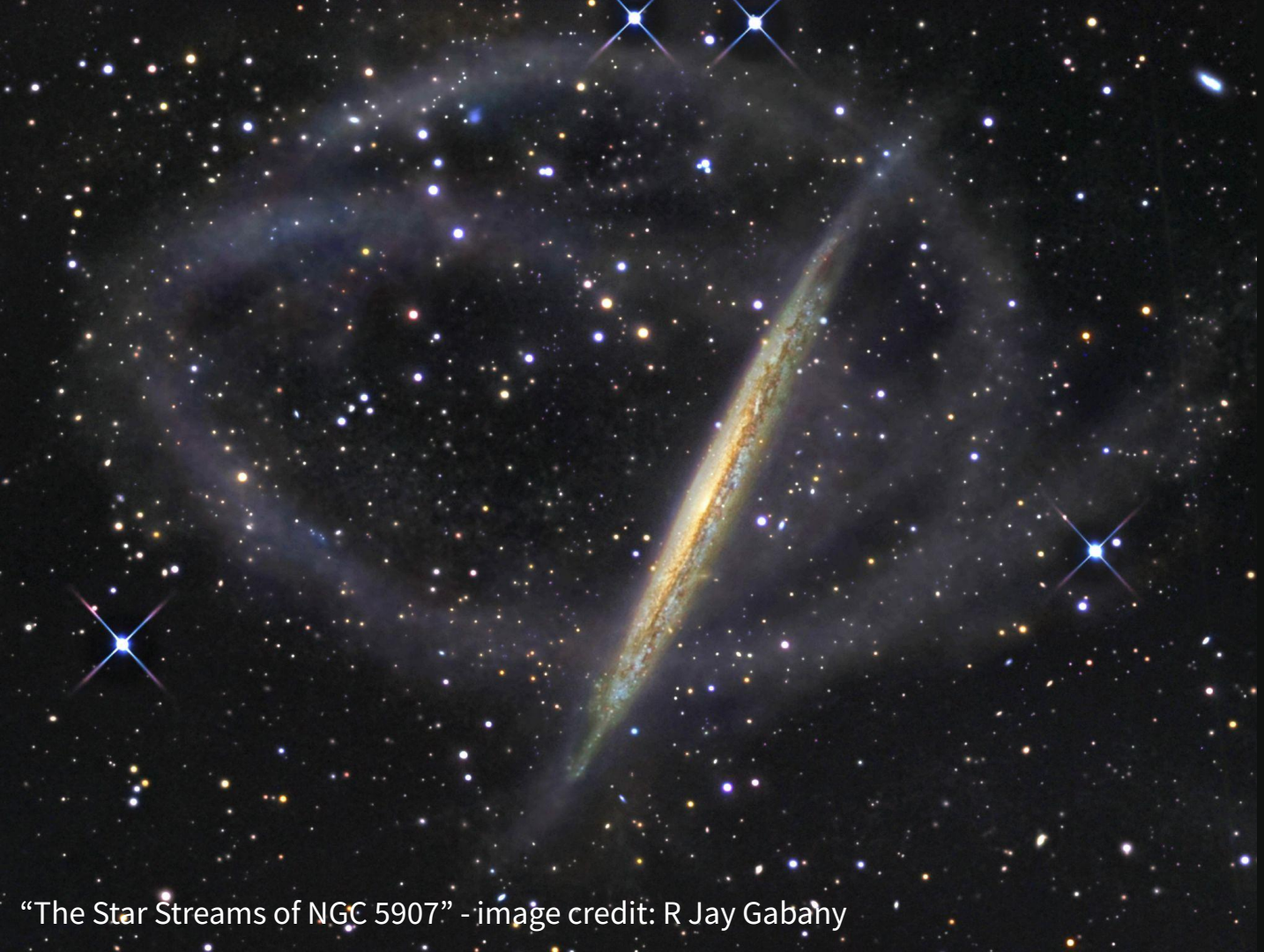
VERA C. RUBIN OBSERVATORY

Reducing LSB Data with the LSST Science Pipelines

Lee Kelvin (Princeton/Rubin Obs.)
& The DM Team

Project and Community Workshop | August 9, 2022

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



"The Star Streams of NGC 5907" - image credit: R Jay Gabany

LSB Structure

Wide **range of morphologies**: tidal tails, streams, haloes, LSB galaxies, ICL…

Provide an insight into the **mass assembly history** of the galaxy

Extremely **faint**; <30 mag/arcsec^2

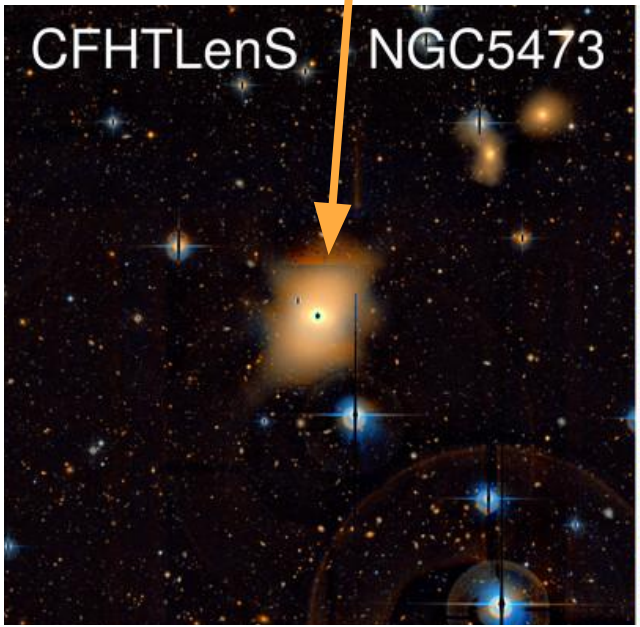
Tough to preserve LSB information post-data reduction; e.g., **sky oversubtraction**

