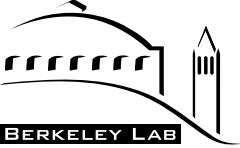


# Neutrino Factory and Beta Beam *R&D Tasks: Choices and Priorities*

## ~~U.S.~~ *My Perspectives*

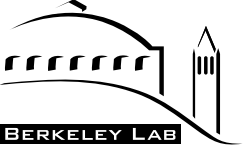
Michael S. Zisman  
Center for Beam Physics  
Lawrence Berkeley National Laboratory

BENE Meeting-DESY  
November 3, 2004



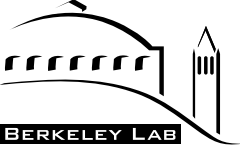
# Introduction

- After completion of the 20-year roadmap it became apparent that the U.S. neutrino physics community did not have a well-articulated roadmap for its scientific program
- A reason for this is that neutrino science intrinsically involves several disciplines
  - particle physics
  - astrophysics
  - nuclear physics
  - and even accelerator physics
- APS Study was launched to permit neutrino scientists to present their view to the funding agencies and politicians



# APS Neutrino Study

- “Year-long” study organized by four APS Divisions
  - DPF, DAP, DNP, DPB
  - Co-chairs: Boris Kayser (FNAL); Stuart Freedman (LBNL)
- Started in December, 2003
  - with two week's notice
- Ended in June, 2004
  - reports of working groups are done
  - summary report is nearly done
    - draft version has been distributed to working groups
    - DOE/NSF briefing took place October 25



# U.S. Neutrino Program

- U.S. (Fermilab) presently has strong accelerator-based neutrino program
  - MiniBooNE: LSND oscillation test
  - MINOS: Long baseline, atmospheric neutrino scale
  - MIPP: Particle production, neutrino beam systematics
  - Minerva: neutrino cross sections
- Also accelerator R&D effort by U.S. Neutrino Factory and Muon Collider Collaboration
  - no program of beta beam R&D in the U.S.
- Proposed long baseline experiments
  - Nova (Fermilab)
  - Wideband on-axis (BNL)

# Proton Driver

- Consensus in U.S. is that we will need a MW-class proton driver to make progress
  - independent of value of  $\theta_{13}$
- At Fermilab, management exploring possibility of 2 MW proton driver (and associated neutrino physics program)
  - aim is to get “CD-0” (mission need approval) from DOE
- BNL has produced White Paper proposing upgrade of AGS along with long baseline experiment to 0.5-Mton water Cherenkov detector

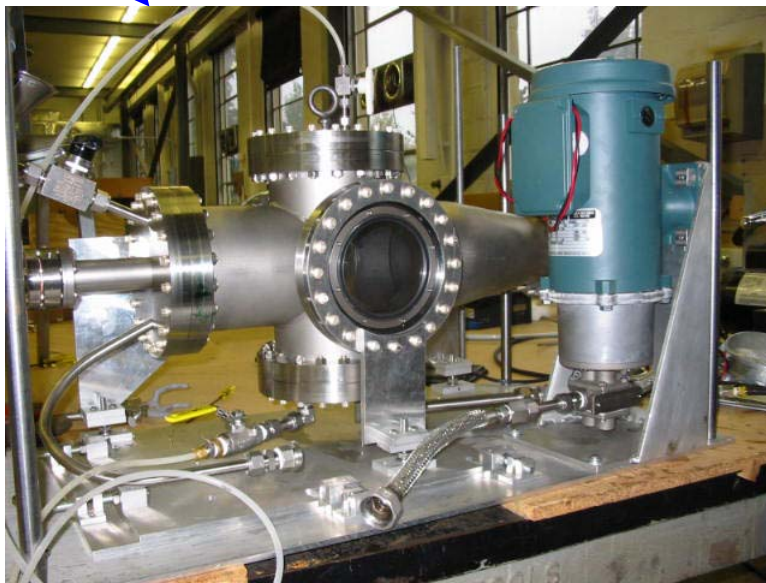
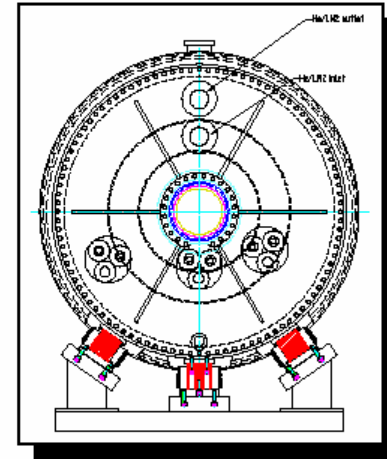
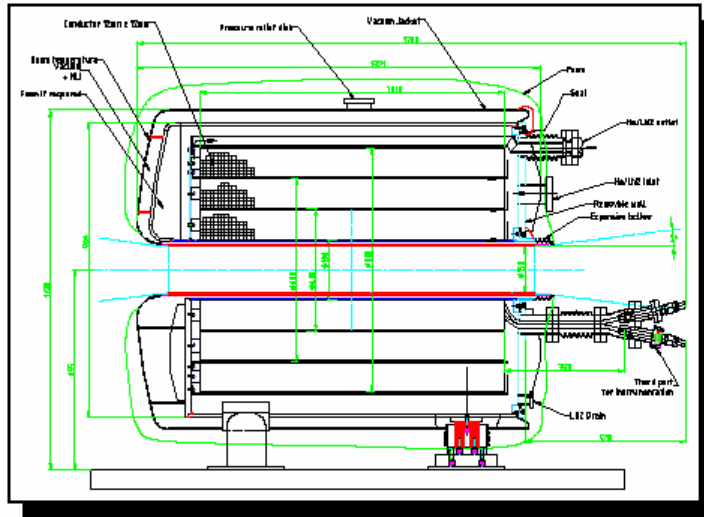
# Neutrino Factory

