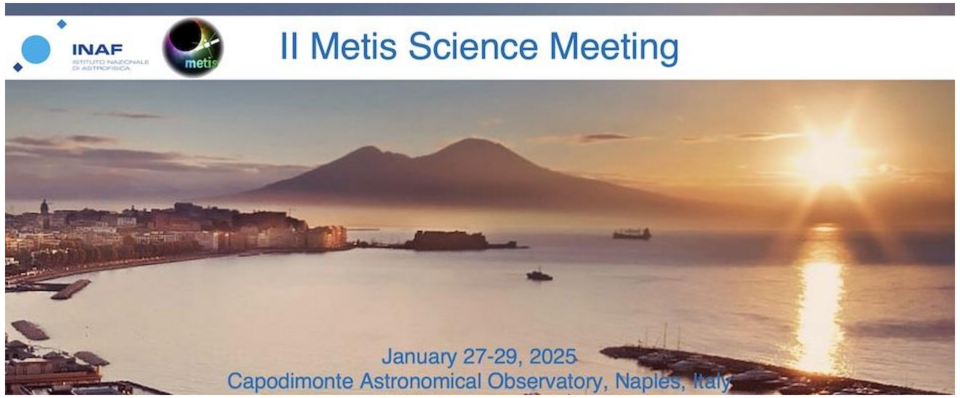
TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA



The European Solar Telescope: Current Status and Scientific Potential

Francesco Berrilli and EST Team

Dipartimento di Fisica, Università degli Studi di Roma Tor Vergata
Accademia Nazionale dei Lincei

The 6 W's

Why, **W**hat, ho**W**, **W**here, **W**ho, **W**hen

Why ?

SCIENCE WITH EUROPEAN SOLAR TELESCOPE

Study astrophysical processes

What can the Sun teach us about fundamental astrophysical processes, both in stars and other celestial objects? Observations of the Sun reveal intricate patterns of magnetic fields and the complex dynamics of a stellar atmosphere at their intrinsic spatial scales.

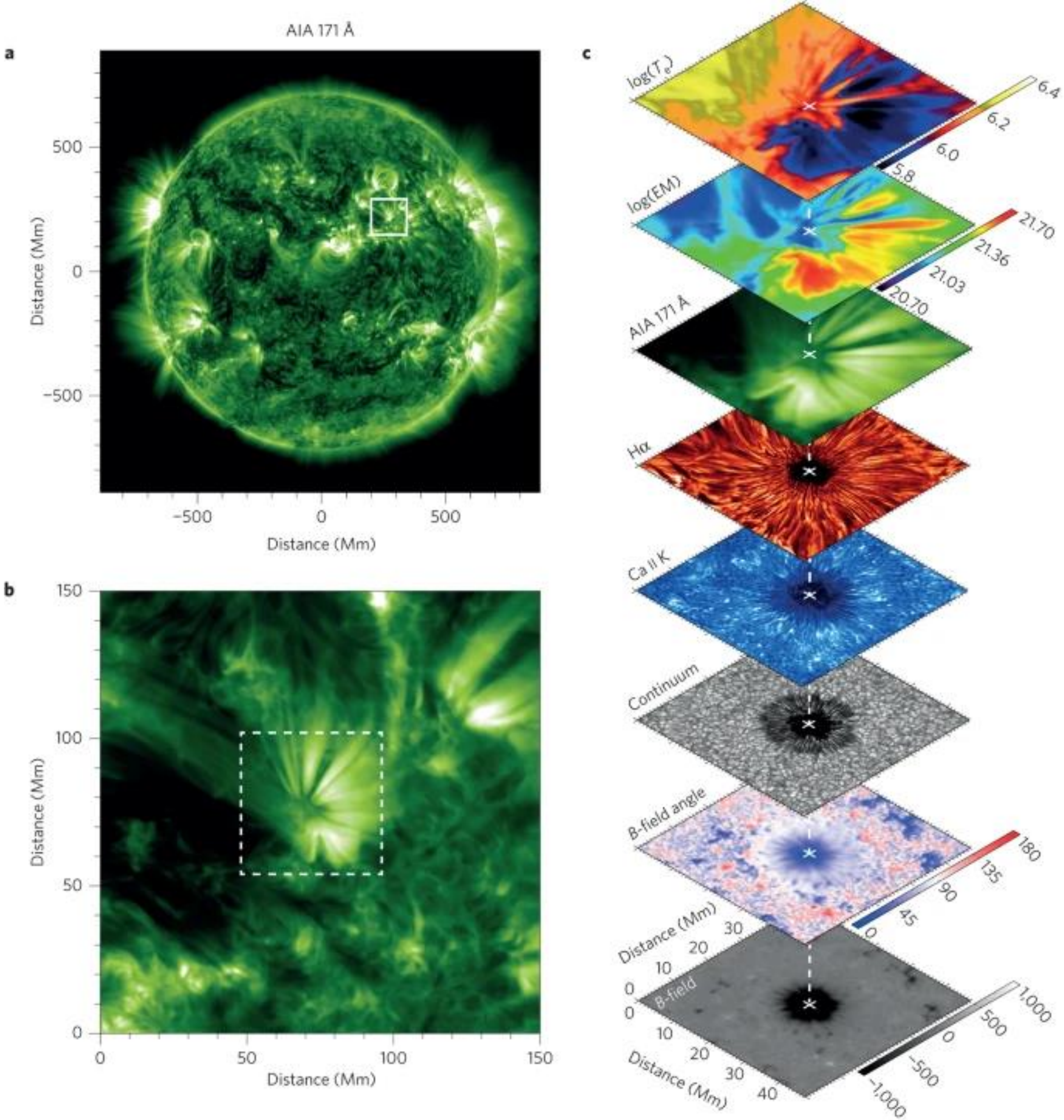
Solar variability

What drives solar variability on all scales? The Sun varies on a wide range of spatial and temporal scales, producing very energetic phenomena. We still do not fully understand these changes and cannot accurately predict basic aspects of solar variability.

Solar activity impact

What is the impact of solar activity on Earth? Solar magnetic activity can affect millions of people on short and long time scales. We need to predict disturbances of the space environment induced by the Sun and to understand the links between the solar output and the Earth's climate.

http://www.est-east.eu/



Credits: Jess+ Nature Physics 12, 179 (2016)

a, A contextual EUV 171 Å image of the entire Sun on 10 December 2011 at 16:10 UT, where a solid white box highlights a 150 × 150 Mm^2 subfield surrounding NOAA 11366.

b, A zoom-in to the subfield outlined in a, with a further 50 × 50 Mm2 subfield highlighted using dashed white lines to show the pointing and size of the ground-based field of view.

c, Co-spatial images, stacked from the solar surface (bottom) through to the outer corona (top). From bottom to top the images consist of snapshots of the photospheric magnetic field strength normal to the solar surface (Bz; artificially saturated at ±1,000 G to aid clarity), the inclination angles of the photospheric magnetic field with respect to the normal to the solar surface (0° and 180° represent magnetic field vectors aligned downwards and upwards, respectively, to the solar surface), ROSA 4,170 Å continuum intensity, ROSA Ca II K lower chromospheric intensity, HARDcam Hα upper chromospheric intensity, coronal AIA 171 Å intensity, emission measure (on a log-scale in units of cm^{-5} K^{-1}) and kinetic temperature (shown on a log-scale artificially saturated between log(Te) = 5.8 and log(Te) = 6.4 to assist visualization). White crosses mark the location of the umbral barycentre and are interconnected as a function of atmospheric height using a dashed white line.

Why a 4-m telescope?

When we observe a star at the fundamental scales of physical processes occurring on the surface, the domain of astrophysics expands.

We enter the domain of Physics of complex systems, of turbulent convection, of magneto hydro-dynamics, of fast and strongly non-linear processes in plasma.

Mean free paths and scale heights

Photons, emerging from an optically thick atmosphere, arise mostly from regions centered around optical depth τ = 1 (last scattering surface).

Landi Degl'Innocenti (2013) demonstrated the curious property that, in stratified layers when the opacity is proportional to pressure, the **photons emerge from a region with an intrinsic thickness of ≈ 1 pressure scale height (H)**.

The photosphere and low chromosphere comprise a partially ionized stratified layer with T ≈ 6000 K, and a pressure scale height (H)

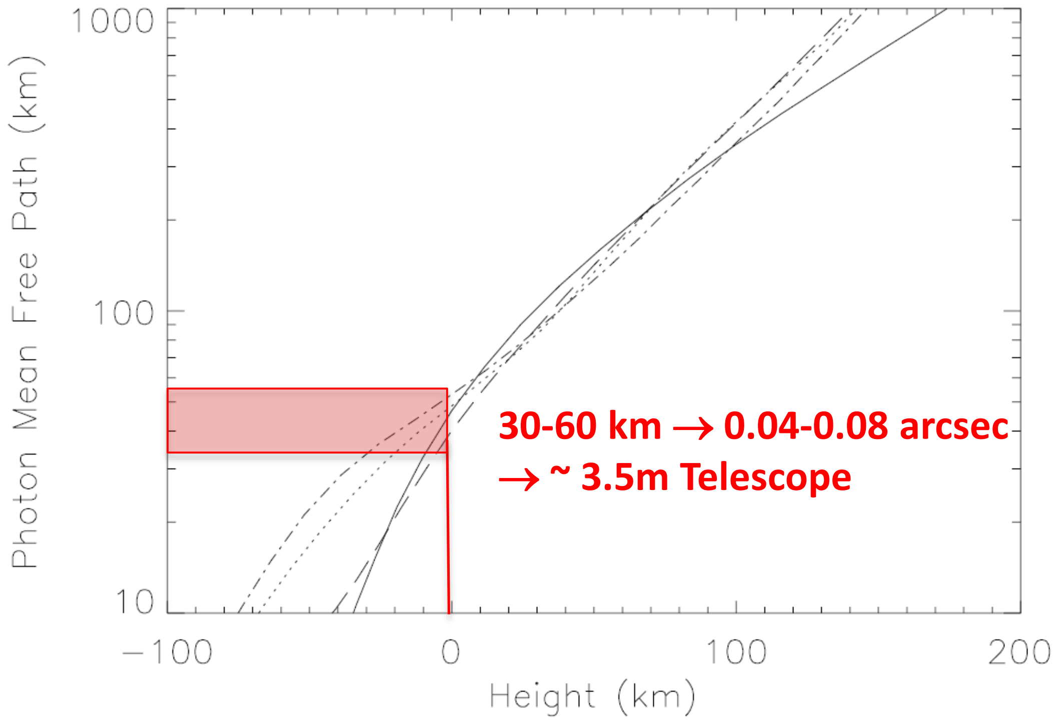
$$H = -\left(\frac{d\ln\, p}{dz}\right)^{-1} = \frac{kT}{\mu m_H g} \approx 130 \quad \text{km}$$

Now, the MFP of a photon where τ = 1 must be ≈ Δ (thickness of the region emitting most observed photons).

$$\text{MFP} \approx \Delta = 2H/(m+1)$$

The photon MFP is of the same order as the pressure and density scale height in the photosphere (m = 1) and lower chromosphere (m = 0).

