Fermilab Directorate

MEMORANDUM OF UNDERSTANDING FOR THE 2008-2009 TEST BEAM PROGRAM

T987

DARK MATTER IN CCD'S (DAMIC)

December 15, 2008

INTRODUCTION

This memorandum of understanding outlines requirements for space in the MINOS near detector hall to install and operate Charge Coupled Devices (CCDs) in an environment with low radiation background. This memorandum is intended solely for the purpose of providing a work allocation for Fermi National Accelerator Laboratory and the participating universities. It reflects an arrangement that is currently satisfactory to the parties involved. It is recognized, however, that changing circumstances of the evolving research program may necessitate revisions. The parties agree to negotiate amendments to this memorandum to reflect such revisions.

The Dark Matter in CCD's (DAMIC) collaboration has been considering the possibility of using DECam CCDs for a direct dark matter search. The detectors have an extremely low readout noise and would allow setting a very low threshold for nuclear recoil detection. The current dark matter searches have limited sensitivity to low mass dark matter particles due to a high threshold setting (in general > 1 keV, with a few experiments setting thresholds around 300 eV). The readout noise achieved in the CCDs under consideration is RMS = 7.2 eV, which means that the experiment could set a threshold at 31 eV, a factor of 5-10 lower than thresholds set for dark matter searches until now.

The CCDs that the experimenters plan to use are the same detectors that are to be mounted in the Dark Energy Camera (DECam) focal plane, another Fermilab project. With the engineering grade detectors available from the DECam R&D project the experimenters will be able to build a 4 g array (corresponding to 4 CCDs), that could become a 10 g array if it is decided to use the more massive detectors. The experimenters expect to operate such an array for 30 days to accumulate between 120 and 300 g-day exposure, that will make the experiment competitive with other dark matter searches in the low mass region.

These CCDs operate at -140 C to reduce dark current. The detectors are inside a vacuum vessel and cooled down with a closed cycle refrigerator using helium gas (CRYOMEC CP510) . The vacuum vessel has been operated at this temperature at SiDet (LabA) without problems. An image of this vessel is shown in Fig. 1.

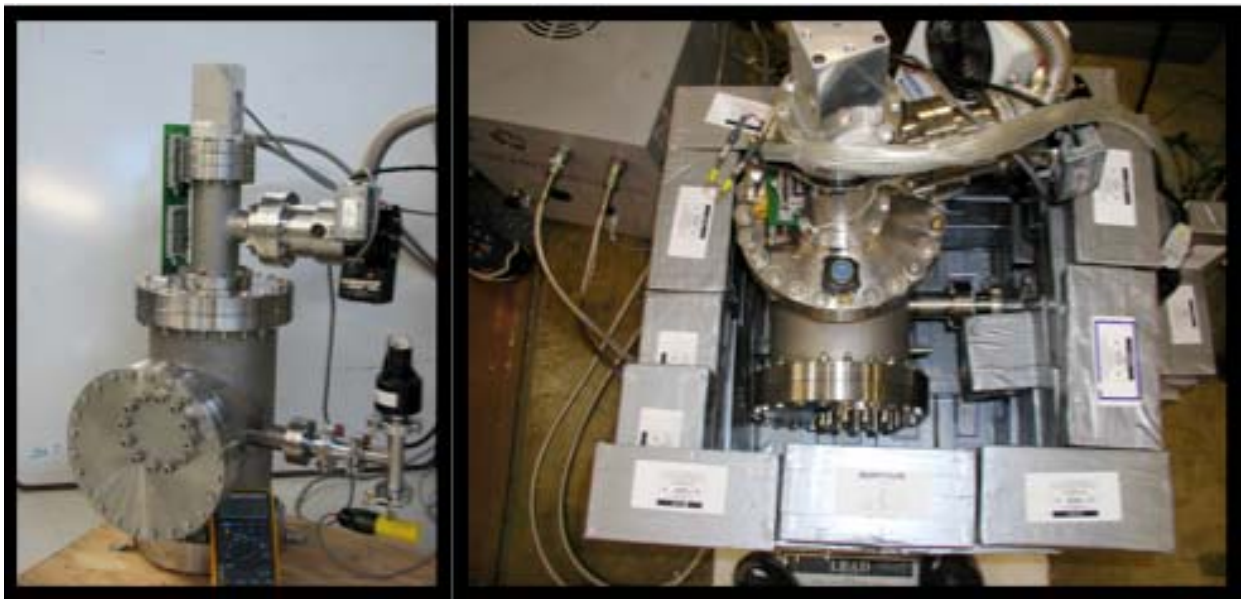


Fig.1. Left: vacuum vessel using for DAMIC. Right: Vacuum vessel seen from top inside a partially assembled lead shield.

