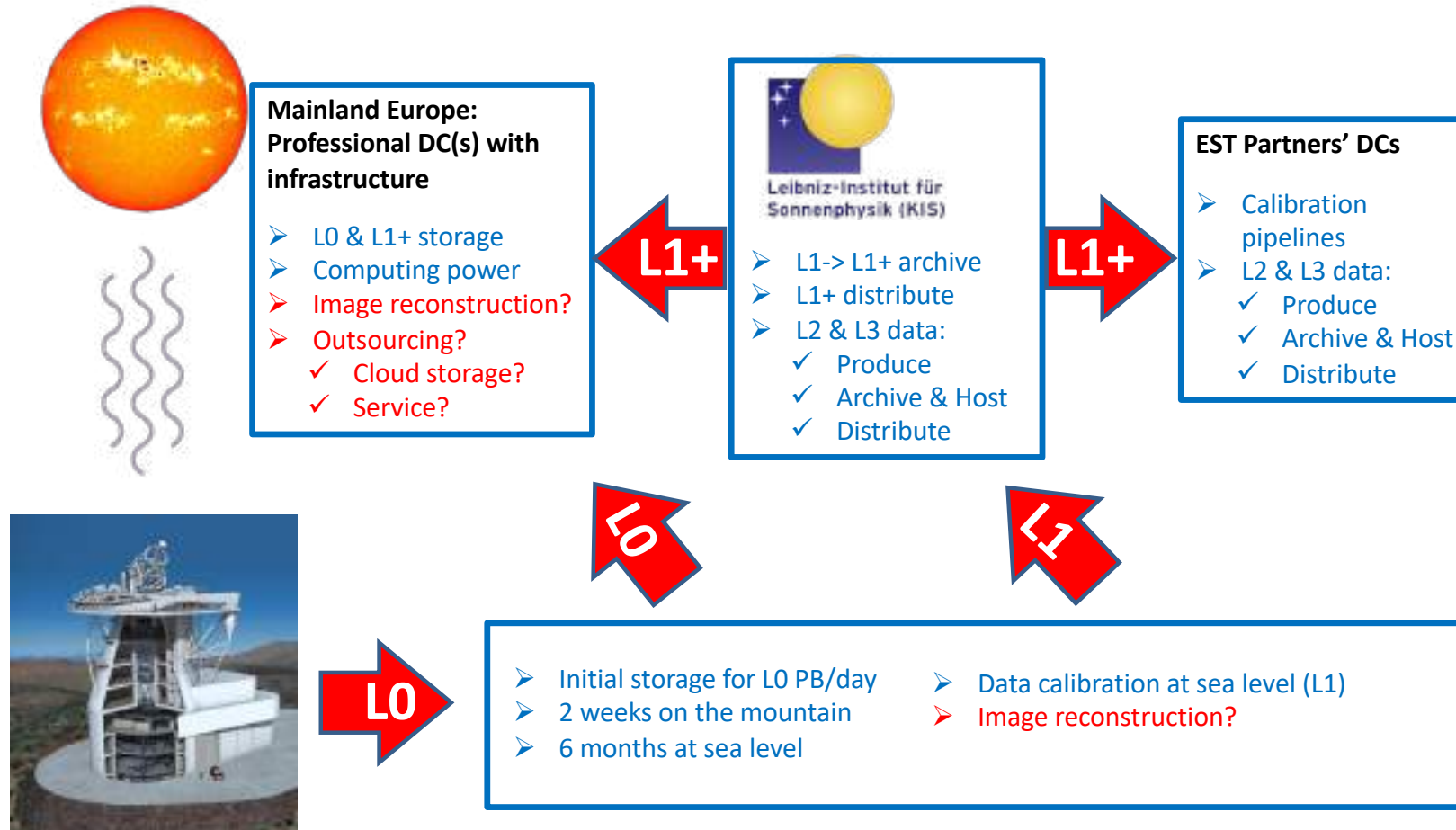
H α 656.3 nm - MIHI (SST, Courtesy of Michiel van Noort)