Adapted from Judge et al., Sol Phys, 2015



Photon MFP at 500nm versus geometrical height for different model atmospheres: quiet sun (solid line), plage (dots) or large spot (dashes).

Adapted from Sobotka, 2001

Imaging spectropolarimetry and plasma dynamics

The measurement of the solar magnetic field (possibly B vector) is a key aspect for the study of MHD dynamics of solar plasma.

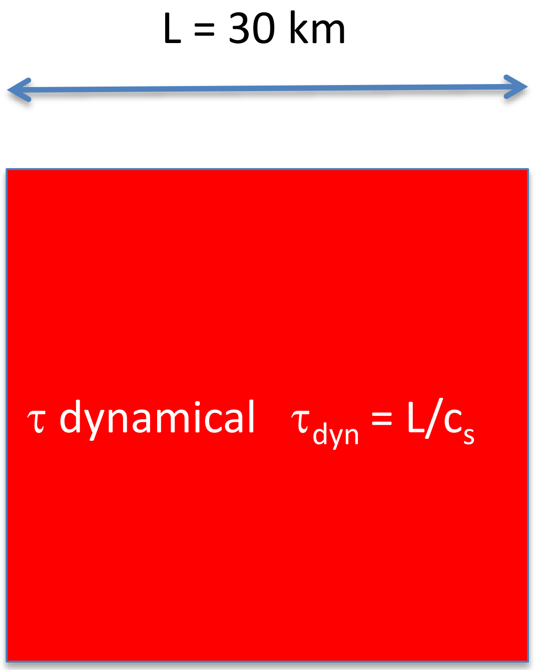
Spectropolarimetry is a powerful tool for measuring these fields.

Question: **Does building a bigger telescope provide you with more photons?** Answer: **Yes and No**

YES - A larger telescope collects more photons, and these are presented to the focal plane of the telescope.

NO - The Sun is an extended source of light: it fills the image plane of a telescope. The photon flux from the Sun per diffraction resolution limit θ is independent of aperture diameter D.

New large telescopes will often operate well away from their diffraction limits to gather enough photons for high-precision polarimetry.



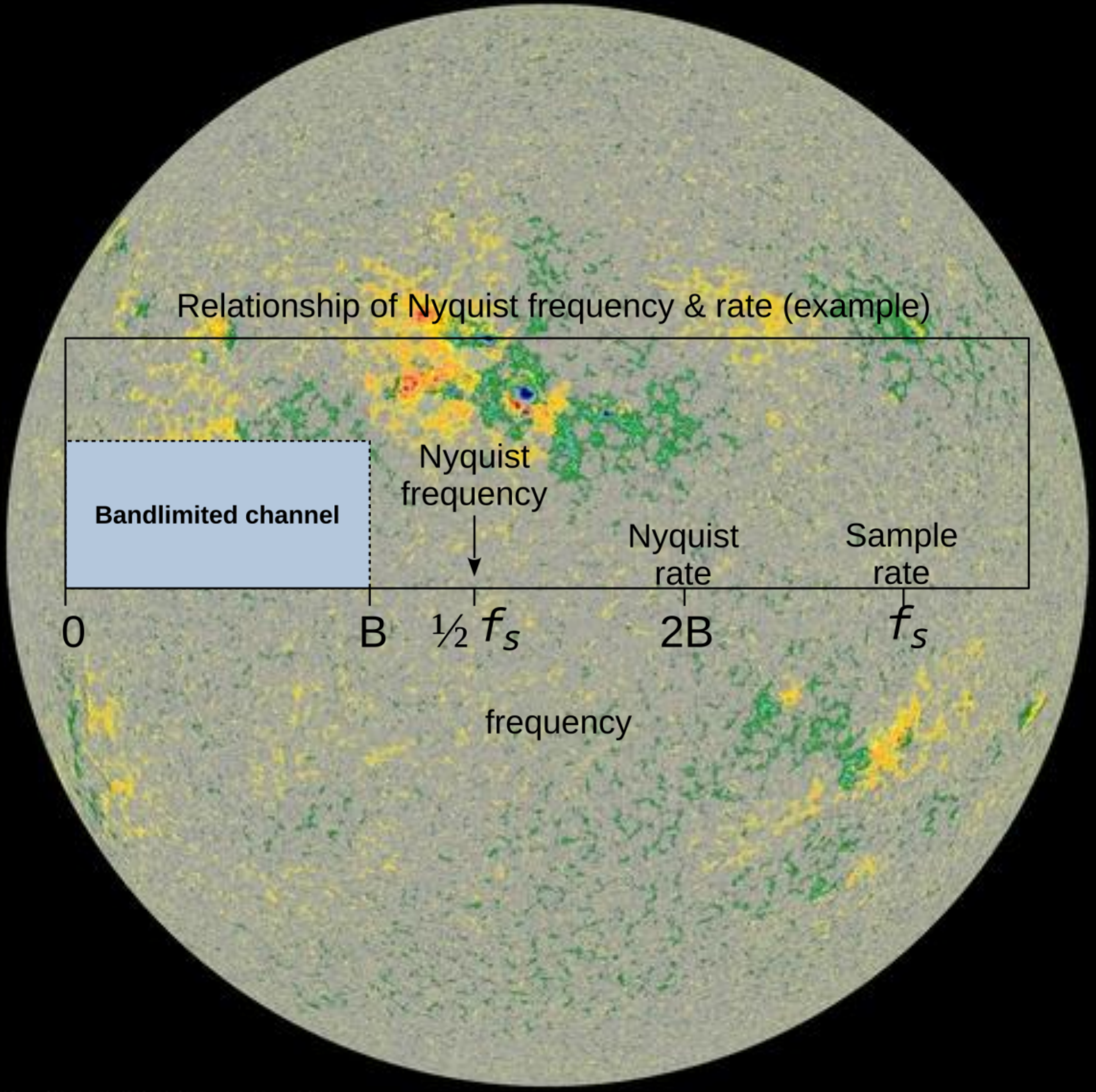
Assuming a typical sound speed (c_s) = 7 km s^{-1} and a scale of 30 km in the photosphere it takes about 4 seconds for the information to travel into the observed plasma element by **setting a limit on the spectral sampling rate and integration times**.

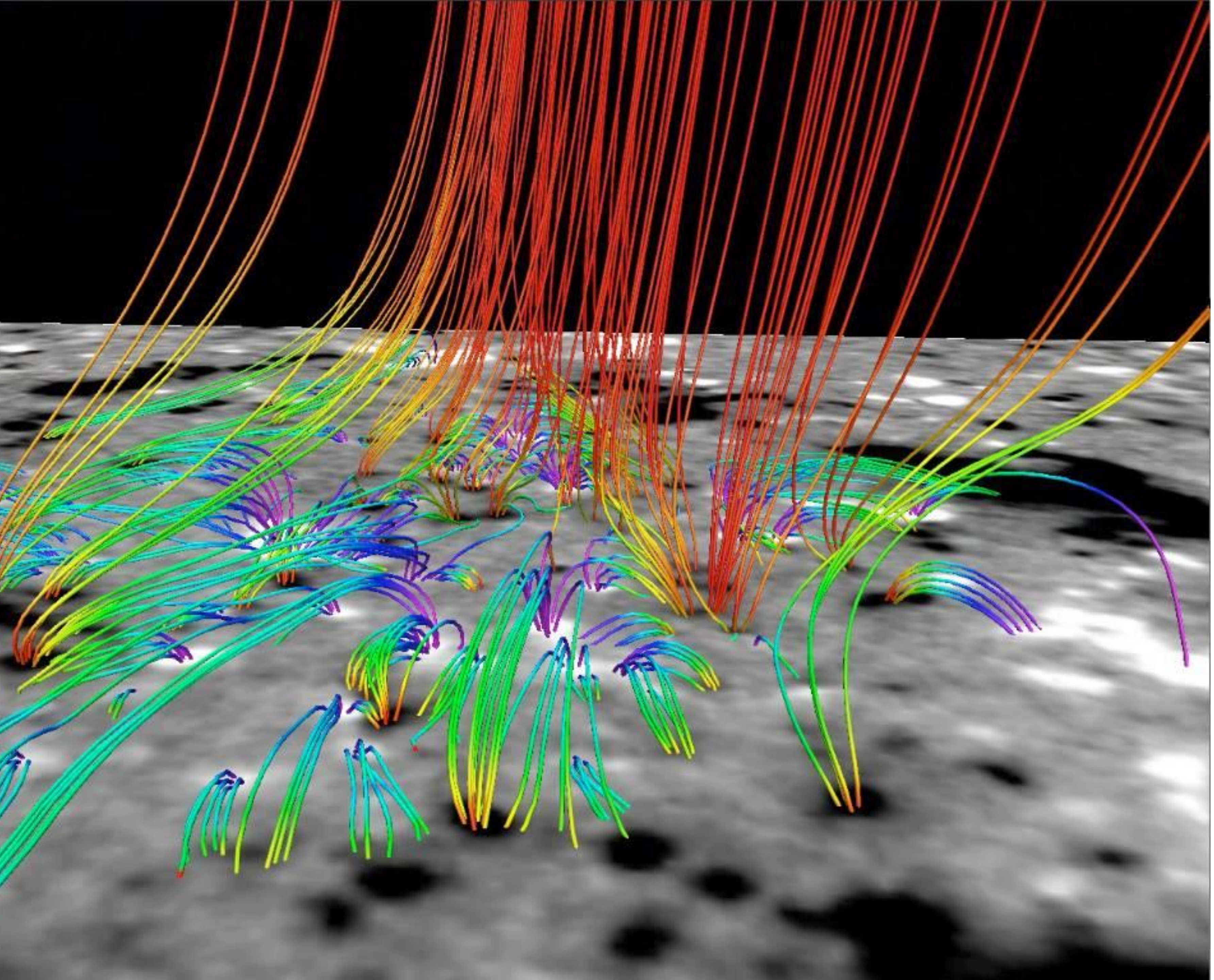
Adapted from B. W. Lites - Solar Polarization Measurements: Instruments and Techniques
https://www2.hao.ucar.edu/sites/default/files/csac/files/instrumentation_spectropolHAO2018_2.pdf

When planning the measurement of a "signal", whether it's time-series intensity or velocity data, spectral images, or other types, for space- or ground-based instruments, the Nyquist-Shannon sampling theorem is a fundamental consideration.

Factors such as the field of view, sampling rate, or available telemetry bandwidth, directly impact our ability to correctly measure these "signals".

For example. if the sampling rate falls below the Nyquist rate, aliasing occurs, where high-frequency components of the signal are misrepresented as lower frequencies within the sampled data, leading to distortions and erroneous interpretations.



