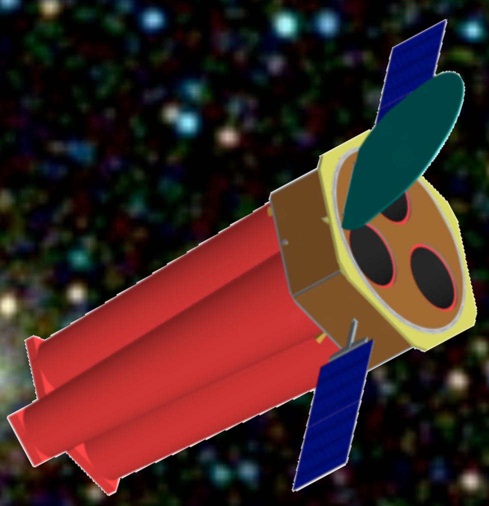


X-ray variability with WFXT

M.Paolillo[1], D.de Martino[2], M.Della Valle[2,8], R.Gilli[3], P.Tozzi[4], S.Borgani[4], P.Rosati[5], R.Giacconi[7], G.Pareschi[6], G.Tagliaferri[6], A.Ptak[7], S.Murray[7] and the WFXT Team

[1]Univ. of Naples/INFN, [2]INAF/Napoli, [3]INAF/Bologna, [4]INAF/Univ. Trieste, [5] ESO, [6]INAF/Milan, [7]JHU, [8]ICRA, Pescara

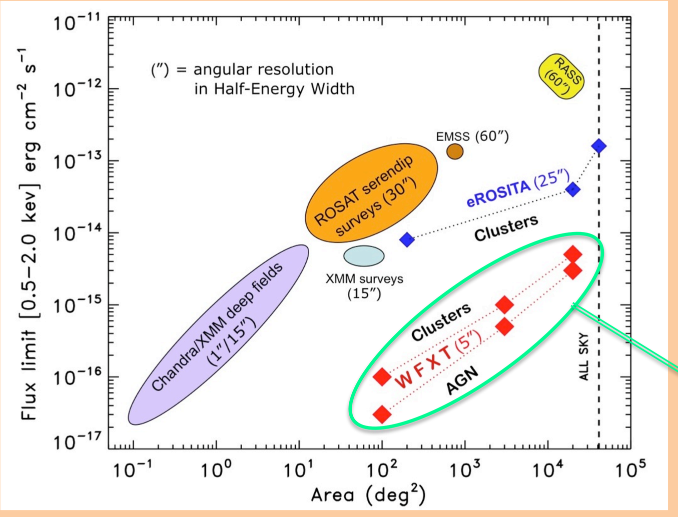
Abstract

The **Wide Field X-ray Telescope** (WFXT) is a proposed mission with a high survey speed, due to the combination of large field of view (1 square degree FOV) and effective area (1 m^2, >10x Chandra) over the 0.1-7 keV band, and sharp PSF across the whole FOV (5″ Half Energy Width). These characteristics make it suitable to detect a large number of variable and transient X-ray sources during its operating lifetime, and to constrain the rates and properties of hundreds of distant, faint and/or rare objects such as X-ray Flashes/faint GRBs, Tidal Disruption Events, ULXs, Type-I bursts etc. The planned WFXT extragalactic surveys will thus allow to trace variable and transient X-ray populations over large cosmological volumes, while dedicated surveys of the Milky Way could extend these studies to faint galactic sources..

WFXT Surveys

Quantity	Survey		
	Deep	Medium	Wide
Ω (deg^2)	100	3000	20,000
Exposure time	400 ks	13 ks	2 ks
Total time	1.67 yr	1.66 yr	1.67 yr
S_{min} (point-like) (*)	3×10^{-17}	5×10^{-16}	3×10^{-15}
Total AGN detected	5×10^5	4×10^6	1×10^7
S_{min} (extended) (*)	1×10^{-16}	1×10^{-15}	5×10^{-15}
Total clusters/groups	3×10^4	2×10^5	3×10^5

(*) Flux limit in erg cm^2 s^{-1} (0.5-2 keV band) at 5σ detection



Flux limit and sky coverage for past and planned X-ray surveys

In 5 years of operation, WFXT will carry out three extragalactic surveys:

- a WIDE survey will cover most of the extragalactic sky (~20,000 deg^2) at ~500 times the sensitivity, and twenty times better angular resolution of the ROSAT All Sky Survey;
- a MEDIUM survey will map ~3000 deg^2 to deep Chandra or XMM - COSMOS sensitivity;
- a DEEP survey will probe ~100 deg^2, or ~1000 times the area of the Chandra Deep Fields, to the deepest Chandra sensitivity.

