Monte Carlo Simulation Study of In-orbit Background for the Soft Gamma-ray Detector onboard ASTRO-H

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on behalf of the HXI/SGD team

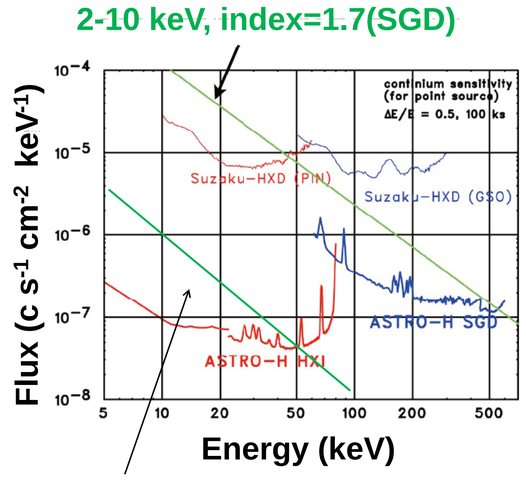
Summary: We are developing a Monte Carlo simulation framework to predict the background of SGD onboard ASTRO-H in orbit. We have been validating our system through comparisons with literature and experimental data, and successfully reproduced the beam test data.

Abstract

The Soft Gamma-ray Detector onboard the ASTRO-H satellite, scheduled for launch in 2014, is a Si/CdTe Compton telescope surrounded by a thick BGO active shield. The SGD covers the energy range from 40 to 600 keV and studies non-thermal phenomena in the universe with high sensitivity. For the success of the SGD mission, careful examination of the expected performance, particularly the instrumental background in orbit, and optimization of the detector configuration are essential. We are developing a Geant4-based Monte Carlo simulation framework on the ANL++ platform, employing the MGGPOD software suite to predict the radioactivation in orbit. A detailed validation of the simulator through the comparison with literatures and the beam test data is summarized. Our system will be integrated into the ASTRO-H simulation framework.

1. Introduction: *Soft Gamma-ray Detector (SGD) onboard ASTRO-H*

1 mCrab spectrum in 2-10 keV, index=1.7(SGD)

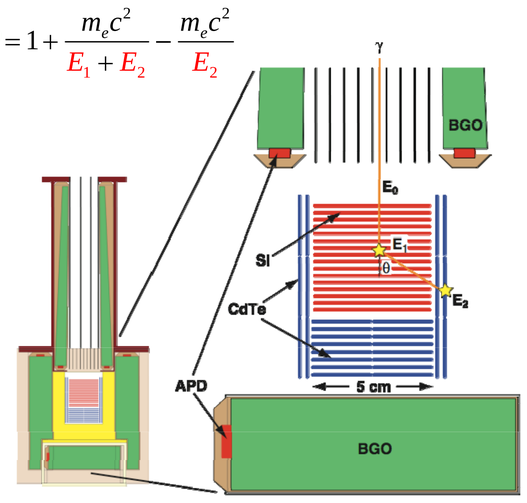


10 uCrab sources (HXI)

- **ASTRO-H:**
  - **scheduled for launch in 2014**
  - **4 instruments from soft X-ray to soft Gamma-ray**
- **HXI (Hard X-ray Imager)**
  - **5-80 keV**
  - **hard X-ray imaging spectroscopy**
- **SGD (Soft Gamma-ray Detector)**
  - **10-600 keV**
  - **narrow field-of-view Compton Camera**

HXI/SGD:
10-100 times higher sensitivity than previous missions

$$\cos\theta = 1 + \frac{m_e c^2}{E_1 + E_2} - \frac{m_e c^2}{E_2}$$



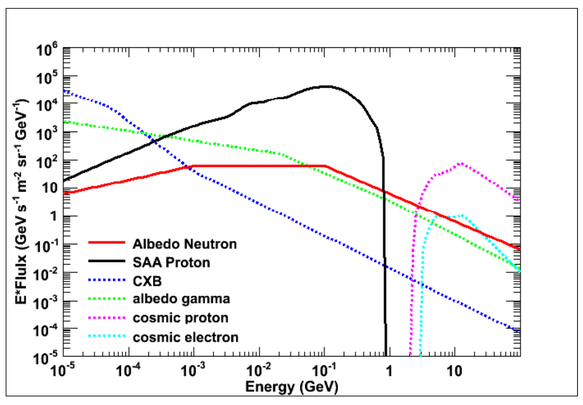
SGD key features:

- **BGO active shield (10deg. FOV) and Fine collimator passive shiled (0.5-1 deg FOV)**
  - **reduction of the BG and source confusion**
- **closely-packed Si/CdTe Compton Camera**
  - **require the reconstructed incident photon direction to be consistent with its presence within the FOV, to further reduce the BG**

2. Simulation Framework: *ANL++, Geant4 and MGGPOD*

- **ANL++ (Ozaki et al. 2006, Terada et al. 2005)**
  - **simulation platform which mandates the modular design of the analysis software**
- **Geant4**
  - **state-of-the-art simulation toolkit with powerful geometry description and particle tracking/recording features**
- **MGGPOD (Weidenspointner et al. 2005)**
  - **predict the radioactivation of instrumental materials in orbit**

Day-average cosmic-ray flux models:
- **key input to the background simulation**



The sequence of sim. steps to predict the activation BG:
- **radioactivity predicted by MGGPOD will be fed into the SGD simulator**

Table 2. The sequence of simulation steps used to predict the SGD radioactivation background.

