LFV $H \rightarrow \mu\tau$

FIRST LOOK

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Summary

- Theoretical reference: arXiv:1209.1397v2
- Aim: Use H→ττ analysis (μτ channel) as a basis to look for a LFV signal, adapting the cuts to the different kinematics
- Workflow:
  - First look at the selection & data/mc agreement (based on H2Tau)
    - Included Data/MC corrections
    - Some disagreement observed
  - Optimization of signal selection criteria
    - Focus on GG for now
  - Background normalization
  - Further away in the future: Limits, etc etc

Object Selection Criteria

- Started from the cuts set up by Nathan
- Some updates already implemented

Muon:
IsoMu24
PT> 30 GeV
|η|<2.1
Rel PF Iso DB <0.12 (1)
PFIDTight (POG)
DZ<0.2

Tau:
PT> 20 GeV
|η|<2.3
TightIsoNHits3 (2)
AntiElectronLoose
AntiMuonTight2 (3)
DecayFinding

Veto (4)
- Extra muons (Iso, Id Muon Pt> 5)
- Extra electrons (CicTightIso)

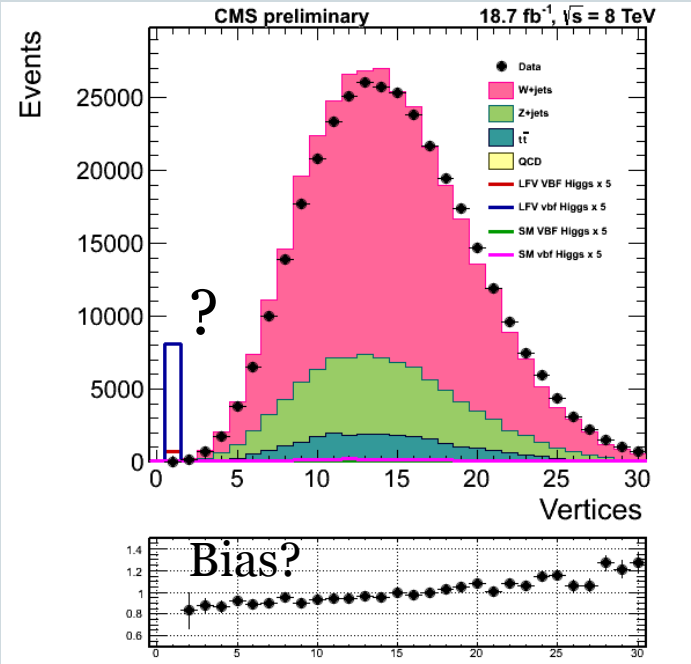
Opposite charge of the Muon-Tau pair

Main differences wrt H2Tau (MuTau):
a) Trigger / Muon Pt Cut (more energetic muon allows to use SingleMuon
b) Muon MT Cut needs to be removed
c) No distinction in Njet bins

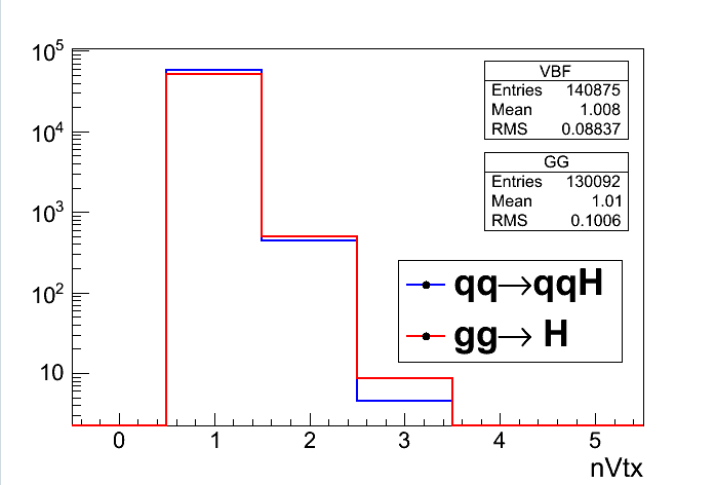
Changes to the baseline:
(1) PU corrected Iso
(2) Tight Iso ? Medium?
(3) Needed. change from AntiMuonLoose to AntiMuonTight
(4) Added Lepton Vetos

Data/MC Corrections

- PU Reweighting
- MuonPOG ID&Iso Corrections for Muons
- MuonHLT corrections for IsoMu24_eta2p1



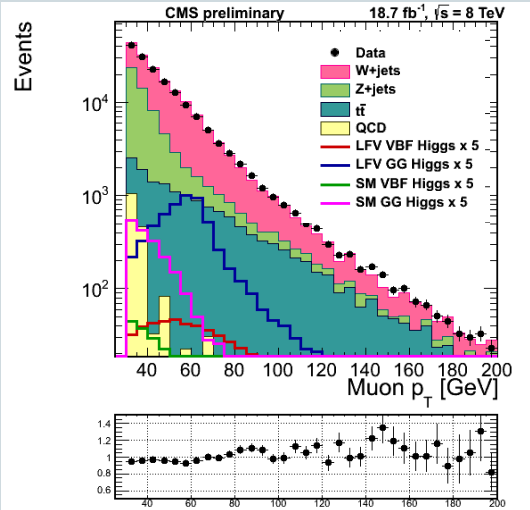
Note: Which PU profile was used for the LFV signal samples?

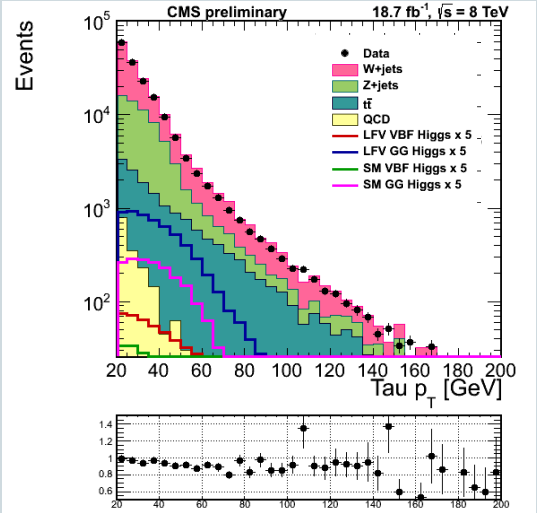


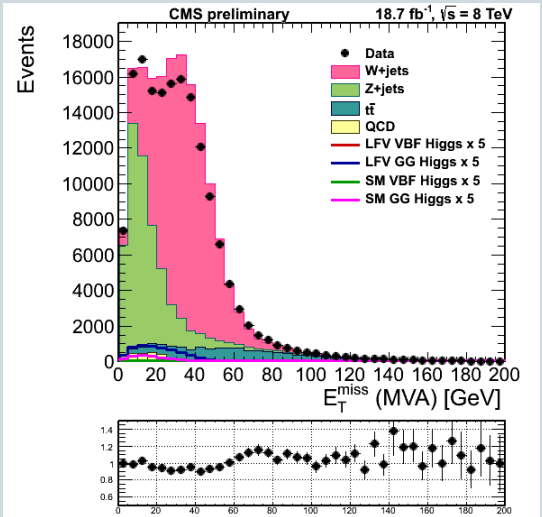
Basic Objects

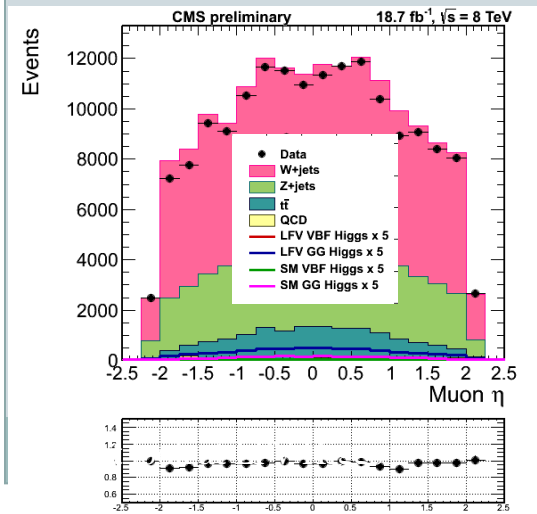
NOTE:
Normalization of QCD & W should come from data

