Large Detector and Long Baseline Summary

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Brookhaven National Lab. 1/5/2004

Speakers

- Mu Chun Chen Theory
- Kate Scholberg Super Scintillation detector
- Dave Cline Liquid Argon TPC
- Masafumi Koike Beam to Kimballton
- Chiaki Yanagisawa Detector Simulation/ backgrounds

Predictions for neutrino masses and mixing

Mu chun SUSY SO(10) model

- Input parameters:

$$\Delta m^2_{atm} = 2.33 \times 10^{-3} eV^2 \quad , \quad \Delta m^2_{sun} = 8.14 \times 10^{-5} eV^2$$

- Predictions: **Agree with all exp. data within 1σ !!**

$$m_{\nu_1} = 0.00262\ eV$$
$$m_{\nu_2} = 0.00939\ eV$$
$$m_{\nu_3} = 0.0492\ eV$$

Hierarchical mass spectrum

$$\sin^2 2\vartheta_{atm} = 1.00$$
$$\tan^2 2\vartheta_{sun} = 0.36$$
$$\sin\vartheta_{rea} = 0.116$$

Predicted value in an interesting range

- will be probed by next generation experiments
- leptonic Dirac CP violating phase measurable

Also able to predict CP and Majorana phase. Perhaps a hint of broader approached to BAU

	Water	L Ar	Scintillator
Proton decay	Yes, must be large	Yes	Yes
Atmospheric	Yes	Yes	Yes (TBD)
Solar	Yes, high threshold	Yes (?)	Yes
Geoneutrinos	No	No	Yes
SN neutrinos	Yes	Yes	Yes
Relic SN nus	No (some)	No(?)	Yes
Long baseline	Yes	Yes	Yes (TBD)
Scaling up	Known	Less known	Known

Kate Scholberg.

Scintillation counters have some advantages.

Cost per ton is a disavantage.

How about imaging detectors for scintillation ?

Many technical problems on LAR solved. 300 ton module in LNGS. Needs work on advocacy for 100kT

Requirements for the LANNDD Detector at DUSEL

David Cline and Franco Sergiampietri
UCLA / PISA

DUSEL STUDY INPUT TO LARGE MODULE GROUPS

Information sent to Homestake WIPP, Teide Crash .... for S2 proposals

- Depth - 2000 MWE or greater
- Total active volume: 50'000 m3
- Total active mass: 69.5 kTon
- Active volume height: 40.5 m
- Active volume diameter: 40.5 m
- Max drift: 5.1 m
- Fiducial volume: 41.4 m3
- Number of channels: 196'000
- Total LAr volume: 60'000 m3
- Total LAr surface: 17'100 m2
- Heat input by radiation (double wall cryostat, vacuum insulated, 40 superinsulation layers -> 0.5 W/m2): 5.1 kW
- Heat input by conduction (cables, mechanical supports): 25 kW
- Total LN2 consumption: 9.2 m3 (liquid)/day.
- Electronics on the detector (about 680 crates for analog and digital processing electronics): ~250 KW
- Counting room + remote electronics + UPS's + air conditioning: ~40 KW
- Pumping system for the insulation vacuum: ~50 KW
- LAr/GAr purification and circulation: ~20 KW
- Underground hall ventilation/air conditioning: ~40 KW
- Underground mechanical workshop and crane: ~30 KW
- Air intake/Ar exhaust fans: ~20 KW

