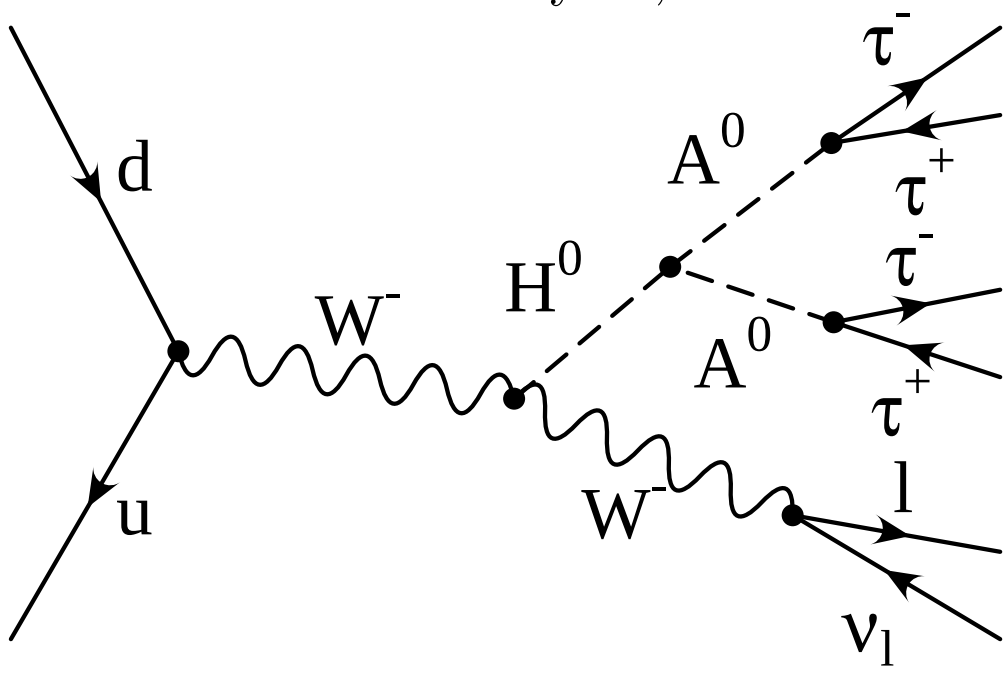
$W + 4\tau$ NMSSM Higgs Search

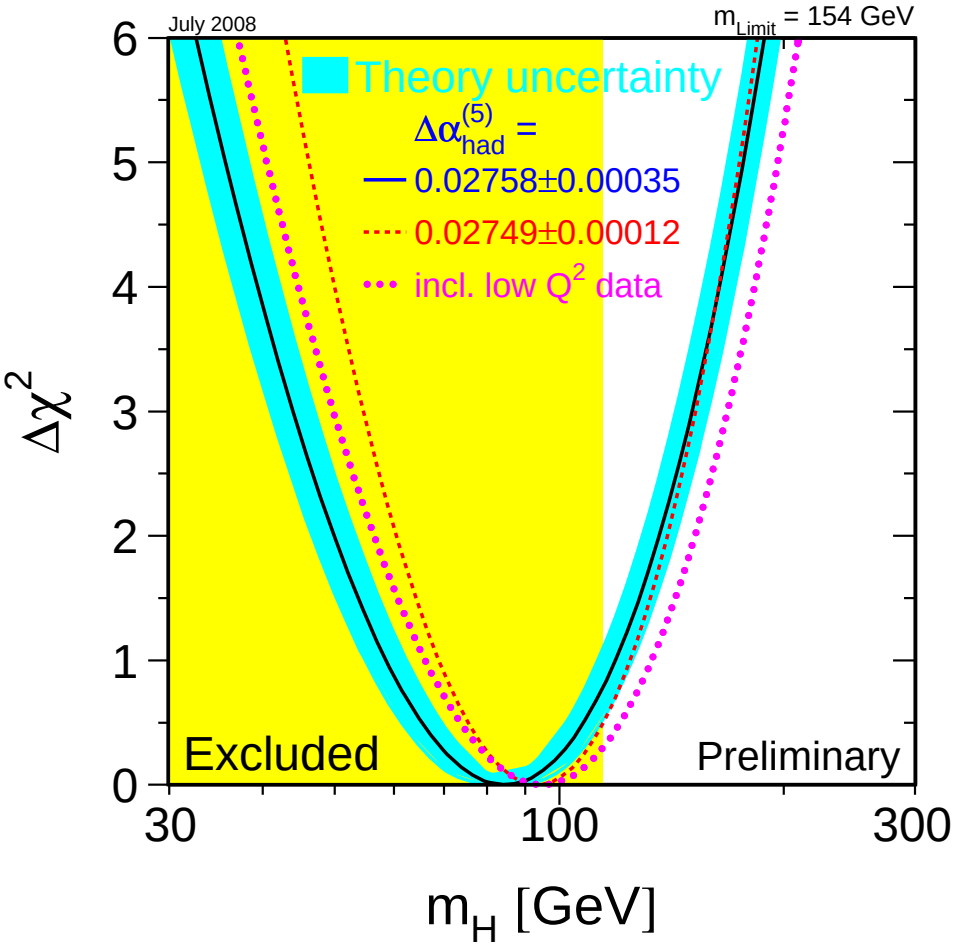
PHENO - May 11, 2009



Scott Wilbur
on behalf of the CDF Collaboration

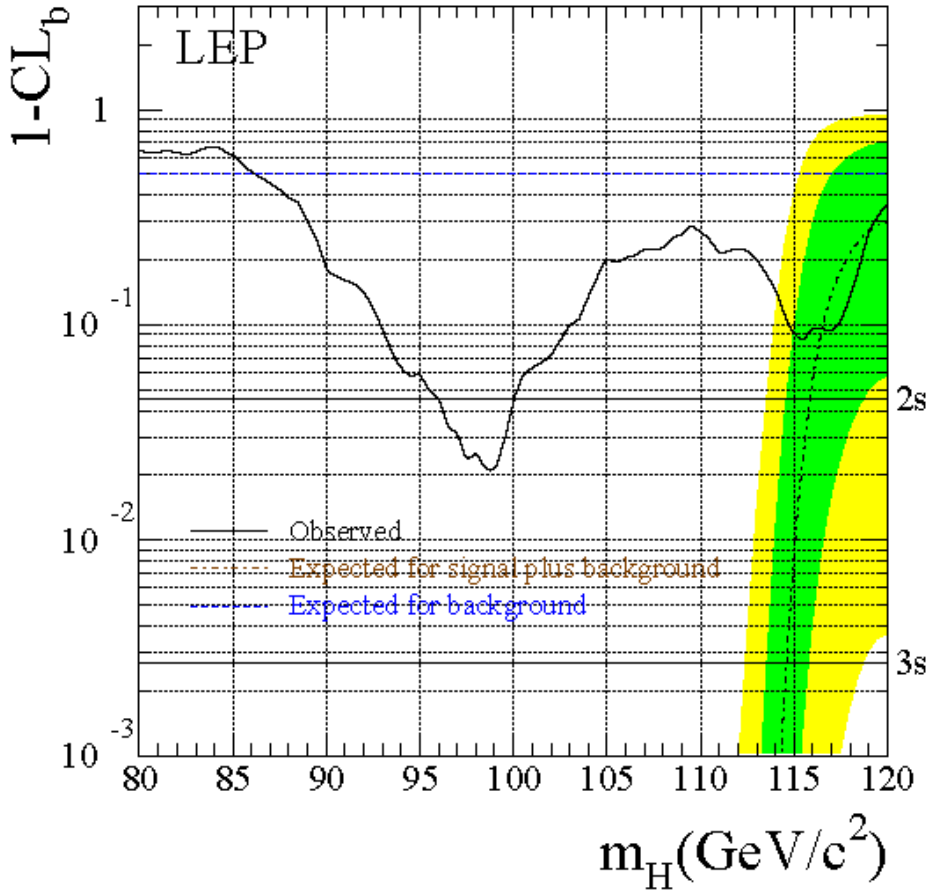
Motivation

- LEP ruled out the SM Higgs below 114.4 GeV
- Electroweak data still favors a light Higgs
- A light Higgs with a non-SM decay could get around the LEP limit

