U.S. ATLAS PIXEL INTERNAL REVIEW
11-12 MARCH 1999

Review Committee: Jim Brau(Oregon), Gunther Haller(SLAC), Steve Kane(U.S. ATLAS), Larry Premisler(Chair: U.S. ATLAS), Knut Skarpaas(SLAC), and Ray Yarema(Fermilab)
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The Review Committee wants to congratulate the Pixel team for the hard work put into preparing the design review data package, and the excellent and comprehensive presentations. The Review Committee was very impressed by the amount of very good technical work that has been completed to date. It is obvious that the people involved in the mechanics and electronics design have a good understanding of the requirements for the Pixel System, and have a reasonable plan for completing the design.

General Comments

1. All changes to the goals that appear in the project management plan must be accompanied by baseline change proposals.
2. It is difficult for reviewers to follow progress without clearly identified specifications and/or goals.
3. There is a lot of critical work scheduled to be completed in September 1999. It may not be possible to determine project readiness for a summer 2000 baseline review until September. A slip in completion of those critical milestones should have a corresponding slip in the baseline review.

Electronics

The U.S.ATLAS pixel group has made significant progress on electronics. It is believed that they are on the right track in several areas:

1. By combining the chip design efforts at CPPM, Bonn, and LBNL, all teams can share ownership of the final design
2. The two vendor choices are reasonable at this time but cannot continue indefinitely. If one vendor is found that meets the basic chip requirements, that vendor may need to be chosen due to schedule requirements.
3. It is appropriate to work on the DMILL submission first since there is more experience with DMILL than HSOI.
4. It is appropriate to isolate each module as much as possible with separate power supplies and optical fibers.
5. The removable B-layer is necessary despite the increased complexity associated with it, due to the high radiation levels close to the beam pipe.

There are, however, several weak points in the pixel design effort.

1. The Honeywell SOI design effort is based on single transistor measurements and the HEP community has little experience with the HSOI process.
2. There is only time for one DMILL and HSOI submission before baselining. A great deal of checking must be done to insure success.
3. Consideration should be given to the impact of single event upset (SEU). A detailed schematic of the minimum size flip-flop should be given to Honeywell to review SEU susceptibility.
4. Corner models for the HSOI do not exist. This makes the performance difficult to predict.
5. Long power supply leads to the modules may cause chip or performance failures due to spikes and transients.
6. The division of the design work between CPPM, Bonn, and LBNL appears reasonable (i.e. CPPM- frontend, LBNL- digital, Bonn- integration coordination). However the separation of design activities has its problems. A complete chip simulation is highly recommended.
7. The baseline review in May 2000 is expected to be based on well-tested and understood rad hard chip designs from both DMILL and HSOI. The schedule for baselining is success oriented. No room is left for an extra DMILL run or, in particular, another HSOI run if there is a design or foundry problem. Efforts to develop a 100 Mrad chip solution should not interfere with development of a 25 Mrad solution until a removable B-layer is well in hand.

Hybrids

The decision to use flexhybrids seems the right choice for the module hybridization. The density and feature sizes used are conservative when compared to other flexhybrids produced for other projects. However:

1. All materials must be qualified for the radiation environment.
2. A thermal analysis is needed.
3. Revise hybrid schedule to show milestones for all prototype iterations.

Module

1. The pixel group must work with manufacturers to develop a bump bonding process that is more reliable and producible.

RODs

1. The decision between DSP and FPGA based readout drivers is overdue and should not be delayed any longer.

Sensors

The work on sensor development is well along and in good shape. A good understanding of sensor properties and evolution with radiation has been developed.

1. We would recommend that the collaboration explore some mechanism to certify each batch of sensors to radiation hardness, either by developing a test structure on each so that each batch can be radiation tested, or by using sample detectors from each batch.

MECHANICS

OVERVIEW

Some mechanics issues require resolution at a higher level and need coordination with groups outside of the Pixel System.

The timing for the Review is appropriate. It is early enough that the Committee recommendations may be pursued without adverse impact to project cost or schedule, as long as the recommendations are considered now. These recommendations are intended to address weaknesses in the current design and current development program, as well as identify issues that are not yet addressed by the Pixel project effort.

