

Report on the ESO Workshop

Solar System Science with the ELTs

held online on 28 April 2022 and at ESO Headquarters, Garching, Germany, 13–15 June 2022

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Solar System Science with the ELTs was a two-part workshop, Part I of which took place virtually on 28 April 2022, followed by Part II as a hybrid meeting at ESO headquarters on 13–15 June 2022. The main motivation for the meeting was to engage the community of Solar System observers in preparation for the forthcoming extremely large telescopes. A special emphasis was placed on exploring how ESO's Extremely Large Telescope (ESO's ELT), alongside the Giant Magellan Telescope (GMT) and the Thirty Meter Telescope (TMT), will fit into the expanding landscape of ground- and space-based facilities and transform Solar System research. The meeting brought together instrument experts and observers at all career stages, working on six continents, and representing the different sub-fields of planetary science. A Zenodo collection of the workshop presentations and discussions was publicly released to the community as a valuable resource to inspire and facilitate the development of the first extremely large telescope observing programmes. Solar System Science with the ELTs was envisaged as the first of the three-part conference series *Extremely Big Eyes on the Solar System* and set the stage for two further workshops in North America and Asia.

Motivation for the workshop

The launch of an outstanding line-up of telescopes and space missions over the next two decades will transform Solar System research. The three extremely large telescopes (ELTs) will offer unprecedented observing capabilities and are expected to play a key role in shaping this landscape. With the advancing construction of ESO's ELT and its instruments,

and the start of its scientific operations currently expected in 2027, the need to engage a broader community of Solar System scientists was recognised. The last workshop that focused on exploring the possibilities of studying Solar System bodies with the next-generation instruments was the INAF/Arcetri-ESO workshop on Future Ground-based Solar System Research: Synergies with Space Probes and Space Telescopes, held in 2008¹. In the 14 years since that meeting, both instrument capabilities and the central science questions have evolved.

The Solar System Science with the ELTs workshop² was inspired by the success of the two previous conference series focusing on the unique capabilities of the ELTs, namely *Extremely Big Eyes on the Early Universe*³ and *Shedding Light on the Dark Universe with Extremely Large Telescopes*⁴. To enable attendance by a broad range of participants, both of these series consisted of three consecutive meetings taking place either in Asia, North America or Europe, each with an emphasis on one of the three ELTs. Building on this experience, we set out to organise a new series focused on Solar System research, *Extremely Big Eyes on the Solar System*. The series took off with Solar System Science with the ELTs, hosted by ESO in 2022, and is planned to continue with two further workshops in 2023–2024.

Solar System Science with the ELTs aimed to ensure that the planetary science community, and especially early-career researchers, will be equipped with well-thought-out science goals to fully capitalise on the capabilities of ESO's ELT. Furthermore, at the time of the meeting it was still possible to adjust some instruments' parameters and their supporting software (Exposure Time Calculators, the Observation Preparation tool, etc.) to enable them to support the vast range of Solar System science cases.

This workshop also provided a timely platform to discuss the future of space missions and their synergies with the ELTs. Many space missions rely on ground-based support campaigns. And the ELTs have the potential to revolutionise the scope of that support. The ELTs will provide both sensitive observations that were

previously only possible with spacecraft fly-bys, and regular monitoring of targets, otherwise requiring long-term orbiter missions. Furthermore, the workshop was planned considering the expected release dates of the ESA Voyage 2050⁵ and NASA's Decadal Strategy for Planetary Science and Astrobiology 2023–2032⁷. These documents determine the science priorities and space missions available to the European and US planetary-science communities. Additionally, Solar System Science with the ELTs took place during the JWST's commissioning phase, when its actual performance was being tested and was indicating the possible synergies with the ELTs.

Workshop format

The workshop format was designed with three main goals in mind: to inform the Solar System community about the specific capabilities of the ELTs and their instruments; to encourage observers to explore potential observing programmes; and to provide feedback to the instrument development teams and involve more Solar System observers in the final steps before the ELTs become operational.

