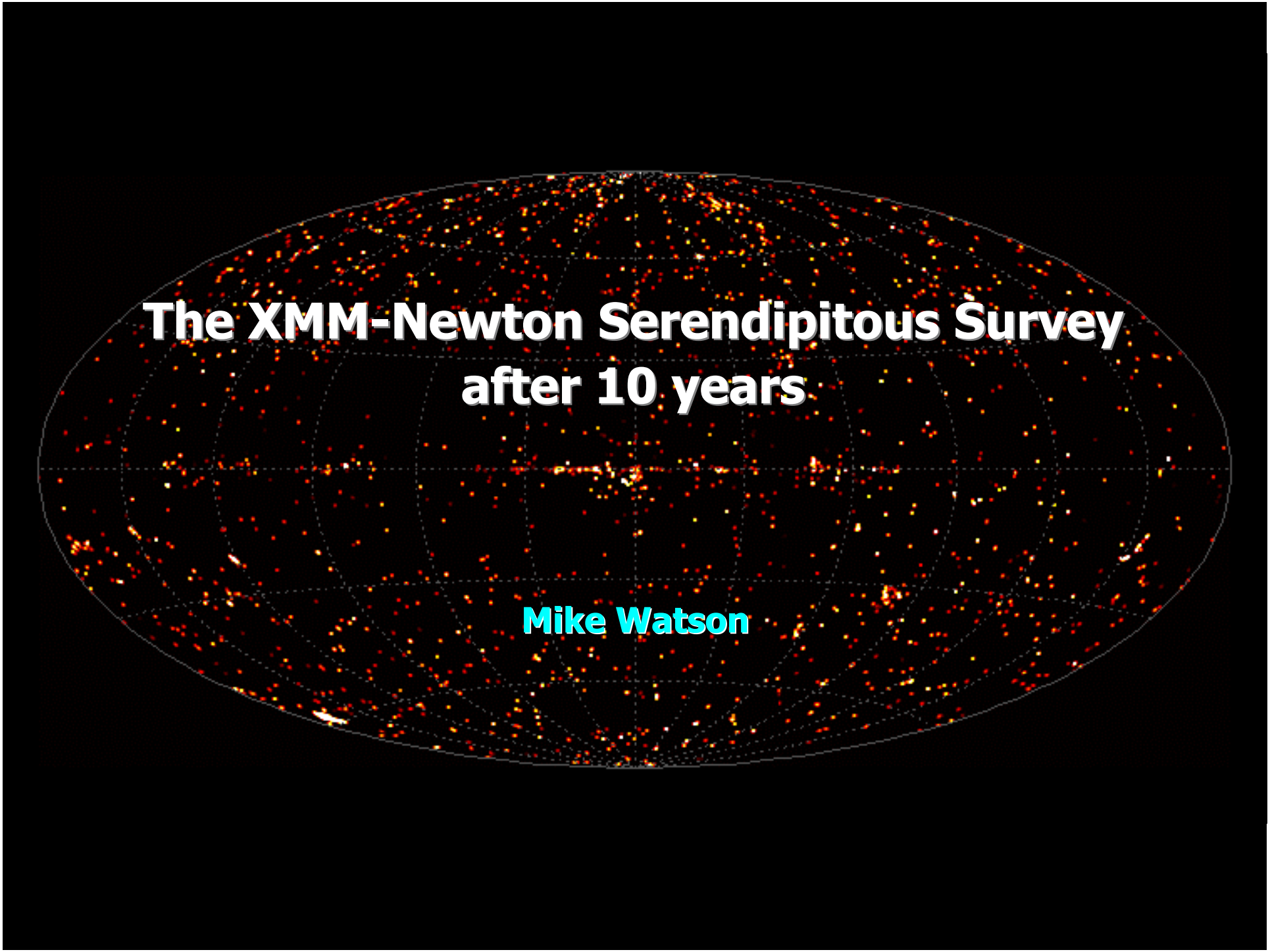

The XMM-Newton Serendipitous Survey
after 10 years
Mike Watson

Outline

- XMM-Newton serendipitous sky survey
  - The catalogues
  - Survey science
  - Future plans
- Lessons learned?

SSC Consortium

University of Leicester (UK)
MSSL (UK)
IoA Cambridge (UK)

SAp/CEA/Saclay (France)
CESR Toulouse (France)
OAS Strasbourg (France)

AIP Potsdam (Germany)
MPE Garching (Germany)

IFCA Santander (Spain)
OAB Milano (Italy)

Mike Watson
Leicester University

XMM-Newton Serendipitous Sky Survey

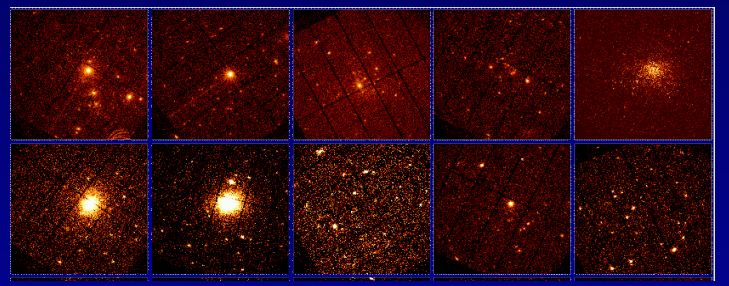
XMM observing program

- 600-700 pointed observations per year
  - ⇒ sky coverage ~90 sq.deg/year
  - ⇒ ~42K detections/year**
  - ⇒ >800 sq.deg. to date
  - ⇒ $f_{x,min} < 10^{-14}$