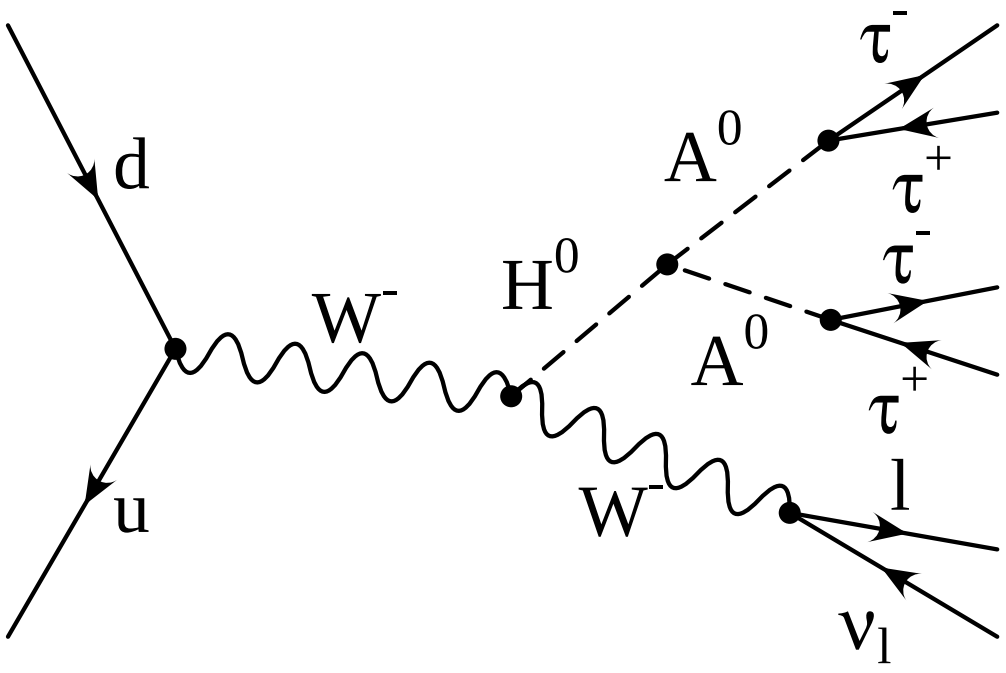


Motivation

- LEP saw a larger excess (2.3 sigma) at 90-100 GeV
- A 90-100 GeV Higgs with a 10% BR to $b\bar{b}$ could explain this excess
- An additional light CP-odd Higgs can provide this BR



Model Overview



- Proposed by Dermisek, Gunion (Phys. Rev. Lett. **95** (2005) 041801)
- 90 - 100 GeV Higgs, 9 GeV CP-odd A^0
- 90% BR to A^0A^0, 10% to $b\bar{b}$
- Final state is $l\nu + 4\tau$

Extremely Subtle Analysis

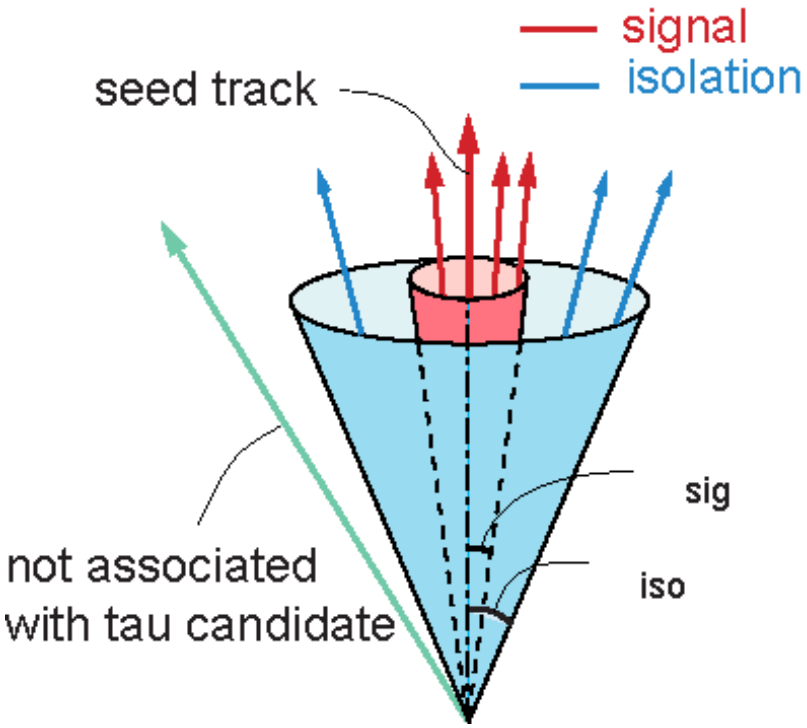
- 4 τ final state: smeared $\not{E}_t$, no visible resonance
- Standard τ ID doesn't work: new techniques required
- W+jets background is nearly overwhelming
- D0 found that 40 fb^{-1} would be required at the Tevatron (D0Note 5891-CONF)
- With higher background at the LHC, this analysis is expected to be much harder there

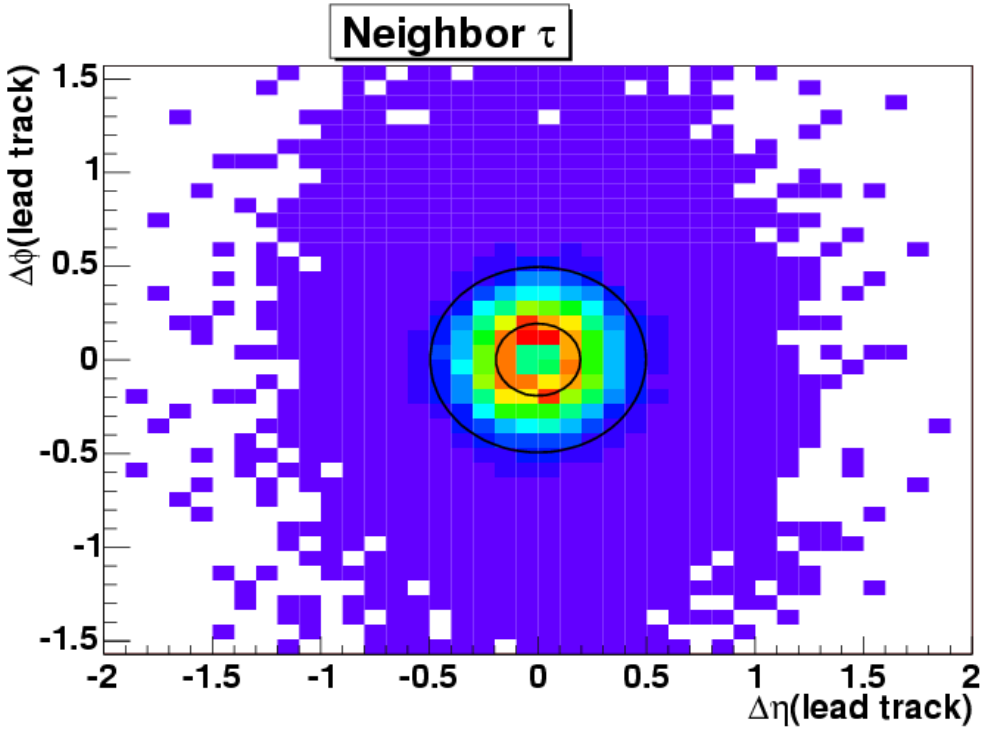
Analysis Overview

- Looking at $W + H$ production, triggering on e or μ from W
- Generated 100k signal events with Pythia
  - 90 GeV H, 9 GeV A^0
  - W is forced to decay leptonically
- Main backgrounds are also modeled with Pythia
  - W+jets, W decays leptonically
  - $t\bar{t}$, single top
- Developing new techniques for τ identification
  - Track/π^0 clusters
  - Likelihood-based jet/τ discrimination
  - Soft lepton identification

Why New Track/π^0 Clusters?

