



# LSST Data Management Status

William O'Mullane, AURA/LSST  
DM Project Manager

DM All Hands  
6<sup>th</sup> March 2018





# Outline

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Data Management Overview

Risks and Opportunities

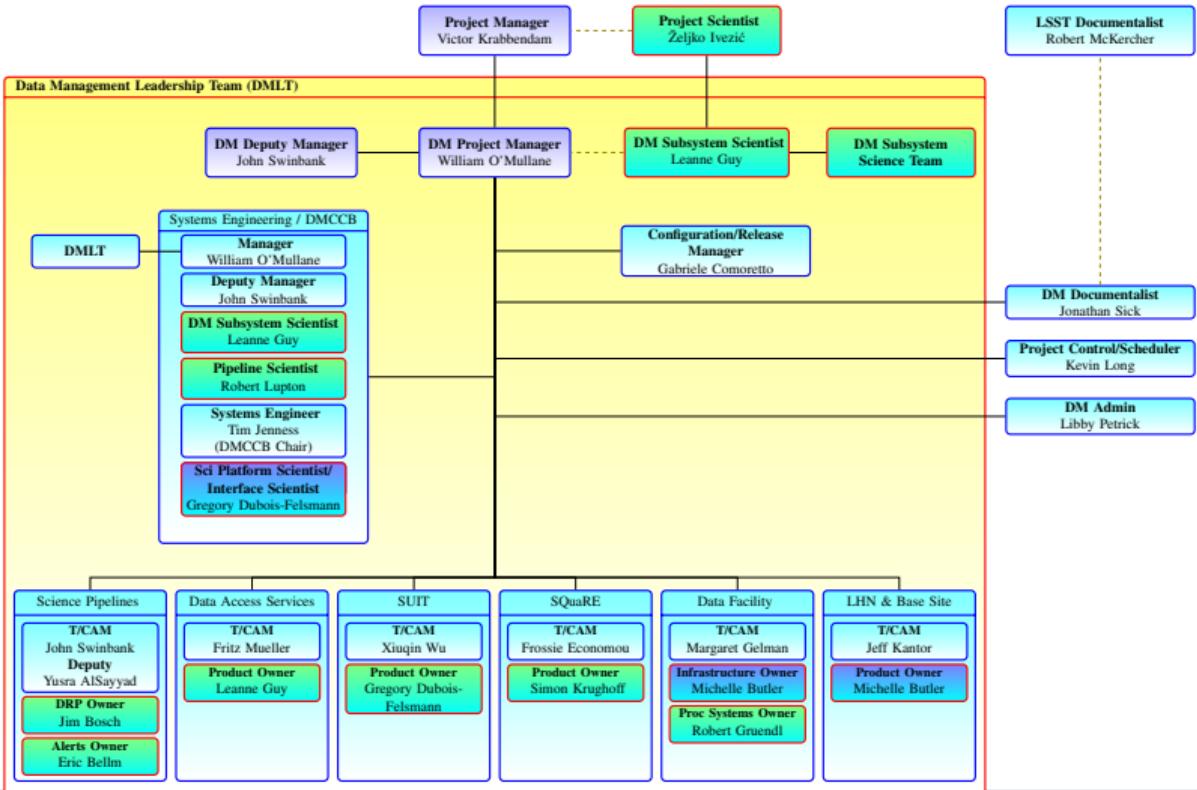
Status

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Conclusion



# Organization



Welcome Leanne Guy and thanks to Mario (who stays with us)!!

Welcome Michelle Butler and thanks to Don

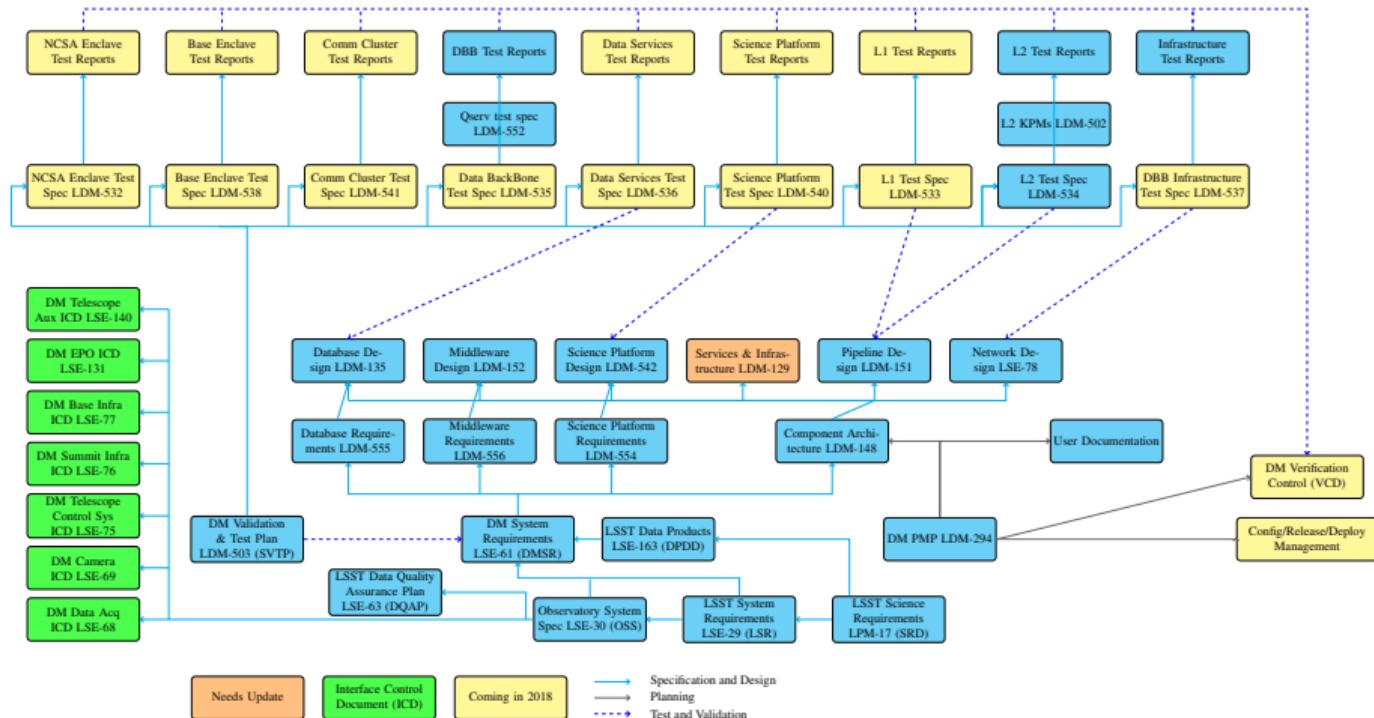
Welcome Gabriele Comoretto.

