



Directorate

Fermilab

MEMORANDUM OF UNDERSTANDING (MOU)

T972

**- Shielding and Radiation Effect Experiments -
(Pbar target station and NuMI absorber & MINOS)**

FNAL-Japan Radiation Physics Collaboration Team

November 2, 2007

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1. INTRODUCTION

This is a Memorandum of Understanding (MOU) between the Fermilab and experimenters who have committed to participate in “the Shielding and Radiation Effect Experiments” to be carried out for several years, starting in October 2007.

This memorandum is intended solely for the purpose of providing a work allocation for Fermilab and the participating institutions and universities. It reflects an arrangement that is currently satisfactory to the parties involved. It is recognized that changing circumstances of the evolving research program may necessitate further revisions. The parties agree to negotiate amendments to this memorandum to reflect such revisions.

In all the phases of the experimental work outlined in this MOU, the experimenters will abide by the Fermilab Environmental Safety and Health Manual (FESHM) as prescribed and guided by the laboratory’s safety staff.

2. PROJECT OUTLINE

The efforts covered by this MOU are meant to be the start of a project of “shielding and radiation effects” using various accelerator facilities at Fermilab. The project includes fundamental research in the following areas for future accelerators with higher energy and higher intensity and space science facilities:

- Shielding data; production and transmission, cascade in targets, collimator and shields,
- Radiation effects on instruments and materials.

The purpose of this project is to obtain the following data for high energy particles using Fermilab accelerator facilities:

(1) Shielding data,

- | | |
|--------------------|---|
| Measuring quantity | - Energy spectra of generated or transmitted particles |
| | - Prompt dose rates |
| | - Radioactive nuclide production rates in materials and air |
| Location | - Beam line, target & beam dump |
| | - Inside & outside shield |
| | - Penetration duct |

(2) Radiation effect data

- | | |
|--------------------|---|
| Measuring quantity | - Absorbed dose |
| | - Radionuclide production and residual dose |
| | - DPA (displacement per atom) of materials |
| | - Soft error of semi-conductors |
| Location | - use same locations for shielding-data measurement |

Since experimental shielding data in the high energy region above 1GeV is very scarce, the data from this experiment will be very useful for the following:

- (a) Benchmarking of simulation codes (MARS, PHITS and FLUKA)
 - Possible accuracy upgrade,
 - Modification of physical model and parameterizations.
- (b) Material science, space science, high energy accelerator science and engineering.
 - Provide irradiation field for radiation effect studies of materials or devices
 - Development of simulation code for radiation damage and radionuclide production.
- (c) Radiation safety estimation for
 - prompt dose distribution inside and outside shield and through penetration ducts
 - residual activity in material and air

The project can make use of the variety of facilities at Fermilab with a wide range of proton-beam energies to obtain systematic data for shielding and radiation effects.

- | | |
|------------------|---|
| 400 MeV Linac - | Neutron therapy facility, etc. |
| 8 GeV Booster - | MI8 Booster Main injector transport line, MINIBooNE, etc. |
| 120 GeV MI - | Pbar target station, NuMI, Meson Test Beam Facility, MIPP |
| 1 TeV Tevatron - | Tevatron beam dump, D0, CDF |

This MOU includes two experiments - one at the “Pbar target station” and one at the “NuMI absorber & MINOS” planned for the first two years of the project (Oct. 2007 – Mar. 2009).

The experiments at the other facilities can be planned for after April 2009, and these will be the subject of a separate MOU.

3. EXPERIMENTS

3.1 Pbar target station

A parasitic experiment will be performed over a period of 2 years at the Pbar target station as follows:

- (1) 1st year (Oct. 2007- Mar.2008) - preliminary measurements
- (2) 2nd year (Apr.2008- Mar.2009) - upgraded measurement with extended locations.

The pbar target, irradiated by 120 GeV protons from the Main Injector, is shielded by 224-cm thick steel and 122-cm concrete. A 183-cm air gap exists between the steel and concrete shields. Spatial distribution and energy spectra of secondary particles around the target, inside and outside of the shield, and through penetration ducts will be measured. Detection techniques, locations and brief schedule are listed in the Table 3-1.

Samples are placed at the end of a shutdown period. Stable irradiation for 1~2 weeks with at least 30% of full power is needed for activation measurement. No beam-off is required for removing the activation foils or disks (See 3.4).

