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The Seyfert galaxies in the local Universe: from BeppoSAX to Simbol-X

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Abstract. The operational conditions found by *BeppoSAX* in observing nearby (z≤0.1) Seyferts were reproduced for *Simbol-X* in order to simulate a realistic final database of the mission. The results indicate that, even in the worst conditions, the *Simbol-X* archive of pointings will allow to fully characterize the high-energy spectrum of nearby Seyferts and, most importantly, to obtain solid results on R and Ec (fundamental to model the cosmic X-Ray background, CXB). The measurement of the inclination angle of the accretion disk will be possible for ∼15 objects allowing to directly test the unified models for AGN. Finally, the time-dependent characteristics of the reflected component will be studied in at least ∼25 objects.

Key words. X-rays: galaxies – galaxies: Seyfert: – galaxies: active

1. Introduction

In X-ray astronomy each mission has been an important step forward in the comprehension of the physics of known sources and in the opening of new interesting fields of research. This is expected to happen also for *Simbol-X* (see, for instance the presentations by Fiore in these proceedings) thanks to its unprecedented sensitivity above 10 keV (∼2-3 orders of magnitude with respect the previous missions). Moreover *Simbol-X* will also work as an observatory that will leave a rich but, as usual, inhomogeneous archive of data. As such,trying to estimate on how many objects deep spectral or timing studies will be performed, so as to fully exploit the astrophysical potentials of the new instruments, is not trivial. To make an attempt of tackling this issue for *Simbol-X*, it has been chosen to test the new mission reproducing the observational conditions (essentially the flux of the sources and the used exposure) really found by the only past mission comparable with *Simbol-X*: *BeppoSAX*. The astrophysical field inspected here is the one concerning the nearby (z≤0.1) Seyfert galaxies, for which *BeppoSAX* obtained important results on the X-rays emission mechanism, on the geometry of the reflector and on the geometry of the cold absorber (Perola et al. 2002, Risaliti et al. 1999). These results were obtained investigating the properties of the high-energy cut-off (Ec), and of the reflection component (R) which study is possible only using broad-band observatories. These quantities are hardly measurable and they are known only for few bright objects. They were mainly measured from *BeppoSAX* which operated above 10 keV with a smaller (∼2-3 order of magni-

Table 1. Grid of possible values for the interesting parameters of the simulated *Simbol-X* spectra.

N_H^a	Γ	R	Ec^b	$F^c_{2-10keV}$	$Exp.^d$
0		0.5	150	1	100
5	1.85^f	1	200	0.1	50
50		1.5	250	0.01	10

^{a} in units of 10^{22} cm^{-2}; ^{b} in units of keV; ^{c} in units of 10^{-11} erg s^{-1} cm^{-2}; ^{d} in units of ks; ^{f} fixed

tude less) sensitivity with respect *Simbol-X* but with a broader band (~0.1-200 keV, instead of ~0.5-80 keV). The capability of inspecting Ec and R is here used as indicator of quality of the data assuming that, if R and Ec are measured, than it will be possible to deeply investigate, both via spectral and timing analysis, the physical conditions close the super-massive black-hole. The goal of this work is to estimate a realistic number of nearby Seyfert that *Simbol-X* will observe in this detail.

2. Methods

The observational conditions (exposure time end fluxes of the sources) found by *BeppoSAX* were grossly reproduced in order to simulate the results that would have been obtained if the nearby Seyferts were observed with *Simbol-X* instead of *BeppoSAX*. To do that, the parameter F defined as follows, has been used:

$$F=(F_{2-10keV}\times\sqrt{T_{exp}}) \qquad (1)$$

where $F_{2-10keV}$ is the 2-10 keV flux in units of 10^{-11} erg s^{-1} cm^{-2} and T_{exp} is the exposure time in units of ks. Thus, the F parameter define how "deep" an observation was with *BeppoSAX* and may be used to quantify the expected improvements achievable with the new instruments. The distribution of F obtained for *BeppoSAX* is presented in figure 1 (note that Log(F)=1 for 100 ks long observations of sources having $F_{2-10keV}=10^{-11}$ erg s^{-1} cm^{-2}). The *BeppoSAX* catalog used here is the one presented in Dadina (2007), which contains 163 observations of 105 objects (of which 62 are type I and 43 are type II Seyferts).

