Status of Hyper-Kamiokande Detector R&D

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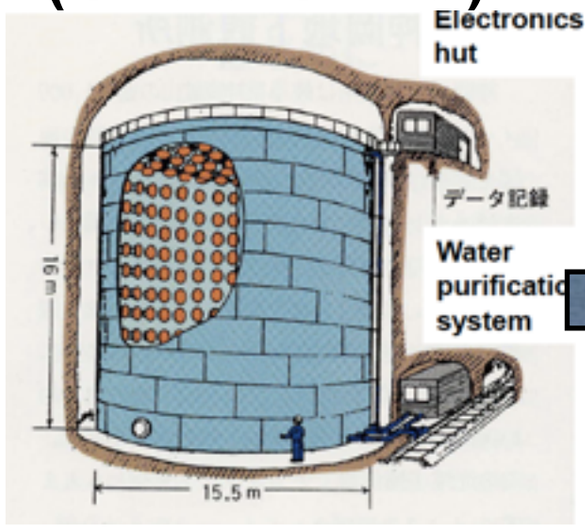
TIPP11, 9-14 June 2011, Chicago

Contents

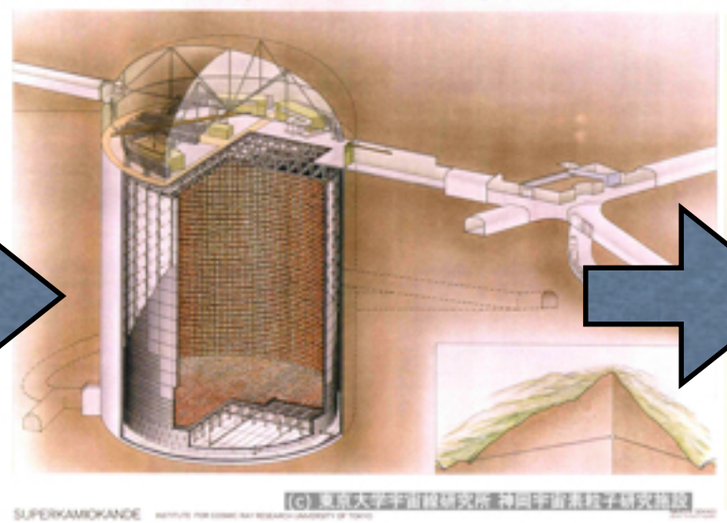
- Baseline design of Hyper-Kamiokande
- Physics capability
- Status of ongoing R&D
- Prospects

Three generations of Water Cherenkov Detector at Kamioka

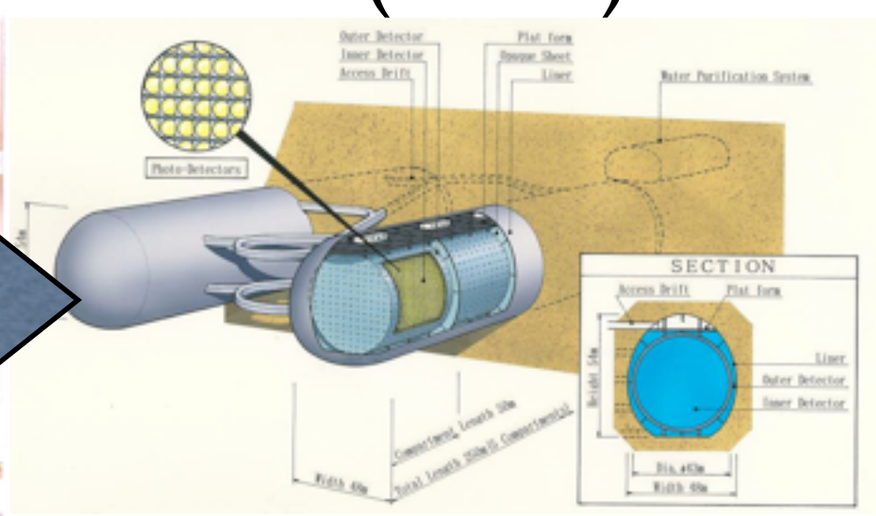
Kamiokande (1983-1996)



Super-Kamiokande (1996-)



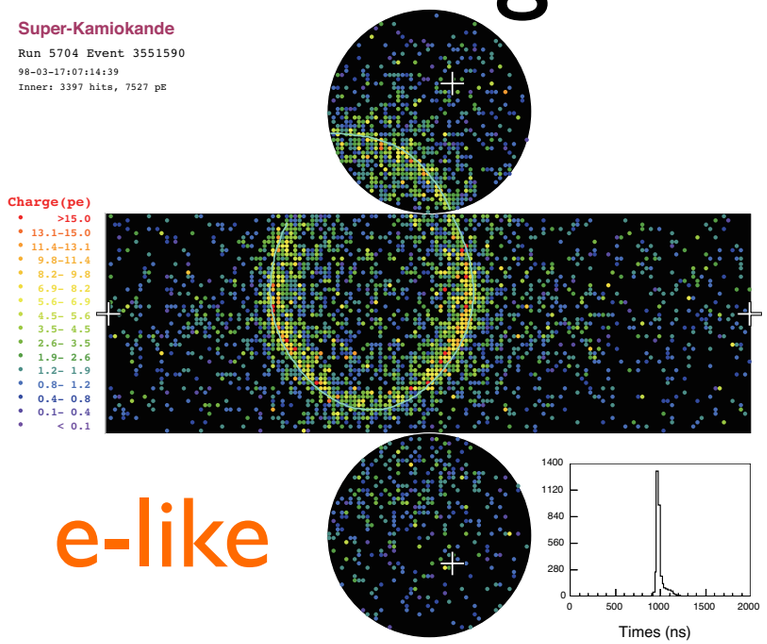
Hyper-Kamiokande (201x-)



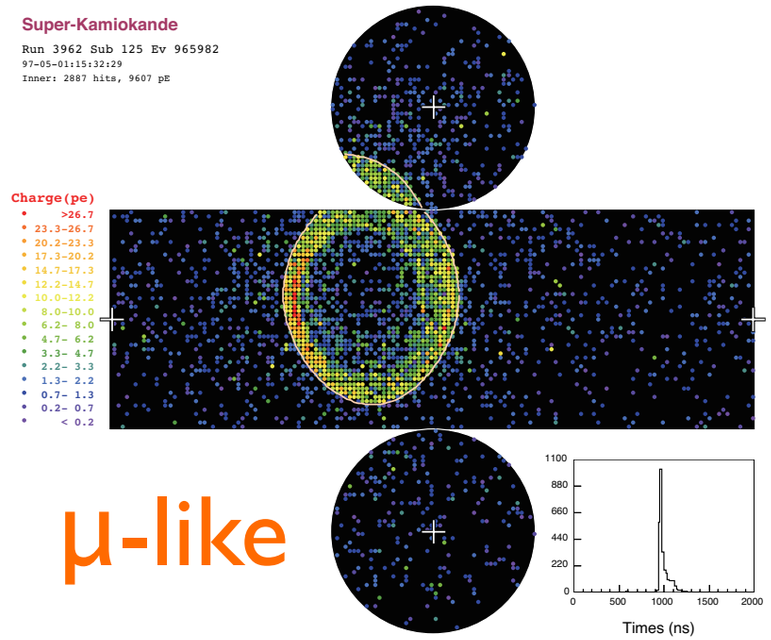
3kton → 50kton → 1Mton=1000kton

x17 x20

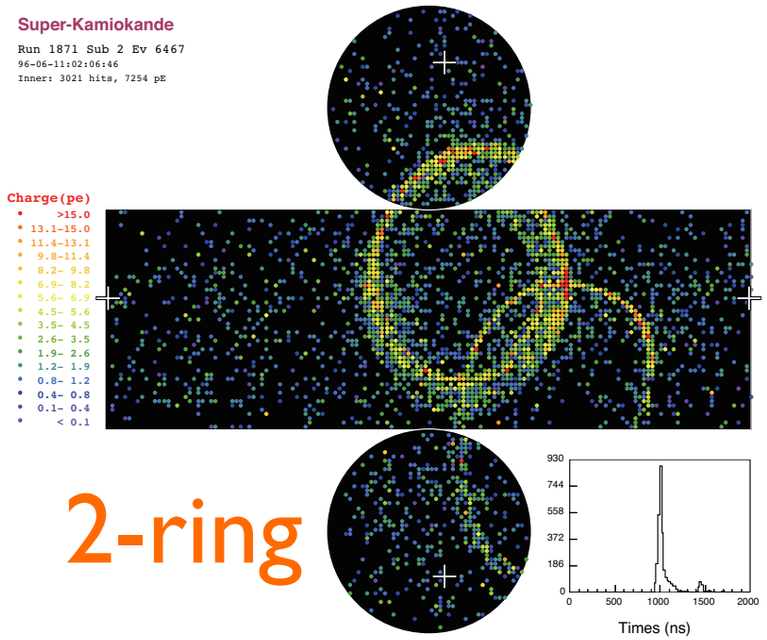
Large Water Cherenkov Detector



e-like



μ-like



2-ring

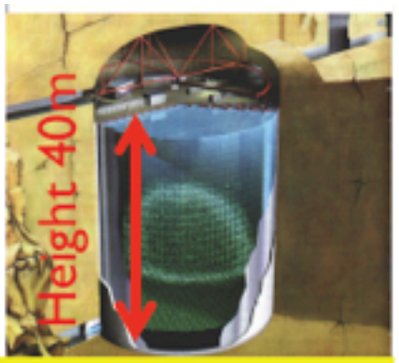
$\nu_e + N \rightarrow e + N'$ $\nu_\mu + N \rightarrow \mu + N'$ $\nu_\mu + N \rightarrow \mu + N' + \pi$

- High efficiency, 4π coverage
- Excellent performance for <~1GeV
  - Nucleon decays, sub-GeV neutrino beam
- e/μ separation: >99%
- E threshold ~5MeV

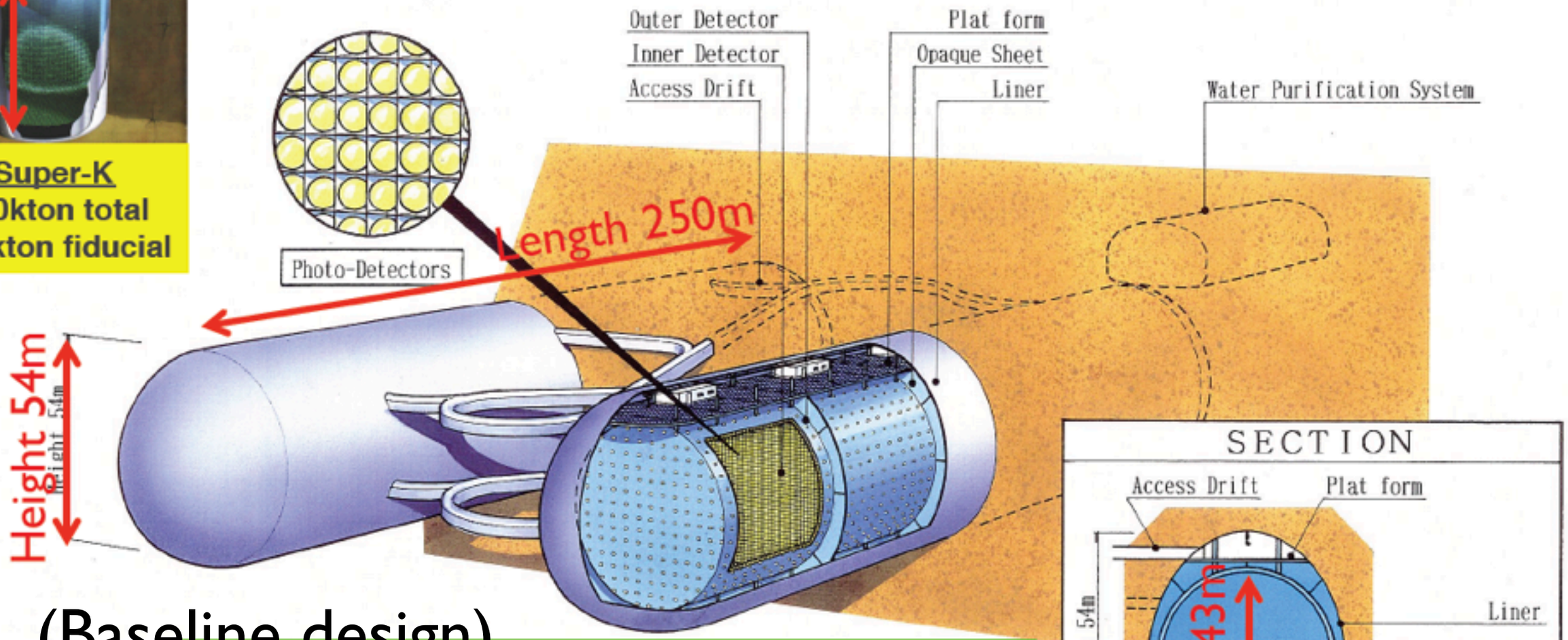
Well established technology with >30years experience.

