OpSim

Michael Johnson

https://store.docker.com/editions/community/docker-ce-desktop-mac

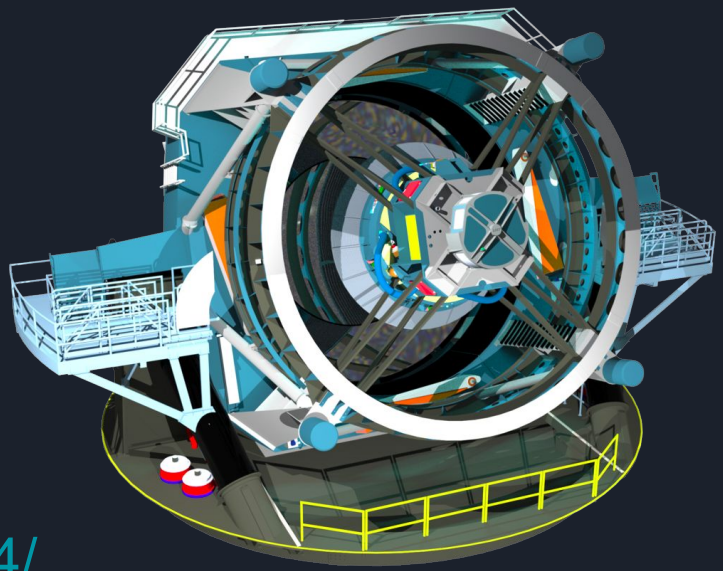
sudo apt-get install docker.io

sudo yum install docker.io

docker pull lsst/opsim

docker pull oboberg/opsim4:081217

https://hub.docker.com/r/oboberg/opsim4/



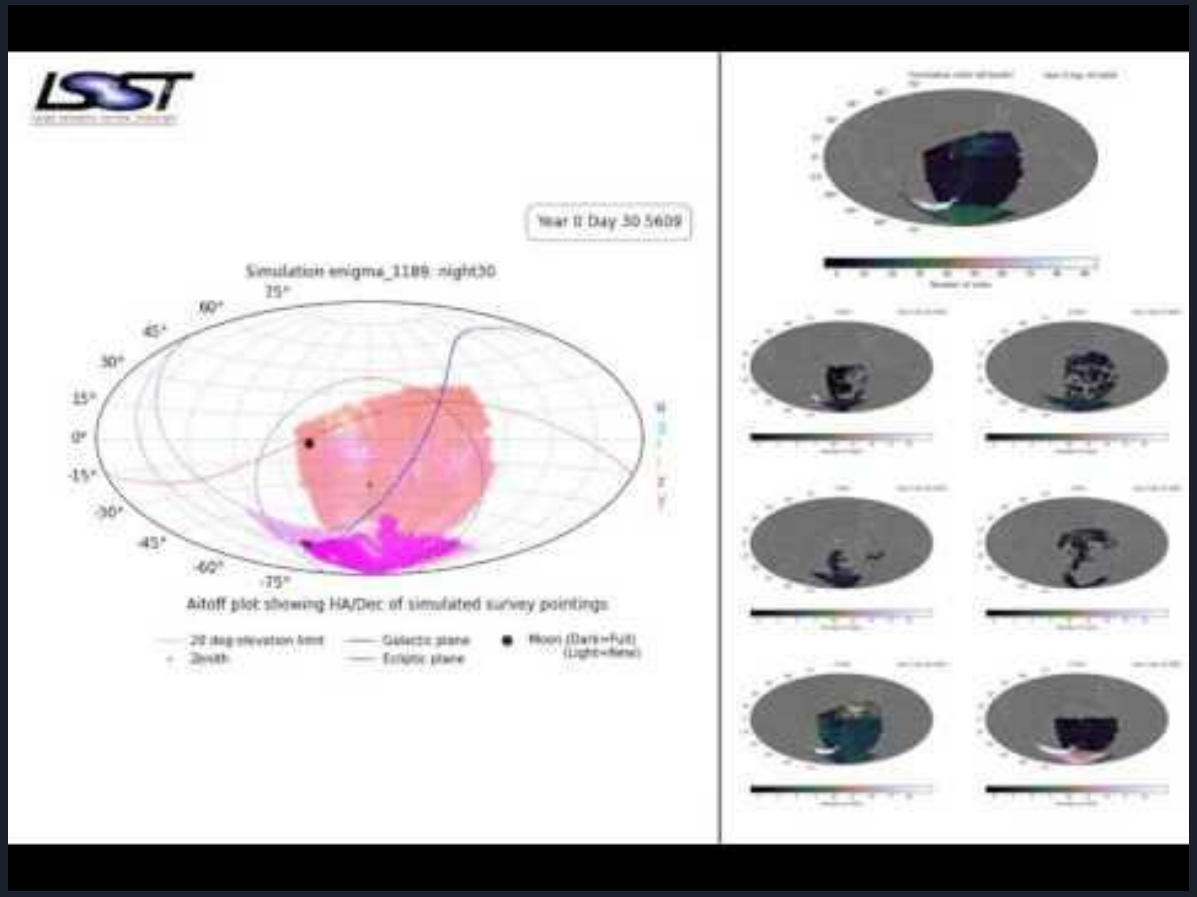
UNIVERSITY OF Southampton

LSST Large Synoptic Survey Telescope

EPSRC Engineering and Physical Sciences Research Council

Introduction to Opsim

- Simulates image acquisition and field selection of LSST
- Each potential field is ranked by OpSim's algorithm
- Positive points for meeting science objectives
- Negative points for slewing, filter changes etc
- Highest ranking field is chosen and observed
- Produces a record of all observations made by LSST over the survey lifetime
- Designed in part to verify whether LSST could meet the scientific requirements



