Proposal Title: LSST:UK In-kind Contributions to the Vera C. Rubin Observatory Legacy Survey of Space and Time

Participating Institution: The LSST:UK Consortium

Program Code: UKD-UKD

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Abstract

We propose to contribute a substantial package of in-kind effort to the Rubin Observatory Legacy Survey of Space and Time (LSST) consisting of 15 contributions within 4 principal categories. The first is a contribution to the annual Data Release Processing (DRP) which includes a fixed quantity of CPU and Data storage combined with associated pipeline operations and staff effort. The second is funded support of the EPO software being provided by the Zooniverse team in the UK (University of Oxford). The third is the construction and operation of a full International Data Access Centre. This will serve both images and catalogues via the Rubin Science Platform together with value added datasets that the UK can provide, allowing joint analysis and processing. The UK IDAC will provide CPU resources for science user analysis and will be available to all scientists holding LSST data rights. Finally we propose a software development programme which is aligned to the priorities of the LSST Science Collaborations and the Rubin Observatory Working Groups. We will deliver advanced data

products or software which will enhance the scientific return from LSST.

In 2014, the LSST:UK consortium proposed to STFC a four-phase programme for UK involvement in LSST. Funding for Phases A (2015-2019) and B (2019-2023) was awarded by STFC, providing support for the initial stages of several of these proposed contributions, while funding for Phase C (2023-2027) and Phase D (2027-2033?) will be confirmed after the agreement of the UK's in-kind package. Significant involvement in the Rubin LSST is a stated priority for the UK astronomical community, as recognised in several prioritisation exercises, and reflected in the following endorsement of this proposal from Dr Colin Vincent, Associate Director Astronomy at STFC:

> *"This proposal for the UK in-kind contribution to Rubin Observatory operations has been developed by the LSST:UK leadership following discussions with the leadership of the Rubin Operations team, and in the light of the feedback received on the Letter of Intent submitted last year.*
>
> *"I endorse this proposal as reflecting the aspirations of the UK community for its future role in the Rubin LSST and confirm that we are seeking funding to support the programme outlined here. As noted in the proposal, initial work on a number of the proposed contributions is being supported by funding that we have already awarded to the LSST:UK Consortium, but the full programme will require additional funding that has not yet been secured. As such, no firm funding commitment can be made at the moment, and negotiations between the US and UK agencies will be required to agree the final form of the UK in-kind contribution.*
>
> *"I am ready to begin those negotiations with US agency colleagues when appropriate, and, in the meantime, am happy to see this proposal proceed for scientific evaluation."*
>
> *Colin Vincent*
> *Associate Director Astronomy, Programmes Directorate, STFC-UKRI*
> *22 September 2020*

S1. Statement of Work and Detailed Plan for Proposed Contribution 1

S1.1 TITLE: LSST:UK's contribution to Annual Data Release Processing

LOI Code: UKD-UKD-1

S1.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

The LSST:UK Consortium includes groups with almost five decades of experience in processing optical and near-infrared sky surveys, starting with photographic surveys in the 1970s, through the pioneering UK Infrared Deep Sky Survey (UKIDSS), to handling the bulk of the imaging data in the ESO Public Surveys Programme (both near-infrared data from VISTA and optical data from the VST), to the Gaia astrometric survey and, soon, Euclid. In addition to this wealth of general sky survey data processing expertise, LSST:UK members have, for several years, been building up experience of running the LSST data processing pipeline software, both on simulated images from (and for) DESC and on observational data from other optical and near-infrared surveys. Further, LSST:UK is about to begin pipeline processing for images from DESC Data Challenge 2 on behalf of and as part of our contribution to the Dark Energy Science Collaboration.

These pipeline tests have been run on IRIS (www.iris.ac.uk), a new shared computing system to support UK involvement in major projects in astronomy, nuclear and particle physics. IRIS comprises a series of sites in the UK that host computing resources of different configurations and capacities, each run by a team with particular expertise in that kind of resource. We will be able to expand one or more IRIS sites to provide the additional capacity required for our DRP contribution, and being embedded in a much larger infrastructure will enable flexibility in job scheduling, while we shall benefit from access to technical expertise residing in all the major projects within the IRIS user community. Our DRP plans are included in future IRIS planning, but the funding is not yet secure.

S1.2.2 Background: One Sentence Summary

The LSST:UK Consortium possesses a wealth of experience in sky survey data processing, and, through the IRIS initiative, access to the computational resources needed to undertake a significant Data Release Processing workload.

S1.3 PLANNED ACTIVITIES

S1.3.1 Activity: Description

The LSST:UK Consortium will provide and manage high-performance-computing capacity, via IRIS, intended to address 25% of the Data Release Processing workload for the Rubin Observatory during the 10-year term of LSST. Computing capacity includes:

- **Storage** (in the nomenclature of DMTN-135, 'Normal Storage' and 'Object Storage') to host topical data during each processing run, including Raw Images, Output Images, Output Coadds, and Output Parquet files, along with working storage ('Scratch' and 'Miscellaneous').
- **CPU hours**, on a compatible platform (for example, based on Intel Xeon or AMD Epyc processor family) with a minimum memory of 12 GB-per-core, to process the Raw Images.
- **Network** capacity to enable the efficient ingestion of Raw Images from and the return of output products to either the Rubin Observatory data facility or the data facility in France, as is deemed most appropriate by the Rubin Director's Office.

LSST:UK will also provide 5.0 FTE of experienced system-administration and data-processing staff to manage the computing capacity and to undertake our share of the DRP workload in a timely and professional manner.

LSST:UK anticipates working collaboratively with the Data Release Processing teams (assumed to be in the USA and France), as part of an international Data Release Processing campaign. For example, collaborating across the facilities on:

- The coordinated deployment, installation and testing of DRP software and supporting services.
- The integration of data-release products from different facilities.
- Typical operational processes, such as incident management and problem resolution.

In advance of Rubin Observatory operations, LSST:UK will mirror the Data Release Processing activities that are planned for the Rubin Observatory Data Facility, during FY2022 and FY2023, including:

- Periodic (e.g., monthly) reprocessing of the HSC RC2 and DESC DC2 datasets with the topical version of the Rubin Observatory Pipeline software.
- Periodic (e.g., annual) reprocessing of the HSC SSP PDR2 dataset.

The pre-operations schedule of processing that we propose may be adjusted to incorporate different datasets and/ or variations of the Pipeline software stack—for example, to accommodate approved LSST:UK contributions to Commissioning activities—should this be deemed by the Rubin Director's Office to be more beneficial to operational preparations, with an expectation that any alternative processing workload would be of a similar scale to that outlined above.

S1.3.2 Activity: One Sentence Summary

LSST:UK will provide computing, storage, and networking capacity, plus experienced system-administration and data-processing staff, to undertake 25% of the anticipated Date Release Processing workload over the lifetime of the LSST.

S1.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S1.4.1 Deliverables: Description

In line with sizing information provided in DMTN-135, LSST:UK anticipates securing capacity outlined in Table S1.1 (and expanded on in the annex that accompanies this proposal), prior to and over the lifetime of the survey. The capacity that is indicated for each year will be available from the beginning of that year. For example, based on the topical timeline, we would provision LOY1 computing capacity from the beginning of FY2024.

	Pre-op / Comm	Survey Operations (based on commencement of survey in FY24)									
Capability	FY23	LOY1	LOY2	LOY3	LOY4	LOY5	LOY6	LOY7	LOY8	LOY9	LOY10
CPU (millions of core hours)	9	45	82	120	160	200	250	290	330	370	410
Normal/ Object Storage (Petabytes)	8.0	9.0	16.0	23.0	30.0	37.0	44.0	51.0	58.0	65.0	72.0
Expert staff (person-years)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

Table S1.1: Summary of Computing Capacity to be provided by LSST:UK for Data Release Processing.

The computing capacity is likely to be provided at a single site — in an IRIS-member data centre — with a minimum network bandwidth into the UK academic network backbone (Janet Network, https://www.jisc.ac.uk/janet) of at least 40 Gbps. Within the IRIS data centre, the data-centre network will have a minimum capacity of 40 Gbps (and more likely 100 Gbps).

S1.4.2 Deliverables: One Sentence Summary

Computing capacity to complete 25% of the Rubin Observatory's expected data-release-processing workload for LSST.

S1.4.3 Deliverables: Timeline

LSST:UK will deliver computing capacity, in line with the sizing information noted above, at the beginning of each fiscal year, as indicated in the table above.

S1.5 EXPECTED RIGHTS TO THE LSST DATA

S1.5.1 Data Rights: Description

Section 2.3.3 of the In-kind Contribution Program Handbook for Proposal Teams gives the computational resources equivalent to 1 PI slot as being 30M core-hours of CPU time or 15 PB-years of disk storage. In light of this, we calculate our in-kind proposal to be worth 105 PI slots, as detailed in the table below.

	Per-measurement units	Number of PIs
Core Hours (Millions)	575	19
Storage (PB-years)	413	28
Effort (staff-years)	58	58
Total PIs		**105**

This is based on Observatory's current sizing model and if this model changes significantly or is determined to be inaccurate, it will affect the scope of the UK contribution.

S1.5.2: Data Rights: One Sentence Summary

We calculate the combined value of our proposal to undertake 25% of the Data Release Processing workload to be worth 105 PI slots.

S1.6 KEY PERSONNEL

Contribution Lead: Bob Mann

Contribution Recipients: Rubin Data Production Group

S2. Statement of Work and Detailed Plan of Proposed Contribution 2

S2.1 TITLE: LSST:UK's contribution to EPO software

LOI Code: UKD-UKD-2

S2.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

A core program in the Rubin Observatory Education and Public Outreach effort is the development of citizen science projects, which enable a large crowd of volunteers to engage with data from the survey in a structured manner. The Observatory has decided to work with the Zooniverse platform and team to host these projects. Building on the success of projects such as Galaxy Zoo and Planet Hunters, the Zooniverse development team have built a platform which allows researchers to quickly and easily use a suite of web-based tools to create and run such projects. Example use cases for the survey include transient labelling and filtering, classification of low surface brightness features around galaxies, and the detection of active asteroids. Preliminary work by the EPO and Zooniverse development teams has designed a system which will allow those with data rights to access LSST data transferred to the Zooniverse, which will then allow rapid development and prototyping of projects via the existing web based project builder facility. The work in this plan will be managed by Lintott and his team, who have been responsible for the platform since its inception and who have a unique track record of producing both research papers from such citizen science projects. Of particular interest is the prevalence - particularly in data from the SDSS survey and from the Kepler and TESS missions - of serendipitous discoveries produced by these projects, including Hanny's Voorwerp, the Galaxy Zoo Peas and Boyajian's Star.

S2.2.2 Background: One Sentence Summary

The Zooniverse platform is the chosen method for delivering the Rubin Observatory citizen science program, allowing data rights holders to quickly and easily build sophisticated web projects which invite volunteers to contribute to Rubin science.

S2.3 PLANNED ACTIVITIES

S2.3.1 Activity: Description

This has been developed in coordination with the Rubin EPO team and we will complete the integration of the Zooniverse and science platform system.

Maintaining the system which connects Zooniverse to the Science Platform, allowing Observatory rights holders to access their data via the Zooniverse project builder tool.

Build and maintain appropriate systems which connect project brokers to the Zooniverse platform, allowing the creation of projects using filtered and/or labelled alert streams.

Build and maintain appropriate systems which allow for the live reporting of results from Zooniverse, both raw classifications (i.e. where we report that User X has said Y about Z) and consensus (i.e. where we report the probability of label Y applying to Z is x, based on classifications from a set of users).

Provide appropriate tools in the Zooniverse open source project builder for the analysis of LSST data; we will regularly solicit development needs from the science collaborations and Rubin Observatory Community Engagement Team to ensure that tools continue to be of use for updated science cases. This activity will include tools for the integration of appropriate machine learning, which can share the burden of classification with the volunteers.

Maintain the facility for discussion about images and data encountered by volunteers during the course of the project, either through the Zooniverse Talk platform or similar tools integrated into the main platform. This is particularly important for facilitating serendipitous discovery.

Manage the review and quality assurance process for Rubin citizen science projects, including organising peer review and review by the panel of citizen scientists, providing advice to the Rubin science community where necessary to ensure that projects reach the required standard.

Ensure tools for translation of projects built on the platform exist, and can support projects in (at least) English and Spanish.

Ensure that, where appropriate, Observatory projects can be accessed through mobile devices, either through responsive development or through the provision of a separate app.

Provide documentation and training for project data rights holders in developing and running citizen science projects, including how they may complete the necessary data analysis to produce scientifically useful results from such projects.

Providing reports. statistics and analysis to the project on the use of Rubin Observatory data in relevant citizen science projects, including studies of participant behaviour and opinions.

Build and maintain appropriate tools to manage communication with citizen science participants throughout the life of the project, including mailing lists and other appropriate content as agreed with the EPO team and science users of the system.

