Transients in DESC Data Challenges

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LSST DESC
Dark Energy Science Collaboration

Outline

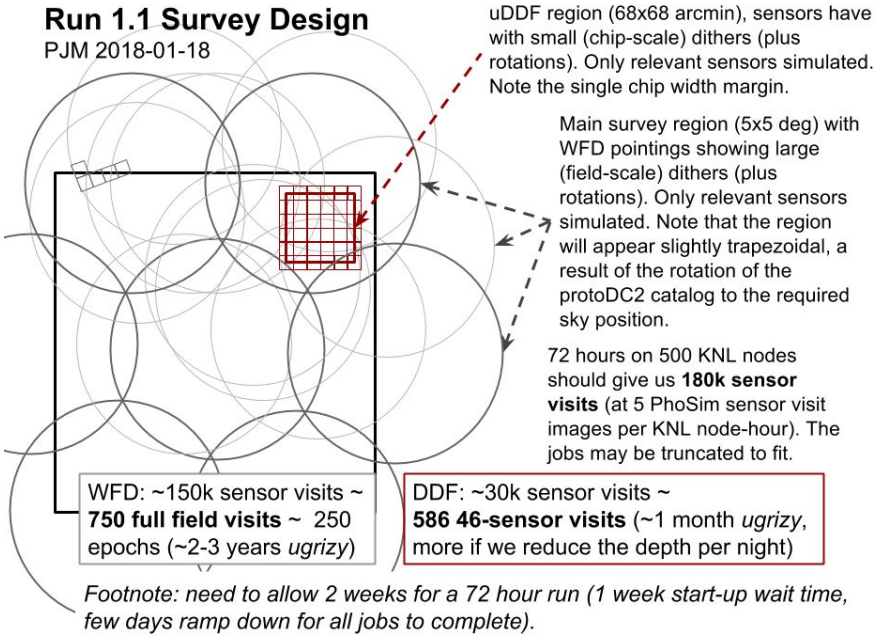
- What are DESC Data Challenges?
- What transients and variable objects are in the Data Challenges?
- What tools are we using to add these objects into the simulations?
- What is the output?

DESC Data Challenges

- Created so the collaboration will be ready for the first incoming data from LSST
- 3 sets of Data Challenges scheduled
  - Increase in size and complexity in each iteration
- Currently in Data Challenge 2 era
  - 300 sq degrees
  - 10 years
  - 6 filters

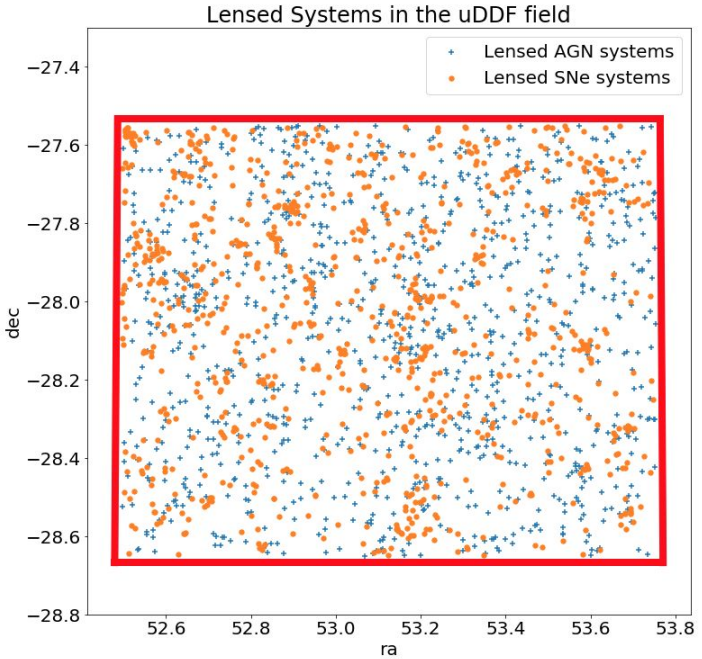
DC2 Ultra Deep Drilling Field (uDDF)