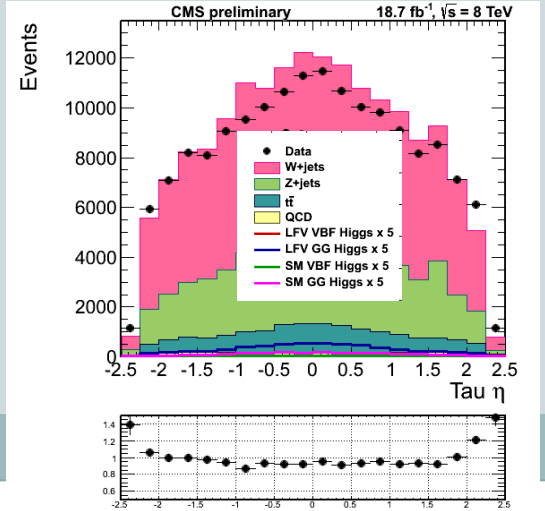
- Checking Data/MC agreement in detail →Small MC Excess Observed → To be improved
- Can be related to **Jets->Tau Fake Rate in Data vs MC**

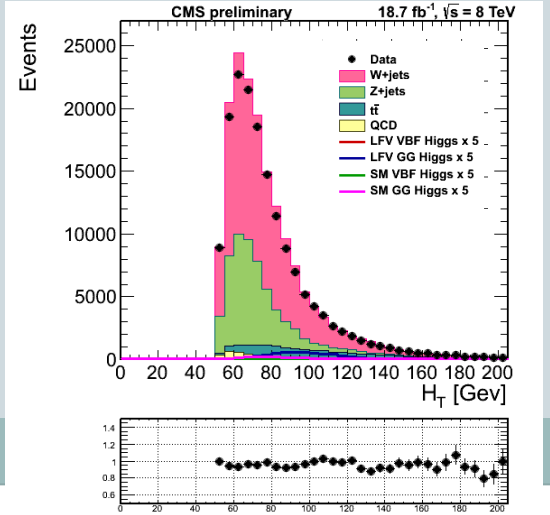






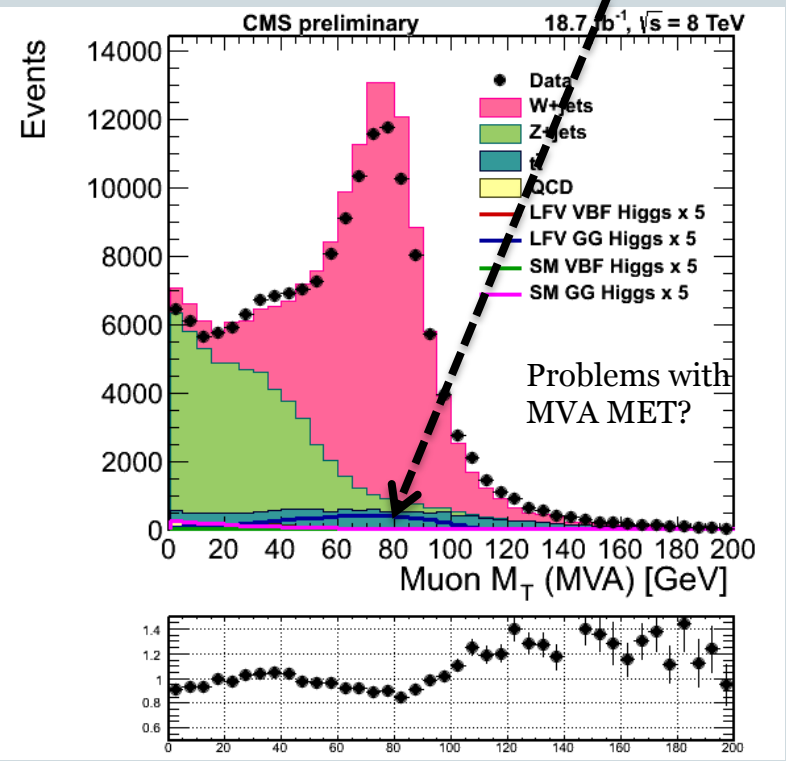


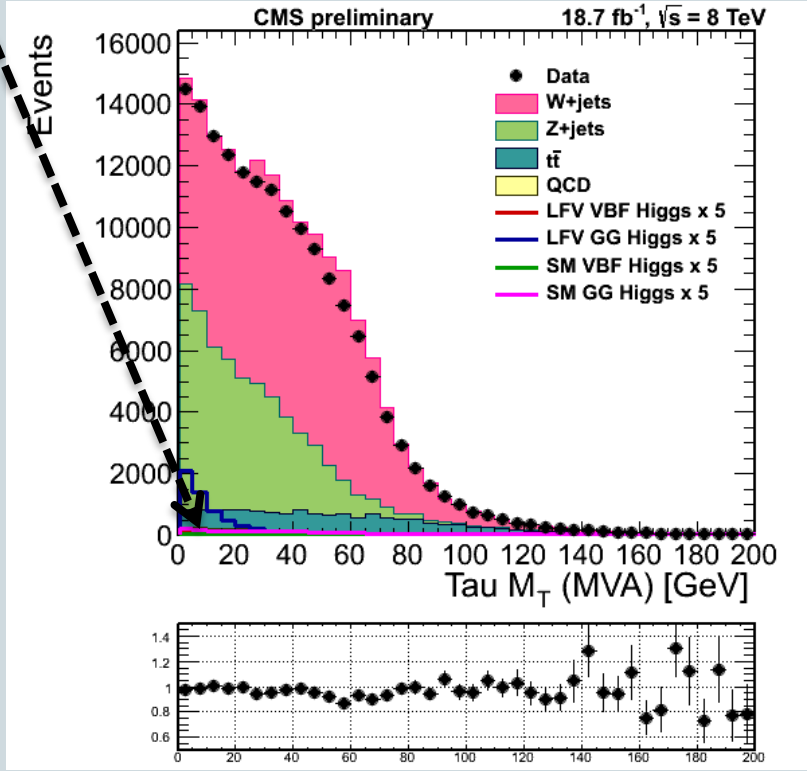




Muon and Tau MT

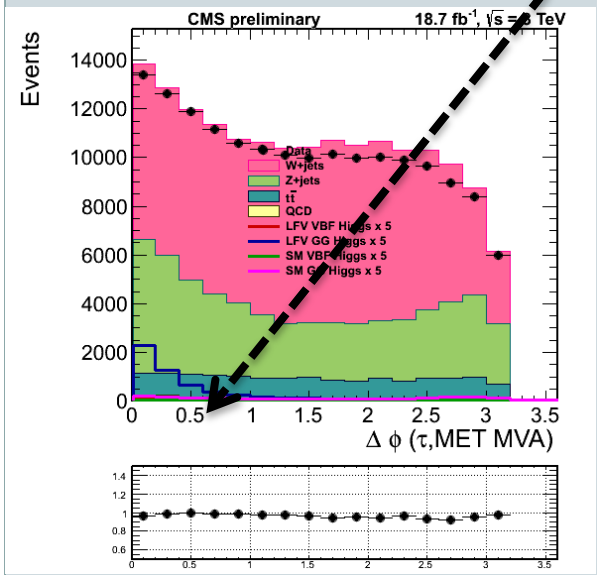
Muon M_T cut (H2Tau analysis, removed) could be exchanged with a Tau M_T cut?