S2.3.2 Activity: One Sentence Summary

LSST:UK will provide 1 FTE of effort for software support to be provided by the Zooniverse team in Oxford, to be funded from October 2020 - March 2033 (a total of 12.5 FTE yrs). This effort is ***directable.***

S2.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S2.4.1 Deliverables: Description

The main deliverable is the 12.5 FTE years of directable software development effort in support of Rubin citizen science efforts, which will offset the corresponding operations cost for Rubin Observatory. This effort will be used to maintain and expand the deployed Zooniverse web-based platform which will allow observatory users to create, deploy and use citizen science projects for research and for engagement.

The fundamental elements of the deployed platform are:

1. A front-end (currently react.js) interface for building projects, accessible to Observatory data rights holders.

2. The ability for citizen scientists to search Rubin Observatory projects, and interact with Observatory data via deployed projects.

3. A back end API which interacts with the Observatory data management tools to provide appropriate access to Observatory data.

4. A system for citizen scientists to participate in discussions regarding the data they encounter in the course of the projects.

5. A means of tracking participation and impact, as agreed with the Engagement team.

S2.4.2 Deliverables: One Sentence Summary

The core deliverable is a deployed and flexible Zooniverse platform, integrated with the Science Platform, which supports a wide variety of citizen science projects for a large distributed crowd of volunteers, working across the range of science addressed by the observatory.

S2.4.3 Deliverables: Timeline

We expect our contribution to the initial software integration to be completed by April 2021. The core work will begin in October 2021 with test projects on the platform (using either simulated data, commissioning data or data from precursor surveys such as ZTF or HSC) being run on a six-monthly basis ahead of the survey launch. The full capabilities of the platform should be made available to the Observatory community by the beginning of the survey.

FY21 - FY33 : 1 FTE of directable software development to enable Zooniverse as Rubin Observatory's Citizen Science platform for a total of 12.5 yrs.

S2.5 EXPECTED RIGHTS TO THE LSST DATA

S2.5.1 Data Rights: Description

In return for 12.5 FTE yrs of directable software development which is dedicated to supporting the Rubin Observatory's chosen platform for Citizen Science we request LSST data rights for 13 PIs.

S2.5.2: Data Rights: One Sentence Summary

LSST data rights for 13 PIs

S2.6 KEY PERSONNEL

Contribution Lead: Prof Chris Lintott

Contribution Recipients: Rubin EPO Department [Primary Contact as listed in the Handbook (Section

1 is Phil Marshall pjm@slac.stanford.edu]

Chris Lintott will be responsible for the scientific leadership of the program, ensuring that the tools built and deployed will produce successful and reliable science. He will also be directly responsible for promoting the citizen science program to Observatory data rights holders, and for coordinating with the rest of the EPO team.

Cam Allen has been the lead developer for Zooniverse for 5 years, having designed and built the Panoptes platform that supports the project builder and our current development. He will be responsible for most of the integration work, and will delegate front end development and support to other members of the team where appropriate.

S3. Statement of Work and Detailed Plan for Proposed Contribution 3

S3.1 TITLE: LSST:UK's operation of an international DAC

LOI Code: UKD-UKD-3

S3.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

The LSST:UK Consortium includes groups with more than two decades of experience in curating, and publishing online, digital archives from optical and near-infrared sky surveys, starting with scanned copies of photographic surveys, through the pioneering UK Infrared Deep Sky Survey (UKIDSS), to handling the bulk of the imaging data in the ESO Public Surveys Programme (both near-infrared data from VISTA and optical data from the VST), to the Gaia astrometric survey and, soon, Euclid.

In addition to this wealth of general sky survey data curation and publication expertise, LSST:UK members have, for several years, been developing a proto-DAC. This has been exercising components of the DAC software — for example, qserv and the Rubin Science Platform — using datasets familiar to the UK DAC team in Edinburgh, as well as developing experience in deploying them (and related technologies, such as Kubernetes) on an OpenStack-based platform provided by IRIS (www.iris.ac.uk). IRIS comprises a series of sites in the UK that host computing resources of different configurations and capacities, each run by a team with particular expertise in that kind of resource. We will be able to expand one or more IRIS sites to provide the additional capacity required for our IDAC, and we shall benefit from access to technical expertise residing in all the major projects within the IRIS user community. Our DAC plans are included in future IRIS planning, but the funding is not yet secure.

S3.2.2 Background: One Sentence Summary

The LSST:UK Consortium possesses a wealth of experience in sky survey data management, and, through the IRIS initiative, access to the computational resources needed to host a Full IDAC.

S3.3 PLANNED ACTIVITIES

S3.3.1 Activity: Description

We propose to operate, for the duration of the survey, a Full IDAC, which will be deployed on computational resources provisioned through the IRIS system. As described in Section S3.4.1 below, it will be sized for 1,000 data rights holders in LOY1 rising to 1,500 data rights holders in LOY10, representing 40% of the expected user community for the Project Data Access Centre in USA. This provision greatly exceeds the capacity required for the UK community, and, so, makes a significant contribution to the international DAC network.

In addition to hosting Data Release products, as specified in RTN-003, the UK IDAC will form the core for a range of activities included in other contributions described elsewhere in this proposal. For example:

- The UK IDAC will host the Lasair alert broker (see UKD-UKD-4), for which we will be seeking Community Broker status, and which would provide targets for the transient spectroscopic follow-up programme outlined in UKD-UKD-10.
- The UK IDAC will curate and publish the optical/near-infrared data products being developed through UKD-UKD-5 and the optimised cross-match catalogues from UKD-UKD-9.
- The UK IDAC will also provide computational resources supporting UK participation in Commissioning (UKD-UKD-13), as well as those required by the post-2023 software development projects to be undertaken under the aegis of UKD-UKD-12.

S3.3.2 Activity: One Sentence Summary

LSST:UK proposes to develop its existing proto-DAC into a Full IDAC, which will run, for the duration of the survey, on resources provisioned through IRIS, and which will publish datasets generated by several proposed UK software development contributions, as well as the standard data release products.

S3.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S3.4.1 Deliverables: Description

We propose to construct and operate a Full IDAC, in line with the outline description provided in RTN-003, and for the duration of the Rubin Observatory operational phase.

We will deliver an IDAC instance, sized to serve 40% of the US Data Access Centre, which meets all of the criteria outlined in RTN-003, Appendix C, as follows (specific cross-references in parentheses). The UK IDAC will:

- Have an authentication/ authorization system in line with Rubin Observatory Access. (C.1.1)
- Be broadly accessible to all Data Rights holders. (C.1.2)
- Incorporate a database system (expected to be Qserv) capable of serving topical versions of all LSST catalogues along with catalogues for approved UK-originating User-generated Products, documented elsewhere in this proposal. (C.2.1 and C.3.3)
- Support common and standard astronomy interfaces, including IVOA TAP, MyDB, Table Upload and CAOM. (C.2.2)
- Be installed, maintained and operated by experienced support staff from the University of Edinburgh Wide-field Astronomy Unit, at the level of 5.0 full-time employees. (C2.4 and C.3.1)
- Be sized to support expected demand of initial 1,000 data-rights holders rising to 1,5000 data-rights holders in LOY10, based on a scaled version of sizing information contained in DMTN-135, including a quota of user-storage in line with those estimates (C.2.3 and C.3.4).
- Expose an instance of the Rubin Science Platform software as the primary user interface. (C.3.2)
- Be funded and operated for the full operations period of the LSST (that is, at least 2024–2034).
- Be accessible over the Internet and able to support data ingestion and user access with at least 20 Gbps of available capacity (more likely 40Gbps). (C.3.6)

The LSST:UK Full IDAC will be deployed onto the IRIS service (www.iris.ac.uk), which has been introduced in Section S1. The IDAC will have the following high-level elements:

- On-line storage capacity of 24 PB in 2024, rising to 175 PB in 2034, to host full copies of the two most recent LSST Data Releases (images and catalogues).
- Computing resources equivalent to 100 'nominal CPU' cores and 0.4 PB of Normal Storage in

2024 rising to 900 cores and 2.0 PB in 2034, to serve the data-analysis requirements of Data Rights holders, accessible via a topical version of the Rubin Science Platform.
- Programmatic access using APIs devised by the Rubin Observatory DM team, for large-scale computing campaigns—for example, the generation of significant User-generated Products.
- Additional on-line storage capacity into which the in-preparation data release may be ingested, ready for prompt publication on a date specified by the Rubin Observatory.
- An instance of the Qserv database, distributed across 96 nodes in LOY1 rising to 418 nodes in LOY10, and hosting topical LSST Data Release catalogues alongside approved User-generated Data Products (where the size of those catalogues warrants use of Qserv technology).
- Additional database services to host relevant ancillary catalogues from complementary astronomy surveys, intended to boost the science capabilities of the IDAC.
- Supporting services, including data-migration, AAAI, infrastructure monitoring, Service Desk, for example, to support an efficient and high-quality IDAC service portfolio.
- A Data Centre Network capacity of at least 20 Gbps, to support required data-transport across the IDAC components.

If the LSST:UK Community Broker proposal, 'Lasair', is accepted, then the LSST:UK IDAC will incorporate the alert-stream products from the Broker, along with the extended functionality of Lasair for interrogation and analysis of those products. Furthermore, the LSST:UK IDAC would host a copy of the Prompt Products database should this be desirable to the Rubin Director's Office.

Storage and compute infrastructure components will be refreshed at least every five years, following a rolling upgrade programme intended to minimise IDAC downtime.

An on-site support team, equivalent to at least 5.0 FTE, will install, maintain and support the IDAC infrastructure, middleware, software and services, for the lifetime of the IDAC. The team is expected to be made up, as follows:

- 1 FTE — Database administration
- 1 FTE — Storage administration
- 1 FTE — Compute-platform administration
- 2 FTE — Science support

More detailed role descriptions for these positions is provided in the accompanying annex.

This team will be available to collaborate with Rubin Observatory staff on the development, deployment and testing/ remediation of software and services, the coordinated ingest and publication of LSST Data Releases and ancillary datasets, and the investigation and diagnosis of inter-IDAC incidents and problems that affect the experience of Data Rights holders or threaten to impact on Rubin Observatory operations.

The LSST:UK IDAC will provide science support (with resources of 2 FTE, as noted above), to assist Data Rights holders in using IDAC services and in exploiting LSST Data Release Products and User-generated Products. This science-support team is willing to collaborate with Rubin Observatory and other IDACs' science-support teams and to participate in a unified Rubin Observatory helpdesk, should that be desirable to the Rubin Director's Office.

The LSST:UK IDAC would be supported by and subject to the UK IRIS Infrastructure Security Policy (at the time of writing, in preparation), which would be used to underpin the LSST:UK approach to data- and infrastructure-security good practice.

The LSST:UK IDAC team will be overseen by a Project Manager (minimum 0.25 FTE) who will liaise with NOIRLab and other IDACs in the Rubin IDAC Network, and coordinate LSST:UK IDAC activities to align with Rubin Observatory plans and schedules.

The LSST:UK IDAC team would be willing to contribute to the development and implementation of a set of Service Level Expectations/ Service Level Agreements, intended to ensure the warranty and utility of the DAC/IDAC network for data-rights holders.

S3.4.2 Deliverables: One Sentence Summary

LSST:UK proposes to deliver a Full Independent Data Access Center throughout the LSST survey (expected to be 2024–2034), hosting Data Release Products and User-generated Products, accessible via the Rubin Science Platform, with a capacity for 40% of the Project Data Access Centre in the USA, along with 5.0 FTEs of expert staff to address administration of the database, storage, and compute elements of the service, and provide science support to Data Rights holders, to enable full scientific exploitation of the LSST.

S3.4.3 Deliverables: Timeline

If selected, LSST:UK propose delivery on the following timeline (which is based on the expected start date for Operations of October 2024).

FY22: Technology preview of the Full IDAC, supporting the Consortium's contribution to Rubin Observatory Commissioning outlined in Section S13 (should that be accepted) based on appropriate ancillary or preview datasets, along with 2.0 FTE of expert-staff effort.

FY23: Provision of initial version of the Full IDAC, hosting Rubin Observatory data previews (subject to approval by the Rubin Director's Office) and running the full Rubin Science Platform. 5.0 FTE of expert-staff effort will be provided to operate and support the IDAC, with a Facility Manager, at 0.25 FTE, to oversee operation of the IDAC and to coordinate IDAC Network activities.

FY24—34: Continued delivery of the Full IDAC, ingesting and hosting topical versions of LSST Data Releases alongside User-generated Products, with infrastructure upgrades to deliver required capacity made in advance of each Data Release. Continued provision of 5.0 FTE of expert-staff efort and 0.25 FTE facility management.

S3.5 EXPECTED RIGHTS TO THE LSST DATA

S3.5.1 Data Rights: Description

Section 2.3.3 of the In-kind Contribution Program Handbook for Proposal Teams gives the computational resources equivalent to 1 PI slot as being 30M core-hours of CPU time or 15 PB-years of disk storage. In light of this, we calculate our in-kind proposal to be worth 179 PI slots, as detailed in the table below.

	Per-measurement units	Number of PIs
Core Hours (Millions)	646	22
Storage (PB-years)	1,240	83
Effort (staff-years), including 16 staff-years of effort invested during 2015—2023	74	74
Total PIs		**179**

S3.5.2: Data Rights: One Sentence Summary

We calculate the combined value of our proposal to provide a full Independent Data Access Centre, sized to be 40% of the Project DAC in the United States, to be worth 179 PI slots.

