

VBF Higgs to Invisible Trigger Efficiencies

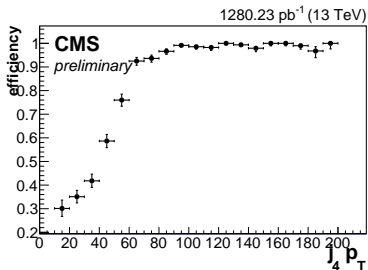
P. Dunne A. Magnan for $H \rightarrow \text{inv.}$ group

Reminder and outline

- ▶ We have previously seen slow trigger turn ons in met (300 GeV 95% efficiency) and jet 2 pt (80 GeV 95% efficiency)
- ▶ We have looked at jet pt turn on in a separate trigger path:
HLT_PFHT750_4JetPt50
- ▶ Behaviour seen there motivates studies of L1 MET turn on and calo jet prefilter

Turn on in jet only trigger

- ▶ Have pass/fail information for HLT_PFHT750_4JetPt50
- ▶ Denominator: SingleMuon events with $HT > 1200$ GeV
 - 1200 is the 90% efficiency point
- ▶ Curve looks good, over 90% efficient by 60 GeV

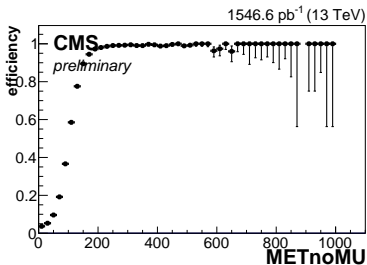


Implications for our trigger

- ▶ As 4JetPt50 trigger behaves well examine differences from our trigger:
- ▶ 4JetPt50 has no L1ETM requirement:
 - Study L1ETM turn on
 - Shown in next few slides
- ▶ 4JetPt50 has no calo jet pt prefilter:
 - According to [these slides](#) wrong JEC was used in HLT during Run2015
 - We only have trigger jet information in events that pass the trigger
 - Study HLT Calo vs offline PF jet response
 - Shown later

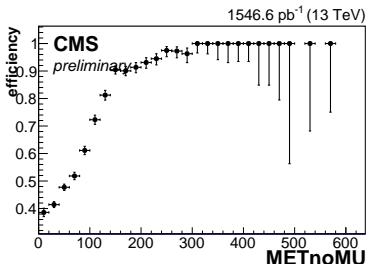
L1ETM60 Efficiency: Inclusive

- ▶ Measure L1 ETM turn on
- ▶ Trigger: L1ETM60
- ▶ Denominator: SingleMuon events passing HLT_IsoMu20
- ▶ 95% efficient by 200 GeV



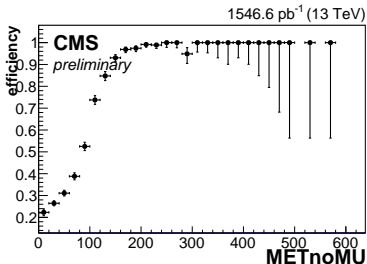
L1ETM60 Efficiency: VBF phase space

- ▶ Measure L1 ETM turn on when there is a VBF-like dijet
- ▶ Trigger: L1ETM60
- ▶ Denominator: SingleMuon events passing HLT_IsoMu20 and dijet $p_T > 80$, $M_{jj} > 600$, $\Delta\eta_{jj} > 3.6$
- ▶ Good turn on to 150 GeV then shelf



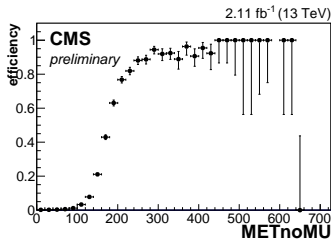
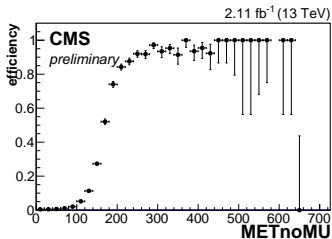
L1ETM60 Efficiency: VBF phase space

- ▶ L1 MET only sums up to $|\eta| = 3$, shelf seen on previous slide could be due to jets in the HF
- ▶ Add requirement that both jets have $|\eta| < 3$ to the denominator
- ▶ Good turn on recovered so shelf is due to events with jets in the HF



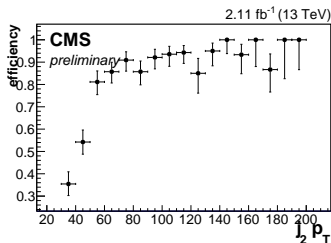
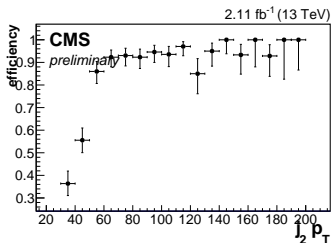
Signal trigger turn on: MET

