



## Study of the trigger efficiency for the $t\bar{t}t\bar{t}$ signal (second part)

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# Two trigger setups



- **From last time:** I tried two different trigger setups:  **$t\bar{t}H$  ML setup** and **multijet trigger** setups
- **$t\bar{t}H$  ML setup**
  - **$1\tau 0L$ : OR of multijet triggers**
  - **$1\tau 1L$ : OR of single lepton and lepton+tau triggers**
  - **$1\tau 2L$ : OR of single lepton, double lepton and  $le+\mu$  triggers**
  - **$1\tau 3L$ : same of  $1\tau 2L$  + OR of trilepton triggers**
  - **$2\tau 0L$ : OR of double tau triggers**
  - **$2\tau 1L$ : same as  $1\tau 1L$**
  - **$2\tau 2L$ : same as  $1\tau 2L$**
- **Multijet triggers setup**
  - **$1\tau 0L$ : OR of multijet triggers**
  - **$1\tau 1L$ : OR of multijet triggers**
  - **$1\tau 2L$ : OR of multijet triggers**
  - **$1\tau 3L$ : OR of multijet triggers**
  - **$2\tau 0L$ : OR of multijet triggers**
  - **$2\tau 1L$ : OR of multijet triggers**
  - **$2\tau 2L$ : OR of multijet triggers**

Details about the triggers are in [▶ backup](#)



## ttH ML setup

- In general ask for leading  $p_T^\ell > 30$  GeV
- In categories with  $N_\ell \geq 2$ , check for flavor of leptons
  - If no muons, ask for leading ele  $p_T > 30$  GeV
  - If no electrons, ask for leading mu  $p_T > 30$  GeV
  - If both ele and muons, ask for both leading ele and leading mu  $p_T > 30$  GeV

## Multijet triggers setup

- No special selection
  - Tried a jet pt  $p_T$  cut, but made things worse



- **$t\bar{t}H$  ML setup**

	1tau0L	1tau1L	1tau2L	1tau3L	2tau0L	2tau1L	2tau2L
num	498.168	263.281	88.1315	6.76591	9.53775	8.83934	1.87699
den	505.174	333.8	90.7069	6.76591	26.889	11.6548	1.98612
trigEff	0.986132	0.788741	0.971607	1	0.354708	0.758427	0.945055

- **Multijet triggers setup**

	1tau0L	1tau1L	1tau2L	1tau3L	2tau0L	2tau1L	2tau2L
num	498.168	413.485	110.481	7.70441	25.9724	12.7461	1.94247
den	505.174	425.052	118.316	8.14092	26.889	14.0338	2.2262
trigEff	0.986132	0.972786	0.933776	0.946381	0.965909	0.908243	0.872549

# New tries with the ttH ML setup



Trigger  
efficiency

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Trigger  
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- Before the **eleID bugfix**, **electron ISO** was set to **loose**
  - The bug caused the loss of many events, tight ISO was too much
- See what happens with **tight ISO now**
  - Tight ISO would also be consistent with muon ISO (tight as well)
- **Drop in efficiency** seems bigger in categories using **tau triggers**
  - Try lower bound in  $p_T$  for taus as well
  - $1\tau 1L$ : leading tau  $p_T > 30$  GeV
  - $2\tau 0L$ : both taus  $p_T > 30$  GeV
  - $2\tau 1L$ : leading tau  $p_T > 30$  GeV



## Baseline

	1tau0L	1tau1L	1tau2L	1tau3L	2tau0L	2tau1L	2tau2L
num	498.168	263.281	88.1315	6.76591	9.53775	8.83934	1.87699
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trigEff	0.986132	0.788741	0.971607	1	0.354708	0.758427	0.945055

## Tight ele ISO

	1tau0L	1tau1L	1tau2L	1tau3L	2tau0L	2tau1L	2tau2L
num	510.564	267.69	82.5223	5.63098	9.75601	8.73021	1.87699
den	517.68	331.748	84.3556	5.65281	27.7402	11.3056	1.94247
trigEff	0.986256	0.806908	0.978266	0.996139	0.351692	0.772201	0.966292



## Baseline

	1tau0L	1tau1L	1tau2L	1tau3L	2tau0L	2tau1L	2tau2L
num	498.168	263.281	88.1315	6.76591	9.53775	8.83934	1.87699
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## $\tau p_T > 30 \text{ GeV}$

	1tau0L	1tau1L	1tau2L	1tau3L	2tau0L	2tau1L	2tau2L
num	510.564	202.541	82.5223	5.63098	7.79171	8.35918	1.87699
den	517.68	252.849	84.3556	5.65281	14.6013	10.7163	1.94247
trigEff	0.986256	0.801036	0.978266	0.996139	0.533632	0.780041	0.966292



# New tries with the multijet triggers setup



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Trigger  
efficiency

- No special selection was applied before
  - Putting cuts on jets  $p_T$  proved to be unsuccessful
- **Try** placing a **cut on** the event  $H_T$ 
  - $H_T > 500$  GeV
  - **NOTE!**: I found out during 4tops discussion that **ATLAS** is making this same **cut** in multilepton final states
  - See [here](#), first presentation
  - They use leptonic triggers though



## Baseline

	1tau0L	1tau1L	1tau2L	1tau3L	2tau0L	2tau1L	2tau2L
num	498.168	413.485	110.481	7.70441	25.9724	12.7461	1.94247
den	505.174	425.052	118.316	8.14092	26.889	14.0338	2.2262
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Trigger  
efficiency



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den	505.174	425.052	118.316	8.14092	26.889	14.0338	2.2262
trigEff	0.986132	0.972786	0.933776	0.946381	0.965909	0.908243	0.872549

## $H_T > 500$ GeV

	1tau0L	1tau1L	1tau2L	1tau3L	2tau0L	2tau1L	2tau2L
num	484.308	347.746	70.431	3.57939	24.5974	8.57743	1.0258
den	488.433	352.286	71.9369	3.62304	25.012	8.88299	1.0258
trigEff	0.991555	0.987114	0.979066	0.987952	0.983421	0.965602	1



