The quest for very high-redshift Black Holes

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According to theoretical models for structure formation, massive black holes ($M_{BH} \sim 10^4$-10^7 M_{sun}) are predicted to be abundant in the early Universe ($z > 6$), but at present there are no observational evidences. The detection of such a population would provide unique constraints on the Massive Black Hole formation mechanism and subsequent evolution. According to XRB synthesis models and theoretical models for structures formation, the early phase of BH growth is expected to happen in a highly obscured environment. Sensitive X-ray surveys have the unique capabilities to detect and study obscured AGN in the early Universe.

The space density of luminous QSO ($L_X > 10^{44}$ erg s^{-1}) exponentially declines above $z \sim 3$ (Fig. 1; Brusa+08) with a behaviour similar to that observed for optically selected SDSS QSO (continuous lines in Fig. 2). Source counts may be computed by extrapolating the results of Fig. 1. The first QSO are likely to have relatively low masses and luminosities. To estimate their number counts alternative possibilities were explored The first (named maxXLF) assumes a constant space density for Seyfert-like AGN up to z=10, the second (continuous curves in Fig. 2) is based on SAM models for structure formation (Marulli+09). The predicted source counts for the 3 different models are reported in Figs. 3 and 4 along with the number counts predicted by other theoretical models as labeled. The total number of high-z AGN which will be eventually detected by IXO, depends from the survey strategy. In Fig. 5 we report the sky coverage of a possible "survey"program totalizing about 6 months of IXO observations. The predicted numbers of $z > 4$, $z > 6$ QSO in IXO surveys for different assumptions on the XLF evolution and a given Wide Field Imager size is reported in the table.

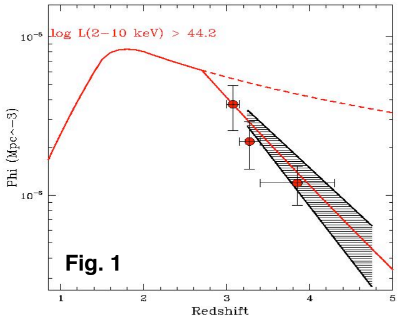

Fig. 1

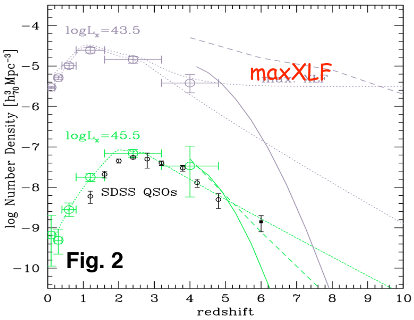

Fig. 2

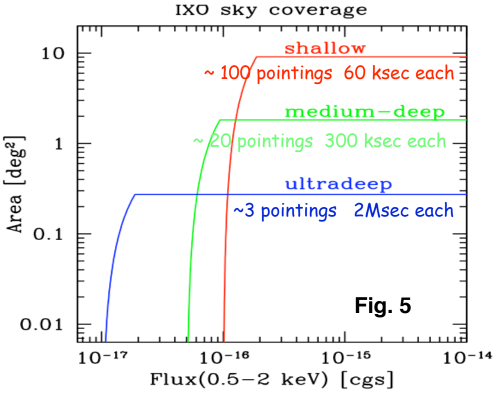

Fig. 5

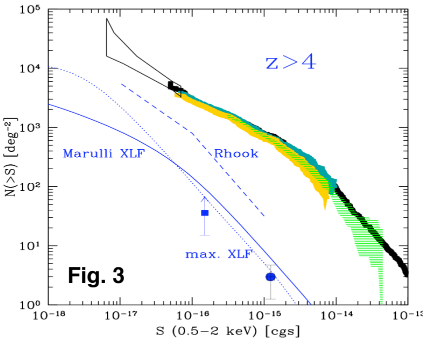

Fig. 3

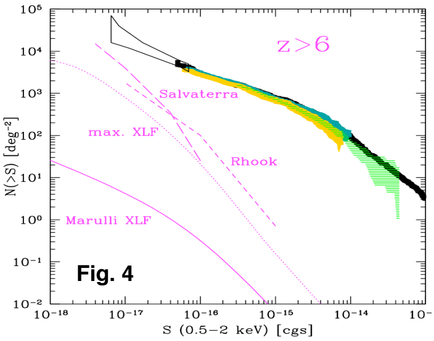

Fig. 4

Predicted numbers of high-z QSOs in IXO surveys for the above sky coverage and different assumptions on the XLF evolution

