Science and Technology Facilities Council

Statement of Interest/Outline Proposal

Before filling in this pro forma or writing your Scientific Justification, please ensure that you have fully read the SOI guidance.

Project Title	The Hyper-Kamiokande experiment (pre-construction)
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Proposers → see authorlist in the Scientific Jutification document. 1. 2. 3.	**Institute → see authorlist in the Scientific Justification document.**

(additional names may be included on separate sheet if necessary)

Brief Project Outline

Hyper-Kamiokande is the flagship neutrino experiment in Japan. It is a multipurpose experiment, as it can act as both a long baseline neutrino experiment and atmospheric and astrophysical neutrino experiment. The UK effort will focus on both the long baseline part of the experiment, with the beam and near and intermediate detector work, and on the far detector, Hyper-Kamiokande, that acts both as far detector of the long baseline neutrino experiment and as atmospheric and astrophysical experiment.

In more detail, the UK contributions will be on:

- the beam upgrade up to 1.3MW, from the current 750MW;
- the near detector with the HPTPC aiming to address the neutrino interaction and reduce the systematic errors;
- the intermediate detector that will provide the same target as the far detector and remove the systematics due to a difference in the target, reduce the beam error component and further reduce the cross section systematics;
- the far detector with:
  - DAQ: we will provide the DAQ for the full far detector based on our expertise, maximizing the physics reach of the experiment;
  - calibration: it's crucial to reduce the systematics at the far detector. We will provide three types of calibration;
  - outer detector: the outer detector is needed for removing the external background.
- The DAQ and calibration will also be re-optimized for the intermediate detector, that we aim to support as well.

Furthermore, we will support the computing, software and physics of the experiment.

Finally, a second tank in Korea is currently being discussed, and we may provide the DAQ and calibration for the Korean tank.

The UK has leadership roles in the overall experiment and its leadership and expertise from T2K in the proposed areas ensure the UK contributions will have maximum impact in this important experiment

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Fit to STFC Strategic Priorities

The proposed activities will eventually address the core scientific questions in STFC's roadmap:
C1: What are the fundamental particles?
C3: Is there a unified framework?
C7: What is the origin of the matter anti-matter asymmetry?
D1: How do the laws of physics work when driven to the extremes?

Timing (e.g. expected project start date, duration, longer-term commitment implications/future decision points)

We are seeking for a two year pre-construction phase, spanning three FYs, starting in October 2017 once the current grant on R&D ends. This will be followed by the request of full funding for the construction phase from 2019 onwards. This will include our work on the beam, near and intermediate detectors, and far detector(s).

Estimate of cost to STFC (including manpower). Please give details in Scientific Justification

Year 1 £k (6months)	Year 2 £k (1y)	Year 3 £k (6 months)	Year 4 £k	Total £k
609	1,077	467	0	2,153

Related projects (and previous investment)

The Hyper-Kamiokande project is based on the T2K (£14M construction + £1M per annum exploitation) and Super-Kamiokande (current work on calibration and gadolinium included in the HK project) experiments and the neutrino beam from J-PARC (included in the T2K funds). The UK built the electromagnetic calorimeter, electronics and DAQ for the T2K experiment near detectors and the target, beam window and baffle collimator for the J-PARC beam. We are currently involved in the calibration and gadolinium phase of Super-Kamiokande. The calibration work also benefits from expertise in SNO/SNO+ and ANTARES and the HPTPC from the work on the DMTPC. The UK was awarded a three year PPRP proposal to work on the Hyper-Kamiokande phase.

Main funding sources (and any financial liabilities)

The main funding source is the STFC with the R&D grant that is current supporting Hyper-Kamiokande postdocs, technical stuff, and consumables. Moreover, we were awarded an EU RISE grant, that partially supports our trips to Japan up to March 2019, so it will be beneficial also for the preconstruction phase.

Principal partners/collaborators (and level of commitment)

Excluding the UK which is a significant principal partner of the project and has been described before.
The project is hosted by Japan and mainly supported by the Japanese funding agency MEXT. The upgrade of the J-PARC beam was approved as highest priority by KEK in 2015. Grant-in-Aid funding for R&D was awarded to Japan, that is supporting the R&D work in Japan and initial geological survey.
Once the Japanese funding is approved (expected 2018), the full Japanese funding for the experiment will be released with no need for further approval. Even before the full approval of the experiment, Japan is moving towards construction with Hamamatsu building a mass production factory, starting the geological survey and approving the J-PARC beam upgrade for Hyper-Kamiokande as mentioned in the motivations. Prof. Kajita (2015 Nobel prize is physics) is leading the HK application to MEXT, and internal review of the Hyper-K request is currently ongoing at the University of Tokyo before Prof. Kajita submits the application.

Furthermore, there are a total of 13 Countries in the experiment.
R&D funding is available in each Country to perform R&D and a major request from Canada is underway for the intermediate detector. Near term planned contributions are from Italy, Poland, Russia and Switzerland as well.
Korea is moving towards supporting the excavation for the Korean tank.

Estimates of key risks associated with the project

The experiment is based on the work that we have performed during the R&D phase and on our expertise. The major risks are related to a possible large scale earthquake in Japan that may delay the construction, in particular the beam, although it took just less than 1y to Japan to restart data taking after the 2011 earthquake. So, we could assume max 1y delay.

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The WC technology for the far and intermediate detectors is already a tested technology but a risk can be associated to a delay in the approval (or excavation for the intermediate detector) of the experiments, although in both cases there is a strong support from the hosting institutions.
Further risk for the UK work can come from a further decrease of the pound exchange rate that could reduce the ability to travel. Although, this can be mitigated by re-arranging some meetings to occur in the UK.

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