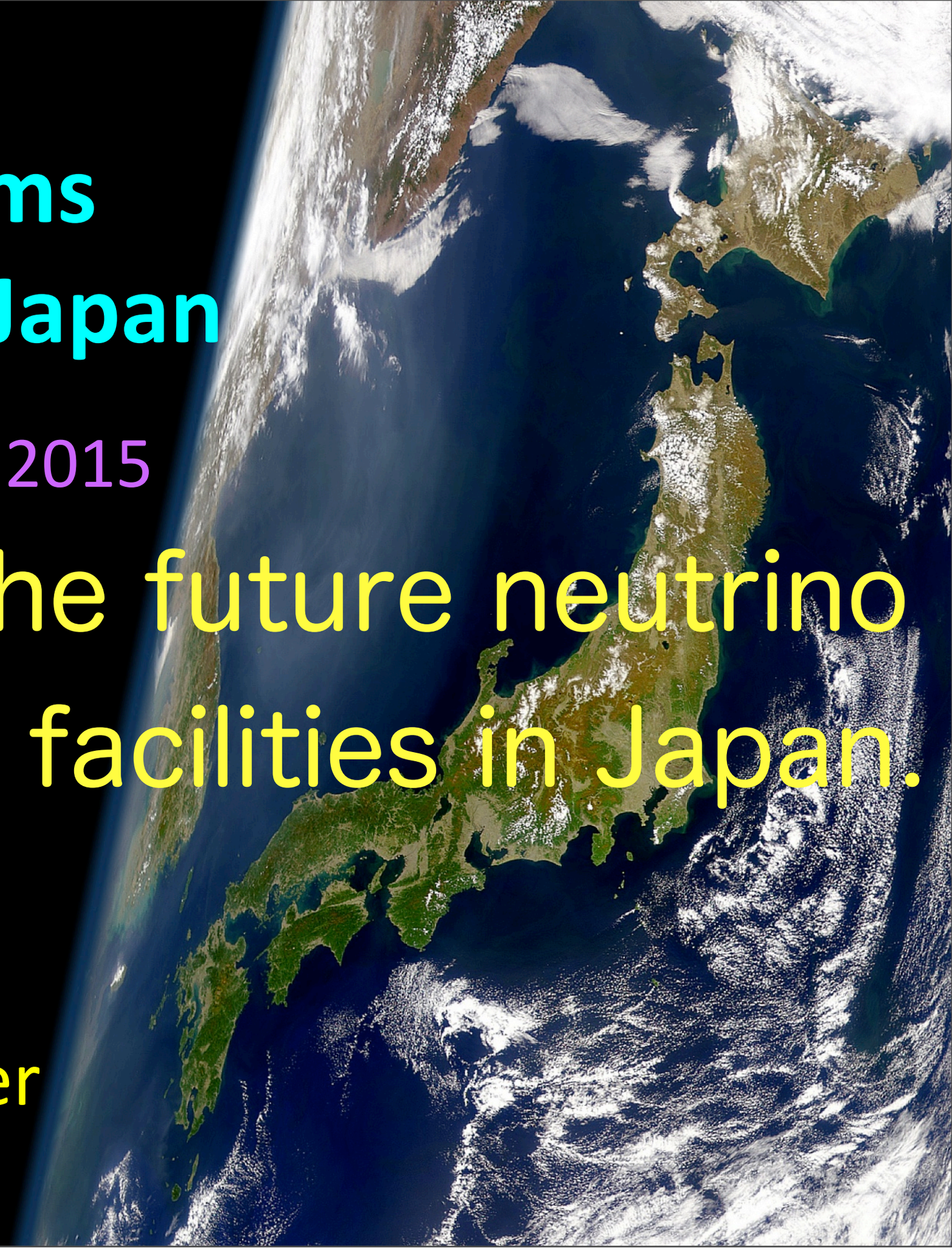
Workshop for Neutrino Programs with facilities in Japan

August 4-6, 2015

We discuss the future neutrino program with facilities in Japan.

Ibaraki Quantum Beam Research Center (IQBRC) 2F B202



Goals of this neutrino workshop

T. Nakaya for the programing committee:

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It is an exciting time with neutrinos

- Large θ_{13} (, θ_{12} and θ_{23})
- Appearance channel of $\nu_\mu \to \nu_e$
  - open the window to study neutrino CPV together with mass hierarchy determination.
- A possibility of sterile neutrinos ..

