



# EST NEWS

THE EUROPEAN SOLAR TELESCOPE NEWSLETTER

SPRING 2019

## INSIDE THIS ISSUE

- EST Preparatory Phase News. Inauguration of the EST Project Office building

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- Portugal joins EAST

---

- New projects: SOLARNET and ESCAPE

---

- Update of the EST Science Requirement Document

---

- EST Technical Advisory Group set up

---

- Ongoing site characterization

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- Outreach activities

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## COORDINATOR'S CORNER

EST continues its path for becoming a reality. The EST community is growing with the inclusion of more organisations in the European Association for Solar Telescopes, the most recent one being the University of Coimbra. EST also continues its involvement in important H2020 EU projects: SOLARNET and ESCAPE started early 2019 and will last until the end of 2022.

All EST partners are making strong efforts to present publicly the progress made during the Preparatory Phase, and different EST aspects are presented in scientific meetings, technological workshops and political fora.

Of particular importance has been the set up of the EST Project Office (EST-PO). Fifteen persons have already been hired and more positions will be announced in the near future. In spring 2019, the new headquarters for the EST-PO were inaugurated.

The EST-PO team is working hard to upgrade the telescope design with the most advanced technological alternatives. Especially relevant is the feasibility study of an Adaptive Secondary Mirror, which may lead to a significant improvement of the performance of the telescope. During the second half of 2019, an international call for tenders for the preliminary design of the telescope structure, and for the primary and secondary mirrors, will be announced. This will represent a major milestone for the project.

The EST-PO team is also in close contact with the Scientific Advisory Group (SAG) and the recently formed Technical Advisory Group (TAG). After the "Science with EST" meeting held in Giardini Naxos (Catania, Italy), a new version of the Science Requirements Document (SRD) has been recently produced by the SAG. This new SRD is fundamental for the Project Office team to freeze all technical requirements in close cooperation with the TAG.

This newsletter is just a glimpse of the things that are happening. I hope you enjoy it.

*M. Collados, EST project coordinator*

## EUROPEAN SOLAR TELESCOPE PREPARATORY PHASE: CURRENT STATUS AND NEXT STEPS

*The inclusion of EST in the ESFRI Roadmap and the accomplishment of the conceptual design led to the achievement of several milestones in the project. The preparatory phase is now under way*



*Artistic view of the European Solar Telescope*

In March 2016 the European Solar Telescope was included in the ESFRI Roadmap. It was a milestone that led to other several key achievements, such as the successful application for EU funds devoted to the preparatory phase of ESFRI infrastructures, the approval of 4.5 million euros in regional funding by the Regional Government of the Canary Islands (committed to set up the Project Office and recruit personnel), and the release of annual contributions by the EAST partners.

Previously, the consortium had successfully accomplished the EST conceptual design, based on knowledge from existing telescopes and novel approaches to the new paradigms in solar physics.

All these elements have favoured the right moment for the EST preparatory phase to start up. This current phase will test the scientific concept and its feasibility. It will also undertake the analysis of the potential

user community, the outlining of a business case, and the issuing of policy recommendations regarding the data acquired by the telescope.

### **A DETAILED PLAN FOR THE IMPLEMENTATION OF THE TELESCOPE IS BEING PREPARED**

The consortium will also take the first steps towards the required financial and political support from governments and funding agencies. Actually, during this phase both the EST consortium and their funding agencies will be provided with a detailed plan regarding the implementation of the European Solar Telescope. This plan will address technical and organisational (strategic) issues, as well as cost and risk analysis, providing the necessary information to make decisions.

Progress made so far has been satisfactorily assessed by the

European Commission, declaring that the consortium is demonstrating its relevant role towards the realization of the European Solar Telescope. The Commission agrees that the EST proposal will add to the attractiveness of the European Research Area and foster international collaboration due to its unique scientific features.

**Next challenges.** From the technical point of view, the greatest challenge is to develop a design capable of delivering the scientific objectives of the European Solar Telescope. This technological effort must be accompanied by a political consensus on the implementation and suitability of the project. The culmination of this consensus will be expressed in the establishment of the EST ERIC (ERIC standing for "European Research Infrastructure Consortium", the optimal legal figure for a pan-European research infrastructure such as EST), as decided by the PRE-EST Board in April 2018.



Regional authorities attended the EST Project Office inauguration. They were greeted by both the EST coordinator and the IAC director.

## JOIN THE EST PROJECT OFFICE

Currently there are 15 members in the Project Office. Two new positions will be announced shortly: quality assurance responsible and computer engineer. More information can be found on the EST website.

Besides, four selection processes are ongoing: mechanical engineer (thermal analysis), mechanical engineer (design), electronic control engineer, and civil engineer. After recruitment is finished, the Office will be a multidisciplinary team of around 20 members. They will be in charge of the scientific and technical management and the definition of construction requirements.

Current members of the office are a technical director (IAC staff Senior Engineer), a system engineer, a chief optical engineer (IAC staff Senior Engineer), a chief mechanical engineer, an optical engineer, a mechanical engineer, a site testing engineer, an administrative, an AO system engineer, an AO electronic engineer, an AO software engineer, an AO electronic engineer, two AO optical engineers, and a project manager.

## INAUGURATION OF THE EST PROJECT OFFICE

The EST Project Office coordinates the scientific and technical management of the project. In February this year, the Project Office headquarters were inaugurated at IACTEC, a new building in the Polo Científico y Tecnológico de La Laguna (Tenerife, Spain). The new building was inaugurated by the Cabildo de Tenerife and authorities of the Canary Islands Government.

The Project Office prepares and supervises the international calls for preliminary design with industrial participation. It is also in charge of defining the technical requirements of construction, and preparing a preliminary design at both system and subsystem levels that is detailed enough for construction.

The office also collaborates with the EST site evaluation committee to choose the best location for the telescope in the Observatorios de Canarias (a decision on the final site is expected to be taken by the end of 2019).



The new Project Office Headquarters. The team is expected to move here in autumn 2019

## THE EUROPEAN SOLAR TELESCOPE JOINS THE LAST TWO ERIC FORUM MEETINGS

*Representatives of EST shared experiences and information with other ERICs, expressing the willingness of joining forces for ERIC implementation improvement*

The European Solar Telescope has attended the last two meeting of the ERIC Forum, held in Sevilla (October 2018) and Oslo (May 2019). EST representatives shared experiences and information with other key European Research Infrastructures, expressing the willingness of joining forces for ERICs implementation improvement.

Although not yet established as an ERIC, becoming one is mandatory for the successful implementation of EST, since this figure provides legal capacity recognised by all members states, flexibility to be adapted to the specific requirements of each infrastructure, and exemptions from VAT. It also constitutes a much faster process than creating an international organization. However, the negotiation and approval procedures for setting up an ERIC are carried out at national level. This process may be long and

represents one of the main risks for a research infrastructure like EST.

The ERIC Forum was created in 2017 to strengthen coordination and achieve a common voice to interact with the European Commission for the full implementation of ERIC regulations.

Its meetings are complementary to the biannual working meetings between the established ERICs and the Commission.

Twenty ERICs have been set up since the European Union approved this legal figure in 2009. Several others are on the way.



*Participants in the 4th ERIC Forum Meeting in Oslo (May 2019)*

## INFORMATION DAY FOR CZECH TECH COMPANIES HELD IN PRAGUE



An information day for Czech technological companies was held on June, 13<sup>th</sup> at the Technological Center of the Czech Academy of Sciences. The aim of the meeting was to provide detailed information about the European Solar Telescope, and to present the first upcoming calls for tenders on preliminary design.

