

Study of neutral hadron production in 31 GeV/c proton interactions with a T2K replica target in the NA61/SHINE experiment to improve the T2K neutrino flux prediction (#: 89)



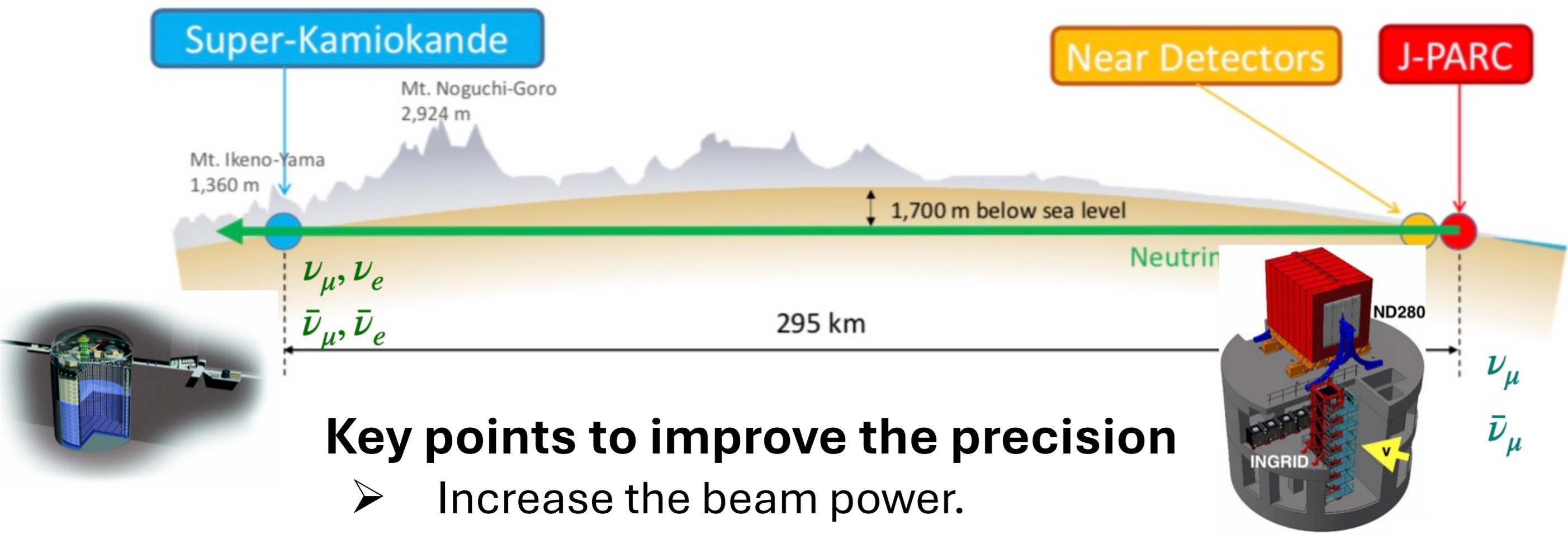
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Motivation