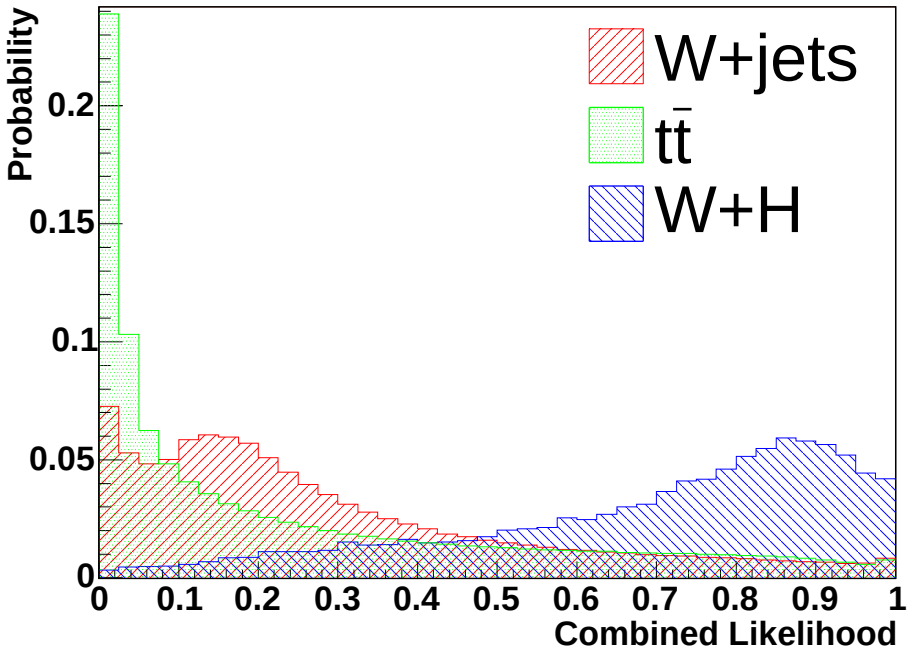
- Standard τ ID requires isolation
- A^0 is created with large boost: two τs end up in each other's isolation cone
- 3% efficiency for $W + 1\tau$, 0.1% efficiency for $W + 2\tau$

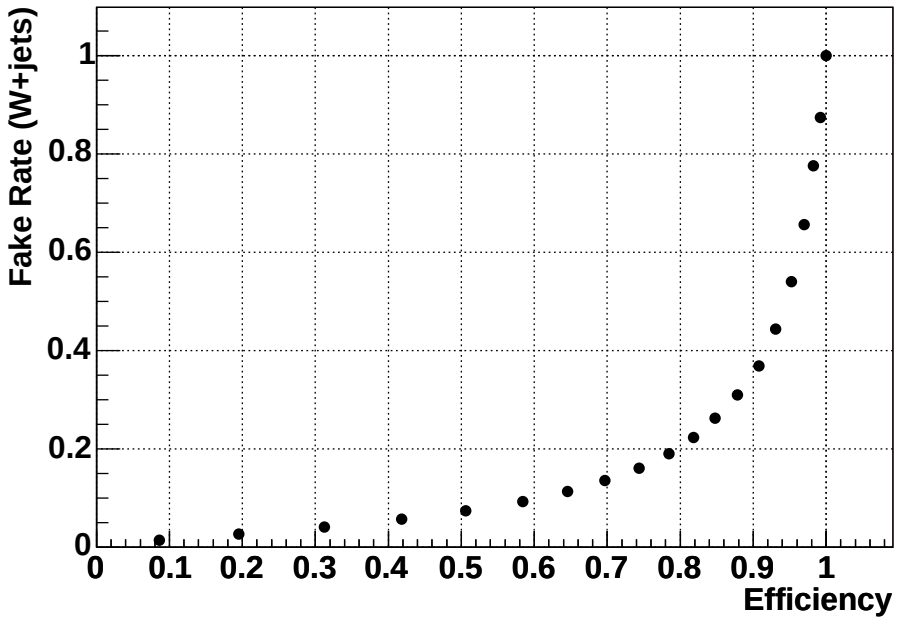




Track/π^0 Clusters

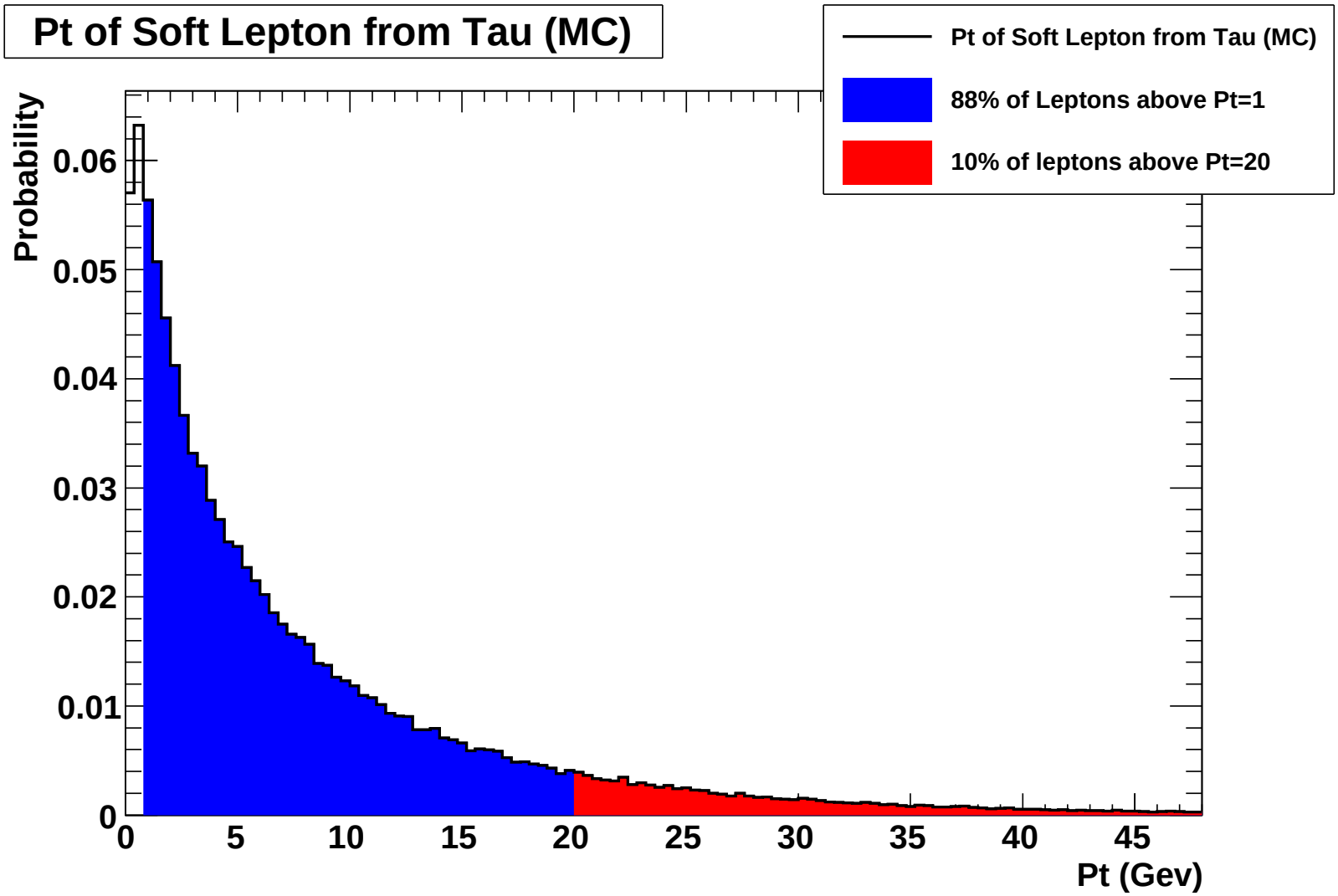
- Identify these di-τ objects
- Find seed track with $P_t > 2.5$ GeV
- Add all tracks and π^0s with $P_t > 2$ Gev within $\Delta R < 0.5$
- Apply likelihood calculation based on N_{live}, N_{tracks}, N_{π^0}, P_t, $k_{||}$, and f_{EM}
- These clusters are effective at discriminating τs from parton jets:





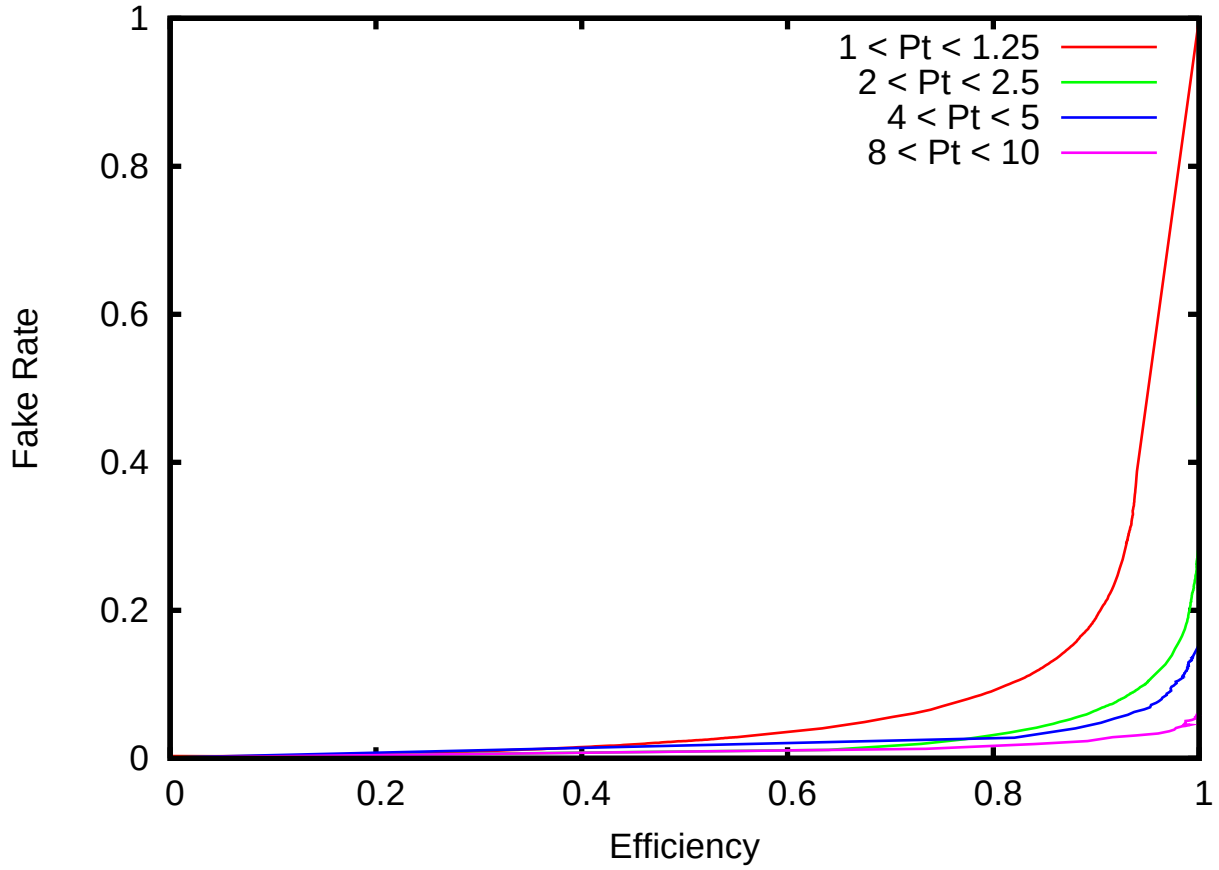
Why New Soft Electron ID?

- Standard electron ID is only guaranteed to be efficient down to $P_t = 20$ Gev
- Electrons from τs are much softer



Soft Electron ID

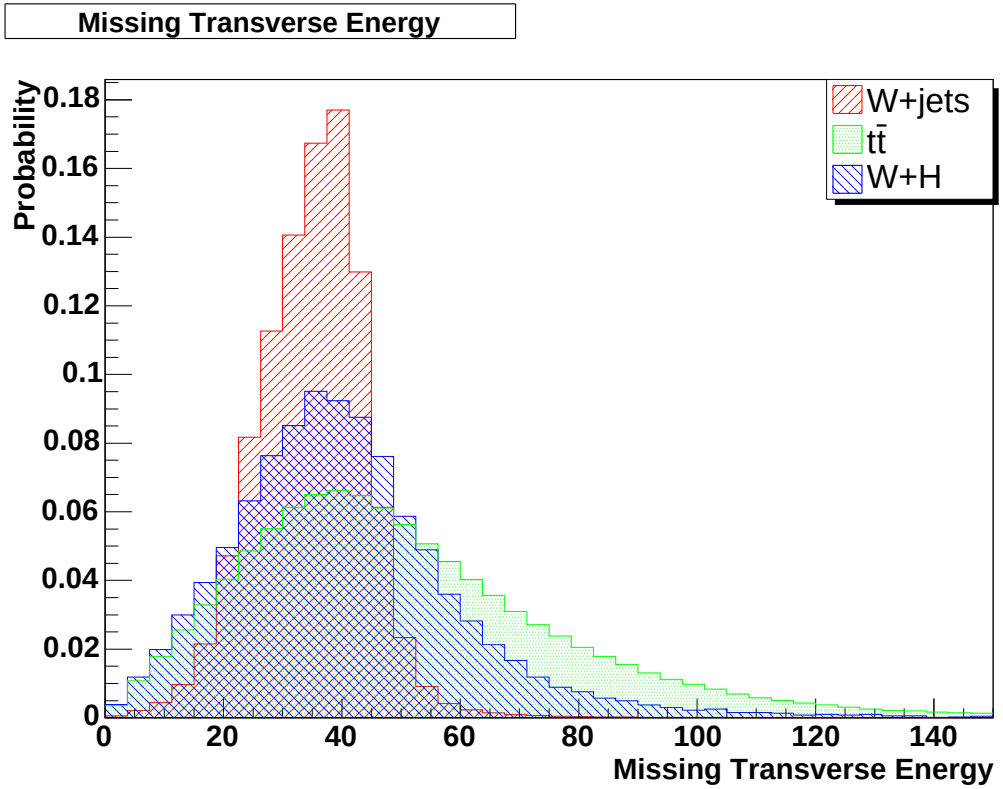
- Likelihood-based: takes information from Tracking Chamber, Preradiator, Calorimeter, and Showermax (adapted from soft electron b-tagging)
- Trained completely on data: real electrons from conversions, fake electrons ($\pi^{\pm}$) from K_s decays



