

Hyper-K Introduction

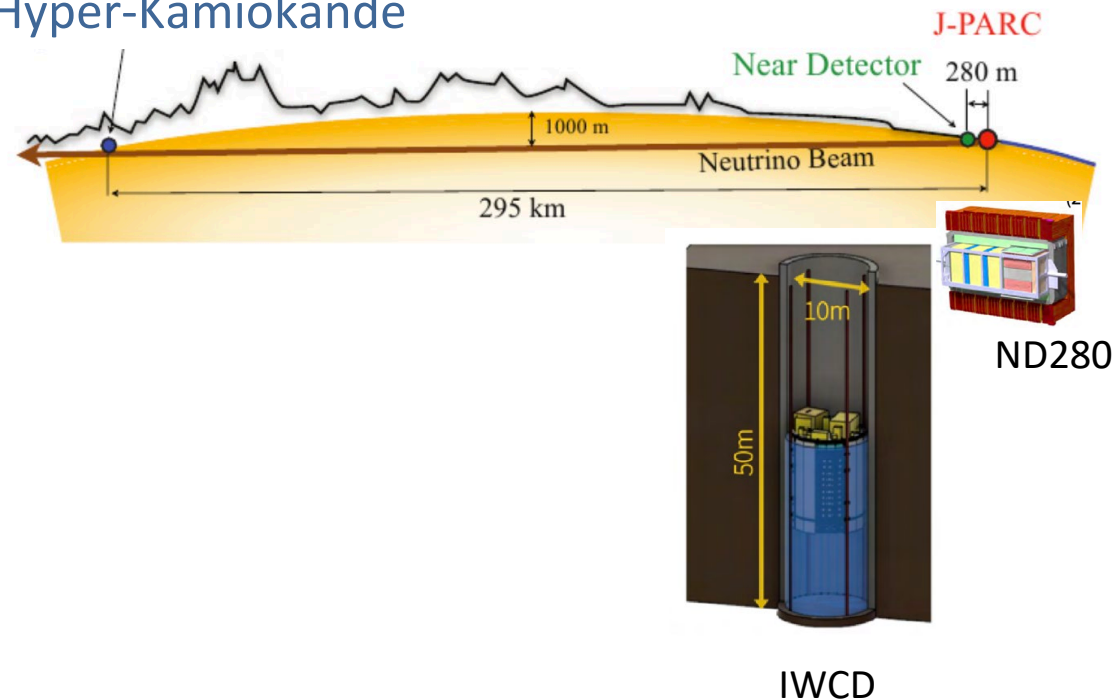
Takashi Kobayashi
J-PARC, JAEA/KEK



Kamioka Observatory, ICRR (Institute for Cosmic Ray Research), The University of Tokyo

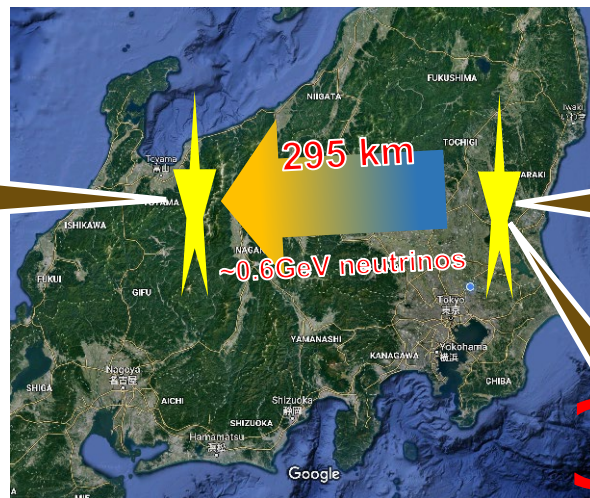
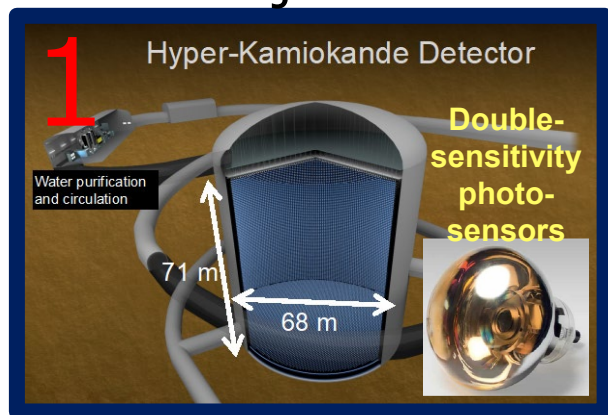
The main Hyper-Kamiokande cavern after excavation completed

Hyper-Kamiokande



PROJECT IN A NUTSHELL:

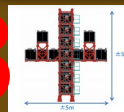
Project started in 2020, Operation start in JFY2028



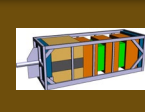
KEK High power proton beams
J-PARC (hosted by KEK)



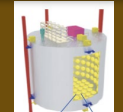
UTokyo Hyper-Kamiokande detector
(hosted by the Univ. of Tokyo)
Optically separate Inner
Detector and Outer Detector



INGRID



ND280



IWCD: New
intermediate
water
cherenkov
detector

1. World-largest detector for Nucleon-decay and Neutrino experiment

to be built with **8.4 times** larger fiducial mass (190 kiloton) than Super-K and to be instrumented with **double-sensitivity photo-sensors**

2. World most-intense neutrino beam

J-PARC neutrino beam to be **upgraded by a factor 2.5** from 0.5 (as of 2019) to 1.3 Mega Watt

3. New and upgraded near detectors to control systematic errors

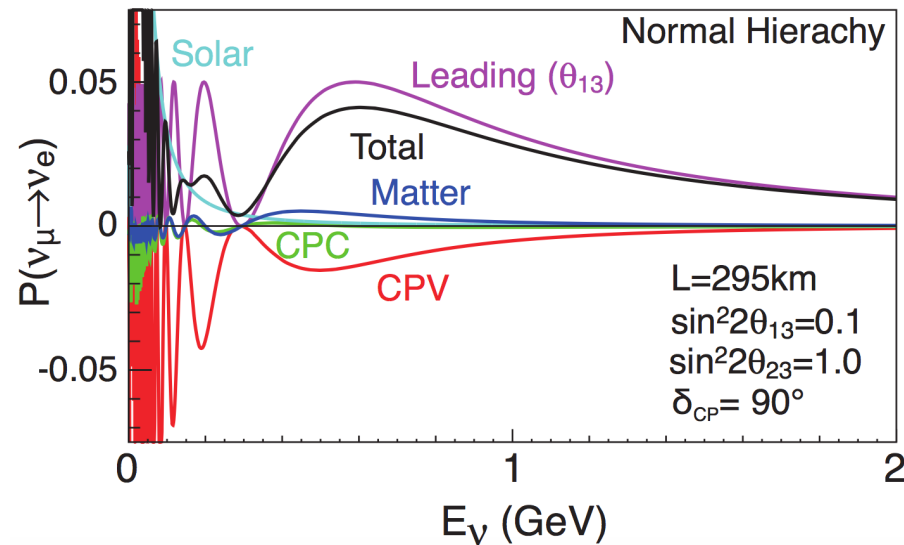
World-leading neutrino physics and astrophysics, and nucleon decay searches



