Hadronic tau jet reconstruction with particle flow algorithm at CMS

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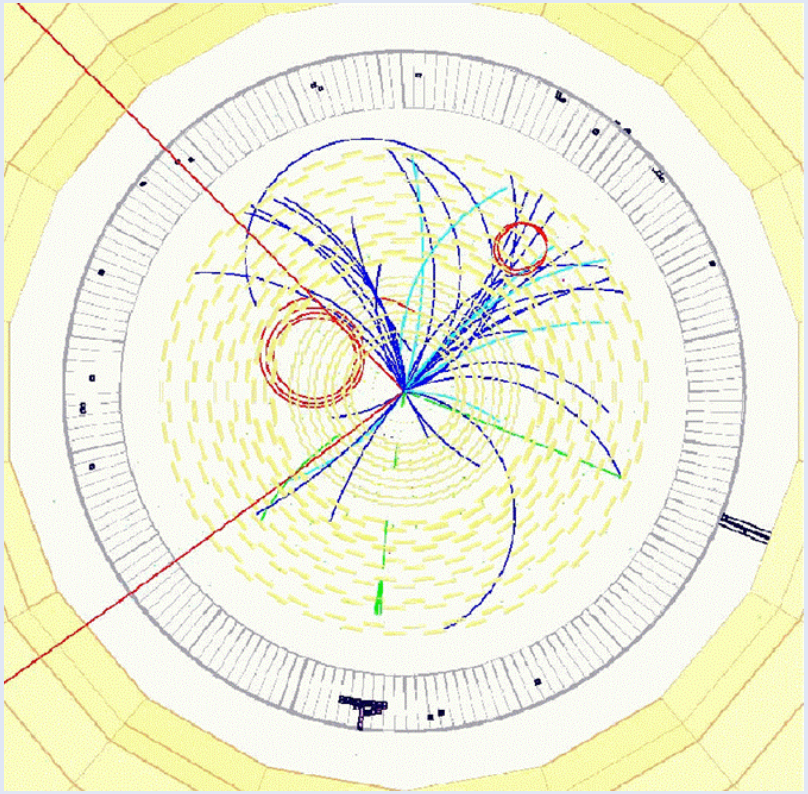
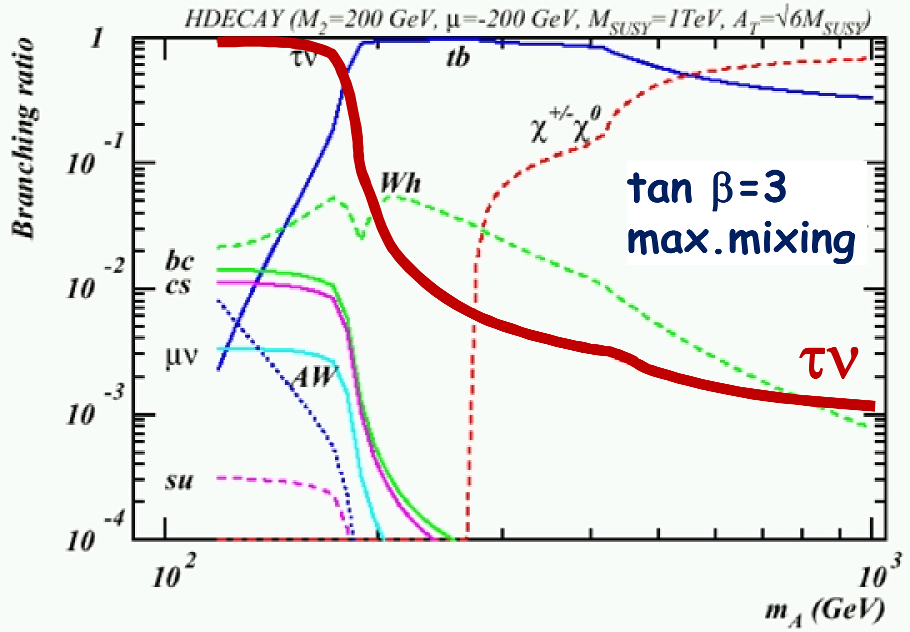
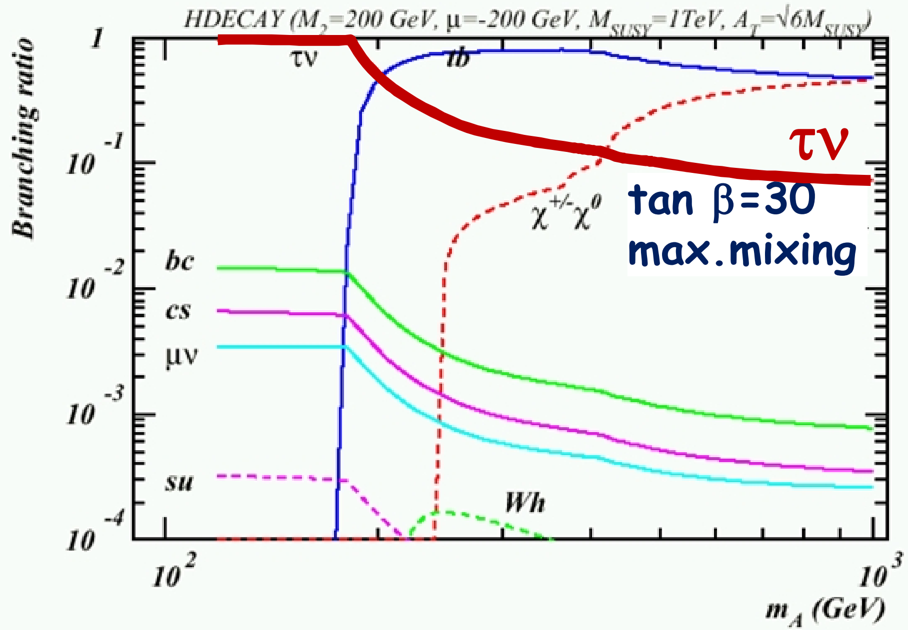


