Higgs input to the Beatenberg Trigger Workshop

Minimum bias triggers

Photon triggers

Electron triggers

Jet/b-jet triggers

Forward jet triggers

Tau/missing ET triggers

Combined triggers

Ricardo Gonçalo

Higgs sub-groups conveners meeting - 26 Jan.09

These transparencies try to collect a summary of the studies done for the Beatenberg trigger workshop

More detailed information can be found in the slides presented at the Higgs meeting of 22 January 09

An indication of the source of material is added for each analysis shown below

This material is intended for the speakers from each trigger slice at the workshop and so is separated by slice

Most material is useful for the motivation session, with some material useful for other sessions

09:00->*12:30* **Trigger Motivation** (Convener: Kevin Einsweiler (

09:00	Introduction (10')
09:10	Requirements from initial physics measurements (20')
09:40	Requirements from combined performance (20')
10:10	Requirements from detector commissioning (20')
10:40	
11:00	Minimum Bias Triggers (10')
11:20	Electron/Photon Triggers (20')
12:00	Muon Triggers (15')

14:00->*18:00* **Trigger Motivation** (Convener: Kevin Einsweiler (

14:00	Jet and b-Jet Triggers (15')
14:30	Tau and ETmiss Triggers (15')
15:00	Combined Triggers (20')
15:40	
16:00	B-physics Triggers (15')
16:30	Forward Triggers (10')
16:50	Exotic Triggers (10')
17:10	Special Triggers (10')
17:30	Overview of Similar Algorithms - Code and Tunings (15')

Minimum bias triggers

- Nothing much to say for now, BUT:
- Will be used in the very beginning to obtain sample of unbiased data
  - Essential for efficiency determination and performance studies
  - Calorimeter noise can be extracted from random-trigger events
  - Pileup subtraction techniques may need to be developed for analysis – use minbias events
- We're hoping there will be large samples of minbias events, but no detailed analysis work plan exists yet

Photon triggers: H->γγ

Photon triggers - I

- See talk by Marumi Kado: http://indico.cern.ch/conferenceDisplay.py?confId=50222
- H->γγ is an important client for γ triggers
  - Experimental sensitivity around $M_H \approx 120$ GeV with ≤ 10 fb^{-1}
- No pure sample of photons exists
  - Offline reconstruction is the only reference definition available of a "photon"
  - But offline reconstruction is looser than trigger selection: background efficiency is higher for offline reconstruction than for trigger when using L1 isolation
  - Creates bias in efficiency determination

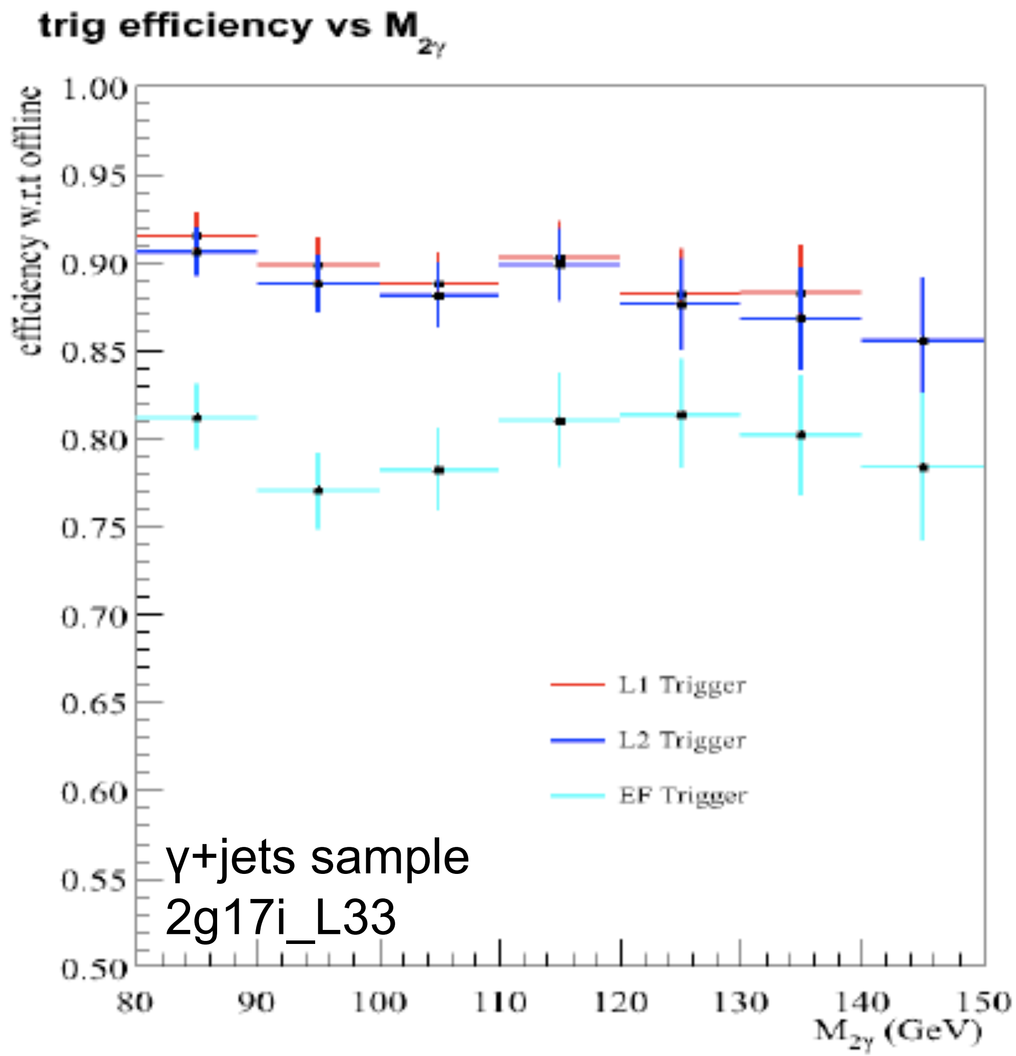
2g17i	Signal	L1	L2	EF
Efficiency (%)	Signal	99.0±0.2	98.9±0.2	93.6±0.4
	γ + jets	90.1±0.6	89.3±0.6	80.2±0.8

$$\varepsilon = \frac{N^{\gamma}_{trig \cap offline}}{N^{\gamma}_{offline}}$$

- Understanding L1 isolation is essential
  - This means that non-isolated electron triggers are needed
- H->γγ group working together with e/γ slice to develop efficiency determination from data (complementary methods): bootstrap, tag&probe (wrt offline electrons!), using Z->ee as proxies for photons, using Zγ->llγ

Photon triggers - II

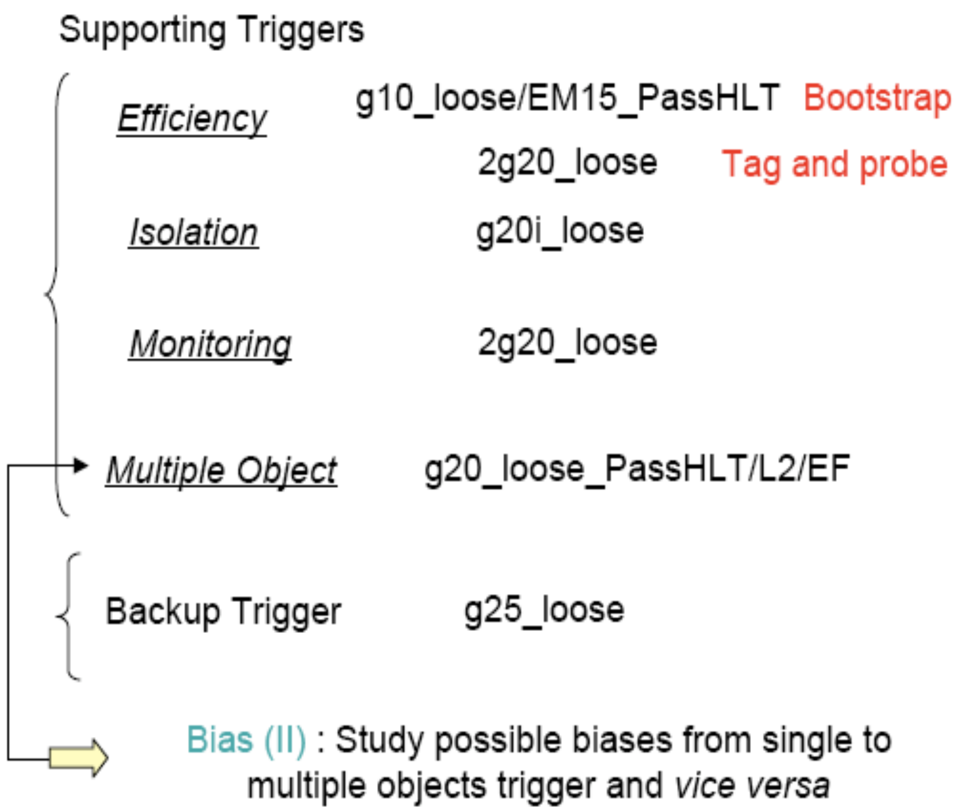
- Large drop between L2 and EF
  - Understood: different online and offline selection
- Probable trigger bias at $m_{\gamma\gamma}$~120 GeV/c^2
  - Cuts tuned on H->γγ sample?
  - Dangerous for analysis



Photon triggers - III

- Main trigger for H->γγ analysis: g20_loose
- Support triggers (kept under the e/γ trigger slice? Should Higgs WG sign up for them?):
  - For bootstrap method: g10_loose or, even better, EM15_PassHLT
  - To study isolation: g20i_loose
  - To study bias on efficiency determination in events with 2 photons: 2g20_loose, g20_loose_passHLT/L2/EF
  - Backup trigger: g25_loose

Main trigger for 2009 data: g20_loose

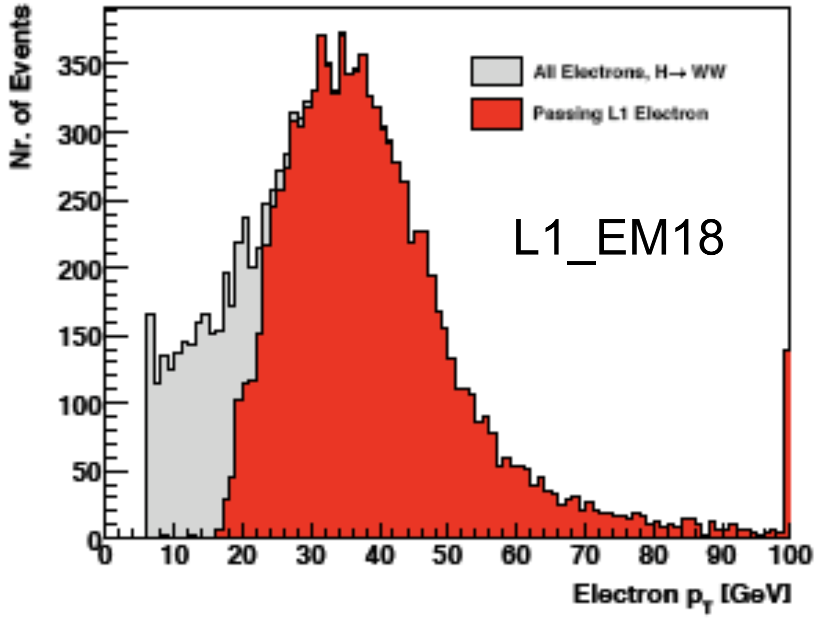


Electron triggers

- H->WW
- H->ZZ$^{(*)}$->4l
- HZ, Z->l^+l^-, H->invisible
- ttH
- tbH$^+$

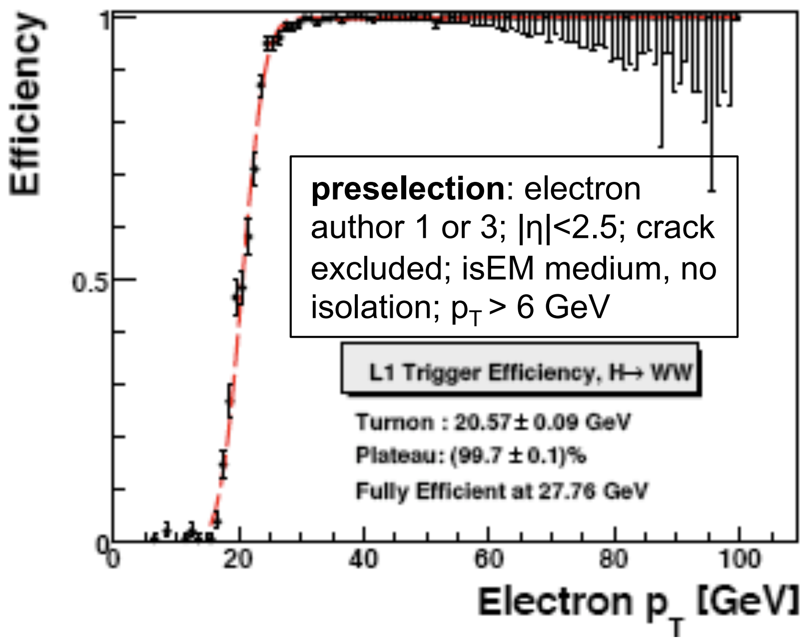
Electron triggers: H->WW

- Talk by Jonas Strandberg:
  - http://indico.cern.ch/conferenceDisplay.py?confId=50222
- Experimental sensitivity around $M_H \approx 160$ GeV with ≤ 2 fb^{-1}
- $H \to WW \to l^+ \nu l^- \nu$
  - Important for SM Higgs, M_H~160GeV
  - ee, eμ, μμ channels investigated
- Interested in:
  - e10_medium and e20_loose
- Basically happy with 10^{31} menu



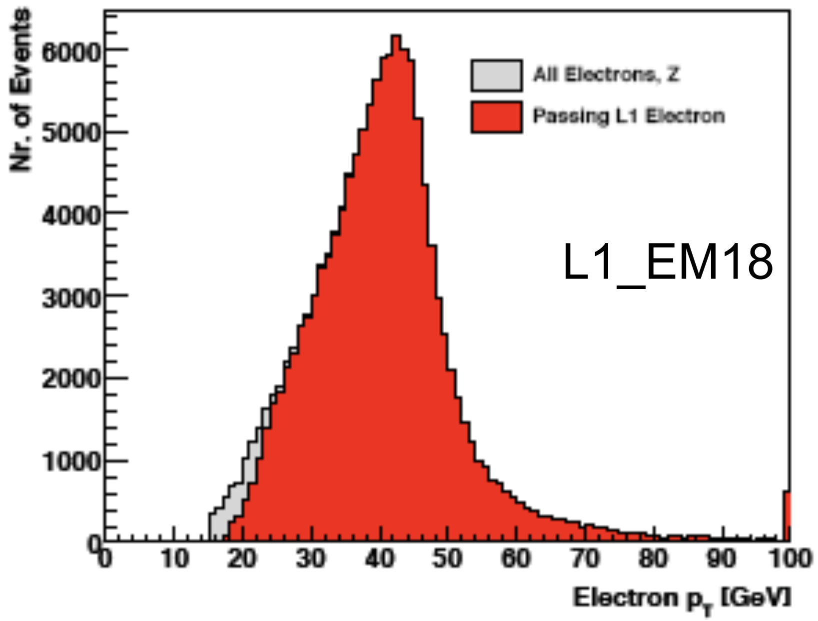
	eμ	ee	μμ
e5_e7_medium	-	98.7%	-
e10_loose	99.0%	99.9%	0.5%
e20_medium	92.5%	99.5%	0.3%

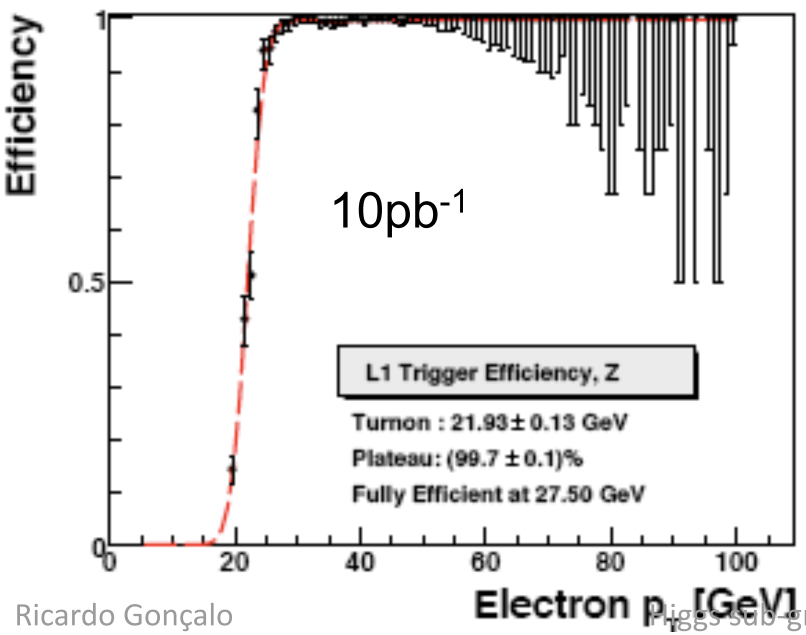
With respect to CSC selection

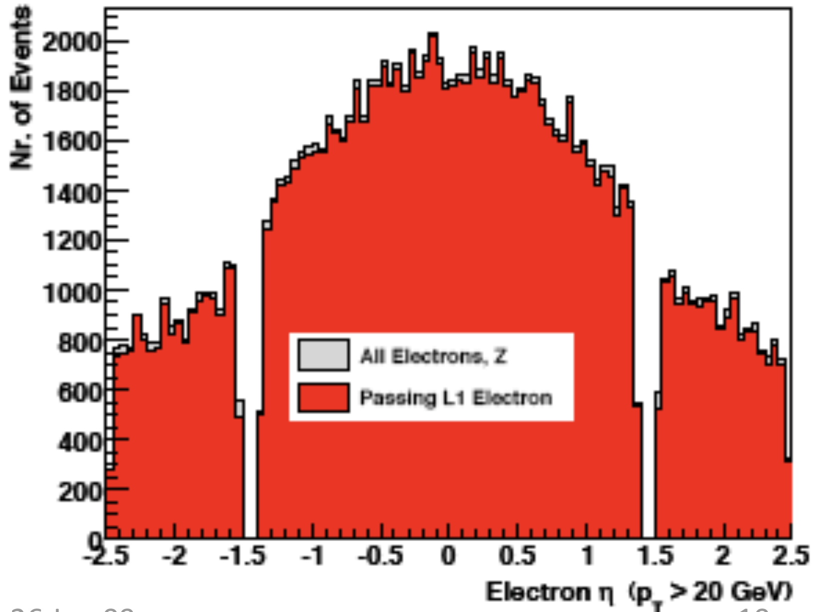


Efficiency determination

- H->WW analysis will look at Z->ll events in 1st data
- Good e20_loose L1 efficiency determination using ~10pb^{-1} of data
- From 10k Z->ee with selection:
  - p_T^{lep}>15GeV
  - $|m_Z-m_{ll}|$<15GeV
  - MET<10GeV
  - Note error bars