S3.6 KEY PERSONNEL

Contribution Lead: Bob Mann rgm@roe.ac.uk

Contribution Recipients: Rubin IDACs Coordination Group

S4. Statement of Work and Detailed Plan for Proposed Contribution 4

S4.1 TITLE: Science Software development: Lasair Transient Broker

LOI Code: UKD-UKD-4

In the LSST:UK LOI, we proposed software development effort for the Lasair transient and variable object broker as an in-kind contribution. Rubin have decided that brokers are not eligible as in-kind contributions and their selection will be handled in a separate process. We respect that decision, but in order to fully deliver on one of our in-kind contributions (UKD-UKD-10, described here in S10) we will need to provide transient data and spectroscopic data through the Lasair Broker. Hence we include this contribution for completeness, but recognise that it will be valued at zero LSST PIs.

S4.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

S4.2.1 Background: Description

We have been developing a broker, called Lasair for for several years, demonstrating a working prototype which distributes, annotates and stores the ZTF transient data for public use. As the ZTF-alerts stream into Lasair, we add multi-wavelength context, IDs, classification and other added value using cross-match software that links all transients to large catalogues (*Sherlock* software with a custom built 4TB database). Users can query the accumulating database in various different ways, or produce a filtered stream which is sent to them. Users can also make a "watchlist" of their favourite objects and get alerted when one of them flares up. We provide a web interface, a SQL query platform and a Jupyter interface. Users can write Python scripts to run on the UK IRIS service (the UK's high performance computing infrastructure for astrophysics and particle physics) , which provides access to a high-powered computing facility for analysis. Further details are on the website (https://lasair.roe.ac.uk), and we have a Lasair cookbook : Lasair Cookbook. We also have expertise in extracting targets for spectroscopic follow-up and linking those data (and meta-data such as redshift, transient classification and phase) back into the broker system for users to access.

S4.2.2 Background: One Sentence Summary

The LSST:UK team have developed a working prototype of a broker to process LSST alerts and make them world public and they will be augmented with value added datasets including spectra.

S4.3 PLANNED ACTIVITIES

S4.3.1 Activity: Description

The Lasair broker will provide user interfaces, data access and computing resources for all LSST data rights holders to access LSST alerts and will add significant scientific value to the objects. Lasair will be made publicly available, but with restrictions on LSST proprietary data products and computing resources allocated. We will provide easy access to the LSST lightcurves and a range of "User Generated data products" to support science users' exploitation of the data. All alerts will be assimilated into discrete objects in our database, cross-matched with all the major stellar, galaxy and multi-wavelength catalogues and annotated with information contained in those catalogues (e.g. redshift, distance, offset, eruptive or variable type). Objects will be probabilistically classified based on the external data and the lightcurve from LSST and users will be able to query the database or receive streams of alerts that match certain criteria. We will also tag objects that are in sky regions of interest, such as gravitational wave maps, Fermi GRB localisation regions, IceCube neutrino error boxes. To support S10, we will provide the means for DESC and S10 personnel to select targets and put them in the 4MOST observing plan. This will be both live transients and positions of most likely host galaxies (for spectroscopic host redshifts). The selection function will be reproducible, traceable and quantifiable. Lasair is being built to accept and distribute the information from the 4MOST spectra (redshifts and types) and to ingest the spectral data when they are fully calibrated and released by S10. The computing resource to provide the platform for Lasair is assured on the UK's IRIS system and the UK's IDAC (see S3). The software developer effort is non-directable effort that is addressing the science requirements of users across several Science Collaborations (TVS, DESC, and AGN).

S4.3.2 Activity: One Sentence Summary

We will develop the Lasair broker to accept LSST alerts and provide the infrastructure to allow targets to be selected for ESO spectroscopy and then to return both the metadata measured and the fully calbrated data products to Lasair (in combination with S10).

S4.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S4.4.1 Deliverables: Description

LSST:UK will deliver 1 FTE between 2020 - 2023 (2019-2020 has already been delivered within the LSST:UK overall project) to enable Lasair development for LSST alerts. Dr Ken Smith is a senior software engineer with many years of experience in running massive (~billion row) relational databases. He has demonstrated the capability of a relational database to hold the ZTF data and provide access and functionality for users. He will work with the S10 team to provide the platform that will allow the DESC to understand and influence the selection function for spectroscopic target selection and ensure that the reduced data products and meta-data are returned to the Lasair broker for user-friendly science use.

S4.4.2 Deliverables: One Sentence Summary

LSST:UK plans to provide skilled software development effort, using already-secured funding until 2023 to deliver the broker software (with effort 2023+ to be jointly decided by LSST:UK and Rubin).

S4.4.3 Deliverables: Timeline

FY19: Dr. Ken Smith (software engineer, 0.75 FTE)

FY20: Dr. Ken Smith (software engineer, 0.75 FTE)

FY21: Dr. Ken Smith (software engineer, 0.75 FTE)

FY22: Dr. Ken Smith (software engineer, 0.75 FTE)

FY22+: potential continued contribution of development effort.

S4.5 EXPECTED RIGHTS TO THE LSST DATA

S4.5.1 Data Rights: Description

Given that broker development is not valued as a primary contribution, LSST:UK agrees that this effort in S5 is not eligible to be valued in terms of LSST PIs. However the project is essential for us to complete in order that we deliver on UKD-UKD-10 as described in S10. We include it as an essential in-kind for the LSST:UK since S10 is critically dependent upon it, but we do not request data rights associated with S5.

S4.5.2: Data Rights: One Sentence Summary

LSST data rights for 0 PIs.

S4.6 KEY PERSONNEL

Contribution Lead: Prof Stephen Smartt (s.smartt@qub.ac.uk)

Contribution Recipients: DESC, TVS

S5. Statement of Work and Detailed Plan for Proposed Contribution 5

S5.1 TITLE: Science Software development: Near infrared data fusion

LOI Code: UKD-UKD-5

S5.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

Raphael Shirley is a postdoctoral researcher and data scientist with significant experience in large survey projects and assembling and validating multi-wavelength datasets. He served as the Project Scientist for the Herschel Extragalactic Legacy Project (HELP), which involved bringing together multiwavelength surveys from the ultraviolet to the far infrared to model spectral energy distributions of millions of galaxies. Shirley is a member of the DESC and Galaxies SCs and has served as a member of the LSST Deblending Task Force.

Carlos Gonzalez-Fernandez is a senior technical research scientist within the Cambridge Astronomical Survey Unit with responsibility for developing the VISTA imaging data reduction pipeline and serving the VISTA data to the ESO science archive.

Manda Banerji has over a decade's experience in the planning and exploitation of wide-field optical and near infrared ground-based surveys. She is PI of the VISTA Extragalactic Infrared Legacy Survey (VEILS), which overlaps several of the currently announced LSST Deep Drilling Fields. Banerji is a member of the AGN and Dark Energy Science Collaborations and currently serves as Co-chair of the Galaxies Science Collaboration. She was responsible for developing the High Redshift Galaxies science case in the LSST Galaxies Roadmap.

Richard McMahon has over 25 years of experience in data management of wide field astronomical surveys primarily in the optical and near infra-red. He is PI of the VISTA Hemisphere Survey. He is a member of the AGN and Dark Energy Science Collaborations.

S5.2.2 Background: One Sentence Summary

Banerji and McMahon have between them several decades of experience in the planning and exploitation of wide-field astronomy survey projects, Gonzalez-Fernandez and Shirley are experienced survey scientists and several team members are active in multiple LSST Science Collaborations with Banerji serving as one of the Galaxies SC Co-Chairs.

S5.3 PLANNED ACTIVITIES

S5.3.1 Activity: Description

The scientific return of LSST will be greatly enhanced by the addition of information at other wavelengths to the LSST optical data. Infrared (IR) photometry for LSST sources will open up the discovery space sampled by LSST to the very distant, obscured and cool Universe. We will build on the UK's leading role in IR surveys with VISTA, to implement a flexible pipeline based on the LSST Stack software suite for processing the VISTA IR pixels jointly with LSST pixels. We will produce science-ready multi-wavelength catalogues for the LSST community. A critical aspect of combining the LSST data with surveys at other wavelengths is ensuring that the photometry is measured consistently across all wavelengths, taking into account variations in angular resolution, depth and signal-to-noise between the different surveys. Joint image-level processing of LSST and IR surveys will enable us to probe considerably deeper than the IR catalogues.

We will make use of photometric positional and shape priors from one survey to measure fluxes in another. The pipeline will be configurable to new datasets as they become available. We will deliver combined multi-wavelength optical+near infrared catalogues (including sources not detected in the optical e.g. those at high-redshifts) together with source-level metadata, detection and measurement image provenance information and workflow provenance information. All images, weight maps and catalogues will be made available to the LSST Community via the UK IDAC.

In order to provide these data sets (in the UK IDAC), it is essential that we deliver a software contribution providing the community with a version of the LSST Stack configured to enable joint processing of LSST pixels with other survey pixels. The VISTA data are ESO public survey data: all raw data are public immediately in the archive and some of the data products are available through the Science Archive Facility. However the scientific value in our proposal is easy access to merged catalogues and software for forced, matched photometry on LSST and VISTA pixels. This will be done at no cost to NOIRLab. Therefore we value this as a software contribution rather than a data set (according to the Handbook). Computing will be provided in the UK IDAC to support this (value included in S3).

The Galaxies Science Collaboration endorses the extension to the LSST software stack to jointly process the pixel data from LSST and VISTA and produce a merged LSST/VISTA catalog. The AGN Science collaboration endorses this contribution. NOIRlab endorses this contribution.

S5.3.2 Activity: One Sentence Summary

We will provide joint LSST+VISTA near infra-red catalogues produced using the LSST Stack and access to VISTA survey images as a dataset contribution, as well as an implementation of the LSST Stack pipeline reconfigured to jointly process LSST pixels with external survey pixels.

S5.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S5.4.1 Deliverables: Description

We will provide effort, using already-secured funding at the level of 1.5 FTE for 2.5 years starting in FY20. This effort is split across two experienced survey scientists (Dr. Raphael Shirley at 1.0 FTE and Dr. Carlos Gonzalez-Fernandez at 0.5 FTE) who bring with them significant expertise in the assembly of multi-wavelength datasets and the VISTA near infra-red data in particular.

The 1.5 FTE per year will include developing an extension of the LSST Stack software to jointly process LSST pixels together with the VISTA pixels in order to produce merged optical + near infrared catalogues. Our initial priority will be high-latitude extragalactic ESO VISTA Public Surveys such as VHS (McMahon et al. 2013), VIKING (Edge et al. 2013), VIDEO (Jarvis et al. 2013) and VEILS (Banerji et al. in prep), which overlap the LSST Wide and Deep-Drilling Fields. The joint catalogues together with associated VISTA images will be made available to the LSST Community via the UK IDAC. By providing the catalogues and the software to run on pixel data in the UK IDAC we will keep this cost neutral to NOIRLab and the Rubin Data Facility.

We will work with the Galaxies and AGN Science Collaborations to prioritise the VISTA public surveys processed and define the data products needed to meet their science goals. We will communicate regularly with the Science Collaborations by presenting our work in relevant telecons and via Slack.

We will also seek input from the LSST DM team and keep the DM team updated regarding enhancements to the pipeline to enable the processing of VISTA pixels.

We will make all software and notebooks developed in this project and corresponding documentation (e.g. user manuals) available to the Rubin data rights holders through the Rubin software stack. Towards the end of the project the responsibility of maintaining any software produced as part of this contribution will be negotiated with the DM team and, if necessary, we will train DM team members in further evolving and supporting this software.

Banerji will also pursue UK funding to support extensions to this work package to e.g. process LSST and VISTA single epoch images (to provide variability information) as well as process Spitzer and WISE images through the pipeline. We will follow the mechanism described in UKD-UKD-12 and foresee the Rubin team playing a role in selecting the work packages to be funded within the UK.

S5.4.2 Deliverables: One Sentence Summary

LSST:UK plans to provide skilled software development effort, using already-secured funding, at the level of 1.5 FTE per year for 2.5 years, starting in FY20, as well as a dataset contribution of VISTA images and joint LSST+VISTA catalogues generated using the LSST Stack.

S5.4.3 Deliverables: Timeline

FY20: Dr. Raphael Shirley (postdoc, 1 FTE for 0.25 yrs Jul 20 - Sep 20), Dr. Carlos Gonzalez-Fernandez (technical research scientist, 0.5 FTE for 0.5 yrs (Apr 20 - Sep 20)).

Dr. Shirley is responsible for the adaptation of the LSST Stack to process VISTA pixel data. Dr. Gonzalez-Fernandez is responsible for curating the VISTA datasets and liaising with the UK IDAC to ensure the data products produced are made available to the LSST community.