(More on Super-K: Talk by Dr. Y. Obayashi, Sat. 8:30-)

Hyper-Kamimokande



Super-K
50kton total
22kton fiducial



(Baseline design)

Hyper-K
1Mton total volume, twin cavity
~0.6Mton fiducial volume
Inner (D43m x L250m) x 2
Outer Detector >2m
Photo coverage 20% (1/2 x SK)
20 inch PMT x 102,000

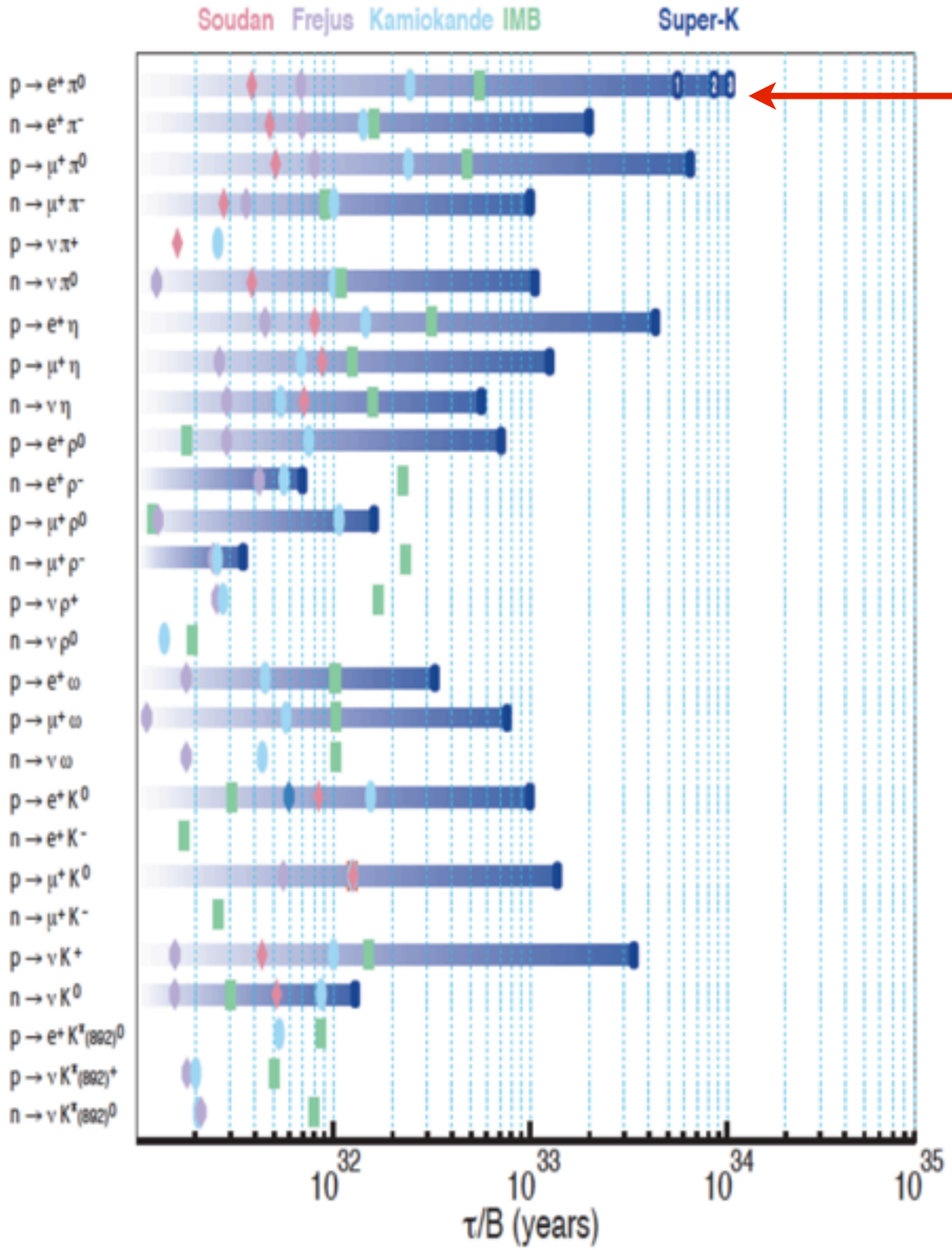
Timeline for Hyper-K

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Site study, design, R&D															
Construction (5yrs assumed)															
				Operation											

Hyper-Kamikande project:
covering a wide range of particle physics/astrophysics

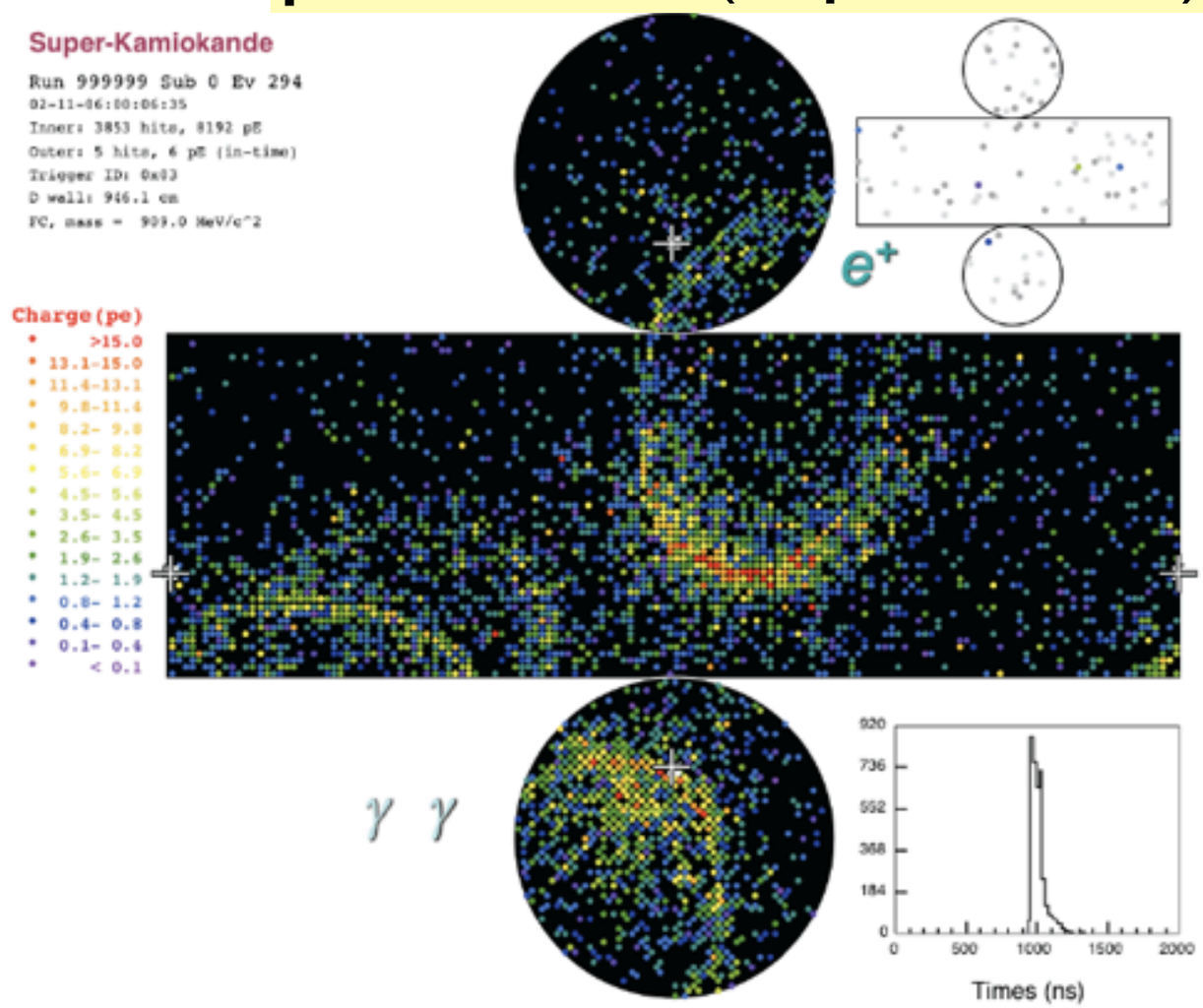
- Search for nucleon decay
- Long baseline neutrino experiment
- Atmospheric neutrino
- Solar neutrino
- Supernova neutrino
- WIMP, GRB,
- ....

Nucleon decay:
Exploring quark/lepton unification



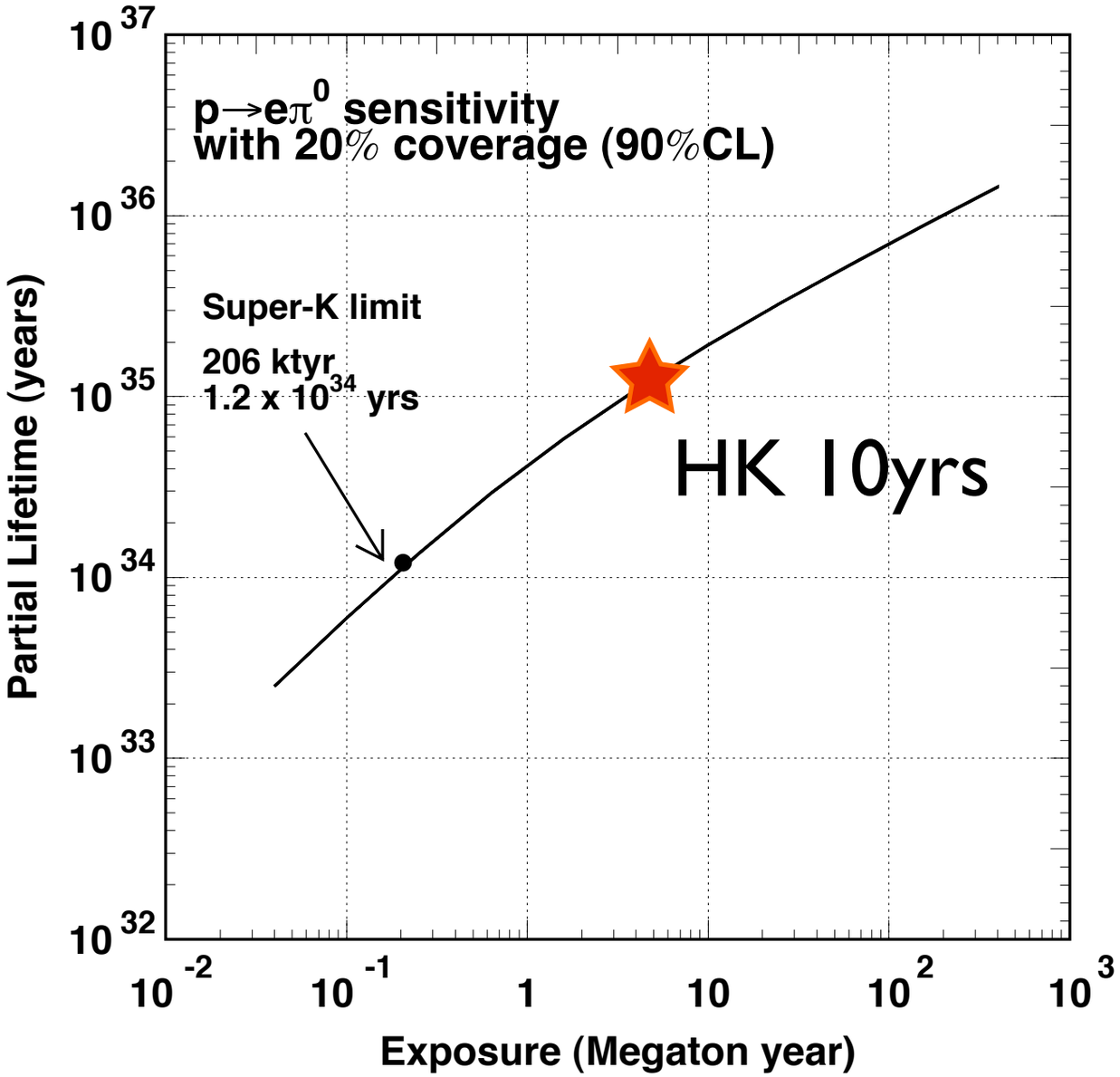
$\tau/B(p \rightarrow e^+ + \pi^0) > 10^{34}$ years!

