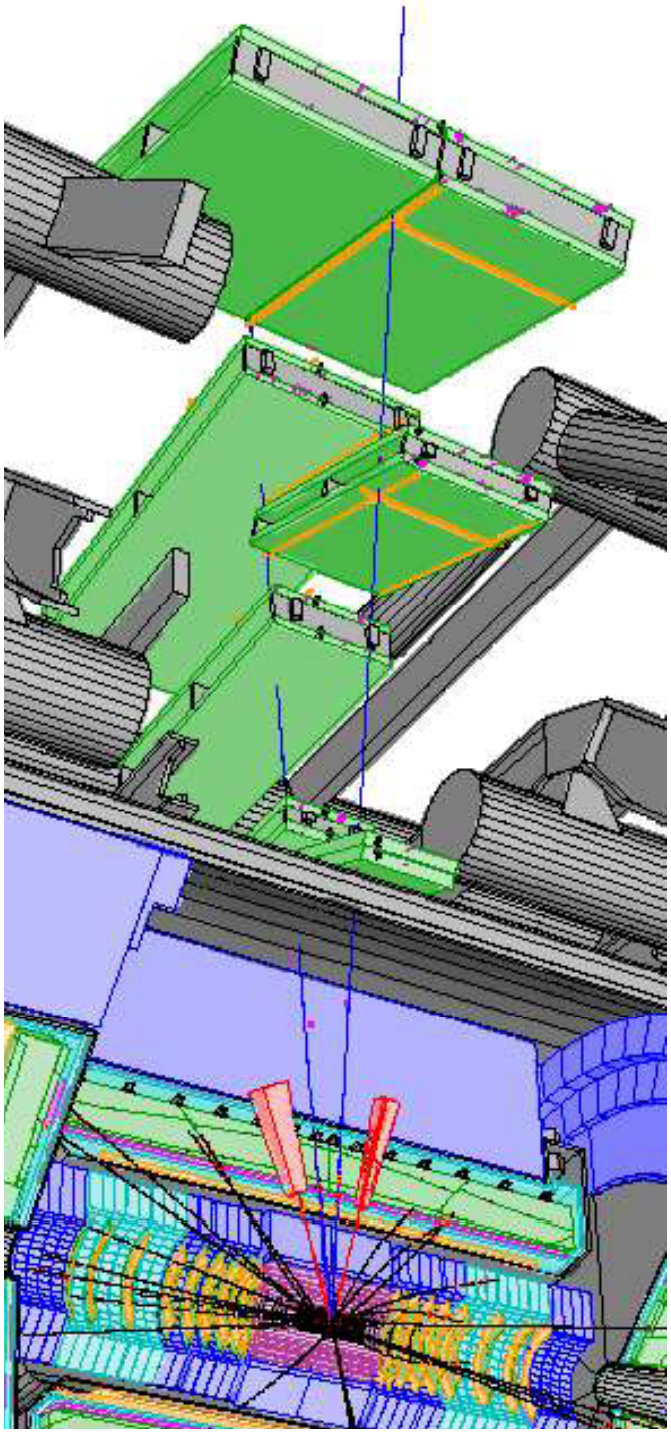

Summary of Higgs Trigger

Higgs Working Group – April 10, 2008

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- The aim of this talk is to review the trigger content of the Higgs CSC analyses and identify:
  - Where needed items were missing from the trigger menu
  - What items need further study in the Higgs group
  - What items need work from the trigger group
  - What triggers can be expected to need higher thresholds

- Outline:
  - News on menu and naming convention
  - Summary of rel.12 triggers used in Higgs CSC
  - Review of signatures and their status
  - Review of analyses/notes

Trigger Menus

- From 11 April 07 Higgs WG meeting:
- Today about 200 chains in each HLT level
- Prescale and passthrough factors, streams, monitoring groups, etc
- Separate menus for:
  - L=10^{31} **well developed**
  - L=10^{32} **optimizing…**
  - L=10^{33} skeleton menu for **for FDR2**

See menus meeting yesterday

Note naming conventions (active topic, also see yesterday's meeting)

What exists in 12.0.6

- 12.0.6.x used for CSC production;
  - Use CSC-06 configuration:

```
TrigT1ConfigVersion="CSC-06"
TrigHLTConfigVersion="CSC-06"
```

- Main physics trigger signatures:

Slice	HLT signatures	Starting from L1 items:	Comments
Electron	2e15i, e25i, e60	2EM15, 2EM25, EM60	No isolation in L1 items; e25i ~realistic
Photon	2g20i, g60	2EM15I, EM60	Start from L1 items with isolation
Muon	mu6, mu20i	MU06, MU20	No isol; mu20i ~realistic; L1 p_T ordering
Tau	tau10i, tau15i, tau20i, tau25i, tau35i	TAU10i, TAU15i, TAU20i, TAU25i, TAU35i	
Jet	j160, 2j120, 3j65, 4j50	J45, 2J45, 3J45, 4J45	L1_J45 not realistic
ETmiss	met10	TAU05	Starts from L1 tau

- In addition, many technical or "expert" signatures for performance studies

Ricardo Goncalo, RHUL Higgs WG, 11 Apr 07 3

https://twiki.cern.ch/twiki/bin/view/Atlas/TriggerMenuConvention

Trigger naming convention

- Still a hot topic as new use cases appear
  - See Srini's talk at Menus meeting yesterday: http://indico.cern.ch/conferenceDisplay.py?confId=24862

- Naming convention for chain names
  - **<LEVEL>_<#><type><threshold><info>_<STRING>**
  - e.g. **EF_2e15i_loosecalo**

- Latest thinking is:
  - Avoid adding luminosity to trigger names (e.g. EF_e22i_L33)
  - If needed simultaneously, have "_loose", "_medium", "_tight" (e.g. EF_e22i_medium)
  - If more needed, have "_loose1", "_loose2",… (increasingly tight selection)
  - **Chains have names and versions in trigger database**
    - Allows for small optimizations of selection short of a p_T cut change
    - Means name will not be unique, but should characterize set of similar versions (unfeasible to keep names unique for 15 years)
    - Will allow long-term high-p_T signatures to remain roughly the same

Review of triggers relevant to Higgs analysis

- Look at differences between menu in rel.12 and 13
- Review list of high-priority triggers for the Higgs group

	HG1	HG2	HG3 ll , lh	HG3 hh	HG4 ll	HG5	HG6	HG7 ll	HG7 lh hh	HG8	HG9 VBF	HG9 ZH	HG10
2g20i													
g60													
mu20													
e25i													
e60													
2mu10													
2e15i													
e15i + mu10													
tau													
tau-tau													
tau35i + MET40													
XE70/80													
e25i+MET30													
mu20+ MET30													
tau35i +MET40 +3j20													
Forward jets (23)													

Green: trigger studied in some detail
Orange: not very performant
Blue: needs to be studied in more detail, or missing in the physics trigger menu

mu20

- mu20 prototype high-p_T muon signature; used in 8 CSC notes
- Isolation will be added only in rel.14; needed for high lumi
- Expect about 25% of bandwidth for muon triggers (rough impression)
- Following numbers from:
  - 10^{31} menu: http://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=24859, MA-Dufour's talk 17/1/08, Menus meeting
  - 10^{32} menu: http://www.hep.physics.mcgill.ca/people/dufourma/public/trigger_rates/AtlasPoint1_rel0/dijets_combined_1e32.xml, M-A Dufour's talk yesterday's Menus meeting)
  - 2x10^{33} menu: Trigger Menus CSC note (draft 9Apr08)

Luminosity	Trigger	Rate	Obs.
10^{31} cm^{-2}s^{-1}	mu15	5.7 ±0.8 Hz	**Can remain unprescaled and as single-object triggers at low lumi: multiple similar signatures for studies**
	mu20	1.9 ±0.4 Hz	
10^{32} cm^{-2}s^{-1}	mu20	29 ±6 Hz	**Perhaps still ok if other muon triggers not very expensive**
2x10^{33} cm^{-2}s^{-1}	mu20i (?)	40 Hz (?)	**No EW processes (relevant at 10^{33})**

e25i and e60

- e25i prototype high-p_T electron signature; used in 7 CSC notes
  - Becomes e22i in new naming convention
  - Should be ok for 10^{32} after optimisation (~1/3 of BW for e/γtriggers)
- Higher-p_T non-isolated signature e60 needed to complement e25i
  - Efficiency loss due to isolation cuts appears at high p_T
  - Replaced by higher threshold in release 13: e105
  - Used in 1 note but useful in 7 notes (being studied for 5)

