LSST:UK Newsletter 10 (April 2021)

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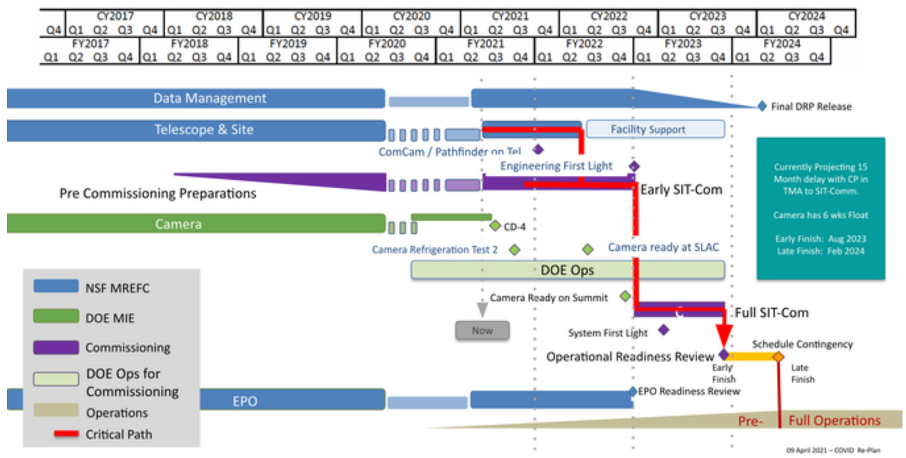
Introduction

Probably the most notable event of the past month in Rubin-land was the publication by the Observatory of a new schedule for the completion of construction, updated to take account of delays induced by the Covid-19 pandemic.

As widely trailed, full survey operations will not now start before October 2023, and it is clear from the updated schedule that it will be a great achievement to make that date. As shown on the right, the *Schedule Contingency* now envisages the potential for the Operational Readiness Review not to take place before 2024 Q1, with Full Operations starting thereafter.



(From https://www.lsst.org/about/timeline)

The Observatory has also announced that the 2021 Project and Community Workshop will take place online between **August 9th and 13th**. No further details are available yet, but this will clearly be a major event, so save the dates if you can.

Closer to home, we are in the process of on-boarding three new Work Packages in the LSST:UK Science Centre (LUSC) programme, funded as part of STFC's support for the UK's in-kind contribution to Rubin operations:

- WP1.7 comprises Aprajita Verma's half-time role as International Programme Coordinator within the Rubin Director's Office;
- WP3.3, led by Mark Sullivan at Southampton, centres on the development of software to pass LSST transients from the Lasair broker for spectroscopic follow-up with 4MOST and to return spectroscopic classification information back to Lasair; and
- WP3.12 covers continuing work by Chris Lintott's Zooniverse team at Oxford providing software support for future citizen science activities using Rubin LSST data.

Chris Frohmaier introduces WP3.3 in an item below and we will have articles outlining WP1.7 and WP3.12 in future newsletters.

Finally, a reminder that the 2021 LSST:UK All Hands Meeting takes place on 11-13 May, with **registrations closing at 16.00 BST on Friday, May 7th**. Further details can be found on the LSST:UK wiki at LSST:UK All Hands Meeting (Virtual, 11th—13th May 2021) .

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

2021 Mid-Year Junior Associates Selection Round

The mid-year call for LSST:UK Junior Associates will open on **Monday 3rd May at 10am BST**. Post-doctoral researchers and Ph.D. students based at LSST:UK Consortium institutions may apply for LSST data rights using the online form, at:

https://edinburgh.onlinesurveys.ac.uk/2021h2-lsst-junior-associate-application-form

The call will close at **4pm BST on Friday 21st May**.

Notes:

- This round is specifically for Junior Associates: Affiliate PI applications will, however, continue to be considered on an annual basis, and the next round is expected to run during the fourth quarter of 2021 and to be advertised via the LUSC-ANNOUNCE mailing list.
- We recognise that Consortium members may have unusual work patterns at this time, due to the effects of the Covid-19 pandemic. If the call window outlined above is challenging for you to adhere to, please contact george.beckett@ed.ac.uk.

