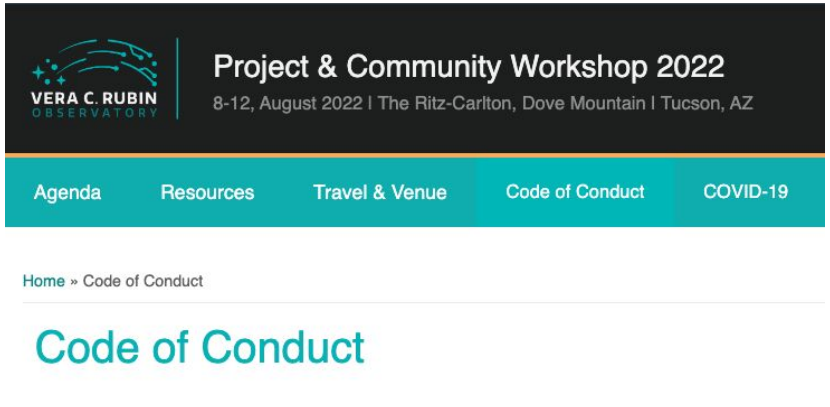
VERA C. RUBIN OBSERVATORY

Updates from the Science Pipelines

Project and Community Workshop
August 10 2022

NSF AURA U.S. DEPARTMENT OF ENERGY SLAC CHARLES AND LISA SIMONYI FUND FOR ARTS AND SCIENCES LSST CORPORATION

Friendly reminders - CoC & Covid



Harassment and unprofessional conduct (including the use of offensive language) of any kind is not permitted at any time and should be reported.

Rubin Observatory adheres to the principles of kindness, trust, respect, diversity, and inclusiveness in order to provide a learning environment that produces rigor and excellence.

Check name-tags for these contact comfort level stickers.

Thank you for masking indoors!

Use the confidential email rubin2022-covid@lists.lsst.org to request a test, report your test results, or ask questions.

Reporting bullying, harassment, or aggression.

The Rubin 2022 Organizing Committee has appointed designated contacts:

- Ranpal Gill (rgill@lsst.org)
- Andrew Connolly (ajc@astro.washington.edu)
- Melissa Graham (mlg3k@uw.edu)

Contact via email, Slack, or the Community Forum.

Friendly reminders - virtual participation

Virtual participants should be muted when they're not speaking.

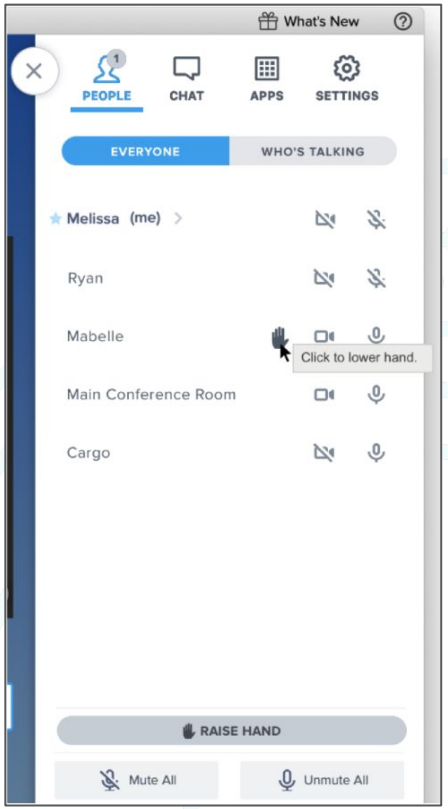
In-person participants should speak into the room microphone(s), or the chair should repeat all questions into the microphone, so that the virtual participants can hear what is said.

In the Rubin2022_PCW Slack Space, all participants can use the session's channel for Q&A and discussion.

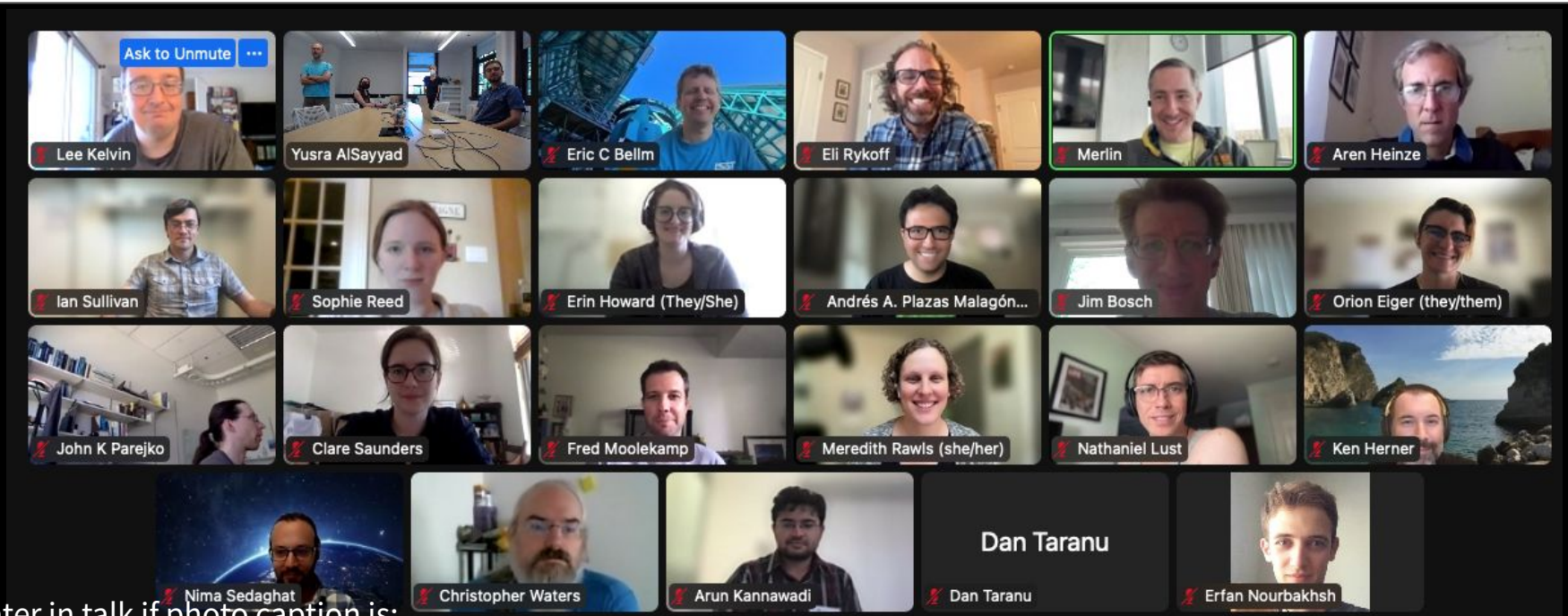
The channel name convention is, e.g.: #day1-mon-slot3a-intro-to-rubin

In BlueJeans, virtual participants should use the **BlueJeans chat** functionality to:
- indicate you have a question and would like to unmute, or
- type your question so that someone in the room can speak it.

BJ "raise hand" feature is hard for moderators to track, not preferred.



We are the Science Pipelines team and scientists first



Later in talk if photo caption is:

- @ slack handle, person is attending virtually. Send questions on Slack
- First Last, person is here in Dove Mountain. Find during coffee break

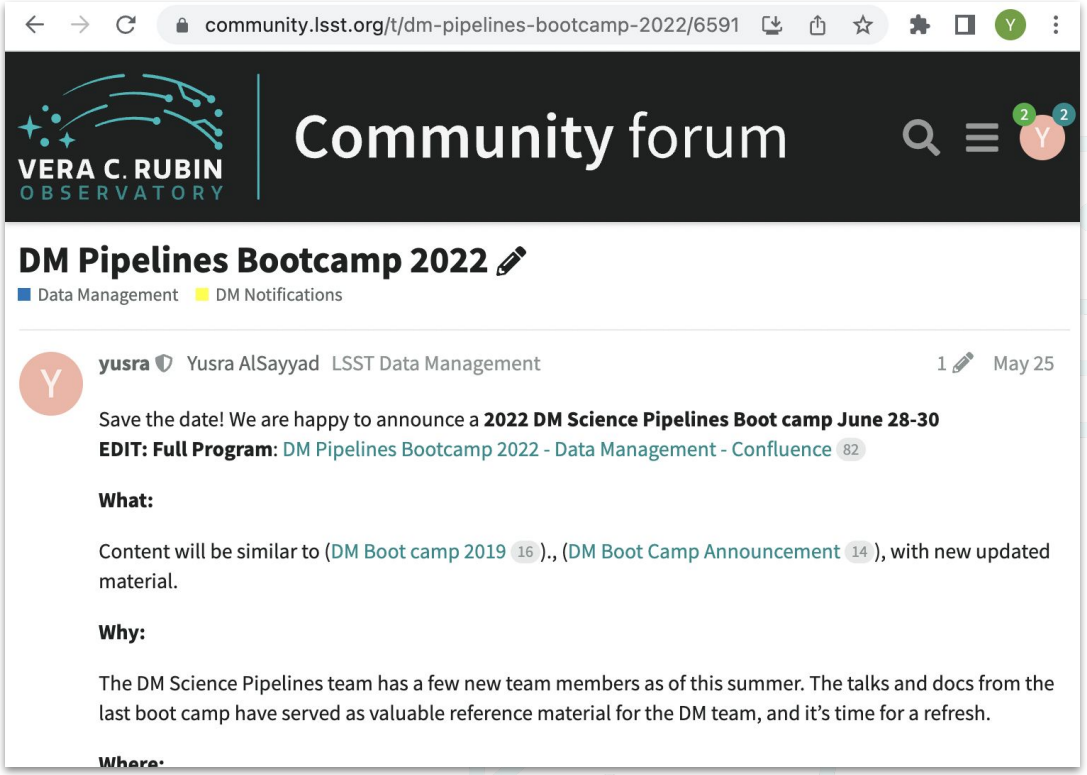
Plans described in the Algorithms Workshop March 2020 talks are still current: ls.st/law

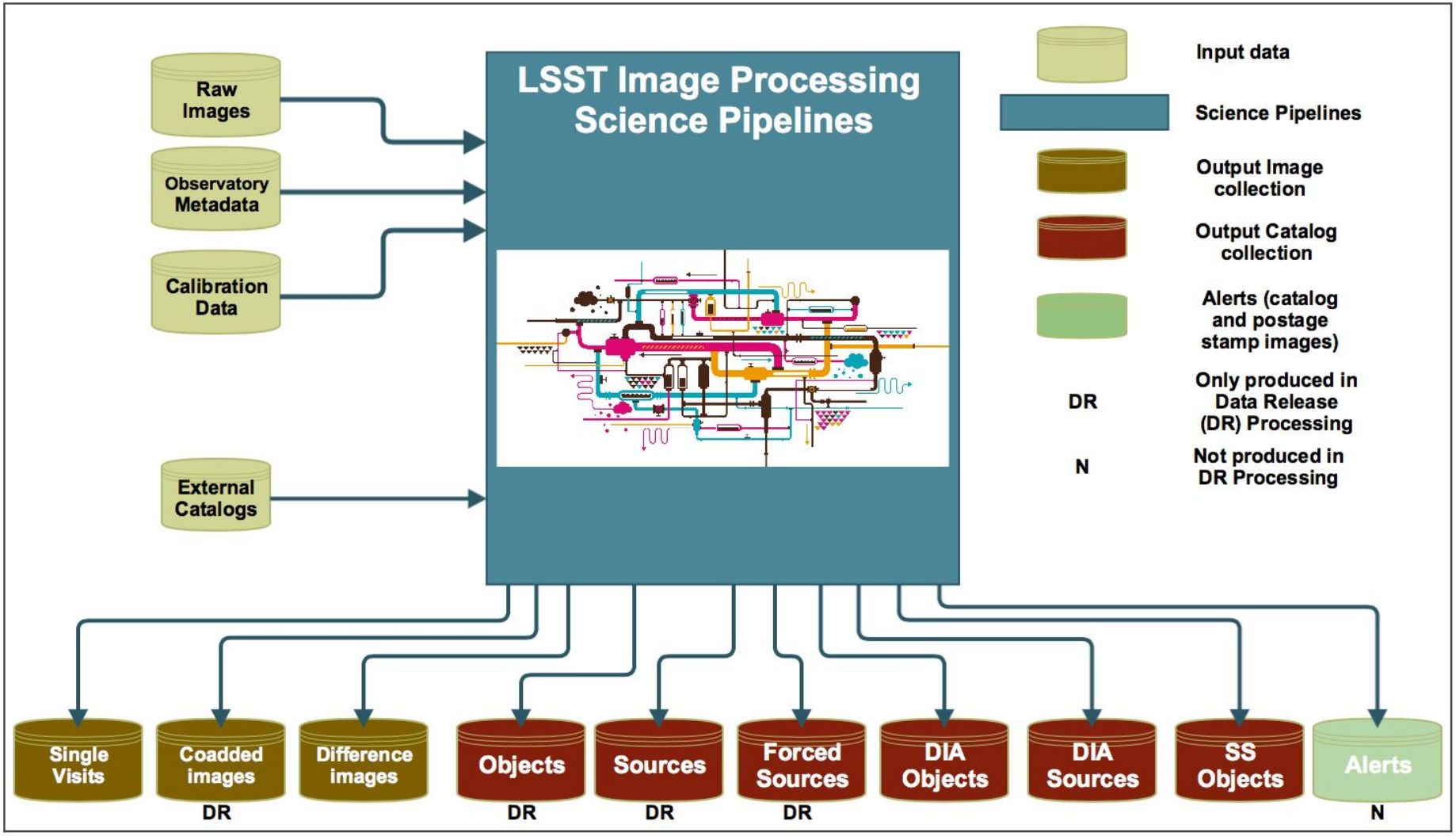
Time				Tuesday 17 March 2020	Wednesday 18 March 2020	Thursday 19 March 2020
PDT	EDT	CET	AEDT(+1)			
08:45	11:45	16:45	02:45	ZOOM connection setup		
09:00	12:00	17:00	03:00	Introduction. Speaker: Leanne Guy (12+3)	Invited talk: Gary B - Systematic effects in photometry and astrometry and lessons learnt from the DES (35+10)	Invited talk: Konrad Kuijken - Galaxy Photometry in KiDS (35+10)
09:15	12:15	17:15	03:15	Introduction to the LSST Science Pipelines. Speaker: Yusra AlSayyad (35+10)		
09:45	12:45	17:45	03:45		Project plans for background Estimation. Speaker: Yusra AlSayyad (35+10)	Project plans for galaxy photometry and model fitting. Speaker Jim Bosch & Dan Taranu (35+10)
10:00	13:00	18:00	04:00	Project plans for ISR and the Atmosphere. Speaker: Robert Lupton (25+10)		
10:30	13:30	18:30	04:30	Break		
11:00	14:00	19:00	05:00	Invited talk: Mike Jarvis - State of the art in PSF modelling (35+10)	Project plans for photometric calibration. Speaker: Eli Rykoff (35+10)	Invited talk: Erin Sheldon - Weak lensing (35+10)
11:45	14:45	19:45	05:45	Project plans for PSF estimation and modelling. Speaker: Josh Meyers (35+10)	Project plans for astrometric calibration and stellar motion measurements. Speaker: Jim Bosch (35+10)	Project plans for shape measurement. Speaker : Jim Bosch (35+10)
12:30	15:30	20:30	06:30	Break		
13:00	16:00	21:00	07:00	Project plans for deblending. Speaker: Fred Moolekamp (35+10)	Invited talk: Gene Magnier - State of the art in difference imaging & lessons learnt from Pan-STARRS (35+10)	Project plans for stellar crowded field processing. Speaker: Colin Slater (35+10)
13:45	16:45	21:45	07:45	Project plans for building and using coadds. Speaker: Jim Bosch (35+10)	Project plans for difference imaging. Speaker: Eric Bellm (35+10)	Project plans for DCR in templates. Speaker: Ian Sullivan (35+10)

← Agenda

5 People have joined since the 2021 PCW. Welcome

- Ari Heinze (Sept 2021)
- Nima Sedaghat (Nov 2021)
- Erfan Nourbakhsh (July 2022)
- Erin Howard (Aug 2022)
- Brianna Smart (Aug 2022)



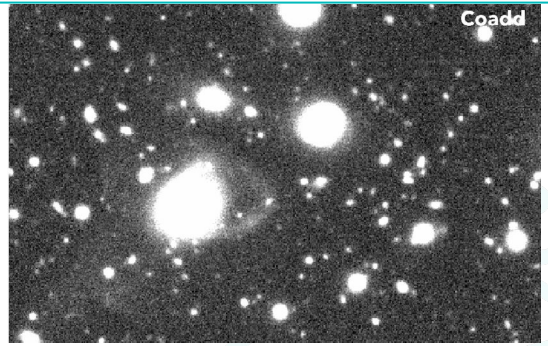

Raw Images
Observatory Metadata
Calibration Data
External Catalogs
LSST Image Processing Science Pipelines
Input data
Science Pipelines
Output Image collection
Output Catalog collection
Alerts (catalog and postage stamp images)
DR
Only produced in Data Release (DR) Processing
N
Not produced in DR Processing
Single Visits
Coadded images
DR
Difference images
Objects
DR
Sources
DR
Forced Sources
DR
DIA Objects
DIA Sources
SS Objects
Alerts
N

You will get data products fast and slow

Annual Data Release Products (DRP)
11 Data releases in 10 years.
Final catalog: 15PB
Final pixels: 100PB

Prompt Data Products via nightly alert streams (Alert Production = AP)
~10 million alerts per night
issued within 60 s of shutter close

You will get data products fast and slow



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11 Data releases in 10 years.
Final catalog: 15PB
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Prompt Data Products via nightly alert streams (Alert Production = AP)
~10 million alerts per night
issued within 60 s of shutter close

Prototype pipelines are in place, but they will evolve over the next decade

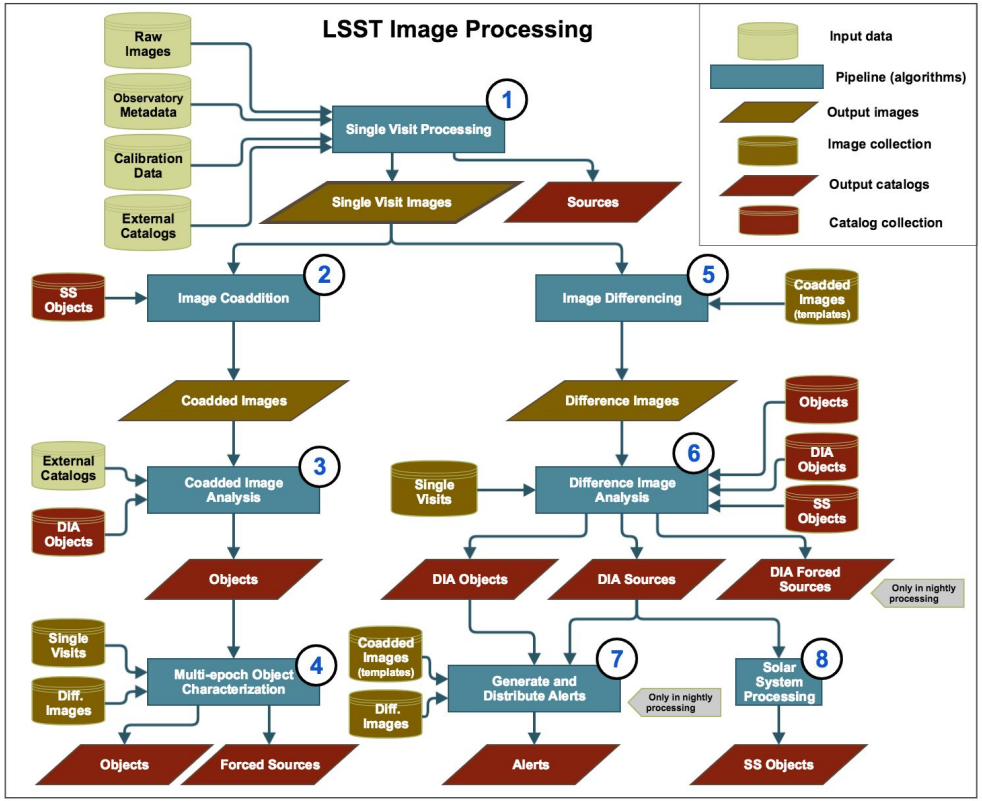
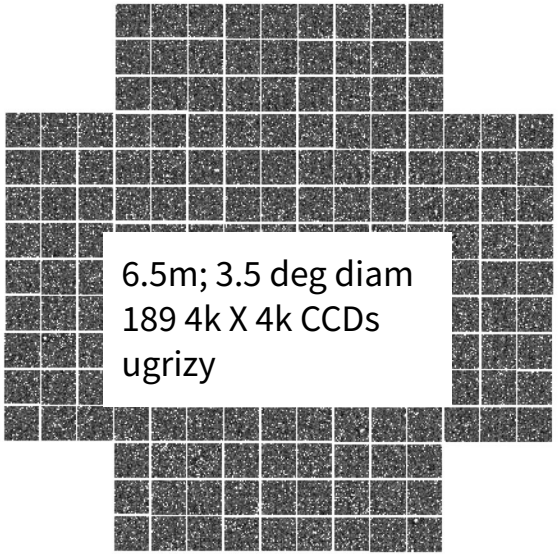


