Quarterly Report FY09Q2
Date: May 26, 2009

Project Name: PHENIX Forward Muon Trigger Upgrade
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# Introduction

This report has been prepared as input for the quarterly review of the PHENIX Muon Trigger Upgrade Project on May 26, 2009. We summarize the progress made since the last quarterly report on February 11, 2009 and present our plans for progress in the next few months. In section A we discuss progress made and plans for the construction of the RPC detectors, the RPC electronics and software and simulations. In section B we present the status of the project budget and in section C we discuss the project schedule.

## A. Status Reports and Plans

### 1. RPC Design, Construction and Integration

#### a. RPC Gap Production at KODEL (Sung Park, Korea University)

At KODEL, RPC-1 prototypes have been completed and the mass production of RPC-3 gas gaps continues since the last quarterly review in January 2009. 10 RPC-1 prototypes were received at BNL on January 2$^{nd}$. 83 RPC-3A gaps arrived at BNL on February 18$^{th}$.

43 RPC-3B top gaps and 43 RPC-3b bottom gaps were assembled, tested and shipped to BNL arriving on April 28$^{th}$ on schedule. Some photos of RPC-3B were included.

All RPC-3A and RPC-3B gaps passed the standard factory exit Q&A tests established for the RPCs used in the CMS muon trigger. All Q&A results have been archived.

Currently, KODEL is producing RPC-3C gaps. Production is expected to be complete by the second week of June.

KODEL will be ready to produce the RPC-1 gaps starting during the third week of June. The delivery of Bakelite sheets to KODEL for RPC-1 production is scheduled for the end of May. However, the schedule for the Bakelite cutting and cleaning in Italy likely will be delayed.

#### b. RPC Boxes and Signal Plane Production in China (Xiaomei Li, CIAE)

The production facilities in China received a 50% down payment for 34 sets of RPC-3 (A+B+C) detector module parts and signal planes from UCR on Feb.16, 2009. With these funds raw materials were purchased and manufacturing began immediately. The original schedule assumed 70 days for PRC-3 detector module and signal plane mass production and 50 days for sea shipment from Beijing to New York. In order to expedite

the schedule it was decided to air freight 16 sets of RPC-3A module parts with the goal to receive these parts at BNL by mid-April.

The first 16 sets of RPC-3A module parts were sent via air shipment on March 20, and arrived in NY on March 24, 15 days ahead of the original schedule. This should be credited to Chinese engineers who had worked very hard and some even gave up their holidays. The parts for RPC-3B and RPC-3C were sent via sea shipment on April 3, and arrived at NY harbor on May 13, one month earlier than scheduled.

The detector boxes are made from 5 mm Al honeycomb sandwiched between two layers of 0.5 mm thick Al sheets. The readout strips are made of copper-laminated G10 sheets. Here we list the detailed time table for manufacturing and shipping:

**1)** The size of the Al sheets and copper-laminated G10 sheets are large and none-standard and require a special order: 15 days.
**2)** Manufacture of the honeycombs, detector box bars and readout strips: 12 days.
**3)** Boring, notching and assembling: 3 days for the first 16 sets of RPC-3A module parts, 10 days for RPC-3B and RPC-3C.
**4)** Packing and transportation to Beijing Airport: 1 day for RPC-3A and in case of RPC-3B&C to Tianjin Harbor: 3 days.

Below are the pictures of readout strips for RPC-3B (Fig.1) and the notching and drilling of honeycomb boxes (Fig.2 and Fig.3).

Fig.1 Readout strips of RPC-3B.

Fig.2 Notching and drilling of honeycomb boxes.

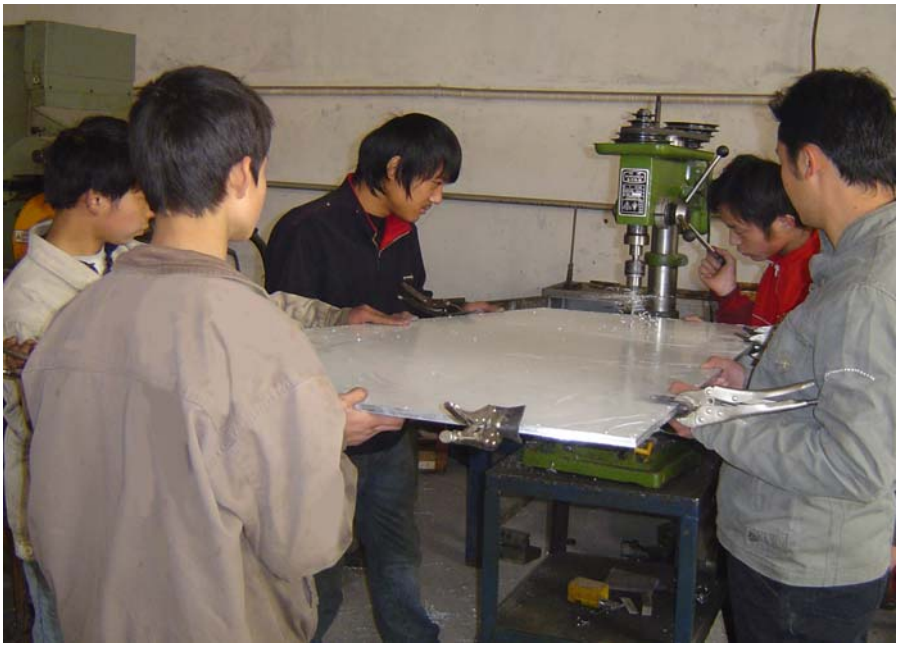

Fig. 3 Notching and drilling of honeycomb boxes

### c. RPC Half-Octant Structure Production in U.S.
(Larry Bartoszek, Bartoszek Engineering)
(Matthias Grosse Perdekamp, UIUC)

The design for the RPC-3 detector stations was completed in the report period. This includes the design of detector boxes which hold the RPC gas gaps and half octant structures that support the detector boxes and serve as building blocks for the octant shaped RPC-3 detector stations.

