Wide-Field X-ray Surveys

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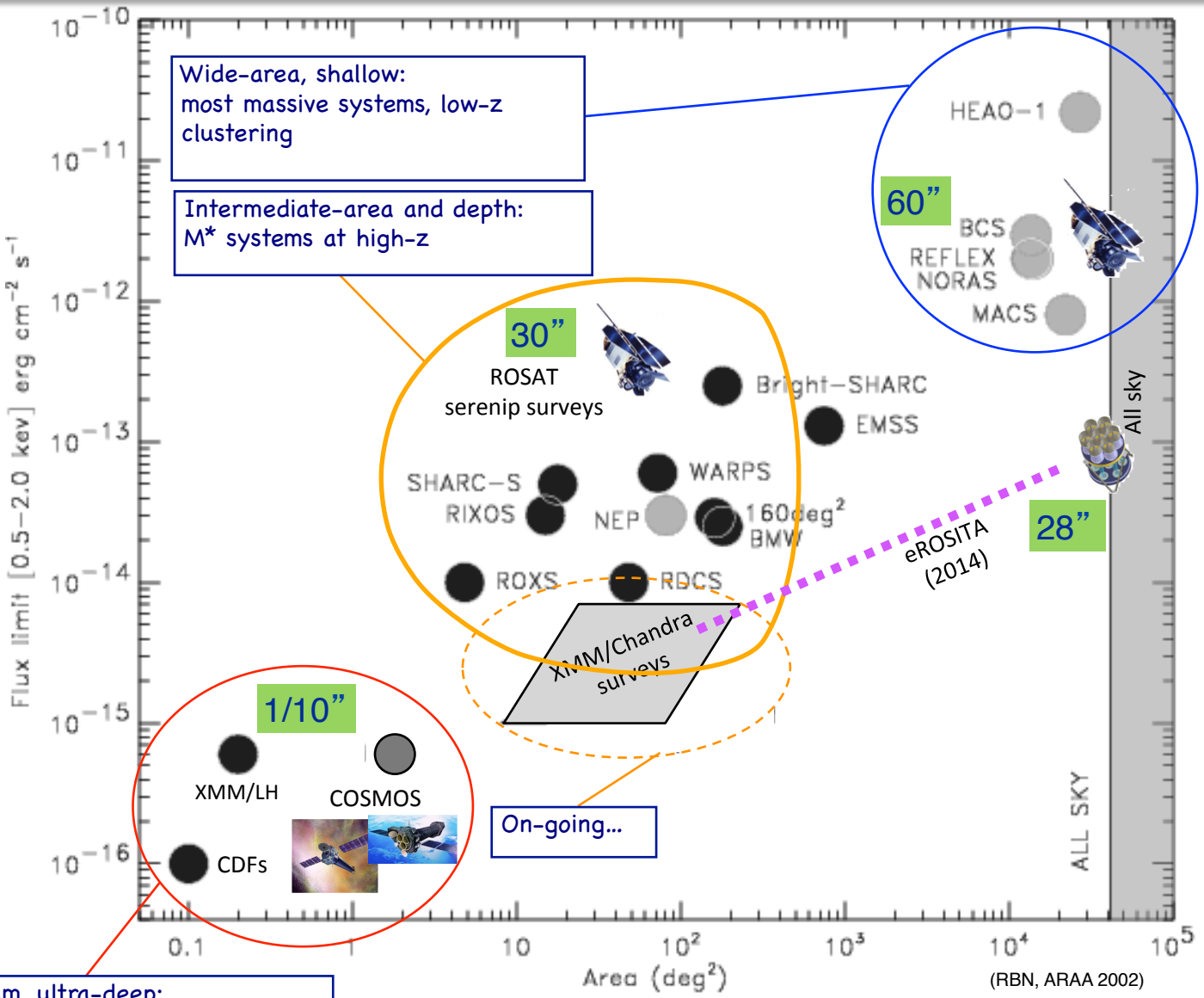
➔ Science cases: two examples
- Galaxy Clusters: cosmology
- Population of distant AGN (see talk by F. Fiore)

➔ Implementation with a Wide-Field X-ray Survey
- Cluster Cosmology
- Tracing the high-z accretion of SMBHs

➔ Synergies with multi-lambda surveys in the >2020 time-frame

X-ray Surveys as of Today



The Power of Surveys

➔ Address fundamental problems in astrophysics and cosmology: SDSS-I to IV, Euclid, Gaia

➔ Lessons learned from the *SDSS*:

- Colors and spectra: it's not just counting sources...
- Prodigious high impact publication record: one SDSS paper a day on arXiv!
- Easy access to homogenous data products unthought science cases

➔ Large number statistics:

- Allows multiple binning across source properties
- Characterization of selection effects, etc.

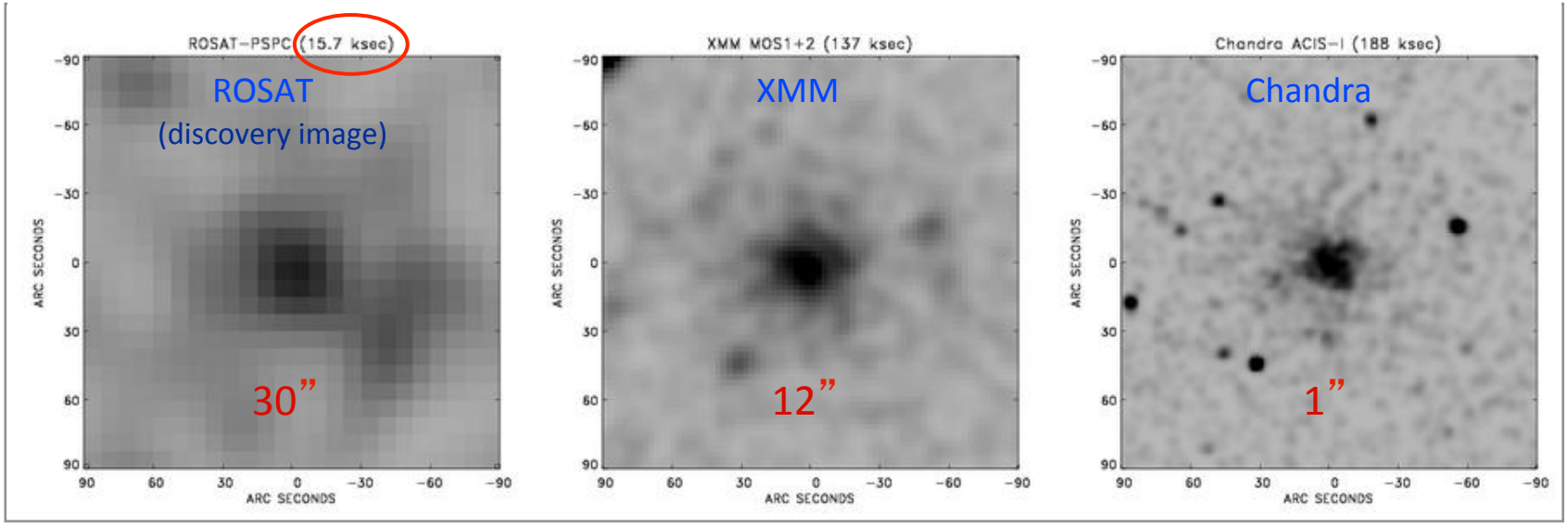
➔ Vast legacy value (and bargaining power), which is greatly enhanced by multi-λ synergy

Cluster Surveys as of 2012

➔ Tremendous progress in sensitivity and angular resolution...