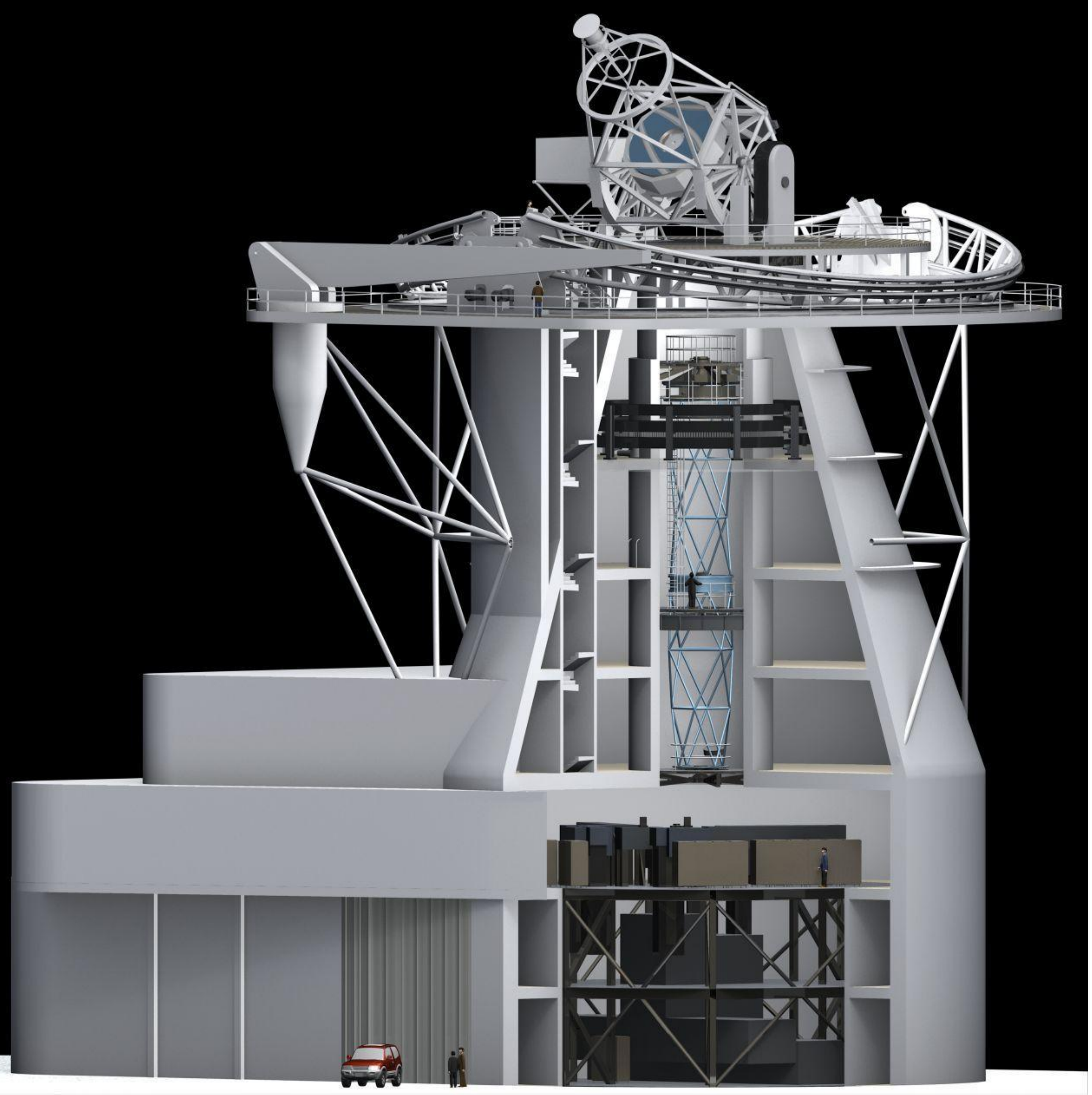


The quiet Sun is the area of the solar surface outside of active regions. Dominated by granular convection, it appears to be dull and uninteresting. However, observations with high sensitivity have demonstrated that the quiet Sun harbors ubiquitous magnetic fields.

These fields are extremely weak, but may contain most of the magnetic energy of the solar surface, outweighing sunspots and active regions by far. Unfortunately, we do not know much about their properties and evolution due to the lack of sensitive measurements at high spatial resolution.

Credit: M. Gosic, M. Cheung, L. Bellot Rubio

What ?



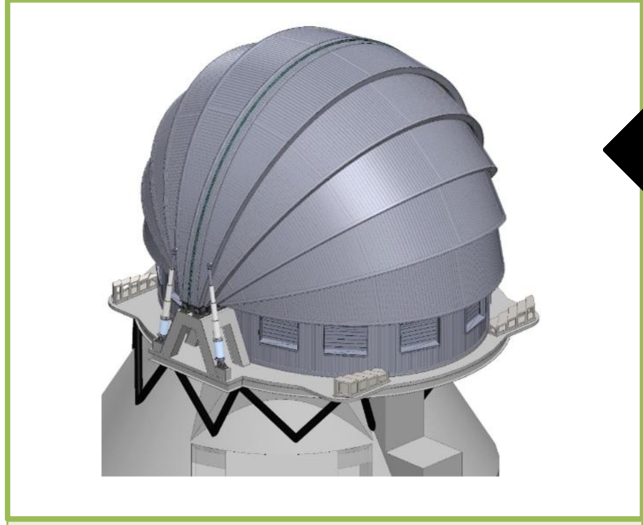
The European Solar Telescope (EST) is a next generation large-aperture on-axis solar telescope with a 4.2-m primary mirror and a suite of instruments for multi-wavelength (multi-layer) imaging, spectroscopy and spectropolarimetry.

EST will specialise in **high spatial and temporal resolution**, using **several instruments simultaneously** to efficiently produce **2D spectral information** (3D in the solar atmosphere).