ATLAS LEVEL ISSUES

1. The ATLAS Project Engineer must define guidelines for acceptable resonant frequencies.
2. The Pixel Project Engineer responsibilities are being transferred and this may impact the schedule. CAD integration is important and must be continued.
3. The ATLAS Inner Detector needs Configuration Control. There is significant potential for interference and incompatibility between the various components of the Inner Detector.
4. A decision must be made soon regarding the cooling system fluid. The different cooling systems may have an effect on the vibrations transmitted through the cooling lines, and the different fluids may present compatibility issues with Pixel components.

PIXEL DESIGN ISSUES

1. There is a need to define thermal barrier requirements for the Pixel detector. This may be an ATLAS issue. The current design is anticipating the use of heater strips to prevent condensation. This will drive up the power consumption for the overall detector.
2. The electrical design currently has no margin for an increase in power requirements. This is not advisable this early in the design effort.
3. There did not seem to be any extra cooling capacity in the Pixel thermal management system.

4. The Committee views the sector cooling tube joint as a concern. There is a risk to the Pixel project schedule and the sector design development if the proposed tubing joint prototype is not successful.

5. Final design for B-Layer depends upon finalization of bake-out jacket design, beam pipe support design and vacuum system design. To this end, the B-layer design requires close coordination with beam tube and bake-out jacket design. The NEG changes discussed in the Review (moving NEG inboard) is viewed as good for B-layer design.

6. ATLAS must define the B-layer installation method (insertion tool versus rails) now. This has a significant impact on B-Layer and Inner Detector design and is viewed as the very next step to be resolved before B-Layer and adjacent systems mechanical design may continue. Several systems may need modification if the rail option is adopted. The insertion tool may need to be developed further.

7. B-layer cable routing must be developed by ATLAS before more of the Pixel System mechanics can be designed, and must be done in conjunction with the installation and beam tube vacuum development. It may be very difficult to have cables connected to each end if the barrel is removable.

8. During the Review it was stated that the alignment tolerance is 25 – 50 μm, but this was not critical because Pixel systems can rely upon x-ray for alignment calibration. However, the viability of the x-ray alignment is not well known for Pixels.

9. The Committee recommends the Pixel Project evaluate the repeatability of distortion on sectors under temperature cycling (hysterisis).

10. The global support progress is encouraging. The decision to go to a flat panel configuration as opposed to a truss structure should save both time and construction costs. A continued concern is the effect of services (which include both cables and cooling tubes) on the mechanical stability of the system. A strain relief system must be well thought out to avoid putting oblique forces on this precision structure.

11. ATLAS needs to be determining whether the flat side of the omega section will warp and potentially contribute to the dimensional instability.

12. The interconnect flex hybrid should be connected to the silicon with a flexible adhesive to avoid distortion. The CTEs for Kapton and silicon differ substantially. There is a potential for distortion of the silicon if a rigid adhesive is used. This should be evaluated.

13. There is a lot of work done on 3-D modeling for the Pixel System. This is a good approach, and permits some early evaluation of interference. However, mock-ups also should be constructed to ensure all potential interference is identified.

14. The current disk design uses a continuous disk. These disks are captive on a welded beam tube. Since the pipe must be installed after the detector is in place, detector delays could affect the beam-commissioning schedule. Disk repair also requires beam line cutting. The consequences of a captive disk system should be fully recognized before the disk and beam pipe designs are finalized.

PIXEL PROGRAMMATIC ISSUES

1. Final Design Reviews must be conducted before the PRR. In addition the design must be finalized before the PRR.
2. This Review indicated the stave and cooling tube back-up designs would be pursued right up to the PRR. We need to make the decision before the PRR. The purpose of the PRR is not a design blessing, but a determination of readiness to proceed to production (design is complete, drawings completed, validation testing is completed, QA program in place, etc.). If the design cannot be finalized in time for the PRR, then perhaps we need to recommend later dates for the CERN PRRs.
3. Schedules need refinement; for example, the test of the second prototype occurs only three weeks after the second prototype design review. Design reviews must be scheduled so their findings may influence the design they are reviewing; e.g. the second prototype design review should be scheduled sufficiently in advance of commencement of second prototype fabrication so issues and conclusions may be addressed in the second prototype.