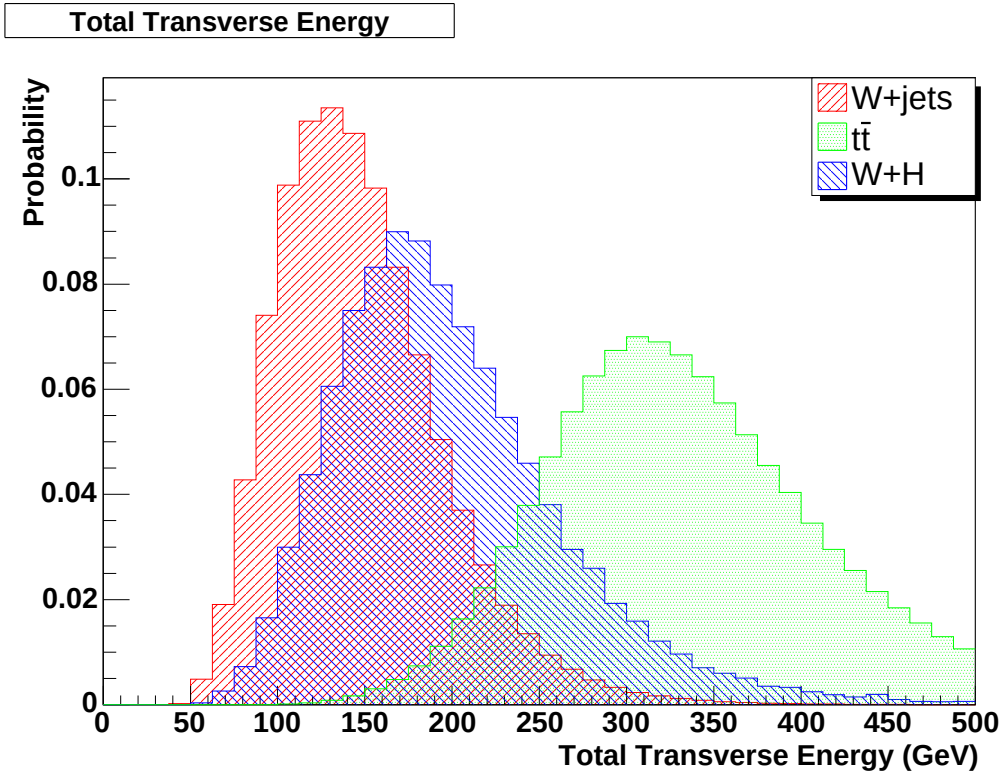
Using These Tools

- These clusters and soft electrons are effective at identifying these τs
- We will examine many signatures made up of these objects and find the best signatures to look for
  - 2 clusters with mass near expected visible Higgs mass
  - Cluster, e^+, μ^-
- Combining all of these signatures into the search gives good sensitivity

Initial Cuts



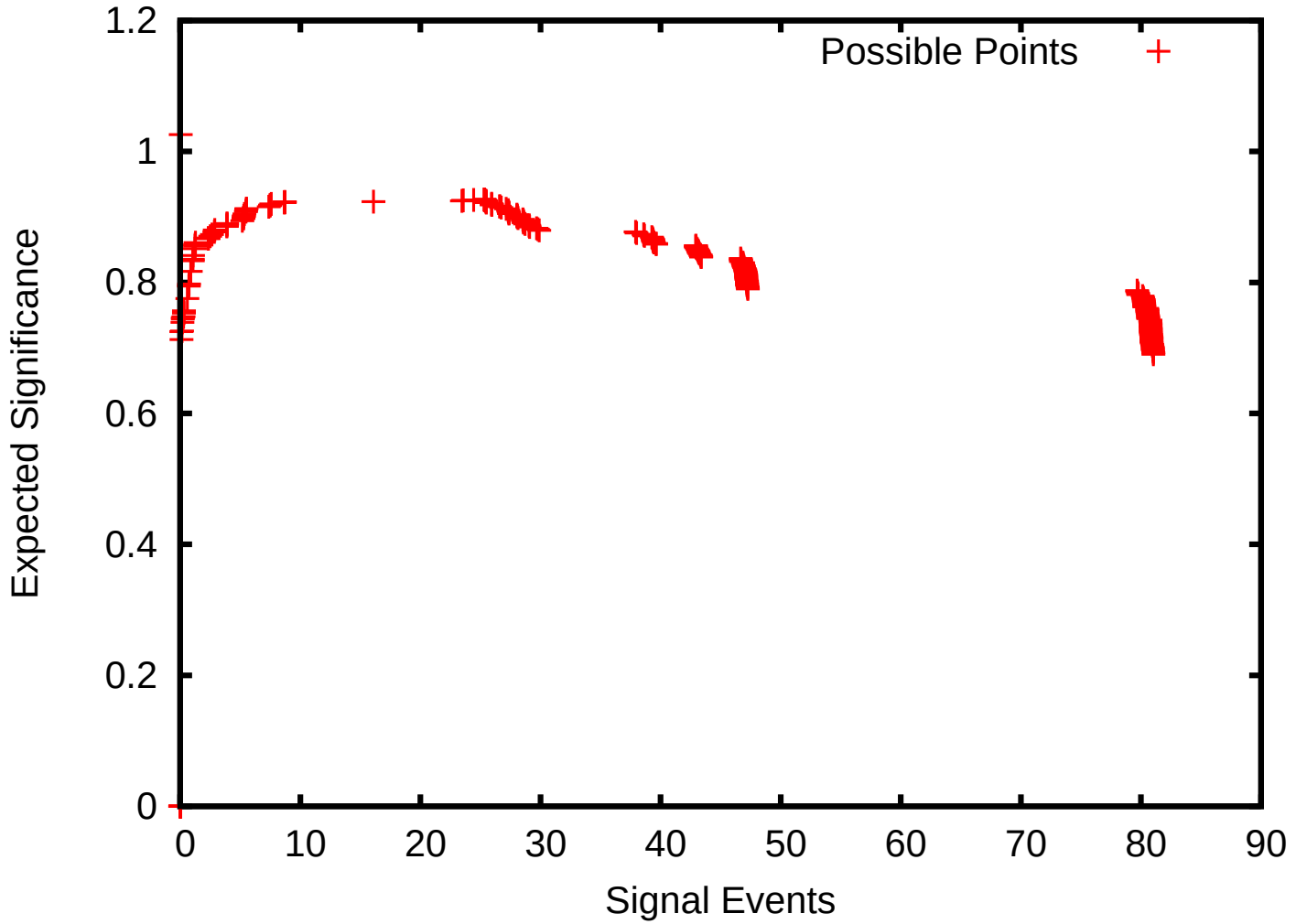
- $\not\!\!E_T$ is smeared out due to the presence of 4-8 additional neutrinos
- Require $\not\!\!E_T > 20$ GeV