FY21: Dr. Raphael Shirley (postdoc, 1 FTE), Dr. Carlos Gonzalez-Fernandez (technical research scientist, 0.5 FTE)

FY22: Dr. Raphael Shirley (postdoc, 1 FTE), Dr. Carlos Gonzalez-Fernandez (technical research scientist, 0.5 FTE)

FY23 : Dr. Raphael Shirley (postdoc, 0.5 FTE)

FY23-FY35: potential continued contribution of development effort. There is potential for this effort to continue beyond August 2023 and this will be presented as an overall UK contribution in FTE yrs in UKD-UKD-12.

S5.5 EXPECTED RIGHTS TO THE LSST DATA

S5.5.1 Data Rights: Description

Given the endorsements of our contribution, the value we provide (at no cost to NOIRLab) and skilled nature of the staff effort provided, LSST:UK considers 4 FTE years to be worth 4 PIs.

S5.5.2: Data Rights: One Sentence Summary

LSST data rights for 4 PIs.

S5.6 KEY PERSONNEL

Contribution Lead: Dr. Manda Banerji

Contribution Recipients: NOIRLab CSDC (Primary Contact: Knut Olsen kolsen@noao.edu), Galaxies Science Collaboration (Primary Contact: Harry Ferguson, ferguson@stsci.edu), AGN Science Collaboration (Primary Contact: Xiaohui Fan fan@as.arizona.edu)

Dr. Raphael Shirley is a postdoctoral research associate at the University of Southampton (from Jul

2020)

Dr. Carlos Gonzalez-Fernandez is a senior technical research scientist at the Cambridge Astronomical Survey Unit based at the Institute of Astronomy, University of Cambridge.

Dr. Manda Banerji is an Associate Professor in Astronomy at the University of Southampton, UK.

Prof. Richard McMahon is Director of the Institute of Astronomy, University of Cambridge, UK.

S6. Statement of Work and Detailed Plan for Proposed Contribution 6

S6.1 TITLE: Science Software development: Low surface brightness science

LOI Code: UKD-UKD-6

S6.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

S6.2.1 Background: Description

Aaron Watkins has developed data-reduction pipelines for broadband and narrow-band deep imaging surveys with multiple telescopes, including the Burrell Schmidt Telescope (KPNO) and the NTT (La Silla). He has 6 years experience in the processing of LSB-optimized imaging and in the analysis of low-surface-brightness (LSB) features in galaxy images.

Chris Collins has extensive experience in LSB cluster science from the near-IR to X-rays. He discovered the slow evolution of BCGs and the causal link with the growth of the diffuse intra cluster light from 8m observations. He was a founding member of pioneering cluster surveys based on their LSB X-ray emission: REFLEX & SHARC (ROSAT); XCS (XMM). Key members of the Rubin Algorithms and Pipelines (DM) team and LSB working group within the Galaxies Science Collaboration (GSC) were his PDRAs/PhD students.

Sugata Kaviraj has a long track record of theoretical LSB studies using high-resolution cosmological simulations, and observational LSB studies using surveys like the Stripe 82 and the HSC-SSP. He has worked across several themes in LSB science, from dwarf galaxies to the impact of mergers on galaxy evolution (traced using merger-induced tidal features in deep images).

Aaron Watkins has already been working with the DM team (Kelvin/Al-Sayyad/Reed/Lupton) since March 2020 on this project, in a directable fashion (see S6.3.1 below). Aaron Watkins, Chris Collins and Sugata Kaviraj are active members of the GSC. Sugata Kaviraj is co-chair of the GSC, while Aaron Watkins serves as co-chair of the LSB working group within the GSC.

S6.2.2 Background: One Sentence Summary

Watkins (senior postdoc) is an expert in the processing and analysis of LSB features in galaxy images, Kaviraj and Collins have a strong track record in LSB science and all three are active members of the GSC, with Kaviraj serving as its co-chair and Watkins serving as co-chair of the LSB working group within the GSC.

S6.3 PLANNED ACTIVITIES

S6.3.1 Activity: Description

The LSB Universe – the regime that is inaccessible in past wide-area surveys – hosts virtually all of LSST's extra-galactic discovery space. However, LSST's ability to access this revolutionary domain depends on the sky-subtraction in the DM pipeline preserving LSB flux in LSST images.

We will contribute directable pipeline development to produce sky-background modelling and subtraction that preserves LSB flux, which is essential for LSST Galaxies science. The immediate recipient is the Rubin Algorithms and Pipelines team and the eventual beneficiary is the Galaxies Science Collaboration (GSC).

We have already been working on this project, in a directable fashion, with the DM team (Kelvin/Al-Sayyad/Lupton/Reed) since March 20. We have developed quality-assurance metrics, in the form of surface-brightness/magnitude deficits, to quantify how the pipeline handles LSB flux. As a proof of concept, injection of fake single-Sersic sources into coadded imaging, from the continuously re-reduced COSMOS tract 9813, has revealed potentially significant sky over-subtraction at flux levels fainter than ~26 mag arcsec^{-2} around large objects (>8 arcsec), with a flux-loss ratio of >15 percent in the worst cases. This relatively aggressive sky-subtraction ensures that LSB flux does not connect objects and confuse de-blenders, making it ideal for weak-lensing science. However, it compromises the majority of Galaxies science. A bifurcation of the pipeline appears necessary to satisfy both communities.

Ongoing testing in collaboration with the DM team will repeat these analyses for a more realistic scenario, injecting fake sources at the visit level and propagating those images through to final coaddition. The broad plan is to explore intermediate points in the DM pipeline, where the sky-subtraction is not as aggressive, as a starting point to developing sky-background modelling and subtraction that preserves LSB flux.

We will continue to work closely with the DM team to identify future development tasks and perform these as an integral part of the GSC, taking input from members and reporting regularly on progress in telecons and via interaction on Slack.

We are using the Rubin Science Platform (RSP) to access and analyze pre- and post-model injection outputs from the DM pipeline, since the RSP computing architecture is built specifically for the Project, and using local resources to interpret the results. We do not anticipate a change in our resource needs. The primary risk is gaining an understanding of the DM pipeline architecture. However, our close and ongoing interaction with the DM team mitigates this.

S6.3.2 Activity: One Sentence Summary

We will provide directable pipeline development effort to the DM team (with the eventual recipient being the GSC) which aims to provide sky-background modelling and subtraction that preserves LSB flux, which will be essential to opening up the discovery space for Galaxies science using Rubin.

S6.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S6.4.1 Deliverables: Description

We will provide effort, using already-secured funding, at the level of 1 FTE per year for 3 years, starting in FY21 (specifically March 20). This effort will come from a senior postdoc, Dr Aaron Watkins, who has more than 6 years experience in the processing of LSB-optimized imaging and in the analysis of LSB features in galaxy images.

While the project will produce infrastructure to enable LSB science, the proposed activities will also produce general enhancements in the pipeline architecture. For example, as a result of our collaboration so far, the DM team have made a number of changes to the fake source injection code base, including improvements to how fake source data is read in, catching large/unreasonable Sersic indices prior to initializing GalSim and preventing potential premature crashing, and adding config options to force image processing across an entire region in cases where no fake galaxies exist, to allow for consistent and comparable fake co-add output to be generated.

We will meet with the DM team regularly, through telecons and on Slack to collect their input, determine the development tasks needed and present progress. We will also regularly report on progress to the GSC through written reports and presentations in the SC telecons and interactions on Slack, and take input from GSC members and functional direction from the GSC leadership through these fora. The project funding will enable multiple two-week-long visits by Watkins to the DM team in Princeton.

We will make all software and notebooks developed in this project and corresponding documentation (e.g. user manuals) available to the Rubin data rights holders though the Rubin software stack. Towards the end of the project the responsibility of maintaining any software produced as part of this contribution will be negotiated with the DM team and, if necessary, we will train DM team members in further evolving and supporting this software.

We have developed this proposal in collaboration with both the DM team (principal contact: Lee Kelvin) and the GSC. The approach outlined above has the support of the GSC (principal contact: Harry Ferguson).

S6.4.2 Deliverables: One Sentence Summary

LSST:UK plans to provide directable, skilled software development, from a senior postdoc and using already-secured funding, at the level of 1.0 FTE per year for 3 years, starting in Mar 2020.

S6.4.3 Deliverables: Timeline

FY20: Dr Aaron Watkins (postdoc, 1 FTE for 0.5 years, Mar 20 - Sep 20)

FY21: Dr Aaron Watkins (postdoc, 1 FTE)

FY22: Dr Aaron Watkins (postdoc, 1 FTE)

FY23 : Dr Aaron Watkins (postdoc, 1 FTE for 0.5 years)

S6.5 EXPECTED RIGHTS TO THE LSST DATA

S6.5.1 Data Rights: Description

Given the directable and skilled nature of the staff effort provided, LSST:UK considers 1 FTE for 3 years to be worth 3 PIs.

S6.5.2: Data Rights: One Sentence Summary

LSST data rights for 3 PIs.

S6.6 KEY PERSONNEL

Contribution Lead: Prof. Sugata Kaviraj

Contribution Recipients: The Algorithms and Pipelines team (Primary Contact : Phil Marshall) and the LSST Galaxies Science Collaboration (Primary Contact : Harry Ferguson)

Dr Aaron Watkins is a senior postdoc at Liverpool John Moores University and the University of Hertfordshire (from Mar 2021), UK. He also serves as the co-chair of the LSB working group within the Galaxies Science Collaboration.

Prof Chris Collins is Professor of Cosmology at the Astrophysics Research Institute at Liverpool John Moores University, UK. c.a.collins@ljmu.ac.uk

Prof Sugata Kaviraj is Professor of Astrophysics at the University of Hertfordshire, UK. He also serves as the co-chair of the Galaxies Science Collaboration. s.kaviraj@herts.ac.uk

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S7. Statement of Work and Detailed Plan for Proposed Contribution 7

S7.1 TITLE: Science Software development: Sensor characterisation and PSF modelling

LOI Code: UKD-UKD-7

S7.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

S7.2.1 Background: Description

Dan Weatherill is a senior postdoc in Ian Shipsey's lab working on LSST:UK projects since 2016. He has experience of CCD characterisation, optimisation and modelling of electric fields within thick, fully depleted devices. He built the LSST CCD test stand at Oxford, visited LPNHE Paris (Feb 2018) and contributed to solutions to issues with the parallel clocking in e2v LSST devices. Dan has a good working relationship with various parts of the camera team facilitated in part by a visit to SLAC in March 2019. He developed a method of post-processing pre-CDS pixel data which could contribute to improving linearity and noise performance of LSST CCDs (presented in December 2018). Since then he has worked on issues around trap-based CTI in LSST devices and the effect of CCD collecting gate width on the brighter-fatter effect.

Farrukh Azfar has many years experience of instrumentation monitoring and control. From 2016 Azfar's time has been devoted at 0.6 FTE to the Camera Control System (CCS) and the software bridge between the Observatory Control System (OCS) - the OCS-CCS bridge. Azfar has worked in close collaboration with Tony Johnson of SLAC to provide automated testing of commands issued by the CCS and OCS and the translation between them over the OCS-CCS bridge. Concurrently he worked on software to generate telemetry and configuration statuses using information from the CCS DAQ conveyed over the bridge. This has been tested on the actual Commissioning Camera and the software is written in a way to incorporate the Auxiliary Telescope and final camera seamlessly.

S7.2.2 Background: One Sentence Summary

Oxford has long-standing experience in developing control system software for advanced instrumentation, in CCD characterization, and in the commissioning of advanced instrumentation for physics experiments which is being made available to LSST on a directed basis.

S7.3 PLANNED ACTIVITIES

S7.3.1 Activity: Description

Oxford will contribute directable effort in the general area of sensor characterization, camera commissioning and the Camera Control System. Oxford staff will work with the Camera Team to define the tasks and employ our advanced custom CCD stand. This proposal has been developed in collaboration with the LSST Camera team (Aaron Roodman, Tony Johnsonl) and (part) endorsed by DESC.

Weatherill: aiding the BOT Eotest data runs at SLAC with remote data analysis, as directed by the LSST camera team. Dan has a strong background in electronics, device physics and software development (python & c++), and is willing and eager to spend extended periods assisting efforts on site at SLAC and the summit. Weatherill's FY17-20 work has been endorsed by DESC SAWG. The future FTE is directable.

Azfar: With most of the software for the OCS bridge now functioning he is working with SLAC to ensure that the system is robust against changes in DAQ configuration - we expect this to continue at a low level for as long as the LSST takes data but at a lower fraction of time with each passing year. The next task is to provide a data quality monitoring system for the commissioning period and throughout the lifetime of the instrument. The data quality monitoring system has two components, an image visualization system (for real-time display of incoming images) and an image analysis system which will provide largely automated tests of image quality. Both components run on the camera diagnostic cluster in the computer center at the summit in Chile.

Azfar will provide software to automatically test and perform statistical comparison of data with provided standards (with Tseng and SLAC) - he expects to spend 8-10 weeks at SLAC or on summit in Chile for the next 6 years. He will provide maintenance of the already provided OCS-CCS bridge software, ensuring that the data-quality monitoring system is working, calibrated and updated (0.6 FTE directable, 6 years). Azfar's past work (FY18-FY20) has been endorsed by Tony Johnson and the Camera (CCS) Team.