Deputies John Swinbank (PM) and Yusra AlSayyad (Pipelines)

Toughest thing in any project is communication.

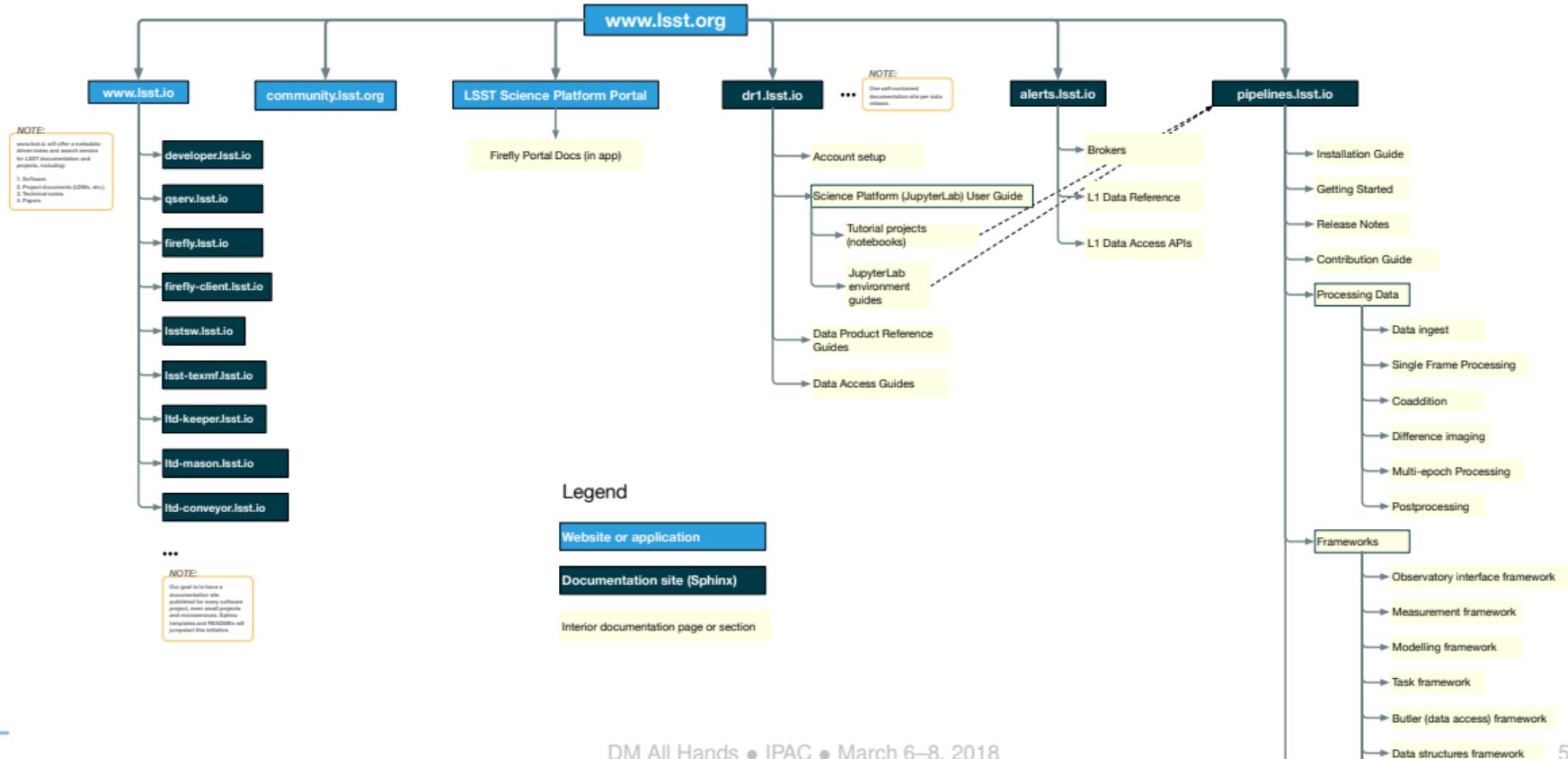


# DM Document Tree



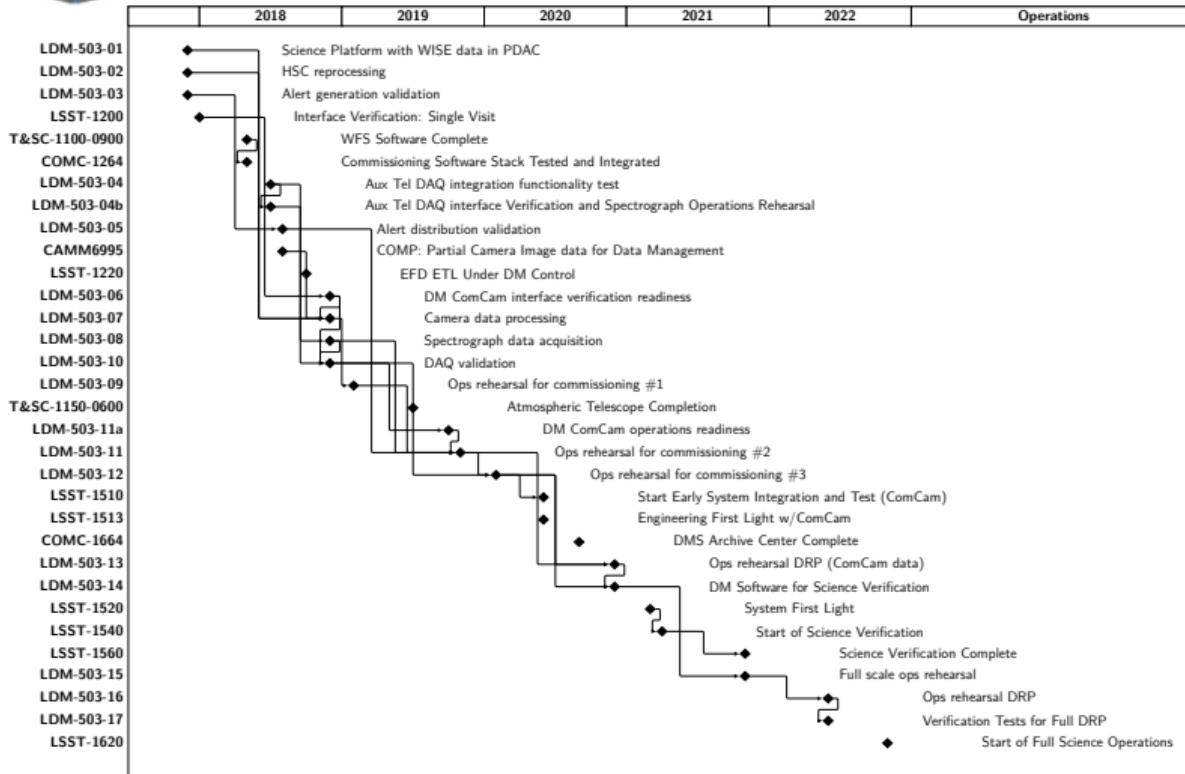


# End-User Documentation on the Web





# Verification is a Priority



Across all of LSST  
verification is a big topic  
right now.

DM is adopting a test  
driven schedule to better  
address this.

LDM-503 Now generated  
from P6



**Verification:** Have we built everything we are supposed to build?

- In line with the Project's System Engineering approach
- Demonstrate that we cover all requirements on DM
- LDM-503 shows the DM verification matrix

**Validation:** Have we built the right thing and does it work as expected?

- Must tackle *both* Scientific and Operational Validation
- Talking with the Commissioning Team: some *rehearsals* will be joint

**LDM-503** addresses DM's plans for verification & validation.



## High level status



- The DM Basline is now the reviewed plan (LCRs processed)
- S18 detail plans submitted
- Milestones now being reported monthly (we are getting a backlog)
- Level 2 milestones achieved in December
  - LDM-503-2 Test report: HSC Reprocessing -DMTR-51
  - LDM-503-3 Test report: Alert Generation Validation -DMTR-53
- Level 2 milestones delayed in December
  - LDM-503-1 Test report: Science Platform with WISE data in PDAC
    - Instability PDAC hardware lack of personnel,
    - Testing commenced late Jan



# High Level Goals



- 2017: Prototyping data access and first access to hardware
