Report of the L1 Cal Technical Readiness Review Committee

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Introduction

The DØ L1 Calorimeter trigger technical readiness review was held at Fermilab on Friday and Saturday August 26-27, 2005. The primary focus of this review was to assess the technical readiness of the hardware and software tools for the installation of the L1 Calorimeter trigger upgrade and to identify any incomplete milestones that should be demonstrated prior to its installation. The committee was not charged to review the installation plan in the context of DØ's overall upgrade installation plan, however certain installation tasks related specifically to the L1 Calorimeter hardware were covered. Hardware and software status and installation plans were presented on Friday after which the committee met and generated a list of questions for the L1 Calorimeter trigger group. The Saturday session included a discussion of the committee's questions, some discussion of tasks required to move from the trigger installation to its operation, and a close-out covering preliminary remarks from the committee.

1. Communication paths

The L1 Calorimeter trigger must communicate over numerous paths to function in the trigger system, including: BLS-to-ADF, ADF-to-TAB, TAB-to-GAB/L2/L3/CAL-TRACK, GAB-to-L3, GAB-to-TFW, and various VME pathways for monitoring and control functions.

The data paths in the L1 Calorimeter trigger have been verified in a number of test facilities. These test facilities include a test bench at Nevis and a slice of the trigger installed at DØ's "sidewalk" test stand in the DØ assembly building. TAB-to-GAB communications have been verified extensively in test bench studies at Nevis. These studied have been performed using test vectors and a fully populated TAB crate. The "sidewalk" test stand receives copies of the analog data from several calorimeter trigger towers as well as SCL event and timing information from the trigger framework. Input channels are available to test data transmission between the L1CAL trigger and both the Level 2 and Level 3 systems.

ADF-to-TAB and TAB-to-GAB communications have been extensively tested and verified to meet operating requirements. Initial tests of TAB-to-CAL-TRACK also do not indicate any problems. The TAB cards use a different brand of Hotlink transmitter than has been installed in the current Run2 trigger. Bit errors rates in the communication paths to L2 and L3 were recently reduced significantly by increasing the capacitance for the synchronization lock on the Hotlink receivers in the VTM cards used at L2 and L3. Indications are that the BERs to L3 are within specifications. While initial measurements show no problems, more running time is required to improve the BER limit measurement for communications to L2.

The Level 2 group reports that the FIC cards receiving data from the TABs required an additional modification to reduce noise on the clock line. Is this still necessary after the VTM changes are installed? All changes to on-line cards should be clearly documented to prevent any unintended

mixing of L1-CAL flavor with other trigger cards.

The GAB-to-TFW communications have not yet been tested.

Recommendations:

i) The GAB-to-TFW communication should be verified as soon as possible.
ii) The protocol for communication with COOR needs to be fully defined. This should be pursued as a high priority item.
iii) Document changes to VTM and FIC cards.

2. Timing

Precise timing is required for fast serial links throughout the system, as well as serial data processing stages within the cards. The overall system latency must fit within allocated time budgets.

Using the readout slice at the sidewalk the timing has been verified for digitization of the analog readout. There is a concern with a small number of zero-energy events that are present in the readout of the TAB. This is believed to be a timing problem internal to the TAB firmware. This is one of the primary concerns of the performance of the system so far.

Measured latencies in the system are in exact agreement with expectations from the firmware simulations. Some additional latency has been added to the ADF to allow for adjustments in the analog sampling without affecting downstream timing. This latency will be removed after installation and final ADF sample time adjustments, thus requiring only a single change to timing for the down stream systems including L1CAL-TRACK.

Recommendations:

i) The presence of out-of-time (zero energy) events in the TT readout at the few 10ths of a percent level needs to be understood. This should be pursued immediately and at highest priority.

