# NuFact 03 WG1 Summary

- Future Experiments
  - G. Feldman — Progress report from NUMI off-axis
  - R. Bernstein — Independent study of NUMI off-axis sensitivity
  - K. Kodama — Progress report on CNGS and Opera/Icarus
  - Y. Obayashi — JHF progress report and $\theta_{13}$ sensitivity
  - J. Burguet-Castell — JHF intermediate detector
  - S. Kahn — BNL/Homestake proposal
  - G. Rajasekaran — A large iron detector for the neutrino factory
  - Y. Efremenko — A long-baseline experiment in the IHEP tunnel

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- Future Experiments
  - LBL; approved, ongoing
    - ✓ K. Kodama — Progress report on CNGS and Opera(/Icarus)
  - LBL; proposed, realistically studied
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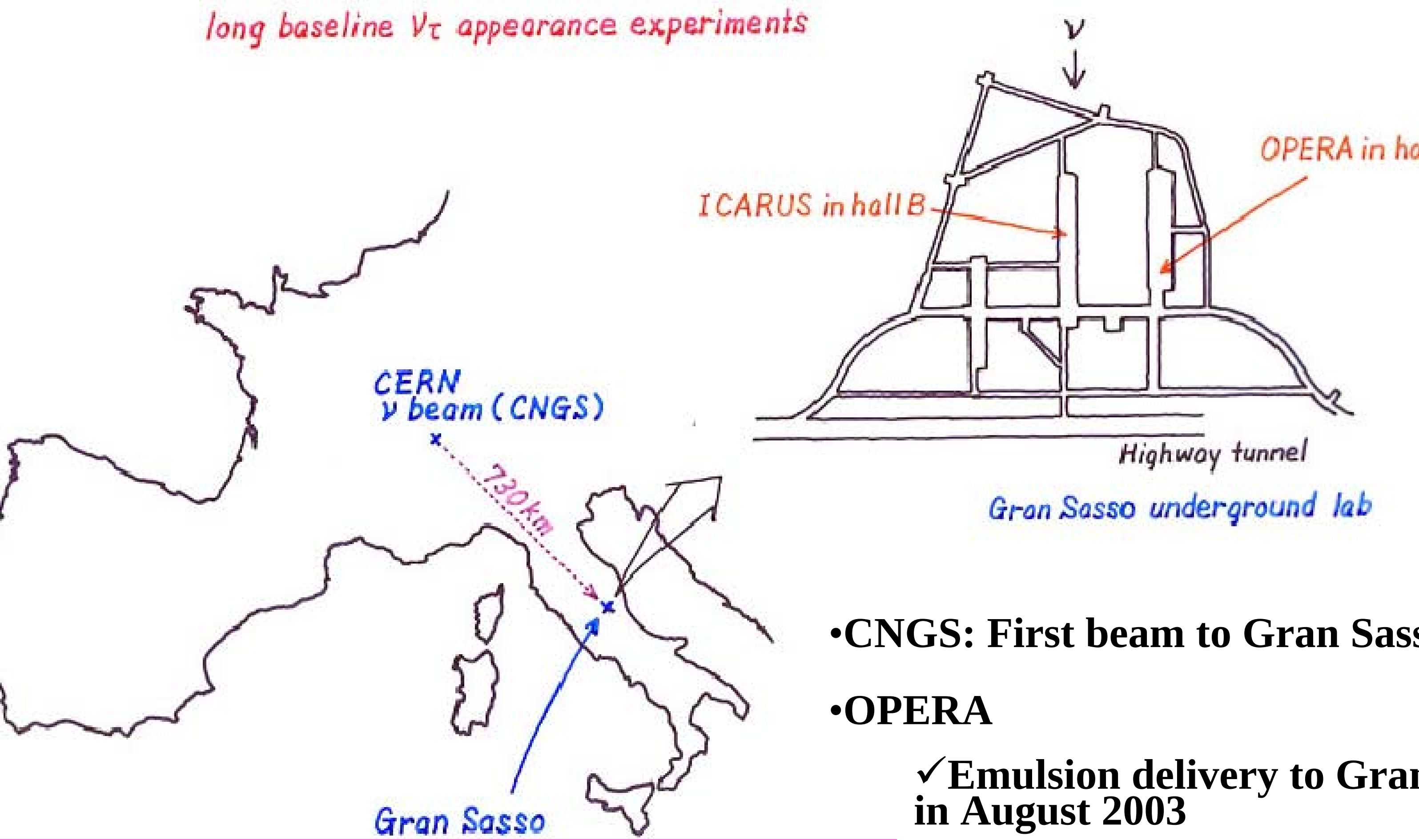
  - VLBL; conventional beam
    - ✓ S. Kahn — BNL/Homestake proposal
    - ✓ Y. Efremenko — A long-baseline experiment in the IHEP tunnel
  - VLBL; neutrino factory
    - ✓ G. Rajasekaran — A large iron detector for the neutrino factory

# CNGS, OPERA and ICARUS status




•**CNGS: First beam to Gran Sasso: May, 2006**

•**OPERA**

- ✓**Emulsion delivery to Gran Sasso starts in August 2003**
- ✓**Run from Day 1**
- ✓**Emulsion analysis for event location must be ready before Day 1**
- ✓**Rehearsal for event location using "mini-OPERA" at KEK-PS in 2004**

•**ICARUS (A. Rubbia, plenary talk)**

- ✓**T600 installation at CNGS has been approved in March 2003.**
- ✓**Transported and installed in 2003-2004.**
- ✓**T3000 = T600 + T1200 + T1200**

