Introduction to Hyper-Kamiokande Project and possible contributions from Latin America

Hyper-Kamiokande

Ponticífica Universidade Católica do Rio de Janeiro - PUC-Rio
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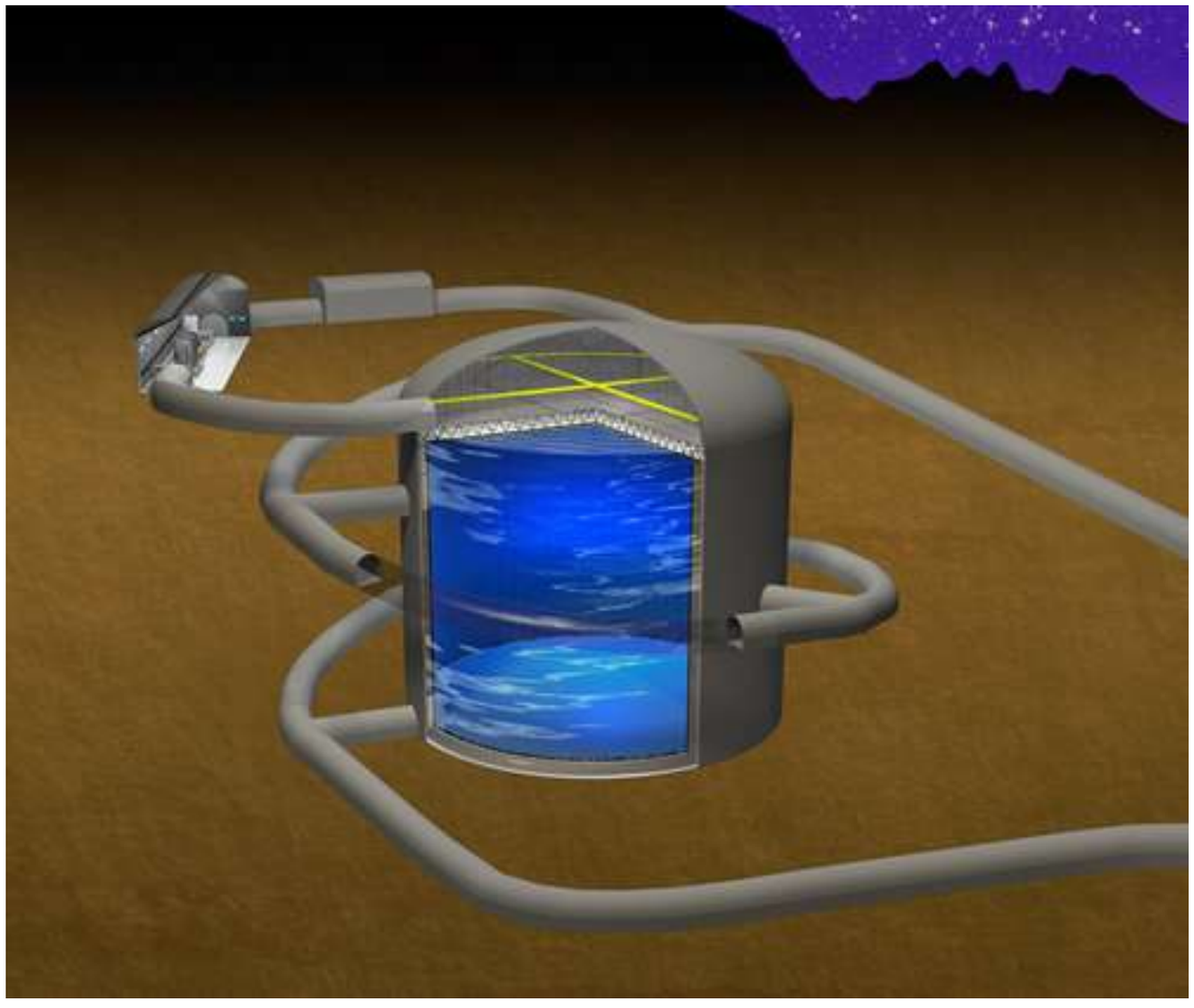
II Latin American Strategy Forum for Research Infrastucture
An Open Symposium for HECAP
July 6-10 2020 (by videoconference)

What is Hyper-Kamiokande?

Hyper-Kamiokande is a next generation large scale Water Cherenkov detector and its associated physics project



Size of Tank

Diameter: 68 m

Height: 72 m

total mass: 260 kt

fiducial mass: 188 kt

(8.4 times Super-K)

Location: under the Nijugo mountain, with overburden of 650 m near Kamioka town

Sucessor (3rd generation) of Kamiokande and Super-Kamiokande

Status of Hyper-Kamiokande

Hyper-K is officially approved in Japan

Feb. 2020: 1st year construction budget (about 32MUSD) has been approved

May 2020: Univ. of Tokyo and KEK signed MOU

Univ. of Tokyo: In charge of Construction and Operation

KEK: In charge of operating JPARC accelerator and providing Neutrino Beam to Hyper-K

KEK U-Tokyo

Hyper-K is now under construction, to start operation in 2027

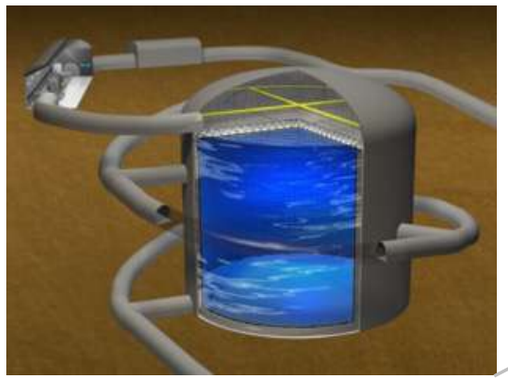
Status of Hyper-Kamiokande

Currently existing Hyper-Kamkokande Proto-Collaboration will be transformed into the formal Hyper-Kamioknde Collaboration

