Demonstration of an Axial PET concept for brain and small animal imaging

Summary

Excellent spatial resolution and high sensitivity are crucial aspects for PET imaging devices. In addition, the combination with MRI is becoming essential. The AX-PET collaboration has developed a novel PET camera concept with the scintillation crystals aligned along the z coordinate with modern photo detectors insensitive to magnetic fields. In order to prove this concept an AX-PET demonstrator has been built. The basic principle consists of an axial arrangement of long scintillation crystals around the Field Of View (FOV) and Wave Length Shifter (WLS) strips orthogonally positioned to the crystal direction. The crystals provide the measurement of the x and y (transverse) of the point of impact of the 511 keV gamma ray, while the strips, collecting the light leaving the crystal sideways, allow a precise determination of the z (axial) coordinate (see Figure 1). A full AX-PET detector will be composed of a number of modules arranged in a ring configuration. Intrinsically this concept is immune from the parallax effect, and the spatial resolution only depends on the cross section of the crystals and on the width of the WLS strips. The sensitivity can be adjusted from the number of crystal layers. Using the information of the single photon interactions, allows to reconstruct the Compton events in the crystal matrix in ~60% of the cases (from MC simulations), reducing in this way the background and further enhancing the sensitivity.

Two modules have been built, each consisting of 48 LYSO crystals (St. Gobain), 10 cm long with a cross section of (3x3) mm$^2$, assembled in a stack of 6x8 bars, and 26 WLS strips of (0.9x3x40) mm$^3$, placed on top of each crystal layer (see Figure 2). The optical photons in the LYSO are read out by Multi Pixel Photon Counters (MPPCs) from Hamamatsu with (3x3) mm$^2$ active area; MPPCs for the WLS readout are custom designed with a dimension of (3.22x1.19) mm$^2$. The signals are amplified and fed into a 128 channel self-triggering readout ASIC VATAGP5 (Gamma Medica-IDEAS), controlled by a VME DAQ system. The modules have been individually calibrated in a test setup using a point-like $^{22}$Na source (see Figure 3). The energy resolution of one module is (11.5±0.6)% FWHM. The spatial resolution, determined using the weighted average of the WLS strips signals for events with photo effect at 511 keV in a single crystal, results to be of 1.65 mm FWHM (the test is dominated by the projected source image size). In parallel to the modules construction appropriate simulation and reconstruction software has been developed.

Finally the module performances will be tested with PET phantoms mounted on a gantry, able to rotate by 180°, where they can be fixed in different distances and at different angles of (180 ± 60) degrees with respect to each other.