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P3.063 Double calorimetry in liquid scintillator neutrino detectors

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Liquid scintillator detectors (LSD) are known for their remarkable ability to provide high precision energy measurements in the context of neutrino detection for fundamental research. In recent years, there has been a relevant boost in the use of LSD in several areas of neutrino research with ever more demanding specifications. One such specification is the high precision characterisation and/or control of calorimetric non-stochastic effects –i.e. calorimetry systematics– as opposed to stochastic effects driven by the number of photoelectrons (PE) detected per unit of energy. As the light level of the LSD increases, the control of systematics becomes of great importance, otherwise the stochastic calorimetric resolution, typically proportional to the most expensive photocathode coverage, could be wasted. Such is the case of the JUNO experiment, where the light level is so high (1200PE/MeV) that the requirements for the calorimetry systematics reach the unprecedented sub-percent level. In the specific case of JUNO, a $\leq 3\%$ total resolution at 1MeV is needed for the significant measurement of atmospheric Mass Ordering.

In this poster, the authors plan to explain a new concept (publication in preparation) called **double calorimetry**, whereby more than one calorimetric estimator is articulated within the same detector. Typically, energy can be measured via “charge integration” (as done in detectors such as Daya Bay, Double Chooz, KamLAND, etc) or via “photon counting” (as done by Borexino). For long, experiments have used either energy estimator. However, in our concept, we demonstrate that the implementation of both energy estimators can have unique advantages – specially in the control of calorimetry systematics to unprecedented levels. In JUNO, we realised this concept by adding $\sim 34,000$ 3” PMTs to the $\sim 17,000$ 20” PMTs, where the 3” PMTs are kept in the photon-count energy regimen. We also used MC simulations to demonstrate that the adoption of double calorimetry could lead to unprecedented calorimetric performance, beneficial to the most demanding LSD, such as JUNO. In this poster, we will use our JUNO studies to illustrate and quantify how the concept can be extended to other detectors upon some degree of generalisation. Indeed, the double calorimetry concept has been embraced by the JUNO detector design, and this poster is the first time all the JUNO dedicated studies are summarised beyond the JUNO collaboration, and beyond the JUNO specific case, for the benefit of future neutrino LSD design.



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