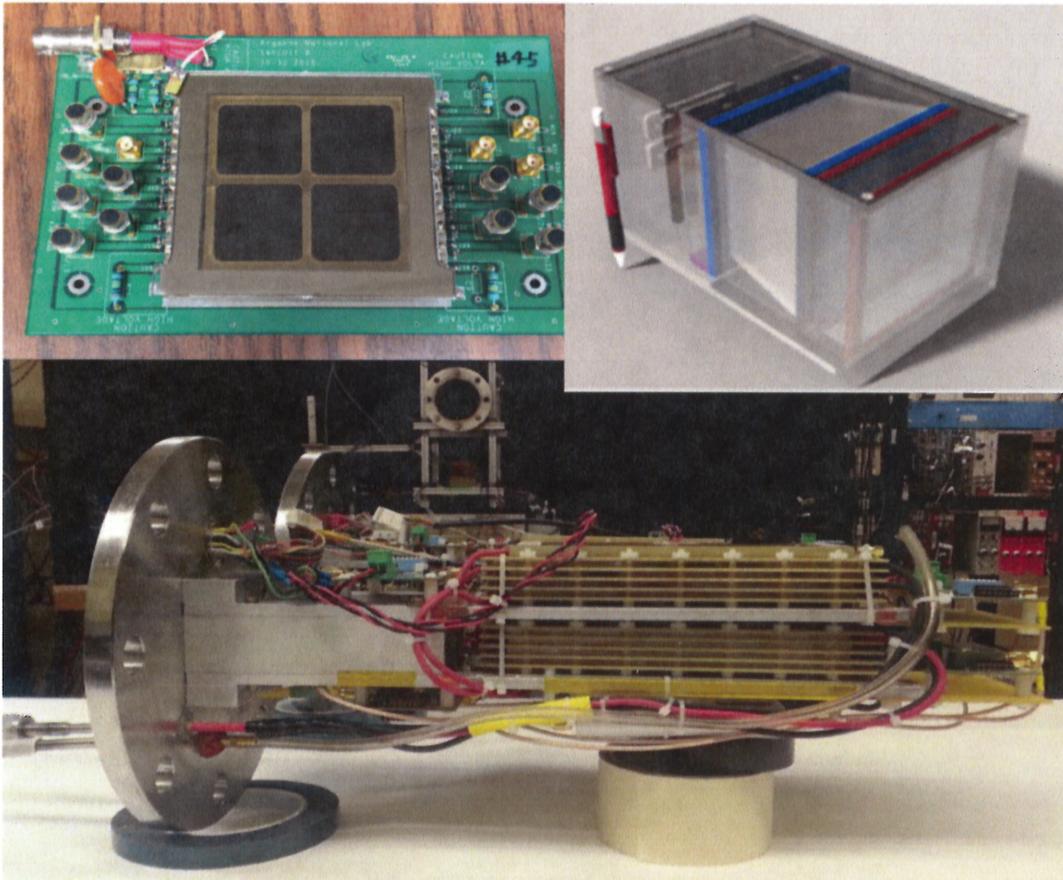


**TECHNICAL SCOPE OF WORK  
FOR THE 2016 FERMILAB TEST BEAM FACILITY PROGRAM**

**T-1048**

**EIC PID R&D: 10 ps TOF and AGEL RICH**

March 8, 2016



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**INTRODUCTION**

This is a technical scope of work (TSW) between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of BNL, UIUC, Howard, ACU, ANL, Georgia State, LANL, Duke, and INFN, who have committed to participate in beam tests to be carried out during the 2016 Fermilab Test Beam Facility program.

The TSW is intended primarily 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 scope of work to reflect such required adjustments. Actual contractual obligations will be set forth in separate documents.

This TSW fulfills Article 1 (facilities and scope of work) of the User Agreements signed (or still to be signed) by an authorized representative of each institution collaborating on this experiment.

