# Search for MSSM Higgs Decaying to $\tau_\mu\tau$ at DØ

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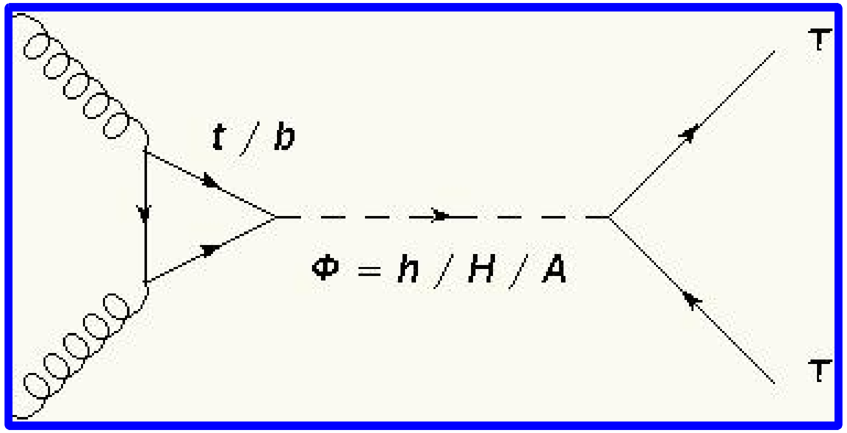
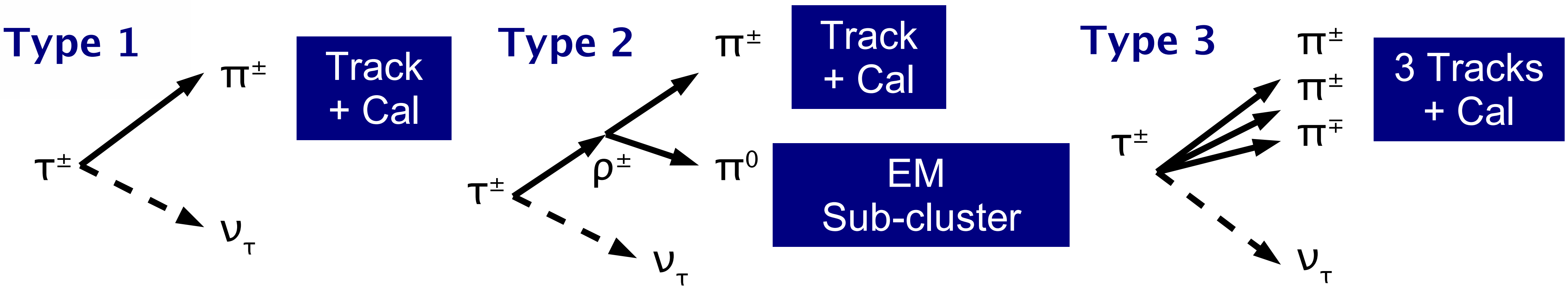
# Introduction to MSSM Higgs

- MSSM has two Higgs doublets.
  - Leads to three neutral Higgs bosons, $\phi$ = h, H, A
- At tree level MSSM is fully specified by two parameters:
  - $m_A$ – mass of CP odd neutral Higgs
  - $\tan\beta$ – ratio of the v.e.v of the two doublets.
- Higher order corrections → dependence on SUSY parameters.
- The production cross section for Higgs production is enhanced by ~ $\tan^2\beta$.
- Main decay modes are bb (~90%) and ττ (~10%).
- The bb decay is swamped by multi-jet background.



# Tau Identification at DØ

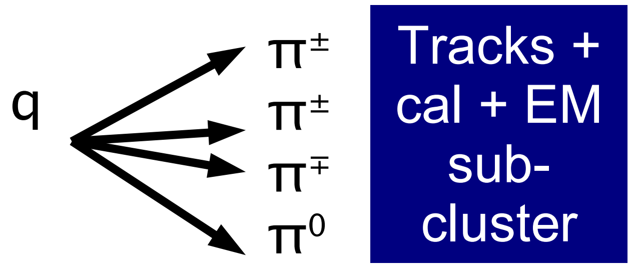
- Taus decay inside the detector:
  - BR( $\tau \rightarrow e / \mu + \nu\nu$ ) ~ 17 % – $\tau_{e/\mu}$
  - BR( $\tau \rightarrow$ hadrons + $\nu$ ) ~ 65 % – $\tau_h$
- Best modes for di-tau decay are  e / μ + hadrons.
- Must be able to separate hadronically decaying taus from jets.
- At DØ we use three tau types:

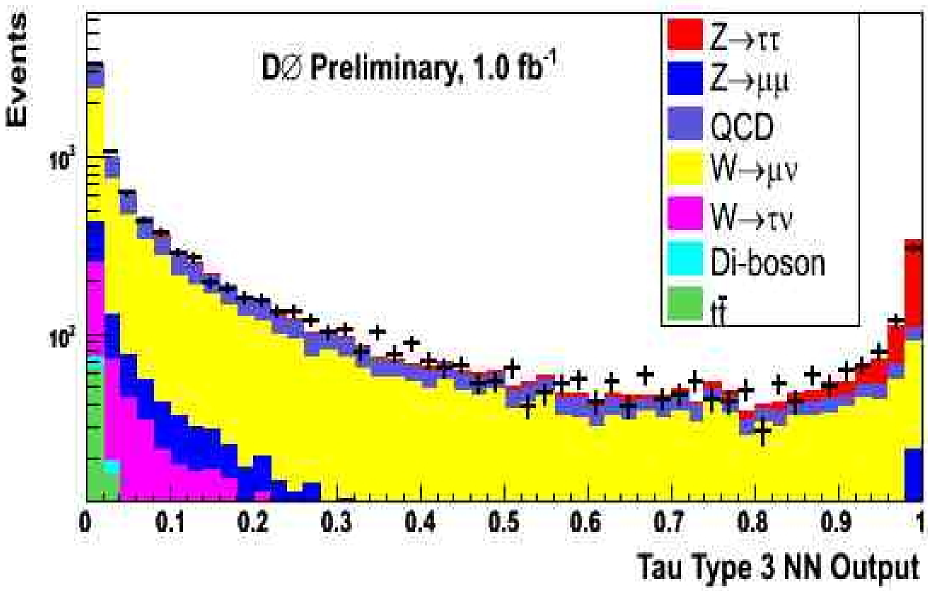


# Tau Identification at DØ

- DØ uses one Neural Network per tau type to discriminate taus from jets.
- Neural Networks use track and calorimeter based variables.
- In the 1.0 $fb^{-1}$ analysis, DØ so far has $\tau_\mu + \tau_h$.