WFI - FOV 18 x 18 arcmin

	Decline	maXLF	SAM
z > 4	355	1350	1375
z > 6	15	300	4

Multi-λ Spectral Energy Distribution

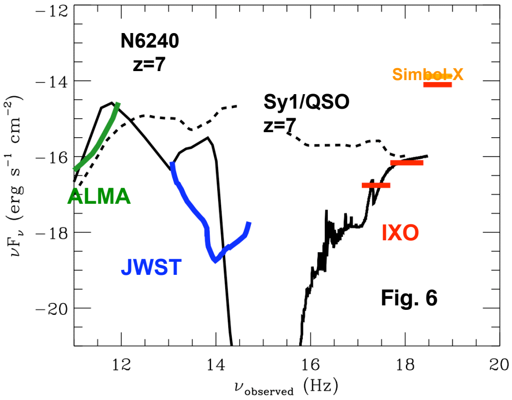

Figure 6: The SED of NGC6240 (a Compton Thick AGN in the nearby Universe) red-shifted to z = 7. The IXO sensitivity is compared with that of foreseen ground and space based facilities.

WFI X-ray spectroscopy

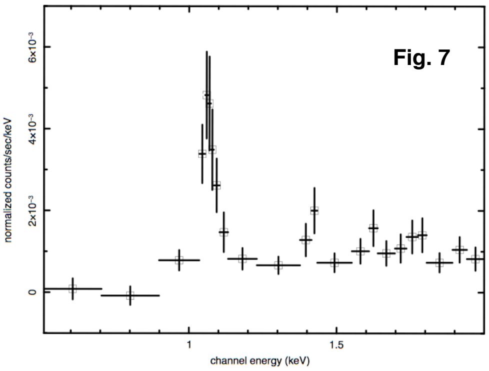

Figure 7: Simulated WFI 0.5-2 keV spectrum of a Compton Thick ($N_H \sim 10^{24}$ cm^{-2}) AGN at z = 5 ($L_X \sim 10^{43}$ cgs - $F_X \sim 10^{-16}$ cgs, line EW ~ 1 keV (rest-frame)

Calorimeter X-ray spectroscopy

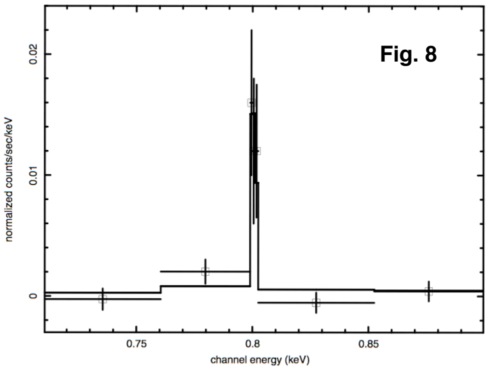

Figure 8: XMS simulation (0.7-0.9 keV zoom) of a Compton Thick AGN at z = 7 $L_X \sim 5 \times 10^{42}$ cgs - $F_X \sim 5 \times 10^{-17}$ cgs , line EW ~ 1.2 keV (rest-frame) .

ALMA and JWST will reveal a large number of high-z galaxies and QSOs. The near-IR spectrometer (Nirspec) onboard JWST is sensitive to extremely faint magnitudes (AB ~ 29 at about 2 μm), however the AGN signatures are likely to be absent among optically and X-ray obscured AGN which may not be recognized as such. The presence of an (obscured) AGN can be unambiguously established only by deep X-ray surveys (Fig. 6). Optical spectroscopy of faint X-ray sources is also likely to be challenging especially for the most obscured objects. X-ray spectroscopy may provide a viable alternative to intensive optical and near-IR spectroscopic campaigns.

Extensive simulations of high-z heavily obscured AGN were performed using the most recent release of the IXO response matrices and backgrounds spectra for both the Wide Field Imager (WFI , Fig. 7) and the calorimeter (XMS, Fig. 8). For relatively bright sources the iron line emission is clearly detected with the WFI (Fig. 7) and allows a fairly accurate red-shift measurement. For fainter sources X-ray color techniques (i.e. Iwasawa+05) may be employed using variable width energy bands. The X-ray spectra of Compton Thick AGN should be characterized by an excess of counts (corresponding to the red-shifted Kα line) over a continuum which is brighter at higher energies wrt to lower energies . Line dominated sources may be identified by means of high resolution XMS spectroscopy where a line-like feature should be detected on top of a extremely weak or absent continuum. More sophisticated simulations are currently performed to study the best trade-off between source flux, line parameters and red-shift distribution and to better assess the statistical significance and systematic errors associated to the search for emission lines.

Deep X-ray surveys are needed to uncover the first accreting Black Holes and their role in shaping galaxy evolution

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