- **Tau triggers** seem to be **inefficient**
- Partially recovered placing lower bound on tau  $p_T$
- I think we should **switch to tight ISO for electrons**
- **Multijet triggers** have **higher efficiency**
- Putting **lower bound on  $H_T$**  makes them highly efficient
- **Question**: does the number of jets in each category look good? See backup slides



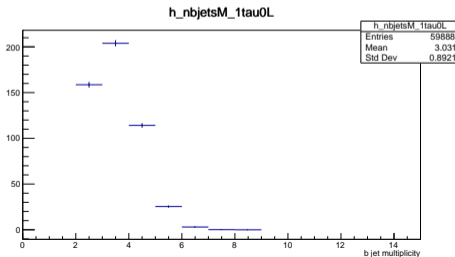
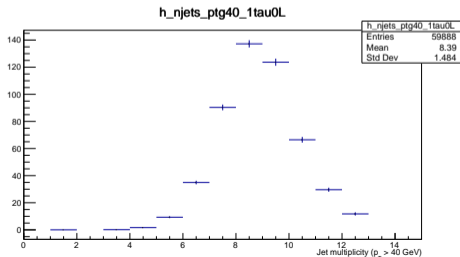
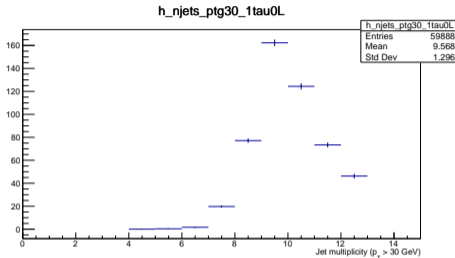
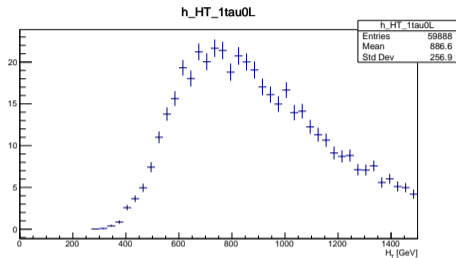
# Backup slides

# Trigger variables: $1\tau 0L$ before trigger



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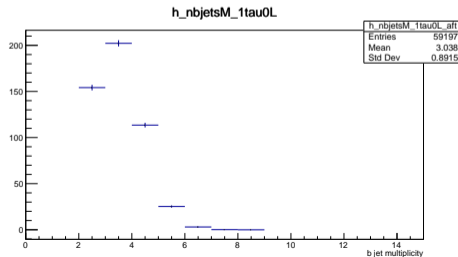
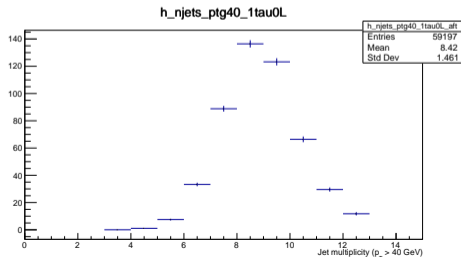
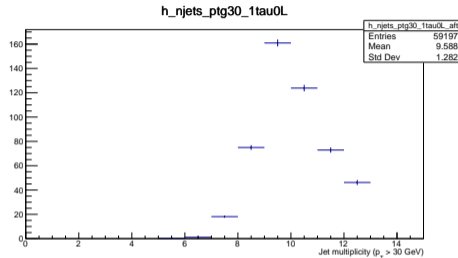
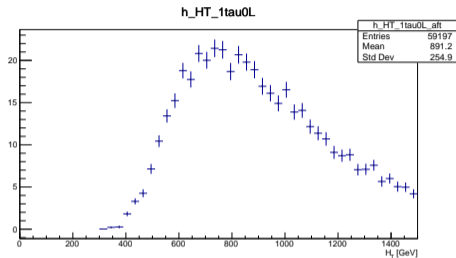


# Trigger variables: $1\tau 0L$ after trigger



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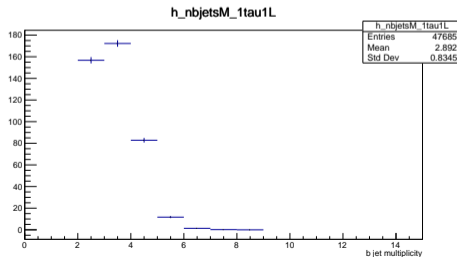
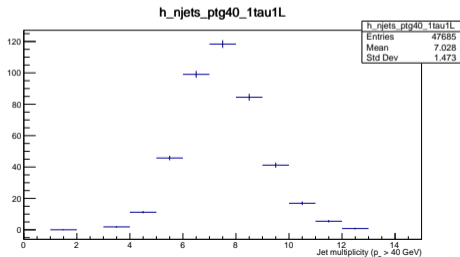
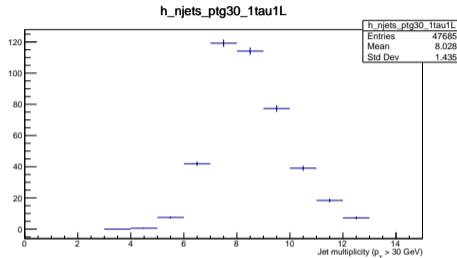
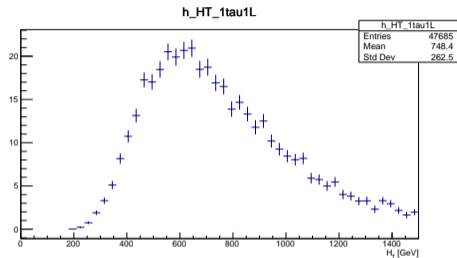


