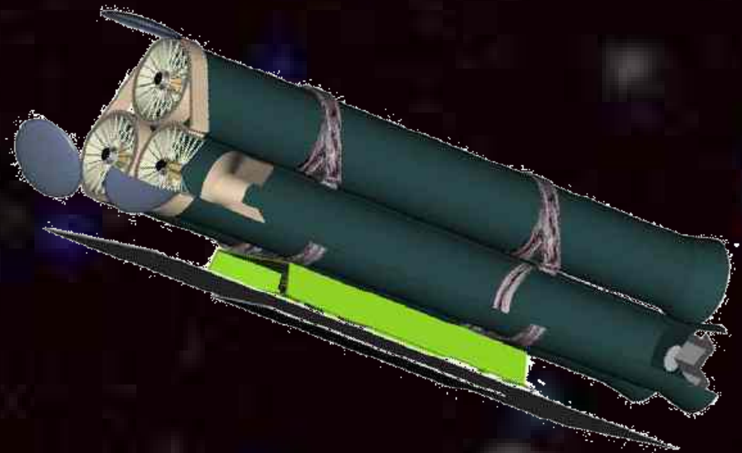
The Wide Field X-ray Telescope



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WFXT in few words

The WFXT mission: one high resolution, high collecting area and wide FOV X-ray telescope with low background, to image the 0.5-7 keV X-ray sky down to very low fluxes and characterize the spectra of millions of X-ray sources.

The scientific outcome will be a coverage of at least half of the 0.5-7 keV X-ray sky with a quality and a depth at the level of future wide area surveys, a product which is not delivered by any other existing or planned mission.

WFXT Key Features

Constant PSF (5" goal HEW) across 1 degree FOV

Effective area ~ 15 X Chandra at 1 keV (goal 10000 cm^2)

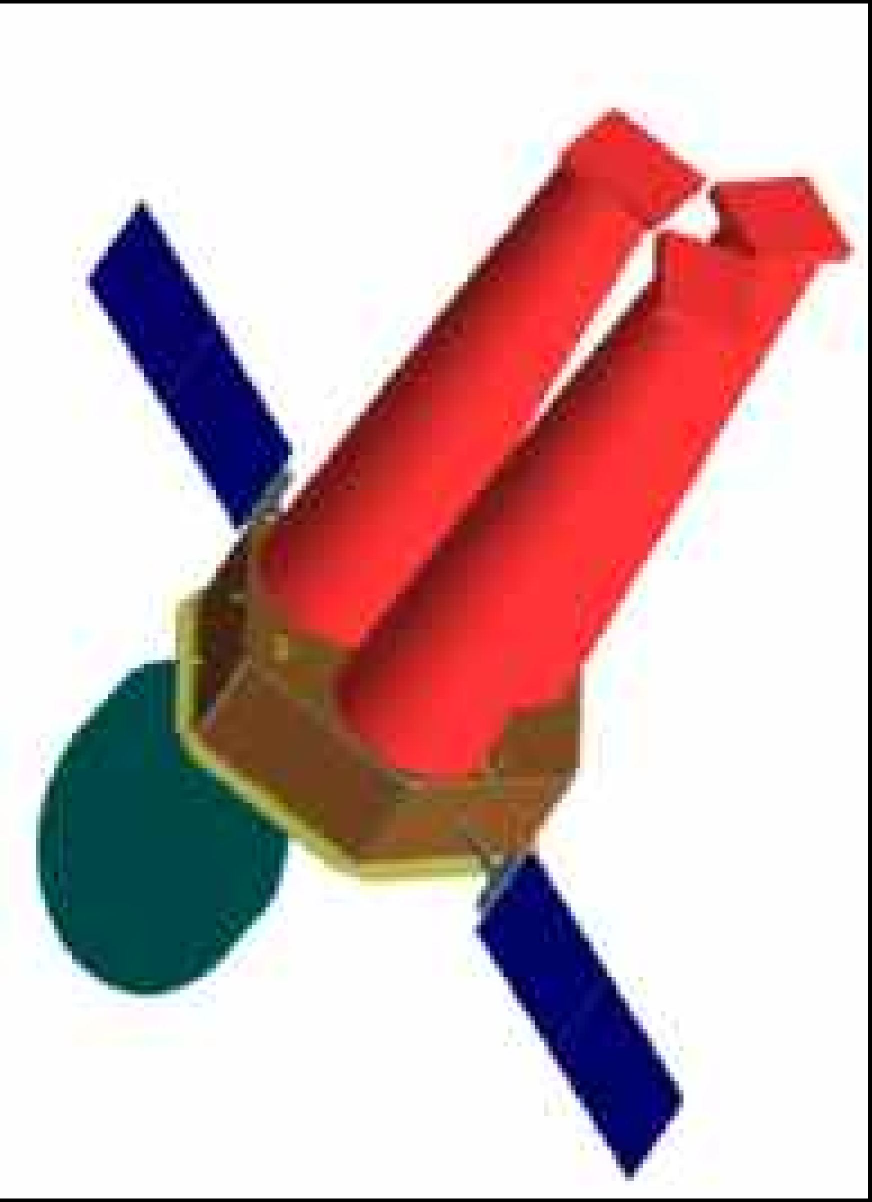
Bandpass: ~ 0.4-7 keV

Dedicated survey mission (no GO program), calibrated data products released with no proprietary period

Science goals: discovery and characterization of groups and clusters, evolution of AGN population, star forming galaxies traced up to z>1, halo stars, SNR and compact Galactic objects...

Will serve as a target finder for future X-ray missions

WFXT Telescope Layout



3 mirror modules

Burrows, Burg & Giacconi (1992)
polynomial perturbation optics design

SiC or glass mirror shells, to be superpolished

Developing wide-field optics and optimizing the complete system with end-to-end modeling

