FIRST RESULTS FROM THE MECS ON BOARD BeppoSAX

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ABSTRACT. In this contribution we discuss briefly a few calibration items relevant to the data analysis and present some preliminary scientific results. The discussion on instrumental topics focuses on the response matrix and Point Spread Function (PSF). In the scientific results section we discuss a first analysis of the two Seyferts MCG 6-30-15 and NGC 4151 and of the Cosmic X-ray Background.

1. Introduction

During the Science Verification Phase (SVP) a number of bright X-ray sources have been observed by BeppoSAX. The aim of such observations is twofold: perform inflight calibrations of the instruments and verify the capabilities of BeppoSAX to achieve the scientific goals for which it has been designed. In this presentation we concentrate on the analysis of SVP data from the Medium Energy Concentrator Spectrometer (MECS) on board BeppoSAX. A more general presentation is given by Piro et al. in these proceedings.

2. Calibration and Instrumental Issues

An extensive description of the MECS ground calibrations can be found in Boella et al. (1997). In this short presentation we focus onto two of the most important calibration aspects that have been addressed using inflight data.

2.1. Response Matrix

The quality of the ground derived response matrix has been tested by observing well known bright sources, the most important being the Crab. For this source residuals to a power-law plus absorption fit are contained within 3% everywhere except in the two critical regions of the Gold M-edge at 2.2 keV and of the Xenon L-edge at 4.7 keV, where they can be as high as $\simeq$ 10%. The measured absolute flux in the 2-10 keV band

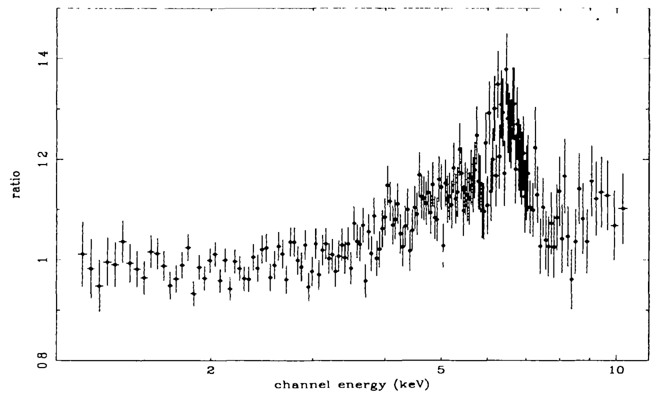

Fig. 1. Ratio, in arbitrary units, of the MECS MCG 6-30-15 to Crab Spectrum.

is within 3% of the nominal value. This is certainly a very encouraging result for a ground response matrix. The MECS hardware group in Palermo has recently finished working on an inflight matrix which has now been released to the scientific community. Fitting of Crab data with this matrix yields residuals contained virtually everywhere within 2%. A plot of these residuals, as well as other relevant information, can be found at the following hyperlink *http://www.sdc.asi.it/software/cookbook/matrices.html.*

2.2. Point Spread Function

The Point Spread Function (PSF) of the MECS results from the convolution of the telescope PSF and the detector PSF. An energy averaged plot of the SAX MECS PSF can be found at the following hyperlink: *http://www.sdc.asi.it/software/cookbook/psf.html.* The measured on-axis PSF is sensibly smaller than the ASCA-GIS on-axis PSF, the half power radius at 6 keV being about a factor 2 smaller. The comparison is even more favorable at the 80% and 90% radii, due to the considerably reduced scattering of the MECS optics. Another important advantage of the MECS-PSF is the moderate off-axis degradation.

3. First Scientific Results

3.1. MCG 6-30-15

During the SVP phase we have carried out a 130 ks observation of the Seyfert galaxy MCG 6-30-15. The MECS lightcurve shows strong (more than a factor 2) and rapid (halfing timescale < 2000 s) variability, consistently with the ROSAT (Nandra & Pounds 1992) and ASCA (Otani et al. 1996) observation of this source. An ASCA observation of this source (Tanaka et al. 1995) has evidenced an excess emission with respect to a power-law model in the energy range 4-6 keV. This feature has been interpreted as the red tail of the Iron K_{α} line peaking around 6.4 keV. Such a tail results from the combination of Doppler and gravitational redshifts when the emitting region is

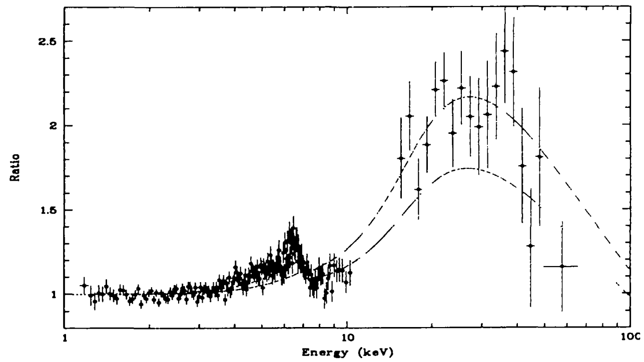

Fig. 2. Ratio, in arbitrary units, of the MECS + PDS MCG 6-30-15 to Crab Spectrum. The two lines represent power-law + reflection models with normalization of the reflection component ($\Omega/2\pi$) set respectively to 1 (lower line) and 1.5 (upper line).