*Description of Detector and Tests:*

The highest priority for a new facility in the U.S. Nuclear Physics community is an electron-Ion Collider (EIC), capable of colliding electrons on Ions or polarized protons at center of mass energies that will be roughly about a third of Hera, but with luminosities 100 times higher. The experimenters are part of the eRD14 consortium developing detectors to be used at an eventual EIC experiment for particle identification (PID). Three different technologies will be tested during this beam test: 6x6 cm<sup>2</sup> LAPPD-style micro-channel plate PMTs (MCP-PMTs) from Argonne, a modular Aerogel RICH, and various multi-gap Resistive Plate Chambers (mRPCs). Brief descriptions of each detector are given below, along with the test beam goals.

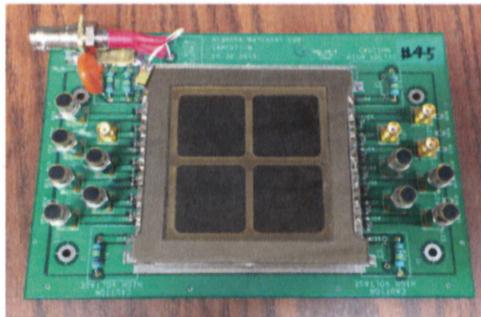


Figure 1: Argonne MCP-PMT

Argonne’s “small tile facility” was created to build small R&D versions of MCP-PMTs to aid in the development of new ideas and designs for LAPPD MCP-PMTs. One of the MCP-PMT’s is shown in Fig. 1. LAPPD is a consortium that has developed a MCP-PMT based on atomic layer deposition on glass capillary arrays to make the micro-channel plates. MCP-PMTs have long been known for their extraordinary performance, with transit-time spreads of ~50 ps, very high gain and high rate capability. They are also known for their prohibitive costs, with a typical price of \$12K for a 6x6 cm<sup>2</sup> PMT. The LAPPD MCP-PMTs, with their much simpler production method, is expected to bring the cost of MCP-PMTs down by an order of magnitude. This would allow future experiments to have contiguous, high performance photo-detector

coverage over many square meters at a reasonable cost. Thus one could have MCP-PMT as the sensor readout for a RICH or TOF wall. The experimenters expect to test, for the first time, one of the Argonne MCP-PMTs from their small tile facility. Features such as its rate capability, its uniformity, its timing performance, and its noise characteristics under realistic conditions, will be studied.

The second technology to be tested is a modular Ring Imaging Cherenkov (mRICH) detector for the hadron particle identification in the forward region of the EIC experiments for separating pions, kaons and protons at momenta below 15 GeV/c. A prototype mRICH detector has been constructed at Georgia State University. It consists a block of aerogel block at front, a thin Fresnel lens, a four-sided mirror set, and a photon sensor readout plane. All of these components are installed inside a holder box made of black acrylic for light tightness. Figure below shows the design of the mRICH detector (in left panel) and the constructed holder box both in the middle panel (without the top cover) and in the right panel (with the top cover).



Figure 2: Modular AGEL RICH

The dimension of the holder box is 5" x 5" x 10". The total weight of the prototype is about 5 lb. The whole mRICH box is mounted inside an extruded aluminum frame together with two sets of scintillator fiber hodoscopes for triggering on beam particles.

Beam particles enter the box and generate Cherenkov lights while traversing the aerogel block. The light is then focused via a thin Fresnel lens and gets reflected by mirrors before arriving at the photosensor readout plane.

The mRICH performance has been extensively studied over the past two years using the GEANT4 software package. This test will allow the experimenters to study the detector performance under real beam conditions and to compare with the simulated results. This test will also allow the experimenter to carefully study the various background photons which possibly hit the sensor plane in order to improve future detector design.