- Creation of a 90 GeV Higgs increases H_T
- Require $H_T > 100$ GeV

Examine Many Signatures

- Count track/π^0 clusters, e^+, e^-, μ^+, and μ^- in each event
- Sort events into bins based on object counts and charge correlation
- Maximize information by looking at bins with best signal to noise ratio

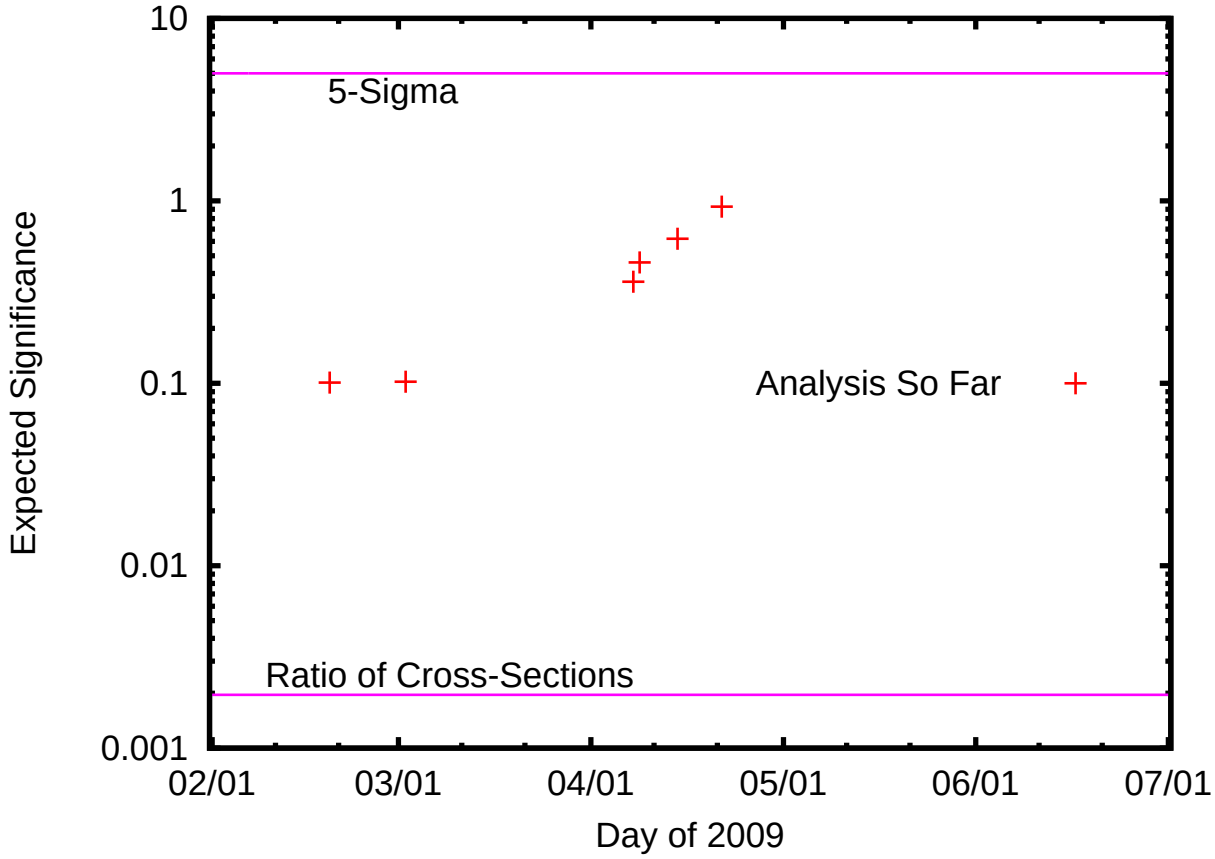


Future Work

- Currently working on improvements to soft electron ID and track/π^0 cluster ID
- Planning to add soft muon ID
  - Same process as electrons: adapt a b-tagger
- Combine event-level discriminating variables into likelihood: 2-cluster mass, $M_t(\text{cluster} + \not{E}_t)$

Conclusion

- Model is well-motivated by LEP data
- Difficult analysis, but better suited to Tevatron than LHC
- We're developing novel techniques to help with the search



