The LSST Catalog Framework (CatSim)

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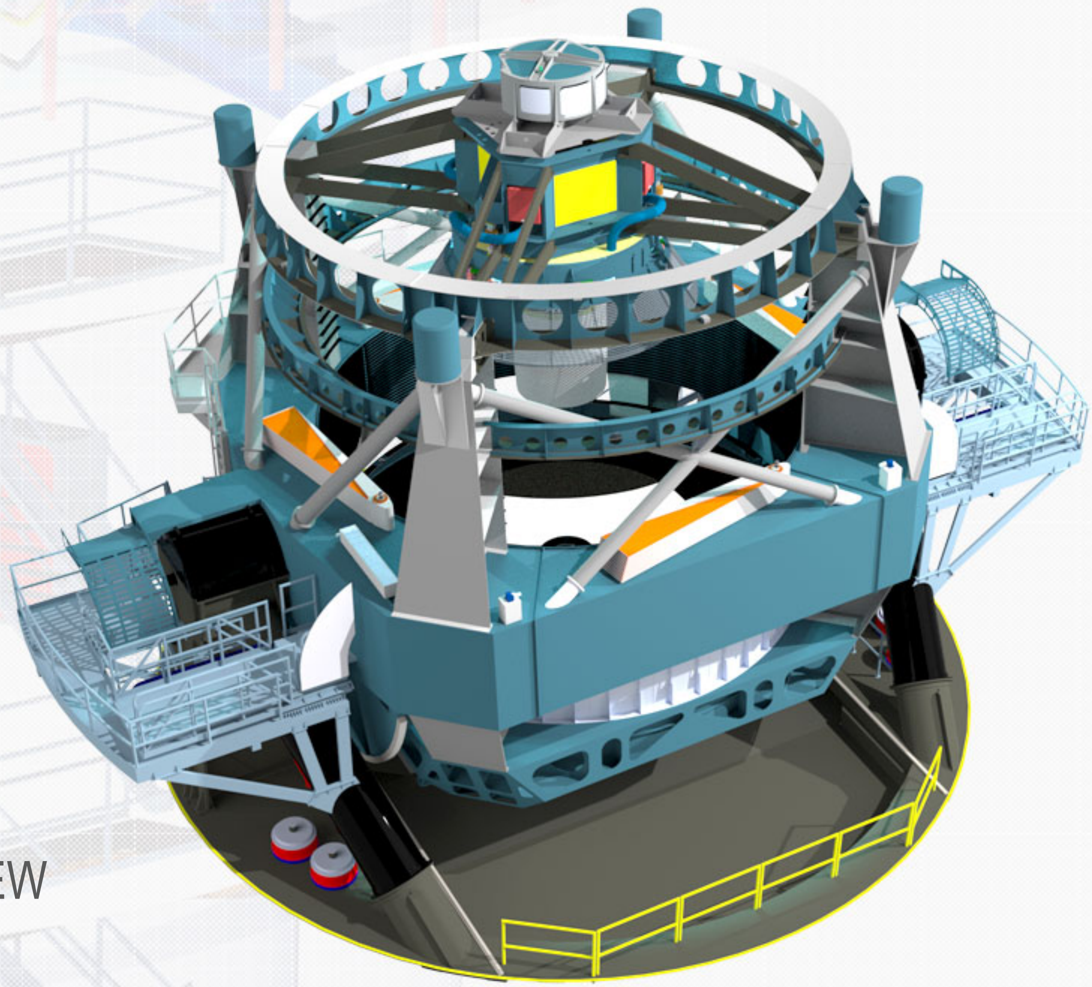