- Experiment time

Sample irradiation: 1~2 weeks (2E18 protons) x 2 times/yr x 2 years
Active counter measurement: 1 week (overlapped with sample irradiation)

- Sample counting

Approximately 150 foils for the first year's exposure are placed in the air gap, with approximately 25 more on the shield. These will be counted at the High Intensity Laboratory as counter capacity allows. The second year's samples will depend upon the results found in the first round.

- Sample transport

The safety departments of Accelerator and Particle Physics Division will work in coordination to develop a protocol for the safe and expeditious transfer of samples from the irradiation area to the counting area at HIL.

Table 3-1:

		1		2		3		4		5	
Detection technique		Activation foil or disk		Organic Liquid scintillator		Multi-moderator spectrometer		Chemical Separation of activation foil		Air sampling	
Material or detector		Al, Bi, In, C, Cu, Au		NE213		Bonner sphere		Au			
Quantity to be measured		Energy spectra (E>10MeV)		Energy spectra (E>1MeV)		Energy spectra (E>Thermal)		Energy spectra		Residual air activity	
thick (cm)		year		year		year		year		year	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
	Above concrete	1	2	1	2	1	2	1	2		
122	Concrete shield		2						2		
183	Air gap above steel	1	2					1	2		
224	Steel Shield		2						2		
45 (from beamline)	Target Vault		2						2	1	2
	Duct		2		2		2		2		

3.2 NuMI Absorber & MINOS

A parasitic experiment will be performed over a period of 2 years at the NuMI beam line as follows.

- (1) 1st year (Oct.2007- Mar.2008) - muon & neutron measurement at muon alcoves
- (2) 2nd year (Apr.2008- Mar.2009) - dose & particle measurement outside absorber shield

The NuMI absorber is located at 73m underground at the end of the decay pipe. Muons and neutrinos go through rock after the absorber. There are 4 muon alcoves between the absorber and the MINOS hall. Energy spectra of neutrons induced by muons and neutrino in the rock will be measured at the MINOS hall & the bypass tunnel. Neutron flux will be measured at the muon alcoves and at the absorber shield surface by activation detectors. Table 3-2 is a summary of measurement. Approximately 50 irradiation samples for the first year's exposure are placed in the NuMI areas. The samples for the second year's exposure will depend upon the results of the first round.

The experimenters will remove or exchange activation detectors in the alcoves or the absorber hall when breaks in beam delivery happen and access is allowed. Irradiation needs 2 weeks to 6 months.

Table 3-2:

	1		2		3	
Detection technique	Activation foil or disk		Organic Liquid scintillator		Multi-moderator spectrometer	
Material or detector	Al, Cu, Bi, C, In		NE213		Bonner sphere	
Particle to be measured	neutron, muon		neutron		neutron	
Quantity to be measured	Radionuclide production rate		Energy spectra (E>1MeV)		Energy spectra (E>Thermal)	
	year		year		year	
	1st	2nd	1st	2nd	1st	2nd
Absorber	1	2				
Muon Alcoves	1	2				
Bypass tunnel			1	2	1	2
MINOS hall			1	2	1	2

3.3 Active counter measurement for prompt radiation

Active counters (NE213 scintillator and Bonner sphere with BF₃ counter) are placed to measure neutron energy spectra at the locations given in Table 3-3.

Electronics circuit using NIM and CAMAC crates, DAQ system and high voltage power supplies are placed at the locations given in Table 3-3.

10 Signal cables (BNC) and 7 high voltage cables (SHV) are used to connect between the counters and the electronics circuit.

Table 3-3: Locations of active counters and electronics

	NE213 or Bonner sphere	Electronic circuit & DAQ
Pbar	Above the concrete shield cap at the target station	counting area at AP0
NuMI	bypass tunnel	bypass tunnel
	MINOS hall	MINOS hall

The detectors are shipped from Japan. Most of the electronic modules (i.e. ADC, CFD, Gate generator etc.) and crates are loaned from PREP (See Appendix II). DAQ systems are shipped from Japan.

For detector calibration and circuit tuning, calibration sources from the Fermilab inventory are used. The experimenters will negotiate with the MINOS Experiment for scheduling any use of the calibration sources at the MINOS hall or NuMI bypass-tunnel. Any calibrations with neutron sources will be conducted at the Radiation Physics Calibration Facility (RPCF) with the approval in advance of the Senior Radiation Safety Officer.

