LSST:UK Newsletter 38 (October 2023)

Introduction

Trailed verbally at the LSST@Europe5 conference, but now confirmed by a Community post, a revision to the Rubin construction schedule has been necessitated by two recent problems. Firstly, some work within the telescope dome is being delayed while the dome crane is being repaired, while the shipping of LSSTCam from SLAC to Chile is on hold, following the discovery of a small leak in its cryostat. The latter is the more serious, as it will delay the arrival of the camera on the summit by at least four months - and, possibly, significantly longer, if it proves necessary to disassemble the camera to fix the leak - and this may have a knock-on effect for how commissioning observations are undertaken. A final decision will be taken in February 2024, but it may now make more sense to begin the programme of on-sky commissioning observations with ComCam, the commissioning camera, rather than awaiting the delayed arrival of LSSTCam.

In better news, an article has been published on the rubinobservatory.org website detailing how the “Rubin Observatory will help unravel mysteries of dark matter and dark energy”. This is the second such “science release”, in which the scientific expectations from the Rubin LSST are outlined for a general audience.

Finally, a reminder that, as mentioned in last month’s Newsletter, we are looking for someone interested in the use of AI/machine learning in LSST science to act as a liaison between LSST:UK and the Alan Turing Institute’s Space Science Interest Group. Please email @Stephen Smartt and myself if you are interested in that role: this won’t be an onerous position, and might suit someone at any career stage - we’re just looking for someone interested in applying AI/ML techniques to LSST data who can help us ensure that LSST is well represented within this SIG.

Those with ideas for future newsletter items should contact the LSST:UK Project Managers (@George Beckett and @Terry Sloan lusc_pm@mlist.is.ed.ac.uk), while everyone is encouraged to subscribe to the Rubin Observatory Digest for more general news from the US observatory team.

@Bob Mann

LSST@Europe5

The LSST@Europe5 conference took place in Porec, on the coast of the Istrian

Peninsula in Croatia during the week of 25-29 September, attracting a very good turnout from across Europe and beyond, including many key Rubin staff. Slides from the talks are now appearing linked from the conference programme page - click on a session for a listing of talks within it - while recordings will be made available through a dedicated YouTube channel.

As in previous LSST@Europe conferences, there was a very strong showing from the UK. This included several talks in the in-kind contributions sessions (from @Aprajita Verma , @Bob Mann , @George Beckett and @Roy Williams), as well as in those organised by various Science Collaborations: AGN (Brian Bichang'a); Dark Energy (Nisha Grewal); Galaxies (@aaron.watkins , Ilin Lazar, @Sugata Kaviraj); Solar System (Steph Merritt); Strong Lensing (@Aprajita Verma , @Dan Ryczanowski , @Graham Smith , Suhail Dhawan); and Transient and Variable Stars (@Christopher Frohmaier , @Ken Smith . @Tom J Wilson and Rokas Zemaitis spoke at a session jointly organised by the Stars, Milky Way and Local Volume SC and the Transients and Variable Stars SC, while @Christopher Frohmaier and @Nicholas Walton gave talks in the session on synergies with other surveys, and @Nicholas Walton led a session planning a COST Action to support LSST science in Europe.

@Bob Mann

Call for Proposals to Contribute to the LSST:UK Component of Rubin Data Release Processing

The LSST:UK Phase C funding includes support for a team to work on the UK contribution to LSST Data Release Processing (DRP). LSST:UK is ready to allocate that funding for the three-year period from 1st April 2024 to the end of Phase C on 31st March 2027, with a likelihood of continued support for the selected team during Rubin operations.

Members of Consortium institutions are invited to submit proposals to address one or more of the roles required for the UK contribution to DRP, as part of a work-package team that will collaborate closely with peers in the Rubin Observatory Data Management Operations team.

Details of LSST DRP and the roles that are required in the UK, along with instructions on how to submit proposals are provided on the LSST:UK wiki at:

https://lsst-uk.atlassian.net/l/cp/F0hLp95A

The deadline for submissions is ***4pm GMT on Tuesday 21st November 2023***.

Any questions regarding the call may be directed to the Chair of the LSST:UK Consortium, Professor Mike Watson mgw@leicester.ac.uk. Questions regarding technical aspects of DRP and the proposed UK contributing roles may be directed to the UK Data Facility Liaison, George Beckett (George.beckett@ed.ac.uk).