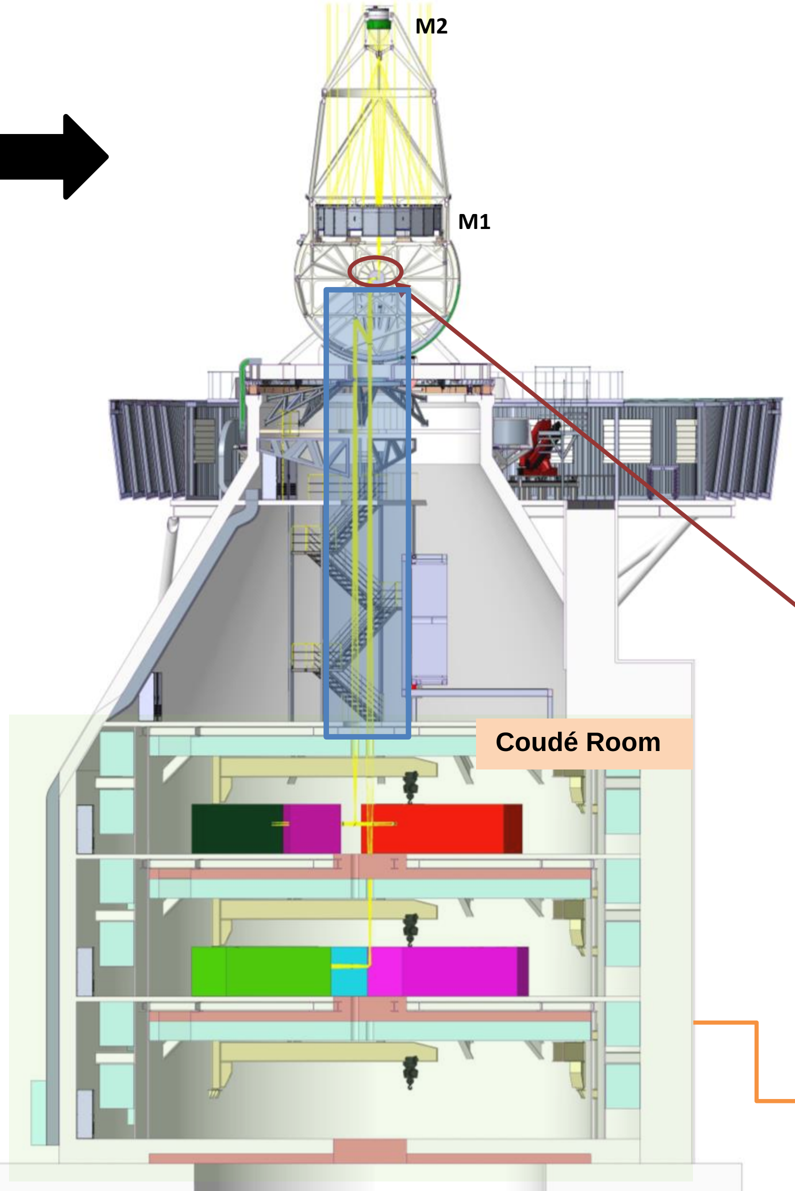
EST VIDEO

Credits: Hector Socas-Navarro - Director, European Solar Telescope Foundation

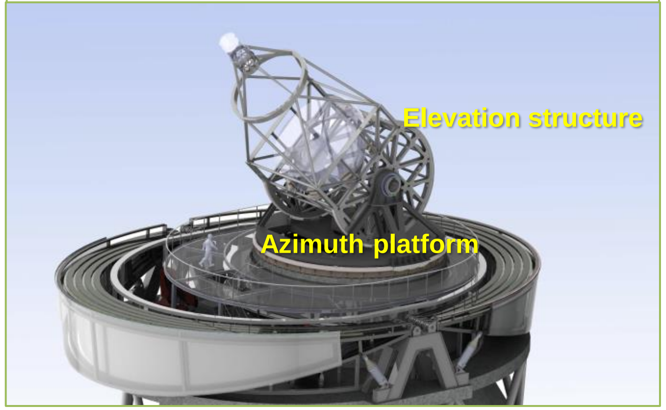
OVERVIEW

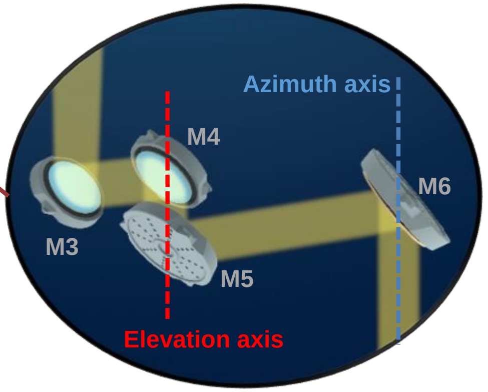


Completely retractable enclosure



Alt – azimuthal structure



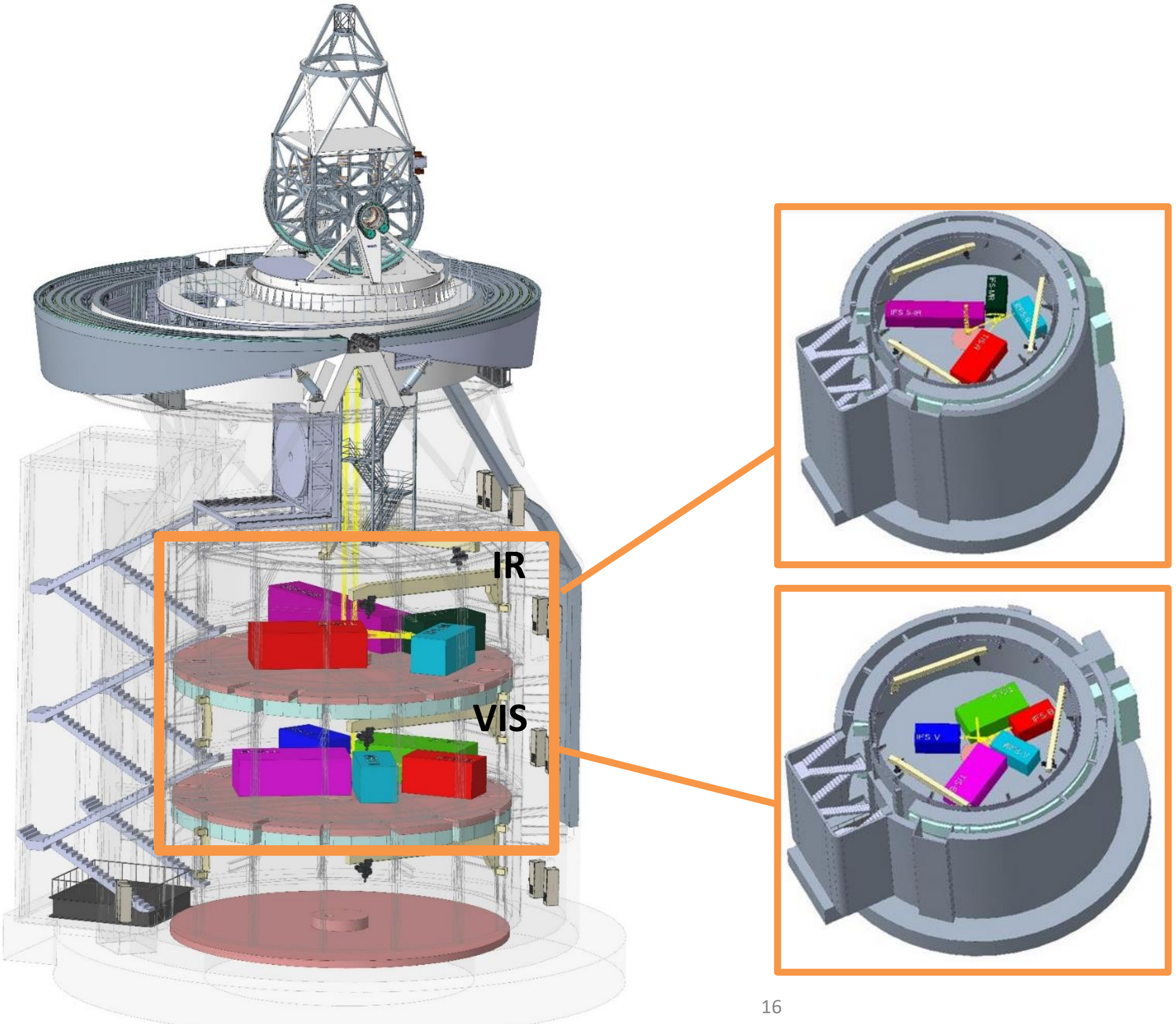


1. Fabry-Perot based Tunable Image Spectropolarimeter coupled to fixed band imagers (**TIS/FBIs**).

2. Grating based spectrographs based on different Integral Field technologies: Microlens-Arrays (**IFS-M**) and Image Slicers (**IFS-S**).

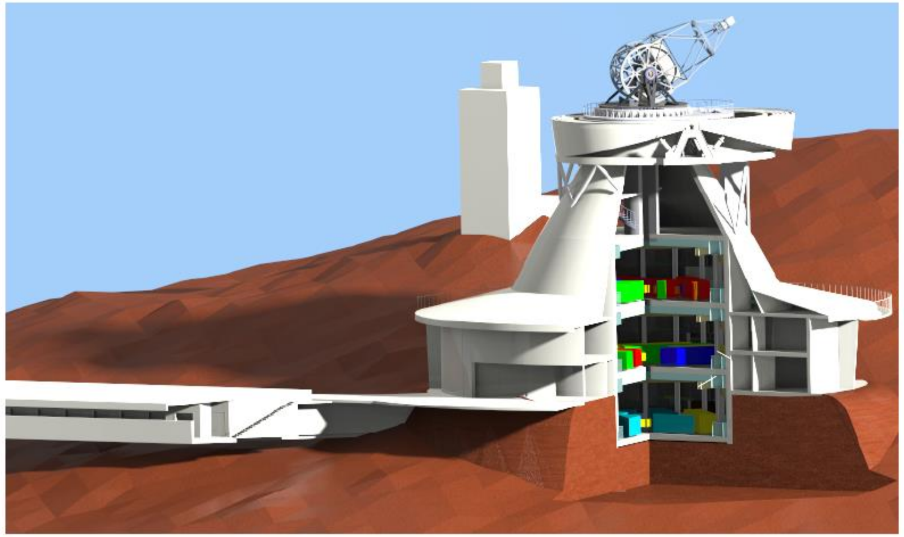
Credits: Hector Socas-Navarro - Director, European Solar Telescope Foundation

COUDÉ LIGHT DISTRIBUTION (CLD)

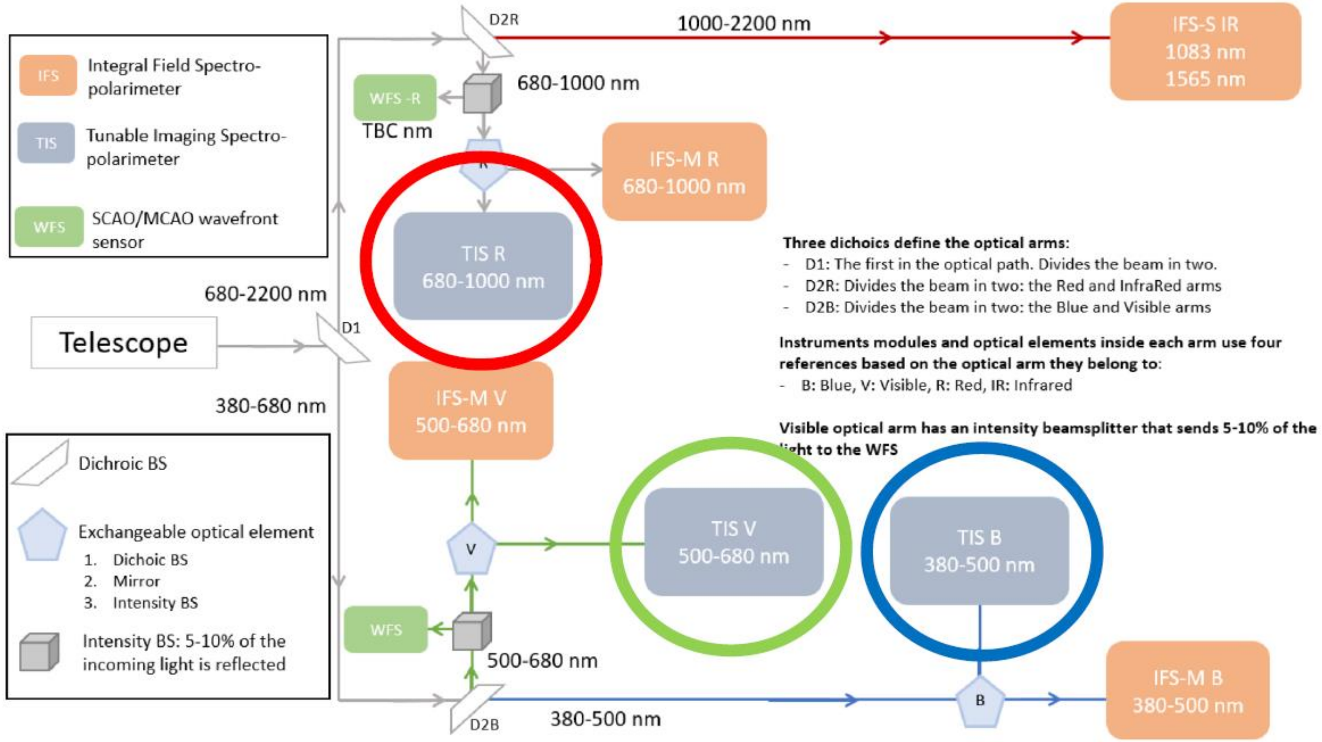


Credits: Hector Socas-Navarro - Director, European Solar Telescope Foundation

EST and the TIS/FBI instruments



- Largest telescope ever built in Europe (4.2 m)
- Optimized to study the magnetic and dynamic coupling of the solar atmosphere
- Simultaneous measurement of photospheric and chromospheric magnetic fields
- 45% of programs in EST SRD require large FOVs
- TIS/FBIs: etalon-based imaging spectropolarimeters, covering three spectral bands (380-500, 500-680, 680-1000 nm)



Credits: Luis Bellot Rubio

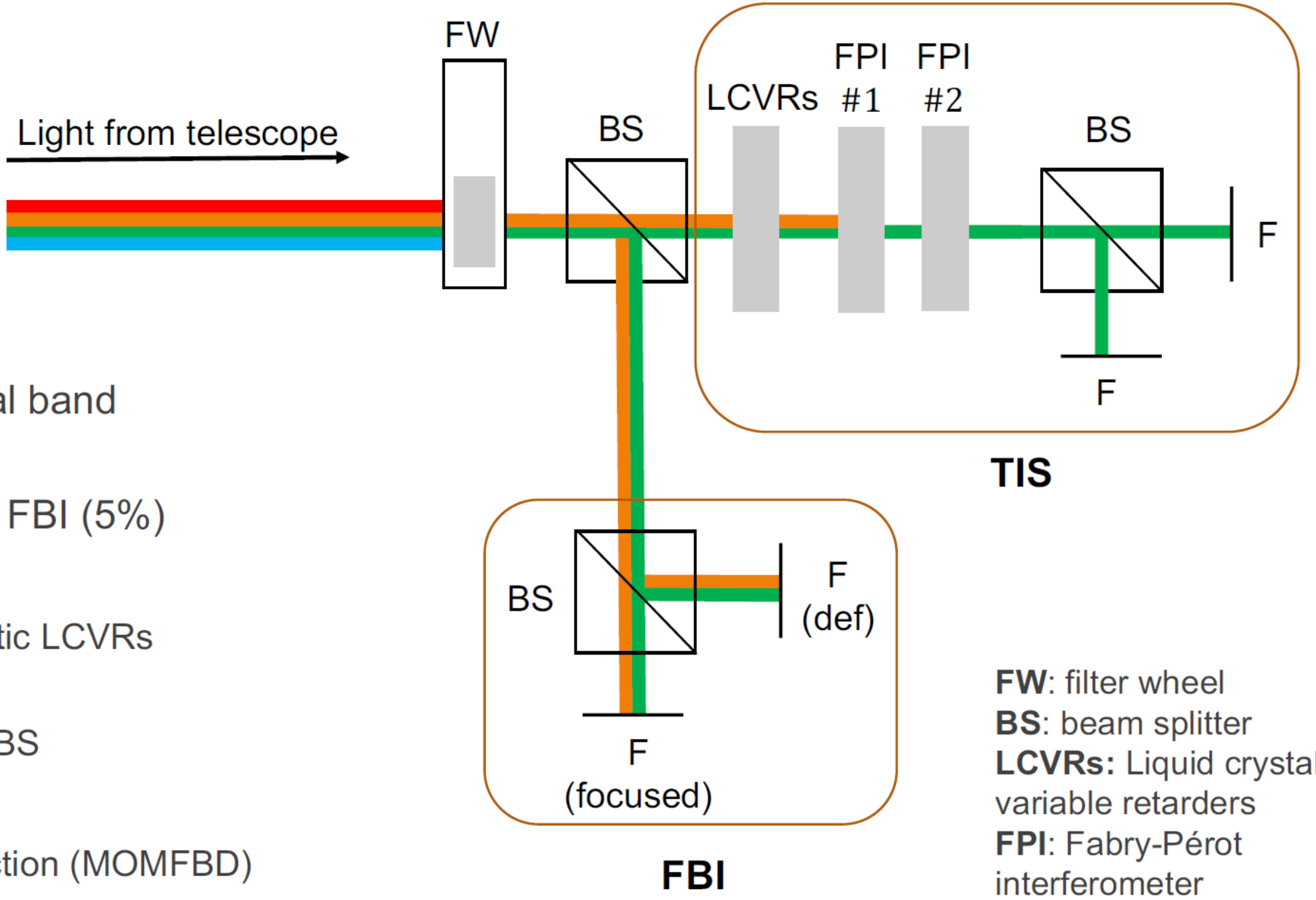
TIS/FBI scientific requirements

Tunable Imaging Spectropolarimeters (TIS) and Fixed-Band Imagers (FBI) are part of same instrument

