Fermilab

Directorate

TECHNICAL SCOPE OF WORK
FOR THE 2015 FERMILAB TEST BEAM FACILITY PROGRAM

T-1059

Optical Time-Projection Chamber

December 1, 2014

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INTRODUCTION

This is a technical scope of work (TSW) between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of University of Chicago who have committed to participate in beam tests to be carried out during the 2015 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:

This is a follow up to the T-979 MOU of Feb 27th, 2008, extending the investigation of using Planacon micro-channel plate photomultipliers with quartz windows to measure fast Cherenkov light to the use of water as the radiator, and the measurement of time-of-flight to an `Optical TPC' in which the drift time of light is used to reconstruct tracks.

The experimenters request beam time at Fermilab during the FY2015 Fermilab Test Beam Run to test a prototype water Cherenkov optical time-projection chamber (OTPC). Optimally, the experimenters would need a slot before the end of the 2014 calendar year, i.e. Nov. or Dec. The goal of the OTPC beam test is to demonstrate a new type of water-based tracking detector, with applications towards neutrino physics. The OTPC will use a number of Planacon micro-channel plate (MCP) photodetectors with a custom readout and DAQ.

The Optical Time Projection Chamber (OTPC) is a small-scale, prototype water Cherenkov detector, such as could be implemented in the Fermilab short baseline neutrino program, using a combination of MCP photo-multipliers and optical mirrors. The goal is to demonstrate the capability of reconstructing 3-D tracks of relativistic particles by sampling the `drifted' Cherenkov light. (An analog to electrons in a liquid noble TPC, for example.) The MCPs, with fast waveform digitizing readout, allow for the tagging single Cherenkov photons with 30 ps timing and few mm spatial resolution.

This experiment was previously installed in the secondary beam-line at MCenter at the very end of the FY2014 Fermilab Test Beam Run. It was run for about a week, from 28-August until 4-September. During that time, access was limited due to the long Labor Day weekend and limited shifters. The short run time gave the experimenters a chance to measure the rates and commission an adequate trigger, but did not allow for identifying and fixing issues with the detector before the run ended. Several problems have now been identified and fixed with the MCP electrical connections and readout. The OTPC, as it was installed at MCenter, is shown in Figure 1.

The initial OTPC beam test was run under the auspices of the 2008 T-979 proposal due to the continued use of Photonis Planacons, sampling electronics readout, Cherenkov light as the

source for psec timing, and the involved researchers. However, because the details of this test beam run have evolved from the initial T-979 MOU, this proposal is being submitted to allow for more flexibility.

