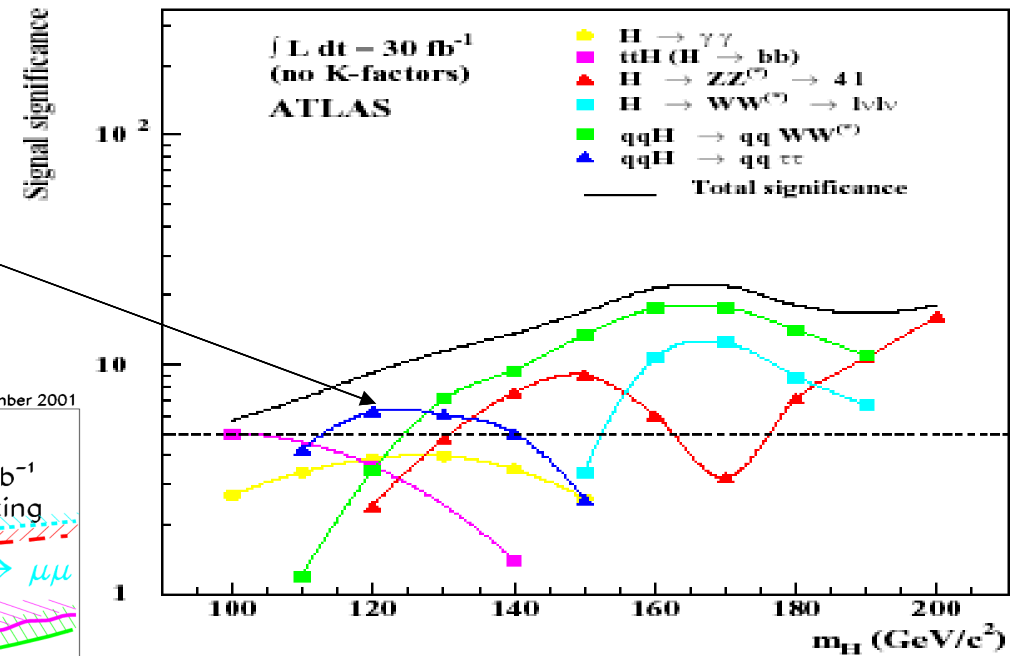
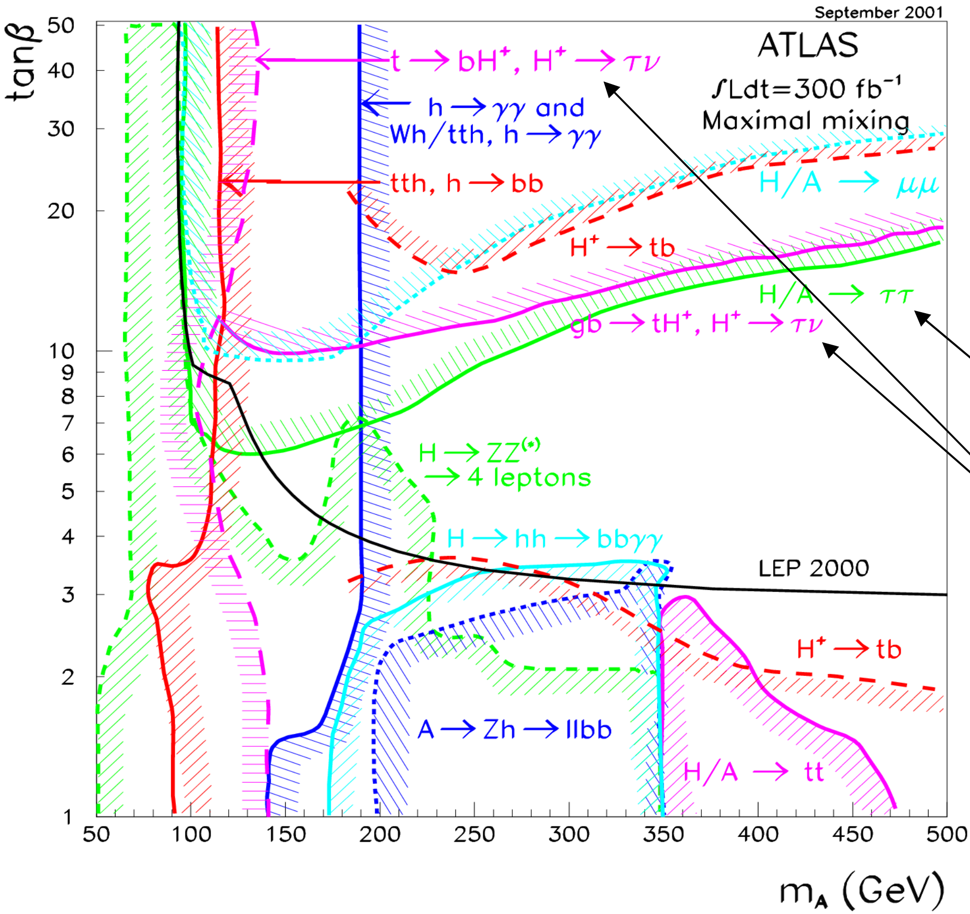
Taus in ATLAS

