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Date: Thu, 18 Apr 2002 18:51:23 -0500 (CDT)
From: Geary Eppley <eppley@physics.rice.edu>
X-Sender: eppley@bonner-pcs6.rice.edu
To: Jay Marx <jnmarx@lbl.gov>,
Billy Bonner <bonner@physics.rice.edu>,
Jay Roberts <roberts@physics.rice.edu>,
Bill Llope <llope@physics.rice.edu>, hoffmann@physics.utexas.edu,
ray@physics.utexas.edu, Jo Schambach <jschamba@physics.utexas.edu>,
Huan Huang <huang@physics.ucla.edu>, christie@bnl.gov,
yesw@rcf.rhic.bnl.gov, Frank Geurts <geurts@physics.rice.edu>,
hfchen@ustc.edu.cn, wangxl@ustc.edu.cn, ludlam@bnl.gov,
fliu@rcf.rhic.bnl.gov, licheng@ustc.edu.cn, slhuang@rcf.rhic.bnl.gov,
Ted Nussbaum <tednuss@physics.rice.edu>,
Lloyd Bridges <lwbridges@earthlink.net>
Subject: cc of update to TOFr proposal

Date: Thu, 18 Apr 2002 18:47:30 -0500 (CDT)
From: Geary Eppley <eppley@physics.rice.edu>
To: hallman@bnl.gov, vigdor@iucf.indiana.edu, Jim Thomas <jhthomas@lbl.gov>,
hhwieman@lbl.gov, ludlam@bnl.gov, christie@bnl.gov
Subject: MRPC TOF proposal update

Dear Tim and STAR management:

A proposal to install a ~200 channel tray of multi-gap resistive plate chamber time-of-flight detectors for STAR (TOFr) was submitted to STAR management in April 2001 and approved by the spokesperson. (A copy may be found at: http://mac8.rice.edu/~TOF/Documents/TOFr_prop.pdf).

The original schedule called for installation of the tray in STAR immediately following the proton run in time for the FY2002 heavy-ion run. For a number of administrative reasons, the project schedule slipped as did the RHIC schedule. It eventually became evident that there would be no heavy-ion run following the delayed proton run.

A 168 channel prototype tray was completed in February 2002. The project was completed within the original budget and no significant technical delays were encountered. In fact, the MRPC modules and the FEE cards were completed by the originally scheduled dates.

The FEEs have been extremely reliable. The first production prototype was tested at CERN in late July and production began in August. Forty-nine 6-channel boards were produced and 43 passed bench testing in all channels. The cards have been used extensively for testing modules at CERN, Rice, and in China and 28, 6-channel cards are currently installed on the tray at the AGS test setup. There has been one possible failure in

a single channel to date. This channel appears to be good on the bench so there may have been a connection problem to the interface card.

Twenty-four 6-channel MRPC modules were constructed at USTC and all were tested in cosmic ray test setups at USTC and at Rice. Nineteen modules apparently worked perfectly and 5 exhibited somewhat pronounced high tails in the ADC spectra in one or more channels. This seems like a very good yield for the initial production. The high ADC tails are thought to be a symptom of either non-parallel glass plates that approach each other too closely or else foreign material between the plates. Previous test beam experience indicates that modules of this type work satisfactorily but with a time resolution impaired by about 10 ps. We have installed all 24 modules in the prototype tray to study the possible variations in timing characteristics.

The full prototype tray was tested with cosmic rays at Rice for about 3 weeks before being transported to BNL for testing at the AGS. The dark current is ~10 nA at 15 kV with 19, 6-channel modules connected in parallel. The noise rates (signals above threshold that generate a logic signal) are about 10 Hz per channel for most modules with some modules at 20 Hz and one at 40 Hz. There are 3 dead channels. This problem is thought to be caused by bad connections between the twisted-pair signal cable and the connector on the inside of the interface card. One additional channel was dead after the tray was set up at the AGS. The noise rates and dark current were the same at the AGS setup as measured at Rice except during AGS beam operation when the entire area is flooded with radiation.

Initial beam tests at the AGS indicate a 90 ps start-subtracted time resolution in the 23 channels tested so far. The beam is confined to 4 cm of the pickup pad by the trigger scintillator as opposed to 1 cm at the CERN tests. Due to the 50 ps/cm signal propagation time in the copper pad, the larger beam area adds a 55 ps smearing. The stop time would be ~70 ps without the additional smearing added by the position uncertainty. In addition, the beam has significant non-relativistic momentum spread. Given the testing conditions it is thought that time resolution is consistent with the 60 ps time resolution measured at CERN with a clean beam and 1 cm^2 triggered beam spot. Each of the 23 ADC distributions measured so far at the AGS test looks good. It is our test experience with these modules that if the ADC distributions look good, then the modules will all exhibit similar time resolutions.