Bids for the half octant structure components were send to 13 companies in Illinois, Indiana, Ohio and New Mexico and also to ISU and CIAE. Responses were received from 10 companies, ISU and CIAE. The lowest bid (without shipping) was about $96k from Hi-Tech Mfg. in Schiller Park the highest was about $260k. The bid was issued to Hi-Tech Mfg. and the components arrived for assembly at UIUC on May 12$^{th}$, 6 days ahead of schedule.

Q&A, cleaning and labeling of the components has been completed and the first two half octant structures have been assembled as of May 22$^{nd}$. A team of 3 graduate and 5 undergraduate students carries out the assembly. Two of these students come to UIUC from Southeast Missouri State University and Muhlenberg College through the REU program.

It is planned to ship a first set of 6 half octants to BNL on June-12$^{th}$. The remaining half octants will be shipped in mid-July.

### d. RPC Prototype-D Installation and Readiness Run-9
(Anselm Vossen, UIUC)

As reported for the last quarterly review, two full size half octant prototypes were installed in the PHENIX north muon spectrometer. The first half octant, station 2, was installed just upstream of the muon identifier and the second half octant, station 3, downstream of the muon identifier. Initially dry detector gas (95% R134, 4.5% isobutane and 0.5% SF6) was used. Starting March 17$^{th}$ about 40% relative humidity was added to the mixed gas via a dedicated bubbler in the staging area of the experiment. No significant effect on dark currents and signals was observed. The final setup for the RPC gas system in Run 9 includes the water bubbler.

Front end electronics and high and low voltage supplies for the prototypes were also finished before the last quarterly review. During the present quarter the RPC FEE was integrated with the half octant prototypes and successfully introduced in the PHENIX data acquisition. During Run 9 with all PHENIX electronics and RHIC rf systems in operation, noise levels exceeded specifications, and reached rates as high as $10^3$ Hz/cm$^2$.

After the grounding scheme was verified and improved by lowering resistances to the common grounding point the noise rate in station 2 remained high. However it was found

that the low voltage lines were carrying noise. After installing LV filters during the access on April 29th, the noise dropped to levels of about $10^{-3}$ Hz/cm$^2$, which exceeds our specifications. See Fig.4 for current noise levels in modules A, B, and C for prototype stations 2 and 3.

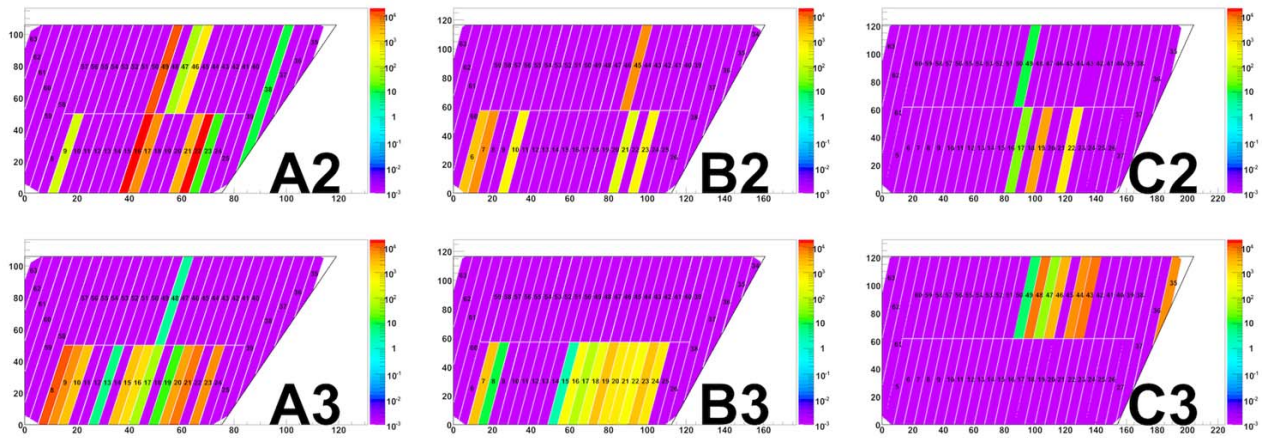


Fig. 4: Observed noise rates in modules A, B, C of prototype stations 2 and 3 in Hz/cm$^2$.

Fig.4 also shows that there still are a limited number of hot channels. With the noise levels greatly reduced the detectors were timed and signals from the incoming and outgoing beam and interaction related particles were observed.

As part of the integration into the PHENIX experiment, the forward upgrade group also provided online monitoring software and HV control software as well as documentation for the shift crews. The HV control program can be operated in expert or non-expert mode. The non-expert mode is designed to allow the shift crew to bring the RPCs to the defined states: “disabled”, “standby” and “up”. It also shows the current HV status of each RPC module in color code and allows for the recovery of tripped channels.

The RPC online monitoring software shows timing spectra and number of hits in the different channels. It enables the shift crew to monitor the signal observed in each RPC module and the expert to quickly check the performance of the detector for each run.

The RPC full size prototype detector performance was found to be satisfactory. The noise levels are very low in most of the channels and the observed signals allow for in depth studies of the RPC performance and timing characteristics of the background. The online software provided, was found to be reliable and enabled the shift crew to operate the detectors with only minor difficulties.

