

## **CALICE Technical Board Review Report**

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***(For Internal CALICE Collaboration Use Only)***

### **1. Introduction**

The CALICE technical board met on Oct. 14, 2005, immediately following the fall collaboration meeting to

- review the status of the ECAL, AHCAL, DHCAL, and TCMT,
- review the status of the CERN and FNAL test beams, the mechanical structures and scanning tables, the slow control, the data acquisition and the software.
- discuss integration, calibration, commissioning and operation of the detector systems, in addition to coordination among the four major projects.
- write the present report containing summaries of current status of all subcomponents as well as assessments of schedule risks and recommendations to mitigate the risk factors.

The review board feels that, given the sensitivity of the content, this report may be used only internally by the CALICE collaboration. It is strongly advised that any external use of this report be discussed with the Technical Board for possible distillation of the document. The review board also would like to recommend strongly that the highest priority of the collaboration should be to accomplish the upcoming most immediate beam test needs. This needs to take precedence over longer-term developments beyond the beam test stage.

### **2. Test Beam Operation**

#### **• Assessment**

- The planned test beam program contains a period with an ECAL fully equipped in depth (but not necessarily complete transversely), first at DESY (low energy electrons) and at CERN (high energy electrons). The agenda could be the following: Test beam at DESY from February to April 2006, then test beam at CERN from July to November.
- As regards the tile HCAL and TCMT, a period of running at CERN is foreseen during the second half of the year 2006, first in stand-alone, then with a combined test with ECAL in front.
- Tests with single layers of RPC and GEMs will be performed at the MTBF at FNAL in late 2005 to early 2006.
- At the end of 2006, we expect to prepare the “main period” of test beams which will involve the ECAL, the AHCAL, the DHCALs and the TCMT.
- These will most probably be performed at FNAL, in 2007-2008.
- To date, the beam test runs have been managed by the small group of people who are involved in the specific components and the people at DESY. Given the imminent large scale beam tests, it would be necessary to have larger contributions from collaborating institutions for the sub-detector(s) under test.

#### **• Schedule risks**

- Commissioning and operations coordinators for beam tests are not in place.

- **Recommendations**

- We strongly recommend the collaboration to appoint liaison persons for DESY and CERN by Jan. 1, 2006, and for Fermilab by March 1, 2006. These liaison persons should report to the Technical Board regularly for the progress.
- We recommend appointing run coordinators and implementing a shift structure for both DESY and CERN beam tests.
- We recommend development and implementation of an online shift logbook that is universally accessible throughout the world.
- We recommend the development and implementation of a remote data quality monitoring shift system with wider contributions from collaborating institutions.
- We recommend the software group to investigate and provide necessary infrastructure for onsite and remote data quality monitoring.
- We recommend all the above recommendations to be implemented during the DESY beam testing.

### **3. ECAL**

- **Assessments**

- It is impressive to see that virtually all other parts for ECAL prototype are in place except for the silicon wafers which were identified as the major schedule risk item at the last review in Feb. 2005. An additional delay in implementing the review committee's recommendation to place an order to the Russian manufacturer was caused by the fact that the funds for the additional 100 wafers had to be identified.
- Two additional slab construction tools have been made, increasing the number of tools to a total of three. This cuts down the time scale for the completion of the slabs to 2.5 weeks to fully cover the shower core and to about four weeks to cover the entire lateral area of ECAL instead of 14 weeks, from the start of the regular wafer delivery.
- A new set-up for sensor characterization before gluing has been developed at LLR for this and the time needed per matrix is around 30 to 45 min which corresponds to about one full slab per day. The slow control and some standalone ECAL mechanical improvement of the support is progressing well.
- It is critical for slabs be calibrated before beam tests in order to take the maximum use of the data. To accomplish the calibration at a level of ~1%, order of one million of cosmic ray events are needed. This takes around 10 days if all layers are calibrated simultaneously using the VME DAQ system. For this purpose it is necessary to build a mechanical support system that can receive all 3 ECAL sub-structures at the same time, before the end of the year.