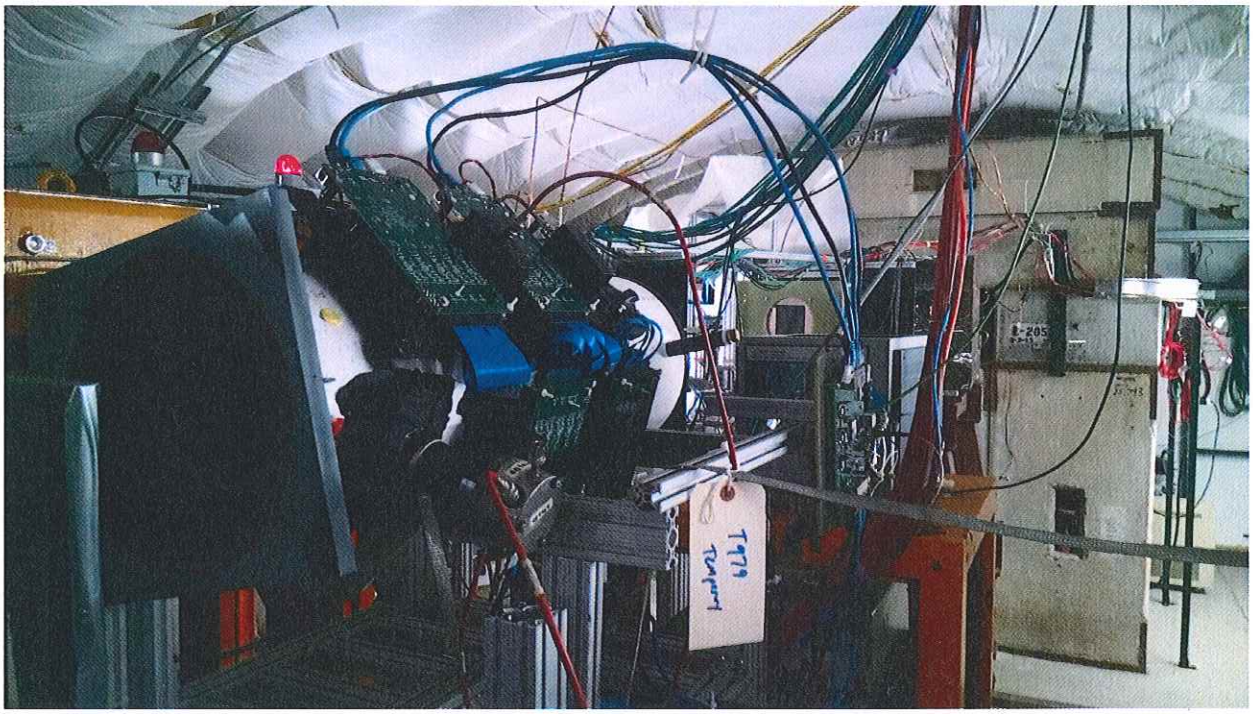


Figure 1: OTPC installed in MCenter secondary line. The photo was taken from behind the OTPC, looking towards the incoming beam. The visible PC cards are each mounted behind a MCP photo-detector, and each board has thirty channels of 10 GSPS waveform digitizing readout.

. PERSONNEL AND INSTITUTIONS:

Spokesperson: Henry Frisch

Fermilab Experiment Liaison Officer: JJ Schmidt

The group members at present are:

	Institution	Country	Collaborator	Rank/Position
1.1	University of Chicago	USA	Henry Frisch	Professor
			Eric Oberla	Grad Student
			Matthew Wetstein	Postdoctoral scholar
			Andrey Elagin	Postdoctoral scholar

I. Experimental Area, Beams and Schedule Considerations:

2.1 Location

2.1.1 The beam test(s) will take place in MC7-south, as shown in Appendix I. The experimenters would prefer to re-install at the same location as the initial run: on the secondary beam-line in MCenter. This would be under similar conditions in which the experiment would run parasitic to and/or schedule around LArIAT's beam requests. If there is interference the experiment could move further downstream.

2.2 Beam

2.2.1 Beam Types and Intensities

Energy of beam: 1 – 4 GeV
Particles: muons
Intensity: <1000 particles/ 4 sec spill

The apparatus will sit in the secondary beamline with the Tertiary target/collimator in place. In this configuration a request of muons with a momentum of 1-4 GeV, a range which may permit velocity measurement and which is also appropriate for short-base neutrino measurements is possible. If time permits, the experimenters would also run electrons and charged pions of the same momentum. An intensity of a few hundred particles per spill is preferred. A rate of up to ~1000 particles/spill will be OK. The DAQ is limited to a few 10's of Hz.

2.2.2 Beam Sharing

The experiment expects to share beam with the T-1034 LAriaT experiment, and can probably share with any other experiment which allows muons through.

The detector, considering all materials in the beam path, is roughly 3 radiation lengths.

2.3 Experimental Conditions

2.3.1 Area Infrastructure

The apparatus is an 11" diameter, 34" long cylinder filled with deionized water (supplied by experimenters, ~11 gallons). One hundred twenty channels of custom, 10 GigaSample/sec (GSPS) waveform sampling readout (PSEC4 ASIC) were used to readout the signal from four 2x2 sq. inch Planacon MCPs. These MCPs look into the water volume in order to detect the Cherenkov photons, as shown in Fig. 3.

