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Fermilab

Directorate

MEMORANDUM OF UNDERSTANDING
FOR THE 2007 MESON TEST BEAM PROGRAM

T-963

STAR MUON TELESCOPE DETECTOR

January 25, 2007

INTRODUCTION

The experimenters propose an R&D research on a large-area and cost-effective muon telescope detector (MTD) for RHIC and for next generation detectors at future QCD Lab from state-of-art multi-gap resistive plate chamber (MRPC) with large module and long strips. Conventional muon detectors rely heavily on tracking stations while this new R&D project proposes to use good timing and coarse spatial resolutions to identify muons with momentum of a few GeV/c. This R&D project was approved as BNL LDRD (Lab Director R&D) project and will focus on studying the capability of muon identification based on timing resolution from the MRPC detector with large module, long strips and fast electronics for online trigger. The experimenters propose to build a prototype MTD with three layers: MRPC TOF + Wire Chamber + Scintillator trays. This will be tested outside the STAR magnet using the return iron yokes as hadron absorber (5 interaction length). It will have excellent timing resolution (<100ps), good spatial points for tracking(<cm) and some dE/dx capability to evaluate the MRPC performance as a compact muon detector.

In addition, STAR has an upgrade project of Time-of-Flight system, which uses MRPC with pad size of (3cmx6cm). The STAR TOF upgrade will provide new capabilities relevant to many of the questions posed by the present state of phenomenology and understanding. The upgrade will provide e, π, k and p separation in the momentum region between those available through dE/dx measurements in the STAR TPC. This new capability will add to the single particle and event by event performance of the apparatus and allow more discriminating tests of current models of freezeout and hadronization, in-medium energy loss processes as well as give access to wide acceptance studies of vector mesons and heavy flavors. One of the TOF milestones is to test the new electronics. TOF is located 220cm away the interaction point, and it is inside the magnet and right outside the STAR Time Projection Chamber (TPC). The prototype of this detector has been installed in STAR and some of the physics results have been analyzed. A newly discovered capability is that the TOF can be used to identify muons at very low momentum (pT~=200 MeV). With ½ T magnetic field, muons at this momentum will have large incident angle, which may result in their detecting efficiency different from nominally implemented in the simulation from efficiency with small incident angle. The size of the detector is 20cmx6cm in a gas box of 50cmx50cmx20cm.

The experimenters will use FNAL test beam facility to test the performance of TOF electronics, MRPC strips and two wire chambers before installation at STAR/RHIC :

A) Time resolution and detection efficiency vs HV, threshold and gas mixture.
B) Position dependence along length- and width- direction
C) Response for inclined particle crossing.
D) With hadron absorber (1—1.5meter steel) in and out of the beam for low-momentum (<10 GeV/c) muon identification.
E) Readout electronics and cable connection test.
F) Footprint (size of the avalanche) of the signal by vertical scan
G) performance of wire chamber (stability, resolution)

The experimenters propose to use the test beam in April/May 2007 and will need a motion table to scan the detector.

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.

References:

1. Zhangbu Xu (Principal Investigator):
   "A novel and compact muon telescope detector for QCDLab", BNL LDRD project
2. RHIC experimental white papers: Nuclear Physics **A 757** (2005)
3. Theoretical overview of dilepton physics:
   R. Rapp and J. Wambach, Adv. Nucl. Phys. 25 (2000) 1
   T. Matsui and H. Saltz, Phys. Lett. B 178 (1986)416
   Electromagnetic Probes at RHIC II (Working Group Report): nucl-ex/0611009
4. Dilepton experimental results in relativistic heavy ion collisions:
   NA50 Collaboration: Phys. Lett. B 410 (1997) 337,
   CERES Collaboration: Phys. Rev. Lett. 75 (1995) 1272,
   PHENIX Collaboration: Phys. Rev. C 69 (2004) 014901
5. Muon Detectors at Colliders (e.g.):
   PHENIX;CDF;BELLE;BES;ATLAS; AMS
6. STAR Time-of-Flight Proposal:
   http://www.star.bnl.gov/STAR/tof/publications/TOF_20040524.p

