

# The Large Synoptic Survey Telescope Science Collaborations

federica b. bianco

University of Delaware

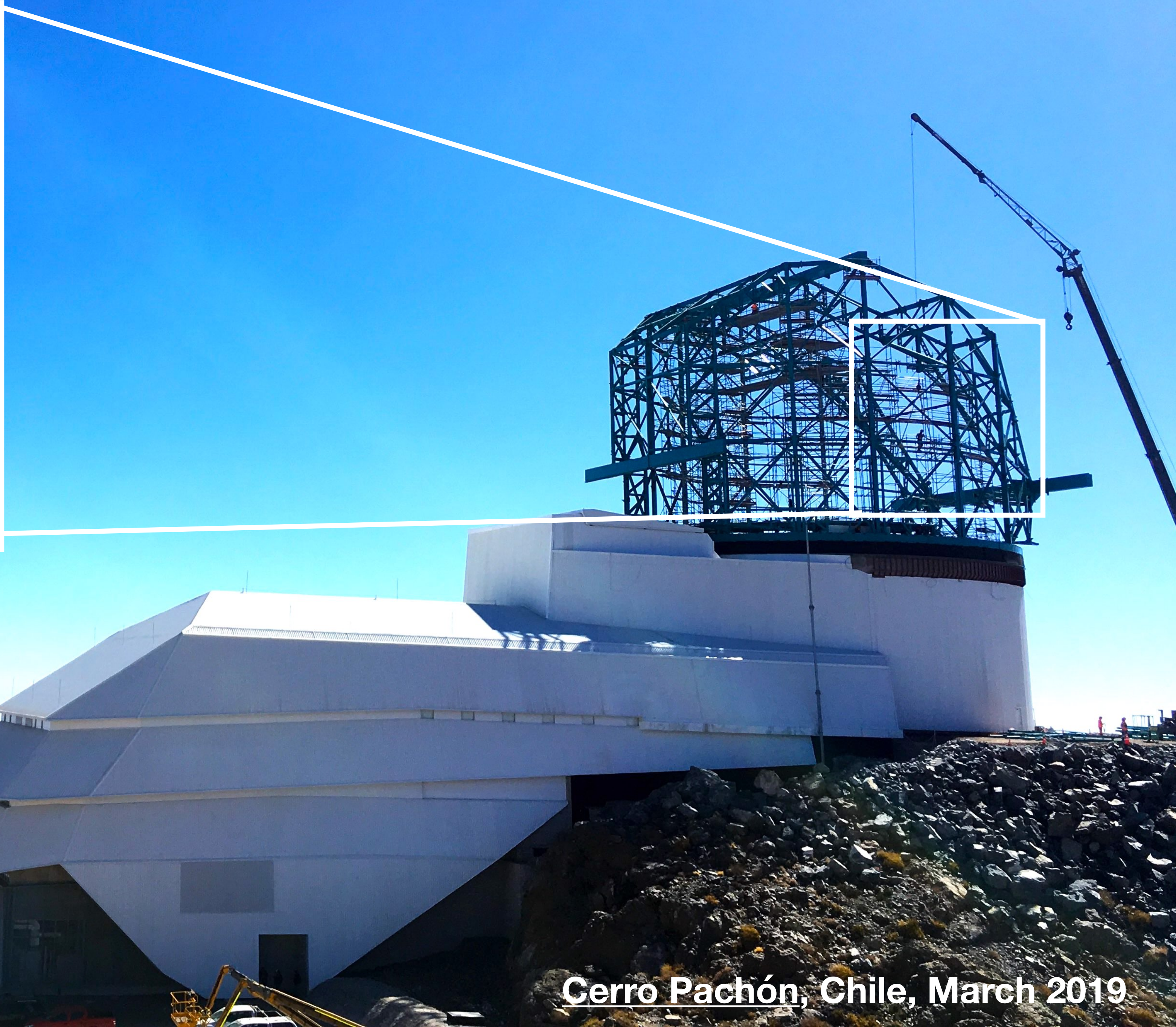
Department of Physics and Astronomy - Biden School for Public Policy & Administration

Data Science Institute

**LSST Science Collaborations Coordinator, LSSTC**

**LSST Transient and Variable Stars Science Collaborations Co-Chair**



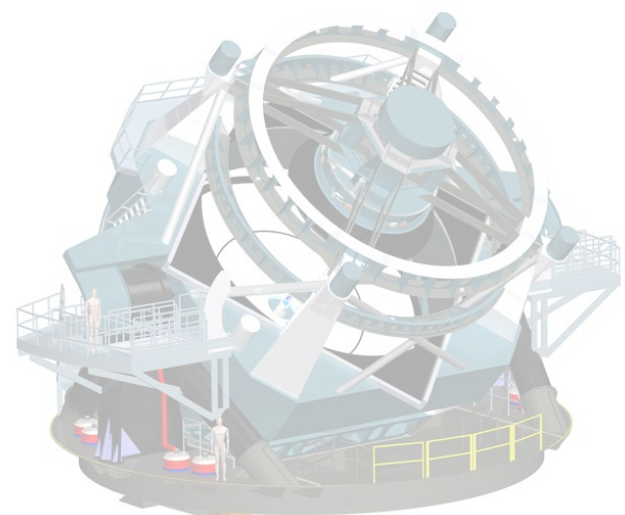


Cerro Pachón, Chile, March 2019

# LSST

each night is 20TB data, coming in at the rate of 30GB per minute *goal: 5 seconds/image*

April 4, 2018 - 100Gbps  
“points of presence,” LSST now has a redundant, high-speed, fiber-optic network between Santiago, Chile, and Miami, Florida.[...] “This network will permit LSST data to travel in seconds to our LSST Data Facility at NCSA where it will be processed...”  
J. Kantor

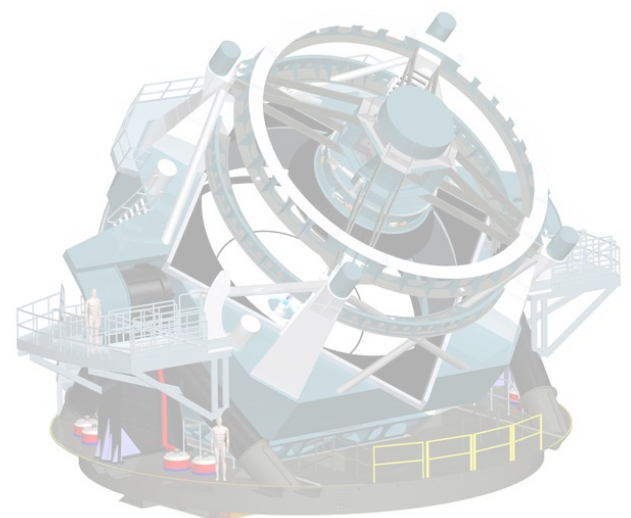
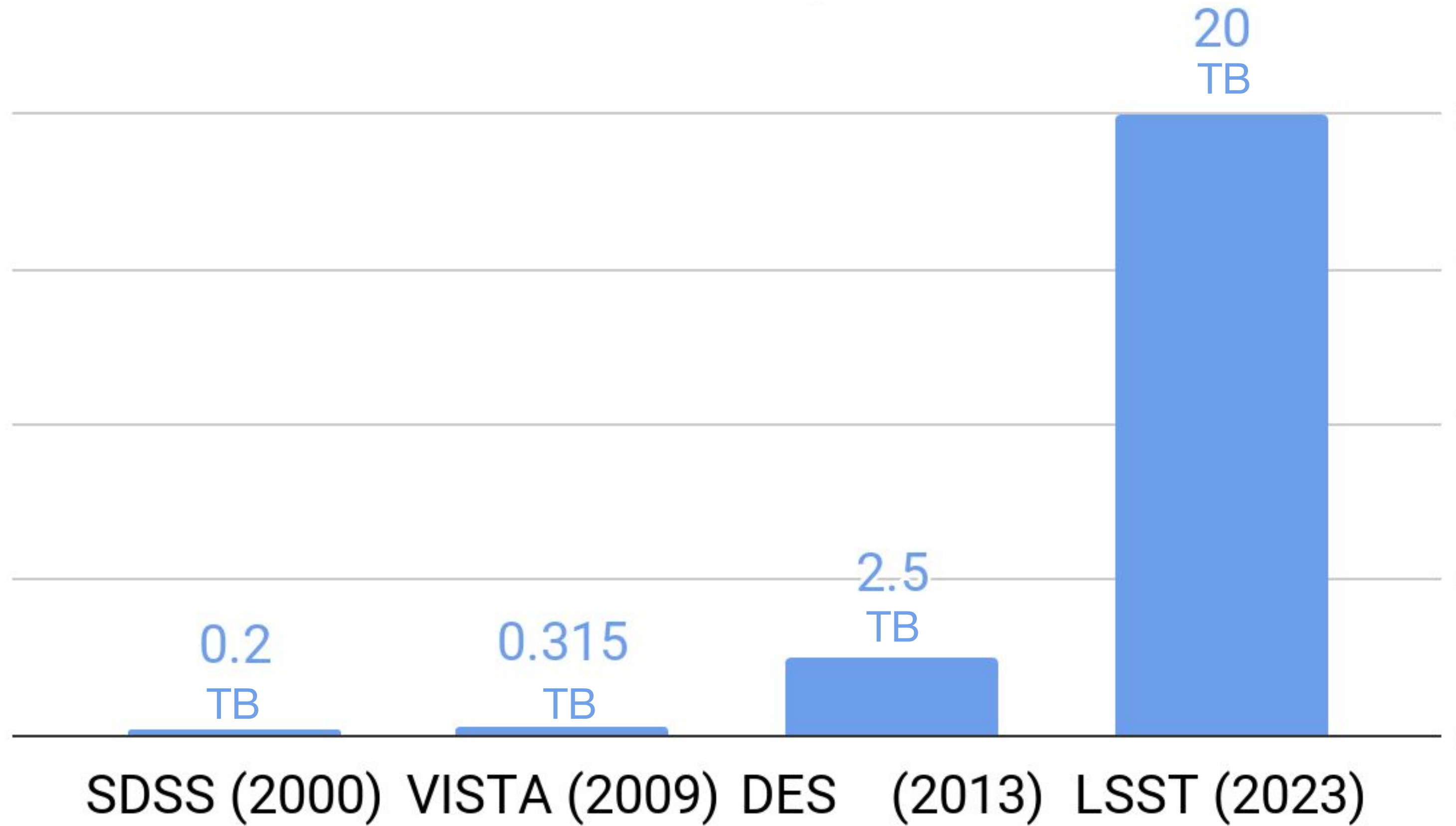


[https://www.amlight.net/wp-content/uploads/2015/03/LSST\\_PNWGP\\_2018.pdf](https://www.amlight.net/wp-content/uploads/2015/03/LSST_PNWGP_2018.pdf)

federica bianco UDel

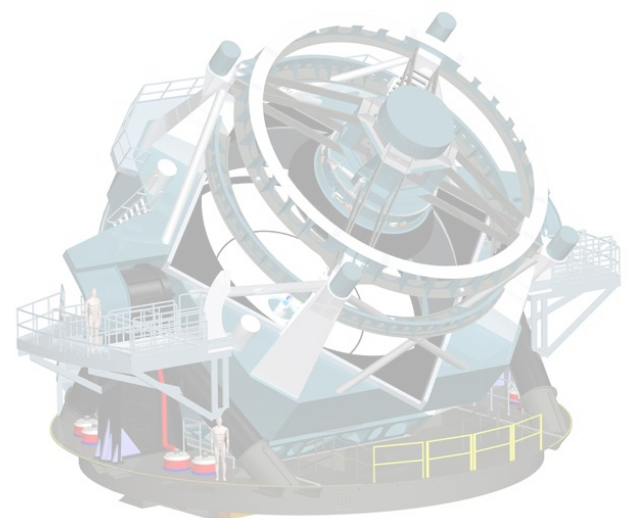
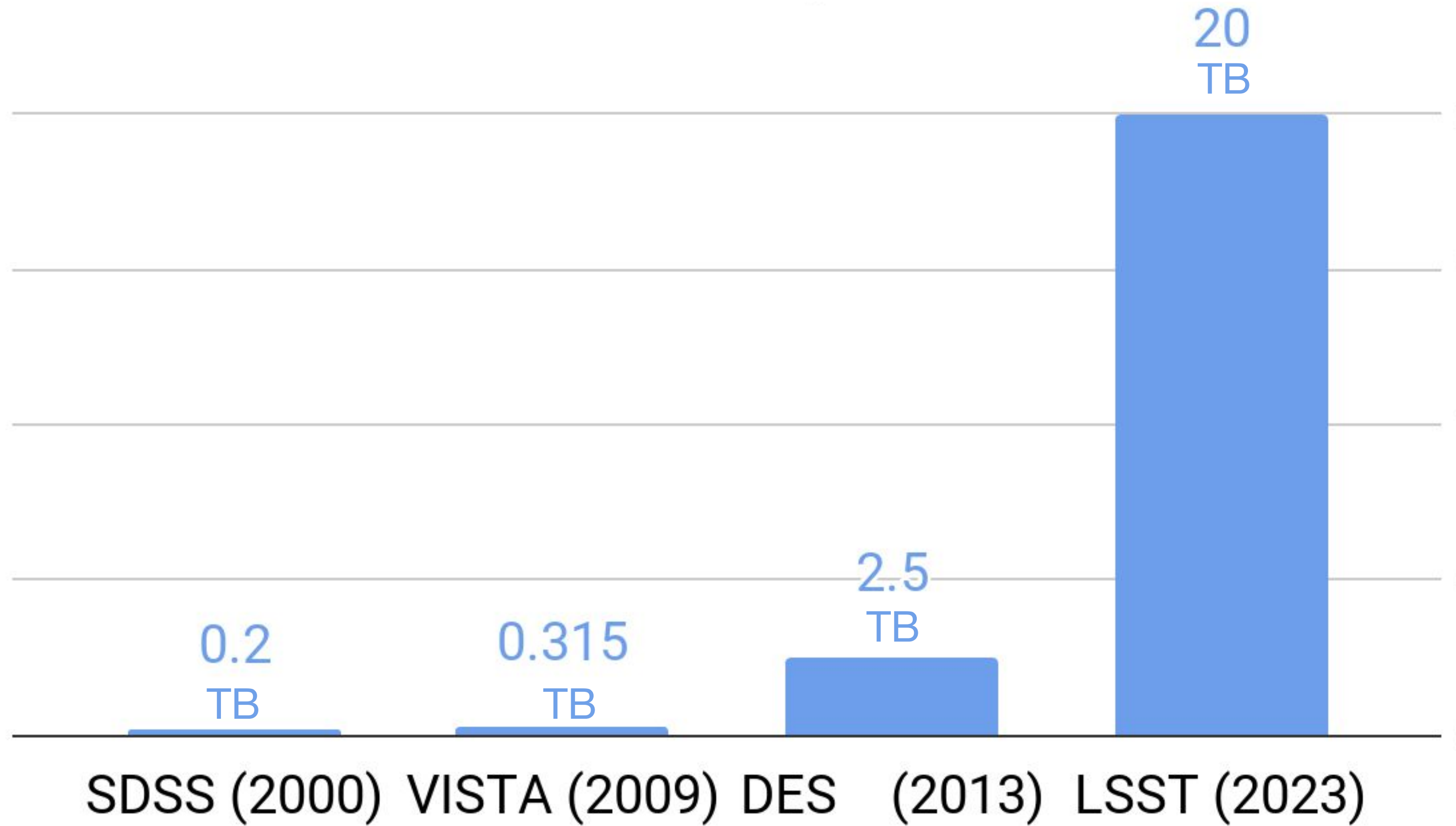
# LSST

- **x10 increase in data volume**



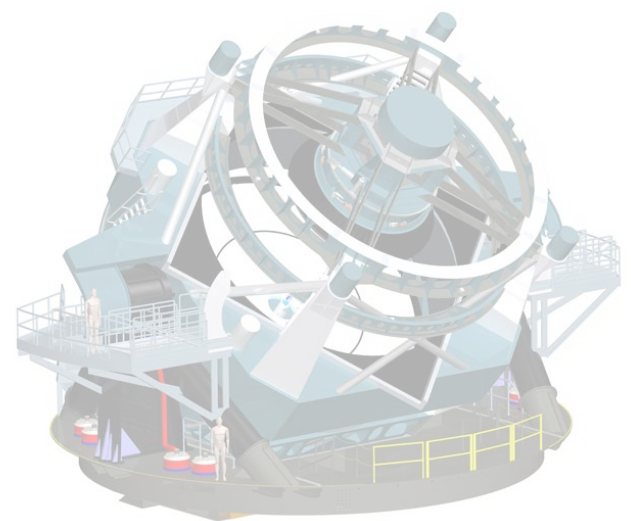
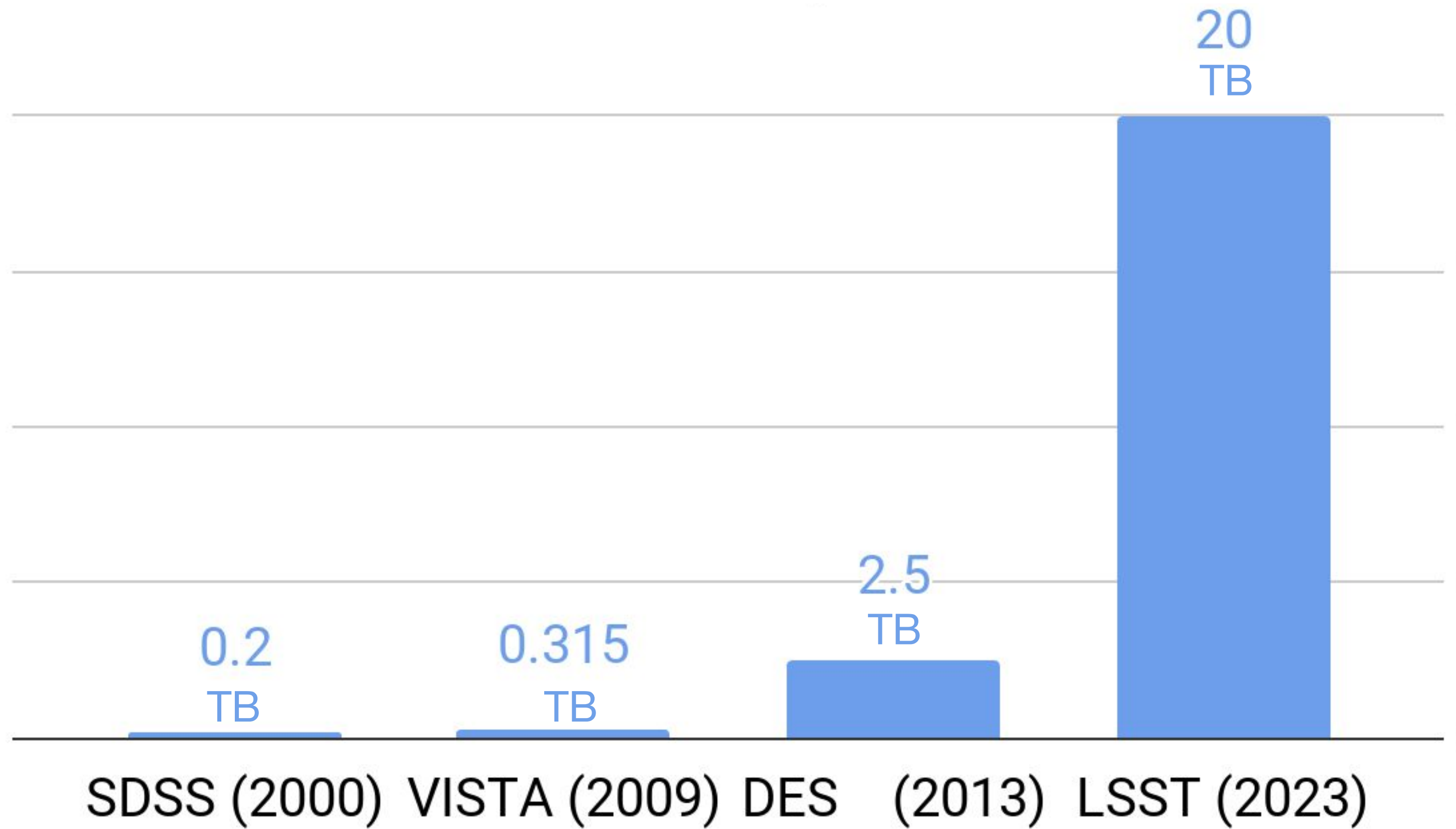
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- **x10 increase in data volume**
- **US-wide public access to data**

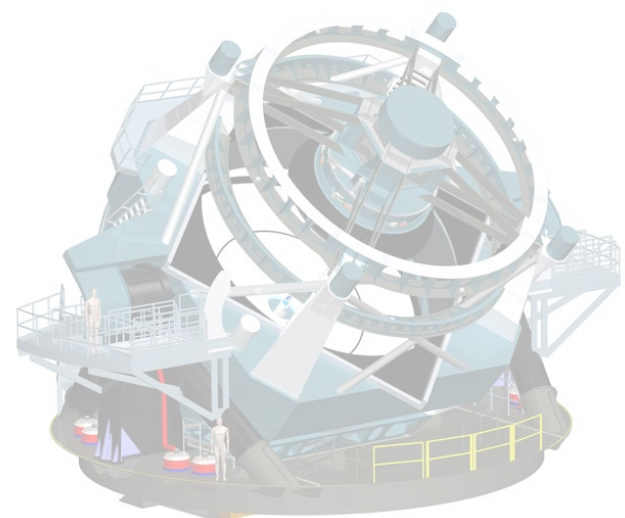
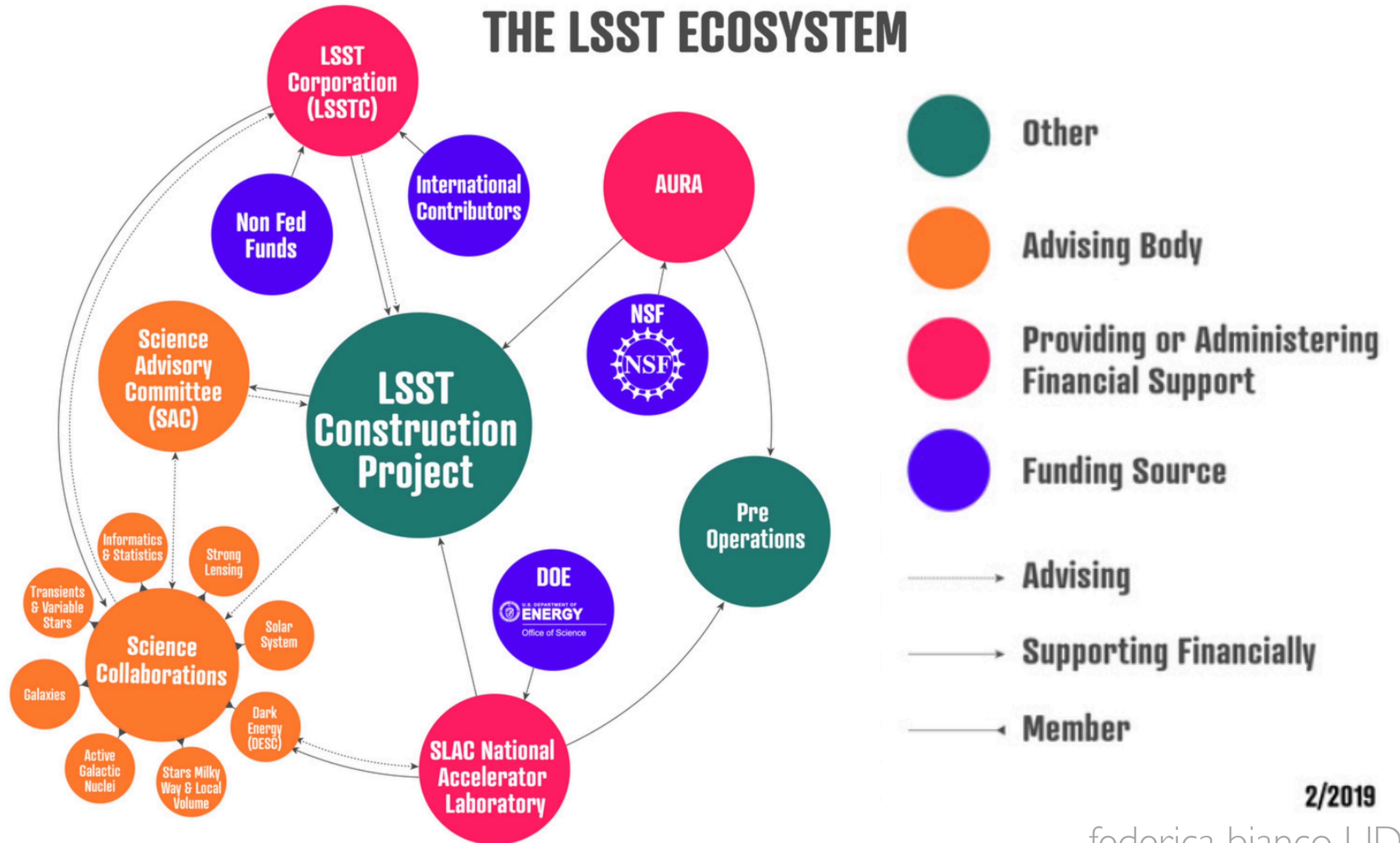


# LSST

- **x10 increase in data volume**
- **US-wide public access to data**
- **information data to be leveraged for multiple science goals**

