Tau id commissioning results from pp collisions at $\sqrt{s}$ = 7 & 8 TeV with data collected at CMS at the LHC

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Abstract: *CMS has developed sophisticated τ identification algorithm for τ hadronic decay modes. Production of τ leptons decaying to hadrons is studied at 7 & 8 TeV centre of mass energy with 2011-2012 collision data collected by the CMS Detector. It is used to measure the performance of τ identification by measuring identification & reconstruction efficiency and mis-identification rates from electrons, muons, and hadronic jets.*

- τ is the heaviest known lepton (1.78 GeV), which decays into lighter leptons (~35%) or hadrons (τ_h) (~65%) in the presence of upto two neutrinos.
- The HPS tau reconstruction algorithm use decay mode identification technique which allows to reconstruct τ_h with high efficiency and suppress the potentially large backgrounds from quarks & gluons that occasionally hadronize into low particle multiplicity jets.

- Hadron Plus Strips algorithm is being used with two types of isolation -
  1. Cut Based Isolation
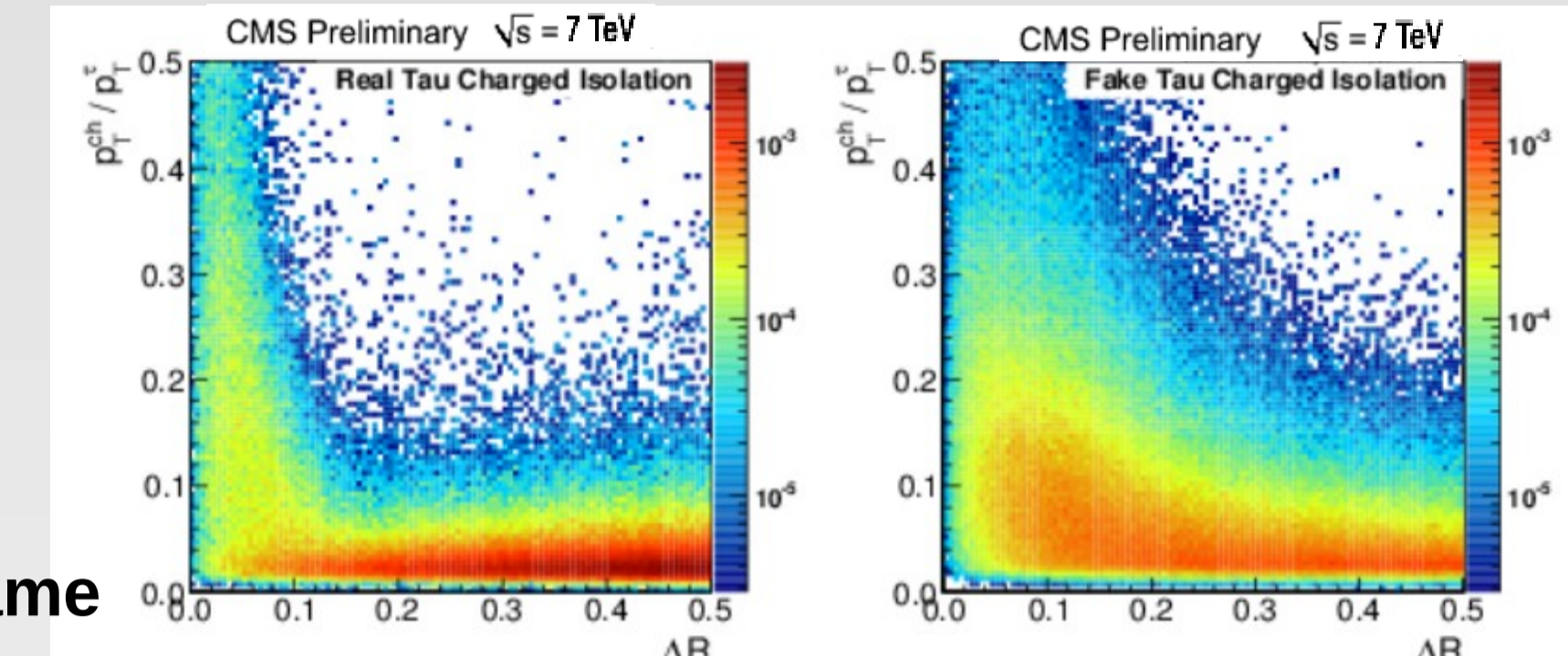 2. Ring based isolation
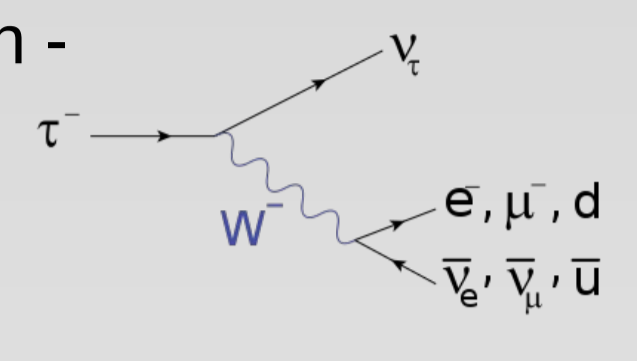
Hadron Plus Strips (HPS)