- Tau physics. Why are they useful?
- Tau reconstruction
- Tau identification
- Tau trigger

Tau Physics

- Several interesting channels involve taus:
  - In the Standard Model
    - $qqH \rightarrow qq\tau\tau$
      $Z \rightarrow \tau\tau$
      $W \rightarrow \nu_\tau \tau$





- In MSSM
  - $A/H \rightarrow \tau\tau$
    $H^{+} \rightarrow \nu_\tau \tau$
  - \+ others

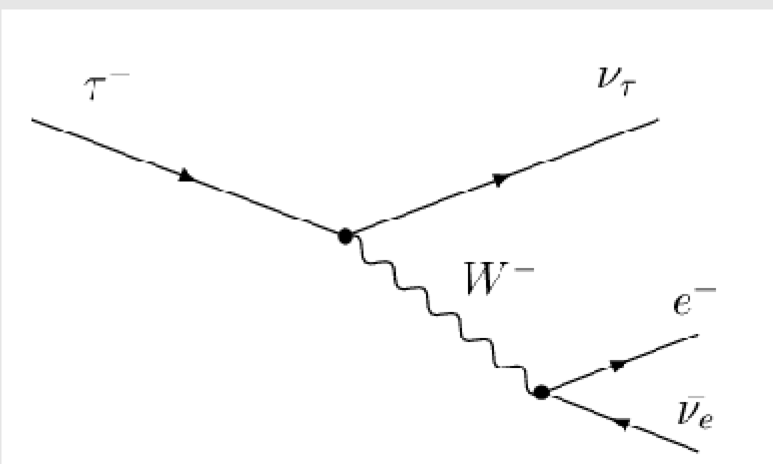
Tau decay

Only live for $290\text{x}10^{-15}s$
so not directly observable with atlas

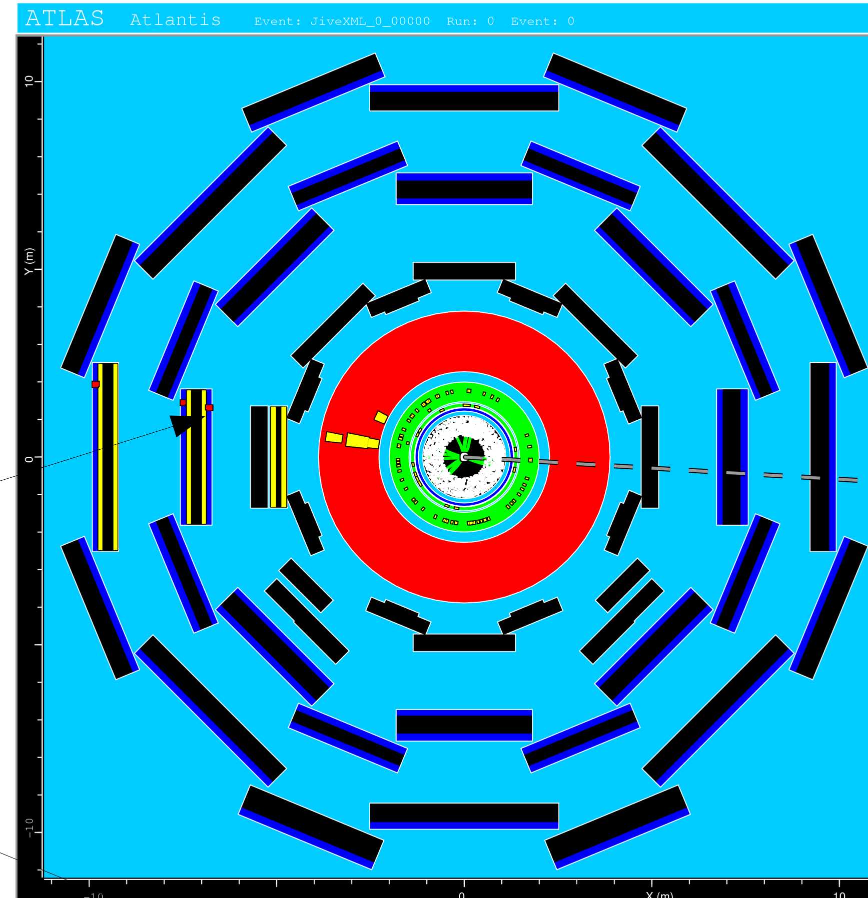
Decay via two modes:

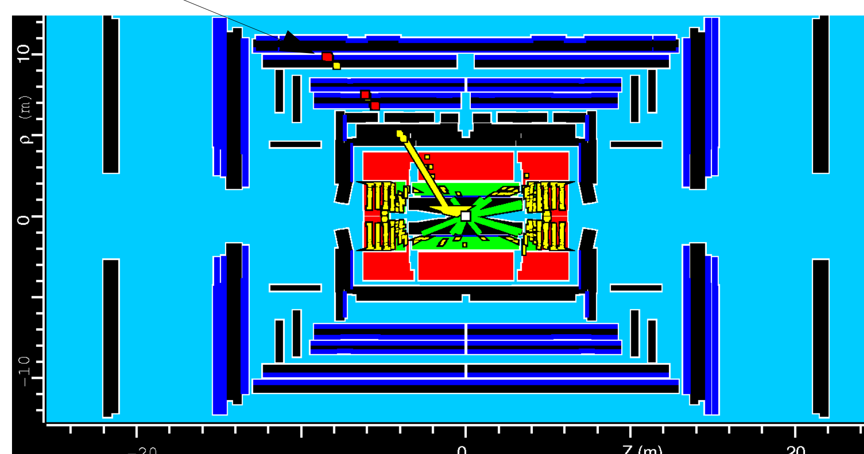
- into leptons

<u>Leptonic:</u> branching ratio 35.2%:



$$\tau \rightarrow \nu_\tau + e + \nu_e$$

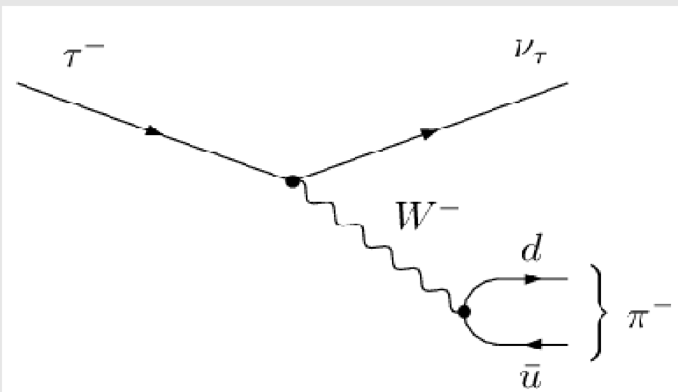




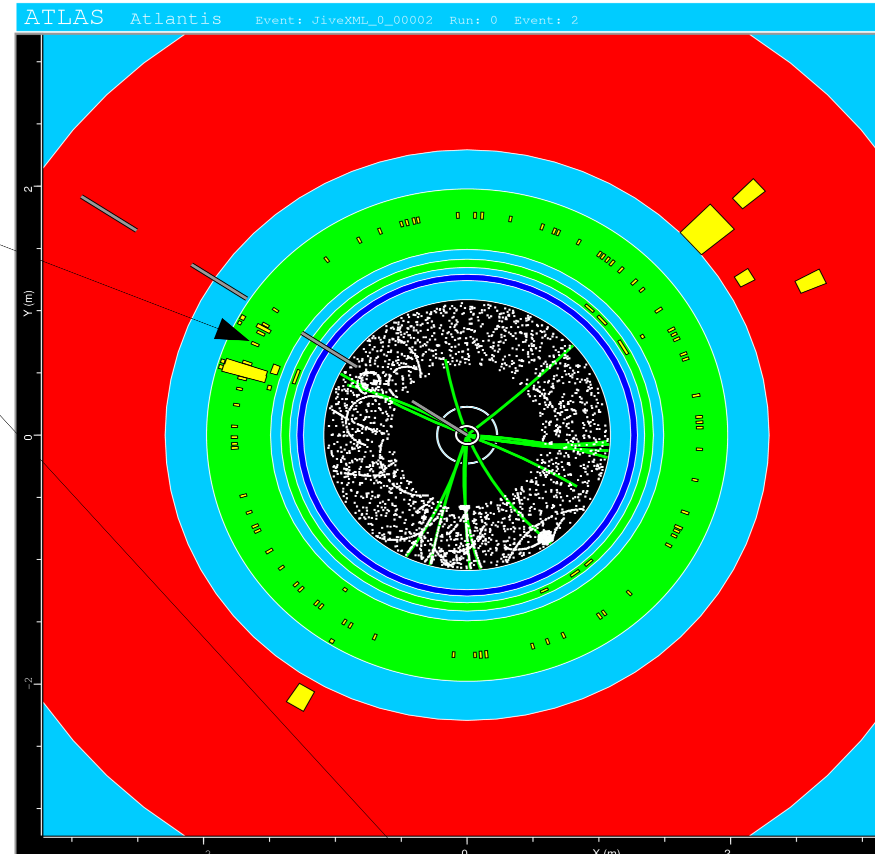
Tau decay cont.

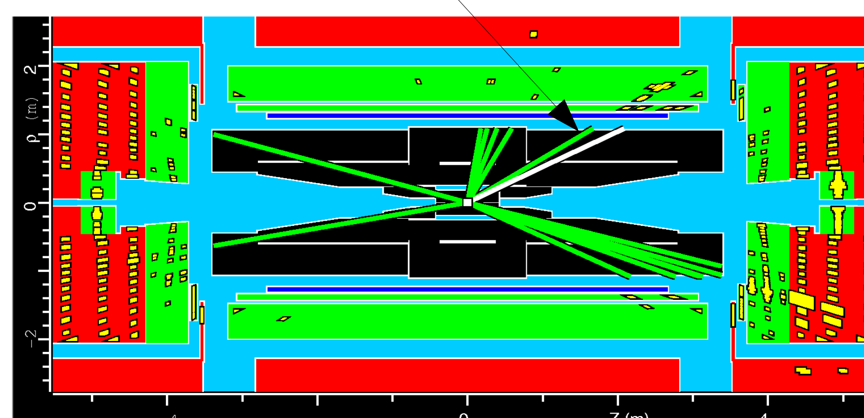
- decay into hadrons

<u>Hadronic:</u> branching ratio 64.8%:



$$\tau \rightarrow \nu_\tau + \pi$$





1 prong (77%):

$$\tau \rightarrow \nu_\tau + \pi^\pm + \pi^0$$

$$\tau \rightarrow \nu_\tau + \pi^\pm$$

$$\tau \rightarrow \nu_\tau + \pi^\pm + \pi^0 + \pi^0$$

$$\tau \rightarrow \nu_\tau + K^\pm + \nu \pi^0$$

$$\tau \rightarrow \nu_\tau + \pi^\pm + \pi^0 + \pi^0 + \pi^0$$

3 prong (23%)

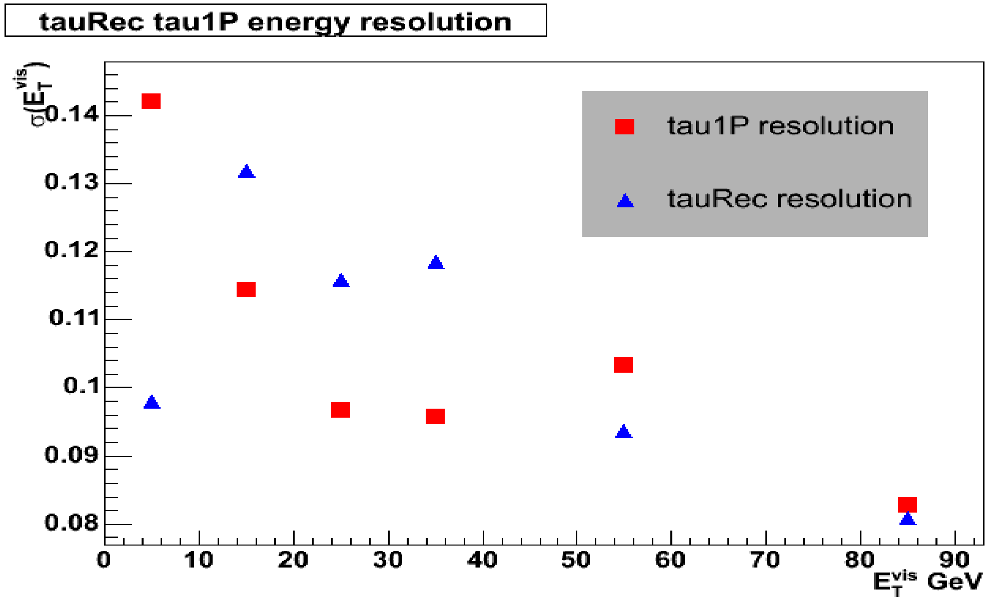
$$\tau \rightarrow \nu_\tau + 3\pi^\pm + \nu \pi^0$$

