Stripe 82X: A Wide-Area X-ray Survey in a Legacy Field

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Goals of Stripe 82X

- Uncover how obscured high-*L* AGN evolve
- Disentangle signatures of black hole growth & star formation
- Study large scale environments hosting AGN
- Search for direct collapse black holes

Importance of Wide Area Surveys

- Only way to discover rare objects, e.g. high-*L* & high-*z* AGN
  - Signal when majority of mass accreted on SMBHs occurs *Hopkins & Hernquist 2009, Treister+ 2012*
  - Key players in galaxy evolution *Glikman+ 2012,2013; Banerji+ 2013, 2015; Stern+ 2014; Assef+ 2015*
- Large angular scales needed to measure unresolved X-ray emission: signatures of $z > 6$ SMBHs

SDSS Stripe 82 Legacy Field 300 deg^2

- High level of spectroscopic completeness

30%– SDSS, 2SLAQ, WiggleZ, DEEP2, PRIMUS, HETDEX

>50%– targeted follow-up eBOSS, WIYN, Palomar, Keck

- Tons of λλλ coverage

ACT 300 deg^2

Radio 300 deg^2

Ultraviolet 300 deg^2

Deep optical (*r* ~ 26) 300 deg^2

NIR (UKIDSS & VHS) 300 deg^2

Spitzer 143 deg^2

Herschel 112 deg^2

Stripe 82 X-ray Coverage

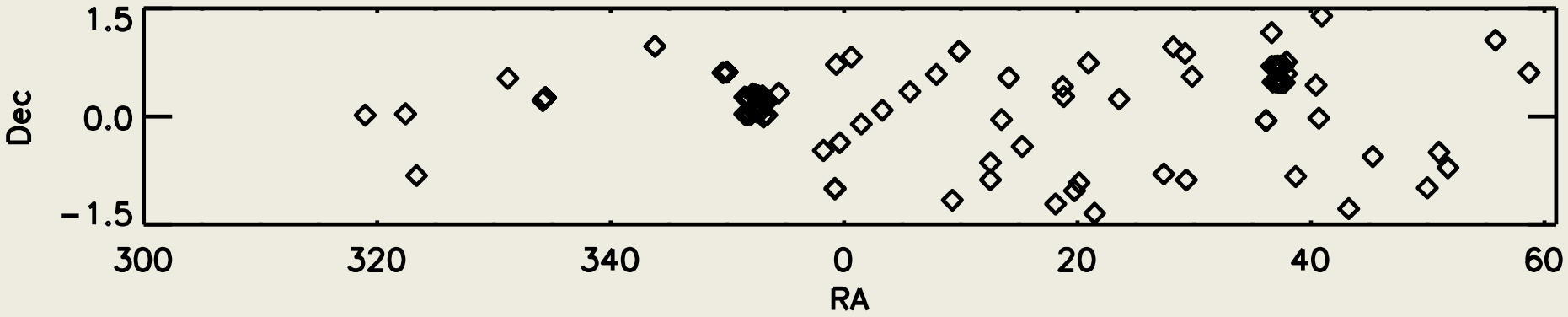
archival *Chandra* *7.4 deg²*

+ archival *XMM-Newton* *6.0 deg²*