Figure from ls.st/dpdd

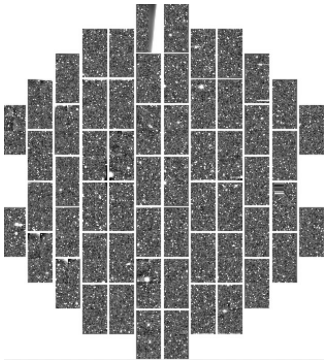
We analyze pipeline performance on datasets from **3 wide field cameras** (1 simulated; 2 precursor surveys)

SIMULATIONS LSST ImSim
DESC's DC2 Run2.2i



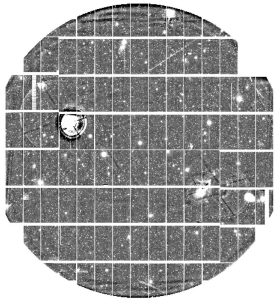
6.5m; 3.5 deg diam
189 4k X 4k CCDs
ugrizy

Dark Energy Camera (DECam)



3.9m; 2.2 deg diam
62 2k X 4k CCDs

Hyper Suprime-Cam (HSC)
Subaru Strategic Program



8.2m; 1.5 deg diam
103 2k X 4k CCDs
grizy

Rubin Obs Auxtel
LATISS

1.2; 6.7 arcmin diam
1 real LSST CCD

Figures: Pipeline-processed visit images (PVIs) aka calexps

We analyze pipeline performance on datasets of **3 sizes** and cadences

- Large areas (100s of deg^2) on **annual** cadence
- Medium areas (~10 of deg^2) on a **monthly** cadence
- Small areas (< 1 deg^2) on a **nightly** cadence

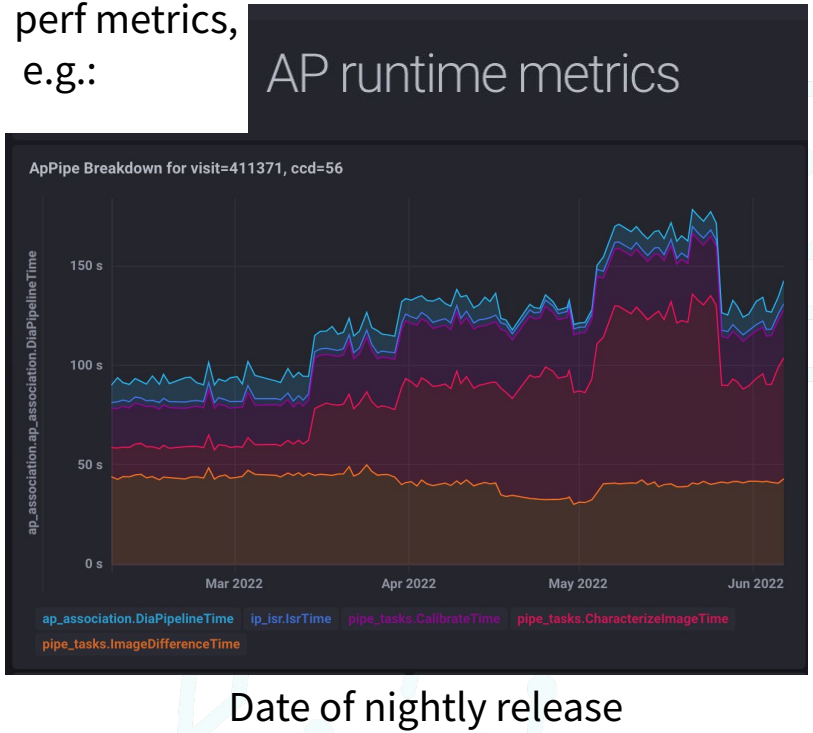
DMTN-091: Test Datasets for Scientific Performance Monitoring

Daily small (<1 deg^2) reruns in continuous integration keep pipelines healthy

Two builds are launched during **each nightly release** that **produce metrics** dispatched to SQuaSH on **Chronograf**.

- **rc2_subset** tests **DRP** and is a one patch subset of **RC2** (next slide) that is the same one as the getting started guide on pipelines.lsst.io
- **ap_verify** tests the **AP** on one
  - HSC ccd
  - DECam ccd

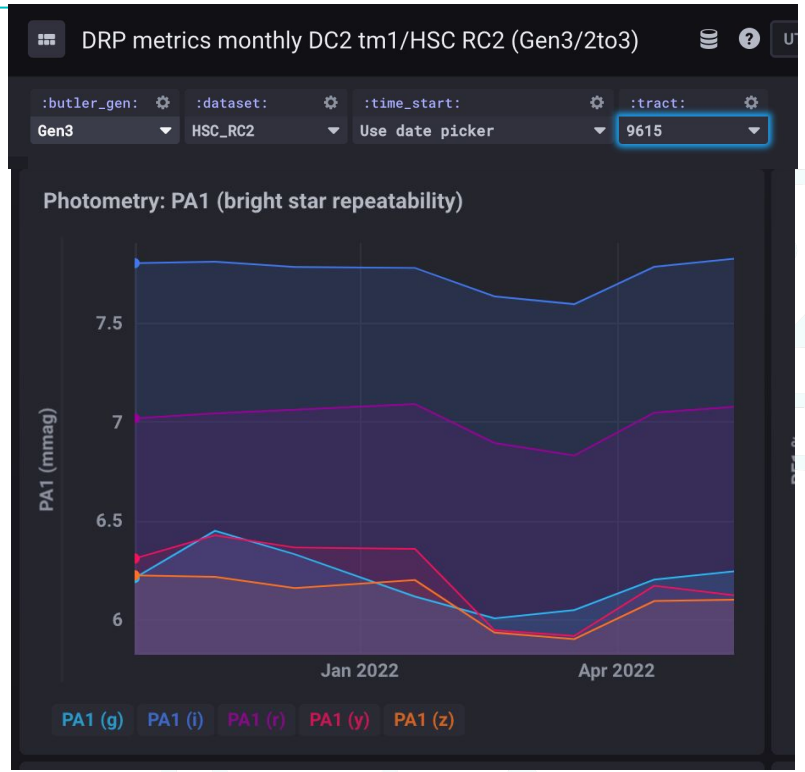
Tracks science quality metrics and comp perf metrics, e.g.:



Monthly medium (<10 deg^2) reruns provide a testbed for new algorithms

Monthly continuous integration on datasets of ~5 deg^2

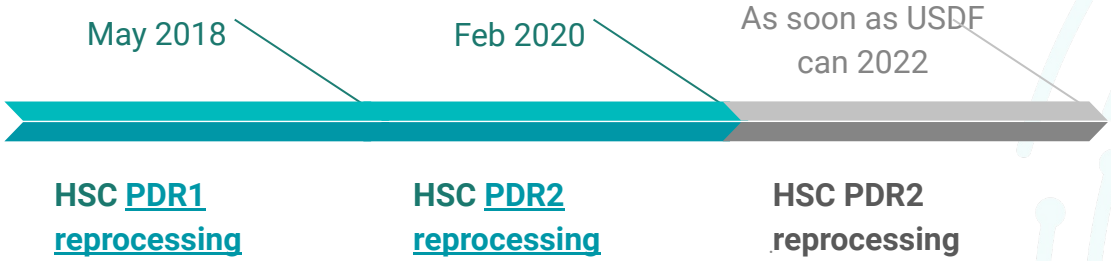
- Tract-sized datasets are the **minimum** to test the speed, robustness, and performance of any algorithmic change.
- Track **metrics** and **plots** as a function of pipeline version (i.e., hold data fixed and change pipeline)
- AP on HSC COSMOS and DECam **HiTS** (Förster+16)
- DRP on **HSC RC2** (3 tracts) and ImSim **DC2 2.2i test-med-1** (2 tracts at 1.5 yr depth). All bands.



Large (100s deg^2) processing campaigns test whole of data management and rare edge cases

Pipelines are used in **external data releases;** the best QA is astronomers publishing papers with your data products:

Internal reprocessing campaigns integrate all of DM, provide data for characterization reports, and test algorithms for robustness:



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New Features

Highlights from the last 12 months

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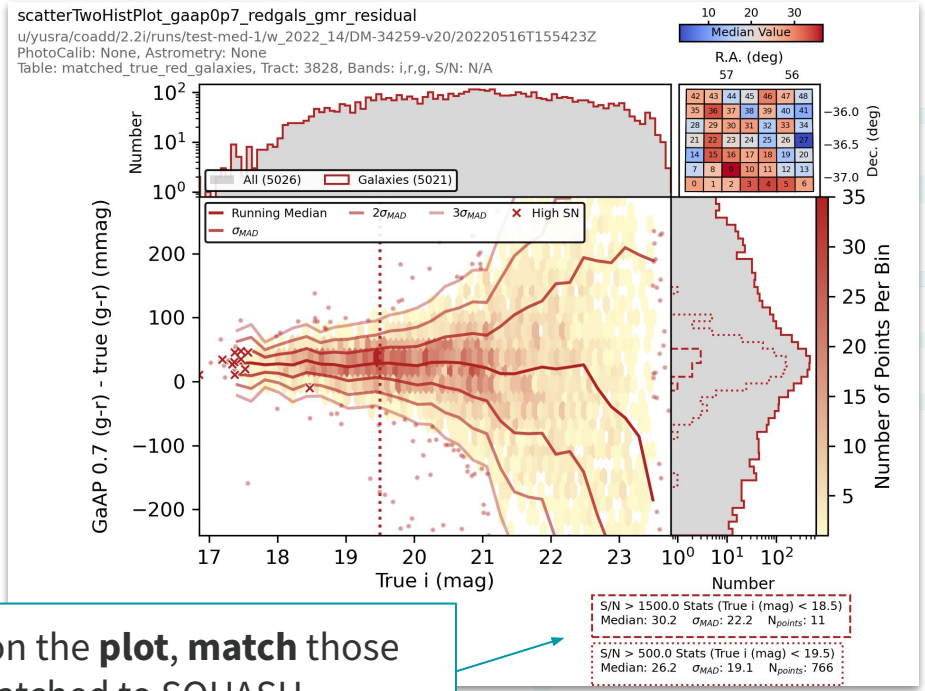
New tooling for monitoring pipeline quality: metrics and plots are generated automatically during pipeline execution

As of March, analysis_drp (the Gen3 port of `pipe_analysis`) automatically makes pipeline quality plots during DRP.

Meet analysis_tools, a redesign of faro/analysis_drp

- shares more **code,** is more **modular,** and **reproducible**:
  - In a notebook, you can load up the exact rows used in an automated metric or plot
  - See video from Nate's demo yesterday @ **Onboarding for SIT-Com In-Kind Contributions**



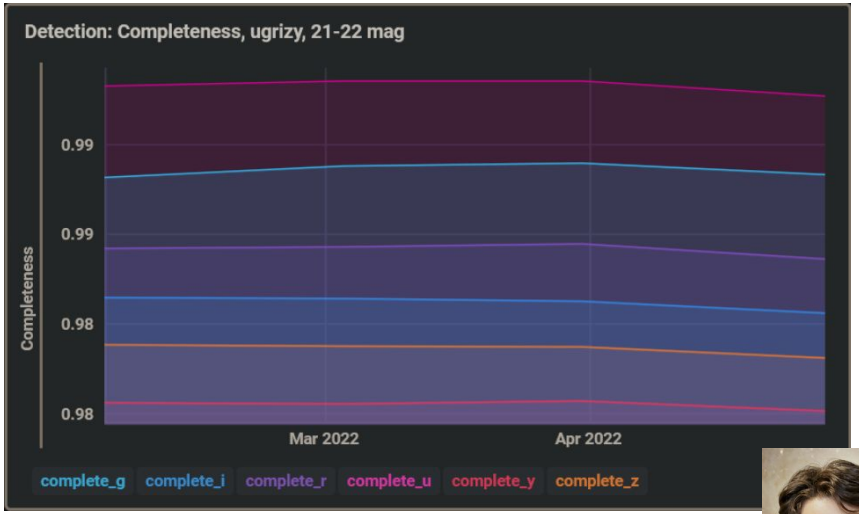
The **metrics** printed on the **plot**, **match** those in the butler and dispatched to SQUASH

Nate Lust

Sophie Reed

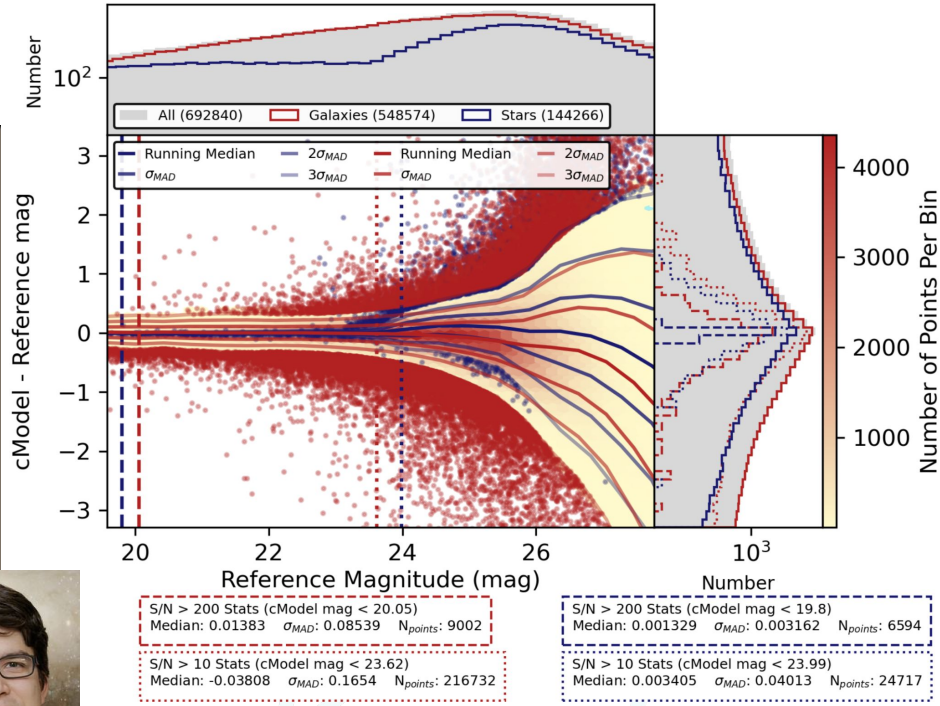
DC2 Truth Match, Plots & Metrics For monthly reruns

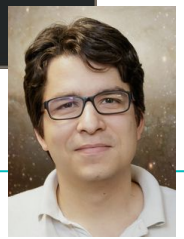
Tasks for probabilistic matching of objectTable_tract w/ reference (truth_summary) Tables in DP0.2; plots/metrics via analysis_tools



Completeness (%)

Date of weekly release



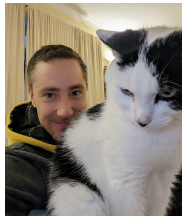


@Dan Taranu

We are using Auxtel for validating calibration products and to prepare for commissioning

- Rubin Observatory's Auxiliary Telescope's spectrograph, LATISS observing ongoing:
  - Using this to design tools to aid commissioning (RubinTV).
  - Commissioning sky transmission code.
- Calibration production code complete for now with 11 calibration types.
- Automated calibration product production at the summit to make/verify daily calibs with OCPS*.
- Tracking calibration/camera evolution by validating quality metrics from these OCPS runs.

@Chris Waters



Merlin Fisher-Levine

@Andrés A. Plazas Malagón

*OCS-Controlled Pipeline System

All-sky camera observations on May 5th 2022

We are using Auxtel for validating calibration products and to prepare for commissioning

- Rubin Observatory's Auxiliary T
  spectrograph, LATISS observing
  - Using this to design tools to aid c
    (RubinTV).
  - Commissioning sky transmission
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  with 11 calibration types.
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  summit to make/verify daily ca
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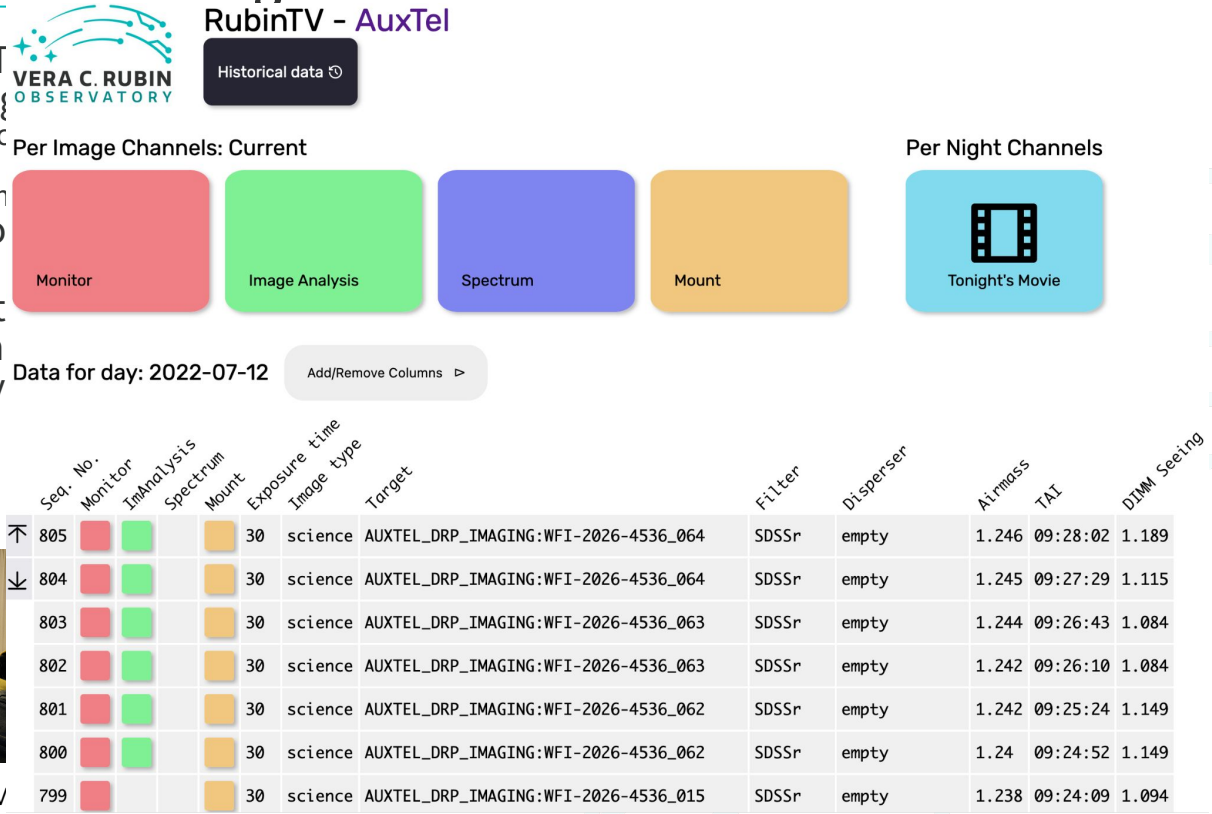


Seq. No.	Monitor	ImAnalysis	Spectrum	Mount	Exposure time	Image type	Target	Filter	Disperser	Airmass	TAI	DIMM Seeing
805					30	science	AUXTEL_DRP_IMAGING:WFI-2026-4536_064	SDSSr	empty	1.246	09:28:02	1.189
804					30	science	AUXTEL_DRP_IMAGING:WFI-2026-4536_064	SDSSr	empty	1.245	09:27:29	1.115
803					30	science	AUXTEL_DRP_IMAGING:WFI-2026-4536_063	SDSSr	empty	1.244	09:26:43	1.084
802					30	science	AUXTEL_DRP_IMAGING:WFI-2026-4536_063	SDSSr	empty	1.242	09:26:10	1.084
801					30	science	AUXTEL_DRP_IMAGING:WFI-2026-4536_062	SDSSr	empty	1.242	09:25:24	1.149
800					30	science	AUXTEL_DRP_IMAGING:WFI-2026-4536_062	SDSSr	empty	1.24	09:24:52	1.149
799					30	science	AUXTEL_DRP_IMAGING:WFI-2026-4536_015	SDSSr	empty	1.238	09:24:09	1.094

@Chris Waters

@Andrés A. Plazas Malagón

M

Running data release production on a one sq. deg. LATISS imaging survey

- One square-degree of the sky as seen by the Auxiliary Telescope
- mapped using the same Feature Based Scheduling algorithm that will control the Large Synoptic Survey Telescope.
- The field is one of the original Harvard Standard Regions used to calibrate the Southern Sky
- This co-added image combines more than 2500 exposures in three different filters (SDSS gri) collected between February and May of 2022.

