Fermilab Directorate

MEMORANDUM OF UNDERSTANDING FOR THE 2007-2008 TEST BEAM PROGRAM

T968

T2K muon monitor prototype test in the NuMI beam

4 September, 2007

INTRODUCTION

This is a Memorandum of Understanding (MOU) between the Fermi National Accelerator Laboratory and experimenters of the T2K muon monitor prototype who have committed to participate in beam tests to be carried out during the 2007 NuMI program.

This memorandum is intended solely for the purpose of providing a work allocation for Fermi National Accelerator Laboratory and the participating universities and institutions. 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.

This proposal outlines requirements for space in the NuMI muon monitor alcove to test a small prototype of T2K muon monitor (MUMON). The prototype, consisting of three channels of ionization chambers and four channels of solid-state detectors will be exposed to the beam in the NuMI beam tunnel. The project will be funded through US-Japan fund and Grant-in-Aid for Scientific Research, MEXT, Japan.

MOTIVATION

As a next generation long baseline neutrino oscillation experiment, T2K experiment in Japan will extend the experimental reach to theta_13, the last mixing angle in neutrino oscillation, by almost an order of magnitude from current best limit. If it is found to be sufficiently large, it also opens a path to study CP violation and mass hierarchy together with NOvA experiment at Fermilab.

In the long baseline experiment, understanding of the beam is of great importance. As was done in K2K and being done in NuMI, properties of muons produced from decays of pions will be used to understand the neutrino beam, which are decay products of the same pion decay. Muon monitor (MUMON) system has been designed to measure the spatial profile of the muon beam. It will be placed behind the beam dump (hadron absorber) to avoid harsh hadron background.

In T2K, MUMON is the only device that can provide bunch-by-bunch information about the secondary/tertiary beam. In the commissioning stage, it will be used to give quick feedback necessary for the beam tuning. During the normal operation, shot by shot quality of the beam will be guaranteed solely with MUMON. Thus, MUMON will provide vital information throughout the experiment. On the other hand, MUMON needs to work under high flux and radiation due to high intensity beam from J-PARC accelerator. The expected charged particle flux at MUMON is about 10^8 particles/cm^2 per spill with the design intensity of J-PARC (0.75 MW) at the maximum.

The T2K-MUMON system is designed as a combination of ionization chamber array and pad solid-state detectors. The Japanese members of this test experiment have performed three sets of beam tests with 100 MeV electron beam at Kyoto University during 2005-2006, using prototype MUMON detectors. Although much information and experience were obtained through one-week long beam tests, it has been realized that an operation experience under high intensity environment with longer term is highly important. There are only a few places where the experimenters can perform such a test, and the NuMI beamline at Fermilab is one of them. With

a run of half a year, the experimenters expect to gain invaluable experience with MUMON system.

This program also strengthens the international collaboration between Fermilab and Japan in the area of neutrino program, which is recently initiated with SciBooNE (E-954) experiment.

PROJECT DESCRIPTION

The MUMON prototypes will be placed in the second muon alcove of the NuMI tunnel, where the second (from upstream) NuMI muon monitor is located. The ionization chamber houses three pairs of 4"x4" parallel plates and the outer size is about 1'x3'. The size of silicon and diamond sensors is about 1x1cm^2 each. The detectors will be `hooked' onto one of the I-beams of the NuMI muon monitor support structure without disturbing the NuMI muon monitor.

The chamber will be designed, fabricated and tested in Japan before being delivered to Fermilab. The chamber gas will be helium, the same as the NuMI muon monitor. The experimenters plan to use exhaust from NuMI muon monitor in order to avoid significant amount of piping from the ground level to NuMI tunnel, which will otherwise be necessary. In order to assure the equipment will not disturb measurements for NuMI, the experimenters need to place a bubbler between NuMI tubing and ours. Funding for this gas system upgrade is being requested as a part of NuMI improvement and its approval has significant impact on this test beam program. The installation of MUMON into beamline will be done with assistance from appropriate Fermilab division/section.

