Trigger Menu Workshop

Higgs group contribution

Ricardo Gonçalo (RHUL)

Higgs WG meeting – 17th September, 2007

Trigger Menu

- Menus workshop Monday and Tuesday next week (24-25 Sep) at CERN
- Main focus is initial menus ($L=10^{31}cm^{-2}s^{-1}$)
- But will establish procedures for data taking phase – or at least start discussion
- Initially, trigger activity dominated by needs of detector commissioning and trigger itself
- Then physics priorities must lead the trigger menu
- Essential that Higgs WG has a say from the start

Note: some of what follows is just my personal assessment; please tell me when I'm wrong

Trigger Menus Workshop

- Define strategy for setting the menu and assigning bandwidth
  - Find needs from each detector and physics groups
    - What is necessary for calibration and alignment
    - What triggers are missing
- What to do if trigger has higher rate than expected
  - Prescale? Doesn't work for statistics-limited channels (e.g. searches).
  - Raise thresholds? May affect selected sample for some analyses
- What triggers must always be unprescaled?
- Establish procedure for adding new triggers
- What are the early priorities? (commissioning needs)
- Each existing trigger must have a justification and known clients

Question A)

- There is a proposed Trigger menu for 10^{31} which can be found at https://twiki.cern.ch/twiki/bin/view/Atlas/TriggerPhysicsMenu

A) We ask that you review this menu's suitability for the physics and performance issues relevant to your group. What is missing? What is the motivation for the desired triggers? Are there triggers that may not be needed, or for which a larger prescaling could be applied if the overall rate is too large? Which triggers are critical for measuring trigger and reconstruction efficiencies and background rejections.

- Most Higgs analyses are concerned with 10^{33} and $10^{34}cm^{-2}s^{-1}$, but the currently available plans are for $10^{31}cm^{-2}s^{-1}$

Question B)

B) What calibration/alignment triggers are needed [to be run concurrently with normal data taking runs]? How many events are needed and what kind of accuracy can you expect as a function of the assumed rate? Can you quantify the impact of a reduced rate on accuracy? [Note that: in some cases, a calibration trigger may be given special treatment in the TDAQ system so that only a subset of the detectors and/or only regions of interest are read out].

- Relevant for detector work, not so much in our case

Question C)

C) What triggers are absolutely "unprescalable" and why?

- Very relevant! May determine the fate of a channel

Question D)

D) What triggers MUST go into the express stream? What will you do with the express stream data sets? What is the impact if it goes only into the regular stream?

[Note: The events in the Express stream are complete events and contain a subset of the events sent to regular stream. Its purpose is to obtain rapid feedback, such as needed for Tier0 monitoring. Hence the question is what needs to be processed in a fast time-scale that can only be accomplished with your trigger in the express stream?]

- See talk by Szymon Gadomski in last TAPM open meeting: http://indico.cern.ch/conferenceDisplay.py?confId=15674 .
- ~10% of the rate
- No luminosity information
- Aimed at early problem detection – may be used to steer stream reconstruction
- Two kinds of triggers:
  - "Standard candles" for calibration (W, Z etc)
  - "Alert" triggers with low rate (<1 Hz or "consistent with zero"; to be defined)

Question E)

E) It can be difficult to estimate some rates, therefore what would you do if some trigger rates are higher than expected by a factors of 2, 5 or 10? Identify the triggers that are candidates for higher thresholds or prescales. Inversely, which triggers are candidates for lower thresholds or smaller prescales if the rates are half of the expected value?

Prescaled triggers become useless as source of signal for Higgs searches. Higher thresholds may affect the phase space that is investigated

Question F)

F) We are starting to consider the 10^{32} menu. New unprescaled triggers will be added at higher thresholds, prescales on 10^{31} triggers increased and perhaps some triggers dropped. We would like your preliminary thoughts on this.

