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Science Pipelines Overview

Yusra AlSayyad and the DRP team

March 17 2020

How do we “best” combine multi-epoch imaging to extract the maximum information?

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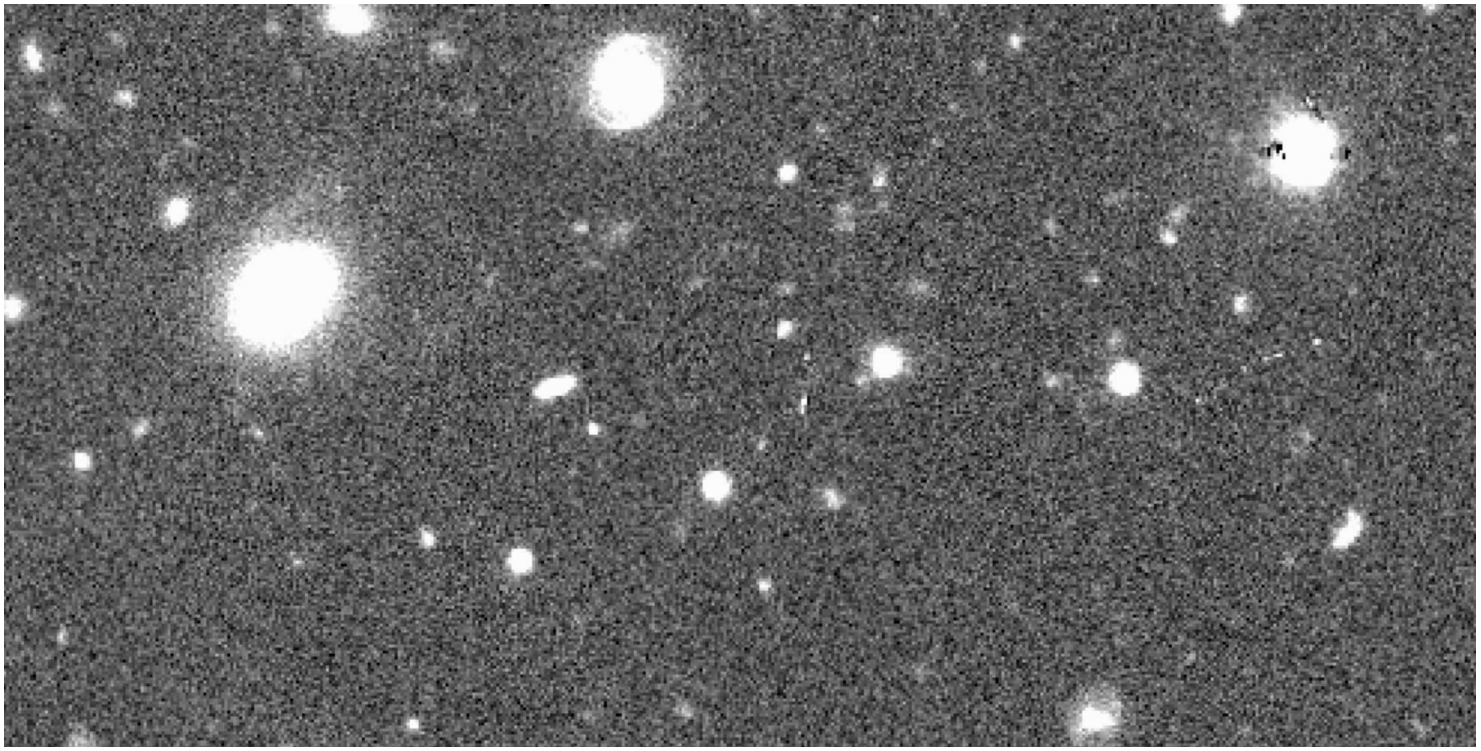
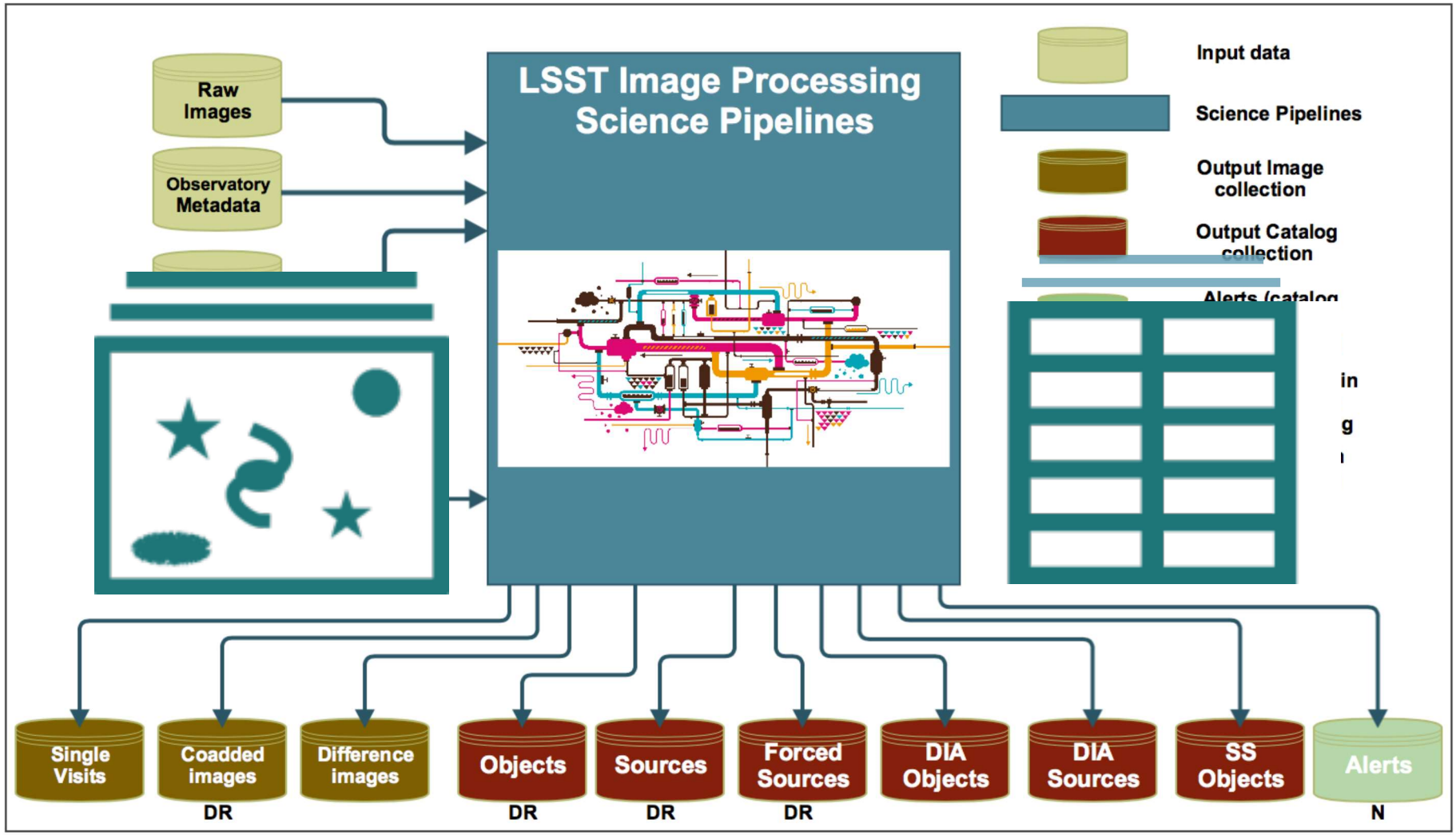