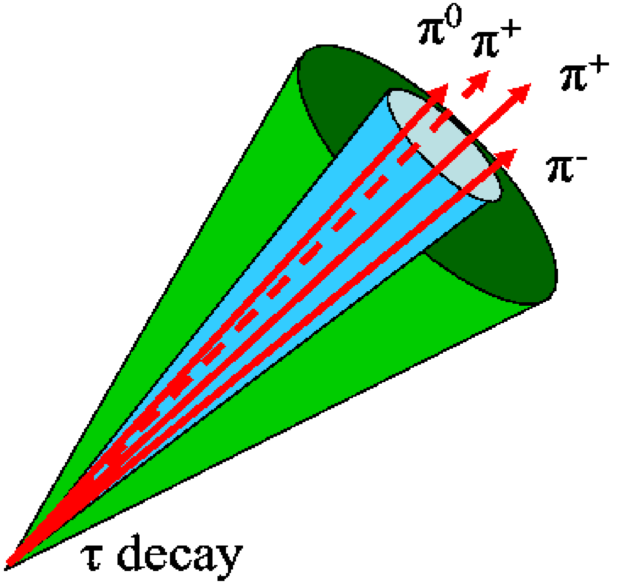
Tau reconstruction

We need to identify taus and reconstruct them.

Two methods (and software packages) for reconstruction/identifying the hadronic part of tau decay:

- tauRec. cluster & track seeded algorithm
- tau1P3P. track seeded algorithm





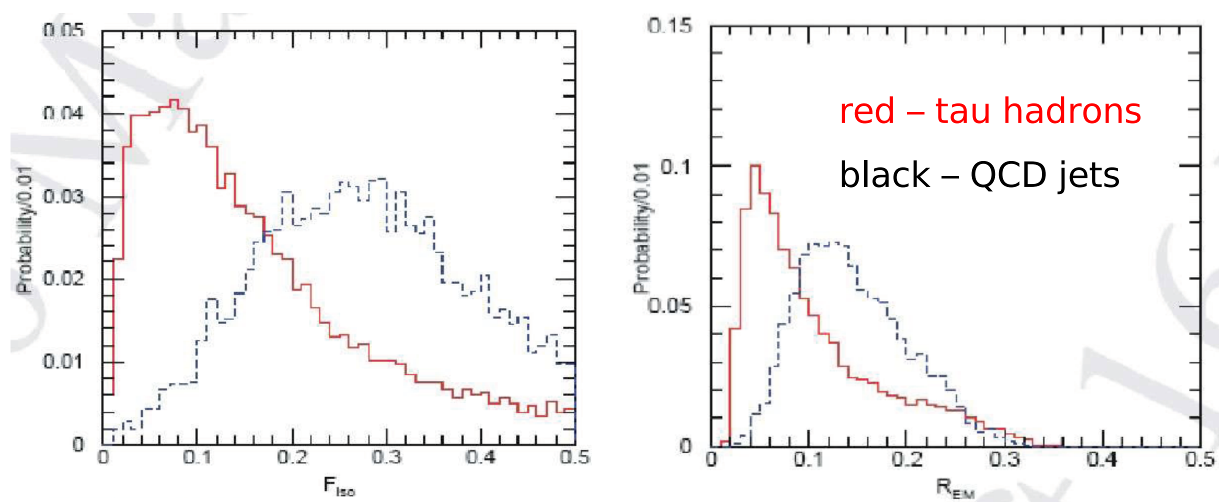
Tau identification

A signal similar to that of the tau may be produced by other things. For example:

- QCD jets (main source of background)
- late showering electrons
- muons in EM and hadronic calorimeters

Taus are identified by calculating a number of variables and comparing to tau & background samples. For example:

- number of tacks
- radius of EM cluster
- hadronic isolation
- EM isolation
- etc...



