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MEMORANDUM OF UNDERSTANDING

FOR THE 2008 MESON TEST BEAM PROGRAM

T-979

PSEC Collaboration

**Argonne National Laboratory, Fermi National Accelerator Laboratory, Saclay/IRFU,
Stanford Linear Accelerator Center, University of Chicago, and University of Hawaii**

March 9th, 2008

Fast Timing Counters for PSEC: MOU for Testing at MTEST

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INTRODUCTION

This is a memorandum of understanding between the Fermi National Accelerator Laboratory (Fermilab) and University of Chicago, Argonne National Laboratory (ANL), Saclay/IRFU and the University of Hawaii experimenters who have committed to participate in beam tests to be carried out during the 2008 Meson Test Beam Facility program. The memorandum is intended solely for the purpose of providing a budget estimate and a work allocation for Fermilab, the funding agencies and the participating institutions. It reflects an arrangement that currently is satisfactory to the parties; however, it is recognized and anticipated that changing circumstances of the evolving research program will necessitate revisions. The parties agree to negotiate the appropriate amendments to this memorandum if adjustments are required.

The experimenters require beam time at Fermilab during the 2008 Meson Test Beam Run to test time-of-flight particle detectors with the ultimate goal of achieving 1 psec timing resolution. Proposed applications are: diffractive Higgs production background reduction at the LHC; measuring the momentum of muons before and after a 6D cooling setup as proposed by the MANX experiment; particle identification at a Super-B factory, LHC detector upgrades, possible third generation Tevatron Collider flavor experiments, precision kaon measurements, and astro-particle experiments. In addition, the development and testing of the associated electronics and timing algorithms may be directly applicable to advances in medical imaging. Much more information can be found at the PSEC web site, at <http://hep.uchicago.edu/psec/>.

The detectors will consist of microchannel plate photo-multiplier tubes (MCP-PMTs) with quartz radiators at the face. Incident particles will pass through the radiators and the tubes. Resultant Cerenkov light will be sensed by the tubes and converted into electronic signals whose leading edges will mark the time of the beam's passage. A variety of MCP-PMTs differing in number and size of anodes, pore size and acceleration gap spacing, will be tested to determine the time measurement accuracy of each. Various connection schemes tying different numbers of adjacent anodes together will also be explored, with the overall goal to determine the optimal MCP-PMT construction and integration of electronics for time resolutions on the order of 1 psec.

Initial tests with the MCP-PMTs will utilize a fast (40Gs/sec) Tektronix TDS6154C oscilloscope to measure the signals from up to four MCP-PMTs. As time and resources permit additional channels will be instrumented using NIM/CAMAC based electronics and possibly also custom waveform sampling electronics in an effort to further improve timing resolution and to gain experience in the type of electronics necessary to construct large systems of this type in future experiments.

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Variation in the spacing between MCP-PMTs will allow systemic exploration of the accuracy of time measurements. Additionally, as the custom waveform sampling electronics is integrated the experimenters will also explore solutions for high precision clock distribution and readout. Larger spacing, up to the maximum available, will be used to measure particle separation performance using the known particle mix of the test beam.

This Memorandum outlines a plan for test beam time during 2008. The detailed goals of this small-scale beam test are listed below.

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I. PERSONNEL AND INSTITUTIONS:

Spokesman and physicist in charge of beam tests: Henry Frisch, University of Chicago

Fermilab liaison: Erik Ramberg

The group members at present and others interested in the test beam are:

- 1.1 Fermilab: Michael Albrow, Erik Ramberg, Anatoly Ronzhin
- 1.2 University of Chicago: Camden Ertley, Henry Frisch, Jean-Francois Genat, Dan Herbst, Fukun Tang, Scott Wilbur
- 1.3 Argonne National Laboratory: Karen Byrum, John Anderson, Gary Drake
- 1.4 University of Hawaii: Gary Varner, Larry Ruckman
- 1.5 Stanford Linear Accelerator Center: Jerry Va'vra
- 1.6 Saclay/IRFU: Patrick Le Du, Christophe Royon