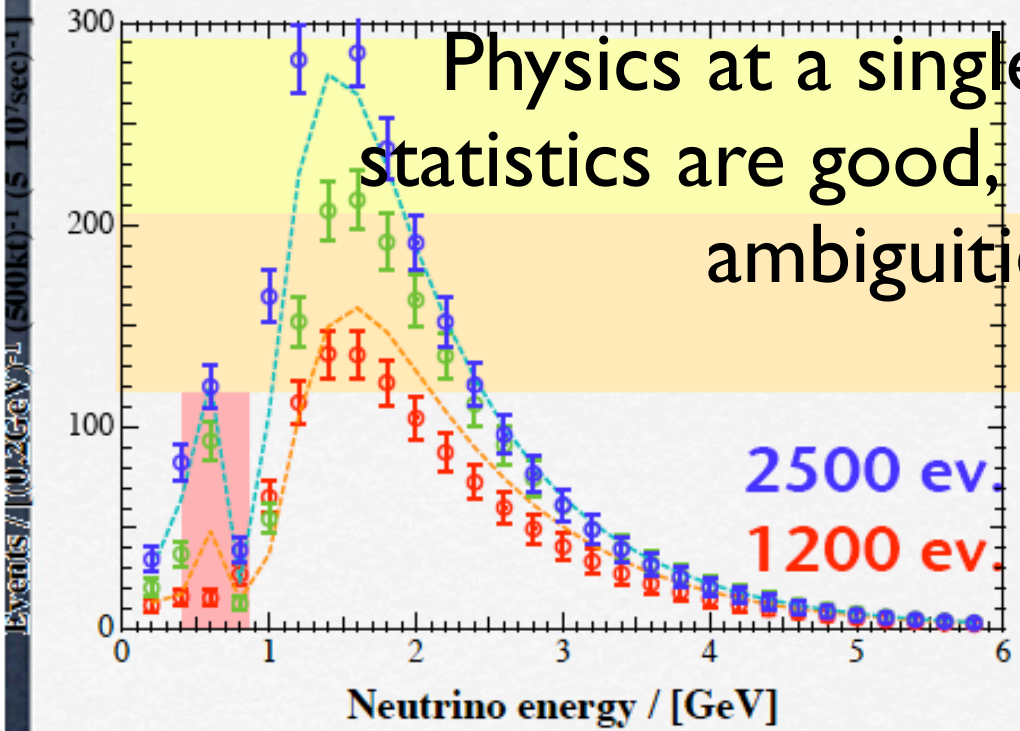
LAR TPC is in principle the ideal detector. 100 kT LAR is equivalent to ~300 kT water Cherenkov for Long Baseline. 10^35 yrs for p-> k nu mode. Needs to have a place in DUSEL.