@ George Beckett

Broker Workshop

I am old enough to remember when talks were given with the aid of an overhead projector and transparent acetate sheets written by hand. Since then Powerpoint and Keynote became the preferred medium, but it was quite different at the LSST C enabling science 2021 broker workshop, where presentations merged with tutorials in a github page consisting of notebooks and markdown, all times in UTC because the 100 or so participants were all on different continents.

Ken Smith presented on behalf of LSST:UK: a number of notebooks on Google Colab, that use the new Lasair API. You can try them here, and read about the API here.

Since the Rubin Observatory is not yet operational, there is no LSST data, so most of the brokers are using the Zwicky Transient Facility (ZTF) as a prototype. ZTF delivers something like 2% to 4% of the expected data rate from LSST, partly because there are fewer transients, partly because the data packets are smaller than LSST.

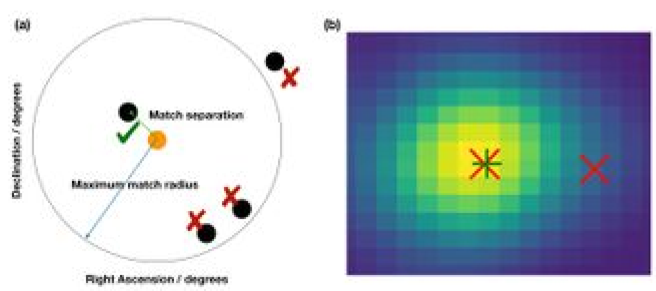
The Alerce and ANTARES brokers are the big players, with significant resources from the Chilean and US governments. In Europe, there is the Fink from France, AMPEL from Germany, and Lasair from the UK. The variety of approaches shows the wisdom of the Rubin Observatory in outsourcing this aspect of the project to a wide community: some brokers have sophisticated classifiers of variable stars and transients, some expect users to write code, while other expect users to build SQL queries.

The life-cycle of a transient alert is emerging through consensus. The telescope makes a source detection and sends out an alert packet; a broker processes the packet and annotates it with context and classification, then the users of the broker are informed of alerts that satisfy their criteria. That user may be a machine, a so-called marshall system, that allows a group of scientists to share opinions, and the marshall may be connect to TOMS (Target and Observation Manager Software) that can initiate follow-up observation of the most interesting sources.

There were many technology innovations on display. As noted above, new ways to combine code, tutorial, and presentation; ways to build sustainable code with pre-commit git hooks and automated testing; Javascript tools for websites such as React/Redux; and authentication services via COManage. There was a discussion section on NoSQL databases, which promise scalability even with very large amounts of data.

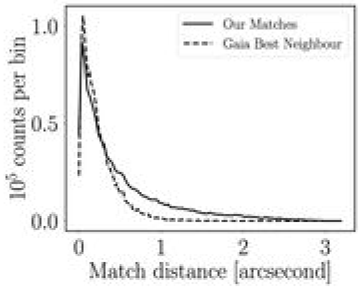
@ Roy Williams

The LSST:UK Photometric Catalogue Cross-Match Service



While the Rubin Observatory's LSST data will be great by themselves, the real benefit will be in combining the data with those from other telescopes. We have therefore been implementing a service to provide the cross-matches between LSST data releases and a set of other datasets, like *Gaia* for its proper motions or those in the IR such as *WISE* or the VISTA survey for the extended wavelength coverage.

However, we expect LSST to simply be too crowded for "traditional" cross-matching methods (such as the nearest neighbour method, shown in (a) to the right) to provide good matches for faint objects – and a significant number of LSST sources are what we might consider "faint"! With *WISE* as our precursor to LSST – both having roughly the same number of sources per point-spread-function area, coincidentally – we have developed a method to overcome the effects of this crowding. In (b) on the right, for an example of *Gaia* (catalogue positions denoted with red xs) vs *WISE* (background image, catalogue position as a green +), we can see an additional *Gaia* source that we don't see in *WISE* due to its low angular resolution, shown by the *WISE* image in the background, where the fainter *WISE* object can (just about) be seen as a (very slight) elongation of the background PSF to the right of the image. This object has been absorbed into the detection of the bright object we did detect, but affects the brighter object by moving its apparent sky position, as what we really end up measuring is the “composite” object of bright and faint source, rather than just the bright object we think we’re looking at.



