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Fermilab

Directorate

MEMORANDUM OF UNDERSTANDING
FOR THE 2007 MESON TEST BEAM PROGRAM

T-965

Readout of Scintillator/WLS Detectors with Pixelated Silicon Photosensors (PSiPs)

January 24, 2007

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1. INTRODUCTION

This MOU covers the use of the FNAL test beam to study the performance of new designs for Pixelated Silicon Photosensors (PSiPs)[1] as the readout for scintillator + WLS-fiber detectors.

The primary target application is the readout of an ILC muon subsystem concept based on MINOS-style bars, spearheaded by Gene Fisk (FNAL) and Paul Karchin (Wayne State U.). The principal PSiP under test will be the GPD (Geiger-mode Avalanche Photo Diodes) developed under a DOE SBIR Phase II award by aPeak Inc., a small business in Newton, Massachusetts. The CSU group has been collaborating with aPeak for several years, advising them on the development of GPDs for HEP applications and testing prototypes. Currently, aPeak is the only US-based commercial developer of these promising devices.

Partial funding for investigating the use of GPDs for use in ILC detectors is provided by an award through the ILC detector R&D program (administered by the University of Oregon).

As an adjunct to the ILC muon system related studies, the experimenters will also investigate GPD readout of triangular scintillator bars planned for use in the DOE-supported T2K and MINERvA experiments (our group is heavily involved in the T2K Pi-zero Detector - P0D). To allow direct comparison of the aPeak devices, the experimenters will also take data with a reference PMT and samples of PSiPs from CPTA in Russia and from Hamamatsu Photonics in Japan (MPPC).

The experimenters current plan is to put two MINOS-style bars and a plank of three MINERvA-style bars in the test beam. The goal will be to take data at several points along the full 1.8 m length of the bars (with the bars horizontal and perpendicular to the beam) and at a few positions vertically across the bar. The experimenters may also want to angle the bar with respect to the beam in a horizontal plane (up to 30-40 degrees). The experimenters would need a method of aligning the detector in the beam and access to the facility trigger and tracking information.

For a trigger, a NIM signal from the beam line hodoscope is the basic requirement – currently, the experimenters plan to bring a basic scintillator hodoscope for this purpose. The experimenters may need additional beam condition, composition, quality, etc. information, but this will become clearer as we gain understanding of the beam test facility.

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.

[1] The term PSiP is generic for this class of devices since many of the other terms in common use are, more or less, associated with particular technologies, designs or producers (such as: SiPM, Silicon Photomultiplier; MRS, Metal-Resistor-Silicon; MPPC, Multi-Pixel Photon Counter; GPD, Geiger-mode PhotoDiode).

References:
1. R. J. Wilson (PI), D. Warner – Linear Collider R&D Program (DOE)
   "Continuing Studies of Geiger-Mode Avalanche Photodiodes for Linear Collider Detector Muon System Readout
2. S. Vasile, aPeak - SBIR Grant Number DE-FG02-03ER83607,
   "Geiger Photodiode Array Readouts for Scintillating Fiber Arrays"

2. PERSONNEL AND INSTITUTIONS

Group leader:	Robert J. Wilson, CSU
Lead experimenter in charge of beam test:	David Warner, CSU
Fermilab liaison:	Erik Ramberg

The group members at present and others interested in the test beam are:

- CSU: Robert Wilson (Professor of Physics), David Warner (project engineer), Pablo Bauleo (Research Scientist-II), Yvan Caffari (post doc), Eric Martin (technician), Jonathan McBee (technician)
- FNAL: H. Eugene Fisk (Staff Scientist, Technical/Administrative resource)

3. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS

3.1 LOCATION

3.1.1 MTEST beam line in the MT6-2B area.

The experimenters will construct a self-contained experimental package containing two MINOS-style bars and a plank of three MINERvA-style bars. This will consist of a light-tight enclosure approximately 2.5 m long, 15 cm tall, and 15 cm deep containing all the scintillator bars and the photodetectors. The experimenters will bring all their own computers, data-collection electronics, amplifiers, power supplies, etc. A small box of amplifiers (probably 30 cm cube) will be mounted within about 30 cm of one end of the detector. The experimenters will provide a VME crate containing readout electronics that will need to be within 1-2 meters of the amplifiers, and the experimental control/data analysis PC should be within about 25 meters of the VME crate. Power requirements for this equipment should be modest. The experimenters will provide a scintillator hodoscope to use as a trigger and start time for the detector but will also read out the facility beam counters.

3.1.2 Non-electronic equipment needs.

The experimenters will provide their own support (table) approximately 4 m long by 1 m wide, on which to mount the detectors. The table will be located transversely to the beam, allow horizontal motion of ~150 cm, which would allow the detectors to be scanned and also to be moved out of the beam line in case there are other users downstream sharing the beam. Vertical scans of up to 10 cm may be done using fixed spacers. Frequent accesses will be needed to reposition the detector. The experimenters need a cable tray to carry the signal cables from the detector to the fast electronics control area. The experimenters will need some support to align the apparatus relative to the beam line.

3.2 BEAM

3.2.1 BEAM TYPE and INTENSITY

Type of Beam Needed:	120 GeV proton beam
Intensity Needed:	25 kHz total beam rate during the 4 seconds spill (possible short-time run at 50 kHz)
Size of Beam needed:	~ 1 cm^2

The experimenters request a nominal beam particle momentum of ~120 GeV/c; approximately 1cm diameter beam spot, with a total average intensity of no more than 25,000 particles per second and a low probability of two beam particles incident on the detector within 5 μs of each other.

The experimenters may be interested in a short period (2-3 hours on our final day of data taking) at 50 kHz to test for high-rate effects in our PSiPs if the data collection system can be operated at this rate reliably.

3.2.2 BEAM SHARING

These detectors could be moved sideways out of the beam, if needed.

3.3 EXPERIMENTAL CONDITIONS

3.3.1 ELECTRONICS NEEDS:

The experimenters will provide 16 channels of ADCs for photosensor readout in a VME-based DAQ system. The long MINOS/MINERVA bars module is being built and will be tested with cosmic rays at CSU. It will be transported to FNAL by truck (by the investigators). No electronics is required from the facility.

3.3.2 SCHEDULE :

The experimenters propose to begin installing the equipment and setting up the electronics on March 28 2007 and take data in the days immediately following. Total duration for setup, data taking, and strip down will be 5 days. Day 1 will be used for setup/commissioning, day 2-4 for running, and day 5 for breakdown/cleanup. Day 1 and 5 may not need to be in the beam-line if the facility has a setup area in close proximity to the beam and a way to move the assembled apparatus easily in and out of the beam area.

3.3.3 DETAILED DESCRIPTION OF TESTS:

(a) Day 1: Timing and PMT-based calibration

- Confirm voltage and cable delay settings for optimal CSU scintillator hodoscope operation
- Integrate CSU trigger and data files with FNAL beam monitoring/tracking system
- Using calibrated PMT, measure light output as a function of beam position for 9 positions along the detector package (3 positions axially along the detectors at three different vertical positions. The experimenters anticipate requiring approximately 12 hours of operation for this setup and calibration phase.

(b) Day 2-4: PSiP measurements

Day 2: Measurements with aPeak detector: Measure performance in detection efficiency and photoelectron counting accuracy as function of bias voltage for 5 detectors at the standard 9 positions along the detector package. The experimenters envision taking approximately 200,000 events per run, each run lasting approximately 2 minutes. The experimenters will have an automated bias voltage supply for the PSiPs, allowing a sweep through the range of interest in bias voltage at each of the nine positions in ~45 minutes with required accesses; we anticipate requiring 12 hours to complete this suite of measurements. Set up the next set of PSiPs under study for next day measurements.