HSC-I COSMOS field (270s exposures)


Raw Images
Observatory Metadata
LSST Image Processing Science Pipelines
Input data
Science Pipelines
Output Image collection
Output Catalog collection
Single Visits
Coadded images
Difference images
Objects
Sources
Forced Sources
DIA Objects
DIA Sources
SS Objects
Alerts
DR
DR
DR
DR
N

Science Pipelines consists of 2 components: Prompt Products and Annual Data Release Production

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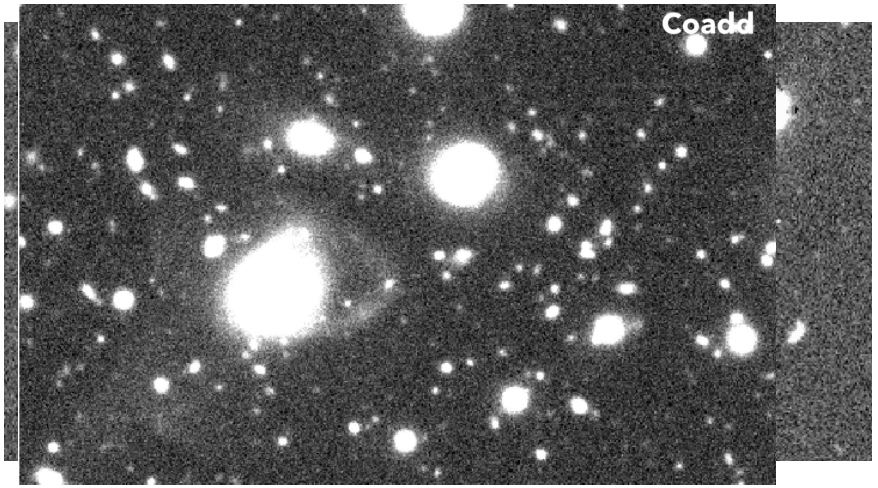
Annual Data Release Products (DRP)
11 Data releases in 10 years.
Final catalog: 15PB
Final pixels: 100PB



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

The DRP and AP pipelines are constructed from the same algorithmic components

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How do we know how well it works?

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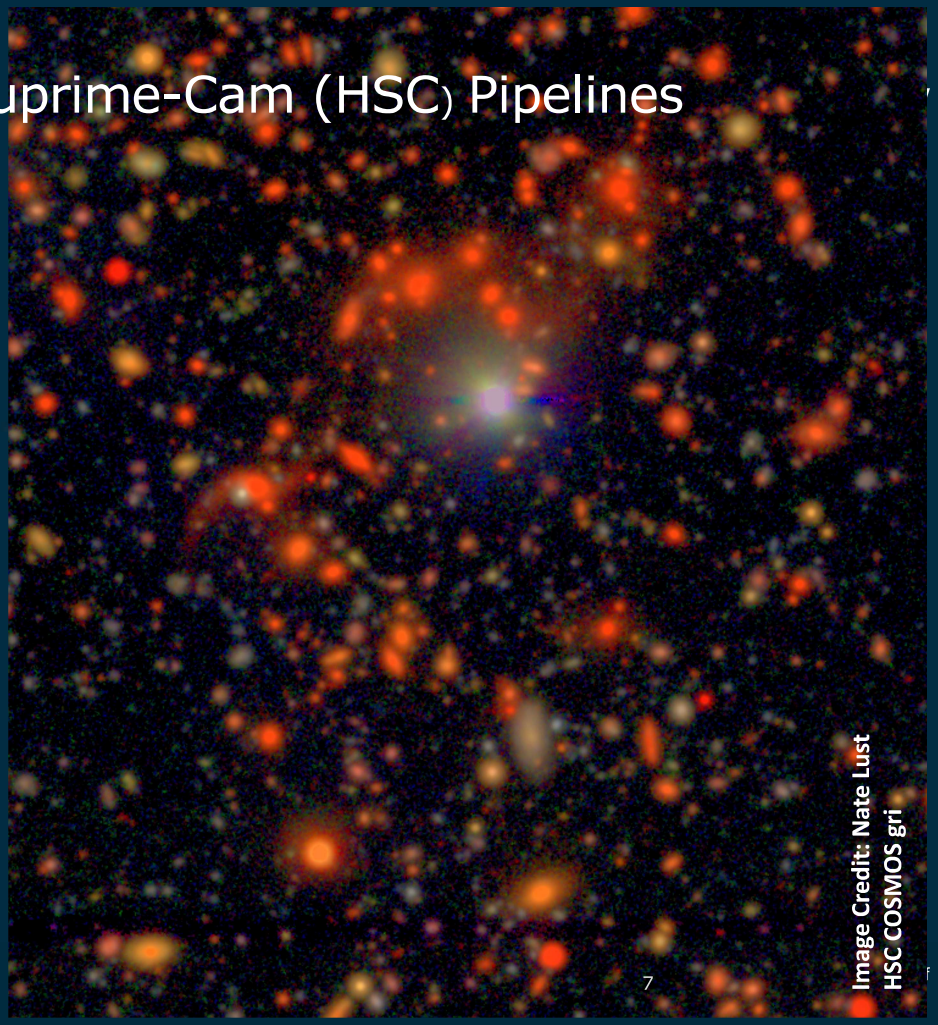
We say "HSC" frequently because the LSST Pipelines **are** the Hyper Suprime-Cam (HSC) Pipelines

Survey Comparison	**LSST**	**HSC (Subaru Strategic Program)**
Effective Aperture	6.5m	8.2m
Filters	ugrizy	grizy + narrow
Exposure time per visit	~30s	~240s
Field of View	10 deg^2 3.5 deg diam	1.8 deg^2 1.5 deg diam
Num CCDs	189 (4k x 4k)	103 (4k x 2k)



How do we know how well it works?

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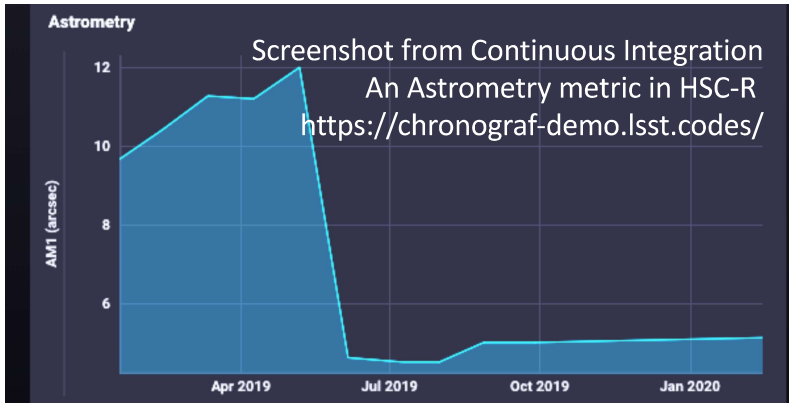
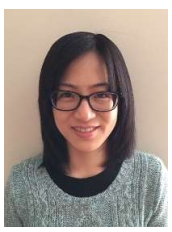
- Real HSC Data Releases
- Month continuous integration
  - Track metrics through time and version.
  - DRP on 5 sq. deg. HSC and LSST ImSim (DESC DC2)
- Nightly continuous integration
  - DRP on patch/ccd scale HSC/CFHT, AP on DECam
- Inject fake sources



Screenshot from Continuous Integration
An Astrometry metric in HSC-R
https://chronograf-demo.lsst.codes/