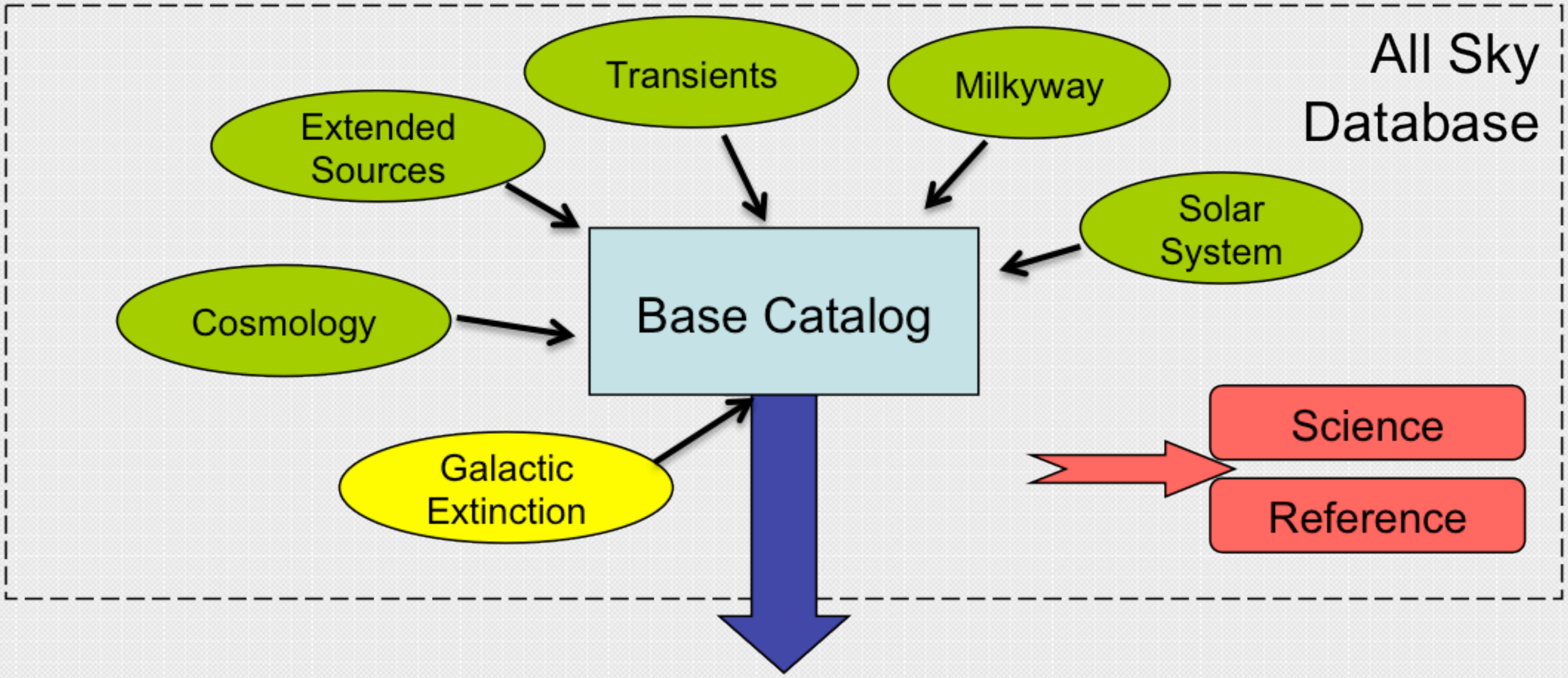
The role of astrophysical simulations

- The performance of the LSST system is determined by the coupling of the properties of the astrophysical sources and the engineering properties of the system.

- Simple analyses can be done with simple catalogs: grids of point sources, or extended sources. To analyze the full complexity of the system a universe model with realistic properties is needed.

- The LSST universe model includes catalogs of galaxies, stars, moving objects and variable objects with properties designed to meet the Simulations Requirements and facilitate development of data processing and science capabilities.