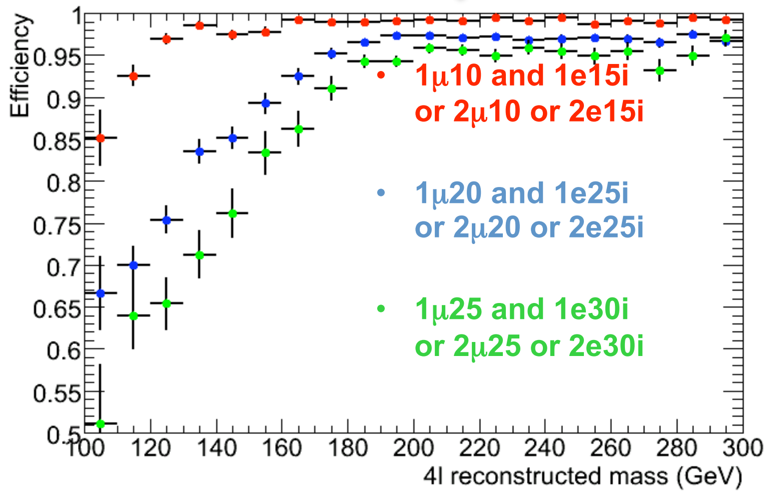


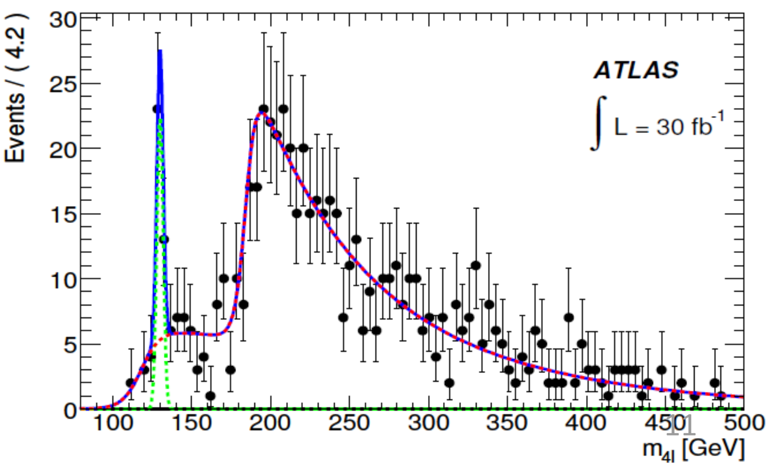


Electron triggers: H->4l

- Stefano Rosati: http://indico.cern.ch/conferenceDisplay.py?confId=50222
- Important channel for SM Higgs searches from M_H>130GeV to about 600GeV
  - Experimental sensitivity above $M_H \approx$ 130 GeV already with 2 fb^{-1}
- Older (CSC) study on ZZ->4l background – efficiency vs M_{4l} invariant mass
  - Measurement of M_H comes from fit to signal + background
- Efficiency wrt offline cuts, M_H=130 GeV
  - Offline selection as in CSC note

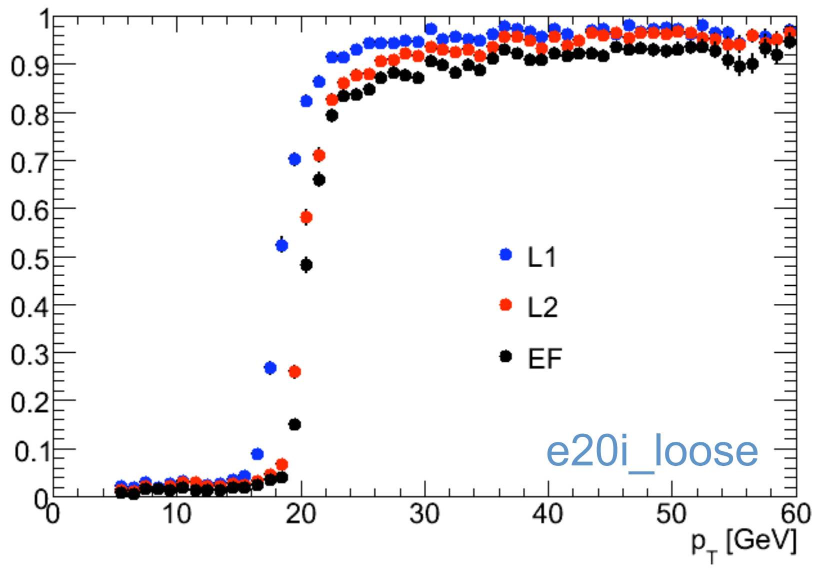
Selection	4e	4μ	2e2μ
e10_medium	>99.8	0.2	99.7
e20i_loose	99.9	0.2	82.9
e25i_loose	99.7	0.1	68.5
2e6_medium	>99.8	-	97.9
2e15_medium	>99.8	-	66.2
2e10_loose	>99.8	-	86.3
2e20_loose	98.6	-	52.4
2e12_tight	96.0	-	57.7
2e10_loose OR 2μ10	>99.8	95.7	99.8
2e20_loose OR 2μ20	98.6	75.5	89.1





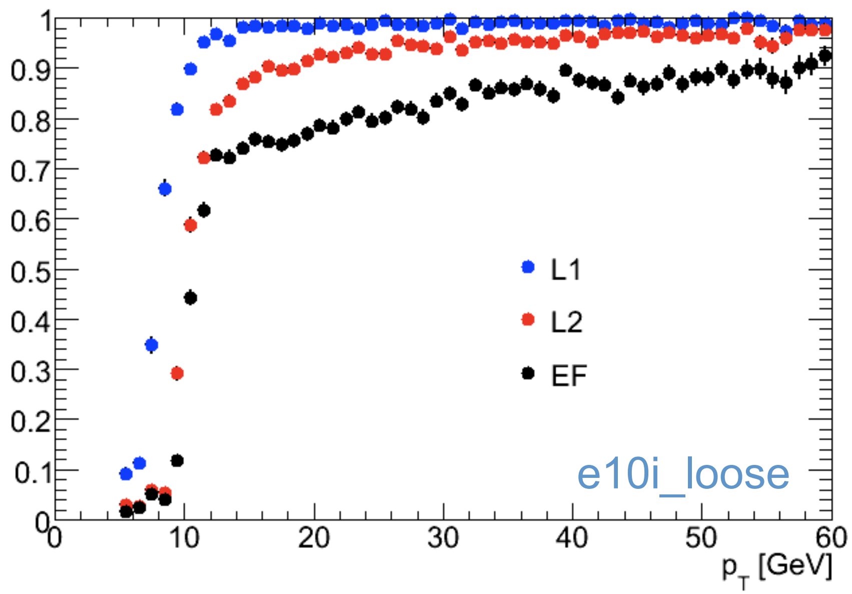
Efficiency curves

- Absolute efficiency curves – matching true leptons to trigger RoIs
- Slow rise in e10 efficiency at EF – different online/offline selection?



- Trigger efficiency for dominant background (ZZ->4l)

	4e	4μ	2e2μ
e10_medium	100%	27%	100%
e20i_loose	100%	3.3%	99%



ZH, Z->ll, H->invisible

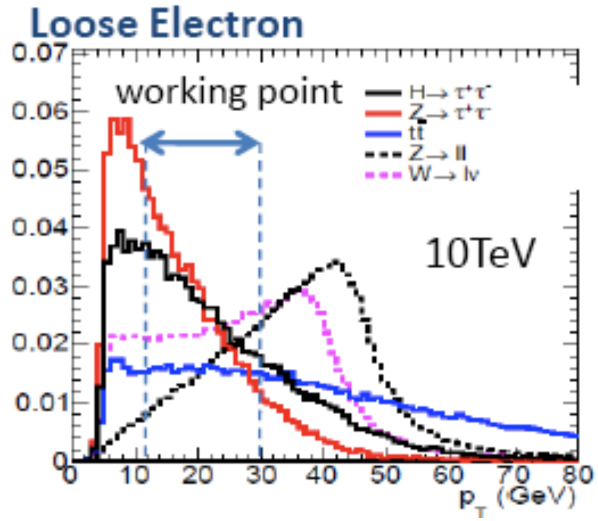
- Pauline Gagnon: http://indico.cern.ch/conferenceDisplay.py?confId=50222
- Signature is a Z->ll decay AND E_T^{miss}
- **EF** efficiency and purity before and after preselection:
  - Same flavour, opposite charge leptons, $|m_{l+l-} - mZ| < 20$ GeV, $E_T^{miss} > 90$GeV
  - All individual signatures give about 98-99% efficiency w.r.t. preselection
  - EF_e20_loose slightly more efficient than EF_e15_medium

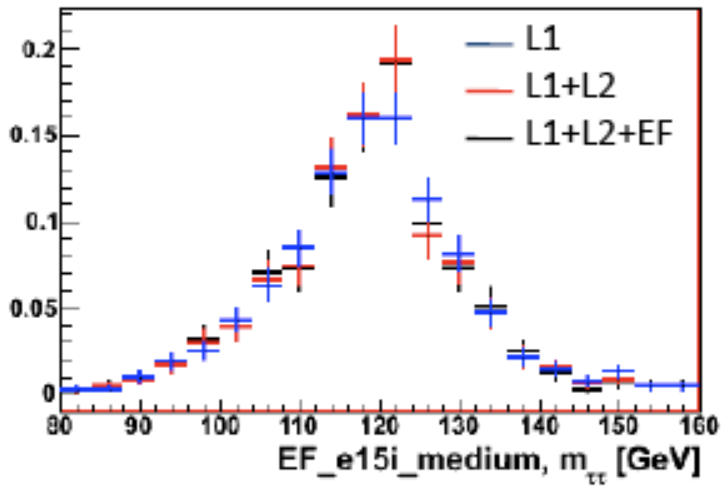
Purity	**selection**	**2e10_loose**	**2e15_medium**	**e15_medium**	**e20_loose**
HZ, mH = 130 GeV	**before**	**81.2%**	**75.3%**	**65.1%**	**63.0%**
	after	**95.2%**	**95.2%**	**94.0%**	**93.0%**
HZ, mH = 200 GeV	**before**	**82.0%**	**76.4%**	**66.9%**	**65.0%**
	after	**94.9%**	**94.8%**	**93.1%**	**92.4%**

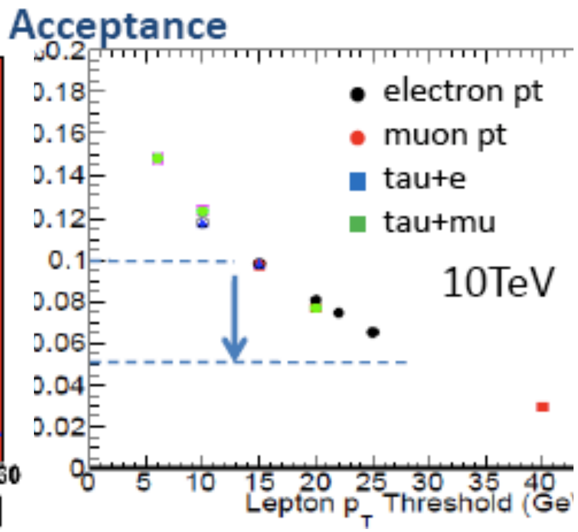
Efficiency	**selection**	**2e10_loose**	**2e15_medium**	**e15_medium**	**e20_loose**
HZ, mH = 130 GeV	**before**	**96.0%**	**71.6%**	**76.2%**	**77.1%**
	after	**98.2%**	**98.1%**	**99.3%**	**99.9%**
HZ, mH = 200 GeV	**before**	**96.2%**	**71.9%**	**76.9%**	**77.8%**
	after	**97.8%**	**97.9%**	**99.1%**	**99.7%**

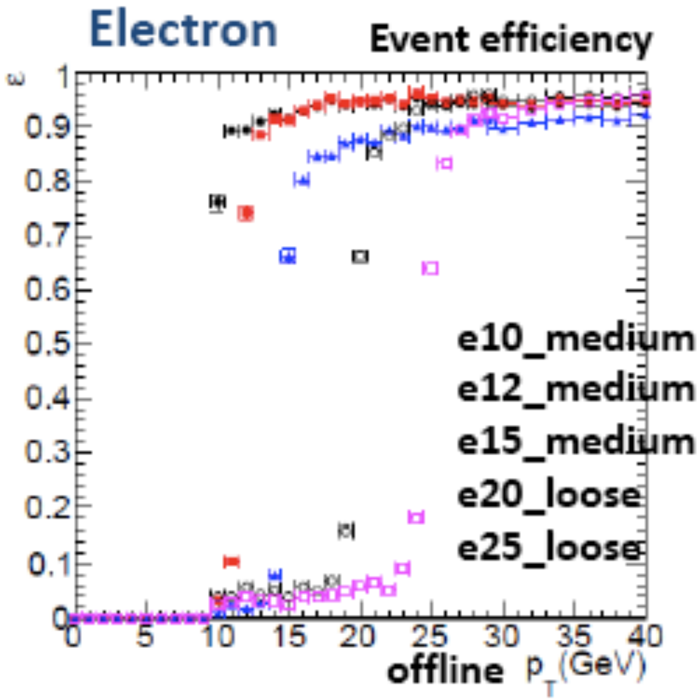
Triggering on τ->e decays

- See talk by Soshi Tsuno: http://indico.cern.ch/conferenceDisplay.py?confId=50222
- Experimental sensitivity around $M_H \approx 120$ GeV with $\approx 10\ fb^{-1}$
- Tau decays to e with BR~17%
  - Need thresholds between p_T=15 GeV and p_T=30GeV
  - 40% acceptance lost going from 15GeV to 30GeV
- No bias found (see bottom left plot)
- Event Filter efficiency for τ->evv after cuts:
  - p_T > 10GeV; |eta| <2.7; author=1 or 3,econe20/p_T<0.2



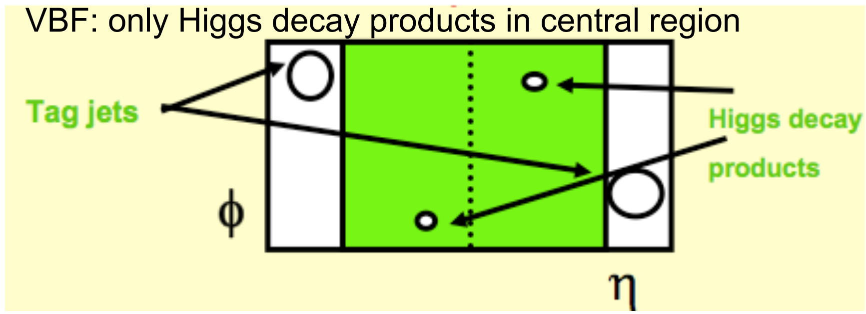




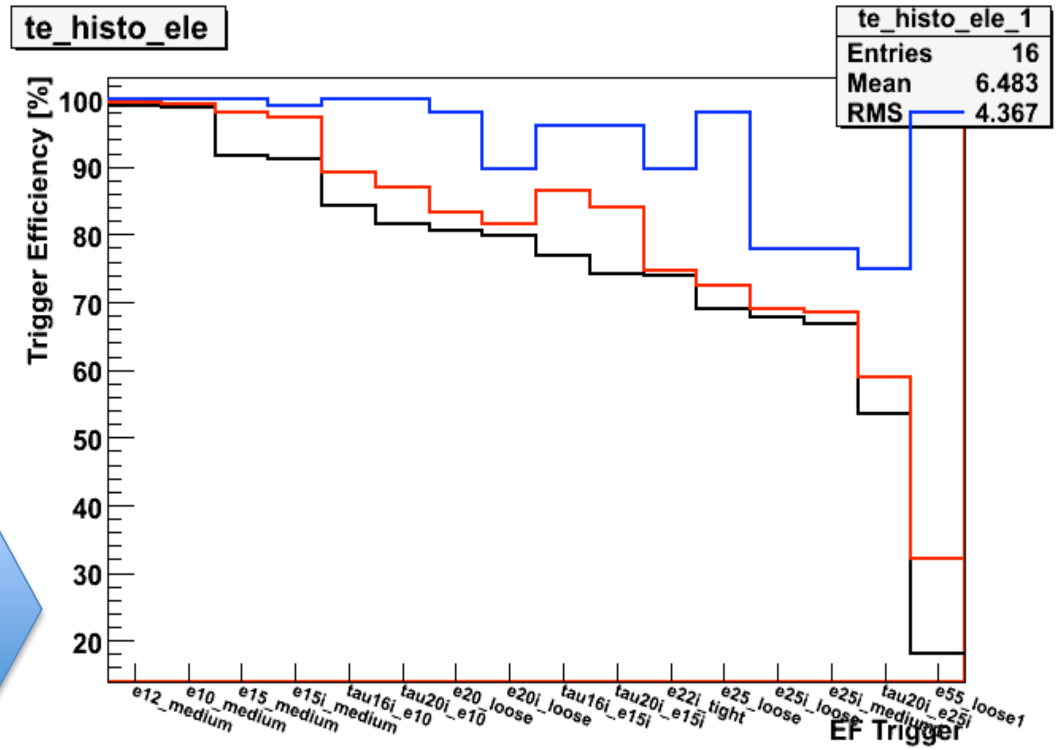


H->ττ in Vector Boson Fusion (lep-had)

