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Improved prediction of the T2K neutrino beam flux by estimation of hadronic secondary interactions in the cooling water of magnetic horns using measurement-based material modeling

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The reliable estimation of accelerator neutrino beam fluxes is important for precise neutrino oscillation measurements in searching for CP violation in the leptonic sector. In long-baseline neutrino experiments, the neutrino flux uncertainties contribute significantly to uncertainties in neutrino oscillation parameters. Hadron production is the largest component of the flux uncertainty, so secondary interactions with materials in the beamline should be considered for better precision. One of the main components of the flux uncertainty from material modeling in the beamline is the interactions of hadrons with the cooling water inside the magnetic horns, which contributes a ~3% uncertainty. The secondary interaction between the cooling water and the neutrino's parent particle is responsible for this, but the effect was not well known. The cooling water is sprayed directly from the outer conductor of the magnetic horn toward the inner conductor, so the water distribution is constantly varying. To estimate the water distribution in more detail compared to the previous estimation, a horn mock-up was made and the water thickness was measured by modeling the cooling water distribution using image analysis. This analysis improved the flux uncertainty around the flux peak (600MeV) by more than 1% compared to the previous error estimation. The results are incorporated into neutrino beam simulations to estimate systematic uncertainties in the flux, and it is expected to improve the precision of the T2K neutrino oscillation analysis. The study will also be useful for HK and other future experiments. In this poster, an analysis development method to estimate the water distribution with image analysis and an improved T2K flux precision with the result are described.

Poster prize

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