Motivation

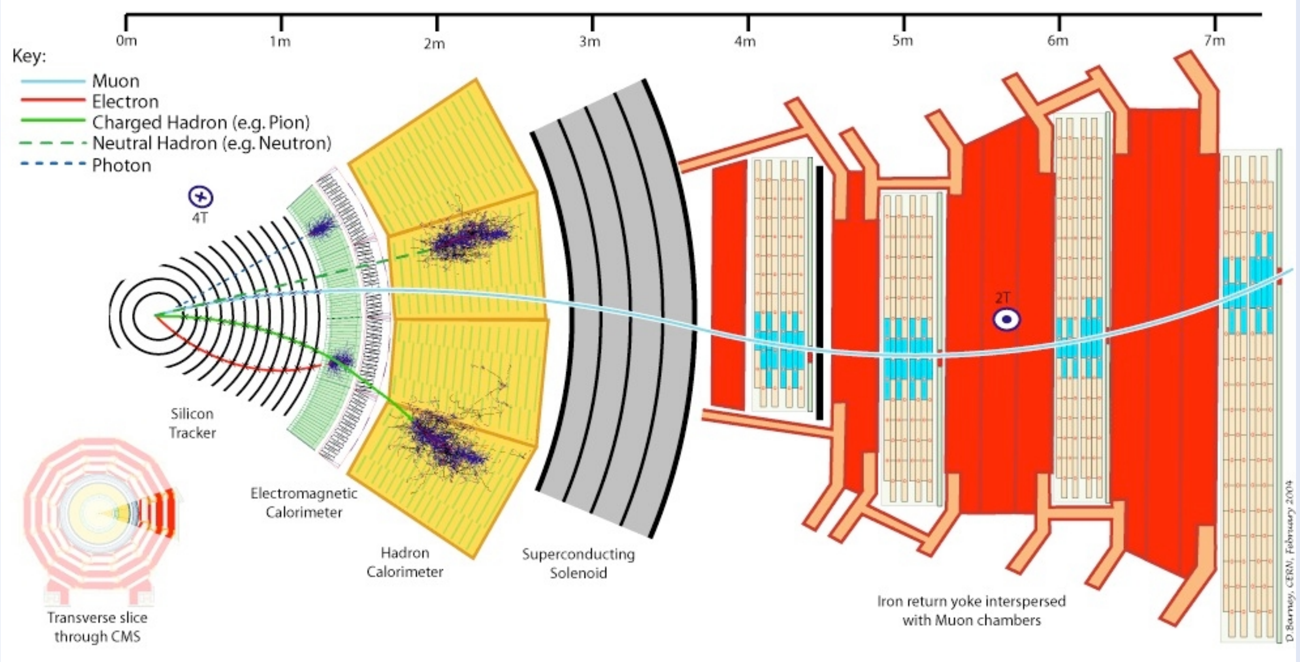
- H+ → τν is the most important decay channel of H+
- Thus need to have as good tau reconstruction algorithm as possible …
- Particle flow algorithm answers to this need