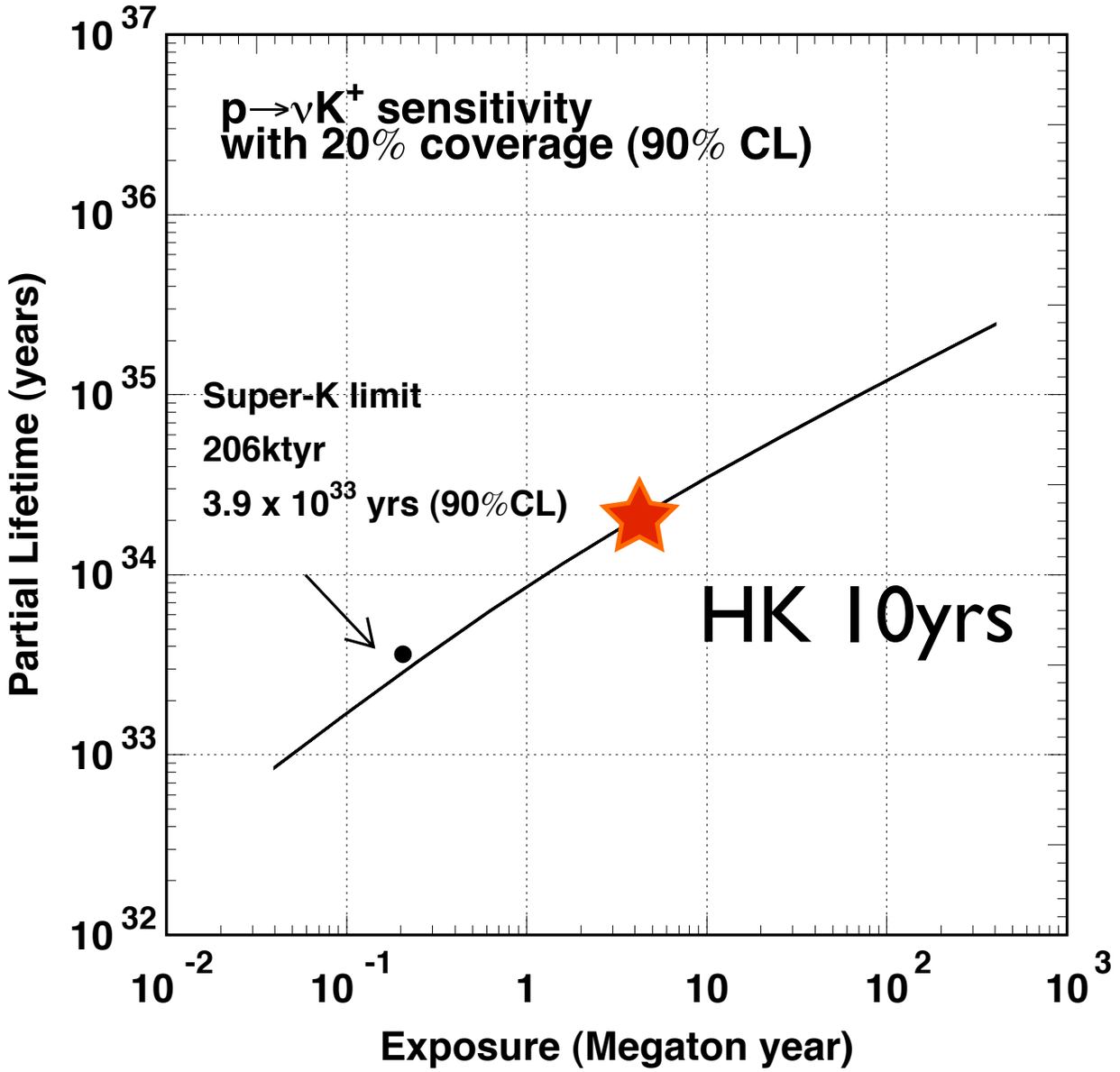
$p \rightarrow e^+ + \pi^0$ (Super-K MC)



Direct evidence of GUT!

Proton decay search with Hyper-K





For 10 years of HK data,

$\tau/B(p \rightarrow e^+ + \pi^0) : > 1.3 \times 10^{35}$ years

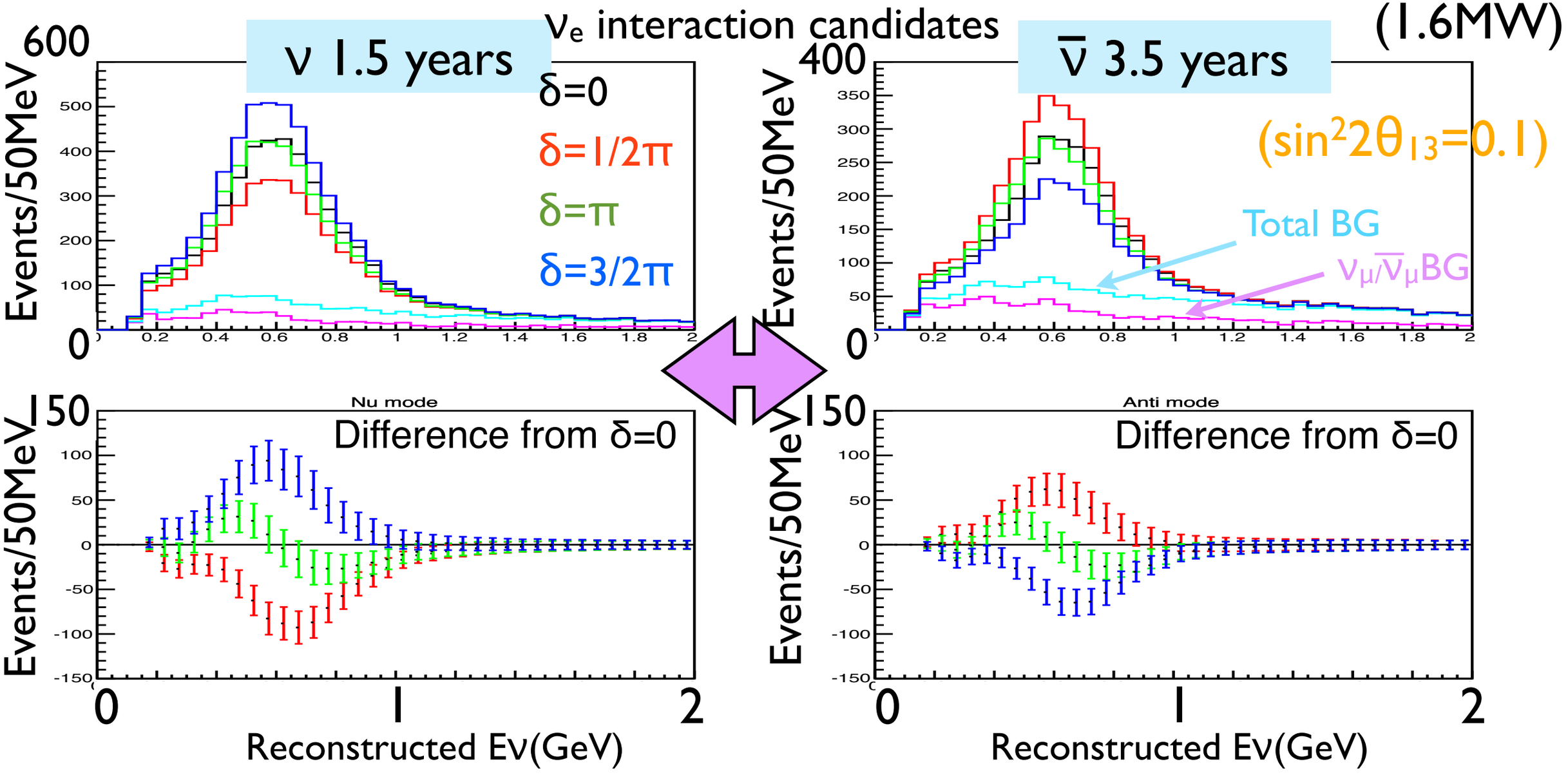
$\tau/B(p \rightarrow K^+ + \nu) : > 2.4 \times 10^{34}$ years