Representatives of the Czech technological companies and the Czech Ministry of Education, Youth and Sports discussed the possibilities of participating in the design, development, and construction of EST with the project team. The future steps for establishment of the EST ERIC were also discussed.

## PORTUGAL JOINS THE EUROPEAN ASSOCIATION FOR SOLAR TELESCOPES

*The number of countries represented within the association is now 18. Profs. Mats Carlsson and Oskar von der Lühe were unanimously re-elected as president and vice-president for 2019-2020*

The EAST general assembly, held last January in the premises of the Spanish National Research Council (CSIC) in Brussels, welcomed three new members: Universidade de Coimbra, representing Portugal; Queen's University (Belfast, UK), and University of Sheffield (UK).

These new membership requests follow a number of research institutes and universities that have manifested their interest in EAST in recent times. With these additions, the association is now formed by 26 institutions from 18 countries (Greece and Belgium joined less than two years ago, in 2017), a number that proves the interest of the solar physics community in coordinated and synergetic cooperation, and the European Solar Telescope project.

During the general assembly, much attention was devoted to the recent progresses accompanying the technical developments and the legal aspects related to EST. These include the main achievements of the H2020



*The EAST Executive Director, Marco Stangalini, opens the EAST General Assembly*

GREST project -completed in 2018- and H2020 PRE-EST. Attention was also paid to the new SOLARNET project, which started at the beginning of 2019 with the aim of integrating all major European research infrastructures in the field of high resolution solar physics, promoting and facilitating the access to them, and fostering collaborations within the solar

physics community at international level.

During the assembly, Profs. Mats Carlsson (RoCS, Norway) and Oskar von der Lühe (KIS, Germany) were unanimously re-elected as president and vice-president of EAST for the period 2019-2020.



### COUNTRIES REPRESENTED IN EAST

AUSTRIA  
BELGIUM  
CROATIA  
CZECH REP.  
FRANCE  
GERMANY  
GREECE  
HUNGARY  
ITALY

NORWAY  
POLAND  
PORTUGAL  
SLOVAKIA  
SPAIN  
SWEDEN  
SWITZERLAND  
THE NETHERLANDS  
UK

## SOLARNET H2020: A CONCERTED EFFORT TO UNIFY ACCESS TO SOLAR TELESCOPES

*The project is a structuring effort to prepare the European solar physics community to the advent of EST. It is therefore joining forces with PRE-EST.*



The Integrating Activity SOLARNET (High-resolution Solar Physics Network) is a project funded under the European Union's Horizon 2020 Research and Innovation programme (Grant Agreement No 824135). The project started on January 1<sup>st</sup>, 2019 and will end on December 31<sup>st</sup>, 2022.

SOLARNET aspires to open the key research infrastructures of the area of high-resolution solar physics for the benefit of all European researchers. These infrastructures include the observatories, data repositories of the space missions and related data from theoretical modelling as well as computing resources.

Another objective is to improve the services provided by these infrastructures. This includes upgrading and designing new instrumentation in its scientific capabilities and the virtual installations in their value as providers of information and generators of knowledge. This also includes the research and development of technologies which will be essential for the European Solar Telescope and their verification with existing facilities.

The third goal is to coordinate activities among those European institutions and organizations that support Europe's

major research groups in solar physics. These groups are widely spread across Europe, and hence networking among the scientists is essential to exchange expertise and training of the large fraction of young researchers in the field.

On January 24<sup>th</sup>, 2019 the SOLARNET General Assembly met in Brussels and kicked-off the new project. The leaders of the work packages and sub-tasks agreed on the harmonized nature of the proposed activities, which is evident in several areas: transnational access and service programs to unify access to solar observatories and data repositories, networking activities for students such as summer and winter schools, and joint research activities to develop new instrumentations and data repositories.

**SOLARNET consortium.** The SOLARNET H2020 Project -coordinated by the Leibniz-Institute for Solar Physics (KIS)- is a consortium of 35 partners, 28 research institutions and 7 companies,

located in thirteen European countries and 3 non-European ones (Japan, USA, and Russian Federation). The project is a logical continuation of the very successful SOLARNET FP7.

SOLARNET H2020 is organised in 10 work packages designed to strengthen the European solar physics community (by integrating all groups with complementary expertise), enhance the scientific productivity of its members (by facilitating access to research infrastructures and data repositories) and ensure that the budding young generation of scientists are prepared to take full advantage of the next generation facilities (planned or under construction).

The project has already issued some calls and access opportunities, such as a transnational access programme for observing time, a mobility programme and a training school for solar researchers. For more information, visit <http://solarnet-project.eu>

### SOLARNET OPEN CALL: SUMMER SCHOOL FOR SOLAR OBSERVERS

'Solar spectropolarimetry: From virtual to real observations' will be held at the Università della Svizzera italiana in Lugano, Switzerland between Sept 9-14, 2019. Further information at <http://solarnet-project.eu>

Deadline: June 30<sup>th</sup>, 2019.

# ESCAPE: PREPARING ASTRONOMY AND SOLAR PHYSICS INFRASTRUCTURES FOR OPEN SCIENCE

*The EST community actively participates in this coordinated effort to prepare ESFRI facilities and other pan-European infrastructures for the European Science Cloud Initiative*



Some of the infrastructures participating in ESCAPE (from left to right and top to bottom): ELT, CTA, FAIR, KM3NeT, SKA, HL-LHC and EST

ESCAPE (European Science Cluster of Astronomy & Particle physics ESFRI research infrastructures) is a project to address the open science challenges in astronomy and particle physics research domains faced by ESFRI facilities (SKA, CTA, KM3NeT, EST, ELT, HL-LHC, FAIR) and other pan-European infrastructures (CERN, ESO, JIVE).

It integrates itself in the European Open Science Cloud Initiative (ECOS), a vision for a federated, globally accessible, and multidisciplinary environment where researchers, innovators, companies,

and citizens can publish, find, use, and reuse each other's data, tools, publications, and other outputs for research, innovation and educational purposes. ECOS will federate existing resources across national data centres, e-infrastructures and research infrastructures.

ESCAPE aims at delivering solutions to ensure integration of data, tools, services and scientific software. These actions will establish interoperability within EOSC as an integrated multi-probe facility for fundamental science.

The project is funded by the European Union through its Horizon 2020 Programme, with a total amount of 16 M€. The EST community is actively represented by the Leibniz-Institut für Sonnenphysik (KIS), Leibniz-Institut für Astrophysik (AIP), Observatoire Royal de Belgique (ORB), Centrum Wiskunde & Informatica (CWI) and Università di Roma Tor Vergata (UToV) with 1M€ funding. This funding will help boost the implementation of the European Open Science Cloud.

**THE EST COMMUNITY IS ACTIVELY REPRESENTED IN ESCAPE** by the Leibniz-Institut für Sonnenphysik (KIS), Leibniz-Institut für Astrophysik (AIP), Observatoire Royal de Belgique (ORB), Centrum Wiskunde & Informatica (CWI) and Università di Roma Tor Vergata (UToV). Together, they have received 1M€ funding for contributing to work packages 3, 4, and 5

## WP3: OPEN-SOURCE SCIENTIFIC SOFTWARE AND SERVICE REPOSITORY

AIP: Building a classification engine for solar and stellar spectra with convolutional neural networks

CWI: Space weather with deep learning

## WP4: CONNECTING ESFRI PROJECTS TO EOSC THROUGH VO FRAMEWORK

UToV: Upgrade of the SWERTO space weather database access

ROB & KIS: Development of an operational SVO

ROB: Interfacing the SOLARNET SVO and the ESA JHelioviewer

ROB: Integrating solar datasets within the astrophysics community

## WP5: ESFRI SCIENCE ANALYSIS PLATFORM

KIS: Visualisation and exploration tool for large volumes of multi-wavelength spectro-polarimetric (solar) data

## THE SCIENCE REQUIREMENT DOCUMENT, UPDATED BY THE SCIENCE ADVISORY GROUP

*The Science Advisory Group presented a draft of the final version in May 2019. One of the main goals of the document is to identify critical science requirements for the telescope*

The SAG was constituted in November 2017 by the General Assembly of EAST and the Board of the PRE-EST project. It was charged with the task of providing a final statement on the science requirements.

