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HPC/Blue Waters' Role in the Dark Energy Survey Data Management

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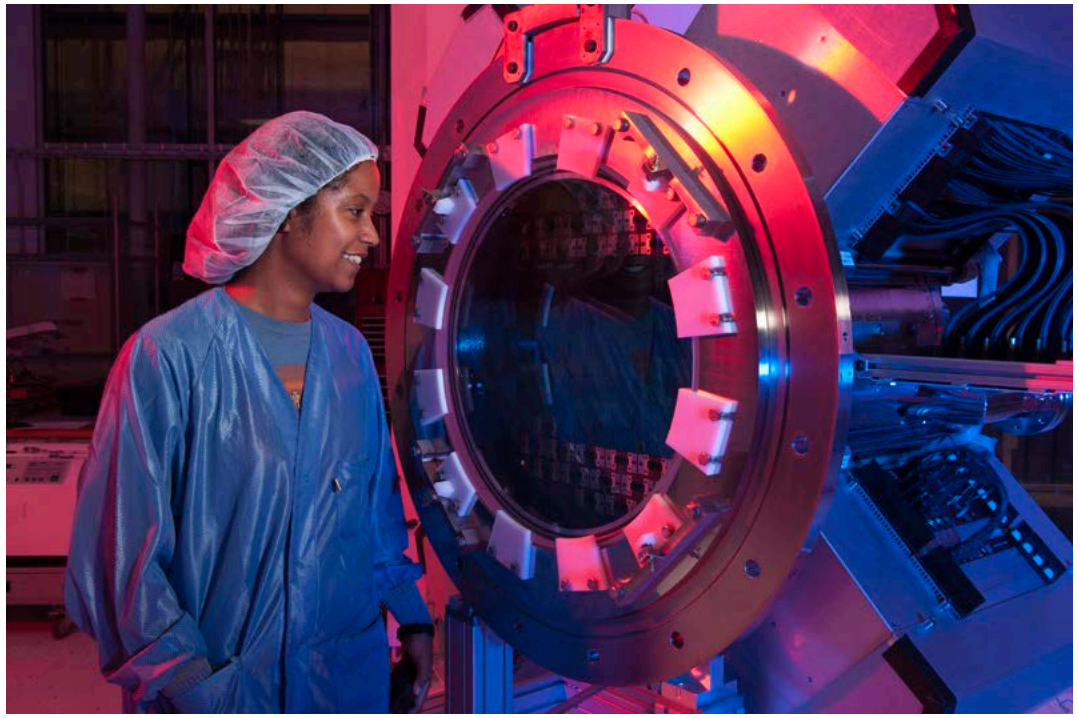
BW summary

- Incorporated BW into an overall Data Management System.
- **Completed a crucial Weak Lensing calculation in 2 weeks on BW,**
  - **where the alternative for us was 6 months.**
- Uses BW at a lessor level for other purposes in the system.
  - Includes making BW ready for the crucial calculation.

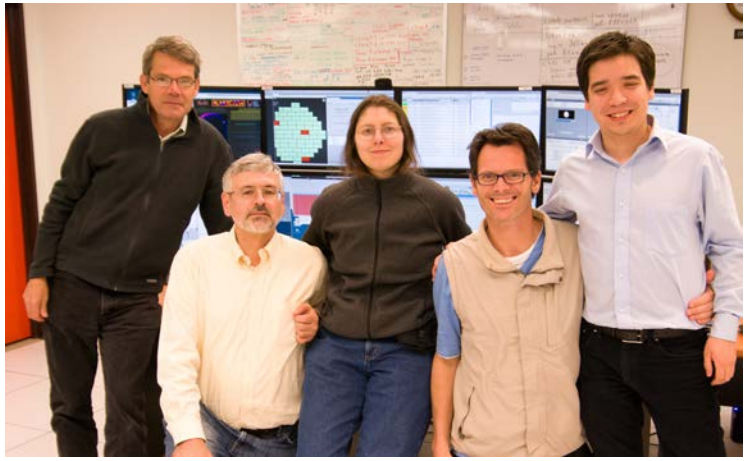
What is the Dark Energy Survey

- Goal :Constrain the characterization of Dark Energy using 4 probes:
  - Galaxy Clustering
  - **Weak Lensing**
  - Large Scale Structure
  - Supernovae
- Plan: Two Surveys:
  - Wide Field Survey in grizY, 5000 Deg^2
  - SNE survey griz 30 deg^2
  - Over 5.5 years.
- Instrumentation
  - 4 m Blanco Telescope, CTIO.
  - DECam 512 Megapixel, 3 deg^2