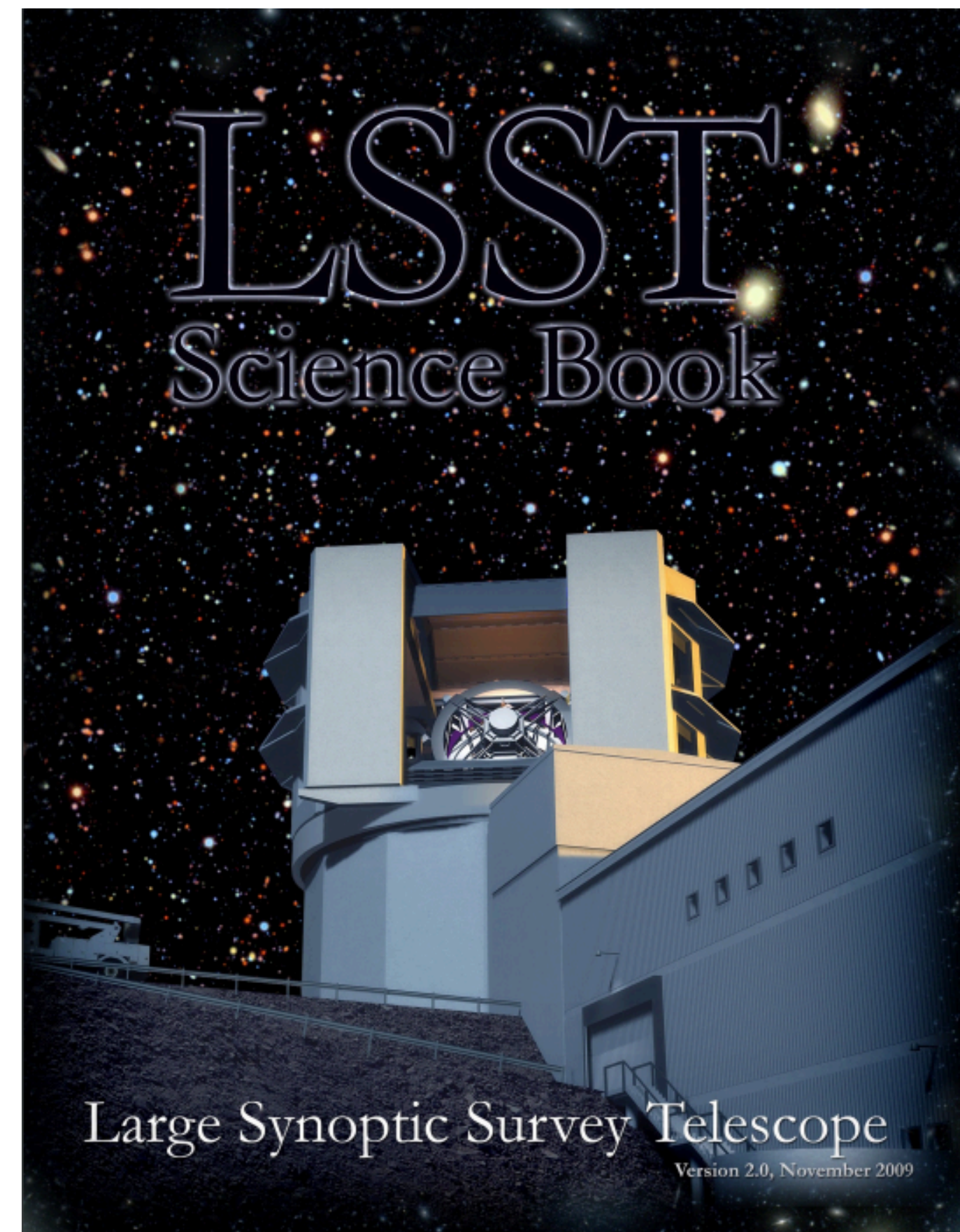
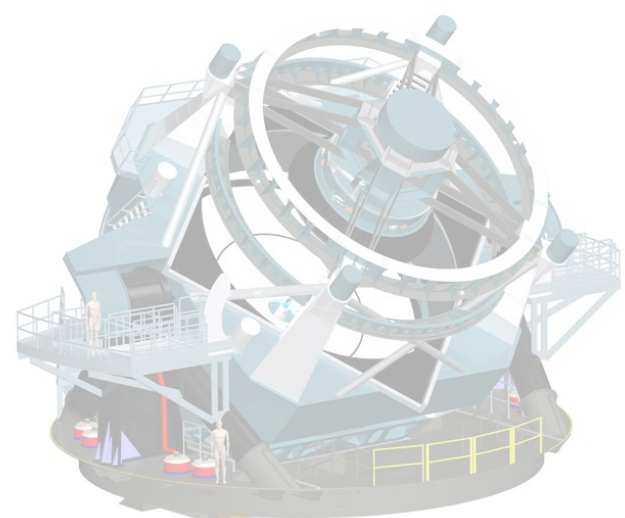


## THE LSST ECOSYSTEM

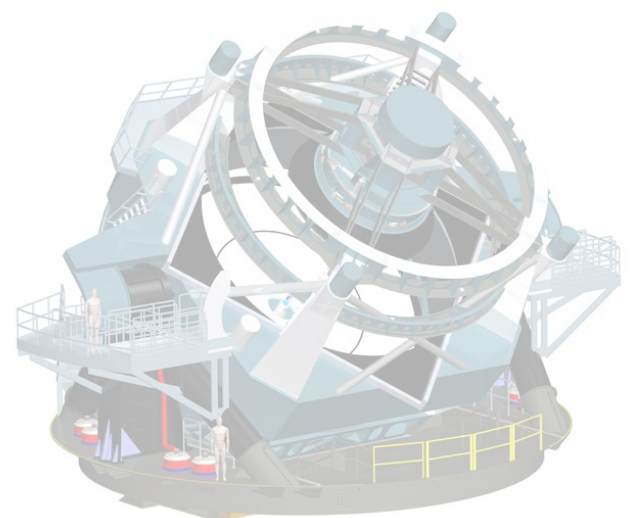
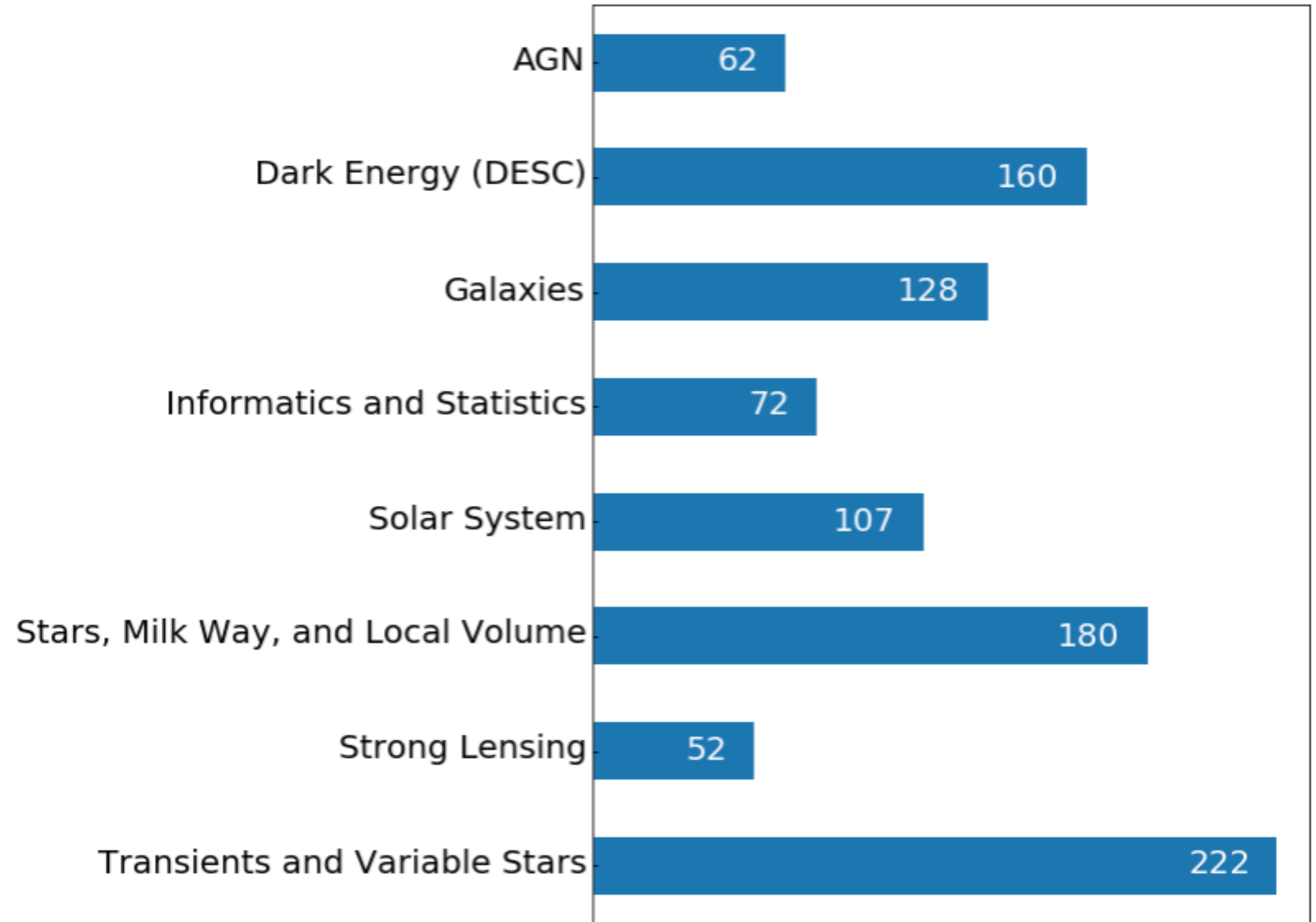


Formed by the LSST Project in 2008 to provide a forum to engage the community in interacting with the LSST Project Science Team played an essential part in producing the LSST Science Book in 2009

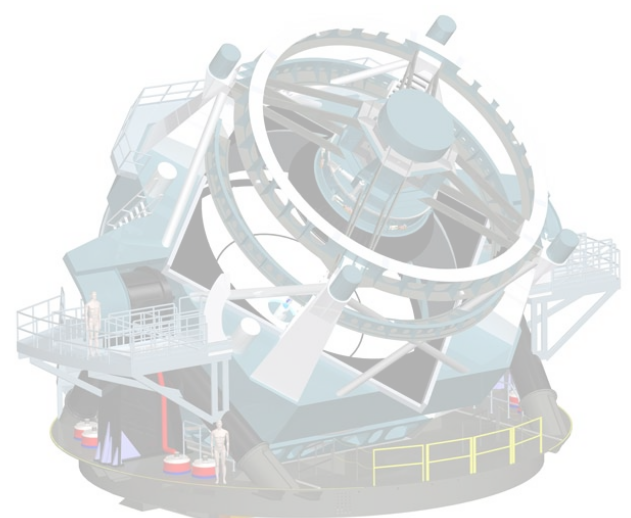
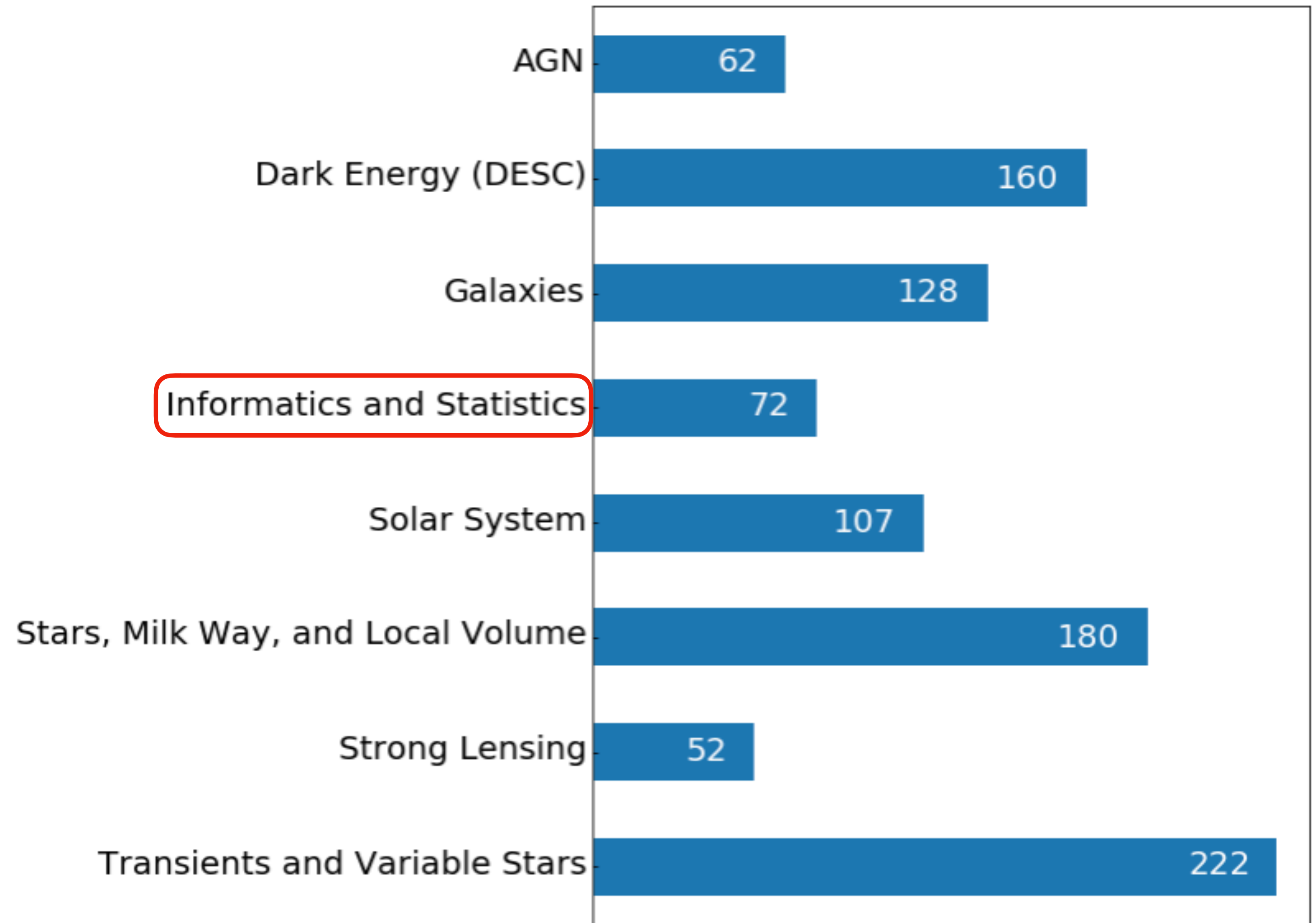
LSST was recognized as the first large ground-based priority of the astronomical community in the *2010 Decadal Survey*



# The LSST Science Collaborations



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# The LSST Science Collaborations

Exploring the transient and variable sky



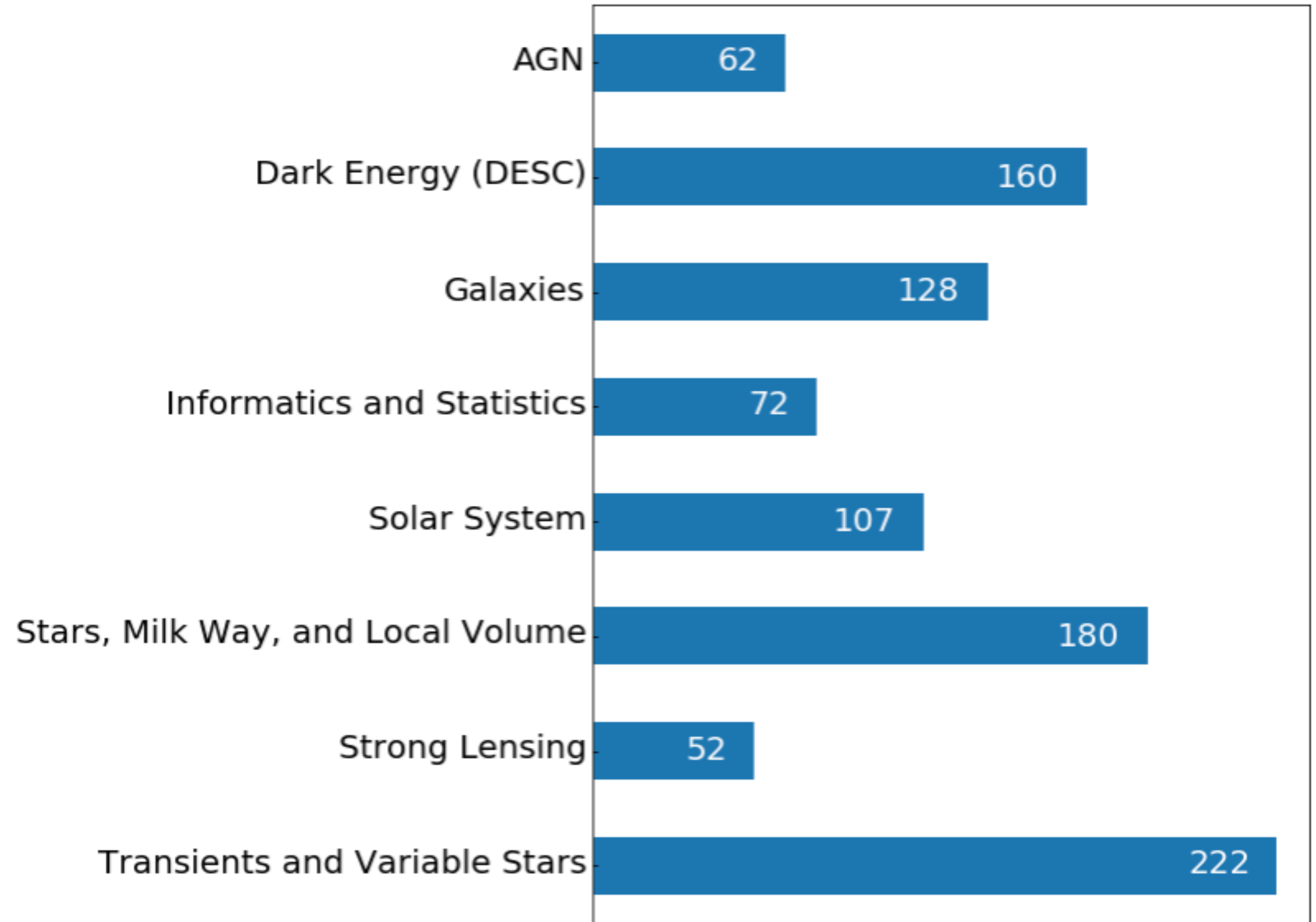
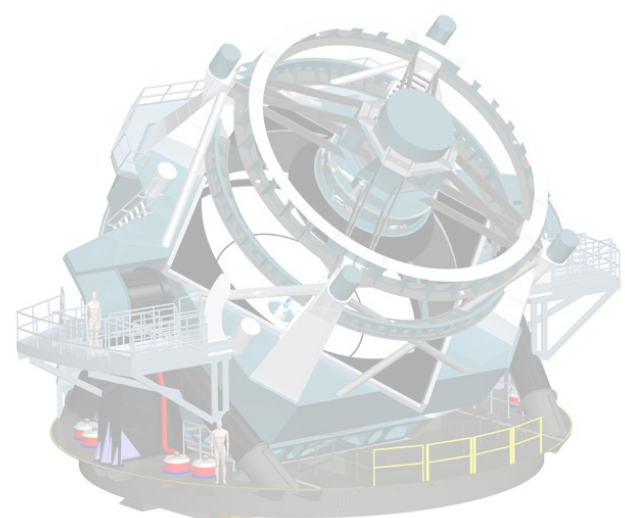
Census of the Solar System



Mapping the Milky Way



Understanding dark energy and dark matter



# The LSST Science Collaborations

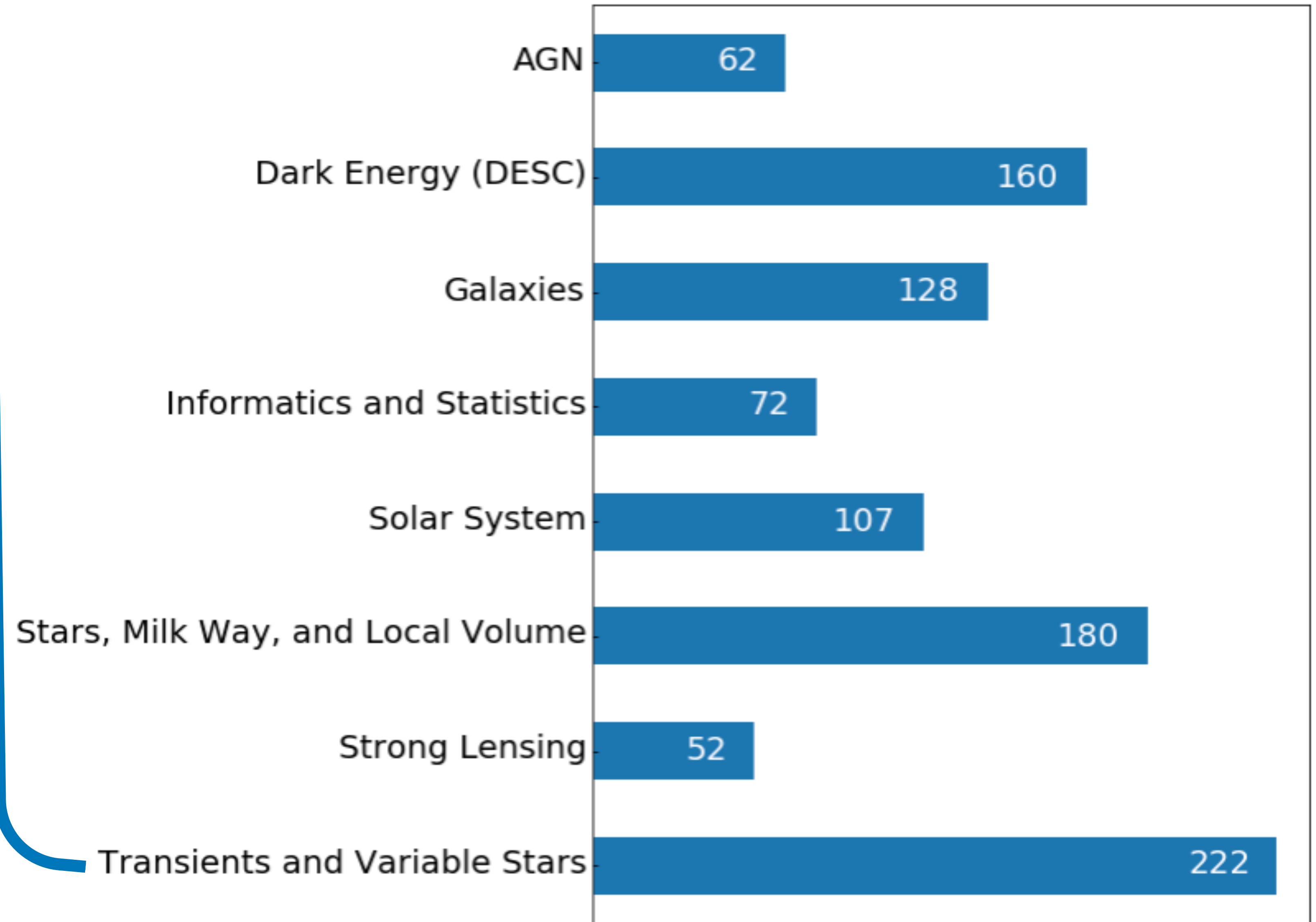
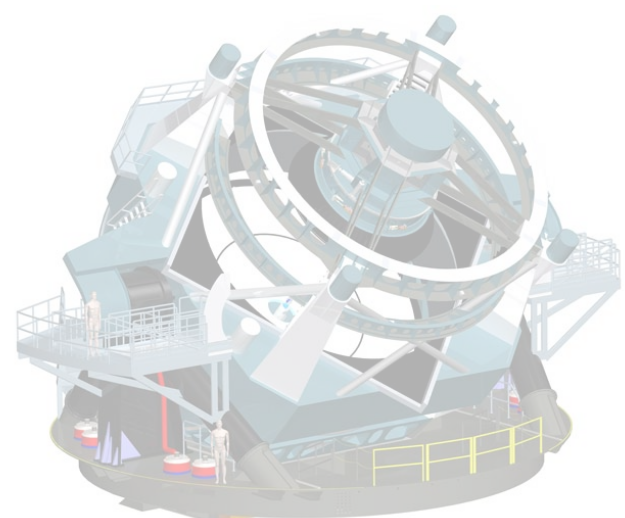
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Mapping the Milky Way

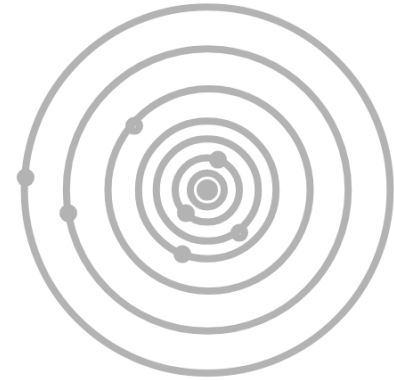
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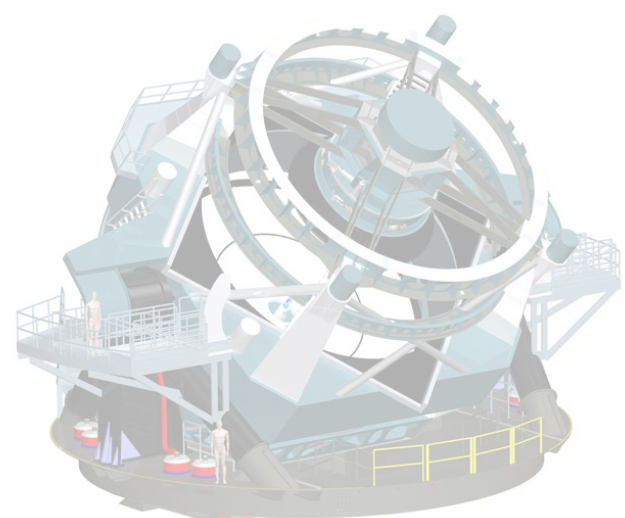
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Stars, Milk Way, and Local Volume

Transients and Variable Stars

Informatics and Statistics

Dark Energy (DESC)