Ask us more about Validation and fake source injection




@hsinfang @Sophie Reed @jcarlin @laurenam

High level overview of the a Data Release Production

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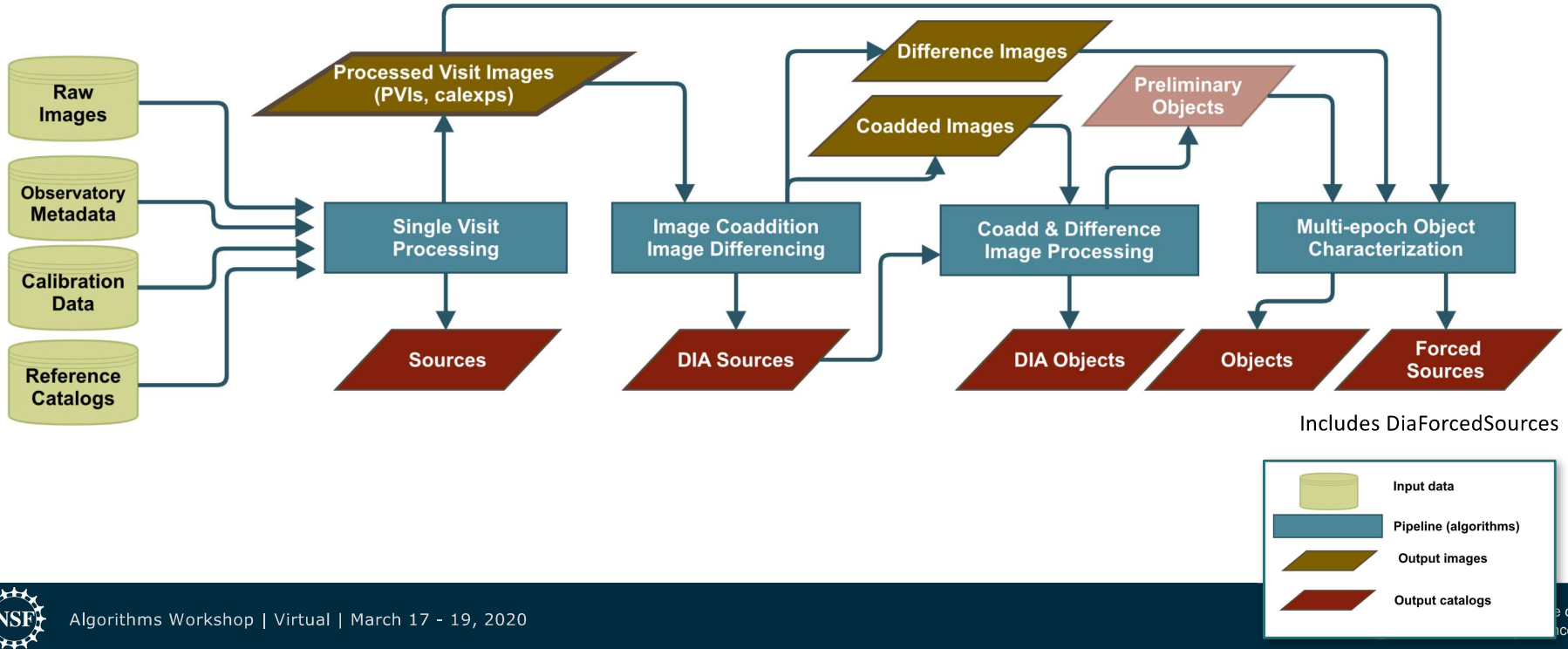
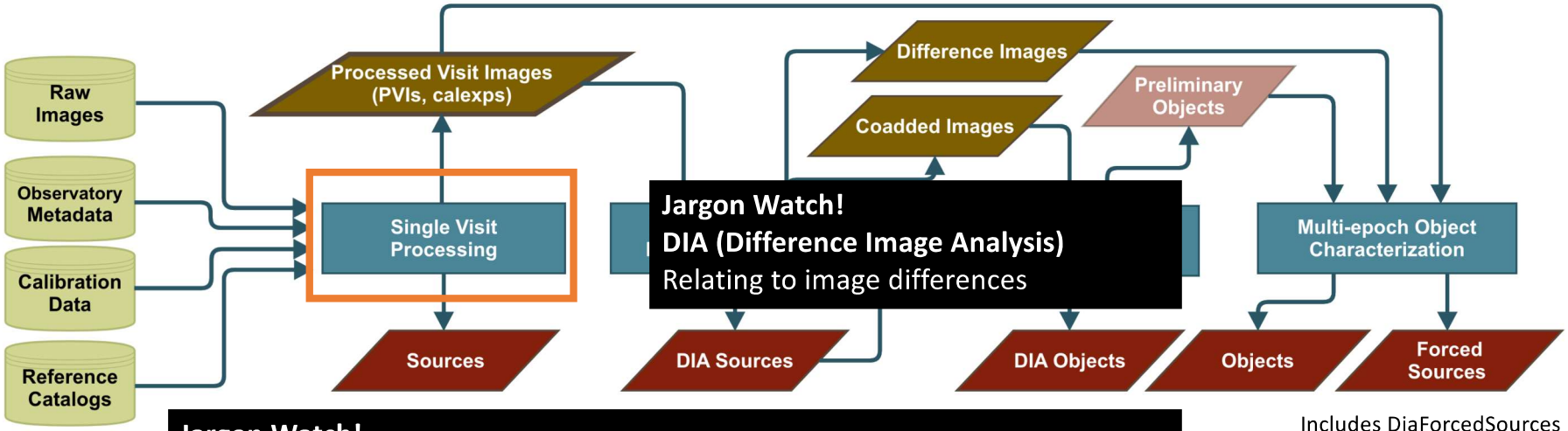


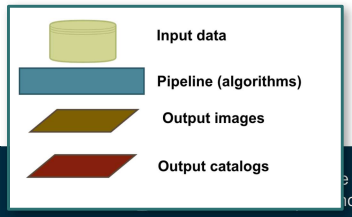
High level overview of the a Data Release Production

Rubin Observatory



Jargon Watch!
Sources: Measurements from a single observation
Objects: Measurements utilizing many (typically all) observations. The logical aggregate (incl. motion, color, variability, deep). **Not matched Sources!**

Includes DiaForcedSources



Jargon watch: Visits, CCDs, Exposures

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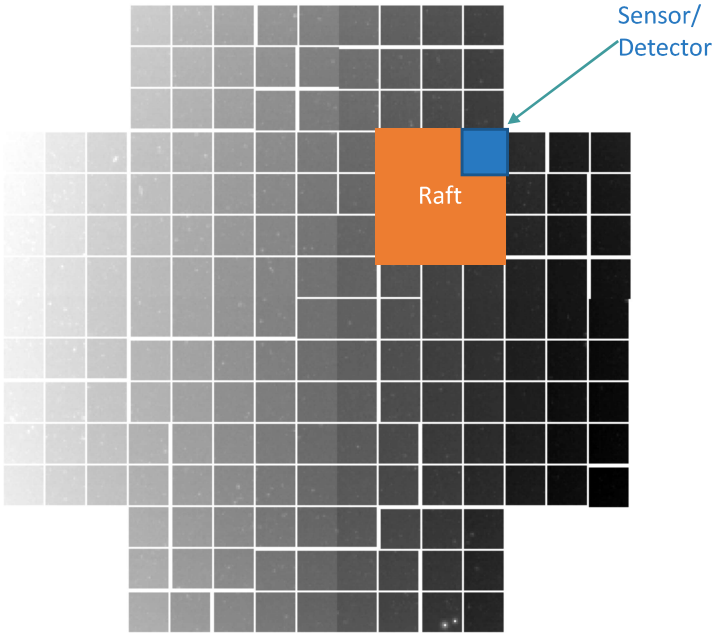

