Adapting DESGW Single Epoch Image Differencing to the LSST Software Stack

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Old Pipeline, New Application

As gravitational wave detections become an ever-increasing part of cosmological research, the Gravitational Waves Group of the Dark Energy Survey (DESGW) seeks to match and interpret optical observations for these short-lived, transient events.[1] To provide timely analysis for each follow up, DESGW has developed a custom Single Epoch Differencing Pipeline for processing optical data obtained from the Dark Energy Camera (DECam).[2] While effective, the pipeline is a custom design and thus requires extra maintenance and specialized knowledge to operate and modify at a time when new projects are taking precedence.

GW170817 Processed with Current Pipeline

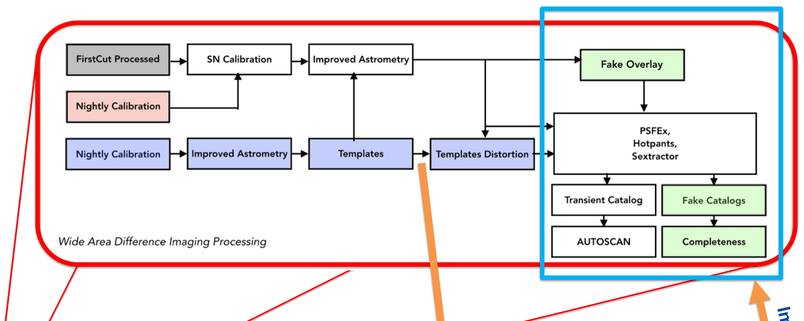
Example Detection Image which would be fed to the pipeline[4]

Example Template Image used in isolating the source of interest[4]

Example Image Differencing Product[4]

LSST Software Stack

The image processing pipeline produced for the Legacy Survey of Space and Time (LSST) provides difference image analysis functionality for a wide array of large telescopes, including DECam.[3] Repurposing DECam specific elements of the LSST Software Stack has potential to provide balance between efficient maintenance and effective, accurate analysis.



Advantages

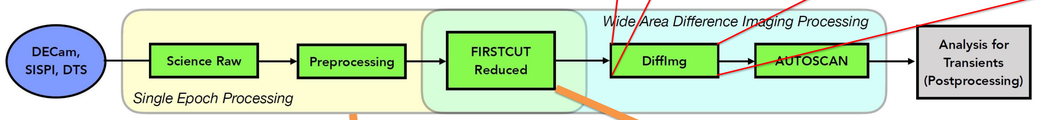
- Open source platform with extensive, active community forum
- Support for many large survey telescopes, including existing limited support for DECam applications
- Butler database for registering data and pipeline scripts simplify data consolidation and image processing

Remaining Challenges

- Expected formatting differs from DESGW Data
- Pipeline requires specific metadata items
- Pipeline wholly dependent on stack-created Butler Databases for incorporating data
- Butler dependence leads to failure when data doesn't ingest

Current Image Pipeline:

Flowchart adapted from Herner et al, 2020[2]



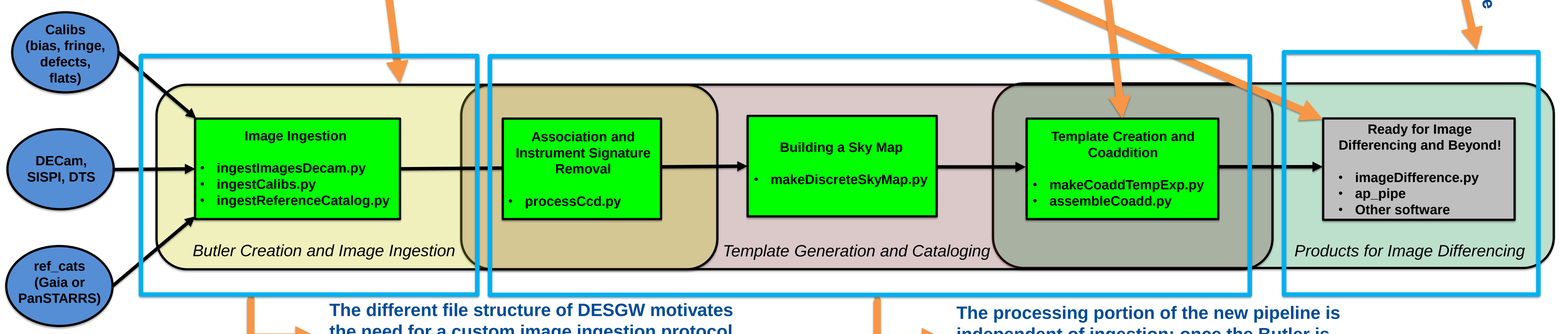
Raw data is ingested and cataloged into a series of databases which are queried by the pipeline tasks during processing. Calibrations and reference catalogs are also ingested during this stage.

The end result of the new pipeline flow are image products which are ready for difference imaging either through one of a few LSST Solutions, or a custom script.

Many of the calibration and template creation stages of the existing pipeline occur during the preprocessing of the LSST Stack, and the results are stored in the corresponding Butler databases.

Image Differencing Stage in Each Pipeline

New Pipeline Using LSST Stack:



The different file structure of DESGW motivates the need for a custom image ingestion protocol within ingestImagesDecam.py

The processing portion of the new pipeline is independent of ingestion; once the Butler is formed, data will pass through the pipeline.

References

1. Dark Energy Survey, *The Dark Energy Survey,* https://www.darkenergysurvey.org/ (Accessed July 2020).
2. Herner, K. et al.. "Optical follow-up of gravitational wave triggers with DECam during the firsttwo LIGO/VIRGO observing runs." arXiv:2001.06551 (2020).
3. LSST, *The LSST Science Pipelines*, https://pipelines.lsst.io/ (Accessed July 2020).
4. Herner, K., "GW170817: Discovery of the Optical Counterpart of a Neutron Star Merger with DECam." Fermilab Computing Techniques Seminar (2018).

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