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS

2.1 LOCATION

- 2.1.1 The tests are to be performed in the MTEST beam line in the MT6-1B and/or MT6-2B areas. All 4 MCP's will be mounted on one 2' long table from 0" to 6" apart. For the second stage of measurements, the MCP's will be mounted as far apart as possible, conducive to an integrated DAQ. This may involve running in both the MT6-1B and MT6-2B areas, or may simply in one of the areas, with wide spacing.
- 2.1.2 The experimenters require two wide locations in the beam line on which to mount the detectors. There should be room for the detectors to be moved out of the beam line in case there are other users downstream sharing the beam. The experimenters will need some Fermilab support to align the apparatus relative to the beam line. The following items will be needed in the beam area:
 - Space in the beam line for a 4-counter beam telescope; one paddle will be located next to each station (See Figures 1 and 2 for typical details)
 - Test-beam beam condition, trigger, and hodoscope information.
 - Cherenkov counter signals and status
 - ACNET, including a 53 MHz clock signal, beam-spill and gating signals, monitoring of beam intensity
 - Four 19-inch racks with wheels, cooling, and a 110V power strip to house NIM/CAMAC crates plus HV supplies, patch panels, monitors, etc.
 - CAMAC/NIM crates and modules listed in Appendix II
 - Patch panels, cable trays, miscellaneous cables and connectors

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2.1.3 Additional work space will be needed in the alcove control room, equivalent to two 6' x 3' tables. This space will be used for the data acquisition PC and as general work space.

2.2 BEAM

2.2.1 BEAM TYPES

The experimenters require a beam momentum of 8 GeV, but can use 120 GeV protons, or any high momentum beam, for setting up and initial calibration. The spot size at the detectors should be as small as achievable. If time permits the experimenters will request one or two additional tunes at 4 and 16 GeV. The tests will use the slow resonantly-extracted Main Injector proton beam focused onto the MTest target.

2.2.2 BEAM INTENSITY

An intensity of ~ 10K particles per spill is preferred, although any intensity between 10K/spill and 50K/spill is acceptable (our DAQ system is limited to approximately 1 KHz in a 1-cm by 1-cm area)..

2.2.3 PARTICLE IDENTIFICATION

The experimenters would like access to the particle tagging information from the Cherenkov counters for the 8 GeV beam momentum setting. The experimenters would like to be able to identify pions, kaons, and protons at each momentum setting and polarity. If electron and muon identification are available the experimenters would like access to it as well.

2.2.4 BEAM SHARING

Because of limited manpower availability and the time needed to analyze the data and make changes to the setup, the experimenters will be unable to run continuously. The experimenters prefer to alternate beam time with other users. The experimenters hope to also be able to run parasitically and expect to be able to use short periods of time (end effects) when other users allow. The main material in the beam will be ~ 0.5 cm of quartz and ~ 0.5 cm more for each MCP-PMT. The experimenters will move the detectors out of the beamline as needed for other experiments.

2.2.5 RUNNING TIME

The experimenters plan to make the following studies, initially independently for each of the different MCP-PMTs.

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(a) Setup the trigger with scintillation counters in coincidence with the spill, and set up spill gating and scalers. Time-in both "fast anode out" and pixel signals from MCP-PMT's. Incorporate read-out of beam detectors. Plateau the MCP's.

(b) After calibration, test timing performance of the setup.

1. with highly relativistic particles (e.g. 120 GeV protons)
2. with 8 GeV beam, with Cherenkov information.
3. if time permits repeat, with 4 and 16 GeV beam

The above program will require accesses to the area ranging from 10 minutes to 30 minutes to change conditions. Due to limited manpower the experimenters prefer to control the beam for no more than 12 hours per day.

The experimenters anticipate that after one week of good data taking, the data will have been analyzed and perhaps improvements to the detector and electronics will be made, on a time scale of a few months. A further period of beam tests would then be requested.

2.3 SETUP

The apparatus consists of 4 MCP-PMT modules, each occupying about 10 cm along the beam. The MCP's will be mounted as shown in Figure 1. For calibration and initial testing all four MCP's will be mounted on a single, 2' table. For the subsequent tests the MCP's will be mounted on two tables separated by a large distance. See Figure 2 for an example. The experimenters will have four small (~1cm x 1cm) scintillation counters for an independent coincidence trigger. One of the MTest facility's wire chamber stations will be used at each location for accurate beam position information.

2.3.1 COMPUTING

The experimenters will use the MTest facility DAQ computer as well as supply their own DAQ computer. The FERA readout system of the facility's DAQ computer will be required. One of the facility's FERA MWPC stations will have to be moved to be in front of the apparatus. A Kerberized Ethernet connection (with capability of using SSH) will be required for data transmission offsite (and downloading of updated versions of codes from outside institutions.) USB connection will be required to transfer data to and from the CAMAC control units.

2.4.1 GENERAL ELECTRONICS NEEDS

a) Electronics needs.:

The electronics needs are itemized in Appendix II. The experimenters are requesting PREP and PPD support as listed, largely for our beam telescope and interfaces to the MTest beam and accelerator timing information. Most of the front-end and DAQ hardware specific to the timing measurements will be supplied by the collaborating institutions, as also listed in Appendix II.

