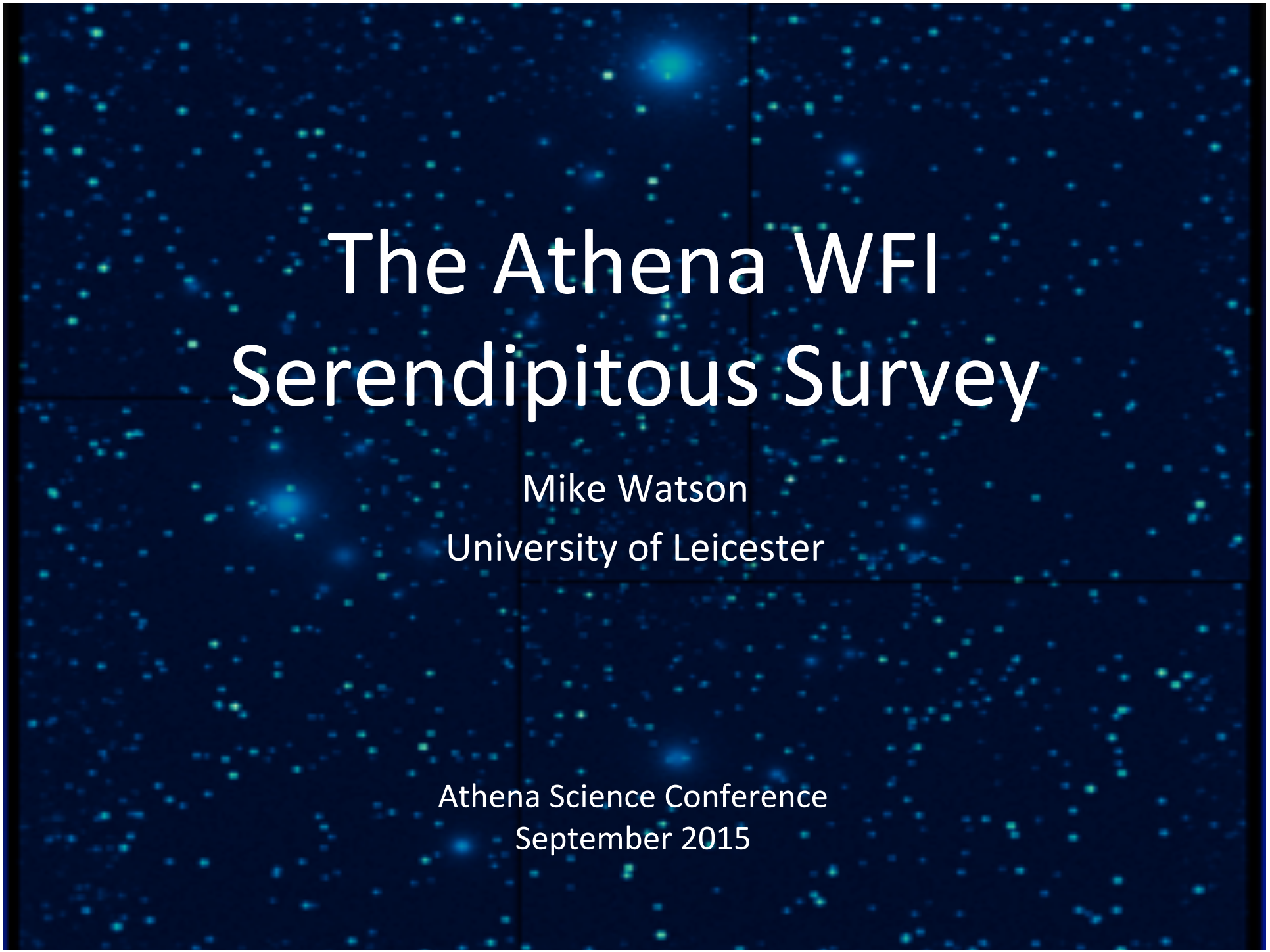


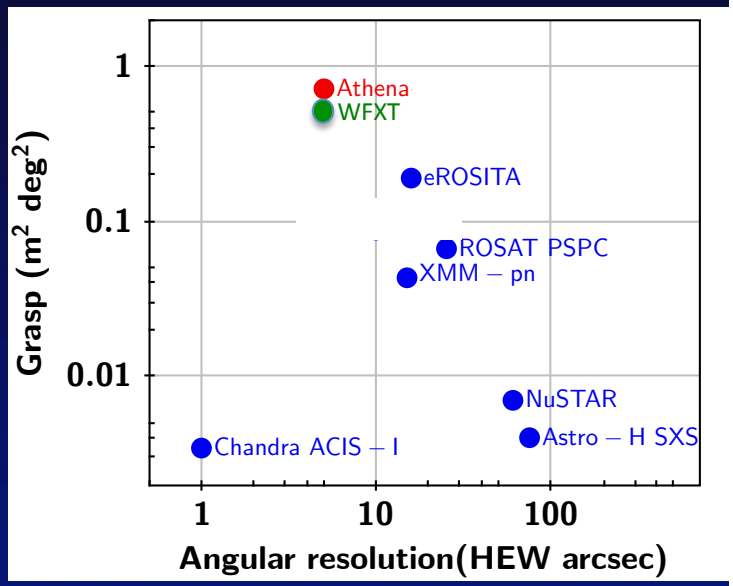
The Athena WFI Serendipitous Survey

Mike Watson
