Fermilab

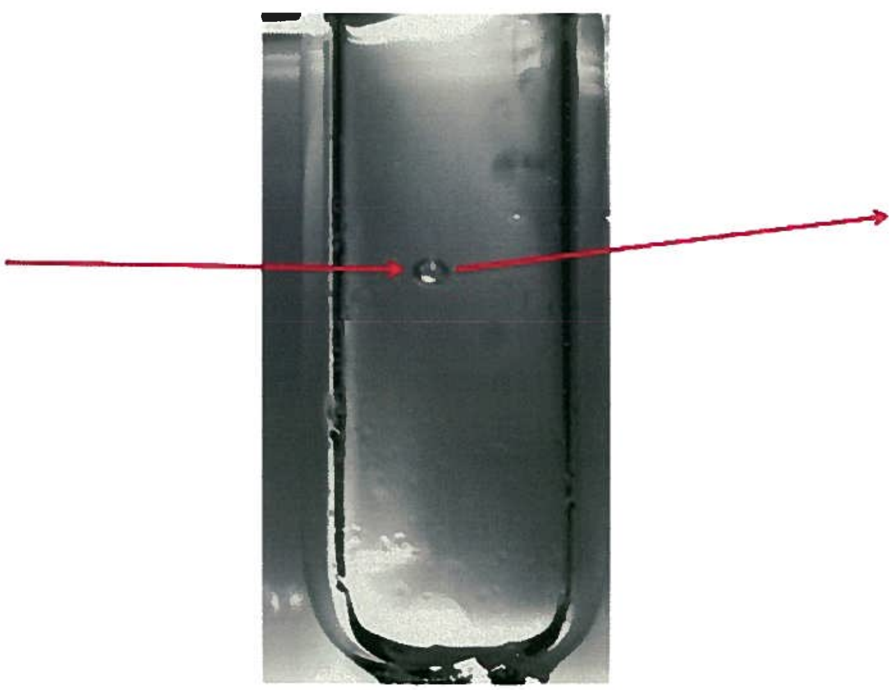
Directorate

MEMORANDUM OF UNDERSTANDING
FOR THE 2011 – 2012 FERMILAB TEST BEAM FACILITY PROGRAM

T-1017

COUPP Iodine Recoil Threshold Experiment (CIRTE)

September 8, 2011



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INTRODUCTION

This is a memorandum of understanding between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of the COUPP collaboration who have committed to participate in beam tests to be carried out during the 2011-12 Fermilab Test Beam Facility program.

The memorandum 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.

Description of Detector and Tests:

COUPP (Chicagoland Observatory for Underground Particle Physics) is an experiment for the direct detection of dark matter, using the technology of continuously sensitive bubble chambers. A bubble chamber can be operated at a point where the initiation of a bubble can indicate ionization densities indicative of only a nuclear recoil, rather than an electron recoil. This provides an intrinsic rejection against most background sources, such as beta or gamma emitters, common to other dark matter detectors. A bubble chamber operated this way is a threshold device that forms a bubble when a nuclear recoil is above a certain kinetic energy level. For dark matter detection, this threshold should be as low as possible, since any massive dark matter candidate has low velocities (~0.001). To provide limits, or an observation, on the mass and cross-section of dark matter in the COUPP detector, it is important to understand the nuclear recoil energy threshold calibration. The CIRTE experiment is designed to test the understanding of the energy threshold for bubble formation around a recoiling Iodine nucleus by using a tagged high-energy pion beam and measuring only elastic scatters.

The requirements for the measurement are rather simple. The experimenters intend to use the silicon pixel detector that resides in the Fermilab Test Beam Facility (FTBF), read out by the CAPTAN data acquisition system. They will install a very small bubble chamber, on order of 1 cm wide, in the 'device under test' region in the middle of the pixel tracker. With approximately 20 micron space point resolution and separation of 20 cm in the upstream and downstream arms, then the hardware resolution would be on the order of 0.1 mrad. The experiment will be dominated by the multiple scattering in the tracker and bubble chamber.

