LSST: Revealing the universe

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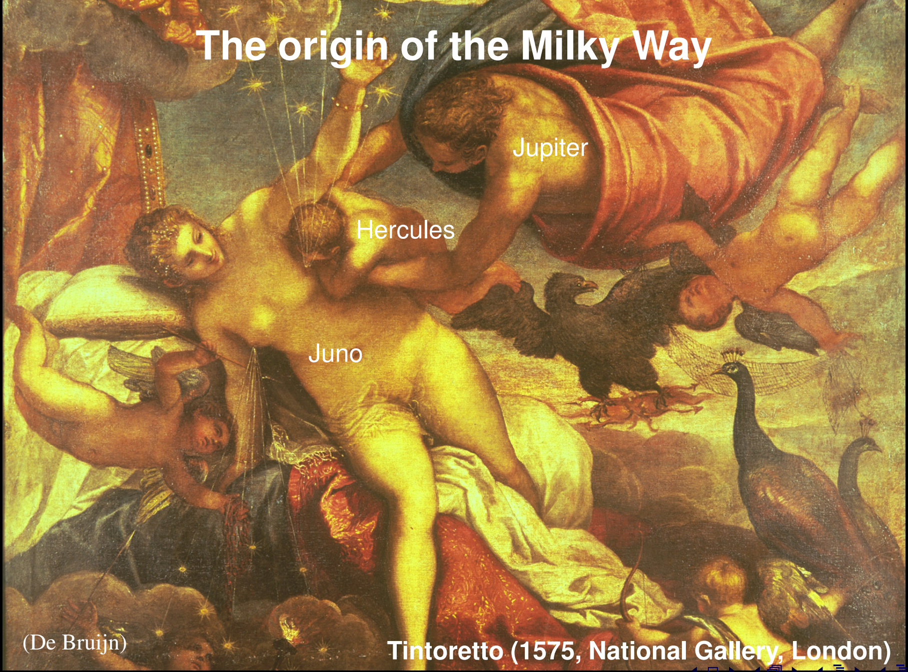
Data management
Large Synoptic Survey Telescope
Tucson, AZ USA

5$^{\text{th}}$ March 2019
NOAO
Tucson

The origin of the Milky Way



(De Bruijn)

Tintoretto (1575, National Gallery, London)

Milky way analogue

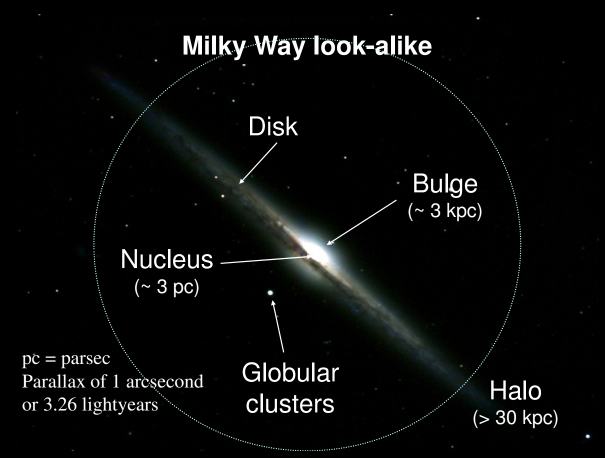
'Our sun'→

Our view is severely obstructed by the dust in the disk and relatively little is known about the origin, history, and structure of our own Galaxy

We are unraveling the formation, composition, and evolution of the Galaxy

Jos de Bruijne

Another Milky way Analogue (NGC4565)



Stellar motions can be predicted into the future and calculated for times in the past when all 6 phase-space coordinates (3 positions, 3 velocities) are known for each star

