Trigger Tables and Settings

- How do we establish trigger tables and settings before and during data taking?
  - Brief discussion during Feb. 07 CMS week resulted in what appeared to be a reasonable plan with the following aspects
    - Allocation of bandwidth to relevant groups
    - Final trigger table assembled by trigger coordinator
    - Spokesperson approval
  - We then decided to check how things work at the Tevatron by consulting the trigger coordinators:
    - Jonathon Lewis (FNAL) for CDF
    - Marco Verzocchi (FNAL) for D0
  - This helped us to formulate a more workable draft plan.

The Experience

- Summary of key observations in common
  - They strongly (categorically) reject allocation of bandwidth
  - Emphasize the difficulty of estimating trigger rates
  - Advocate the use of global trigger tools and special datasets

CDF Operation

- Trigger and Datasets Working Group (TDWG)
  - Chairman that has final authority over decisions on trigger table content
  - Unpopular decisions must be taken very often.
  - Chairman must have a broad view of the physics program.
- Triggers established on the basis of need and balancing of priorities.
- Several standard trigger tables are available at any given time.
- Dynamic pre-scales maximize efficiency.
  - Fixed triggers for main signal samples.
  - Triggers for background, biases, operation studies can be pre-scaled.
  - Pre-scales are dynamic: At high luminosity they are high to make room for the fixed triggers. At low luminosity the pre-scales are relaxed.
- L3 trigger
  - To always be in a position to understand the L3 decisions, CDF operates L3 by first creating a set of standard analysis objects that are used for all trigger decisions and which are output as part of the event.
  - Warned against using filters (needs clarification)

CDF experience

- Allocation of bandwidth creates inherent inefficiency
- Predicting trigger rates at higher luminosities is doable (but only with data from *this* experiment)
  - CDF Run 1 data failed to predict CDF Run 2 rates despite the same central calorimeter and similar central & muon chamber…
  - But, At any given luminosity, a fraction of events will have significantly more interactions per bunch crossing than average.
  - These events provide the most reliable estimates of trigger rate changes with increasing luminosity.

CDF Experience (2)

- Initially the bandwidth required for background samples is very high but diminishes over time - sometimes by many orders of magnitude.
- Since triggers are associated with specific programs, it is possible for them to be retired with those programs.
  - E.g. when an analysis becomes systematics limited.
- If a trigger has an unacceptably high rate, it has been found to effective to tell the proponents to raise thresholds or be pre-scaled…

D0 Operations

- D0 has a Trigger Board (TB)
  - meets regularly to discuss trigger-list changes, priorities, etc.
  - Every physics group has representatives in the TB.
  - There are also a few at-large members (wise people with trigger and physics knowledge).
  - Has been an open meeting with frequent personality clashes.
- D0 originally made the various physics groups responsible for trigger design and rate estimates.
  - This led to an inherent inefficiency and additional conflicts.
  - Each group would come up with a different version of a particular trigger (e.g. inclusive electrons) and then it was incredibly difficult to get them to converge on one trigger.
- Therefore formed a trigger studies group (TSG).
  - In practice the TSG and TB have a very large overlap but they nevertheless are both needed because they address different things.
- The TSG in conjunction with the TB allows triggers to be designed centrally and this has several benefits:
  - "…a scheme in which trigger studies are centralized encourages the sharing of the work (and of the trigger bandwidth) much more than a scheme in which each physics group is on its own."

Do Experience

- The TB chair originally reported to the spokespeople but now the TB and TSG are under the physics coordinator.
  - Two reasons.
    1. the physics coordinator had more control over the manpower needed to make the relevant studies.
    2. It was important to have the physics coordinator more directly involved in the process.
- Prediction of rates.
  - For a single trigger this is not such a problem but for N»1 triggers things can be complicated as a result of correlations.
  - MC turns out to generally do a poor job of estimating total rates
  - Issue of non-linearities

D0 Tools

  - "This tells you quickly what was the challenge for the trigger list design and why an approach based on bandwidth allocation (to physics groups, to final states,....) doesn't work. How do you count the bandwidth of electron (single, di-electron, plus muon, plus tau, plus track, plus jet) triggers ? That becomes quickly a nightmare and essentially this is a doomed approach."