The LSST universe model

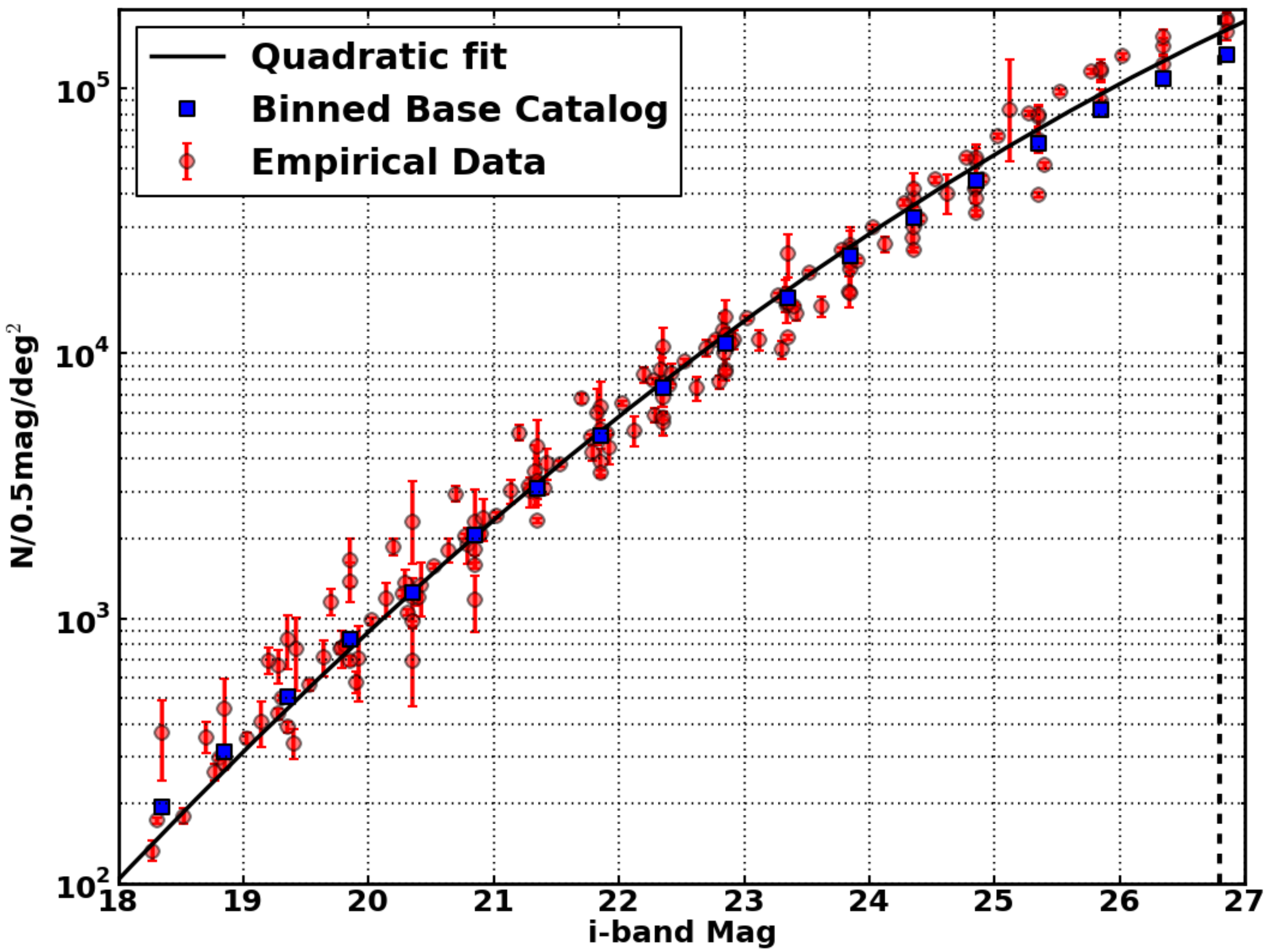


Introduction to catalogs: galaxies

Galaxy properties drive the computational requirements for data management (i.e. measuring galaxy shapes) and our ability to distinguish between stars and galaxies.

