Search for the Standard Model Higgs Boson in WH Production at CDF

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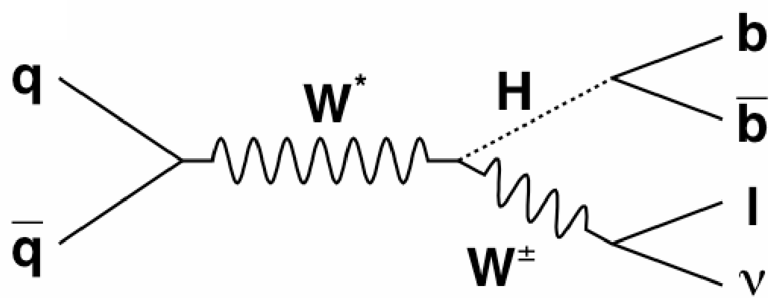
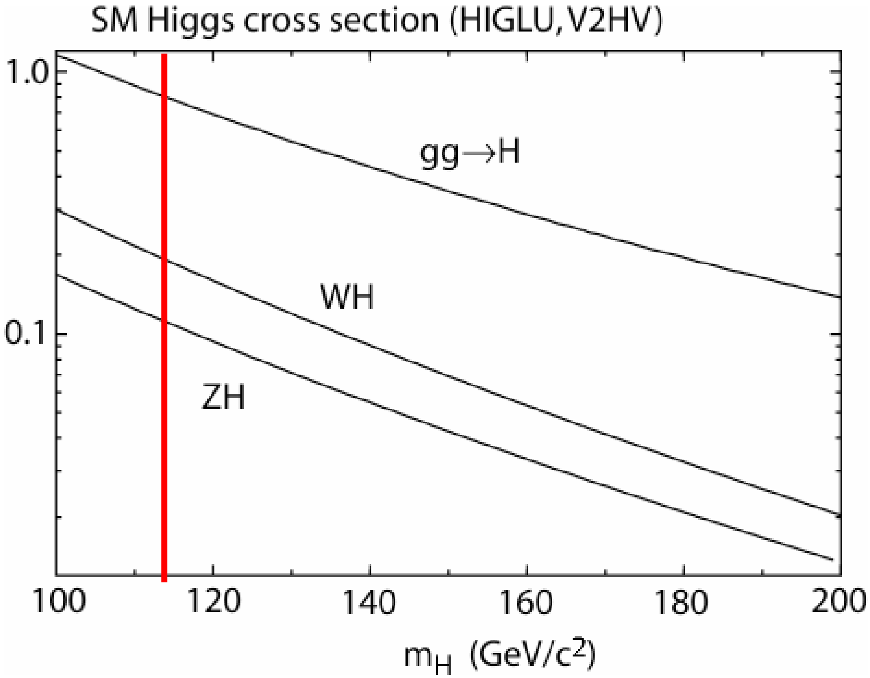
(for the CDF collaboration)

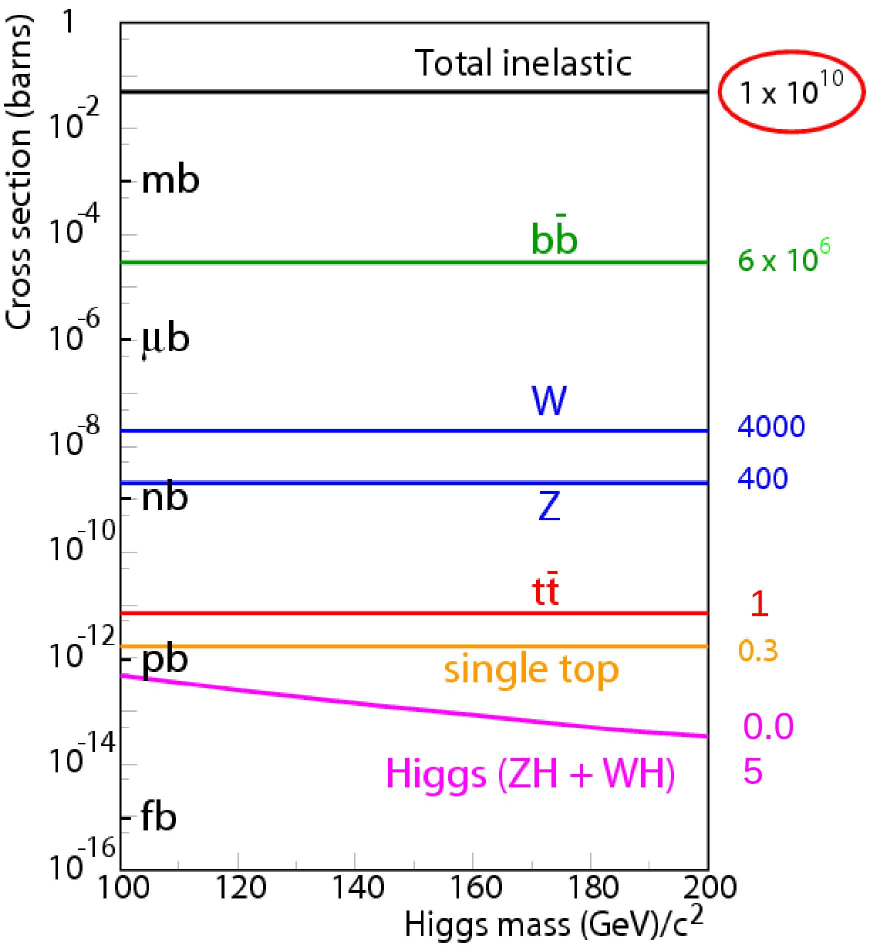


WH vs. ZH vs. gg→H

Desirable gg→H→bb channel overwhelmed by bb production

Lose factor of 5 with WH but high-pt lepton suppresses bkgd





CDF searches for SM Higgs in all 3 production mechanisms

Triggers and WH Event Selection

Triggers for high-energy electrons and muons

Reconstruct electron cluster or muon stub
- Require fast-reco track, confirm track at Level 3