  - Jun: Prototype Data Access Center with SDSS + WISE Data
  - Aug: Working with camera test stand data
  - Dec: Prototype notebooks, private databases for Science Platform
- 2018: Prototypes for various processes and databases - “Minimum Viable System”
  - Jun: Calibration Products accessible through Butler
  - Aug: Mountain base network up
  - Oct: Spectrograph data acquisition
  - Dec: Prototype QA/Commissioning Environment
- Dec 2019: ComCam L1, L2 Production
- Dec 2019: Base Center Integration Complete
- Jun 2020: Camera L1, L2 Production
- Jul 2021: US Data Access Center Integrated

*Test plans to confirm milestone completion are under development.*



# Commissioning Start Requirements



November 2019: DM for Commissioning (minimum required for start of commissioning with ComCam): **(See LSE-79 §3.3 and table 8)**

- Pipeline: single-frame measurement including ISR, ghost masking, cosmic ray detection, PSF estimation, astrometric and photometric calibration, background estimation, single-frame deblending, master calibration image generation, atmospheric characterization
- Services: archiving, EFD transformation, Data Backbone for files (Base/NCSA), telemetry gateway, OCS-controlled batch, offline processing
- LSST Science Platform on Commissioning Cluster: Notebook Aspect, image access, user file storage, batch computing

## Milestones:

- LDM-503-9 – 2018-11-30: on the right track with beta software.
- LDM-503-11 – 2019-10-31: verification of ComCam commissioning requirements.



