CDFでのWH→lνbbチャンネルを用いたヒッグス粒子探索

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February 21th 2007

Outline

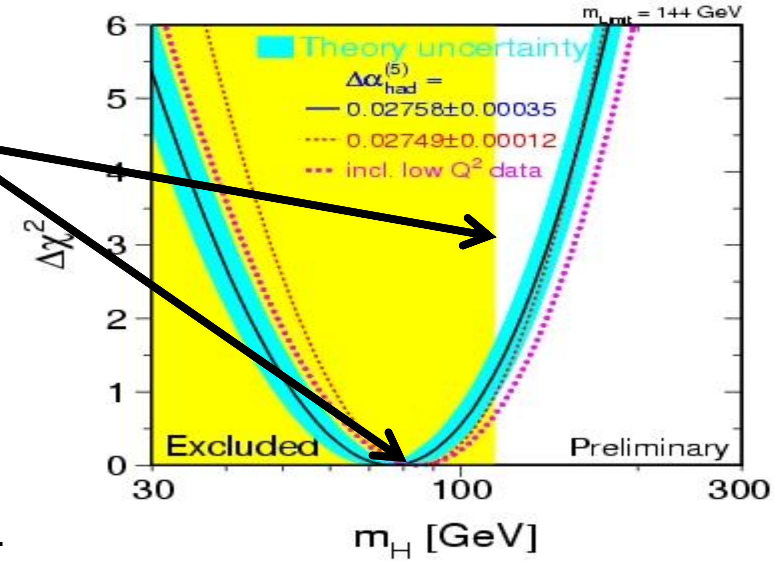
- Introduction
- Analysis & Current Upper Limit on WH
- Conclusion & Tevatron Results

Introduction

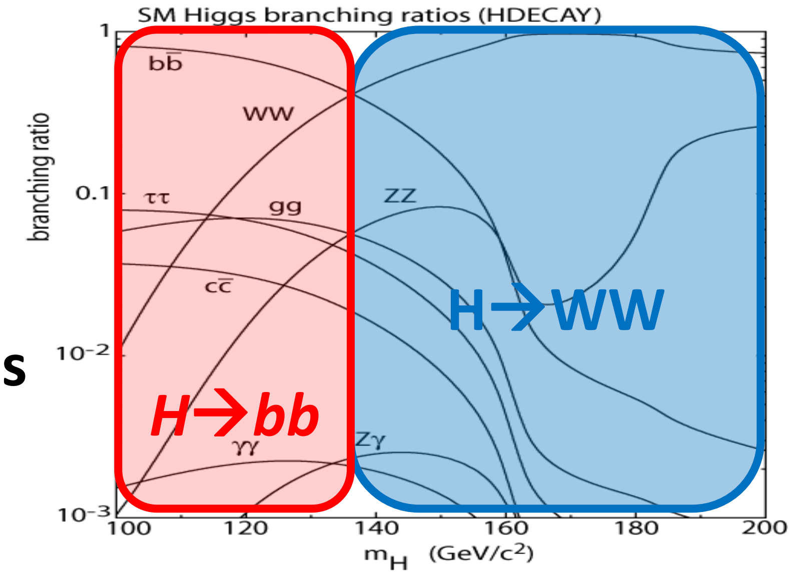
- **Current Experimental Constraint on Higgs mass**

114.4 GeV < m_h < 144 (182) GeV
Most probable value
$m_h = 76^{+33}_{-24}$ GeV

SM prefers low mass Higgs boson!!

