The XMM-SERVS Survey of the LSST Deep Drilling Fields

Niel Brandt (Penn State), Qingling Ni (Penn State), for the XMM-SERVS Team

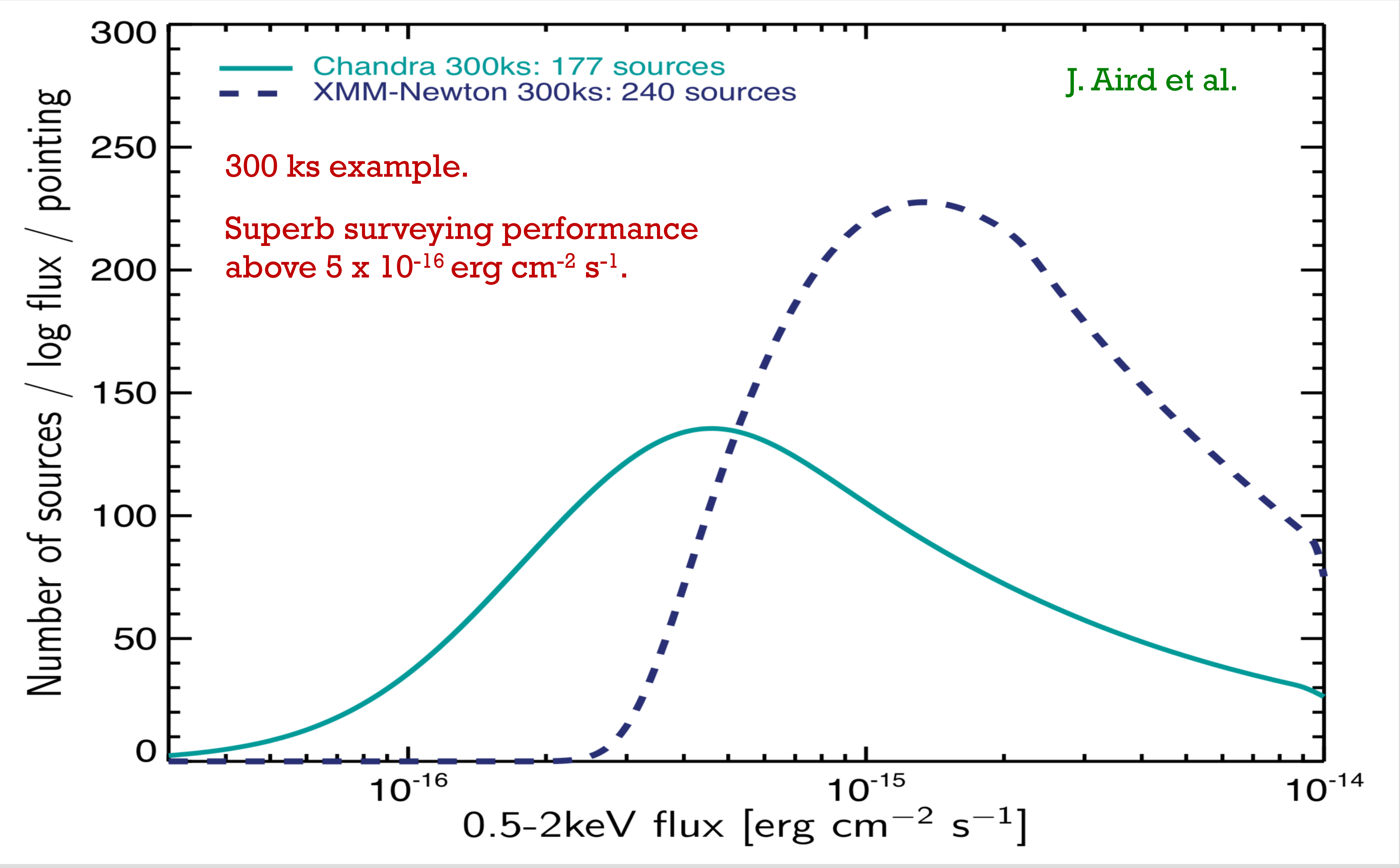
Large Effective Area (~ 2000 cm^2)

Good Field of View (~ 800 $arcmin^2$)

Good Angular Resolution

Broad Bandpass (0.3-10 keV)

AGN Generation Rate



X-ray Survey Achievements

Big Survey Advances Since 1999

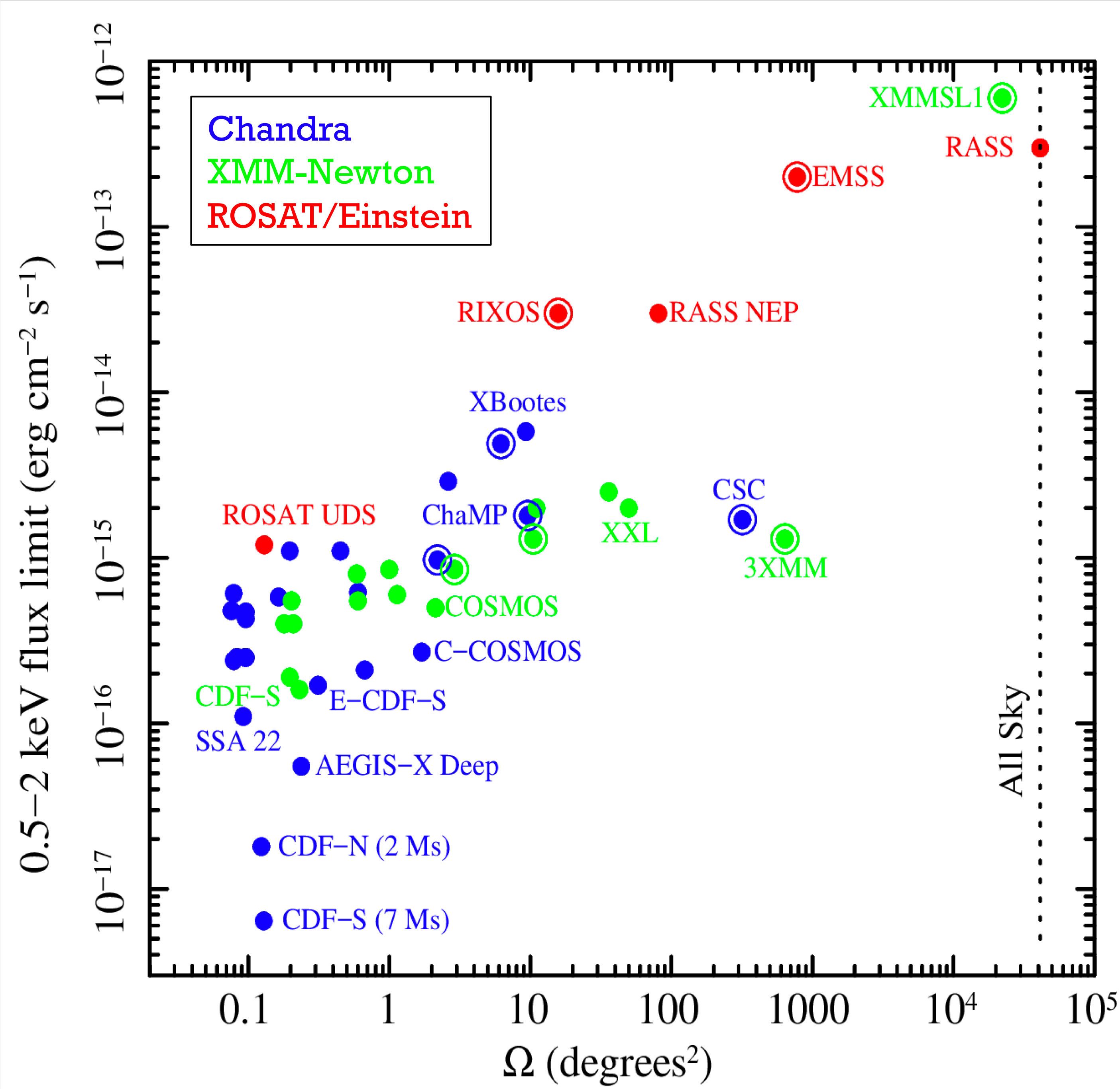
Resolved much of the CXRB.

Revealed most/much of obscured SMBH growth.

Totally changed understanding of AGN evolution and the "cosmic balance of power".

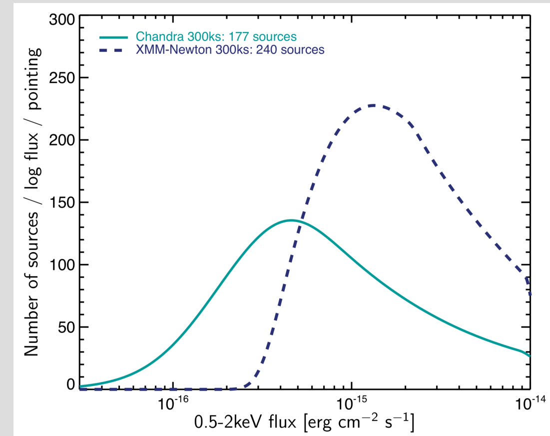
Much better understanding of high-redshift AGNs and contribution to reionization.

Strong progress on AGN-galaxy and AGN-LSS connections.



Updated from Brandt & Alexander (2015)

Note XMM-Newton contributions.

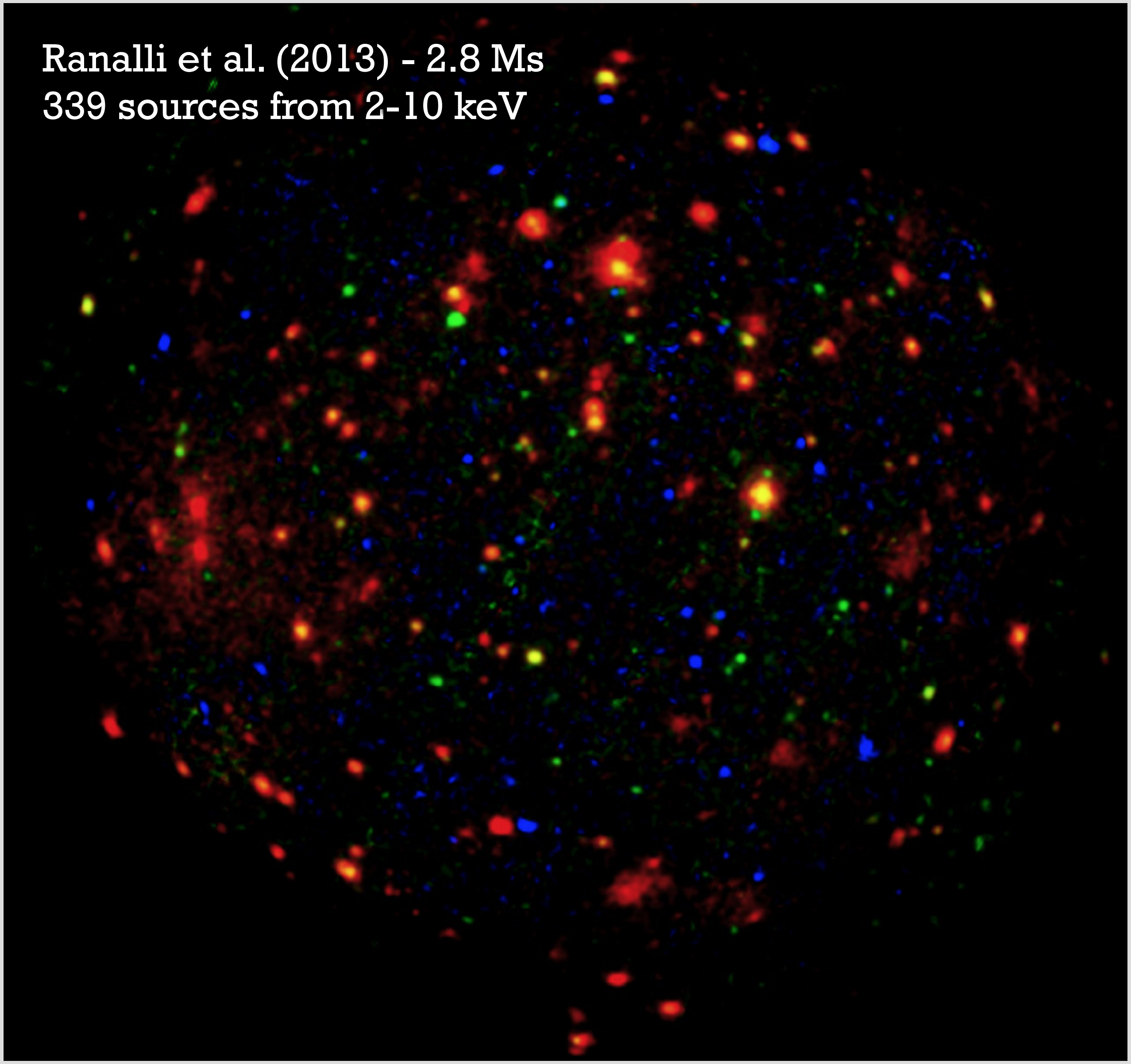


Will briefly review labeled XMM-Newton surveys from deepest to widest.

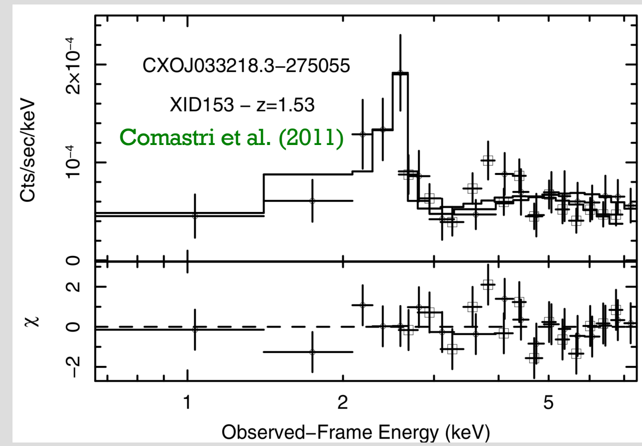
Each with just a couple science highlights.

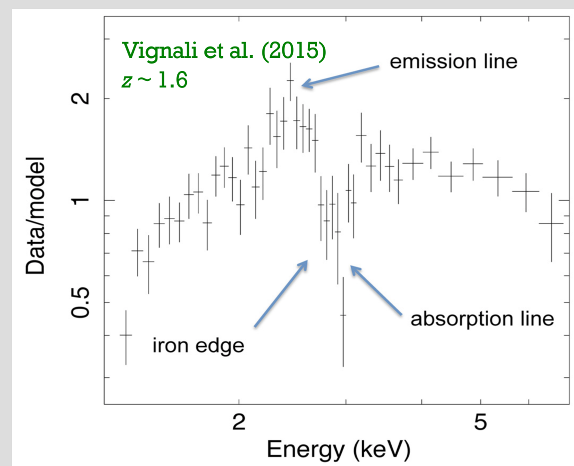
Many more great science results and surveys!

XMM-Newton CDF-S



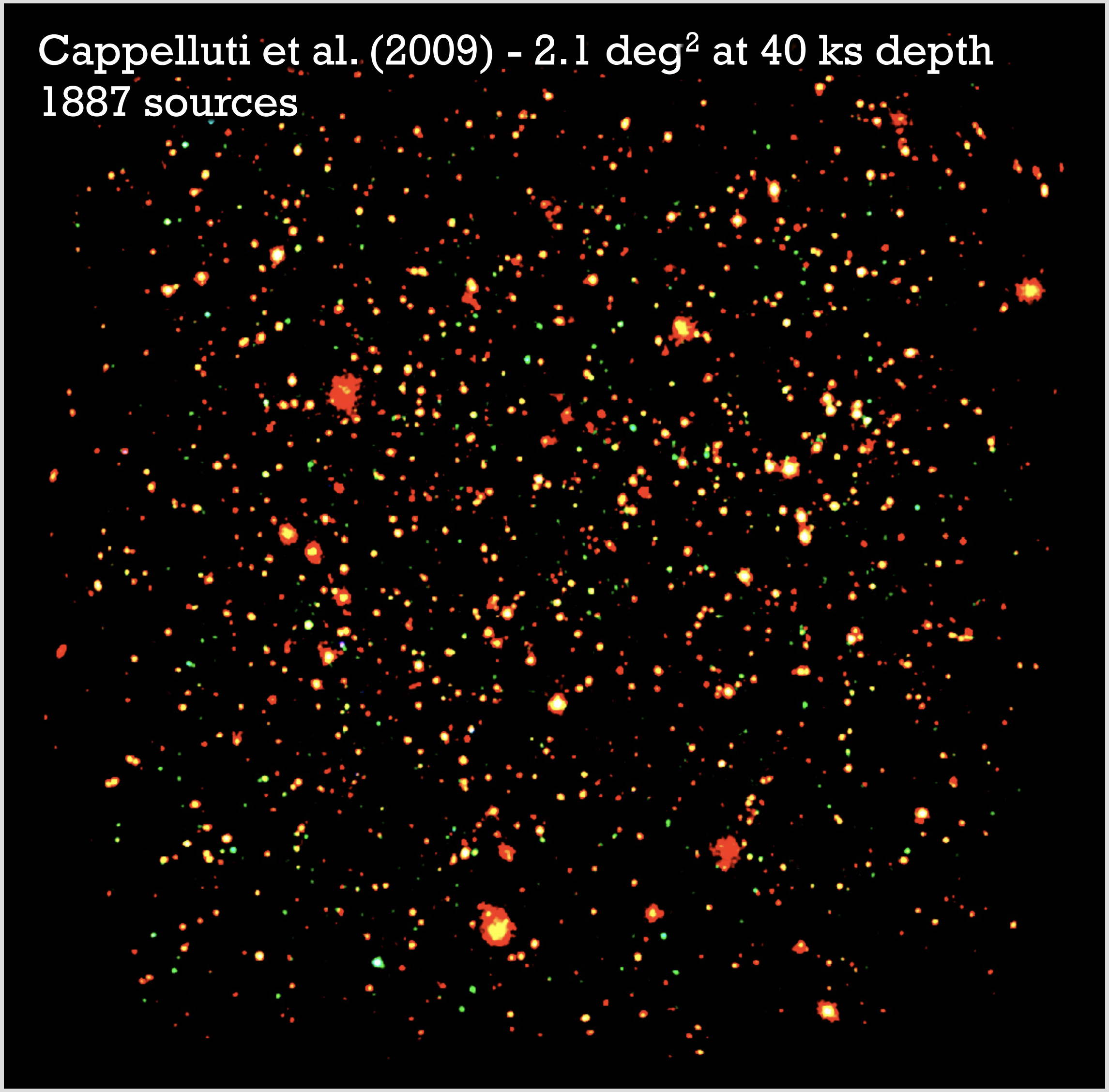
Detection and spectra of highly obscured AGNs.





Iwasawa et al. spectral atlas of 185 brightest AGNs.

XMM-COSMOS



Study LSS to ~ 50 Mpc as traced by AGNs and groups/clusters.