A GEANT4 simulation of the setup has been made, as shown in Figures 1 and 2. These figures show that the iodine elastic recoil spectrum dominates the turn on of the efficiency curve, with the chamber set for 10 KeV and 15 KeV bubble nucleation threshold. This is crucial to the experiment. This simulation was based on a run of $2\text{x}10^6$ beam pions and shows that a statistically significant measurement of the efficiency turn-on of bubble formation can be made at the Test Beam.

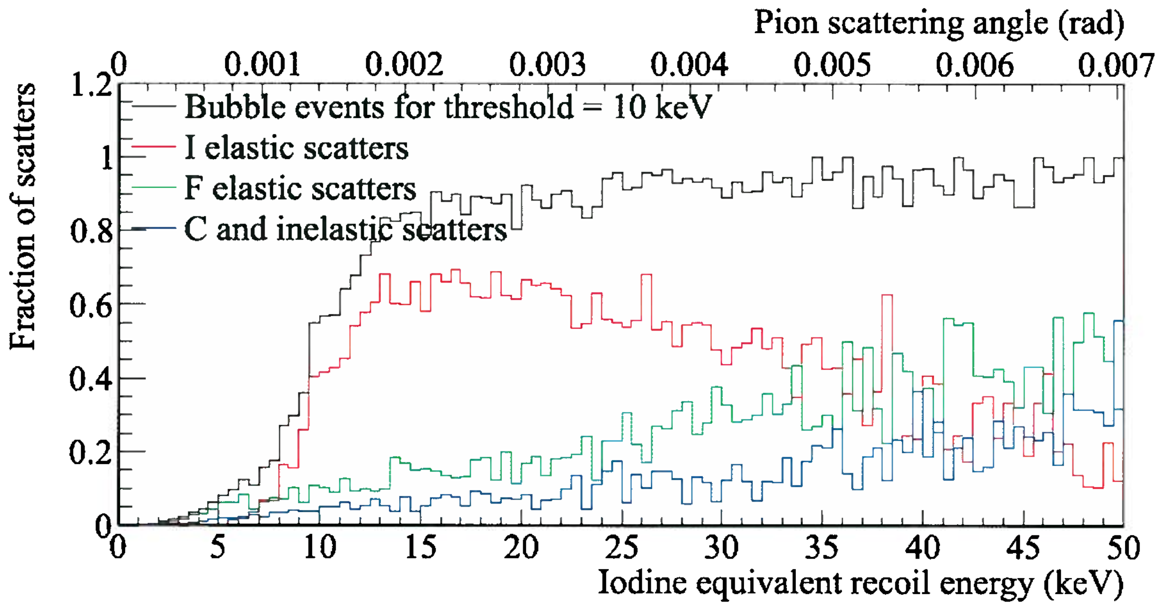


Figure 1 – Fraction of scatters with a bubble as a function of scattering angle and equivalent iodine recoil kinetic energy for a sharp 10 KeV bubble nucleation threshold.

