Restless AGNs in the Legacy Survey of Space and Time

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For the LSST AGN
Science Collaboration

2023
June

Quick Status Update

Rubin has come a long way since the 2013 Naples meeting.

Was top-ranked large ground-based project in 2010 Decadal.

Project construction began in 2014 August.

Has survived many great challenges; e.g., COVID delays.

System first light forecasted for 2024 October.

Survey operations to begin in early 2025.

Need to get ready for the data flood and enormous work!

Talk Outline

Brief review of the LSST surveys (from an AGN variability perspective).

LSST AGN selection; e.g., using variability.

AGN variability investigations.

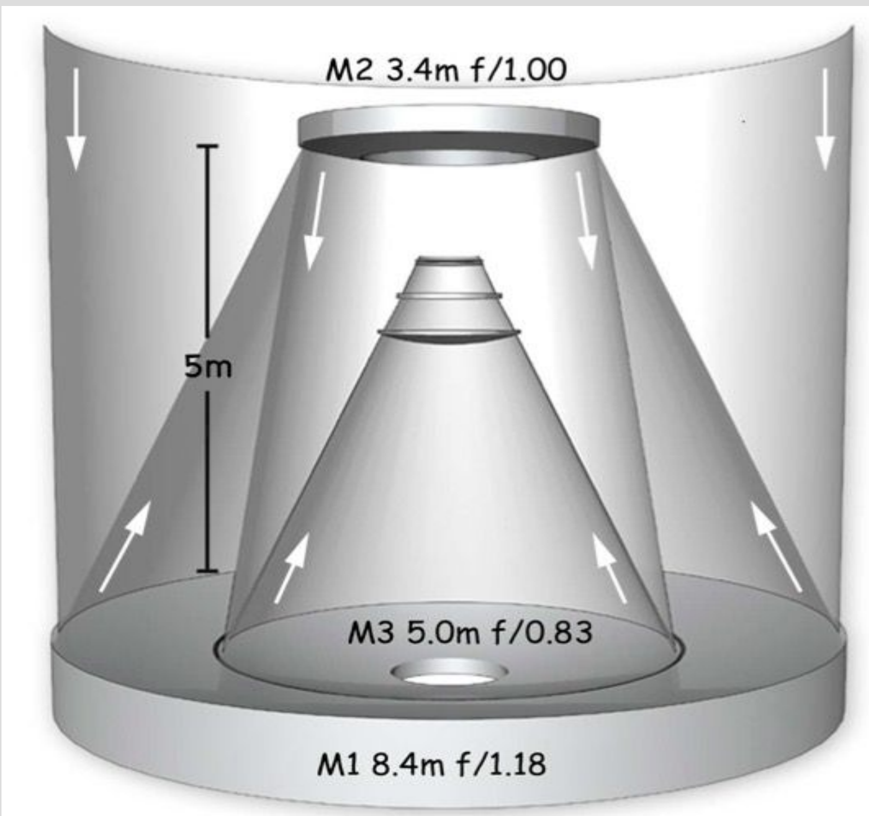
The LSST AGN Science Collaboration.

Brief Review of the LSST Surveys

(from an AGN variability perspective)

Main Survey Summary

A public optical/NIR survey of ~ half the sky in the *ugrizy* bands to *r* ~ 27 based on ~ 820 visits over a 10-year period.



8.4 m, 6.4 m effective - 9.6 deg^2 - 3.2 Gpix camera

Wide (W)
The observable (mostly) southern sky. Each exposure covers 40-50 full Moons.

Fast (F)
Rapidly scans the sky with pairs of 15 sec exposures, providing a color movie of objects that change or move.

Deep (D)
10-100 times deeper than other very wide-field surveys after co-adding.

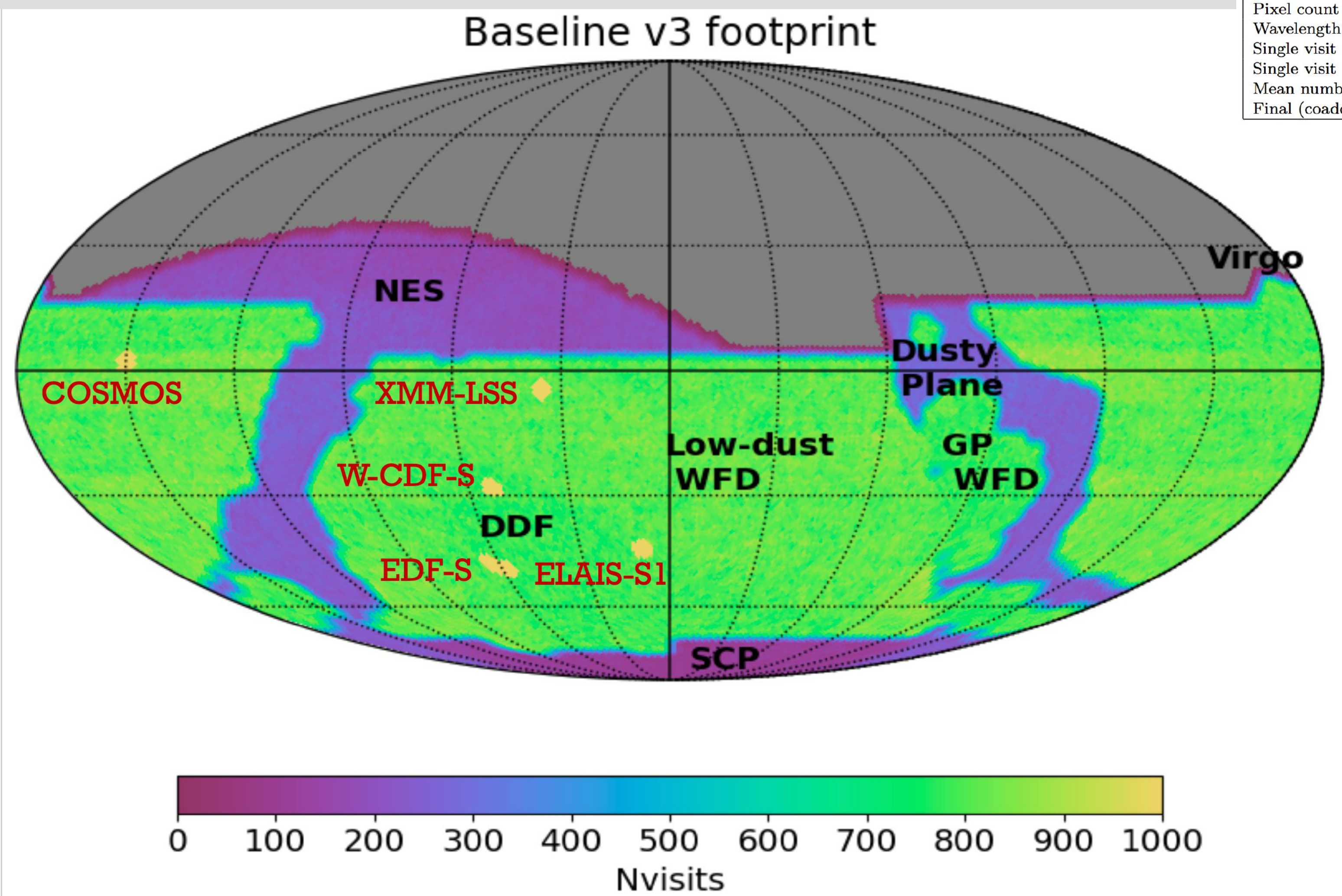
See Ivezic et al. (2019) and Bianco et al. (2022) for many more details.

Main Survey Simulation

Example Operations Simulation of Baseline Survey Strategy (Details Subject to Change)

The LSST Baseline Design and Survey Parameters

Quantity	Baseline Design Specification
Optical Config.	3-mirror modified Paul-Baker
Mount Config.	Alt-azimuth
Final f-ratio, aperture	f/1.234, 8.4 m
Field of view, étendue	9.6 deg^2, 319 m^2deg^2
Plate Scale	50.9 μm/arcsec (0.2" pix)
Pixel count	3.2 Gigapix
Wavelength Coverage	320 – 1050 nm, *ugrizy*
Single visit depths, design [a]	23.9, 25.0, 24.7, 24.0, 23.3, 22.1
Single visit depths, min.[b]	23.4, 24.6, 24.3, 23.6, 22.9, 21.7
Mean number of visits[c]	56, 80, 184, 184, 160, 160
Final (coadded) depths[d]	26.1, 27.4, 27.5, 26.8, 26.1, 24.9



W-F-D survey optimized for homogeneity of depth and number of visits.

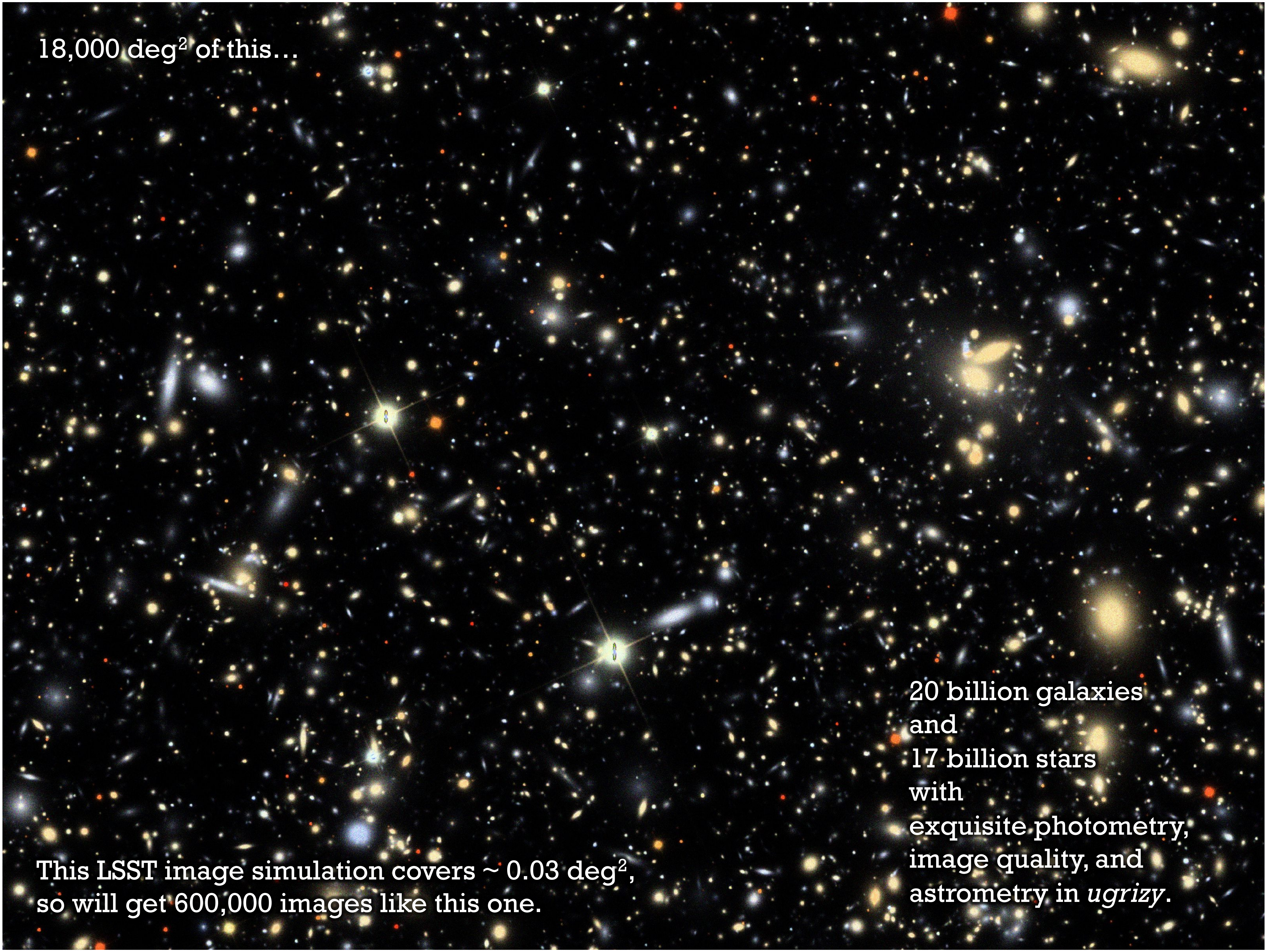
18000 deg^2

Uses ~ 90% of the LSST time.

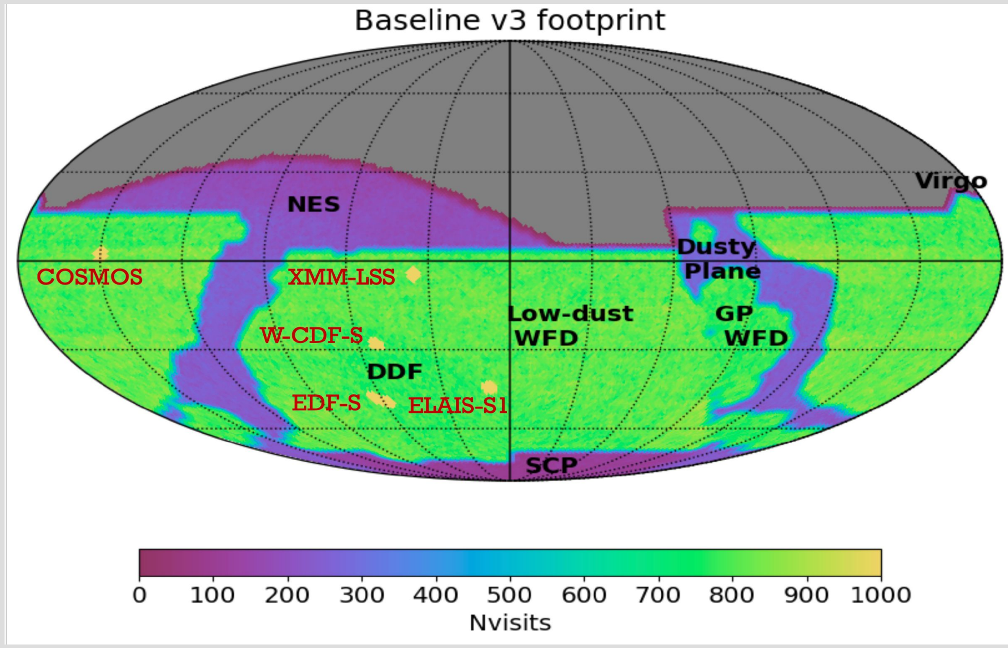
Table 2
Expected Properties of the Rubin System and LSST Survey

System Constraints	
Readout time	2 s
Time needed for filter exchange	2 minutes[a]
Minimum slew+settle time between fields	3 s[b]
Expected fraction of time lost to weather	∼30%[c]
Expected fraction of time lost to maintenance	∼10%
Maximum number of filter loads on filter carousel	3,000
Maximum number of filter changes over the lifetime of the carousel	100,000
Maximum number of filter changes per filter	30,000
Filter effective wavelength for *u*, *g*, *r*, *i*, *z*, *y* filters in angstroms	3887.9, 4746.4, 6201.5, 7535.7, 8701.8, 10103.6[d]
Survey characteristics from the Science Requirements Document[e]	
Standard visit exposures (expected)	2 × 15 s[f]
Expected number of visits in *u*, *g*, *r*, *i*, *z*, *y*	56, 80, 184, 184, 160, 160
Single image 5σ depths in *u*, *g*, *r*, *i*, *z*, *y*	23.9, 25.0, 24.7, 24.0, 23.3, 22.1[g]
10 yr coadded image stack 5σ depths in *u*, *g*, *r*, *i*, *z*, *y*	26.1, 27.4, 27.5, 26.8, 26.1, 24.9[h]
Photometric precision (at the bright end)	5 mmag
Photometric accuracy	10 mmag
Astrometric precision (at the bright end)	10 mas
Astrometric accuracy	50 mas
Survey characteristics from the baseline simulated survey[i]	
Median slew time between visits	4.94 s
Median (mean) visit time (including shutter, readout and slew time)	39 s (42.2 s)[j]
Median seeing in *u*, *g*, *r*, *i*, *z*, *y* in arcseconds	1.10, 1.03, 0.99, 0.95, 0.93, 0.92
Single image median 5σ depths in *u*, *g*, *r*, *i*, *z*, *y*	23.50, 24.44, 23.98, 23.41, 22.77, 22.01
10 yr coadded image stack 5σ depths in *u*, *g*, *r*, *i*, *z*, *y*	25.73, 26.86, 26.88, 26.34, 25.63, 24.87

Notes.
[a] This is the time required if the filter is already mounted on the filter wheel. The filter wheel houses five of the six filters at once.
[b] See https://github.com/lsst-pst/survey_strategy/blob/main/wp-call/WPcall2018.pdf page 22.
[c] A conservative estimate based on weather statistics for the Gemini Observatory South telescope; https://www.gemini.edu/.
[d] Filter throughputs available at https://github.com/lsst/throughputs.
[e] More detailed information, including minimum requirements and stretch goals for the WFD are included in the SRD (https://ls.st/srd).
[f] 30 s single exposures are explored in several `OpSim` simulations, especially in `OpSim` release 1.5.
[g] Single-visit depths are referenced to zenith and dark sky.
[h] Based on expected single-visit depths, expected number of visits, and expected 0.2 mag loss due to various observational effects.
[i] More details and additional metrics based on this baseline simulation are available at http://astro-lsst-01.astro.washington.edu:8082/allMetricResults?runId=5.
[j] This time includes exposure, readout, and slew—no filter change.


18,000 deg^2 of this…
20 billion galaxies
and
17 billion stars
with
exquisite photometry,
image quality, and
astrometry in *ugrizy*.
This LSST image simulation covers ~ 0.03 deg^2,
so will get 600,000 images like this one.