**Jet Background**



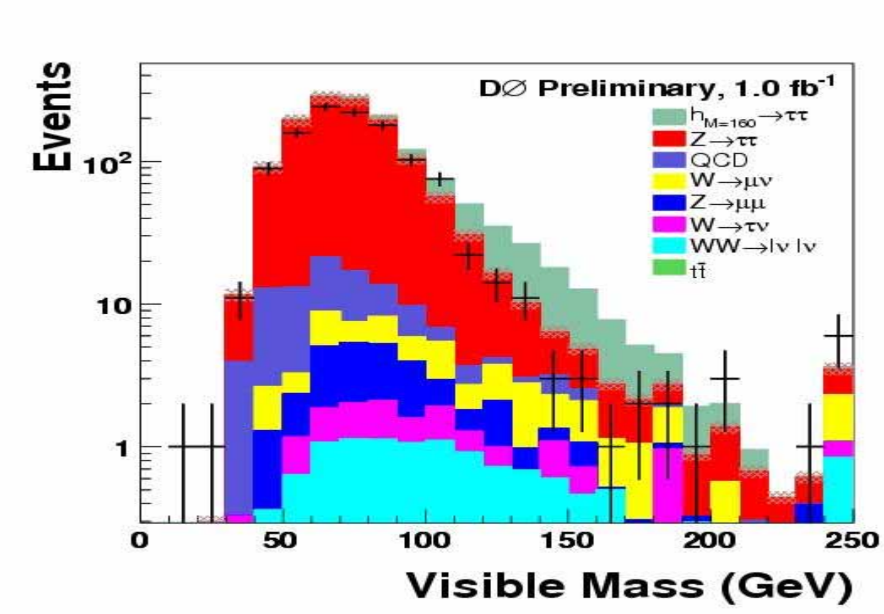



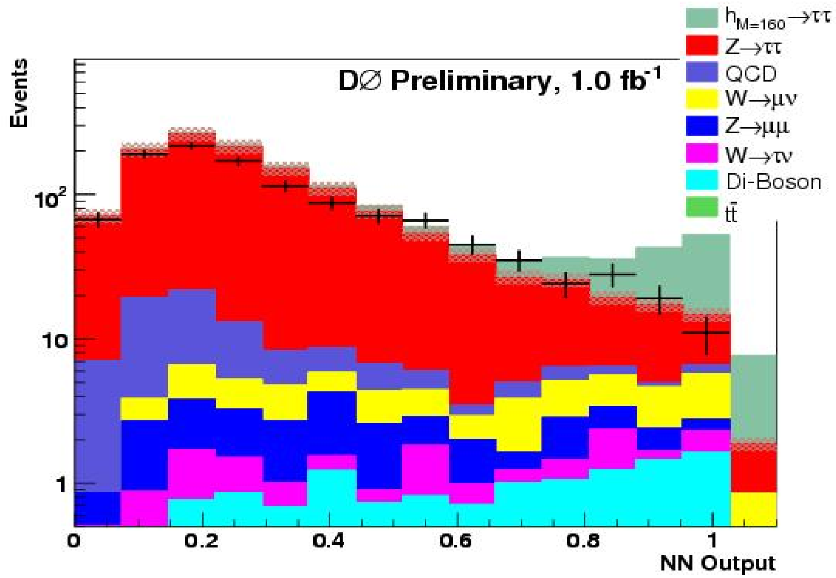
# Searching for the Higgs

- Once fake taus are removed, $Z/\gamma^* \rightarrow \tau\tau$ dominates.
- Cannot fully reconstruct the Higgs mass due to the neutrinos.
- Closest variable is the visible mass, $M_{vis}$.
- Achieve better Higgs sensitivity (10–40% improvement) by using a Neural Network that takes 6 different kinematic variables as input.

$$M_{vis} = \sqrt{(P^{\mu} + P^{\tau} + P^{\not{E}})}$$

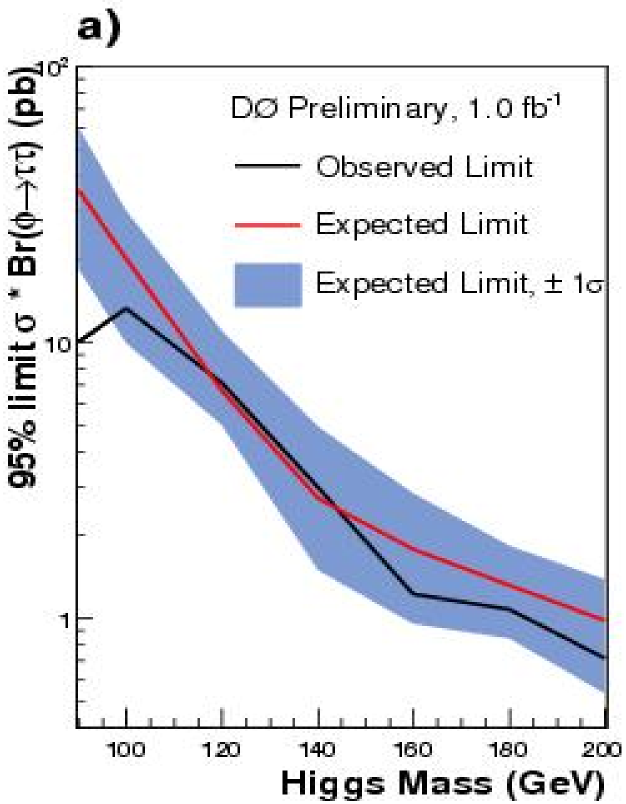
$$P^{\not{E}} = (\not{E}_T, \not{E}_x, \not{E}_y, 0)$$