ν_e appearance

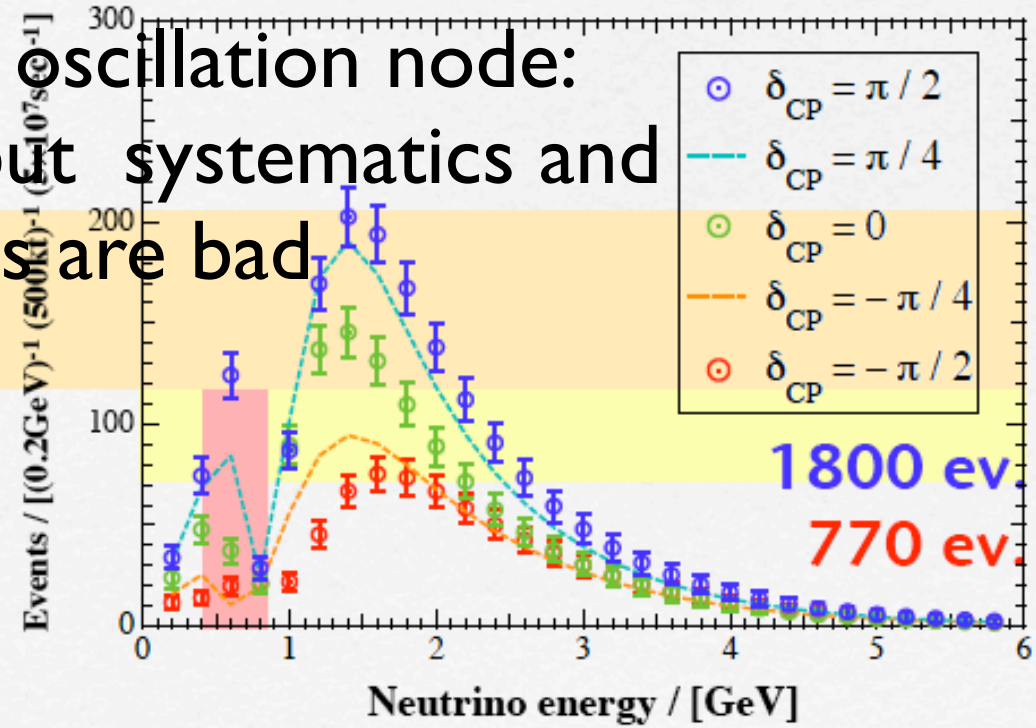
Masafume Koike

770km Baseline

Normal hierarchy



Inverted hierarchy



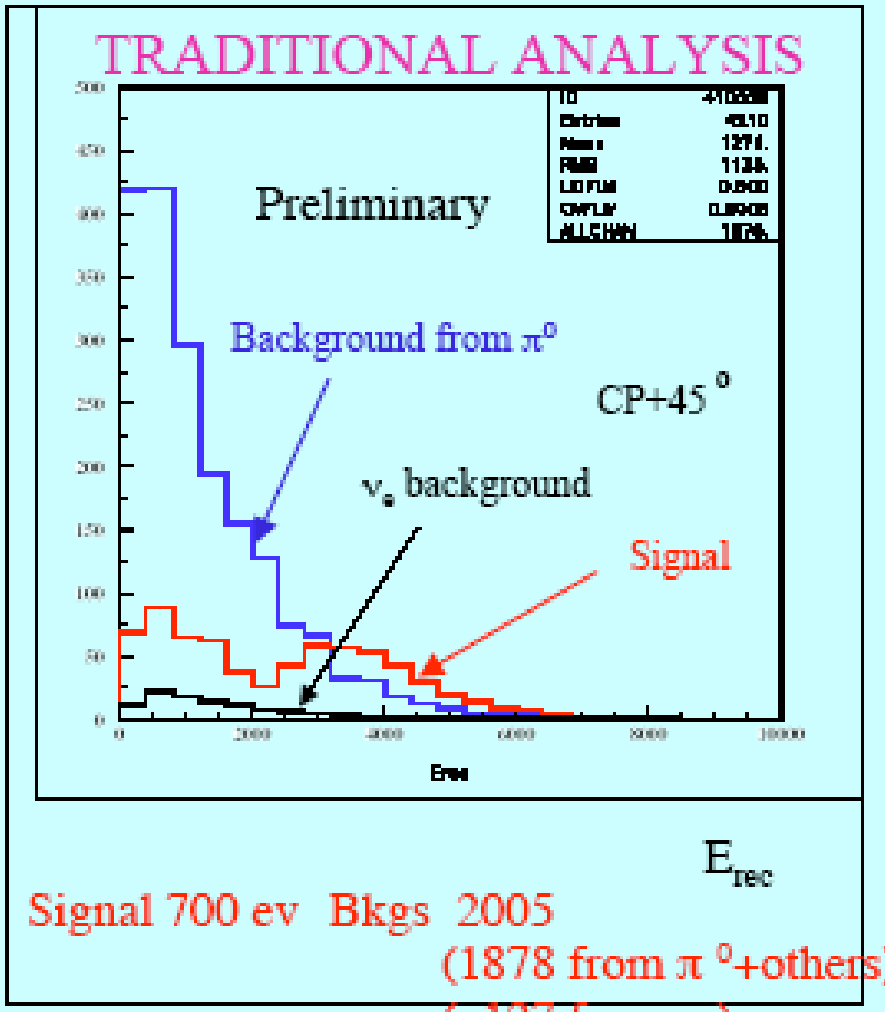
Physics at a single oscillation node: statistics are good, but systematics and ambiguities are bad

