Monte Carlo simulations of Compton polarimeter systems

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Compton polarimetry has proven to be a powerful tool to measure the linear polarization of hard x-rays. In the GSI atomic physics department, several measurements of this type have been carried out using a lithium-drifted silicon (Si(Li)) double-sided strip detector (DSSD) [1,2]. This device works well in a photon energy range of about 60 keV to 150 keV. An extension to higher energies can be achieved by using a heavier detector material. In this work, germanium DSSD has been simulated, using concepts from previous simulations of the same type [3]. For the low-energy region of about 20 keV to 80 keV, an entirely new concept for Compton polarimetry is proposed: the polarimeter consists of a low-Z cylindrical scatterer and - around it - a ring of individual high-Z absorber plates. Each of these plates is a high-resolution microcalorimeter which is a novel development of the "Magnetic Calorimeters" group in Heidelberg [4]. In this work, the efficiencies of both polarimeter systems have been investigated in Monte Carlo simulations using EGS5 [5]. In both cases, this quantity was given by the fraction of identified Compton events. Simulations were carried out for different polarimeter configurations and for different photon energies.

The geometry the germanium DSSD has always been choosen to be symmetric in x- and y-direction. Also, the strip width was fixed at 1 mm. The parameters varied were the number of strips (this number for each direction x and y) and the detector thickness (z-direction). First, results were obtained for a point-like (p) incidence in the center of the detector, then the incoming photons were spread over the detector area (s). Results are shown in figure 1.

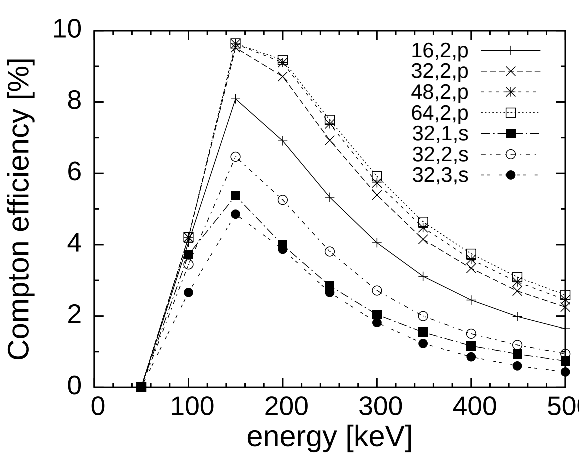

Figure 1: DSSD results. Legend format: number of strips, detector thickness [cm], incidence spread (p=no, s=yes).

For the microcalorimeter polarimeter, the following geometry has been considered: the scattering cylinder had a diameter and length of 1 mm. The area of the absorber plates (here: gold) facing the scatterer was 1 mm by 1 mm, the absorber thickness 0.2 mm. The radius of the absorber ring was dervied from the requirement that one absorber covers the θ-range of $90° \pm \Delta\theta$. The angular acceptance $\Delta\theta$ was choosen here according the number of absorbers to minimize the gaps between them. So far, three configurations have been simulated: 40 absorbers and $\Delta\theta = 3.5°$ with (1) a beryllium and (2) a carbon scatterer, and (3) 31 absorbers and $\Delta\theta = 5.8°$ with a carbon scatterer. Figure 2 shows the microcalorimeter simulation results.

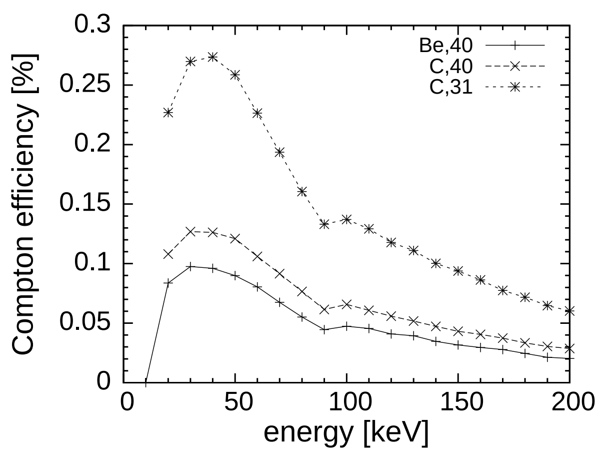

Figure 2: Microcalorimeter results. Legend format: scatterer material, number of absorbers.

References

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