Preparation of the Hyper-Kamiokande experiment

Claire Dalmazzone, Gonzalo Diaz Lopez

LPNHE

From T2K to Hyper-Kamiokande

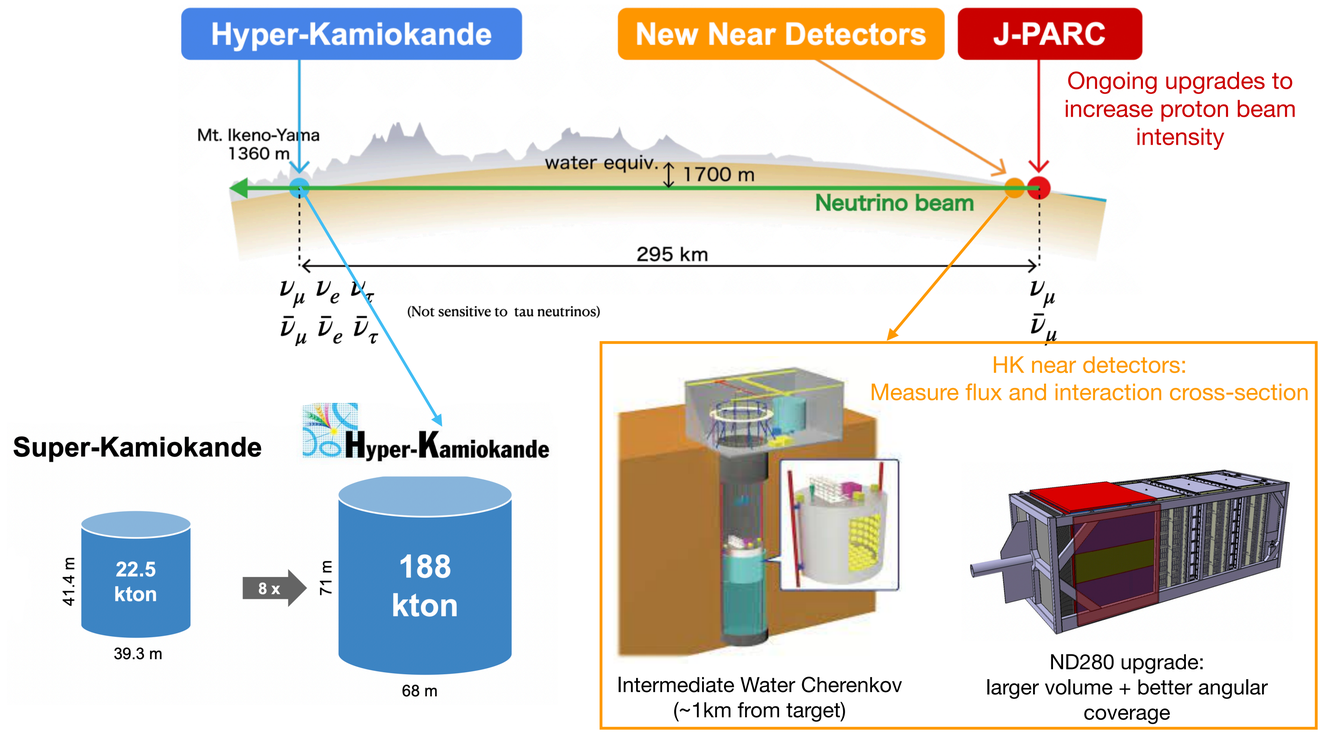


Figure 1. The HK long baseline program will use the same neutrino beam as T2K but a bigger far detector with the same off-axis angle of 2.5°*. The neutrino flux will be well characterized thanks to NA61/SHINE hadron production measurements.*

$$\begin{pmatrix}\nu_e\\ \nu_\mu\\ \nu_\tau\end{pmatrix} = \begin{pmatrix}1 & 0 & 0\\ 0 & \cos\theta_{23} & \sin\theta_{23}\\ 0 & -\sin\theta_{23} & \cos\theta_{23}\end{pmatrix}\begin{pmatrix}\cos\theta_{13} & 0 & \sin\theta_{13}e^{-i\delta_{CP}}\\ 0 & 1 & 0\\ -\sin\theta_{13}e^{i\delta_{CP}} & 0 & \cos\theta_{13}\end{pmatrix}\begin{pmatrix}\cos\theta_{12} & \sin\theta_{12} & 0\\ -\sin\theta_{12} & \cos\theta_{12} & 0\\ 0 & 0 & 1\end{pmatrix}\begin{pmatrix}\nu_1\\ \nu_2\\ \nu_3\end{pmatrix}$$

Parameters constrained by T2K and HK LBL program: δ_{CP}, $\sin^2\theta_{13}$, $\sin^2 2\theta_{23}$ and Δm^2_{32}

Figure 2. Parametrization of the PMNS matrix

The systematic parameters

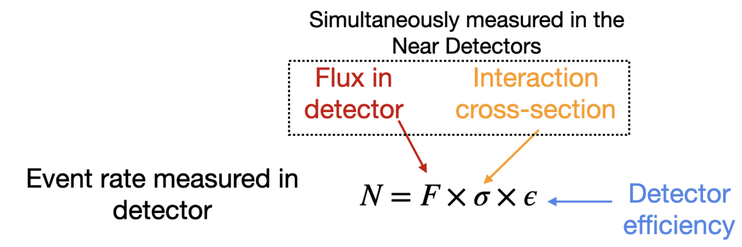


Figure 3. Three types of systematic parameters impact the measured event rates.