Detectors: CCD or CMOS

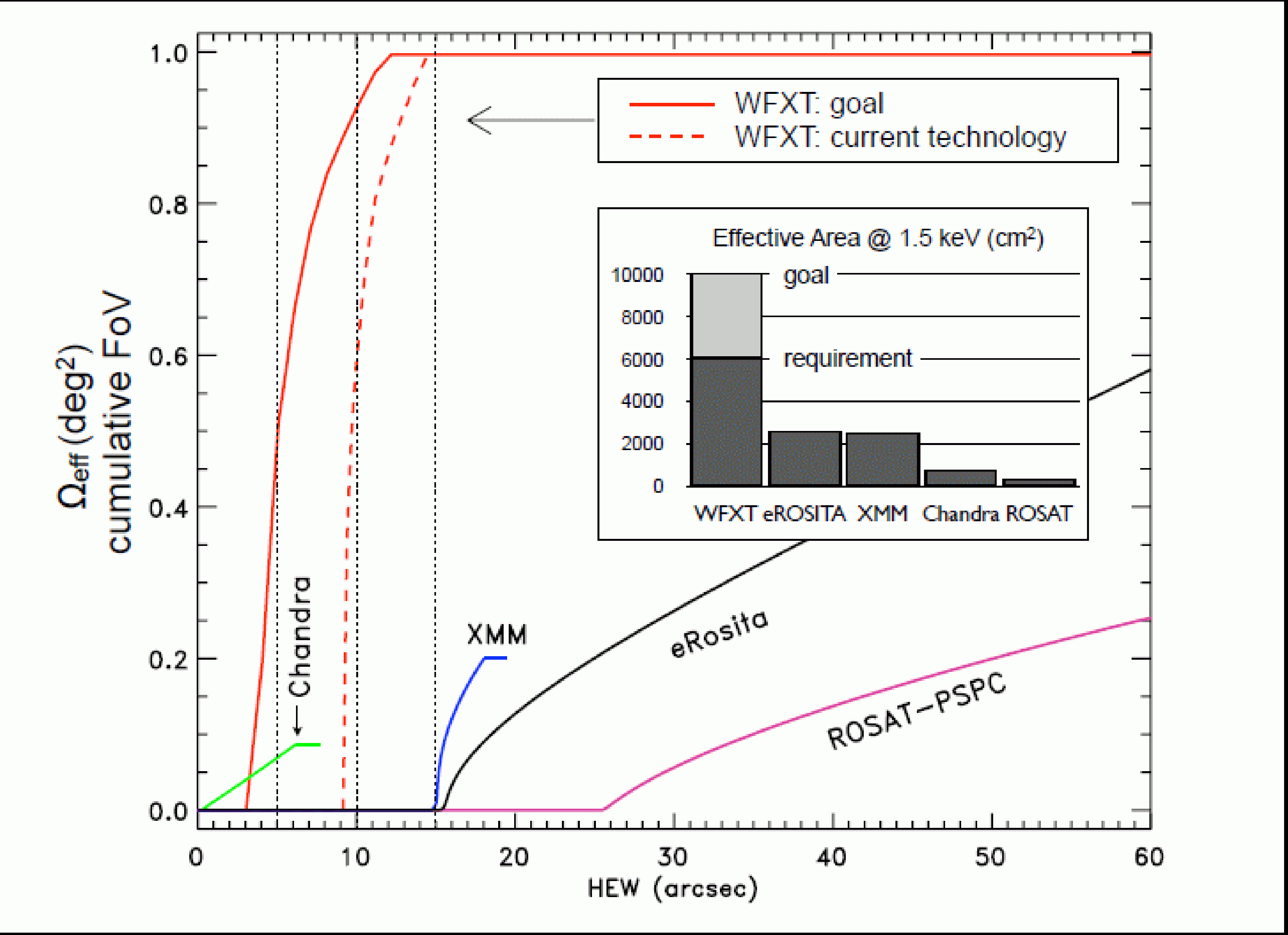
Grasp

Grasp = Aeff x FOV measured at 1.5 keV in $cm^2\,deg^2$

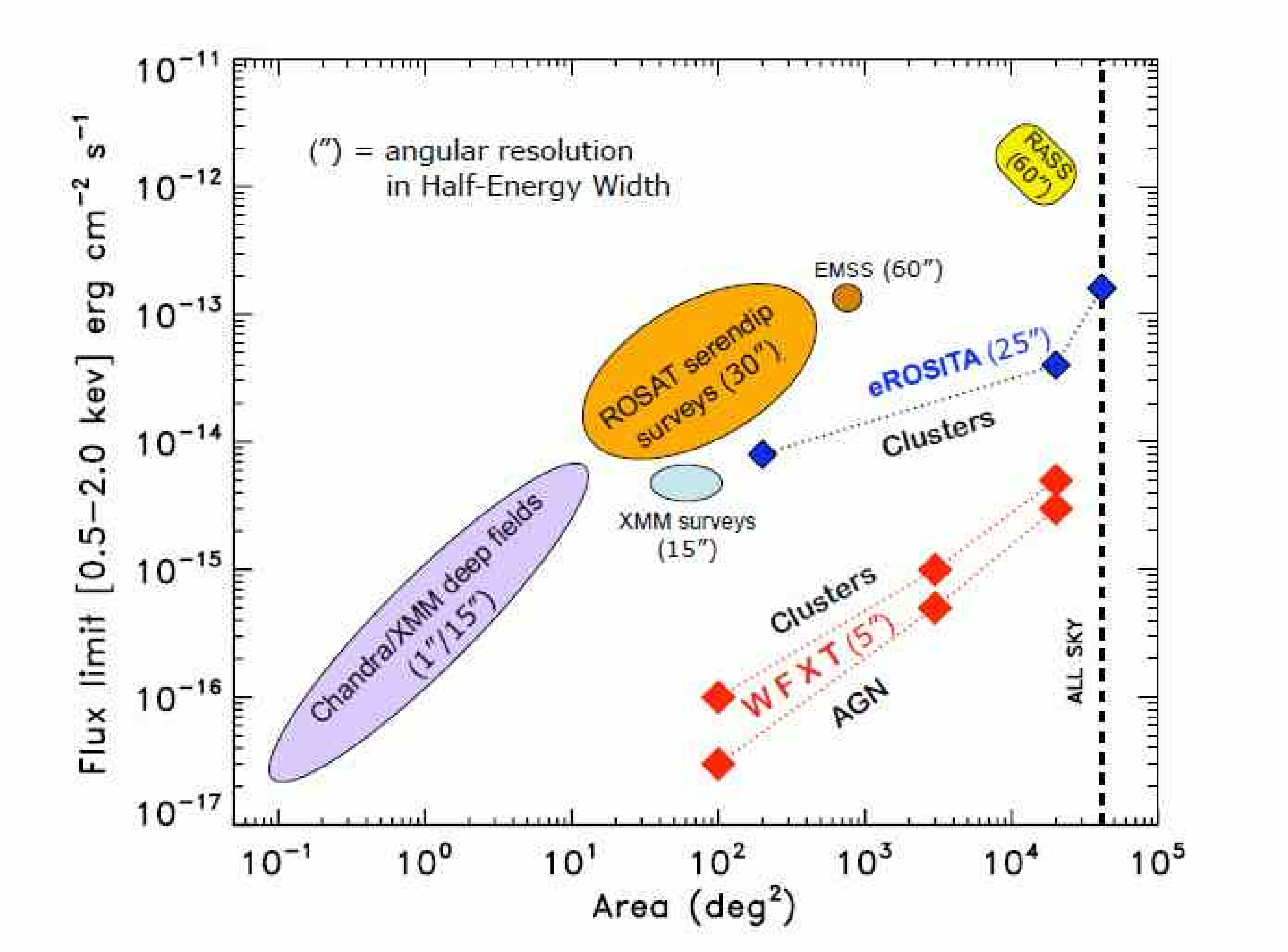
Grasp measures the speed in which a survey can cover an area of the sky down to a given flux limit.
Better angular resolution results in better efficiency and source identification.

	WFXT	eROSITA	XMM	ROSAT	IXO	Chandra
Grasp	9000	1150	900	630	1500	50
HEW	5	30	15-25	25-60	~5	1-5