Rubin's LSST Deep-Drilling Fields



	ELAIS-S1	XMM-LSS	Wide Chandra Deep Field-South	Euclid Deep Field-South	COSMOS
RA 2000	00 37 48	02 22 18	03 31 55	04 04 58	10 00 26
DEC 2000	-44 01 30	-04 49 00	-28 07 00	-48 25 12	+02 14 01
Galactic l	311.28	171.10	224.07	256.06	236.78
Galactic b	-72.88	-58.91	-54.60	-47.17	42.13
LSST Solid Angle (deg^2)	10	10	10	20	10
Prime Multiwavelength Solid Angle (deg^2)	3.2 (XMM-SERVS)	5.3 (XMM-SERVS)	4.6 (XMM-SERVS)	TBD	2 (COSMOS)
Relevant Reference	Ni et al. (2021)	Chen et al. (2018)	Ni et al. (2021)	Laureijs et al. (2019)	Civano et al. (2016)

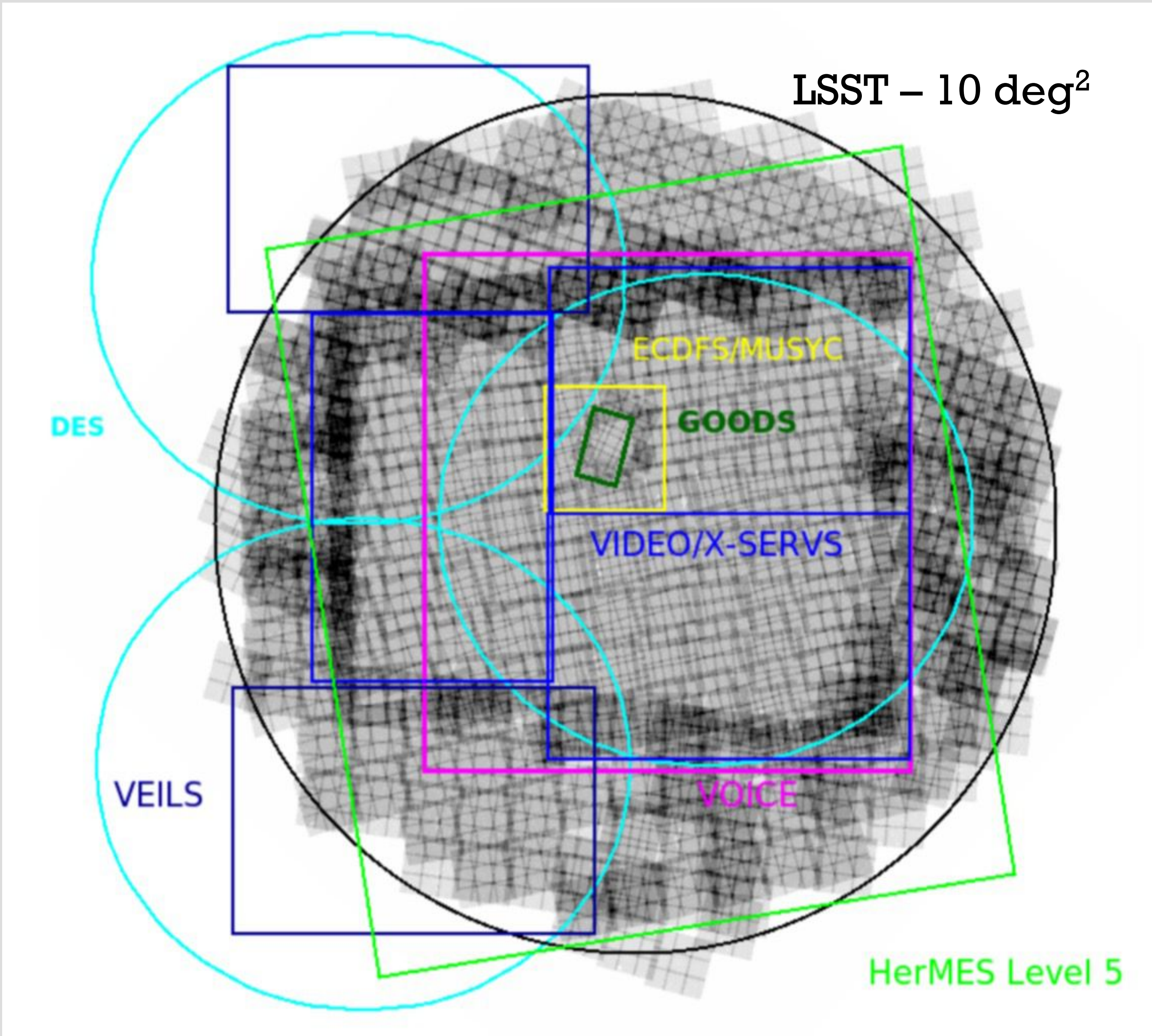
Part of ~ 10% on mini-surveys.

The DDFs have superb and rapidly growing deg^2 multiwavelength coverage.

Critical for AGN science!

Extensive AGN selection work done.

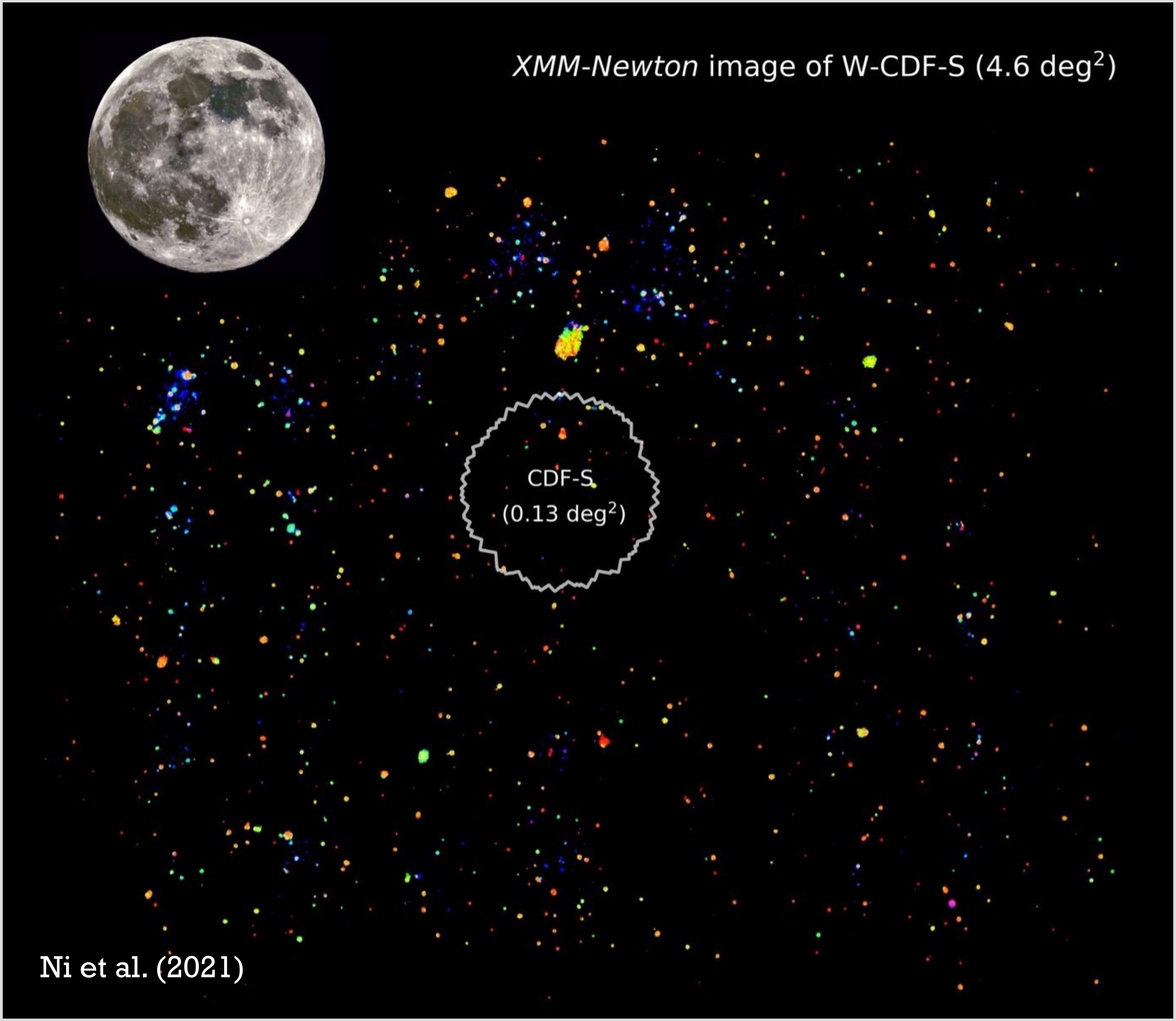
Example: Wide Chandra Deep Field-South



Grayscale is Spitzer DeepDrill

Brandt et al. (2018) - arXiv:1811.06542

Panoramic CDF-S Coverage

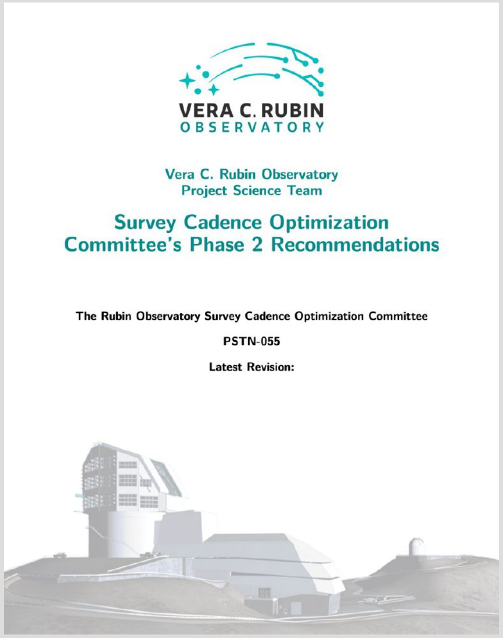


Survey Strategy Optimization Process

Goal: Determine how to observe main survey and spend 10-20% of time on “mini-surveys”.

Wide-Fast-Deep survey will have half-sky “rolling cadence” to improve sampling density in 3-5 day range.

5-7% of the time should be spent on the Deep-Drilling Fields – should allow excellent deep and densely sampled coverage for AGN variability studies.



Vera C. Rubin Observatory
Project Science Team

Survey Cadence Optimization
Committee's Phase 2 Recommendations

The Rubin Observatory Survey Cadence Optimization Committee

PSTN-055

Latest Revision:

arXiv:1811.06542v2 [astro-ph.IM] 21 Nov 2018

Active Galaxy Science in the LSST Deep-Drilling Fields: Footprints, Cadence Requirements, and Total-Depth Requirements

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November 2018

Abstract

This white paper specifies the footprints, cadence requirements, and total-depth requirements needed to allow the most-successful AGN studies in the four currently selected LSST Deep-Drilling Fields (DDFs): ELAIS-S1, XMM-LSS, CDF-S, and COSMOS. The information provided on cadence and total-depth requirements will also likely be applicable to enabling effective AGN science in any additional DDFs that are chosen.

1 White Paper Information

The contact author for this white paper is W.N. Brandt (wnbrandt@gmail.com).

This white paper addresses active galactic nucleus (AGN) science in the LSST Deep-Drilling Fields (DDFs), including transient supermassive black hole (SMBH) activity. It is thus relevant to the “Exploring the Changing Sky” main LSST science theme.

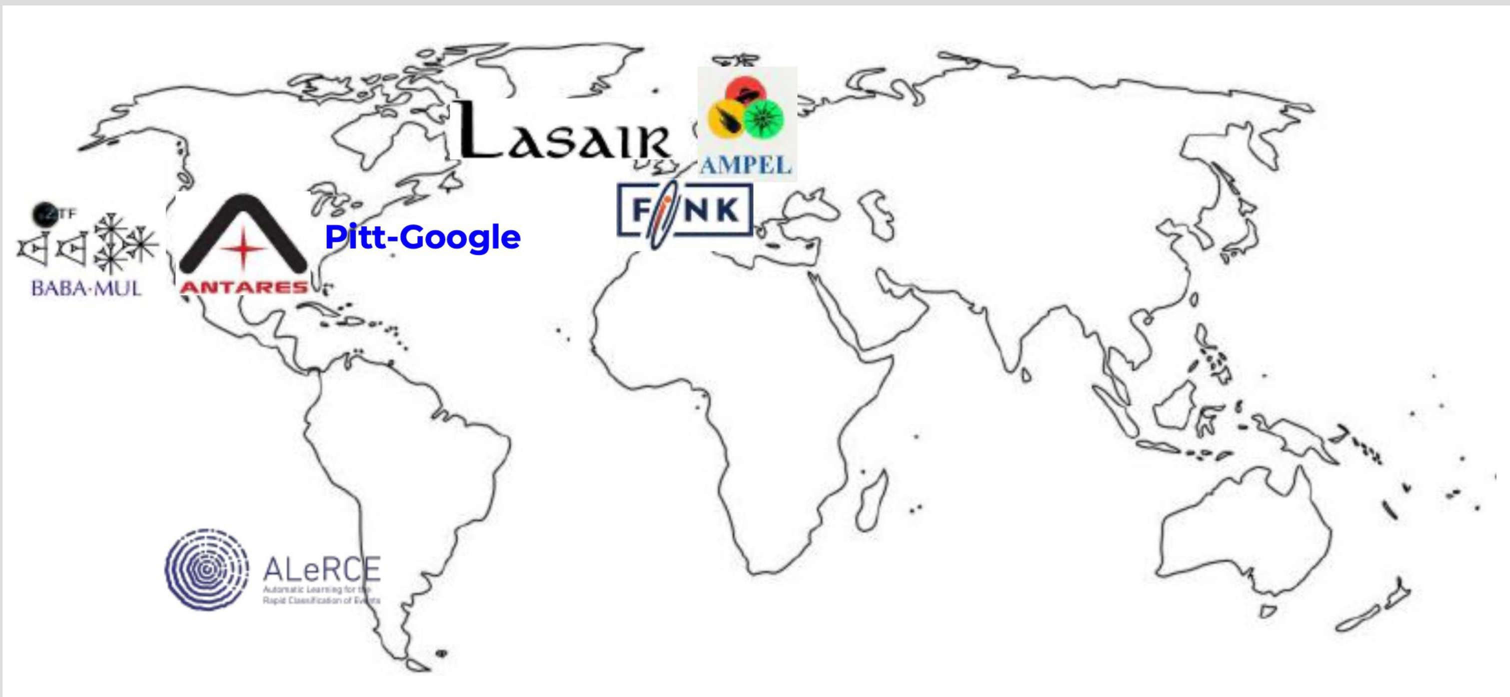
1

Quantity of Interest	u	g	r	i	z	y
Visits Every 2 Nights	4	1	1	3	5	4
Depth Every 2 Nights	24.6	25.0	24.7	24.6	24.2	22.9
Total Visits in 10 yr	3600	900	900	2700	4500	3600
Total Depth in 10 yr	28.3	28.7	28.4	28.3	27.9	26.5

Role of Alert Brokers

Alert Brokers will ingest, process, and serve alerts about variable Rubin sources (e.g., AGNs) to the astronomical community.

Seven brokers will have access to the full Rubin alert stream.



Brokers will be essential for enabling time-critical studies of AGN variability events – worth learning about them.

Selection of Tens of Millions of AGNs

LSST AGN Selection

Multicolor selection in *ugrizy* from $z = 0\text{-}7.5$

- Ultraviolet excess below $z \sim 2.5$
- Lyman-α forest at high redshifts
- Works best when $L_{\mathrm{AGN}} > L_{\mathrm{Host}}$

Variability

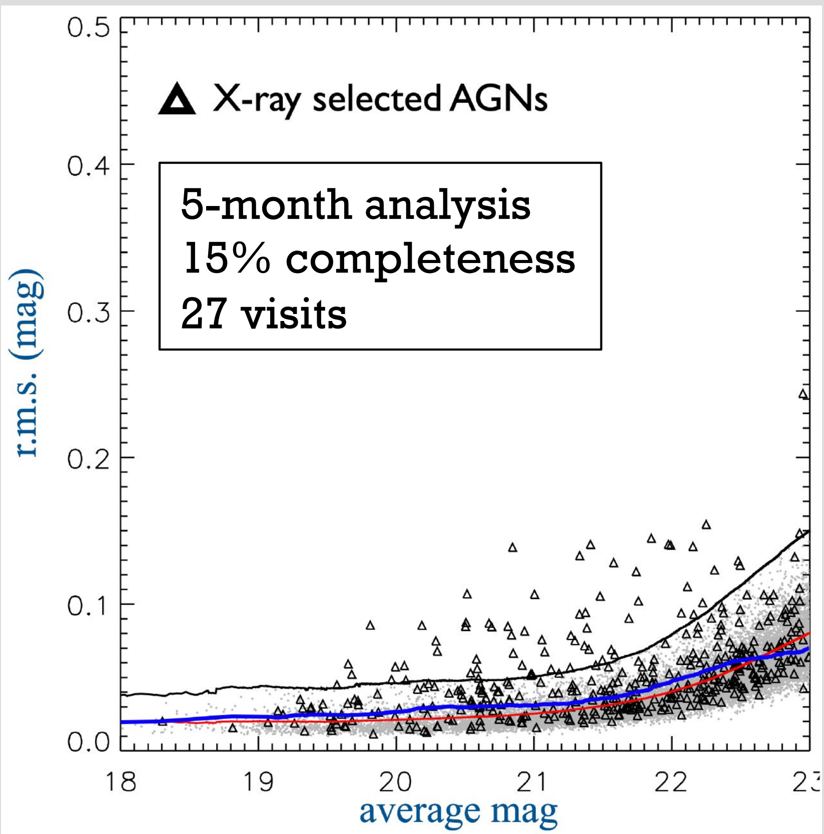
- 55-185 visits per band over 10 yr
- Highly effective complement to color selection
- Helps find AGNs when $L_{\mathrm{AGN}} \sim L_{\mathrm{host}}$

