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Fermilab

Directorate

MEMORANDUM OF UNDERSTANDING FOR THE 2007 MESON TEST BEAM PROGRAM

T-966

Test of Monolithic Pixel Sensors and a Thin CMOS Pixel Beam Telescope

February 12, 2007

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1. INTRODUCTION

This Memorandum of Understanding applies to the use of the FNAL test beam to study the performance of monolithic pixel sensors developed at LBNL, Berkeley as part of an R&D program to design and build sensors matching the specs of the ILC Vertex Tracker. This activity is carried out with funding from a Laboratory Directed R&D (LDRD) grant (P.I. Marco Battaglia) in collaboration with INFN Padova, Italy. The tests will be carried out as as a collaborative effort of UC Berkeley, LBNL, INFN Padova and Purdue University.

The sensors which will be characterized on the Fermilab beamline are two CMOS pixel sensors, one with 3T pixels of different sizes and a second-generation device which includes in-pixel CDS and fast, column-parallel readout. The third sensor is a pixel device, which is currently being fabricated in SOI technology, featuring sectors with analog and digital pixels. The detectors under test (DUT) will be mounted at the end of a beam telescope consisting of three or four planes of thinned CMOS pixel sensors, each featuring 1 M pixels.

The purpose of the beam test is first to determine the response of the DUTs with high energy particles in terms of S/N, single point resolution, two-track separation and detection efficiency for particle tracks both at normal incidence and inclined. Then the experimenters intend to operate the beam telescope at various levels of particle densities to study tracking with four layers of thinned CMOS pixel sensors in a realistic environment, matching the track density values expected at the ILC in the core of hadronic jets. Finally, the experimenters plan to take data with 120 GeV protons on a thin target and an interaction trigger, to study vertex reconstruction capabilities. These data will be used both to guide the R&D process and to validate the event simulation and reconstruction of benchmark physics reactions at the ILC.

The 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.

2. PERSONNEL AND INSTITUTIONS

PI and Group Leader: Marco Battaglia (UC Berkeley and LBNL)
Lead Experimenter in charge of beam test: Marco Battaglia
Deputy Experimenter in charge: Devis Contarato (LBNL)
Fermilab liasion: Erik Ramberg (FNAL)

The members of the group which will take part to the installation, data taking activity and dismantling at Fermilab are:

Marco Battaglia, LBNL
Devis Contarato, LBNL
Piero Giubilato, INFN Padova and LBNL
Lindsay Glesener, UC Berkeley and LBNL
Silvia Franchino, Universita' di Pavia and LBNL
Gino Bolla, Purdue U.
Daniela Bortoletto, Purdue U
Ian Shipsey, Purdue U.

3. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS

3.1 LOCATION

3.1.1 The experimenters plan on using the beam MT6-2b area.

3.1.2 The experimenters shall mount the experimental setup on an optical rail, which will offer the possibility of alignment in height. The optical rail should rest on a flat surface, possibly an optical table.

3.1.3 The experimenters shall need some lab space for pre-testing of the detectors and possible repairs. The experimenters estimate to need two 30x72 desks in a low dust environment (but not requiring clean room specs), equipped with ESD-safe surfaces and grounding. The experimenters shall also need some office space with two desks and ethernet connections.

3.1.4 The experimenters shall bring all the computers needed for DAQ and data analysis and ethernet disks for data storage. The experimenters would like to have the possibility to back-up approximately 250Gb of data on a centrally managed disk server until the data has been transferred to the LBNL cluster.

3.2 BEAM

3.2.1 Type of Beam Needed: 120 GeV proton beam and 16 GeV pion beam
Intensity Needed: 0-100k particles/ (4s spill)
Beam Size Needed: ~ 3 cm^2

The Experimenters shall need the beamline clear of significant material upstream of the apparatus during data taking, but can tolerate material in front during setup and tuning. The apparatus can be removed from the beamline if needed, but requires accesss.

3.3 EXPERIMENTAL CONDITIONS

The telescope and DUT are installed in an optical box, equipped with ventilation and all connections for supplying voltages and trigger signals and computer connections for data transfer. The DUT is installed on a pair of computer controlled XY stages for relative alignment wrt the beam telescope and scanning different sectors. For a trigger, the experimenters shall need a NIM/TTL signal from the beam line hodoscope and a begin-of-spill which precedes the spill by at least 100ms. The experimenters would benefit by being able to record the Cherenkov response on beam composition and have information on beam energy and energy spread. For the run with a target the experimenters shall add a detector plane in front of the target and provide an interaction trigger signal using a pair of scintillators installed in the telescope box.

