



# *Neutrino Factory and **M**uon Collider **C**ollaboration*

## *Overview*

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**MC** Spokesperson

DOE/NSF HEPAP Subpanel on Long Range Planning for High Energy Physics  
April 19, 2001



# Agenda

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- Overview (A. M. Sessler, LBNL)
- Physics at a Neutrino Factory (D. Harris, FNAL)
- Feasibility Studies of Neutrino Factories (R. Palmer, BNL)
- Targetry Experiment and Plans (K. McDonald, Princeton)
- MUCOOL Component R&D, Test Facilities, and University Participation (D. Kaplan, IIT)
- Acceleration (H. Padamsee, Cornell)
- R&D Plans (M. Zisman, LBNL)
- Wrap-up (A. M. Sessler, LBNL)



## References



- 1 N. Holtkamp and D. Finley "A Feasibility Study of a Neutrino Source Based on a Muon Storage Ring", (2000), [http://www.fnal.gov/projects/muon\\_collider/nufactory/fermi\\_study\\_after\\_april1st/](http://www.fnal.gov/projects/muon_collider/nufactory/fermi_study_after_april1st/)
- 2 Muon Collaboration Home Page: [http://www.cap.bnl.gov/mumu/mu\\_home\\_page.html](http://www.cap.bnl.gov/mumu/mu_home_page.html)
- 3 A.N. Skrinsky and V.V. Parkhomchuk, Sov. J. of Nuclear Physics 12 , 3 (1981)
- 4 D. Neuffer, Particle Accelerators 14, 75 (1983)
- 5 Charles M. Ankenbrandt *et al.* (Muon Collider Collaboration), Phys.Rev. ST Accel. Beams 2, 081001 (1999) (73 pages),  
<http://publish.aps.org/ejnl/przfetch/abstract/PRZ/V2/E081001/>
- 6 Muon-Muon Collider: A Feasibility Study, BNL-52503, Fermilab Conf-96/092, LBNL-38946 (1996)
- 7 D. Koshkarev, CERN/ ISR-DI/74-62 (1974)
- 8 S. Geer, Phys Rev D 57, 6989 (1998)
- 9 Physics at a Neutrino Factory, Fermilab-FN-692 (2000)  
[http://www.fnal.gov/projects/muon\\_collider/nu/study/study.html](http://www.fnal.gov/projects/muon_collider/nu/study/study.html)



## References



- 10 The Potential for Neutrino Physics at Muon Colliders and Dedicated High Current Muon Storage Rings, Fermilab (in progress)
- 11 MUCOOL Notes, <http://www-mucool.fnal.gov/notes/notes.html>
- 12 MUCOOL home page  
[http://www.fnal.gov/projects/muon\\_collider/cool/cool.html](http://www.fnal.gov/projects/muon_collider/cool/cool.html)  
  
Emittance exchange home page  
[http://needmore.physics.indiana.edu/~gail/emittance\\_exchange.html](http://needmore.physics.indiana.edu/~gail/emittance_exchange.html)  
  
Targetry home page  
<http://www.hep.princeton.edu/mumu/target/>
- 13 NuFact99, Lyon,  
<http://lyopsr.in2p3.fr/nufact99/>
- 14 NuFact00, Monterey, <http://www.lbl.gov/Conferences/nufact00/>
- 15 Snowmass Muon Based Accelerators (M1) home page  
<http://www.hep.princeton.edu/~mcdonald/mumu/snowmass01/m1.html>



## Topics Covered



- **Motivation for the agenda and topics that will be covered in the presentations:**
  - **Concept, long-term plan, international cooperation**
  - **Physics motivation for a Neutrino Factory**
  - **Feasibility has been established but need much R&D (to further improve, bring down costs, establish parameters by demonstration)**
    - **Shows that either BNL or Fermilab are possible sites, and that staging is possible**
  - **The R&D experiments: goals and current status, i.e., the major hardware effort of recent years**
  - **Lab G and linac area; absorber work; university involvement**
  - **The SCRF program at Cornell, and NSF involvement there and elsewhere**
  - **Components of the R&D plan; timelines and R&D costs**