# JHF-Kamioka Neutrino Experiment

Y. Obayashi

*Plan to start in 2007*

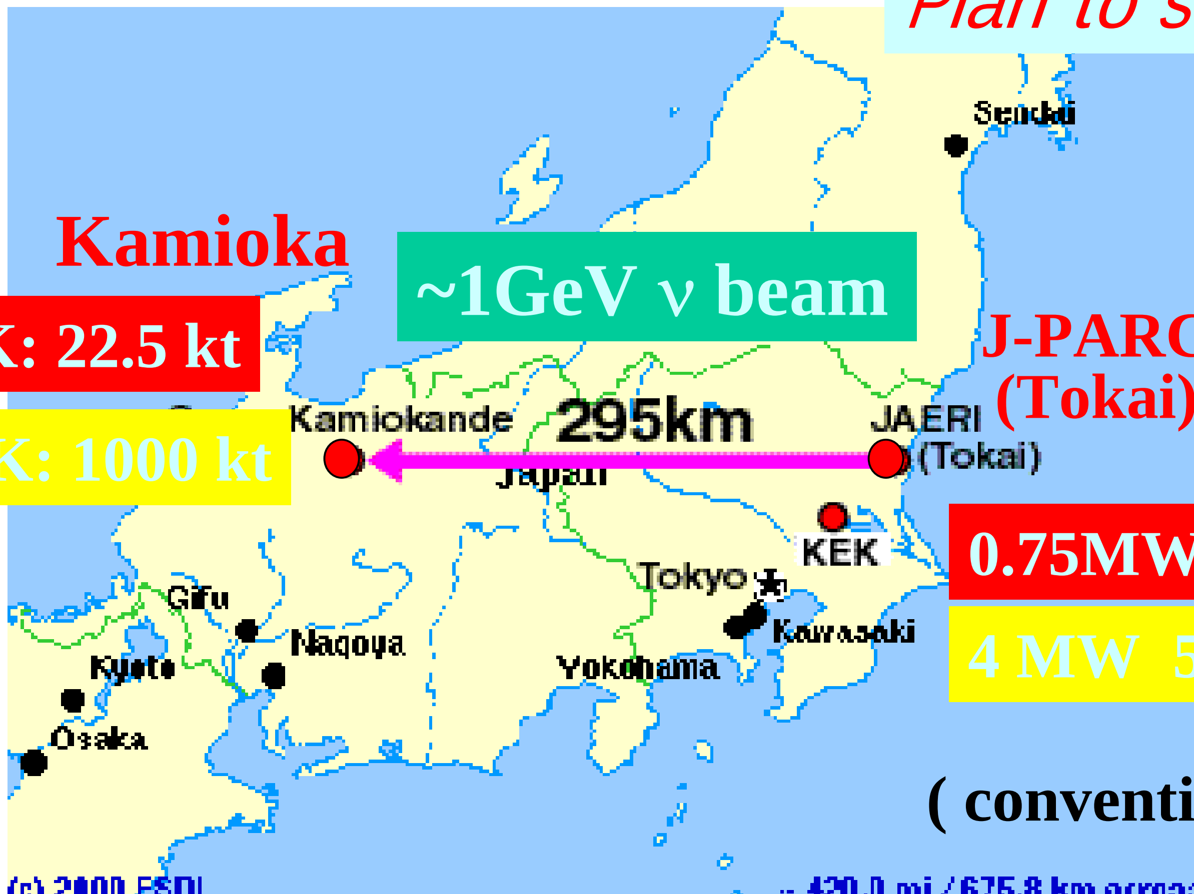
Kamioka

Super-K: 22.5 kt

Hyper-K: 1000 kt

~1GeV ν beam

J-PARC (Tokai)