Tseng: ComCam and LSSTCam will require detailed monitoring of images taken by these components - this will require a data quality monitoring software infrastructure as well as automated statistical tests. Tseng will develop the infrastructure for such a system in collaboration with SLAC. This will lead naturally into the statistical tests themselves along with definition of data for comparison which will be done in collaboration with SLAC and Azfar (0.3 FTE directable, 6 years).

S7.3.2 Activity: One Sentence Summary

From now, Oxford will provide 1.9 FTE of directable software development effort to the LSST Camera Team in the general area of sensor characterization, camera commissioning and the camera control system.

S7.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S7.4.1 Deliverables: Description

Weatherill: Aiding the BOT Eotest data runs at SLAC with remote data analysis, and then generally support comcam and main camera commissioning as directed by the camera team. This may include extended periods assisting efforts on site at SLAC and the summit.

Azfar: The maintenance of the already provided OCS-CCS bridge software, ensuring that the data-quality monitoring system is working, calibrated and updated.

Develop robustness of the OCS bridge against changes in DAQ configuration and update it for the duration of the survey.

A data quality monitoring system: Component #1: an automated image visualization system. Component #2 an automated image analysis system. Both components run on the camera diagnostic cluster at the summit and will need refinement over the duration of the survey.

Software to automatically test and perform statistical comparison of data with provided standards (with Tseng and SLAC). He will, in this effort, spend 8-10 weeks at SLAC or on summit in Chile for each of the next 6 years.

Tseng: Development of the image monitoring software and automated statistical tests infrastructure for ComCam and the full camera in collaboration with SLAC and Azfar.

The Oxford group will continue to meet regularly with the Camera team, through telecons and on Slack and at SLAC and subsequently in Chile to collect their input, determine the development tasks needed and present progress.

S7.4.2 Deliverables: One Sentence Summary

LSST:UK has provided endorsed non-directable effort at 1.6 FTE per year for 3 years (FY18-F20), and will provide fully directable effort at 1.9 FTE for 3 further years (FY21-FY23), and fully directable effort at 0.9 FTE for a further 2 yrs (FY24-FY25), for a total of 11.8 FTE yrs.

S7.4.3 Deliverables: Timeline

FY18: Dr. Dan Weatherill (postdoc 1.0FTE), Dr Farukh Azfar (0.6 FTE) [backdated and endorsed : S7.4.1]

FY19: Dr Dan Weatherill (postdoc 1.0 FTE), Dr Farrukh Azfar (0.6 FTE) [backdated and endorsed : S7.4.1]

FY20: Dr. Dan Weatherill (postdoc 1.0 FTE), Dr Farrukh Azfar (0.6 FTE) [backdated and endorsed : S7.4.1]

FY21: Dr. Dan Weatherill (postdoc 1.0 FTE), Dr Farrukh Azfar (0.6 FTE), Dr Jeff Tseng (0.3 FTE)

FY22: Dr. Dan Weatherill (postdoc 1.0 FTE), Dr Farrukh Azfar (0.6 FTE), Dr Jeff Tseng (0.3 FTE)

FY23: Dr. Dan Weatherill (postdoc 0.5 FTE), Dr Farrukh Azfar (0.6 FTE), Dr Jeff Tseng (0.3 FTE)

FY24: Dr Farrukh Azfar (0.6 FTE), Dr Jeff Tseng (0.3 FTE)

FY25 :Dr Farrukh Azfar (0.6 FTE), Dr Jeff Tseng (0.3 FTE)

We note that the future contributions of Azfar and Tseng as directable effort within the camera team FY22-FY25 will be provided by University of Oxford directly (see letter here). Weatherill's contribution is currently funded by LSST:UK as listed above.

FY23-FY35: potential continued contribution of development effort. There is potential for Weatherill's effort to continue beyond August 2023 (and Azfar/Tseng to continue beyond FY25) and this will be presented as an overall UK contribution in FTE yrs in UKD-UKD-14 (see S14)

S7.5 EXPECTED RIGHTS TO THE LSST DATA

S7.5.1 Data Rights: Description

Given the directable and skilled nature of the staff effort provided, LSST:UK considers 11.8 FTE years to be worth approximately 12 PIs.

S7.5.2: Data Rights: One Sentence Summary

LSST data rights for 12 PIs.

S7.6 KEY PERSONNEL

Contribution Lead: Prof Ian Shipsey Ian.Shipsey@physics.ox.ac.uk

Contribution Recipients: The Rubin Observatory Science team (Primary Contact Phil Marshall : pjm@slac.stanford.edu) or the DESC (Primary Contacts : Rachel Mandelbaum <rmandelb@andrew.cmu.edu>, Richard Dubois <dubois@stanford.edu>)

Dr Dan Weatherill is a senior post doc at Oxford University, UK (since May, 2016) .

Dr Farrukh Azfar is a senior researcher and University Lecturer at Oxford University, UK.

Dr Jeff Tseng is an Associate Professor Tutorial Fellow at Oxford University, UK.

S8. Statement of Work and Detailed Plan for Proposed Contribution 8

S8.1 TITLE: Science Software development: DESC operations

LOI Code: UKD-UKD-8

S8.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

S8.2.1 Background: Description

This contribution consists of software and operations support from Dr Joe Zuntz and Dr James Perry. Zuntz is currently acting as a DESC Pipeline Scientist. He was previously co-lead of the DESC weak lensing working group, led shear catalog creation in DES Year 1, and is the lead developer of: the CosmoSIS parameter estimation package (in use by DESC), pipeline framework software Ceci, data format interface library Sacc, and weak lensing / galaxy clustering pipeline TXPipe (all in DESC; the latter implements a key science paper pipeline). Perry is an HPC professional acting as a DESC Data/Simulations Wrangler, who has contributed to ImSim, the DESC image simulator, and generated two years of DESC simulated images using the UK grid computing resources called the "GridPP" system.

S8.2.2 Background: One Sentence Summary

Zuntz and Perry are embedded in DESC, and are developing the lensing/clustering analysis pipeline and supporting the generation of DESC image simulations.

S8.3 PLANNED ACTIVITIES

S8.3.1 Activity: Description

Zuntz is designing and implementing the catalogue-to-cosmology pipeline, TXPipe, for the weak lensing and large-scale structure joint analysis, implementing (at LSST scale) algorithms for data reduction and analysis from DM catalogues into two-point measurements and other summary statistics. This has been identified as a key pipeline in the DESC Science Roadmap. He has also written and is managing the infrastructure framework, Ceci, for running the collected complete pipeline. This software was/is all written specifically for the DESC.

Perry will manage simulation data generation, storage, and analysis as a key part of the data challenge simulation process. In both cases this activity is **directable** by the collaboration; Zuntz reports to the analysis coordinator, providing quarterly reports and annual plans, and Perry ultimately to the computing coordinator, with day-to-day coordination by Zuntz. Computing for Zuntz's work on the lensing/clustering pipeline is available from NERSC via DESC's allocation. Computing for Perry's work on the UK Grid is provided by an existing GridPP grant. All software developed by the team will be public, in accordance with the proposed DESC software policy.

This proposal has been developed in consultation with DESC. The past contribution FY19-FY20 has been endorsed by DESC.

S8.3.2 Activity: One Sentence Summary

Zuntz and Perry will develop DESC software for simulation and analysis, and support DESC image simulation execution at scale.

S8.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S8.4.1 Deliverables: Description

LSST:UK plans to provide directable effort, using already-secured funding, for at total of 2.3 FTE (breakdown in S8.4.3). Faculty member (Zuntz) has 7 years of software survey experience with DES and DESC, and a postdoc-level HPC professional (Perry) has three years of experience with DESC.

The team meets, and will continue to meet, monthly to assess progress for Perry's work on ImSim and simulation wrangling

In terms of a delivery plan, both staff members will meet regularly with the relevant working group within the collaboration to present progress and garner domain input, and also be active participants in the collaboration's ongoing “roadmap realization” effort where they will take functional direction from collaboration leadership. NAOB expects to make all software developed as part of this contribution public at or before the time of the publication of the collaboration papers that first present the software and its application. Software will be developed in shared repositories accessible to AGN SC members throughout the development phase.

Zuntz'z top-level software and data outputs are:

- TXPipe, the DESC pipeline for the analysis (catalogue to summary statistics) of lensing and clustering data, targeting the first year data release (2022)
    - Runs of TXPipe on DESC-generated simulation data
    - Integration of TXPipe with photometric redshift, lens selection, and other DESC software components
- Ceci, an interface for DESC pipelines to workflow management frameworks (2020)

Perry's top-level software and data outputs are:

- Contributions for performance at scale to ImSim (2020)
- A segment of the DC2 image simulations generated using GridPP (2020)
- Docker and UK DAC support for the LSST Science Pipelines (2021)

Zuntz will provide extensive documentation for TXPipe and ceci for continuing usability, and commit to supporting them throughout the nominal 10 year project lifespan. His direct 0.3 FTE includes coordinating, leveraging, and catalyzing extensive (voluntary) contributions to DESC software from the wider DESC membership, and should in part be considered as supporting this activity and therefore impactful enough to qualify for the minimum effort level. Together with DESC, Zuntz will pursue UK funding to support this through the mechanism described in UKD-UKD-12. As described there, we foresee the Rubin team playing a role in selecting the work packages to be funded within the UK. If funding were not forthcoming, then Zuntz will still be engaged with this pipeline support in his own research time. Perry will fully document ImSim contributions, and docker / DAC pipelines.

S8.4.2 Deliverables: One Sentence Summary

LSST:UK plans to provide skilled and directable software development effort by experts already embedded within DESC adding up to a total of 1.9 FTE years and 2 Million CPU hrs.

S8.4.3 Deliverables: Timeline

We note that Zuntz and Perry have been working in these roles within DESC since 2019

FY 20: Dr Joe Zuntz (Faculty, 0.3 FTE), Dr James Perry (HPC Professional 0.5 FTE) + 2.005 million CPU hours on the UK's GridPP system for DESC simulated images.

FY 21: Dr Joe Zuntz (Faculty, 0.3 FTE), Dr James Perry (HPC Professional 0.5 FTE)

FY 22: Dr Joe Zuntz (Faculty, 0.3 FTE), Dr James Perry (HPC Professional 0.25 FTE)

FY23 : Dr Joe Zuntz (Faculty, 0.15 FTE)

FY23-FY35: potential continued contribution of development effort. There is potential for this effort to continue beyond August 2023 and this will be presented as an overall UK contribution in FTE yrs in UKD-UKD-12.

S8.5 EXPECTED RIGHTS TO THE LSST DATA

S8.5.1 Data Rights: Description

The formal exchange rate of 2.3 FTE years and 2 million CPU hrs equates to 2.36 PIs. Hence we propose 2 PIs.

S8.5.2: Data Rights: One Sentence Summary

LSST data rights for 2 PIs.

S8.6 KEY PERSONNEL

Contribution Lead: Dr Joe Zuntz joe.zuntz@ed.ac.uk

Contribution Recipients: DESC (Primary Contacts : Rachel Mandelbaum <rmandelb@andrew.cmu.edu>, Richard Dubois <dubois@stanford.edu>)

S9. Statement of Work and Detailed Plan for Proposed Contribution 9

S9.1 TITLE: Science Software development: Cross-matching

LOI Code: UKD-UKD-9

S9.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

S9.2.1 Background: Description

Tim Naylor and Tom Wilson have previously delivered a catalogue of Gaia-WISE cross-matches (Wilson & Naylor 2018MNRAS.481.2148W). Tim Naylor is a member of the SMWLV and TVS SCs.

Tom Wilson has also worked at STScI on the astropy sub-package photutils, maintaining the PSF photometry module, including writing and updating documentation, bug fixing, API development, and feature improvement. This involved working within a larger team of software developers and to specification using cutting edge open source software development methods.

Tim Naylor has experience of managing the delivery of software for larger collaborations through the Terra Hunting and eSTAR projects. In the Terra Hunting project he has management responsibility for the development and delivery of the telescope scheduler and data archive. eSTAR was a distributed telescope network in which Naylor was involved in the deployment of real-time software both locally in Exeter and at the United Kingdom Infra Red Telescope in Hawaii.

Tim Naylor also has a strong record in developing astronomical algorithms including developing an earlier generation of the matching procedure to be used here and then applying it to the large MYStIX dataset which is publically available (Naylor, Broos & Feigelson 2013ApJS..209...30N). In addition he developed the photometric optimal extraction (Naylor 1998MNRAS.296..339N; Naylor et al 2002MNRAS.335..291N) which he then helped implement in the Starlink GAIA package. He has also developed Bayesian fitting for colour-magnitude diagrams (Naylor & Jeffries 2006MNRAS.373.1251N; Naylor 2009MNRAS.399..432N).

S9.2.2 Background: One Sentence Summary

Tom Wilson and Tim Naylor have developed the techniques required for cross-matching data at LSST depths to other catalogues, and Tim Naylor is a long-standing member of the SMWLV and TVS science collaborations and has a track-record of delivering both software and algorithm development as part of larger collaborations.