# History



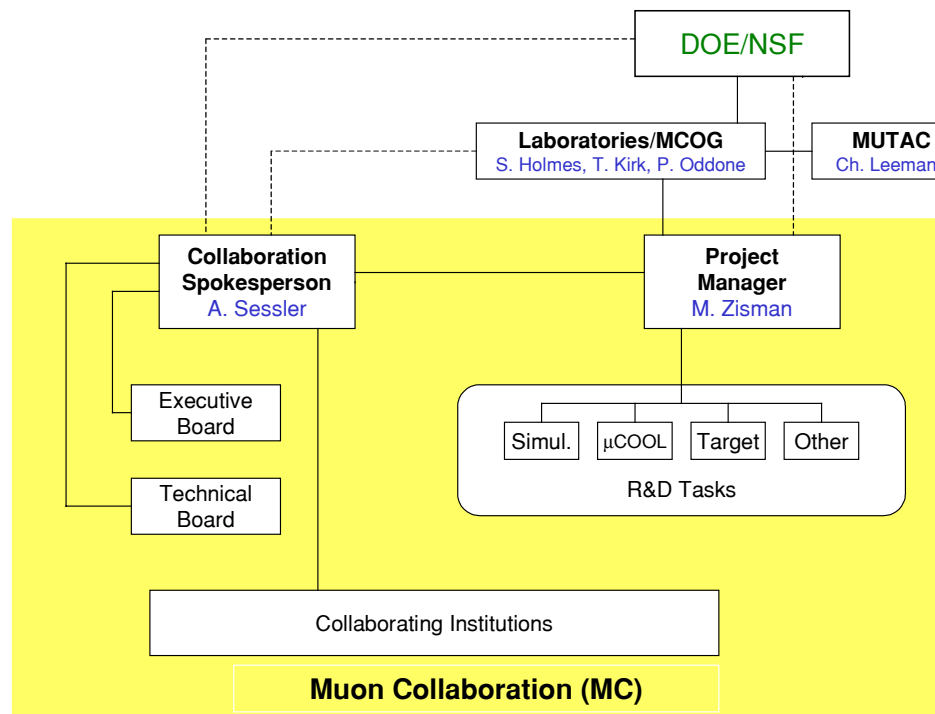
- Muon Collider
  - concept of muon collider is not new [Tinlot (1960); Charpak *et al.* (1960); Budker (1969); Skrinky (1971); Neuffer (1979)]
  - high-luminosity concepts more recent [Neuffer (1985); Palmer (1994)]
  - strong physics interest led to Collaboration (1995) to plan and carry out R&D work aimed at a Muon Collider [see Snowmass report, BNL-52503, Fermilab Conf.-96/092, LBNL-38946, (1996) ed. J. Gallardo; Ankenbrandt *et al.*, Phys. Rev. ST AB 2, 081001 (1999)]
  - identified as promising in report of 1998 HEPAP (Gilman) Subpanel
- Neutrino Factory based on muon storage ring
  - secondary beam from SR: Koshkarev, CERN/ISR-DI/74-62 (1974)
  - muon ring for neutrinos from Geer; Phys. Rev. D 57, 6989 (1998)
- Collaboration members played seminal role in advancing these ideas

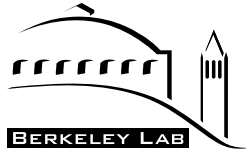


# Collaboration Organization



- Oversight role of “sponsoring” Labs (≡ BNL, Fermilab, LBNL) via MCOG (Directorate level)
  - MCOG appoints Technical Advisory Committee (MUTAC)
  - Project Manager has line responsibility for R&D implementation, working closely with Spokesperson on planning





# Collaboration Organization



- **MC** (140 members; 30 institutions) has broad international community involvement (National Labs, Universities, non-U.S. institutions)
  - reflected in Board membership
- **MC** has grown and has expanded efforts on Neutrino Factory R&D

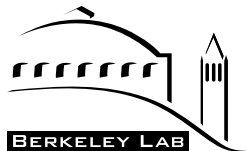
## Executive Board:

J. Gallardo, BNL (Secretary)  
R. Palmer, BNL (Associate Spokesperson)  
S. Geer, Fermilab  
A. Tollestrup, Fermilab (Associate Spokesperson)  
A. Sessler, LBNL (Spokesperson)  
J. Wurtele, LBNL/UC-Berkeley  
M. Zisman, LBNL (Project Manager)  
D. Summers, U. Mississippi  
K. McDonald, Princeton U.  
D. Cline, UCLA  
D. Kaplan, Illinois Institute of Technology  
A. Skrinsky, BINP  
M. Tigner, Cornell (Associate Spokesperson)

## Technical Board:

A. Sessler, LBNL (Spokesperson)  
A. Caldwell, Columbia U.  
J. Corlett, LBNL  
S. Geer, Fermilab  
C. Johnson, CERN  
D. Kaplan, IIT  
H. Kirk, BNL  
K. McDonald, Princeton U.  
J. Miller, NHMFL  
Y. Mori, KEK  
R. Palmer, BNL  
T. Roser, BNL  
M. Tigner, Cornell U.  
J. Wurtele, LBNL/UC-Berkeley  
M. Zisman, LBNL (Project Manager)





# Collaboration Activity



## • Participating institutions

### Beam Simulations

ANL  
BNL  
CERN  
Fermilab  
LBNL  
Michigan State U.  
Princeton U.  
U. Chicago  
UC-Berkeley  
UCLA

### MUCOOL

ANL  
BNL  
Columbia U.  
Fermilab  
Illinois Institute of Technology  
Indiana U.  
LBNL  
National High Magnetic Field Lab  
Northern Illinois U.  
Northwestern U.  
U. Mississippi  
UCLA

### Targetry

ANL  
BNL  
CERN  
Fermilab  
LBNL  
Michigan State U.  
MIT  
ORNL  
Princeton U.

### Acceleration/Storage Ring

BNL  
Cornell U.  
Fermilab  
Jlab  
Michigan State U.  
UCLA

### Proton Driver

BNL  
Fermilab

### Phase Rotation

BNL  
Fermilab  
LBNL



## Elements



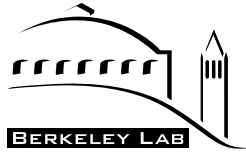
- World-wide interest in neutrino factories
  - a] Physics World, CERN Courier, Nature
  - b] Activities at all high energy physics laboratories
  - c] A Physics Study was completed by Fermilab
  - d] Suggestion of an MOU from Maiani and search for a muon beam facility
  - e] NuFACT'99 (Lyon), NuFACT'00 (Monterey), NuFACT'01 (Tsukuba) and NuFACT'02 (London)
- The NSF has become a significant player
- Continued DOE support through the base programs and explicit support
- Growth of the Collaboration
- MCOG Charter and a Muon Collaboration Charter
- Project Manager for the **MC** (Mike Zisman)



# Elements



- Feasibility Studies I and II
- Emittance Exchange Workshop held and another planned for 2001
- From a Neutrino Factory to a Higgs Collider: Muons All the Way
- Follow-up Physics Study at Fermilab (Barger, Geer, Shrock)
- Technical progress on many fronts:
  - a] Proton Driver
  - b] Target
  - c] MUCOOL
  - d] Simulations
  - e] Acceleration
  - f] Storage Ring
  - g] MUCOOL Notes up to 129
- An R&D Plan has been developed  
[http://www.cap.bnl.gov/mumu/RandD/RandD\\_R3.pdf](http://www.cap.bnl.gov/mumu/RandD/RandD_R3.pdf)
- Snowmass Group M1: Muon-Based Accelerators  
<http://www.hep.princeton.edu/~mcdonald/mumu/snowmass01/m1.html>



## MC Activity



- For past two years, **MC** effort has focused primarily on Neutrino Factory R&D topics
  - Muon Collider issues have not been forgotten
    - emittance exchange workshop held at BNL in September 2000
    - Higgs Factory workshop held at UCLA in February 2001
- In addition to our primary R&D activities, two “Feasibility Studies” have been undertaken



# Neutrino Factory Concept



- An introduction, both to the neutrino physics and the nature of a factory, can be found in the articles by Steve Geer and myself, hard copies of which you have
- Bob Palmer's talk will go into the nature of a factory in much more detail

