Report from Annual FVTX Review – November 2010

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A review of the PHENIX Forward Silicon Vertex Tracker (FVTX) took place at Brookhaven National Laboratory on November 17-18, 2010. The PHENIX FVTX has been an approved DOE MIE project since April 2008 and is nominally scheduled for completion by September 2011 in time for installation and commissioning in preparation for RHIC Run-12 which is scheduled to begin late Fall 2011.

The FVTX group provided a comprehensive and coherent set of presentations for the review from which the review committee was able to evaluate the status of the individual components of the FVTX and assess the overall progress of the project. The committee reviewed the technical progress of the project with respect to the milestones in its Management Plan, assessed the project's cost, schedule and management performance to date, evaluated the FVTX team's plan to complete the detector and examined the plans for commissioning and initial operation of the FVTX in PHENIX. In addition the review committee evaluated the level to which the FVTX group has addressed the recommendations from last year's review and composed a list of findings, comments and recommendations based on the information provided at this review. The list is the basis for this report which contains five recommendations that the FVTX team shall address on the time scale specified in this document.

Progress on all recommendations should be reported at each monthly phone conference held among the FVTX team, BNL and DOE. It is especially important that the FVTX group closely track and report on the progress of the critical path and near critical path items associates with this project: The High Density Interconnects, extension cables, ROCs and carbon composite Cages. Though many positive aspects of the FTVX project were identified by the review committee and reflected in the report, there are a number of significant technical and schedule issues that must be resolved by FVTX management if this project is to be brought to a successful completion.

We would like to thank the FVTX group for providing the reviewers with the documentation and details necessary to allow a thorough evaluation of the status of this project. There has been a great deal of progress on the FVTX project since the last review in November 2009 and the FVTX team should be commended for its achievements in the past year. Much has been accomplished in the last 12 months but many challenges remain if the FVTX is to be completed, installed and commissioned in time for RHIC Run-12. Full attention from the FVTX team in addition to substantial help from the PHENIX Collaboration as a whole will be necessary over the next 10 months if the FVTX project is to meet its project milestones and performance specifications in advance of the 2012

RHIC run. We look forward to seeing the FVTX installed, commissioned and operating in PHENIX for RHIC Run-12.

Electronics

Finding:

- The wedges on two different disks will be assembled and operated with the components (FPHX chips, silicon sensors, etc.) facing each other.

- The HDI is a challenging design with very difficult design rules. The vendor, Dyconex, has produced several "surprises" in the past including de-lamination and via failures. Following the 2009 review recommendations, the FVTX team made several visits to Dyconex in Switzerland and followed their recommendations for mitigating the de-lamination problem. The fix to the de-lamination, using relief holes to allow outflow of trapped gasses, was apparently successful in the latest run of HDIs for the small wedges. The production version of the larger wedge didn't work, and Dyconex has established that the problem was associated with the 70 um laser-drilled vias. To alleviate these via failures, Dyconex recommended larger mechanically drilled vias and this change was reflected in the new design.

- The ROC card has 2x16 fiber optics communication lines with each FEM card. The DAQ system will operate with a total of 24 ROC cards. There is a total of 768 fiber optical links connecting the FEMs to the ROCs. The Serializer/De-Serializer (SERDES) used is the TLK2711, which operates between 1.6-2.7 GBPS. Before the transmission can start, the lock between the transmitter and receiver SERDES has to be established.

- The FEM design is complete and the fabrication of production FEMs has begun. The board uses 16 SERDES chips external to the FPGA.

Comments:

- The FVTX electronics team did a good job of identifying and mitigating risks. They must continue to stay on top of the production and testing of these components.

- Signals from adjacent wedge circuitry can capacitively couple to the strips on the silicon detectors. Since the wedge components on two different disks will be facing each other, there is the possibility that some circuitry will inject signals into the adjacent wedge.

- While the committee has high expectation that the new design of the large wedge HDIs and extension cables will perform correctly, there is a schedule risk if the production is delayed.

- The ROC has a fairly straightforward electrical design but with a complex physical layout, leading to a 22-layer board. LVDS transmission line simulations between the wedges and the FPGA on the ROC are convincing. The transmission distances for these traces are not that great and the frequency not that high. The risk of transmission line problems for this case is therefore fairly low. A netlist check should give high confidence that the layout will perform as expected from the schematic design.

- Three risks are identified in the ROC design: (i) an engineering risk is the possibility that there is an error in the schematic design; (ii) a manufacturing risk is that the pc board vendor cannot deliver the boards on time and with sufficient yield; (iii) a technical risk that there are errors associated with the SERDES transmission. The FVTX team should proceed with the procurement and assembly of prototypes.

- It is common to observe in high speed SERDES links two types of "soft" failures: bit errors or the loss of lock between transmitter and receiver. Frequently, bit errors can be disregarded, but if the lock is lost, the link (or even the system) has to be resynchronized. Given that the number of links is substantial (768), these errors may impact the overall performance of the system.