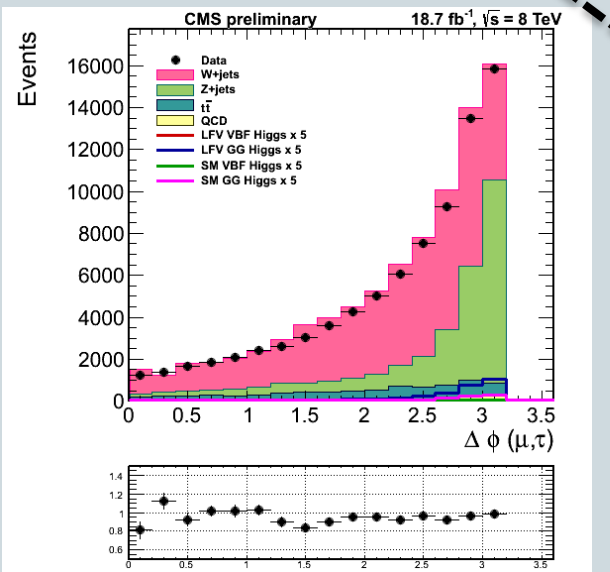


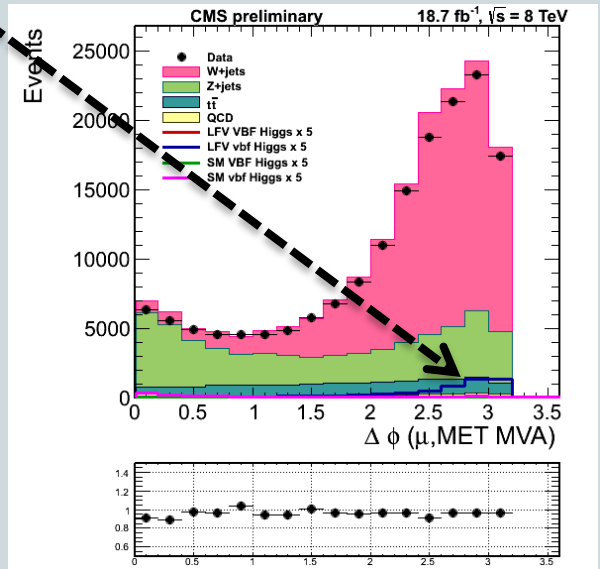


Angles

Alternatively / Additionally → Angles between muon, tau, MET

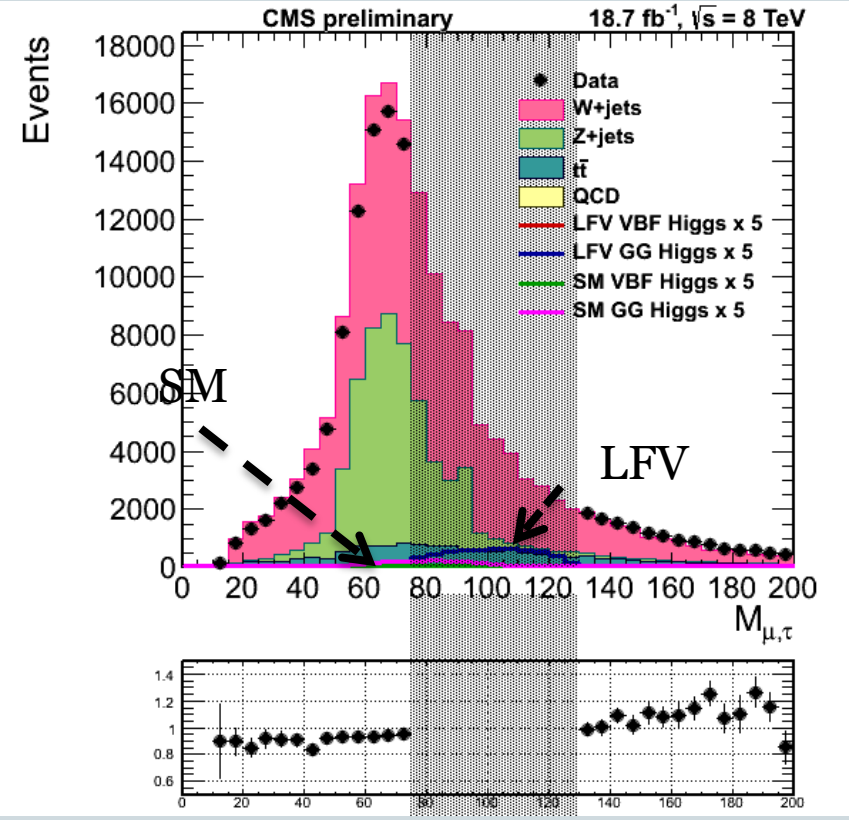






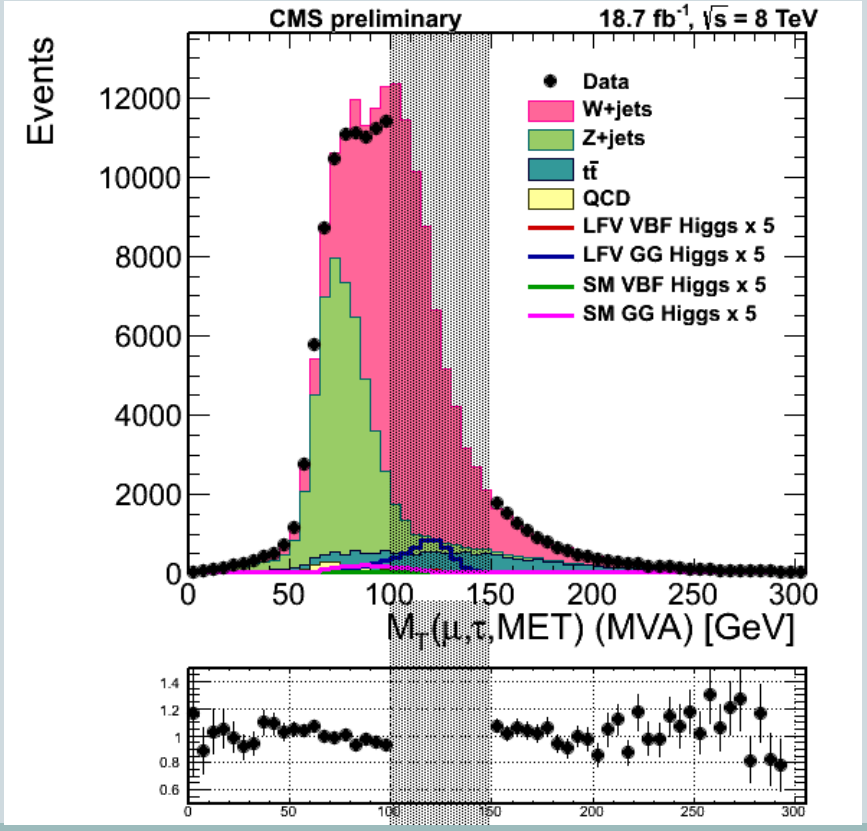
Mu-Tau system

Currently very small S/B ratio



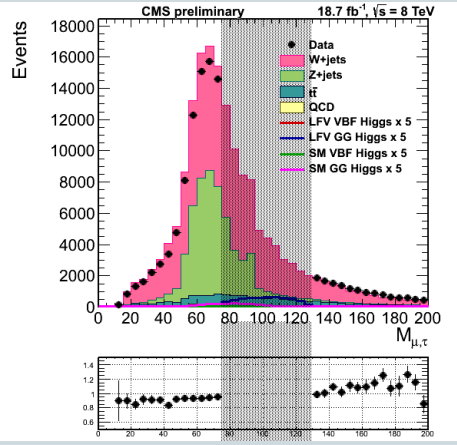
Need tighter cuts to be able to discriminate the signal:

- Angles between Muon,Tau,MET
- Kinematics: Increased Energy of the objects

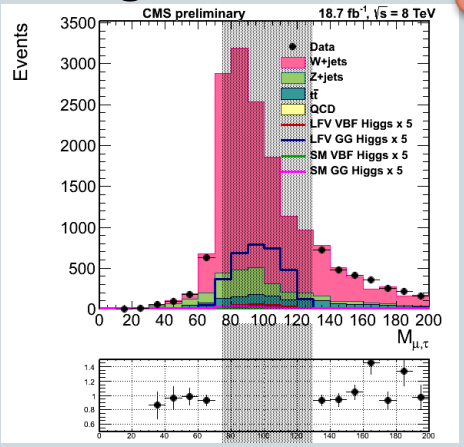


Signal Optimization: M_{vis}

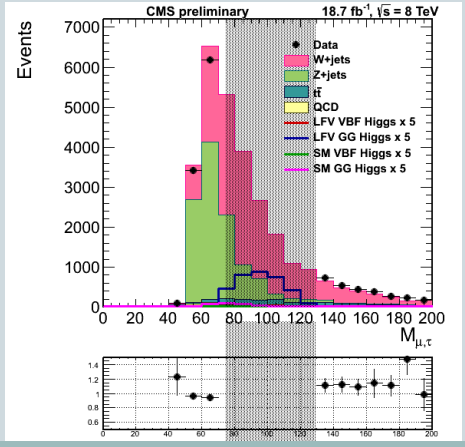
PreSel



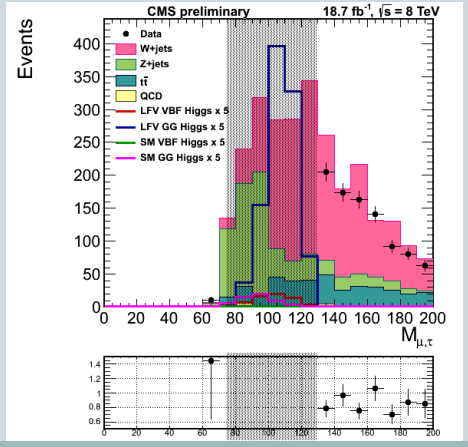
a) Tighter Kin



b) Angular Cuts



c) Very Tight



PreSel: Slide 4

a) Tighter Kin

- ptMu> 50 GeV
- MT(tau. MET)<20 GeV
- MT(mu, MET)>30 GeV (Zs)
- HT>75

b) Angles

deltaPhi(tau,MET)<0.5
deltaPhi(mu,tau)>2

c) Tighter Kin + Angles

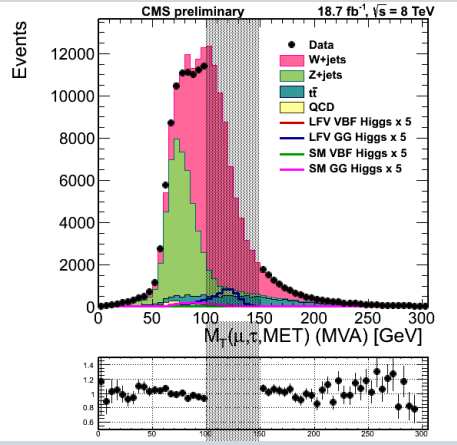
- ptTau> 40 GeV
- MT(tau. MET)<20 GeV
- deltaPhi(tau,MET)<0.5
- deltaPhi(mu,tau)>2
- deltaPhi(mu,MET)>2