- Positions and redshifts are from n-body simulations (De Lucia et al. 2006) assuming a standard Λ-CDM cosmology.
- This light cone produces a 4.5x4.5 degree footprint to redshift z=6 and is matched to the densities of observed galaxies.
- Spectral energy distributions are fit to the disk, bulge and active galactic nuclei (AGN) components of the galaxy model.
- Sizes (half-light radii) are assigned using the absolute-magnitude vs. half-light radius relation from Gonzalez et al. (2009).

Introduction to catalogs: galaxies



Galaxy number counts matched to observed number counts (Metcalf et al. 2010)

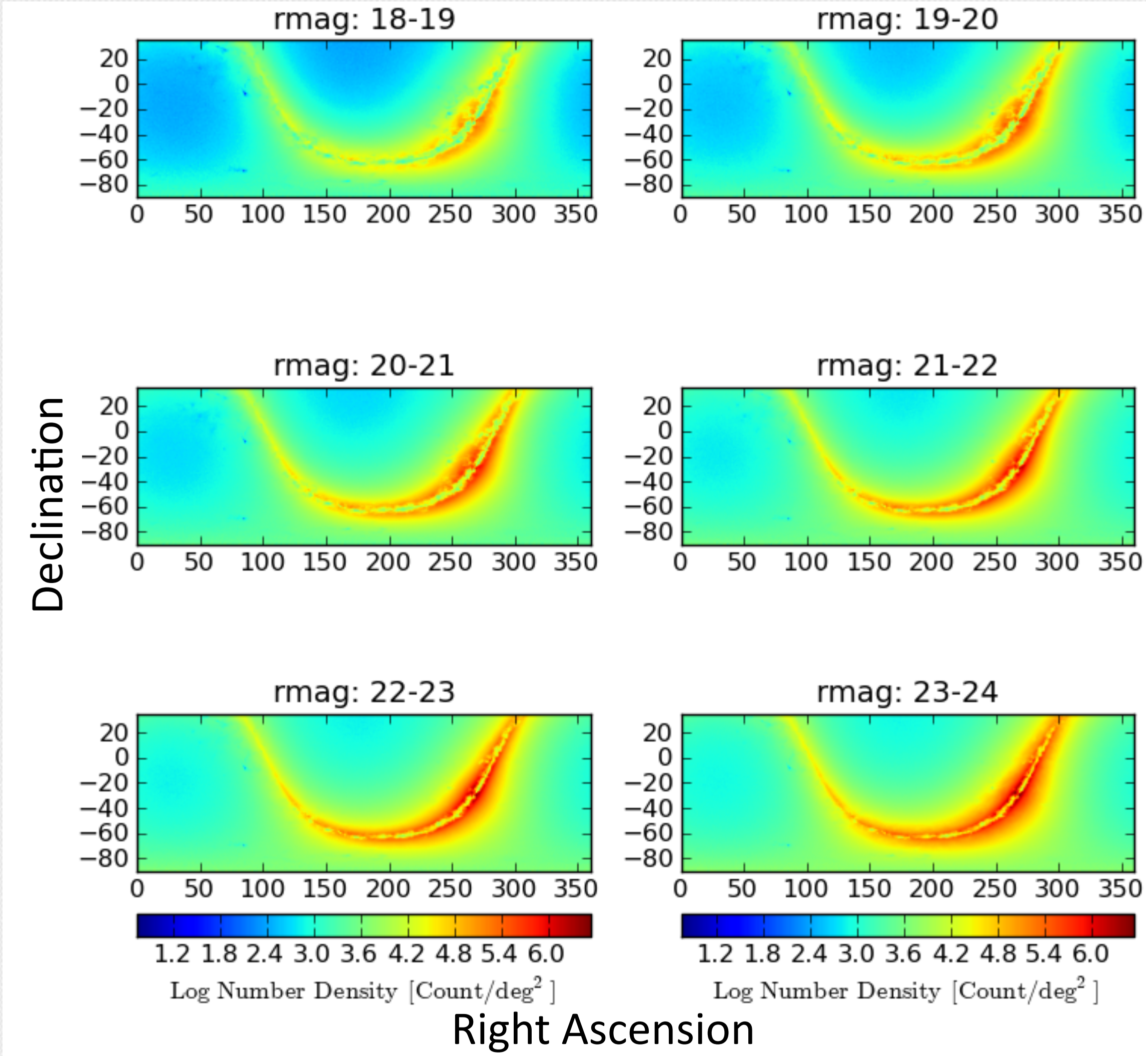
- Sizing models
- Star-galaxy separation
- Weak lensing