Based on the conceptual design, the update of the Science Requirement Document (SRD) takes into account recent technical and scientific developments, to ensure that EST provides significant advancement beyond the current state-of-the-art.

### THE SRD DEVELOPS THE TOP LEVEL SCIENCE OBJECTIVES OF EST INTO SCIENCE CASES

The SRD develops the top-level science objectives of EST into individual science cases. Identifying critical science requirements is one of its main goals. Those requirements will define the capabilities of EST and the post-focus instrument suite. The technical requirements for the final design of EST will be derived from the SRD.

**EST science cases.** In May 2019, the SAG presented a draft of the final version of the SRD. Such a draft is currently under discussion.

The science cases collected in the SRD are not intended to cover all the science questions to be addressed with EST, but rather to provide a precise overview of the capabilities that will make EST a competitive state-of-the-art telescope, one to push the boundaries of our knowledge over the next few decades.

Science Requirement Document (SRD) for EST		Prepared by the EST Science Advisory Group	
<b>I</b>	<b>Introduction</b>		<b>4</b>
<b>II</b>	<b>Top-level science goals</b>		<b>5</b>
<b>1</b>	<b>Structure and evolution of magnetic flux</b>		<b>5</b>
<b>2</b>	<b>Wave coupling throughout solar atmosphere</b>		<b>12</b>
<b>3</b>	<b>Chromospheric dynamics, magnetism, and heating</b>		<b>19</b>
<b>4</b>	<b>Large scale magnetic structures: sunspots, prominences and filaments</b>		<b>24</b>
<b>5</b>	<b>Coronal Science</b>		<b>30</b>
<b>6</b>	<b>Solar Flares and Eruptive Events</b>		<b>32</b>
<b>7</b>	<b>Coupling in partially ionized solar plasma</b>		<b>37</b>
<b>8</b>	<b>Scattering physics and Hanle-Zeeman diagnostics</b>		<b>41</b>
<b>9</b>	<b>Nasmyth focus science</b>		<b>48</b>
<b>10</b>	<b>Tables for Observing Programmes</b>		<b>51</b>
<b>III</b>	<b>Discussion and Requirements</b>		<b>120</b>
<b>11</b>	<b>What are the particular strengths of the EST design?</b>		<b>120</b>
<b>12</b>	<b>Discussion</b>		<b>121</b>
<b>13</b>	<b>Scientific Requirements</b>		<b>123</b>

*Contents of the Science Requirement Document prepared by the EST Science Advisory Group*

Those science cases are then translated into observing programmes specifying the type of detailed observations needed to solve specific science problems. An effort is being made to define the parameters of the required observations as accurately as possible, taking into account both present capabilities and technological developments expected in the near future.

As the top-level goal of EST is to understand small-scale processes in the solar atmosphere, it is designed to be a solar 'microscope'. EST should be capable of reaching the highest possible image quality and spatial resolution. The final design must be optimised for the highest possible photon flux, with the premises of securing polarimetric accuracy and sensitivity.

# FIRST EST SCIENCE MEETING ORGANISED IN ITALY BY UNIVERSITY OF CATANIA

*The scientific objectives and the status of EST were discussed. Members of the EST Science Advisory Group presented the updated version of the EST Science Requirement Document.*

For five days (June, 11-15, 2018) the European solar physics community met in Giardini-Naxos (Italy) for the first EST Science Meeting, organised by University of Catania.

The scientific objectives and status of the EST project were discussed during the meeting. Members of the EST Science Advisory Group presented an updated version of the EST Science Requirement Document.

The scientific programme of the meeting, attended by over 75 scientists, included about 60 oral presentations, as well as several posters. Long time slots in each session were allocated to discuss how the many "hot topics" in Solar Physics could benefit from the European Solar Telescope.

The first session described the status of the EST project. Manuel Collados, from Instituto de Astrofísica de Canarias, PI of the project, gave a review talk of the EST history. Other presentations focused on the characteristics and capabilities of the instruments the EST will be equipped with, as well as the collaboration activities toward an EST Data Centre.

The following sessions were devoted to present the "hot topics" in Solar Physics which the EST is expected to address. Scientific presentations, as well as the discussions at the end of each session, provided useful suggestions for future "science cases" for the EST.

A video summary of the meeting is available at [science-media.org](http://science-media.org)



## Scientific Sessions

- The state-of-the-art of the EST project.
- Magnetised plasma dynamics and fundamental processes.
- Scattering physics and Hanle-Zeeman diagnostics.
- Wave coupling throughout solar atmosphere.
- Structure and evolution of magnetic flux.
- Chromospheric dynamics and heating.
- Solar flares and eruptive events.
- The solar corona.

## SOC

L. Belluzzi (RSOL, CH)  
M. Carlsson (UIO, NO)  
M. Collados Vera (IAC, ES)  
J. Jurcak (IAS, CZ)  
M. Mathioudakis (QUB, UK)  
S. Matthews (MSSL, UK)  
R. Erdelyi (U. of Sheffield, UK)  
R. Schlichenmaier (Co-Chair, IIS, DE)  
D. Utz (IGAM, AT)  
F. Zuccarello (Chair, UNICT, IT)

## LOC

C. Anastasi (UNICT, IT)  
G. Bellasai (INAF-OAC, IT)  
M. Falco (INAF - OAC, IT)  
M. González (IAA-CSIC, ES)  
S. Guglielmino (UNICT, IT)  
A. Martín Gálvez (IAC, ES)  
E. Marinetti (INAF - OAC, IT)  
P. Romano (Co-Chair, INAF-OAC, IT)  
G. Santagati (INAF - OAC, IT)  
F. Zuccarello (Chair, UNICT, IT)

*The EST Science Meeting is an opportunity to contribute to the definition of the telescope Science Requirements.*



<http://www.oact.inaf.it/est/>

This activity has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 739000



## AO4ELT6: ADAPTIVE OPTICS FOR EXTREMELY LARGE TELESCOPES

The European Solar Telescope was one of the sponsors of the conference on Adaptive Optics for Extremely Large Telescopes that took place in Québec (Canada) on June, 9-14, 2019.

Luzma Montoya, from the Instituto de Astrofísica de Canarias (Spain) delivered a keynote presentation on the progress along the EST MCAO roadmap. A poster on the real time MCAO demonstrator for the EST was also on display at the event. Promotional EST material was brought to the venue.

Solar adaptive optics was one of the topics covered in the meeting, including daytime atmosphere characterization, extended source wavefront sensing and alternative sensing methods, and image quality parameters.

## GRANADA HOSTED THE HINODE-12 SCIENCE MEETING: "THE MANY SUNS"

The Hinode-12 Science Meeting, 'The many Suns', took place in Granada (Spain) from 10th to 13th of September 2018. The Hinode Science Working Group met at the same venue one day later, on the 14<sup>th</sup>.

The conference was held at the Palacio de Congresos de Granada. It was organized by Luis Bellot Rubio (IAA-CSIC, Spain) and Ada Ortiz (RoCS/UiO, Norway).

More than 140 attendees from all over the world participated in the conference and the SWG meeting, which was by invitation only. There was a mix of invited reviews (26), contributed talks (51) and posters (65). In addition, two Metcalf Lectures were delivered by Dr. Clara Froment (RoCS/UiO, Norway) and Dr. Milan Gošić (LMSAL/BAERI, USA), recipients of the Metcalf Travel Awards.