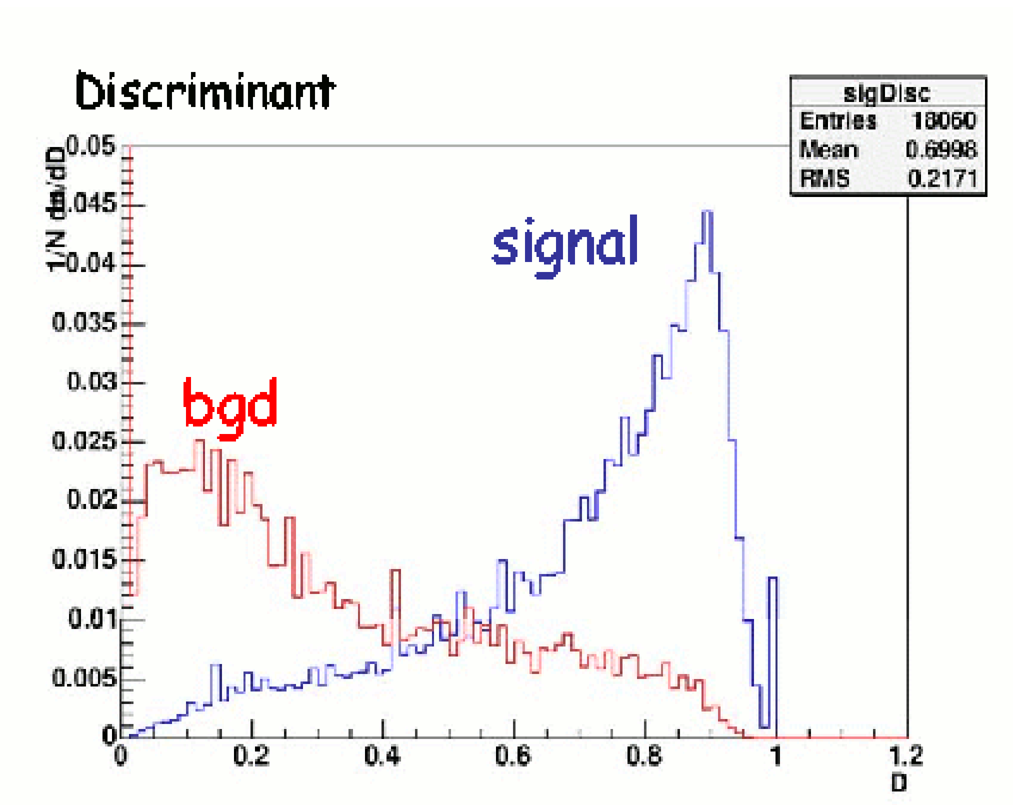
$$frac E_T^{R12} = \frac{\sum E_T^{cell}(R^{\tau_{1P},cell} < 0.2) - \sum E_T^{cell}(R^{\tau_{1P},cell} < 0.1)}{\sum E_T^{cell}(R^{\tau_{1P},cell} < 0.2)}$$