FOV at a given spatial resolution



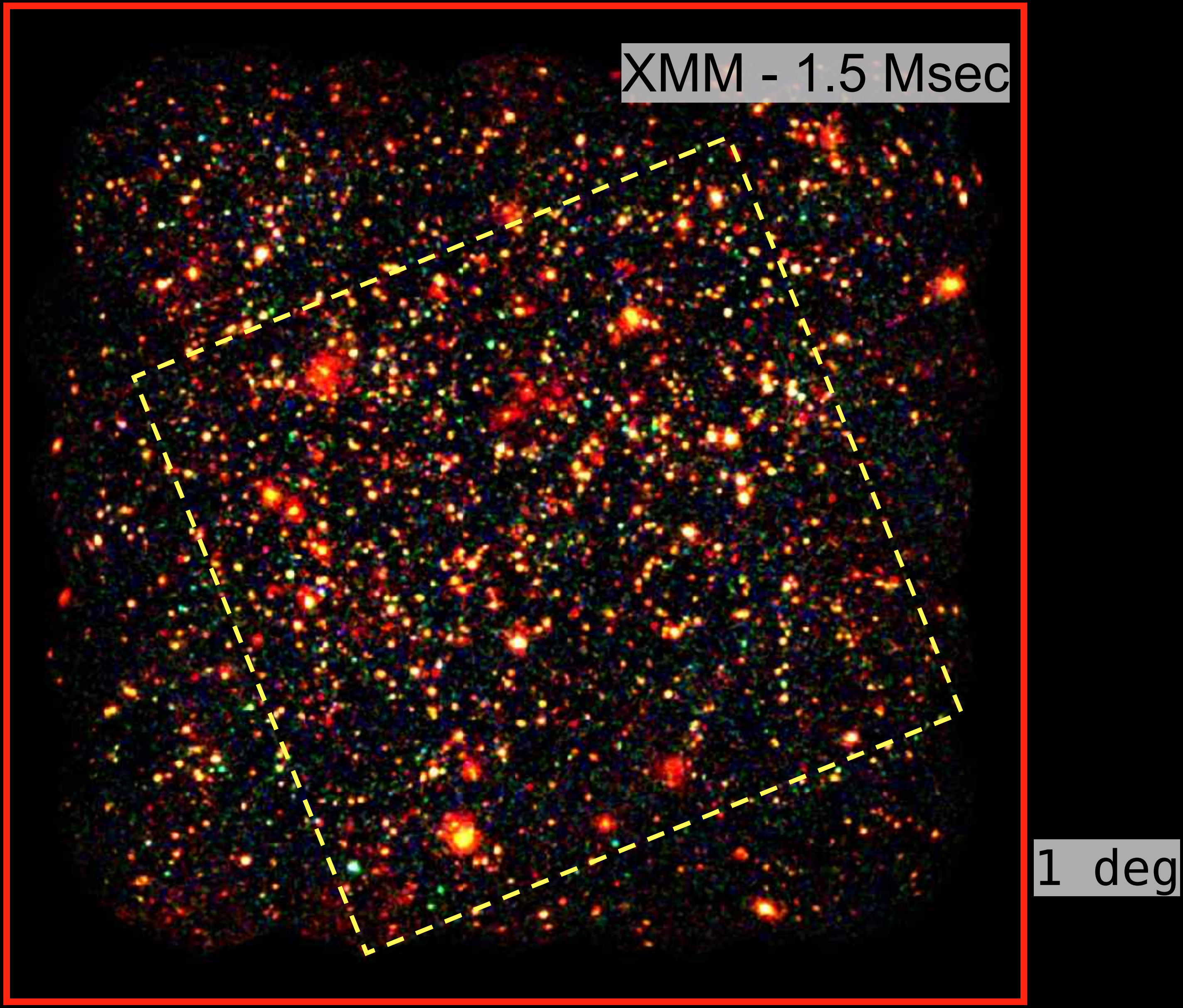
Flux limit vs solid angle



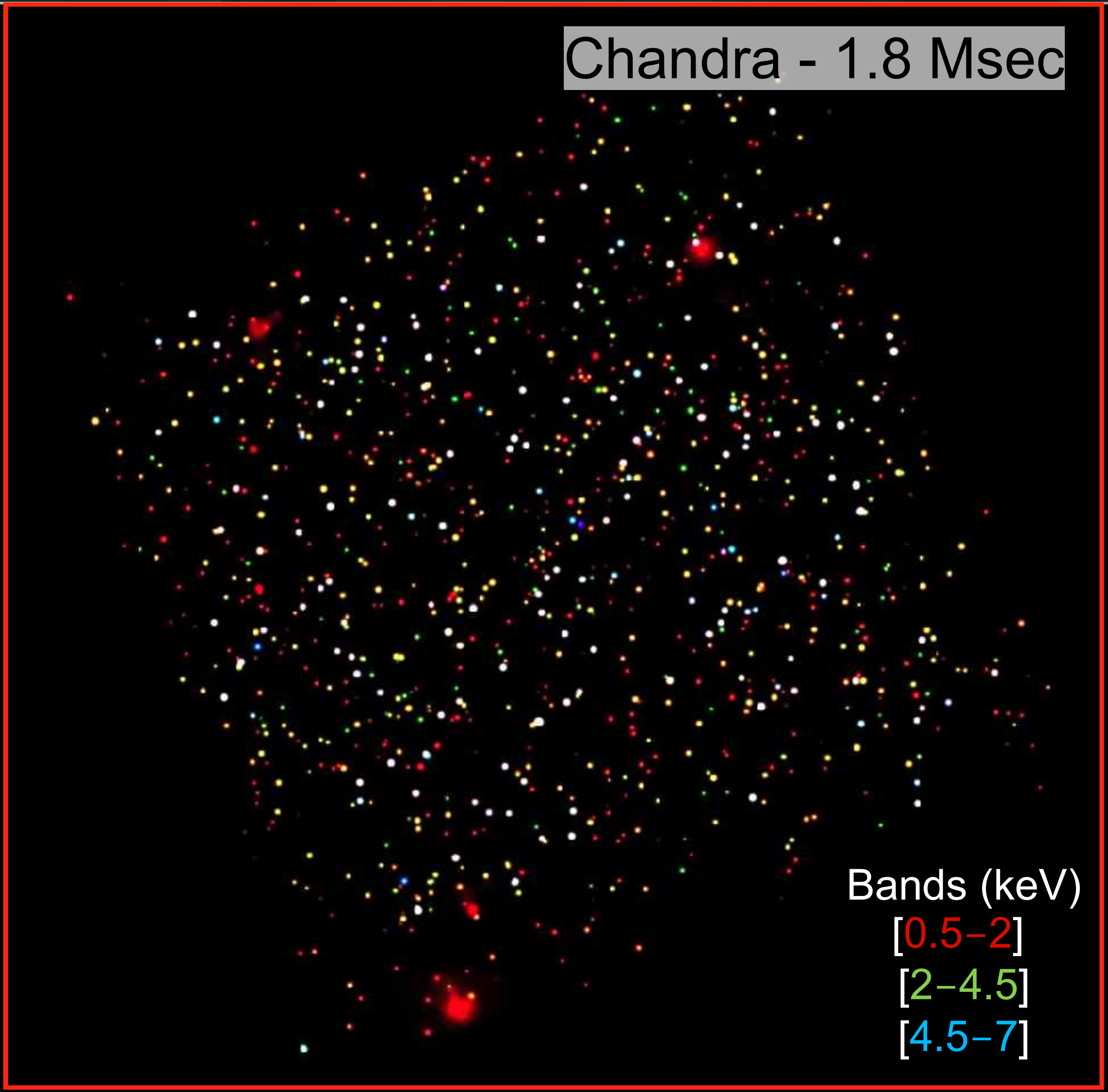
Planned Surveys

	Wide	Medium	Deep	(Milky Way)
Area (deg^2)	~20,000	~3,000	~100	~1000
$F_{lim,ext}$ (cgs)	5×10^{-15}	1×10^{-15}	1×10^{-16}	5×10^{-16}
$F_{lim,pt}$ (cgs)	3×10^{-15}	5×10^{-16}	3×10^{-17}	1×10^{-16}
Exposure Time (sec)	2×10^{3}	1.3×10^{4}	4×10^{5}	$\sim5\times10^{4}$
Duration	~2 yr	~2 yr	~1 yr	~1 yr

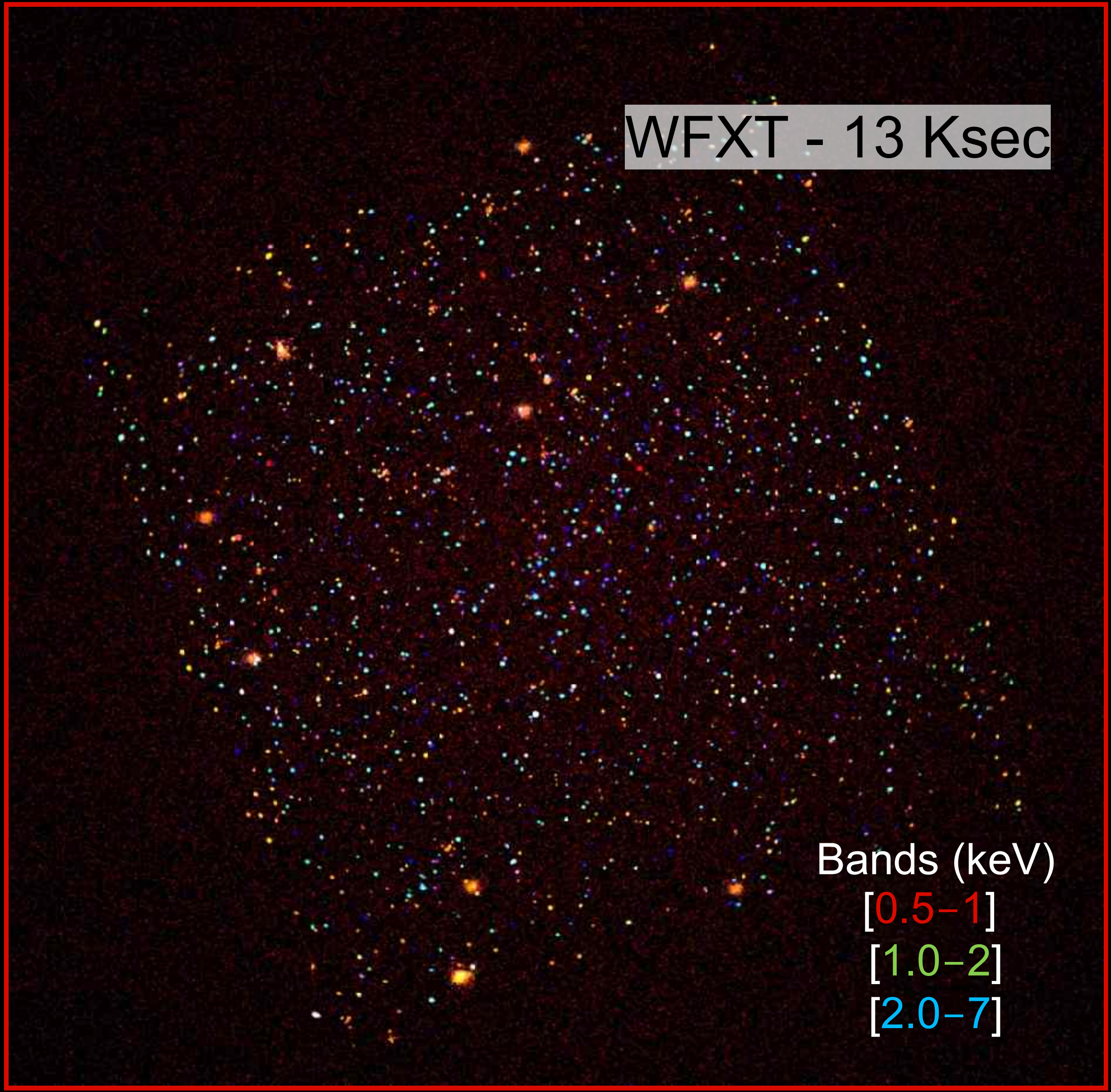
XMM COSMOS survey (2 deg^2) (Cappelluti et al. 2009)



Chandra COSMOS survey (1 deg^2) (Elvis et al. 2009)



WFXT simulation (one tile from the medium survey)



X-ray optics with polynomial profile

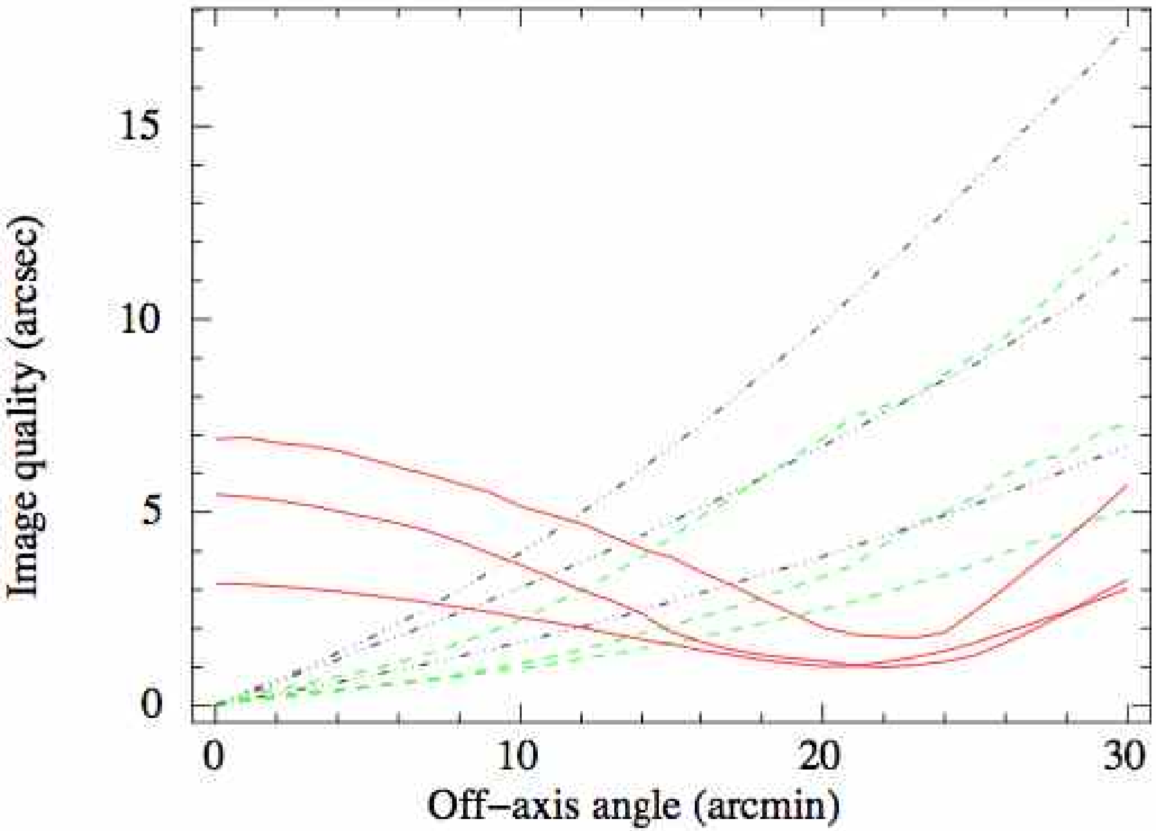
Mirrors are usually built in the Wolter I (paraboloid-hyperboloid) configuration which provides, in principle, perfect on-axis images.

This design exhibits no spherical aberration on-axis but suffers from field curvature, coma and astigmatism, which make the angular resolution to degrade rapidly with increasing off-axis angles.

