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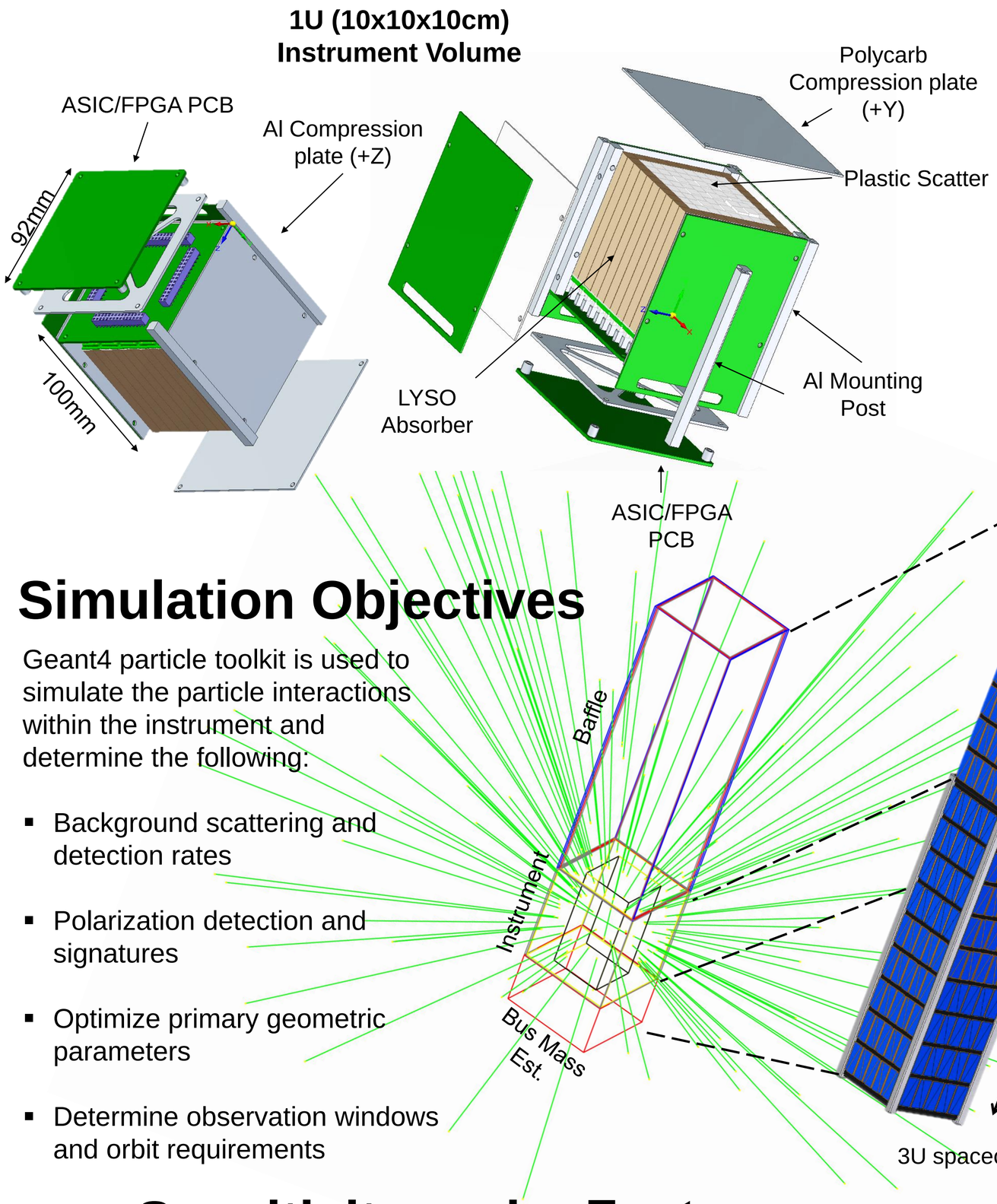
Simulation of an X-ray/Gamma-ray Polarization CubeSat

Jared Fuchs, Lucas Capps, and Jeren Suzuki - College of Science

Introduction

POLARIS is a Compton scattering polarimetry detector that measures scattering in the azimuthal plane by a segmented center of low density plastic scintillator surrounded by segmented high density LYSO scintillator. If an incident photon is polarized it will cause a non-uniform distribution of scattering in the azimuthal plane at 90º from the E-field vector.