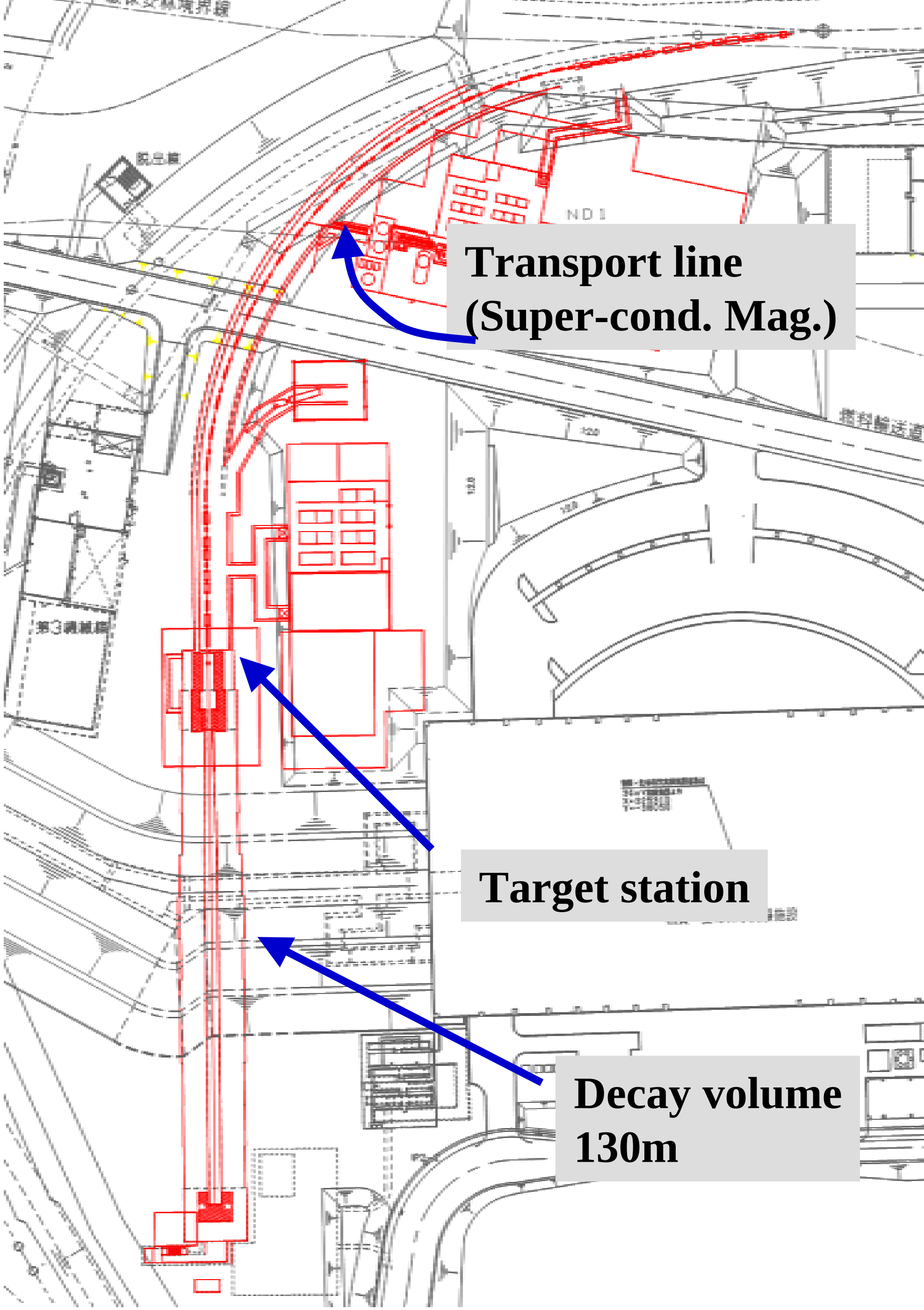

0.75MW 50 GeV PS

4 MW 50 GeV PS

( conventional ν beam)

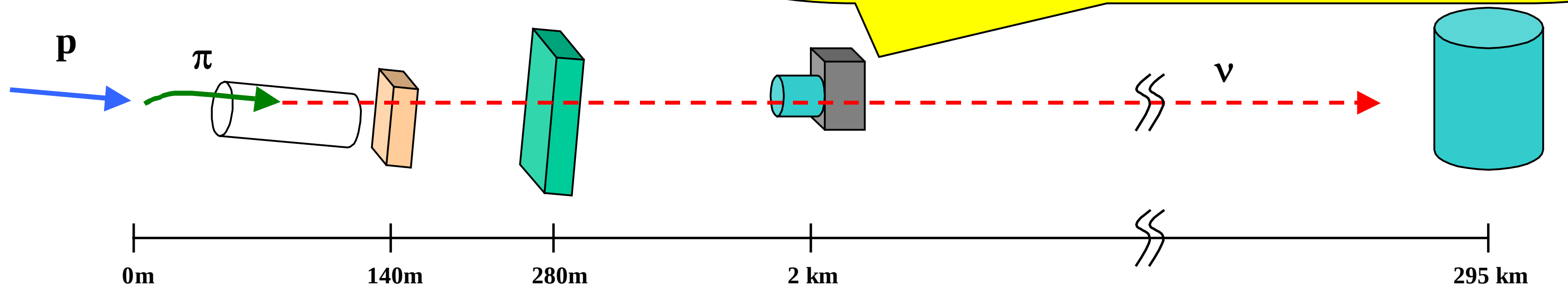
# Neutrino Beamline

- Off-axis
- Design in progress.
- Budget request submitted.
- Will be ready to start construction in 2004.



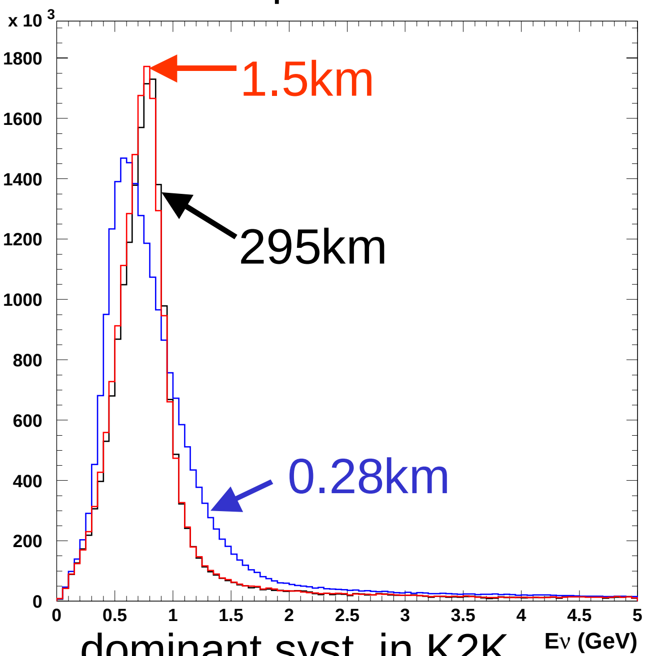
# Detectors

**Role of the 2 km intermediate detector studied by Burguet-Castell: It will drastically simplify the systematic error analysis.**




- **Muon monitors @ ~140m**
  - **Fast (spill-by-spill) monitoring of beam direction/intensity**
- **First Near detector @280m**
  - **Neutrino intensity/spectrum/direction**
- **Second Near Detector @ ~2km**
  - **Almost same $E_\nu$ spectrum as for SK**
  - **Water Cherenkov can work**
- **Realistic sensitivity studies and detector design studies started.**