512 MP DECam during its fabrication at Fermilab

Who is the Dark Energy Survey



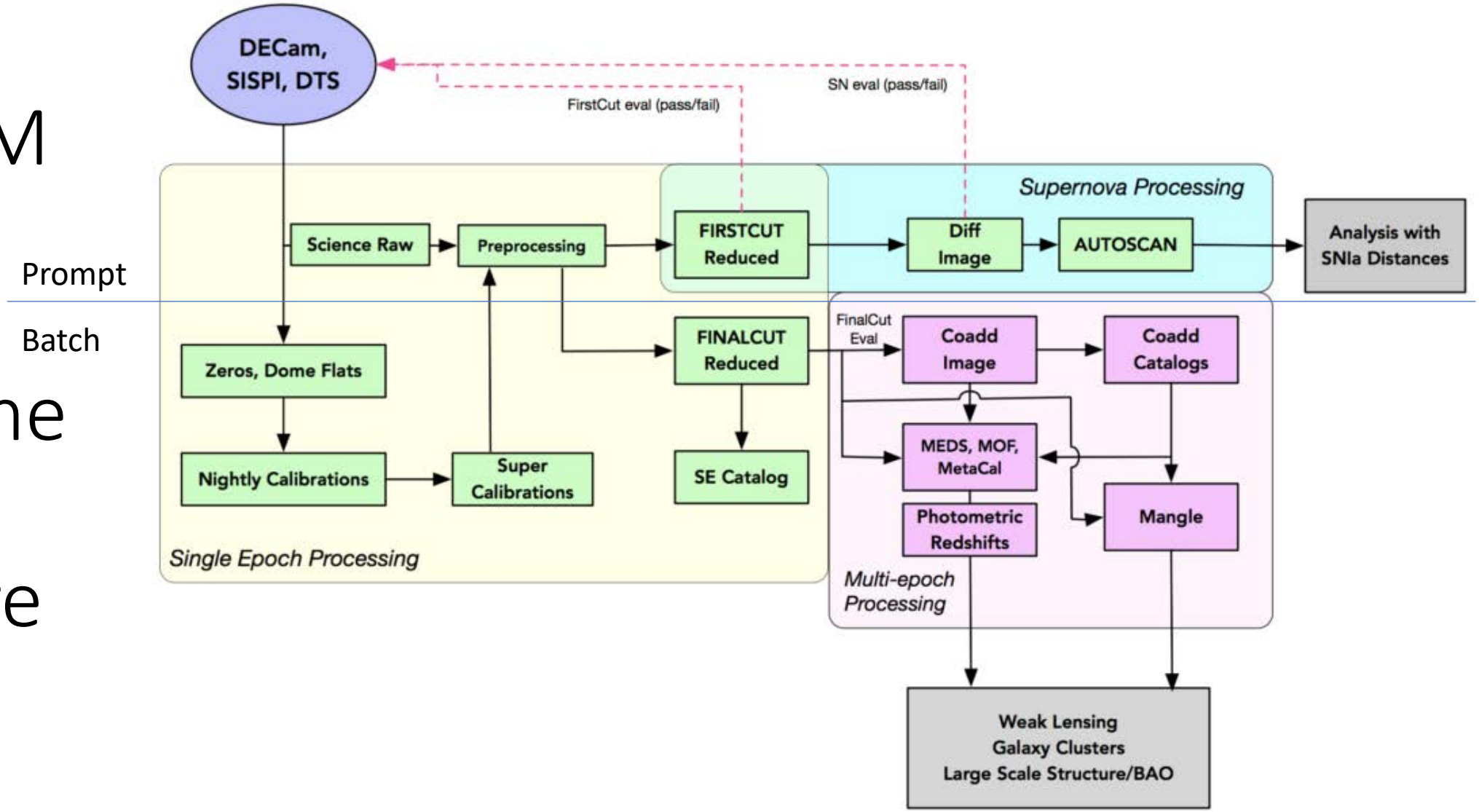
Observation → Data Production → Knowledge

DES: Rotating DES observing teams, FNAL: DECam Support. CTIO site: Telescope and instrument support.

