Soft Gamma-ray Detector (SGD) for the NeXT Mission

The NeXT/SGD team

The SGD and the NeXT

To explore the frontiers of non-thermal universe: what causes the non thermal phenomena, and why it breaks the energy equilibrium.

The gamma-ray detector with quite high S/N ratio enables us to clearly resolve the photon spectra up to 300 keV, signals from the non-thermal universe Suzaku is touching. For bright historical sources, detection of the positron annihilation line and the linear polarization will directly show us the nature of the emission.

The Soft Gamma-ray Detector (SGD)

Low background: two orders of magnitude lower than that of Suzaku/HXD
Spectroscopy with a few keV resolution
Sensitivity to linear polarization

The Soft Gamma-ray Detector on NeXT

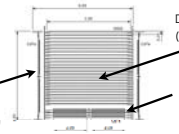
Basic Concepts

- Application of our novel Si/CdTe semiconductor Compton camera technology ("Narrow field of view (FOV) Compton camera")
- Utilize the background rejection concept developed for and proven with the Suzaku HXD ("the Well-type active shield")
- High commonality with the HXI system to secure high reliability
- Optimization to the NeXT mission's operation: finer collimation to be lined up with the narrow field of view focusing optics

Design

SGD requirements

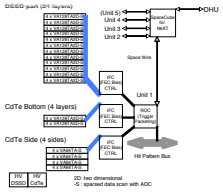
Energy coverage	10 - 300 keV
Effective area	>100 cm² (Photo-abs. mode, 10-100keV)
Detector FOV	< 0.6° x 0.6° (<100 keV)
Timing resolution	a few micro sec
Energy resolution	< 2 keV (FWHM) @60 keV
Detector background	<1 x 10^{-6} ph/cm²/s/keV
Operation temperature	-20°C



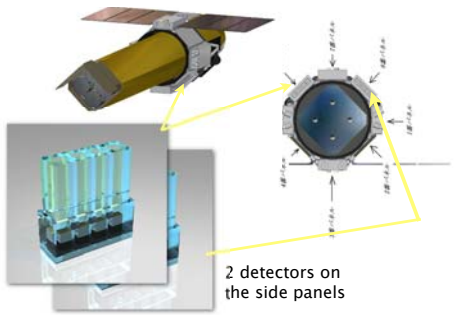
'03 design : Single large detector with 25 sub-units. Needs deployable bench structure to avoid the X-ray optics on top of the satellite interfering the FOV. Also requires very high density packaging technology.

'05 design : Optimized for < 300 keV. Two detectors each with 4 sub-units are mounted in the outmost panels of the satellite to secure FOV without deployment benches. Increase the weight margin and reduce the technical risks.

Data stream



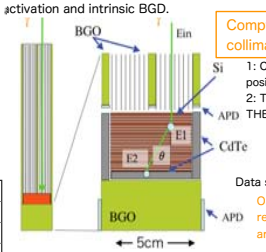
The NeXT new design and the SGD



2 detectors on the side panels

Our Novel Narrow FOV Compton Camera Concepts

Modern hard X-ray instruments are hitting the ultimate limit caused by activation and intrinsic BGD.



Compton Camera with fine collimated entrance window

1: Collimator and the two interaction position gives an angle
2: Two energy deposit value gives THE SAME ANGLE as follows

$$E_2' = \frac{(E1+E2)}{1+\frac{(E1+E2)(1-\cos\theta)}{m_e c^2}}$$

Data selection "1=2" --> BGD reduction

Only a new high density, high resolution semiconductor detector arrays can realize this idea

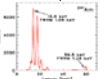
The most effective approach to obtain high sensitivity in the Sub-MeV regime, where the intrinsic angular resolution of Compton scattering is larger than several degrees. Also capable of linear polarimetry.

Verification

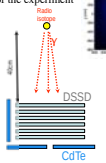
We have developed a high energy resolution DSSDs and CdTe pixel detectors. Obtained a Compton image below 100 keV for the first time.

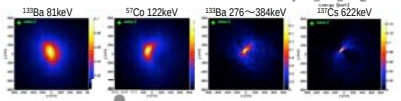
DSSD stacked system

DSSD spectra



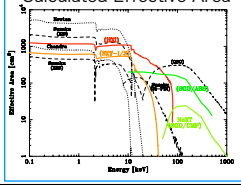
schematic view of the experiment



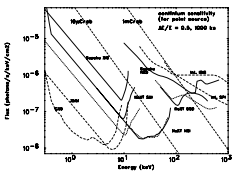


Brand new 40×40 mm² DSSD and shadow image

Calculated Effective Area



Continuum Sensitivity



Polarization Sensitivity