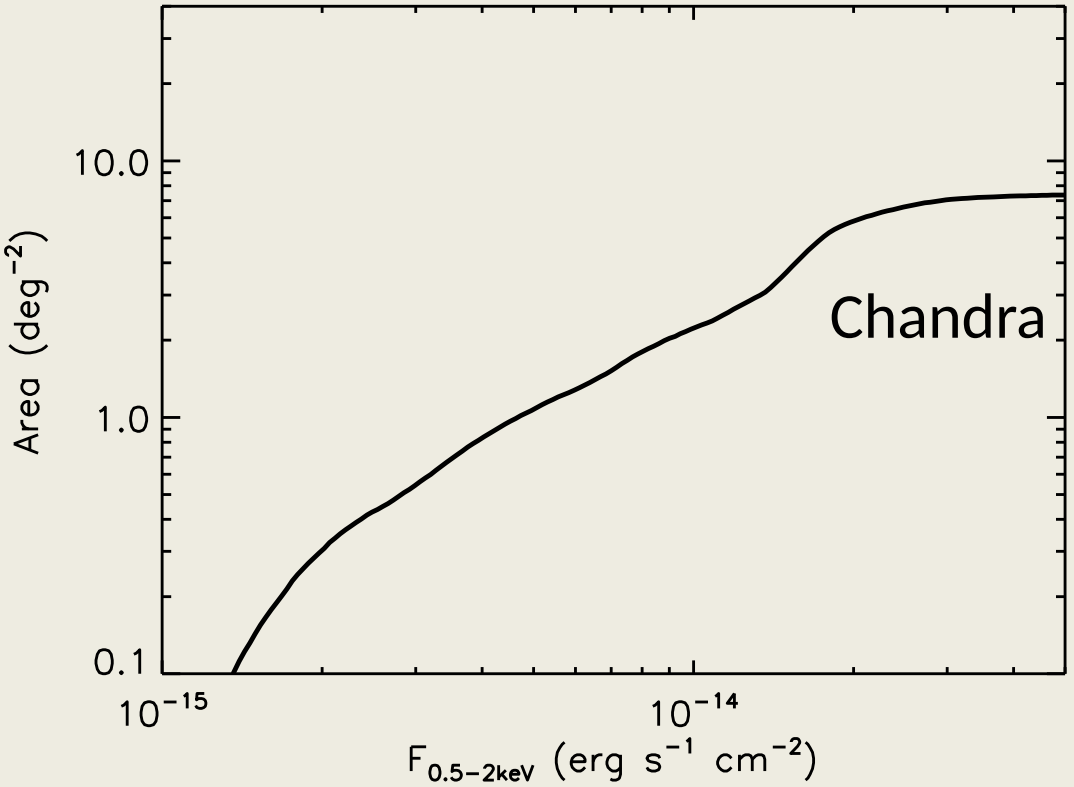
+ AO10 *XMM-Newton* *4.6 deg²*

+ AO13 *XMM-Newton* *15.6 deg²*

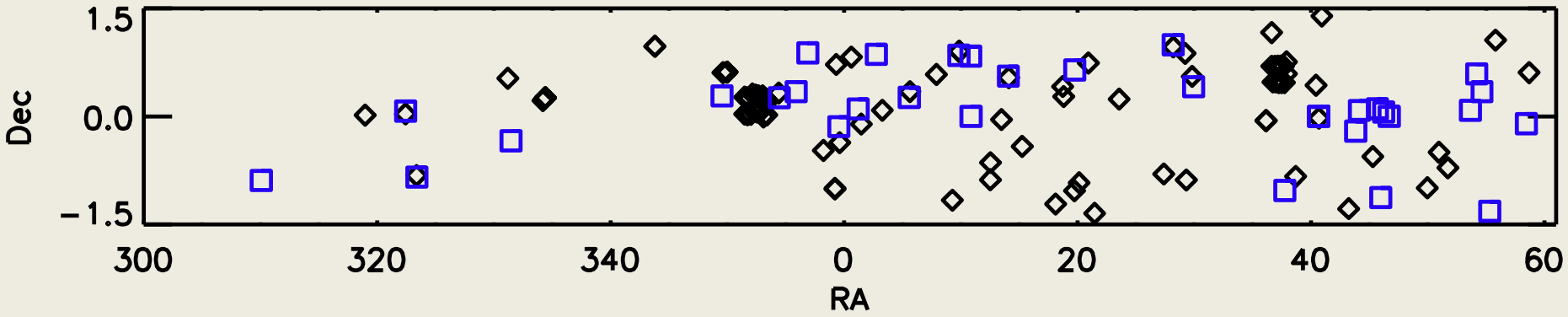
Stripe 82 X-ray Coverage



◆ Archival *Chandra*
LaMassa+ 13b

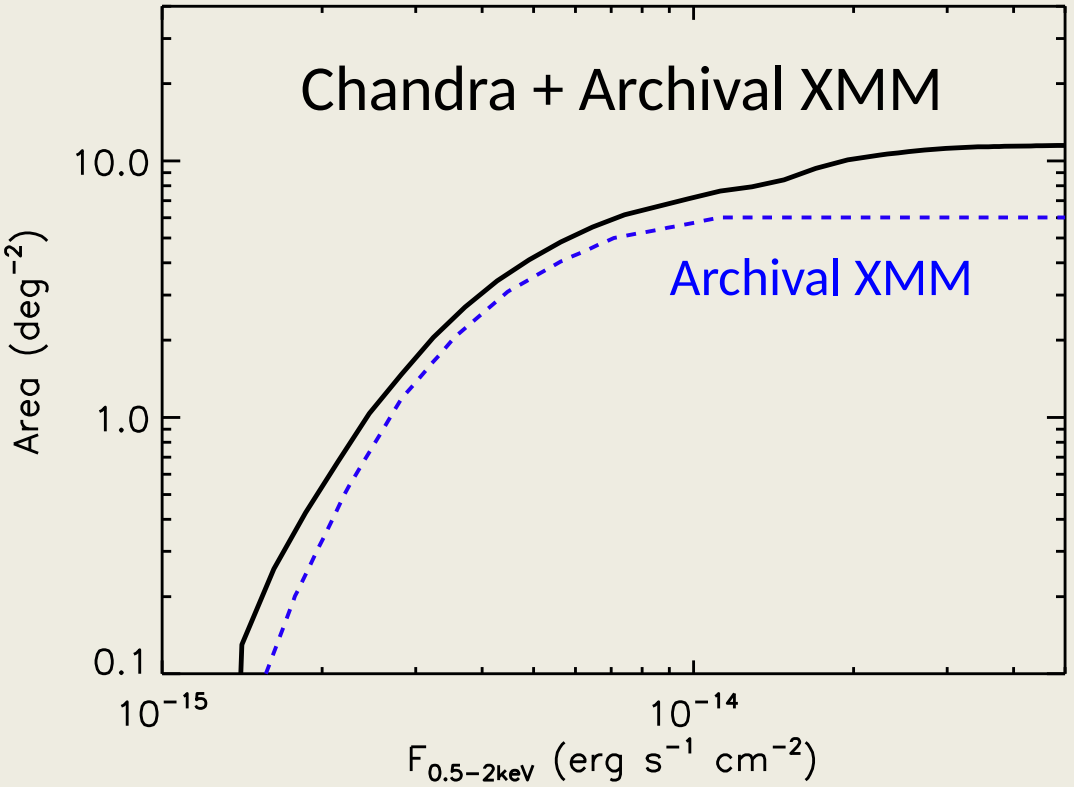


Stripe 82 X-ray Coverage

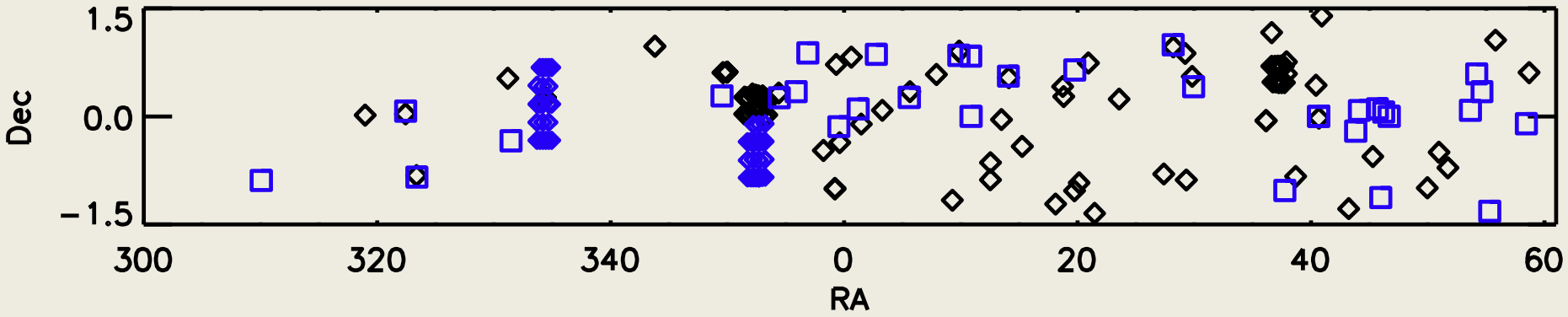


Archival *Chandra*
LaMassa+ 13b

Archival *XMM*
LaMassa+ 13c



