Linear accelerator for energy calibration at Hyper-Kamiokande

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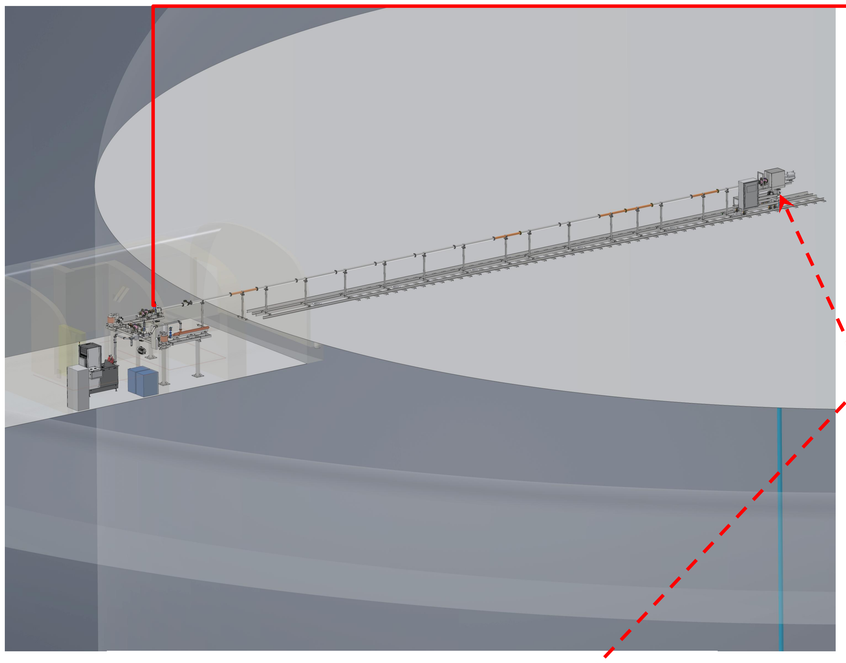
Introduction

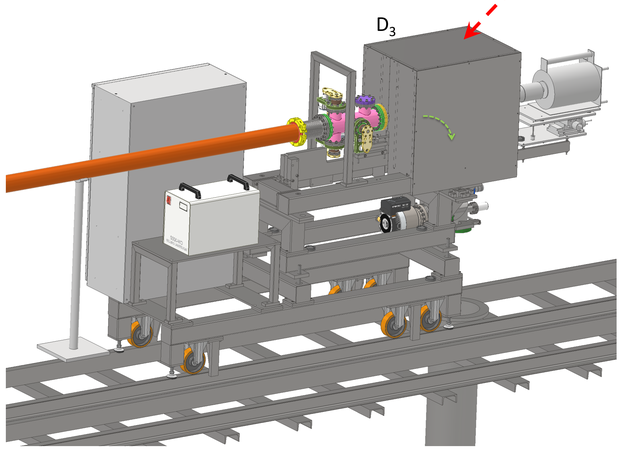
Precise reconstruction of low-energy electrons is essential for the Hyper-Kamiokande physics program, including solar neutrinos, supernova neutrinos, and nucleon decay searches.

LINAC-based calibration system:

- provides monoenergetic electrons (3.5-24 MeV) with well-defined energy, position, and direction inside the detector volume;
- enables precise calibration of the energy scale, position dependence, reconstruction performance, and systematic uncertainties;
- calibration requires events with exactly one electron exiting the output chamber;
- main challenge: maximize the single-electron event rate.

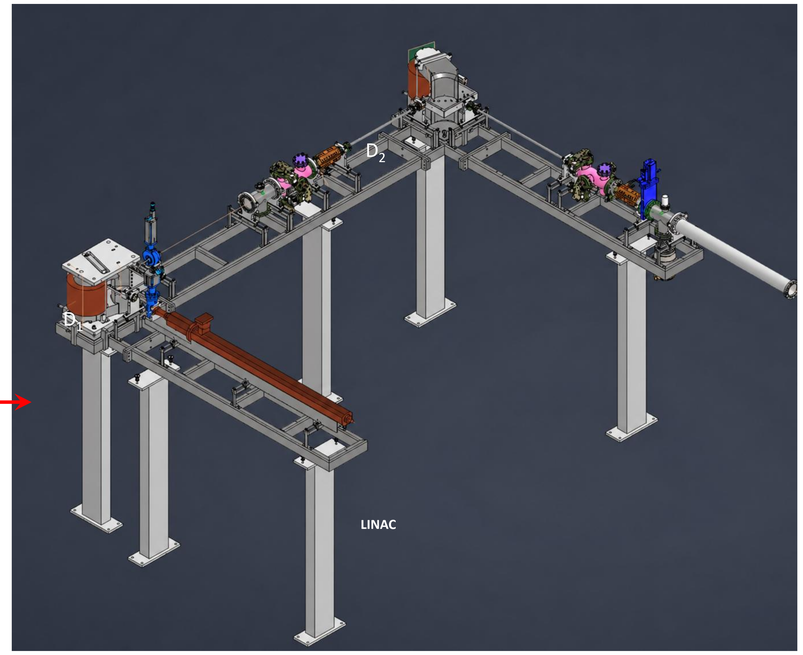
The calibration data will be used to validate detector simulations and ensure the accuracy required for precision neutrino measurements.