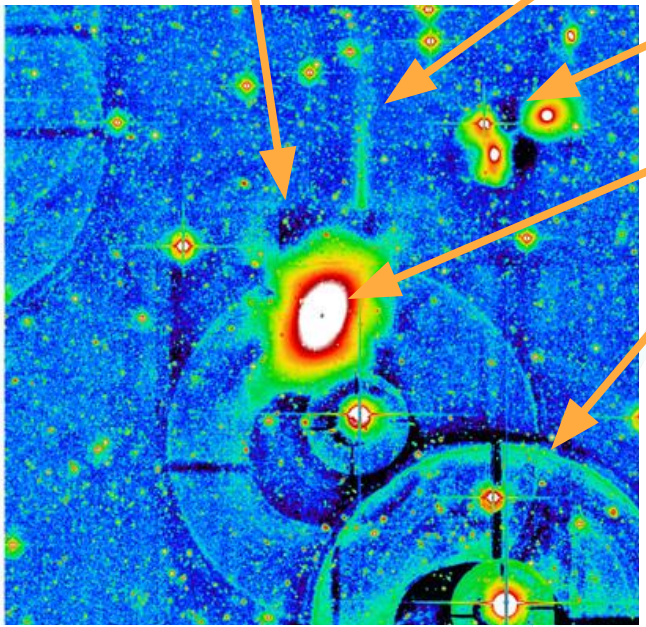
LSB Light Contamination

CCD edge effects

sky over-subtraction due to bright sources

diffraction spikes





sky over-subtraction due to crowded fields

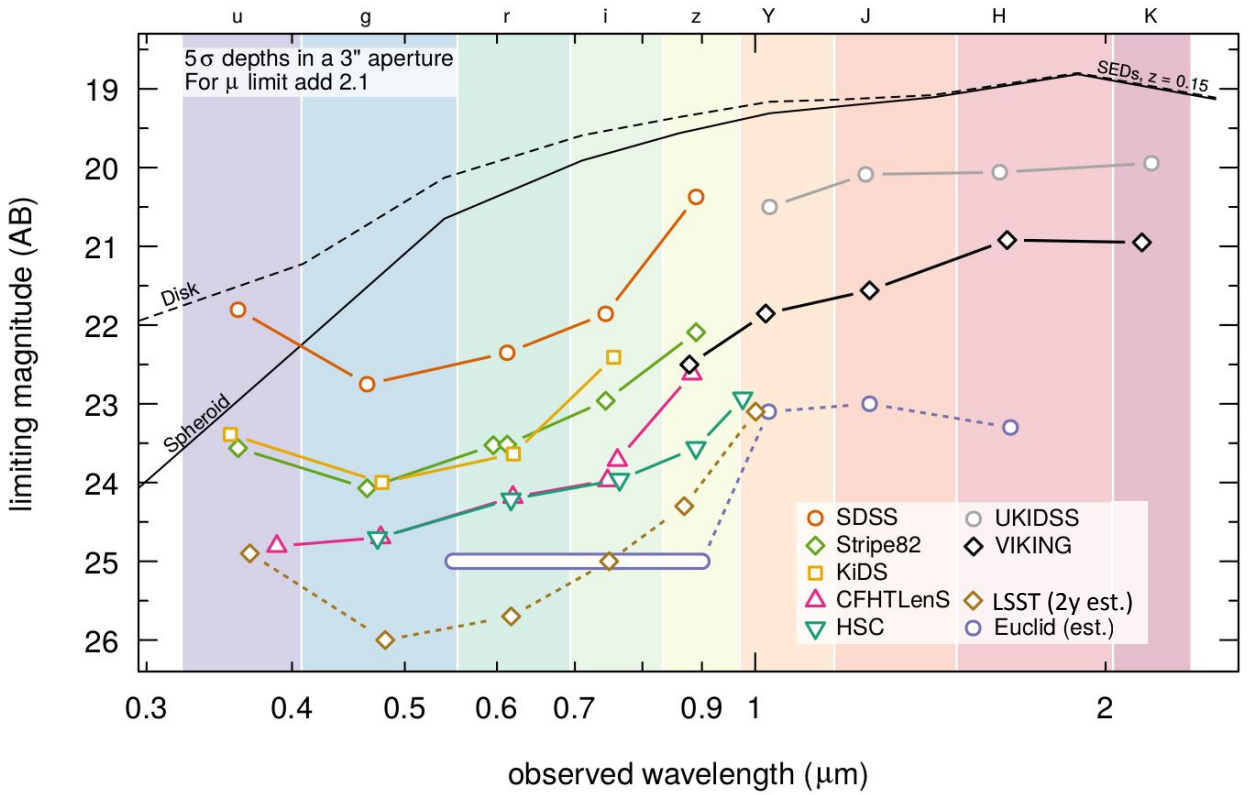
saturation

ghosts / ghouls

also:

- obs. technique
- cirrus
- haloes

Good news: the game-changing depth of LSST



Background subtraction with the LSST Science Pipelines

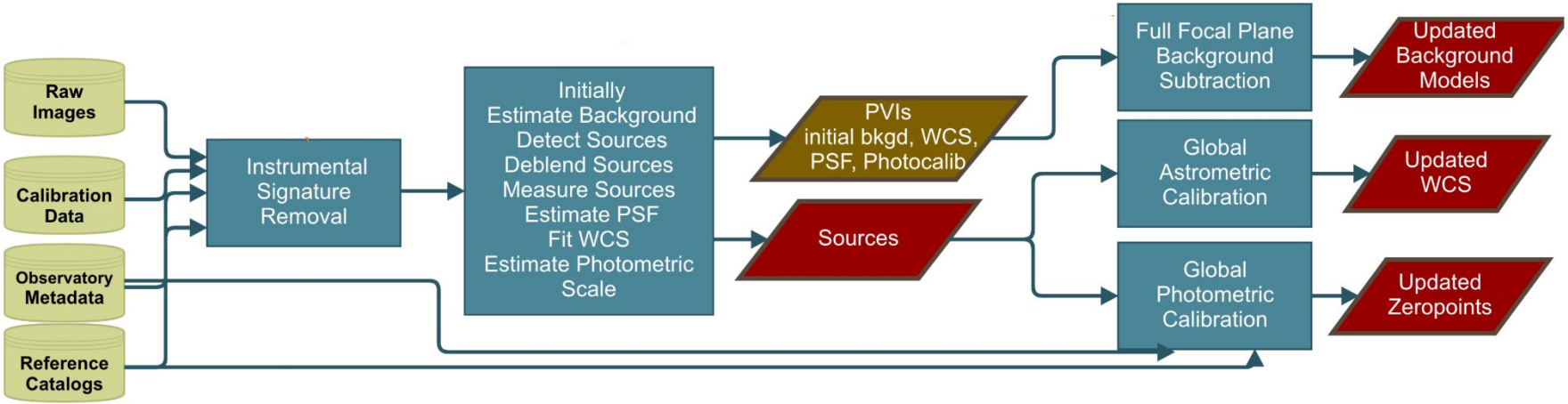


Image credit: Yusra AlSayyad

More info

- **Update from Science Pipelines (Weds, Yusra AlSayyad et al.)**
- **LSST Algorithms Workshop: https://project.lsst.org/meetings/law/ (March 2020)**