S9.3 PLANNED ACTIVITIES

S9.3.1 Activity: Description

The depth of the LSST survey represents an almost unique challenge to attempts to cross-match the catalogues to other surveys, because of the combination of depth and point-spread function. The LSST is deeper than any ground-based survey to date, yet the Rubin observatory is still limited by ground-based seeing. As a result the number of stars per point-spread function is very large. At the most basic level this means that traditional matching by (say) a 2” proximity match will get confused. As an example, roughly half the galactic plane within $-90 < l < 90$ and $|b| < 10$ reaches a density of sources such that in a single visit that there will (on average) be one random match per 2” circle. Hence as the survey becomes deeper this problem will spread out of the plane until by full depth it is even having a small effect on high latitude fields. This problem can be overcome by using the uncertainties in the astrometry to show whether sources are truly co-incident, but requires a fully Bayesian approach which takes into account the local stellar density (see Sutherland & Saunders 1992MNRAS.259..413S).

However, there is also a second more subtle problem which affects the astrometric uncertainties and means one cannot simply use the uncertainties from image centroiding. This is that the stellar densities at magnitudes below the survey detection limit are so high that undetected stars affect the centroids. These effects are significant, but can be modelled (Wilson & Naylor 2017MNRAS.468.2517W). Finally, photometric information can also be used to assess whether a match is likely (Wilson & Naylor 2018MNRAS.473.5570W).

This proposal is to make cross-matches between the LSST and the VISTA, VPHAS, WISE and Spitzer surveys using these up-to-date techniques available to astronomers both as a software package and tables of matches.

The work is endorsed by the TVS SC, hence we are proposing this as non-directable effort. An endorsement has been requested from SMWLV, and we have engaged with the Rubin Crowded Field Coordination Group.

We have LSST:UK funding in place to write the software, validate it against Hyper Suprime-Cam data and integrate it into the UK IDAC. During operations the software could be run either on the UK IDAC, or be part of the standard release pipeline, producing cross-match tables between the entirety of the LSST and the other surveys. The compute time required to build the tables will be provided through the UK IDAC computing resource as described in S3.

S9.3.2 Activity: One Sentence Summary

We will enable cross-matching between the LSST catalogues and a range of other catalogues which make use of the latest cross-matching algorithms, solving many of the problems caused by crowding in Rubin data.

S9.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S9.4.1 Deliverables: Description

The proposed software will require 2 SY of PDRA effort which is already funded through LSST:UK. It will be carried out by Tom Wilson, who (as described in Section S9.2.1) developed many of the algorithms required, has already delivered one cross-match catalogue, and is experienced in developing software within larger collaborations.

One of the strengths of this proposal is that the only interface between the software and the Rubin Observatory system is the Rubin source catalogues, making it very simple to maintain, and meaning it does not have to be embedded within the Rubin software (though it could be).

The long term maintenance of the software will be pursued through the UK's UKd-UKD-12 (post 2023+ funding) and UKD-UKD-3 (the UK's IDAC). We will run the software at the time of each data release either on the UK IDAC or can offer it as part of the Rubin software stack which produces the yearly release. Either of these options is particularly user friendly, providing cross-matches over the entire LSST sky as readily accessible tables. These tables could be accessed either by being distributed to the other IDACs, or by allowing international partners access them through the UK IDAC.

Our initial deliverable will be well-documented software, updated if there are changes. For each star in each catalogue this software will calculate either the probability that the star is unrelated to stars in the other catalogue, or a record of the most likely counterpart, and its probability of matching both with and without the photometric information. In addition, there will be columns related to the likely level of contamination of the photometry of the star by unresolved stars within its PSF.

We will work closely with TVS and other SCs to ensure that our work is complementary to any other cross-matching efforts, with the eventual aim of providing cross-matches between a much larger range of catalogues than could be provided by this contribution-in-kind alone. We believe we have a unique contribution to make as the techniques are more sophisticated than any LSST cross-matching efforts we are aware of. We are also aware of broker services which will provide relatively simple cross-match services, which we could improve on using our techniques. In the longer term we would therefore like to provide an "on-the-fly" cross-match service in collaboration with TVS, though this lies outside the current effort available.

S9.4.2 Deliverables: One Sentence Summary

LSST:UK plans to provide skilled software development effort, using already-secured funding, at the level of 1.0 FTE per year for 2 years, starting in 2020.

S9.4.3 Deliverables: Timeline

FY20: Dr. Tom Wilson (postdoc, 0.8 FTE).

FY21: Dr. Tom Wilson (postdoc 1.0 FTE)

FY22: Dr. Tom Wilson (postdoc 0.7 FTE)

FY23-FY35: Potential contribution of software maintenance effort and running.

S9.5 EXPECTED RIGHTS TO THE LSST DATA

S9.5.1 Data Rights: Description

Given the skilled nature of the staff effort provided, LSST:UK considers 1 FTE for 2.5 years to be worth approximately 3 PIs.

S9.5.2: Data Rights: One Sentence Summary

LSST data rights for 3 PIs.

S9.6 KEY PERSONNEL

Contribution Lead: Prof. Tim Naylor. T.Naylor@exeter.ac.uk

Contribution Recipients: TVS and SMWLV Science collaborations.

S10. Statement of Work and Detailed Plan for Proposed Contribution 10

S10.1 TITLE: Science Software development: spectroscopic classification of transients and 4MOST spectra

LOI Code: UKD-UKD-10, UKD-UKD-4

S10.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

S10.2.1 Background: Description

We have a wealth of experience in designing and running transient surveys and their spectroscopic follow-up from the SuperNova Legacy Survey, the Palomar Transient Factory, Pan-STARRS1, the Dark Energy Survey and PESSTO. These included major spectroscopic follow-up campaigns using competitively-won time on VLT, NTT, Keck, Gemini, and AAT (OzDES). The team also has experience with HST imaging surveys and their spectroscopic follow-up (e.g. the See Change survey).

We are experts in managing transient alerts (of a wide variety of types) and obtaining time-critical follow-up observations. We have experience developing and carrying the processes involved in spectroscopic observations of transients from triggering of follow-up observations, data acquisition, processing data and scientific analysis. For example, Sullivan has been a leading member of the PESSTO collaboration. Hook gained considerable experience of commissioning, operations and data flow while working on development and commissioning of the GMOS instrument and as an astronomer at the Gemini observatory.

Sullivan and Hook are founding members of Time Domain Extragalactic Survey (TiDES) within the 4MOST project; financial contributions to 4MOST by our universities (Southampton, Lancaster) and by Portsmouth University and Queen’s University Belfast led to the formation of the TiDES survey. Sullivan is now PI of TiDES and Hook represents TiDES on the 4MOST Executive Board.

We are also active in DESC. Sullivan is co-chair and Hook is a member of the DESC External Synergies Working Group. Both Sullivan and Hook are members of the DESC Supernova WG and the DESC Observing strategy Working Group.

S10.2.2 Background: One Sentence Summary

We have 15+ years experience leading optical transient surveys (e.g., SNLS, PS1, PTF, DES) including software/pipeline/infrastructure development and science exploitation, and are active in DESC.

S10.3 PLANNED ACTIVITIES

S10.3.1 Activity: Description

TiDES, the Time Domain Extragalactic Survey, is a survey on the 4-metre Multi-Object Spectrograph Telescope (4MOST) focused on the spectroscopic follow-up of Rubin Observatory LSST extragalactic optical transients. We have 250,000 fibre-hours of spectroscopy time available within the TiDES survey (2% of the total 4MOST fibres). With this, we will obtain (i) spectroscopic observations of 35,000 live transients to i_{AB}=22.5, and (ii) follow-up of 70,000 transient host galaxies to obtain redshift measurements for photometric classification and cosmological applications.

We will contribute non-directable software development effort to support developing TiDES into a contributed dataset to DESC and TVS. We expect there to be between 5-10 live (i < 22.5 mag) extragalactic transients per 4MOST field, and we will put a fibre on all these, effectively giving a magnitude limited sample. We will work closely with the DESC SN Working Group to design a selection function for the LSST transient stream to optimise the type Ia SN selection (including host galaxies) for cosmology. We will implement the DESC agreed strategy within the Lasair broker to select SNe with high quality LSST lightcurves (or other measured characteristics as desired).

We will provide immediate information, to DESC and TVS on

- Which objects have fibres: DESC will primarily drive the selection function. As it is a magnitude limited sample there will be many spectra of interest to TVS. Through Lasair, we will highlight which targets will get a spectrum.
- Which targets have been (successfully) observed : immediate meta-data on what has been observed, signal-to-noise estimate of data.
- Rapid estimate of redshift and type from quick-look data – available to all DESC, TVS and all LSST scientists to help decide on other triggers.
- Full, staged, data releases of fully calibrated data, accessible through the Lasair broker.

The 4MOST are ESO public survey data and the raw data are public in the ESO archive immediately. However these data are not in scientifically accessible or useable form without deep knowledge of the pipeline, fibre allocation processes and selection function. Hence we propose this as a non-directable software contribution to ensure maximum scientific exploitation of the data (in line with the Handbook's guidance on public data).

The DESC and TVS endorse this contribution. We note the latter is on the condition that TVS members will be kept informed in a timely manner of all information relevant to these surveys, in collaboration with DESC and we are happy to accept that condition.

S10.3.2 Activity: One Sentence Summary

We will provide non-directable software development effort to the LSST DESC for transient spectroscopic follow-up, developing software to ensure successful scheduling and observation of transients and their host galaxies by 4MOST, and the return the transient types and redshifts to the collaboration (through the Lasair broker, within 24hrs) and the final calibrated spectra as contributed data sets on an annual basis.

S10.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S10.4.1 Deliverables: Description

We will provide software development effort at the level of 1 FTE for an initial 2.5 yrs starting in FY21. This FTE will design the selection function for LSST transients in close collaboration with the DESC SN Working Group. The developer will work with the Lasair team to ensure selection can be achieved efficiently and reproducibly with the transient alert data. They will write, and document, software modules that extract the transients from the Lasair databases and produce a workflow that places them in the 4MOST observing queue and allocates fibres at high priority.

As we are limited to $i < 22.5$ mag for spectroscopic classification, it will be a magnitude limited survey that provides type Ia SNe for DESC cosmological analyses. We will closely work with the DESC SN working group and take functional direction from the DESC collaboration leadership on choices within the algorithm development.

We are acutely aware that there will be many spectroscopic follow-up telescope programmes. Hence a crucial aspect of this contribution is to coordinate target selection and immediately share information without delay. It will be critical for DESC and TVS members to know which objects 4MOST will target, which have been allocated fibres, which have been observed, and which fibres produce a successful measurement. All of this information will be shared in a workflow within the Lasair broker, tied to the transient data.

Since this is an ongoing operational task, we are proposing both software development effort (embedded primarily within DESC, with a secondary affiliation to TVS) and a contributed data set.

The 1 FTE per year developer will manage this information flow and define the spectral success criteria and figures of merit for data quality. They will implement a fast redshift measurement and classification and tool, and return this information to DESC and TVS via the Lasair broker.

The TiDES data will be wavelength and flux calibrated and released at regular intervals to both DESC and TVS (and all LSST scientists) and be accessible through the Lasair broker, allowing the lightcurve data and spectra of 35,000 transients to be statistically analysed. The 1 FTE over the initial 2.5 yrs will be sufficient to deliver the selection workflow and code to return information to Lasair. With DESC and TVS, we will be bidding for part of the Phase C funding in this LSST:UK proposal to operationally deliver the spectral data during LSST and 4MOST early operations.

S10.4.2 Deliverables: One Sentence Summary

LSST:UK plans to provide skilled software development effort, using already-secured funding, at the level of 1.0 FTE per year for 2.5 years, starting in 2020.

S10.4.3 Deliverables: Timeline

FY21: 1 FTE software developer for 0.5 yrs

FY22: 1 FTE software developer for 1.0 yrs

FY23: 1 FTE software developer for 1.0 yrs

S10.5 EXPECTED RIGHTS TO THE LSST DATA

S10.5.1 Data Rights: Description

Given the directable and skilled nature of the staff effort provided, LSST:UK considers 1 FTE for 2.5 years to be worth approximately 3 PIs.

S10.5.2: Data Rights: One Sentence Summary

LSST data rights for 3 PIs.

S10.6 KEY PERSONNEL

Contribution Lead: Profs Mark Sullivan (m.sullivan@soton.ac.uk) and Isobel Hook (i.hook@lancaster.ac.uk)

Contribution Recipients: DESC (Primary Contacts : Rachel Mandelbaum <rmandelb@andrew.cmu.edu>, Richard Dubois <dubois@stanford.edu>)

S11. Statement of Work and Detailed Plan for Proposed Contribution 11

S11.1 TITLE: Science Software development: photometric redshift estimation and DESC related software development

LOI Code: UKD-UKD-11, UKD-UKD-14

S11.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

S11.2.1 Background: Description

The group at UCL has a strong track record of enabling cosmology from large galaxy surveys. Joachimi is Kilo-Degree Survey weak lensing team co-coordinator, responsible for uncertainty modelling/propagation for large-scale structure statistics and photo-z-derived redshift distributions. He is also Deputy Lead of ESA's Euclid "LE3", overseeing the work of the largest unit in the space mission's Ground Segment with 500+ researchers and software engineers. He has recently led the weak lensing covariance task force and (with Lahav) demonstrated Euclid redshift calibration via clustering cross-correlations with SDSS and DESI. Joachimi is a DESC Full Member since 2014, has served on the DESC Membership and Operations Committees, and is UK point of contact for DESC.