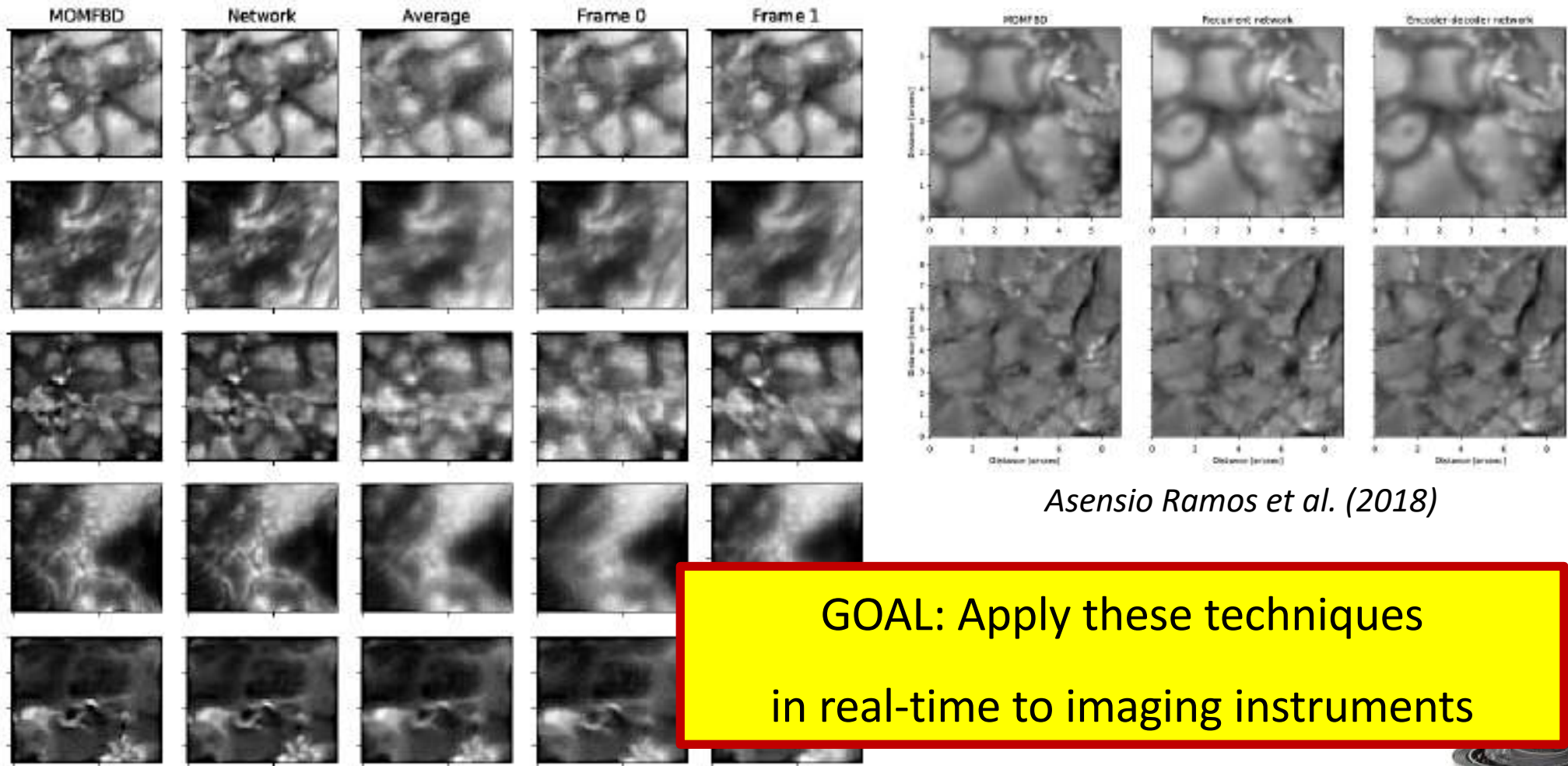
van Noort (this meeting)