Background subtraction with the LSST Science Pipelines

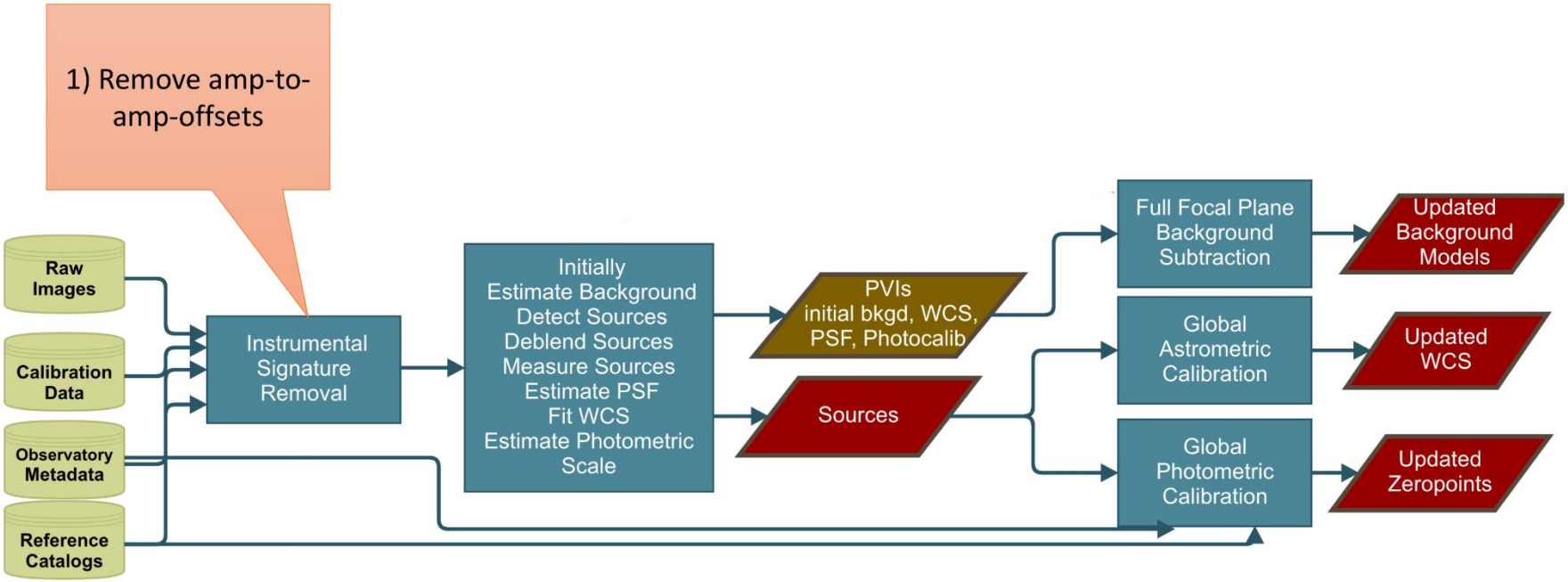
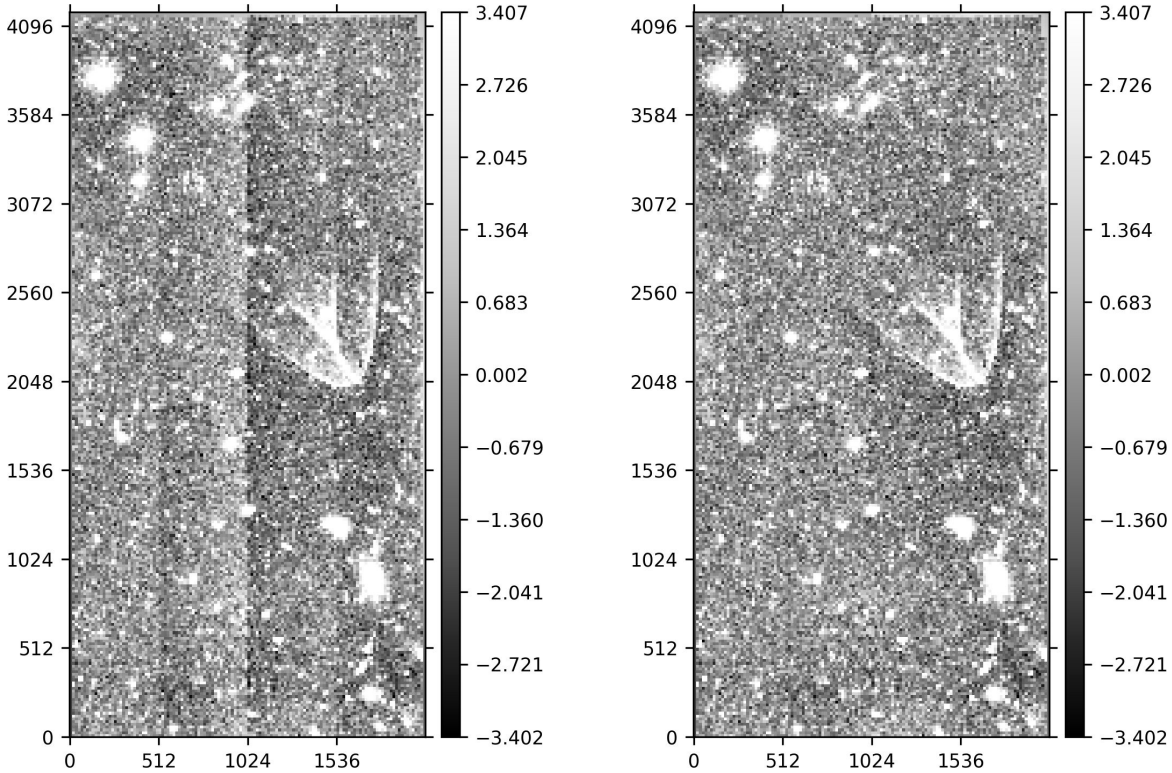


Image credit: Yusra AlSayyad

1) Amp offset (pattern continuity) corrections

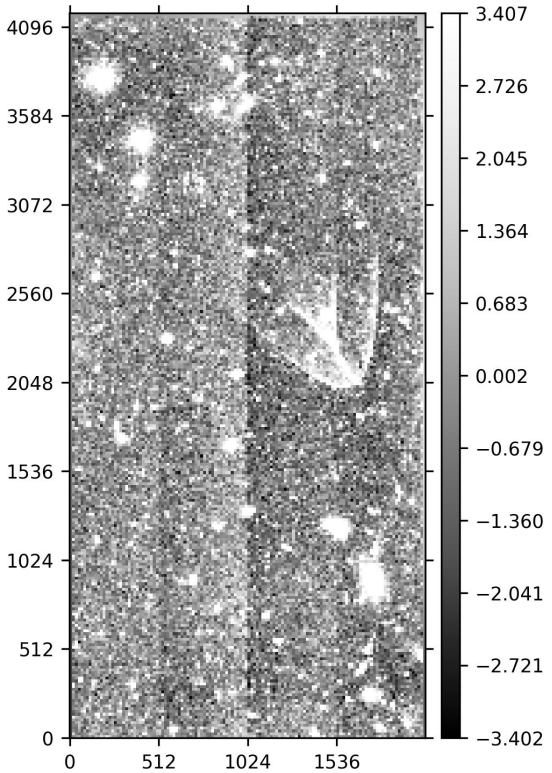


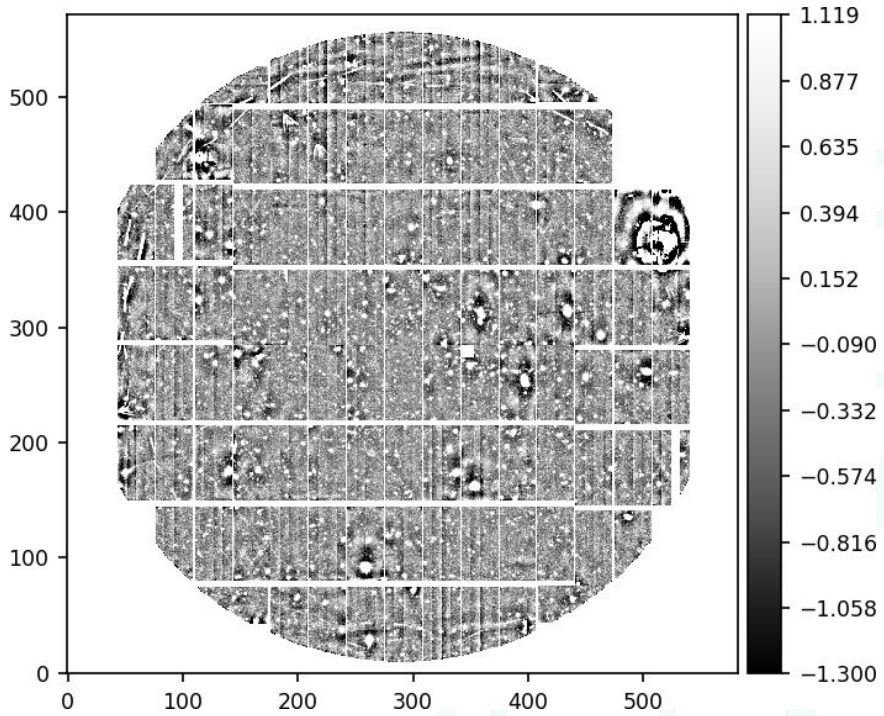
Following initial source detection and masking, a rolling average measure of the background is performed along each amp edge.

Amp pedestals (persisted as metadata) typically ~1 count.