Galaxies

AGN

Solar System

Strong Lensing

62

160

128

72

107

180

52

222

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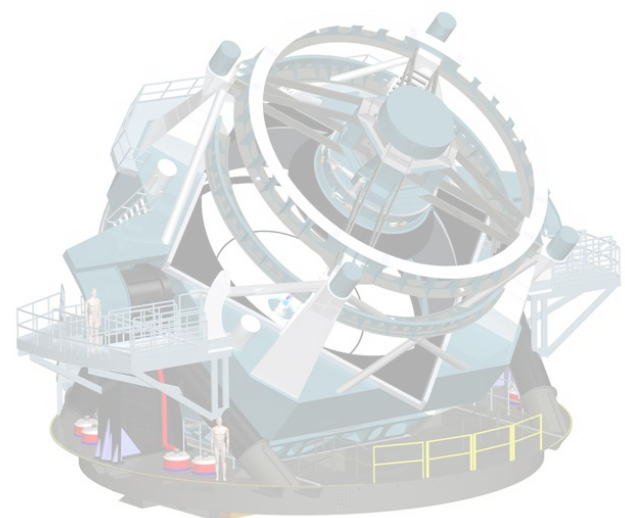
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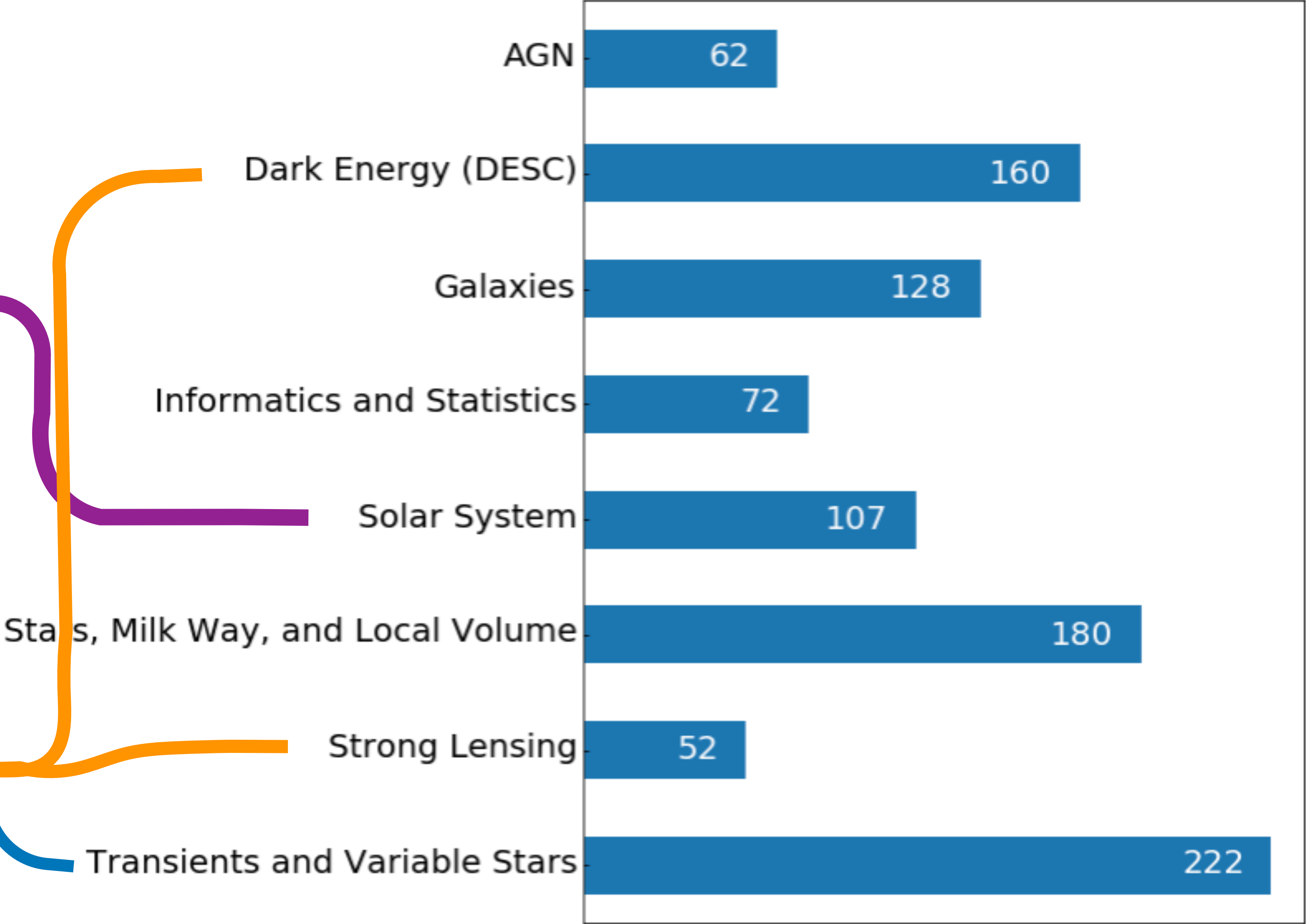
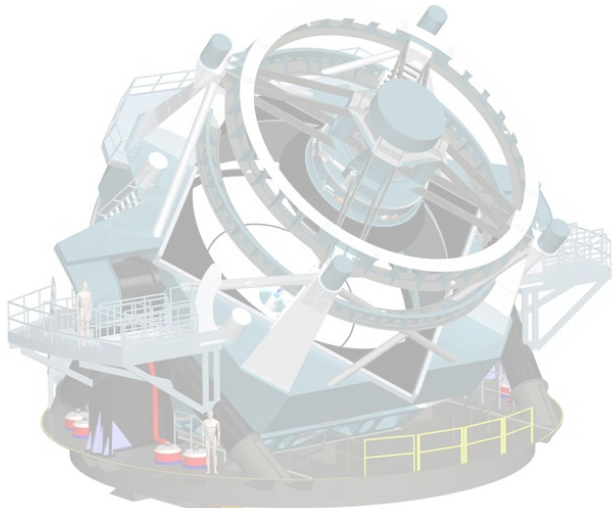
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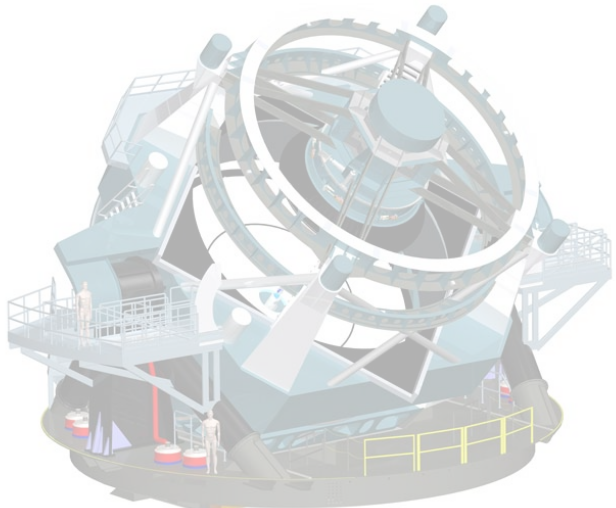
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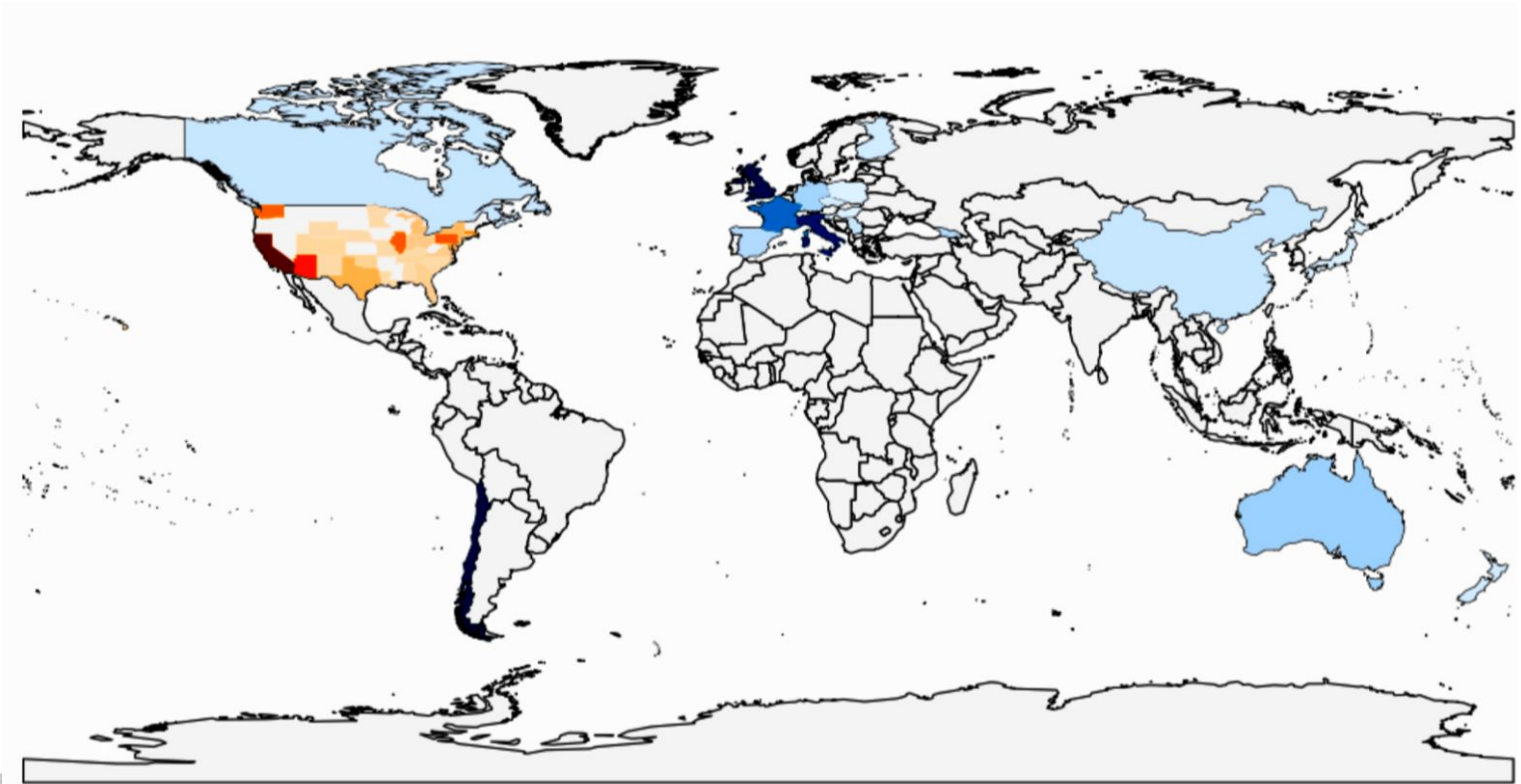
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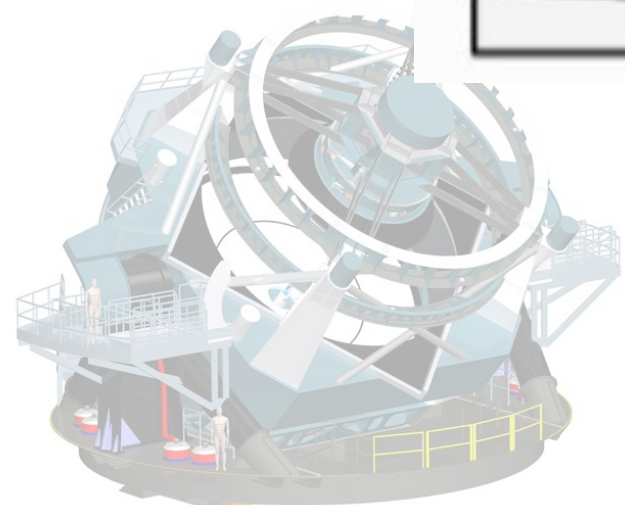
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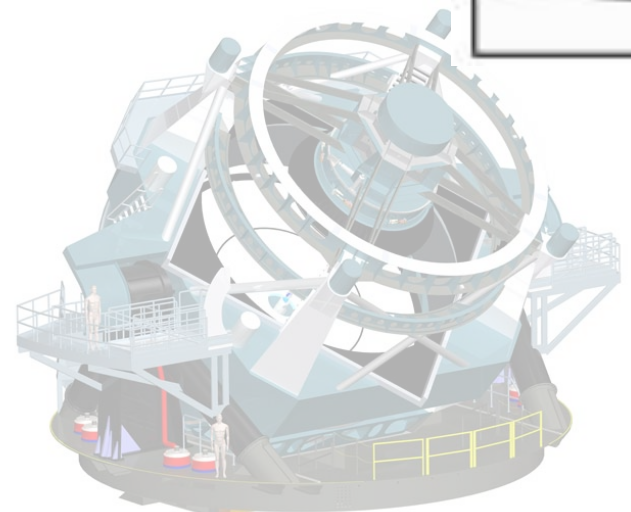
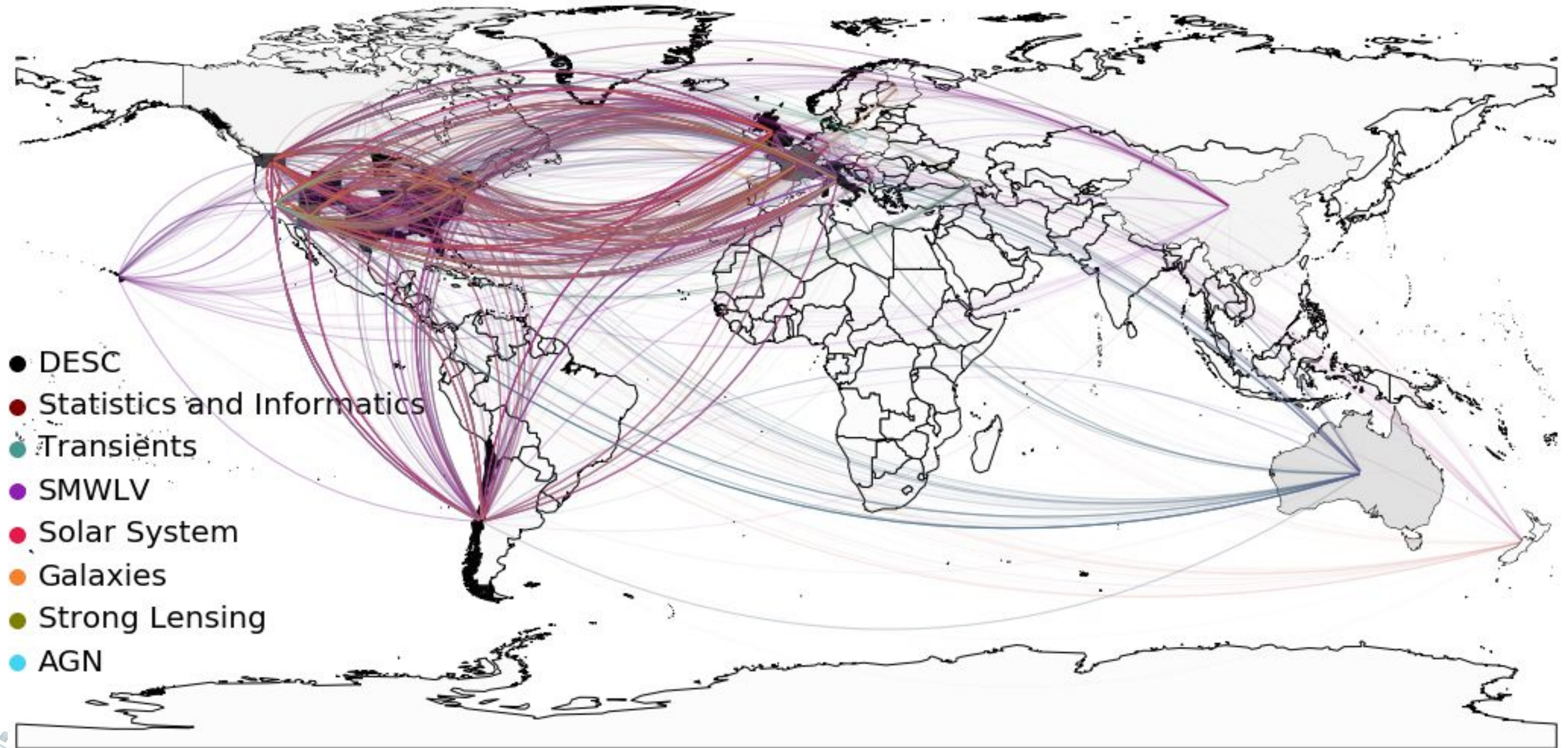
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California: 144 Washington: 88 Arizona: 52 Pennsylvania: 40

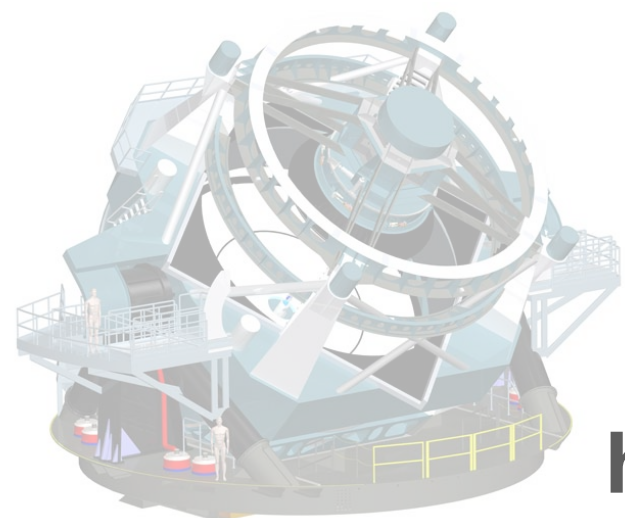
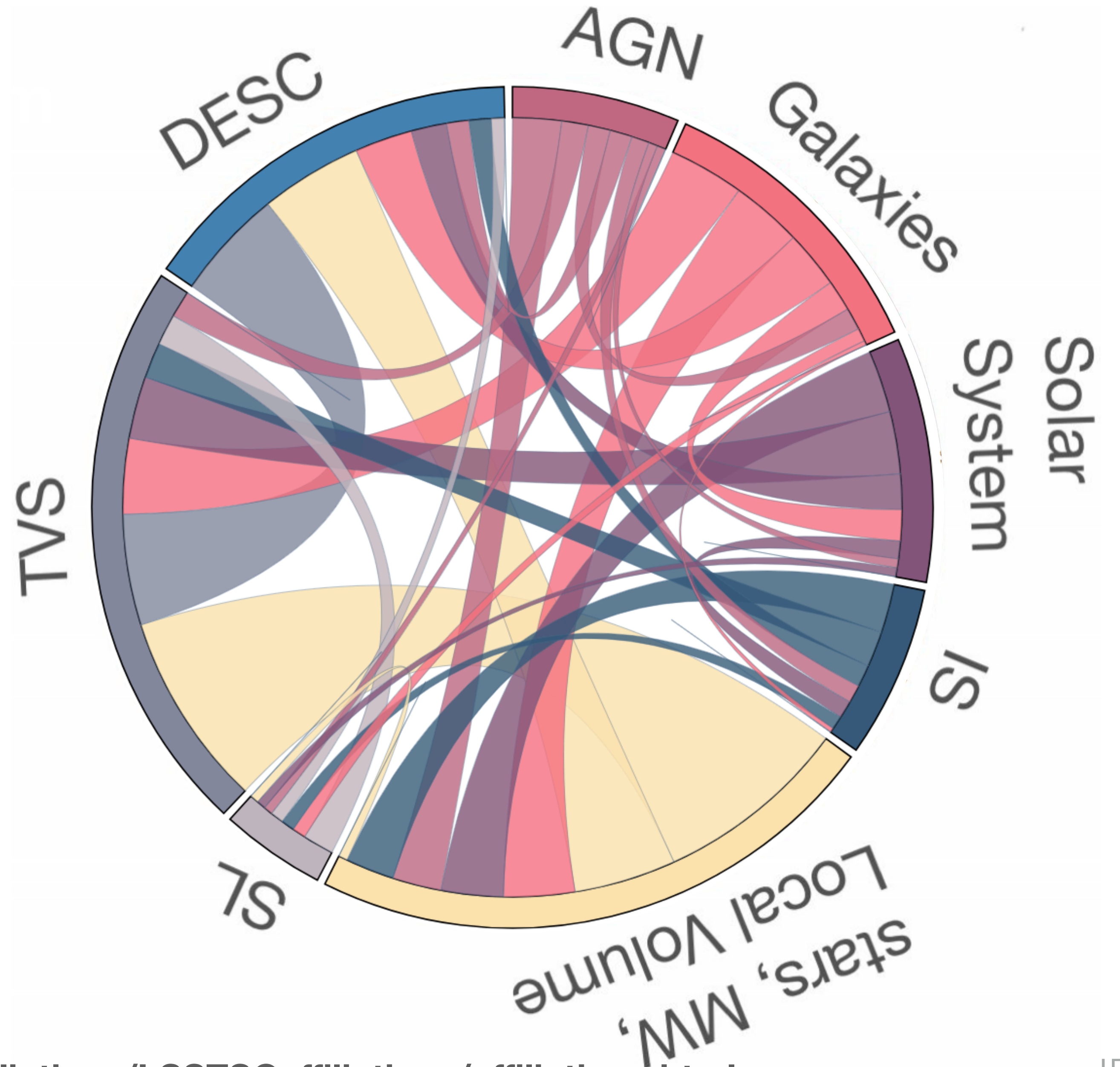
federica bianco UDel



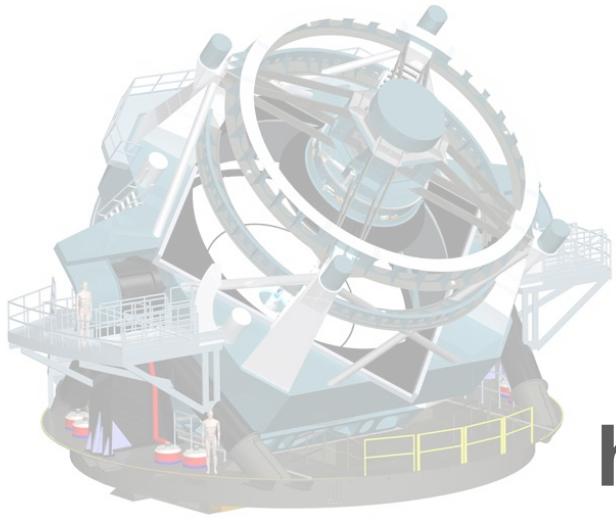
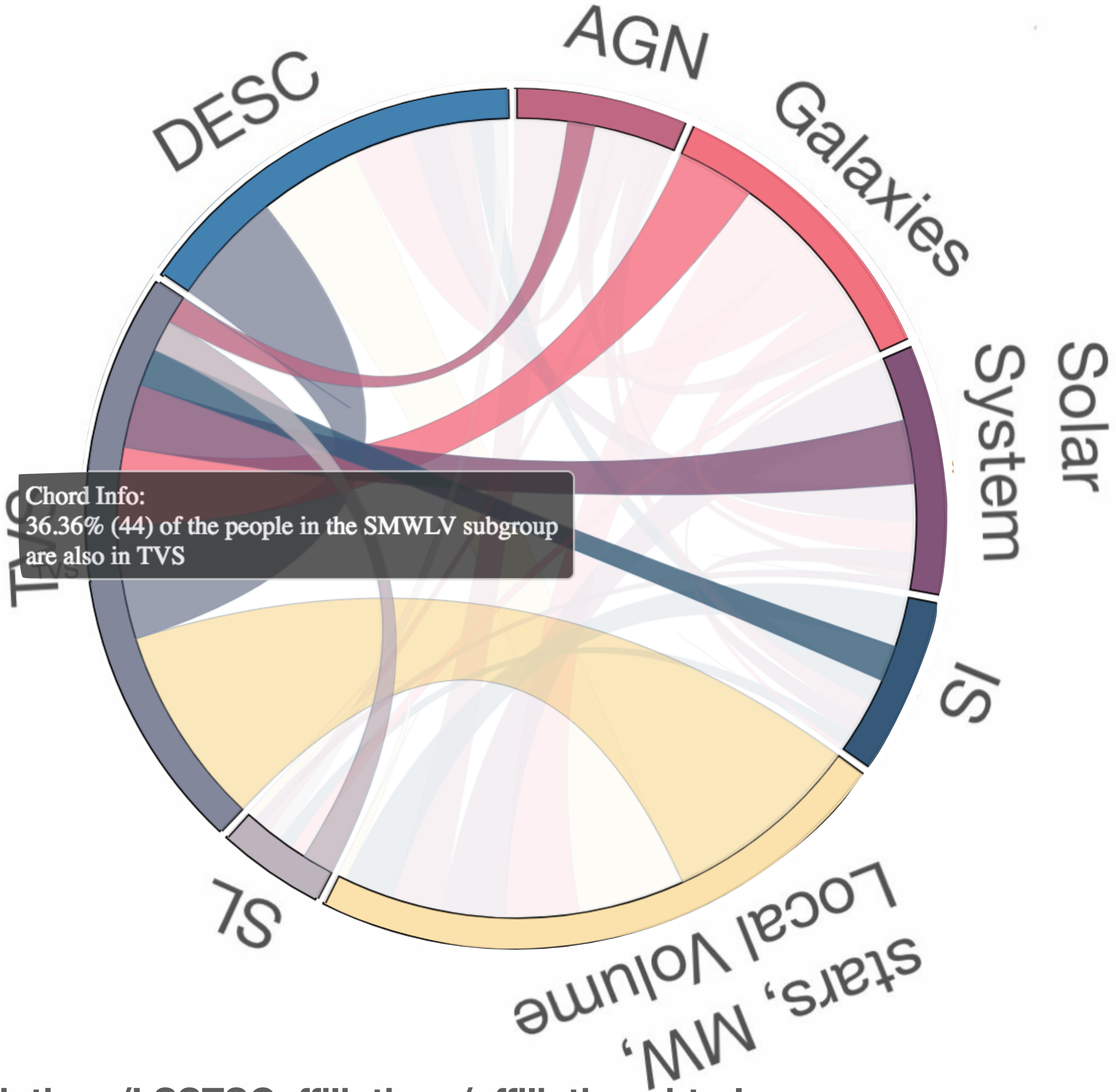
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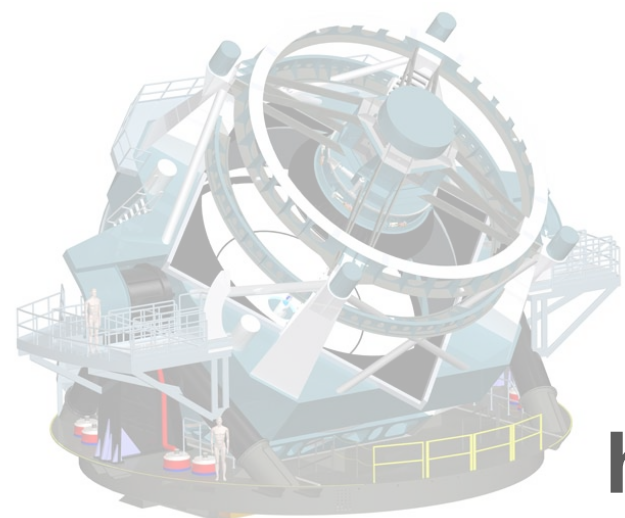
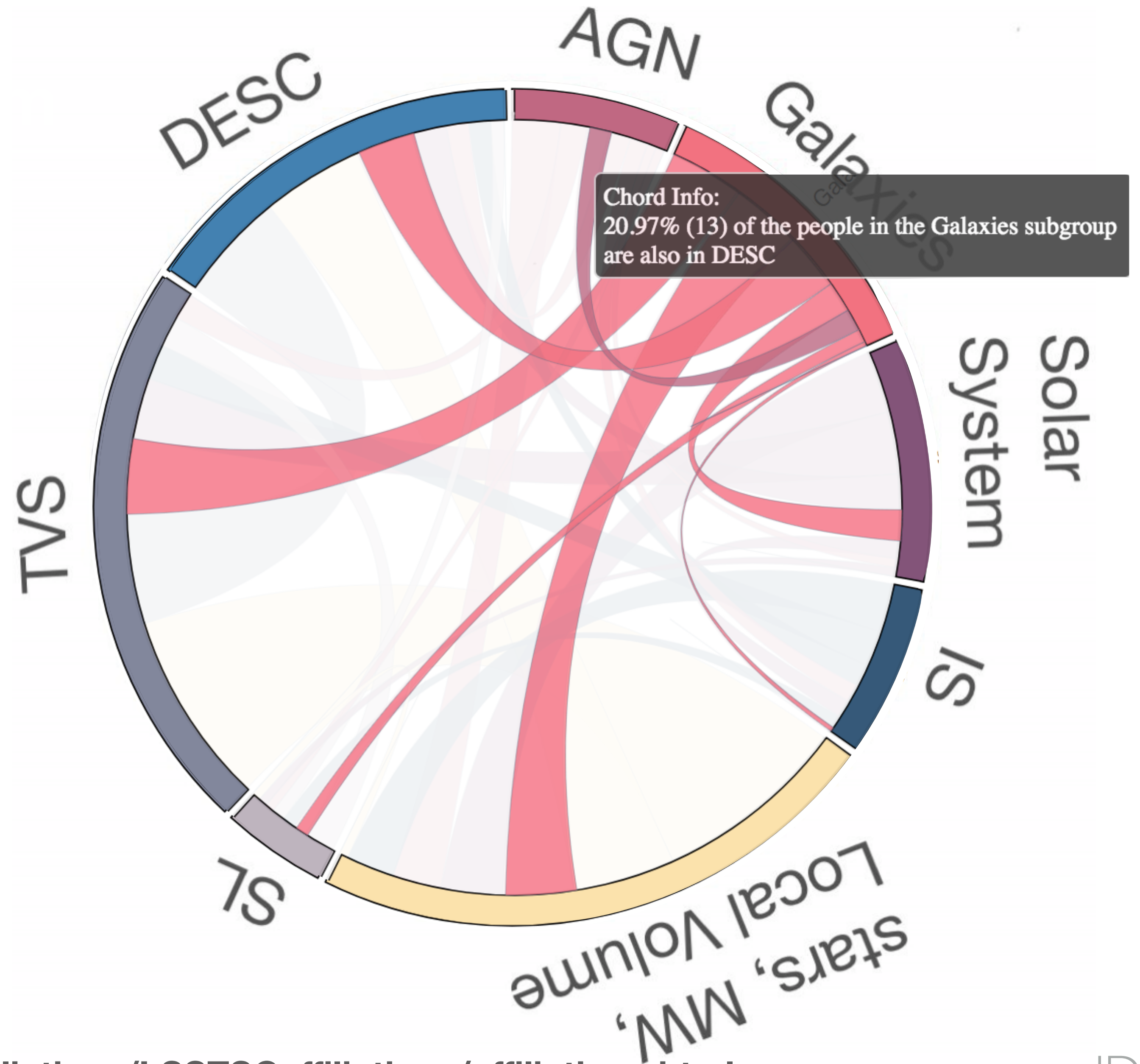
# A Network