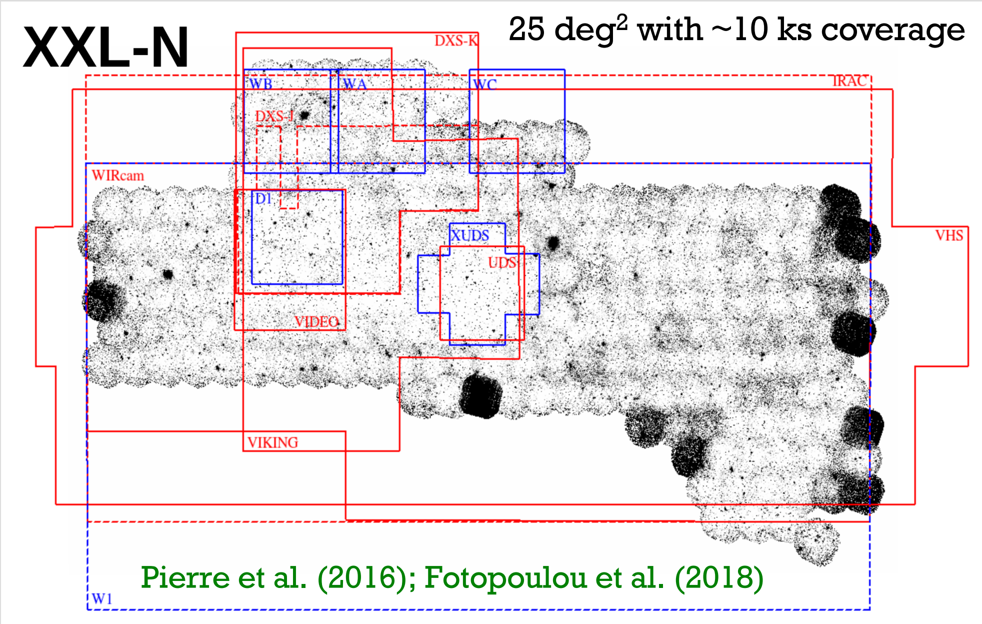
Assess environmental effects upon SMBH growth.

Good balance of depth vs. area for AGN evolution studies.

Also, extensive Chandra COSMOS Legacy observations.


Cosmos Team Meeting Copenhagen 2018

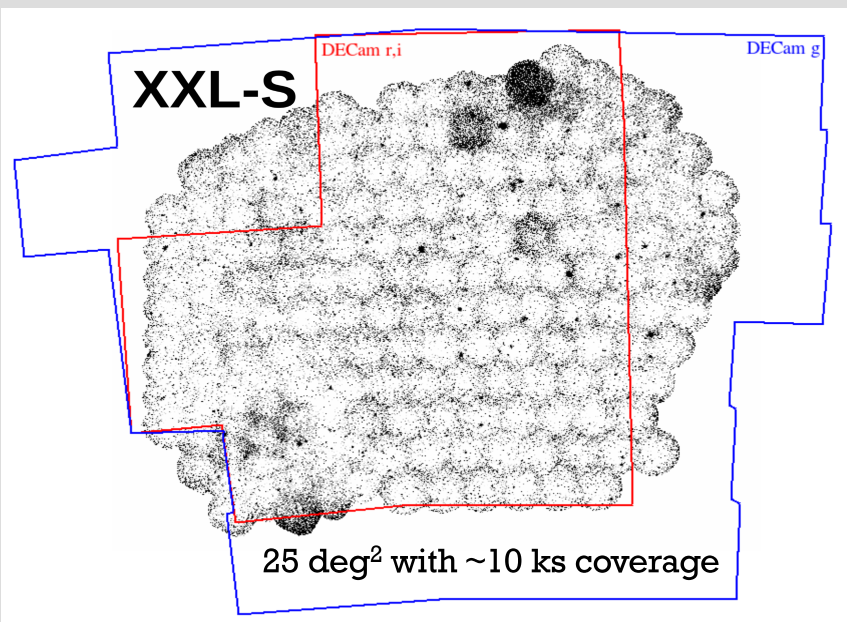
The XMM-Newton XXL Survey



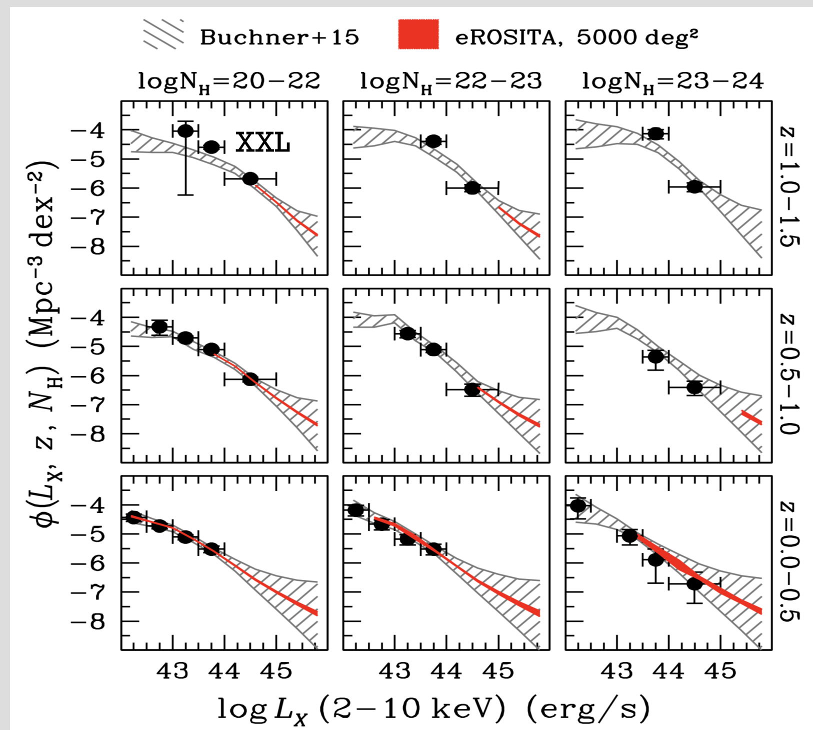
Cluster-driven survey.

26,056 point sources (and 365 clusters).

Can detect rare, luminous AGNs - but misses most cosmic accretion power.

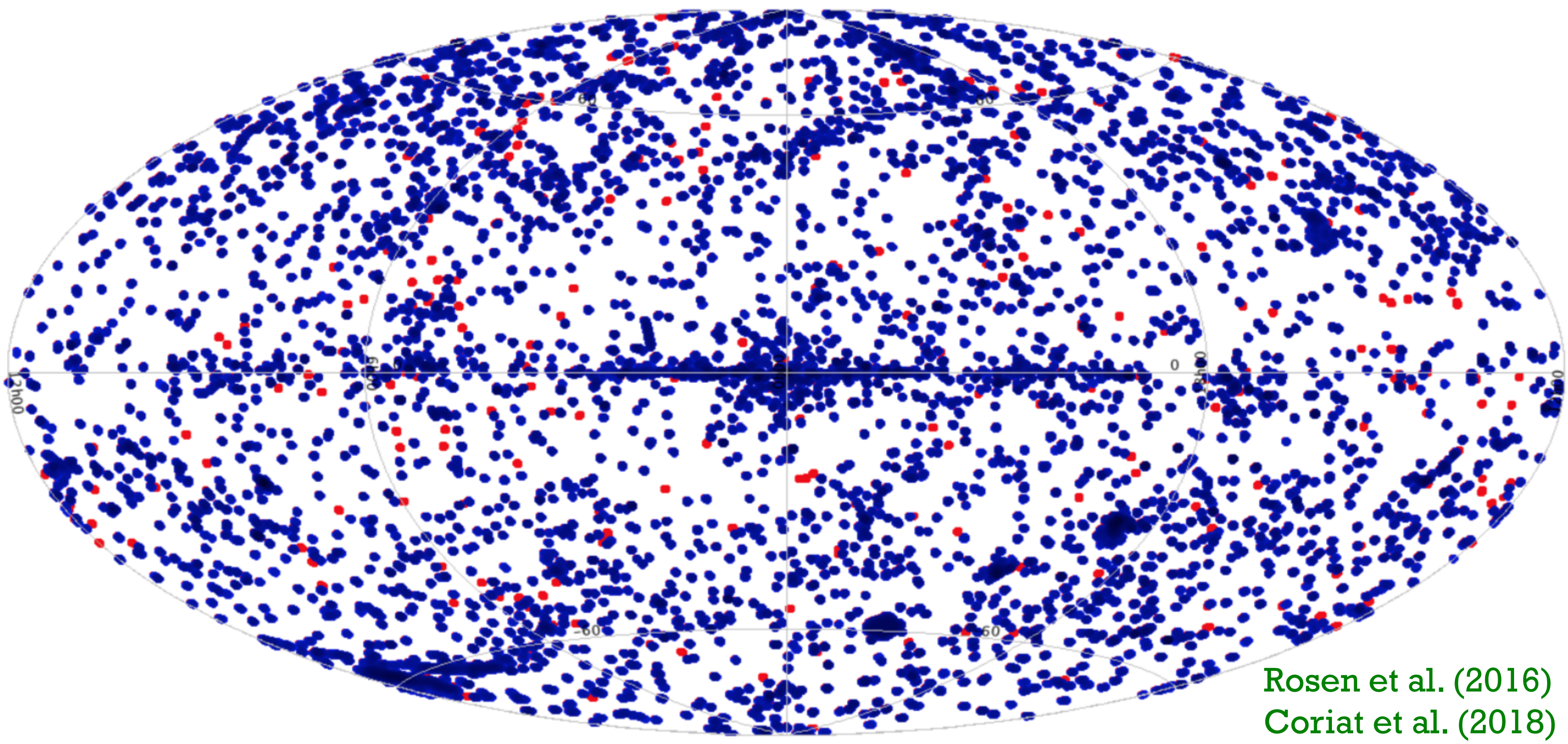


Space Density and f_{obsc} at High L_X



Georgakakis et al. (2017)

3XMM-DR8 from SSC



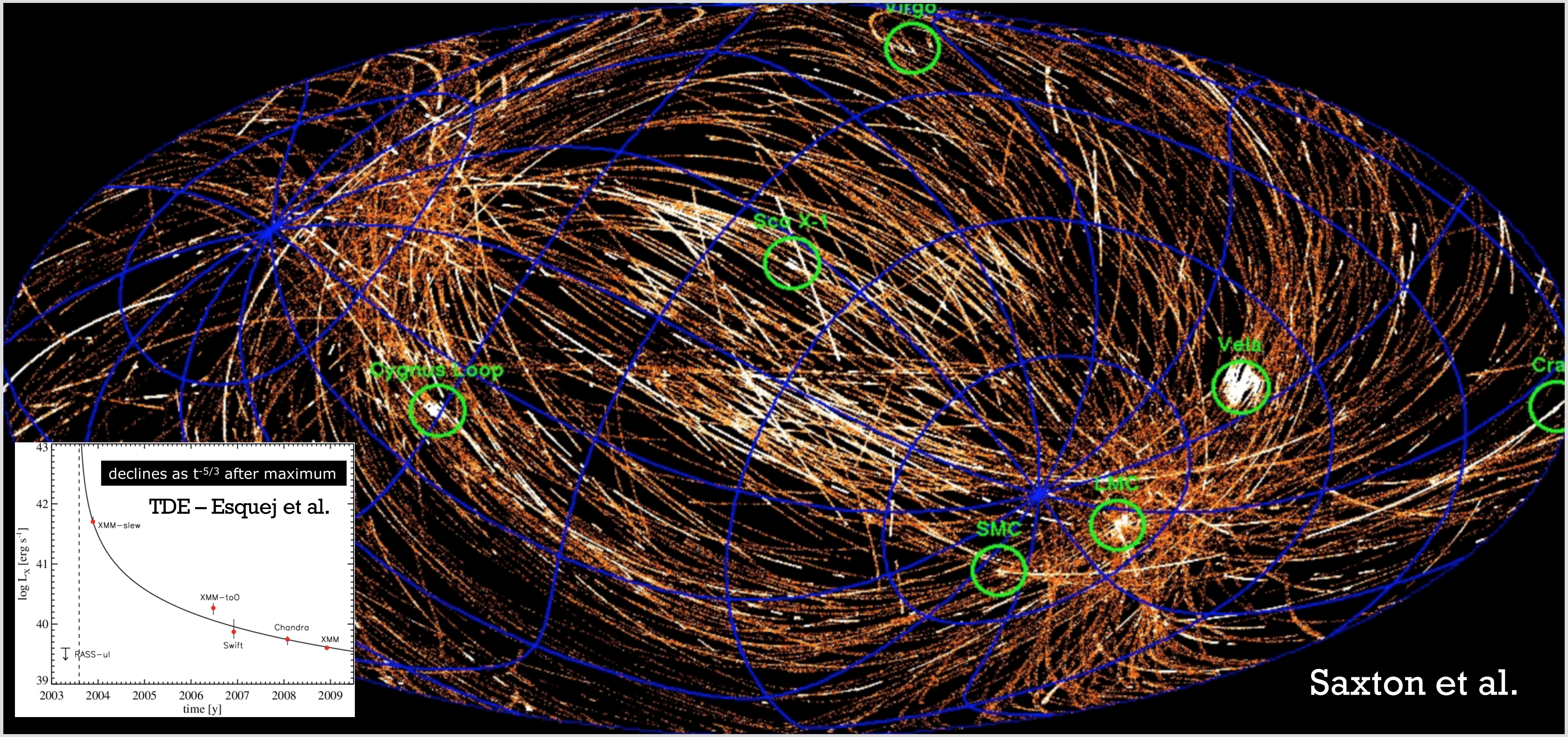
Rosen et al. (2016)
Coriat et al. (2018)

1089 deg^2 - 530,000 unique sources – largest X-ray source catalog.

Used for 500+ science studies across all source types.

Even more potential with LSST, PFS, DESI, Euclid, WFIRST, VLASS, ASKAP, etc.

XMM Slew Survey (XMMSL2)



65000 deg^2 - 85% sky covered at least once - 23,000 sources

TDEs, highly variable AGNs, supernovae, flare stars, transients

Prelude to eROSITA and Einstein Probe X-ray transients.

XMM-SERVS and the Future

Some Big Questions for Surveys

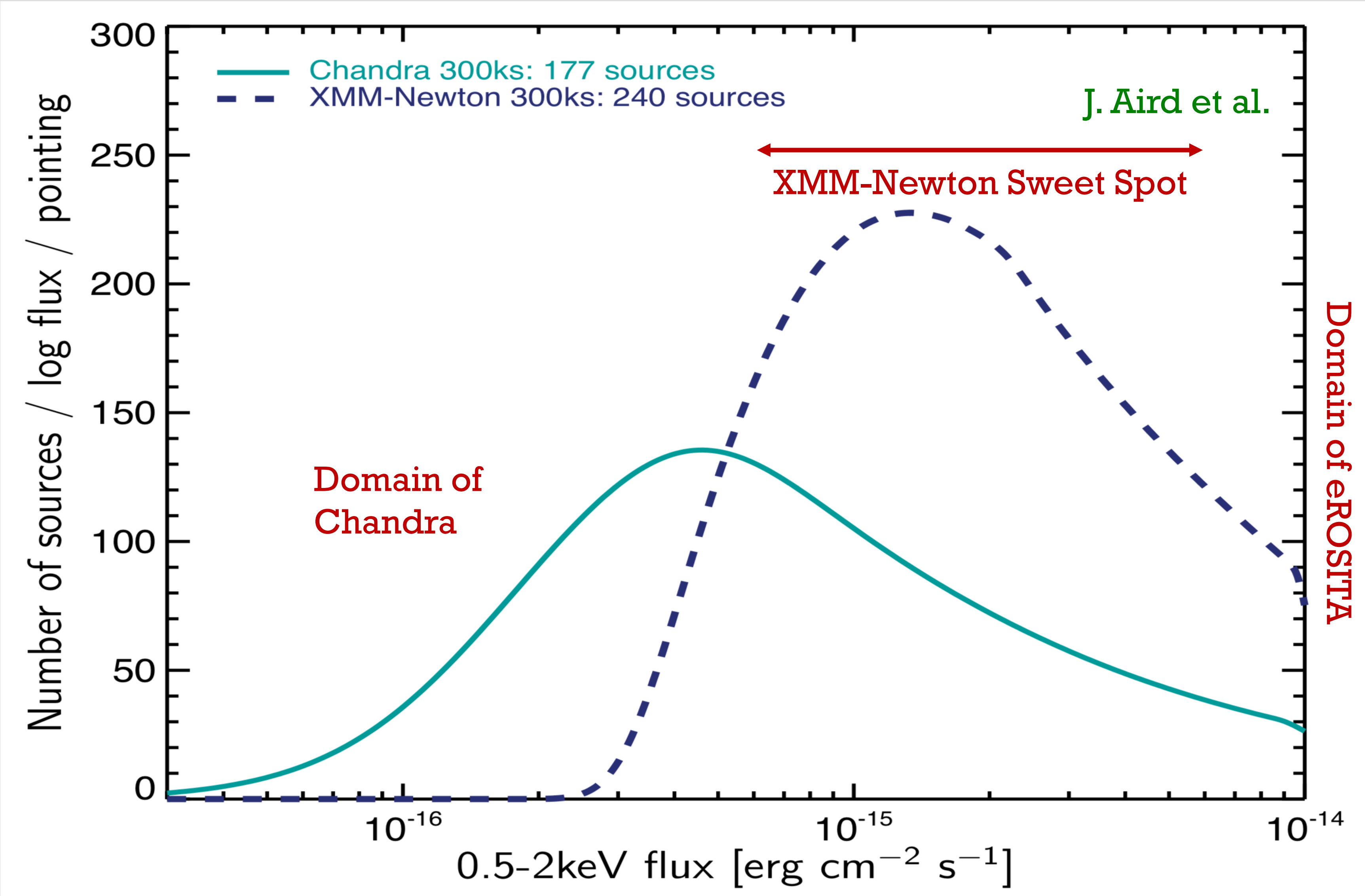
Complete our understanding of AGN obscuration.

Growth and feedback of highly obscured SMBHs through the $z \sim 1$-4 galaxy formation era.

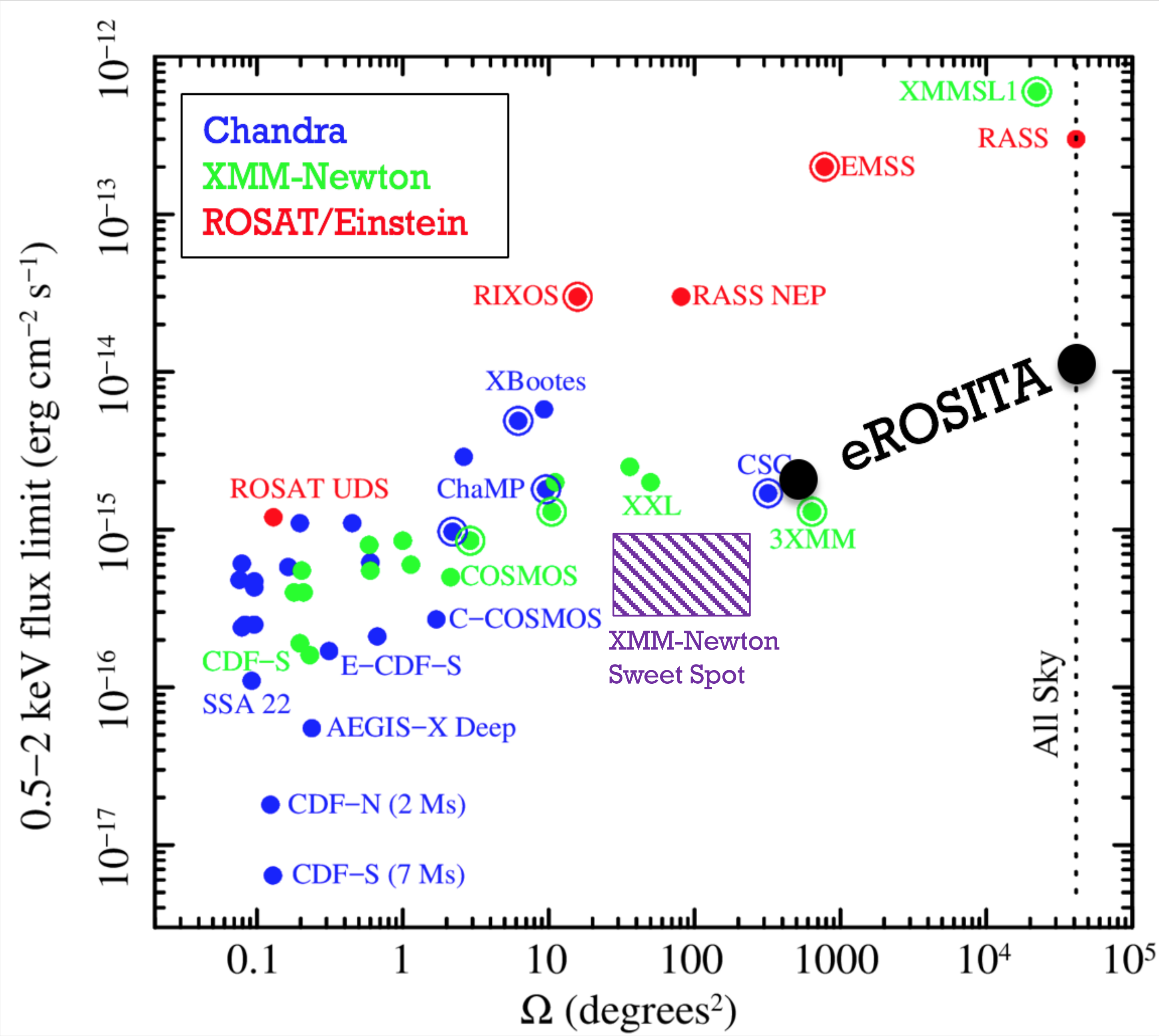
SMBH growth in the first galaxies at $z \sim 4$-10 and the $z \sim 10$-15 "seeds" of SMBHs.