Visit 1252 (detector 68), HSC-I, 30s

1) Amp offset (pattern continuity) corrections





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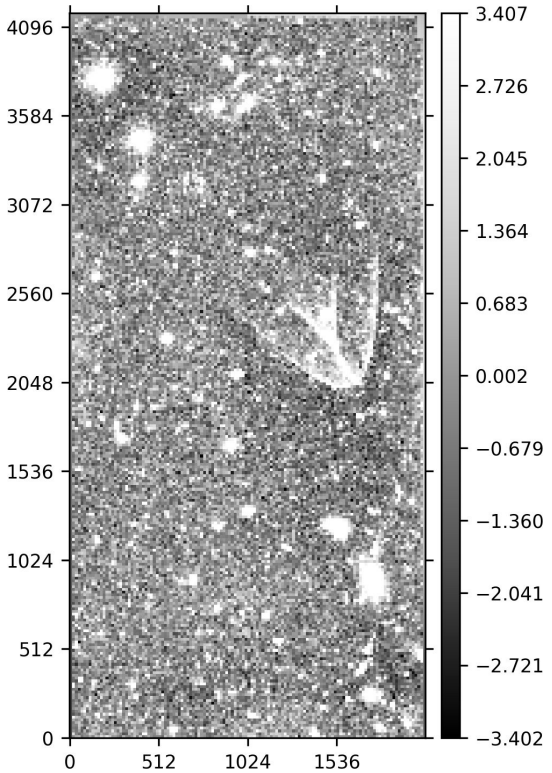

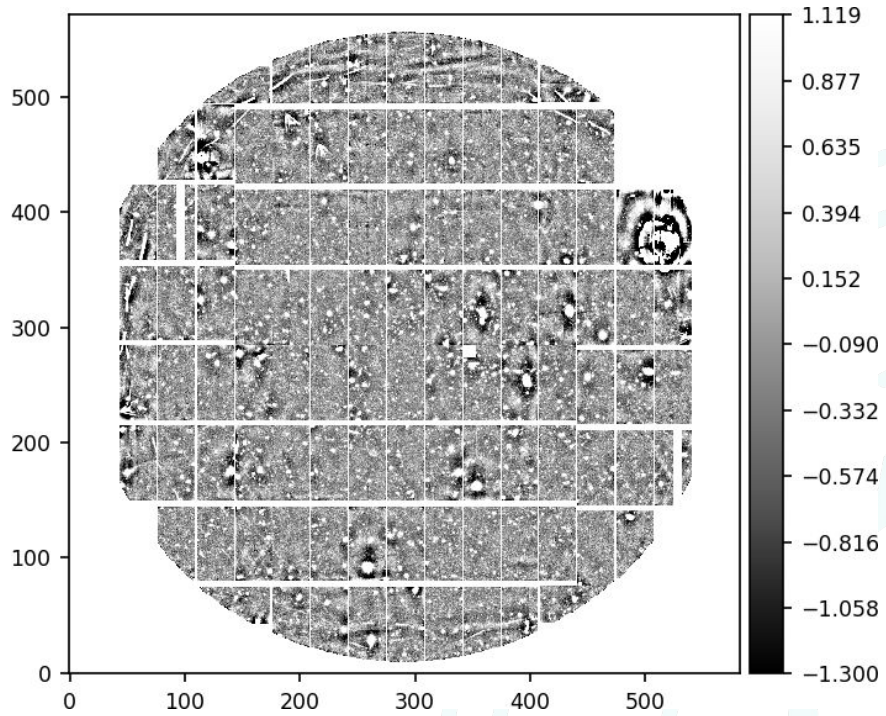

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Background subtraction with the LSST Science Pipelines

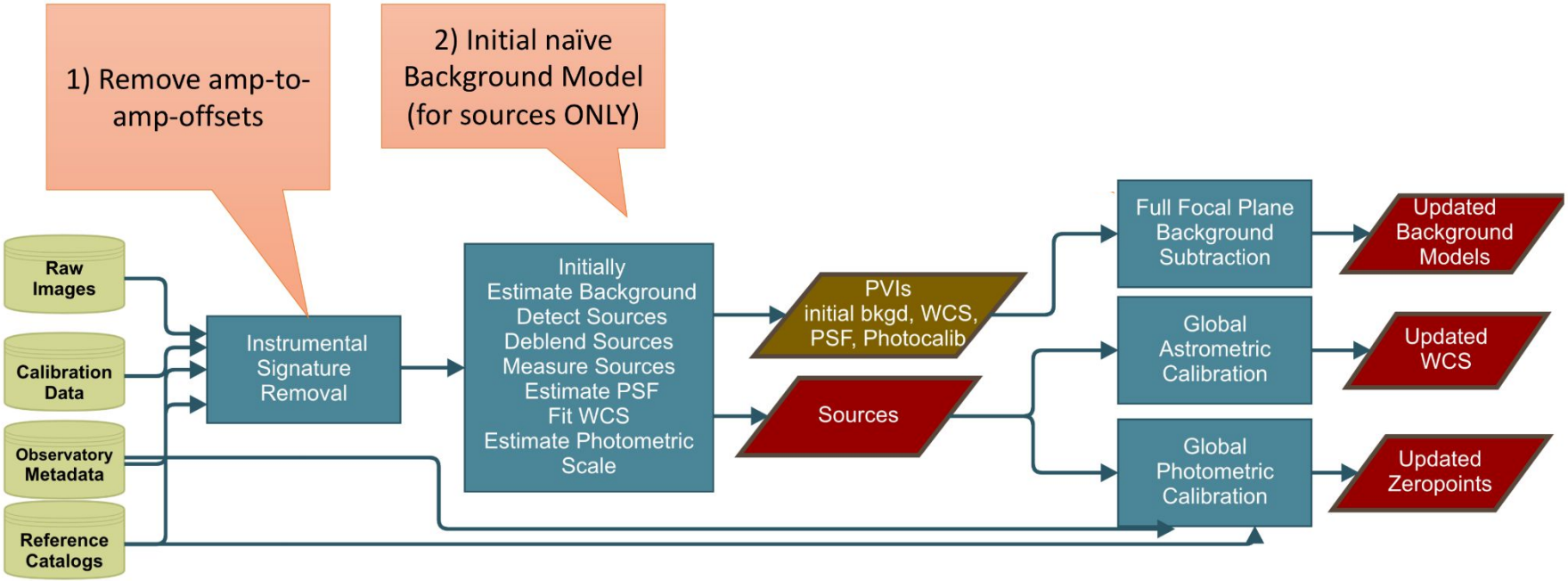
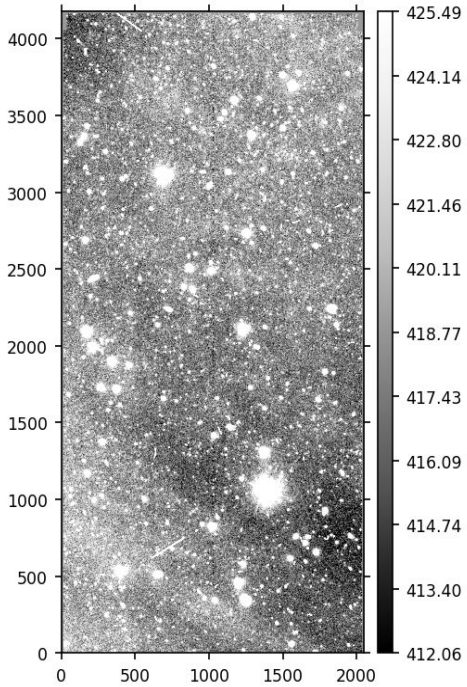


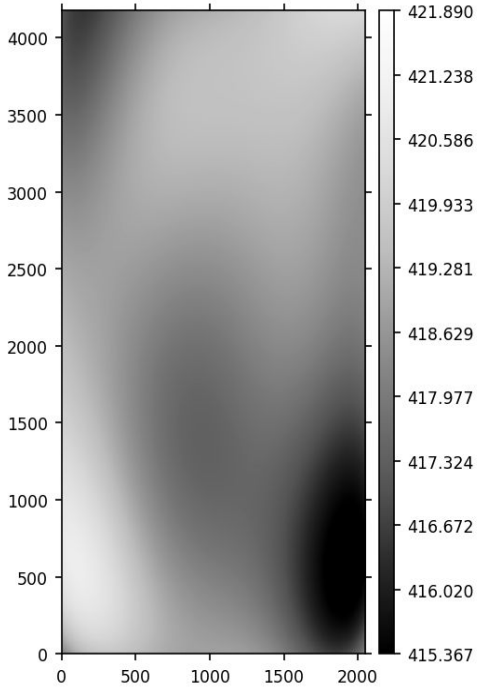
Image credit: Yusra AlSayyad

2) Initial naïve bg model: detect, mask, bin, 6th order Chebyshev

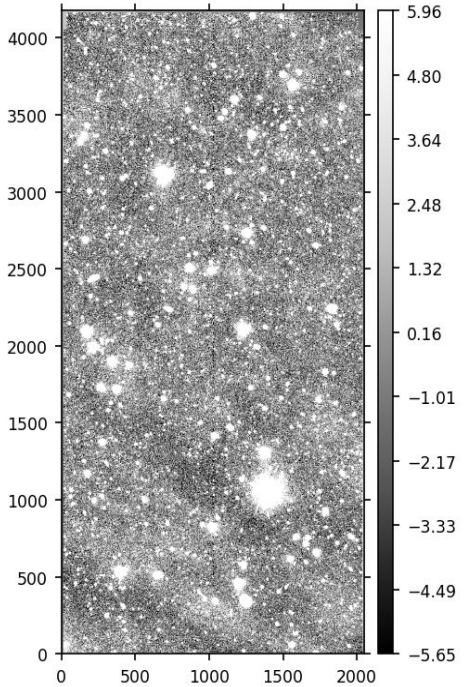
post-ISR CCD



calexp background



PVI (calexp)