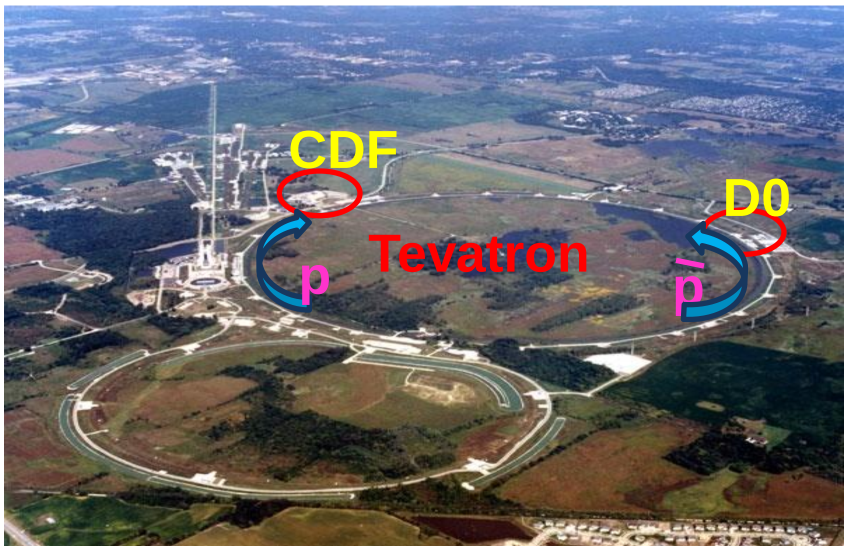


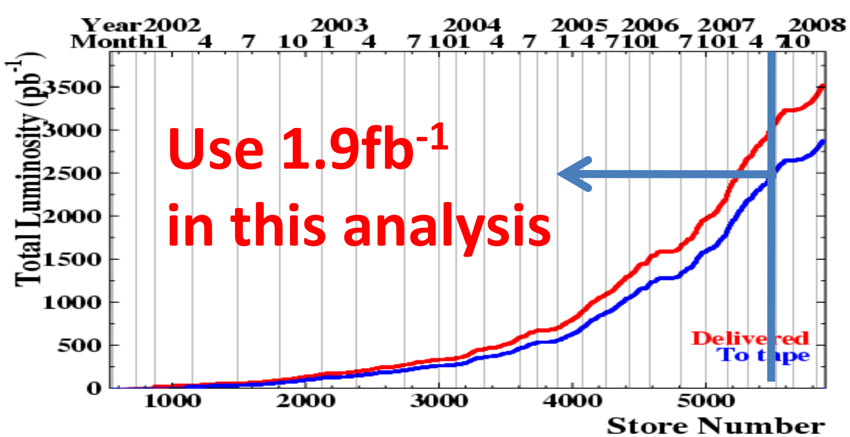
- **<u>Low Mass Higgs Search at Tevatron</u>**
  - ***gg →H*** **: highest cross section**
    - ✓ Huge QCD background in low mass
    - ✓ *H →WW* is promising in high mass
  - ***qq →WH/ZH*** **: Next highest x-sec**
    - ✓ Most promising channel in low mass
    - ➔ *W/Z* leptonic decay is available for event trigger



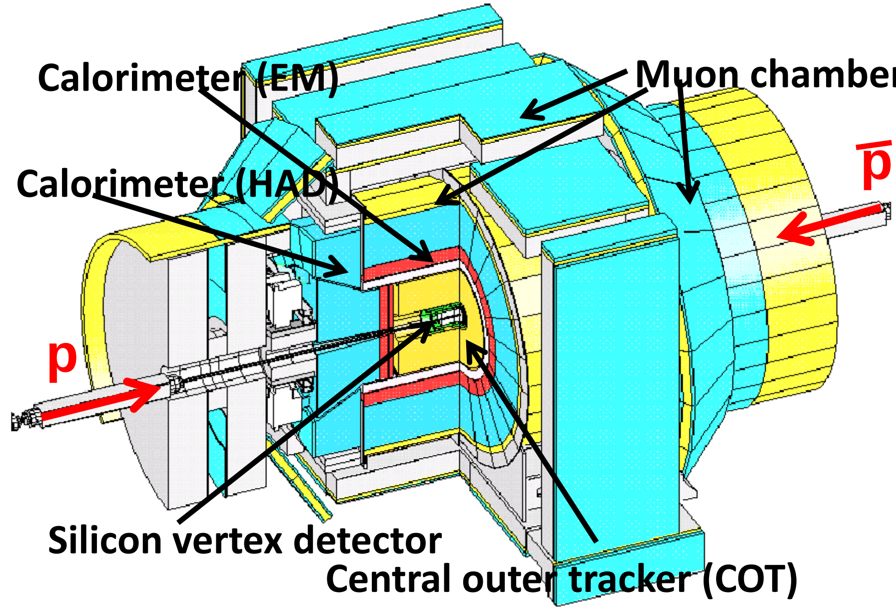
Tevatron and CDF

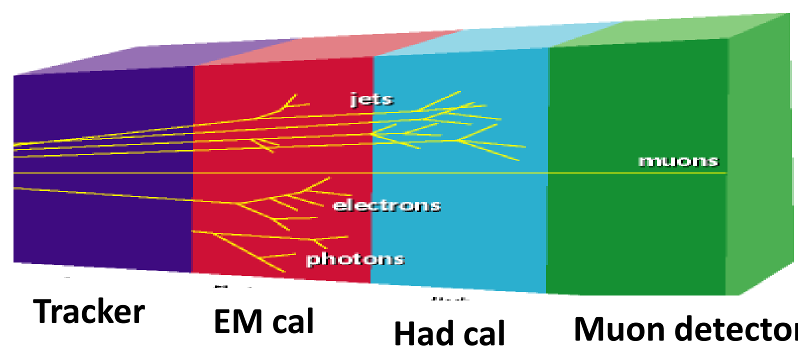
- $p\bar{p}$ collider : c.m. energy 1.96 TeV
- Direct Higgs search is capable in Tevatron only





