Fermilab

Directorate

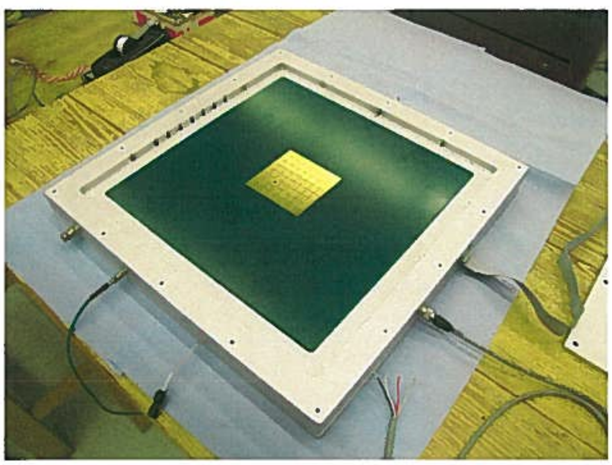
MEMORANDUM OF UNDERSTANDING

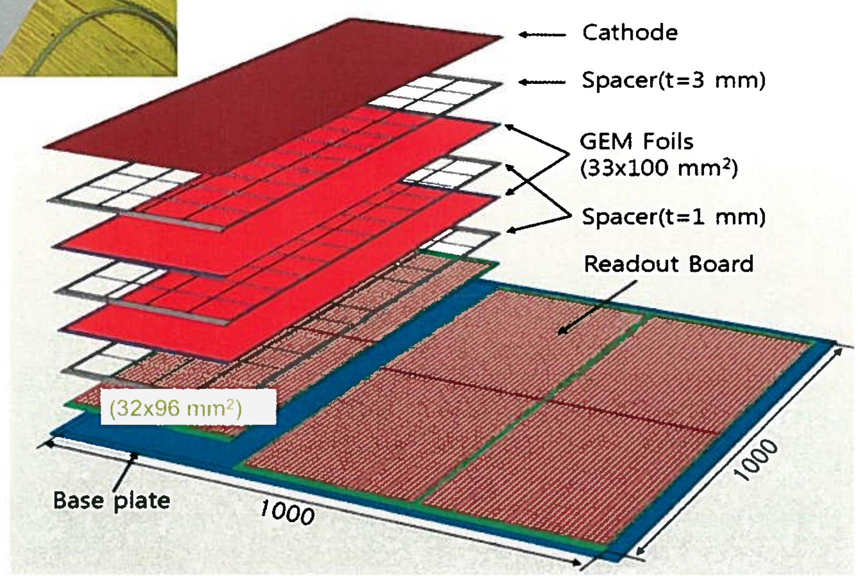
FOR THE 2011 FERMILAB TEST BEAM FACILITY PROGRAM

T-1010

Gas Electron Multiplier (GEM) Chamber Characteristics Test

January 11, 2011





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INTRODUCTION

This is a memorandum of understanding between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of the University of Texas Arlington who have committed to participate in beam tests to be carried out during the 2011 Fermilab Test Beam Facility program. This is an updated version of the previous beam test (T-964) in March 2007 testing Gas Electron Multiplier chambers for the International Linear Collider (ILC) Digital Hadron Calorimeter R&D.

The memorandum is intended solely for the purpose of recording expectations for budget estimates and work allocations 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 modify this memorandum to reflect such required adjustments. Actual contractual obligations will be set forth in separate documents.

Description of Detector and Tests:

Gas Electron Multipliers (GEMs) have been used in many HEP experiments as tracking detectors. They are sensitive to X-rays which allows use beyond that of HEP. The UTA High Energy group has been working on using GEMs as the sensitive gap detector in a DHCAL for the ILC. The physics goals at the ILC put a stringent requirement on detector performance. Especially the precision required for jet mass and positions demands an unprecedented jet energy resolution to hadronic calorimeters. A solution to meet this requirement is using the Particle Flow Algorithm (PFA). In order for PFA to work well, high calorimeter granularity is necessary. Previous studies based on GEANT simulations using GEM DHCAL gave confidence on the performance of GEM in the sensitive gap in a sampling calorimeter and its use as a DHCAL in PFA.