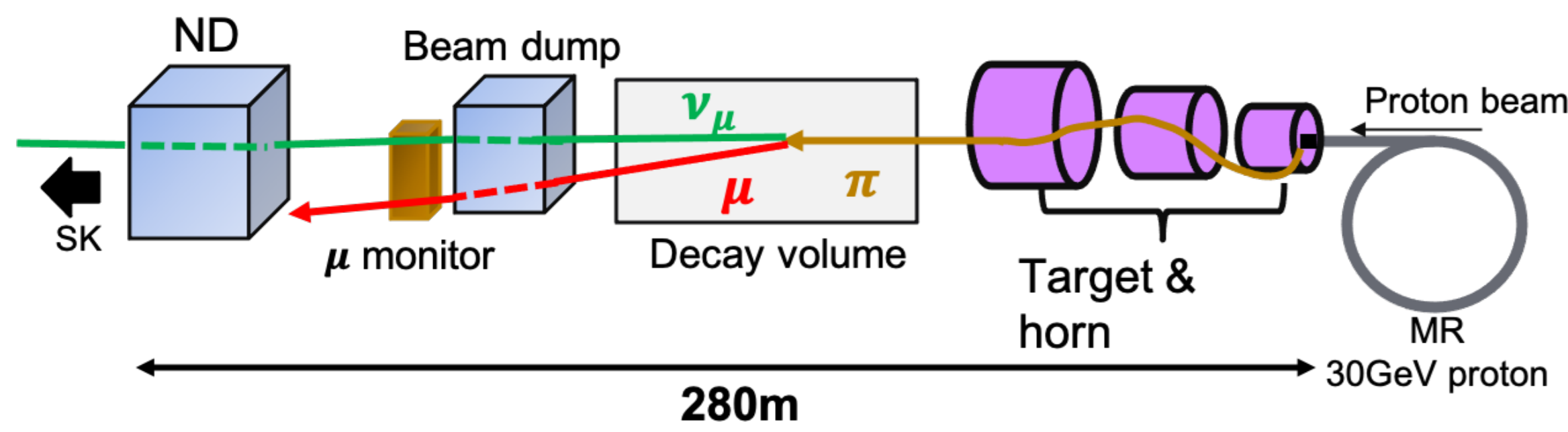
- To improve the precision of the oscillation analysis of T2K, the background neutrino ($\bar{\nu}_e, \nu_e$) flux uncertainty from hadron (K_L^0) production and the $\bar{\nu}_\mu$ flux uncertainty need to be reduced.
- For the first time NA61/SHINE is measuring neutral hadron production from the T2K replica target: K_S^0 and Λ measurements are being performed to reduce the T2K neutrino flux uncertainties.

1. T2K: Long-baseline neutrino experiment

Search for CP violation in the lepton sector by precision measurement of neutrino oscillations with accelerator neutrinos.



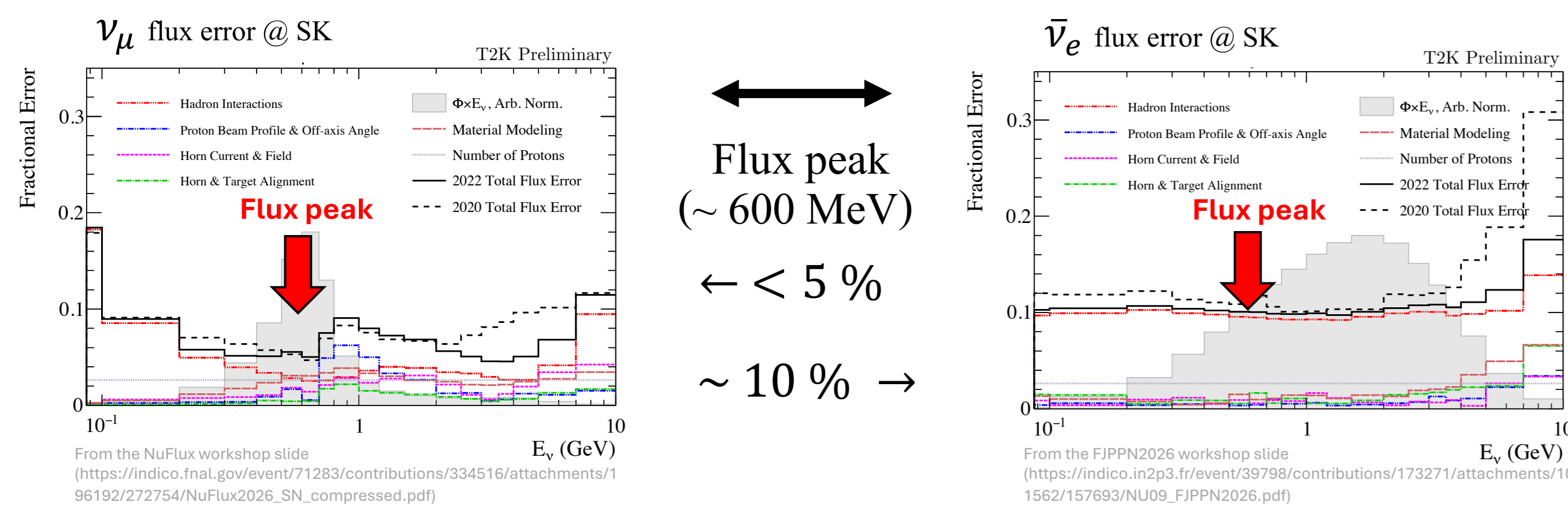
Neutrino beam



[Reference] "T2K neutrino flux prediction" K. Abe et al, *Phys.Rev.D* 87 (2013) 1, 012001