Visit 34464, detector 10, HSC-G, 150s

Background subtraction with the LSST Science Pipelines

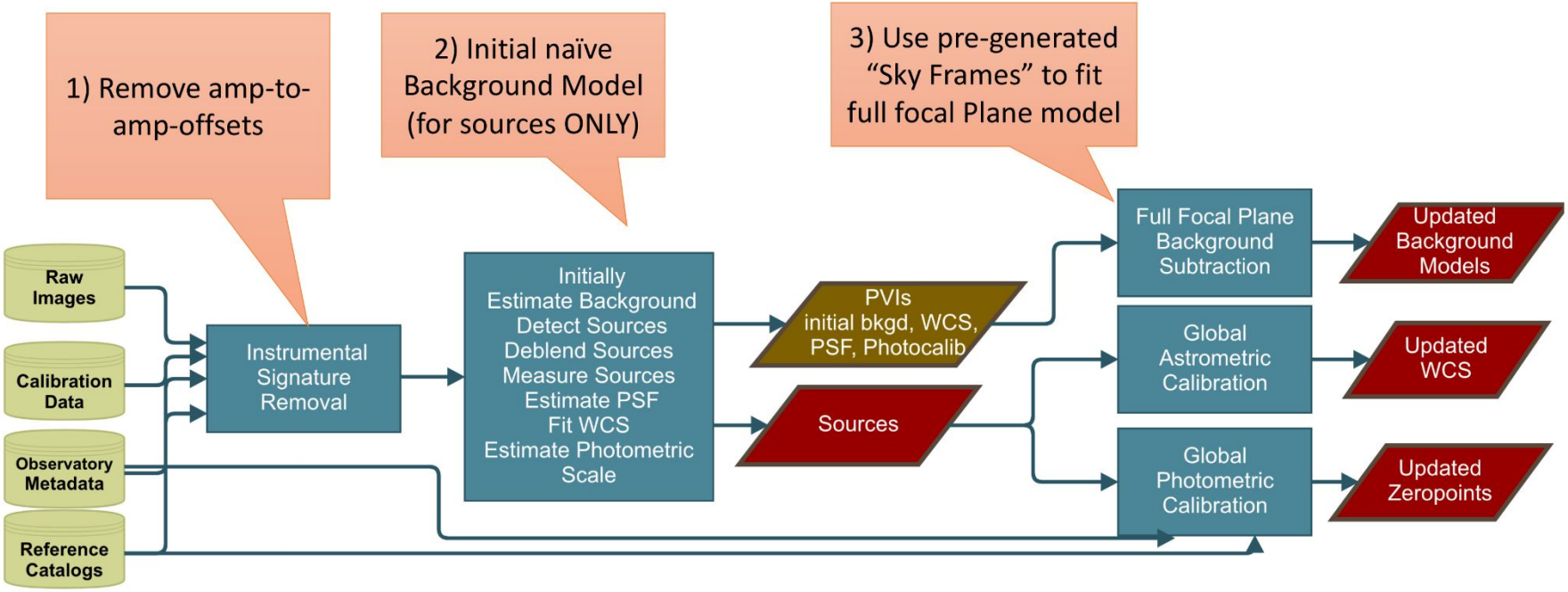
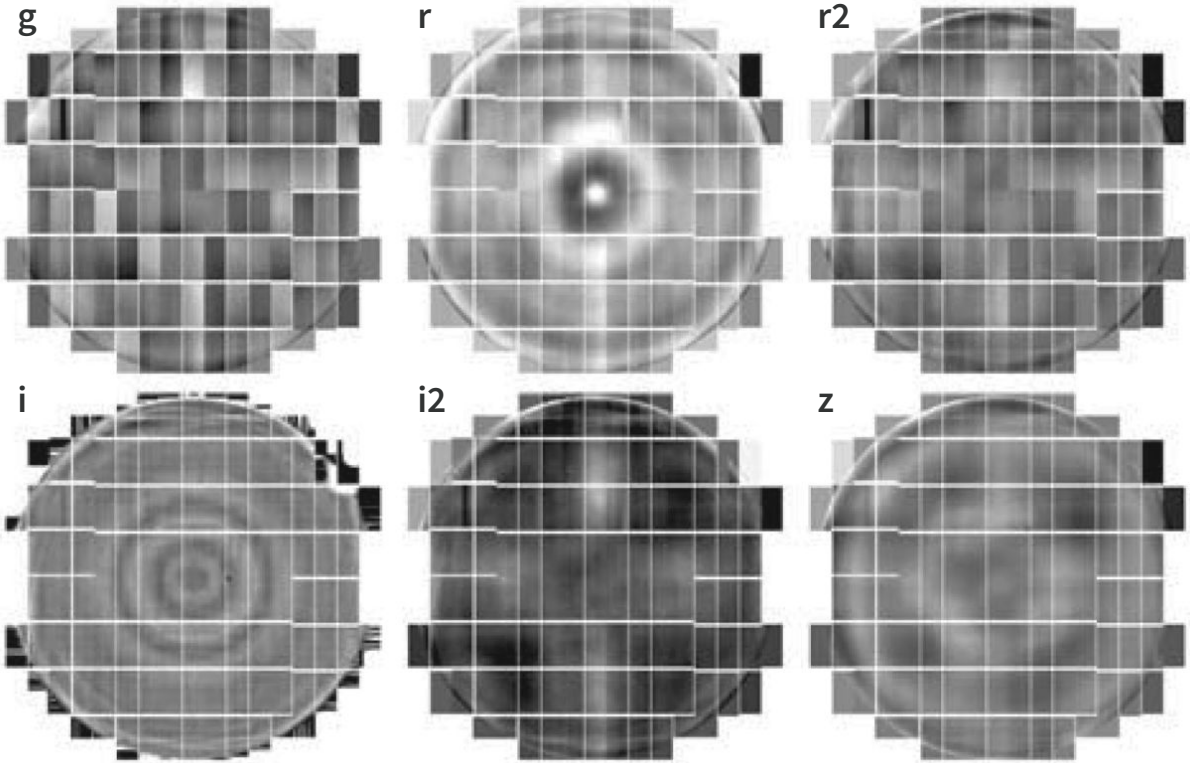


Image credit: Yusra AlSayyad

3) Sky frames and sky correction



Temporally coherent spatial structure over CCD and focal plane coordinates.

A full focal plane model is constructed (the sky frame) and scaled to perform a per-visit sky correction.