CDF Detector



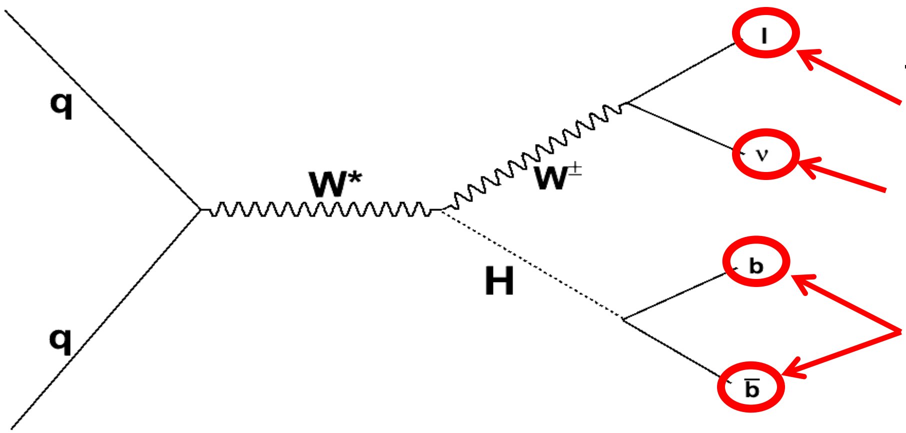


Analysis

- **Analysis Overview**
- ***b* Flavor Tagging Algorithm**
- **Event Selection**
- **Signal and Background Estimation**
- **Search for Higgs Boson with NN Discriminant**

Analysis Overview

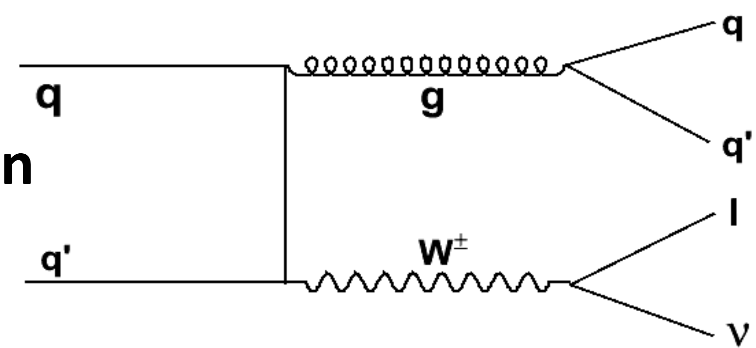
- Signal ($WH \rightarrow l\nu b\bar{b}$) Signatures



Final State
One lepton (electron or muon)
Large missing transverse energy from neutrino (MET)
Two jets derived from *b* quark

- Main Backgrounds : *W*+jets

jets : (light flavor quark (*u*,*d*,*s*), gluon
and heavy flavor quark(*c*,*b*))



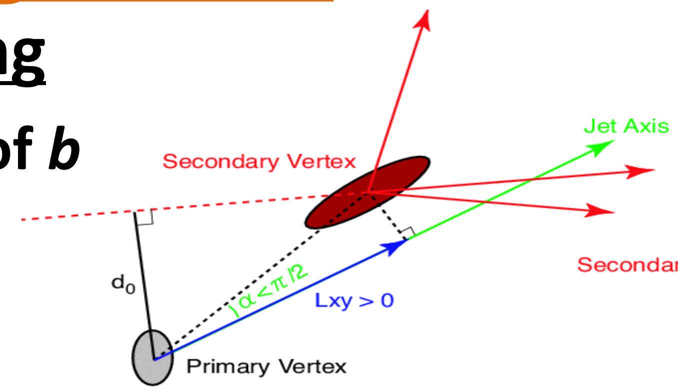
Why *b*-tagging is important?