- On-going experiments with some upgrades can address an unexplored area.
- Future experiments are under design to study neutrinos in ultimate precision.

Time is crucial

- On-going experiments
  - Peak time: now ~ 2020?
- Future Big Experiments
  - Hyper-K and DUNE will come after 2025 with several important challenges
    - Higher beam power
    - Well-control of systematic uncertainties
    - New detector technologies

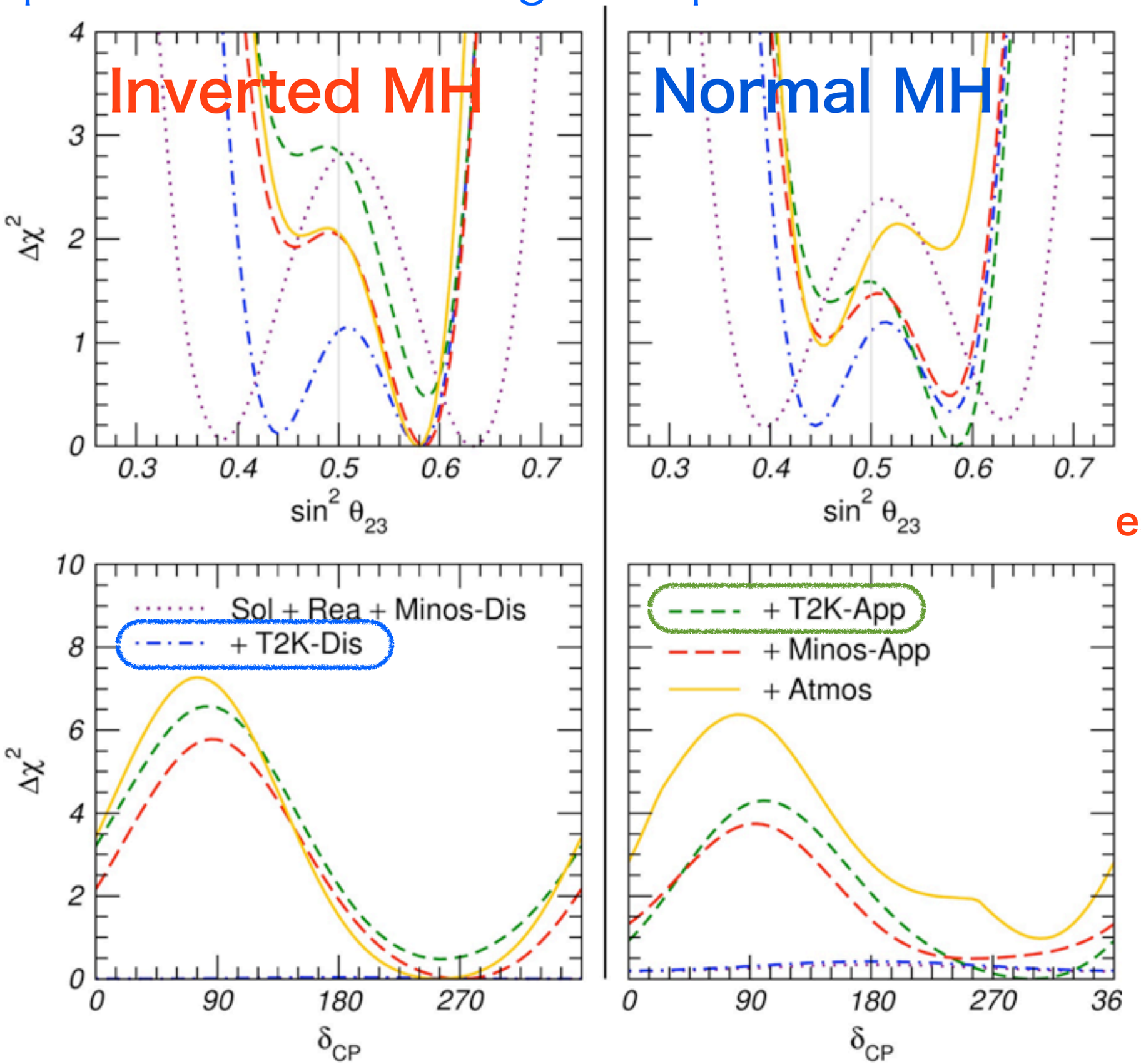
- We can tackle the challenges now at neutrino facilities in Japan.
- We can make the on-going experiments more attractive with more physics by overcoming the challenges.