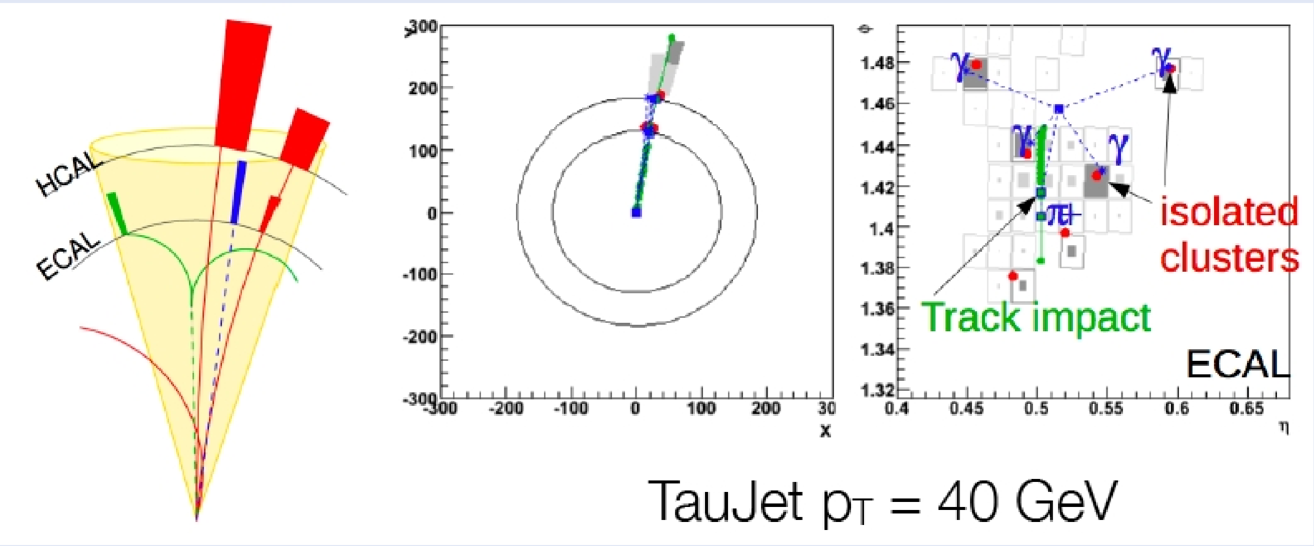
Why is tau reconstruction so tricky?

- Tau decays may contain electrons, muons, charged hadrons, neutral hadrons, photons
- Additional difficulty: unstable particles, nuclear interactions, photon conversions
- Need measurements from each subdetector of the experiment!



Idea of particle flow algorithm

- Goal: provide a complete and unique event description at the level of individually reconstructed particles
- Optimal combination of information from all subdetectors used
- The particles can be non-isolated or even merged
- The complete list of particles can be used to derive physics objects, which improves the performance compared to previous algorithms