- Signature of signal is *W*+2jets → Enormous *W*+jets background : $\sigma_{W+jet}/\sigma_{sig}$ = ~20000
- After requiring lepton, MET, 2jet : N_{bkg}/N_{sig} = ~5000 N_{sig} =~6

b Flavor Tagging Algorithm

1. Secondary Vertex (SECVTX) *b*-tagging

- ✓ Identify *b*-jets using the long lifetime of *b* hadron
- ✓ tagging eff : ~40%, fake rate : ~ 1%



2. Jet Probability *b*-tagging

- ✓ Identify *b*-jets using impact parameter of track in jets
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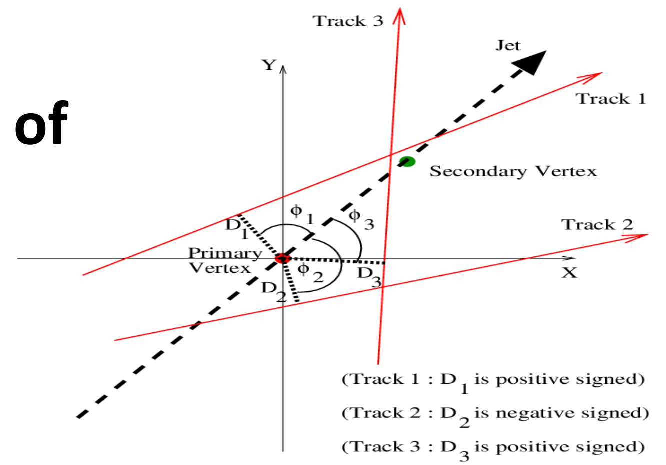
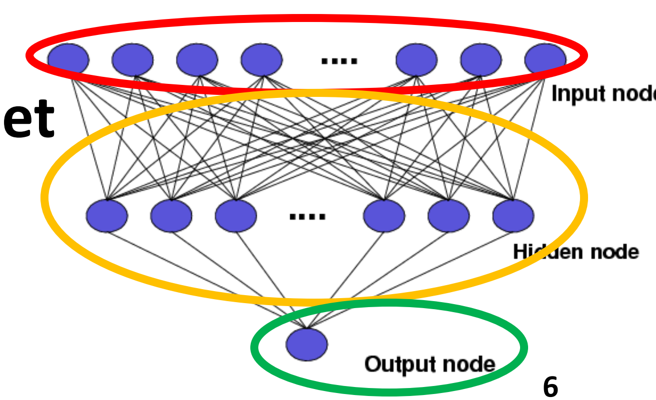


3. Neural Network (NN) *b*-tagging

- ✓ Use 16 jet parameters (L_{xy}, N_{trk}, M_{vtx} …)
- ✓ Optimize NNs to separate *b*-jet from *c*-jet and light-jet
- ✓ Keep 90% *b*-jet, reject 65% light-jet, 50% *c*-jet (for SECVTX tagged jets)



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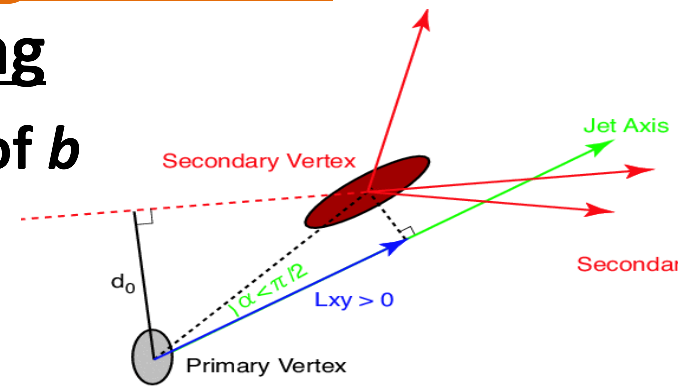

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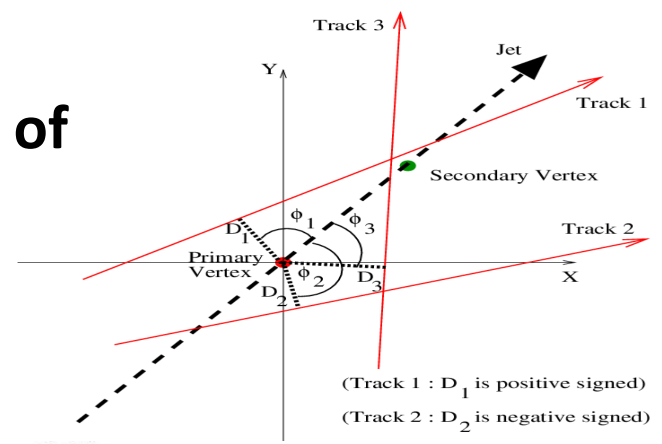