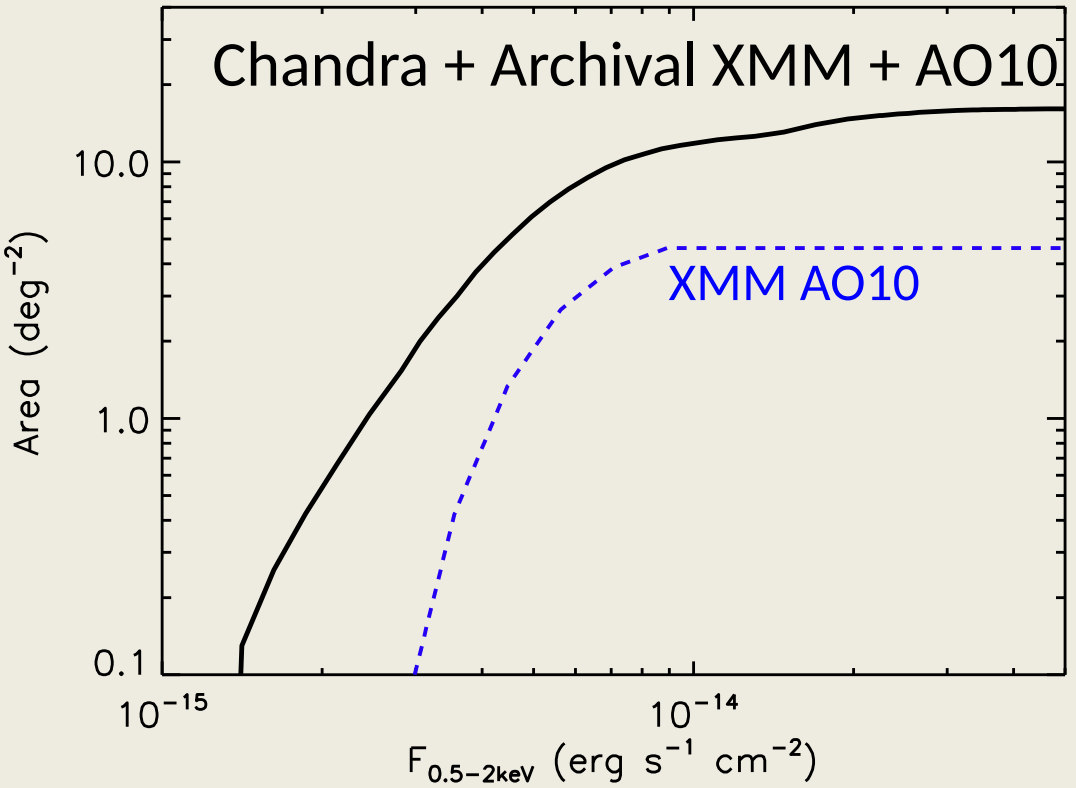
Stripe 82 X-ray Coverage



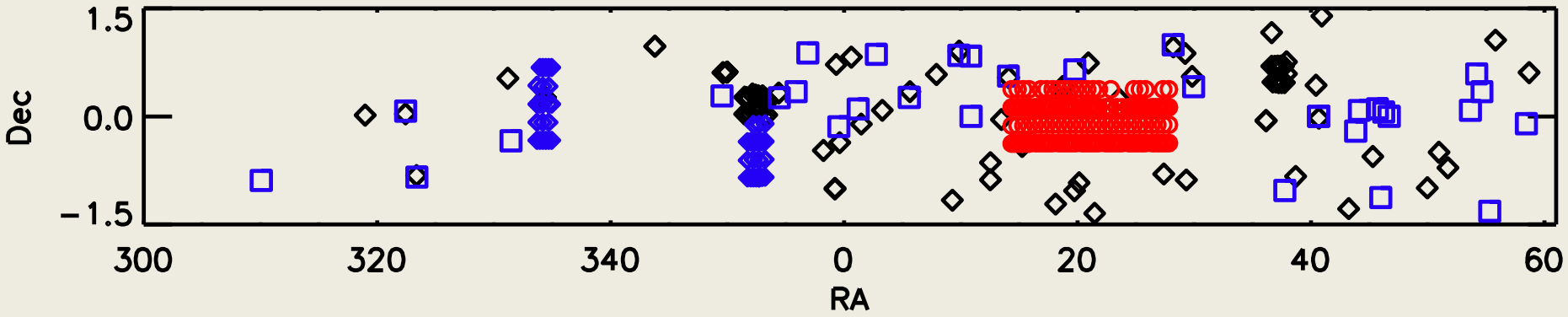
Archival *Chandra*
LaMassa+ 13b

Archival *XMM*
LaMassa+ 13c

XMM AO10
LaMassa+ 13c



Stripe 82 X-ray Coverage

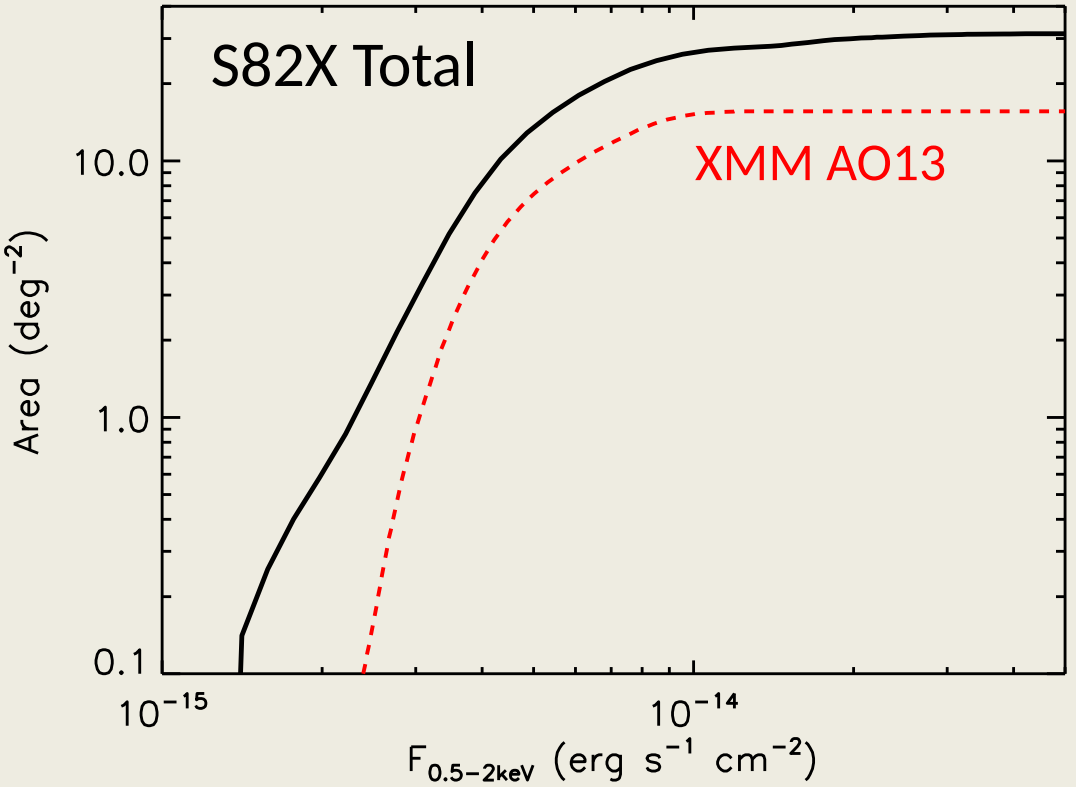


Archival *Chandra*
LaMassa+ 13b

Archival *XMM*
LaMassa+ 13c

XMM AO10
LaMassa+ 13c

XMM AO13
LaMassa+ 16a



Stripe 82 X-ray Survey Summary