Expected Signal yield halved

Kin Cuts → Decreased discrimination power of Mvis against W+jets → peak pulled to large values of M(Mu+Jet)

Signal Optimization: M_T (τ,μ,MET)

PreSel



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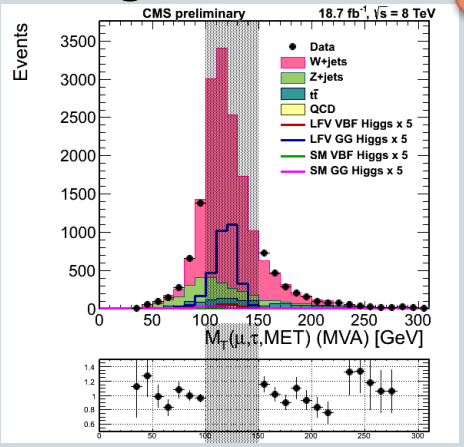
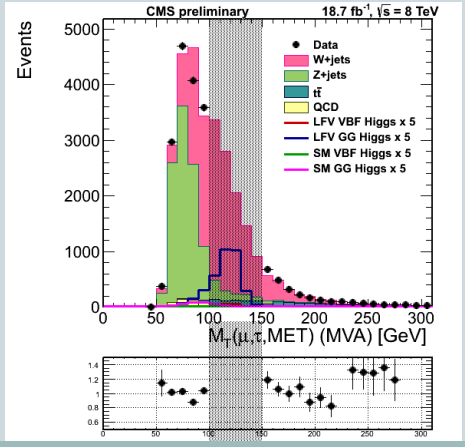


b) Angular Cuts



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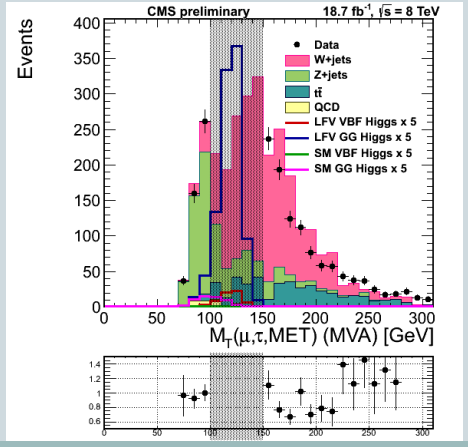

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c) Tighter Kin + Angles

- ptTau> 40 GeV
- MT(tau. MET)<20 GeV
- deltaPhi(tau,MET)<0.5
- deltaPhi(mu,tau)>2
- deltaPhi(mu,MET)>2

Close to the mass of the full system ☺

Signal Optimization: Plans

- Tightening of Kin cuts → W+Jets Shape brought closer to the signal by tightening of the cuts --> Not good! ☹
- Angular variables → Bit safer, but eventually similar effect → Tigthening of the angular cuts potentially beneficial (efficiency loss, but more discrimination power?)
- #Jets in the event (as Daniel proposed)

- → Missing VBF optimization yet!