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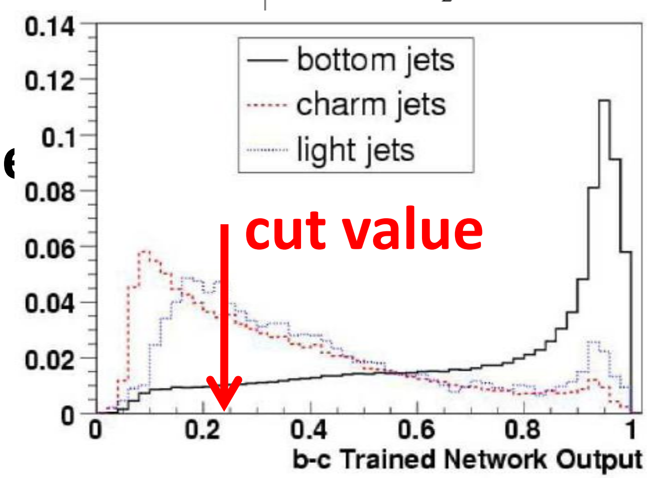


Event Selection

- **Baseline Selection**
  - High p_T central isolated electron or muon
  - High missing transverse energy
  - Exact two high E_T jets
  - At least one SECVTX *b*-tag

W boson selection

W + 2jets selection

- ***b* Flavor Tagging Category**
  1. Double SECVTX *b*-tag : (ST+ST)
  2. SECVTX + Jet Probability *b*-tag : (ST+JP)
  3. SECVTX *b*-tag w/ NN tag : (1NNtag)

Two *b*-tag events
✓High S/B
✓Low statistics

One *b*-tag events
✓High statistics
✓Low S/B

Background Estimation

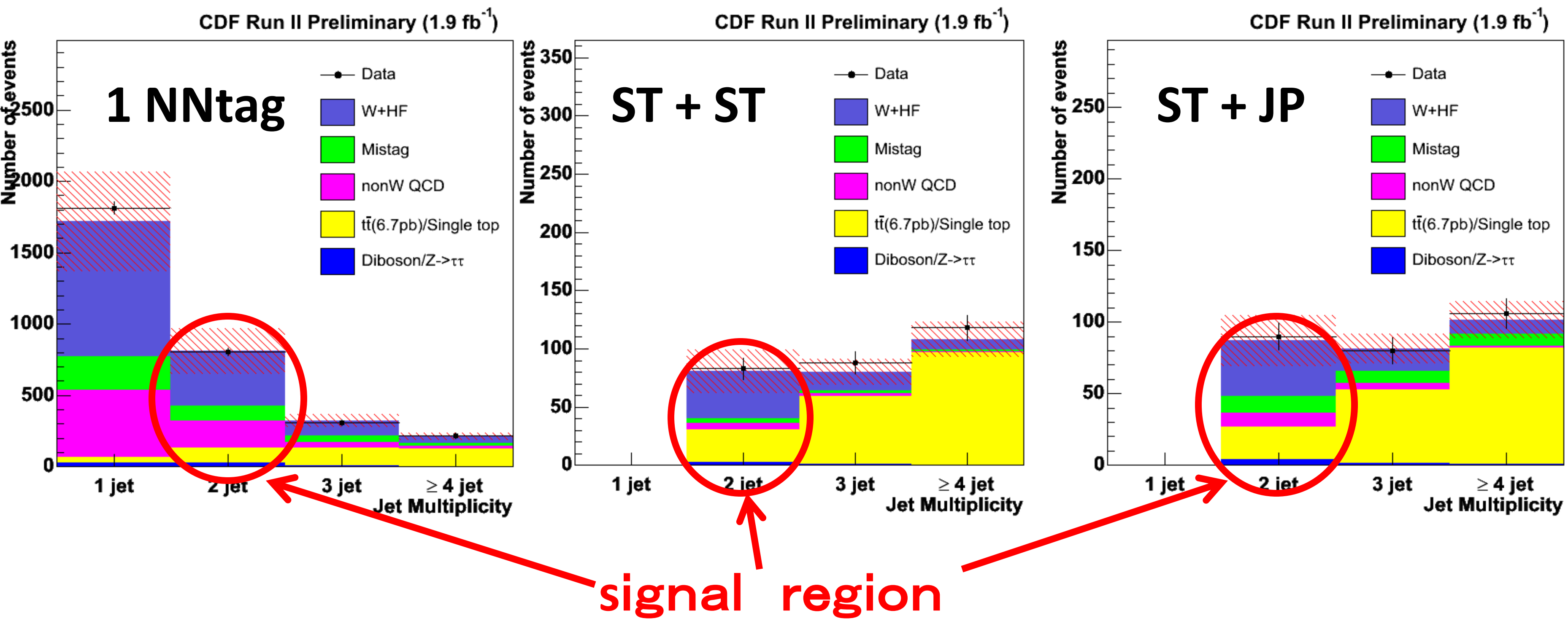
- These event selections contain many kinds of backgrounds → Key is understanding backgrounds
- <u>Background Components</u>
  - QCD (non-W)
  - W+LF (Mistag)
  - W+HF ($W+b\bar{b}$,$W+c\bar{c}$)
  - $t\bar{t}$
  - single top
  - Diboson (WW,WZ,ZZ)
  - $Z\rightarrow\tau\tau$