https://youtu.be/lihiuTTinYg

Installation - OpSim 3.38

LSST Stack Install

- Requires a list of dependencies to be met

Conda Installation

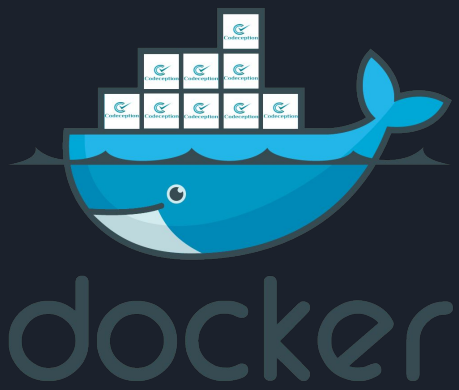
- Local installations of python can disrupt the path

Docker Installation

- Requires a local installation of Docker

More info: http://ops2.lsst.org/docs/current/

Docker



Designed to easily ship software

Inspired by shipping containers

Each container is packed independently but handled identically once at the ship

Makes an image of the host machine with a working copy of the software

Removes the requirement to install dependencies

More lightweight and flexible than virtual machines

Docker OpSim Installation

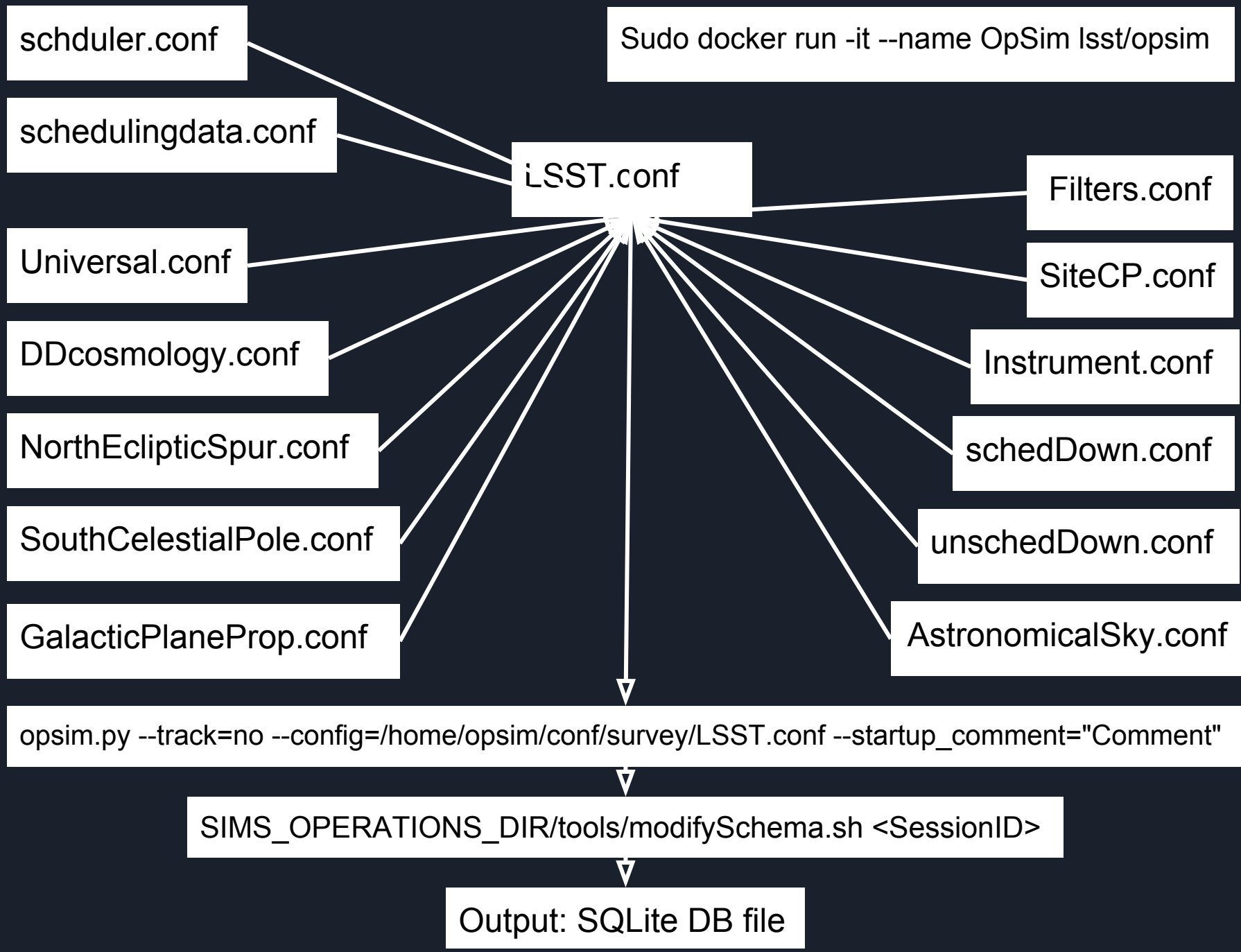
OpSim Installation:

docker pull lsst/opsim

More info: https://hub.docker.com/r/lsst/opsim/

Open an OpSim Instance:

docker run -it --name OpSim lsst/opsim

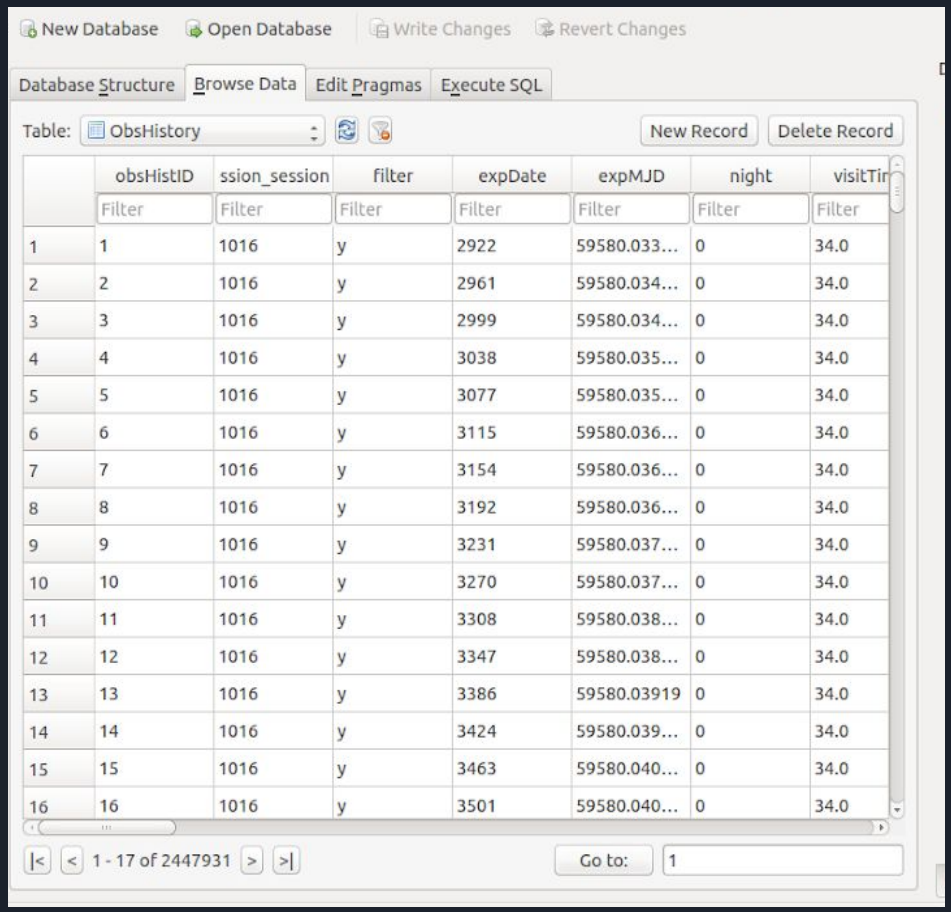

schduler.conf
schedulingdata.conf
Sudo docker run -it --name OpSim lsst/opsim
LSST.conf
Filters.conf
Universal.conf
SiteCP.conf
DDcosmology.conf
Instrument.conf
NorthEclipticSpur.conf
schedDown.conf
SouthCelestialPole.conf
unschedDown.conf
GalacticPlaneProp.conf
AstronomicalSky.conf
opsim.py --track=no --config=/home/opsim/conf/survey/LSST.conf --startup_comment="Comment"
SIMS_OPERATIONS_DIR/tools/modifySchema.sh <SessionID>
Output: SQLite DB file

Opsim Output Data

Relational database containing every observation LSST made during the 10 year survey