University of Leicester

Athena Science Conference
September 2015

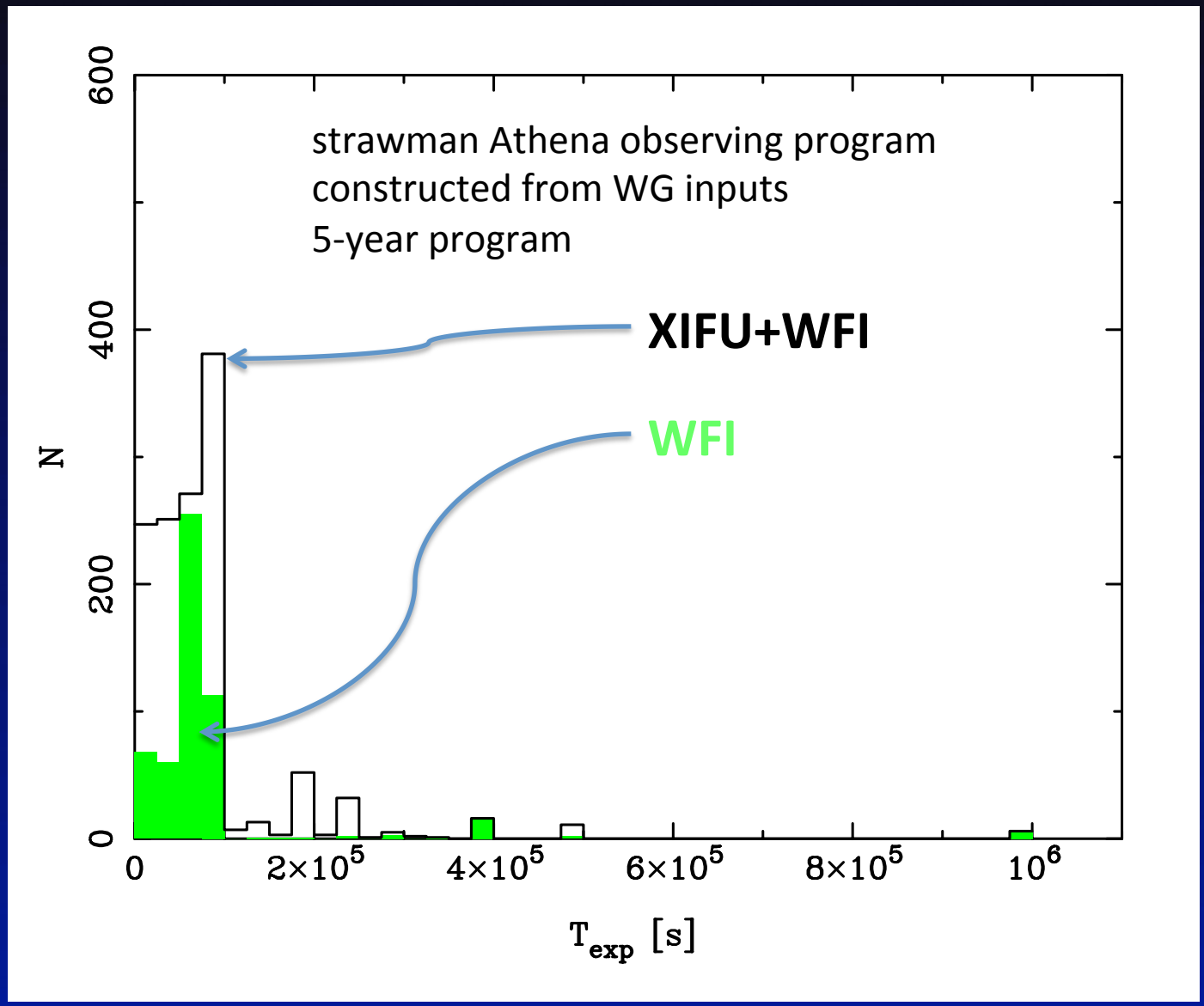
Serendipitous survey with Athena?