More general mirror designs than Wolter's exist in which the primary and secondary mirror profiles are expanded as a power series. These polynomial solutions are well suited for optimization purposes, which may be used to increase the angular resolution at large off-axis positions, degrading the on-axis performances (Burrows, Burgh and Giacconi 1992)

Constant PSF on a large FOV

Polynomial shell (f = 5, l = 7) versus Wolter I and W-S



(Conconi et al., Applied Optics , 2009, under submitted)

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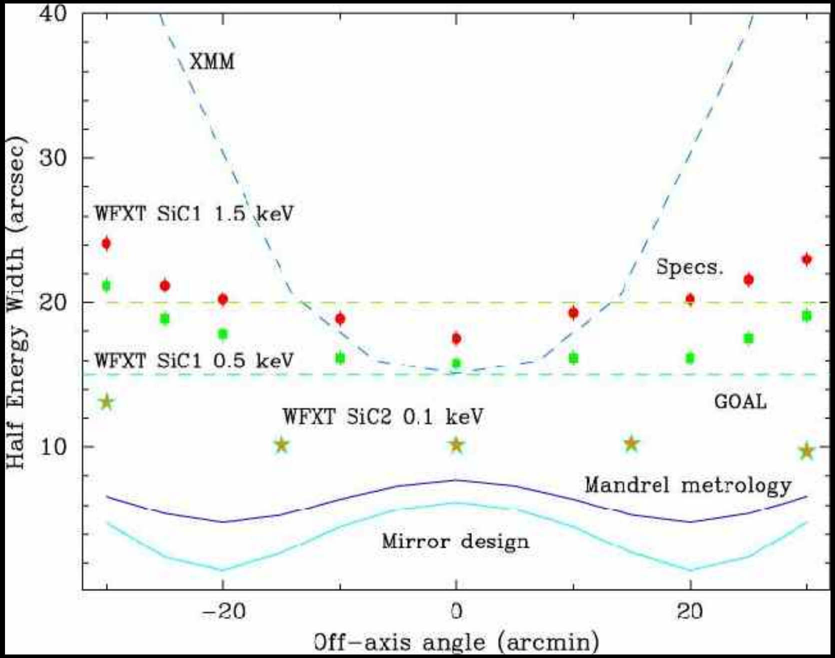
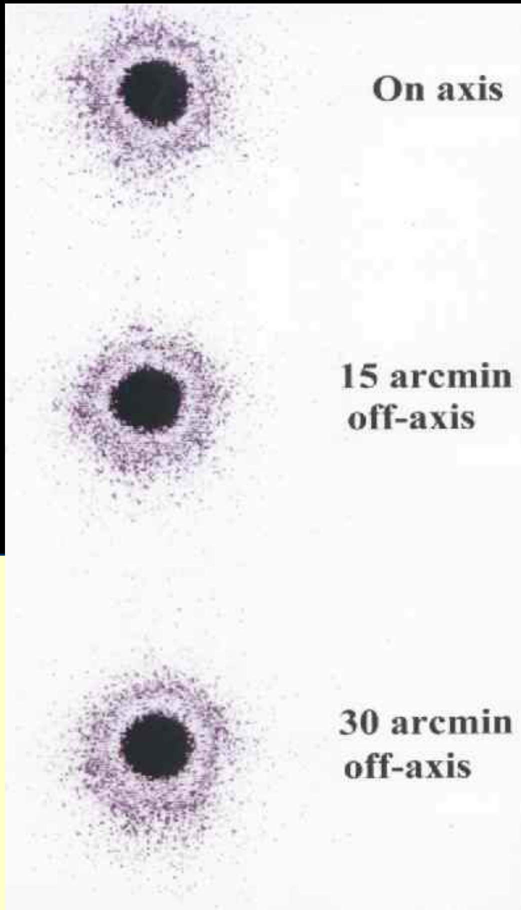
WFXT prototypes in SiC by epoxy replication

Polynomial mirrors (1998-2001) INAF-OAB and MSFC



Tests @ Panter-MPE
& Marshall XRF



WFXT (epoxy replication on SiC) – Ø

Height = 20 cm

F. L. = 300 cm

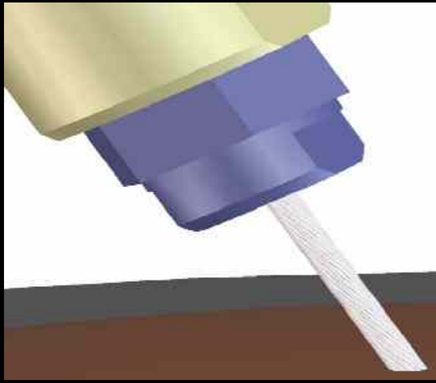
HEW = 10 arcsec @ 0.1 keV

Jet polishing approach

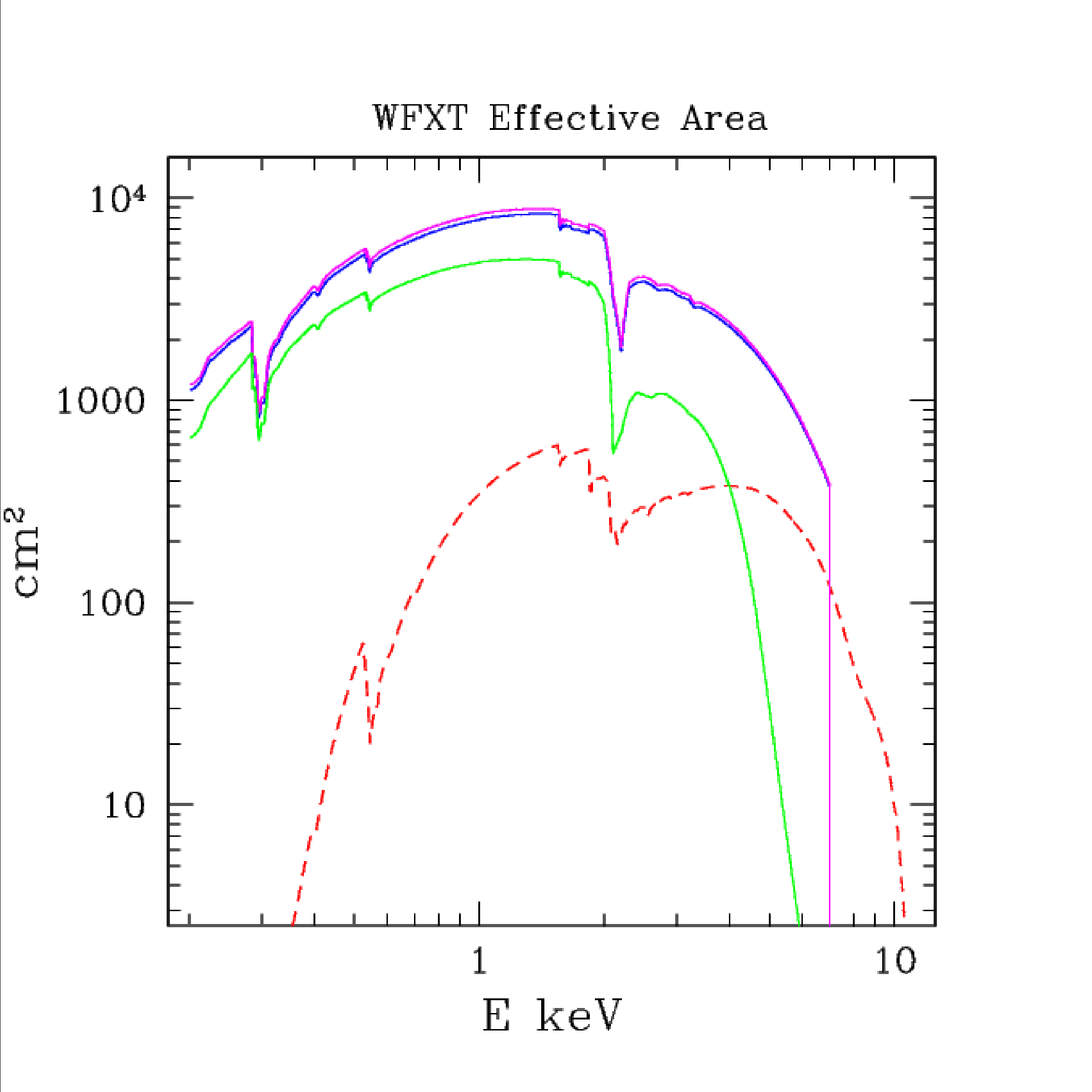
The Jet polishing process replaces the variable geometry soft polishing tool with a controlled “jet” of slurry to create a polishing “spot” on the surface being polished.

The position and pressure of that “spot” is again controlled by a 7 axis CNC machine tool controller

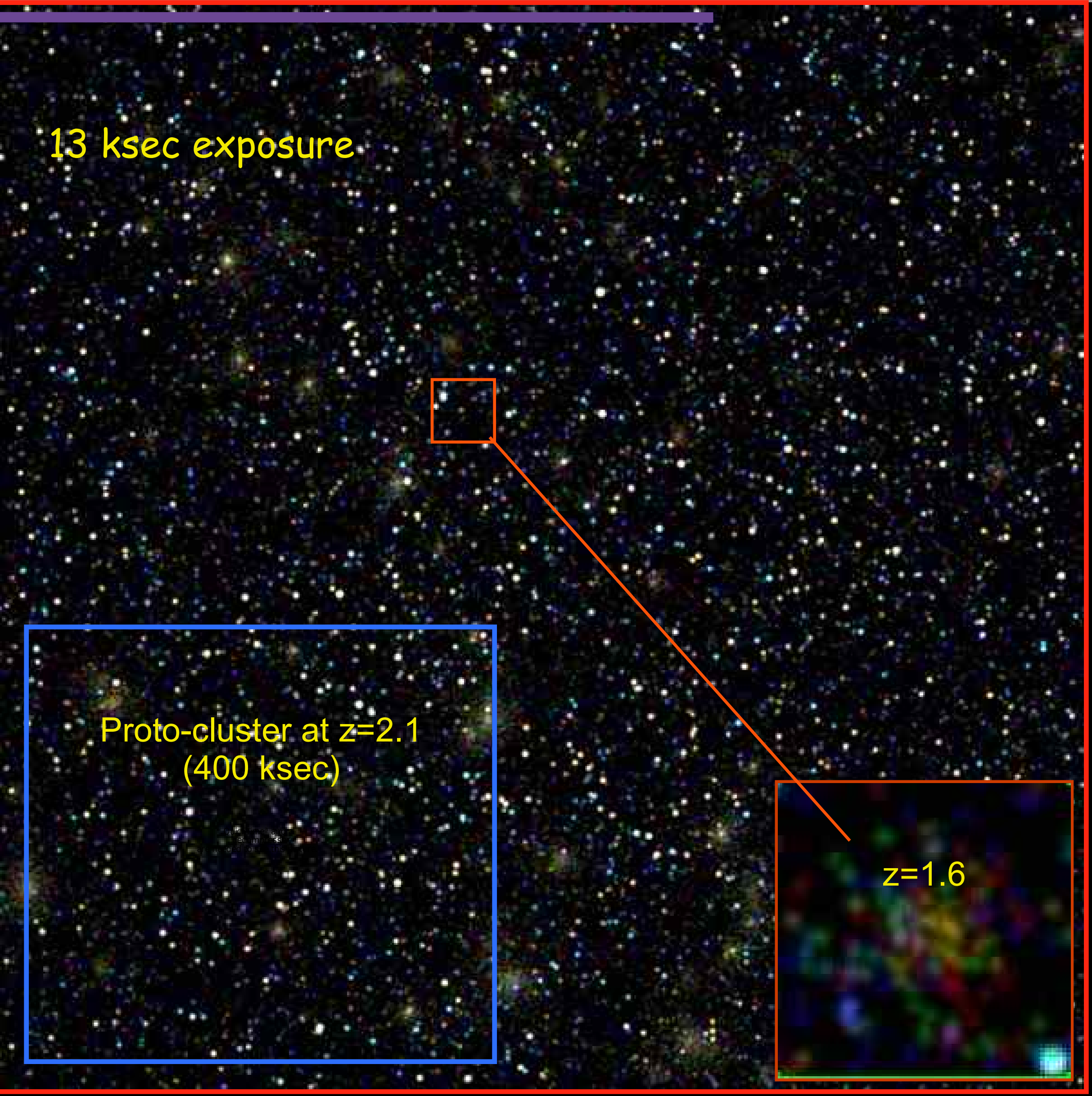
It’s a “deterministic” process, in the sense that it’s able to return the desired profile if the map of profile errors is known