The UTA HEP team has built several GEM prototype chambers, including the current 30cmx30cm chamber integrated with the SLAC-developed 64 channel kPiX analog readout chip. This chamber has been tested on the bench using radioactive sources and cosmic ray muons.

In order to have fuller understanding of various chamber characteristics, the experimenters plan to expose 1 – 3 GEM chambers of dimension $35\text{cm}\times 35\text{cm}\times 5\text{cm}$ with $1\text{cm}\times 1\text{cm}$ pad granularity with 64 channel 2-D simultaneous readout using the kPiX chip. In this experiment the experimenters plan to measure MiP signal height, chamber absolute efficiencies, chamber gain versus high voltage across the GEM gap, the uniformity of the chamber across the 8cmx8cm area, cross talk and its distance dependence to the triggered pad, chamber rate capabilities, and the maximum pad occupancy rate.

I. PERSONNEL AND INSTITUTIONS:

Spokesperson and Physicist in Charge of beam tests: Jae Yu

Fermilab liaison: Aria Soha

The group members at present are:

	Institution	Collaborator	Rank/Position	Other Commitments
1.1	University of Texas at Arlington	Jae Yu	Associate Professor	ATLAS, ILC
		Andy White	Professor	DØ, ATLAS, ILC
		Seongtae Park	Senior Researcher	ATLAS, ILC
		Changhie Hahn	Visiting Researcher	ILC
		Edwin Baldeloma	Undergraduate	ILC
		Nam Tran	Undergraduate	ILC
		Austin McIntire	Undergraduate	ILC

II. Experimental Area, Beams and Schedule Considerations:

2.1 Location

2.1.1 The experiment is to take place in the MTEST beamline and will be situated in the MT6 enclosure. The experimenters' first choice for location, in the same enclosure as the T-978 experiment, is MT6-2C on the existing motion table.

2.1.2 Space for a CAMAC crate and a NIM crate, low voltage power supplies and DAQ computers will be needed inside the enclosure. In addition, the main control room to the west of the MTest beamline will be used to house DAQ control and monitoring computers, and should provide a limited amount of work space for five people after the setup completes.

2.2 Beam

2.2.1 Beam Types and Intensities

Energy of beam: >10 GeV
Particles: 120 GeV protons and >10 GeV secondaries (muons,pions, electrons)
Intensity: 400 – 10k particles/4 sec spill
Beam spot size: less than 8x8 cm^2

2.2.2 Beam Sharing

It is not ideal for GEM chambers to run downstream of other detectors that present high radiation lengths of material except for the setup stage. High momentum muon runs will allow such a concurrent running. Therefore, the experiment can share the beam with others, so long as additional experiments are located downstream of the detector setup.

2.3 Experimental Conditions

2.3.1 Apparatus

The detector setup will consist only of one UTA 64 channel chamber of dimension $35cm \times 35cm \times 5cm$. This chamber will be surrounded by two $10cm \times 10cm$ scintillation counters. These counters will cover the central active area of the chamber. The experimenters also plan on constructing prototype chambers of dimension $33cm \times 100cm \times 1.5cm$ and testing in beam before putting three of these chambers together to make up $1m \times 1m \times 1.5cm$ detector planes that can be put into the existing CALICE stack for DCAL testing.

This setup of the chambers sandwiched by the two large scintillation counters will be placed on the movable table. The coincidence of these two large counters along with three 1cmx1cm finger counters placed in front of the chamber but off the movable array will provide the primary trigger. This setup allows the chamber array to move with respect to the beam location for the position scan.

Access to the beam area will be needed periodically for installation and cabling.

2.3.2 Electronics Needs

The trigger will be formed using NIM coincidence modules. Space for a NIM crate near the trigger counters is needed. The experimenters will set up trigger counters, using components already in existence at FTBF or at the Fermilab equipment pool.