XMM Catalogues

- constructed from whole pointed program by XMM-Newton Survey Science Centre on behalf of ESA

** 33K distinct sources/year



Every new XMM-Newton pointing discovers ~30-100 serendipitous X-ray sources

		year	sources
[EDR]	1XMM	2003	23685
DR0	2XMMp	2006	123170
DR1	2XMM	2007	191870
DR2	2XMMi	2008	221012
DR3	2XMMi DR3	2010	262902

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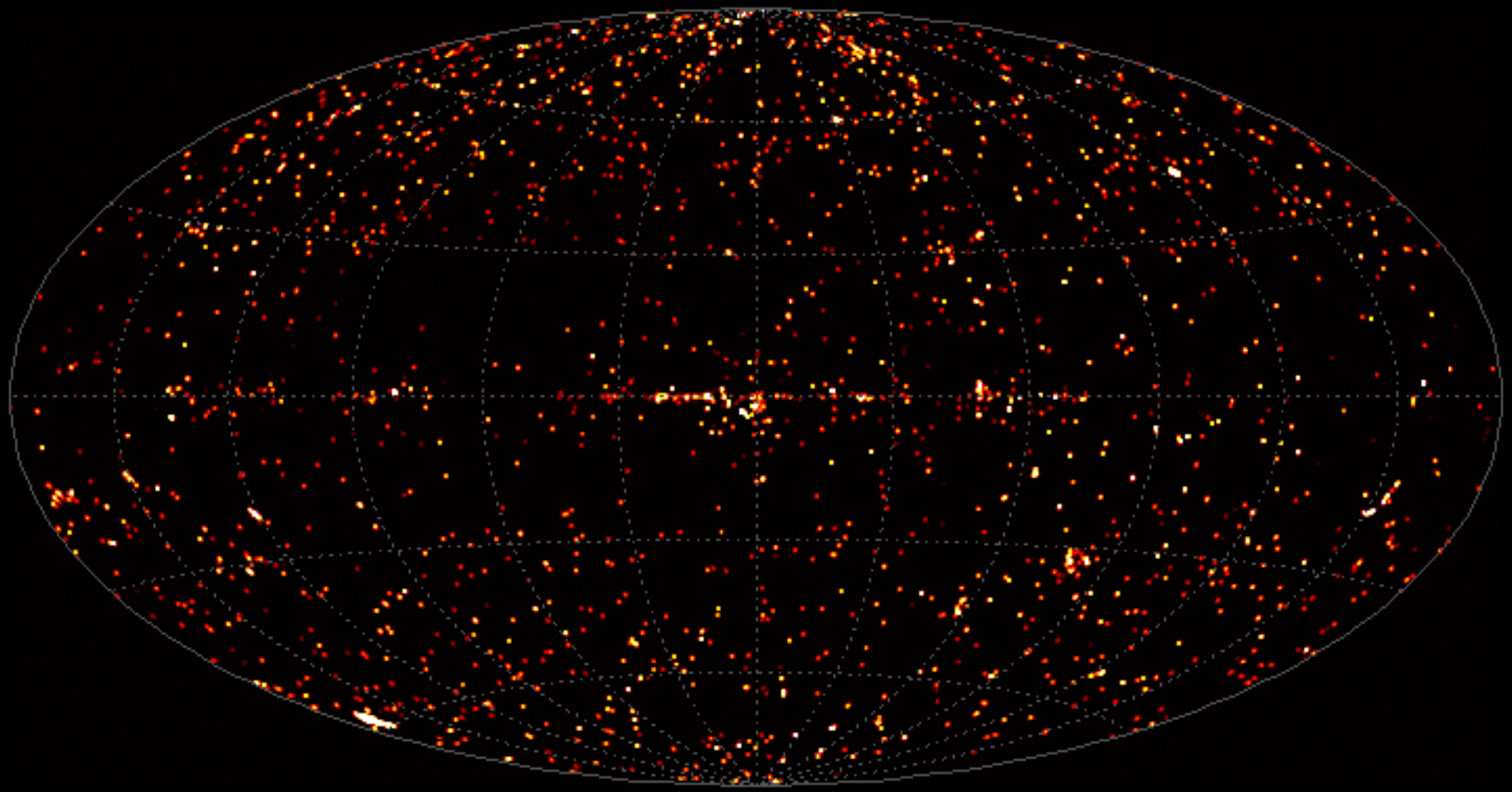
2XMMi catalogue sky density map - Galactic coordinates