The conference's eight sessions were a success. Aside from the seven normal scientific sessions there was a special session on 'Next Generation Solar Physics Missions', where an overview of future solar missions was presented. The level of contributions was very high, and lively discussions occurred in the hall as well as in the poster section.



The EST model was displayed in the conference

**EST contribution.** The EST model at 1:100 scale was on exhibition for the first time ever outside the conference room together with brochures, calendars and stickers. In addition, there were two EST related talks, with Manuel Collados (IAC, Spain)

giving an invited review on "Integral field units for solar observations" and Rolf Schlichenmaier (KIS) delivering a review on "Recent advances in the EST project", an update to the community on the status of the EST project.

## EST, AT THE ITALIAN ASTRONOMICAL MEETING



The European Solar Telescope was present in the LXIII Congresso della Società Astronomica Italiana, held in Rome on May, 14-17. The congress intended to look into the future of Italian astronomy in the international context, featuring the most prominent research projects by Italian universities and research centres.

Francesco Berrilli, from University of Rome Tor Vergata, introduced the European Solar Telescope to an audience of Italian astronomers and astrophysicists on behalf of the EST project.

## THE TECHNICAL ADVISORY GROUP GETS SET UP

*The first meeting of the TAG took place in March 2019. The group is formed by partners with previous responsibilities in the EST conceptual design study.*



The Technical Advisory Group (TAG) is one of the advisory committees working with the EST Project Office to ensure adequate internal communication (the other one being the Science Advisory Group).

The group was formed at the beginning of 2019 and is composed by partners with previous responsibilities in the EST conceptual design, as well as in the design, manufacturing, integration, and

operation of other solar telescopes. The Project Office will periodically inform the TAG to monitor the progress of the design and to get its reviews and suggestions if needed.

The first EST PO-TAG meeting took place on March, 15<sup>th</sup>, 2019 with the participation of Francesco Berrilli and Dario Del Moro (UNITOV), Paolo Di Marcantonio and Marco Stangalini (INAF), Oskar von der Lüche and Reiner

Volkmer (KIS), and Manuel Collados and Mary Barreto (IAC). A new member, Dan Kiselman (SU), has joined since then. Other new members will be welcomed, specially for those systems that will be consolidated and designed during 2020.

The next TAG meeting will take place after the Secondary Adaptive Mirror market consultation.

## ONGOING TECHNOLOGICAL DEVELOPMENTS

Updating and consolidating the 2011 EST conceptual design were the main task for the Project Office in the last year. The definition of the specific requirements and the validation of its cutting edge adaptive secondary mirror are part of the Project Office main duties.

These efforts will lead to a call for tenders for the preliminary design of the primary mirror M1, secondary mirror M2, and the structure of the telescope.

During the consolidation and review of the 2011 conceptual design, the possibility of an adaptive secondary

mirror (ASM) was considered. This addition modifies the 2011 telescope optical concept and will allow to reduce the number of optical surfaces by half.

EST will be the first solar telescope assembling an adaptive secondary mirror. Besides, it will push current night time adaptive optics technology to the next level, addressing several challenges that night time AO has not solved yet. A market consultation was launched in regard of the adaptive secondary mirror, and results were received on May 31<sup>st</sup>, 2019. This information is key to continue the design consolidation.

In the case the new EST concept is adopted, a conceptual design review will take place in September 2019.

On the other hand, the IAC has made an effort to define a legal framework to run collaboration agreements with public and private European agents (see [www.est-east.org](http://www.est-east.org)). In particular, the exchange of knowledge and experience with industrial organisations pushing technological developments has been pursued. The IAC collaboration with industry in different astronomy-related technological areas will contribute to meet some of the EST specific technical challenges.

## ADAPTIVE SECONDARY MIRROR (ASM) OPTICAL DESIGN

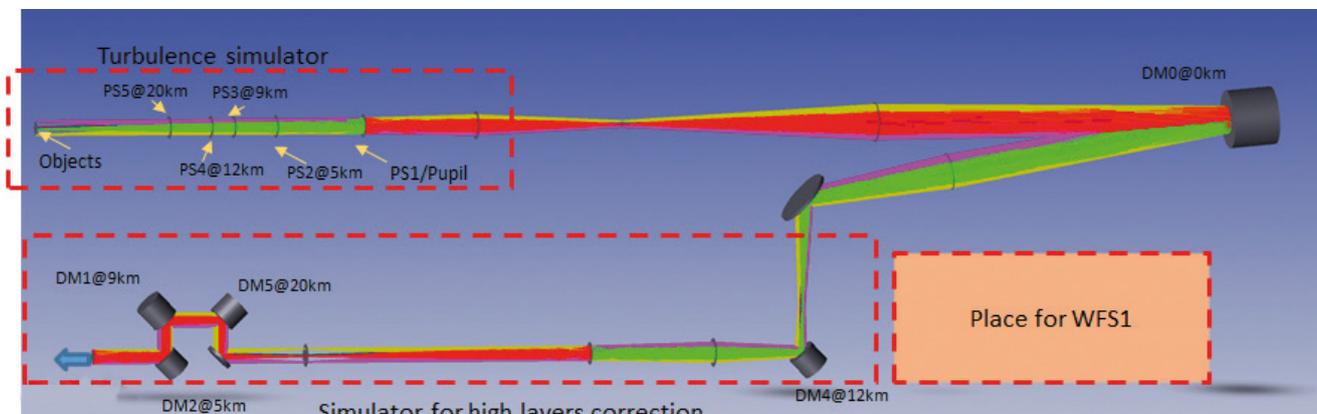
The secondary mirror M2 is an on-axis ellipsoid, giving an F/12.6 F2 focus. M2 is defined as the aperture stop of the whole optical system and has a diameter of ~800mm. This implies that is in the right place to correct wavefront errors in the telescope pupil.

It is part of the current evaluation to figure out if, besides the M2 adaptive optics mode, there should be an uncoupled M2 active mode. This M2 active mode could control the position of M2 along 5 degrees of freedom: one for focusing, two for decentering, and two for tilting. The active optics should always be operative when the adaptive optics mode is used. Besides atmospheric turbulence, the performance of the

telescope is affected by disturbances like gravity induced deflections, thermal effects and wind buffeting which cause a modification of the relative position between M1 and M2.

Those low frequency effects should be compensated by the ASM. In particular, M2 decentering is used to cancel coma due to M1-M2 lateral misalignment, mainly caused by structural flexibility or by residual optical adjustment errors. Besides, tip-tilt and M2 focus corrections can cancel tracking error sources derived from the alt-azimuth control system, gravity deflection of the telescope structure, wind buffeting and atmospheric image motion, which do not have a specified direction and vary continuously.

## REAL-TIME SOLAR MCAO DEMONSTRATOR FOR THE EUROPEAN SOLAR TELESCOPE



Sketch of the solar MCAO demonstrator with a turbulence simulator, deformable mirrors and two wavefront sensors

The European Solar Telescope will be equipped with a multi-conjugate adaptive optics system (MCAO) to provide excellent image correction within one arcminute field. A demonstrator of solar MCAO with similar requirements as the EST is being designed at IAC.

This bench will test new and existing concepts for solar MCAO, as, e.g., the integration of neuronal networks in the reconstruction process. A high-resolution image of the Sun will be created and perturbed by a turbulence simulator with different phase screens placed at different heights.

MCAO correction will be performed by one pupil deformable mirror and two altitude deformable mirrors. Two wide-field wavefront sensors will be used to perform the tomography and a scientific camera will evaluate the performance within one arcminute field.

