Triggering on hadronic decays of τ-leptons

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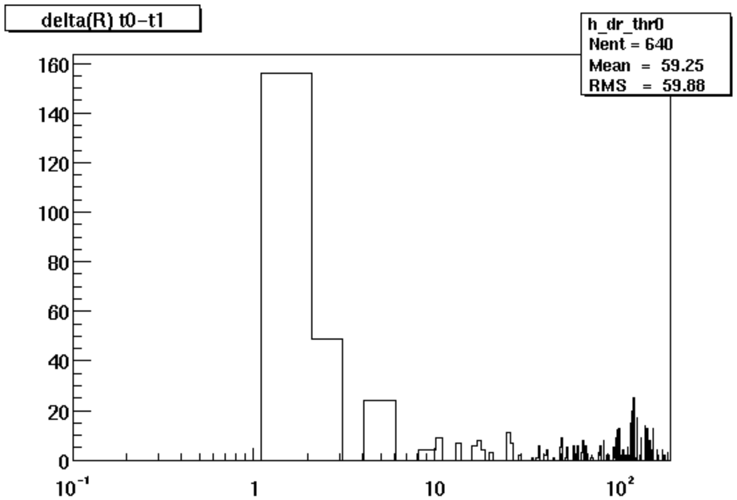
Physics motivations

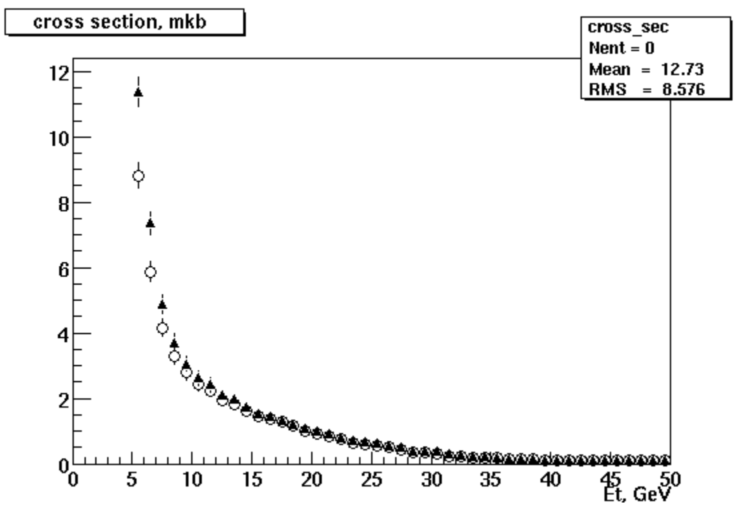
- SM Higgs $\rightarrow\tau\tau$
- MSSM H/A/h $\rightarrow$ $\tau\tau$
- High tanβ region of MSSM, in particular mSUGRA – multi-τ final states
- need “tagged” samples of τ-s with Z->$\tau\tau$ being one of the best options
- Tau-tau final states:
  - Lepton-hadron final state (46%) explored (see CDF-4718)
  - Hadron-hadron final state (42%)
  - Lepton-lepton final state (12%)

Tools/datasets

- RUN2TRS / FINDTAU / TAUFND
- Interface to C++ STNTUPLE
- Run1 minimum bias sample - 1.5 million events - for L1 and L2 rates
- Run1 Jet20 sample for L3 rates
- Z->$\tau\tau$ MC to estimate efficiencies