Introduction to catalogs: galactic structure

Stellar densities drive the sizing models for Data Management (including storage requirements and alert generation). Stellar colors determine how well we calibrate the data photometrically .

- Stars in the Galaxy are drawn from a realization of the Galfast model which uses density laws from Jurić et al. (2008) and metallicity and kinematic models Bond et al. (2010)
- Spectral Energy Distributions (SEDs) are assigned
  - F, G, and K main sequence stars use Kurucz (1993) models
  - White Dwarfs use Bergeron et al. (1995) models
  - M, L, and T Dwarfs are derived from SDSS data.
- 10% of stars are variable at a level observable by LSST including RR Lyrae, Cepheids, and M-dwarf flares.

Introduction to catalogs: galactic structure



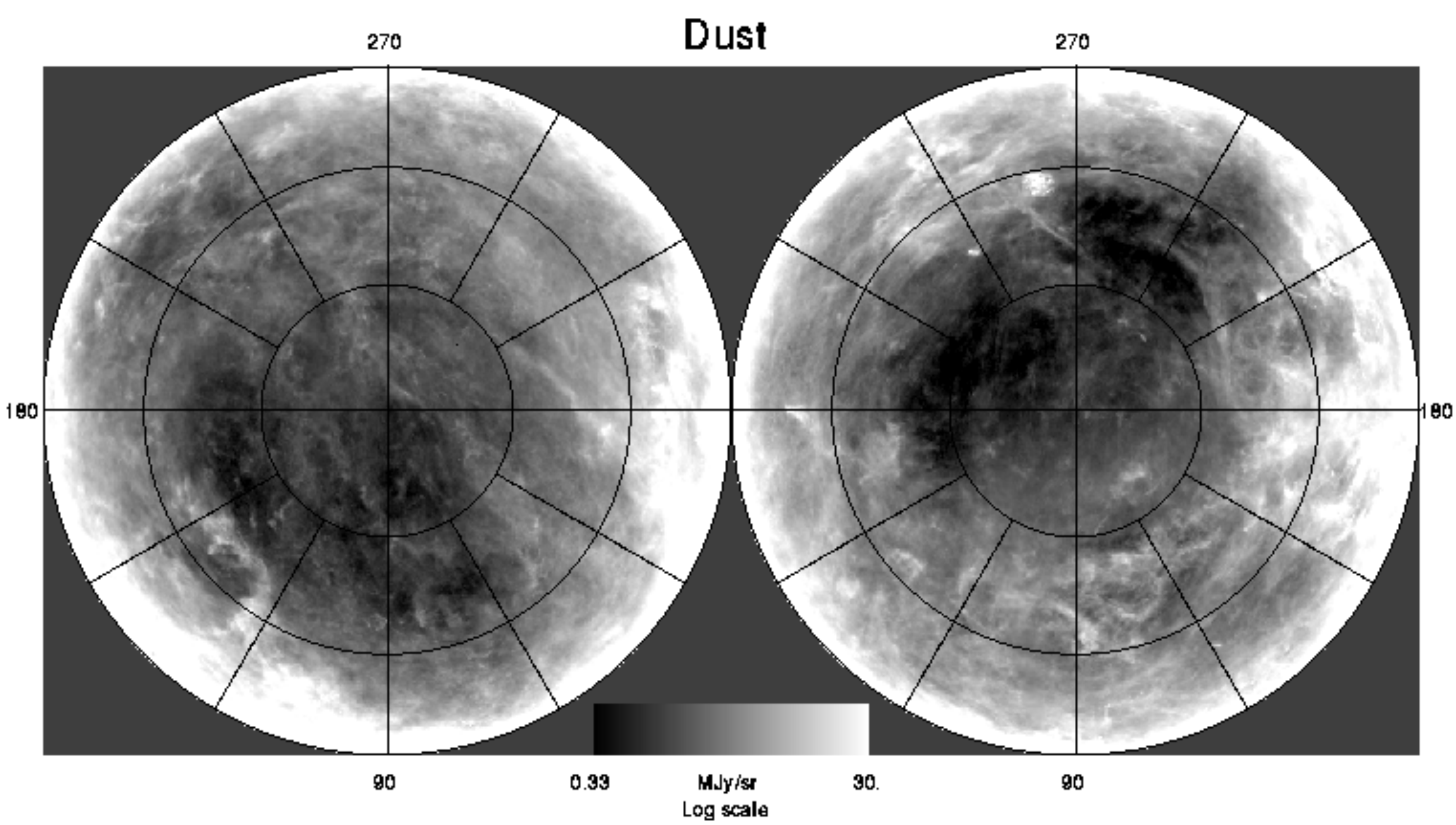
15 billion stars in the simulation of our Galaxy (Milky-Way)

