Introduction

A formal review of the STAR Silicon Vertex Tracker (SVT) mechanical components was held at BNL on March 5, 1998. Presentations were made by the SVT team on the design, analysis, testing, assembly, integration, installation and schedule. The committee, composed of individuals with relevant experience and interest in the SVT's interfaces, discussed and evaluated the information presented during the morning of the 6th and then held a close-out meeting to present their findings and recommendations later that day.

The charge to the committee was to review all aspects of SVT mechanical engineering, from the carriers and Beryllium parts through the water and air cooling systems. This was done in order to understand the inter-relationships of the parts; however, the primary goal of the SVT team was to get approval to procure the Beryllium detector carrier and electronics carrier components as these parts are needed before the long assembly process can begin. The other components, assembly tooling, water manifolds, cooling systems, etc. will require a final review at a later date.

The review agenda, presentation materials and action items can be found in the SVT Carrier Final Design Review (FDR) binder located in the STAR Project office. Many comments and issues are presented in some detail in the action items; thus, these should be considered to be an appendix to this report.

Tooling and Assembly

The tooling and assembly plans of the SVT have progressed well.

1. The precision of the Nikon VMS and the Cordax CMM are adequate for the assembly of the SVT.
2. Successful assembly of the System Test prototype has demonstrated the use of fixtures and reference pins to make up for the limited working volume of the Nikon unit.
3. While the SVT group has indicated a desire to improve the specialized tooling for wafer and hybrid bonding (to increase the speed of this operation) the current techniques and tooling have been used successfully. The committee supports the continued improvement of these processes.
4. Further empirical tests are needed to determine the optimum wire diameter and length/loop-height for wire bonding.
5. Fixturing to assure the safe handling and controlled bending of the detector carrier/hybrid mount hinge needs to be developed.
6. The tooling for the assembly of ladders exists as a concept only. The process appears reasonable and consistent with determining part location to the stated 20 micron precision.
7. Given the micron level measurement precision requirements, temperature of the parts and CMM must be maintained within some bounds that should be predetermined and incorporated into the assembly procedures.
8. The rigidity of the ladder assembly fixture must be sufficient to assure that the fixture does not distort the ladders during the assembly process.

SVT System Test

The committee recognizes the importance of the System Test. The first stage ladder test, currently underway, will be used for thermal measurements. Later stages will be used to test wire bond flexing.

The committee agrees with the SVT group that thermal measurements should be performed on the detectors and hybrids in the ladder test prior to releasing the purchase order for the Beryllium detector and the electronics carriers. While thermal analysis predicts that cooling should be adequate with the present design, ladder test measurements will confirm the modeling and the design. Direct measurements of hybrid temperatures are possible but thermal gradients on the detectors themselves can only be measured by observing drift behavior of the detectors.

The existing ladder configuration does not allow testing at full voltage or power, but the test conditions - air and water temperature - can be modified to allow a good test of the predictions. Using reduced air flow to give heating comparable to the final configuration will allow validation of the thermal modeling.

Structural analysis of wire bond flexing between the detector and electronics carriers appears to be impractical. Further experimentation will be needed to determine the loop height and other bonding parameters. The ladder assembly, currently being tested, is not suitable for a final test of the bonding; a demonstration using a full length carrier should be performed. This test need not take place prior to the fabrication of the carriers.

Design Details

Most of the assembly drawings reviewed by the committee were conceptual. It is the committee's feeling that many of these drawings are the basis for sub-assemblies and top assembly drawings. It is therefore recommended that:

1. An overall subsystem drawing number tree be designed and incorporated to control both detail and assembly drawings.

2. Numeric revision numbers be used to minimize confusion in the concept design stage until final drawings are released.

3. It is strongly recommended that all drawings be independently checked by a design checker for form, fit, and function prior to the release of drawings for fabrication and/or procurement. The time spent now could eliminate time and money loss later due to rework.

4. It is required that all references to Associated Universities Incorporated (AUI) be removed from all drawings and documentation.

Engineering Analyses and Test

Recommendations:

1. The use of thin brick elements in ANSYS FEA code should be avoided. Multi-layer shell elements might be a better choice for modeling the carrier assembly.

2. The results of the deflection, stress, and safety factors as well as the presented analyses were for individual load conditions. It is recommended that an all-encompassing analysis be performed that incorporates all loads on the system at its worst case so that a true factor of safety can be established. These load cases should include pre-stress on wafers from the straightening of ladder assemblies due to worst case fabrication tolerances, gravitational loads, thermal loads, installation loads, and seismic events.