Figure 3: Multi-Gap Resistive Plate Chamber

The third technology being tested, mRPC's, are gaseous detectors consisting of multiple thin glass plates that are stacked on top of each other. Each plate is separated by about 150  $\mu\text{m}$  using, for instance, fishing line, and a high voltage is applied across the gas gaps. When a charged particle crosses the detector, a fast electron avalanche is generated in the gas gaps. Interleaved between the stacks are copper cathodes which pick up the fast signal inductively. Due to their low cost and good performance of  $\sim 100$  ps, mRPC's are currently used extensively as TOF PID detectors in many experiments (Alice, PHENIX, and STAR, for example). The experimenter's current research focuses on improving the timing resolution of mRPCs by an order of magnitude to about 10 ps. This is thought to be possible by, among other changes, increasing the number of gaps and reducing the size of the gaps. An early glass mRPC prototype built by the experimenters was tested at the FTBF as part of T1048. This latest version has achieved 18 ps timing resolution with cosmic muons in the lab, and is shown in figure 3. The experimenters will also test a mRPC variant made using 3D printed plastics, and possibly a variant made with mylar. Both have the potential of dramatically reducing the cost, while maintaining or even improving the timing performance beyond 18 ps. In the beam test the timing and spatial resolution of the mRPC prototypes will be studied as a function of beam rate, position, angle, gas mixture, and particle type (electron vs hadron, etc).

The above three technologies are among the leading candidates to be used for PID detectors at the EIC, and each push the state of the art in performance and sometimes in cost. The experiments will run over the 4 weeks parasitically off the T1044 sPHENIX Calorimeter beam-time without interfering with T1044, which means that the experiments will be conducted when T1044 is not using the beam, likely during the overnight hours. The PID detectors above are thick enough to be detrimental to the calorimeter studies if they were in the beam-line. Within our experiment the three detectors will share the beam-time, either by running concurrently or staggered one week at a time.

## EIC PID R&D

### PERSONNEL AND INSTITUTIONS:

Spokesperson: Mickey Chiu

Lead Experimenters in charge of beam tests: Mickey Chiu (mRPC), Junqi Xie (MCP-PMT), Xiaochun He (AGEL RICH)

Fermilab Experiment Liaison Officer: Mandy Rominsky

The group members at present are:

	<u>Institution</u>	<u>Country</u>	<u>User</u>	<u>Rank/Position</u>	<u>Other Commitments</u>
1.1	Brookhaven National Laboratory	USA	Mickey Chiu	Physicist	PHENIX, sPHENIX, NEXO
			Edward Kistenev	Physicist	PHENIX, sPHENIX
			Andrey Sukhanov	Scientist	PHENIX, sPHENIX
			Bob Azmoun	Physics Associate	PHENIX, sPHENIX
1.2	Univ of Illinois at Urbana-Champaign	USA	Matthias Perdekamp	Professor	PHENIX, sPHENIX, COMPASS
1.3	Howard University	USA	Marcus Alfred	Professor	PHENIX, sPHENIX
1.4	Abilene Christian University	USA	Rusty Towell	Professor	PHENIX, sPHENIX
1.5	Argonne National Laboratory	USA	Junqi Xie	Scientist	LAPPD
1.6	Georgia State University	USA	Xiaochun He	Professor	PHENIX, sPHENIX
1.7	Los Alamos National Lab	USA	Hubert vanHecke	Physicist	PHENIX, sPHENIX
1.8	INFN	Italy	Marco Contalbrigo	Physicist	mRICH
1.9	Duke University	USA	Zhiwen Zhao	Physicist	mRICH

**IV. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS:**2.1 LOCATION

2.1.1 The beam test(s) will take place around MT6.2B, as shown in Appendix I. The T1044 EMCAL will use the 2B table for the first week of the data-taking period. During this time, the mRPC, MCP-PMT, and AGEL RICH will be placed downstream of the EMCAL, just behind table 2B. After approximately the first week, the EMCAL will be moved downstream to the MT6.2D area to be mated to the HCAL. The mRPC will then take over the 2B table.