New neutrino activities in J-PARC

- Not only for the standard neutrino oscillations, there may be more surprising physics in neutrinos.
  - Sterile Neutrino Search?
  - Broad view with Super-nova neutrinos, cosmic neutrinos, atmospheric, proton decays,
- How shall we address the important physics subjects at the neutrino facilities in Japan.

Recent Milestones

T2K results lead the precision of neutrino oscillation parameters including CPV phase.



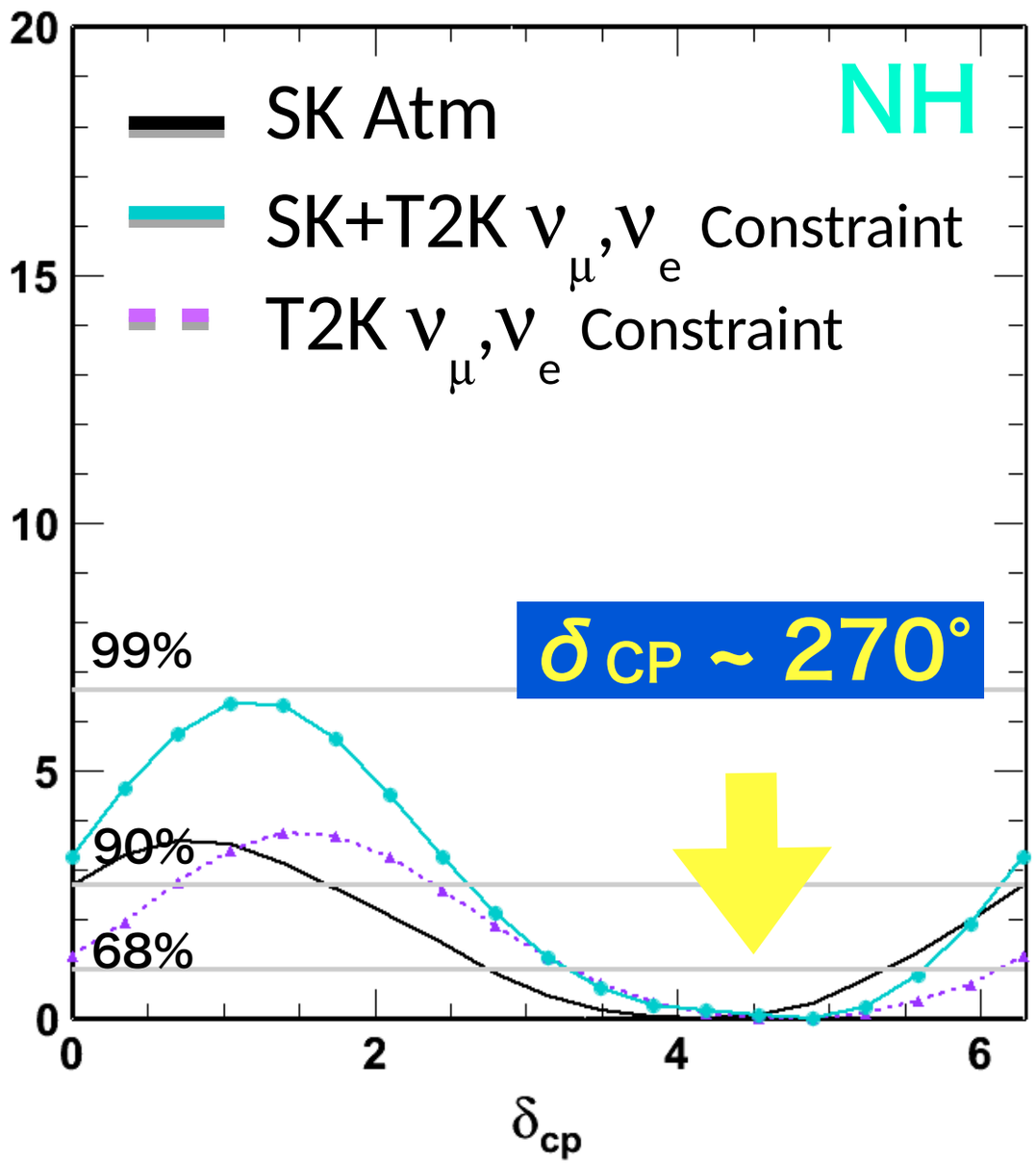
NuFIT 2.0 (2014)