# Trigger variables: $1\tau 1L$ before trigger



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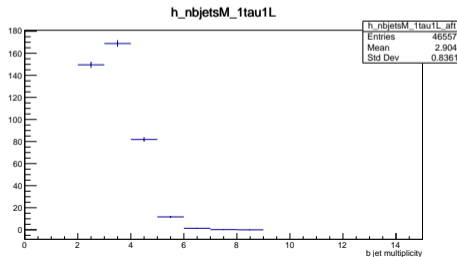
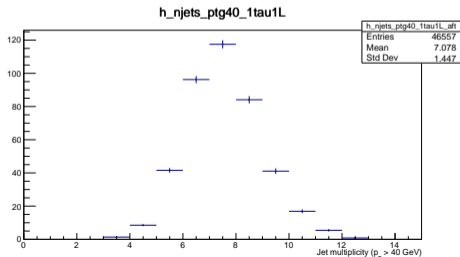
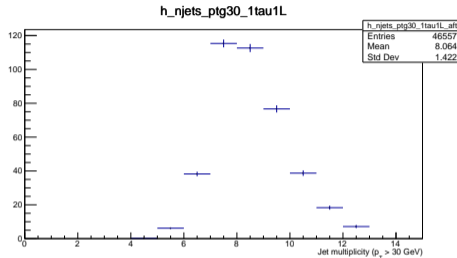
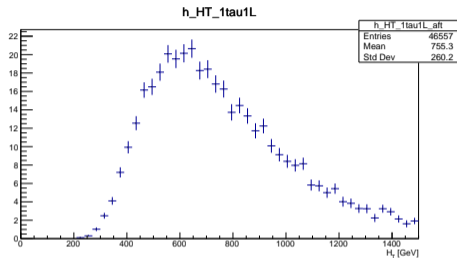


# Trigger variables: $1\tau 1L$ after trigger



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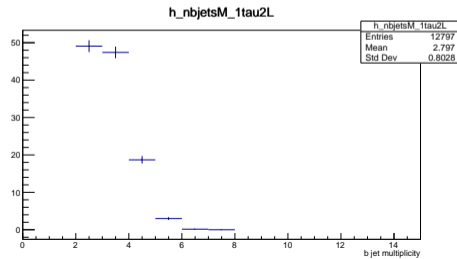
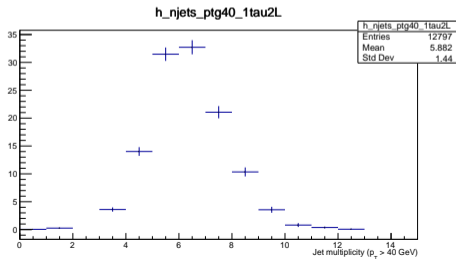
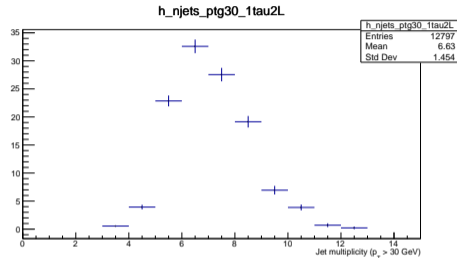
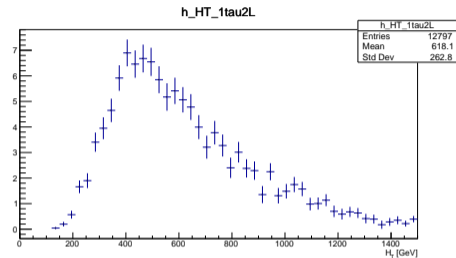


# Trigger variables: $1\tau$ $2L$ before trigger



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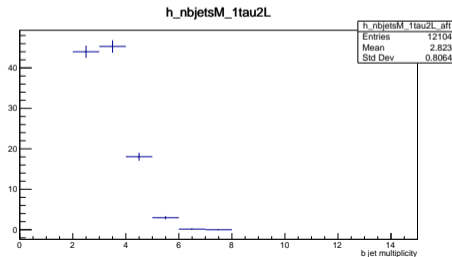
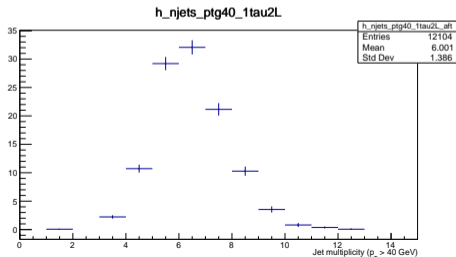
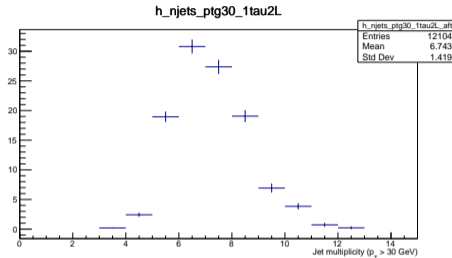
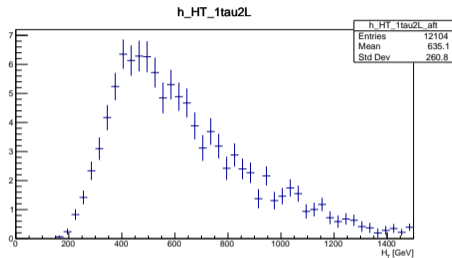


