# Search for serendipitous TNO occultation events in X-rays with Athena

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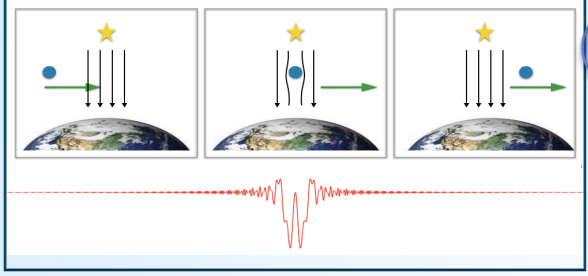
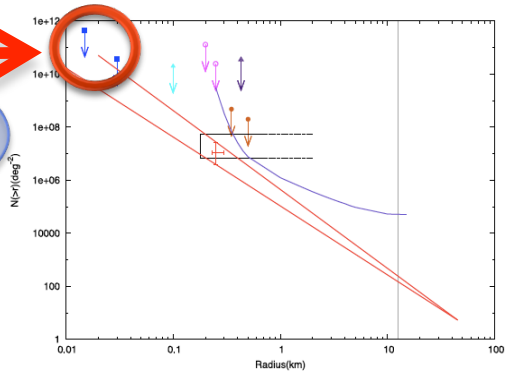
**Summary**

Because of its large effective area, and thus high count rates, Athena can potentially detect occultation events caused by small KBOs. However, Athena count rates of bright non-extended X-ray sources are roughly 3 times that of RXTE. It therefore can only play a role similar to RXTE, i.e. Sco X-1 being the only bright enough source, in searching for serendipitous occultation events at millisecond time scale. That is relevant to KBOs of size about 30-300 meters. In this regard, the proposed LOFT mission remains a more powerful one.

Serendipitous occultation events caused by small KBOs have been being used to explore their size distribution.



RXTE result based on 334-ks data of Sco X-1 observation (Ref.[1])

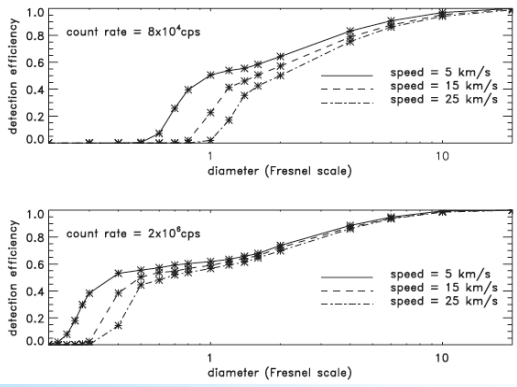



(Ref.[2]) The solid black line represents the weighted average values for the minimum radii of our 13 POEs. Our results were compared to those of the literature (the red points and lines: Schlichting et al. 2012, the solid brown circles: Bianco et al. 2009, the hollow violet triangle: Bickerton et al. 2008, the hollow pink circles: Wang et al. 2010, the solid cyan triangle: Roques et al. 2006, the solid blue squares for *RXTE*: Chang et al. 2013, and the solid slate-blue curve for TAOS: Zhang et al. 2013).

| Sources | Athena, and LOFT count rates (cps) | | | Other names |
|---|---|---|---|---|
| | WFI (0.2-2 keV) | WFI (2-12 keV) | LOFT (2-12 keV) | |
| 4U 1758-25 | $9.9 \times 10^2$ | $1.5 \times 10^4$ | $2.4 \times 10^5$ | 1H1758-250, GX5-1 |
| 4U 1758-20 | $2.7 \times 10^3$ | $7.0 \times 10^3$ | $1.5 \times 10^5$ | 1H1758-205, GX9+1, Sgr X-3 |
| 4U 1617-15 | $5.3 \times 10^5$ | $2.6 \times 10^5$ | $3.1 \times 10^6$ | 1H1617-155, Sco X-1 |
| 4U 1813-14 | $1.6 \times 10^3$ | $7.7 \times 10^3$ | $1.2 \times 10^5$ | 1H1813-140, GX17+2, Ser X-2 |
| 4U 1702-36 | $4.5 \times 10^3$ | $1.0 \times 10^4$ | $1.6 \times 10^5$ | 1H1702-363, GX 349+2, Sco X-2 |
| 4U 1642-45 | $1.9 \times 10^2$ | $4.7 \times 10^3$ | $7.8 \times 10^4$ | 1H1642-455, GX340+0 |
| 4U 1837+04 | $6.1 \times 10^3$ | $3.5 \times 10^3$ | $4.8 \times 10^4$ | 1H1837+049, Ser X-1 |
| 4U 2142+38 | $4.5 \times 10^3$ | $8.0 \times 10^3$ | $1.0 \times 10^5$ | 1H2142+380, Cyg X-2 |
| 4U 1956+35 | $1.5 \times 10^4$ | $8.0 \times 10^3$ | $1.3 \times 10^5$ | 1H1956+350, Cyg X-1 |

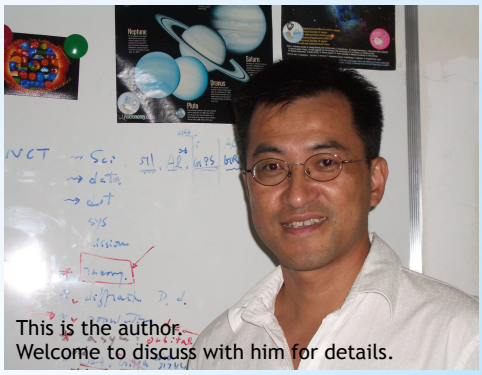
(Possible Athena flux saturation is not taken into account.)

**Table 1.** Estimated count rates for some non-extended bright X-ray sources, which are potential background targets for serendipitous TNO occultation search in X-rays. All the 9 listed sources are brighter than 0.1 Crab in all the 4th Uhuru (4U), HEAO 1 A-1 (A1), and RXTE All Sky Monitor (ASMquick) catalogues. The 4U catalog was compiled with observations conducted during 1972-1973, the A1 catalog was during 1977, and the ASMquick information is based on weekly average in August 2011. The estimated count rates are based on spectral models of each sources reported in the literature (Chang, Liu & Chen (2013), and references therein). WFI is the Wide Field Imager on board Athena. The LOFT count rates in this table is somewhat different from that in Chang, Liu & Chen (2013) because a more updated LOFT instrument response matrix (version 'M4') is used. This list is sorted with the absolute value of their ecliptic latitude.




Detection efficiency study based on the RXTE spectrum of Sco X-1. (Ref 1)

One Fresnel scale is about 30 m (40 au, 4 keV (0.3 nm)). For Athena, it would be about 45 m (40 au, 2 keV (0.6 nm)).



This is the author. Welcome to discuss with him for details.

**References**

[1] Hsiang-Kuang Chang; Chih-Yuan Liu; Kuan-Ting Chen: **Search for serendipitous trans-Neptunian object occultation in X-rays**, MNRAS 429, 1626–1632 (2013)

[2] Liu C.-Y., Doressoundiram A., Roques F., Chang H.-K., Maquet L., Auvergne M., Search for sub-kilometre trans-Neptunian objects using *CoRoT* asteroseismology data, MNRAS, 446, 932 (2015)