For this test to be successful the experimenters need to properly shield the detectors. The experimenters propose to build an 8'' lead shield around our vacuum vessel with openings for the cryo-cooler and the vacuum pipes. The outer 6'' of this shield will be built using lead available at Fermilab and for the inner layers they will use new lead purchased from a mine known to have low radioactivity (Doe Run). The schematic of the proposed lead shield is shown in Fig. 2. The complete shield consists of ~700 bricks of the lead available at Fermilab and ~130 bricks of Doe Run lead. The bricks will be painted to avoid lead contamination in the working area.

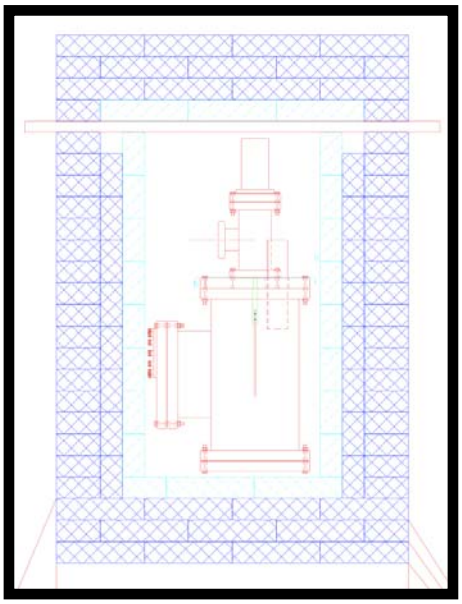


Fig. 2. Schematic of the lead shield proposed for DAMIC.

I. PERSONNEL AND INSTITUTIONS:

Physicist in charge of beam tests: Juan Estrada, Fermilab

The group members at present and others interested in this test are:
Juan Estrada, Spokesman, Fermilab
Tom Diehl, Fermilab
Brenna Flaugher. Fermilab
Ben Kilminster, Fermilab
Erik Ramberg, Fermilab
Andrew Sonnenschein, Fermilab

Other commitments:
Dark Energy Survey: J. Estrada, T. Diehl and B. Flaugher
Coupp: E. Ramberg, A. Sonnenschein
CDF, CMS: B. Kilminster

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS

1. LOCATION

The test is to take place in the MINOS near detector tunnel. There is a large area immediately upstream from the MINOS near detector which was heavily used for rigging and staging during the near detector installation. This area has been recently used for the COUPP experiment, which is currently upgrading. Much of this area is well off the beam axis and would be ideal for the DAMIC test. The experimental apparatus plus shielding will occupy a footprint roughly eight feet square. A plan for the proposed location is included in APPENDIX II. The schematic (agreed to by Cat James from the Minos Department) also shows the location for the new COUPP chambers. The apparatus requires one 208/230 VAC single phase 1.2 kW for the cryocooler and stantard 110 VAC lines for the pump and electronics.

2. BEAM

The DAMIC test does not utilize any particle beams. For this initial test the experimenters will be able to operate when the beam is on. In the future the expreimetners will consider vetoing the detectors while the beam is on.

3. SETUP

The complete DAMIC equipment list:

- DAMIC dewar shown in Fig. 1 with turbo pump and backing pump attached
- DAMIC shield shown in Fig. 2

- CRYOMEC CP510 (cryocooler)
- electronics rack #1:
    - windows XP computer for monitoring temperature and pressure
    - scientific linux computer for DAQ
    - temperature controller
    - 2 pressure gauge monitors
    - pump controller
- electronics rack #2:
    - Monsoon CCD controller
    - Monsoon power supplies

Fig. 3. Example of the unistrut clean tent that the experimenters would like to build in the Minos hall. The picture was taken from a similar tent located at SiDet.