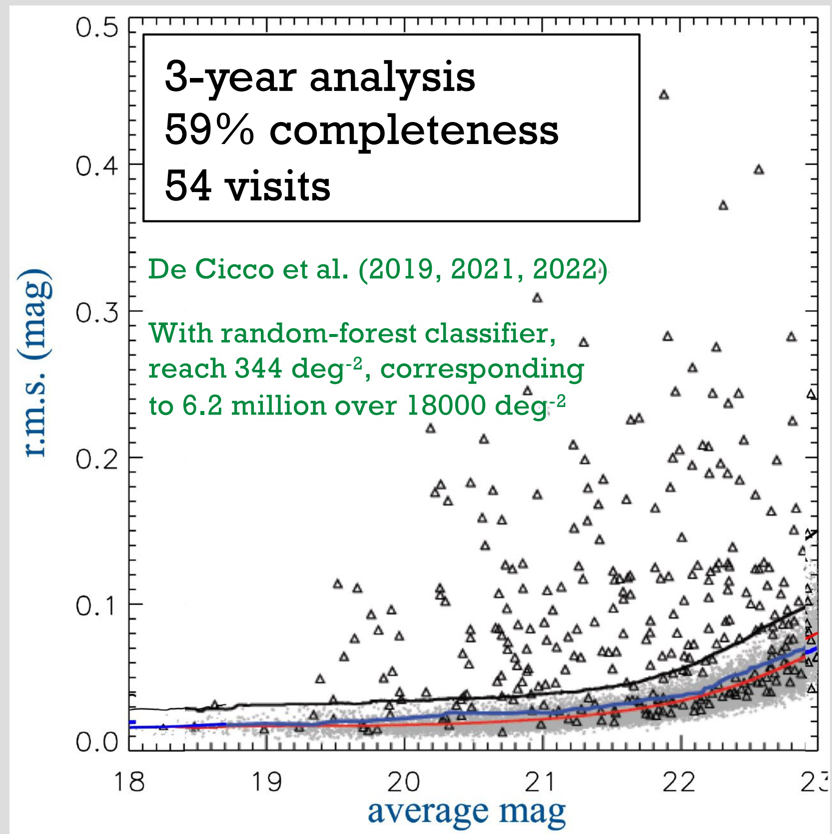
Astrometry - Lack of proper motion and differential chromatic refraction

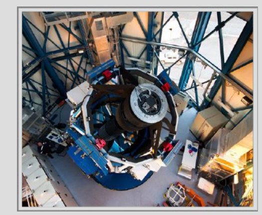
- Will reach ~ 1 mas yr^{-1} at $r \sim 24$
- Minimizes confusion with stars

Optical Variability Selection of X-ray AGNs in COSMOS

Long Baselines and Many Epochs Greatly Aid AGN Selection (*r* band)





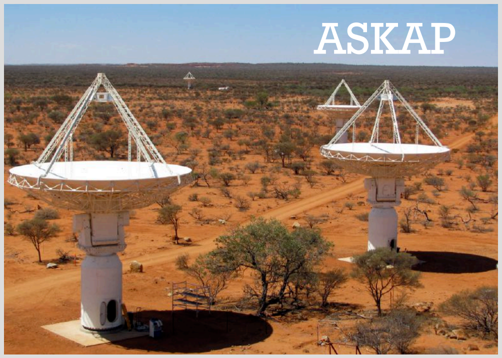


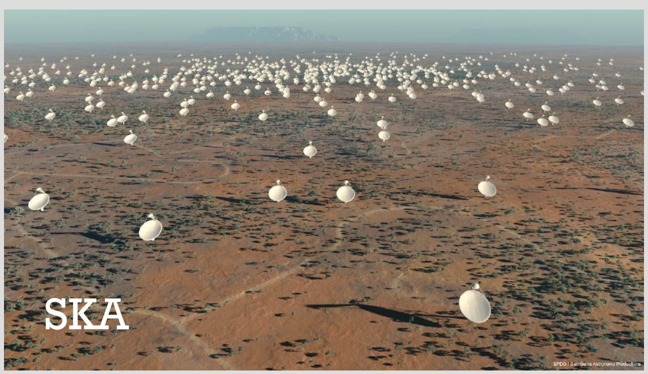
VST

LSST will do even better with 10 yr baseline, more visits, deeper visits, and more bands.

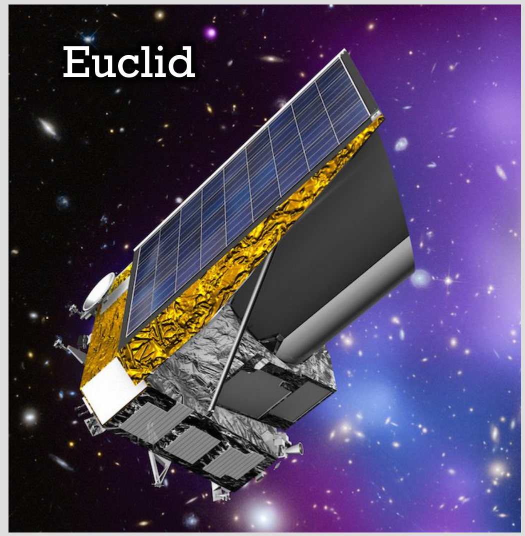
Power of LSST and Multiwavelength Data

L_{R}, q_{24}, α_{r}, morphology

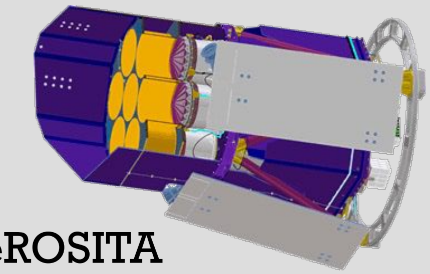




Infrared-optical colors



L_{X}, $L_{\mathrm{X}}/L_{\mathrm{O}}$, and Γ_{X}



eROSITA

Aim to detect 20-50+ million AGNs with LSST + multiwavelength data reaching to $z \sim 9$-10.

AGN Variability Investigations

Massive AGN Variability Studies

Millions of 10-year, well-sampled, high-SNR, multicolor AGN light curves, (billions of photometric measurements).

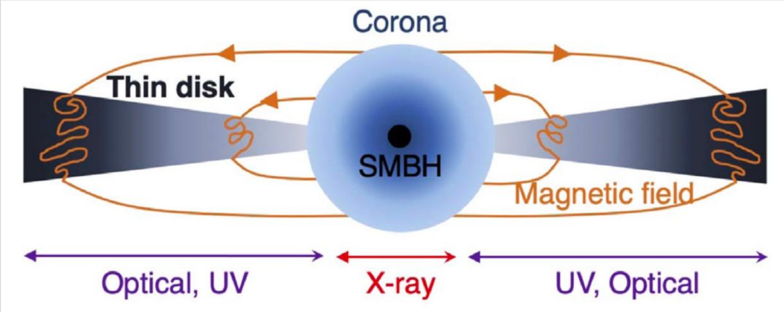
Even better sampling and SNR for ~ 60,000 AGNs in the DDFs.

Combine with DES, VST, ZTF, HSC, Pan-STARRS, SDSS for longer baselines.

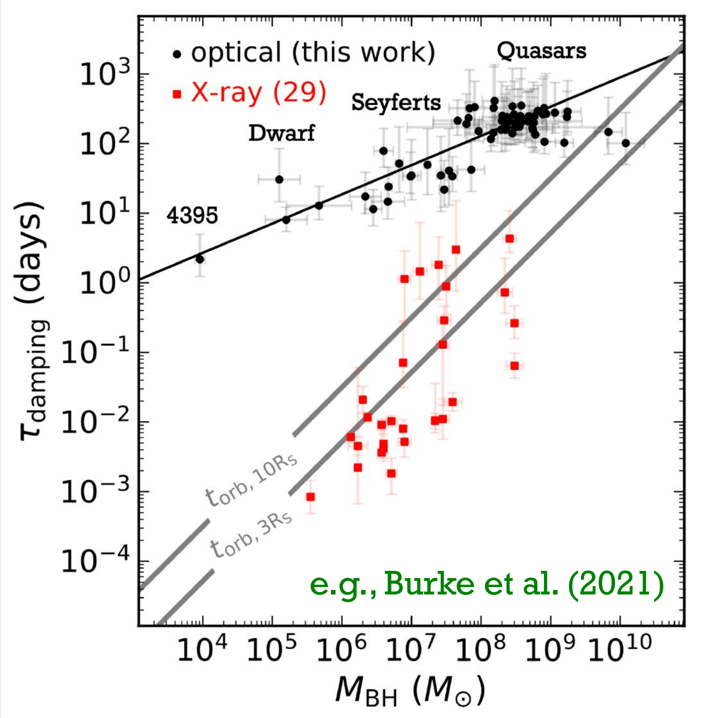
Improving statistical models for variability (with parameters) ⟷ Improving physical disk/AGN models (with parameters)

CARMA (DRW, DHO)
CARIMA
CARFIMA
Multi-process

Mass
Accretion rate
Spin
Magnetic field
Critical radii



e.g., CHAR (Sun et al. 2020)

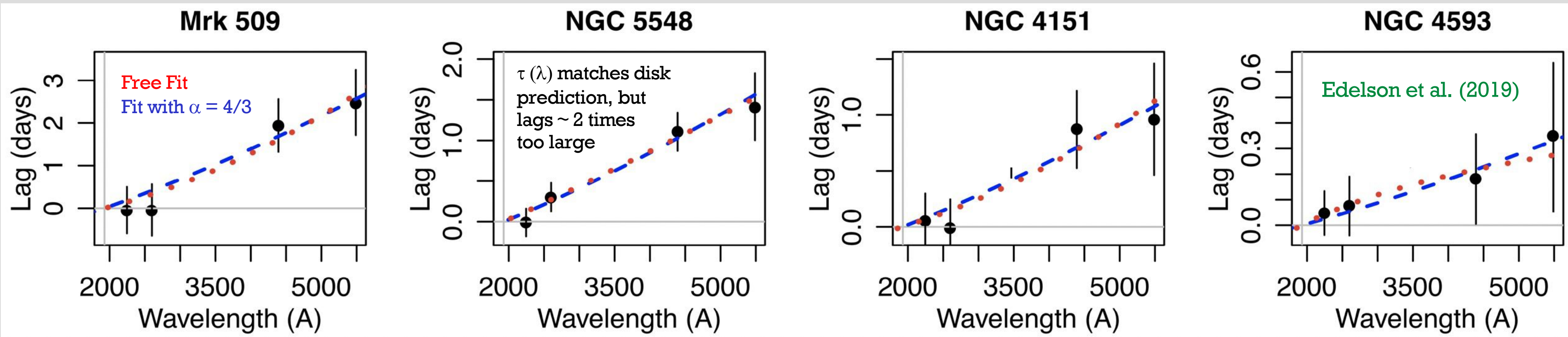


e.g., Burke et al. (2021)

Reverberation

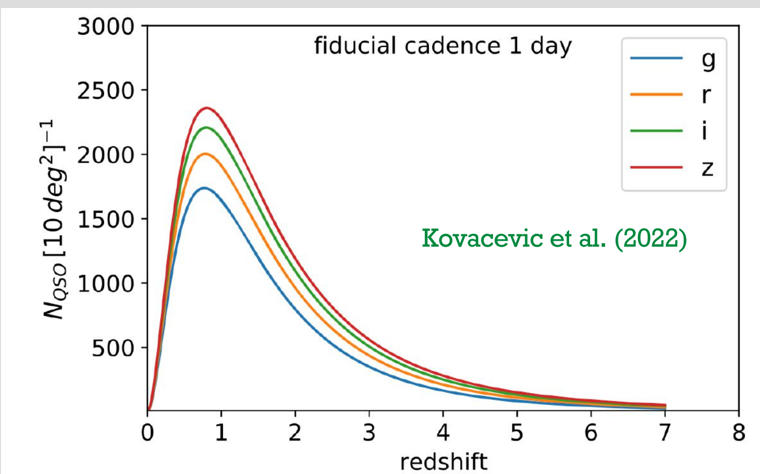
Continuum Reverberation of “Disks”

Continuum Reverberation Lags from Swift

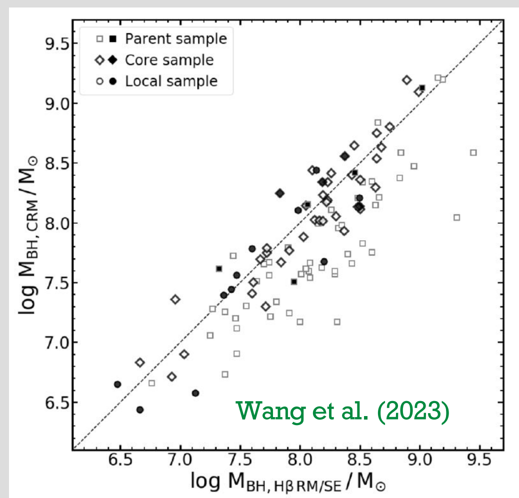


Significant contribution from diffuse BLR emission?

Rubin Forecasting



BH Masses from Continuum RM?



Also ”long lags” from inward-moving accretion (e.g., Yao et al. 2022)

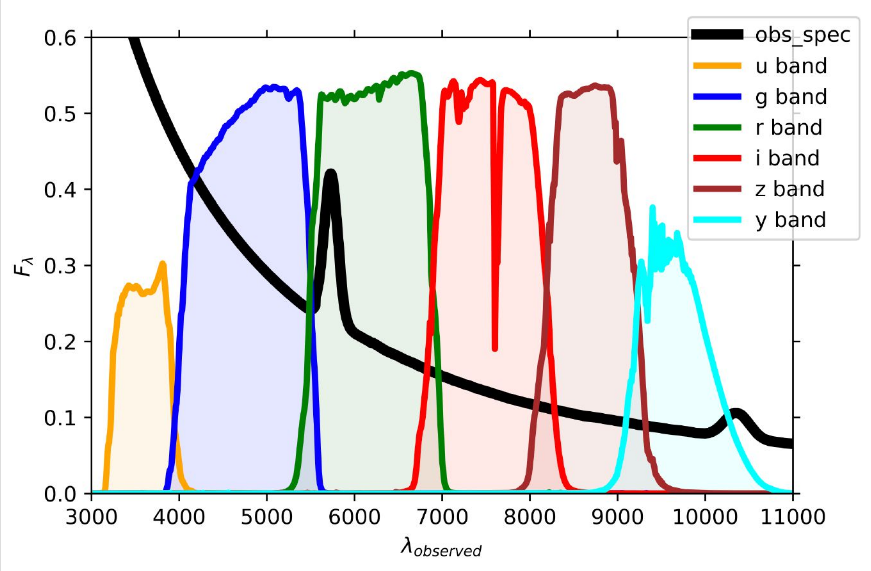
LSST can perform quality continuum RM for ~ 1100 AGNs per DDF.

LSST Reverberation of BLR

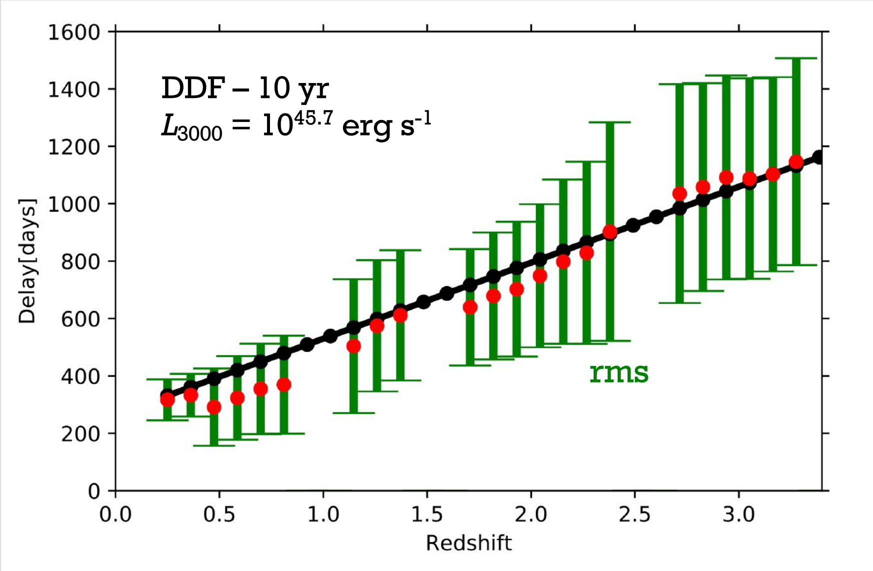
Time delays of emission lines vs. continuum can be measured, in some cases, from LSST photometric data alone.

The approach is best applied on average for large statistical samples, and numerical simulations can correct for systematic offsets.

