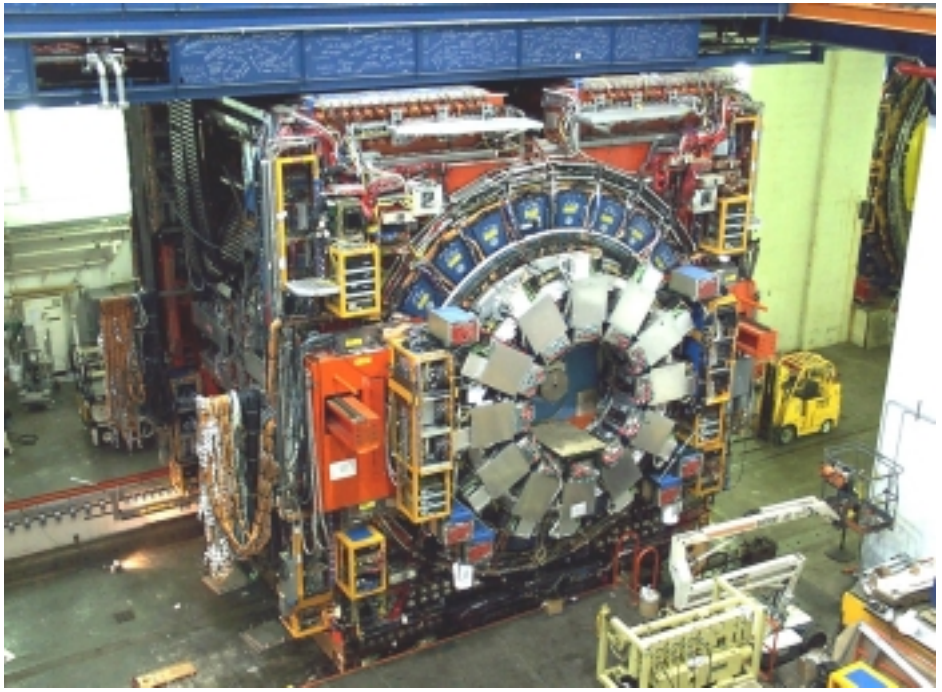
Higgs Discovery Sensitivity

Jerry Blazey, John Womersley D0
Luciano Ristori, Nigel Lockyer CDF
Spokespersons



Viewpoint CDF&D0 Exps. (>1300 Physicists+135 Institutions+30 Countries)

Joseph Kroll, Brian Winer Co-chairs CDF
Boaz Klima Chair D0

Between CDF and D0 there are ~250 identified Run 2 Ph.D. thesis projects

CDF Higgs Sensitivity Group

People:

Joseph Kroll (co-chair, Penn), Brian Winer (co-chair, Ohio State), Tommaso Dorigo(Padova), Tom Junk (Illinois), Mario Martinez (FNAL/Barcelona), Pete McNamara (Rutgers), Fumi Ukegawa (Tsukuba), Weiming Yao (LBNL), John Conway (Rutgers), Martin Hennecke (Karlsruhe), Luca Scodellaro (Padova).

…many many hours of work by these people in a very short amount of time!

Documentation:

CDF Notes: 6353, 6446, 4527, 5517, 6450, 6496, 6525

Review:

- Reviewed by collaboration (~6 major presentations)
- Reviewed Physics Group Conveners

Constraints on the SM Higgs Mass

Lower bound on SM Higgs at 95% CL is 114.4 GeV (LEP)

