Report from STAR MTD Review – September 2010

A review of the STAR Muon Telescope Detector proposal was held September 17, 2010 at Brookhaven National Laboratory. The review committee members Russell Betts, Vince Cianciolo, Peter Petreczky, Vinnie Polychronakos, and Julia Velkovska evaluated the MTD's proposed physics program, detector design, technology choices, project budget, schedule, resources and management plans. They assessed whether the project as proposed could meets its physics objectives and whether the MTD could be completed by 4QFY13 with its initial operation scheduled for RHIC Run-14.

After considering all the material presented at the review, the committee has composed a list of their findings, comments and recommendations for the project. There are 7 recommendations that the MTD project team must address. In addition to addressing the review recommendations the MTD team should consult with BNL Management to develop an *initial packet* for this project which will include project deliverables, a list of milestones, project schedule, budget information and details about the MTD management organization.

We'd like to thanks the STAR Muon Telescope Detector group for providing the review committee with a coherent set of presentations and a comprehensive collection of background documentation on the MTD project. There has been a great deal of progress on the MTD R&D and the detector design is advanced. The MTD group should be commended for developing a proposal that takes optimal advantage of both the existing STAR detector and the collaboration's technical expertise.

Physics Justification

Findings

- The proposed MTD upgrade was rated by STAR as their highest near-term upgrade priority (after the HFT).
- Major physics goals include measurement of the three upsilon states, the measurement of the J/psi over a broad transverse momentum range, and e-mu correlated heavy flavor decays.
- The detector will cover 45% of the azimuth over eta < |0.5|.
- Backgrounds presented were quite low, but were not presented as a function of transverse momentum.

Comments

- The proposed physics program is high-quality and complementary to expected results from PHENIX.
- Measurement of quarkonium states in heavy ion collisions could provide an interesting probe of the hot matter produced in these collisions. Extending the

J/psi measurements to higher p_T as well as J/psi v2 measurements are complementary to PHENIX program and will help in the understanding of the mechanism of quarkonium production in hot medium. Measurements at higher p_T are interesting as initial state effects will be smaller there. The v2 measurements will provide a crucial test of the in-medium formation of J/psi from correlated pairs and/or the recombination mechanism from uncorrelated cc-bar pairs. The measurements of Upsilon yields will be an interesting new development, especially the measurements of the excited states 2S and 3S. This will be the first measurement of excited bottomonium states at RHIC. The ratio of the yield of excited states to that of the ground state has proven to be a good indicator of the quarkonium production mechanism. This has been demonstrated in arXiv:0803.2866 for charmonium and probably this is also the case for bottomonium. From the theoretical point of view bottomonium measurements are more interesting than charmonium for two reasons. First, the recombination from uncorrelated quark anti-quark pairs is negligible for bottomonium. Second, due to the larger quark mass the theoretical treatment of bottomonium is easier. The physics impact of quarkonium measurements hinges on theoretical understanding of their production in heavy ion collisions. This is a quite complex problem that unfortunately does not receive adequate attention on the theory side. The theoretical uncertainties become obvious when reading the proposal.

- The quarkonium dissociation temperatures quoted in the proposal are a factor of two larger than some more recent theoretical estimates, translating into a factor of 16 in the energy density.

- Dilepton measurements in the intermediate mass region (IMR) are potentially very valuable probes of the matter produced in heavy ion collisions. Dileptons from open flavor decay are the dominant source of background for the thermal dileptons in the intermediate mass region. The MTD proposal deals with this problem using e-mu correlations. Nonetheless, more work is needed to make a physics case for IMR dilepton measurements with MTD. Several other physics topics have been mentioned during the review process (e.g. muonic atoms). These too need more work both on the experimental and the theory sides.

- The fact that there is only one graduate student working on the simulations and the physics case (under supervision of S. Mioduszewski) is a subject of concern. From the proposal and the presentations it is not clear who will be in charge of running and physics analysis once the construction of the MTD is complete. Statements like the entire STAR collaboration is responsible for the physics analysis are not satisfactory.

Recommendations

- Calculate the backgrounds vs. transverse momentum.

- Identify the STAR group or groups that will be in charge of MTD physics analysis and detector operations once the detector is complete.

- Make the physics case of the MTD project crisper. Organization of topical workshops may be useful.

Design and Technology

Findings

- The detector builds on the successful STAR TOF detector and uses nearly identical electronics.