The center-line of the detector is to be aligned with the beam. As in the first run, an upstream 0.25" quartz radiator will be mounted to an MCP to determine the trajectory of the thru-going particle. The trigger signal will be formed using this signal in coincidence with a scintillator paddle on a PMT, which is mounted at the rear of the detector.

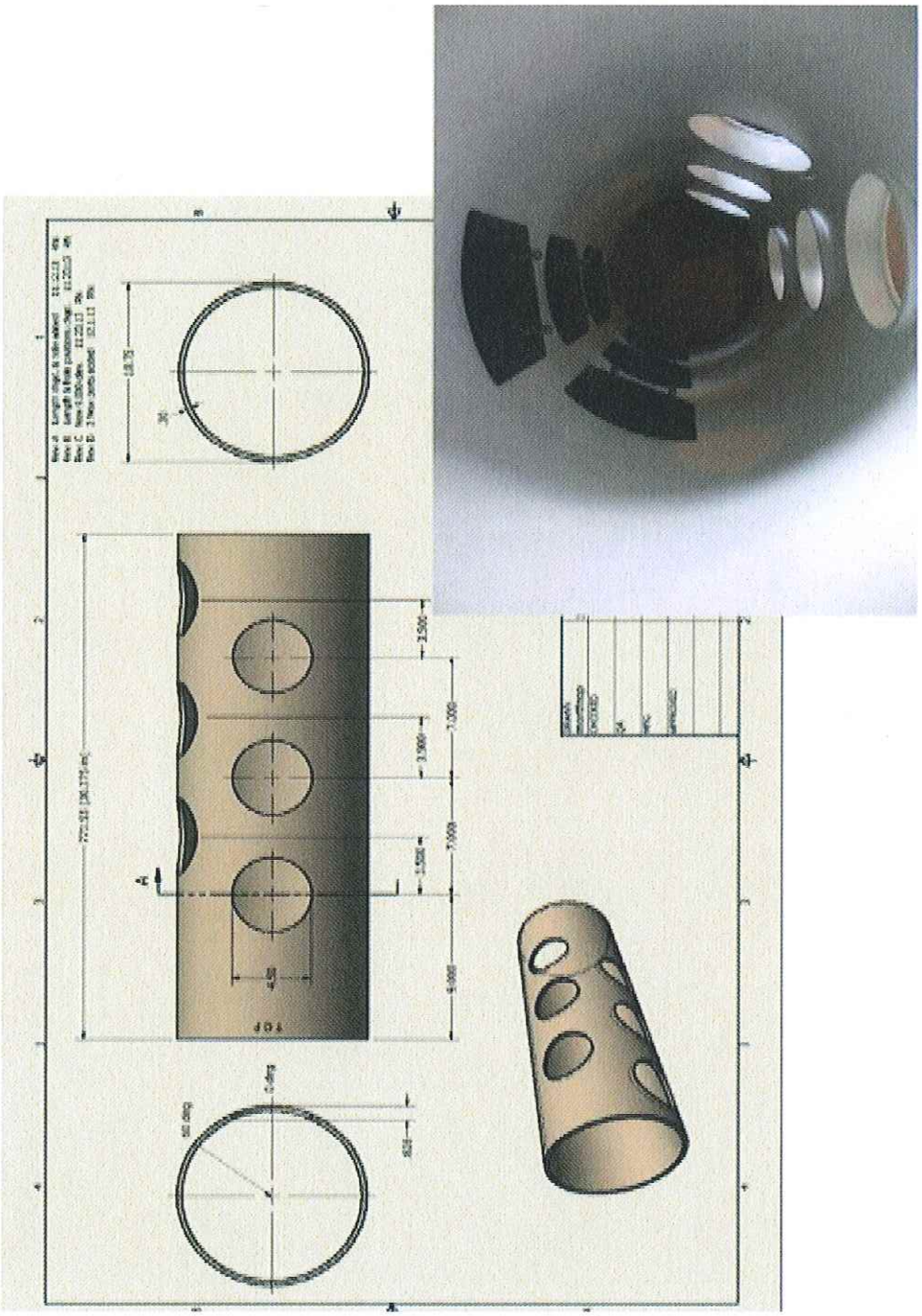


Figure 2: OTPC mechanical drawing (Courtesy of Rich Northrop, UC). Inset shows inner part of detector during beginning of construction. Ports are for MCP mounts and internal platforms stage the mirrors.

