WFIRST in the LSST Era

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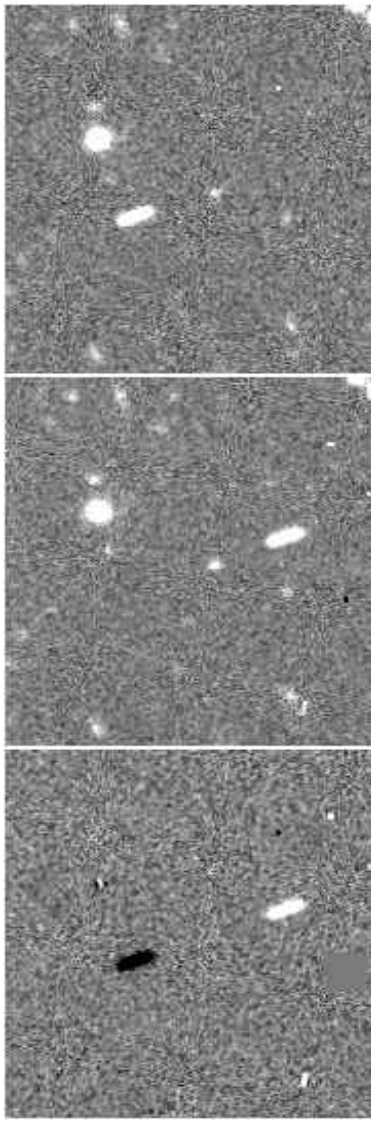
WFIRST Community Meeting
February 29 – March 2, 2016

LSST was designed to deliver in four key science areas

- Time domain science
  - Nova, supernova, GRBs
  - Source characterization
  - Instantaneous discovery
- Census of the Solar System
  - MBAs, NEOs, Comets
  - KBOs, Oort Cloud
- Mapping the Milky Way
  - Tidal streams
  - Galactic structure
- Dark energy and dark matter
  - Strong Lensing
  - Weak Lensing
  - Constraining the nature of dark energy



Exposure 1

Exposure 2

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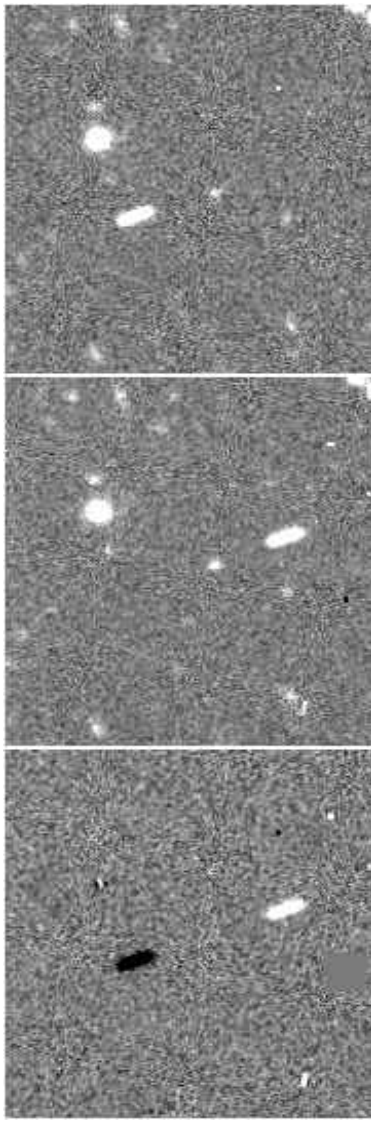

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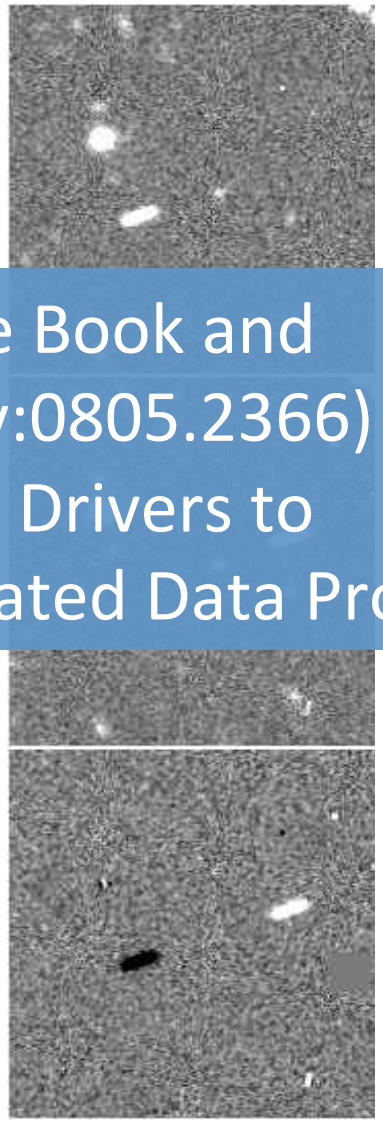
See the LSST Science Book and Ivezic et al 2008 (arXiv:0805.2366) "LSST: From Science Drivers to Reference Design and Anticipated Data Products"



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What is the LSST?