- **Schedule Risks**

- The production and the yield of the Si matrices remains the major schedule risk since any delays in delivery beyond Dec. 1, 2005 would start cutting into the beam test running time of the prototype. New production of the Russian wafers is at 62% yield before gluing (was 75% before). The gluing process does not seem to reduce the yield based on previous experience with this manufacturer but this remains to be verified. So the total expected number of useable wafers after gluing is about 62. Since we need minimum 96 wafers to

equip the shower core for meaningful test beam runs, we still lack 34 wafers even after the full delivery of the Russian wafers. The yield of the new Russian production is only measured on a first delivery of 24 matrices and it could increase with the next batch up to the previous one (75%). Koreans will deliver 50 wafers in Dec. but its yield is not known, nor their characteristic (mainly after the gluing process). New batch of Czech wafers seems better than before since the breakdown voltage seems to be stable even after gluing but their leakage current increased dramatically. So they are not up to par yet (at least for the Feb. 06 DESY test beam). There are close contact with two other producer but no schedules are envisaged.

- This item also remains as the critical schedule risk for the future detector modules unless a reliable source for Si wafers is identified.

- **Recommendations**

- ECAL group is on the right path in search of new manufacturers to provide sufficient number of wafers to complete full depth and full width prototype. We, however, recommend preparing to coordinate a purchase of remaining wafers to complete the full beam test module from the most reliable source (Hamamatsu?).
- We recommend the ECAL group to identify the most reliable and cost effective sources of Si wafers and to start working on mass production R&D, as soon as possible.
- For the beam test at DESY we recommend to evaluate and change if possible the gas mixture with non flammable gas. The use of non gas beam hodoscope may also need to be investigated.
- We strongly recommend setting up a cosmic test stand that can calibrate multiple slabs using a VME-based readout at a time sufficiently before the beam test at DESY.

#### **4. AHCAL**

- **Assessment**

- The committee was impressed by the progress made in production and commissioning of the active detector modules. A total of 2500 SiPMs have been produced to date of which 1300 tiles were certified and delivered and 6 modules are assembled or close to completion.
- Tools and test benches are set up so that cassette production can proceed at a speed of two per week at all intermediate stages compared to half that rate earlier in 2005.
- The first module has been commissioned with test beam at DESY. First results from multi-channel test and calibration procedures are becoming available. Data taking has been completed.
- Experience from commissioning is being fed back into the SiPM and tile quality control procedures. Noise occupancy indicates that there is little room for looser selection criteria.
- Of particular concern is the occurrence of long discharge signals from SiPMs. The origin is thought to be understood, but this needs to be verified as more modules are being tested. Additional measures were taken to identify problematic sensors at an early stage.

- Production and tests of front end electronics ASICs and boards are completed.
- The basic functionality of the calibration system has been established with component prototypes. A prototype of the integrated calibration and monitoring board (CMB) has been designed, but not yet built and tested. The CMBs are expected to start construction in December due to schedule conflicts and resource limitations.
- The stack mechanical support structure has been built and modified such that it accommodates both scintillator and gaseous HCAL modules. The design of the movable stage has been finalized, taking constraints from FNAL and CERN beam areas into account.
- **Schedule risks**
  - Complete and satisfactory understanding of the long discharge signals must be obtained, and efficient preventative measures need to be fully reflected into the production and selection criteria. This is critical since the continuation of SiPM production with high yield and high efficiency depends on it. This also ultimately affects the detector performance after the construction of the prototype.
  - Mass production of SiPMs has been well prepared, but is not yet running smoothly. Further problems might be discovered and may need adjustments of the quality control, which might cause delays.
  - The time scale for the production of the second half of the SiPMs is uncertain, due to the still limited experience with SiPM mass production. This item has been identified in the previous review and remains to be at the critical path.
  - The calibration system is critical for commissioning the active modules. If the outcome of prototype tests requires a re-design, it will have strong impact on the overall schedule.
  - The completion, integration and commissioning of CMB need to be on schedule in order to assist the commissioning of AHCAL.
- **Recommendations**
  - Complete the full and satisfactory understanding of long discharge signals and implement the relevant preventative measures to minimize the future LD's in the detector. This should be done as soon as possible.
  - Provide feedback from assembled modules as soon as possible, and correlate test results with those from the test bench.
  - Identify bottle-necks in various production sequences and provide manpower-resources which make optimum use of existing facilities.
  - Intensify the software effort to ensure fast feedback during commissioning in the CERN beam.