DESDM Group: Research Scientists, Operations staff.
Technical services from overall NCSA staff.
Pipeline contribution from many in the collaboration.

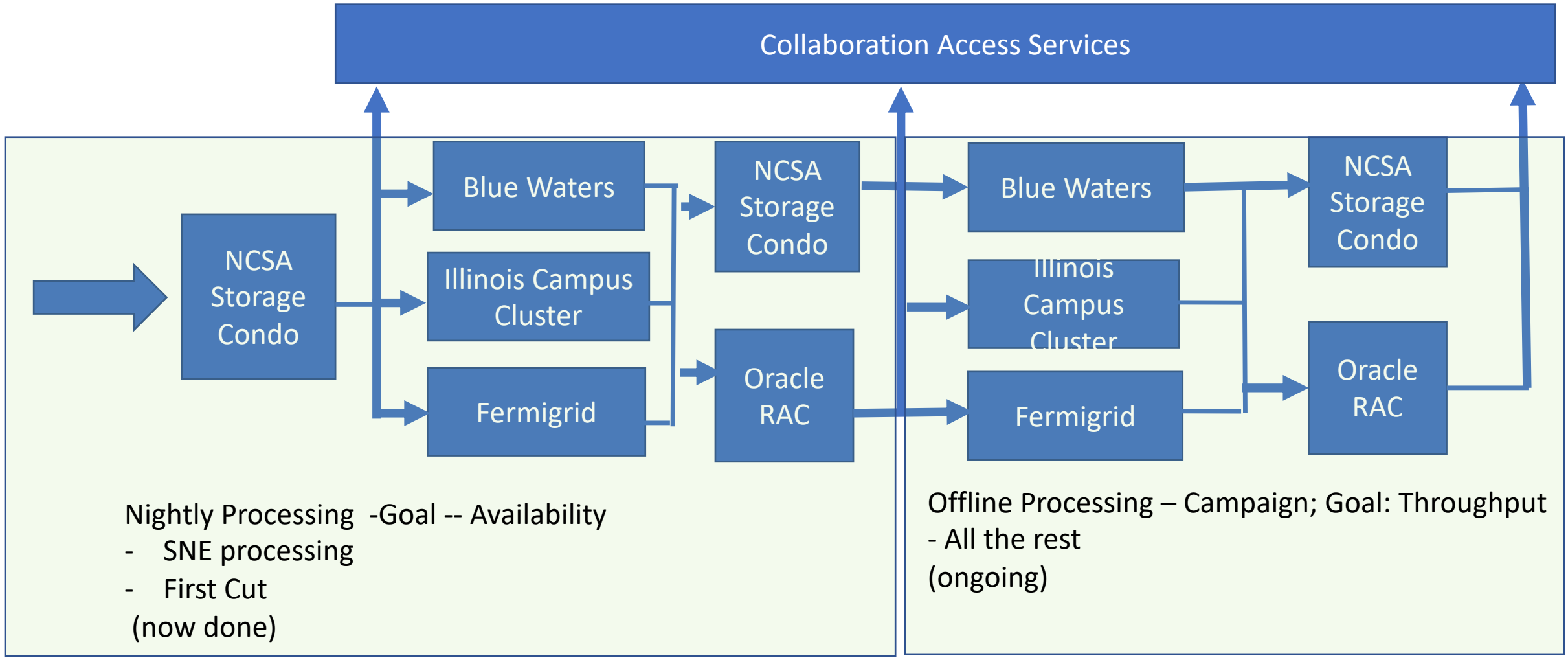
More than 400 scientists from U.S. Department of Energy, the United Kingdom, Spain, Brazil, Germany, and Switzerland.