- These detectors are significantly larger than earlier prototypes and the TOF detector. A full-size detector will be tested this year.

- Triggering will be provided by timing correlation w/a minimum bias trigger. Results were shown from several years of detector prototypes that indicate acceptable dimuon trigger rejection powers. No trigger estimate was given for the e-mu signal.

- The intrinsic MTD resolution was calculated to be ~100 ps, corresponding to a spatial resolution of 2.5cm.

- The project is based on a detector technology (Multigap RPC) used for the STAR Time of Flight Detector. Generally the same groups will be involved in the MTD project instilling confidence in the success of the project.

- A series of tests have been conducted using both existing TOF modules and pre-production prototype of the Long MRPC with double ended read-out. This has been carried out both in STAR and in beam test. The results of these tests lend confidence to the soundness of the basic concept.

- The proposed electronics is a modest evolution from the existing TOF electronics.

- The gas system is planned to be separate from the TOF gas system providing the possibility to add SF6 in the mixture to control noise rate and streamers. We note that the use of SF6 has not yet been approved by STAR.

- The final proposed LMRPC design differs from the pre-production prototypes in two aspects that may affect the detector performance in terms of timing and position resolution:
    - A double stack 10 gap module was tested, while a single stack 6 gap structure is proposed.
    - 87(z)x17(ϕ) cm^2 were tested , while 87(z)x52(ϕ) cm^2 are proposed. The mechanical construction of the larger modules may present challenges in achieving the desired performance. Initial cosmic ray test results look promising. A beam test is planned for Nov – Dec 2010 and a test in STAR during Run 11.

- The measured streamer component of 20% in a prototype of the final design LMRPC seems high. The effect on the performance of the MTD was not evaluated.

Comments

- The facilities for construction, assembly and testing are high quality and available as a benefit of the successful TOF project.
- The mechanical assembly of the trays and installation plan appear straight forward.
- The MTD electronics should present no major technical problems aside from possible issues related to the availability of components.
- The technology choices have been fairly well prototyped, and don't seem to present significant technical challenges.
- Backgrounds will likely worsen at high transverse momentum as the tracks become stiffer, and more likely to punch through the absorber.
- The proposed design and the assembled team are likely to be successful in producing the detector with specifications that would achieve the physics goals.

Recommendations

- Demonstrate performance of the MTD preproduction module and electronics design in a test beam and in the RHIC environment for Run-11.

Budget, Schedule, Resources and Management

Findings

- A budget profile was shown with a goal of project completion by the beginning of FY14.
- Chinese and Indian groups will build the RPC modules. This is not part of the $1.5M cost shown and represents an in-kind contribution of ~$1M.
- Rice University, University of Texas and BNL will take responsibility for electronics, mechanical design, installation, and operation.
- A contingency of 15% was proposed.
- No cost backup material was presented.
- No resource-loaded schedule exists.
- The total cost including contingency requested by the MTD group from the BNL capital equipment funds is estimated to be $1.51M AY$ extending over 3 years, FY11-13. In addition the Chinese groups will provide the equivalent of $0.8M for the fabrication of 102 of the trays, and the Indian groups an additional $150k for the

additional 15 trays and LV power supplies. Funding for the Chinese contribution to the MTD has been already approved.

- The detectors are to be completed and commissioned by the end of FY13 in time for Run14

Comments

- If project contingency is increased, as seems likely, it will start to approach the $2M threshold. As a result a more careful project plan is essential. The 15% contingency in the current budget plan is not commensurate with typical DOE capital construction projects.
- The number of people and expertise in these groups are deemed adequate for the success of this project.
- The experience gained in fabricating the TOF detectors in China is invaluable but the MTD detectors are much larger and likely to present challenges that may impact the rather aggressive schedule.
- The cost, but more importantly the funding profile assumed, is inconsistent with the BNL management guidelines.
- The collaboration assumes involvement of DOE supported institutions. An understanding and agreement with their respective research program managers about their work on this project should be sought as early as possible.
- Any possible conflict with the parallel construction of the HFT project which should be carefully evaluated in consultation with the BNL management.

Recommendations

- Revise the MTD project budget to include contingency at levels commensurate with typical DOE capital construction projects.
- Develop a resource-loaded schedule as soon as possible and present it to BNL Management. This will enable better management and tracking of the project in addition to a better understanding of the total project cost.
- Work with BNL Management to establish a realistic budget profile for this project.