## e. RPC Factory Progress and Status
(Young Jin Kim, UIUC)

There has been a lot of progress in the RPC factory since last quarterly review on February 11th.

1) Gas system

The gas mixing system upgrade has been completed. As a result the gas flow capacity at the RPC factory is 5 times larger (~1 liter/min.) than before and allows supplying gas simultaneously to the RPC gap dark current test stand (200 cc/min.), the RPC module cosmic ray test stand (200 cc/min.), and the RPC half octant burn-in station (600 cc/min.).

The modification to dual gas bottle supply lines permits us to switch to a new gas supply without interruption of the gas flow.

We obtained safety approval for increased R134 gas consumption and completed a review of piping for the flammable compressed gas system.

Gas lines to the half octant burn-in station have been installed and the gas distribution panel has been setup and connected to the gas lines. Technicians at PHENIX and UIUC are working on mini gas panels for individual half octants which will control gas pressure and flow rate for each half octant.

2) Half octant burn-in station and half octant transport table

A mechanical design review of the half octant burn-in station and the half octant transport table was completed by the C-A Department. The construction of the half octant station is in progress and assembly of the half octant transport table has been completed.

The half octant burn-in station and transport table will be commissioned with a full size half octant loaded with decoy detector modules for testing mechanical stability.

3) RPC gap and detector module storage

5 RPC gap and module storage shelves have been enclose with non-flammable welding curtains. Humidifiers have been added to control temperature and humidity in the storage facility. The entire RPC-3A and RPC-3B gaps for both north and south RPC station 3 have been securely placed in the new storage facility.

4) RPC half octant frame storage

Three large shelf structures have been placed next to the RPC half octant assembly area. However, additional storage space may be needed to store all half octants both for RPC-3 detector stations north and south.

5) Mass production status

A significant amount of factory entry Q&A for RPC gaps has been completed. The Q&A procedures include the RPC gap gas leakage test, the spacer pop-up test and dark current tests. Only two RPC gaps out of 20 failed this Q&A. On gap failed the spacer pop-up test and the second gap was found to have a gas leak. The factory entry Q&A for the other RPC gaps is in progress.

Due to some delay in detector part delivery, we just started to assemble the first RPC 3A module. However, due to the previous assembly experience with the full size prototype D we expect that we will achieve an assembly speed of one module/day.

Below is shown in Fig. 5 and Fig. 6 the status of the RPC overall factory and RPC factory tent, respectively.

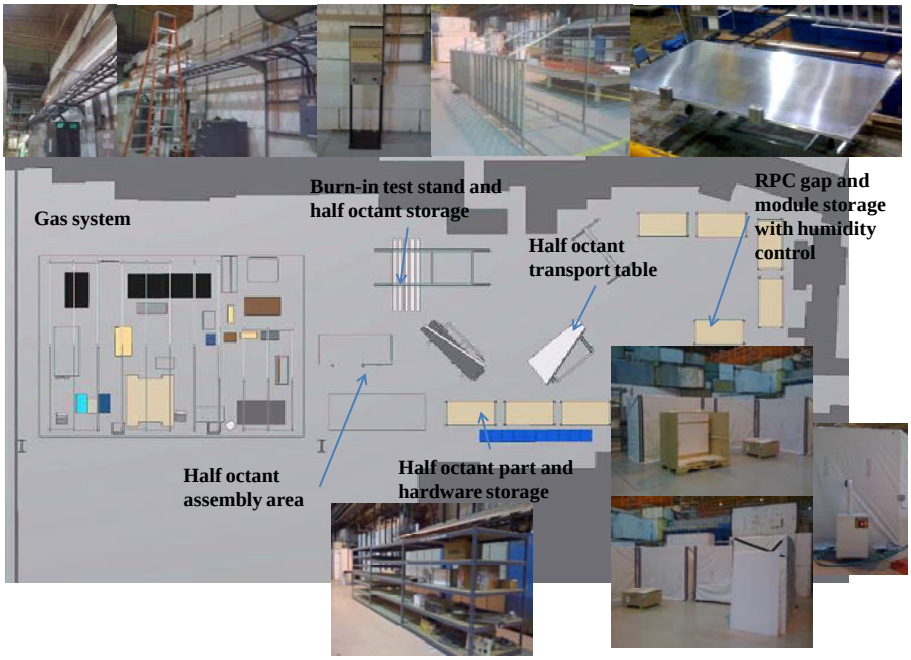


Fig. 5: Status of overall RPC factory.