XMM-Newton
SURVEY SCIENCE CENTRE

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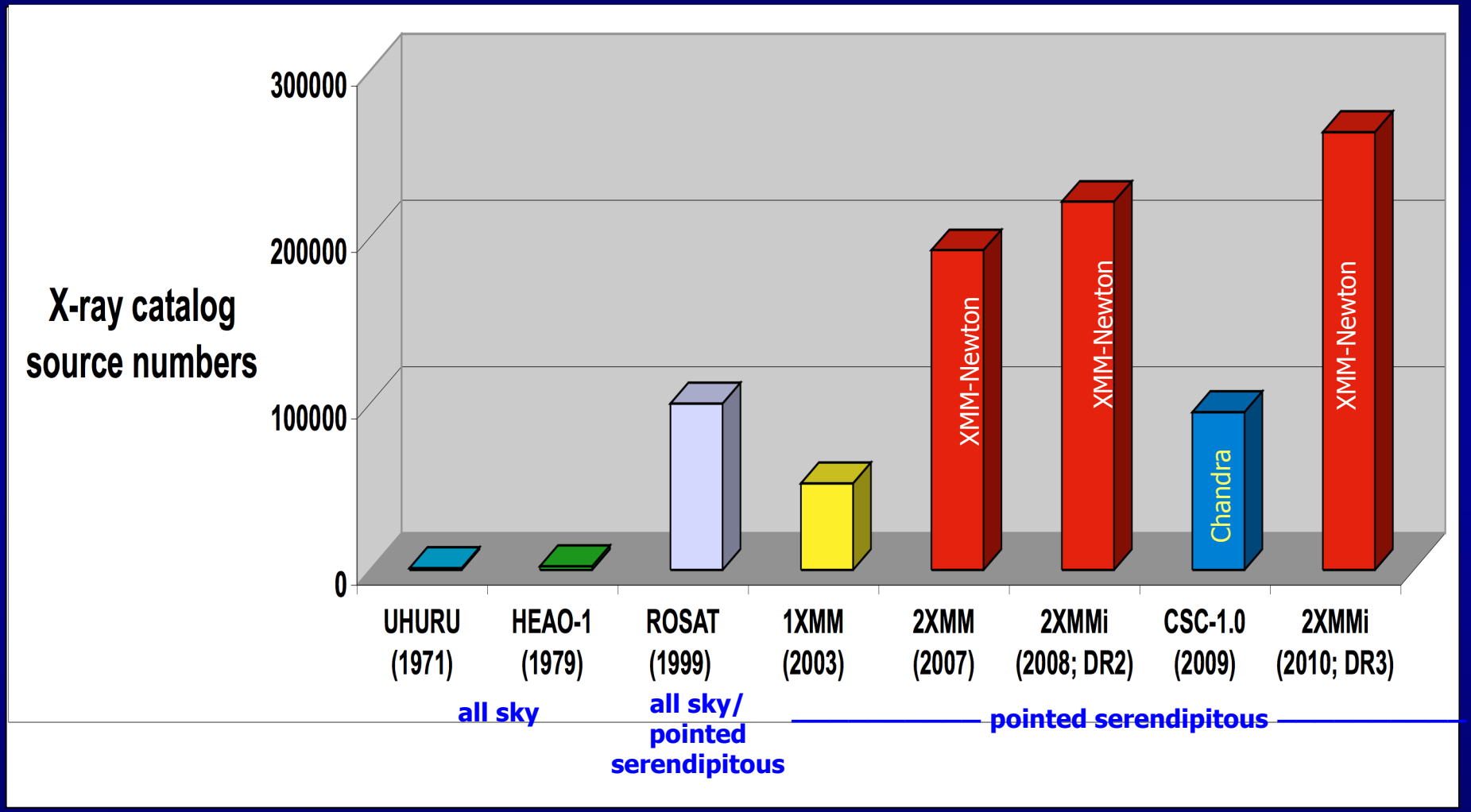

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2XMM catalogue properties

SKY AREA

- ~500 sq.deg. (net coverage)