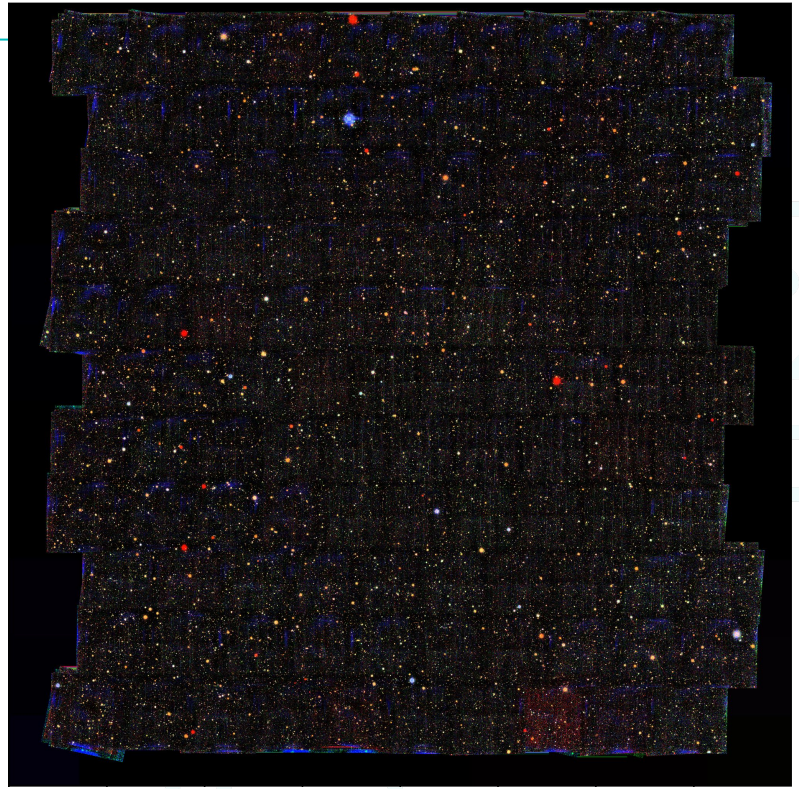


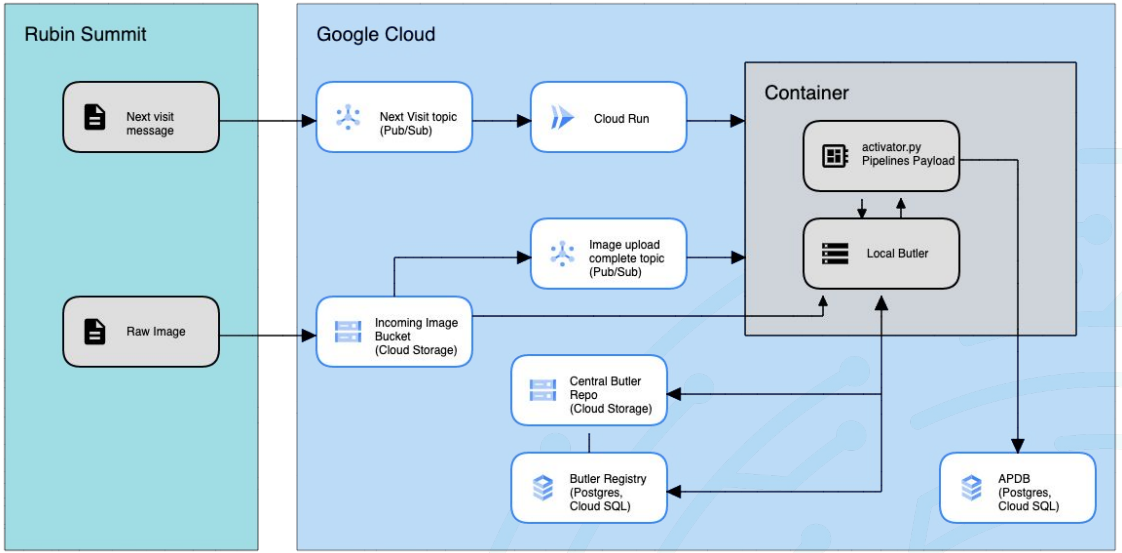
Figure credit: Erik Dennihy

A prototype of the Prompt Processing Framework is in operation at the interim data facility

Meeting AP's 60 sec latency budget requires a specialized execution environment.

A sprint in March 2022 succeeded in running Science Pipelines within a prototype Prompt Processing environment running in Google Cloud.

Future tests with AuxTel and migration to the USDF are planned.





@kfindeisen @parejkoj Eric Bellm

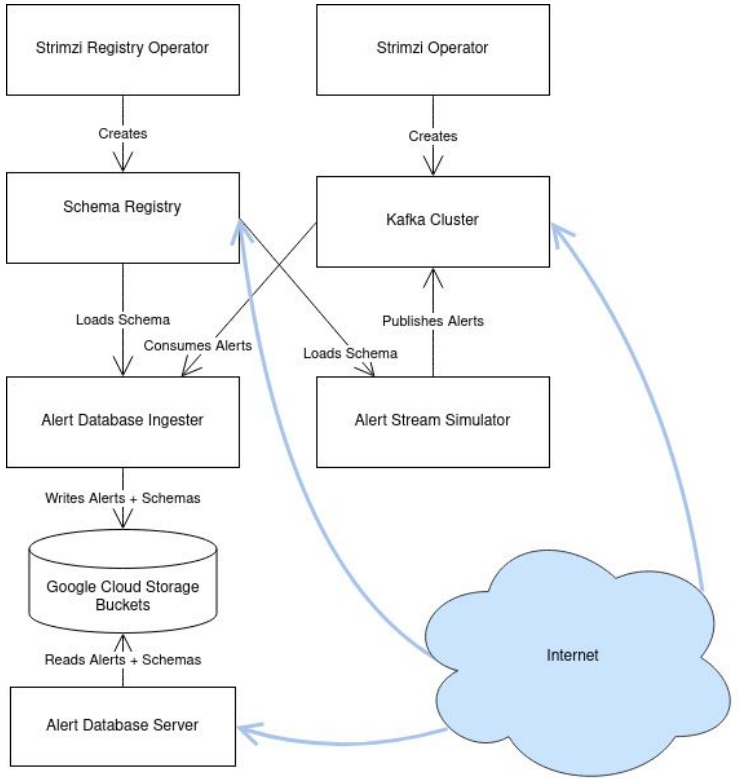
Community Alert Brokers connected to a prototype Rubin Alert Distribution system running in the IDF.

For the first time, we stood up a production-like Kafka cluster and alert archive.

Community broker teams successfully authenticated and received sample alerts during a test run in January 2022.

Next: migratation to USDF.

(Spencer Nelson, Eric Bellm)



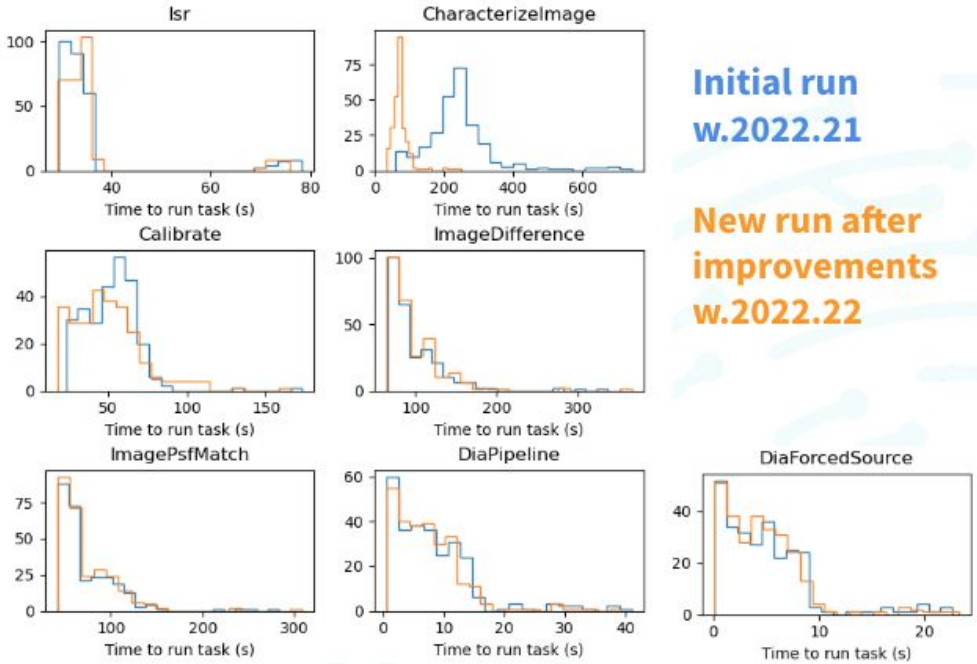
Characterized the Alert Production runtime performance using ImSim data and began optimization

AP must execute within 60s but little performance tuning had been done to date

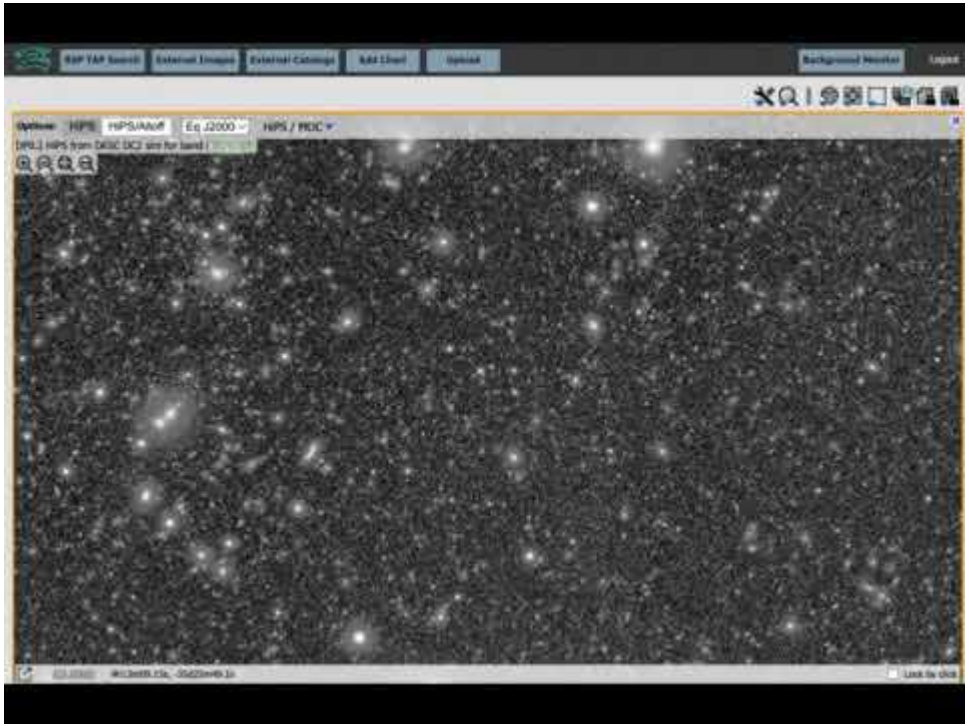
A profiling sprint in May 2022 eliminated nonessential processing, cutting execution time from >400 s to ~200 s on NCSA hardware. See also RFC-857.

Further optimization is ongoing.

@parejkoj Meredith Rawls



Native pipelines code to generate healpix-projected coadds and HiPS trees used for DP0.2



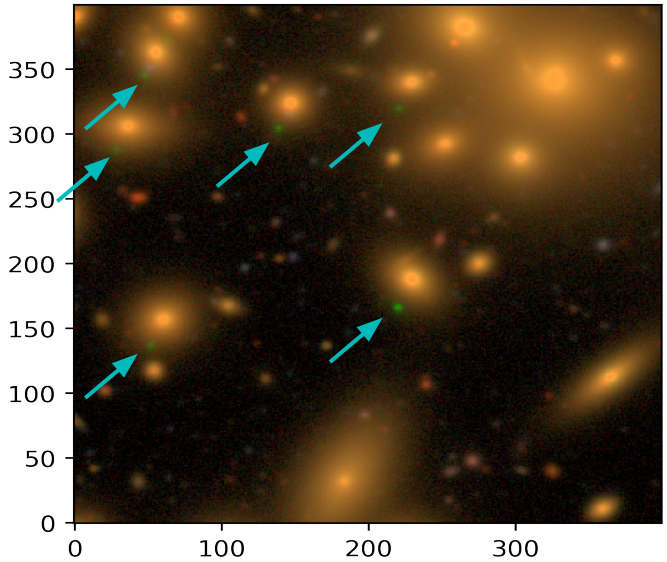
i-band DP0.2 HiPS viewer

- ugrizy + gri color HiPS maps generated

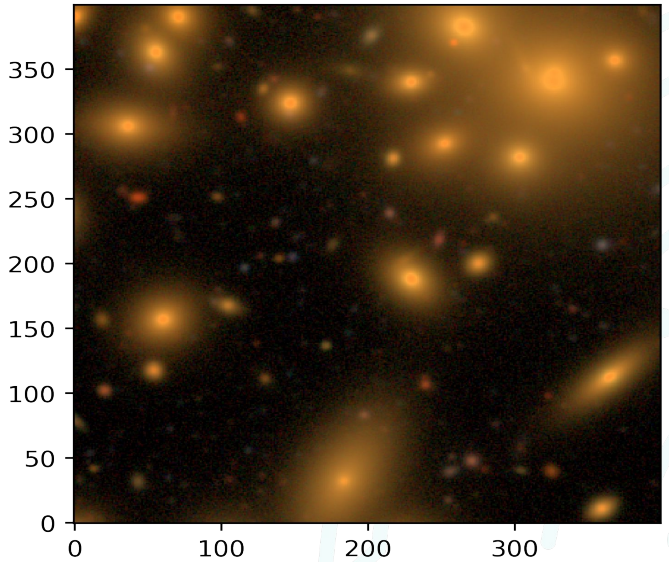
Eli Rykoff

Pipeline features: Stricter guards against bad single-frame measurement astrometric fits from getting into the coadds

DP0.1 processing:
-> note unphysical “green peas”



DP0.2 processing:
-> unphysical “green peas” are gone



Lauren MacArthur

Pipeline features: Stricter guards against bad single-frame measurement astrometric fits from getting into the coadds

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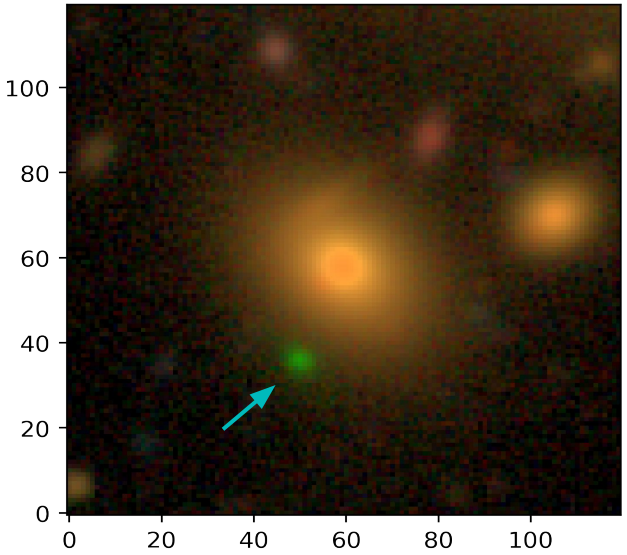

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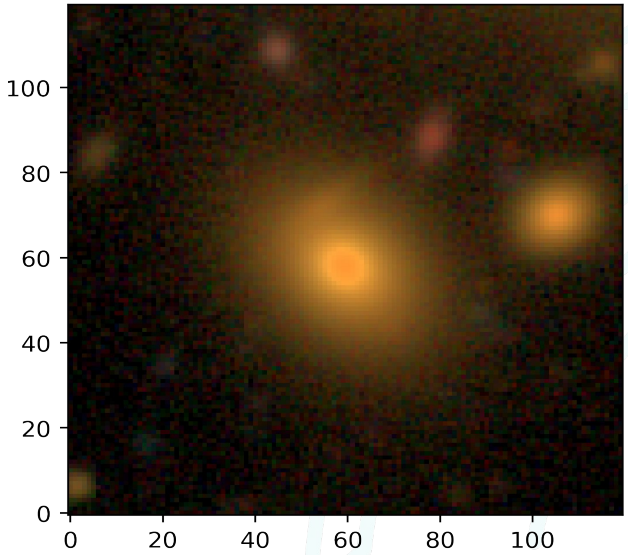

Lauren MacArthur

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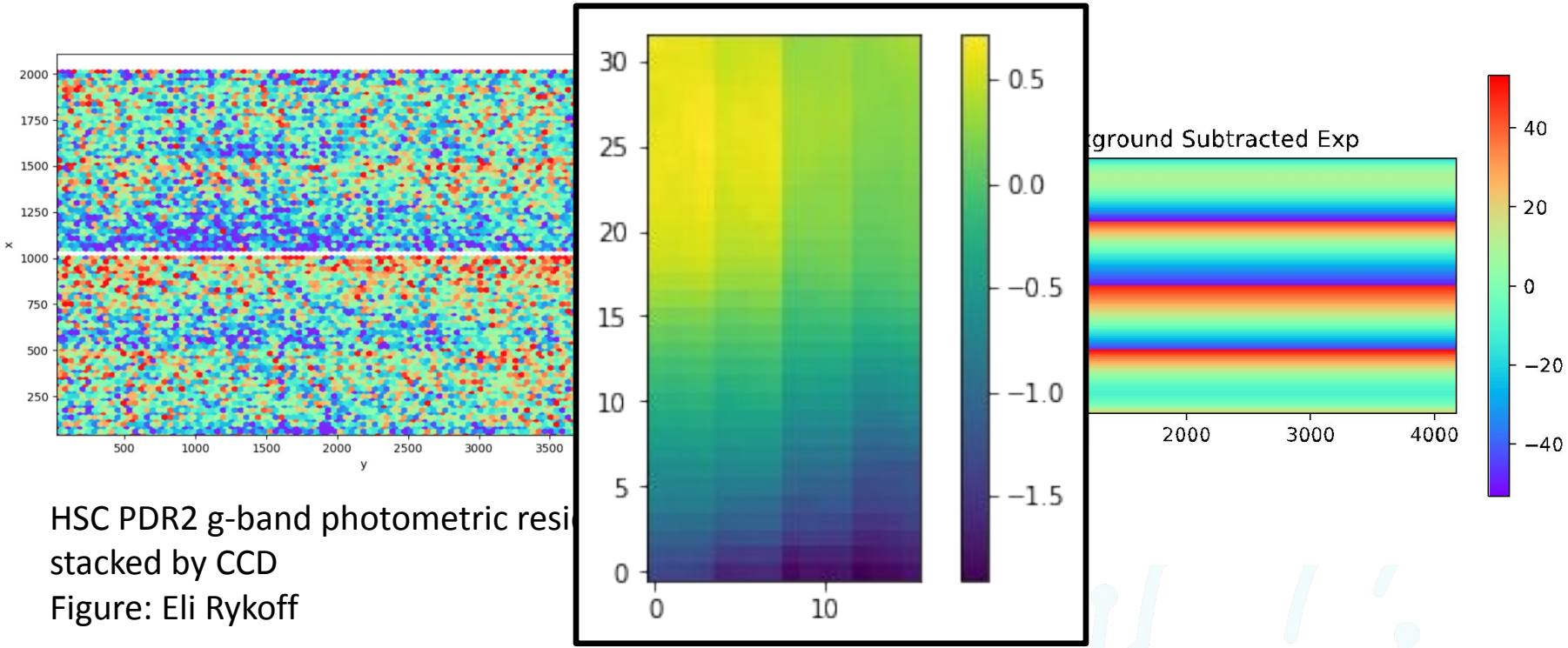
Updates on algorithmic components