2.1.2 A clean work space may be needed to work on detector repairs or modifications.

2.2 BEAM

## 2.2.1 BEAM TYPES AND INTENSITIES

Energy of beam: 4-120 GeV

Particles: pions, kaons, protons, muons

Intensity: 10 – 100k particles/ 4 sec spill

Beam spot size: about 1-10cm<sup>2</sup>

For the rate capability tests, we would like particle rates of about 1 Hz/cm<sup>2</sup> to 10 kHz/cm<sup>2</sup>.

## 2.2.2 BEAM SHARING

The three detector types in this experiment are all O(10%) of a radiation length, and therefore can significantly impact the calorimeter tests. Therefore they should all be out of the beam-line when the calorimeters are running their studies. Within this experiment, for some studies the beam can be used concurrently, while for other studies the experiments may want no interference from any other detectors in the beam-line. For concurrent running, the detectors will be ordered by their thickness in terms of radiation and interaction lengths, with the thinner detectors placed further upstream. The FTBF wire chambers are thin enough that we do not expect any issues with them in the beam-line.

2.3 EXPERIMENTAL CONDITIONS

## 2.3.1 AREA INFRASTRUCTURE

The ANL MCP-PMT is only about 8x12 cm<sup>2</sup>, in the transverse dimensions, and about 2 cm in the longitudinal direction. Each PMT weighs less than 0.5 kg, can be placed on a stand in the beam-line.

The AGEL RICH is similarly small and light, about 5x5x10 in<sup>3</sup>, and less than 5 kg. It will be used on Table 2B.

The mRPC's are housed in gas-tight metal cylinders. There will be two cylinders, one from UIUC and one from BNL. The larger of the two has a diameter of 34.2 cm and a height of 52 cm. This cylinder was used in T1048, Feb 2014. The two gas cylinders will sit on Table 2B

## EIC PID R&D

during data-taking periods. The larger of the two cylinders weighs about 20 kg fully loaded with mRPCs, while the smaller one is about 10 kg. The mRPC's use a mixture of R134A/isobutane/SF<sub>6</sub>, with nominal percentages of 95/4.5/0.5%. We may vary the percentages of the isobutane and/or SF<sub>6</sub> up to a maximum of 10%. The gases should be provided from 3 independent cylinders into a gas mixing rack, with the output going to a gas distribution rack that feeds up to four independent gas volumes. These racks are the same as the ones used in the Feb 2014 T1048 run. The isobutane flow controller in the gas mixing rack is slaved to the R134A, so that if the R134A flow goes to zero, the isobutane will also stop flowing. Help in acquiring the gases (R134A, isobutene, and SF<sub>6</sub>) would be appreciated.

The experimenters would also like to use 3 FTBF wire chambers for tracking particles through the detectors, and at least two scintillators for triggering.

### 2.3.2 ELECTRONICS AND COMPUTING NEEDS

The MCP-PMTs are digitized by the PSEC4 board, and readout by a standard PC serving as the DAQ computer. The PSEC4 is described at <http://hep.uchicago.edu/~eric/?ic/PSEC4/>. Standard linear supplies will be used to supply the LV, and a Bertan NIM HV module will provide the HV of ~2 kV.

The mRPC's are amplified by TI LMH5401 evaluation boards or similar variants, or by a custom preamp board based on the TI LMH. Information on this custom preamp board is available at <https://www.phenix.bnl.gov/WWW/publish/chiu/pstof/electronics/>. The amplified signals are then digitized using DRS4 evaluation boards (<https://www.psi.ch/drs/evaluation-board>), or a CAEN DT5472 waveform digitizer. The data from the digitizers is read into a standard DAQ PC. The LV is supplied by standard benchtop supplies. The HV of  $\pm 10$  kV is supplied by a CAEN A1526 module, powered from a SY1527 mainframe.

