Search for MSSM Higgs Decaying to Taus

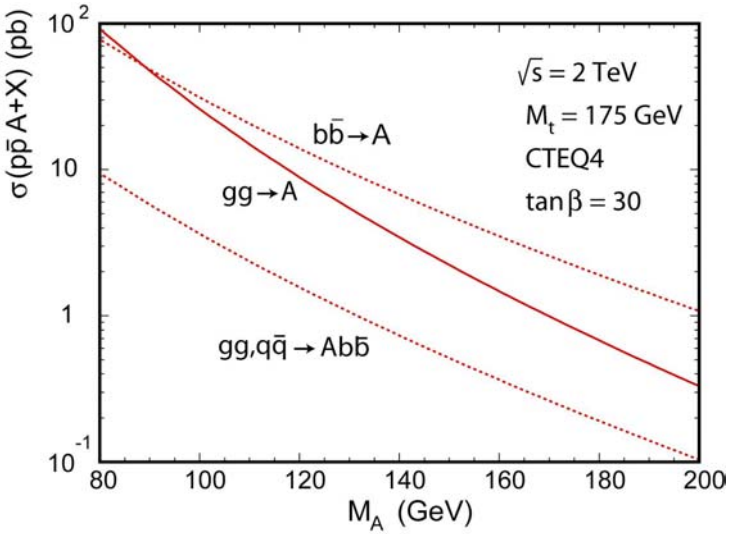
Dongwook Jang

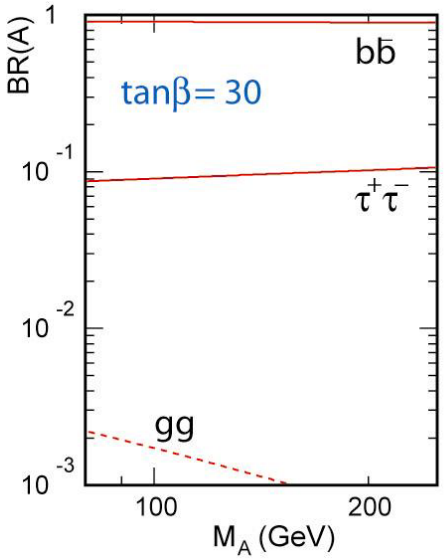
Rutgers University

On behalf of the CDF collaboration

- **Motivation**
- **CDF Detector, Taus at CDF**
- **Event Selection, Backgrounds**
- **Results**
- **Summary**