- Searches for major τ decay modes within PFJets
- Mainly τ decaying to 1 or 3 charged hadrons.
- Photons/Electrons clustered in strips to reconstruct π^0.
- Discriminating variables computed on reconstructed τ object :
  1. Decay Mode Finding 2. Electron Rejection
 3. Muon Rejection   4. Isolation
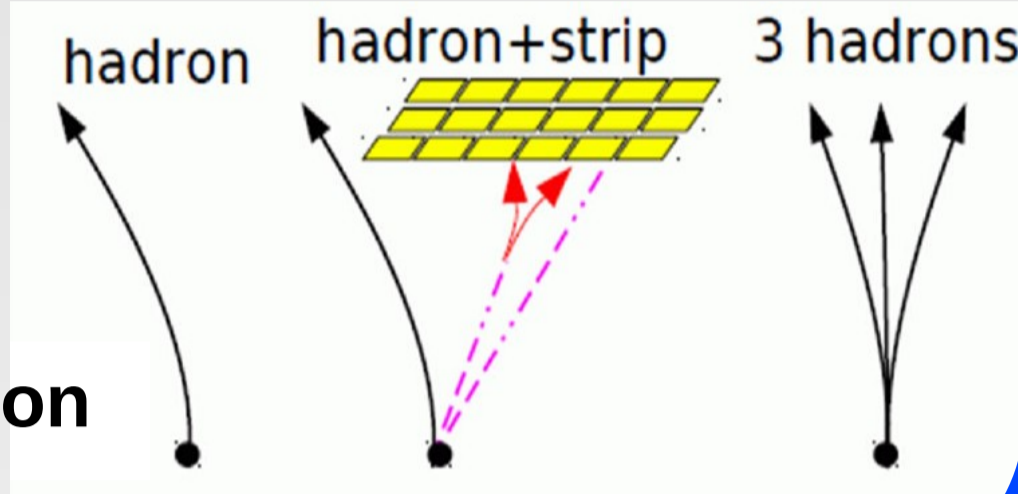
Cut Based vs Ring Based Isolation (MVA)

- **Cut based** isolation uses sum pt of charged & gamma candidates not belonging to τ within the cone of ΔR = 0.5.
- **MVA isolation** uses same PF candidates used by cut-based isolation but isolation pt is summed in ΔR rings around τ.
- BDT trained against jet $\longrightarrow \tau$ mis-identification
- Achieves lower mis-Identification rate at the same efficiency.
- Loose, Medium, and Tight working points defined.