Pipeline features: what's new in **background estimation**
Pan-STARRS "pattern continuity" (a.k.a amp-to-amp matching)



HSC PDR2 g-band photometric resi
stacked by CCD
Figure: Eli Rykoff

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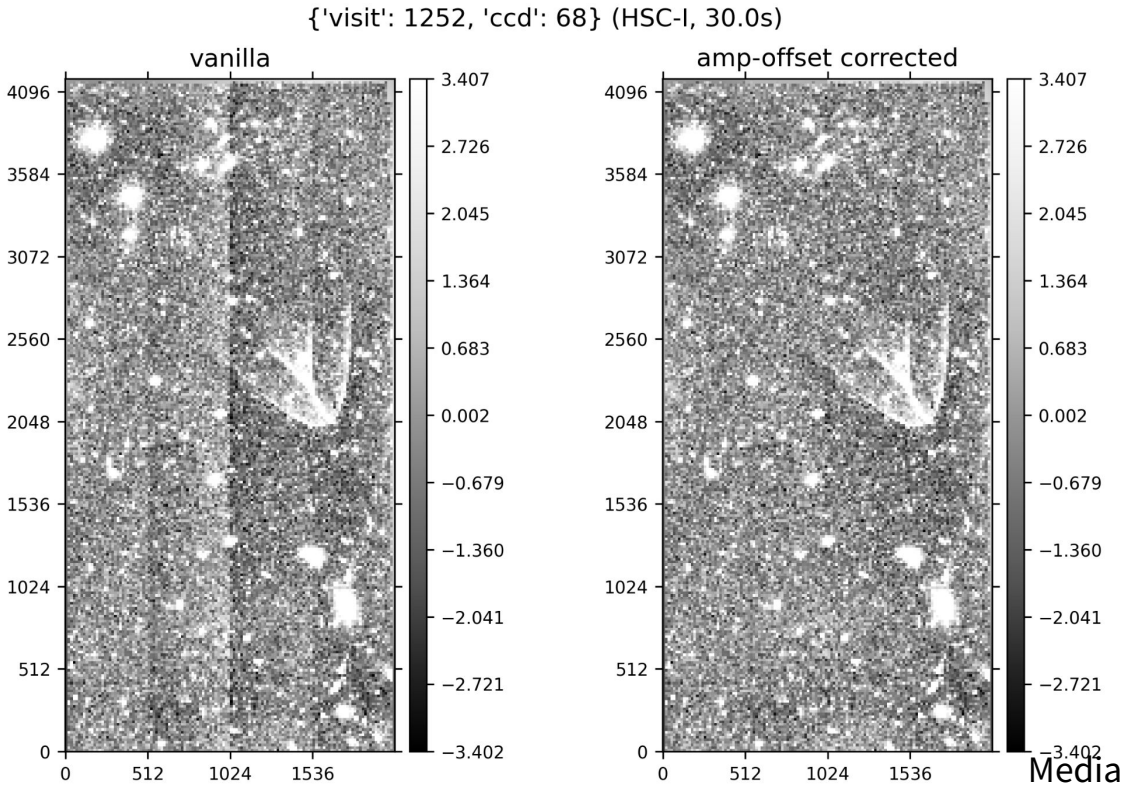
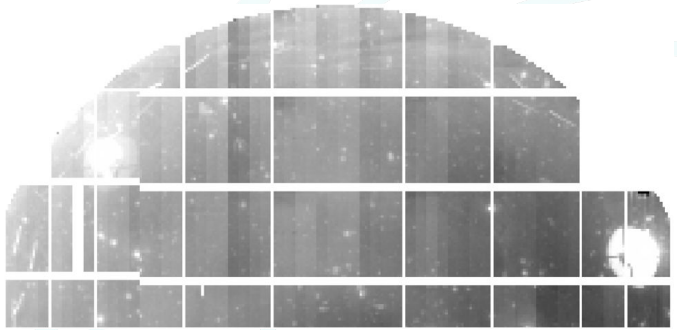


Lee Kelvin



Median binned (128x128) HSC-I visit=1252 (short exp)

Pipeline features: what's new in **photometric calibration**

Where we've been:

- ~5 mmag uniformity and repeatability

Where we are. New for HSC-PDR4 we:

- Better handle of survey edges. Survey edges are more dependent on reference stars because the coverage is thinner. In PDR3, the reference stars were more heavily weighted. NOW, we are more robust to reference star outliers, by looking at statistics of the full focal plane.
- Better handling of HSC-I/HSC-I2, HSC-R/HSC-R2. In PDR4, Tanaka-san will not have to do the stellar locus regression.

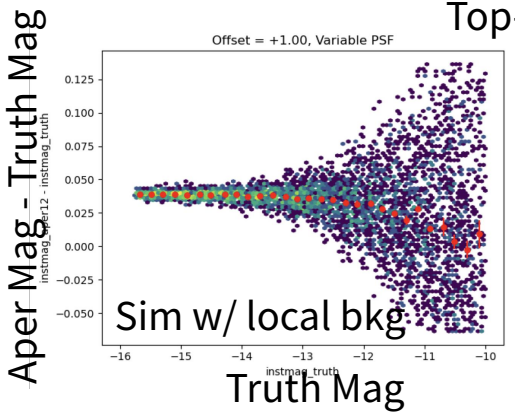
Where we are going:

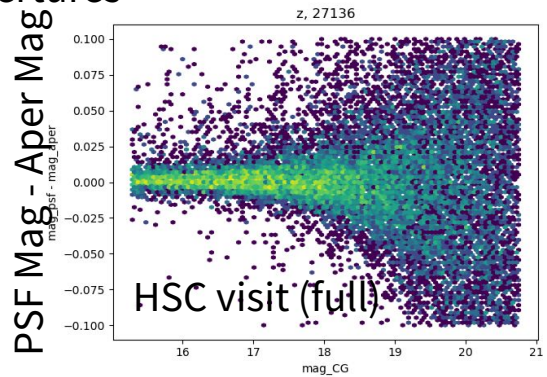
- Background estimation is the limiting factor
- Pursuing local backgrounds via "Compensated aperture fluxes"

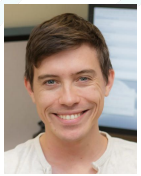
Compensated Filter Fluxes show promise for mitigating local backgrounds for photometric calibration

- Robert Lupton suggests “compensated filter” fluxes – fancy name for local background subtraction
- Nate Lust made first implementation of a “Gaussian Compensated Filter”
  - Immune to local background offsets
  - Higher signal-to-noise at faint end vs top-hat apertures.

Top-hat apertures







Nate Lust

Eli Rykoff

Compensated Filter Fluxes show promise for mitigating local backgrounds for photometric calibration

- Robert Lupton suggests “compensated filter” fluxes – fancy name for local background subtraction
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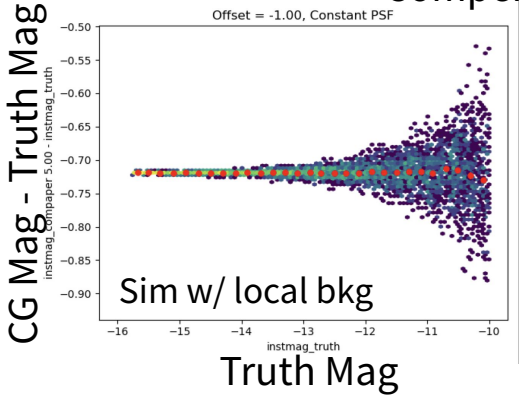
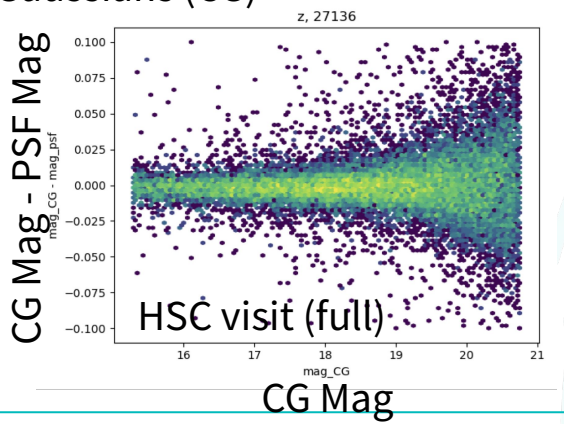
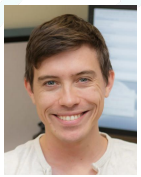
  - Higher signal-to-noise at faint end vs top-hat apertures.

Compensated Gaussians (CG)







Nate Lust

Eli Rykoff

Pipeline features: what's new in **PSF Estimation**
Where we've been: PIFF PixelGrid is now the default PSF model

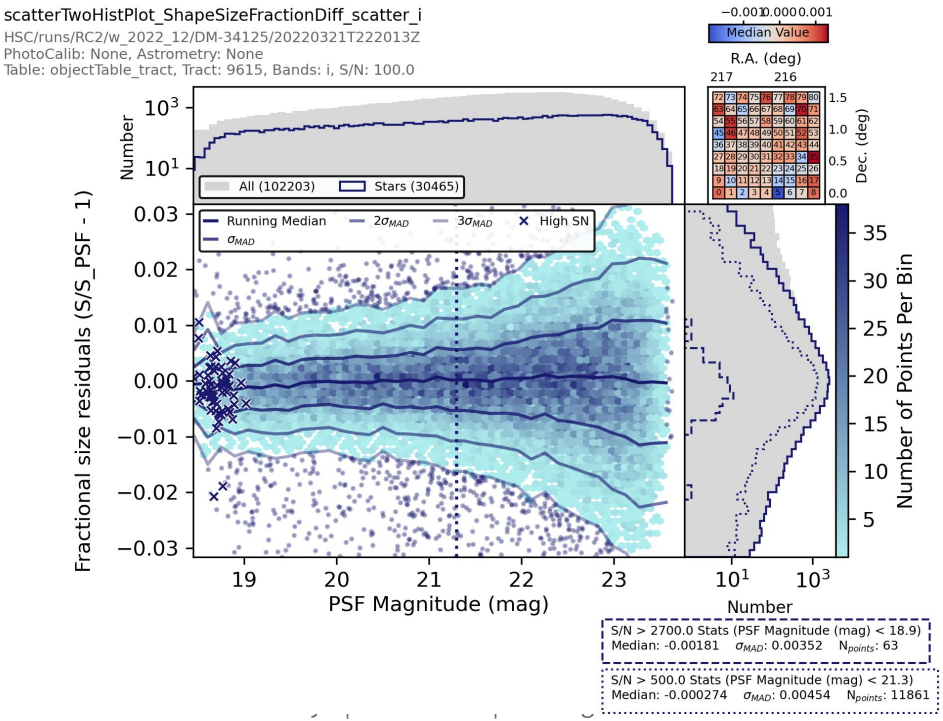
- Repeatable star selection for PSF Modeling (Rykoff)
  - Now associating isolated stars in Source Catalogs so that same stars are used for PSF Estimation in every visit.

- Switched default PSF modeling algorithm from PSFex to Piff in the DRP Pipeline w_2022_14
- The commissioning process yielded 2 PIFF config tweaks:
  - **kernelSize = 21 → 25**
  - **Interp = galsim.Lanczos(3) →galsim.Lanczos(11)**
    - PixelGrid needs to specify an interpolant to define how to values between grid points are determined from the pixelated model. Any galsim.Interpolant type is allowed. The default interpolant is galsim.Lanczos(3)

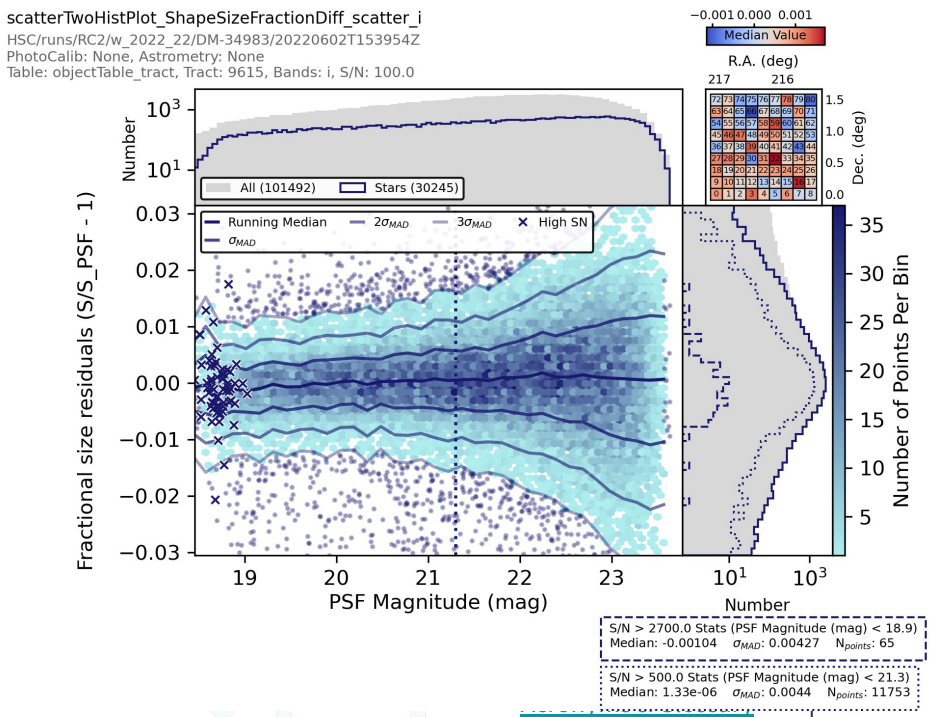
Josh Meyers Arun Kannawadi

Pipeline features: what's new in **PSF Estimation**
Where we are: Comparable performance with PIFF

w_2022_12: Last HSC rerun with PSFEx



w_2022_22: 3rd HSC rerun with PIFF

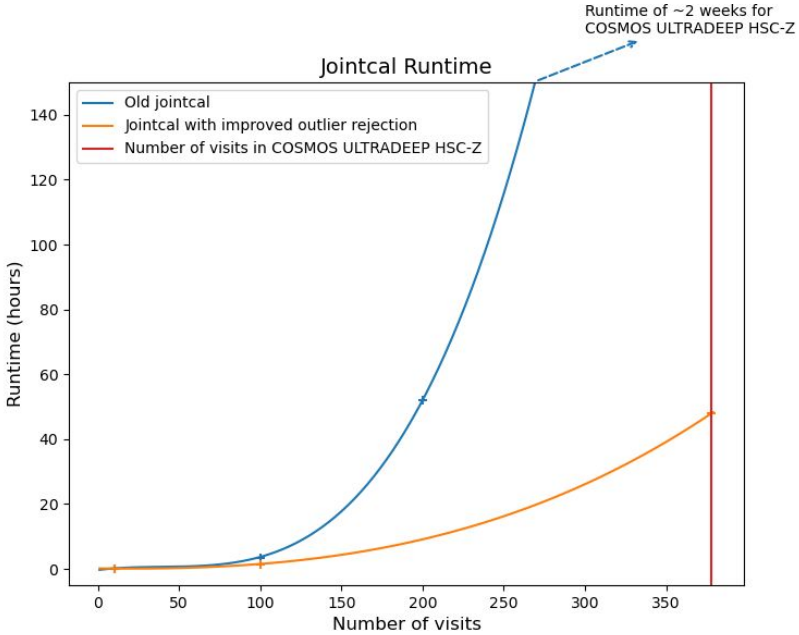


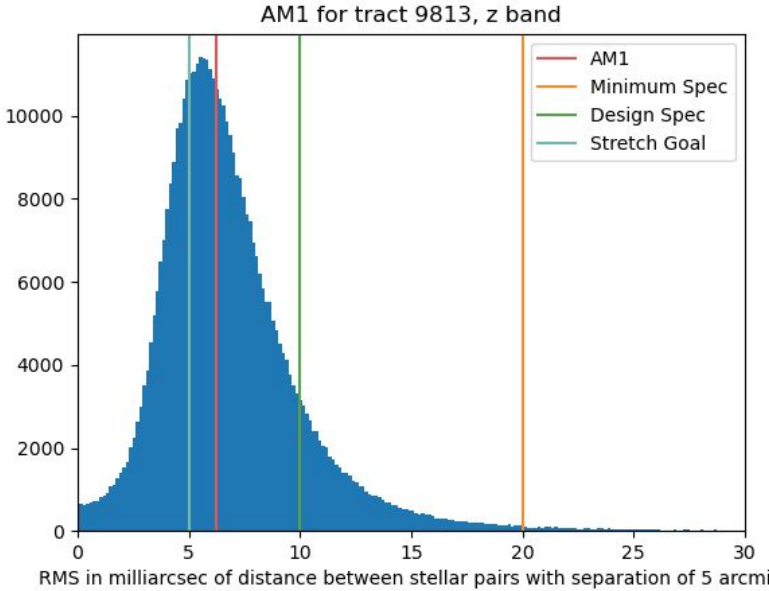
Pipeline features: what's new in **PSF Estimation**
Where we're going: PIFF fitting in SkyCoords

- Next step is to switch over to fitting in Sky Coordinates instead of Pixel Coordinates
- Incorporating camera-distortion model
- Advantage of PIFF is that it is in active development and new features added to PIFF are available to us.

Pipeline features: what's new in **astrometric calibration**
Where we've been

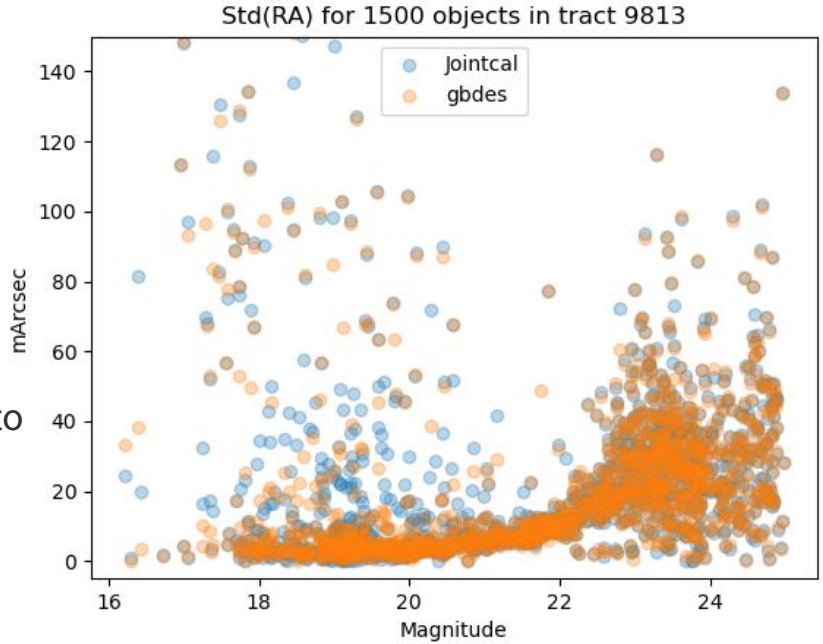
- For HSC PDR4, the Jointcal package is still being used for astrometric calibration
  - Improved outlier rejection algorithm yields a faster runtime





Pipeline features: what's new in **astrometric calibration**
Where we are — Adding the gbdes package

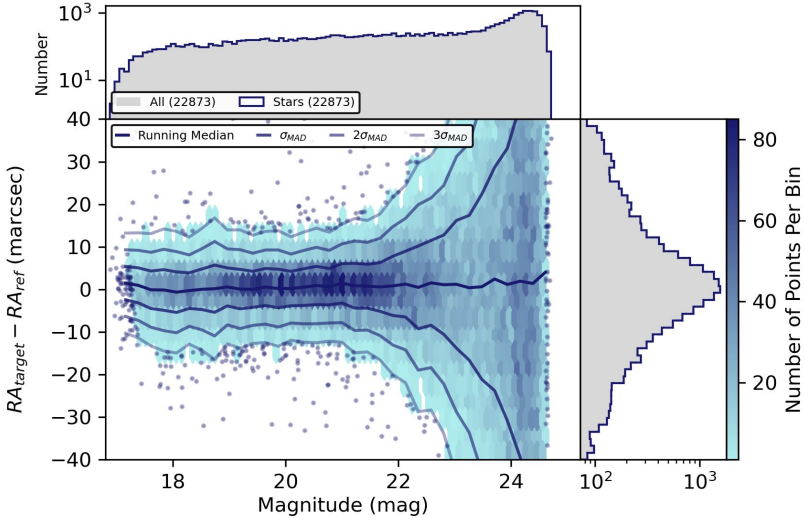
- GBDES is a C++ package for fitting the astrometric solution developed by Gary Bernstein for DES (see Bernstein+2017, arXiv:1703.01679):
  - Implements **fitting of proper motion and parallax**.
  - Is significantly **faster for large datasets.**
  - Can **accommodate effects like tree rings** and can use adaptations to the mapping between pixels and the sky.
- Current Status:
  - GBDES has been refactored to make its interface more object-oriented and adaptable to wrapping in Python.
  - A Pybind11 wrapper and new build system have been added to GBDES.
  - A `PipelineTask` drop-in replacement for Jointcal is being added to the DRP pipeline.
  - As expected, GBDES performs equivalently to Jointcal with equivalent model parameters, as expected (see right).



