JHF workshop

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- **Atmospheric neutrinos**
  - Where ($\Delta m^2 = 1.6 \cdot 10^{-3} \sim 4 \cdot 10^{-3}$ eV^2 , $\sin^2 2\theta > 0.89$)
  - Most likely $\nu\mu \rightarrow \nu\tau$
- **Solar neutrinos**
  - LMA likely Large θ_{12} ,$\Delta m^2_{12} \sim 10^{-5}$: CPV asym. may be large
- **Reactor neutrinos**
  - $\sin^2 2\theta_{13} < 0.1$ for atmospheric Δm^2 region
- **K2K**
  - Decrease over 250km of ~1GeV neutrino
  - Spectrum distortion
- **Minos, MiniBooNE, CGN, Kamland**
  - Oscillation pattern, ν_τ appearance, LSND, LMA

- **Many loose ends and interesting question, but……..**

Focus of the next generation oscillation experiments

- **Why we are here ? CP-violation exist in lepton ?**
- **Baryon number non-conservation**
- **Mass-Interaction : mixing ($\theta_{13} << \theta_{12}, \theta_{23}$ or $\theta_{13} < \theta_{12}, \theta_{23}$?)**

$$\begin{pmatrix} \cos\theta_{12} & \sin\theta_{12} & 0 \\ -\sin\theta_{12} & \cos\theta_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \cos\theta_{13} & 0 & \sin\theta_{13} \\ 0 & 1 & 0 \\ -\sin\theta_{13}e^{i\delta} & 0 & \cos\theta_{13}e^{i\delta} \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_{23} & \sin\theta_{23} \\ 0 & -\sin\theta_{23} & \cos\theta_{23} \end{pmatrix}$$

solar **reactor** **atmospheric**

$\Delta m_{12} << \Delta m_{23} \approx \Delta m_{13}$

θ_{12} large (solar)

θ_{23} large (atmospheric)

1. θ_{13} (remain to be discovered)
2. δ

No strict prediction

What kind of experiment ?

$$\text{Osc. Prob.} = \sin^2 2\theta \cdot \sin^2\left(\frac{1.27\ \Delta m^2(eV^2)\ L(km)}{E_\nu(GeV)}\right)$$

1. **Beam energy and Detector**

   Finite E_ν resolution **S/N** $\propto \delta E/E$

   - $\delta(E_\mu+E_{had})/E_\nu \sim 10\% \oplus 50\%/\sqrt{E_{had}}$ (high energy)
   - Two-body kinematics (QE) (low energy)

     $\delta E_\nu/E_\nu \sim 80$ MeV/1000 MeV

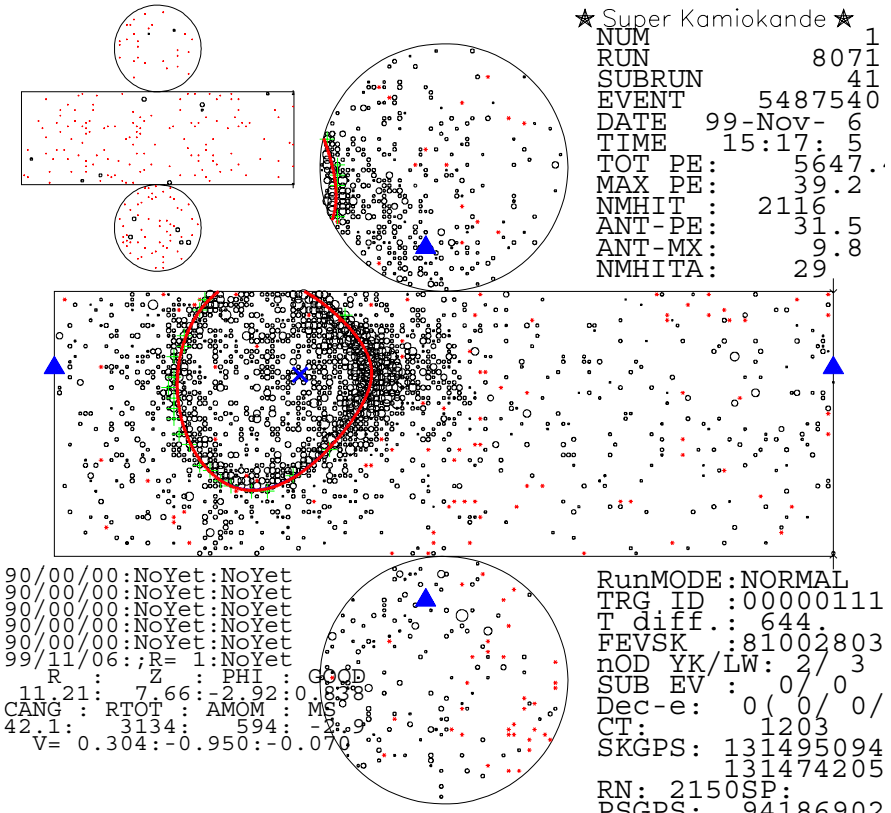
2. **QE fraction**
3. **Matter effect (CPV study in ν_e related)**