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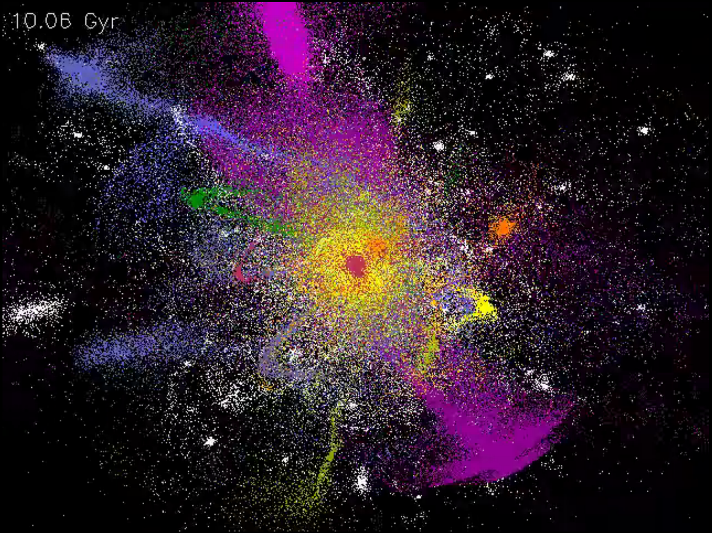
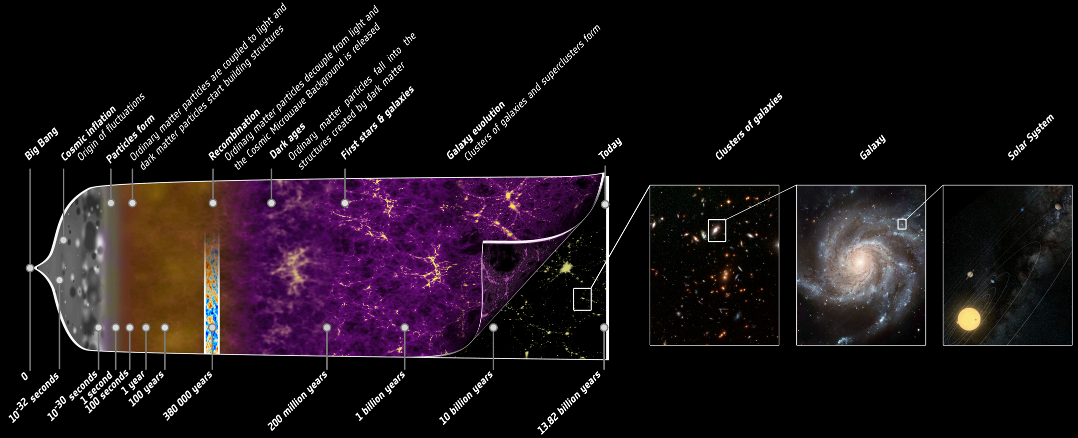
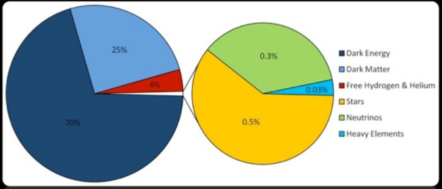
In such processes, stars got spread over the whole sky but their energy and (angular) momenta were conserved. Thus, it is possible to work out, even now, which stars belong to which merger and to reconstruct the accretion history of the halo (de Bruijne)

Origin of the Milky Way



Streams paper using Gaia DR2 Koppelman et al. (2018)

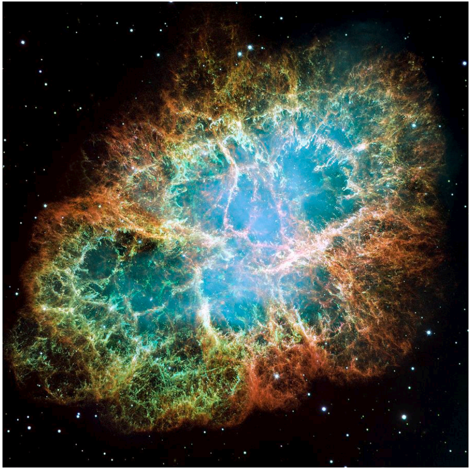




The modern cosmological models can explain all observations, but need to postulate dark matter and dark energy (though gravity model could be wrong, too)

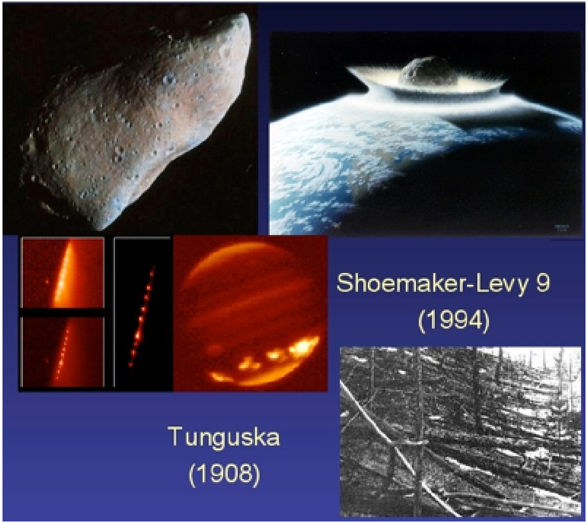
LSST scans the sky repeatedly and compares the images with templates allowing us to:

- discover new, distant transient events
- study variable objects in universe
- capture rare and exotic objects
- gain new insight into known transients:
  - new remnants of dead massive stars, including neutron star and black hole binaries;
  - variability at the heart of distant galaxies - feeding habits of the rapacious supermassive black holes at their centers;
  - catch the faint cosmological explosions of dying, merging stars, illuminating where the universe's heavy metals are forged.

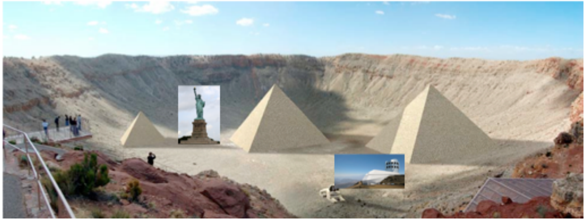


The Crab Nebula, result of a supernova noted in 1054 A.D.

Killer asteroids: the impact probability is not 0!

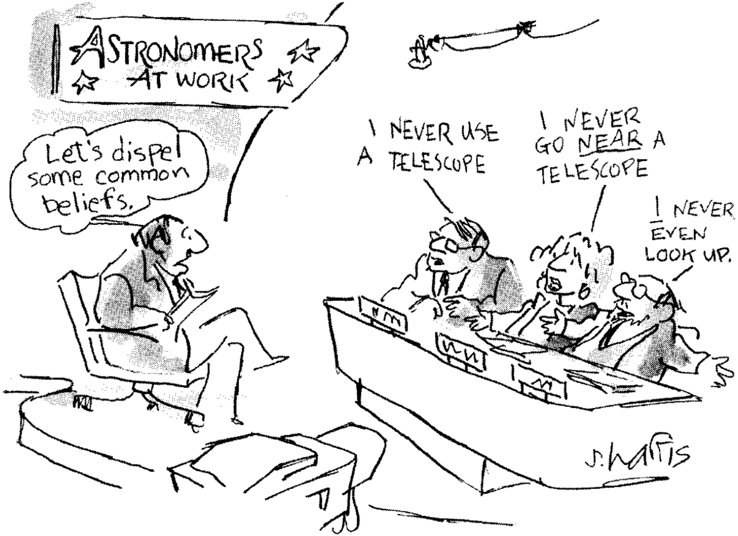


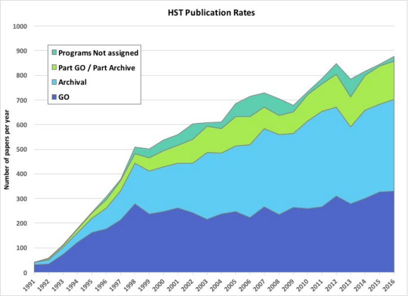
LSST is the only survey capable of delivering completeness specified in the 2005 USA Congressional NEO mandate to NASA (to find 90% NEOs larger than 140m)