EST Science data Center: Distributed organization



Neural networks applications to image reconstruction

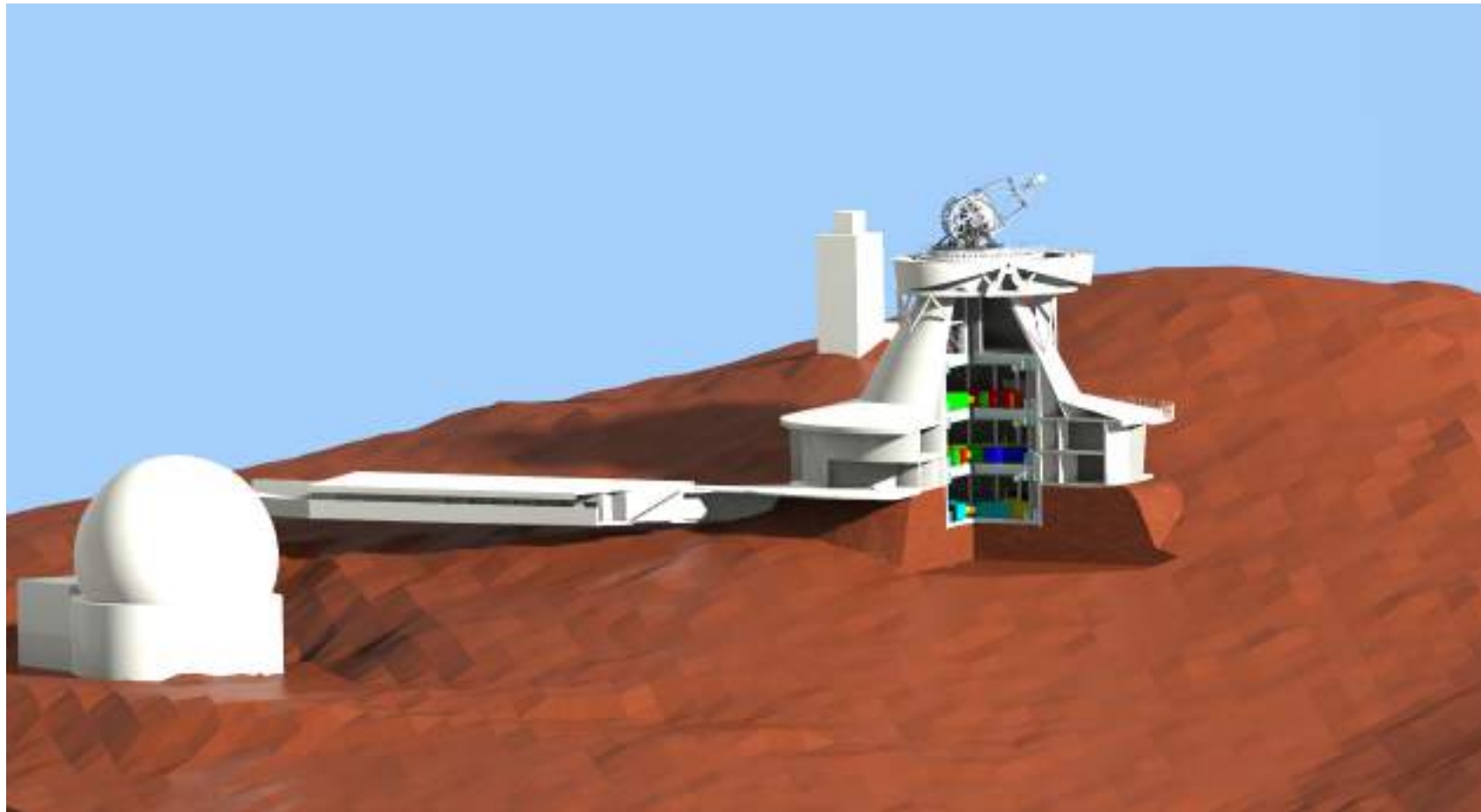


Asensio Ramos et al. (2018)