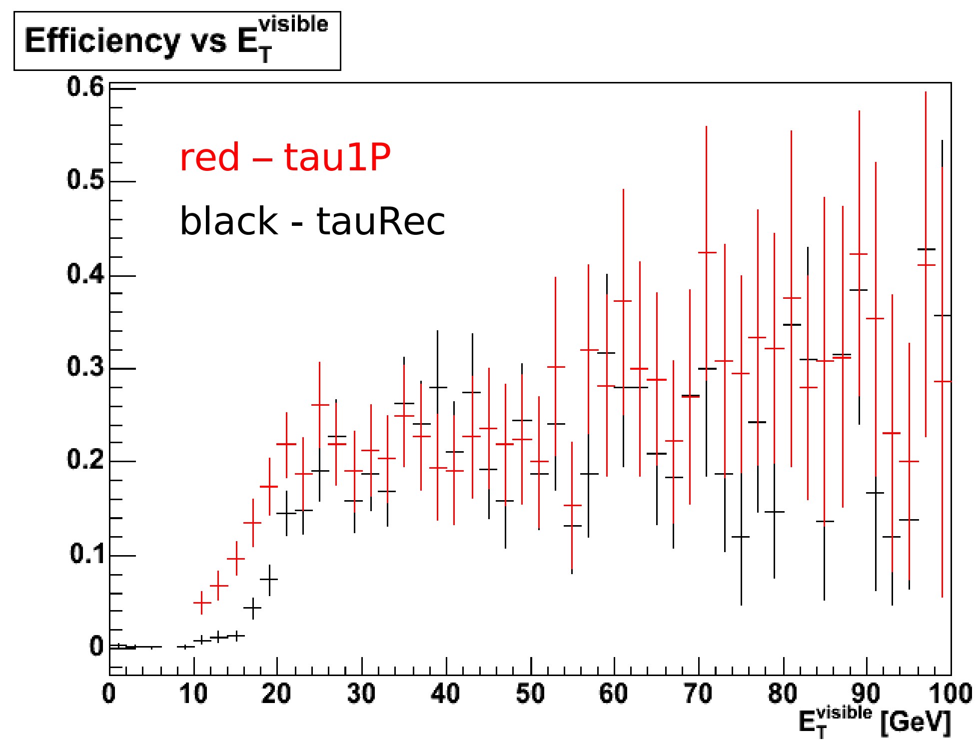
$$R_{em}^{\tau} = \frac{\sum \Delta R^{\tau_{1P},cell} \cdot E_T^{cell}}{\sum E_T^{cell}}$$

Some examples of tau vs jets distributions.
(from M. Pilar Casado & Carlos Osuna, L2 Tau Trigger, 14/9/2005)

Tau Identification cont.

Variables are compiled into one variable which mesures the likelyhood of the signature being from a tau