Operation modes (simultaneous)	Narrowband spectropolarimeter (TIS) Broadband context imager (FBI)
Spatial resolution	Diffraction-limited. Critical sampling: 0.010” at 396 nm, 0.013” at 517 nm, 0.017” at 854 nm
FOV	60” diameter circular
Tunable	4-5 spectral lines in each spectral arm
Resolving power	50 000 at 396 nm, 100 000 at 630 nm, 80 000 at 854 nm
Spectral sampling	10 wavelength positions per line (goal: 20 positions)
Scanning time	10 s per spectral line
Polarimetry (TIS mode)	Polarimetric sensitivity of 10^{-3} of I_{cont} Dual-beam to reduce seeing-induced crosstalk

Credits: Luis Bellot Rubio

TIS/FBI concept



- Pre-filter allows only a narrow spectral band (~0.5 nm) to enter the instrument
- Light divided between TIS (95%) and FBI (5%)
- TIS channel
  - Polarization modulation using 2 nematic LCVRs
  - Spectral analysis by dual-FPI system
  - Polarization analysis using polarizing BS
- FBI channel
  - Focused camera for image reconstruction (MOMFBD)
  - Defocused camera to extend MOMFBD with Phase Diversity (Scharmer et al. 2010; Löfdahl & Hillberg 2022)

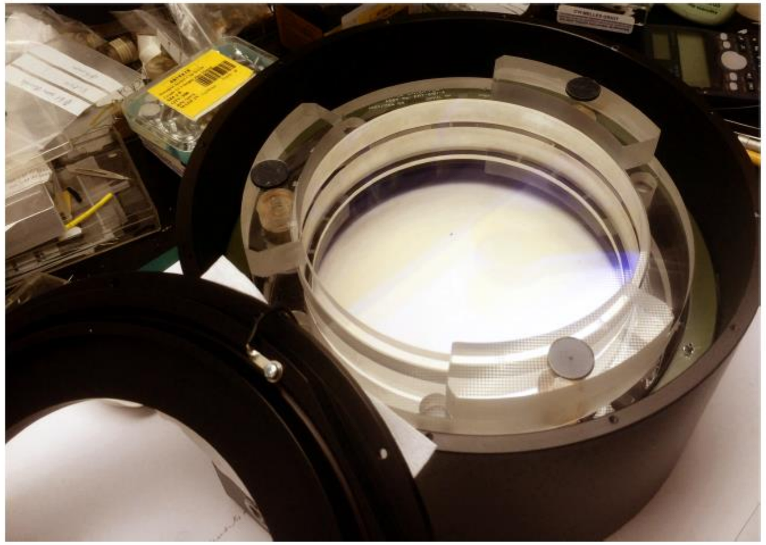
FW: filter wheel
BS: beam splitter
LCVRs: Liquid crystal variable retarders
FPI: Fabry-Pérot interferometer
F: focal plane

Credits: Luis Bellot Rubio

FPI optimization

Carried out by G. Scharmer (ISP)

ICOS ET150
Courtesy: UTOV



Optimization drivers

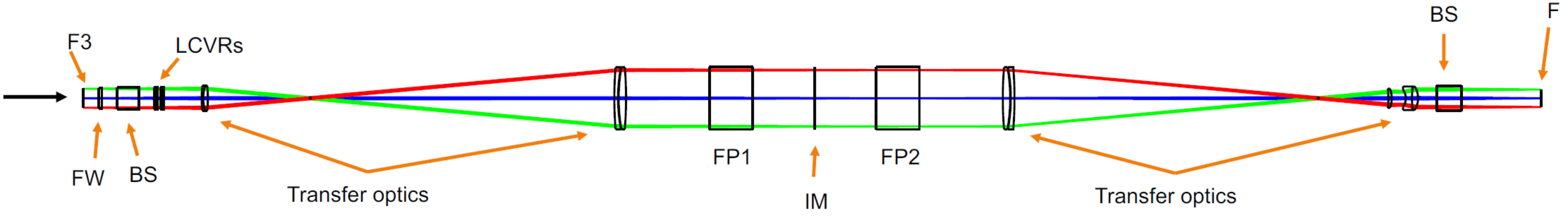
- High image quality (Strehl > 95%): telecentric mount
- Small pupil apodization effects: F-ratio of 147 at etalons
- Required FOV: 60” circular
- Required resolving power: R=100 000 at 630 nm
- Very low parasitic light (<1%)
- High transmission at peak wavelength (>90%)
- Reflectivities/cavity ratios chosen as in Scharmer (2006)

TIS-V specs (at 630.2 nm)

Etalon clear aperture	180 mm
Cavity ratio (d_2/d_1)	0.382
Reflectivities	FP1: 94%. FP2: 86%
Assumed rms cavity error	2 nm
Parasitic light	0.91%
Transm. at peak wavelength	93.5%
Strehl at optimum refocus	95.8%
FWHM for f/147	6.41 pm (R = 98,300)

Credits: Luis Bellot Rubio

TIS optical design



- First design by UTOV, updated by ISP
- Simple, all-refractive design similar to CRISP/CHROMIS
- Etalons illuminated with f/147 telecentric beam to reduce pupil apodization problems (Beckers 1998, von der Lühe & Kentischer 2000, Bailén et al. 2020)
- No folding mirrors needed
  - High throughput, no instrumental polarization
  - Compact linear design, ~4700 mm for each TIS
  - Etalons mounted vertically: same deformation as horizontally (Greco et al. 2022)

F3: focal plane provided by telescope (f/50)
FW: filter wheel
LCVRs: Pol modulator
BS: beam splitter
IM: intermediate image (f/147)
FP: Fabry-Pérot etalon
F: final focal plane

Credits: Luis Bellot Rubio

hoW ?

Contribution of the Italian Community: Technology

- M1 thermal control (EST)
- Heat rejecter (EST, GREST)
- AO and MCAO & DM2 (EST, SOLARNET, GREST, SOLARNET2)
- Broad Band Imager (EST)
- Narrow Band Tunable Imager (EST, SOLARNET2)
- Large Etalons and digital control (EST, GREST)
- Detectors (EST)
- Telescope Control and Data Handling (EST, SOLARNET)
- VSO (SOLARNET)
- Polarization induced by DM (GREST)

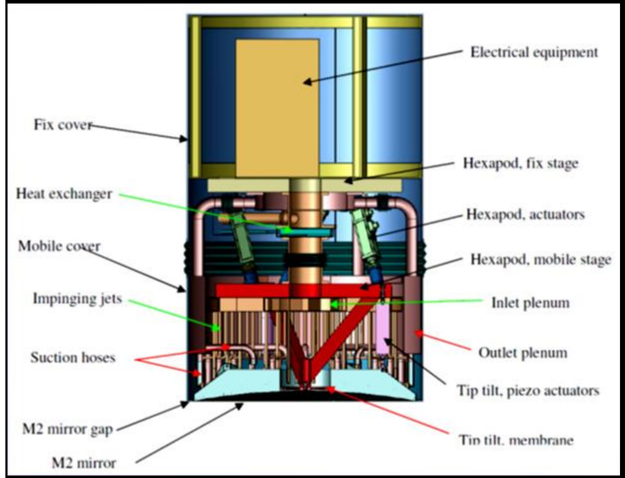
35 Italian researchers from

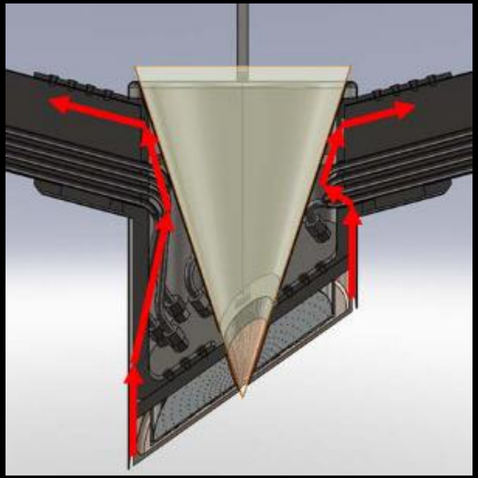
- 8 **INAF Institutes**: Observatory of Arcetri, Catania, Naples, Palermo, Rome, Trieste, IAPS, TNG-FGG
- 6 **Universities**: Calabria, Catania, Florence, L'Aquila, Palermo, Rome Tor Vergata
- CNR-INO

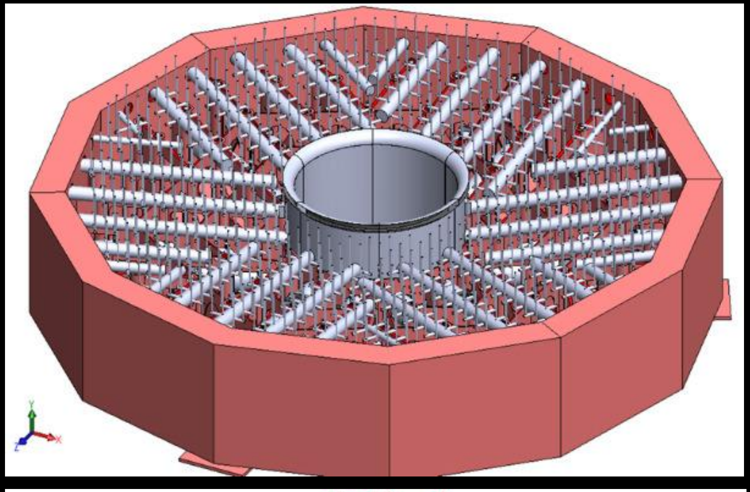
- 3 medium-sized Companies: S.R.S. Engineering Design, A.D.S. International, B.D.P. Engineering -Opto Service