Motivation



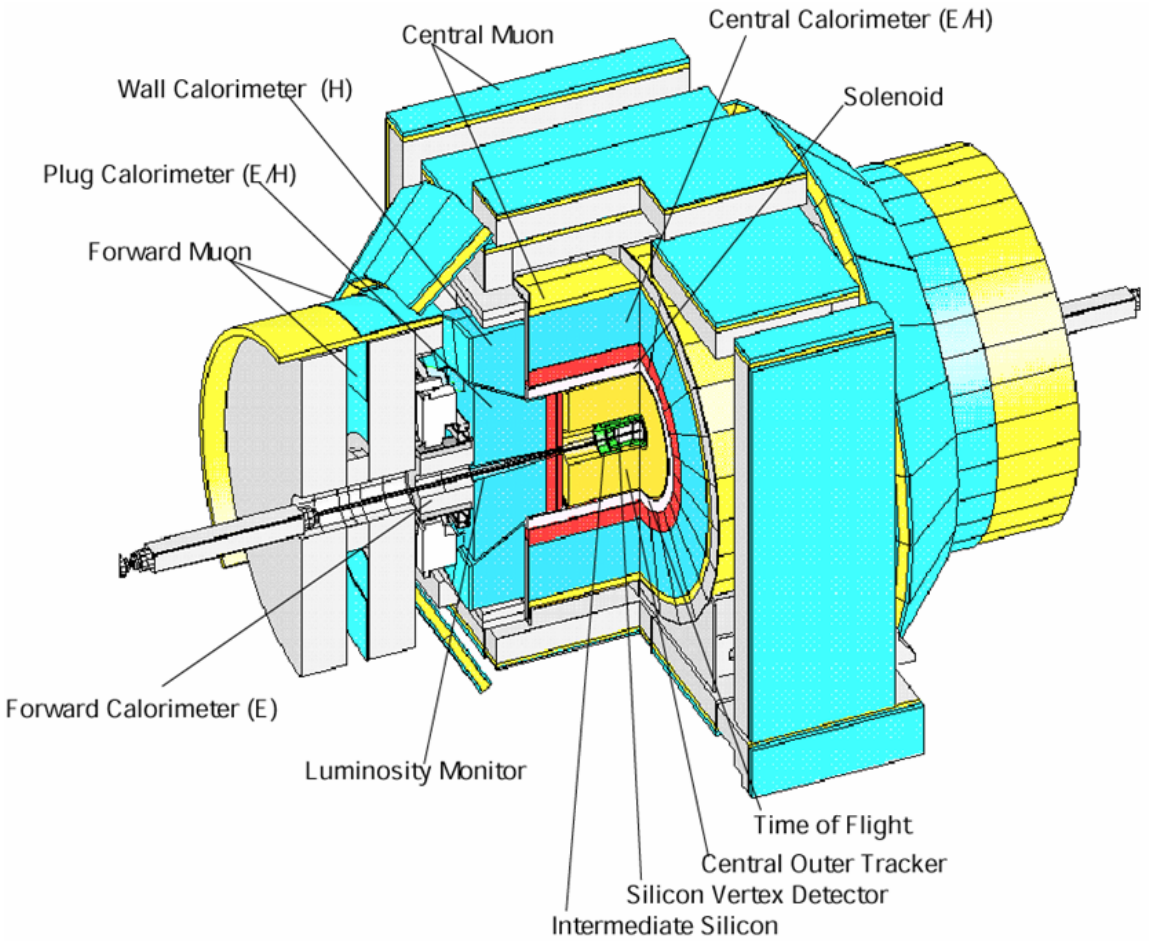


[Ref] Report of the Higgs Working Group of the Tevatron Run 2 SUSY/Higgs Workshop, hep-ph/0010338, M. Carena, J. S. Conway, H. E. Haber, J. D. Hobbs, et al

- **Minimal Supersymmetric extension of the Standard Model (MSSM) predicts five Higgs bosons : h^0/H^0(CP-even), A^0(CP-odd), $H^{\pm}$**
- **Higgs production enhanced at high tanβ**
- **$\phi \rightarrow b\bar{b}$: dominant decay mode, hard to control background**
- **$\phi \rightarrow \tau\tau$: Clean compare to $\phi \rightarrow bb$, the second largest mode, τ has interesting characteristics**

CDF Detector

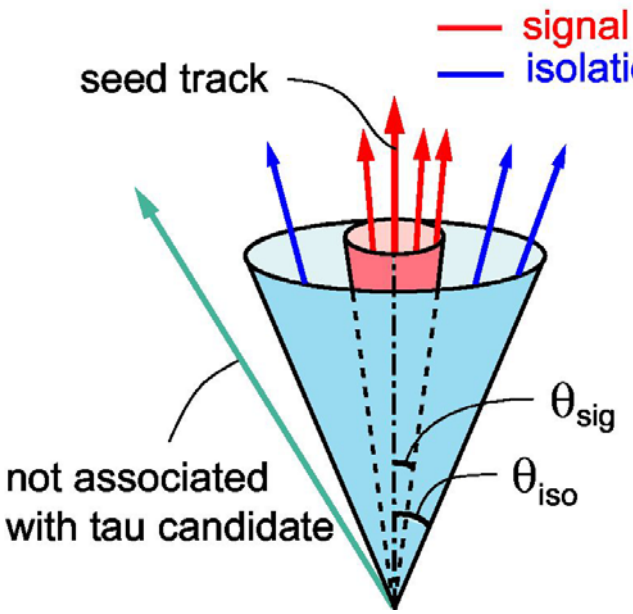
- **Tracking: Silicon Vertex Detector, Central Outer Tracker**
- **Energy: EM & Hadronic Calorimeters**
- **pi0 : Shower Max, EM**
- **Muon : Muon Chambers**



Taus at CDF

τ decay

- $\tau \rightarrow e\nu_e\nu_\tau$, $\tau \rightarrow \mu\nu_\mu\nu_\tau$: leptonic decays (~36%).
- $\tau \rightarrow \pi\nu_\tau$, $\tau \rightarrow \pi\pi^0\nu_\tau$, $\tau \rightarrow \pi\pi\pi\nu_\tau$, … : hadronic decays (~ 64%).
- Always accompanied by missing energy due to neutrinos in final state.