- Athena WFI
  - large area, large FOV → large grasp
  - grasp similar to WFXT
  - major potential for serendipitous survey
- Calculations for serendipitous survey
  - WFI background (FOV-averaged)
  - WFI response matrix (FOV-averaged)
  - assumed: HEW=3", s/n=5σ for detection
  - strawman Athena observing program
  - extragalactic log N – log S as parameterised by Moretti+ 2003



Source	core science group all	core science group A:+, B:-	double	Type	RA	Dec	l	b	# of obs	exp / obs (ksec)	Total (ksec)	total min double	cat ego ry	TOO*	contin uous	INST	Tobs XIFU > limit	Tobs WFI > limit
formation and evolution of groups and clusters of galaxies / Etorri, added 1 degree offset pointings for background X-IFU (18 pointings of 50 ks)																		
A1795	5	5	N	Galaxy cluster	207.22083	26.59556	33.8857839	77.1757443	1	100	100	100	A	NO	NO	WFI	0	0
A1795	6	6	N	Galaxy cluster	207.22083	26.59556	33.8857839	77.1757443	1	100	100	100	A	NO	NO	XIFU	0	0
A1795	6	6	N	Galaxy cluster	208.22083	26.59556	34.2707831	76.2859299	1	50	50	50	A	NO	NO	XIFU	0	0
Sersic159-03/S1101	5	5	N	Galaxy cluster	348.49417	-42.73389	348.392322	-64.8187592	1	100	100	100	A	NO	NO	WFI	0	0
Sersic159-03/S1101	6	6	N	Galaxy cluster	348.49417	-42.73389	348.392322	-64.8187592	1	100	100	100	A	NO	NO	XIFU	0	0
Sersic159-03/S1101	6	6	N	Galaxy cluster	349.49417	-42.73389	347.489103	-65.4474634	1	50	50	50	A	NO	NO	XIFU	0	0
A262	5	5	N	Galaxy cluster	28.195	36.151	136.646769	-25.0867677	1	100	100	100	A	NO	NO	WFI	0	0
A262	6	6	Y	Galaxy cluster	28.195	36.151	136.646769	-25.0867677	1	100	100	0	A	NO	NO	XIFU	0	0
A262	6	6	N	Galaxy cluster	29.195	36.151	137.504944	-24.8703155	1	50	50	50	A	NO	NO	XIFU	0	0
A133	5	5	N	Galaxy cluster	15.67542	-21.874	149.663123	-84.1492013	1	100	100	100	A	NO	NO	WFI	0	0
A133	6	6	N	Galaxy cluster	15.67542	-21.874	149.663123	-84.1492013	1	100	100	100	A	NO	NO	XIFU	0	0
A133	6	6	N	Galaxy cluster	16.67542	-21.874	157.327058	-83.6966705	1	50	50	50	A	NO	NO	XIFU	0	0
A478	5	5	N	Galaxy cluster	63.35667	10.467	182.50726	-28.2781268	1	100	100	100	A	NO	NO	WFI	0	0
A478	6	6	N	Galaxy cluster	63.35667	10.467	182.50726	-28.2781268	1	100	100	100	A	NO	NO	XIFU	0	0
A478	6	6	N	Galaxy cluster	64.35667	10.467	183.199868	-27.5085229	1	50	50	50	A	NO	NO	XIFU	0	0
A1413	5	5	N	Galaxy cluster	178.82709	23.408	226.272493	76.7929282	1	100	100	100	A	NO	NO	WFI	0	0
A1413	6	6	N	Galaxy cluster	178.82709	23.408	226.272493	76.7929282	1	100	100	100	A	NO	NO	XIFU	0	0
A1413	6	6	N	Galaxy cluster	179.82709	23.408	227.676407	77.6565905	1	50	50	50	A	NO	NO	XIFU	0	0