Fake backgrounds
Data based estimation

Dominant backgrounds
Data and MC based estimation

Other physics backgrounds
MC based estimation

Number of Signal and Background



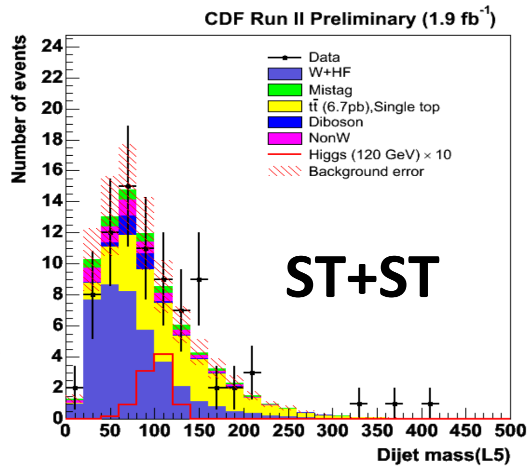
Tagging Categories	1tag w/ NNtag	ST + ST	ST + JP
Data (before *b*-tagging)	32242		
Total Backgrounds	809.61±159.38	80.62±18.75	86.99±17.99
WH signal(120 GeV)	1.82±0.15	0.94±0.11	0.74±0.09
WH acceptance (%)	0.93±0.05	0.48±0.05	0.38±0.38
Observed Data	805	83	90

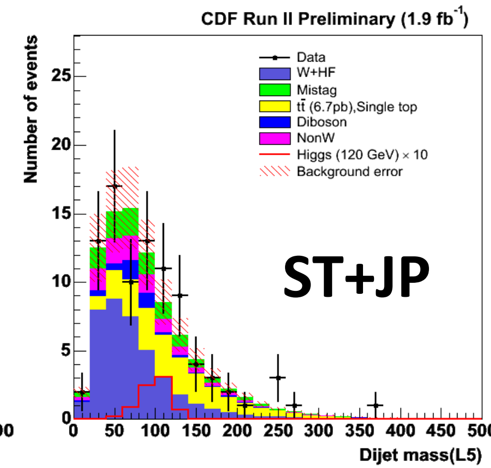
Search for Higgs Boson

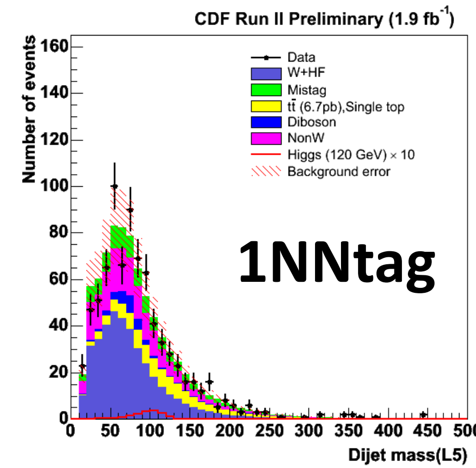
Check excess in dijet mass distribution

⇩

No significant excess !!