Efficiency

- Tau Isolation efficiency as a function of number of pile up vertices -
  - For Cut based Isolation
  - For MVA Tau Isolation
  - For loose, medium and tight working points.
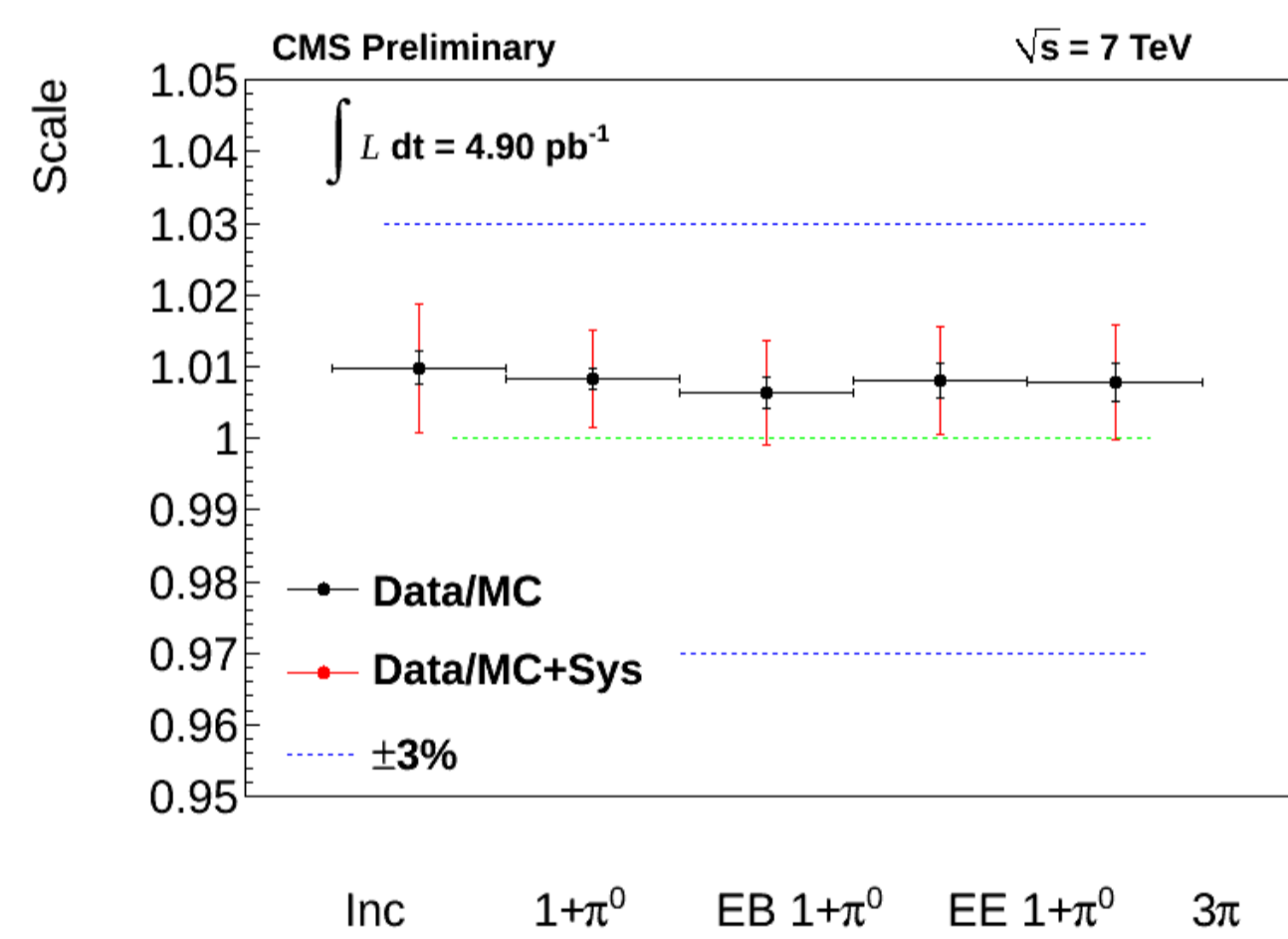- Efficiency as a function of pt is flat after 25 GeV for both Cut based & MVA.
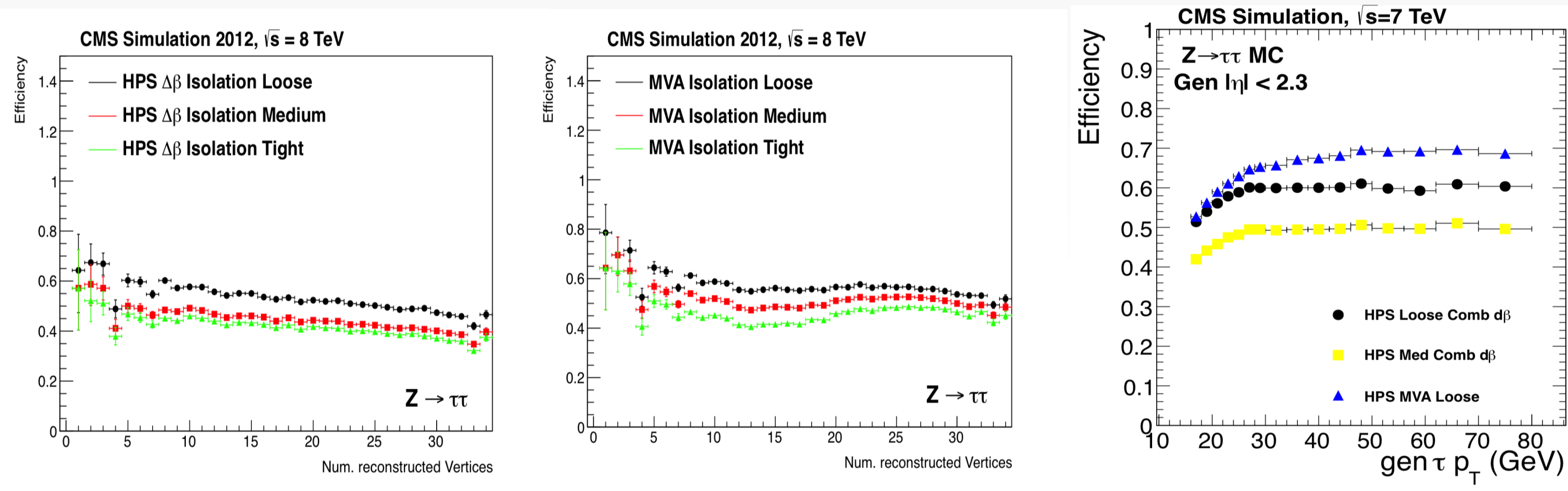
Mis-Identification Rate