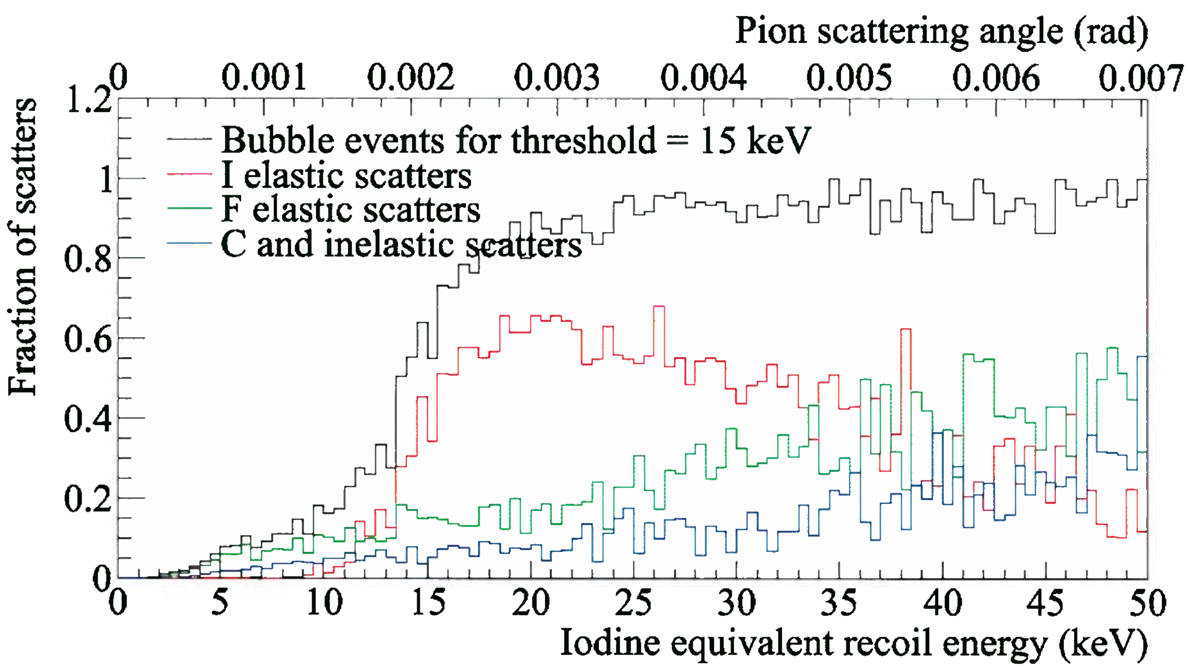


Figure 2 – Fraction of scatters with a bubble as a function of scattering angle and equivalent iodine recoil kinetic energy for a sharp 15 KeV bubble nucleation threshold.

The assumption in the experimental run plan is that the DAQ will trigger on the first bubble observed in the chamber and we will then disregard any subsequent bubbles that may occur in the spill. This means that each spill will give a single measurement. The experimenters will need about a week of running to obtain enough statistics – comparable with the 4000 bubbles shown in Figures 1 and 2 (12 hours/day x 50 spills/hour x 6 days = 3600 events). The ratio of total number of bubbles formed per incoming beam particle is about 10^{-2}. This means that the experimenters will want at least 200 to 300 pions per spill. At 10 GeV, this means a beam rate on order of 1000/spill. The experimenters will need to count all beam pion particles coming into the chamber and gate that counter off after the appearance of a bubble. The pressure or video trigger has a response time on the order of 1 msec. The experimenters will want to use the Cerenkov tag to count only pions, since electrons are not relevant to this measurement (they do not form bubbles in our chamber).

The experimenters will first want to test the elastic scattering measurement on a simple set of foils, such as copper, Teflon and carbon, and an empty chamber. Since they will not be worried about bubble formation with these tests, they will be able to take enough statistics quite rapidly – on the order of hours. These preliminary tests will inform the run plan with the real chamber, which will take place at a later date.

I. PERSONNEL AND INSTITUTIONS:

Spokesperson and Physicist in charge of beam tests: Peter Cooper

Fermilab liaison: Aria Soha

The group members at present are:

	Institution	Collaborator	Country
1.1	University of Chicago	Juan Collar C. Eric Dahl Drew Fustin Alan Robinson	USA
1.2	Indiana University of South Bend	Ed Behnke Joshua Behnke Tonya Benjamin Austin Connor Cale Harnish Emily Grace Kuehnemund Ilan Levine Timothy Moan Thomas Nania	USA
1.3	Fermilab	Steve Brice Dan Broemmelsiek Peter Cooper Mike Crisler Jeter Hall Hugh Lippincott Erik Ramberg Andrew Sonnenschein	USA
1.4	SNOLAB	Eric Vazquez Jauregui	Canada

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS:

2.1 LOCATION

2.1.1 The beam test(s) will take place in section MT6.1B

2.1.2 The experimenters will require use of the Alcove control room, as well as desk space in the MTest control room.

2.2 BEAM

2.2.1 BEAM TYPES AND INTENSITIES

Energy of beam: 8 to 32 GeV.
Particles: tagged pions – *The experiment requires negative beam so that there will be minimal background from proton interactions.*
Intensity: 1,000 – 2,000 particles/ 4 sec spill
Beam spot size: minimum 1 cm radius

The experiment acknowledges profiles from the SWICs will be unavailable to check the spot size at this low beam rate.