- The use of a more functional FPGA on the FEM could have eliminated the external SERDES chips. Nonetheless, the prototype FEMs function well and there would be nothing to be gained by revisiting the issue. The production run is in progress and the risk associated with the FEM is low. However, there is the risk that the bit error rate tests of the ROC-FEM communication will reveal problems.

Recommendation:

1. Run bit-error rate tests to establish the performance of the SERDES. Long duration testing of multiple links should be sufficient to establish a bit error rate and rate of loss-of-lock conditions. Before the production quantities of ROCs are ordered, the bit-error rate has to be established.

2. Test as soon as practical whether facing wedges generate electronics interference in each other.

Assembly, Integration, and Infrastructure

Findings:

- All of the necessary small wedges and 20 large wedges have been assembled at SiDet. SiDet has all of the components in hand to assemble the rest of the large wedges, except for the rest of the large HDIs.

- SiDet plans to accelerate the assembly of the large wedges by performing more work in parallel. A second wire-bonding machine is now available to facilitate this.

- Plans were presented for the assembly of the disks and cages. The necessary fixtures have been fabricated. The assembly team has been gaining experience working with the small wedges.

- The plan is for the wedge locations to be measured while the disks are held in the vertical position. The metrology is to be performed by Hexagon Metrology in Rhode Island.

- The first disk has recently arrived. All are expected to be in hand by the end of January. The first cage is expected around the New Year, with the rest to arrive shortly thereafter. Extension cables are expected in February 2011.

- At present, there are four items on or close to the critical path: the large wedge HDIs, the carbon composite Cages, the extension cables, and the ROC boards.

- The current schedule includes 3 weeks of float between the end of the testing period for the disk/cage assembly and the beginning of the installation of the FVTX into the PHENIX IR.

- The FVTX and VTX share a common enclosure. They will also use similar slow controls, interlocks, low-voltage, and cooling systems. The design of these systems is piggy-backing off the VTX efforts. These support systems are scheduled to be fabricated and installed in the coming months.

- The current schedule contains no float between the time when the collaboration will gain access to the IR after Run-11 and the scheduled September 30, 2011 project completion date.

Comments:

- The wedge assembly process appears to be going very well, with an excellent yield of good wedges.

- The addition of a jumper line to the existing large wedges to address the potential issue associated with the HDI calibration line should be considered.

- The sequence of steps during disk assembly appears to be clearly thought out.

- The process of assembling disks into cages involves several mounting and dismounting steps after the wedge locations have been measured. Care will be needed to ensure that no stresses are introduced that could distort those locations.

- The current disk and cage assembly schedule has become very compressed as the necessary parts are becoming available much later than previously anticipated. This has introduced substantial schedule risk into these steps.

- It will be very important that the first disk and cage are subjected to very extensive testing to reveal any system-related issues before subsequent disks/cages are assembled.

- Once the first disk/cage has passed tests and any necessary modifications have been identified, it should be possible to accelerate the assembly process for the remainder.

- By January 2011 the actual, as opposed to “hoped for”, delivery dates for the remainder of the components should be much clearer. In addition, the assembly team should have considerable experience with the small disks, and the first experiences with the VTX in the IR should be known. It would then be valuable to work out a detailed plan for the remainder of the assembly process.

- The plans for integration of the FVTX into PHENIX are benefiting from the experience that is being gained this year with the VTX. This should allow the physical installation to go smoothly.

- There is considerable risk that not all of the FVTX functional requirements will be demonstrated in the IR before the September 30, 2011 project completion date.

- It appears to the review panel that there is a high probability that the FVTX will be ready for RHIC Run-12 (to begin December 2011).

Recommendations:

3. A detailed schedule for the final assembly and testing of the disks and cages should be presented in the next quarterly report. This schedule should include as much compression of the assembly time as practical, in order to maximize the time available for bench testing of full cages before they must be installed in the PHENIX IR.

4. A schedule for installation of the FVTX into the IR, which accounts for any anticipated VTX activities, should be described in the next quarterly report.

Physics Analysis:

Blind analysis of D and B meson distributions

Findings:

- The FVTX group presented an iterative method for deducing the D- and B-meson pt distributions from the measured muon DCA distributions as function of muon momentum. In so doing they completed the GEANT/detector/reconstruction analysis chain well before the start of data taking. The key assumption in the analysis is that the simulated DCA distributions for D and B mesons as well as backgrounds are accurate. The latter assumption was addressed in a separate analysis of background DCAs.

- The analysis method is based on the following: Daughter muons of fixed momentum result from a distributed pt range of parent mesons. Thus, the DCA distribution shape at fixed muon momentum depends on the assumed D and B-meson plus background distributions. The momentum dependent muon DCA distributions, when decomposed into D, B and backgrounds from the blind analysis (or from real data) and when compared to the simulated, or training distributions, suggest changes (pt slope and/or yield changes) in the assumed parent distributions for the training model. The process is repeated until the simulated DCA distributions match that in the blind analysis.