Figure from Aihara et al. 2019

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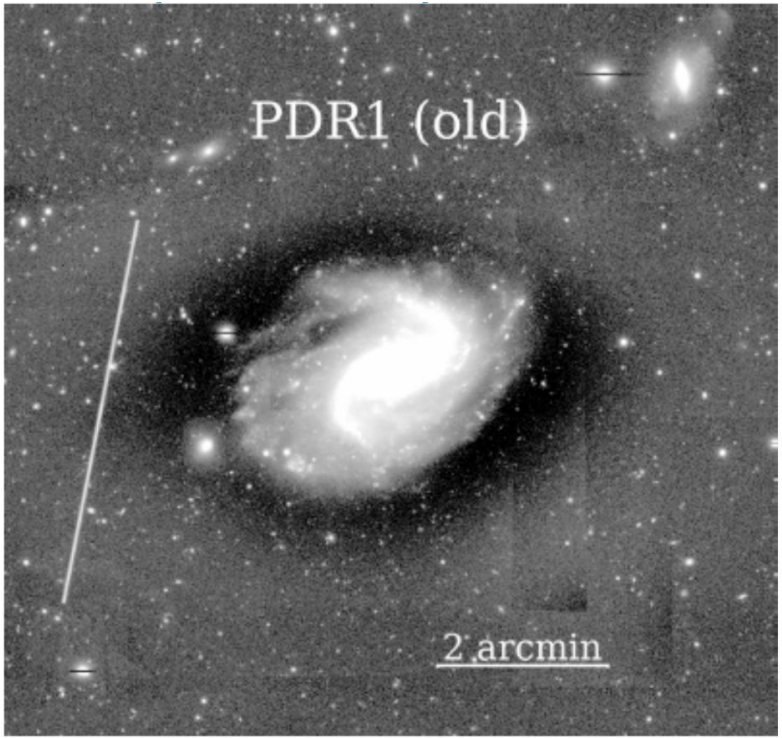


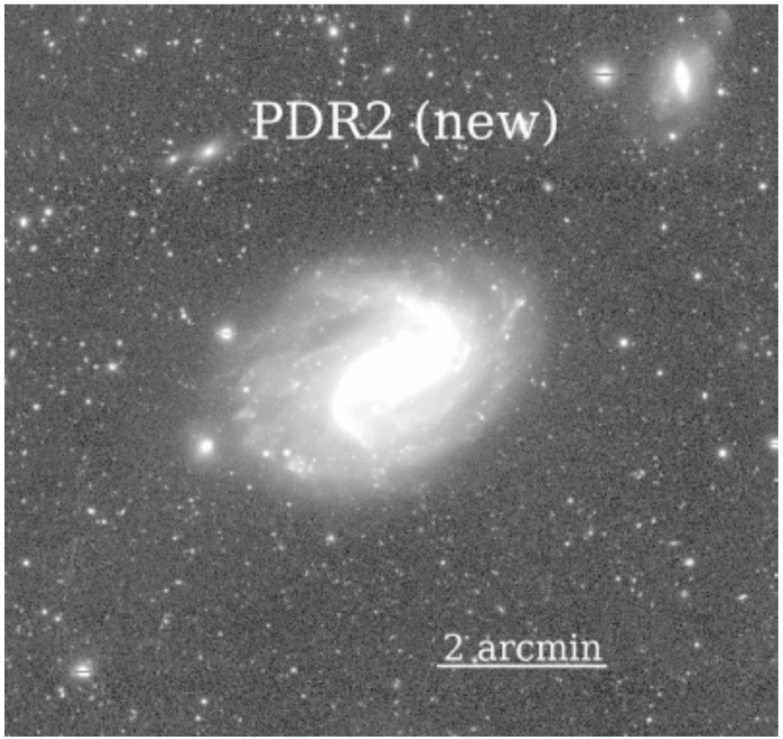


Figure from Aihara et al. 2019

Background subtraction with the LSST Science Pipelines

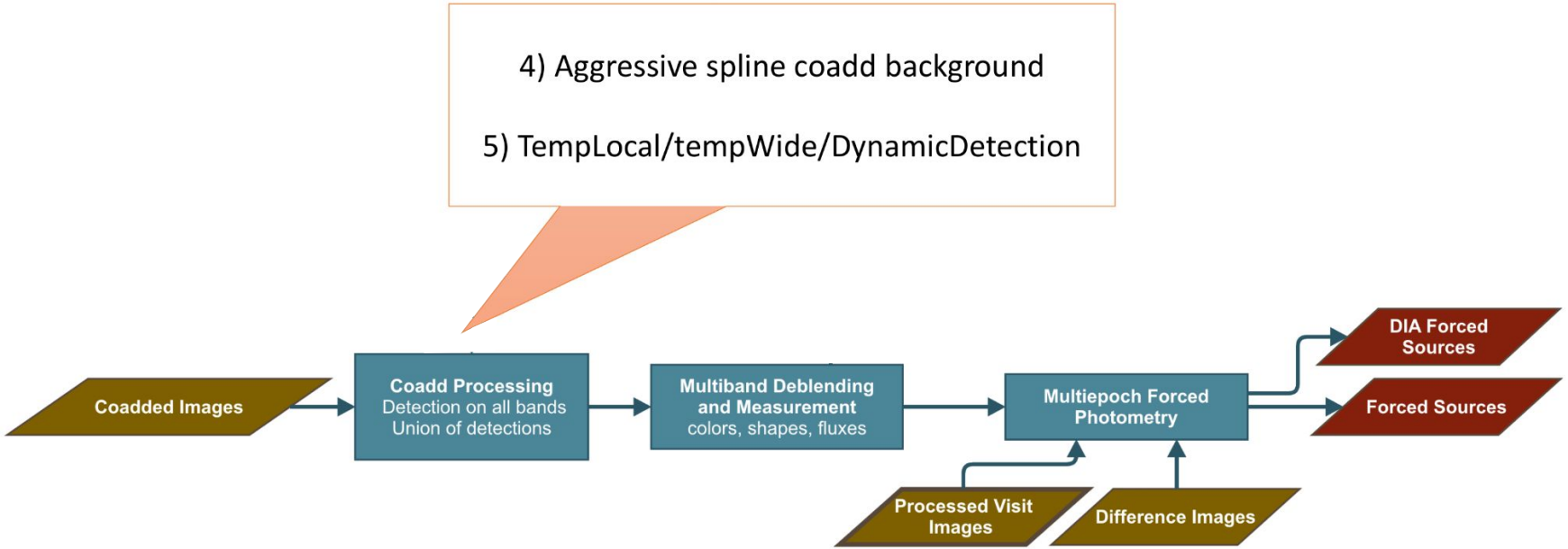
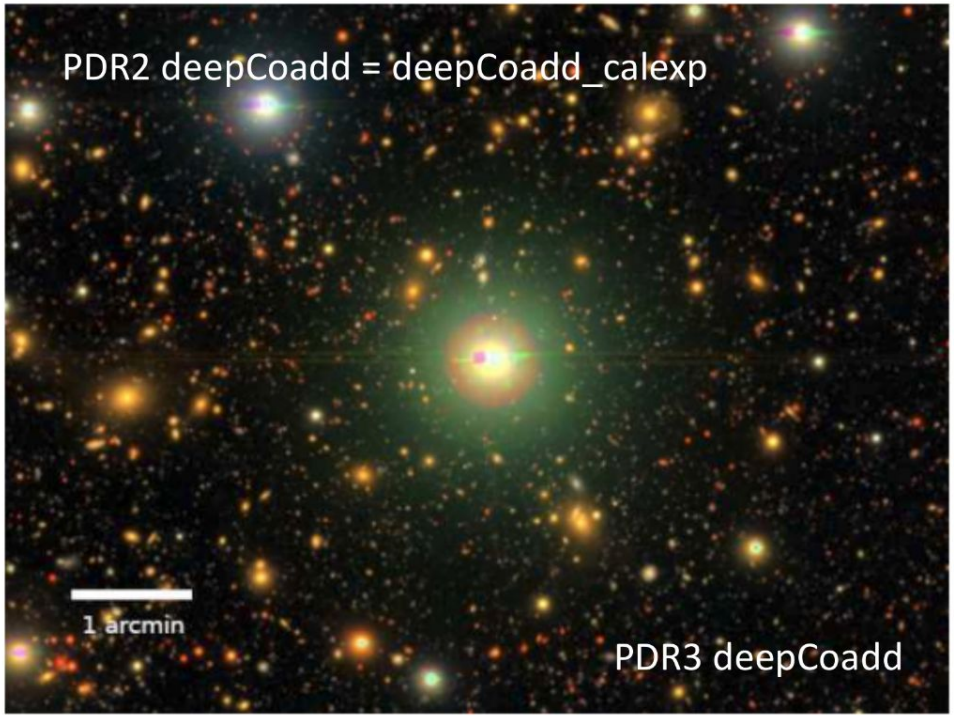