18 countries, 82 institutions, about 400 members

Physics Goals of Hyper-Kamiokande

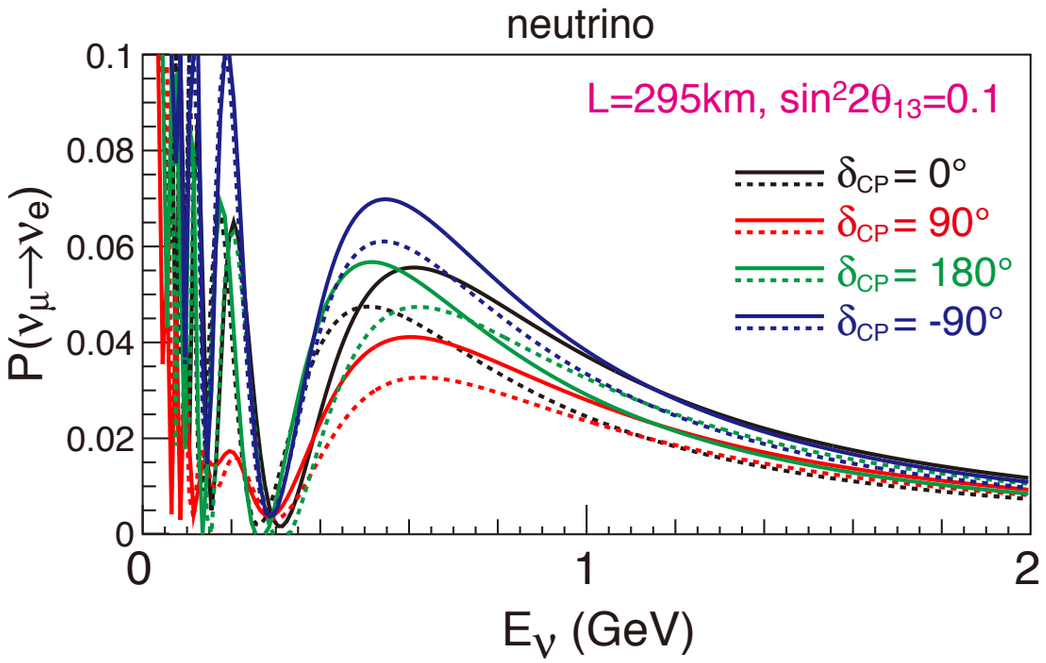
Longbasline Oscillation Physics

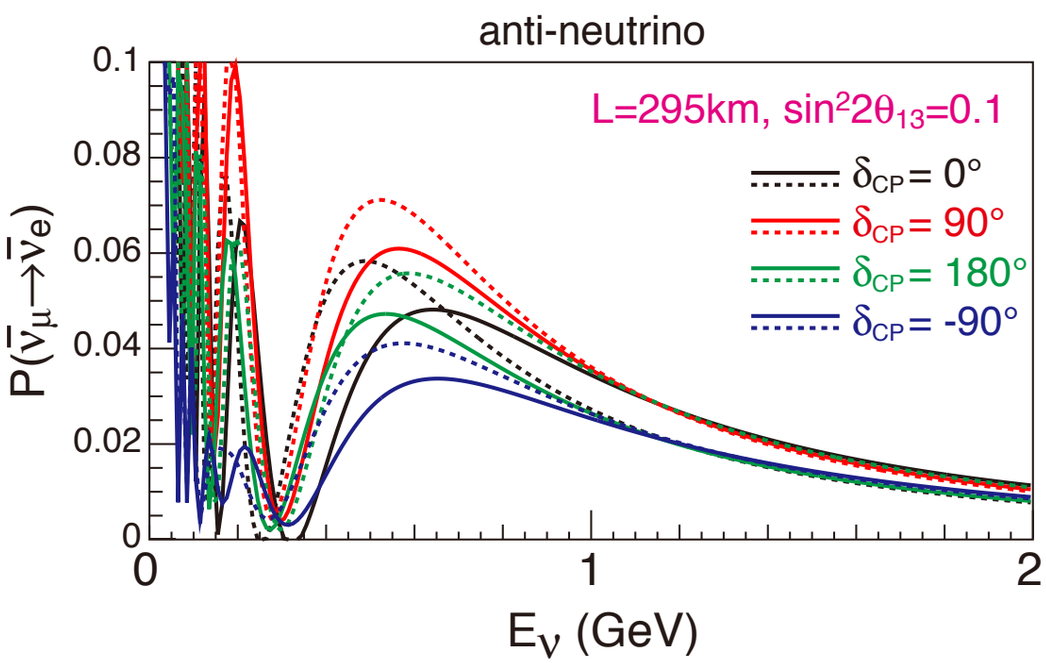


Hyper-K

J-PARC
Accelerator Complex

Observation of CP Violation



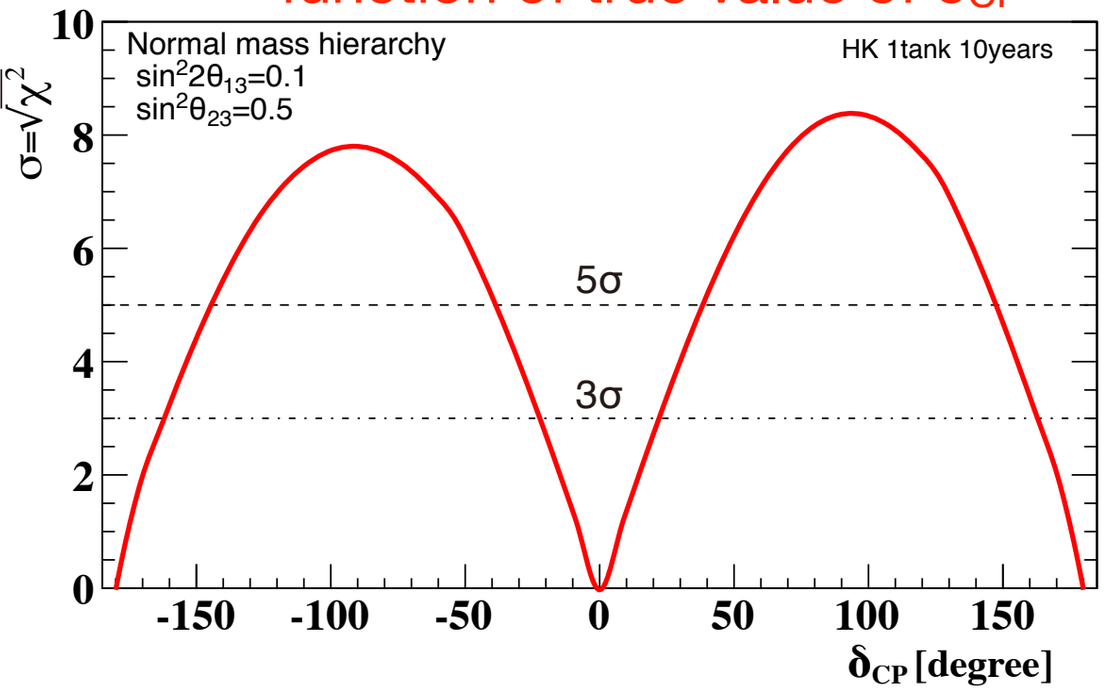


by comparing oscillation probabilities in ν and $\bar{\nu}$ channels

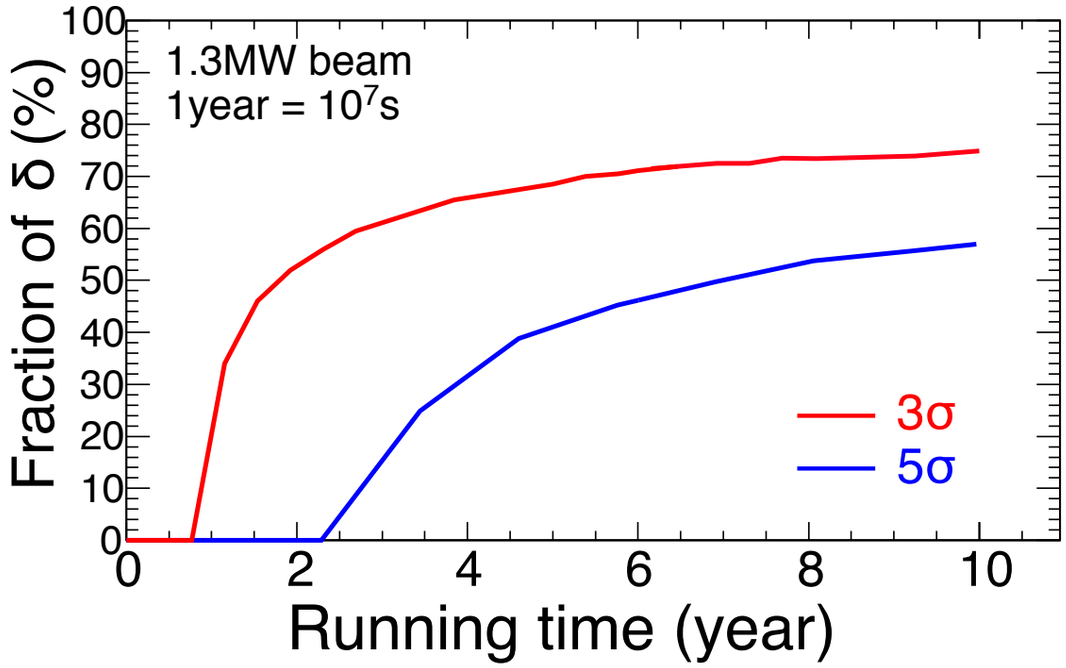
Physics Goals of Hyper-Kamiokande

