



Neutrino Factory and Muon Collider Collaboration Meeting

Introduction

Fermilab

March, 2007

Alan Bross



Welcome

Collaboration Meeting XII

*Well, we are getting older
But still getting Better*

- It has been a very productive year with a great deal of progress
 - ◆ MuCool (Interesting new results on RF)
 - ◆ MERIT (Successful completion of the experiment!)
 - ◆ MICE (Beam line commissioning has started)
 - ◆ Simulations/Design - International Design Study for a Neutrino Factory has started and work on 1.5-4 TeV MC has accelerated
- The upcoming year is shaping up to be quite exciting
 - ◆ First beam experiment in the MTA
 - ◆ MICE makes first cooling measurement
 - ◆ Neutrino Factory International Design Study
 - ◆ Muon Collider Design Effort



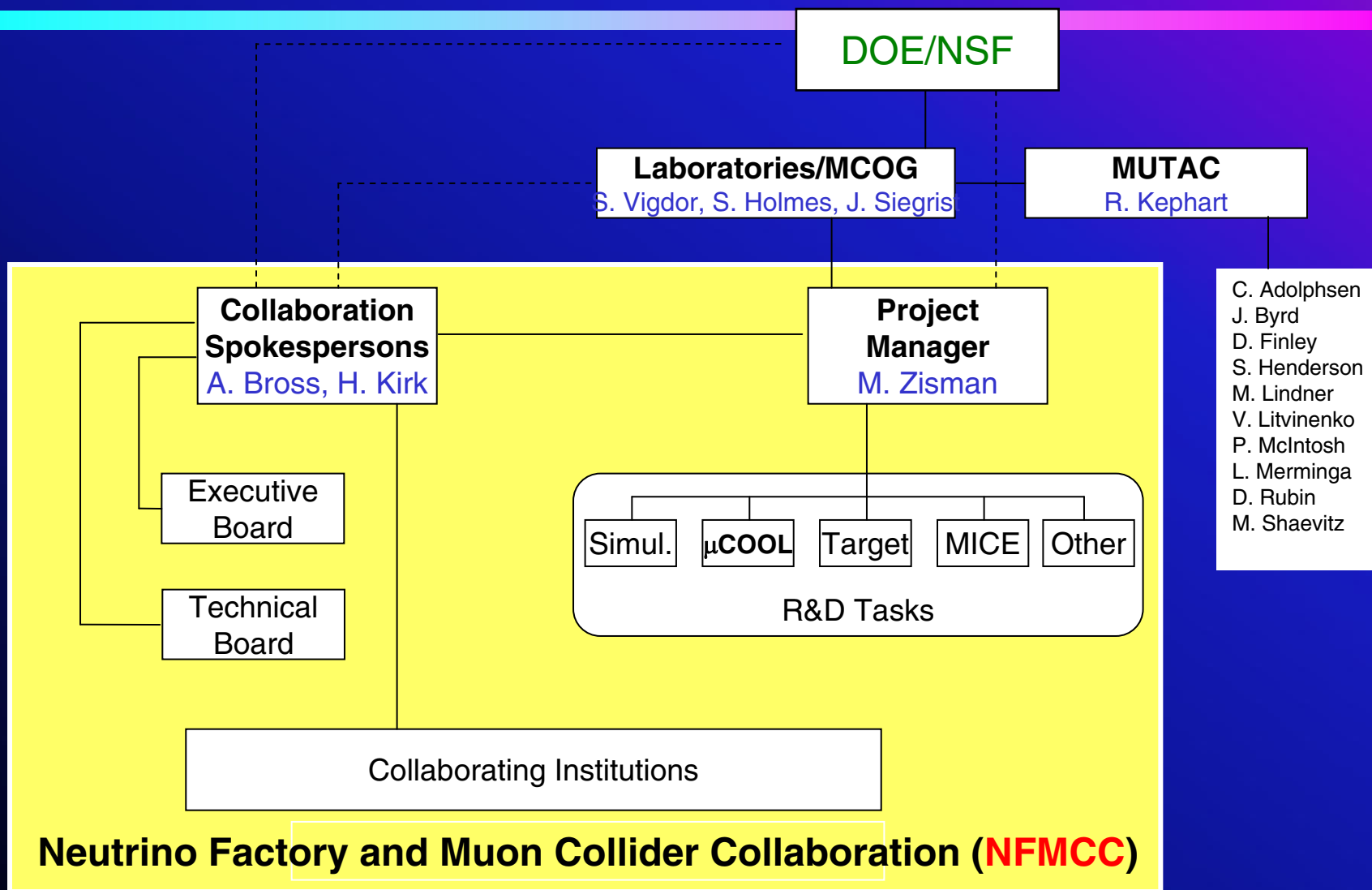
NFMCC Mission

To study and develop the theoretical tools, the software simulation tools, and to carry out R&D on the hardware that is unique to the design of Neutrino Factories and Muon Colliders

- Extensive experimental program to verify the theoretical and simulation predictions



Current Organization





Collaborating Institutions

US

National Labs

ANL
BNL
FNAL
LBNL
ORNL
TJNAF

Universities

Chicago
Cornell
Illinois
IIT
Indiana
Iowa
Michigan State
Mississippi
Northern Illinois
Princeton
UC-Berkeley
UC-Davis
UC-Los Angeles
UC-Riverside
Wisconsin

International

National Labs

Budker
CERN
DESY
INFN
JINR, Dubna
KEK
RAL
TRIUMF

Universities

Karlsruhe
Imperial College
Lancaster
Max Planck
Osaka
Oxford
Pohang
Tel Aviv

Corporate Partners
Muons Inc.
Tech-X Corporation



Executive Board

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Core Program

Targetry R&D: Mercury Intense Target Experiment
MERIT

Co-Spokespersons: Kirk McDonald
Harold Kirk

Ionization Cooling R&D: MuCool and MICE

MuCool Spokesperson: Alan Bross
US MICE Leader: Dan Kaplan

Simulations & Theory

Coordinator: Rick Fernow

Fermilab Muon Collider Task Force



Design Studies

- Muon Collider Design and Simulation work has reached a new level of intensity this year