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## Realized Risks



As part of the replan three risks were realized:

- DM-062 Programming team productivity below estimate due to geographical distribution/competing priorities.
- DM-085 SUI workload underestimated.
- DM-087 SUI requirements change.

These risks are being addressed in the new DM plan and the associated request to draw on contingency.

New management and organization allowed us to reduce exposure on some other risks. This plus assessment of exposure on other risks reduced our risk exposure at the level of ~\$12M (to ~\$12M).



## Top risks



DM-018 Computing power required for Data Release Production exceeds estimates

- Lots of verification testing (e.g. HSC processing)

DM-023 Unanticipated characteristics of real data result in poor MultiFit performance (computational)

- Lots of verification testing (e.g. HSC processing)

DM-042 Loss of key personnel

- Management structure reducing ‘single points of failure’
- Focus on written design documentation & verification plans

DM-021 Object counts exceed expectations, leading to insufficient compute

- Improved modeling: work in progress (Jurić)

DM-032 LSST DM hardware architecture becomes antiquated

- Core algorithmic code is flexible and hardware-agnostic
- Actively tracking and anticipating the state of the art



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# Architecture





## LDM-503-1: Alert generation milestone

- First (equal) post-replan, NSF-visible milestone hit by the project.
- Demonstrating a *end-to-end* alert production pipeline.
- Milestone successful (DMTR-53)!



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- Effort to upgrade, enhance, expand, etc the AP pipeline will continue throughout construction.
- Currently focusing on improved source association routines, and making it a more idiomatically “stack-like” system.
- Will form the basis of QA efforts going forward.



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## SkyWcs

- Entirely new back-end for WCS (pixel to/from sky coordinate) transformations.
- *Months* of effort, just merged a couple of weeks ago.



## Moving Objects

- Awesome new MOPS linking algorithm under development.
- In the process of reconsidering our moving objects strategy and integrating more closely with the Minor Planet Center. Watch for more soon...



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## Jointcal

- Simultaneous astro- and photometric fitting to source lists derived from multiple images.
- The all new, much improved, more generic replacement for the HSC-specific meas\_mosaic.
- Still getting the rough edges smoothed off... aiming to have this entirely supersede meas\_mosaic (which will be removed from the stack entirely) really soon now.

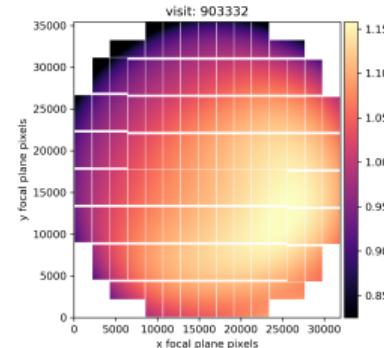


Figure: Parejko.



# Alert Production



## Alert Distribution

- Prototype alert distribution system using Kafka & AVRO; benchmark results on DMTN-028.
- Moving on to start prototyping filtering technologies and the “mini-broker”.

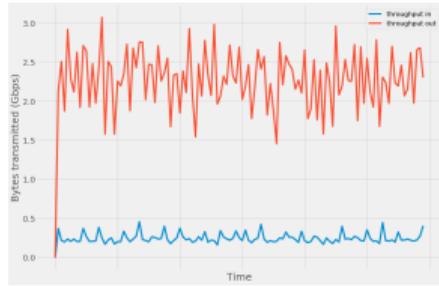


Figure: Patterson.



# Alert Production



## Alert Distribution

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## DCR-matched Template Generation

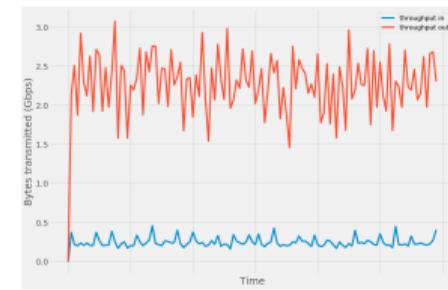


Figure: Patterson.

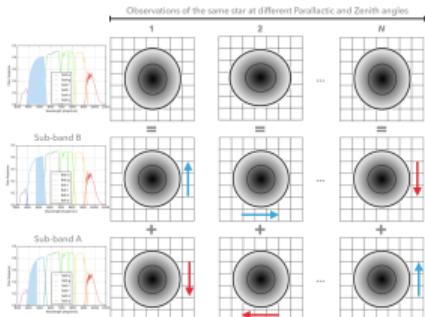


Figure: Sullivan.

- Initial algorithm for making differential chromatic refraction-matched templates about to be come available in the stack.
- Moving on to address variable PSFs, journal publication, and large-scale, real-world testing.



## LDM-503-2: HSC reprocessing milestone

- First (equal) post-replan, NSF-visible milestone hit by the project.
- Joint effort to reprocess (LDF team) and analyze (DRP team) HSC data under operations-like conditions
- Milestone successful DMTR-51!