Comments:

- The method seems to be sound but depends on the accuracy of the simulated muon DCA distributions. This issue was addressed in the DCA verification study.

- Comparison of the converged meson pt distributions to the assumed distributions in the blind analysis provides a rigorous test of the method which they have shown works quite well.

Recommendations:
None

Muon DCA distribution verification

Findings:

- The group presented a very brief description of a method of estimating the muon DCA distribution from J/Psi and hadron decays plus punch through hadrons.

Comments:

- The presentation of this analysis in the review was too brief and was unclear. However, all concerns were cleared up in one-on-one discussions.

- The test using muon DCA from J/Psi decay should work well. At the pt of interest the background under the J/Psi peak is small and the muon daughters from J/Psi decays can be accurately identified. The true DCA is 0, hence the actual DCA distributions can be compared unambiguously to the simulated DCA and will provide a rigorous test of their simulations and tracking.

- The group also presented results from hadronic weak decays producing muons which range out in the PHENIX muon ID detector and from hadrons which punch through the magnet steel and range out in the muon ID detector. The analysis indicates a clear separation of these backgrounds on muon momentum enabling specific checks of the simulated DCA distributions for each respective background process against real data. Their presented method provides a clever and rigorous test of the simulation quality of the muon DCA background.

- Overall the FVTX software and physics analysis effort is in very good shape and one can expect that the collaboration will be ready for the offline calibration, alignment and heavy flavor physics analysis tasks in Run-12.

Recommendations:
None

Commissioning Plan:

Findings:

- The FVTX group presented a bulleted list of installation and commissioning tasks to be done between now and the project completion date including a detailed list of personnel for each set of tasks.

Comments:

- Given that much of these tasks will have been done for the barrel VTX, the FVTX will undoubtedly profit from that shared experience.

- The commissioning tasks are as expected but not very detailed. However, the level of detail listed for these tasks is sufficient at this point in the project. The identification of people to do the work is very good.

- The installation and commissioning schedule is the main issue and depends totally on the schedule for the HDIs, ROCs, extension cables and cage assemblies. Any of these deliveries may be further delayed. Much of the installation and testing, e.g. detector timing, performance optimization, hit resolution studies, and the infrastructure installation and testing are planned to occur in parallel. Given the expected very tight schedule to complete the installation and initial testing by 9/30/2011 the group should prepare for accelerated bench tests and commissioning of the assembled cages, so as to optimally match the cage assembly throughput. This may require additional lab test support equipment and manpower. All of this is contingent on the timely delivery of the HDI and ROC items which BNL and the FVTX group will know much more about by January 2011.

Recommendations:

5. A well-documented commissioning plan should be presented by the end 2QFY11

Performance Deliverables:

Findings:

- These were listed in the report section on the Commissioning Plan.

Comments:

- Both the bench tests of cages and the IR tests of the full system should be sufficient to determine if the FVTX achieves the toughest requirements – hit resolution and noise limits. However, the tight schedule may result in insufficient time to conduct thorough cosmic ray data accumulation in order to check hit resolution across all the wedges. Resolution studies in the IR for a subset of wedges in all cages and layers should suffice for the purposes of project completion. Prior to physics analysis, a thorough study of hit resolution should be done as part of the ongoing work during the time between FVTX installation on or about 9/30/11 and the start of Run-12.

- Correlated noise studies are not listed as a performance deliverable but must be studied prior to useful physics data. The FVTX group appears to have the necessary expertise on-hand for such studies starting in Run-12.

Recommendations:
None

Management, Cost and Schedule

Findings:

- The project is about 10 months away from the expected completion date. Because of unexpected problems in the production of the High Density Interconnects (HDI) and the design of the Readout Card (ROC) the schedule float has been reduced to about three weeks. A schedule with a completion date of September 30, 2011 was shown by the project manager. Options that would increase the schedule float by up to two months were presented. These include parallel assembly of disks and potentially earlier delivery of the first large wedges. Items on the critical path include wedge assembly, the extension cables, the cages, and the readout card.

- The sum of $4376k of the management cost plan has been committed to date. The remaining cost to complete is $523k with $101k of contingency (19%). A cost increase dominated by an increase of $506k for the production of the large high density interconnects and an increase of the N.R.E. for the extension cables resulted in the reduction of the project's contingency. More than half of the remaining cost to complete is earmarked for the production of the readout cards.

Comments:

- The project is well managed and organized in sub-tasks led by competent and experienced individuals.

- The management is to be commended for taking steps to reduce the impact of the cost increases and the resulting reduction in contingency.

- Substantial cost risk remains in the production of the readout cards.

- The schedule to complete the project is “success oriented” and quite aggressive.

- The option to generate additional schedule float by the parallel assembly of the disks seems reasonable but careful planning is needed for its implementation.

Recommendations:

- See the recommendation in the **Assembly, Integration and Infrastructure** section of this report.