Image credit: Yusra AlSayyad

4) Additional coadd bg subtraction - NOT FOR LSB SCIENCE



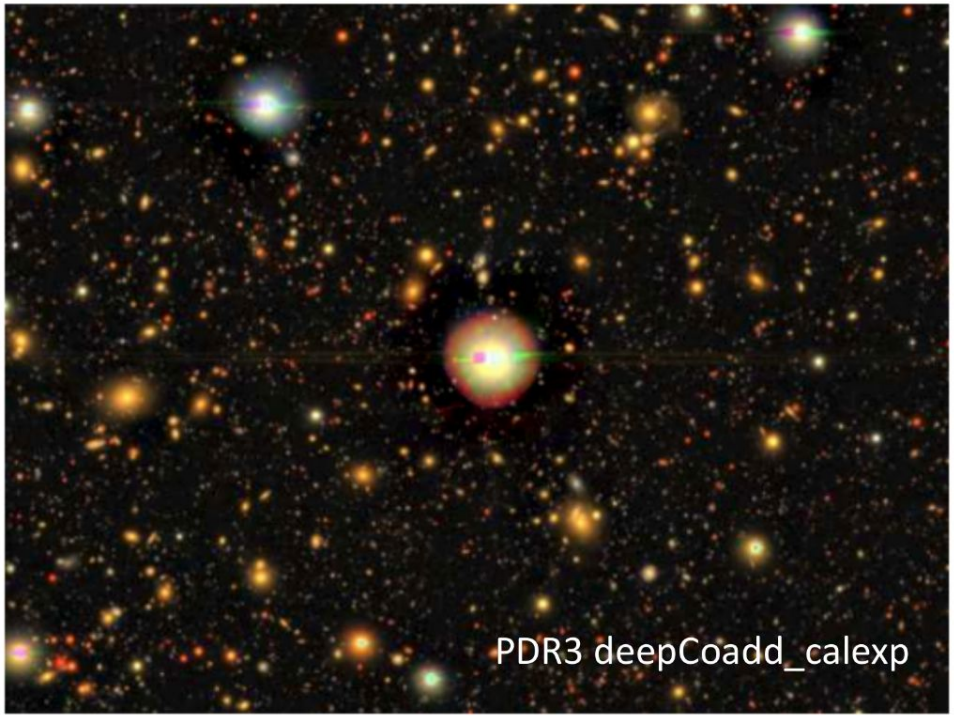
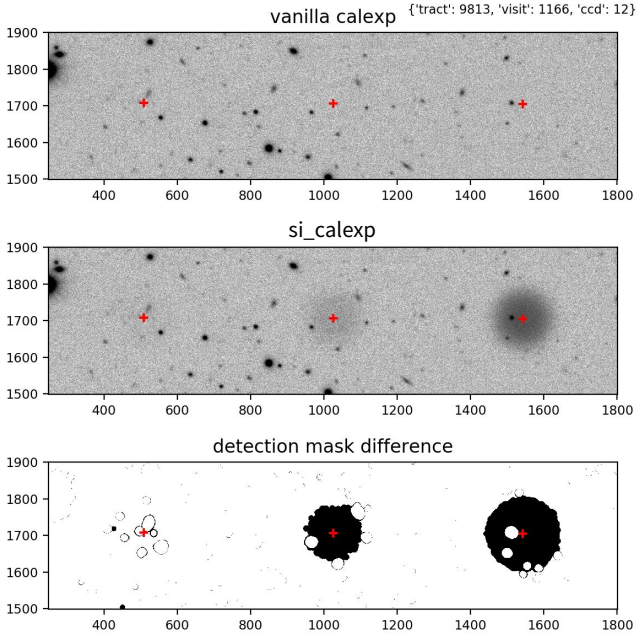


Figure from Aihara et al. 2022

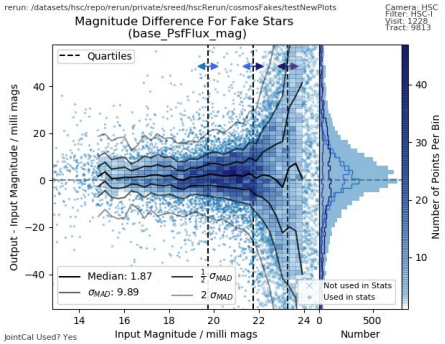
Stress testing with (Synthetic) Source Injection



Data: Aaron Watkins / LSST:UK LSB WG

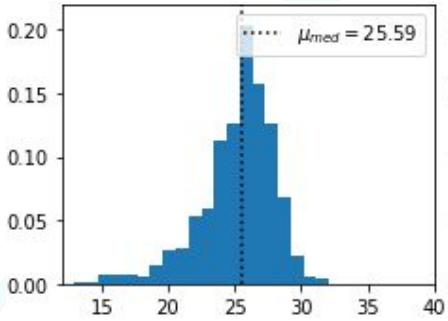
SI an incredibly useful tool for QA analysis, where the 'truth' is known.

HSC data regularly processed with SI switched on → QA metrics.



plots to test pipeline outputs;
→ e.g. Δm (output - input) vs m.

Image credit: Sophie Reed

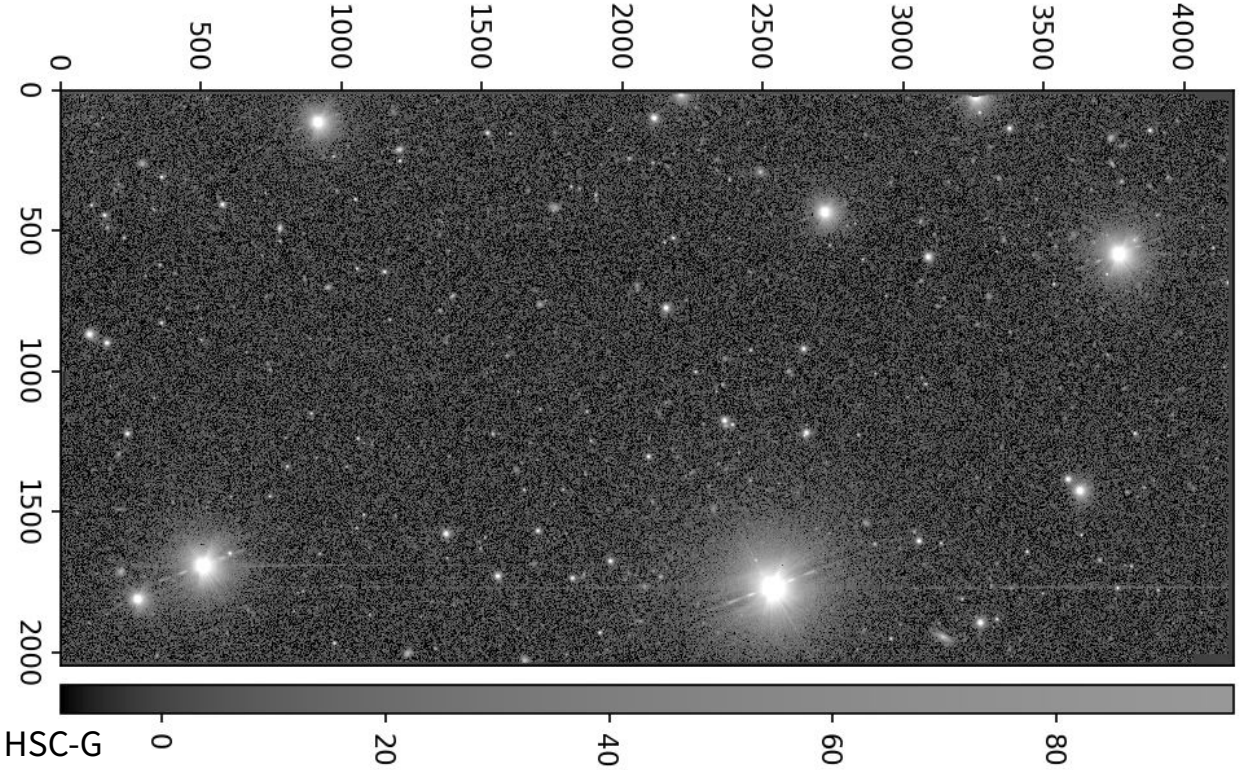


new metrics to be tracked;
→ eg. 10% μ deviation magnitude.