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## “Warp Compare” coadds

- New algorithm to robustly reject artefacts when coadding images.
- Now default for HSC processing; stack-wide default to be RFCed soon.

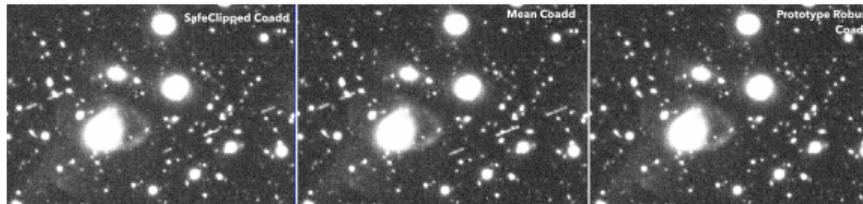


Figure: AlSayyad.



# Data Release Production



## Scarlet: the “new deblender”

- Key pipeline component; separates overlapping astrophysical objects into their constituent components for measurement.
- Recent activities:
  - Prototype code developed over the last ~year with exceptionally promising results.
  - Journal paper describing the algorithm submitted.

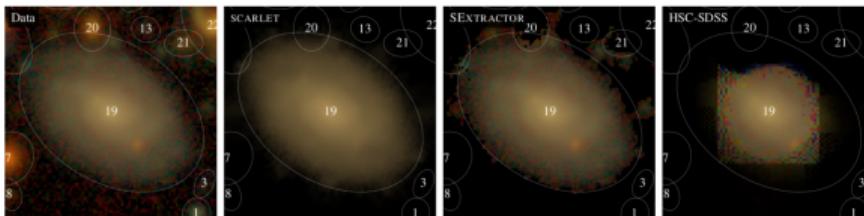


Figure: Melchior et al., 2018



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- Recent activities:
  - Prototype code developed over the last ~year with exceptionally promising results.
  - Journal paper describing the algorithm submitted.
- Coming up:
  - Performance optimization.
  - Demonstrate performance at-scale on real data with real pathologies.
  - Considering how deblender results should affect our approach to measurement.

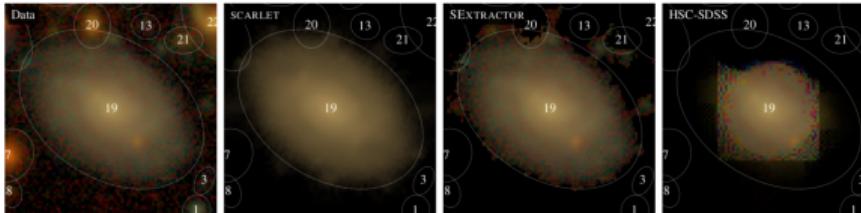


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## “Clever” coadds

- Investigating to what extent we could refine our coaddition techniques to enable us to meet our requirements on galaxy shear by measuring *only* on coadds (i.e., avoiding the cost & complexity of MultiFit).
- Still a work in progress... watch this space.



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## Calibration products & Auxiliary Telescope

- First version of calibration products pipeline added to stack: the cp\_pipe package.
- Currently working on Brighter-Fatter mitigation.
- Expecting to start on collimated beam projector analysis in F17.
- Major push on AuxTel spectrophotometric pipeline this year: intensive planning in January; tests planned for May & August; aiming for prototype pipeline late summer followed by stack integration.



## “QA” on HSC data

- Continued effort to flush out and eliminate all the weird issues that crop up when we run the DRP pipelines at scale.
- Plus: new tooling! Come and learn all about it at the Wednesday morning session.



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## Do(ough)nuts!

- ...or rather: using out-of-focus images of stars to measure the wavefront, then using that to derive the PSF due to the optical system (as opposed to the atmosphere).
- See results in DMTN-064.

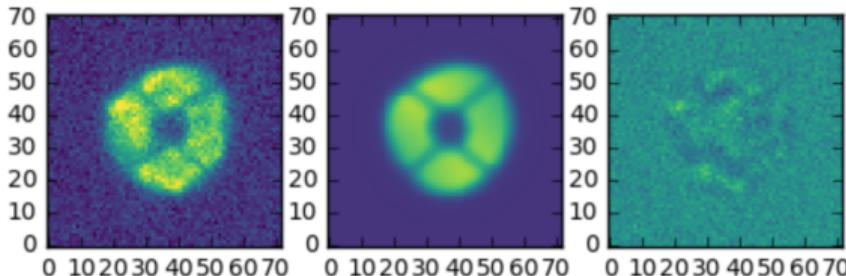


Figure: Meyers, DMTN-064



## And more!

- Work getting started on:
  - Star-galaxy separation
  - New galaxy fitting algorithm

... watch for news at the LSST 2018 Joint Technical Meeting.
- Lots of effort going into Butler Generation 3.