Offline requirements for W boson + jets

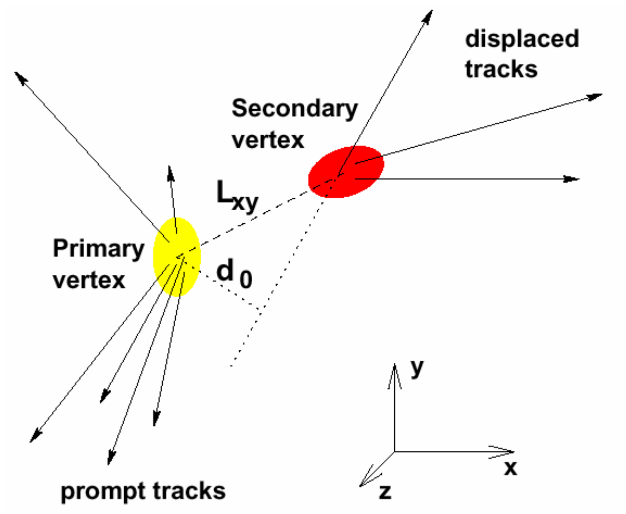
- Exactly one isolated e/μ with E_T>20 GeV
- Total missing E_T>20 GeV
- Exactly two jets with ET>15 GeV and $|\eta|<2.0$
- At least one jet must be b-tagged with secondary vertex

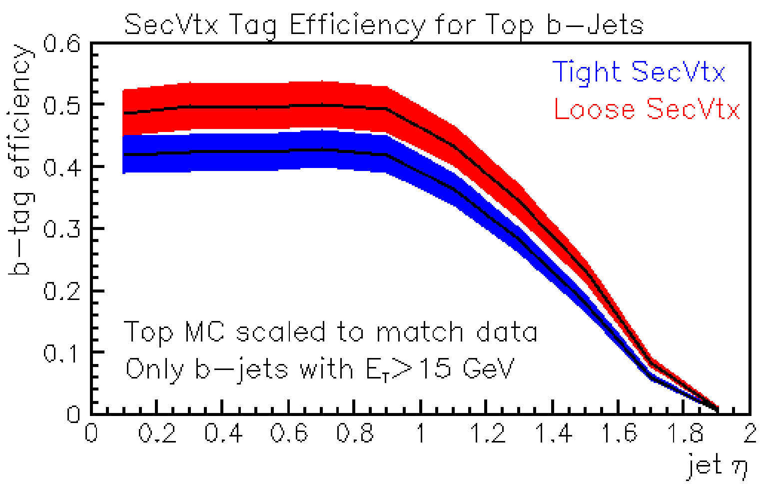
Rejection of pesky top quark events

Veto events with a second isolated track p_T> 20 GeV
- No extra jets with 8 < ET < 15 GeV or with $|\eta|>2.0$

Secondary Vertex Tagging at CDF

B hadrons in WH signal events are long-lived <u>and massive</u>





Form vertex of displaced tracks
• Sec vtx major err: 190 microns
Cut on decay length significance

Event is tagged if <u>any</u> jet is tagged

Also check efficiency in data events vs. efficiency in simulation: need scale factor of 0.91±0.06

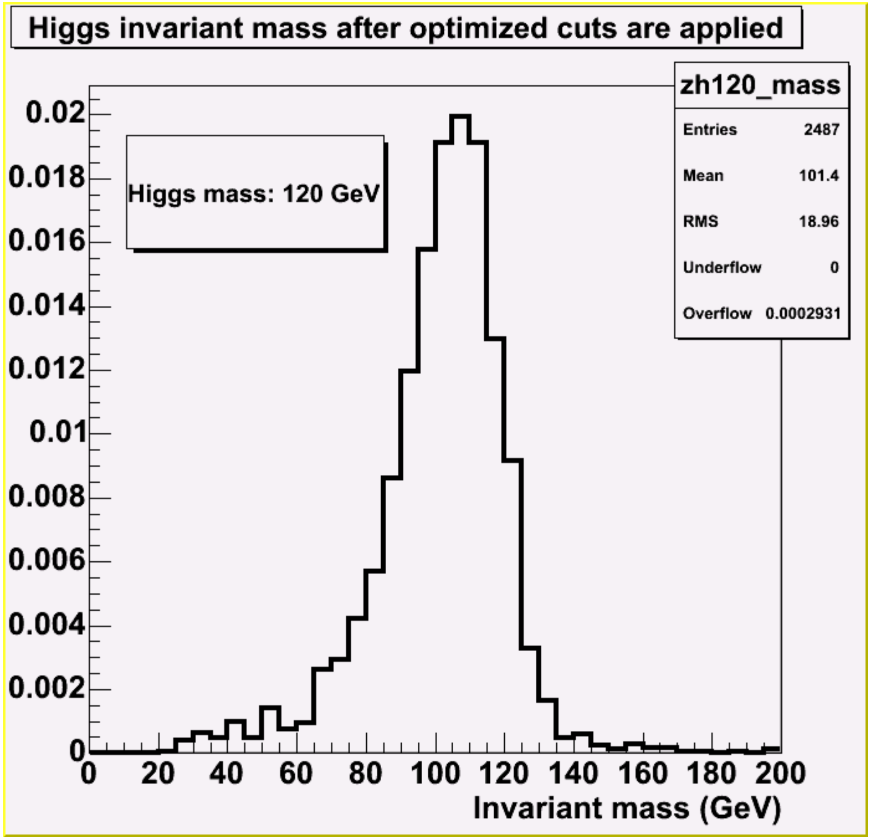
Dijet Signal Mass Resolution

Important handle in Higgs search: bb pair mass resonance

Derive average jet energy corrections from b-jet simulation
- in the future, measure this from $Z \rightarrow bb$ data fit

