September 27, 2000

# CDF TDC Status Review- Sept. 14, 2000

## Committee and Agenda

The committee consists of Henry Frisch (Chicago, Chair), Bill Foster (Fermilab), Tony Liss (UIUC), Michael Schmidt (Yale) , Aseet Mukherjee (Fermilab), Rick Van Berg (Penn), Harold Sanders (Chicago), and Terri Shaw (Fermilab).

The committee met in an open meeting at 9 am Sept. 14 in the Snake Pit. Myron Campbell reviewed the project, starting with the design and fabrication of the TDC custom chip and continuing to the present production boards. Peter Wilson then gave a summary of the operational status and known problems. Myron then gave a lengthy and detailed summary of the technical details. The committee then went into Executive Session, joined by Myron, Ron Moore (Michigan), Peter Wilson, and Bob Kephart. The review ended at 1:15 pm. Discussions with principals have continued intensively since the review until the present.

## Charge

The charge to the TDC Review Committee is quoted in full below, as it is a good summary of why the review committee was called as well as the description of what we've been asked to do:

"CDF employees a custom VME TDC to readout the Central Outer Tracker and Muon chambers for Run II. A total of 540 TDC's including spares are being built. (405 LVDS for COT, and 135 ECL input for Muon systems) These TDC's were designed by University of Michigan. The PC boards are manufactured and partially assembled in industry. The final assembly and testing is done at Michigan. Maintenance of the system is shared between FNAL (PREP) and Michigan."

"Serious manufacturing problems have delayed completion of these modules. Defects in the vias in one batch of PC boards has substantially complicated the testing of some TDC modules and required a large investment in checkout labor at Michigan. A number of tested TDC modules that were installed at Fermilab have failed. Several failure modes have been identified. Failure of previously good vias has been identified as a systemic problem for boards manufactured with small vias. This could negatively impact the long term reliability of these modules during the course of the experiment."

"A proposal will be presented to build additional replacement TDC modules to insure that CDF has a reliable compliment of TDC's for Run II. Schedule information indicating when TDC's will be available for installation at CDF will be provided. The plan will include cost estimates and a labor plan."

"The purpose of this review is to evaluate the current state of the TDC project from a technical standpoint. The committee should make recommendations on the proposal to build additional TDCs and on the associated cost and schedule estimates. The committee should evaluate the experience with board checkout to date, the nature and frequency of the observed TDC failures or problems, and the expected long term reliability of the TDC modules. The committee should recommend an overall course of action to the head of the CDF FE/Trig subsystem and to the CDF upgrade project managers that they believe will lead to a full compliment of reliable TDC's installed at CDF at the earliest date."

## Recommendations

1. CDF should immediately start a two-pronged approach, one prong aimed at being able to replace the small-via boards necessary for Run IIa in time for the run assuming that none are reliable enough for steady running, and the other prong aimed at accumulating a reliable and incisive body of information about the performance of the TDCs in a full operational setting of full crates and high readout rates.

2. In order to have TDCs ready for the run, parts with long-lead times need to be ordered now. This includes locating and appropriating, if possible, TDC chips that were fabricated for other uses than CDF, and other long-term parts.

3. A 'TDC Task Force' should be immediately formed at Fermilab, with the charge to aggressively accumulate reliable data from the presently installed TDCs, document each failure in a systematic way that allows the history to be traced and understood, and to be in close daily communication with Michigan and the COT and muon systems. All transactions need to be recorded electronically, with a time stamp at each point. The history accumulated so far needs to be filled out and understood. The Task Force should meet daily.

4. In addition, the TDC Task Force should, in conjunction with Michigan, establish the list of changes to be made to the board. We recommend that these changes be the minimal list to ensure that the board functions to meet the specs and that parts are obtainable.

5. Every change should be vetted by several independent engineers.

6. The order for the boards to replace all the small-via cards in the present base-line design, with a suitable number of spares, should be readied to go as soon as we are confident that the design has been sufficiently tested in the real environment.

7. The Run 2b Upgrade Committee should consider what changes will be necessary to the TDC, including a new design, for higher luminosity running.

## Comments

1. The via problem is serious; a majority of the committee believes that we should replace all the boards in the base-line upgrade that have small vias.

2. There are other, probably fixable, problems on all boards that will affect operation.

3. We do not have enough operational experience to know if we have found and understood all the problems with the current boards.

4. We do not yet have an adequate reporting, tracking, and analyzing effort to deal with the difficult task of understanding the histories and conditions of board failures, report them back to Myron and Ron, and vice-versa.

5. We must have great confidence in the next order- we need to check all changes, and should have enough information that we are confident we know that the boards will work at high-rates in real running conditions, that the backplane signals are of sufficient quality for the TDC to have the required resolution, etc.

6. There may in fact be sub-samples of boards with small vias that do not fail, but we cannot be confident in that. We should count on replacing them while we learn more about operating experience. They could provide spares for the boards not in the pit, possibly, but the majority view is that we should get rid of them entirely unless definitively proven otherwise. Proving otherwise will involve accelerated life-testing, among other things, and will be neither easy nor quick.

7. This is, was, and will be a Herculean task– vendor problems happen. The original spec for the vias was adequate to avoid this problem. The severity of the via problem has made enormous demands on the Michigan group, and has complicated the finding and understanding of other problems.

## Acknowledgments

We thank all the folks working on the TDCs and related systems, and especially Myron Campbell, Eric James, Ting Miao, Bill Orejudos, and Ron Moore, for the hard and excellent work they have been doing.