- Must make sure this doesn't affect our ability to do some analyses – take into account in feedback given

What we should answer today

To help prepare this info for next week, each group was asked to answer these questions:

1. What is the ideal menu for each channel (at $L=10^{33}$ $cm^{-2}s^{-1}$ and higher) – i.e. triggers with high efficiency wrt the analysis baseline selection/preselection

2. How we plan to determine the trigger efficiency (or it's corresponding systematic error) and what is needed from the trigger to do this – orthogonal triggers, loose (prescaled) triggers, etc

3. What initial triggers would be useful – i.e. what data samples would be useful to study background shapes and reconstruction performance

Note on estimating trigger efficiency

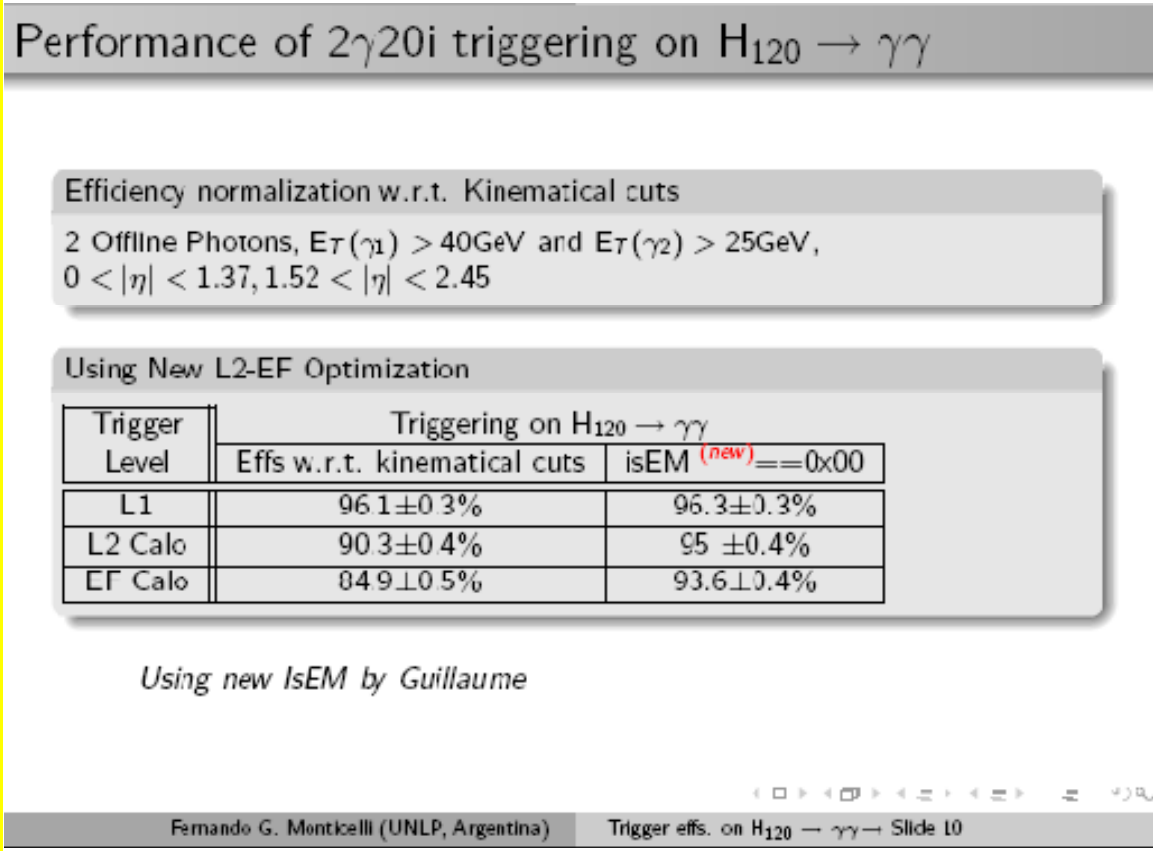
- Some ways of estimating efficiency:
  - Tag-and-probe: in sample passing 2-object selection, take one object (tag) and check how often other object (probe) passed single-object trigger
    - Gives e.g. single-lepton efficiency for an inclusive trigger
  - Bootstrap: random accepts $\rightarrow$ min.bias $\rightarrow$ loose/orthogonal triggers $\rightarrow$ selection trigger
    - Gives absolute efficiency of the whole chain, step by step – must be careful with bias
- The above methods are complex analyses on they own – too time consuming/technical for most physics analyses
- From an analysis point of view, in practice, would like to do just last step of bootstrap method
  - Most analyses can easily find efficiency from orthogonal trigger sample
- Propose that Trigger maintains efficiency and prescale table for loose “calibration” triggers for each running period