## **6. DHCAL**

- **Assessment**
  - Despite the abysmal funding situation in the US and Russia, the group has made steady progress towards the construction of a prototype hadron calorimeter section (PTS). The R&D on the RPC chambers is complete in both Russia and the US. Default designs for the chambers to be used in the PTS have been presented. R&D on GEMs is progressing towards the

assembly of a five 30cm×30cm layer stack for cosmic ray studies and is exploring the production of larger foils.

- The bulk of the effort is concentrating on the development of the electronic readout system. A conceptual design has been documented and will serve as basis for detailed design work of the subcomponents. The first prototypes of the front-end ASIC have been produced and are being tested. Measurements with test boards, to guide the design of the front-end board (containing the readout pads as well as the front-end ASIC), have been initiated.
- The aim of the group is to provide a fully equipped PTS by early 2007. A tentative agreement to produce half the chambers in Russia and the other half in the US has been reached. The electronic readout system will be provided by the US groups.
- **Schedule risks:**
  - Funding remains a serious concern. At this point it appears unlikely that sufficient funds for the construction of the PTS will be made available during FY 2006.
- **Recommendations:**
  - We strongly encouraged the group to explore all possible sources of funding.
  - We strongly encouraged the group to explore the possibility of (re)-using the AHCAL CRC boards as back-end, thus saving the expenses of designing and producing super concentrators and data collectors.
  - We encouraged the group to study the variations of the hit multiplicity as a function of the operational conditions and to develop ways to monitor it during data taking, if necessary.
  - We recommend the chamber designs (RPCs and GEM) to mechanically accommodate the DHCAL front end boards.
  - We encouraged the French groups to develop a front-end readout ASIC for the next generation of tests. The new chip will explore the possibilities of power pulsing, minimal thickness, and increased number of readout channels.

## 7. TCMT

- **Assessment**
  - Impressive progress has been made on the construction and assembly of the TCMT cassette. All the strips and fibers required for the device have been fabricated and detailed quality control measurements taken. The mechanical assembly of the full complement of the cassettes is finished. Further progress awaits the delivery of SiPM's. After SiPM delivery it will take around 12 weeks to assemble and characterize the requisite number of 16 cassettes.
  - One cassette has been fully instrumented with the photo-sensors. It has been successfully integrated into the full electronics and DAQ chain at DESY in Oct. 2005 test. The successful integration is going to be followed up by exposure of the cassette to the electron test beam at DESY in the first week of November 2005.
  - The two major tasks that will be addressed in the next 4 months are:
    - Completion of the LED driver board and the integration of the calibration and slow control system.

- Construction of the absorber stack. The stack has been designed and the steel plates necessary have been acquired.

An initial design of the table on which the stack sits also exists but may have to be modified as the situation on the prospective test beam areas becomes clearer.

- **Schedule Risk**

- SiPM production and delivery are the common schedule risk as AHCAL.
- Assembly and characterization of the cassette that takes 12 weeks from the time of the SiPM delivery.
- Completion of LED driver boards and integration into the slow control and calibration system must be in place before the full scale beam test run at CERN.
- Preparation of test stand at FNAL must be done sufficiently before the shutdown of Fermilab beam in March 2006 to be able to use beam for commissioning.

- **Recommendations**

- We recommend the TCMT group to work closely with the CMB group to complete the development of LED driver and integrate it into the CMB so that common system can be used for both the scintillator based AHCAL and TCMT.
- We recommend the TCMT group to start working on establishing a test stand set up at FNAL using the borrowed VME crate as soon as possible so that standalone calibration and cosmic testing can be performed before the beam test at FNAL.
- The TCMT test stand in FNAL should make all efforts to obtain a HAL-supported VME readout interface to reduce the DAQ effort needed.