Massive ($6\times10^{14}M_{\odot}$) cluster at z=1.24

(RDCS1252, Rosati et al. 04)



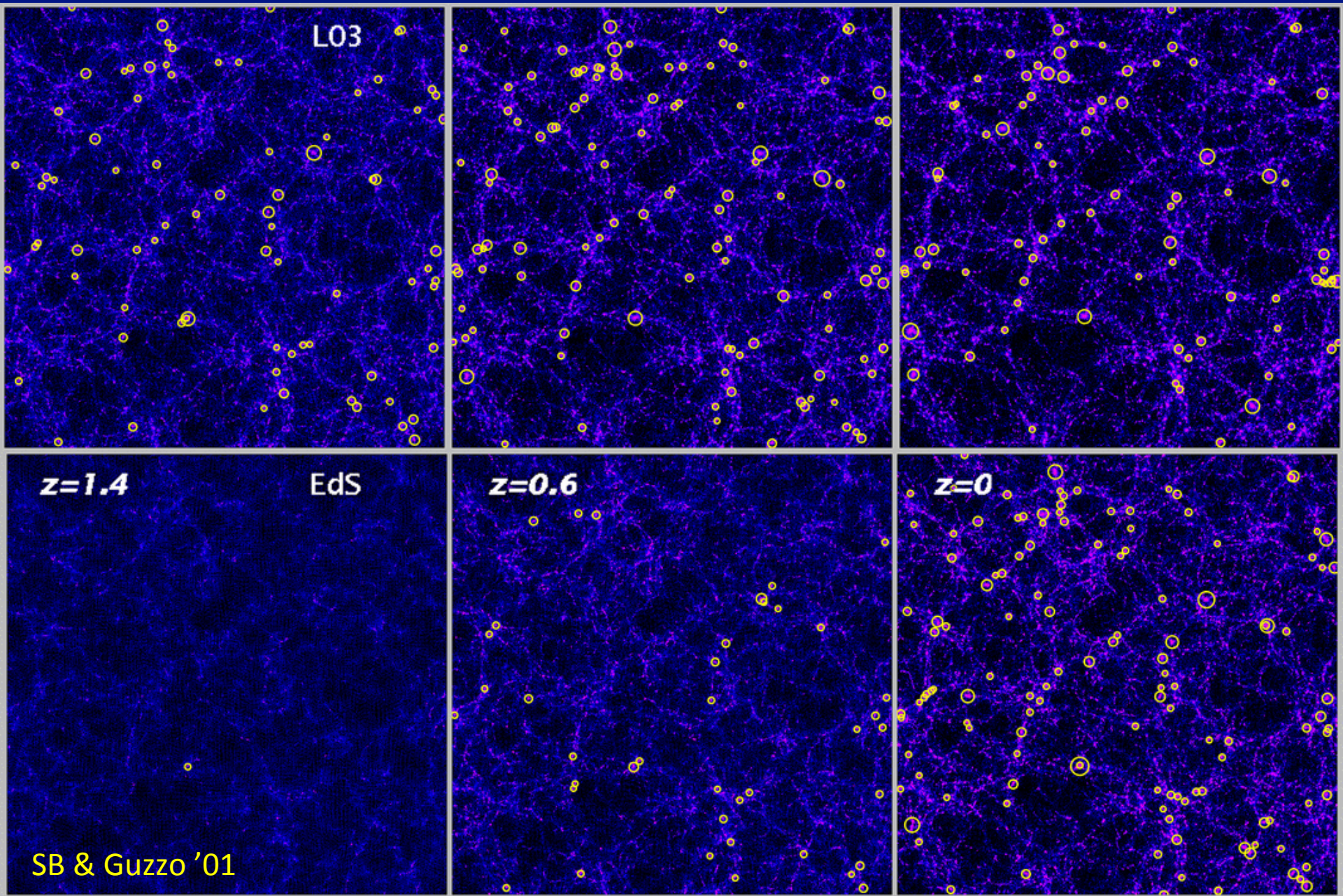
➔ Little progress in survey area (*grasp*) over the years: $FoM = A \cdot \Omega \cdot T \cdot (PSF)^{-2}$

➔ Lack of an X-ray mission with wide-field optimized optics

➔ eROSITA survey will be a significant step forward (~30” resolution, z<~1.2)

➔ **Motivation for a *Wide Field X-ray Telescope* mission** (FoM 10^2 x higher)

Galaxy Clusters as Tracers of Cosmic Growth



Cosmological information from a cluster survey

$$\frac{dN(X;z)}{dXdz} = \frac{dn(M,z)}{dM}\frac{dM}{dX}(z)\frac{dV}{dz}$$

➔ No. of clusters of given observable X and redshift z within the survey area

$$P_{cl}(k;M,z) = b_{cl}^2(k;m,z)P_m(k,z)$$

➔Distribution of clusters of given mass

1. Friedmann background: $\frac{dV}{dz}(\Omega_i)$

➔ Priors on cosmoloical parameters Ωi from CMB, SnIa, $f_{bar}(z)$, ….

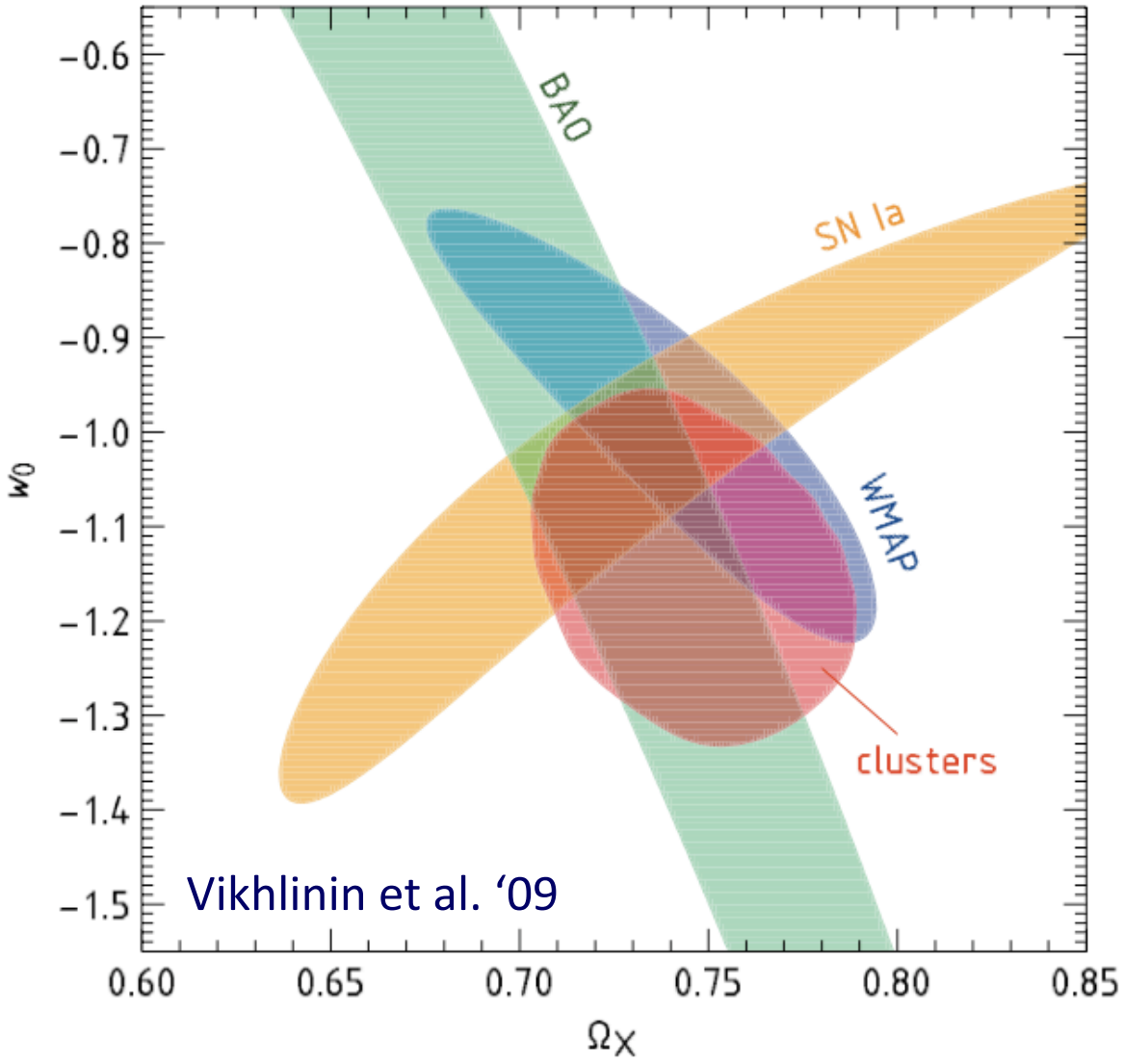
2. Growth history and nature of perturbations: $\frac{dn(M,z;\Omega_i)}{dM}$ $P_{cl}(k;M,z;\Omega_i)$