WFXT effective area



The potential of a WFXT survey



With 13 ks: ~L* clusters at z=1.6 detected with ~ 500 counts.

With 400 ks: the simulated Spiderweb cluster detected with > 10^4 counts.

Redshifts measured with ~600 counts for the 17 brightest clusters in this field

Completely X-ray based cluster redshift survey!

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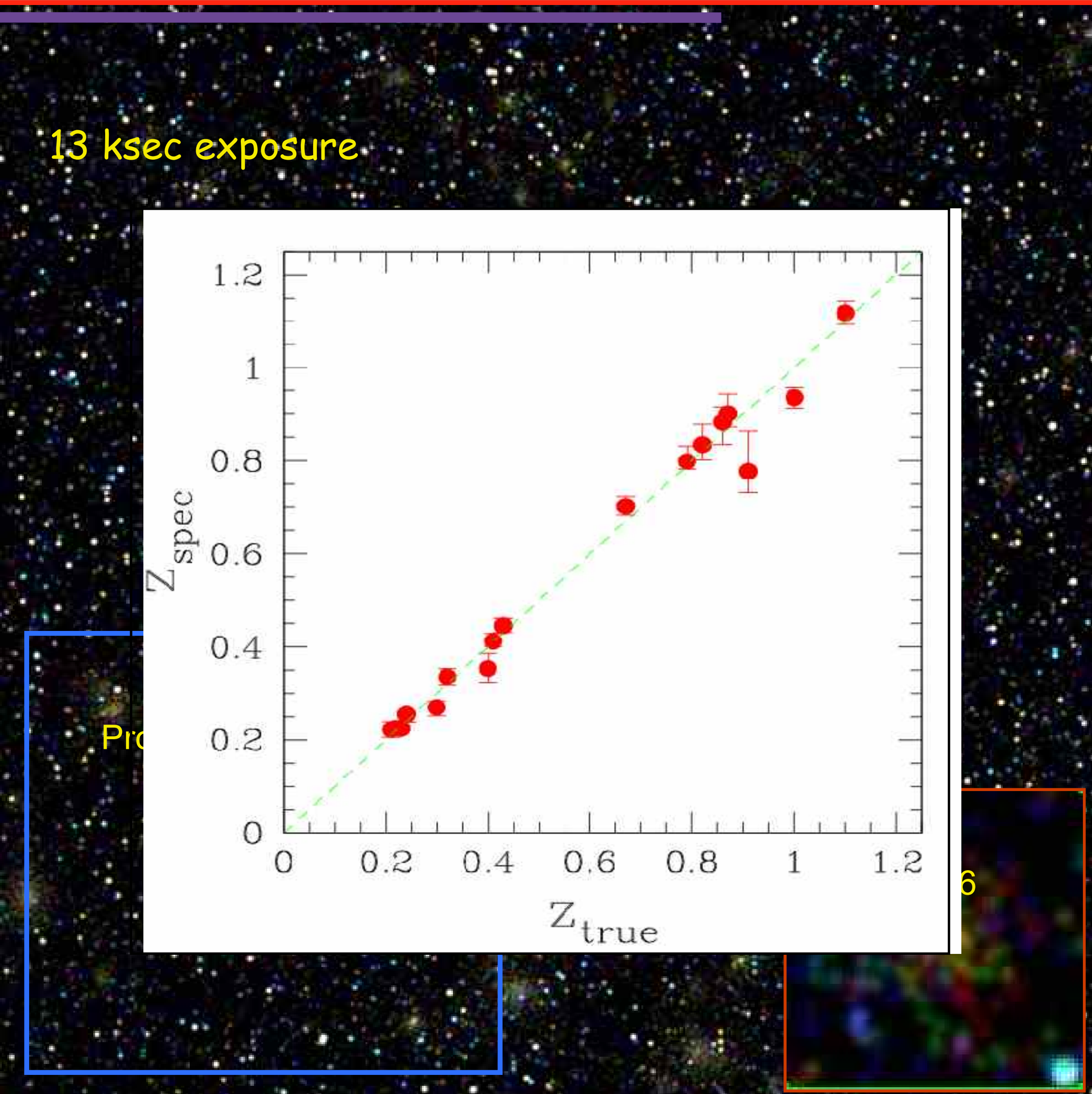

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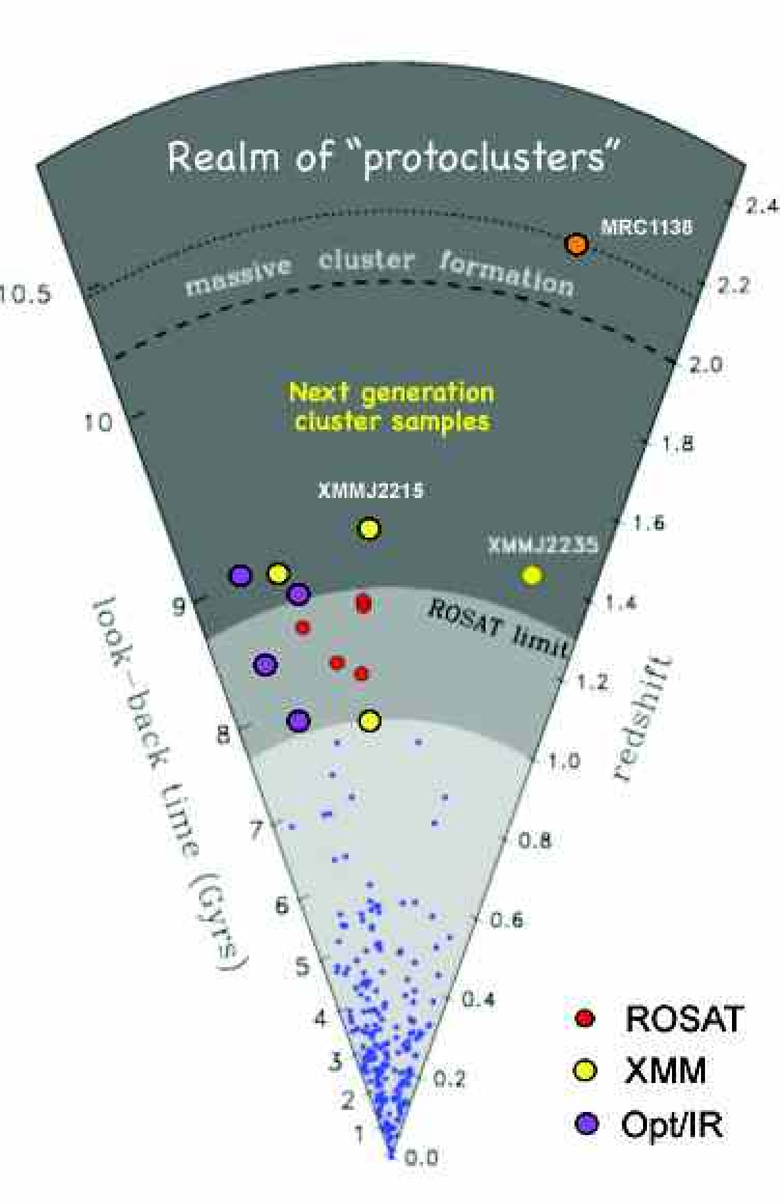
Science with WFXT: Clusters of galaxies



Not just a cluster counting machine:

- Characterize ICM properties and measure mass proxies for thousands of clusters at z>1.
- Trace the epoch of entropy injection and metal enrichment of the ICM.
- Study the intense dynamics of proto-cluster assembly at z~2.
- Multi-λ synergies: a vast scientific legacy for decades to come
- Path finder for follow-up studies with ELTs, IXO, ALMA,...