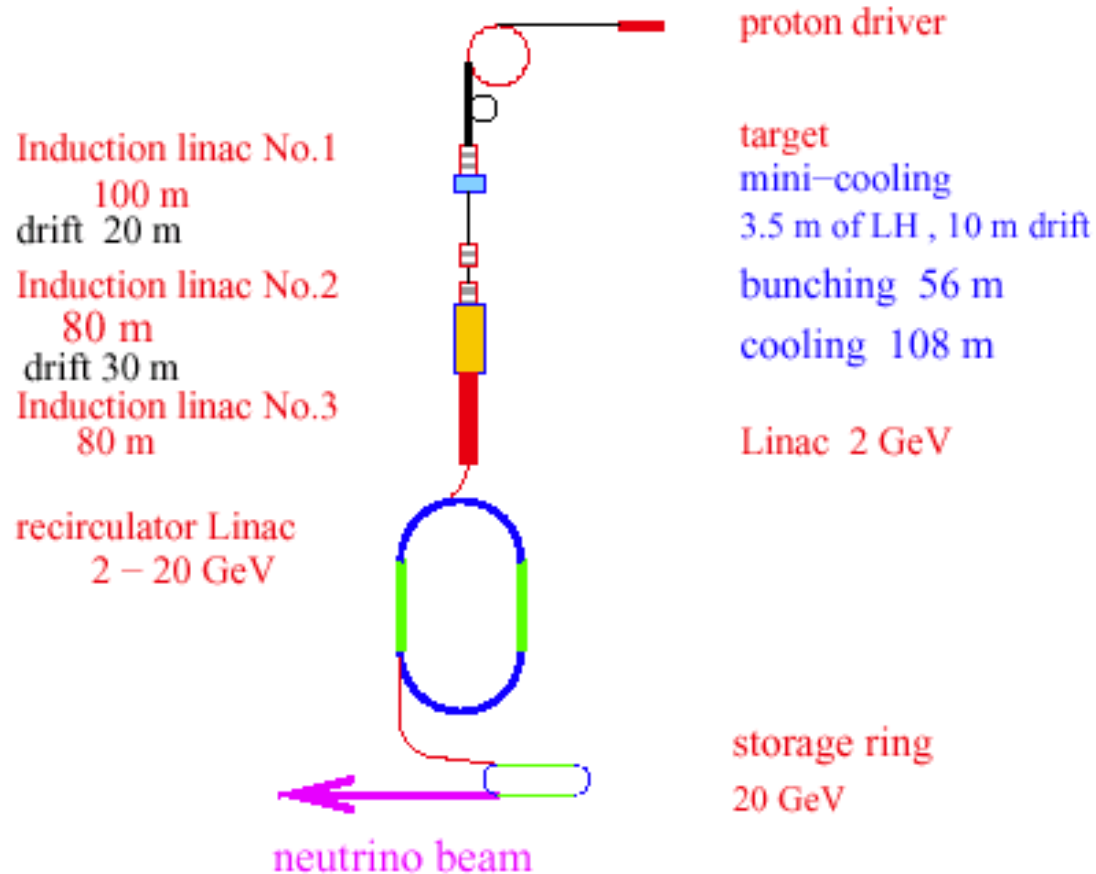


# Neutrino Factory Overview



- Neutrino Factory comprises these sections (**MC** doing R&D on all)
  - **Proton Driver** (primary beam on production target)
  - **Target and Capture** (create pions and capture into decay channel)
  - **Phase Rotation** (induction linac to reduce energy spread of bunch)
  - **Cooling** (reduce transverse emittance of beam)
  - **Acceleration** (raise energy from 200 MeV to 20-50 GeV with RLAs)
  - **Storage Ring** (store muon beam for  $\approx 500$  turns; optimize yield with long straight section aimed in desired direction)
- **MC** participated in Neutrino Factory Feasibility Studies at Fermilab (**Holtkamp, Finley**) and BNL (**Ozaki, Palmer, Zisman**)
  - identify for **MC** R&D program technologies required for feasibility demonstration (credibility) and associated with “cost drivers” (need to improve technology)
- Envision summary of feasibility studies at Snowmass '01
- Not an easy project, but no fundamental problems found