The LSST system will include:

(i) an 8.4m (6.7m effective aperture) optical telescope with a 3.5-degree diameter field-of-view, a 3.2 billion pixel camera, and 6 broad-band, optical filters

(ii) a data facility that will process, archive, and distribute survey images, associated transient alerts, and calibrated catalogs, as well as calibration and other metadata.

We will deploy this system for a 10 year, time domain survey covering > 18,000 deg^2

What is the LSST?

Survey Property	Performance
Main Survey Area	18000 sq. deg.
Total visits per sky patch	825
Filter set	6 filters (ugrizy) from 320 to 1050nm
Single visit	2 x 15s exposures, 2s readout
Single Visit Limiting Magnitude	u = 23.5; g = 24.8; r = 24.4; I = 23.9; z = 23.3; y = 22.1
Photometric calibration	2% absolute, 0.5% repeatability & colors
Median delivered image quality	~ 0.7 arcsec. FWHM
Transient processing latency	60 sec after last visit exposure
Data release	Full reprocessing of survey data annually

LSST Data Products

- A stream of ~10 million time-domain events per night, detected and transmitted to event distribution networks within 60 seconds of observation.
- A catalog of orbits for ~6 million bodies in the Solar System.

Level 1

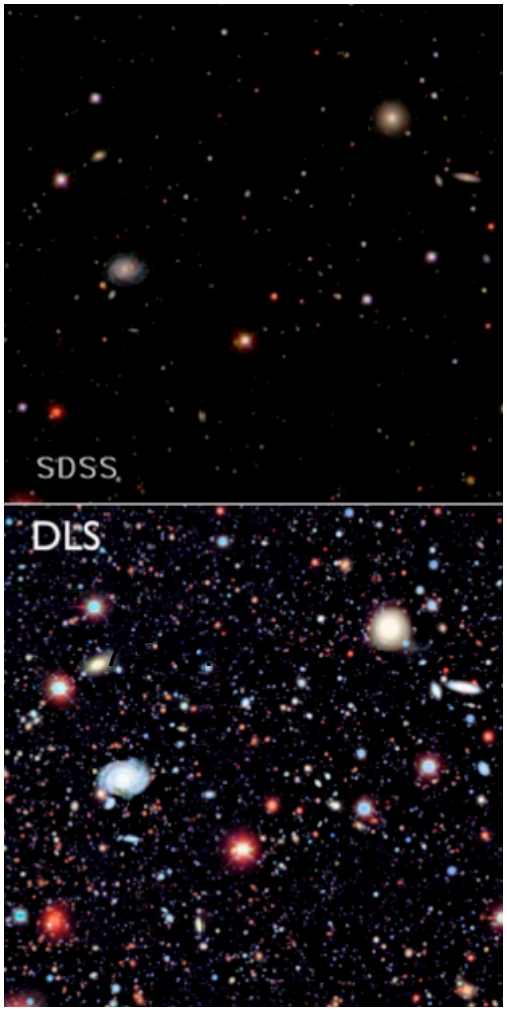
- A catalog of ~37 billion objects (20B galaxies, 17B stars), ~7 trillion observations ("sources"), and ~30 trillion measurements ("forced sources"), produced annually, accessible through online databases.
- Deep co-added images.

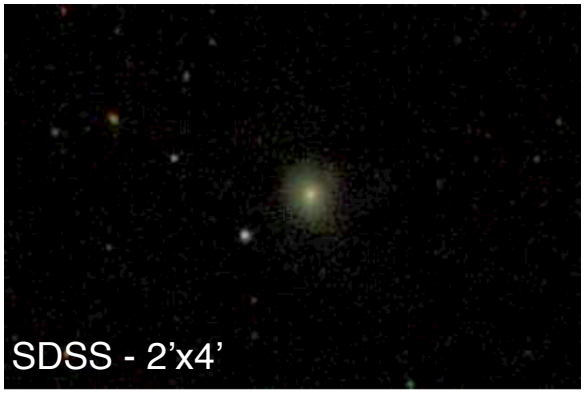
Level 2

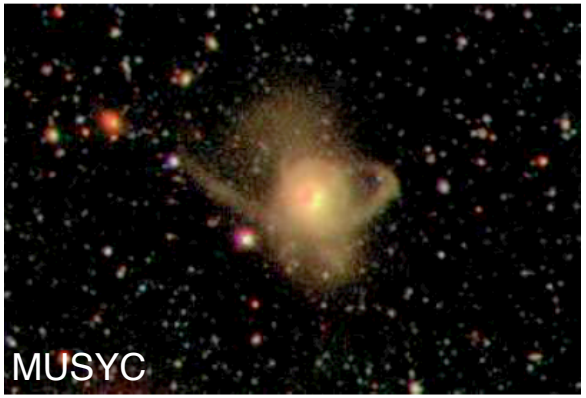
- Services and computing resources at the Data Access Centres to enable user-specified custom processing and analysis.
- Software and APIs enabling development of analysis codes.

