



Contribution ID: 21

Type: Oral

IBEX based CdTe Detectors for Spectral Applications at High X-ray Energies

Tuesday 26 June 2018 10:50 (20 minutes)

IBEX is a versatile readout ASIC developed at DECTRIS as successor of PILATUS and EIGER [1] that can be operated in electron collection mode to count the number of X-ray photons absorbed in pixelated CdTe sensors. Since it also implements multiple energy thresholds, it is very well suited for spectral applications at X-ray energies up to 160 keV. To quantify how well photons of different energies can be separated, we recently introduced a quantity called Spectral Efficiency [2]. This figure of merit is defined as the fraction of the incoming photons that is measured within a certain energy window around the incident photon energy. The Spectral Efficiency of IBEX based detectors with different pixel sizes was measured at the BAM beamline at BESSY as a function of the photon energy and flux. The results show very good agreement with the outcome of detailed Monte-Carlo simulations. The Spectral Efficiency turns out to be a very useful tool to quantitatively optimize the pixel size for spectral applications. For a given photon flux it allows finding the ideal pixel size that simultaneously minimizes the effects of charge sharing and pulse pile-up.

Some novel medical applications, such as molecular imaging using gold nanoparticles, require the energy threshold to be set above 75 keV. For a uniform response of all pixels, an accurate equalization of their energy thresholds is essential. Since fluorescence radiation above the $K\alpha$ doublet of Pb is not practically available, an alternative energy reference point like the end-point of an X-ray tube spectrum has to be used. Due to the finite energy resolution of the ASIC, the measurement of the position of the end-point is not straightforward. However, by using a very simple model to describe the spectrum, we found a reliable way to use the end-point for accurate threshold equalization. The procedure has been validated with 140.5 keV photons from a ^{99m}Tc source at the Nuclear Medicine Department of the Kantonsspital Baden. The energy threshold is found to only deviate by 0.5 keV from the nominal value and the response is very uniform with a threshold dispersion as low as 1.7 keV rms.

[1] Bochenek, M. et al. (2018), IBEX: Versatile Readout ASIC with Spectral Imaging Capability and High Count Rate Capability. Submitted to Transaction on Nuclear Science

[2] Trueb, P., Zambon, P. and Broennimann, C. (2017), Assessment of the spectral performance of hybrid photon counting x-ray detectors. Med. Phys., 44: e207-e214. doi:10.1002/mp.12323

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Session Classification: Oral

Track Classification: general