TITUS Near Detector: Study on Photo-Coverage

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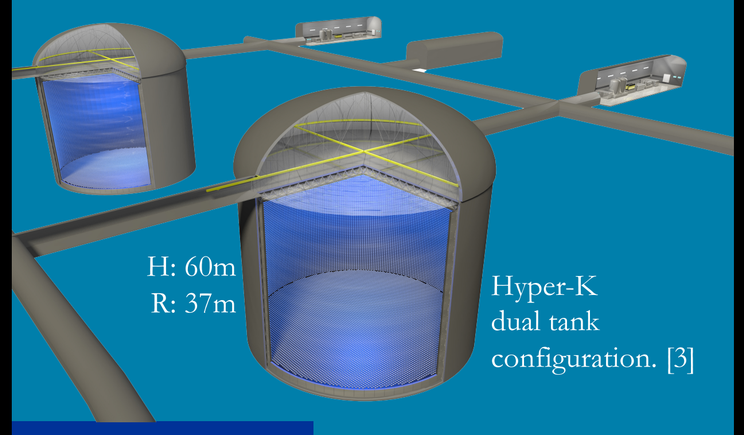
Hyper-Kamiokande

- Water Cherenkov (WC) detector with a combined mass of 0.52 Mtons
- Off-axis far detector for long base-line ν experiment using the J-PARC ν-beam
- Physics goals include ν CP-violation and mass hierarchy measurements

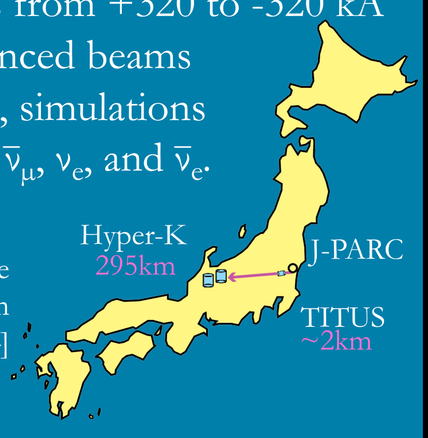


Hyper-K dual tank configuration. [3]

J-PARC

Japan Proton Accelerator Research Complex

- 1.3 MW p-beam, 0.6 GeV ν-beam
- Horn currents from +320 to -320 kA for $\nu_\mu/\bar{\nu}_\mu$ enhanced beams
- For each horn, simulations are run for ν_μ, $\bar{\nu}_\mu$, ν_e, and $\bar{\nu}_e$.

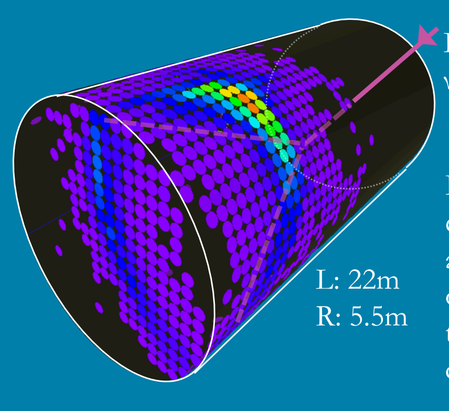


The path of the beam projected on a map of Japan. [4]

TITUS

Tokai Intermediate Tank for the Unoscillated Spectrum

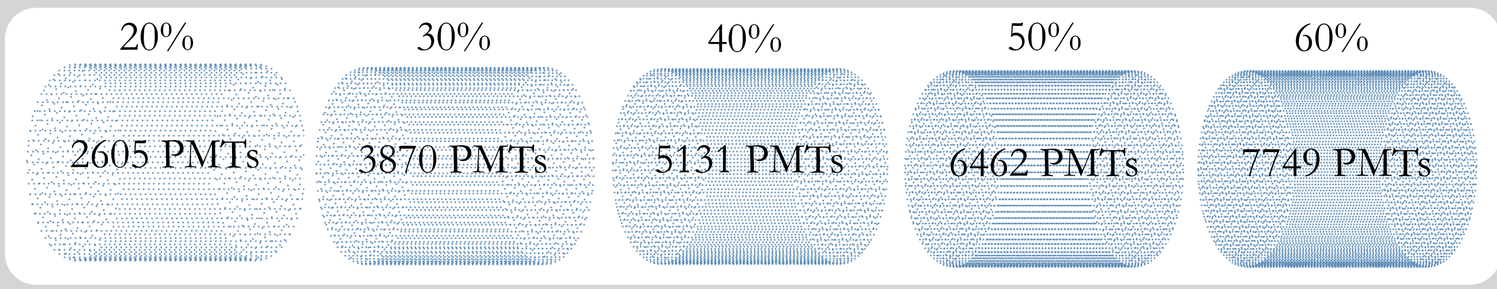
- WC tank with a total mass of 2.1kton horizontally placed along the beam
- Same off-axis line and target as Hyper-K reducing systematics in physics goals set for far detector
- Provides information about unocila-ted ν-beam (flux, contamination etc)
- Physics goals include: cross section determination, SM measurements, supernova ν and Beyond the SM physics



Example of the event signature of a Cherenkov ring on the PMTs of the TITUS detector [5].