Tau Triggers

- electron + isolated track
- muon + isolated track
- tau + $\not{E}_T$
- two taus

Tau signature

- Narrow Isolated jet
- 1 or 3 tracks, net charge 1
- Low π^0 multiplicity
- M < 1.8 GeV

Backgrounds

Sources:

- $Z \rightarrow \tau\tau$ (dominant, irreducible)
- Jet $\rightarrow \tau$ misidentification : multi-jet, W + jet(s)
- $Z \rightarrow ee, \mu\mu$: e, $\mu \rightarrow \tau$ misidentification
- WW, ZZ, WZ, $t\bar{t}$ (small cross-sections)

Event Selection

- **Select two taus:**

  One tau decays to electron or muon, and neutrinos

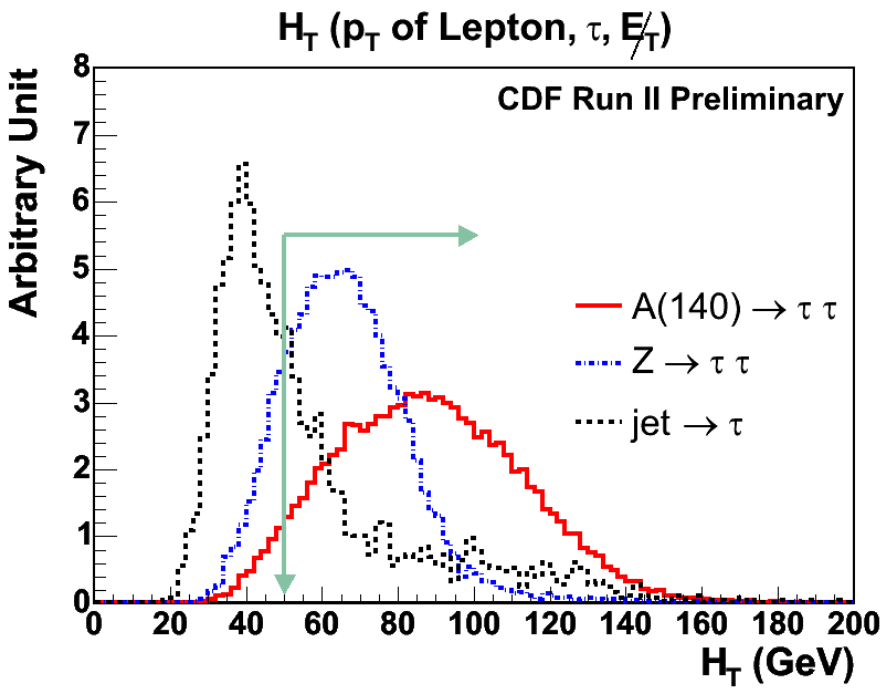
  Second tau decays to hadrons and a neutrino