- Jet Mis-Identification rate as a function of pt for MVA & Cut based Isolation.
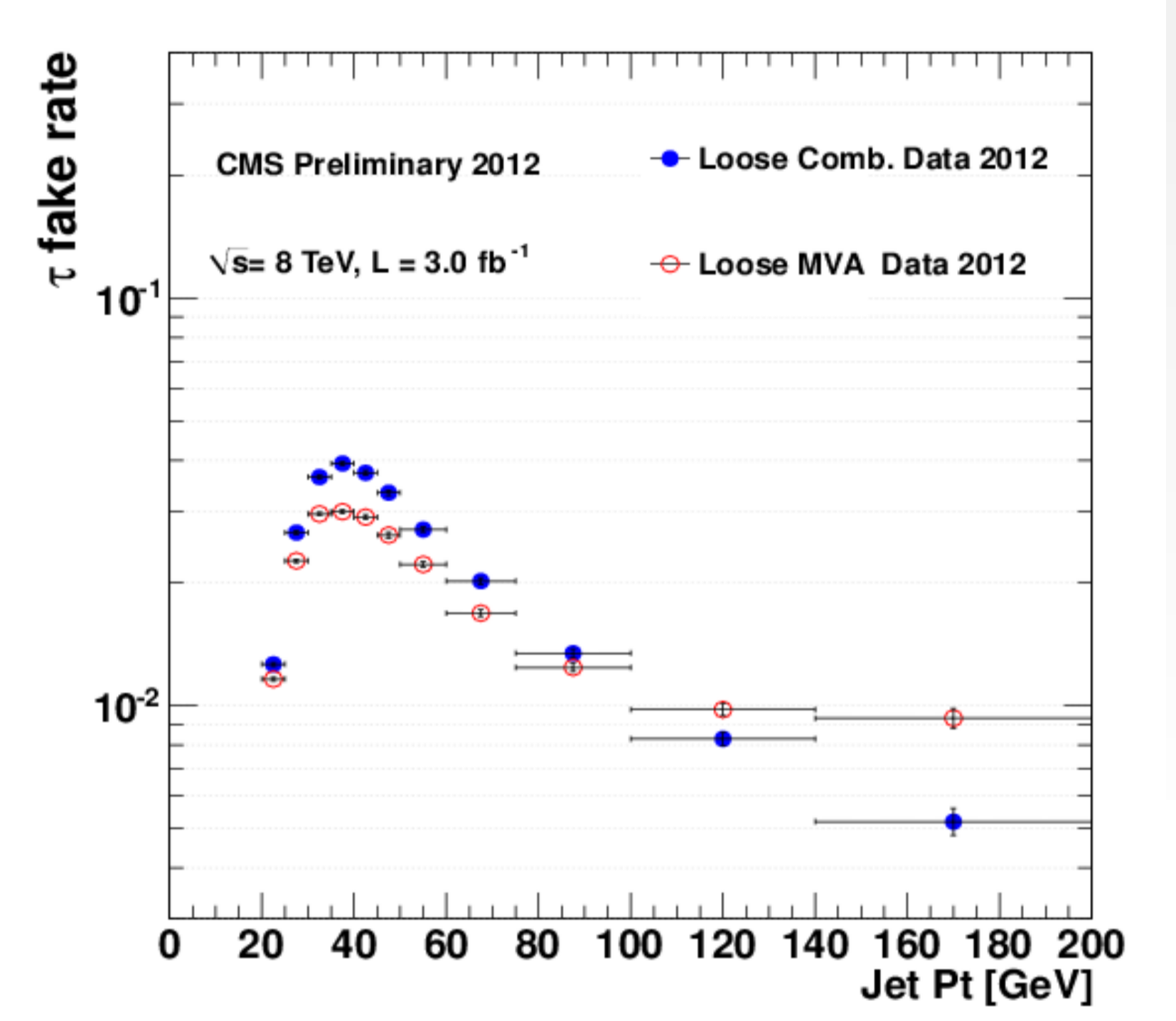
- Mis-identification rate for MVA isolation is smaller compared to cut based isolation for the same efficiency.