~×10 improvement

Long baseline experiment

Quest for *CP* violation in lepton sector

Effect of CP asymmetry



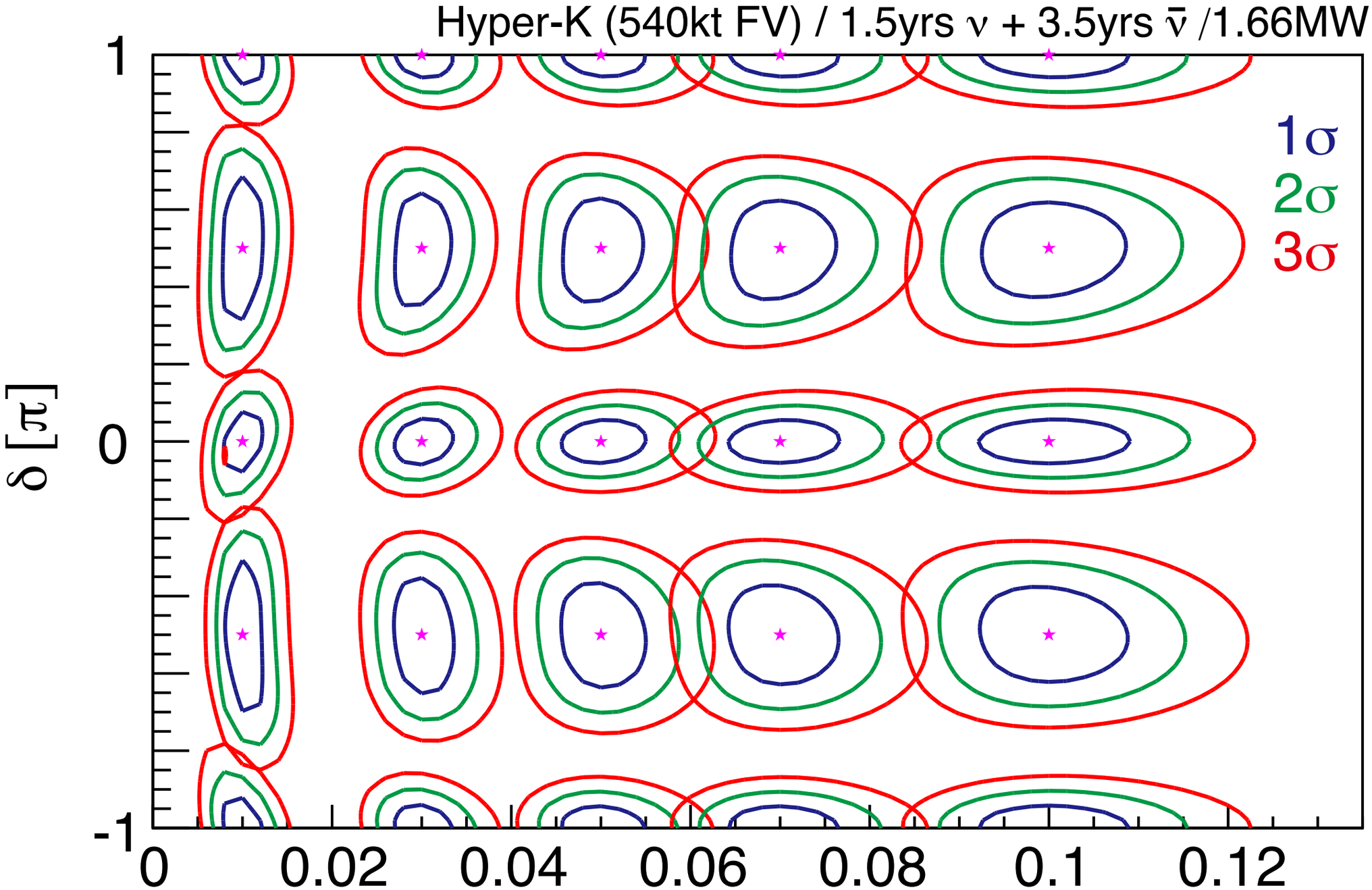
Compare $\nu_\mu \rightarrow \nu_e$ and $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$

$\sin\delta \neq 0 \rightarrow$ CP violation!

Full simulation with latest J-PARC / Super-K (20% cov.) MC

Basic selection established for T2K

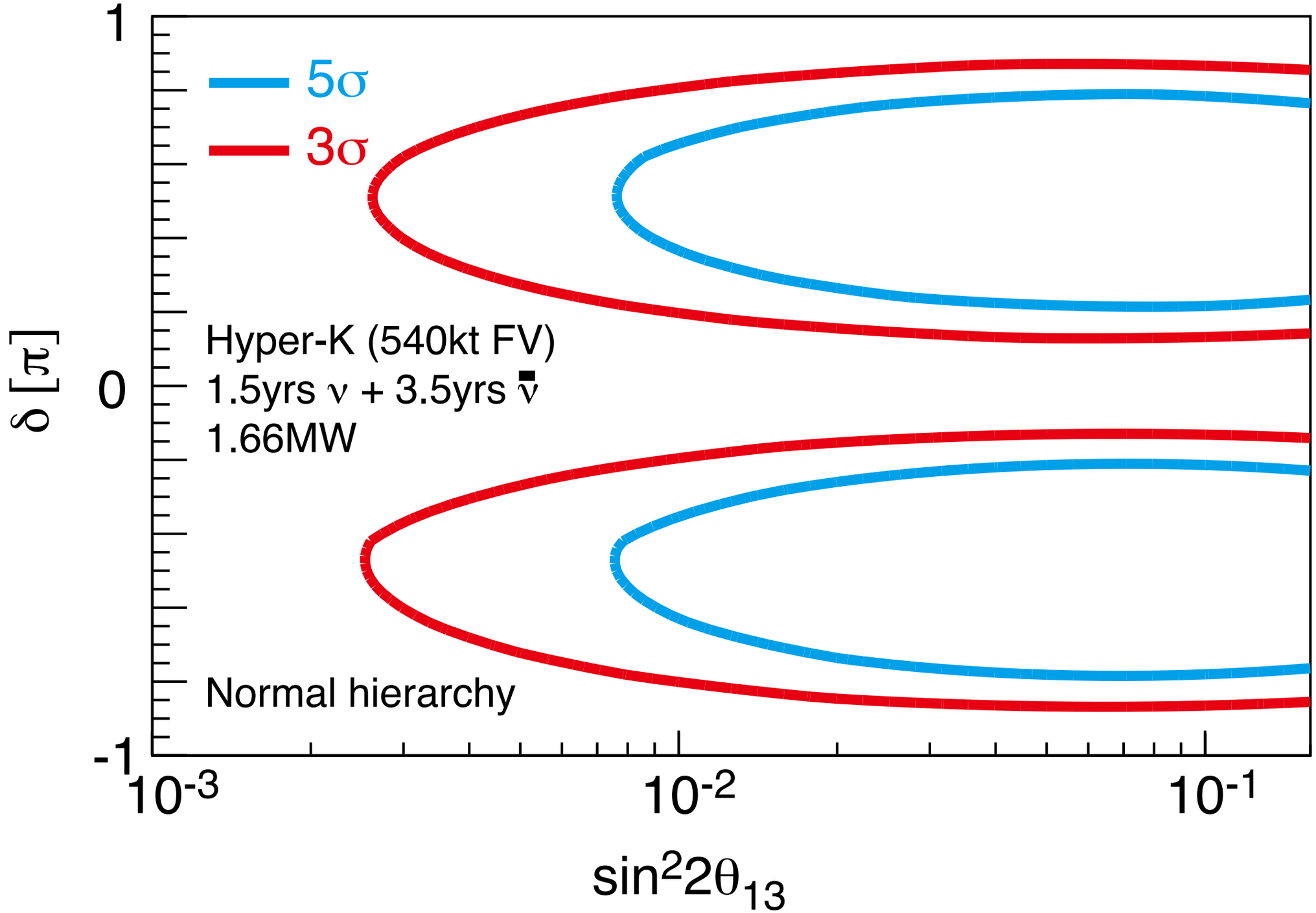
Allowed region



Total 5 years running

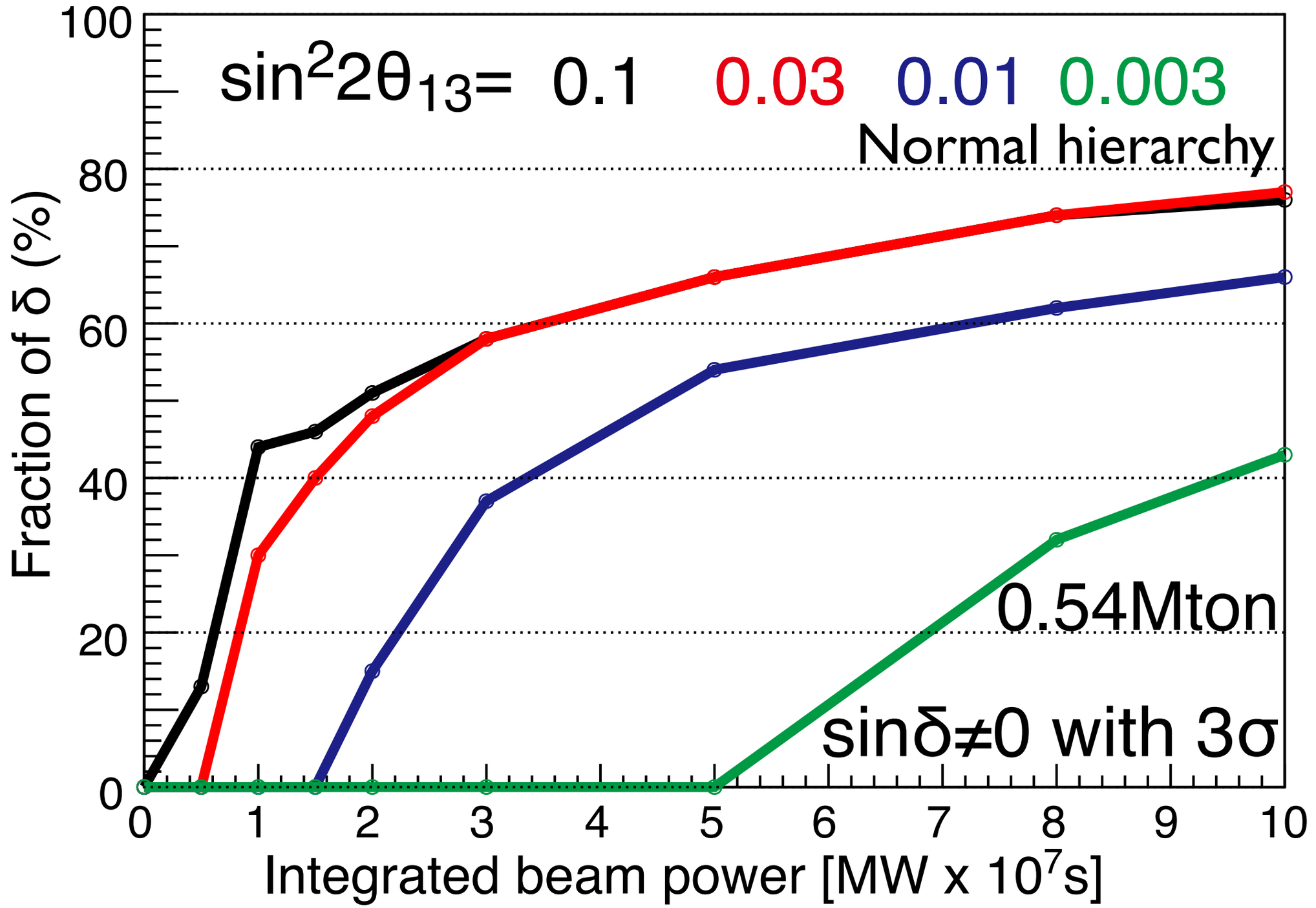
5% syst. error for signal, ν_μBG, ν_eBG, $\nu/\bar{\nu}$ assumed

Sensitivity to CP violation (sinδ≠0)