## 8. VFE

- **Assessments:** The committee is impressed with the progress made in this area for physics prototype of the chips including power-pulsing.
  - The front-end ASICs for both ECAL and AHCAL have been available and used to build the physics prototype since 2004 and although their performance should be carefully examined on test beam data, no problem requires further developments on these ASICs. The effort now shifts towards the final ASIC front-end with developments on the technological prototype accompanied by a change of technology, from BiCMOS 0.8 $\mu$ m to SiGe 0.35 $\mu$ m. This will now require three main developments.
    - Feature full power pulsing
    - Integrate ADC inside front-end
    - Autotrigger on  $\frac{1}{2}$  MIP

A step has been taken in this direction for the ECAL with the fabrication in July 2005 of a new ASIC (FLC\_PHY4) compatible with the physics prototype (18 channels) which integrates a 12 bit ADC and a complete power pulsing scheme. It is crucial to validate the power pulsing capability for the VFE in order to embed the electronics inside the detector and this validation will be carried first on test bench but in the end in the test beam, to prove the good and stable performance in the calorimeter. To this end, 2 boards with 12 ASICs will need be produced in 2006 to be mounted on the prototype and readout along with the other former boards. This will require a modification in the DAQ to readout digital signals and send power pulsing signals.

- The groups in charge of VFE will continue in parallel the development of proprietary low power ADCs and prototypes for on-chip zero suppress to prepare

the next generation of VFE ASICs. These developments will have features common to the HCAL and a VFE ASIC for the AHCAL will be developed in 2006 as a further step towards a final VFE.

- **Schedule risks:**
  - While we do not see any obvious schedule risk items at this time, the integration of chip readout through the CRC for an in-the-high-flux beam testing is going to be useful for further understanding of chips' performance while irradiated.
- **Recommendation**
  - We recommend the VFE group to work with the DAQ group to prepare for its readout in the latter part of beam test runs at CERN. This, however, should not take higher priority than preparation for the CERN beam test with the existing VFE.
  - Given the importance and the difficulty of integrating power-pulsing into these chips and the fact that this challenge is shared by DHCAL, we recommend the VFE group to work with DHCAL electronics group in development and implementation of this feature to the VFE chips.

## **8. DAQ**

- **Assessment**
  - The committee commends the readiness of DAQ hardware for beam test runs. The remaining CALICE Readout Cards (CRC) are expected within a few weeks. All DAQ PCs, disks and other hardware needed for the DESY run have been purchased except for the cables and trigger backplanes. In addition, beam equipment readout for CERN may need to be purchased.
  - The system seems capable of performing to requirements. Runs are currently terminated at the 2GByte Linux file size, which takes less than five minutes at full speed. A major upgrade of the software is in progress and this should have improved online monitoring and run control.
  - There are some worrying hardware problems with the existing CRCs which have developed during their use in the AHCAL system. These are being investigated and repairs will be made if possible.
- **Schedule risks**
  - Firmware upgrades to allow spill triggering of 2000 events. Failure to do this would result in a reduction of the CERN data rate by factor of three, requires us to run with only one trigger enabled at once, and will make us blind to particles immediately before the event.
  - Firmware upgrade to accommodate FLC\_PHY4 digital readout and possibly DHCAL readout. In particular, not achieving the first would prevent the new VFE chip being tested in the CERN beam run.
  - Late delivery of the next release of online software. Failure of accomplishing this will require the AHCAL group to continue to work inefficiently on their test stand and delaying setting up the TCMT test system at FNAL.
  - If the new CRCs have problems, their testing could continue for much longer than the few weeks foreseen. This would delay the DAQ equipment being shipped to DESY and hence all integration tests.