SENSITIVITY

typical (deepest) sensitivity limits

f_X (soft) ~ 3 (1) x 10^{-15}

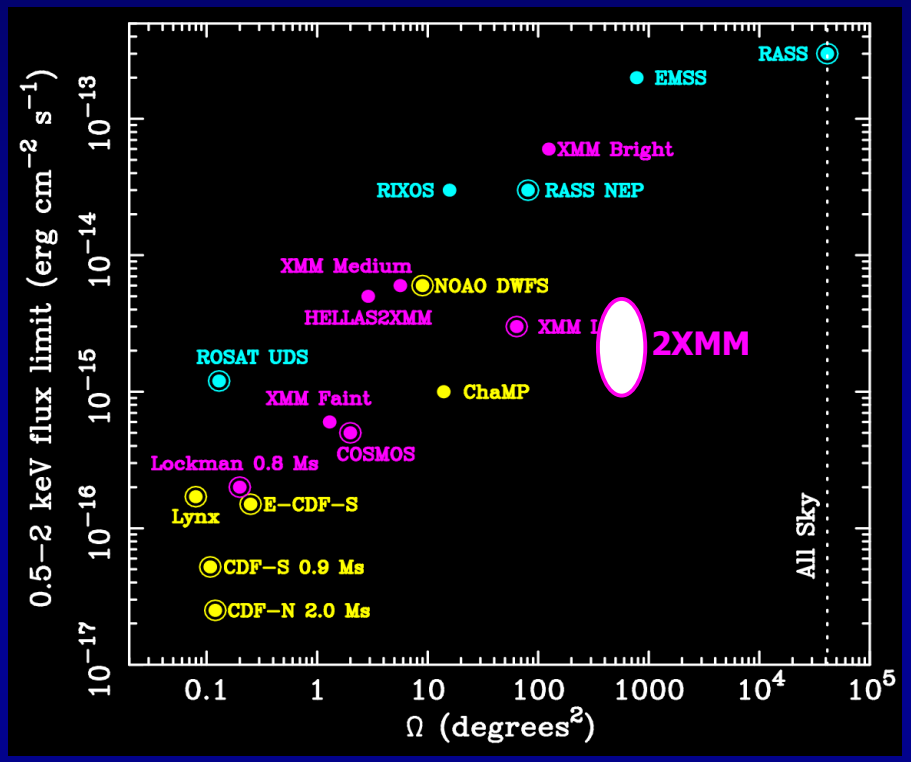
f_X (hard) ~ 1.5 (0.8) x 10^{-14}

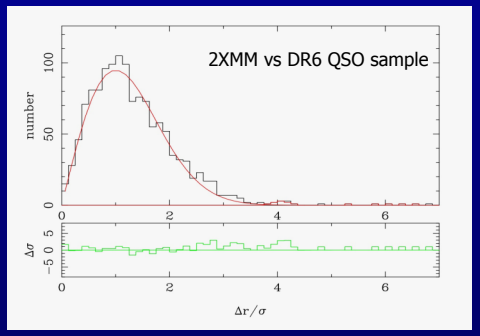
ASTROMETRY

position errors $<\sigma>$ = 1.5 arcsec

➔ average position offset ≤2 arcsec

➔ systematics ≤ 0.35”





XMM-Newton SURVEY SCIENCE CENTRE

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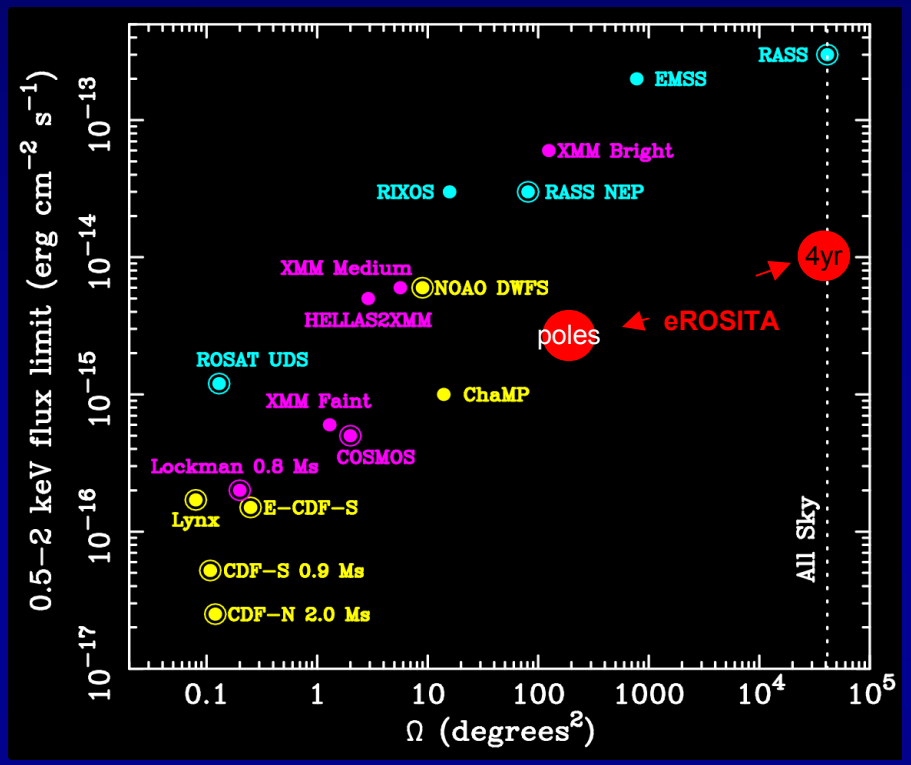

