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The measurement of liquid scintillator nonlinear response and intrinsic energy resolution

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For Jiangmen Underground Neutrino Observatory the requirements < 1 % energy scale uncertainty and 3 % at 1 MeV energy resolution are crucial in order to determine neutrino Mass Hierarchy. Several effects determine the energy scale and response function of the detector. To measure two of them, ionization quenching and intrinsic energy resolution, small-scale laboratory setup was developed.

The setup consisted of a quartz cell, filled with liquid scintillator and coupled with a photomultiplier (PMT), High Purity Germanium detector (HPGe) and monoenergetic gamma source. The response of the liquid scintillator was measured by observation of Compton scattering events in coincidence. There were several problems with application of this technique that were never settled in literature. In the present study some of them were overpassed by means of setup development and Monte Carlo simulation. It was shown that quenching, if it is small enough, could be effectively decoupled from Cherenkov effect. The structure of bidirectional coincidence diagram was explicitly investigated. The systematic effect of multiple Compton events was also estimated. The stability of the system was checked and gain variations were corrected. The technique to estimate non-linearity of PMT was developed.

Several problems, such as a light collection uniformity, are still remaining. Thus, it is too prematurely to guarantee that measured quenching parameter kB represents the non-linearity of liquid scintillator and it is not biased by experimental artifacts. The sensitivity of the setup in term of resolution was found to be not yet sufficient for intrinsic resolution measurement. The strategy for setup improvement was proposed. Further work, especially in direction of Monte Carlo - data comparison, may significantly increase the reliability of the measurement.

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