Neutrino spectra at diff. dist




dominant syst. in K2K

# NuMI off-axis

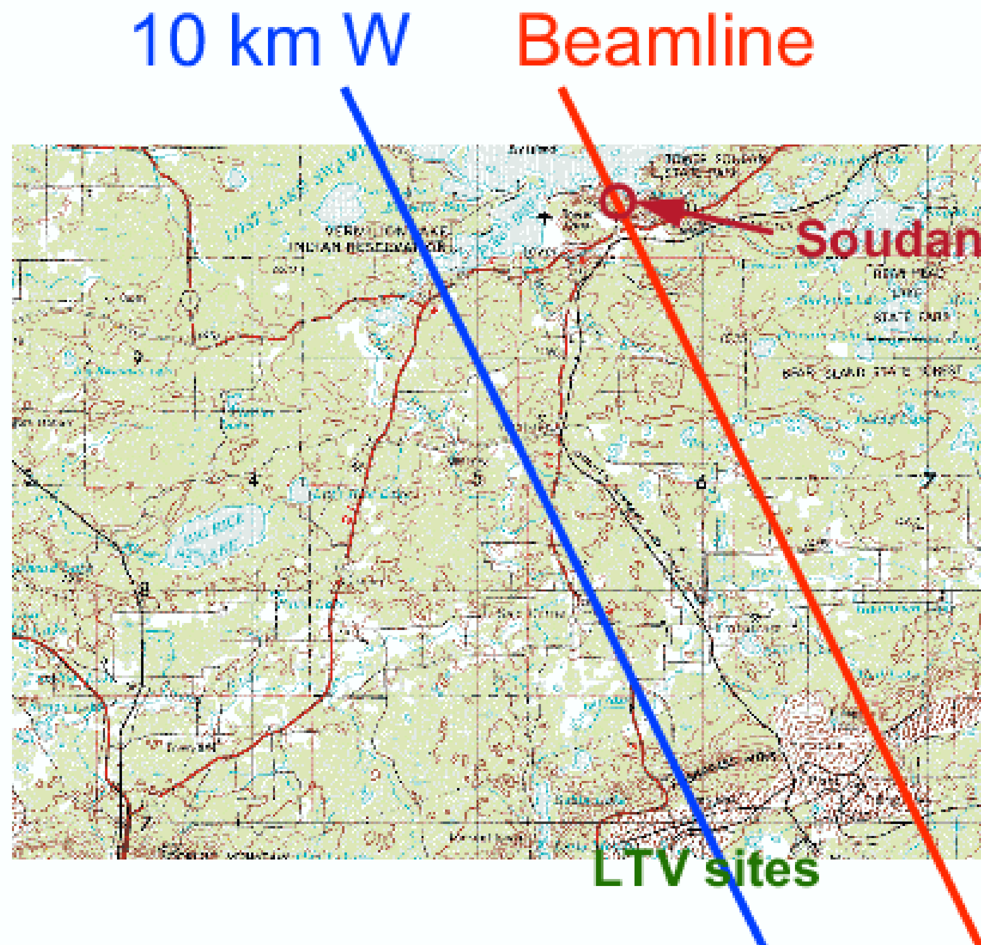
## G. Feldman

## LTV Site 712 km

Former surface mining site, no longer used.

Large site, 25 by 5 miles.

Road and rail access. Power, fiber, and cell phone.




There are some other longer baseline sites up to ～950 km.

# Detector Technology Choice

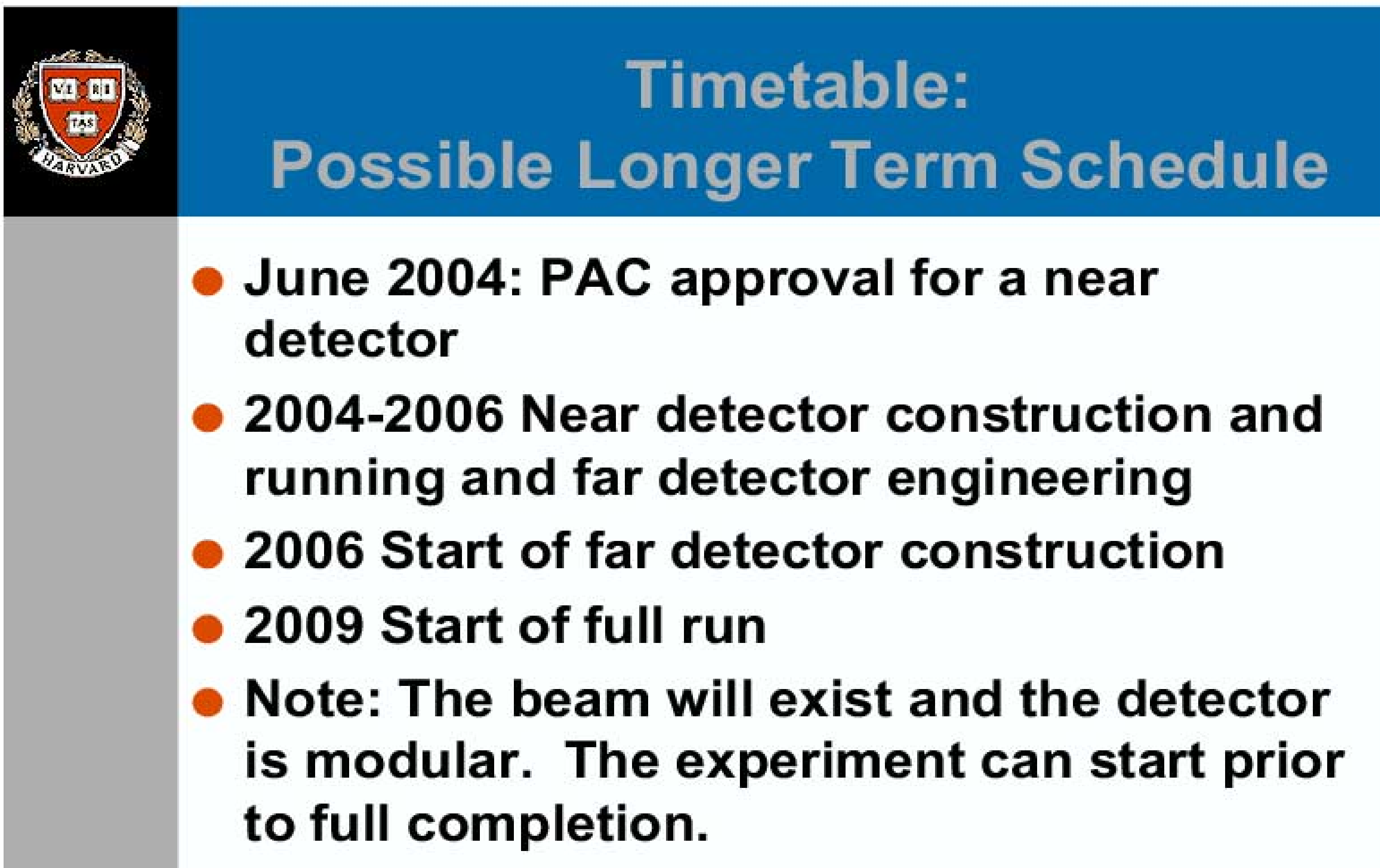
- Most troublesome backgrounds are asymmetric $\pi^0$ decays from NC and $\nu_\mu$ CC events where the muon is not detected.
- $H_2O$ Cerenkov detectors do not provide optimum rejection for $E > 1$ GeV.
- Best rejection is given by liquid argon detectors, but required R&D is not compatible with the envisioned time scale.
- Next best option is highly-segmented (~1/3 $X_0$) medium-Z sandwich detectors.