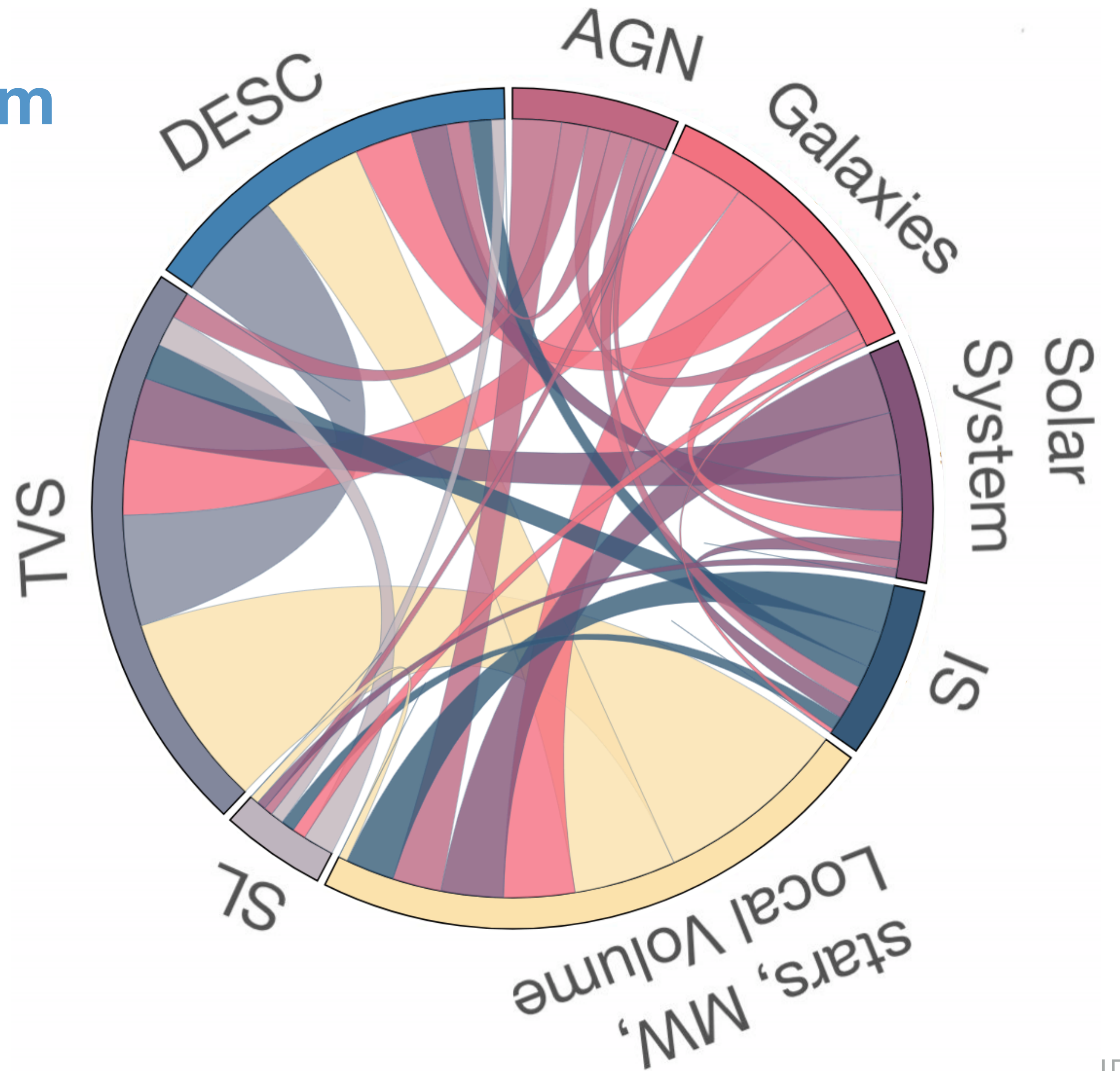
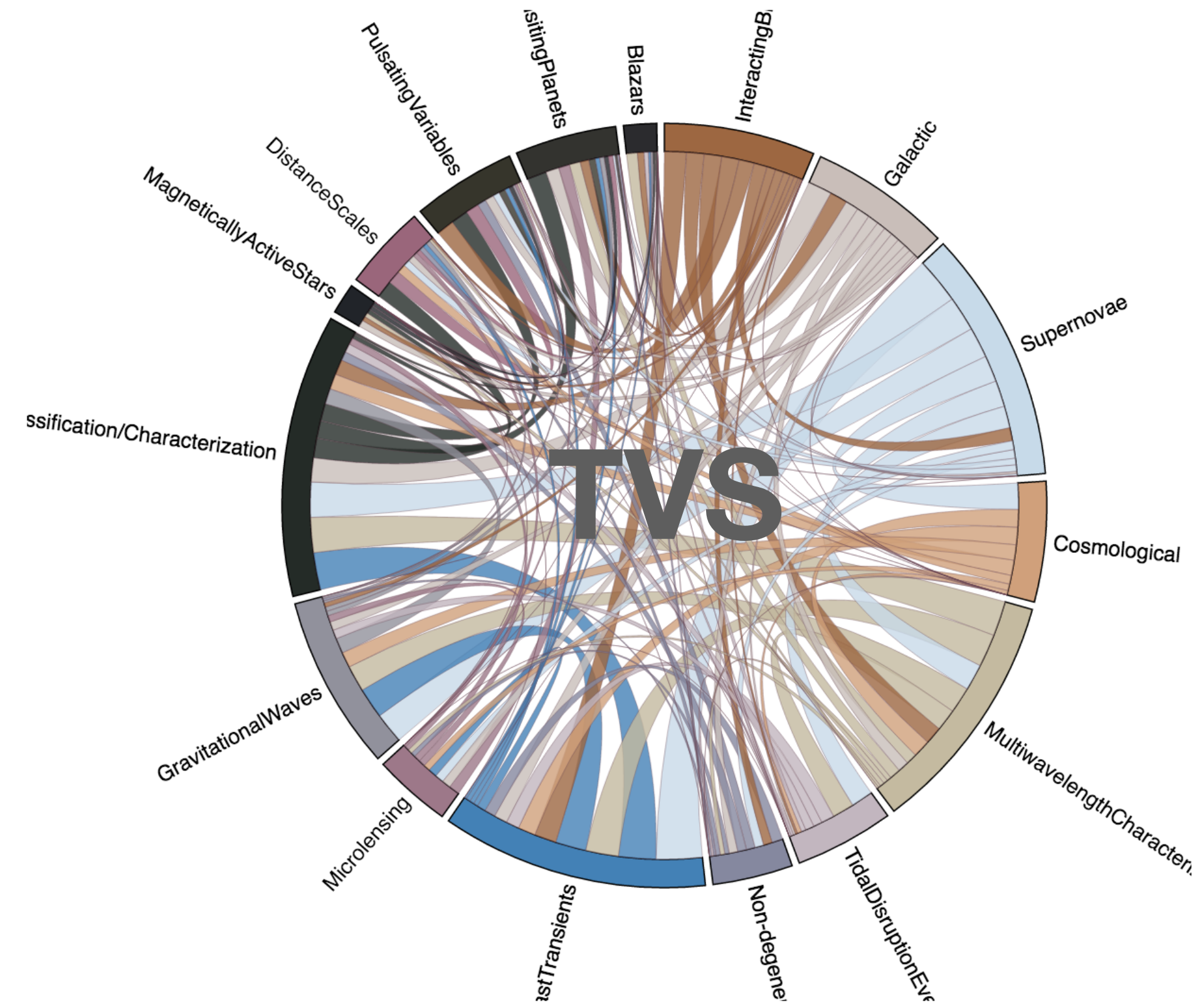
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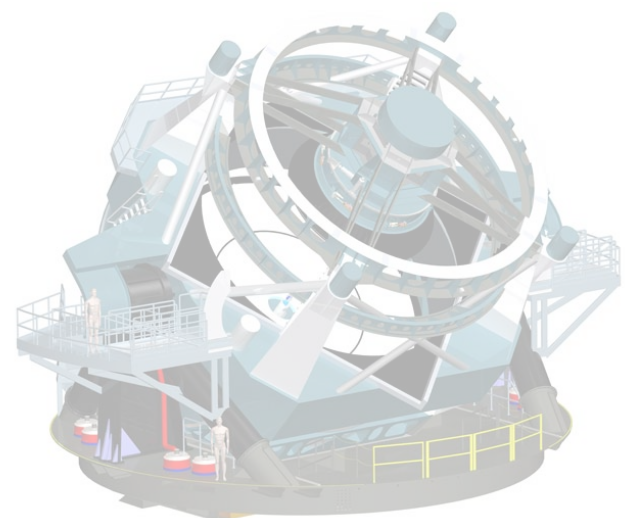
## A Network



# A Network-to-Network system



<https://lsst-tvssc.github.io/>



# The LSST Science Collaborations

LSST Community

Any opinions, statements (including statements about LSST and what it will deliver), or recommendations expressed on this forum are those of the author and do not necessarily reflect the views of the LSST Project.

Please take a moment to review our [community guidelines](#).

Do you want live notifications when people reply to your posts? [Enable Notifications](#).

Science Collaborations | all | all tags | Latest | Bookmarks | Unread (2) | My Posts | + New Topic

Topic	Replies	Views	Activity
<b>About the Science Collaborations category</b> Science discussions for members of LSST Science Collaborations. Use this category for discussions across all LSST Science Collaborations. If want the discussion to be visible to the public, use the general Science cate... <a href="#">read more</a>	1	24	Feb '17
LSST AGN SC, 12 February 2019 Telecon Minutes AGN SC agn	0	9	22d

## direct contact with the Project

LSSTC

- Unread Mentions
- #lsst\_patchno
- #lsst-brokerworkshop19
- #lsst-communications
- #lsst-project
- #lsst2018coc
- #lsst-slack
- #lsstorg-sprint
- #msdfftvs
- #plasticc-metrics
- #scicollab-discuss
- #scicollchairs
- #sims-maf
- #solarsystem
- #speaker-pool
- #stack-club
- #stats

#scicollab-discuss

August 1st, 2018

groups in astronomy.

Please visit <https://astrodatascience.org> to learn more!

Lucianne Walkowicz, Director  
Adam Miller, Program Director

Thursday, February 21st

**Leanne Guy** 1:55 PM  
@channel As recently announced in "Plans and Policies for LSST Alert Distribution" (LDM-612; <http://ls.st/LDM-612>), the selection of community alert brokers to receive the full LSST alert stream begins with a call for Letters of Intent.

The call for Letters of Intent and a submission template are now available as LDM-682 (<http://ls.st/LDM-682>). Individuals at any institution worldwide are invited to submit 4-page LOIs.

For full consideration, LOIs should be submitted by May 15, 2019. Submission of an LOI is required in order to be invited to submit a full proposal.

Please direct any questions to [lsst-community-brokers@lists.lsst.org](mailto:lsst-community-brokers@lists.lsst.org). We look forward to receiving your LOIs.

<https://www.youtube.com/playlist?list=PLPINAcUH0dXacwsNrhNnQSq0rOTRf0lfU>



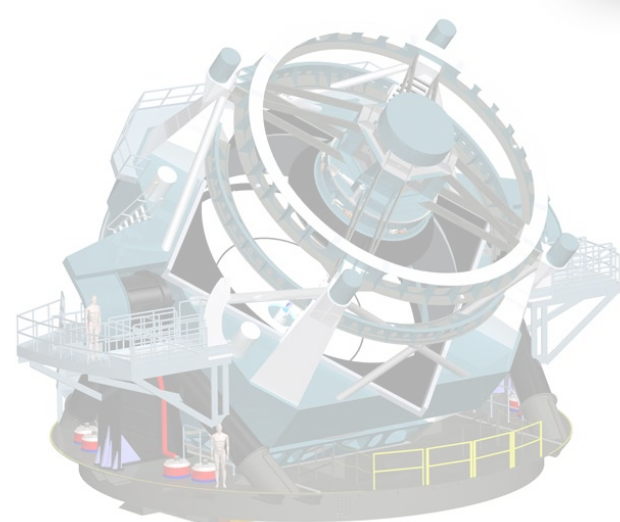
### PST talks

12 videos • 11 views • Updated 6 days ago



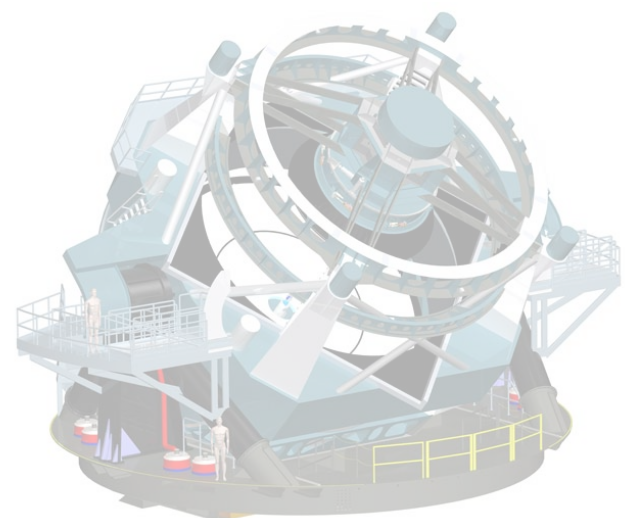
Project Science Team talks to the Science Collaboration chairs

- 2019-02-27 LSST Science Platform, Final Design Review - Leanne Guy  
39:05 Large Synoptic Survey Telescope
- 2019-01-30 Survey Strategy White Papers - Lynne Jones, Peter Yoachim, Tiago Ribeiro,  
40:19 Large Synoptic Survey Telescope
- 2018-12-19 Commissioning Science Verification Status - Chuck Claver & Leanne  
1:04:38 Large Synoptic Survey Telescope
- 2018-10-24 LSST Science Collaborations Status - PST-SC chairs  
1:08:43 Large Synoptic Survey Telescope



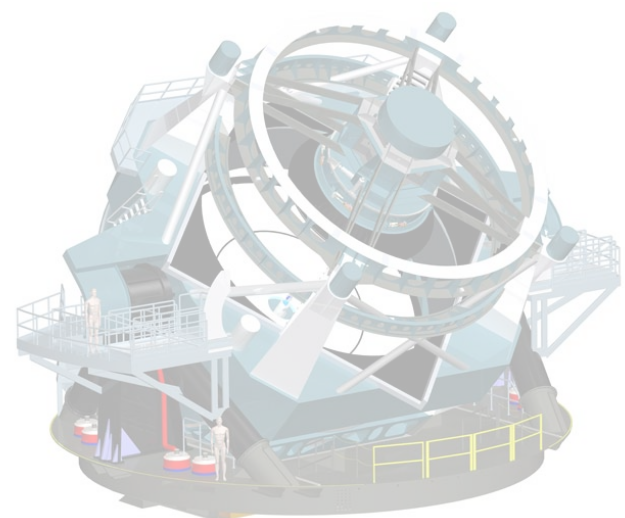
## LSST SCs current activities include:

- **designing and scoping LSST observing strategies** for different science cases
- learning and testing the **LSST pipeline and science platform**  
identifying **gap in scientific preparation** that would impair the LSST success in *theoretical advancement* (e.g. predictions on photometric observables, sparse time series analysis), *software* (e.g. sparse time series analysis tools, crowded field photometry, TOM), *existing data* (e.g. multiwavelength coverage of Deep Drilling Fields)  
preparing of **User-Generated data products**



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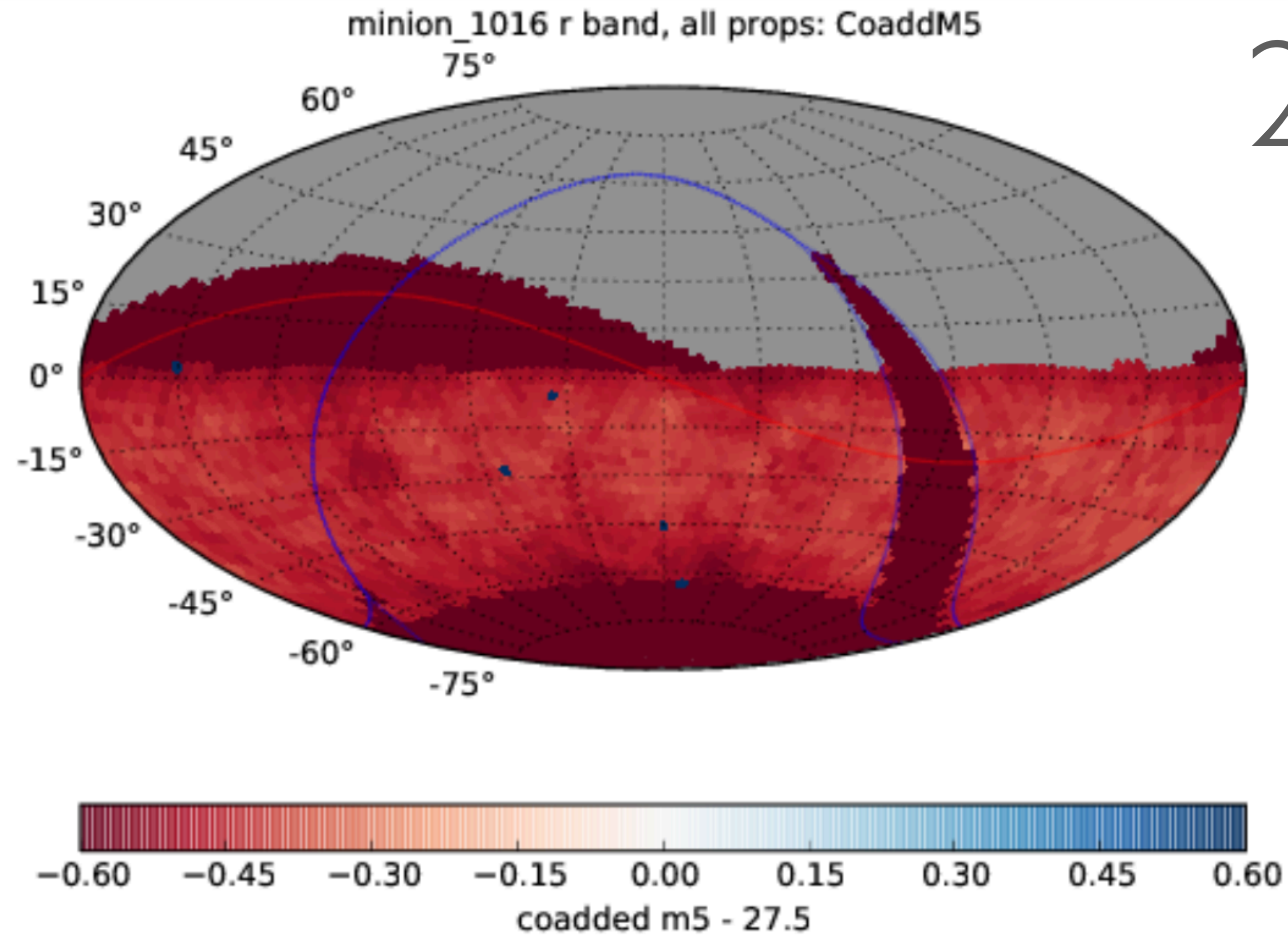


# Refining the observing strategy

Wide Fast Deep - Minisurveys - DDF - ToO

LSST

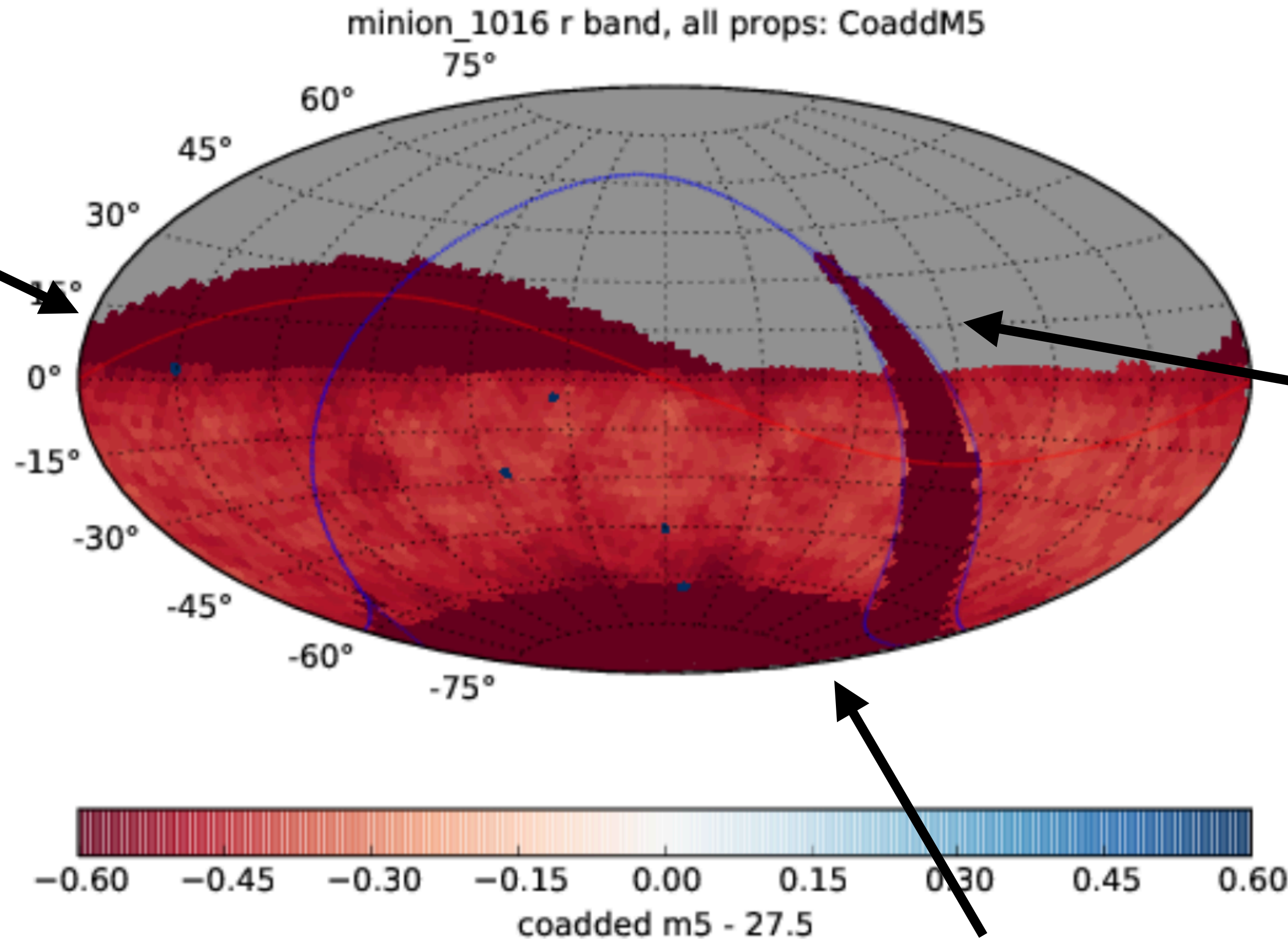
2023-2033



**Wide-Fast-Deep**  
(85.1%)

# Refining the observing strategy

## Wide Fast Deep - Minisurveys - DDF - ToO



### North Ecliptic Survey

The NES is an extension to reach the Ecliptic at higher airmass than the WFD survey typically covers, no  $u$

### Wide-Fast-Deep (85.1%)

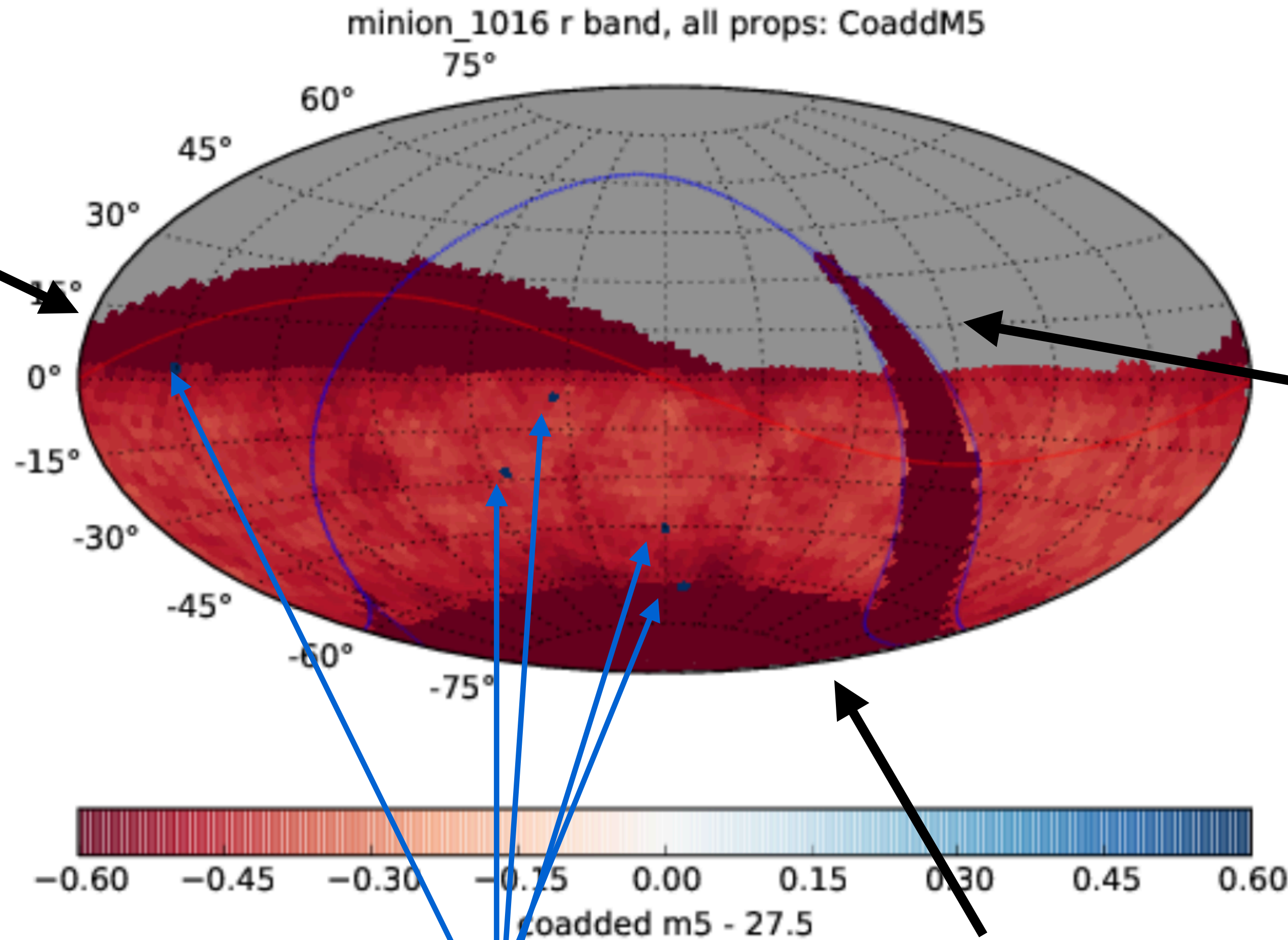
### Galactic Plane (1.7%)

covers the region where LSST is expected to be highly confused by the density of stellar sources; fewer total exposures/field and does **not collect in pairs**

**South Celestial Pole (2.2%)**: higher airmass  $\text{decl} > -65$  degrees. includes  $ugrizy$ , but takes fewer exposures/field than the WFD and does **not collect in pairs.**

# Refining the observing strategy

## Wide Fast Deep - Minisurveys - DDF - ToO



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The NES is an extension to reach the Ecliptic at higher airmass than the WFD survey typically covers, no  $u$

