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Simulation studies of reconstruction of hadron shower direction in INO ICAL detector

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The Iron Calorimeter (ICAL) detector at the India-based Neutrino Observatory (INO) is a proposed 50 kton magnetised iron detector optimised for the detection of atmospheric muon neutrinos (and anti-neutrinos). These neutrinos interact with the target iron via both charged current (CC) and neutral current (NC) interactions. The CC interactions produce a muon and hadrons in the final state, which are observed as a track and shower respectively in the detector; in contrast, only a hadron shower is visible in NC events since the secondary neutrino is invisible. We present a GEANT4 based simulation study of neutrino events generated using the NUANCE neutrino generator to obtain the direction of the hadron shower in both types of interactions. (The calibration of the hadron energy from the shower has been studied earlier). We implement two methods, namely the orientation matrix method (OMM) and the raw hit method (RHM) to reconstruct the shower direction. While the OMM requires information about the interaction vertex obtained from muon track reconstruction and is applicable only to CC events, the RHM requires only the hit positions and timings (and no vertex information) and is thus applicable for both CC and NC events. The former performs better owing to the information on the vertex: a direction resolution of 16◦–7◦ is obtained for hadron showers with energy in the range E′h = 0.5–15 GeV which are produced in the direction cosθ′h = [0.8, 1]. In contrast, the RHM achieves a relatively poorer resolution of 18◦–10◦ for the same data set, and a similar resolution of 18◦–11◦ for NC events in the same energy and angle bins.

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