Introduction to catalogs: Galactic dust model

Systematics drive our ability to calibrate the LSST data. A realistic dust distribution enables studies of the foregrounds that impact photometric calibration, photometric redshift algorithms, stellar population modeling, among others.

- The stellar objects are embedded in a 3-D dust model based on that of Amôres and Lépine (2005).
- So that there is no discontinuity in the measured reddening between stars and galaxies, the dust model is normalized to the Schlegel et al. (1998) maps at 100 kpc.

Distributions of dust in our Galaxy

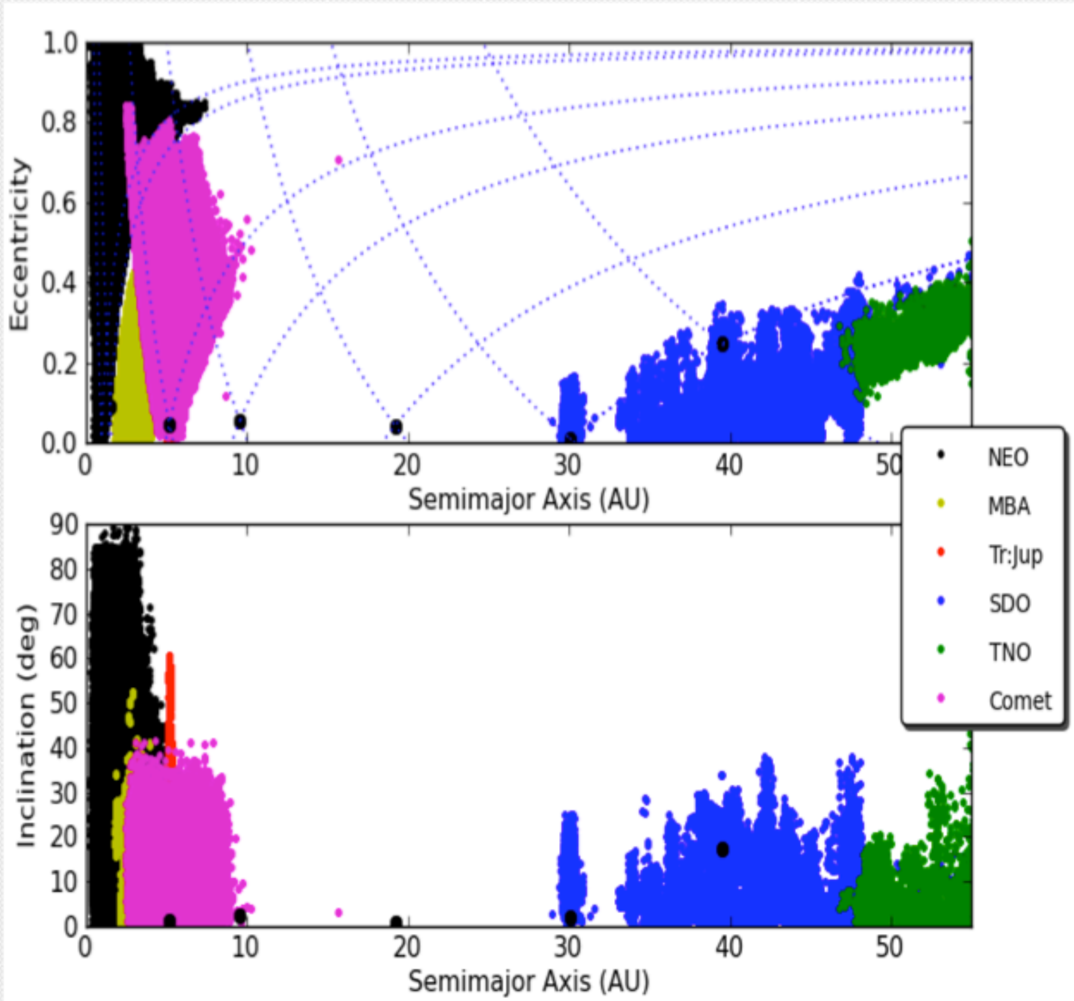


Introduction to catalogs: Solar System

Characterizing moving sources is critical to our alert generation and our ability to identify near-Earth objects and provide a census of the Solar System.

- The solar system model is a realization of the Grav et al. (2007) model. This is the same model used by the Pan STARRS project.
- All major groups are represented: main belt, NEO, trojans, TNOs and comets (11 million Solar System sources).
- The sample is complete to V=24.5.
- The package oorb (Granvic et al. 2009) is used to calculate the orbit and V band magnitude which is used to derive the LSST band observations at a given point in time.