Expected CP Violation Sensitivities

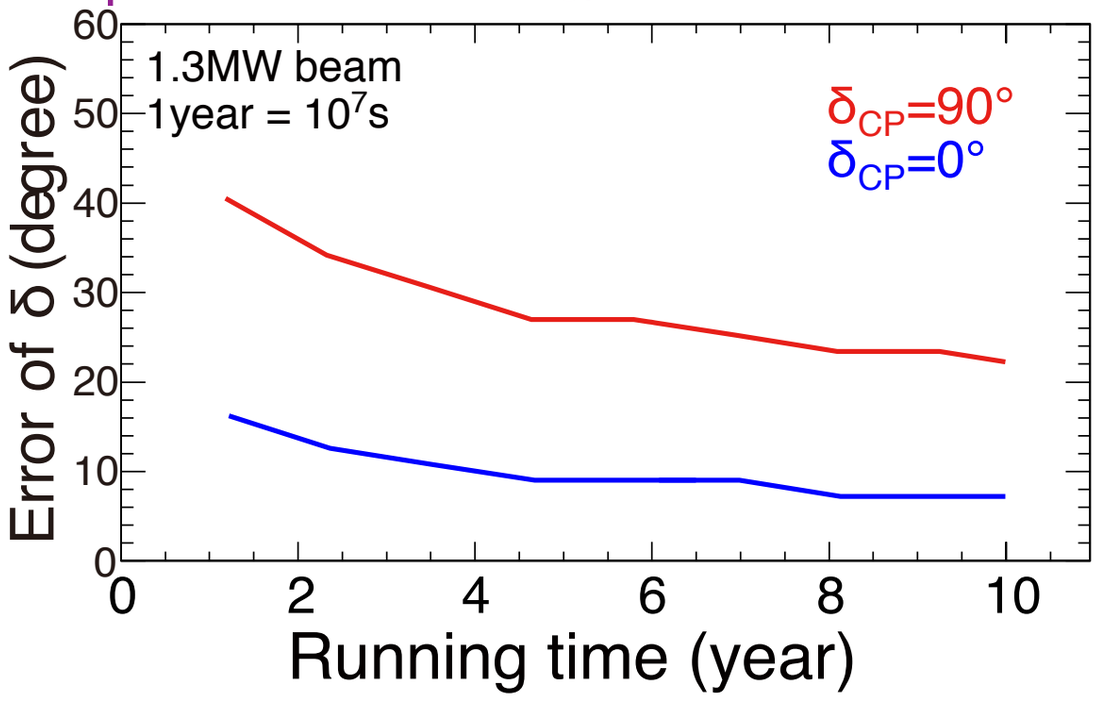
CPV significance as a function of true value of δ_{CP}



Fraction of δ_{CP} for which $\sin\delta_{CP} = 0$ is excluded



Expected error of δ_{CP} as a function of time



Hyper-K Design Report, arXiv:1805.04163v2 [hep-ex]

Physics Goals of Hyper-Kamiokande

Nucleon Decay Search

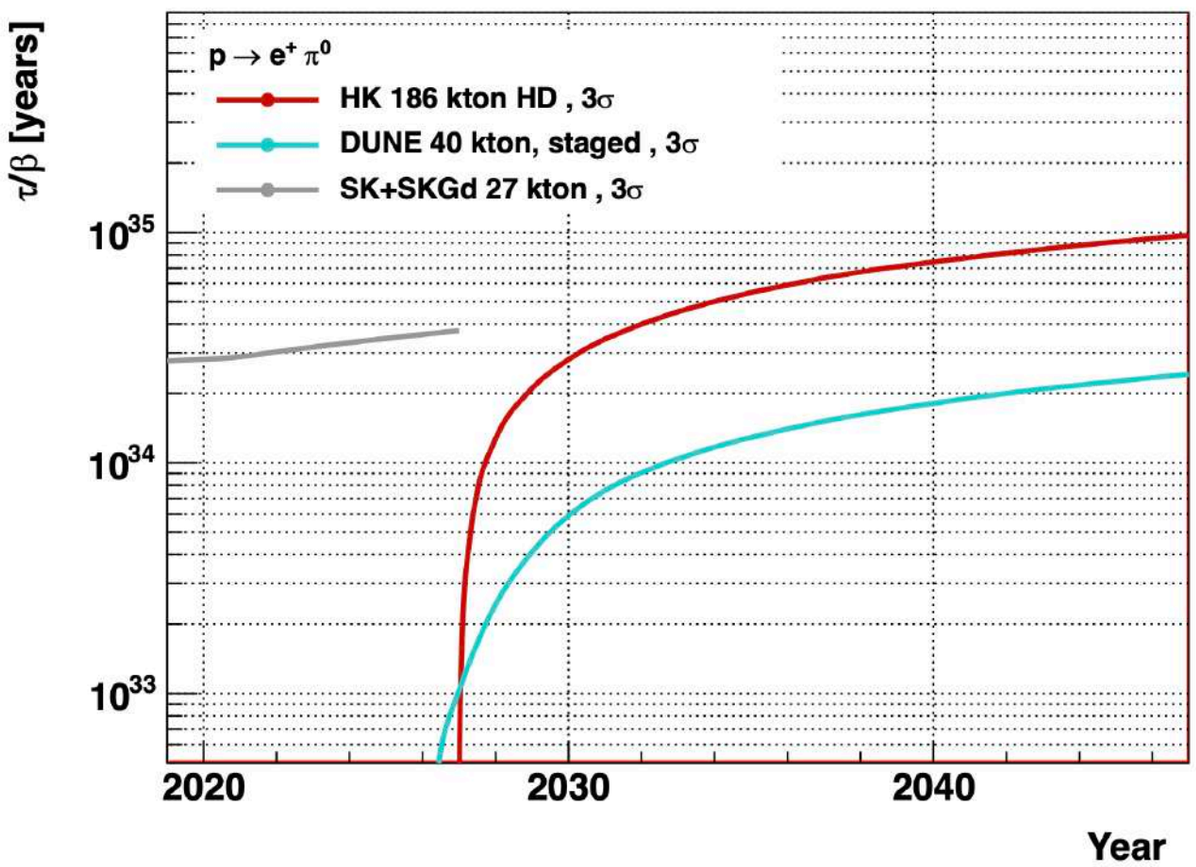
Study stability of proton to probe GUT physics