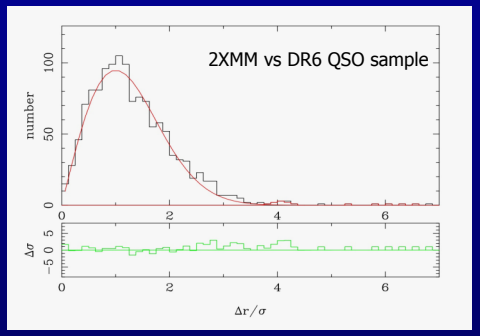

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Identification programs

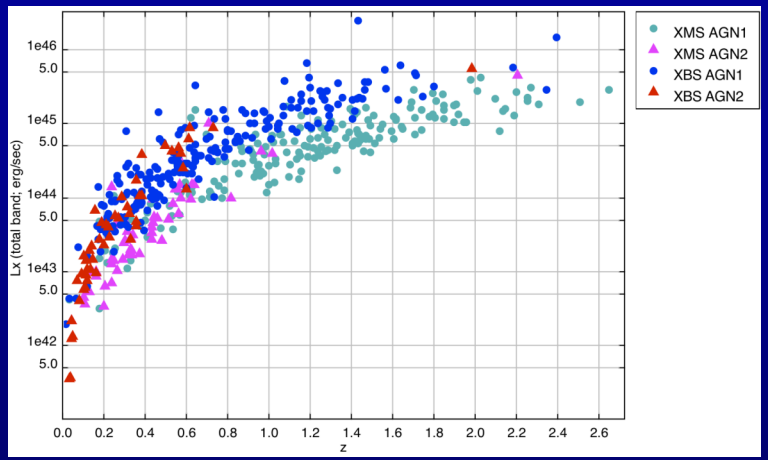
- SSC "XID" Programs
  - complete identification of flux-limited samples based on XMM-Newton Serendipitous Survey
  - characterise XMM source populations

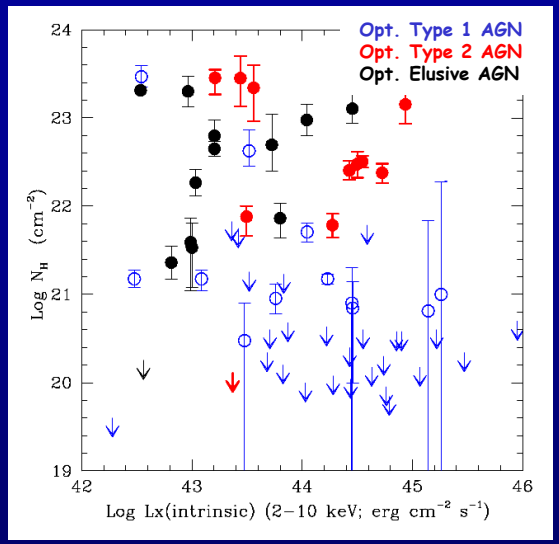
SSC XID spectroscopic IDs: bright and medium flux samples

project	#IDs	completeness
XMS-N	318	v high
XMS-XWAS	~970	medium
XBS	348	v high
GPS	~500	low

XBS: ~400 sources
spectroscopic ID ≈ 97%
Della Ceca et al. 2004

XMS and XBS samples: AGN





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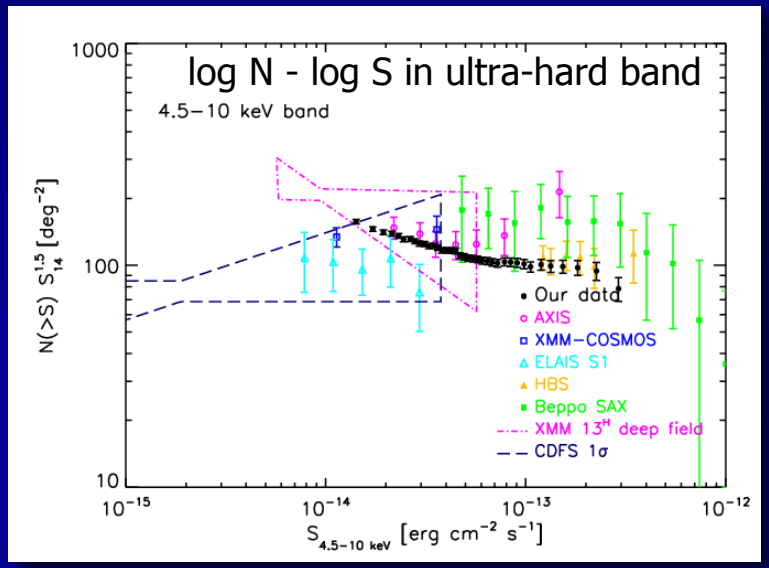
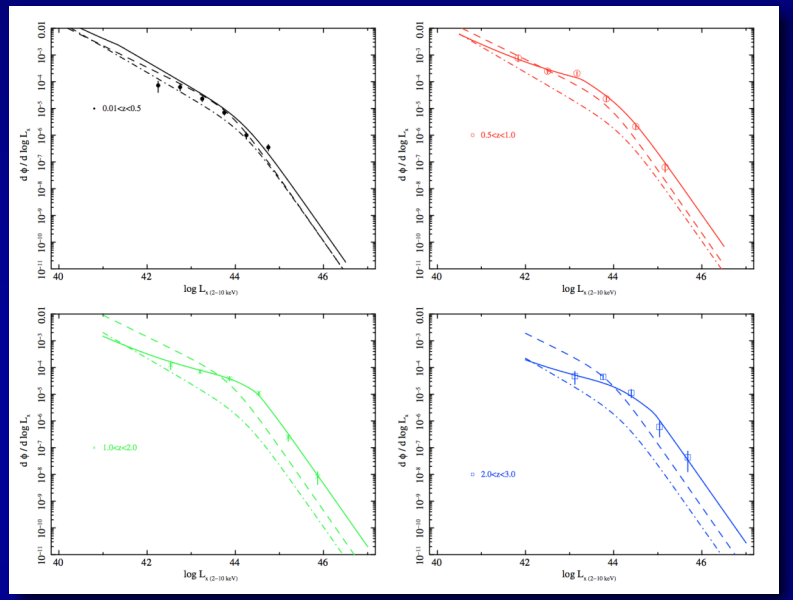
High precision characterisation of X-ray source population