**GOAL: Apply these techniques
in real-time to imaging instruments**



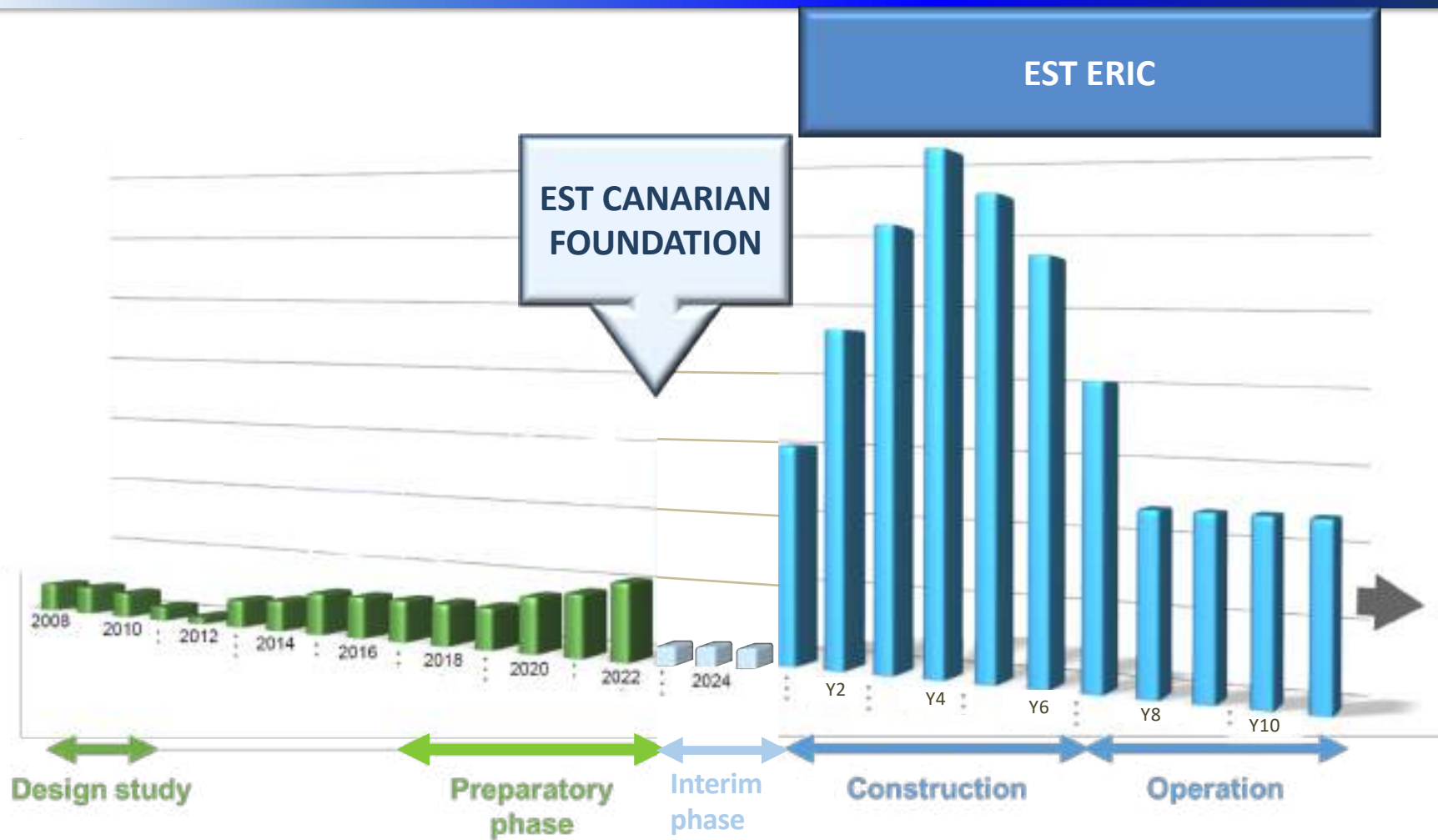
Location – Roque de los Muchachos – La Palma



Solarnet S3 Meeting, Mestre, Venezia, Italy, 11-15 Sep 2023



Timeline



Solarnet S3 Meeting, Mestre, Venezia, Italy, 11-15 Sep 2023



EST Interim Phase



- European Solar Telescope – Canarian Foundation
 - ✓ Application for ERIC creation
 - ✓ Pass Preliminary Design Review
 - ✓ Preparation of construction calls for tender
 - ✓ Construction permits and associated studies
(environmental impact study, ...)

Created on July 25th, 2023

First round: MPS, KIS, SU, UoS (representing six UK Universities, UKUC),
AIAS-CR, AISAS, USI, CSIC, IAC;

Others are pending and are expected to join later

Solarnet S3 Meeting, Mestre, Venezia, Italy, 11-15 Sep 2023



EST is closer and closer to start construction!