The modular RICH readout is composed by three boards as described in [http://inf.nfe.infn.it/~mcontalb/JLAB12/RICH\\_midterm\\_review/RICH\\_Electronics\\_Turisini.pdf](http://inf.nfe.infn.it/~mcontalb/JLAB12/RICH_midterm_review/RICH_Electronics_Turisini.pdf). The adapter board is a passive board mounting connectors to couple the MA-PMTs socket to the electronics. The ASIC board is based on the MAROC3 chip by OMEGA described in [http://omega.in2p3.fr/index.php/download-center/doc\\_details/393-proceedingsieeens2010maroc3.html](http://omega.in2p3.fr/index.php/download-center/doc_details/393-proceedingsieeens2010maroc3.html) served by voltage regulators, e.g. AD5620 by Analog Devices. The FPGA board is based on the Xilinx Artix7 and uses the Finisar FTE8510N1LCN optical transceiver to connect to a N-GXE-LC-01 fiber gigabit Ethernet to PCI express bus adapter in the readout computer.

Our DAQ computers will need to be networked in order to transfer data to outside servers. As one possibility, we may connect our DAQ computers to a private internal network that is gatewayed to the FNAL network, similar to the set-up by Martin Purschke during the T1044 test in Feb 2014, but we would also be okay with connecting directly to the FNAL network if that is the only choice.

See Appendix II for summary of PREP equipment pool needs.

### 2.3.3 DESCRIPTION OF TESTS

It is expected that the AGEL RICH and MCP-PMTs will need no major effort to install in the beam-line. A movable stand will need to be provided for the MCP-PMTs, and a rolling table would be ideal for the AGEL RICH. The mRPCs will need a technician to hook up the gas lines, from the cylinders to the mixing racks, and from there to the gas cylinders. It is expected that this will take a few hours for the initial installation. From our experience last time, there was some difficulty getting the gases delivered in time, so any help in procuring the gases for our mRPC test would be appreciated.

As stated previously, the experimenters expect to run overnight (midnight to 8AM), to avoid disturbing the T1044 studies. Generally only a few accesses are expected to be required, except when doing a position or angle scan. During those scans, which will happen perhaps two days per week, the experimenters will need to go in regularly to move the detectors by hand, since some of the detectors are not on remotely movable tables.

For many studies we expect to run with 120 GeV protons. For the rate tests, we hope to be able to vary the rate from a few Hz/cm<sup>2</sup> to 10 kHz/cm<sup>2</sup>.

## 2.4 SCHEDULE

The experiment expects to request a few weeks of running every year for the next few years, while the EIC Detector R&D Program is active. Sometime after 2020 the R&D program is expected to move to an active construction program, and testing will continue using the PID technologies that are accepted for the EIC detector.

### *Experimental Planning Milestones*

- 1 Mar 2016    Begin procurement of gas for mRPC detectors
- Mar 2016     Detectors and equipment are shipped to FTBF
- 3 Apr 2016    Experimenters arrive at FNAL to be ready for ID application and training starting Monday
- 6 Apr 2016    Installation of detectors in MT6.2B area
- 7 Apr-3 May    Data-taking period

**VI. RESPONSIBILITIES BY INSTITUTION – NON FERMILAB**

3.1 NAME OF INSTITUTION:

- Brookhaven National Laboratory;
  - mRPC Detector: \$0K
  - Readout and DAQ Electronics: \$50K
  - Installation and commissioning of detectors
  - Staffing of data taking shifts
  - Data Analysis
- University of Illinois at Urbana-Champaign
  - mRPC Detector: \$50K
  - Readout and DAQ Electronics: \$50K
  - Installation and commissioning of detectors
  - Staffing of data taking shifts
  - Data Analysis
- Howard University
  - Installation and commissioning of mRPC
  - Staffing of data taking shifts
  - Data Analysis
- Abilene Christian University
  - Installation and commissioning of mRPC
  - Staffing of data taking shifts
- Argonne National Laboratory
  - MCP-PMT Detector: \$25K
  - Readout and DAQ Electronics: \$25K
  - Installation and commissioning of detectors