Deeper understanding of AGN-galaxy and AGN-LSS connections.

Use XMM-Newton in Regime Where It Works Best!



The Post-eROSITA Landscape



Want COSMOS-like surveys over larger solid angles.

Need aggressive projects to break new ground.

But where to point for the most compelling science at these X-ray fluxes?

XMM-SERVS:
Coverage of the LSST Deep Drilling Fields

LSST

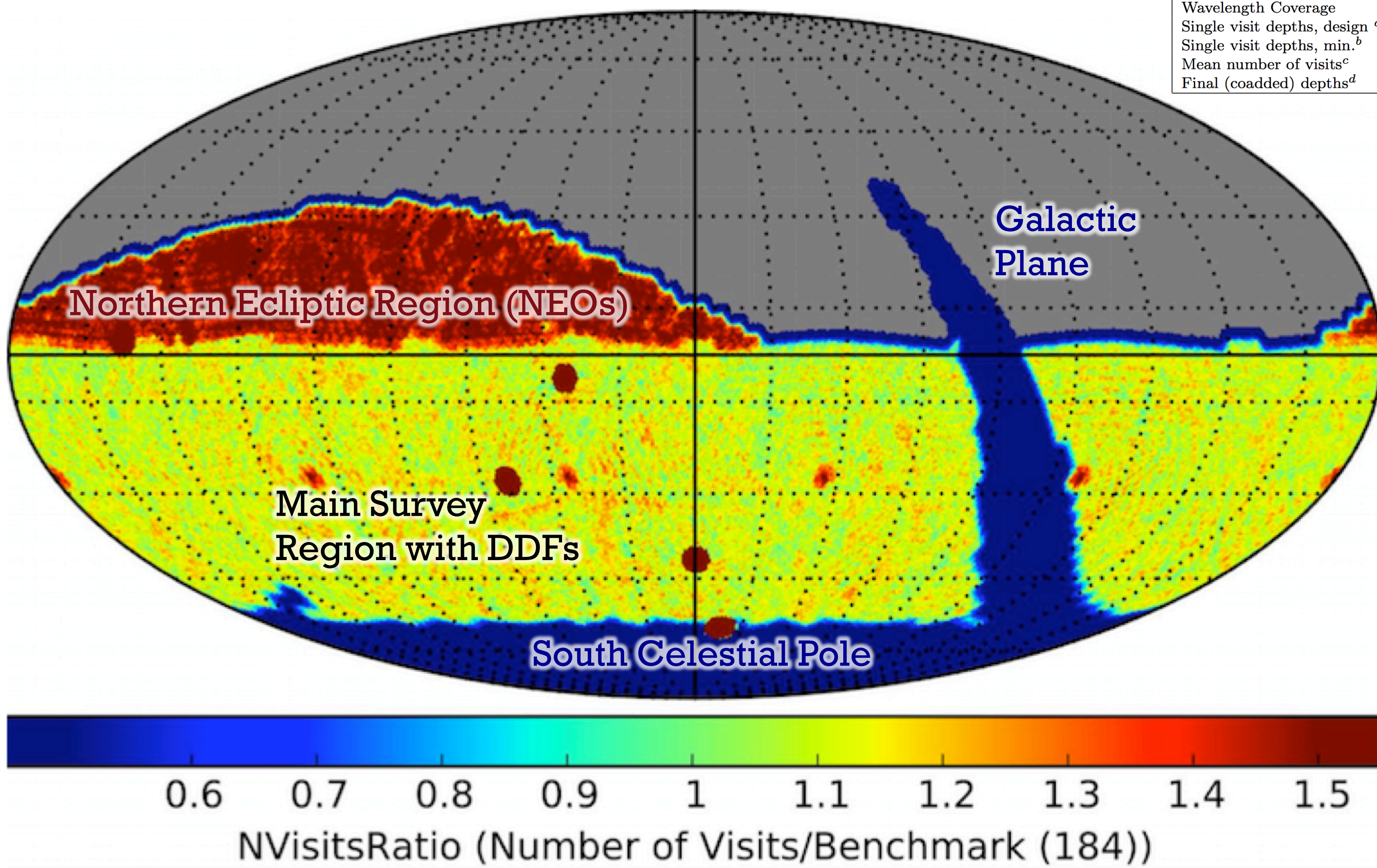
Full science operations: 2023

Main Survey - Brief Details

Example Operations Simulation of *r*-Band Visits
(Details Subject to Change)

The LSST Baseline Design and Survey Parameters

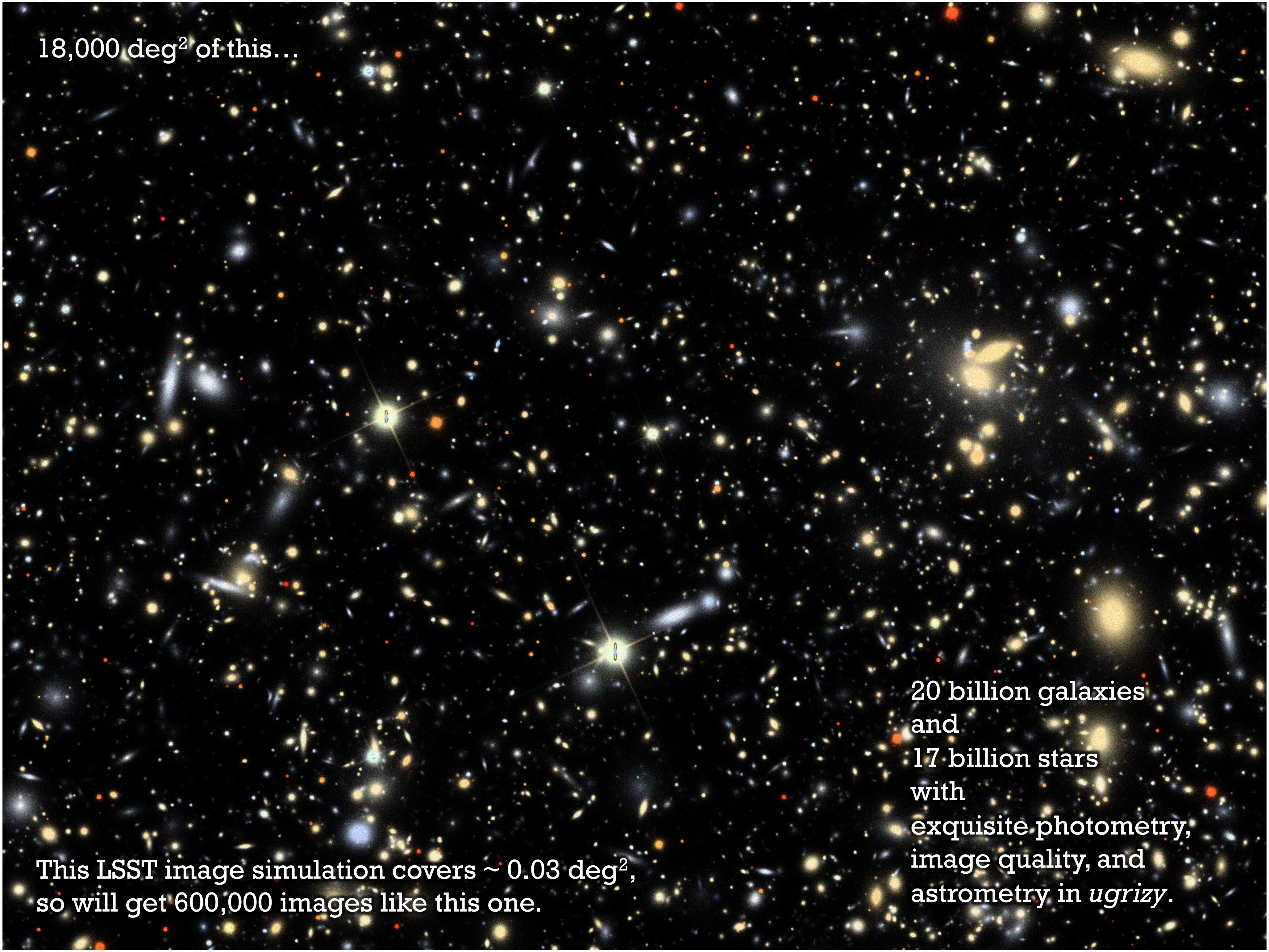
Quantity	Baseline Design Specification
Optical Config.	3-mirror modified Paul-Baker
Mount Config.	Alt-azimuth
Final f-ratio, aperture	f/1.234, 8.4 m
Field of view, étendue	9.6 deg^2, 319 $m^2 deg^2$
Plate Scale	50.9 μm/arcsec (0.2" pix)
Pixel count	3.2 Gigapix
Wavelength Coverage	320 – 1050 nm, *ugrizy*
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



Main survey optimized for homogeneity of depth and number of visits.

~ 18000 deg^2

Uses ~ 90% of the LSST time.


18,000 deg² of this…
This LSST image simulation covers ~ 0.03 deg²,
so will get 600,000 images like this one.
20 billion galaxies
and
17 billion stars
with
exquisite photometry,
image quality, and
astrometry in *ugrizy*.

2012 Announcement of Four DDFs

LSST E-News March 2012 • Volume 4 Number 4

Selection of Four Deep Drilling Fields for the LSST

LSST sky coverage map showing four Deep Drilling Fields.

The LSST Science Council has selected four distant extragalactic survey fields that the project guarantees to observe as Deep Drilling Fields with deeper coverage and more frequent temporal sampling than provided by the standard LSST observing pattern. These four fields are only the first chosen for deep-drilling observations; more such fields will be chosen later.

In addition to executing its 18,000 deg^2 main survey via its "universal cadence", the LSST will also intensively observe a set of Deep Drilling Fields. Deeper coverage and more frequent temporal sampling (in at least some of the LSST's ugrizy filters) will be obtained for the Deep Drilling Fields than for typical points on the sky. The full Deep Drilling Field program will address a broad range of science topics, including Solar System, Galactic, and extragalactic studies. Up to about 10% of the LSST time will be devoted to Deep Drilling Fields and other cadence programs outside the universal cadence. Chapter 2 of the LSST Science book provides additional details.

Science possibilities for the LSST Deep Drilling Fields are currently being investigated by the LSST Deep Drilling Interest Group and the LSST Science Council. The LSST Deep Drilling Interest Group includes more than 60 members of the astronomy and physics communities who are members of LSST Science Collaborations and the LSST Project. Additional members are welcome; those interested should first join one of the LSST Science Collaborations via the proposal process operated by NOAO.

Informed by feedback from the LSST Deep Drilling Interest Group, the LSST Science Council has selected for prompt announcement four distant extragalactic survey fields, each covering approximately 9.6 deg^2, which the LSST Project will commit to observing as Deep Drilling Fields. These are four well-studied survey fields with substantial existing multiwavelength coverage and other positive attributes. In addition to enabling their primary distant extragalactic science, these fields will enable Solar System and Galactic science as well. The four fields, listed below, are just part of the broader LSST Deep Drilling Field program. There will be additional fields chosen in the future for Solar System, Galactic, and extragalactic studies. In total there may plausibly be 20-40 Deep Drilling Fields to cover all the science topics. The aim will be to have these well distributed across the sky to enable efficient LSST observing.

The LSST Science Council's motivation for prompt selection of these four distant extragalactic Deep Drilling Fields is one of community service. For example, the Science Council recognizes that space-based multiwavelength observatories have limited lifetimes, and thus it is important to declare a few fields promptly so they can be appropriately observed over the needed approximately 9.6 deg^2. Similarly, extensive ground-based efforts will be needed to acquire requisite supporting data (e.g., in the near-infrared and with narrow-band filters).

While the locations of these fields have been chosen, many observational details, such as for the best choices of cadence, filter balance, and total time investment, remain to be determined and may vary from field to field. These issues will be considered by the LSST Deep Drilling Interest Group, the LSST Project, and the broader scientific community over the coming years. Constructive feedback on observational details may be sent to lsst-deepdrill@lsstcorp.org.

The table below lists the four selected fields with approximate field center positions. Each field is approximately circular with diameter 3.5 degrees. Some observational dithering will likely be used (both in position angle and boresight location) to fill in CCD gaps, aid with artifact removal, etc. The details of the dithering are yet to be determined.

	ELAIS S1	**XMM-LSS**	**Extended Chandra Deep Field-South**	**COSMOS**
RA 2000	00 37 48	02 22 50	03 32 30	10 00 24
DEC 2000	-44 00 00	-04 45 00	-28 06 00	+02 10 55
Galactic l	311.30	171.20	224.07	236.83
Galactic b	-72.90	-58.77	-54.47	42.09
Ecliptic l	345.97	31.04	40.29	150.70
Ecliptic b	-43.18	-17.90	-45.47	-9.39

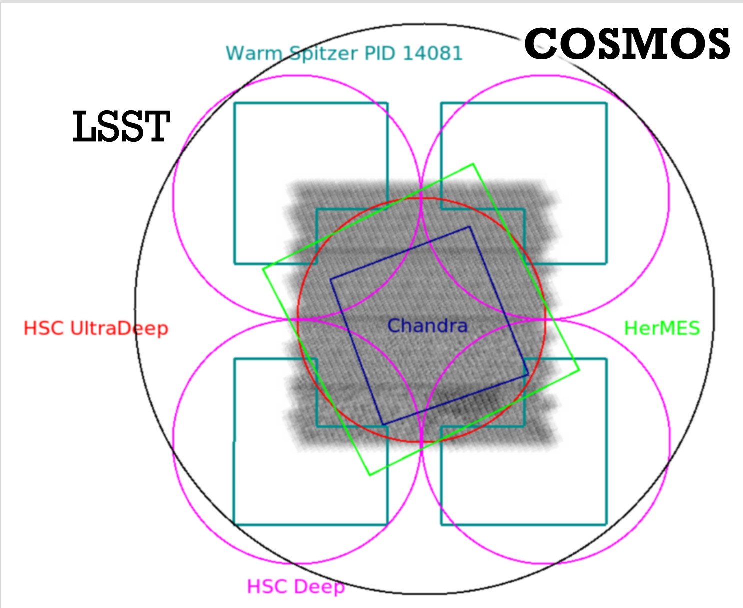
Article written by Niel Brandt

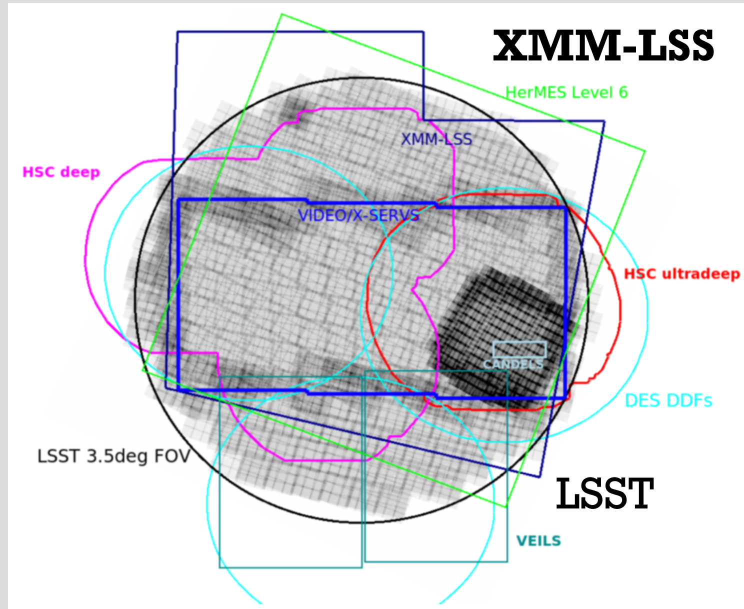
LSST is a public-private partnership. Funding for design and development activity comes from the National Science Foundation, private donations, grants to universities, and in-kind support at Department of Energy laboratories and other LSSTC Institutional Members:

Adler Planetarium; Brookhaven National Laboratory (BNL); California Institute of Technology; Carnegie Mellon University; Chile; Cornell University; Drexel University; Fermi National Accelerator Laboratory; George Mason University; Google, Inc.; Harvard-Smithsonian Center for Astrophysics; Institut de Physique Nucléaire et de Physique des Particules (IN2P3); Johns Hopkins University; Kavli Institute for Particle Astrophysics and Cosmology (KIPAC) – Stanford University; Las Cumbres Observatory Global Telescope Network, Inc.; Lawrence Livermore National Laboratory (LLNL); Los Alamos National Laboratory (LANL); National Optical Astronomy Observatory; National Radio Astronomy Observatory; Princeton University; Purdue University; Research Corporation for Science Advancement; Rutgers University; SLAC National Accelerator Laboratory; Space Telescope Science Institute; Texas A & M University; The Pennsylvania State University; The University of Arizona; University of California at Davis; University of California at Irvine; University of Illinois at Urbana-Champaign; University of Michigan; University of Pennsylvania; University of Pittsburgh; University of Washington; Vanderbilt University

Announced early to stimulate multiwavelength data gathering – this approach worked!