Signal/Background

ν_e CC for signal ; all $\nu_{\mu,\tau,e}$ NC , ν_e beam for bkg

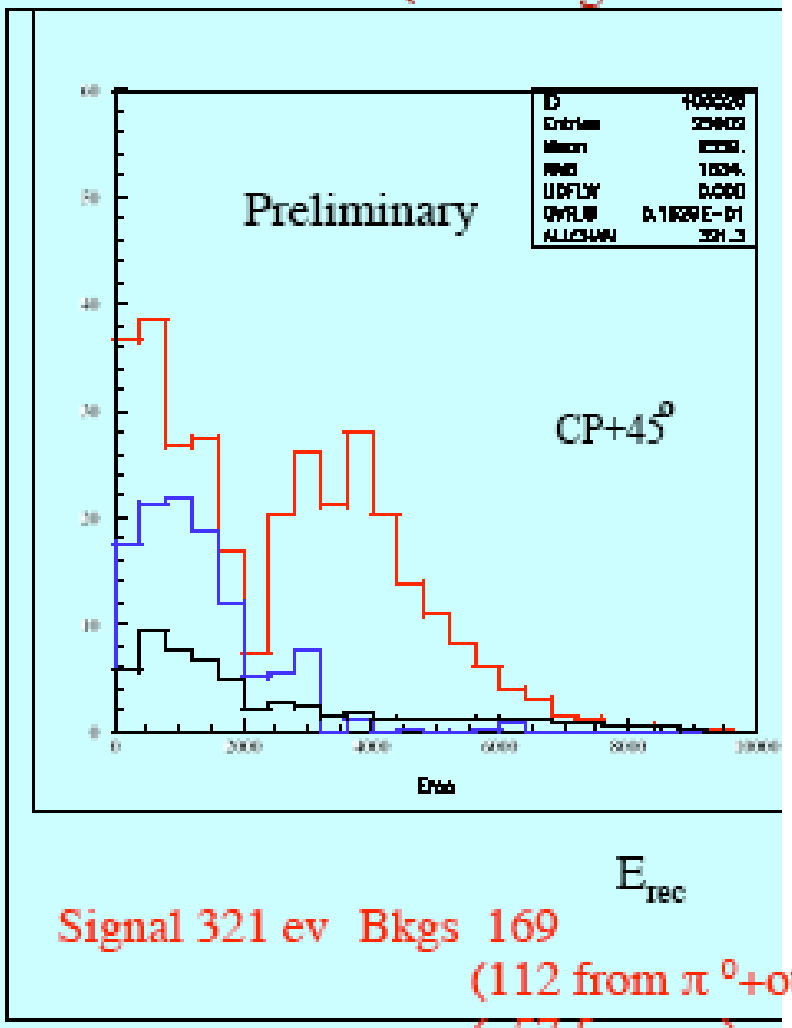
Effect of cut on Δ likelihood

Δlikelihood cut (100% signal retained)



Signal 700 ev Bkgs 2005
(1878 from π ⁰+others)
(127 from ν_e)

Δlikelihood cut (~50% signal retained)



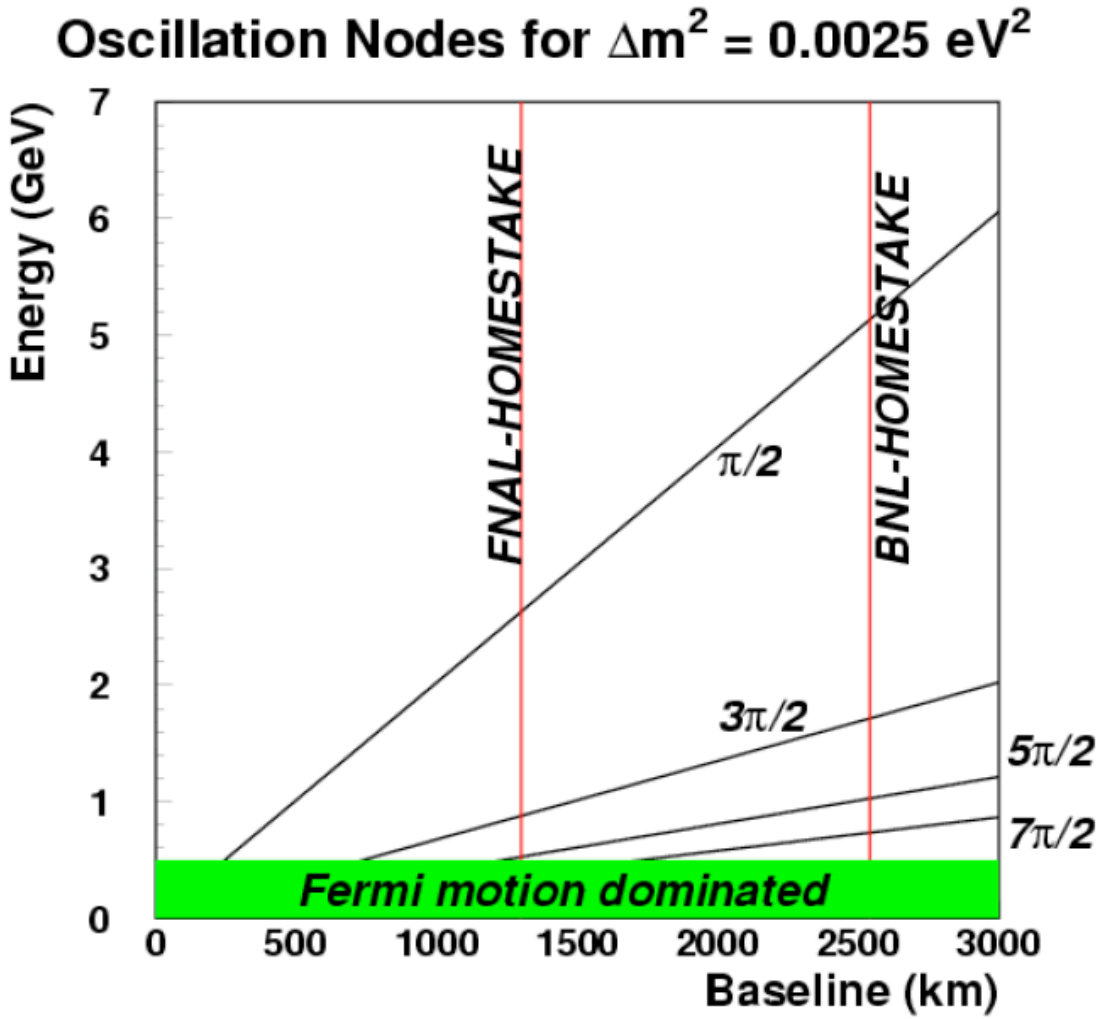
Signal 321 ev Bkgs 169
(112 from π ⁰+others)
(57 from ν_e)