2.2.2 BEAM SHARING

The experiment will need dedicated run time for this experiment and cannot effectively share the beam.

2.2.3 RUNNING TIME

The majority of time for the experiment will be spent at a single operating point for the beam, and the experiment will collect statistics for a long period – on the order of a week. It is likely the experimenters will require two, separate, week long running periods. One week will be used to understand how to setup the infrastructure and to test scattering off passive fixed targets, such as a copper sheet, or the empty bubble chamber vessel. Another week will be required to collect data with an operational chamber.

2.3 EXPERIMENTAL CONDITIONS

2.3.1 AREA INFRASTRUCTURE

The experimenters will be using the section 1B area with the bubble chamber installed inside the pixel tracking station. They will require space to set up a pressure control panel of approximately 1 cubic foot in size, which contains pressure lines that lead to the glass vessel.

2.3.2 Electronics Needs

Besides support for the pixel tracking station and Cerenkov trigger signals, the experimenters will not need any electronic support.

2.3.3 Description of Tests

For our first run, the experimenters will install a thin foil of copper in the middle of the pixel tracking station to simulate the thickness of the bubble chamber. For about one week they will obtain enough statistics to fully characterize the system at several different beam energies. The second week, at a significantly later time, would consist of taking data at one or two beam energies.

2.4 Schedule

The experimenters would like approximately 3 days run in the time frame of mid-September, 2011. In addition, they would like a second, one-week run in approximately mid-January, 2012.

III. RESPONSIBILITIES BY INSTITUTION – NON FERMILAB

3.1 UNIVERSITY OF CHICAGO:

The University of Chicago will provide assistance in construction of the bubble chamber and will assist in all data taking and analysis. [$20K]

3.2 UNIVERSITY OF INDIANA AT SOUTH BEND

The University of Indiana at South Bend will provide any acoustic transducers used in the beam test, and will assist in data taking. [$5K]

IV. Responsibilities by Institution – Fermilab

4.1 Fermilab Accelerator Division:

4.1.1 Use of MTest beamline 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. [1.0 person weeks]
4.2.2 The experiment will require use of the FTBF pixel tracking system. [0.2 person weeks]
4.2.3 The PPD will provide R&D funding for construction of the test bubble chamber, its pressurization system and video data acquisition and triggering system. [$15K]

4.3 Fermilab Computing Section

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.
4.3.3 The experimenters will require support for operation and maintenance of the CAPTAN pixel tracking system. [0.8 person weeks]

4.4 Fermilab ES&H Section

4.4.1 Assistance with safety reviews.
4.4.2 Provide necessary training for experimenters.

V. SUMMARY OF COSTS

Source of Funds [$K]	**Materials & Services**	**Labor** (person-weeks)
Particle Physics Division	$15K	1.2
Accelerator Division	0	0.5
Computing Section	0	0.8
Totals Fermilab	$15K	2.5
Totals Non-Fermilab	$25K	4

VI. SPECIAL 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 Section management. The Spokesperson also undertakes to ensure no modifications of PREP equipment take place without the knowledge and written consent of the Computing Section 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 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:

Peter Cooper, Experiment Spokesperson — 9 / 8 / 2011

Michael Lindgren, Particle Physics Division, Fermilab — 9 / 9 / 2011

Roger Dixon, Accelerator Division, Fermilab — 9 / 9 / 2011

Lee Lueking, Computing Section, Fermilab — 9 / 9 / 2011

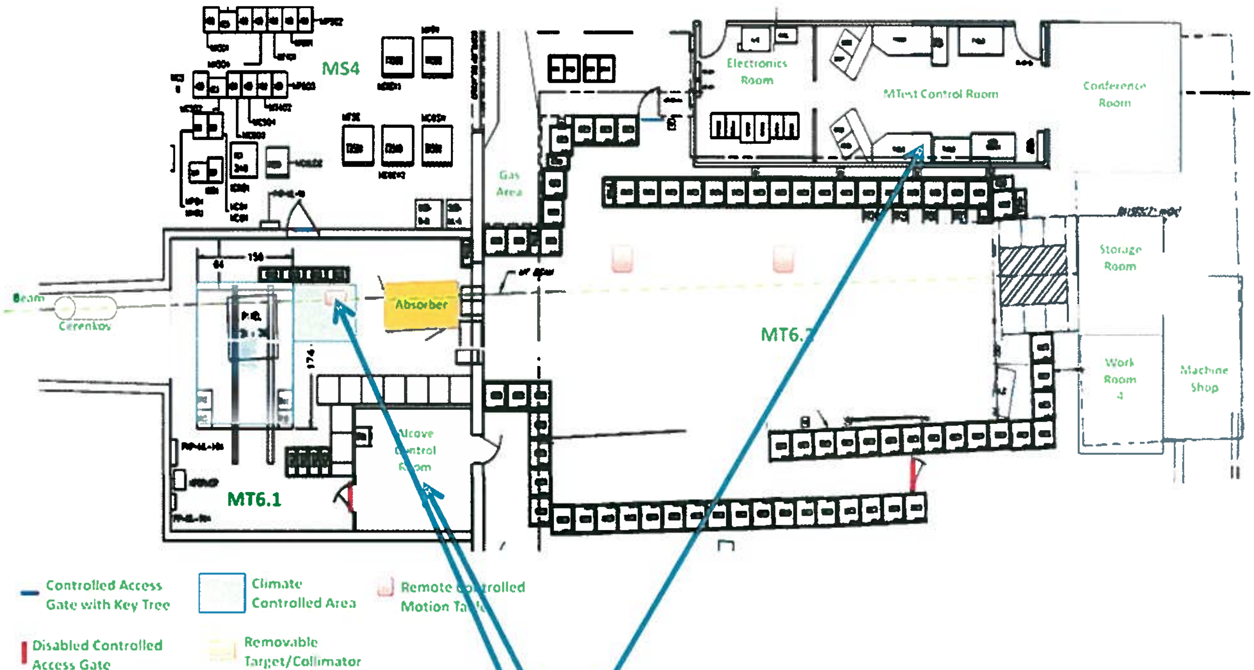
Nancy Grossman, ES&H Section, Fermilab — 9 / 8 / 2011

Greg Bock, Associate Director for Research, Fermilab — 9 / 9 /2011

Stuart Henderson, Associate Director for Accelerators, Fermilab — 9 / 16 /2011

Appendix I: MT6 Area Layout

MTest Areas



- Desk space in MTest control room
- Use of Alcove control room
- Bubble chamber located inside Telescope box.
- Pressure control cart

APPENDIX II: - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need have been 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	X	Quartz 2 mm		PolyChlorinatedBiphenyls	
	Temporary Use	X	Carbon 8 mm		Scintillation Oil	
Type:		X	Teflon 25 mm		TEA	
Strength:		X	Iodine 8 mm		TMAE	
Lasers		X	Copper 2 mm		Other: Activated Water?	
	Permanent installation			X	CF3I (~10 cc)	
	Temporary installation			**Nuclear Materials**		
	Calibration	**Electrical Equipment**		Name:		
	Alignment		Cryo/Electrical devices	Weight:		
Type:			Capacitor Banks	**Mechanical Structures**		
Wattage:			High Voltage (50V)		Lifting Devices	
Class:			Exposed Equipment over 50 V		Motion Controllers	
			Non-commercial/Non-PREP		Scaffolding/ Elevated Platforms	
			Modified Commercial/PREP		Other:	
Vacuum Vessels		**Pressure Vessels**		**Cryogenics**		
Inside Diameter:		Inside Diameter:	1 cm		Beam line magnets	
Operating Pressure:		Operating Pressure:	160 psi		Analysis magnets	
Window Material:		Window Material:			Target	
Window Thickness:		Window Thickness:			Bubble chamber	