- ◆ Work in all areas

- ▲ Cooling

- ▲ Acceleration

- ▲ Ring and IR

- ▲ Start on Detector design considerations

The Collaboration's Focus has shifted somewhat to the MC

- Neutrino Factory

- ◆ Start of the International Design Study for a Neutrino Factory

- First International Workshop on NF & MC

- ◆ Synergy between the Physics and R&D programs

- ▲ Hosted by the UK Science and Technology Facilities Council



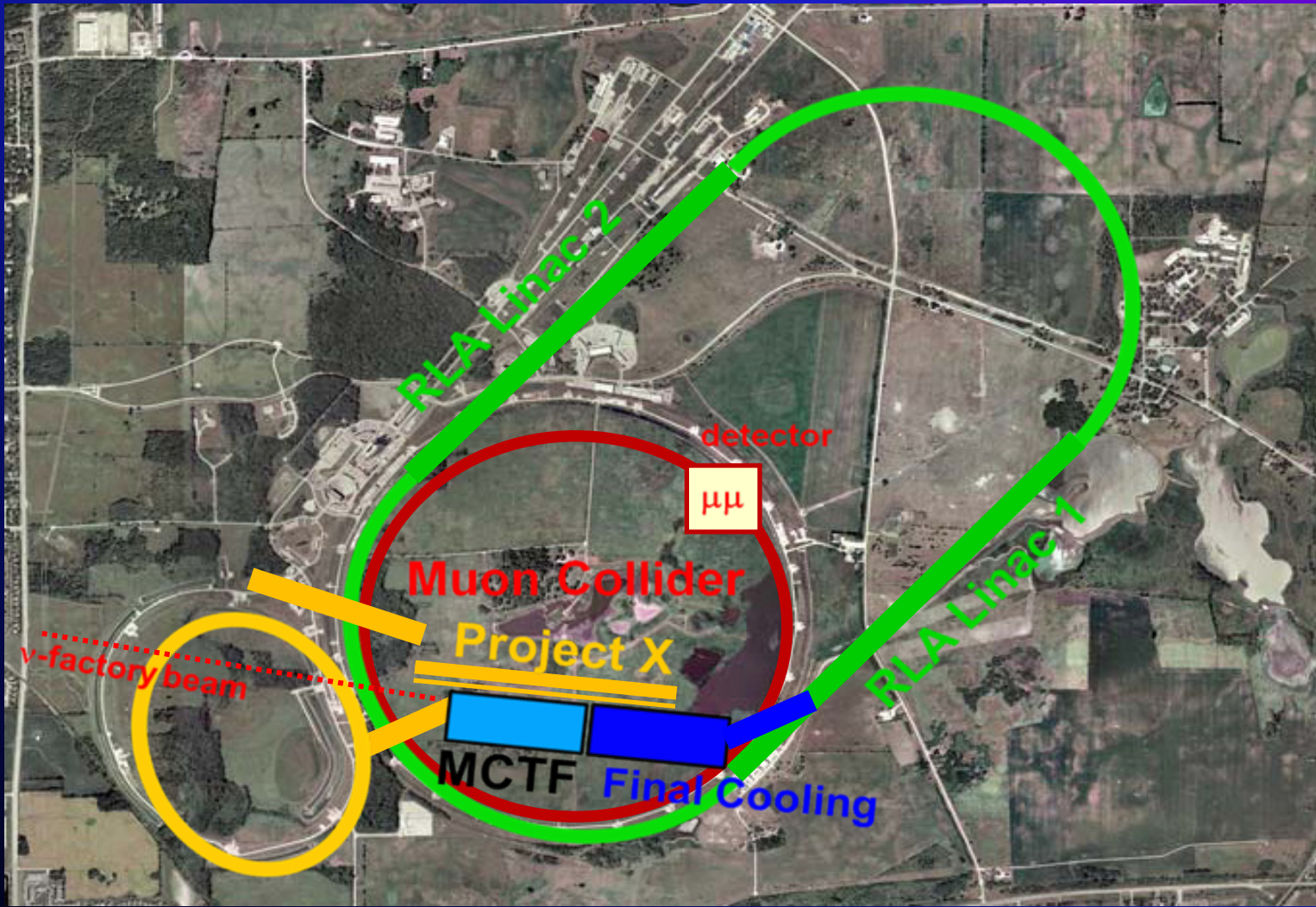
Muon Collider - Motivation

Reach Multi-TeV Lepton-Lepton Collisions
at High Luminosity

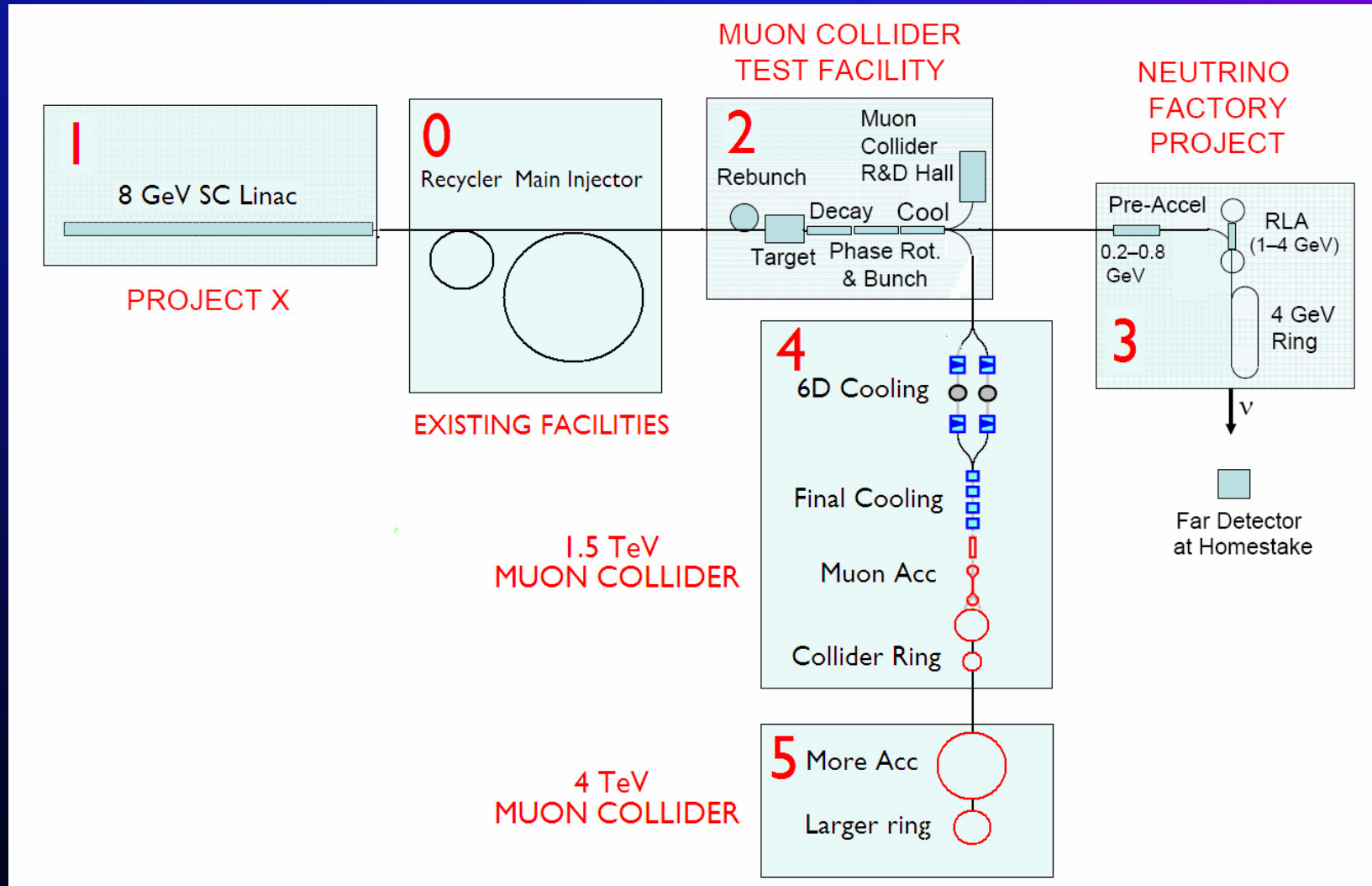
Muon Colliders may have
special role for precision measurements.
Small ΔE beam spread -
Precise energy scans