strawman (mock) Athena observing program (5y)
constructed from WG inputs

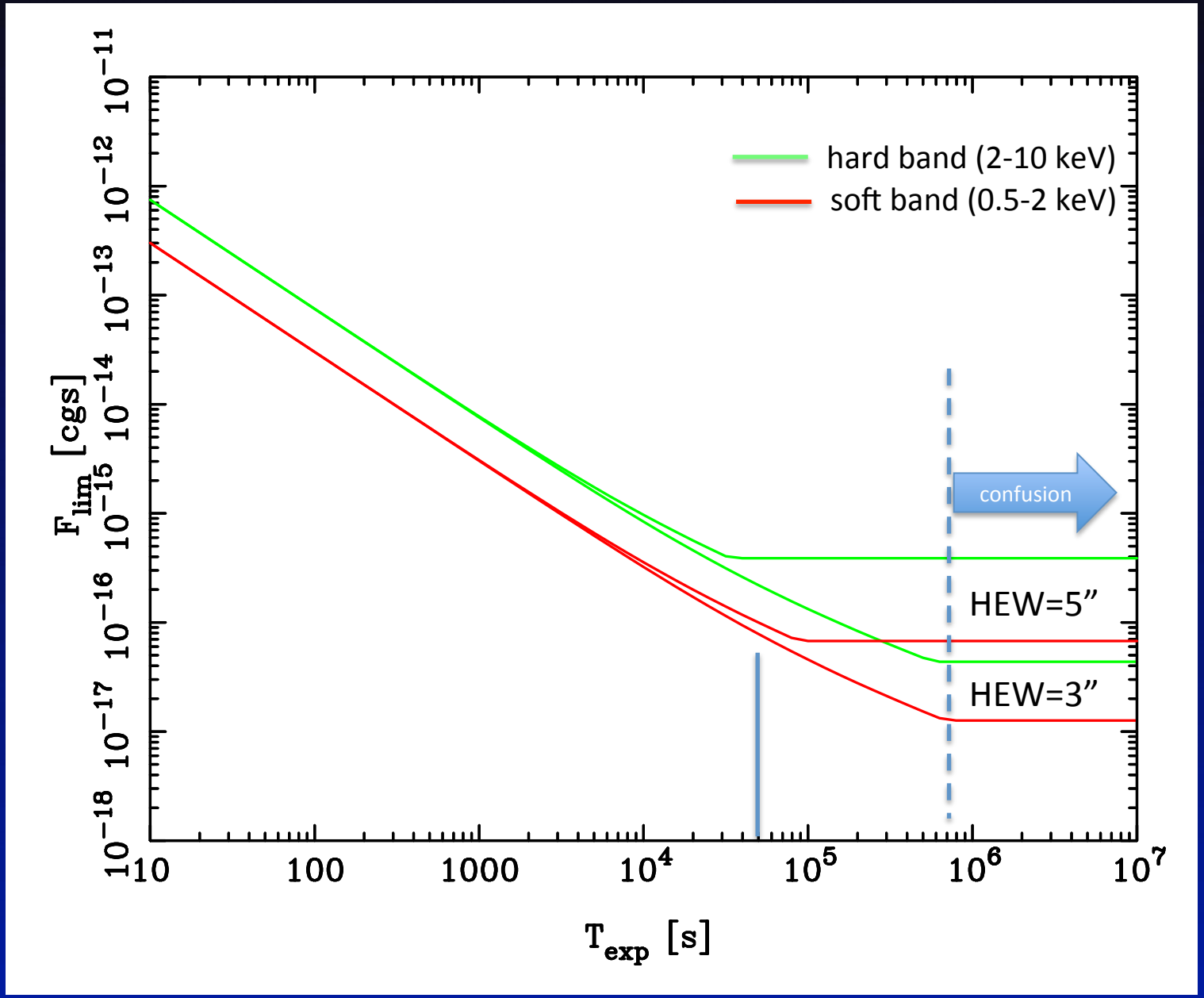

strawman Athena observing program
constructed from WG inputs
5-year program
XIFU+WFI
WFI
N
0
200
400
600
0
2×10^5
4×10^5
6×10^5
8×10^5
10^6
T_exp [s]