Simulated Spectrum
(z = 2.7) with LSST Filters



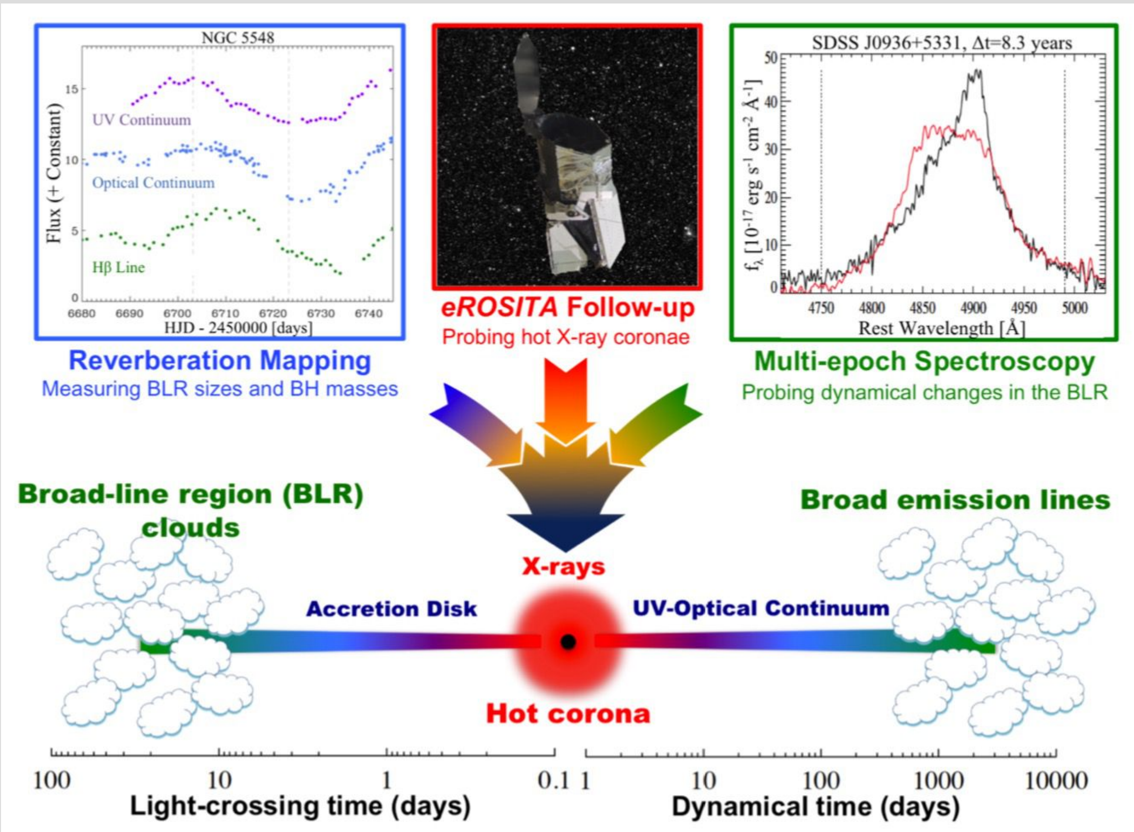
Adopted vs. Recovered
Time Delays



e.g., Czerny et al. (2023)

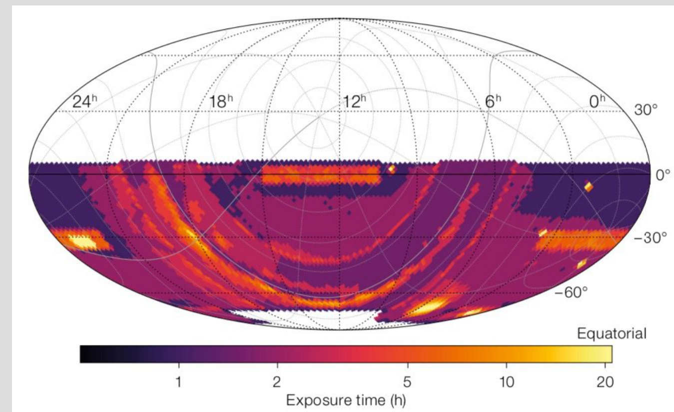
LSST + Spectroscopic Reverberation of BLR

SDSS-V Black Hole Mapper is Reverberation Mapping AGN BLRs in 3 LSST DDFs: 2020-2027



4MOST TiDES Component in LSST DDFs: 2025-2030

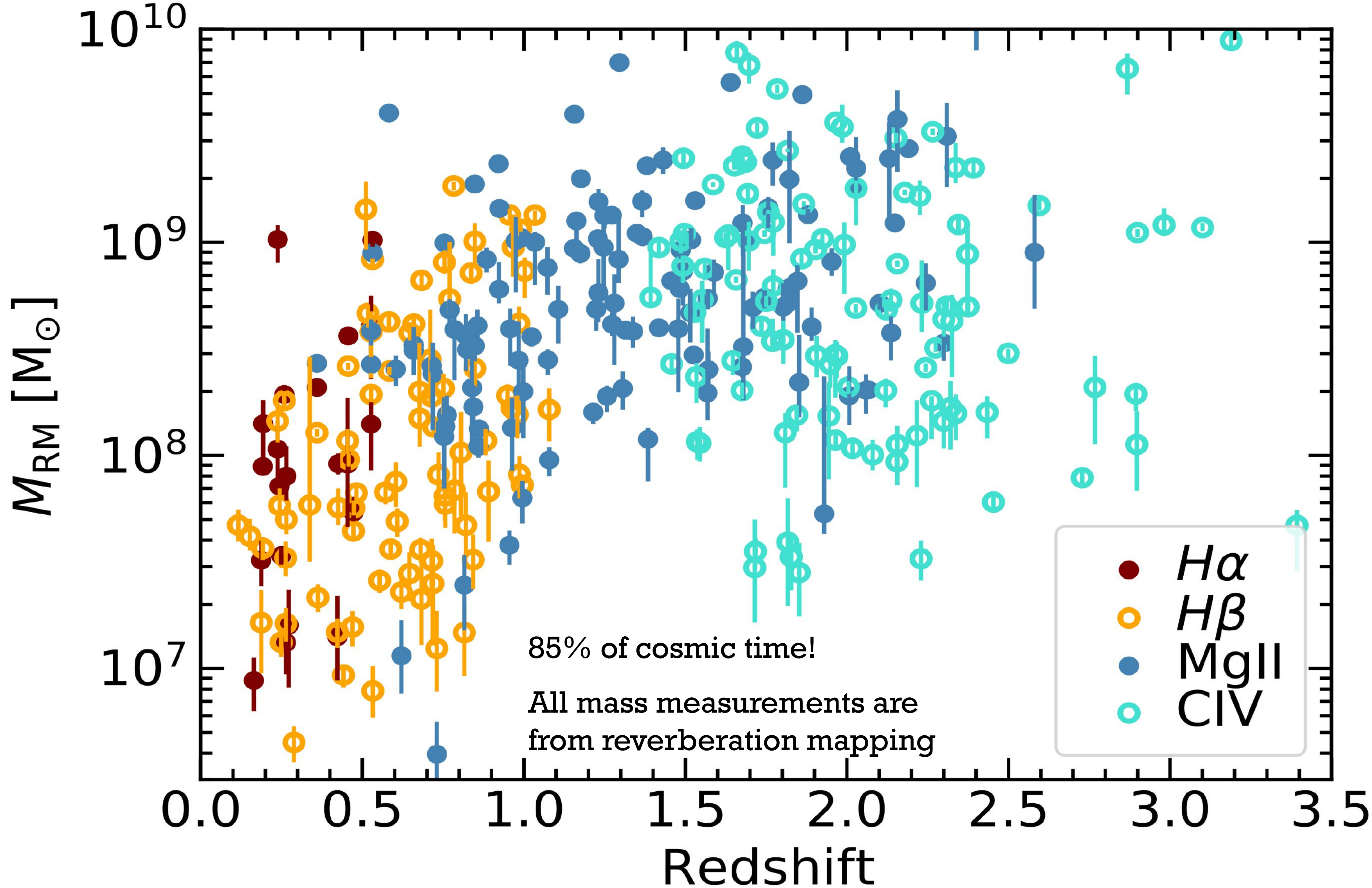
Location	Area (square degrees)	Average t_{exp} (hours)
Bulge and Inner Galaxy	500	4–6
Magellanic Clouds	200–300	2–10
WAVES-Wide	1300	3–4
WAVES-Deep	50	7
LSST Deep Drilling Fields	4 × 4.2	4 × 60 (or more)
South Ecliptic Pole area	300	4



Guiglion et al. (2019)

LSST will provide ~ 900 epochs of outstanding *grizy* photometry (also *u*) to aid BLR reverberation mapping.

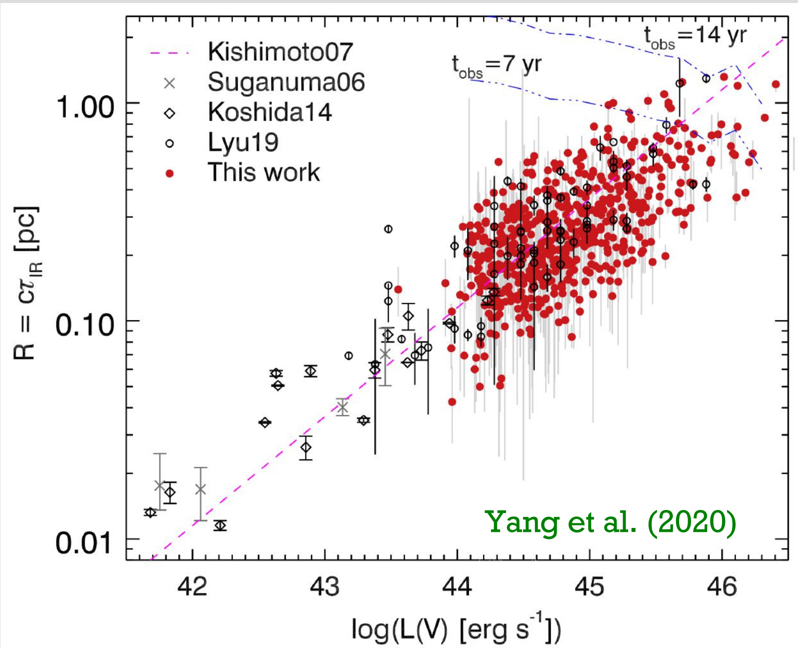
300 M_{BH} from SDSS-RM



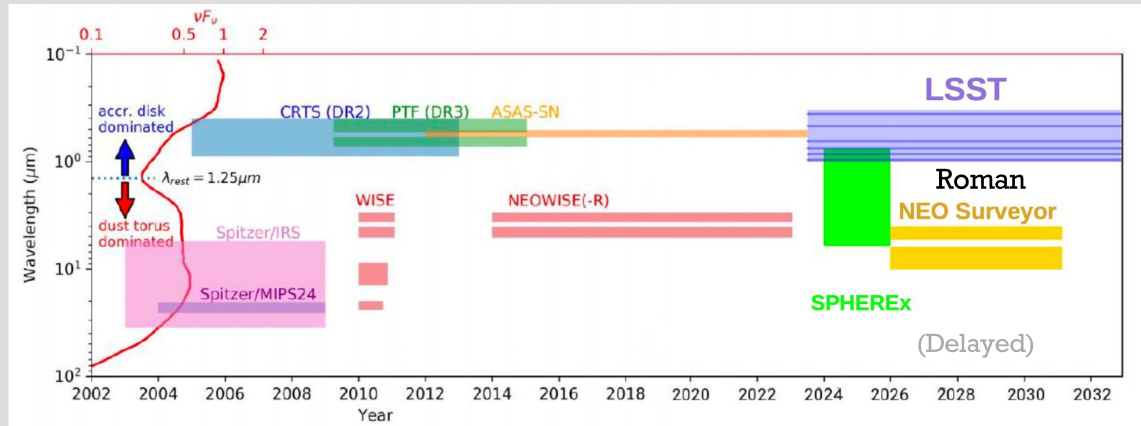
Shen et al. (2016, 2023); Grier et al. (2017, 2019); Homayouni et al. (2020)

LSST + Infrared Reverberation of Torus

Torus Size vs. Luminosity



Facilities for Torus Reverberation



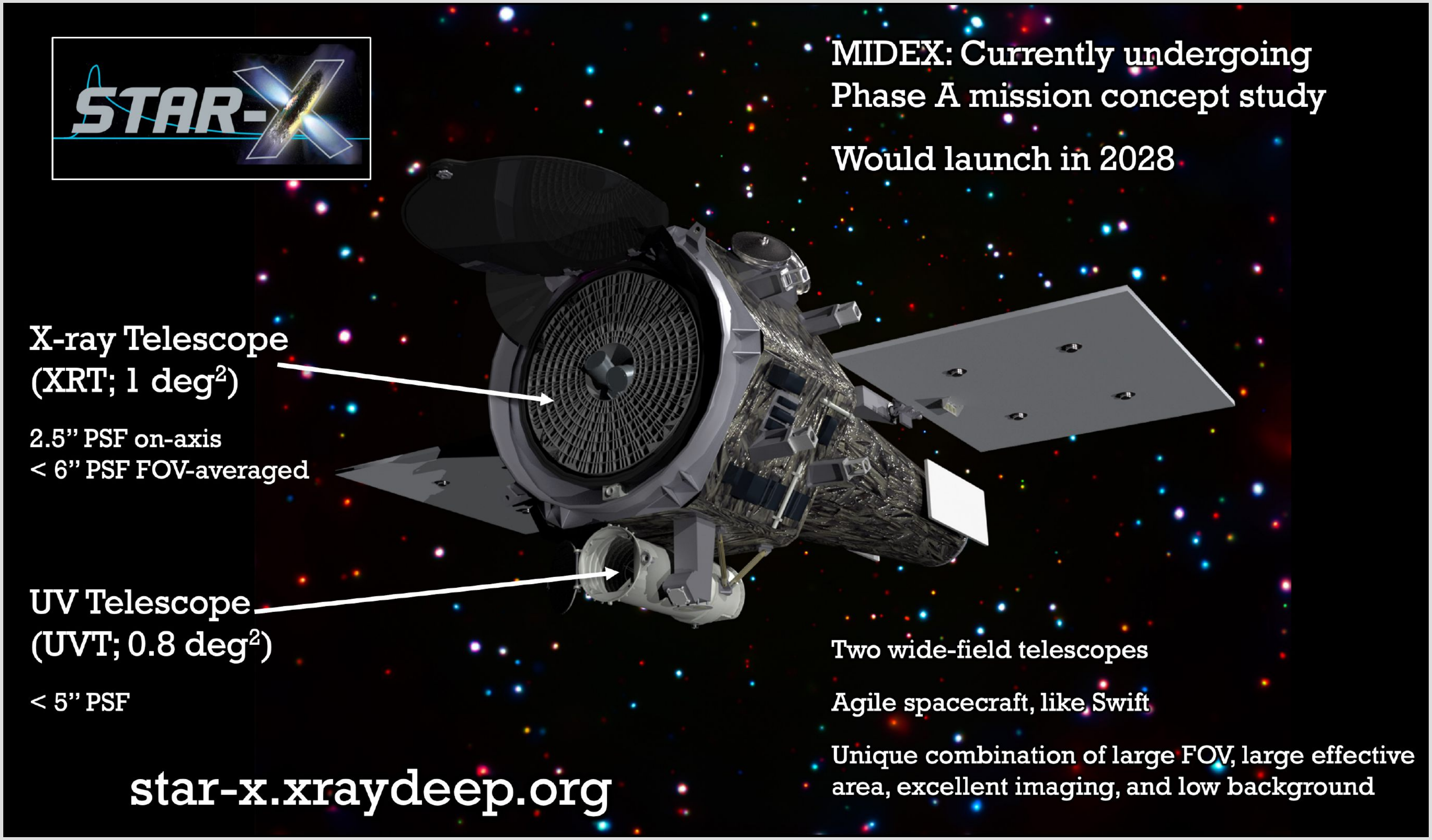
Lyu et al. (2019, 2021)

Tens of thousands of AGNs will have sufficient optical and infrared data for torus RM from LSST, SPHEREx, NEO Surveyor, Roman, and earlier facilities.

Can look for additional R_{Torus} dependences – e.g., Eddington ratio.

In high-SNR cases, can look for multiple lags (e.g., graphite vs. silicate sublimation), receding torus effects, and secular torus evolution.

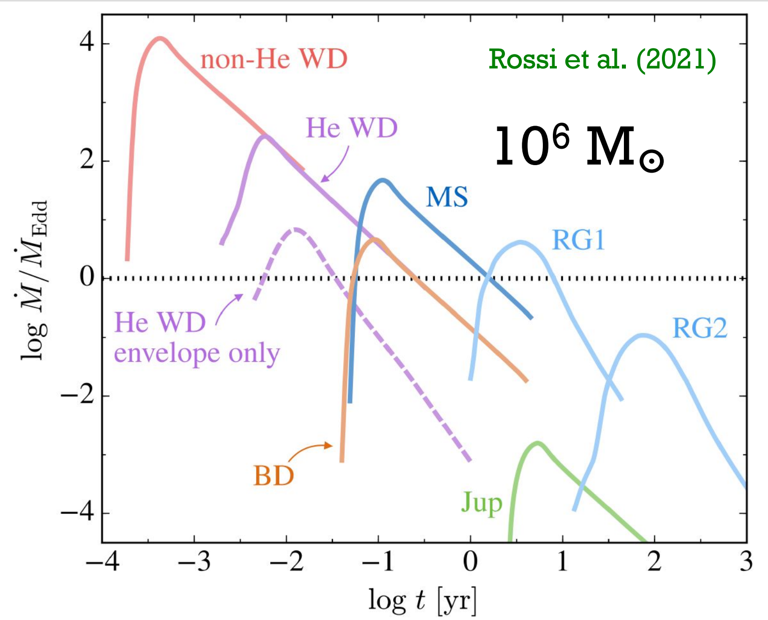
LSST + X-ray/UV from STAR-X

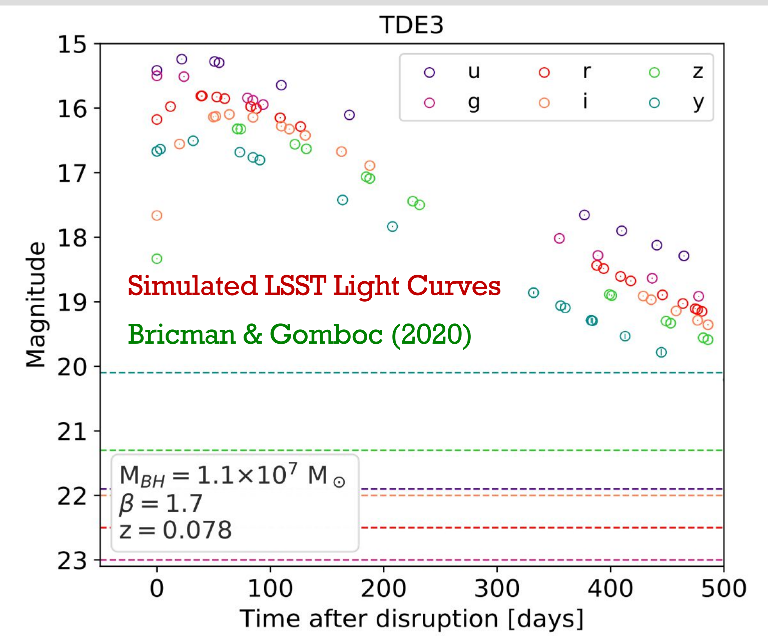


STAR-X would add daily X-ray/UV monitoring of the prime areas of the Deep-Drilling Fields for 2+ years - see talk by Roberto Gilli.

Remarkable Variability Modes with Good Source Statistics

Tidal Disruption Events





Now being found in wide-field optical/UV and X-ray surveys.

LSST forecasted to discover 10-20 per night, though will need to avoid SNe confusion.

Will provide sufficient source statistics to fill the (apparently large) TDE parameter space.