**Active elements: scintillators or RPCs considered**

**Absorber: consensus to use particle board**

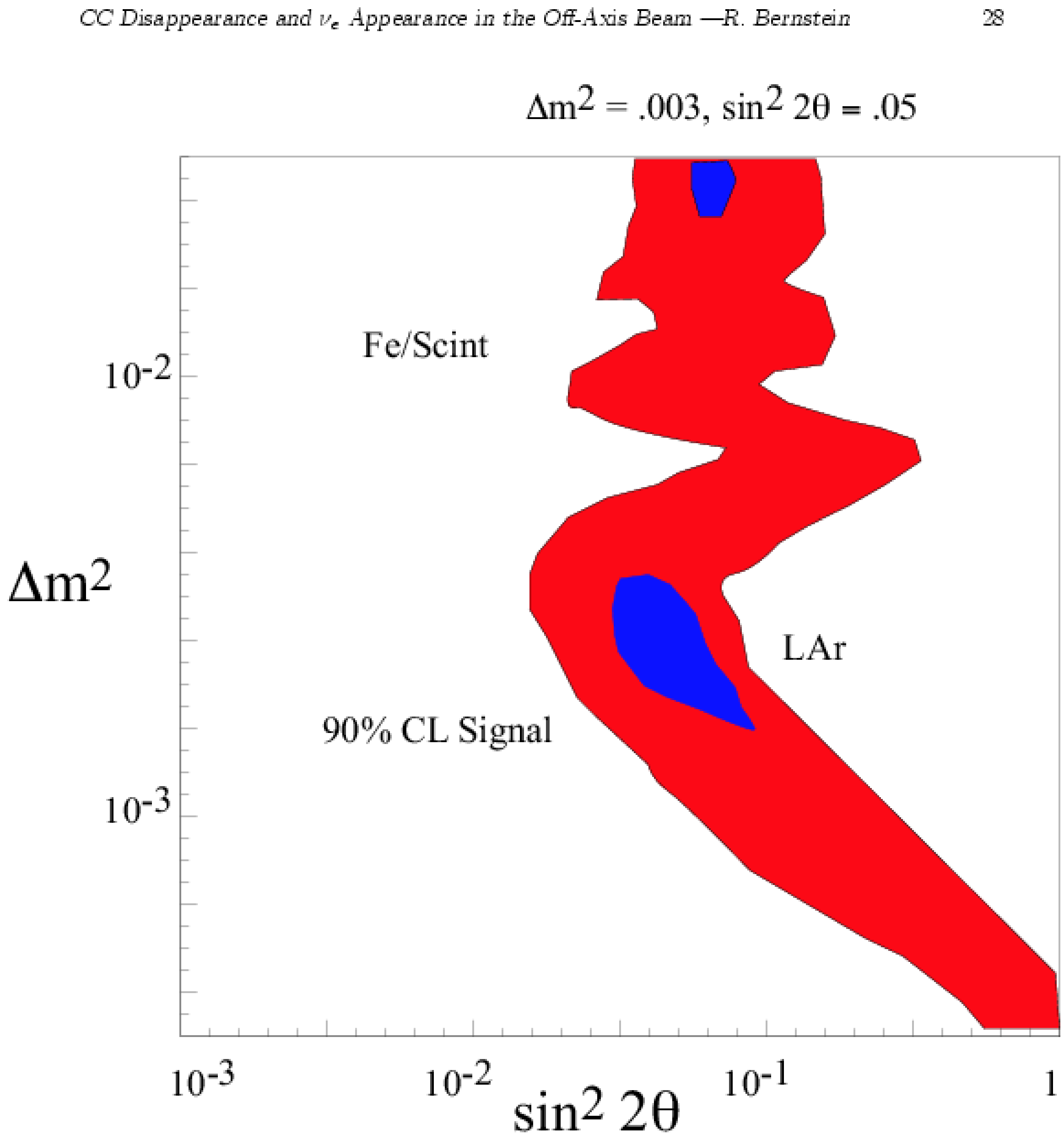
## NuMI off-axis

- LOI submitted August 2002 (P929)
- Intention to submit proposal to November 2003 PAC
- 50 kton, 5 yr, $4 \times 10^{20}$ pot/yr



