Draft Outline for Study II

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1 Executive Summary

2 Introduction

2.1 Charge

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DATE:	May 12, 2000
TO:	Robert Palmer, Satoshi Ozaki
CC:	Thomas Kirk, Peter Paul, Andrew Sessler
FROM:	John Marburger
SUBJECT:	Muon device studies

I am writing to request that you organize, in cooperation with the Muon Collider Collaboration, a BNL site-specific study on the feasibility of a 'high performance' muon storage ring neutrino source. The study would complement the recently completed 'entry level' study commissioned by the Fermilab director and carried out together with the Muon Collider Collaboration.

The scope and parameters for this study have been developed and approved by the Muon Collider Collaboration Spokesperson, Andy Sessler, and Project Manager, Mike Zisman. The Muon Collaboration will participate in the study. The study will also complement the AGS Targetry Experiment, E951, that will study two crucial components of the high performance version of the muon storage ring. The study should consist of two components:

A. A BNL site specific part, led by S. Ozaki and including:
1. a technical description of upgrades to the AGS to reach an average beam power of 1 MW (e.g. 1014 pps at 24 GeV at 2.5 Hz), together with a preliminary cost estimate for this upgrade;
2. a design, layout and preliminary cost estimate for a muon storage ring with the requirement that it be sufficiently above the water table to minimize environmental impacts;
3. magnet studies for the above ring.

B. A generic part, led by the collaboration management, funded by DOE MCC Collaboration funds, and including:
1. the design and technical description of the non-AGS components of a high performance muon storage ring neutrino source, including liquid metal target, muon capture, cooling, acceleration and storage;
2. determination of cost drivers in these systems where not already covered in the Fermilab study;
3. areas for potential cost reduction;
4. continued physics and detector studies as needed.

The study should consider a facility with the following characteristics:
1. a muon storage ring energy of approximately 20 GeV;
2. a neutrino beam aimed at an optimized 50 kT detector located approximately 1800 km from BNL;
3. 2 10^{20} muons per (10^7 sec) year decaying in the detector direction; this is approximately one order of magnitude higher than the 'entry level' machine.

The written report on this new study should be submitted to me by April 30, 2001.

Thank you for agreeing to undertake this important project.

2.2 Performance specifications

Muon Energy	20	GeV
Muons per (10^7 sec) year in straight section	$2\ 10^{20}$	
Distance to Detector	$\approx$ 1800	km

3 Physics

4 Simulation tools

4.1 ICOOL

4.2 ICOOL spin treatment

4.3 ICOOL space charge treatment

4.4 Minimization with ICOOL

4.5 DP GEANT

4.6 MARS

4.7 PATH

5 Driver

5.1 Proton driver table of specifications

p Energy	24	GeV
average beam power	1	MW
Protons per bunch	$1.7\ 10^{13}$	
number of bunches	6	
flat top	75	ms
bunch extraction spacing	15	ms
Repetition rate	2.5	Hz
Extracted Bunch length	1-2	nsec

5.2 Introduction

5.3 Power supply

5.4 RF

5.5 SC linac

5.6 Final buncher

5.7 Possible upgrade to 4 MW

6 Target and Pion Capture Channel

6.1 Target table of specifications

Target material	Hg	
length	30-45	cm
diameter	5	mm
velocity	20-30	m/sec

6.2 Introduction

6.3 Calculation of deceleration and deflection

6.4 Simulation of beam heating effects

6.5 Hg pump and jet design

6.6 Hg cooling and purification

6.7 Target vessel windows

6.8 Beam dump

6.9 Enclosure and ES&H

6.10 Temperature reduction by focused p beam

6.11 Alternative Carbon target

6.12 Pion capture table of specifications

field	20	T
length	45	cm
inside radius	7.5	cm
field fall off over	12-18	m
design life	20	years

6.13 Introduction

6.14 Optimization

6.15 GEANT calculations of radiation

6.16 MARS calculations of radiation

6.17 Magnet design

Design should aim for a hollow copper insert coil as a complement to Study I choice of a Bitter magnet alternative and for long lifetime.

7 rf and Induction Linac Phase Rotation

7.1 rf phase rotation table of specifications

rf frequency	30	MHz
length	40	m

7.2 Introduction

Double phase rotation and polarization.

7.3 ICOOL simulations

Including simulation of discontinuous focus magnets as function of their fields and spacing.

7.4 Alternative design without polarization

7.5 Cavity and conventional rf source

7.6 SC magnets

Solutions with coils outside RF and inside nose cones.

7.7 Alternative resonator with multiple tetrodes

7.8 Alternative Holotron source

7.9 Induction linac table of specifications

	1st	2nd	
length			
pulse length	100	300	nsec
gradients	-1.5 to 0.5	-.5 to 1.5	MV/m

7.10 Introduction

Non-distorting Phase Rotation.

7.11 Induction linac design

7.12 ICOOL study of magnetic fields

Study effects of discontinuous solenoid coils.

Study benefits of choosing a field in drifts and induction units that would match the amplitude momentum correlation to the cooling system.

8 Cooling

8.1 Cooling lattice table of specifications

Muon momentum	220	MeV/c
RF frequency	201.5	MHz
RF Gradient	15	MV/m
Lattice	Super FOFO	

8.2 Introduction

8.3 ICOOL simulations

8.4 Tolerance studies

8.5 Space charge studies

8.6 Integration

8.7 Magnet design

8.8 Cavities

8.9 Be windows

8.10 Klystrons

8.11 Hydrogen absorbers

Including study cryo properties and availability of AlBemet for hydrogen windows.

8.12 Alternative grid tubes

8.13 SLED's and other alternative RF sources

Including study of 2 or 3 coupled cavity SLED.

9 Acceleration

9.1 Acceleration table of specifications

Initial Energy	.22	GeV
Final Energy	20	GeV
Muons per bunch	$4\ 10^{12}$	
number of bunches	50	
bunch spacing	5	ns
transverse acceptance	15	mm rad
longitudinal acceptance	150	mm rad

9.2 Introduction

9.3 Base design

9.4 Superconducting acceleration

9.5 Alternative Dog Bone design

9.6 Alternative FFAG design

10 Storage Ring

10.1 Storage ring table of specifications

Energy	20	GeV
Muons per bunch	$4\ 10^{12}$	
number of bunches	50	
bunch spacing	5	ns
transverse acceptance	15	mm rad
longitudinal acceptance	300	mm rad
β minimum in straight	?	m

10.2 Introduction

Is debuncher needed to reduce momentum spread?

10.3 Lattice

10.4 Bending magnets

10.5 Injection

10.6 Layout

10.7 Civil construction

10.8 ES&H

10.9 Alternative bow tie design for polarization

10.10 Lattice design 50 GeV

11 Possible Implementations

11.1 Phased Construction

11.2 Construction at other sites

11.3 Upgrade to Higgs Muon Collider

12 Costs and Cost drivers