49104 initial events	After analysis
Without trigger	1149
With trigger	983
Efficiency	85.5% (2% absolute)

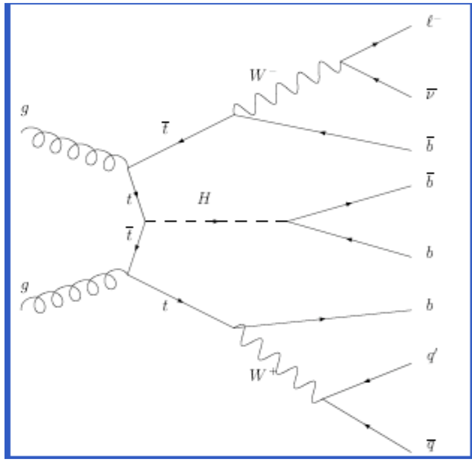


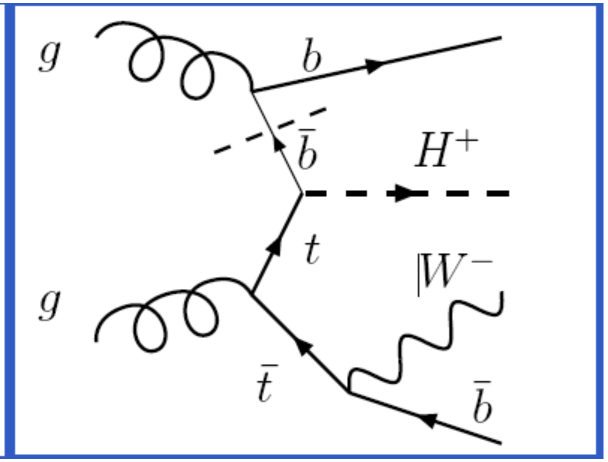
- After all analysis cuts
  - For M_H=120GeV
  - Using e12_medium and mu10
- Efficiency wrt analysis cuts:
  - Lower efficiency using combined electron+tau signatures; equivalent to higher electron E_T thresholds



Electron triggers for ttH and tbH+

- See talk by Chris Potter: http://indico.cern.ch/conferenceDisplay.py?confId=50222





- ttH
  - Lep lep: both tops decay leptonically
  - Had had: both decay hadronically
  - Lep+ had: 1 top decays to $bl^+\nu$ and the other hadronically
- Absolute efficiencies (wrt to the whole generated sample)

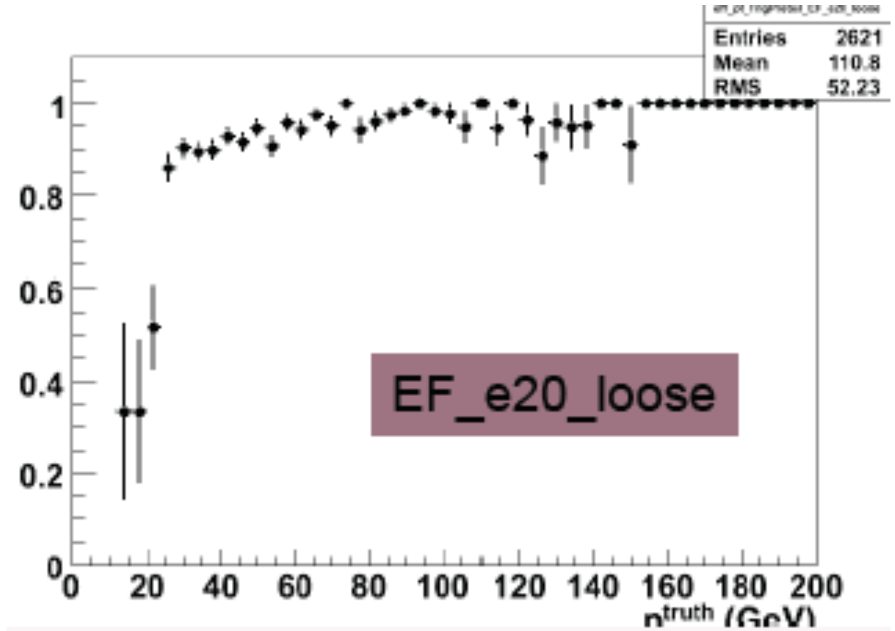
e20i_loose efficiency (wrt MC generated sample)				
ttH	lep-lep	lep^+ had	lep^- had	had-had
efficiency	55.2%	34.4%	36.7%	2.1%
tbH^+; m_{H+}=	200GeV	250 GeV	300 GeV	400 GeV
efficiency	34.4%	35.7%	35.3%	33.1%

Electron triggers for ttH

ttH study by Catrin Bernius

Efficiencies wrt preselection:

- 1 isolated lepton:
  - Electron: isEM&&0xFF, pT>25GeV, |η|<2.5
  - Muon: pT>20GeV, |η|<2.5, ETcode20<10GeV+pTratio<0.3
- 6 jets with pT>20GeV, |η|<5, 4 central jets b weight>0



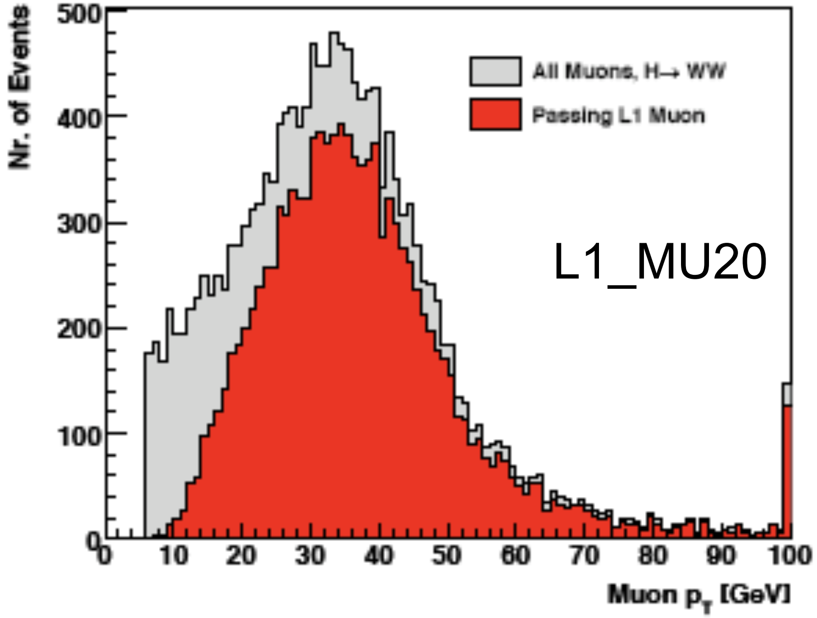
	e15_medium	e20_loose	e20i_loose	e25i_loose	mu15	mu20	mu20i_loose
L1	100%	99.9%	89.4%	88.3%	88.3%	87.0%	87.0%
L2	96.3%	95.1%	86.8%	85.4%	84.4%	81.7%	62.3%
EF	84.2%	92.9%	85.6%	84.2%	83.0%	80.6%	61.5%

Muon triggers

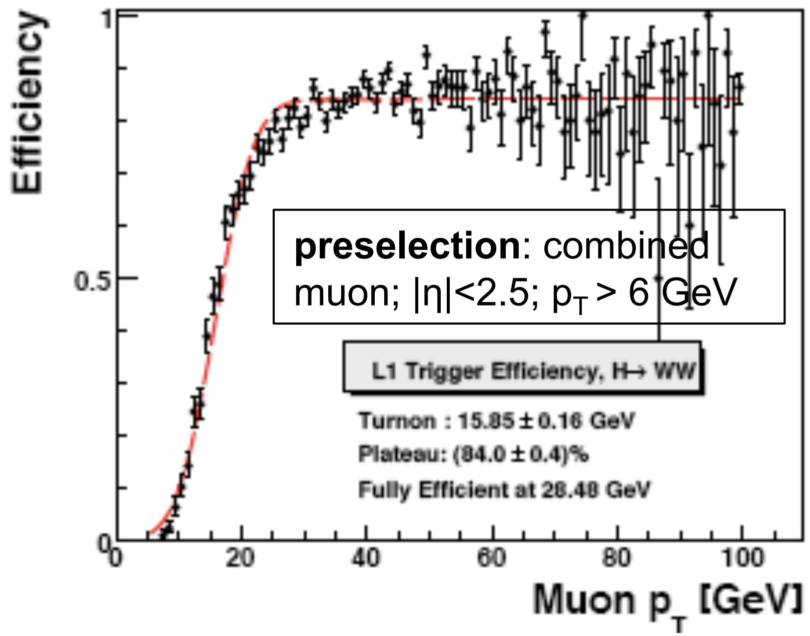
- H->WW
- H->ZZ$^{(*)}$->4l
- HZ, Z->l^+l^-, H->invisible
- ttH
- tbH^+

Muon triggers: H->WW

- Talk by Jonas Strandberg:
  - http://indico.cern.ch/conferenceDisplay.py?confId=50222
- Experimental sensitivity around $M_H \approx 160$ GeV with $\leq$ 2 fb^{-1}
- H->WW->$l^+\nu l^-\nu$
  - ee, eμ, μμ channels investigated
- Interested in:
  - mu10, mu20, looked at mu4_mu6
- Basically happy with 10^{31} menu

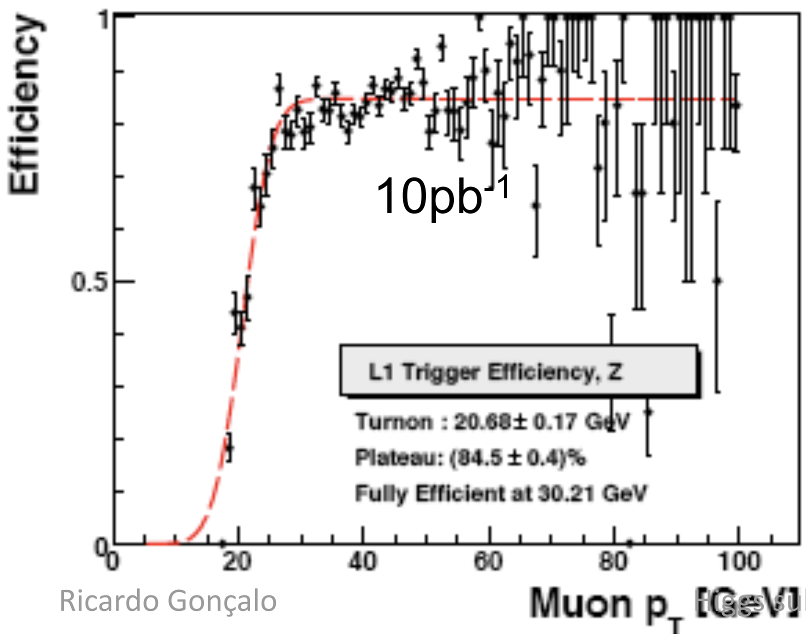


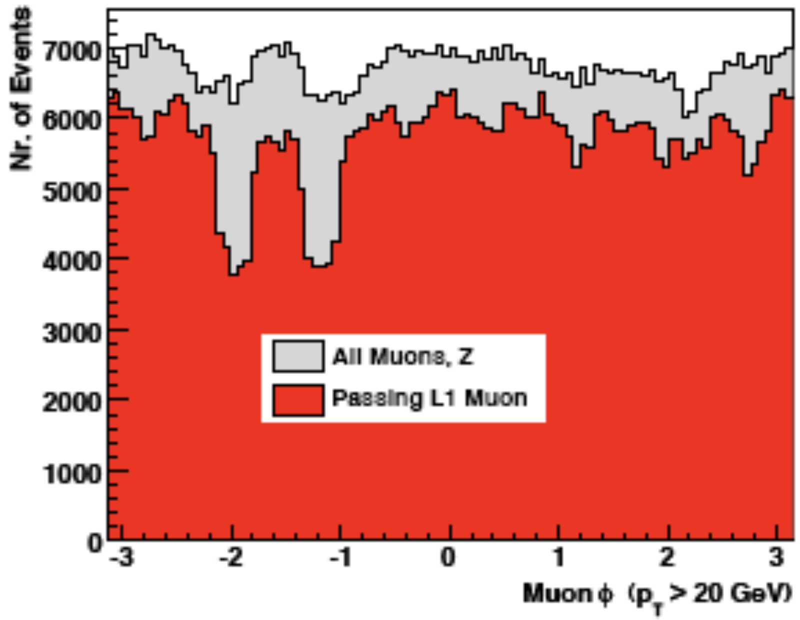
Event Filter	eμ	ee	μμ
mu4_mu6 (bug)	86.9%	98.7%	62.7%
mu10	86.9%	0.1%	98.2%
mu20	76.4%	0.0%	94.7%
Efficiency **with respect to CSC selection**			

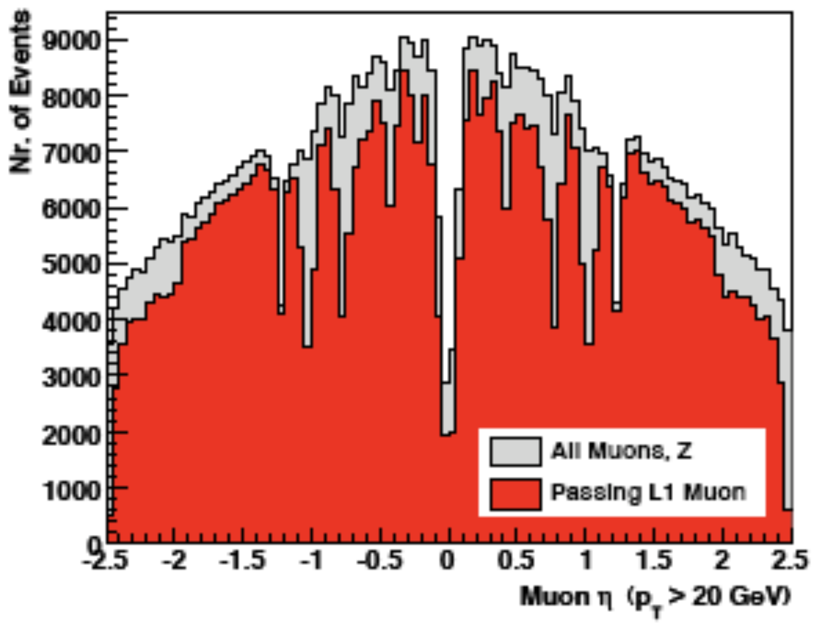


Efficiency determination

- H->WW analysis will look at Z->ll events in 1st data
- Can get good mu20 L1 efficiency determination using ~10pb^{-1} of data
- From 10k Z->ee with selection:
  - p_T^{lep}>15GeV
  - $|m_Z - m_{ll}|$<15GeV
  - MET<10GeV
  - Note error bars



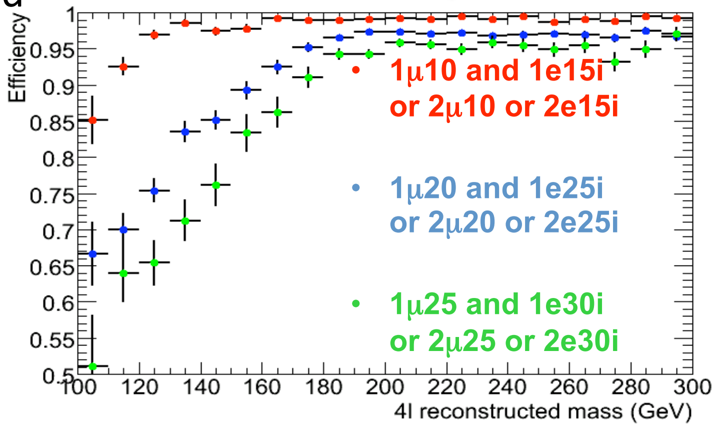


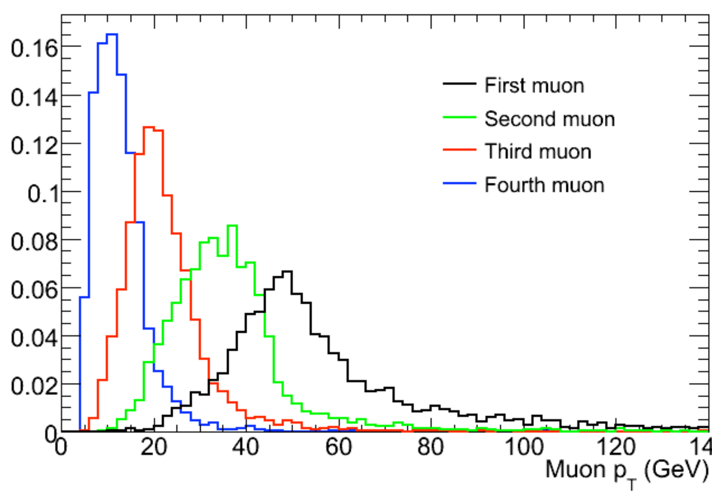


Muon triggers: H->4l

- Stefano Rosati: http://indico.cern.ch/conferenceDisplay.py?confId=50222
- Experimental sensitivity above $M_H \approx 130$ GeV already at 2 fb^{-1}
- Identified list of useful triggers from 10^{31} menu:
- Older (CSC) study on ZZ->4l background – efficiency vs M_{4l} invariant mass
- Measurement of M_H comes from fit to signal + background
- Efficiency wrt offline cuts (as in CSC note), M_H=130 GeV:

Selection	4e	4μ	2e2μ
mu10	0.6	99.9	94.6
mu20	-	98.1	70.9
mu15i_loose	0.3	99.0	81.0
mu20i_loose	-	97.7	66.6
mu40	-	67.7	35.6
e10_medium	>99.8	0.2	99.7
e20i_loose	99.9	0.2	82.9
e25i_loose	99.7	0.1	68.5