➔ Precisely calibrated with N-body simulations

3. Astrophysics: $\frac{dM}{dX}(z;p_j)$

➔ Priors on “nuisance parameters” pj from follow-up observations and/or cosmological simulations

Current Constraints from Clusters

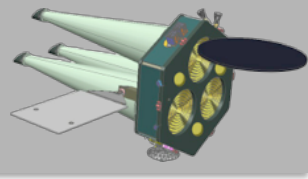


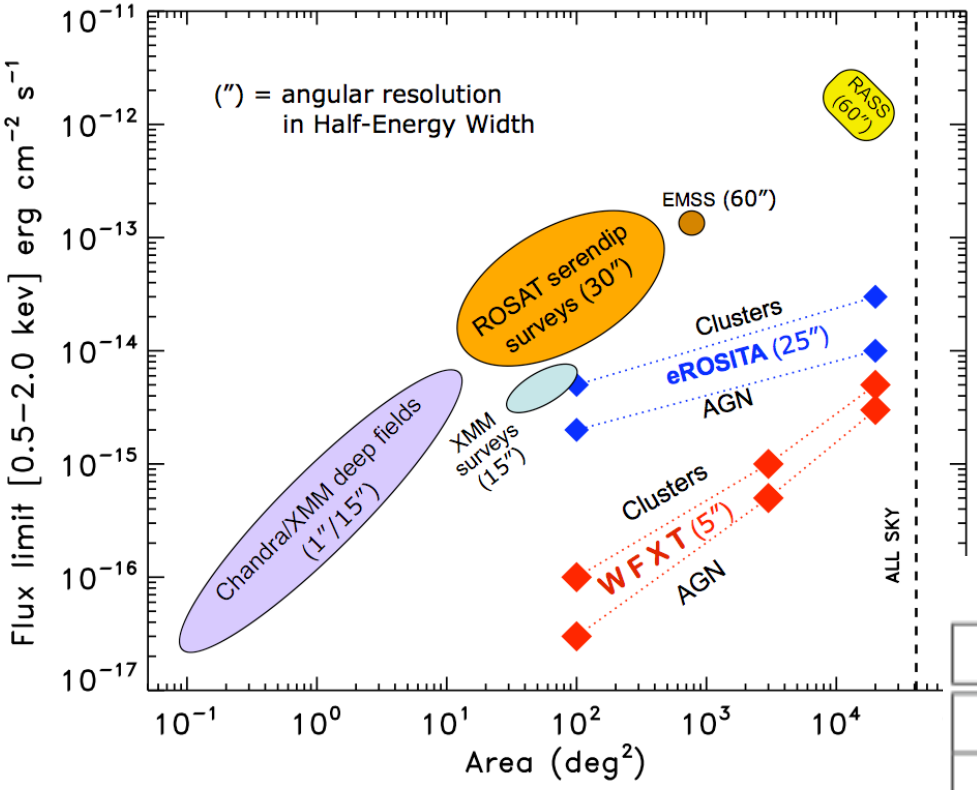
➔ Current constraints:
~100 ROSAT clusters at <z>~0.5 followed-up **with Chandra** (e.g. Vikhlinin et al. 09, Rapetti et al. 12)

The Wide-Field X-ray Telescope

http://www.wfxt.eu

The Wide Field X-ray Telescope





See Giovanni's Talk

Giacconi et al. arXiv:0902.4857

SB et al. arXiv:1010.6213

Rosati et al. arXiv:1010.6252

Conconi et al. 2010, MN, 405, 877

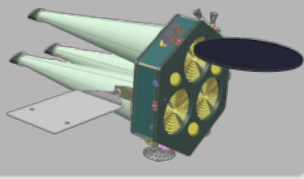
RFI Whitepaper submitted to the Decadal Survey:

Murray et al.: Wide Field X-Ray Telescope Mission

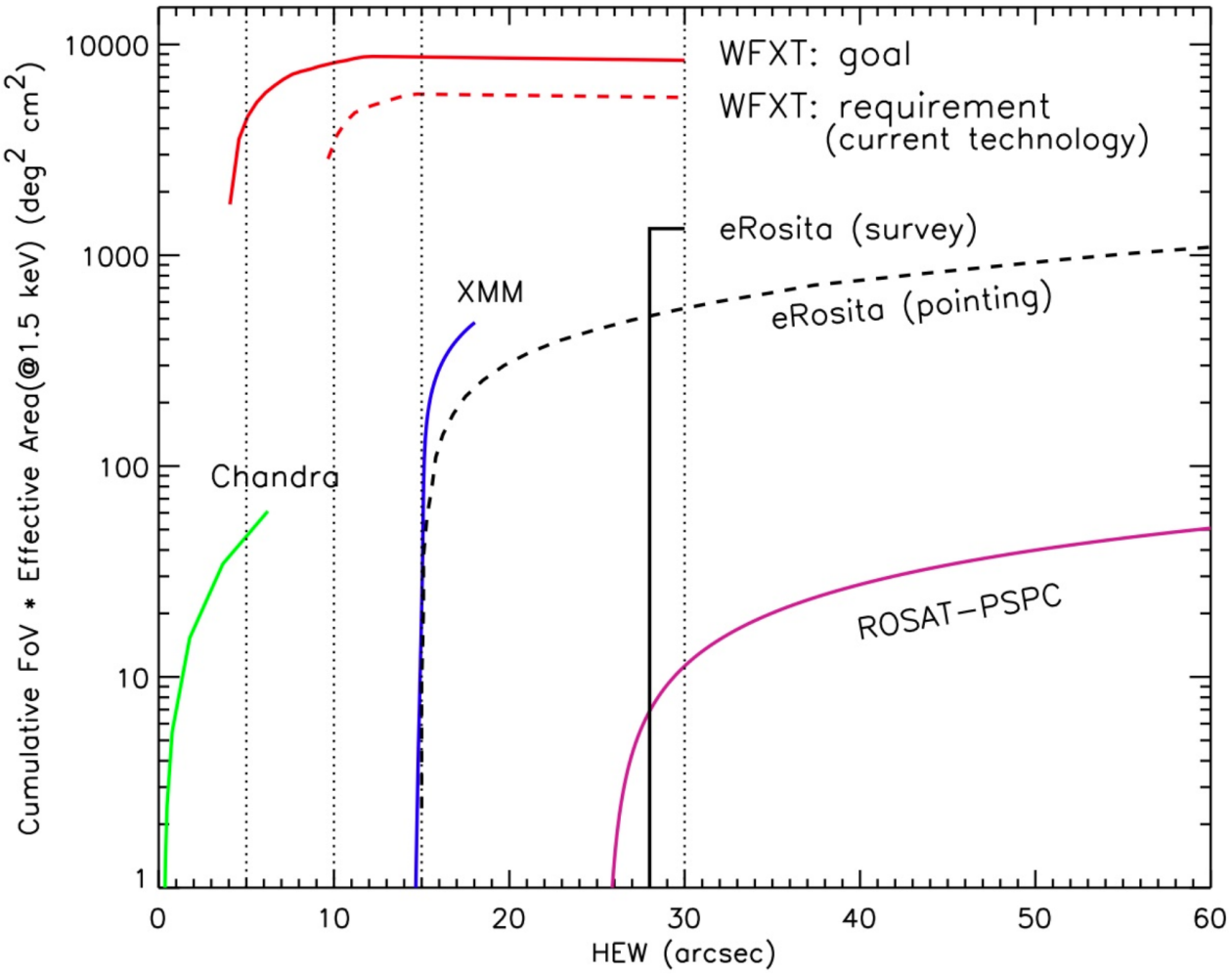
Table 1: WFXT Mission Performance Requirements

Parameter	Requirement	Goal
Area (1 keV)	$6,000\,cm^2$	$10,000\,cm^2$
Area (4 keV)	$2,000\,cm^2$	$3,000\,cm^2$
Field of View	1^o diameter	1.25^o diameter
Angular Resolution	$< 10''$ HEW	$\leq 5''$ HEW
Energy Band	0.2 - 4 keV	0.1 - 6 keV
Energy Resolution	$\frac{E}{\Delta E} > 10$	$\frac{E}{\Delta E} > 20$
Time Resolution	$<$ 3 seconds	$<$ 1 second