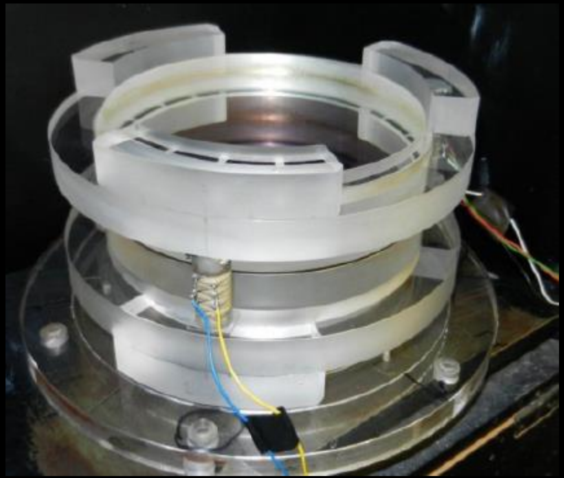
Yellow shows the projects financed under FP7 and H2020

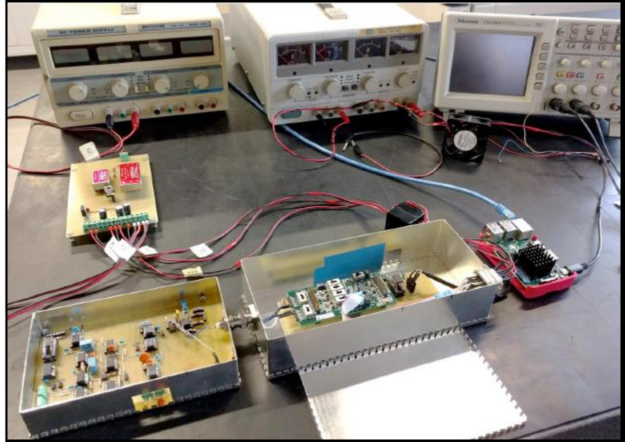
Contribution of the Italian Community: Technology

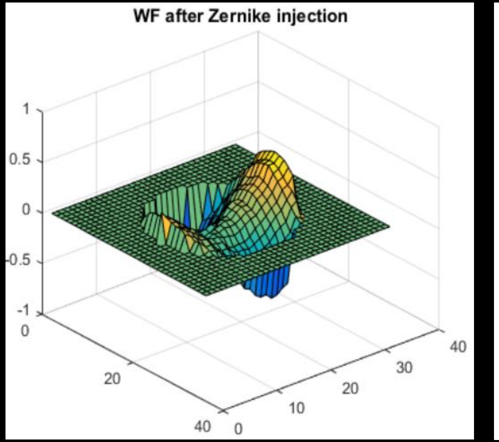


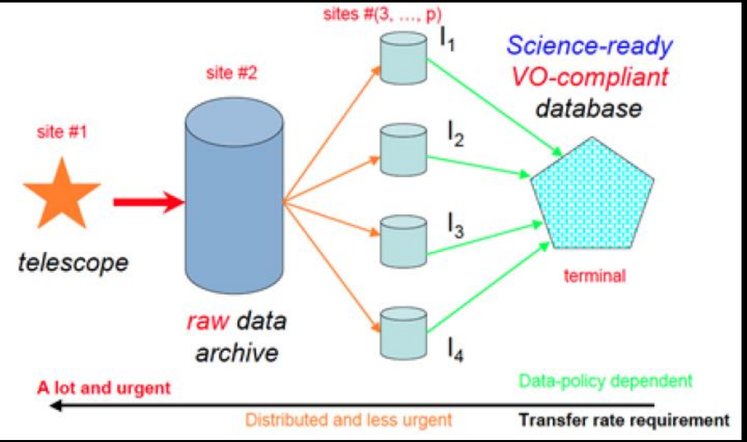


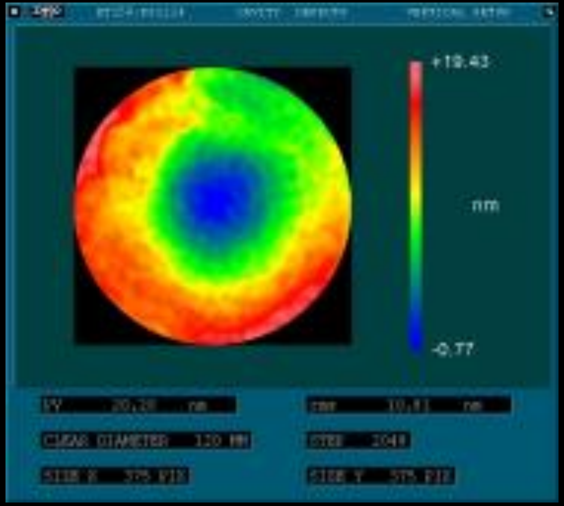












The Heat Rejecter (HR) is a vital system of EST and a challenge for the engineers.

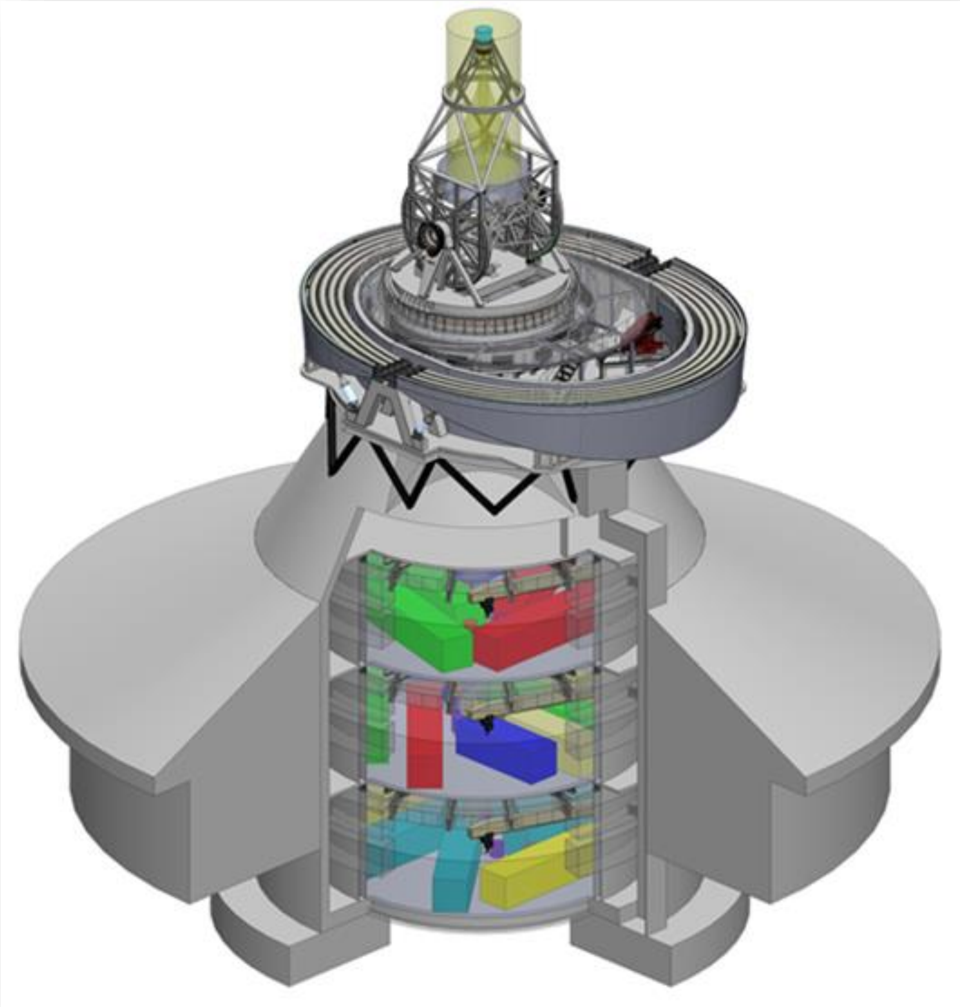
From an optical point of view it is the Field Stop of the telescope. But from a thermal point of view it must perform two tasks: reflect the heat in F1 (to reduce the thermal load in the optical path), have a temperature close to the environment one in order not to produce convective plumes that would affect the optical quality.

The energy concentrated in the focal plane can reach up to 5 MW m^{-2}, a density similar to the one in the core of a nuclear reactor.

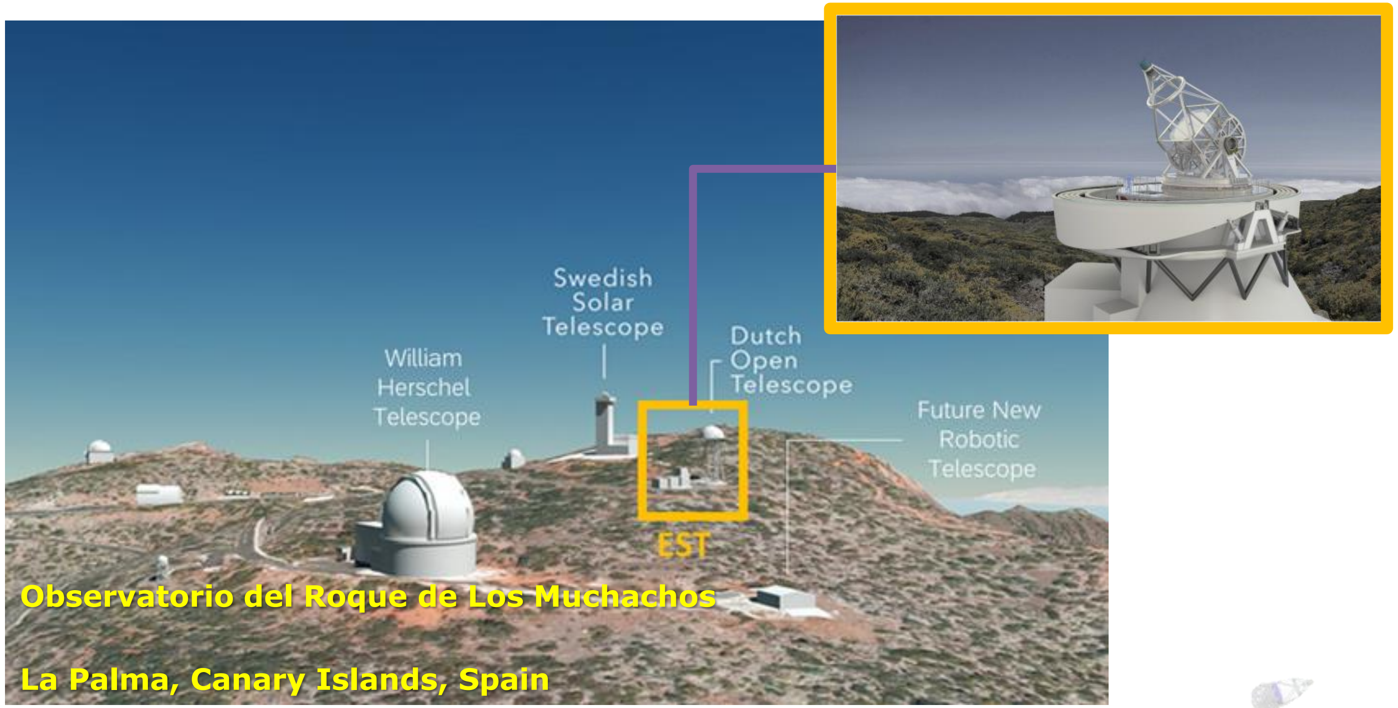
An Italian team designed a HR based on Multiple Jet Impingement (heat tr. Coeff. 25-40 kW/m^2 ^oC) technology, similar to the one used in cooling system adopted in nuclear fusion reactor divertors.