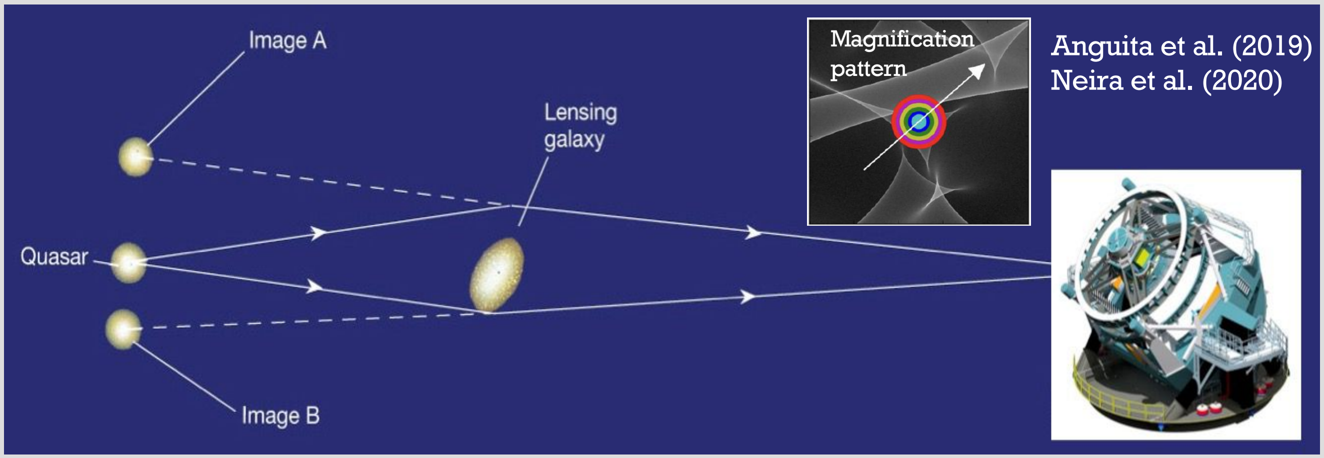
Rates as functions of galaxy type and redshift.

Understand diversity of these events ($L_{\rm Bol}$, kT, jet power).

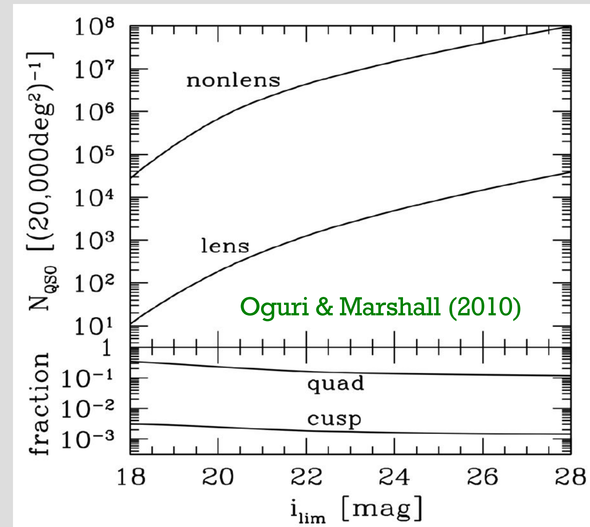
Find remarkable events - e.g., white-dwarf disruptions by IMBH, giant-planet disruptions, gas-cloud captures.

Microlensing of Accretion Disks

Gravitational Microlensing Geometry



Expected Macro-Lensed AGNs



Rubin will monitor ~ 3000 AGNs macro-lensed into ~ 7500 images.

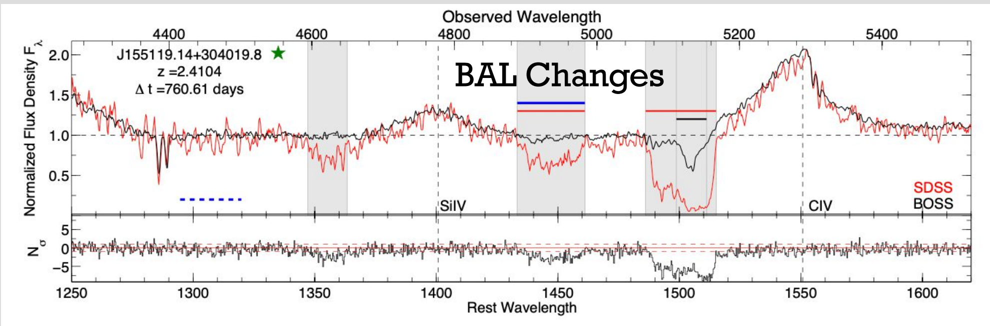
About one high-magnification (Δmag > 1) microlensing event expected daily – effective nas resolution imaging of accretion disk for size and emission profile constraints.

Typical event durations of 10-100 days.

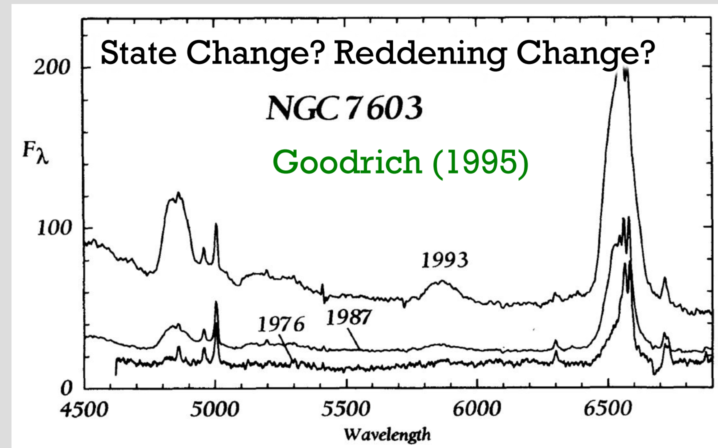
For good light curve coverage, will often need additional monitoring observations.

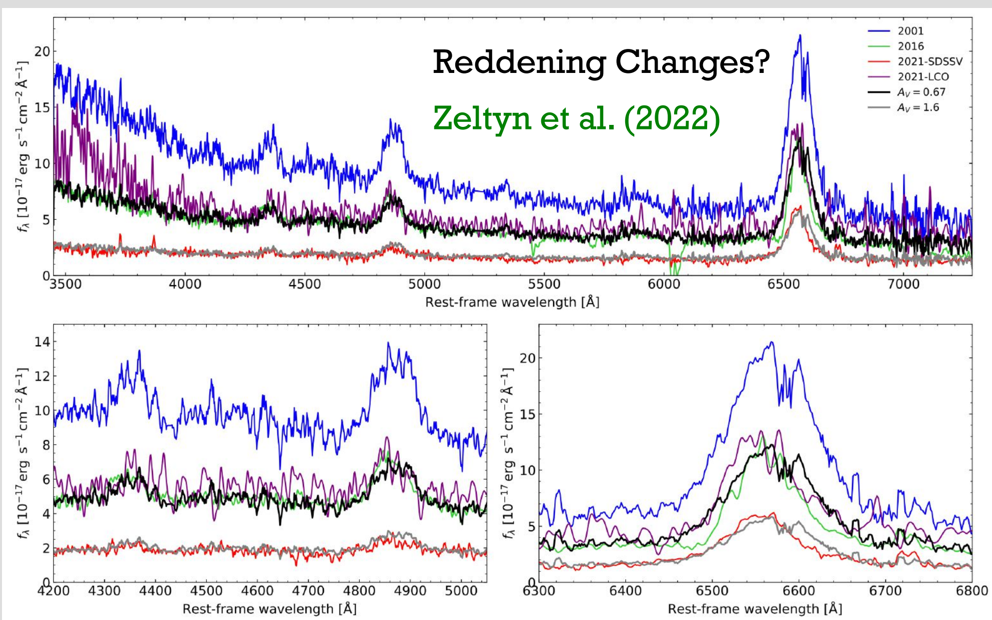
Changing Obscuration and State

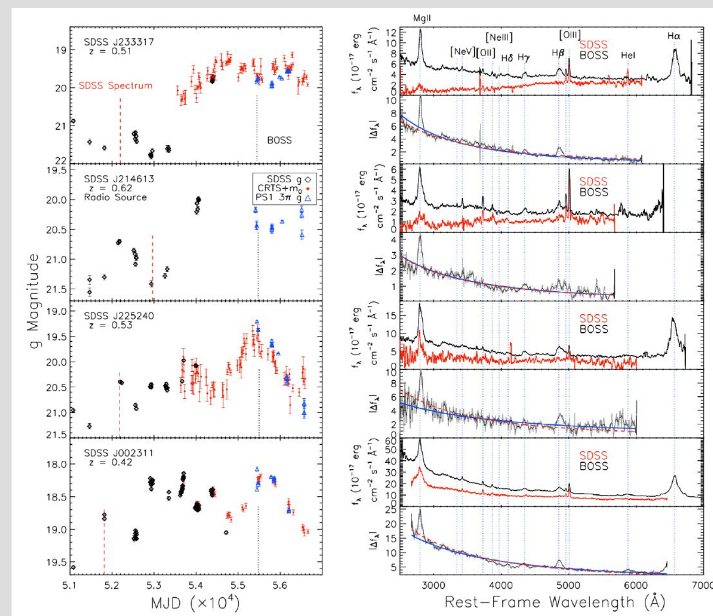
Rubin anomaly monitoring can trigger rapid spectroscopic and multiwavelength follow-up studies.



Filiz Ak et al. (2012)







State Changes

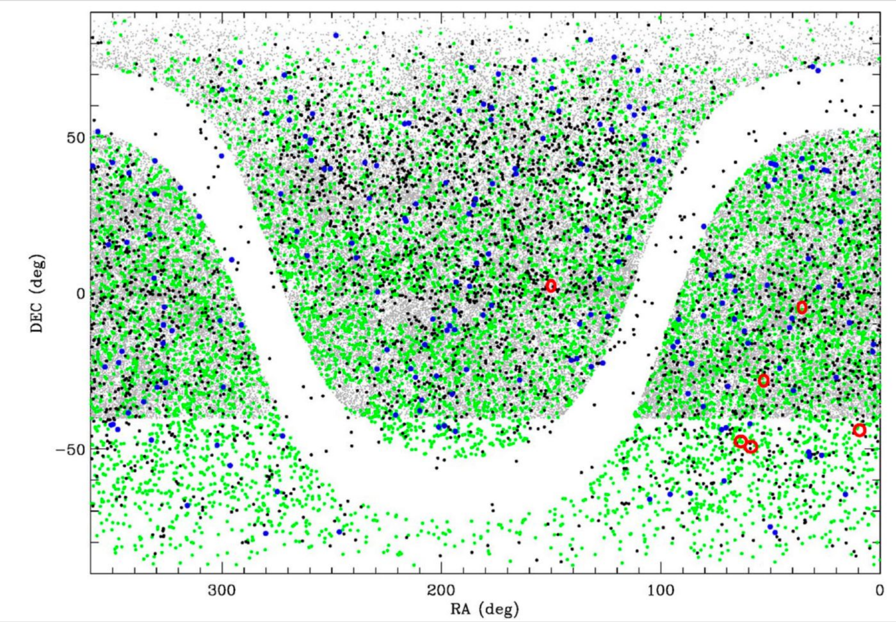
MacLeod et al. (2016)

Blazar Variability Monitoring

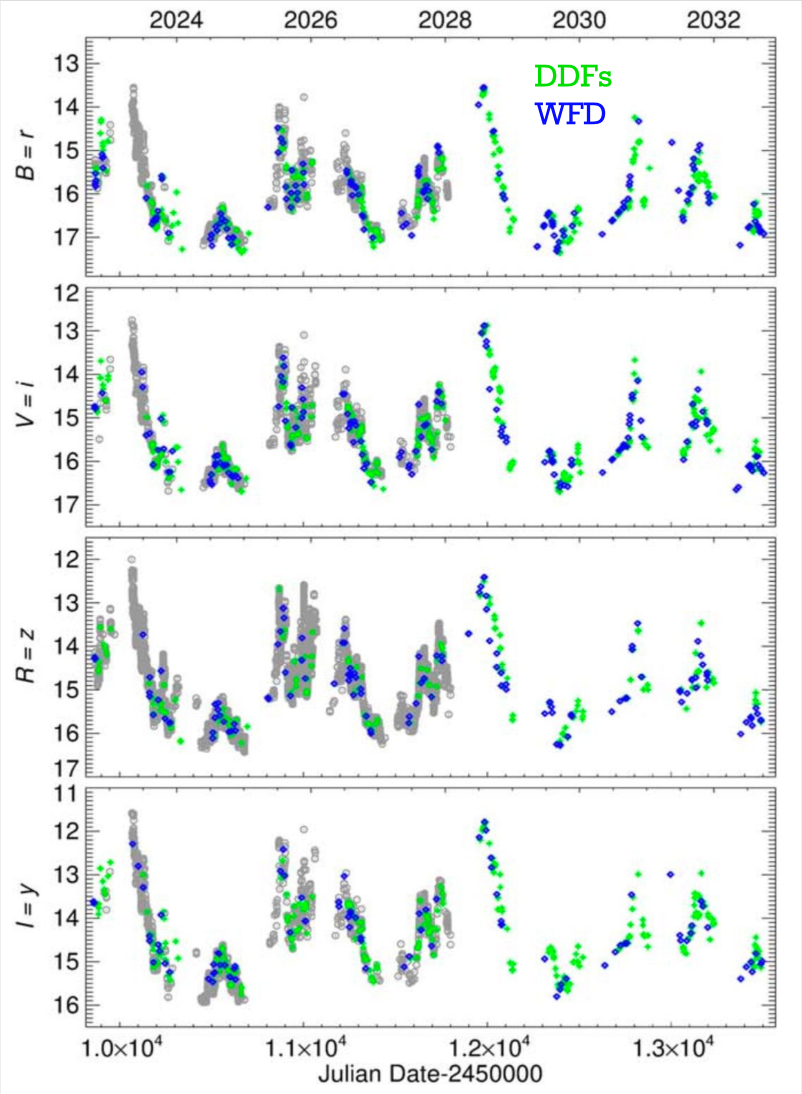
LSST will monitor ~ 60,000 blazars in the main survey and ~ 150 in the DDFs.

Will allow follow-up of strong nonthermal flares, jet QPOs from kink instabilities, etc.

BZCAT5 Blazars and Other Blazar Candidates



Simulated LSST Blazar Sampling



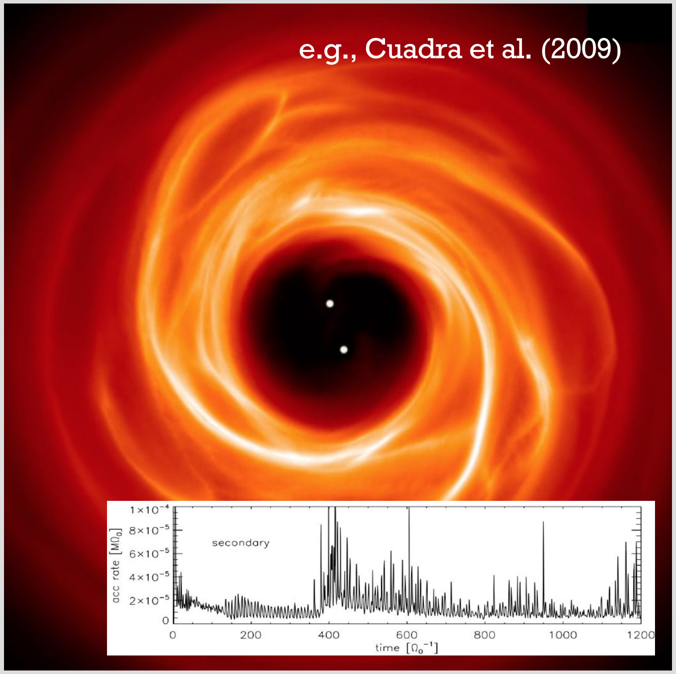
Raiteri et al. (2022)

Small-Separation Binary SMBH

To move from pc to 10^{-3} pc separations, likely need accretion to remove $L=mvr$.

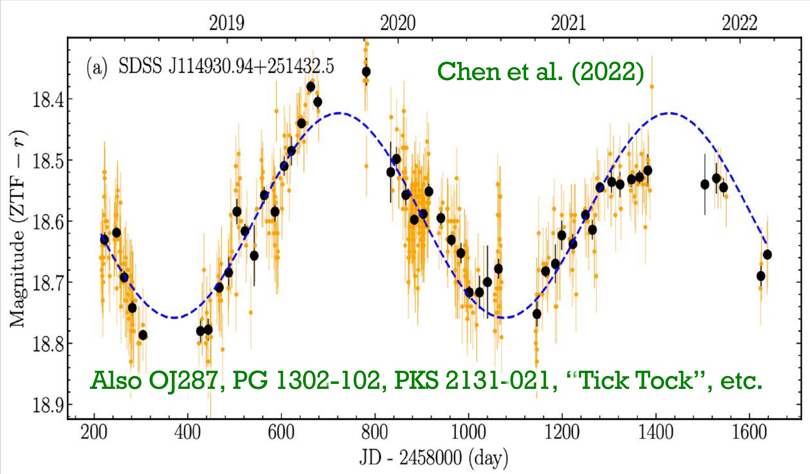
Accretion rate onto both SMBHs varies on timescales of the binary period, and also have Doppler boosting.

Month-to-year timescales at ~ 10^{-2} pc, well-suited to LSST monitoring.



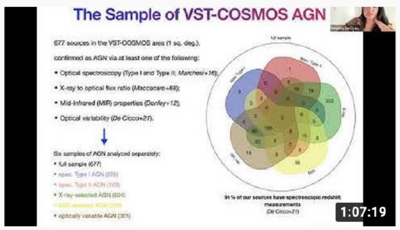
About 250 candidates put forward already (includes many false positives).

LSST forecasts span few hundred to tens of thousands, including valuable short-period systems (e.g., Witt et al. 2022).