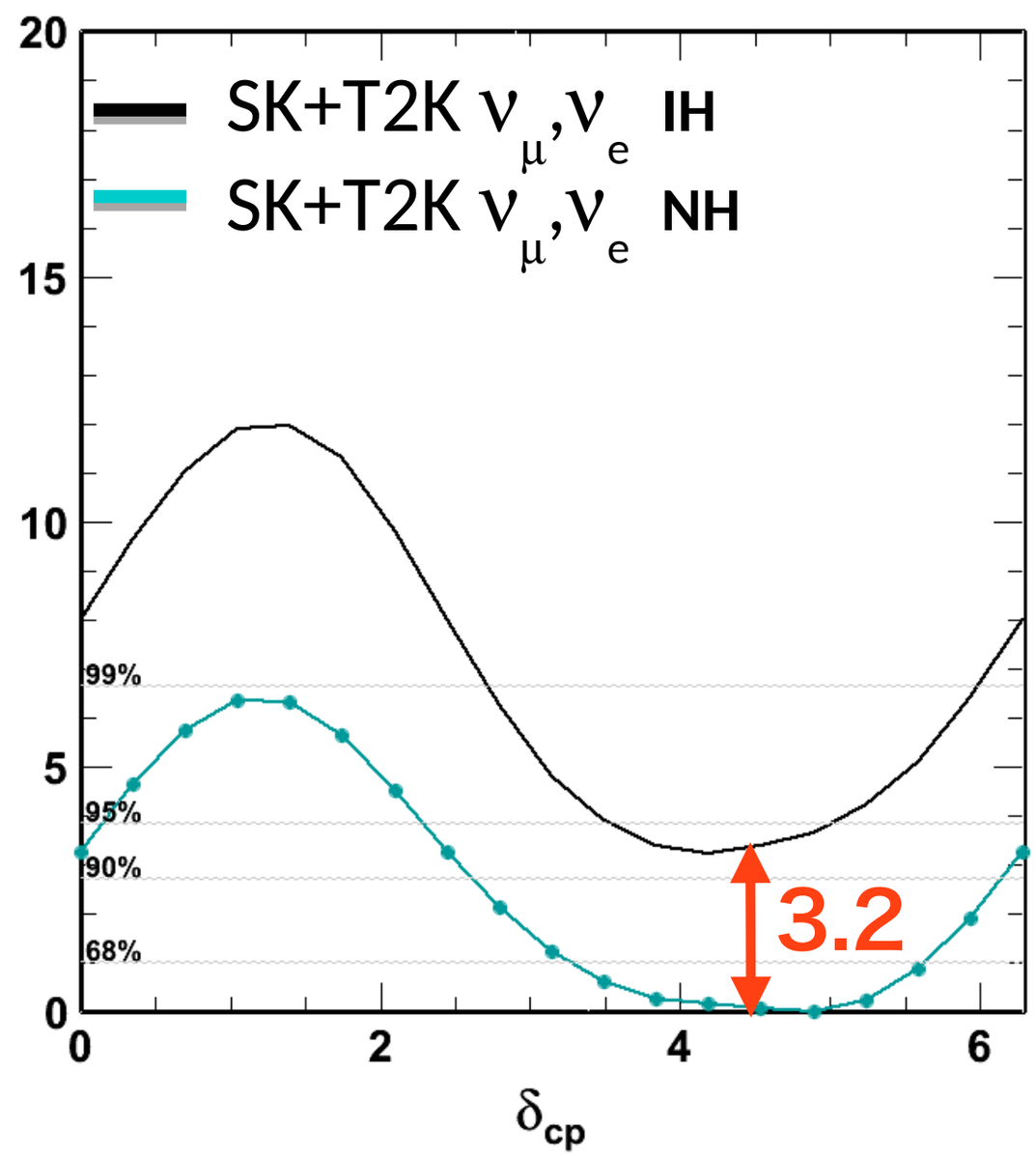
http://www.nu-fit.org

More T2K data are essential for Neutrino Oscillation Physics.