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- Staffing of data taking shifts
- Data Analysis
- Georgia State University
  - AGEL RICH Detector: \$XXX
  - Installation and commissioning of detectors
  - Staffing of data taking shifts
  - Data Analysis
- Los Alamos National Laboratory
  - Installation and commissioning of detectors
  - Staffing of data taking shifts
  - Data Analysis
- Duke University
  - Installation and commissioning of detectors
  - Staffing of data taking shifts
  - Data Analysis
- INFN
  - Installation and commissioning of detectors
  - Staffing of data taking shifts
  - Data Analysis

**V. RESPONSIBILITIES BY INSTITUTION – FERMILAB**

4.1 FERMILAB ACCELERATOR DIVISION:

- 4.1.1 Use of MTest beamline as outlined in Section II. [0.25 FTE/week]
- 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 readouts will be made available via ACNET in the MTest control room.
- 4.1.4 Reasonable access to the equipment in the MTest beamline.
- 4.1.5 Connection to ACNET console and remote logging 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). [0.25 FTE/week]
- 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 neutrino flux by more than an amount set by the office of Program Planning, 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 TSW will make use of the Fermilab Test Beam Facility. Requirements for the beam and user facilities are given in Section II. The Fermilab PPD DDO Test Beam Group 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 FTBF computers. [6.5 FTE/week]
- 4.2.2 Various NIM modules (discriminators, logic modules, gate delay generators), and at least one NIM bin. We also will need help to procure the gases for the mRPC.
- 4.2.3 No cranes or forklifts will be needed.
- 4.2.4 Conduct a NEPA review of the experiment.
- 4.2.5 Provide day-to-day ESH&Q support/oversight/review of work and documents as necessary.
- 4.2.6 Provide safety training as necessary, with assistance from the ESH&Q Section.
- 4.2.7 Update/create ITNA's for users on the experiment.
- 4.2.8 Initiate the ESH&Q Operational Readiness Clearance Review and any other required safety reviews.

4.3 FERMILAB SCIENTIFIC COMPUTING DIVISION

- 4.3.1 Internet access should be continuously available in the MTest control room.
- 4.3.2 The Si tracking system will not be needed.
- 4.3.3 See Appendix II for summary of PREP equipment pool needs.
- 4.3.4 We will use the internal private network set up by T1044.

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### 4.4 FERMILAB ESH&Q SECTION

4.4.1 Assistance with safety reviews.

4.4.2 Provide safety training, with assistance from PPD, as necessary for experimenters. [0.2 FTE]

### 4.5 FERMILAB COLLABORATORS

4.5.1 At the moment we do not have any Fermilab collaborators.

EIC PID R&D

V. SUMMARY OF COSTS

<b>Source of Funds [\$K]</b>	<b>Materials &amp; Services</b>	<b>Labor (person-weeks)</b>
Accelerator Division	0	0.5
Particle Physics Division	0.0	6.5
Scientific Computing Division	0	0
ESH&Q Section	0	0.2
Totals Fermilab	\$0.0K	7.2
Totals Non-Fermilab	0	7.2

## VI. GENERAL CONSIDERATIONS

- 6.1 The responsibilities of the Spokesperson and the procedures to be followed by experimenters are found in the Fermilab publication "Procedures for Researchers": (<http://www.fnal.gov/directorate/PFX/PFX.pdf>). The Spokesperson agrees to those responsibilities and to ensure that the experimenters all follow the described procedures.
- 6.2 To carry out the experiment a number of Environmental, Safety and Health (ESH&Q) reviews are necessary. This includes creating an [Operational Readiness Clearance](#) document in conjunction with the standing Particle Physics Division committee. The Spokesperson 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 Spokesperson 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 ESH&Q 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 Spokesperson 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 Scientific Computing Division management. The Spokesperson also undertakes to ensure no modifications of PREP equipment take place without the knowledge and written consent of the Computing Sector 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.
- 6.8 An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters' Meeting.
- 6.9 The co-spokespersons are the official contact and are responsible for forwarding all pertinent information to the rest of the group, arranging for their training, and requesting ORC or any other necessary approvals for the experiment to run.
- 6.10 The co-spokesperson should ensure the appropriate people (which might be everyone on the experiment) sign up for the test beam emailing list.
- 6.11 The spokesperson, or designee, will generate a one-page summary of the experiment's use of the Test Beam facility during the fiscal year, to be included in the annual Test Beam Report Fermilab submits to the DOE.