This bench is currently under construction at the IAC headquarters. Construction and alignment of the system is expected to be finished in the coming year, although first results from completed modules will be available earlier.

# ONGOING SITE CHARACTERIZATION: DECIDING ON THE OPTIMUM LOCATION FOR EST

*EST will be built either on La Palma or Tenerife. To assess which location is better, it's important to develop a genuine understanding of the image quality conditions of the atmosphere*

An obviously critical part of the EST project is to identify the optimum site for the construction of EST. It is well-known that the observatories on La Palma and Tenerife are the best locations for solar telescopes in Europe, but how to assess whether one site is better than the other?

A project has therefore been initiated that aims at developing a genuine understanding of the contributions to image quality ("seeing") from the atmosphere above two currently-operational solar telescopes: the Swedish 1-m Solar Telescope (SST) on La Palma and the Vacuum Tower Telescope (VTT) on Tenerife.

The method used is based on a well-known concept proposed for night-time site testing and further developed for solar telescopes, namely to measure the relative image motion of solar fine structure observed with two small telescopes. This provides quantitative information about the integrated seeing along the line of sight to the Sun. We have taken this method one step further by using several 14-cm telescopes (divided optically within the apertures of the 1-m SST and 70-cm VTT). We furthermore observe a large field of view to allow a tomographic view of the contributions to the seeing from different heights in the Earth's atmosphere.

Figure 1 shows how this works. Using two telescopes separated by a distance  $s$ , we observe a particular seeing feature at some height  $h$ . This seeing feature is observed against different solar fine structures for the two solar telescopes and this allows us to measure the height of the feature. Figure 2 shows similar-looking seeing

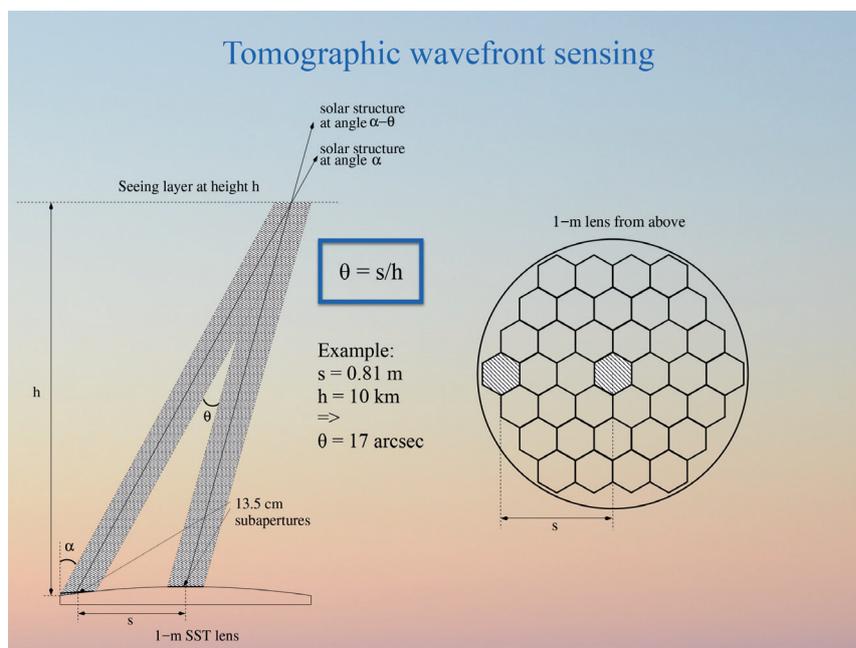


Figure 1. Principle of tomographic wavefront sensing

structures observed through 37 small telescopes at the SST.

The status of the project is that we have established in two publications (one in press) that the measured seeing quality

is strongly correlated to the quality of science images. The systems for SST and VTT are installed and operational. We are waiting for the replacement of the VTT vacuum window to start recording comparative data.

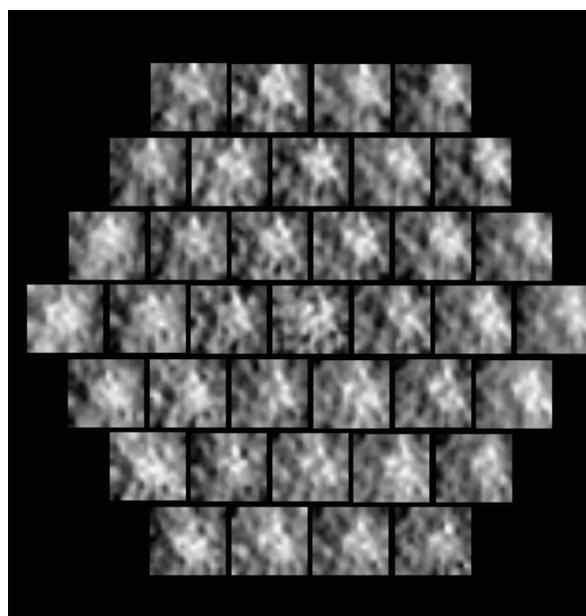
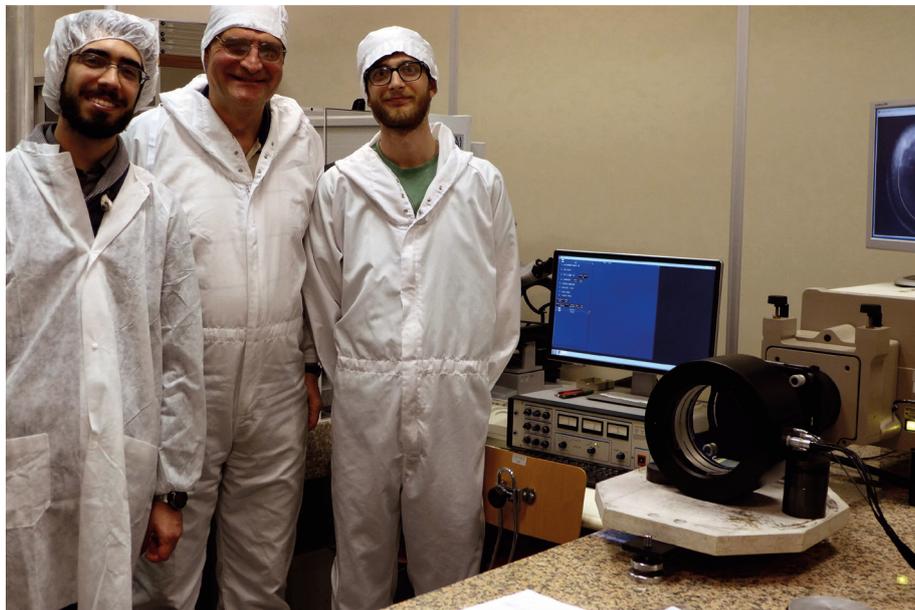


Figure 2. This picture shows 37 grey-scale coded maps of relative image motions, all obtained from within the 1-m SST aperture (see Fig. 1). The maps display small-scale structure because of turbulent seeing at large distance from the SST. By measuring the displacements of these structures relative to each other, the distance to the turbulent layer can be measured.

## UPDATE ON FABRY-PÉROT INTERFEROMETERS DEVELOPMENT

Fabry-Pérot interferometers (FPIs) are a crucial technological element of the European Solar Telescope focal plane instruments. Actually, the narrow band tunable instruments of EST will be based on FPIs to achieve high spatial and spectral resolution images, with high cadence, together with unique polarimetric capabilities. FPIs are tunable narrow band filters that make it possible to obtain nearly monochromatic images and can change very rapidly the wavelength.