Level 3

LSST-like Images







The Deep Lens Survey image is an analog in depth and image quality to a single LSST epoch

This MUSYC image is ~1 mag shallower than the co-added LSST; highlights possible LSB science

Final anticipated coadded depths:
u:25.9, g:27.3, r:27.2,
i:26.8, z:26.3, y:25.4

images from Ivezic et al. arXiv:0806.2366

LSST Astrometry

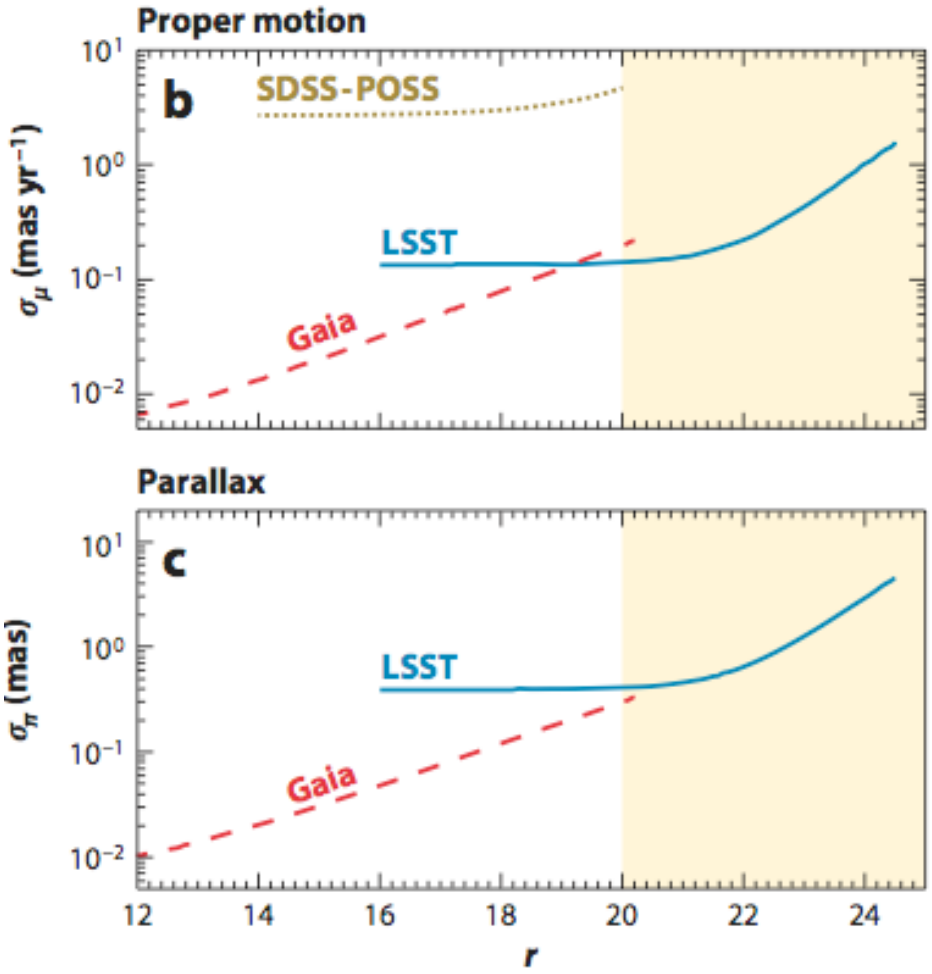


Figure from Ivezic, Beers & Juric 2012. See David Spergel's talk on WFIRST astrometry.

LSST and WFIRST science

We anticipate that LSST will be an essential resource for the WFIRST community.

- For example, it will be crucial for the computation of photometric redshifts for cosmological analyses.
- An extensive discussion is presented in Appendix H of the 2015 WFIRST-AFTA SDT report.
- The maximum value will be obtained from joint processing of the data, allowing the highest-resolution data to guide the photometric analyses in all bands. Others will speak about this later in the meeting, and much more detailed study of this will follow.

This will also be the case for GO / GI science, in selection of targets and in analysis of the resulting data.

- We are aiming at building systems that will support this.