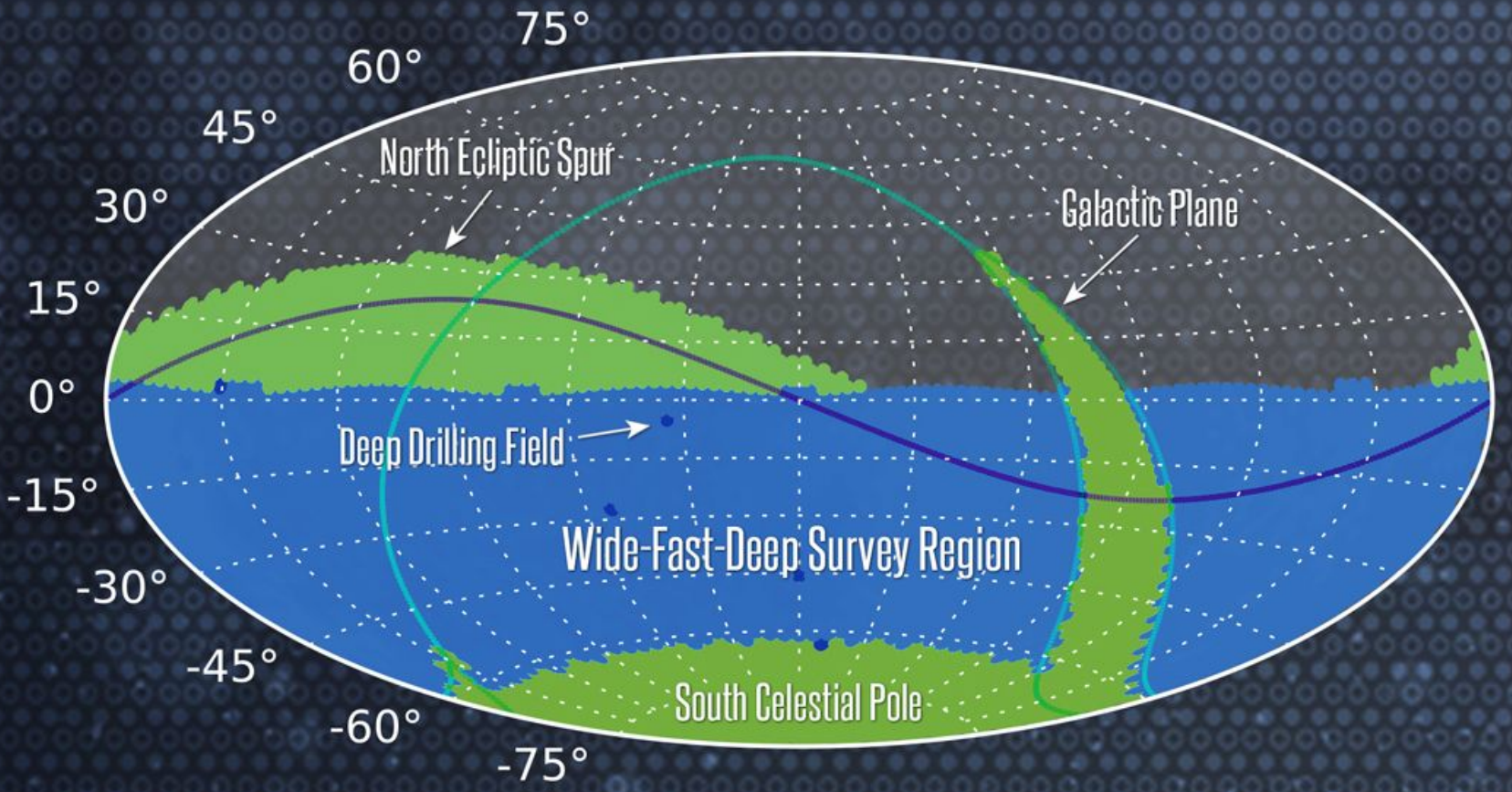
SQLite DB file

Analyse with SIMS MAF or SQL (etc)



Number of Visits

(all-band, 10 years)

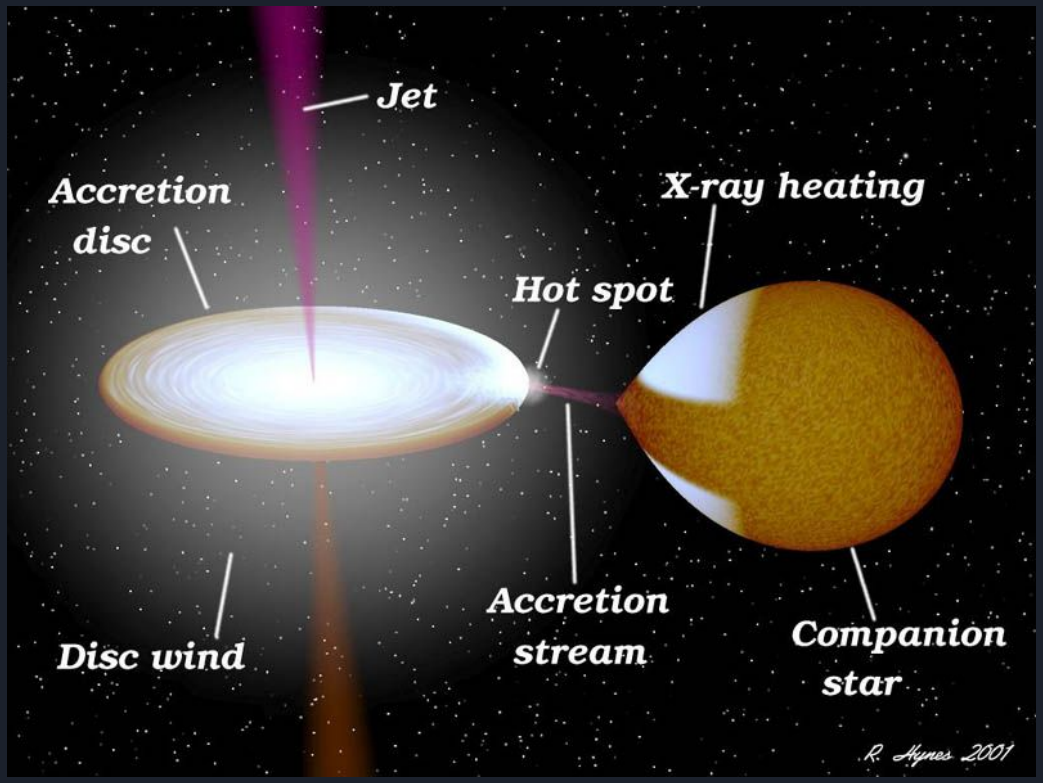


Low Mass X-ray Binaries

Low mass companion star ($<1M_{\odot}$) in orbit around a black hole or neutron star

Compact object accretes matter via Roche Lobe overflow, forming an accretion disc

Many LMXBs exhibit very bright, rare X-ray outbursts separated by decades of quiescence