@George Beckett

The Rubin calibration system

In this article I wanted to write a short introduction to the hardware calibration systems of the Rubin Observatory, as it's an area that the team at Oxford is starting to get involved in along with our other activities, in the area of contributions to the operating software. Most of what I highlight can be found in much more detail in some published SPIE proceedings by the real experts, which I've listed at the end. I am also not really talking about the photometric or astrometric calibration of the survey itself, which is a much broader topic. Neither are we talking about the weather and airmass monitoring instruments on Pachon like the DIMM and the all-sky camera. I suppose also that systems like the wavefront sensors, the encoders on the telescope mount itself and other various components could count as part of "calibration" but those are, I'm afraid, also out of scope today. The article as written is for interest and information, and I encourage those interested to consult the sources at the end, from where I drew bits of information I wasn't immediately familiar with from the top of my head. We are having a great time getting up to speed and beginning to contribute to this important aspect of the project, but we are newcomers to this part!

The Auxiliary Telescope

The Auxiliary telescope is currently installed on "calibration hill" at the Rubin Observatory site. The telescope itself is a 1.2m diameter primary mirror and has a camera with a single 16MPix ITL sensor of the same type found in LSSTCam focal plane. This telescope was formerly situated at Kitt Peak observatory in Tucson, known as the Calypso telescope, and has been refurbished for use at Rubin. It has been in operation there routinely for over a year to perform pathfinder operations and commissioning shakedown for LSST. However, it also has a purpose throughout the duration of the main survey - the instrument onboard, called LATISS (LSST Atmospheric Transmission Imager and Slitless Spectrograph) is intended for use as a transmission calibration for the atmosphere - in broad terms this can be achieved by measuring the absorption lines in selected spectral targets (for example by water vapour). The slitless spectrograph design enables quick acquisition of good flux levels on chosen targets even in high airmass conditions. It has not yet been fully settled exactly how the scheduling for the auxiliary telescope will work for the LSST survey, proposals range from covering many good targets throughout the sky to determine nightly airmass and transmission conditions as well as possible, to following the main telescope pointings synchronously.

The auxiliary telescope is, well, a telescope, and so requires calibration itself - mirror coatings, glass filters and dispersive elements change transmission over time due to ageing, and even anti-reflection coatings on the detector can gradually change throughput gradually at the blue end of the spectrum, whilst operating voltages of the detector can in principle affect efficiency at the red end. Thus to obtain absolute radiometric results on the ground we need to calibrate the calibrator. The final calibration system for Auxtel was installed in December 2022, replacing a simple dual LED projection system that was used up to that point. To those familiar with normal falt-field calibration systems in telescopes (which is probably much of the readership of this, and to a greater degree than myself who normally only has to worry about carefully illuminating just the detector for calibration!) this system is quite standard. Illumination is provided by a temperature stabilised 1000W Xenon arc lamp which is passed through a monochromator, allowing us to obtain high flux narrow band illumination all the way from 350nm-1050nm (basically the full possible range of a Silicon detector). We use a similar system (albeit lower power and with a Tungsten rather than Xenon source) at OPMD lab to do calibrated flat field illumination on CCD detectors. One of the problems of such an illumination source is that it requires a long time to switch on and stabilise properly, and indeed due to its nature retains fairly high fluctuations even in operation. In addition, the monochromator is a mechanical system and so is subject to small alignment errors over time - for this reason, a separate fibre-coupled spectrograph is used to measure the actual spectral output of the light source after monochromation during operation. The output of the light source is cast to a reflective dome screen to obtain flat field illuminations of the auxtel. A calibrated photodiode is used to measure the integrated flux of the illumination and allow for correcting the fluctuations of the halogen source.

Flat-field calibration for the main telescope

Much as with the auxiliary telescope, good flat fielding is required for the main telescope, though of course the challenges are on a different scale. A good flatfield illumination is obtained when the reflecting screen is a true lambertian source, and this is difficult to say the least on a screen which has to be 9 metres in diameter. The screen for the main telescope has been custom fabricated, and is coated with a proprietary coating called "Permaflect" which is similar to that used in commercial integrating spheres though enhanced to be more weather-proof. Most coatings intended to create lambertian reflectors are based on barium sulphate, which is one of the "whitest" crystals known to humankind in the optical range, having a >90% reflectivity across the entire visible spectral region. It is also extremely cheap - cheap enough to be used in oil well drilling fluid! Unfortunately, it's extremely difficult to get it to stick to things whilst retaining this reflectivity, and generally speaking the proprietary part of the (very expensive) coatings used in commercial integrating spheres and flat field dome screens contain some "secret sauce" which solves this problem.