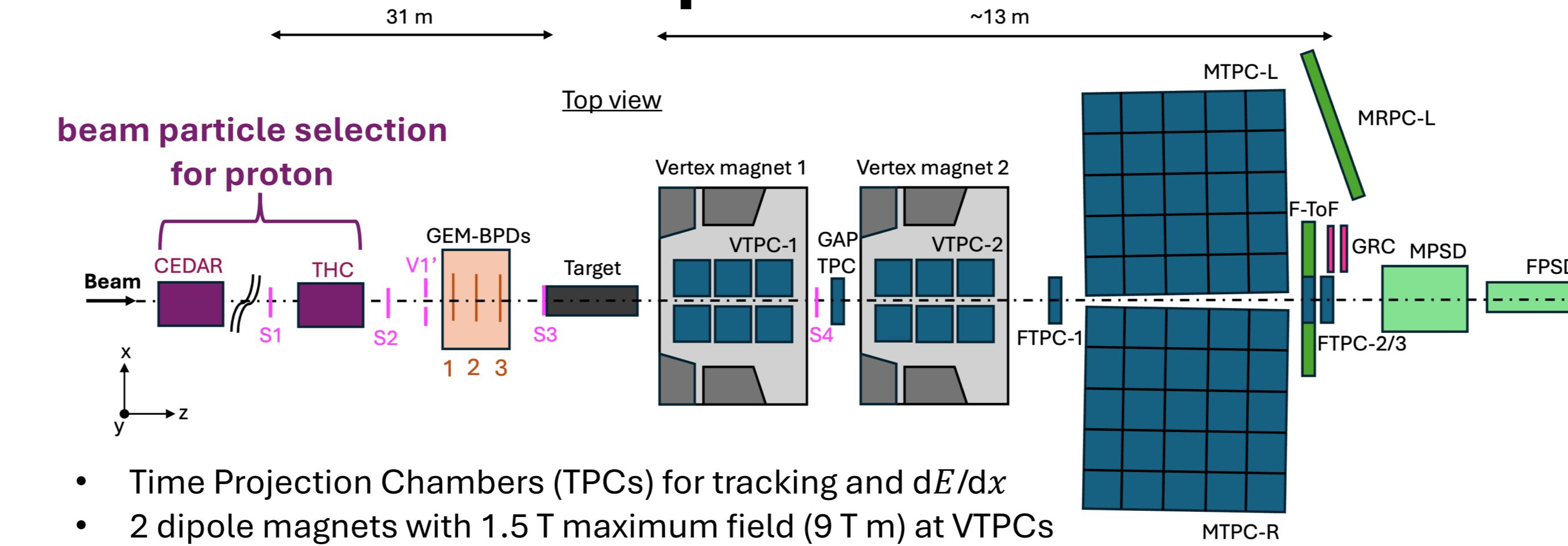
Neutrino flux prediction

- Using MC simulations constrained by measured hadron production inside the target.
- NA61/SHINE measures the hadron production ($\pi^\pm, K^\pm, p, K_S^0, \Lambda$) from the target (length: 2 cm thin target, 90 cm replica target).



The intrinsic neutrino (such as $\bar{\nu}_e$) flux uncertainties should be reduced.