DESDM High-Level Pipeline Archi-tecture

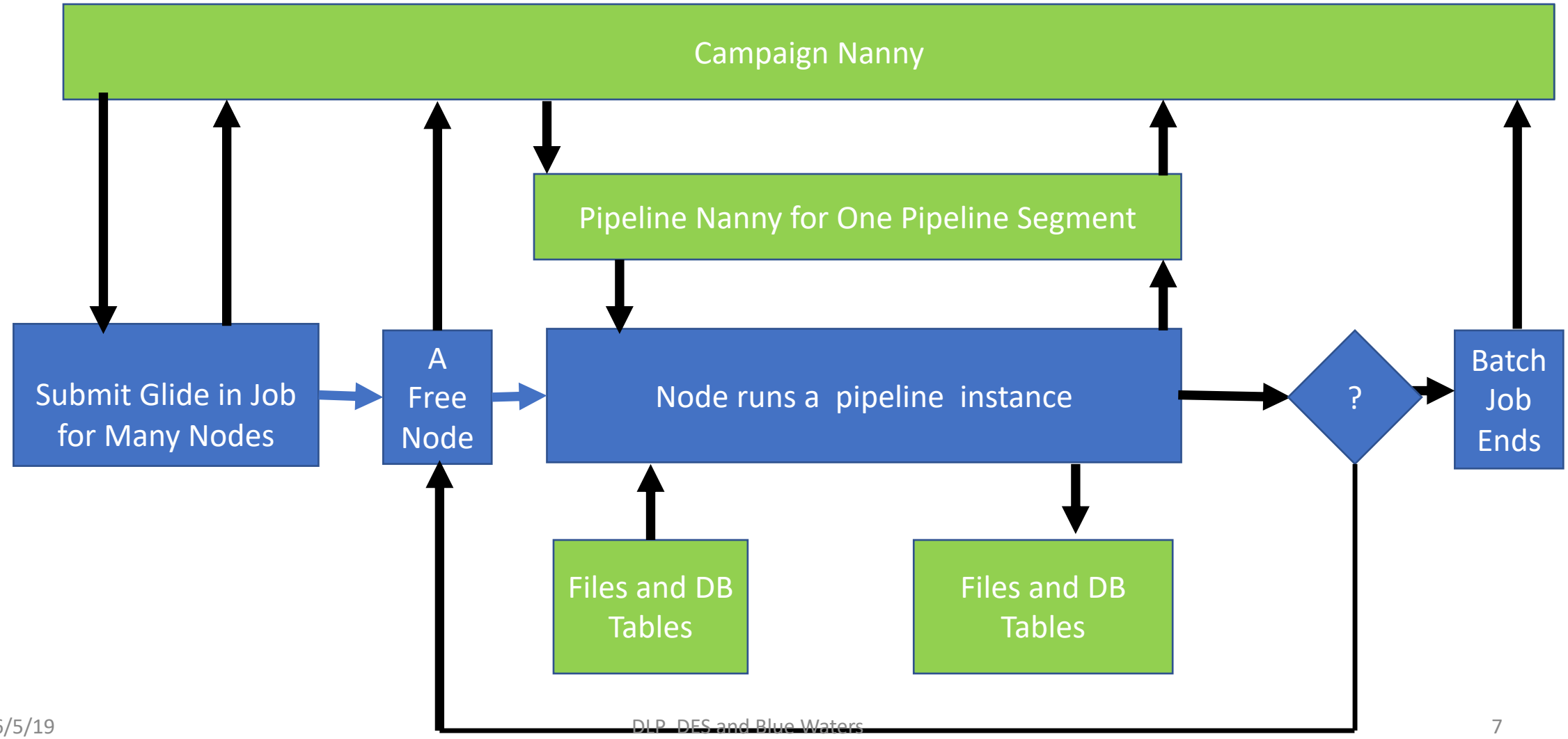


High Level overview of DESDM pipelines Credit Eric Morganson

Technical Services Architecture



DESDM Job Management -Common pattern



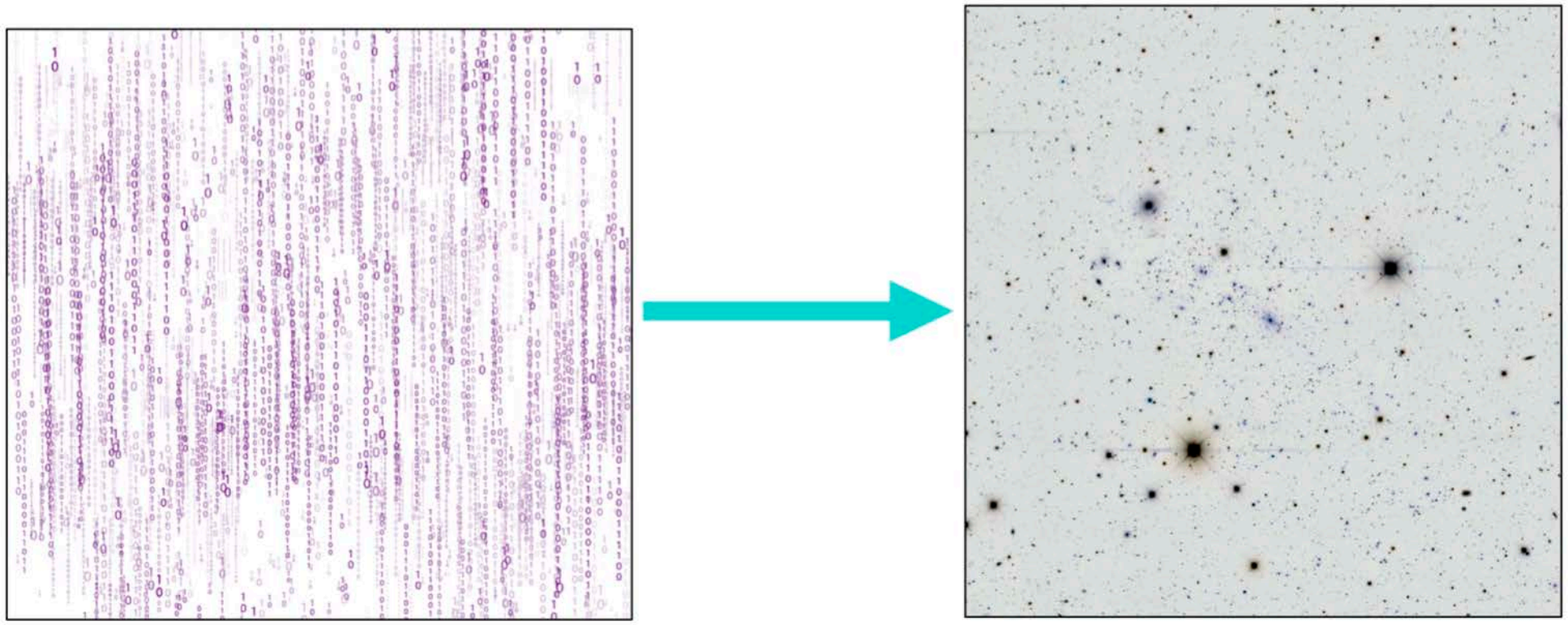
BW integration topics.

Goal – Satisfy needs at a scale beyond Illinois Campus Cluster and Fermigrid with minimal framework differences.

The primary challenges

- The large number of outbound connections DESDM Jobs make due to
  - Condor Framework
  - DB integration (upload detected objects, general status).
- Many small jobs – trivially parallel at scales of 1000-2000.
- File system load – community code integrations – “Hostile” to framework.
  - Pipeline modules use file system for inputs and outputs.
  - Many supplemental files.