The muon fluence at proposed position in NuMI is about 10^6/cm^2/spill. This roughly corresponds to the anticipated fluence at T2K MUMON position in the commissioning stage of the experiment. The data will be taken during NuMI/MINOS running. The run plan is included as Appendix IV.

PERSONNEL AND INSTITUTIONS:

Scientific spokesperson: Masashi Yokoyama, Kyoto University

Fermilab liaison: R. Rameika

The group members at present are:

1.1 Kyoto University: H. Kubo, K. Matsuoka, T. Nakaya, M. Yokoyama

Other commitments:
SciBooNE: T. Nakaya, M. Yokoyama
T2K: H. Kubo, K. Matsuoka, T. Nakaya, M. Yokoyama

1.2 Fermilab: R. Rameika

Other commitments:
MINOS: R. Rameika

1.3 University of Texas, Austin : S. Kopp, M. Proga

Other commitments:
MINOS: S. Kopp

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS

2.1 LOCATION

2.1.1 The prototype MUMON detectors will be located in the second muon alcove of the NuMI beamline (see Appendix II). There is a space available to house 1'x3' prototype (including support structure) behind NuMI muon monitors, where there is no interference with operation of NuMI muon monitors. From viewpoint of particle flux, it is preferred to place MUMON just behind NuMI monitor at the center of beam, if it is confirmed not to disturb NuMI operation. The installation is planned during FY2007 shutdown of the FNAL accelerators.

2.1.2 Additional workspace will be needed nearby, equivalent to at most one 6'x3' tables. This space will be used for general workspace.

2.1.3 Access to a computer network will be necessary.

2.2 BEAM

2.2.1 This test utilizes the NuMI beam. Any of the NuMI beam tunes are acceptable for the test.

2.2.2 Data from NuMI muon monitor will be combined with data from the T2K-MUMON prototype. S. Kopp is the expert on NuMI muon monitor and will be expert.

2.3 SETUP

2.3.1 All of the equipment will be lowered to NuMI beamline using the elevator.

2.3.2 New fireproof cables for signal readout and high voltage supply are laid on the existing cable rack.

2.3.3 Piping of gas tubes inside and around the muon alcove will be needed. The experimenters plan to use exhaust gas from NuMI muon monitor to minimize the necessary work. Approval of gas system upgrade for NuMI muon monitor is necessary to realize this plan.

2.3.4 Spare channels of NuMI muon monitor may be used for data acquisition of MUMON.

2.3.5 Additional high voltage supply will be necessary because there are no spare channels in the NuMI system. The cables for HV supply need to be terminated.

2.3.6 All electronics racks will have rack protection smoke detectors and shunts installed.

2.4 SCHEDULE

2.4.1 The experimenters anticipate that the MUMON prototypes will be ready to come to Fermilab in Summer, 2007.

2.4.2 Installation of the detectors is scheduled during accelerator shutdown in FY2007.

2.4.3 After the detectors are installed in place, there will be some ‘commissioning’ period where the detectors will be operated without beam and the performance checked.

2.4.4 Once the NuMI beam is turned on, the experimenters of this test experiment will not request to stop the beam for e.g. maintenance of our equipment in the beamline, but may utilize downtime of the beam for other reasons, if any, for that purpose with coordination by PPD and NuMI/MINOS group.

2.4.5 The run plan is included as Appendix IV.

III. RESPONSIBILITIES BY INSTITUTION - NON FERMILAB

([] denotes replacement cost of existing hardware.)

Kyoto University

3.1	Ionization chamber	[$10k]
3.2	Silicon PIN diode	[$0.5k]
3.3	Diamond detectors	[$5k]
3.4	Digital Oscilloscope	[$5k]
3.5	Support structure	[$5k]
3.6	Gas tube	[$1k]
3.7	Cables	[$1k]
3.8	Gas quality monitors	[$5k]
	Total existing items	[$32.5k]

IV. RESPONSIBILITIES BY INSTITUTION - FERMILAB

([] Denotes replacement cost of existing hardware.)