Luminosity	Trigger	Rate	Obs.
10^{31} $cm^{-2}s^{-1}$	e20i	3.2 ±0.6 Hz	**Menu optimized for low lumi but contains some high-lumi triggers**
	e22i_L33	1.4±0.4 Hz	
	e25i	2.0±0.5 Hz	**"_L33" likely to change**
	e55_L33	0.1±0.1 Hz	
	e105	0 Hz	**New higher-pT signature e105**
10^{31} $cm^{-2}s^{-1}$	e25i_tight	15.6±4 Hz	**Menu still being optimized**
	e105	0.4±0.6 Hz	
$2x10^{33}$ $cm^{-2}s^{-1}$	e22i (?)	40 Hz (?!!)	**Needs more study**

2e15i

- Double electron signature; used in 3 CSC notes
- Becomes e12i in new naming convention
- Triggers e12, e15 and e15i exist unprescaled in 10^{31} menu, as well as 2e15
- Should be ok for 10^{32} and 10^{33}

Luminosity	Trigger	Rate	Obs.
10^{31} cm^{-2}s^{-1}	e12	19 $\pm$1 Hz	**Can remain unprescaled and as single-object triggers at low lumi: multiple similar signatures for studies**
	e15	7.6 $\pm$0.9 Hz	
	e15i	5.4 $\pm$0.9Hz	
	2e12_L33	0.1 $\pm$0.1 Hz	**Double object has negligible rate**
10^{32} cm^{-2}s^{-1}	2e15i	<1 Hz	**Double object has negligible rate**
2x10^{33} cm^{-2}s^{-1}	2e12i (?)	<1 Hz (?)	**Needs confirmation**

2g20i and g60

- Single and double photon signatures; used in 1 CSC note
- 2g20i should be g17i in new naming scheme
- New complementary signature g105 to compensate for losses due to L1 isolation
- Should be ok for 10^{32} and 10^{33}

Luminosity	Trigger	Rate	Obs.
10^{31} cm^{-2}s^{-1}	g20i	6 $\pm$0.8 Hz	**Can remain unprescaled and as single-object triggers at low lumi**
	g55_L33	0.2 $\pm$0.1Hz	
	g105	0 Hz	**Higher-pT signatures cheap in rate**
	2g17i_L33	0 Hz	**Double object has negligible rate**
10^{32} cm^{-2}s^{-1}	g105	1.1 $\pm$1.1 Hz	
	2g20	0.4 $\pm$0.6Hz	**Double object has negligible rate; not sure what actual p_T cut is**
2x10^{33} cm^{-2}s^{-1}	2g17i (?)	2 Hz (?)	**Needs confirmation**

Tau/ETmiss

- Single and double tau signatures; used in 3 CSC notes
  - Hadronic taus hard to identify and reconstruct
  - Essential for a few channels
- ETmiss also essential for some channels
  - Difficult trigger: sensitive to every detector systematic effect
  - Slow turn-on curve: must have high thresholds

Luminosity	Trigger	Rate	Obs.
	tau60	2.4 ± 0.5 Hz	**Can remain unprescaled and as single-object triggers at low lumi**
	tau100	0.2 ± 0.1Hz	
	xe70	0.2 ± 0.1 Hz	**Lowest unprescaled ETmiss threshold**
10^{31} $cm^{-2}s^{-1}$	2tau35i	1.4 ± 0.4Hz	**Under study for HG3**
	xe70	4.1 ± 2 Hz	**Unprescaled**
$2x10^{33}$ $cm^{-2}s^{-1}$	tau35i_xe45	5 Hz	**Needs confirmation**

Review of trigger sections in Higgs analysis

- Some quick remarks on the trigger sections of each note

Loose remarks…

- **Trigger rates:**
- Should be provided by the trigger group using validated tools
- Should not be included in Physics CSC notes; a reference to the appropriate trigger note should be included instead
- Rates estimated using a biased sample were included in one note leading to differences wrt trigger validated numbers (760Hz vs 140Hz at L1_2g20i)