$\sin^2 2\theta_{13} \sim 10^{-2}$ for 5σ, $\sim 3\times10^{-3}$ for 3σ

Sensitivity vs. exposure

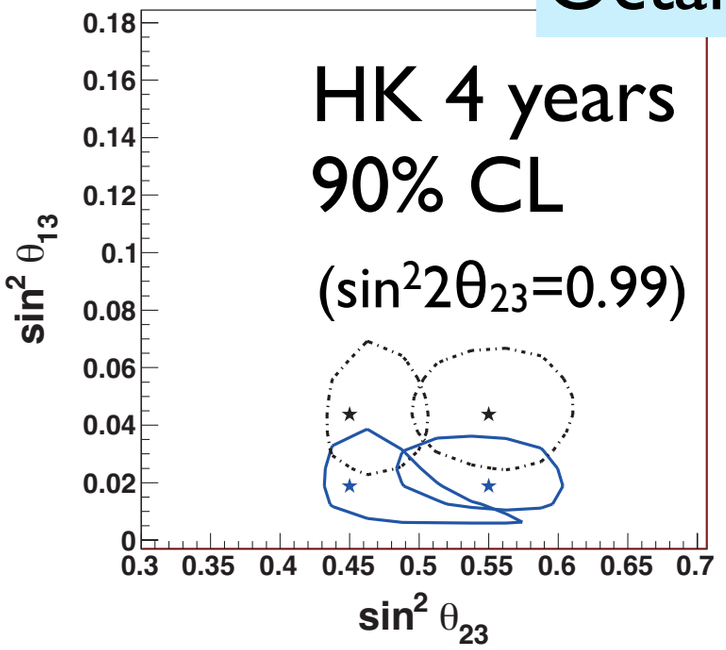


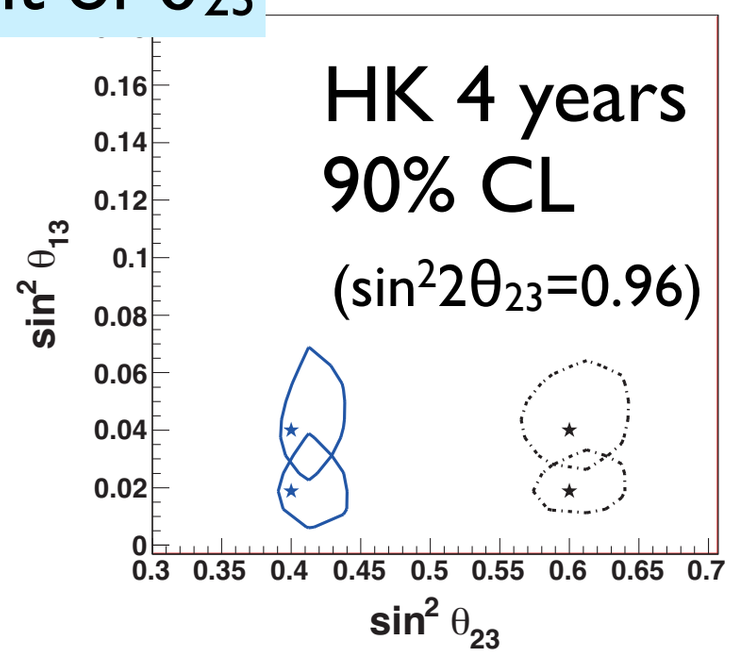
For $\sin^2 2\theta_{13}$>0.03,(0.01), 58(62)% of δ covered with 3(8)MWyrs

Atmospheric neutrinos

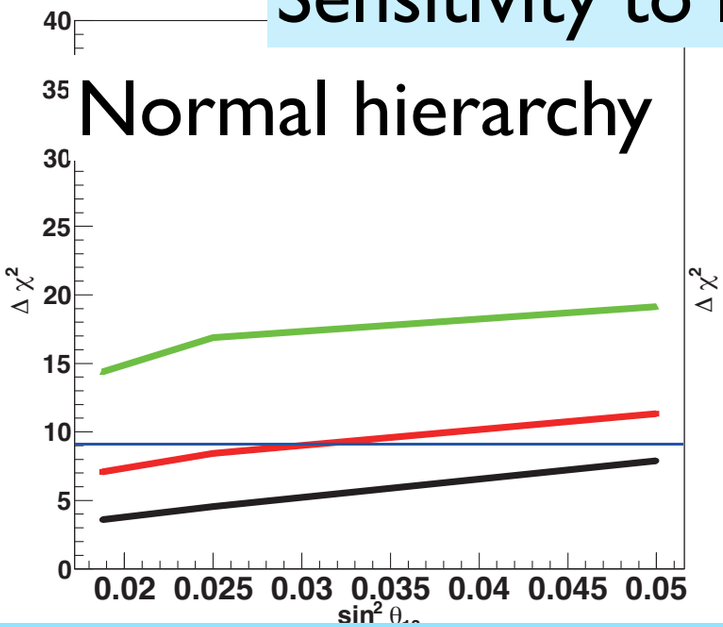
- Wide range of
  - energy
  - travel length
  - flavor
- For free
- High stat. sample with HK will provide more info on ν parameters

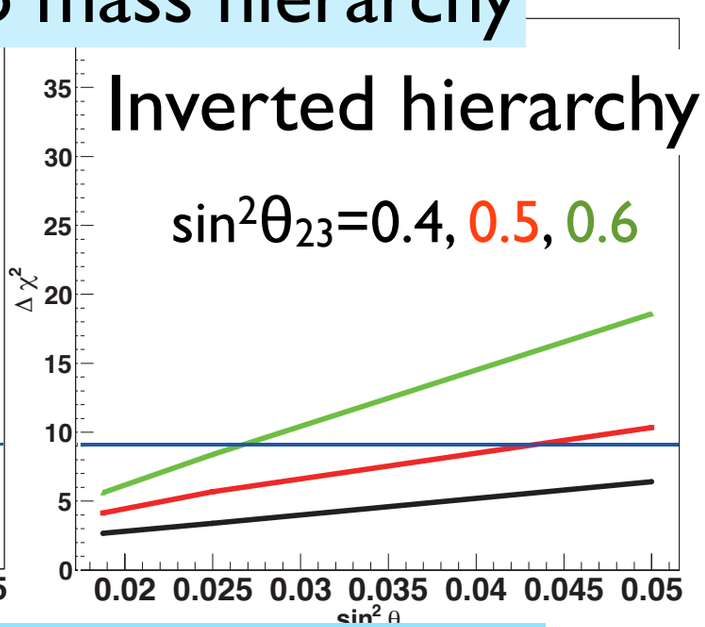
Octant of θ_{23}





Sensitivity to mass hierarchy



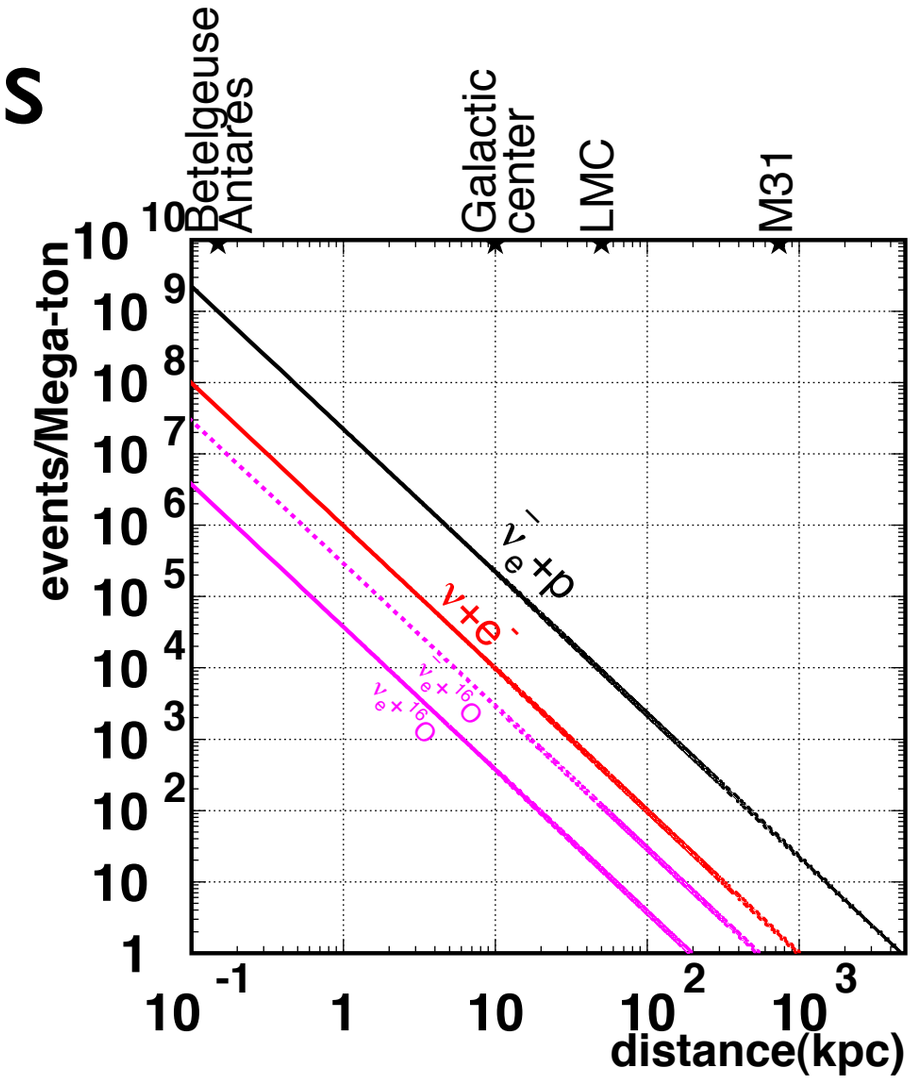


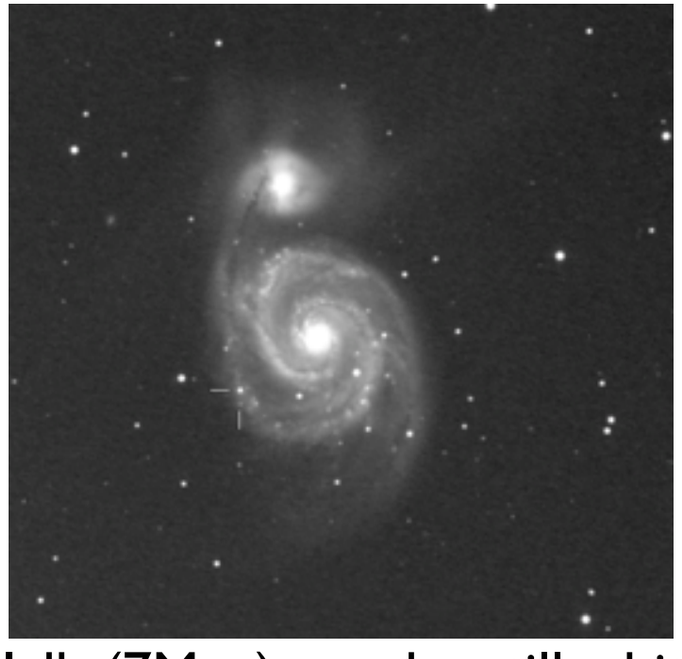
Complimentary to accelerator experiment

Exploring full picture of ν mass and mixing

Other topics

- Precise meas. of solar neutrino
  - Short time variation (~4hrs) neutrino solar physics
- Supernova neutrinos
  - For SN @10kpc, ~240k evts
    - Energy+time meas.
      →discriminate models
  - Relic neutrino (w/ Gd?)
- WIMP, GRB, solar flare, ...



