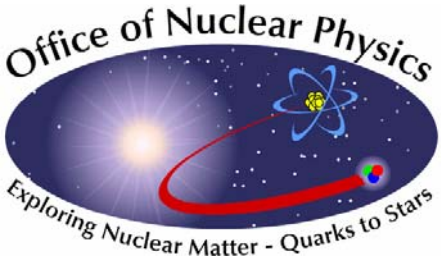

Department of Energy
Office of Nuclear Physics

Reviewer Excerpts from the

Technical, Cost, Schedule and Management Review

of the

STAR Time-of-Flight (TOF) Detector

August 22-23, 2005

EXCERPTS FROM PANEL MEMBER REPORTS

The Technical, Cost, Schedule and Management Review of the STAR Time-of-Flight (TOF) Detector was held at Brookhaven National Laboratory (BNL) on August 22-23, 2005. Excerpts from the reports of the review panel members regarding their findings are provided below in their responses to the review criteria they were asked to address.

The merit and significance of the planned project:

Reviewer:

"The STAR-TOF detector is a large acceptance device that is intended to significantly increase the particle identification (PID) capabilities of the STAR detector at RHIC. The STAR-TOF consists of an array of 120 trays of multi-gap resistive plane chamber (MRPC) modules that cover the entire acceptance of the STAR Time-Projection-Chamber (TPC). There are a total of 3800 MRPC modules with 23,000 readout channels. The main features of the proposed arrangement is to achieve a timing resolution of at least 100 *ps* and more than double the momentum range for particle identification. Cost and space available within the STAR detector were the main design considerations that led to the choice of this MRPC system over more conventional technologies. The MRPCs are compact, do not exhibit performance deterioration in the presence of magnetic fields, and cost significantly less than scintillators coupled with phototubes capable of operating under the STAR magnetic field. The construction of the MRPCs is paid and done by China. Thus, the contribution of China to the project is sizable in terms of both cost and impact.

"The proposed STAR-TOF detector can significantly augment the scientific output of the STAR detector. For example, due its PID capability the STAR-TOF can extend the jet quenching studies (one of the major discoveries at RHIC) to include fluctuations and correlations. The STAR-TOF would also allow a lepton program extending to heavy flavor particles that could potentially contribute to clarify the quark-gluon plasma signature.

"In summary, the STAR-TOF project is a novel system with the potential to significantly increase the STAR's scientific output. The collaboration has the knowledge and expertise to carry out the project on a timely basis and on cost. If there is a slippage on the delivery of components then the manpower for assembly is an area of concern. The hope is that this would not be an issue but in order to ensure the project success it may be worthwhile to plan for it in advance."

Reviewer:

"The RHIC program to date has been enormously successful, with a combination of four experiments producing a vast array of data and results which strongly suggest that Au+Au collisions at RHIC have produced a new form of hadronic matter – the Strongly

Interacting Quark-Gluon Plasma (sQGP). The STAR experiment has been integral in this discovery.

"As the RHIC program moves from completion of the discovery phase to a more detailed characterization of the various phenomena and testing of theories of the properties of the sQGP, the capabilities of both the accelerator and the experiments will be tested to the limits of their current capabilities and it is therefore timely and essential that significant upgrades to both be undertaken. The proposed addition of a full-acceptance TOF capability to the STAR experiment will provide vastly improved particle identification capabilities to the experiment and open up new avenues for detailed studies.

"As the study of hadronic matter in its extreme forms will shed light on one of the most important physics questions of the day – the nature of the mechanism whereby quarks and gluons are confined within the observed hadrons – the improvement in capability to STAR brought about by the TOF addition is of the highest significance and merit."

Reviewer:

"The proposed project will significantly enhance the PID capability of the STAR detector. The p-K separation is extended out to 3 GeV and the pi-K separation is extended to 1.6 GeV with efficiencies greater than 80%. It will allow a clean electron identification without hadron background and will yield clean open charm measurements."

Reviewer:

"I found it very interesting to see how powerful the particle ID became when the TOF was added to STAR – not just the particle identification with the TOF but how well the TOF complements and enhances the particle identification of the TPC. We were shown that low momentum electrons could be cleanly tagged using dE/dx once all the slower particles had been removed using the TOF data – and that dE/dx could be used to identify particles on the relativistic rise (up to 5 to 10 GeV/c) once the TOF was in place, since the TOF allows precise dE/dx calibration. I am certain that such particle identification will really lead to an unsuspected physics yield and look forward to reading about it in some years time."

The technical status of the project:

Reviewer:

"Technically, the proposed detector relies on a new technology that has just come to fruition. However, in the last few years the proponents have led a research and development program on the MRPCs. They have gone through several stages of prototyping (trays containing MRPCs and their associated electronics), have performed *in situ* beam tests and in the process they have met the physics goals."

