# rojects in apan

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### T2K (JPARC v+Super-K)





 $N_{obs}: 28 \ Ve \ candidates \\ N_{exp}: 4.9 \pm 0.6 (syst) \\ for \ sin^2 2 \theta_{13} = 0 \\ (6.57 \times 10^{20} \ POT)$ 

## $V_{\mu} \rightarrow V_{e}$ appearance measurement with high S/N has been established! $\rightarrow$ make CP test possible

- S/N~5 or so, clean  $V_e$  appearance signal can be observed.
- Key elements are (i) narrow-band sub-GeV v beam, (ii) 300km baseline, and (iii) large water Cherenkov detector

### Hyper-Kamiokande detector

Letter-of-Intent for conceptual design and physics sensitivities: arXiv:1109.3262 [hep-ex] ~100 pages

Total Volume:I million ton (20×Super-K)Photo-sensors:50cmφ×99,000(Inner Detector)20cmφ×25,000(Outer Detector)

Cavity (Lining) Total Length 247.5m (5Compartments) Water Purificatiom System

Compart ment Length 49.51 (Optimistic) Timeline for anticipated results

- -2022 ~2 $\sigma$  CPV indication (sin<sup>2</sup> $\delta$ =1) by T2K+reactors (also in Nova)
- -2023 Start Hyper-K data taking
- -2026 Discovery of leptonic CPV w/ >5 $\sigma$  (MH at the same time or earlier)
- -2028 Discovery of proton decays
- -20XX Always ready for Supernova neutrino burst

Width 48m

#### Geological survey racterizatic Cavern Design and Analysis







#### GUT tests by Nucleon Decay Searches



Good discovery potential, 90% CL sensitivity of 10<sup>34</sup>~10<sup>35</sup> yrs

### Multi-purpose detector, Hyper-K

Letter of Intent, Hyper-KWG, arXiv:1109.3262 [hep-ex]

- Total (fiducial) volume is 1 (0.56) million ton – 25 × Super-K
- Explore full picture of neutrino oscillation parameters.
  - Discovery of leptonic CP violation (Dirac  $\delta$ )
  - v mass hierarchy determination( $\Delta m_{32}^2 > 0$  or <0)
  - $\theta_{23}$  octant determination ( $\theta_{23}$ < $\pi$ /4 or > $\pi$ /4)
- Extend nucleon decay search sensitivity
  - $-\tau_{proton}$ =10<sup>34</sup>~10<sup>35</sup> years (~10×Super-K)
- Neutrinos from astrophysical objects
  - 250,000 ν's from Supernova @Galactic-center (50 from Andromeda)
  - ~300 v's / 10 years (>20MeV) SN relic v
  - 200 v's / day from Sun
    - possible time variation, ~3 $\sigma$  day/night asym.
  - Indirect Dark Matter Detection, etc







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#### International Hyper-K Working Group ~100 participants, ~50 non-Japanese 3rd Open Hyper-K meeting



- International open Hyper-K meetings: Aug. 2012, Jan. 2013, Jun. 2013 and Jan. 2014. Slides are public for community.
- ~100 participants from Canada, Japan, Korea, Russia, Spain, Switzerland, UK, US, and so on.

- Your participation to the international Hyper-K working group is welcome.

- Next HK meeting will be held in Vancouver.

#### Report on future projects by Japanese HEP community (February 2012)

The committee makes the following recommendations concerning large-scale projects, which comprise the core of future high energy physics research in Japan.

- Should a new particle such as a Higgs boson with a mass below approximately 1 TeV be confirmed at LHC, Japan should take the leadership role in an early realization of an e<sup>+</sup>e<sup>-</sup> linear collider. In particular, if the particle is light, experiments at low collision energy should be started at the earliest possible time. In parallel, continuous studies on new physics should be pursued for both LHC and the upgraded LHC version. Should the energy scale of new particles/physics be higher, accelerator R&D should be strengthened in order to realize the necessary collision energy.
- Should the neutrino mixing angle  $\theta_{13}$  be confirmed as large, Japan should aim to realize a large-scale neutrino detector through international cooperation, accompanied by the necessary reinforcement of accelerator intensity, so allowing studies on CP symmetry through neutrino oscillations. This new large-scale neutrino detector should have sufficient sensitivity to allow the search for proton decays, which would be direct evidence of Grand Unified Theories.
- LC and neutrino detector are recommended as big projects
  Support by Cosmic-Ray community as well
- In the list of important large-scale projects *i.e.* "Roadmap" of MEXT (Japanese funding agency)

### Americas

#### • US

- 'Snowmass' process to collect input from community
  - Intensity Frontier report (arXiv:1401.6077)
     "Complementary experiments with different energies, baselines, and detector technologies (e.g., Hyper-K in Japan) are required in order to fully exploit conventional neutrino beams."
- Discussion in P5 ongoing
- Canada
  - "(T2)Hyper-Kamiokande is the path for Canada" (ICFA v panel meeting @ Fermilab)
  - Proposal to Canadian Foundation for Innovation under preparation, for submission in June 2014
  - Green light from TRIUMF to proceed

### Europe

- European Strategy for Particle Physics (May 2013):
  - "Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan."
  - In Physics Briefing Book: "a substantial European involvement in T2HK (if it goes ahead) seems probable."
- First European Hyper-K meeting was held in Dec. 2013.
  - >40 participants from 9 countries (incl. non-T2K countries).
- Budget request for Hyper-K R&D ongoing in UK.
  - Statement-of-interest approved in the UK.
  - Proposal to STFC to be submitted in May 2014.

### Summary

- The establishment of the clean  $v_{\mu} \rightarrow v_{e}$  measurement in T2K
- CPV test by extending the JPARC-SK experimental setup
   J-PARC is expected to be upgraded to ~700kW and beyond
   well-proven & high performance detector technique w/ the successful

  - experiences in Super-K
- Rich physics topics can be covered by the extension.
   extend nucleon decay search capability to O(10<sup>35</sup>) years

  - high statistics atmospheric neutrino study
  - Supernova V
  - indirect dark-matter searches etc.

 Hyper-K project is completely open to the international community. We'd like to contribute to the world-wide effort to make a strong neutrino physics program.