The Trigger Simulator

Trigger Commissioning Meeting

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Outline

- Intro
- D0TrigSim on MC
- D0TrigSim on Data
- Analyze Without Sim on Data
- Configuration (Lists)
- Comparing Online and Offline
- Current Status
- Sample Analysis from Physics Group
- Problems/Missing Features

Intro

- The d0trigsim package produces a combined L1/L2/L3 executable capable of running on Data or MC inputs and producing ntuple and DSPACK output.
- Homepage: http://www-d0.fnal.gov/computing/trigsim/trigsim.html
- Mailing list: d0trigsim-users@fnal.gov
- Executable Manager: Dugan O'Neil

D0TrigSim on MC

- Input to D0TrigSim is a RawDataChunk. This is the output of d0sim on the MC farms. Can also be kept in reco output.
- Running on MC is the default configuration for D0TrigSim:

```
setup D0RunII p12.02.00
setup d0tools -t
runD0TrigSim -filelist=myfiles.txt
```

D0TrigSim on MC -2

- Runs L1 muon, cal, cps, ctt and L2 and L3 algos specified in triggerlist. Default list is hand-written. Can use triggerdatabase-generated lists...will discuss later.
- Analysis is done by either looking at ntuple output of trigsim directly or by processing DSPACK file output through d0_analyze and looking at ntuple.
- Should be part of MC farm chain so that trigger info is present in outputfiles. On Ian's schedule for September. Requires triggerlist to be specified.

D0TrigSim on Data

- Everything is harder with data. People keep changing the trigger! The nerve...
- Instructions for running aren't that different:

```
setup D0RunII p12.02.00
setup d0tools -t
runD0TrigSim -filelist=myfiles.txt
             -rcp=runD0TrigSim_data.rcp
```

- However, everyone wants to run on RECENT data. trigsim falls behind and users get frustrated.
- L1 packages go into "pass-through" mode (if possible) and pass online results to L2 and L3. L2 and L3 simulate.

Analyze Without Sim on Data

- Analyze packages for all three levels of the trigger run on Raw data or MC inputs.
- d0_analyze runs on FNAL production farm. Output ntuple contains branches from reco and trigger info from each of the 3 levels.
- Can mix analyze and Sim. eg. run D0TrigSim with L1/L2 analyze-only and L3 sim. Editing D0TrigSim top level rcp can completely change behaviour.

Configuration (Trigger Lists)

- d0trigsim uses three types of configuration files
  1. rcps
  2. calibration/equation files
  3. a trigger list
- rcps and calib files should be fine with sensible defaults. Trigger list is more tricky.
- We want a default list which exercises all certified or nearly certified filters and tools. Physics group input welcome but not essential in first instance.

Configuration (Trigger Lists) -2

- Users can use their own trigger lists by passing them on the commandline:

```
runD0TrigSim -filelist=blah.txt -trglst=mylist.xml
```

- This causes COORSIM to be run on the XML file and the outputted *.sim files are used to configure D0TrigSim. Issues:
  - People want latest online list. Offline release of COOR cannot keep up with online version. How do we run COOR and D0TrigSim within a single release?

Configuration (Trigger Lists) -3

- Users cannot create their own trigger lists using trigger database. Have been using objects in ntuple instead. This becomes more difficult in time. L3 needs a good list, L2 global will start matching at some point...
- L3 configures some things through XML file which are not really part of the triggerlist. For example, what unpacking, calib, etc. are used for data/MC for a certain time period changes.

- Once you have used COOR to generate *.sim config files you may simply keep reusing them. Create “trigsim” subdir and copy them in there and D0TrigSim will find them.

Comparing Online and Offline

- Two types of comparisons: bit-by-bit and ntuple-based.
- Bit-by-bit involves saving two RDCs and two L3 chunks (online and offline) and using a program to check them at the bit level. Oklahoma (Xiaojian Zhang) is doing this for the RDC (L2).
- Ntuple-based involves running analyze packages twice so that you get online and offline braches in ntuple. Then plot both types of quantities. Can run both in same executable (works now) or can save two sets of chunks to file and choose between them (on the task-list).