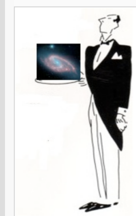
Four 10 deg^2 LSST Deep Drilling Fields

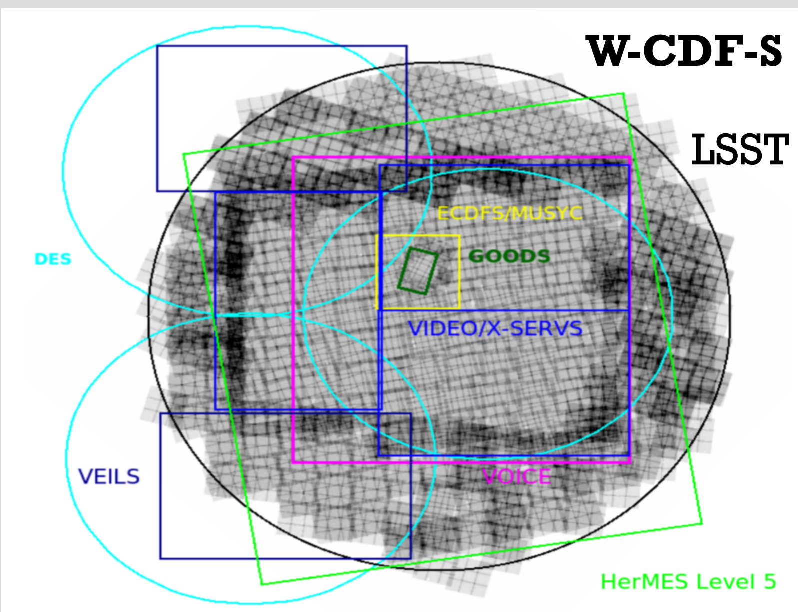


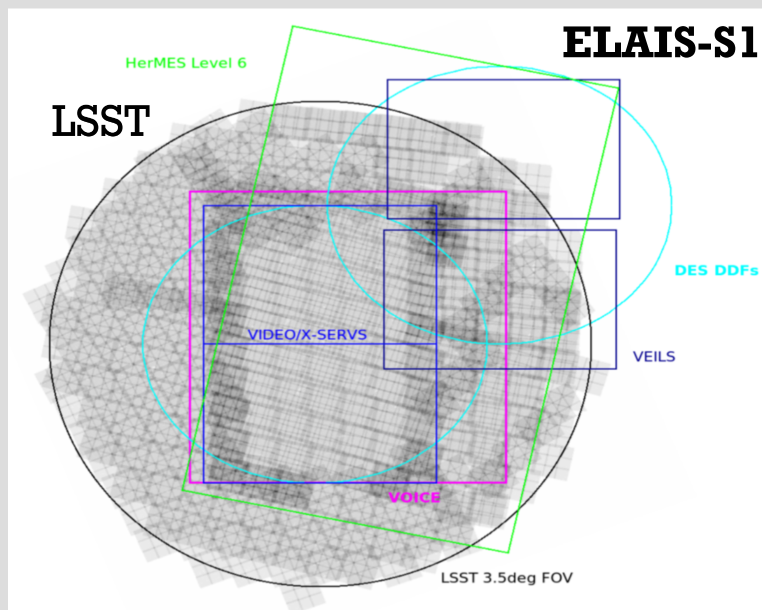


Three SERVS fields and COSMOS.

The Spitzer Extragalactic Representative Volume Survey (SERVS) and the DeepDrill survey







Brandt et al. (2018)
arXiv:1811.06542

Cadence and Other Details

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

W.N. Brandt (Penn State), Q. Ni (Penn State), G. Yang (Penn State), S.F. Anderson (Univ Washington), R.J. Assef (Univ Diego Portales), A.J. Barth (UC Irvine), F.E. Bauer (Católica), A. Bongiorno (Oss Ast Roma), C.-T. Chen (MSFC), D. De Cicco (Católica), S. Gezari (Univ Maryland), C.J. Grier (Penn State), P.B. Hall (York Univ), S.F. Hoenig (Univ Southampton), M. Lacy (NRAO), J. Li (Univ Illinois), B. Luo (Nanjing Univ), M. Paolillo (Univ Naples Fed II), B.M. Peterson (Ohio State), L.Č. Popović (Ast Obs Belgrade), G.T. Richards (Drexel Univ), O. Shemmer (Univ N Texas), Y. Shen (Univ Illinois), M. Sun (USTC), J.D. Timlin (Penn State), J.R. Trump (Univ Connecticut), F. Vito (Católica), Z. Yu (Ohio State)

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.

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

Optimizing the LSST Observing Strategy for Dark Energy Science: DESC Recommendations for the Deep Drilling Fields and other Special Programs

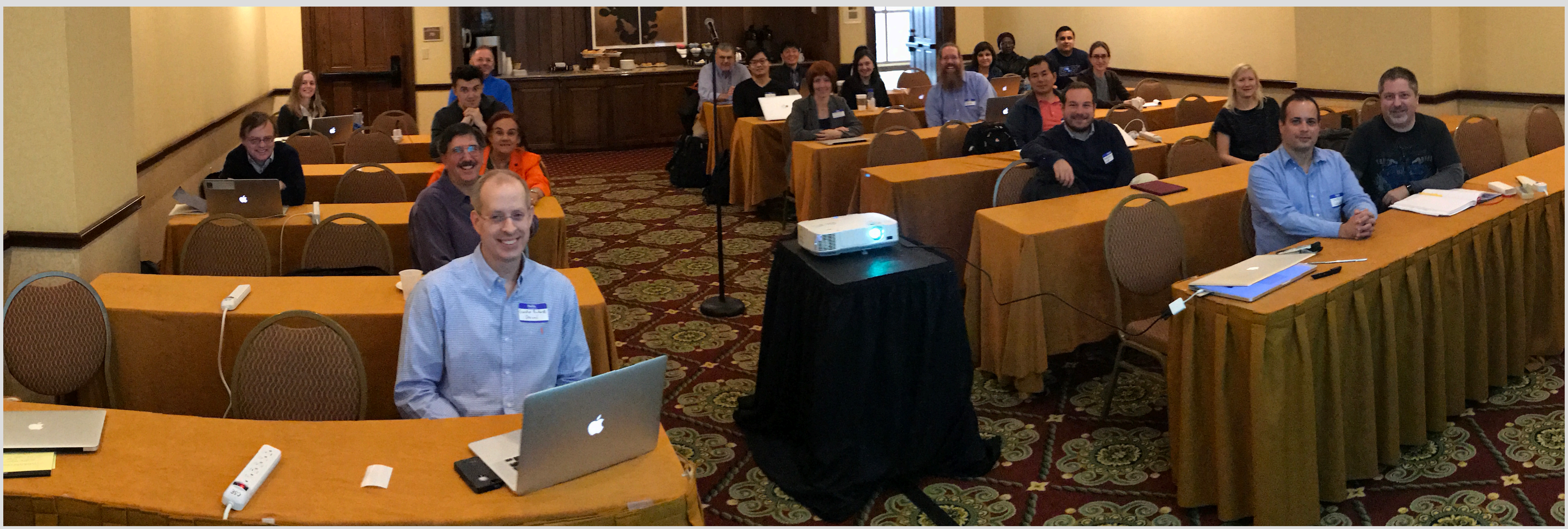
Daniel M. Scolnic[1], Michelle Lochner[2,3], Phillipe Gris[4], Nicolas Regnault[5], Renée Hložek[6,7], Greg Aldering[8], Tarek Allam Jr[9], Humna Awan[10], Rahul Biswas[11], Jonathan Blazek[12,13], Chihway Chang[14], Eric Gawiser[10], Ariel Goobar[15], Isobel M. Hook[16], Saurabh W. Jha[10], Jason D. McEwen[9], Rachel Mandelbaum[17], Phil Marshall[18], Eric Neilsen[19], Jason Rhodes[20], Daniel Rothchild[21], Ignacio Sevilla-Noarbe[22], Anže Slosar[23], Peter Yoachim[24]

(The LSST Dark Energy Collaboration)

Abstract

We review the measurements of dark energy enabled by observations of the Deep Drilling Fields (DDFs) and the optimization of survey design for cosmological measurements. This white paper is the result of efforts by the LSST DESC Observing Strategy Task Force (OSTF), which represents the entire collaboration, and aims to make recommendations on observing strategy for the DDFs that will benefit all cosmological analyses with LSST. It is accompanied by the DESC-WFD white paper (Lochner et al.). We argue for altering the nominal deep drilling plan to have > 6 month seasons, interweaving gri and zy observations every 3 days with 2, 4, 8, 25, 4 visits in $grizy$, respectively. These recommendations are guided by metrics optimizing constraints on dark energy and mitigation of systematic uncertainties, including specific requirements on total number of visits after Y1 and Y10 for photometric redshifts (photo-z) and weak lensing systematics. We specify the precise locations for the previously-chosen LSST deep fields (ELAIS-S1, XMM-LSS, CDF-S, and COSMOS) and recommend Akari Deep Field South as the planned fifth deep field in order to synergize with Euclid and WFIRST. Our recommended DDF strategy uses 6.2% of the LSST survey time. We briefly discuss synergy with white papers from other collaborations, as well as additional mini-surveys and Target-of-Opportunity programs that lead to better measurements of dark energy.

The LSST AGN Science Collaboration

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Spitzer DEEPDRILL Survey of LSST DDFs

Spitzer Space Telescope General Observer Proposal #11086.

A warm Spitzer survey of the LSST/DES "Deep drilling" fields

Principal Investigator: Mark Lacy

Institution: National Radio Astronomy Observatory (NRAO)

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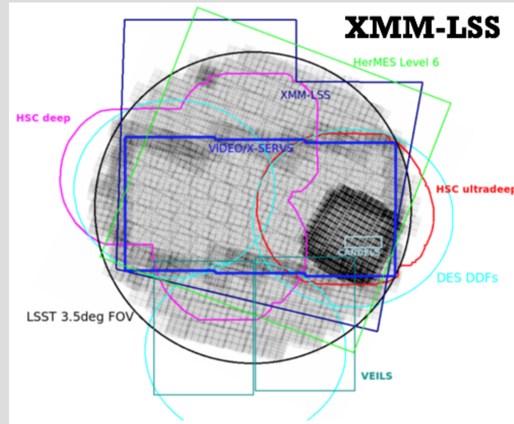
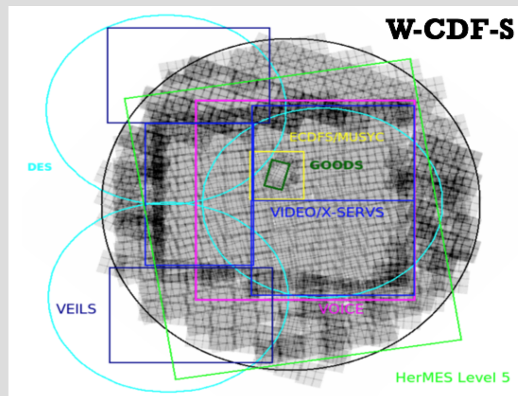
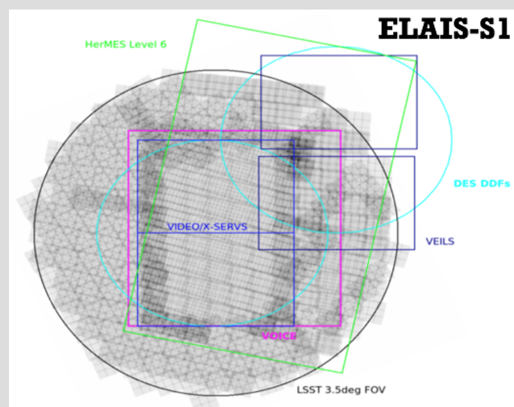
Co–Investigators: Duncan Farrah, Virginia Tech
Niel Brandt, Penn State
Masao Sako, U Penn
Gordon Richards, Drexel
Ray Norris, CSIRO/Macquarie University
Susan Ridgway, NOAO
Jose Afonso, Lisbon
Robert Brunner, Illinois
Dave Clements, Imperial College

et al.

Abstract:
We propose a warm Spitzer survey to microJy depth of the four predefined Deep Drilling Fields (DDFs) for the Large Synoptic Survey Telescope (LSST) (three of which are also deep drilling fields for the Dark Energy Survey (DES)). Imaging these fields with warm Spitzer is a key component of the overall success of these projects, that address the "Physics of the Universe" theme of the Astro2010 decadal survey. With deep, accurate, near–infrared photometry from Spitzer in the DDFs, we will generate photometric redshift distributions to apply to the surveys as a whole. The DDFs are also the areas where the supernova searches of DES and LSST are concentrated, and deep Spitzer data is essential to obtain photometric redshifts, stellar masses and constraints on ages and metallicities for the >10000 supernova host galaxies these surveys will find. This "DEEPDRILL" survey will also address the "Cosmic Dawn" goal of Astro2010 through being deep enough to find all the >10^11 solar mass galaxies within the survey area out to z~6. DEEPDRILL will complete the final 24.4 square degrees of imaging in the DDFs, which, when added to the 14 square degrees already imaged to this depth, will map a volume of 1–Gpc^3 at z>2. It will find ~100 > 10^11 solar mass galaxies at z~5 and ~40 protoclusters at z>2, providing targets for JWST that can be found in no other way. The Spitzer data, in conjunction with the multiwavelength surveys in these fields, ranging from X–ray through far–infrared and cm–radio, will comprise a unique legacy dataset for studies of galaxy evolution.







Spitzer coverage is gray shading.

Where Are the X-rays?

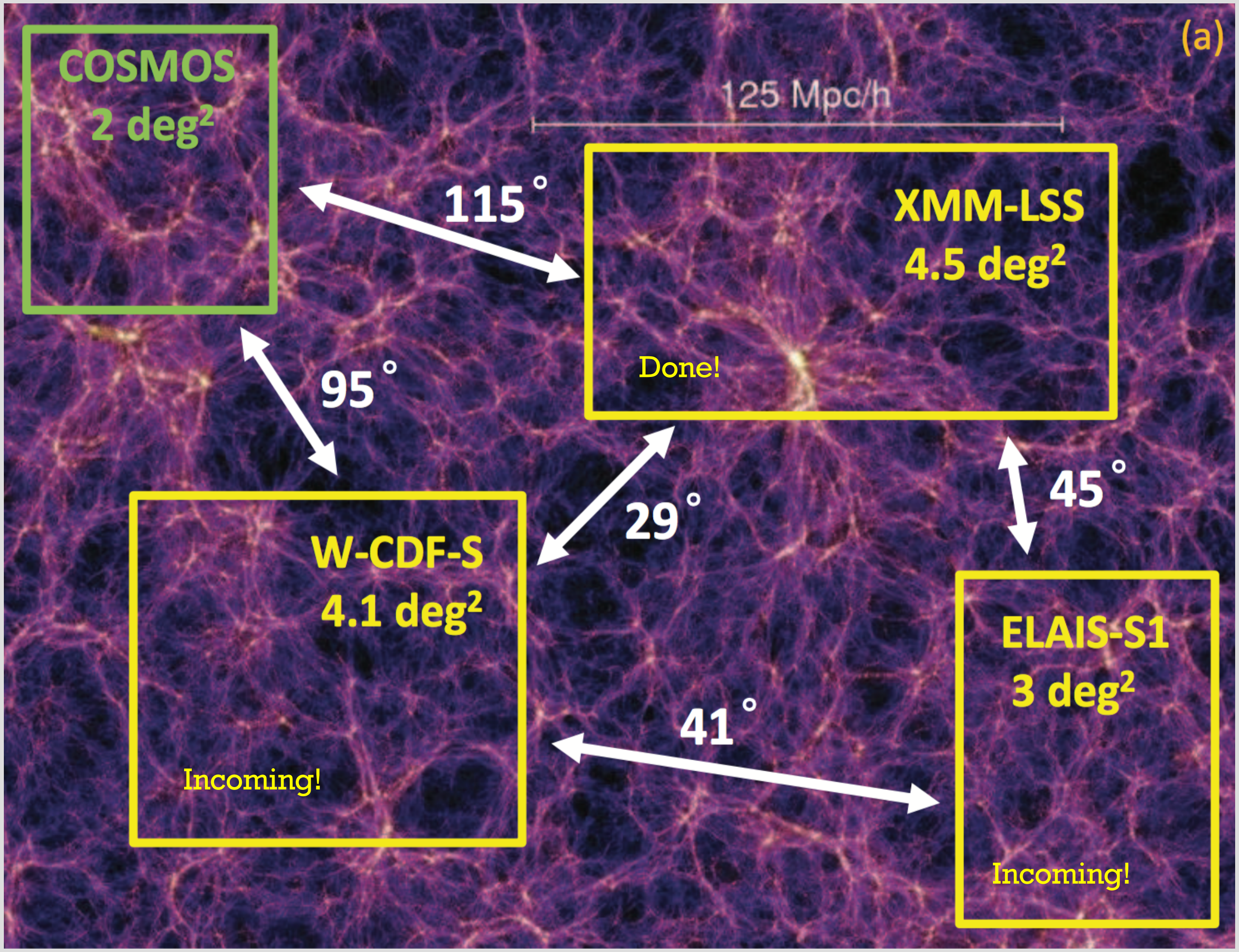
Table 1: Some of the Current/Scheduled 1–10 deg^2 Multiwavelength Coverage of XMM-SERVS

Band	Survey Name	Coverage (W-CDF-S, ELAIS-S1, XMM-LSS); Notes
Radio	Australia Telescope Large Area Survey (**ATLAS**)[a]	3.7, 2.7, – deg^2; 15 μJy rms depth at 1.4 GHz
	MIGHTEE Survey (Starting Soon)[b]	4.5, 3, 4.5 deg^2; 1 μJy rms depth at 1.4 GHz
FIR	*Herschel* Multi-tiered Extragal. Surv. (**HerMES**)[c]	0.6–18 deg^2; 5–60 mJy depth at 100–500 μm
MIR	*Spitzer* Wide-area IR Extragal. Survey (**SWIRE**)[d]	8.2, 7.0, 9.4 deg^2; 0.04–30 mJy depth at 3.6–160 μm
NIR	*Spitzer* Extragal. Rep. Vol. Survey (**SERVS**)[e]	4.5, 3, 4.5 deg^2; 2 μJy depth at 3.6 and 4.5 μm
	VISTA Deep Extragal. Obs. Survey (**VIDEO**)[f]	4.5, 3, 4.5 deg^2; $ZYJHK_s$ to $m_{\rm AB} \approx 23.8$–25.7
	VISTA Extragal. Infr. Legacy Survey (**VEILS**)[g]	3, 3, 3 deg^2; JK_s to $m_{\rm AB} \approx 24.5$–25.5
	Euclid Deep Field[h]	10, –, – deg^2; YJH to $m_{\rm AB} \approx 26$, VIS to $m_{\rm AB} \approx 26.5$
Optical Photometry	Dark Energy Survey (**DES**)[i]	9, 6, 9 deg^2; Multi-epoch $griz$, $m_{\rm AB} \approx 27$ co-added
	Hyper Suprime-Cam (**HSC**) Deep Survey[j]	–, –, 5.3 deg^2; $grizy$ to $m_{\rm AB} \approx 25.3$–27.5
	Pan-STARRS1 Medium-Deep Survey (**PS1MD**)[k]	8, –, 8 deg^2; Multi-epoch $grizy$, $m_{\rm AB} \approx 26$ co-added
	VST Opt. Imaging of CDF-S and ES1 (**VOICE**)[l]	4.5, 3, – deg^2; Multi-epoch $ugri$, $m_{\rm AB} \approx 26$ co-added
	SWIRE optical imaging[d]	7, 6, 8 deg^2; $u'g'r'i'z'$ to $m_{\rm AB} \approx 24$–26
	LSST deep-drilling field (Planned)[m]	10, 10, 10 deg^2; $ugrizy$, $\gtrsim 10\,000$ visits per field
Optical/NIR Spectroscopy	Carnegie-*Spitzer*-IMACS Survey (**CSI**)[n]	4.8, 3.6, 6.9 deg^2; 140 000 redshifts, 3.6 μm selected
	PRIsm MUlti-object Survey (**PRIMUS**)[o]	2.0, 0.9, 2.9 deg^2; 77 000 redshifts to $i_{\rm AB} \approx 23.5$
	AAT Deep Extragal. Legacy Survey (**DEVILS**)[p]	1.5, –, 3.0 deg^2; 43 500 redshifts to $Y = 21.2$
	VLT **MOONS** Survey (Scheduled)[q]	4.5, 3, 4.5 deg^2; 210 000 redshifts to $H_{\rm AB} \approx 23.5$
UV	*GALEX* Deep Imaging Survey[r]	7, 7, 8 deg^2; Depth $m_{\rm AB} \approx 25$

References: [a] Franzen et al. (2015); [b] Jarvis et al. (2017); [c] Oliver et al. (2012); [d] Lonsdale et al. (2003); [e] Mauduit et al. (2012); [f] Jarvis et al. (2013); [g] http://www.ast.cam.ac.uk/~mbanerji/VEILS/veils_index.html; [h] Scaramella et al. (2017); [i] Diehl et al. (2014); [j] http://www.naoj.org/Projects/HSC/surveyplan.html; [k] Tonry et al. (2012); [l] Vaccari et al. (2017); [m] http://www.lsst.org/News/enews/deep-drilling-201202.html; [n] Kelson et al. (2014); Patel et al. (2015); [o] Coil et al. (2011); [p] https://devilsurvey.org/wp/; [q] http://www.roe.ac.uk/~ciras/MOONS/VLT-MOONS.html; [r] http://www.galex.caltech.edu/researcher/techdoc-ch2.html.