Where ?

SITE: ORM

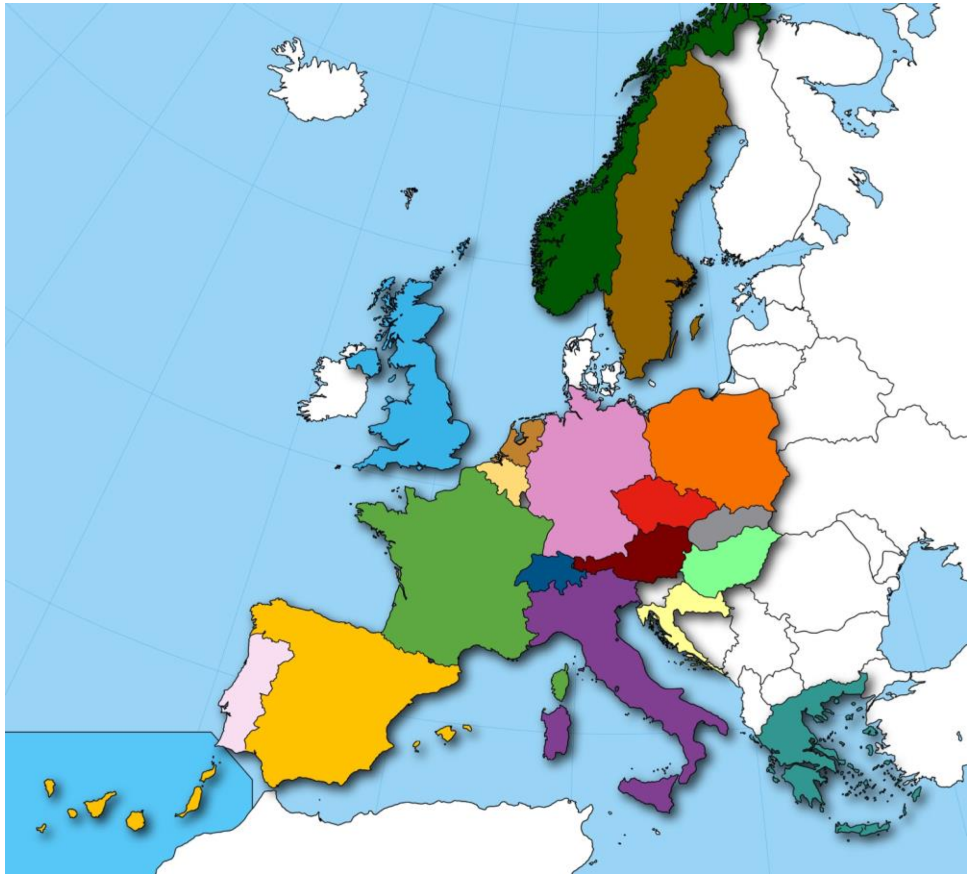


- Largest Solar Telescope in Europe (M1 ø4.2 m).
- Aimed to study the magnetic coupling of the solar atmosphere.
- High spatial resolution, high photon flux, optimal polarimetric performance.



Who ?

EST Scientific partners



EAST

European Association for Solar Telescopes

Bringing together research groups from 18 European countries

Italy: INAF, UNICAL, UNICT, UNITOV

EST became an ESFRI Strategic European Infrastructure in March 2016

EST FUNDACIÓN CANARIA

Legal Figure for the Interim Phase

July 25, 2023

9 institutions from 7 European countries signed the **deed of the Foundation**

1. Astronomický Ústav AV ČR, V. V. I. (**Czech Republic**)
2. Astronomický ústav Slovenskej Akadémie vied (**Slovakia**)
3. Agencia Estatal Consejo Superior de Investigaciones Científicas - Instituto de Astrofísica de Andalucía (**Spain**)
4. Instituto de Astrofísica de Canarias (**Spain**)
5. Leibniz Institute für Sonnenphysik KIS (**Germany**)
6. Max Planck Institute for Solar System Research (**Germany**)
7. Stockholms Universitet (**Sweden**)
8. Università della Svizzera italiana - Istituto Ricerche Solari Aldo e Cele Daccò (**Switzerland**)
9. University of Sheffield (**UK**), representing the United Kingdom Universities Consortium (Aberystwyth, Durham, Exeter, Glasgow, Sheffield and Queen's University Belfast).

December 21, 2023

10. University of Graz **(Austria)**

UNIVERSITÀ DELLA CALABRIA — Università di Catania — TOR VERGATA UNIVERSITÀ DEGLI STUDI DI ROMA

ACCORDO PER LA CREAZIONE DELLA JOINT RESEARCH UNIT (JRU) EST-IT
PER LO SVOLGIMENTO DI ATTIVITA' DI RICERCA E SVILUPPO NEL CAMPO DELL'ELIOFISICA E PER LA PROMOZIONE DELLA INFRASTRUTTURA ESFRI European Solar Telescope (EST)

Con il presente atto fra le sottoelencate Parti:

- Università della Calabria (di seguito anche "UNICAL") - in persona del suo Rettore e legale rappresentante, Prof. Nicola Leone
- Università di Catania (di seguito anche "UNICT") - in persona del suo Rettore e legale rappresentante, Prof. Francesco Priolo
- Università degli Studi di Roma Tor Vergata (di seguito anche "UNITOV") - in persona del suo Rettore e legale rappresentante, Prof. Nathan Levialdi Ghiron

PREMESSO CHE

La JRU EST-IT ha un interesse primariamente legato allo studio dell'eliofisica, della fisica solare e dello Space Weather e in questo contesto intende promuovere la realizzazione di EST (European Solar Telescope). EST è un telescopio solare di futura generazione riconosciuto come Infrastruttura Europea di Ricerca (IR) inclusa nella roadmap ESFRI 2016 e costituirà la più grande infrastruttura Europea di ricerca nel settore della fisica solare *ground based*. I principali obiettivi di EST (https://www.est-east.eu/) sono:

1. Studio dei processi astrofisici fondamentali
2. Variabilità solare e principali driver della variabilità solare
3. Impatto dell'attività solare sulla Terra

La fase preparatoria di EST è stata promossa e coordinata dalla European Association for Solar Telescopes (EAST, http://www.est-east.eu/est/index.php/people) dal 2006. A questa associazione afferiscono ricercatori e istituti di 18 nazioni Europee. La realizzazione di EST è prevista nell'isola di La Palma (Isole Canarie), tra i migliori siti astronomici al mondo.

EST intende divenire nel più breve tempo possibile un ERIC (European Research Infrastructure Consortium), la cui forma legale è pensata per facilitare il funzionamento delle infrastrutture di ricerca Europee. Nelle more per consentire una roadmap verso l'ERIC, è stata costituita, in data 25 luglio 2023, la Fondazione EST Fondazione Canaria (di seguito anche "EST-FC").
Gli ERIC sono riconosciuti come organismi internazionali, per cui beni e servizi possono essere acquistati senza IVA e dazi doganali.

UNITOV coordina la realizzazione del nodo italiano di EST che perseguirà a livello nazionale gli obiettivi di EST.
Le Parti sottoscriventi il presente accordo hanno sviluppato rilevanti attività, a livello internazionale, di ricerca e tecnologiche nel campo dell'eliofisica, della fisica solare e dello Space Weather anche in connessione al progetto EST e riconoscono l'alto valore scientifico, sociale ed economico della ricerca nel campo eliofisico anche in connessione allo studio del clima terrestre ed allo space weather. Il ruolo del Sole e delle connessioni Sole-Terra è nell'agenda dei maggiori Panel intergovernativi e delle maggiori agenzie spaziali.

EST

LETTER OF INTENT
THE EUROPEAN SOLAR TELESCOPE INITIATIVE

Noi sottoscritti, in rappresentanza delle aziende:

- **A.D.S. International srl**
- **BPD Engineering & Manufacturing SCaRL**
- **EIE GROUP srl**
- **Microgate srl**
- **Opto Service srl**
- **SRSED srl**
- **Tomelleri srl**

confermiamo la nostra disponibilità a sviluppare le azioni utili a sostenere la possibilità di una partecipazione italiana al progetto EST – *The European Solar Telescope* – in aderenza agli obiettivi scientifici della relativa comunità astrofisica nazionale, ad una ottimale collaborazione con tutti gli altri paesi partecipanti al progetto ed interessati alla costituzione del relativo ERIC – *European Research Infrastructure Consortium* – ed alla piena realizzazione della politica di ricerca e collaborazione internazionale italiana.

In questo contesto ci impegniamo a coordinarci e a collaborare per garantire il miglior risultato possibile, ad individuare e proporre, fin dalle prime fasi della negoziazione internazionale, quegli ambiti del progetto EST che consentano all'industria e alla ricerca nazionale di candidarsi per la realizzazione di un sistema quanto più possibile completo e integrato. Oltre che consentire un giusto ritorno delle risorse economiche impegnate nel progetto, tale approccio permetterebbe di qualificare e rafforzare nel paese una capacità realizzativa di sistemi e tecnologie avanzate, peraltro già implementate con successo in progetti affini, in modo fa massimizzare il ritorno e le prospettive economiche in questo campo.

Una ipotesi di lavoro rappresentativa di questa opportunità appare configurabile nella realizzazione della struttura primaria (*main structure*) del telescopio e dei relativi meccanismi e sistemi di controllo, sistemi di supporto idrostatici, supporto dello specchio primario e delle ottiche. Altre competenze da noi sviluppate e già implementate nelle fasi preliminari del progetto EST riguardano i sottosistemi di controllo termico (*heat stop*), i sistemi per le ottiche adattive e la strumentazione di piano focale.

Padova, 24 maggio 2019

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Meritevolezza scientifica Joint Research Unit (JRU) EST-IT from MUR and Letter from FC EST

Ministero dell'Università e della Ricerca

Segretariato Generale

Direzione generale dell'internazionalizzazione e della comunicazione

Prof. Nathan Levialdi Ghiron
Rettore
Università degli Studi di Roma "Tor Vergata"
rettore@uniroma2.it

e p.c. Prof. Francesco Berrilli
Università degli Studi di Roma "Tor Vergata"
francesco.berrilli@roma2.infn.it

Oggetto: meritevolezza scientifica della Joint Research Unit (JRU) EST-IT.

Magnifico Rettore,

facendo seguito alla Sua cortese richiesta, pervenuta con nota Prot. MUR n. 11870 del 31/07/2024, questo Ministero ha operato alcune verifiche circa la Joint Research Unit (JRU) EST-IT ed il relativo accordo fondativo, sottoscritto dai seguenti partner:

1. Università degli Studi di Catania (UNICT);
2. Università degli Studi di Roma Tor Vergata (UNITOV);
3. Università della Calabria (UNICAL).