Level 1 trigger



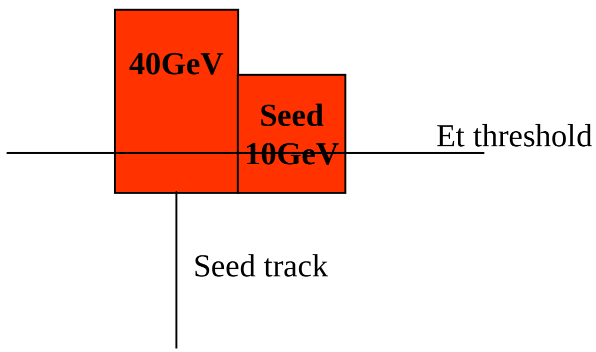


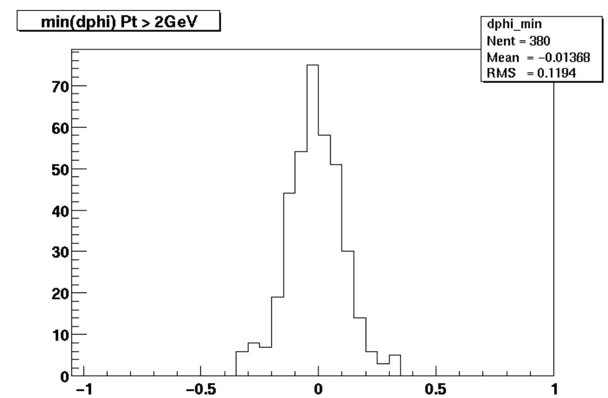
- 2-τ event topology:
  - 2 narrow isolated jets with low track multiplicity
- L1 requirement:
  - 2 central trigger towers with Et > Et(min)
- keep the thresholds as low as possible, start from Et(min) = 5 GeV
- effect of the inst. luminosity (<n> = 2)
- check the trigger path (YMON) – about 10% of the events in minimum bias sample with 2 central towers Et > 5 GeV are jet triggers
- single jet background (2 adjacent towers above the threshold) increases the cross section by about 30%
- overlap with the 10 GeV single tower trigger is about 45%
- Non-overlapped part of the L1 cross section is σ(L1) = 6.3μb
- can increase the Et threshold

Level 2 trigger

- At L2 can use more handles
- L2 requirements:
  - 2 central clusters with Et > Et(min)
    - need to optimize the clustering thresholds
  - Each cluster has a XFT track with Pt > Pt(min) matching to it within $\Delta(\phi) < \Delta\phi(\mathrm{min})$
  - Require τ-jet to be isolated
    - need to choose on tracking vs calorimetry isolation
- Different parameters are correlated
- Start from the low thresholds:
  - Clustering: seed/shoulder = 5GeV/1GeV
  - Cluster Et > 5 GeV
  - Track Pt > 3 GeV
- Raise the thresholds until the L2 rate gets low enough
- See what is the efficiency for the control MC sample ($Z\to\tau\tau$)

L2: track-to-cluster matching





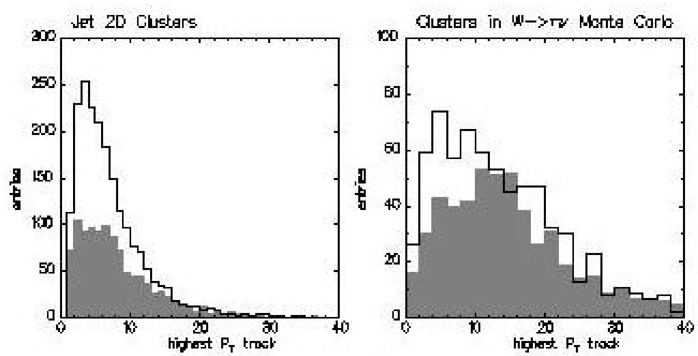
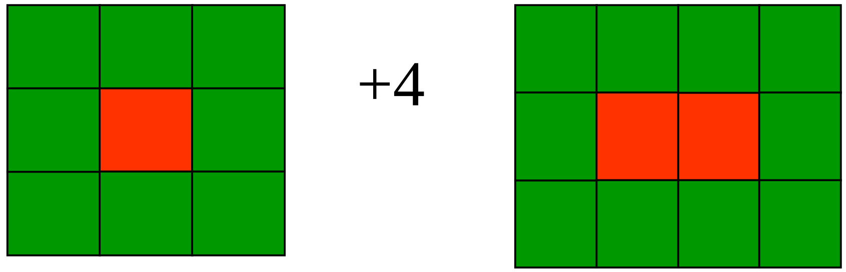


Figure 2: Transverse momentum (in GeV) of the leading track associated with Level–2 jet pass clusters over 20 GeV E_T, in Jet 20 data and in W→ $\tau\nu$ Monte Carlo. The open histogram corresponds to tracks of negative charge, the shaded histogram to tracks of positive charge. Clusters without an associated track are not shown. The excess of clusters where the associated leading track is negative is most striking for tracks with a p_T below 15 GeV. The excess is smaller in the W→ $\tau\nu$ Monte Carlo sample, partly because the track p_T distribution is harder.