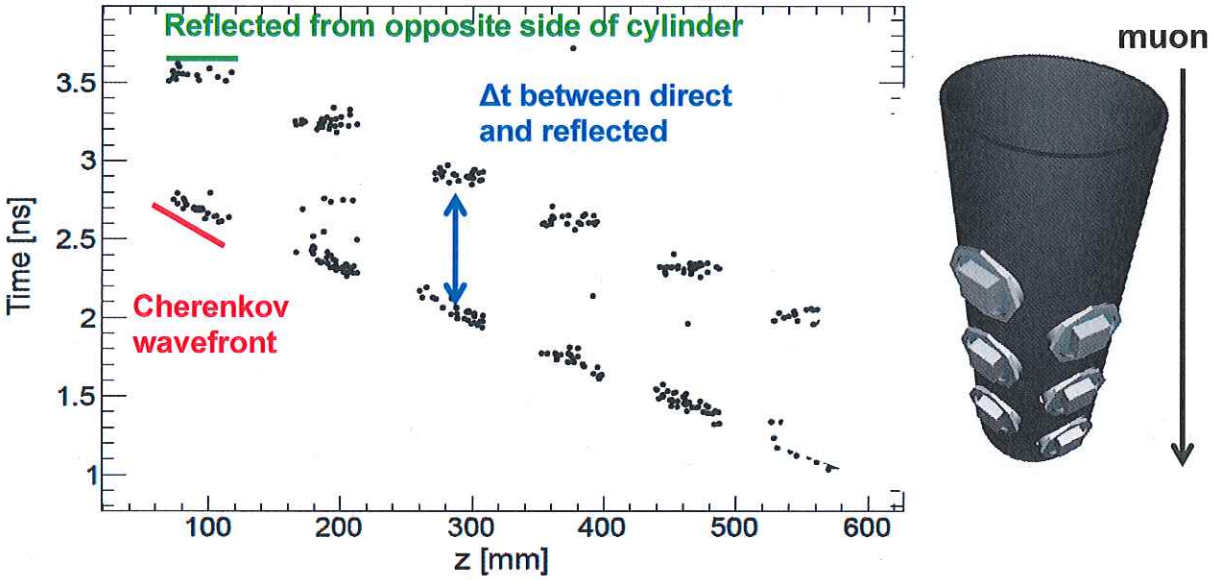


Figure 3: Simulated time-projection of Cherenkov photons from 1 GeV muon on OTPC detector plane.

The experimenters request to re-use the multi-purpose stand built by Todd Nebel as it has a configurable height and a custom mount for the OTPC cylinder.

The following items were installed in the beam area or counting room for the first run, and the experimenters would like to use them again if possible:

- HV patch panel access. At most 8 SHV lines.
- HV, and signal cables, miscellaneous connectors
- Wired Ethernet connection
- Beam spill and gating information

