Targetry Plans and Status

MUTAC Review

FNAL

March 17, 2006
Question: Given a “Green Field” what are the most favorable parameters for a proton driver to a Neutrino Factory?

A related question: Liquid or Solid Target
Can a solid target survive a >1MW proton driver beam?
(Nick Simos → Solid Target Studies)
Is a liquid target for a >1MW proton driver technically feasible?
(MERIT target experiment at CERN)

What is the “preferred” proton driver energy?
Achieving Intense Muon Beams

Maximize Pion/Muon Production

- Soft-pion Production
- High Z materials
- High Magnetic Field

Meson Production - 16 GeV $p + W$

$\pi^-\pi^+$

Pion Kinetic Energy, GeV

dN/dKE (1/GeV/interacting proton)

Harold G. Kirk
Optimizing Soft-pion Production

16 GeV on Hg

\[ R_T = 2.5 \sigma_{x,y} \]

\[ \pi^- + \mu^- \]

\[ \pi^+ + \mu^+ \]

Yield at 9 m

Target radius (mm)

Tilt angle (mrad)

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Consider mesons within acceptance of $\varepsilon_\perp = 30\pi \text{ mm}$ and $\varepsilon_L = 150\pi \text{ mm}$ after cooling.

Use Meson count with KE < 350 MeV as a figure of merit.

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Meson KE < 350 MeV at 50m

Mesons/Proton

Mesons/Proton normalized to beam power
Post-cooling 30\(\pi\) Acceptance

MARS14

![Graph showing the relationship between Proton Kinetic Energy and Pion-Muons/Protons*GeV for Positives and Negatives.](image)

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Carbon Target Parameters Search
Carbon Target Optimization

Set R=1.25cm; tilt angle = 50 mrad; Length=60cm; Z=-40cm
Count mesons within acceptance of 
$\varepsilon_\perp = 30\pi \text{ mm}$ and 
$\varepsilon_L = 150\pi \text{ mm}$ after cooling
Summary of Results

<table>
<thead>
<tr>
<th>Compare Meson production for Hg at 24 GeV and 10 GeV</th>
<th>( \frac{N^+<em>{24\text{GeV}}}{N^-</em>{24\text{GeV}}} ) = 1.07</th>
<th>( \frac{N^-<em>{10\text{GeV}}}{N^+</em>{10\text{GeV}}} ) = 1.10</th>
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<tbody>
<tr>
<td>Compare Meson production for C at 24 GeV and 5 GeV</td>
<td>( \frac{N^+<em>{24\text{GeV}}}{N^-</em>{24\text{GeV}}} ) = 1.90</td>
<td>( \frac{N^-<em>{5\text{GeV}}}{N^+</em>{5\text{GeV}}} ) = 1.77</td>
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<tr>
<td>Compare Meson production for Hg at 10 GeV and C at 5 GeV</td>
<td>( \frac{N^+<em>{Hg-10\text{GeV}}}{N^+</em>{C-5\text{GeV}}} ) = 1.18</td>
<td>( \frac{N^-<em>{Hg-10\text{GeV}}}{N^-</em>{C-5\text{GeV}}} ) = 1.22</td>
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</table>
The Target Experiment at CERN

“R&D on the muon production target experiment at CERN will also be funded”

Presidential FY07 Budget Request to Congress
The MERIT (nTOF11) Experiment

MERcury Intense Target

Harold G. Kirk
Target Test Site at CERN
The Tunnel Complex

Harold G. Kirk
Profile of the Experiment

- 14 and 24 GeV Proton beam
- Up to $>30 \times 10^{12}$ Protons (TP) per 2μs spill
- Proton beam spot with $r \leq 1.5$ mm rms
- 1 cm diameter Hg Jet
- Hg Jet/Proton beam off solenoid axis
  - Hg Jet 33 mrad
  - Proton beam 67 mrad
- Test 50 Hz operations
  - 20 m/s Hg Jet
  - 2 spills separated by 20 ms
PS Beam Characteristics

- PS will run in a harmonic 16 mode
- We can fill any of the 16 rf buckets with sub-bunches at our discretion.
- Each microbunch can contain up to 3 TP.
- Fast extraction can accommodate entire 2μs PS fill.
- Extraction at 24 GeV
- Partial/multiple extraction possible at 14 GeV
- Beam on target April 2007
Run plan for PS beam spills

The PS Beam Profile allows for:

- Varying beam charge intensity from 6 TP to > 30 TP.
- Studying influence of solenoid field strength on beam dispersal (vary $B_0$ from 0 to 15T).
- Study possible cavitation effects by varying PS spill structure (Pump/Probe)
- Study 50 Hz operation.
Key Experimental Sub-systems

