Fermilab

Directorate

TECHNICAL SCOPE OF WORK
FOR THE 2018 FERMILAB TEST BEAM FACILITY PROGRAM

T-1048

EIC PID R&D: 2nd mRICH Prototype Test

May 30, 2018

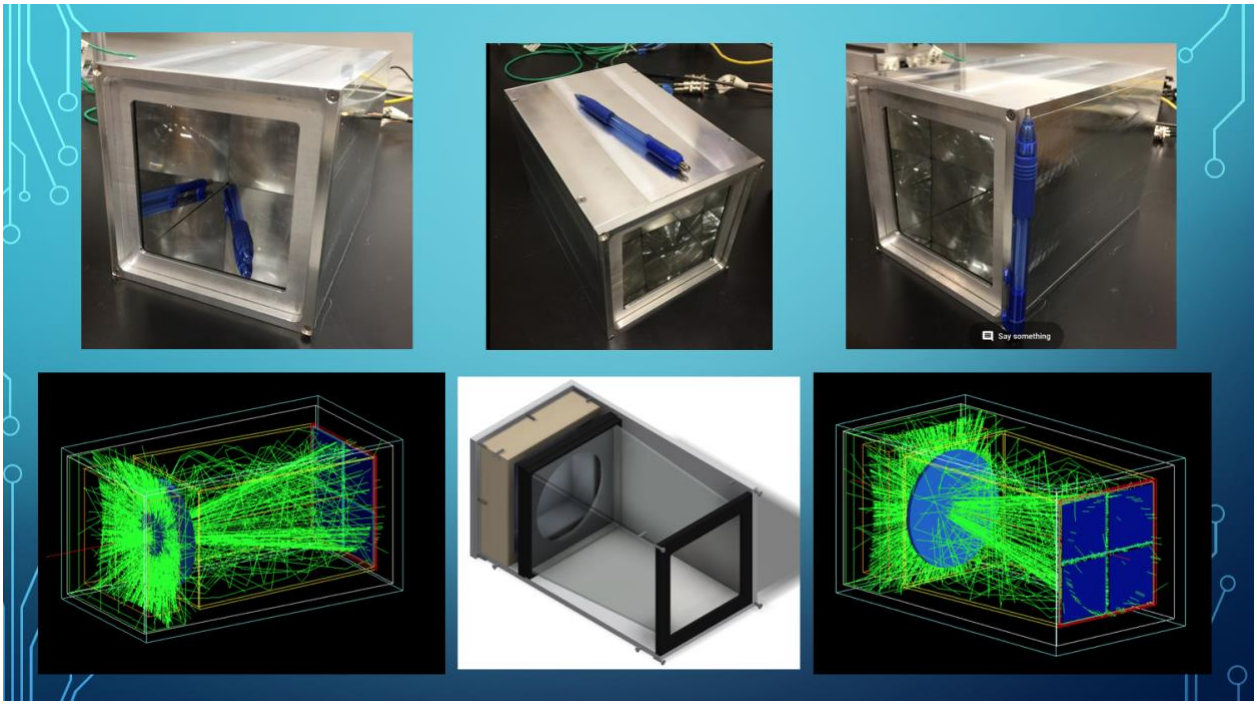


TABLE OF CONTENTS

I. INTRODUCTION

This is a technical scope of work (TSW) between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of the EIC PID Consortium (eRD14) who have committed to participate in beam tests to be carried out during the 2018 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 eventual EIC experiments for particle identification (PID). One of the key PID detectors based on the ring imaging Cherenkov technology is a modular RICH (mRICH) developed by the eRD14 collaboration for kaon and pion identification in momentum range from 3 to 10 GeV/c. This detector could also be used for pion and electron identification below 1.5 GeV/c. The first mRICH prototype has been successfully tested at Fermilab in April of 2016. The results have been published in NIM A 871, (2017) 13-19.

This test will be focused on the PID performance test of the 2nd mRICH prototype. The overall test arrangement is shown in Figure 1 without readout electronics. The setup consists of three main components which include the mRICH detector (shown Figure 2) and a pair of beam hodoscopes (shown in Figure 3).