Lahav, a DESC Full Member, has held a range of senior leadership roles in galaxy surveys (chair of DES Advisory Board, co-chair of DES Science Committee, Euclid Founder, chair of DES:UK and DESI:UK). A pioneer of the use of machine learning for photo-z, he was DESC photo-z working group co-convener and part of the DESC Leadership Team during 2014-2017, with major contributions to the DESC Science Road Map.

Under Joachimi's and Lahav's supervision, significant contributions to photo-z challenges in the DESC (Schmidt et al. 2020) and beyond (e.g., Soo et al. 2018) were made. Examples of widely used public software whose development was guided by Joachimi and Lahav are the photo-z codes ANNz/2 (Collister & Lahav 2004, Sadeh et al. 2016) and the fast simulation software FLASK (Xavier et al. 2016).

S11.2.2 Background: One Sentence Summary

We have long-standing experience in developing software and analysis methodology for large galaxy surveys, with key leadership roles in the DESC and LSST's precursor surveys held by the PIs, Joachimi and Lahav.

S11.3 PLANNED ACTIVITIES

S11.3.1 Activity: Description

This directable staff effort contribution has been developed jointly with DESC. We will contribute directable software development effort to the DESC primary science analysis, including but not limited to robust photo-z solutions, modelling and validation of photometric redshift sample distribution, their uncertainties and how these impact the DESC cosmological parameter pipelines. As directable effort within DESC we will model statistical and systematic uncertainties in weak lensing and clustering signals, as well as propagation of these uncertainties, especially their spatial variation across the survey, into cosmological likelihoods. Joachimi and Lahav will work with relevant members of the DESC Management Team and Working Group conveners to define needed software development tasks, and then carry out those tasks as an integral part of the collaboration, reporting regularly on progress, taking input from the rest of the collaboration, and supporting the collaboration's members in the use of the code. Joachimi and Lahav have also joined Rubin's Photometric Redshift Coordination Group and will work with this Team to define additional benefits of the proposed work for LSST's users beyond the DESC remit.

The work will make use of DESC's computing resources, HPC facilities at UCL, as well as UK 's IRIS computing dedicated to LSST (as part of the UK's IDAC, see S3), all of which are already available or are part of this in-kind proposal. Note that Joachimi's PhD student is currently road-testing GridPP facilities for DESC photo-z applications. The primary risk associated with this work is the timely hiring of qualified personnel. This will be mitigated by fast-tracking the funding line of this proposal if and when successful. Moreover, we have ample experience recruiting highly qualified staff for infrastructure work in galaxy surveys, and are currently gaining experience with COVID-era hires and work models. We will also invite additional DESC management personnel onto the recruitment panel.

S11.3.2 Activity: One Sentence Summary

We will provide directable software development effort to the DESC in the area of photometric redshifts and uncertainty modelling of cosmological probes, with additional benefits of the proposed work to be explored and coordinated with Rubin's Photometric Redshift Coordination Group.

S11.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S11.4.1 Deliverables: Description

We will provide a total of 2.5 FTE-years of effort during LSST:UK's Phase B, ending in June 2023, with potential for continued funding beyond this date, and during the lifetime of the LSST. This effort will be at the postdoctoral level with provisions for hires with up to three years of postdoctoral experience. It is planned to recruit an astrophysicist with a strong infrastructure and scientific computing skill set for the full funding period, to be complemented in the later stages by an implementation-/computing infrastructure-oriented person with a physics or software engineering background. Funding for these posts is expected to become available upon Rubin's approval of the proposed contribution. Recruitment processes will be required, advertised globally but also with the opportunity to take on staff already in post at UCL.

SInce Joachimi and Lahav are already embedded in the relevant Rubin coordination teams (DESC Management and Rubin Photometric Redshift Coordination Group), a delivery plan will be developed and in place prior to the research staff beginning their tenure. The contribution effort will be directed by the DESC Analysis Coordinator with input from the DESC Photo-z and TJP Working Group convenors, as well as the Rubin Photometric Redshift Coordination Group. The relevant DESC working groups and the UCL leads will provide practical guidance in the day-to-day work. Joachimi, Lahav and the employed research staff will continually engage with the working groups and the DESC Science Roadmap, contribute to the Roadmap's evolution, and help to adjust the priorities of the contributed effort accordingly.

Software will be developed, validated, documented, and published according to the standards of the DESC's Coding Guidelines. We will also adopt the DESC's Software Review Policy that stipulates publication of fully documented and validated code on publication of any resulting papers. Joachimi has gained experience with this policy already as part of the Kilo-Degree Survey core analysis team that was an early adopter of the draft policy. Full integration with the DESC software framework and standards will ensure the maintenance of software produced as part of this contribution during and beyond the lifetime of the LSST Project.

S11.4.2 Deliverables: One Sentence Summary

LSST:UK plans to provide skilled software development effort, using already-secured funding, at the level of 1.0 FTE per year for 2.5 years, starting in 2021.

S11.4.3 Deliverables: Timeline

FY21: New hire (postdoc, 0.75 FTE)

FY22: New hire (postdoc, 1 FTE)

FY23: New hire (postdoc, 0.75 FTE)

FY23++: potential continued contribution of software development and DESC data processing effort

S11.5 EXPECTED RIGHTS TO THE LSST DATA

S11.5.1 Data Rights: Description

Given the directable and skilled nature of the staff effort provided, LSST:UK considers 1 FTE for 2.5 years to be worth approximately 3 PIs.

S11.5.2: Data Rights: One Sentence Summary

LSST data rights for 3 PIs.

S11.6 KEY PERSONNEL

Contribution Lead: Dr Benjamin Joachimi b.joachimi@ucl.ac.uk

Contribution Recipients: DESC, Rubin Photo-z Coordination Group

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S12. Statement of Work and Detailed Plan for Proposed Contribution 12

S12.1 TITLE: Science Software development: Phases C and D

LOI Code: UKD-UKD-12

S12.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

S12.2.1 Background: Description

LSST:UK has been running a successful software development programme in preparation for the Legacy Survey of Space and Time for more than five years, through the "DEV" strand of the STFC-funded LSST:UK Science Centre (LUSC) project. LUSC Phase A (July 2015 - March 2019) funding was awarded on the basis of UK science priorities, but greater UK involvement in the Science Collaborations over time led these activities to become more closely aligned with SC priorities and to the realisation of impact within them. For example, funding for transients at Southampton and UCL developed software defined by the DESC SRM and used in the PLAsTiCC challenge, while further transients-related funding at QUB (in conjunction with effort in Edinburgh from the LUSC DAC strand) delivered the first version of the Lasair broker, running on the ZTF alert stream. The weak lensing funding line morphed into support for Joe Zuntz's Pipeline Scientist role in DESC, and sensor characterisation experiments in Oxford fed the DESC Sensor Anomalies WG, as well as supporting the Project camera team.

Phase B DEV funding (for July 2019-March 2023) was awarded on the basis of competitive proposals developed by UK groups in conjunction with Science Collaborations and assessed by a panel, two of the six members of which (Melissa Graham and Phil Marshall) provided input to ensure that the funded effort supported and complemented existing work underway in the US and elsewhere, leading to the High rankings awarded to these contributions in the CEC feedback to our LoI.

S12.2.2 Background: One Sentence Summary

The LUSC DEV programme has been successfully delivering software to several different parts of the international Rubin community for more than five years, serving as a valuable pilot for the proposed contribution.

S12.3 PLANNED ACTIVITIES

S12.3.1 Activity: Description

We propose to fund a cadre of *directable* software developers during Phases C and D of the LUSC programme, running from April 2023 to March 2027 and April 2027 to March 2033, respectively; although the Phase D end-date will depend on when the final data release appears. These developers will be physically located in UK universities but functionally embedded within an appropriate *Recipient Group*, usually a Science Collaboration, but, potentially, part of the Rubin Observatory operations team. Our nominal plan is for 7 full-time positions to be funded for the four years of Phase C (i.e. 28 staff years in total) and a further six staff-years during Phase D, for a total contribution of 34 staff-years of directable effort, although the detailed profiling of this effort can be negotiated.

Our proposal is that bids for developer positions are developed by UK groups in conjunction with a relevant Recipient Group, and, as for our Phase B DEV WPs, are assessed by a panel that combines senior UK scientists and Rubin-nominated representatives, to ensure that the selected projects both make best use of existing expertise within the UK community and deliver high priority outputs to the Recipient Group. These bids should include consideration of maintenance of software to be delivered, for which support can be provided in Phase D.

Projects selected by the panel would then be included in the LUSC Phase C funding proposal to be submitted to the STFC Project Peer Review Panel (PPRP) some time around April 2022; this would be a submission against an agreed funding line, but all project grants are peer reviewed by PPRP. This timescale then necessitates the start of the proposal preparation phase in Summer 2021 - i.e. as soon as this in-kind package is agreed. Computational resources will be provided through IRIS (www.iris.ac.uk), a collaboration between the providers and users of computing infrastructure for STFC-funded astronomy, particle and nuclear physics projects; as an IRIS member, LSST:UK makes an annual bid to secure IRIS resources for the coming year.

STFC will require that all funded teams report to an Oversight Committee, which will monitor progress against deliverables. This has begun during LUSC Phase B, with a process based around six-monthly plans, so we propose that this should be the mechanism through which funded staff are redirected, with new six-monthly plans agreed between the Recipient Group and the local supervisor.

S12.3.2 Activity: One Sentence Summary

We propose to contribute 34 staff-years of directable software development effort over the period April 2023-March 2033 (TBC), allocated to hosting universities in the UK by a panel including representatives from the Science Collaborations and the Observatory on the basis of competitive proposals developed by UK groups in conjunction with relevant Recipient Groups.

S12.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S12.4.1 Deliverables: Description

The deliverable is 34 staff years of effort, with a nominal profile outlined below in S12.4.3. The recipient groups will depend on the outcome of the bidding and selection process that will involve Rubin Observatory staff and the Science Collaboration representatives in suitable proportion to the appointed LSST:UK reviewers. The staff FTE will either be directable or endorsed as suitable high priority non-directable work (by the appropriate Rubin recipient group) at the point of the work being proposed. The work may be continuation of the software contributions already described in this LSST:UK proposal, or it may be new.

Software development will follow the Rubin protocols of being documented, maintained and made public when publications first arise. The effort to achieve this will be documented in the proposals.

The type of staff employed in Phase A and Phase B have typically been experienced, project-minded postdocs or trained software developers and professional staff. We envisage such experienced staff profiles remaining common in Phase C and D.

We propose this effort as either directable or embedded (and endorsed) non-directable rather than pooled, since LSST:UK will decide jointly with Rubin and the Science Collaborations which are the highest priority projects for funding. We expect an oversubscription, and LSST:UK will retain a decision making position rather than providing 34 staff years as pooled effort as defined in the Handbook. An indicative profile is provided below, but that for Phase D should be confirmed nearer the time.

S12.4.2 Deliverables: One Sentence Summary

LSST:UK plans to provide skilled software development effort, using already secured funding, at the level of 34 staff years, starting in FY2023, profiled as follows.

S12.4.3 Deliverables: Timeline

FY2023 : 7 FTE for 0.5 yr (April - September) funded in LSST:UK Phase C

FY2024 : 7 FTE for 1.0 yr funded in LSST:UK Phase C

FY2025 : 7 FTE for 1.0 yr funded in LSST:UK Phase C

FY2026 : 7 FTE for 1.0 yr funded in LSST:UK Phase C

FY2027 : 7 FTE for 0.5 yr (October to March) funded in LSST:UK Phase C

FY2028 : 1 FTE for 0.5 yr (April to September) funded in LSST:UK Phase D

FY2029 : 1 FTE for 1 yr funded in LSST:UK Phase D

FY2030 : 1 FTE for 1 yr funded in LSST:UK Phase D

FY2031 : 1 FTE for 1 yr funded in LSST:UK Phase D

FY2032 : 1 FTE for 1 yr funded in LSST:UK Phase D

FY2033 : 1 FTE for 1 yr funded in LSST:UK Phase D

FY2034 : 1 FTE for 0.5 yr (April to September) funded in LSST:UK Phase D

S12.5 EXPECTED RIGHTS TO THE LSST DATA

S12.5.1 Data Rights: Description

Given the directable and skilled nature of the staff effort provided, LSST:UK considers 34 staff-years to be worth approximately 34 PI slots.

S12.5.2: Data Rights: One Sentence Summary

LSST data rights for 34 PIs.

S12.6 KEY PERSONNEL

Contribution Lead: Bob Mann rgm@roe.ac.uk

Contribution Recipients: Rubin Observatory and the Rubin Science Collaborations (Phil Marshall and Federica Bianca).