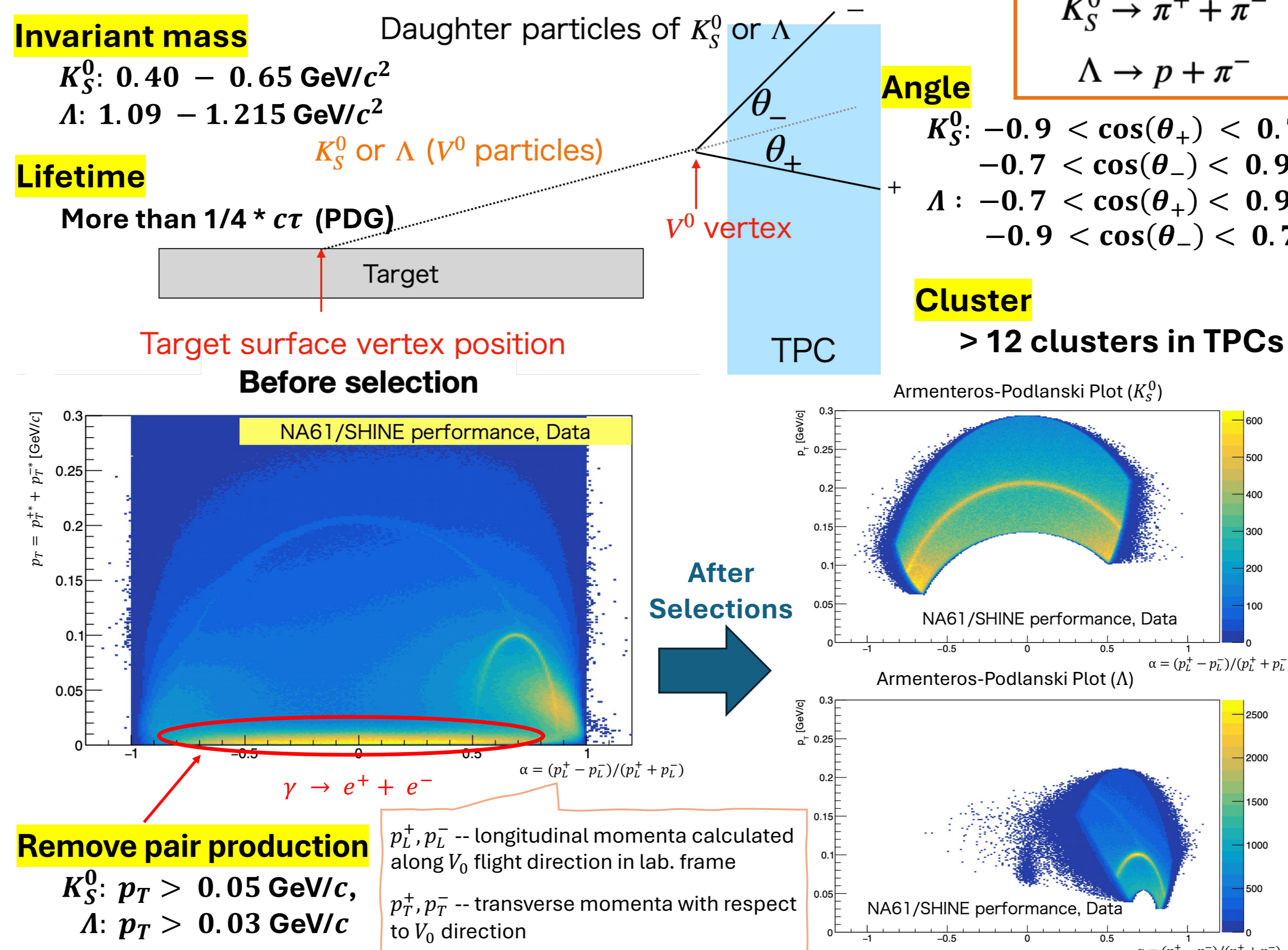
2. NA61/SHINE experiment



Data taking with a T2K replica target (2022)