Energy Scale

- Charged hadrons and photons are reconstructed with high precision using the PF techniques.
- The reconstructed τ_h energy is expected to be close to the true energy of its visible decay products. The quality of the τ_h energy scale simulation can be examined by analyzing the Z $\longrightarrow \tau\tau \longrightarrow \mu\tau_h$.

Tau Energy Scale is independent of pile up and is constant for all decaymodes.
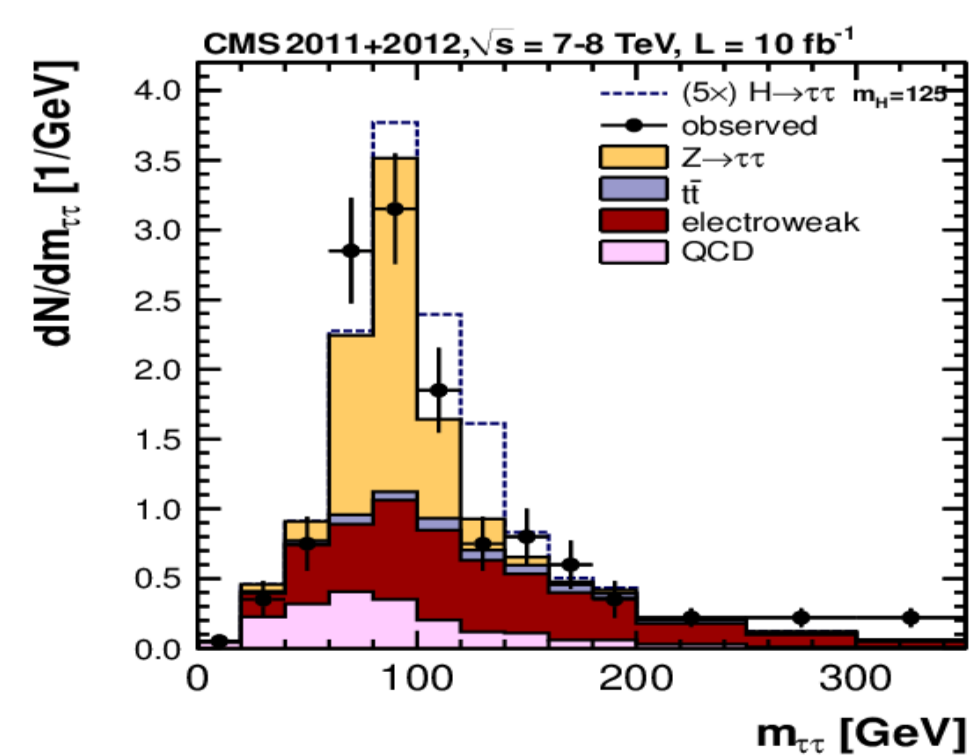
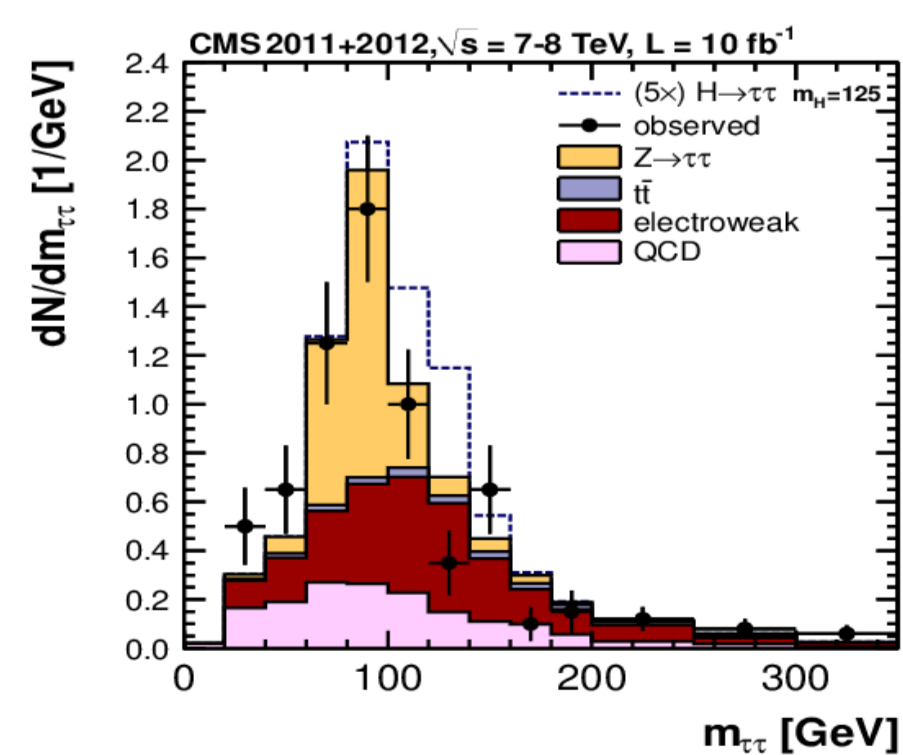## Physics Analysis using Cut based isolation
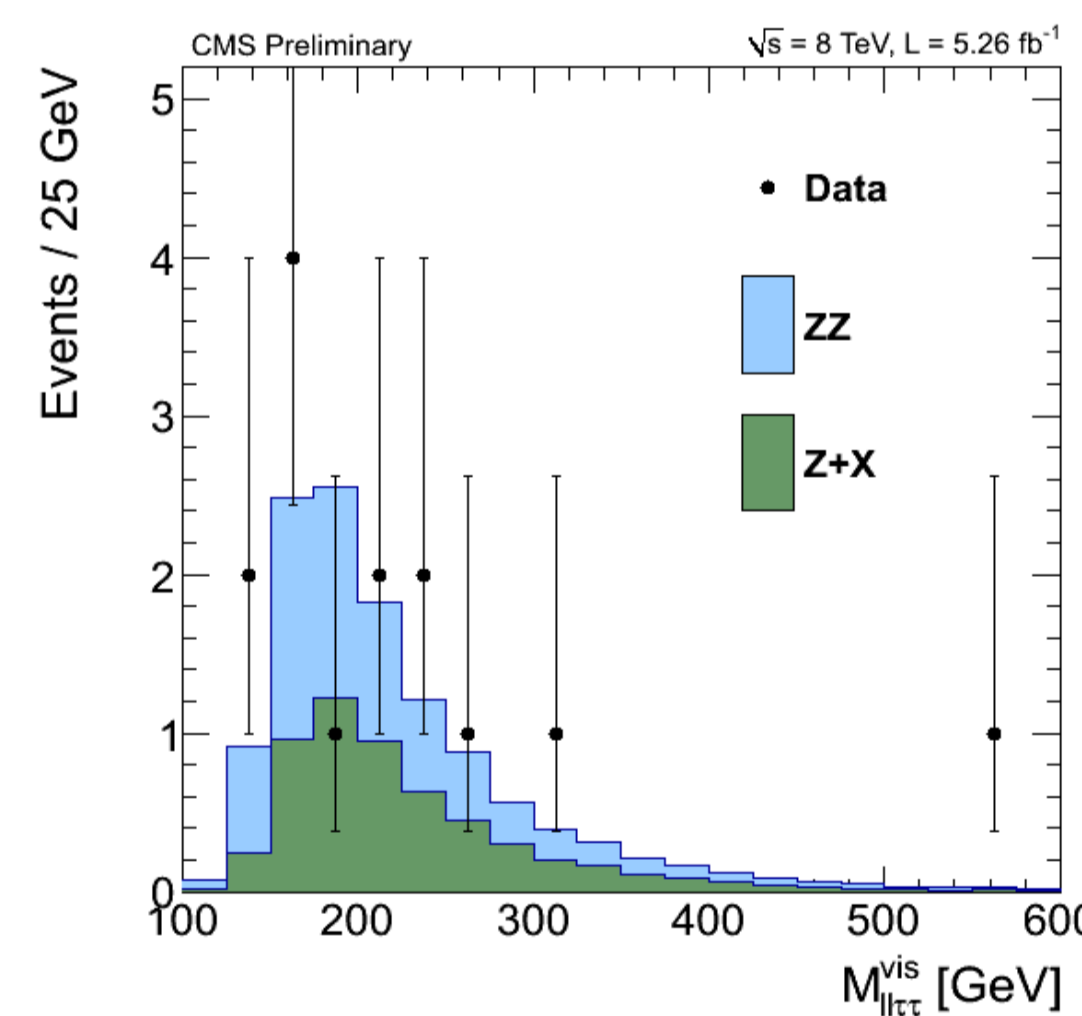
ZZ→ ll$\tau\tau$ invariant Mass
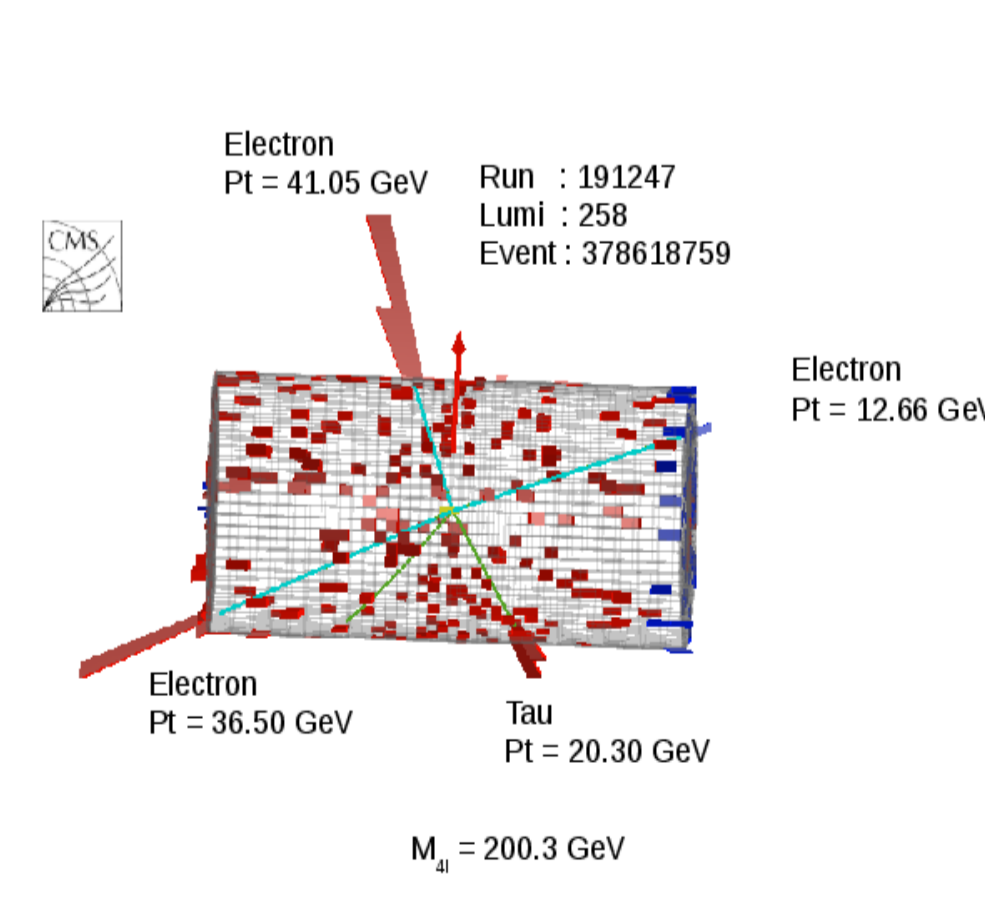
ZZ→ $\mu\mu\tau_h\tau_h$ event display in $\rho-\phi$