- In Run1 a seed track was required to extrapolate to a seed tower
- L2 clustering is implemented in such way that the seed tower is not always the one with the highest Et
- This lead to large asymmetries observed in the Run 1 data
- Used $|\Delta\phi| < 20°$, can use $|\Delta\phi| < 30°$

L2: tracking ISO vs calorimetry ISO

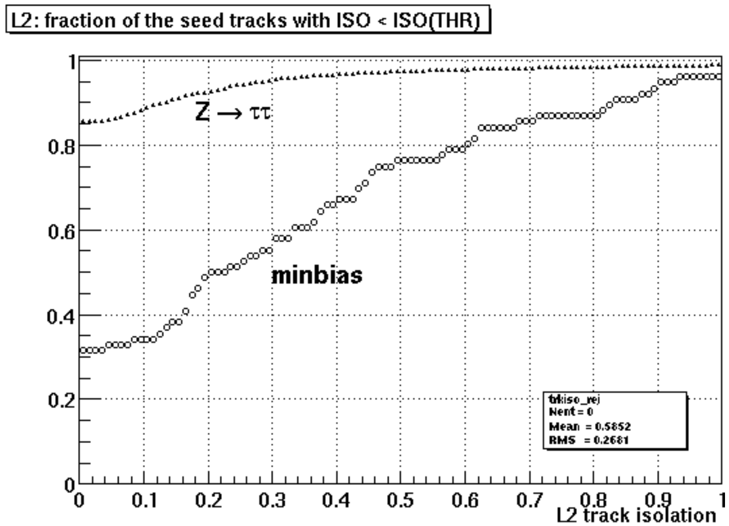


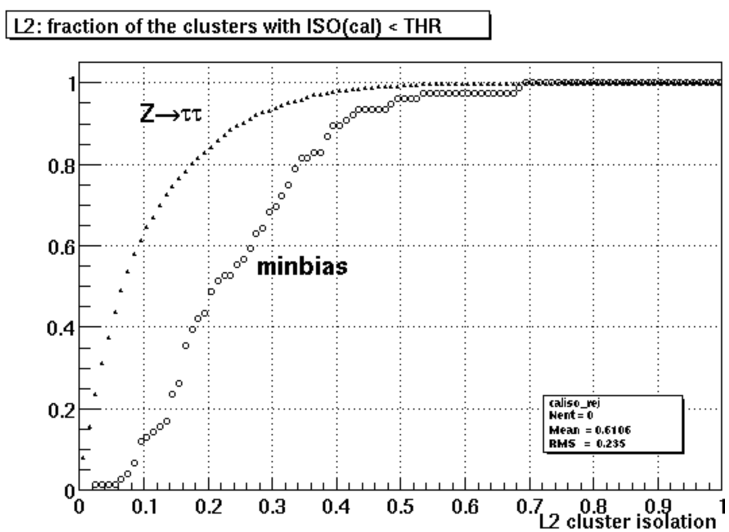
Isolation sums : sums over the green towers

The seed and the next-to-seed towers shown in red

- ISO(trk) = ΣPt(10•-30•)/Pt(seed)
- end of the day: ISO(trk) = 0, i.e. no tracks in 2D 10-30• annulus
  Seed track: the most energetic one within 20• from the cluster
- all the tracks are XFT tracks
  - 2D tracks
  - Pt > 1.5 GeV
- for each central L2 cluster 5 isolation sums can be calculated
- assumption: a jet is well contained in 1 or 2 trigger towers (about 0.25x0.2 in η–ϕ)
- ISO(cal)=ISO(min)/Et(cluster)