**Wide-Fast-Deep (85.1%)**

**Deep Drilling Fields DDF (4.5%)**

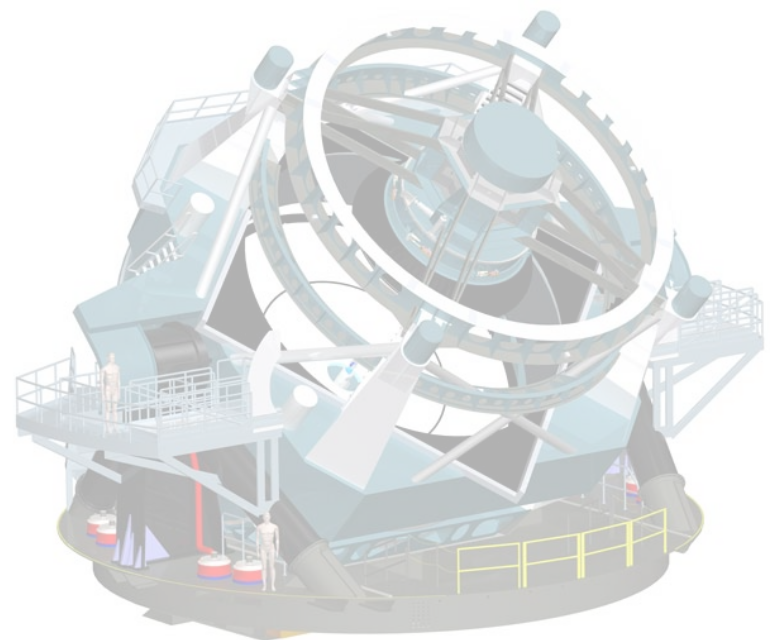
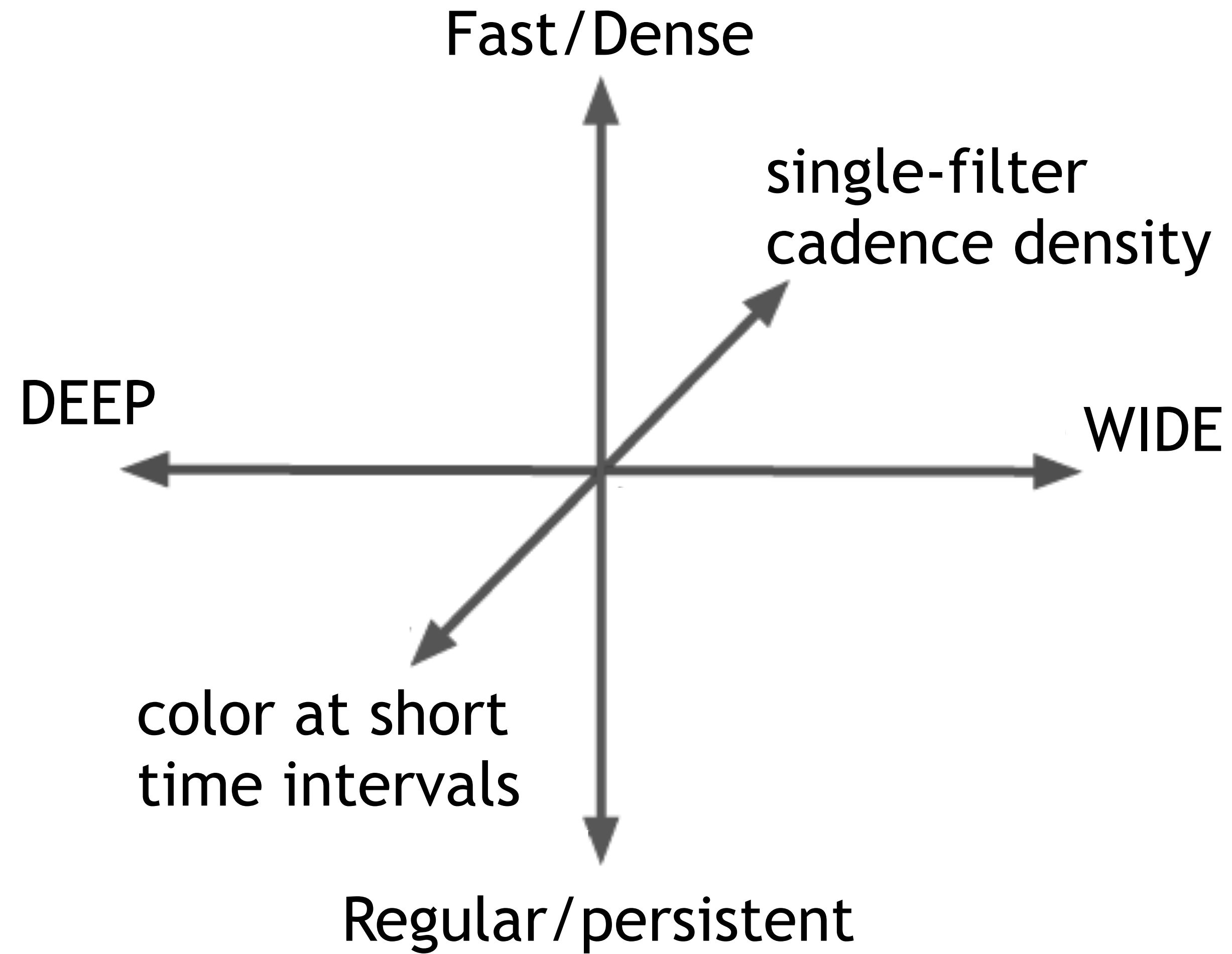
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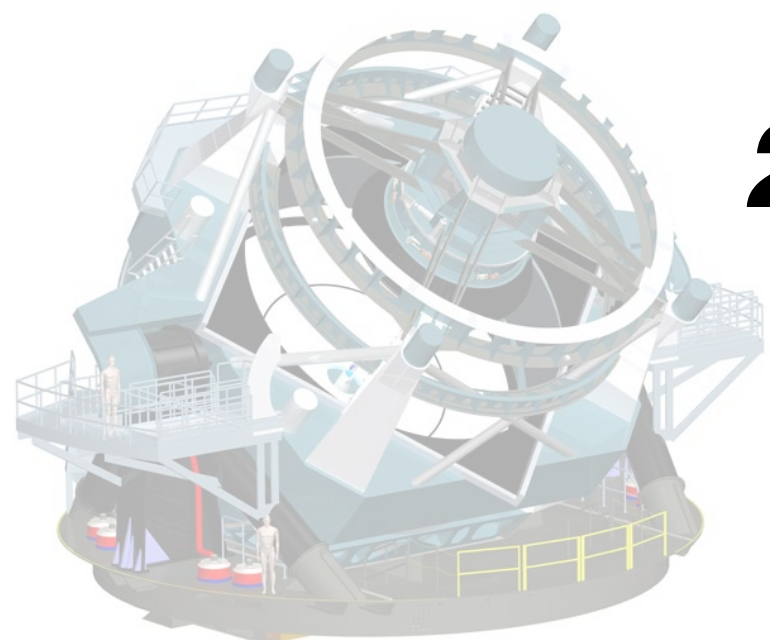
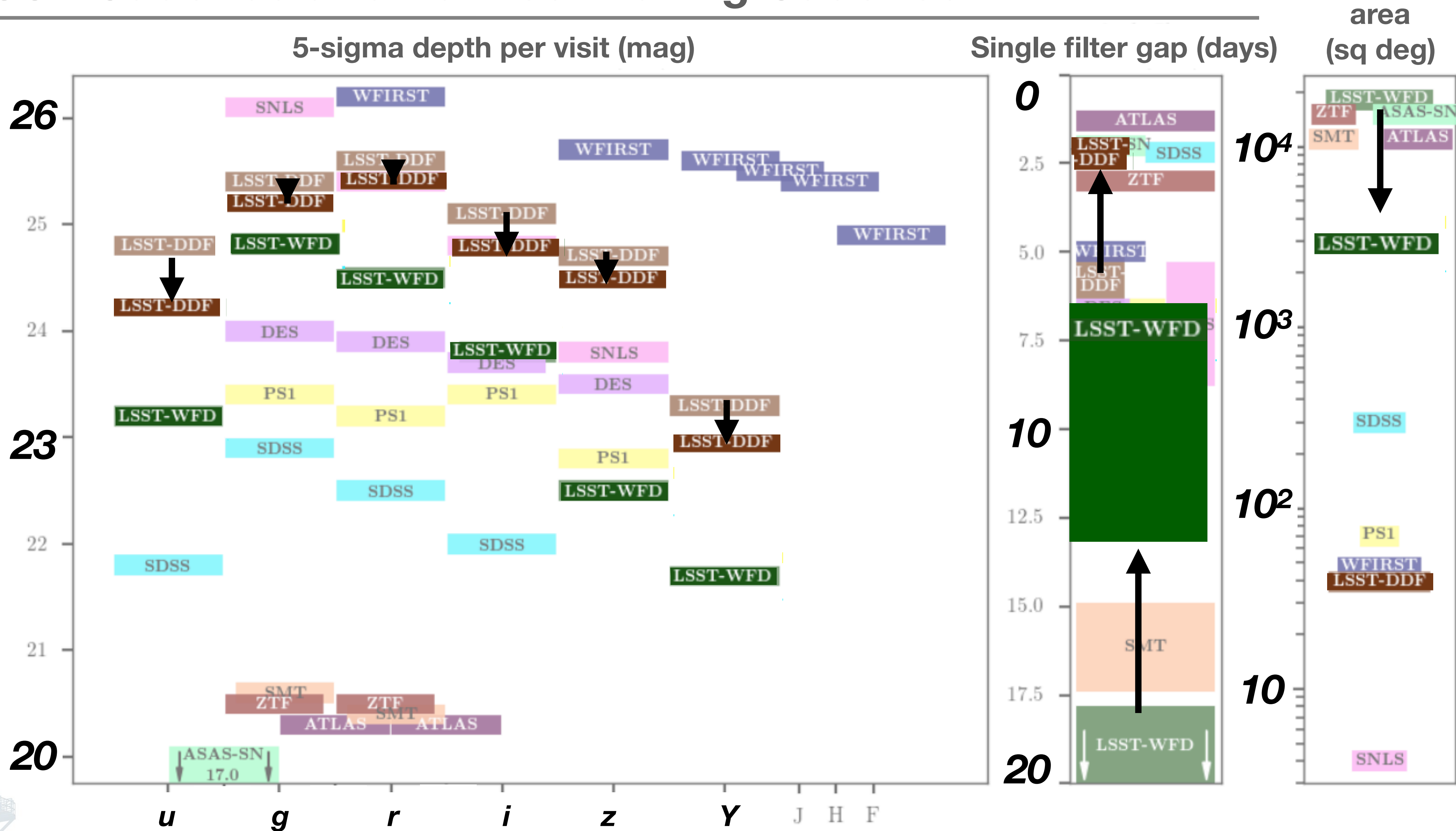
# LSST cadence tensions

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# LSST Cadence alternatives: Rolling Cadence

Rolling cadence



Scolnic+ 2017 ApJ 852,1

Dan Scolnic with Kessler, Biswas, Jha, Hložek, DESC SNWG

federica bianco NYU

## LSST Science Collaborations

COSEP living document testing LSST observing strategies for different science cases

<https://github.com/>

[LSSTScienceCollaborations/ObservingStrategy](https://github.com/LSSTScienceCollaborations/ObservingStrategy)

arXiv:1708.04058v1 [astro-ph.IM] 14 Aug 2017

## Science-Driven Optimization of the LSST Observing Strategy

### Contributing Authors

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A graphical representation of the contributions made to this white paper can be found on this paper's [GitHub repository](#).

Prepared by the LSST Science Collaborations,  
with support from the LSST Project.

Version 1.0

Most recent commit: [fe3d2ad](#)

(Mon, 14 Aug 2017 02:08:33 -0700)

# Refining the observing strategy - COSEP

drphilmarshall Merge pull request #684 from LSSTScienceCollaborations/mschwamb-singl... Latest commit 35ca2aa on Oct 19, 2017

commissioning	Wes's co
opsim	Merge pu
whitepaper	More det
workshop	restore d
.gitignore	Ignore er
.nukePDF	Comman
.travis.yml	Merge pu
README.md	Added bi

- [Read the current draft of the white paper](#) (automatically generated PDF, rebuilt every time the `master` branch is updated) `build error`
- [Download v1.0 of the white paper](#) This is the initial arxiv version, visible at <https://arxiv.org/abs/1708.04058>
- [Join the conversation about this project at its issues list](#)
- [Gauge the project's activity level](#)
- [Suggest a new OpSim experiment](#)
- [Suggest some interesting commissioning observations](#)

README.md

## Science-Driven Optimization of the LSST Observing Strategy

Welcome to the online community thinking about LSST survey strategy ("cadence"), with quantifications via the Metric Analysis Framework.

We are writing a white paper on this topic, primarily composed of a set of individual science cases that are either very important, and somehow stress the observing strategy, and describing how we expect them to be sensitive to LSST observing strategy. MAF metric calculations are then being designed and implemented: these form the quantitative backbone of the document. You may have heard of the coming "Cadence Wars" - this white paper represents the "Cadence Diplomacy" that will allow us, as a community, to avoid, or at least manage, that conflict. We welcome contributions from all around the LSST Science community.

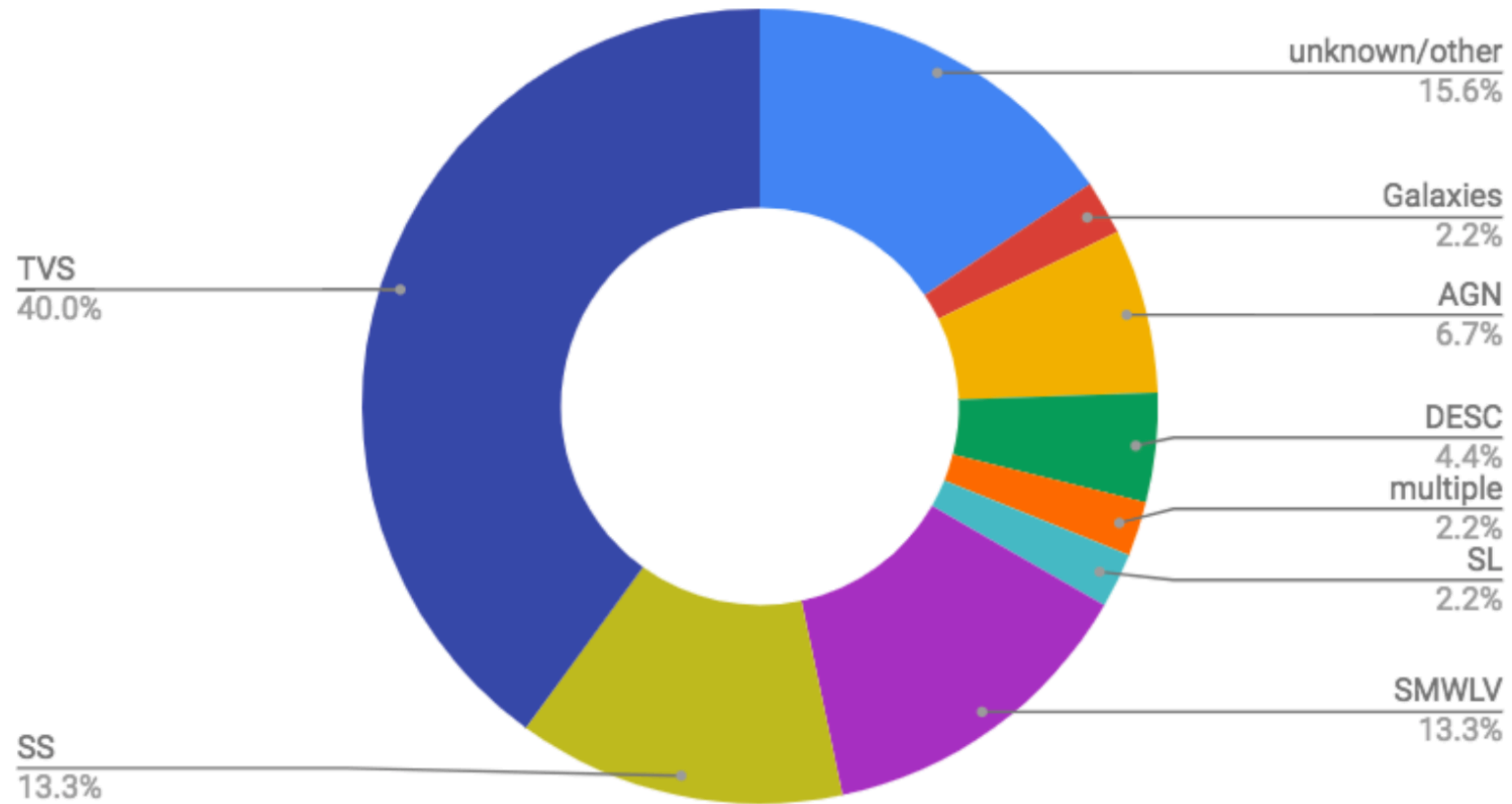


<https://github.com/LSSTScienceCollaborations/ObservingStrategy>

federica bianco UDel

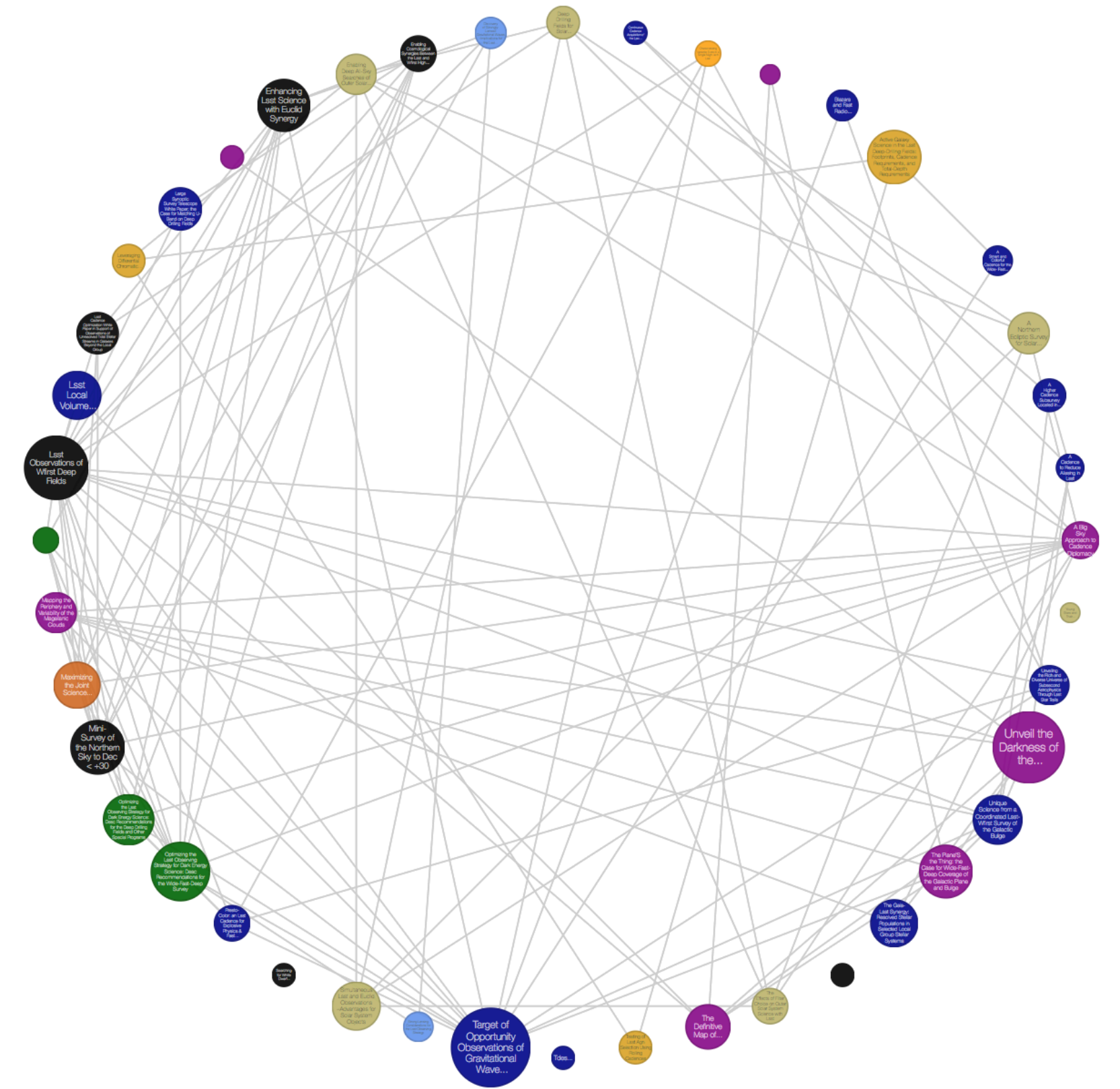
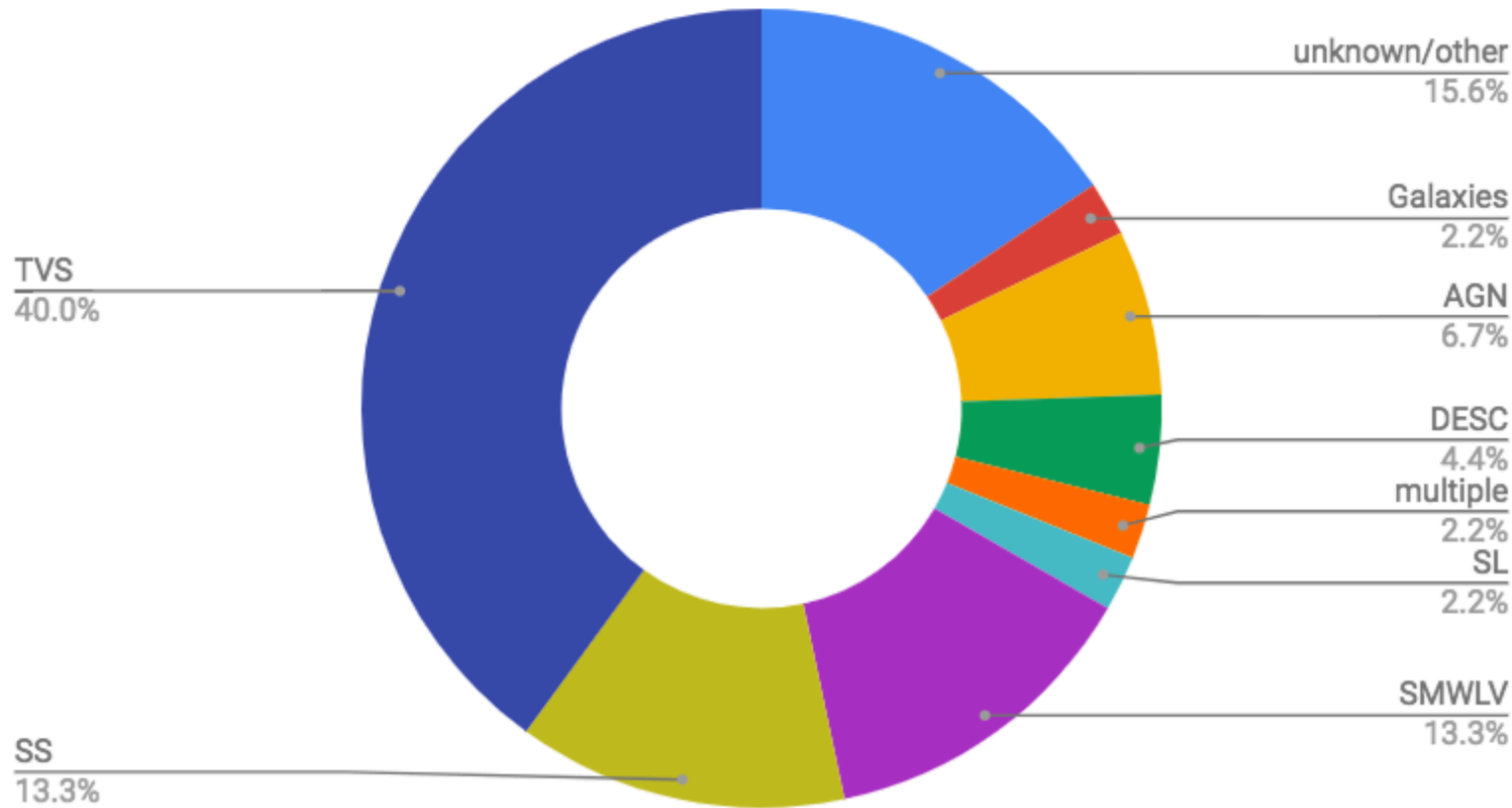
# Refining the observing strategy - 2018 White Paper