Active counter measurements above the concrete shield at the pbar target station will be made in a number of sessions as listed in the attached schedule. The liaison physicist for the pbar target station will coordinate the accesses in conjunction with the AD ES&H Department collaborator to minimize the impact on pbar stacking operation. Each access will require a few minutes of stacking off time while experimenters access the target vault to change the counting setup. The key to the target vault will be kept by a person designated by the ES&H collaborator. Before each access the person holding the target vault key will notify the AD MCR crew chief and request that the beam switch be taken to interrupt stacking. Upon confirmation that stacking has been turned off, the key holder will unlock the target vault and permit experimenters to access the target vault. The accesses should be pre-planned and executed safely, efficiently and deliberately to minimize interruption in pbar stacking operation. Upon completion of the target vault access, the key holder will ensure that all personnel have left the target vault enclosure and will then notify the AD MCR crew chief that it is safe to resume stacking operations. The total interruption in stacking operation (beam off time) for the accesses (estimated at 25) related to active counter measurements above the concrete shield for all sessions listed in the attached schedule should not exceed approximately 4 hours.

3.4 Remove irradiated samples and residual activity measurements

The irradiated samples are removed from the irradiation spots at Pbar under supervision of AD Radiation Safety Group personnel, either through penetration ducts from the air gap, or over the target-station concrete wall from the concrete shield cap. The samples are pulled by strings connected to the sample holders. This should be well arranged at the setting up stage. In case of difficult situations for this procedure, samples are taken out by accessing when beam is off.

The irradiated samples are removed from irradiation spots at NuMI muon alcoves or absorber hall when access is allowed.

The samples irradiated both at Pbar or NuMI are transported by a government vehicle to a counting room at HIL (High Intensity Lab.), and the gamma rays from radionuclide produced in the samples are measured by High Purity Germanium (Hp-Ge) detectors. A part of irradiated samples with low residual dose rates (< 1 mrem/hr) can be measured by Ge-detectors at RAF in case of sample overflow. Measurement period is approximately 2~4 weeks for each experiment.

Several Ge-detectors are shipped from JAEA and KEK, Japan. About 100 pieces of lead bricks ($5 \times 10 \times 20 \text{cm}^3$) are loaned from PPD for shielding these Ge-detectors. MCAs (Multi-channel analyzer) are also shipped from Japan. These Ge-detectors are set up in a counting room at HIL. Liquid nitrogen should be supplied every couple of days. A total of 270 liters per week may

be needed during the initial cool down of the crystals, with a use of 120 liters per week afterward.

3.5 Chemical analysis of irradiated sample

A part of foils, water and concrete samples irradiated at Pbar or NuMI are transported by a government vehicle to a chemical laboratory at RAF, and the radionuclides produced in the samples are chemically separated. Only samples registering a contact dose rate of less than 1 mrad/hr will be processed at the Fermilab RAF chemistry lab and when this work does not interrupt services to the primary Fermilab program. The number of samples will be limited so that the integrated dose rate remains less than 1 mrad/hr at one foot from the set. The process takes 1 week for each experiment. Samples which need long term analyses are shipped to Japan.

4. PERSONNEL AND INSTITUTIONS

Spokesperson: Hiroshi Nakashima (JAEA)

Particle Physics Division Liaison Physicist: David Boehnlein (Fermilab, PPD Neutrino Department)

Accelerator Division Liaison Physicist: Tony Leveling (Fermilab, AD Pbar Department)

David Boehnlein is the physicist in charge of T972 activities in PPD-controlled areas, including MINOS, High Intensity Lab and other fixed-target areas under the control of PPD.

Tony Leveling is the physicist in charge of T972 activities in AD-controlled areas, including the antiproton area, and the NuMI absorber and muon alcove areas.

The group members at present are:

JAEA (Japan Atomic Energy Agency)

Hiroshi Nakashima (Principal Scientist, Radiation Safety Section Leader)

Yukio Sakamoto (Principal Scientist, Leader for Appl. Rad. Physics Research Group)

Yoshimi Kasugai (Senior Scientist)

Yoshihiro Nakane (Senior Scientist)

Yosuke Iwamoto (Scientist)

Norihiro Matsuda (Scientist)

Fumihito Masukawa (Scientist)

Tokushi Shibata (Scientific Consultant)

KEK (High Energy Accelerator Research Organization), Japan

Toshiya Sanami (Scientist)

Hiroshi Matsumura (Scientist)

Hiroshi Iwase (Scientist)

Masayuki Hagiwara (Scientist)

Norikazu Kinoshita (Scientist)

Hideo Hirayama (Professor)

Syuichi Ban (Professor)

Kyoto Univ., Japan

Hiroshi Yashima (Scientist)

Shimizu Corporation, Japan

Takashi Nakamura (Scientific Consultant, Professor emeritus of Tohoku Univ.)