Reviewer:

"The design of the TOF array is well advanced and has largely been tested through the operation of a prototype detector in the STAR experiment in recent RHIC runs. There are a number of technical issues requiring decisions before production of the entire array can begin. These include the choice of resistivity of the plates and of the gas used. The trade-offs between performance and risks should be clearly understood and documented prior to commitment to the final design and operational parameters. Overall, the proposed detector should perform more than adequately. There may be some room for improved performance however. It is essential to have a clearly delineated and validated plan for the system integration and testing, prior to the start of fabrication of the electronics."

Reviewer:

"The project is set to switch from the R&D phase to the construction phase relatively soon. It is of utmost importance to address the system integration, maintenance, testing and production issues as soon as possible. Since the preamplifier, discriminator and HPTDC systems are mounted on top of the MWPC chamber, the access and repair of these systems will be very difficult. There is no test pulse function on the preamplifier/discriminator board which would allow for testing before and after the electronics are mounted on the chamber. Therefore, I believe such a function should be added to the design to aid in the testing process."

Reviewer:

"Three years of prototyping has yielded a mature and professional design. The collaboration should be commended for having produced physics results from the prototype tray. The collaboration presented good reasons for their design approach but were still receptive for suggestions of possible modifications. However, at this stage care should be taken to make sure that if changes are made they do not prevent a fall back to the current design. Changes in gas mixtures were discussed but are not deemed to be a critical issue since new information can be implemented at any time even after construction is complete. The gas system should have a provision for a three components. The current design presented gives confidence of success with little risk.

"The electronics system seems to be well thought out and prototyped. It will be important to make a NINO decision soon as well as get the TDIG module fabricated soon. A test pulse should be added since it will greatly facilitate debugging and testing after installation."

Reviewer:

"For the last two or three years the STAR TOF group has concentrated on running a prototype TOF detector in the STAR experiment. It is clear that they have been somewhat successful since physics papers have already been produced, so building a barrel TOF with 100 ps resolution is certainly feasible. The group should be complimented on this prototype work that they have done. I have two comments; the first is that since the prototype was successful the STAR TOF group gives the impression that all problems are solved and now one just turns the handle of mass production. However the problems of mass production have not really been addressed: one hopes that things do indeed go smoothly since the schedule is tight, but at this moment it is not obvious. The second comment is that even though a complete TOF barrel with a system resolution of 100 ps will be a great achievement, current MRPC technology together with modern electronics could get to 50 ps. However to delay the project for an additional year or two to investigate how to push the limits of the technology would endanger the long term goals of the STAR TOF upgrade. Nonetheless I would encourage the group to worry about all sources of jitter and aim for a time resolution below 100 ps in all steps in this project."

Reviewer:

"The STAR TOF detector's front-end electronics have been well prototyped. The prototype which was constructed from commercial preamplifiers, discriminators and CERN's HPTDC chip has shown adequate performance based on the RHIC Run 4-5 data. To further minimize the power usage, the group is proposing to adapt ALICE's NINO chip to be used as the preamplifier and discriminator. A prototype of this new board should be completed and tested promptly in order to minimize a schedule delay on the overall project. The downstream portions of the TOF electronics are not as well prototyped as the electronics near the chamber. To fit the cost and schedule of the experiment, the progress of these electronics should be closely tracked."

Reviewer:

"Because of the difficulty of accessing the electronics, procedures would have to be established to maximize the lifetime of these boards. It will be very important to qualify a PCB assembler who will review the PCB design for manufacturability. Doing so will increase the yield and reliability of the assembled boards. The electronics industry has developed procedures to rule out the premature failure of these boards. These procedures are called the Highly Accelerated Life Test (HALT) and Highly Accelerated Stress Screening (HASS). Adapting some of these procedures will be helpful in reducing mean time between failures (MTBF) of the system.

“There are roughly 2000 boards in the system, meaning the production will most likely be done in batches. It will be important to have a procedure set up ahead of time to deal with the material flow, quality control and problem tracking. This will help prevent unnecessary scheduling and cost overrun.”

The feasibility and completeness of the budgets and schedule:

Reviewer:

"The cost of the project including contingency is estimated to be ~ 4.6 million actual year dollars. The bulk of this cost (3.5 million) is on the MRPCs electronics (the MRPCs cost is an additional 2.2 million paid by the Chinese government). A detailed cost breakdown of the project components has been presented and there are no major uncertainties on these costs.

"The project calls for a 3-year construction phase. This schedule is feasible although it is contingent to two significant factors not entirely under the full control of the STAR-TOF collaboration. These are the on-schedule delivery of the MRPCs from China and the prompt fabrication and delivery of the electronics components done by commercial companies."

Reviewer:

"The total estimated cost of $4.8M appears adequate and the proposed schedule is feasible but aggressive. With careful monitoring and involvement from BNL and STAR management the cost and schedule are achievable.

"This reviewer has some concerns on three counts. First, the university participants may not have a sufficiently disciplined approach to the organizational challenges that this construction project will bring – as mentioned above the strong involvement of BNL and STAR management will be essential. Second, at Rice and UT, the level of institutional commitment to Nuclear Physics research, measured by the number of tenure track faculty, is small. In itself this may not be too much of a problem but suffers from the danger that the group then lacks the clout to protect its resources (eg space) in the highly competitive environment of a major research department and college. This may be a very significant issue in the case of Rice where the – space intensive - tray assembly will take place. Formal assurances of the commitment to the needed space would alleviate this concern. Lastly, given the nature of the appointments of many of the participants – as Research Faculty – there is a heavy reliance on DoE for salary support. One would feel more comfortable if the institutions would back up this support from DoE with some hard line positions or institutional support. Implied commitments, if any, for additional positions funded by DoE should be made explicit."

