Characterization of the TexNAAM detector

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The TexNAAM array is a detector to perform gamma spectroscopy in experiments studying nuclear reactions of astrophysical interest. The array is made of 16 NaI(Tl) detectors of size 11x5.5x40 cm^3. Each detector is coupled to a photomultiplier. A drawing of the TexNAAM array is shown in Fig. 1. The signal output from each NaI(Tl) detector is read directly by SIS3316 digitizers from STUCK. The array was assembled and tested in the laboratory with different gamma sources ^{137}Cs, ^{60}Co, and ^{22}Na. Count rates up to 15kHz were measured during the tests. The dead time of the system was evaluated by counting the events from an 11 Hz pulser fed to one of the channels. With the present configuration, the measured dead time is zero up to count rates of 5kHz and raise to 5% at 15 kHz. The energy resolution of each scintillator was measured as a function of the PMT bias. After a rough gain matching obtained by tuning the PMT bias, we performed an energy calibration using the three gamma sources mentioned above.

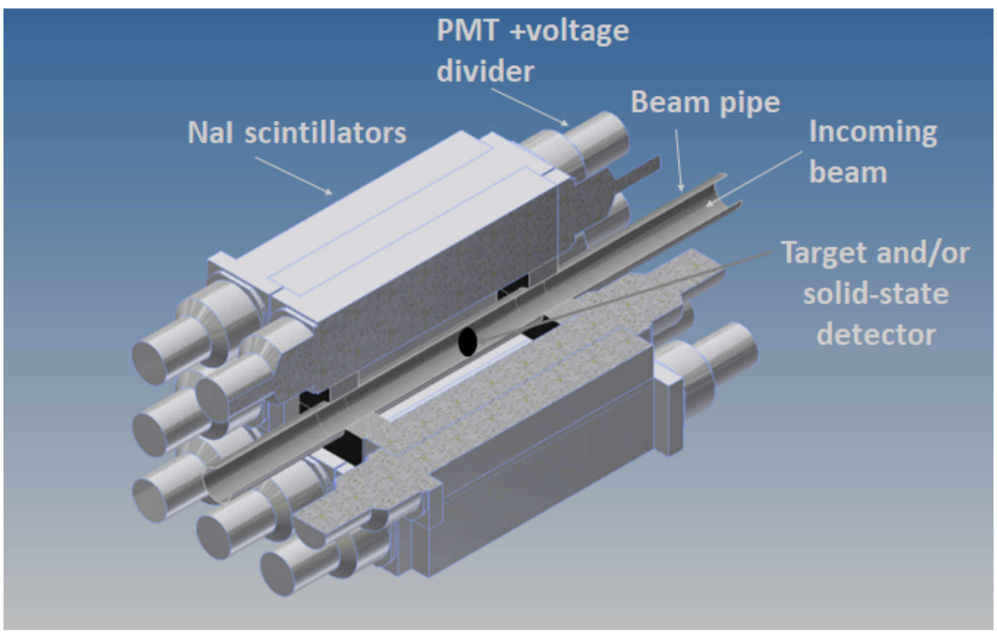

Fig. 1. Drawing of TexNAAM. The array top-right quarter is removed to allow the view of the interior of the assembly. Each scintillator is sealed in a 1mm-thick Aluminum case and coupled to the PMT through a glass window. The PMTs are surrounded by mu-metal.

We measured the photopeak efficiency of the system at 511 keV, 1173 keV, 1274 keV, and 1332 keV, using ^{60}Co and ^{22}Na sources of known activity. We compared the measured photopeak efficiencies with a Geant4 evaluation of the array's efficiencies for the ^{60}Co and ^{22}Na gamma sources. The efficiency from Geant4 is systematically 10-12% higher than the experimental value. Fig. 2 shows the experimental photopeak efficiency determined from the sum spectra and the corresponding Geant4 calculation. The causes of this discrepancy are under investigation. Using different physical models available in Geant4 did not produce significant differences in the calculated efficiency. The current simulation is based on the simulated gamma-ray energy deposit in the scintillators.

The loss of scintillation light due to the absorption in the crystal and the photocathode efficiency were not explicitly treated in the simulation. The loss of energy resolution due to these effects is accounted for, crystal by crystal, by folding the simulated energy deposit with the measured energy resolution as a function of the energy. For each scintillator, the experimental energy thresholds are also included in the simulation.

We did not consider the possible presence of an inactive layer on the crystal surface due to oxidation of the NaI(Tl) scintillator.

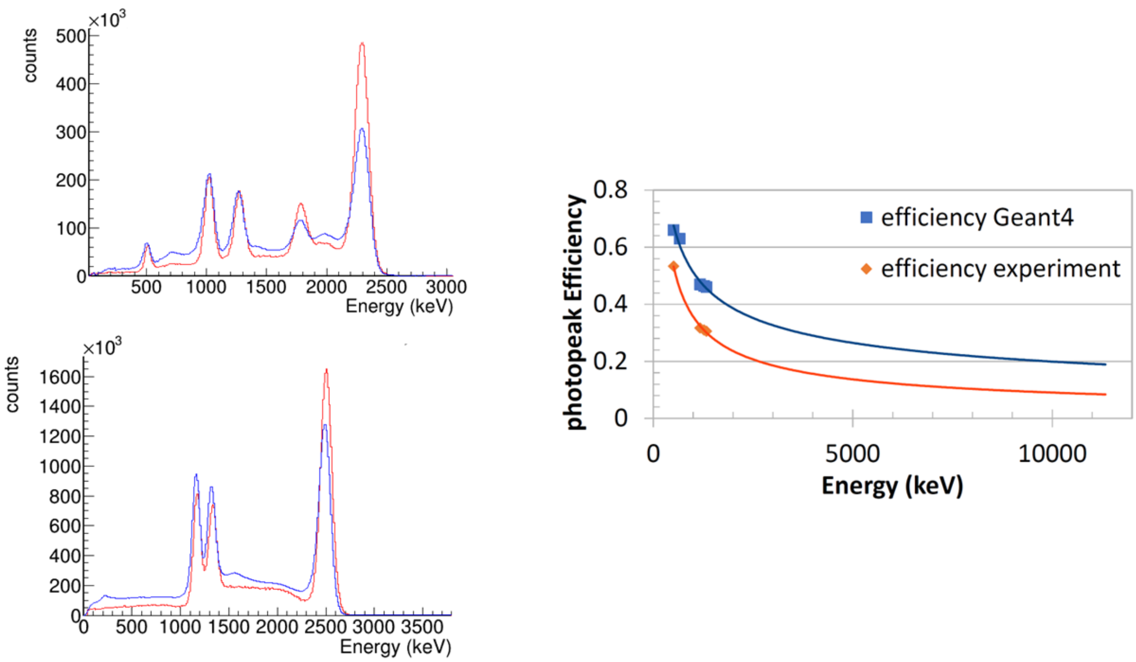

Fig. 2. The two spectra on the left show the sum of the gamma-ray energies measured by the 16 detectors with the gamma sources ^{22}Na (top) and ^{60}Co (bottom). The blue line is from the experimental data; the red line is from the Geant4 simulation. The figure on the right shows the photopeak efficiency obtained with these sources in the experiment and in the Geant4 simulation.

Further tests will be performed with a beta-decaying ^{11}Be beam to measure the photopeak efficiency at higher energies.