strawman Athena observing program: statistics

T_{exp} (s)	N_{WFI}	N_{XIFU}	N_{TOTAL}	WFI sky area [$deg^2\ yr^{-1}$]	XIFU sky area [$deg^2 yr^{-1}$]
<25000	68	179	247	29.7	0.3
25000-50000	60	191	251	26.2	0.3
50000-75000	255	16	271	111.3	1.1
750000-100000	113	268	381	49.3	0.5
100000-200000	3	72	75	1.3	0.0
200000-300000	5	36	41	2.2	0.0
300000-400000	16	3	19	7.0	0.1
400000-500000	2	9	11	0.9	0.0
>500000	5	1	6	2.2	0.0
	527	775	1302	229.9	2.3

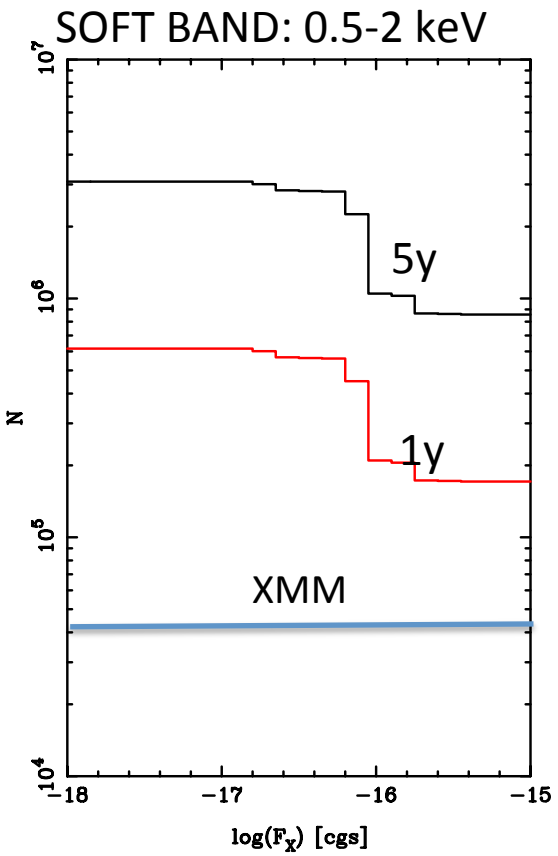
Mean WFI exposure ~50 ksec → $f_{min,s}$~10^{-16}
→ ~3500 sources per observation