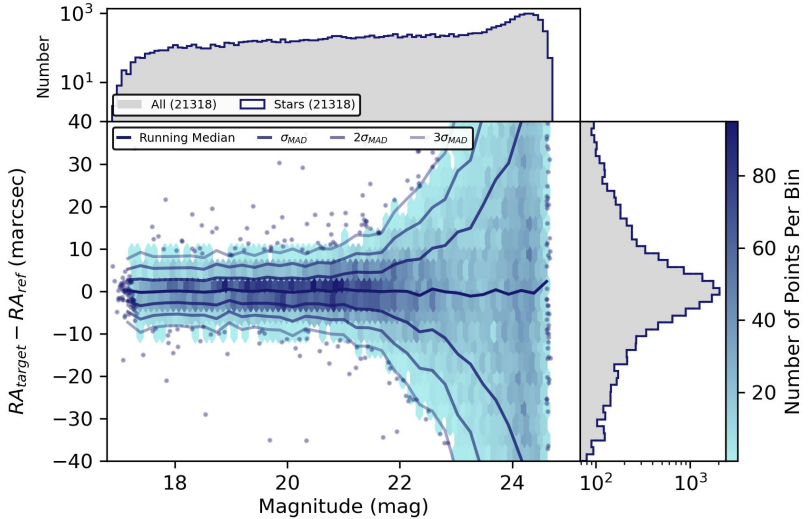
Pipeline features: what's new in **astrometric calibration** Where we are going

- We are currently in the final stages of adding GBDES to the DRP pipeline.
- After establishing the baseline performance, proper motion fitting will be turned on, taking advantage of the proper motion information in the GAIA catalog.

Without fitting proper motions

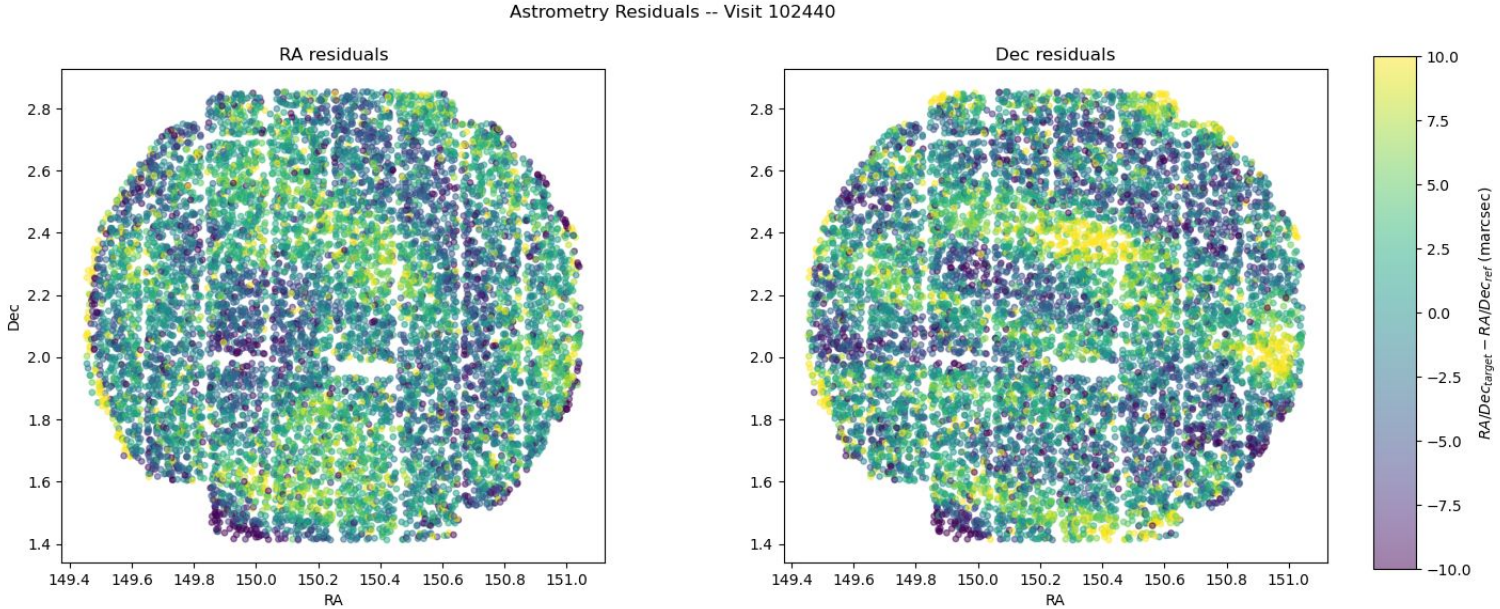


Fitting proper motions



Pipeline features: what's new in **astrometric calibration** Where we are going

- Next steps: accounting for atmospheric effects
  - Fortino+ 2020 and Leget+ 2021 showed good results fitting out atmospheric results using Gaussian Processes

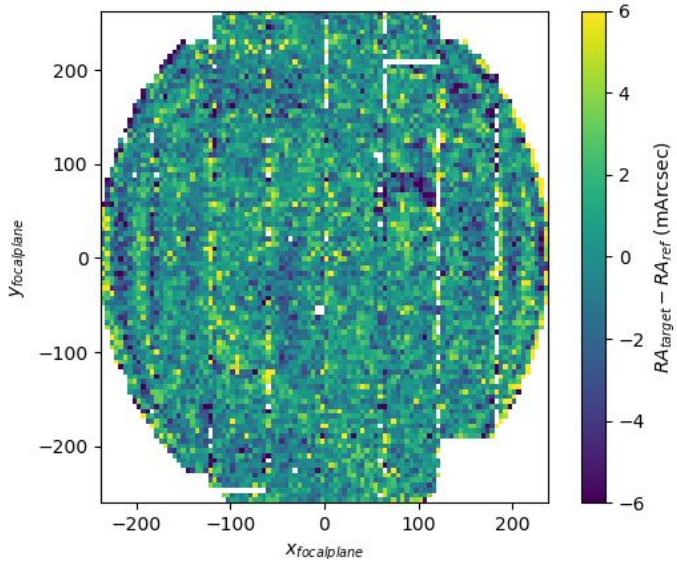


Pipeline features: what's new in **astrometric calibration** Where we are going

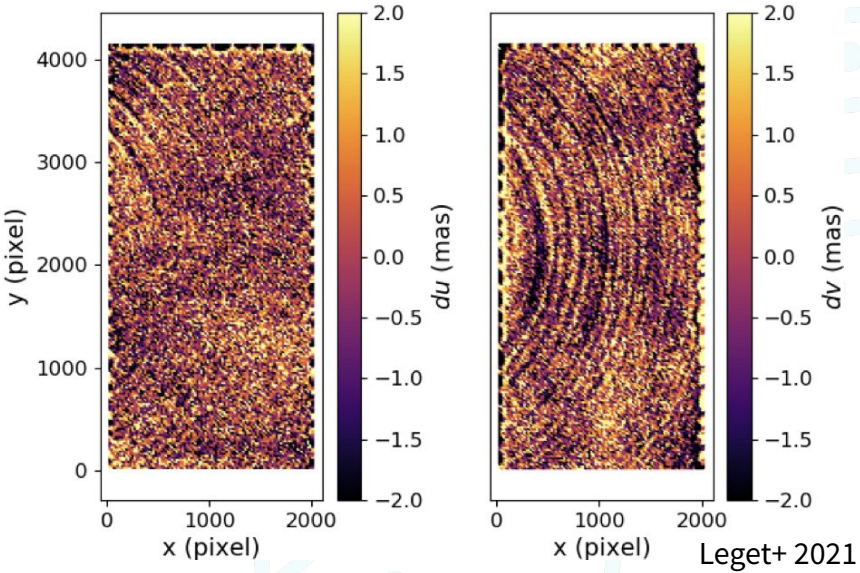
- Next steps:
  - Accounting for subtler effects from the camera geometry and detectors
  - Changes in the camera over time

Average Residuals over Focal Plane

Using simple model to highlight camera geometry



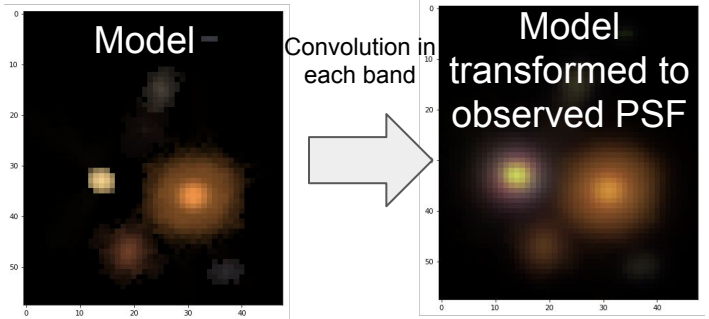
Average Residuals over ~100s of HSC Visits for one CCD



Leget+ 2021

Pipeline features: what's new in **deblending**
Multi-band deblending with scarlet (w_2021_05 to w_2022_08)

- Processing with scarlet
  - Improvement over the single-band blender by taking advantage of color information
  - Generates a model in partially deconvolved space and convolves to each observed band in the appropriate pixel grid
- Designed to be an all-purpose deblender
  - Capable of joint processing of images from ground, space, grism, etc.
  - Requires a complicated framework to handle transformations
  - Uses autograd to calculate gradient updates during optimization



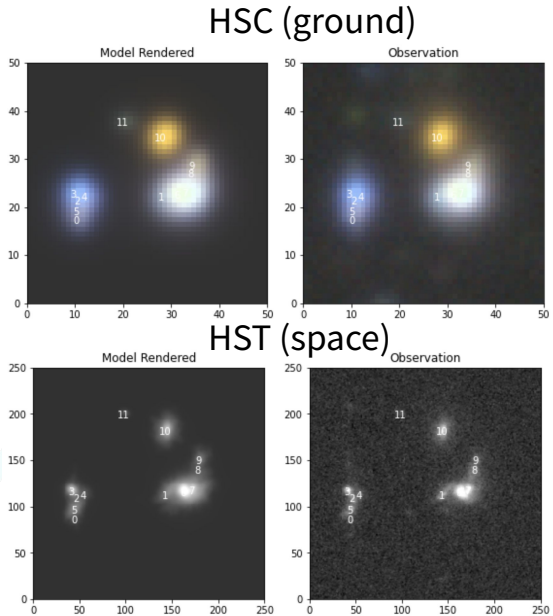
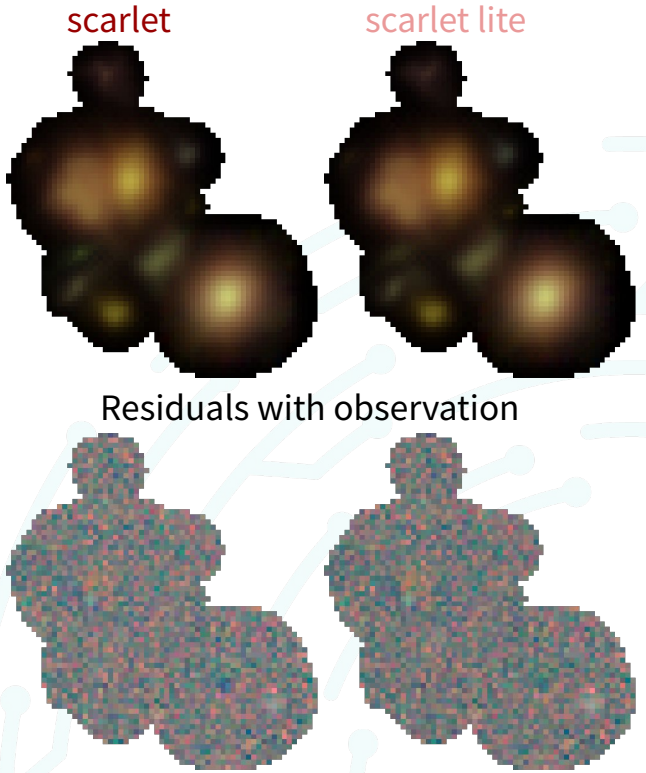


Image credit:
https://pmelchior.github.io/scarlet/tutorials/multiresolution.html

Pipeline features: what's new in **deblending**
Deblending during operations

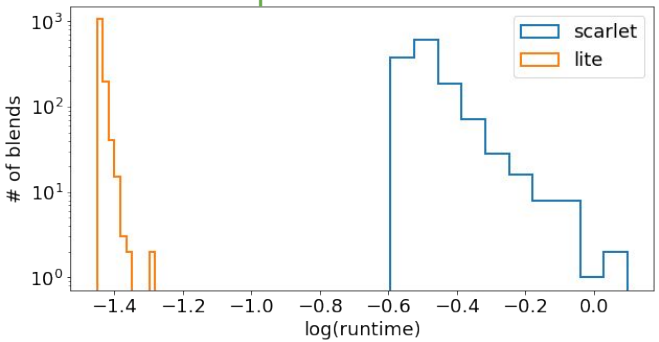
- Use the deblender with the best demonstrated performance at scale
- Currently the plan is to use scarlet-lite: an *algorithmically identical* version of scarlet *optimized for performance with Rubin data*
  - Changes from scarlet to scarlet-lite
    - **Analytic Gradients** (removal of autograd for calculating gradients)
    - Significant changes in the class hierarchy for faster development
  - Works because LSST coadds are already re-projected onto the same pixel grid and our models are simple
- Models should be available to end users to deconstruct blends and even sources
- Metrics will provide tools for evaluating the effectiveness of the deblender and identify blends, or portions of blends, that likely failed
- We're still evaluating algorithms for quantifying the model errors and are open to suggestions



Pipeline features: what's new in **deblending**
scarlet-lite (beginning in w_2022_08)

- We recently ran both scarlet main and scarlet lite on all of the parent blends in an HSC RC2 patch (tract 9813, patch 40) with between 3-10 children
  - max scarlet memory used: 526.5 MB
  - max scarlet lite memory used: 5.7 MB
- Outputs include the scarlet lite models, offering significant savings in disk space for measurement catalogs

Improved runtime



Compression improves storage

Output (patch, rc2_subset)	**Previous disk space**	**Compressed disk space**
Deblender catalog	1.5G	112M
Measurement catalog	1.9G	787M
Forced phot catalog	2.0G	345M

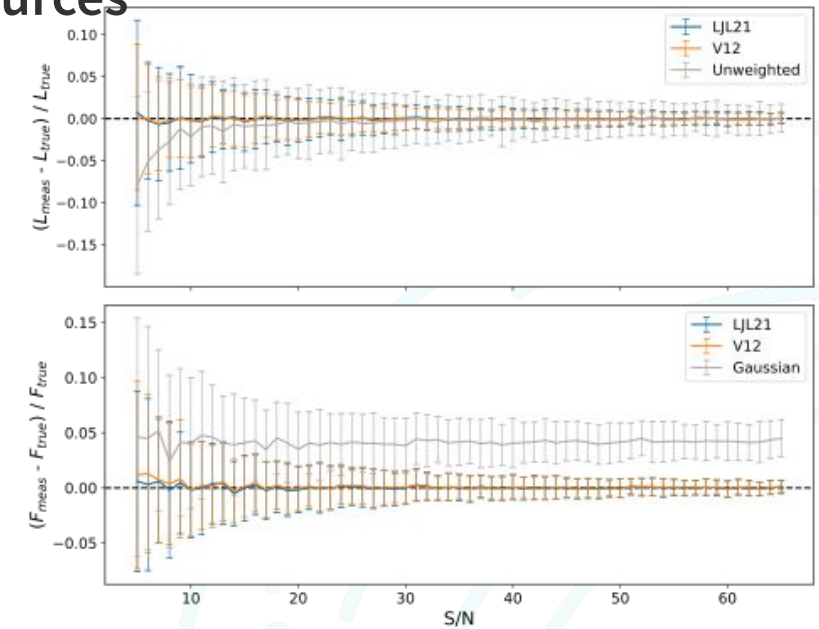
Pipeline features: what's new in **image differencing**

Where we've been

Image Differencing now measures trailed sources

- Implements a fast, semi-analytic, fitting technique using adaptive 2nd order moments
- Estimates the centroid, flux, length, angle, and uncertainties.
- Now run by default in image differencing
- https://github.com/lsst/meas_extensions_trailedSources
- Source injection code can also now create trailed sources

Figure Credit
Zach Langford



Marginal precision difference between moments and Veres et al 2012 algorithms. ~10x speed up, and less variance in compute time.

Pipeline features: what's new in **image differencing**
Where we've been

The image differencing pipeline has been refactored.

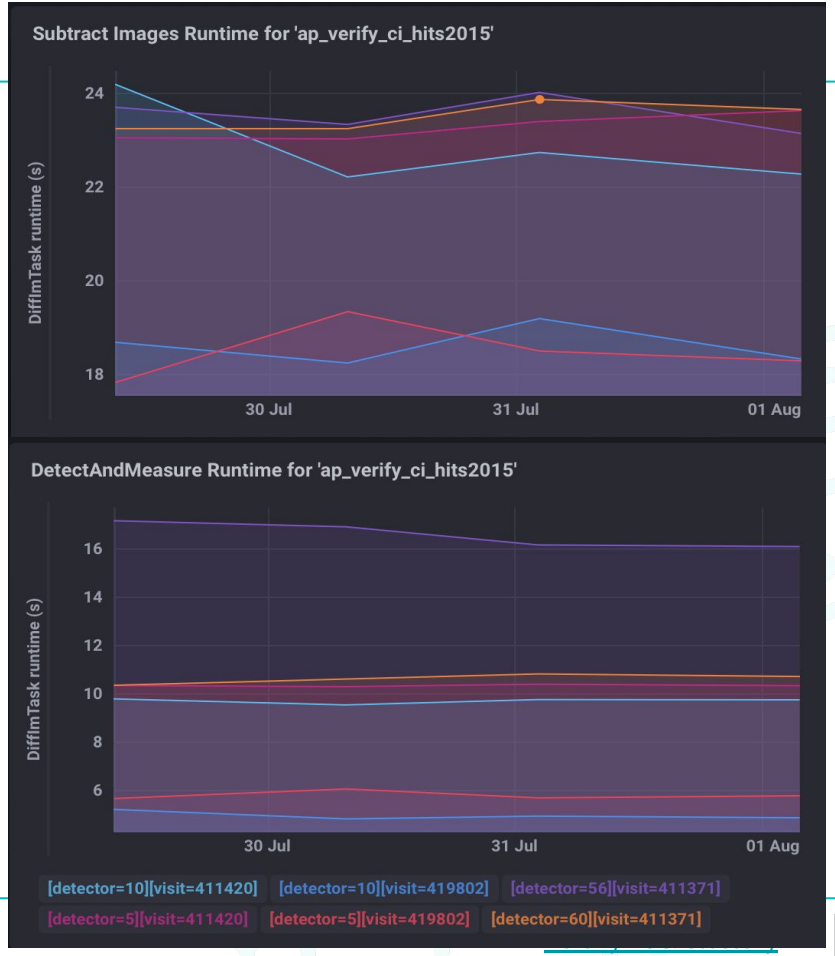
- The new design is more modular and leverages pure Gen 3 capabilities
- Instead of `lsst.pipe.tasks.ImageDifferenceTask`, the image differencing pipeline now consists of three steps:
  - `lsst.ip.diffim.GetTemplateTask`which constructs the warped and cropped (and possibly DCR-corrected) template exposure.
  - `lsst.ip.diffim.AlardLuptonSubtractTask`which PSF-matches either the template or science image, and subtracts the template from the science image.
  - `lsst.ip.diffim.DetectAndMeasureTask`which runs source detection and measurement on the difference image, including adding sky sources and forced measurement.