Requirements:

1. Analysis is required of the screw connections and their specified torque to insure that ladder positioning requirements within the SVT assembly is maintained throughout the operational lifetime.

2. A modal and seismic analysis is required of the entire subsystem assembly to determine the risk of subsystem failure and its impact on surrounding subsystems. This analysis should include the cone assembly with and without the SVT installed.

Installation

All the presented installation plans are in the concept stage; it is recommended that the SVT group continue their effort to define, refine, and design the systems and procedures required for the successful installation of the SVT into the STAR Detector.

The committee recognizes that the cone assembly is an essential element to the operation of the baseline STAR Detector. Due to space constraints, the cone assembly can only be installed in the Assembly Building, therefore, it is essential that the cone assembly be installed in the detector prior to day one operations. This should minimize the impact on future shutdown operations for installation of the SVT into the STAR Detector when located in the Wide Angle Hall.

The committee agrees with the SVT Group that their highest priorities are the design of installation tooling, and the installation procedures needed to insert the cone assembly into the STAR Detector by 12/98. The installation plan and tooling design will require a Final Design Review by STAR management.

Installation plans and procedures to place the SVT assembly and related utilities into the STAR Detector need to be developed. The latching mechanism needed to lock both halves of the SVT ladder assemblies around the beam pipe is yet to be designed. An understanding of how the two SVT mounting plates on the cone assembly are aligned at beam height in the Wide Angle Hall so as not to transfer loads into the SVT requires further study. These installation plans will also require a Final Design Review by STAR management.

Construction Status & Schedule

A milestone-based, resource-loaded project schedule has been developed and is being implemented. Per Bill Leonhardt, there is a three month period of time in which two individuals (Leonhardt & Soja) are over-allocated (125%). However, Bill is not overly concerned with this allocation. It was reported that project funding exists to support the SVT Mechanical Project schedule and there is some “slop” in the schedule. However, during the review the contingency in the schedule was not able to be quantified.

Concerns were raised by the committee, regarding the fabrication schedule and the availability of material, specifically Beryllium. The SVT group has contacted Beryllium vendors/manufactures and reported that the quantities required are readily available. The manufacturing process is relatively easy and quick. What will take the longest is fitting the SVT components into the vendor/manufacturers schedules. However, this also has been considered and is accounted for in the project schedule. Additionally, the SVT group is looking into a fabrication and delivery schedule that supports phased delivery. Assembly of components at BNL does not require all parts to be delivered simultaneously. A schedule and plan is being developed which includes phased shipments and will support assembly requirements.

As mentioned elsewhere in this review report, there are some items that may have impact on the project schedule: a) additional analysis needs to be performed, b) there are key interfaces that are still in the conceptual design phase and c) drawings remain to be checked. Incorporation of the time required to perform these tasks needs to be rolled into the schedule.

Finally there are two components that are considered to be key to the STAR baseline schedule: the SVT support cones and beam pipe supports. These two components have fixed delivery and installation requirements. Therefore it is recommended that the SVT group interface with STAR Project Management and the Installation & Test Manager in tracking delivery and installation requirements.

Safety

Open items addressing ES&H concerns have been identified during the review. (See action items in appendix.) There are additional items that we would like to bring to the attention of the SVT group that will aid in the ES&H process.

1. Activities being performed in the Physics building are to comply with Physics Department standards and requirements.

2. When working with Beryllium in the SVT laboratory you are required to comply with ES&H standards as defined by the Physics Department and in Lab manuals.

3. RHIC management requires that all RHIC personnel be trained in the task they will be performing. Therefore, we are requesting that the SVT Activity Manager provide the following information to the STAR Safety Coordinator: a) a description of the activities that are and/or will be performed in the SVT Laboratory, b) identify who will be performing the activities, c) training that individuals already have or will be receiving and d) a list, by individual, of training required that is to be revised as training requirements become satisfied. This information should be provided as soon as possible.

4. During the review various monitoring and interlocks were discussed. A document needs to be developed that will contain information regarding set-points and safety margins. Additionally, the SVT monitoring and interlock requirements will have to be integrated into the overall STAR interlocks program.

5. RHIC Experimental Safety Committee will be issuing minutes from the review of the SVT Mechanical Systems Review. The ESC will require resolution of the open items identified in the STAR Mechanical Review as well as a formal review of the SVT Installation Plan.

6. Procedures (installation, operation and maintenance) will need to be developed and submitted to the ESC for review and approval.

7. When activities are performed in building 1006 or any other RHIC controlled facility they must be performed in accordance with RHIC guidelines.