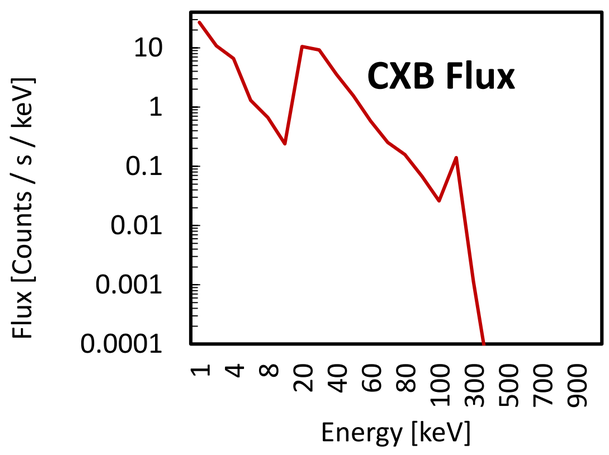
Simulation Objectives

Geant4 particle toolkit is used to simulate the particle interactions within the instrument and determine the following:

- Background scattering and detection rates
- Polarization detection and signatures
- Optimize primary geometric parameters
- Determine observation windows and orbit requirements

Background Rates

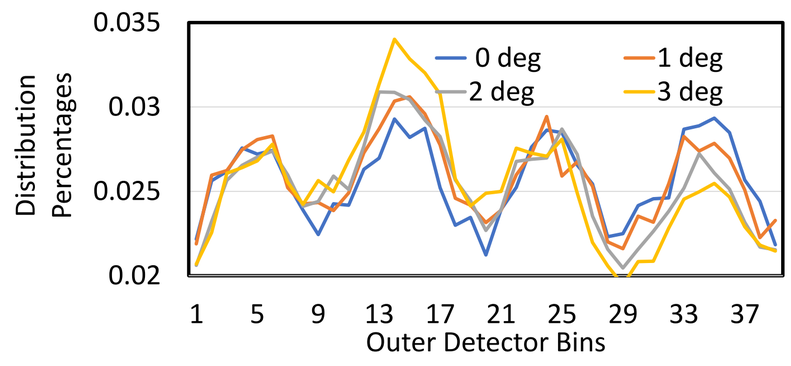
A spherical background source with different particle spectrums is used to determine the interactions percentages for any given spectrum. Results for the cosmic x-ray background (CXB) and galactic cosmic rays (GCR) are shown



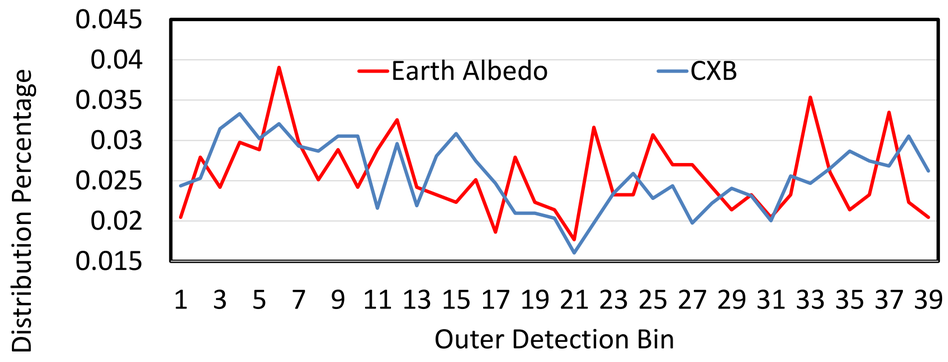
Background Rates		
Low Cutoff Threshold [keV]	CXB Rates [cnts/s]	GCR Rates [cnts/s]
0	219	207
30	45	203
50	38	203
800	0	193

Systematics

An off axis source beam at an angle incident on the surface is used to see how false polarization signatures might be induced.

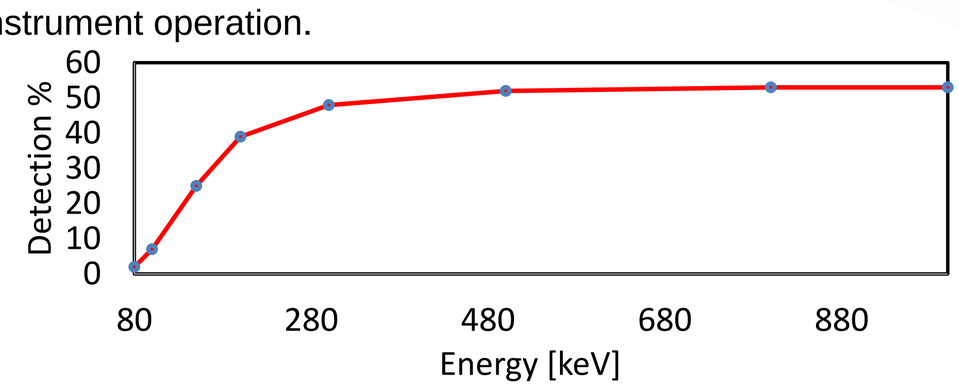


Secondly we consider a differential background spectrum, as would be seen on orbit between the Earth albedo and CXB, might skew bin populations towards one side of the instrument.