- Inside main DC2 survey area
  - 1.25 sq degrees
  - ~20,000 total visits over 10 year simulated survey
  - Contains strongly lensed transients and higher density of unlensed Type Ia SNe

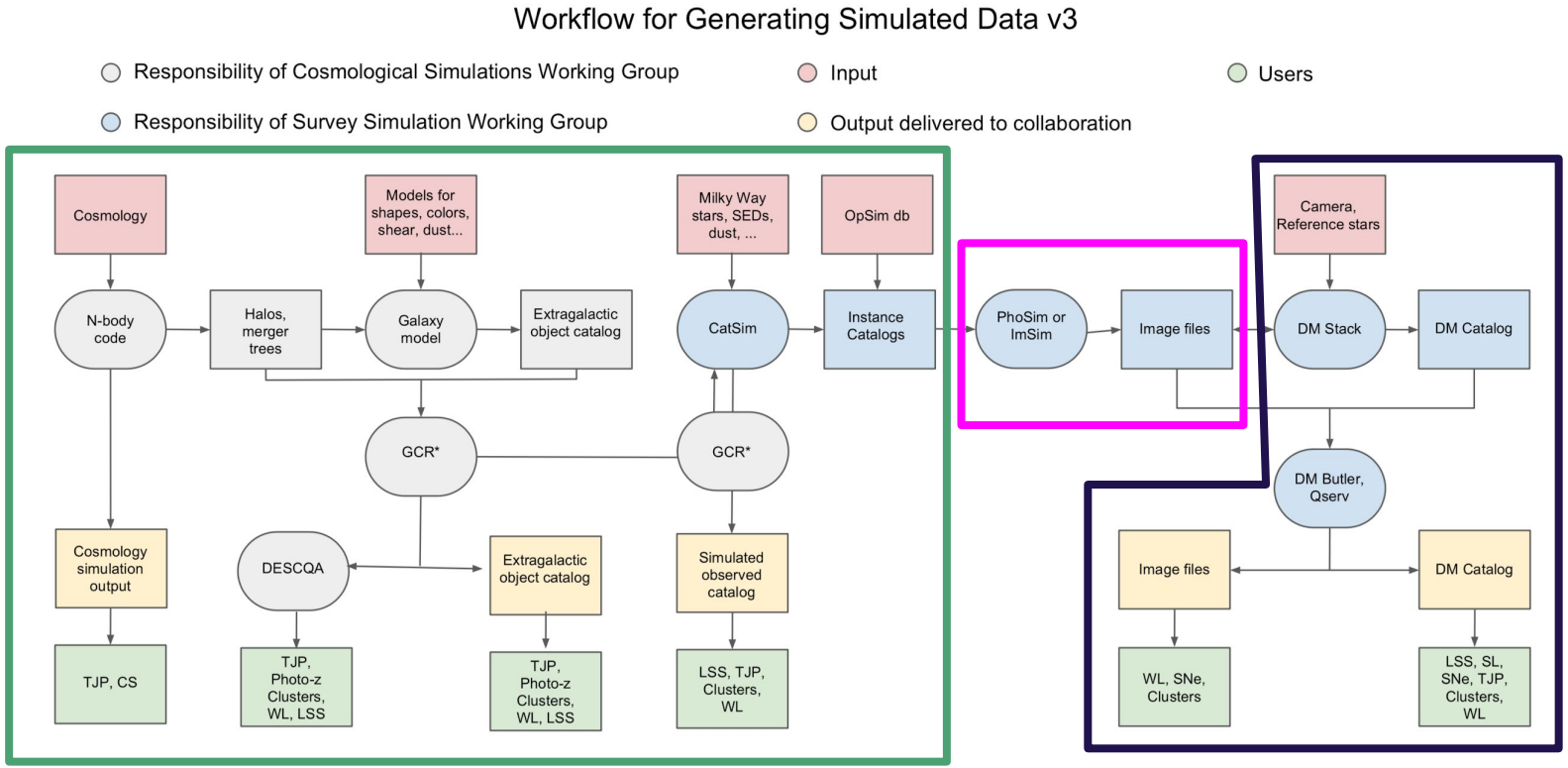


Transients and Variables in DC2

- Main Survey
  - Galactic
    - M-dwarf flares
    - RR-Lyrae
    - Phenomenological variability models from Kepler light curves
  - Extragalactic
    - AGN
    - SNe Ia
- uDDF
  - Strongly Lensed AGN and SNe