- ▶ Measure HLT efficiency (left) and L1+HLT efficiency (right)
- ▶ Dataset: Full 2015D data with latest JECv6
- ▶ Trigger: HLT_DiPFJet40_DEta3p5_MJJ600_PFMETNoMu140
- ▶ Denominator: SingleMuon events with dijet $p_T > 80$, $M_{jj} > 600$, $\Delta\eta_{jj} > 3.6$ plus for left plot only L1ETM60
 - Jet pt cut very high due to slow jet pt turn on
- ▶ HLT only efficiency slightly better



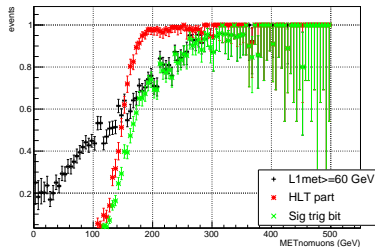
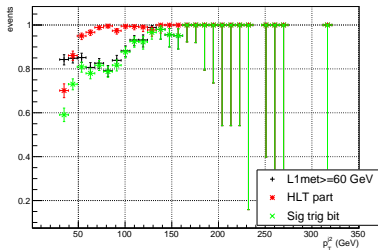
Signal trigger turn on: jet pt

- ▶ Measure HLT efficiency (left) and L1+HLT efficiency (right)
- ▶ Dataset: Full 2015D data with latest JECv6
- ▶ Trigger: HLT_DiPFJet40_DEta3p5_MJJ600_PFMETNoMu140
- ▶ Denominator: SingleMuon events with dijet $pt > 80$, $MET_{noMU} > 300$, $M_{jj} > 600$, $\Delta\eta_{jj} > 3.6$ plus for left plot only and L1ETM60
 - MET cut very high due to slow MET turn on
- ▶ HLT only efficiency slightly better



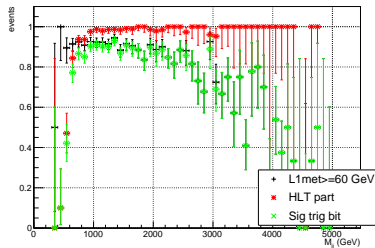
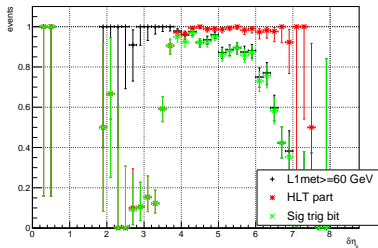
Impact of L1MET inefficiencies on signal

- ▶ Signal $\Delta\eta_{jj}$ higher than background so may be more affected by L1 inefficiency
- ▶ Check efficiencies in MC of HLT (red), L1 (black) and L1+HLT (green)
- ▶ MC sample: VBF_HToInvisible_M125_13TeV_powheg_pythia8
- ▶ Denominator: dijet $p_T > 50$ GeV, $M_{jj} > 800$ GeV, $\Delta\eta_{jj} > 3.6$, $MET_{noMU} > 200$ GeV
- ▶ We lose a lot of signal due to L1 inefficiency



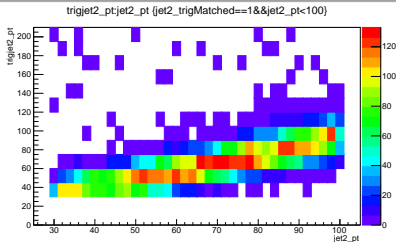
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- ▶ Denominator: dijet $p_T > 50$ GeV, $M_{jj} > 800$ GeV, $\Delta\eta_{jj} > 3.6$, $MET_{noMU} > 200$ GeV
- ▶ Inefficiency for jets in the HF can be clearly seen in the left plot



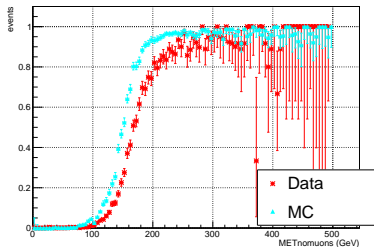
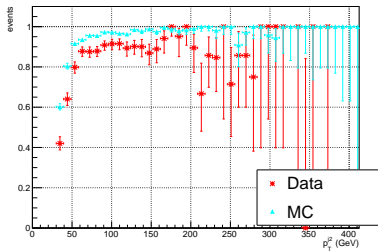
Calo jet prefilter