- **Cosmic removal**
- **$Z \rightarrow ee, \mu\mu$ suppression:**

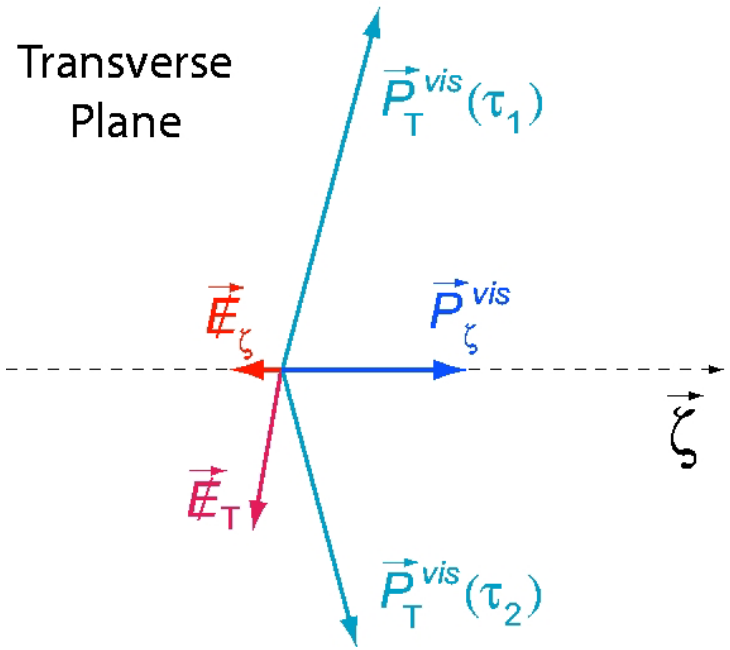
  $|m_{\tau\tau}-m_Z| > 25\ GeV/c^2$

- **Multi-jet background suppression:**

  $|P_T^{\tau 1}| + |P_T^{\tau 2}| + |\not{E}_T| > 50\ GeV$



Event Selection cont'd

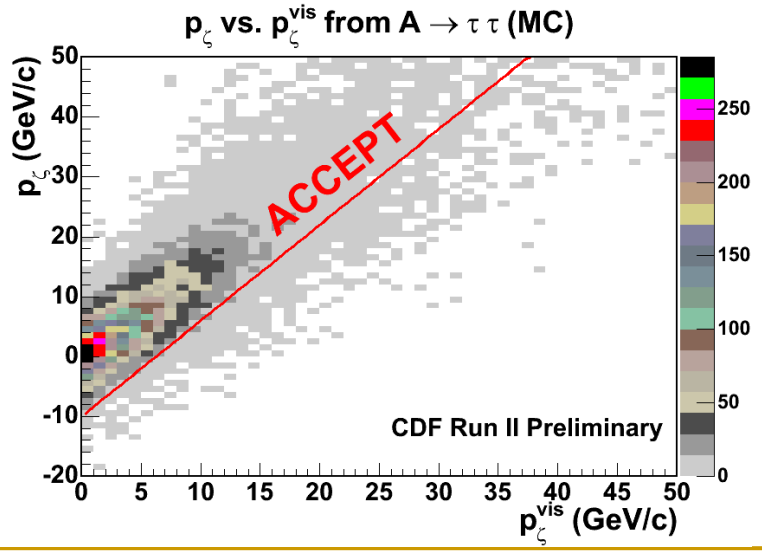


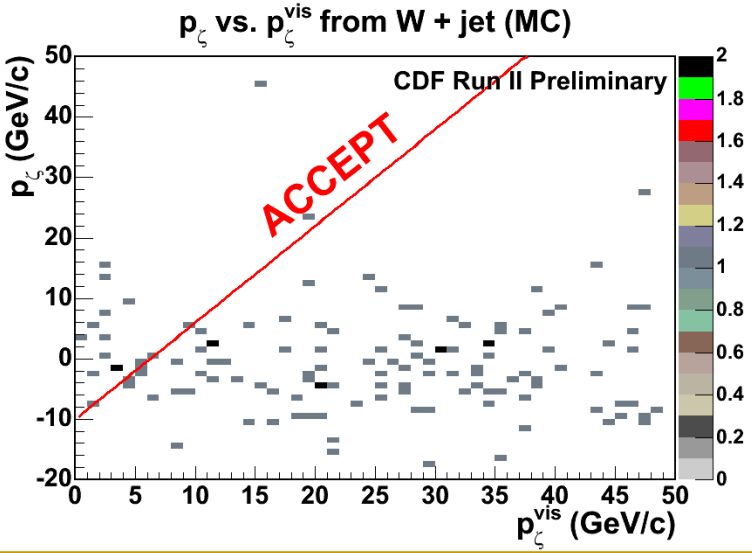
Suppress W + jet(s) background:

$$P_\zeta > 1.6\, P_\zeta^{vis} - 10$$

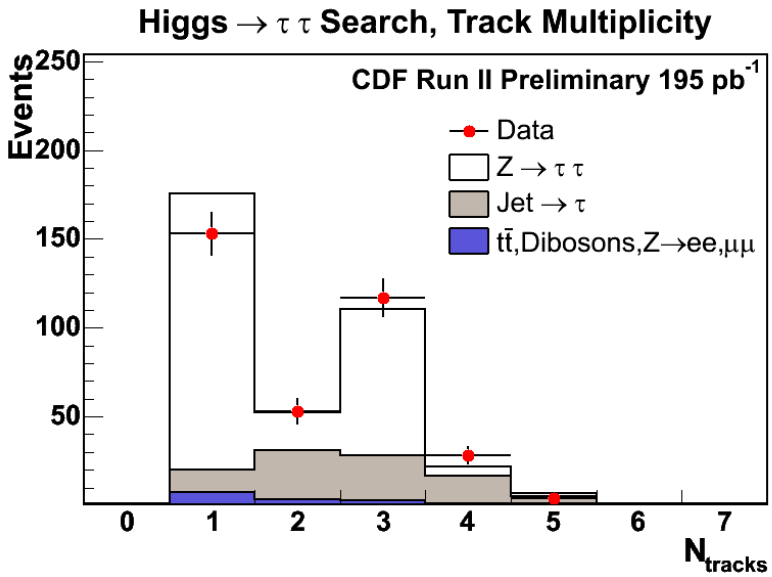
P_ζ = sum of the projections of visible products and missing transverse energy