Science User Interface and Tools

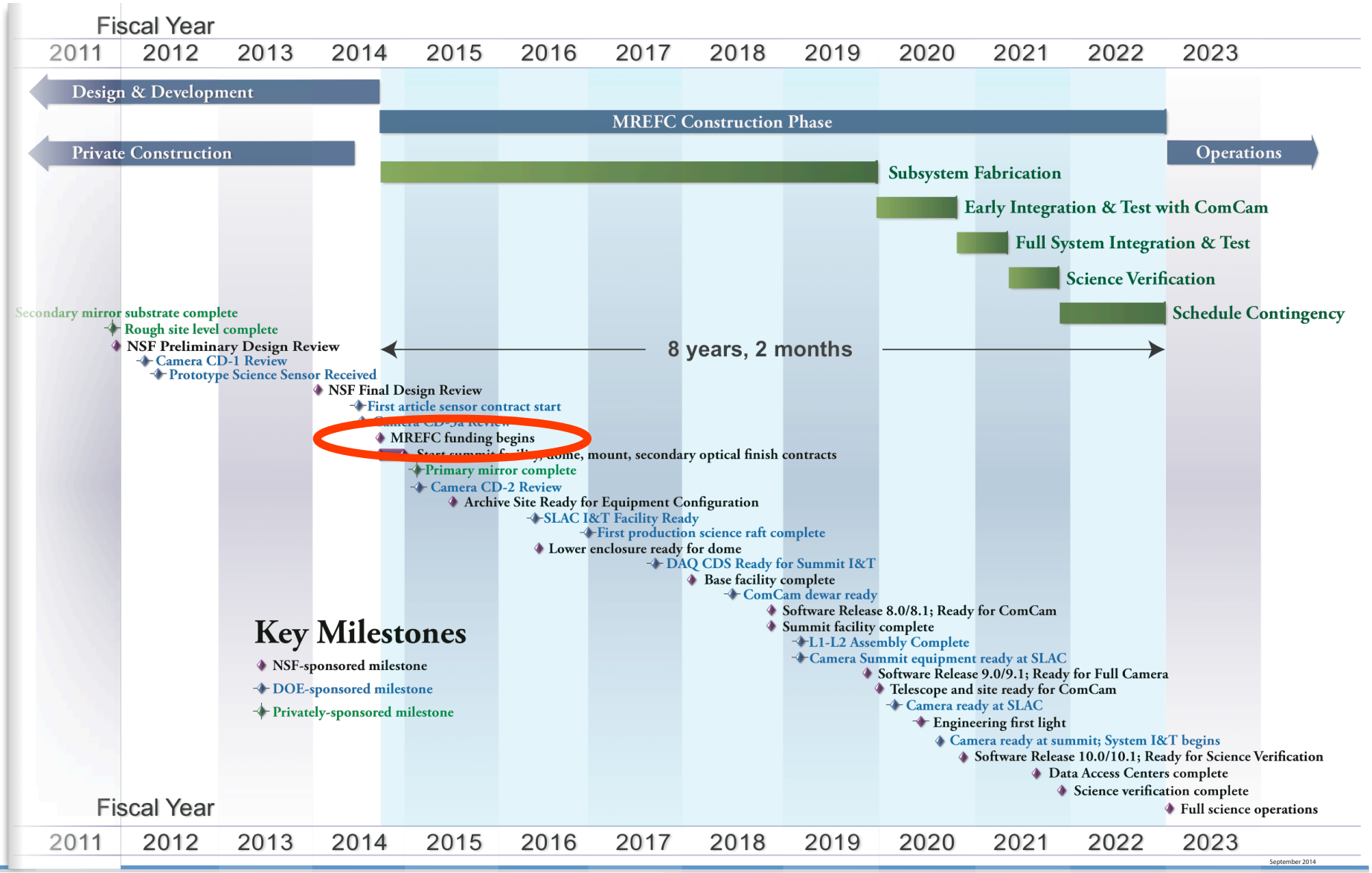
LSST will build a portal that fulfills the needs of the general user

- Searching, image visualization, table manipulation, plotting, providing a workspace, managing your analysis workflows and data collections, etc.)
  - Enabling *programmatic* as well as *visual* exploratory data analysis
  - Enabling access to data from other sources … such as WFIRST

We cannot anticipate all the desires of the community, so…

- We are building *components re-usable by others* to build environments that meet their and their groups' own special needs
- We will enable you to use the LSST (science pipelines) software, and your own code, to extend the capabilities of the interface
  - Provenance systems will ensure that you can run the pipeline code just as we did, modify it, process data, and track what you did
- The tools will be usable both on our systems and yours