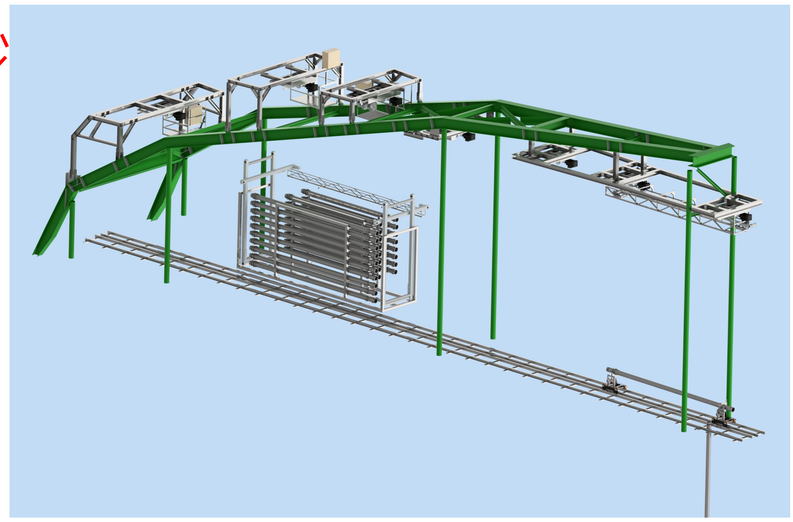


Experimental Setup

- Two 90° dipole magnets D_1 and D_2 with energy-selection collimators provide precise momentum analysis.



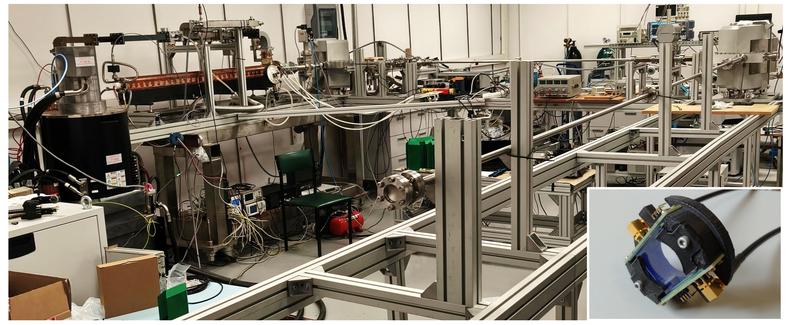
- A third dipole magnet transfers the beam from the horizontal to the vertical beamline.



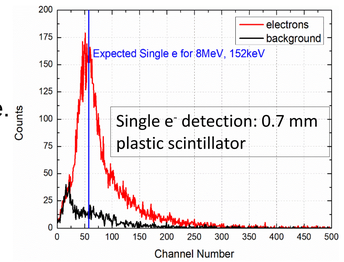
- Modular 4.5 m and 6 m vacuum pipe sections are assembled in the calibration shafts using a dedicated winch-based deployment system.
- The system enables calibration at multiple locations within the Hyper-Kamiokande detector volume.

Results

- LINAC installation test stand completed and operational.
- Beam transport through D_1 and D_2 successfully demonstrated for the full energy range (3.5-24 MeV).

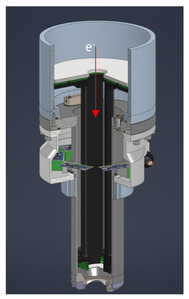


- Initial commissioning confirms proper operation of the energy selection system.
- Ongoing activities include beam tuning, optimization of transport efficiency and integration of the remaining beamline.

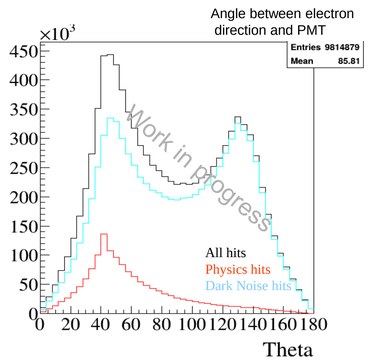


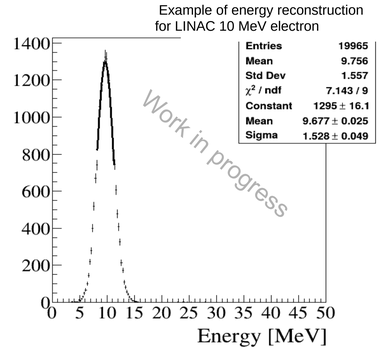
Monte Carlo simulations

Monte Carlo simulations of LINAC calibration have been performed to study electron transport through the vacuum beamline, energy losses in the titanium beam exit window, and hardware shadowing effects. The results will be used to compare measured data with the Hyper-Kamiokande LEAF low-energy reconstruction which provides us with reconstructed vertex, direction and energy of electron (from LINAC in case of calibration measurement, or from ν_e interaction in case of physics measurement.).



Beam exit head





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