Modelling this effect, we can correct for it in the questions we ask during the cross-match process, the most important of which is “what are the chances that these two objects are counterparts to one another, and two detections of one actual sky object, given the recorded distance between them on the sky?” If we neglected this effect, we would think that the objects, now much too far apart to be explainable as being the same object detected twice, were two separate objects which happen to be near to one another on the sky. The user of these matches would then think “okay, the infrared brightness of this source must be below that detectable by this survey” and could, for example, use upper flux limits in a spectral energy distribution fit – when really the source is very bright, just a little further away than we deemed okay!

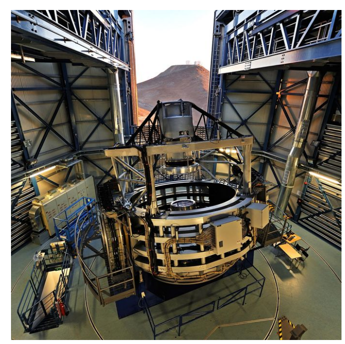
This effect is very important for *WISE* – the figure on the left shows a comparison between our matches, including this effect where hidden sources move the recorded positions of other objects, and those provided by the *Gaia* team, where they don’t include the effect. We recover many more sources beyond half an arcsecond separation, which would otherwise be missed from the composite dataset created from the lists of matching pairs.

Accounting for these hidden contaminant sources is important for two reasons. First, if anyone wanted to create a combined dataset of LSST with other surveys which suffer from significant crowding, their composite photometric catalogue would be incomplete. Second, as we anticipate LSST itself suffering from high levels of crowding due to the sheer number of sources that will be detected down to 27th magnitude, we must model the LSST data as being a combination of several unresolved objects. Conveniently, however, this modelling allows us to provide information on *how much* too bright the objects are, providing users will an estimate of the flux of these perturbing sources.

@ Tom J Wilson

The Time-Domain Extragalactic Survey (TiDES)

The start of the Rubin Observatory Legacy Survey of Space and Time is rapidly approaching and, as has been well-documented, we will enjoy an order-of-magnitude increase in the discovery of transient events. Much of the scientific exploitation that comes from transient studies, however, results from spectroscopic observations. Whether these spectra are used for object classification, chemical abundance studies, or even just to obtain a redshift, the growth in spectroscopic resource needed to exploit the potential of LSST will be comparable to that of LSST's photometric revolution. This is where the 4m Multi-Object Spectroscopic Telescope (4MOST) enters the picture with our program: the Time-Domain Extragalactic Survey (TiDES), focussing on the industrialisation of spectroscopic observations for transient science and AGN reverberation mapping.



The VISTA telescope located at the Paranal Observatory in Chile. Credit - G. Hüdepohl (ESO)

4MOST will survey the southern sky at least twice during its 5-year operation, ~2,400 targets targeted with a fibre-fed spectrograph in every 4.2 square degree pointing. The comprehensive sky coverage from LSST will result in recently discovered "live" transient events or the host galaxies of "dead" transients within every 4MOST observation. TiDES has 250,000 fibre-hours of spectroscopy time available to conduct a census of the time-domain Universe to meet three key science goals: (i) spectroscopic observations of live transients, (ii) redshift measurements of host-galaxies for supernova photometric classification and cosmological measurements, (iii) cadenced spectra to enable the reverberation mapping of Active Galactic Nuclei out to a redshift of 2.5.