`Exposure`: A software Object that contains an image plane, mask plane, variance plane, PSF model, WCS, photoCalib and visit metadata. Stored in FITS format

Single Visit Processing (as it works now)
Image Characterization and Calibration

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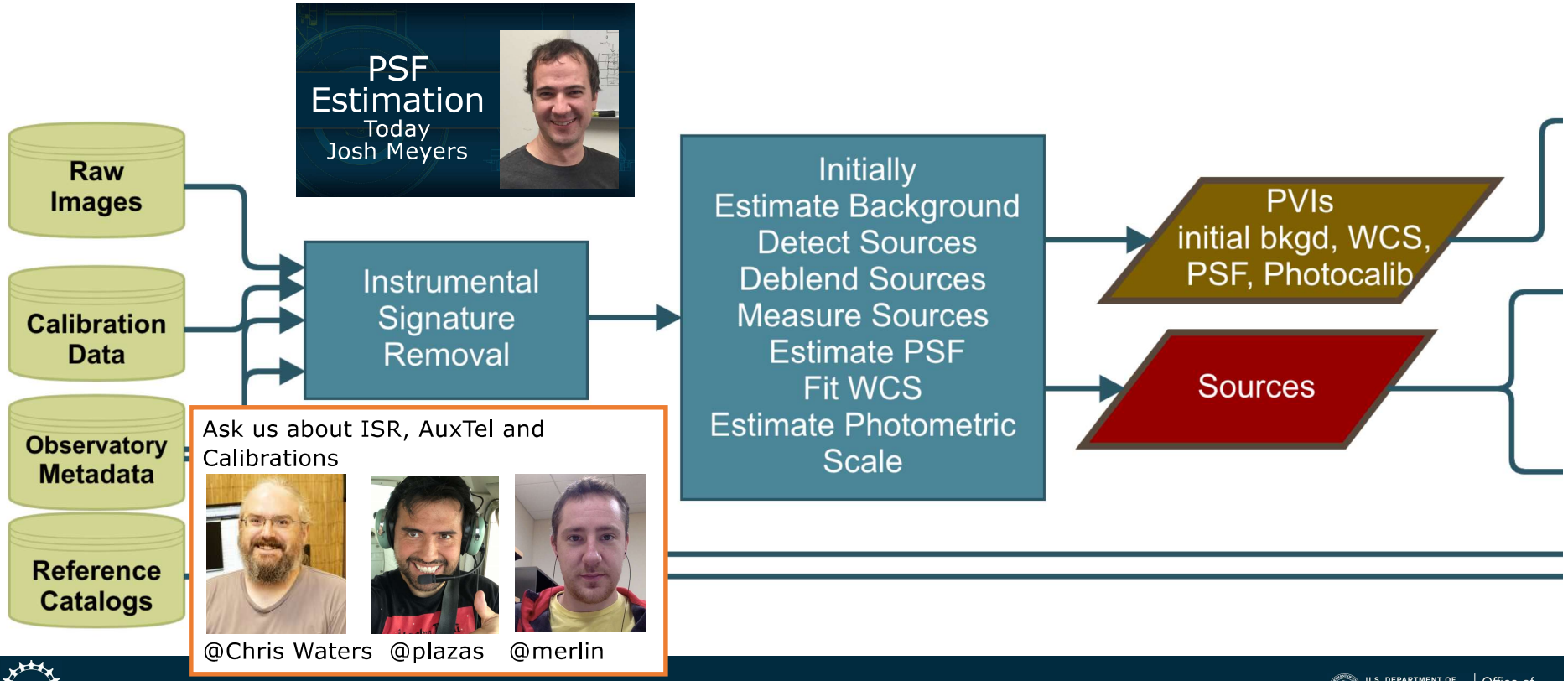
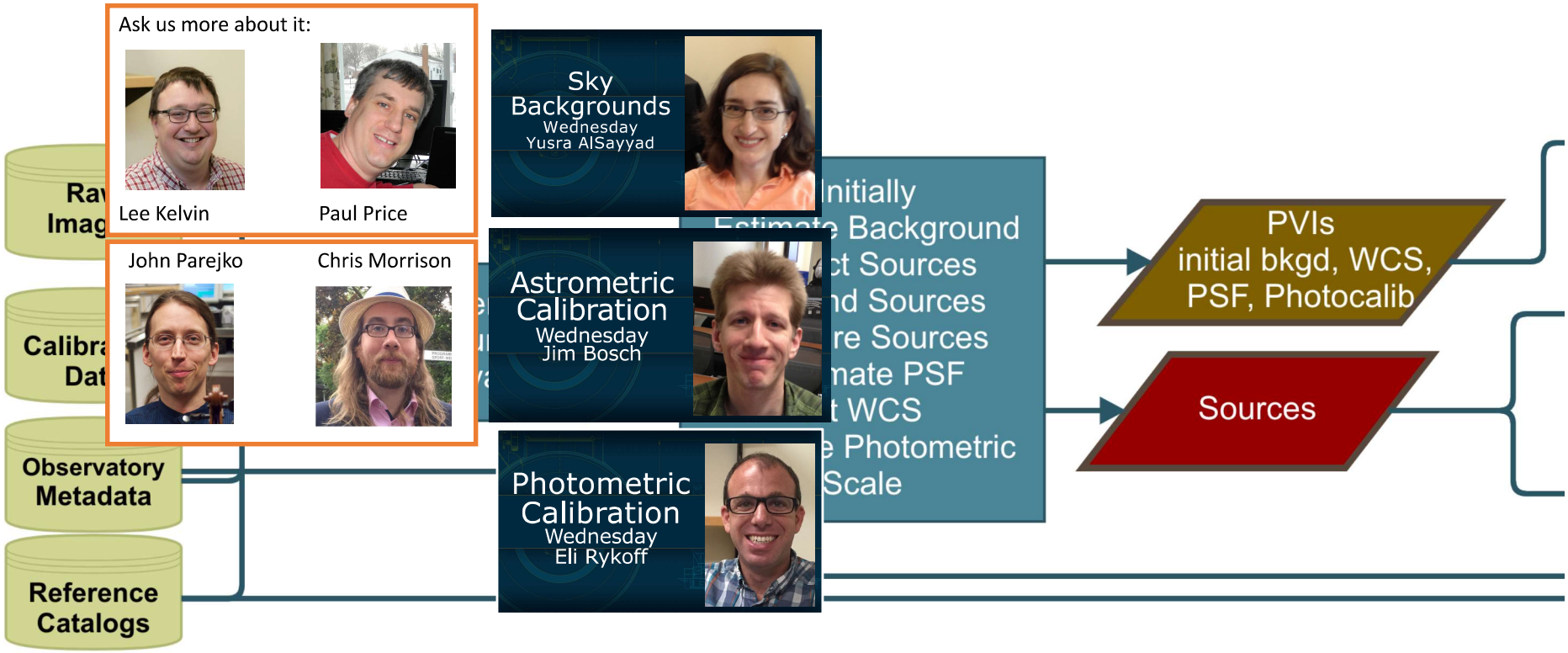