- Generic elements of a neutrino factory

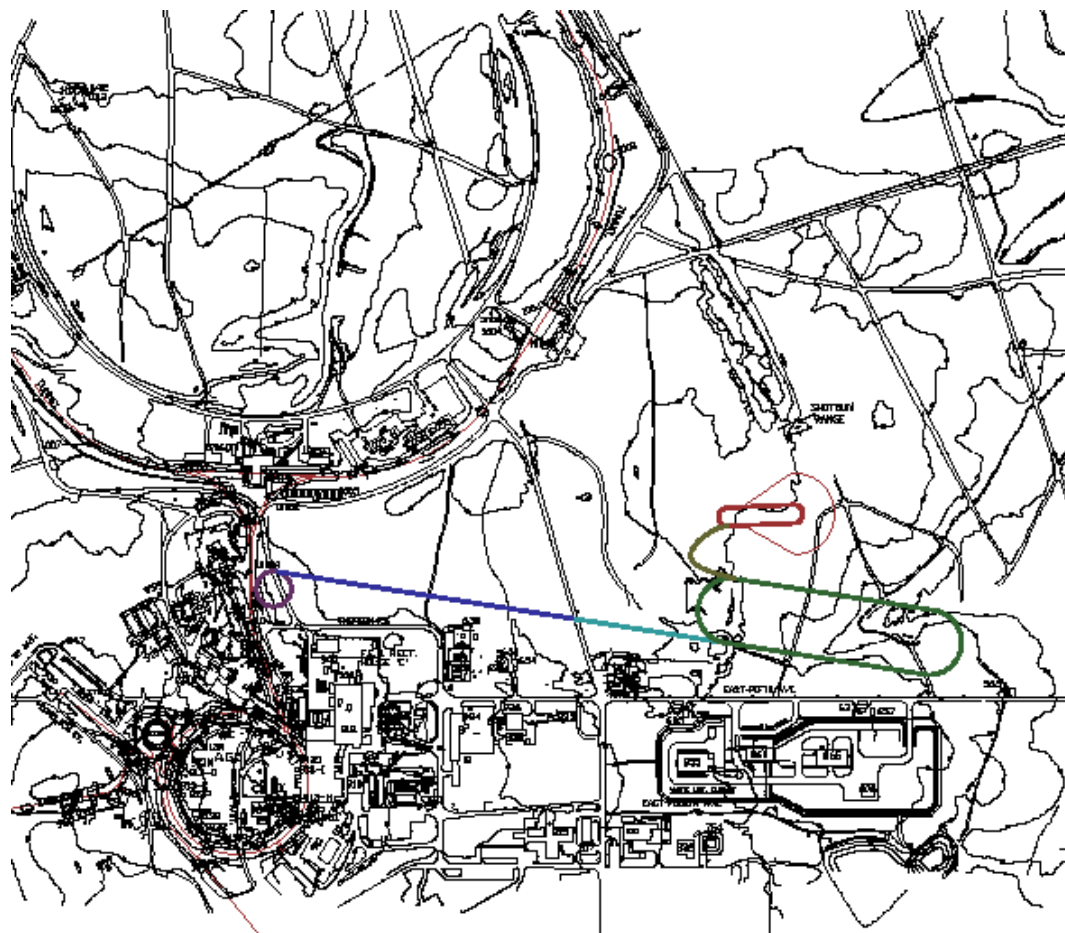




# Neutrino Factory Overview

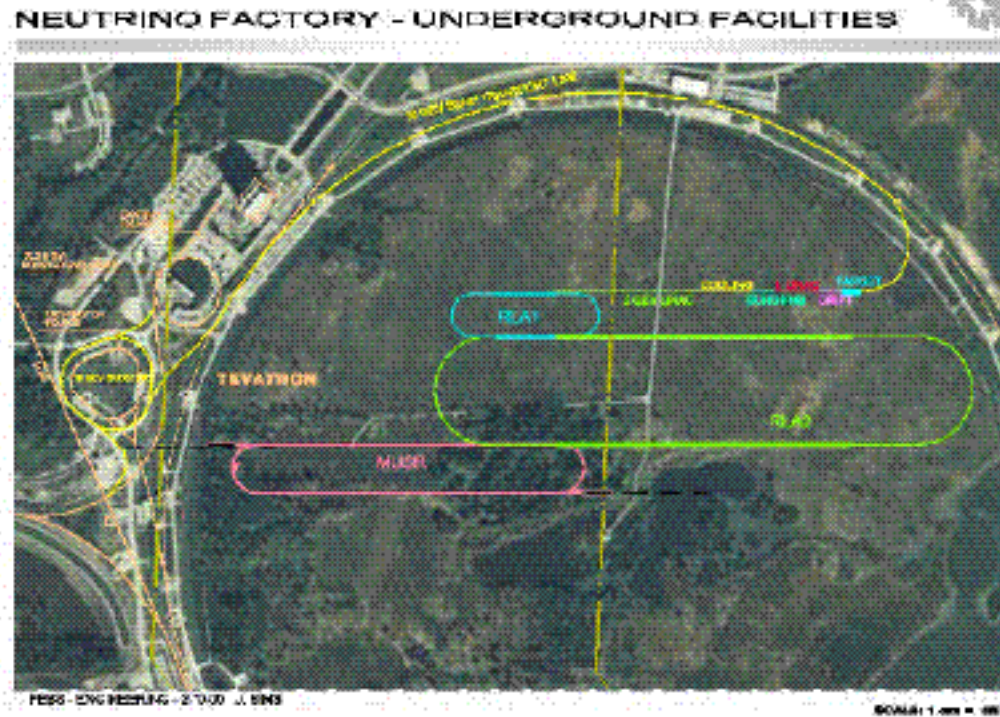


- Footprint on BNL site





- Footprint on FNAL site





# Cooling Demonstration



- We are working towards having a string test in the U.S. (More details in Zisman talk)
  - This will serve to demonstrate that we can build the cooling channel and that it will perform as expected (rf gradients, sc magnets, cryogenics, absorber, diagnostics, etc.)
  - We plan to subject it to an intense beam (**protons, not muons**)
- A cooling demonstration will be done on an international basis
  - CERN is interested in cooperating with us
  - Probably the facility (beam, shielding, etc.) will be in Europe with the U.S. contributing components of the cooling channel
  - This is most likely a “single particle at a time” test and not an intense muon beam test



# Conclusions for a Neutrino Factory



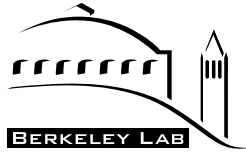
- Most interesting physics  
(We know almost nothing about the neutrino sector)
- Seems likely to “work”
- Cost should not be “excessive”  
...(by U.S. Congressional criteria)
- Within 6 years the R&D should be sufficiently advanced that a serious proposal can be made  