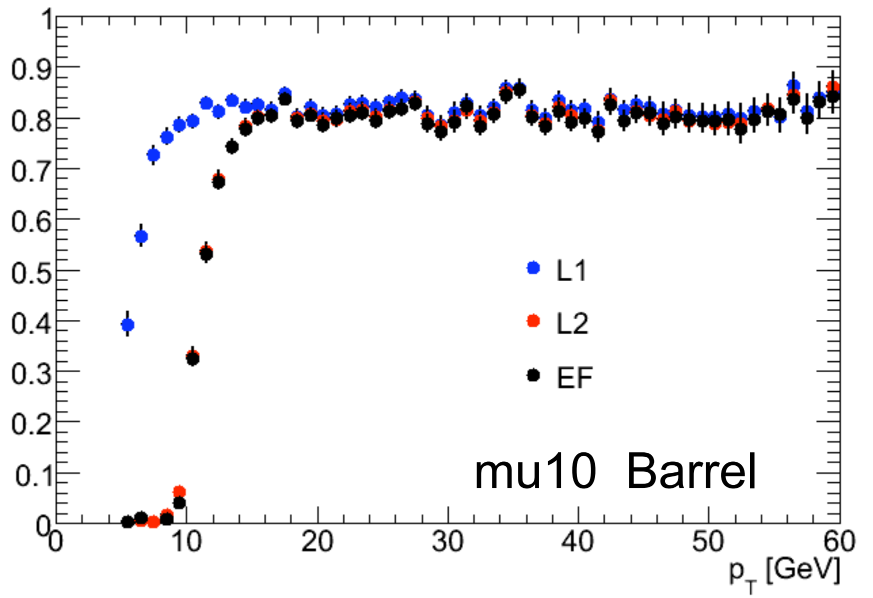




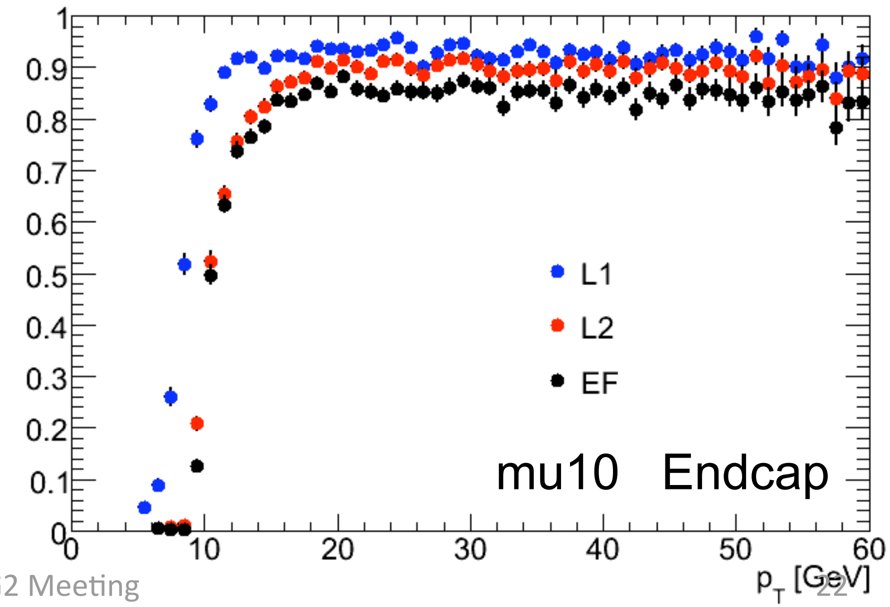
p_T of muons in H->4μ; M_H=130GeV

Efficiency curves: H->4l

- Absolute efficiency curves – matching true leptons to trigger RoIs
- Barrel efficiency affected by coverage (MS feet)
- Endcap EF efficency 5-10% less than L1 efficiency (support ribs)
- Trigger efficiency for dominant background (ZZ->4l)



	4e	4μ	2e2μ
mu10	0.6%	100%	98.1%
mu15_loose	0.2%	99.9%	96.9%
2mu10	0.1%	99.1%	74.9%
2mu20	0.0%	97.4%	64.5%



H->4l at higher M_H

- Also looked at H->4l with M_H=300GeV
- Higher mass scale means even mu40 has good efficiency

Selection	4e	4μ	2e2μ
mu40	-	97.7	84.8
2e10_loose/2mu10	>99.8	98.0	>99.8
2e20_loose/2mu20	>99.8	93.7	99.0

ZH, Z->ll, H->invisible

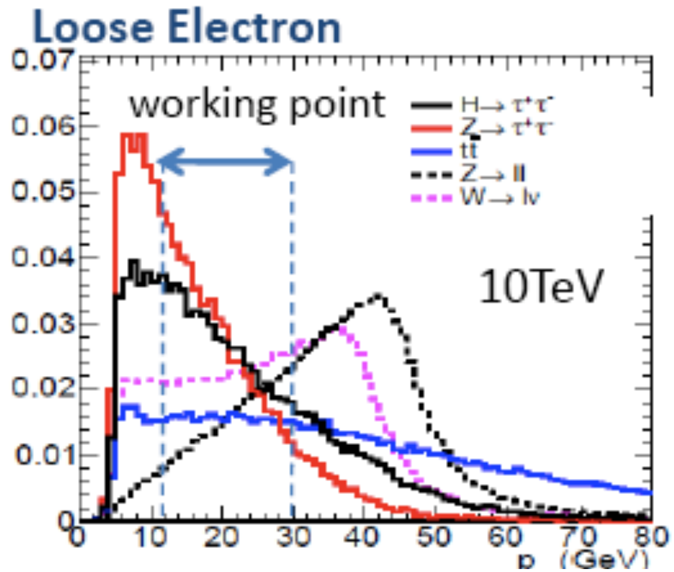
- Pauline Gagnon: http://indico.cern.ch/conferenceDisplay.py?confId=50222
- Signature is a Z->ll decay AND E_T^{miss} > 90GeV
- **EF** efficiency and purity before and after preselection
  - Same flavour, opposite charge leptons, $|m_{l+l-} - mZ| < 20$ GeV, E_T^{miss}> 90GeV
  - All individual signatures give about 98-99% efficiency w.r.t. preselection
  - EF_mu10 only slightly more efficient than EF_mu15

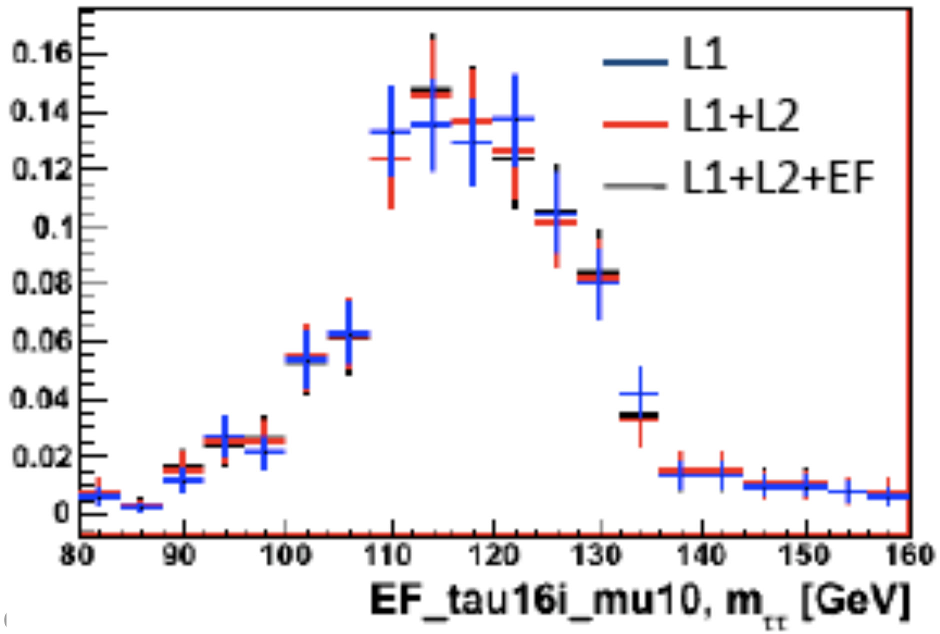
Purity	selection	2mu10	mu10	mu15
HZ, mH = 130 GeV	before	98.7%	82.0%	82.6%
	after	99.7%	99.4%	99.5%
HZ, mH = 200 GeV	before	98.4%	84.4%	84.4%
	after	99.5%	99.4%	99.4%

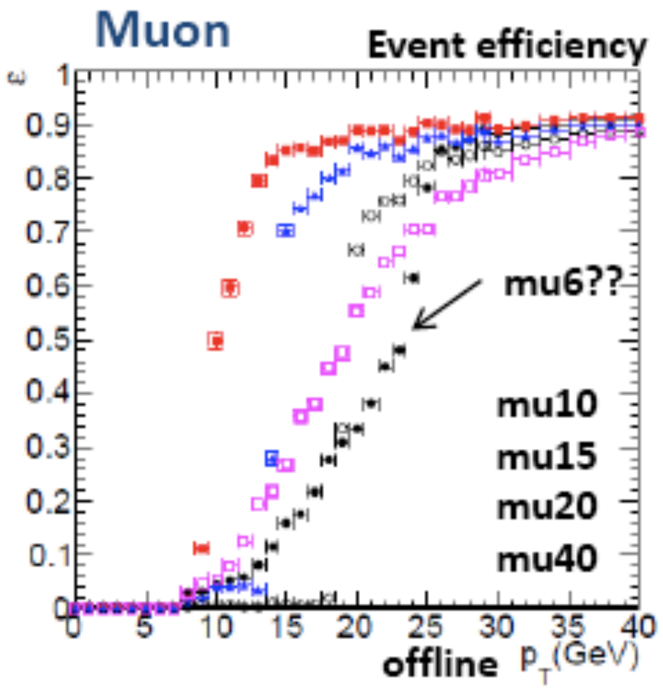
Efficiency	selection	2mu10	mu10	mu15
HZ, mH = 130 GeV	before	69.7%	96.9%	94.9%
	after	70.0%	97.1%	95.1%
HZ, mH = 200 GeV	before	69.9%	96.9%	94.9%
	after	70.4%	96.9%	95.0%

Triggering on τ->μ decays

- See talk by Soshi Tsuno: http://indico.cern.ch/conferenceDisplay.py?confId=50222
- Experimental sensitivity around $M_H \approx 120$ GeV with $\approx 10\ fb^{-1}$
- Tau decays to e with BR~17%
  - Need thresholds between p_T=15 GeV and p_T=30GeV
  - 40% acceptance lost going from 15GeV to 30GeV
- No bias found (see bottom left plot)
- Event Filter efficiency for τ->evv after cuts:
  - p_T > 10GeV; |eta| <2.7; author=1 or 3,econe20/p_T<0.2

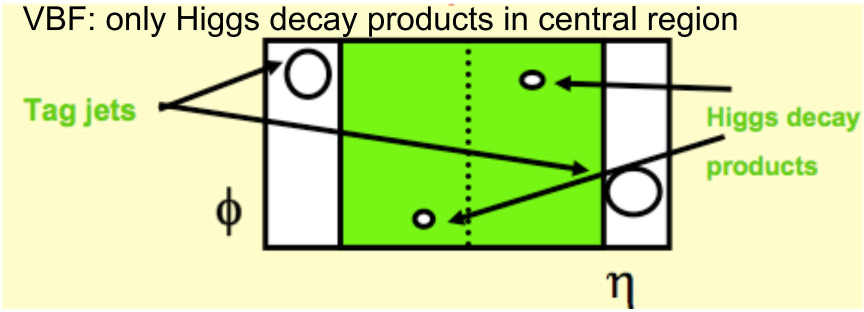






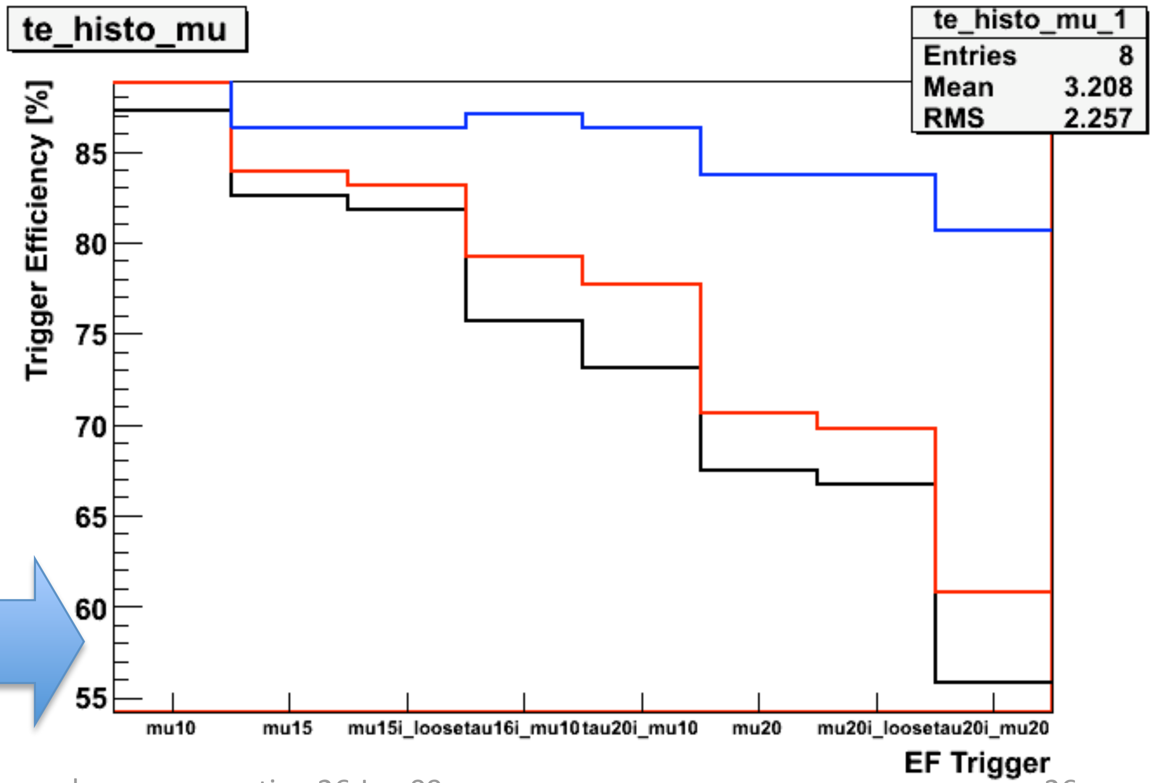
H->ττ in Vector Boson Fusion (lep-had)

49104 initial events	After analysis
Without trigger	1149
With trigger	983
Efficiency	85.5% (2% absolute)



- After all analysis cuts
- For M_H=120GeV
- Trigger: e12_medium OR mu10

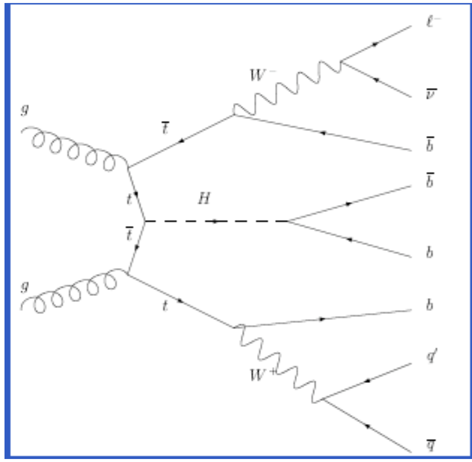
- Efficiency wrt analysis cuts:
  - Lower efficiency using combined electron+tau signatures; equivalent to higher electron E_T thresholds

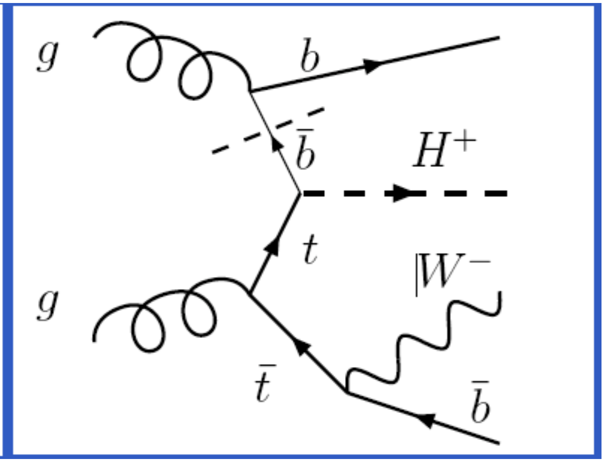


Muon triggers for ttH and tbH+

- See talk by Chris Potter: http://indico.cern.ch/conferenceDisplay.py?confId=50222

- ttH
  - Lep lep: both tops decay leptonically
  - Had had: both decay hadronically
  - Lep+ had: 1 top decays to bl$^+$v and the other hadronically
- Absolute efficiencies (wrt to the whole generated sample)





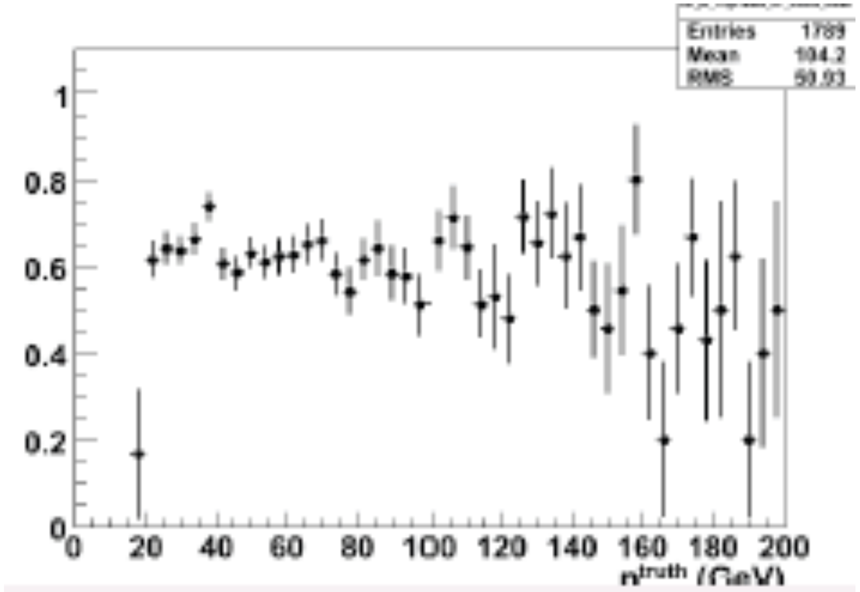
mu20 efficiency (wrt MC generated sample)				
ttH	lep-lep	lep$^+$ had	lep$^-$ had	had-had
efficiency	57.3%	34.6%	38%	4.9%
tbH$^+$; m_{H+}=	200GeV	250 GeV	300 GeV	400 GeV
efficiency	34.1%	33.2%	34.5%	39%