The Barringer Crater, Arizona: a 40m object 50,000 yr. ago

The Era Of Surveys



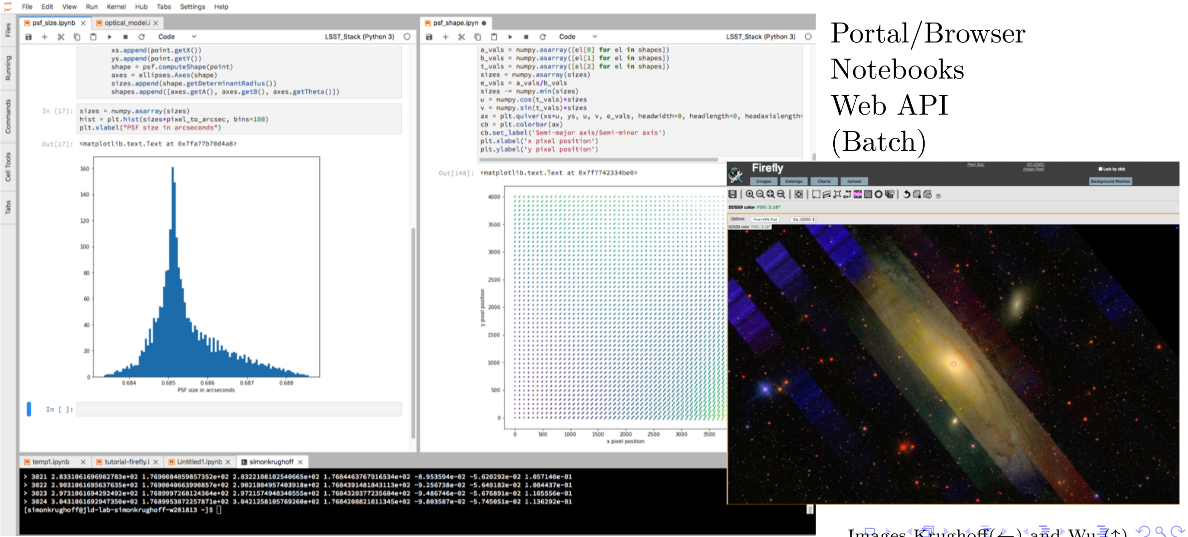


https://archive.stsci.edu/hst/bibliography/pubstat.html

...indicates archival research probably play an important role in the scientific success of XMM-Newton Ness et al. (2014)

Science Platform Vision to Reality

Vision: LSE-319 — Design: LDM-542 — Test: DMTR-51 at NCSA



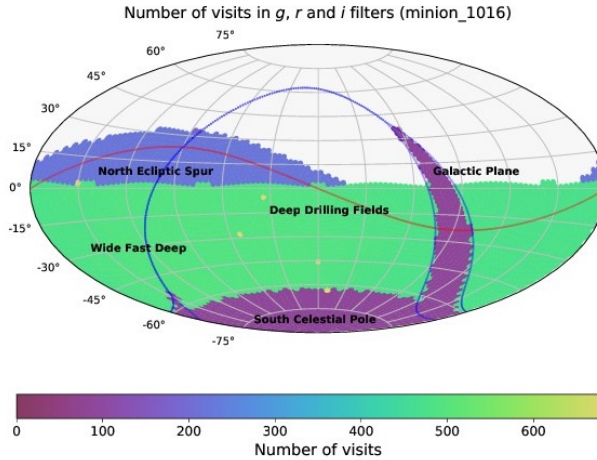
- Portal/Browser
- Notebooks
- Web API
- (Batch)

Images Krughoff(←) and Wu (↑)

An optical/near-IR survey of half the sky in ugrizy bands to r 27.5 (36 nJy) based on 825 visits over a 10-year period: deep wide fast.

- 90% of time spent on uniform survey: every 3-4 nights, the whole observable sky scanned twice per night
- 100 PB of data: about a billion 16 Mpix images, enabling measurements for 40 billion objects!

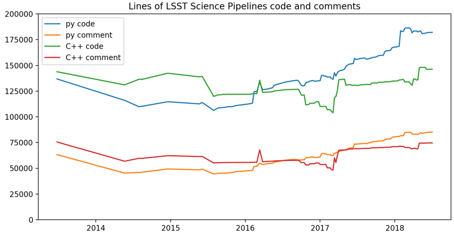
see also http://www.lsst.org and Ivezic et al. (2008)-arXiv:0805.2366



10-year simulation : number of visits in u,g,r band (Aitoff projection of eq. coordinates)

DM Mission :
Stand up operable, maintainable, quality services to deliver high-quality LSST data products for science, all on time and within reasonable cost.

LSST DM development is distributed across the Americas.
Plus we have partners like IN2P3
See Management Plan LDM-294.



DM must build everything to get LSST data products—as described in LSE-163—to end users.

- Large data sets (20 TB/night)
- Complex analysis with small systematics
- Science alerts issued within one minute

$\sim {}^{3}/_{4}$ million lines of code/comments (C++/Python/Java/JavaScript/Kotlin)

See SPIE paper by Jenness et al. (2018)

Architecture and Components LDM-148.

Concept of Operations LDM-230.

Upper diagram courtesy K-T Lim, LDM-148.

Lower diagram by Tim Jenness; covers only the Science Pipelines codebase.