Additional dedicated galactic surveys are also under study [1].

The three WFXT surveys provide an unsurpassed combination of sensitivity and sky coverage with good angular resolution

Transient and variable sources

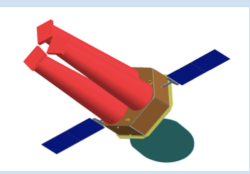
In addition to AGNs, which will represent the bulk of the unresolved population [2], a large variety of variable and transient sources will be observed by WFXT during it's operating lifetime, among which:

Table 1. Number of transients expected in the WFXT extragalactic surveys, along with the physical parameters used in the simulations and the calculated distance limits.

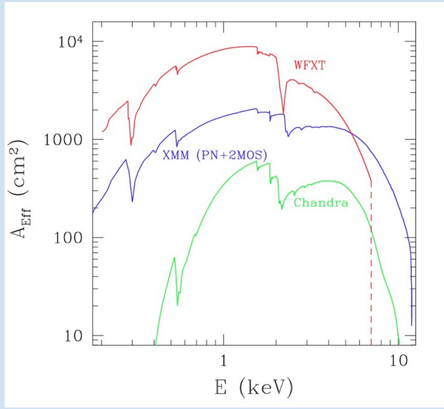
Type	N.sources	L_X^{burst} (10^{40} erg/s)	$L_X^{quiescent}$ (10^{40} erg/s)	timescale (s)	Rate (Mpc^{-3} yr^{-1})	Dist.limit (Mpc, z)
SNIbc/II	226	10^3	1.0	500	10^{-3}	2.8×10^3, **0.50**
SNIa	2.1×10^{-5}	10^2	0.0	0.01	10^{-2}	3.8, **0.0009**
LL-GRB	290	10^4	0.0	10^4	3×10^{-5}	3.8×10^4, **4.2**
TCE	0.0062	10^2	0.0	10	10^{-4}	120, **0.028**
TDE	77.6	10^2	0.0	5×10^5	5×10^{-5}	1.8×10^4, **2.3**
SSS	1.1	10^{-4}	0.0	5×10^5	30	18, **0.004**
ULX	411	1	0.5	10^5	0.1	920, **0.19**
Type I bursts	395	10^{-2}	0.0	100	30	3.8, **0.0009**

- ***Tidal Disruption Events:*** occur when a star is disrupted in the proximity of a quiescent SMBH. So far only a handful of candidate events have been serendipitously observed [4]; the detection of such events with WFXT is very likely, since their emission is expected to peak in the FUV/soft X-ray bands.
- ***X-ray Flashes:*** X-ray bursts have been detected in coincidence with SN explosions. The phenomenology of such events is still poorly understood and both precursor type and rates are very debated in the literature: their emission can be due to the breakout of either the SN shock [8] or a mildly relativistic [9].
- ***Low Luminosity GRB***: transients such as GRB060218 [10] could represent the X-ray counterpart of many associated GRB-SNe. The number of future detections depends on both the intrinsic SN rates and the opening angle of the jet [11].
- ***Super Soft Sources:*** are detected at energies below 1 keV, with X-ray luminosities of $10^{36\div38}$ erg/s, kT~15-80 keV [12]. Believed to be mostly hydrogen-burning white dwarfs, they have complex time variability which is irregular over hours to years.
- ***Ultraluminous X-ray Binaries***: accreting systems with luminosities $L_X>10^{39}$ erg/s, which can produce X-ray flares on timescales of hours, they are proposed as candidates for intermediate >100 $M_\odot$ BH [13], despite the difficulties in explaining their existence in standard star-formation scenarios.
- ***Type I bursts:*** accreting neutron stars in low-mass X-ray binaries displaying rapid (tens to hundreds of seconds), recurring bursts with X-ray intensity many times brighter than the persistent level. The burst X-ray spectrum is generally consistent with a blackbody with kT~2-3 keV, reaching X-ray luminosities up to 10^{38} erg/s [14].