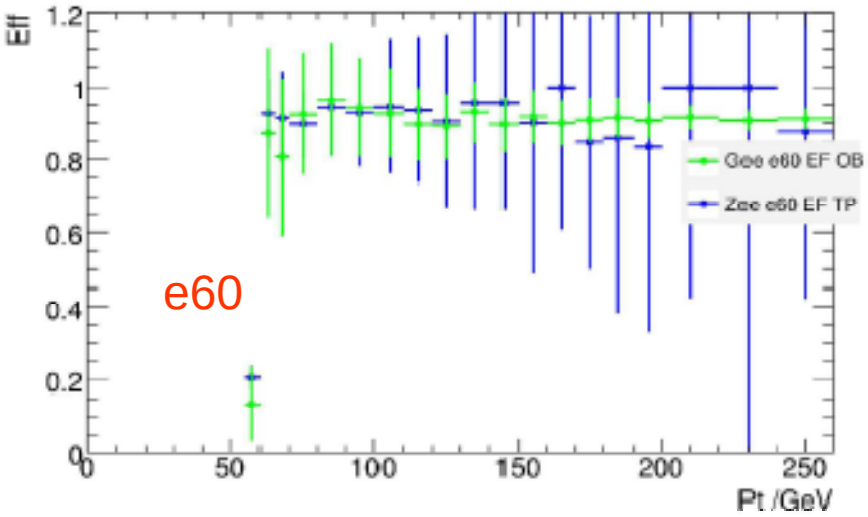
	J17 Dijet rates		
Trigger Level	2g20i	g60	2g20i || g60
LVL1	140 ± 10 Hz	960± 25 Hz	1100 ± 30 Hz
LVL2 Calo	4.7 ± 1.6 Hz	46 ± 5 Hz	50. ± 5 Hz
EF Calo	1.6 ± 1 Hz	14 ± 3 Hz	16. ± 3 Hz

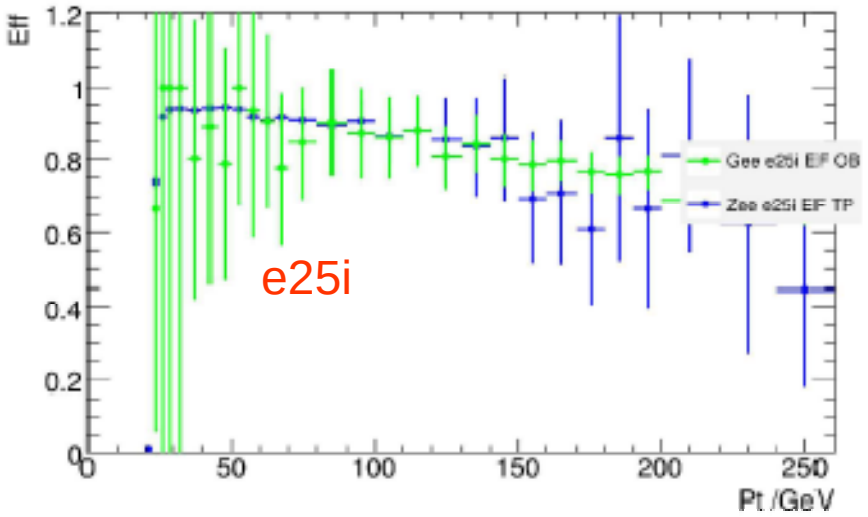
Table 9: Dijet rates of J70 sample for 2g20i, g60 and 2g20i||g60 trigger menus.

F.Monticelli, estimated with release 12 and di-jet data

L1 isolation in e/γ triggers

- **Efficiency drop at high-p_T:** in electron and photon signatures caused by isolation cuts at L1
- Use a high-p_T non-isolated signature together with a lower-p_T isolated one



