Contribution ID: **167** Type: **Poster presentation + pitch**

Hexagonal Pixel Multi-element Germanium Detector For Synchrotron Applications: Simulation of Detector Performance

One of the major limitations of the X-ray Absorption Spectroscopy (XAS) experiment at synchrotron facilities is the performance of the detectors. In order to be able to measure more challenging samples and to cope with the very high photon flux and input count rate of the current and future light sources, technological developments to enhance the performance of various detectors are necessary. In this paper, a performance study of potential configurations of a monolithic multi-element germanium detector is presented.

In this context, the signal-to-background ratio and energy resolution are two key detector features that characterize the detector performance, especially for complex targets and at high throughput where a weak fluorescence peak from an element trace must be discriminated from the elastic peak or other more intense element lines. One of the options to increase the throughput of photons is to reduce the pixel size and therefore increase the number of photons per unit area. Hence, monolithic multi-element detectors with hexagonal pixels have been proposed for XAS applications mainly to maximize the compactness and granularity of the traditional multi-element germanium detectors. One of these proposals is a demonstrator composed of a monolithic Ge sensor with the backside electrode segmented in 19 hexagonal pixels of 2 mm inner diameter. [1]

In this work, the detector response for different configurations is simulated. A simulation chain combining both Allpix2 Simulation [2] with 3D electrostatic field simulation performed with COMSOL Multiphysics® has been used in this study. The previously mentioned simulation chain has been validated with experimental data [3]. In addition, new features in the Allpix2 framework have been implemented to model hexagonal pixel shape.

Several configurations of a new generation of multi-element germanium detectors have been studied. The results present a comparison of the detector response in these different cases in terms of signal-to-background ratio, signal and background efficiency as well as the charge sharing effect in these configurations for direct X-ray beam in the energy range (0-80 keV). In addition, these simulations help to build a trusted simulation model to be used in studying variant hexagonal shaped germanium detector for future applications.

Keywords: Charge sharing, hexagonal pixel, HPGe, semiconductor radiation detectors, X-ray detectors, X-ray spectroscopy.

References:

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Session Classification: Poster session 2

Track Classification: Sensor Materials, Device Processing & Technologies