Best determination of extragalactic X-ray source counts

(Mateos et al. 2008)



new determination of the XLF

(Ebrero et al. 2009)

- 1129 XMM-*Newton* observations at $|b| > 20^{\circ}$; > 30,000 source detections
- immune from cosmic variance

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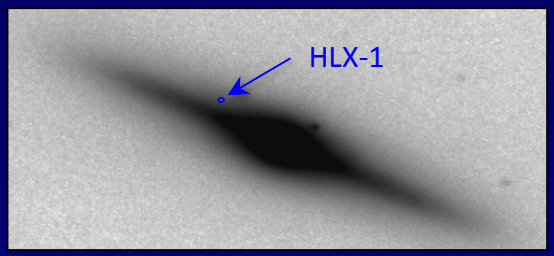
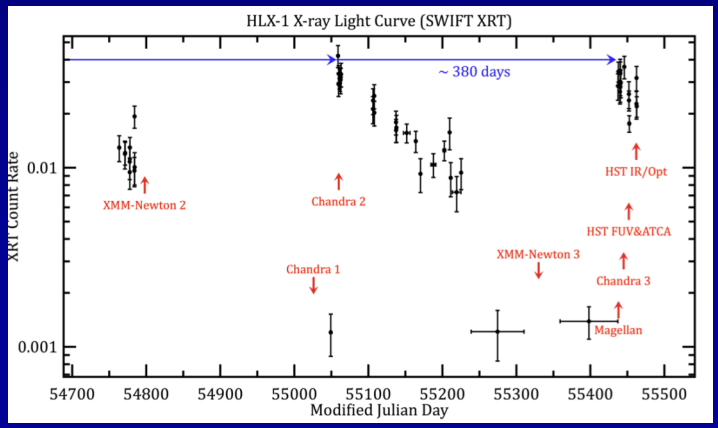
Hyperluminous X-ray Source

Farrell et al.

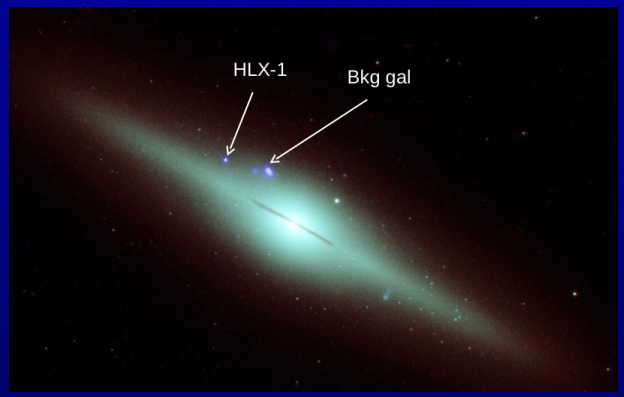


Farrell et al., 2009, Nature, 460, 73

- HLX-1 - discovered in 2XMM through search for soft-spectrum objects (2XMM J011028.1-460421)
- Coincident with galaxy ESO 243-49, ~8" from nuclear bulge
- $L_x \sim 10^{42}$ erg/s (0.2-10 keV) - extreme ULX but highly variable
- Location of HLX-1 in galaxy now confirmed by VLT spectroscopy and HST imaging
- *currently best IMBH candidate*
  - maximum L_x implies mass > 500 $M_\odot$ even if 10x super-Eddington



Lasota et al.