Pool of all tracks, ECAL/HCAL clusters and muon hits inside the jet cone

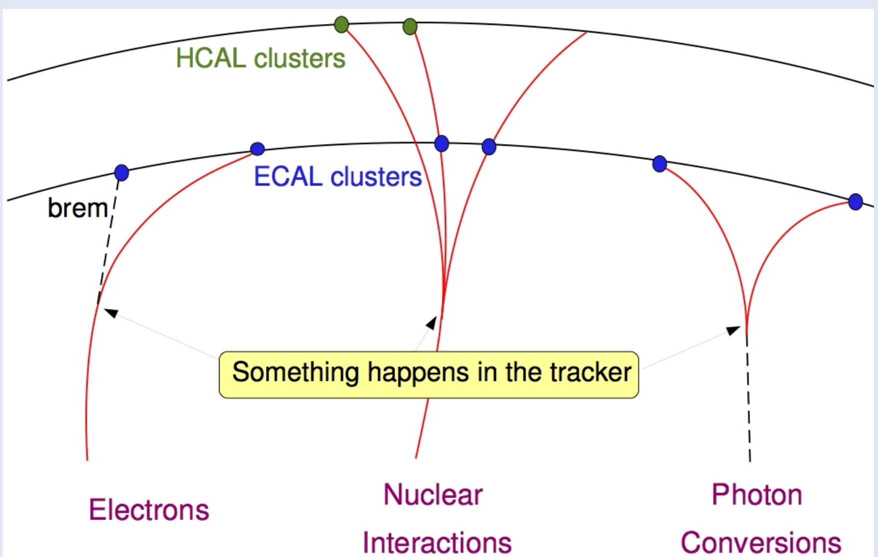
- muons
- electrons
- photons
- charged hadrons
- neutral hadrons

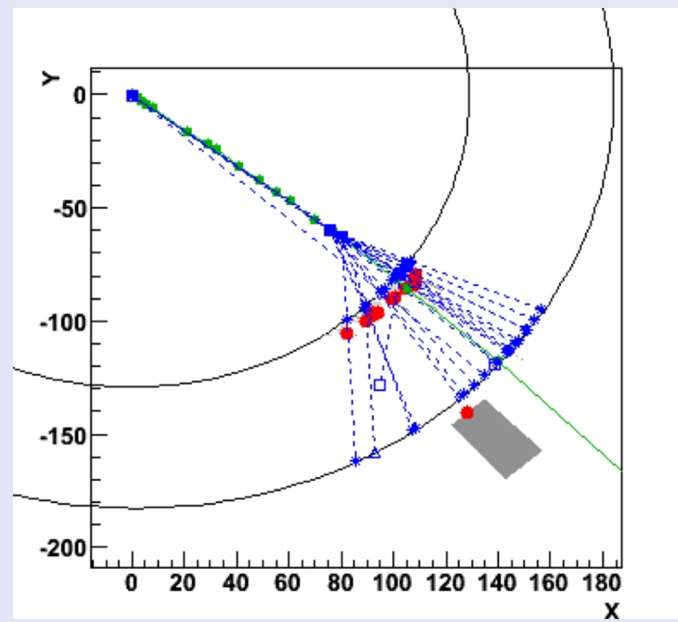
Primary track reconstruction

- Efficiency of tau identification is directly proportional to the track reconstruction efficiency
- Iterative track reconstruction approach developed and used for particle flow
- First, use very pure seeds to build tracks
  - Tight vertex cuts, a high minimum number of hits
  - a small fake rate and moderate tracking efficiency is achieved
- Then, on each iteration:
  - clean hits used in previous iterations
  - and progressively loosen track quality criteria
  - fake rate is remains constant and tracking efficiency is improved
- Result:
  - Small fake rate
  - Improved overall tracking efficiency (tracks with $p_T > 0.3$ GeV/c and a minimum of 3 hits can be reconstructed)

Secondary track reconstruction

- Goal: reconstruct tracks coming from secondary processes such as nuclear interactions, photon conversions or the decay of unstable hadrons
- Solution:
  - Examine the remaining track seeds after the first track building iteration
  - Example 1: if hit density increases along the reconstucted track, a nuclear interaction must have occurred
  - Example 2: If an isolated ECAL cluster is found, it points to a converted photon
- Development is well underway





Identification of muons, electrons and converted photons

- Muon id:
  - Reconstructed tracks and ECAL/HCAL clusters compatible with the muon chambers are tagged as muons
- Electron id:
  - The tracker is used as a "preshower" to identify particles, which radiate
  - Tracks and ECAL clusters compatible with electrons are tagged as electrons
  - Energy losses are taken into account with Gaussian sum filter and the possible individual bremsstrahlung photons are tagged as photons
  - Final identication takes into account several variables (distance between ECAL and track, track fit quality, momentum difference at the beginning and end of track, ECAL/track compatibility, cluster shape, number of bremsstrahlung photons, etc.)
- Converted photons:
  - If an isolated ECAL cluster is found, an outside-in track building compatible with the cluster is done
  - The final fit for the converted particle is done with an inside-out track fit