Background Modeling

Background Modelling:

- Z+jets, TTBar → normalization and shape from MC
- W+Jets → Shape from MC, normalization from data (?)
- QCD → Shape and normalization from data

→ Before moving on with the analysis, data-driven techniques to determine W&QCD backgrounds are a priority

How to extract the normalization of both W+Jets and QCD? → MT sideband cannot be used to extract the W normalization.

Proposed set of cuts for inversion:

- Muon Isolation (discrimination against QCD)
- Tau Isolation (tight vs loose, discrimination against W+Jets and QCD)

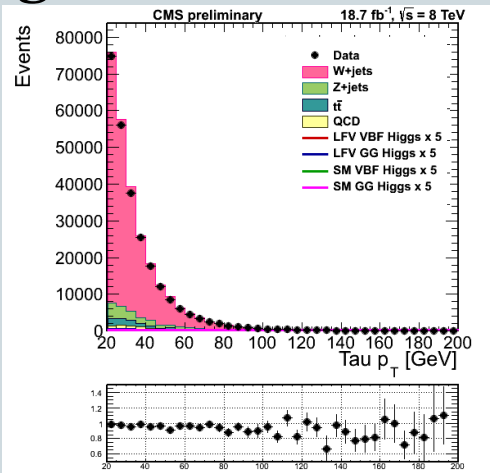
Next Steps: Fake Rate method

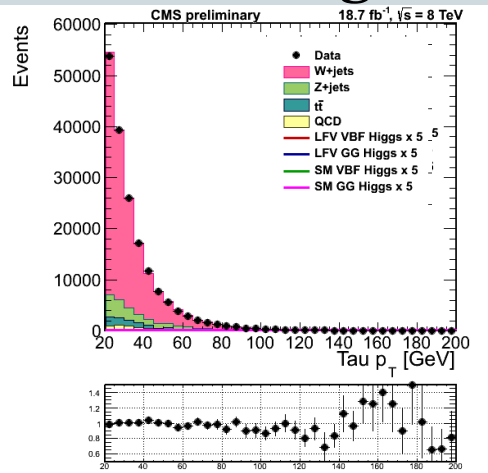
- https://indico.cern.ch/conferenceDisplay.py?confId=254127

Isolation Sidebands: W & QCD Control Regions

- Opposite Sign
- Same Sign

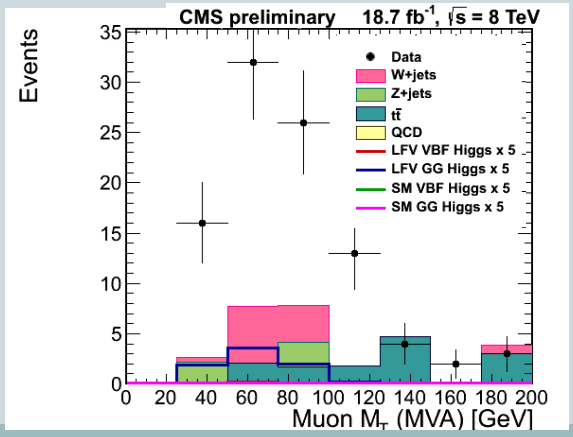
! Tau LooseIso

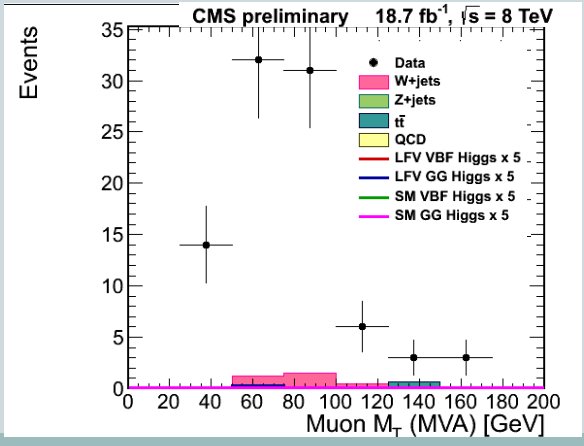




→ W yield check?

Muon Iso > 0.2





→ QCD dominated sideband → Shape modelling? (warning: limited stats)

Next Steps?

- **Study Data/MC agreement**
- **Background Modeling → Fake Rate method**

- Check Signal MCs
  - Status of the new production?

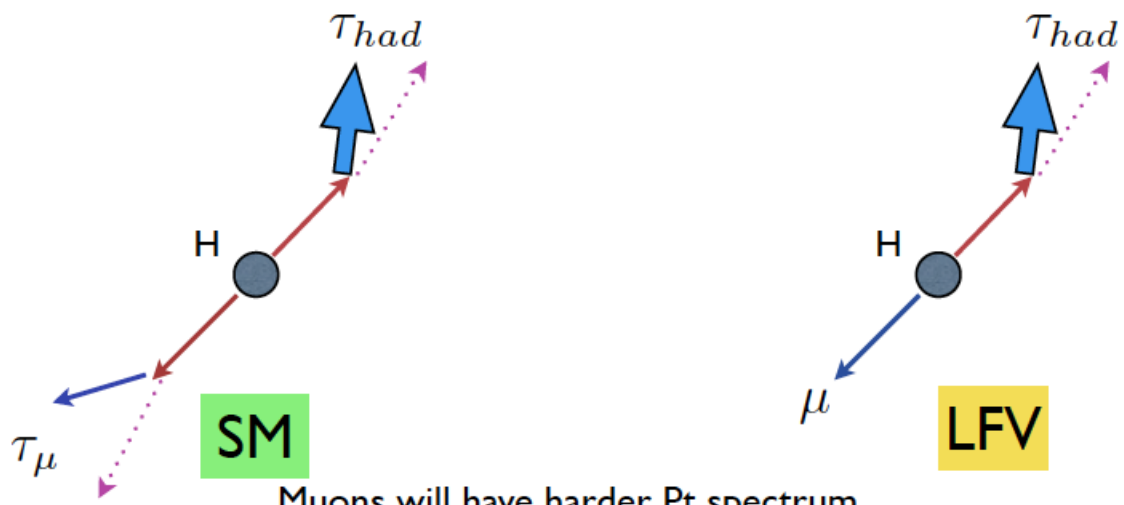
- Optimization of S/B → Is there still some room for improvement?