Small Footprint -
Could Fit on Existing Laboratory Site

Fermilab Muon Complex - Vision



Muon Complex Evolution



Muon Collider

- Exploring 2 approaches

Palmer et al:

RFOFO Ring
Guggenheim
50-60T Solenoid Channel

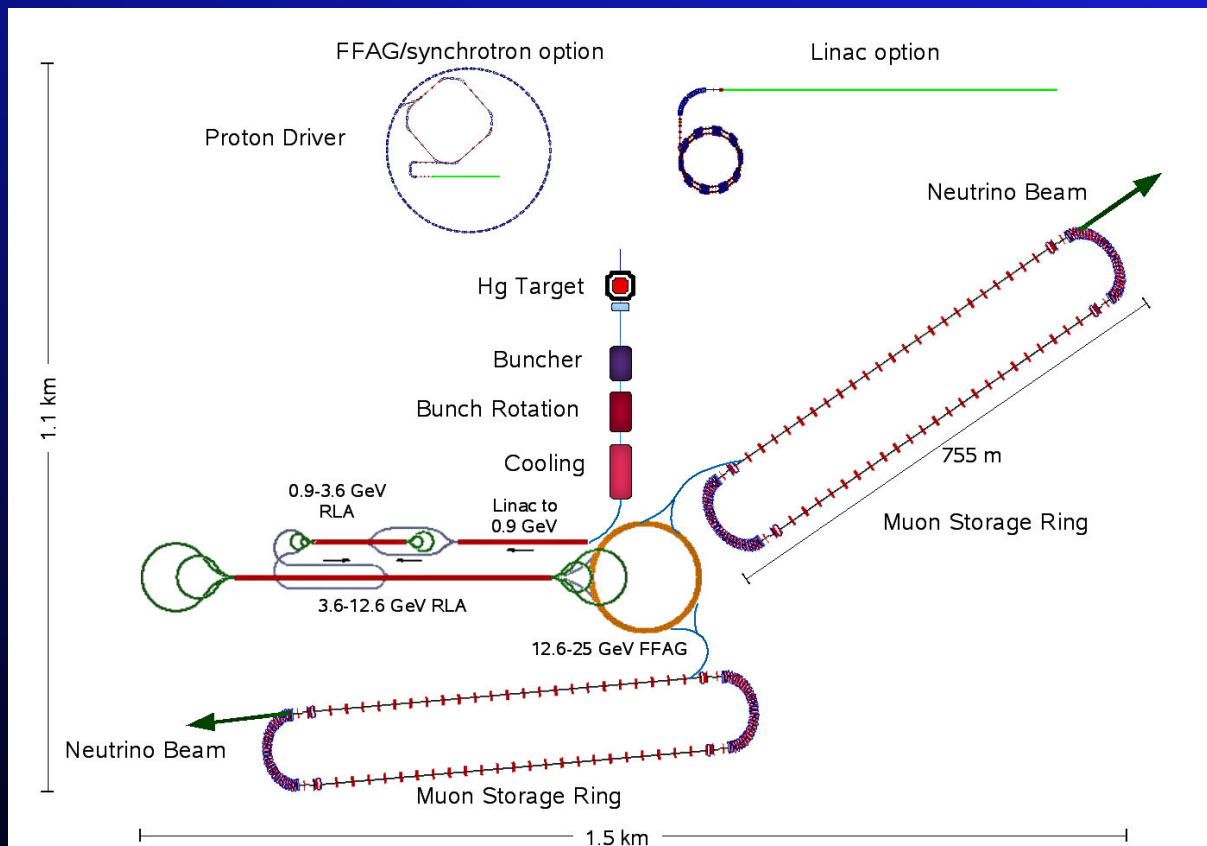
Muons Inc.*

High pressure gas-filled cavities
Helical Cooling Channel
Reverse Emittance Exchange
Parametric Resonance Induced Cooling

- Ingredients needed in Collider cooling scenario include:
 - ◆ Longitudinal cooling by large factors ...
 - ◆ Transverse cooling by very large factors
 - ◆ Final beam compression with reverse emittance exchange
 - ◆ Improvements in bunch manipulations (bunch recombination?)
 - ◆ Reacceleration and bunching from low energy

*Sign up for LE MC Workshop April 21-25: <http://www.muonsinc.com/Lemc2008>

Neutrino Factory - IDS Starting Point



- **Proton Driver**
 - ◆ 4 MW, 2 ns bunch
- **Target, Capture & Phase Rotation**
 - ◆ Hg Jet
 - ◆ 200 MHz train
- **Cooling**
 - ◆ 30 pmm (\perp)
 - ◆ 150 pmm (L)
- **Acceleration**
 - ◆ 103 MeV \rightarrow 25 GeV
- **Storage/Decay ring**



The Neutrino Factory - The first Step in *Muon Complex Vision?*

- Neutrino Physics is at the Forefront of HEP and will remain so for years to come
- The Big Questions:
 - ◆ What is the origin of neutrino mass?
 - ◆ Did neutrinos play a role in forming galaxies?
 - ◆ Did neutrinos play a role in birth of the universe?
 - ◆ Are neutrinos telling us something about unification of matter and/or forces?
 - ◆ Will neutrinos give us more surprises?

Big questions \equiv Hard/Important questions to answer

Is a Neutrino Factory needed in order to answer these questions?