The AGS beam resumes April 18 and we plan another four weeks of testing. We will resume running HV plateaus at a number of thresholds to determine an optimum setting. We will then scan over all of the modules to see that they give good results.

We would like to install this tray in STAR for the FY2003 run replacing a CTB tray. We would like to leave it installed until the final modules of

the EMC barrel are completed. It has to be removed at that time since the electronics and cabling encroaches on the EMC integration volume.

We plan to instrument 72 channels this year. (The primary limitation on the number of channels is the availability of CAMAC ADC and TDC modules.) This will more than double the number of channels of TOF for STAR and increase the total effective area producing useful TOF data by about 60%.

Advantages to STAR

1) Doing this involves little cost and little risk. We need to make 216 rg58 signal cables and 300, 16 foot rg316 pigtails. Most of the connectors are on hand. We need to acquire the HV supply, and purchase and install the gas pipe. All of this fits within the original project budget. The tray is otherwise installed and working at the AGS. It will require a more detailed safety review than it received at the AGS but the committee will be the same and they have already seen the setup and do not see any problems in installing this in STAR.

2) This has minor impact on this year's shutdown schedule. All the installation work except installing the gas pipe can be performed by the TOF group and will take about a week. The main installation task is running the signal cables. These will be laid along exactly the same path already taken by TOFp cables. Along this path there is plenty of space and no conflicts with existing or planned cabling for other STAR detectors.

3) Since TOFp is already commissioned and the TOFr addition is already at BNL and operating successfully, it is expected that commissioning of the enhanced TOF system will be minimal. This is because the cabling of the TOFr system between the detector and the rack will be identical to that presently working for the TOFp System. There will thus be no need to 'time in' TOFr with respect to STAR DAQ and trigger. In terms of commissioning and integration of the detector in the next STAR run, it is realistic to consider TOFr as simply more stop channels in the TOFp System. The start detector, digitization, control, monitoring, and the interaction with STAR DAQ and TRG are all done by existing TOFp components. In fact STAR DAQ and TRG will not "see" TOFr at all.

4) This technology seems to work very reliably and the prospects for installing a large area TOF in STAR economically using MRPCs seem excellent. Having a patch of MRPC TOF installed in STAR will greatly increase our credibility with DOE when we apply for funding.

5) The MRPC TOF has always performed well in test beam runs at CERN and BNL. Other than the tests planned for the coming month of AGS running, there is little additional benefit from further extensive running of this system at a test beam. Most of what can be learned at a test beam

has already been learned. The design of the detector modules, and the techniques to properly assemble and run them, have been fixed for some time. The FEE electronics operate very well. The FEE and the modules have been shown to work together in a tray configuration which is appropriate for installation in STAR as is.

However, the vast body of test beam data that we have collected so far does not insure that a large-area TOF system based on this technology will function as expected when installed in STAR. One concern is that since the detector signals are so small (~50 fC), noise and grounding become major concerns. The current electronics are extremely robust and work well at the AGS. While the AGS area appears to be an extremely noisy environment, there is no reason to assume STAR's noise environment is the same in all respects. There is only one place in the world that has exactly the noise characteristics of STAR, and that is inside STAR itself. It would be nice to know if there are any surprises at STAR before designing and building the final system.

Test beams cannot answer all the questions that are relevant and crucial. Having a patch of MRPC TOF installed in STAR for several years will provide the ideal way to perfect this system before building a large area TOF for STAR.

6) The expected occupancy in TOFr is about 11% in central collisions as compared to 33% in TOFp allowing more efficient particle identification. A 72-channel TOFr system will augment the acceptance of TOFp by about 60%. It will produce the same physics and allow comparison between the two systems. For the FY2004 run, TOFp could be removed and the remaining channels of TOFr could be instrumented.

The proposed prototype MRPC TOF tray, TOFr, was reviewed in July 2000 by a STAR installation review committee chaired by Bill Christie and approved for installation into STAR. There were some open questions following that review and the remaining questions that are not answered by the existence proof of a working detector on the floor of the AGS are addressed separately in a reply to the review committee.

STAR TOF Group