Koji Oishi (Principal Scientist)

Kyushu Univ., Japan

Kenji Ishibashi (Professor)

Nobuhiro Shigyo (Assistant Professor)

JASRI (Japan Synchrotron Radiation Institute)

Shingo Taniguchi (Scientist)

RIST, Japan

Koji Niita (Head of Simulation code development group)

(TBD)

Noriaki Nakao

Fermilab

Nikolai Mokhov (Principal Physicist, Head of Energy Deposition Group, APC)

Igor Rakhno (Physicist, APC)

Kamran Vaziri (Physicist, ES&H, Radiation Physics)

Tony Leveling (Physicist, AD, Pbar)

David Boehnlein (Physicist, PPD, Neutrino Department)

Nancy Grossman (Physicist, AD, Projects)

Wayne Schmitt (Radiation Physicist, PPD, ES&H Radiation Safety)

Gary Lautenschlager (Radiation Physicist, AD, ES&H Radiation Safety)

5. RESPONSIBILITIES BY INSTITUTION - NON FERMILAB

JAEA, KEK, ETC.

- Shipping Ge-detectors, scintillation counters, activation samples etc. from and back to Japan
- Setting up for Ge-detectors, active counters, their electronic circuit, and DAQ system
- Setting and removing sample to be irradiated
- Measurements of gamma rays from radionuclides from irradiated sample with Ge-detector
- Active counter measurements
- Chemical separation process
- Data analysis
- Provide 5 support stands for Ge-detectors (1st year)

6. RESPONSIBILITIES BY INSTITUTION – FERMILAB

ACCELERATOR PHYSICS CENTER (APC)

- Assistance for the experimenters of this project
- Full simulation support prior and after measurements

ACCELERATOR DIVISION (AD), PBAR

- Survey and assistance to install and remove the detectors.
- Assistance to transport irradiated samples from the radiation area to the counting room.
- Assistance for Fermilab safety training for the experimenters in AP0 building.
- Coordinate access to the experimental area (target vault) at AP0 building.
- Number of protons at the Pbar target is provided as real-time electric signal pulse and/or as data of particle number history after beam time.
- Assistance of placing electronics with CAMAC crate and DAQ system at a counting area of AP0 building for active counter measurement
- Lend cables and connectors
- Open, close and moving the concrete shield cap or steel shielding of air gap (parasitic to other needs to open the cap or shielding)"
- Use of existing crane for detector setting and removing during operation.
- Use of penetration ducts to pull detectors inside the air gap between steel and concrete shields using rope.
- Assistance in transporting irradiated samples from the radiation area to the counting room.
- Coordinate access to the muon alcoves during changing of detectors
- Assistance with placement of samples in NuMI areas.

PARTICLE PHYSICS DIVISION (PPD)

- Assistance for Fermilab safety training for the experimenters to access the MINOS Near Detector Hall and adjacent area.
- Assistance with placement of samples in the MINOS hall and PPD part of the bypass tunnel.
- Accumulated toroid readings and POT history for the run.

- Assistance of placing electronics with CAMAC crate and DAQ system at bypass tunnel by muon alcoves.
- Lend 100 lead bricks until this project completes. The bricks will be wrapped or coated for safe handling.
- Lend 3 counting rooms in HIL (High Intensity Lab, Fig. 1) for measurement of sample activities with several Ge-detectors, for data analysis, and for storage of all detectors, electronics, etc. until this project completes.
- Carry out an ODH Risk Assessment for the HIL. The counting area for the HIL will be set up to be ODH Class 0.
- Assistance making 5 Ge-detector support stands

COMPUTING DIVISION

- Lend and maintain electronic modules & tools from PREP (See Appendix II)
- Set up connection of an internet access in a counting room at HIL to observe a real-time beam status (the connection may already exist).
- Lend and set up a printer for data analysis in a counting room at HIL.
- Provide server and backup for DocDB document database.