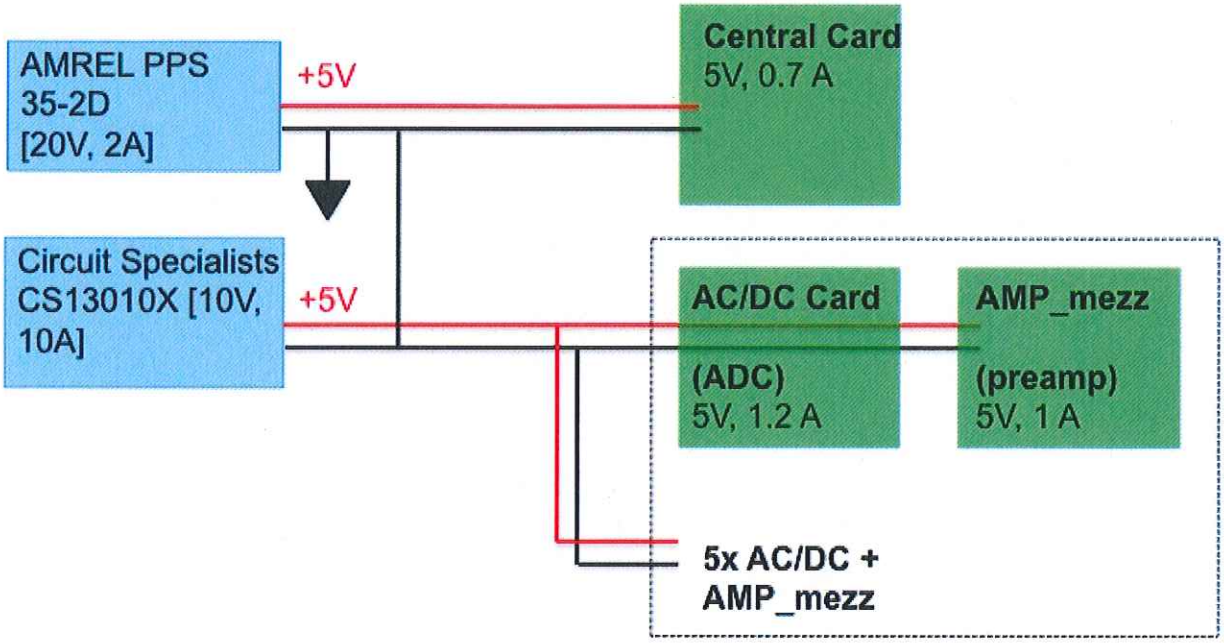
The experiment does not use any gasses.

2.3.2 Electronics and Computing Needs

A Linux laptop left in the enclosure was used to readout the events over USB 2.0. This laptop is controlled remotely from the counting room over a wired Ethernet connection.

The experimenters require minimal rack space in the control room to place an HV supply, a NIM crate, and a Berkeley cow. These are currently installed in the MCenter control room.

The setup, HV, and low-voltage electronics were ORC-cleared during previous run, no major modifications to any of these are expected for proposed upcoming beamtime.



T979 Optical TPC
Low Voltage Drawing, rev 0.1 (14-Aug 2014)
Eric Oberla
University of Chicago

Figure 4: Block diagram of low voltage. Electronics were ORC-cleared during previous run, no modifications are expected for proposed upcoming beam time