Project Schedule



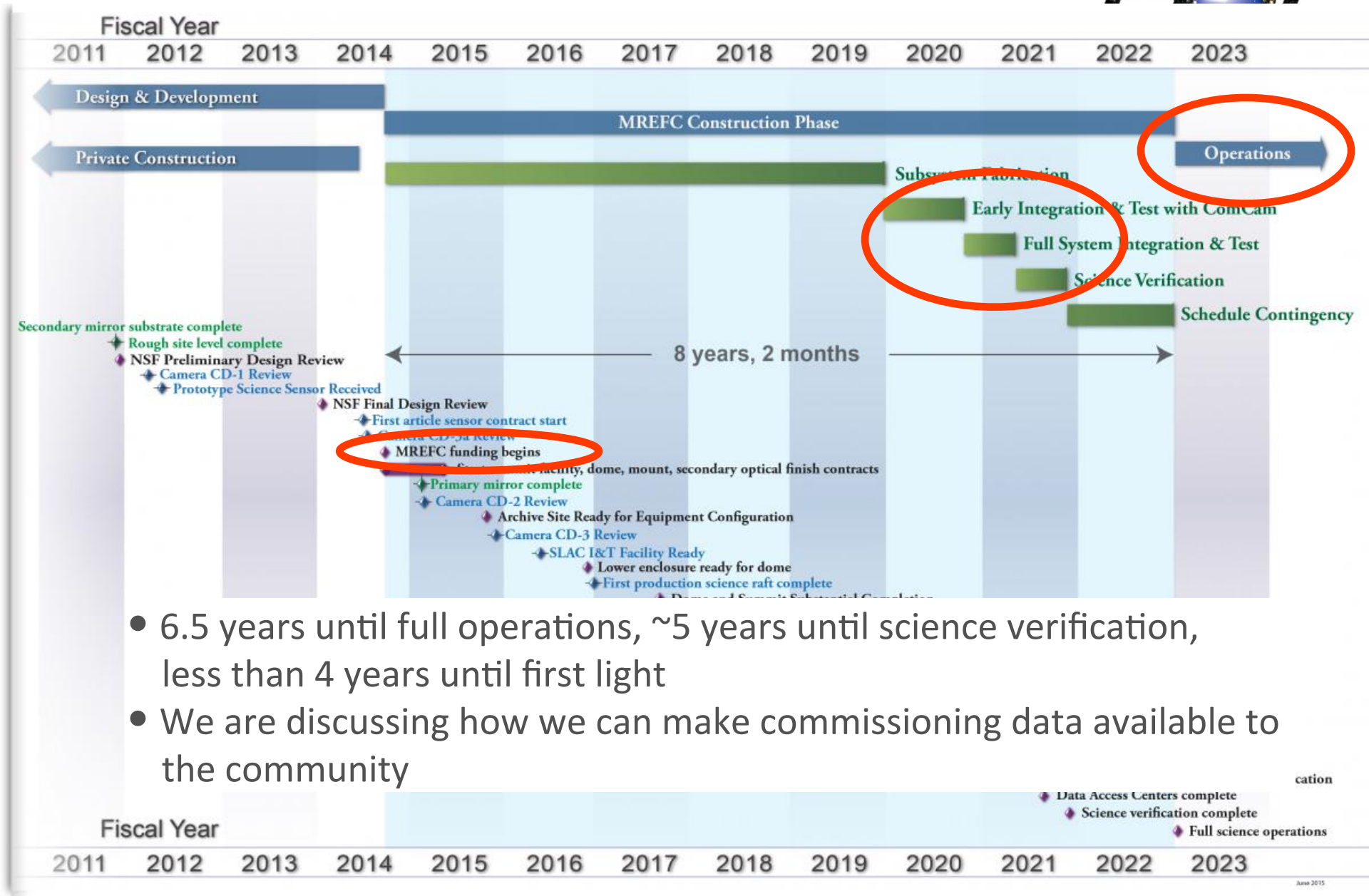

January 8, 2016


February 15, 2016
material staging
Provisional plywood walkways
Service building concrete structure in progress
Excavation for telescope pier foundation - rebar placed for pour Feb 22 to 24
Excavation for platform lift
Excavation for lower enclosure foundation
Elec. & tank area
Formwork for beams to support level 3 floor & mirror cart rails


January 4, 2016


February 4, 2016

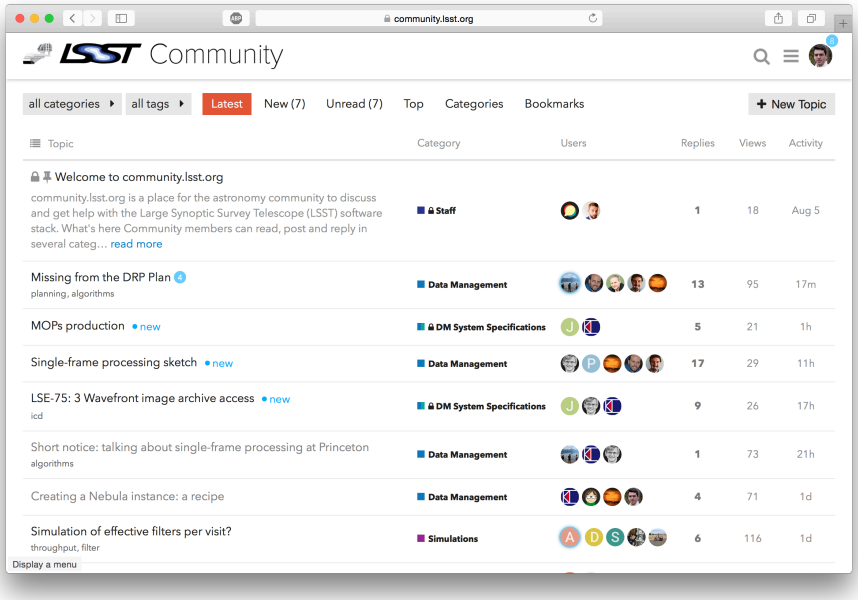
February 23, 2016



- 6.5 years until full operations, ~5 years until science verification, less than 4 years until first light
- We are discussing how we can make commissioning data available to the community

LSST Information for the Community

- Key project information, including software and simulations, at www.lsst.org
- Weekly email digest (Spanish + English) and email exploder for scientists – Anyone can subscribe
- Science Advisory Committee minutes and membership



http://community.lsst.org

LSST Resources for the Community

- Operations Simulations (OpSim)
- Image Simulations (ImSim)
- Base catalogs of stars and galaxies in LSST filters (CatSim)
- Key Project Documents (Science Requirements Document, Data Products Definition Document)