Higgs analyses

CSC note	subject	Triggers	editors
HG – 1	H -> gamma gamma	2γ20i; γ60	Leonardo Carminati
			Bruce Mellado
HG – 2	H -> 4l	μ20i; e25i	Aleandro Nisati
		plus: 2eXX; 2μYY; eXX_μYY; 3-lep; 4-lep	Stathis Paganis
HG – 3	VBF, H -> tau tau	Tau35i_xe40	Kyle Cranmer
		μXX_tauYY, eXX_tauYY under study	Soshi Tsuno
HG - 4	H -> WW	μ20i; e25i	Michael Duehrssen
		lepton+jets to be studied	Bill Quayle
HG - 5	ttH, H -> bb		Chris Collins-Tooth
			Lorenzo Feligioni
HG - 6	ttH, H -> WW		Huaqiao Zhang
HG - 7	H/A -> tau tau		Michael Heldmann
			Silvia Resconi
HG - 8	bbh/H/A, h/H/A -> mu mu	μ20i	Dimitrios Fassouliotis
			Sandra Horvat
HG - 9	H -> invisible		Pauline Gagnon
			Gerald Oakham
HG - 10	Charged Higgs		Martin Flechl
			Bjarte Mohn

HG1: inclusive H→γγ

- Ideal menu for normal running: 2γ20i
- "Unprescalable"
- Well studied and well suited to this channel – Fernando and Valeria working on γ trigger
- Efficiency determination: what's the plan?
- Early running plan established



Performance of 2γ20i triggering on $H_{120} \rightarrow \gamma\gamma$

Efficiency normalization w.r.t. Kinematical cuts

2 Offline Photons, $E_T(\gamma_1) > 40GeV$ and $E_T(\gamma_2) > 25GeV$,
$0 < |\eta| < 1.37, 1.52 < |\eta| < 2.45$

Using New L2-EF Optimization

Trigger Level	Triggering on $H_{120} \rightarrow \gamma\gamma$	
	Effs w.r.t. kinematical cuts	isEM $^{(new)}$==0x00
L1	96.1±0.3%	96.3±0.3%
L2 Calo	90.3±0.4%	95 ±0.4%
EF Calo	84.9±0.5%	93.6±0.4%

Using new IsEM by Guillaume

Fernando G. Monticelli (UNLP, Argentina) Trigger effs. on $H_{120} \rightarrow \gamma\gamma$ Slide 10

F.Monticelli – Higgs WG 28/8/2007

HG1: H→γγ + Jets

- Ideal menu for normal running: 2γ20i + γ60
- Both unprescalable
- Efficiency determination: what's the plan?
- Early running plan established

Baseline cut flow

VBF analysis

A	$Pt(\gamma_1) > 50GeV$, $Pt(\gamma_2) > 25GeV$ (inclusive)
B	$Pt(j_1) > 40GeV$, $Pt(j_2) > 20GeV$, $\Delta\eta(j_1j_2)>3.6$, $\eta(j_1) * \eta(j_2)<0$
C	Photons in between tagging jets
D	$M(j_1j_2) > 500GeV$
E	Central jet veto : $Pt(j)>20GeV$, $\lvert\eta(j)\rvert<3.2$
F	Mass window: +-2σ (at the moment, we use 2GeV.)

H+1jet analysis

A	$Pt(\gamma_1) > 45GeV$, $Pt(\gamma_2) > 25GeV$ (inclusive)
B	$Pt(j_1) > 20GeV$, $\eta(j_1)<5.0$
C	$M(Hj) > 350GeV$
D	Mass window: +-2σ (at the moment, we use 2GeV.)

Trigger

- I talked about photon trigger performance of VBF H->γγ in the last EG2 meeting. (2 days ago.)
  - Please see my slide for the detail.
- A combination of "g60+2g20i" is OK for this process.

Pileup effect

HW samples, %

mH=120GeV	w/o pileup	with pileup
L1	100	100
L2	99.9	99.8
EF	99.0	98.6

- Only non-converted photon
- ~0.4% degradation after EF is observed under 10^{33} condition.
  - It is not so large.
  - Pileup effect (<10^{33}, first physics) does not give a large effect on trigger performance.

My conclusions for this signal are
- mass dependence -> negligible
- pileup effect (10^{33}) -> ~0.4% degradation
- conversions -> can be triggered by the present photon trigger.