ES&H SECTION

- Assistance with safety reviews
- Lend a chemical laboratory in RAF for chemical separation of irradiated samples (Only samples registering a contact dose rate of < 1 mrad/hr. can be processed at the Fermilab RAF chemistry lab and when this work does not interrupt services to the primary Fermilab program.)
- Lend RAF Ge-detectors when available
- Lend a PC, to be used for the data acquisition only
- Assistance for calibration sources
- Arrangement of a source storage box for calibration sources & irradiated samples in the counting rooms at HIL.
- Supervise transportation of radioactive samples within the laboratory.
- Assistance with shipping radioactive samples from and to Japan.

7. ITEM TO BE NEGOTIATED

- Provide additional concrete shielding with detector slots above Pbar target station (2nd year).

8. SUMMARY OF COSTS

Source of Funds [\$K]	Equipment	Operating	Personnel (person-weeks)
(Oct. 2007 - Mar. 2008)			
Accelerator Physics Center	0K	0	2
Accelerator Division	0	0	2
Particle Physics Division	0	0	3
ES & H Section	0	0	2
Computing Division	0	0	0

Totals Fermilab	0 K	0	9
Totals Non-Fermilab	40 K	0	40
(Apr. 2008 - Mar. 2009)			
Accelerator Physics Center	0K	0	2
Accelerator Division	0	0	2
Particle Physics Division	0	0	2
ES & H Section	0	0	2
Computing Division	0	0	0

Totals Fermilab	0 K	0	8
Totals Non-Fermilab	40 K*	0	40

* Non Fermilab costs in second year are predominantly travel and manpower.

There is no provision in this tally for any modifications to HIL to accommodate cryogenics.

9. SPECIAL CONSIDERATIONS

- 9.1 The responsibilities and 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.
- 9.2 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 and follow all procedures in the [PPD Operating Manual](#).
- 9.3 The spokesperson will ensure that at least one person who is knowledgeable about the experiment's hazards is present at the access of the Pbar target station, NuMI muon alcoves, or NuMI absorber.
- 9.4 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.
- 9.5 All items in the Fermilab Policy on Computing will be followed by the experimenters. (<http://computing.fnal.gov/cd/policy/cpolicy.pdf>).
- 9.6 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 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.
- 9.7 The experiment 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.
- 9.8 At the completion of the experiment:
 - 9.8.1 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 of the group will be required to furnish, in writing, an explanation for any non-return.
 - 9.8.2 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.
 - 9.8.3 The experimenters will assist the Fermilab Divisions and Sections with the disposition of any articles left in the offices they occupied.
 - 9.8.4 An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters Meeting.

10. SPECIAL CONSIDERATIONS FOR SAFETY AND HANDLING OF RADIOACTIVE MATERIALS

- 10.1 All experimenters should receive Fermilab Radiological Worker training prior to beginning experiments.
- 10.2 All irradiated materials will be handled and transported by AD Radiation Safety per Fermilab regulations. AD Radiation Safety shall retain possession of all irradiated materials at their discretion until such materials can be safely transported and handled according to AD Radiation Safety.
- 10.3 All accesses to APO building and NuMI Absorber access ramp to remove materials require AD Radiation Safety presence at all times. Any desire to manipulate irradiated materials must be coordinated and supervised by AD Radiation Safety.
- 10.4 All equipment for the experiment will remain at Fermilab until such equipment has been verified to be free of contamination or activation.
- 10.5 Calibration sources must be pre-approved by the Fermilab ES&H section before they are brought on site. Isotopes and activity in Bq must be specified in the request. Sources must be secured while on site from theft or loss. Such arrangements for security of radioactive sources, and activated materials must be made prior to beginning the experiments in coordination with the Fermi Source Manager.
- 10.6 The counting lab at HIL must be approved by the PPD RSO and SSO. The area must meet Fermilab radiological and ODH requirements. Arrangements must be agreed upon prior to beginning the experiments between Accelerator Division and Particle Physics Division, with respect to chain of custody and transportation of materials.
- 10.7 Prior to shipment of radioactive materials to Japan, the FNAL ES&H section must receive the materials for shipping. Experimenters will provide shipping containers that meet US and International shipping requirements for radioactive materials. FNAL ES&H section must also receive licensing or equivalent documentation from recipient institution in Japan prior to shipping that recipients are authorized to receive the radioactive materials.
- 10.8 All radioactive chemical byproducts that may be generated by the experiment must be returned to Japan.
- 10.9 Chemical analysis of irradiated samples- procedures should be provided that describe the process and meet Fermilab approvals by RAF, ES&H.
- 10.10 Procedures for material placement and retrieval mechanisms for irradiated materials must be pre-approved by AD Radiation Safety. AD Radiation Safety must be present and directly supervise all such operations. Under no circumstances will irradiated materials be transported by the experimenters.