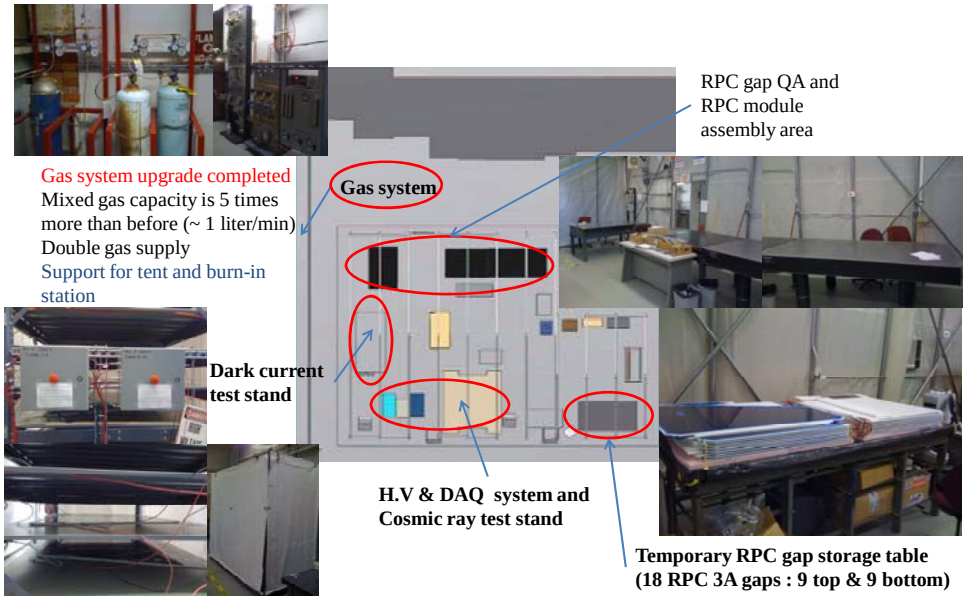


Fig. 6: Status of RPC factory tent.

## f. Status of RPC-3 and RPC-1 Design
(Ralf Seidl, RBRC)
(Don Lynch, BNL)

The RPC-3 detector station had been completed before the last quarterly review and bidding and orders for RPC-3 production were completed. Finalization of the RPC-1 design is presently waiting for final results from RPC-1 prototype tests in the RPC factory. We expect to complete the RPC-1 detector station design, including the absorber, during the upcoming quarter.

Very significant progress was achieved in the RPC-3 detector integration design. A conceptual design is available and production drawings are presently being made. Fig.7 shows the installation of a RPC-3 north half octant using a flexible single arm crane available to PHENIX at BNL. The responsibility for the RPC-3 north support structure design and installation has been taken over by the PHENIX support group under leadership of the PHENIX lead engineer Don Lynch. The anticipated installation schedule is shown in Table 1.

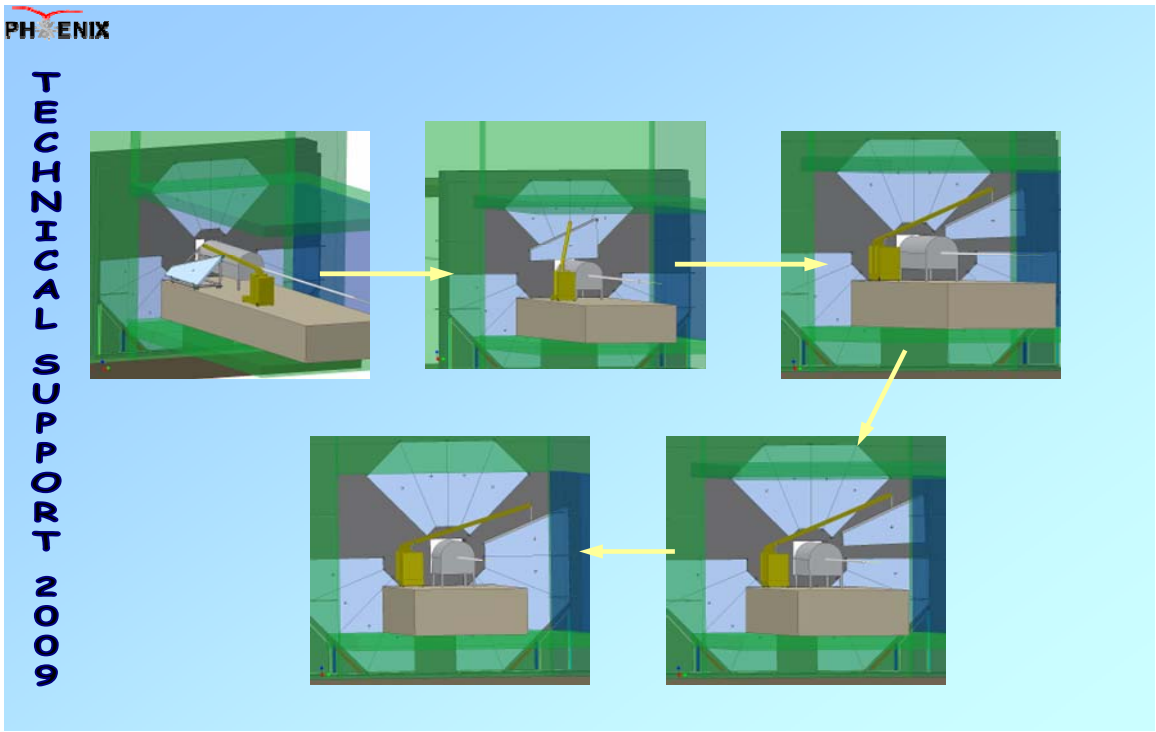


Fig.7 Engineering study of RPC-3 north half octant installation. The flexible single arm crane used is available to PHENIX at BNL.

PHENIX

TECHNICAL SUPPORT 2009

## RPC3 North Installation Schedule

| Task | Completion Date |
|---|---|
| Installation Concept Finalized | Apr. 24 |
| Half-Octant Brackets, Connecting Blocks, under detector translating support design | Apr. 30 |
| Installation Fixturing and Tooling Design | May 15 |
| Redesign crystal palace/IR Gas Barrier | May 29 |
| End of Run 9 | June 28 |
| Fixturing/Tooling, Brackets/Block/support Fabrication | June 30 |
| Move Shielding/Remove Crystal Palace | June 29-July31 |
| Move cable trays and piping in gap 5 | June 29-July 31 |
| Simulated (practice) installation with new fixturing/ tooling | July 13-July 31 |
| Install, level & survey support structure | Aug. 3 - Aug 14 |
| Half Octant Testing and Assembly Complete (1st half Octant ready by Aug.17, 16th by Sep.18) | Aug. 17- Sep. 18 |
| Mechanical Install Align & survey RPC3 N | Aug 17 – Sep. 30 |
| Install 3 elect. Racks, all cables & gas system | Oct. 1 – Oct. 30 |
| Commissioning | Nov. 1 – Nov. 30 |
| Install new crystal palace/IR Gas Barrier & Shielding | Nov. 1 – Nov. 30 |
| Start Run 10 | Dec. 1 |

Fig.8 Schedule for the RPC-3 north detector station installation.