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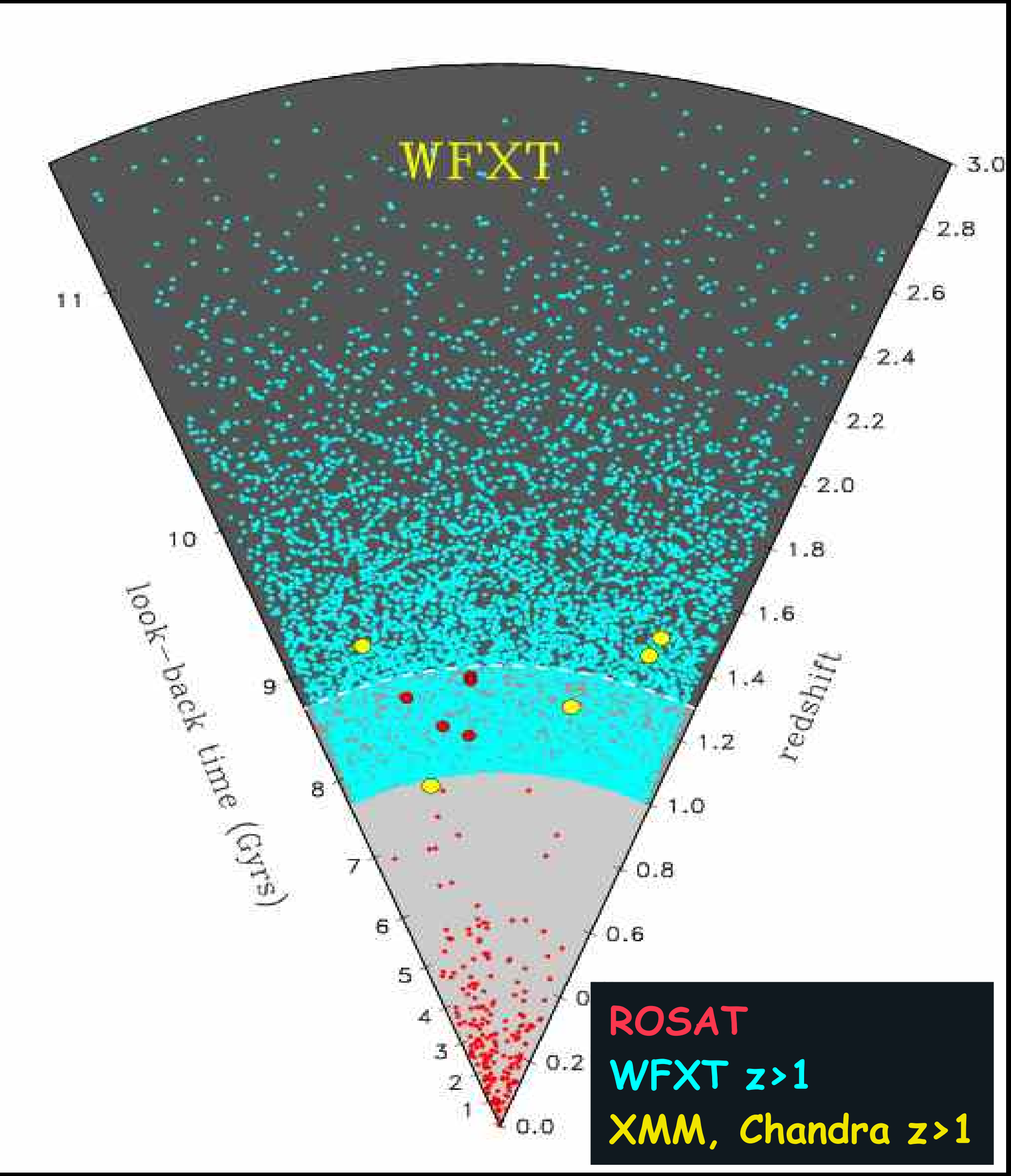

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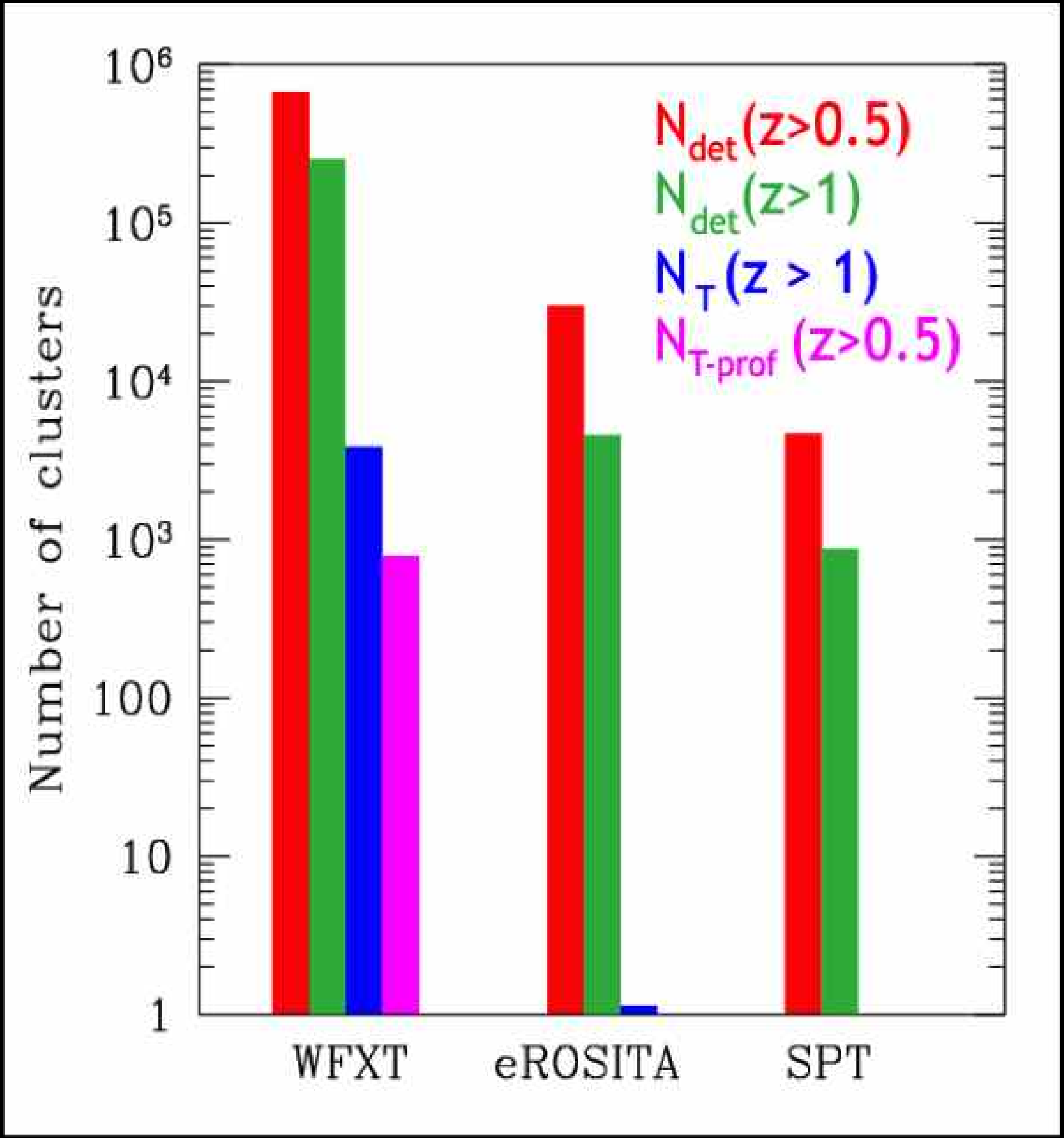
WFXT Cluster sample



Detection: 50-100 counts

T measurements: 1500 counts

T profiles: 15.000 counts

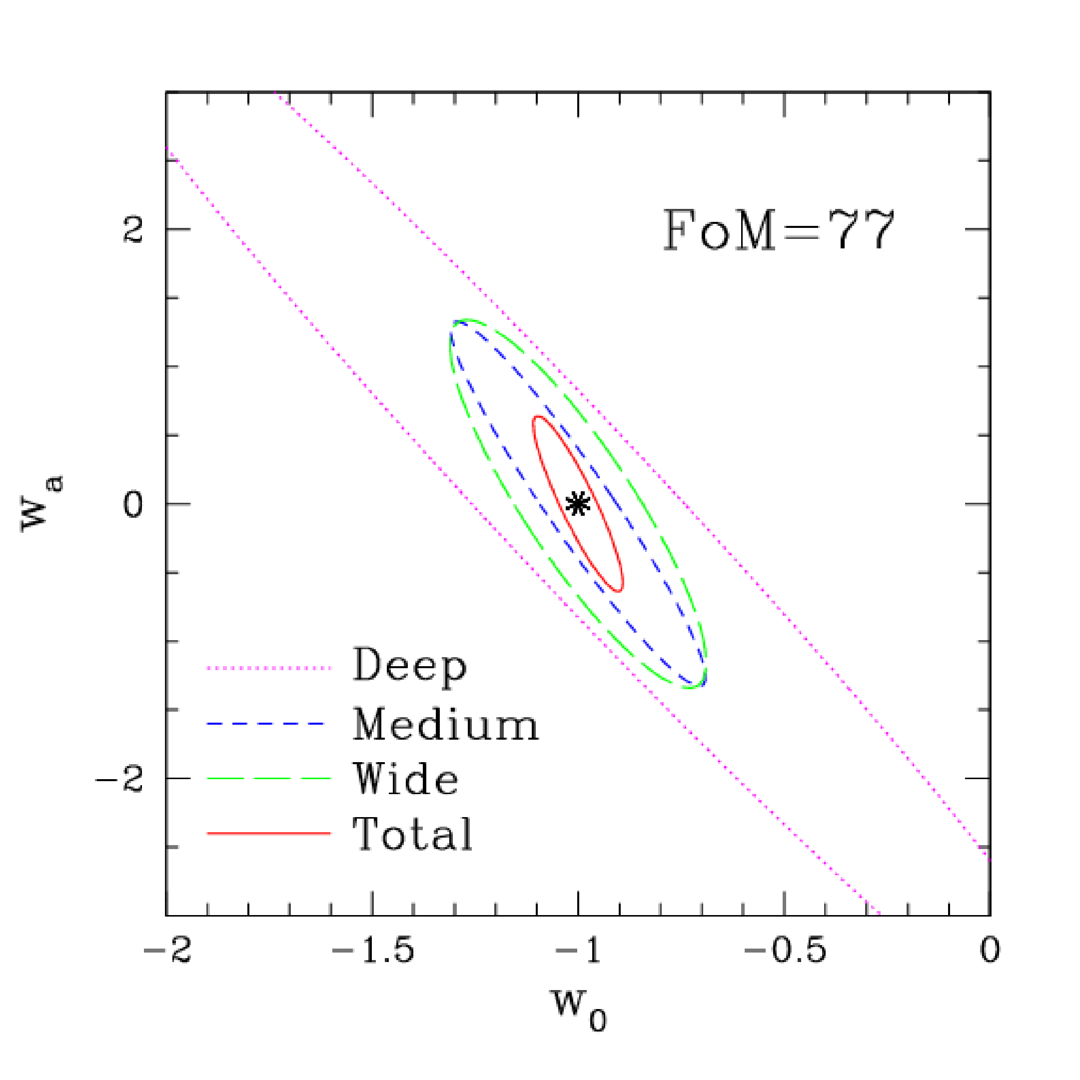
Temperatures critical to cluster cosmology