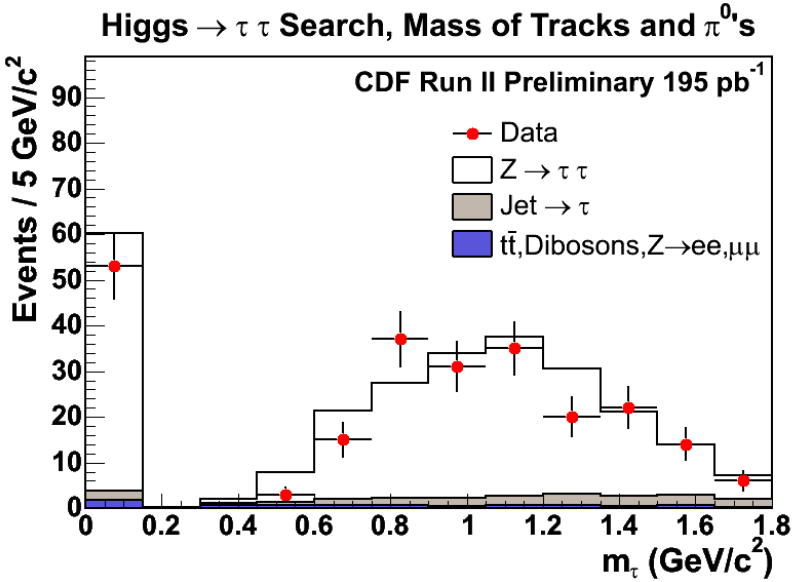
P_ζ^{vis} = sum of the projections of visible products





Signature of Hadronically decaying Taus





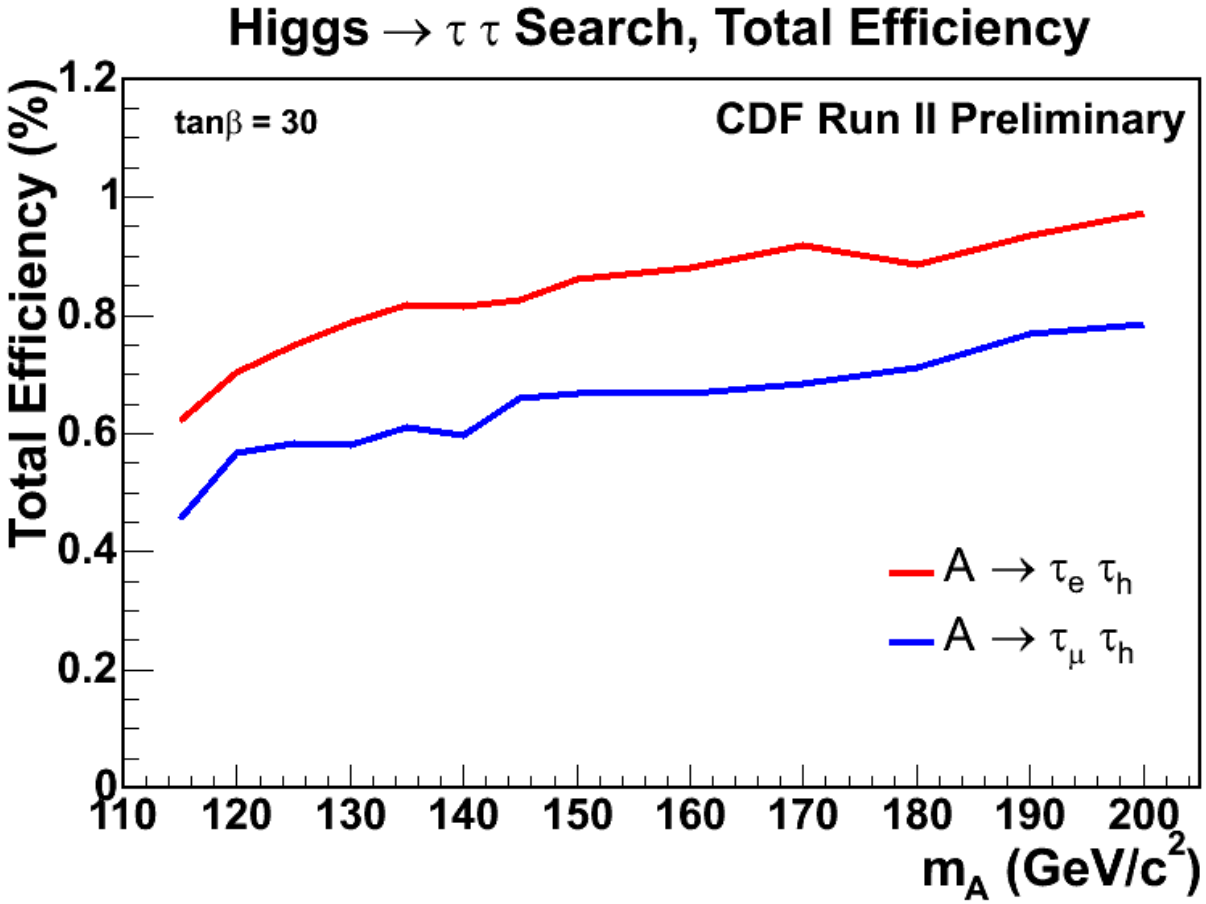
- **1,3 track enhancement in track multiplicity**
- **Good agreement within errors**
- **N_{tracks} = 1,3 and $|Q_\tau| = 1$ is applied, expect for the left plot to demonstrate tau signature**