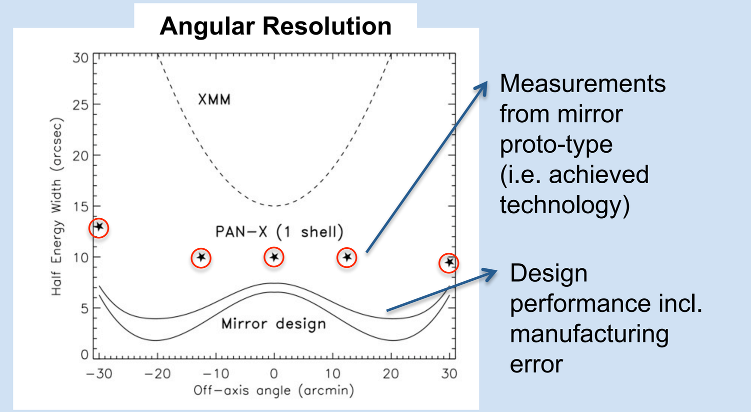
Key mission concept components



Three co-aligned telescopes with wide field optics and CCDs with ΔE/E~20 resolution



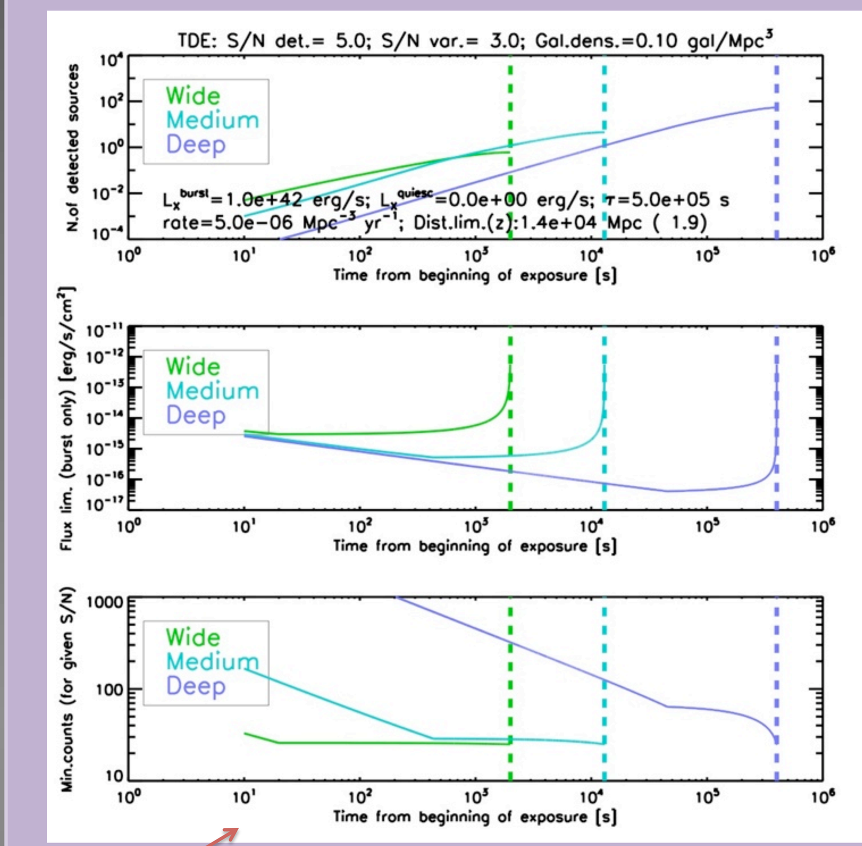
Large effective area: ~1 m^2 (goal) @ 1 keV from 78 shells in 3 telescopes. Excellent effective area to 6 keV



Wide field optics ensure constant good PSF over 1 sq.deg. (5″ HEW goal) [5,6,7]