Pipeline features: what's new in **image differencing**
Where we are

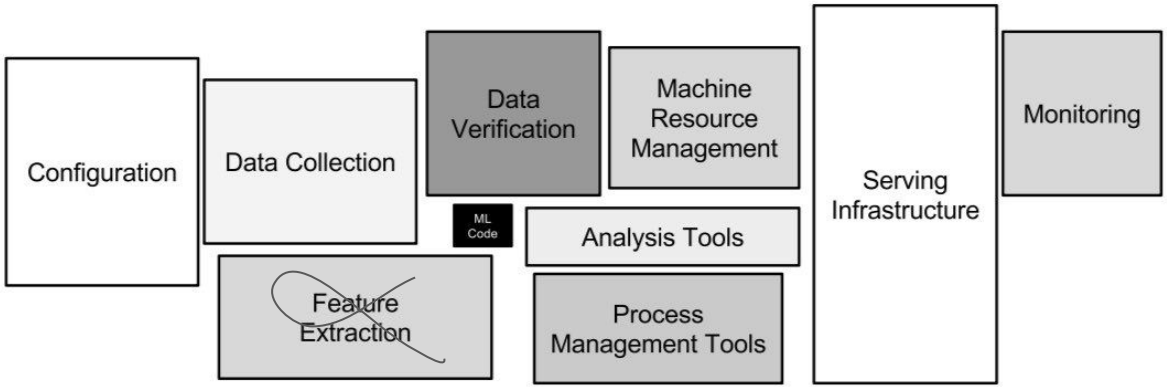
- The AP and DRP pipelines have both been switched to use the new image differencing Tasks.
- The new pipeline is configured to produce very similar results to the old pipeline, though that will soon change as we take advantage of the new framework to fix bugs and add new features.
- New features coming soon:
  - Programmatic convolution of the science or template image, depending on seeing
  - Preconvolution with the science image PSF, and DiaSource detection on the maximum likelihood image

Pipeline features: what's new in **image differencing**

Chronograf metrics mostly unchanged

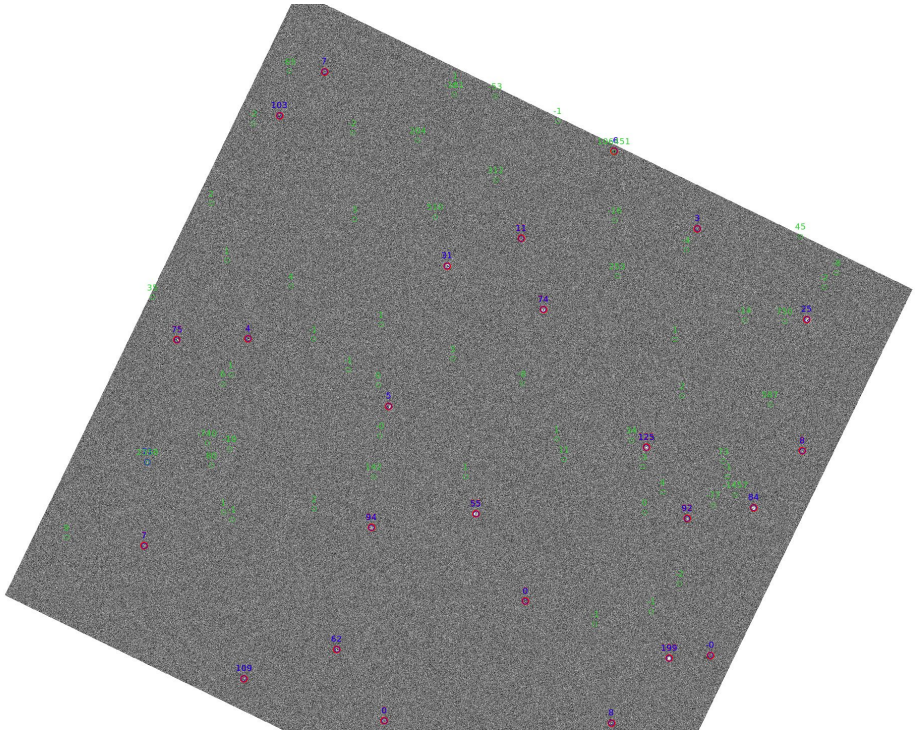


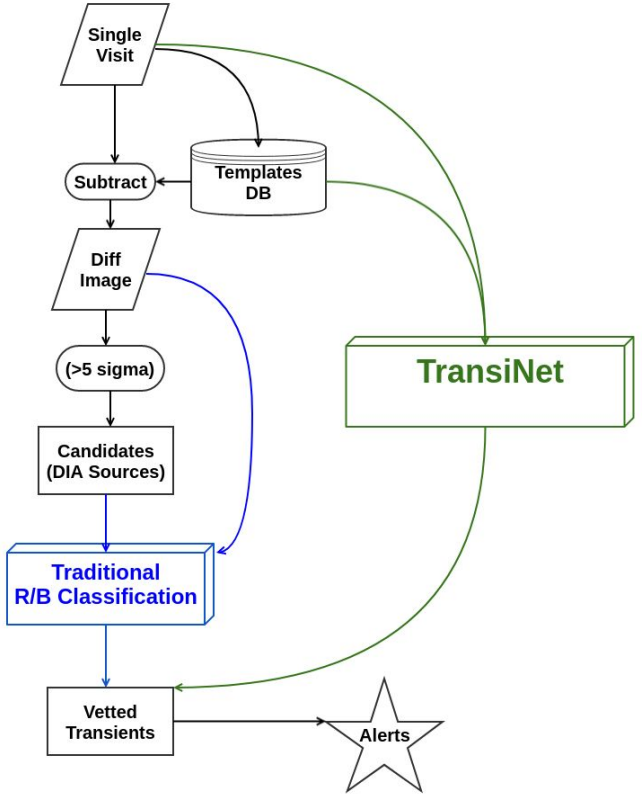
Pipeline features: what's new in **image differencing**
Where we are going: implementing **learning-based source scoring**



Sculley, D., Holt, G., Golovin, D., Davydov, E., Phillips, T., Ebner, D., Chaudhary, V., Young, M., Crespo, J.F. and Dennison, D., 2015. Hidden technical debt in machine learning systems. *Advances in neural information processing systems*, *28*.

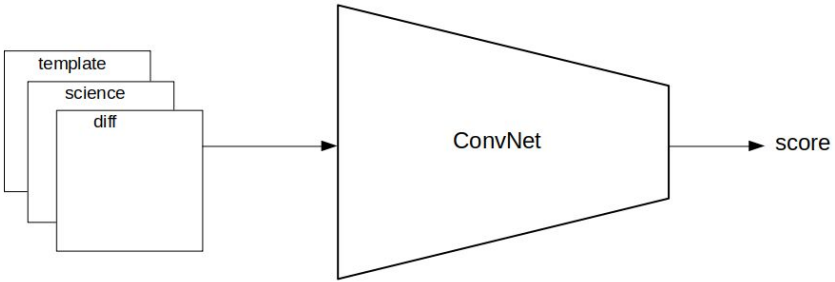
Pipeline features: what's new in **image differencing**
Learning- based Transient Detection: 2 || Avenues





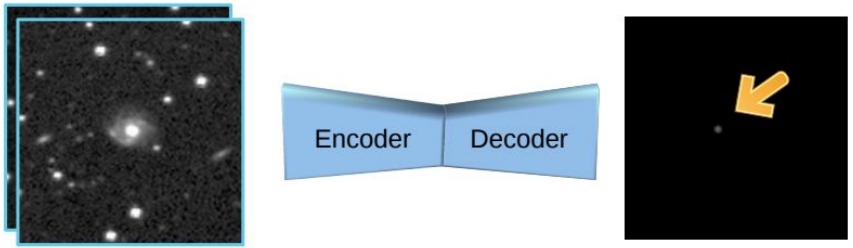
Pipeline features: what's new in **image differencing**
Learning- based Transient Detection: 2 || Avenues

Binary Classification
Discriminative



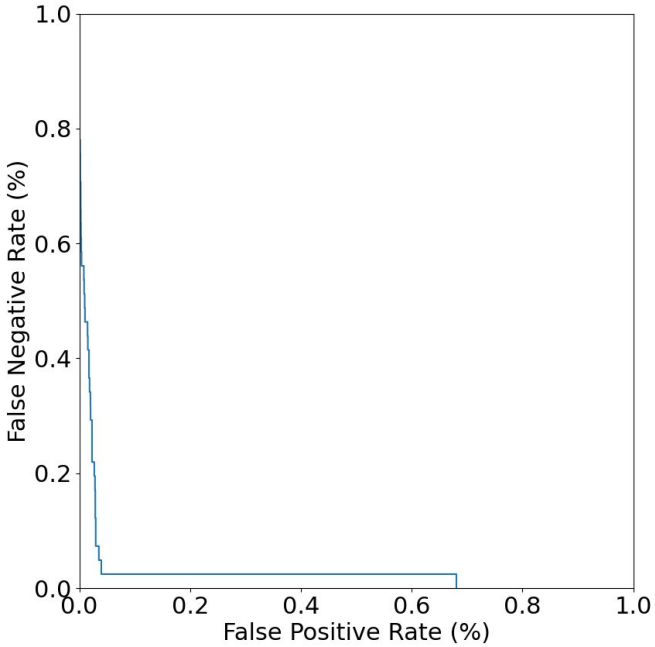
- \- Helps with Purity, only
- \- Single candidate at the patch center, only → ill-defined
- \+ Comparable to existing traditional implementations

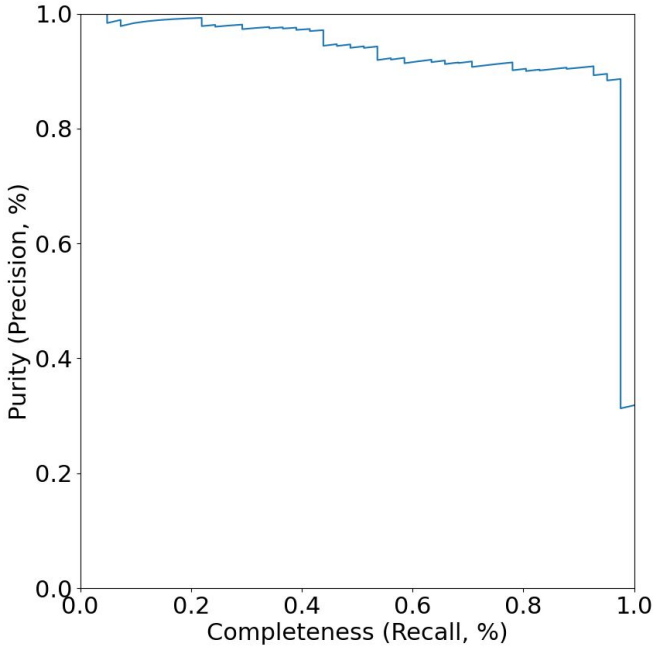
End2End TransiNet
~Generative

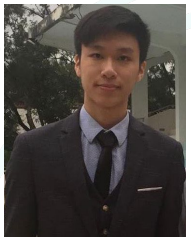


- \+ Helps with Purity and **Completeness**
- \+ **Any number** of candidates, **Anywhere**
- \+ Independent of Diff (is a diff method on its own)
- \+ Processes the **Whole Visit** at once (near future)

Pipeline features: what's new in **image differencing**
Real/Bogus Classifier – Current Status (DC2)

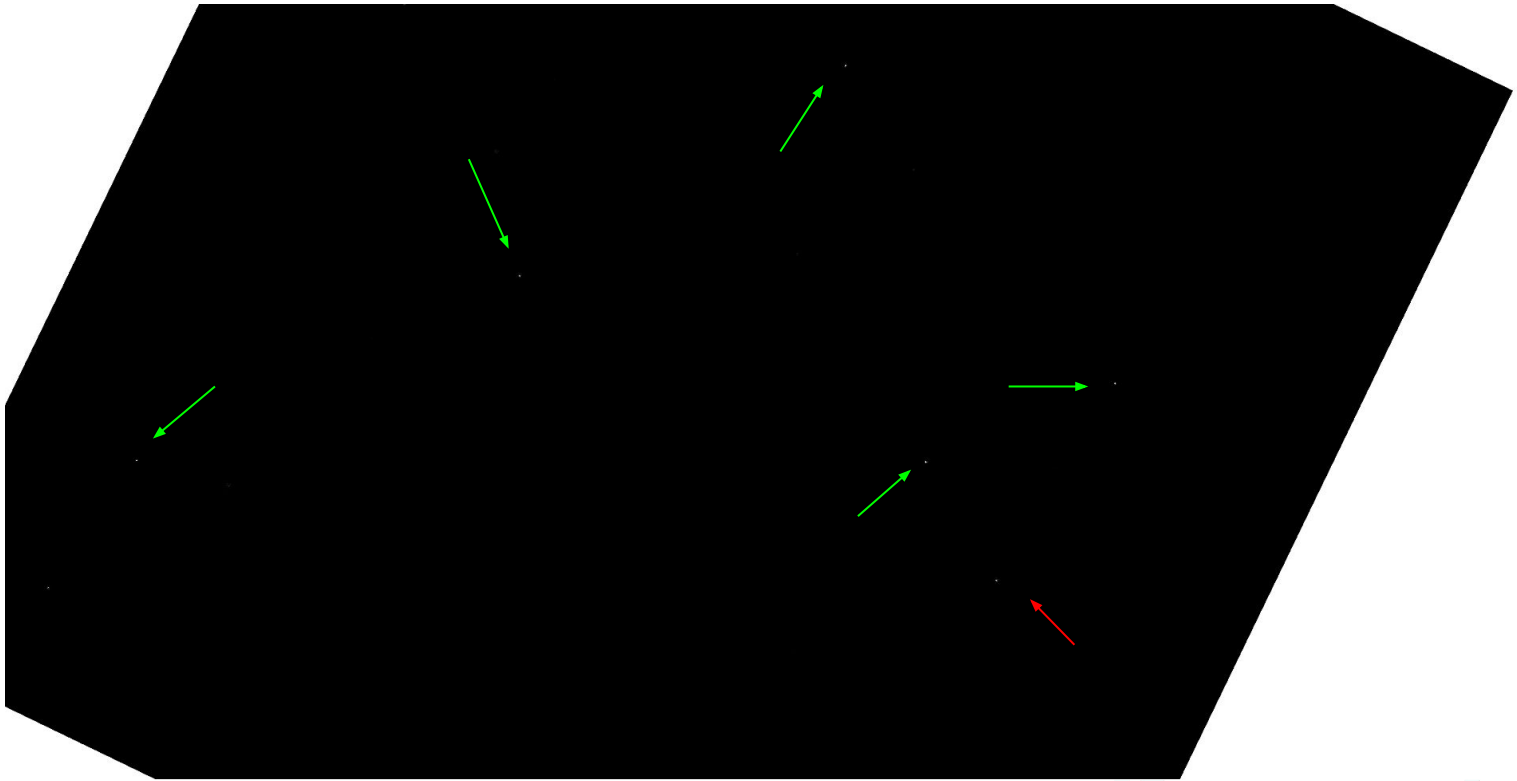




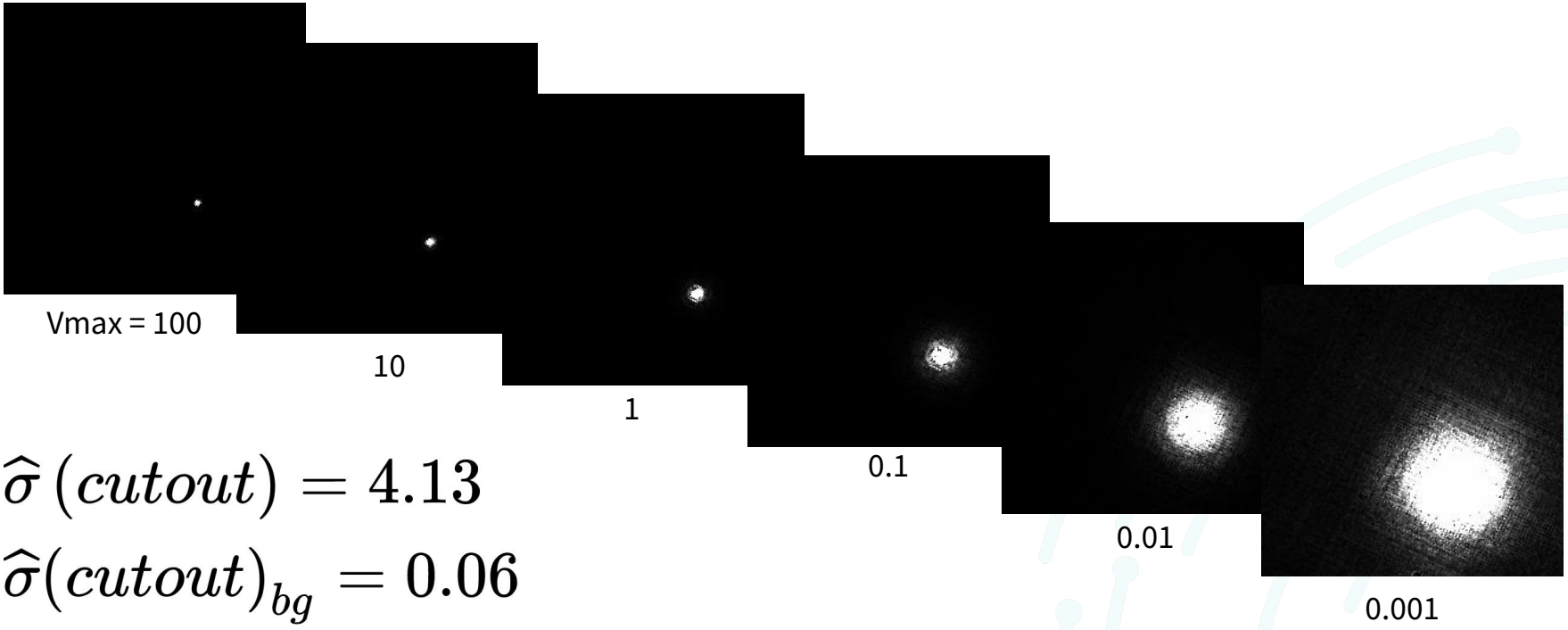


Arif Chu

Pipeline features: what's new in **image differencing**
TransiNet – Current Status (DC2)