Single Visit Processing (as it works now)
Image Characterization and Calibration

Rubin Observatory



Single Visit Processing (as it works now)
Image Characterization and Calibration: printout

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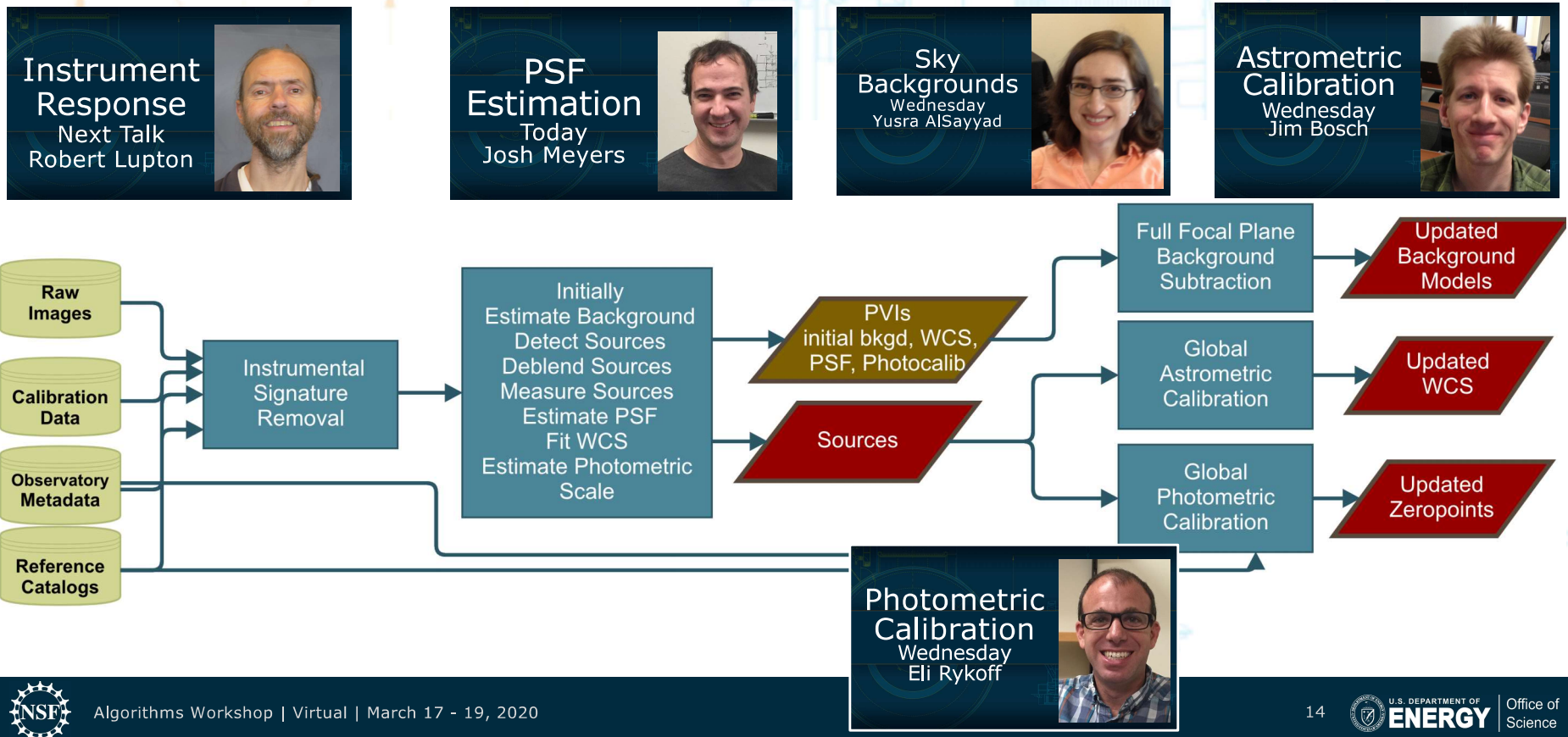

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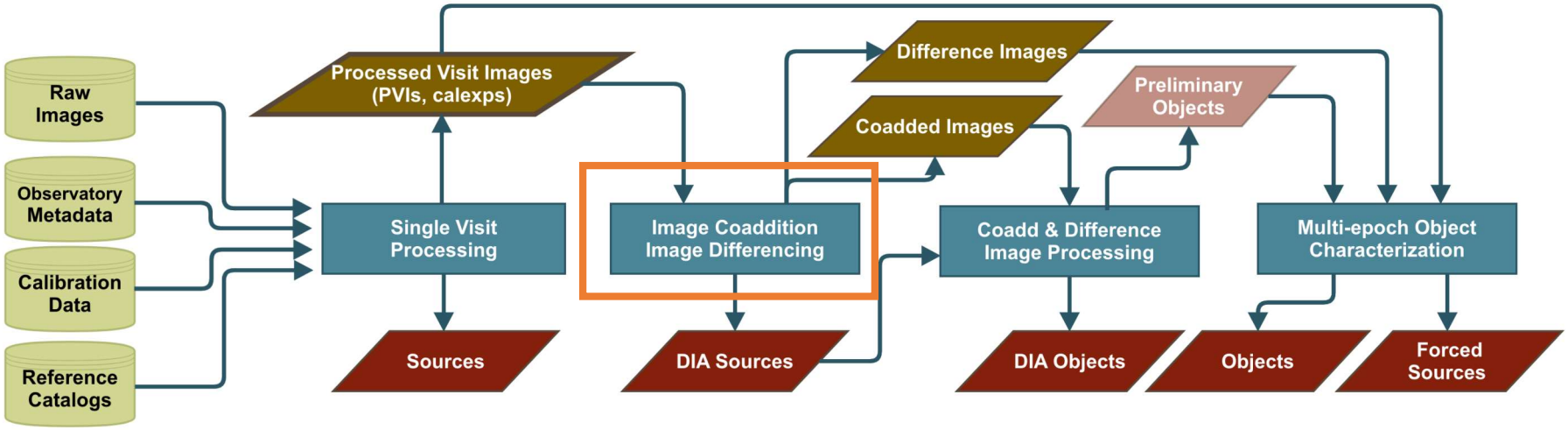

