



iWoRiD 2022

23rd International Workshop on Radiation Imaging Detectors

26 – 30 June 2022

Riva del Garda, Italy

Contribution ID: 190

Type: Poster

Optimization of energy threshold for fluorescence rejection in K-edge subtraction in synchrotron-based imaging with a spectral CdTe detector

Monday, 27 June 2022 17:23 (1 minute)

K-edge Subtraction (KES) X-ray imaging is used to single out and quantify the presence of a contrast agent embedded in a biological matrix, and its most well-known application is in the field of cardiovascular imaging [1]. KES exploits the sudden increase of the linear attenuation coefficient of the contrast material corresponding to its k-shell electrons binding energies that, for commonly used contrast agents (e.g., iodine, barium, gadolinium), is in the range from 30 to 50 keV.

By acquiring two images at different energies, respectively above and below the k-edge, and performing logarithmic subtraction, it is then possible to highlight the presence of the sole contrast medium avoiding anatomic noise. This, in traditional systems, is typically accomplished by using two different energy spectra (dual-energy) or a layered detector (dual-layer). In this context, the advent of photon-counting detectors (SPCDs) with pixel-by-pixel energy discriminating capabilities is revolutionizing the field of KES imaging. Specifically, the possibility of acquiring in a single shot two (or more) images over different energy bins brings to a great simplification of the imaging system, where only one spectrum and one detector are required, and allows to target, in principle, any contrast medium without changing the hardware. On the other hand, the spectral response of SPCDs featuring high-Z sensors (e.g., CdTe) is significantly affected by the presence of fluorescence and escape photons generated within the sensor. These effects, along with threshold calibration and energy resolution, must be modeled and accounted for when performing KES imaging, to maximize image quality and/or reduce radiation dose.

In this framework, we report for the first time on a KES imaging study performed at the Gadolinium k-edge (50.2 keV) by using a spectral detector and an ad-hoc spectrally shaped (pink) synchrotron radiation (SR) beam at the Elettra synchrotron facility (Trieste, Italy). The used detector is Pixirad-PixieIII, featuring a 650 μm thick CdTe sensor, 512 X 402 pixels with 62 μm pitch, two tunable energy thresholds per pixel that can be both operated in the charge-sharing recovery (NPISUM) mode, leading to an energy resolution comprised between 3 and 4.5 keV [2]. The high intensity of SR allows to optimally shape the X-ray spectrum that can be centered at the k-edge energy and made sufficiently narrow to maximize KES signal while retaining a sufficient flux. Specifically, a low energy threshold optimization has been performed experimentally and cross-validated with a dedicated Geant4 simulation including a detailed description of the detector's energy response [3]. Results on Gd-filled phantoms show that a careful threshold enables for effective rejection of fluorescence, therefore, reducing the contamination between the two energy bins, this leading to a maximization of the gadolinium KES signal.

[1] W Thomlinson, et al., *Physica Medica* 49 (2018): 58-76

[2] V Di Trapani, et al, *Nucl. Instrum. Methods Phys. Res. A* 955 (2020): 163220.

[3] L Brombal, et al., *JINST* 17.01 (2022): C01043.

Primary authors: Prof. DELOGU, PASQUALE (University of Siena, Department of Physical Sciences, Earth and Environment, Siena, Italy and INFN Division of Pisa, Pisa, Italy); Dr BROMBAL, Luca (INFN Division of Trieste, Trieste, Italy); Prof. ARFELLI, Fulvia (University of Trieste, Department of Physics, Trieste, Italy and INFN Division of Trieste, Trieste, Italy); Dr DI TRAPANI, Vittorio (University of Trieste, Department of Physics, Trieste, Italy); Prof. BRUN, Francesco (University of Trieste, Department of Engineering and Architecture, Trieste, Italy and INFN Division of Trieste, Trieste, Italy); Prof. LONGO, Renata (University of Trieste, Department of Physics,

Trieste, Italy and INFN Division of Trieste, Trieste, Italy); Dr MENK, Ralf Hendrik (Elettra Sincrotrone S.C.p.A., Basovizza, Trieste, Italy and INFN Division of Trieste, Trieste, Italy); Prof. RIGON, Luigi (University of Trieste, Department of Physics, Trieste, Italy and INFN Division of Trieste, Trieste, Italy); Prof. OLIVA, Piernicola (Department of Chemical, Physical, Mathematical and Natural Sciences, University of Sassari, Italy and INFN Division of Cagliari, Cagliari, Italy)

Presenter: Prof. DELOGU, PASQUALE (University of Siena, Department of Physical Sciences, Earth and Environment, Siena, Italy and INFN Division of Pisa, Pisa, Italy)

Session Classification: Poster