SCIENTIFIC GOALS

- By sending neutrino and anti-neutrino beams from J-PARC to Hyper-Kamiokande, the difference, if any, between the oscillation nature of those two (CP violation) can be measured.
- Prove the grand unification of three forces by discovering the proton decays.
- Precision measurements of neutrino oscillation phenomena through the observation of solar and atmospheric neutrinos.
- Reveal the mechanism of the supernova explosion by observing large number of neutrinos emitted from them.
- Reveal the history of supernova explosions by observing remnant of neutrinos from supernova explosions that occurred during the history of the evolution of the Universe.
- Others

CP violation in neutrino oscillation



- Potentially large CP violation in neutrino oscillations due to large lepton mixing angles

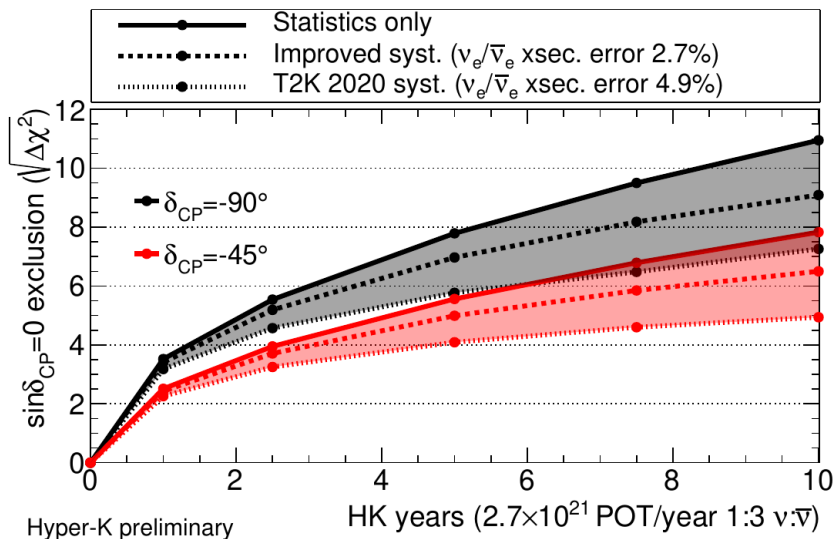
$$\frac{\text{Prob}(\nu_\mu \rightarrow \nu_e) - \text{Prob}(\bar{\nu}_\mu \rightarrow \bar{\nu}_e)}{\text{Prob}(\nu_\mu \rightarrow \nu_e) + \text{Prob}(\bar{\nu}_\mu \rightarrow \bar{\nu}_e)}$$

$$\simeq -0.28 \sin \delta_{CP} + 0.07$$

matter effect

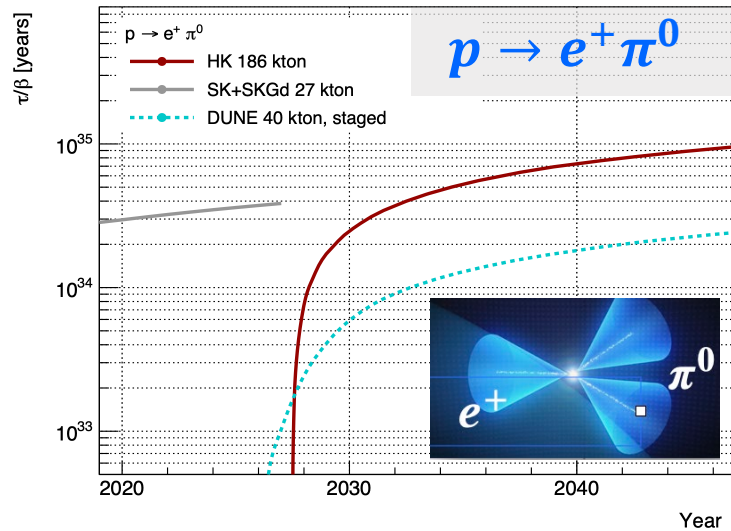
- Hyper-K CP sensitivity is limited by systematic uncertainties

- ν cross sections
 $\rightarrow$ IWCD

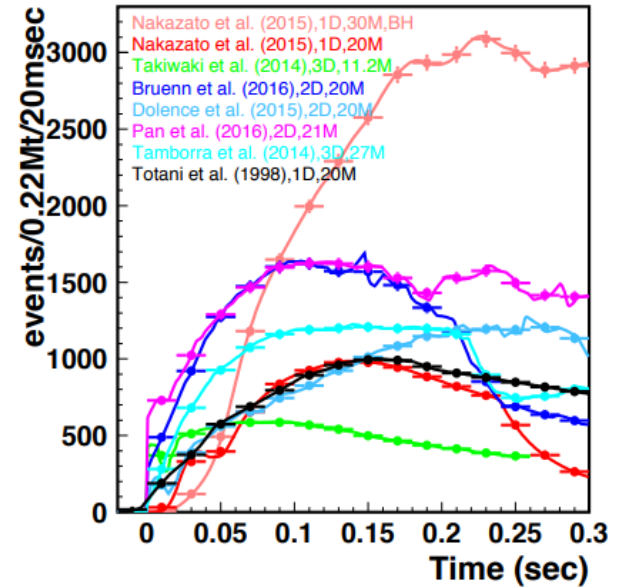
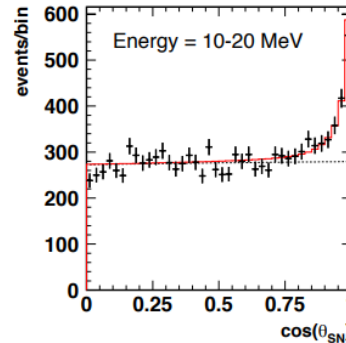