# R. Bernstein

- Simulation studies of NuMI off-axis
- For $\nu_e$ appearance, simulated LAr and Fe/Scint, 100 kt/yr.
- Can see effects down to $\sin^2 2\theta = 0.01$.
- LAr much better



# BNL $\rightarrow$ Homestake Super Neutrino Beam

**S. Kahn**


28 GeV protons, 1 MW beam power

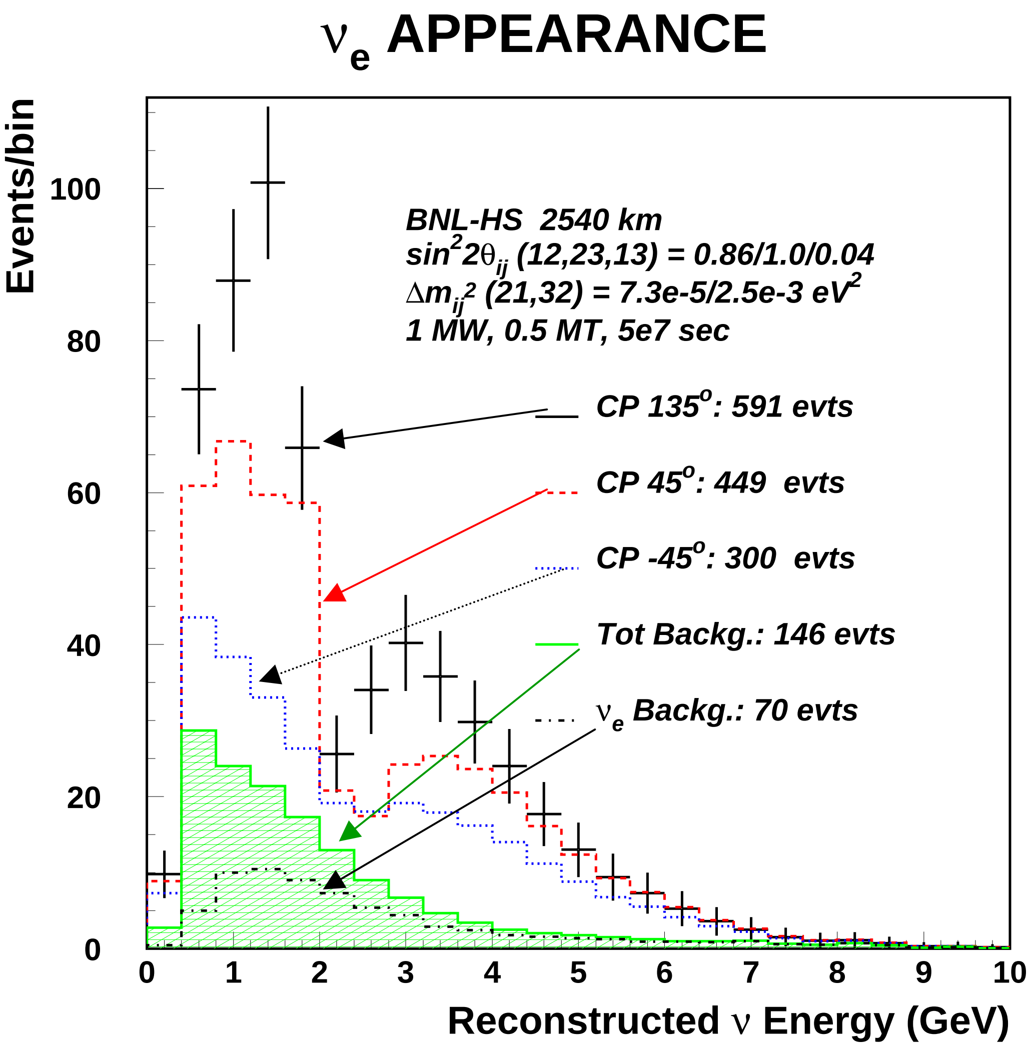
500 kT Water Cherenkov detector

$5 \times 10^7$ sec of running, Conventional Horn based beam



BROOKHAVEN NATIONAL LABORATORY

# $\nu_e$ Appearance Measurements




- a direct measurement of the appearance of $\nu_\mu \rightarrow \nu_e$ is important; the VLB method competes well with any proposed super beam concept
- for values > 0.01, a measurement of $\sin^2 2\theta_{13}$ can be made (the current experimental limit is 0.12)
- for most of the possible range of $\sin^2 2\theta_{13}$, a good measurement of $\theta_{13}$ and the CP-violation parameter $\delta_{CP}$ can be made by the VLB experimental method

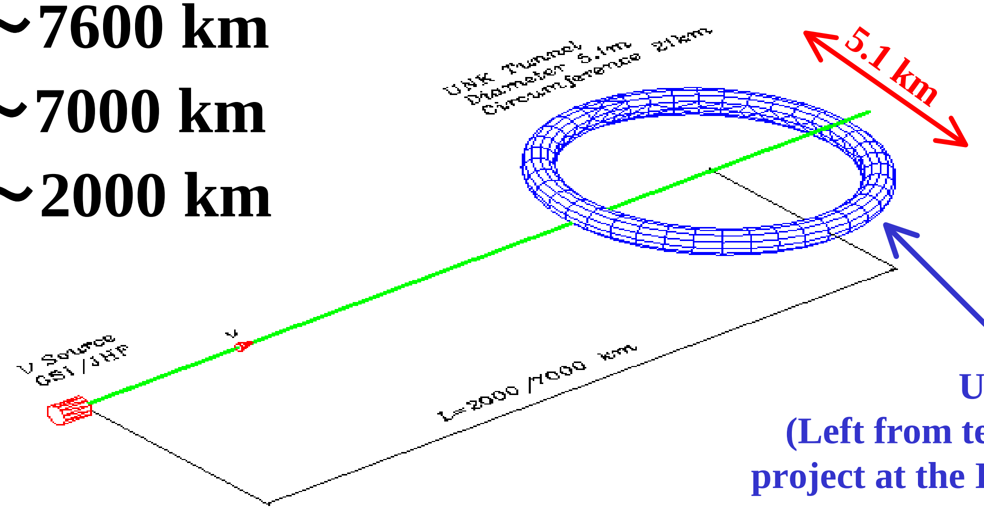
**DISCUSSION**

- 1-ring QE event selection above a few GeV suffers from more BG.
- More realistic BG estimation suggested.

