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Application of Artificial Neural Network in 3D Imaging with Lanthanum Bromide Calorimeter

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Gamma-ray astronomy in the energy range from 0.1 up to 100 MeV holds many understudied questions connected with stellar nucleosynthesis, the active Sun, neutron stars and black holes. To access the physics behind, a significant improvement in detection sensitivity is needed compared to previous missions, e.g. CGRO and INTEGRAL. One of the promising concepts for a future gamma-ray mission is an Advanced Compton telescope. Under the project of creating a prototype of such instrument, we study the perspectives of using a novel inorganic scintillator as a calorimeter part. Modern inorganic crystal or ceramics scintillators are constantly improving on qualities such as energy resolution and radiation hardness, and this makes them a smart choice for a new space-borne telescope. At CSNSM Orsay, we have created a new detection module from a 5x5 cm^2 area and 1 cm thick, cerium-doped lanthanum (III) bromide ($LaBr_3$:Ce) inorganic scintillator coupled to a 64 channel multi-anode photomultiplier. The readout of the PMT signals is carried out with the ASIC MAROC, used previously for the luminometer of the ATLAS detector (CERN). Characterization, thorough measurements with various radioactive sources, as well as, single photoelectron detection have been done. Furthermore, we made a comparison of measurements with a detailed GEANT4-based simulation which includes tracking of the optical photons. Finally, we have studied the 3D reconstruction of the first interaction point of incident gamma rays, utilizing a neural network algorithm. This spatial position resolution plays a crucial part in the future implementations and, together with the other measured properties, it makes our detector module very interesting for the next generation of space telescopes operating in the MeV range.

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