Muon triggers for ttH

ttH study by Catrin Bernius

Efficiencies wrt preselection:

- 1 isolated lepton:
  - Electron: isEM&&0xFF, pT>25GeV, |η|<2.5
  - Muon: pT>20GeV, |η|<2.5, ETcode20<10GeV+pTratio<0.3
- 6 jets with pT>20GeV, |η|<5, 4 central jets b weight>0



	e15_medium	e20_loose	e20i_loose	e25i_loose	mu15	mu20	mu20i_loose
L1	100%	99.9%	89.4%	88.3%	88.3%	87.0%	87.0%
L2	96.3%	95.1%	86.8%	85.4%	84.4%	81.7%	62.3%
EF	84.2%	92.9%	85.6%	84.2%	83.0%	80.6%	61.5%

Jet and b-jet triggers

- ttH, H->bb
- tbH^+, H^+->tb
- Other channels use jet triggers combined with lepton/tau/MET triggers

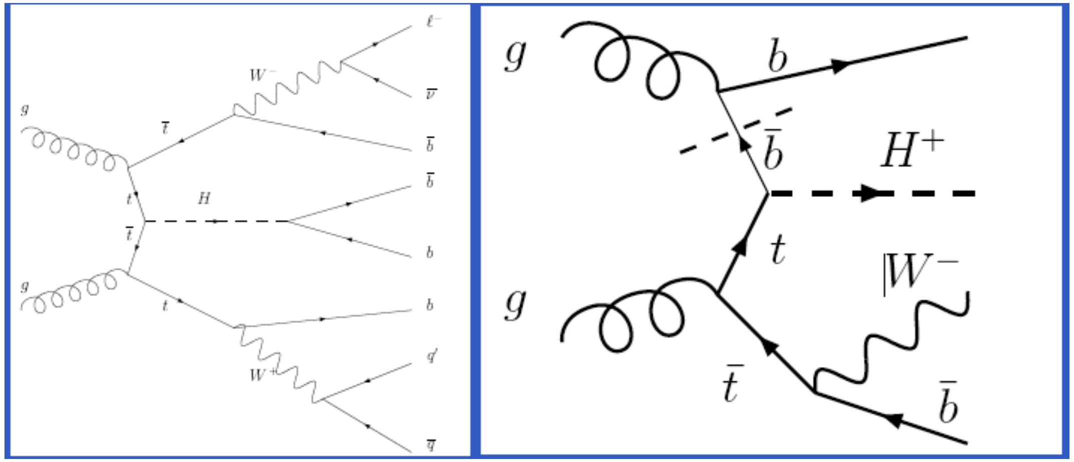
Jet/b-jet triggers for complex final state Higgs

- See talk by Chris Potter: http://indico.cern.ch/conferenceDisplay.py?confId=50222

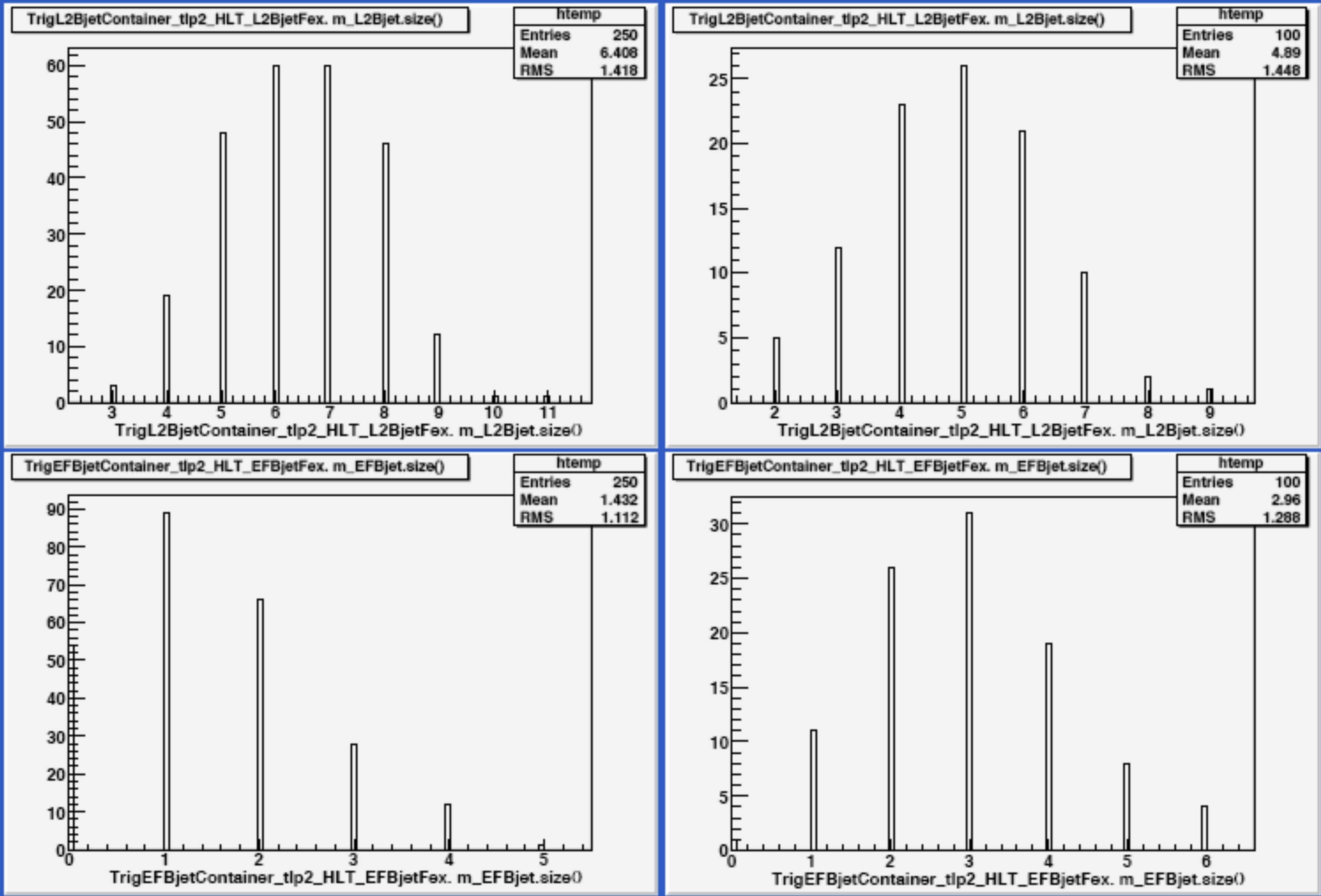
- ttH, H->bb and tbH$^+$, H$^+$->tb have 4 b quarks and 2 W bosons in the final state

- ttH with both tops decaying hadronically has the largest branching ratio
  - Jet triggers are essential, but this channel is not much explored yet – ongoing

- Both analyses are investigating the b-tag triggers



2b23_3L1J23 efficiency (wrt MC generated sample)				
ttH	lep-lep	lep$^+$ had	lep$^-$ had	had-had
efficiency	7.4%	8.9%	11%	14%
tbH$^+$; m_H=	200GeV	250 GeV	300 GeV	400 GeV
efficiency	17.4%	27.6%	33.7%	37.3%



Level 2 (top) and Event Filter (bottom) b-jet multiplicity. At left is $ttH_{120}(bb)$, at right $tbH^{+}_{250}(tb)$.

Jet triggers for ttH

ttH study by Catrin Bernius

Efficiencies wrt preselection:

- 1 isolated lepton:
  - Electron: isEM&&0xFF, pT>25GeV, |η|<2.5
  - Muon: pT>20GeV, |η|<2.5, ETcode20<10GeV+pTratio<0.3
- 6 jets with pT>20GeV, |η|<5, 4 central jets b weight>0

- B-jet trigger may be an option; sould investigate further
- Unprescaled non-tagged jets not really an option: investigate lower pT jets + lepton
- Current prescales (10^{31}): L1_4j23: 20; L1_XE40: 20; L1_XE50: 2

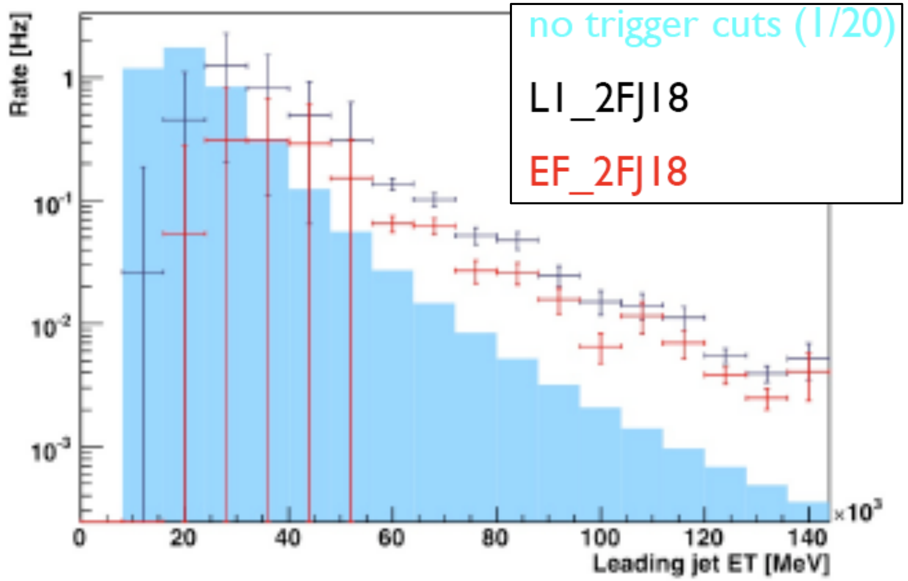
	bjet	3j180	4j95	4j125	xe40	xe50
L1	90.0%	35.6%	86.8%	68.4%	65.9%	55.6%
L2	15.2%	0%	0%	0%	56.8%	44.7%
EF	13.5%	0%	0%	0%	49.1%	37.9%

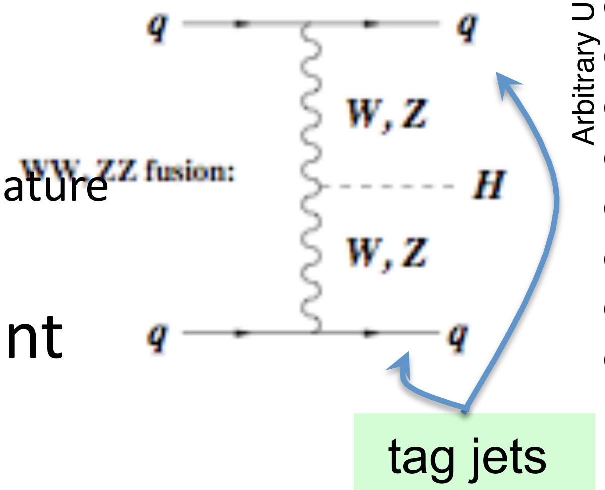
Forward Jets

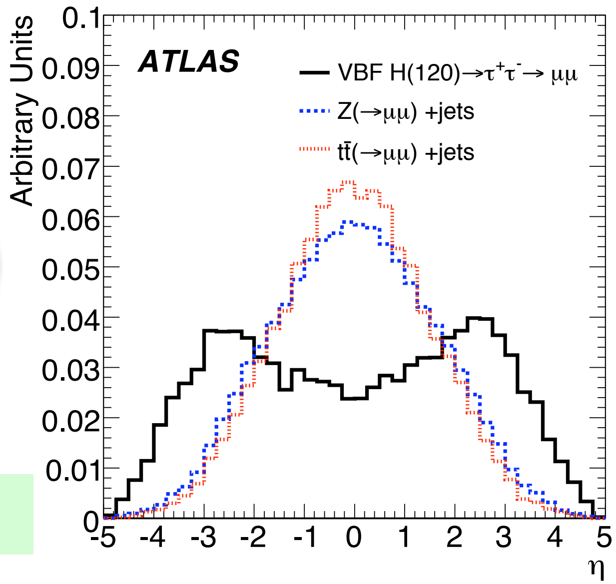
- Vector Boson Fusion Higgs production
  - Several Higgs searches may benefit from this trigger
    - VBF H->WW
    - VBF H->ττ
    - VBF H->invisible
  - Didn’t exist for CSC exercise but physics studies beginning to appear

VBF Higgs and Forward Jet Triggers

- See talk by Mario Campanelli : http://indico.cern.ch/conferenceDisplay.py?confId=50222
- FJ add coverage from η=3.2 to η=4.9 (one eta bin)
- May provide a way to tag Vector Boson Fusion events through their tag jets
- VBF important for several early-discovery (Standard Model) Higgs searches:
  - H->WW (needs ~2fb^{-1})
  - H->ττ (needs ~10fb^{-1})
- Also: H->invisible, where signature is E_T^{miss} + 2 tag jets
- FJ trigger also relevant for Diffractive Higgs





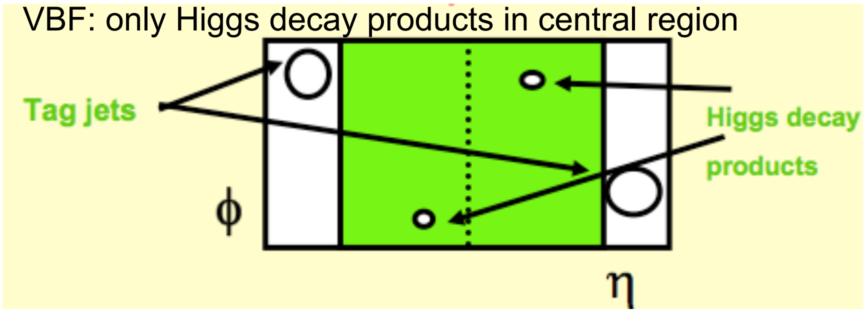


Forward Jet triggers for VBF Higgs

- VBF H->l^+l^-
  - Triggers in previous study (CSC): e22i, mu20
- Currently in the menu:
  - EF_FJ18 (PS=7000)
  - EF_FJ35 (PS=700)
  - EF_FJ70 (PS=20)
  - EF_FJ120 (PS=1)
  - EF_2FJ18 (PS=100)
  - EF_2FJ35 (PS=1)
  - EF_2FJ70 (PS=1)
- Need also:
  - Central-central and central-forward jet configurations for VBF and diffractive physics
- High prescales make searches impossible
  - Trigger can combine central and forward jets and request Δη and E_T cuts
  - Need to find FJ+J or FJ+J+lepton triggers with good rate and performance

E_{CM}=10TeV

L2 cuts	EF cuts	MiBias rate	QCD
before trigger		7E5	1000
L1 only(2j18)		1.4E4	480
2j18	2j18	520	120
2j25	2j35	140	4
Δη>3	Δη>3.5	550	15
2j18+Δη>3	2j18+Δη>3.5	100	9
2j25+Δη>3	2j35+Δη>3.5	65	3.7
Δη>4	Δη>5	25	1.1
2j18+Δη>4	2j18+Δη>5	21	0.7
2j25+Δη>4	2j35+Δη>5	15	0.3



Proposal for new trigger for VBF H->ll

- Several combinations tried (see table)
  - Loose lepton (muon or electron): L1 p_T>6GeV, L2 p_T>6GeV, EF p_T>10GeV
  - Loose jets: $\Delta\eta$>3, E_T>18GeV (L2); $\Delta\eta$>3.5, E_T>18GeV (EF)
  - Tight jets: $\Delta\eta$>4, E_T>25GeV (L2); $\Delta\eta$>5, E_T>35GeV (EF)
- Proposal is tight jet cut + 1 loose lepton
  - 40% gain in signal acceptance wrt CSC cuts (which used lepton p_T>20(μ)/25(e) GeV)
  - Efficiency is 53% wrt offline CSC cuts
  - The price is a rate of 16Hz (**not** unique rate)
- Plans:
  - L1 $\Delta\eta$ trigger (with Alan Watson)
  - Look at rapidity gap trigger (with Diego Casadei)
  - Produce working version of trigger and include it in test menu for official rate estimates

Efficiency(%):	VBFHttll:	minbias:	Ztautaujets:
Tight jets + 1 lep loose:	15.93	0.0002	0.23
Loose jets + 1 lep loose:	41.89	0.0020	1.59
Tight jets + 1 lep loose + OF tight	4.42	0	0.0005
Tight jets + 1 lep loose + OF Loose:	6.51	0	0.0016

Tau and ETmiss triggers

- Standard Model:
  - Vector Boson Fusion H->ττ
- MSSM:
  - enhanced H->ττ xsection
  - Charged Higgs
- BSM:
  - Invisible Higgs: HZ, H->invisible

Tau Triggers for Higgs

Tau analysis for Higgs (I)