Super-K and T2K

- Super-K atm-ν has some sensitivity on Mass Hierarchy and CPV.





$\chi^2_{NH} - \chi^2_{IH}$ = **-3.2** (SK Only -3.0,

NOvA and T2K

- NOvA will soon release the new result.
- The NOvA measurement will be important to determine the Mass Hierarchy, that is a benefit for T2K.

First Analysis

By P. Shanahan @FNAL PAC, June 23 2015

- Data set through Mar. 14, 2015
  - 1.9×10^{20} POT – 14 kT equivalent exposure
- Preliminary expected yields
  - ν_e appearance

Assuming $\delta_{CP}=0$, no matter effect, $\sin^2(2\theta_{13})=0.095$
Maximal 23 mixing,
Unknowns can change signal by +/- 60%

	Osc. ν_e CC Signal	Total BG	ν_μ CC	NC	Beam ν_e	Cosmic Background
LID	3.25	1.02	0.05	0.32	0.33	0.29
LEM	3.48	1.14	0.05	0.41	0.36	0.29

T2K: 28 ν_e events with 6.6×10^{20} POT
(Expect: 17.3 Signal + 4.3 BG)

The first anti-ν_e appearance search

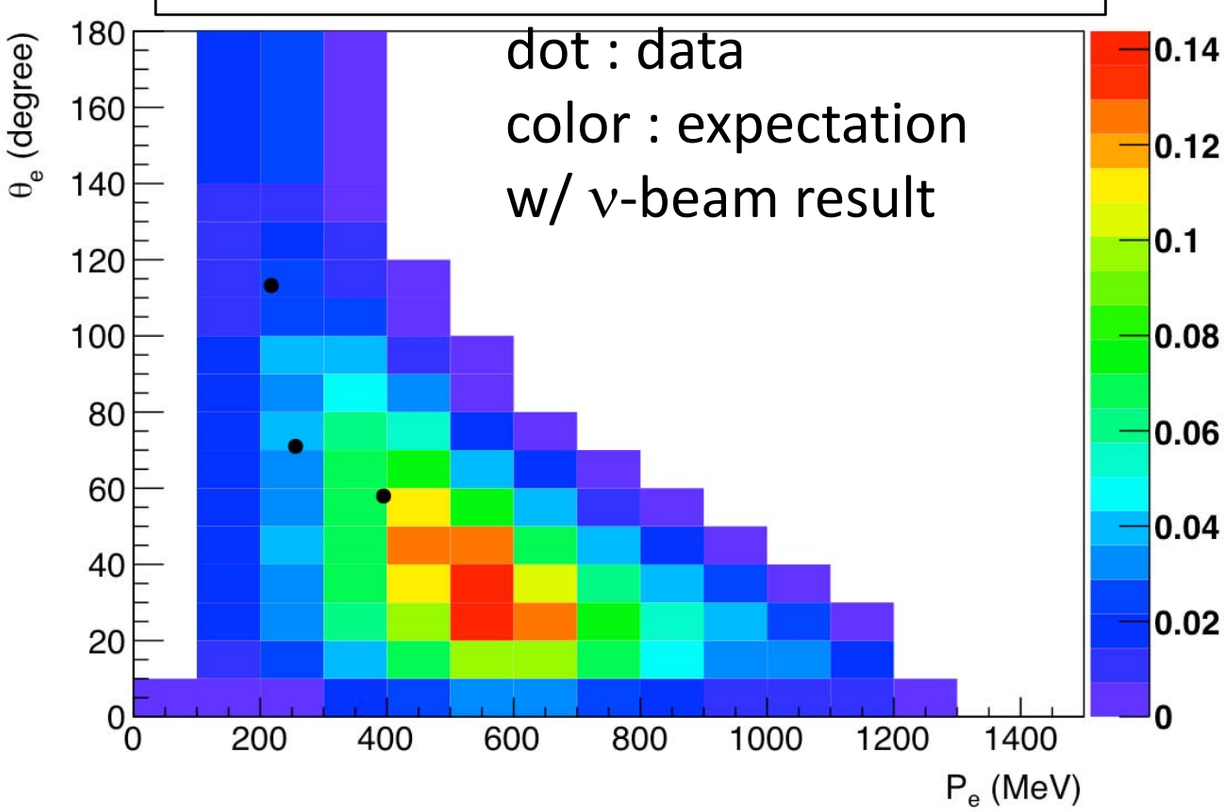
w/ 4E20 POT

- First step towards CP-phase measurement
- Enhanced(Suppressed) if $0<\delta_{CP}<\pi(-\pi < \delta_{CP}< 0)$
- Expect 3.7~5.5 events while background is 1.5~2.1 depending on δ_{CP}

