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## NuCubes: R&D towards a 3D Water-Based Liquid Scintillator near detector for Hyper-Kamiokande

Next-generation long-baseline neutrino experiments, such as Hyper-Kamiokande (HK) and DUNE, require unprecedented control of systematic uncertainties to fully realize their potential in measuring neutrino mixing parameters. Achieving this precision depends critically on advances in near-detector technologies, which provide detailed and high statistics measurements of neutrino interactions before oscillations.

In this context, the T2K collaboration, whose beamline and near detector complex will be inherited by HK, has recently completed the upgrade of its magnetized Near Detector (ND280). ND280 now includes the SuperFGD, a highly segmented plastic scintillator detector composed of optically isolated 1cm<sup>3</sup> cubes, totaling an active mass of ~2 tons, and surrounded by two High-Angle Time Projection Chambers.

Building on this technology, a further upgrade of the Near Detector (ND280++) is envisaged for the high statistics phase of the HK experiment, after 2030. One of the detectors of ND280++ will be a multi-ton three-dimensional Water-Based Liquid Scintillator (WbLS) detector, structurally similar to the Super-FGD but with voxels filled with WbLS containing the maximum possible water fraction. The aim is to have high-granularity reconstruction of neutrino and anti-neutrinos interactions on water, matching the far detector target, to study nuclear effects, that are one of the dominant source systematic uncertainties in LBL experiments, and measure electron neutrino and anti-neutrino cross-section.

Ongoing R&Ds focus on maximizing the light yield through optimization of the voxel structure, of the wavelength-shifting fibers, improvements in the fiber-SiPM coupling and developments of a transparent water tight containment box for the detector.

The project is supported by ANR through an International Collaborative Research Project (PRCI) between LPNHE and ETH Zurich and is done in collaboration with BNL and Kyoto University. A first prototype of this detector is expected to be installed at J-PARC in 2027.

### Title

### Topic

Photosensors

**Auteurs:** GIGANTI, Claudio (LPNHE Paris); GAIOR, Romain (LPNHE Paris)

**Orateur:** GIGANTI, Claudio (LPNHE Paris)