Coaddition and Image Differencing

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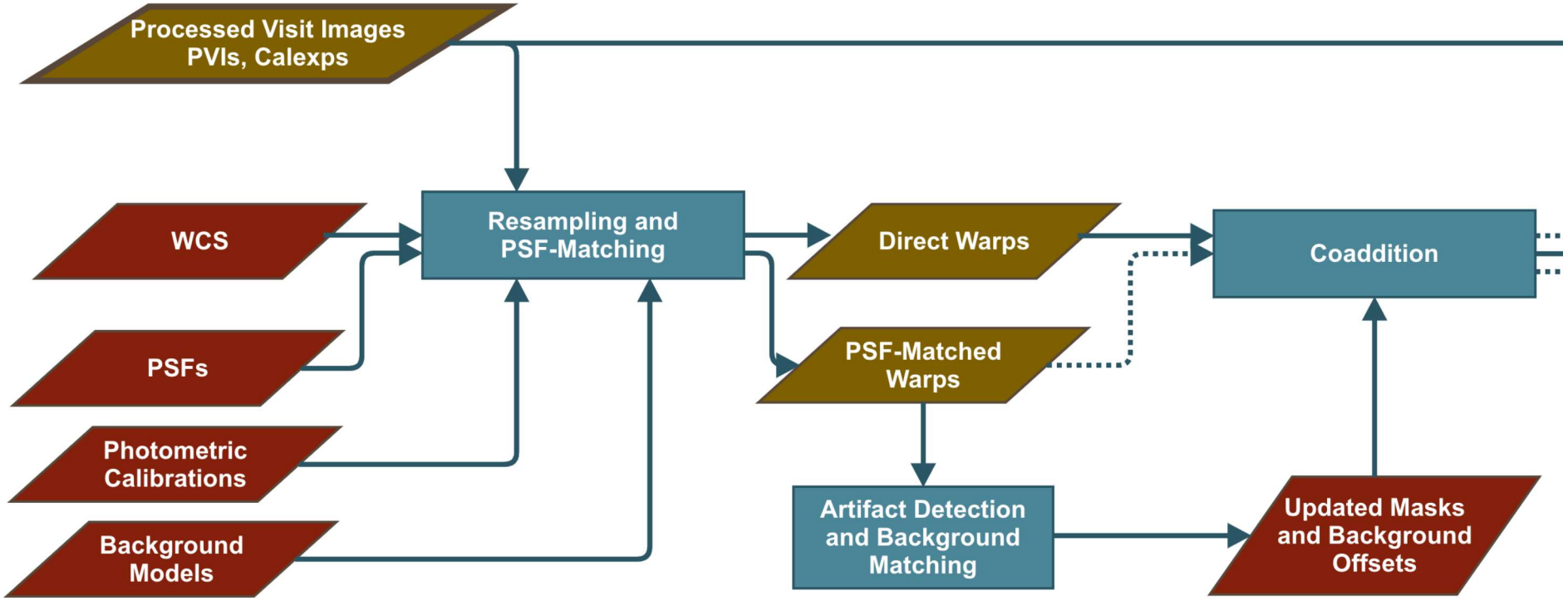
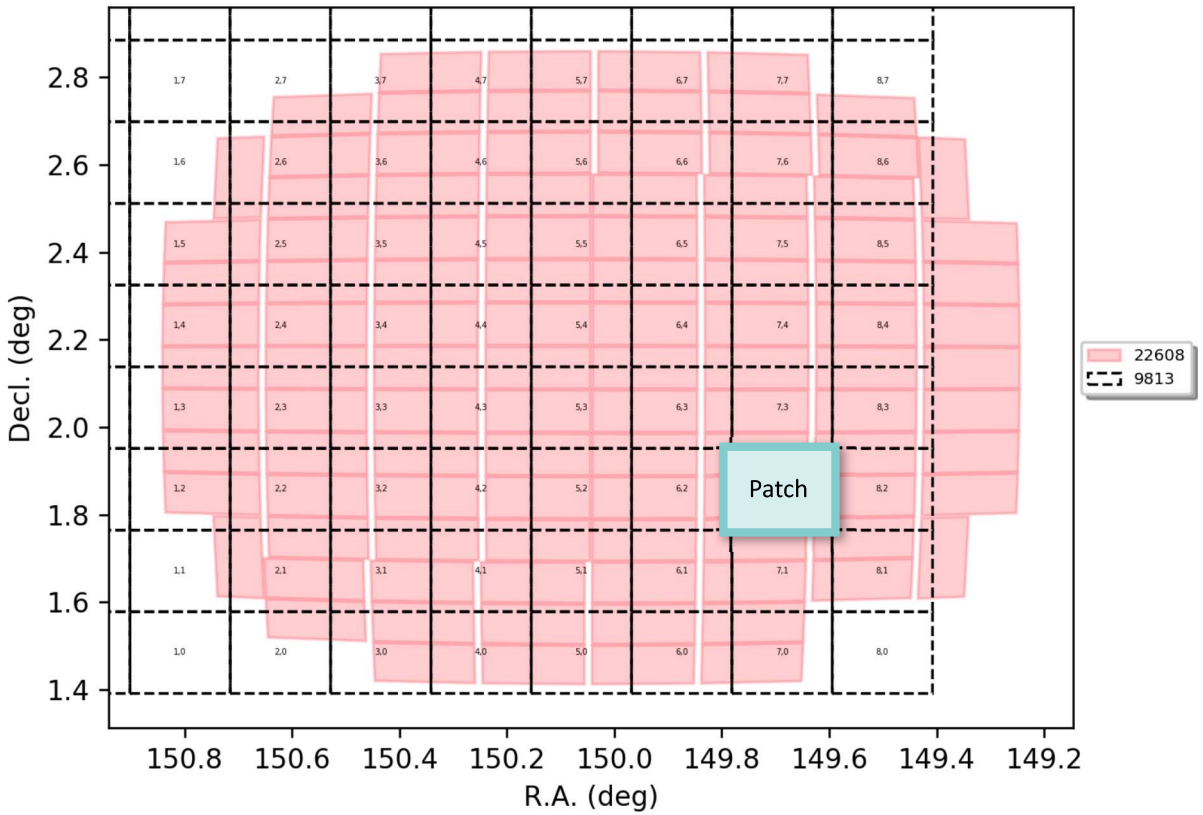


Jargon Watch! Tract, Patch HSC's skyMap:

SkyMap: a Software Object that defines a coadd's:

- WCS/Projection: TAN (gnomonic)
- Pixel Scale: ~Native
- Tract Size: ~FOV
- Patch Size: ~CCD

Modular implementation makes it easy to swap projections and tessellations at runtime



Coaddition and Image Differencing

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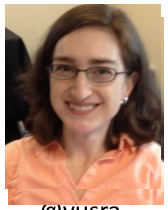
Ask us about satellite masking and coaddition:


@Clare Saunders


@yusra

WCS

PSFs

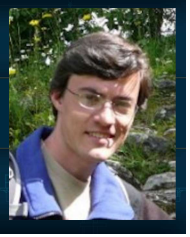
Photometric Calibrations

Background Models

Coaddition
Today
Jim Bosch

Resampling and PSF-Matching

Differential Chromatic Refraction
Thursday
Ian Sullivan



Direct Warps

PSF-Matched Warps

Artifact Detection and Background Matching

Image Differencing
Wednesday
Eric Bellm

Coaddition

Ask us about image differencing:


@mrawls


@Gabor Kovacs

Coaddition and Image Differencing Procedure
Hidden Slide for Printouts

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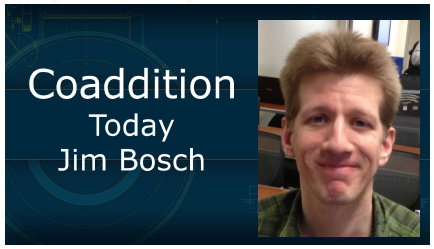