## Cadence White Paper Submissions



# Refining the observing strategy - 2018 White Paper

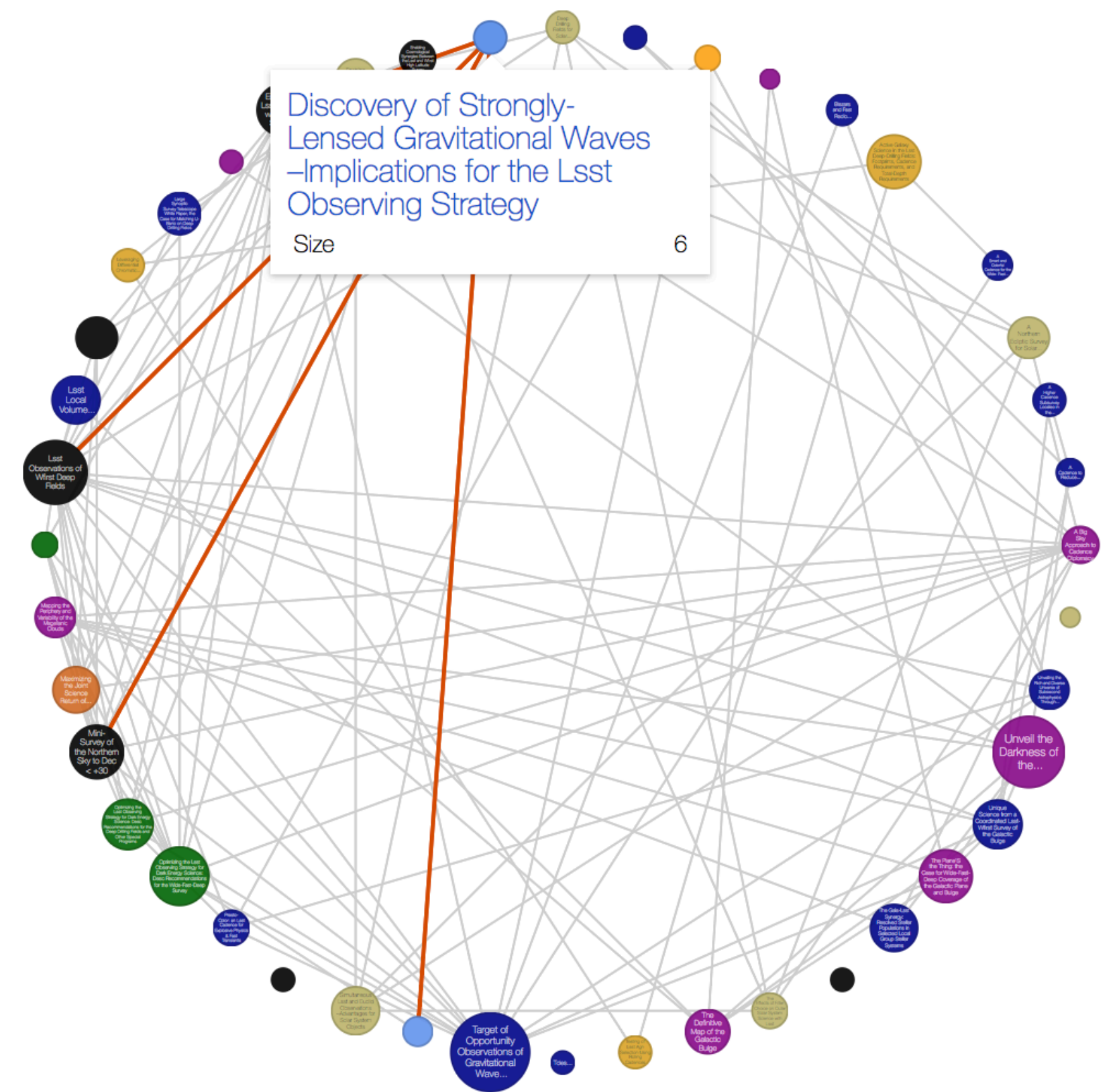
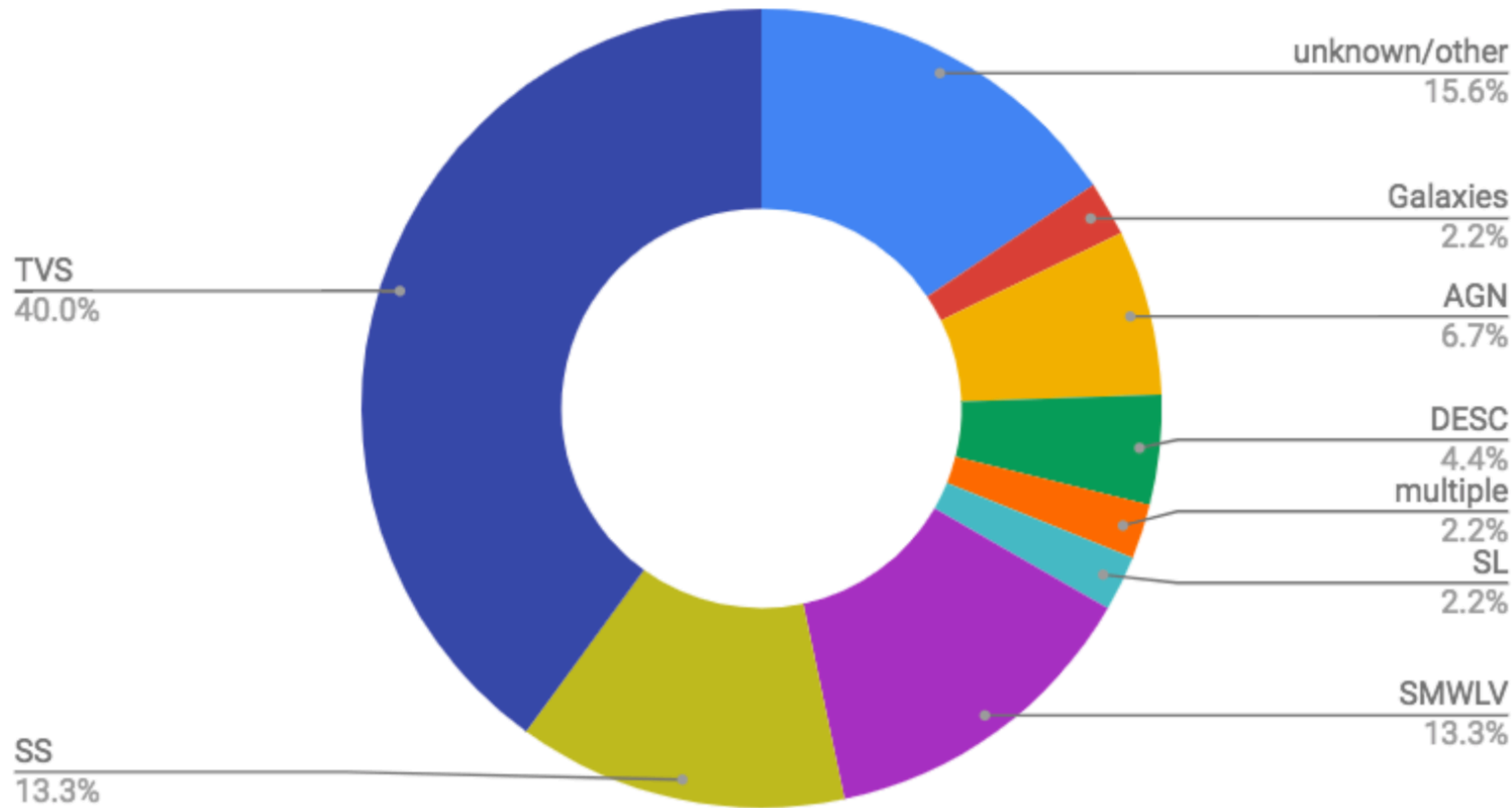
## Cadence White Paper Submissions



<https://cosmo.nyu.edu/~fb55/LSSTWP>

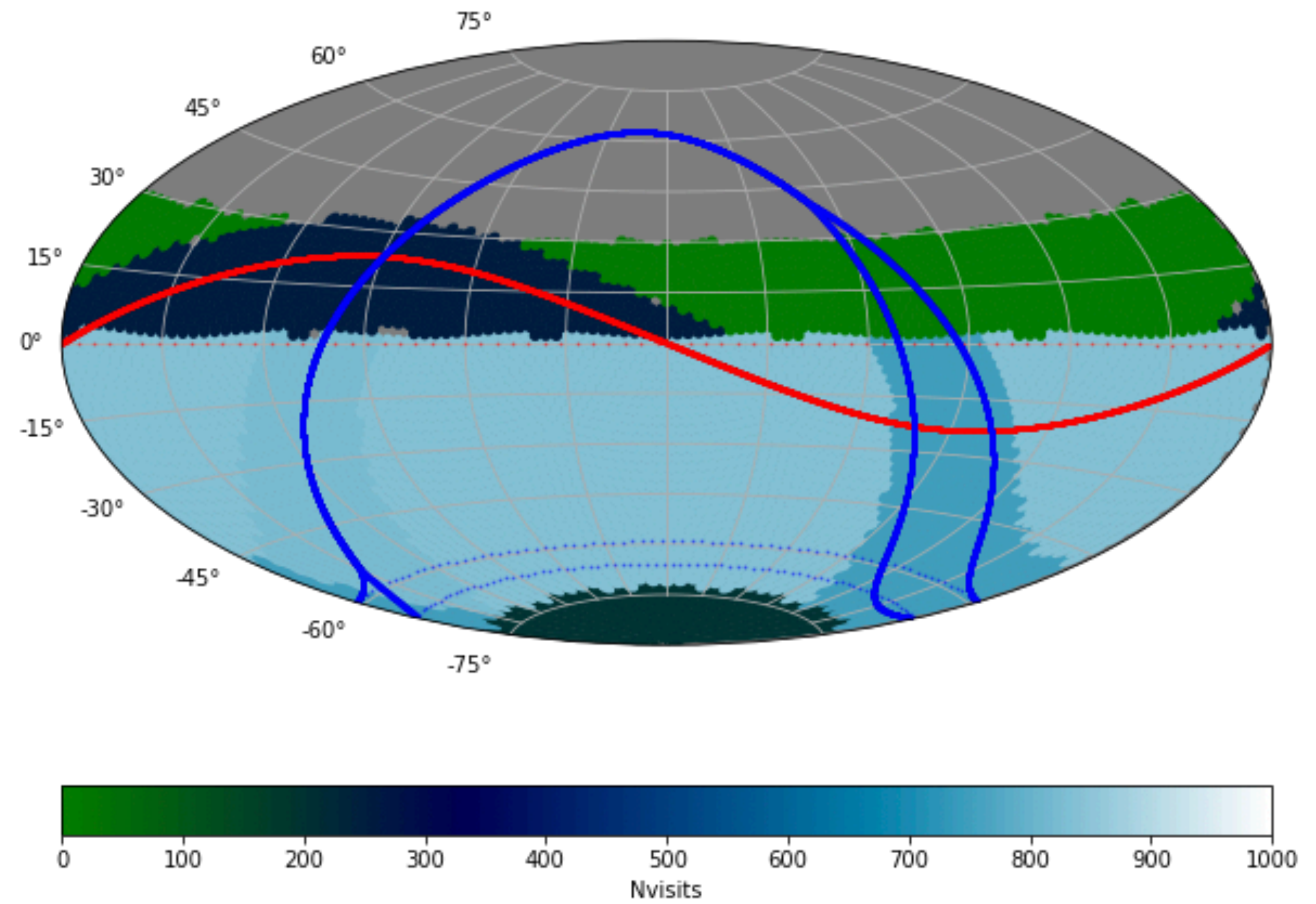
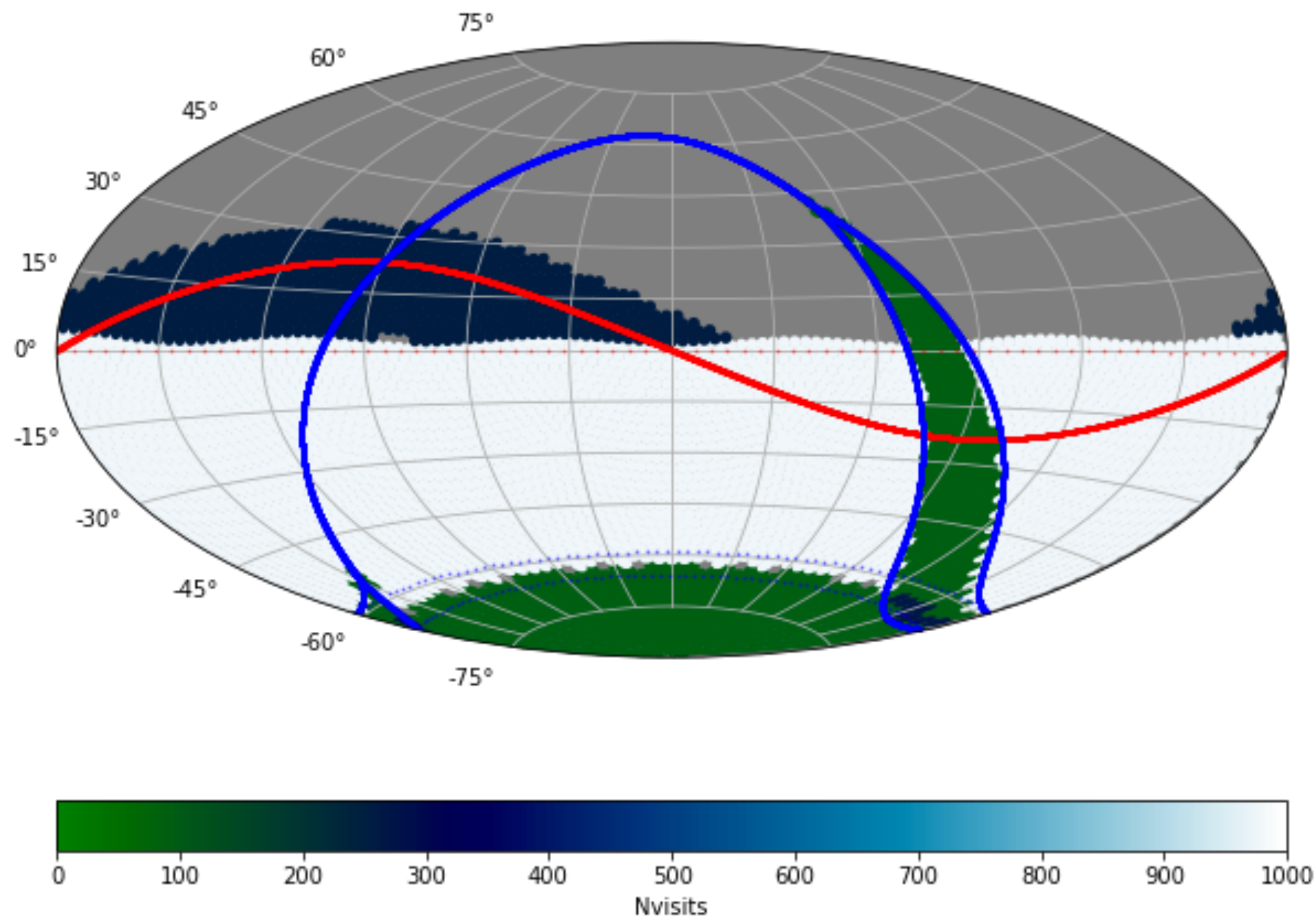
# Refining the observing strategy - 2018 White Paper

## Cadence White Paper Submissions



<https://cosmo.nyu.edu/~fb55/LSSTWP>

# Refining the observing strategy - New footprint?



# Refining the observing strategy - More colors?

*Presto-Color: A Photometric Survey Cadence for Explosive Physics & Fast Transients*

FEDERICA B. BIANCO,

MARIA R. DROUT,

MELISSA L. GRAHAM,

TYLER A. PRITCHARD,

RAHUL BISWAS,

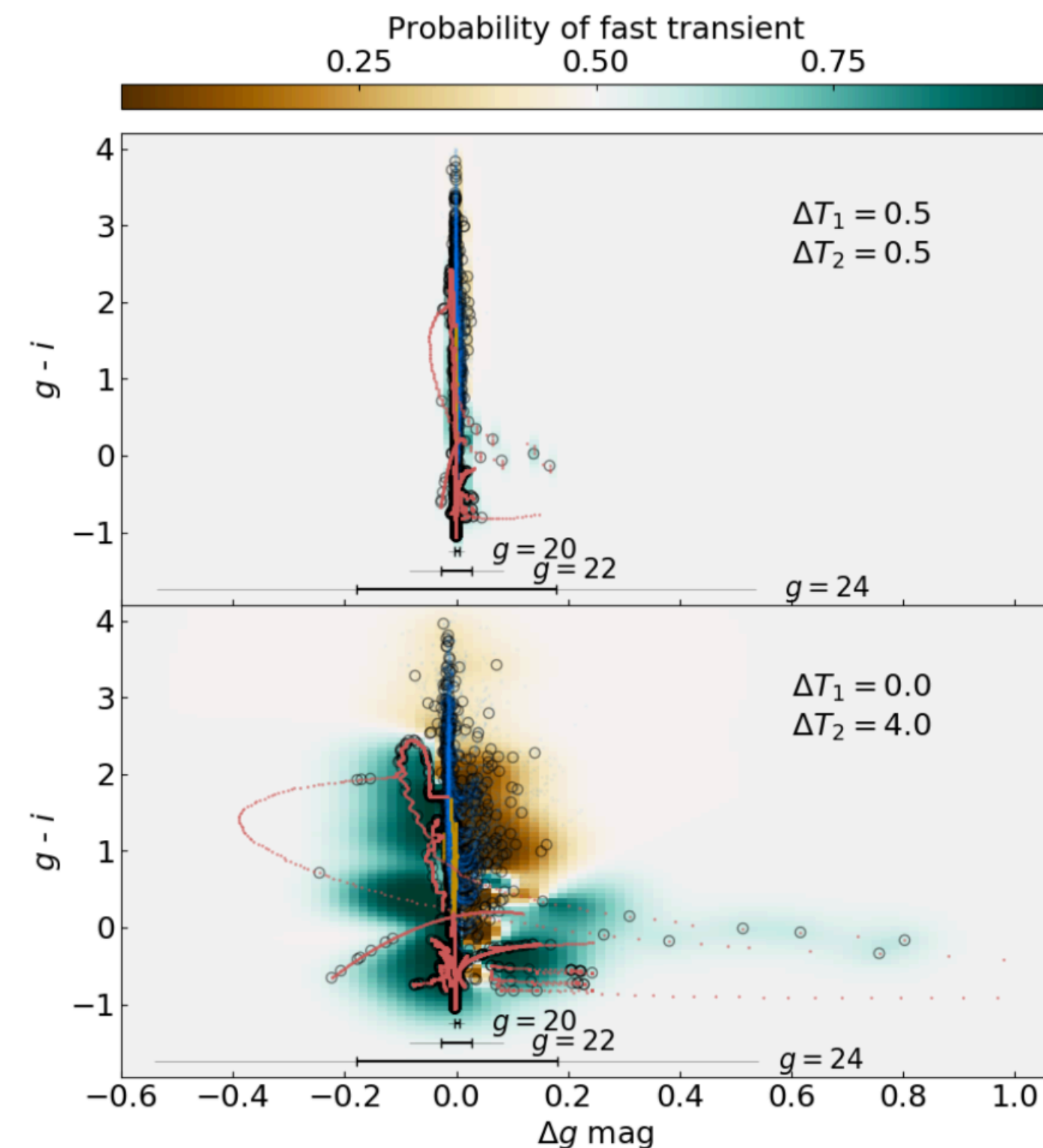
GAUTHAM NARAYAN,

IGOR ANDREONI,

PHILIP S. COWPERTHWAIT, AND

TIAGO RIBEIRO

WITH THE SUPPORT OF THE LSST TRANSIENT AND VARIABLE STARS COLLABORATION



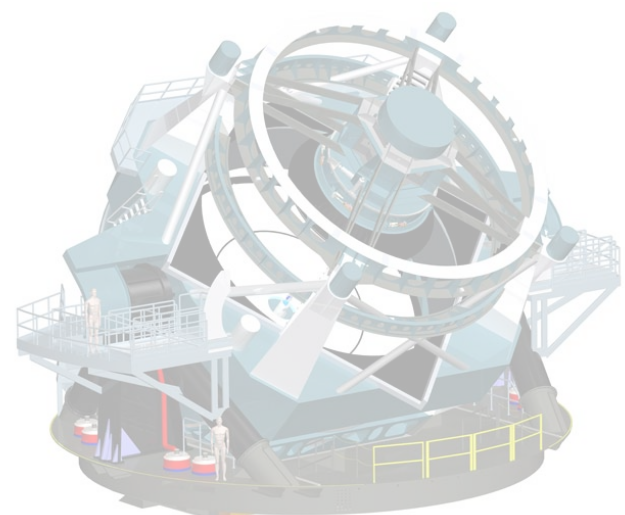
**Bianco et al. 2019**  
**PASP,**  
**Special issue on**  
**Time Domain Astronomy,**  
**in publication**

federica bianco UDel

- $u$ -band
- more  $g$ -band
- specific filter pairs
- filters for triplets  
(smaless plug...)

## LSST SCs current activities include:

- designing and scoping LSST observing strategies for different science cases
- learning and testing the **LSST pipeline and science platform**  
identifying **gap in scientific preparation** that would impair the LSST success in *theoretical advancement* (e.g. predictions on photometric observables, sparse time series analysis), *software* (e.g. sparse time series analysis tools, crowded field photometry, TOM), *existing data* (e.g. multiwavelength coverage of Deep Drilling Fields)  
preparing of **User-Generated data products**



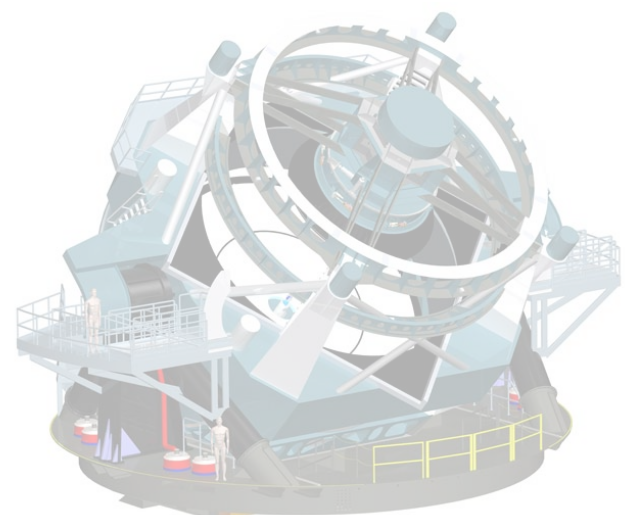
## LSST Data Products

- 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.
- 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.

Prompt

Data  
Releases

Data Products  
Definition Document  
<http://ls.st/dpdd>



## LSST Data Products

“Recognizing the diversity of astronomical community needs, and the need for specialized processing not part of the automatically generated LSST products, LSST plans to devote 10% of its data management system capabilities to User Generated 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.
- 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.

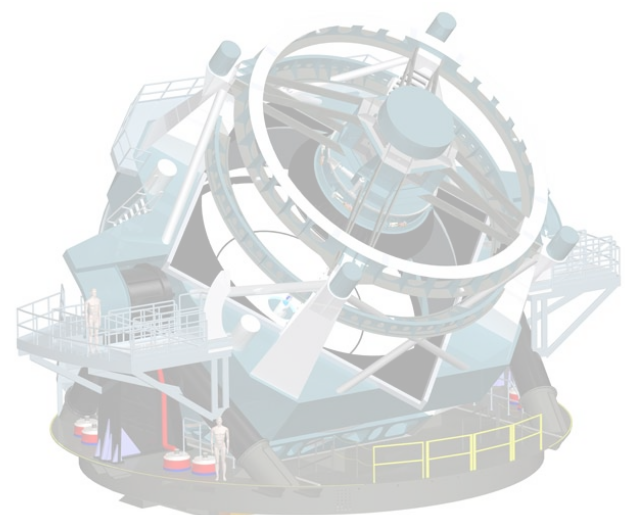
Prompt

Data  
Releases

User  
Generate

SCs are designing data products and generating pipelines to be processed in the LSST computational environments

Data Products  
Definition Document  
<http://ls.st/dpdd>



**AGN** - synergistic data analysis

**DESC** - systematics

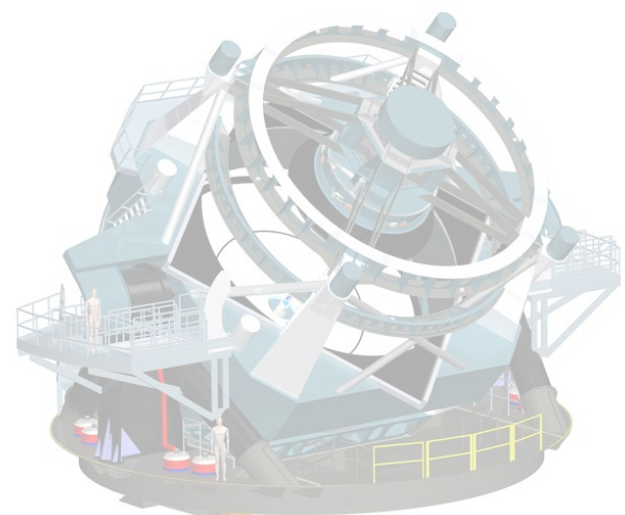
**Galaxies** - deblending, morphology

**Solar System** - refining MOPs

**SMWLV** - crowded fields photometry

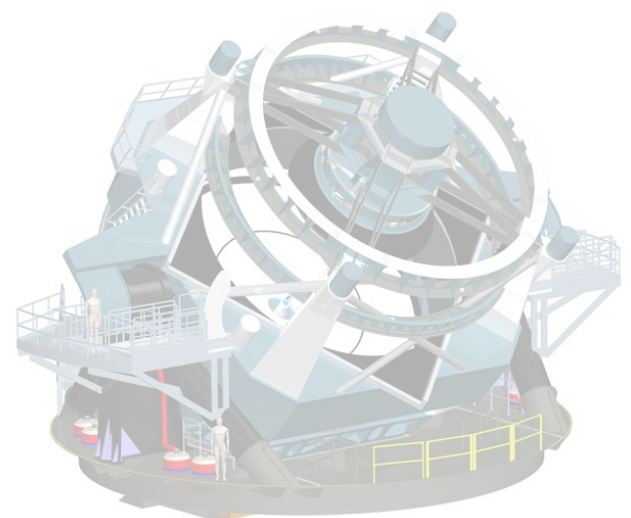
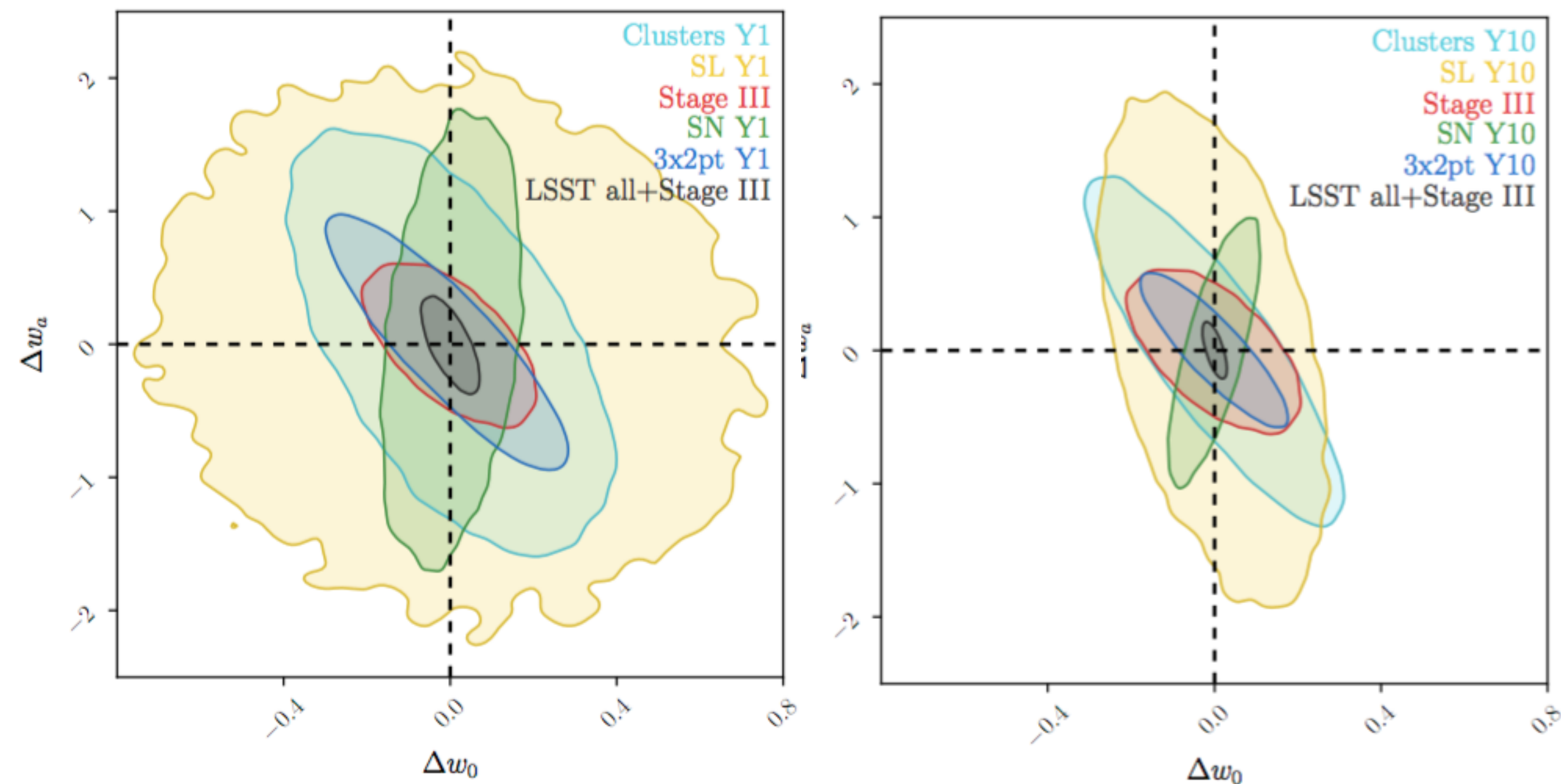
**Strong Lensing** - morphology