Clean area in the minos hall:

The experimenters plan to install this equipment inside a clean tent to avoid getting dust, with potential radioactivity, inside the lead shield. The tent that the experimenters propose to build will have a unistrut structure with herculite panels and HEPA filters on top. The structure will be similar to the one shown in Fig. 3, located at SiDet.

4. SCHEDULE

The DAMIC apparatus would be ready for this test immediately. The experimetners expect to be able to start building the shield and installing the clean tent in December. After the installation is complete the experimetners would collect data continuously for 1 month. At that point the experimetners would look at the results and decide on the next step for this project.

III. RESPONSIBILITIES BY INSTITUTION - NON FERMILAB

([] denotes replacement cost of existing hardware.)

The only institution involved in this R&D project is Fermilab.

IV. RESPONSIBILITIES BY INSTITUTION - FERMILAB

([] Denotes replacement cost of existing hardware.)

4.1 Fermilab Accelerator Division:

No Accelerator Division support is required.

4.2 Fermilab Particle Physics Division

1.1.1 The PPD Mechanical Department will be responsible for analysis of the mechanical support issues for the vacuum chamber and its associated shielding. PPD/MD will be responsible for moving the equipment into the MINOS hall and for rigging and handling of the equipment into its final location.

1.1.2 The PPD ES&H Department will assist in all of the necessary safety reviews.

1.1.3 The PPD will coordinate access into the MINOS tunnel.

1.1.4 The PPD will support the construction of the clean tent in the MINOS hall

Summary of Particle Physics Division costs:

Type of Funds	Equipment	Operating	Personnel (person-weeks)
Rigging, Installation Analysis			2.0 engineer
Rigging and Installation			2.0 tech
Clean Tent	$6K	$0K	1.0 tech
Total new items	$6K	$0K	5.0

4.3 Fermilab Computing Division

No support from Computing Division is required. The experiment will use the already available ethernet connections for the DAQ system.

4.4 Fermilab ES&H Section

The experimenters require help from ES&H section in handling the lead to be used for the shield. The experimenters will need support from this section painting the lead to avoid creating a lead area in the MINOS hall. Additional assistance with safety reviews will be provided as appropriate.

Summary of ES&H costs

Type of Funds	Equipment	Operating	Personnel (person-weeks)
Painting of lead bricks	0	0	3.2
Total existing items	[$0.0K]	$0K	0.0
Total new items	$0.0K	$0K	0.0

V. SUMMARY OF COSTS

Source of Funds [$K]	Equipment	Operating	Personnel (person-weeks)
Particle Physics Division	$6K	$0.0K	5
Accelerator Division	0	0	0
Computing Division	0	0	0
ES&H			3.2
Totals Fermilab	$6K	$K	8.2
Totals Non-Fermilab	0		

VI SPECIAL CONSIDERATIONS

6.1 The responsibilities of the spokesman of the DAMIC group and the procedures to be followed by experimenters are found in the Fermilab publication "Procedures for Experimenters": (http://www.fnal.gov/directorate/documents/index.html). The Physicist in charge agrees to those responsibilities and to 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 spokesman of the DAMIC group 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 spokesman of the DAMIC group will ensure that at least one person is present at the Meson 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 spokesman of the DAMIC group 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 Division management. They also undertake to ensure that no modifications of PREP equipment take place without the knowledge and consent of the Computing Division management.

6.7 The DAMIC group will be responsible for maintaining and repairing both the electronics and the computing hardware supplied by them for the experiment. Any items for which the experiment requests that Fermilab performs maintenance and repair should appear explicitly in this agreement.

6.8 At the completion of the experiment:

6.8.1 The PI of the DAMIC group 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 DAMIC of the Minerva group will be required to furnish, in writing, an explanation for any non-return.

6.8.2 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.

6.8.3 The experimenters will assist the Fermilab Divisions and Sections with the disposition of any articles left in the offices they occupied.