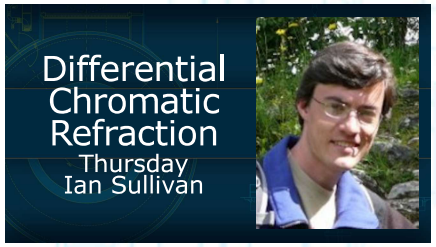

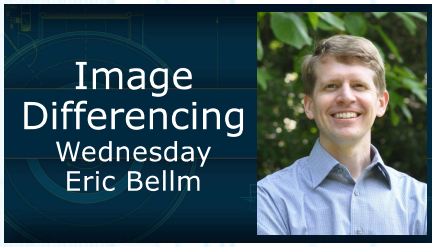

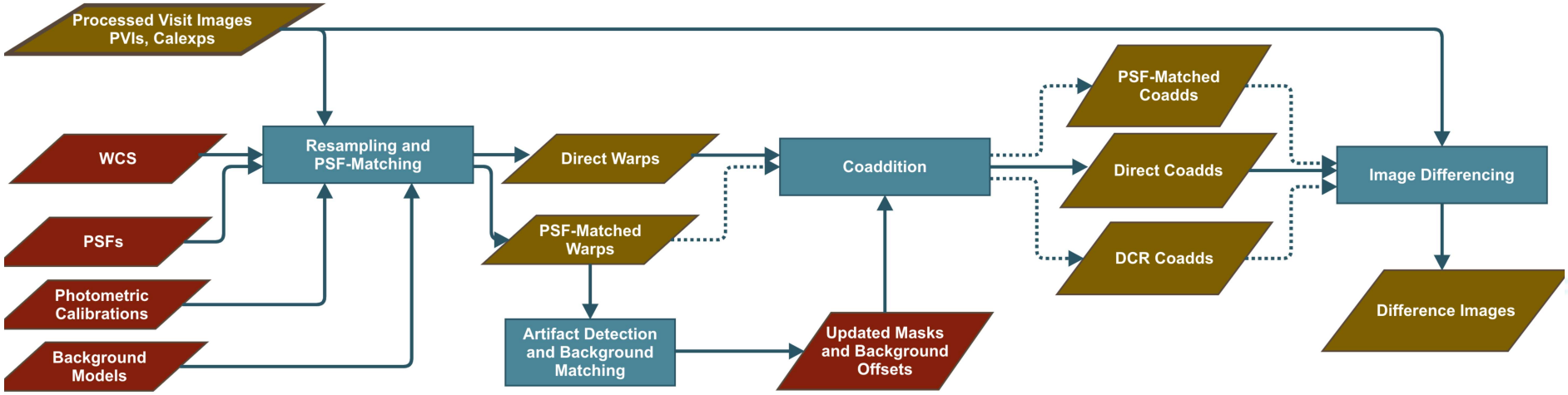

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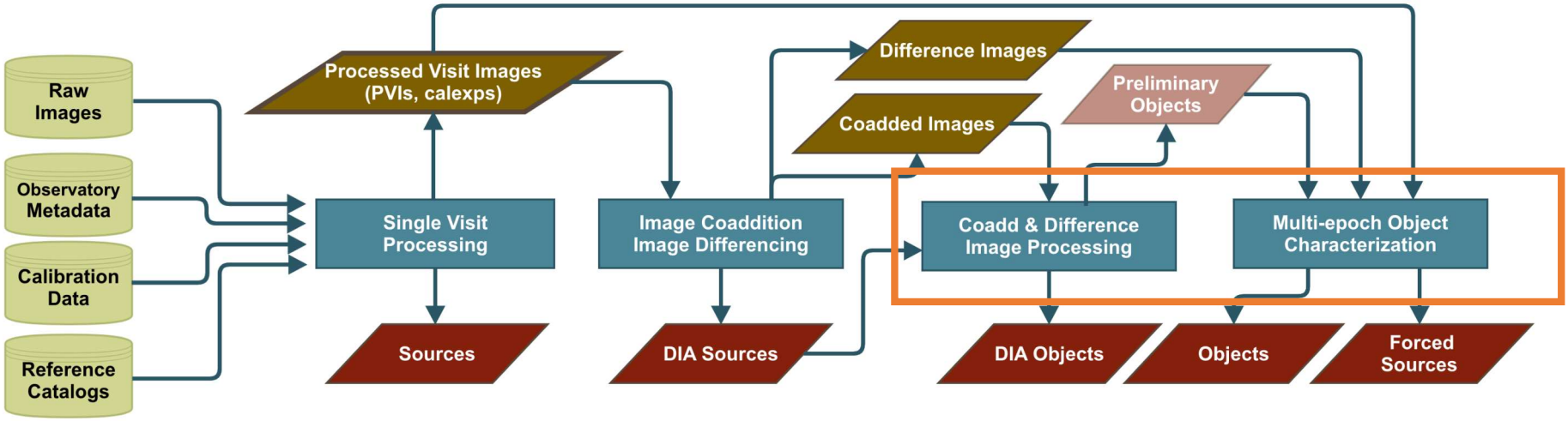

Multi-band and Multi-epoch Object Characterization

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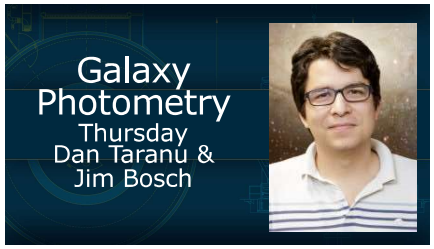
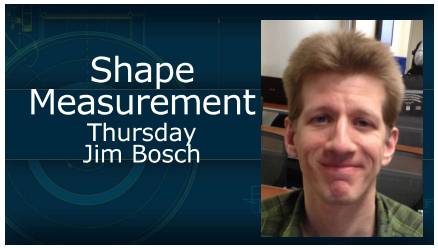




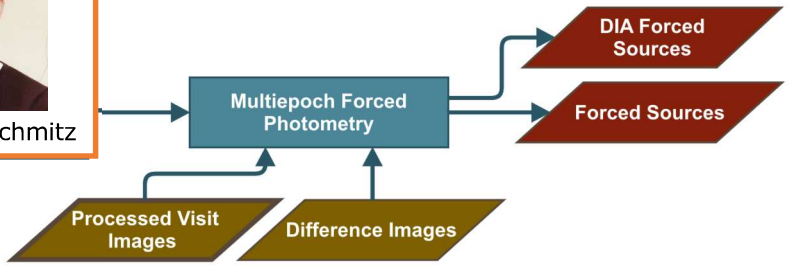
Ask me more about the Measurement Framework:

@natelust

Ask us more about shear:

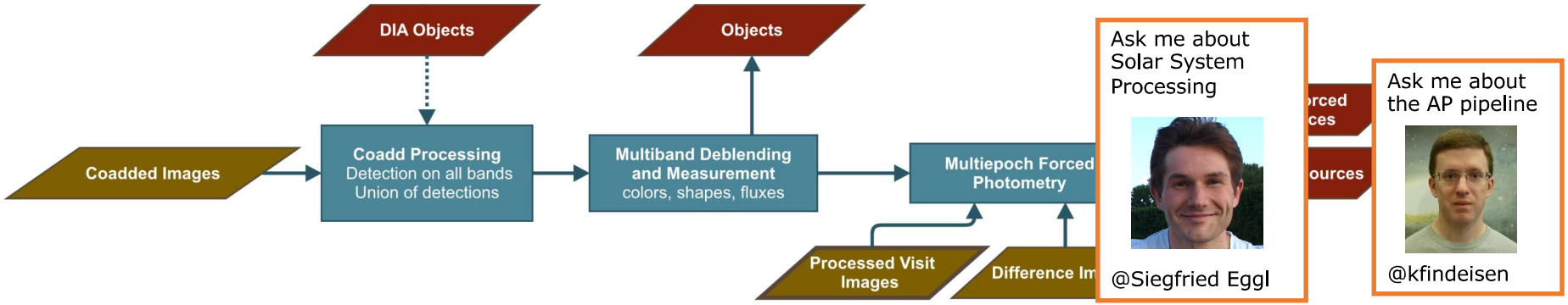
@Arun Kannawadi

@Morgan Schmitz



Multi-band and Multi-epoch Object Characterization

Rubin Observatory



Multi-band and Multi-epoch Object Characterization (hidden slide for print out)