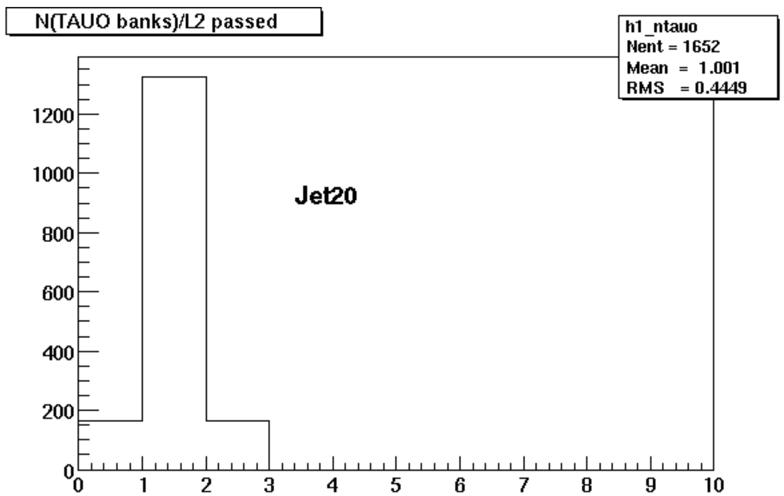
Level 2 cross section

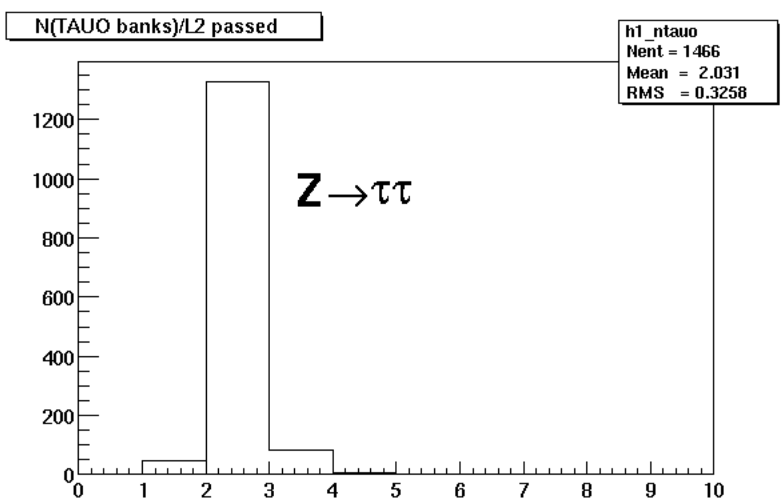




- conclusion: if we require efficiency to be high, the tracking isolation gives 30-40% better rejection power at the same efficiency
- require N (XFT tracks) = 0 in 10°-30° 2D annulus around the seed track
- Thresholds
  - Clustering: 8GeV/1GeV
  - Cluster Et > 10 GeV
  - Seed track Pt > 5 GeV
- 3 events out of 1.5*10**6 survive
- σ(L2) = 3*18nb = 55 nb
- total L2 budget is about1800nb
- Z→ττ:
  - 27% of all the events have 2 central towers with Et > 5 GeV, i.e. acceptance is a major factor
  - L2 efficiency is of the order of 40%, which is 63% per τ
  - E(L1 • L2) • acceptance = 11%

L3 trigger





- Run Run1 L3 filter (FINDTAU) with the default settings on Jet20 sample
- L3 requirement: 2 TAUO banks in the event
- Rejection for Jet20 sample ~10
- Efficiency for Z->tt sample: ~97%
- s(L3) = 55/10 = 5nb

Summary

- We proposed a central 2-τ hadronic trigger. The cross sections are
  - L1: ~ 6mb
  - L2: ~ 50nb
  - L3: ~ 5mb
- E(Z->$\tau\tau$)xacceptance ~10%
- N(Z->$\tau\tau$) in 2pb-1: about 16000
- Efficiency per τ in acceptance: about 60%

Next steps

- Explore plug region (1 central τ and 1 plug τ)
- W->$\tau\nu$ trigger (τ+MET)
- mSUGRA trigger: cut off back-to-back jets, move all the thresholds down