Each $1\text{cm} \times 1\text{cm}$ pad in the GEM anode board is connected to a preamplifier mounted on the chamber. The signal from the preamplifiers is then fed into a shaper to increase the width of 50ns chamber signal to 4 – 10 μs. The shaper is going to be powered through a CAMAC crate. So the experimenters need a space to hold this CAMAC crate near the chamber array. The signal from the shaper board is then sent to the ADLINK ADC card installed in the DAQ computer via two 2m long SCSI cables. This DAQ computer must be located close to the chamber array inside the enclosure. This computer must be on the local area network since it is controlled and monitored by another computer outside the beam enclosure.

Droege HV supplies are used to power the chambers, and thus need rack space to hold and power a NIM crate. The experiment will also need rack space to mount three low voltage power supplies.

See Appendix II for an equipment request list.

2.3.3 Description of Tests

In order to have fuller understanding of various chamber characteristics, the experimenters plan to expose 1 – 3 GEM chambers of dimension $35\text{cm} \times 35\text{cm} \times 5\text{cm}$ with $1\text{cm} \times 1\text{cm}$ pad granularity with 64 channel 2-D simultaneous readout using the kPiX chip. In this experiment the experimenters plan to measure MiP signal height, chamber absolute efficiencies, chamber gain versus high voltage across the GEM gap, the uniformity of the chamber across the 8cmx8cm area, cross talk and its distance dependence to the triggered pad, chamber rate capabilities, and the maximum pad occupancy rate.

Beams of momentum selected muons, pions and electrons above 10 GeV/c range and 120GeV proton to minimize multiple scattering effects will be needed for MiP identification and various position and HV scans, both transverse and longitudinal. Triggered beam spot sizes will be controlled using a set of two $2cm \times 3cm$ counters perpendicular to each other to form $2cm \times 2cm$ trigger area in the center of the $8cm \times 8cm$ active area of the chamber. These two trigger paddles will sandwich the chamber to form coincidence by themselves and with two $10cm \times 10cm$ scintillation counters for broader beam profile trigger in the active area of the chamber. The experimenters request a week of dedicated or secondary running for these tests.

For the above, a rate of approximately 100 Hz is assumed.

2.4 Schedule

Initially, the experimenters will run in January of 2011 for 1 – 2 weeks as a secondary to the T-978 beam run. Additional 1 – 2 week periods will be requested as the primary experiment throughout the years 2011 and 2012. The experiment plans to run during the 14 hour beam period allowed for data taking.

III. RESPONSIBILITIES BY INSTITUTION – NON FERMILAB

3.1 UNIVERSITY OF TEXAS AT ARLINGTON

The University of Texas at Arlington team is solely responsible for this beam test and the equipment as follows. [Cost in USD]

- The detectors and electronics	
- $35\text{cm} \times 35\text{cm} \times 5\text{cm}$ UTA chamber	[3K]
- $33\text{cm} \times 100\text{cm} \times 1.5\text{cm}$ UTA chamber	[10K]
- Electronics cards for the chambers	[10K]
- Scope	[15K]
- Pulser	[3K]
- LV Power supplies	[3K]
- Cables	[1K]
- 2 sets of PCs and monitors	[5K]
- Beam trigger telescope set	[2K]

IV. Responsibilities by Institution – Fermilab

4.1 Fermilab Accelerator Division:

4.1.1 Use of MTest beam as outlined in Section II.
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 Scalers and beam counter signals should be made available in the counting house.
4.1.4 Reasonable access to the equipment in the MTest beamline.
4.1.5 Connection to beams control console and remote logging (ACNET) should be made available.
4.1.6 The test beam energy and beam line elements will be under the control of the AD Operations Department Main Control Room (MCR). [0.5 person weeks]
4.1.7 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 may be delegated to the experimenters as long as it does not violate the Shielding Assessment or provide potential for significant equipment damage.
4.1.8 The integrated effect of running this and other SY120 beams will not reduce the antiproton stacking rate and the neutrino flux by more than 5% globally, 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 Fermilab Test Beam Facility. Requirements for the beam and user facilities are given in Section II. 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 computers. [1 person-weeks]
4.2.2 Pre-mixed ArCO2 (80/20) gas in 50” bottles [$0.2k]

4.3 Fermilab Computing Division

4.3.1 Internet access should be continuously available in the counting house.
4.3.2 Registering of IP addresses to UTA DAQ and analysis computers for access from outside the enclosure.
4.3.3 See Appendix II for summary of PREP equipment pool needs.

