

The XMM-COSMOS survey results and perspectives

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The XMM-COSMOS survey: AGN in the COSMIC web

"study the <u>evolution of (obscured) Active Galactic Nuclei</u> over the cosmic time and the dependence of black hole growth on galaxy morphology and environment"

(Hard) X-ray selection

Large, contiguous area

High resolution Optical/mw date Massive Redshift campaigns

Quoted from the proposals:

- 1) Study/investigate cosmic variance [large area]
- 2) AGN in the cosmic web [large area, redshifts]
- Provide the first, large sample of z>3 QSO [large area, redshifts, multiwave]

Cosmos Survey 2 deg² (PI: N. Scoville)



AO3: 800 ks of XMM [25x32 ks pointings]

AO4: 600 ks of XMM (Total = 1.4 Ms) → ~50 ks average exposure ~2000 sources detected

XMM-Newton PI: G. Hasinger

C-COSMOS 1.8 Ms 1.8 Elvis) (PT M. Elvis)

> **Soft 0.5-2.0 keV** medium 2.0-4.5 keV hard 4.5-10.0 keV



"Technical" points

XMM Observations: tiling



Why 1.4 Ms?

Average 50 ks exposure transition between source and background limited detection + not confusion limited

Homogeneous exposure map → homogeneous limiting flux

→Mosaic of 25 pointings, closely spaced, repeated twice

2 pointings lost due to high background flaring → requested and approved in AO6 (PI: Nico Cappelluti)

Data just arrived.. Coverage completed!!!

Courtesy: N. Cappeluti



Simulated image

Real image

Optical identification of AGN

optically faint (I>24) → difficult to identify using optical bands only [see also Alexander et al. 2001, Mignoli et al. 2004, Mainieri et al. 2005 + others] → most interesting sources candidate high-z QSO2

NEED a complete, deep, multiwavelength coverage



Scientific results

XMM-COSMOS ApJS COSMOS special issue papers

□ Hasinger G. et al. 2007 (astro-ph/0612311)

The XMM-Newton wide-field survey in the COSMOS field (XMM-COSMOS)

- I. Survey Description
- Cappelluti N. et al. 2007 (astro-ph/0701196)
- XMM-COSMOS: II. X-ray data and the logNlogS
- Brusa M. et al. 2007 (astro-ph/0612358) XMM-COSMOS: III. Optical identifications and multiwavelength properties of AGN
- □ Mainieri V. et al. 2007 (astro-ph/0612361)
- XMM-COSMOS: IV. X-ray spectral analysis of AGN
- Miyaji T. et al. 2007 (astro-ph/0612369)
 XMM-COSMOS: V. Angular Correlation Function of X-ray point sources
- Finoguenov A. et al. 2007 (astro-ph/0612360)
 XMM-COSMOS: VI. Statistical properties of cluster of galaxies
- to appear in an ApJS special issue (2007) http://www.mpe.mpg.de/XMMCosmos/PAPERS/

1) logN-logS and cosmic variance studies 5-10 keV logN-logS



→5-10 keV [250 sources]

In between previous determinations in the flux range 8×10^{-15} - 5×10^{-12} cgs and in excellent agreement with models predictions

Cappelluti et al., 2007, COSMOS special issue ApJS Models by Gilli, Comastri, Hasinger 2007

Cosmic Variance

Large area \rightarrow investigate the relative contribution of LSS and Poissonian noise to source counts fluctuations

using:
$$\sigma_{cl}/\sigma_p \propto \mathcal{N}^{0.5} \theta_0^{(\gamma-1)/2} a^{(3-\gamma)/2}$$

parameters from ACF (Miyaji et al. 2007)

Summary of the 0.5–2 keV sample variance in the COSMOS field. Prediction and observation at a flux limit $S_{lim}=5\times10^{-15}$ erg cm⁻² s⁻¹