Due to larger fiducial mass, current limits

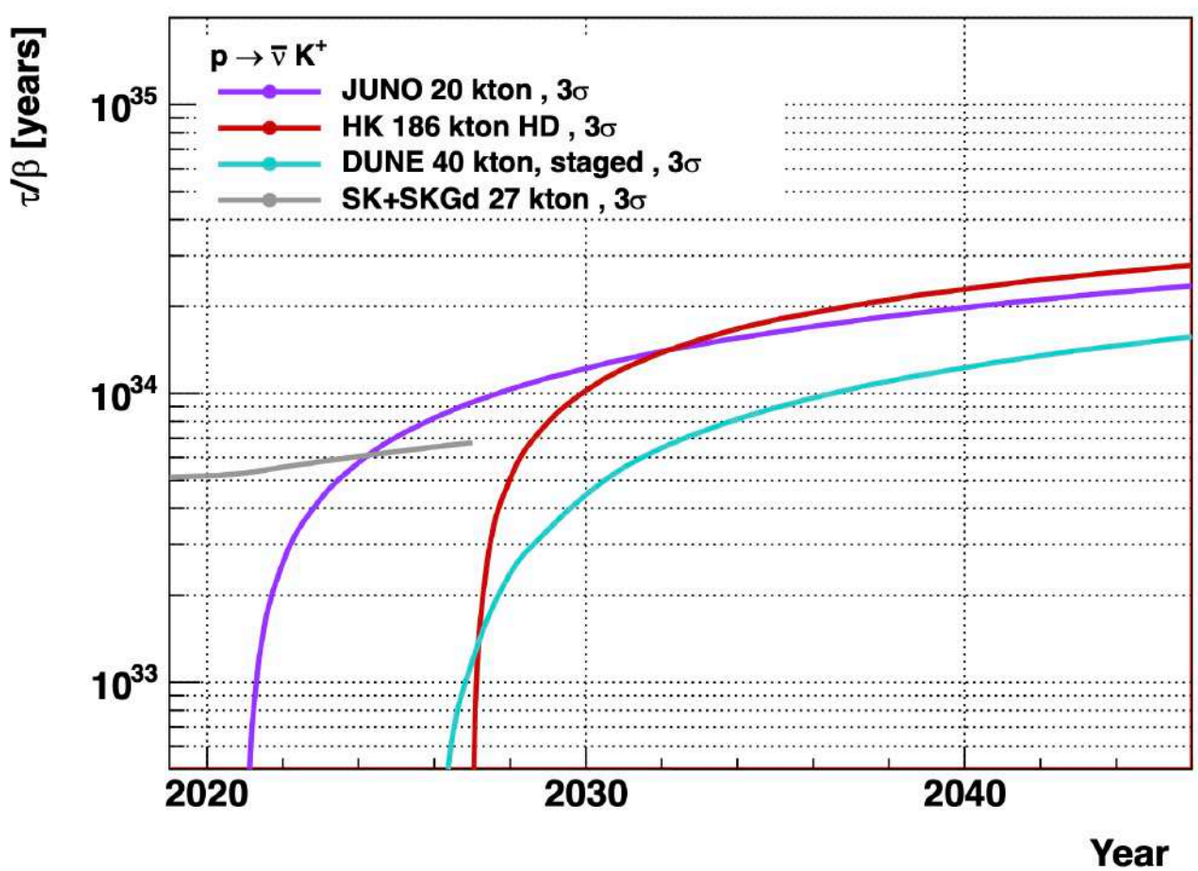
can be significantly improved

2 major decay modes predicted by many models

$p \to e^+ + \pi^0$



$p \to \bar{\nu} + K^+$



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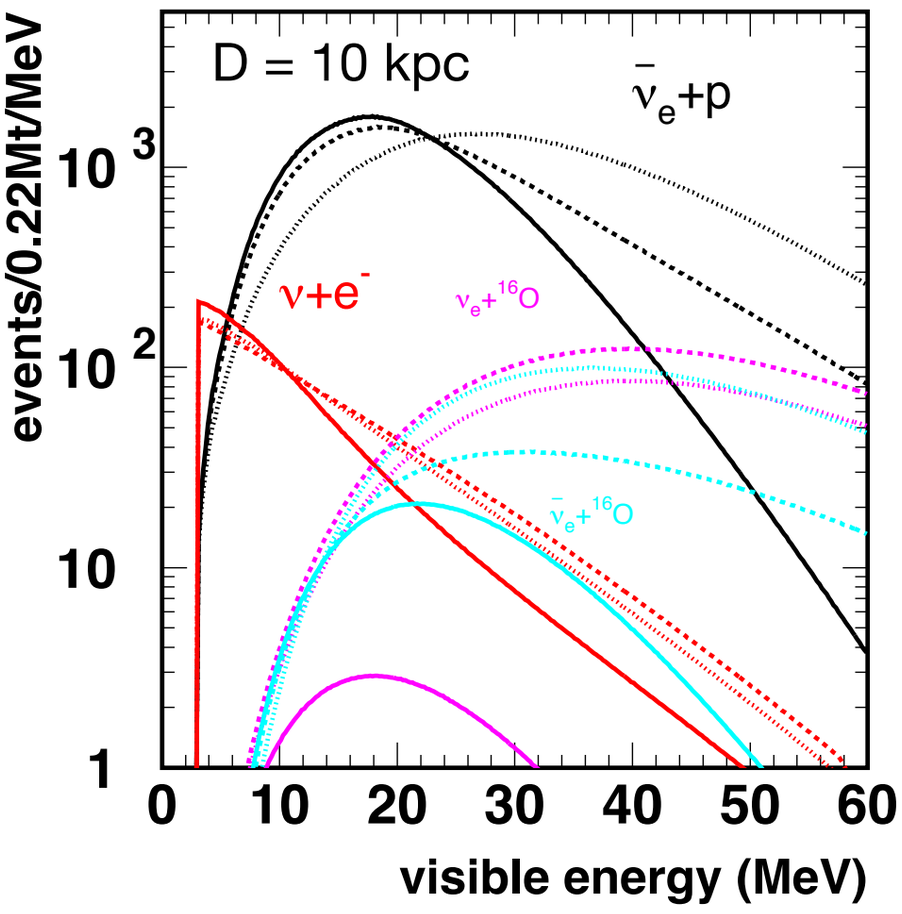
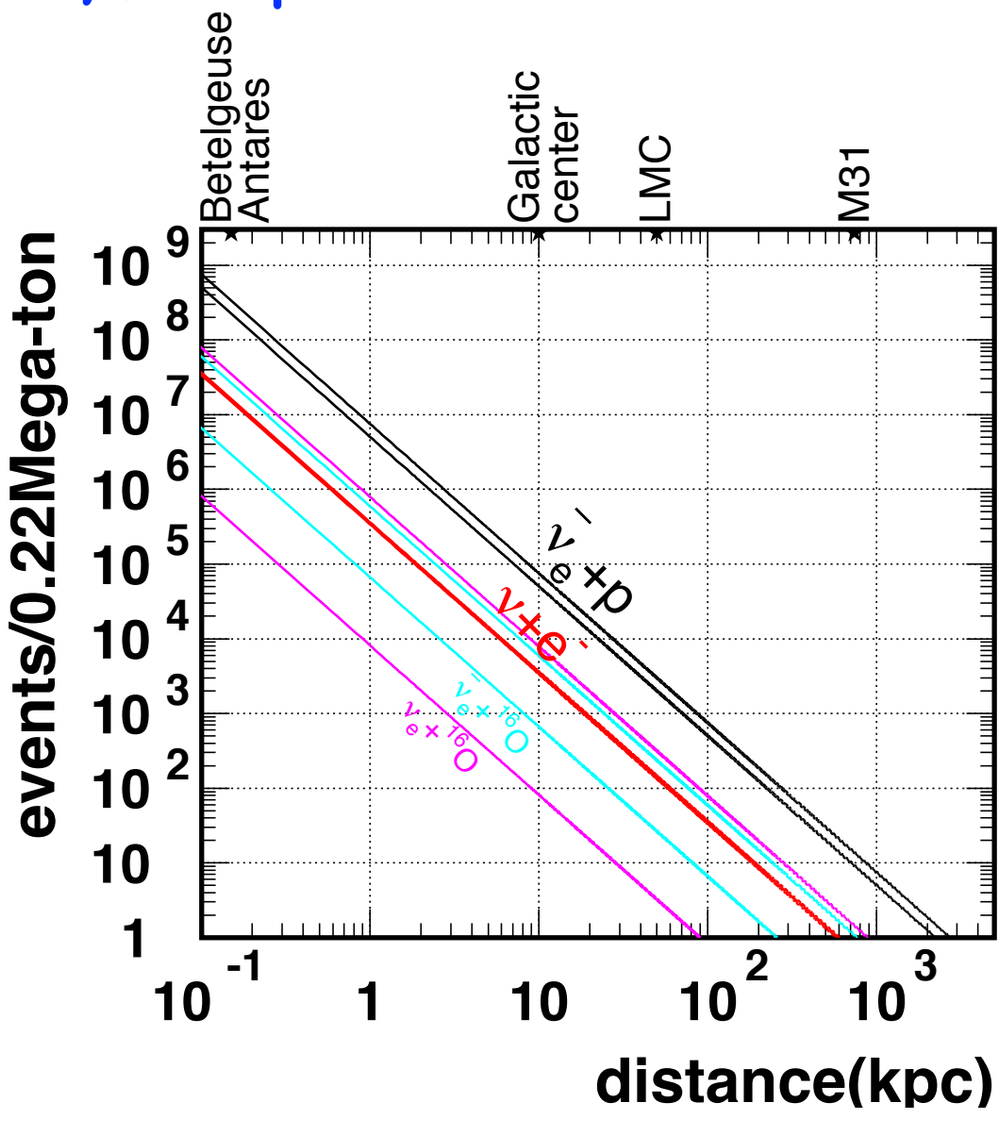
Physics Goals of Hyper-Kamiokande