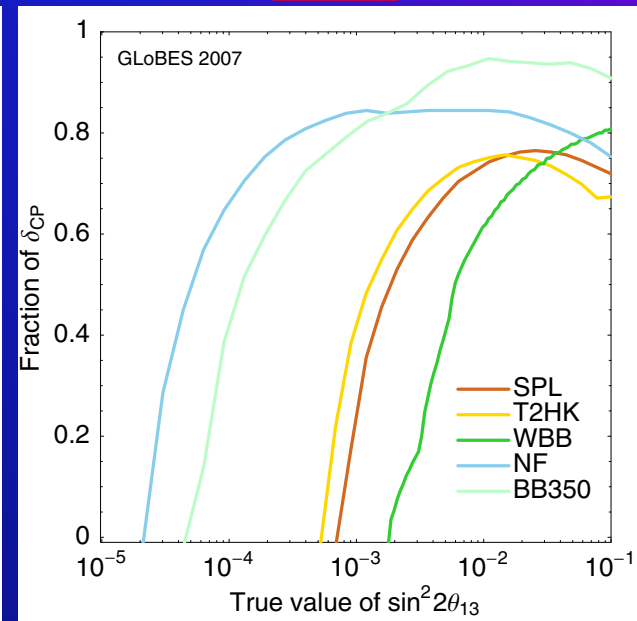
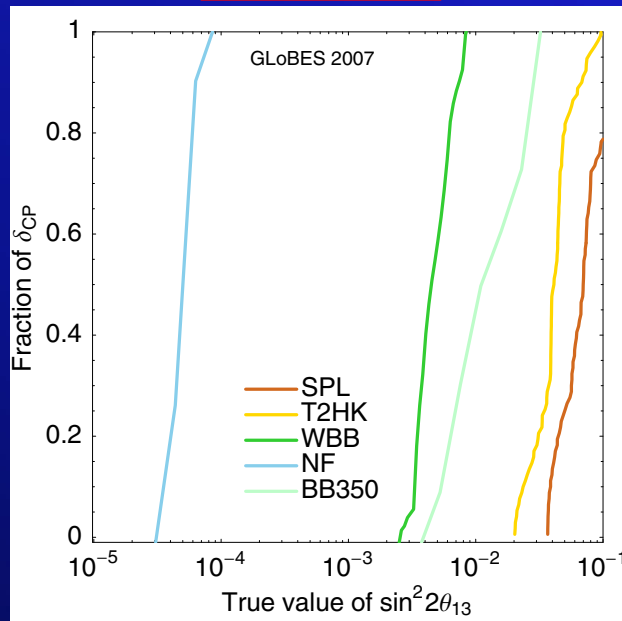
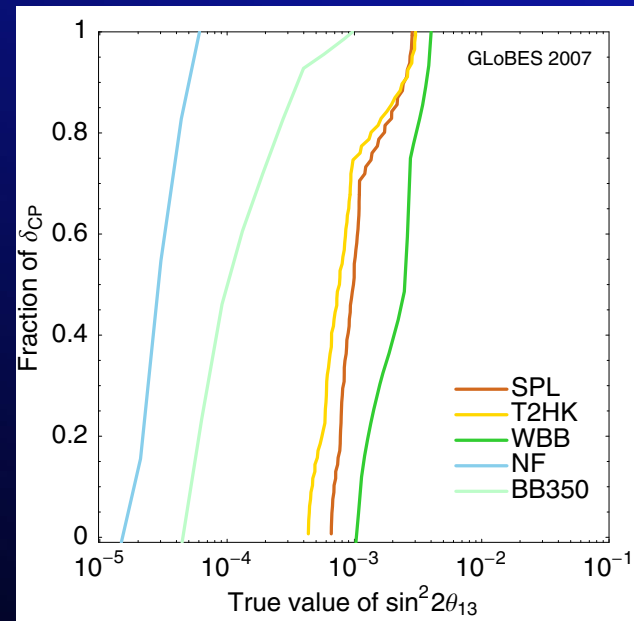
ISS - NF Physics Reach

- What we do know is that the NF gives the best Physics Reach
 - ◆ NF \equiv PRECISION