Profiles, cluster physics

Large samples allow study of systematics

WFXT can reach into early groups

Forecasts on DE constraints



- Use Planck prior;
- Flux limits for precise mass proxy (i.e. avoid self-calibration);
- Assume:

  $M_{bias} = (0.85 \pm 0.15)\, M_{true}$

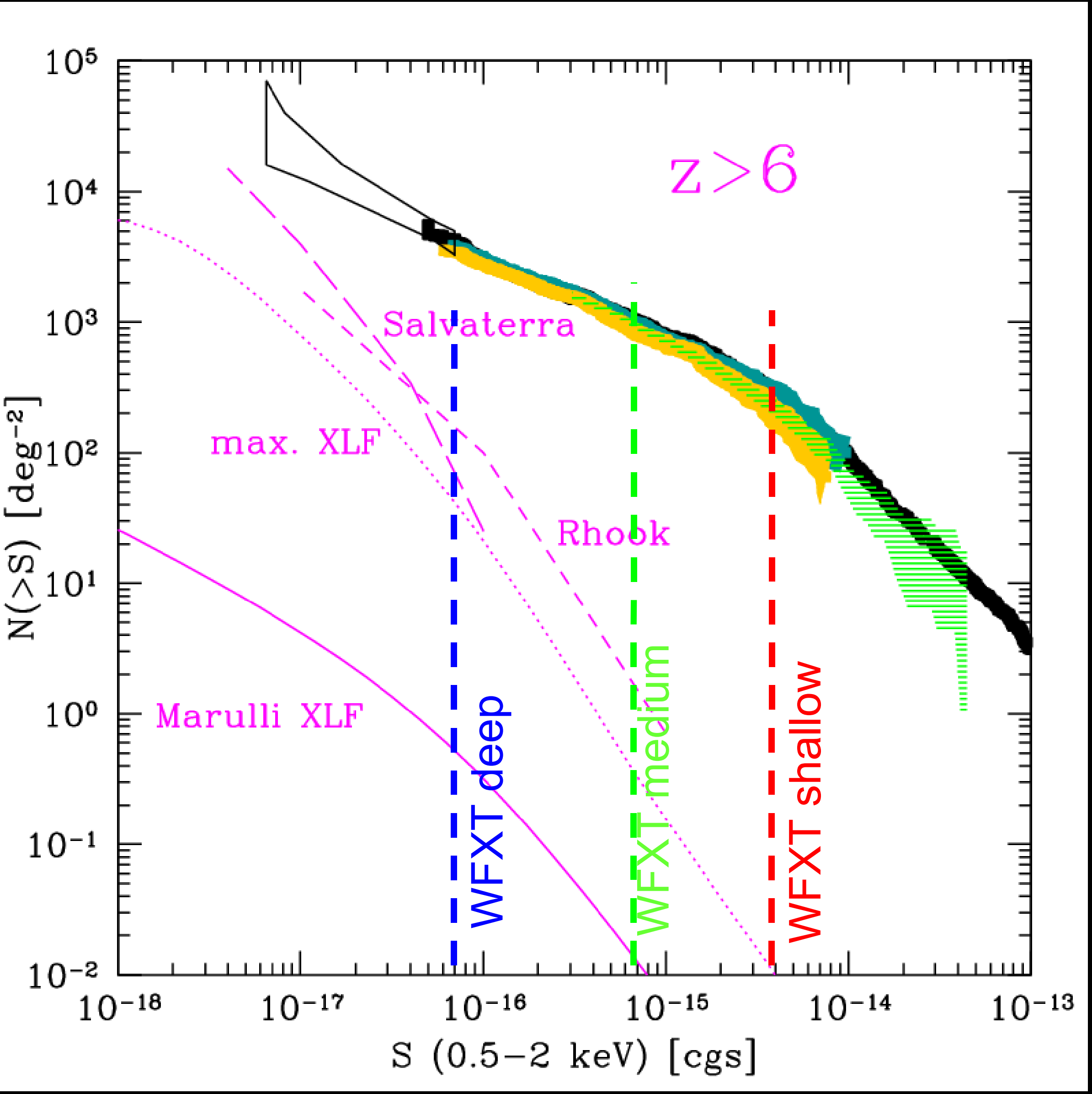
  $\sigma_{\ln M} = 0.35 \pm 0.20$
- DE eq. of state:

  $$w(a) = w_0 + w_a(1-a)$$

⇒ Most of constraining power from Wide & Medium surveys

Sartoris, et al. '09

The LogN-logS

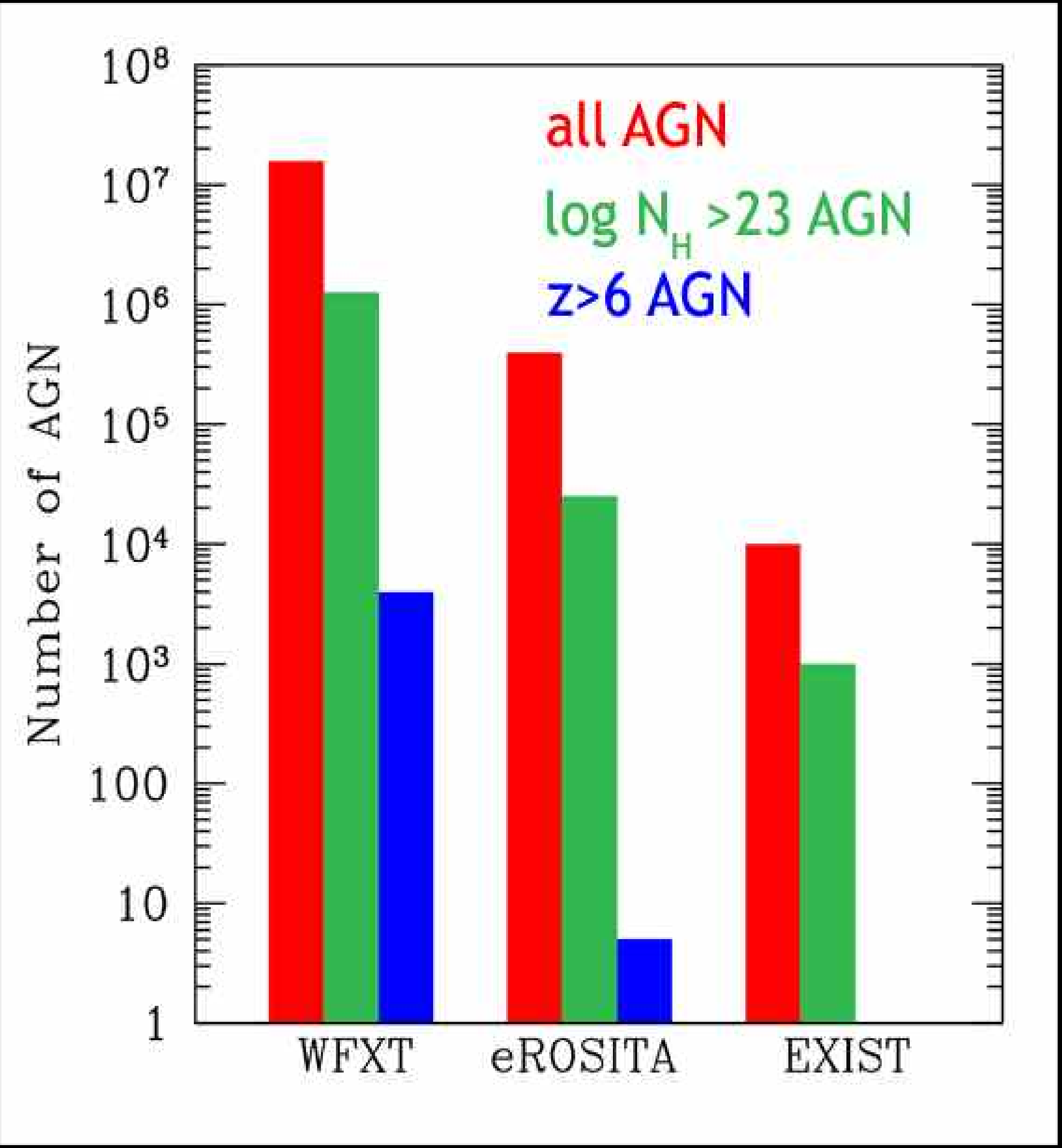


Very wild range of predictions for z>6 AGN:

Observations of significant samples at z>6 would constrain the physics of early BH formation disentangling between several scenarios e.g. providing info on mass of BH seeds, accretion mechanisms

How many WFXT will see?