...if the R&D funding support is forthcoming
- It is an **important first step** towards a Muon Collider



## International Activities



- There is activity in Japan (note the JHF which will be the world's first MW driver, as well as interest in FFAG, etc.) and at CERN. Interaction with these groups is good, but not **yet** at a higher level than exchanging information.
  - The CERN Group has a Web page:  
<http://alephwww.cern.ch/~bd1/muon/MUG/welcome.html>
- Information is exchanged at the series of Neutrino Factory Workshops (NuFact 99 - Lyon, NuFact 00 - Monterey, NuFact 01 - Tsukuba, and NuFact 02 - London)
- There is the beginning of international laboratory interest:
  - Maiani Letter and subsequent letters
  - Kurt Hübner interest and CERN activity (e.g., HARP)
  - Steve Geer assignment



# The Grand Scheme of Things



- Lots of R&D

(Started: 1996)  
(Needed: 2000 + 5-10 years)

- Build a Neutrino Factory

(Start in 2007; Completed in 2012)

- Build a Higgs Factory Collider

(Start major R&D in 2007 + 10 years = 2017; Completed in 2024)

-----For Next Subpanel-----

- Build a Few-TeV Collider

(Start major R&D in 2025 + 10 years = 2035; Completed in 2042)

- Build a 10-100 TeV Collider

(????)