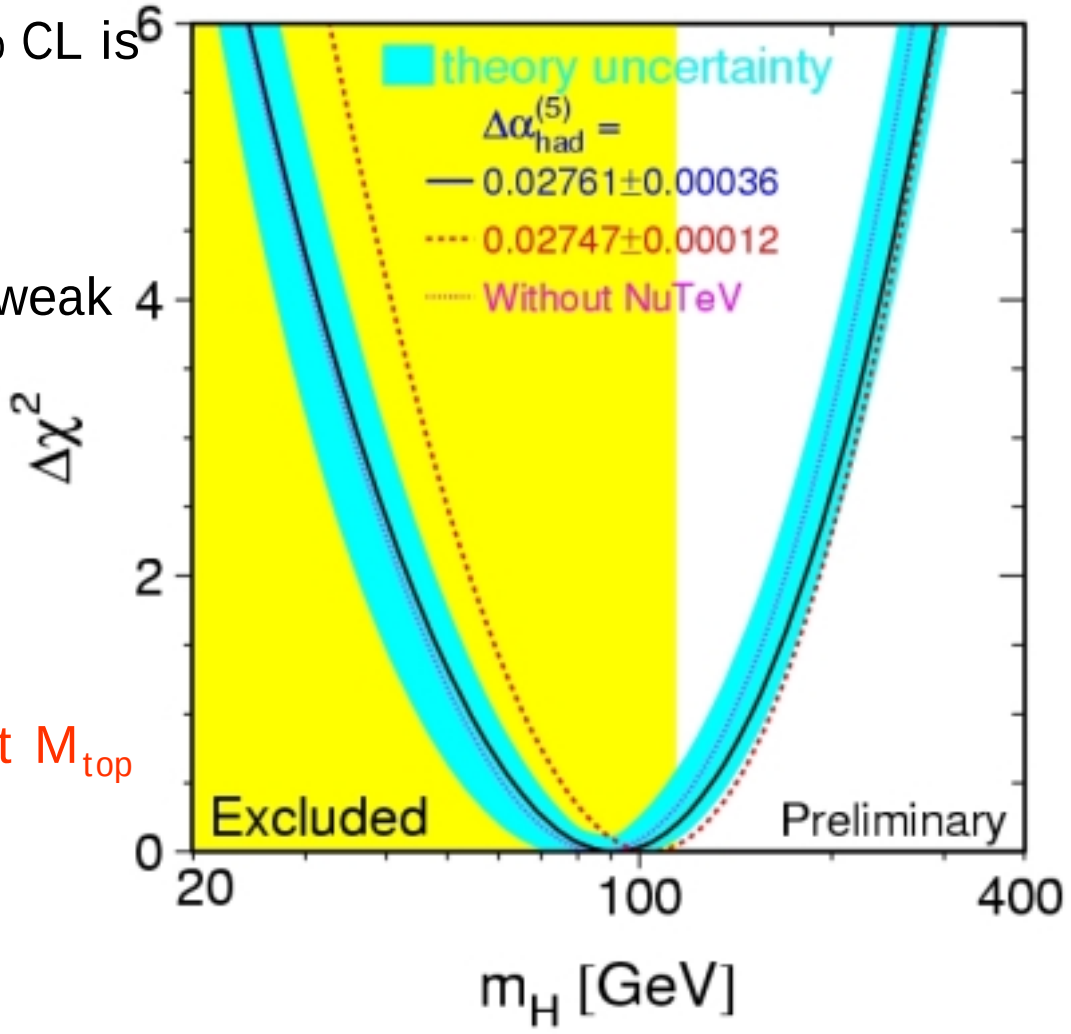
- Hint from LEP: ~2σ Excess

Upper Bound comes from electroweak fits < 211 GeV

Preferred Value is 91+58-37 GeV

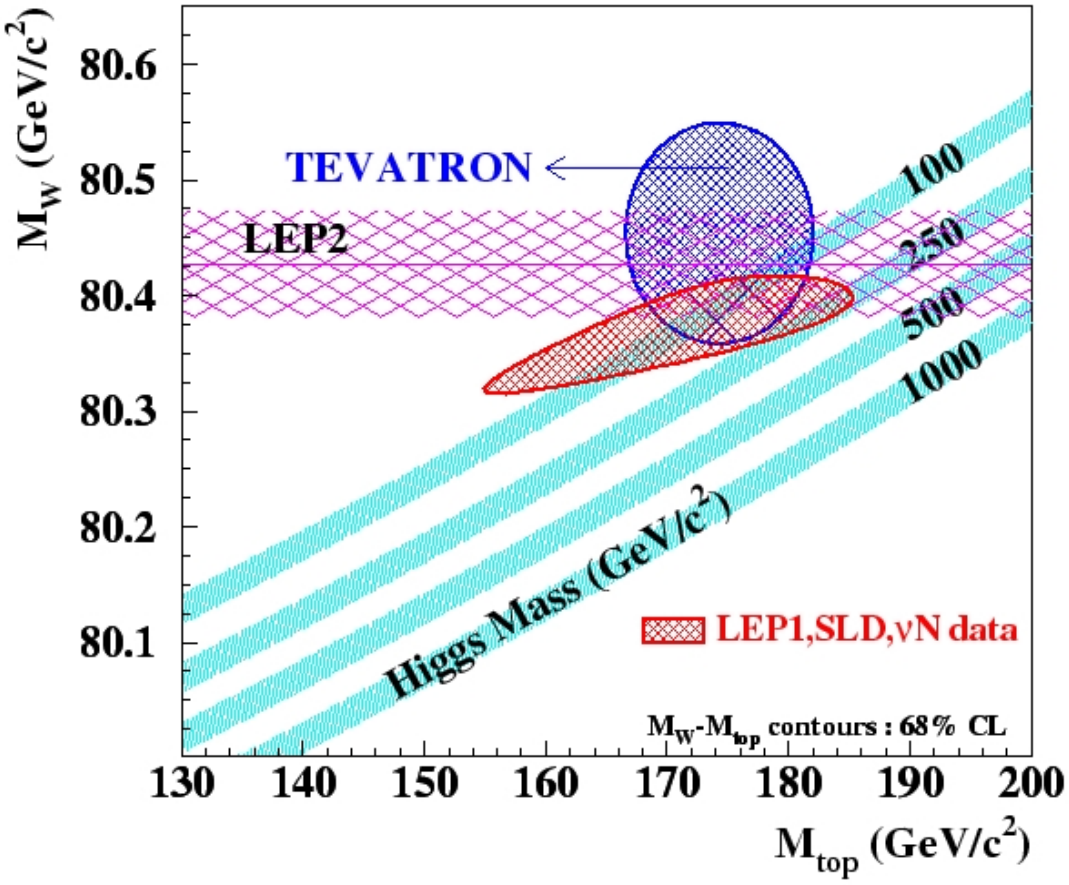
SM prefers a low mass Higgs

Past: EWK Fits Indicated Correct M_{top}



Top Mass Measurement Crucial

35% shift in mass of Higgs for 5 GeV in top mass

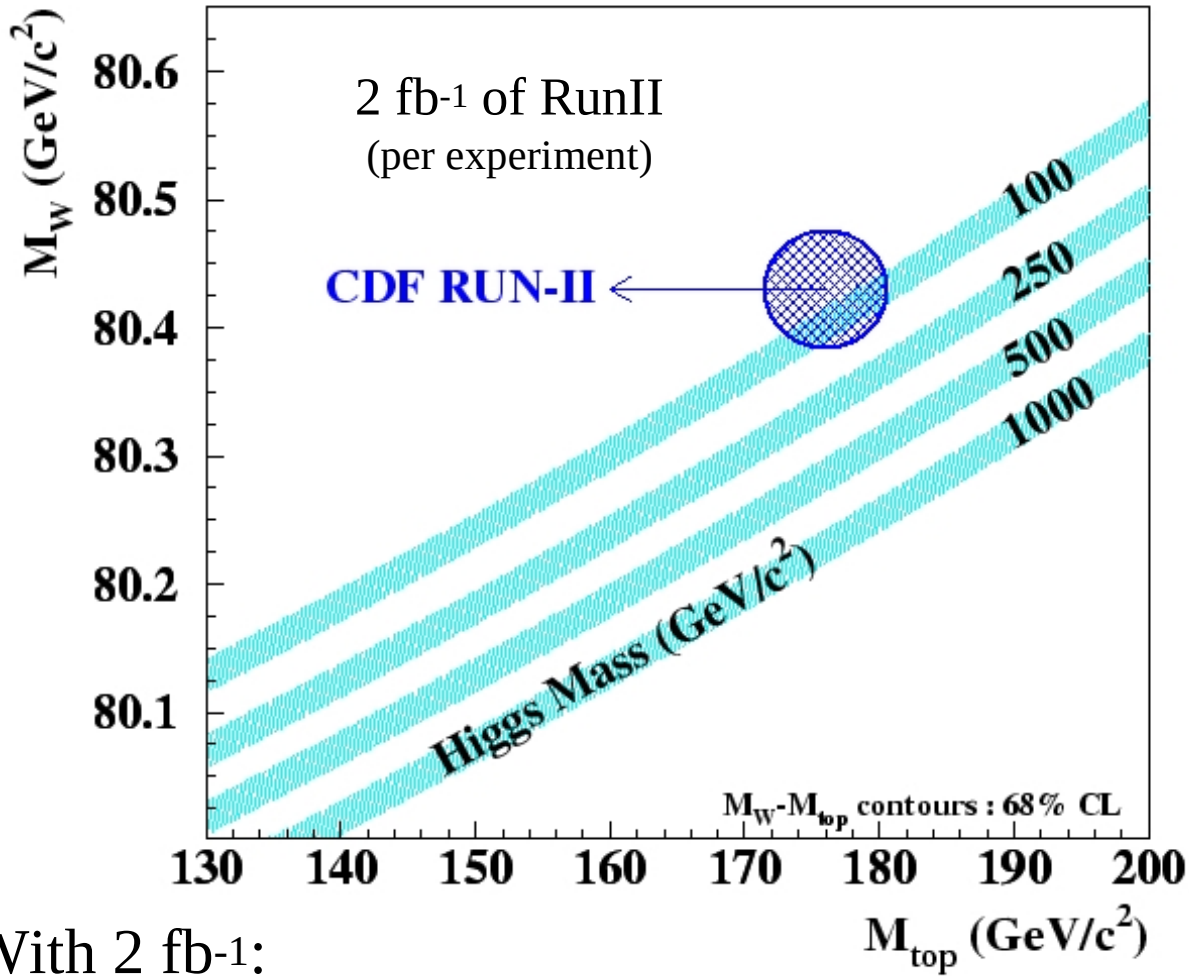


TeV RunI

We measure
<u>both</u>
M_W and M_{top}

Electroweak Physics at the Tevatron

Electroweak Measurements and SM Higgs



$\sqrt{s} = 1.96\ \text{TeV}$

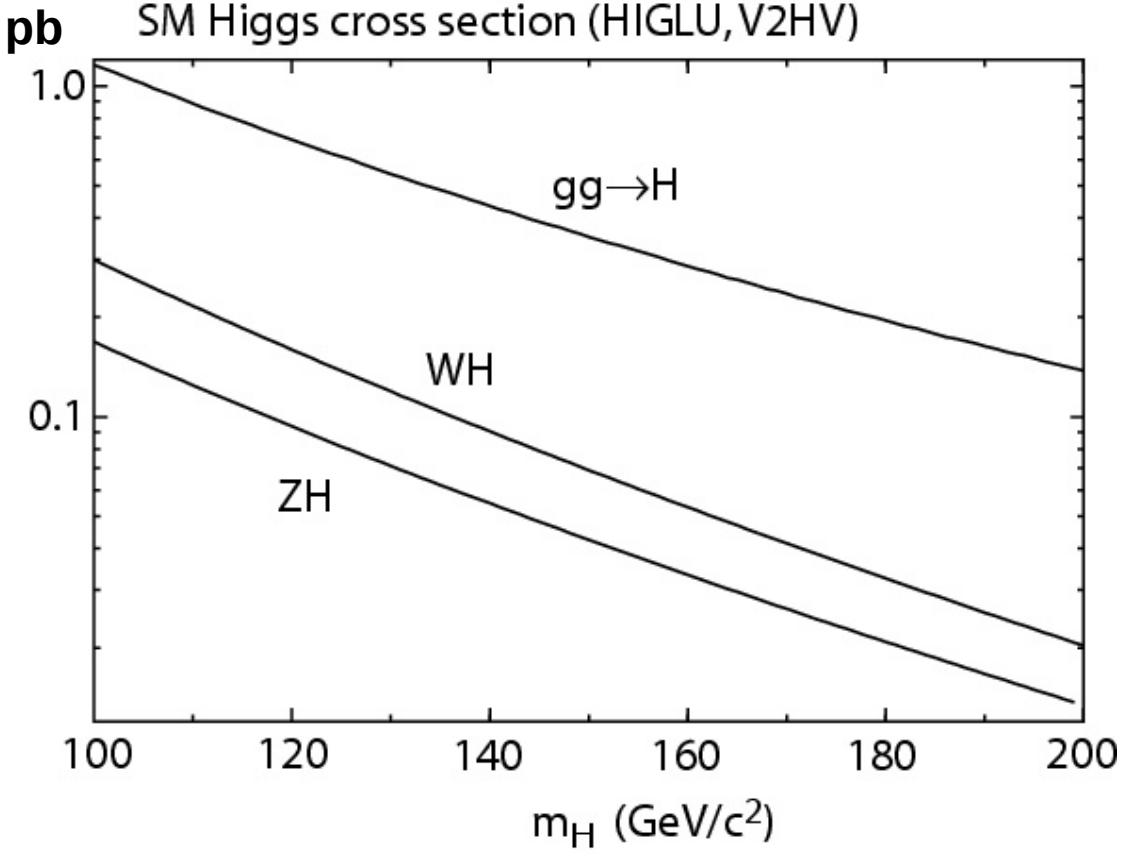
σ(W,Z)~10% higher
σ(tt) ~ 35% higher

With 2 fb-1:

- $\Delta M_w = 30$ MeV/exp
- $\Delta M_{top} = 3$ GeV/exp

Standard Model Higgs Cross Section

- gg→ H dominated by QCD Background
- WH: trigger on W->lepton, small instrumental bkg
- ZH: large missing energy, dilepton decays
- Small cross section down X 15-20 vs top

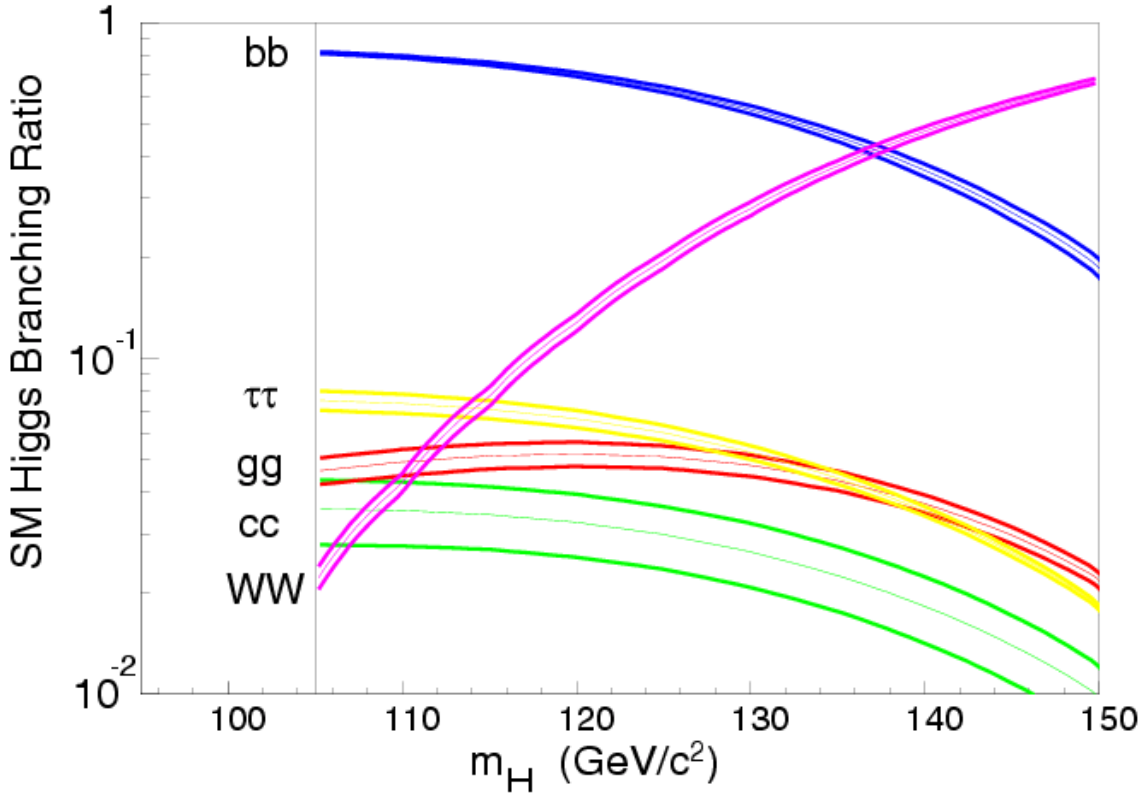


W, Z Boson Decays:

$$W \to \ell^{\pm}\nu$$

$$Z \to \ell^{\pm}\ell^{\mp}, \nu\bar{\nu}$$

Standard Model Higgs Branching Ratios



Need to use H→bb and H→WW to maintain sensitivity over wide mass range

-WH: W→l ν, H→bb lνbb: "Lepton+Missing Energy + bb"

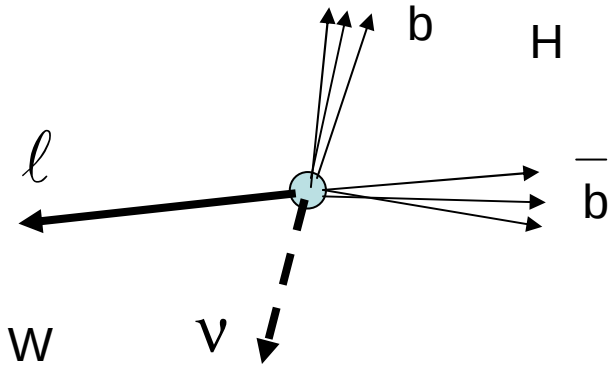
-ZH: Z→l l , νν H→bb llbb, ννbb: "Missing Energy + bb"

-N.B. Significant contribution of WH to ZH channel.

lvbb Signature already Interesting

- List of Publications:
  - The CDF Collaboration, Phys. Rev. Lett. 90, 081802 (2003). Search for W' Boson Decaying to a Top and Bottom Quark Pair in 1.8 TeV p anti-p Collisions
  - The CDF Collaboration, Phys. Rev. D65, 091120 (2002) Search for Single-Top-Quark Production in p anti-p Collisions at s**(1/2) = 1.8 TeV
  - The CDF Collaboration, Phys. Rev. Lett. 84, 5273 (2000) Search for Scalar Top Quark Production in p anti-p Collisions at s**(1/2) = 1.8 TeV
  - The CDF Collaboration, Phys. Rev. Lett. 81, 5748 (1998). Search for Higgs Bosons Produced in Association with a Vector Boson in p anti-p Collisions at s**(1/2) = 1.8 TeV
  - The CDF Collaboration, Phys. Rev. Lett. 79, 3819 (1997) Search for New Particles Decaying into b anti-b and Produced in Association with W Bosons Decaying into e nu and mu nu at the Tevatron
  - Plus a series of SUSY Higgs Search papers.