More Science Examples

About 20 Hours of Science Talks on YouTube from 2020, 2021, and 2022 Summer Meetings



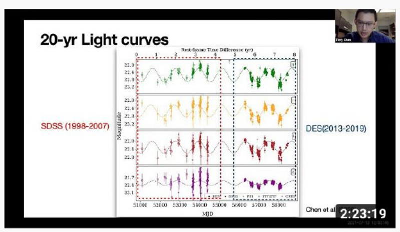
Supermassive Black Hole Studies with the Legacy Survey of Space and Time: 2021 - Part 3 of 6

111 views • 11 months ago

Niel Brandt

This is a recording of a meeting titled "**Supermassive Black Hole Studies** with the Legacy Survey of Space and Time: **2021**" held ...

Predictions | Sample of Nonverbal Sources | Structure of the Agn | Accretion Disk — 4 moments

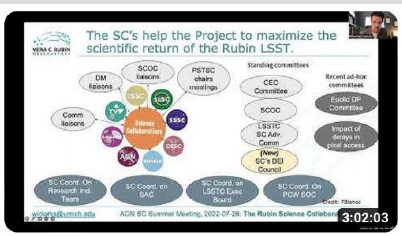


Supermassive Black Hole Studies with the Legacy Survey of Space and Time: 2021 - Part 4 of 6

174 views • 11 months ago

Niel Brandt

This is a recording of a meeting titled "**Supermassive Black Hole Studies** with the Legacy Survey of Space and Time: **2021**" held ...



Supermassive Black Hole Studies with the Legacy Survey of Space and Time - 2022 - Part 1 of 3

235 views • 10 months ago

Niel Brandt

This is a recording of a meeting titled "**Supermassive Black Hole Studies** with the Legacy Survey of **Space** and **Time** - 2022: ...

Introduction | Will Clarkson | Ribbon Observatory Science Collaborations | Science Collaborations |... 17 moments

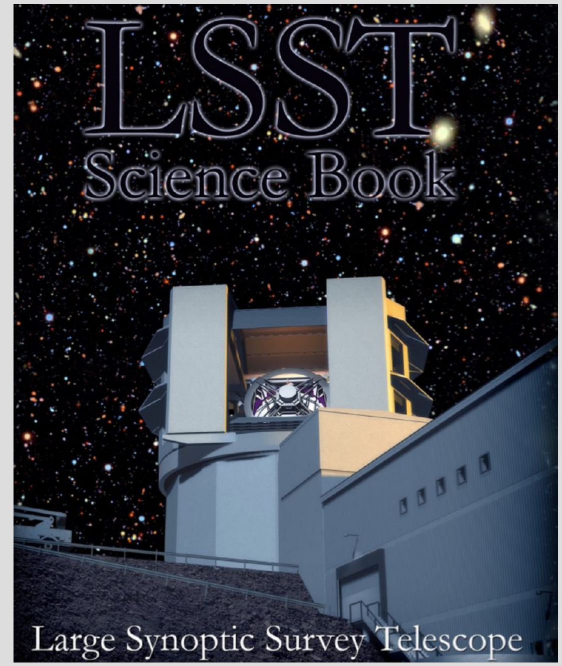
Supermassive Black Hole Studies with the Legacy Survey of Space and Time - 2022 - Part 3 of 3

141 views • 10 months ago

Niel Brandt

This is a recording of a meeting titled "**Supermassive Black Hole Studies** with the Legacy Survey of **Space** and **Time** - 2022: ...

Summary of the Submissions to the Data Challenge | Classification Accuracy | Updates to the Dat... 20 moments



(See Chapter 10)

LSST AGN Science Collaboration

agn.science.lsst.org

The LSST AGN Science Collaboration

The AGN Science Collaboration (SC)

Presently 181 members - largest national memberships:

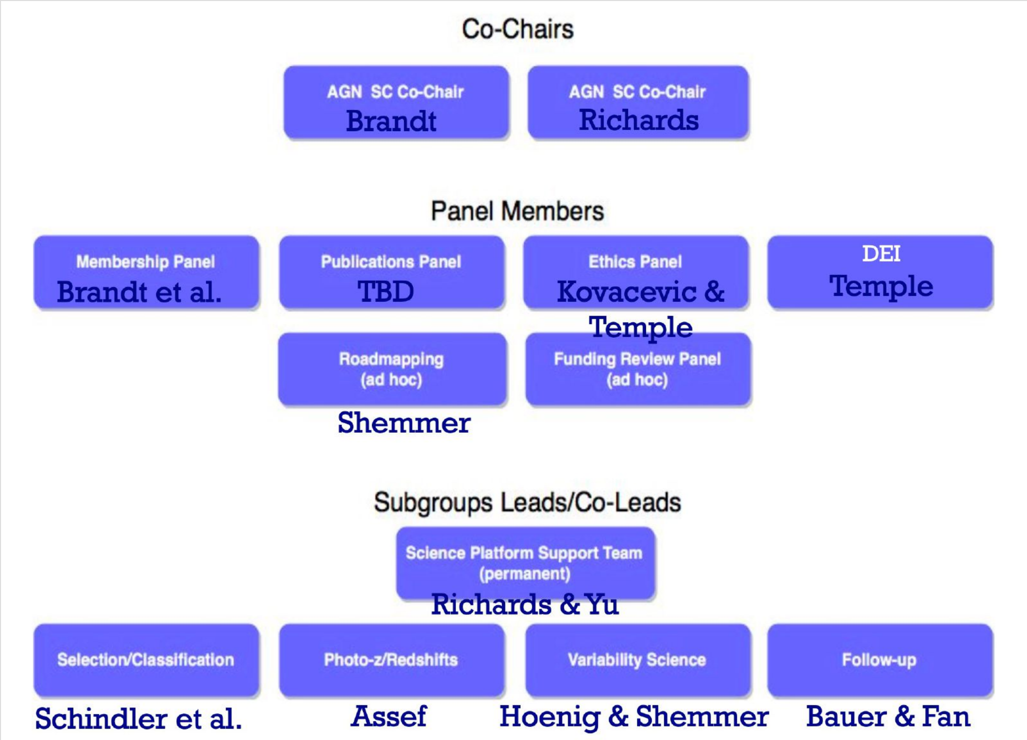
Country	Number of Members
USA	82
Brazil	17
Italy	17
UK	14
Chile	12
Serbia	9
Australia	5
Germany	5
Argentina	4
Poland	4

New members are welcome!

But note that AGN SC membership does not give data rights.

Overall SC Organization

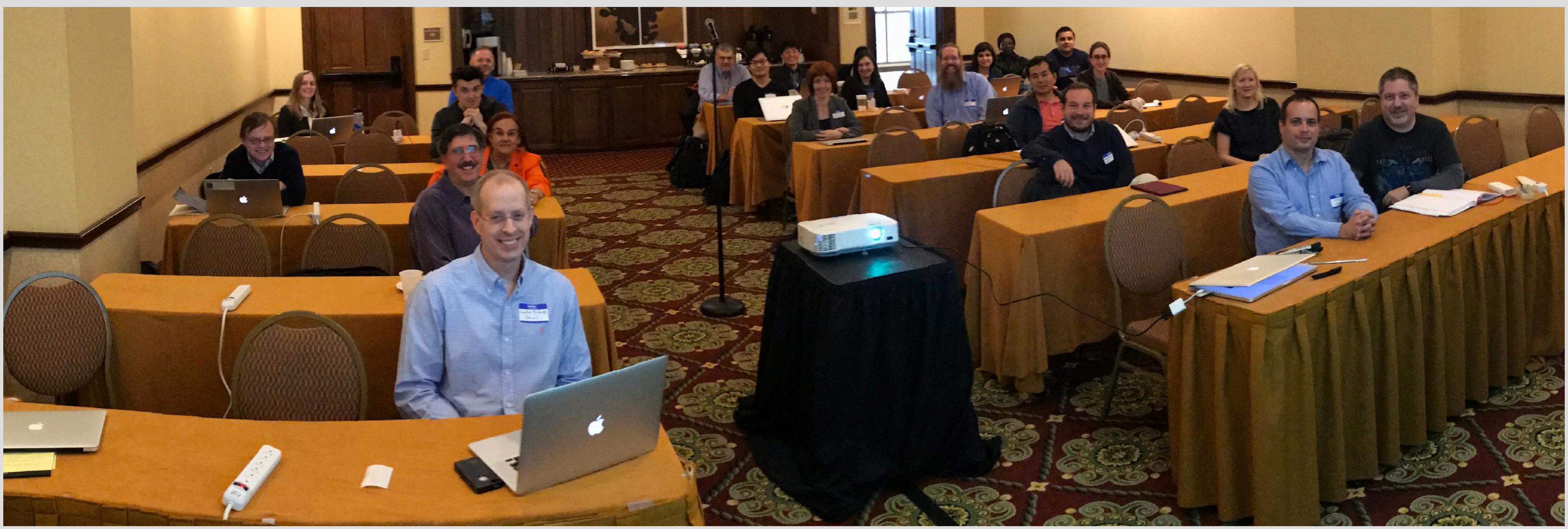
Organization Chart with Leader/Coordinator Names Listed



Also:

- In-kind coordinators – Hoenig & Coppi
- SCOC liaison for AGN SC – Bauer
- Users committee – Ni & Villar

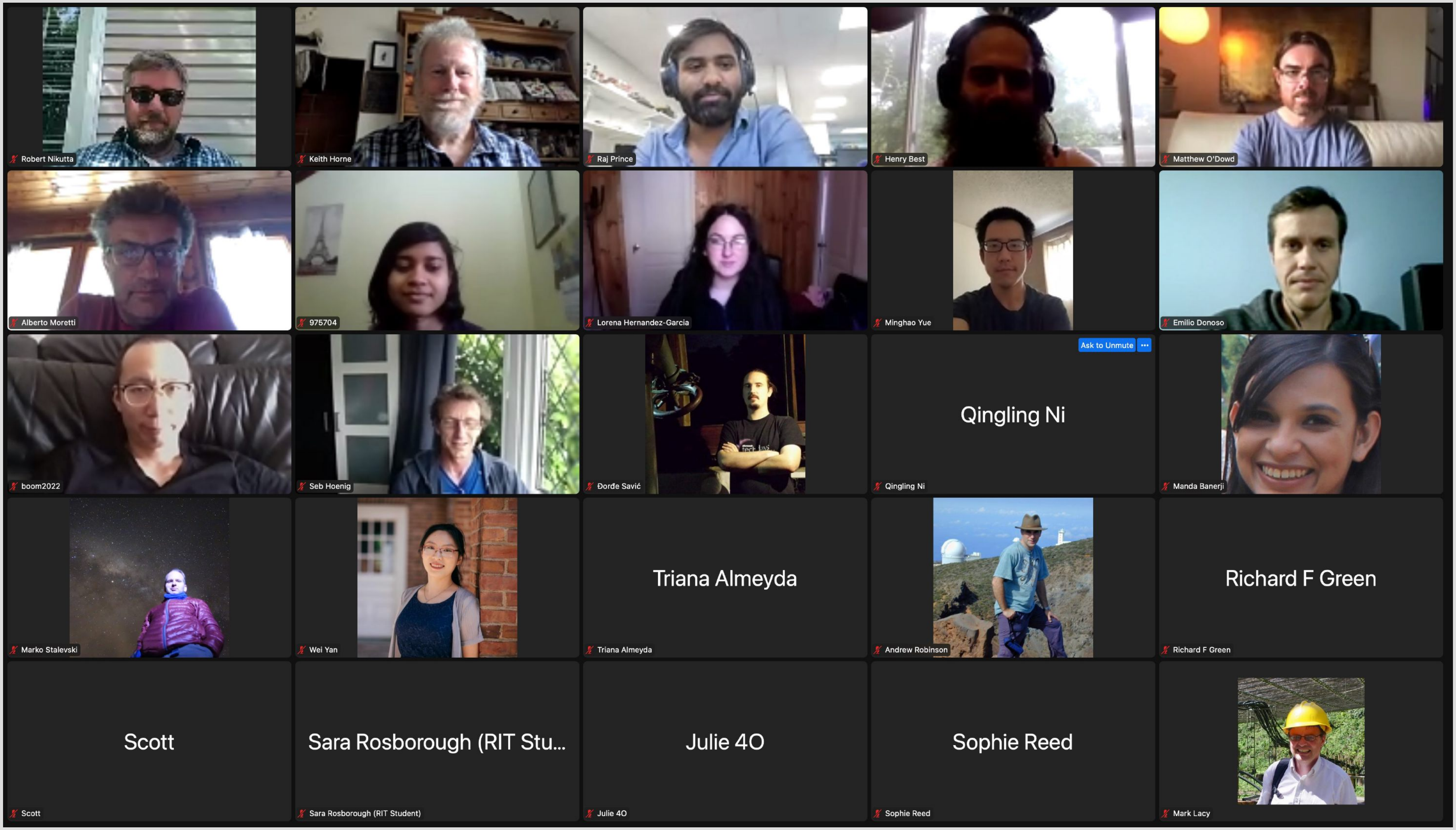
2017 January - Grapevine, Texas



2022 Summer Meeting - 1

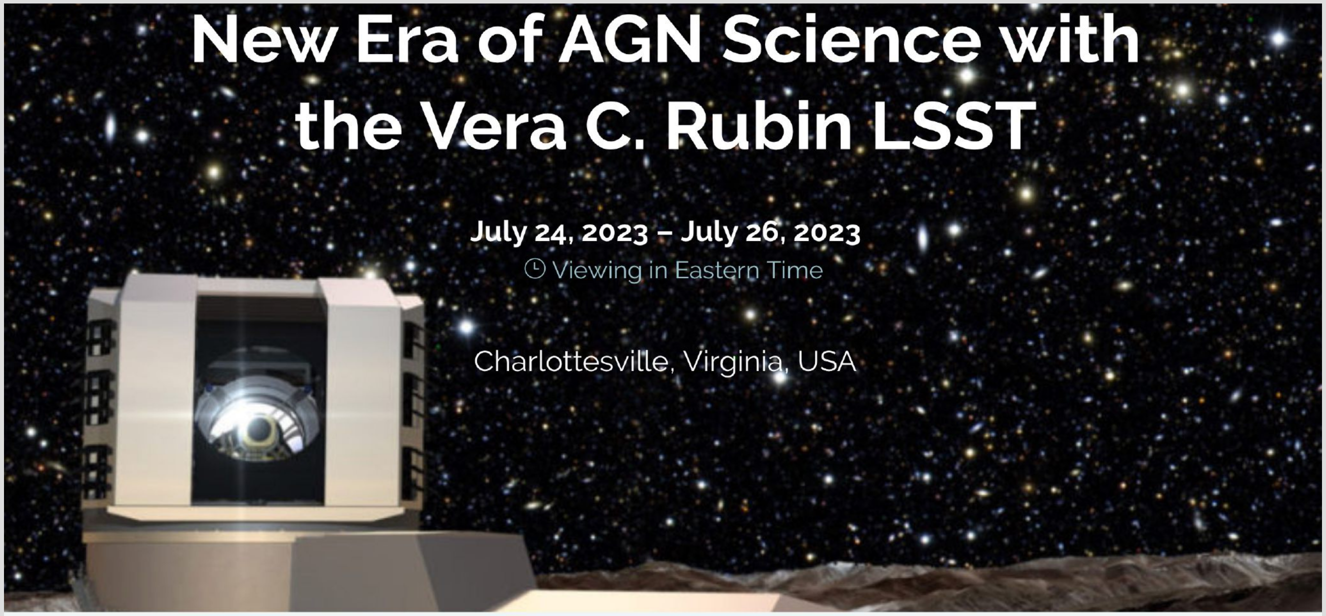
Full recording is on YouTube

2022 Summer Meeting - 2



Full recording is on YouTube

2023 July Meeting – In-Person



Updates

"Program" page updated with the scheduled talks and abstracts

Hotel reservation instruction (download)

Overview

The Legacy Survey of Space and Time (LSST), to be conducted by the Vera C. Rubin Observatory beginning in 2025, will enable studies of the growing supermassive black holes (SMBHs) in active galactic nuclei (AGNs) on a truly massive scale. This workshop will enable the LSST AGN Science Collaboration (AGN SC) to (1) continue building up the effort of the AGN SC to prepare for the LSST operations in 2025 and (2) broaden the participants and interests from early career scientists by introducing the LSST AGN SC and having an interactive discussion on various aspects of AGN science in the LSST era. **Although this meeting will be an in-person meeting to encourage productive discussion and foster collaborative projects, the presentation will be recorded (with agreement) and posted later.**

Your attendance is welcomed!

LSST AGN Cadence Notes

LSST AGN SC Cadence Note: Type-1 Quasar Colors in the Context of Photometric Redshifts

Roberto J. Assef, Matthew Temple (UDP), Gordon Richards, Weixiang Yu (Drexel), and Franz Bauer (PUC) – on behalf of the AGN SC

1. EXECUTIVE SUMMARY

We have developed two metrics to evaluate the 10yr co-added depths expected for each band in the context of photometric redshifts for type-1 quasars as function of OpSim runs from FBS 1.5, 1.6 and 1.7. Each metric focuses on a different aspect. The first one focuses exclusively on the depth expected for u-band with the aim of detecting the SED break short of Lyα. The second one compares the depths of contiguous bands in wavelength to the expected colors of type-1 quasars. In both cases, while we find that some OpSim runs perform better than others, we do not find any of them to be critically detrimental for type-1 quasar photometric redshifts in the context of these metrics, although we remark on the usefulness of having as deep u-band coverage as possible.