Photo-Coverage

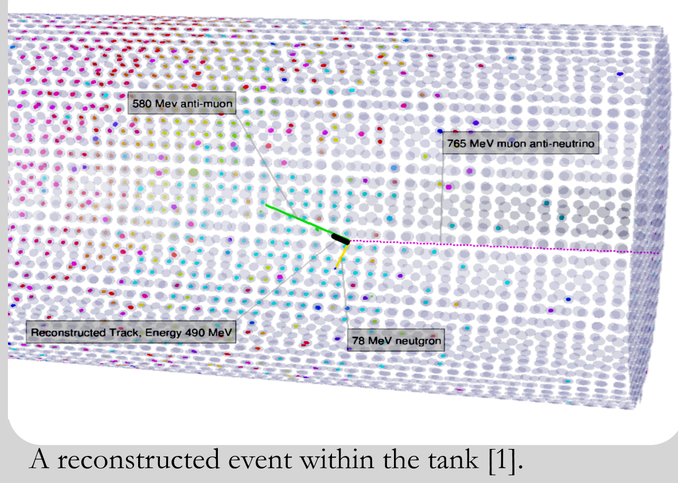
- A uniform distribution of 12” PMTs is assumed
- Photo-coverage is mea-sured in the percentage of the area of the tank covered by PMTs
- The PMTs are arranged in a square grid over all surfaces
- Below 20% insufficient data are gathered for event reconstruction



Examples of the different PMT configurations considered in the study to follow.

Simulation & Reconstruction

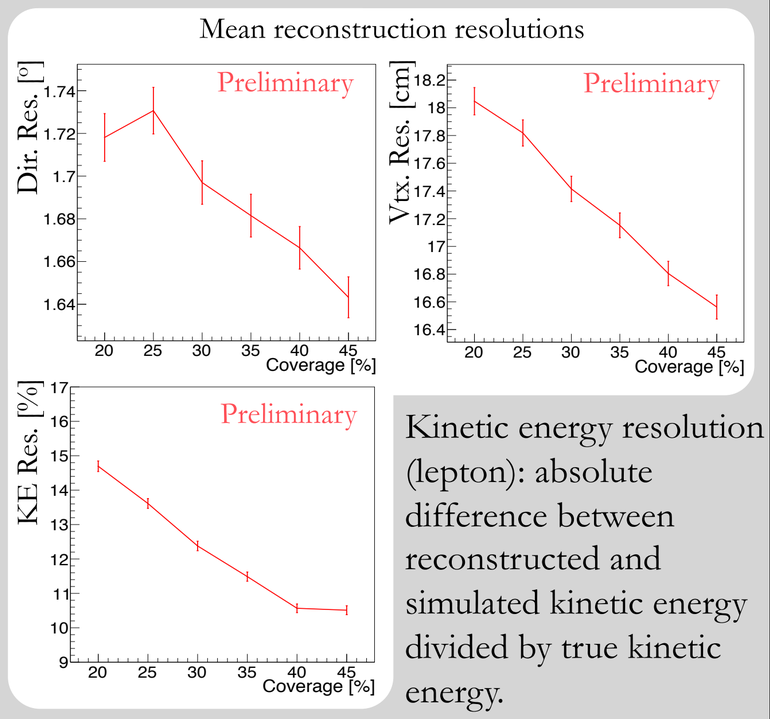
- The ν interactions are simulated using Geant4-based software.
- Given a specific detector configuration, a photo-electron signature on the PMTs is constructed (photon mask).
- The mask is then used to simulate the hits collected by the PMTs.
- During reconstruction of events, if the lepton’s KE is calculated as more than 60 MeV a more detailed reconstruction code is applied.
- In each step the vertex, direction and energy are determined.



A reconstructed event within the tank [1].

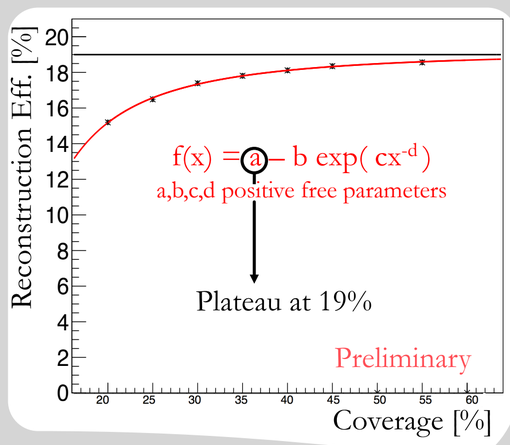
Resolution & Efficiency

Direction/Vertex resolution: absolute difference between reconstructed and simulated dir./vtx.