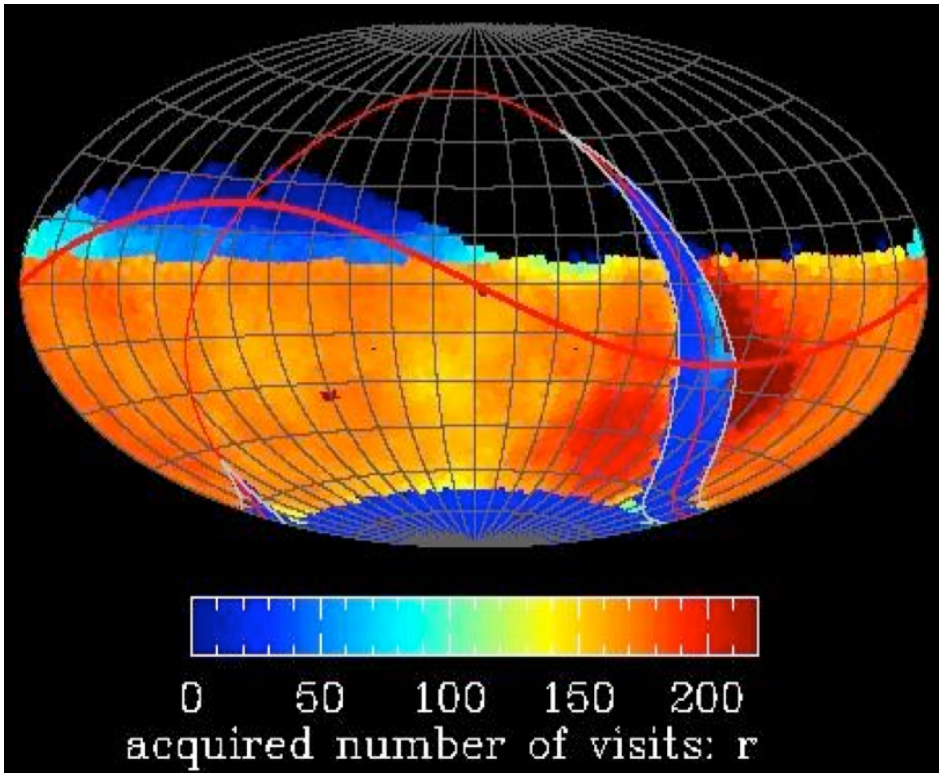
http://www.lsst.org

image from Ivezic et al. arXiv:0806.2366

LSST Observing Strategy

The basic LSST observing strategy includes ~90% of the time dedicated to a monolithic survey of ~18,000 deg^2 of sky and ~10% reserved for several specialized surveys and deep drilling fields.

We are currently investigating a variety of rolling cadences for the monolithic survey area, and the boundaries/strategies for the specialized surveys (Northern Ecliptic Spur, Galactic Plane, Magellanic Clouds)