LSST CADENCE NOTE: BLAZAR VARIABILITY

C. M. Raiteri[1,2], M. I. Carnerero[1], B. Balmaverde[1] (*INAF-OATo, Italy*), F. D'Ammando[1,2] (*INAF-IRA, Italy*), M. Paolillo[1,2] (*Napoli Univ., Italy*), I. Yoon[2] (*NRAO, USA*), E. Bellm[1] (*Washington Univ., USA*), W. Clarkson[3] (*UM-Dearborn, USA*)

April 15, 2021

[1]TVS, [2]AGN, and [3] SMWLV Science Collaborations

Active Galaxy Science in the LSST Deep-Drilling Fields: Additional Points on Footprints, Cadence Requirements, and Total-Depth Requirements

W.N. Brandt (Penn State), Y. Homayouni (STScI), Q. Ni (Penn State), G. Yang (Texas A&M), F. Zou (Penn State), S.F. Anderson (Univ Washington), R. Assef (Univ Diego Portales), F.E. Bauer (Pont Univ Catolica), A. Bongiorno (Oss Ast Roma), F. D'Ammando (INAF – Inst Rad), G. Fonseca Alvarez (Univ Conn), C.J. Grier (Univ Arizona), P.B. Hall (York Univ), S. Hoenig (Univ Southampton), K.D. Horne (St Andrews), D. Ilic (Univ Belgrade), A.M. Koekemoer (STScI), A. Kovacevic (Univ Belgrade), M. Lacy (NRAO), J. Li (Univ Illinois), M. Paolillo (Univ Naples Fed II), L. Popovic (Ast Obs Belgrade), C.M. Raiteri (Oss Ast Torino), G.T. Richards (Drexel Univ), D.P. Schneider (Penn State), Y. Shen (Univ Illinois), M. Sun (Xiamen Univ), B. Trakhtenbrot (Tel Aviv Univ), J.R. Trump (Univ Conn), C. Wolf (ANU), Y.Q. Xue (USTC), W. Yu (Drexel Univ), Z. Yu (Ohio State), on Behalf of the Rubin LSST Active Galactic Nuclei Science Collaboration

LSST AGN SC Cadence Note: Non-Parametric Structure Function Metric

Weixiang Yu and Gordon Richards – on behalf of the AGN SC

1. EXECUTIVE SUMMARY

We have developed a model-independent metric ("SFErrorMetric") to assess the level to which we can derive the "structure function" of variable sources (e.g., AGNs) in LSST as a function of OpSims from versions FBS 1.5, 1.6 and 1.7. No presumptions about the actual underlying process that is responsible for the observed variability are used in this metric; this metric depends solely on the survey parameters (e.g., number of visits). Most of the survey simulations being considered for LSST operations performed equally well, with one exception being the `u_long` family, which significantly enhance this metric in the u-band without inducing observable drawbacks in other filters. Thus, we would favor longer u-band exposure time if the total number visits in the u-band can stay relatively unchanged.

LSST AGN SC Cadence Note: Two metrics on AGN variability observables

Andjelka Kovačević, Dragana Ilić, Isidora Jankov, Luka Č. Popović, Ilsang Yoon, and Viktor Radović, Neven Caplar, Iva Čvorović-Hajdinjak – on behalf of the AGN SC

1. EXECUTIVE SUMMARY

We have developed two metrics related to AGN variability observables (time-lags, periodicity, and Structure Function (SF)) to evaluate LSST OpSim FBS 1.5, 1.6, 1.7 performance in AGN time-domain analysis. For this purpose, we generate an ensemble of AGN light curves based on AGN empirical relations and LSST OpSim cadences. Although our metrics show that denser LSST cadences produce more reliable time-lag, periodicity, and SF measurements, the discrepancies in the performance between different LSST OpSim cadences are not drastic based on Kullback-Leibler divergence. This is complementary to Yu and Richards results on DCR and SF metrics (see Yu's talk https://docs.google.com/presentation/d/12Q1zKiWtoQAXsh7GS6J9TYhEKsWfkN5sVDufEyCKkEE/edit#slide=id.gc6954dd1ce_0_3), extending them to include the point of view of AGN variability.

LSST AGN SC Cadence Note: Differential Chromatic Refraction

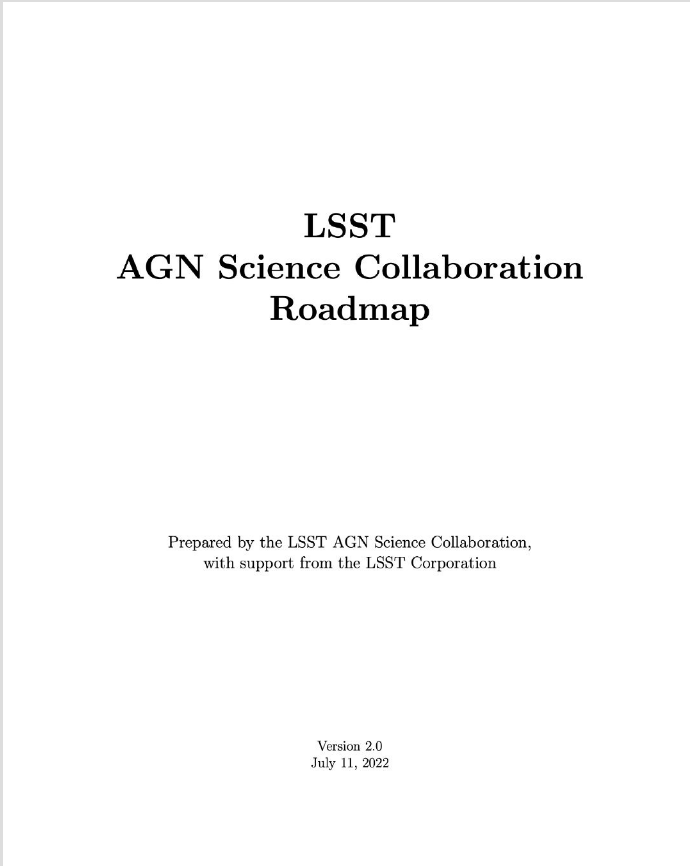
Weixiang Yu and Gordon Richards – on behalf of the AGN SC

1. EXECUTIVE SUMMARY

We have developed a metric to evaluate both the relative and absolute signal that can be expected from differential chromatic refraction (DCR) in LSST (Yu et al. 2020a) as a function of OpSims from versions FBS 1.5, 1.6 and 1.7. While there are LSST survey simulations that would significantly enhance this metric to the benefit of AGN classification and photo-z (and the study of objects exhibiting strong emission lines), such OpSims were meant as tests and not for operations. Among the feasible choices for LSST operations, we identify no simulations that are particularly bad or particularly good when it comes to DCR. Thus the choice of cadence can largely be made without consideration of this work. Nevertheless the tools are in place to double check that this remains true for the finalist(s).

Available at https://www.lsst.org/content/survey-cadence-notes-2021

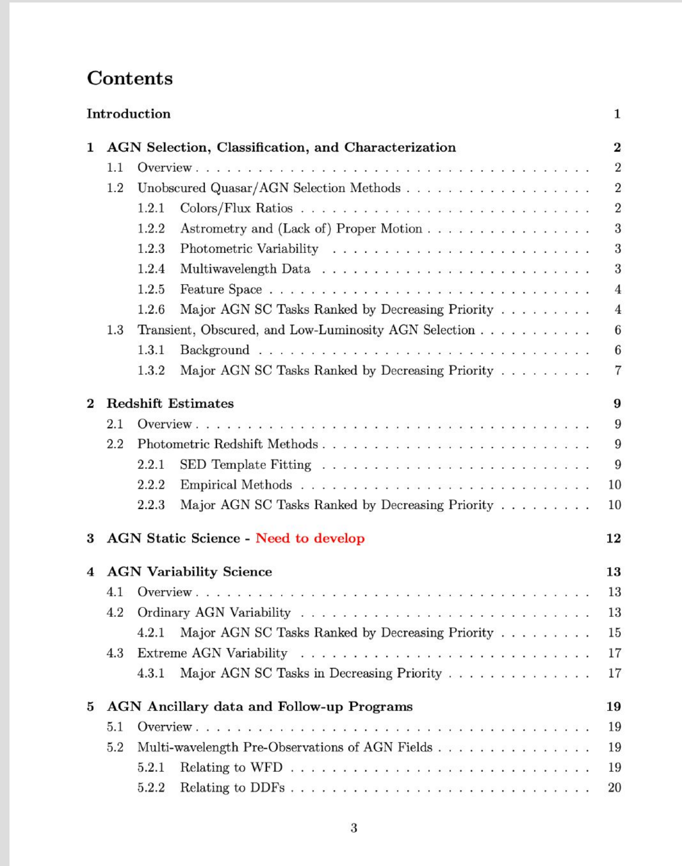
The AGN SC Roadmap



LSST
AGN Science Collaboration
Roadmap

Prepared by the LSST AGN Science Collaboration,
with support from the LSST Corporation

Version 2.0
July 11, 2022



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Defines and prioritizes AGN SC activities needed to prepare for Rubin operations.

Work ongoing to address many Roadmap goals.

Spitzer DeepDrill Survey of LSST DDFs

Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

MNRAS **501,** 892–910 (2021) doi:10.1093/mnras/staa3714
Advance Access publication 2020 November 30

A *Spitzer* survey of Deep Drilling Fields to be targeted by the Vera C. Rubin Observatory Legacy Survey of Space and Time

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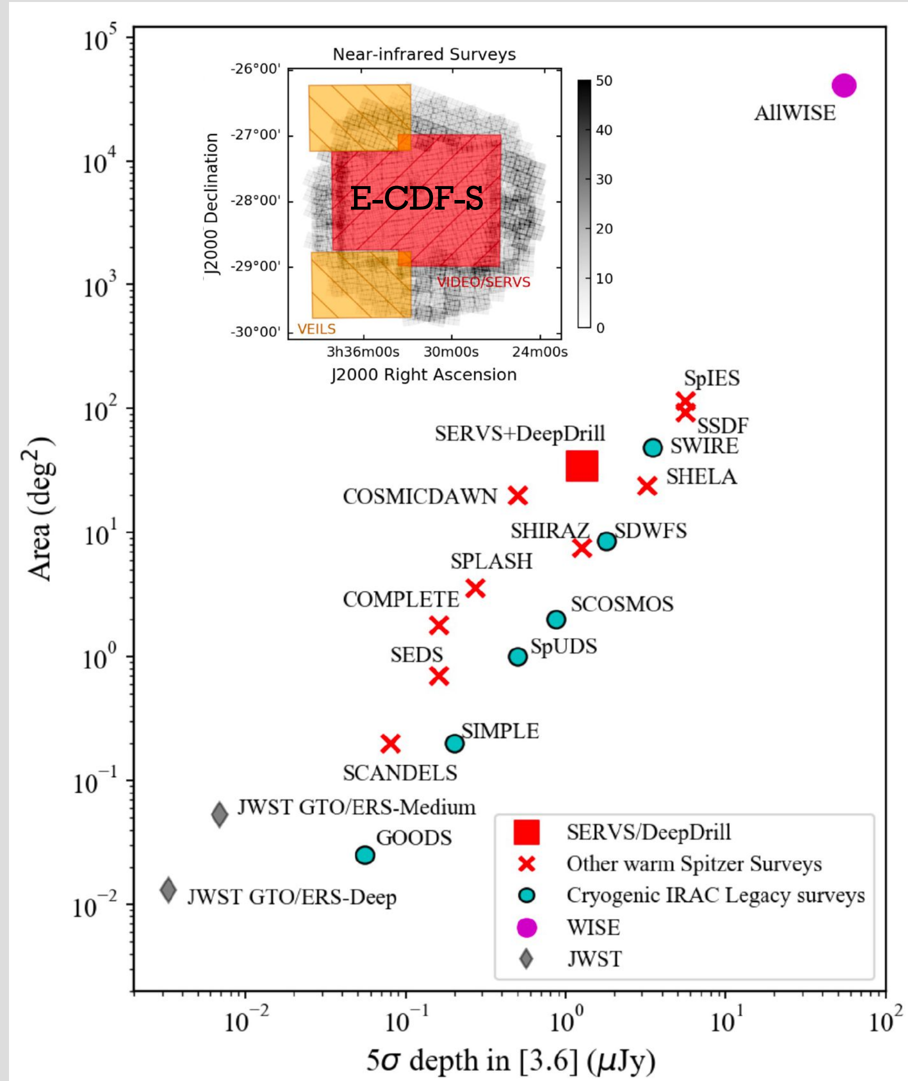
Affiliations are listed at the end of the paper

Accepted 2020 November 25. Received 2020 November 25; in original form 2020 August 7

ABSTRACT

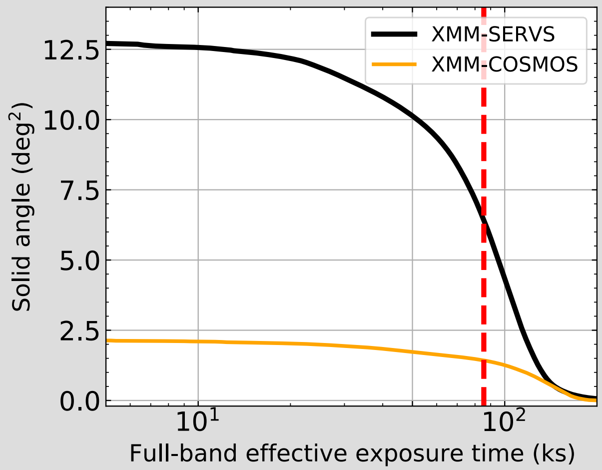
The Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST) will observe several Deep Drilling Fields (DDFs) to a greater depth and with a more rapid cadence than the main survey. In this paper, we describe the 'DeepDrill' survey, which used the *Spitzer Space Telescope* Infrared Array Camera (IRAC) to observe three of the four currently defined DDFs in two bands, centred on 3.6 and 4.5 μm. These observations expand the area that was covered by an earlier set of observations in these three fields by the *Spitzer* Extragalactic Representative Volume Survey (SERVS). The combined DeepDrill and SERVS data cover the footprints of the LSST DDFs in the Extended Chandra Deep Field–South (ECDFS) field, the ELAIS-S1 field (ES1), and the *XMM*-Large-Scale Structure Survey field (*XMM*-LSS). The observations reach an approximate 5σ point-source depth of 2 μJy (corresponding to an AB magnitude of 23.1; sufficient to detect a 10^{11} $M_{\odot}$ galaxy out to $z \approx 5$) in each of the two bands over a total area of ≈ 29 deg^2. The dual-band catalogues contain a total of 2.35 million sources. In this paper, we describe the observations and data products from the survey, and an overview of the properties of galaxies in the survey. We compare the source counts to predictions from the SHARK semi-analytic model of galaxy formation. We also identify a population of sources with extremely red ([3.6]−[4.5] >1.2) colours which we show mostly consists of highly obscured active galactic nuclei.

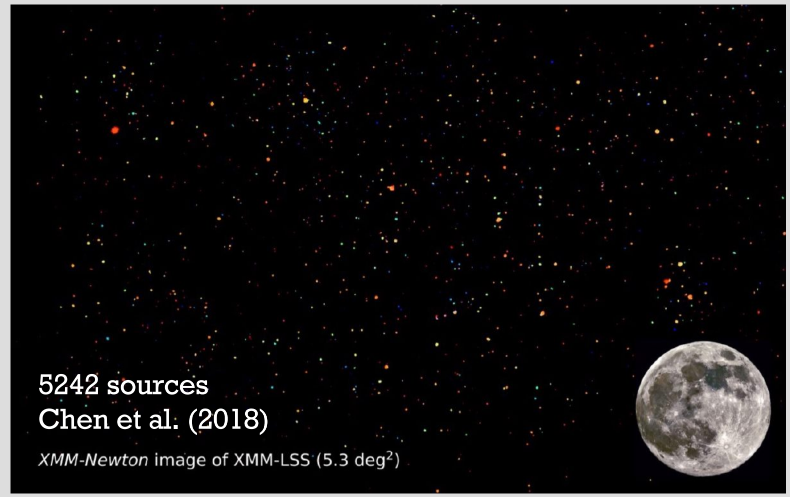
Key words: catalogues – surveys – infrared:galaxies – infrared: general.

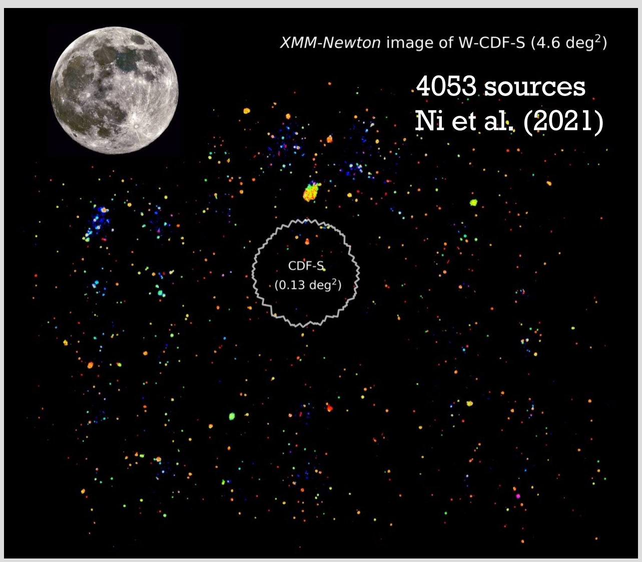


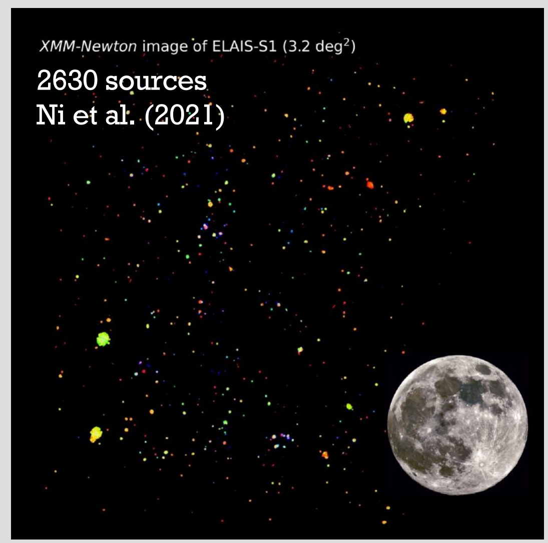
XMM-SERVS: XMM-Newton Coverage of LSST DDFs

XMM-SERVS vs. XMM-COSMOS
Sky Coverage









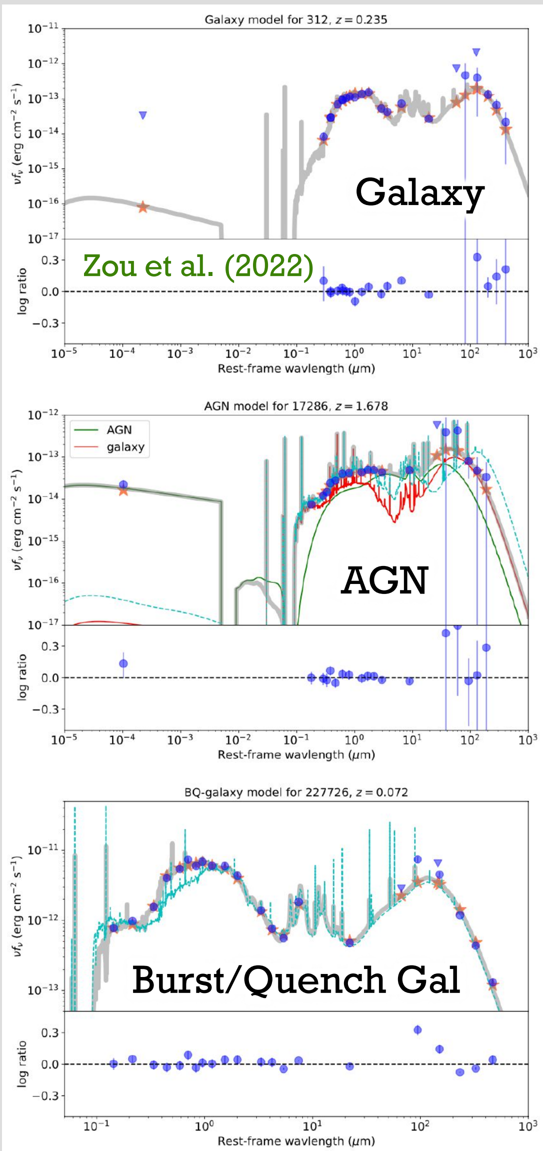
personal.psu.edu/wnb3/xmmservs/xmmservs.html

At 50 ks XMM-Newton depth, detect 10,200 AGNs and many X-ray groups/clusters.