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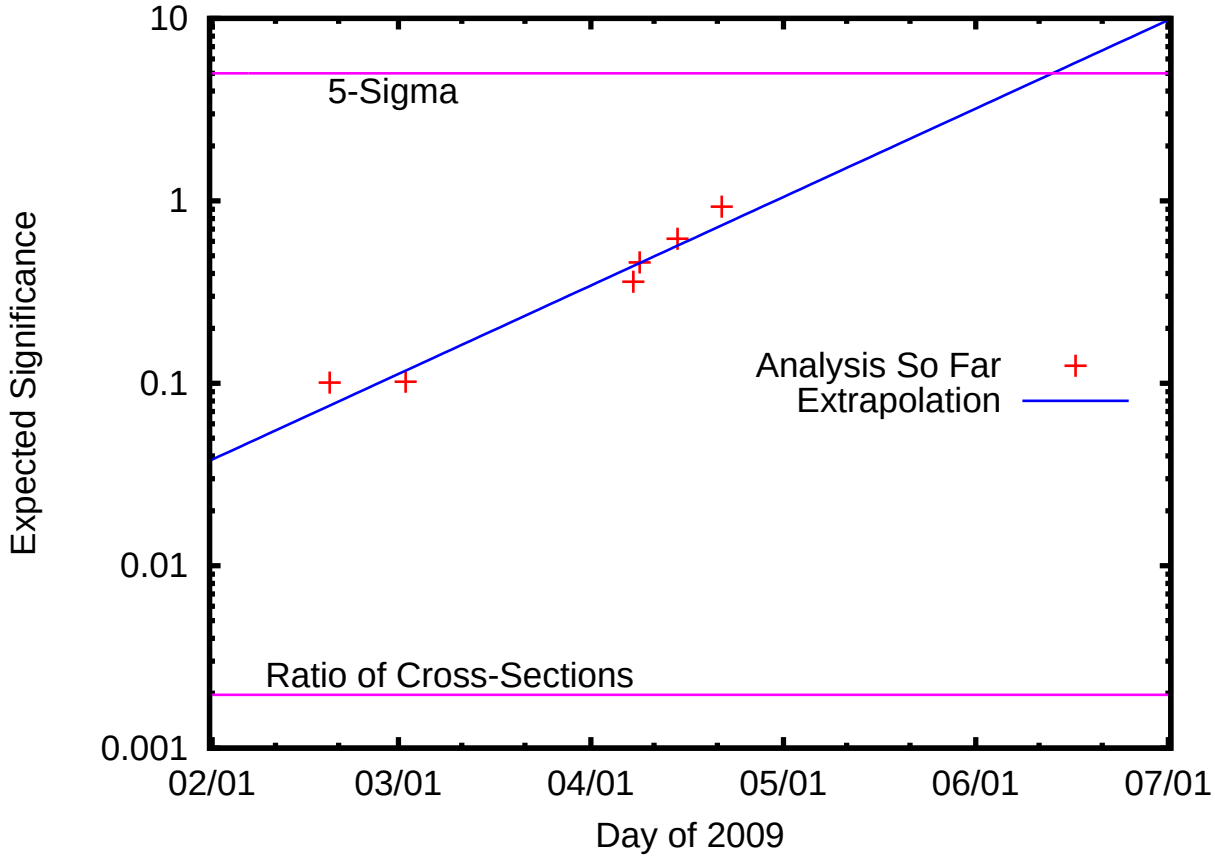
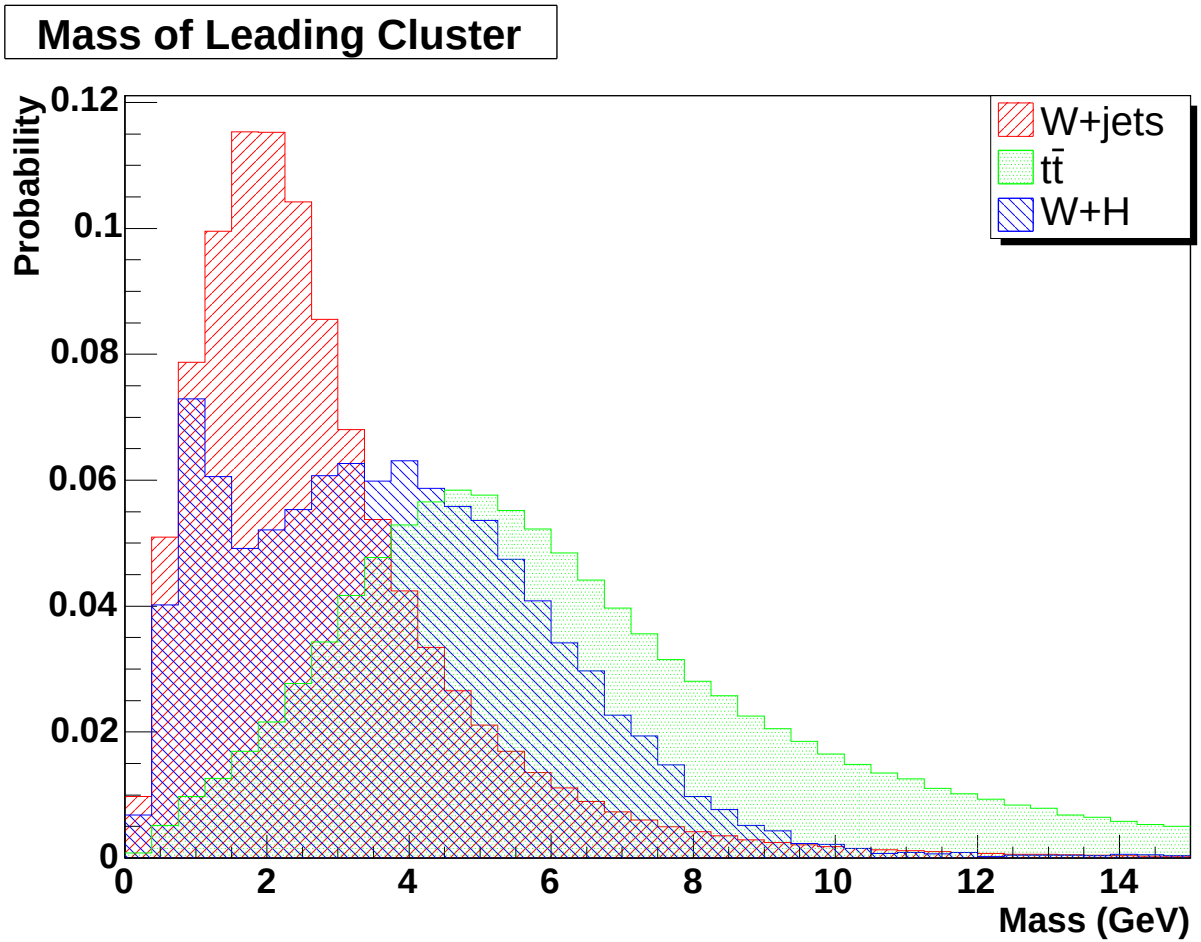


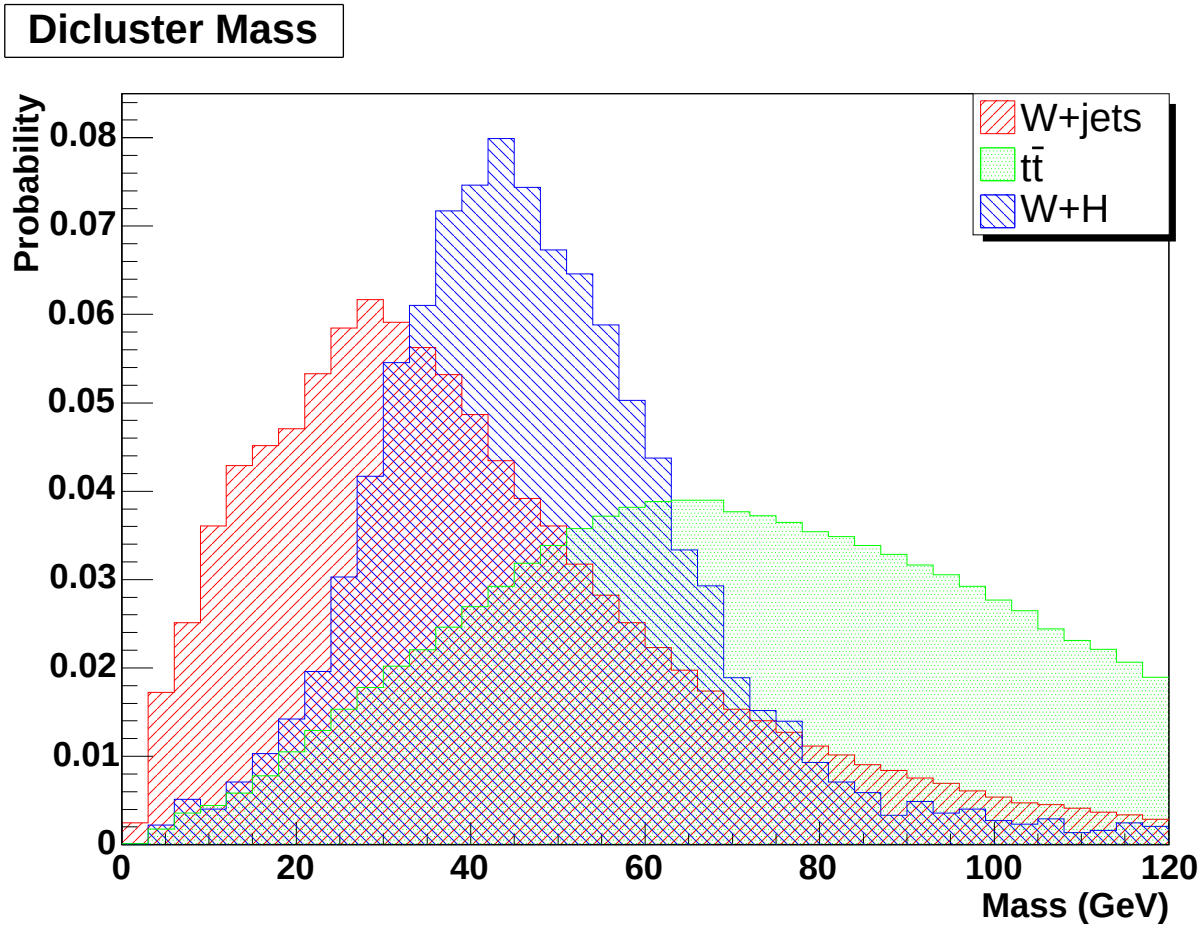
- Plan to reach 5-sigma sensitivity this summer