Chiaki Yanagiswa: key technical progress on large detector and long baseline. Has managed to reduce background to acceptable level.

Big Issues

- Technical: Length of the baseline and the type of beam. Depth of the detector.
- Size of cavern, lifetime, power requirements, etc well known.
- Strategy: Should we include the large detector and the super beam in the first round of projects ?
  - Cost
  - Impact on other projects
  - Impact of NOT having a center piece project

Length of the baseline



Issues

Quality of signal: oscillations in spectrum

Separation of various effects to allow extraction of CP violation

Technical feasibility: beam power (MW), running time, etc

Depth of the detector

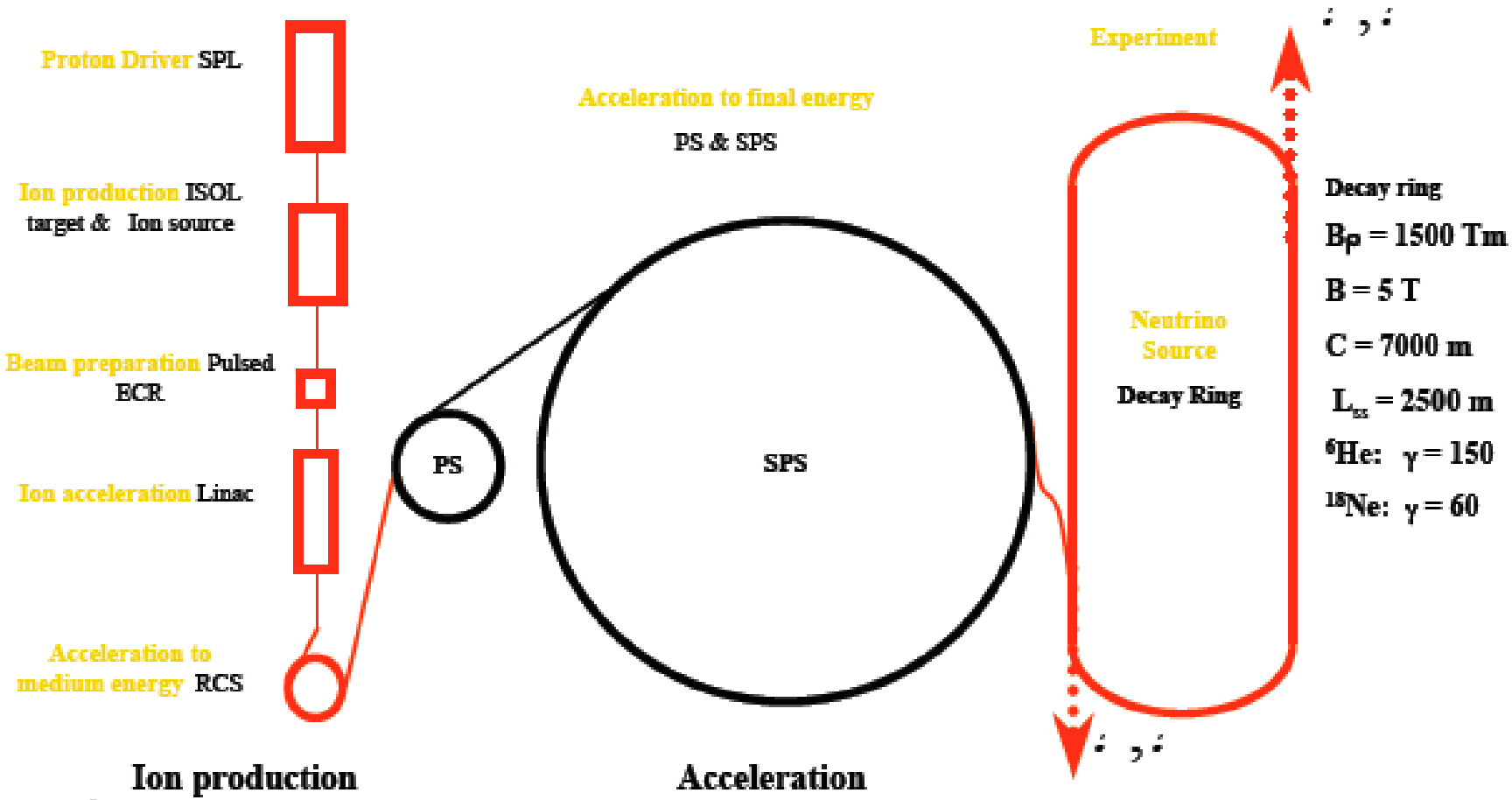
	Muons	Neutrons
Raw rate kHz	81.7	2.7
Reduction factors		
Beam time structure	2.5×10^{-7}	2.5×10^{-7}
Passive/active shielding	10^{-3}	0.18
Energy cuts	0.47	0.26
Vertex and Direction	3.3×10^{-3}	6.2×10^{-2}
Total reduction	3.9×10^{-13}	7.2×10^{-10}
Background in 16 months	1.1 events	68 events