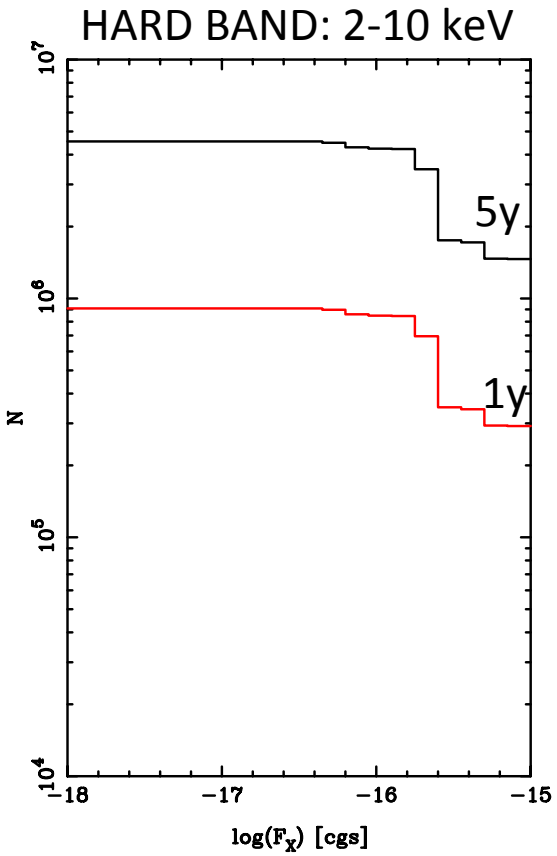
WFI sensitivity curves



WFI *observed* log N – log S

HEW=5" gives
500/700K sources per year





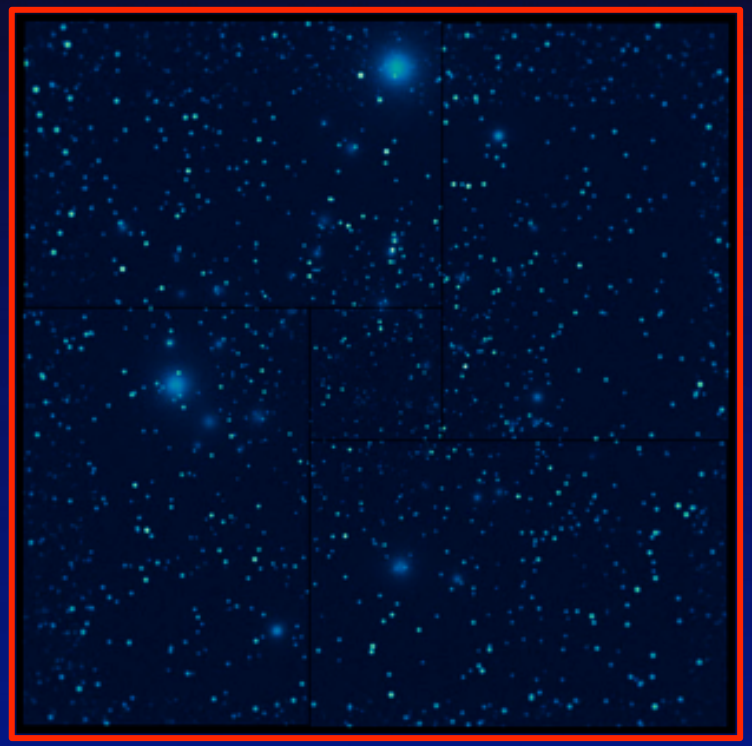
Serendipitous source numbers
- Soft-band: 600K per year!
- Hard-band: 900K per year!

cf. XMM serendipitous source numbers: ~40K per year

Scope and potential of Athena WFI serendipitous survey

- Estimated source numbers per year: 900K
- Fraction useable for serendipitous science: 60% (XMM experience)
- WFI 'clean' catalog grows at 500K sources per year

- Effective utilisation depends on availability of (all sky) multi-λ resources
  - Today: SDSS, WISE …
  - 2028: LSST, PanStarrs, large MOS surveys …
- *Serendipity example from XMM: existence of true Seyfert 2s?*

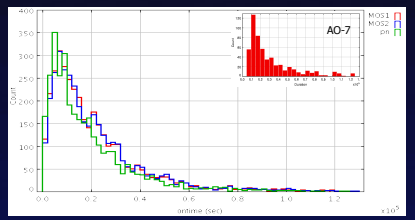


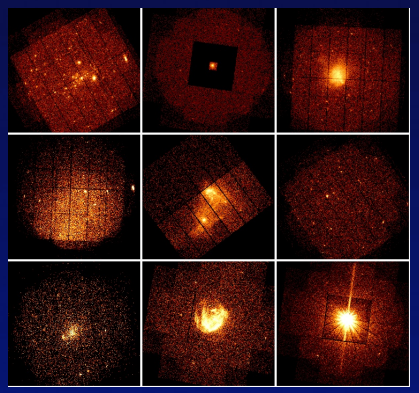
Note that *planned* Athena surveys are about 16% of the observing program but *shallow* survey dominates source no.s → ~95% of serendipitous survey is truly serendipitous

Key characteristics of XMM serendipitous sky survey

- Heterogeneous survey (by definition)
  - wide range of observation times
  - 65% at high b_{II}, 35% at low b_{II}
  - mixed observing modes/filters
- Image content/quality issues for survey science
  - bright point sources (PSF wings & OOT events)
  - bright extended sources
  - image defects
- Net effect for surveys
  - 30-70% useable fraction for serendipitous science: depending on project

observation time per field
(net science exposure)





2XMM source detection & characterisation
- 60% of obs. have <1% problem area
- 85% of obs. have <10% problem area

Field content: XMM targets
- 50% point-like
- 33% extended (10% <3')
- 15% "survey" (no discrete target)

