4/18 Run

CC: R. McNabb
D. Bock
R. Dixon
V. White
W. Griffing
E. Ramberg
4/19/07

FERMILAB-PROPOSAL-0967

Fermilab

Directorate

MEMORANDUM OF UNDERSTANDING FOR THE 2007 MESON TEST BEAM PROGRAM

T967

Muon g-2 Calorimeter Prototype

March 23, 2007

INTRODUCTION

This is a Memorandum of Understanding (MOU) between the Fermi National Accelerator Laboratory and experimenters of the muon g-2 experiment who have committed to participate in beam tests to be carried out during the 2007 MTBF program.

This memorandum is intended solely for the purpose of providing a work allocation for Fermi National Accelerator Laboratory and the participating universities and institutions. It reflects an arrangement that is currently satisfactory to the parties involved. It is recognized, however, that changing circumstances of the evolving research program may necessitate revisions. The parties agree to negotiate amendments to this memorandum to reflect such revisions.

Description of detector and tests

The muon g-2 experiment at Brookhaven Nation Laboratory has measured the muon anomalous magnetic moment to 0.54 ppm. A proposed upgrade to the experiment would increase the precision of the measurement to 0.2 ppm. In order to achieve this, a factor of 5 increase in the rate of muon beam is necessary along with a reduction of systematic errors. One of the primary systematic errors in the experiment is due to pileup. Using the current g-2 lead-scintillating fiber calorimeters, a factor of 5 increase in the muon rate will result in a proportional increase in the pileup systematic error which is unacceptable. In order to overcome this problem a new, segmented calorimeter design has been developed.

The proposed design is a tungsten-scintillating fiber calorimeter with 20 segments, each read out by a separate PMT. The use of tungsten, which is significantly denser than lead, produces compact showers. This is necessary, in order to improve shower separation in analysis and to fully contain the showers within a calorimeter that satisfies the strict space constraints of the experiment. A single calorimeter segment has been constructed in order establish the feasibility of the new design and study its properties. Initial tests of the detector segment at the Paul Scherrer Institute have been promising, however the maximum electron beam momentum obtainable was <400 MeV/c, whereas the important energy range in the g-2 experiment is up to 3.1 GeV.

The experimenters propose to use 1-4GeV electrons from the Fermilab test beam to measure the energy resolution, linearity, and shower size of the calorimeter segment. This will provide important information for the simulation and construction of the full calorimeters.

References:

1. Carey *et.al.*, "A $(g\text{-}2)_\mu$ Experiment to 0.2ppm", BNL proposal.
2. Bennett *et.al.*, PRD **73,** 072003(2006).

I. PERSONNEL AND INSTITUTIONS:

Spokesman and physicist in charge of beam tests: Ron McNabb
Fermilab liaison: Erik Ramberg

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

University of Illinois at Urbana-Champaign(UIUC):
David Hertzog(professor), Ron McNabb(postdoc), Jason Crnkovic and David Webber(grad students), Josh Kunkle(undergrad)

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS

2.1 LOCATION

2.1.1 These tests will be carried out in beamline MT6 section 2A.

2.2 BEAM

2.2.1 BEAM TYPE and INTENSITY

Type of Beam Needed:	Electron or Positron
Intensity Needed:	0.1-1 KHz
Size of Beam needed:	1-10cm^2 (as small as achievable)

The experimenters would like an electron beam that can be tuned between 1 and 4GeV/c with $\Delta p/p$=5% or better. The Accelerator Division will make a best effort at attempting to deliver a beam with better resolution, down to 2%. The experimenters and Fermilab will collaborate in determining the momentum dispersion as a function of position in the beam. Pions will likely be a major background in the beam. A Cerenkov detector should allow tagging such that electrons will be the dominant component of the analyzed data.

2.2.2 BEAM SHARING

The small size of the calorimeters and other detectors used for the test should make moving the apparatus out of the way relatively easy if necessary.

2.3 EXPERIMENTAL CONDITIONS

2.3.1 SCHEDULE : The experimenters propose to use the test beam for 5-6 days in April, with one day for equipment setup prior to running.

2.3.2 DETAILED DESCRIPTION OF TESTS: The apparatus will consist of a tungsten-scintillating fiber calorimeter which is the focus of the test, plus two lead-scintillating fiber calorimeters on either side, which provide information about shower containment. Scintillator tiles and fibers will be used for triggering and to select hits in particular positions on the detector. A Cerenkov detector, provided by Fermilab, will be used to tag electrons. One MWPC station will be provided by the test beam facility to accurately measure position of beam on the calorimeter.

The major steps in the test are as follows:

(a) Set up trigger scintillators and Cerenkov detectors and time in with calorimeter signals.

(b) Perform HV scan to determine proper HV settings for calorimeters.

(c) With beam centered on tungsten calorimeter record ADC spectra for beam energies between 1 and 4 GeV in 0.5 GeV steps.

(d) Using 1mm trigger fibers, scan horizontally at 1-2mm intervals near the edge of the tungsten calorimeter in order to study detector response and shower containment at several energies

(e) With beam centered on the calorimeter tilt the detector at 0, 5, and 10 degree angles to check for changes in detector response due to channeling effects in fibers.

III RESPONSIBILITIES BY INSTITUTION - NON FERMILAB(All UIUC)

3.1 Scintillator detectors for triggering and position resolution
3.2 CAMAC and NIM crates
3.3 NIM and CAMAC logic/ADC/TDC modules
3.4 CAMAC readout and DAQ

IV. RESPONSIBILITIES BY INSTITUTION – FERMILAB

4.1 FERMILAB ACCELERATOR DIVISION:

4.1.1 Use of MTest beam as outlined in Section 2.

4.1.2 Maintenance of all existing standard beam line elements (SWICs, loss monitors, etc) instrumentation, controls, clock distribution, and power supplies.