3.4 ELECTRONICS:

The system is readout through a custom DAQ system. The readout boards will be located in the same box housing the telescope and DUT and will communicate with the DAQ PC via a NI PCI interface. The board firmware is uploaded through a USB-2 link. The board takes a TTL signal input for the trigger and the experimenters shall route about ten digital signals out to the control room for diagnostics during tuning and data taking. All detectors are operated at low voltage (6

V), low currents (< 2 A) with the only exceptions of the SOI detector which will be biased to 50-60 V. HV connectors will be installed on the telescope optical enclosure and no exposed HV parts will be present.

3.5 SCHEDULE:

The experimenters are currently envisaging two possible run periods, depending on the Fermilab accelerator schedule. The first is from June 25 and the second from August 12.

Day 1: Installation in Lab, detector tests, cable connection, PC connection and tests, deploy setup on beamline, basic test with random trigger.
Day 2: Safety inspections, alignment and setup with beam.
Day 3: Run beam Telescope with 120 GeV protons, track alignment
Day 4: Run beam Telescope with 16 GeV pions, change intensity, tracking tests.
Day 5: Install LDRD-1 detector, run with 120 GeV protons
Day 6: LDRD-1 detector, sector scan, inclined tracks
Day 7: Install LDRD-2 detector, run with 120 GeV protons
Day 8: LDRD-2 detector run, inclined tracks
Day 9: Install SOI detector, run 120 GeV protons
Day 10: beam Telescope 120 GeV protons on target, standard trigger
Day 11: beam Telescope 120 GeV protons on target, interaction trigger
Day 12: Commission LDRD-2 tracking setup, alignment, run with 120 GeV protons
Day 13: LDRD-2 setup run with 120 GeV protons at varying intensities, tracking studies, 16 GeV pion run
Day 14: Spare time for additional run, start dismantling by late afternoon.
Day 15: Complete dismantling.

4. RESPONSIBILITIES BY INSTITUTION - NON FERMILAB

LAWRENCE BERKELEY NATIONAL LABORATORY: All non-beam aspects of the test. LBNL will deploy the detectors under test, a pixel beam telescope. LBNL personnel will set-up equipment on the beamline under the Fermilab Particle Physics Division guidance and supervision, provide the DAQ and slow control systems, provide test beam coordination and funding for its personnel during the beam test.

The other collaborating institutions will contribute to their share for their personnel costs.

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 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 PPD will maintain scintillation counters and Cerenkov counters that are part of the Meson Test Beam Facility.

5.2.3 PPD will provide on-call LINUX DAQ computing support during normal working hours.

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.

5.3.3 Availibility of 250 Gb data storage on a centrally backed-up server for the duration of the beam test.

5.4 FERMILAB ES&H SECTION

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	[$50 K]	$15K	

7 SPECIAL CONSIDERATIONS

7.1 The responsibilities of the PI of the LBNL 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 LBNL 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 LBNL 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 LBNL 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 LBNL 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:

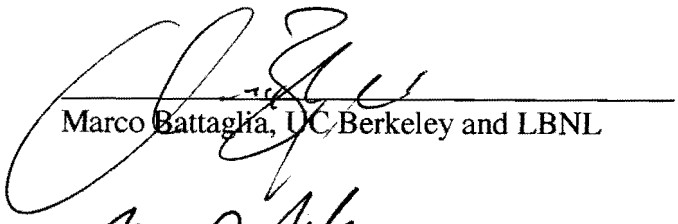
7.8.1 The PI of the LBNL group is responsible for the return of all PREP equipment, computing equipment and non-PREP data acquisition electronics. If the return is not completed after a period of one year after the end of running the PI of the LBNL group will be required to furnish, in writing, an explanation 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.

SIGNATURES



5 / 12 / 2007
Marco Battaglia, UC Berkeley and LBNL

2 / 22 / 2007
Greg Bock, Particle Physics Division

3/ 5 / 2007
Roger Dixon, Accelerator Division

3 / 14 / 2007
Victoria White, Computing Division

2/ 27/ 2007
William Griffing, ES&H Section

3 /14/2007
Hugh Montgomery, Associate Director, Fermilab

3 /14 /2007
Stephen Holmes, Associate Director, Fermilab

7 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		
	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