Day 3: Repeat Day 2 measurements for the Hamamatsu PSiP. 12 hours duration. Set up the next set of PSiPs under study next day for next day measurements.

Day 4: Repeat Day 2 measurements for the CPTA/MRS PSiP devices. 12 hours duration.

Day 5: Repeat any measurements from the earlier running that require clarification. Re-calibrate the fiber light output using the calibrated PMT. Possible high beam intensity (50kHz) run. Break down the apparatus. 12 hours duration.

4. RESPONSIBILITIES BY INSTITUTION - NON FERMILAB

4.1 COLORADO STATE UNIVERSITY

Essentially all non-beam aspects of the test. CSU will provide scintillator test modules and photosensors; setting up electronics, cabling, temperature control system; readout DAQ (VME), test beam coordination; funding for the CSU costs for the beam test.

5. RESPONSIBILITIES BY INSTITUTION - FERMILAB

5.1 FERMILAB ACCELERATOR DIVISION:

5.1.1 Use of MTest beam as outlined in Section 3.

5.1.2 Maintenance of all existing standard beam line elements (SWICs, loss monitors, etc) instrumentation, controls, clock distribution, and power supplies.

5.1.3 Reasonable access to the experimenters' equipment in the test beam.

5.1.4 The test beam energy and beam line elements will be under the control of the AD Operations Department Main Control Room (MCR).

5.1.5 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 will be delegated to the experimenters as long as it does not violate the Shielding Assessment or provide potential for significant equipment damage.

5.2 FERMILAB PARTICLE PHYSICS DIVISION

5.2.1 The test-beam efforts in this MOU will make use of the Meson Test Beam Facility. Requirements for the beam and user facilities are given in Section 3. 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 gateway computer.

5.2.2 Scintillator/Cerenkov counters provided by facility for trigger and start time

5.2.3 Facility DAQ LINUX computing support as needed (24/7 support may not be available)

5.3 FERMILAB COMPUTING DIVISION

5.3.1 Ethernet and printer should be available in the counting house.

5.3.2 Connection to beams control console and remote logging (ACNET) should be made available in the counting house.

5.4 FERMILAB ES&H SECTION

5.4.1 Assistance with safety reviews.

6. SUMMARY OF COSTS

Source of Funds [$K]	Equipment	Operating	Personnel (person-weeks)
Particle Physics Division	$0 K	$0 K	1.0
Accelerator Division	0	0	0.5
Computing Division	0	0	0
Totals Fermilab	0 K	0	1.5
Totals Non-Fermilab	[$30 K]	0	5.0

7. SPECIAL CONSIDERATIONS

7.1 The responsibilities of the PI of the CSU 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.

7.2 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 PI of the CSU group will follow those procedures in a timely manner, as well as any other requirements put forth by the division's safety officer.

7.3 The PI of the CSU 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.

7.4 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.

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

7.6 The PI of the CSU 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.

7.7 The CSU 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.

7.8 At the completion of the experiment:

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

7.8.2 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.

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

7.8.4 An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters Meeting.

8. SIGNATURES

_________________________ 3 /29 / 2007
Robert J. Wilson, Colorado State University

_________________________ 1 /31 / 2007
Greg Bock, Particle Physics Division

_________________________ 2 / 5 / 2007
Roger Dixon, Accelerator Division

_________________________ 2 / 7 / 2007
Patricia McBride, Computing Division
VICTORIA WHITE

_________________________ 2/1 / 2007
William Griffing, ES&H Section

_________________________ 2 /25 /2007
Hugh Montgomery, Associate Director, Fermilab

_________________________ 2 /11 /2007
Steven Holmes, Associate Director, Fermilab

9. 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	X	Motion controllers
Wattage:			photographic developers		scaffolding/elevated platforms
class:			Other: Activated Water?		Others