4.1.3 Reasonable access to the experimenters' equipment in the test beam.

4.1.4 The test beam energy and beam line elements will be under the control of the AD Operations Department Main Control Room (MCR).

4.1.5 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.

4.2 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.

4.2.2 Scintillator/Cerenkov counters provided by facility for trigger and start time.

4.2.3 One of the MWPC stations will be moved into place in front of the calorimeter. Assistance will be provided in integrating this chamber into the experimenters' DAQ system.

4.2.4 The test beam facility shall provide a table or cart upon which the counter assembly is mounted, with a total weight of 100 lbs. The cart needs to provide vertical as well as horizontal motion to a precision of 1mm. The value of the position needs to be available.

4.2.5 A low level radioactive beta source will be made available to the experimenters.

4.3 FERMILAB COMPUTING DIVISION

4.3.1 Ethernet and printer 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 Test beam facility DAQ computing support as needed during normal working hours. — only limited

4.4 FERMILAB ES&H SECTION

4.4.1 Assistance with safety reviews

V. Summary of Costs

Source of Funds [$K]	Equipment	Operating	Personnel (person-weeks)
Particle Physics Division	$0 K	$0 K	0.5
Accelerator Division	0	0	0.5
Computing Division	0	0	0
Totals Fermilab	0 K	0	1.0
Totals Non-Fermilab	0K	0	4.0

VI. SPECIAL CONSIDERATIONS

6.1 The responsibilities of the spokesman of the g-2 calorimeter group and procedures to be followed by experimenters are found in the Fermilab publication "Procedures for Experimenters": (http://www.fnal.gov/directorate/documents/index.html). The Physicist in charge agrees to those responsibilities and to follow the described procedures.

6.2 To carry out the experiment a number of Environmental, Safety and Health (ES&H) reviews are necessary. This includes creating an Operational Readiness Clearance document in conjunction with the standing Particle Physics Division committee. The spokesman of the g-2 calorimeter group will follow those procedures in a timely manner, as well as any other requirements put forth by the division's safety officer and follow all procedures in the PPD Operating Manual.

6.3 The spokesman of the g-2 calorimeter group will ensure that at least one person is present at the Meson Test Beam Facility whenever beam is delivered and that this person is knowledgeable about the experiment's hazards.

6.4 All regulations concerning radioactive sources will be followed. No radioactive sources will be carried onto the site or moved without the approval of the Fermilab ES&H section.

6.5 All items in the Fermilab Policy on Computing will be followed by the experimenters. (http://computing.fnal.gov/cd/policy/cpolicy.pdf).

6.6 The spokesman of the g-2 calorimeter group will undertake to ensure that no PREP or computing equipment be transferred from the experiment to another use except with the approval of and through the mechanism provided by the Computing Division management. They also undertake to ensure that no modifications of PREP equipment take place without the knowledge and consent of the Computing Division management.

6.7 The g-2 calorimeter group will be responsible for maintaining and repairing both the electronics and the computing hardware supplied by them for the experiment. Any items for which the experiment requests that Fermilab performs maintenance and repair should appear explicitly in this agreement.

6.8 At the completion of the experiment:

6.8.1 The spokesman of the g-2 calorimeter group is responsible for the return of all PREP equipment, computing equipment and non-PREP data acquisition electronics. If the return is not completed after a period of one year after the end of running the spokesman of the group will be required to furnish, in writing, an explanation for any non-return.

6.8.2 The experimenters agree to remove their experimental equipment as the Laboratory requests them to. They agree to remove it expeditiously and in compliance with all ES&H requirements, including those related to transportation. All the expenses and personnel for the removal will be borne by the experimenters.

6.8.3 The experimenters will assist the Fermilab Divisions and Sections with the disposition of any articles left in the offices they occupied.

6.8.4 An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters Meeting.

SIGNATURES:

________________________ 4 /18 / 2007
Ron McNabb, University of Illinois Urbana-Champaign

________________________ 3 /24/ 2007
Greg Bock, Particle Physics Division

________________________ 3 /28/ 2007
Roger Dixon, Accelerator Division

________________________ 4 / 4 / 2007
Vicky White, Computing Division

________________________ 3 /26 / 2007
William Griffing, ES&H Section

________________________ 4 / 11 /2007
Hugh Montgomery, Associate Director, Fermilab

________________________ 4 / 6 /2007
Stephen Holmes, Associate Director, Fermilab

APPENDIX I - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need have been checked

Cryogenics		**Electrical Equipment**		**Hazardous/Toxic Materials**	
	Beam line magnets		Cryo/Electrical devices		List hazardous/toxic materials planned for use in a beam line or experimental enclosure:
	Analysis magnets		capacitor banks		
	Target	X	high voltage		
	Bubble chamber		exposed equipment over 50 V		
Pressure Vessels		**Flammable Gases or Liquids**			
	inside diameter	Type:			
	operating pressure	Flow rate:			
	window material	Capacity:			
	window thickness	**Radioactive Sources**			
Vacuum Vessels			permanent installation	**Target Materials**	
	inside diameter		temporary use		Beryllium (Be)
	operating pressure	Type:			Lithium (Li)
	window material	Strength:			Mercury (Hg)
	window thickness	**Hazardous Chemicals**			Lead (Pb)
Lasers			Cyanide plating materials		Tungsten (W)
	Permanent installation		Scintillation Oil		Uranium (U)
	Temporary installation		PCBs		Other
	Calibration		Methane	**Mechanical Structures**	
	Alignment		TMAE		Lifting devices
type:			TEA	X	Motion controllers - manual
Wattage:			photographic developers		scaffolding/elevated platforms
class:			Other: Activated Water?		Others