Charged hadron identification

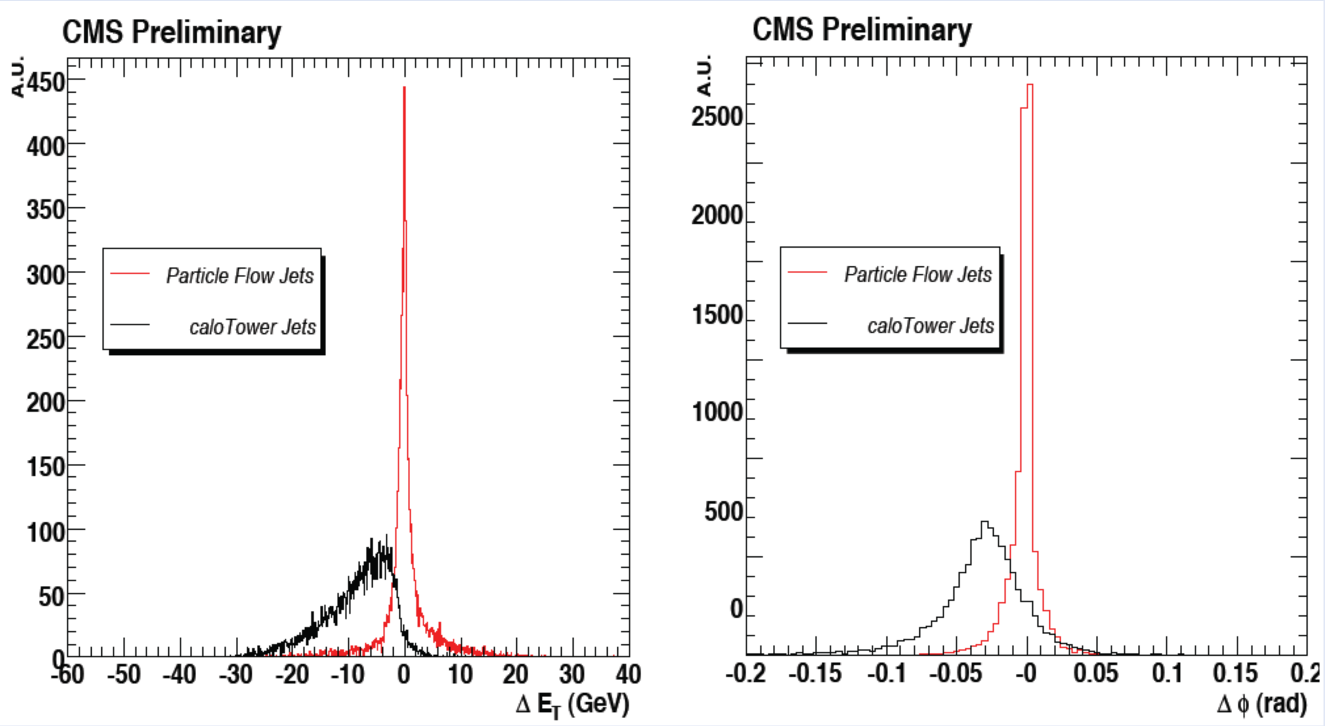
- Calibrated HCAL cluster is compared with track momentum
- If E and p_T are compatible, object is tagged as charged hadron
  - The energy is determined from weighted average of the track p_T and cluster energy
- If E and p_T are incompatible, a neutral hadron or photon is created from the excess cluster energy
  - A multivariate analysis is conducted on track pT, ECAL and HCAL energy ratio, cluster-track compatibility and the energy cluster shapes
  - Depending on the result, the neutral object is tagged as a photon or a neutral hadron

Neutral particle identification: neutral hadrons and photons

- At this stage, only energy clusters, which are not associated to tracks are left in the pool of tracks and ECAL/HCAL clusters
- Remaining unassociated HCAL clusters are assumed to be neutral hadrons
- Remaining unassociated isolated ECAL clusters are assumed to be photons

Example results (Energy and angular resolution)

- Particle flow jet energy is calibrated by charged particle momentum and photon energy
- Further improvement is expected from detailed analysis including π^0's, converted photons, etc.