Current resolution is 17 GeV
- defines mass window
- direct factor in acceptance
- luminosity equivalence

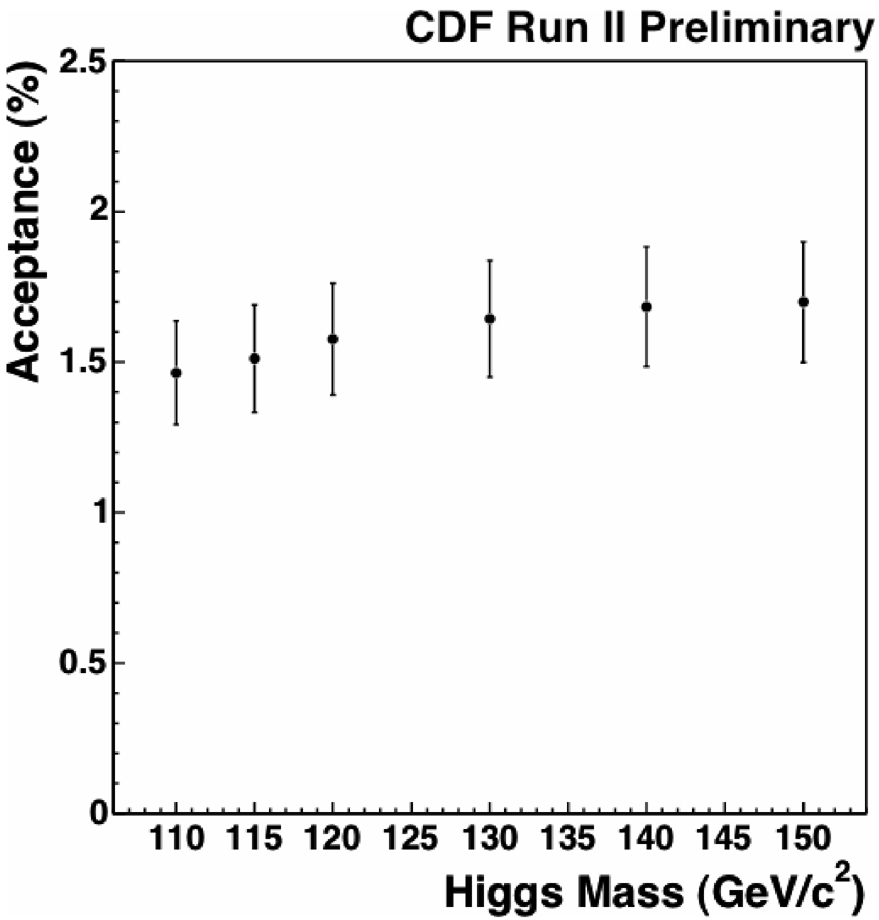
Working to improve resolution
- track + calorimetry (H1)
- multi-dim lookup (hyperball)
- advanced analysis (NN)



$WH \rightarrow l\nu b\bar{b}$ Signal Acceptance

Calculated using PYTHIA Monte Carlo and full simulation

Rough break-down:
- $BR(W \rightarrow l\nu) = 33\%$
- 2-jets – 50%
- isolated lepton – 25%
- missing E_T cut – 85%
- b-tagging – 50%



Includes effects from:
- all selection criteria
- simulation/data differences
- trigger efficiencies

Overview of Backgrounds to WH$\rightarrow$lνbb

Presented in rough order of increasing contribution to the vertex-tagged lepton + jets sample:

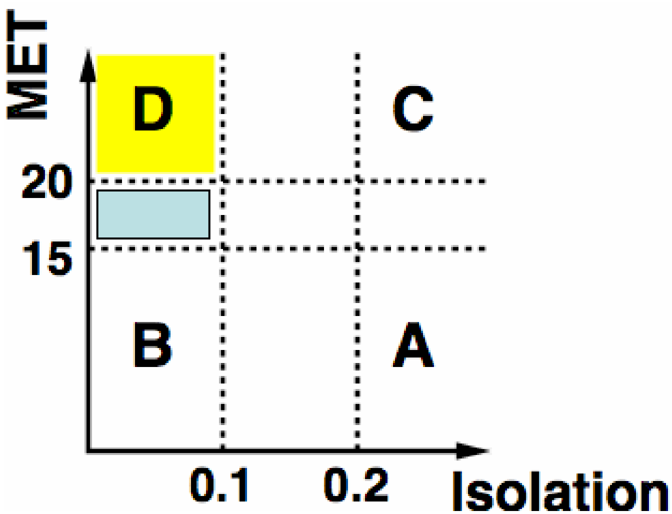
non-W QCD	false isolated leptons or false missing energy
top quark production	physics background
mistags in W events	false b-tags w/ lepton + MET
W + heavy flavor	physics background

Each background estimate is a miniature analysis unto itself.
Techniques can be spun off to measure other physics processes.