Current Status

- in P11, MC with default trigger list certified since p11.08. See certification webpage. Just starting to do certification for multiple lists (including online lists). Should also add certification on data.
- P11 does not handle new data (new L1Cal pedestals, gains, etc.) well without some work on part of user.
- P12 certification is highest priority. Want to move online L2 and online L3 to p12 as soon as possible

Analysis from Physics Group

- Lukas Phaf has recently done a study of e+jets triggers for the top group. He uses d0trigsim on MC for signal and data for background. Nice writeup exists:

  http://www-d0.fnal.gov/Run2Physics/top/d0_private/wg/triggers

  ....follow the e+jets link.

- On data he used L2 objects from the online data and simulated L3, obtained L2 and L3 rejections, overlaps with selected other triggers.

Here we will describe the e+jets trigger studies for $t\bar{t}$ and Single Top.

1 Trigger system

The trigger studied uses all levels of the D0 trigger. For now, only calorimeter information is used in the e+jets triggers. The available calorimeter triggers are described in the following subsections.

1.1 L1

At L1, calorimeter triggering is based on towers. The size of these is 0.2x0.2 in $\eta x \phi$ space. Both the energy deposited in the EM part of the tower (the first 4 layers) and the total energy deposited in the tower is available. Trigger can be set to require a number of both EM and total towers above certain thresholds. An example is CEM(1,10)CJT(2,5). This requires an EM tower above 10 GeV, and two total (jet) towers above 5 GeV. It should be noted that the EM and total towers are not exclusive, so the EM tower above 10 GeV will also count as one of the total towers.

1.2 L2

At L2, trigger decisions are also based on towers. L2 receives from L1 all trigger towers, both the EM E_T and total E_T. L1 also sends two seed masks (one for EM and one for total), which have bits for every trigger tower. The EM bit is set to 1 if the trigger tower has at least 1 GeV EM E_T. The total bit is set to 1 if the trigger tower has at least 2 GeV total E_T. The L2 cal algorithms will only attempt to find jets or electrons around trigger towers for which the seed bit is set. Electromagnetic (EM) and jet objects are handled in different ways.

1.2.1 EM objects

For every seed tower, the neighbour with the largest ET deposit is found, out of the 4 neighbouring towers. The seed tower and its largest neighbour form the L2 electron. The total E_T of the electron is the sum of the energy deposited in the two EM towers. The EM fraction of the electron is the sum of the EM E_T's of the two trigger towers divided by the sum of the tot E_T's of the two trigger towers. Trigger requirements can be both on E_T and EM fraction of the L2 electrons.

1.2.2 Jet objects

All energy deposited in the seed tower and all 8 of its neighbours is added, and this is defined as a L2 jet. The E_T of the L2 jet is the sum of the total energy deposited in these 9 towers. Trigger requirements are on the number and E_T of the L2 jets.

1.2.3 Overlap between L2 electrons and L2 jets

Because of the algorithm used, all L2 electrons that pass a certain E_T requirement will also pass as a L2 jet of the same E_T.

1.3 L3

At L3, the full cell information of the calorimeter is available. Again, L3 electrons and jets are treated differently.

1.3.1 L3 electrons

L3 electrons start out using a narrow cone (0.4) jet algorithm (based on towers). This defines the electron cluster. In the next step, only cells with a dR of 0.25 around the axis of this cluser are used to define the electron object. Trigger requirements can be both on the E_T (which is the sum

Sample Analysis from Physics Grou

L2 L2EM(1,W,0.85) L2JET(2,X)
L3 L3EM(1,Y,0.90) L3JET(2,Z)
The W,X,Y and Z are E_T thresholds, and the 0.85 and 0.90 are EM fractions. Also, the effect of using shower shape on L3EM objects was studied. If shower shape cut is on, the following cuts are used on the width of EM1, EM2 and EM3: $W_1 < 0.09$, $W_2 < 0.08$, $W_3 < 0.05$.

L1 and L2 only look at a restricted η range of $|\eta| < 2.4$, because that is what is available in the detector hardware.