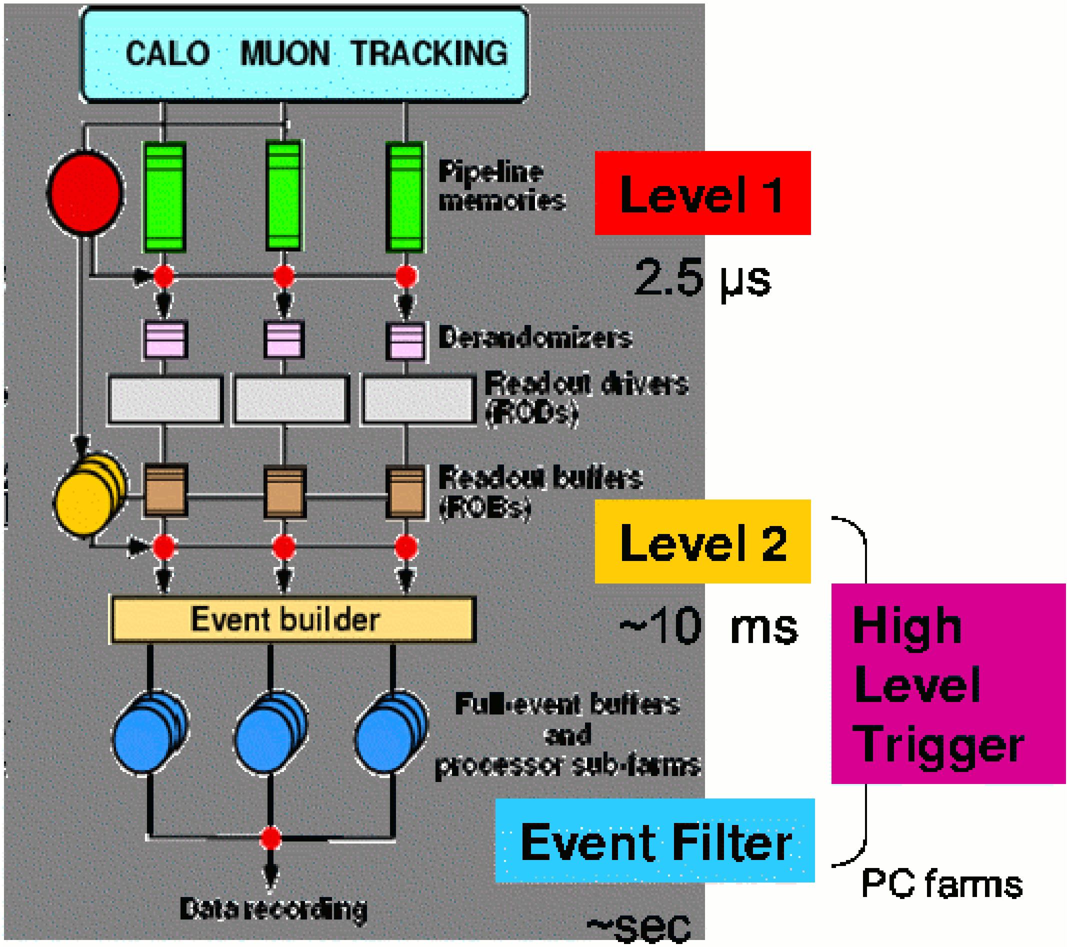




(from Ola Oye)

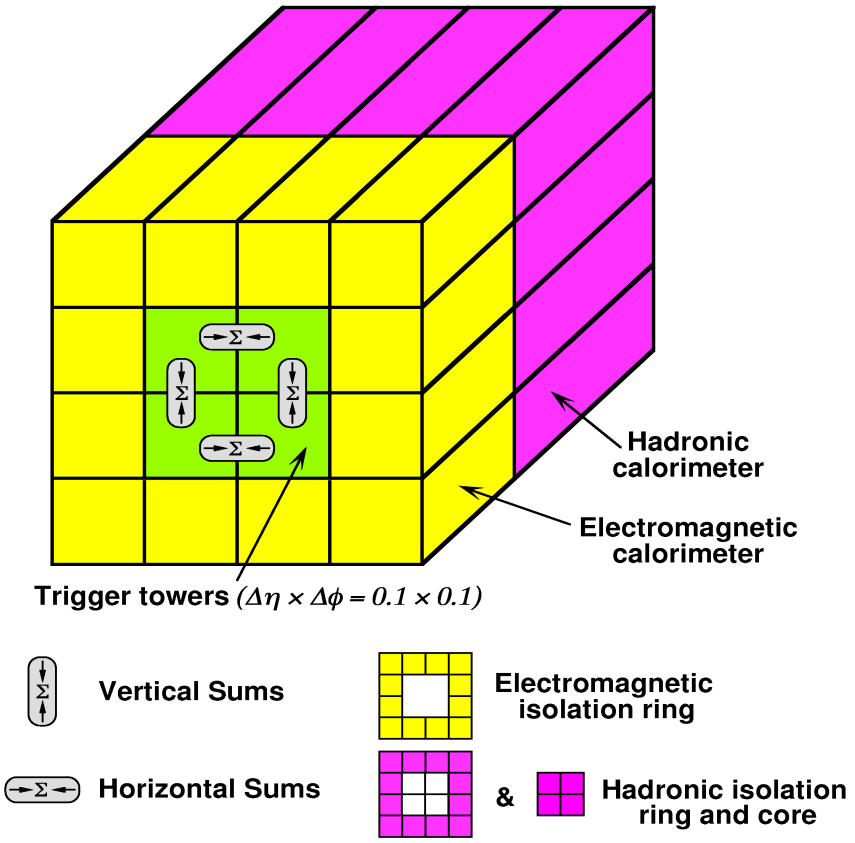
Tau Trigger

- Need to discriminate between event with and without interesting physics before the offline reconstruction stage.
- Taus need to be triggered:
  - for leptonic decay use electron and muon triggers
  - for hadronic decay a trigger just for taus is used. Much of the same principles used to identify taus in the reconstruction phase are used.



Tau trigger

- Level 1
  - Uses only calorimeter information.
  - Selection based on 4x4 array of trigger towers.
  - Tower granularity is 0.1x0.1 $(\Delta\eta \times \Delta\phi)$
  - Selection bases on:
    - E_T in 2x2 core of EM and hadronic calorimeters.
    - E_T in EM and hadronic isolation towers surrounding the core
  - Region of interest defined



Tau trigger cont.

- Level 2
  - Refine Level 1 decision with tracking information and better granularity of calorimeter data.
  - Examples of variables:
    - EM radius
    - Isolation fraction
    - Width in energy deposition
    - Core and isolation energies of hadronic calorimeter
    - No. of tracks
- Event Filter
  - Calibrated data
  - Based on offline software: tauRec