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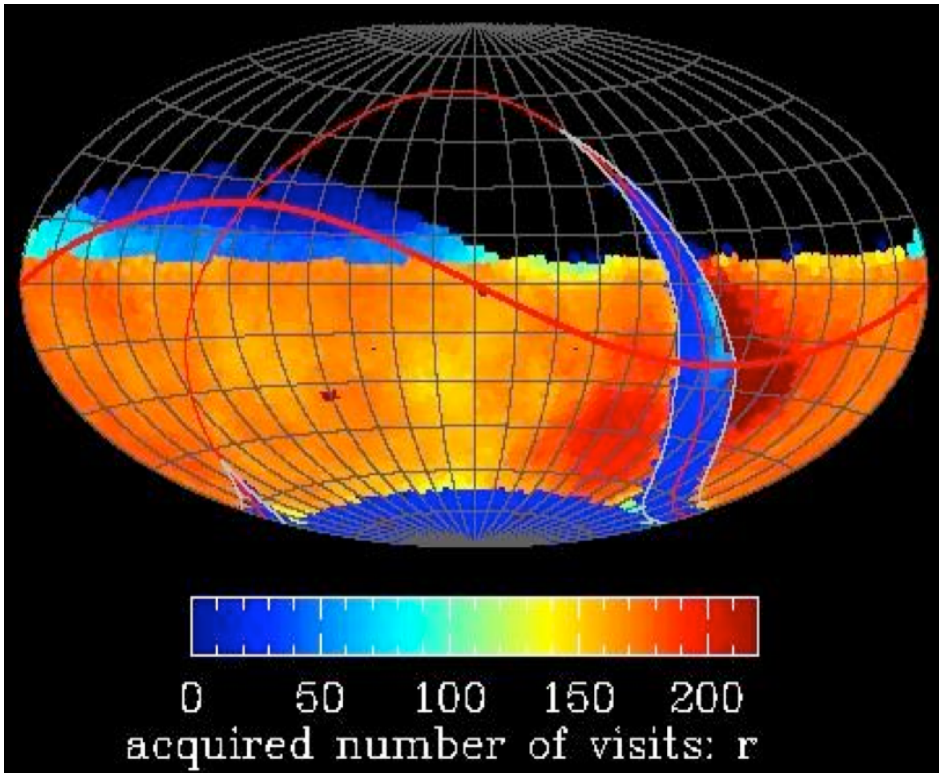
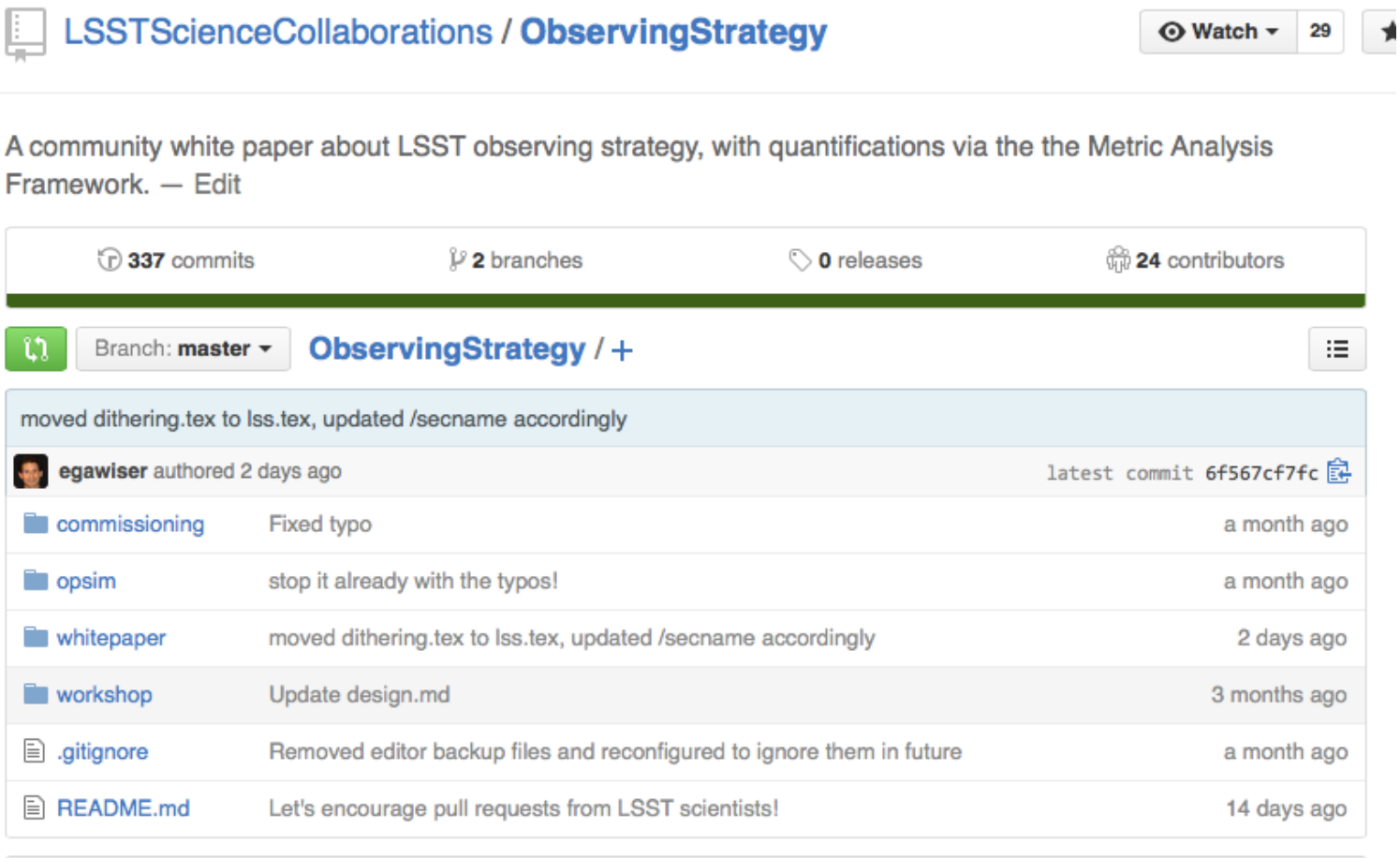


The implementation of this basic strategy can be optimized for science output. Community strategy project:

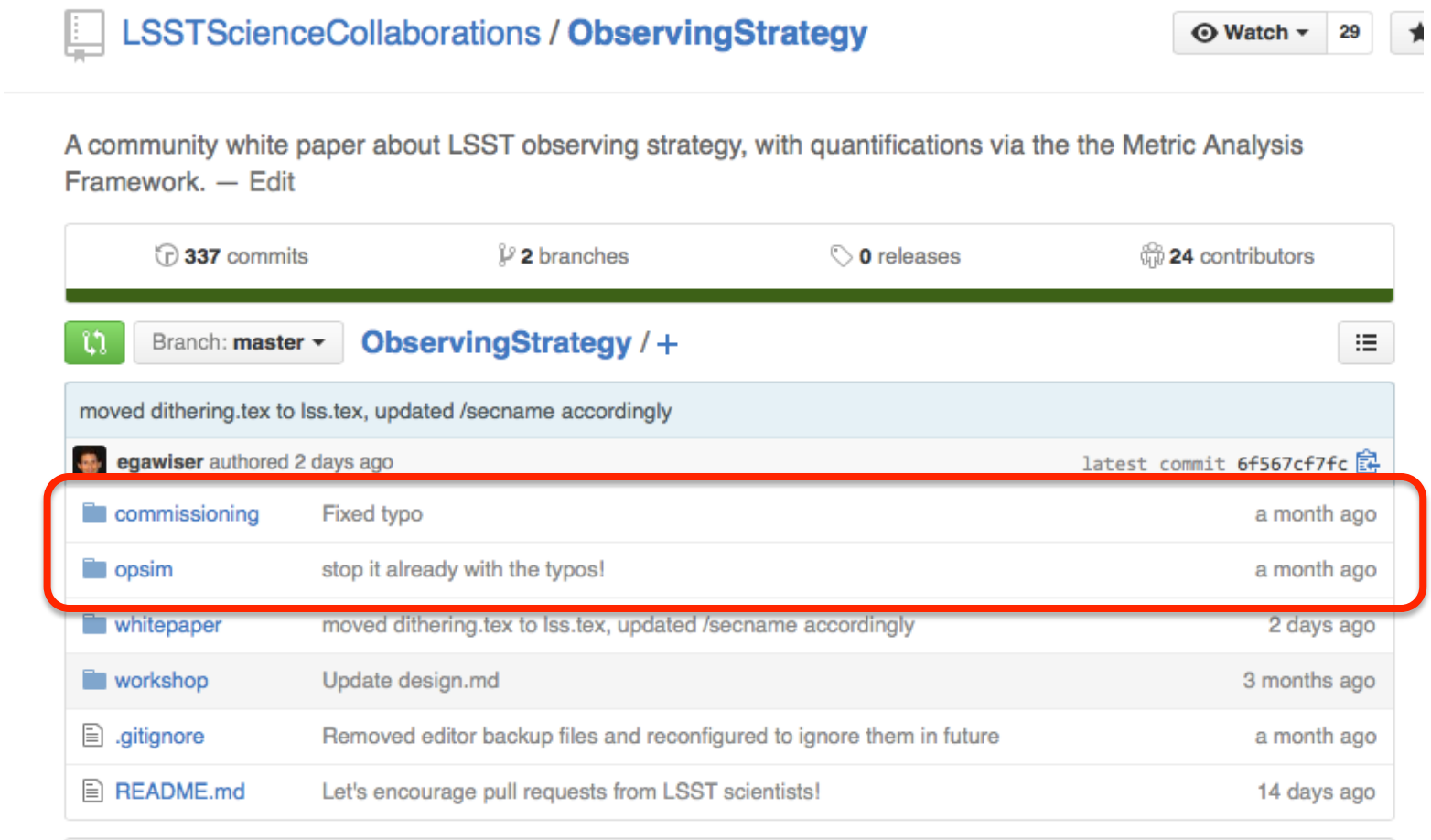
http://ls.st/o5k

LSST Observing Strategy



A community-based observing strategy study is underway

LSST Observing Strategy



You can suggest an observing strategy to simulate, or a commissioning experiment

The current community list of suggested observing strategies (dozens more are being simulated by the Project):

Proposed New OpSim Experiments

Name	Proposer(s)	Issue Thread	Description
No Extragalactic Visit Pairs	Marshall	#66	Dont observe in pairs of visits above the Galactic and Ecliptic planes
Target of Opportunity Observations	Soares-Santos, Bellm	#75	simulate TOO Observations
Coordination with WFIRST	Gawiser, Rhodes	#114	Add Special Survey to duplicate WFD observations of 2300 degrees during first 5 years
NEO optimized runs	SS SC	#120	Find more and different NEOs
Normal Plane	Strader (for SMWLV)	#162	Do Galactic Plane with normal WFD cadence
Rolling Cadence Optimized for SN Cosmology	Jeonghee Rho [and SN Cosmology Team]	#159	Modified Rolling Cadence for densely populated SN light curves
...	...	...	

Discovery Volumes for Some Key Stellar Tracers

- Old, metal-poor MSTO ~140 kpc (single-visit), ~ 400 kpc (co-add)
- Horizontal branch ~500 kpc (single-visit), 1.6 Mpc (co-add)
- Old, metal-poor RGB ~3.5 Mpc (single-visit), 6 Mpc (co-add)
- RR Lyrae ~600 kpc (VanderPlas & Ivezic 2015)

Star-galaxy separation will be a limiting factor for how well MSTO, BHB, and RGB stars can be used to trace low surface brightness stellar structures throughout the Local Volume.

WFIRST's superior image quality and IR magnitudes will enable refined star-galaxy separation over ~2,000 deg^2 and provide a truth table for refining star-galaxy separation algorithms over the wider LSST survey area.

Closing Remarks

LSST community resources are available now, as is the opportunity to contribute to optimizing LSST's observing strategy.

There are numerous WFIRST-LSST synergies in science based on resolved stars (see Tuesday afternoon talks), as well as in the core cosmological investigations.

There is a tri-agency, three project working group (focused on cosmological science) that is discussing possible pixel-level joint processing of WFIRST, LSST, and Euclid. (B. Jain and D. Spergel are the corresponding authors.) Several members of that group are here…