Harvard University
High Energy Physics Lab
27 January 2003 – Review

Updated : 13 Feb. 2003
Review follow-up issues
Appendix A (General comments)
Appendix B (Radiation tolerance)

Presenter : Kevan Hashemi

Reviewers: Eric Hazen, Paul O'Connor, John Oliver

The reviewers would like to thank Kevan Hashemi for a well-documented and thorough presentation of the function and operation of the alignment instruments and their electronics. The readout electronics, referred to as LWDAQ, is a well thought out and efficient strategy for operating the light sources, temperature sensors, and CCDs in the system. The many existing prototypes have been shown to operate with accuracy suitable for its intended operation. Further, the system is robust in the sense of being immune to failure due to programming error, operator "hot-plugging", and single-point failure. Redundant components allow for gradual system degradation from radiation effects.

Power management was well thought out, resulting in an efficient low power system. Many failure modes of components and connectors were adequately analyzed and tested. The use of LVDS for long distance signaling was strictly adhered to for reasons of low EMI emission to other parts of the detector.

A unique feature of the design is the use of single differential twisted pairs for analog and digital communication using a custom pulse-width discriminated protocol. This protocol has been tested with cable lengths greater than 100meters. Careful attention has been paid to details of the required cabling, both with regard to signal integrity and careful cable assembly procedures. The use of this custom protocol, as opposed to a commercially supported field bus, was adequately addressed and justified on the basis of simplicity and cost.

Recommendation #1

Command bits are decoded in the BCAMs using commercial one-shots without external timing capacitors. To be error free, the pulse width of the one-shot must lie between the ‘0’ and ‘1’ defined widths with adequate margin. The reviewers expressed some concerns over the distribution of this timing with off-the-shelf one shots, and for their stability due to aging and radiation dose.

Specifically, we recommend that the possibility of a QA procedure to measure this margin be investigated with the objective of replacing one-shots which operate too close to one of the timing thresholds. A second recommendation is to look into the possibility of firmware features which might allow for adjustments to the timing from the Driver, should the one-shots drift over time or radiation.

Recommendation #2

Low on-resistance MOSFETs are used extensively in the system to power down the remote components, such as laser drivers. The NDS355AN n-channel MOSFET was chosen for its low on-resistance, which is expected to rise with radiation dose. This effect is likely small for a component whose threshold voltage is “typical” for the part, but much larger if the threshold voltage is at the maximum spec of 2.4 volts. In combination with tolerance of the 3.3V regulators, the voltage-over-threshold of this component may become small, resulting in higher than spec on-resistance.

We recommend that a test for Rds(on) be performed on a sample of irradiated and non-irradiated BCAM main head circuit boards. If indicated by the sample test, an Rds(on) screen should be considered as part of the quality assurance (QA) of the laser driver, and other circuits where this might be a problem. This might be accomplished by a simple voltmeter or oscilloscope measurement during test procedure.

Recommendation #3 : BCAM grounding

The laser driver boards are placed in the BCAM with the physical laser diode package inserted into a mating hole drilled into the aluminum BCAM housing. The laser diode package (can) is at the positive power supply of the board, +15 volts, while the housing is at an undefined potential. The anodic oxide on the BCAM housing provides isolation between these two. The fit between the can and housing is described as tight, but not press-fit. Although never observed, an oxide fault could, in principle, bring the BCAM housing up to the laser driver power supply rail. The designers regard the anodic oxide as sufficiently reliable to prevent this possibility.

It appears that the tight fit between the laser diode and the BCAM housing is not an essential feature of the design. We recommend that a minor mechanical adjustment be considered, to assure that laser diode is insulated from the housing without relying on the oxide. This might be done, for example, with larger clearance hole combined with a plastic sleeve on the diode or other simple means. We further recommend that a clear definition of the BCAM housing potential be assured. This might be done, for example, by removing or breaking the oxide from the mounting holes of the BCAM housing, so that contact with the structure on which it is mounted be assured. Alternatively, the BCAM housing might be defined at either the ground return potential of its electronics board or the potential of the cable shield, in which case the isolation of the housing from the mounting structure should be assured without the reliance on the anodic oxide.