Credit: NASA/R. Hynes

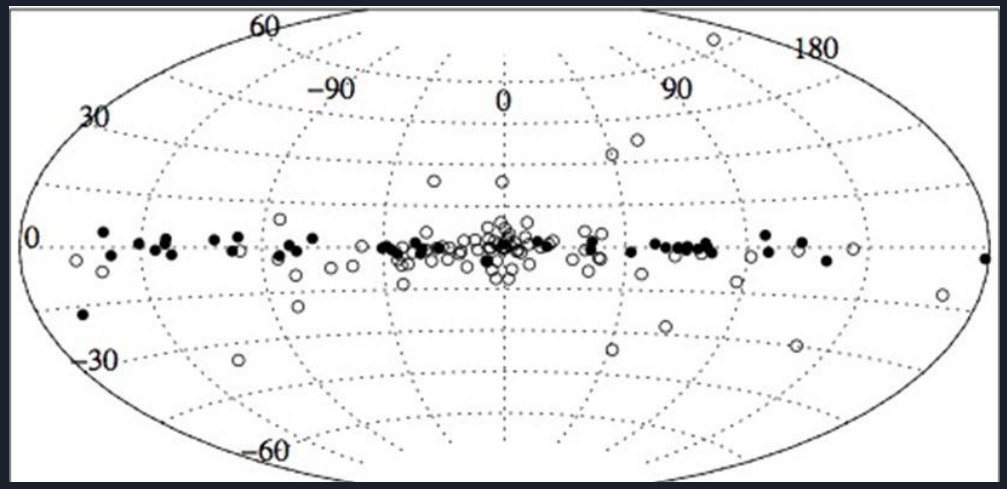
LMXB Population

Estimated to be thousands of LMXBs within the Milky Way however, there are only ~200 known systems.

~60 of which are thought to contain a black hole

~20 dynamically confirmed black hole masses

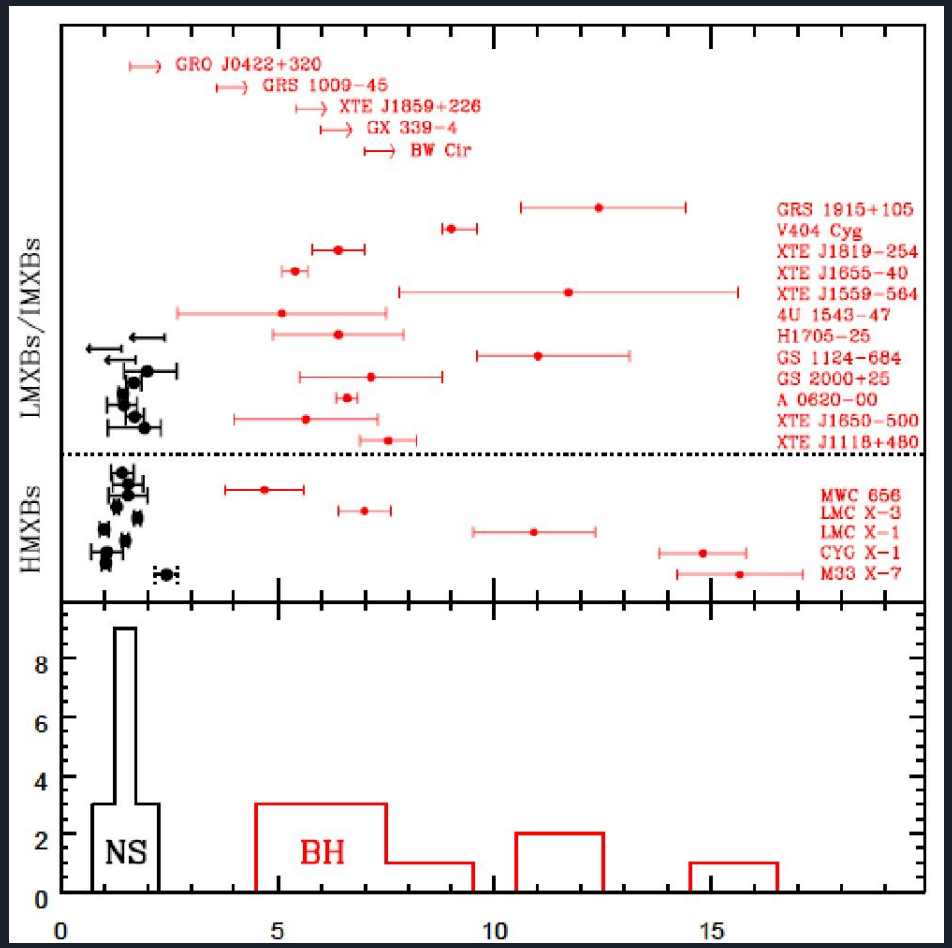
~90% of known systems reside in the Galactic Plane



Grimm et al. 2002

Extinction from Galactic gas and dust means that the vast majority are too faint to observe routinely in the optical.

NS/BH mass Distribution



Casares et al. 2017

Observations of the periodic variability of LMXBs can be used in conjunction with spectral information to determine the masses of the binary components.