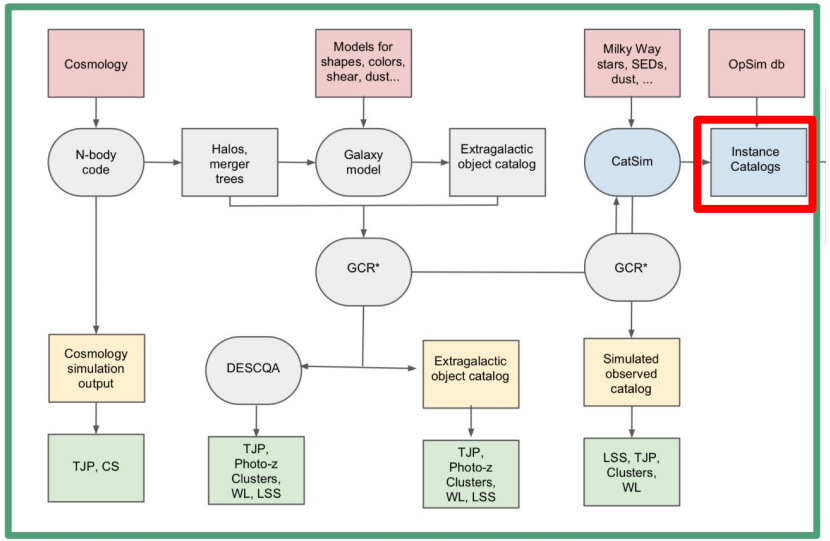
Simulation Workflow



*GCR = Generic catalog reader

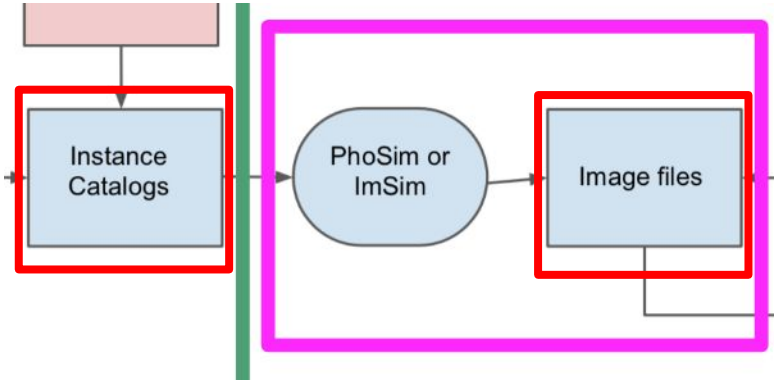
Simulation Workflow

- Generate simulated catalogs of objects in a visit
  - “Instance Catalogs”
  - Inputs
    - Extragalactic catalog
      - From Cosmological Simulations group
    - Galactic catalog and dust map
      - From LSST Catalog Simulations DB (CatSim)
    - Visit Details
      - From LSST Operations Simulator (OpSim)