W+2Jets Run 1

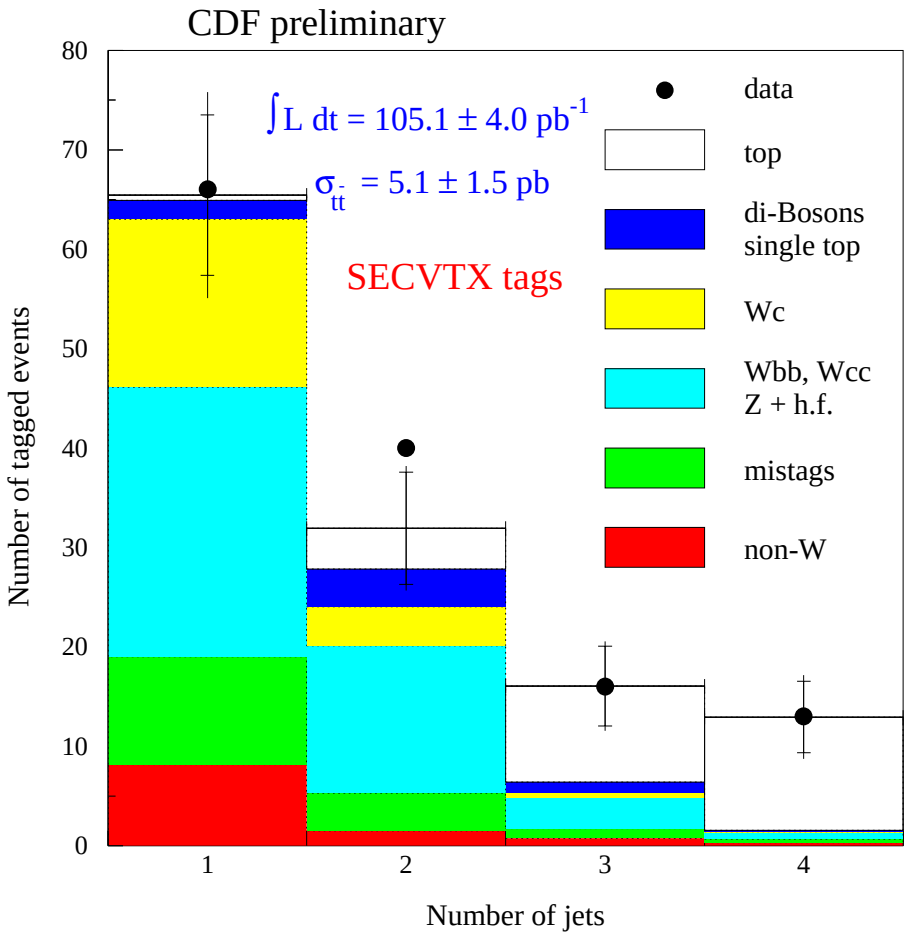


Resides in 2-Jet Bin

Composition of the W + jet sample with SECVTX tags

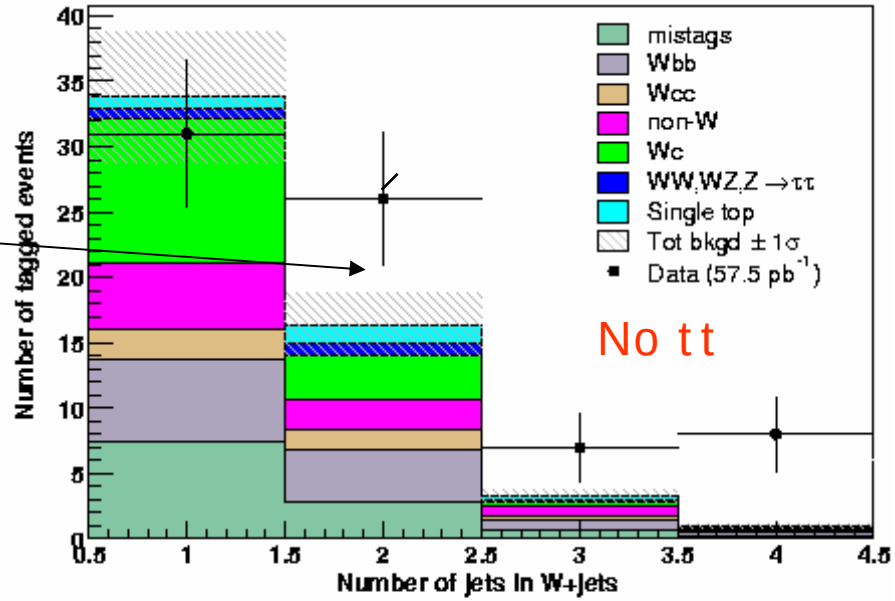
- **Observed excess of b-tags in the 2 jet bin**
- Too many double tags (more than one b-tagged jet/event)
- Too many multiple tags (more then one b-tag/jet)

➔ A lot of speculation, need to increase statistics.

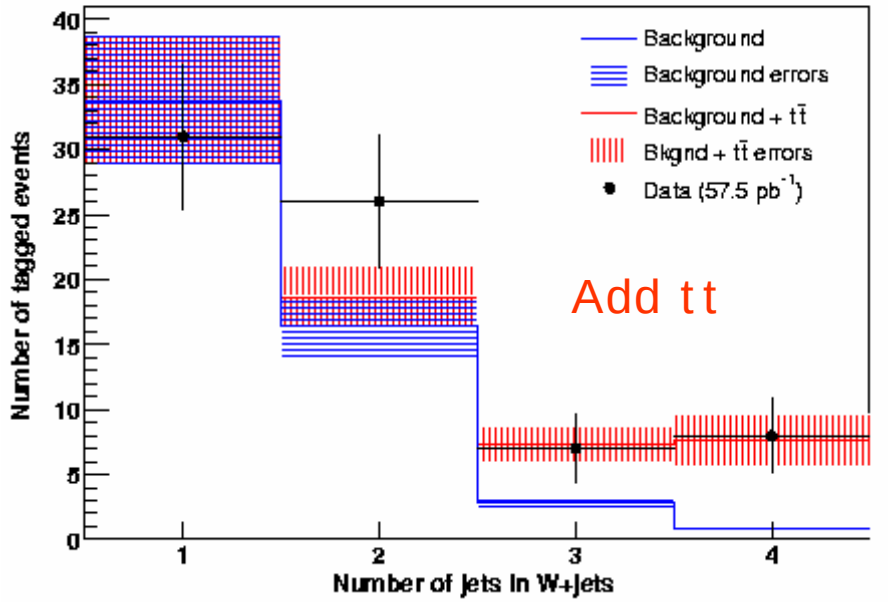


Top studies from lepton plus jets Run 2

W+2 jet bin



- Top found in W+2,3,4 jet bin
- Again excess in W+2 jet bin
- Higgs resides in W+2 jet bin



CDF Higgs Sensitivity Study

- Search for Higgs depends critically 3 issues:
  - Event Yields
    - Production Cross Section **small** backgrounds large
  - Identification of b-quarks from Higgs decay
    - Keep b tag efficiency high for **both b's** ($N \sim \varepsilon^2$)
  - Invariant Mass peak of Higgs decay products (bb)
    - Sensitivity depends critically on mass resolution

- For these three are point of reference is Run 2A data.
  - Extrapolate to our abilities in 4-5 years using **simulation**.

CDF Event Yields and B-tagging

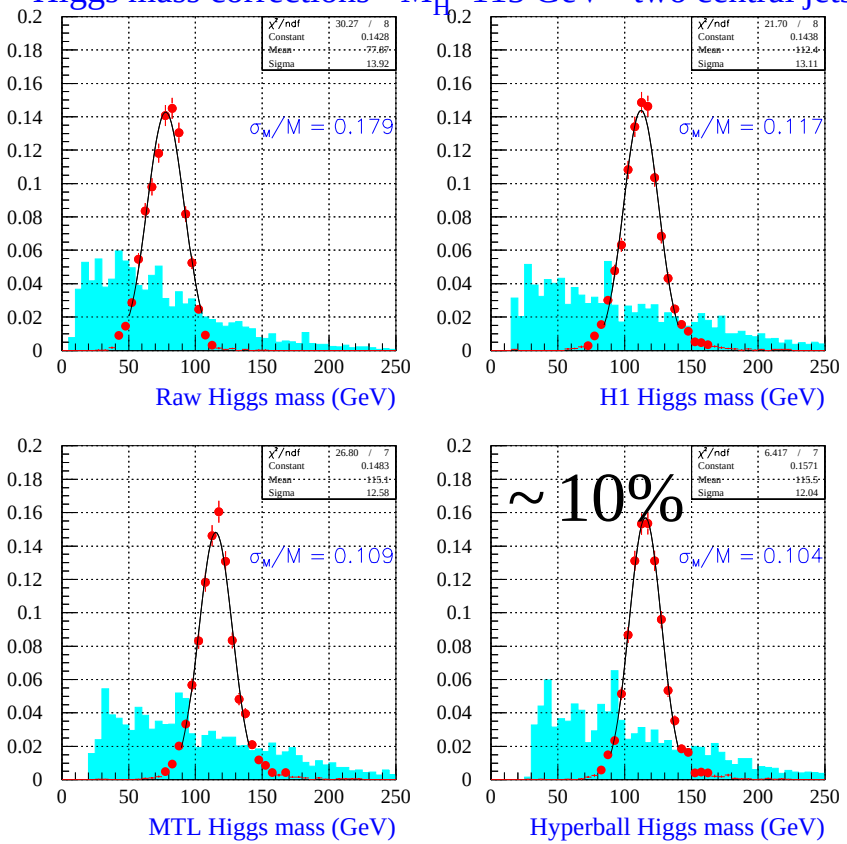
- Event selection for current top quark analysis used
  - Results at winter conferences based on the selection.
  - B-Tagging developed over the past +10 years of data analysis.
- Extrapolations:
  - Expand acceptance for lepton ID to new portions of the detector.
    - Not "routine" yet but work in progress.
  - Expand b-tagging for jets that are closer to the beam line.
    - Depends on tracking in forward direction - work in progress
  - Increase acceptance by loosening lepton criteria
    - Make other event quantities more strict.
- Improvements are being actively pursued and will enhance or ability in many high Pt physics areas (top, SUSY, etc.)
  - Will be part of the physics program in the near future.