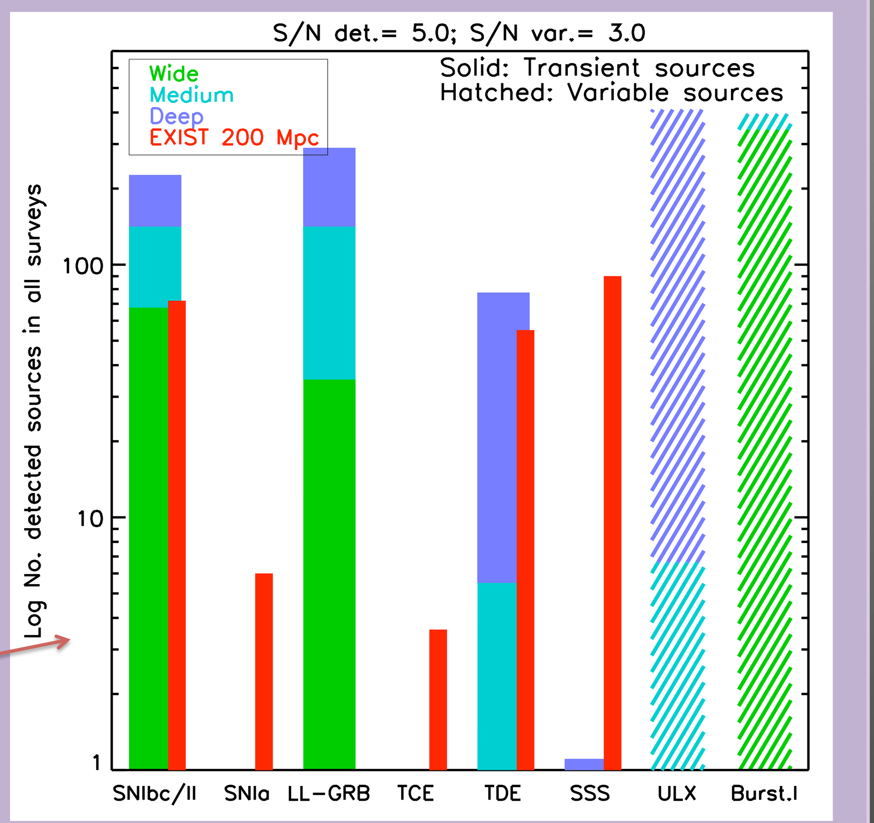
Low-earth orbit (550 km @ 6 deg) to minimize particle background

Transients detections with WFXT



Example of the WFXT performance for Tidal Disruption Events. The number of detected sources, limiting flux and minimum counts for each survey is shown as a function of the observing time.

- The WFXT performance is estimated assuming a simplified burst model where a source of luminosity L_X^{quiesc} in the pre-burst phase, undergoes a burst of luminosity L_X^{burst} for a duration equal to the characteristic timescale of source.
- We required that a source is detected with S/N>5 and that its variability is ascertained with S/N>3. The number of objects is calculated integrating over the cosmological volume accessible to WFXT for each source.
- The number of expected transients in each survey varies greatly depending on the luminosities, volumetric rates and timescales of each class.



Number of transient sources expected from the WFXT extragalactic surveys. EXIST estimates [3] are shown for comparison.

- The values presented in this work are mainly intended to highlight the mission capabilities as a function of the observational parameters. **An online version of the WFXT transient simulator is available at** **http://wfxt.na.infn.it/**, allowing the interested user to test additional type of sources and parameter combinations.

Conclusions

While not a monitoring missions, with its large effective area, wide FOV and stable PSF, **WFXT will offer an unprecedented view of the variable high-energy Universe**. WFXT will allow to study thousand of variable AGNs, and hundred of other transient and variable sources. The study of such populations has been mostly limited to the local Universe so far, while WFXT will be able to sample cosmologically relevant volumes, thus constraining their rates, evolution and the underlying physics

Recent studies suggest that **the X-ray band could be the optimal energy range to use in order to identify triggers and/or counterparts for next generation Gravitational Wave and Neutrino experiments** [15]. WFXT thus would prove extremely valuable in validating and characterizing the astronomical events detected by these facilities.

References

Decadal Survey Articles
[1] Ptak et al. 2009, 240; arXiv:0902.4239
[2] Murray et al. 2009, 217; arXiv:0903.5272
[3] Soderberg et al. 2009, 278; arXiv:0902.3674
[4] Gezari et al. 2009, 88; arXiv:0903.1107
[5] Burrows, Burg, Giacconi 1992, ApJ, 392, 760
[6] Conconi et al. 2010, MNRAS, 405, 877
[7] Elsner et al. 2009, SPIE 7437, 13
[8] Soderberg et al. 2008, Nature, 453, 469
[9] Mazzali et al. 2008, Science, 321, 1185
[10] Campana et al. 2006, Nature, 442, 1008
[11] Guetta & Della Valle 2007, APJL, 657, L73
[12] Kahabka & van den Heuvel 2006, "Compact stellar X-ray sources", 461
[13] Fabbiano 2006, ARA&A, 44, 323
[14] Galloway, et al. 2008, ApJS, 179, 360
[15] Guetta & Eichler 2010, ApJ, 712, 392

Acknowledgements

We acknowledge support from ASI-AAE grant

WFXT Website:
EU: http://www.wfxt.eu
US: http://wfxt.pha.jhu.edu