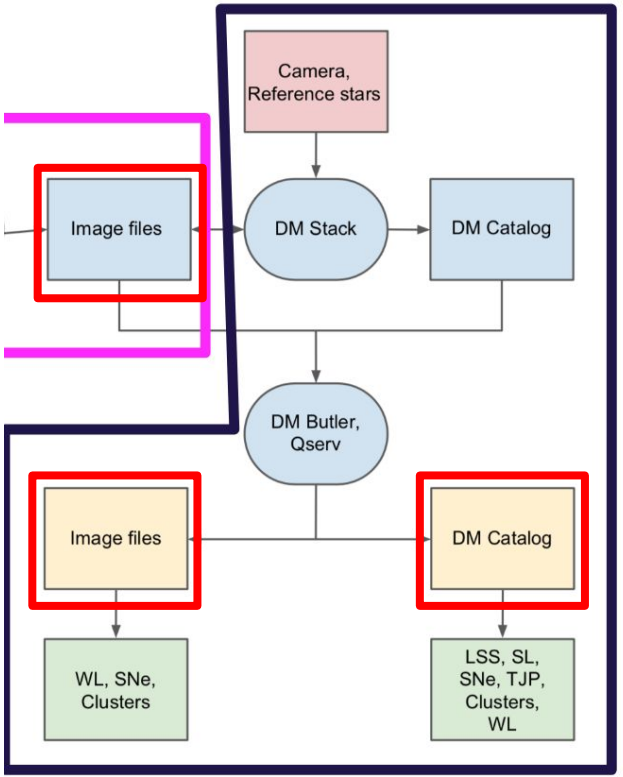
Simulation Workflow

- Generate simulated images
  - Two different image simulators
    - PhoSim
      - Full end-to-end realistic physics simulator
    - ImSim
      - Open source
      - Modular approach



Simulation Workflow

- LSST Data Management Processing occurs on images
  - Outputs
    - DM Catalogs
  - Processed Images
    - Coadds
    - Difference Images
- Truth Information
  - Will be able to compare results to expected outputs



Main Survey Transients and Variables

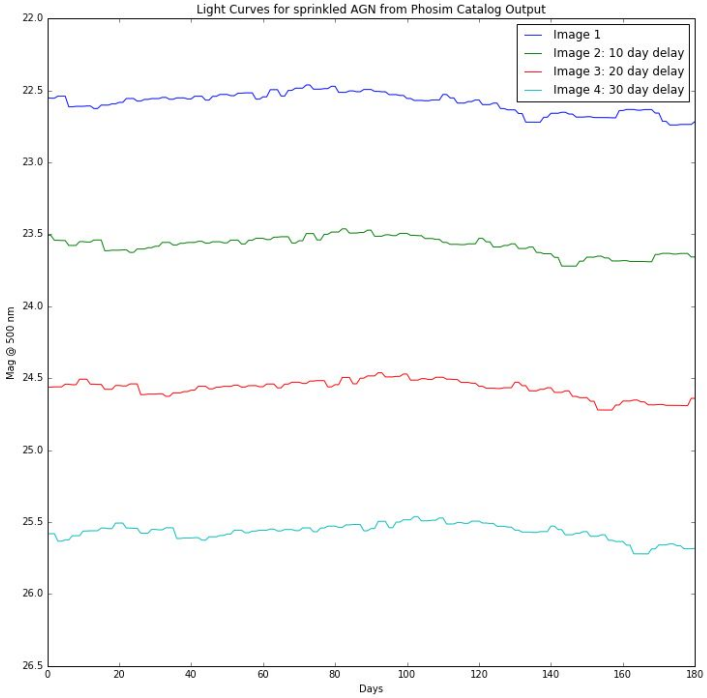
- Milky Way Sources
  - Milky Way catalog comes from output of the Galfast simulation of Juric et al. (2008)
    - Stored in a database at UW
- Galactic Variable Sources
  - M-dwarf flares based upon Davenport et al. (2014)
  - RR Lyrae from Sesar et al. (2009)
  - All other stars were matched to Kepler light curves
    - Based upon color-magnitude diagram position (*r* vs *g*-*r*)

Main Survey Transients and Variables

- AGN
  - Matched to galaxies in the extragalactic catalogs provided by cosmological simulations group
    - Variability modeled as a damped random walk based upon MacLeod et al. (2010)
- SNe
  - All type Ia
  - Added to extragalactic catalog hosts based upon total stellar mass and light distribution
  - Numbers boosted in uDDF region

