An Overview of the LSST Pipelines
Jim Bosch, Princeton/LSST - ADASS 2018
A Detailed Look at Some of

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Woefully Incomplete

Large Synoptic Survey Telescope
Making a Catalog

Let's start with a simple operation: we want to make a catalog containing measurements of the sources detected in a single image.

The LSST Pipeline splits this into three steps.
Detection

- Smooth image by the PSF.
- Find above-threshold regions.
- Find peaks within them.
- Grow regions by PSF width.

Not heuristic: this is maximum likelihood for isolated point sources.

And it's usually fine for extended and slightly-blended sources.
Deblending

We want to measure all of these, even #2.

Two(-ish) choices:

- Fit models to all sources iteratively or simultaneously.
- Construct a counterfactual image that isolates each source, and measure them individually.
Deblending

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Parents, Children, & HeavyFootprints

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Measurement

- Replace all Footprints with noise.
- For each source:
  - Insert HeavyFootprint.
  - Run centroid algorithms.
  - Run shape algorithms.
  - Run flux and other algorithms.
  - Re-replace with noise.
- Re-insert all HeavyFootprints.
Catalog Complete!

That was easy.
Catalog Complete!

Too easy.
Starting from Zero

First we need to get these!
Not Appearing in this Talk: Instrument Signature Removal

All the flat/bias/dark/fringe correction you know and love, plus:

- a Collimated Beam Projector
- an Auxiliary Telescope
- forward modeling of the atmosphere

*and more!*
Background Modeling

- Mask out detections and artifacts.
- Spatially bin pixel values (sigma-clipped mean).
- Either interpolate (splines) or approximate (polynomials) to smooth.

Bin or approximate on the largest continuous scale possible
Background Modeling

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PSF Modeling

- Select securely-classified, isolated stars from source measurements.
- Fit a spatially varying model to them.

Could fit over the full focal plane if the model could handle changes in focus between chips.
It's a Puzzle!

- DetrendedImage
- Background
- PSF
- DetectionMask
- ArtifactMask
- Footprints
- HeavyFootprints
- SourceCatalog

Diagram:

- EstimateBackground
- FitPSF
- Detection
- Measurement
- Deblending
Zooming Out

all of the previous slides just describe the Bootstrap step!
Zooming Out, Again

...and even the previous slide is just this bit.
Zooming Out, Again

Remember these?
Data Releases vs. Prompt Processing

Data Release
Data Releases vs. Prompt Processing

Prompt
For More Information

- Check out LSST's *Data Products Definition Document* at [http://ls.st/dpdd](http://ls.st/dpdd) for more information about the pipelines and particularly the data products they'll produce.

- LSST pipeline code is already being used to process data from Subaru's Hyper Suprime-Cam (right); see the *HSC Pipeline Paper* ([Bosch et al 2018](https://doi.org/10.3847/1538-4357/aae6a5)) to learn more about the algorithms and how they're working today.
LSST is also providing a data access system and analysis environment, which we're calling the *LSST Science Platform*.

Learn more at [http://ls.st/lse-319](http://ls.st/lse-319)
Got More Questions? Want Swag?

- Visit the LSST booth
- Get a demo
- Pick up some cool items!
Coaddition and Image Differencing

- Image Characterization and Calibration
- PVIs
- Resampling
- Direct Warps
- Artifact Detection and Background Matching
- Coadd
- Updated Masks and Backgrounds
- PSF Smoothing
- PSF Matching
- Smoothed Warps
- Coadd
- Matched Warps
- Coadd
- Matched Coadds
- Detection Coadds
- Difference Images
- Difference Image Processing
- DIA Sources

Possible iteration.
Multi-Epoch Object Characterization

PVIs ➔ Multi-Epoch Fitting ➔ Forced Photometry ➔ Forced Sources

PVIs ➔ Multi-Epoch Fitting ➔ Forced Photometry ➔ Difference Images

PVIs ➔ Multi-Epoch Fitting ➔ Forced Photometry ➔ DIA Objects

PVIs ➔ Multi-Epoch Fitting ➔ Forced Photometry ➔ Objects

PVIs ➔ Multi-Epoch Fitting ➔ Forced Photometry ➔ Preliminary Objects
One More Step

Once we've got good measurements built with the best PSF and background, we can match and calibrate to a reference catalog.