**TVS** - classification and follow-up



## DESC cosmology - systematics

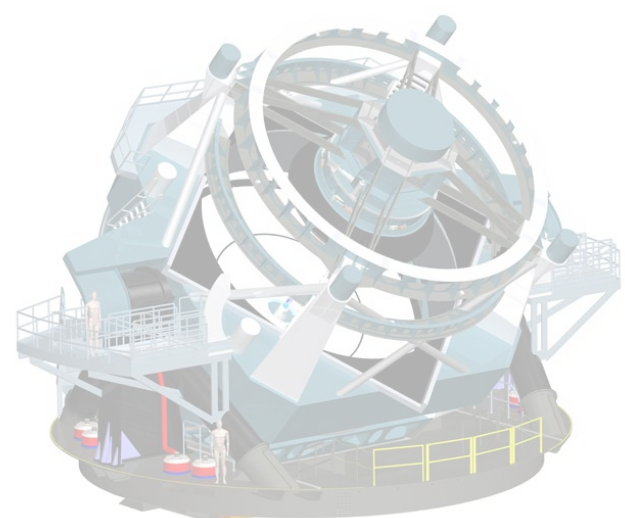
Forecasted 68% credible regions on  $(w_0, w_a)$  for individual probes and their combination after 10% (Y1, left) and all (Y10, right) LSST data is analyzed. (LSST DESC SRD v1, <https://arxiv.org/abs/1809.01669>)



**SMWL** - crowded fields photometry

**Galaxies** - deblending, morphology

**Strong Lensing** - morphology

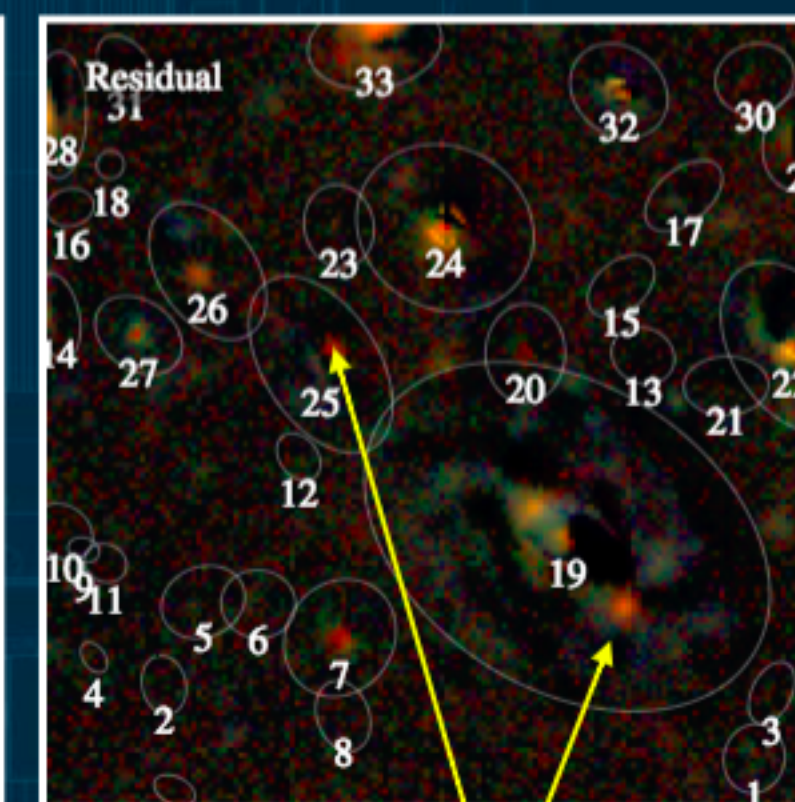
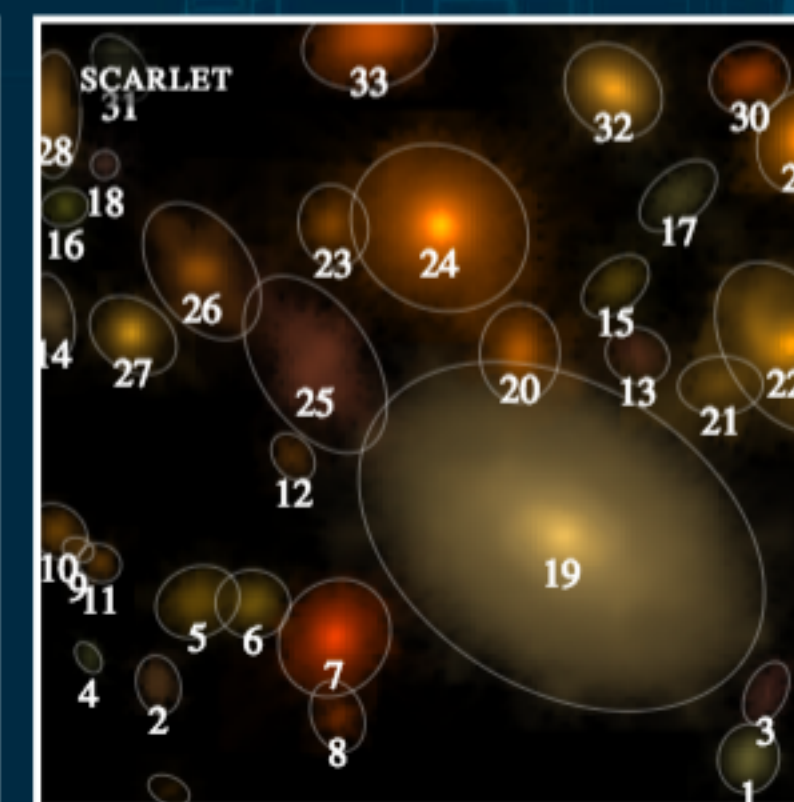
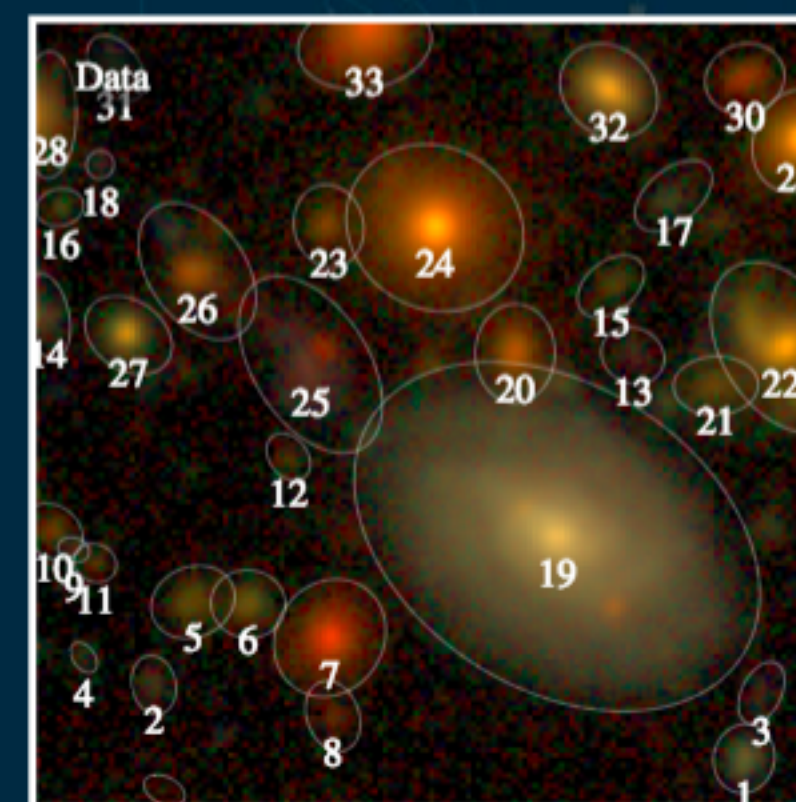


## Crowded Field Photometry



### Iterative Multiband Detection (future work)

- Detection clearly missed some faint objects
- Some objects need to be modeled with multiple components (eg Bulge-Disk)
- Color residuals clearly show where new components/sources are needed



credit: Melchior et al. 2018

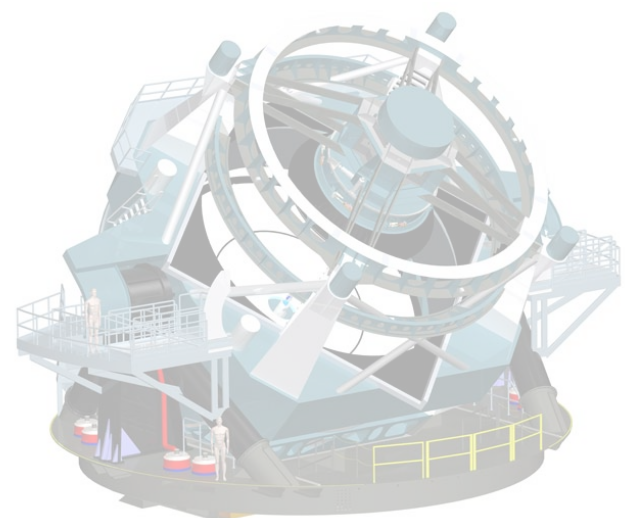
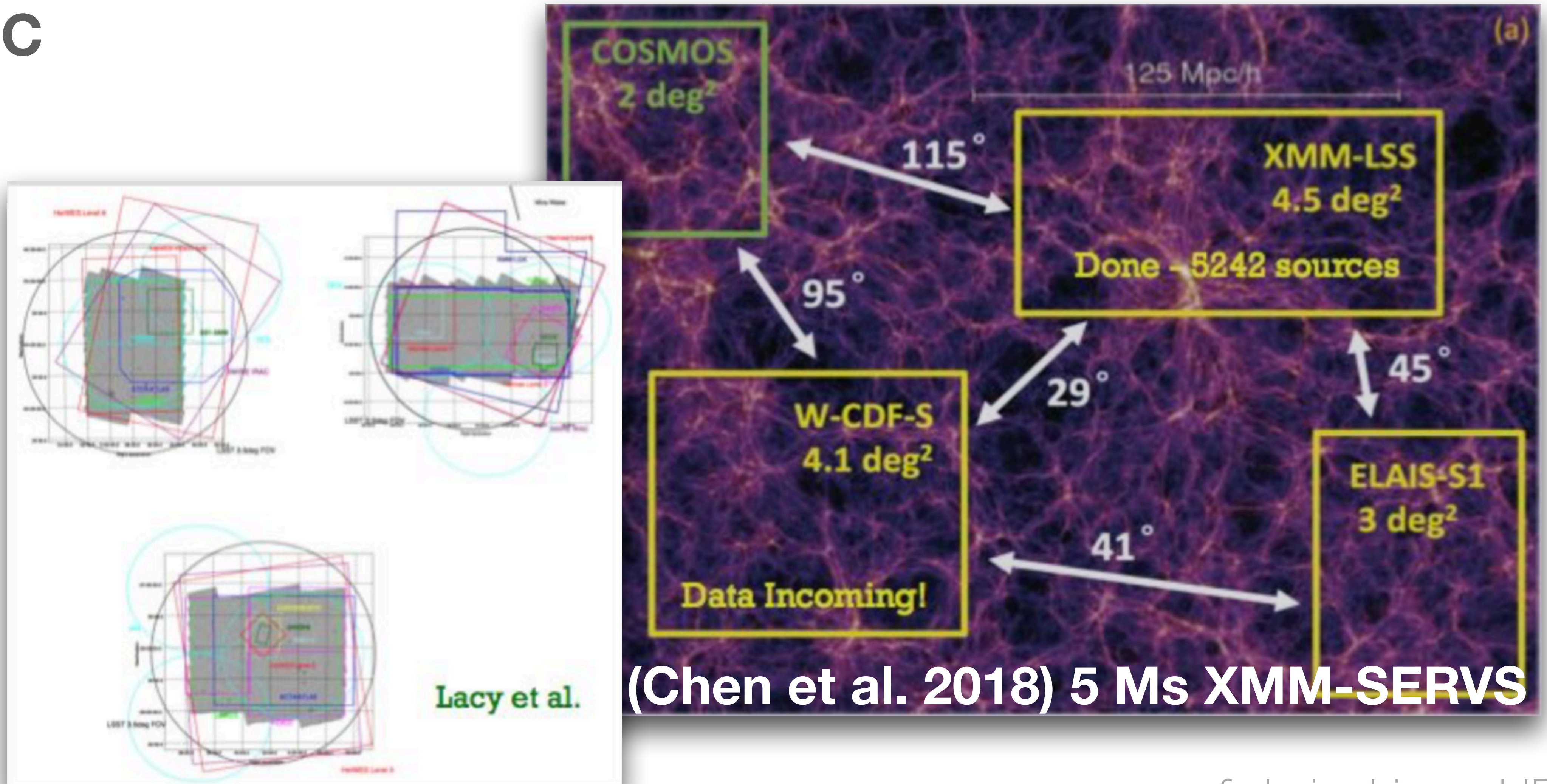
July 17, 2018

undetected sources

26

# AGN - synergistic data analysis

Gathering legacy data in sight of the LSST survey, e.g. AGN SC

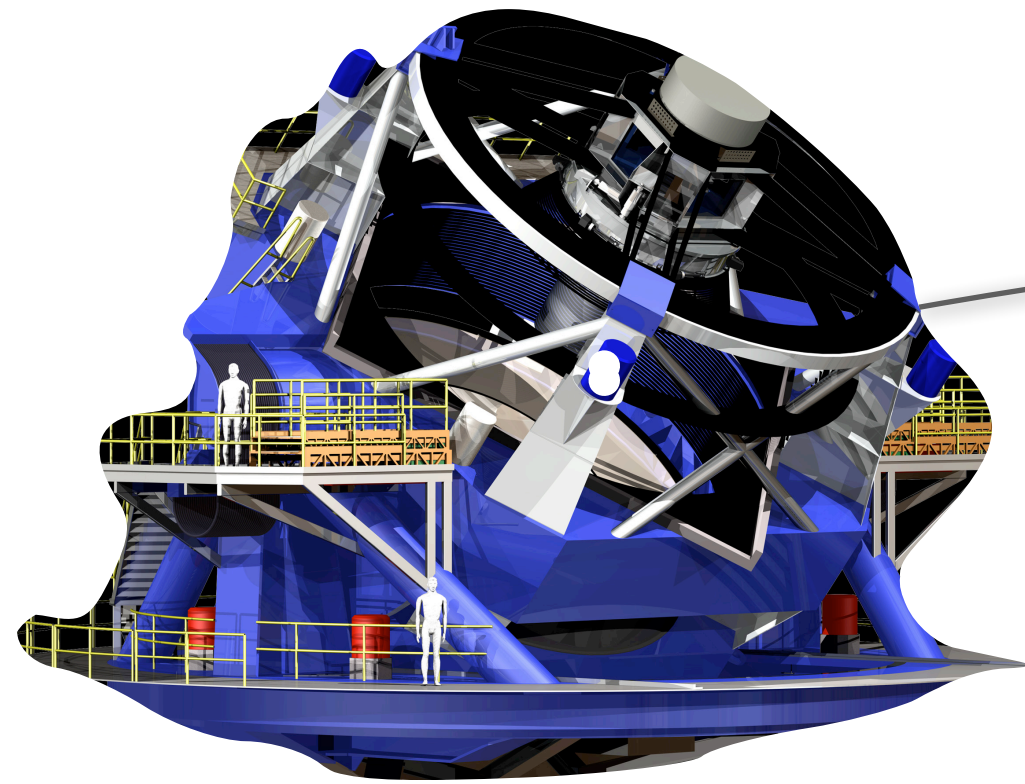


# LSST scientific readiness

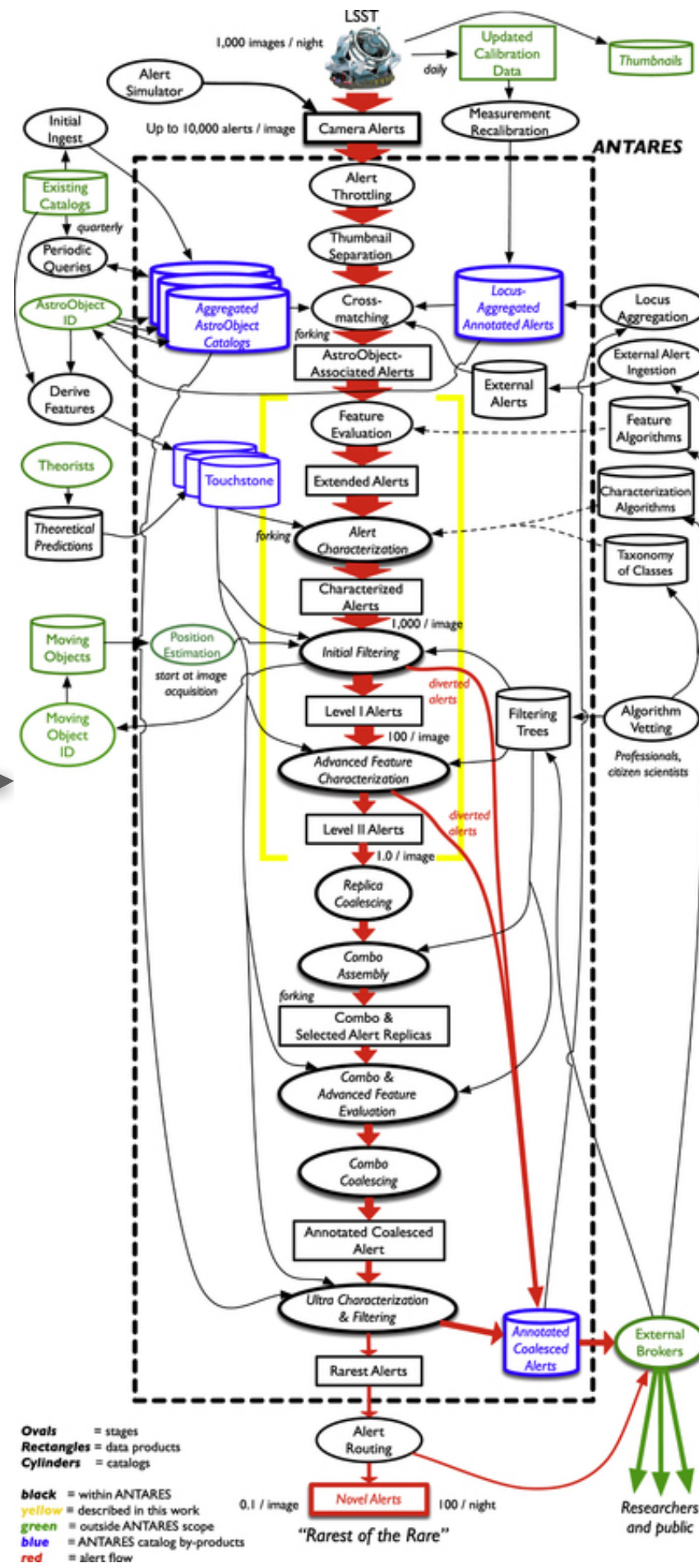
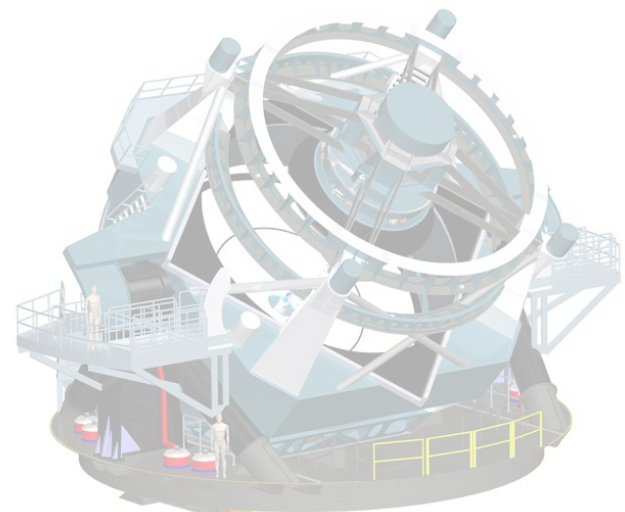
**TVS / DESC - classification and follow-up**

**Solar System - follow-up**

**Strong Lensing- follow-up**



**Discovery engines 10M alerts/night**



**Broker services**

## Astronomy's Discovery Chain

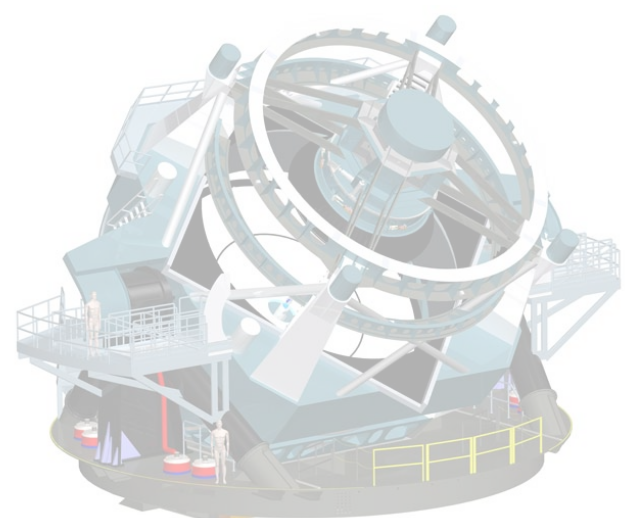
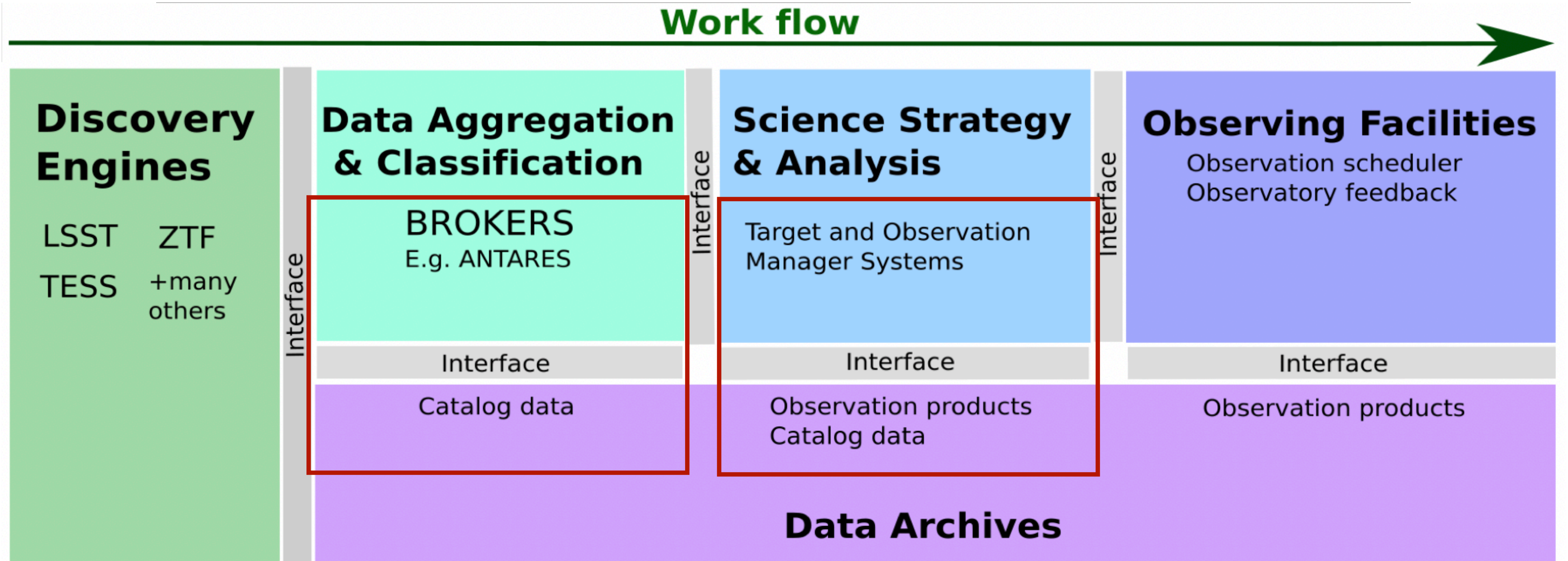