- **General view:** Neutrino Factory provides best tool for exploring  $\sin^2(2\theta_{13})$  down to  $\mathcal{O}(10^{-4})$
- **R&D program in support of Neutrino Factory is very challenging**
  - we **must** work on it vigorously now if a Neutrino Factory is to be a future option for HEP
    - funding support is key to continued progress
- **R&D effort has been very successful to date**
  - Feasibility Studies
  - Targetry experiment
  - MUCOOL program (high-gradient RF, LH<sub>2</sub> absorbers)

# Targetry R&D

Targetry magnet

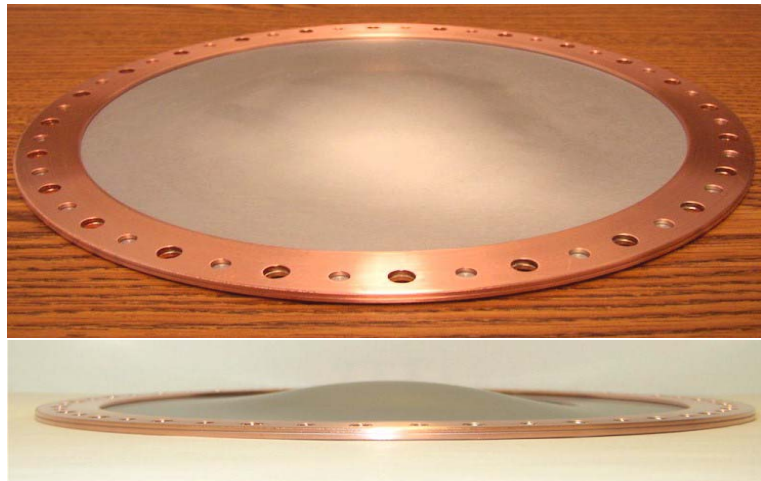
Hg jet test



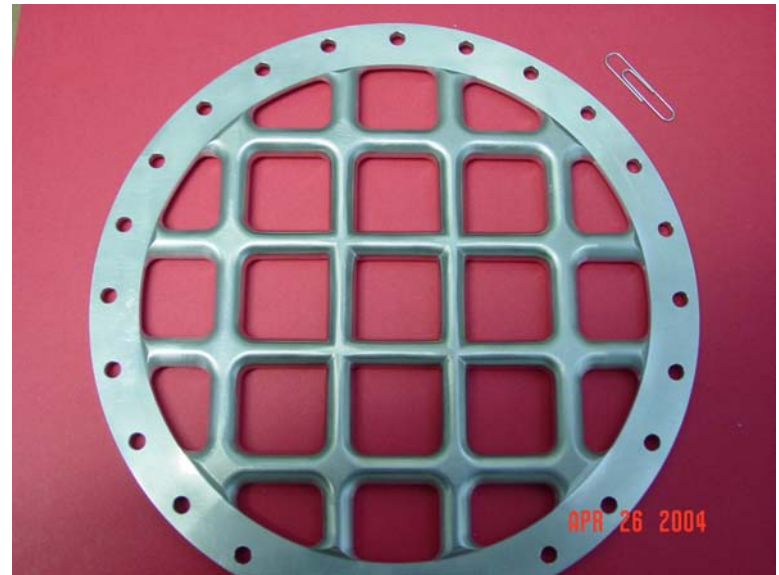


# RF Cavity R&D - II

- Cavity apertures terminated with pre-curved (TiN-coated) Be windows or Al grids
  - test windows and grids for 805 MHz cavity have been successfully fabricated
    - tests planned for MTA this fall