Programs for Neutrino Astrophysics

For example,

Observations of a galactic (nearby) supernova neutrinos

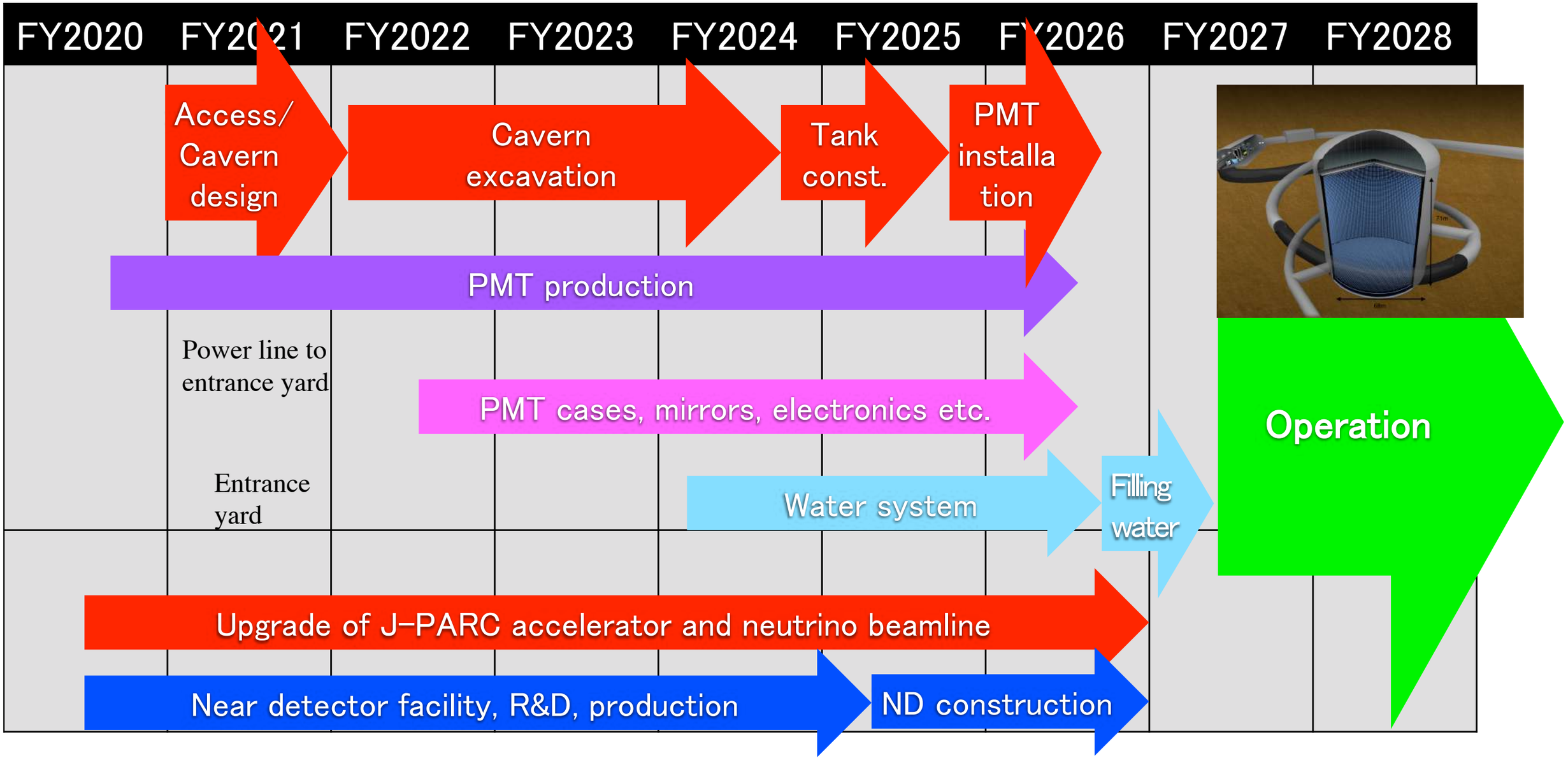




For more detailed studies of SN explosion menchanism,
formation of neutron star and/or black hole

Hyper-K Design Report, arXiv:1805.04163v2 [hep-ex]

Time Schedule of Hyper-Kamiokande



From talk given by M. Ishitsuka at Neutrino 2020

Current members of Hyper-Kamiokande Proto-Collaboration in Brazil

Currently, 3 people (theorists) from PUC-Rio

2 faculty members + 1 Pos-doc = 3

Hiroshi Nunokawa (Faculty)
Arman Esmaili (Faculty)
Alexander A. Quiroga (Pos-doc)

Recently, from Latin America, new grupos from Mexico (Univ. de Guadalajara and Univ. Autonoma de Sinaloa) joined Hyper-K

Possible Contributions

Theory (or Analysis) Oriented Contributions

Explore (study) as much as possible

Physics Potential Hyper-Kamiokndе