located in the immediate vicinity of a massive blackhole. As pointed out by Tanaka and collaborators, the detection of the extended red tail of the Fe K_α is of great importance since it can be considered one of the most direct manifestations of the blackhole at the center of active galaxies.

To investigate the presence of the excess in the 4-6 keV band discovered by ASCA we have divided the MCG-6-30-15 spectrum by the Crab Spectrum. In such a way any residual calibration systematics at the Xenon edge energy ($E \simeq 4.7$keV) does not affect our result. In order to increase the statistics, data from all 3 MECS has been used. As can be seen in Figure 1 our observation confirms the presence of the excess in the 4-6 keV band. We consider this result of some importance as it is the first confirmation of such a spectral feature from a satellite other than ASCA.

Having confirmed the presence of the feature, clearly the most important thing to do is to verify its proposed origin (i.e. red tail of the K_α line) by making use of information that can be extracted only from the BeppoSAX observation. One of the key aspects in understanding the nature of the excess in the 4-6 keV band is a reliable estimate of the underlying continuum. In this band a contribution to the emission comes from the reflection component observed by GINGA in this and other Seyferts (Nandra & Pounds 1994). The entity of this contribution could not be easily assessed with ASCA as the effective areas of the mirrors drop rapidly above 7 keV where the contribution from the reflection component rises sharply. The BeppoSAX observatory, with its high energy instruments, can perform measurements around 40 keV where the reflection component peaks. In Figure 2 we show the combined MECS PDS spectrum of MCG 6-30-15. To avoid intercalibration problems between the 2 instruments we use again the ratio of the MCG 6-30-15 to the Crab spectrum. The lower line indicates a powerlaw plus reflection model with the normalization of the reflection component ($\Omega/2\pi$) set to 1 as in the fit reported by Tanaka and collaborators on the ASCA data. The model clearly falls short of the data. A reasonable agreement between the two can be achieved by

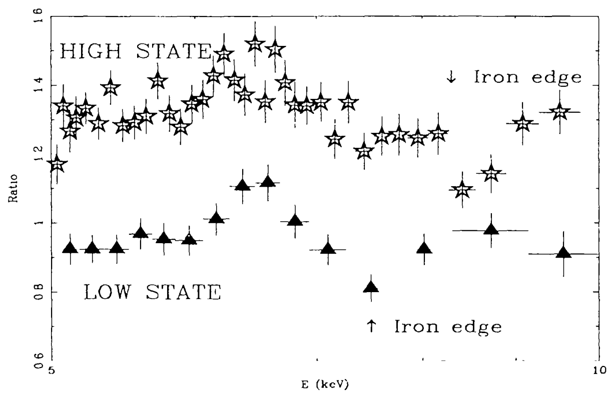

Fig. 3. Ratio, in arbitrary units, of the MECS MCG 6-30-15 to Crab Spectrum. The open stars represent the high state and the filled triangles the low state

increasing the normalization of the reflection component by about 50% (higher line). If the extrapolation of the reflection component used in the ASCA fit underestimates the data at 40 keV it may be reasonable to assume that the model applied to fit the ASCA data also underestimates the contribution of this component in the 4-6 keV band. Following this line of reasoning, if we use a model with reflection normalization $\Omega/2\pi = 1.5$ we find that: 1) a large fraction of the flux previously attributed to the red wing is now produced by the reflection component 2) the data is still in excess of the model, suggesting the presence of an emission component other than the powerlaw and the reflection. A further complication comes from the Fe K-edge around 8 keV, observed by GINGA and not seen by ASCA. Inspection of our spectrum shows some interesting but rather complex structure in the residuals around 8 keV. The picture simplifies considerably if we divide our observation in a low (source countrate lower than 1 cts/s) and a high state (source countrate higher than 1 cts/s) and accumulate separate spectra. As shown in Figure 3 the edge is present and variable in energy: in the low state it is centered below 8 keV while in the high state above 8 keV. A plausible interpretation is that the ionization state of the reprocessing matter which supposedly surrounds the primary source varies as a function of the intensity of the continuum. The effect of an edge of variable energy when accumulating a spectrum of the entire observation would be to produce a depression in the continuum in the region between 7 and 9 keV.