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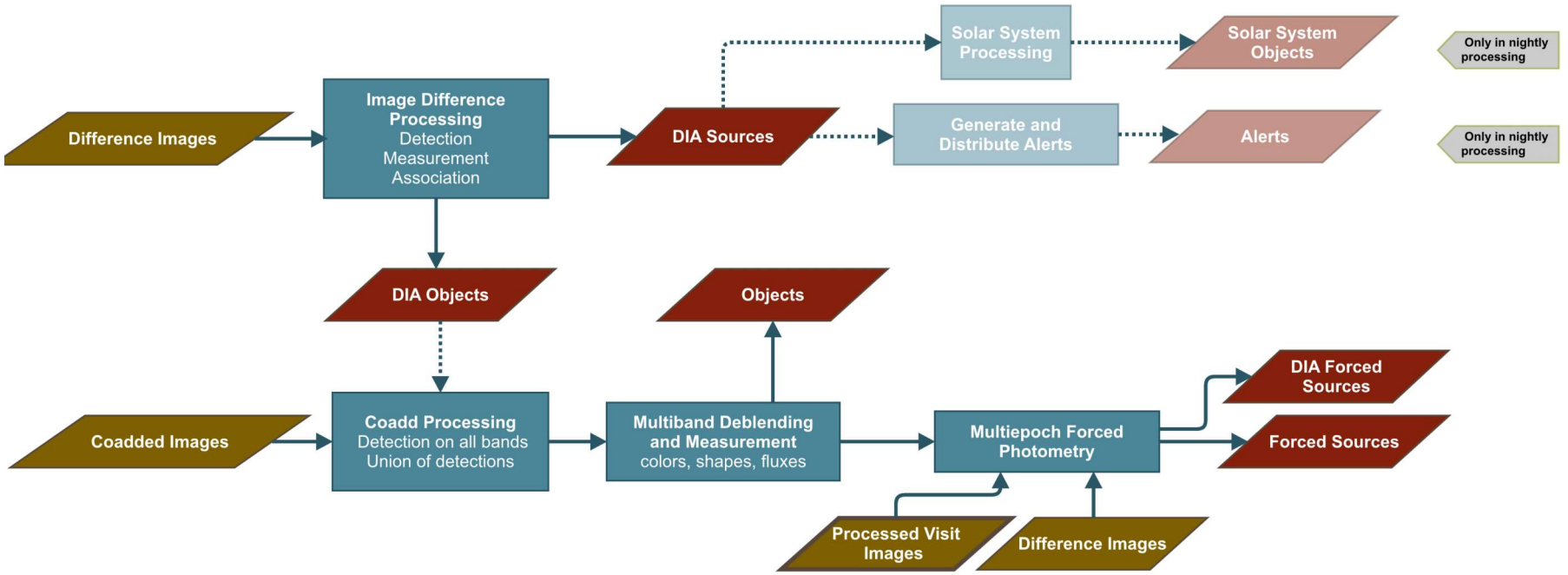

You
(Avatars in #mtg-algorithms-workshop)

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We asked you: "What aspects of the Science Pipelines Processing are you most interested in?"

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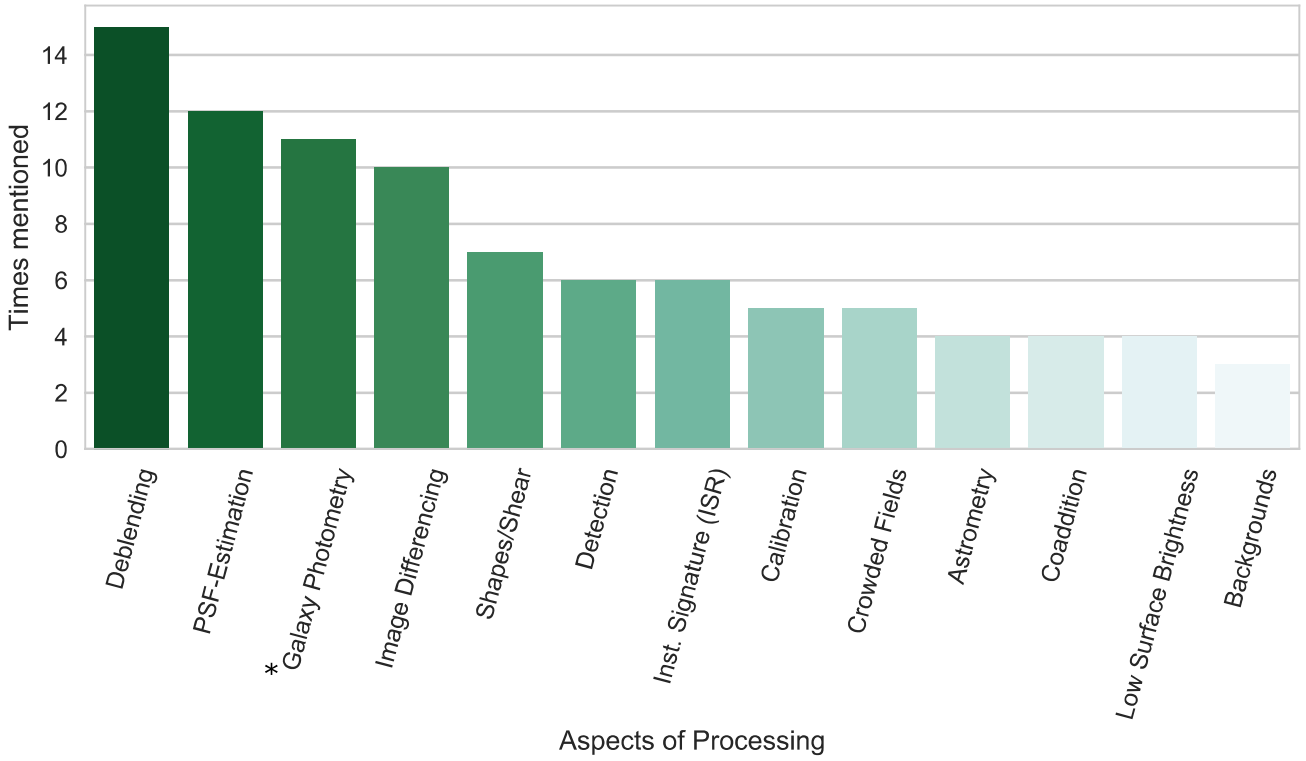

←An unscientific coding

Also mentioned:

Templates
Stellar motion
DCR
Coadd Artifact Rejection
Coadd processing
Brighter-Fatter

Some topics with interest **did not** make the cut for this workshop (beyond a brief mention)

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- Software
- Data products
- Science Platform, Visualization
- Middleware
- Solar System Processing, moving objects processing
- Slow moving objects (Coaddition talk)
- Alerts
- Fake source injection
- Star Galaxy Separation
- Photo-z's (Galaxy Photometry talk)
- Dust Extinction
- Extended transients

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- In talks that follow, we'll tell you:
  - Why is this component important and challenging?
  - What do we do now?
  - What are the limitations?
  - What are the plans for overcoming the limitations?

- We'd like:
  - To hear your lessons learned!
  - Your metrics. (i.e. will this support my science?)

More Information

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- Data Products Definition Document (LSE-163): http://ls.st/dpdd
- Science Pipelines Design Document (LDM-151): http://ls.st/ldm-151
- Post questions at https://community.lsst.org/c/sci/data
- Post questions on LSSTC Slack if you're on Project or in a Science Collaboration
- Documentation and code: https://pipelines.lsst.io
- https://www.lsst.org/scientists/glossary-acronyms