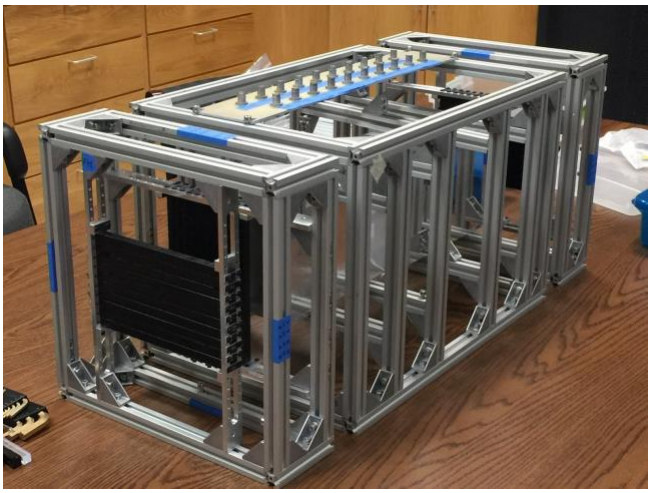


Figure 1: 2nd mRICH prototype in the test stand (at the center) with a pair of beam hodoscopes (front and back).

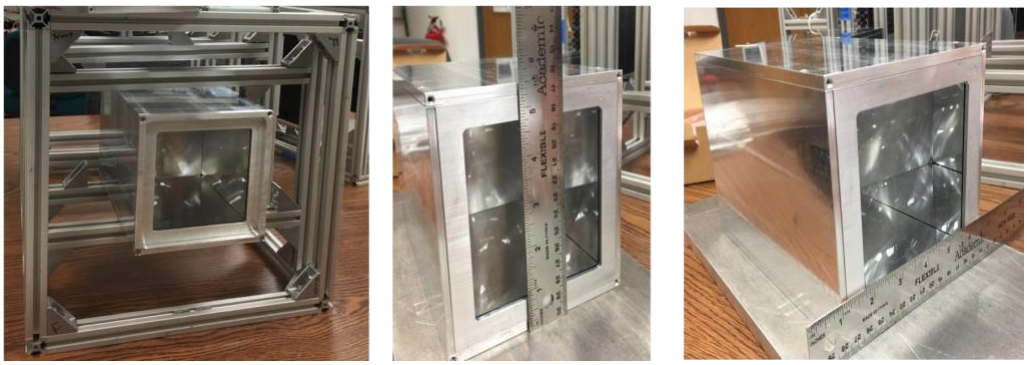


Figure 2 mRICH detector: left picture shows the test stand with the detector mounted at the center; the right two pictures show the detector dimension.

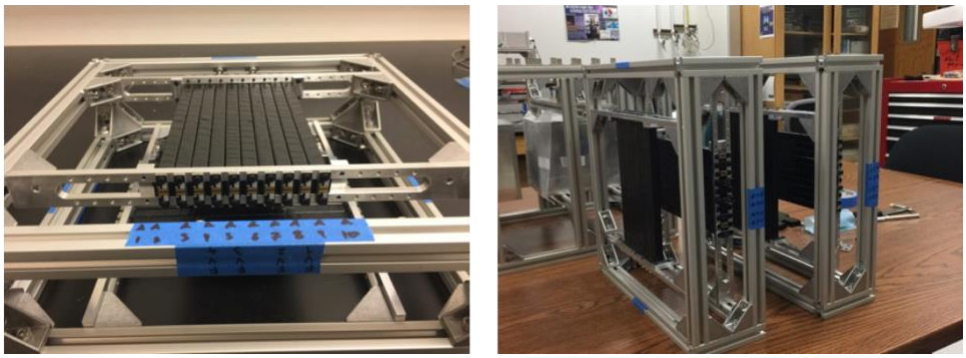


Figure 3 mRICH hodoscopes. Each plane consists of 10 finger scintillator rods (1cm x 1cm x 20cm).