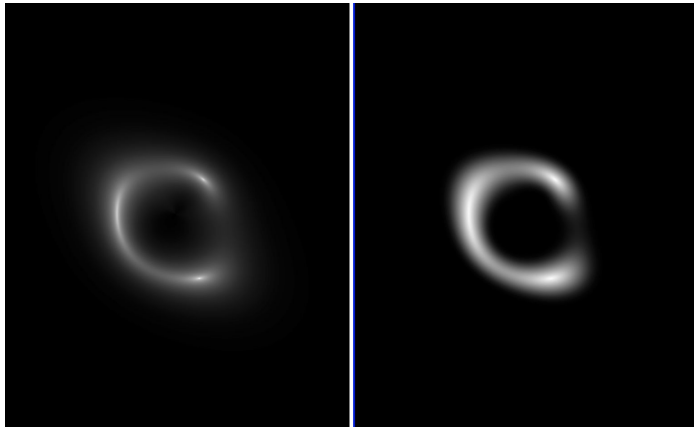
uDDF Strongly Lensed Objects

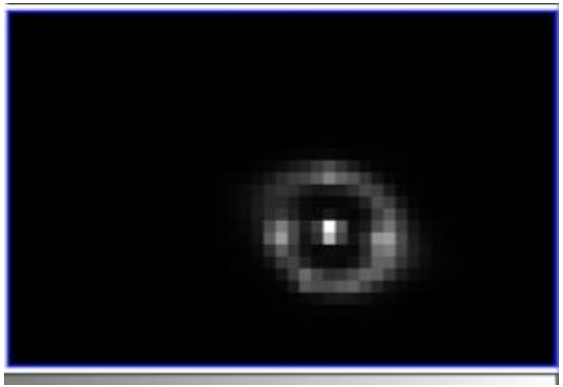
- Strongly Lensed objects appear only in uDDF
  - AGN
    - From Oguri and Marshall (2010) catalog
  - SNe
    - From Goldstein et al. (2017) catalog
- ~1000 of each type of system added
- Time delays included



uDDF Strongly Lensed Objects

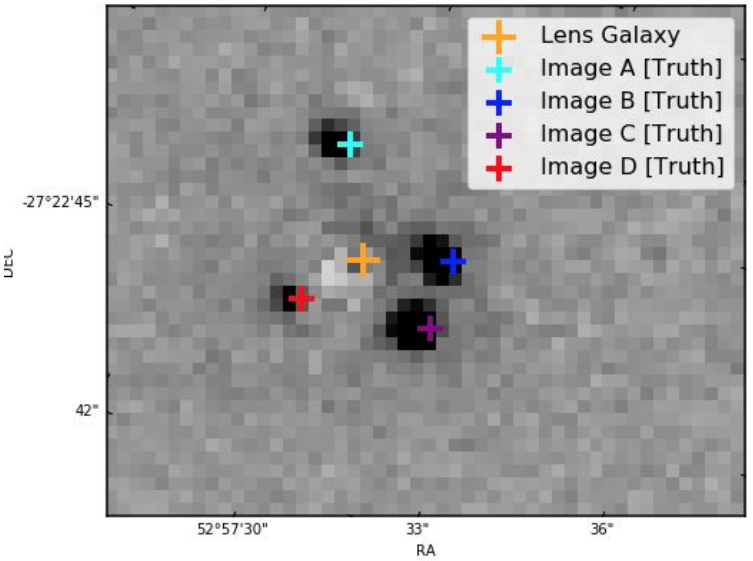
- Inserted using the DESC Sprinkler code
  - Matches to existing objects in catalog and replaces them with lensed systems
- Working on including host galaxies in lensed images
  - Finishing up to get this into DC2