Junichi Tanaka, Higgs WG 31/8/07

HG2: $H \rightarrow ZZ^{(*)} \rightarrow 4l$

- Ideal menu for normal running:
  - μ20, e25i – unprescalable
  - 2μXX, 2eYY, μXX_eYY needed?
  - Would 3-lepton trigger be useful? (shared with SUSY)
- Would 4-lepton trigger be useful as "alert" trigger in express stream?
- Efficiency determination: what's the plan?
- Early running plan established

Test of Trigger Menus: LVL1

Signal M_H=130 GeV

- LVL1 Efficiencies (in %) for:
  - all events in the sample (filter: 4-leptons with pT>5 GeV and |η|<2.7)
  - events after all H→4l offline selection cuts (kinematic cuts + Isolation + Impact parameter cuts)
- Errors are ~0.3% (~0.5%)
- No change in 12.0.3 w.r.t. 11.0.5

Trigger Menu	Channel 4e	Channel 4μ	Channel 2e2μ
1μ20	0.3 (<0.4)	98.7 (>99.6)	88.3 (90.6)
1e25i	98.5 (99.8)	3.0 (1.8)	77.3 (77.2)
1μ20 or 1e25i	98.5 (99.8)	98.7 (>99.6)	98.7 (99.4)
1μ10 and 1e15i or 2μ10 or 2e15i	97.6 (99.8)	98.1 (99.5)	98.3 (99.8)
1μ20 and 1e25i or 2μ20 or 2e25i	86.2 (96.4)	89.7 (95.1)	87.3 (92.4)

22/5/2007 S. Rosati - Higgs Trigger 10

Test of Trigger Menus: LVL1+HLT

Signal M_H=130 GeV

New: including HLT in the trigger selection:

- Barrel Muons: LVL1→LVL2→EF
- Endcap Muons: LVL1→EF
- Electrons: LVL1→EF
- Efficiencies (in %) for:
  - all events in the sample
  - (events after the H→4l selection)

Trigger Menu	Channel 4e	Channel 4μ	Channel 2e2μ
1μ20	0.1 (<0.4)	94.1 (97.9)	68.5 (72.4)
1e25i	93.5 (99.2)	0.2 (<0.4)	66.3 (72.1)
1μ20 or 1e25i	93.5 (99.2)	94.2 (97.9)	94.1 (98.9)
1μ10 and 1e15i or 2μ10 or 2e15i	85.7 (97.5)	91.7 (96.7)	90.9 (98.2)
1μ20 and 1e25i or 2μ20 or 2e25i	63.3 (89.3)	65.8 (79.4)	66.3 (83.5)

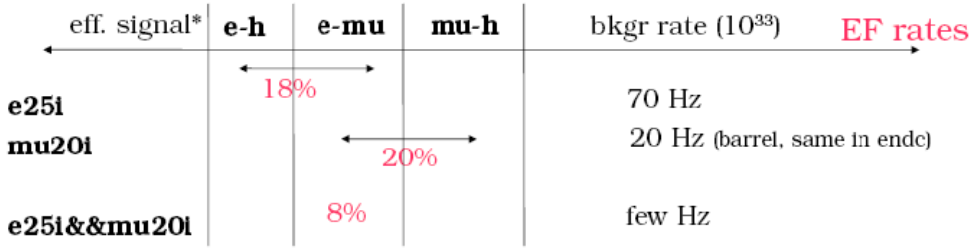
22/5/2007 S. Rosati - Higgs Trigger 11

Stefano Rosati – Higgs WG 22/5/2007

HG3: VBF H→ττ→lep-had / lep lep

- Ideal menu for notmal running: e25i, μ20i
  - Will 2-lep triggers be needed?
  - μXX_tauYY, eXX_tauYY?
- Efficiency determination: use standard-candle (Z→ee, etc) samples to determine/verify eff
- Early running: plan established

l-h and l-l channel



* includes acceptance too

(*numbers from from egamma and muon presentations at T&P week march 2007 && CSC VBF meeting April 19th, 2007 : T.Vickey*)

l-h and l-l channel

as secondary (?) menus, in case rate too high , to avoid prescale:

ll channel : 2e15i or 2mu15i , for e+mu keep e25imu20i from before
l-h channel : e&&tau menus (see below)

other possibility (need to be studied yet, not yet established):

- combine e/mu with MET (there is not very large MET in these events, better avoid this)
- use **forward jets** (better choice than MET, probably)

Selection	L1 Rate (Hz)	L2 Rate (Hz)	EF Rate (Hz)
tau10i+e10	4184	237	37
tau15i+e10	1397	115	20
tau10i+e15i	222	0.7	0.0
tau15i+e15i	107	0.4	0.0
tau10i+mu6	71	7.3	2.5
tau15i+mu6	31	2.2	0.2
tau10i+mu10	40	4.5	1.3
tau15i+mu10	16	1.6	0.1