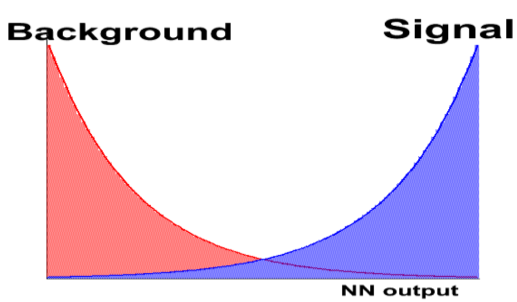






Neural Network Discriminant

- ✓ Input (some event kinematic variables)
- ✓ Neural Network is trained by MC samples (Higgs Signal, *W*+jets, $t\bar{t}$, single top)
- ✓ Signal discriminates from backgrounds with NN output



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6 Neural Network inputs

✓ **Dijet mass+**

: include looser jet (E_T>12, |η|<2.4) if ΔR(selected jet-loose jet) < 0.9

✓ **p_T imbalance**

: $p_T(j1)+p_T(j2)+p_T(l)$-MET

✓ **p_T(*W*+2jets)** : p_T of *W*+2jets system

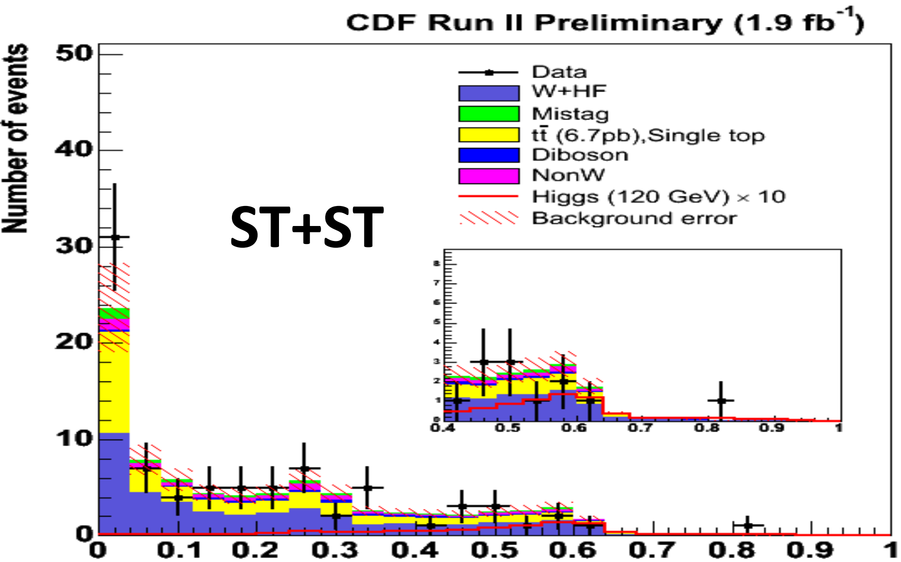
✓ **Sum E_T of loose jets**

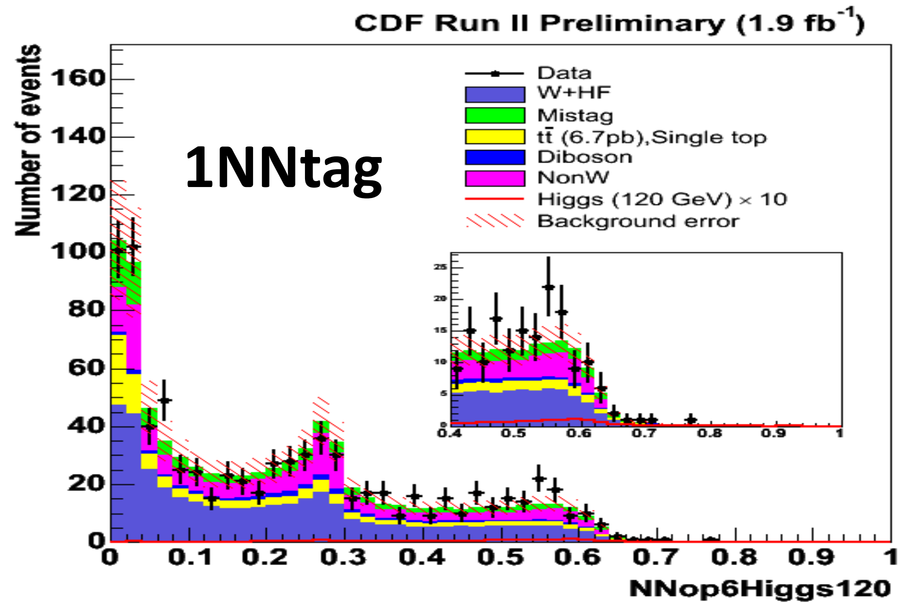
✓ **ΔR(lepton-ν)** : $\Delta R = \sqrt{\Delta\varphi^2 + \Delta\eta^2}$