SIGNATURES:

_____/ / 2007
Hiroshi Nakashima,
spokesperson, JAEA

_____/ / 2007
Nikolai Mokhov,
Energy Deposition Group, APC, Fermilab

_____/ / 2007
Dave Boehnlein,
Liaison Physicist, PPD Fermilab

_____/ / 2007
Vladimir Shiltsev,
Accelerator Physics Center

_____/ / 2007
Tony Leveling,
Liaison Physicist, AD Fermilab

_____/ / 2007
Roger Dixon, Accelerator Division

_____/ / 2007
Yukio Sakamoto,
Leader, Applied Radiation Physics Research
Group, JAEA

_____/ / 2007
James Strait, Particle Physics Division

_____/ / 2007
Toru Ogawa,
Director General,
Nuclear Science and Engineering
Directorate, JAEA

_____/ / 2007
Victoria White, Computing Division

_____/ / 2007
William Griffing, ES&H Section

_____/ / 2007
Hugh Montgomery,
Associate Director, Fermilab

_____/ / 2007
Stephen Holmes,
Associate Director, Fermilab

APPENDIX I - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need have been checked

Cryogenics		Electrical Equipment		Hazardous/Toxic Materials	
X	LN2 filled Ge detector		Cryo/Electrical devices		List hazardous/toxic materials
	Analysis magnets		capacitor banks		planned for use in a beam line or experimental enclosure:
	Target	X	high voltage (power supply, 2kV, 4kV)	X	Radiation hazard: Irradiated foils or disks (Al, Bi, In, Au, Cu, Fe)
	Bubble chamber		exposed equipment over 50 V	X	Pb bricks for shielding Hp-Ge counters
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	
	inside diameter	X	temporary use (at AP0 building) (at NuMI bypass tunnel, need negotiation)		Beryllium (Be)
	operating pressure	Type:	Co-60, Na-22, Cs-137		Lithium (Li)
	window material	Strength:	100 µCi		Mercury (Hg)
	window thickness	Hazardous Chemicals			Lead (Pb)
Lasers			Cyanide plating materials		Tungsten (W)
	Permanent installation		PCBs		Uranium (U)
	Temporary installation	X	NE213 organic liquid scintillator (Sealed in glass capsule)	X	Other (foils, Al, Bi, In, Au, Cu, Fe) (Irradiated at AP0 building, measured at counting room)
	Calibration		Methane	Mechanical Structures	
	Alignment		TMAE		Lifting devices
type:			TEA		Motion controllers - manual
Wattage:			photographic developers		scaffolding/elevated platforms
class:		X	See attached list		Others
		X	Other: Activated Water?		

Hazardous Chemical list (MSDS will be provided for these)

(Product No. is from catalog of SIGMA-ALDRICH Corp.) Quantities and concentrations are approximate.

Beryllium ion chromatography standard solution
1000ppm, 100mL (Product No.:14203)

Iron(III) chloride hexahydrate
25g (Product No.:14-1140-2)

Hydrogen peroxide
30-35.5%, 600mL (Product No.:13-1910-5)

Phosphate ion chromatography standard solution
1000ppm, 100mL (Product No.:79409)

Sulfate ion chromatography standard solution
1000ppm, 100mL (Product No.: 86126)

Ammonium molybdate tetrahydrate
100g (Product No.: A7302)

Barium chloride dihydrate
30g (Product No.: 03-0240-2)

Magnesium chloride hexahydrate
100g (Product No.: M2670)

Nitric Acid 50 mL
Available at Fermilab - concentration TBD

Hydrochloric Acid 50 mL
Available at Fermilab – concentration TBD.