- Optimize as well for VBF search

- Limit setting

Back-Up

Differences between LFV and SM Higgs



Muons will have harder Pt spectrum

Less Missing Energy

Different angle between Muon and tau

Mvis will be different

- Slide by Nathan (17/May)

Datasets (8 TeV)

- **Data:**
  - Partially analyzed all of SingleMu 2012 (some jobs failed, 18.7 fb^{-1})
  - Patuples available in the T2
- **MC**

Sample	σ (pb)
/WJetsToLNu_TuneZ2Star_8TeV-madgraph-tarball + /WXJetsToLNu_TuneZ2Star (X=1-4)	36257.2
DYJetsToLL_M-50_TuneZ2Star_8TeV-madgraph-tarball/	3503.7
TTJets_TuneZ2star_8TeV-madgraph-tauola	225.2
/GluGluToHToTauTau_M-125_8TeV-powheg-pythia6	19.6
/VBF_HToTauTau_M-125_8TeV-powheg-pythia6	1.58
/LFV_VBFHToTauMu_M126_8TeV_Tauola_Pythia6	19.22
/LFV_GluGluHToTauMu_M126_8TeV_Tauola_Pythia6	1.57

Add remaining MCs (contributions from Diboson, SingleTop → Smaller in comparison, ~negligible)

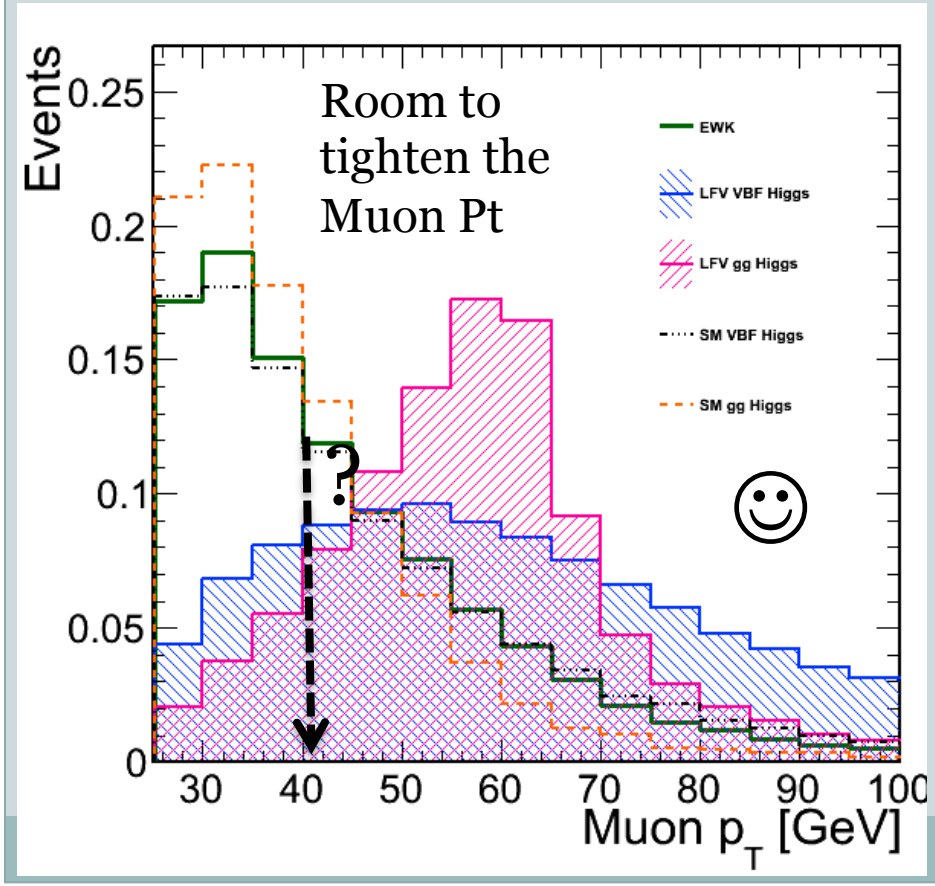
Br(H→μτ) assumed to be 10%

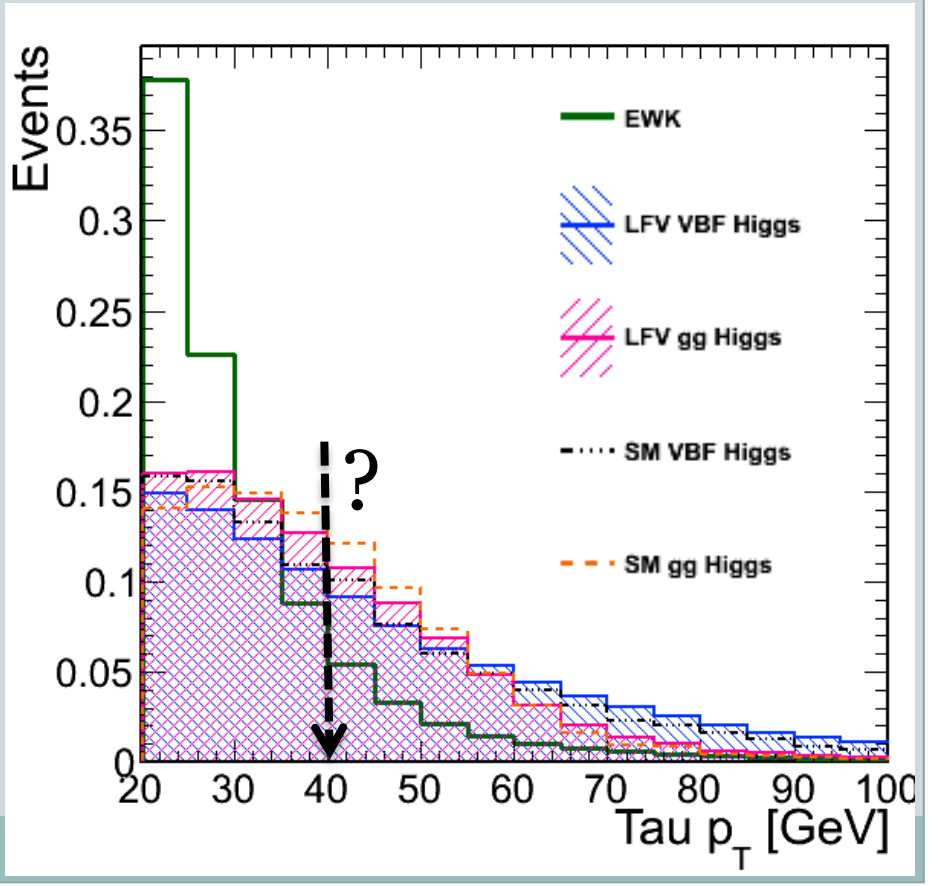
Object Issues to check

- Isolation:
  - Muons: DB, threshold 0.12 (from MuonPOG). Check other WPs?
  - Taus: Isolation.
- Tau discrimination
  - Feedback from Evan: Move to tAntiMuonTight2
- Veto optimization
  - Naively used the first choices available, don't expect much gain though
  - Check NJet Bins