In any case, the main telescope screen consists of several coated panels mounted on aluminium honeycomb support structures. These will be laser aligned when installed to ensure good alignment and flatness. The annular nature of the Simonyi telescope allows an elegant arrangement for the illumination for flat fields - collimated light is shone out from the centre of the dome screen, and is then reflected off a custom reflecting surface manufactured by NOIRLab which will be mounted at the centre of the telescope. In other systems of this scale to obtain good lambertian and even reflectance off the screen it's often necessary to have the light fed to the screen in multiple places (e.g. by optical fibres), or use multiple illuminants, which introduces all sorts of complications. This reflector also has smaller retro-reflectors which are designed to work with the observatory's laser tracking system, to ensure good alignment of the whole system.

There are two illumination systems that will be used with the main telescope dome screen. Firstly, a series of high intensity LEDs with band-passes of ~10nm that can be rapidly and remotely swapped into the boresight path. These will be used for routine, daily flat field calibration. Secondly, a tunable pulsed laser is installed in a separate laser room and fed into the system via fibre-optics. The laser is capable of wavelength outputs between 300nm - 1100nm with ~2nm bandwidth. This is a commercial system procured from Ekspla. There are numerous safety and operational complications when using the laser system (including that it measurably increases the dome seeing due to temperature changes) and so it is not planned to be used every day for calibration. One problem with using temporally coherent illumination for flat fields (i.e. a laser) is that when reflecting off a rough surface it may produce a "speckle pattern". Indeed, speckle patterns themselves are a powerful technique for measuring the transfer functions of optical components and one that we are also involved in developing at OPMD. They are, however, exactly what one does not want when a flat field is needed. Speckle pattern production is heavily suppressed using a short pulsed laser rather than continuous wave. The laser used for Rubin has a pulse width of around 0.1ms, which should be more than enough to eliminate speckle patterns from the dome screen.

As with the auxtel system, this flat field system needs its own calibration, and that is achieved in a similar manner, with a fibre spectrograph and calibrated photodiodes (this time mounted on the telescope itself).

The Collimated Beam Projector

Despite all the considerations made in the calibration system, it's still the case that such a large dome flat will likely have intensity variations over the focal plane of the main telescope, due to factors such as available stray light paths that aren't present when the telescope is observing the sky (it is, after all, an extremely fast optical system, and the sky does not look like a very large lambertian source, at least after twilight). The final piece of the puzzle is the collimated beam projector, a technology that has been demonstrated in operation at Haleakala Observatory for the Pan-STARRS survey. The idea is to produce a highly collimated beam (as opposed to the cosine intensity pattern of a true lambertian source) down the optical path of the telescope to mimic starlight paths. The instrument that does this is a projector (roughly a telescope but with the light path the opposite way round) called, imaginatively, the "collimated beam projector" (CBP). Light is taken from an integrating sphere, passed through a pinhole mask, and then the telescope optics re-image this onto the focal plane. This allows for calibration of the relative illumination of different parts of the focal plane when combined with the information from the dome flats. With a careful mask preparation and alignment, it should be possible to produce calibration images with a single collimated spot on each of the CCDs of the camera focal plane. And we are then left with yet again the same question: how do we calibrate the throughput of the CBP? This is performed, fascinatingly, by pointing the CBP at a calibrated solar cell on the dome. Comparing this output to a calibrated diode inside the CBP at the integrating sphere allows for unfolding its own throughput.

References and Further Reading

The Vera C. Rubin Observatory 8.4m telescope calibration system status - **Ingraham et al, SPIE Astronomical Telescopes 2022, 10.1117/12.2630185**

“Reflecting on Calibration” - LSST project blog post, Reflecting on Calibration | Vera C. Rubin Observatory Project

The LSST calibration hardware system design and development - **Ingraham et al, SPIE Astronomical Telescopes 2016,** The LSST calibration hardware system design and development

Horiba Tunable Kiloarc system - Tunable KiloArc

NT240 Tunable laser system - NT240 – Ekspla

Permaflect coatings - Permaflect® Coatings - Labsphere

Sensor modulation Transfer Function measurement using band-limited laser speckle - Chen et al, https://opg.optica.org/oe/viewmedia.cfm?uri=oe-16-24-20047&html=true

@Daniel Philip Weatherill

New LUSC Team members

The past month has seen the onboarding of an unusual number of new members of the LSST:UK Science Centre (LUSC) team: some are new to the LSST community; others have been involved scientifically before, but are now starting to contribute to one of the UK's in-kind contributions; and some have been contributing to Rubin construction for many years, but are only now moving into the reporting framework for UK in-kind contributions.

@Behnood Bandi is a doctoral researcher working under the supervision of @Jon Loveday at the University of Sussex and studying galaxy clustering for 4MOST and in LSST. Behnood already holds LSST data rights, as an LSST:UK Junior Associate, and is thrilled to be contributing to LSST commissioning, through performing angular clustering analysis of commissioning data.