Having no X-rays would be an epic fail for AGN and cluster science!

5 Ms XMM-SERVS: Pushing Beyond COSMOS

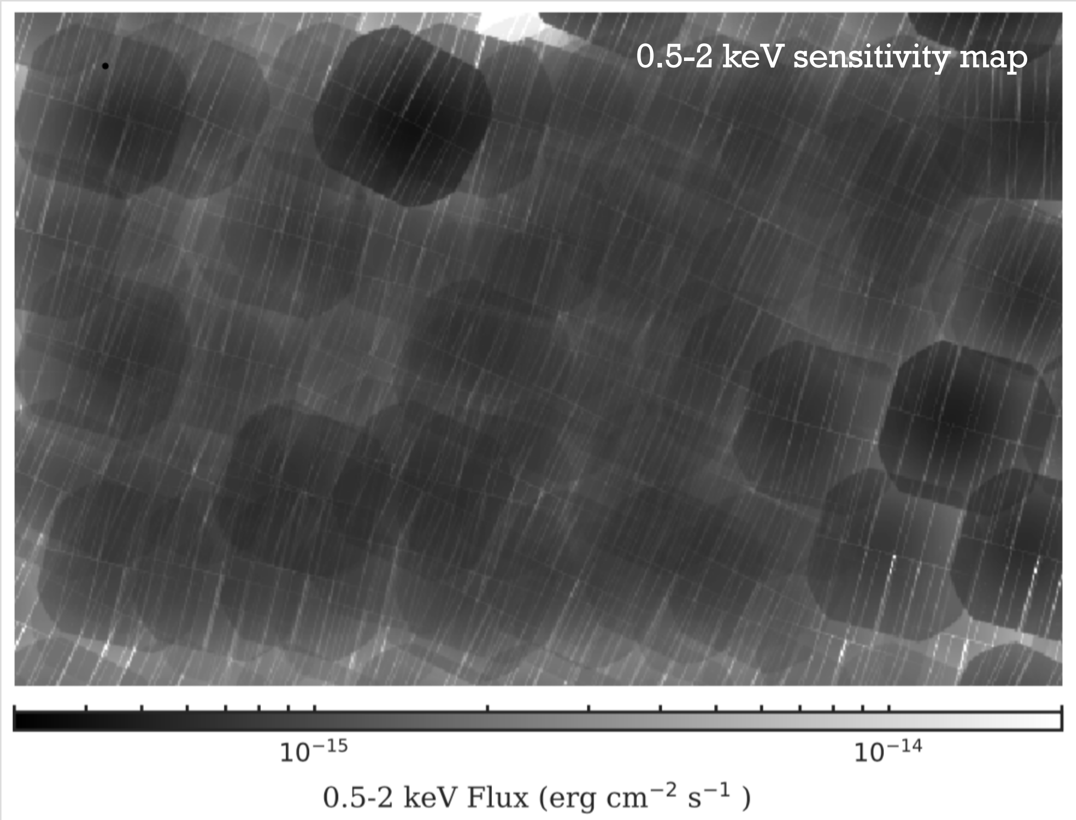


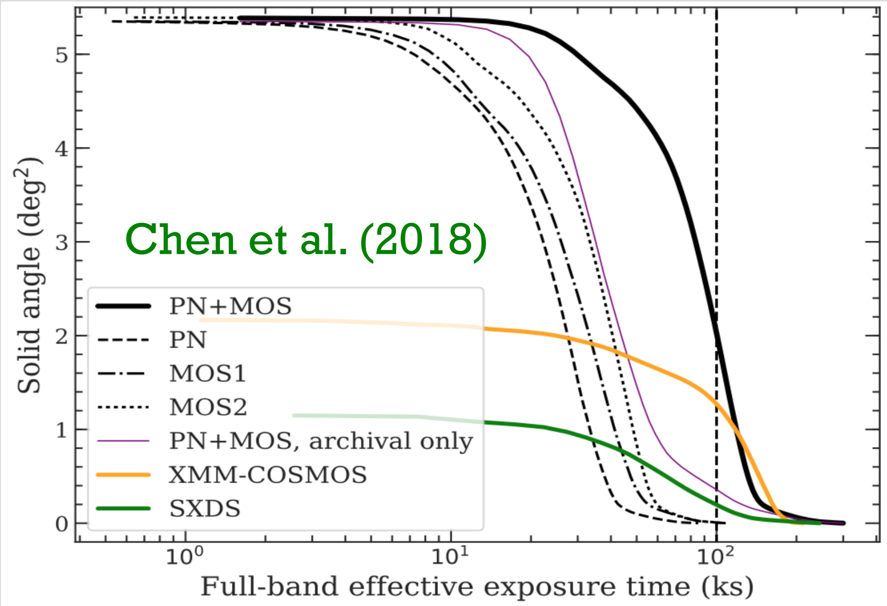
At 50 ks XMM-Newton depth, expect ~ 12,000 AGNs and ~ 760 X-ray groups/clusters.

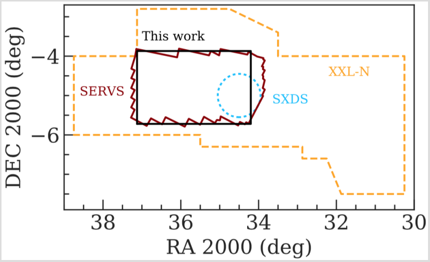
SMBH growth across the full range of cosmic environments and SMBH/galaxy connections.

Incredible legacy value as LSST/DES DDFs, MOONS/PFS fields, TolTEC/ALMA fields.

Results from the XMM-LSS Field





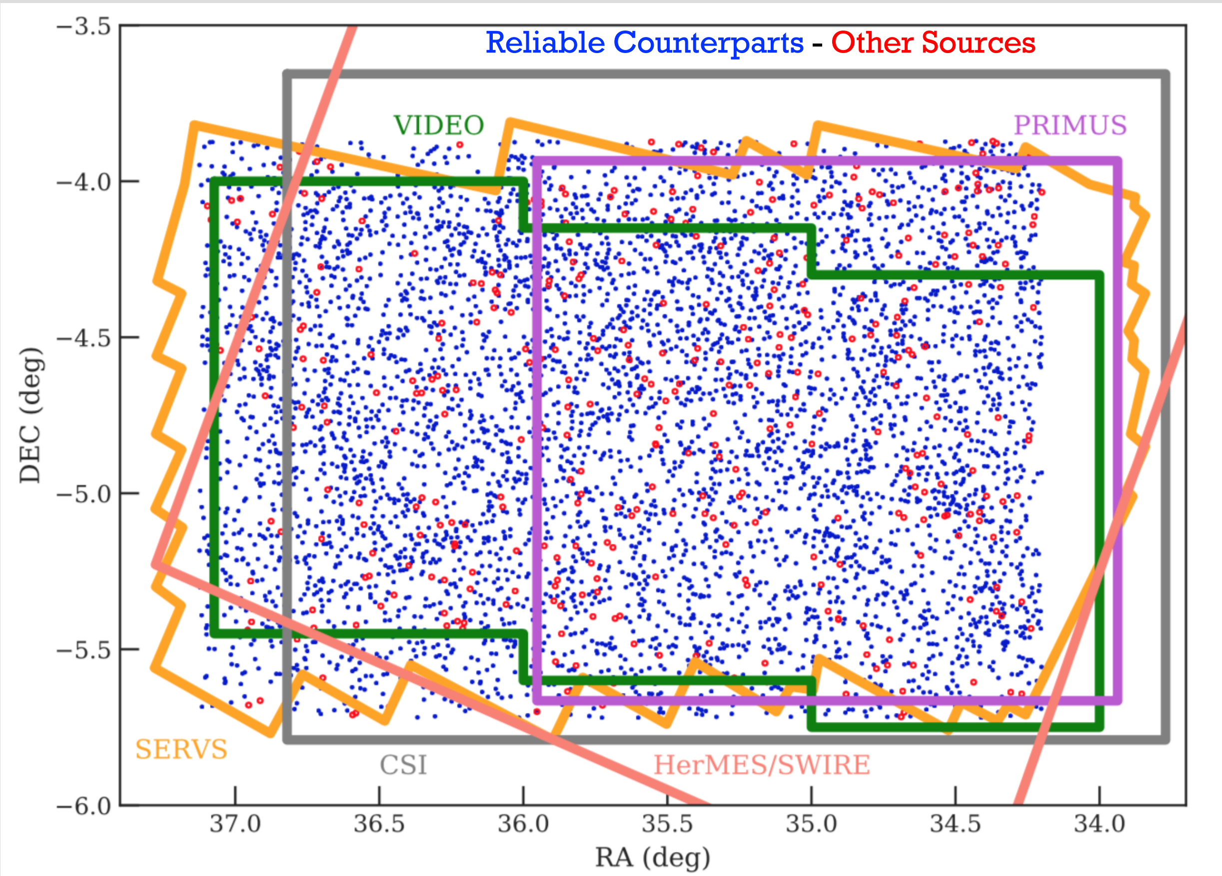


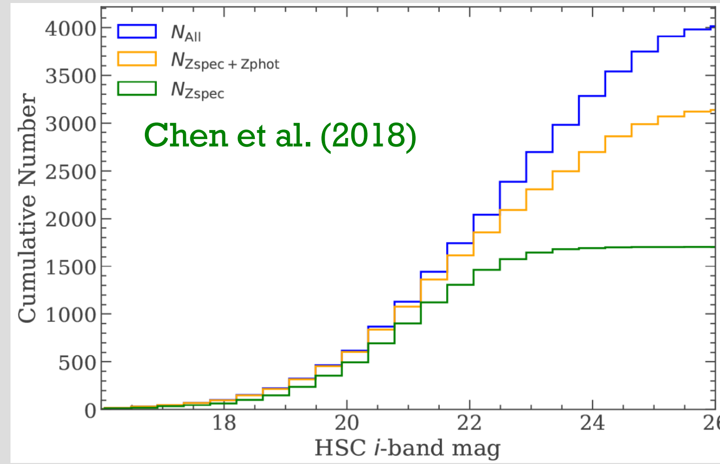
1.1 Ms additional good XMM-Newton exposure (2.7 Ms total).

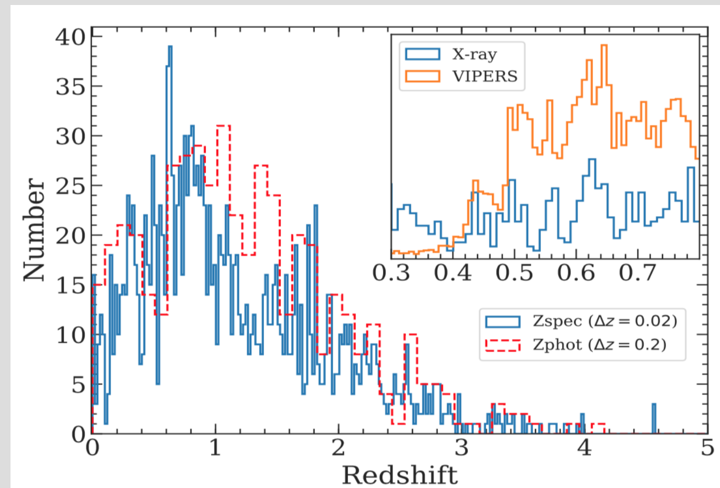
5.3 deg^2 at 46 ks median PN depth – good uniformity after make-ups.

5242 total X-ray sources – 2381 new (cf. 1887 in XMM-COSMOS).

Results from the XMM-LSS Field





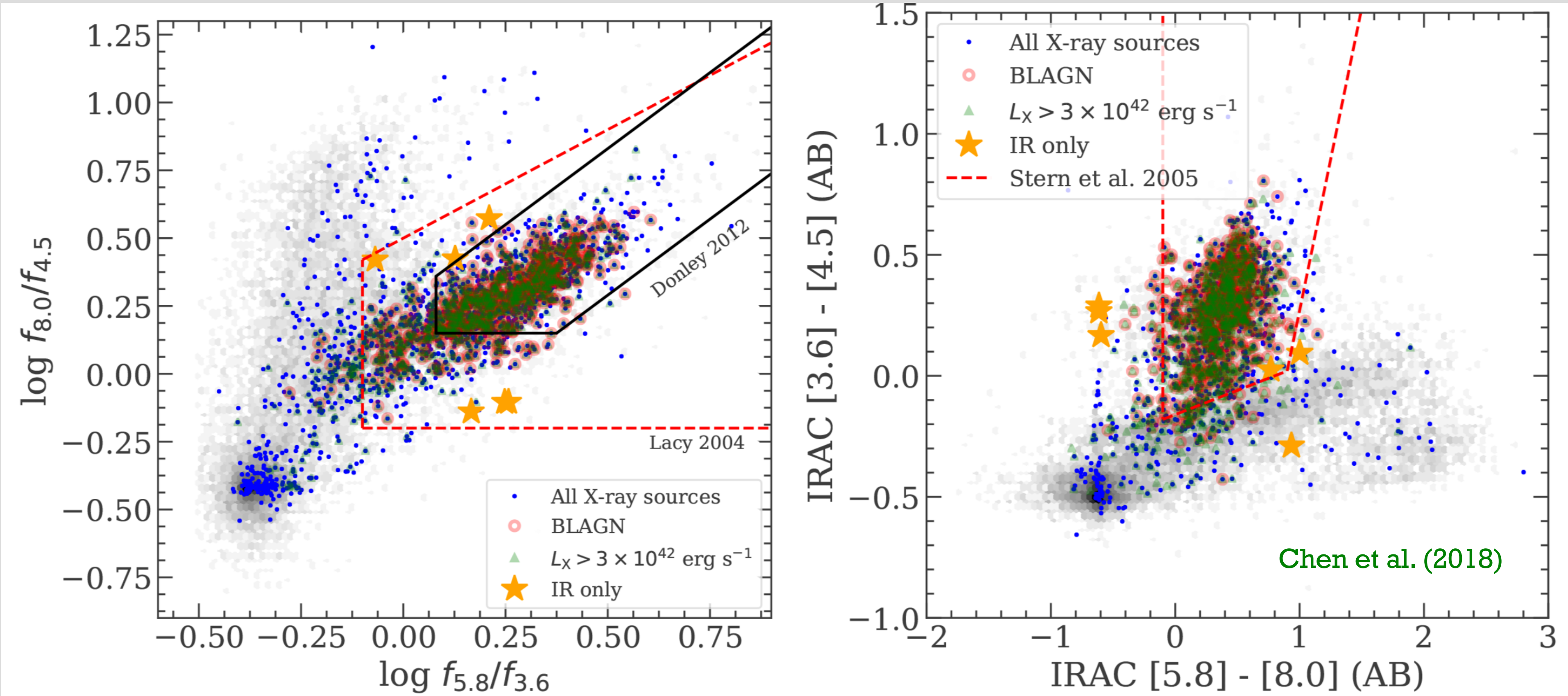


90% reliable counterpart identification rate (assessed with Chandra).

In our prime 4.5 deg^2, more than 70% of sources have spectroscopic or high-quality photometric redshifts. MOONS/PFS will soon improve further.

96.7% of X-ray point sources identified as AGNs or likely AGNs.

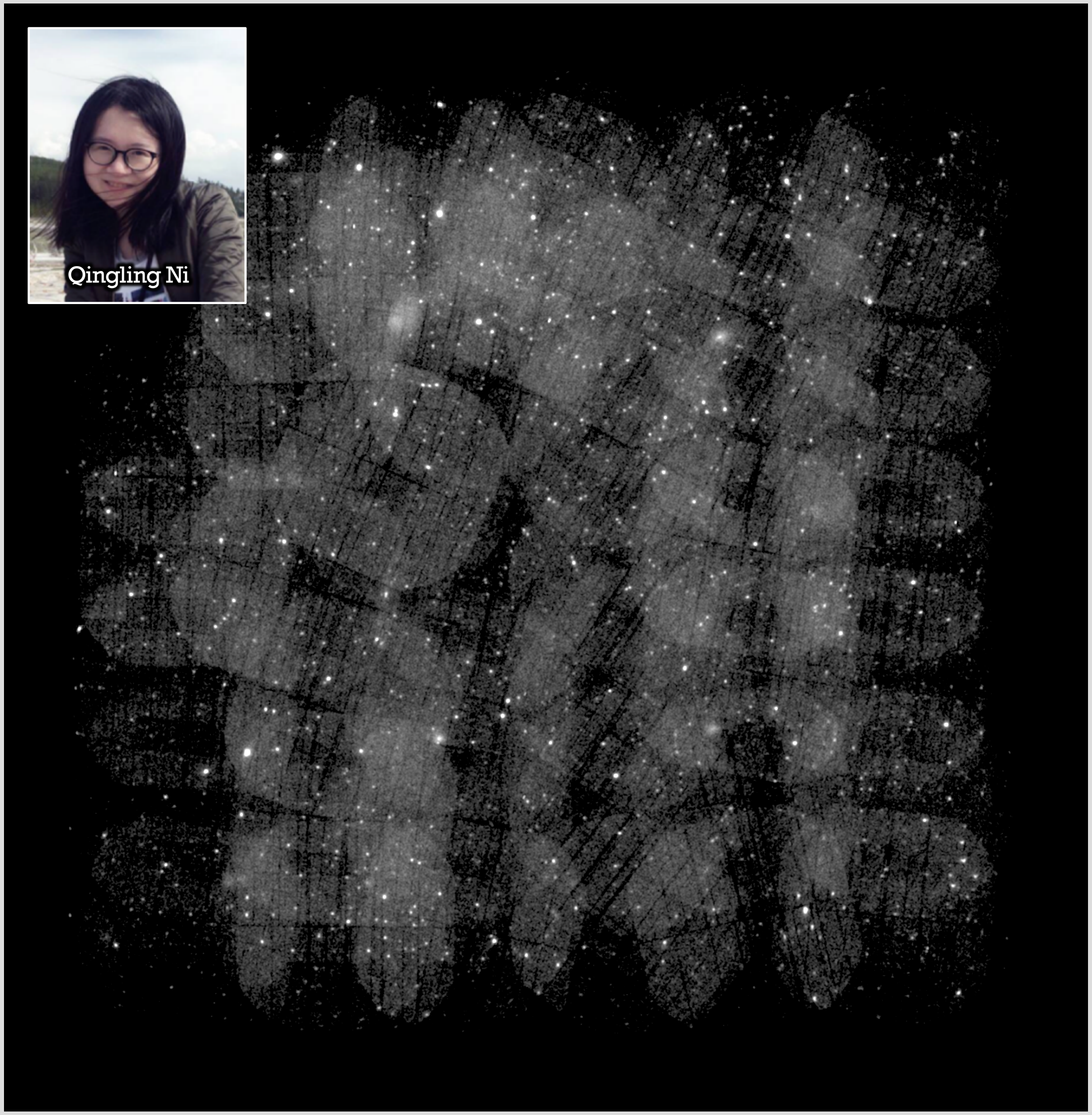
X-ray vs. Spitzer Selection



Have performed comparisons of X-ray vs. mid-infrared (hot-dust) selection.