I. PERSONNEL AND INSTITUTIONS:

Spokesman and physicist in charge of beam tests: Zhangbu Xu, BNL
Fermilab liaison: Erik Ramberg

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

1.1 BNL: Patricia Fachinia, Frank Laue (physicist), a postdoc,
+ engineers help on cables, electronics and gas systems

1.2 USTC/China: Yongjie Sun (staff), Cheng Li and Hongfang Chen (professors)

1.3 Tsinghua University: Yi Wang (professor)

1.4 Yale University: Richard Majka and Nikolai Smirnov (scientist)

1.5 Rice University: Bill Llope, Jing Liu and Geary Eppley (Scientists),
Ted Nussbaun (Engineer)

1.6 University of Texas/Austin: Jo Schamback, Jerry Hoffmann, Kohei Kajimoto, a postdoc

1.7 UCLA: Vahe Ghazikhanian

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS

2.1 LOCATION

2.1.1 The tests are to be performed in the MTEST beam line in either the MT6-2A or MT6-2C area on a motion table. The total length of the detectors along the beam is ~ 1.5m, including end effects. Transversely the detector is 2.4 m x .5 m. The experimenters will use Beam counters provided by facility as trigger and start time detector, or will put some beam counter upstream before the steel of hadron absorber.

2.1.2 The experimenters need a support (table) on which to mount the detectors. This should allow horizontal and vertical scans of ~20cmx100cm , 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. If the experimenters can not scan the whole detector in full length and width, access may 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.

2.2 BEAM

2.2.1 BEAM TYPE and INTENSITY

Type of Beam Needed: pion or muon beam, proton beam also desirable
Intensity Needed: < 1 KHz
Size of Beam needed: 1--10cm^2

The experimenters would like to have nominal beam particle momentum ~5 GeV/c, and intensity <200Hz/cm^2, and at least one test at 50Hz/cm^2. The experimenters would also like to take a few data points at beam momentum of 2, 5, 10, and 20 GeV/c with and without half (1.5m steel) absorber. And 120 GeV/c beam with and without full (3m steel) absorber. As long the beam particle momentum and direction can be identified, the beam spot can be large (~10cm^2).

2.2.2 BEAM SHARING

Because of limited manpower availability and other commitments the experimenters will be unable to run continuously. These detectors could be moved sideways out of the beam, if needed.

2.3 **EXPERIMENTAL CONDITIONS**

2.3.1 ELECTRONICS NEEDS: The experimenters will have 12 channels of TDC and ADC for MRPC readout, and pico4 readout system for wire chamber. Both will use CAMAC system. The Long MRPC modules have been built and tested with cosmic ray at USTC/China. It will be shipped to BNL. Readout electronics have been used in PHENIX TOF in last year's RHIC run. The TOF MRPC and its start counters will have Tray electronics: 8 TINO, 8 TDIG, 1 TCPU and 3 TPMD, 3 TDIG, 1 TCPU, and a PC for the DAQ with one RORC card and a CANbus interface. Details of the electronics are described in Reference 6 (TOF proposal). These electronics will be provided by TOF project (Rice and UT). No equipment is anticipated of PREP at this time.

2.3.2 SCHEDULE : The experimenters propose to begin installing the equipments and setting up the electronics in early April 2007 and take data sometime in middle to end of April. The experimenters may have to come back in fall 2007 to perform another test if improvement of the R&D is needed.

2.3.3 DETAILED DESCRIPTION OF TESTS:

(a) Set up trigger scintillators and Cerenkov detectors timing in with MRPC detectors. It will be necessary to have scintillators or Cerenkov detectors (<100ps) upstream (before the absorber) to measure the Time-of-Flight and reject events from pion showers. This should be provided by the facility. This will provide a trigger counters as well as start timing for MRPC.