An FPI is essentially an optical cavity and the spectral filtering properties depends on the nanometric control of the cavity distance. The large entrance pupil (4 m) of the future solar telescopes requires large interferometers (about 300 mm in diameter) for which the thermo-mechanical deformations of the plates become critical and could deteriorate the spectroscopic and imaging instrumental performances. For this reason, a detailed study was performed during FP7-SOLARNET to define the constraints in the use of large FPIs for the future solar instrumentation that was used



*The Fabry-Pérot prototype can be seen at the bottom right*

to build the prototype of a large diameter FPI (150 mm). The prototype is stabilized via capacitive sensors and piezo actuators loop, i.e. it has a Capacitance Stabilized Etalon (CSE) configuration, and it includes a new geometry to reduce static and dynamical stresses on the optical surface.

The stability of the FPIs is crucial, and so it is the electronic control of the interferometer. A new controller was developed under the H2020-GREST project to further improve the capabilities of the FPIs using the most recent communication interfaces and a digital approach to the capacitance-

stabilization. Furthermore, digital filtering of the control signal from the capacitive sensor can improve the stability of the optical cavity during observations.

H2020-SOLARNET is a great opportunity to further improve our development of the crucial technologies regarding FPIs for the European Solar Telescope. The goal is to design a Narrow-Band Tunable-Filter Imager for EST based on a tandem of capacitance-stabilised FPIs. This activity will address a broad range of key technical tasks, such as configurations trade-offs, analysis of the optical tolerances and stray light analysis.

## UPCOMING PUBLIC CALLS FOR TENDERS

The first EST public call for tenders will address the Preliminary Design of M1, M2 and the structure of the telescope. The aim is to have the contract awarded by the end of 2019. The design is expected to be accomplished by January 2021 in order to have the Preliminary Design Review in February 2021.

This review makes it necessary to develop the preliminary design of the rest of the subsystems during 2020 (or at least

the ones that will be included in the February-March review). These studies may also give rise to other calls for tenders during 2020.

A civil engineer is under selection to prepare the necessary works to consolidate the site to be chosen and define all necessary steps for the preparation of the site and the consolidation of the building construction.

## OUTREACH ACTIVITIES: SPREADING THE WORD ABOUT THE EST

*EST scientists and technicians do their best to share the excitement about the European Solar Telescope, not only in scientific meetings but also in festivals and conferences for general public*

The EST project actively participates in the many outreach activities taking place across Europe, such as the European Researchers' Night, an initiative intended to build bridges between citizens and scientists. In 2018, the Researchers' night took place on September 28<sup>th</sup>. Activities were organised by EST scientists from Osservatorio Astronomico di Roma (Italy), Instituto de Astrofísica de Andalucía (Granada, Spain), Università degli Studi di Catania (Italy) and Trinity College Dublin (Ireland).

Scientists from Università di Roma Tor Vergata (Italy) also took the stage for Pint of Science 2018, a global science festival that brings scientists to the pub to share their research with interested citizens. A similar initiative -Astronomy on Tap- saw EST scientists from the Institute of Theoretical Astrophysics in Oslo (Norway) go to the pub in June 2018.

**EST documentary.** A preview of the EST TV documentary, *Reaching for the Sun*, was showed during the Science and Technology Month in La Laguna (Spain), at the city's first exhibition of science documentaries (May 23-26, 2018),

*Reaching for the Sun* (now in post-production) will be a 50 minute documentary on the history of solar observations. A journey across the last 400 years of solar observations that culminates in one of the biggest challenges for the European solar physics community: the construction of the European Solar Telescope.



*The EST model on display in the Spanish Amateur Astronomy Congress*

The documentary features 16 interviews with EST scientists and footage from five different observatories and eleven telescopes. It also features unique sites, such as the Accademia dei Lincei (Roma, Italy), where original documents from Galileo are kept. Once released, it will be offered to TV channels and festivals.

**EST model.** The EST model and several other promotional materials were brought to events such as the European Week of Astronomy and Space Science 2018 (the largest conference for European astronomy, held in Liverpool, UK), the XIII meeting of the Spanish Astronomical Society (Salamanca, Spain), the XXX IAU



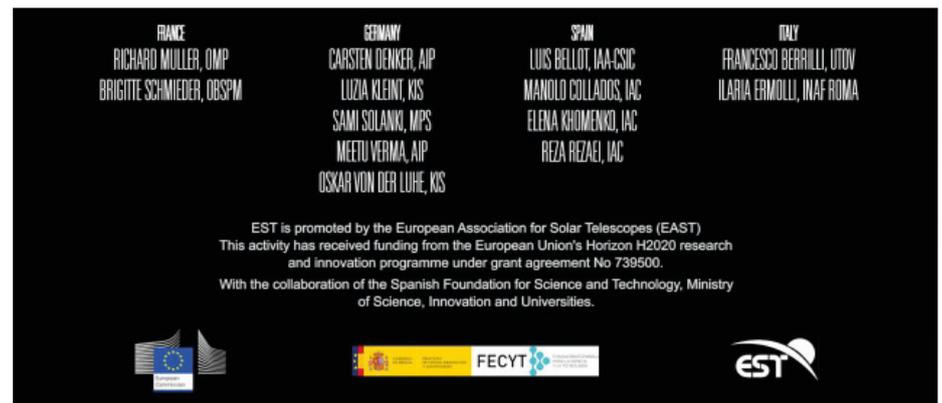
*Salvo Guglielmino (UNICAT) during the 2018 European Researchers' Night in Catania*

General Assembly (Viena, Austria), the HINODE-12 conference (Granada, Spain), the AO4ELT6 congress (Quebec, Canada), the XXIII Spanish Amateur Astronomy Congress (Cuenca, Spain), and the meeting of the Swedish Astronomical Society (Stockholm, Sweden). It was also on display at University College London (UK), Instituto de Astrofísica de Andalucía (Granada, Spain), Max-Planck Institute for Solar System Research (Göttingen, Germany), Leibniz Institut für Astrophysik (Postdam, Germany), and the Leibniz Institut für Sonnenphysik (Freiburg, Germany).

The EST model was also displayed in the European Parliament (Brussels) from April 8-12, 2019, as part of the "100 Square Moons" exhibition organized by Instituto de Astrofísica de Canarias (Spain).

#### Other outreach activities and public talks.

Scientists and engineers from the Università degli Studi di Roma Tor Vergata (Italy), presented the EST in several public nights observations, the Maker Faire and the Giornata Scienza e Ambiente 2018 (this



Two stills from the EST documentary

one in L'Aquila). They also participated in the Italian science TV programme C'è Spacio.

The Astronomical Institute of the Wrocław University (Poland) presented the European Solar Telescope at the Lower Silesian Science Festival and the Dzień Odry, a one-day festival in Wrocław

devoted to children and families. In Austria, the University of Graz organised EST related activities for The Long Night of the Museums 2018, as did the Leibniz Institut für Astrophysik and the Max Planck Institute for Solar System Research (Germany) for the Lange Nacht der Wissenschafte 2019 (the Long Night of Science).

In Spain, the Instituto de Astrofísica de Canarias integrated EST in the Feder Looks at the Sky exhibition and the Young Researchers Day. In the UK, the University College London took part in the activities of the International Day of Light. Meanwhile, in Slovakia, the Astronomical Institute of the Slovak Academy of Sciences participated in the "Weekend with the Academy" programme. Finally, the Astronomical Institute of the Czech Academy of Sciences (AIASCR) presented EST in the Open Days of the Institute in 2018.