Predicted Backgrounds and Observed Events

CDF Run 2 Preliminary (195 pb^{-1})

source	$\tau_e\tau_h$	$\tau_\mu\tau_h$	combined
$Z/\gamma^* \rightarrow \tau\tau$	132.3±17.1	104.1±13.3	236.4±29.5
$Z/\gamma^* \rightarrow ee, \mu\mu$	1.8±0.2	4.9±0.4	6.7±0.6
VV, $t\bar{t}$	0.7±0.1	0.8±0.1	1.5±0.1
Jet → τ fakes	12.0±3.6	7.0±2.1	19.0±5.7
Total predicted BG	146.8±17.5	116.8±13.5	263.6±30.1
Observed	133	103	236

Signal Acceptance

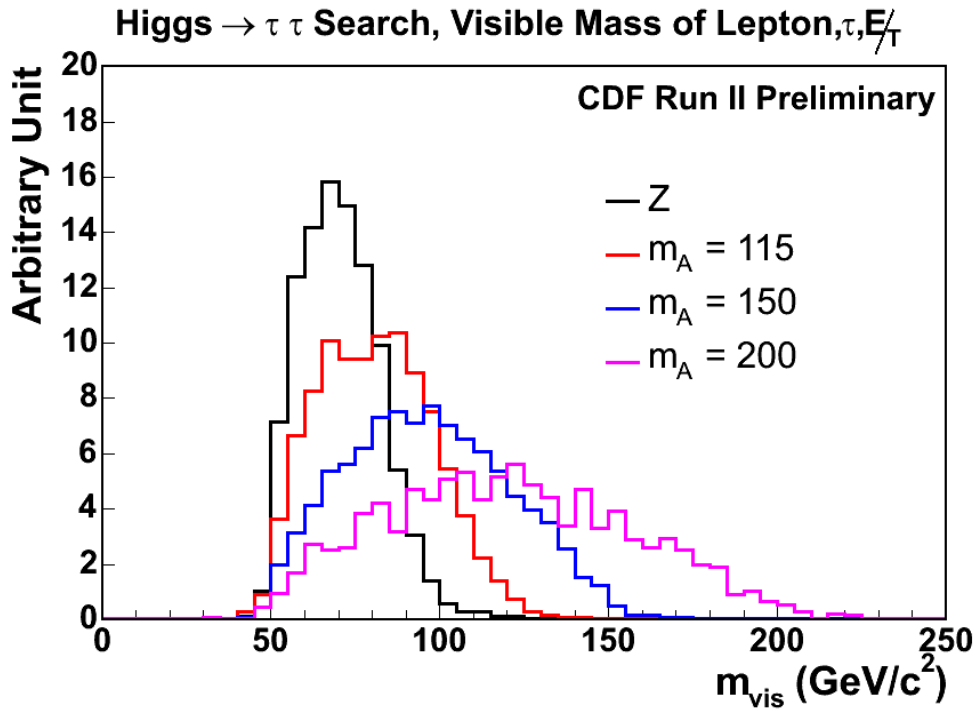


Pseudo scalar MSSM Higgs generated with tanβ=30 used as acceptance model

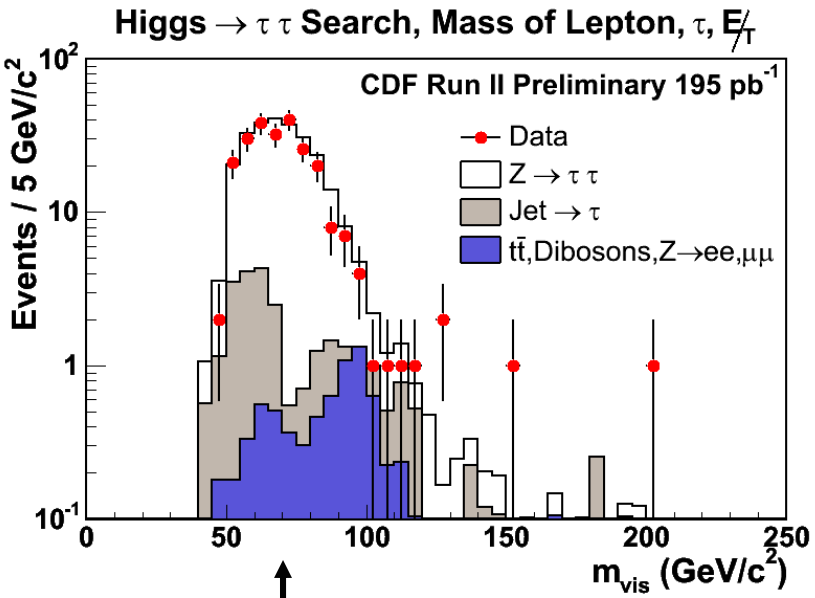
Z / Higgs Separation

Define $\vec{p}(\not{E}_T)$ as $(\not{E}_X, \not{E}_Y, 0, \not{E}_T)$

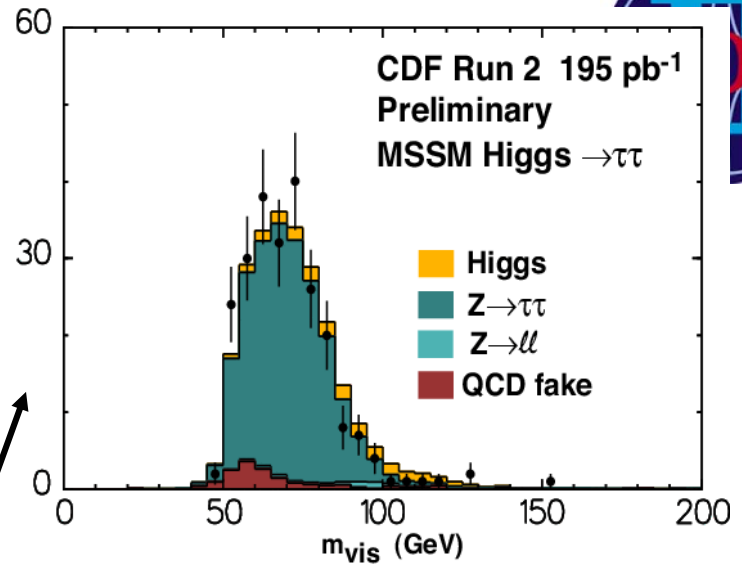
Define $m_{vis} = m(\vec{p}(\tau_1) + \vec{p}(\tau_2) + \vec{p}(\not{E}_T))$

