Fermilab

Directorate

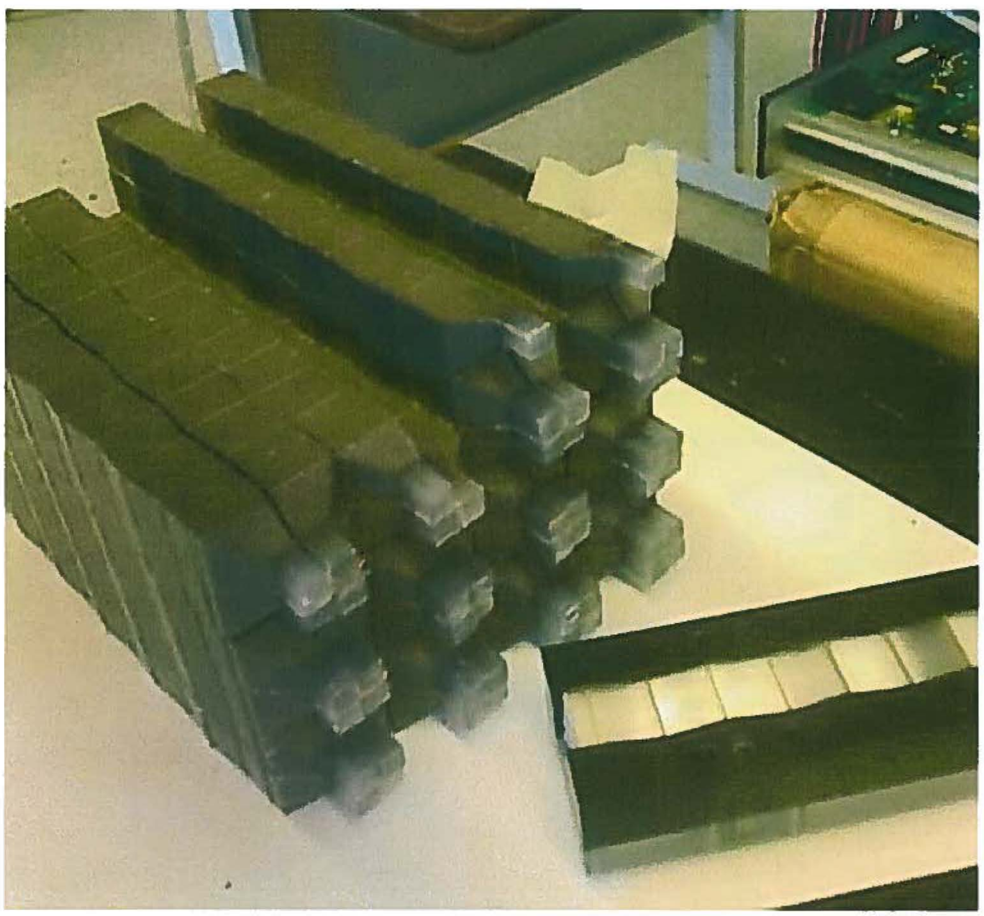
TECHNICAL SCOPE OF WORK

FOR THE 2012 – 2015 FERMILAB TEST BEAM FACILITY PROGRAM

T-1018

UCLA Spacordion Tungsten Powder Calorimeter

November 16, 2011 / Update: December 16, 2013



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INTRODUCTION

This is a technical scope of work (TSW) between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of the University of California at Los Angeles (UCLA), Pennsylvania State University (PSU), Texas A&M University (TAMU), IUCF, BNL and LBNL who have committed to participate in beam tests to be carried out during the 2012 – 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 memorandum 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 present experiments at the BNL-RHIC facility are evolving towards physics goals which require the detection of medium energy electromagnetic particles (photons, electrons, neutral pions, eta mesons, etc.), especially at forward angles. New detectors will place increasing demands on energy resolution, hadron rejection and two-photon resolution and will require large area, high performance electromagnetic calorimeters in a variety of geometries. In the immediate future, either RHIC or JLAB will propose a facility upgrade (Electron-Ion Collider, or EIC) with physics goals such as electron-heavy ion collisions (or p-A collisions) with a wide range of calorimeter requirements. The calorimeter R&D program started in 2011 at Brookhaven National Laboratory has awarded funding of approximately $110,000 to develop new types of calorimeters for EIC experiments.

