

Lvl-1 Trigger Upgrades

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This document describes the R&D work towards a new trigger system for CMS at the Super-LHC which took place after the kick-off meeting last Spring and makes proposals on how to proceed in the new feature. At the end it recommends a set of issues that should be discussed during the November 08 FNAL workshop.

Status of the trigger upgrade activities

Since June 2008 the following groups within the trigger activities have met and planned their activities:

- I. The **Tracking Trigger group** (Ryd, Jones) and the **Simulations group** (D. Newbold) have met four times and have started the design of the simulation code. The work is at an early stage and concentrates in developing code which should produce the tracking trigger primitives from the stacked tracker design as proposed by the tracker upgrades group. There was some momentum at the early stages which was of course interrupted in August and September 08 by the LHC run and preparations for it. A considerable amount of work is still needed come up with results for electron, tau and muon triggers. However, the tasks are clear and are aiming to answer the following questions:
 - a. Is the radial distance and pixel size of the detector proposed adequate for triggering ?
 - b. What is the change in trigger efficiency, rate and resolution for matching tracker objects with calorimeter and muon detector objects if one was to deviate from the proposed design towards either larger or smaller radius and smaller or larger pixel size ?

This work should be mature for a workshop during the early spring next year.

- II. The **Calorimeter Trigger group** (Dasu, Nachtman) have shown studies of new clustering algorithms which aim to improve the calorimeter-only tau trigger. They expect considerable improvements if one were to go to finer calorimeter granularity (trigger tower instead of 4x4 tower region) in searching for tau trigger. The advantage of these studies is that, unlike the tracking trigger studies, they can use directly the current CMSSW software and do not require simulation of new detectors. Except of the tau triggers finer calorimeter granularity may benefit other trigger algorithms or quantities such as:
 - a. One can certainly improve on the jet rapidity and phi resolution of the Lvl-1 jets which could be important when one imposes cuts on combined trigger objects for example rapidity gap cuts (qqH).

- b. We could have jets of varying jet size as we go forward to account for the fact that for constant jet radius the actual jet size decreases as we go forward in rapidity.
- c. Revisit the issue of forward jet triggers with better granularity. Can we improve the forward jet triggers (W_L scattering + VBF) ? This question was raised back in 2002 and there was a study by S. Nikitenko which answered this negatively. However, the CMS software back then was different and the issue certainly deserves to be revisited.

III. **uTCA group** (Foudas): There were three meetings on uTCA work within the SLHC upgrade group as well as within the GCT group on issues that affect the SLHC work. The progress so far focuses in the following three points:

- i. The GCT Matrix card is at the production stage with PCBs already made and about to start the assembly. The card is expected in two weeks at CERN where it will be tested.
- ii. Minnesota (J. Mans) has already designed and produced a uTCA card with optical links on it and is currently under test in Minnesota.
- iii. Wisconsin is producing a uTCA card which could interface future uTCA systems with the current CMS DAQ. The design receives data from uTCA backplane and transmits them to an FRL via an S-LINK64 interface. In addition to this the card interfaces with the TTC system to receive clock and trigger information.

Hence, it is fair to expect that we should have working uTCA devices in 2009. The group needs to gain experience with these devices and control and monitoring software needs to be written for them. It is expected that in 2010/2011 we will be ready to introduce a test system in CMS. How and when to do this should be a topic for the upcoming workshop at FNAL.

Proposals for the immediate future

This section is aiming to start the discussion for mapping the trigger upgrades work. The focus is on Phase-I upgrades. However, enough attention is given to the planning of the Phase-II upgrades.

Calorimeter trigger work

There is a general agreement that during Phase-I and before tracking information is available at Lvl-1 we will be changing all the HCAL electronics. The uTCA standard along with 3 GBps optical links appears at the moment (no formal decision has been made yet) to be the accepted platform for this and several groups have started gaining experience and knowledge on uTCA. It is certain the new system will provide its outputs using commercial optical links of the type used now by GCT and GT with the difference that they will be faster by at least a factor of two.