# Data Access Services



- Catalog Database (Qserv) to 100 TB range
  - Three 30-node clusters operating:
    - NCSA (PDAC): science dataset (Stripe 82 + AllWISE + NEOWISE)
    - CC-IN2P3 (2 x dev): synthetic dataset
  - 30% DR1 KPM measurements in progress
  - Jun 2018:
    - Deployment under Kubernetes
    - Data replication and auto-recovery
    - Revamped loader/ingest tools
    - HSC load
  - Dec 2018:
    - GAIA DR2 load





# Data Access Services



- Web Services for Science Platform – Standards Orientation
  - Bespoke endpoints now being replaced with IVOA compliant services:
    - TAP/ADQL, SIAv2, SODA, VOspace, UWS
  - Standards-oriented metadata:
    - RegTAP, VOResource, ObsCore, CAOM, UCD
  - Jun 2018: Revamped TAP/ADQL query services
  - Dec 2018: Revamped image cutout and metadata services





- Gen 3 Data Butler and Supertask

An object-oriented data archive abstraction (Butler) and workflow infrastructure (Supertask). Needed cleanup/attention!

- Working group convened; from scratch in-depth exploration of use cases
- New design resulted; scrum team assembled
- Jun 2018: support for HSC camera
- Dec 2018: replace Gen 2 code throughout DM stack



# LSST Data Facility (NCSA) I



- Observatory Operations Support (Level 1) Services

- Working within the LSST Systems Engineering Early Pathfinder group, developing and testing integration of T&S, Camera, and DM service software via a series of early integration activities.
- Initial header service developed and configured for Camera subsystem and AuxTel use cases, ability to acquire pixel data and write FITS files, all commandable by OCS. Demonstrated on Level 1 Complete Test Stand.





- Offline Campaign Processing and Batch Production Services
  - Production processing of HSC data for 503-2 milestone, working with DRP group.
  - Upgrades to existing production framework based on DES data management system, including migration to Python 3.
  - Regular dataset reprocessing for developers based on biweekly stack updates.
- Data Backbone Services
  - Single-node consolidated database operational, supporting integration and testing of the batch production service.
  - Provided operations use cases and developed requirements for Gen3 middleware working groups.
- Container Application Management Services
  - Investigated deployment documentation and service level configurations requirements for FY18 Kubernetes deployment.



- Worked with SLAC, SQuaRE, and IPAC for requirement investigation and deployment configurations for initial use case support.
- Developer Support Services
  - Upgrades to PDAC, including new dedicated Qserv head node provisioned in PDAC and interim Kubernetes installed on single PDAC node for special testing
  - LSST-DB (MySQL developer database) replacement provisioned.
  - Expand Level 1 Complete Test Stand to support early pathfinder testing and other cross-subsystem use cases.



## – ITC and Facility

- Capabilities provisioned include: initial production Kubernetes cluster, infrastructure for Chilean Base network security and identity management endpoint (shipped, installed, tested, and shipped), 3PB GPFS expansion for initial production file systems, consolidated database (Oracle cluster), Level 1 Complete Test Stand expansion, system for Tucson ATS Test Stand, data transfer nodes, disaster recovery capability for site file systems, central core network upgrade supporting large capability expansion.
- Matured system configuration management and operations with xCAT and Puppet.





- Service Monitoring and Management
  - LDF service monitoring framework designed, implemented, and deployed; beginning integration of systems and base services.
- Other technical work within the project
  - Lossy Compression Working Group
  - Data Access Working Group – policies at the project-level
  - End-to-end long-haul network test



- AuxTel Operations (Fall) (LSST- and DM-level milestones)
  - AuxTel Test Stand operations (April).
  - Provisioning of Chilean ITC (Summit facility) for AuxTel operations.
  - Spectrograph Archiving Service building raw images, Header Service.
  - Data transfer to NCSA, ingestion and archiving into Data Backbone (single site).
  - CPP production processing.
  - EFD ETL Service operational, including database and Large File Annex.
- Chilean Base AA and security monitoring systems installed, services deployed, and monitored (April 2018) in NOAO facility.
- Application-level integration with service monitoring framework, initial dashboards for service operations and capacity management
- Supporting ongoing development



## NCSA - 2018 plans II



- Initial Kubernetes Service in VERY friendly user mode March 2018. Integration for developers use cases (e.g., hosting Jupyter notebooks, Alert Distribution system testing, etc.) throughout CY18.
- Full HSC PDR reprocessing campaign and continued dataset processing.
- Continue providing production-oriented input into Gen3 Middleware development, including design, testing, and planning use in production framework.
- Improvements to Developers Support Services.



## Base & Network:DWDM



Installed Dense Wave Division Multiplex (DWDM) equipment on Cerro Pachon and in La Serena