The UCLA group is developing a method to manufacture very flexible and cost-effective, yet high quality calorimeters based on scintillating fibers and tungsten powder. The design and features of the calorimeter can be briefly stated as follows: an arbitrarily large number of small diameter fibers (<0.5mm) are assembled as a matrix and held rigidly in place by a set of precision screens inside an empty container. The container is then back-filled with tungsten powder, compacted on a vibrating table and infused with epoxy under vacuum. The container is then removed. The resulting sub-modules are extremely uniform and achieve roughly the density of pure Lead. The sub-modules are stacked together to achieve a final detector of the desired shape. There is no dead space between sub-modules and the fibers can be in an accordion geometry bent to prevent 'channeling' of the particles due to accidental alignment of their track with the module axis. This technology has the advantage of being modular and inexpensive to the point where the construction work may be divided among groups the size of typical university physics departments. The proof of principle was demonstrated during the T-1018 test beam run at FNAL in 2011.The experimenters have constructed prototypes of three different designs in order to investigate the characteristics of practical devices such as uniformity, linearity, longitudinal and transverse shower shapes.

The first design is an array of 4x4 modules intended as a prototype for a practical device to be installed within two years in the STAR experimental hall. The modules are a combination of a spaghetti calorimeter and an accordion (hence "spacordion"). Each sub-module is 1.44cm x 1.44cm x15cm and constructed individually. The second design is a prototype of 4 sub-modules constructed in one step, using a different construction technique. These are compensated hadronic calorimeter sections consisting of a 4 x4 matrix, with tower size 10 x 10 cm and a length of 4 interaction lengths)