3. System scaling

The full L1 calorimeter trigger includes 80 ADF cards, 8 TABs, and a GAB card. Partial mock-ups of the system have been tested throughout the commissioning project. Since the cards and crates will be available in advance of installation, it is possible to test both a fully populated ADF crate and the fully populated TAB crate prior to installation. Each stage of the system is capable of generating extensive test vector data.

Recommendations:

i) L1CAL should be running in the trigger system as soon as the GAB is timed into the TAB and made to communicate with the framework. Operation of the system with at least 40 ADFs (50%) and all TABs prior to shutdown must be demonstrated. The demonstration of acceptable BERs over multiple days of running in the trigger system (a full readout chain test) must also be done.

4. Parallel readout tests

Parallel readout tests allow the verification of the L1Calorimeter trigger components during Run2a operations. A set of 4 trigger towers (EM and HAD components) has been readout to L3 as part of the sidewalk tests. The noise measured in the trigger towers is consistent with or below levels in the current system. There are no indications of problems with ground loops caused by the new connections in the Run2b trigger.

In a presentation of data quality measurements the hadronic towers components sometimes showed zero difference from the precision readout. This trend was not evident in the EM tower sections. After some discussion the cause of these events was not clear. These events should be investigated thoroughly.

Recommendations:

i) see recommendation under System Scaling.
ii) Investigate "zero difference" hadronic tower data.

5. Software tools

The Level 1 Calorimeter trigger requires a large and diverse collection of software tools for the commissioning of the hardware, verification of the installation, as well as calibration and operations tasks.

The question of data unpackers was not completely resolved. A stand alone unpacker will be used for L3 while an IOGEN-based unpacker is required for L2 on-line. The use of the L3 IOGEN-based unpacking within the trigger simulator was not resolved. Also an unpacker for the GAB data has not yet been written.

Recommendations:

i) Resolve unpacker issues for trigsim and identify manpower to complete the unpacker tasks (GAB).
ii) A large amount of software needs to be completed to verify and operate the L1 CAL trigger. We recommend the generation of a software task schedule for on-line trigger control, slow control, monitoring (TCC monitoring and examines), and alarm system software with manpower required to reach completion by Dec 1. Critical components required earlier for

the installation tasks should be clearly defined.

6. Documentation

Recommendations:

i) The documentation project for non-expert shifters should begin well in advance of turn-on.

7. Installation plans

An overview of the installation plan was presented, including the efforts necessary to remove the existing L1 Calorimeter trigger crates from the movable counting house. Due to the exceptional difficulty of locating spare lines in the cable tray from the MCH to the platform, it is vitally important that the BLS cables not be damaged in the removal/installation process. In the event of accidental damage to a BLS cable or connector, approximately 20 feet of slack is available at the MCH end to repair the cables. An adequate supply of replacement connectors in on-hand. The committee is pleased to note that protection of the BLS cables is prominent in the installation plan.

Shortly after the review ORC approval was obtained to run the L1 Calorimeter trigger unattended.

While the tasks related to various trigger components were discussed, no overview of the pre-installation tasks was presented as part of the review. The L1 Calorimeter management should complete a detailed list of pre-installation tasks including any dependencies of one task on others.

Recommendations:

i) Develop a complete pre-installation task list.
ii) To prevent confusion in testing the installation, a final mapping of dead BLS lines, noise levels, etc should be prepared prior to the shutdown.
iii) The plan for installation and verification of connections should minimize handling and connection/reconnection of the BLS cables to prevent any unnecessary wear or damage. Careful training should be mandatory for anyone handling the BLS cables.
iv) A clear plan should be developed for securing the BLS cables in the MCH while they are disconnected during removal of the old L1 Calorimeter trigger.
v) We recommend the creation of a detailed installation schedule by Oct 1. We urge the group to build in additional contingency for the installation and testing phase, possibly by finding efficiencies in the disassembly phase.

8. Maintenance

Any necessary board maintenance, throughout the life of the system, will be performed by engineers at either MSU (ADF) or Nevis (TAB/GAB). Adequate spares are on hand for each component: ADF (80 installed/20 spares), TAB (10 installed/5 spares), GAB (1 installed/ 3 spares).

