Characterization of a Si(Li) Compton polarimeter for the hard x-ray regime, using synchrotron radiation.*

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Novel highly-segmented semiconductor detectors which combine a good detection efficiency, energy and time resolution, together with millimetre to sub-millimetre position sensitivity, represent a versatile tool for Compton polarimetry in the hard x-ray regime [1]. Such detection systems have recently been introduced for the investigation of radiative processes involving high-Z ions in collisions with gaseous matter at the storage ring ESR [2,3,4] as well as in electron-atom collisions at the TU Darmstadt [5].

In the present experiment, a novel Si(Li) Compton polarimeter [6], which was developed for experiments at the international FAIR facility, has been tested at the DESY PETRA III beamline P07-EH1. For this purpose, the detector was exposed to the synchrotron radiation. Since the synchrotron radiation is nearly 100% linearly polarized, we were able to test the detector performance as an x-ray polarimeter for photons in the hard x-ray regime.

Figure 1 shows the Si(Li) detector response to the incident synchrotron radiation. The monochromator of the beamline was set to 57.3 keV. The clearly visible line at 161.1 keV could be identified as the third harmonic. The broad structures at lower energies belong to recoil electrons of the Compton-scattered photons.

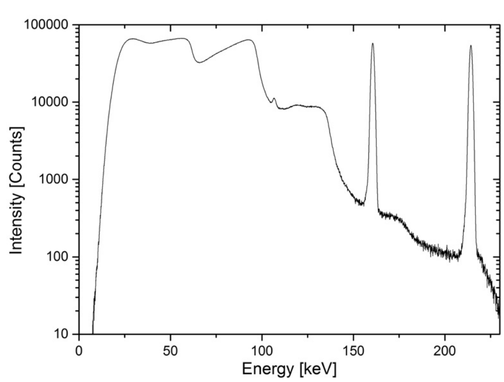

Figure 1: Si(Li) detector response to the incident synchrotron radiation.

Figure 2 shows the position distribution of Compton scattered photons inside the Si(Li) detector crystal. In this case, only the 161.1 keV incident photons of Figure 1 and only polar scattering angles of 90°+-10° are taken into account. The incoming x-ray beam was centred on the centre of the detector. Compton recoil electrons (spot in the centre of Figure 2) have been detected in coincidence with the corresponding Compton scattered photons. To reconstruct the whole kinematic process, each pair of Compton-electron and Compton-photon has been quantified in position and energy.

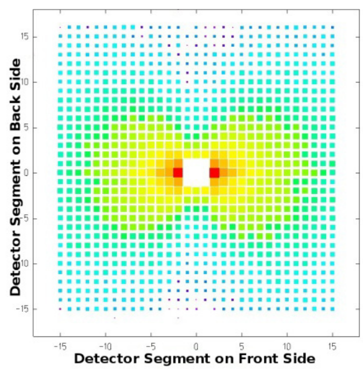

Figure 2: The position distribution of Compton scattered photons inside the Si(Li) detector crystal for 161.1 keV incident photons. The strong anisotropy indicates the high degree of linear polarization of the incident synchrotron radiation.

According to Klein-Nishina equation, the photons are scattered mostly perpendicular to the incident photon electric field vector (polarization axis). This is clearly reflected in the strong azimuthal anisotropy of Figure 2, which indicates a very high degree of linear polarization, typical for synchrotron radiation facilities. The degree of linear polarization as well as the polarization orientation of the incident radiation can be reconstructed apllying a least-squares adjustment to the azimuthal scattering distribution [7].

We have acquired the Compton scattering data for different x-ray energies as well as different detector orientations. The evaluation is currently under way.

References

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