A monitor of the diffuse Cosmic X-ray Background

Abstract

We propose a monitor that attempts to measure the diffuse Cosmic X-ray Background (CXB) in the 10-100 keV energy band with unprecedented precision, so as to: 1). help to understand the source population of the CXB, most of which are proposed to be Active Galactic Nuclei (AGNs); 2). study the anisotropy of the CXB intensity over the sky, which helps to understand the large-scale structure of the Universe. An obstacle of the above studies is the difficulty of measuring the absolute intensity of the CXB. Detectors working at X-ray bands suffer from time-dependent backgrounds which are hard to be subtracted. Our design is similar to the projected MVN (Monitor Vsego Neba) Russian experiment, which mainly consist of four collimated spectrometers with a rotating aperture shutter on top. In this paper, we will show its performance simulations and some preliminary setup of the prototype, we will also discuss some launch opportunities.

Introduction

- The diffuse Cosmic X-ray background (CXB) was first revealed during a rocket flight [1].
- Its high isotropy, measured by *Uhuru*, suggested an extragalactic origin [2].
- Active Galactic Nuclei (AGNs) are the primary contributors to the CXB flux below 10 keV [3].
- Some experiments used an on-board obturator (HEAO-1) or Earth occultations [4] to separate the CXB from other components. The uncertainty on the CXB normalization is of the order of 20%.
- Synthesis models of the CXB rely on integrated AGN luminosity functions, obscuration distributions and spectral templates.
- Hard X-ray observations indicates that only 10-15% of Seyfert 2s are Compton thick [5, 6].
- The uncertainties on the CXB hard X-ray spectral shape and of its normalization is a major source of difficulty for the synthesis models, the CXB flux need therefore to be determined with a much better accuracy.
- We follow a similar idea with the Russian MVN (Monitor Vsego Neba) instrument [7] (not yet launched), for a collimated instrument surveying the sky through a rotating obturator.

Construction

Our design is mainly consist of four collimated spectrometers with a rotating obturator on top. The major components are listed below.

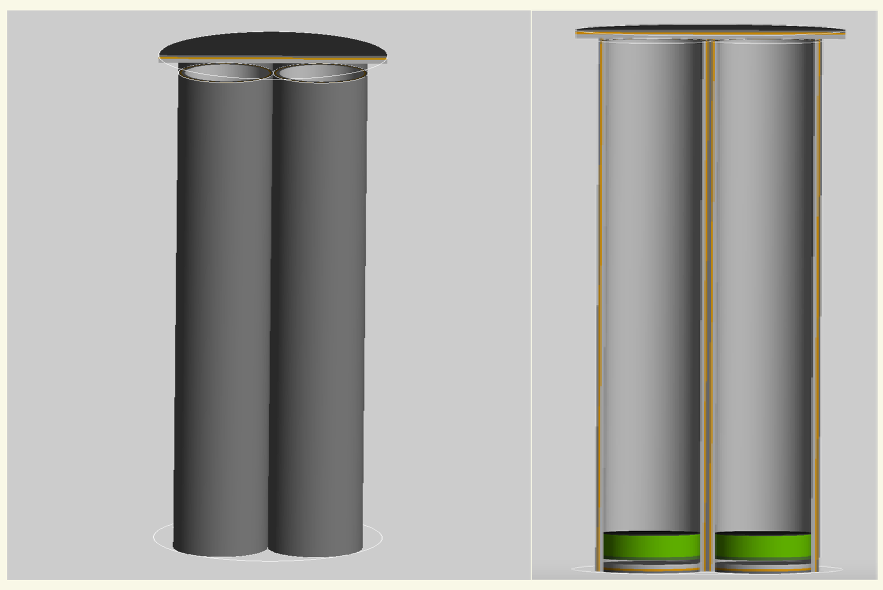

Figure: 1. A simplified construction drawn by [8] . Left: the shutter and four collimated spectrometers. Right: a vertical section of them, where you can see the layers of collimators, and inside spectrometer modules. One tube: diameter 51 mm, length 500 mm, FoV 26 deg^2.

- Collimator, a sandwich layers. From inner to outer: Aluminium (2 mm), Copper (1 mm) and Tin (1 mm). Calibration sources could be attached.
- Crystal, $CeBr_3$ (Radius 51 mm, Thickness 20 mm).
- SiPM array, channel quantity and size of a channel to be determined.
- Wheelwork, to drive the obturator and its contrarotation rotor that aiming to counteract total torque.