Improve CDF Dijet Mass Resolution

- Key Improvement: **Use more information!**
  - Use calorimeter measure with corrections.
    - Developed with current data.
  - Include Tracking Information for individual particles in a jet.
    - Developed in current data.
  - Include Corrections that are specific for b-quark
    - Developed in Simulation
  - Use other event information
    - e.g. Distance to next jet.

Central Jets

Higgs mass corrections - M_H=115 GeV - two central jets



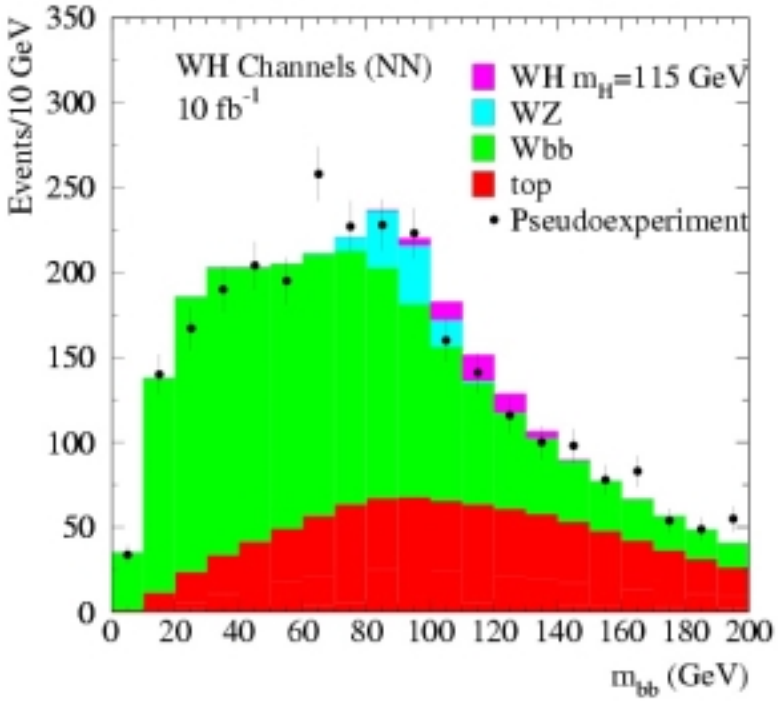
KEY Test: Check $Z \rightarrow b\bar{b}$ data Need 300-400 pb^{-1}

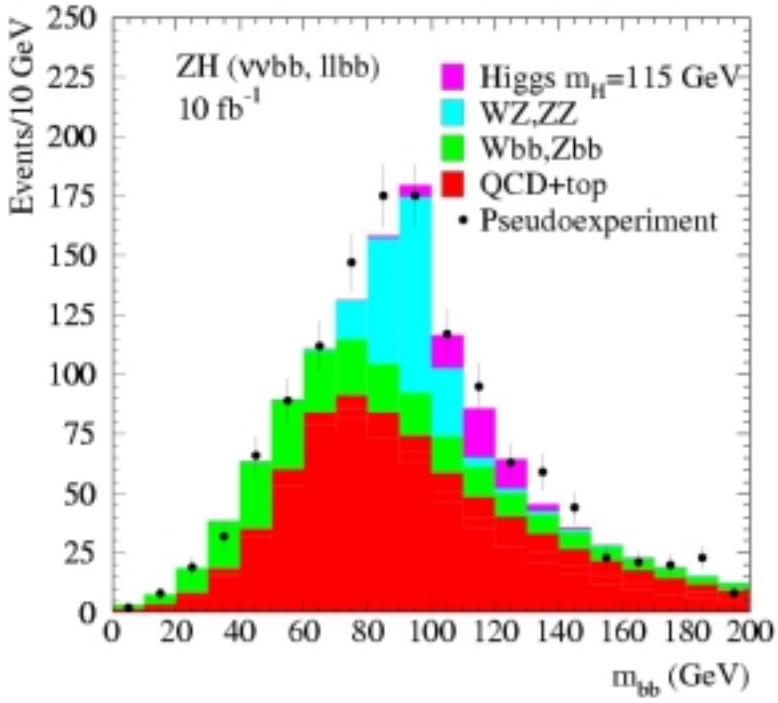
Evaluating Sensitivity

- Evaluate sensitivity by running "pseudo-experiments"
- Includes:
  - Expected Signal and Background Rates
  - Allow statistical fluctuation of # of events.
- For each pseudo-experiment:
  - Construct and Fit Dijet Mass
  - Ask what statistical statement each can make

A Pseudo Experiment with Background and Signal (115)

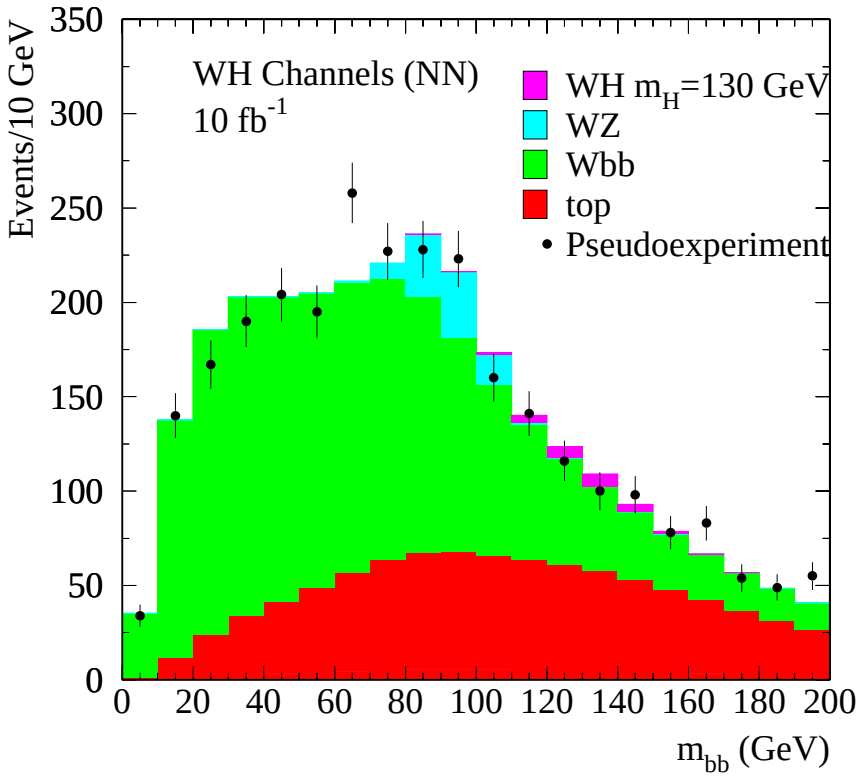
Fit the Dijet Mass Distributions ~ Extra Power over Windowing around M_H