The whole setup can put on a movable table along the beam line. As a reference, Figure 4 shows the first mRICH beam test setup in April of 2016.

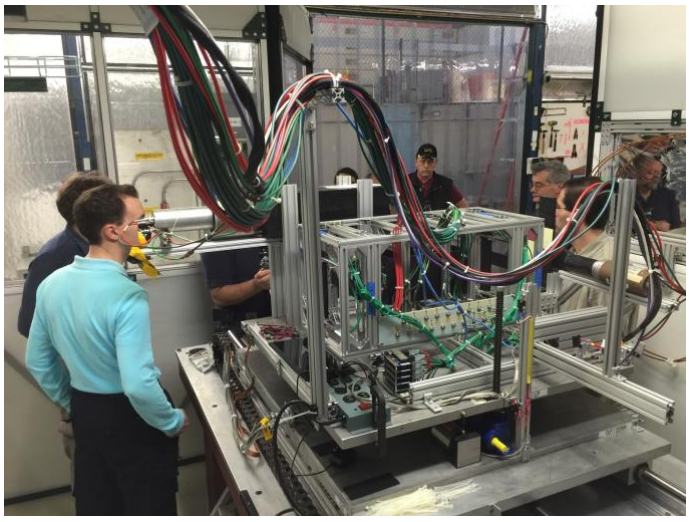
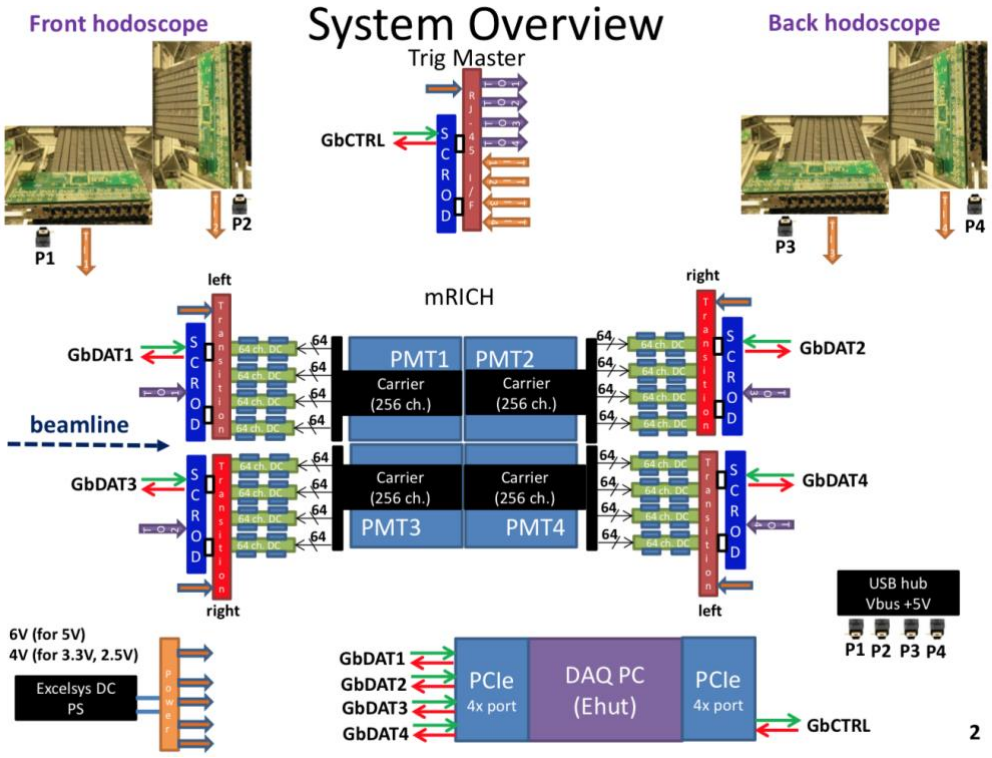
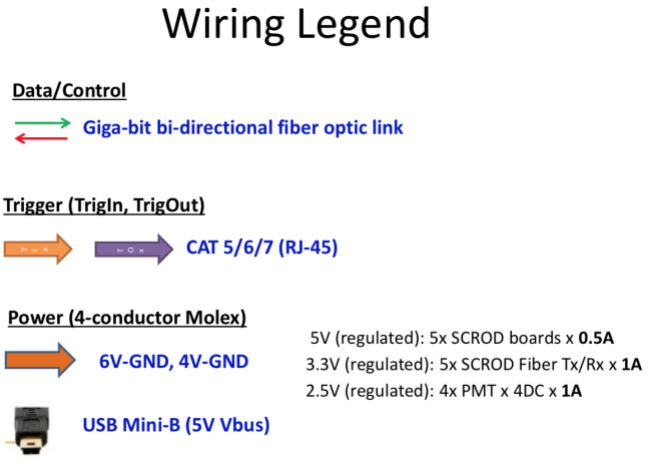