4.1 Fermilab Accelerator Division:

4.1.1 Accelerator Division will assist the experimenters to access to the NuMI tunnel.

4.1.2 Accelerator Division Networking will support the experimenters in the network connection.

4.1.S Summary of Accelerator Division costs:

Type of Funds	Equipment	Operating	Personnel (person-weeks)
Total new items	$0.0K	$0K	0.0

4.2 Fermilab Particle Physics Division

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

4.2.2 The PPD will assist in the installation of detectors into NuMI tunnel, including piping of gas from NuMI muon monitor exhaust to MUMON system. (4 person-weeks)

4.2.3 The PPD will ensure that all electronic racks have smoke detection protection circuits installed.

4.2.4 The PPD / Neutrino Dept. will coordinate access into the NuMI tunnel.

4.2.5 The PPD / Neutrino Dept. will supervise the installation of a computer network at the muon alcove location.

4.2.S Summary of Particle Physics Division costs:

Type of Funds	Equipment	Operating	Personnel (person-weeks)
Total new items	$0K	$0K	4

4.3 Fermilab Computing Division

4.3.1 Some PREP equipment, such as high voltage supply system, will be required. The list of requested equipment is attached in appendix.

4.3.2 Will install computer networking at the muon alcove location, as managed by the PPD.

Type of Funds	Equipment	Operating	Personnel (person-weeks)
PREP equipment	[$5.0K]	$0K	0.2
Total existing items	[$5.0K]	$0K	0.0
Total new items	$0.0K	$0K	0.2

4.4 Fermilab ES&H Section

4.4.1 Assistance with safety reviews.

V. SUMMARY OF COSTS

Source of Funds [$K]	Equipment	Operating	Personnel (person-weeks)
Particle Physics Division	$0K	0	4
Accelerator Division	0	0	0
Computing Division	[$5.0K]	0	0.2
Totals Fermilab	[$5.0K]	$0.0K	4.2
Totals Non-Fermilab	[$32.5K]		

VI. SPECIAL CONSIDERATIONS

6.1 The responsibilities of the MUMON Spokesperson 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.

6.2 To carry out the experiment, a number of Environmental, Safety and Health (ES&H) reviews are necessary. This includes creating a Partial Operational Readiness Clearance document in conjunction with the standing Particle Physics Division committee. The MUMON 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 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.

6.4 Because the gas used for ionization chambers will be identical to what is already used for NuMI chambers in type and quantity, there is no ODH concern.

6.5 A list of material used in the test chamber is given in Appendix III.

6.6 All items in the Fermilab Policy on Computing will be followed by experimenters (http://computing.fnal.gov/cd/policy/cpolicy.pdf).

6.7 The MUMON Spokesperson will undertake to ensure that no PREP and 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.

6.8 Each institution 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.

6.9 If the experiment brings to Fermilab on-line data acquisition or data communications equipment to be integrated with Fermilab owned equipment, early consultation with the Computing Division is advised.

6.10 At the completion of the experiment:

6.10.1 The MUMON 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 three months after the end of running the MUMON Spokesperson will be required to furnish, in writing, an explanation for any non-return.

6.10.2 The experimenters agree to remove their experimental equipment as the Laboratory requests them to. They agree to remove it expeditiously (in 30 days) 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.

6.10.3 The experimenters will assist the Fermilab Divisions and Sections with the disposition of any articles left in the offices they occupied, including computer printout and magnetic tapes.

6.10.4 An experimenter will report on the test beam effort at a Fermilab All Experimenters Meeting.

SIGNATURES:

_____ / / 2007
Masashi Yokoyama, Kyoto University

_____ / / 2007
Regina Rameika, MINOS group

_____ / / 2007
Greg Bock, Particle Physics Division

_____ / / 2007
Roger Dixon, Accelerator Division

_____ / / 2007
Victoria White, Computing Division

_____ / / 2007
William Griffing, ES&H Section

_____ / /2007
Hugh Montgomery, Associate Director, Fermilab

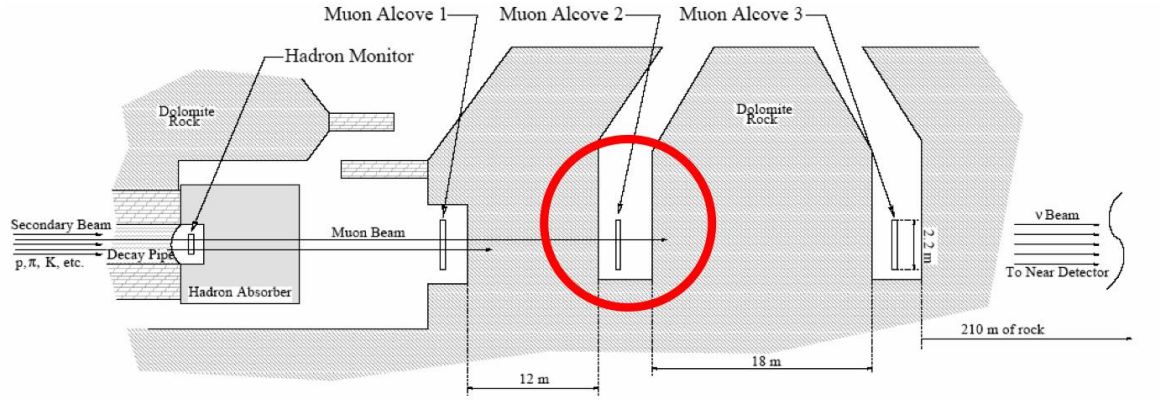
_____ / /2007
Stephen Holmes, Associate Director, Fermilab

APPENDIX I - Hazard Identification Checklist

Items for which there is anticipated need have been checked

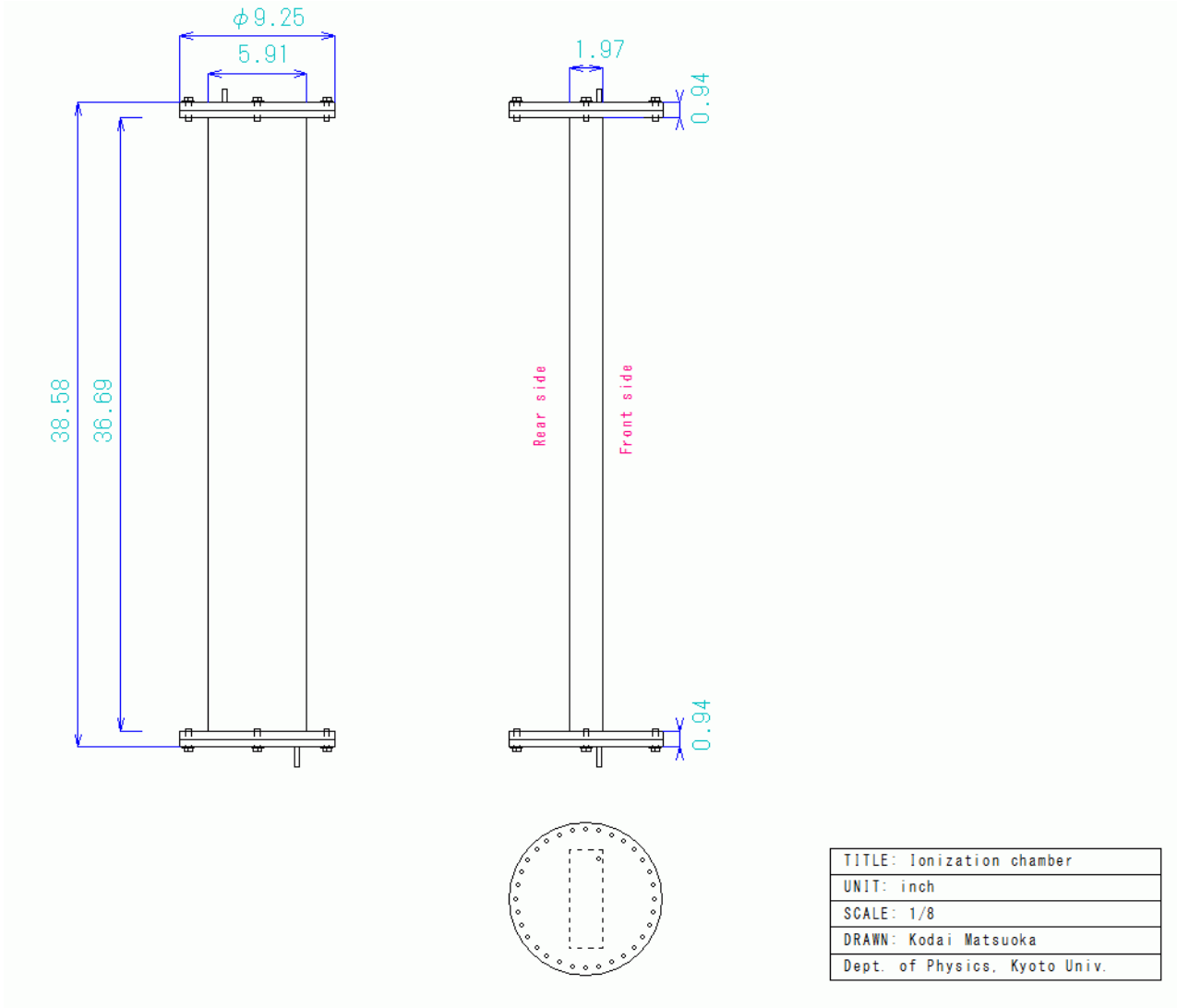
Cryogenics		Electrical Equipment		Hazardous/Toxic Materials	
	Beam line magnets		Cryo/Electrical devices		List hazardous/toxic materials
	Analysis magnets		capacitor banks		planned for use in a beam line or experimental enclosure:
	Target	X	high voltage		
	Bubble chamber		exposed equipment over 50 V		
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**	
	inside diameter		temporary use		Beryllium (Be)
	operating pressure	Type:			Lithium (Li)
	window material	Strength:			Mercury (Hg)
	window thickness	**Hazardous Chemicals**			Lead (Pb)
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 LAYOUT OF THE MUMON TEST IN THE NuMI AREA.