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b) An explanation of the DAQ plans as related to the electronics request:

The data acquisition will proceed on 3 steps:

1) The data from the MCP's will initially be read-out from the 4-channel Tektronix 40GHz digital sampling scope, triggered by the beam telescope. The scope has a USB output and these data can be analyzed offline.

2) At the start of data-taking the experimenters will also have 4 channels of high-resolution (~3 psec) electronics available for time and amplitude measurements, each from a 6mm x 6mm MCP-PMT pixel. Each channel feeds an Ortec-9327 Constant Fraction Discriminator, which in turn feeds an Ortec-5666 TAC and an Ortec-AD114 ADC. The memory will be read out using the facility FERA readout system. A schematic for the planned DAQ is shown in Figure 3.

3) If the experimenters succeed with the above, they plan to use fast waveform-sampling boards (from the Hawaii group) to sample at least one pixel per station at rates up to 6 GHz at approximately 9-bit resolution.

2.5.1 SCHEDULE

The experimenters propose to begin installing the equipment and setting up the electronics in late May/early June, and take data in one of the first weeks of June. The experimenters can co-exist with upstream users time-sharing on a daily basis as mutually convenient.

III. RESPONSIBILITIES BY INSTITUTION - NON FERMILAB

([] denotes replacement cost of existing hardware.)

3.1 Univ. Chicago: Setting up electronics. Integrating detectors in readout. Test beam coordination. Providing detectors, scope, some mechanical support, computing analysis.	[\$162K]
40 Gs/sec Oscilloscope	[\$142K]
4 Photonis Planacons	[\$20K]
3.2 Univ. Hawaii: Providing electronics and support.	[47\$]
Custom test scope, signal generator	[\$25K]
cPCI readout crate cPCI CPU	[\$10K]
BLAB1-based custom readout electronics	[\$12K]
3.3 Argonne: Providing NIM/CAMAC readout electronics and precision clock distribution system. Providing a DAQ computer, including disk and monitor. Setting up electronics and integrating detectors into the readout. Providing overall system engineering.	[72K\$]
NIM/Camac Timing Electronics	[\$40K]
DAQ Computer System	[\$12K]
Misc cables, connectors	[\$20K]

Total: \$ 251K

IV. RESPONSIBILITIES BY INSTITUTION – FERMILAB

4.1 FERMILAB ACCELERATOR DIVISIONS:

- 4.1.1 Use of MTest beam as outlined in Section 2.
- 4.1.2 Maintenance of all existing standard beam line elements (hodoscopes, SWICs, loss monitors, etc) instrumentation, controls, clock distribution, and power supplies.
- 4.1.3 Beam counter signals, 53 MHz clock, beam-spill gates, and ACNET available in the counting house.
- 4.1.4 Reasonable access to the experimenters' equipment in the test beam.
- 4.1.5 The test beam energy and beam line elements will be under the control of the AD Operations Department Main Control Room (MCR).
- 4.1.6 Position and focus of the beam on the experimental devices under test will be under control of MCR. Control of secondary devices that provide these functions will be delegated to the experimenters as long as it does not violate the Shielding Assessment or provide potential for significant equipment damage.
- 4.1.7 The integrated effect of running this and other SY120 beams will not reduce the antiproton stacking rate or protons on target for NUMI by more than 5%, with the details of scheduling to be worked out between the experimenters and the Office of Program Planning.

4.2 FERMILAB PARTICLE PHYSICS DIVISION

- 4.2.1 The test-beam efforts in this MOU will make use of the Meson Test Beam Facility. Requirements for the beam and user facilities are given in Section 2. The Fermilab Particle Physics Division will be responsible for coordinating overall activities in the MTest beam-line, including use of the user beam-line controls, readout of the beam-line detectors, and MTest gateway computer and installation tasks such as moving wire chambers. [1.0 person weeks]
- 4.2.2 Facility LINUX DAQ computing support as needed (J. Ormes). [0.5 person weeks]

4.3 FERMILAB COMPUTING DIVISION

- 4.3.1 Ethernet and printers should be available in the counting house.
- 4.3.2 Connection to beams control console and remote logging (ACNET) should be made available in the counting house.
- 4.3.3 See Appendix II for summary of PREP equipment pool needs. The experimenters request maintenance for and repair of the PREP-supplied equipment if needed.

4.4 FERMILAB ES&H SECTION

- 4.4.1 Assistance with safety reviews.

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V. Summary of Costs

Source of Funds [\$K]	Equipment	Operating	Personnel (person-weeks)
Particle Physics Division	0	0	1.5
Accelerator Division	0	0	0
Computing Division	0	0	0
Totals Fermilab	0	0	1.5
Totals Non-Fermilab	[\$251 K]	0	15.0