optical counterpart for HLX-1 from HST imaging
courtesy Sean Farrell

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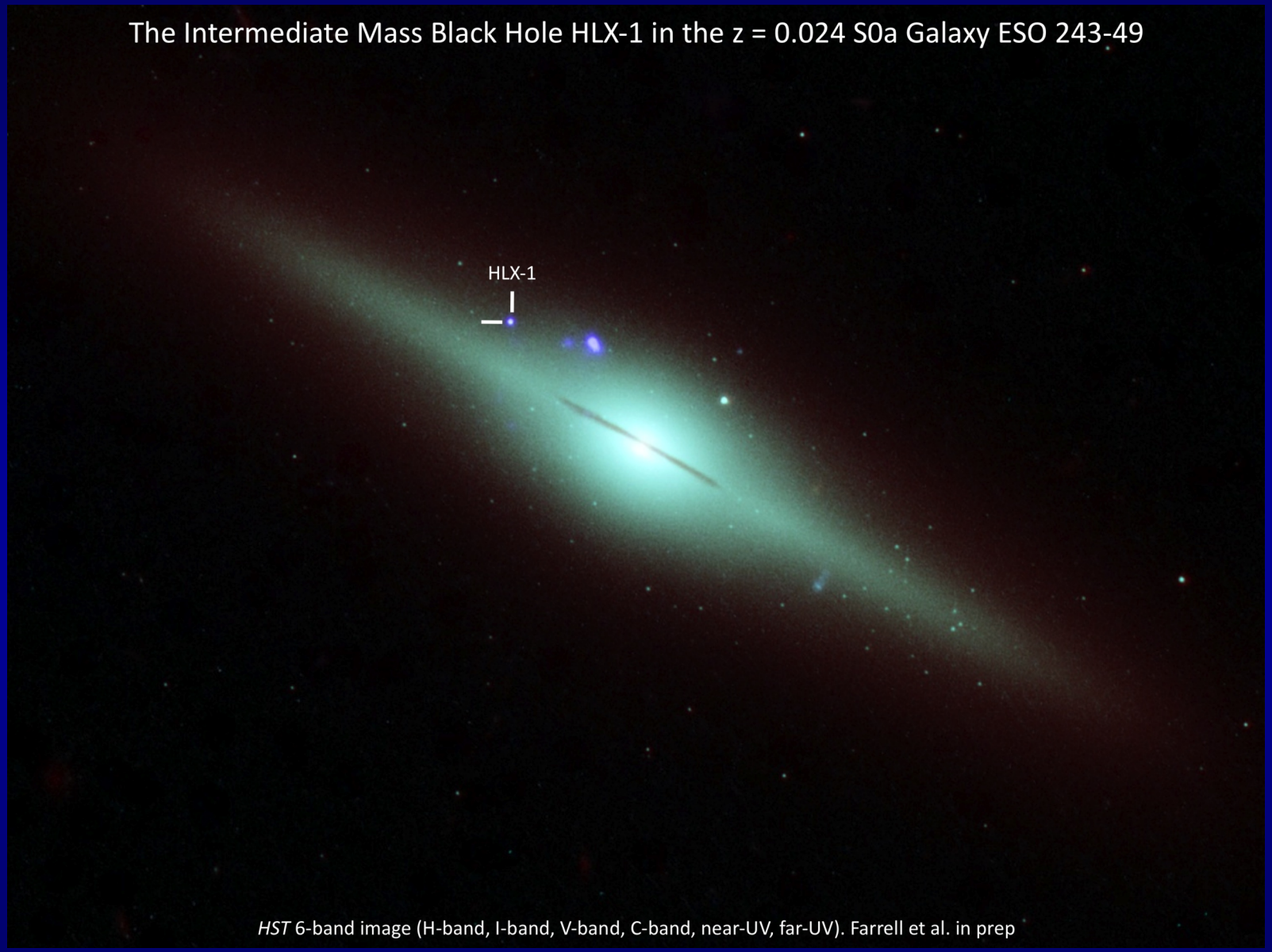
The Intermediate Mass Black Hole HLX-1 in the z = 0.024 S0a Galaxy ESO 243-49



HST 6-band image (H-band, I-band, V-band, C-band, near-UV, far-UV). Farrell et al. in prep

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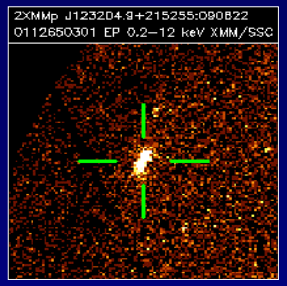
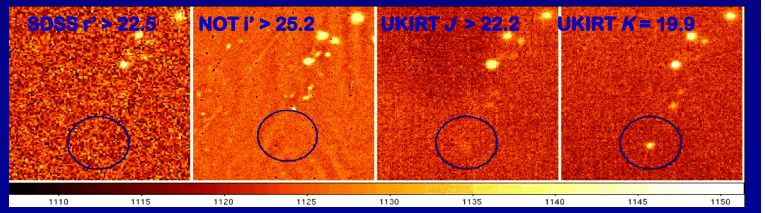
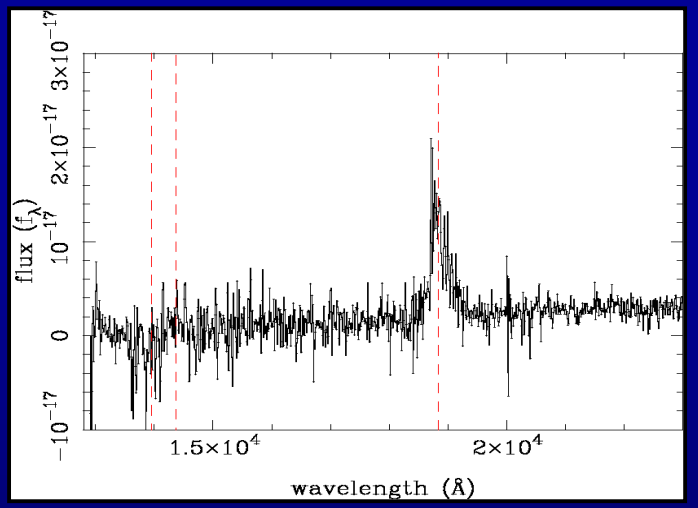
Extreme type 2 AGN