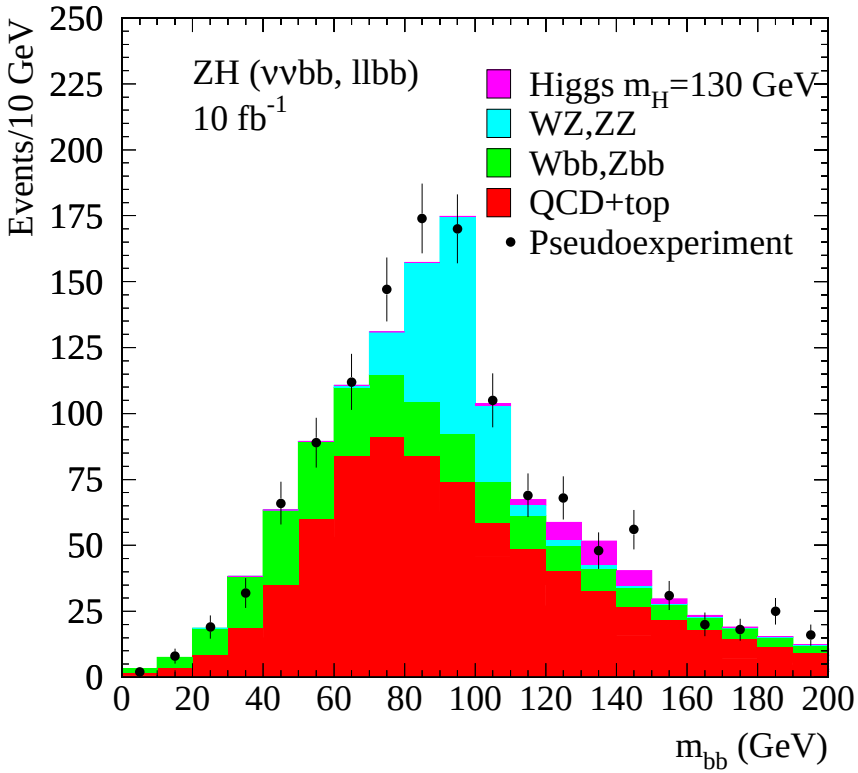




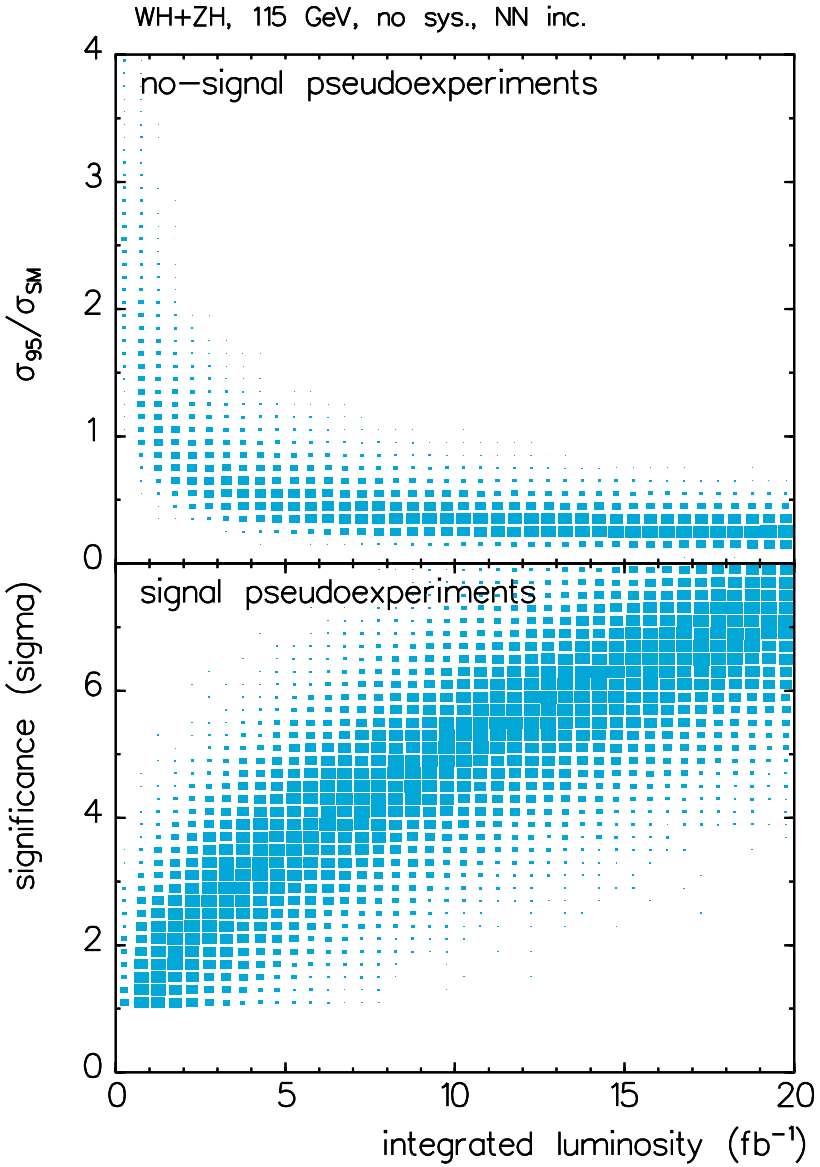
Challenge: Control the systematic errors on the shape

A Pseudo Experiment with Background and Signal (130)