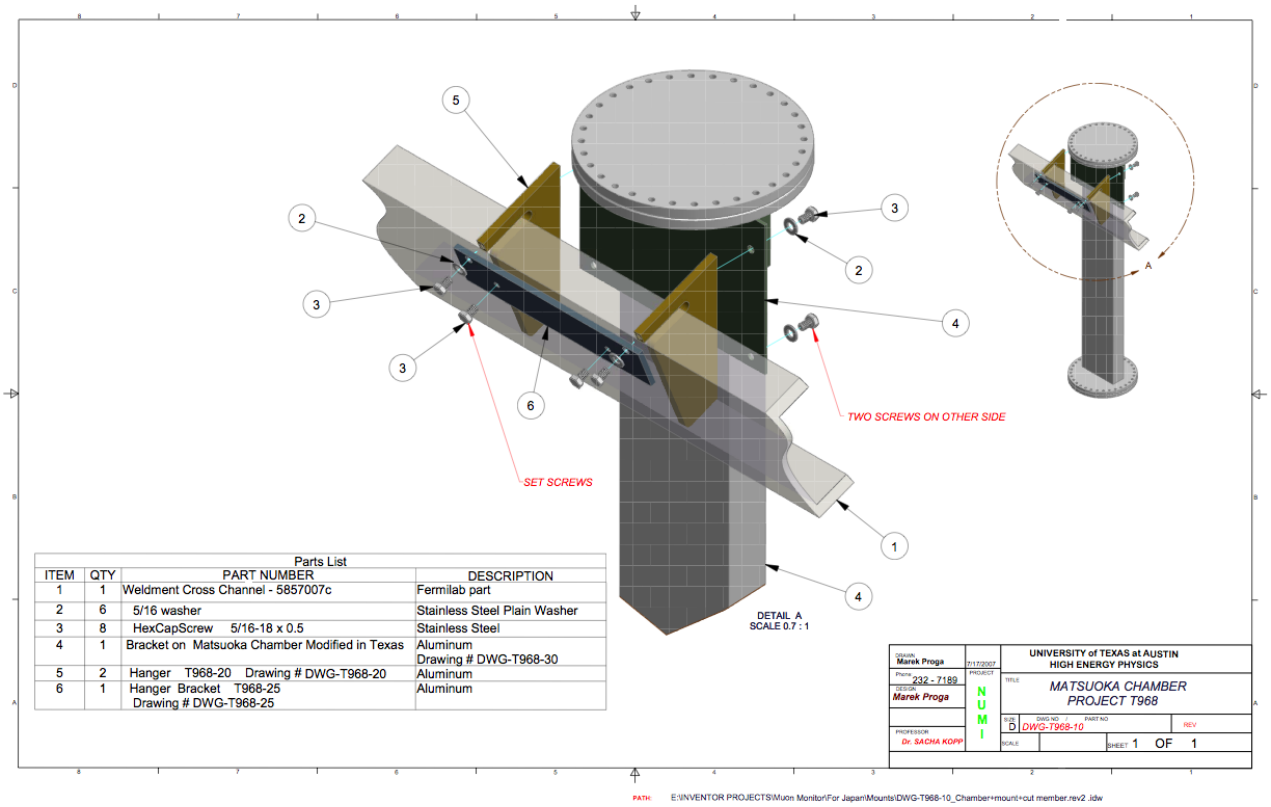


Schematic view of NuMI beamline around muon alcoves. MUMON will be placed in Alcove 2 in the above figure.

Photo of the proposed site for the MUMON test in the NuMI muon alchove. MUMON will be fixed to the I-beam of the structure, behind the NuMI muon monitor.



Drawing of the T968 test chamber (by Kodai Matsuoka).



Drawing of parts to fix the T968 test chamber onto the NuMI muon monitor stage (by Marek Proga of University of Texas, Austin).

APPENDIX III MATERIAL USED IN PROTOTYPE DETECTORS

This section may be updated as needed.

Below is a list of material used for prototype MUMON detectors.
The material was chosen to minimize any radiation effects, referring to past study done for NuMI, T2K and other experiments.

Ionization Chamber
Ionization chamber tube : Aluminum
Chamber electrode plate: Ceramic (Al_2O_3) with Ag/Pt plating.
Spacer between electrode plates: Ceramic (Al_2O_3)
Plate stand : PEEK plastic and Aluminum
Electrical feedthrough connector insulator : PEEK plastic
O-ring for gas sealing : Aluminum
Cable insulator: Polyimide (Kapton)
Gas tube: stainless and aluminum
Tube coupler: stainless and aluminum
HV cable: Fireproof rated

Solid State Detectors
Diamond detector: Diamond ($1x1cm^2$) x2
Silicon PIN diode: Silicon ($1x1cm^2$) x2
Detector holder : PEEK
Cable: Polyimide

APPENDIX IV REQUEST FOR PREP ELECTRONICS

The following list may be updated as needed:

1) Crates
   a) Mechtronics 156 NIM bin, 1 unit
   b) CAMAC crate, 1 unit
2) Power Supplies:
   a) LeCroy 4032 HV power supply, 1 unit
   b) BiRa systems 6700P CAMAC power supply, 1 unit
3) CAMAC modules
   a) LeCroy 2249W ADC, 1 unit
   b) LeCroy 2132 HV-CAMAC interface, 1 unit
4) NIM modules
   a) LeCroy 222 dual gate generator, 2 units
   b) LeCroy 428 quad in fan-in/out, 1 unit

APPENDIX V RUN PLAN

1)	Installation, setup	3 weeks
2)	Commissioning	2 weeks
3)	Data taking	6 months

Most of work in the beamline is to be done during the installation period, while occasional, short accesses into the beamline are anticipated in commissioning and data taking periods.