(b) With beam centrally through Cerenkov detectors, scan in HV, determine the optimal range/value for MRPC and wire chambers. 20 HV points.

(c) With the HV set, scan vertically and horizontally (x-y scan) over steps of ~1cm. The experimenters would aim for 10,000 events (1% statistics) on a 1cm x 5cm grid. This will sample horizontally 30 data points and vertically 20 data points.

d) Gas composition from nominal Freon 134a (95%)+ Isobutane (5%) to Freon 134a (92%)+ Isobutane (5%)+SF6 (3%) and find the optimal HV range/value for MRPC. Gas flow will be less than 50 cc/minute. The experiment will report to Fermilab on the total gas emission from the experiment and ensure that it is below the limit of 0.1 lbs/hour.

e) For small pad TOF MRPC, measure the responses with incident beam particle angle. 0—90 degree with 10 data points. And vertical and horizontal scans similar to c) for long MRPC.

f) With and without thin absorber, study muon beam efficiency and pion beam particle rejection. The beam particle momentum at 2, 5, 10 GeV/c.

g) With and without thick (3m steel) absorber, study muon beam efficiency and pion beam particle rejection at beam particle momentum of 120 GeV/c.

III RESPONSIBILITIES BY INSTITUTION - NON FERMILAB

3.1 BNL: Setting up electronics, assemble MRPC and gas systems, readout CAMAC, test beam coordination, providing LDRD fund for the testing
3.2 USTC/China: providing long MRPC modules
3.3 Yale University: Wire Chamber and pico4 readout system
3.4 Rice University: MRPC FEE, tray box
3.5 University of Texas/Austin: Assembly TOF tray and DAQ
3.6 UCLA: LV/HV power supplies

IV. RESPONSIBILITIES BY INSTITUTION – FERMILAB

4.1 FERMILAB ACCELERATOR DIVISION:

4.1.1 Use of MTest beam as outlined in Section 2.

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

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

4.1.4 The Accelerator Division will provide the ability to independently control the 4.5 foot half sections of the beam stop in enclosure MT6-section 1.

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

4.1.6 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.

4.2 FERMILAB PARTICLE PHYSICS DIVISION

4.2.1 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 2. 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.

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

4.2.3 Test beam facility computing support as needed, although 24/7 support may not be available

4.2.4 The test beam facility shall provide a table or cart upon which the counter assembly is mounted, with a total weight of 250 lbs. The cart needs to provide vertical as well as horizontal motion to a precision of a few mm. PPD personnel will make modifications to mount the counter assembly and stabilize the load and to provide linear motion. The value of the position needs to be available.

4.3 FERMILAB COMPUTING DIVISION

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

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

4.3.3 Assistance with setup of CAMAC system.

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	$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	[$60 K]	0	5.0

VI. SPECIAL CONSIDERATIONS

6.1 The responsibilities of the spokesman of the STAR MTD 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 STAR MTD 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 STAR MTD 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 STAR MTD 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 STAR MTD 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 spokesman of the STAR MTD 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 spokesman of the Iowa 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.

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

SIGNATURES:

______________________________ / / 2007
Zhangbu Xu, Brookhaven National Laboratory

______________________________ 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

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 planned for use in a beam line or experimental enclosure:
	Analysis magnets		capacitor banks		
	Target	X	high voltage		
	Bubble chamber		exposed equipment over 50 V		
Pressure Vessels		**Flammable Gases or Liquids**			
	inside diameter	Type:	92% Freon 134a, 5% isobutene, 3% SF6		
	operating pressure	Flow rate:	50 cc/minute		
	window material	Capacity:	10 Lbs		
	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	X	Lifting devices
type:			TEA	X	Motion controllers - manual
Wattage:			photographic developers		scaffolding/elevated platforms
class:			Other: Activated Water?		Others