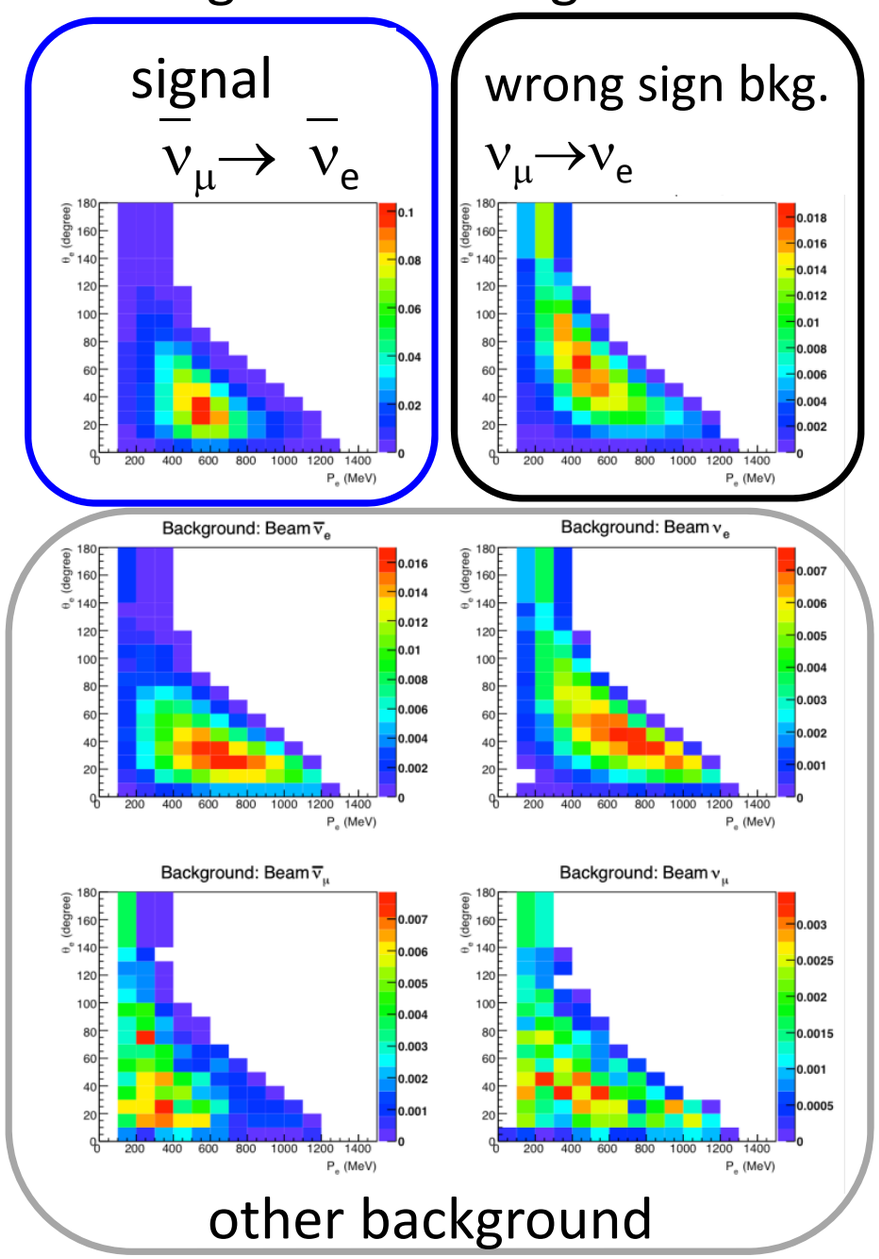
Result

- Three events observed.
- More statistics is necessary.