15T Pulsed Solenoid
8 MVA Power Supply
LN$_2$ Cryo-system
Hg Jet Delivery System (K. McDonald)
Diagnostics (K. McDonald)
Optical
Particle Detection
CERN Infrastructure (I. Efthymiopoulos)
Simulations (R. Samulyak)
High Field Pulsed Solenoid

- 80° K Operation
- 15 T with 5.5 MW Pulsed Power
- 15 cm warm bore
- 1 m long beam pipe

Peter Titus, MIT

Harold G. Kirk
## Pulsed Solenoid Milestones

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Date</th>
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<tbody>
<tr>
<td>Delivery to MIT</td>
<td>January 06</td>
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<tr>
<td>Reception Testing</td>
<td>March 06</td>
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<tr>
<td>Integration Testing</td>
<td>September 06</td>
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<tr>
<td>Ship to CERN</td>
<td>December 06</td>
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<tr>
<td>Installation at CERN</td>
<td>January 07</td>
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</table>
The Pulsed Solenoid

CVIP December 2005

First Current: MIT
March 9, 2006
System Commissioning

- Ship Pulsed Solenoid to MIT
  January 2006
- Test Solenoid to 15 T peak field
  March-April 2006
- Integration of Solenoid/Hg Jet system
  September 2006
# Power Supply Milestones

<table>
<thead>
<tr>
<th>Task</th>
<th>Date</th>
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<tr>
<td>Site Preparations</td>
<td>January 06</td>
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<tr>
<td>Relocate and Install</td>
<td>February 06</td>
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<tr>
<td>DC Cabling</td>
<td>March 06</td>
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<td>AC Cabling</td>
<td>March 06</td>
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<tr>
<td>Refurbish PS</td>
<td>March-April 06</td>
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<td>Interlocks</td>
<td>September 06</td>
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<tr>
<td>Commissioning</td>
<td>October 06</td>
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</table>
Power Converter (From SPPS Transfer Line)
8000 Adc, 1000 Vdc

Strategy:

- Refurbishment of the West Area Power Converter, making it compatible with the project requirements

Global view

Rectifier bridges

Passive filter

Self capacitors

DC output

Passive filter capacitors

Harold G. Kirk
# Cryogenic System Milestones

<table>
<thead>
<tr>
<th>Activity</th>
<th>Date</th>
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<tr>
<td>TT10 Vent Installation</td>
<td>January 06</td>
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<tr>
<td>Cold Valve Box Fabrication</td>
<td>April-July 06</td>
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<tr>
<td>Control System Development</td>
<td>January-June 06</td>
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<td>Surface Preparations</td>
<td>May 06</td>
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<td>Transfer Line Installation</td>
<td>July 06</td>
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<td>Cold Valve Box Testing</td>
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<td>Heater System Installation</td>
<td>September 06</td>
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<tr>
<td>Cold Valve Box Installation</td>
<td>November 06</td>
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<td>Commissioning</td>
<td>December 06</td>
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The Cryogenic System

Key Features

- 30 minutes rep-rate
- LN\textsubscript{2} purge before shot
- Liquid purge to buffer storage
- Gas purge to TT10
LN$_2$ and N$_2$ gas stored on the surface.

Cold valve box in the TT2 tunnel.

Exhaust gas vented into TT10 tunnel through filtration system.

~ 150 liters of LN$_2$ per Magnet pulse.

Magnet flushed with N$_2$ prior to each pulse, to minimize activation of N$_2$. 
The Cold Valve Box (DVB)
The Hg Jet System
The Hg Jet Injection System

$Z = 0$ at the Solenoid mid-point. The Hg Jet axis and proton beam trajectory intersect.

Harold G. Kirk
Primary Containment Cross Section

Primary Containment
Optics
Hg Supply
Hg Jet
Sight Glass
Sight Glass Cover
Magnet Bore
OD = 6.18" (157mm)
ID = 6.38" (162mm)

Secondary Containment
Reflectors

Harold G. Kirk
Princeton Nozzle R&D

- Replaceable Nozzle Head
- Lexan Viewing Channel
- 20 HP Pump
The Nozzle Test Setup
Fast camera capture of waterjet
September 16, 2005 @ Princeton

Measured Waterjet Velocity 12 m/s

Camera: FastVision 13 capability
1280x1024 pixels, 500 frames/sec, 0.5 sec video

nozzle: diameter ~8 mm, length 6-inch
# Project Major Sub-systems

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<th>2006 Q1</th>
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CERN Infrastructure

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Summary

The MERIT (nTOF11) Experiment

- Study single beam pulses with intensities >30TP
- Study influence of solenoid field strength on Hg jet dispersal (B₀ from 0 to 15T)
- Study 50 Hz operations scenario
- Study cavitation effects in the Hg jet by varying PS spill structure—Pump/Probe
- First beam expected April 2007
- Confirm Neutrino Factory targetry concept