Other Hyper-K physics

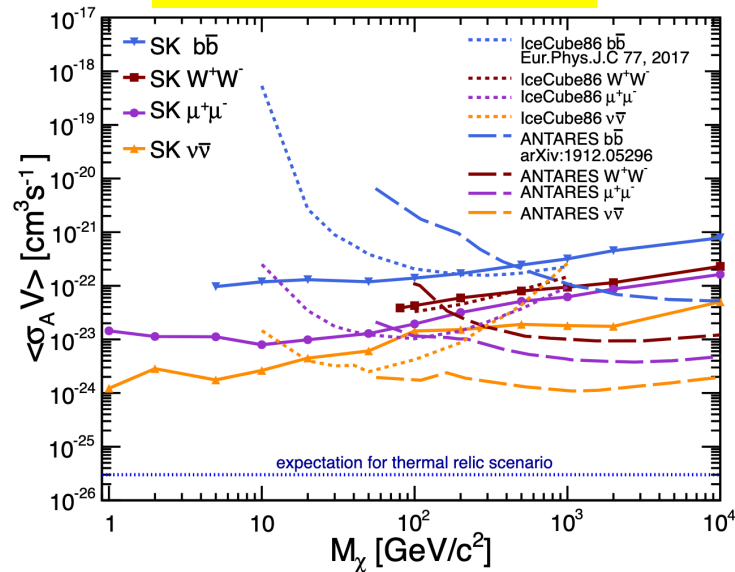
Proton decays



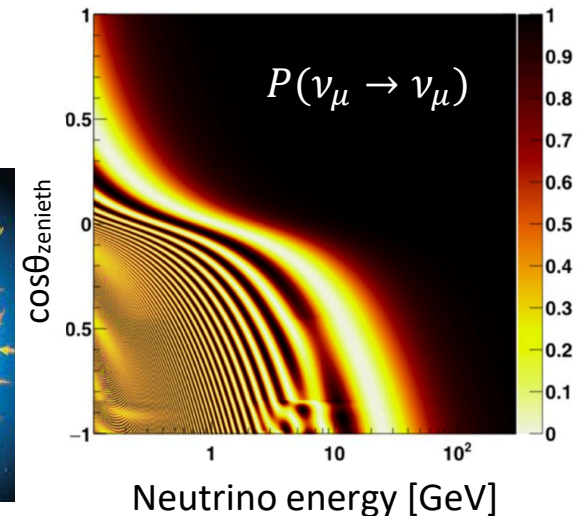
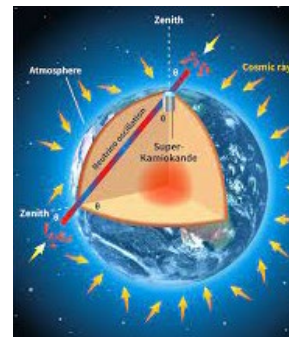
Supernova ν - detailed explosion mechanism



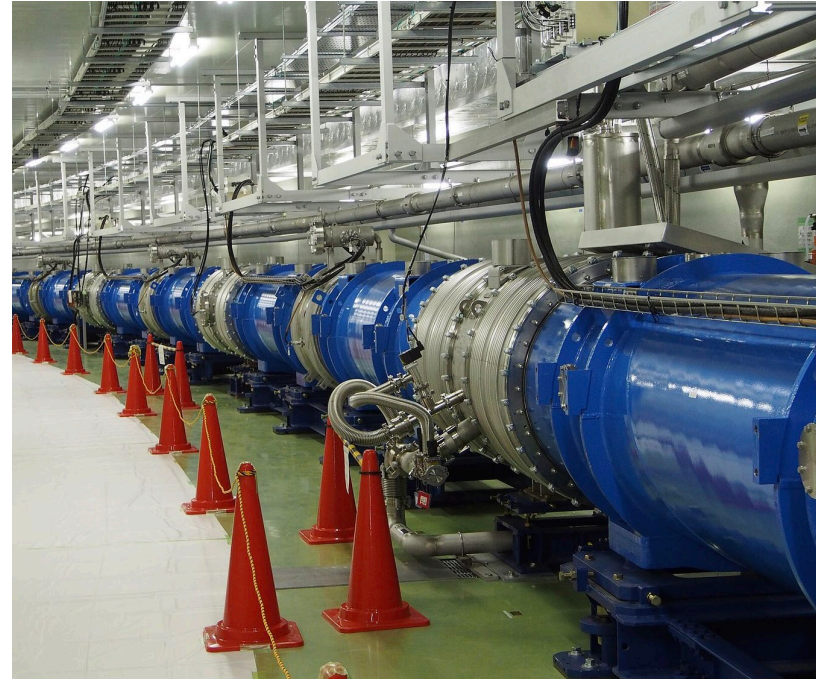
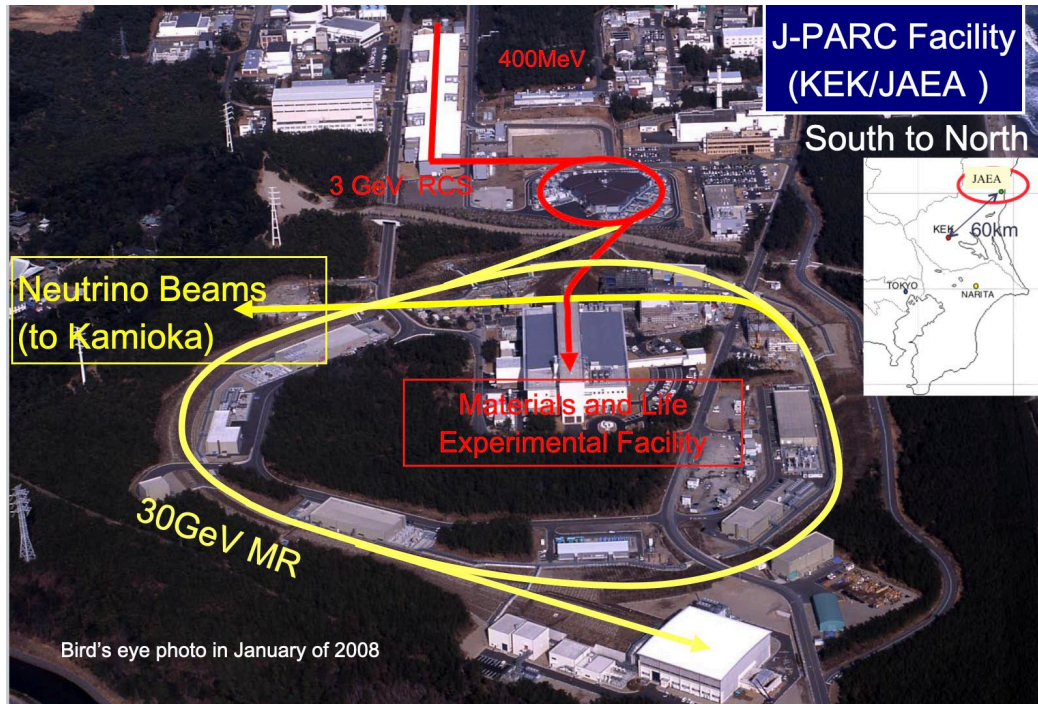
Indirect dark matter and galactic ν search