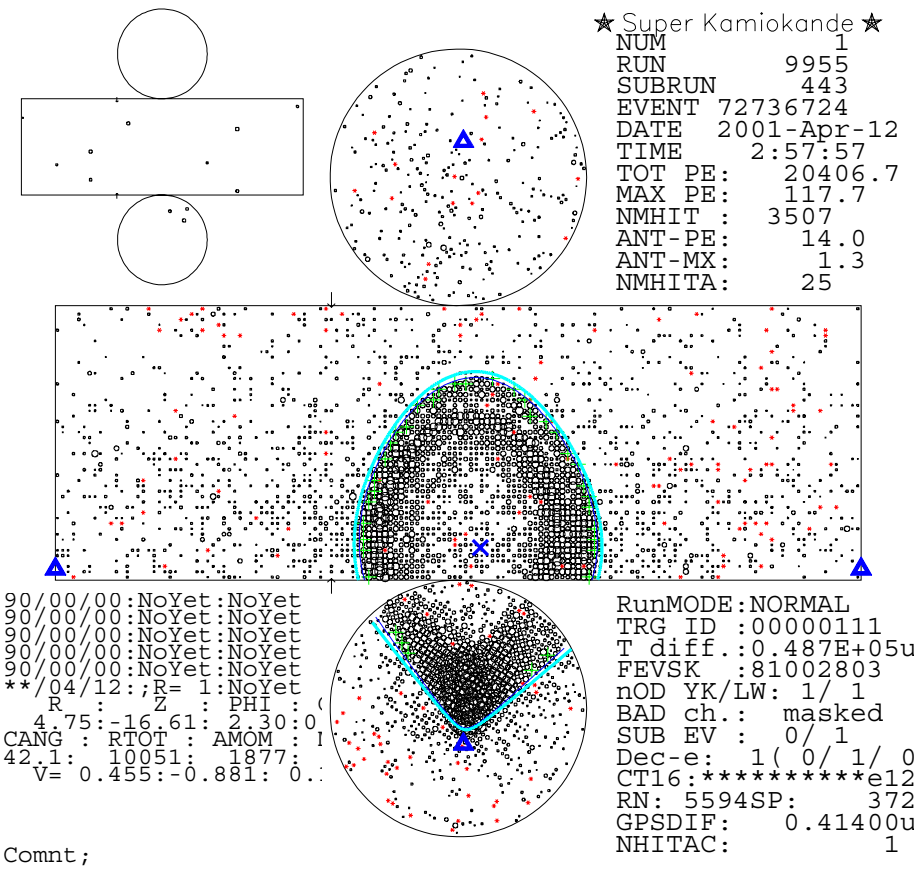
   – $\propto$ E x L

   - **CPV**
   - ✓ **sign(m_3-m_1)**

Electron-like and Muon-like events in SK

High resolution and good PID at low energy





Basic design of experiment

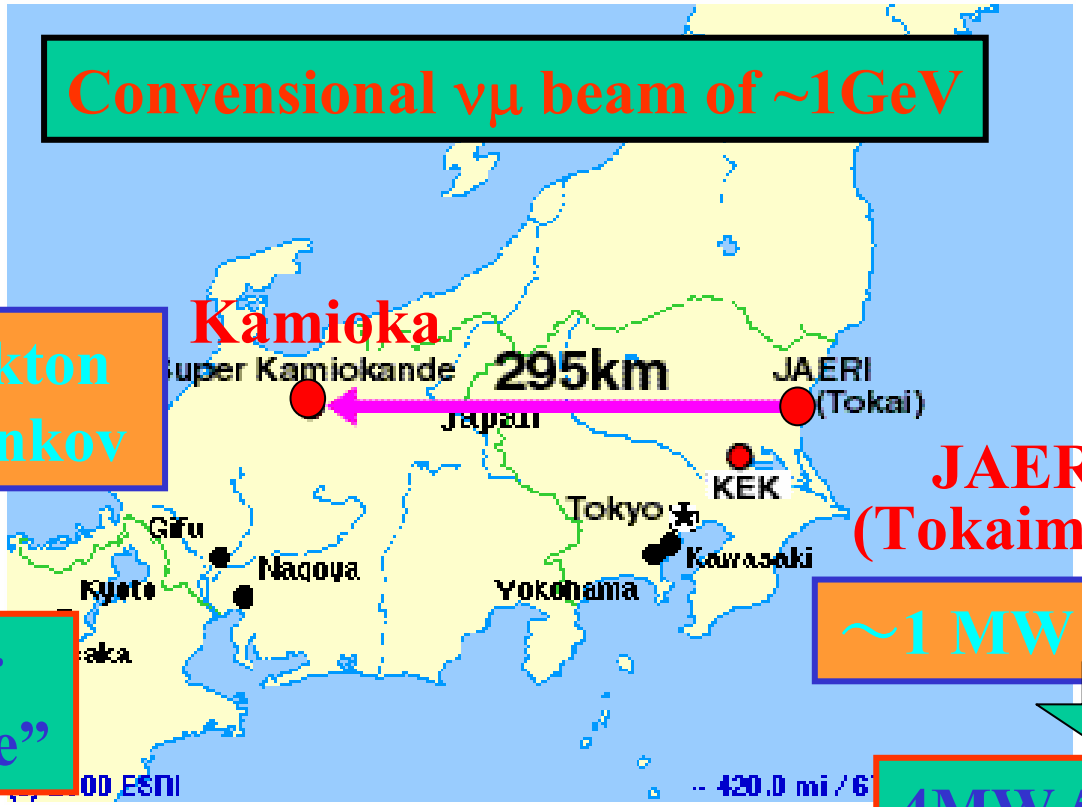
θ_{13} $\rightarrow$ CP violation measurement

➢ Oscillation pattern , θ_{23} , Δm^2, NC

Sub-GeV Beam + Large water Cherenkov detector

- **Highest intensity at low energy with small tail**
  - **Off-axis beam (2 ~ 3 degree)**
- **Ambiguity of ν and anti-ν interactions**
  - **study at near detector with narrow band beam**
- **Near/Far extrapolation**
  - **~2km detector**
- **Three detectors configuration**
  - ➢ **280m, 2km, and 295km**

JHF-SK(HK) ν Experiment



Super-K: 50 kton Water Cherenkov

~Mt "Hyper Kamiokande"

JAERI (Tokaimura)