## 2. RPC Electronics and Triggering

### a. RPC Front End Electronics
(Cheng-Yi Chi, Columbia)
(Kenneth Barish, U. C. Riverside)

The RPC cable adapter boards have been fully assembled. Except for 32 boards, all the discriminator boards have been delivered by the assembler. The testing is ongoing both at the University of Colorado and Columbia University. The Colorado facility will be the main testing site. The Columbia site will perform the acceptance Q&A of the assembled boards and necessary board repair. The testing of the discriminator boards is ahead of the RPC module assembly and is not in the critical path.

The production of the TDC modules and their support electronics has started. Purchase orders for the required components have been issued. The TDC module printed circuit boards will be ordered as soon as the prototype trigger module is tested with the TDC modules.

In the next quarter we expect that the TDC module production will continue. The testing of the TDC modules will be started either at the end of this quarter or the beginning of the next quarter. All the discriminator board testing will be completed. The installation of the electronics for Run 10 will be started.

### b. Status of MuTr FEE Electronics
(Tsutomu Mibe, KEK)

New JSPS funded muon tracker trigger electronics was installed in the PHENIX north muon spectrometer prior to the ongoing Run 9. The new electronics has been operated successfully and detailed studies of the MuTr FEE electronics based on Run 9 data are underway. The communication between the MuTr MRG board and a LL1 trigger processor prototype tile has been tested successfully. Further detail can be found in the following section. Production of the MuTr FEE electronics for the south muon spectrometer is underway and it is planned to install the south MuTr FEE electronics during the 2009 shutdown.

### c. Trigger Electronics
(John Lajoie, Iowa State)

Since the last review development work has continued on the “base” board that will hold up to eight trigger tiles (four required for the Muon Trigger Upgrade). A decision was made to manufacture the base board prototypes (five in total) using a material similar to FR4, instead of the Rogers 4350B material that was used for the trigger tiles. The Rogers 4350B material has a much better high frequency response than FR4, reducing the

degradation of high-speed serial signals transmitted on the board. However, this material has a greater coefficient of thermal expansion, and when manufacturing the boards it also demonstrates a greater degree of “slip” between layers when the board is being pressed. In a multilayer board at 9U size, this requires larger tolerances, pads and keep-clear areas than needed with FR4. It would not be possible to manufacture the base board without significant redesign, as well as switching to components with a larger pin spacing. In fact, it was not clear such a board could be manufactured using the FG1136 Xilinx FPGA’s.

Based on tests of bit-error rates and signal transmission through varying lengths of FR4, it was concluded that signal quality should be sufficient with the FR4-based board, particularly if use was made of the advanced features of the Xilinx GTPs (transmitter boost and pre compensation, as well as the ability to control the latching of the data within the “eye” diagram). Five base board prototypes were ordered using the FR4 material, and two boards were populated for initial testing.

Initial testing with the base board focused on the required infrastructure to support the VME interface (for PHENIX communication) and the on-board I2C interface to communicate with the trigger tiles. Because the VME interface is entirely contained within the on-board Virtex-5 FPGA, this interface was developed entirely in firmware, duplicating the functionality of the LL1 VME interface used on other LL1 boards. The I2C interface was developed using an Open Cores I2C module that supports both slave and later operation. This was connected to a set of VME registers to allow external processes to issue commands that will power up/down the trigger tiles, as well as read diagnostic information (voltages, temperatures, fan speeds, etc.)

A full suite of VME and I2C tests were performed to verify functionality of both the hardware and the software. Software was developed to permit control of the trigger tiles through the VME-I2C interface, and verified. The base board has been tested with up to eight trigger tiles installed (a full complement, double what will be required for the muon trigger). The I2C interface is stable and reliable, and there are no apparent power or stability issues with all eight tiles powered up.

With the basic infrastructure for the MuTrig LL1 boards completed, attention turned to testing and verifying the signal integrity for the serial traces on the board. In total there are 40 serial communication lines between the transceivers and the first column of LL1 tiles. These serial lines are used to bring in the data from the detectors (MuTr and RPC). In addition, there are 16 serial communication lines between the trigger tiles and the base board FPGA, as well as eight communication lines between the first and second column of trigger tiles. In order to fully verify the design of the board communication along all these serial lines must be established.

For the serial lines connected to the transceiver (bringing up detector data), tests were done using the MuTr MRG boards installed at BNL and a base board (with trigger tiles) in an LL1 crate. In initial testing, high error rates of were observed. These errors were characterized by the RXNOTINTABLE flag from the GTP receivers being set, indicating corruption in the incoming data stream. It was determined that by configuring the Xilinx

GTPs to use a dual-loop PLL for clock recovery as well as shifting the point within the data "eye" where the data is latched, this error rate could be reduced to 1-3 errors in 15hrs of running. It is important to note that the automatic synchronization and data alignment firmware that we have written for the FPGA is able to handle these errors, and resynchronizes the data automatically within 1-2 beam clocks. Within the trigger logic, we will handle bad data transmission in the same way as for the MuID LL1 trigger. All the trigger bits in a bad frame will be set high, which prevents the trigger from becoming inefficient. It is important to note that an error in one data link will not automatically result in a triggered event, as this data is combined with bits in other links to form the trigger decision. As long as the error rate is sufficiently low (per data link) it will not adversely affect the trigger rejection.