L= 10^{31} rates

need to check efficiency on signal , but EF rate is < 1/100 of single menu (-> certainly no prescale here needed) and eff. might be better since Pt cut is lower

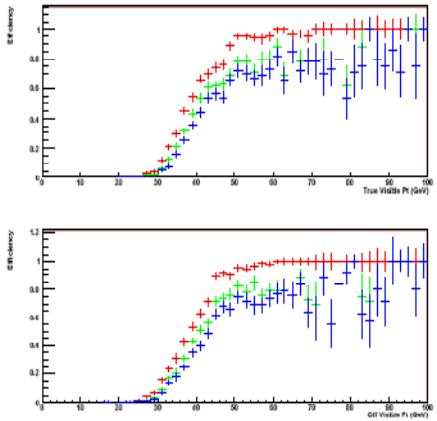
Eric Torrence, T&P week March 20, tau session

Stefania Xella, Higgs WG 7/6/07

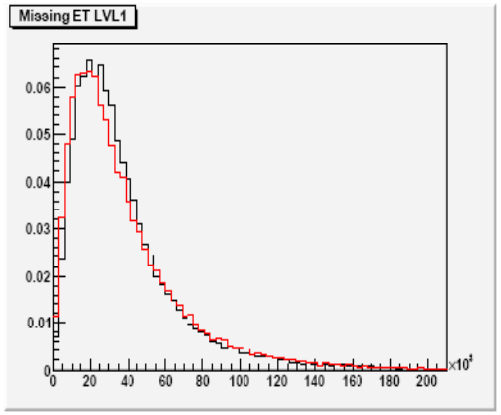
HG3: VBF H→ττ→had had

Difficult trigger: affected by high QCD background

- Trigger for normal running: 2tau35i
  - Possibly tau35i_xe40,
- Studies being developed in Higgs WG by tau trigger experts
- Efficiency determination in data taking: use Z→ττ
- Initial running: single e/μ with good acceptance for Z→ττ



(a) tau35i menu



(b) Missing Et

Figure 1: Tau35i efficiency wrt offline and truth, vs True PtVisible and Et offline(tauREc). MET distributions at L1 (black) and Offline(red).

menu	L1	L2	EF	H (pTVis>12GeV,η < 2.5)
tau25i+L1MET30	3.6K	1.3K	313	27%
tau25i+L1MET40	1.4K	206	64	19%
tau35i+L1MET30	2.5K	644	176	23%
tau35i+L1MET40	1.2K	113	34	15%
tau35i+tau35i	634	19	7	8%
tau25i+tau35i	1.6K	68	27	13%

Table 1: trigger rates 10^{33}, and signal efficiencies, for various trigger tau menus

HG3 draft CSC note

HG4: H→WW

- Ideal menu for normal running: e25i, μ20i
  - Lepton plus jets or lepton plus MET need to be studied
- Would 4-lepton trigger be useful as “alert” trigger in express stream?
- Efficiency determination: what’s the plan?
- Early running: what’s the plan ?

Efficiency wrt kinematic cuts but only on offline reconstructed quantities

Trigger Efficiencies

Cut	Electron Channel	Muon Channel
LVL1	93.9%	85.5%
LVL2	84.4%	81.8%
HLT	81.8%	80.4%

- Trigger efficiencies for single-lepton triggers are about 80%
  - Studies of lepton-plus-jets triggers, etc. are well-motivated
- Menus considered:
  - Electrons - L1_EM25I, L2_e25i, EF_e25i
  - Muons - L1_MU20, L2_mu20i, EF_mu20i

W. Quayle Page 8 Higgs WG Meeting, 07 June 2007

Bill Quayle, Higgs WG 7/6/07

HG5: ttH, H→bb

- Semileptonic channel:
  - mu20i and e25i:
    - High efficiency important, but matching between ID and MS maybe needed to keep rate under control; same thing for muon isolation
  - If needed: e20_xeNN or e20_jeMM or e20_teKK: with the aim of lowering the lepton threshold (& same for muons); needs to be studied

- Efficiency determination in data taking: use orthogonal triggers, verify with standard candles (e.g. Z→ee, Z→μμ)

- Initial running:
  - Follow top triggers closely
  - Need samples to check both trigger and reconstruction performance (and bias)
  - Important to study background distributions early: signal must be extracted by shape analysis