# Base & Network:Summit Computer Room



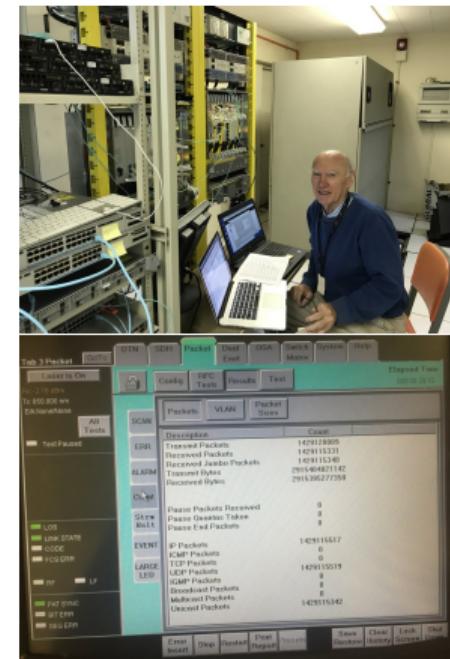
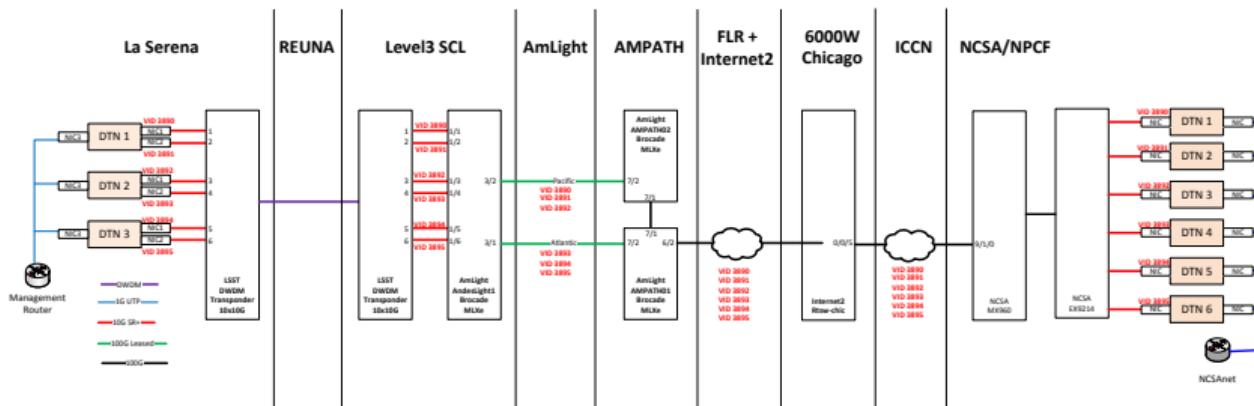
Coordinated implementation of LSE-299 Summit Computer Room Requirements Document with Summit Construction Team



## Base & Network: Fiber First Light



Successful transfer of digital data over LSST/AURA fiber optic networks from the Summit Site on Cerro Pachon to NCSA. A set of 6 x 10 Gbps Network Interface cards on Data Transfer Nodes (DTN) configured with iPerf3 generated a sustained data rate of approximately 44 gigabits per second, over a period of 24 hours, exceeding the target of 40 gigabits per second.





## Base & Network:2018 activities



- Initial Summit Network Ready (DM-NET-3)
- Summit Computer Room installations (Aux Tel, EFD, ECS, etc.)
- Base LAN Design Complete
- LSE-239 Base Data Center Requirements updated/rebaselined
- 100 Gbps test between Chile and NCSA
- Activation of Spectrum Link (Sao Paolo → Boca Raton)



- Current status and recent highlights:
  - Notebook Aspect meets most requirements. Deployments:
    - Two SQuaRE development deploys on GKE (1 stage, 1 semi-prod)
    - Other deploys: SysEng, EPO, tutorials
    - DM deploy coming soon on LDF k8 commons prototype
  - CI developer wishlist done including much improved Slack notifications
  - SQuaSH
    - Developer metric support in pre-release testing
    - Replaced Django with flask to match other teams technical stack
    - Moved architecture to Kubernetes for consistent deployment in LDF
  - Documentation:
    - lsst.io landing page / doc index
    - Pipelines getting-started tutorial
    - package documentation example using ‘pipei\_base’
    - LaTex support for LSST-The-Docs