- Possible additional production of CRCs if DHCAL decides to use CRCs and decides that more CRCs are needed; the previous production took more than 6 months so a decision after mid 2006 could mean delays in DHCAL commissioning.
- CRC availability for multiple test stands may be limited, particularly if the three spares are not fully functional. This could lead to delays in setting up and/or expanding the number of CRCs in the extra test stands.
- Late purchase of cables because of delays in agreeing on crate locations on the detector support and hence cable lengths.
- **Recommendations**
  - The DAQ and DHCAL groups should further investigate the feasibility of using CRCs for DHCAL readout.
  - The committee feels that the DAQ group is being overloaded. Thus, we recommend the collaboration seek additional manpower to help the DAQ group, especially in setting up further test stands.
  - The LCCD database should store the user-accessible slow data. This should be entered into the database via the existing conversion program from DAQ native raw data files, rather than write a new interface to the AHCAL slow controls PC data.
  - The TCMT test stand in FNAL should make all efforts to obtain a HAL-supported VME readout interface to reduce the DAQ effort needed.
  - The testing of the new CRCs should proceed as soon as possible within the UK. The DAQ system should be shipped to DESY immediately afterwards so as to start on the AHCAL integration and trigger tests as well as the ECAL cosmic ray run before the end of the November. The UK groups should consider using UCL equipment to set up a second test system in the UK, which would allow the main system to be shipped to DESY if the CRC tests are delayed.
  - The use of the CRCs and test systems should be scheduled by the Technical Board to set priorities and avoid collisions.
  - Effort should be found to commission the drift chambers in the DESY beam line with non-flammable gas.
  - The online and offline software should be adapted to allow multiple native raw data files per run, so the run length is not artificially limited.

## **9. Software**

- **Assessment** The committee was impressed with marked progress made in software and commends its effort to complete the preparation of software for the large scale run in the upcoming years. We repeat here (in italics) the recommendations of the February 2005 TB review, with comments on progress:
  - **Monte Carlo:** *Each detector group will have to be responsible for and maintaining the geometrical description of their detector within Mokka and for implementing the digitization (noise, crosstalk etc.) as and when necessary. We recommend the use of the DigiSim framework within MARLIN for digitization. Although detailed work may need to await the arrival of data, each group should consider whether the information stored by MARLIN is sufficient for their needs.* Not much progress, but what we have is probably



- adequate for our immediate needs. The test beam ECAL /HCAL/TCMT configuration is modelled. The upstream drift chambers have been incorporated by a new collaborator (RHUL). This work needs to be continued to include all upstream material, e.g. scintillators. First results on comparisons between data and simulation for the ECAL suggest that fairly good agreement can be achieved if the tracking cutoffs in Mokka are reduced.
- **Data analysis framework:** *Work on the lightweight “intelligent” decoding of the data into LCIO objects needs to start expeditiously. Aim to agree on data content by NIU Calice meeting, and have a first version of code by end March. We recommend the use of MARLIN as the analysis framework. Individual processing tasks, such as mapping, calibration, alignment, histogramming, should be packaged as separate MARLIN processors. This task proved slower than anticipated, mainly owing to problems in handling the trigger data. The February ECAL data have now all been converted to LCIO. The HCAL cassette #1 data have also been routinely converted to LCIO. MARLIN processors to treat pedestals and apply calibrations to the ECAL ADC data exist, and also processors for decoding and track finding in the drift chambers. Physics results based on this system have been presented and compared with Monte Carlo.*
  - **Database:** *The use of the LCCD package to access a MySQL database in the LCIO/MARLIN framework is recommended. A database manager will need to be appointed. The database has been set up at DESY, in such a way that network access is available from trusted outside sites. At present the database is only used for trigger configuration data, and for some HCAL data. The ECAL calibrations exist in a private copy of the database, and need to be made publicly available. Database access is potentially the greatest hurdle for novice users to surmount – to ease the learning curve for novice users it may be useful to include some data (e.g. trigger bits) in the event record.*
  - **Data storage:** *The data (native, raw LCIO and processed LCIO) will be stored in the dCache mass storage at DESY. All members of Calice need to be informed how they can access to these data, the preferred method of access being Grid-ftp. Write access needs to be restricted to a very small group of experts (to be identified). This has been done. Access is possible to users with a DESY account, or via the Grid. Need to enhance the Grid-awareness of the collaboration.*
  - **Code sharing:** *Authors of code are strongly encouraged to store their work at the CVS repository recently established at DESY-Zeuthen. The LCIO conversion code is available in CVS. Provides tagging of releases and versioning. Not much else is stored there. Continue to encourage its use.*
  - **Documentation:** *Documentation needs to be improved, and a central point of access to documentation (e.g. a web page) should be established. Web page has been set up, linking to information about basic software tools like Mokka, LCIO, Mokka. Needs an update soon. An urgent need is a simple “pedestrian’s” guide to getting started with the various Calice tools.*

