Gamma ray Angular Correlations of Nuclear Beta Decays As a Novel Medical Imaging Modality

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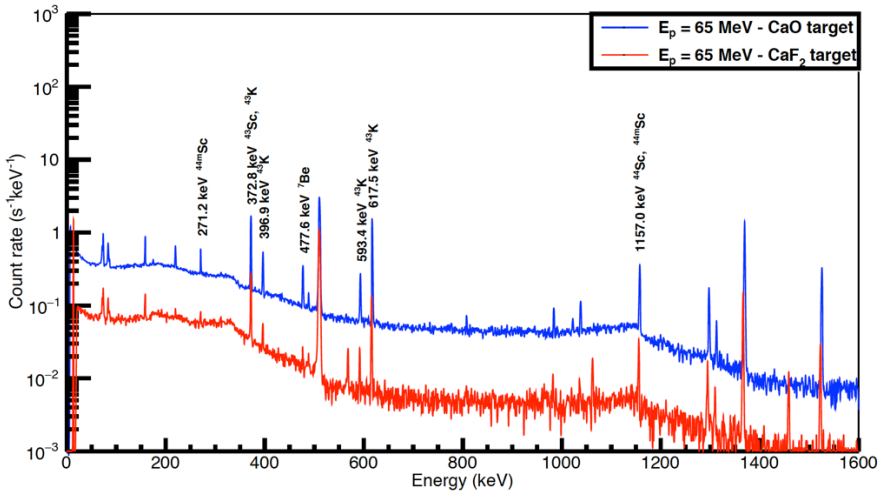
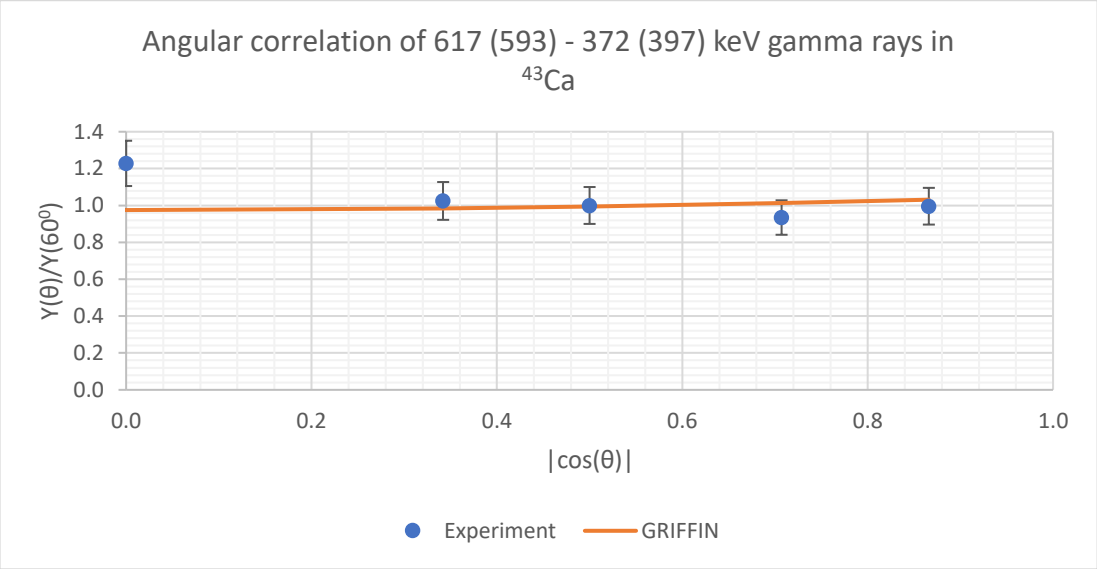
We produced ^{43}K isotope by ^{44}Ca(p,2p)^{43}Ca reactions at the proton kinetic energies of 30, 40, 53 and 65 MeV at the AVF cyclotron of the RCNP. We also measured the angular correlations of the 617 and 372 keV gamma ray pair subsequent to the ^{43}K(β^-)^{43}Ca decay. This work was motivated to introduce a new modality of nuclear medical imaging by exploiting the non-collinear angular correlations of gamma ray cascades in beta minus (β^-) decays. In favorable cases, these correlations enable us to determine the position of each decaying nucleus, which is in the tumor volume. Thus, the image reconstruction does not require statistical back projections, the methodologies adopted in the conventional Single Photon Computed Tomography (SPECT) and Positron Emission Tomography (PET). In addition, the gamma rays are emitted at the location of the decaying nucleus, free from random motion artifacts of the positron movement in PET imaging.

We performed two sets of measurements with CaO and CaF_2 targets of about 130-200 mg/cm^2 thicknesses. The figure below shows the gamma ray spectra, where the 43K gamma rays (617,593,396, and 372 keV) are clearly seen. Also, seen are the 271 keV and 1157 keV gamma rays from ^{44m}Sc, a product of ^{44}Ca(p,n) reaction.



To ascertain the non-collinearity of the gamma ray cascade, we performed angular correlation measurements with a pair of NaI(Tl) counters in coincidence setting. Figure 2 shows that the non-collinearity is maximum in that the correlation is nearly isotropic. The red line is the theoretical calculation for the $J^{\pi-}$ combinations using GRIFFIN code.



Future plans: To establish the utility of this decay as a new modality of the medical imaging, we plan to perform prototype imaging with a mini PET machine at the RIKEN facilities. We are in the process of designing a collimator system and organize the measurement and imaging protocols to this end. It is likely that there are other isotopes as good candidates for this modality. Research along those lines is contemplated.

REFERENCE:

GRIFFIN collaboration (2015), DOI: 10.5281/zenodo.455587
And visit
http://griffincollaboration.github.io/AngularCorrelationUtility/