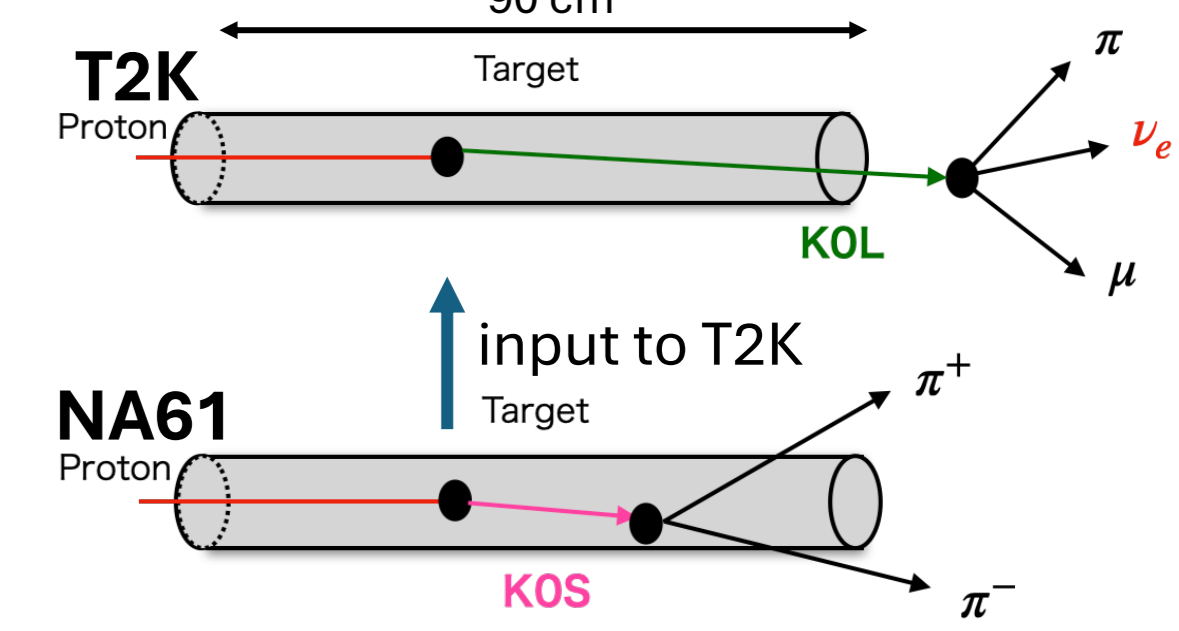
- Collected ~180 M events. (Data taking in 2010: ~10 M events.)
- First measurement for K_S^0 and Λ .