HG5: ttH, H→bb

- All-leptonic channel
  - mu20i and e25i
  - If needed: 2e15i , 2mu15i – same comments apply as for the single-lepton triggers used in semileptonic channel (low thresholds, good purity, high efficiency)
  - Maybe good to have triggers for 2e_xeYY, 2mu_xeUU and eXX_muYY
- All-hadronic channel
  - Multijet + b-tagging at HLT
  - teXX, jeYY, 2j42_XE30 (what will the real thresholds be)?
  - Non-isolated muon trigger
    - muon + N jets at L1: this can either be followed by a (non-isolated) muon + Njets at HLT or used to pass events to HLT where b-tagging would run after L2 jet reconstruction
- Same comments apply wrt initial running as for previous slide
- Studies only really starting

HG8: bbh/H/A→μμ

Rates wrt to the simulation and only for coverage of detector

- Ideal menu for normal running: μ20i (unprescalable)
- Efficiency determination: use standard candle Z→μμ
- Early running: use μ6 and 2μ6 to select dominant background sample, tt→bμν bμν

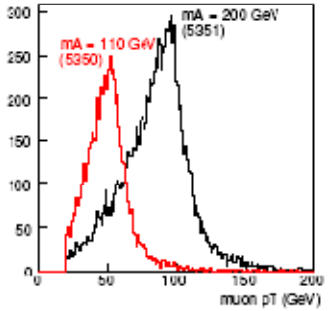
Trigger menues

Trigger selection	Efficiency for bbA200 (5351) L1	L2 & L1	EF & L2 & L1
(*L1_MU20* || *L1_MU40*), *L2_mu20i*, *EF_mu20i*	96.16 / 98.52	94.05 / 97.19	92.25 / 96.67
L1_MU20 || *L1_MU40* || "*L1_2MU10*" (LVL1 RoI)	96.36 / 98.72		
L1_MU20 || *L1_MU40* || "*L1_2MU06*" (LVL1 RoI)	96.38 / 98.72		

Before / after the baseline event selection.

Trigger selection	Efficiency for bbA110 (5350) L1	L2 & L1	EF & L2 & L1
(*L1_MU20* || *L1_MU40*), *L2_mu20i*, *EF_mu20i*	95.70 / 97.97	92.14 / 96.61	90.18 / 96.50
L1_MU20 || *L1_MU40* || "*L1_2MU10*" (LVL1 RoI)	96.10 / 98.08		
L1_MU20 || *L1_MU40* || "*L1_2MU06*" (LVL1 RoI)	96.20 / 98.08		

- LVL1 trigger efficiency: ∼98%, as expected.
- Overall trigger efficiency: ∼96.5%, determined by the requirement of 2 reconstructed muons in event.
- Trigger not influenced by the remaining analysis cuts.



Cut	Dataset 5350 $bbA(110)$, $\tan\beta = 45$	Dataset 5351 $bbA(200)$, $\tan\beta = 30$
All events	96.18	92.25
2μ	96.53	96.30
μ-isolation	96.53	96.30
(μ^+,μ^-)-pair	96.53	96.47
MET_Final<50 GeV	96.62	96.30
$n_{b-jets}>0$	96.50	96.67

Sandra Horvat – Higgs WG 14/6/ 07

HG9: Invisible Higgs - VBF

Ideal trigger for normal running:

- For 10**33:
  - Missing energy Et > 50 GeV
  - Two jets with ET > 20 GeV and |eta| < 4.9 (95% signal acceptance; 50Hz QCD background)
- Failing this less performant trigger still possible:
  - Missing energy Et > 50 GeV
  - One forward jet (3.2<|eta|<4.9) with pT >20 GeV
  - This provides an 80% signal acceptance and reduces QCD backgrounds to 20 Hz)

- For luminosity of 10**34:
  - Missing energy Et > 50 GeV
  - Two tagged jets between 1.6 < |eta| 4.9 and with pT > 20GeV

- Topological information (1 forward jet+1 central jet) may be important in reducing backgrounds
- Will investigate jet+XE