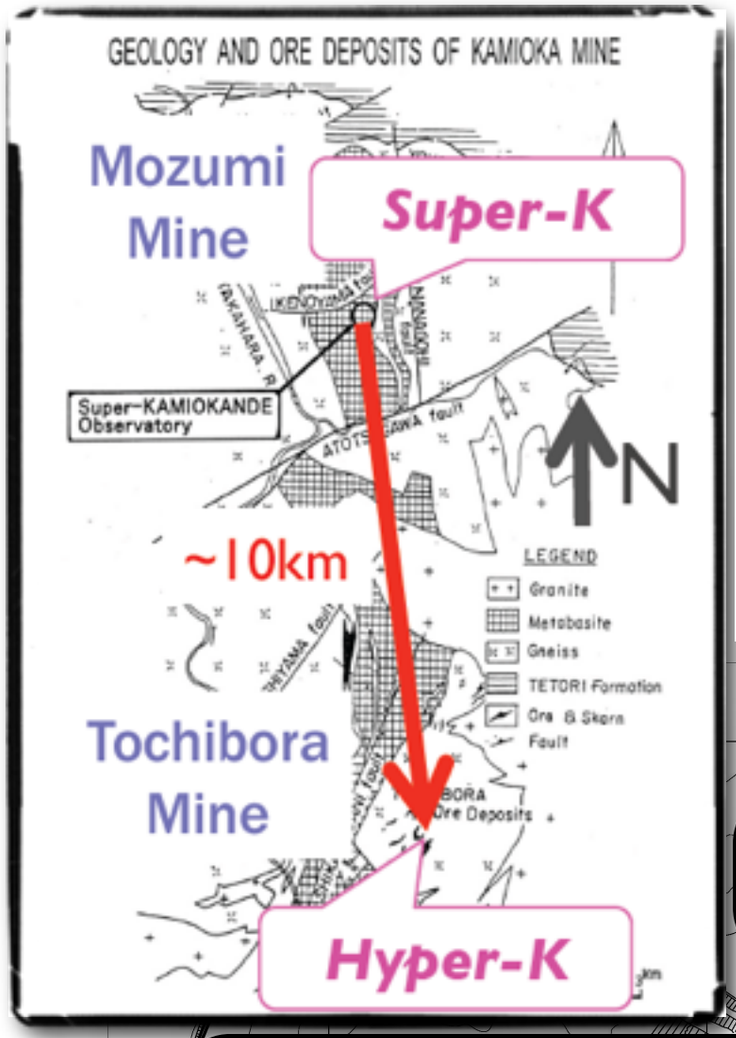


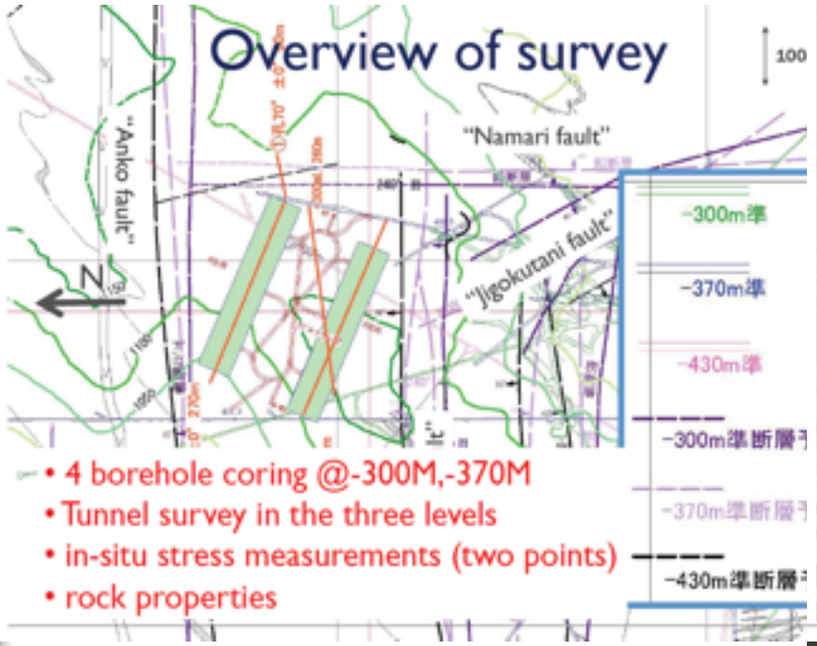
SN2011dh (7Mpc) may be still a bit far..

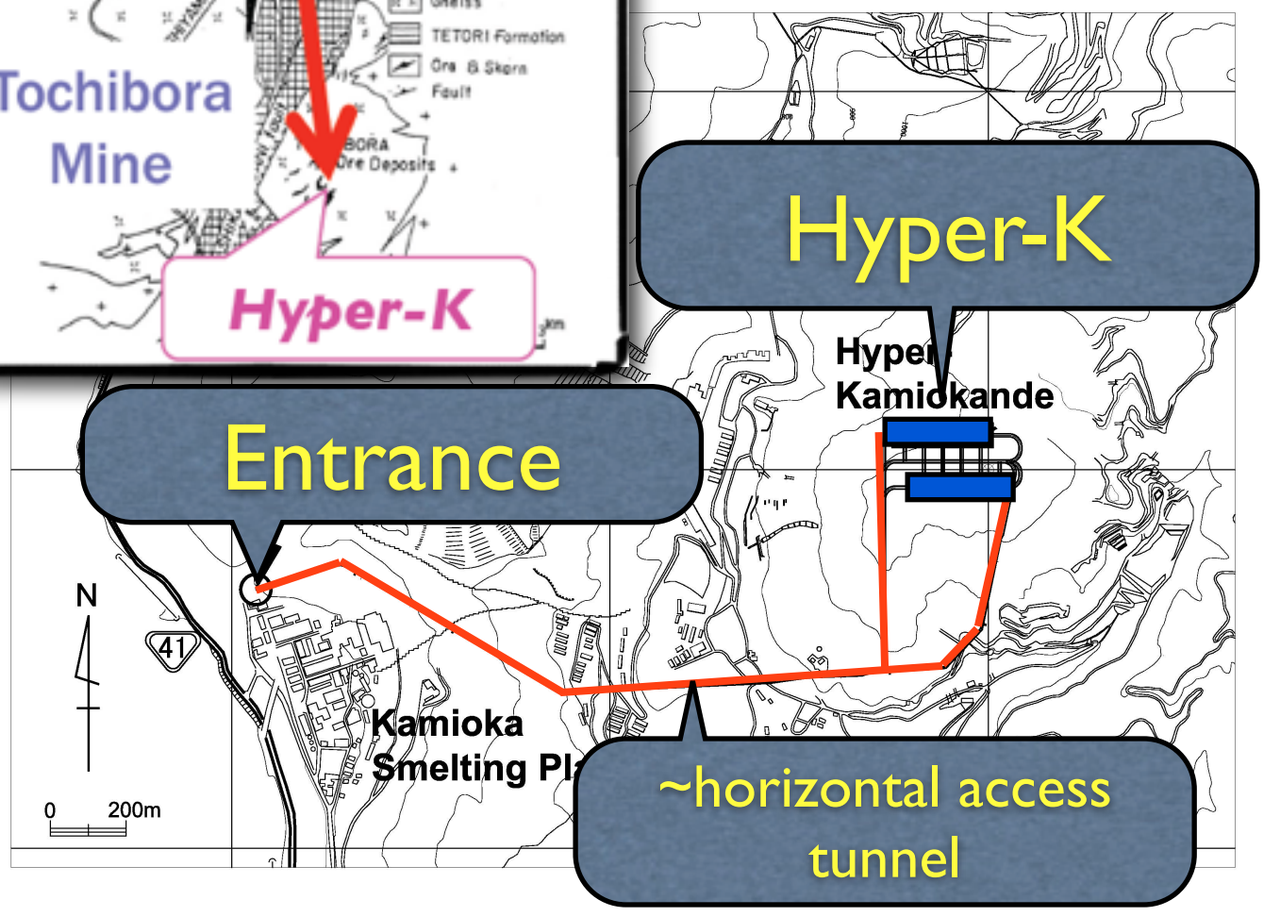
R&D list for Hyper-K

- Feasibility of large cavern
  - Geological survey
  - Stress analysis
  - Excavation procedure
  - Design of tank
  - Water purification system
  - Photosensor
  - Readout and DAQ
  - Realistic construction procedure