Image credit: Aaron Watkins

More info → Source Injection in the Rubin Pipelines (Thurs, Sophie Reed)

Prototype Bright Star Subtraction Task



A bright star prototype is constructed based on existing point source detections → bright stars are modelled and subtracted.

This process is an important step in further unlocking the LSB regime.

@Morgan Schmitz

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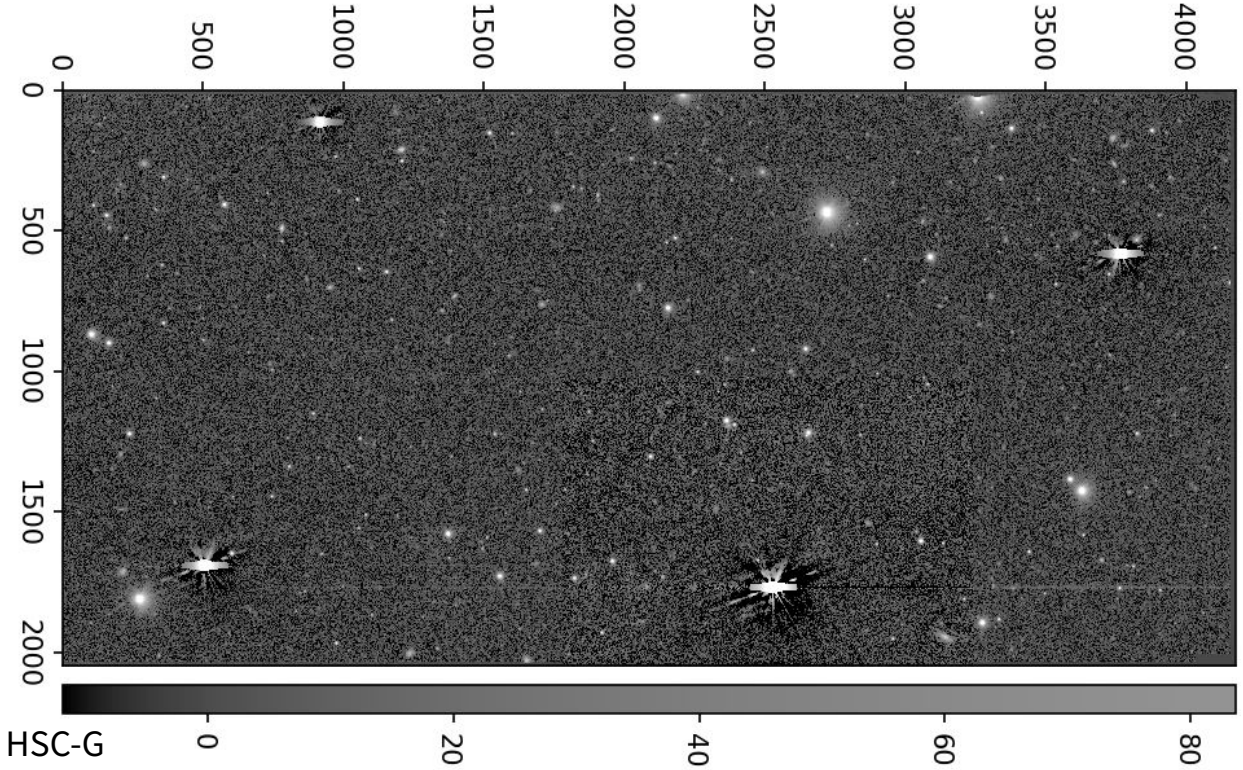

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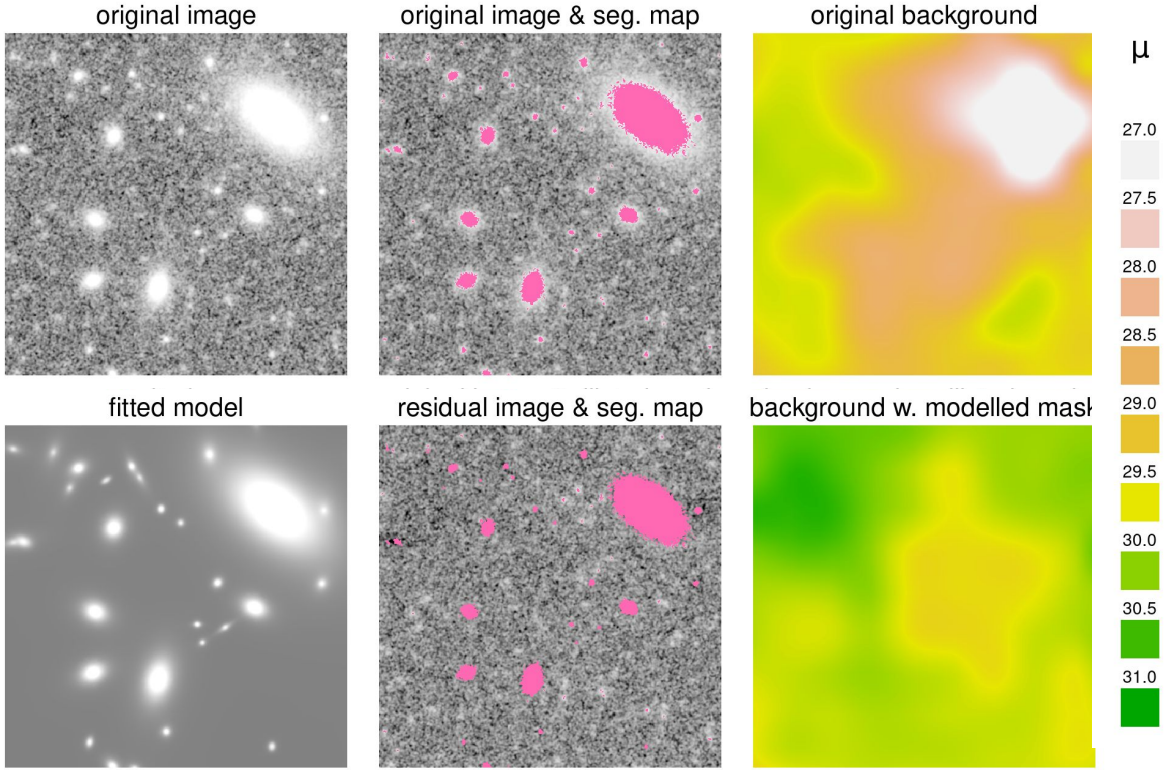
Further such novel techniques - e.g., model masking



Fit bright sources with a simple parametric model and subtract.

Allows for a more accurate determination of the background, reducing source flux contamination.

Resultant skies fainter by ~1 mag/arcsec^2

Figure from kelvin et al. 2022 (subm.)

Summary

Rubin is ideally suited for LSB science; Rubin data reduced using the LSST Science Pipelines should be ‘LSB-ready’

A number of background subtraction algorithms operate throughout standard data processing - at detector level, focal plane level, and tract/patch level

LSB science users should utilize `deepCoadd` dataset types (*not* `deepCoadd_calexp`)

Background quality will be regularly assessed using, e.g., SI and associated metrics/plots

Novel techniques such as bright star subtraction are currently being prototyped, with further such algorithms being considered for inclusion into the stack in the future.