Mid-infrared selection works fairly well for luminous AGNs, but X-ray selection is required to minimize interlopers and find moderate-luminosity systems.

W-CDF-S Data Incoming Now!



42 / 54 observations done with total exposure of 1.6 Ms, covering 3.7 deg^2.

Mild background flaring so far.

Observations will finish by 2021.

2660 X-ray sources already detected, and almost all are new.

About 90% have reliable multiwavelength counterparts.

HSC imaging published and archival data assembled. Photo-z’s computed.

Ni et al., in preparation

W-CDF-S HSC Images & Catalog

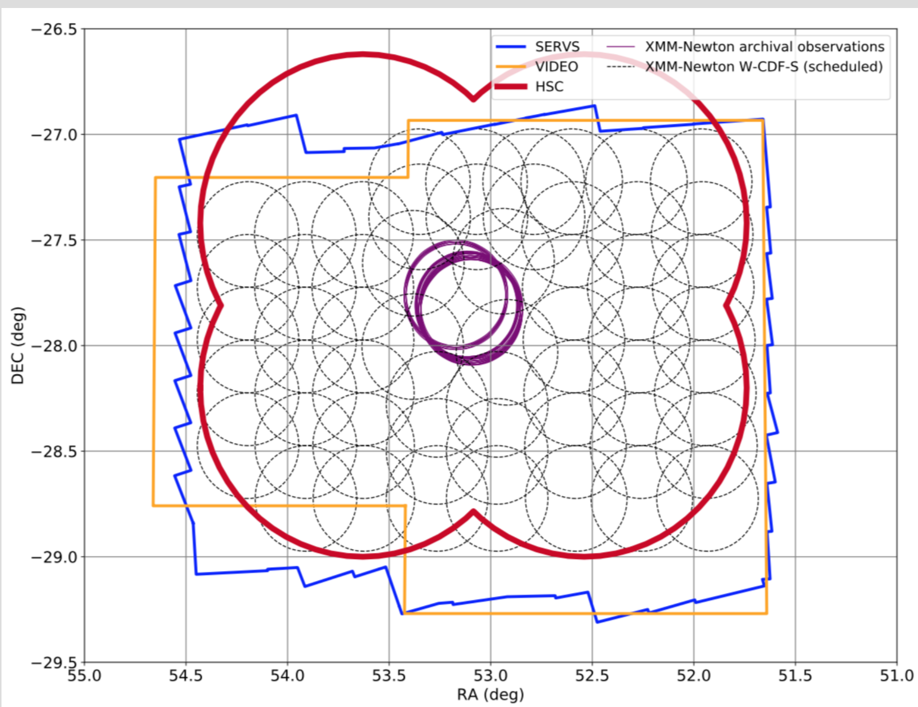
Deep Hyper Suprime-Cam Images and a Forced Photometry Catalog in W-CDF-S

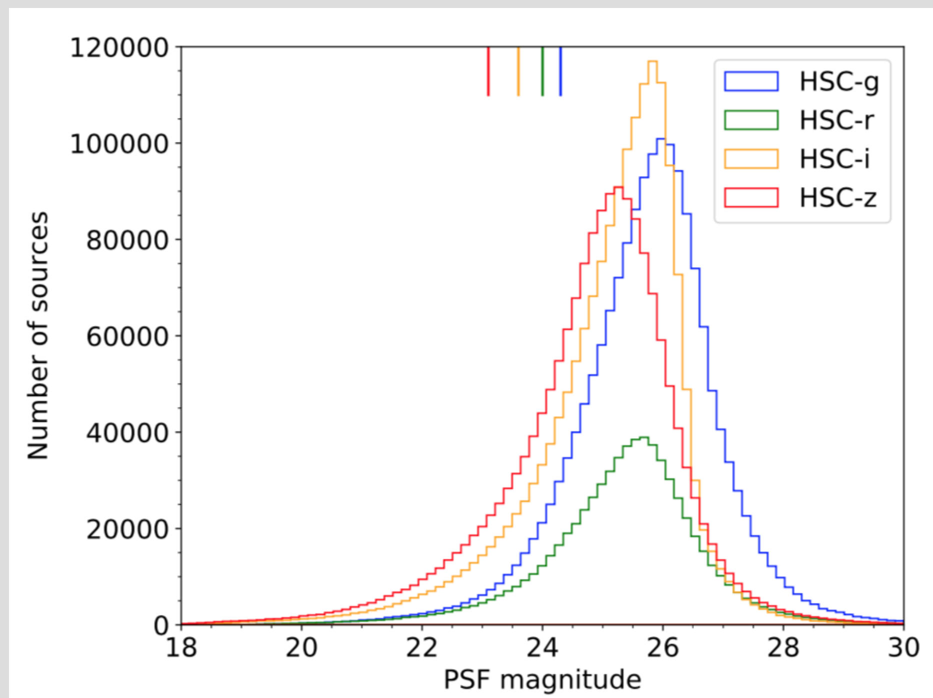
Q. Ni,[1] J. Timlin,[1] W. N. Brandt,[1] and G. Yang[1]

[1] *Department of Astronomy & Astrophysics, 525 Davey Lab, The Pennsylvania State University, University Park, PA 16802, USA*

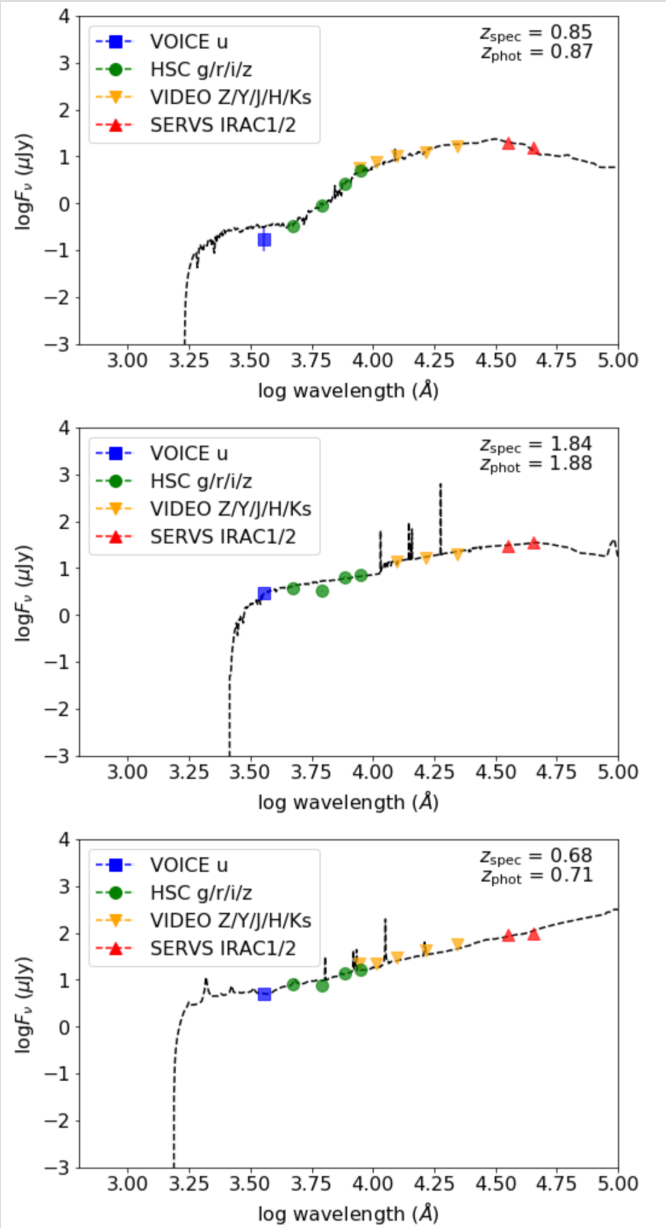
ABSTRACT

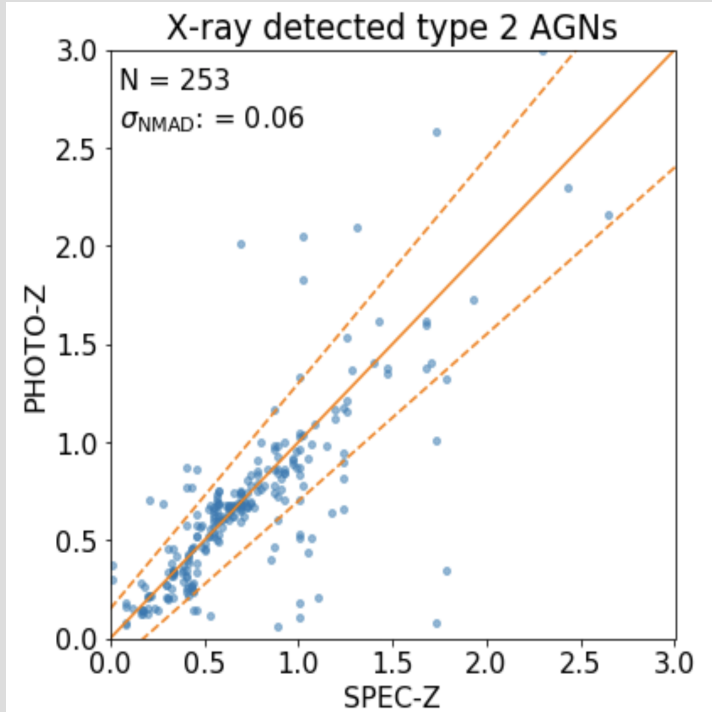
The Wide Chandra Deep Field-South (W-CDF-S) field is one of the SERVS fields with extensive multiwavelength datasets, which can provide insights into the nature and properties of objects in this field. However, the public optical data from DES (*grizy* to $m_{\rm AB} \approx 21.4 - 24.3$) are not sufficiently deep to match well the NIR data from VIDEO ($ZYJHK_s$ to $m_{\rm AB} \approx 23.5 - 25.7$), which limits the investigation of fainter objects at higher redshifts. Here, we present an optical catalog of $\approx$ 2,000,000 objects in W-CDF-S utilizing archival Hyper Suprime-Cam observations in the g,r,i,z bands covering ≈ 5.7 deg^2. The estimated depth is $\approx$ 25.9 for g-band, 25.6 for r-band, 25.8 for i-band, and 25.2 for z-band, which is deep enough to complement the NIR data, and will benefit AGN/galaxy studies in W-CDF-S in the future.

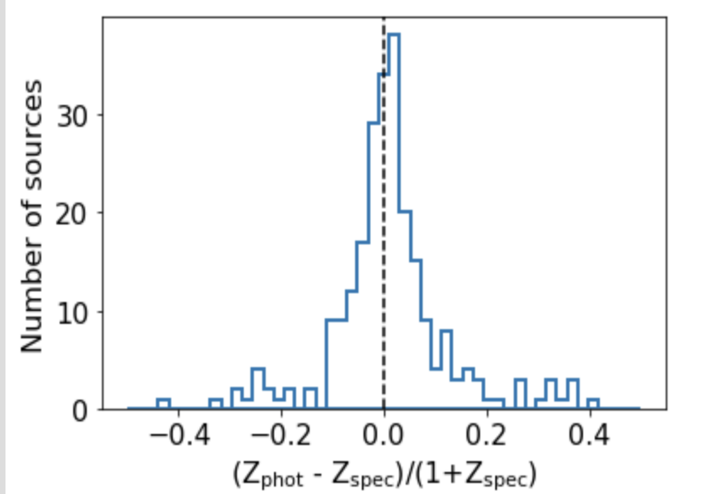


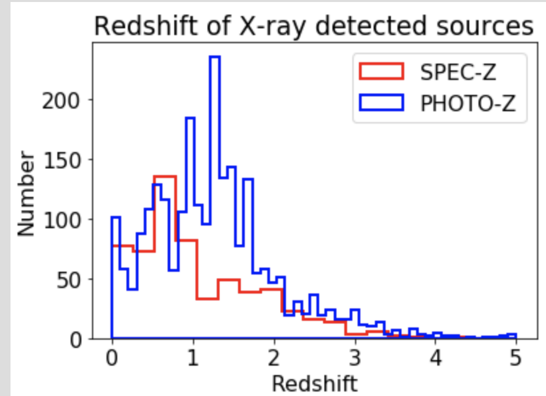


W-CDF-S Photometric Redshifts



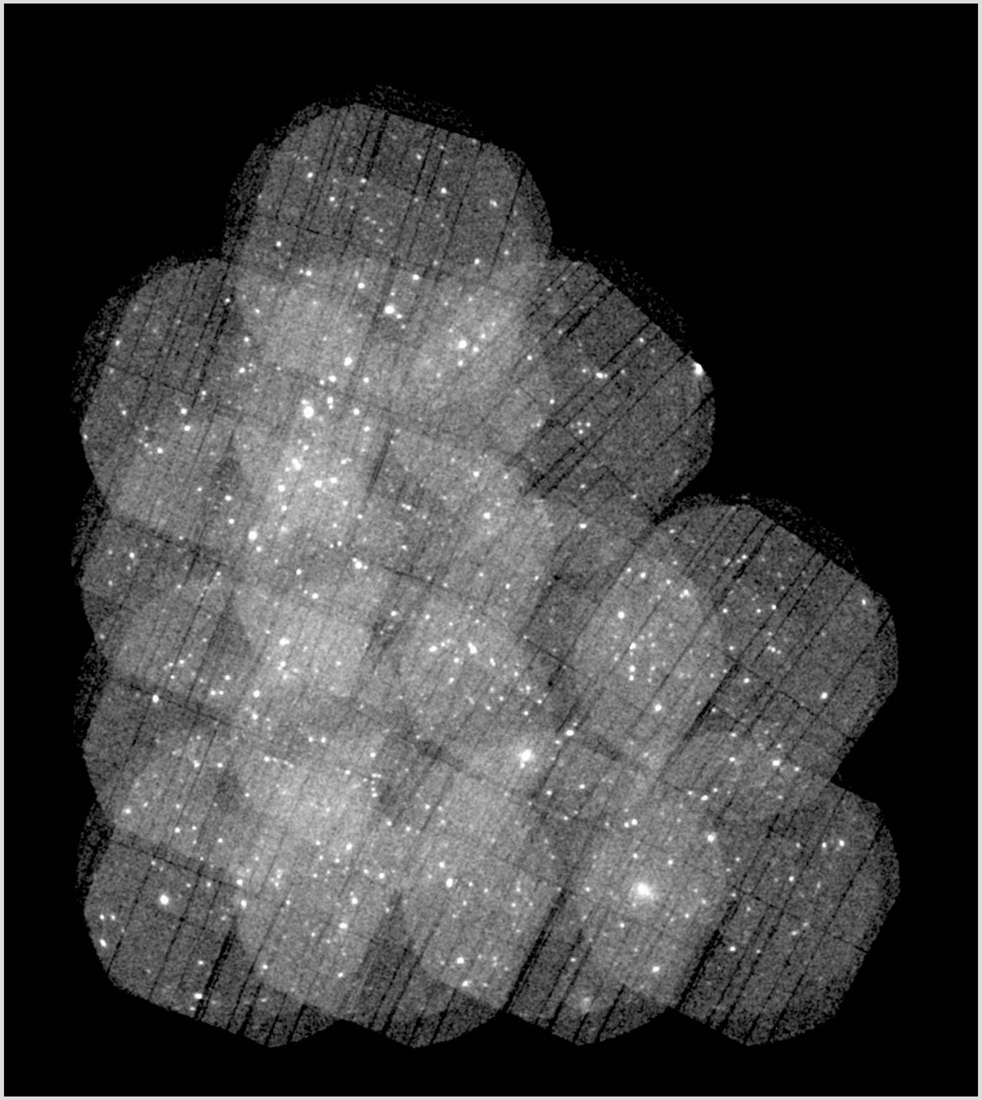






Computed by Guang Yang for Ni et al., in preparation.

ELAIS-S1 Data Incoming Now!



14 / 25 observations done with total exposure of 450 ks, covering 1.5 deg^2.

Almost no background flaring so far.

Observations will finish by 2021.

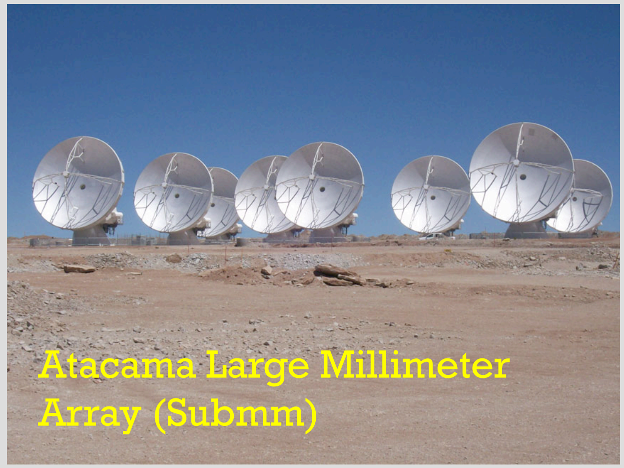
1470 X-ray sources already detected.

About 90% have reliable multiwavelength counterparts.

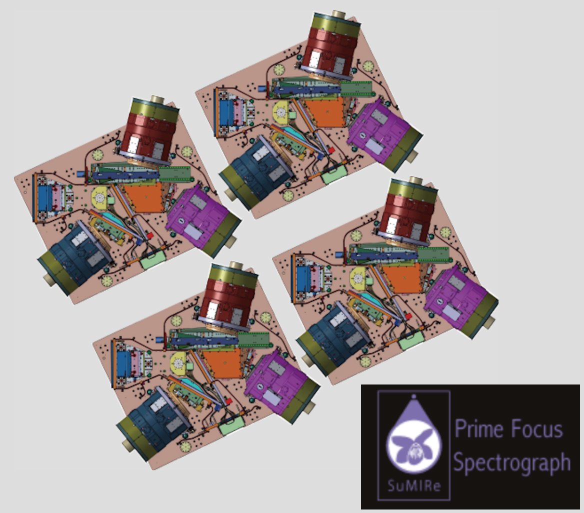
First photo-z's computed and better multiwavelength data being assembled.

Ni et al., in preparation

Complementary Multiwavelength Data Flooding In for XMM-SERVS!