- **Schedule Risks**
  - It is highly desirable to be able to process and analyze data rapidly during test beam running, so as to identify problems, and influence the running strategy. It is fortunate (from the point of view of the small software team) that further ECAL running has been delayed, so that the software is now largely in place well before the next data run.
  - Knowledge and expertise is currently too strongly concentrated in a very small number of people, especially R.Pöschl. It is, therefore, essential that more of us use the software and look at the current data before we run again, in order to mitigate this problem.
  - Communications between CALICE members need to be improved so that the members confined to their home institute can still help look at the data soon after they are recorded.
- **Recommendations**
  - **Monte Carlo:** The detector groups should still consider whether the information stored by MARLIN is sufficient for their needs. It seems probably adequate for the ECAL. A complete simulation of the beam line material in Mokka is greatly needed (for each beam line we patronise). Need to support other Monte Carlo models (Geant3, Fluka etc).
  - **Data analysis framework:** Need to assess the adequacy of the present LCIO data. Consider adding trigger summary information to event header. Relevant slow controls info (temperatures, drift chamber positions, detector angle etc) to event or database. Make processors to read the data available and get people using the code.
  - **Database:** Need to populate the database with ECAL calibration and configuration data; make tools to use this information available.
  - **Data storage:** All members of Calice need to be informed how they can access to these data, using either their DESY account or the Grid-ftp tools. Make available simple Grid jobs for data conversion, Monte Carlo and Marlin-based analysis. Need to think about data storage options when running at CERN.
  - **Code sharing:** Authors of code are still strongly encouraged to store their work at the CVS repository recently established at DESY-Zeuthen.
  - **Documentation:** Documentation still needs to be improved. A simple introduction “Calice Data analysis for Pedestrians” may help.
  - The online and offline software should be adapted to allow multiple native raw data files per run, so the run length is not artificially limited.
  - We recommend the software group to host a tutorial workshop before the start of the CERN beam test so that the collaboration members could be trained and prepared for the rapid feedback of the beam test data quality.

## 10. Mechanical Structure

- **Assessment:** The committee appreciates the effort invested by K. Gadov in incorporating the committee recommendations to accommodate the still-uncertain DHCAL data concentrator boards.

- **Schedule Risks:** While we do not see any immediate schedule risk items, it would be important to maintain good communications between K. Gadow and I. Fang at FNAL and between K. Gadow and the liaison engineer from CERN. Detailed safety requirements at FNAL and CERN should be given to Karsten to adequately implement them into the design. The ordering and construction of the structure seems to be on schedule but needs to be followed through to keep them on time.
- **Recommendation:** We recommend Karsten Gadow to work with CERN and FNAL liaison engineers to meet safety requirements of each lab.

## **11. Conclusions**

We conclude that the progress in the collaboration has been marked. Many of the committee recommendations have been implemented. We, however, have identified several remaining critical schedule risk items, notably the Si wafer and SiPM production and delivery, and new sets of items. We hope and feel confident that this review report will help expeditious preparation of beam tests within the collaboration. We recommend the next workshop to occur soon after the completion of DESY beam test run in May or June 2006.

## **12. Acknowledgements**

The review board would like to express appreciation to all collaborators who provided information to make this second review such a success and who participated in the open session of the workshop. The board also would like to express our deepest appreciation to DESY and Felix Sefkow for hosting the meeting and making the review a success.