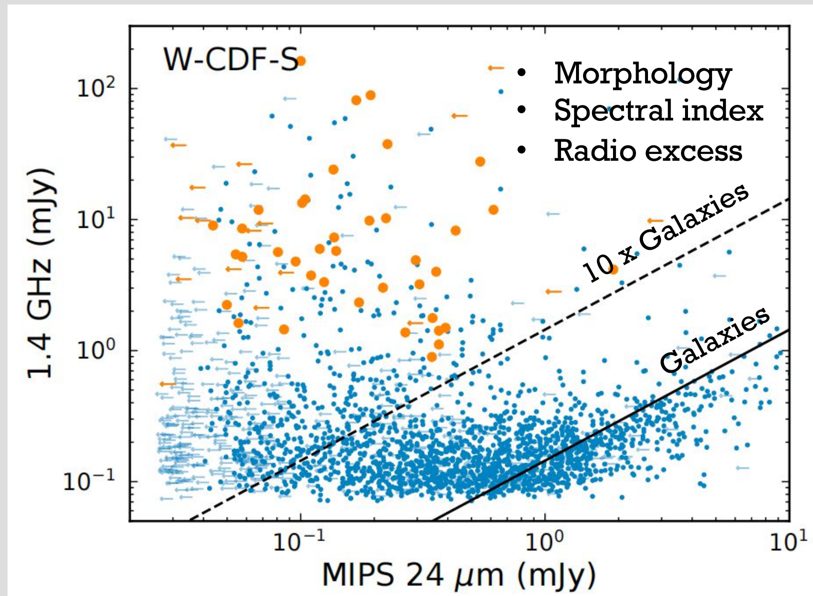
Ground-truth AGN sample for calibrating LSST AGN selection in DDFs and main survey.

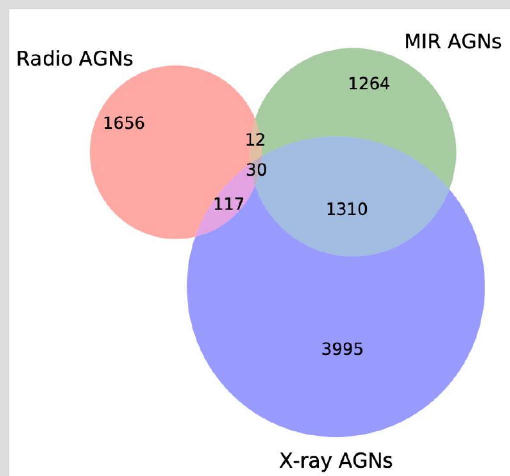
SED and Radio AGN Selection

2.8 Million X-ray-to-FIR SED Fits with CIGALE



Radio AGN Selection from ATLAS, VLA, and MIGHTEE





1815 radio AGNs selected

91% not X-ray/MIR

Zhu et al. (2023)

Other Key Activities of the AGN SC

Data challenge events with monetary prizes.

AGN SC members are involved in Data Previews.

Assessing operations simulations to ensure excellent AGN science.

Coordinate with other AGN projects; e.g., reverberation-mapping experiments and spectroscopic surveys.

Other Key Activities of the AGN SC

Advocate for AGN science to the broader photometric-redshift working group.

Support the Contributions Evaluation Committee, which assesses which international partners earn data rights.

AGN SC has several members on the Rubin-Euclid Derived Data Products Working Group.

Outreach activities at multiple levels.

AGN SC Web Site

LSST
AGN Science Collaboration

PUBLIC & SCIENTISTS PROJECT TEAM LSST CORPORATION

agn.science.lsst.org

Home | Meetings | Projects | Documents | Talks | Members | Apply | Contact

Home » LSST AGN Science Collaboration Membership Application

LSST AGN Science Collaboration Membership Application

Membership in the LSST AGN Science Collaboration implies a commitment to work toward the common scientific goals of the collaboration, and affords one the opportunity to be involved directly in the core projects undertaken by the Science Collaboration. The Science Collaboration also provides a natural route for giving feedback to the LSST Project about issues related to AGN science.

Proposals are currently invited from individuals in the following categories:

- All scientists employed or studying at institutions in countries with LSST data rights (e.g., USA, Chile).
- Any individuals specifically listed in signed Memoranda of Agreement with the LSST Corporation.
- Scientists employed by the LSST Project.
- Members of institutions that have explicit data-rights agreements with the LSST, such as IN2P3.
- Individuals hoping to obtain data rights through in-kind contributions, recognizing that their membership level will be limited to Associate (until data rights are obtained) and may have to be dropped as members should negotiation for data rights not be successful

USER LOGIN

Username *

Password *

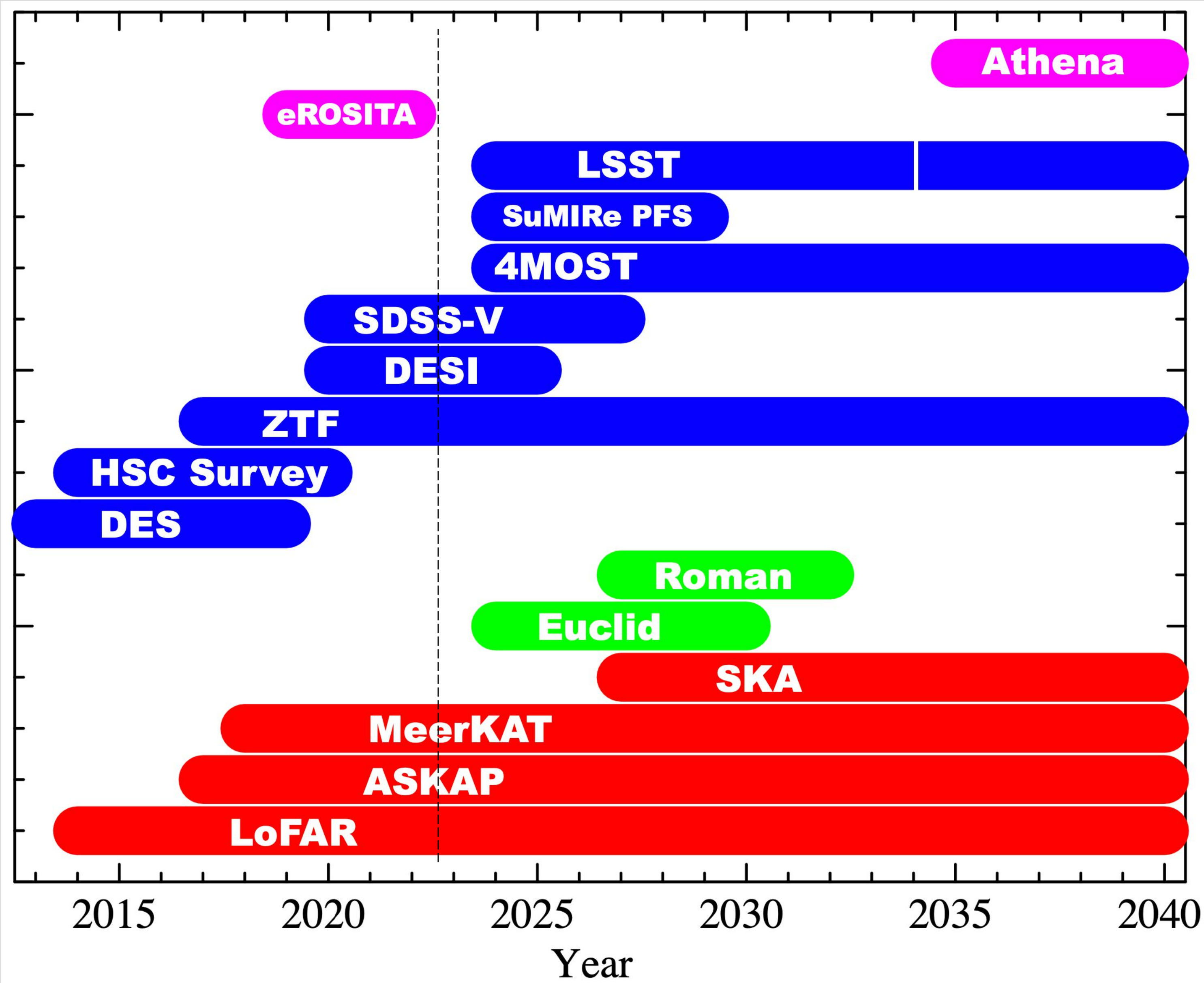
- Request new password

Log in


The End
NSF
NASA
esa
PennState
Eberly College
of Science

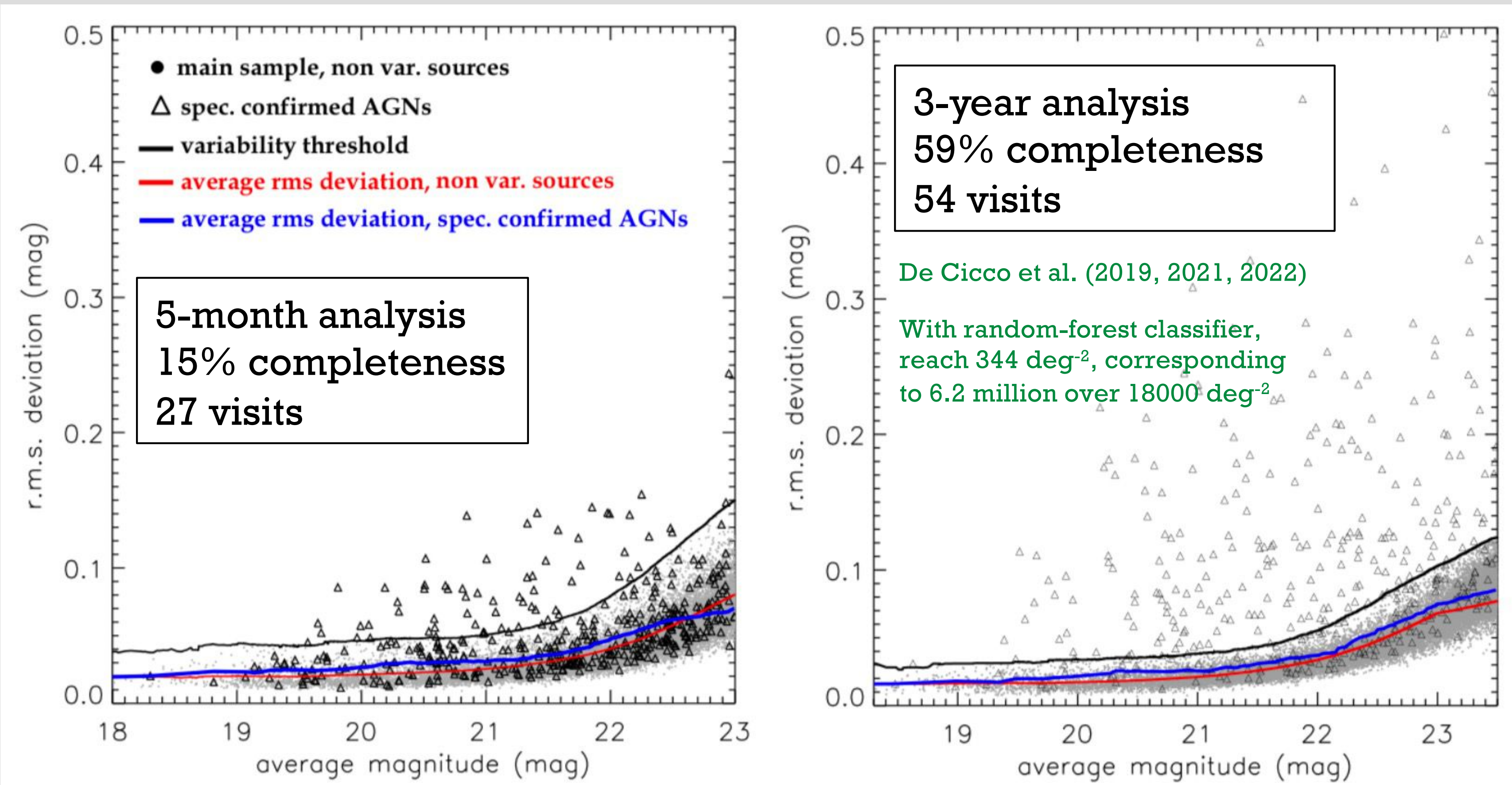
Extra Slides

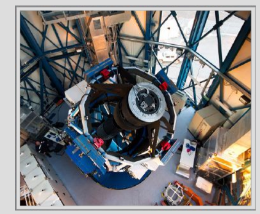
Power of LSST and Multiwavelength Data



Optical Variability Selection of X-ray AGNs in COSMOS

Long Baselines and Many Epochs Greatly Aid AGN Selection (*r* band)



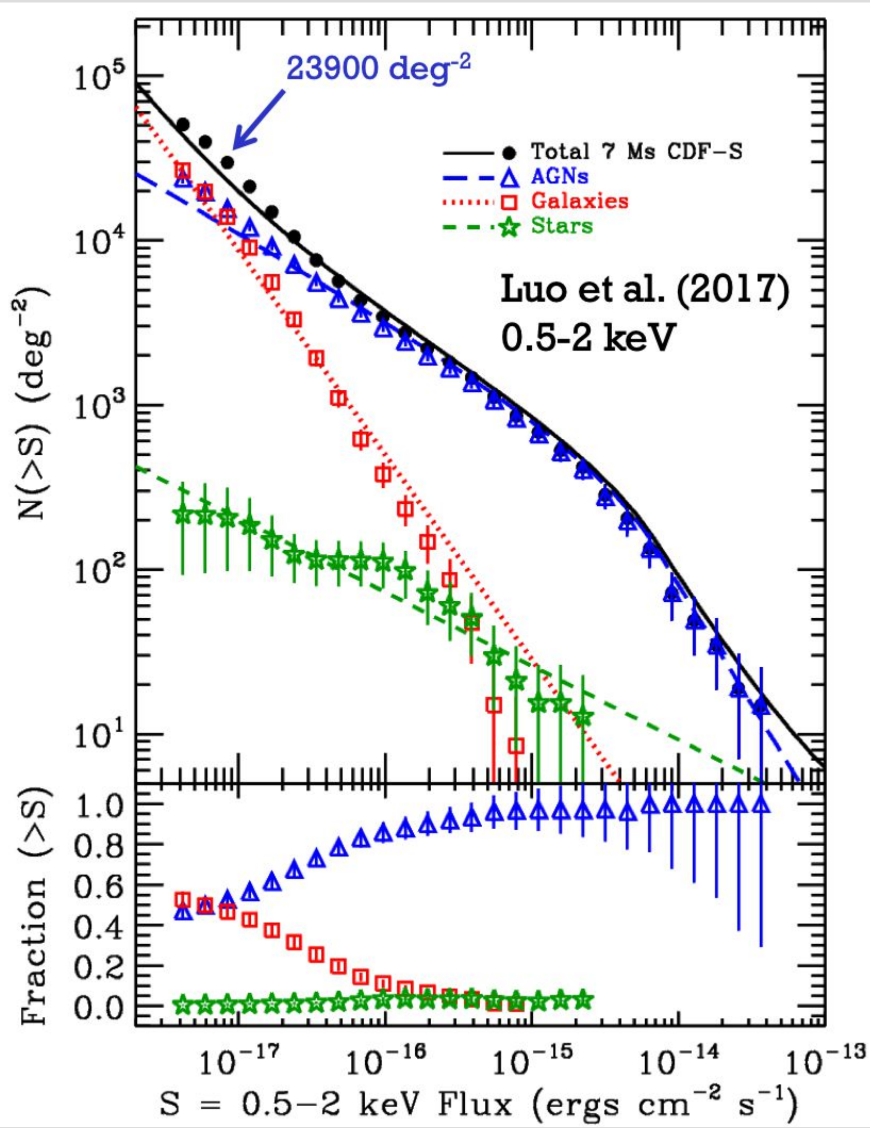


VST

LSST will do even better with 10 yr baseline, more visits, deeper visits, and more bands.

Plausible AGN Yields

Chandra Deep Field-South Number Counts



LSST will *detect* ~ 300+ million AGNs in 18000 deg^2 main-survey area.

Obscuration and host-galaxy dilution will hinder AGN *selection*.

Confidently can select <u>20 million</u> (7%).

Hope to select <u>50+ million</u>, especially using multiwavelength data.