Muon End Cap Alignment Electronics Technical and Production Readiness Reviews

Technical Review Summary

- The LWDAQ system is well engineered, well executed, and functions up to its design specification. We consider that the three technical points above can be easily addressed by the designers and should not impact the schedule significantly.
- After review by the designers, these points should be revisited by the committee in a phone meeting before final sign-off.

Production plan

Most of the components for the Alignment electronics system are readily available, multiply sourced commercial parts. For the majority of the production the Brandeis group intends to procure components and bare PCBs, then assemble the component printed circuit boards in the normal manner; using commercial assembly houses employing machine assembly and solder reflow ovens. In order to supply instrumentation for immediate needs in test beams, early chamber production, and DAQ development, they intend to supplement commercial production with in-house hand soldered assembly. The boards in question contain no very fine pitch packages or difficult to solder components, and the reviewers agree that the hand soldered units are of standards at least as high as commercial assemblies. Over all, the production plan is sound.

QA/QC

The hierarchical nature of the system makes it natural to use known working units to test other units in the system. Thus, a Driver and multiplexer, with suitable software, can be used to production test BCAMs, temp sensors, and so forth. The Brandeis group has adopted this approach to component testing. We agree that this is a sound and workable approach.

The issue of component burn-in was discussed at the review. The Brandeis group has expressed its willingness to implement burn-in procedures, but at the present time, there appears to be no ATLAS wide policy in this regard. Thus, no firm conclusion was made on this issue.

Radiation tolerance

1. Radiation test limits: Simulated radiation levels (SRL) in the worst location are 10 krad TID and 10^{12} 1 MeV-equivalent neutrons/cm^2. Safety factor chosen (10x SRL) exceeds ATLAS Radiation Hardness Assurance Policy, provided that a single lot of each component type is used and accelerated-temperature aging tests are performed. Every effort should be made to procure components in single lots. A representative sample of each component lot should be tested. Quantity of units tested: Radiation tests should include a minimum of 10 components of each type to measure the effects of component variability.3. Board test vs. individual component test: Brandeis group has planned irradiation campaigns with fully-populated circuit boards. This is acceptable, but post-irradiation tests should exercise all functions of the board (including power-down and all operating modes) and verify operation with margin. 4. Test status of each component type

TC255P CCD

TID: test only performed to 60krad

NIEL: dark current increase at 10^{12} n/cm^2 can be accommodated by imposing an upper limit on exposure duration.

IR LED

TID: test only performed to 40krad

NIEL: loss of 90% output is acceptable if exposure duration can be extended (note: this sets a lower limit on the post-rad exposure duration).

LASER

TID: test ok to 100krad

NIEL: not tested for this part (extrapolating results from similar parts is not a substitute for qualifying this laser diode.)

MOSFET

TID: test ok to 100krad but on-state resistance not measured

NIEL: irradiated but not tested (should be tested before procurement)

VHC Logic

TID: 40krad test showed damage (recovered with room-temp annealing -- NIKHEF report). Test should be done to 100krad on each VHC component type. Sufficient quantity of each part type should be tested.

NIEL: ok (but was each part type tested?)

LVDS180 Tx/Rx

TID: 100krad ok. If both LVDS and LVDM parts are used both should be tested.

NIEL: irradiated but not tested (should be tested before procurement)

MAX6329 Regulator

TID: 20krad Vout=3.5V (seems risky at 100krad. Endorse plan to replace in in-plane sensor heads)

NIEL: irradiated but not tested (should be tested before procurement)

INA155 Instrumentation Amp

Untested (test or design out)

Summary of radiation test status: TID tests considered incomplete on CCD, IR LED, VHC logic, MAX9329 regulator, INA155 amp. NIEL tests considered incomplete on Laser, MOSFET, VHC logic, LVDS Tx/Rx, MAX6329, INA155.

PRR Summary

After successful review of the technical points in the Technical Design Section, production of the Muon Alignment Electronic components should proceed.