Figure 4 The first mRICH test setup in April 2016.

The mRICH readout will be supported by two groups: Hawaii University Group led by Prof. Gary Varner and the Italian INFN Group led by Prof. Marco Contalbrigo who also led the readout for the first beam test. The general readout system overview is shown below:





The experiment will run parasitically off the FLYSUB experiment. A detailed discussion with FLYSUB group (led by Prof. Kondo Gnanvo) was held on May 10, 2018. All parties have a detailed plan in regarding to the locations of experiment setup in the test area. The setup of this experiment will be at MT6.2C.

Personnel and Institutions:

Spokesperson: Xiaochun He

Lead Experimenters in charge of beam tests: Xiaochun He

Fermilab Experiment Liaison Officer: Mandy Rominsky

The group members at present are:

	Institution	Country	User	Rank/Position	Other Commitments
1.1	Georgia State University	USA	Xiaochun He Xu Sun William Roh Sawaiz Syed	Faculty Post-doc Student Staff	
1.2	Hawaii University	USA	Gary Varner Isar Mostafanezhad Tommy Lam	Faculty Researcher Student	
1.3	INFN, Ferrara	Italy	Marco Contalbrigo Luca Barion	Faculty Post-doc	

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS:

1.1 LOCATION

1.1.1 Our experiment will be placed on the movable table at MT6.2C as we did for the first beam test.

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

1.2 BEAM

1.2.1 BEAM TYPES AND INTENSITIES

Energy of beam: 1-120 GeV
Particles: pions, kaons, protons, electrons
Intensity: 10 – 100k particles/4 sec spill
Beam spot size: about 1-10cm^2

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

1.2.2 BEAM SHARING

We are working with Kondo Gnanvo to run our test parasitically with the FLYSUB experiment. Detailed will be added once it is available.

1.3 EXPERIMENTAL CONDITIONS

1.3.1 AREA INFRASTRUCTURE

The test setup will be similar to the setup we had in April 2016, see Figure 4.

The experimenters would also like to use 2 FTBF wire chambers for tracking particles through the detectors, and at least two scintillators for triggering.

1.3.2 ELECTRONICS AND COMPUTING NEEDS

The data acquisition system for this test will be supported by two search groups: Hawaii University (led by Gary Varner) and INFN, Ferrara, Italy (led by Marco Contalbrigo). The Hawaii group is currently assembling a readout unit to readout forty channels of beam hodoscope and 1024 channels of Hamamatsu H13700 multi-anode PMTs (total of 4). In parallel, the INFN group is working on a readout system for MPPC arrays.

A Bertan or similar NIM HV module will provide the HV of up to 1 kV for four H13700 modules.

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 FY2016, 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.

1.3.3 DESCRIPTION OF TESTS

It is expected that the mRICH test system will need no major effort to install in the beam-line.

As stated previously, the experimenters expect to run the test parasitically with the FLYSUB experiment. Generally only a few accesses are expected to be required, except when doing an angle scan when more frequent accesses may be needed.