Candidate site and geological survey



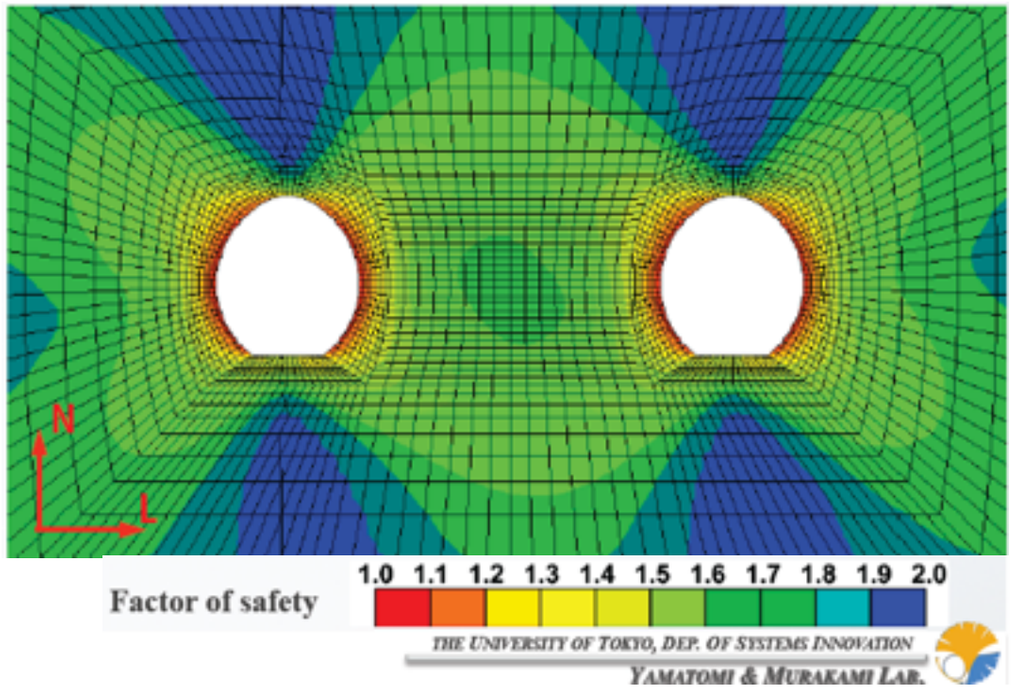


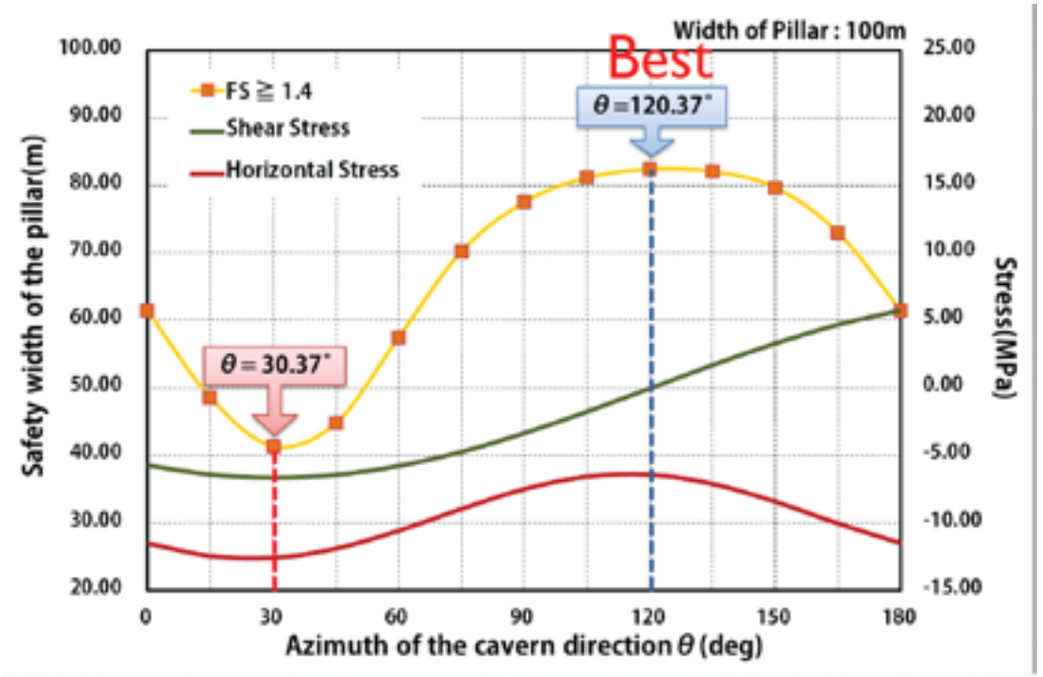


1750m.w.e (648m overburden)
Effect to low-E physics under study

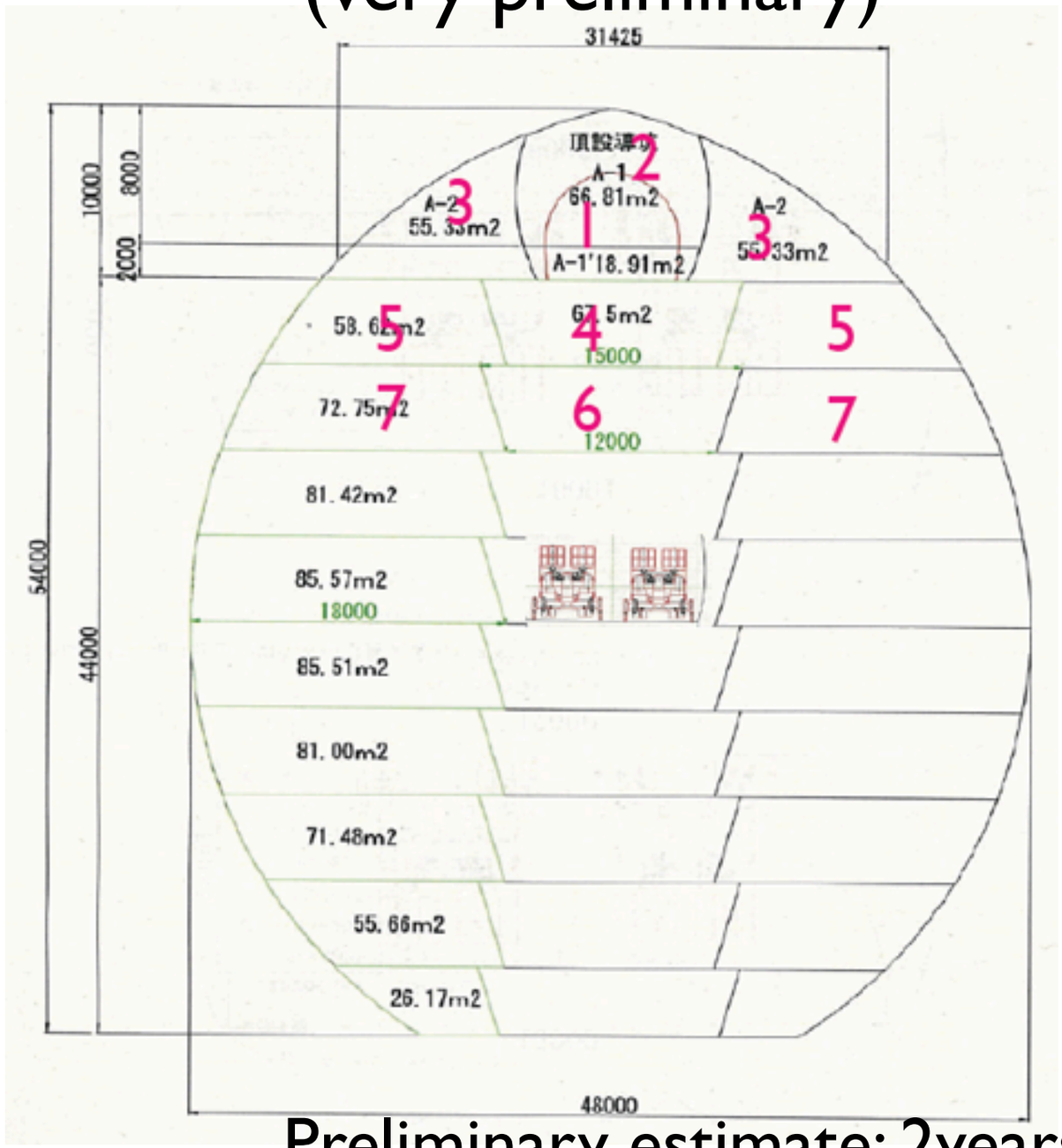
R&D for cavern design

3D analysis with measured rock stress





Excavation procedure (very preliminary)



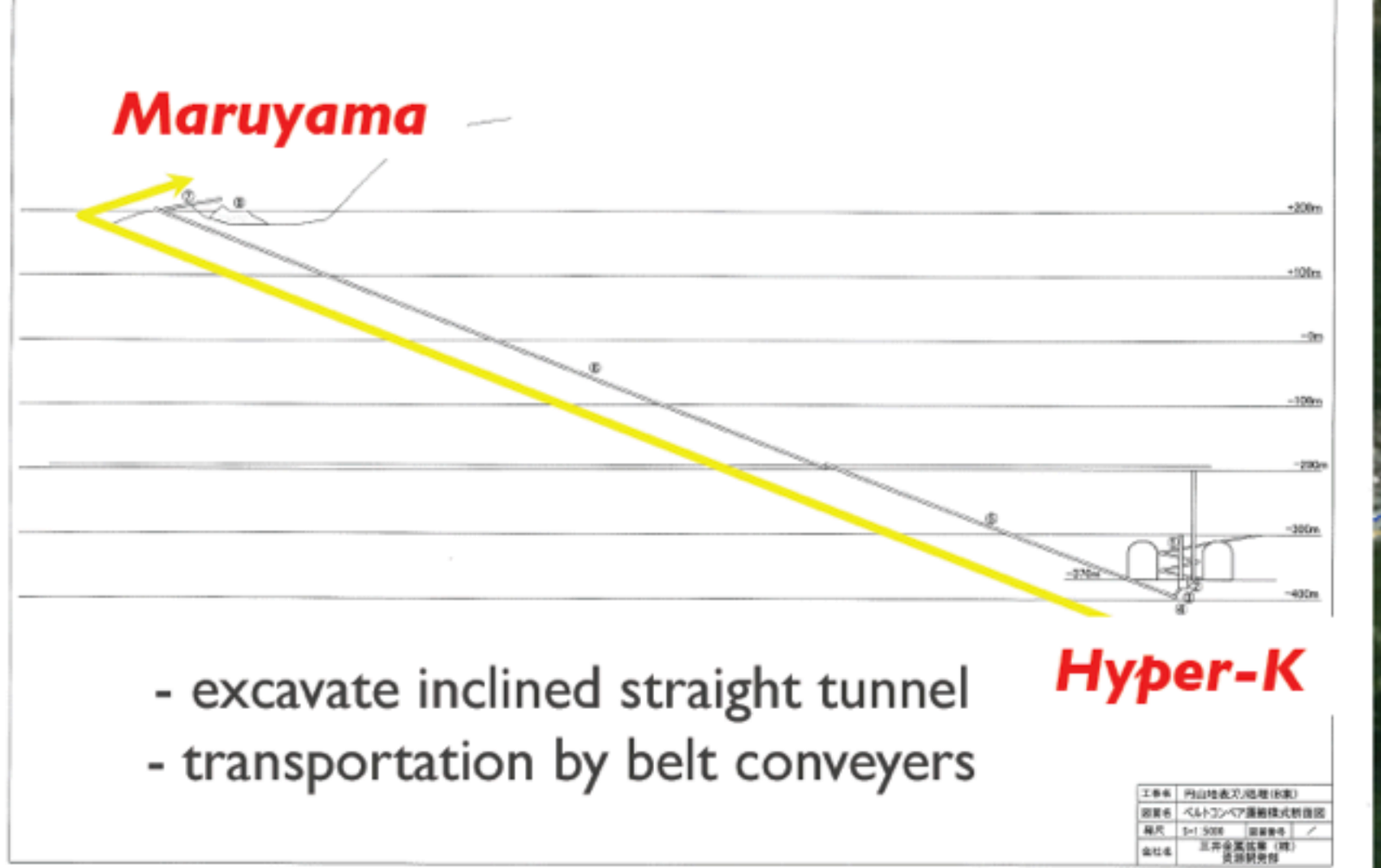
Preliminary estimate: 2years under optimization

Disposal of excavated waste rock

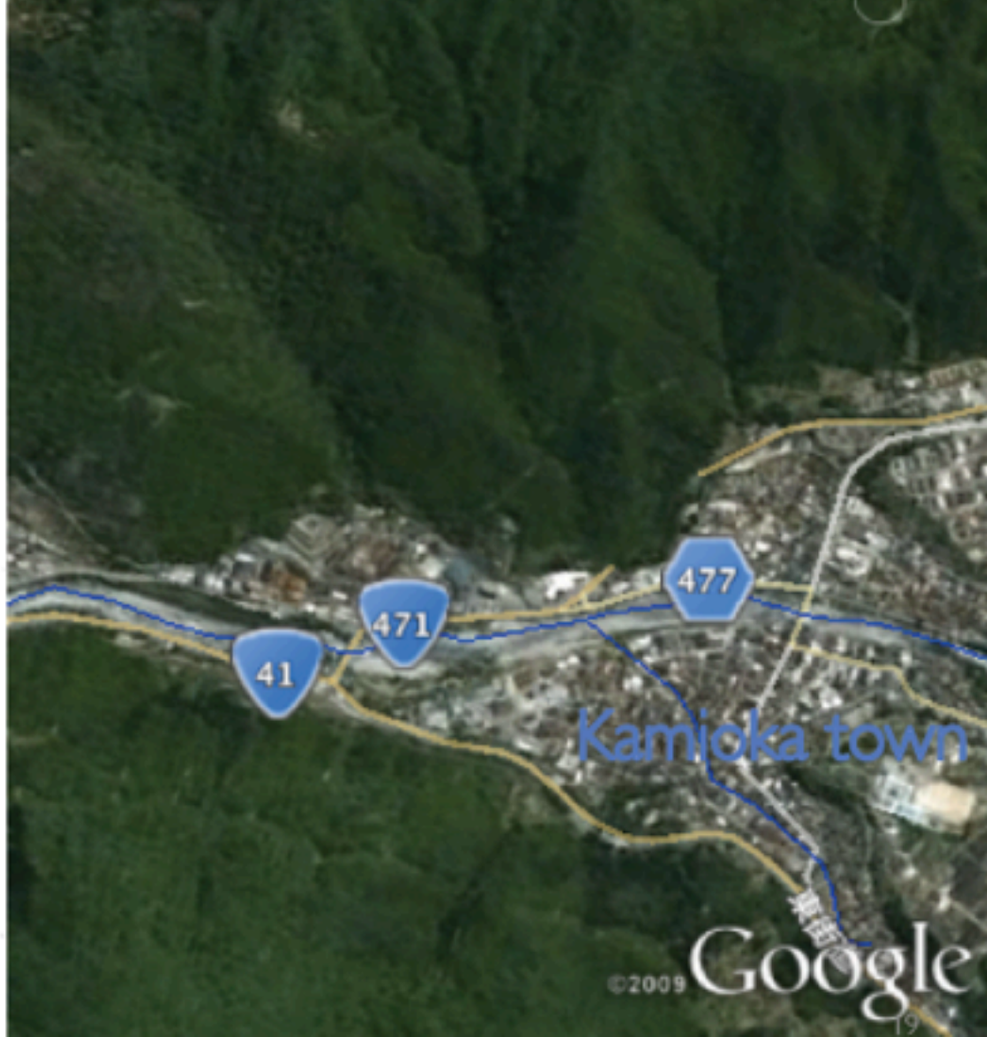
Maruyama
(collapsed mountain)