Shape Comparison: LFV vs SM

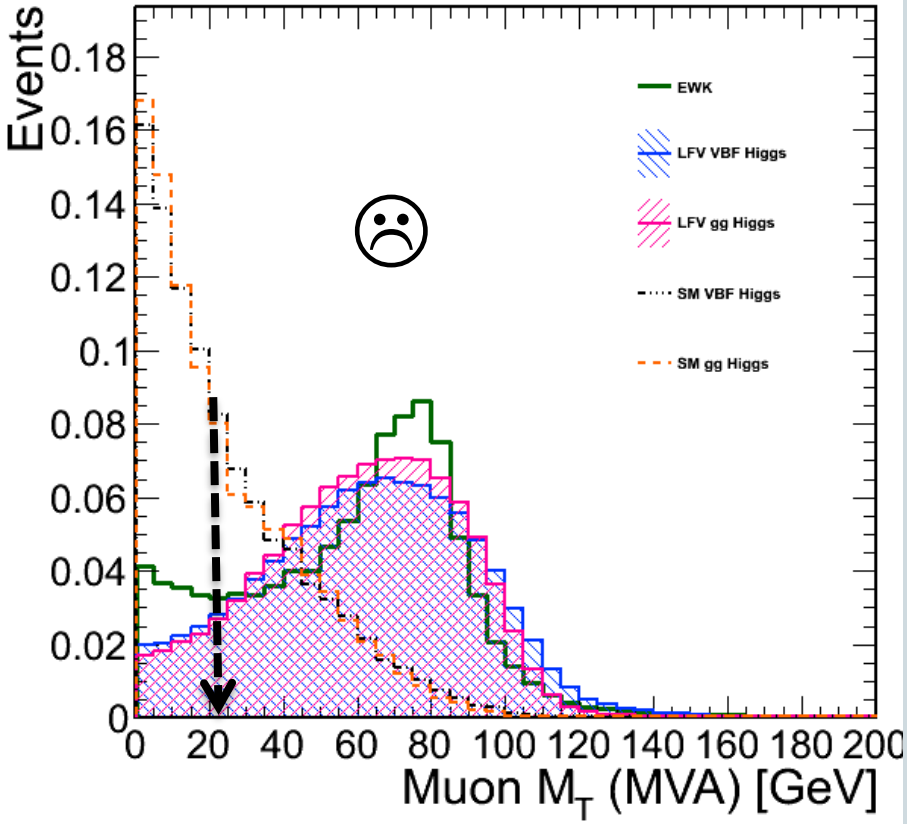
- We can do better looking at the rest of the kinematical variables
- Normalized Plots (Shapes only). EWK backgrounds combined in one shape (taking into account cross sections correctly)

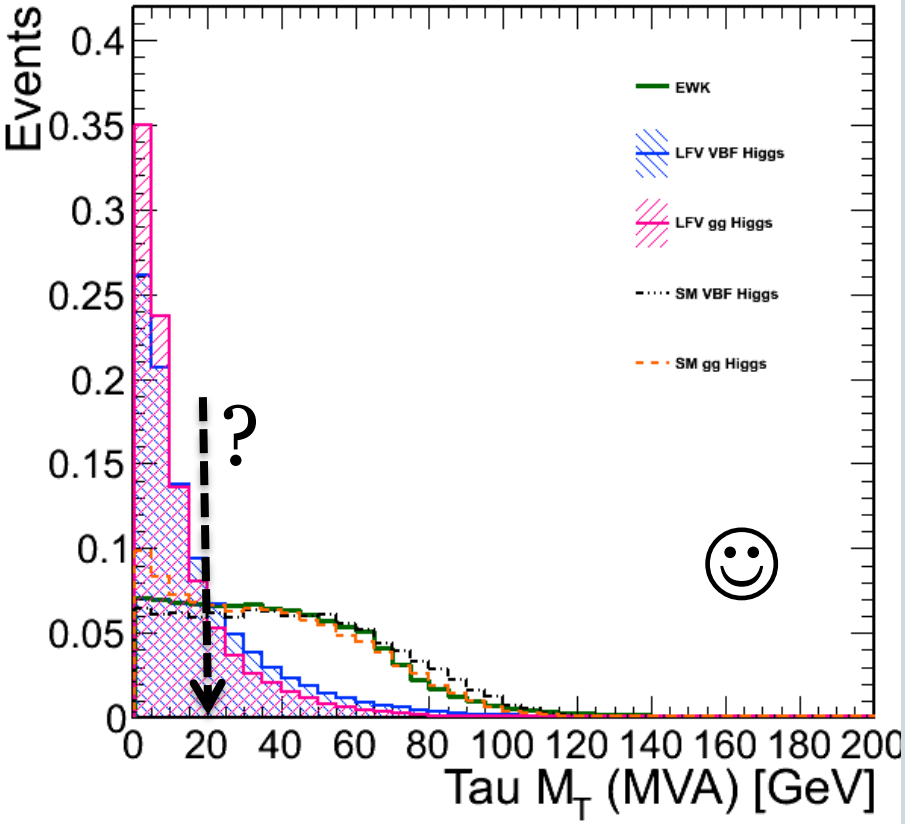




Shape Comparison: LFV vs SM

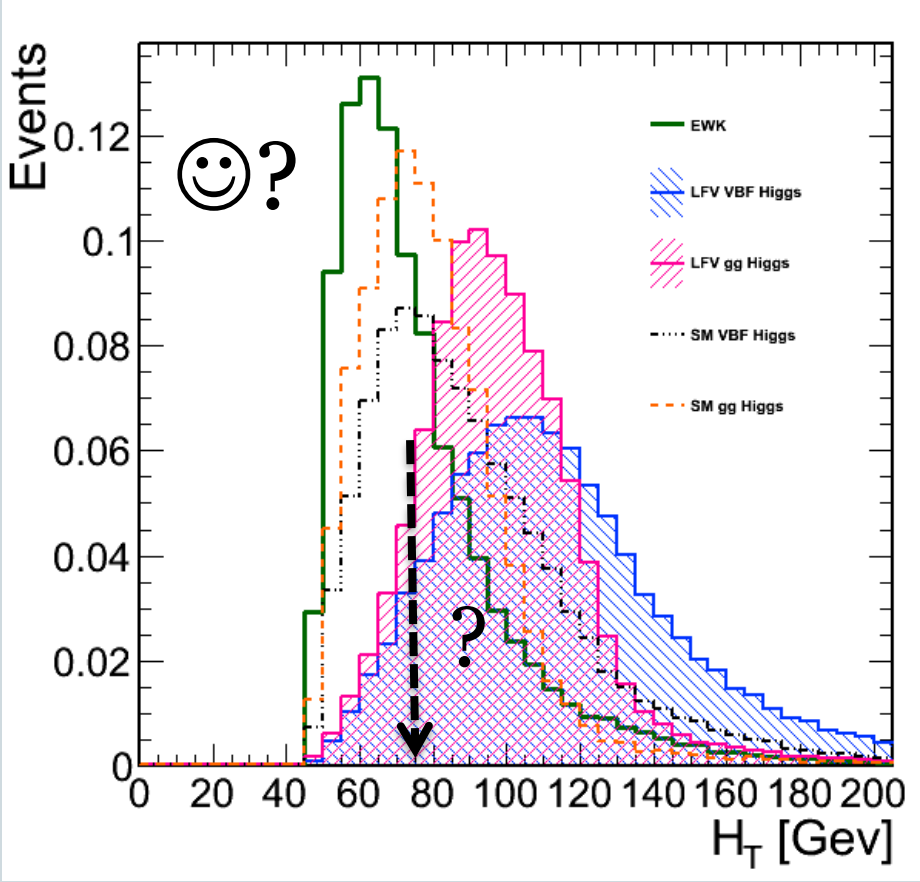
- Tau MT could replace the Muon MT sideband
- Muon MT > threshold to remove DrelYan background