One of the major goals of this test is to study the mRICH PID capability for separating pions and kaons from 3 to 9 GeV in momentum. We also plan to test electron and pion separation at lower momentum range (< 2 GeV/c) if it is possible. At the same time, we expect to run with 120 GeV protons as well to verify the working principle of the mRICH detector.

For the rate tests, we hope to be able to vary the rate from a few Hz/cm^2 to ~100 kHz/cm^2.

1.4 SCHEDULE

The experiment expects to request one to two 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

June 20 2018	Experimenters arrive at FNAL to be ready for ID application and training starting Monday
June 22 2018	Installation of detectors in MT6.2C (or B) area
June 25 to July 2, 2018	Data-taking

III. RESPONSIBILITIES BY INSTITUTION – NON FERMILAB

1.5 NAME OF INSTITUTION

- Georgia State University
    - Installation and commissioning of detectors
    - Staffing of data taking shifts
    - Data Analysis
- Hawaii University
    - Readout and DAQ Electronics
    - Installation and commissioning of detectors
    - Staffing of data taking shifts
- INFN, Ferrara, Italy
    - Readout and DAQ Electronics
    - Installation and commissioning of detectors
    - Staffing of data taking shifts

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IV. RESPONSIBILITIES BY INSTITUTION – FERMILAB

1.6 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.

1.7 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.
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.

1.8 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 as the one set up by T1044.

1.9 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]

1.10 FERMILAB COLLABORATORS

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

V. SUMMARY OF COSTS

Source of Funds [$K]	Materials & Services	Labor (person-weeks)
Accelerator Division	0	0.5
Particle Physics Division	0.0	0.0
Scientific Computing Division	0	0
ESH&Q Section	0	0.2
Totals Fermilab	$0.0K	0.7
Totals Non-Fermilab	0	2.0

VI. GENERAL CONSIDERATIONS

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.
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.
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.
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.
5. All items in the Fermilab Policy on Computing will be followed by the experimenters. (http://computing.fnal.gov/cd/policy/cpolicy.pdf).
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.
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.
8. An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters' Meeting.
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.
10. The co-spokesperson should ensure the appropriate people (which might be everyone on the experiment) sign up for the test beam emailing list.
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:

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

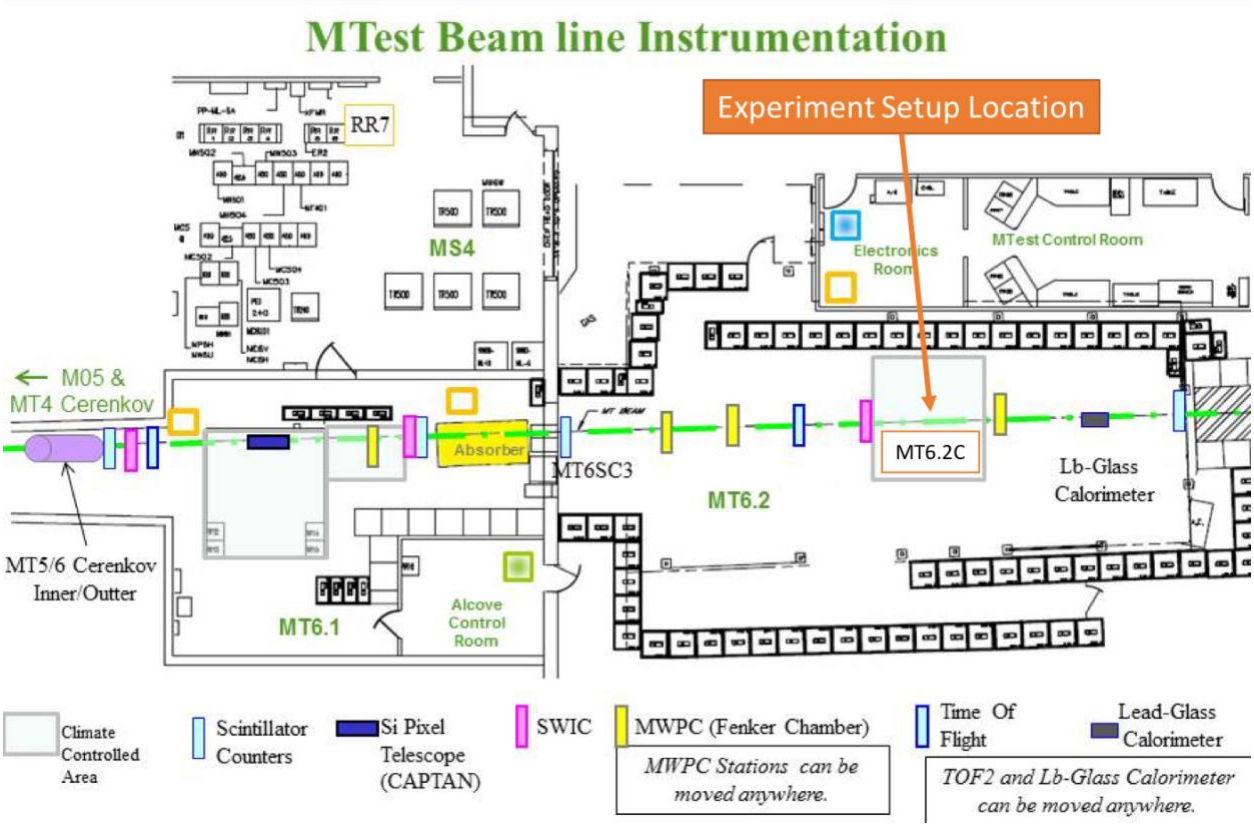
13. The experimenters agree to remove their experimental equipment as the Laboratory requests them to. They agree to remove it expeditiously and in compliance with all ESH&Q requirements, including those related to transportation. All the expenses and personnel for the removal will be borne by the experimenters unless removal requires facilities and personnel not able to be supplied by them, such a rigging, crane operation, etc.