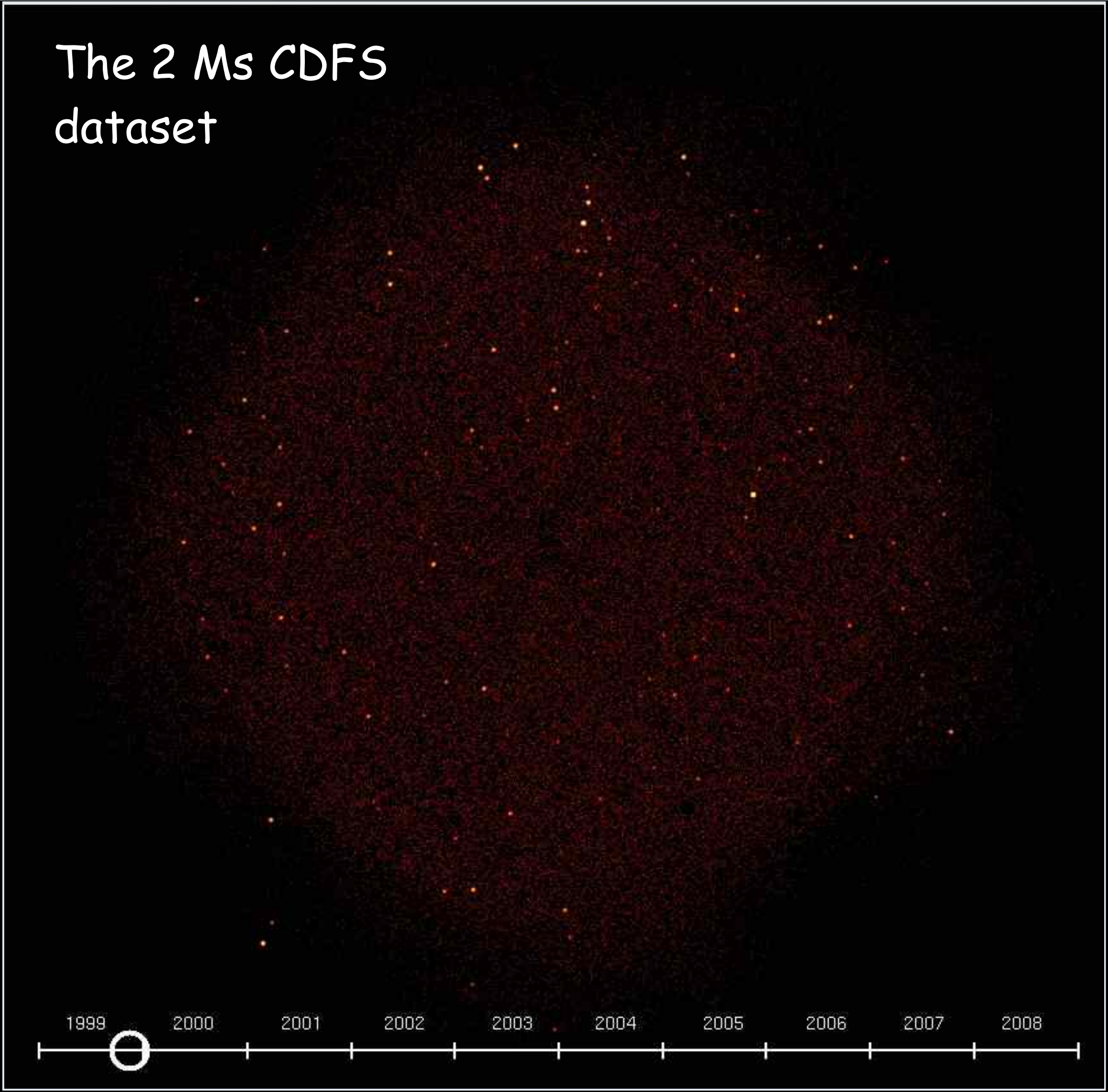
AGN and Galaxies



- *WFXT* will be an "X-ray *GALEX*",
- detecting > 10^7 AGN, > 10^5 galaxies
- –Luminosity function
- –Minimal bias
- –Environment and evolution

- Deep survey will reach CDF
- depths

AGN X-ray variability with WFXT



WFXT Deep survey: 400 ks per field, 100 sq.deg - will allow to sample homogeneously broad range of masses and timescales.

Assuming 30 cts per time bin:

30% fluctuations @2σ =>

typical in CDFS (Paolillo et al. 2004).

For 3 $\times 10^{-16}$ erg/s/cm^2 -> 2×10^5

on timescales of 40 ks, i.e. half day

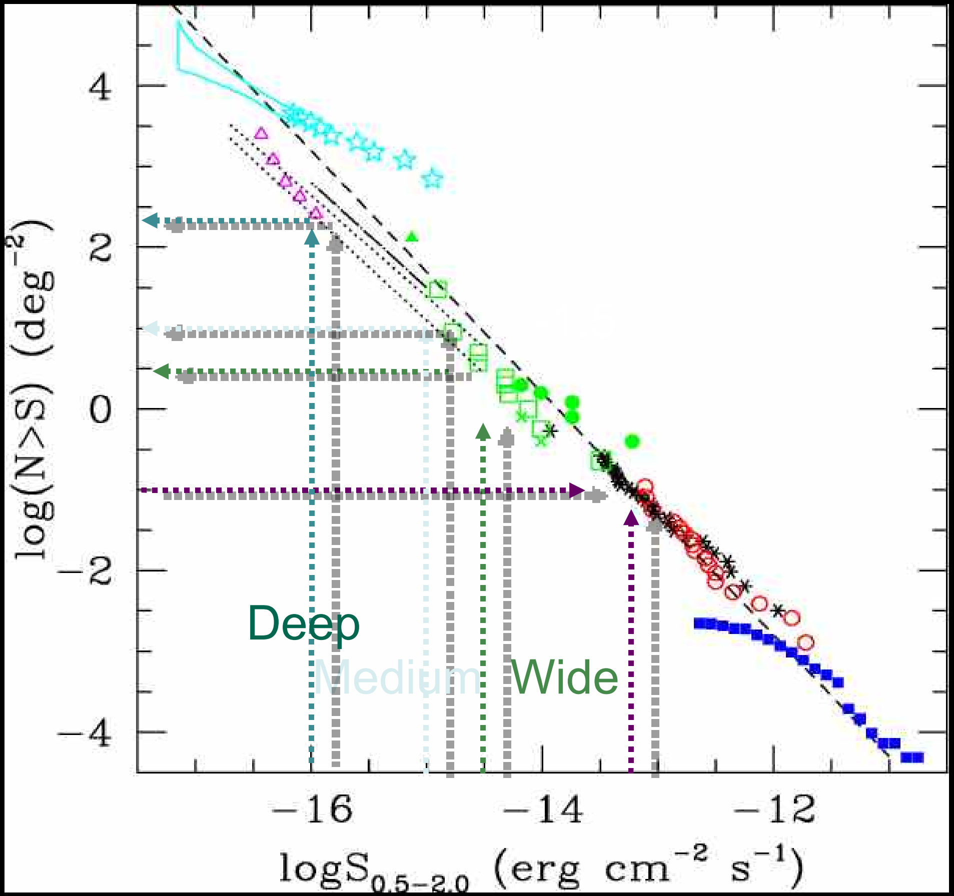
to months,

depending on sampling. Assuming 50%

efficiency on monthly scales it's still 10^5.

Galaxies with WFXT

Log-N Log-S for normal galaxies : Einstein-ROSAT-XMM-Chandra



WIDE: ~1.5/field = 30000 total
Ave mag ~ 16 (r-band)
Medium: ~10/field = 30000 total
Ave mag ~18 (r-band)
Deep: ~300/field = 30000 total
Ave mag ~ 20 (r-band)

BUT >2000 in WIDE (m<15)
for which :
Spatial: detailed morphology
Separation between
ISM – PS – AGN – IGM
Spectra: PL - plasma parameters

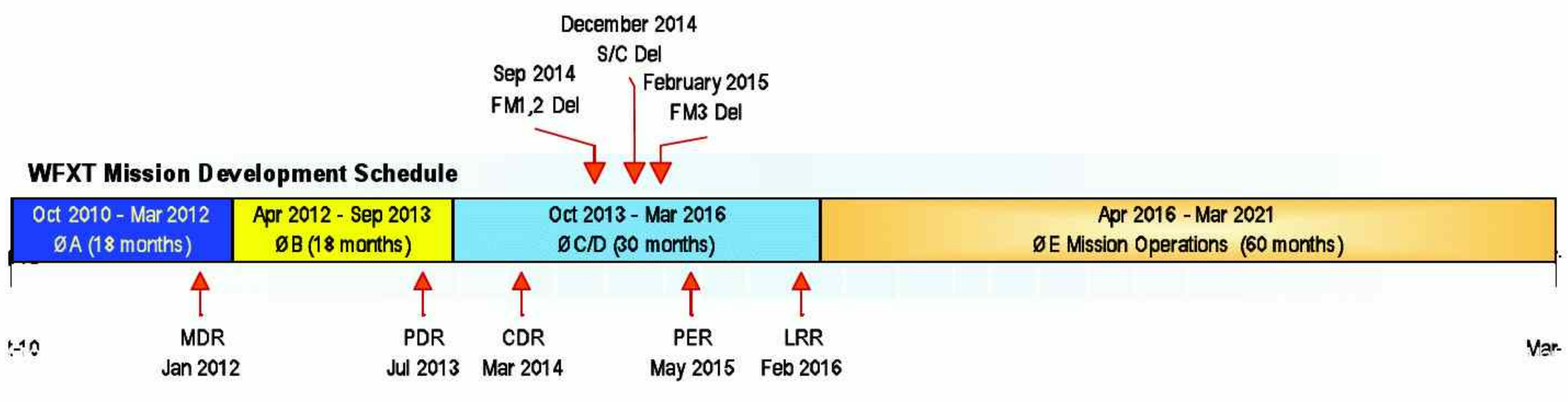
From Tajer, Trinchieri, Wolter, Campana, Moretti Tagliaferri 2005

Wide range of science

Halo stars
LMXB and HMXB population
SNR remnants
Obscured accretion at high-z
Source variability
Distribution of intrinsic absorption at different L
Evolution of Fe abundance in the ICM
Evolution of cool cores in clusters and feedback
Low SB regions in the outskirts of clusters
Solar System
...

Time schedule

Submitted to the Decadal Survey



Conclusions

Grasp and PSF are crucial to deliver an X-ray survey competitive with large area survey in other wavelength.

From these surveys, WFXT will generate a legacy dataset of ~> 5 x 10^5 clusters of galaxies to z~ 2, while characterizing the physics of the ICM form many of them, and a sample of > 10^7 AGN to z > 6, a substantial fraction with X-ray spectra sufficient to distinguish obscured from unobscured quasars. These surveys will address fundamental questions of how supermassive black holes grow and influence the evolution of the host galaxy and how clusters form and evolve, as well as providing large samples of massive clusters that can be used in cosmological studies. WFXT surveys will map systems that span many square degrees on the sky including star forming regions in the Galaxy, the Magellanic Clouds and the Virgo Cluster with unprecedented sensitivity. All WFXT data will become public through a series of annual Data Releases that will constitute a vast scientific legacy for decades. Immense legacy value and synergies future instruments: ALMA, JWST, EUCLID/JDEM, IXO, …