p-θ distribution of emitted electron



expected distribution for signal and background



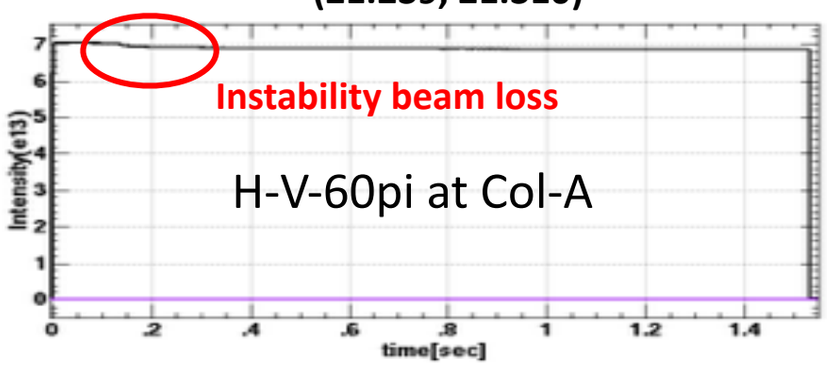
A neutrino experiment is possible with >1MW beam in the near future (before the Hyper-K era)

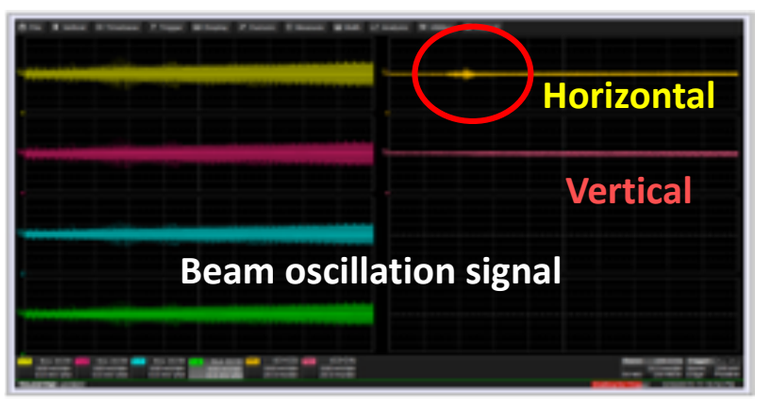
PAC July/15/2015

J-PARC

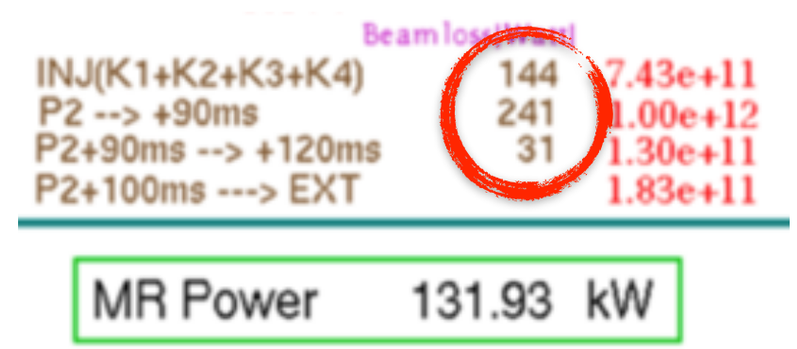
30GeV Acceleration by new operation point with two bunches

(21.239, 21.310)





Peak:40mA, Macro:0.5ms, Chop:489ns, Thining:32/32
2bunches, Trim-Qs:ON, Trim-Ss:ON, Inj.KM: (K1,K2,K2,K2)
Chrom. Corr. of 75% DC for reduction of instability



Tunable knobs:
Injection kicker, BxB feed-back,
2nd harmonic cavity, VHF cavity

	Bunch number	repetition period (sec)	Beam power (kW)	Beam loss (kW)	Notes
1	***2***	***2.48***	***132***	***0.42***	***measurement***
2	8	2.48	530	*1.7*	estimation
3	8	1.3	1000	*3.2*	estimation

Discussion subjects

- T2K upgrade (beam, near detectors and Super-K)
- J-PARC accelerator upgrade
- Super-K upgrade
- Hyper-K project and the connection/relation with T2K and Super-K
- Any new ideas to make the neutrino program with Japanese facilities more fruitful

Goals

- We aim to make the strategy of the neutrino programs with facilities in Japan as soon as we can.
- We collect new studies and new ideas to make the strategy at the workshop.
- We may have the follow-up workshop to finalize the strategy (roadmap) before the end of this year.