EST model at MPS (Göttingen, Germany) during the Night of Science 2019

## THE EUROPEAN SOLAR TELESCOPE MEETS SPANISH AMATEUR ASTRONOMERS

*The EST participated in the XXIII Spanish Amateur Astronomy Congress held last October in Cuenca. The motto was "a bridge to the future", and it featured a mix of scientific and outreach talks*

EST participated in the XXIII Congreso Estatal de Astronomía, a biennial meeting that brings together professional and amateur astronomers in Spain. An audience of almost 300 people gathered for the invited talk on the European Space Telescope. The EST representatives introduced the future telescope, and gave an overview of the science behind the infrastructure and how it will deepen our knowledge of the Sun.

The event was an opportunity for amateur and professional astronomers to come together. It featured a mix of scientific results, outreach activities, historical perspectives on astronomy and new projects from both astronomy clubs and big research centers.

The congress' motto for this edition was "Un puente hacia el futuro" (A bridge to the future), referring to collaboration as a way of strengthening ties between professional



*Invited talk at the XXIII Spanish Amateur Astronomy Congress*

and amateur astronomers, with a focus on how new technologies have fostered a renaissance of citizen science astronomy projects.

With this activity, the EST consortium

wants to approach the very active amateur community, and make them aware of the European Solar Telescope and the possibilities it will open in solar physics research.

## EST, SPONSOR OF THE IAU 100TH ANNIVERSARY

The International Astronomical Union was founded exactly one century ago, in 1919. To commemorate this milestone, the IAU has organized a number of activities worldwide, with the motto "IAU 100 Years: Under One Sky".

The Flagship Event was held on April 11-12 at the Palais des Academies (Brussels, Belgium). Prominent astronomers, astronauts, policy makers, and high-level representatives gave talks with a focus on the role of astronomy for diplomacy, peace, development, education, and the arts; as well as the involvement of the high-tech industry.

On April 13<sup>th</sup>, the IAU Amateur Astronomy Day took place at the same venue. The event acknowledged the contributions of amateur astronomers to the advancement of astronomy. There were talks showcasing collaborative projects between professional and amateur astronomers, and parallel sessions where amateur astronomical associations exposed their work and history.



As one of the IAU100 Organisational Associates, the EST project was invited to attend the Flagship Event and the IAU Amateur Astronomy Day. A representation of EST from RoCS/UiO (Norway) and IAA-CSIC (Spain) participated in those meetings, advocating for EST and networking with other astronomers as well as with the amateur community. Amateur astronomers in particular showed a big interest in solar observations and enthusiasm in this pan-European project.

## #TheScienceOfEST: WHERE SCIENCE AND SOCIAL MEDIA MEET EACH OTHER

The series started last year and has continued in 2019. Posts are published weekly on Facebook, Twitter, and LinkedIn. All EST scientists are contributing with their texts and pictures

#TheScienceOfEST is a series of social media posts intended to draw the attention of the non-scientific community to solar physics and the importance of EST to expand our knowledge of the Sun and solar physics.

The idea behind the series is to write about highly complex solar physics topics in a way that can also engage non professionals, so their understanding about the Sun and telescopes gets enriched.

These social media posts are a key activity to spread the importance of astronomy and solar physics among the general public. Typically, the posts have three or four paragraphs of text and some visual support such as a picture or a movie. They are tagged as '#TheScienceOfEST' to easily find them on the internet.

The first series of posts were published between May and September, 2018. They were written by the members of the Science Advisory Group. A total of 18 posts were weekly published on Facebook and LinkedIn. The posts were seen by thousands of people (the top post reached up to 6.8K people).

The series has continued this year, starting in March 2019. This time, the posts are being written by scientists from PRE-EST and SOLARNET, and posted regularly each Wednesday on Facebook, LinkedIn and Twitter.

All posts are managed and collected by a small team consisting of A. Ortiz (UiO), S. J. González Manrique (AISAS), R. Morton (NU), L. Bellot (IAA) and C. Kuckein (AIP). The series will continue for the whole year.

**European Solar Telescope - EST**  
12 June at 02:15 · 🌐

A new post in #TheScienceOfEST series by Dr. Michal Sobotka from the Astronomical Institute of the Czech Academy of Sciences - Astronomický ústav AV ČR

"Solar Pores"

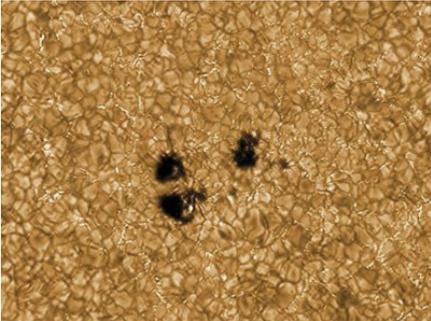
Pores are "naked" sunspots without a penumbra. A pore appears when a strong magnetic field emerges through the solar surface and inhibits the convective transfer of heat from lower layers - that is why pores look dark. If the magnetic flux increases, the field becomes strongly inclined at the edge of the pore, the penumbra is formed, and the pore transforms into a sunspot.

Pores - which are themselves "small" (1000 - 6000 km in diameter)- include much smaller bright structures, which indicate that the convective heat transfer from below is not completely suppressed. Dispersed magnetic fields around the pores also produce small bright points and chains in lanes between solar granules.

Thanks to their relatively simple magnetic-field configuration, pores are a good opportunity to study interactions between the magnetic field and moving plasma. Since such processes take place on very small spatial scales, the extremely high resolution of tens of kilometers, provided by the European Solar Telescope - EST, will be fully utilized.

The picture of pores in the active region NOAA 11516 was obtained with the Vacuum Tower Telescope at Tenerife on 1st July 2012 in the G-band (430 nm) and it was numerically reconstructed.

#ESFRI #ResearchInfrastructures #H2020 #ERIC #solarphysics #astronomy #Sun



👍👎❤️ 70      2 comments 32 shares

🔗 Share      📌 Buffer

## THE QuEST: EST CARTOONS COMING SOON!

The QuEST is a four-episode educational cartoon video series about the long-standing questions in solar physics and the EST science goals. It will be available on the EST YouTube channel.

The first episode -The QuEST for Sunspots- will be released on June 28th. It features Galileo Galilei and George E. Hale, two influential solar physicists who studied sunspots with the instruments they built.

With this series, we expect to communicate solar physics to both adults and teenagers in an informative and entertaining way. It will also be distributed as an educative resource.



A still image from the first episode of The QuEST: Galileo drawing sunspots

# EST NEWCOMERS

## MARY BARRETO CABRERA

EST TECHNICAL DIRECTOR



She holds an Industrial Electrical Engineer degree from University of Zaragoza and started working at the Observatorio Roque de los Muchachos (ORM, La Palma) as site testing engineer for the Large Earth Solar Based Telescope. She has also worked for the Instituto de Astrofísica de Canarias as ORM Site Manager, and as Project Manager at IAC Technology Division. Thirty three years' experience in different fields related to the design, construction, operation and maintenance of instrumentation and telescopes will be her contribution to the EST project.

## MIGUEL NÚÑEZ CAGIGAL

EST SYSTEM ENGINEER



Miguel is an engineer with 16 years experience. He was software developer and AIV tester for the GTC active optics and EELT M1 actuators prototypes. He was also responsible for the electronics of the GTC infrared instrument EMIR, including contributions to the detector controller and characterization. He also organized the integration of the electronics subsystems of EMIR at the GTC telescope. Right before joining EST he was in charge of the servo control and reconstruction strategy for the GTC Adaptive Optics project. He joined EST in April 2019 as EST system engineer.

## JORGE SÁNCHEZ CAPUCHINO

MCAO TEAM



Jorge has a M.Sc. degree in Applied Physics and a Ph.D. in Optical Engineering, as well as 20 years of experience as optical engineer in the design, specification and testing of imaging, non-imaging, spectroscopy and optical calibration systems. The last 15 years he has developed optical engineering tasks focused on large astronomical telescopes and their instrumentation. Besides, since 2018 he is in charge of the EST optical design.