A valle delle predette verifiche e dopo le interlocuzioni tecniche con il Prof. Berrilli, è stata riscontrata la correttezza formale dell'Accordo di Collaborazione firmato dai Rettori dei tre atenei, rispettivamente in data 5/04/2024 (UNICAL), 9/04/2024 (UNICT) e 11/04/2024 (UNITOV). Tenuto conto che il citato Accordo di Collaborazione, valido fino al 31 dicembre 2025 (e rinnovabile fino al 31 dicembre 2027), risulta correttamente formulato, e preso atto del rilievo scientifico dell'iniziativa, si evidenzia l'utilità della JRU EST-IT quale strumento di collaborazione tra istituzioni accademiche nel settore dell'eliofisica, della fisica solare e dello *Space Weather*.

Ministero dell'Università e della Ricerca

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In tale contesto, si rappresenta come la JRU EST-IT intenda promuovere la realizzazione di EST (*European Solar Telescope*), telescopio solare di futura generazione riconosciuto quale Infrastruttura Europea di Ricerca inclusa nella roadmap ESFRI 2016, anche attraverso la possibile partecipazione alla Fondazione "*European Solar Telescope - Fundación Canaria*".

Alla luce di quanto sopra rappresentato, questo Ministero tiene a sottolineare la meritevolezza scientifica dell'iniziativa in parola, nonché il pregio delle attività di ricerca scientifica realizzate dagli atenei partner nel settore di riferimento.

L'occasione è gradita per porgere cordiali saluti.

Il Direttore Generale
Dott. Gianluigi Consoli
Firmato digitalmente ai sensi del c.d. Codice dell'Amministrazione digitale e norme ad esso connesse

Largo Antonio Ruberti, 1 – 00153 Roma
dginternazionalizzazione@mur.gov.it
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EST Fundación Canaria

MR. MANUEL ARTURO COLLADOS VERA, PRESIDENT OF THE EUROPEAN SOLAR TELESCOPE FUNDACIÓN CANARIA BOARD OF TRUSTEES, REGISTERED IN THE REGISTRY OF FOUNDATIONS OF THE CANARY ISLANDS WITH NUMBER 403.

INFORMS:

That the Board of Trustees of the Foundation, during its ordinary meeting held via virtual means on December 19, 2024, at 4:00 PM, reviewed the request submitted by the Italian Joint Research Unit (JRU), to become a Founder of the EST Foundation.

Following the corresponding analysis, the Board of Trustees resolved the following:

1. To accept the incorporation of the Italian Joint Research Unit (JRU) as a Founder of the EST Foundation. This decision includes the approval of the proposed cash contribution of 200.000,00 €.
   i. The transfer of funds shall be carried out at the earliest convenience.
   ii. The incorporation of the Italian JRU will take effect once the funds have been successfully transferred to the Foundation's bank account.
2. To approve the inclusion of Dr. Luca Giovannelli as its representative on the Board of Trustees.
   i. Dr. Luca Giovannelli's membership at the Board of Trustees will become effective upon the receipt of the bank transfer and its formal notification to the Registry of Foundations.

La Laguna, on 3th January 2025

The President

Signed.: Manuel A. Collados Vera

JRU EST-IT

Assemblea Generale

→ **Gruppo di Coordinamento**

Coordinatore Luca Giovannelli (UNITOV)

JRU Manager Danilo Aceto Zumbo (UNITOV)

Liaison Officer Andrea Attanasio (UNICAL)

UNICAL

Prof. Vincenzo Carbone* (delegato)

Prof. Fabio Lepreti (attaché tecnico scientifico)

UNICT

Prof.ssa Francesca Zuccarello* (delegato)

Prof. Alessandro Lanzafame (attaché tecnico scientifico)

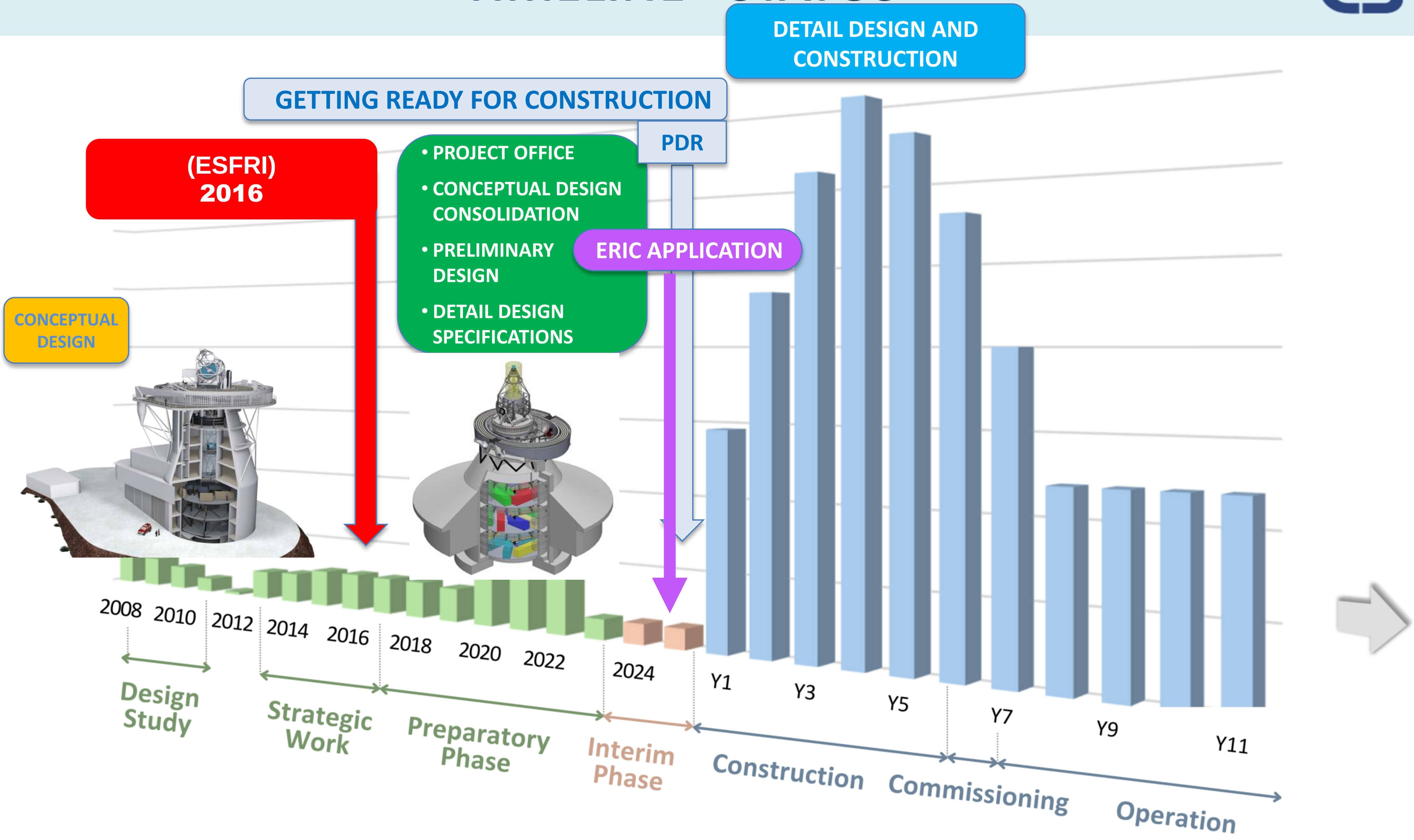
UNITOV

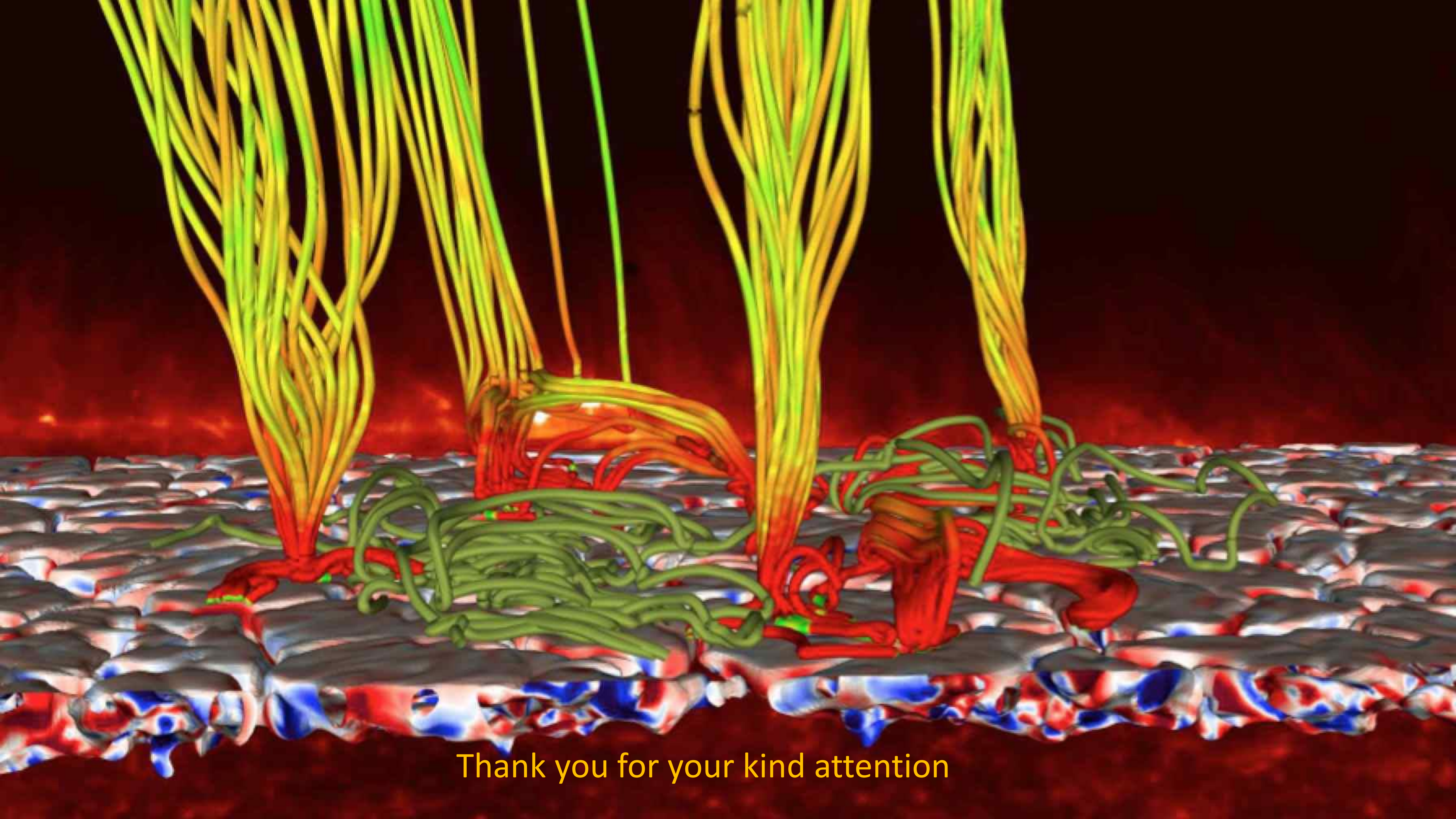
Prof. Francesco Berrilli (delegato)

Prof. Dario Del Moro (attaché tecnico scientifico)

When ?

TIMELINE - STATUS




Thank you for your kind attention