To produce the *Simbol-X* fake spectra it was assumed that the X-ray emission of the sources is described by an absorbed (by cold matter) power-law with an Ec, plus a cold reflection component and a narrow emission line. Each combination of the values presented in Table 1 has been used to simulate the fake *Simbol-X* spectra. When R and Ec were available from *BeppoSAX*, the closest value between the 3 reported in table 1 were used for fake data, otherwise it was set R=1 and Ec=200 keV. The resulting grid of spectra have been fit with what presented in Dadina (2007) in order to reproduce for *Simbol-X* the distribution of F presented in figure 1. Finally 90% cofidence levels have been obtained for each interesting parameters in the simulated spectra.

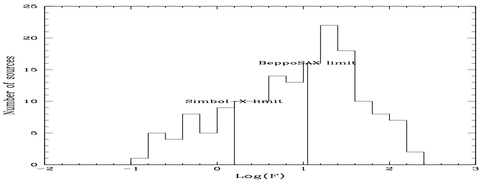

Fig. 1. Histogram of the real distributions of the F parameters (see text for details) obtained for the *BeppoSAX* list of observations of the nearby Seyferts. The vertical line at F~1 is the limit reached for *BeppoSAX* in inspecting R and Ec, while the one at F~0.2 is the expected limit for *Simbol-X*.

The configuration assumed for *Simbol-X* is characterized by the following specifications:

- Internal particle background for the low energy detector MPD = 2×10^{-4}cts/s/keV
- Internal particle background for the high energy detector CZT = 3×10^{-4}cts/s/keV
- MPD dead-time = 17%

as specified in the tutorial for the *Simbol-X* simulations (Sauvageot, 2007).

3. *Simbol-X* vs. *BeppoSAX*

The first remarkable results obtainable with *Simbol-X* is that all the pointed nearby Seyfert galaxies observed with *BeppoSAX* are expected to be detected above 10 keV with respect ~80% detected by *BeppoSAX*. At the same time the range of F parameters available for the inspection of the properties of R and Ec increases by ~1 order of magnitude (see figure

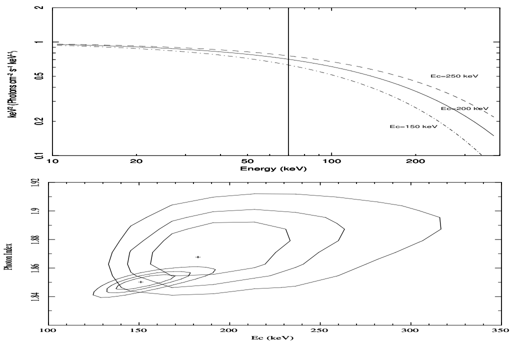

Fig. 2. Upper panel: 10-200 keV spectra for power-law with Ec=150 keV (lower curve), Ec=200 keV (middle curve), and Ec=250 keV (upper curve). It is worth noting that at 70 keV the three line differ for ~10% each other and that the difference decreses as Ec= increases. Lower panel: Γ vs. Ec confidence contours for a F=1, R=1 observation for Ec=150 keV (smaller contours) and Ec=200 keV (bigger contours).

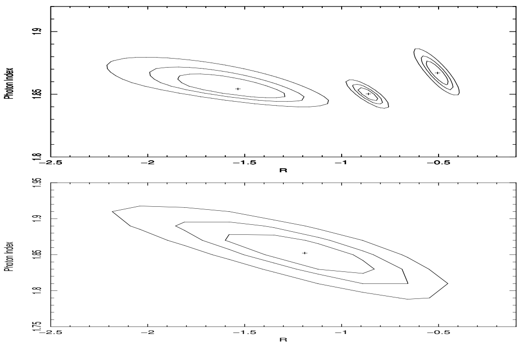

Fig. 3. Upper panel:confidence contours for R going from 0.5 to 1.5 for a simulated type I objects (F=1, Ec=200 keV). Lower panel: confidence contours for a simulated Seyfert II with R=1 (F=1, Ec=200 keV).

1). The high sensitivity expected in the range 10-70 keV will allow to study Ec even well above 70 keV (see figure 2), i.e. at energies exceeding the upper end of the nominal working range of the CZT. Nonetheless, the possibility to detect Ec at energies above 200 keV is limited to brighter sources (see lower panel of figure 2).

The number of Seyfert for which we can have information (both detections and reliable lower limits) about Ec and R will double (going from 41 to 82) assuming the *BeppoSAX* archive as the reference one. Most interestingly, a significant fraction of the "new" sources (26 out of 41) for which information about Ec and R will be for the first time achievable are type II objects. These were almost excluded in the *BeppoSAX* era since the spectral complexity due to the cold absorption. The coupling offered by *Simbol-X* of a good sensitivity below 10 keV (comparable to the one of *XMM-Newton* or *Suzaku*) and the great improvement (~two orders of magnitude if compared with *BeppoSAX* and *Suzaku*) between 10-70 keV should at least partially disentangle this degeneracy.