Single Epoch to Science-Ready Images

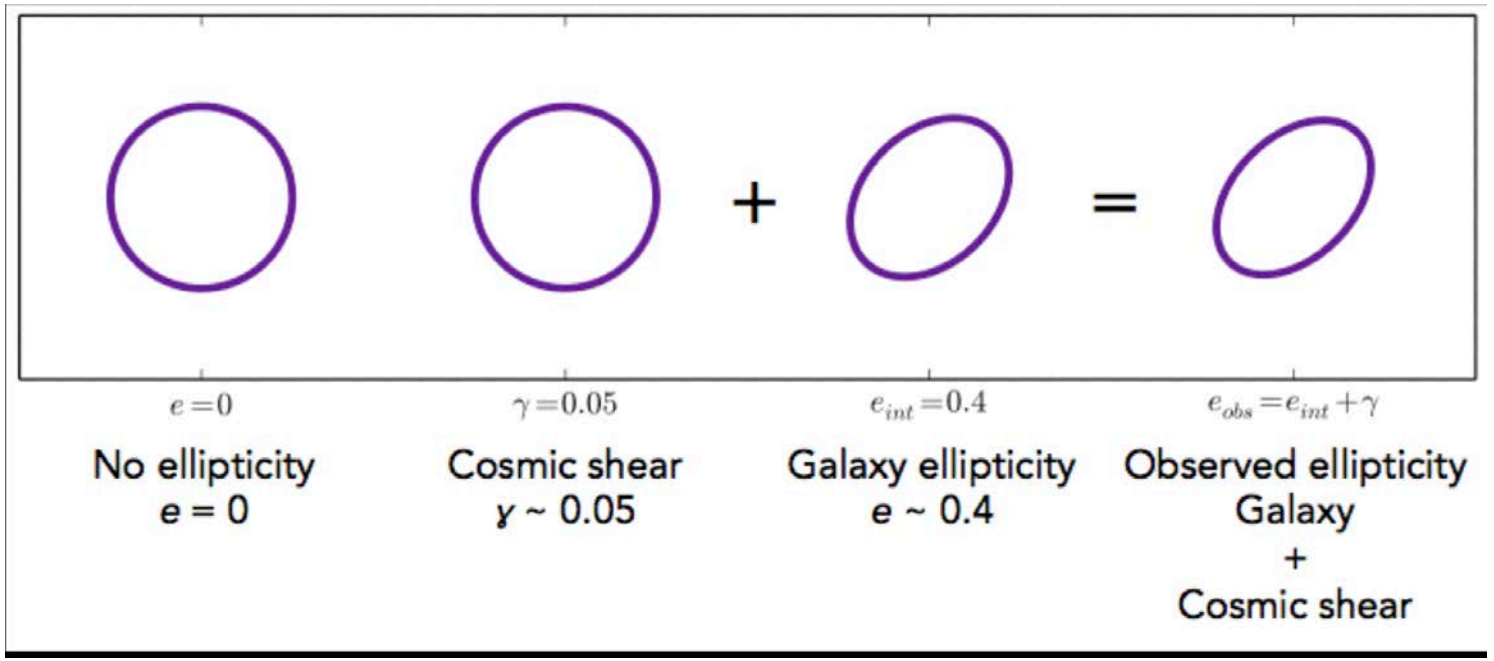


False color Images depicting raw (defects exaggerated) and processed image) Modified from original by Felipe Menanteau.

Difficulties of Weak Lensing

An example of strong lensing

- **The process of co-addition degrades the weak lensing signal present in the data.**
- **Weak lensing codes consider all the individual image simultaneously, guided by a co-added detection images.**
- **DES weak lensing codes are a the state of the art.**



Nature of the weak lensing signal from one galaxy. Credit: Felipe Menanteau Not shown are instrumental effects, such as variation of the PSF over the focal plane, These need to be characterized, and accounted for in the Weak Lending codes.

BW and DESDM

BW capacity is crucial for DES weak lensing processing, and able to provide a large amount of computing resources needed due to the intrinsic difficulty of the method the and the state of the art of these codes.

- Achievement:
  - Production run was 2 weeks
  - 6 months estimated on other infrastructure available to DESDM.
- Usage ~3 million core hours
- Codes: Multi-object fitting
- Observations included: Science verification though year 3.

Other uses:

- Usage: 1 million core hours for other DESDM data products
- Codes: single epoch and co-addition
- Observations: Varied, general resource complimenting
  - Illinois campus cluster
  - Fermigrid