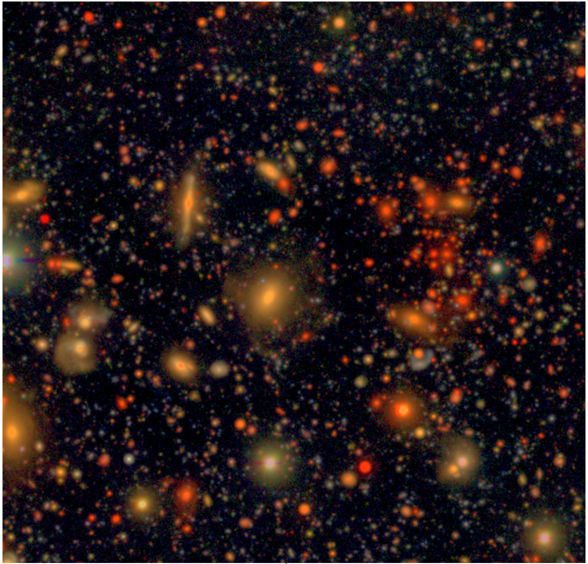
All comes down to image- SDSS example

Nice colours Lupton et al. (2004)

$\approx 3.5'$

Image Robert Lupton

Hyper Suprime Cam (HSC) on Subaru



HSC image (COSMOS) from g,r(1.5 hrs) ,i(3 hrs) PSF matched co-add (≈ 27.5)

Processed with LSST Stack
https://pipelines.lsst.io/

YES the Pipelines are already in use with other facilities like Hyper Suprime-Cam.

Still working on performance, algorithmic enhancements, orchestration, etc.

Design LDM-151; Test Specs LDM-533; LDM-534; Test Reports DMTR-52; DMTR-53

Image HSC collaboration, Robert Lupton

Alerts: identify time varying objects

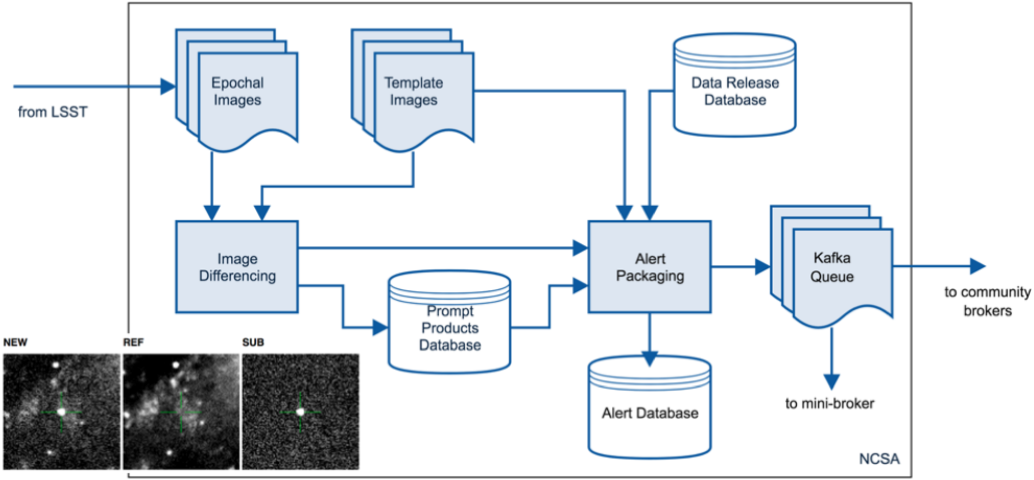


Figure from Eric Bellm

Brokers

- LSST Mini Broker - Users can create filters that return
  - a subset of LSST alerts based only on data in the alert packet
  - can use lightcurve, variability parameters, colors, etc.,
  - no crossmatch to external catalogs
  - Runs in the LSST Data Access Center(-> users must have data rights)
- Community Alert Brokers - further enabling science on alerts e.g.:
  - Provide public access to alerts
  - Classification and Crossmatch to other catalogs or data streams
  - Provide filtering, visualization, and search
  - Coordinate scientific activity and/or followup observations
  - Aggregate alert annotations (community classifications, etc.)
- Call has gone out for community brokers
- Mini Broker capacity/Number of community brokers limited by bandwidth

see also LDM-612

The END

Questions?

Blast 20 Cerro Pachón April 2011.

Gaia blast off on Soyuz December 2013

http://www.lsst.org http://community.lsst.org http://www.cosmos.esa.int/web/gaia

Acronyms I

Acronym	Description
AURA	Association of Universities for Research in Astronomy
DM	Data Management
LSST	Large Synoptic Survey Telescope
NASA	National Aeronautics and Space Administration
NEO	Near-Earth Object

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