3.1 Rejections and rates

The following table shows the trigger rejections and rates (at instantanious luminosity of 30E30), calculated from real data run 160686. The L1 rate at this luminosity is 60 Hz.

L2	L2 rej.	L2 rate (Hz)	L3	L3 rej.	L3 rate (Hz)
L2EM(1,5)L2JET(1,8)	1.3	46	-	1.0	46
L2EM(1,8)L2JET(2,8)	1.7	35	L3EM(1,15)L3JET(2,15)	3.0	12
L2EM(1,10)L2JET(2,10)	2.1	29	L3EM(1,15)L3JET(2,15)	2.7	11
L2EM(1,10)L2JET(2,10)	2.1	29	L3EM(1,15)L3JET(2,20)	3.3	9
L2EM(1,10)L2JET(2,10)	2.1	29	L3EM(1,20)L3JET(2,20)	6.4	5
L2EM(1,10)L2JET(2,10)	2.1	29	L3EM(1,15,sh)L3JET(2,15)	6.6	4

3.2 Overlap with other triggers

The trigger rates calculated above are exclusive rates. The increase in rate that comes from including these triggers might be much smaller, because there could be overlap with (existing) triggers. Therefor, we calculated the overlap of
L1 CEM(1,10)CJT(2,5)
L2 L2EM(1,10,0.85) L2JET(2,10)
L3 L3EM(1,15,0.90) L3JET(2,15)
(with L3EM with an without shower shape) with other triggers.

58 % of events that pass this trigger WITHOUT shower shape would have also passed CEM(1,15) L3EM(1,15,0.90).

60 % of events that pass this trigger WITH shower shape would also pass CEM(1,10) L3EM(1,20,0.90,sh).

3.3 Efficiencies

The following table show the total trigger efficiencies for the different signals.

L2	L3	$t\bar{t}$(tot)	s chan.	2to2	Wg fusion
L2EM(1,8)L2JET(2,8)	L3EM(1,15)L3JET(2,15)	81.5 %	75.7 %	71.9 %	73.3 %
L2EM(1,10)L2JET(2,10)	L3EM(1,15)L3JET(2,15)	81.4 %	75.5 %	71.5 %	73.4 %
L2EM(1,10)L2JET(2,10)	L3EM(1,15)L3JET(2,20)	81.4 %	74.6 %	70.5 %	72.3 %
L2EM(1,10)L2JET(2,10)	L3EM(1,20)L3JET(2,20)	74.5 %	68.2 %	63.2 %	67.0 %
L2EM(1,10)L2JET(2,10)	L3EM(1,15,sh)L3JET(2,15)	75.0 %	71.2 %	68.3 %	69.8 %

For $t\bar{t}$, the L1, L2 and L3 efficiencies are given in the table below. Here, L2 efficiency means the percentage of MC events that have passed L1 that also pass L2.

L2 trigger	L3 trigger	L1 eff.	L2 eff.	L3 eff.
L2EM(1,8)L2JET(2,8)	L3EM(1,15)L3JET(2,15)	98.8 %	97.2 %	84.9 %
L2EM(1,10)L2JET(2,10)	L3EM(1,15)L3JET(2,15)	98.8 %	96.0 %	85.9 %
L2EM(1,10)L2JET(2,10)	L3EM(1,15)L3JET(2,20)	98.8 %	96.0 %	85.9 %
L2EM(1,10)L2JET(2,10)	L3EM(1,20)L3JET(2,20)	98.8 %	96.0 %	78.6 %
L2EM(1,10)L2JET(2,10)	L3EM(1,15,sh)L3JET(2,15)	98.8 %	96.0 %	79.1 %

Problem Summary

- Trigger simulator lags behind hardware. Hardware is still changing rapidly.
- Several issues with configuration. How can users create their own lists? Get right version of COOR? Remove hand-editing L3 configurations in XML file. Others?
- Documentation is behind. Once situation departs from default test (MC inputs, default trigger list) docs are very limited.
- Certification has gotten much better lately (thanks Josh Dyer!) still need to add data, multiple lists, more automation, etc.