Del Moro et al. 2009



- Sample of extreme F_X/F_{opt} objects - search for type 2 AGN at high L_X
- 100+ candidates from 2XMM and SDSS
  - IR and optical followup
- Most extreme example
  - 2XMM J123204+215255: F_x/F_{opt}>3000
  - z=1.9, $L_X \approx 4 \times 10^{46}$ erg s^{-1}
  - X-ray type 2, optical/IR type 1 AGN





IR spectroscopy (Subaru MOIRCS)
Hα at z=1.9

- Type 2 AGN are rare at high luminosity
- 2XMM J123204+215255 maybe in transition phase from type 2 to type 1

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Ubiquity of soft excess in type 1 AGN

Scott et al. 2011

- Sample of 761 type 1 AGN from cross-correlation of 2XMMi with SDSS DR5 quasar catalogue

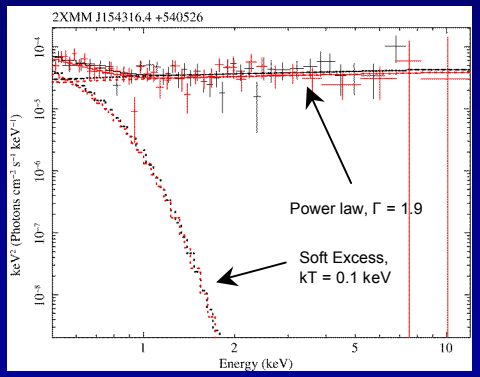
  z ~ 0.11 - 5.41

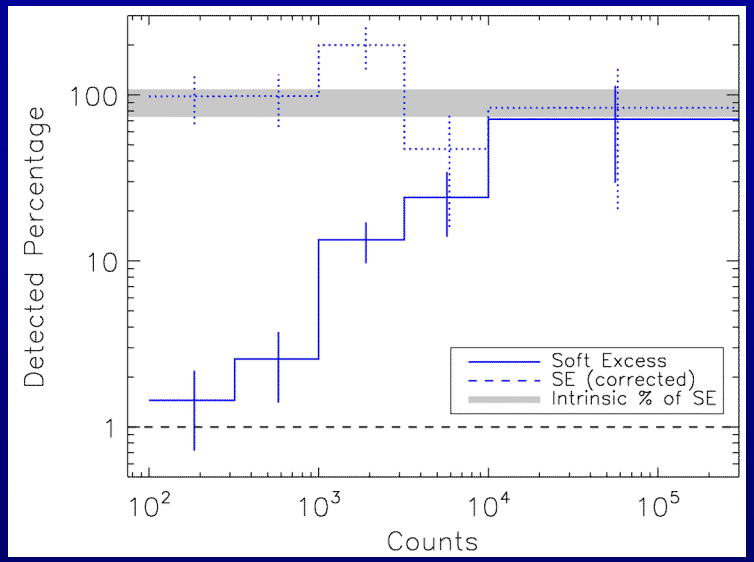
  >75 counts

- Fitting of XMM spectra + simulations to quantify detectability
  - s/n and redshift effects

⇒ Intrinsic fraction with soft excess very high ~90%

and we still don't know what it is for sure





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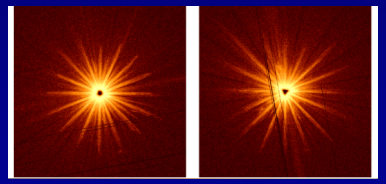
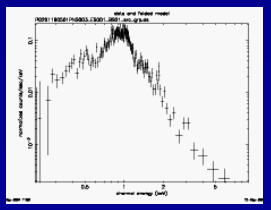
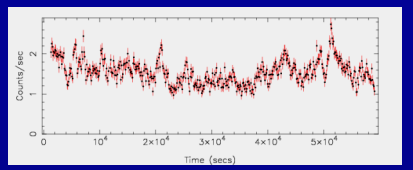
Future: 3XMM catalogue planned for 2012

3XMM - complete uniform reprocessing of database







ENHANCEMENTS

- use of 2D PSF
  - better fidelity
  - reduction in spurious detns (close to bright sources)
  - cleaner extended source detection
- spectral and time series extraction
  - better optimisation of extraction
  - more intelligent background region selection
- large number of other improvements

SCOPE

- release at end 2012, expect 3XMM to contain
  ~450,000 detections ~350,000 unique sources

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Concluding remarks

XMM serendipitous sky survey rich resource

- 2XMM catalogues contain
  >100,000 AGN
  1000s of clusters …
- Key to exploitation
  - large area catalogues
    - 2MASS, SDSS, UKIDSS, WISE: 10,000 - 100,000 matches
  - focussed ID programs

Lessons for eRosita?

- XMM serendipitous survey shows how rich eRosita data will be
  - eRosita survey will eventually be ~50-100 times larger than the XMM serendipitous survey
- plan to calibrate off the sky!
  - astrometry
  - flux calibration
  - in-orbit PSF and vignetting …

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