Events with Fake W Bosons

Fake isolated (I<0.1) lepton along with fake missing E_T

- for QCD background these fakes are uncorrelated



Signal region D predicted by

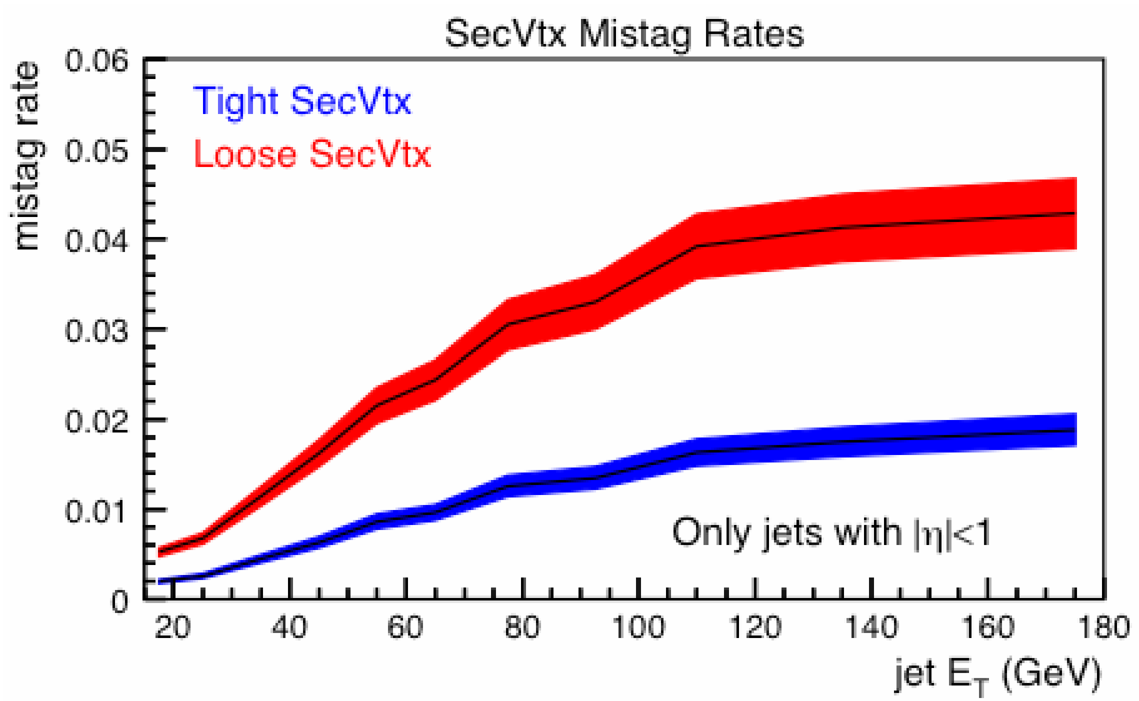
$$QCD_D = \frac{N_B \times N_C}{N_A}$$

Model event kinematics from sideband

	1 jet	2 jet	3 jets	$\geq$ 4 jets
Tagged non-W events				
Electrons	27.3 ± 5.1	12.3 ± 2.5	3.0 ± 0.7	1.1 ± 0.3
Muons	6.0 ± 1.2	3.8 ± 0.8	1.8 ± 0.4	0.8 ± 0.2

Events with False Vertex b-Tags

Fraction of light flavor jets are “mistagged” with displaced vertex



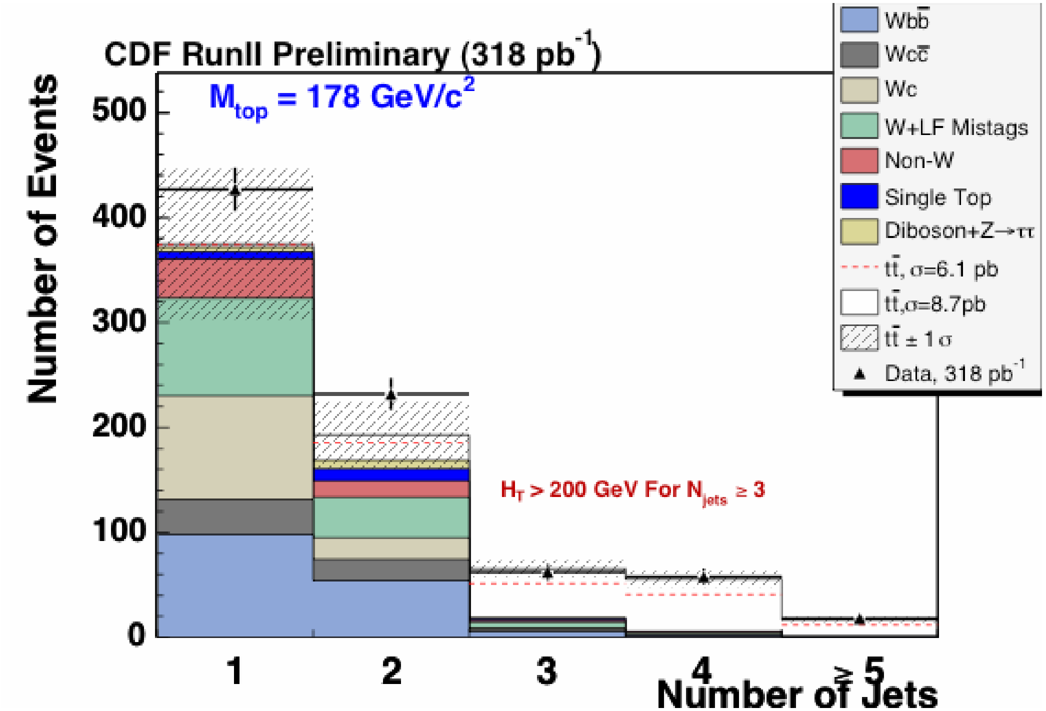
- Light flavor L_{xy} distribution is roughly symmetric about 0
- Use negative L_{xy} distribution to predict positive side “mistags”