Combined Pseudo-Experiments



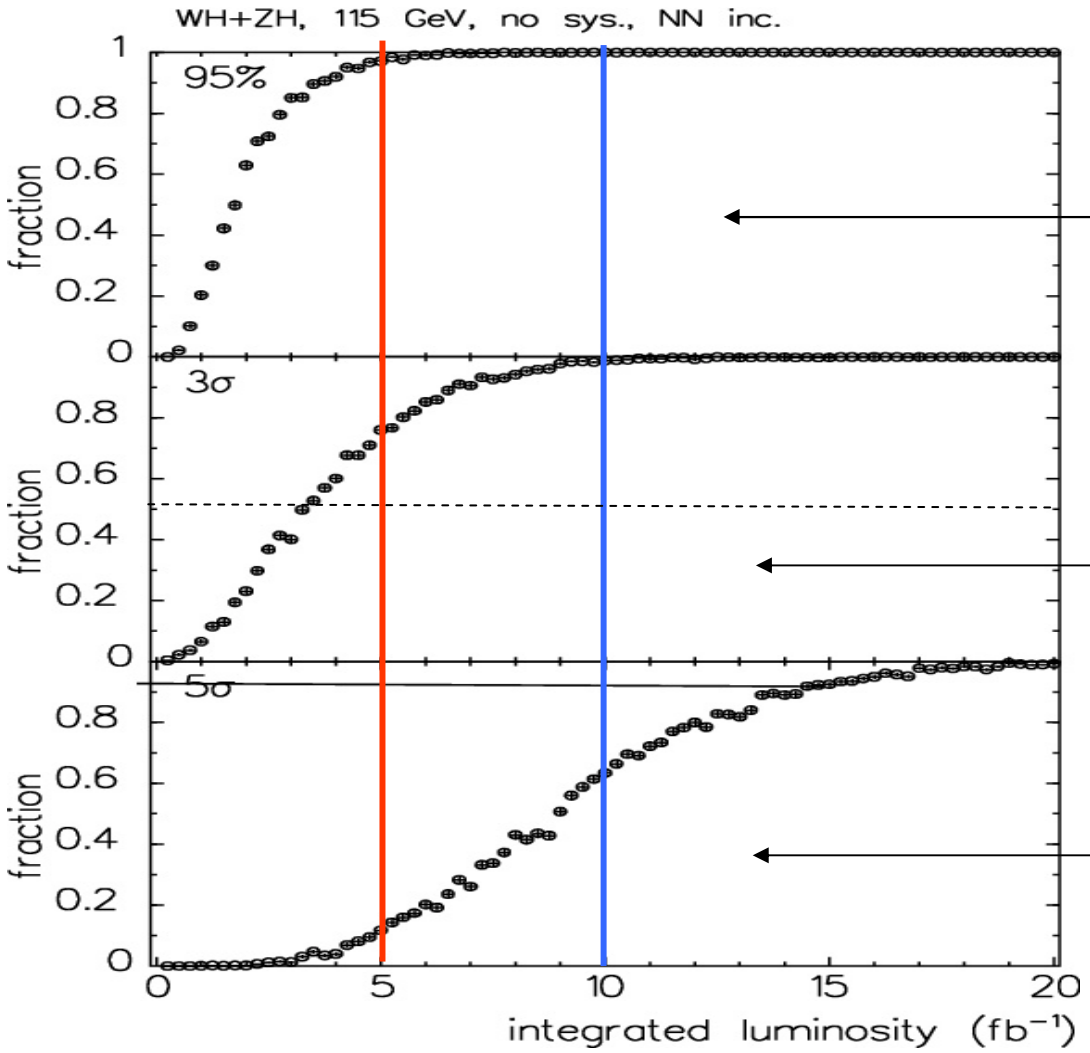
Broad range of statistical outcomes

With 5 fb-1, 1-5 sigma significance at 115 GeV both experiments

Mostly likely at 3.5 sigma

Int. Luminosity per experiment

WH+ZH 115 GeV Pseudo-Exps Fractions



95% CL

3 sigma

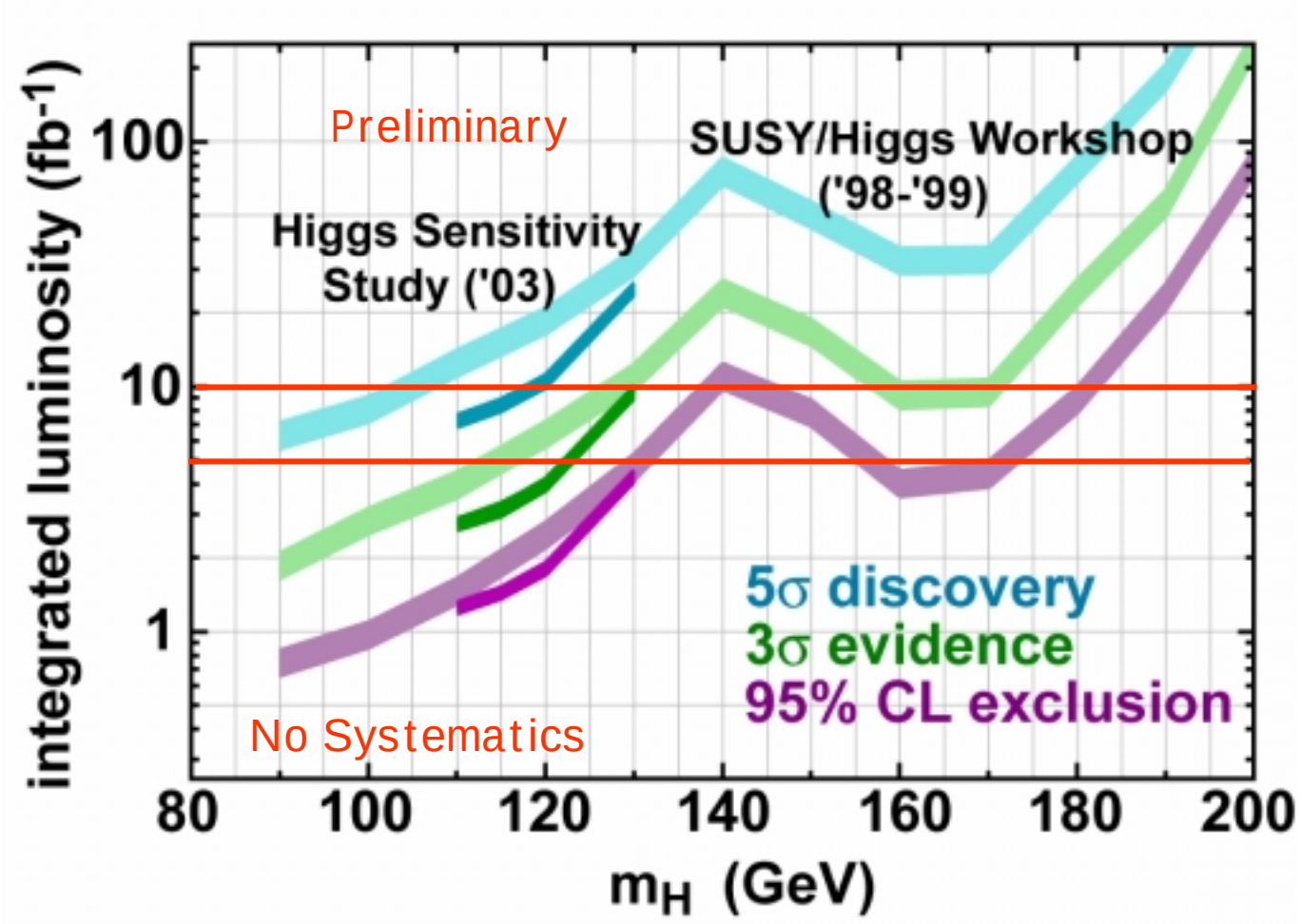
5 sigma discovery

Int. Luminosity per experiment

N.B: SHWG Report and next slide uses the 50% value

Higgs Sensitivity CDF+D0

N.B: Uses the 50% of Pseudo experiment threshold

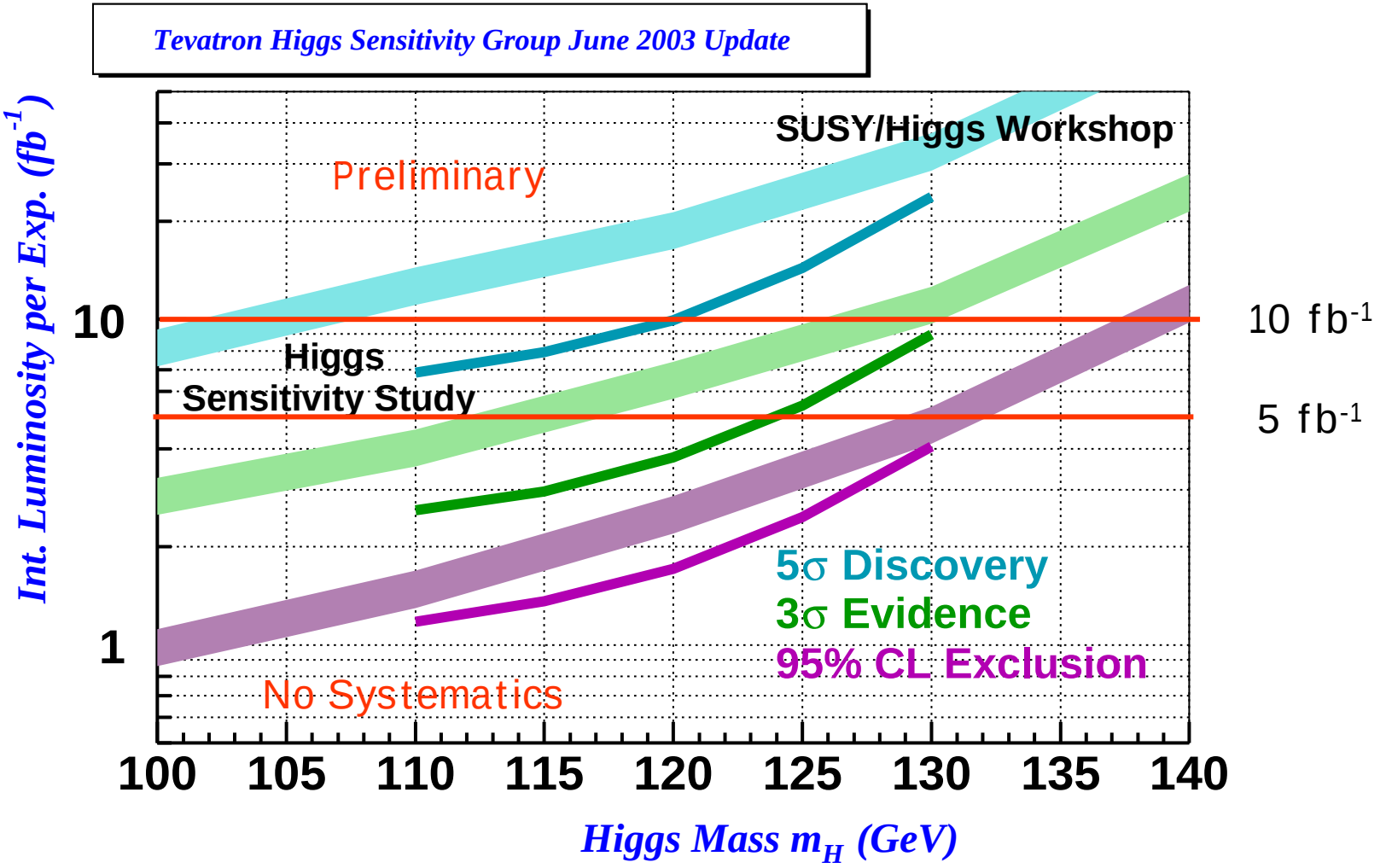