Y. Efremenko

# Concept
## Measurement of $\nu_\mu$ disappearance with a very large baseline

| | |
|---|---|
| **Fermilab** | **～7600 km** |
| **JHF** | **～7000 km** |
| **GSI** | **～2000 km** |




UNK tunnel
(Left from terminated accelerator project at the IHEP, Protvino, Russia)

- **UNK tunnel - huge scintillator based muon counter (not calorimeter !)**
- **Surrounding soil is a neutrino target ～1 Mton**
- **TOF and segmentation gives direction to the neutrino source**
- **Location at 50 m underground gives good cosmic ray background suppression**
- **Energy scan with Narrow Band neutrino beam to see oscillation pattern**

# Expected Sensitivity

**For $\Delta m^2_{atm}$ in the range of**

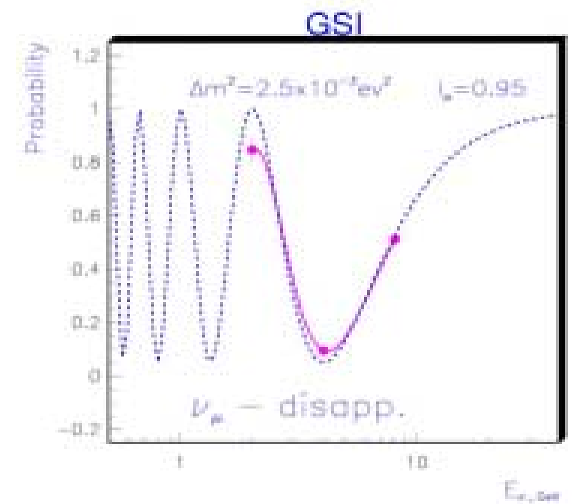
**$1.5\ 10^{-3}\ ev^2 < \Delta m^2 < 4.0\ 10^{-3}\ ev^2$**

**Expected accuracy in parameters measurements**

**For GSI: $\sigma_{\Delta m^2} = 2.7 \cdot 10^{-5}\ ev^2$, $\sigma_{Sin^2 2\theta} = 0.01$**

**For JHF: $\sigma_{\Delta m^2} = 1.5 \cdot 10^{-5}\ ev^2$, $\sigma_{Sin^2 2\theta} = 0.01$**

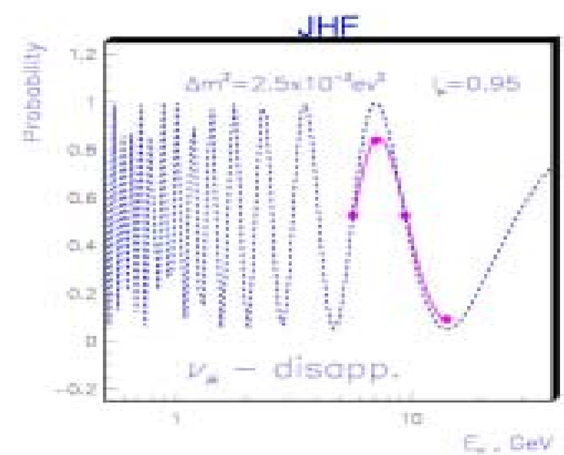
**This is ~1% error !!!**




## If we can do the same for antineutrinos say with 2% accuracy, then:

**Test of CTP on the 3% level**

**by compare $\Delta m^2$ for neutrinos with $\Delta m^2$ for antineutrinos**




**Sensitivity to matter effects on the 3% level**

**For $\Delta\mu = P(\nu_\mu) - P(\text{anti-}\nu_\mu)$**

A large iron detector in India as a far-end detector for a neutrino factory

(or)

India-based

Indian Neutrino Observatory (INO) and its role in long-base-line experiments

(Talk at NuFact 03, New York, June 2003)