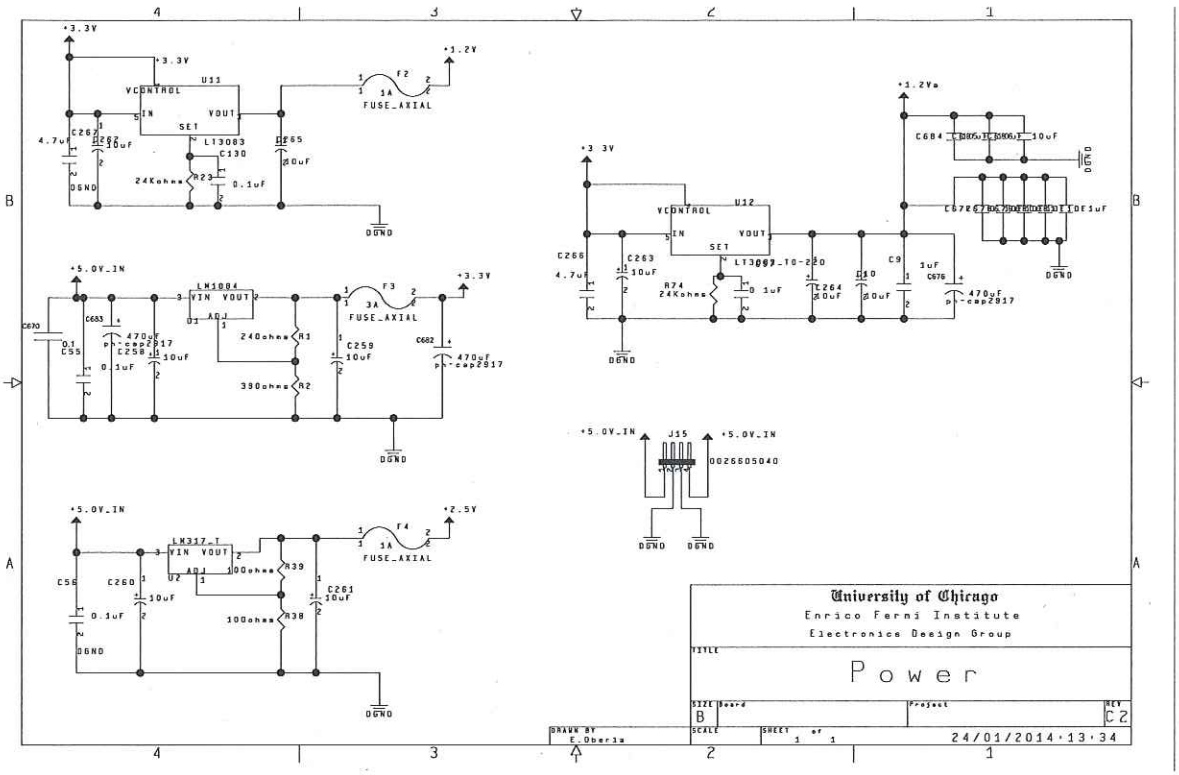


Figure 5: Block diagram of power on the front-end AC/DC digitizer cards. Downstream regulators all fused. The 5V coming into the board is fused in-line with the supply cables.

2.4 SCHEDULE

The experimenters propose to begin installing in mid-November. The experiment would like to take data for 2 weeks, with shifts no more than 12 hours per day. Since the primary beam request is muons, the experiment can co-exist with upstream users time-sharing on a daily basis as mutually convenient.

III. Responsibilities by Institution – Non Fermilab

3.1 University of Chicago:

- The Optical Time Projection Chamber (OTPC)
- Electronics to read out the detector
- Shifters to monitor the experiment while taking beam

IV. Responsibilities by Institution – Fermilab

4.1 Fermilab Accelerator Division:

4.1.1 Use of MCenter 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 MCenter control room.
4.1.4 Reasonable access to the equipment in the MCenter 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 Particle Physics Division will be responsible for coordinating overall activities in the MCenter beam-line, including use of the user beam-line controls, readout of the beam-line detectors, and FTBF computers. [6.5 FTE/week] >> THIS IS TOTAL SUPPORT OF FACILITY. NEED TO APPROPRIATE PROJECTS
4.2.2 Conduct a NEPA review of the experiment.
4.2.3 Provide day-to-day ESH&Q support/oversight/review of work and documents as necessary.
4.2.4 Provide safety training as necessary, with assistance from the ESH&Q Section.
4.2.5 Update/create ITNA's for users on the experiment.
4.2.6 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 MCenter control room.
4.3.2 See Appendix II for summary of PREP equipment pool needs.

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]

7. Summary of Costs

Source of Funds [$K]	Materials & Services	Labor (person-weeks)
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	8

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 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:

6.10 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.

6.11 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.