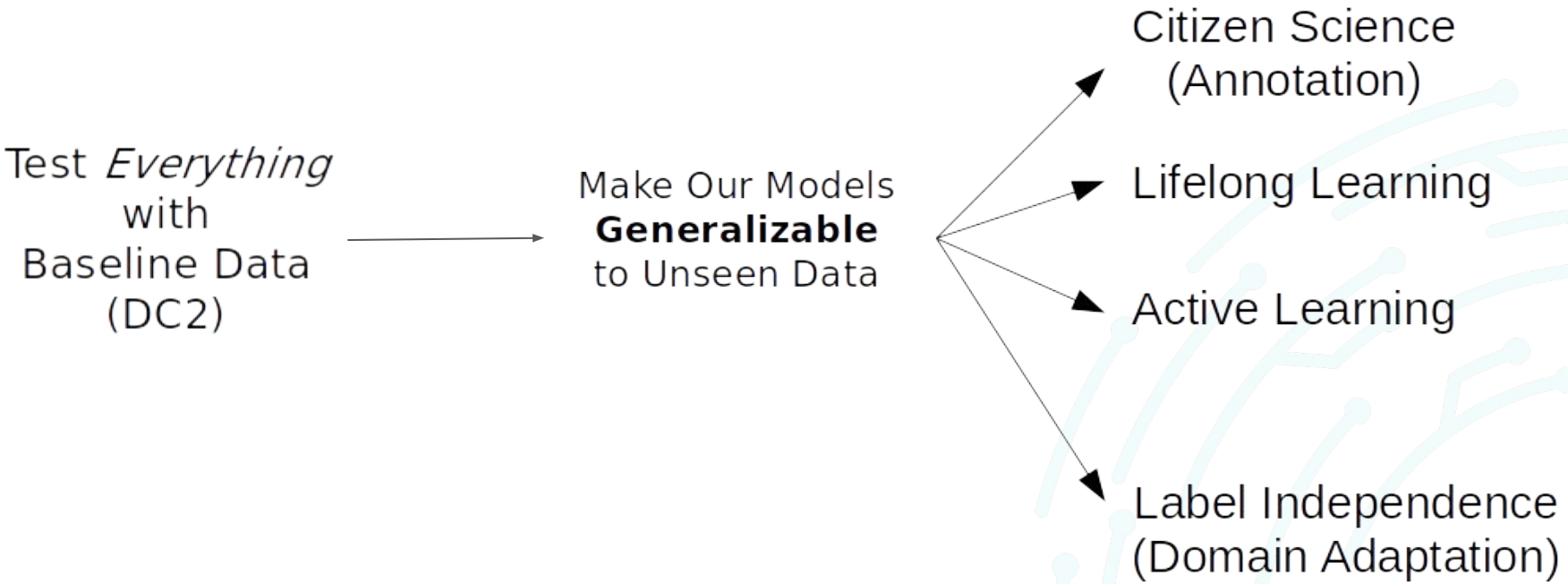
Pipeline features: what's new in **image differencing**
TransiNet: Diff Image Quality



$$\hat{\sigma}\left(cutout\right) = 4.13$$

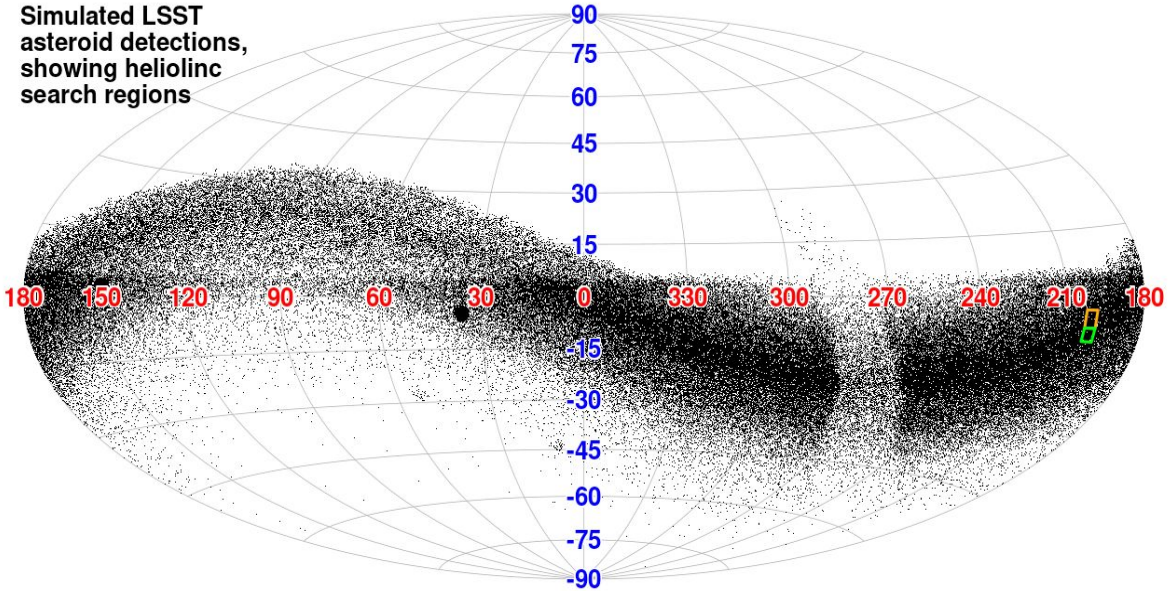
$$\hat{\sigma}(cutout)_{bg} = 0.06$$

Pipeline features: what's new in **image differencing**
Learning- based Transient Detection: Future



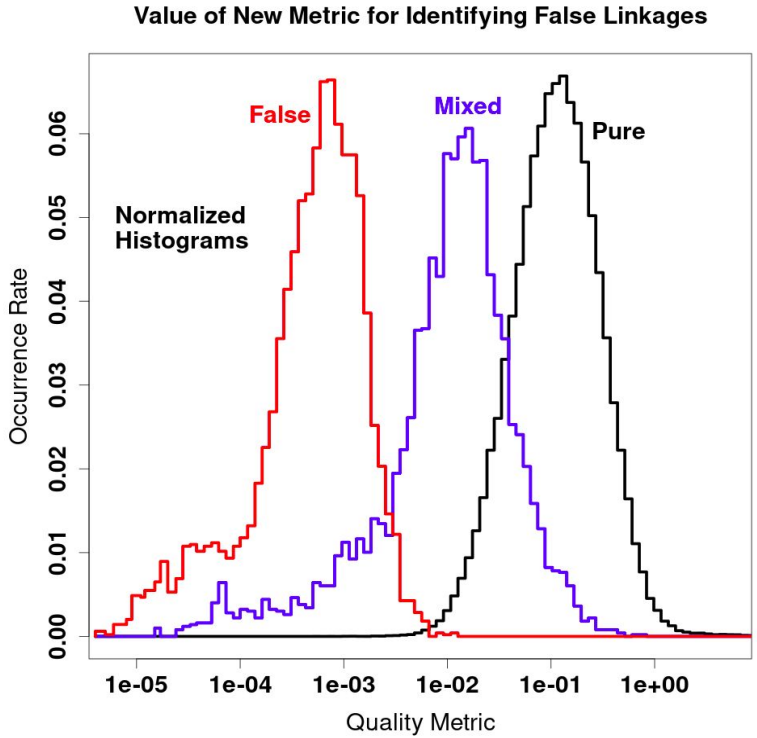
Pipeline features: what's new in **solar system object linking**
Where we have been

- October 2021: python implementation of HelioLinc3D is operational.
- Tests are limited to small regions of sky – orange and green rectangles at far right.
- Python HelioLinc3D is too slow to process full-sky data sets.
- Many linkages are incorrect (mixed).



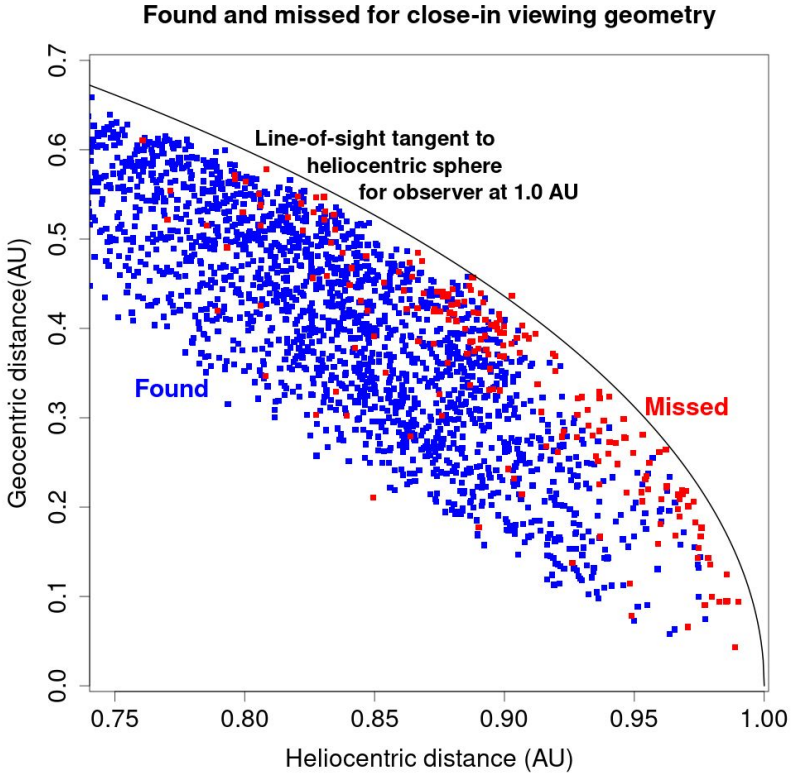
Pipeline features: what's new in **solar system object linking** Where we are

- New C++ implementation of HelioLinc3D handles full-sky simulations spanning two weeks of LSST observations, links 200,000 distinct objects.
- More sophisticated hypothesis sampling now uses a 3-term Taylor Series approximation for heliocentric distance as a function of time.
- Post-processing of linkages using quality metrics powerfully selects pure (correct) linkages over mixed ones (see figure).
- **Over 97% completeness** for pure linkages on simulated **main-belt asteroids and NEOs**.
- Successful tests on real data demonstrate robustness even with many false detections.



Pipeline features: what's new in solar system object linking Where we are going

- High performance orbit determination in linkage post-processing will further increase purity and completeness.
- Optimized handling of Trans-Neptunian objects (TNOs) will allow successful linkages over periods much longer than two weeks.
- Certain rare viewing geometries are intrinsically problematic (see figure), but this can be improved with specialized code.
- Integration with the wider LSST pipeline will enable development of new features, including the use of trailed images to find fast-moving NEOs.



VERA C. RUBIN OBSERVATORY

Wrap up

Talks or sessions with Pipelines team members That have already happened, look for the videos

Tuesday
11:00 Ian, Nima, and Eric @ Difference Image Analysis (Remote)
11:00 Meredith @ Satellite Constellations (Remote)

13:30 Lee @ Low Surface Brightness Science with Rubin: Unlocking LSST's Discovery Domain I (Remote)
13:30 Eric @ Multi-Messenger Astronomy with Rubin Observatory (Remote)
13:30 Nate @ Onboarding for SIT-Com In-Kind Contributions

15:30 Lee @ Low Surface Brightness Science with Rubin: Unlocking LSST's Discovery Domain II

Wednesday
11:00 All @ Update from Science Pipelines (Remote)
11:00 Merlin @ Introduction to the Auxiliary Telescope (AuxTel), Its Data & Commissioning
11:00 Josh @ Active Optics Commissioning

Talks or sessions with Pipelines team members that are coming up

Wednesday

13:30 Merlin @ Instrument Signature Removal and Characterization of the LSST Camera

Thursday

11:00 Sophie, Lee, Josh @ Source Injection in the Rubin Pipelines (Remote)
13:30 Eli @ Bootstrapping Photometric Calibration (Remote)
15:30 Fred, Erfan, Dan @ Deblending: Plans and Challenges (Remote)

More information

- Most recent bootcamp: confluence.lsstcorp.org/display/DM/DM+Pipelines+Bootcamp+2022
- For project plans on particular algorithms and high level intro to science pipelines see the Algorithms Workshop Talks: project.lsst.org/meetings/law
- Post questions at community.lsst.org/c/sci/data
- Data Products Definition Document (LSE-163): ls.st/dpdd
- Documentation and code: pipelines.lsst.io
- www.lsst.org/scientists/glossary-acronyms
- Bosch+17 on the DRP pipeline HSC@PDR1

VERA C. RUBIN OBSERVATORY

The End

NSF AURA U.S. DEPARTMENT OF ENERGY SLAC CHARLES AND LISA SIMONYI FUND FOR ARTS AND SCIENCES LSST CORPORATION

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Appendix

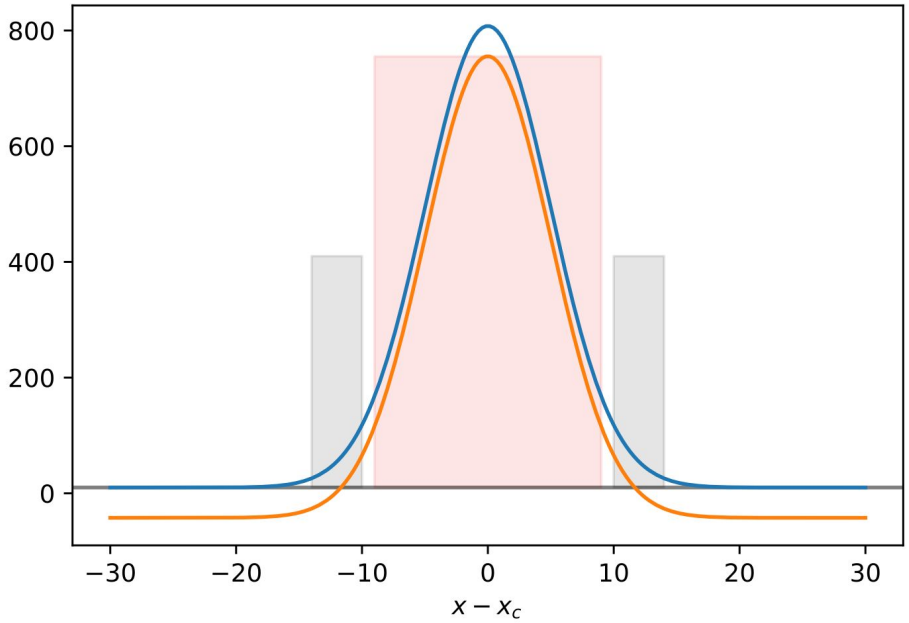
Can present status on these topics if asked in Q&A

NSF AURA U.S. DEPARTMENT OF ENERGY SLAC CHARLES AND LISA SIMONYI FUND FOR ARTS AND SCIENCES LSST CORPORATION

Stickers anyone? (see Lauren)

Compensated top hat filter

$$S = \frac{1}{\pi(R_2^2 - R_1^2)} \int_{R_1}^{R_2} I(\boldsymbol{x}) 2\pi r \, dr$$



Forecast completion dates shift and have errorbars
Find the latest at www.lsst.org/about/project-status:

Rubin Baseline Data Release Scenario	Jun 2021	Jun 2022	Apr 2024 - Jul 2024	Dec 2024 - Mar 2025	Oct 2025 - Jan 2026
	DP0.1	DP0.2	DP1	DP2	DR1
Data Product	DC2 Simulated Sky Survey	Reprocessed DC2 Survey	ComCam On-Sky Data	LSSTCam On-Sky Data	LSST First 6 Months Data
Raw images	☑	☑	☑	☑	☑
DRP Processed Visit Images and Visit Catalogs	☑	☑	☑	☑	☑
DRP Coadded Images	☑	☑	☑	☑	☑
DRP Object and ForcedSource Catalogs	☑	☑	☑	☑	☑
DRP Difference Images and DIASources	☐	☑	☑	☑	☑
DRP ForcedSource Catalogs including DIA outputs	☐	☑	☑	☑	☑
PP Processed Visit Images	☐	☐	☑	☑	☑
PP Difference Images	☐	☐	☑	☑	☑
PP Catalogs (DIASources, DIAObjects, DIAForcedSources)	☐	☐	☑	☑	☑
PP Alerts (Canned)	☐	☐	☑	☑	☑
PP Alerts (Live, Brokered)	☐	☐	☐	☑	☑
PP SSP Catalogs	☐	☐	☑	☑	☑
DRP SSP Catalogs	☐	☐	☐	☐	☑

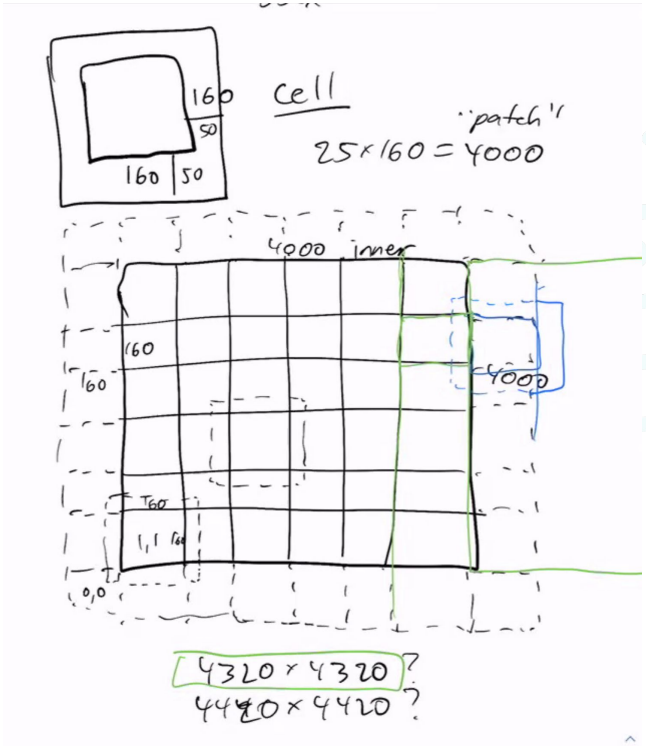
Select Milestones

Due	Name
29-Sep-2022	TMA Contract Complete
30-Sep-2022	EPO Construction Finish
20-Mar-2023	COMP: Camera Pre-Ship Review at SLAC
28-Mar-2023	Dome Complete
17-May-2023	3-Mirror Optical System Ready for Testing
19-Jul-2023	Engineering First Light w/ComCam
05-Sep-2023	Camera Ready for Full System AI&T
14-Feb-2024	System First Light
11-Jun-2024	Test report: Final Pipelines Delivery
11-Jun-2024	Mini-Survey 2 Complete
18-Jun-2024	Operation Readiness Review Complete

Using June 2022 project controls data.

Enable **Shear Measurement** by small-cell, constant-PSF coadds

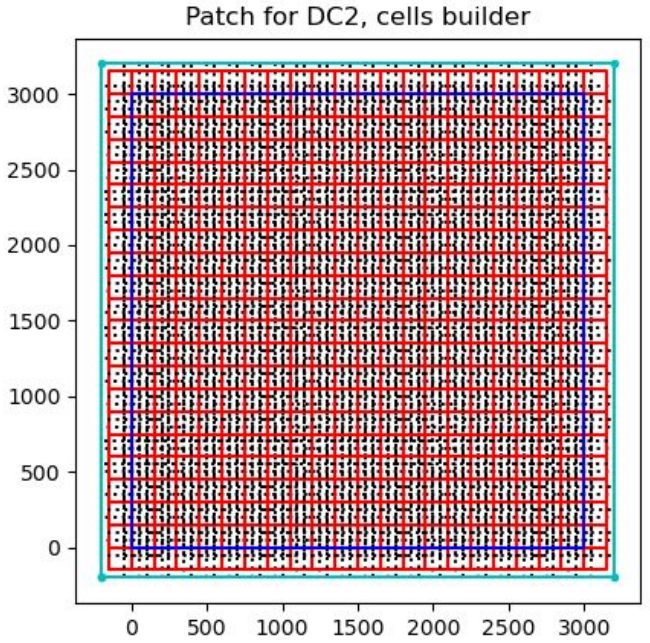
- Goal: Integrate a battle-tested, state-of-the-art, third-party code that runs with our PSF models on our coadds.
- **Where we've been:**
  - FY21: Announced death to Multifit. Long live small-cell, edge-free coadds! Prereqs: survey property maps + integrating PIFF
  - FY22:
    - October 2021 DESC-DM Cell-based Coadds Sprint
    - Collaborating with DESC on input requirements for metacalibration/metadetection. We learned that:
      - we can assume PSF constant over cell!
      - Erin needed to commute the translation in warpedPsfs to reduce biases. Implemented in stack as DM-32411
    - Skymaps can now make cells within patches.