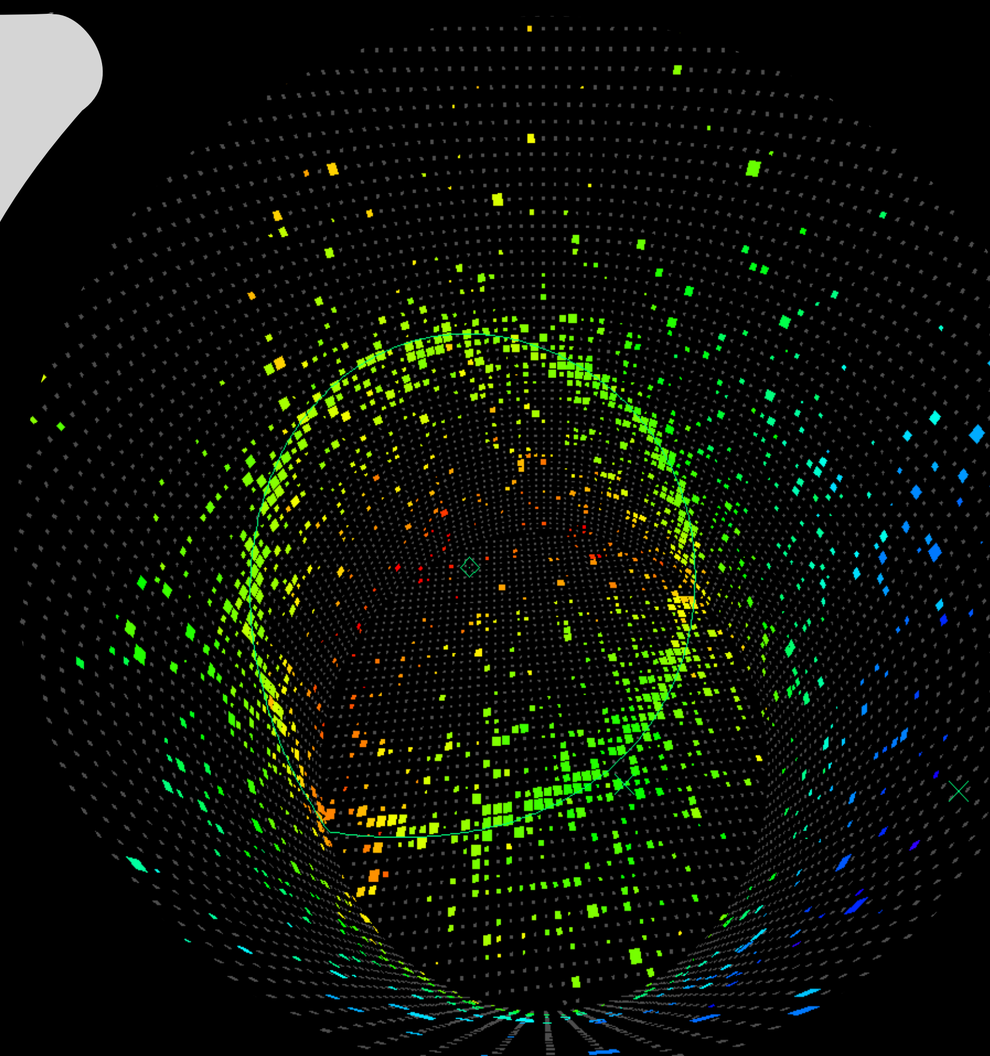
Kinetic energy resolution (lepton): absolute difference between reconstructed and simulated kinetic energy divided by true kinetic energy.

Reconstruction efficiency: percentage of total reconstructed events over total simulated events.



Concluding Remarks

- Evidence suggests that beyond 35% photo-coverage reconstruction effi-ciency improves only marginally while the resolution improves li-nearly with photo-coverage.
- To lift the efficiency plateau, one has to focus efforts on improving reconstruction algorithms.



References

[1] TITUS: the Tokai Intermediate Tank for the Unoscillated Spectrum arXiv:1606.08114v1 [physics.ins-det]
[2] K. Abe et al., “Physics Potential of a Long Baseline Neutrino Oscillation Experiment Using J-PARC Neutrino Beam and Hyper-Kamiokande,” published in PTEP, May 2015, arXiv:1502.05199 [hep-ex]
[3] Hyper-Kamiokande. 2015. [ONLINE] Available at: http://www.hyper-k.org/en/. [Accessed 6 Sep. 2016]
[4] Kearns E. 2011. T2K Submits First Electron Neutrino Appearance Result to Physical Review Letters. [ONLINE] Available at: http://physics.bu.edu/sites/neutrino/2011/06/14/. [Accessed 6 Sep. 2016]
[5] Prouse N. 2015. TITUS An Intermediate Distance Detector for the Tokai-to-Hyper-K Neutrino Beam. [Presentation slides]. Available at: http://indico.hep.manchester.ac.uk/. [Accessed 6 Sep. 2016]
Background image: Barszczak T. 2000. Available at: http://www.ps.uci.edu/~tomba/sk/tscan/compare_mu_e/. [Accessed 6 Sep.2016].