SIGNATURES:

_____ / / 2018
Xiaochun He, Experiment Spokesperson

APPENDIX I: MT6 AREA LAYOUT

The experiment's detector will be located in the MT6.2C as it was agreed with the FLYUSB group. The mRICH test stand will set up on the movable table in there.



MTEST AREAS

APPENDIX II: EQUIPMENT NEEDS

Provided by experimenters:

GSU: DAQ computer, NIM HV modules

Hawaii group: readout electronics for Hamamatsu H13700 modules and beam hodoscope

INFN Group: readout electronics for Hamamatsu H13700 modules and MPPC arrays

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

PREP EQUIPMENT POOL:

Quantity	Description
2	NIM Discriminator, Logic, and Gate Delay modules
1	NIM Bin
1	NIM HV modules

PPD FTBF:

Quantity	Description
2	MWPC Stations
2	Scintillator Counters (not necessary to include MT6SC1)

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:			Cyanide plating materials	List hazardous/toxic materials planned for use in a beam line or an experimental enclosure:
Flow rate:		Flow rate:			Hydrofluoric Acid	
Capacity:		Capacity:			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:		**X**	High Voltage (50V)		Lifting Devices	
MFR Class:			Exposed Equipment over 50 V		Motion Controllers	
		X	Non-commercial/Non-PREP		Scaffolding/ Elevated Platforms	
			Modified Commercial/PREP		Other:	
Vacuum Vessels		**Pressure Vessels**		**Cryogenics**		
Inside Diameter:	7”	Inside Diameter:			Beam line magnets	
Operating Pressure:	10^{-7} torr	Operating Pressure:			Analysis magnets	
Window Material:	Glass	Window Material:			Target	
Window Thickness:	1 cm	Window Thickness:			Bubble chamber	

The following people have read this TSW:

_____ / / 2018
Patty McBride, Particle Physics Division, Fermilab

_____ / / 2018
Sergei Nagaitsev, Accelerator Division, Fermilab

_____ / / 2018
Martha Michels, ESH&Q Section, Fermilab

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Robert Roser, Chief Information Officer, Fermilab

_____ / / 2018
Joe Lykken, Chief Research Officer, Fermilab