These objectives motivated the Scientific Organising Committee's (SOC) decision to divide the workshop programme into two parts. Part I of the workshop was envisaged as a technical session during which telescope and instrument experts presented the capabilities of the instruments. It was followed by a 6-week period allowing time for observers to explore the feasibility of multiple science cases of interest and to engage with the instrument teams and ELT Working Groups (WGs) in preparation for their talks. In Part II of the workshop the science presentations and discussions took place during a three-day meeting.

One other key aspect of the meeting was the SOC's intention to select talks for Part II which presented specific science cases for the ELTs. To address this, all participants registering for the meeting were encouraged to use the conference materials and Slack channel to further develop specific ideas for observations uniquely possible with the ELTs. Moreover, in an attempt to focus these efforts,

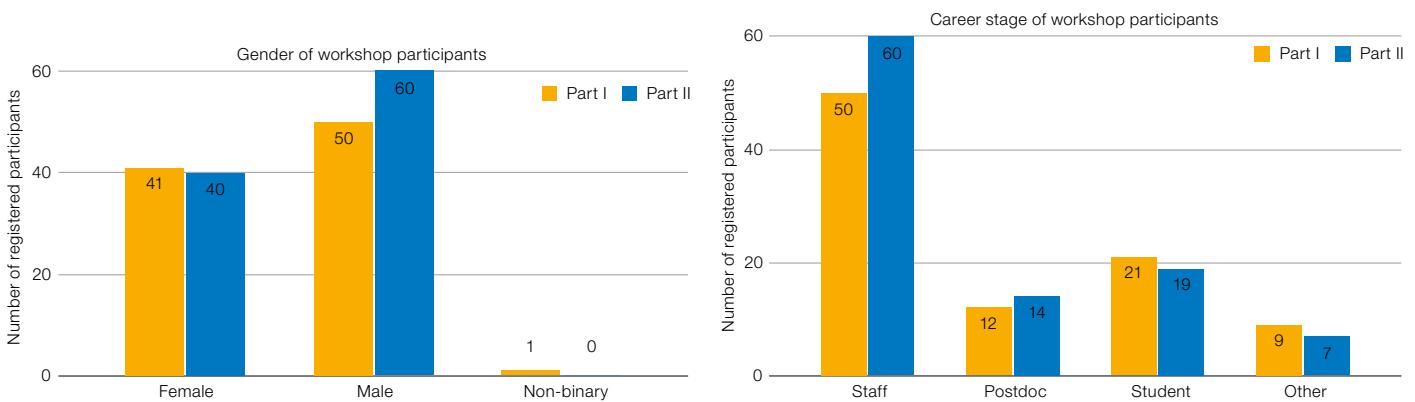


Figure 1. Distribution of the gender (left) and career stage (right) of the registered participants for Parts I and II of the workshop.

the abstract submission form required a brief description of one observing programme idea as a mock proposal for ESO's ELT.

Interaction between the workshop participants was considered essential for the success of the meeting. Rather than broadcasting the talks, the SOC and the Local Organising Committee (LOC) decided to encourage live interaction during the sessions. This was achieved by hosting the talks as live meetings on Microsoft Teams and supporting parallel discussions over Slack. For those who were not able to attend the meeting live, a Zenodo collection⁷ of video lectures and selected slide decks has been curated and will remain available for free access.

The SOC and LOC wanted to reach a broader range of participants and therefore advertised the meeting to a large number of institutes in ESO Member States and worldwide. The conference was also advertised on social media, using the hashtag #SolSysELTs2022. However, the level of social media engagement was less than that of other recent ESO workshops. This was partially attributed to the relatively smaller target audience of the meeting. Even though the workshop was interdisciplinary over the scope of Solar System research, it was highly specialised when set against the scope of astronomy or physics.