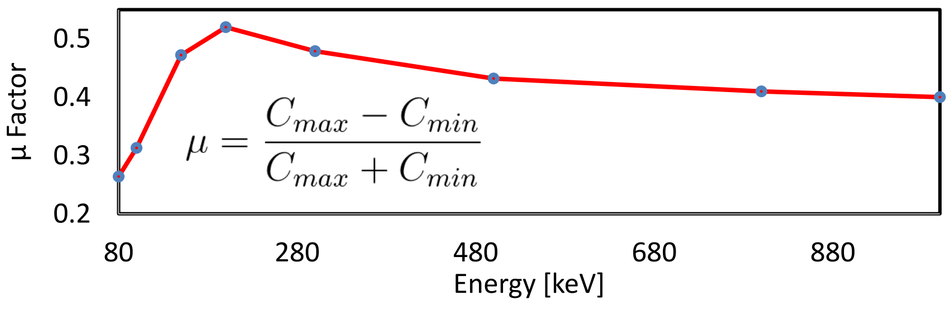


Sensitivity and μ Factor

A monoenergetic beam is incident on the face of the instrument, an event logic of 20keV energy deposition and coincidence events in both the scatter and absorber elements is applied to simulate actual instrument operation.

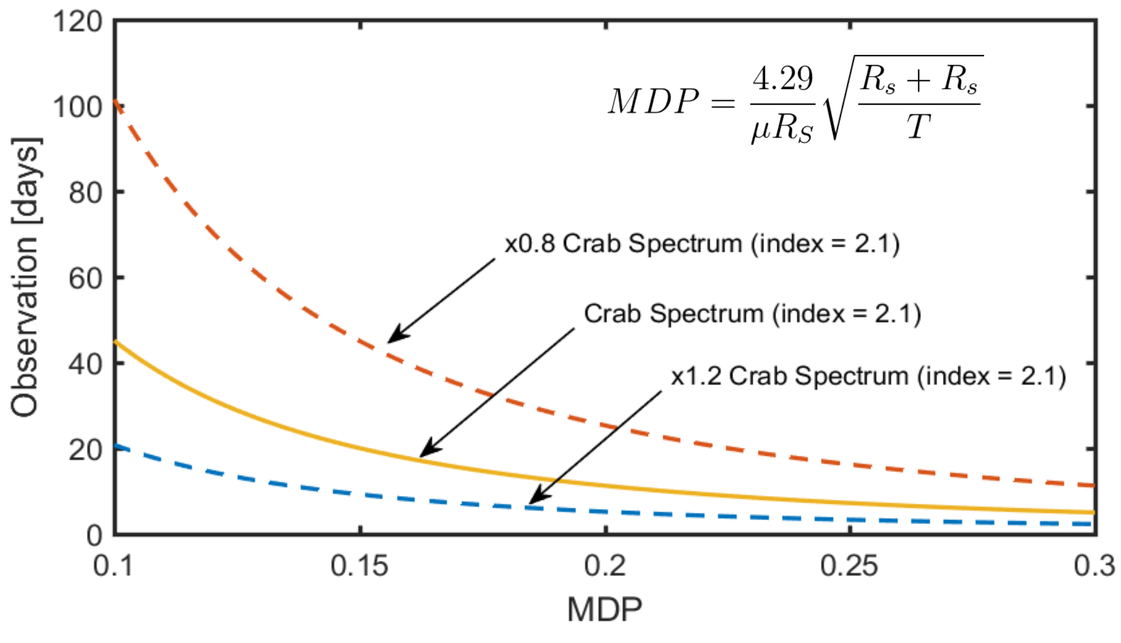


The μ factor is calculated for the monoenergetic by considered the maximum and minimum counts in the absorber bars (equation in the figure below). This is a key factor of polarization signatures.



Results

Taking the simulations of the primary instrument factors of sensitivity, μ, and background we plot the observation time required to detect a minimum detectable polarization (MDP) to 99% confidence. The Crab SNR is used as an example of the observations time windows needed for typical X-ray/Gamma-ray sources



Acknowledgements

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