Introduction to catalogs: Solar System



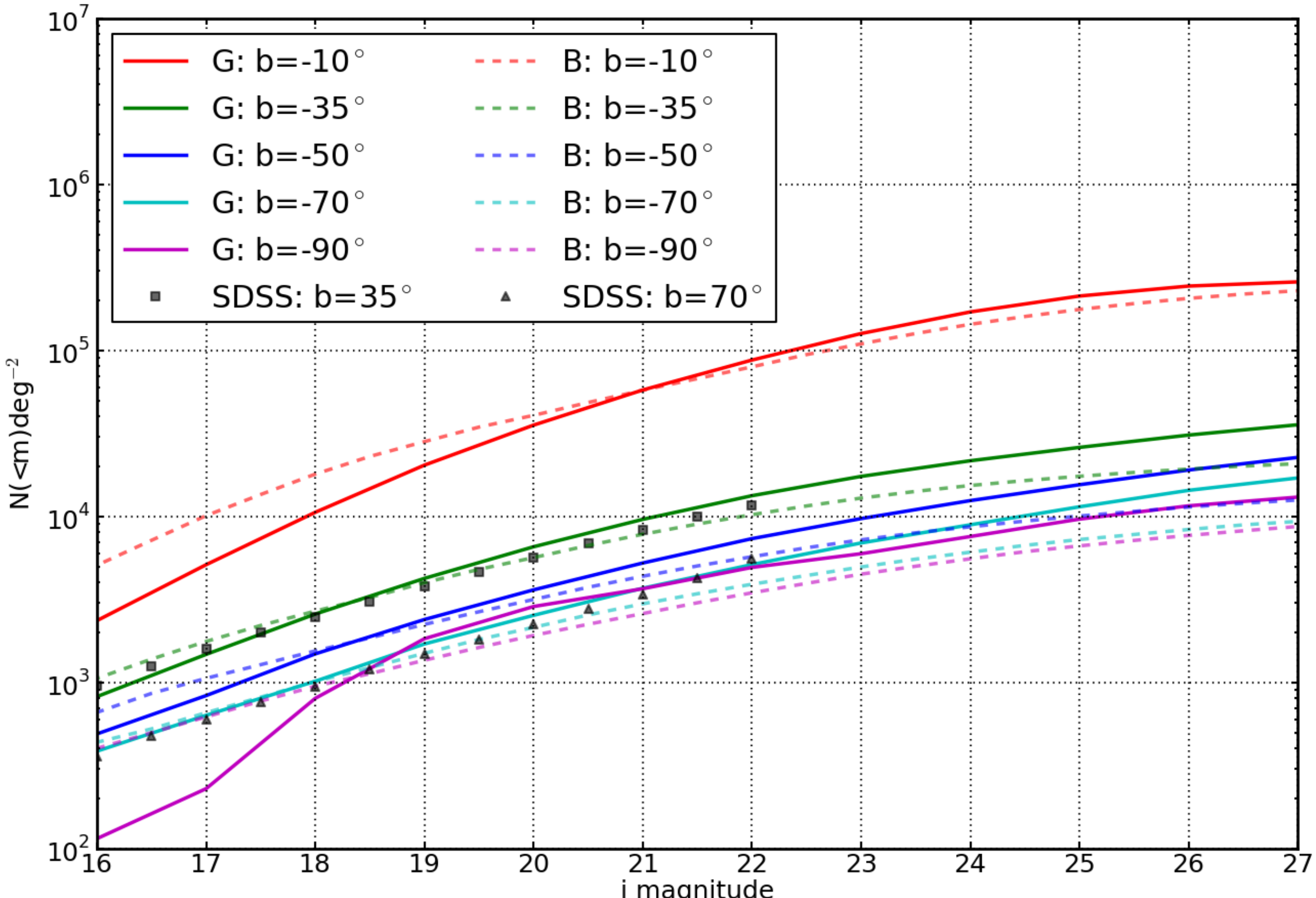
The distribution of Solar System objects color coded by population

Introduction to catalogs: query framework

An extensible catalog framework enables science and engineering data sets to be incorporated into the simulation framework.

- The catalog framework is written in Python and integrates a query framework with a database of astrophysical sources. Querying these databases we can generate validated distributions of astrophysical sources.
- Extensible through python sub-classing and inheritance.
- Examples of catalogs are:
  - Inputs to PhoSim.
  - Reference and calibration catalogs.
  - Moving objects and simulated alert streams.

An extensive validation framework: stellar number counts



Cumulative star counts for fields at l=90°

Star counts from Galfast (Jurić et al. 2008; solid) compared to counts from the Besançon model (Robin et al. 2003). Symbols are star counts from the SDSS catalog.

- Sizing models
- Star galaxy separation
- Deblending
- PSF modeling

CatSim development plan

- Activities supported by the CatSim resources.
  - Data challenges.
  - Full scale calibration simulations.
  - User support and science applications.
- Data Management data challenges.
  - Realistic galaxy morphologies.
  - The diffuse emission model for the sky background.
  - Calibration simulations and calibration telescope.
- Sizing models.
  - Variability and transient models tied to the astrophysical sky.
  - Validated solar system model for moving sources.

Summary

- The LSST universe model enables the simulation of the astrophysical properties of the LSST (including stars, galaxies, and Solar System objects).
- Coupled to OpSim and PhoSim it provides the capability of testing and evaluating the end-to-end performance of the LSST system.
- The LSST universe model has been validated against observational data, and is also currently being used for both engineering and science studies.