Correction factor (27 ± 13)% accounts for material interactions, long-lived light flavor particles (K_S, Λ)

Events from Top Quark Production

In ten years, top quark has gone from new particle to background

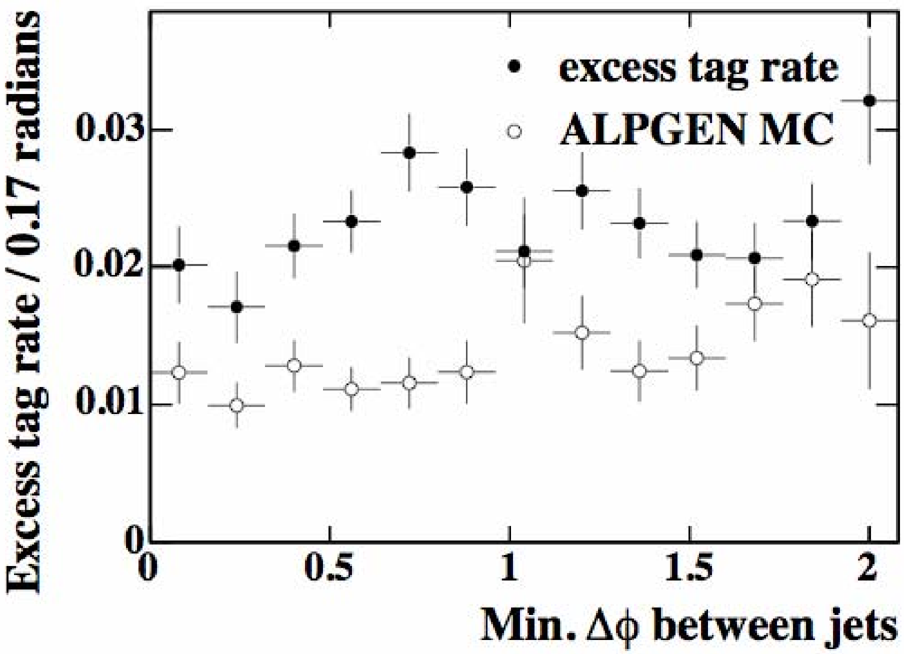
Strong motivation for measuring σ_{tt} precisely!
- here measured in sample
- effective fit to 3,4-jet bin
- consistent with theory calc



Electroweak single top production also important in 2-jet sample
- measurement anticipated at Tevatron with more data
- currently assume theory prediction: (2.0+0.9) pb

Events from W + heavy flavor Production

- Calculate fraction of W+HF in W+jets using ALPGEN
- Calibrate calculations using jet processes without W boson



Calibrated correction factor 1.5±0.4 consistent with phenomenological “factor” based on NLO studies

Additional factor 1.2 from fit to W+1-jet data (normalization)

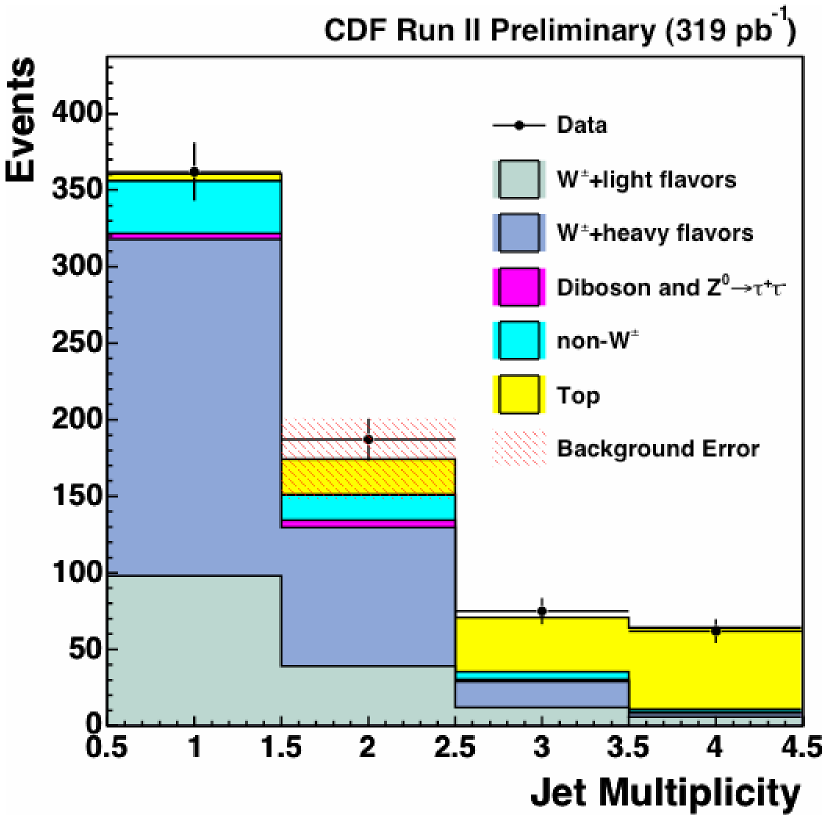
Final calculation of true W+HF backgrounds is then:

$$N_{pretag}^{W+jets} \times F_{HF} \times \epsilon_{b-tag}$$

Checks of Background Estimate

Vertex-Tagged Counting

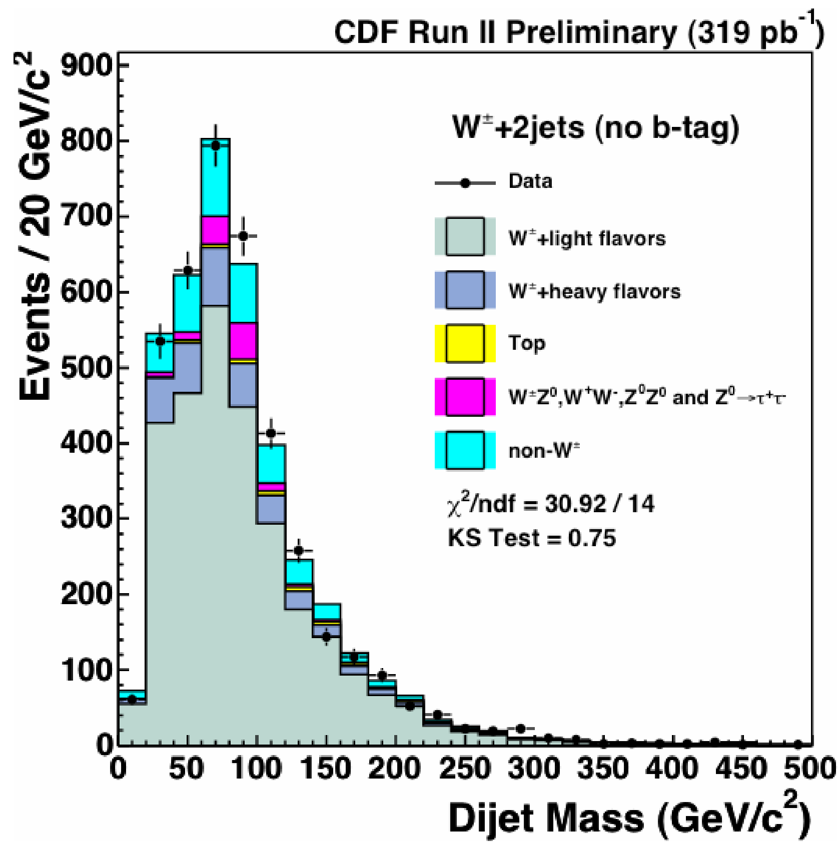
Checking event counts



1,3,4-jet bins constrained by data

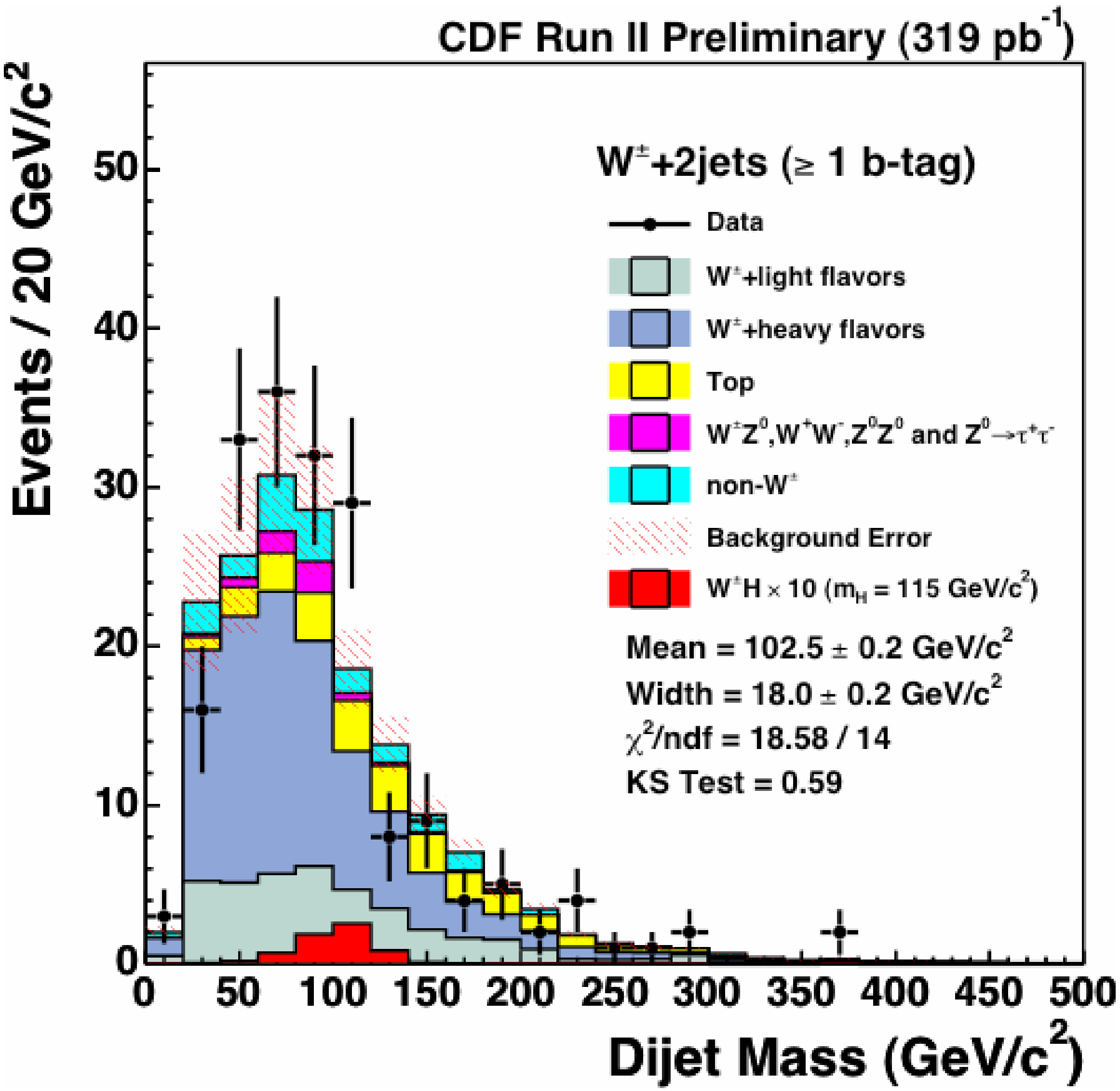
No b-tagging required

Checking kinematics



MC bkgds same after tagging

Dijet Mass Spectrum in Tagged lνbb Events

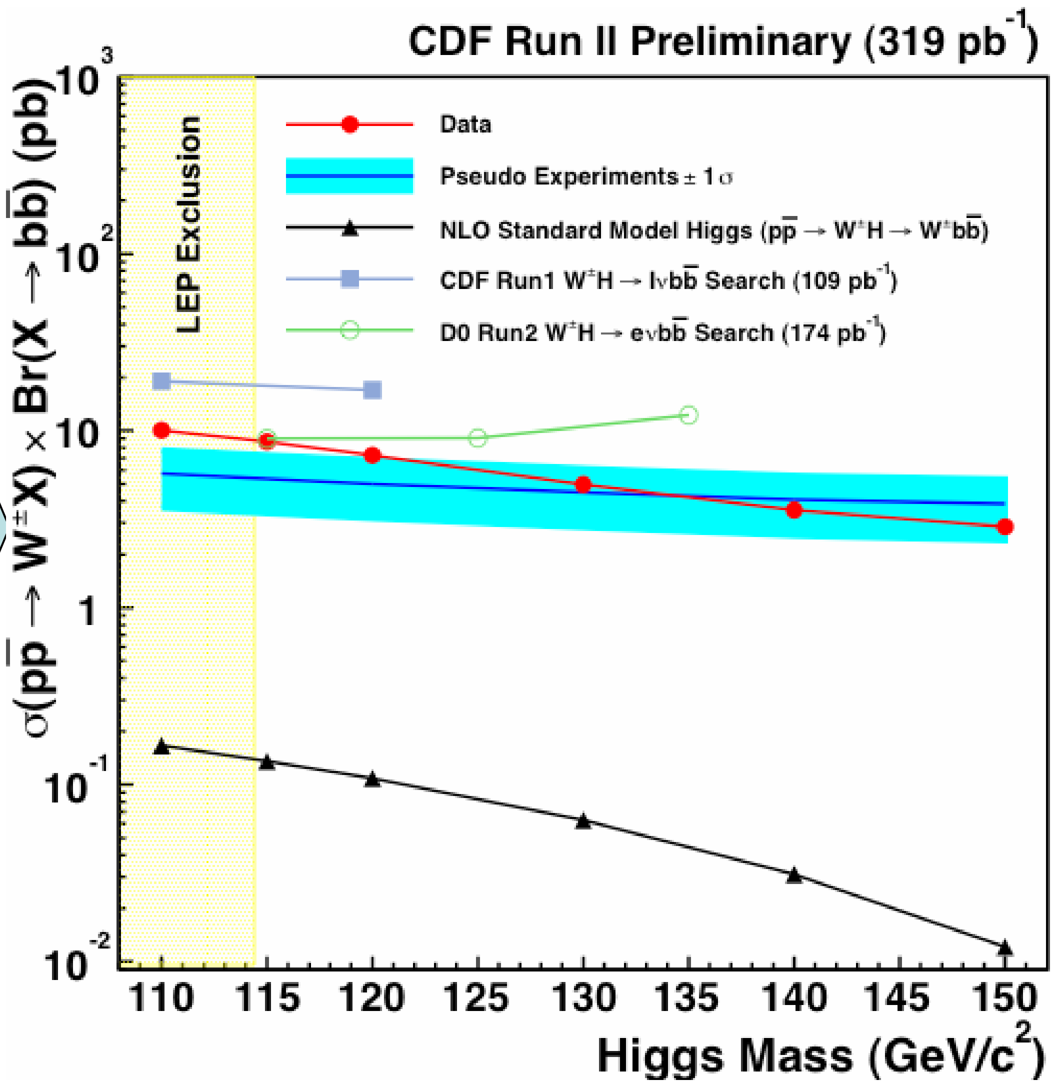


Fit Procedure and WH Exclusion Results

Fit for number of WH evts

- given dijet mass resolution
- constraining bkgds

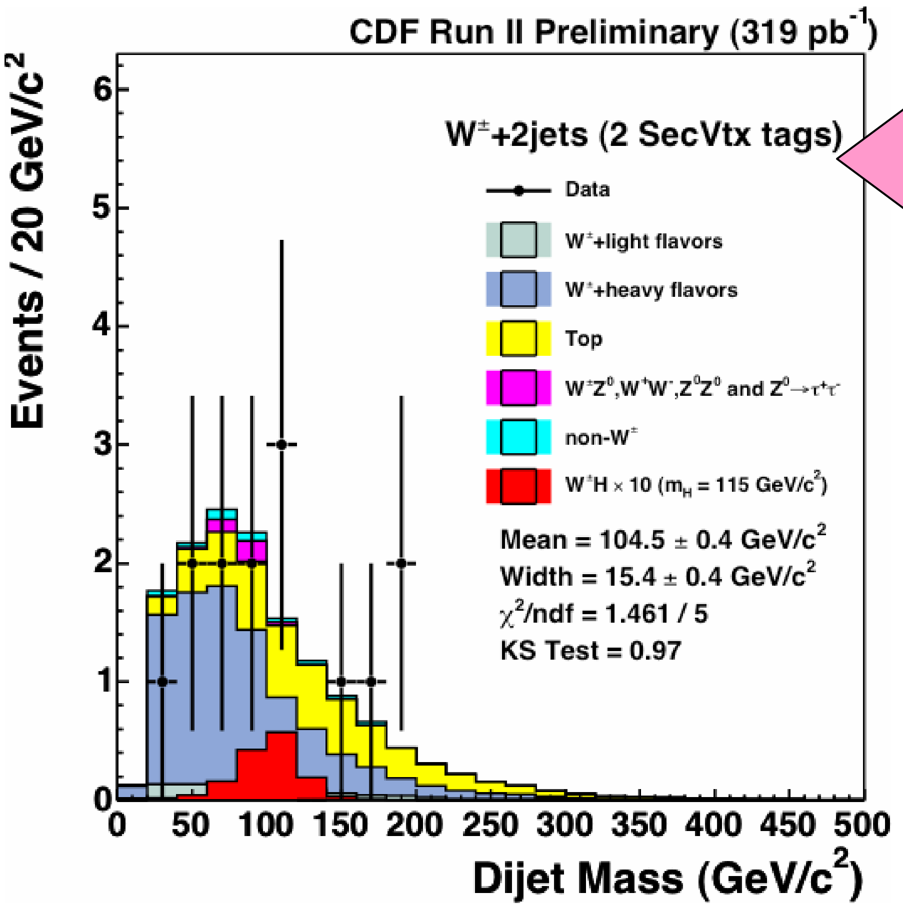