ZZ→ ee$\tau_e\tau_h$ event display
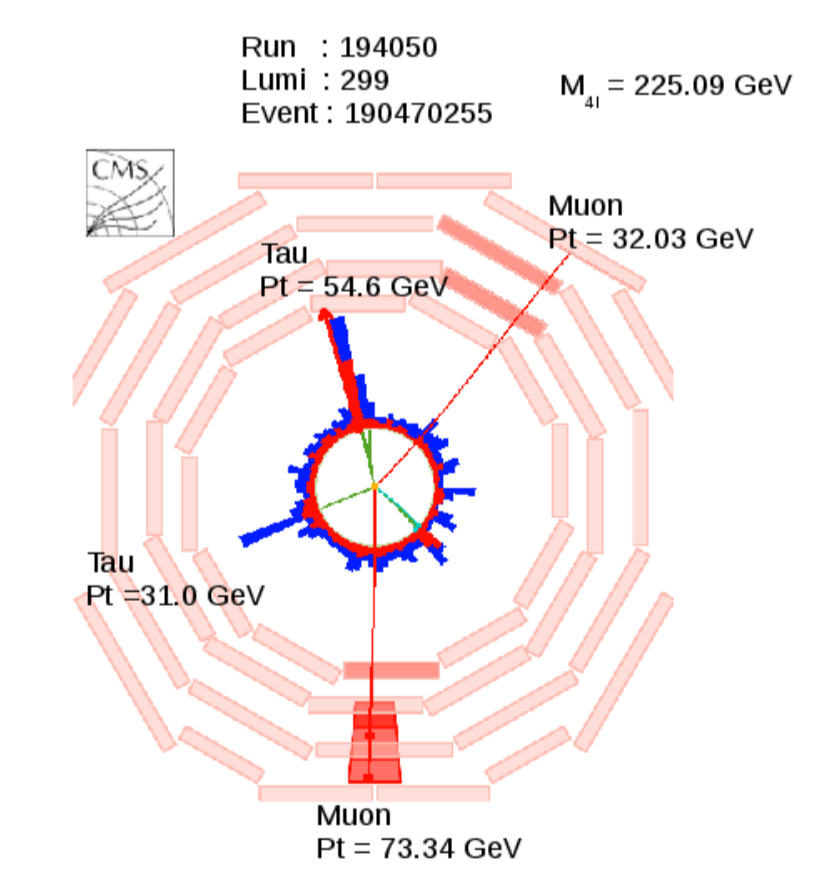
ZZ→ $\mu\mu\tau_h\tau_h$ event display