### *At the completion of the experiment:*

- 6.12 The Spokesperson 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

## EIC PID R&D

period of one year after the end of running the Spokesperson will be required to furnish, in writing, an explanation for any non-return.

- 6.13 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 ESH&Q 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.

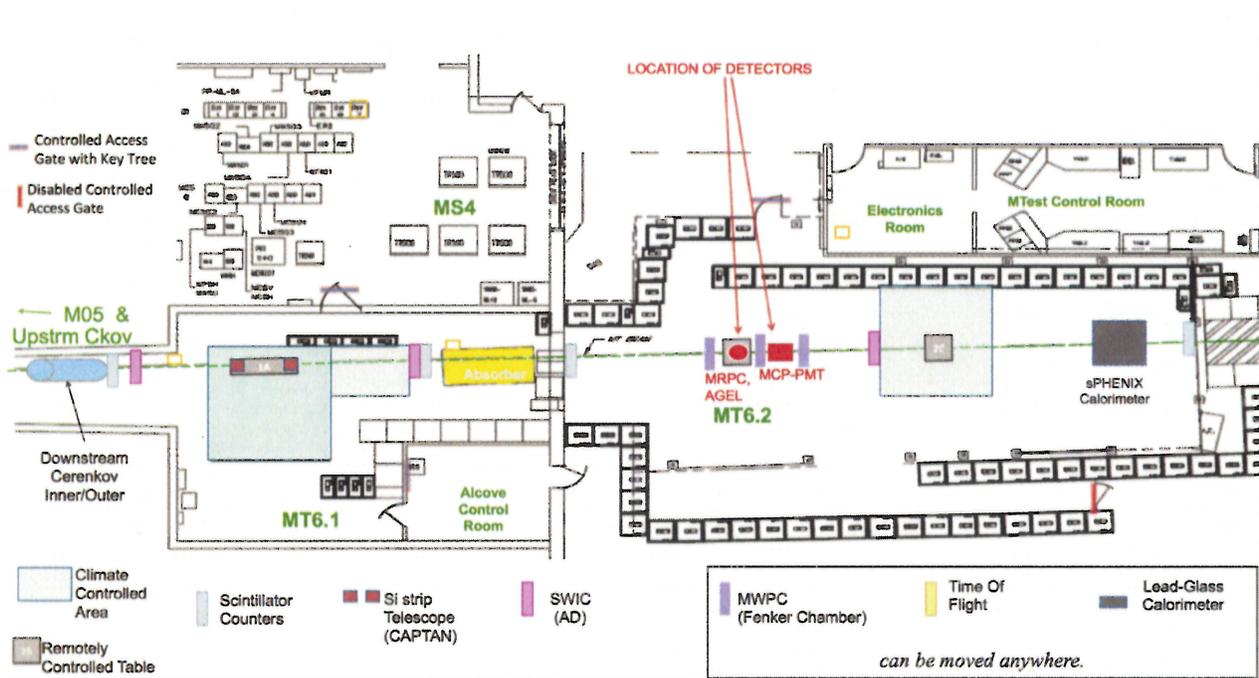
SIGNATURES:

*Mickey Chiu*  
 Mickey Chiu, Experiment Spokesperson

/ / 2015

APPENDIX I: MT6 AREA LAYOUT

The experiment's detectors will be located in the MT6.2B section. The MCP-PMT and AGEL RICH experimenters will set up just behind the 2B table, on a movable stand or rolling table. The mRPC experimenters request use of the 6.2B table after the 1<sup>st</sup> week, when it is expected that the sPHENIX EMCAL is done with their use of the table. The experimenters also want to arrange 3 of the MWPC's along the beam line as in the below picture, to make for easy tracking through the detectors.