# Trigger variables: $1\tau 2L$ after trigger

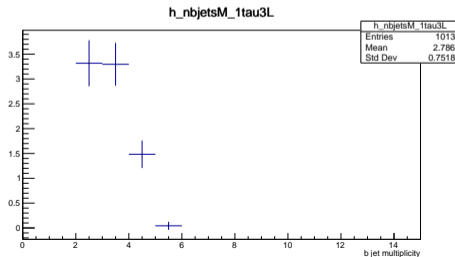
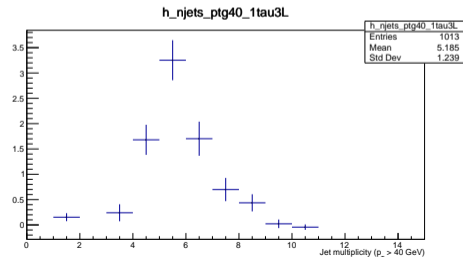
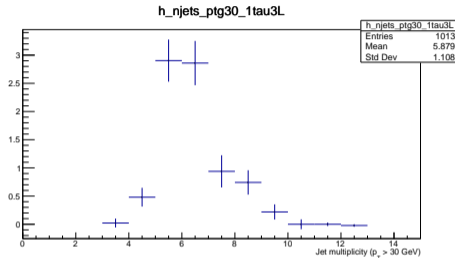
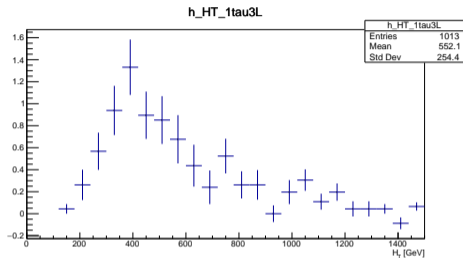


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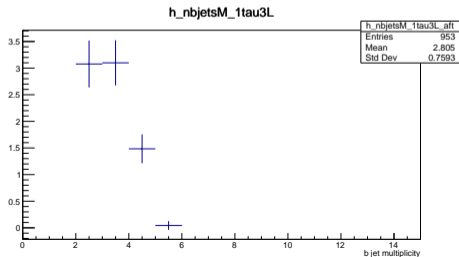
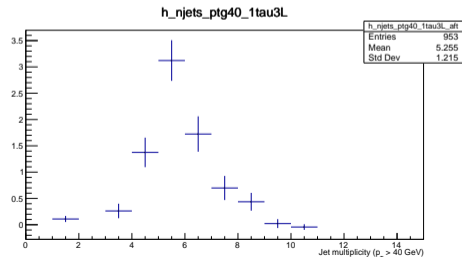
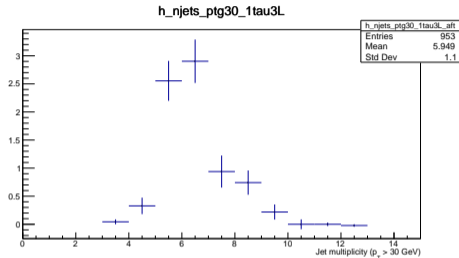
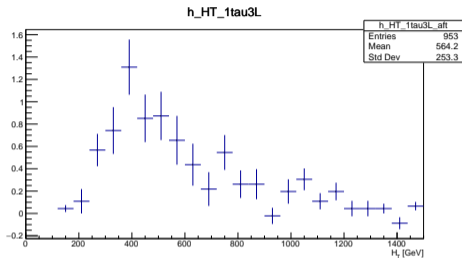
# Trigger variables: $1\tau 3L$ before trigger



Trigger efficiency

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Trigger efficiency

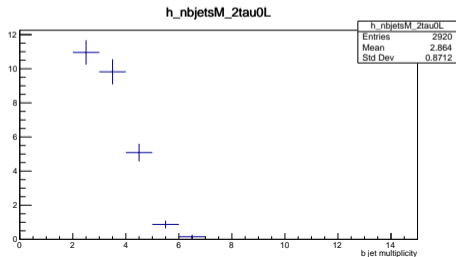
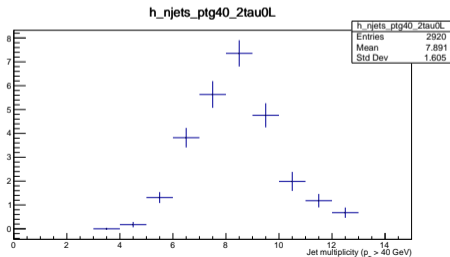
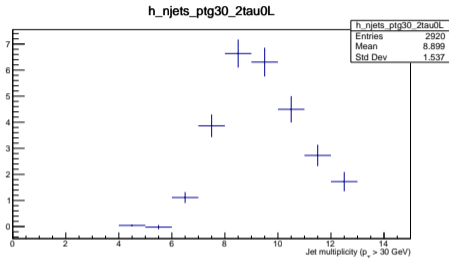
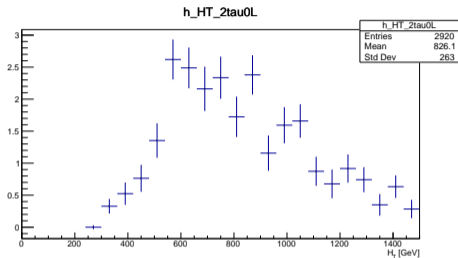
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# Trigger variables: $2\tau 0L$ before trigger



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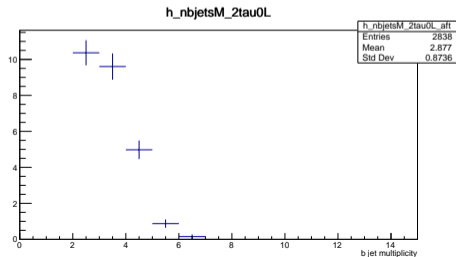
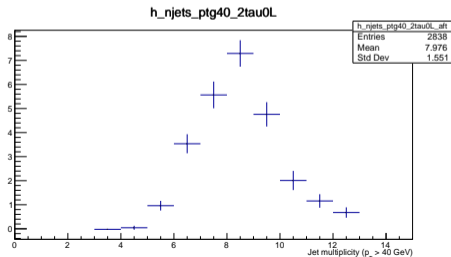
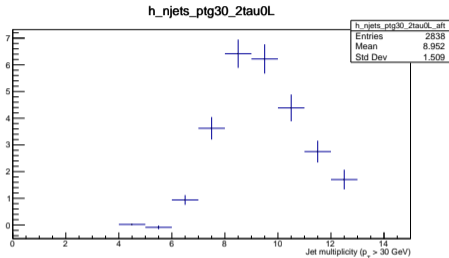
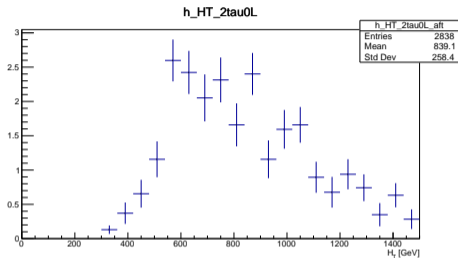