Despite the fact that the meeting was timely with respect to other contemporaneous milestones of Solar System

research development, the workshop was inevitably affected by the COVID-19 pandemic. The SOC and LOC were inspired to follow the models of recent ESO virtual workshops, providing a fantastic opportunity to engage a broader audience by hosting Part I of the workshop entirely virtually on Microsoft Teams and facilitating the subsequent discussions in a devoted Slack channel.

However, the pandemic had a less desirable impact on Part II of the workshop. The original intention was for Part II of the workshop to be a predominantly in-person event at ESO's HQ in Bavaria, Germany. To minimise the risks of delaying the meeting because of COVID-19 restrictions, the organisers aimed for a time of the year when the COVID-19 incidence rate was lower in Bavaria (and in the northern hemisphere more generally) during the first two years of the pandemic. To maximise participation, dates were carefully selected to avoid overlap with other major meetings relevant to the audience of this workshop.

Despite these efforts, the in-person attendance at Part II of the workshop was lower than anticipated. The COVID-19 incidence rates in many countries were rising in May and June 2022, which drove most conference participants to attend the meeting remotely. The same period in 2022 was also unusually busy with travel for many of the conference participants. Many other events had been rescheduled for 2022 and overbooked calendars were another reason to motivate online participation. These major factors (and possibly others) heavily skewed the meeting towards virtual participation. To maximise the exchange

between the conference participants, the SOC adapted the programme accordingly, introducing extended discussions (of 30–60 minutes) at the end of each session during Part II. They were facilitated by a SOC member or an invited speaker and included discussions of a preplanned list of topics, as well as exchanges on other compelling questions arising during the meeting.

Special consideration was given to designing a schedule for the virtual meeting so that it was convenient for the European community but also accommodated attendance from several other time zones. Part I of the workshop included presentations from the US west coast and was therefore scheduled in the afternoon hours for the Central European Time Zone. Part II of the workshop included one afternoon, one full day and one morning on three consecutive days, and was scheduled so that participants from the Americas and from Japan and New Zealand could give their presentations at reasonable times agreed in advance with the speakers.

Workshop programme

Part I of the workshop took place over one afternoon on 28 April 2022. The programme began with a general presentation on ESO's ELT, followed by talks focusing on individual instruments (HARMONI, MICADO+MORFEO, METIS and ANDES) and their capabilities for Solar-System observations, presented by the instrument Principal Investigators. To emphasise the connection between ground-based observations and space missions, a talk on ESA's planetary

science missions was presented by Luigi Colangeli. James Fanson and Christoph Dumas gave detailed overviews of the capabilities of the GMT and TMT, respectively, and the ongoing efforts to plan and develop them. All presentations were followed by sufficient time to answer all immediate questions, after which any further questions by the attendees were taken either to the meeting Slack channel or offline for private communication.

Part II of the workshop encompassed the large variety of topics studied by observational planetary science. The programme was organised into four sessions, reflecting the different populations of objects observable with the ELTs: terrestrial planets (Venus and Mars), outer planets (giant planets, their satellites and rings; tenuous atmospheres in the outer Solar System), asteroids (near-Earth, main-belt, active asteroids) and ice-rich small bodies (short- and long-period comets, trans-Neptunian objects, interstellar objects).

The sessions included invited talks, contributed talks and discussions. The invited talks provided an overview of the key questions in the given subfield and discussed how the ELTs, in synergy with current and future observing facilities and space missions, can be used to address those challenges. The contributed talks focused on specific science cases that are going to be enabled by the ELTs. Finally, each session concluded with a discussion round providing opportunities for feedback and exchange between the observers, on one hand, and those involved in the instrument and observing tool development, on the other.

This is a very brief summary of the workshop programme. We invite everyone who is interested in observations of Solar System objects with the ELTs to visit the conference website² for more details of the workshop programme and to explore the Zenodo collection⁷ where the conference talks and discussions have been archived.