- D0 found that the whole process was improved when they were able to provide all the relevant parties with tools for using the data to measure and predict rates for an entire trigger list.
- This allows proponents of new triggers or changes to existing triggers to take into account all the correlations with the other triggers.

D0 Lessons

- The most important lesson they learned is that it is important to make people think about the impact of their trigger list changes on the entire trigger list.
  - This improves rate predictions and greatly diminishes conflicts.
    - This is particularly important when OR'ed triggers are used for which one has a huge number of correlations.
- The other lesson they learned is that you want to put people in charge of trigger list design who are capable of seeing the big picture of the full program of the experiment.
  - Benefit of speeding the adjustments to rising luminosities.

A Draft Plan for CMS

- Integrate “lessons learned” at the Tevatron, namely:
  - Keep a close and active link between the physics and trigger.
  - Trigger studies shall maintain a “global view” in that the effect of each trigger is studied in the context of the full trigger table.
    - The early, wide and well documented deployment of tools that enable users in physics groups to evaluate the effects of various changes to the triggers – always on the global trigger menu – is imperative for involving the collaboration and creating an efficient trigger/physics team.
  - Bandwidth allocations should be avoided.
    - Perhaps initially some “indicative budget” can be given to broad categories, like “detector studies” vs “physics”.

Driving Principles

- Trigger tables shall optimize the entire physics program of the experiment.
- Individual triggers will be designed to fulfill the needs of specific programs.
- There will be no a-priori bandwidth allocations,
  - Though guidelines may be given prior to first datataking

Organization

- Sharing of bandwidth will be established by a Trigger Executive Board (TEB)
  - Chaired by the Trigger coordinator
  - Representatives of all relevant of the CMS programs
  - Goal : review all program needs and priorities to establish trigger tables that optimize the fulfillment of the needs of the experimental program of CMS to the greatest extent possible.
- Integrating the various trigger codes (especially for the High-Level Trigger) will be carried out in a dedicated group, the Trigger Studies Group (TSG).
  - TSG will have representatives and receive contributions from all the detector performance groups, the physics object groups and the physics analysis groups.
  - The TSG is also charged with providing tools that are made widely available and easily usable to determine the effect of individual triggers in the overall trigger menu of the experiment.

Trigger Coordinator and TEB

- The trigger coordinator will be the person who is responsible for the determination of the trigger tables and the associated datasets.
  - Those will then be presented to the spokesperson for the final approval.
- The Trigger Coordinator will chair a regular meeting of the Trigger Executive Board (TEB) w/ representatives as noted earlier
  - Experts may be invited to make presentations to the TEB to justify the addition of new triggers or changes to triggers. Presentations will include the results of whatever studies were performed to establish:
    - The efficacy of the trigger for fulfillment of the needs of the program.
    - The bandwidth burdens of the trigger in question as a function of instantaneous luminosities in the range of current and anticipated near-term luminosities.
- The coordinators who are members of TEB will, in turn, meet with their relevant sub-group coordinators to establish the trigger needs, and the associated configurations and settings that are dictated by the needs of their programs.

TSG & TEB

- The trigger studies group shall be responsible for
  - providing tools that allow any proponents of new triggers or changes to existing triggers to assess the impact of their new or changed triggers on the total rates of the current trigger tables
- TEB meetings will focus on modifications to the trigger tables and a consensus for final tables will be established.
  - In the event that a consensus cannot be reached on all items, the trigger coordinator will resolve all conflicts to establish final tables.

Summary of Key Points

- Trigger tables will be established by prioritization of needs to optimize the physics program as a whole.
- Cases for specific triggers and thresholds will be presented to the TEB.
- The TEB shall make every attempt to arrive at a consensus agreement of trigger tables at each meeting.
- The TEB chair (CMS Trigger Coordinator) will have the authority and responsibility to form the final recommendations on all triggers and datasets to the CMS spokesperson.
- The Trigger Studies Group will be responsible for providing and maintaining widely accessible tools and datasets to be used for trigger rate estimates.