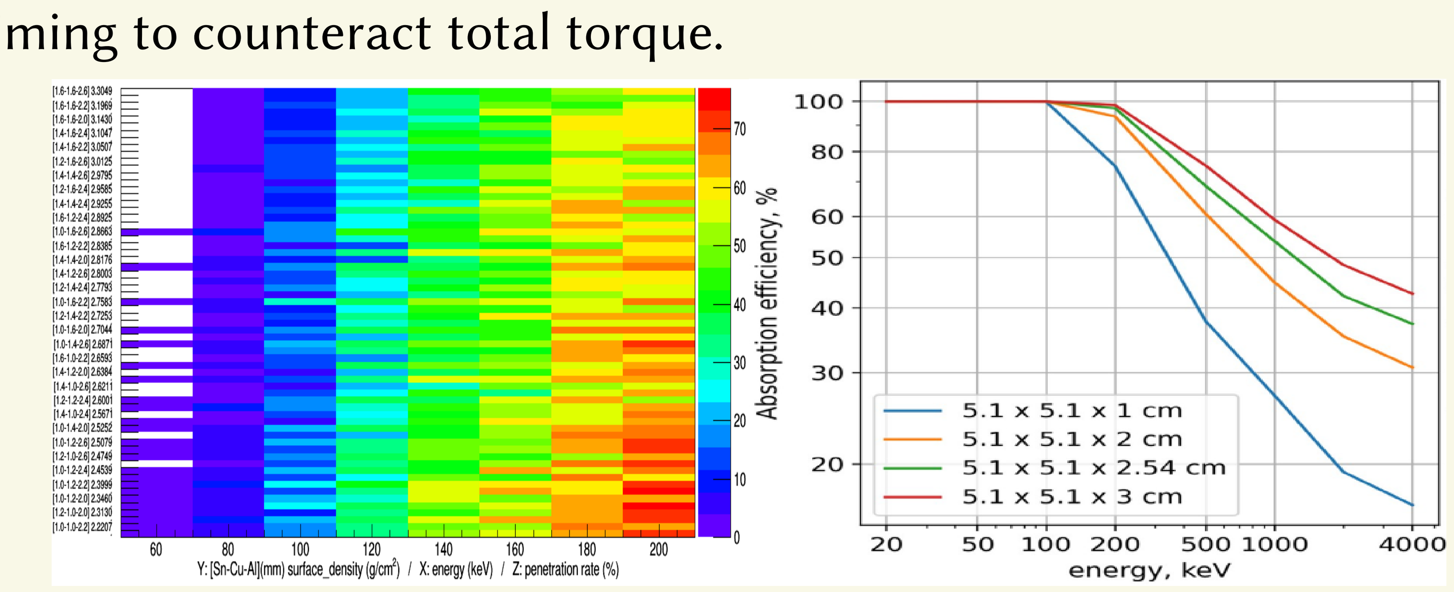

Figure: 2. Left: transparency of collimator with different thicknesses. Rigth: absorption efficiency v.s. energy for different thicknesses of $CeBr_3$ [9].

Simulation

Based on the simplified construction, we employ Geant-4 framework [8] to build the mass model of the detector. In a static analysis, the shutter is fixed. The effective area of two types of tubes are shown in Figure 3. We use spectrum models of the CXB [10] and the Crab pulsar [11] to obtain the predicted count rate of both them (Figure 4), a significant difference between two types of tubes allows to extract the CXB flux. In a dynamic analysis, the shutter is rotating, the changing of effective areas are shown in Figure 5. This move will change the effective area of the spectrometers, and modulate the CXB flux and other components.