$\sin^2 2\theta_{13}$

Hierarchy

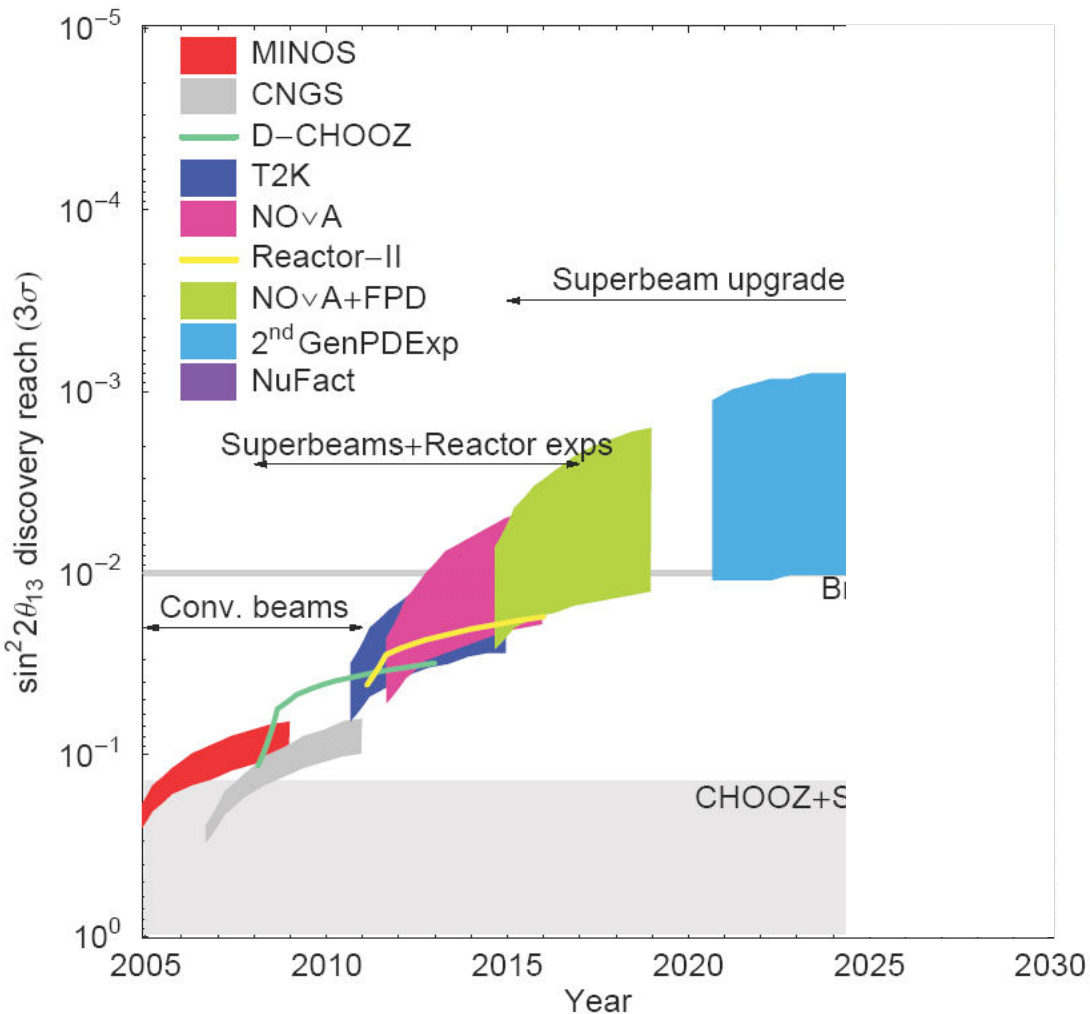
δ_{CP}



SPL: 4MW, 1MT H₂OC, 130 km BL
 T2HK: 4 MW, 1MT H₂OC, 295 km BL
 WBB: 2MW, 1MT H₂OC, 1300 km BL

NF: 4MW, 100KT MIND, 4000 & 7500 BL
 BB350: $\gamma=350$, 1MT H₂OC, 730 km BL

Neutrino Factory - The Physics Case



We Don't Know -
But
 There is a Natural Decision Point
 ≈ 2012

After NOvA and T2K
 If θ_{13} not seen
 or
 seen at 3σ
 Consider New Facility

In order to make an informed
 decision whether or not a NF is
 this new facility -
 Will need a CDR ready at this
 time
 This defines the R&D Program



Conclusions

We Find Ourselves in Interesting Times

- **The Muon Collider as a mid-Term Priority for DOE?**
 - ◆ The MC may be the way towards Lepton-Lepton collisions at the Energy Frontier
 - ◆ Will require increased effort on our part to make the technical case and increased support
 - ▲ Design and Simulation
 - ▲ Experimental verification of the many emerging new ideas
 - ◆ Synergy with the Neutrino Factory remains
 - ▲ Phased Approach to a Muon Complex looks promising
- **Neutrino Factory**
 - ◆ Compelling case for a precision neutrino program remains
 - ▲ With present assumptions Neutrino Factory out-performs other options. However, more is needed before concluding this is the right path
 - What the on-going Neutrino Physics program tells us
 - **Must Remain an Option – IDS delivered CDR by 2012**



Outlook

- As you are all aware, this has been a very tough year and next year looks scary
 - ◆ We still have managed to make good progress, but this situation is certainly limiting what we can do
- There is also a great deal of uncertainty (and opportunity)
 - ◆ P5 Report
 - ◆ HEPAP's Reaction to P5 Report
 - ◆ DOE's Reaction to HEPAP Reaction to P5 Report
- And There will be more reviews
 - ◆ Horizontal AARD DOE review this summer