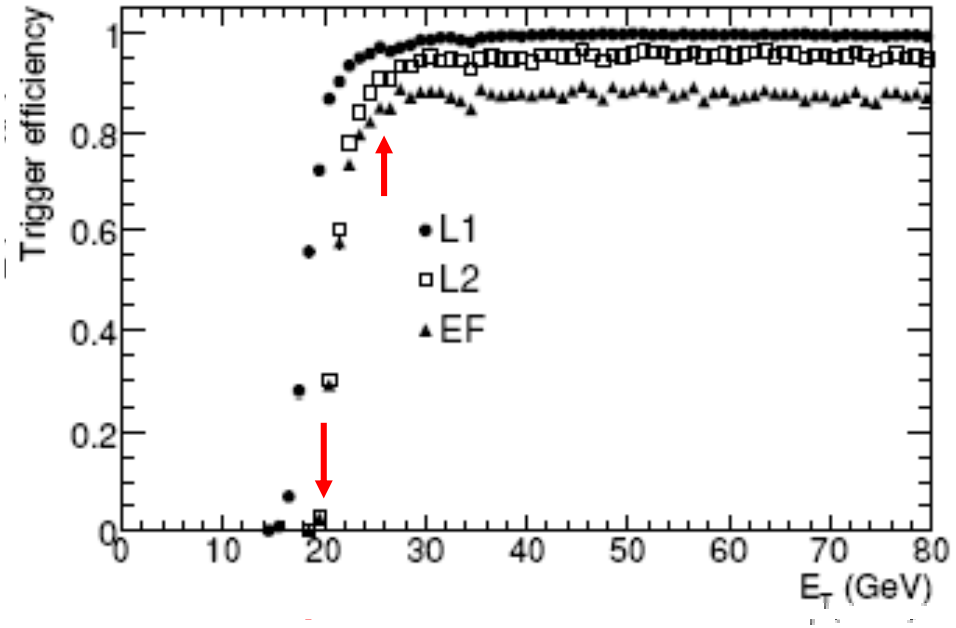


M.Tamsett, TAPM egamma 29/11/07

Analysis cuts

- **Know your trigger**
- In new naming scheme, cut is indicated in chain name. Analysis cuts need to reflect that. E.g. if requiring e22i need to have analysis cut on electron p_T at ~25 GeV or more

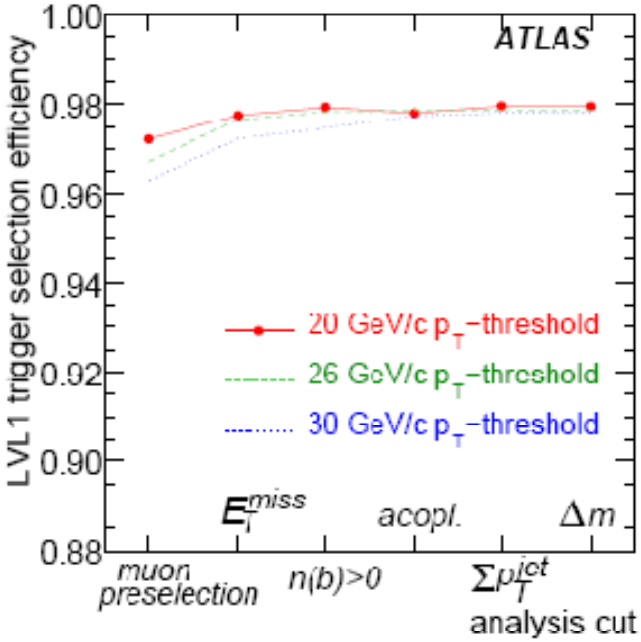
- In some cases, analysis request e.g. a 6 GeV muon but use the mu20i trigger to select data. This increases the analysis sensitivity to systematic effects happening in the trigger (miscalibration, misalignment, wrong energy scale, etc)

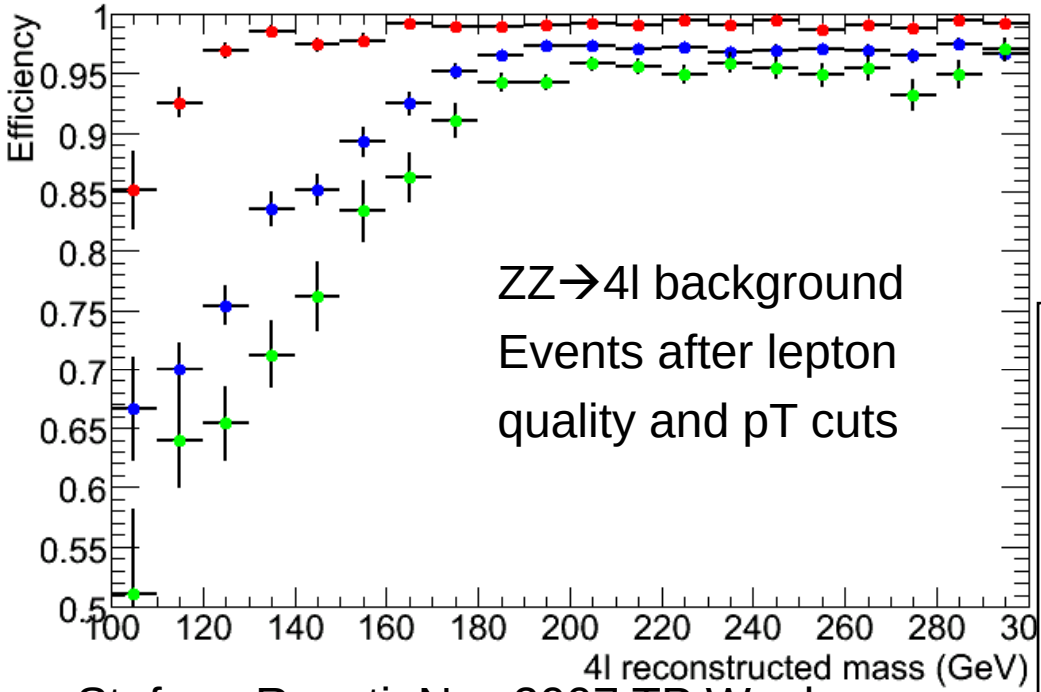


Worry about systematics!