HG9: Invisible Higgs – ZH

Pauline Gagnon, Invisible Higgs CSC phone meeting – 4/9/07

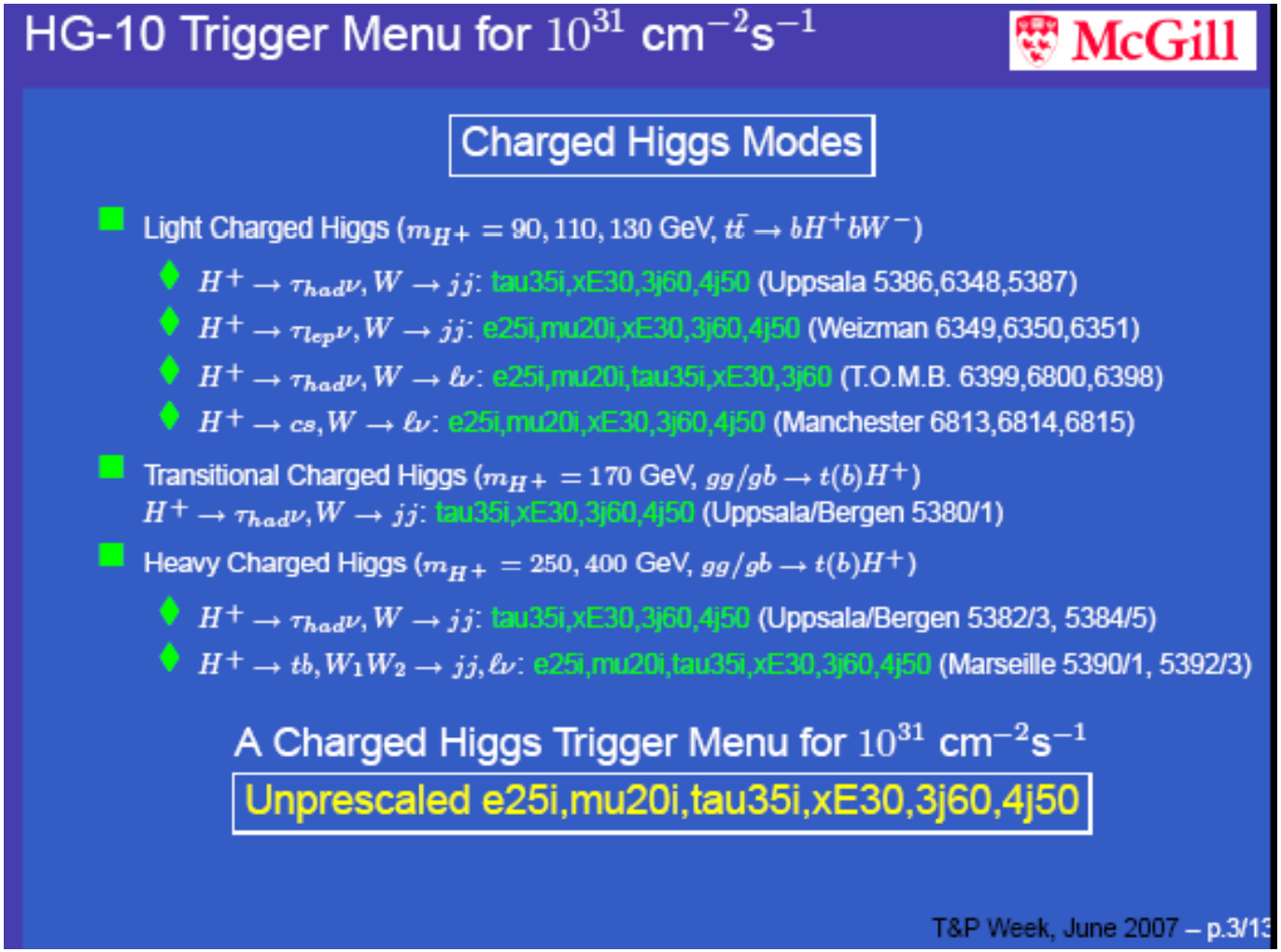
- Selected signatures at EF: e25i, 2e15, mu20i, met10
  - 2mu10 not yet implemented

signatures	L1	L2	EF	overall
all	99.4%	98.6%	98.9%	96.9%
selected	98.9%	94.9%	98.9%	92.8%
Cuts based on fully reconstructed values after filter (1e > 25 GeV; 2e>15GeV; 1μ>20 GeV; 2μ>10 GeV)				91.8%

HG9: Invisible Higgs – ttH : studies starting

HG10: Charged Higgs

- May have early chance of finding a H+
- Chris Potter HWG June 07
- Quite complete menu



Summary and outlook

- Please send me your comments:
  - Iwill present the Higgs WG needs/ideas at the Menus Workshop (24-25 Sep)
  - During rest of this week will be completing the info on this talk

- My apologies for still incomplete review

Backup

Proposal for e-gamma triggers for L = 10^31

Notations: PS = Prescale; PT = Pass Through. All rates in Hz.