# Trigger variables: $2\tau 0L$ after trigger



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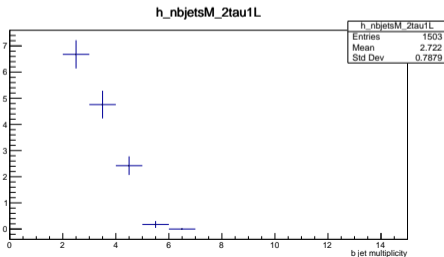
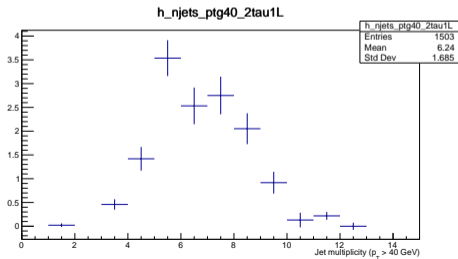
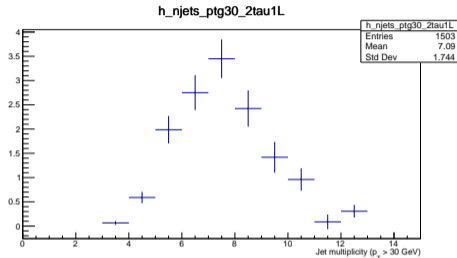
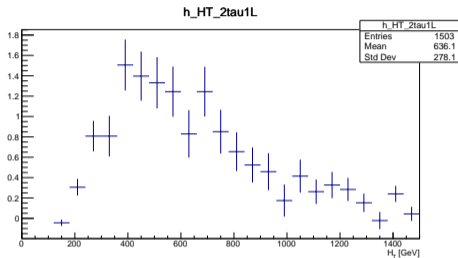


# Trigger variables: $2\tau$ 1L before trigger



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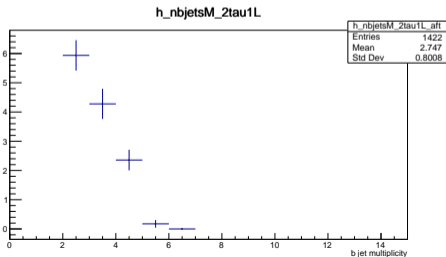
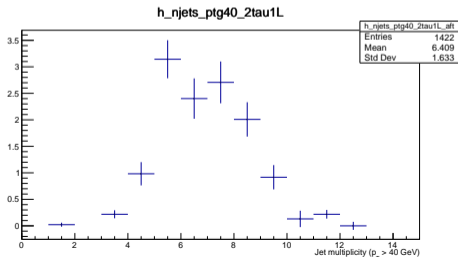
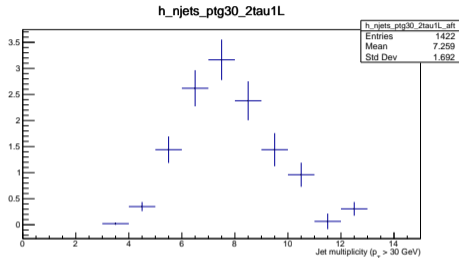
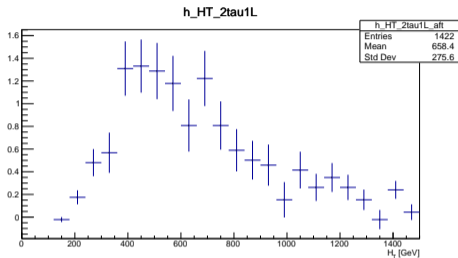


# Trigger variables: $2\tau 1L$ after trigger



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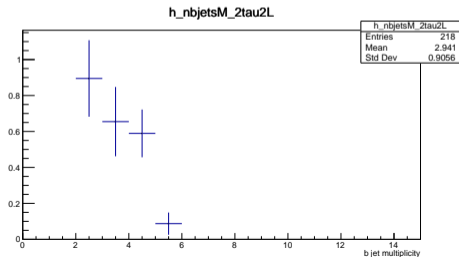
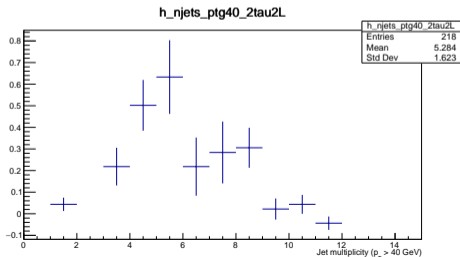
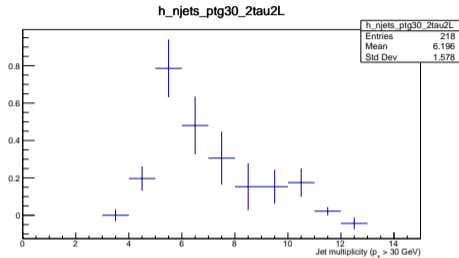
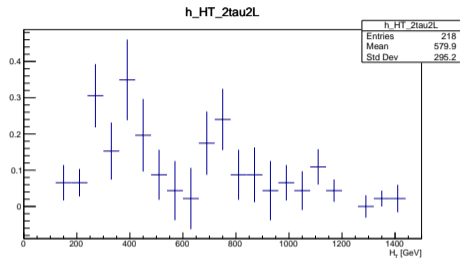


