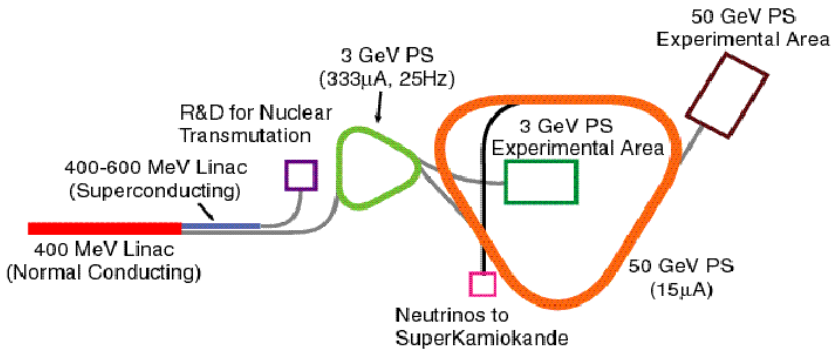
Fermilab – Beijing
Long Baseline Neutrino Oscillation Experiment

- The Institute for High Energy Physics (IHEP) in Beijing is the major HEP laboratory in China. It is the site of the Beijing Electron-Positron Collider (BEPC) for J/Ψ experiments.
- In the IHEP's 5-10 year's plan, one project is to build a large underground detector for neutrino experiments.
- Prof. Chen, Director of the IHEP and Prof. Totsuka, Director of the KEK, had a meeting discussing the collaboration of a long baseline neutrino oscillation experiment between J-PARC/Tokai and Beijing (~2000 km).
- At an ICFA meeting last February in Paris, Prof. Chen expressed interest in a similar experiment but at a much large distance between the Proton Driver at Fermilab and Beijing (~9400 km).
- It is planned to have video-conferences between the two labs.
- There will be further discussion at the next ICFA meeting in August in Beijing.

Japan: K2K and J2K



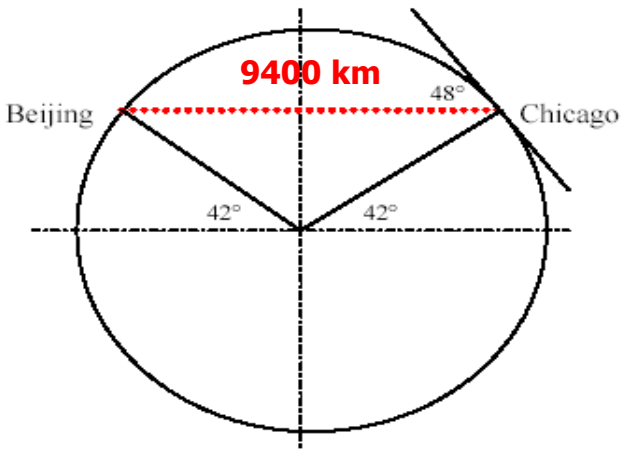
- **KEK: 12 GeV PS protons → ν to Kamiokande**
- **J-PARC: 50 GeV protons (0.75 MW) → ν to Kamiokande**

Tokai – Beijing Long Baseline

Fermilab – Beijing Long Baseline

Fermilab Proton Driver: 120 GeV protons (2 MW) → ν to Beijing

	Latitude	Longitude
Chicago	41:50:13 N	87:41:06 W
Beijing	39:55:00 N	116:23:00 E
Tokyo	35:41:00 N	139:44:00 E



Issues

- Is the physics case strong? (*Para*)
- Is the tunneling feasible and affordable? (*Bogert and Laughton*)
- Assuming two neutrino beams to the detector – one from J-PARC, another from Fermilab – how would it enhance the physics?
- Is there any physics other than HEP? Any application other than physics? (e.g., earth science, mine/oil exploration using neutrino beams)

Adam Para's Talking Points

Physics motivation:

Disappearance: at such a long distance the first minimum occurs at 17 GeV. High energy NuMI beam is the preferred choice. Good, as the event rates are a lot higher. Energy resolution is good, can get very precise mass determination. Oscillation pattern will be very spectacular, second minimum at 5.5 GeV should be clearly visible.