Atmospheric ν oscillogram - matter effect - non-standard ν interactions



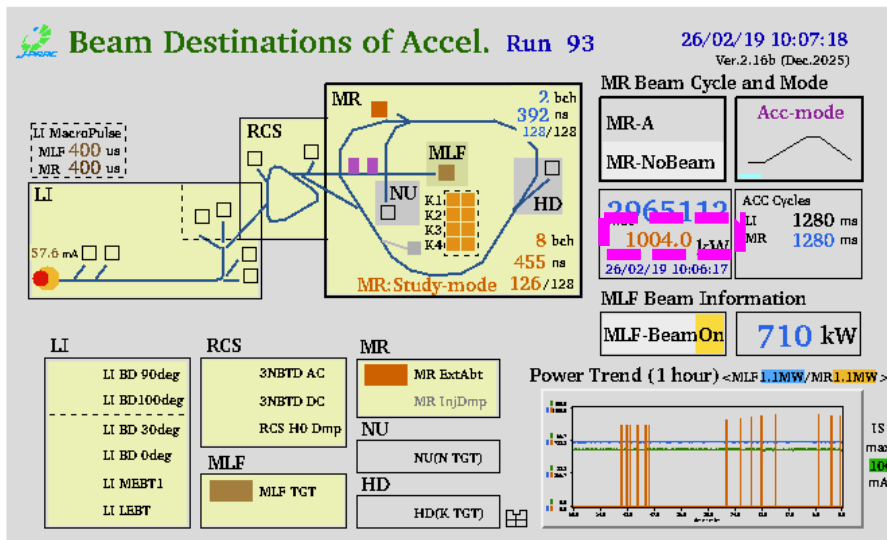
J-PARC Accelerator



- 90 deg. Bend of a 30 GeV proton beam towards Kamioka (east)
 - Superconducting LHC-type magnets were adopted
- Contributions by TRIUMF scientists and engineers:
 - FODO optics to avoid magnet quenching
 - Combined-function magnets to bend and focus over a short distance
- TRIUMF kicker proposal (IGBT switch) was not used → used for the UCN kicker