# Trigger variables: $2\tau$ $2L$ before trigger



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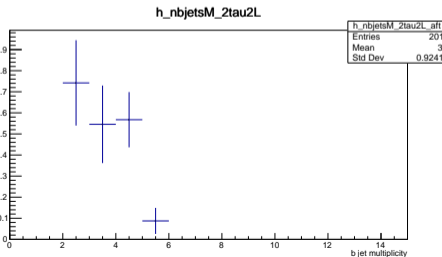
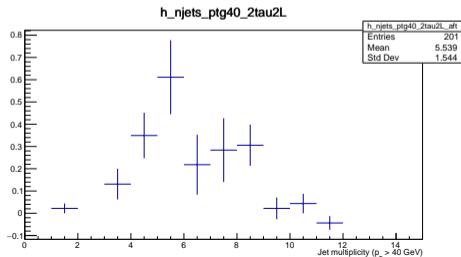
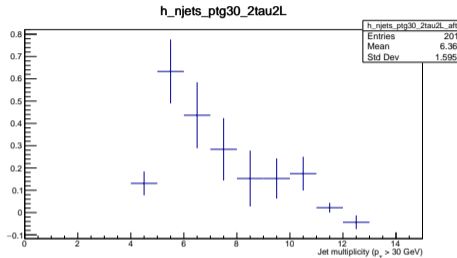
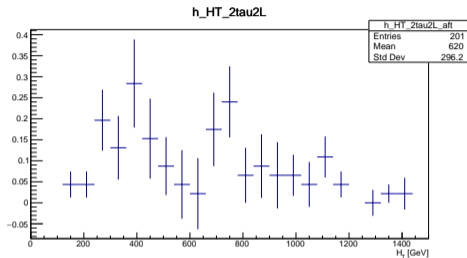


# Trigger variables: $2\tau 2L$ after trigger



Trigger efficiency

F. Lemmi

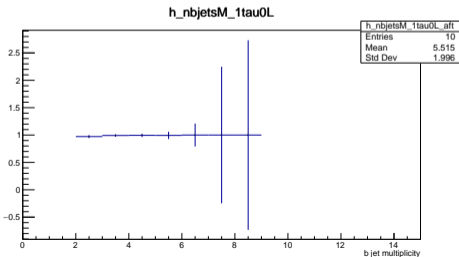
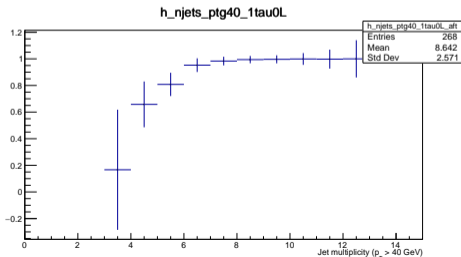
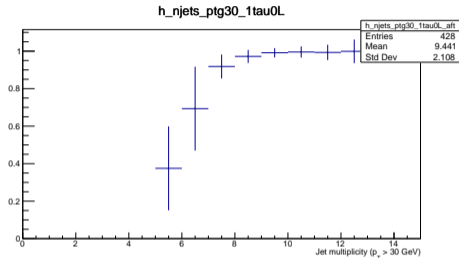
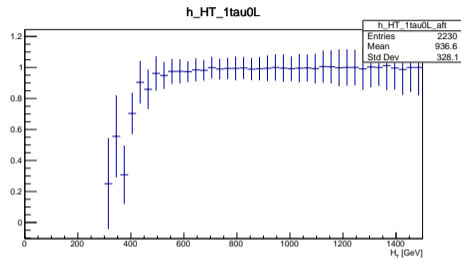


# “Efficiencies”: $1\tau 0L$



Trigger efficiency

F. Lemmi

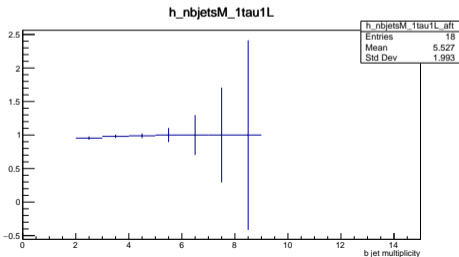
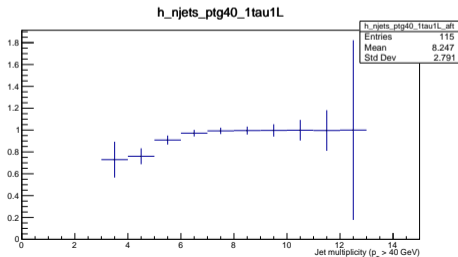
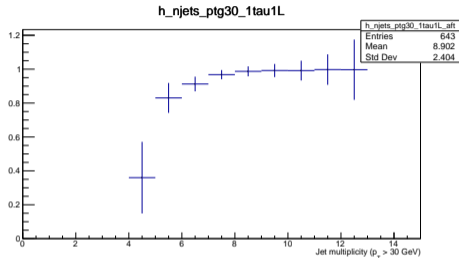
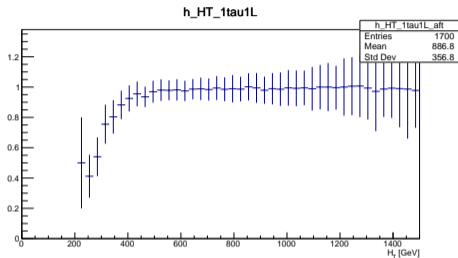