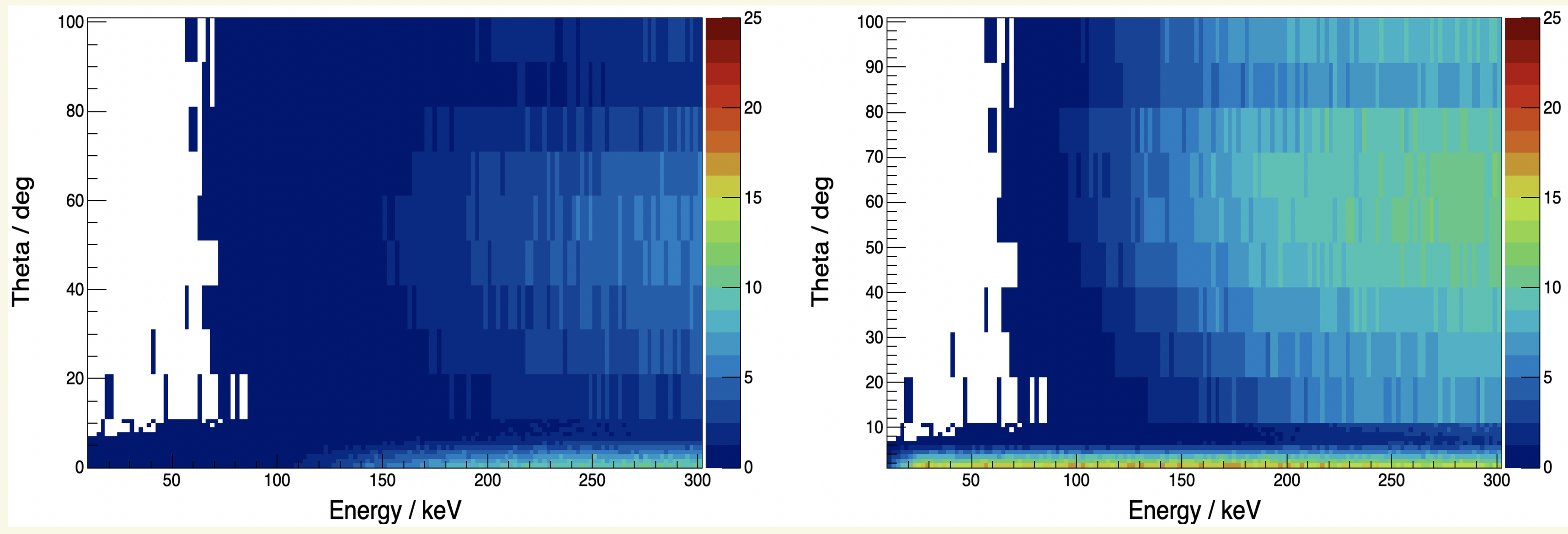

Figure: 3. Effective area as a function of theta and energy (one tube). The left plot is for obscured tube, and the right is for opened tube.

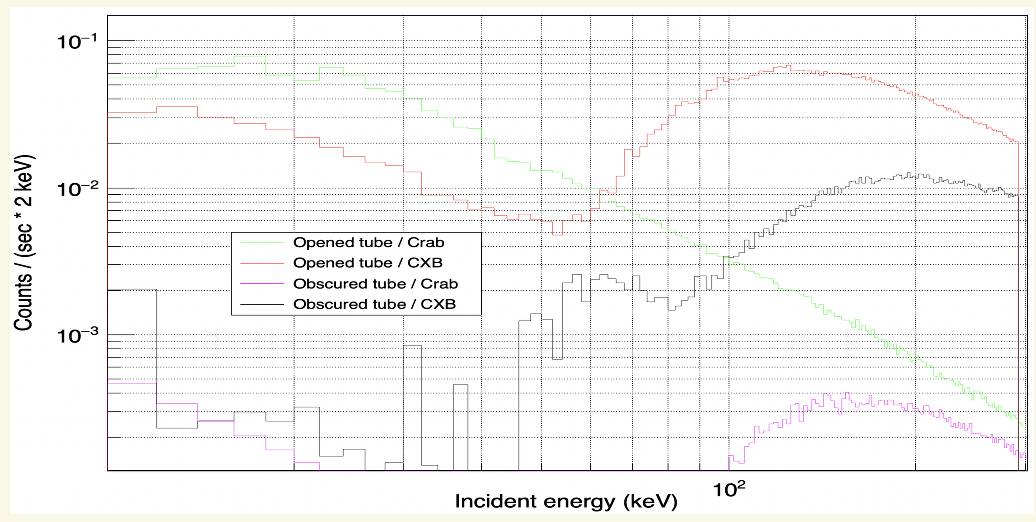

Figure: 4. Predicted count rate spectrum of both the CXB and the Crab pulsar (one tube). Different colors are represented for different tubes & sources.

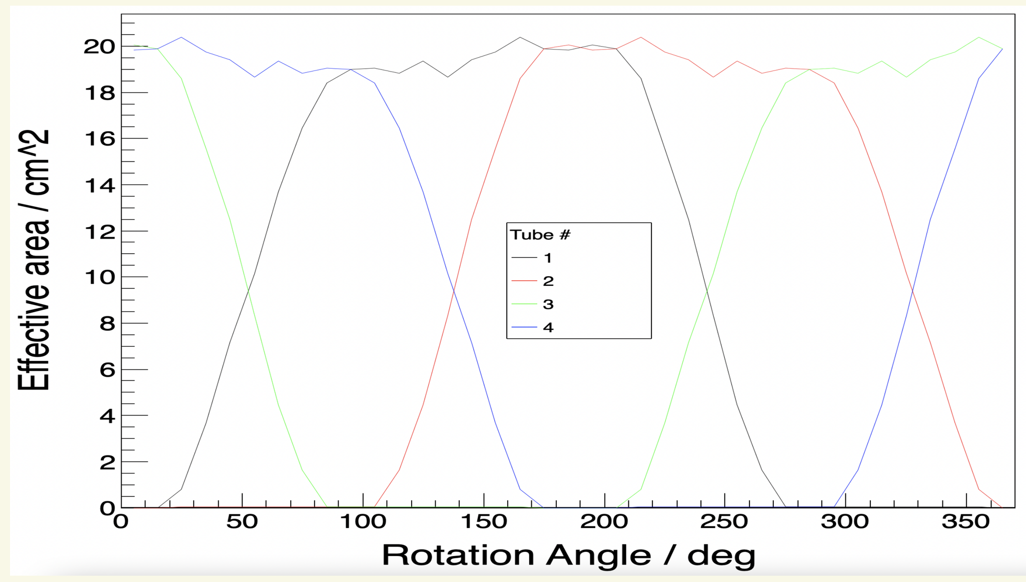

Figure: 5. The changing of effective area with the rotation phase of obturator.

Discussion and outlook

The performance simulation shows that this kind of detector is adequate for the CXB measurement. A lab prototype will be soon built in our lab to do verification tests, and to figure out how to apply an absolute calibration. This detector is feasible to be mounted on any space platforms. We will seek for launch opportunity.

References

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