Once the HCAL trigger and readout electronics changes to uTCA using optical links there is an obvious problem with the upstream electronics which means that changes there are inevitable. This generates several issues both in hardware and also in simulations to be discussed at the FNAL workshop:

- I. The goals of what one can learn in terms of better reconstruction and algorithms using a uTCA system during LHC running have to be discussed. This means that we need to start a Phase-I trigger studies program. The Calorimeter upgrades group is and should be doing this but we need more work and concrete results on new calorimeter trigger algorithms.
- II. How do we translate the current copper ECAL data to the same format ? While this does not appear to be a technologically challenging task it is a design that needs to be carefully planned and executed. Possibly a new Opto-SLB needs to be designed to interface the ECAL electronics with the rest of the trigger which will be on uTCA. This issue needs to be addressed jointly with the ECAL group.
- III. The uTCA work so far gives hope that we will have some prototypes of a uTCA system perhaps as early as by the end of 2009 or the beginning of 2010. The question of course is how do we integrate a number of uTCA crates in the current trigger system without interfering at all the LHC data taking ? There are several ways of doing this but this has to be discussed and planned. One thing is clear though: we need the running experience with uTCA triggering at the LHC to insure that the Phase-I upgrades will go smoothly and relatively fast considering that the maximum shutdown foreseen is a 6-month one. Hence, a way has to be found to have a uTCA system running parasitically with the current trigger system during the LHC running.
- IV. The entire new uTCA system will need to be integrated in a test area (904) and be tested thoroughly before moving it to USC-55 to replace the current system. Even so it is estimated that it will take about a year replacing the current system with the new system. If there is no 1-year shutdown for LHC we will be forced to do this over two successive periods. This means that we need to design a modular system and plan the trigger upgrade in several compatible steps. How we do this should be a topic at the FNAL workshop. Do we replace RCT first leaving the global components (GCT, GT) for the end or do we replace GCT and GT first leaving RCT for the end ? Depending on the answer we give to these questions we have very different roadmaps leading to a new trigger system.
- V. Whatever may be the final system we choose to install it should be able to either accommodate data from a tracking trigger or it should be designed in such a way so that it can be easily upgraded. It needs to be discussed on how it is best to proceed in this.

Tracking trigger work for Phase - II

The obvious need here is to come up a model of trigger from detector to TPGs all the way to off detector electronics which can provide the tracker upgrade group with the feedback they need early in 2009. The workshop should concentrate in further organizing the effort already on the way with focus on:

- I. Review the work done on tracking triggers so far (brief): In the summer 08 an effort has started to provide code for the tracking trigger TPGs. The status of this work needs to be reviewed. We need a realistic projection of what to expect in the future and for this we need to:
 - a. Review the manpower available for tracking trigger simulations.
 - b. Register commitments from institutions interested in contributing.
 - c. Prepare milestones for the simulation effort.

- II. Complete the planning that has already started this summer in terms of regular meetings and organizing the trigger participation in the tracker upgrades group.

Based on these the proposed working groups/meetings for the FNAL workshop are:

(1) **uTCA meeting on Thursday morning** to review the work and progress on uTCA. The agenda of these meeting should include the following topics:

- a. Progress Reports on uTCA hardware under development (HCAL, Trigger)
- b. Proposals for control systems (software) using the uTCA crates.
- c. Proposals for integrating the first uTCA system in the CMS Trigger.

(2) **Main trigger meeting on Thursday afternoon** which should include:

- a. Introduction
- b. Progress on CAL and Muon Trigger simulations
(see page 1 and point I of page 3)
- c. Progress on Track Trigger Simulations
(points I-II of page 4)
- d. Summary of the uTCA meeting
- e. Implementing uTCA in the Lvl-1 trigger
 - i. (points II-V of page 3)
- f. Summary