Prague, Czech Republic June 21-25, 2021

Contribution ID: **54** Type: **Oral presentation**

#08-54 Deep Learning for Compton image reconstruction with Caliste miniature imaging spectrometer: An innovative approach to enhance detection sensitivity

Wednesday, June 23, 2021 11:00 AM (20 minutes)

Caliste is a miniature CdTe-based pixelated imaging spectrometer. The detector is a single plane 1 cm² crystal readout by 8 low noise full custom ASICs enabling high energy resolution. Thanks to its position sensitivity and its spectrometric performances, this detector is able to perform Compton imaging in order to localize radioactive point sources, emitting high-energy gamma-ray photons, and its compactness is advantageous to be the detection component of a portable Compton gamma camera. However, our current prototype is equipped with a small detection volume of 100 mm3 (1 mm thick). Because our detector is thin and the photon interaction positions are determined in 2D, Compton reconstruction in such a miniature single plane detector is challenging. More specifically, the 3D interaction position uncertainty in the crystal and the small detector volume are both critical limitations for efficiency and sensitivity of the detector for Compton reconstruction. Nonetheless, Compton reconstruction is possible and reported in the paper. Classical backprojection and more advanced algorithms in the literature, such as LM-MLEM (List-Mode Maximum Likelihood Expectation Maximisation) and SOE-RR (Stochastic Origin Ensemble with Resolution Recovery), require to detect at least an order of magnitude of 2000 Compton events to reconstruct a radioactive point source. With Caliste geometry, this necessitates at least 7 hours of acquisition to localize a 137Cs point source of an activity of 1.6 MBq at 30 cm from the detector, with a corresponding dose rate of 1.4 μSv/h at the detector level. In order to enhance the sensitivity of our tiny system, we develop in this work a Deep Learning approach to reconstruct Compton images from spectroscopic data and identify the position of point sources over 2π steradians field of view and we demonstrate the feasibility of this new algorithm for high-energy imaging. We train a Convolutional Neural Network (CNN) with a synthetic database to localize a point source from direct backprojections, computed by Monte-Carlo simulations. We apply this CNN to real data at the 662 keV line of 137Cs, acquired with Caliste and we show that we are able to reconstruct point sources with an order of magnitude of 200 Compton events. This corresponds to a sensitivity of about 150 nSv/h with only a 0.1 cm3 detector, which surpasses the performances of classical algorithms.

Primary authors: DANIEL, Geoffrey (CEA); LIMOUSIN, Olivier (CEA/DRF/Irfu/Département d'Astrophysique); Mr GUTIERREZ, Yann (CEA/DRF/Irfu/Département d'Astrophysique)

Presenter: DANIEL, Geoffrey (CEA)

Session Classification: 08 Decommissioning, Dismantling and Remote Handling

Track Classification: 08 Decommissioning, Dismantling and Remote Handling