Simbol-X is expected to give a major contribute in the measurements of the reflection characteristics in nearby Seyfert galaxies. In fact, the reflection hump peaks at 30-40 keV (Lightman & White 1987), i.e. just in the middle of the working range of the CZT detector. Moreover, *Simbol-X* will permit to investigate the time-dependent behavior of the reflection. In figure 3, the confidence contours are plotted for three different observations of a Seyfert 1 (upper panel) with F=1 of that changes the value of R from R=0.5 to R=1.5. In the lower panel of the same figure, the contour plot for a type II source (F=1, R=1, Ec=200 keV) is presented and shows how the presence of the cold absorption prevent this kind of studies.

For very bright (F≥10) sources, *Simbol-X* is expected to allow the study of the inclination angle of the accretion disk (figure 4). This kind of studies will be permitted only in type I sources since the spectral complexity introduced by the absorber at low energy will hamper to constraint this parameter.

4. Summary and conclusions

This work is a first attempt to determine a realistic number of nearby (z≤0.1) Seyfert galaxies for which *Simbol-X* will carry deep spectral and timing analysis. The basic assumption here are: 1) that these studies will be possible when the measurements of R and Ec are possible; 2) that Simbol-X will observe sources

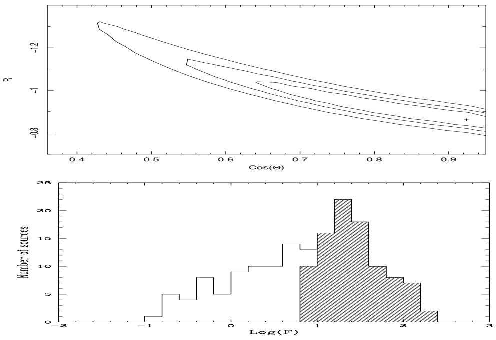

Fig. 4. Upper panel: Confidence contours for the inclination angle (Θ) for a type I source with F=1, R=1 and Ec=200. Lower panel: histogram of the F parameter. The shaded region correspond to the observations for which information on the inclination angle is available studying the reflected component.

with a distribution of F similar to what done by *BeppoSAX*. The last assumption is quite strong and it is probable that the characteristics of Simbol-X will be used to inspect sources that were barely detectable with *BepoSAX*, as the Compton-thick sourcces. Thus, what obtained here may be considered as lower limits. The results can be summarized as follows: i) the fraction of nearby Seyfert galaxies detected above 10 keV should be ∼100%; ii) for ∼80 Seyfert galaxies in the local universe it will be possible to measure Ec and R; iii) ∼50% of these sources are expected to be type II sources; iv) for ∼25 objects it will be possible to perform meaningful time dependent studies of R; v) for ∼15 type I sources is will be possible to study the inclination angle of the accretion disk inspecting the properties of the reflected components.

These results, thus, indicate that *Simbol-X* is expected to leave an archive of pointed observations that will allow to fully characterize the average spectrum of nearby Seyfert galaxies on solid statistical basis (for instance, the distribution of N_H for the Seyfert galaxies in the local Universe was obtained with a sample of 74 objects, Risaliti et al. 1999). Most importantly, it is expected to obtain solid description of the distributions of R and Ec, fundamental to synthesize the CXB. Moreover it will be possible to test the UM for the brightest Seyferts checking if the inclination angle of the system is in accordance with the optical classification of the sources. Finally, the astrophysics of the accretion will be studied using timing techniques at the energies where the bulk of the reflection peaks.

4.1. Caveats

Some basic assumption and simplifications have been made in this work and these must be kept in mind when evaluating the the opportunities offered by *Simbol-X* in the inspected astrophysical field. The sample of objects/observations used here have been accumulated in six years while *Simbol-X* is expected to fly for 2-5 years (Ferrando et al., 2006). Nonetheless, the higher observational efficiency (up to ∼90%, Ferrando et al., 2006) should permit *Simbol-X* to observe the nearby Seyferts for ∼10 Ms as BeppoSAX did. The baseline model assumed here does not include warm absorber or ionized reflection, nor include soft excess in type I sources. All these components introduce additional spectral complexities not accounted for. On the contrary, the capabilities of *Simbol-X* in measuring R and Ec were here tested only on pure statistical basis: i.e. no physical assumption were made during the fitting and the significance of the measurements of R and Ec were calculated leaving all the other parameters free to vary.

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