XMM-Newton
SURVEY SCIENCE CENTRE

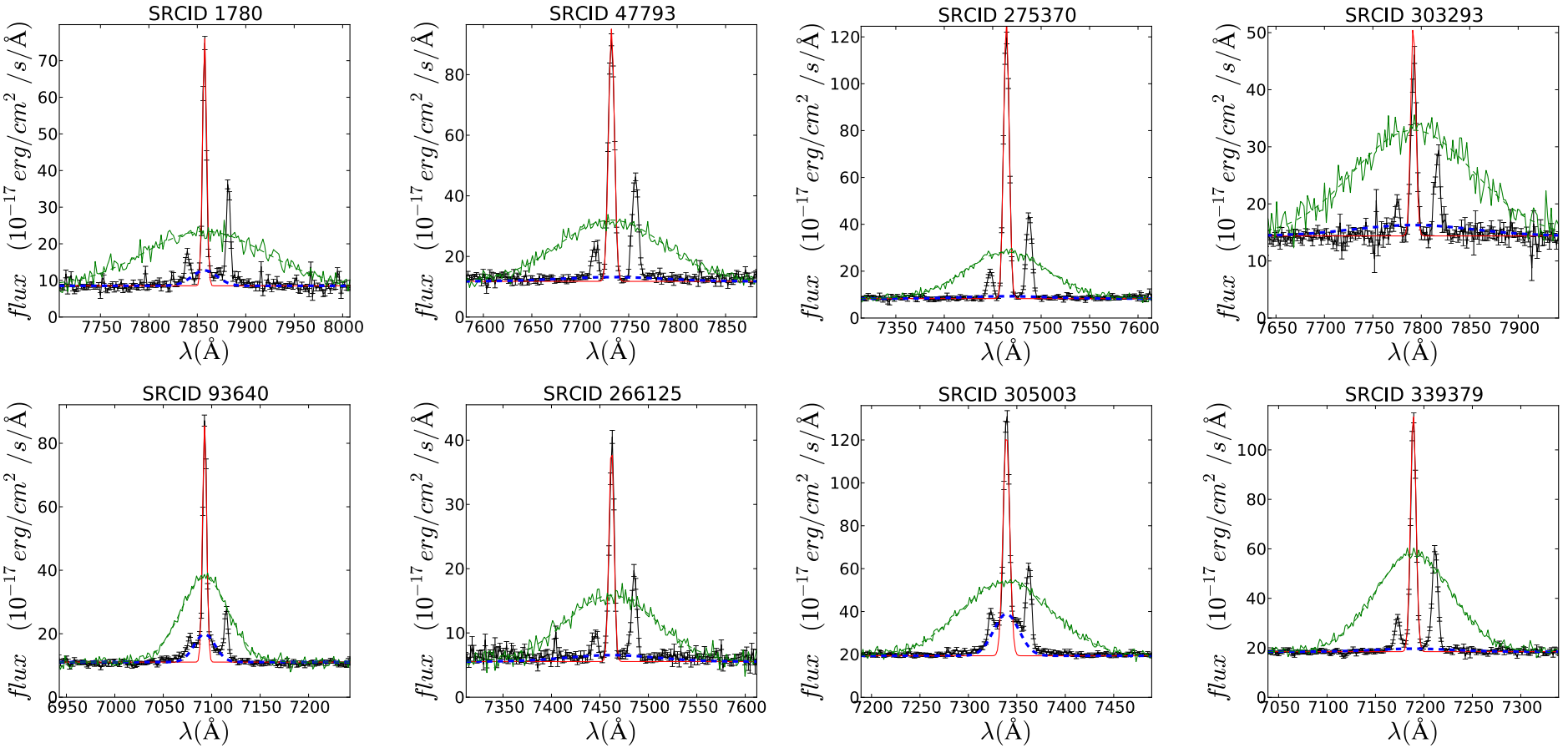
Pons & Watson, 2014

True Sy2

$M_{BH} \propto L_{5100Å}^{0.52} \cdot FWHM_{B.H\alpha}^{2.06}$
$L_{B.H\alpha} \propto L_{5100Å}^{1.16}$

- True Sy2: no optical BL + no intrinsic absorption
  - No BLR: BLR disappear for $\lambda < 10^{-2}$ (Trump et al 2011)

NL fitted BL predicted BL measured / upper limit



Concluding remarks

- Potential of Athena serendipitous survey is very large, important facet of mission
- Implications for Athena Science Ground System