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Statement of Interest
for the Hyper-Kamiokande Experiment

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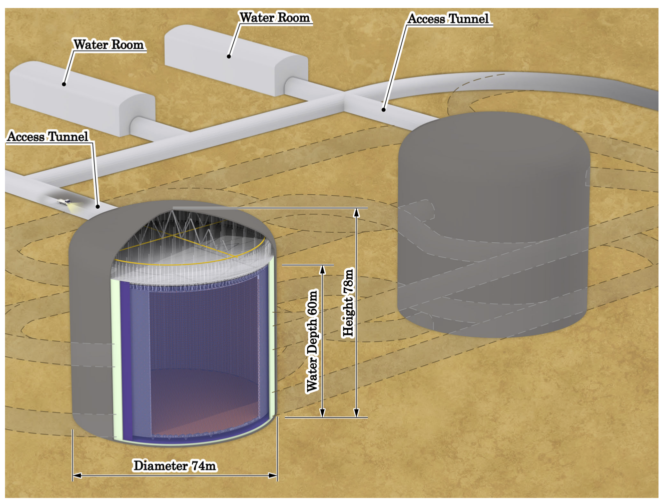

Hyper-Kamiokande is the flagship experiment in Japan. It is the latest in the generation of highly successful Kamiokande experiments with the T2K, Super-Kamiokande and Kamiokande experiments (awarded a Breakthrough prize, and two Nobel prizes respectively) as its predecessors.

The experiment will be developed by an international collaboration that will inherit the expertise and experience to provide a world-leading experiment capable of addressing the biggest unsolved questions in physics through an exciting multi-decade physics programme that will start in the middle of the next decade.

The Hyper-Kamiokande detector will be hosted in the Tochibora mine, about 295 km away from the J-PARC proton accelerator research complex in Tokai, Japan. A new cavern will be excavated and necessary infrastructure will be built. The detector will be the largest underground water Cherenkov detector in the world and will be instrumented with new technology photosensors, faster and with higher quantum efficiency than the ones in Super-Kamiokande. Pressure tests demonstrate that they will be able to withstand the pressure exerted by a massive tank.

The currently existing accelerator serving the T2K experiment will be steadily upgraded to reach a 1.3 MW beam before the start of the experiment. Enhancements to the existing array of near detectors will provide a precision tool for investigating the CP violating nature of the neutrino. The enhancements will consist of upgrades and new detectors at a distance ranging from 280 m to 1-2 km from the neutrino target.

A recent new proposal includes a second detector in Korea that will be able to further augment the physics of the first detector in Japan.

The science that will be done will shape the future theoretical framework and generations of experiments. The experiment will be sensitive to beam and atmospheric neutrinos. It will be able to measure with the highest precision the leptonic CP violation that could explain the baryon asymmetry in the Universe. A precise measurement of the other oscillation parameters will be performed, including the determination of the θ_{23} octant and mass hierarchy. The unprecedented precision and sensitivity of the experiment will enable a detailed study of the nature of the neutrino to be made allowing deviations from the three flavour neutrino mixing to be studied and enable new phenomena searches to be made.

The experiment will also have excellent sensitivity and precision for proton decay studies, providing a significant improvement over existing or planned experiments. strong astrophysical programme will be carried out at the experiment that will also allow to measure precisely solar neutrino oscillation. A program of other main physics searches are planned such as indirect dark matter.

In summary, a new experiment, based on the experience and facilities of the already existing Super-Kamiokande and long baseline neutrino experiment T2K, is being developed by the international physics community to provide a wide and groundbreaking multi-decade physics programme from the middle of the next decade. The beam upgrade for the Hyper-Kamiokande experiment is the highest priority for the KEK lab and it is already approved. The PMT specifications should be ready by the end of 2017. Already preaparation for their mass production has started with the creation of a new Hamamatsu mass production factory. Finally, a Memorandum of Understanding for the cooperation in supporting Hyper-Kamiokande has been signed by the KEK/IPNS and University of Tokyo/ICRR.

The international community is composed of 13 Countries, the UK is the largest in size outside of Japan. International contributions include the beam, near/intermediate detectors, half of the photodetection system for Hyper-Kamiokande as well as the DAQ and electronics. The second tank in Korea contribution is currently being discussed. The UK contributions span the complete experiment configuration from the beam through to the near and intermediate detectors and finally the far detector(s). The UK contributions will also include the computing infrastructure and tools necessary to successfully deliver world's best measurements.

Beam: The UK have made key contributions to the existing T2K facility, including the beam window, baffle collimator and target system for operation at up to 0.75 MW. As beam powers increase to the MW level, the beam window and target in particular are expected to become limiting technologies. We continue to keep our leadership in the beam for the update up to 1.3 MW. We will focus our efforts on upgrading the target and beam window to operate reliably at the 1.3 MW beam power based on an evolution of the current monolithic target, potentially a good solution for the upgraded beam conditions.

Near detector: The T2K near detector is fundamental to understanding the beam before oscillation, and constrains the expected spectrum at the far detector through the direct measurement of the beam flux and cross sections. We aim to add a new detector, the High Pressure TPC. Gas detectors allow detection and reconstruction of very low momentum particles, which significantly improves the ability of neutrino experiments to distinguish between neutrino interaction models and test them against data in regions of phase space that were not accessible to previous experiments.

Intermediate detector: As demonstrated by the T2K near detector, it is crucial to use the same target material, water, as at the far detector. This is necessary for reducing the systematic errors on the measurements which is essential for CP violation measurements. Furthermore, a location around 1-2 km will minimize the beam errors. We will work on a water Cherenkov at 1-2 km, and we envisage using gadolinium-doped water to identify neutrino and antineutrino interactions with neutrons in the final state.

Far detector: Three main contributions are planned for the far detector: DAQ, calibration and outer detector (OD). The DAQ and calibration systems will also be adapted to the intemediate detector which will use the same technology as the far detector.

DAQ: The UK is responsible for all the T2K near detector DAQ, and aims to include responsibilities for the DAQ for the intermediate and far detectors. A robust DAQ system capable of achieving the maximum physics reach in all areas is required. A framework DAQ has been developed and will need to be adapted to the final chosen PMTs and electronics.

Calibration: We have a strong experience in the calibration in SNO and SNO+ on which we base our contribution to the calibration. To meet the Hyper-Kamiokande physics goals, it is necessary to reduce both the errors in photodetector calibration and the uncertainties in the reconstruction efficiency of the neutrino events. We have a total of three calibrations that we are developing and also possibly test in Super-Kamiokande. The calibration methods will also be applied to the intermediate detector.

Outer Detector: As demonstrated in Super-K, the OD is crucial to provide a background reduction, tagging the external backgrounds. An original design using smaller PMTs than in Super-K allows to engage a UK company for the development and future production.

Computing & Software: The UK is responsible for the software release management and data distribution, that is supported by the GridPP in the UK. We are also responsible for the triggering and low energy simulation for the Hyper-K simulation package.

Physics: The UK is leading the oscillation analysis in T2K, and adapting those techniques, is now providing the sensitivities estimates for Hyper-Kamiokande.

Discussions for the second tank in Korea are preliminary, but we may provide the DAQ and calibration also for the Korean detector.

The UK have leadership roles in all the areas we work demonstrating the indispensible contribution the UK is making to the experiment. Strong connections with the UK industries are being developed.

Finally, the current work will be able to provide training in technical skills for STEM, leading to a skilled workforce with an improved understanding of technology and its relevance for science, leading to an increased revenue generation for the UK, and a more technically literate society. We address several projects for students and a variety of occasions to communicate the physics to the wider public.