- ▶ Even after factoring out L1 effect jet pt is less efficient than in run 1
- ▶ According to [these slides](#) wrong JEC was used in HLT during Run2015
 - We have a calo prefilter at 30 GeV
 - Calo JEC are large so wrong JEC could cause the remaining jet pt issues
- ▶ Plot offline jet pt (x axis) against trigger calo jet pt (y axis)
- ▶ Large differences seen between calo jet pt and offline jet pt



Calo jet prefilter

- ▶ Further check, compare HLT efficiency in data (with wrong JEC) to that in MC (with correct JEC)
- ▶ MC sample: WJetsToLNu-mg and all the HT-binned samples
- ▶ Denominator: dijet $p_T > 50$ GeV, $M_{jj} > 800$ GeV, $\Delta\eta_{jj} > 3.6$, $MET_{noMU} > 200$ GeV
- ▶ MC efficiency quite a bit better: more evidence wrong JEC could be to blame



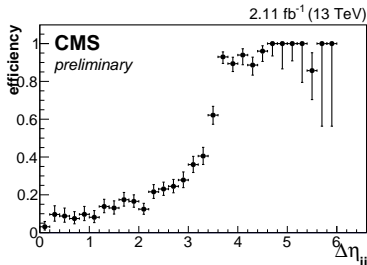
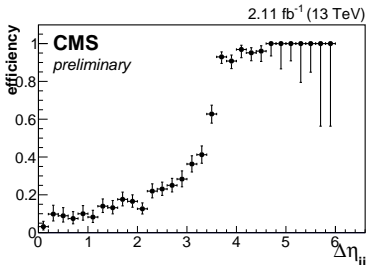
Summary

- ▶ L1ETM60 is inefficient in the VBF phase space due to it ignoring the HF
 - We lose a lot of signal from this L1 inefficiency
 - Correlation between variables forces cuts used making data turn ons to be very high, situation even worse for softer events
 - Even after factoring out L1 effect still less efficient than in run 1, especially jet p_T
- ▶ Incorrect JEC was used in HLT during Run2015
 - Calo jet JEC are large so this could cause problems
 - We see calo jets with 30 GeV p_T frequently have offline p_T above pf trigger threshold
 - HLT efficiency is better in MC than data
 - Suggests wrong JEC could be to blame
- ▶ Needs more investigation: We currently only have trigger jet information for events that pass the trigger
 - Reemulating trigger on raw data so we can check if events failing trigger fail calo filter or pf filter

Backup

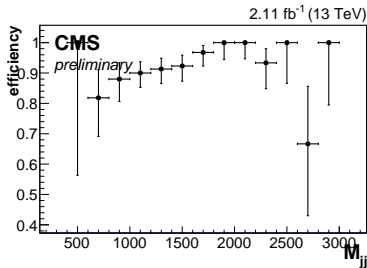
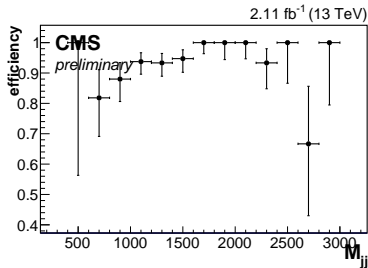
$\Delta\eta_{jj}$ data turn on

- ▶ Measure HLT efficiency (left) and L1+HLT efficiency (right)
- ▶ Dataset: Full 2015D data with latest JECv6
- ▶ Trigger: HLT_DiPFJet40_DEta3p5_MJJ600_PFMETNoMu140
- ▶ Denominator: SingleMuon events with dijet $p_T > 80$, $M_{jj} > 600$, $\Delta\eta_{jj} > 3.6$ plus for left plot only L1ETM60
- ▶ Possible decrease at end of L1+HLT efficiency due to HF jets



M_{jj} data turn on

- ▶ Measure HLT efficiency (left) and L1+HLT efficiency (right)
- ▶ Dataset: Full 2015D data with latest JECv6
- ▶ Trigger: HLT_DiPFJet40_DEta3p5_MJJ600_PFMETNoMu140
- ▶ Denominator: SingleMuon events with dijet $p_T > 80$, $M_{jj} > 600$, $\Delta\eta_{jj} > 3.6$ plus for left plot only L1ETM60



Impact of L1MET inefficiencies on signal

- Check effect of L1 inefficiency as a function of jet eta
- MC sample: VBF_HToInvisible_M125_13TeV_powheg_pythia8
- Denominator: dijet $p_T > 50$ GeV, $M_{jj} > 800$ GeV, $\Delta\eta_{jj} > 3.6$, $MET_{noMU} > 200$ GeV
- L1 inefficiency for jets in the HF can be clearly seen