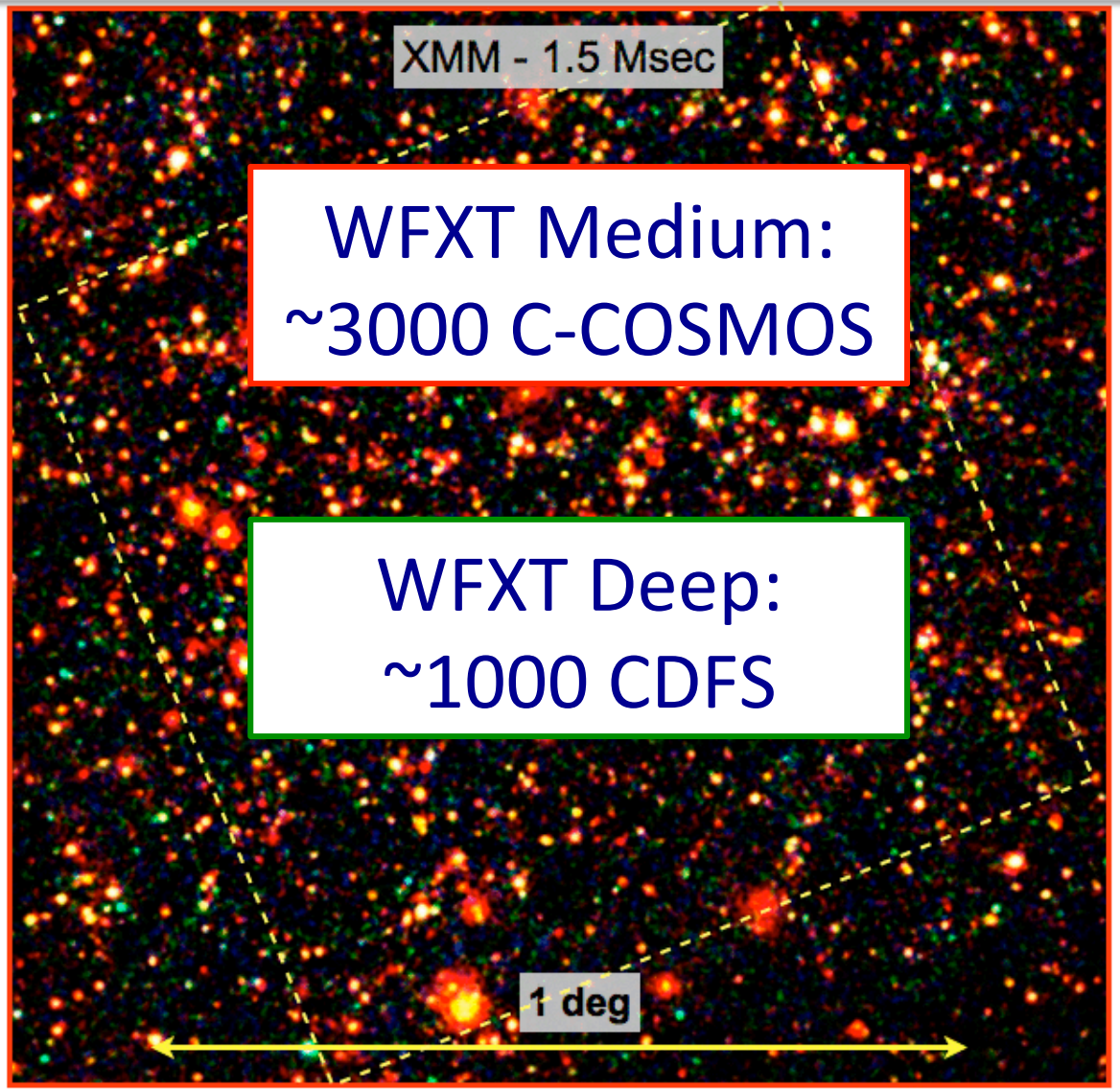
Survey Speed of WFXT



A unique combination of FoV, collecting area and PSF

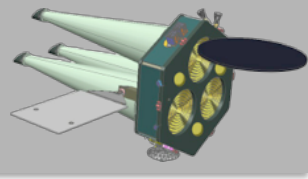


COSMOS Field with WFXT



The WFXT Cluster Survey

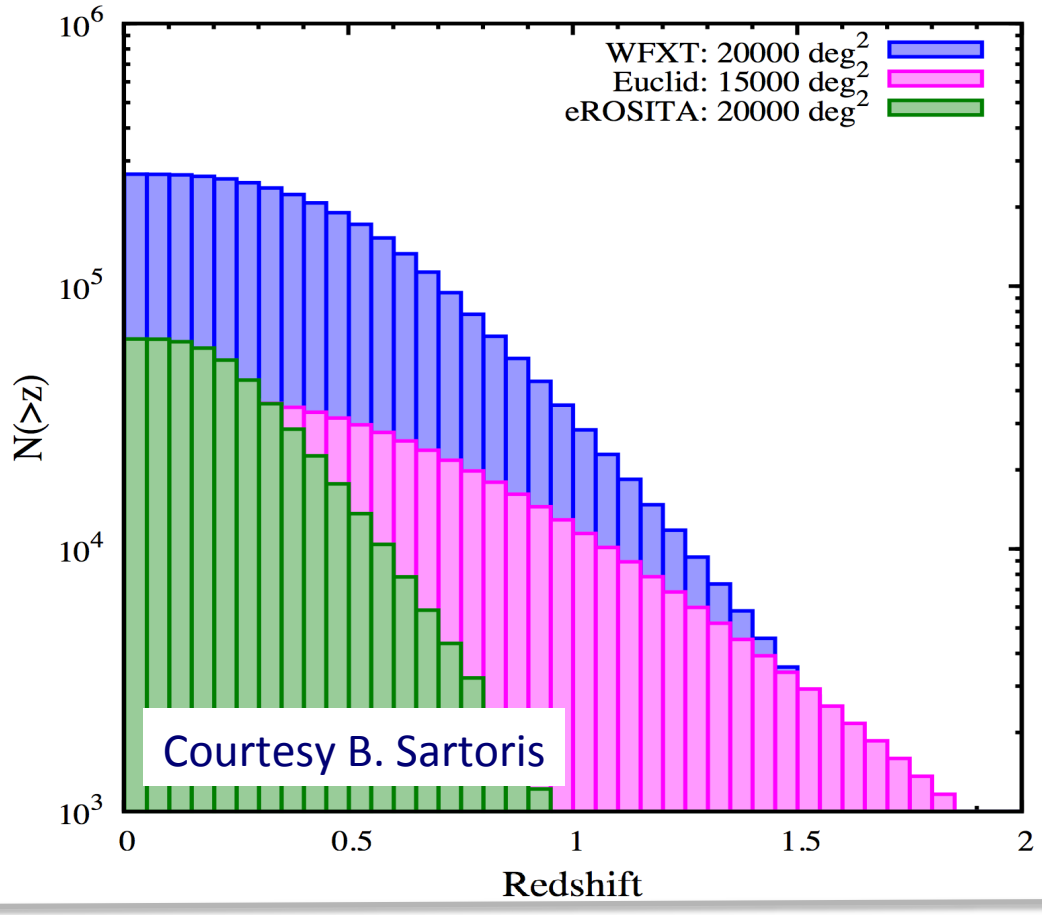
The Wide Field
X-ray Telescope



Detection: 50-100 counts
T_X measurements: 1500 counts
T_X profiles: 15.000 counts

eROSITA improves wrt RASS

WFXT opens a new discovery space!

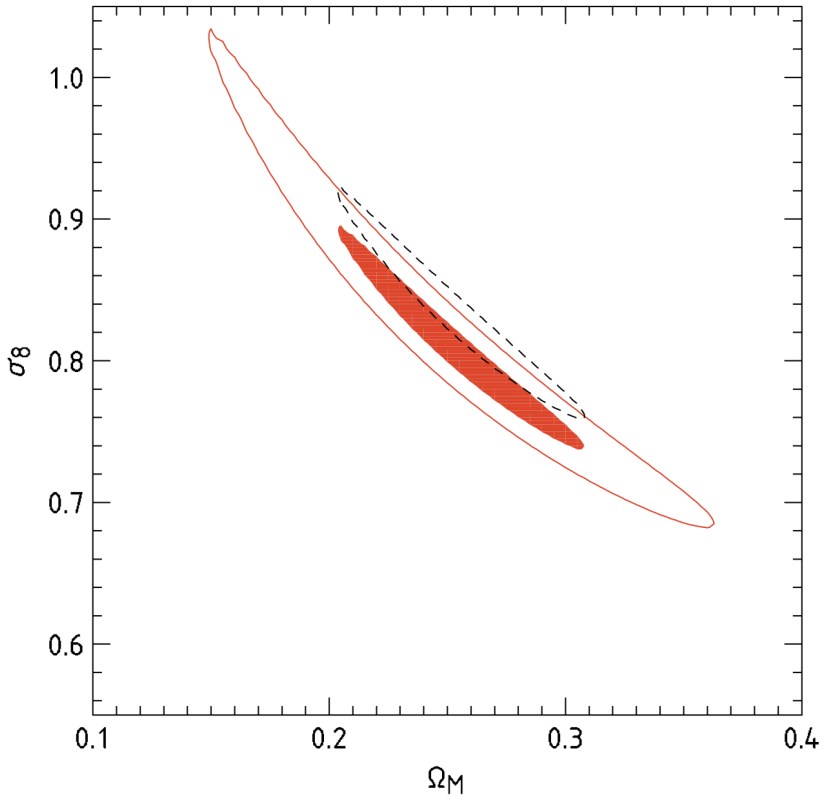


Not just a cluster-counting machine:

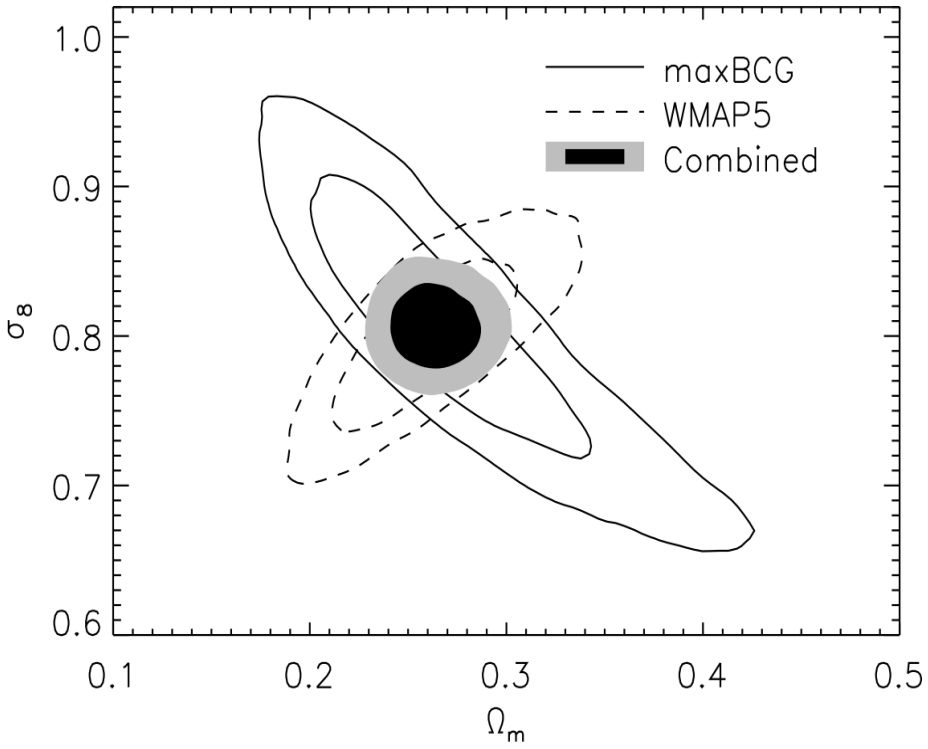
- Measure mass proxies and redshifts for >2x10^4 clusters from X-ray spectra.
- Characterize ICM properties for thousands of clusters at z>1.
- Ideal match to optical/near-IR surveys in the >2020 time frame

Cluster cosmology: why in X-rays?