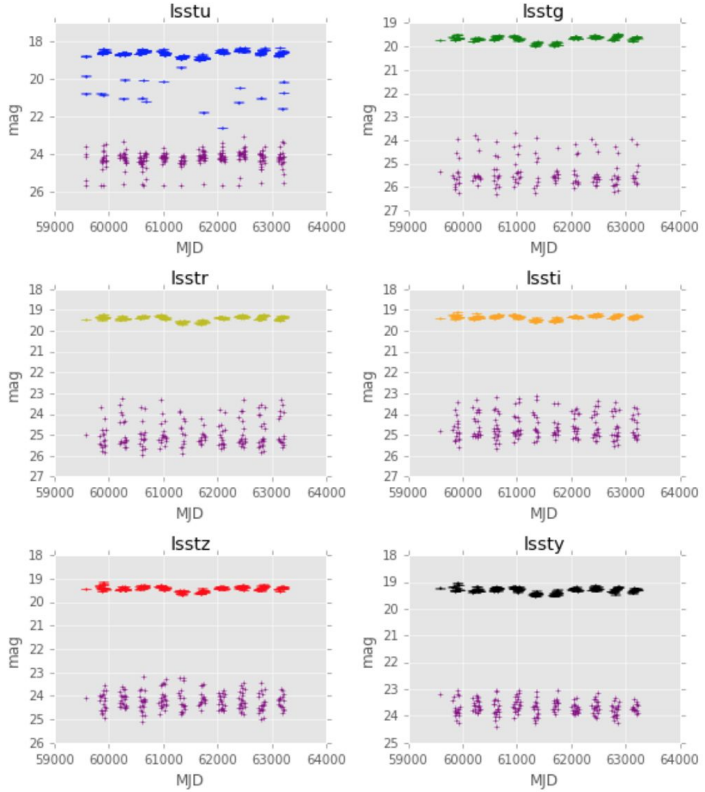
Outputs

- Science images, Coadds are being produced for all survey area
- Diff Ims for uDDF area
- These images are also used to produce DM Catalogs
    - NERSC hosted database (qserv)
    - Dask/Pandas dataframes



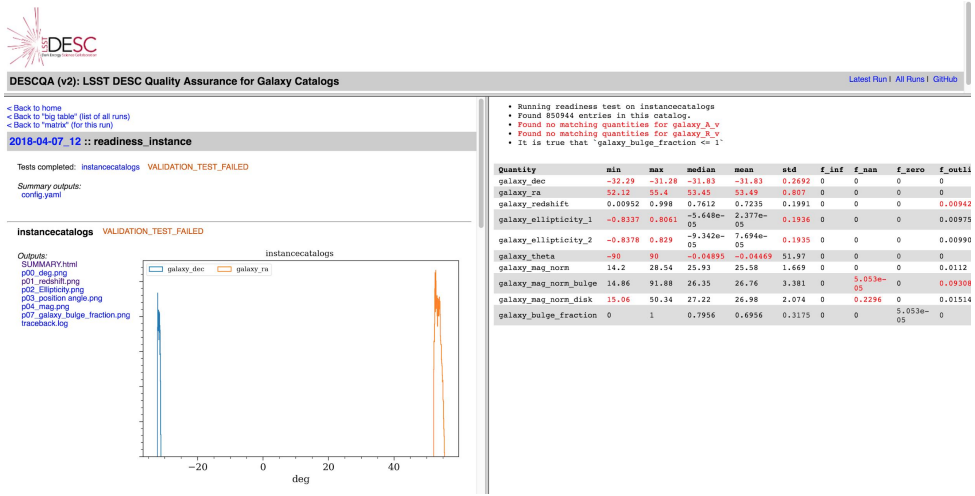
Analyzing Outputs

- Dask/Pandas Dataframes
  - Will load easily in jupyter notebooks
- QServ Database
  - Able to query following tentative LSST DM schema
- DESC developed tools
  - DESC Monitor for light curve extraction
    - Sample DC1 Monitor Light Curves at right



Validating Outputs

- Writing validation codes to make sure instance catalogs are correct
  - DESCQA
    - Mao et al. (2018)
    - Interface pictured at right
- Will also want to verify Images are correct
  - Code currently under development



Current DC2 Status

- Set of small scale DC2 testing runs performed
  - Image generation complete on final prototype run
  - Data Management processing now starting
- Full DC2 simulation run this summer
  - Followed by data release
- Sample projects for DC2 data
  - Comparison of Machine Learning Classifiers
  - Efficiency of detection of variable sources
  - Simulating the effect of incomplete data on photo-z estimation

Future Work and Data Challenges

- Sprinkler paper and production release of code
  - Allow easy way to inject lens transients into image simulations
- Data Challenge 3
  - Further increase scale and complexity of simulations