In testing the serial lines between tiles and the FPGA on the base board, similar RXNOTINTABLE errors were detected, and often at higher rates for elements that are farther from each other on the base board (the traces for the transceiver to tile communication are very short). This indicates that the data transmission through the FR4 material is an additional factor for these communication lines. Tests are underway using the experience gained with the MRG board testing to reduce the error rate for communication lines on the base board. It should be noted that for these lines we control both the transmitting and receiving end (both are in Xilinx FPGAs) and therefore we have a wide array of configuration options available to minimize the error rate. While initial tests are promising, a full study has not yet been completed. There is some indication that the error rate is higher for the base board transmitting to the trigger tiles, perhaps indicating some noise issues in the linear supplies used for the GTPs.

In considering the data communications on the base board it is important to note that only a subset of these data links are required for the MuTrig operation. Only the transceiver links (which have been demonstrated) and the <u>four</u> data links from the tile to the base board FPGA are required. Of these four links, in initial testing only one link, the one furthest from the FPGA, had what was deemed to be an unacceptably high error rate (1-2 bad frames per second). We are confident that with additional study and configuration this error rate can be brought down to acceptable levels.

As noted previously, only two base boards have been fully populated. This was done in order to save the considerable parts cost if it was determined that the prototype base boards were unacceptable. At the present time there are no critical issues with the base board that would require an additional production run of the base board. Population of the three additional base boards will be delayed until August due to the availability of the tile to base board connectors. While only 24 parts are required to finish the remaining boards, the manufacturer (ERNI) was unwilling to sell us the parts in quantities less than 440. After negotiating with the manufacturer, we have obtained an agreement that we will be able to purchase a lot of 50 parts after the new production run this summer. It is expected that full testing of the base board will be complete by that time, and a final decision will be possible on whether the existing boards are acceptable, or a revised base board will be required.

During RHIC Run-9 it has been our stated goal to attempt to implement and demonstrate at least one octant of the Muon Trigger Upgrade. We now believe that we will able to do this in a full trigger tile + baseboard combination. Based on the recent results from the MRG communication testing, we now feel that the hardware is stable enough to permit this testing, and work is underway to install a prototype algorithm within the tile board FPGA code. Because of the complicated nature of the system and the great deal of work required to achieve this goal we do not anticipate that the trigger will be available at PHENIX to take data, but will be implemented for debug operation that will allow us to get the experience required to set up the full system in time for RHIC Run-10 (and beyond).

# 3. Software, Simulations and Backgrounds

## a. Software and Simulations
(Ralf Seidl, RBRC)

In 2007 and 2008 we have carried out extensive Monte Carlo studies of measurements on parity violating single spin asymmetries from W-production through single high $p_T$ inclusive muons. Elements of these studies included realistic simulations of backgrounds from hadron decay muons falsely reconstructed with high $p_T$, punch through hadrons and cosmic ray particles. The Monte Carlo studies included event generation, GEANT, detector response, reconstruction and asymmetry analsyis.

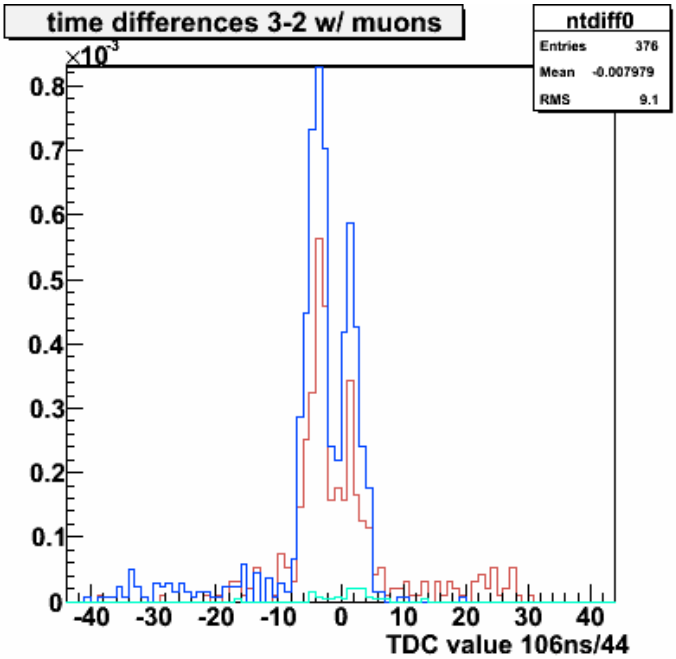


Fig.9 Distributions of timing differences between RPC prototype stations 2 and 3. The two peaks correspond to the timing for collision related tracks and the timing for the incoming beam.

In the past and present quarter we have started to form a group that eventually will grow to carry out the W-analysis in PHENIX. Concrete tasks undertaken are (1) a study to determine if increased MuTr HV will improve the position resolution in the muon spectrometers and therefore the momentum resolution. This aims at decreasing the smearing contribution of low $p_T$ muons into the high $p_T$ signal sample, (2) introduction of the RPC hit information into the muon spectrometer reconstruction software, (3) updated absorber geometry information for Run 9 and future runs to PISA and (4) the analysis of RPC prototype performance and the MuTr trigger electronics from Run 9.

While the final analysis of the RPC prototypes and the new MuTr trigger electronics will have to wait for the completion of the Run 9 data production we show in Fig.9 an online result with timing information from the RPCs.