Generic Name	Level 1				Level 2			Event Filter		
	Name	Raw Rate	PS	Rate	Name	PS	Rate	Name	Rate	
e5	EM3	58000	10	5800	L2_Calo_ID			EF_Calo_ID		
e7	EM3	10000	1	10000	L2_Calo_ID		92	EF_Calo_ID	26	
e10	EM8	5500	1		L2_Calo_ID			EF_Calo_ID		
g10					L2_Calo	20	35	EF_Calo	5	
e15					L2_Calo_ID		60	EF_Calo_ID	40	
g15	EM13	1100			L2_Calo		115	EF_Calo	35	
em15_passHLT					PT	1000	1	PT	1	
e15i					L2_Calo_ID		60	EF_Calo_ID	30	should be tight selection
g15i	EM13I	510			L2_Calo		94	EF_Calo	28	should be tight selection
em15_passHLT					PT	500	1	PT	1	
e20					L2_Calo_ID		20	EF_Calo_ID	10	
e20_passL2					PT		300	EF_Calo_ID	10	
e20_passEF					L2_Calo_ID		15	PT	15	
g20					L2_Calo		28	EF_Calo	6	
em20_passHLT	EM18	300			PT	300	1	PT	1	
e25					L2_Calo_ID		5	EF_Calo_ID	3	
e25_passL2					PT		300	EF_Calo_ID	4	
e25_passEF					L2_Calo_ID		5	PT	5	
g25					L2_Calo		8	EF_Calo	3	
e20i					L2_Calo_ID		10	EF_Calo_ID	7	
e20i_passL2					PT		110	EF_Calo_ID	8	
e20i_passEF	EM18I	110	1	110	L2_Calo_ID		10	PT	10	
g20i					L2_Calo		20	EF_Calo	5	
em20i_passHLT					PT	110	1	PT	1	
e25i					L2_Calo_ID		5	EF_Calo_ID	4	
e25i_passL2	EM23I	42	1	42	PT		55	EF_Calo_ID	4	
e25i_passEF					L2_Calo_ID		5	PT	5	
em110_passHLT	EM100	1	1	1	PT		1	PT	1	
2e5	2EM3	9000	1	9000	L2_Calo_ID			EF_Calo_ID	3	
e5_e7	EM3_HA5	2000	1	2000	L2_Calo_ID			EF_Calo_ID		
e5_e10	EM3_EM8	1000	1	1000	L2_Calo_ID			EF_Calo_ID		
2e10	2EM8	2000	1	2000	L2_Calo_ID			EF_Calo_ID		
2g10					L2_Calo		3	EF_Calo	1	
2e15	2EM13	140	1		L2_Calo_ID			EF_Calo_ID		
2g15	2EM13	101	1		L2_Calo			EF_Calo	1	
2e20	2EM18		1		L2_Calo_ID			EF_Calo_ID		
2g20	2EM18	35	1		L2_Calo			EF_Calo	0.1	
Ze10e10	2EM8		1		L2_Calo_ID			EF_Calo_ID		
e20_XE15	EM18_XE15		1		L2_Calo_ID		13	EF_Calo_ID	9	

Sources of Information

- Progress towards initial menu continuing
  - Trigger menu for $L=10^{31}\ cm^{-2}s^{-1}$: https://twiki.cern.ch/twiki/bin/view/Atlas/L31TriggerMenu
  - trigger rates plus overlaps : http://www.hep.physics.mcgill.ca/people/dufourma/public/trigger_rates/rel_13/J0.xml
  - See last TAPM open meeting for more: http://indico.cern.ch/conferenceDisplay.py?confId=15674

Commissioning

- Commission Level 1
  - Get the timing right, so that all detectors are looking at same event (cosmics+test runs)
  - Bootstrap:
    - random accepts $\rightarrow$ min.bias $\rightarrow$ selection
    - Means collecting a lot of random accepts and min. bias in the beginning to find out the min.bias efficiency, etc
- Commission the HLT
  - Run the HLT in flagging mode for some time and validate offline
- Certify at each step that we're getting meaningful results
  - Prescaled, loose triggers for each selection trigger