With both LSST and 4MOST dominating their respective observational regimes, we are presented with an opportunity to influence both survey's strategies to maximise the transient-science return. WP3.3 has been established to deliver software products that perform and analyse LSST and 4MOST simulations to allow an optimised operational strategy. Once the surveys commence, if TiDES were to target anything that goes bump-in-the-night from LSST data, our resulting transient samples would be contaminated with junk and fibre-hours would be wasted on spurious candidates. To mitigate this, effort within WP3.3 will be directed towards producing transient selection functions to enable a clean sample of events with quantifiable systematics and biases -- which are crucial for precision cosmology experiments. We will also produce software to streamline the discovery of suitable candidate events from LSST to create the necessary 4MOST commands to observe our targets. This will involve direct collaboration with other LSST:UK work packages, especially WP3.2 Lasair - the UK transient broker for LSST, to directly interface with their APIs for rapid turnaround of discovery to spectra. This automation will allow a seamless progression from LSST discovery to 4MOST observation. Starting 2023, TiDES will lead the spectroscopic revolution of transient observations.

@ Christopher Frohmaier

Recent LSST:UK outputs

LSST:UK has recently produced the following technical reports.

Title	Author	Description
D3.7.2: Report on Mock Testing Results	Aaron Watkins, Chris Collins, Sugata Kaviraj	The WP3.7 team have analyzed a new set of model galaxies injected into the LSST pipeline meant to test the pipeline sky-subtraction routines, using the metric reported in their previous D3.7.1 deliverable. This new catalogue includes a wider array of parameter space—magnitudes, sizes, light profile shapes, and model axial ratios. WP3.7 found that regardless of profile shape or axial ratio, trends similar to what was identified in D3.7.1 still appear in this expanded model set: under the current full focal plane sky subtraction routine, faint, low surface brightness objects suffer significantly more than bright, high surface brightness objects, with the faintest models losing on average ~0.5 magnitudes of flux due to the algorithm. Additionally, the WP3.7 team devised a new metric: the average surface brightness at which any given model's radial surface brightness profile is over-subtracted by 0.1 magnitudes/arcsec2 . WP3.7 found that this value is stable regardless of which sub-sample of models was used to test it: for a typical galaxy, serious flux loss begins below ~26 magnitudes/arcsec2 , with a scatter of ~2.7 magnitudes/arcsec2 . Through further experimentation, WP3.7 found that the total amount of flux lost around each model due to the sky-subtraction follows a loglinear relationship with the model magnitudes, which explains much of the behavior described above. WP3.7 explain that all of this has serious implications for low-surface-brightness (LSB) science, which requires accurately measured fluxes as low as 32 magnitudes/arcsec2 , orders of magnitude fainter than is apparently currently achievable with the LSST pipeline. However, knowing this behavior, WP3.7 can now easily propose a concrete target to aim for when amending the pipeline.
D3.9.1 Detailed laboratory characterisation of the LSST sensors, enabling sensor responses to be quality controlled, calibrated and modelled	Dan Weatherill	This deliverable consists of two reports presented as conference contributions to SPIE (The international society of optics & photonics). They are the result of experimental investigations into various performance parameters of the CCD250 sensor as used in the LSST camera focal plane, and performed in the Oxford OPMD lab. Though the title of the deliverable is very broad, the WP3.9 team have focussed on some specific operating parameters of the sensors which have not been deeply investigated by other collaborators in the LSST project or in the LSST DESC (Dark Energy Science Collaboration). Short summaries of the content of the proceedings are provided in this document.

@ Terry Sloan

Forthcoming meetings of interest

The global pandemic has led to almost all face-to-face meetings being cancelled. However, in light of continued restrictions on travel, Rubin Observatory business has moved online and we aim to maintain a list of relevant/ interesting upcoming meetings on our Confluence site. Some specific highlights include:

- The ESCAPE project is holding a Summer School on Data Science for Astronomy, Astroparticle, and Particle Physics, during **7th--18th June**. Details on IN2P3 Indico site.
- The next DESC Virtual Collaboration Meeting is scheduled for **19th--23rd July 2021**. Details provide on the DESC Confluence site (login required).
- The 2021 Rubin Project and Community Workshop will take place online from **9th--13th August**. Details to follow.

@ George Beckett