G. Rajasekaran
Institute of Mathematical Sciences,
Chennai (Madras)
India

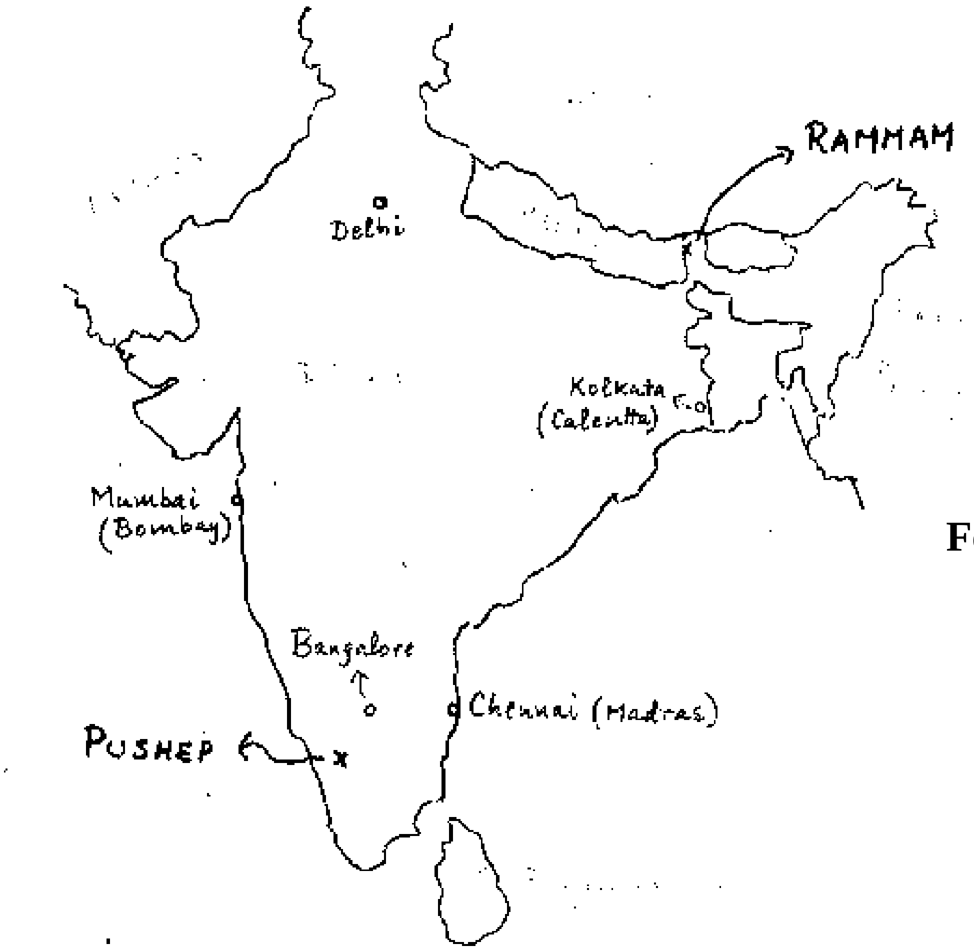
①

**Detector: 30 kt magnetized iron calorimeter**

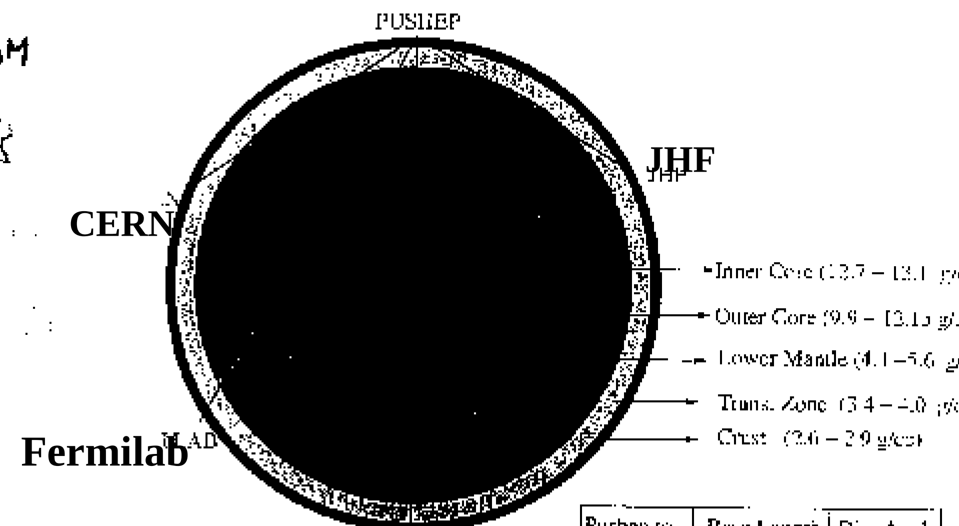
**Phase 1: atmospheric neutrino measurements**

**Phase 2: far detector for a neutrino factory experiment**

(E)




The Ultimate Neutrino Collaboration




| Pushep to | Base Length | Dip Angle |
|---|---|---|
| Fermi Lab | 11300 km | 62 deg |
| CERN | 7145 km | 34 deg |
| JHF | 6595 km | 31 deg |

# ("super-beam") LBL experiments

| | $E_p$ (GeV) | Power (MW) | Beam | $\langle E_\nu \rangle$ (GeV) | $L$ (km) | $M_{det}$ (kt) | $\nu_\mu$CC (/yr) | $\nu_e$ @peak |
|---|---|---|---|---|---|---|---|---|
| K2K | 12 | 0.005 | WB | 1.3 | 250 | 22.5 | ~50 | ~1% |
| MINOS(LE) | 120 | 0.41 | WB | 3.5 | 730 | 5.4 | ~2,500 | 1.2% |
| CNGS | 400 | 0.3 | WB | 18 | 732 | ~2 | ~5,000 | 0.8% |
| JHF-SK | 50 | 0.75 | OA | 0.7 | 295 | 22.5 | ~3,000 | 0.2% |
| JHF-HK | 50 | 4 | OA | 0.7 | 295 | 1,000 | ~600,000 | 0.2% |
| OA-NuMI | 120 | 0.4 | OA | ~2 | 730? | 50kt? | ~2,500? | 0.5% |
| OA-NuMI2 | 120 | 1.2 | OA | ~2 | 730? | 20kt? | ~4,000? | 0.5% |
| AGS→?? | 28 | 1.3 | WB/OA | ~1 | 2,500? | 1,000? | ~1,000? | |
| SPL-Furejus | 2.2 | 4 | WB | 0.26 | 130 | 40(400) | 650(0) | 0.4% |
| OA-CNGS | 400 | 0.3 | OA | 0.8 | ~1200 | 1,000? | ~400 | 0.2% |

T. Kobayashi, NuFact 02 (with modification for OA-NuMI)

# Future Experiments: Summary

- CNGS: First beam May 2006
- OPERA: Preparing for Day 1
- ICARUS: T600 installation in Gran Sasso 2003 - 2004
- JHF: Ready to start construction in 2004
- NuMI off-axis: Detector choice advanced,
  Proposal November 2003
- BNL/Homestake: Realistic BG estimate suggested
- IHEP, INO detectors: New comers welcome,
  Realistic sensitivity studies encouraged