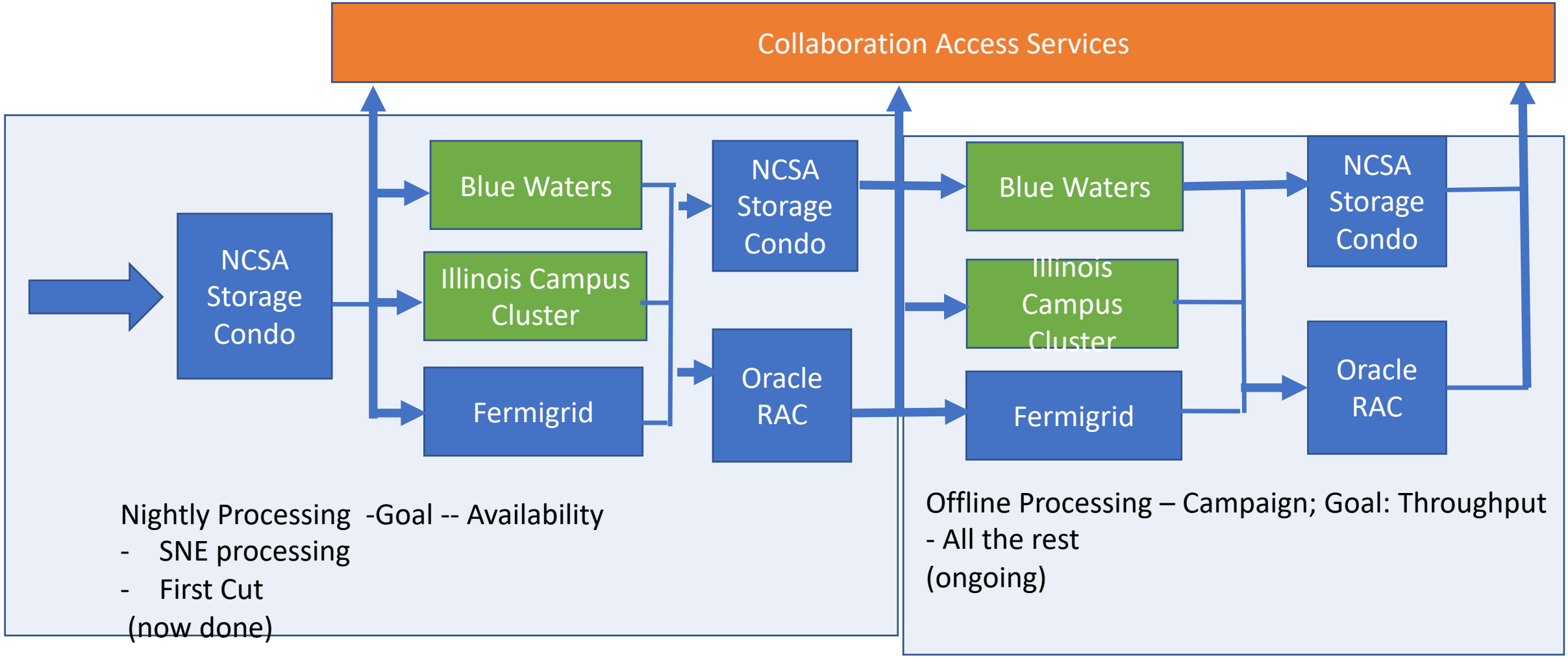
Other uses of BW by DESDM

Recall that BW is integrated into an overall system that can use many bulk computing resrources.

BW is also used when

- DESDM has many campaigns
- Other compute resources are unavailable (mainentance, upgrades)
- Summary:
  - Usage: 1 million BW core hours for other DESDM data products
  - Codes: single epoch and co-addition
  - Observations: Up to and including Year 5.5.