Demographics

The two parts of the workshop required separate registrations which yielded 92 (Part I) and 100 (Part II) registered participants. As discussed above, owing to the

various interplaying factors, only 17 people expressed interest in attending Part II of the workshop in person at ESO’s HQ, and fewer than 15 were actually able to be present during the meeting. Between the two parts of the workshop, there were participants from 27 different countries on six continents (all but Antarctica). The gender balance and career stages of the participants can be seen in Figure 1.

Ensuring diversity in terms of gender balance, career stage, nationality and ethnicity was an integral aspect of the conference organisation. The results of these efforts are partially evidenced by the gender balance among the SOC members (4 female and 6 male) and the invited speakers for Part II of the workshop (7 female and 6 male). However, we acknowledge that further efforts are strongly desirable in order to ensure equal representation in future meetings.

Concluding remarks and outlook

The idea for this conference started taking shape in the midst of the COVID-19 pandemic. The conference aimed to bring the Solar System community together in an effort to kick off the planning of observations with the ELTs. Even though most of the conference participants could not attend the workshop in person, the hybrid format of the meeting enabled effective exchange of ideas among all participants. The meeting facilitated conversations between Solar System observers and the representatives of the ELT instrument teams and working groups, thus providing the necessary input to guarantee that the instruments and their operation will provide the means to answer many essential science questions. The talks during the meeting captured the state of the art in the wide range of sub-fields in planetary science and presented a rich sample of science cases which would harness the unique capabilities of the next generation of telescopes. Additionally, the active discussions during the conference gave a platform to expand on the specific ideas discussed in the talks, and to clarify how to optimise the use of the ELTs in the existing landscape of other ground-based telescopes, space observatories and space missions in the coming decades.

A collection of all talks and discussions during Parts I and II of the meeting can be found in the Zenodo library⁷. With the agreement of all participants, these recordings have been made publicly available, and they are currently the most comprehensive resource to inform and inspire the development of observing programmes in anticipation of the fast approaching first light of ESO’s ELT.

Solar System Science with the ELTs was envisaged as the first of three coordinated meetings in the Extremely Big Eyes on the Solar System series. As a meeting in Europe, this workshop provided a platform to focus on ESO’s ELT and the ESA space missions. We are therefore looking forward to continuing the important discussions arising from the workshop and exploring in greater depth the capabilities of the GMT and TMT during the upcoming meetings in North America and Asia in the next few years.

Acknowledgements

We warmly thank all of the conference speakers and attendees for their active co-creation of a workshop packed with illuminating talks and discussions. We are extremely grateful to Nelma Silva, Stella Chasiotis-Klingner and Dominika Itrich for their dedication and indispensable help in ensuring the success of this workshop. We wholeheartedly thank the SOC members for their invaluable ideas and support in designing and curating this meeting, as well as for their key contribution in chairing several of the workshop sessions and discussions. We also thank Dusan Catricheo Maulén and Martin Wallner for creating the poster and visual identity materials for the meeting.

Links

- ¹ INAF/Arcetri-ESO workshop: <https://link.springer.com/journal/11038/volumes-and-issues/105-2>
- ² Workshop webpage: <https://www.eso.org/SolSysELTs2022>
- ³ Sheding Light on the Dark Universe with Extremely Large Telescopes: <https://conferences.pa.ucla.edu/dark-universe/index.html>
- ⁴ Extremely Big Eyes on the Early Universe: <https://indico.ict.inaf.it/event/779/>
- ⁵ ESA Voyage 2050: <https://www.cosmos.esa.int/web/voyage-2050>
- ⁶ Decadal Strategy for Planetary Science and Astrobiology 2023–2032: <https://nap.nationalacademies.org/catalog/26522/origins-worlds-and-life-a-decadal-strategy-for-planetary-science>
- ⁷ Workshop Zenodo collection: <https://zenodo.org/communities/solsyselts2022/>