Fabricated pre-curved Be window:  
16-cm in diameter and 0.254 mm thick



# Absorber R&D - I

- Absorber body has been completed at KEK
  - fill-tested in MTA with  $\text{LH}_2$  in July

MICE absorber body



KEK test cryostat at MTA



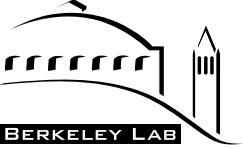
# Cost Savings

- Perceived drawback of Neutrino Factory is high estimated cost
  - these are hardware-only costs (no ED&I, burden, escalation, contingency)
- We have made good progress in reducing costs, while maintaining performance, in “FS2a”
  - we have done well with the major cost items, but savings on the lesser items are not yet exploited

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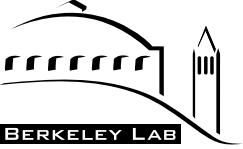
	All	No PD	No PD & Tgt.
	(\$M)	(\$M)	(\$M)
FS2	1832	1641	1538
FS2a-scaled (%)	67	63	60

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# Required R&D Program - NF

- **MICE** (Muon Ionization Cooling Experiment)
  - demonstrate operation of realistic section of cooling channel
    - experiment has scientific approval from RAL
      - about half of the funding is in hand
- **Targetry experiment**
  - beam test of Hg jet in 15-T magnetic field at CERN
- **Acceleration**
  - develop high-gradient SC RF cavity
  - build electron model of FFAG
- **Feasibility Study**
  - carry out "world" design study of **cost-optimized NF** design
  - establish its cost



# Required R&D Program - BB

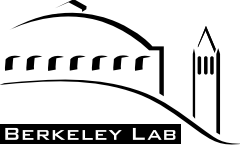
- **Isotope production**
  - merging of beams from multiple targets
- **Target design**
  - limitation on intensity (<100 kW)
- **Bunching of ion beam**
  - high frequency ECR source
- **Bunch merging at high intensity in decay ring**
  - concept looks reasonable
- **Design of SC dipoles**
  - need radiation hard design for decay ring
  - may need ramped magnets if upgrade PS or SPS

# Questions - I

- When can we propose/decide on next large facility? How many steps (Superbeam, Mton detector, Beta Beam) before Neutrino Factory?
  - we need to complete the key R&D tasks and do a reasonable cost estimate ( $\pm 50\%$ ) before proposing a new facility
    - I would like to see a cost-optimized “world” feasibility study and detailed physics case for each option before deciding
  - no. of steps should be determined by the science
    - if it is decided that a Neutrino Factory is where we want to go, then the Beta Beam facility is a very expensive detour (in terms of time and money) to follow
    - if a Beta Beam facility performance is “good enough,” and if the potential investment in technology for a muon collider is not compelling, the “distraction” of a Neutrino Factory will slow us down

# Questions -II

- **What are the accelerator R&D requirements?**
  - **First, feasibility studies, with cost estimates, for the desired configuration**
    - site-dependent approaches are okay if they are realistic
    - cost estimates should not take credit for items that must be replaced or rebuilt
  - **Second, component R&D to validate the basic operational parameters**
    - target performance, capture and bunching, acceleration, cooling, critical magnets
  - **Third, systems tests of key subsystems**
    - MICE, Targetry experiment, FFA $G$
    - target, ion source, bunch merging from target and into decay ring



# WG Recommended That

- ongoing **Neutrino Factory R&D** in the US be given continued encouragement and financial support
  - HEPAP suggested \$8M per year; much less being provided
- US funding agencies find a way to support **MICE**, in collaboration with EU and Japanese partners
  - experiment has scientific approval to run at RAL
- support be found to ensure that the **international Targetry R&D experiment** proceeds as planned
  - proposal submitted to CERN, awaiting response
- a **World Design Study**, aimed at solidly establishing the cost of a cost-effective Neutrino Factory, be supported at the same level as FS1 and FS2
  - planning for this is already under way
- progress on **Beta Beam development** be monitored, and that US colleagues cooperate fully with EU counterparts in assessing how US facilities might play a role in such a program
  - no significant US R&D effort due to limited resources

# Summary

- **Proton driver** (MW-class) is important first step toward NF
  - not critical for BB facility
- **Adequately-funded accelerator R&D program** crucial to eventual success in creating such a facility
- One issue: U.S. community is not yet **unequivocally** convinced NF or BB facility is needed
  - facilities still viewed by many as a back-up option to Superbeams
- We need to make the scientific case stronger
  - cost matters, and efforts to reduce price tag will help