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**

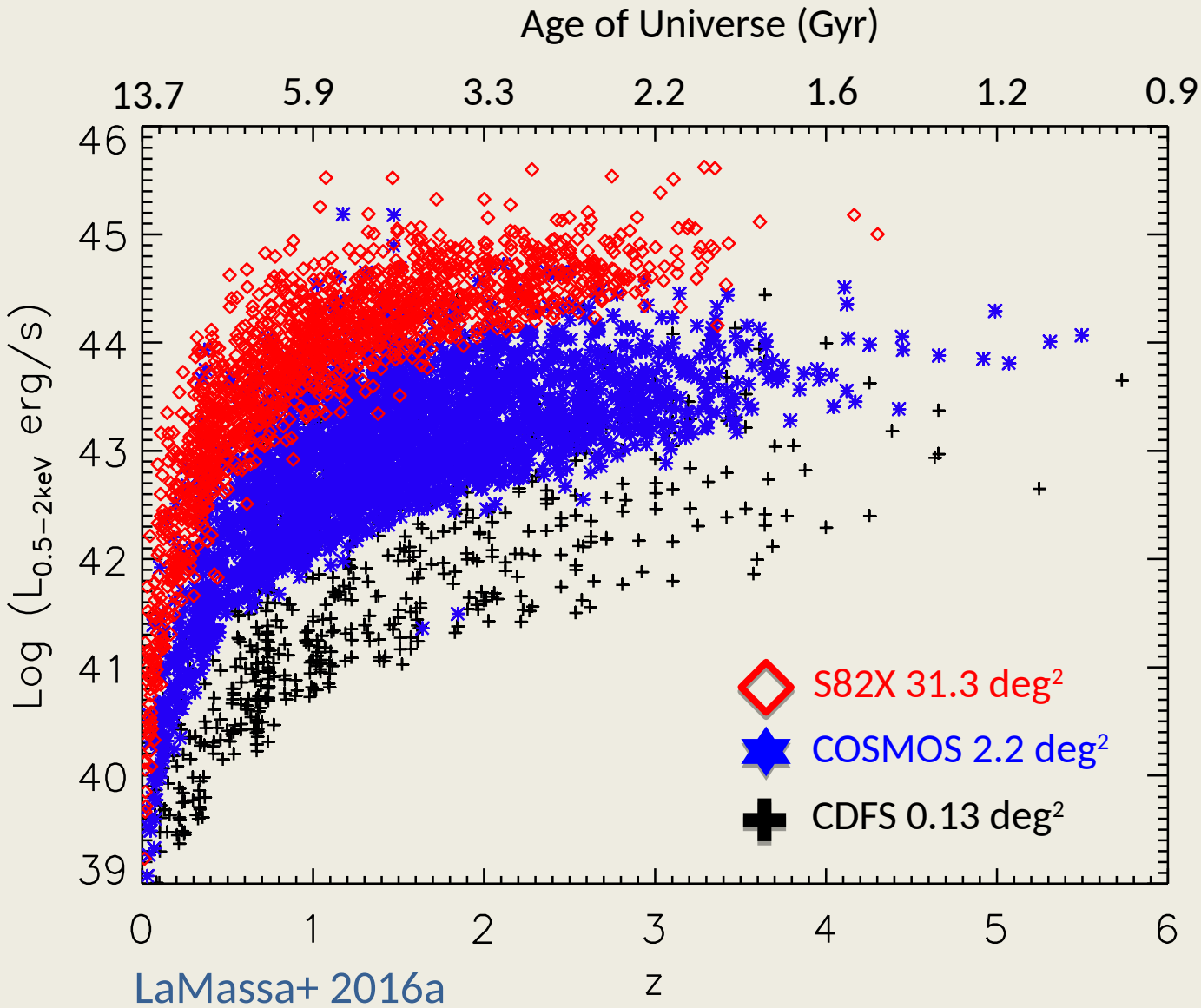
LaMassa+ 2016a

λλλ Counterparts to S82X Sources via Maximum Likelihood Estimator

	Survey	Number
81%	**Optical** (SDSS)	**5009**
65%	**MIR** (*WISE*)	**4006**
72%	**NIR** (UKIDSS)	**3643**
	NIR (VHS)	**4093**
	FIR (*Herschel*)	**133**
17%	**UV** (*GALEX*)	**1080**
4%	**Radio** (FIRST)	**232**
30%	**Redshifts**	**1841**