21 realistic masses of BHs 5-16 M_O

Typical errors 30%

Goals: improve statistics and reduce errors to 10%

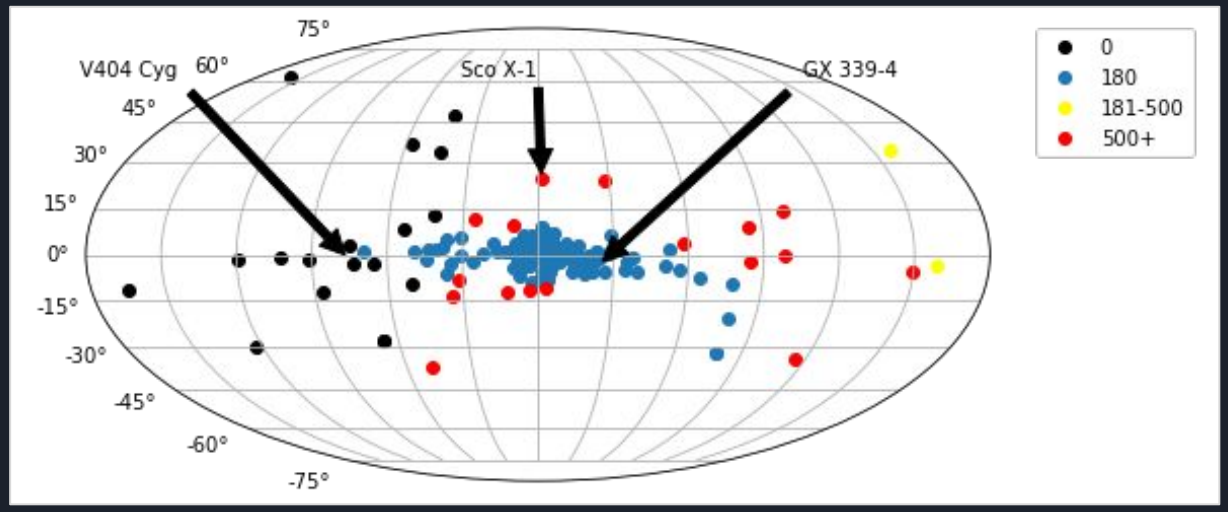
Credit: Phil Charles

The Baseline Strategy Minion_1016

Location of 180 LMXBs referenced with the results of the current baseline strategy, Minion_1016

Each dot represents a field that contains at least one LMXB

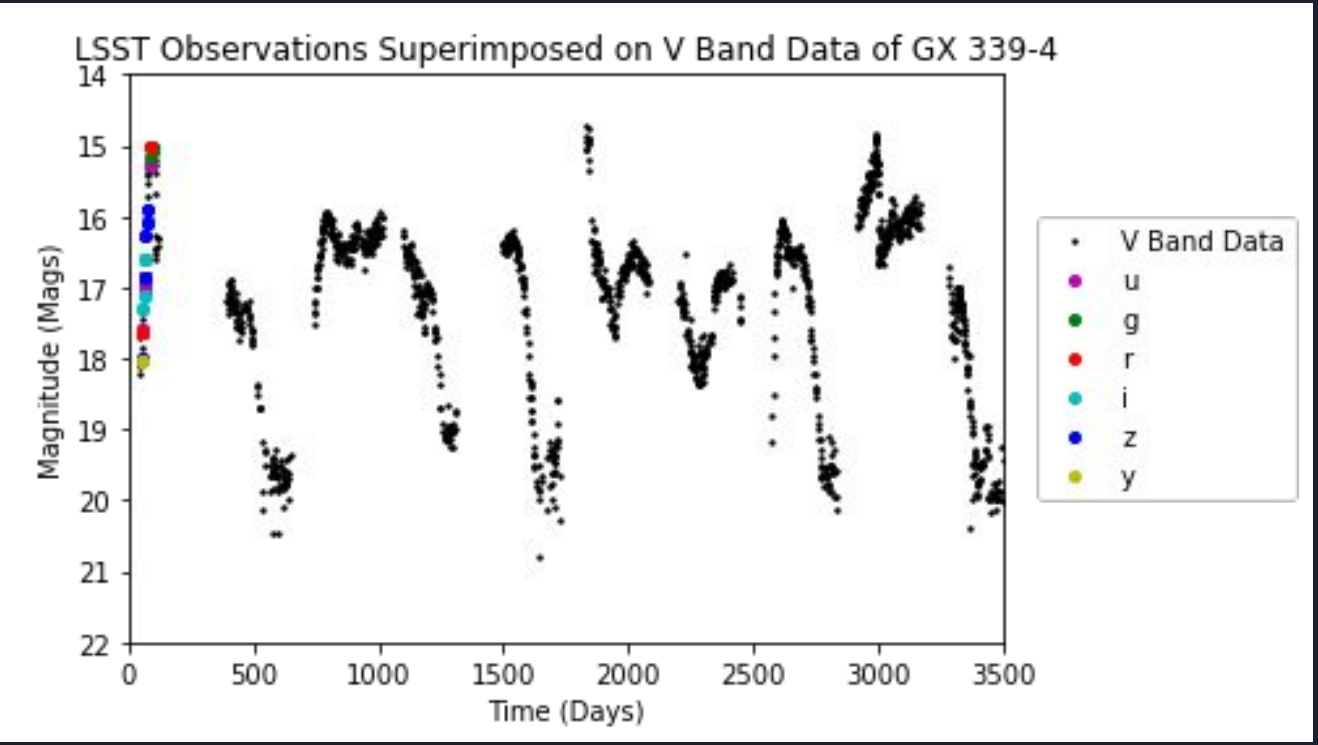
Numbers represent the total observations made in all filters over the full 10 year survey