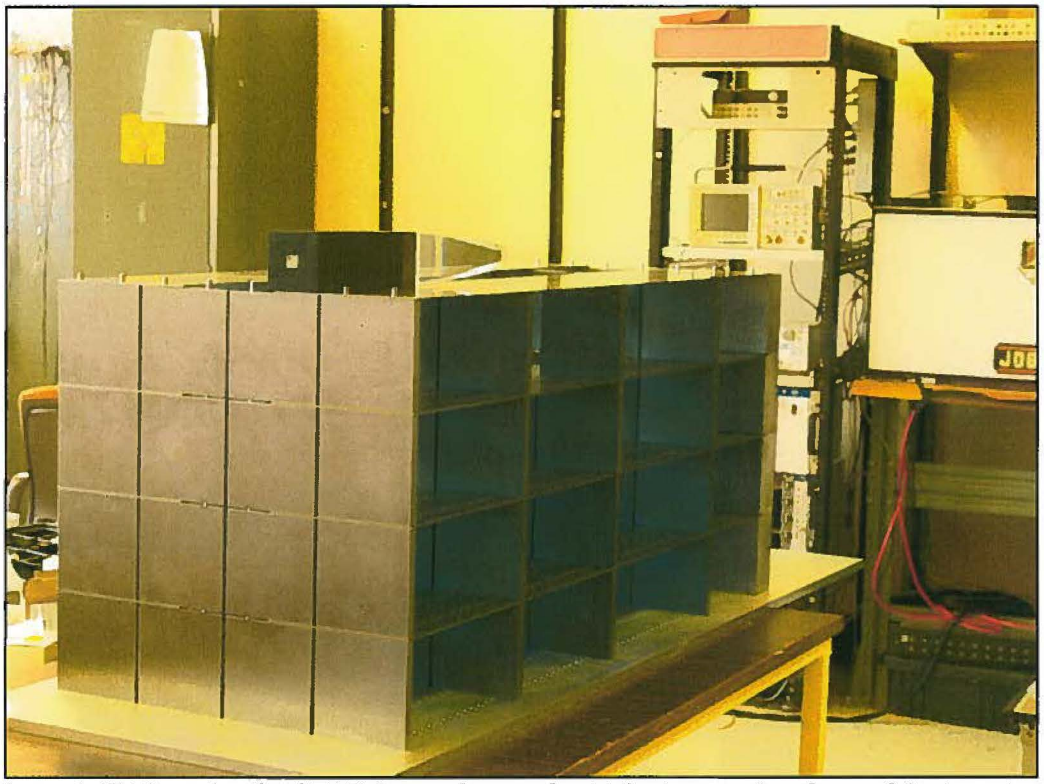


Figure 1: HAD section for STAR forward upgrade. At the top we placed one of the tungsten powder /Sc fiber EM supermodules which was tested previously at FNAL T-1018.

In front of the HAD section the experimenters will place a finely-segmented EM section, built with the technology developed last year. The transverse size of the EM section is about one HAD tower. Both HAD and EM sections will be read out with SiPMs (during T1018 we used PMT readout) .

The third design is a set of single sub-modules each intended to test variations of the tungsten powder/embedded fiber concept by enhancing the light output /density using liquid scintillator or heavy liquids. This is a design for the barrel EMC intended for a dedicated EIC detector. It will be constructed using similar techniques as those for the STAR forward EM section, however the towers in this prototype will have a wedge shape. The entire detector construction will be completed at UCLA, and contained in a light-tight box, before being brought to Fermilab. The size of the prototype is a matrix of 3 x 5 towers and the main goal of the test run is to measure resolution and investigate dependence of response of the EIC EMC vs incident angle (45 -90 degrees, which covers the range of impact angles for the central barrel EMC).

PERSONNEL AND INSTITUTIONS:

Spokesperson and Physicist in charge of beam tests: Stephen Trentalange (UCLA)

Fermilab Experiment Liaison Officer: Aria Soha

The group members at present are:

	Institution	Collaborator	Rank/Position	Other Commitments
1.1	University of California, Los Angeles	Oleg Tsai	Research Scholar	STAR
		Stephen Trentalange	Researcher	STAR
		George Igo	Professor	STAR
		Huan Huang	Professor	STAR
		Yu Xi Pan	Graduate Student	STAR
		Jay Dunkelberger	Graduate Student	STAR
		Keith Landry	Graduate Student	STAR
1.2	Pennsylvania State University	Steven Heppelmann	Professor	STAR
1.3	Institute for Theoretical and Experimental Physics	Igor Alexeev	Researcher	SITEP
		Dmitry Svirida	Researcher	
1.4	Brookhaven National Laboratory	Salvatore Fazio	Researcher	STAR/RHIC
		Alexander Kisilev	Researcher	RHIC
		Zhangby Xu	Physicist	STAR
1.5	Texas A&M	Carl Gagliardi	Professor	STAR
		Mriganka Mondal	Postdoc	STAR

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS:

2.1 LOCATION

2.1.1 The EM Calorimeter will be placed in MT6.2C. The HAD section will be in the 2D area.

2.1.2 The experimenters will require work space for 3-5 people in the MTest Control Room for laptops connected through Ethernet. All electronics, including the DAQ PC for the device, will be located in a single standard rack within 3 meters of the apparatus. The experimenters anticipate a single Ethernet connection from this rack to the control room PC.

2.2 BEAM

2.2.1 BEAM TYPES AND INTENSITIES

Type of Beam: electrons
Energy of electron beam: 1, 2, 4, 8, 16, 32 GeV

Type of Beam: pions
Energy of pion beam: 8 – 60 GeV (5 points: 8,16, 32, 40, 60 or something close to these points)

Type of Beam: protons
Energy of proton beam: 120 GeV

Energy spread of beam: less than 2.5%
Intensity: 10k – 100k particles/ 4 sec spill
Beam spot size: about 1-10 cm^2

The expected resolution of the detector is about 10%/sqrt(E_beam), so the expected resolution would be ~2.5% at 16 GeV, which is about the intrinsic resolution of the beam. It is possible to 'deconvolute' the true resolution if the beam resolution is known. In any case, if the detector resolution is very large, then this will be seen at 16 and 32 GeV. The experiment accepts this resolution.