LaMassa+ 2016a

Distance v. Luminosity by Survey



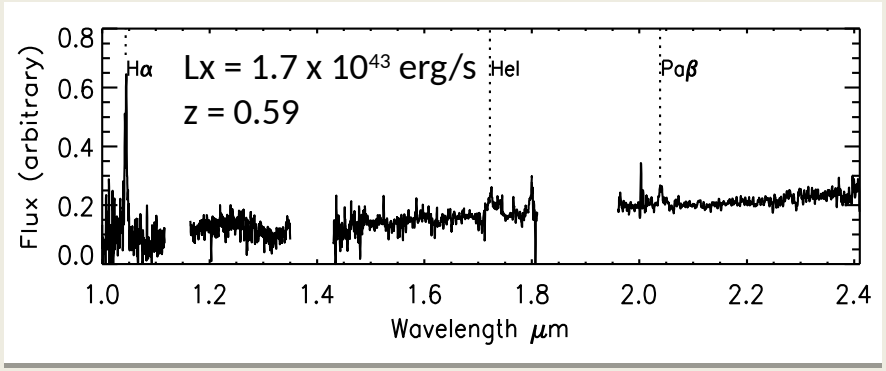
LaMassa+ 2016a

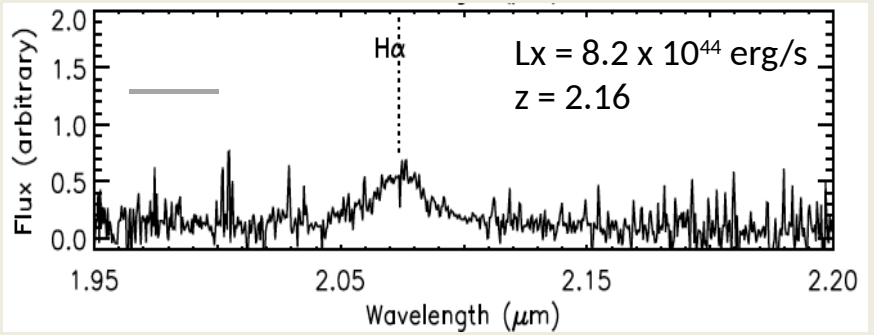
Discover missing links in SMBH growth

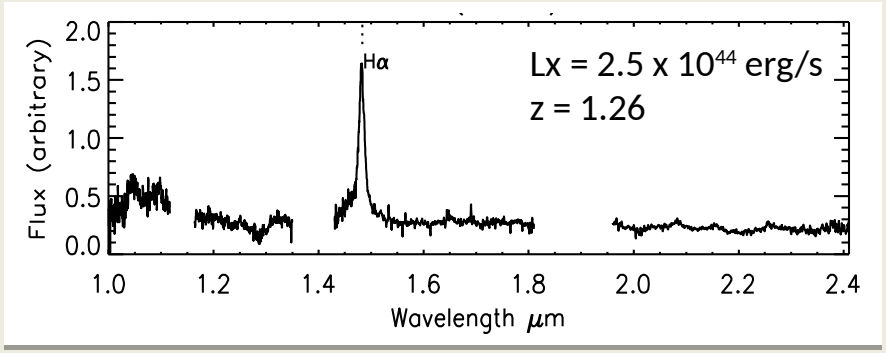
- Explore color diagnostics to hone target selection for future missions: *R-W1* *LaMassa+ 2016b*
  - Available over most of sky (SDSS, Pan-STARRS, *WISE*)
  - *R-W1* > 4 recovers obscured AGN $z > 0.5$
- Follow-up obscured AGN candidates *LaMassa+ in prep*
  - Keck NIRSPEC (2013-2015), Palomar TSpec (2014-2015), Gemini GNIRS (2015)