For example, probe new physics not expected in νSM (SM + 3 massive neutrinos) such as neutrino decay, sterile neutrino, non-standard interactions, etc, using various sources including solar, atmospheric, supernova neutrinos

Explore (study) synergy of Hyper-K with other experiments, such as DUNE and JUNO

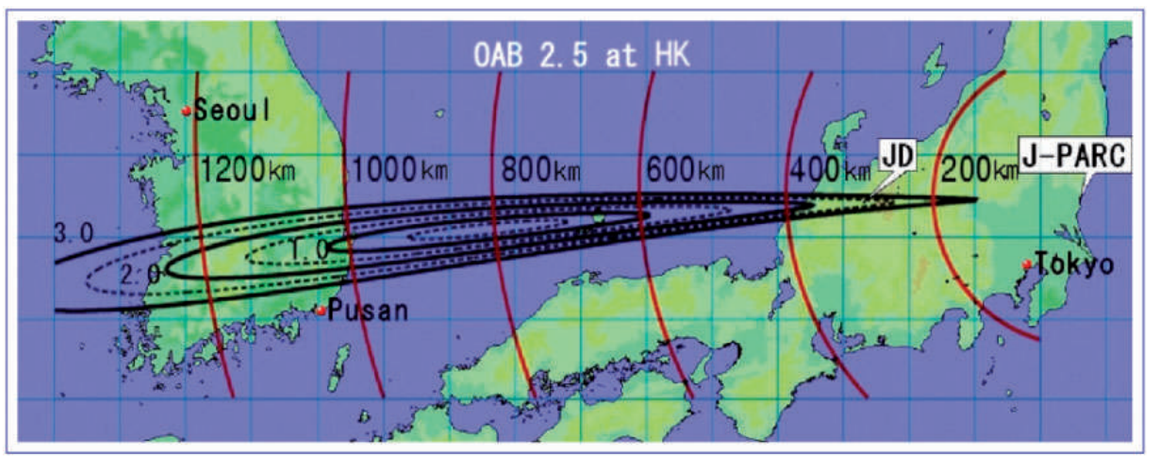
Discussions and/or collaboration with people from other groups such as from DUNE, JUNO can be very interesting

Possible contribution to computing and storage through GRID

Just an example of our current activity

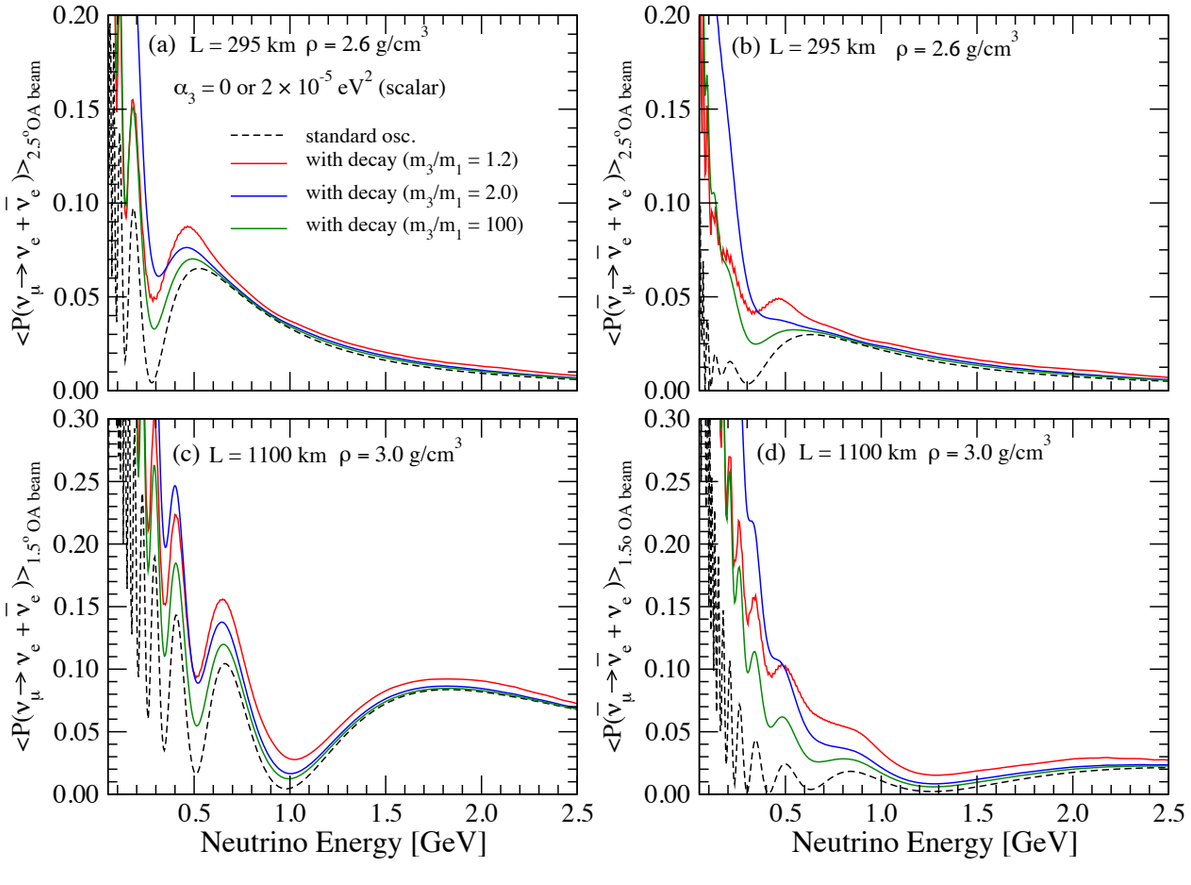
By extending the work published by HK proto-collab. in
PTEP 2018, 063C01 (arXiv:1611.06118[hep-ex])

We are studying the physics potential of the possible 2nd HK detector in Korea (under discussion), to probe new physics, such as neutrino decay scenario



J-PARC neutrino bem will pass Korea for free!