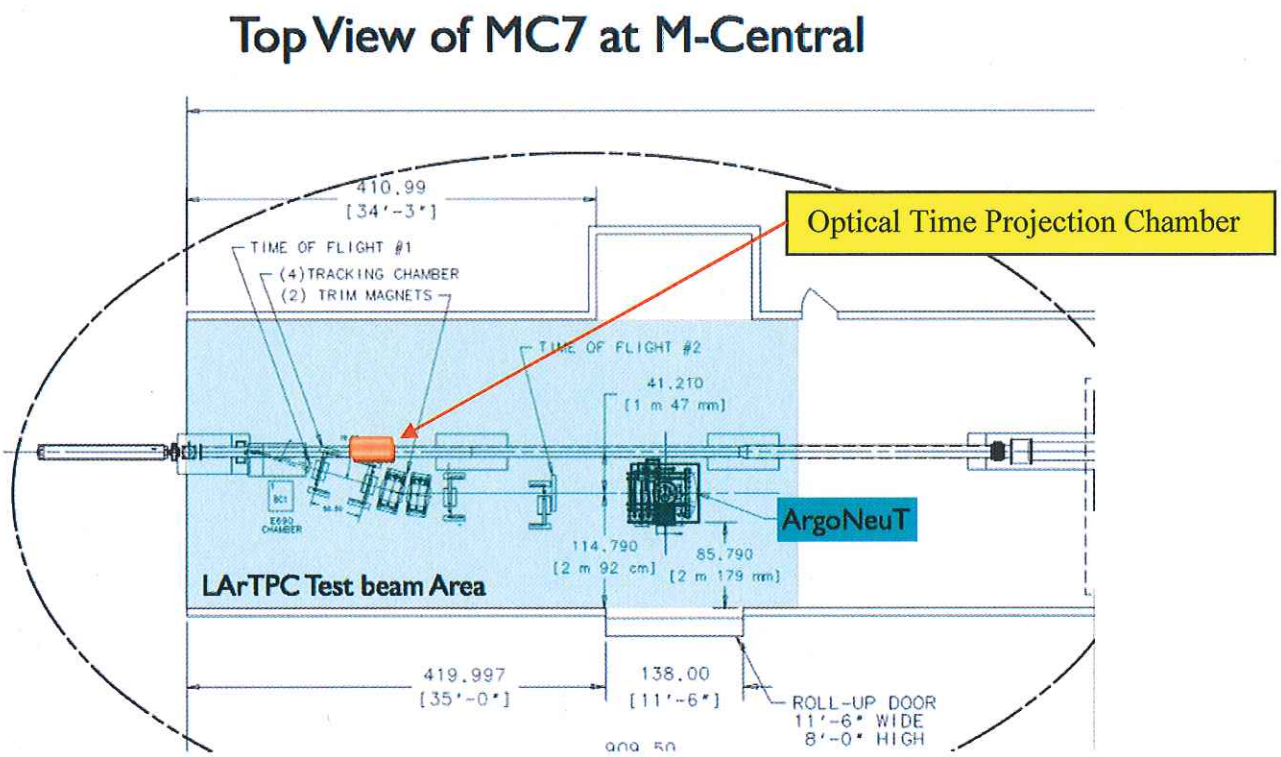
SIGNATURES:

The spokesperson is the official contact and is 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. The spokesperson should also make sure the appropriate people (which might be everyone on the experiment) sign up for the test beam emailing list.

_____ / / 2014

Henry Frisch, Experiment Spokesperson

APPENDIX I: MC7-SOUTH AREA LAYOUT



APPENDIX II: EQUIPMENT NEEDS

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

PREP EQUIPMENT POOL:

Quantity	Description
1	HV supply
1	NIM crate
1	Berkeley cow

APPENDIX III: - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need have been 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:		Inside Diameter:			Beam line magnets	
Operating Pressure:		Operating Pressure:			Analysis magnets	
Window Material:		Window Material:			Target	
Window Thickness:		Window Thickness:			Bubble chamber	

The following people have read this TSW:

FOR PATTY MCBRIDE 12 / 2 / 2014
Patty McBride, Particle Physics Division, Fermilab
SEE NOTE ON PAGE #12

12 / 12 / 2014
Sergei Nagaitsev, Accelerator Division, Fermilab

12 / 4 / 2014
Martha Michels, ESH&Q Section, Fermilab

12 / 14 / 2014
Robert Roser, Chief Information Officer, Fermilab

12 / 11 / 2014
Joe Lykken, Chief Research Officer, Fermilab