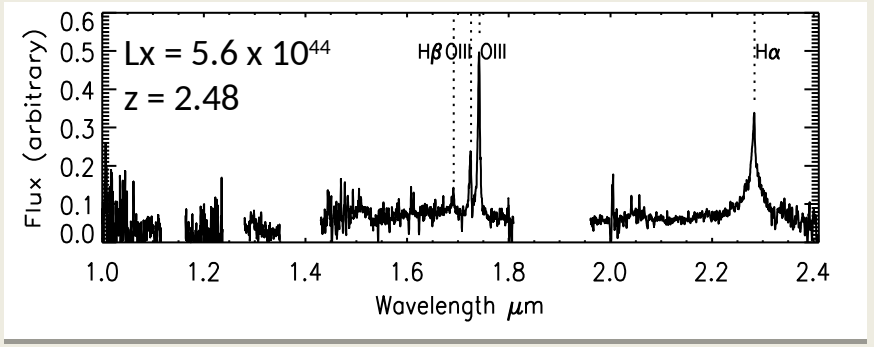
Unveiling Hidden Black Hole Growth

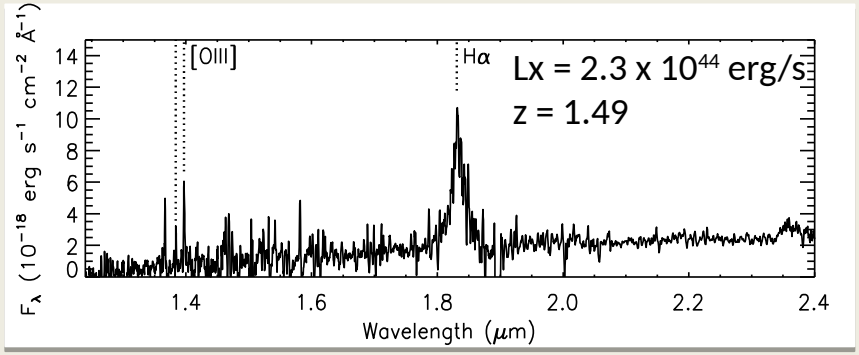
LaMassa+ in prep











Summary

- Address gap in census of SMBH growth with Stripe 82X
  - 31.3 deg^2: 6186 X-ray sources *LaMassa+* 13b,c,16a
- Upcoming science highlights
  - photo-*z* catalog *Ananna+ in prep*
  - Understanding AGN triggering via clustering *Cappelluti+ in prep*
  - Search for signatures of $z > 6$ SMBHs *Cappelluti+ in prep*
- Increase area to 100 deg^2
  - *Chandra* competitive w/ *XMM* for wide-area surveys
  - $z > 3$, $L_x > 10^{45}$ AGN/galaxy co-evolution
  - best constraints on black holes in the early Universe until *Athena*

Table 1: Multi-wavelength Coverage in Stripe 82

Wavelength	Survey	Reference
UV	GALEX - 300 deg^2; $m_{fuv} \sim 23.5$ (AB)	Morissey+ 2007
Optical	SDSS - coadd: 300 deg^2; $r \sim$24.6 (AB)	Annis+ 2014, Jiang+ 2014
	CFHT: 140 deg^2; $i \sim$23.5 (AB)	PI: A. Leauthaud
	Subaru HSC: 270 deg^2; $r \sim 26$ (AB)	Miyazaki+ 2012
	DES: 300 deg^2 deg^2; $r \sim 25.1$ (AB)	astro-ph/0510346
	PanSTARRS: 300 deg^2; $r \sim 21.6$ (AB)	Kaiser+ 2010
	Spectroscopy: SDSS, BOSS, eBOSS, WiggleZ, PRIMUS, DEEP2, 2SLAQ, 6dF, VIMOS VLT Deep Survey (VVDS); 30% coverage of Stripe 82-XMM sources	Ahn+ 2012, 2014, Drinkwater+ 2010, Coil+ 2011, Newman+ 2013,Croom+ 2009, Jones+ 2009, Garilli+ 2008
NIR	UKIDSS - LAS: 300 deg^2; K$\sim$20.3 (AB)	Hewett+ 2006, Lawrence+ 2007
	VHS: 300 deg^2; K$\sim$20 (AB)	McMahon+ 2013
MIR	*Spitzer* - SpIES: 115 deg^2; [3.6]μm - 21.9 (AB)	PI: G. Richards; Timlin+ *subm. to ApJ*
	Spitzer - SHELA: 28 deg^2; [3.6]μm - 22.8 (AB)	PI: C. Papovich
FIR	*Herschel* - 112 deg^2; 250μm - 13 mJy beam^{-1}	Oliver+ 2012, Viero+ 2014
Millimeter	ACT/ACTPol: 300 deg^2; 148, 218, 277 GHz; 2,3,7 mJy	Fowler+ 2007; Swetz+ 2011; Niemack+ 2010
Radio	FIRST (1.4 GHz): 300 deg^2; 0.75-1 mJy	Becker+ 1995; Helfand+ 2015
	VLA-L (1.4 GHz): 92 deg^2; 52μJy	Hodge+ 2011
	VLA-B (3 GHz): 270 deg^2; 40μJy	Mooley+ 2016
	VLA-C (1-2 GHz): 70 deg^2; 40-50μJy	PI: M. Jarvis