So why not use it?



Due to a larger baseline (>1000 km), the impact of neutrino decay would be significantly larger (at least at probability level) at the 2nd HK detecto in Korea

A. Esmaili et al, in preparation

Possible Contributions

Contribution to Hardware (Dectectors) ?

Some direct hardware (instrumental) contribution for (near/far) detectors could be possible if we will have some more new members from Brazil who have expertise in hardware/instrumentation. This possibility must be explored if we want to ask for a larger financial support for Hyper-K

Concluding Remarks

No real progress can be made without new data coming from new experiments

"It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong." by Richard Feynman

We believe that the Hyper-K project has strong scientific motivations and have a good prospect to obtain some new significant scientific results

We believe that collboration/interaction between theorists and experimentalists can be very fruitful

It would be very interesting to consider complementarity and/or synergy between Hyper-K and different experiments such as DUNE and JUNO to maximize the extraction of physics results

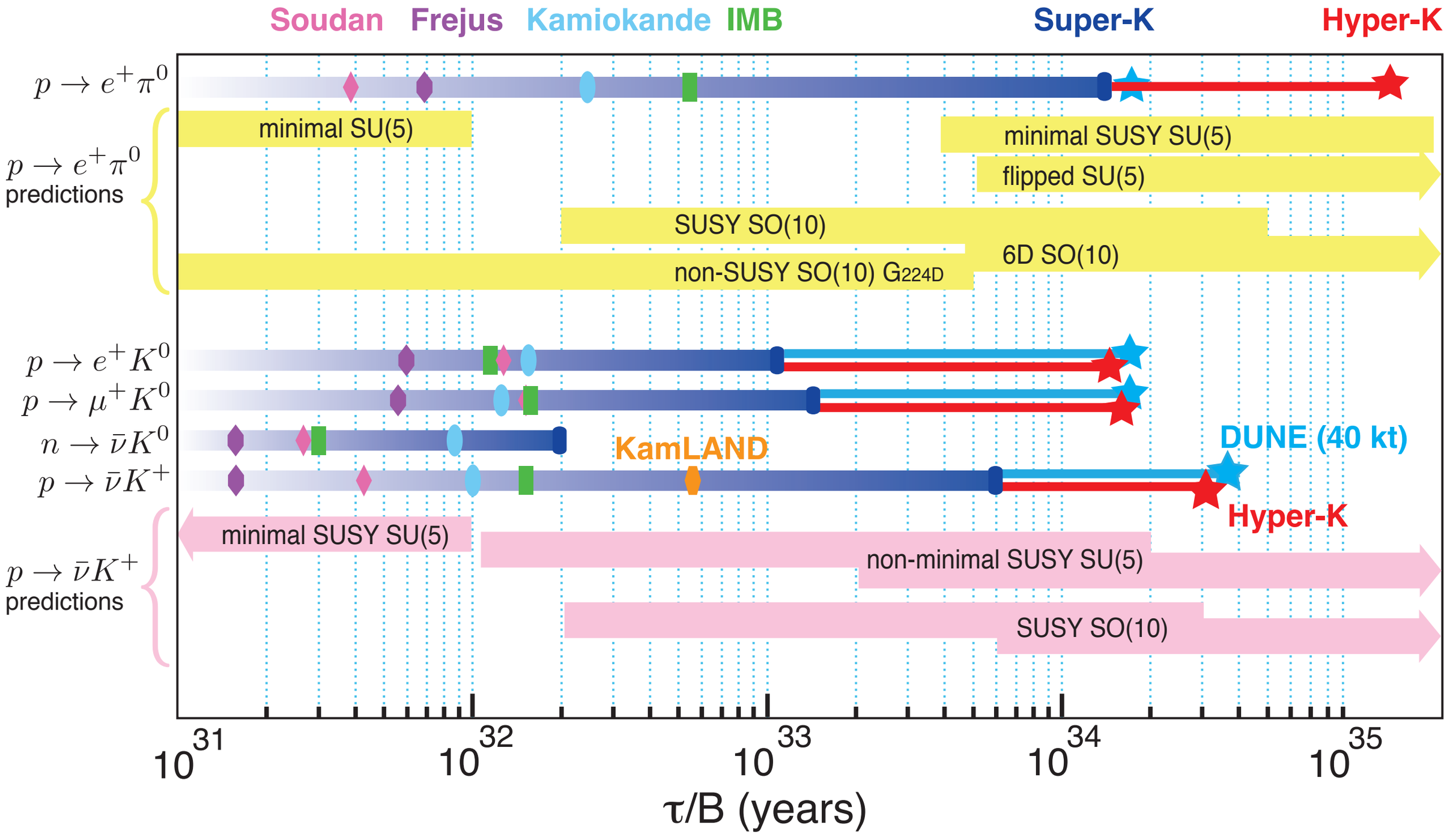
New participations to Hyper-K project is very welcome!