# “Efficiencies”: $1\tau 1L$



Trigger  
efficiency

F. Lemmi

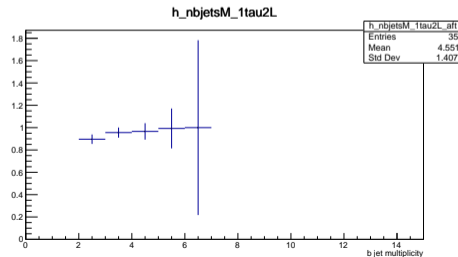
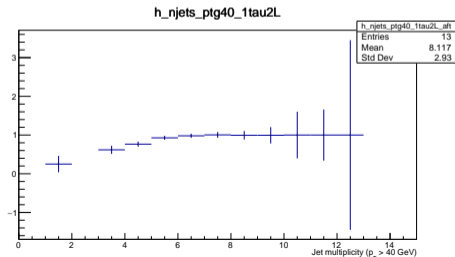
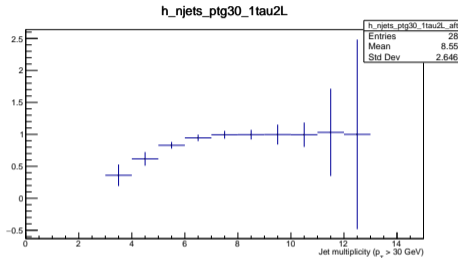
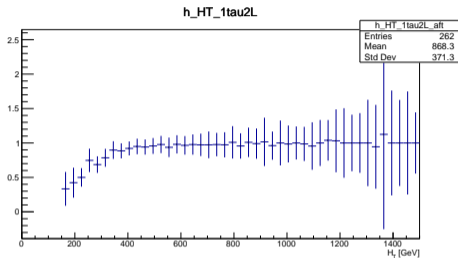


# "Efficiencies": $1\tau 2L$



Trigger efficiency

F. Lemmi

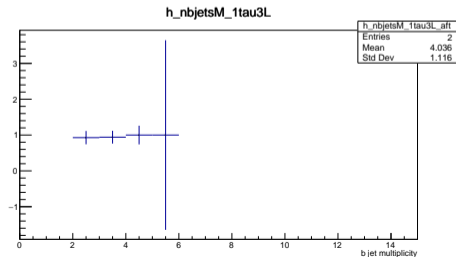
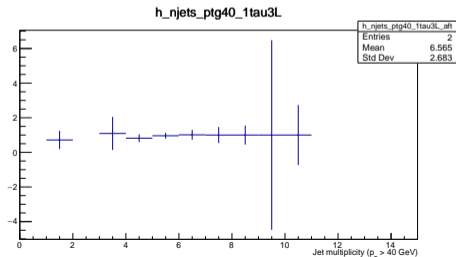
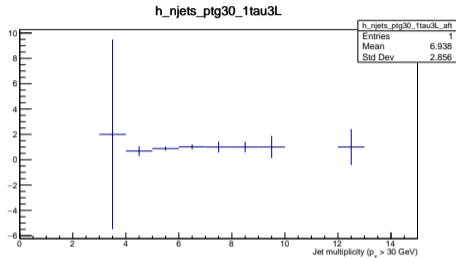
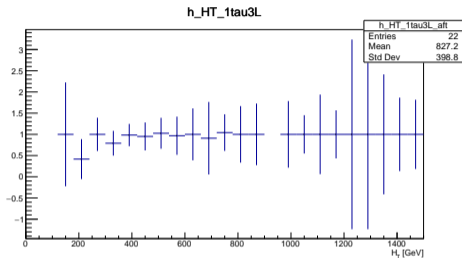


# "Efficiencies": $1\tau 3L$



Trigger efficiency

F. Lemmi

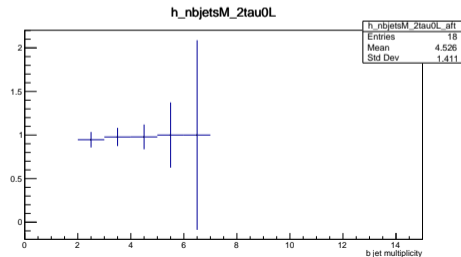
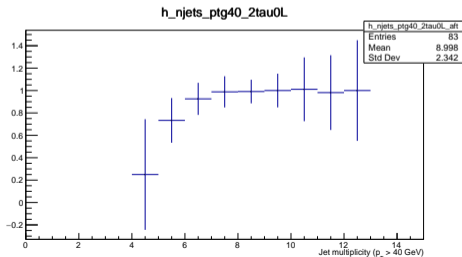
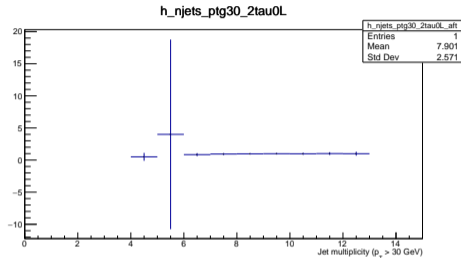
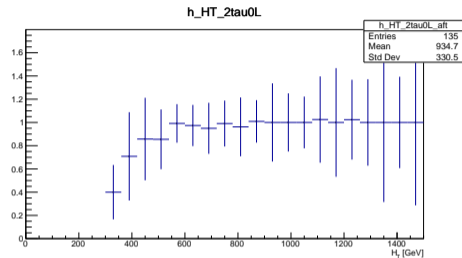


# “Efficiencies”: $2\tau 0L$



Trigger efficiency

F. Lemmi



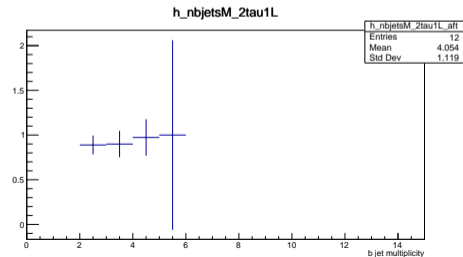
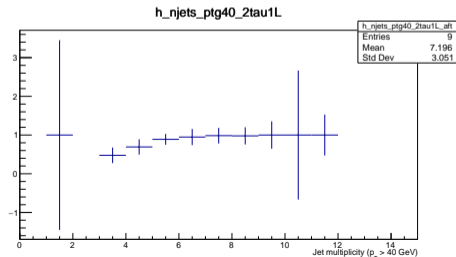
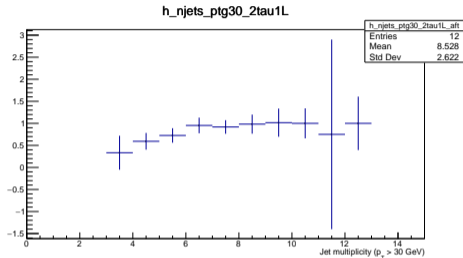
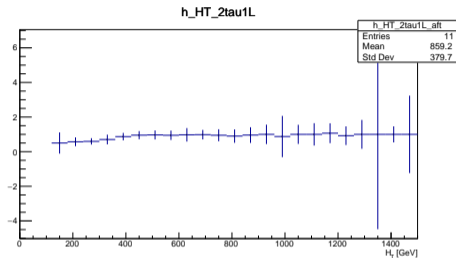