~1 MW 50 GeV PS

4MW 50GeV PS

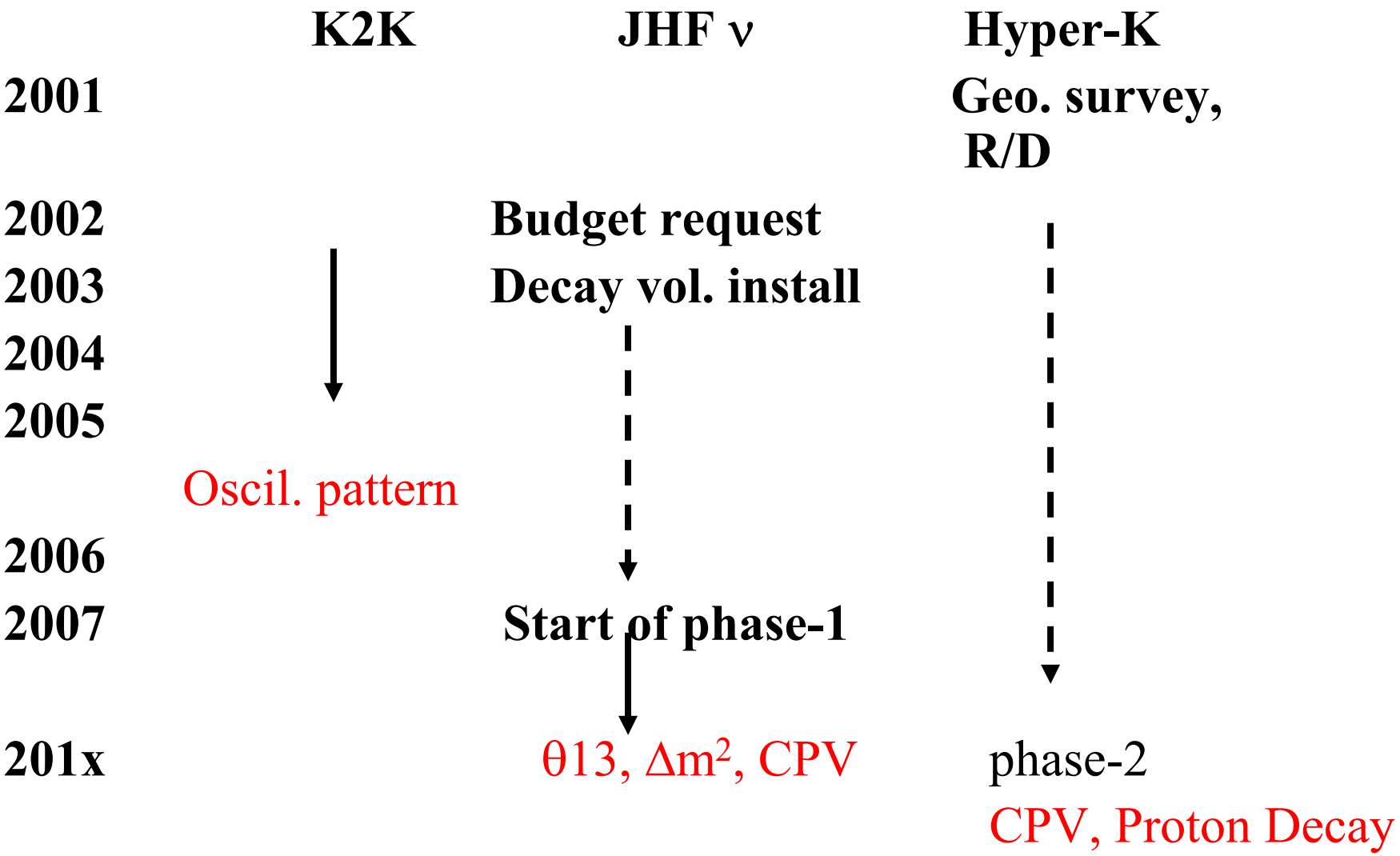
First Phase

- $\nu_\mu \rightarrow \nu_e$ appearance
- (Large CPV)
- $\nu_\mu \rightarrow \nu_x$ disappearance
- NC measurement

Second Phase

- CPV
- proton decay

Road Map


K2K
JHF ν
Hyper-K
2001
Geo. survey,
R/D
2002
Budget request
2003
Decay vol. install
2004
2005
Oscil. pattern
2006
2007
Start of phase-1
201x
θ13, Δm², CPV
phase-2
CPV, Proton Decay

- **CPV in Kaon system was discovered just below Adair's measurement**
- **CP phase is large in K,B (Jarlskog factor is small)**
- **No theorist predicted large mixing θ_{23}**
- **No strict prediction on θ_{13} , δ**
- **14 order of magnitude extrapolation for proton decay prediction**

- **One order of magnitude improvements are worth the effort !**
- **Major discoveries may be around the corner**

work item

- **Decay volume (2003 installtion)** — **cost estimate**
- **Proton beam optics** — **almost done**
- **GPS measurement** — **in analysis**
- **Radiation safety** — **ok upto 4MW**

- **Budget request will be in coming year(2002)**

- **Super-conducting magnets in high radiation**
- **Target**
- **Horn design**
- **Beam monitor/near detector for high precision measurements**
- **2 km detector site**
- **Collaboration for Proposal**