@Farrukh Azfar is a Lecturer in the Department of Physics at the University of Oxford, and a long-time member of the LSST Camera team, earning Builder status for his work on the Camera Control Software. Farrukh is interested in multi-messenger physics and also work on SNEWS (Super Nova Early Warning System), which will use the arriving neutrinos from a core-collapse supernova to point to the location of the supernova for timely detection of its optical component.

@James Robinson is a postdoc at the University of Edinburgh, researching asteroids and comets in the Solar System. Jamie is particularly interested in determining the physical properties of these small bodies from photometric observations in order to constrain their size, shape, composition and spin state or the presence of activity. Jamie is excited to be developing analysis tools for the Adler platform which will work alongside Lasair to extract this information for the vast number of small bodies that will be characterised by LSST

@William Lucas works at EPCC in Edinburgh as an HPC Applications Consultant. A lot of his time in the past few years has been spent working as computational science and engineering (CSE) support on the ARCHER2 UK national supercomputing service and HPC-Europa3, and also organising and lecturing the numerical algorithms course on EPCC's MSc. William's background is in astrophysics - on the computational side of star formation - and is very happy to be returning to the field. He will be working on WP 3.8.3 (S8), taking over from James Perry's work and in the short term at least looking to port more of the imSim pipeline with GalSim and batoid to run on GPU using OpenMP.

@Dave McKay is a Data Architect at EPCC at the University of Edinburgh. After being a heavy high-performance computing (HPC) user during his PhD in computational chemistry, and combining physical simulations and data science techniques in subsequent postdocs, Dave joined EPCC as an Applications Consultant in 2020. At EPPC, he has built data pipelines for Earth observation satellite data ingest, processing and analysis and taught data analytics on the Masters programme, among other projects. On LSST, Dave will be taking up the role of the UK's Data Release Processing Scientist and will also be working with the DAC team on LSST:UK IR-Fusion work.

@Cyrielle Opitom obtained her PhD in Astronomy at the Université de Liège in Belgium in 2016 and then moved to Chile as a fellow at the European Southern Observatory (ESO). She joined the University of Edinburgh in 2019 and is currently a chancellor's fellow. She studies small bodies of the solar system, and in particular comets. Her research focuses on using the latest astronomical instrumentation, including mainly spectroscopic techniques in the optical and UV, to investigate the composition of comets and understand what it can teach us about the history of the solar system. She is currently the lead of the Active Object working group within the LSST Solar System Science Collaboration.

Not pictured are four further new members of the LUSC team:

- @Thomas Cornish is a postdoc working with @David Alonso and @Boris Leistedt on their in-kind contribution studying galaxy clustering systematics; he is currently based at Oxford with David, but will be moving to work with Boris at Imperial for the latter part of Phase C;
- @gavindalton holds a chair in Astrophysics at Oxford, along with a position in RAL Space, and will be contributing his expertise in the commissioning of astronomical instrumentation to the UK's in-kind contribution to Rubin Commissioning;
- @Elham Saremi is a research fellow at Southampton, where she is working with @Manda Banerji on the LSST-VISTA optical/near-infrared data fusion project;

- @Jeff Tseng is Professor of Physics at Oxford, where he is a member of the experimental particle physics group. He is interested in multi-messenger studies of supernovae and is contributing to the development of LSST camera software.

@Terry Sloan and @Bob Mann

Forthcoming meetings of interest

Things are relatively quiet, meeting-wise, over the next month or so. However there are still several upcoming meeting, which may be of interest, plus some provisional dates for your diary in early 2024:

Dates	Meeting Title/ Event	Meeting Website/ Contact	Venue
12/Mar/24—15/Mar/24	Preparing for the Statistical Age of Strong Gravitational Lens Science with the Rubin Observatory Legacy Survey of Space and Time (LSST)	Pre-registration will open in October (meeting dates are tbc). More information available from @Aprajita Verma .	Oxford, UK
22/Jan/24 - 26/Jan/24	What was that? - planning ESO follow up for transients, variables and solar system objects in the era of LSST	ESO - LSST	
11/Dec/23—15/Dec/23	Unveiling the Dynamic Universe: Cosmic Streams in the Era of Rubin	Scientific Rationale	Puerto Varas, Chile

Members of the Consortium (not in receipt of travel funding through one of the Science Centre grants) may apply for travel support for meetings of this kind via the the LSST:UK Pool Travel Fund. Details are available at Forthcoming LSST-related Meetings .

Note that the current list of forthcoming meeting is always available on the Relevant Meetings page. You may also wish to check information held on the LSST organisation website LSST-organised events and the LSST Corporation website.

@George Beckett

Announcements

If you have significant announcements that are directly relevant to LSST:UK and would like to share the announcement in a future newsletter, please contact the LSST:UK project managers.