### b. Cosmic Ray Background Determination in Run 9 (Xiaochun He, Georgia State)

Our effort on making quantitative measurements of cosmic ray backgrounds for W-physics with the existing muon spectrometer is about complete. In comparison to preliminary results from the Run 7 cosmic data set, the Run 9 data set significantly improves the statistics. Fig. 10 below shows the comparison of the uncertainties that result from the error in the knowledge of the cosmic ray background. The uncertainty is shown as the ratio of the uncertainty on $A_L$ resulting from the cosmic ray background over the statistical uncertainty from the inclusive $A_L$ W signal. Indicated are the ratios based on the Run 7 and Run 9 cosmic runs. In Run 9 we took about 100 hours of high quality cosmic ray data in early February during the RHIC Run 9 start-up period.

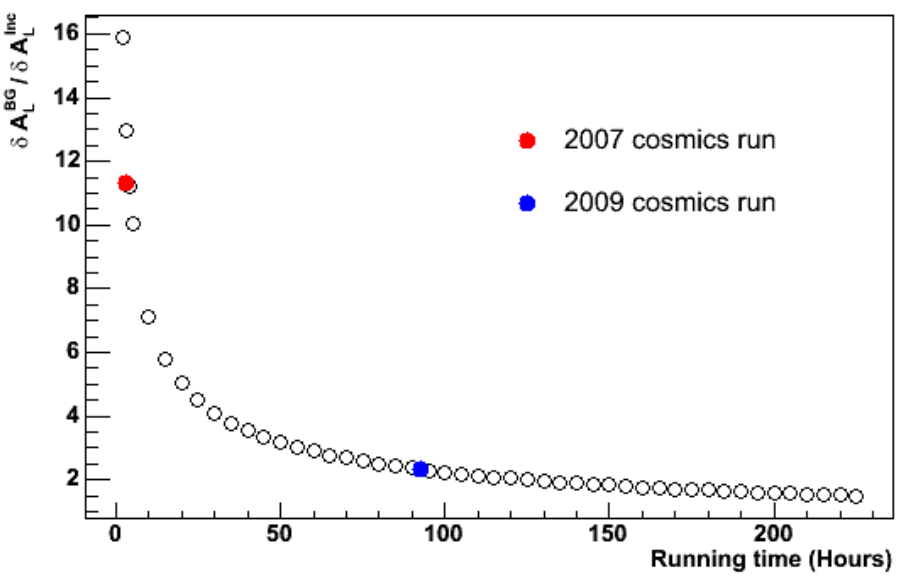


Fig.10 Relative size of the uncertainty from the cosmic ray background level..

Because of the relatively small data file size (~40 MB per hour), the entire data set was copied both to RCF and to an analysis cluster at Georgia State University for an independent data scan as indicated in the previous report. A rigorous data quality assurance study was performed for this data set. It resulted in 9 field-off and 100 field-on runs which were used for determining the irreducible cosmic ray muon background for the W measurement. The extracted cosmic muon rate is 2.5 +/- 0.1 mHz for the $p_T$ range of 20 to 40 GeV/c.

The expected rate from W-decay muons is ~0.5 mHz based on the RHIC Spin 2008 document. This indicates that it is crucial to be able to use RPC timing information to further reject cosmic ray muons by a factor of 5 within a 20 ns timing window. Assuming that the expected timing rejection works, the cosmic ray muon background rate would be very close to the W-decay muon rate.

The projected progress for the coming months is to complete a data analysis note for this study which will be submitted to the PHENIX collaboration. We also plan to make a series set of simulation studies for understanding the reconstruction efficiency of cosmic ray muons. This work has been started at the GSU analysis cluster.

## 4. Personnel for RPC Production

The factory at BNL for the production and testing of the RPC detectors in managed by Young Jin Kim, a UIUC post doc. In addition IhnJea Choi and Anselm Vossen, also UIUC post docs spend a major part of their efforts in the RPC factory. Major work at the factory is carried out by senior UIUC graduate students Beau Meredith, Scott Wolin and Ruizhe Yang. In addition Dave Northacker, an expert on gas systems, will spend about one week per month working in the factory. Since our last report our manpower has increased by 3.5 man years from Korea and 1.2 man years from Muhlenberg plus Morgan State.

Two senior graduate students from Korea, Byungil Kim and Kwangbok Lee, will spend 50% of their time working on RPC production. Also student Chong Kim from the University will spend 100% of his time in the RPC factory beginning June 1. In addition two students from Hanyang University in Korea, Jeong Su Kang and Byeong Hyeon Park, will spend 12 and 6 months, respectively, working in the RPC factory starting May 1.

UIUC will contribute two new graduate students, Martin Leitgab and Cameron McKinney, who will each work for about two months in the RPC factory during Fall 2009.

For the summer of 2009 a large number of undergraduate students from Abilene Christian University, Morgan State University and Muhlenberg College will travel to BNL to work on construction and testing of the RPC-3N chambers as follows:

Abilene Christian University: Keller Andrews (May 26 to August 7)
Doug Coley (May 26 to August 7)
Kyle Gainey (May 26 to August 7)
Dillon Thomas (May 26 to August 7)
Ryan Wright (May 26 to August 7)
Under the supervision of Prof. Rusty Towell
(Prof. Towell's work is supported by the NSF-MRI and the DOE Medium Energy Program)

Morgan State University: 3 Students (most of summer 2009)
Under the supervision of Prof. William Powell
(Prof. Powell is supported by FaST-NSF grant)

Muhlenberg College: David Broxmeyer (May 27 to July 27)
Caitlin Harper (May 31 to July 27)
Tally Sodre (May 31 to July 27)
Under the supervision of Prof. Brett Fadem
(Prof. Fadem is the recipient of a new NSF grant)