~3km

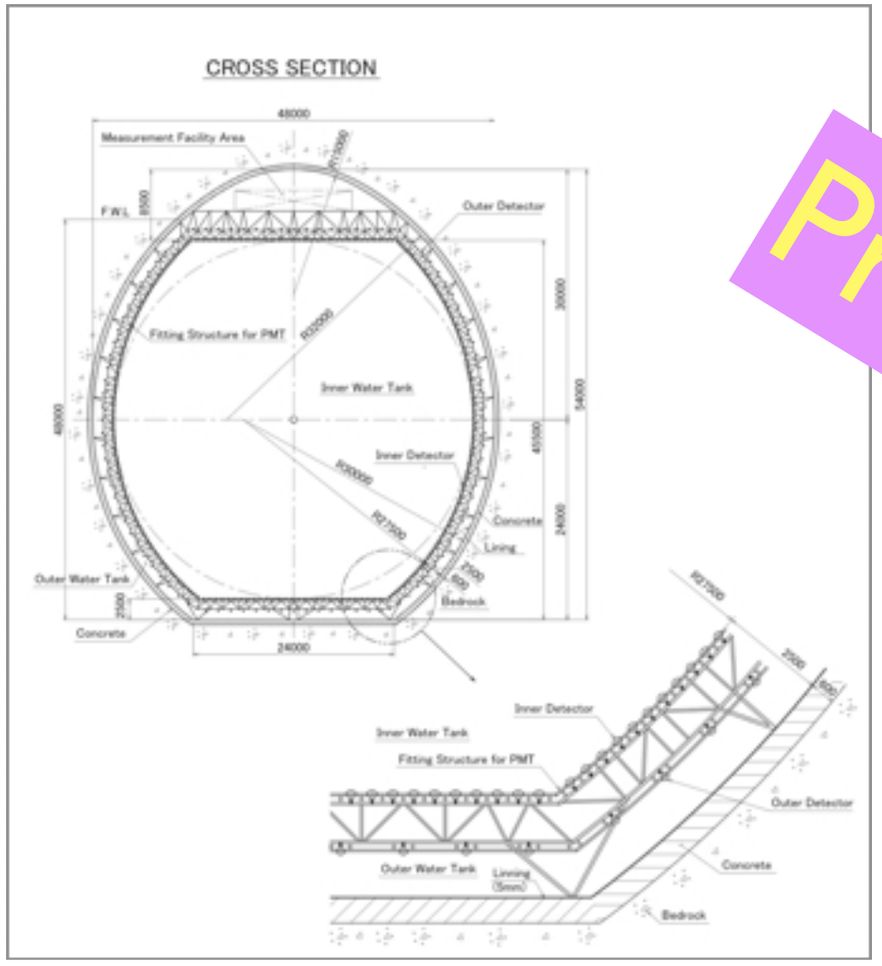
Tochibora
(Hyper-K)



- excavate inclined straight tunnel
- transportation by belt conveyers

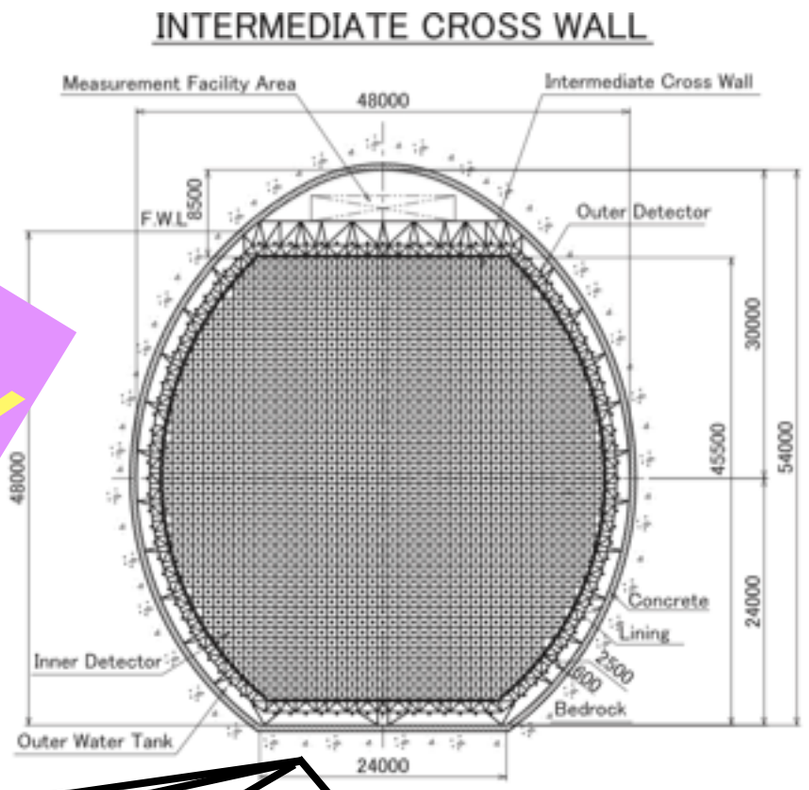


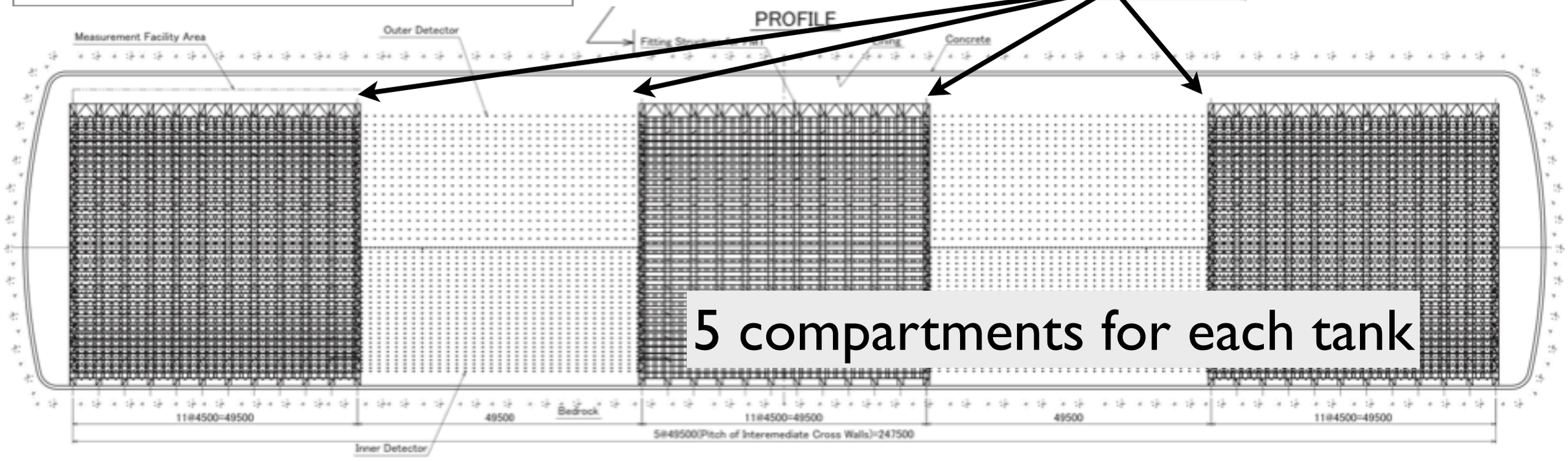
Designing tank



Preliminary

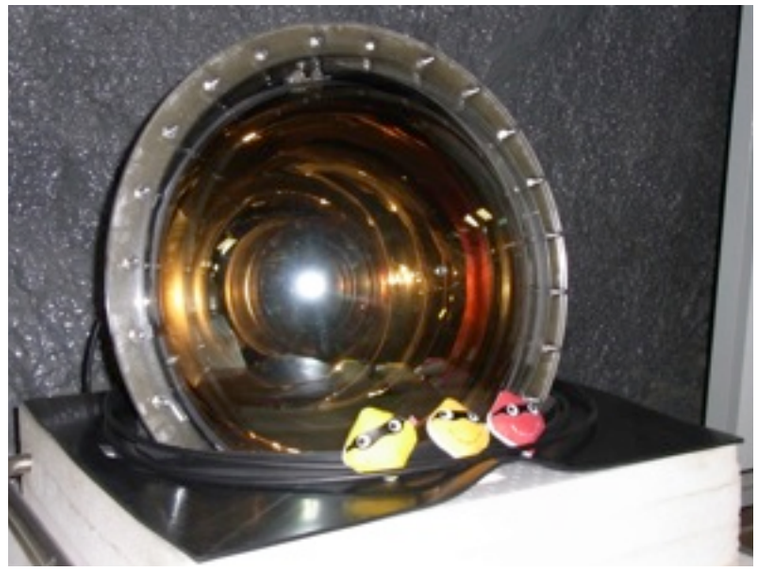
Optical separation



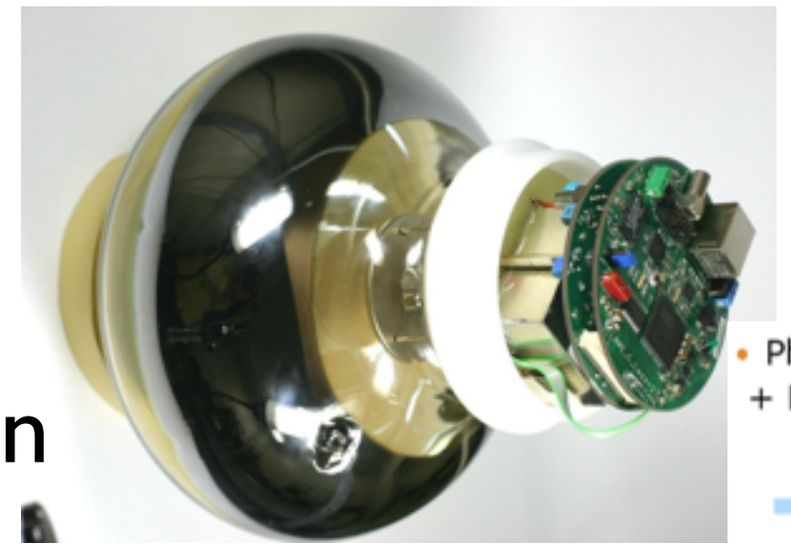


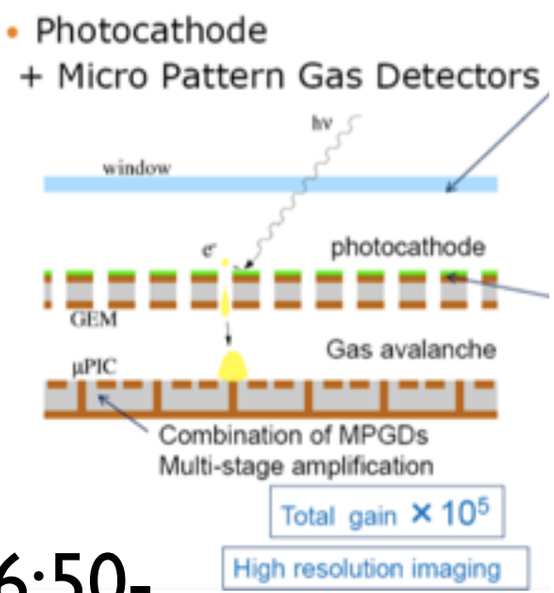
5 compartments for each tank

Photosensor



- Baseline: 20inch PMT (same as SK)
  - Proved to work!
  - Single photon capability, low dark rate, timing resolution
- One of cost drivers
- R&D ongoing/starting
  - Size/number optimization
  - New sensor (high QE PMT, HPD, gas PMT? ...)
  - Pressure tolerance, avoiding chain implosion





Dr. T. Abe : Fri. 16:50-
Dr. H. Sekiya: Sat. 11:00-

DAQ/Electronics

- Requirements basically the same as SK
  - Can be realized with current technology
  - Conceptual design exists
    - Handling of cables, attenuation of signal, ...
      - Front-end electronics inside water under consideration

Summary and prospects

- Hyper-Kamiokande, a megaton water Cherenkov detector, will provide excellent opportunities for a wide range of science.
- Feasibility studies close to completion.
- Optimization study and R&D for real construction are ongoing.
- Preparing a report summarizing baseline design and physics potential. Will be released soon.

Timeline for Hyper-K

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
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