Appendix A : General comments on Recommendations
Review follow-up
13 Feb. 2003

Recommendation #1

The Brandeis group indicated that it had examined samples of one shots from multiple vendors and multiple lots and found none to be out of timing spec by more than a few percent. It was concluded, however, that no sampled screening of these parts can be relied upon to locate out-of-spec parts in the outer tails of their tolerance distribution. The Brandeis group intends, therefore, to do 100% testing at the assembled board level, to locate and replace (or adjust by resistor change) out-of-spec one shots whose timing deviation might be responsible for long term reliability problems. *The review committee considers this to be a completely acceptable solution.*

Recommendation #2

Kevan has done a worst case analysis of threshold voltages and radiation induced shifts in the circuits containing these mosfets. His conclusion is that in some cases, replacing nfets by npn bipolar transistors will insure proper operation after radiation damage. In other cases, the mosfets will be individually tested for threshold voltage prior to assembly. *The committee agrees that the combination of these two approaches will insure long term reliability.*

Recommendation #3

The Brandeis group maintains that the combination of anodic aluminum oxide and epoxy is sufficient to insure isolation between the BCAM body, and the laser diode package. At the committees recommendation, the Brandeis group intends to do 100% testing of this isolation with an ohmmeter. In addition, they will insure that the potential of the BCAM body is maintained at the ground potential of the structure on which it is mounted, by masking the mounting holes before anodization. Mounting screws will then provide the necessary connection. *The committee is satisfied with this isolation/grounding approach*.

“Super Multiplexing”

The idea of adding an additional layer of multiplexing to the LWDAQ, was suggested at the general Alignment PRR held at Brandeis in January. This issue was revisited in the electronics review and both the Committee and the Brandeis group agree that, in principle, the system can accommodate an additional level of multiplexing. The Brandeis group is opposed to implementing this for several reasons. They point out that the alignment cable plant is only 7% of the total Muon cable plant so that the cable savings is not significant. They also point out that a catastrophic failure of a “Super-Multiplexer” module would bring down a significant portion of the system. This would be in violation of their principle of “graceful degradation” due to failed components. And finally, they point to the cost and schedule impact. Given the required redesign of the LWDAQ Driver and new design of the SuperMux, they estimate the cost and schedule impact to be $100k and 1 year.

The Committee feels that the argument in favor of multiplexing is not compelling and that the cost and schedule impact would be non-negligible. Therefore, any decision to implement such a scheme must come from the Muon community in general.

Appendix B : Radiation Tolerance
Review follow-up
13 Feb. 2003

The Brandeis group is following a science-based radiation qualification procedure, which differs in some details from the official ATLAS Radiation Tolerance Assurance policy. While there were no radiation effects specialists on the review committee, we feel that a sufficient attention to radiation levels and potential adverse effects on the electronics has been followed in most cases.

The production of some components has already been completed, and further production of some additional components must begin very soon to meet the schedule for the assembly of alignment bars. The committee feels that it is acceptable to continue with production inasmuch as it is essential to meet scheduling needs, but that the radiation test campaign must be completed as soon as possible. All assemblies which are produced using non-qualified batches of components should be identified unambiguously, and installed in low-radiation locations of the detector.

The committee recommends that a follow-up meeting be held in one year to review the status of the radiation qualification program for the alignment electronics.

Outstanding deviations from policy (other than those noted in the main report):

- Some parts have not been tested. A list is included in the primary report. In addition, it appears that none of the VHC logic components was tested; the NIKHEF report details testing of another logic family. The committee feels that the results of tests of “similar” components are not an acceptable substitute for tests of the *actual* components used. Specifically, the specific part number of laser used should be tested, and each type of VHC logic component should be tested.
- Some components were not powered during TID testing. Since static electric fields are known to significantly effect the rate of ionizing radiation damage in some devices, the committee feels that it is important that the DC operating conditions during irradiation be representative of the actual conditions during ATLAS running. All components should be biased during TID tests.

Finally, the committee would like a complete list of active components used in all assemblies which are to be mounted in radiation areas, with details of the radiation test status of each component. Individual members of a common logic family should be listed separately. This list should include (for NIEL and TID tests):

- Part number
- Number of components tested
- Bias conditions during test
- Post-test results (brief)
- Details of high-temperature annealing (if any) and test results after annealing.

The list should be used as a basis (updated appropriately) for the one-year follow-up review of the radiation test status.