back up

Physics Goals of Hyper-Kamiokande

Nucleon Decay Search

Comparison with the existing limits

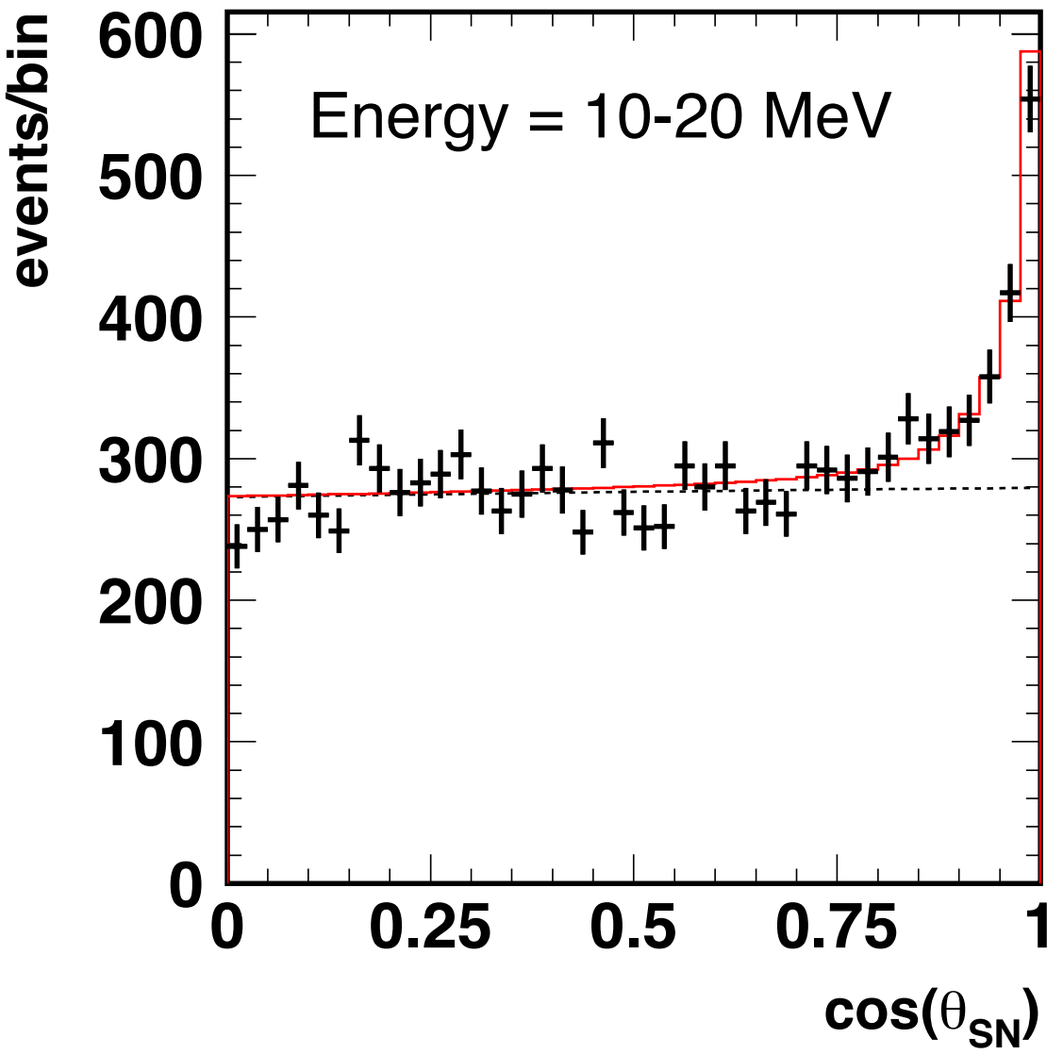


Physics Goals of Hyper-Kamiokande

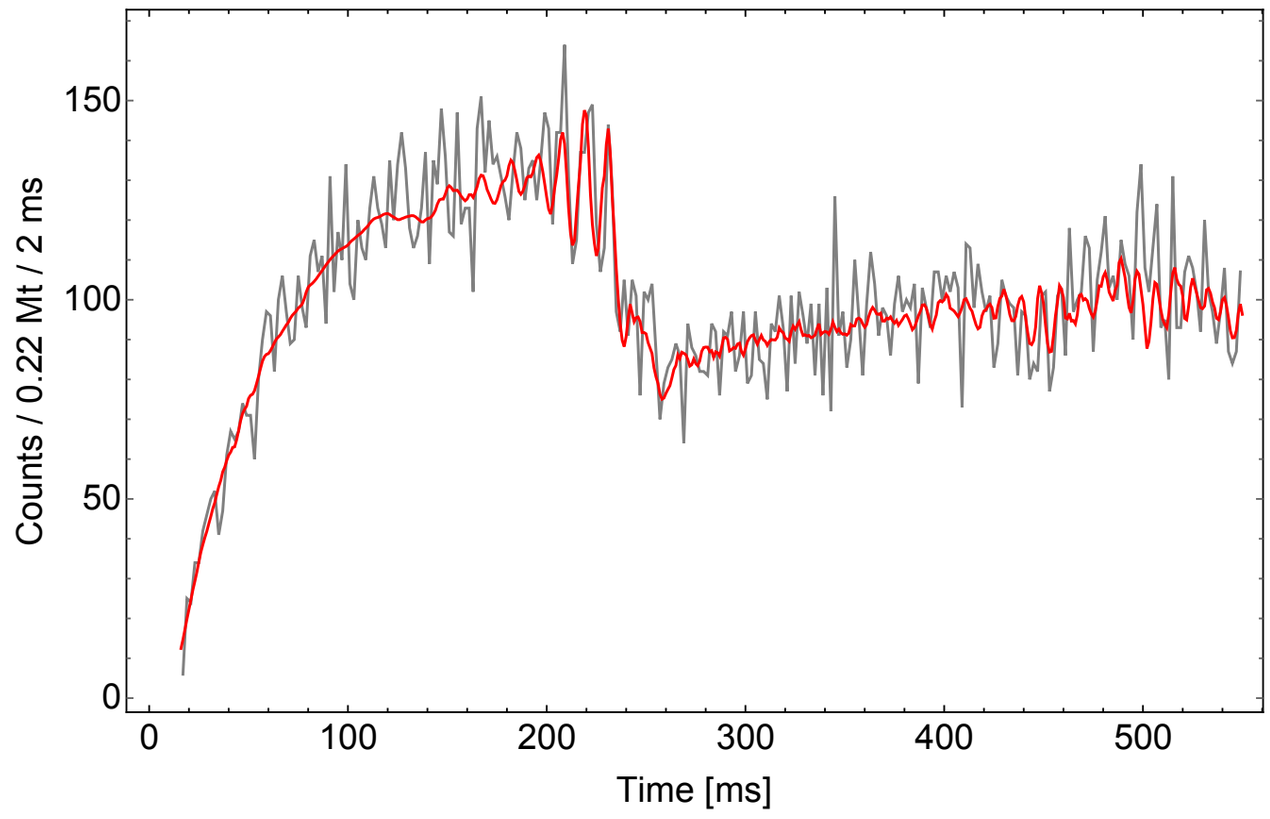
Programs for Neutrino Astrophysics

Observations of a galactic (nearby) supernova neutrinos

Determination of SN direction



Observation of SASI
(Standing Accretion Shock Instability)



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Physics Goals of Hyper-Kamiokande

More Programs for Neutrino Astrophysics

Observations of solar neutrinos

More precise measurements of ^{8}B neutrino
Day-Night Asymmetry, spectra up-turn, hep neutrino, etc.

Observations of diffuse supernova neutrinos (neutrinos coming from the past supernova) to know more about past universe and star formation history

Indirect Dark matter search at Galatic Center and in Earth

HK can play an important role in the context of multi-messenger observations, e.g. + Gravitational Wave

Physics Goals of Hyper-Kamiokande

Many other possible studies:

Atmospheric neutrinos

Earth Tomography

neutrinos from solar flare

neutrinos from Gamma Ray Burst Jets/Newborn Pulsar Winds

Any New physics effect in oscillation study from
various sources, artificial and astrophysical ones