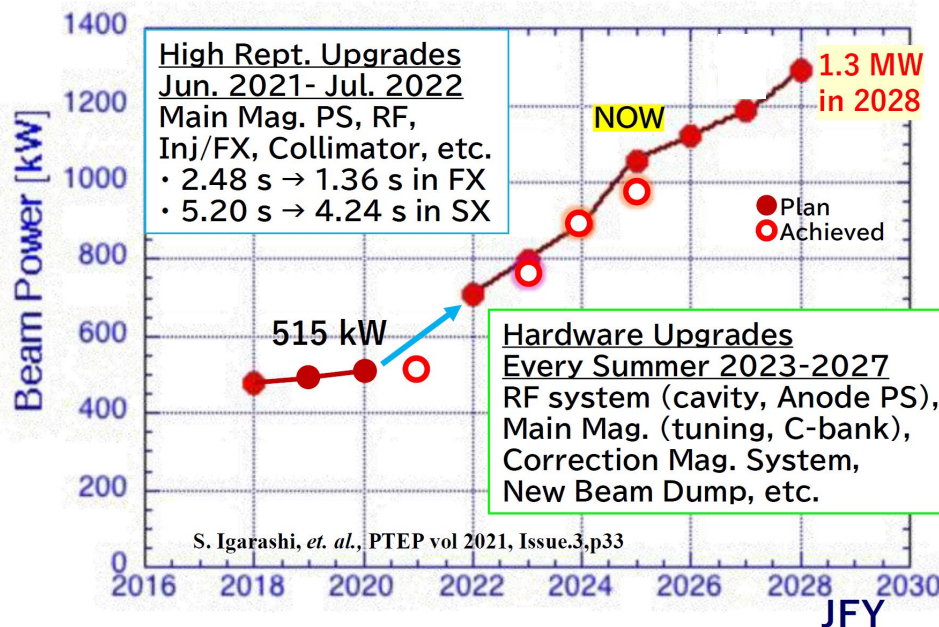
Status of Accelerators

19th Feb. J-PARC MR Achieved **1MW**



T2K Program operate **until the end of May 2027**

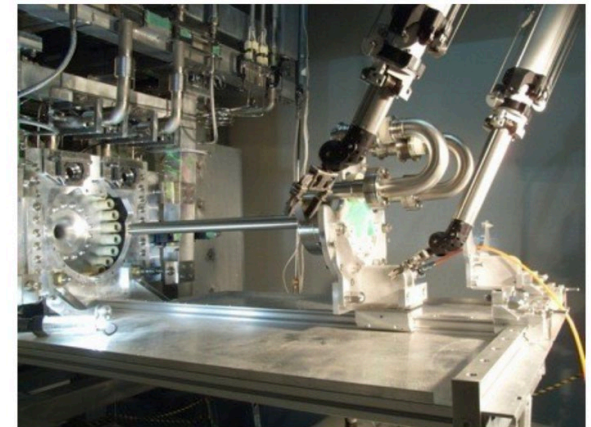
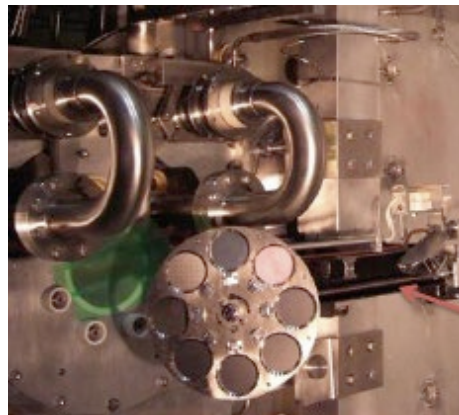
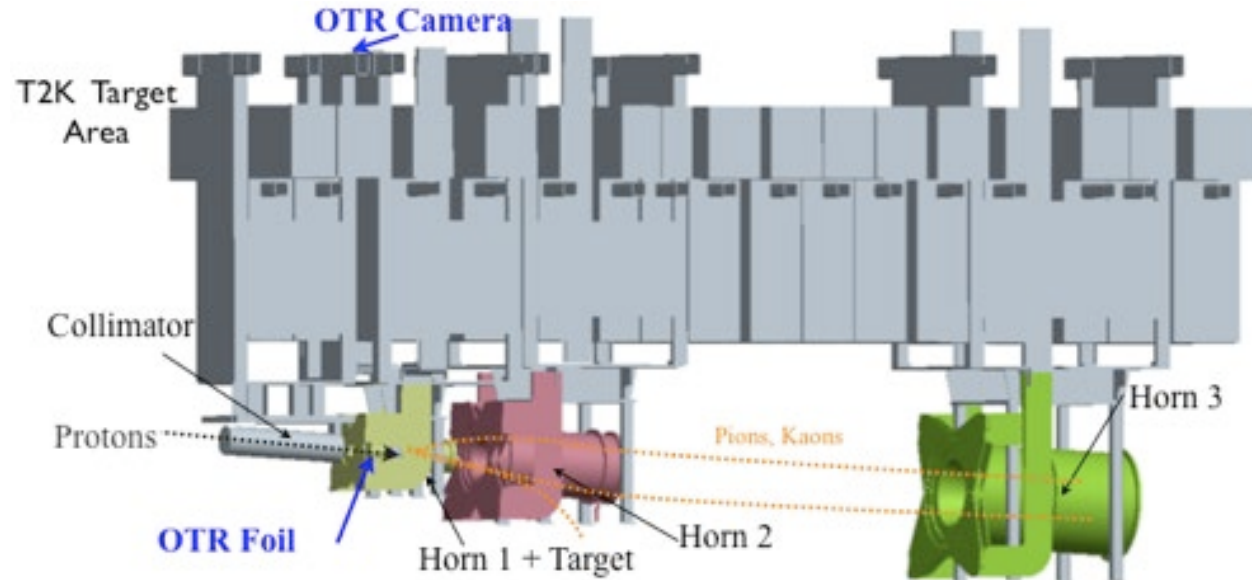
Acc. Power Update is on Schedule



From 2027 June
we focus on commissioning
with ~ 1.3 MW.

Target Station

- Horn magnets are hanging from the top
 - Services through shields (ISAC approach)
- OTR foil disk in front of the graphite target
 - 1.3MW beam will hit OTR and the target
- 3 horns focus the pions which decays into neutrinos in the 100m-long decay volume



T2K Remote handling

Coming from Japan

Takashi Kobayashi – KEK, Head of Neutrino Facility Construction Group
Yoshikazu Yamada – KEK, Target Station Design (will bring Hitachi design report for review)

Wednesday P.M.

2:00-4:00 – Visitors arrive
– Tour of ISAC Target Hall and Meson Hall

C. Mark
E. Blackmore

4:00-5:00 – General meeting discussions

E. Blackmore
A. Konaka

Thursday

9:00-10:00 *ISAC-II Conference Room*
– Introduction to T2K Neutrino Target Station

T. Kobayashi
Y. Yamada

10:00-10:30 – ISAC Remote Handling

C. Mark

10:30-11:00 – Discussions/questions

Informal Meetings: Trailer Hh Conference Room (or elsewhere)

11:00-12:00 – Target engineering design and RH

G. Stanford
C. Mark

1:00-2:00 – Beam monitoring

D. Gray
E. Blackmore

2:00-3:00 – High radiation area design – TRIUMF experience
e.g. vacuum, electrical, water

G. Clark
R. Kuramoto

3:00-4:00 – Air and water systems

G. Battersby

Friday

Informal Meetings: Trailer Hh Conference Room (or elsewhere)

9:00-10:00 – Radiation issues

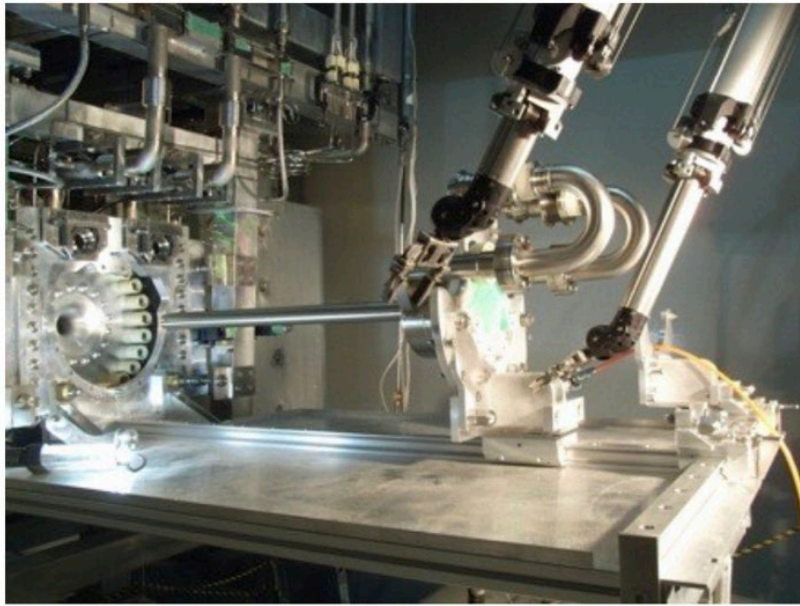
A. Trudel

10:00-11:00 – T.B.A.