"In general",

In order to achieve $10^{5\text{-}8}$ bkg. rejection,

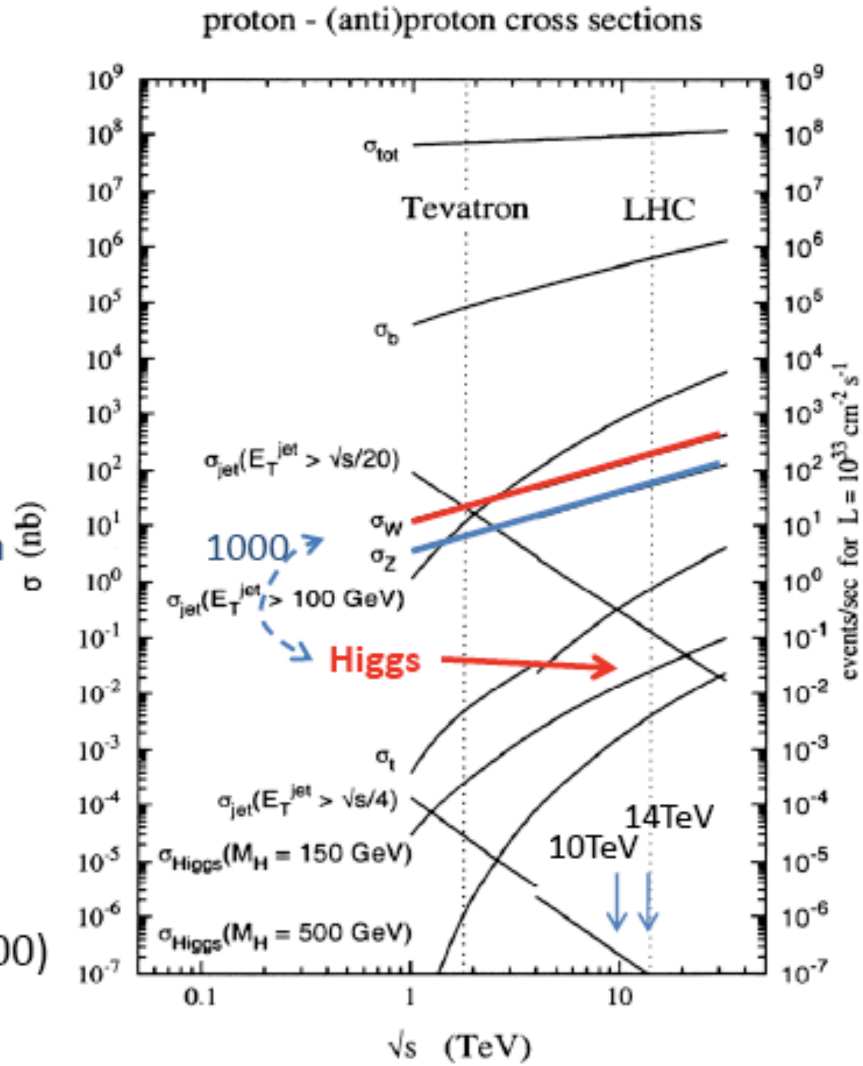
{ Low mass MSSM Higgs
  Charged Higgs

- large cross section.
- suffer from large QCD bkg.

tighter / **tau/lep. ID** / **looser** → **larger** / **cross section** / **smaller**

{ VBF SM Higgs
  High mass MSSM Higgs

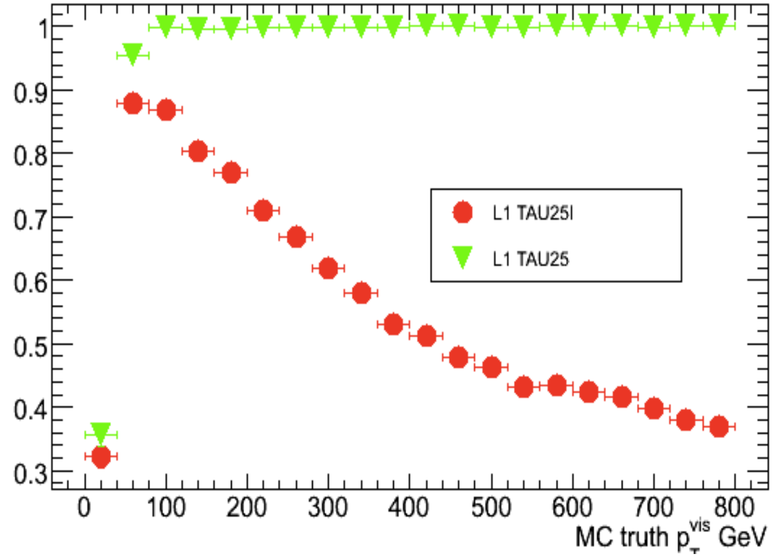
- suffer from low signal statistics.
- unique event topology.
  (VBF cut kills bkgs. w/ factor 300~500)



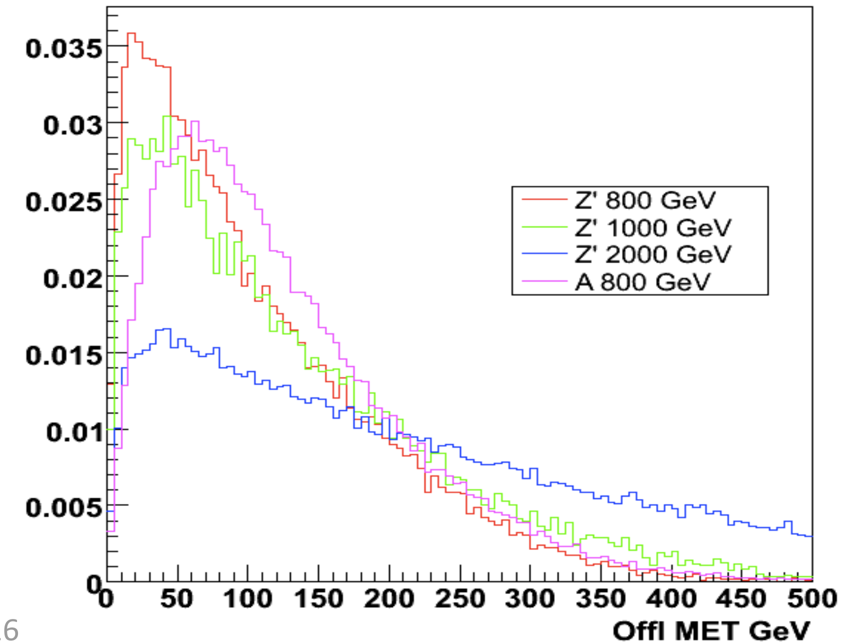
- See talk by Soshi Tsuno: http://indico.cern.ch/conferenceDisplay.py?confId=50222

Heavy Neutral Higgs in the MSSM

- In parts of the MSSM parameter space the Higgs coupling to τ is greatly enhanced
- A->ττ->had.had is most significant channel
- Important to use un-isolated tau trigger
- For A->ττ->had.had with M_A~800GeV
- Efficiency wrt **offline selection**: 2 τ with p_T>60GeV and MET>40GeV



Lumi	Signature	Evts/100pb^{-1}	EF Rate
10^{31} cm^{-2}s^{-1} **Loose selec.**	tau125	0.72	0.2Hz
	tau38_tau50	0.72	0.3Hz
10^{32} cm^{-2}s^{-1} **medium selection**	tau125	6.6	0.5Hz
	tau38_tau50	6.4	0.3Hz
	2tau50	5.7	0.7Hz
10^{33} cm^{-2}s^{-1}	2tau50	50.5	0.2Hz

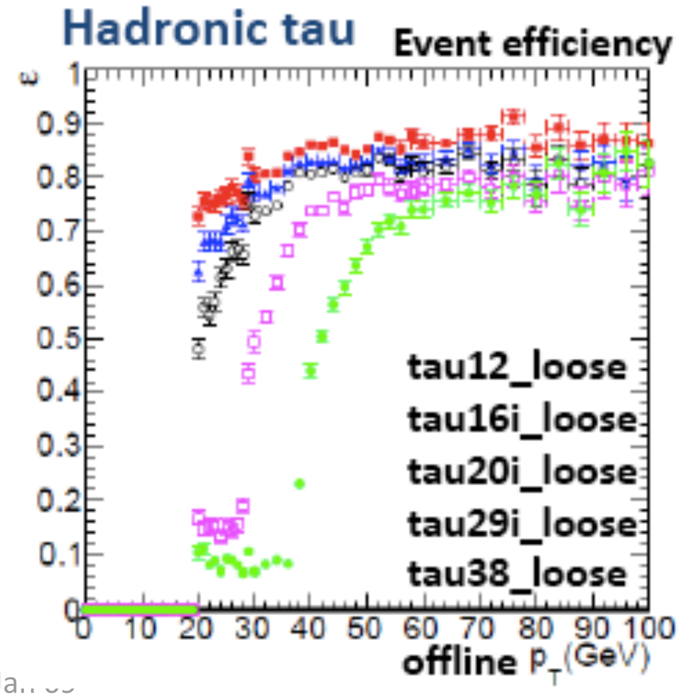


Different menus tried

- Trigger efficiency for 10^{33} menu
- Channel sensitivity starts at $10fb^{-1}$ (10^{33} $cm^{-2}s^{-1}$)
- Used 14TeV (no 10TeV samples ready)
- Offline selection:
  - tau > 35/45GeV for tau29i/tau38i respectively
  - llh cut (1-, 3-prong dependent);
  - MET>40GeV

Trigger	Rate	Off.eff.	Trig.eff.	Tot.eff.	Nev100pb-1 (10^31)
Main: 2tau29i(tight)	9 Hz	9.4 %	50 %	4.7 %	0.34
Backup: tau38i_xe40(tight)	12 Hz	8.5 %	55 %	4.7 %	0.35
tau38i_EFxe40(tight)	49 Hz !	8.5 %	62 %	5.3 %	0.39

- Tau trigger efficiency: 10^{31} menu
- Offline selection:
  - pT > 30GeV, | |<2.7
  - Author = TauRec
  - Ntrack = 1 or 3, |charge| = 1
  - LLH>0, El.LLH>0



Control samples

Stefania

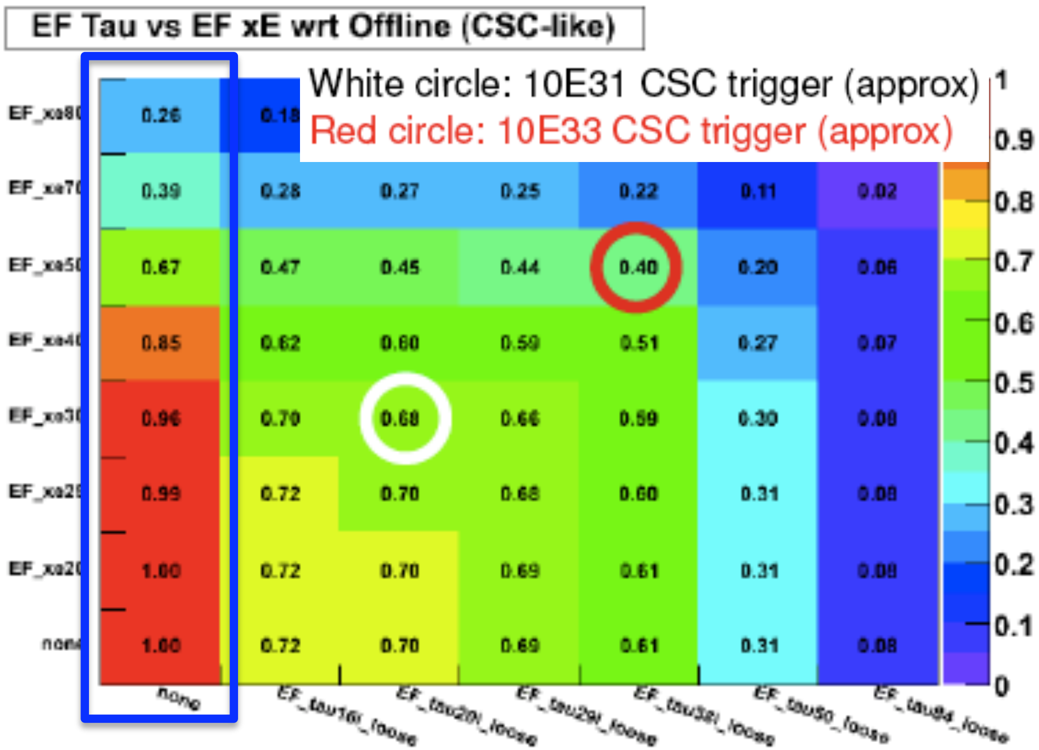
Background	for final fit, trigger is: (Z->tautau replacement)	for study at preselection of size/shape of main backgrounds:
Z+ jets	electron/muon	trigger of signal (see before)
W+jets	electron/muon	trigger of signal
ttbar	electron/muon	trigger of signal
QCD	trigger of signal	trigger of signal

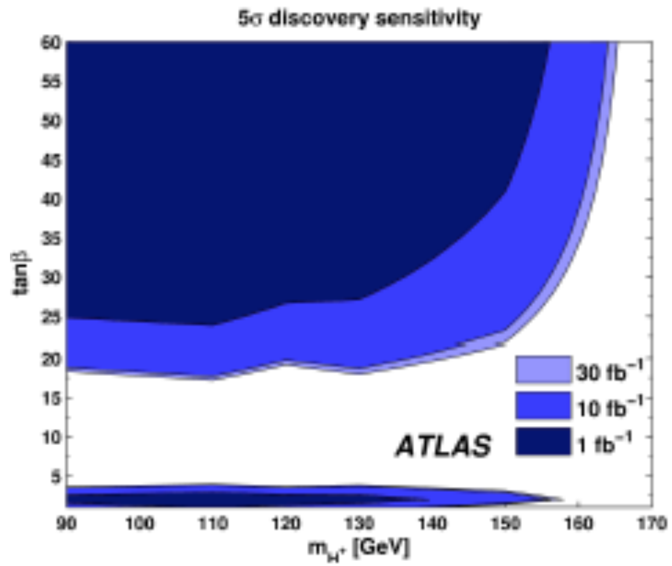
Basically we want the 2tau29i/tau+xe triggers on always, continue
Taking data unprescaled, for the relevant phase space of the search

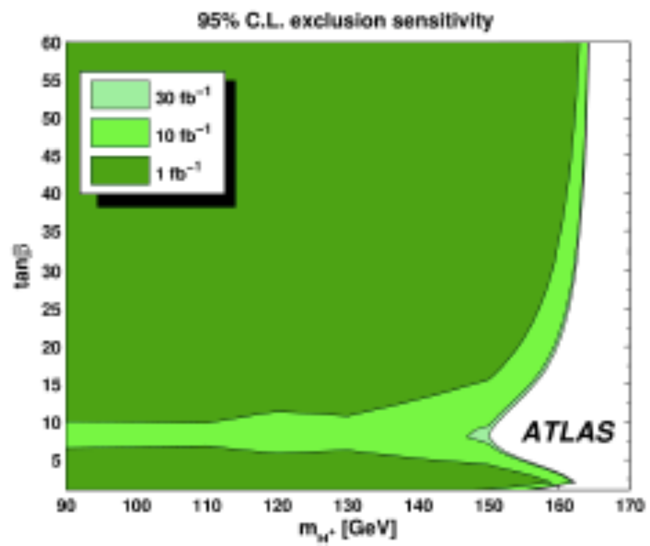
at 10^31 one can afford 2tau29i(loose)/tau38_xe40 (loose) 1-2 Hz
at 10^32 one can afford 2tau29i(medium)/tau38_xe40(medium) 6-7 Hz

MET triggers for Higgs: $H^+ \to \tau\nu$

- $t\bar{t} \to (bqq)(bH^+)$ with $H^+ \to \tau\nu$ (hadronic τ decay)
- Sensitivity already for $1fb^{-1}$
- Investigated using a pure MET trigger xE40
  - See blue rectangle
- Unfortunately this trigger is prescaled by a factor of 20 already at 10^{31}

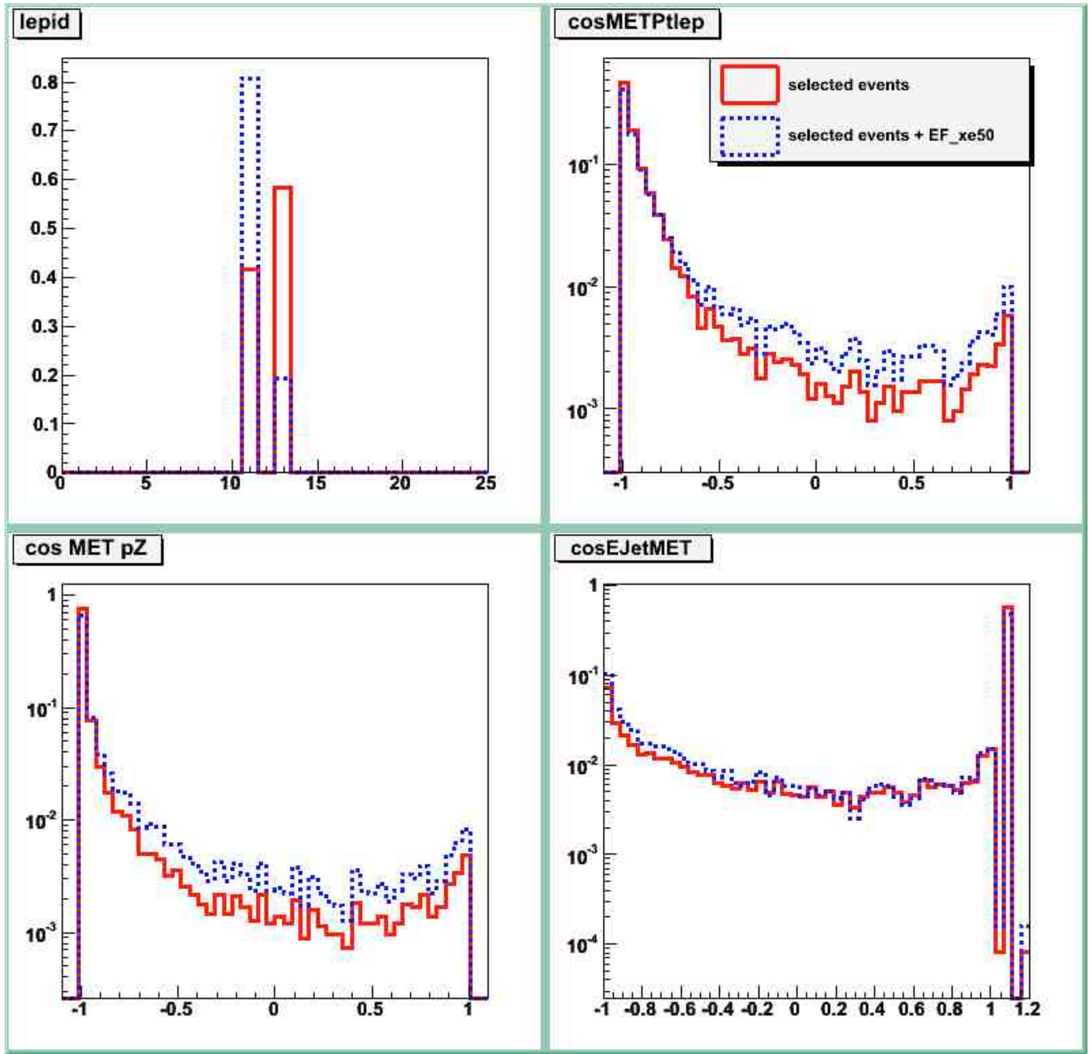






MET Triggers for Higgs: ZH->inv

- xE50 tried in analysis of ZH, H->invisible
- Strange feature found:
  - Events with Z->μμ suppressed by trigger and distributions distorted
- Will not use xE in analysis
  - Overlap with other (lepton) triggers in signal events is almost complete: only 0.2% signal loss
  - Increases acceptance for ttbar background