3. Event selection

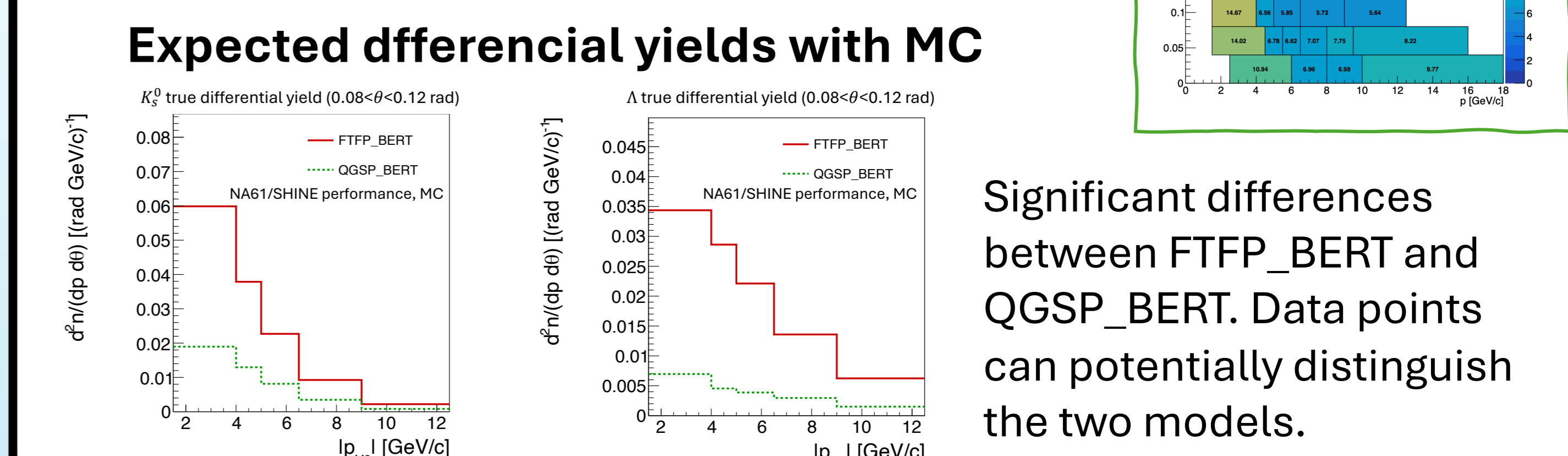
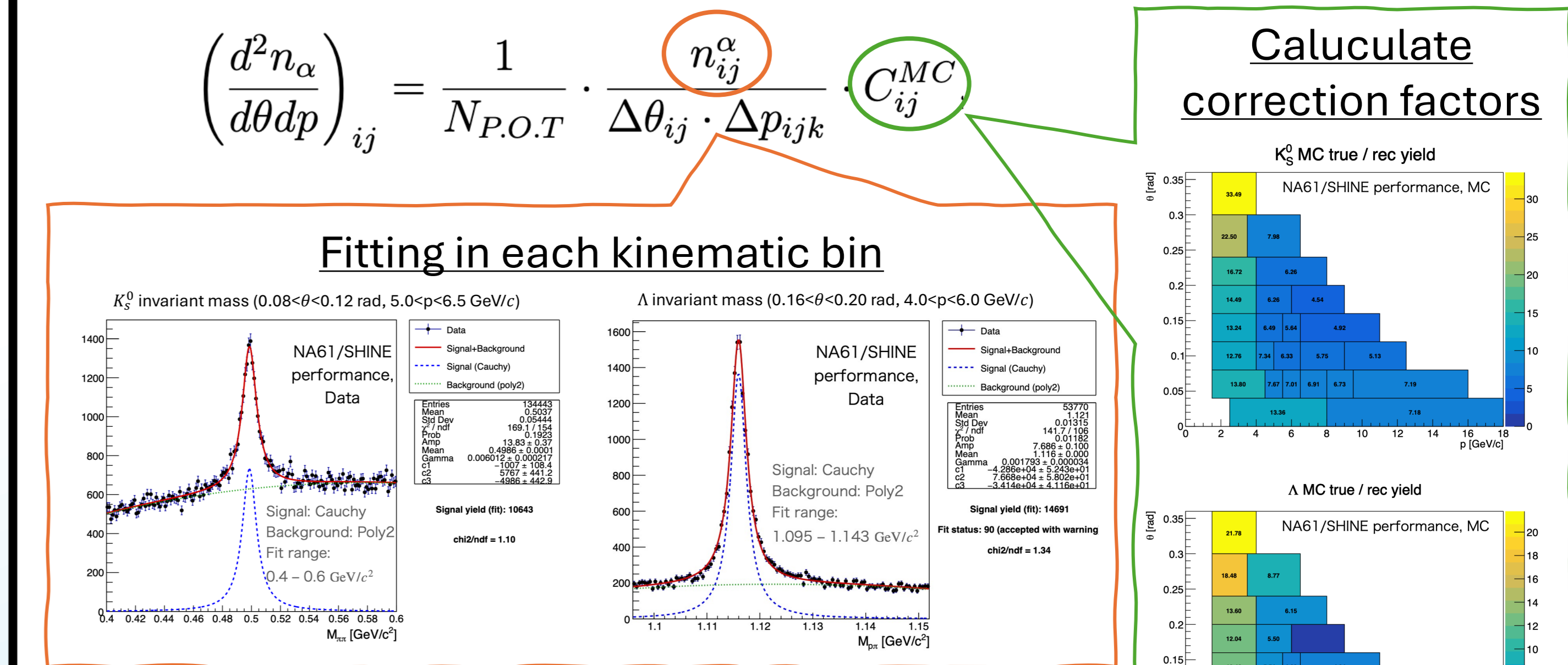


How to estimate K_L^0 in NA61?

- Differential production cross sections of K_S^0 in total momentum and polar angle bins are measured in NA61.
- K_L^0 production in the T2K beam simulation is estimated with the result from NA61.



4. Expected differential yields of K_S^0 and Λ



5. Prospects

- The results based on experimental data will be published after the systematic uncertainty evaluation is finalized.
- The target longitudinal (z)-binning is planned for more precise measurements in the future analyses.

Summary

- For improving the flux prediction of the background neutrinos, replica target measurements of the neutral hadrons (K_S^0 and Λ) should be done with high statistics data (T2K 2022 run), which will allow to improve the precision of the lepton CP-violation search in long-baseline neutrino oscillation experiments.
- K_S^0 and Λ measurements with the T2K 2022 run data are in progress, and the first results will be published soon.