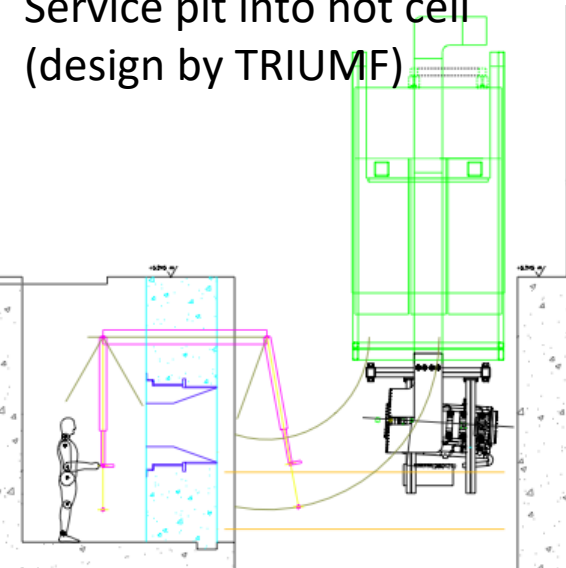
11:00-12:00 – Collaboration issues

E. Blackmore
J-M. Poutissou

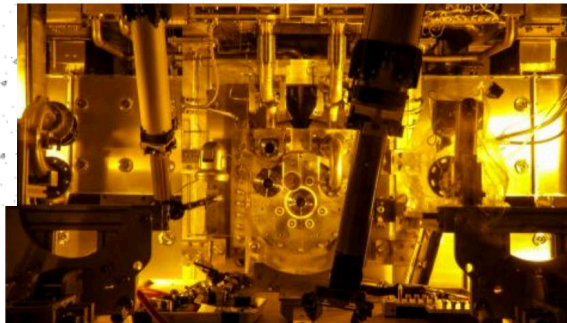
- KEK neutrino group visited TRIUMF on May 19-21, 2004
 - ISAC target station design was adopted for T2K
 - The design was adopted by DUNE
- TRIUMF's engineering contributions
 - Beam window & monitor:
 - services above shielding
 - pillow seal used at ARIEL
 - Proposed and designed "hot cell" for maintenance:
 - the manipulator & window were built by TRIUMF
 - Essential after the earthquake
 - Continued remote handling contribution is essential
- TRIUMF, KEK, RAL, CERN and Fermilab lead the high-power neutrino beamline
 - NBI workshop series
 - RADIATE collaboration



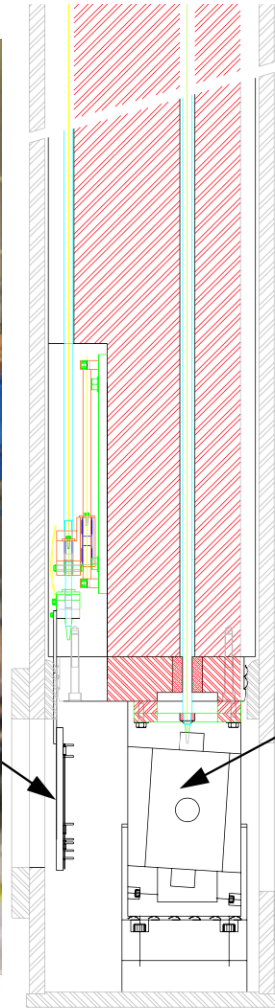
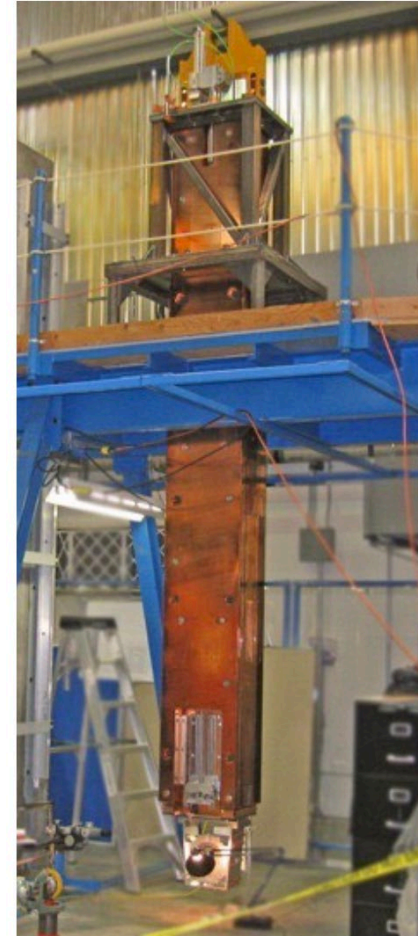
Service pit into hot cell
(design by TRIUMF)



Remote work by TRIUMF team

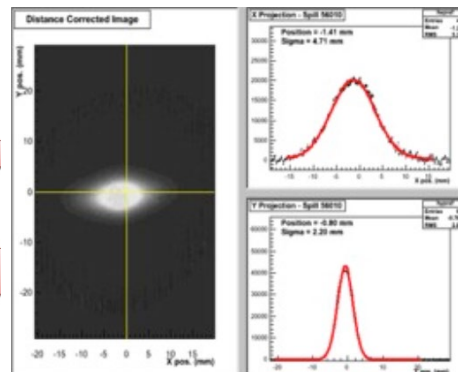
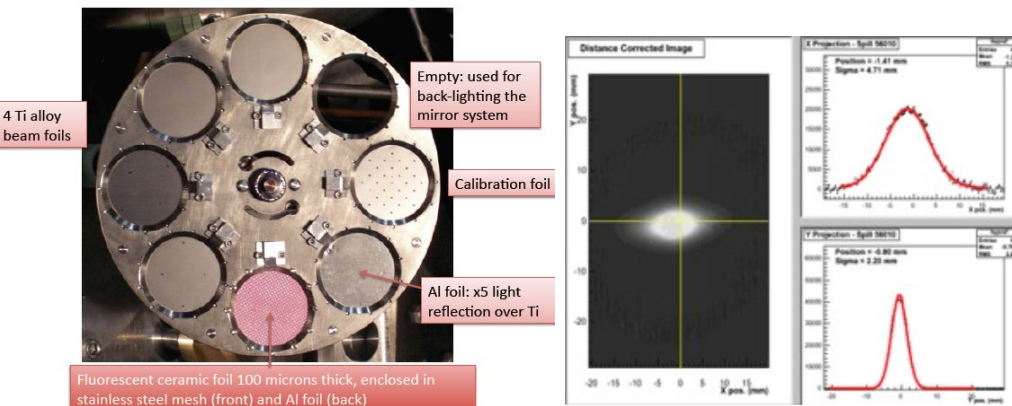
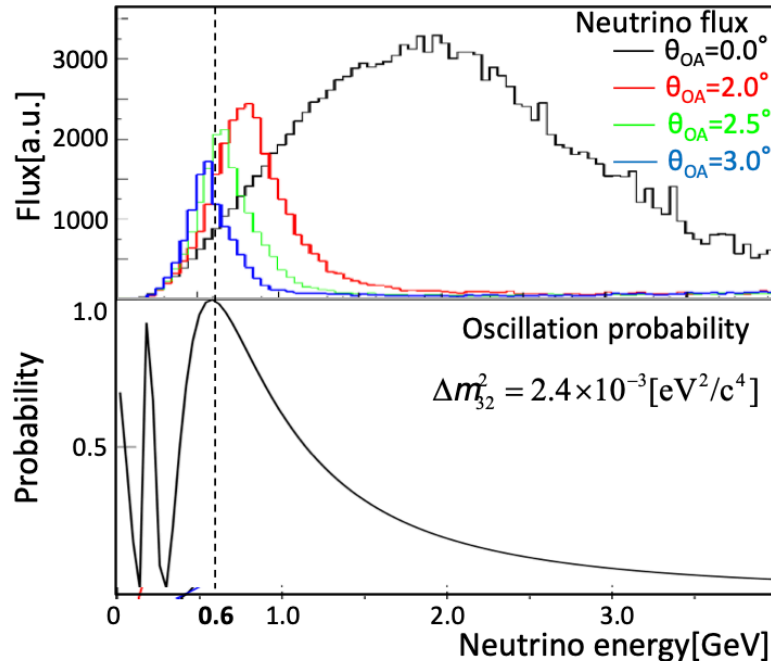