S13. Statement of Work and Detailed Plan for Proposed Contribution 13

S13.1 TITLE: Commissioning Support

LOI Code: UKD-UKD-13

S13.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

S13.2.1 Background: Description

The UK has a wealth of experience in commissioning wide-field survey instruments. Our recent call for expressions of interest yielded 23 expressions of interest led by colleagues at 15 different institutes, and covering the following topics:

- Active optics: Will Sutherland (VISTA Project Scientist 2000-2009) and Gavin Dalton tested and debugged the active optics subsystems during VISTA commissioning. Early career colleagues are also keen to contribute on-summit, including both instrumentation postdocs with experience of commissioning instruments on wide-field and/or large telescopes, and students who have relevant experience from wide field surveys including the Dark Energy Survey (DES).
- Data analysis: Eleven different UK groups (mostly embedded in LSST Science Collaborations) have technical expertise required to analyse commissioning data and correlate with telemetry and other observing parameters, including off-axis angle. For example, analysis of commissioning observations of strongly lensed quasars would test Rubin's active optics performance, and has strong synergy with the UK's VISTA-based expertise discussed above.
- Visual inspection: Colleagues at the University of Sussex have expertise in visual inspection of commissioning data from the DES "eyeball squad". Colleagues at the Open University have complementary expertise in crowd sourcing visual inspection using the Zooniverse platform.
- Operational rehearsals: Cambridge Astronomical Survey Unit have expertise in designing and supporting "Operational Rehearsals" for the commissioning of wide-field survey instruments, including design of data quality checks. We envisage this being relevant to planning, testing and rehearsing Rubin's nightly workflow in the latter stages of commissioning.

S13.2.2 Background: One Sentence Summary

The UK has a broad base of expertise relevant to commissioning the Rubin Observatory including wavefront sensing and active optics subsystems from VISTA, detailed pixel-level analysis of commissioning data and correlation with telemetry, visual inspection of commissioning data via an eyeball squad and/or the Zooniverse, and detailed planning and support of operational rehearsals of the nightly workflow.

S13.3 PLANNED ACTIVITIES

S13.3.1 Activity: Description

We propose a directable contribution to Rubin commissioning that is fully integrated with the Rubin SITCom team. The primary point of contact between SITCom and the UK-based team will be Graham Smith, who is funded by STFC as the LSST:UK Commissioning Coordinator (0.1FTE). Smith will be responsible for coordinating the UK team, and distributing tasks defined by SITCom colleagues to UK team members. We envisage organising our contribution around a "summit team" and a "remote team".

The summit team will concentrate on testing the active optics sub-systems. We propose a team comprising Will Sutherland (Queen Mary University of London), Gavin Dalton (Oxford University and Rutherford Appleton Laboratory), and at least two postdocs. Based on VISTA commissioning we recommend a shift pattern of 5 weeks on-summit followed by >=3 weeks in the UK, spanning 12-18 months. Sutherland and Dalton are available to commence this pattern from mid-2021, which is well matched to possible ComCam first-light in October 2021. We envisage either Sutherland or Dalton plus >=1 UK postdoc participating in each shift, with Sutherland/Dalton having day-to-day management responsibility for the postdoc(s) on summit. When not in Chile, summit team members will be embedded in the remote team, thus enhancing the expertise delivered by both summit and remote teams.

The remote team will be UK-based, contributing to data analysis, visual inspection and operational rehearsals, as agreed with SITCom colleagues. We propose that each junior (student or postdoc) and senior (faculty) team members will contribute at least 0.5FTE and 0.25FTE to commissioning tasks respectively. For senior team members, this excludes the time they spend supervising their students. The remote team will take full advantage of the time zone differences between the UK, Chile and the US, and their existing knowledge of Rubin from involvement in their respective LSST Science Collaborations. We also envisage remote team members making several extended visits each to Chile and/or the US.

We aim to build a UK team ready to contribute to SITCom from mid-2021 onwards. As part of this, there is a strong case for senior summit team members Sutherland and Dalton to attend weekly active optics meetings with immediate effect. We prefer to select junior summit team members and all remote team members via a transparent process as early as the in-kind negotiations allow. For example, a call for applications in early 2021 could be followed by selecting team members jointly with Chuck Claver or his representatives (e.g. Kevin Reil, Leanne Guy, Keith Bechtol) before the end of June 2021. We would then expect team members to attend active optics meetings, Friday Stackclubs, and Bootcamps, as appropriate to their agreed role.

S13.2 Activity: One Sentence Summary

We will propose a single integrated and directable contribution to Rubin commissioning that combines hands-on work at the summit focussed on the active optics sub-systems, and remote data analysis in the UK.

S13.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S13.4.1 Deliverables: Description

LSST:UK plans to provide on-summit commissioning and remote data analysis expertise at the level of at least 3 staff years of directable effort. The baseline of 3 staff years will be funded by STFC and will include the senior members of the summit team. Junior members of the summit team and most members of the remote team will be supported by their own funding. The precise make up of the team and thus mix of funding will emerge following the proposed joint selection of team members in the first half of 2021.

S13.4.2 Deliverables: One Sentence Summary

LSST:UK plans to provide skilled on-summit commissioning and data analysis expertise at the level of at least 3 staff years of directable funded effort.

S13.4.3 Deliverables: Timeline

FY21 >=1FTE for 3 months

FY22 >=1.25FTE for 12 months

FY23 >=1.25FTE for 12 months

FY24 >=1FTE for 3 months

S13.5 EXPECTED RIGHTS TO THE LSST DATA

S13.5.1 Data Rights: Description

Given the directable and skilled nature of the staff effort provided, LSST:UK considers 3 staff-years to be worth approximately 3 PI slots.

S13.5.2: Data Rights: One Sentence Summary

LSST data rights for 3 PIs.

S13.6 KEY PERSONNEL

Contribution Lead: Graham Smith (LSST:UK Commissioning Coordinator; also Strong Lensing Science Collaboration Commissioning Liaison and incoming SLSC co-Chair). gps@star.sr.bham.ac.uk

Contribution Recipients: Rubin Commissioning Team (Phil Marshall, Chuck Claver, Kevin Reil)

S14. Statement of Work and Detailed Plan for Proposed Contribution 14

S14.1 TITLE: International Program Coordinator

LOI Code: None

S14.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

S14.2.1 Background: Description

Aprajita Verma is a Senior Researcher in the Oxford Astrophysics group. She has worked with a number of space-borne and ground-based observatories both with the results data and part of the observatory team. She is currently Project Scientist for the UK ELT programme. Her research interests are in Galaxy Evolution formation and has participated in many large surveys. For almost 4 years she has served as co-chair of the Strong Lensing Science Collaboration, and is a member of DESC and strong lensing lead for the Galaxies Science Collaboration. As such, Dr Verma has a strong background in survey science and telescope projects, as well as having an established connection to Rubin and LSST. She has participated on the CEC, and was a member of CEC software and IDAC sub-committees and therefore has a good grasp of the in-kind process.

S14.2.2 Background: One Sentence Summary

At the invitation of the Director's Office, we are proposing to support Dr Aprajita Verma in a 0.5 FTE position as International Program Coordinator, from 1 January 2021 to 31 December 2033.

S14.3 PLANNED ACTIVITIES

S14.3.1 Activity: Description

Working within the Director's Office, and liaising with the Rubin Observatory leadership, the CEC, AURA, SLAC, NSF, DOE and international groups with approved in-kind agreements, the International Program Coordinator will help monitor compliance, delivery, and status of the contributions and the status of the associated PIs. The International Program Coordinator will pay specific attention to in-kind contributions that add value to the Rubin Observatory and/or LSST, including via contributions to external science infrastructure.

S14.2 Activity: One Sentence Summary

The holder of this half-time International Program Coordinator position will liaise with multiple stake-holders to help ensure the successful delivery of international contributions.

S14.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S14.4.1 Deliverables: Description

The deliverable from this contribution is 0.5 FTE of Dr Verma's time for a nominal 14-year period. This will be directable staff effort, deployed as directed by the Observatory leadership.

S14.4.2 Deliverables: One Sentence Summary

The deliverable from this contribution is 0.5 FTE of directable effort, supplied by Dr Verma for a nominal 14-year period, and to be deployed as directed by the Observatory leadership.

S14.4.3 Deliverables: Timeline

FY21: 0.375 staff-years of effort (i.e. 0.5 FTE for nine months, Jan - Sept 2021)

FY22: 0.5 staff-years of effort (0.5 FTE for the full year)

FY23: 0.5 staff-years of effort (0.5 FTE for the full year)

FY24: 0.5 staff-years of effort (0.5 FTE for the full year)

FY25: 0.5 staff-years of effort (0.5 FTE for the full year)

FY26: 0.5 staff-years of effort (0.5 FTE for the full year)

FY27: 0.5 staff-years of effort (0.5 FTE for the full year)

FY28: 0.5 staff-years of effort (0.5 FTE for the full year)

FY29: 0.5 staff-years of effort (0.5 FTE for the full year)

FY30: 0.5 staff-years of effort (0.5 FTE for the full year)

FY31: 0.5 staff-years of effort (0.5 FTE for the full year)

FY32: 0.5 staff-years of effort (0.5 FTE for the full year)

FY33: 0.5 staff-years of effort (0.5 FTE for the full year)

FY34: 0.125 staff-years of effort (0.5 FTE for three months, Oct - Dec 2033)

S14.5 EXPECTED RIGHTS TO THE LSST DATA

S14.5.1 Data Rights: Description

This contribution comprises seven staff-years of directable effort, and, hence, is worth 7 PI slots.

S14.5.2: Data Rights: One Sentence Summary

LSST data rights for 7 PIs.

S14.6 KEY PERSONNEL

Contribution Lead: Bob Mann rgm@roe.ac.uk

Contribution Recipients: Rubin Director's Office (Bob Blum, Phil Marshall)

S15. Statement of Work and Detailed Plan for Proposed Contribution 15

S15.1 TITLE: Community Scientists (secondments)

LOI Code: None

S15.2 BACKGROUND: RELEVANT EXPERTISE AND EXPERIENCE

S15.2.1 Background: Description

The LSST:UK Consortium includes researchers from 36 UK astronomy groups, with expertise spanning the whole range of LSST science. The Consortium as a whole is, therefore, well placed to provide postdocs from a wide range of science areas to fill Community Scientist positions on secondment within the Rubin Community Engagement team.

S15.2.2 Background: One Sentence Summary

The LSST:UK Consortium comprises astronomy groups spanning the full range of science areas relevant to the Rubin Observatory LSST, and is, therefore, well placed to source postdocs to perform Community Scientist roles on secondment at either NOIRLab or SLAC.

S15.3 PLANNED ACTIVITIES

S15.3.1 Activity: Description

At the suggestion of the Director's Office, we propose to operate a scheme whereby postdocs funded on research grants in the UK - typically, grants with a large LSST exploitation element - will undertake one-year, half-time secondments in the US, located at either NOIRLab or SLAC, and performing a Community Scientist engagement role, directed by local Observatory staff, as part of the Community Engagement team. It is expected that the post-holders will liaise closely with the Observatory Operations and Data Production teams, to diagnose and respond to issues identified by the scientific community.

Our intention is to have two such positions filled at any one time and to run the scheme from a year before the start of operations until six months after the final data release. We would run a competitive annual application scheme, with guidance from Observatory staff as to the priority science areas, and expertise required, for each round and with their direct involvement in the selection panel, to ensure that appropriate candidates are selected for these roles.

S15.2 Activity: One Sentence Summary

At the suggestion of the Director's Office, we propose to operate a secondment scheme which, at any one time, will see two postdocs from UK universities working as half-time Community Scientists for one-year stays at either NOIRLab or SLAC.

S15.4 TECHNICAL OBJECTIVES AND DELIVERABLES

S15.4.1 Deliverables: Description

The deliverable from this contribution will be the directable effort of the Community Scientists; with two half-time positions filled at any one time, this will be 1 FTE of staff effort with expertise in the prioritised science areas, with the exact model for filling the posts TBD, following discussion between the Community Engagement team and LSST:UK.

S15.4.2 Deliverables: One Sentence Summary

One FTE of directable effort, provided by experienced postdocs, through two half-time Community Scientist posts, renewed on an annual basis and located at NOIRLab or SLAC.

S15.4.3 Deliverables: Timeline

FY23: 1.0 staff-years of effort

FY24: 1.0 staff-years of effort

FY25: 1.0 staff-years of effort

FY26: 1.0 staff-years of effort

FY27: 1.0 staff-years of effort

FY28: 1.0 staff-years of effort

FY29: 1.0 staff-years of effort

FY30: 1.0 staff-years of effort

FY31: 1.0 staff-years of effort

FY32: 1.0 staff-years of effort

FY33: 1.0 staff-years of effort

FY34: 1.0 staff-years of effort

S15.5 EXPECTED RIGHTS TO THE LSST DATA

S15.5.1 Data Rights: Description

1.0 FTE of directable staff effort for twelve years = 12 PI slots

S15.5.2: Data Rights: One Sentence Summary

LSST data rights for 12 PIs.

S15.6 KEY PERSONNEL

Contribution Lead: Bob Mann rgm@roe.ac.uk

Contribution Recipients: Community Engagement Team (Phil Marshall, Melissa Graham, Leanne Guy)