Reviewer:

"The manpower presented for the UT effort relies on 2 FTE students. While the contact hours may be correct the number of students needed on a full time basis is probably more. The impact of more students on the budget is small and provisions should be made to increase the number if needed. The budget is $4.8M and extremely close to the $5.0 M DOE ceiling. It is vital that the budget not exceed $5.0M so due diligence will be

necessary to keep a close reign on costs. Procurement delays have to be avoided to keep the schedule on time."

Reviewer:

"Obviously the budget and schedule has been carefully studied by the STAR TOF group and it is certainly feasible. There is some built in contingency and with this one expects that the budget can be met. However as everyone on the committee repeats the schedule is tight and also the manpower is limited. However since this project has exciting physics potential in a relatively short timescale, uses new detector technology and state-of-the-art electronics; I suspect that it will not be difficult to involve extra physicists and students if (and when) the time schedule slips."

The effectiveness of the management structure:

Reviewer:

"The project management structure assumes a mass production project with timely tasks being performed at different institutions in the US and China. The project is divided into sub-systems and individuals have been identified at the different institutions for overseeing the sub-systems. The project management is done by a coordinated effort between a project manager and a project engineer. The model should work well for a mass production although extra attention would be needed in the initial phases of the project to ensure that all the pieces for a mass production are in place. Contingency plans should be devised in case of a significant delay of one (or more) of the MRPCs shipments. The same would apply to alterations on the delivery of some electronics parts.

"The area of manpower is one of concern. Specifically, the project calls for only one full-time technician (to be hired) to assemble and test all the 120+ trays, each containing 32 MRPC detectors with associated electronics and cooling system. It is assumed that one or two undergraduate students will assist the technician. This does not appear to be sufficient for a project of this scale and importance. Although undergraduate students can be trained to perform many of the required tasks, they are not commensurate for a mass production enterprise of this scale that would require, at a minimum, 8-hour day shifts for many straight months. Undergraduates take classes and they are not necessarily reliable from one semester to another. Graduate students would be much preferable, especially because they can tie the assembly project to Ph.D. theses. If graduate students are not available, project management should find the resources to hire a second full-time technician from the beginning. This is critical because the tray fabrication and assembly will take place at universities far away from BNL and it is not clear that extra resources can be brought to bear in case the mass production is falling behind schedule. If the assembly activities would take place at a national lab for example then this would not be a serious issue because the laboratory can always rearrange resources to take care of emergencies. In summary, project management should secure a firm commitment by the participating universities that extra resources (manpower, space) would be made available in case they are needed."

Reviewer:

"The construction of the elements of the TOF Array will be carried out at several different institutions in the US and in China. This will require careful coordination and monitoring, particularly in the early stages of the project. The management structure internal to the project has been augmented by the addition of the STAR lead engineer who will act as the TOF Project Engineer. This, together with the active participation of BNL and STAR management will ensure the success of the project. The liaison to the Chinese group appears to be well set up and functioning – experience shows that such overseas collaborations do not always follow the same rules as those internal to the US – cultural differences often playing a significant role. Overall, the project is well set to go."

Reviewer:

"The group has reasonable amount of expertise and, given enough attention, the electronics portion of project should be successful."

Reviewer:

"The management chart looks quite adequate with all the appropriate boxes filled. However, the time estimate by the project manager and project engineer (15% each) is inadequate. Project reporting and tracking will consume this time and leave no time left for all of the other necessary activities such as site visits, travel, reviews, etc."

Reviewer:

"It is very difficult to talk about the effectiveness of the management when the management team has no track record. However some members of the management are based at BNL and have a record to be proud of. Thus probably there is no fundamental problem with the proposed management except that much of it is an untried entity. The relationship between the Chinese and US groups seems healthy; this is a good example of an International collaboration. Such collaborations are part of the benefits of large experiments such as STAR."

Other issues related to project:

Reviewer:

"It was stated that the STAR TOF is not allowed to use SF6 since there are worries that the gas within the TPC could be contaminated. Indeed this is valid and important concern and I am sure that no one wants to compromise the performance of the TPC. However without SF6 the performance of the STAR TOF is compromised. There are safe guards one could take to ensure that the TOF does not contaminate the TPC (such as Freon detectors within the STAR endcap; enhanced flow of air in the endcaps to remove any Freon or SF6; stringent leak tests of all trays). One gets the impression that some members of STAR must regard the TOF upgrade as a separate experiment – however the true benefits of the TOF will only be apparent when the TOF and TPC are truly integrated. One hopes that everyone within STAR will work together to get the best out of both the TPC and TOF and a solution to this SF6 problem (if it remains a problem) can be found."