HTC, HPC, and Cloud Native Style Elements in DESDM



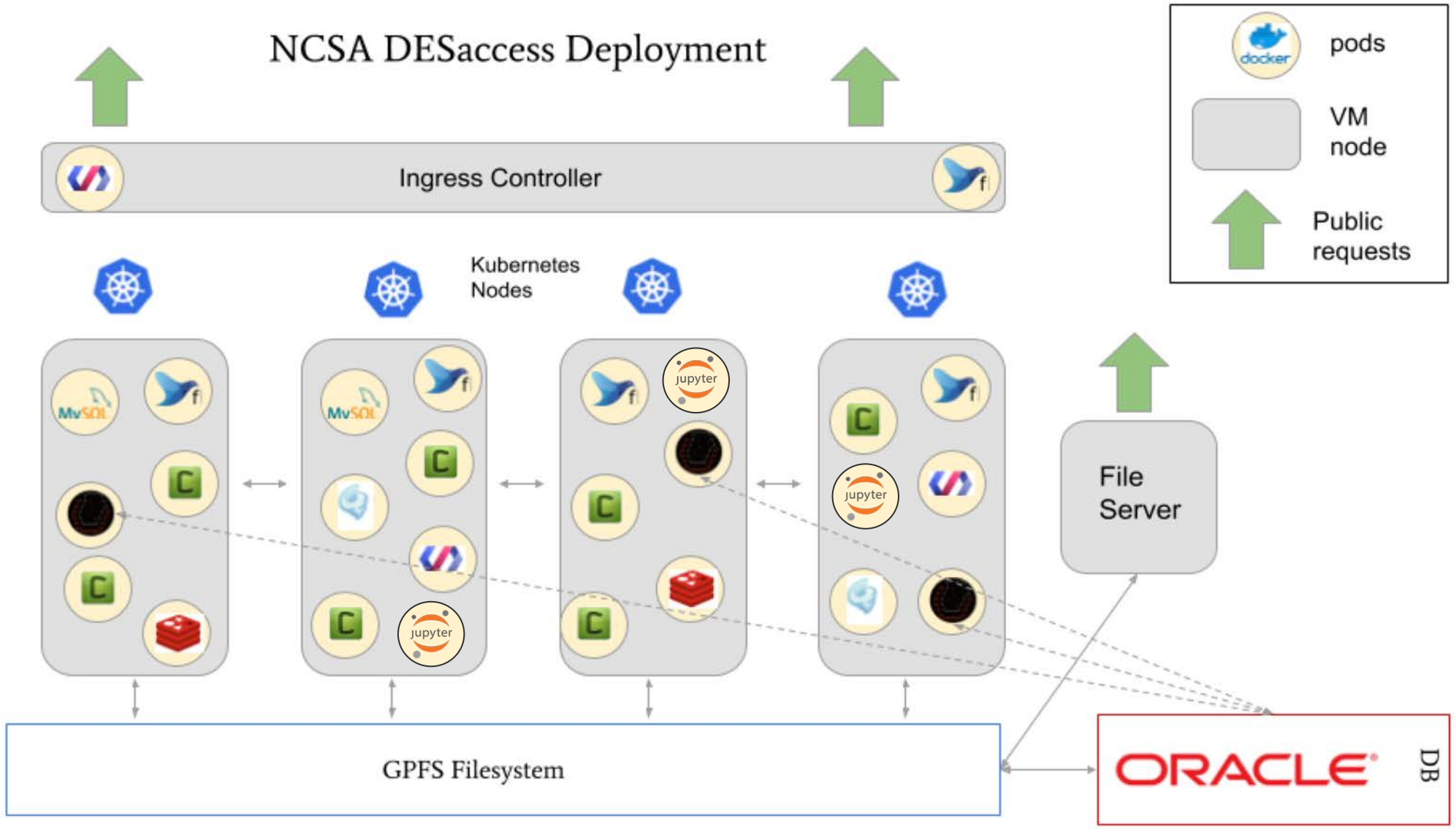
The storage system is the technical basis for co-existence of the HPC, HTC, and cloud-native cultures.

- In the opening talk, the speaker mentioned that
  - HPC people publish and talk to each other
  - AI/Cloud Native infrastructure people meet and talk to each other
  - But the two groups hardly interact.
- In DESDM the data is in a neutral storage systems **primarily accessed by services.**
  - GPFS Posix file system (3.5 PB)
  - A VM infrastructure with excellent access to the storage resources, an integral part of the storage condo.
  - A large relational database (500 TB usable table space)
- The Neutral storage system is the technical basis for co-existence of the HPC, HTC, and cloud-native cultures.

DES Labs: Collection of containerized tools for DES access

- Used by the DES Collaboration and general public.
- Over 1000 users
- Running at NCSA using Kubernetes and NCSA cloud
- Data access, exploration and visualization
- AI models for anomaly detection and similarity search

NCSA DESacces: Deployment



Summary

- BW was **crucial** resource for DESDM's most cycle intensive processing needs.
- BW also plays a role for ordinary processing in DES.
  - DES has ~8,000,000 CDD level Images.
  - BW was used to process over 1,000,000 DECam images for non DES processing at NCSA, in other BW allocations.
- BW was able to integrate into a processing framework more like High Energy Physics experiments use:
  - Based on HT-Condor
  - Extensive Transfers of data into and out of BW.
- BW Support staff have been excellent.