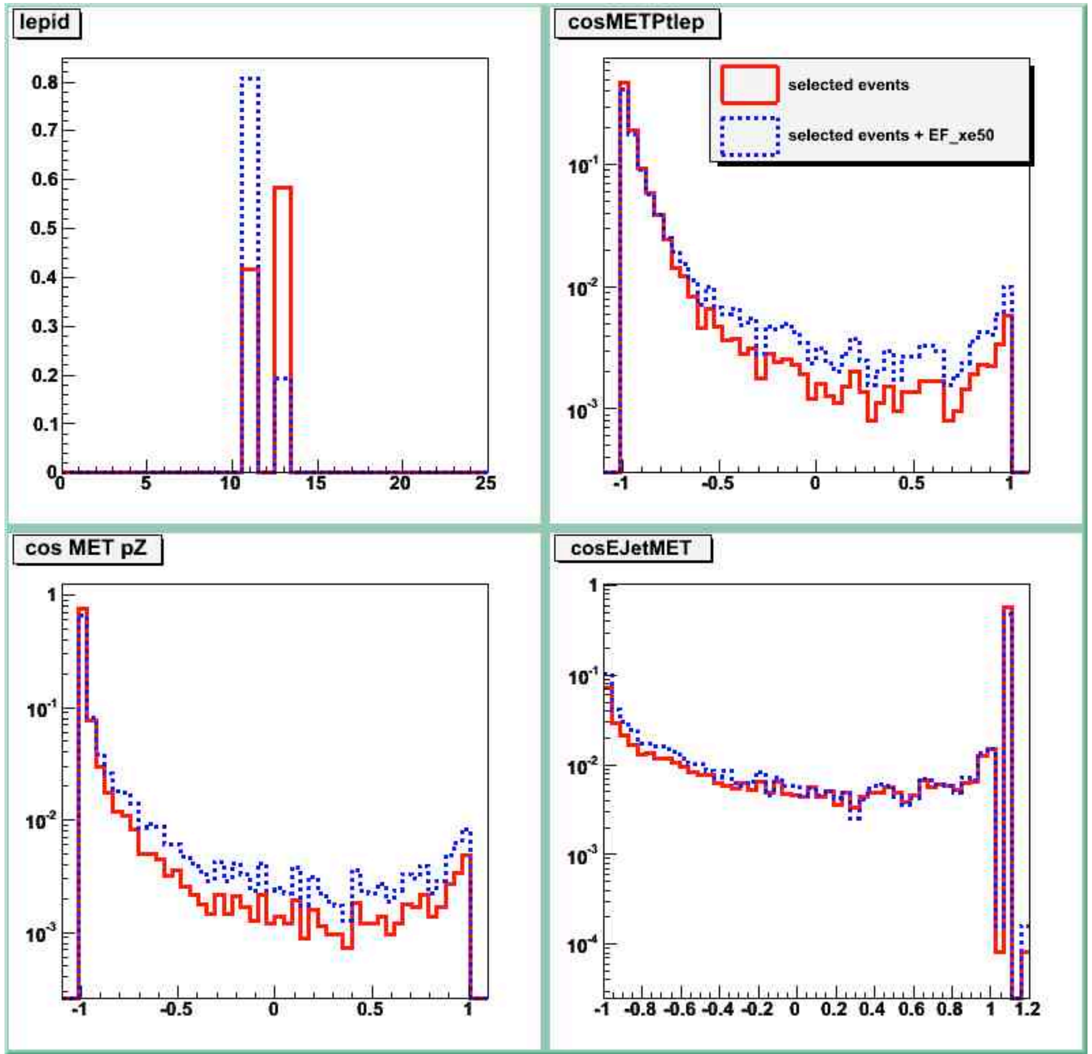


Modified input distributions used for final selection when using EF_xe50 trigger:

lepton ID, angles between (MET, pT lepton), MET and pZ, MET and leading jet.

- lepton composition changes: selects more electrons
- seems to select events with different characteristics…
- **all angular distributions are slightly modified**

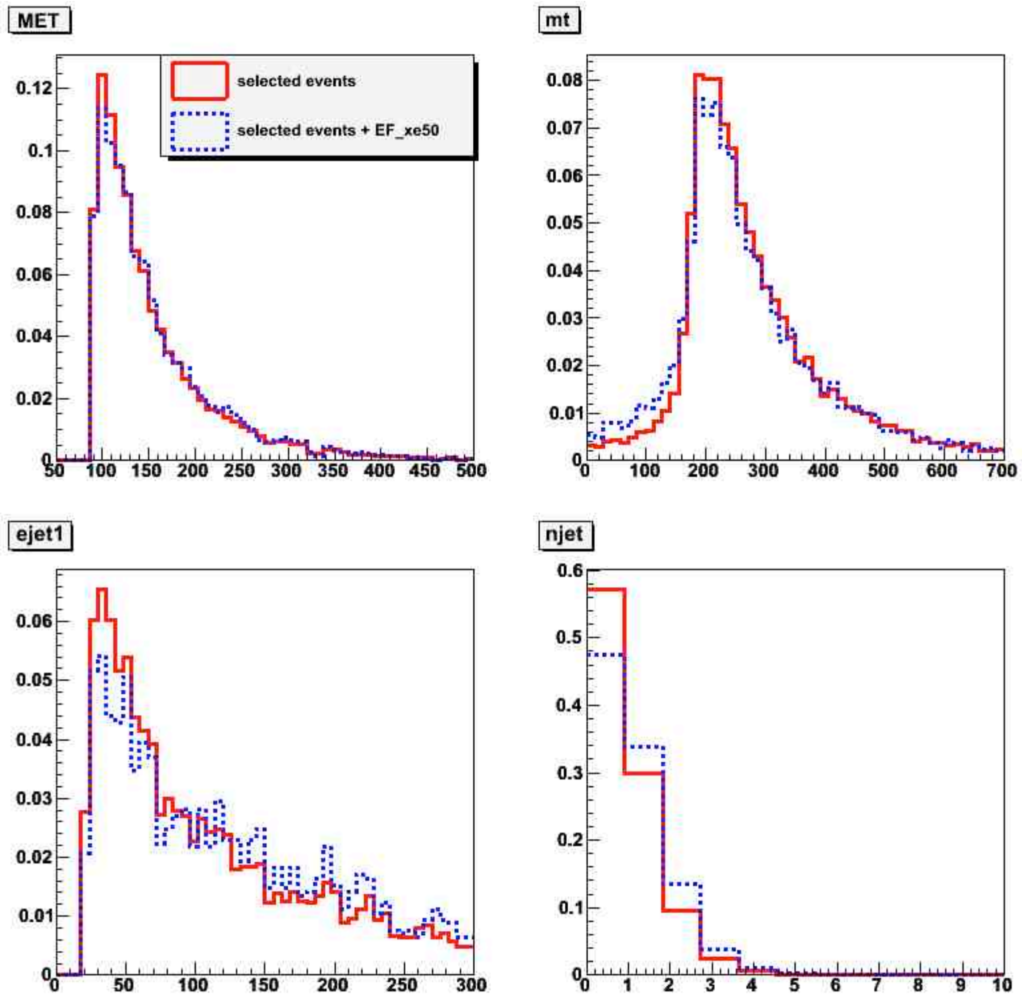
Not quite understood since 50% of all selected events pass this trigger…



Modified input distributions used for final selection when using EF_xe50 trigger:

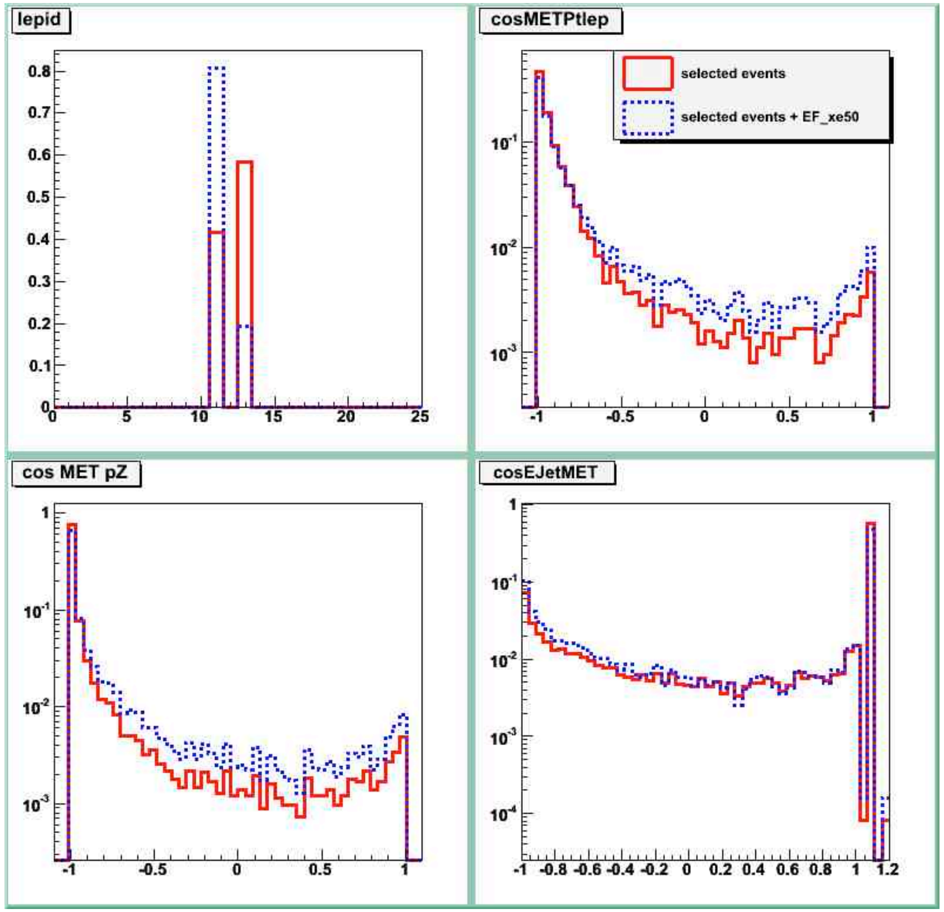
MET, transverse mass mT, E leading jet, # jets.

- sees more jets in HZ → ll events
- MET and transverse mass distributions are also affected

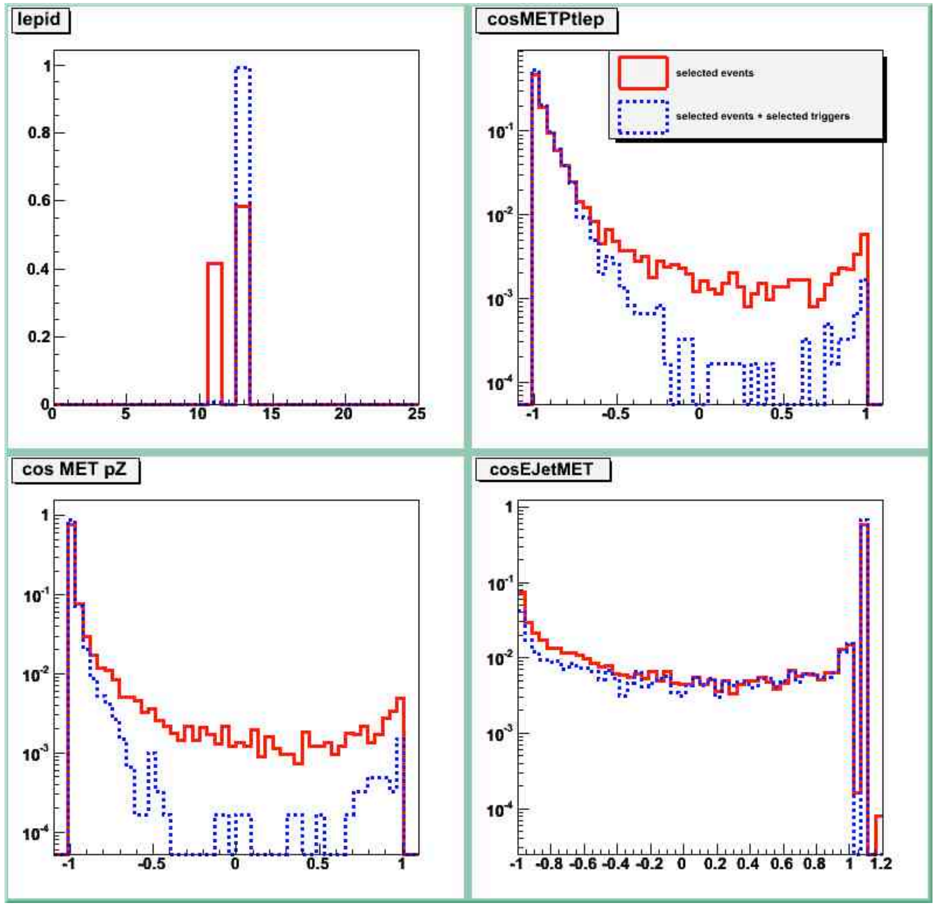


Preselected events passing or not passing EF_xe50 trigger

Passing EF_xe50



Not passing EF_xe50



MET triggers for ttH

ttH study by Catrin Bernius

Efficiencies wrt preselection:

- 1 isolated lepton:
  - Electron: isEM&&0xFF, pT>25GeV, $|\eta|<2.5$
  - Muon: pT>20GeV, $|\eta|<2.5$, ETcode20<10GeV+pTratio<0.3
- 6 jets with pT>20GeV, $|\eta|<5$, 4 central jets b weight>0

- MET triggers don't look very useful due to prescales, but could maybe be used in combination with lepton
- Current prescales (10^{31}): L1_4j23: 20; L1_XE40: 20; L1_XE50: 2

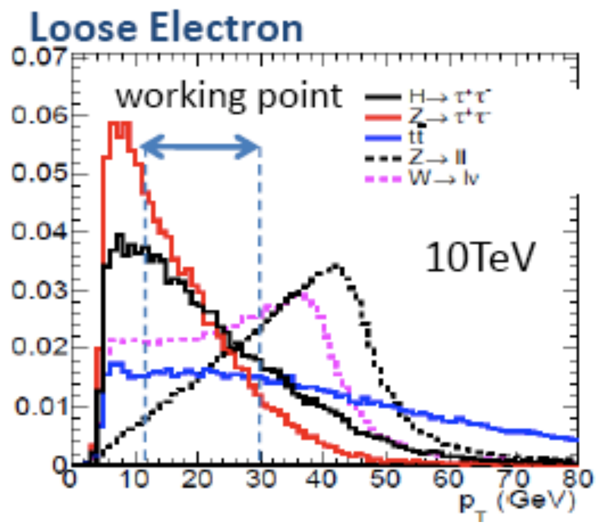
	bjet	3j180	4j95	4j125	xe40	xe50
L1	90.0%	35.6%	86.8%	68.4%	65.9%	55.6%
L2	15.2%	0%	0%	0%	56.8%	44.7%
EF	13.5%	0%	0%	0%	49.1%	37.9%

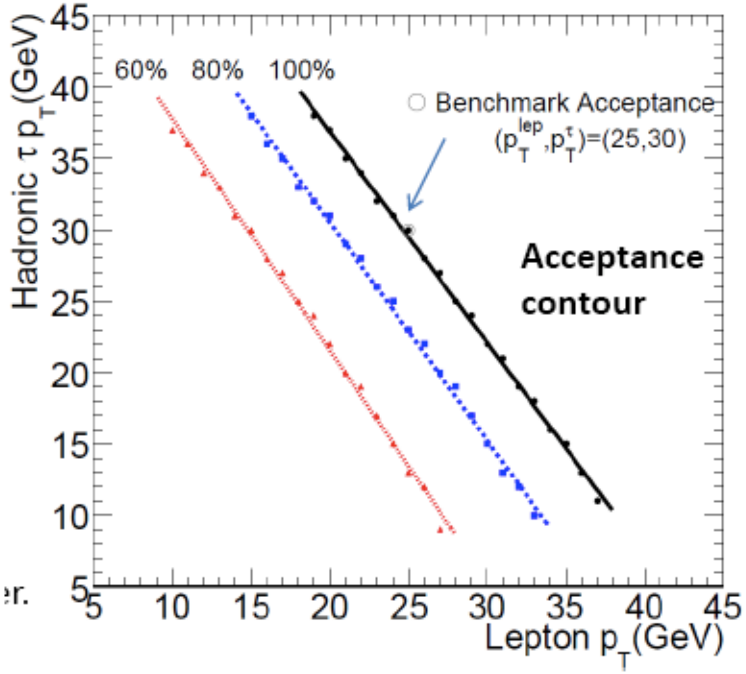
Combined triggers

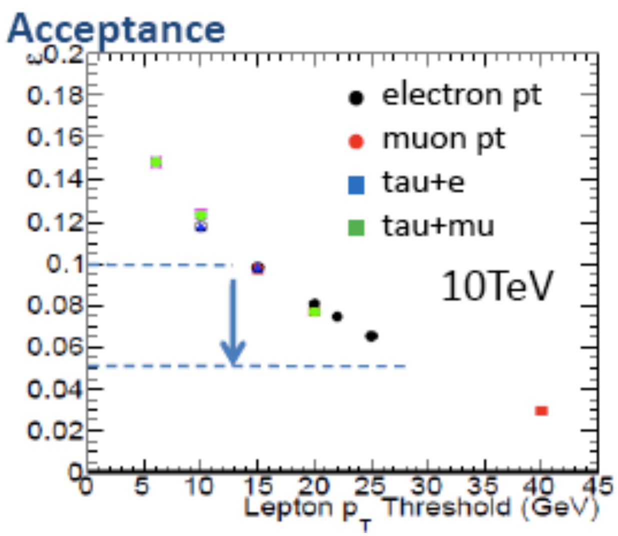
- Vector Boson Fusion H->ττ
- Low-mass charged Higgs: H^+->τ(had)ν
- High-mass charged Higgs: tbH^+, H^+->tb
- Associated production: ttH