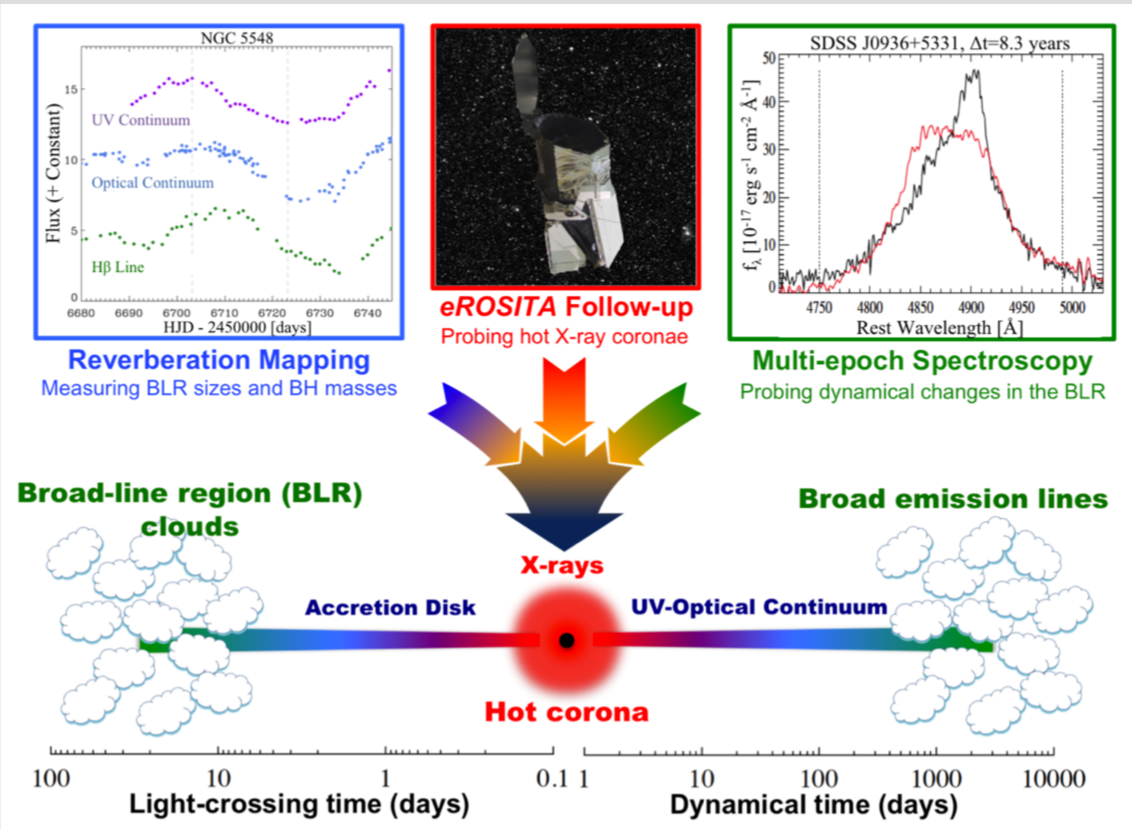


ToltEC
LMT
ASU Cardiff INAOE Michigan NIST Northwestern UMass Wisconsin



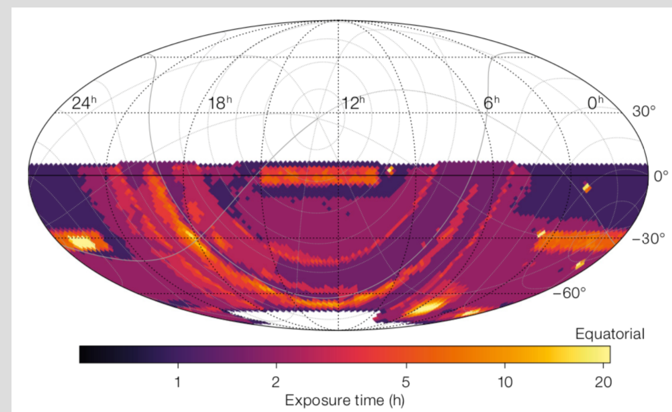
Multi-Object Reverberation Mapping

SDSS-V Black Hole Mapper will Reverberation Map AGNs in Three LSST DDFs: 2020-2025



4MOST TiDES Component in LSST DDFs: 2022-2027

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)

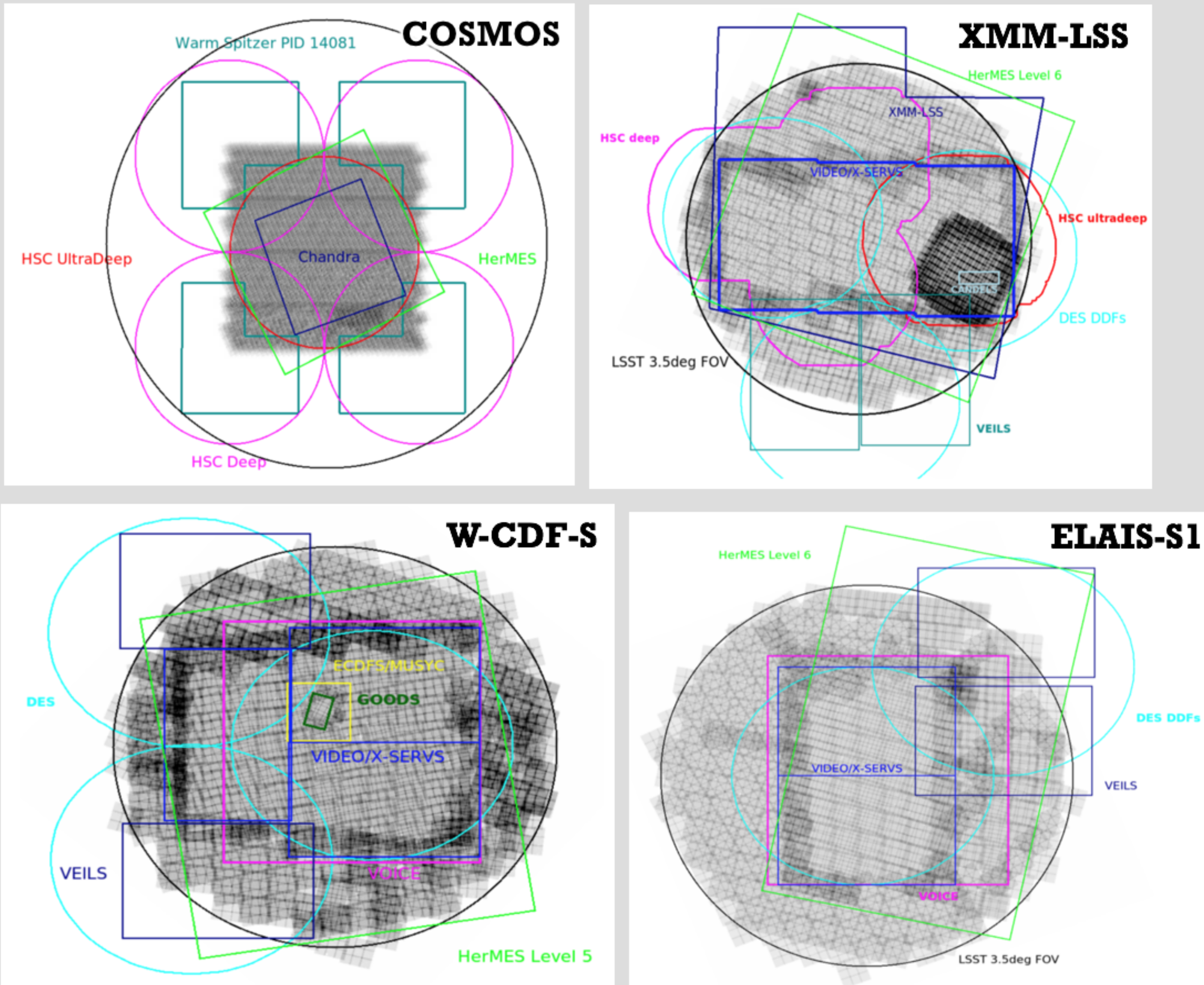
LSST will provide ~ 900 epochs of outstanding photometry for reverberation mapping.

All of these sources will have XMM-Newton X-ray characterization.

Also BAL variability, reddening variability, changing-look quasars, general emission-line variability, etc.

50+ Ms of Additional Survey Possibilities for the 2020's

Finish/Improve LSST DDFs



Brandt et al. (2018)

Currently only 13.6 / 40 deg^2 of the DDFs will have good XMM-Newton coverage.

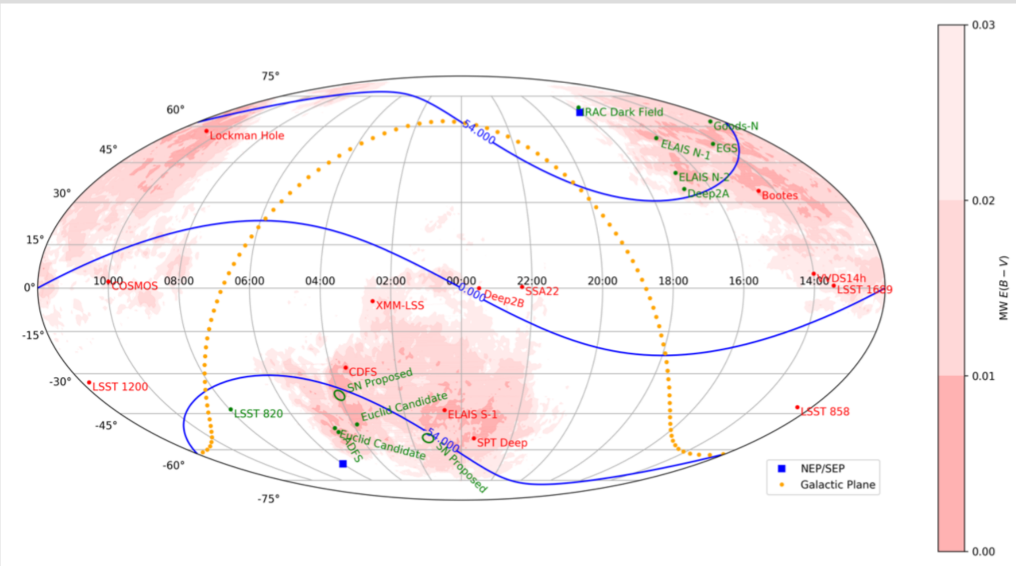
Completing them is very tempting - cost of ~ 15 Ms.

Also could push them deeper to ~ 150 ks depths.

The Akari Deep Field-South has been proposed as another ~ 20 deg^2 LSST DDF.

Will be Euclid and likely WFIRST deep field.

WFIRST Deep SNe Fields



WFIRST aims to produce several 10+ deg^2 ultradeep fields via its supernova survey - in its CVZ.

Amazing samples of morphologically well-characterized AGN hosts out to $z \sim 3$.

Proposing for near-simultaneous LSST coverage.

Cost to cover ~ 10 Ms+.

LSST Observations of *WFIRST* Deep Fields

The WFIRST Deep Field Working Group,
WFIRST Science Investigation Team Members,
and Community Members:
R. J. Foley, A. M. Koekemoer, D. N. Spergel,
F. B. Bianco, P. Capak, L. Dai, O. Doré, G. G. Fazio, H. Ferguson,
A. V. Filippenko, B. Frye, L. Galbany, E. Gawiser, C. Gronwall,
N. P. Hathi, C. Hirata, R. Hounsell, S. W. Jha, A. G. Kim,
P. L. Kelly, J. W. Kruk, S. Malhotra, K. S. Mandel, R. Margutti,
D. Marrone, K. B. W. McQuinn, P. Melchior, L. Moustakas,
J. A. Newman, J. E. G. Peek, S. Perlmutter, J. D. Rhodes,
B. Robertson, D. Rubin, D. Scolnic, R. Somerville, R. Street,
Y. Wang, D. J. Whalen, R. A. Windhorst, E. J. Wollack

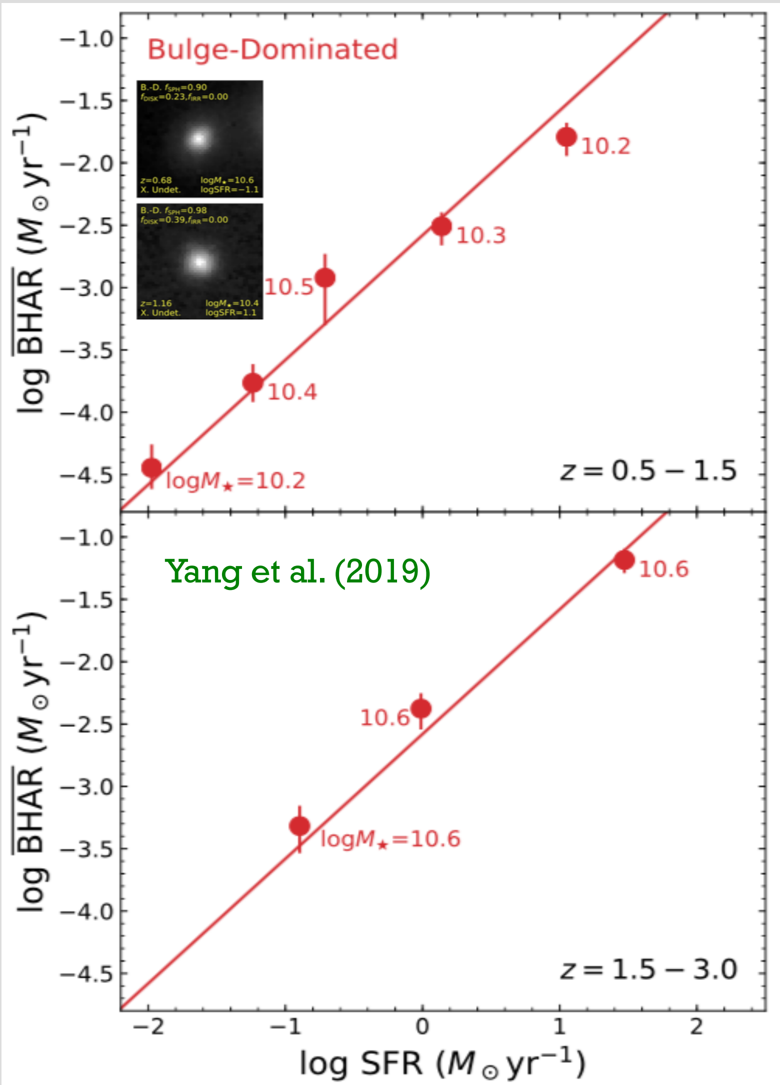
November 30, 2018

Abstract

The Wide-Field Infrared Survey Telescope (*WFIRST*) is expected to launch in the mid-2020s. With its wide-field near-infrared (NIR) camera, it will survey the sky to unprecedented detail. As part of normal operations and as the result of multiple expected dedicated surveys, *WFIRST* will produce several relatively wide-field (tens of square degrees) deep (limiting magnitude of 28 or fainter) fields. In particular, a planned supernova survey is expected to image 3 deep fields in the LSST footprint roughly every 5 days over 2 years. Stacking all data, this survey will produce, over all *WFIRST* supernova fields in the LSST footprint, ~12–25 deg^2 and ~5–15 deg^2 regions to depths of ~28 mag and ~29 mag, respectively. We suggest LSST undertake mini-surveys that will match the *WFIRST* cadence and simultaneously observe the supernova survey fields during the 2-year *WFIRST* supernova survey, achieving a stacked depth similar to that of the *WFIRST* data. We also suggest additional observations of these same regions throughout the LSST survey to get deep images earlier, have long-term monitoring in the fields, and produce deeper images overall. These fields will provide a legacy for cosmology, extragalactic, and transient/variable science.

Lockstep SMBH-Bulge Growth

CANDELS Infrared Morphology to Select Only Bulges is *Essential*



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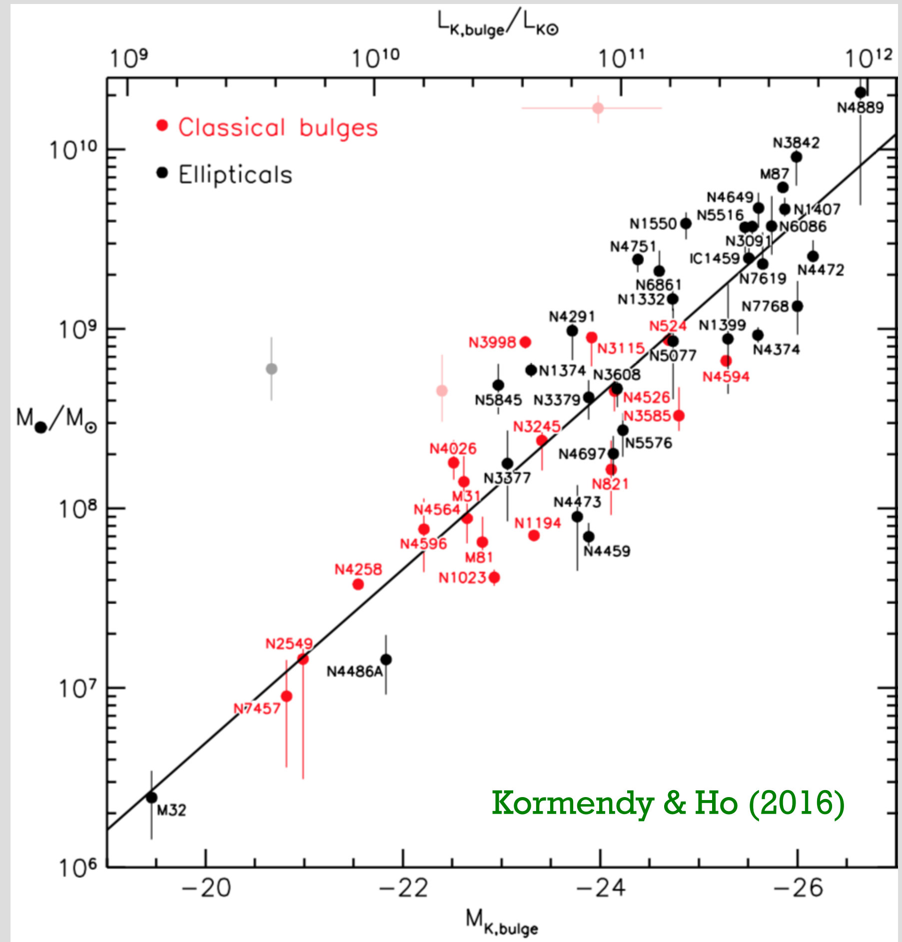
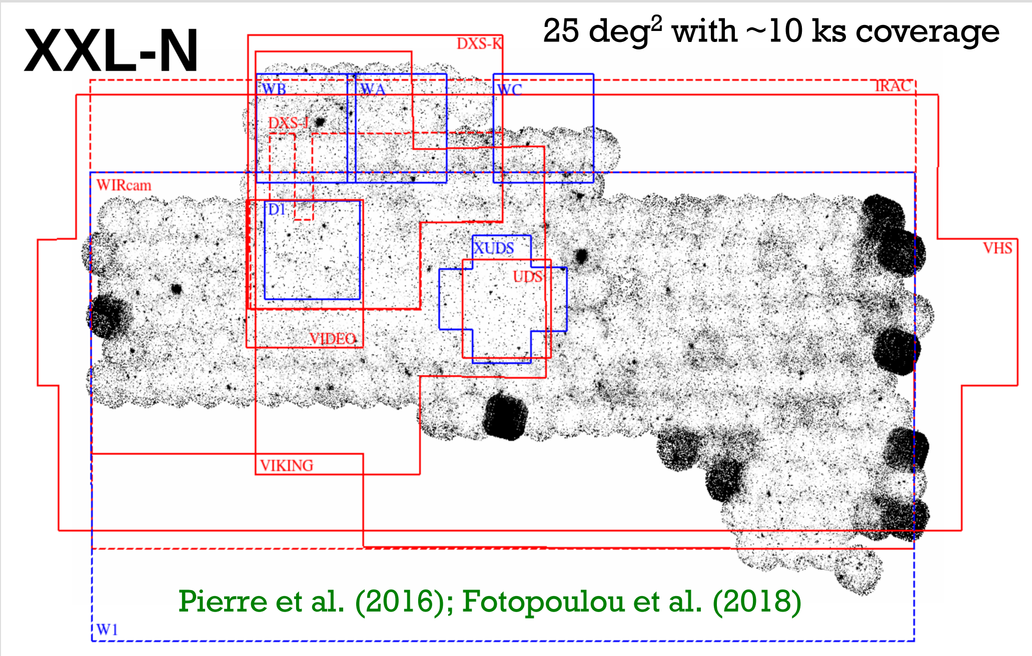
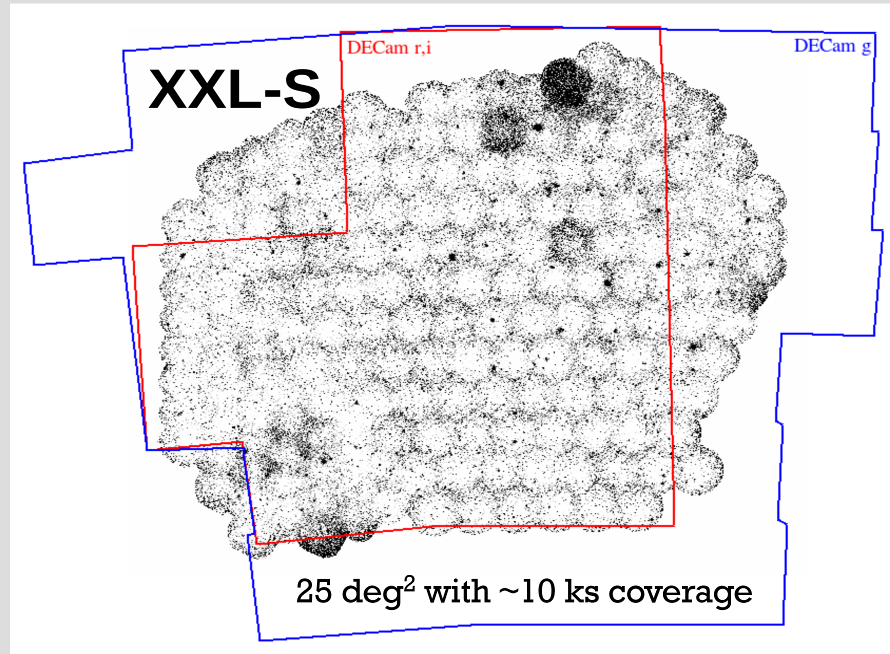


Results do *not* hold when large non-bulge components present.