	Step 1	Step 2	Step 3
Input	Mass model and radiation environment	Isotope production rates and radiation history	Mass model and activity per isotope and volume
Tool	MGGPOD (MGEANT, GCALOR, PROMPT)	MGGPOD (ORIHET)	Geant4 and ANL++
Output	Isotope production rates	Activity per isotope and volume	Delayed energy deposit

3. Verification of Simulator: *Comparison with the Beam Test Data*

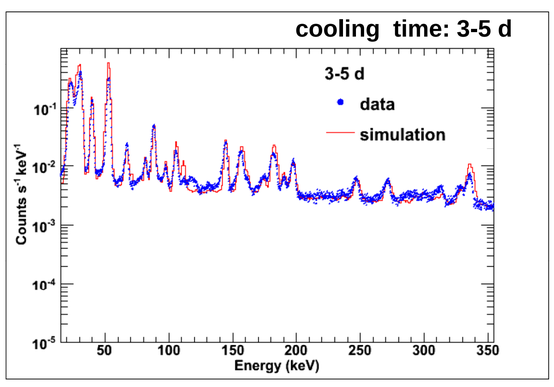
- **Through careful comparisons of the simulator with literature and beam test data, we have identified several issues to be addressed and fixed them:**
  - **incomplete treatment of fluorescent X-rays following the electron capture (Geant4)**
  - **inaccurate branching ratios of some isotopes into the ground state and isometric state (MGGPOD step2)**
  - **lack of isomers in the produced isotope list (MGGPOD step1)**

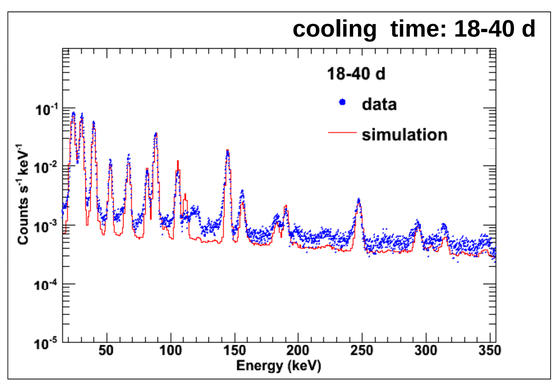
150 MeV protons (typical energy of SAA protons for materials inside the BGO shield)

CdTe or FC

(Murakami et al. 2003)

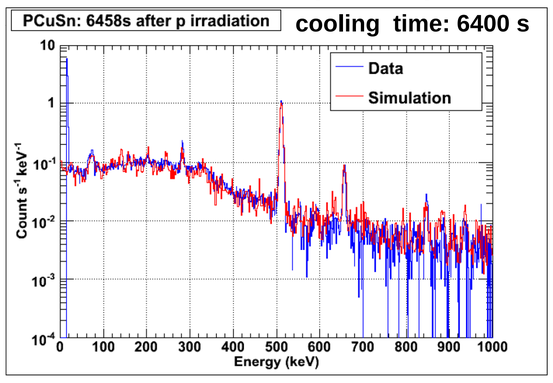
CdTe: data vs. simulation

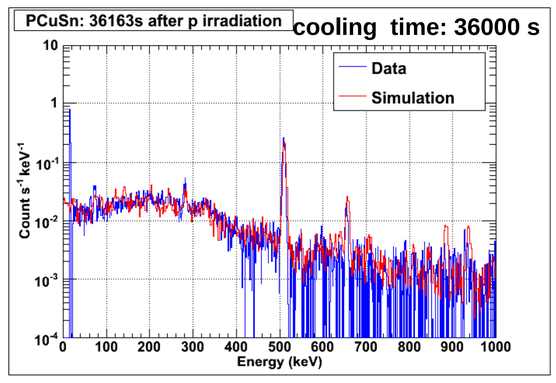




Fine Collimator (PCuSn): data vs. simulation

radioactivations of CdTe (internal measurement) and Fine Collimator (external measurement) are well reproduced by the simulation





- **We have a solid basis to predict in-orbit background of the SGD**
- **Study of event selection in progress**

Reference

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