In addition two first year graduate students from Iowa State University will work on the RPC project as follows:

James Bowen (May 20 to June 30)
Joshua Perry (May 20 to June 30)
Under the supervision of Prof. John Lajoie

# B. Budget Summary

(Matthias Grosse Perdekamp, UIUC)

| Item | budget 9-08 | projected cost 1-09 | projected cost 5-09 | change in projected cost |
|---|---|---|---|---|
| FEE R&D | $ 261,709 | $261,709.0 | $261,709.0 | $0.0 |
| FEE | $ 600,337 | $535,332.0 | $519,822.0 | $80,514.8 |
| LL1 | $ 299,520 | $288,920.2 | $274,192.5 | $25,327.5 |
| RPC Engineering | $ 161,716 | $159,248.4 | $158,358.6 | $3,357.0 |
| RPC R&D | $ 117,562 | $143,862.0 | $143,862.0 | ($26,300.0) |
| RPC Production | $ 707,116 | $610,606.9 | $576,841.2 | $130,274.8 |
| Gas System | $ 60,000 | $60,000.0 | $60,000.0 | $0.0 |
| High Voltage | $ 96,000 | $96,000.0 | $128,000.0 | ($32,000.0) |
| Total | $ 2,303,959 | $2,155,678.5 | $2,122,785.3 | $181,174.1 |
| contingency | $ 183,372 | $255,611.4 | $243,611.4 | |
| committed | $1,086,468 | $1,403,364.8 | $1,673,896.0 | |
| fraction committed | 47% | 61% | 73% | |

We use as reference the budget presented at the BNL review of the PHENIX muon trigger upgrade from September 2008. This budget is based on the muon trigger configuration with two RPC stations. The “projected cost” is updated from the reference budget using improved cost estimates obtained from orders submitted and bids received. Changes in projected cost also arise from unspent contingency. The uncommitted contingency is currently $243.6k. The amount of funds committed has increased to about $1.67 million or about 73% of the total project cost. The projected total cost to completion is $449k.

Significant commitments since the last report include (1) orders of parts for the front end electronics for about $104k (2) order of RPC-3 half octant support frame structures for about $91k and (3) the purchase of parts for the LL1 trigger processors and (4) the purchase of HV connectors and cables from CPE in Italy.

It was found that the budget for HV equipment underestimated the cost for HV power supplies and HV connectors and cables. We used contingency to increase the budget for HV equipment to $128k in order to acquire the HV connectors and cables needed from CPE in Italy.

In the current and next quarter we expect to order the detector hardware for RPC-1 and we will continue procurement for the electronics mass production.

## C. Schedule Summary
### (Matthias Grosse Perdekamp, UIUC)

We believe that the schedule for trigger processors and front end electronics is not on the critical path and that all electronics will become available as needed for the detector assembly and integration. However, in the RPC detector hardware production delays have occurred compared to the project schedule presented at the BNL project review in September, 2009. The delays were reported on February 11 at the last quarterly review. Here we provide an update of the schedule.

Compared to the schedule given in February we are attempting to accelerate the RPC-3 detector module and half octant production in order to meet the ambitious PHENIX installation schedule for RPC-3 north. The accelerated schedule becomes possible with the help of significant additional manpower for the detector module assembly at BNL and through the pre-assembly of the RPC half octant structures with new manpower at UIUC thus reducing the work load from the assembly factory at BNL.

(1) The **RPC gas gap production for RPC-3 South + North**

| Schedule Date | Schedule Estimate |
|---|---|
| 09/25/08 | 12-05-08 - 03-12-09 |
| 02/11/09 | 01-02-09 - 06-04-09 |
| **05/25/09** | **01-02-09 - 06-12-09** |

The RPC gas gap production schedule remains stable. The RPC gas gaps for detector modules RPC-3A&B already have been received at BNL. The production of RPC-3C has been completed. However, factory exit Q&A only will be completed in the first week of June.

(2) The **RPC-3 detector module north production**

| Schedule Date | Schedule Estimate |
|---|---|
| 09/25/08 | 01-30-09 - 06-18-09 |
| 02/11/09 | 04-15-09 - 09-30-09 |
| **05/25/09** | **04-15-09 - 08-21-09** |

The schedule accelerates because of significant new manpower available for the RPC factory. There are additional 3.5 man years from graduate students at Hanyang and Korea Universities and for the summer of 2009 there will be 6 undergraduate students from Muhlenberg College plus Morgan State University who will make highly valuable contributions to the pre-production of detector parts.

(3) The **RPC-3 half octant north production:**

| Schedule Date | Schedule Estimate |
|---|---|
| 09/25/08 | 04-27-09 - 07-20-09 |
| 02/11/09 | 07-15-09 - 10-30-09 |
| **05/25./09** | **05-12-09 - 09-18-09** |

The acceleration of the half octant production relies on the pre-assembly of half octants at UIUC with “new manpower”. The pre-assembly at UIUC has started and presently is one week ahead of schedule. The work is carried out by 3 UIUC graduate students, 1 UIUC technician, 3 UIUC undergraduates and 2 REU summer students.

It is desirable for PHENIX to split the RPC-3 installation into two steps and to carry out the north installation in the summer shutdown of 2009 and the south installation in the shutdown 2010. The main advantage of a staged integration is the ability to better balance efforts for different detector upgrades within the PHENIX technical support group. We believe that still a major fraction of the RPC-3 north half octants could be installed in the summer of 2009, and depending on the shutdown schedule possibly all could be installed.