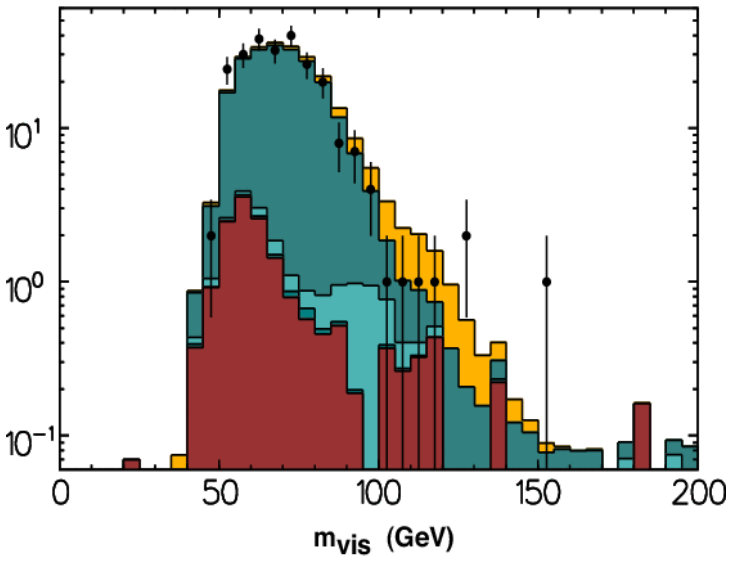


m_{vis} distribution



Normalized at 195 pb^{-1}

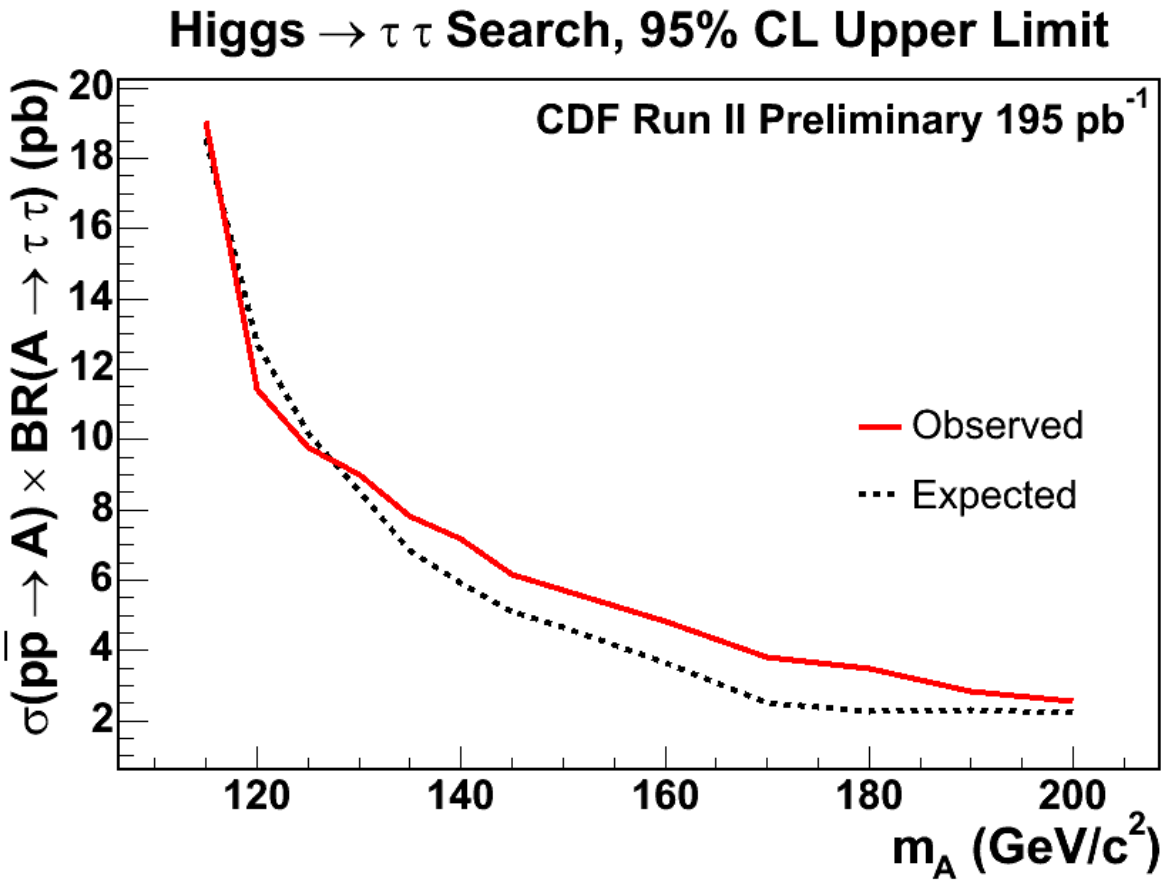




Binned likelihood fit

m_A = 130 GeV constraint

Results



Observed limits and pseudo experiment predictions

Summary

- Studied τ behavior at CDF detector.
- Performed $A \rightarrow \tau\tau$ search using CDF data and found no evidence of MSSM Higgs.
- Set 95% CL upper limits for m_A = 115-200 GeV/c^2