For **m_H=115 GeV**:
Expected limit: 5.4 pb
Observed limit: 8.6 pb
SM prediction: 0.14 pb



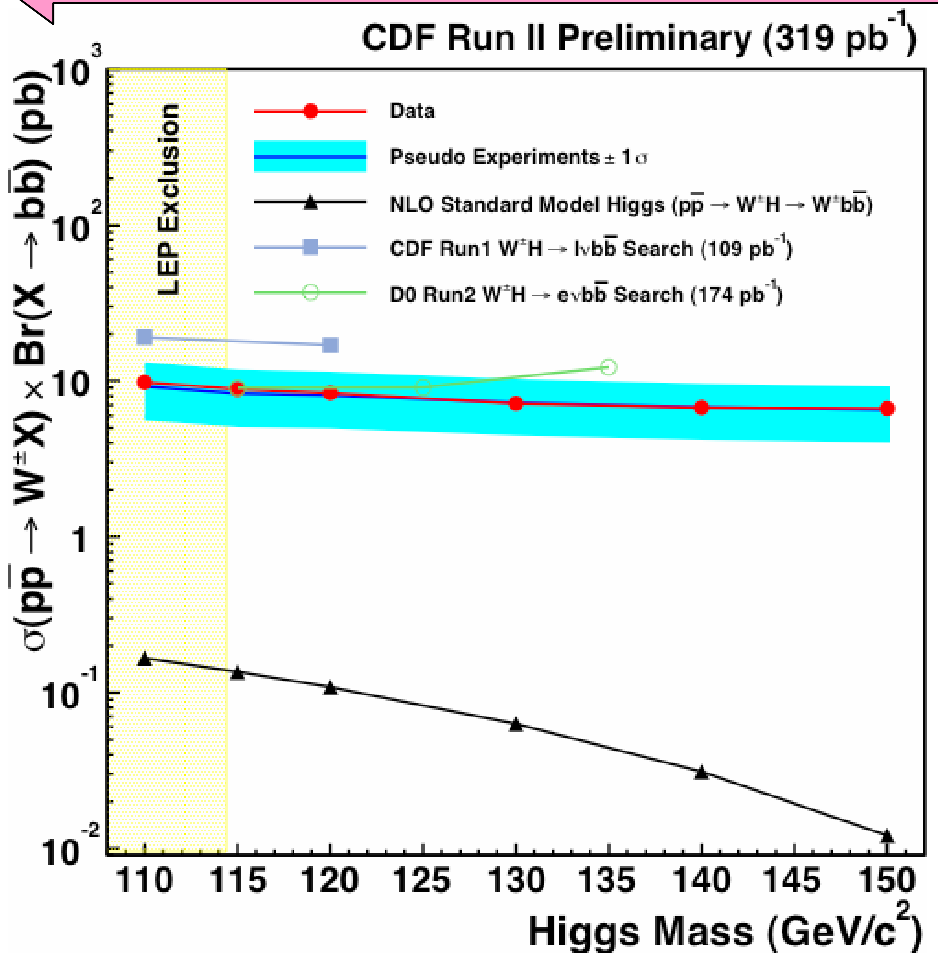
Systematic uncertainties are not the issue here!

Simply need more events!

Results in Double-tagged Sample



Fluctuation at 100 GeV not present in this data sample



Slightly worse expected limits due to reduced acceptance

Prospects for Future Improvement

Identified potential to approach SM cross section exclusions

Tools common to CDF analyses

Analysis-specific improvements

Anticipated Improvement	WH→lνbb
Mass resolution	1.7
Continuous b-tag (NN)	1.5
Forward b-tag	1.1
Forward leptons	1.3
Track-only leptons	1.4
NN Selection	1.75
Product of above	8.9
CDF+DØ combination	2.0
All combined	17.8

In parallel, work to improve background estimates

Summary of WH Search

- Benchmark realistic WH search in CDF as part of larger push towards SM Higgs reach
  - Practical b-tagging, lepton identification
  - Data-driven background estimates

- Sensitivity is factor of 40 below SM prediction
  - Poor observed limit due to 1σ excess

- Reasonable plan to recover needed factors
  - See also following talks, Tom Junk's plenary talk