Vikhlinin+09:
~100 X-ray clusters

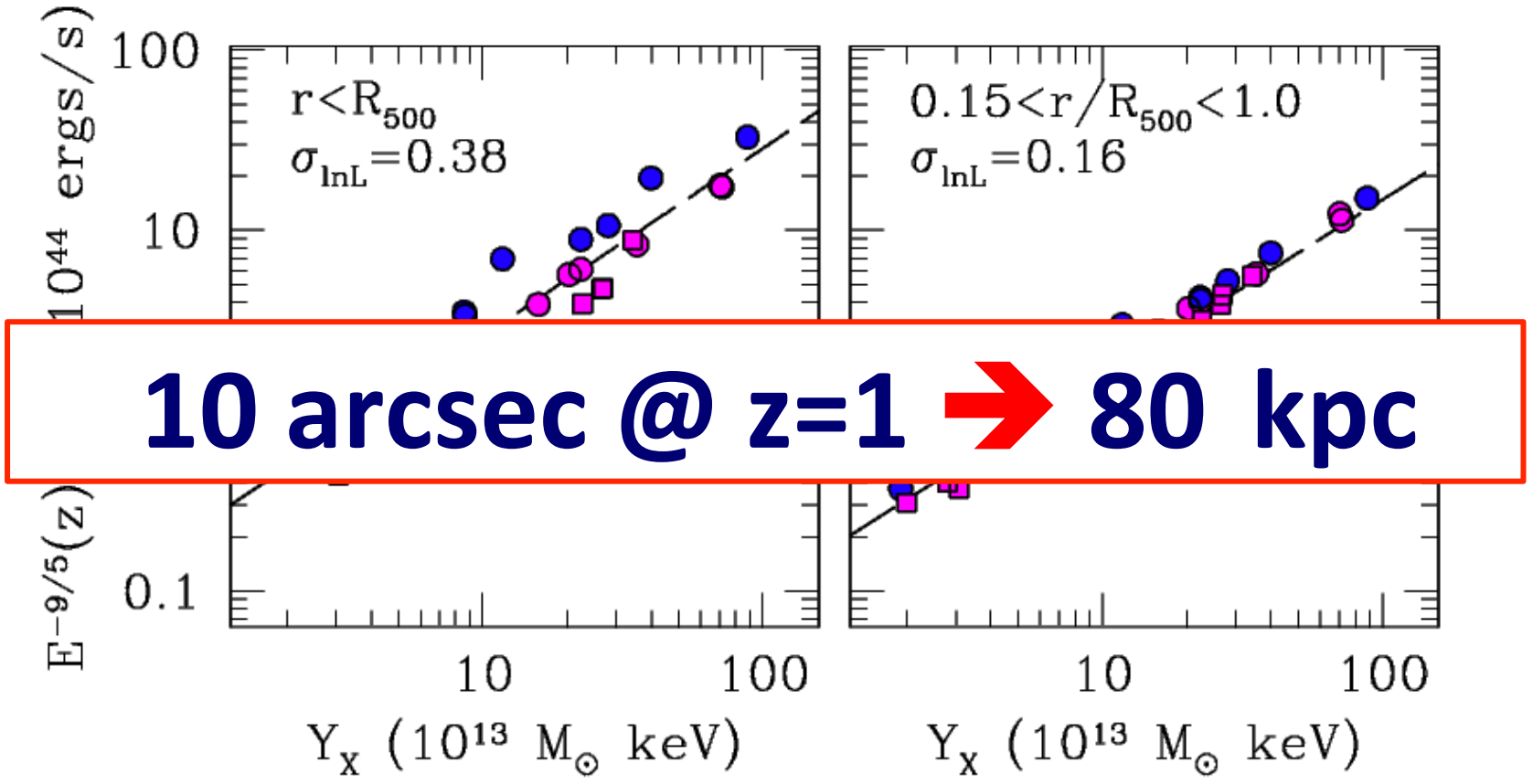


Rozo+09:
~10^4 SDSS MaxBCG clusters



Why 5 arcsec?

Data from Pratt et al. '09: representative sample of 31 nearby clusters observed with XMM



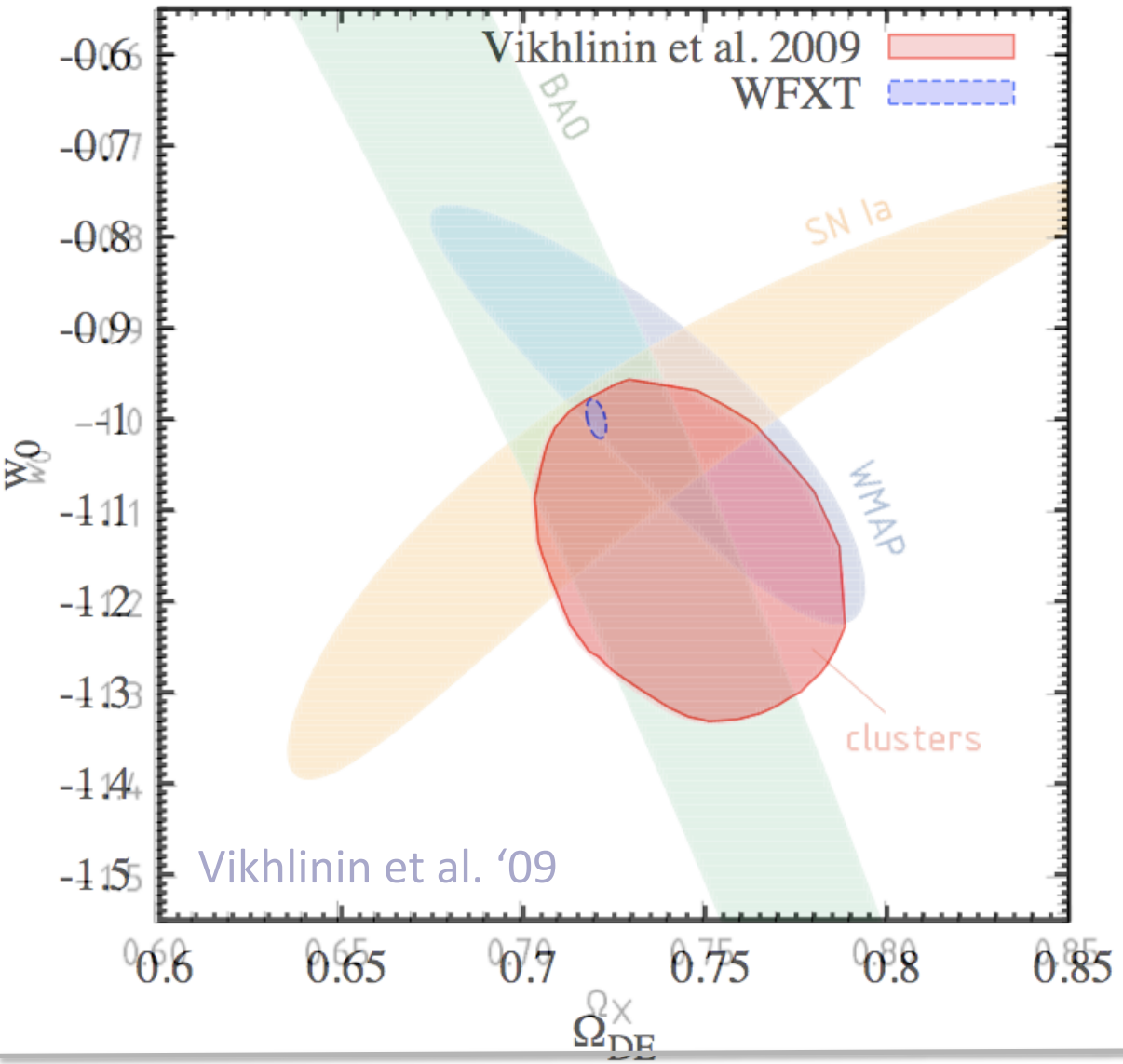
10 arcsec @ z=1 → 80 kpc

Excising cores → Decrease of scatter by factor >2

→ No diversity between CC and NCC clusters

Expectation for Cosmology

The Wide Field
X-ray Telescope



➔ Current constraints: ~100 ROSAT clusters at <z>~0.5 followed-up with Chandra (e.g. Vikhlinin et al. 09, Rapetti et al. 12)