Physics Analysis using MVA isolation

$\mu-\tau_h$ visible Mass

e-τ_h visible Mass
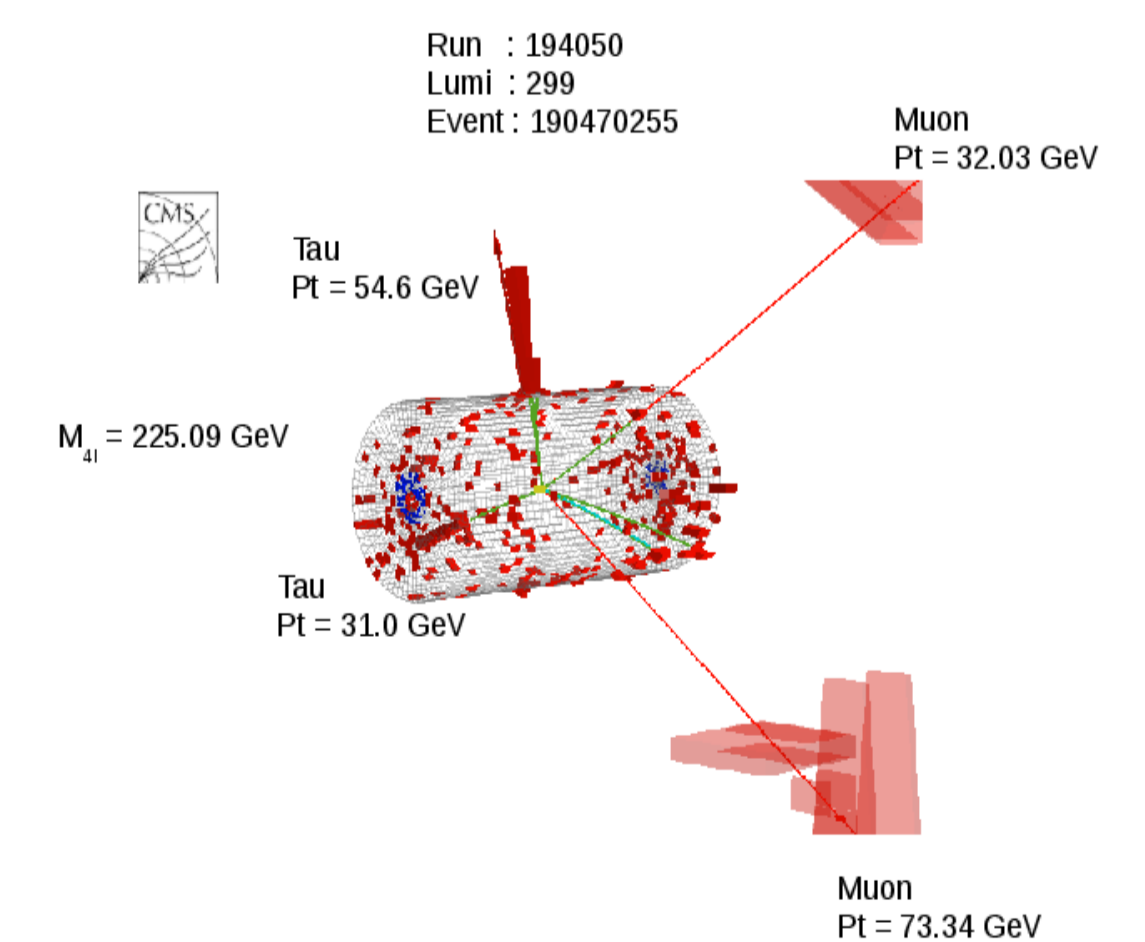
References

[1] CMS Collaboration: Search for a Standard Model Higgs boson in the H→ZZ→2l2τ decay channel in pp collosion at $\sqrt{s}$ = 7 TeV, [JHEP03(2012)081]
[2] CMS Collaboration: Search for neutral Higgs bosons decaying to tau pairs in pp collisions [CMS PAS HIG-12-018]
[3] CMS Collaboration: Measurement of ZZ production cross section in ZZ→2l2l' decay channel in pp collisions at $\sqrt{s}$ = 8 TeV [CMS PAS SMP-12-014]
[4] CMS Collaboration: Performance of tau-lepton reconstruction and identification in CMS, JINST 7 (2012) P01001, arXiv:1109.6034.

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