Appearance: higher energy: higher rates. Tau appearance may be an achievable experiment. Kinematics the same as Gran Sasso, but the oscillation probability is one and not a very tiny number. Nue appearance may be harder, as the tau to e background may be prohibitive if the angle theta13 not very large (worth checking).

Relatively high energy - energy resolution should be quite good compared to the size of the oscillation features.

Comparison of nue appearance on JHF baseline and Fermilab baseline may be a source of important physics info (CP vs matter effects).

Adam Para's Talking Points (cont…)

Detector issues:

Underground or above the ground? Backgrounds are small for JHF baseline, no cosmic ray backgrounds at the energies of the Fermilab beam. Choose the most convenient location.

JHF baseline calls for several GeV energy, NuMI much higher. Events mostly inelastic, with fairly complicated final states. Probably too complicated for water Cerenkov even for JHF, certainly water Cerenkov is not a good detector for NuMI. Very fine grained calorimeter might do for electrons. Certainly not for taus.

Very likely a liquid argon TPC is an optimal detector: have a shot at taus using kinematical approach as ICARUS. Underground location would help to broaden the physics reach by having a better proton decay capability.

Liquid argon is quite a mature technology, but little expertise exists outside the ICARUS group. I am about to propose an vigorous R&D effort towards a NuMI off-axis experiment. Large detectors will share all the technological problems irrespective of the location: common R&D can help very much. I would be delighted if our Chinese colleagues would be interested in joining the letter of intent.

Fritz DeJongh's Comments

The key to this baseline is the possibility of getting a very strong matter effect at a particular energy. The matter effect can give a factor of ~20 amplification in the electron appearance signal.

1) This makes up for the reduced flux from the very long baseline.

2) You basically want one beam energy, perhaps allowing ±10% energy variation for systematic studies.

3) You might not need a near detector, you might be able to calibrate from the muon appearance events in the far detector.

4) The determination of sign of dm**2 becomes unambiguous (arguably a more interesting measurement than the value of delta).

5) S/N is better than for other conventional beam experiments thanks to the matter amplification.

6) The signal does have different dependence on parameters than shorter baseline experiments, so combining results does help extract the theory parameters.

7) The motivation for this experiment is strongest if θ_{13} is small enough to be out of reach or marginal for Nova. (And you're not yet ready to build a neutrino factory).

Dixon Bogert's Questionnaire

1) What neutrino energy(s) should the beam provide? (In asking this question I am asking in comparison to the "low" – "medium" – "high" energy options provided in the NuMI neutrino production for the Soudan MINOS experiment.)
2) It is possible that shielding requirements might be reduced if production originated from a lower energy proton beam. Should this be a serious consideration?
3) The flux at Beijing will be reduced in comparison to that at Soudan for MINOS proportional to the square of the relative distances. What event rate is required by the experimentation in Beijing, and what fraction of the offset in the loss of flux to geometry is recovered by: A) Increase in proton intensity on the target? B) Increased efficiency of production (i.e. more horn, Hadron Hose, whatever)? And C) Increase in detector mass?
4) What power is the target going to receive? #Protons on Target? Rep rate? Single turn extraction?
5) Is a near detector required?

Dixon Bogert's Questionnaire (cont…)

6) Must the neutrino energy be variable?

7) Must the targeting geometry be variable? Narrow band beam? Off axis production?

8) Length of decay pipe?

9) Diameter of decay pipe?

10) Muon monitors?

11) Access to Absorber, near detector, etc.

12) Access to target hall/service and reconfiguration of production geometry?

13) Is simultaneous operation of NuMI and Beijing envisioned?

14) May I have some money for some drafting sketches in FESS and for consultation with Chris Laughton, etc.?

15) May I have access to some help from Beam line designers?