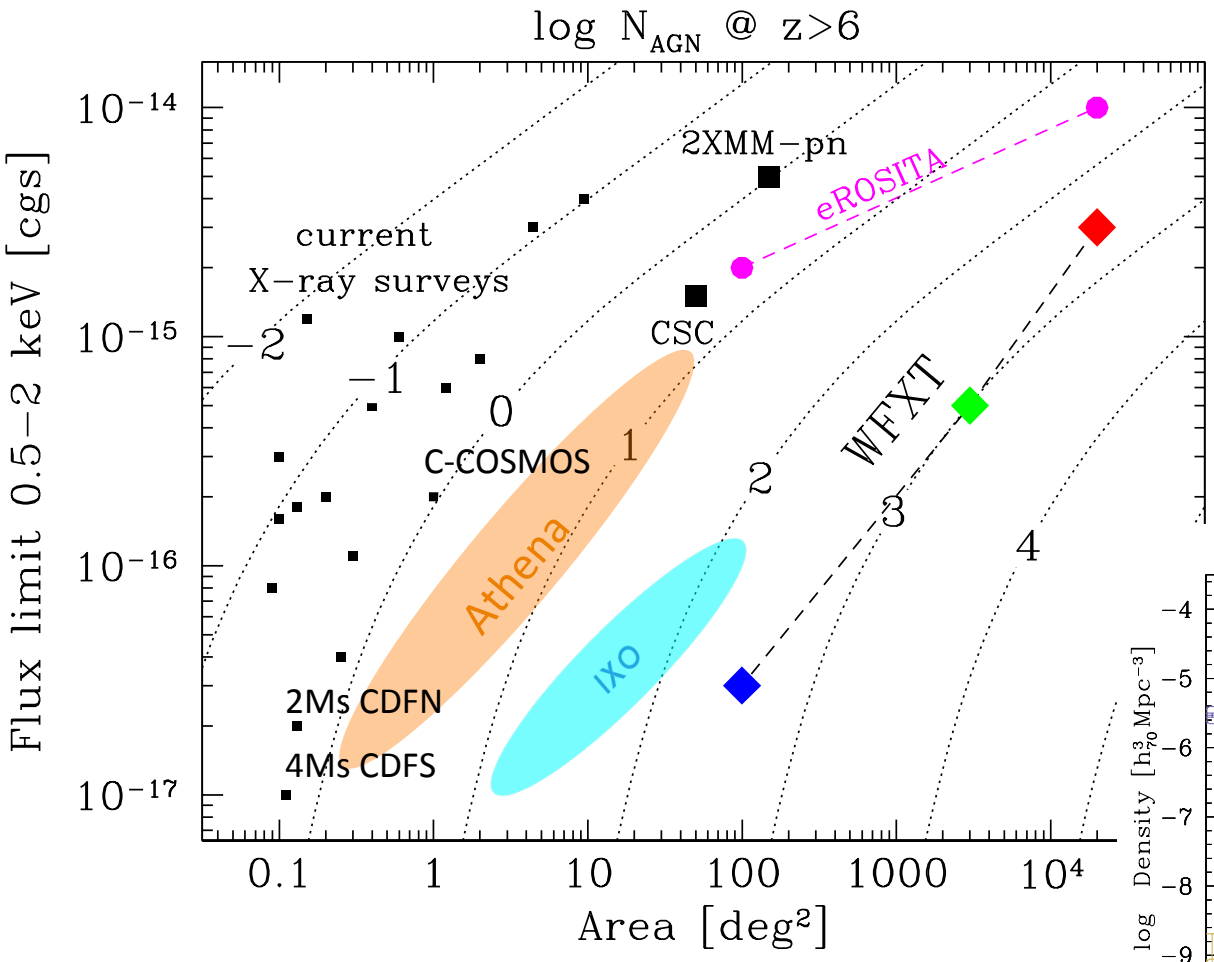
➔ WFXT: ~2×10^4 clusters expected to be observed with quality comparable to Chandra observations

