Summary of FVTX HDI Design review, October 23, 2009

Reviewers: Cheng-Yi, John Haggerty, Mike Leitch, Eric Mannel, and Atsushi Taketani

A single presentation was made by Doug Fields on behalf of the FVTX group summarizing the overall design of the HDI, testing of the prototype HDI and design changes that have been made since the design and fabrication of the prototype HDI.

The overall design has remained stable for some time. Prior to the first prototype production the following changes were made to the baseline design: In order to maintain the line impedance the thickness of the kapton layers was reduced, reducing the overall thickness of the HDI. The effect on the radiation thickness however is minimal since the radiation thickness is dominated by the copper layers. It was however necessary to increase the diameter of some of the vias and the corresponding pad sizes for manufacturing reasons. It was pointed out that the overall design was pushing the limits of the technology, but was still within the capabilities of the vendor Dyconix.

The results of testing the HDI in conjunction with sensors and FPHX chips was shown to demonstrate that the HDI does not have a negative impact on the performance of the detector. Plots shown included results of calibration runs with 15 chips mounted on an HDI, observation of signals from a Sr-90 source, and measurements of the high speed (200 MHz) clock signals, along with a simulation of the clock signal at both the connector and last FPHX chip on the serial clock bus.

There was also a discussion of the bending procedure for the HDI, however no slides were presented on the procedure. The current method is to use a metal clamping fixture with the required bend radius on the HDI at the bend point and then heat the HDI with a heat gun while bending the HDI. After bending and cooling, the HDI maintains the bend shape, but the resulting bend radius is slightly larger then the desired radius. It is felt that the larger bend radius will not be an issue in the final assembly of the detector and that the overall detector design can accommodate the resulting bend radius.

The presentation then shifted to issues with the prototype HDI and design changes. The major issue with the prototype was that during the re-flow process to mount the surface mount components, out gassing from the kapton caused bubbles to form in the HDI and resulted in de-lamination of the layers. To prevent this from occurring, the vendor drilled holes through the HDI at locations that did not have traces, however, the drilled holes did pass through the solid ground and power layers, with no clearance of copper from the hole edge. This resulted in allowing only one prototype kapton HDI to have a sensor mounted on it due to shorts between the bias power and ground. In order to prevent the out gassing and de-lamination problems, the design has been modified to include holes in the HDI with clearance around them on the copper and power ground planes to prevent shorting between layers. Other proposed changes included minor mechanical changes to the HDI to accommodate the overall mechanical design, correction of the FPHX pin out, hanging the FPHX chip id assignment, and using a different connector for the bias power connection. The design of the corresponding small wedge HDI has also been completed.

A brief summary of the QA plans were presented which calls for the vendor to do electrical testing on the HDI (testing for continuity and shorts) before component placement, visual inspection and testing at UNM by FVTX technicians and students.

The schedule for the procurement of the production HDIs was discussed and the desire is to place an order for the full quantity of large and small HDIs with first article delivery followed by the full production upon acceptance of the first articles. This is to allow for the start of assembly in early 2010 when the production sensors and FPHX readout chips will be available.

The review then moved to discussion by the reviewers and concerns over different aspects of the design. The main issues that were discussed included the bending of the HDI, the out gassing and de-lamination Q/A procedures and the overall schedule.

For the bending of the HDI, it was pointed out that the heat gun technique is not totally reproducible for applying heat and that a method of heating the HDI in a controlled and reproducible manner should be developed. It was also discussed that the bend tests were done on HDIs with out sensors and there is concern that the bending process may transfer stress and/or heat to the sensor and result in failure of wire bonds to the sensor or FPHX chips near the bend. Since the bending was done on a non-functional HDI, no testing of a bent HDI has yet been done, which was of some concern to the reviewers. It was also noted that there has not yet been any extensive thermal cycling of the HDI. While it is not thought that an increase in the HDI temperature of 20 to 30 degree C would cause the HDI to relax back to an unbent shape or place additional stress on the sensor, it should be verified. So the recommendation is that the bend process should be reviewed to include a controlled application of heat during the process, that thermal cycling tests should be performed on a bent HDIs and a functional HDI should be bent and tested to make sure that there are no negative effects as a result of the bend procedure.

The out gassing and de-lamination of the HDI was also a topic of discussion and concern by the reviewers. It was not clear that the issue was fully understood and if the modified design would actually solve the problem. As pointed out by Atsushi Taketani, the out gassing problem is not a new problem and the vendor should have been aware of it. One solution that the VTX pixel project used was to bake the pixel bus, which has a similar construction, before surface mount components are attached. It also requires that HDI be properly stored after baking to prevent re-absorption of water after the baking process. It is recommended that other groups such as ATLAS, CMS, DO and CDF be contacted to see if they experienced similar problems and what steps they took to resolve the problems.

There was some concerns that the Q/A procedures presented were sufficient to insure a high yield of functional HDIs after assembly with FPHX readout chips and sensor. Detailed procedures need to be written up to make sure that HDI is fully functional before assembly of the readout chips and sensors. The FVTX group should consider all possible problems that might arise and tests that can be done to identify them at an early stage.

The desire by the FVTX group to go into production of first article HDIs at this point is of great concern to the reviewers. There has been one round of prototyping and only one of the prototypes was fully functional. While many of the layout changes appear to be minor, they have not been tested and verified. Furthermore, no prototyping of the small HDI has been done at this point. As presented, the actual design files are relatively new, some being finalized the day of the review. There also has not been a true system chain test. The tests done used cables, interface boards and a readout card designed for the iFVTX detector and not the actual interconnect cable and FVXT readout card. While it was argued that any issues that might arise from going to the actual interconnect cable and read out card would not change the current HDI design, it is hard to verify.

The overall time schedule for delivery was also currently unclear. In addition it is not possible to estimate production yields based on the HDI prototype tests done to date. Further discussions with the vendor are needed to understand what the full delivery schedule is, when HDIs would be available for testing and what the costs estimates would be for different delivery schedules would be. The review committee believes that it would be hard to justify to an outside review committee that the HDI as presented at this review is ready for first article production. It is the recommendation of the reviewers that the FVTX group should look into the delivery of a small number of preproduction HDIs, both large and, small, with a quick delivery, along with a first prototype of the interconnect cable. If the preproduction HDIs perform satisfactorily, they can be considered first article and full production can proceed.

In summary the reviewers make the following recommendations to the FVTX group. Prior to starting the production of the FVTX HDIs FVTX group should:

1. Develop and document a bending procedure that uses a well defined and reproducible heating mechanism that .does not depend on a heat gun and verify that it can be successfully done on a fully assembled HDI with out damaging it.
2. Perform and document electrical testing on bent HDIs.
3. Perform and document thermal cycle testing on bent HDIs.
4. Discuss with other groups that have developed flex circuits the out gassing and de-lamination problems observed and what methods were used to resolve any problems encountered.
5. Discuss with the vendor, Dyconix, realistic production and delivery schedules for both the large and small HDIs and what the cost implications are.
6. Proceed with a rapid turn around production of a limited number of HDIs (large and small).
7. Proceed with a rapid turn around production of a limited number of interconnects that are as close as possible to the maximum length interconnects expected for the final detector.
8. Use the the next round of prototype HDIs and Interconnect cables to determine the expected yield for the full production.
9. Perform and document a system chain test using as many of the preproduction components as are available including the long version of the interconnect cable.

The committee also recommends that the FVTX group develop and document the Q/A procedures that will be used to certify the acceptance of the production HDIs. Start of production is not contingent on the procedures being fully developed, but they should be in place by the time the first articles are expected to arrive.