2.2.2 BEAM SHARING

Tests will require many short runs at different energies and detector positions. This will be followed by periods of data analysis which may allow users downstream to piggy-back for periods ~ hours. The apparatus is less than 1 cubic meter and weighs approximately 100 kg (221 lbs), so it should be possible to move it out of the beam using a short access or a remote XY stage.

Radiation lengths of equipment to be put in beam: EM Section 23X0, HAD Section ~116X0

2.2.3 Running Time

The experimenters believe it will be most efficient to run 2 shifts of 8 hours per day. Data will be taken as many short runs at different detector positions and should only require beam energy changes or access infrequently (~1-2/day). At the beginning we will need 12 hours to setup detectors at the beam line. See section 2.3.3 for total run time.

2.3 Experimental Conditions

2.3.1 Area Infrastructure

The EM apparatus is table-size, measuring about 20x20x50cm and weighs approximately 80 kg. (40 lbs) It will be placed on a facility motion table which exceeds the requirements of a remote controlled XY staging platform, about 30x50 cm and able to move +/-10 cm in each direction with 1 mm reproducibility, and able to support a load of approximately 100 kg.

The footprint for the HAD +EM section for the STAR upgrade is 18" wide, 50" long and 18" high, and weighs 2500 lbs. The HAD section will be assembled at the beam line from components which can be easily lifted by hand (less than 20 lbs). PPD will provide a stand with a reasonably good quality, flat surface where the base plate (aluminum plate shown on Fig 1.) of the setup will rest. The center of the HAD section will be at the beam line. The experimenters do not plan to move the HAD section (i.e. perform scans for different towers, however if it is possible to find an appropriate movable XY stage the possibility is preferred).

The experiment would make use of the FTBF Cerenkov detector to tag electrons, and one MWPC station for tracking. A lead-glass calorimeter will be provided by FTBF.

All other test beam counters are the same ones used for T-1018: two scintillation hodoscopes, a trigger counter and an additional veto counter. All counters have or will have SiPM readout.

The experiment will use a Class 3B laser for gain monitoring. It is a commercial product and completely enclosed.

2.3.2 Electronics and Computing Needs

The experiment requests a CAMAC crate (experimenter's controller), Lecroy 1440 with 32 channels of negative HV up to -2.5 kV, see Appendix II for summary of PREP equipment pool needs.

If wire chamber information is available for beam particles, it may be possible to increase the efficiency of data-taking by incorporating this data stream into the DAQ system.

The Front End Readout for SiPM is non-commercial. It uses low voltage/low power.

A single 19" rack of electronics plus a PC will operate inside the enclosure within 3 meters of the apparatus. The experimenters will control data-taking from another PC in the control room through a single Ethernet connection.

The experiment will setup a private network for all of the hardware, no need to connect to Fermi network.

2.3.3 Description of Tests

SiPM and PMT voltage adjustment and signal timing will be mostly accomplished prior to test beam using cosmic rays. The absolute calibration of all channels will be determined using single photoelectron signals.

The test will begin with tuning and understanding beam parameters using a standard Lead Glass calorimeter

Once beam conditions are understood, the experimenters will test the STAR EM and EIC EM sections with these settings. For the EIC EM section, the experimenters will measure the response of the detector at all energies and at four different angles of impact for every energy point. For the STAR upgrade prototype, the experimenters will measure the response at a single angle for all energies. Tests will require a few accesses to re-arrange setups.