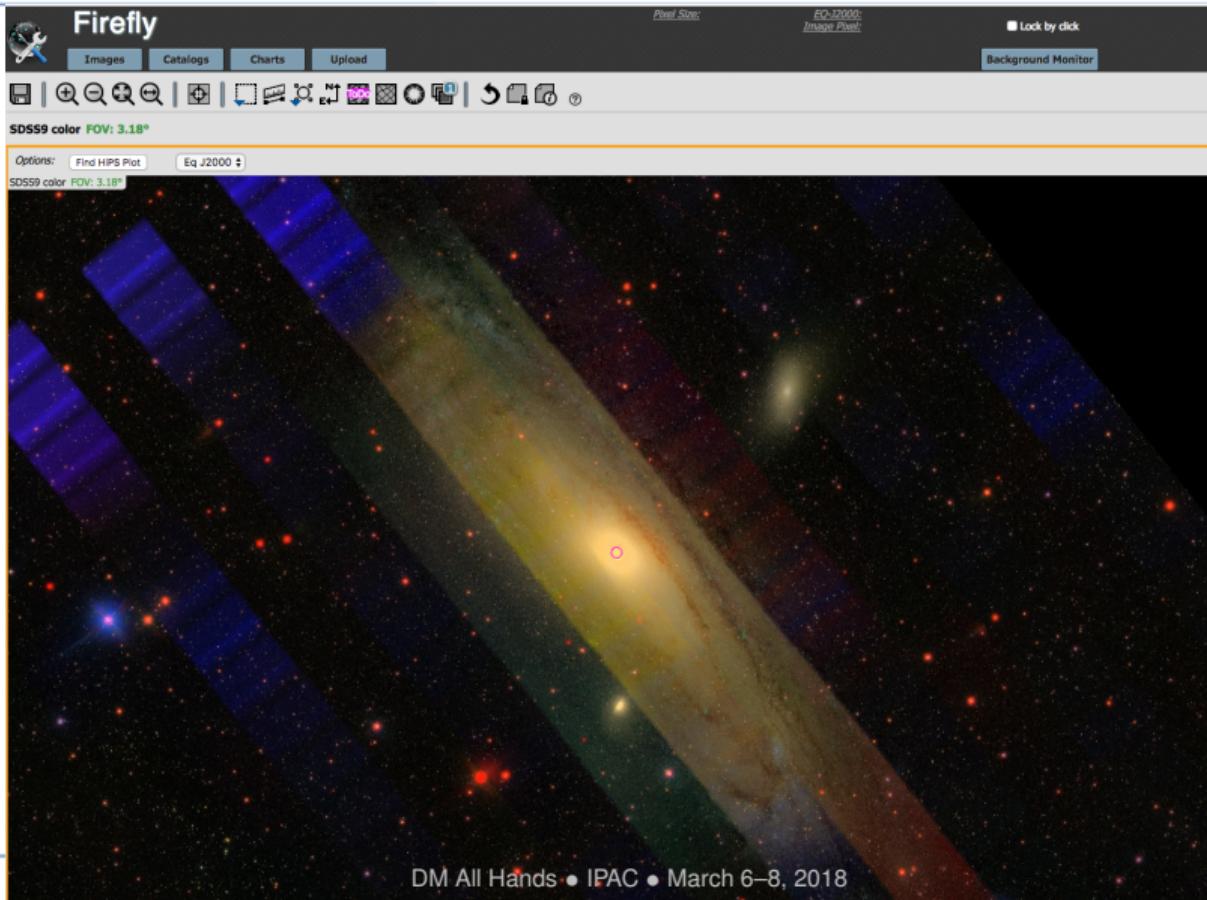
# SUIT: Major Achievements



- New Features in PDAC
  - Search and display WISE single epoch sources
  - Incorporated the DAX imgServ v1 in SUIT
- Visualizaiton
  - Search and display HiPS images
  - Multiple scattered plots within one plotting area
- Build and deployment
  - Experimented with docker and Kubernetes
  - Added Jenkins task to build Firefly docker image
  - Added Jenkins tasks to deploy/destroy Firefly application as Kubernetes pod
- Implemented embedded database HyperSQL for table data support in Firefly
- Updated 3rd party packages: React, Webpack ...
- Various improvements and bug fixes



# SDSS HiPS images in Firefly





# SUIT: Plan for Next 6 Months



- New Features in PDAC
  - Search and display HSC data reprocessed by LSST pipeline
  - Use the new version of DAX APIs: metaServ, imgServ, dbServ
  - Integrate the authentication system
  - Access workspace when available
- Improve overall user experience in SUIT
- Make Firefly npm installable to support using Firefly API in JupyterLab



- Data Access Policy LSE-349 draft prepared; now under review by project management
- Alerts Broker Policy LDM-612 draft is underway; UW broker team focused on ZTF Alerts
- DM & Special Programs DMTN-065 spawned RFC-412 and Jira tickets under discussion (to close in next month)
- Initial testing of pipeline performance in crowded fields is complete; written report available soon.



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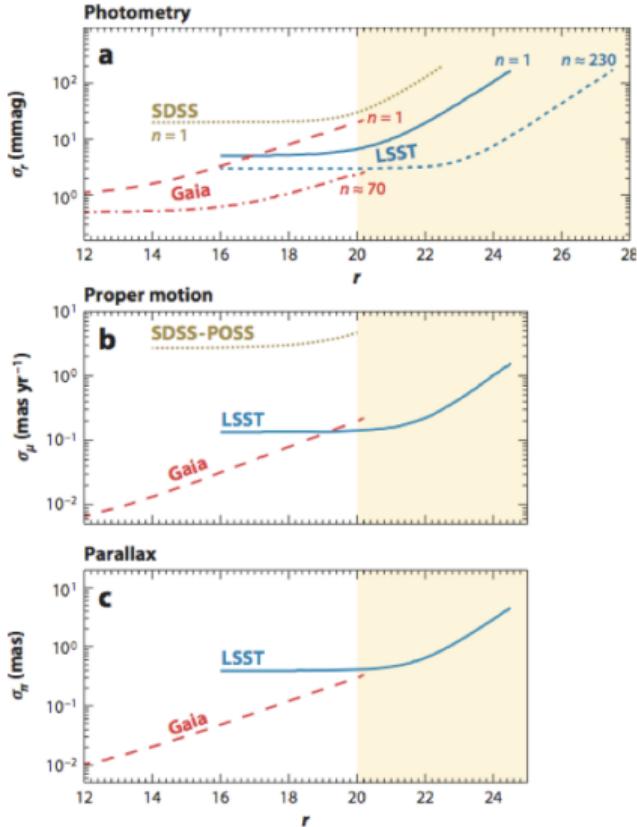
# Conclusion



- New DM Project Management is in place since April 2017.
- Organization, prioritization and specification have been the first priority.
- To date encountered a real willingness to cooperate on DM and *get the job done*.
- Will make pragmatic and timely decisions to see DM works.
- We had a successful NSF/DOE Review in July. Got some recommendations on how to make an *even better* DM.
- LSST has the potential for a *huge* impact in astronomy; DM is fundamental to this.
- Looking forward to the first LSST images!



# The END



The Milky Way disk *belongs* to Gaia, and the halo to LSST (plus very faint and/or very red sources, such as white dwarfs and LT(Y) dwarfs).

Željko Ivezić

Questions ??



# Outline



Reference material



# Acronyms I



Acronym	Description
IPAC	Infrared Processing and Analysis Center



# References I



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