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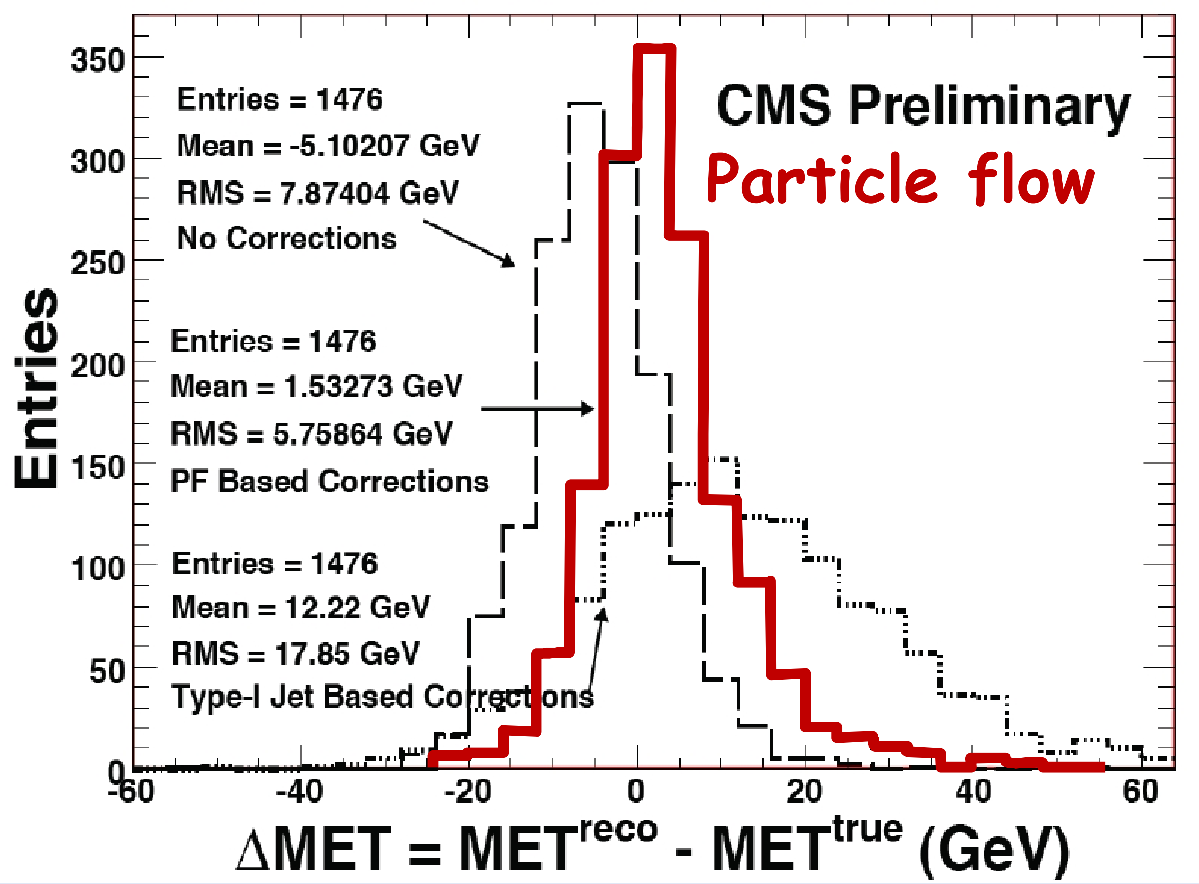
Energy (left) and azimuthal angle (right) resolution for single taus with p_T=40 GeV/c

Example results 2 (Missing E_T resolution)

- The complete event description approach of the particle flow algorithm gives the smallest bias in missing E_T (MET) resolution compared to previous MET algorithms



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Summary

- Good tau identification is essential for H+ discovery in the H+ → $\tau\nu$ decay channel
- Particle flow provides a complete and unique event description at the level of individually reconstructed particles (also in non-isolated or merged cases)
- The complete list of particles can be used to derive composite physics objects
- This leads to improvement of tau reconstruction performance
- Improvement work is ongoing…