6.9 An experimenter will be available to report on the test beam effort at Fermilab All Experimenters Meetings.

SIGNATURES:

_____ / / 2008
Juan Estrada, DAMIC spokesman

_____ / / 2008
Robert Plunkett, MINOS group

_____ / / 2008
Greg Bock, Particle Physics Division

_____ / / 2008
Roger Dixon, Accelerator Division

_____ / / 2008
Victoria White, Computing Division

_____ / / 2008
Nancy Grossman, ES&H Section

_____ / /2008
Stephen Holmes, Associate Director, Fermilab

_____ / /2008
Young Kee Kim, Deputy Director, Fermilab

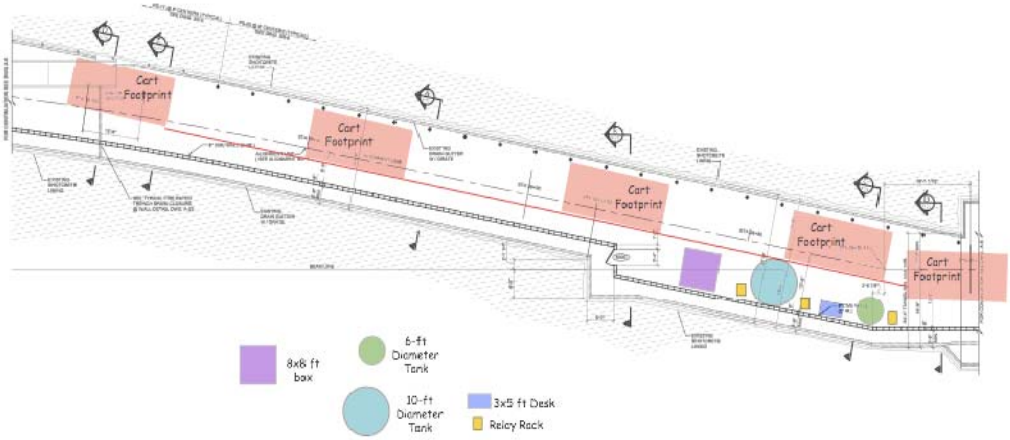
APPENDIX I - Hazard Identification Checklist

Items for which there is anticipated need have been checked

Cryogenics		Electrical Equipment		Hazardous/Toxic Materials	
	Beam line magnets		Cryo/Electrical devices		List hazardous/toxic materials
	Analysis magnets		capacitor banks		planned for use in a beam line or experimental enclosure:
	Target		high voltage		700 lead bricks
X	Helium gas refrigerator		exposed equipment over 50 V		
Pressure Vessels		**Flammable Gases or Liquids**			
	inside diameter	Type:			
	operating pressure	Flow rate:			
	window material	Capacity:			
	window thickness	**Radioactive Sources**			
Vacuum Vessels			permanent installation	**Target Materials**	
8”	inside diameter		temporary use		Beryllium (Be)
1E-6 torr	operating pressure	Type:			Lithium (Li)
no window	window material	Strength:			Mercury (Hg)
	window thickness	**Hazardous Chemicals**		X	Lead (Pb) (used as shield)
Lasers			Cyanide plating materials		Tungsten (W)
	Permanent installation		Scintillation Oil		Uranium (U)
	Temporary installation		PCBs		Other :
	Calibration		Methane	**Mechanical Structures**	
	Alignment		TMAE		Lifting devices
type:			TEA		Motion controllers
Wattage:			photographic developers		scaffolding/elevated platforms
class:			Other:		Others

APPENDIX II Proposed location of the DAMIC setup.

View of the proposed location for the DAMIC setup (8x10 ft tent).



Appendix III: Run plan for December 2008-February 2009

The experimenters expect to have the experiment ready to move underground in December 2008. They plan to operate the 4 DECam detectors at -140C during one month of continuous data collection.

At the beginning of this run they will readout the detectors every few minutes, to have a good measurement of the noise and make any optimization needed to achieve the same readout noise that has been seen in Lab A. They will do this outside the lead shield, or with a partially assembled lead shield, to have access to cables and connectors on the detector vessel.

Once the noise level is under control, the experimenters will finish the construction of the lead shield and start the readout of the detectors every few hours (~3 hours). They plan to run continuously in this way for 1 month.

After 1 month of running the experimenters will evaluate the results and consider the next step. If the results look competitive and are limited by the exposure time, the experimenters will most likely propose an extension of the run.