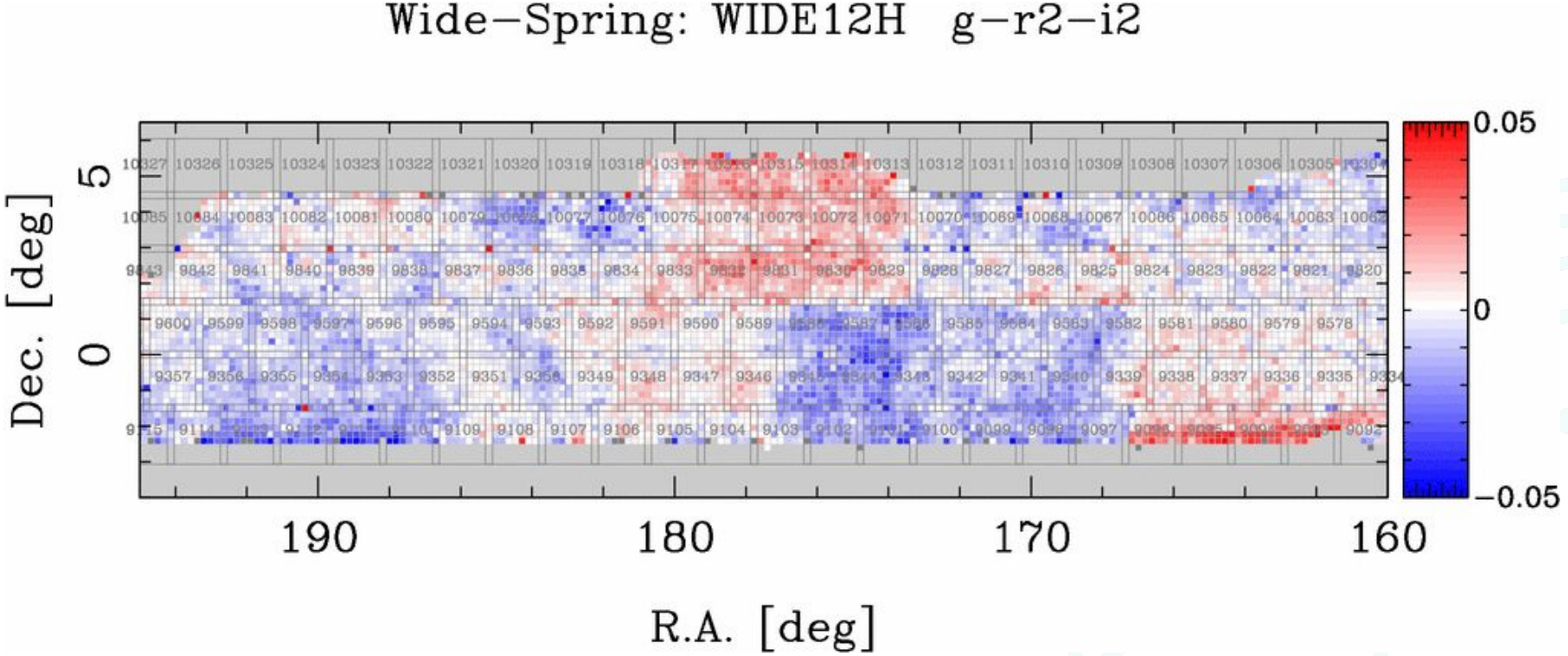


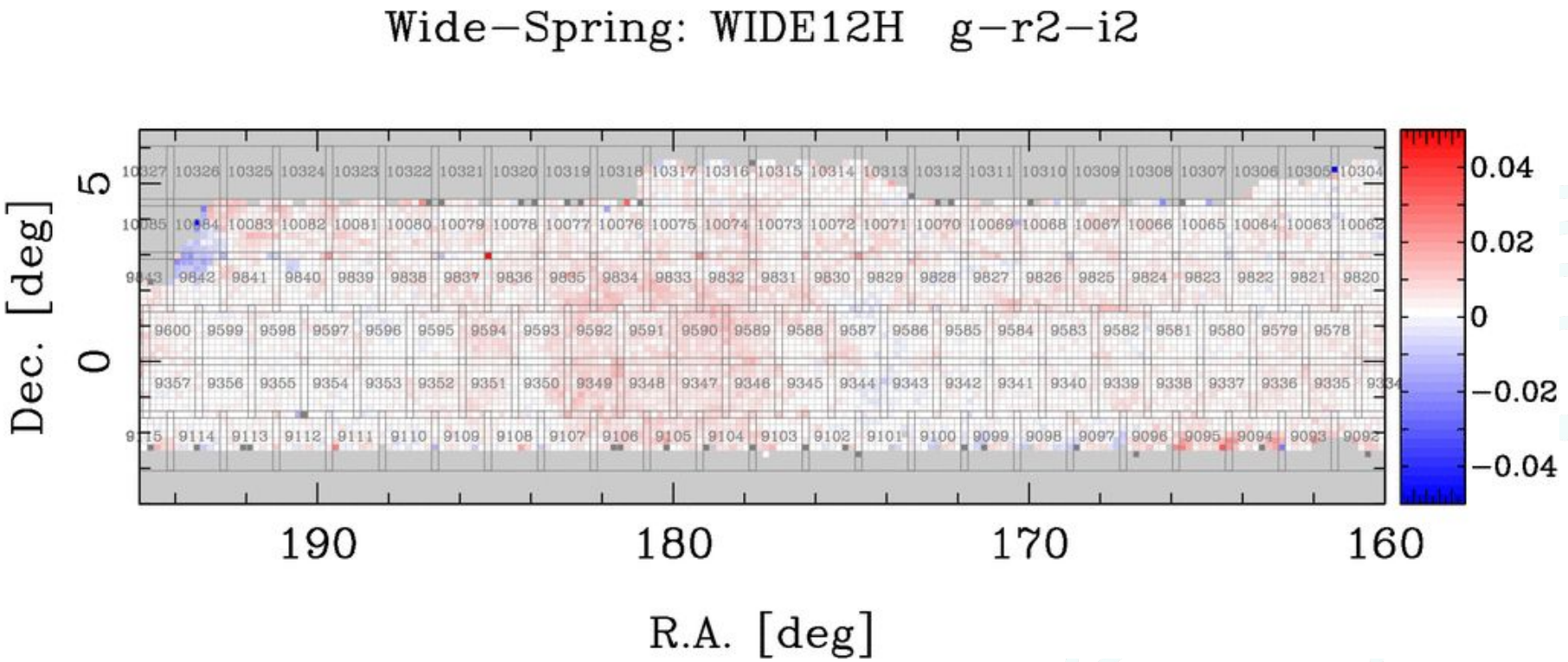
Enable **Shear Measurement** by small-cell, constant-PSF coadds

...

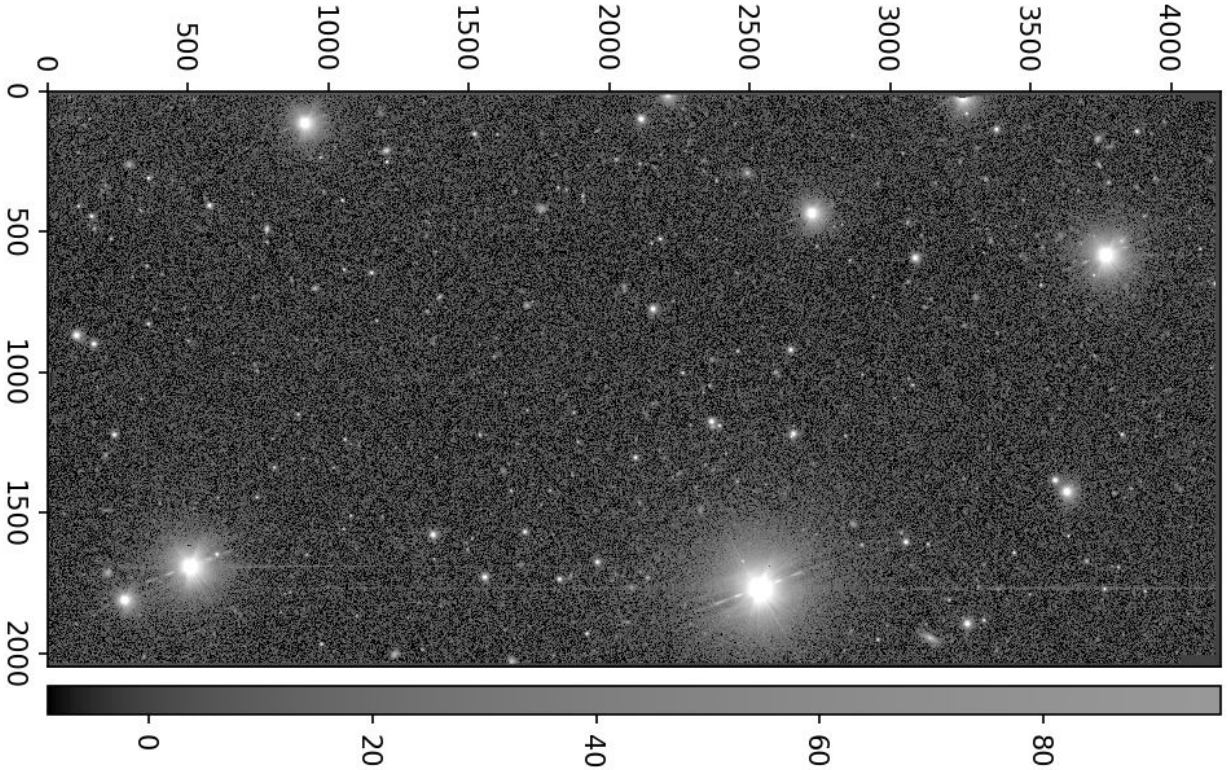
- Where we are:
  - Focused all efforts on PSFs this past year.
  - Default shape measurements today are same as 2020: GalSim-based HSM algorithms (e.g. regaussianization) on direct coadds with PSFs propagated through coaddition (Jee & Tyson 2011)
  - Controls systematics well enough for a DETF Stage II Survey (HSC@PDR1) if they're combined with a major simulations-based calibration effort
- Where we are going:
  - Matt, Erin, Bob are dev cell-based coadds for DES
  - Develop cell-based coadds and reconcile with ^^ as we go
  - Convince Matt, Erin, Bob that they work as well as theirs.
  - Integrate metacal/metadetect algorithm with the stack
  - Reproducible interpolation over defects during ISR and single-frame (to support metacal sims)




Wide−Spring: WIDE12H g−r2−i2
Dec. [deg]
5
0
190
180
170
160
R.A. [deg]
0.05
0
−0.05


Wide−Spring: WIDE12H g−r2−i2
Dec. [deg]
5
0
190
180
170
160
R.A. [deg]
0.04
0.02
0
−0.02
−0.04

Background Estimation
Prototype task to model and subtract halos of bright stars

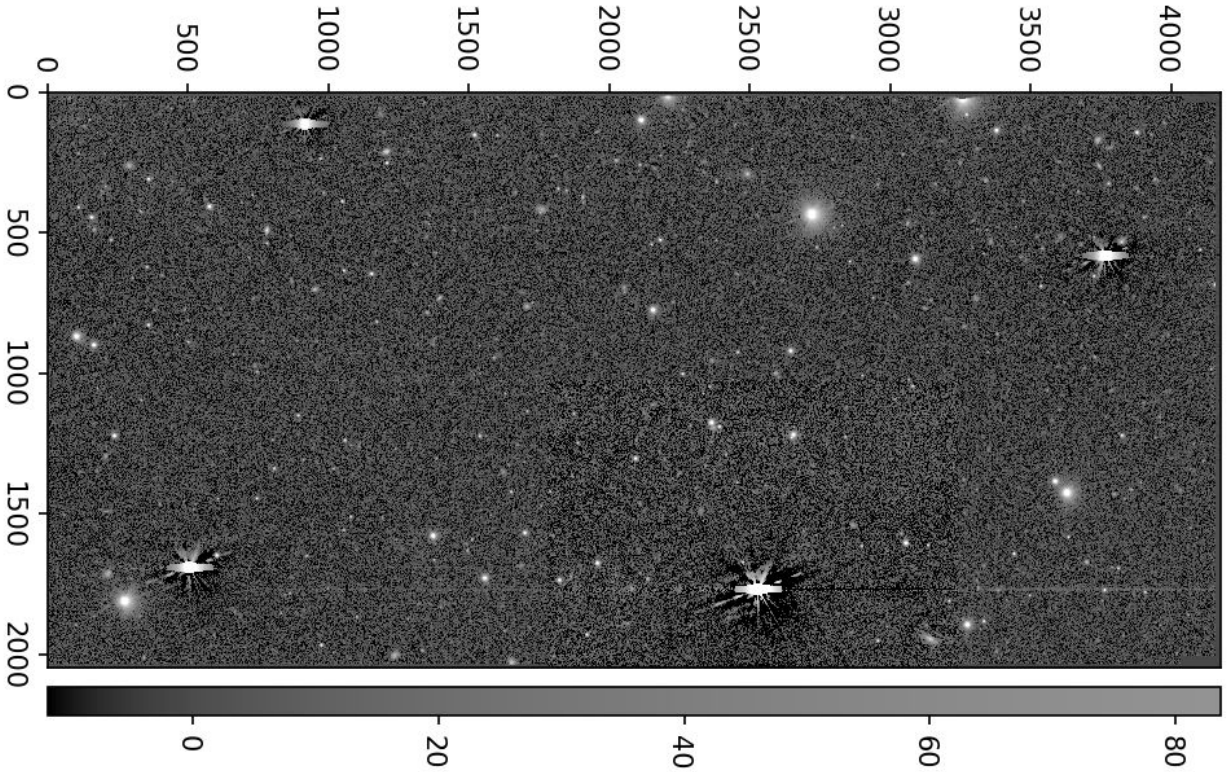


HSC-G

@Morgan Schmitz

Acronyms & Glossary

Background Estimation
Prototype task to model and subtract halos of bright stars



HSC-G

@Morgan Schmitz

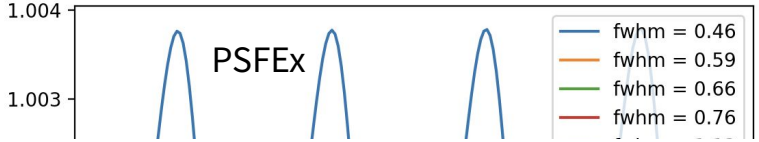
Acronyms & Glossary

August 3rd intro to Practice Run
This slide is getting deleted

- Info here: https://project.lsst.org/meetings/rubin2022/presenter-information
- Recommendation is that we spend > 40% of time on Q&A/discussion: 0.6*90 = 54 minutes, which matches up pretty well with the time we have available for the talk part today.
- Identify in-person helpers for your session:
  - a note-taker,
  - a time-keeper,
  - a Slack monitor,
  - and a breakout summary slide presenter for Fri Aug 12 at 9:00am
- Instructions for today:
  - Record your questions and suggestions per slide number and send to the presenter.

Pipeline features: what's new in **PSF Estimation**

ixelGrid is now the default PSF model



ot currently fit the full focal plane.

hm

PIFF

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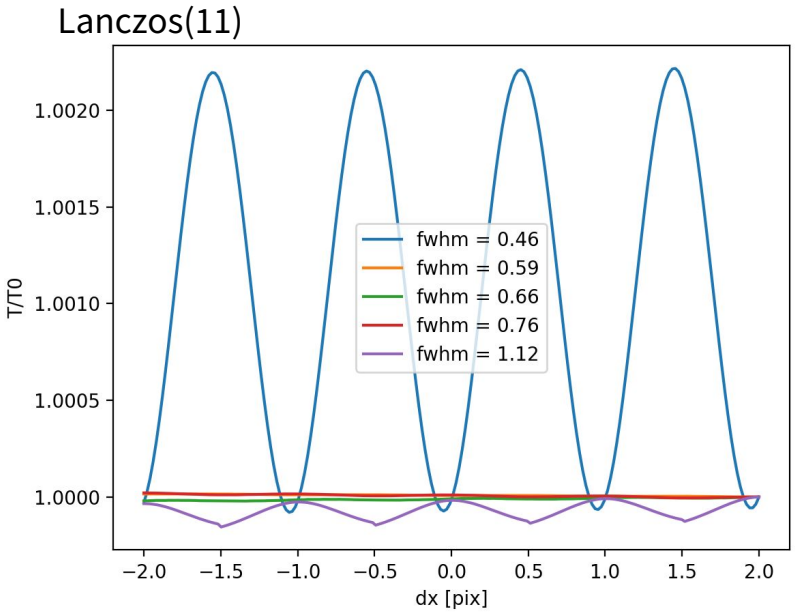
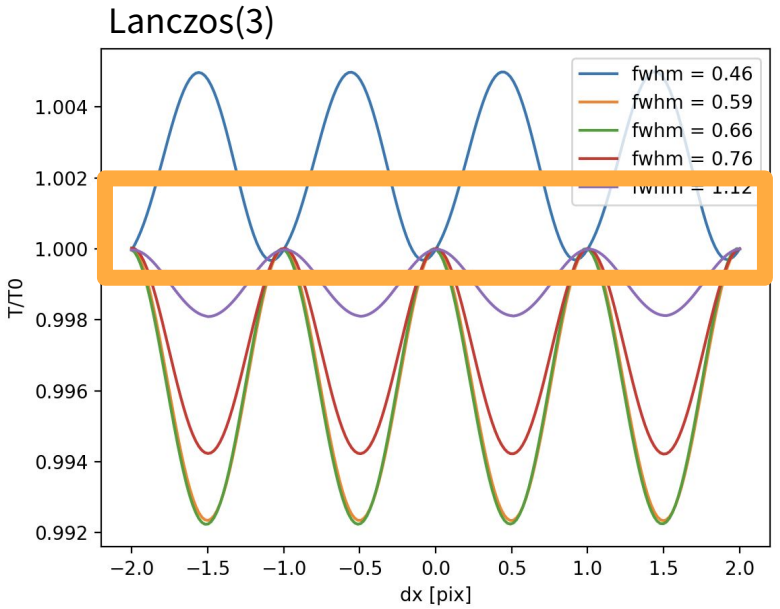
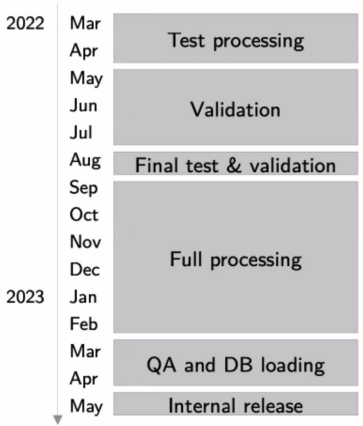
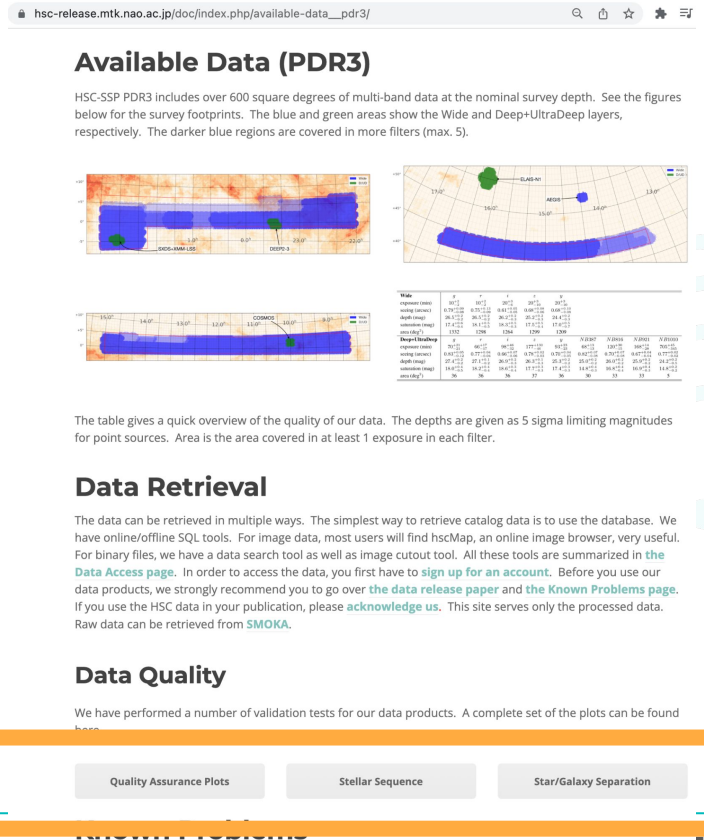




Next test of pipelines at 100s sq deg is HSC PDR4

- Using w_2022_22
  - May 25 2022
- NAOJ running 100 sq deg for validation now
- HSC weak lensing group will verify that PSF models and coadds are sufficient for a final weak-lensing paper.
-





Pipeline features: what's new in **image differencing**

Real/Bogus Classifier is a "Task"