Recommendations:

i) MOU agreements for long-term maintenance should be formally negotiated with the DØ Management.

9. Additional Recommendations

i) We recommend completion of the jet firmware verification by the end of September. This should be completed to the same level as the verification of the electron algorithm.
ii) It is clear that the L1 tau algorithm requires additional development work.
iii) We recommend that L1CAL start providing weekly reports at the operations meeting.
iv) New manpower should be added to provide an updated calibration of the present L1 TTs and to repeat this work for the new trigger after the upgrade. The group should also consider finding new manpower to develop monitoring tools via TCC, possibly including a hot tower finding tool TCC. This work should proceed in addition to other L1CAL tasks and not detract from engineering efforts on installation and commissioning of the system.

Conclusion

The committee feels that the L1CAL system is well on track to begin installation on Oct. 31. The remaining tasks to complete the system are well understood by the L1CAL group. In this report we have noted the tasks that should be pursued with highest priority to complete the remaining checks of the system and to prepare for installation. We commend all of the speakers in the review on their very well prepared presentations and the L1 Calorimeter trigger group for their efforts to provide significantly enhanced L1 trigger capabilities for Run 2b.

Charge for the L1cal Technical Readiness Review

All of the individual boards which make up the upgrade of the L1Cal have been shown to work on the test bench and meet their design specifications. The purpose of this review is to verify that all of the parts work in concert as a system so that there are no reservations about installing the system from the technical point of view. The scope of this review includes the online software as well as the hardware.

Particular points which should be covered include:

- Communication paths
    - Have the transmission of data and control signals been verified across all of the relevant communication paths (BLS/ADF,ADF/TAB, TAB/GAB, TAB-GAB/L2-L3, GAB/TFW, SCL/L1cal, ...). Are the bit error rates low enough for long-term operation? Have new cables been tested?
    - Has the connection to the Cal Track Match system been tested?

- Timing
    - Are there demonstrated procedures for properly adjusting the timing of each element of the system?
    - Is the overall latency understood and within specifications?

- System scaling
    - Has it been demonstrated that multiple ADF's in a crate (a full crate, ideally) operate without interference?
    - Has it shown that multiple TABs operate without interference when all of their inputs and outputs are used?
    - Has it been shown that multiple TABs in a crate (a full crate, ideally) communicate with the GAB without interference?
    - Is the measured power consumption compatible with specification?

- Parallel readout tests: The sidewalk system can be read out through the standard DZero data path in coincidence the entire DZero detector. From these data, have the following been demonstrated:
    - acceptable TT noise performance
    - ability to read pulser data
    - mechanism for calibrating TT's against precision readout

- Software tools: Has software (expert tools, at least) been written and exercised which:
    - download the hardware
    - verifies the download
    - monitors the operation for errors
    - compares hardware output with emulation
    - unpacks the L1cal data which is written to the raw data chunk
    - archives/tracks history of installed firmware
    - monitors the system online
    - interfaces with COOR for configuration

- Documentation: Is there adequate documentation for
    - configuring and initializing the system
    - interpreting errors flagged by the monitoring utilities
    - specifying the data formats
    - documentation for each piece of hardware in the system

- Installation plans:
    - have all the required safety approvals for installation been obtained, or are in the works?
    - is the installation infrastructure planned out, for example power, real estate, cabling, etc.?
    - what is the installation plan and who is going to do it?
    - is a method in place for identifying bad BLS trigger outputs so that they can be fixed during the shutdown?

- Maintenance: While this will be reviewed as part of the collaboration review, we would appreciate hearing about the following:
    - how are boards going to be repaired in the long run? Are there adequate spares and test stands?
    - is it conceivable that changes might be required to hardware and/or firmware after installation and technical commissioning? How will the facilities and expertise for making these changes be available?