**Target & Observation Manager Systems**



**Observing facilities**

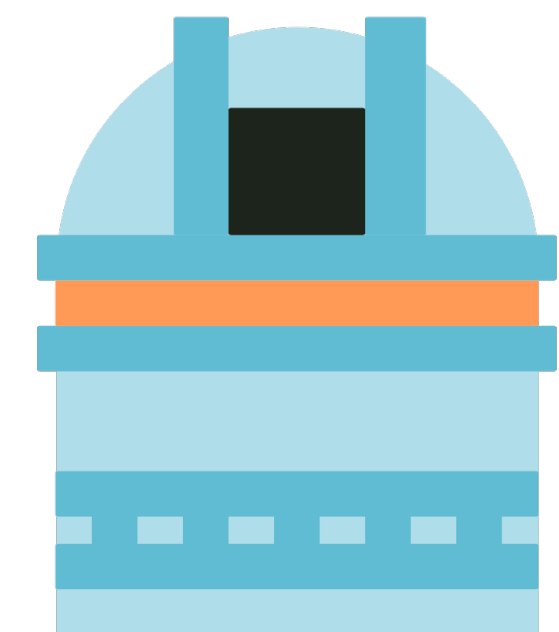
federica bianco UDel



**ALeRCE**  
Automatic Learning for the Rapid Classification of Events



**ANTARES**  
*beta*



**TOMS**

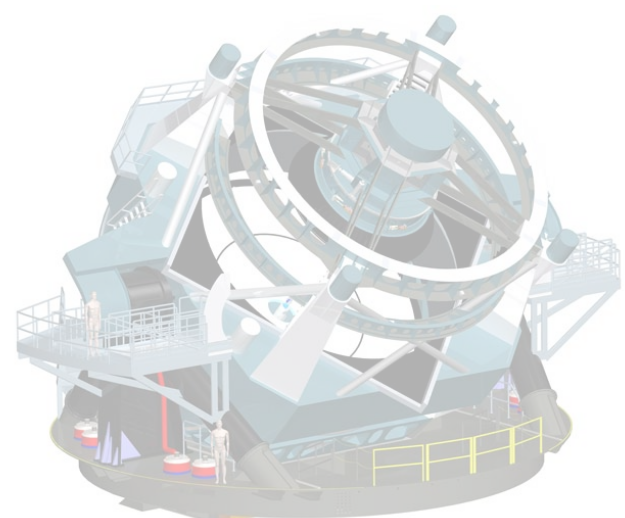


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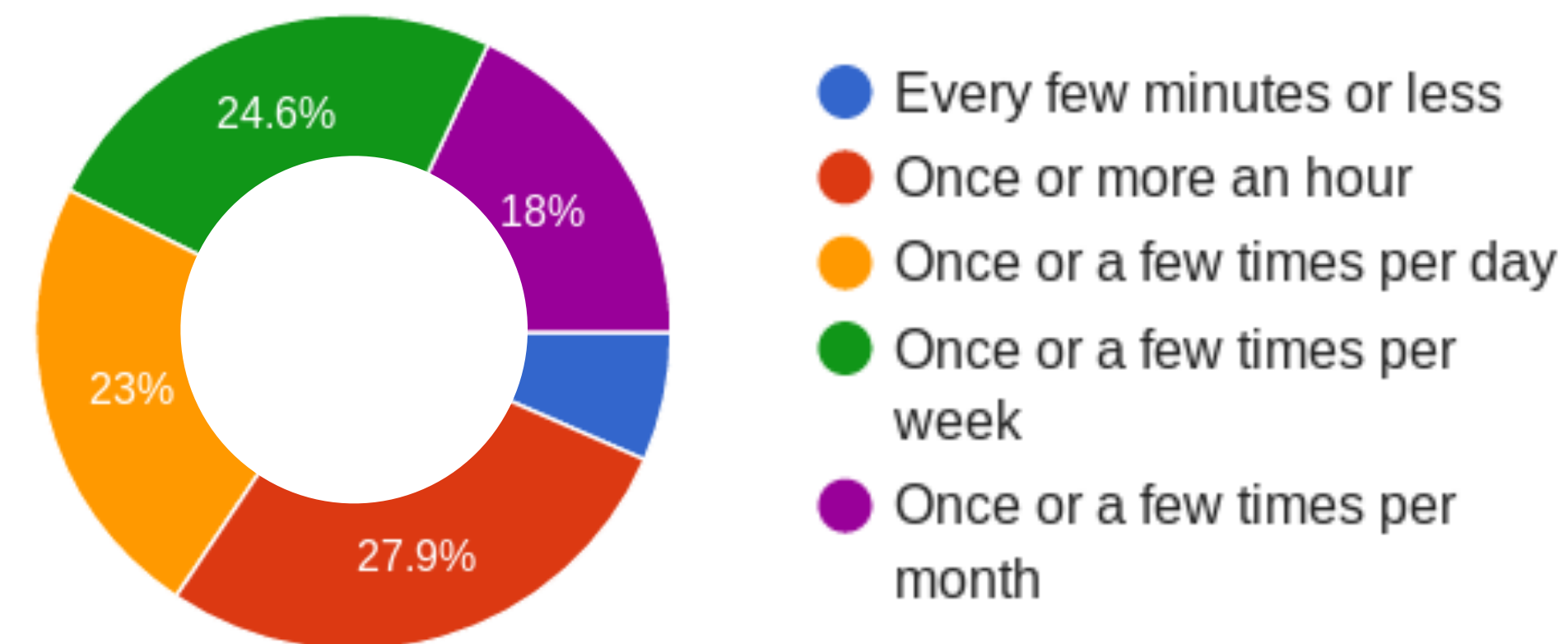
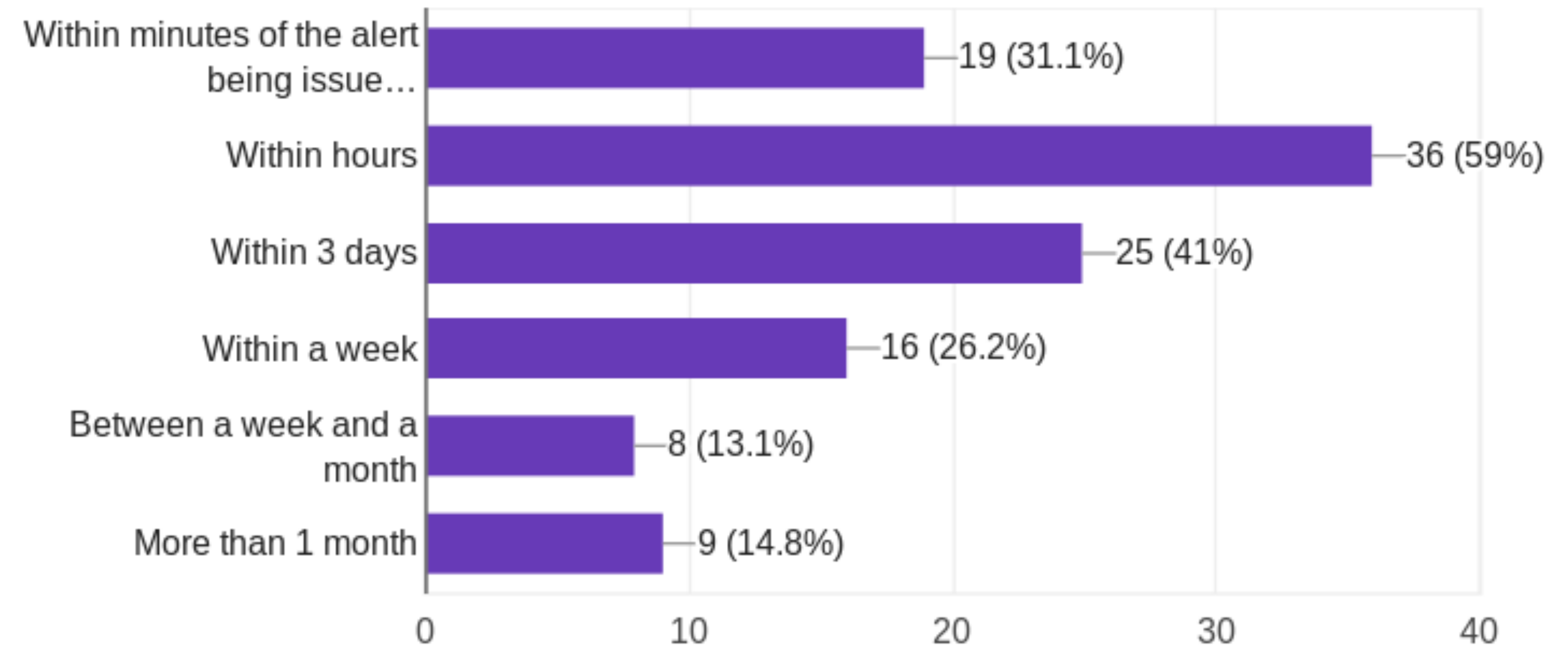
## Surveying the community to design a broker

*How quickly should alerts be disseminated?*

*How often would you query a broker to search for new targets?*



## TVS Broker Requirements Task Force



# LSST scientific readiness

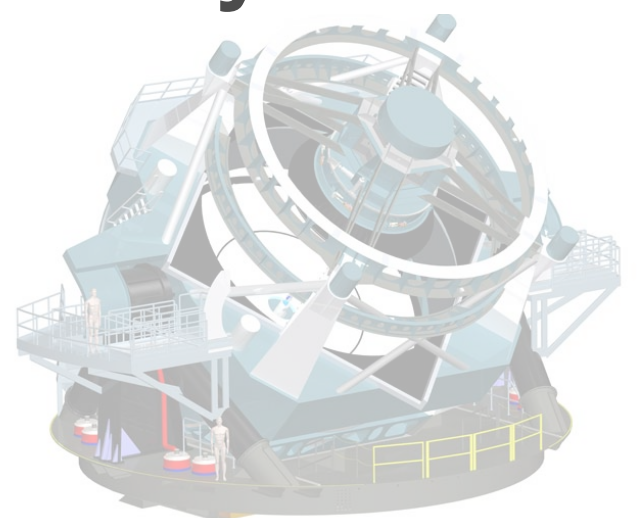
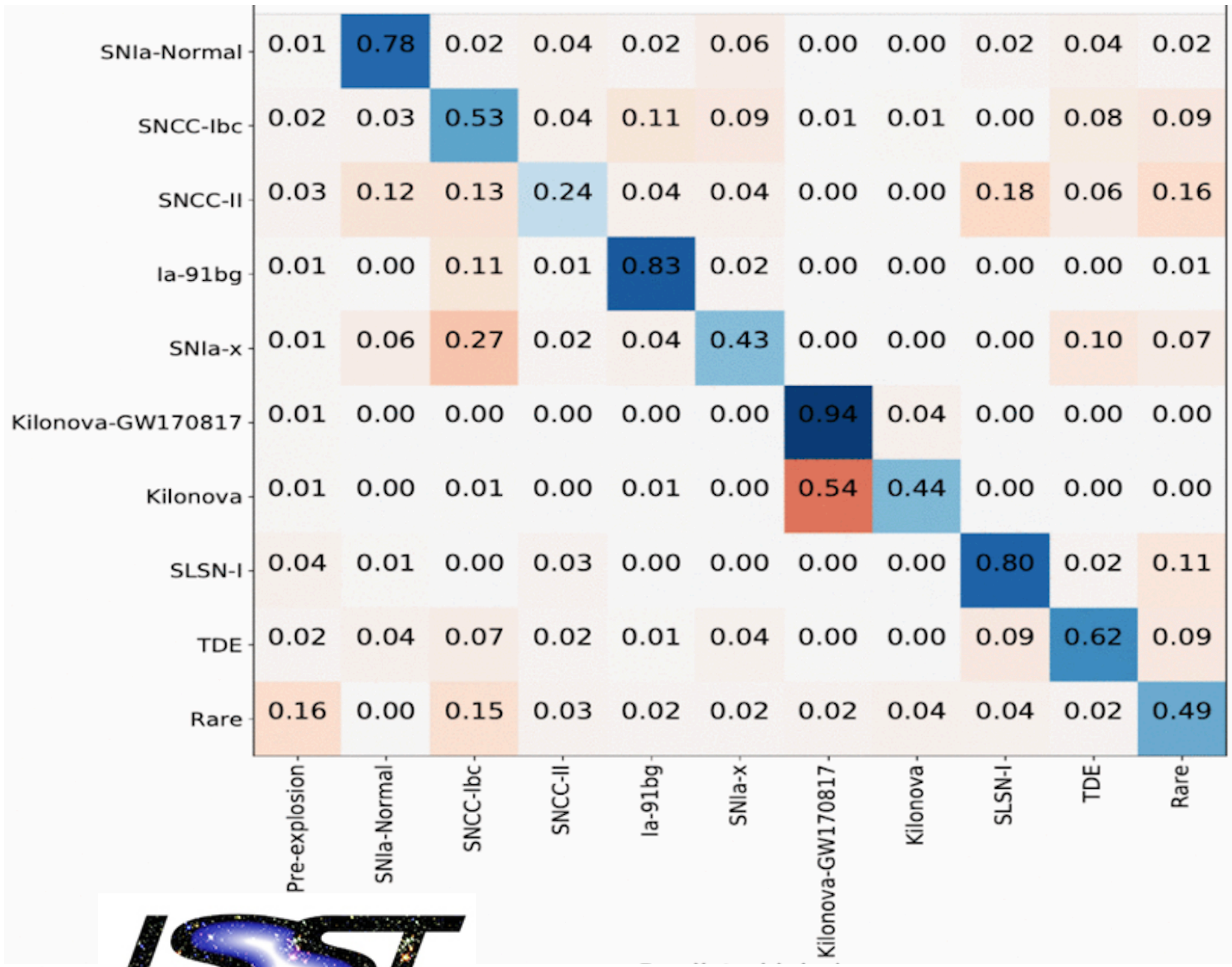
Featured Prediction Competition

## PLAsTiCC Astronomical Classification

Can you help make sense of the Universe?

LSST Project · 1,094 teams · 3 months ago

The Photometric LSST Astronomical Time-Series Classification Challenge (PLAsTiCC) asks Kagglers to help prepare to classify the data from this new survey. Competitors will classify astronomical sources that vary with time into different classes



## The LSST Science Platform - A collaborative Research Environment

A set of integrated web applications and services deployed at LSST Data Access Centers (DACs) through which the scientific community will access, visualize, subset and perform next-to-the-data analysis of the LSST Data products.



### Portal Aspect

exploratory analysis and visualization of the LSST archive



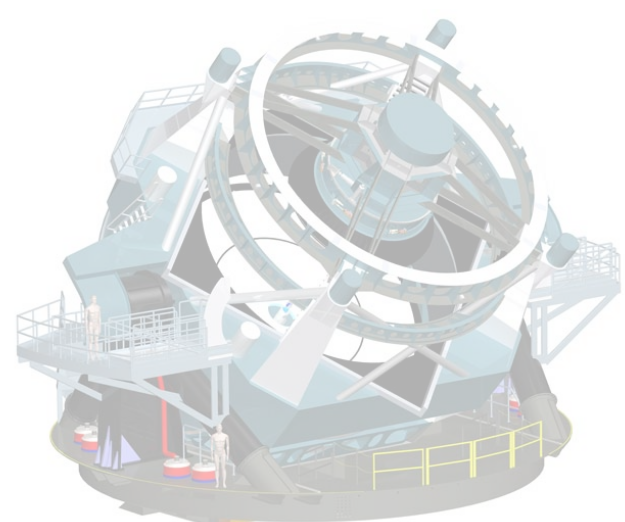
### JupyterLab Notebook Aspect

in-depth 'next-to-the-data' analysis & creation of added-value data products



### Web API Aspect

remote access to the LSST archive via industry-standard APIs

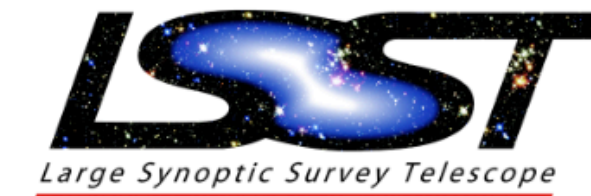
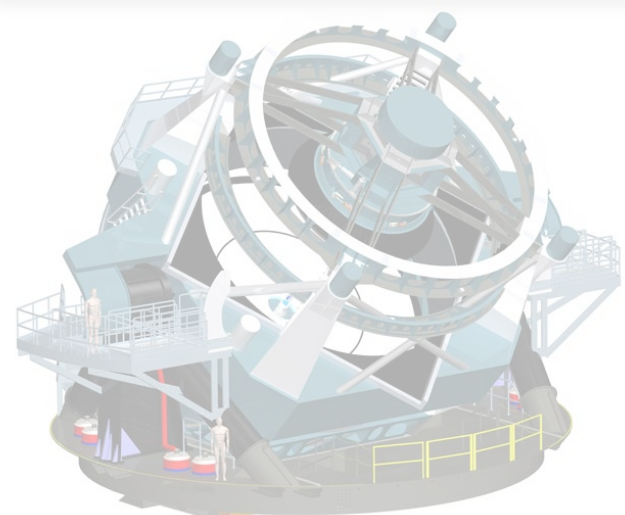


## LSP Review April 2019

### LSST Science Collaborations representation

- **Rachel Street: TVS, (LCO, archives)**
- **David Kirkby: DESC, (SAC)**
- **Michael Mommert: SSSC**
- **Christian Johnson: SMWLV**
- **Lee Steven Kelvin: Galaxies**
- **Tina Peters: AGN**

**The committee is asked to provide science-oriented feedback and recommendations on the design of the LSST Science Platform**



[Agenda](#) [Venue](#)

[Home](#) » [LSST Software Community "Stack Club"](#)

### LSST Software Community "Stack Club"

**Posted on:** 8 May 2018 **By:** pjm

Come and learn about the LSST processing software (the "LSST Software Stack") by working your way through one of our community-built tutorial Jupyter notebooks, and then extending it to do the things you are most interested in. We'll provide access to a JupyterLab instance, so no installation will be required: you can just jump in. We'll give you a quick guided tour of the tutorials we've got, and a demonstration of one of them in action. Then, we'll break up into a short hack session. The Stack Club is an LSSTC-supported initiative that will be active by video through the Fall: you can get started in Tucson at the PCW, and then carry on learning with us when you get home.

- [Please register for a temporary LSST Science Platform account for use at the meeting](#) if you don't already have one.
- You can [browse the Stack Club GitHub repo](#) to find out more about what we are doing
- [Check out the slides for this session](#) (under development until Monday 1:30pm PDT)
- The session will be in the Joshua Tree room, but we'll use the Stack Club Zoom Room, <https://stanford.zoom.us/j/946390572>, instead of BlueJeans (so that we can record the session). Here's the program for the session:

**the Science Collaborations are an army of 1500 scientists**

**the science collaborations are an army of 1500 scientists**

**their work is essential to return on the LSST promise to deliver  
transformational science**

**the science collaborations are an army of 1500 *volunteers***

**their work is essential to return on the LSST promise to deliver  
transformational science**

***a funding system for LSST scientific preparedness is not in place***

# LSST Science Collaboration - funding

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Founded in 2003 as a not-for-profit 501(c)3 Arizona corporation to maximize the scientific impact of the LSST project

*LSSTC Director for Science*  
Jeno Sokoloski



*LSSTC Senior Director of Development*  
Dan Petrocelli



Strategizing fund-raising:

- approaching foundations
- securing funds for scientific activities for SCs
- supporting Institutional Members of LSSTC

# LSST Science Collaboration - funding



## 2019 Enabling Science Call for Proposals

The 2019 Enabling Science Call for Proposals is available to provide funding for workshops and other programs, including limited funding for undergraduate students to engage in research in preparation for LSST.

This Call also solicits Notices of Intent to request support for undergraduate researchers to attend a two-day student-specific program at the LSST Project & Community Workshop in August 2019.

**LSSTCorp provides support for meetings and training since 2015: funded by a 2015 \$500k Match Challenge from Charles+Lisa Simonyi and Bill Gates**

The Enabling Science Proposal Call distributed \$1,487,953.50  
2019 Proposals Call makes \$200,000 available

- Science and Science Collaboration Activities

  - SC and topical meetings/workshops/hackathons

  - Stack Club : a reading group to learn the LSST processing software and platform

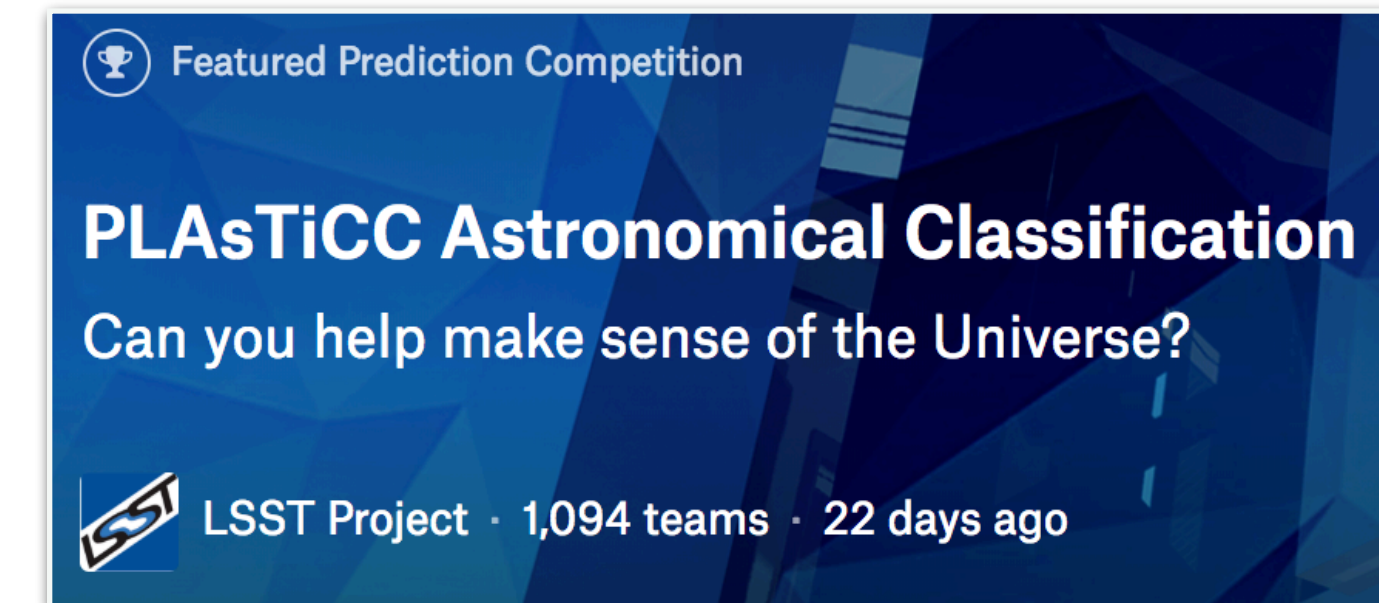
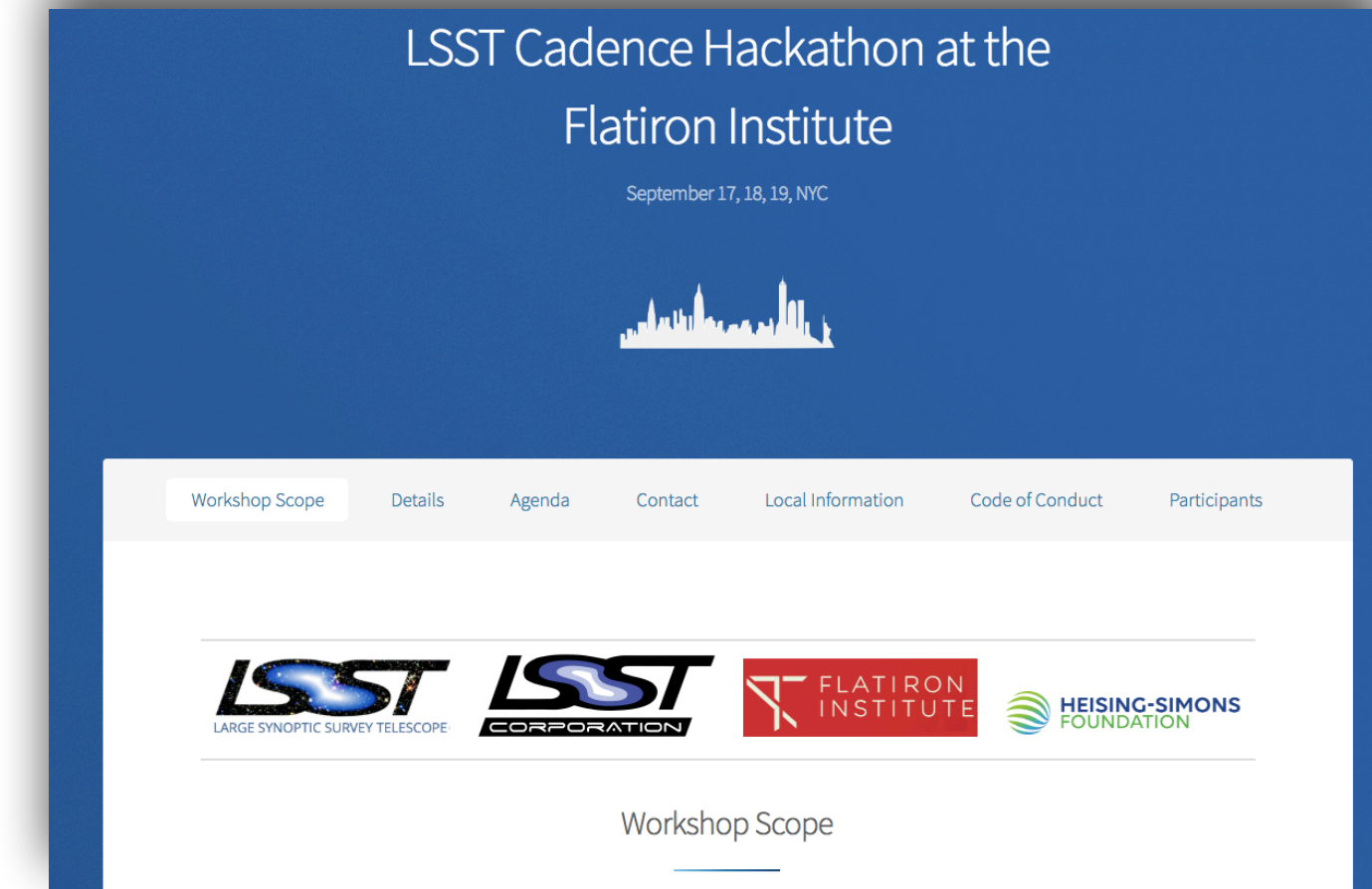
- Broader Education and Outreach:

  - Undergraduate training

  - PLAsTiCC Kaggle challenge seed funding

  - Big Data Academy for High School Students

  - The LSST Data Science Fellowship Program



# LSST Science Collaboration - funding

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Seeking funds outside of the astro budget: Proposal submitted to NSF including a team dynamics and conflict resolution expert - Prof. Sleesman (UDel)

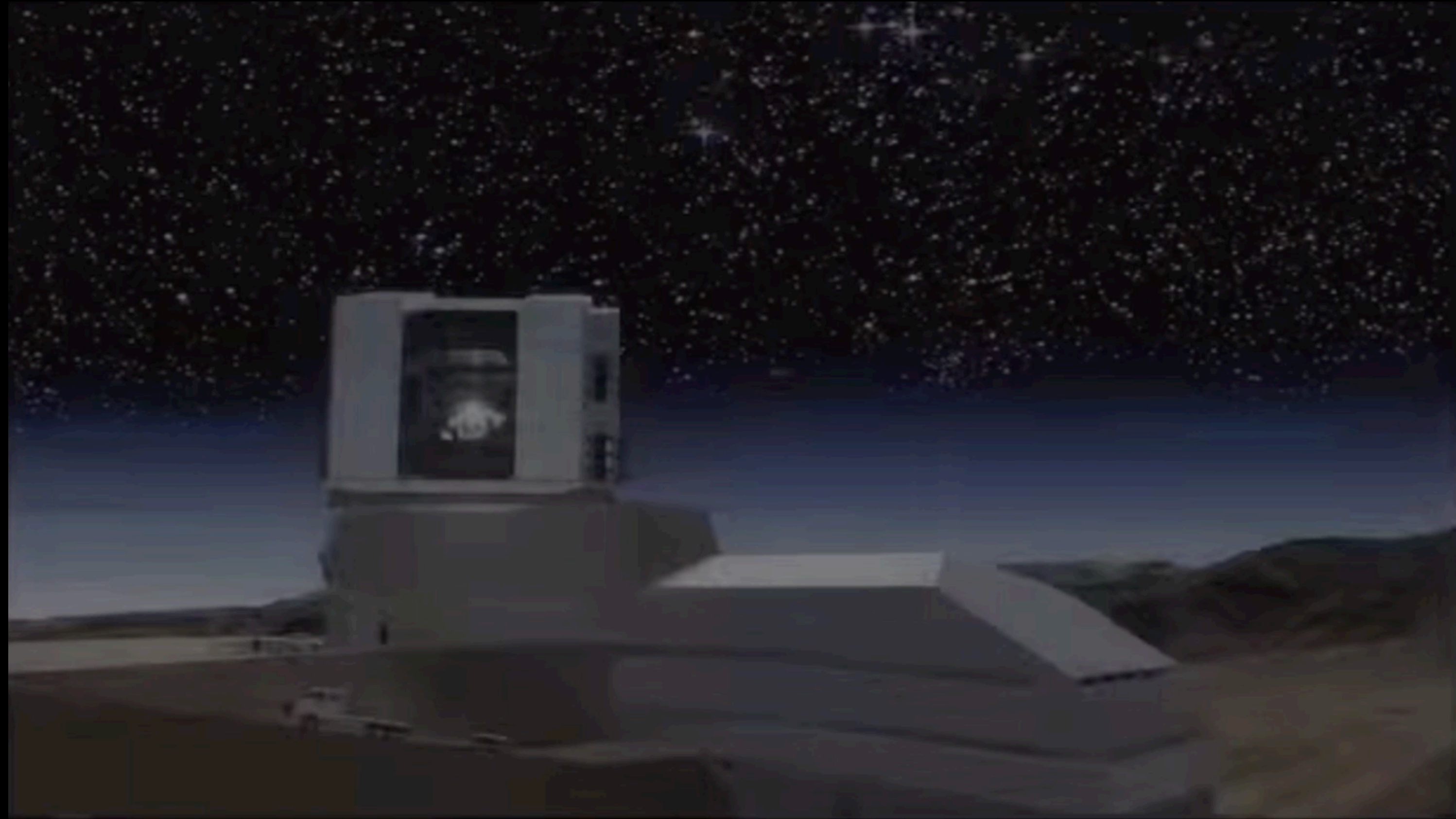
## INTERNATIONAL NETWORK-TO-NETWORK COLLABORATION



Accelerating Research through International Network-to-Network Collaborations (AccelNet)

*accelerate the process of scientific discovery and prepare the next generation of U.S. researchers for multiteam international collaborations.*





*Somewhere, something incredible is waiting to be known.*  
*Carl Sagan*

[fbianco@udel.edu](mailto:fbianco@udel.edu) - LSST SC coordinator, LSST TVSSC co-chair