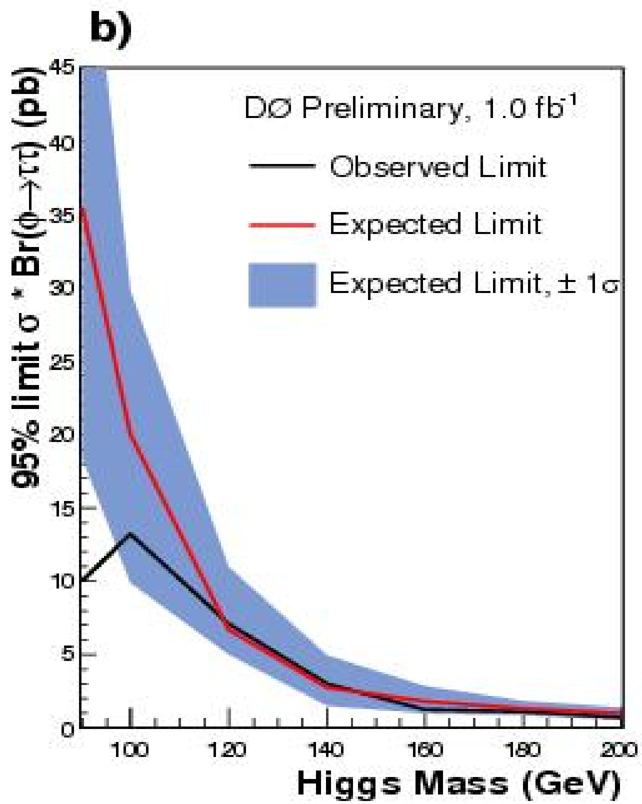


# Limit Setting

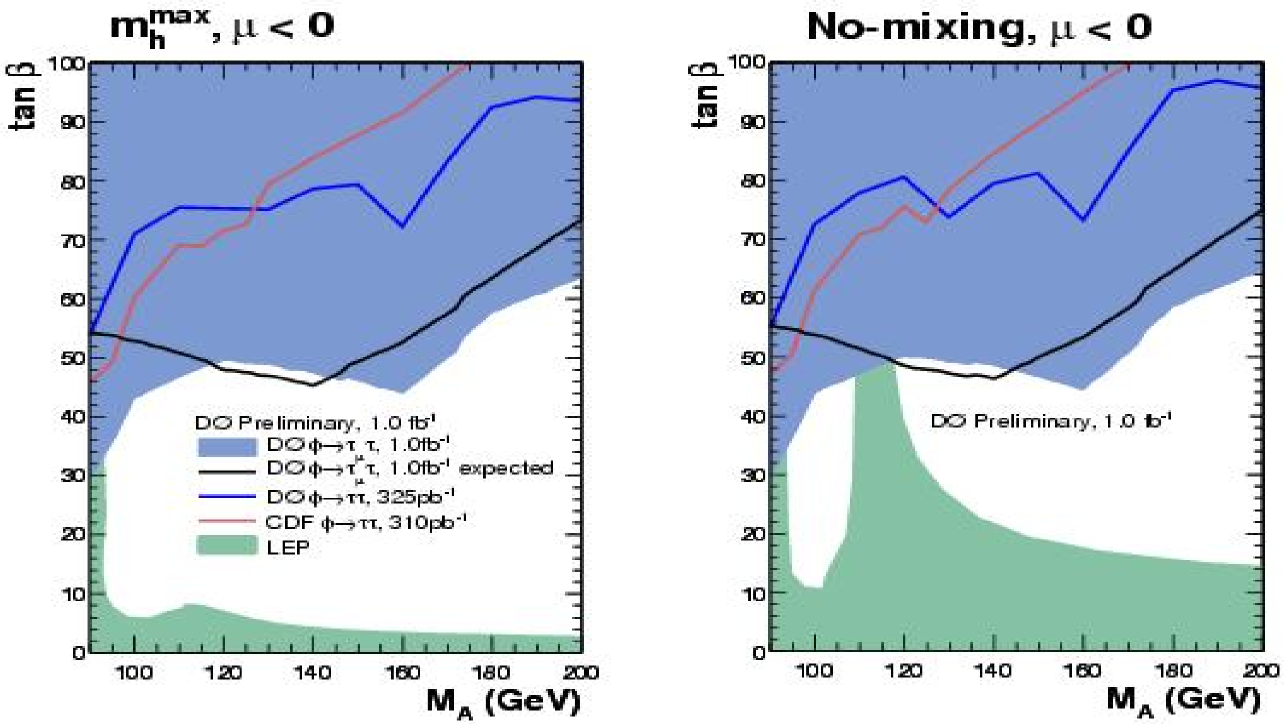
- No excess seen in the data above background expectation.
- Set limits on the cross-section times branching ratio to tau pairs.



# Results & Conclusion

- MSSM benchmark scenarios, $m_h^{max}$ and no-mixing.




- DØ analysis has sensitivity similar to recent 1 $fb^{-1}$ CDF result.
- Adding the electron channel and more data will increase the sensitivity even further.

# Backup

# MSSM Exclusion

- Higher order corrections bring dependence on SUSY parameters into the cross-sections and branching ratios for the Higgs bosons.
- Use FeynHiggs to calculate the excluded point in tanβ for each value of $m_{A.}$
- Since the h and H are often degenerate with the A, the cross-sections of the Higgs bosons are added if the difference in their mass is less than 15 GeV.
- The 2 benchmark scenarios, $m_h^{max}$ and no-mixing with $\mu = \pm 200$ GeV, are used.

# MSSM parameters

| The parameters: | $m_h^{max}$ | no-mixing |
|---|---|---|
| – Mixing parameter, $X_t$ | 2 TeV | 0 TeV |
| – Mass parameter, μ | ±0.2 TeV | ±0.2 TeV |
| – Gaugino mass term, $M_2$ | 0.2 TeV | 0.2 TeV |
| – Gluino mass, $m_{\tilde{g}}$ | 0.8 TeV | 1.6 TeV |
| – Common scalar mass, $M_{SUSY}$ | 1 TeV | 2 TeV |