10 fb^{-1}

5 fb^{-1}

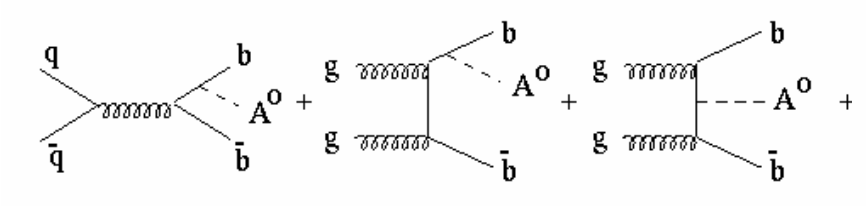
Higgs Sensitivity CDF+D0

N.B: Uses the 50% of Pseudo experiment threshold



Higgs SUSY Production at the Tevatron

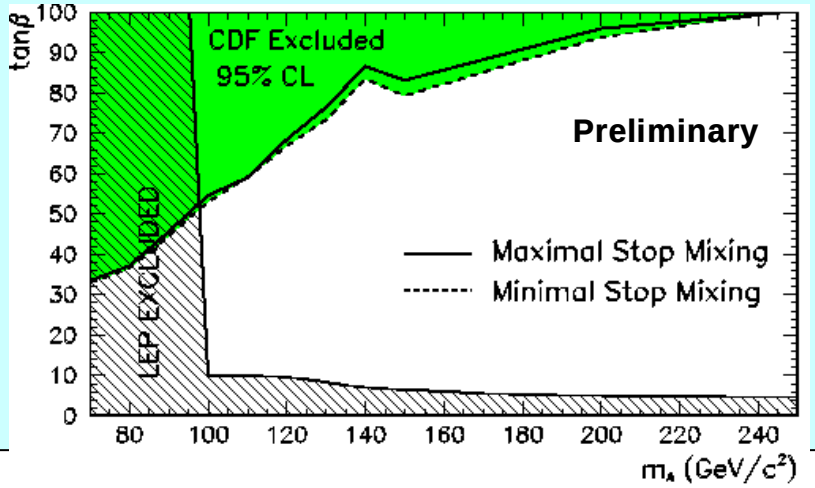
- bb(h/H/A) enhanced at large tan β:



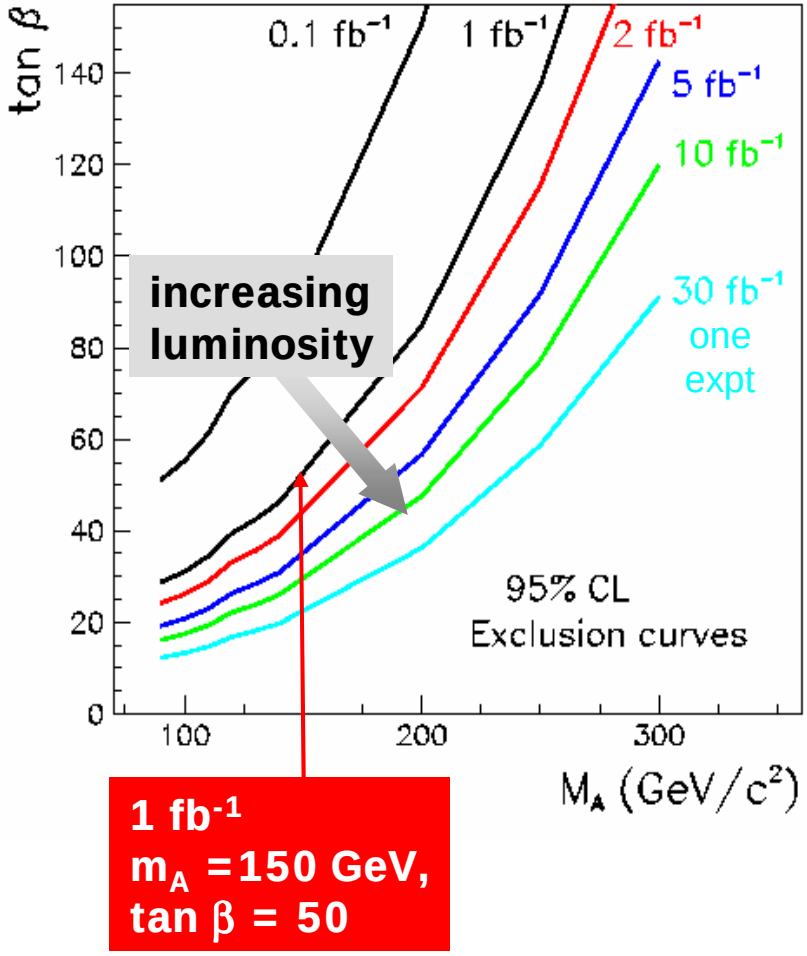
CDF Run 1 analysis (4 jets, 3 b tags) sensitive to tan β > 60

- σ ~ 1 pb for tanβ = 30

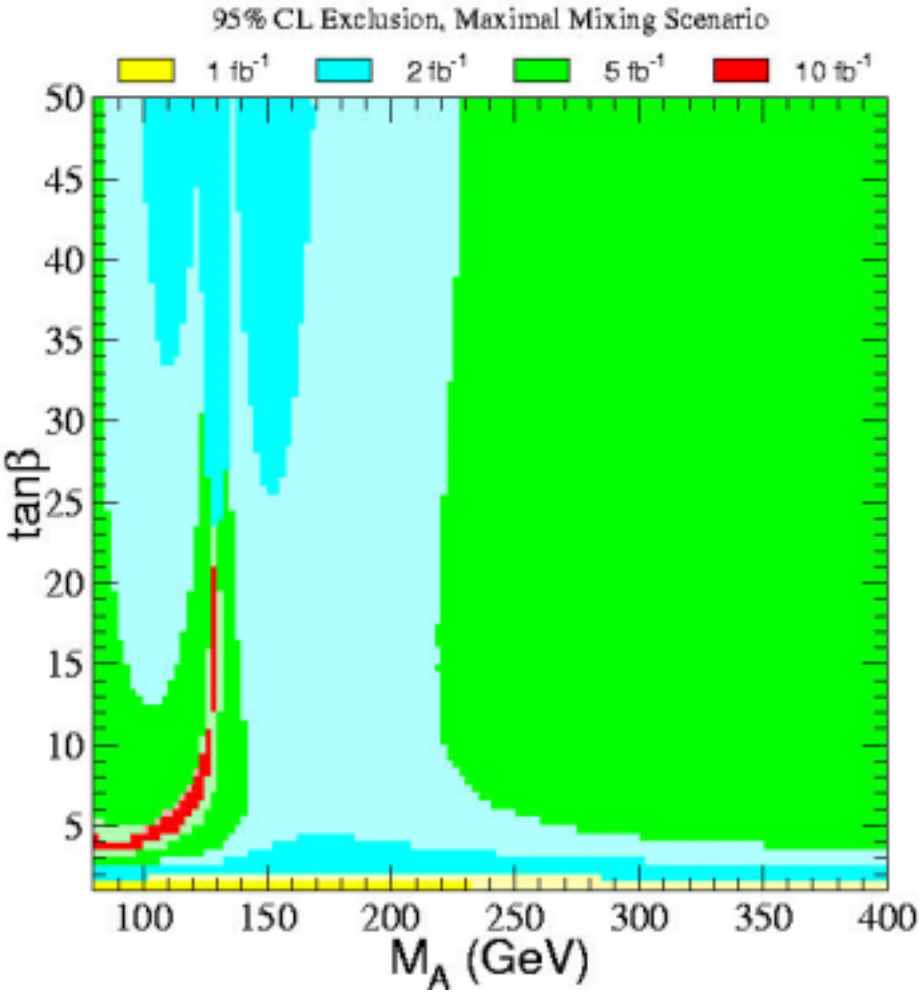
m_h = 130 GeV



bb(h/A) → 4b



SUSY Higgs Sensitivity



Cover most of MSSM space with 5 fb-1