- **Be worried, be very worried!**
- Estimate all systematic uncertainties
- Re-run the trigger hypothesis with different cuts or
- E.g. move the ET cut by 5 GeV
- Evaluate effect on your measurement (number of events, shape of distribution, invariant mass)

HG8 CSC draft 17/3/08





ZZ→4l background

Events after lepton quality and pT cuts

- mu10 and e15i or 2mu10 or 2e15i
- mu20 and e25i or 2mu20 or 2e25i
- mu25 and e30i or 2mu25 or 2e30i

Stefano Rosati, Nov.2007 TP Week

Trigger rates

- In some cases, more work by the trigger group is needed to reliably calculate rates:
  - Updated cross sections of heavy flavour production
  - In-flight decay of flavoured particles,
  - EW corrections (at some point need to include Drell-Yan, W production etc
- In some cases good solutions exist: e.g. mu20 →mu20i : rate reduced by a factor of 10 : L=10^{33} , rate =13 Hz
- Some thresholds will for sure need to change

Event Filter muon trigger rates						
	$L = 10^{31} cm^{-2} s^{-1}$		$L = 10^{33} cm^{-2} s^{-1}$		$L = 10^{34} cm^{-2} s^{-1}$	
	Barrel (Hz)	Endcaps (Hz)	Barrel (Hz)	Endcaps (Hz)	Barrel (Hz)	Endcaps (Hz)
	4 GeV/c		6 GeV/c		20 GeV/c	
π/K	125	119	1900	1200	50	40
beauty	44	56	1900	2200	220	380
charm	60	76	2400	2800	260	330
top	0	0	0	0	0	0
W	0	0	3	4	20	30
TOTAL	229	251	6200	6200	550	780
	5 GeV/c		8 GeV/c		40 GeV/c	
π/K	36	25	290	260	0.1	0.2
beauty	27	33	550	800	10.5	16.3
charm	36	43	640	930	7.1	11.1
top	0	0	0	0	0.1	0.1
W	0	0	3	4	3.9	6.1
TOTAL	99	101	1480	1990	21.7	33.8

Table 8: Single muon trigger rates at EF muon combined, for various low and high p_T thresholds, at L = $10^{31} cm^{-2} s^{-1}$, L = $10^{33} cm^{-2} s^{-1}$ and L = $10^{34} cm^{-2} s^{-1}$.

Muon trigger CSC note

Conclusions & Outlook

- Most notes have a healthy trigger section and show that efficiencies are high and channels are feasible
- In some cases we have found that the analysis depends critically on the trigger performance: HG3, HG9, HG10… i.e. trigger work must continue
- High-priority triggers for the Higgs group (or their rel.13 equivalents):
  - **e/gamma**: 2g20i, g60, mu20, e25i, e60, 2e15i
  - **muons**: 2mu10
  - **tau**: 2tauXXi (2tau35i?)
  - **ETmiss**: XE70, XE80 (threshold will need to increase)
  - **Mixed**: tau35i_xe40, e15i_mu10, e25i_xe30, mu20_xe30, tau35i_xe40_3j20 (tau35i_xe40 exists)
  - **Forward jets** (in the menu since rel.13.0.40.x)
    - Missing in the current menu
  - **Note**: high-priority work for trigger group must be to prepare for data
- Some of the thresholds are likely to increase, so analysis should not depend on the exact values
- Lots of work is still needed for each analysis, but a lot was accomplished with the CSC notes (final steps to go…)

Backup

Why it matters…

- Much of ATLAS physics means cross sections at least ~10^6 times smaller than total cross section
- For the Higgs group, think ~10^6 times smaller than total cross section
- 25ns bunch crossing interval (40 MHz)
- Offline storing/processing: ~200 Hz
  - ~5 events per million crossings!
- In **one second** at design luminosity:
  - 40 000 000 bunch crossings
  - ~2000 W events
  - ~500 Z events
  - ~10 top events
  - ~0.1 Higgs events?
  - **200 events written out**
- The right 200 events must be written out!