Table 4: *Cosmic ray background to quasi-elastic muon neutrino events in each detector tank after 16 months of running. Over 1100 quasi-elastic muon events are expected in D68 over the same period.*

E889 proposal from 1995. For a 5 kT detector.
Multiply by about 200-500 for a much larger detector. Signal level ~ few hundred events. Need ~100 suppression, at least, even for Long baseline.

Discussion session with S. Katsanevas

Beta-beam baseline design



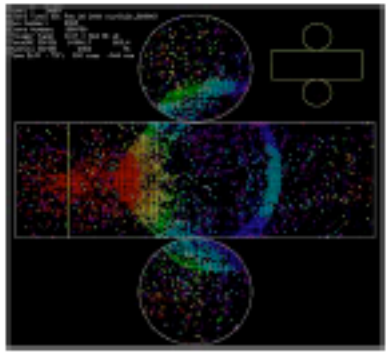
beta beam is pure nu_e or anti-nue, not pulsed like superbeam, is low energy ~200 -1000 MeV, upper range very hard.

betabeam- high energy superbeam

- Advantage of beta beam is purity of nu_e beam. Signal is nu_e -> nu_mu. Does NOT mean no background !
- Low energy beta beam with 130 km baseline will have roughly same number of oscillation events as high energy superbeam with long baseline.
- Low energy beta-beam will have no spectrum information. CP effects will be smaller. Matter effects small.
- Low/medium energy beta beam will require a RHIC size storage ring. Cost and technical risks are higher.
- A medium/higher energy beta beam with longer baseline will most likely be superior to a 1 MW superbeam. But remember that we can always upgrade the superbeam to 4 MW. A high energy beam has a lot of flexibility in long run.

Strategy Issues for big detector and superbeam

- Construction time ~10 yrs. Running time ~10yrs. Some overlap.
- Cost: $400 M for beam, $500M for detector.
- If built well physics impact is huge and broad.
- "Physics of the Universe" report has already given a policy decision that this is considered a key project ready to go.
- Broader HEP community involvement. Is there a problem ? Is it a question of resources: intellectual and $$.



Workshop registration

Faculty Center

UCLA Guest House

Off-campus accommodations

Campus parking

UCLA maps

More information

3rd BNL/UCLA Workshop on Multipurpose Detectors for Proton Decay and VLBL Neutrino Physics

February 28 and March 1, 2005
Faculty Center, University of California, Los Angeles

Preliminary Topics

- Latest on Proton Decay Theory
- Latest on Neutrino OSC/CP Theory
- Supernova Physics
- VLBL Neutrino Beams and Proton Driver Upgrade
- Concepts (BNL, FNAL, Other)
- T2K Expectations
- Water Detectors (SK Experiment, Hyper K Prospects, Very Large Water Detectors, UNO etc.
- Liquid Argon Detectors (Very Large Liquid Argon Detector, LAR Experience)
- Liquid Scintillator Detectors (KamLAND Experience,
Very Large Scintillator Detector)
- Discussion on R&D, Proposals for design studies, relation to DUSEL, etc.

Organizing Committee

David B. Cline (UCLA) co-chair, Barry Barish (Caltech), Jordan Goodman (UMD),
Vernon Barger (U. Wisc.), E.W. Beier (UPENN),
Hitoshi Murayama (UC Berkeley), Hank Sobel (UCI),
Nicholas Samios (BNL) co-chair.