$Area^a$ $arcmin^2$	$\sigma_{obs}{}^{\mathrm{b}}$	$\sigma_p{}^{\rm c}$	$\sigma_{cl}{}^{\mathrm{d}}$	$\sigma_{exp}{}^{\mathrm{e}}$	$\chi^2/{ m d.o.f.}^{ m f}$
$40' \times 40'$ $26' \times 26'$	$0.09{\pm}0.04$ $0.20{\pm}0.05$	$\begin{array}{c} 0.10 \\ 0.15 \end{array}$	$\begin{array}{c} 0.09 \\ 0.10 \end{array}$	$\begin{array}{c} 0.13 \\ 0.19 \end{array}$	$\frac{4.21/3}{8.93/8}$
$20' \times 20' \\ 16' \times 16'$	$0.21 \pm 0.04 \\ 0.24 \pm 0.02$	$0.20 \\ 0.25$	$\begin{array}{c} 0.11 \\ 0.12 \end{array}$	$0.23 \\ 0.28$	$rac{16.63/1}{25.15/2}$

Size of the independent cells.

The observed standard deviation.

The predicted Poissonian standard deviation σ_p .

¹ The predicted standard deviation due to clustering σ_{cl} .

The total predicted standard deviations. Value of the fitted $\chi^2/d.o.f.$



→able to explain most of differences in source counts from different surveys as a combination of Poissonian noise (bright fluxes) and clustering effects (faint fluxes)

0.5

 \rightarrow Cosmic or Sample variance have been reduced to 5% in studying X-ray source counts at the depth and area of XMM-COSMOS

2) Sample of z>3 QSO



Radio QSO (Wall et al., 2005)

Soft X-ray ROSAT/Chandra/ XMM (Hasinger, Miyaji & Schmidt 2005)

Chandra/ROSAT(Silverman et al. 2005)

Optical QSOs (Schmidt et al., 1995, Fan et al. (2001,2004)

What happens at z>3, X-ray selected AGN? decline or ~costant?

Statistics is needed ...

z>3 QSO in COSMOS

Predictions: 13-39 deg-2 (unabs+abs) at S(0.5-2 keV) >2e-15 cgs (from Gilli et al. 2007 model)



Expected in COSMOS: ~25-80

<u>Observed (so far)</u>: 7 (all BL AGN) → but only 48% spectroscopic completeness

lower limit How to catch all the others? And how many are them?

BL AGN: (classic) color selection



→5-10 additional BL AGN candidates isolated from optical color-color diagrams

... what about obscured AGN?



→~20-25 obscured AGN candidates, 2/3 with z(phot)>1 1/3 with z(phot)>2

Observations vs. predictions

A total of ~40 z>3 QSO

Upper and lower limits consistent with cut off evolution

Confirmation from ongoing DEIMOS, MOIRCS zCOSMOS (faint) programs

Extension also at fainter fluxes



3) AGN in the cosmic WEB

See Lilly et al. 2007, Trump et al. 2007 in ApJS Mainly I<22.5 objects





What's next...?

 <u>Still lot of work to do on present dataset</u>! (can start only now...)

- Luminosity function and evolution
- SED studies
- Variability studies
- X-ray and optical absorptions
- Morphologies of AGN + hosts studies
- activity vs. evironment
- Theory vs. observations

Perspectives for XMM

Focusing on the COSMOS-field

Enlarge the area? From 2 to 8 deg2 (additional 4-5 Ms)
 X-ray science (ACF, counts etc)

Focusing on the COSMOS-science

- 5-10 keV counts: a deep (3Ms) pointing on central area of COSMOS
- Study of AGN in LSS Another COSMOS-like 2deg2 survey (maybe contiguous to COSMOS)? Need to bring the mw + spectroscopic coverage at the level of COSMOS...
- High-z and Obscured AGN census pointed 50-100ks XMM observations on preselected candidates based on optical/IR colors? SDSS/SWIRE surveys... Maybe coordinated with HERSCHEL



EXO5?

Candidate very high-z qso...