Ammonia Water 50 mL - available from Aldrich

APPENDIX II – ELECTRONIC MODULES LOAN FROM PREP

The following electronic modules to conduct the experiment are loaned from PREP of computing division for a few months. Computing division can also lend additional electronic modules which are not in the list due to measurement progress or schedule change

Number Module name

<Scintillator>

- 1 QDC (LeCroy 2249A) --OK
- 1 TDC (LeCroy 2228A) --OK
- 2 Constant Fraction Discriminator (ORTEC935 or ORTEC934) --OK 934
- 2 Discriminator (LRS: 623B or 623A) --OK
- 2 Gate Generator (LRS 222) --OK
- 1 Visual Scaler --OK Fermi: RFDVS
- 2 Coincidence (LRS 622) --OK
- 3 Variable delay (ORTEC DB463 or ORTEC DB263) --OK we need a testing cycle to make one ready.
- 2 100ns delay box -- Ours are 0 to 63.5 ns. Chroneti M21
- 1 Level adopter (LRS 688AL or 688L or 688) --OK 688AL
- 2 Logic FAN-IN/FAN-OUT (LRS429A or 429) -- OK 429 or 429A
- 1 Clock generator -- BNC 8010 NIM module
- 4 High Voltage power supply -- OK BERTAN210-05R or Fluke 415
- 2 CAMAC Crate -- OK DSP 860C, power supply and fan for two CAMAC crates
- 4 NIM Crate (6V) -- OK Ortec 401A and 402H or equiv PS

<Bonner Sphere>

- 1 Pre-Amplifier -- 109A
- 1 Pre-Amp Power Supply (ORTEC 114) -- OK
- 2 Oscilloscope -- a TDS 640A and TEK2467s.

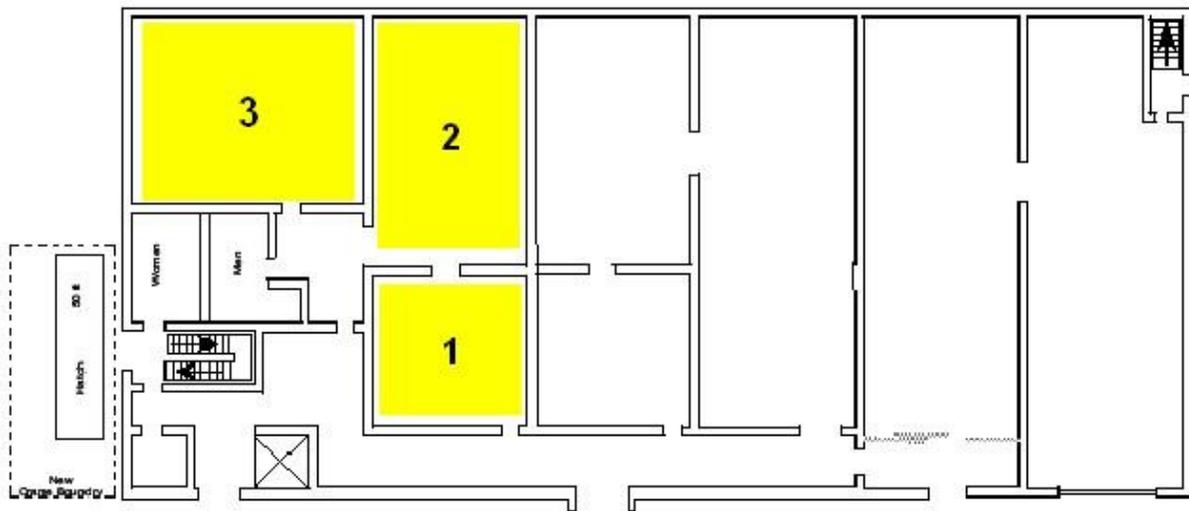
<Ge-detector>

- 1 Oscilloscope (faster than 200MHz) -- OK TEK 2465 or 2467
 - 2 NIM Crate (ORTEC 401) --OK Ortec 401A and 402H or equiv PS
-

APPENDIX III – LAYOUT OF HIGH INTENSITY WORK SPACE



High Intensity Lab



LOCATION: _____		DATE: _____	TIME: _____	PURPOSE: _____
Radiation Instruments Used Inst. Type: _____ Inst. No.: _____ Batt./Source Chk: _____ Cal. Due Date: _____		Bkgd _____ open Wipe r _____ Reading _____ _____ copm _____ copm _____ copm _____ copm _____ copm _____ copm _____ copm _____ copm _____ copm _____ copm	Comments: Surveyed By: _____ Reviewed By: _____	
LEGEND Numbers appearing on map are mR/hr @ 1 ft readings unless denoted with symbols below * = mR/hr @ contact △ = Wipe △ = Floor wipe				

Revised 3/13/07

Figure 1. Plan drawing of High Intensity Lab. Shaded and numbered rooms 1, 2 and 3 are the ones requested for the detector lab set up area (2), Counting and office room (1), and storage area (3).