- Also including clustering infos

Sartoris+12

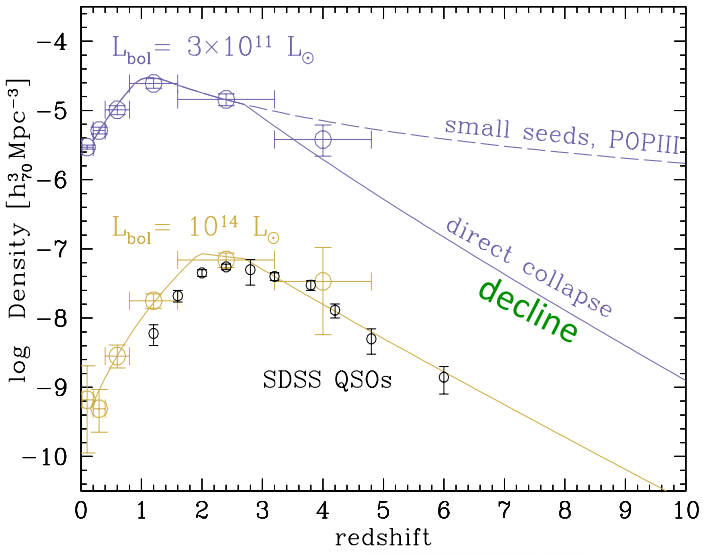
X-ray detection of high-z AGN

The Wide Field X-ray Telescope



➔4-yr eROSITA: ~40 QSOs at z>6, mostly SDSS-like

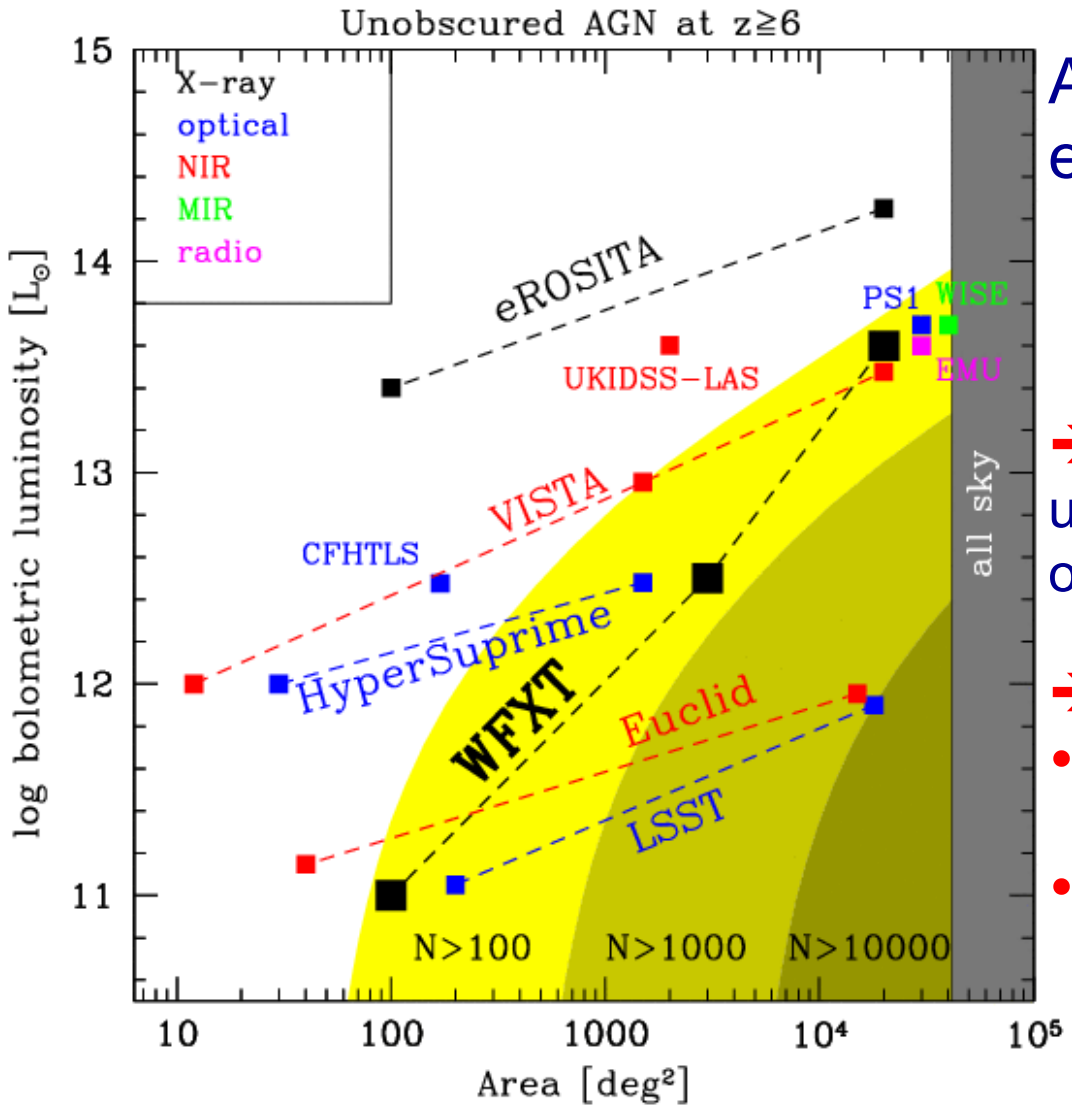
➔5-yr WFXT: >10^3 QSOs at z>6, >10 times fainter



Dotted lines:
Log (No. of AGN at z>6 expected with "decline")

Unveiling AGN population at z>6

The Wide Field
X-ray Telescope



Assume AGN population to exponentially decline at z>3

WFXT goal design

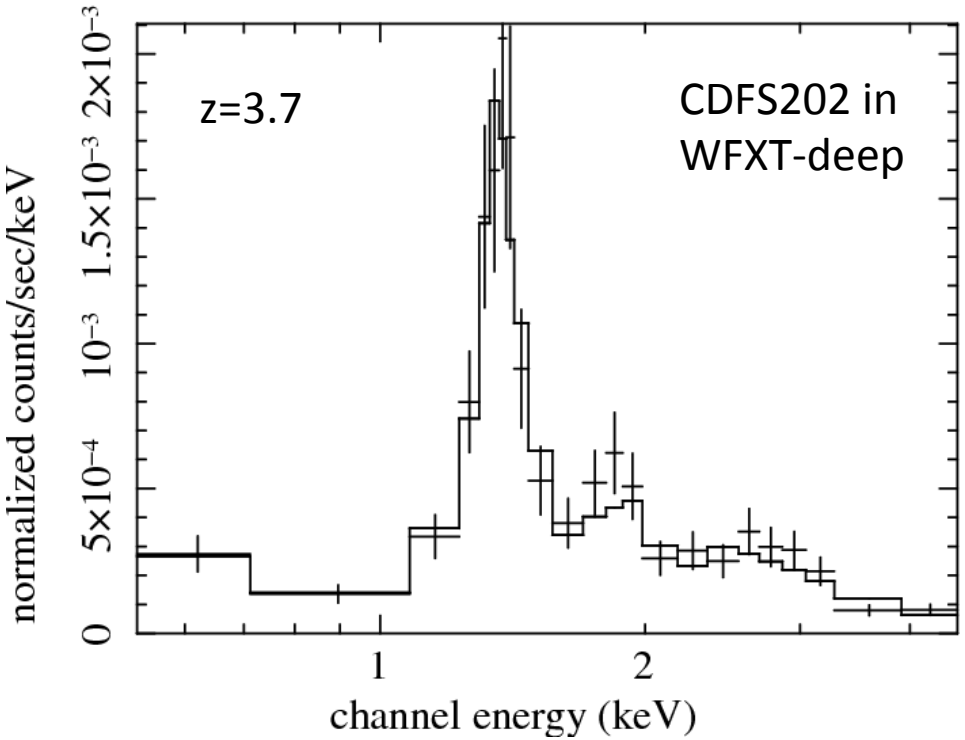
➔WFXT detects close to 900 unobscured z>6 QSOs and ~700 obscured

➔Synergistic:

- Euclid and LSST identify the WFXT sources;
- WFXT picks out the AGN (especially high-z, obscured)

Distant C-thick AGN

F(2-10) = 3 10^{-15} cgs, ~500 cts > 0.5 keV
Err. on Line EW ~ 1 keV : ~ 30%
Err. on line centroid: ~ 2%



N_H and redshift directly from Fe line
(see also Iwasawa+12)

z >	N thick
1	500
2	270
3	60
4	12

➔ Much improved statistics of C-thick AGN
➔ Far better characterization of the contribution to the XRB

What else with a wide-field survey?

1. History of entropy and metal injection in the ICM
2. Protoclusters & ICM at z>2: epoch when SF and SMBH accretion peak
3. Outskirts of galaxy clusters
4. Evolution of cool-cores beyond z~1 (ask P. Tozzi)
5. Variability: can perform better than dedicated missions (ask M. Paolillo)
6. Large- and small-scale AGN clustering (ask R. Gilli)
7. Recent star formation rate in the solar neighborhood
8. Hot interstellar medium in galactic star forming regions and in nearby galaxies.
9. Luminosity function of normal/starburst galaxies
10. .....

So, why a wide-area X-ray survey >2020?

➔ Potential of cluster cosmology won't be exploited by eROSITA, Euclid and next-gen SZ telescopes

➔ Need the combination of large area and high sensitivity to unveil the process of SMBH accretion at z>6

➔ Multi-λ synergies with future surveys/observatories:
Euclid, SKA, "Athena", CCAT, SPT-3G, ...

➔ A vast scientific legacy for decades:

- SDSS: prodigious high impact publication record
- RASS: still digging into it after >20 years!
- Unthought science cases

➔ Beneficial for a much wider (Italian) community than "just" the X-ray one!

R. Giacconi:
"*Surveys are not limited by imagination but only by Nature*"