MTEST AREAS

**APPENDIX II: EQUIPMENT NEEDS**

Provided by experimenters:

BNL: mRPC prototypes, preamps, DRS4, DAQ computer, Raspberry Pi's, CAEN HV, NIM HV modules

UIUC: mRPC prototypes, preamps, DRS4, DAQ computer

ANL: MCP-PMTs, PSEC4, DAQ computer

Ga State: AGEL RICH

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

PREP EQUIPMENT POOL:

<u>Quantity</u>	<u>Description</u>
12?	NIM Discriminator, Logic, and Gate Delay modules
1	NIM Bin

PPD FTBF:

<u>Quantity</u>	<u>Description</u>
3	MWPC Stations
2	Scintillator Counters (not necessary to include MT6SC1)

EIC PID R&D

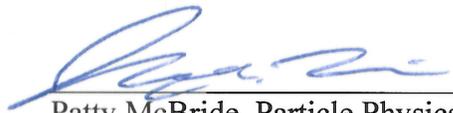
**APPENDIX III: - HAZARD IDENTIFICATION CHECKLIST**

Items for which there is anticipated need should be checked.  
See [ORC Guidelines](#) for detailed descriptions of categories.

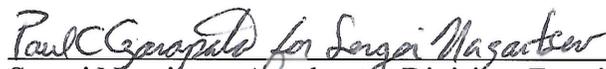
Flammables (Gases or Liquids)		Gasses		Hazardous Chemicals		Other Hazardous /Toxic Materials	
Type:		Type:	R134A/iso/SF6 95/4.5/0.5% ratio	in	Cyanide plating materials	List hazardous/toxic materials planned for use in a beam line or an experimental enclosure:	
Flow rate:		Flow rate:	400 ccm		Hydrofluoric Acid		
Capacity:		Capacity:	640L		Methane		
Radioactive Sources		Target Materials		photographic developers			
	Permanent Installation		Beryllium (Be)	PolyChlorinatedBiphenyls			
	Temporary Use		Lithium (Li)	Scintillation Oil			
Type:			Mercury (Hg)	TEA			
Strength:			Lead (Pb)	TMAE			
Lasers			Tungsten (W)	Other: Activated Water?			
	Permanent installation		Uranium (U)				
	Temporary installation		Other:	Nuclear Materials			
	Calibration	Electrical Equipment		Name:			
	Alignment		Cryo/Electrical devices	Weight:			
Type:			Capacitor Banks	Mechanical Structures			
Wattage:		<input checked="" type="checkbox"/>	High Voltage (50V)	Lifting Devices			
MFR Class:			Exposed Equipment over 50 V	Motion Controllers			
		<input checked="" type="checkbox"/>	Non-commercial/Non-PREP	Scaffolding/ Elevated Platforms			
			Modified Commercial/PREP	Other:			
Vacuum Vessels		Pressure Vessels		Cryogenics			
Inside Diameter:		Inside Diameter:		Beam line magnets			
Operating Pressure:		Operating Pressure:		Analysis magnets			
Window Material:		Window Material:		Target			
Window Thickness:		Window Thickness:		Bubble chamber			

EIC PID R&D

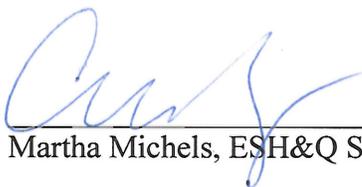
The following people have read this TSW:

  
\_\_\_\_\_  
Patty McBride, Particle Physics Division, Fermilab  
JONATHAN LEWIS

3 / 30 / 2016

  
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Sergei Nagaitsev, Accelerator Division, Fermilab

3 / 24 / 2016

  
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Martha Michels, ESH&Q Section, Fermilab

3 / 22 / 2016

  
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Robert Roser, Chief Information Officer, Fermilab

4 / 1 / 2016

  
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Joe Lykken, Chief Research Officer, Fermilab

3 / 31 / 2016