DOI: 10.18727/0722-6691/5373

Report on the ESO workshop

What was that? — Planning ESO follow-up for transients, variables, and Solar System objects in the era of LSST

held at ESO Headquarters, Garching, Germany, 22–26 January 2024

Colin Snodgrass[1]

[1] Institute for Astronomy, University of Edinburgh, Royal Observatory, Edinburgh, UK

This workshop aimed to bring together the various communities of astronomers who observe the changing night sky, from studies of nearby moving targets to the most distant transient sources. All of these fields will soon enter a new era of discovery with the beginning of the LSST, and many of the most exciting science cases will need detailed follow-up observations (for example spectroscopic characterisation), which will place significant demands on ESO's facilities. Participants at the workshop discussed the how, why, and when of obtaining ESO observations to find out 'what was that?', in the era of millions of alerts per night.

Introduction

Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST; Ivezić et al., 2019) is expected to begin in 2025. This survey will yield a revolutionary view of the changing night sky, with deep images of almost the entire sky visible from Chile every few nights. With individual images reaching a depth of around 24th magnitude in broad SDSS-like *ugrizy* band-passes, and high-cadence monitoring over a vast area of sky, the LSST will discover an unparalleled number of variable, transient, or moving objects. Real-time processing of the data will lead to millions of public alerts, indicating that something changed or moved, every night. Response to these alerts, for example obtaining follow-up spectroscopy of interesting targets, will be a significant scientific and logistical challenge. It is clear that ESO's facilities in Chile will be perfectly positioned and often uniquely capable of providing such follow-up observations — the purpose of this workshop was to bring together the LSST and ESO communities to discuss how best to coordinate such efforts.

The scientific topics covered by the workshop[1] were very broad — everything from the smallest near-Earth asteroids to the highest-energy high-redshift explosions. To cover such a range, the meeting was arranged around common topics of interest, on LSST and ESO capabilities, software, and lessons learned from previous large surveys. Scientific topics, and the motivations for follow-up observations to LSST discoveries that they provide, were introduced in a series of invited review talks. These were grouped into Solar System, Galactic, and Extragalactic sessions. The invited reviews were complemented by contributed presentations, which were mostly given as virtual posters and pre-recorded 'lightning' introductions to them, which were played in blocks within relevant sessions, providing a wide selection of topics as food for thought. As the workshop was intended to enable real organisation and consortium building, a significant part of it was dedicated to breakout sessions in smaller groups.

The meeting began with introductory talks on the LSST and what the community can expect from it, and on the outlook for ESO facilities over the next decade, which includes the beginning of ESO's Extremely Large Telescope (ELT) operations, as well as next generation Very Large Telescope (VLT) instruments and relevant projects like Son Of X-Shooter (SOXS; Schipani et al., 2018) at the New Technology Telescope (NTT). Future facilities that are of particular relevance, including SOXS, the 4-metre Multi-Object Spectroscopic Telescope (4MOST; de Jong et al., 2019), and the proposed Wide-field Spectroscopic Telescope (WST; Mainieri et al., 2024) were described in greater detail in the Thursday morning session. The sessions dedicated to the science drivers for LSST follow-up observations began with the most distant, and showed the significant contributions the LSST is expected to make to studying variable (for example, active galactic

nuclei) and transient (for example, supernovae) extragalactic sources, and the importance to these of rapid-response spectroscopy to measure redshifts and understand the underlying physics. In the session on Galactic science we discussed variable, pulsating and accreting stars, and related novae. The discussion here focused on the vast numbers (~ 10^8) of variable stars that the LSST will follow, and how to optimise and prioritise spectroscopic follow-up. Finally, we learned in the Solar System session that the LSST will be a discovery machine, providing an approximately order of magnitude increase in the known numbers of all small body populations, and that follow-up observations will be critical to understanding the things which are both moving and transient, such as the evolving debris from asteroid collisions or outbursts from comets.

Given the large number of discoveries that will flow from the survey every night, an essential part of the LSST ecosystem is the collection of software Brokers that will filter and distribute alerts. All six of the community Brokers that are being developed for the LSST were presented by their respective teams, and there was productive discussion of how these will serve different science goals throughout the week; getting these software teams in the same room as astronomers from such a wide range of science communities proved to be a very useful part of the workshop. There were also presentations on how software systems can further automate rapid response follow-up observations, in particular the Astrophysical Events Observatories Network (AEON) system (Street et al., 2020), which is used for automated observation scheduling in various US telescope facilities (Las Cumbres Observatory, NOIRLab, Gemini), and discussion on how such systems could work within ESO operations.

As we looked towards how best to coordinate ESO follow-up observations, we made a concious effort to do so in an equitable way, and dedicated a session to equality, diversity and inclusion (EDI), with presentations on how both ESO and the LSST are working to improve this, and a panel discussion on best practices. We also had invited talks on lessons learned from current/past surveys and alert follow-ups, from the highly successful Gaia Alerts (Hodgkin et al., 2021) and PESSTO/ePESSTO+ (Smartt et al., 2013) projects. Finally, the workshop concluded with short contributed talks on a diverse range of interesting topics related to follow-up of alerts in the era of the LSST, covering multi-messenger astronomy, machine learning tools for alert characterisation and follow-up prioritisation, and the future of smaller telescopes at the La Silla site for dedicated alert follow-up.