3.2. NGC 4151

NGC 4151 has been observed for about 40 ks during the SVP. The observation is divided into 2 periods separated by about 200 ks. In the first period the source countrate for the 3 MECS is about 1.2 cts/s increasing to 2.1 cts/s in the second period. A description of the broad band spectrum can be found in Piro et al. in these proceedings. In this presentation we focus on the MECS data. In Figure 4 we report the low (first period) and high (second period) state spectra of NGC 4151. To avoid calibration uncertainties the

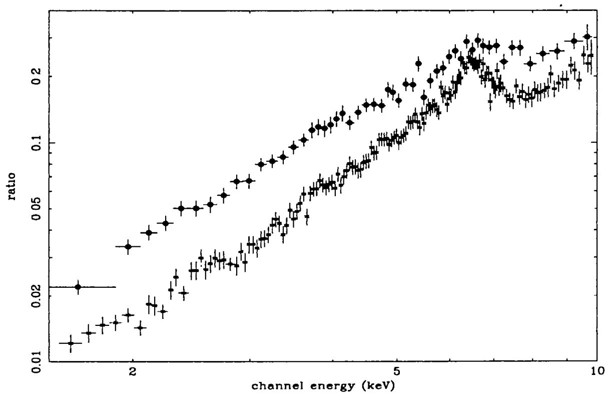

Fig. 4. Ratio, in arbitrary units, of the NGC 4151 to Crab Spectrum. The open circles represent the high state and the crosses the low state.

reported spectra are obtained by dividing the NGC 4151 spectra by the Crab spectrum. The shape of the continuum is different in the two states, in the sense that the source is softer when it is brighter, as seen in previous observations of this source (e.g. Perola et al 1986, Yaqoob & Warwick 1991). On the contrary the K_α line intensity has not changed substantially (a similar behaviour has been found in GINGA data Yaqoob & Warwick 1991). This result indicates that the region responsible for the emission of the line does not experience a significant variation of the ionizing continuum between the first and second period. A possible interpretation is that the size of the line emitting region is larger then 200 kilo lightseconds.

3.3. The Cosmic X-ray Background

While the satellite was recovering from a minor failure in July 1996, SAX was placed in default pointing mode, that is with the solar panels pointing directly towards the sun and the Narrow Field Instruments (NFI) pointing in the direction of Polaris. During this period a long (100 ks) exposure was performed with the MECS. Since Polaris is not a detectable X-ray source this observation can be considered as a first deep pointing of a "blank" area of the high galactic latitude sky. The limiting sensitivity of the field, roughly estimated as the flux of the weakest detectable source, is $\simeq 6\times10^{-14}$ erg cm^{-2}s^{-1} in the 2-10 keV band. A first inspection of the central and most sensitive region of the detector reveals that the number of detected sources is consistent with that estimated by ASCA (Ogasaka et al. 1996 and Cagnoni et al. these proc.)

In Figure 4 we show the Cosmic X-ray Spectrum obtained by subtracting the "dark earth" spectrum (i.e. a 100 ks spectrum obtained by summing up observing periods during which the satellite NFIs were pointing in the direction of the dark earth) from the Polaris spectrum. Both spectra have been accumulated from the central circular region of the 3 detectors using an extraction radius of 8.4 arcminutes. The Cosmic X-ray Spectrum was fitted with a power-law plus galactic absorption model yielding the following best fitting parameters for the photon index and the normalization: $\Gamma =$

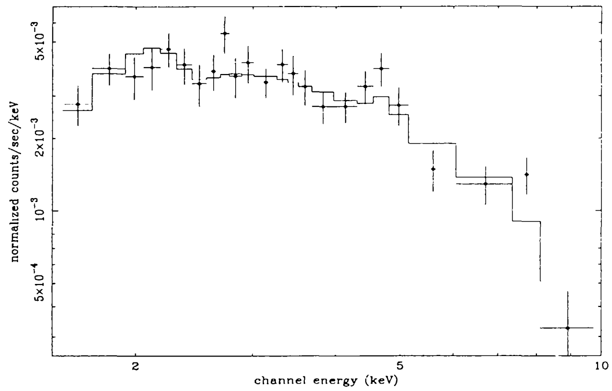

Fig. 5. Spectrum of the Cosmic X-ray Background, the normalization is in arbitrary units. The solid line represents the best fitting absorbed power-law model.

$1.47^{+0.11}_{-0.15}$ and $A = 11.9^{+1.7}_{-2.0}$ keV $cm^{-2}s^{-1}sr^{-1}keV^{-1}$, were the quoted intervals are 68.3% confidence intervals on 2 interesting parameters (i.e. $\Delta\chi^2 = 2.3$) These numbers are in agreement with those derived from simultaneous fitting of ROSAT + ASCA background spectra (Chen et al. 1997)

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