4.4 Fermilab ES&H Section

4.4.1 Assistance with safety reviews.
4.4.2 The experiment needs Fe55, Cs137 and RU106 radioactive sources to ensure the functionality of the chamber.
4.4.3 Provide necessary training for experimenters.

V. SUMMARY OF COSTS

Source of Funds [$K]	Materials & Services	Labor (person-weeks)
Particle Physics Division	0.2	1.0
Accelerator Division	0	0.5
Computing Division	0	0
Totals Fermilab	$0.2K	1.5
Totals Non-Fermilab	$42K	7

VI. SPECIAL CONSIDERATIONS

6.1 The responsibilities of the Spokespersons and the procedures to be followed by experimenters are found in the Fermilab publication "Procedures for Experimenters": (http://www.fnal.gov/directorate/documents/index.html). The Spokespersons agree 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 Spokespersons will follow those procedures in a timely manner, as well as any other requirements put forth by the division's safety officer.

6.3 The spokespersons will ensure at least one person is present at the Fermilab 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 Spokespersons 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 experimenters will be responsible for maintaining both the electronics and the computing hardware supplied by them for the experiment. Fermilab will be responsible for repair and maintenance of the Fermilab-supplied electronics listed in Appendix II. Any items for which the experiment requests that Fermilab performs maintenance and repair should appear explicitly in this agreement.

At the completion of the experiment:

6.8 The Spokespersons are 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 Spokespersons will be required to furnish, in writing, an explanation for any non-return.

6.9 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 unless removal requires facilities and personnel not able to be supplied by them, such a rigging, crane operation, etc.

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

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

SIGNATURES:

_______________________________________ 3 / 1 / 1 / 2010

Jaehoon Yu, The University of Texas at Arlington

_______________________________________ 1 / 11 / 2010

Michael Lindgren, Particle Physics Division

_______________________________________ 1 / 14 / 2010

Roger Dixon, Accelerator Division

_______________________________________ 1 / 12 / 2010

Peter Cooper, Computing Division

_______________________________________ 1 / 12 / 2010

Nancy Grossman, ES&H Section

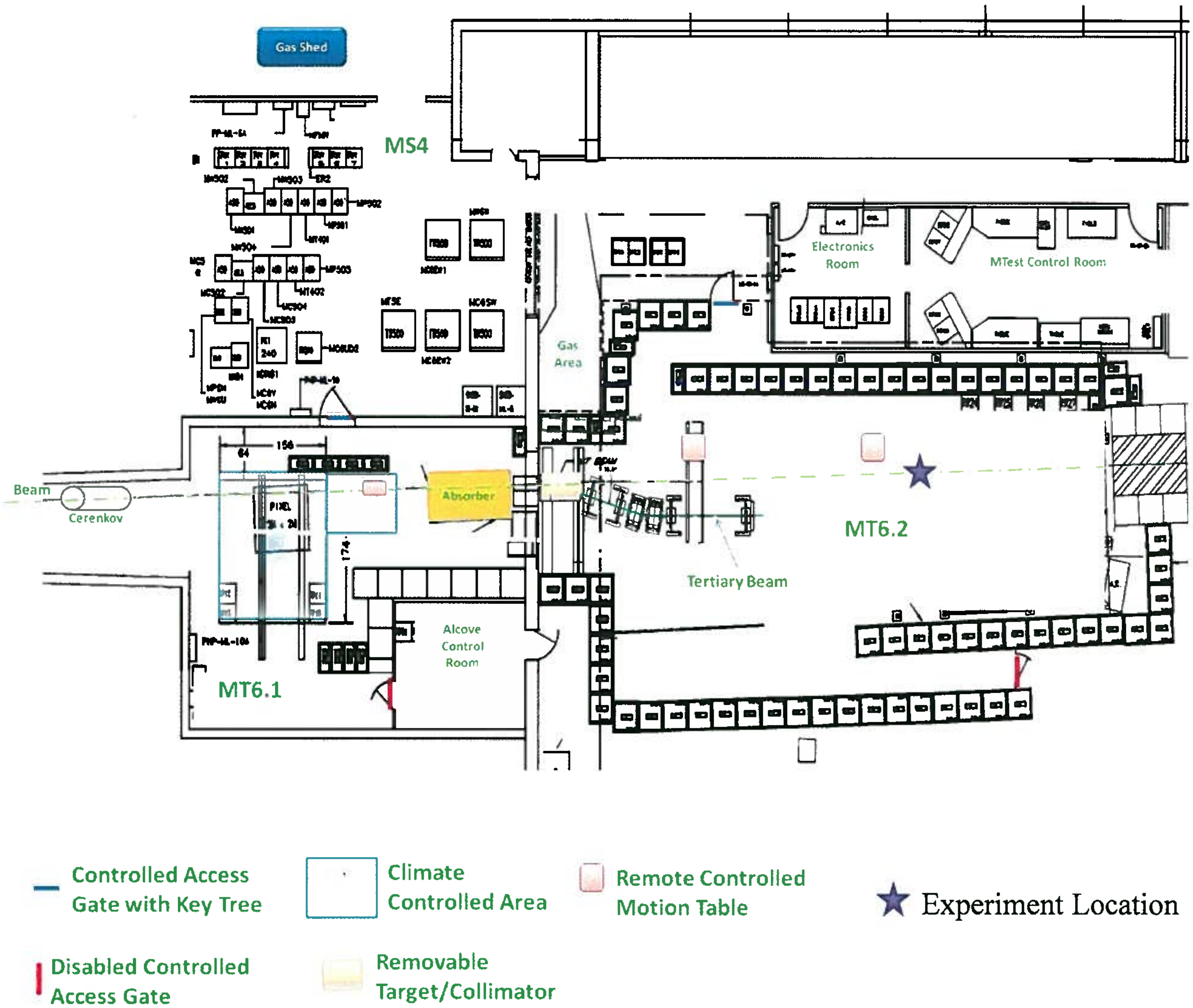
_______________________________________ 1 / 14 / 2010

Greg Bock, Associate Director for Research, Fermilab

_______________________________________ 1 / 27 / 2010

Stuart Henderson, Associate Director for Accelerators, Fermilab

APPENDIX I: MT6 AREA LAYOUT



Appendix II: Equipment Needs

Equipment Pool and PPD items needed for Fermilab test beam, on the first day of setup.

PREP Equipment Pool:

Quantity	Description
3	Four fold coincidence logic units
2	Droege negative power supplies: two channel supplies
3	Quad discriminators
2	NIM crates: with power supplies attached
2	CAMAC crates
2	Logic gates: quad channel
2	visual scalers: two channel scalers
3	Fanout modules
2	Digital oscilloscopes (0.5GHz)

APPENDIX III: - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need have been checked.

Cryogenics		**Electrical Equipment**		**Flammable Gases or Liquids**	
	Beam line magnets		Cryo/Electrical devices	Type:	
	Analysis magnets		capacitor banks	Flow rate:	
	Target	x	high voltage (-2100V)	Capacity:	
	Bubble chamber		exposed equipment over 50 V	**Hazardous/Toxic Materials**	
Pressure Vessels		**Other Gas Emissions**		List hazardous/toxic materials planned for use in a beam line or experimental enclosure:	
	inside diameter	Type:	Ar/CO_2		
	operating pressure	Flow rate:	one 2200 psi-g bottle/week		
	window material	Capacity:			
	window thickness	**Radioactive Sources**			
Vacuum Vessels			permanent installation	**Target Materials**	
	inside diameter	x	temporary use		Beryllium (Be)
	operating pressure	Type:	**Fe55, Cs137, Ru106**		Lithium (Li)
	window material	Strength:	**1 - 10μCi**		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		Motion controllers
Wattage:			photographic developers		scaffolding/elevated platforms
class:			Other: Activated Water?		Others