The topics for the small group breakout discussions were decided on during the workshop using a virtual noticeboard and voting system that allowed attendees to suggest and select relevant discussions. These were then organised into similar topics, broadly following the Solar System, Galactic, and Extragalactic science themes, and the general topics of Communication, Policies, and Brokers. Discussions included how best to rapidly share information, including between communities — where ‘my junk is your data’ means we can help each other out, and make more efficient use of precious follow-up opportunites, by efficiently communicating what we find. There was quite a lot of discussion on how best to approach applying for ESO time for follow-up — whether or not the best approach for such proposals would be large public surveys with no proprietary time, and how ‘data driven’ proposals covering a wide range of scientific topics can be proposed through the Observing Programmes Committee.

With the start of LSST operations expected in 2025, this meeting was a timely opportunity to bring together the communities who study the changing sky. Across Europe and beyond, these astronomers will look to ESO’s unique facilities to study the targets that the LSST finds; this will be an exciting era of discovery, and it will begin very soon. The conclusion of the community members present at the workshop was clear: we need to be ready for the coming step-change in the discovery rate of transient, variable and moving objects, and it is in the best interests of ESO and ESO’s user community to be organised in the way that observations are proposed, carried out, and analysed. The workshop recommended that ESO consider a call for (a) specific large and/or public survey type programme(s) dedicated to LSST follow-up, to which these communities could respond in an organised way, rather than dealing with many competing urgent requests following discoveries. If ESO decides to follow this recommendation, it should do so soon — the era of million-alert nights is just around the corner.

Demographics

In order to have a balanced programme across diverse scientific fields, and to have significant time for discussion and collaboration building, the Science Organising Committee (SOC) decided to have most of the schedule based on invited talks. In so doing the committee paid careful attention to having a balance of invited speakers between scientific topics, career stage, geographical distribution, and gender. The final list had 16 men and 14 women, with 19 speakers from Europe, nine from North America, two from South America, and none from other continents. Most contributed presentations were given as virtual posters, with a short pre-recorded ‘lighting talk’ to introduce each one, although six contributed talks were selected on the basis of their expected broad general interest to the workshop attendees. These speakers were all from Europe, and had a 50/50 gender split, although no particular effort was made to enforce balance here; the decision on which contributed talks to select was made entirely based on the perceived quality of the abstract and appeal to a broad audience, using a scoring system with the contributions anonymised. The workshop had a high level of participation, with approximately 100 participants in person and another 50 online. Of the total around 60 were early career researchers (~ 20 students and 40 postdocs).

Acknowledgements

This workshop would not have been possible without the generous support of ESO, including the financial and logistical support for the meeting itself and the engagement of ESO staff astronomers in helpful discussions throughout the week. The enthusiastic participation of the teams responsible for the hardware and software that will enable the LSST was also a big part of the success of this workshop. We

are grateful to everyone who gave their time generously to take part. As the SOC chair, I also want to thank the members of the SOC (Joe Anderson, Amelia Bayo, Rosaria Bonito, Benoit Carry, Jesus Corral-Santana, Alessandro Ederoclite, Markus Hundertmark, Laura Inno, Valentin Ivanov, Rosita Kokotanekova, Michaël Marsset, Cyrielle Opitom, Paula Sanchez Saez, Linda Schmidtobreick, Meg Schwamb, Mark Sullivan, Rachel Street) and the Local Organising Committee (Matej Barta, Jesus Corral-Santana, Valentin Ivanov, Daniel Jadlovsky, Rosita Kokotanekova, Michaël Marsset, Nicolás Monsalves, Amanda Rubio, Paula Sanchez Saez, Felipe Schmidt, Linda Schmidtobreick, Denisa Tako, Sebastian Zuniga Fernandez), who put together an excellent programme and ensured that it would all run smoothly. The Local Organising Committee chair, Paula Sanchez Saez, and ESO workshop organiser extrordinaire Denisa Tako also deserve particular recognition for their efforts.

References

de Jong, R. S. et al. 2019, The Messenger, 175, 3
Hodgkin, S. T. et al. 2021, A&A, 652, A76
Ivezić, Ž. et al. 2019, ApJ, 873, 111
Mainieri, V. et al. 2024, arXiv:2403.05398
Schipani, P. et al. 2018, Proc. SPIE, 10702, 107020F
Smartt, S. J. et al. 2013, The Messenger, 154, 50
Street, R. A. et al. 2020, Proc. SPIE, 11449, 1144925

Links

[1] Workshop programme: https://www.eso.org/sci/meetings/2024/lsst

ESO Acknowledgements: Flickr user hdahle70

Astronomers are well-known for naming objects with odd conventions, and the cometary globule GN 16.43.7.01 is no exception. Cometary globules have nothing to do with comets aside from appearance: they are named for their dusty head and elongated, dark tail, as seen in this image taken with the VLT Survey Telescope (VST) hosted at ESO's Paranal Observatory in Chile. This globule, dubbed the Dark Tower — astronomers compensate with obvious names — lies about 5000 light-years away from Earth in the southern constellation Scorpius (the Scorpion). It contains dense clumps of collapsing gas and dust out of which stars will be born.