Introduction to the Work on the 2nd Phase Experiment with J-PARC Neutrino Facility

Takuya Hasegawa(KEK)

Primary Motivation of T2K

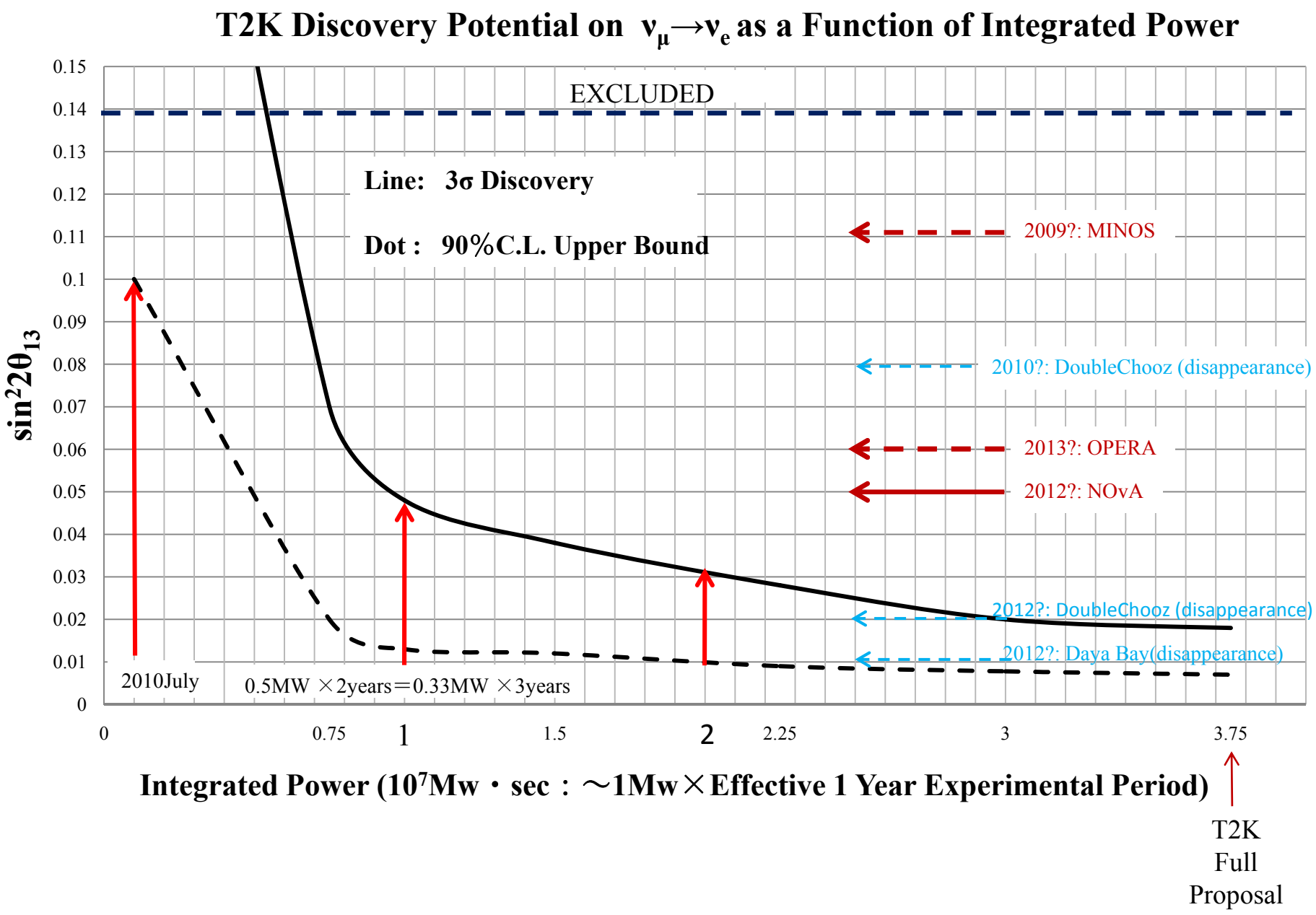
Discover $\nu_\mu \rightarrow \nu_e$ Conversion Phenomenon
Prior to Any Other Experiment in the World

Conclude Lepton Flavor Mixing Structure

T2K Proposal Accepted by J-PARC PAC

"We request total integrated beam power larger than 0.75MW × 15000h at any proton energies between 30 and 50 GeV. "

$$15000\ \mathrm{h} = 5 \times 3000\mathrm{h}$$
$$\fallingdotseq 5 \times 10^{7}\mathrm{sec}$$