Discriminating Variables: Mass of Cluster



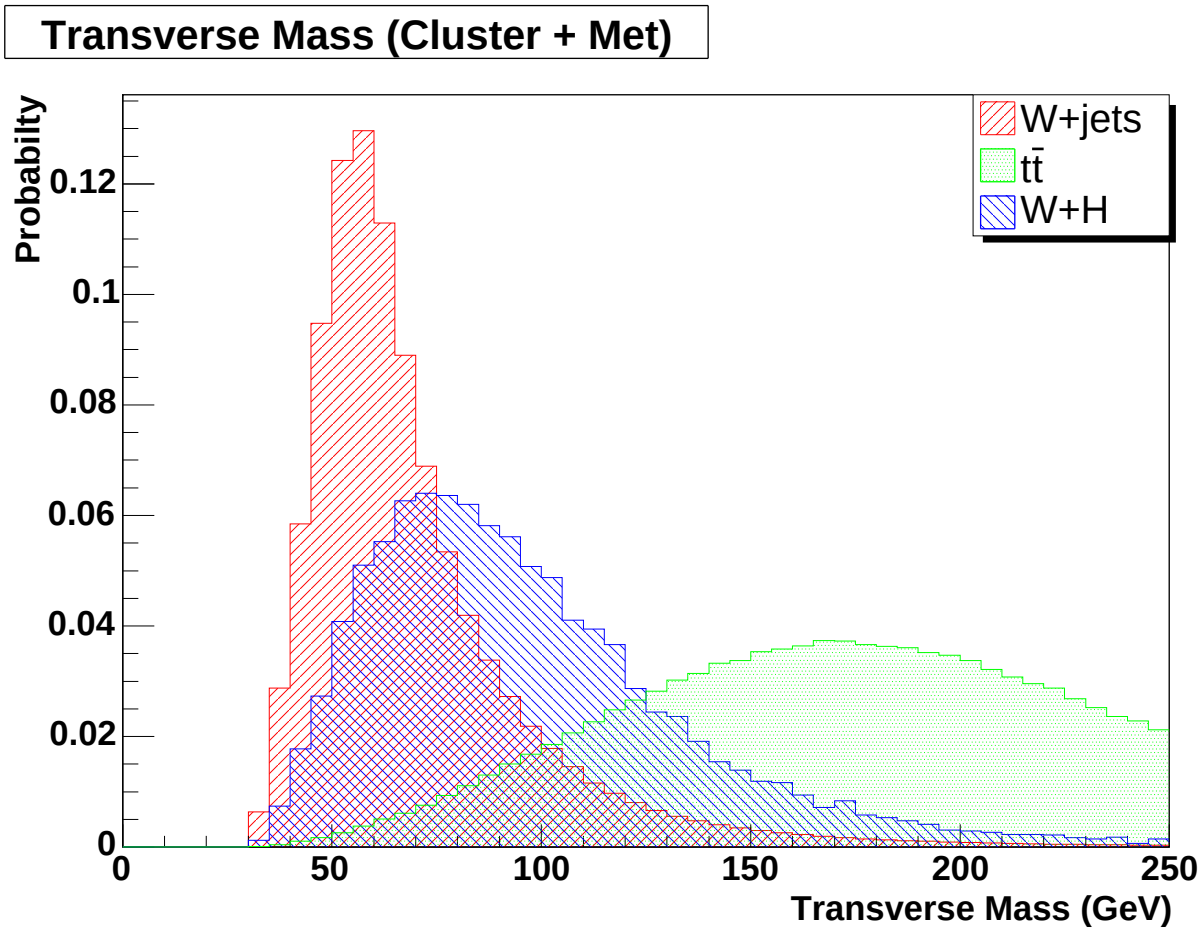
- Cluster will often pick up both taus from A^0
- Planned to be included in cluster identification

Discriminating Variables: Mass of Two Clusters



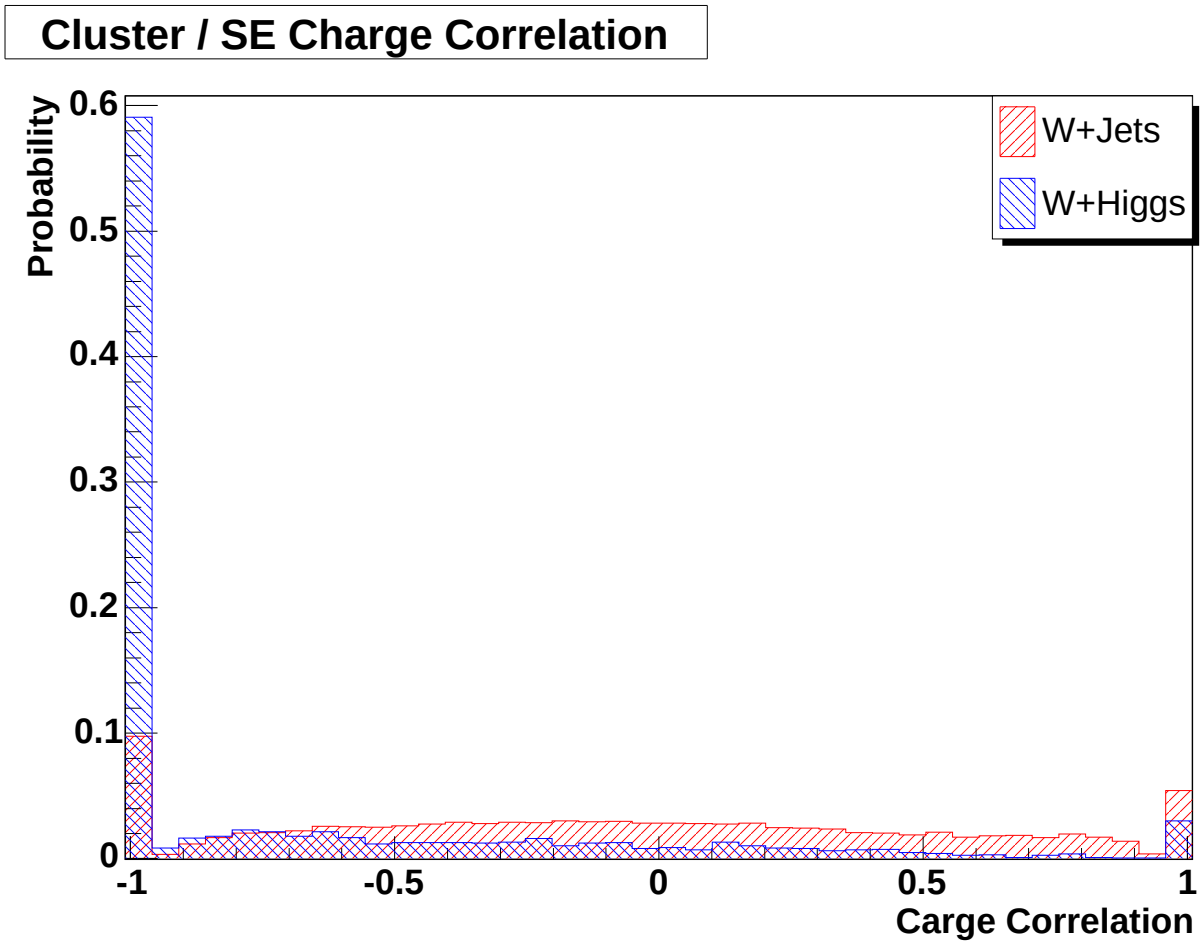
- In signal, two clusters will often capture the entire (visible) Higgs mass
- Planned to be used in event-based likelihood

Discriminating Variables: M_T of Cluster + $\not\!\!E_T$



- Good separation from $t\bar{t}$, reasonable separation from W+jets
- Planned to be used in event-based likelihood

Discriminating Variables: Charge Correlation



- If soft electron carries charge of one tau, cluster should have opposite charge
- Included in "many signature" search, may be included in cluster identification