Towards a Fast and Precise Pipeline for Neutrino Event Reconstruction in Hyper-Kamiokande

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Hyper-Kamiokande (HK) is the next generation of water Cherenkov detector in Japan, currently under construction and scheduled to begin data-taking in 2028. With a fiducial volume about 8 times larger than Super-Kamiokande's (SK), HK will record an unprecedented number of neutrino interactions, enabling precise measurements of neutrino oscillation parameters, searches for CP violation in the lepton sector, and searches for nucleon decay. This increased event rate brings two major challenges for event reconstruction in HK: processing the large volume of data with sufficient speed, and improving reconstruction performance to reduce systematic uncertainties which will otherwise become a limiting factor for several key measurements.

The reconstruction efforts pursued in HK address both challenges through complementary approaches. The baseline reconstruction, inherited from SK's likelihood algorithms such as fiTQun, will provide a robust starting point for seamless day-one physics analyses. Several developments aim to improve the processing time and performances of this likelihood-based approach. In parallel, machine-learning models are being actively developed as a complementary reconstruction pipeline, and have already demonstrated improved performance for single-ring reconstruction, in some cases matching or surpassing the likelihood methods. This ML pipeline is now being extended towards multi-ring reconstruction, while its robustness against detector systematics is being investigated.

In this talk, I will present the status of the aforementioned efforts towards an improved reconstruction pipeline for the start of HK data-taking. In particular, I will report on the neutrino event reconstruction speed and resolution performances for the different likelihood and ML approaches.