Once responses of the EM sections are studied the plan is to re-arrange the setup so that the STAR EM section is attached to the front face of the HAD section. The experiment will again take data in the energy range 1-8 and 16 GeV with both electrons and pions, then take data at a few points up to 66 GeV with pions and finally take 120 GeV data with protons.

Both EM sections for STAR and EIC will be first tested with the electrons.

For the STAR prototype, the experimenters will move the EM section to the front of the HAD section and test the system with electrons and hadrons.

2.4 Schedule

The test beam run will occupy a single two-week period from January 18-January 31, 2012, and the period from Feb. 26-Mar. 18, 2014. . The experiment may return for more test beam runs until 2023.

III. RESPONSIBILITIES BY INSTITUTION – NON-FERMILAB

3.1 UCLA:

UCLA will provide all detector elements and electronics for readout and control of apparatus, except for a CAMAC crate and HV system to be provided by the Fermilab PREP.

3.2 TAMU/PSU

Are to provide personnel for data-taking and analysis.

IV. RESPONSIBILITIES BY INSTITUTION – FERMILAB

4.1 FERMILAB ACCELERATOR DIVISION:

4.1.1 Use of MTest beam 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 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). [0.25 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 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 Use of the Fermilab Test Beam Facility, as 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 FTBF computers. [6.5 FTE/week]
4.2.2 Setup and maintenance of Cerenkov particle ID system sufficient to tag particle species at DAQ or Trigger level.
4.2.3 Use of 2 MWPC stations as outlined in section 2.3.2
4.2.4 Use of Lead glass calorimeter.
4.2.5 Conduct a NEPA review of the experiment.
4.2.6 Provide day-to-day ES&H support/oversight/review of work and documents as necessary.
4.2.7 Update/create ITNA's for users on the experiment.
4.2.8 Provide safety training as necessary, with assistance from the ES&H Section.
4.2.9 Initiate the ES&H Operational Readiness Clearance Review and any other required safety reviews [0.2 person weeks]
4.2.10 Table to lift the assembled HCAL to beam height, as described in 2.3.1.

4.3 FERMILAB COMPUTING SECTOR

4.3.1 Internet access should be continuously available in the counting house.
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. [0.25 FTE]

SUMMARY OF COSTS

Source of Funds [$K]	Materials & Services	Labor (person-weeks)
Accelerator Division	0.0	0.5
Particle Physics Division	0	6.75
Scientific Computing Sector	0	0
ESH&Q	0	0.25
Totals Fermilab	$0.0K	7.5
Totals Non-Fermilab	$200,000	16

I. 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 (ES&H) 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 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 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 Computing Sector 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.

At the completion of the experiment:

6.8 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.

6.9 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 Fermilab 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:

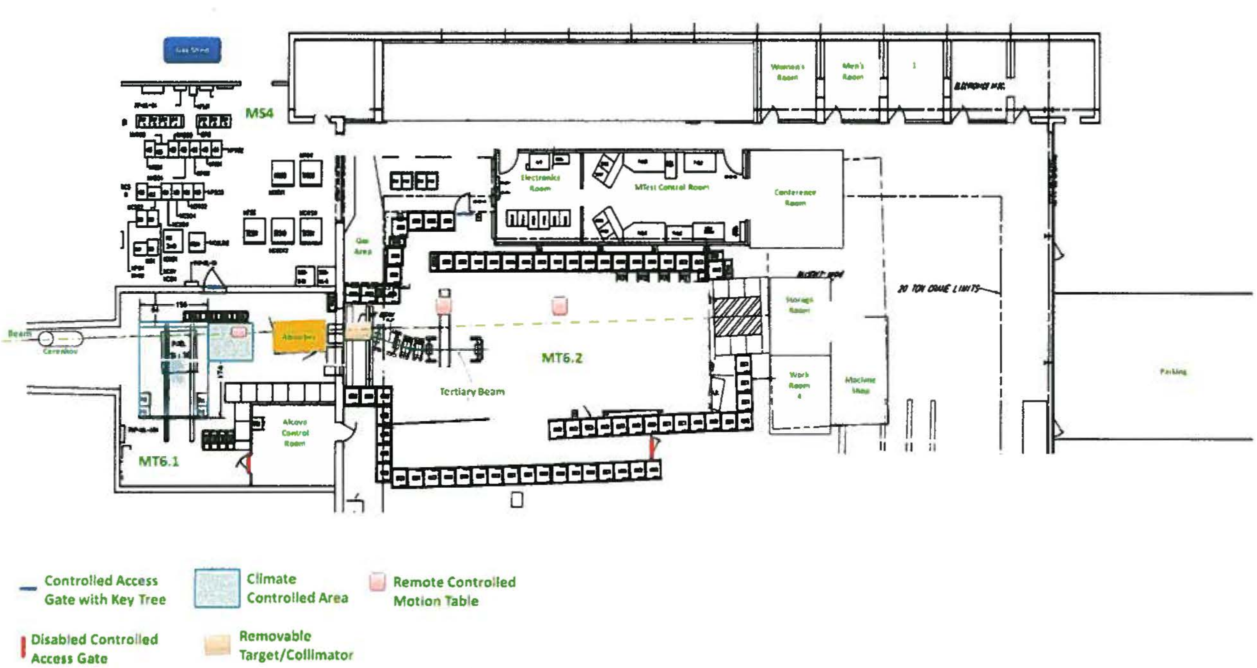
The spokesperson is the official contact and is responsible for forwarding all pertinent information to the rest of the group, arranging for their training, and requesting ORC or any other necessary approvals for the experiment to run.
The spokesperson should also make sure the appropriate people (which might be everyone on the experiment) sign up for the test beam emailing list.

__________________________ 12 / 03 / 2013
Stephen Trentalange, Experiment Spokesperson

APPENDIX I: MT6 AREA LAYOUT

The apparatus will be placed on a moveable XY stage in area MT6.2. An electronics rack containing a CAMAC crate, NIM Crate, Multichannel HV system and DAQ PC will be placed within 3 meters of this table. Connection to electronics room/control room should be via a single Ethernet connection. It is not anticipated to connect any signal or HV cables between the control room and the apparatus.

MTEST AREAS



APPENDIX II: EQUIPMENT NEEDS

Provided by experimenters:

UCLA/TAMU/PSU will provide:

- Detector elements (Calorimeters modules, Hodoscopes and PMTs)
- Trigger/Control Electronics (NIM crate, oscilloscopes, Signal/HV cables, NIM logic modules)
- DAQ System EXCEPT CAMAC Crate (Camac Modules, DAQ PC)

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

PREP EQUIPMENT POOL:

Quantity	Description	
1	CAMAC Crate	Bi Ra 6700P Power Supply
1	HV System	Lecroy 1450 HV System
4	HV System	Lecroy 1461 Negative HV cards for Lecroy 1450 System

PPD FTBF:

Quantity	Description
1	Cerenkov Detector
1	MWPC station
1	lead-glass calorimeter

APPENDIX III: - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need are checked. See next page for detailed descriptions of categories.

Flammable Gases or Liquids		**Other Gas Emissions**		**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		X	Tungsten (W)		Other: Activated Water?	
	Permanent installation		Uranium (U)			
X	Temporary installation		Other:	**Nuclear Materials**		
X	Calibration	**Electrical Equipment**		Name:		
	Alignment		Cryo/Electrical devices	Weight:		
Type:	Hamamatsu C10196 controller/ Model 10306-03		Capacitor Banks	**Mechanical Structures**		
		X	High Voltage (50V)		Lifting Devices	
Wattage:	115mWatts		Exposed Equipment over 50 V		Motion Controllers	
Class:	3B		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:

1 / 8 /2014
Michael Lindgren, Particle Physics Division, Fermilab

/for Sergei Nagaitsev 1 / 10 /2014
Sergei Nagaitsev, Accelerator Division, Fermilab

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