WFIRST will allow on industrial scale!

Push XXL Deeper for AGNs + Clusters



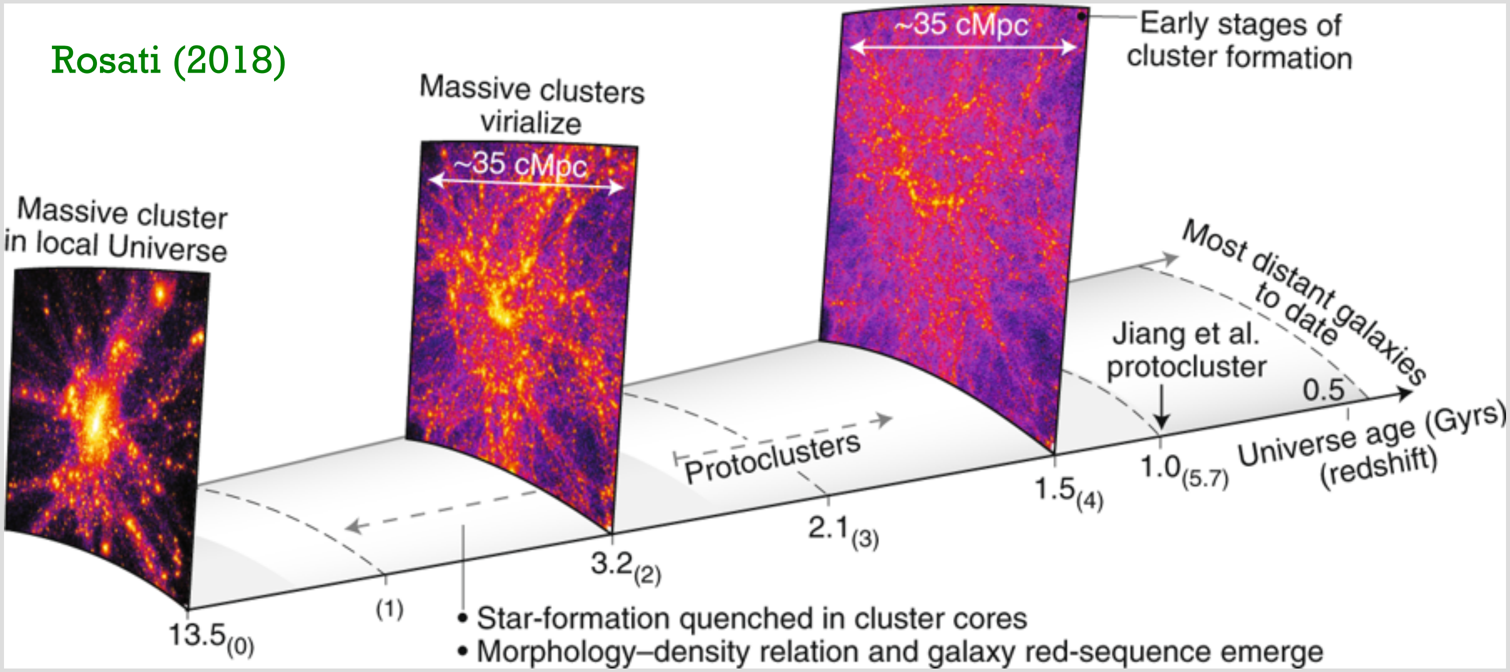


Pushing XXL deeper could let these fields probe most of cosmic accretion power and provide a superbly characterized sample of ~ 100,000 AGNs.

Would want to improve depth from ~ 10 ks to 40-50 ks. Cost ~ 15-20 Ms.

Could consider a similar program on Stripe 82X.

AGN Content of Protoclusters



Protocluster discoveries at $z \sim$ 2-6 from wide-field surveys continue to accelerate.

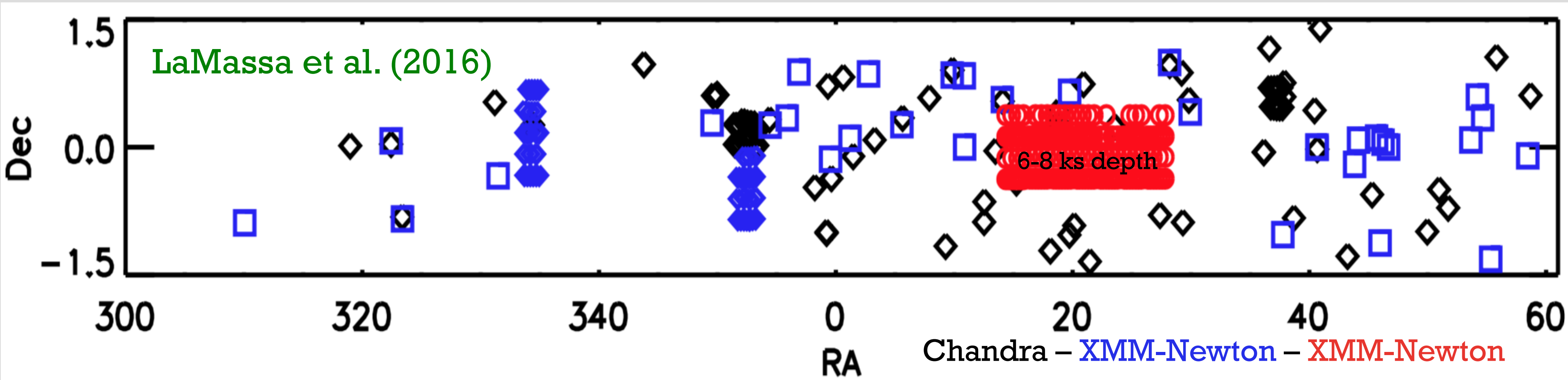
Would like to measure reliably the AGN content in these rare over-densities to assess an extreme of AGN-LSS connections.

Could target 20-50 protoclusters deeply at cost of ~ 2-5 Ms.


The End
NASA
NSF
PennState
Eberly College
of Science

Extra Slides

Stripe 82X Survey



Survey	# of Sources	Area (deg^2)
Archival *Chandra*	1146	7.4
Archival *XMM*	1607	6.0
XMM **AO10**	751	4.6
XMM **AO13**	2862	15.6
Total	**6181**	**31.3**

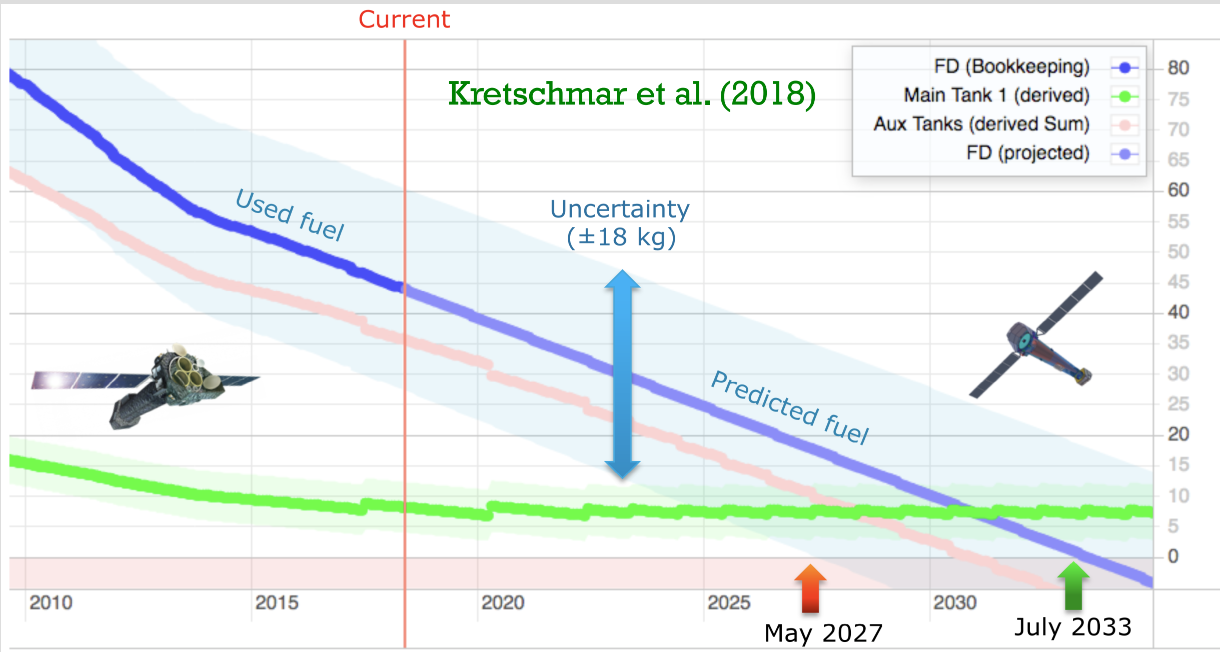
Similar Ω-F_X as XMM-XXL, but with excellent SDSS Stripe 82 complementarity.

eBOSS spectroscopy of X-ray and WISE sources completed – LaMassa et al. (2019).

Exciting science projects in the pipeline.

XMM-Newton Is Healthy

XMM-Newton Fuel and General Status



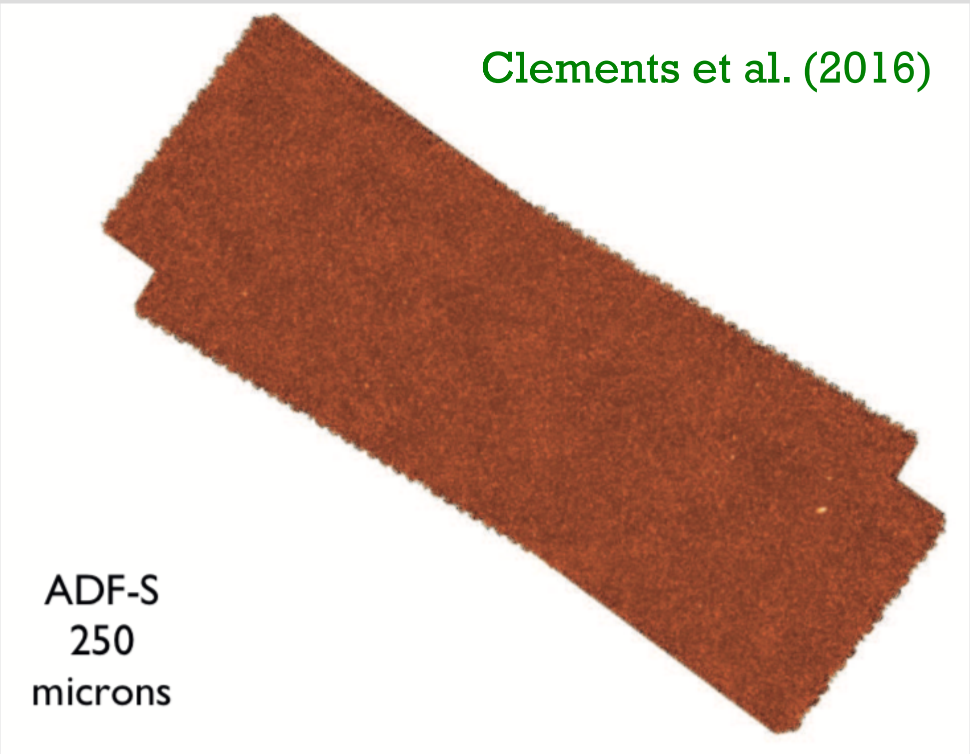
- Stable community interest and productivity
- Spacecraft & instruments remain in good shape
- Progress in (cross-)calibration, but several open issues
- Good progress on tasks from roadmap, effort continues
- SPACON merge ➡ impact on science ➡ mitigation effort
- Major changes in SOC, e.g., due to retirements

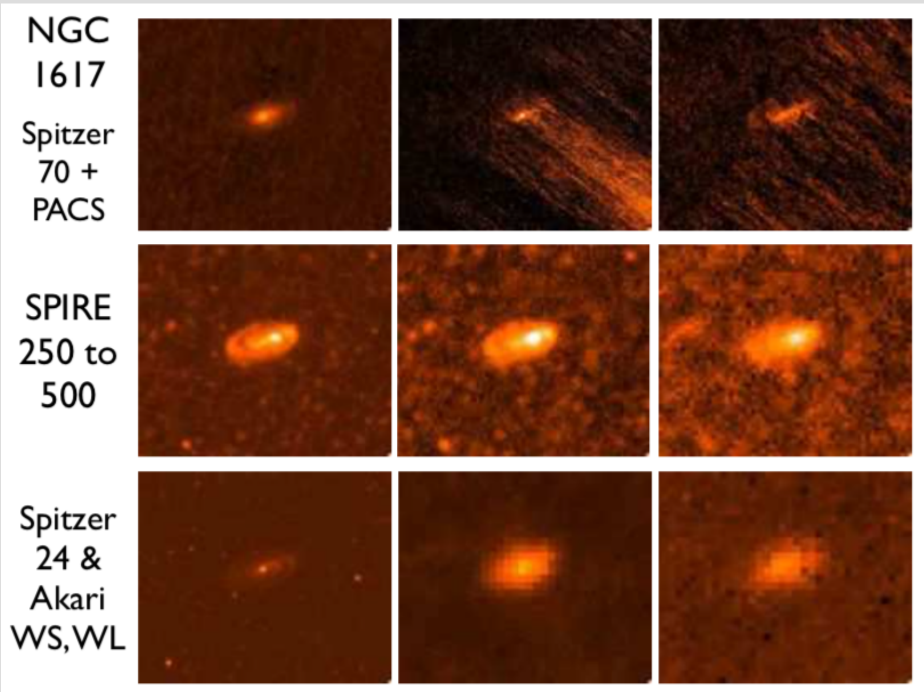
With luck, XMM-Newton can likely last for more than a decade.

Hope for another great ~ 10+ years of X-ray surveys.

But need to conduct **aggressive projects** to break new ground!

Akari Deep Field-South

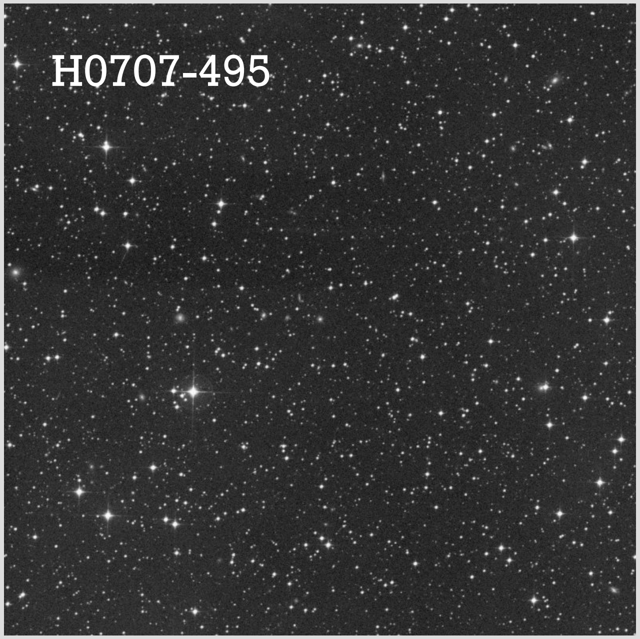


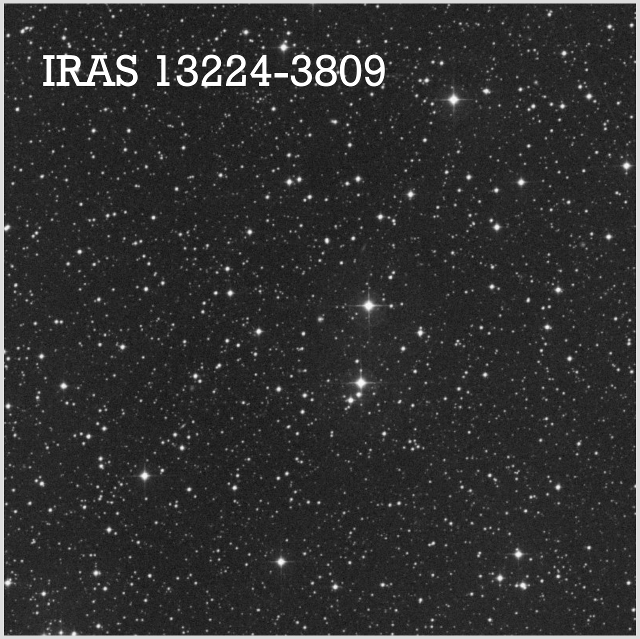


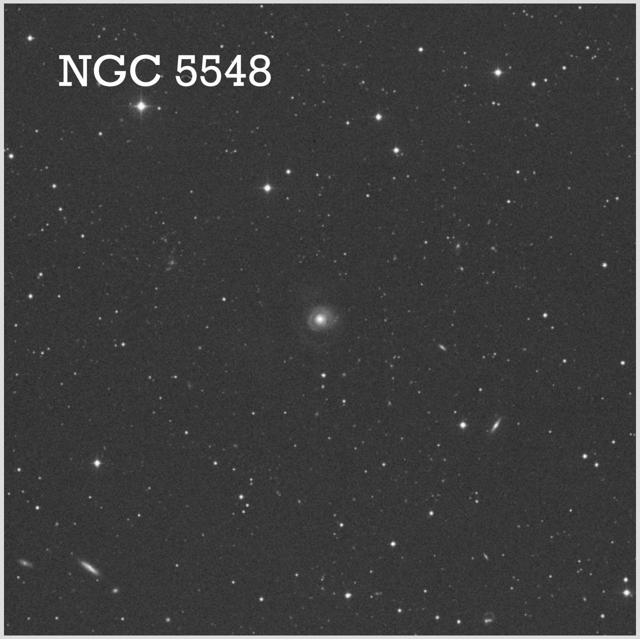
Planned deep field for Euclid and WFIRST - in their continuous viewing zone.

Proposed to be another LSST Deep Drilling Field over 20 deg^2.

Seyfert Galaxies Serendipitous Survey







Very large amounts of XMM-Newton and Chandra time have been built up on ~ 15 local Seyfert galaxies, for X-ray spectroscopic and variability studies.

Should improve the optical spectroscopy and multiwavelength data around the most intensively studied of these, so that future X-ray campaigns can serve "double duty" as survey fields for free.

Could help to motivate further a Seyferts Multi-Year Heritage Program.

This is the Title

This is some text.

Chen et al. (2018)