“Hot” Service cell



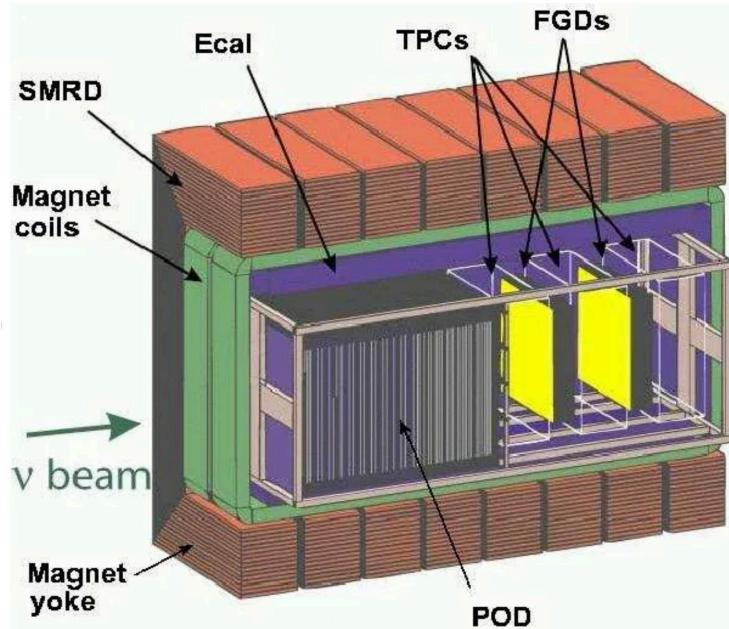
Monitor stack
support last SSEM
and the beam window

OTR monitor and the off-axis beam



- Off-axis beam
 - Suppress higher-energy backgrounds
 - Enhance signal at the oscillation maximum.
 - Proposed by TRIUMF
 - First found by a TRIUMF co-op student
- Optical transition radiation (OTR) beam monitor
 - 2D beam profile in front of the 1 MW beam target
 - Point-to-Parallel horn magnet focus
 - 1mm at the target
 - 1mrad angle shift
 - 10MeV E_ν bias
 - 0.3mm resolution by OTR

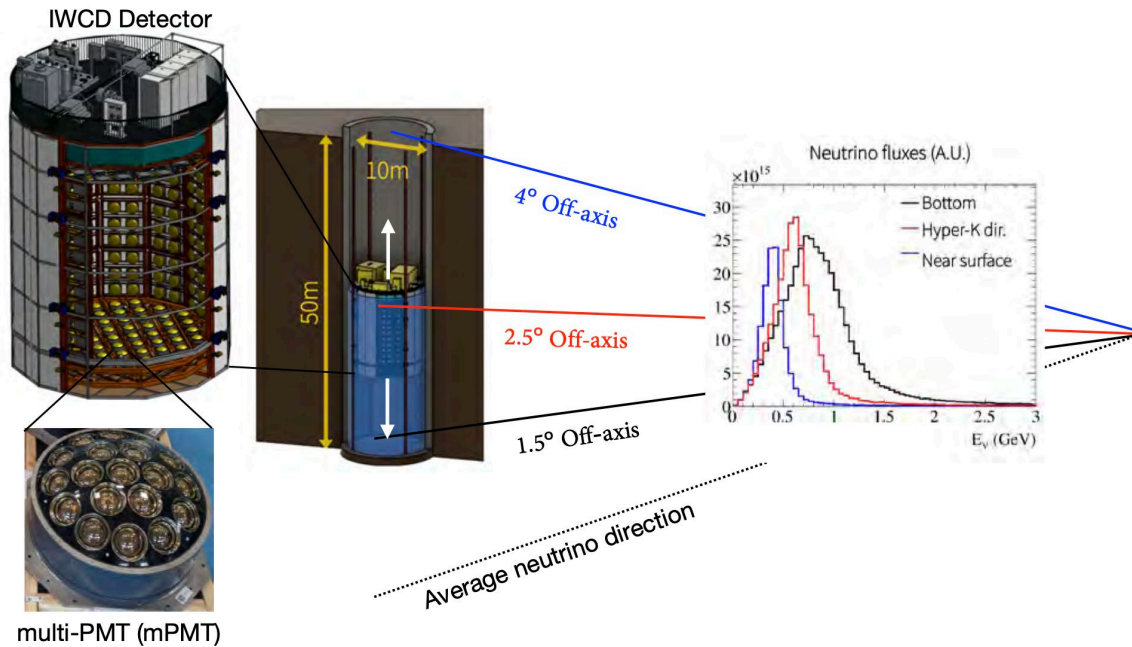
Canadian T2K near detector contributions



- T2K ND280 detector
 - FGD with SiPM:
 - The first to adopt SiPM
 - Proposed by TRIUMF
 - led the SiPM technology
 - TPC with Micromegas:
 - Early technology adoption
- Responsibility transferred to EU groups



Intermediate Water Cherenkov Detector (IWCD)



- Same water Cherenkov as the far detector
 - 850m from the target: π decay as point source
 - Detector systematics cancellation
- IWCD samples ν at 1.5° - 4° off-axis by water level change
 - Correlated E_ν spectra (NuPRISM)
 - Precise study of ν cross sections
- Proposed and led by TRIUMF
 - DUNE also adopts this (DUNE-Prism)
- Construction of the pit is in rapid progress