## LUZMA MONTOYA MARTÍNEZ

MCAO TEAM



Luzma holds a PhD degree in Physics and more than 15 years of experience in Astronomical Instrumentation. She works at Instituto de Astrofísica de Canarias as Adaptive Optics Scientist. She is responsible for the development of Adaptive Optics for the EST. She is skilled in the design, specifications and numerical simulation of the Multi Conjugated Adaptive Optics system of the future EST. She is currently working in the construction of a solar MCAO demonstrator which will be installed in the IAC headquarters.

## **ALBERTO ESCOBAR**

### **EST PROJECT OFFICER**



Alberto is a Physicist (Kharkov State University, Ukraine, 1985), and Ph.D. (University of the Basque Country, Spain, 2007). He has wide experience managing European projects as well as national and regional ones. He joined IAC in 2013 and has managed SOLARNET-FP7 and GREST-H2020 European projects. In October 2018 Alberto joined the EST Project Office, where he is in charge of managing the direct grant awarded to EST by the Canary Government, and SOLARNET-H2020.

## **JORGE QUINTERO NEHRKORN**

### **MCAO AND AO TEAMS**



Computer engineer from the University of La Laguna, Jorge has worked in multiple private companies as a software engineer (mainly in JAVA). He has also developed applications for the Canarian regional government. Before joining EST, he worked for IACTEC, developing medical applications based on knowledge obtained from astrophysical instrumentation. He now works in MICAL, developing software for the GRIS spectrograph (GREGOR telescope) to allow simultaneous observations at several wavelengths. He is also part of the EST Adaptive Optics team.

## **JUAN CÓZAR CASTELLANO**

### **EST PRELIMINARY DESIGN TEAM**



Juan holds a MSc degree in Mechanical Engineering since 2014. His professional career is devoted to the design, manufacturing and testing of cryogenic prototypes, such as the mechanism of EMIR's configurable slit unit. He also worked in the QUIJOTE experiment for two years. In 2017, Juan joined the team of IACTec, connecting the ongoing projects in the Large Telescope Programme (EST and Liverpool Telescope II) with industry. He joined the EST Project Office in the summer of 2018, and works towards the consolidation of the preliminary design of EST.

## **HORACIO RODRÍGUEZ HIDALGO**

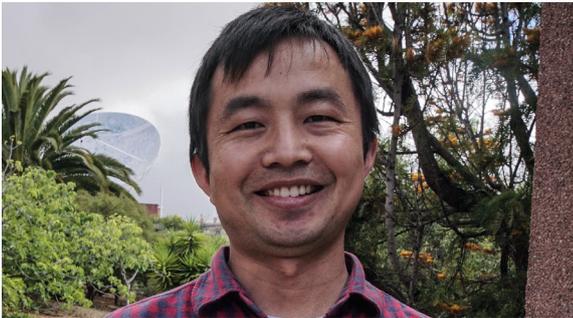
### **MCAO TEAM**



Horacio is an electronic engineer, a telecommunications technical engineer, and a senior technician in occupational risk prevention. He worked for more than 10 years as a specialist in Storage and Backup Systems, performing maintenance and configuration tasks in critical environments. He is currently developing the update of the new synchronism system for the TIP2 instrument of the GREGOR solar telescope, being part of the team in charge of the design of the MCAO demonstrator for EST.

## LIAN QIANG ZHANG

MCAO TEAM



Qiang is skilled in the conception and simulation of solar Adaptive Optics (AO), and Multi-Conjugated Adaptive Optics (MCAO), as well as the system optical design and operation both in laboratory and on-sky with seven years' experience. He took part in the development of a 151-element solar AO and MCAO experiment system at the NVST in China. He works at IAC as a postdoc for MICAL project on the optical design of the MCAO test bench.

## YOLANDA MARTÍN HERNANDO

MCAO TEAM



Yolanda holds a degree in Telecommunications Engineering from the University of the Basque Country (Spain) and an MSc degree from the University of Sherbrooke (Canada). She has worked for more than 9 years on scientific instrumentation projects, mainly at IAC, where she collaborated both in telescopes and space observatories (focusing mainly on control systems, data acquisition, data processing and laboratory characterization of image sensors). She joined EST in 2019 and currently works on the MCAO test bench as an electronics and control engineer.

## ADELINA PASTOR CAÑEDO

EST COMMUNICATION OFFICE



Adelina has a journalism degree and fifteen years experience in science communication and journalism. She has worked as a press and communication officer for the Spanish National Research Council and the European Research Council. She was also in charge of communications for the NEMESIS H2020 project, and a project and communication manager for the WWViews Climate and Energy citizen consultation in Spain. She joined the EST Communication Office in May 2019.

## VÍCTOR ANÍBAL LÓPEZ

EST COMMUNICATION OFFICE



Víctor is a journalist by University of Seville and holds an AV Communication degree, and a Science Information master degree from University of Granada. He has worked for the digital departments of some of the main regional media companies in Spain, such as Vocento and Joly. Before joining EST, he worked at Parque de las Ciencias, one of the most visited science museums in Spain, where he carried out promotional strategies for contents and activities, and was responsible of relations with media and also with professionals of tourism sector.

## EST PRESENTATIONS

### UK SOLAR ORBITER WORKSHOP

UCL, London (UK), 3-4 June 2019

R. Erdelyi - "MHD wave coupling the solar atmosphere"

### SOLAR PHYSICS SUMMER SCHOOL

Leh (India), 10-16 June 2019

R. Erdelyi - "New opportunities in MHD wave research enabled by EST"

### 14<sup>th</sup> CONFERENCE OF THE HELLENIC ASTRONOMICAL SOCIETY

Volos (Greece), 7-11 July 2019

G. Tsiropoula - "The solar chromosphere: outstanding problems and new opportunities"

### PREPARING FOR THE NEXT GENERATION OF GROUND-BASED SOLAR PHYSICS OBSERVATIONS

UCL, Mullard Space Science Laboratory (UK), 23-25 July 2019

M. Collados - "Prospects for the instrumentation of EST"

E. Khomenko - "Science Requirement Document for the European Solar Telescope"

### SOLAR POLARISATION WORKSHOP 9

Göttingen (Germany), 26-30 August 2019

R. Schlichenmaier - "EST Uniqueness"

## OTHER EVENTS

### EUROPEAN WEEK OF ASTRONOMY AND SPACE SCIENCE

Lyon (France), 24-28 June 2019

### IAU SYMPOSIUM 354. SOLAR AND STELLAR MAGNETIC FIELDS: ORIGINS AND MANIFESTATIONS

Copiapó (Chile), June 30- July 6, 2019

### SPACE CLIMATE 7 SYMPOSIUM

Canton Oxford (Canada), 8-11 July 2019

### SOLARNET SUMMER SCHOOL FOR SOLAR OBSERVERS

Tenerife (Spain), 5-9 August 2019

### Hinode-13 SCIENCE MEETING

Tokyo (Japan), 2-6 September 2019

### SOLAR SPECTROPOLARIMETRY: FROM VIRTUAL TO REAL OBSERVATIONS (SOLARNET SCHOOL)

Lugano (Switzerland), 9-14 September 2019

### IRIS-10 SCIENCE WORKSHOP

Bangalore (India), 4-8 November 2019

### 16<sup>th</sup> EUROPEAN SCIENCE WEATHER WEEK

Liege (Belgium), 18-22 November 2019

### XXXI CANARY ISLANDS WINTER SCHOOL OF ASTROPHYSICS: COMPUTATIONAL FLUID DYNAMICS IN ASTROPHYSICS

La Laguna (Spain), 19-28 November 2019

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