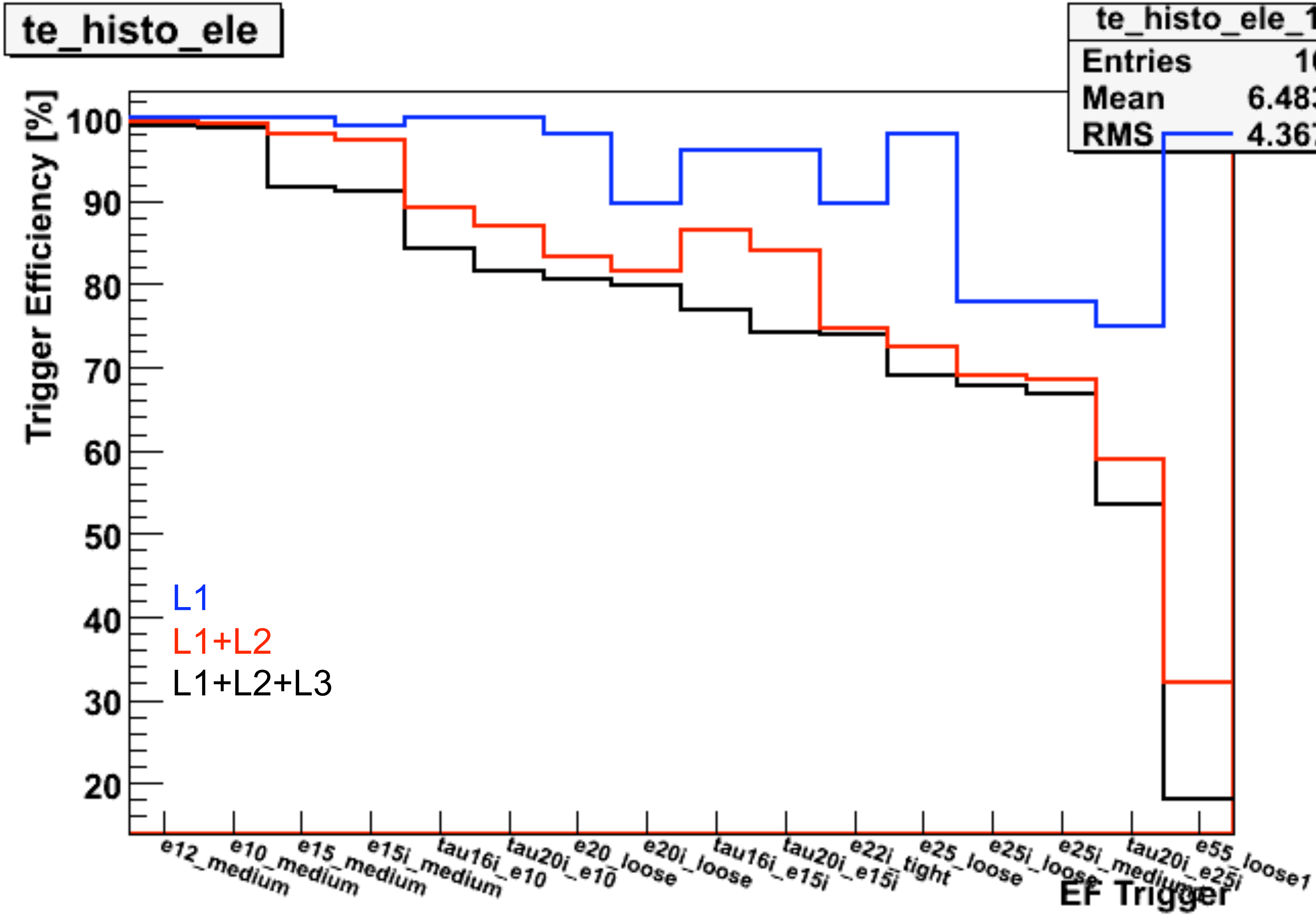
Combined triggers for H->ττ

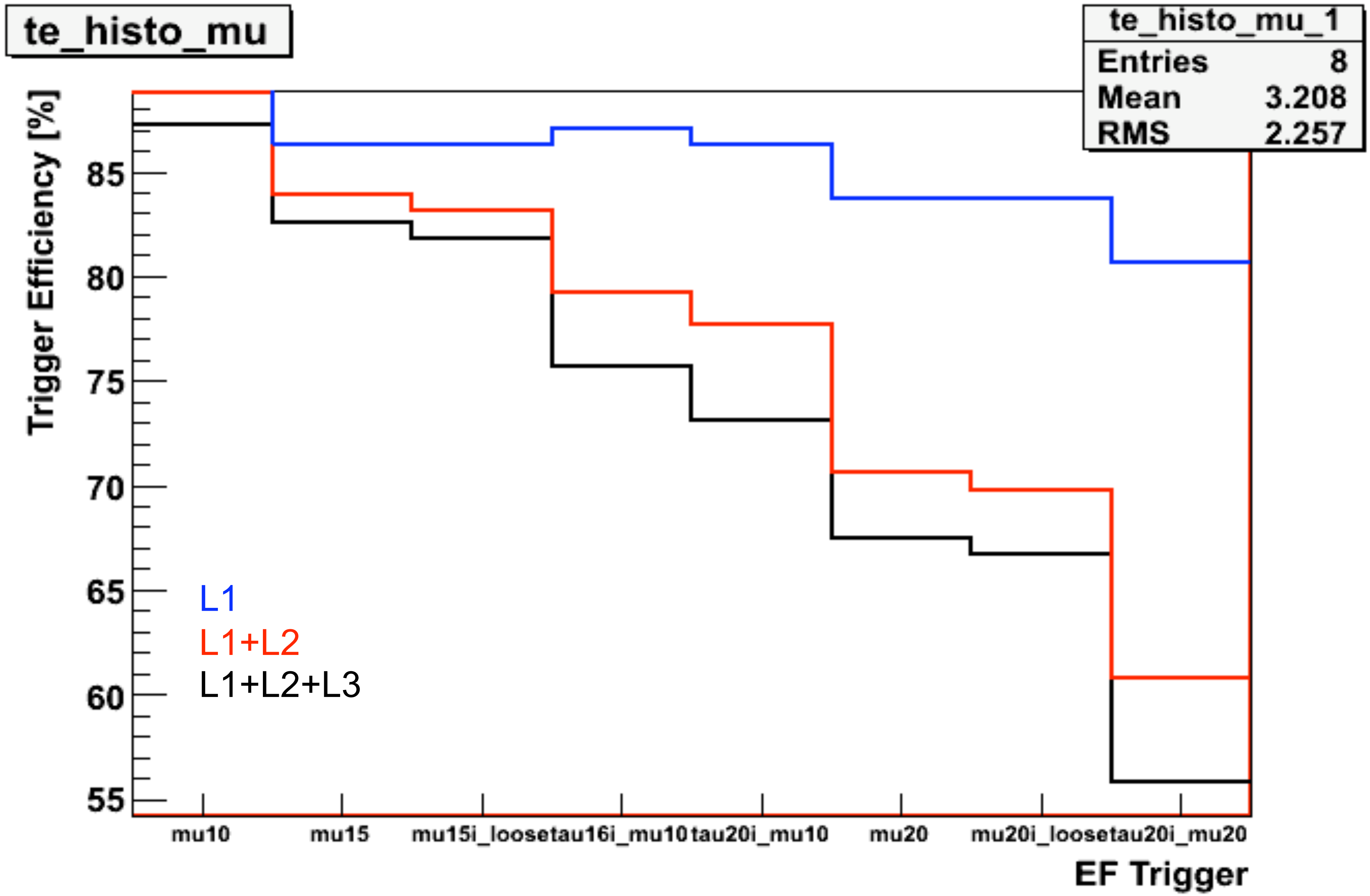
- See talk by Soshi Tsuno: http://indico.cern.ch/conferenceDisplay.py?confId=50222
- Tau decays to e/μ with BR~34%
  - Need e/mu thresholds between p_T=15 GeV and p_T=30GeV
  - 40% acceptance lost going from 15GeV to 30GeV
- Combined trigger (τ+e, τ+μ) may help keep low thresholds and low rate








te_histo_ele
te_histo_ele_1
Entries 16
Mean 6.483
RMS 4.367
Trigger Efficiency [%]
100
90
80
70
60
50
40
30
20
L1
L1+L2
L1+L2+L3
e12_medium
e10_medium
e15_medium
e15i_medium
tau16i_e10
tau20i_e10
e20_loose
e20i_loose
tau16i_e15i
tau20i_e15i
e22i_tight
e25_loose
e25i_loose
e25i_medium
tau20i_e25i
e55_loose1
EF Trigger

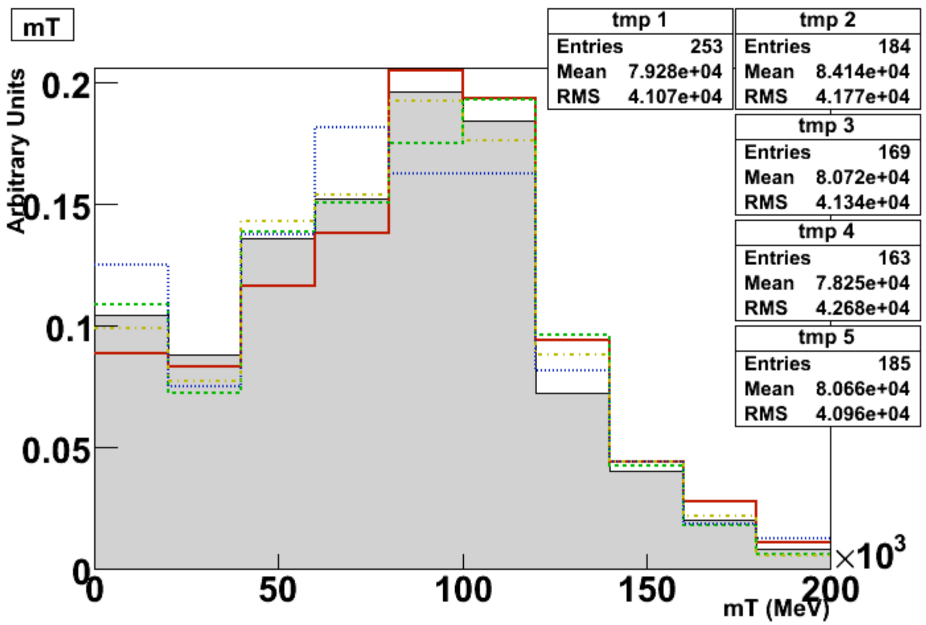

te_histo_mu
te_histo_mu_1
Entries 8
Mean 3.208
RMS 2.257
Trigger Efficiency [%]
85
80
75
70
65
60
55
L1
L1+L2
L1+L2+L3
mu10
mu15
mu15i_loosetau16i_mu10
tau20i_mu10
mu20
mu20i_loosetau20i_mu20
EF Trigger

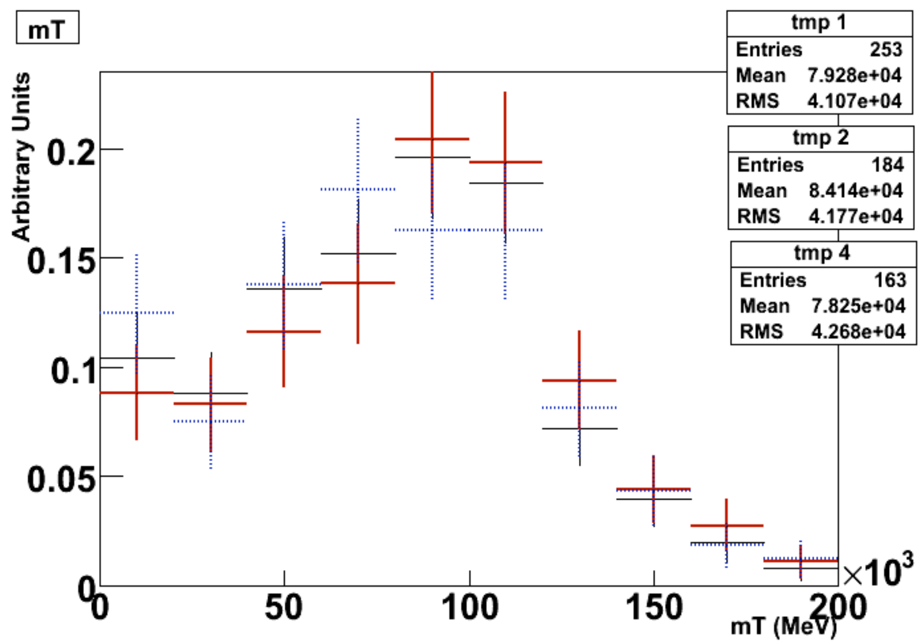
Combined triggers for $H^+ \to \tau(had)\nu$

- See talk by Elias Coniavitis: http://indico.cern.ch/conferenceDisplay.py?confId=50222

- Searched for bias in transverse mass from different triggers: variation within statistical fluctuation

EF_xe40 (no PS!)
EF_tau20i_xe30
EF_tau16i_3j23
EF_2j42_xe30





Combined triggers for ttH and tbH$^+$

- Take advantage of features in event topology other than leptons, and of post-rel.12 developments in trigger: MET, b-tag

Sample	3b23_3L1J23	e20_xe30	mu20_xe30	e20i_loose	mu20
$[\ell^+ h]t\bar{t}H_{120}(b\bar{b})$	0.089	0.27	0.033	0.344	0.346
$[\ell^- h]t\bar{t}H_{120}(b\bar{b})$	0.111	0.318	0.044	0.367	0.38
$[hh]t\bar{t}H_{120}(b\bar{b})$	0.14	0.016	0.001	0.021	0.049
$[\ell\ell]t_{lep}\bar{t}_{lep}H_{120}(b\bar{b})$	0.074	0.471	0.118	0.552	0.573
$[\ell h]tbH^+_{200}(t\bar{b})$	0.174	0.254	0.023	0.344	0.341
$[\ell h]tbH^+_{250}(t\bar{b})$	0.276	0.259	0.025	0.357	0.332
$[\ell h]tbH^+_{300}(t\bar{b})$	0.337	0.265	0.027	0.353	0.345
$[\ell h]tbH^+_{400}(t\bar{b})$	0.373	0.262	0.032	0.331	0.39
$[hh]t\bar{t}$	0.078	0.008	0.0	0.015	0.027
$[\ell h, \ell\ell]t\bar{t}$	0.024	0.225	0.014	0.279	0.274

Other numbers for ttH->(blv)(bjj)(bb):

With respect to preselection:

1 isolated lepton:

Electron: isEM&&0xFF, pT>25GeV, |η|<2.5

Muon: pT>20GeV, |η|<2.5, ETcode20<10GeV+pTratio<0.3

6 jets with pT>20GeV, |η|<5, 4 central jets b weight>0

	e20_loose || mu15	e20i_loose || mu15	e25i_loose || mu20i_loose
L1	99.8%	92.2%	90.6%
L2	91.8%	87.8%	75.6%
EF	90.0%	86.7%	74.6%

Conclusions

- In general:
  - Try to tighten purity cuts instead of raising pT thresholds
  - Prescaled triggers are usually unusable for Higgs: use combined triggers
- Minimum bias: will need samples from random and minimum bias triggers!
- Wishlist:
  - E/gamma: Important to study L1 electron/photon isolation
    - H->4l, H->WW: e10_medium, e20i_loose, e20_loose, 2e6_medium, 2e15_medium
    - G10_loose, g20i_loose, g20_loose, 2g20_loose, g25_loose, g20_loose_PassHLT/L1/EF
  - Muons: H->4l, H->WW: mu10, mu20, mu15i_loose, 2mu10,
  - Tau/Etmiss: 2tau29i, tau38i_xe40, tau38i_EFxe40; xe40, xe50 (but problem with prescales)
  - Jet/b-jet: 2b23_3L1J23
  - Combined: tau16i_e10, tau16i_e15i, tau20i_e15i, tau20i_e25i, tau16i_mu10, tau16i_mu20, tau20i_mu10, tau20i_xe30, tau16i_3j23, 2j42_xe30
- Forward Jets: VBF H->ll; proposal for new trigger:
  - $\Delta\eta>4$, $E_T>25$GeV (L2); $\Delta\eta>5$, $E_T>35$GeV (EF) + 1 e or μ lepton with $p_T>10$GeV
  - 40% gain in signal acceptance wrt CSC cuts (which used only lepton $p_T>20(\mu)/25(e)$ GeV)
  - Efficiency is 53% wrt offline CSC cuts
  - The price is a rate of 16Hz (**not** unique rate)