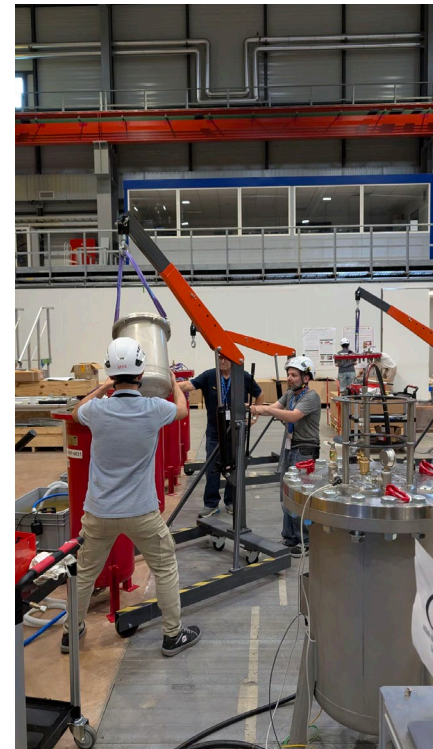


Status of Far detector

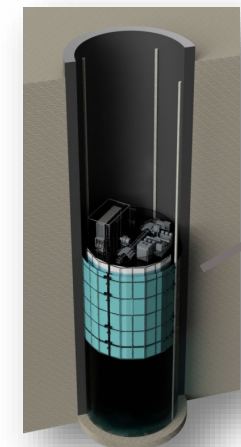
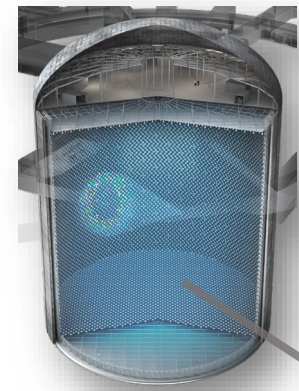
- The tank lining work is completed.
- The electronics assembly at CERN (NP08) is now underway.

July 24, 2026@Kamioka

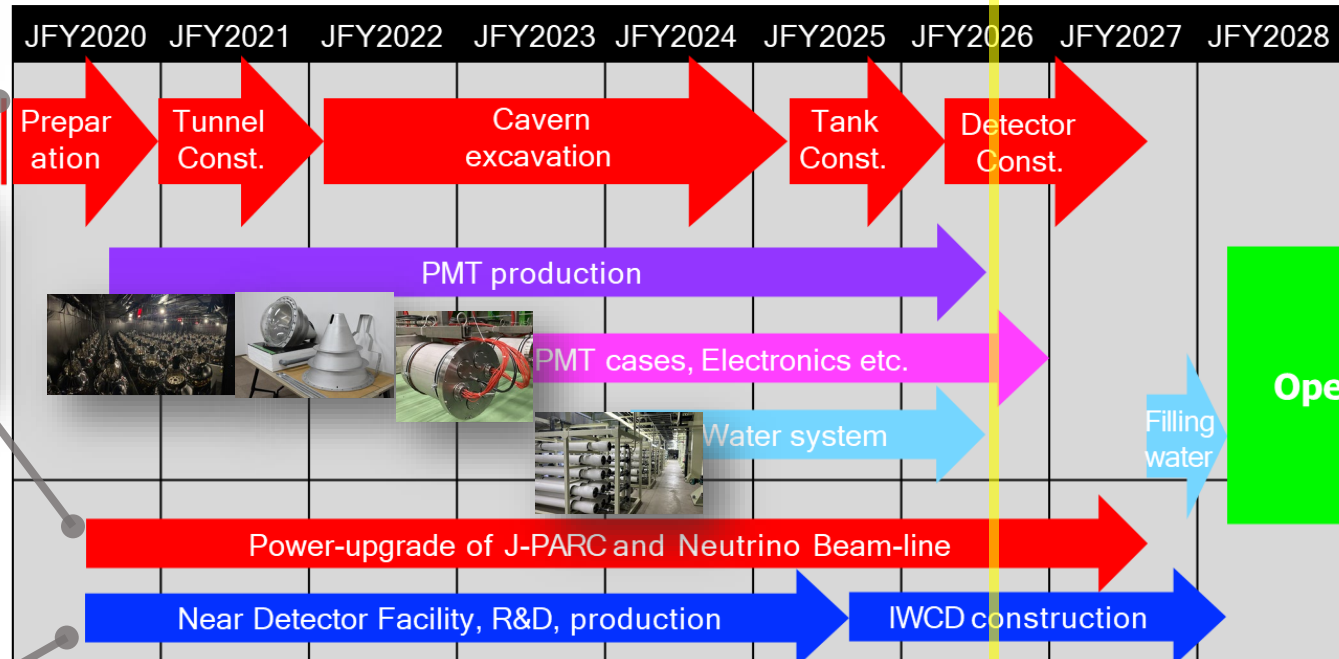
July 6, 2026@CERN



Hyper-K Time table

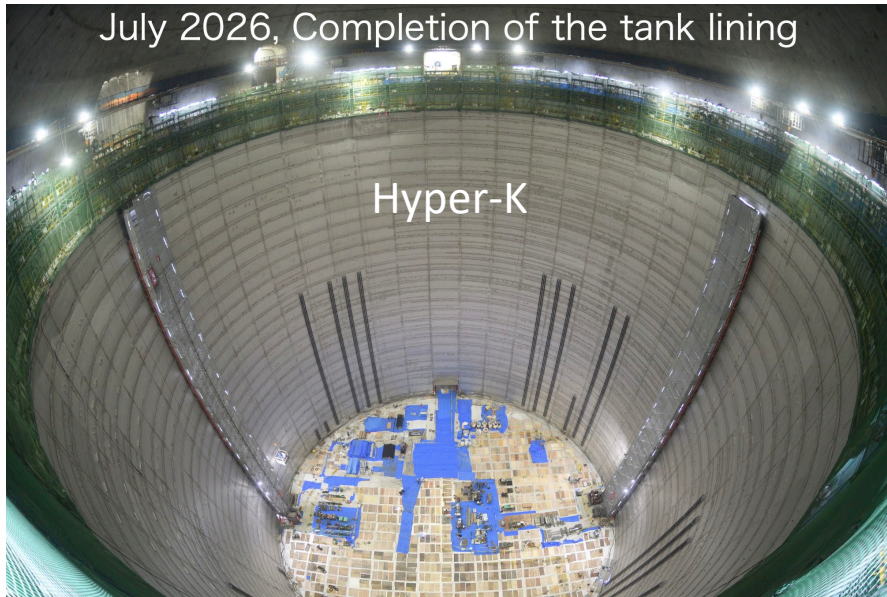


We are here



Operation starts in FY2028

Summary



- Construction of Hyper-K and IWCD is ongoing
 - Leptonic CP violation
 - Commissioning in FY2028
- Key innovation through KEK-TRIUMF collaboration
 - IWCD
 - OTR
 - Remote handling