T2K Discovery Potential on $\nu_\mu \rightarrow \nu_e$ as a Function of Integrated Power
EXCLUDED
Line: 3σ Discovery
Dot : 90%C.L. Upper Bound
2009?: MINOS
2010?: DoubleChooz (disappearance)
2013?: OPERA
2012?: NOvA
2012?: DoubleChooz (disappearance)
2012?: Daya Bay(disappearance)
2010July
0.5MW ×2years＝0.33MW ×3years
$\sin^2 2\theta_{13}$
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
0.75
1
1.5
2
2.25
3
3.75
Integrated Power (10^7Mw・sec : ～1Mw×Effective 1 Year Experimental Period)
T2K
Full
Proposal

Integrated Power of 1～2MW×10^7seconds

is

a Turning Point to Decide

Next Project Utilizing J-PARC Neutrino Facility

Future Investment for the "Discovery" in ν Physics we are High Energy Experiment Researcher

Not much Interested in Upper Bound Physics

If **Significant** ν_e Signal →Try CP Violation Discovery

MUST: Improve ν Beam Intensity

MUST: Improve the Main(Far) Detector Quality

In terms of

Detector Technology, Volume and Baseline+Angle

optional: improve Near Detector(whatever it is)

Possible MR Power Improvement Scenario

	Day1 (up to Jul.2010)	Next Step	KEK ROADMAP	Ultimate
Power(MW)	0.1	0.45	1.66	?
Energy(GeV)	30	30	30	
Rep Cycle(sec)	3	3-2	1.92	
No. of Bunch	6	8	8	
Particle/Bunch	1.2×10^{13}	$<4.1\times10^{13}$	8.3×10^{13}	
Particle/Ring	7.2×10^{13}	$<3.3\times10^{14}$	6.7×10^{14}	
LINAC(MeV)	181	181	400	
RCS	h=2	h=2 or 1	h=1	

After 2010, plan depends on financial situation

Brand New Far(Main) Detector

- Detector Technology
  - Water Cherenkov
  - Liquid Ar TPC
  - Etc.

  } Focused in this Workshop

- Baseline＋Angle

Depend on
How to Approach Lepton Sector CP Violation

Lepton Sector CP Violation

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} c_{12}c_{13} & c_{13}s_{12} & e^{-i\delta}s_{13} \\ -s_{12}c_{23} - e^{-i\delta}c_{12}s_{13}s_{23} & c_{12}c_{23} - e^{i\delta}s_{12}s_{13}s_{23} & c_{13}s_{23} \\ -e^{i\delta}c_{12}s_{13}c_{23} + s_{12}s_{23} & -e^{i\delta}s_{12}s_{13}c_{23} - c_{12}s_{23} & c_{13}c_{23} \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

- Effect of CP Phase δ appear as
  - ν_e Appearance Energy Spectrum Shape
    (Sensitive to All the Non-Vanishing δ including 180°)
  - Difference between ν_e and $\overline{\nu}_e$ Behavior

Assumption of Beam for This Workshop KEK Road Map

- MR Beam Power: 1.66MW
- MR Beam Energy: 30GeV
- Beam Time: 10^7sec/year
- pot/year: 3.45×10^{21}pot/year
- Beam Axis 2.5° for Kamioka
- 5 Years or 10 Years

Sharing of the Neutrino and anti-Neutrino Beam

Discussion in This Workshop 1
Discovery of Lepton Sector CP Violation

- Method to Approach Lepton Sector CP Violation
- Detector Technology
  - Liquid Ar TPC: Precision Measurement Detector
  - Water Cherenkov: Simplicity, Mass
- Baseline
  - Long: Oscillation Maximum at Higher Energy, Utilize Matter Effect
    (Neutrino Cross Section is Higher at High Energy)
  - Short: More Intense Neutrino Flux, Control of π^0 Background
    Less Matter Effect
- Angle w.r.t On-Axis
  - On-Axis: Wide Energy Coverage
  - Off-Axis: Narrow Energy Coverage, Control of π^0 Background
- Size of the Detector

Discussion in This Workshop 2
Discovery of Proton Decay
Detector Challenge

Huge Main Neutrino Detector

- The Discovery Potential for the Proton Decay
- The Realistic Step to Realize Huge Detector
  (what is achieved and what should be achieved to realize experiment)

Spirit of this Working Group

- Starting Point toward 2nd Phase Experiment
- Seek the Best Way

  to Obtain Maximum Physics Outcome

  Not a Competition at This Stage

  But a Place to Understand Well about

  the Advantage/Difficulty of

  Each Strategy

We Should be Prepared

NOT MISSING

Rare Opportunity

(Probably Only Once at the $\nu_\mu \rightarrow \nu_e$ Discovery)

to Initiate the Discovery Experiment of

Lepton Sector CP Violation and Proton Decay

Let's Start Discussion