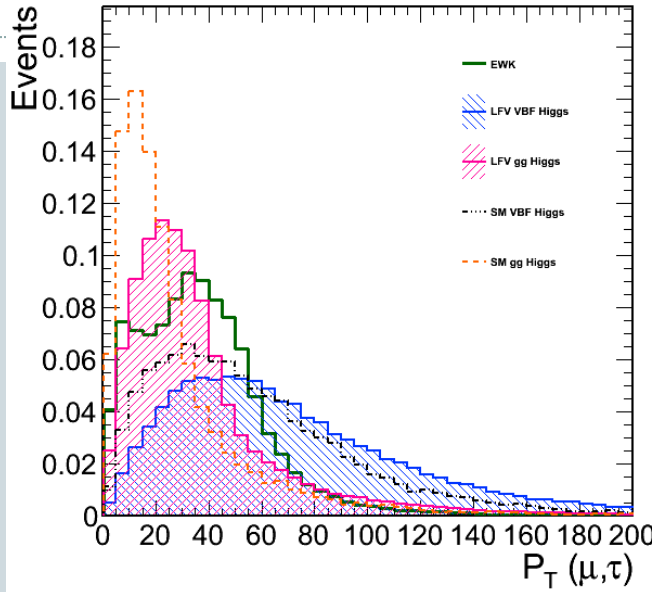


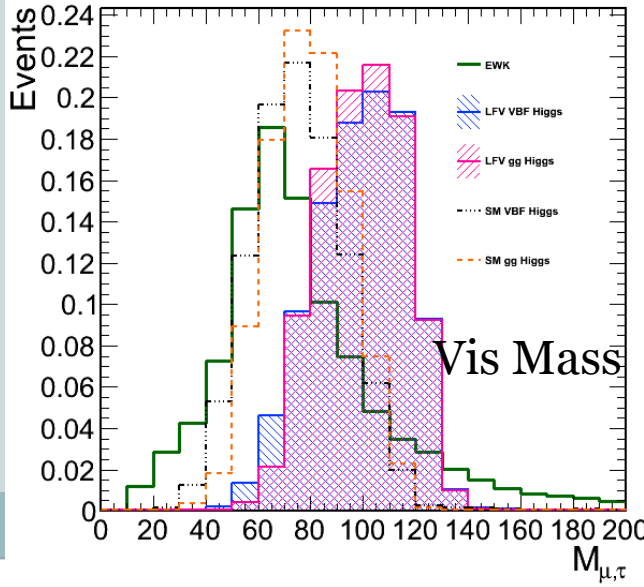


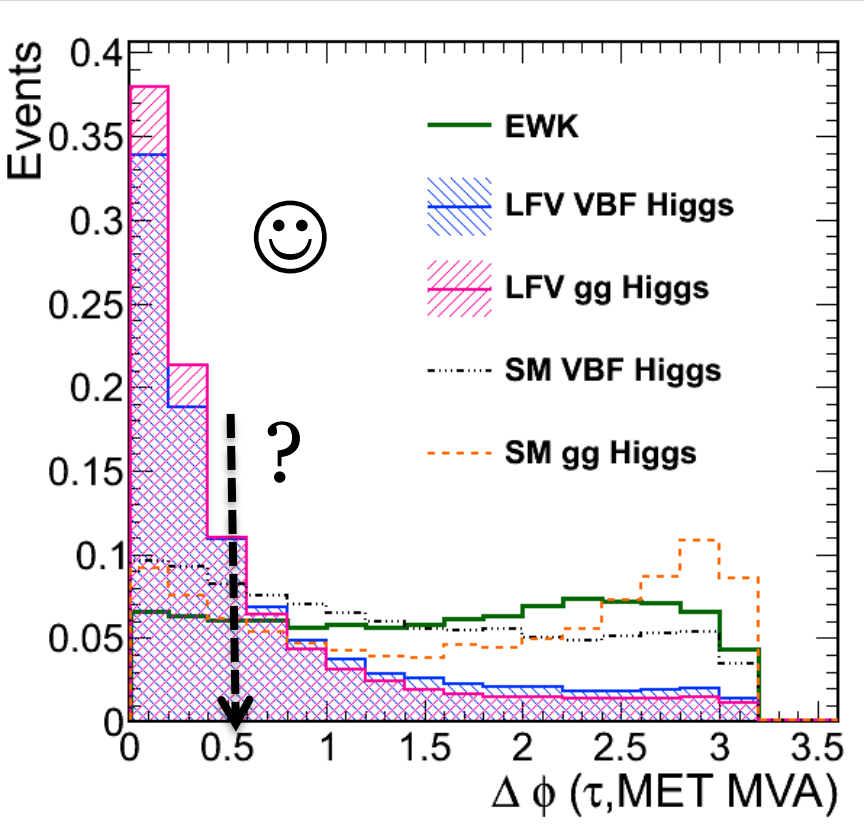
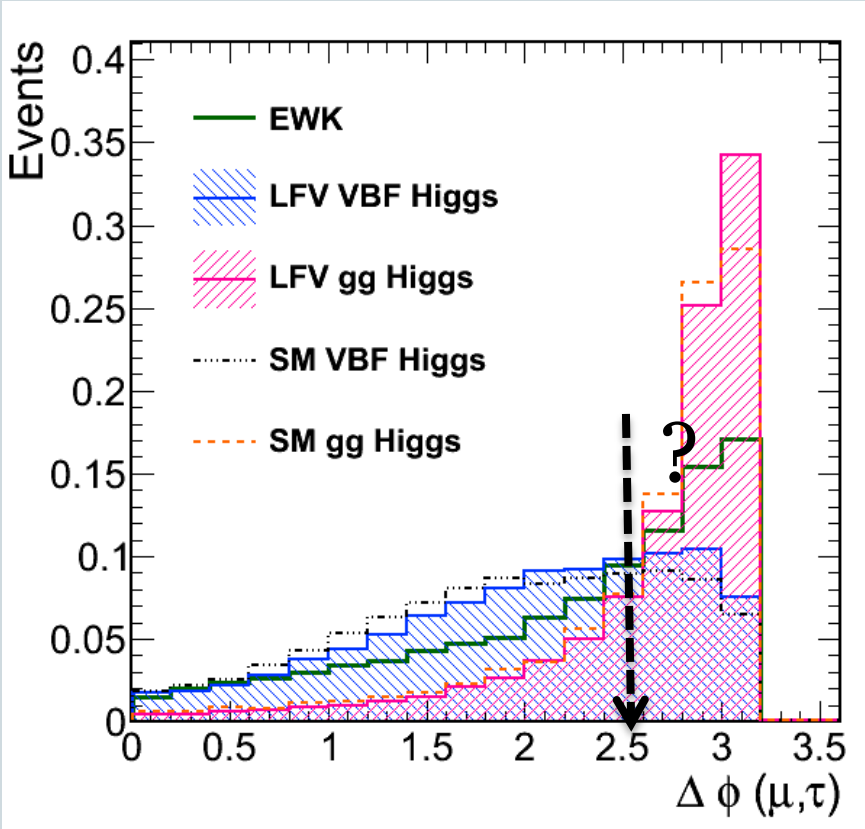
Shape Comparison: LFV vs SM

- HT as discriminating variable?
- Careful: correlation with Muon Pt







Shape Comparison: Angular Variables

- (Tau-MET) angle separates well the signal. Correlation with Tau MT.
- (Tau-Mu) –used in daniele's μτ(e) selection - less clearly