Galactic Plane Observations in Minion_1016

Observations taken throughout the survey of the region containing GX 339-4 were superimposed onto the optical SMARTS data

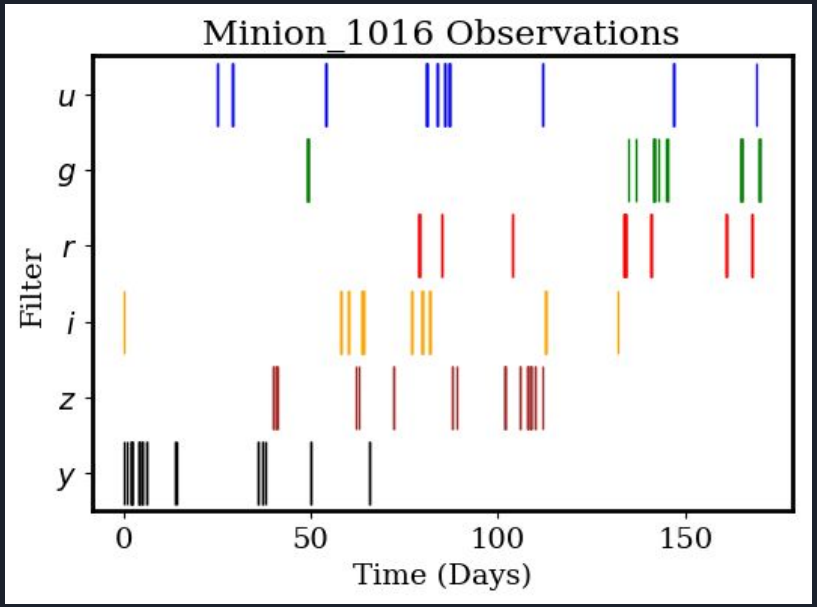
All Galactic Plane observations are taken during the first 7-10 months



Galactic Plane Observations in Minion_1016

Each line represents an observation of GX 339-4 taken by LSST, colour denotes the filter

The observations are very clustered with it being common for ⅙ of all observations per filter per field within the 10 year survey to occur within 2 hours



Alternative Strategies

Minion_1016 - baseline strategy

Minion_1016j - baseline strategy with random time jitter between ± 1 day for each observation

Minion_1020 - observations distributed evenly amongst all fields

astro_lsst_01_1004 - baseline strategy with Galactic Plane included in the main survey region

LMXB light curves

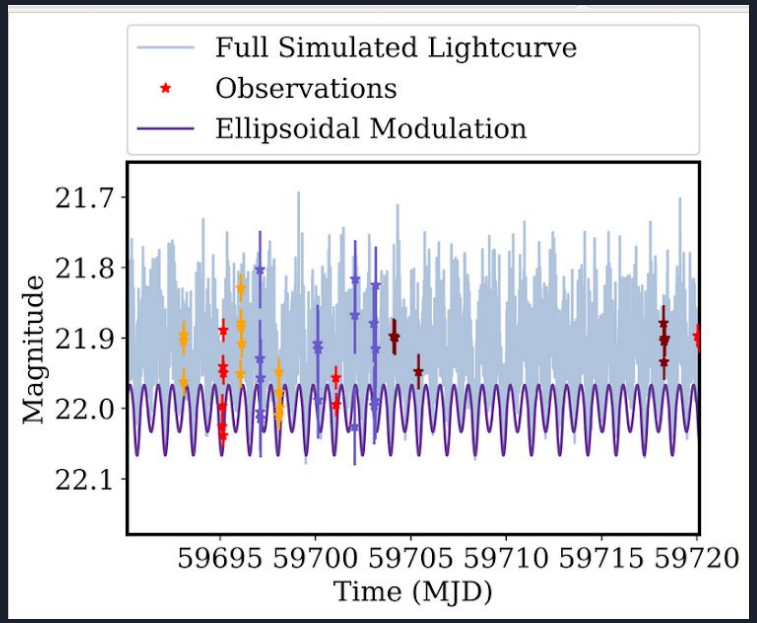
10 year simulated light curves composed of a base magnitude corresponding to the donor star, plus optical variation.

Light curves sampled by LSST observations (shown as *s)

Optically variability composed of two parts:

Ellipsoidal Modulation - due to orbital motion

Flaring - red noise thought to be due to instabilities in the accretion flow



Johnson et al. Submitted

Period Recovery - Method

A Multi-band Lomb-Scargle algorithm was used to recover the periods (VanderPlas and Ivezic 2015)

To determine the significance:

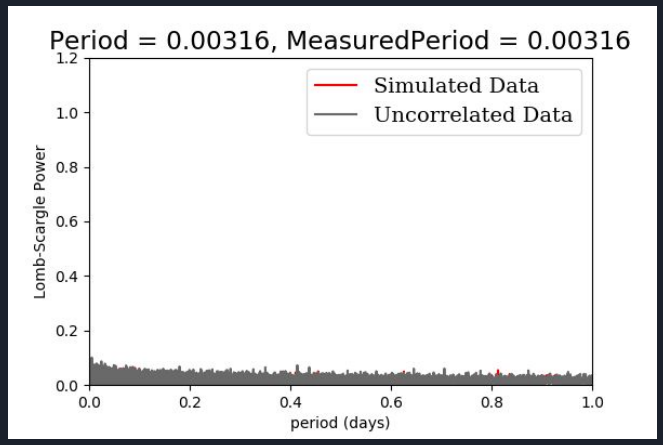
Magnitudes and dates in the light curve were shuffled, creating an uncorrelated data set