# “Efficiencies”: $2\tau$ 1L



Trigger efficiency

F. Lemmi

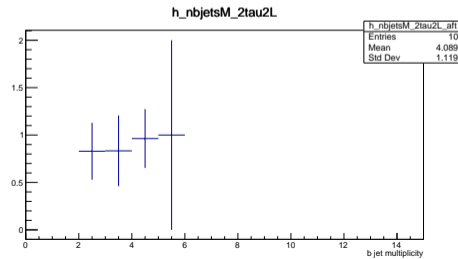
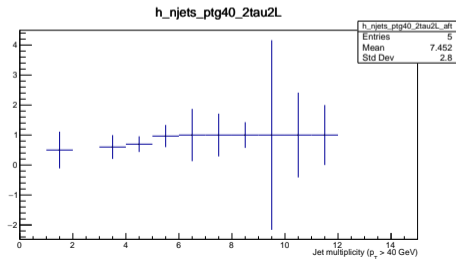
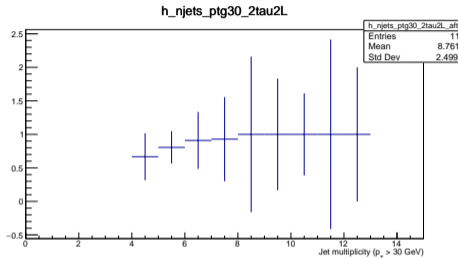
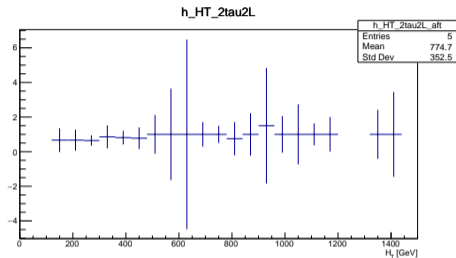


# “Efficiencies”: $2\tau$ $2L$



Trigger efficiency

F. Lemmi





- **Multijet triggers**

- HLT\_PFHT450\_SixJet40\_BTagCSV\_p056
- HLT\_PFHT400\_SixJet30\_DoubleBTagCSV\_p056

- **Single lepton triggers**

- HLT\_Ele25\_eta2p1\_WPTight\_Gsf
- HLT\_Ele27\_WPTight\_Gsf
- HLT\_Ele27\_eta2p1\_WPLoose\_Gsf
- HLT\_IsoMu22
- HLT\_IsoTkMu22
- HLT\_IsoMu22\_eta2p1
- HLT\_IsoTkMu22\_eta2p1
- HLT\_IsoMu24
- HLT\_IsoTkMu24



- **Lepton+tau triggers**

- HLT\_Ele24\_eta2p1\_WPLoose\_Gsf\_LooseIsoPFTau20
- HLT\_Ele24\_eta2p1\_WPLoose\_Gsf\_LooseIsoPFTau20\_SingleL1
- HLT\_Ele24\_eta2p1\_WPLoose\_Gsf\_LooseIsoPFTau30
- HLT\_IsoMu19\_eta2p1\_LooseIsoPFTau20\_SingleL1

- **Double lepton triggers**

- HLT\_Ele23\_Ele12\_CaloIdL\_TrackIdL\_IsoVL\_DZ
- HLT\_Mu17\_TrkIsoVVL\_Mu8\_TrkIsoVVL
- HLT\_Mu17\_TrkIsoVVL\_Mu8\_TrkIsoVVL\_DZ
- HLT\_Mu17\_TrkIsoVVL\_TkMu8\_TrkIsoVVL
- HLT\_Mu17\_TrkIsoVVL\_TkMu8\_TrkIsoVVL\_DZ



- **Electron+muon triggers**

- HLT\_Mu8\_TrkIsoVVL\_Ele23\_CaloIdL\_TrackIdL\_IsoVL
- HLT\_Mu8\_TrkIsoVVL\_Ele23\_CaloIdL\_TrackIdL\_IsoVL\_DZ
- HLT\_Mu23\_TrkIsoVVL\_Ele8\_CaloIdL\_TrackIdL\_IsoVL

- **Trilepton triggers**

- HLT\_Ele16\_Ele12\_Ele8\_CaloIdL\_TrackIdL
- HLT\_TripleMu\_12\_10\_5
- HLT\_Mu8\_DiEle12\_CaloIdL\_TrackIdL
- HLT\_DiMu9\_Ele9\_CaloIdL\_TrackIdL

- **Double tau triggers**

- HLT\_DoubleMediumIsoPFTau35\_Trk1\_eta2p1\_Reg
- HLT\_DoubleMediumCombinedIsoPFTau35\_Trk1\_eta2p1\_Reg

# Selection for leptonic categories in $t\bar{t}H$ ML setup



Trigger  
efficiency

F. Lemmi

- In general ask for leading  $p_T^\ell > 30$  GeV
- In categories with  $N_\ell \geq 2$ , check for flavor of leptons
  - If no muons, ask for leading ele  $p_T > 30$  GeV
  - If no electrons, ask for leading mu  $p_T > 30$  GeV
  - If both ele and muons, ask for both leading ele and leading mu  $p_T > 30$  GeV