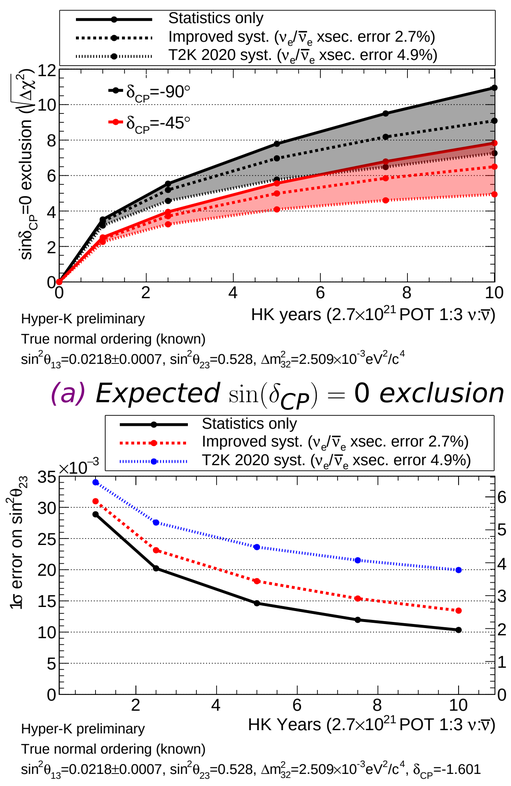
1. **Flux parameters** characterize the expected number of neutrinos to cross the detector per energy bin
2. **Cross-section parameters** characterize the neutrino interaction model
3. **Detectors parameters** characterize the response of the detectors

Predictions for Hyper-Kamiokande

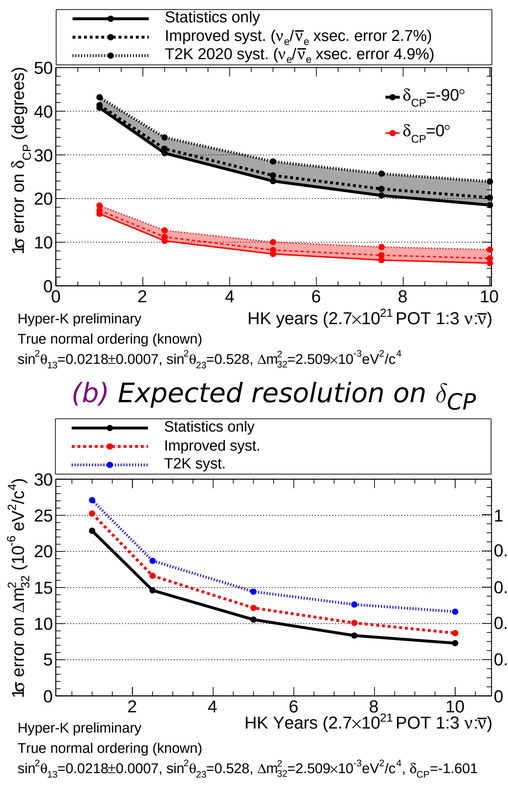
New sensitivity studies were performed in France (LPNHE+LLR) using the latest published T2K results [1].

T2K 2020 (Imp.) syst.	ν-mode *e*-like	ν-mode μ-like	$\bar{\nu}$-mode *e*-like	$\bar{\nu}$-mode μ-like
ND constrained				
Flux+cross-section	3.6% (1.8%)	2.1% (0.9%)	4.3% (1.6%)	3.4% (0.9%)
Not ND constrained				
Cross-section	3.0% (1.6%)	0.5% (0.4%)	3.7% (1.4%)	2.6% (0.4%)
Detector	3.1% (1.1%)	2.1% (0.8%)	3.9% (1.5%)	1.9% (0.7%)
All	4.7% (2.1%)	3.0% (1.2%)	5.9% (2.2%)	4.0% (1.1%)

Table 1. 1σ *uncertainty on the expected number of events in HK with the T2K 2020 or Improved error model. The Improved error model was built by shrinking the individual systematic uncertainties from T2K 2020 systematic error model to take into account the expected effects of the upgrades and the statistics increase.*



(a) Expected $\sin(\delta_{CP}) = 0$ *exclusion*



(b) Expected resolution on δ_{CP}

(c) Expected resolution on $\sin^2\theta_{23}$

(d) Expected resolution on Δm^2_{32}

Figure 4. Prediction of HK sensitivity to oscillation parameters: impact of the statistics and the systematic uncertainties.

HK could exclude $\sin\delta_{CP} = 0$ (CP symmetry) with a few years of data ($\approx$ 2 years for $\delta_{CP} = -90°$) only if the systematic uncertainties are reduced compared to T2K! After 10 years, δ_{CP} could be measured with a less than 20° precision and the resolution would reach a few percent and less than a percent for $\sin^2\theta_{23}$ and Δm^2_{32} respectively.

The WCTE project

References

[1] The T2K Collaboration. Measurements of neutrino oscillation parameters from the t2k experiment using 3.6×10^{21} protons on target, 2023.

cdalmazz@lpnhe.in2p3.fr gonzalo.diazlopez@lpnhe.in2p3.fr