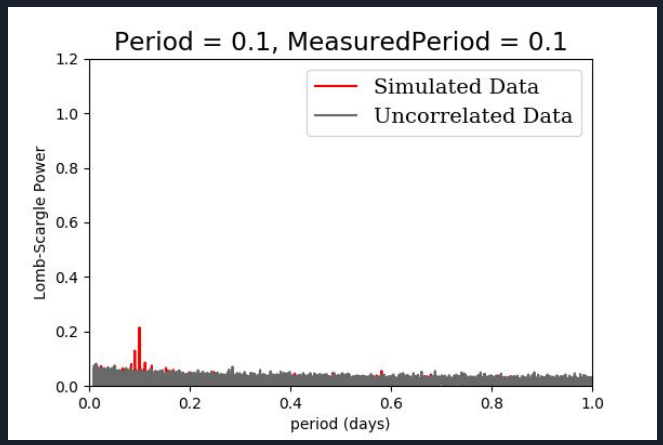
LS algorithm was evaluated over uncorrelated data set and the maximum peak recorded

This was repeated 10,000 times

x = no. of times the highest peak in the correlated data set was greater than that of the uncorrelated set

Sig = x / 10,000





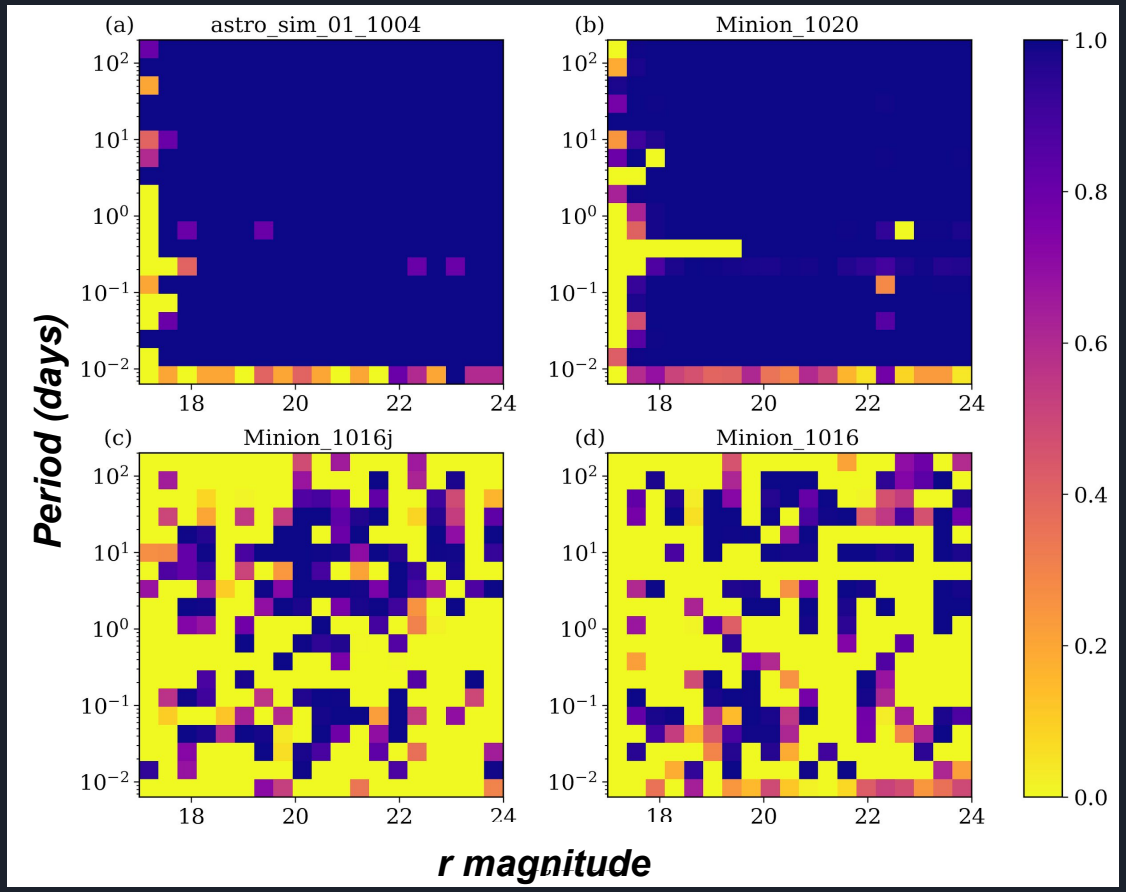
Period Recovery - Results

The multi-band Lomb-Scargle algorithm was applied to the results from the sampled lightcurve to determine what periods could be recovered.

Period ranges from ~9 minutes to 200 days to encompass all known LMXBs

Magnitude range from 17-24 mags in *r*, motivated by the visible range for LSST

Colour denotes significance



Johnson et al. Submitted.

Summary

OpSim produces a relational database including every observations made by LSST throughout the 10 year survey

OpSim was used to quantise the period recovery of different observing strategies, demonstrating a factor of ~2 increase when not including a reduced cadence on the Galactic Plane