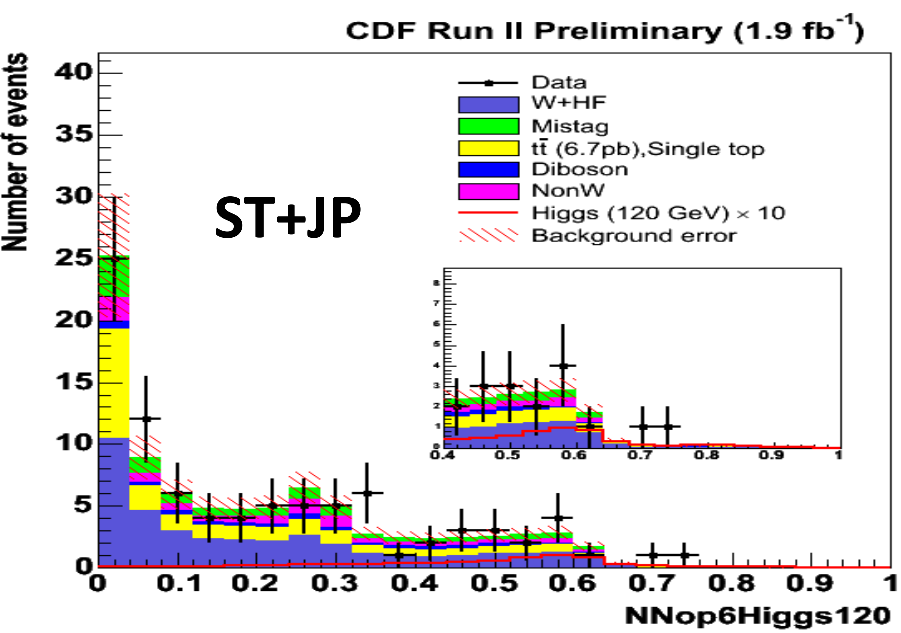
✓ **$M_{l\nu j}$** : minimum invariant mass of l,ν, jet1 or jet2

NN Output Distribution

- Check NN output distribution instead of dijet mass





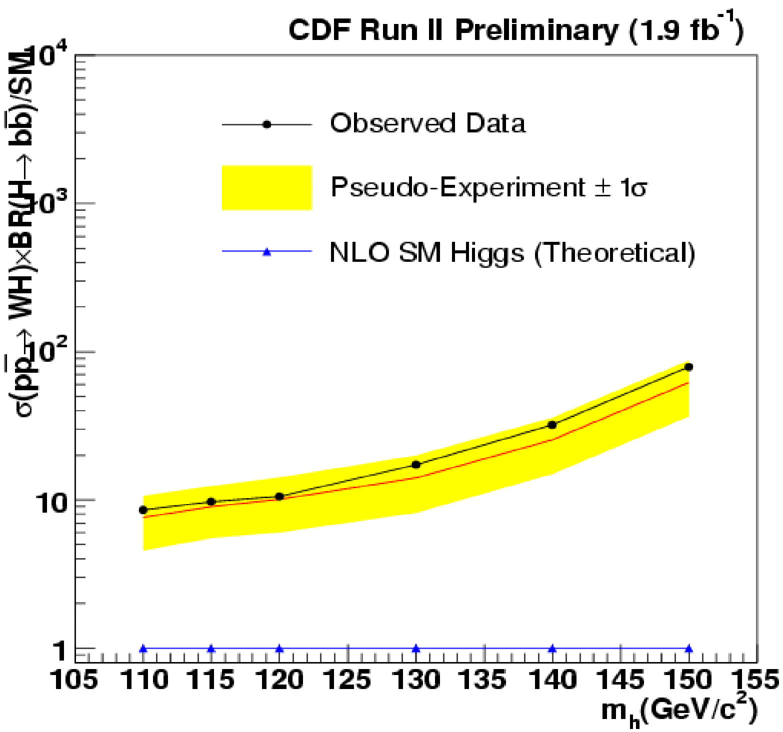


No significant excess in even NN output variable

<u>Set 95% C.L. upper limit on Higgs boson production cross section</u>

95% C.L. Upper Limit Result

- $\sigma(p\bar{p} \to WH) \times BR(H \to b\bar{b})$ upper limit is calculated from NN output fitting of 3 *b*-tagging categories (binned likelihood)
- Observed limit is consistent with null signal hypothesis



Mass	ST+ST & ST+JP & 1NNtag [pb] , (normalized by SM)
110 GeV	1.38 (8.5)
115 GeV	1.28 (9.7)
120 GeV	1.08 (10.5)
130 GeV	1.08 (17.2)
140 GeV	1.98 (31.9)
150 GeV	1.93 (78.9)

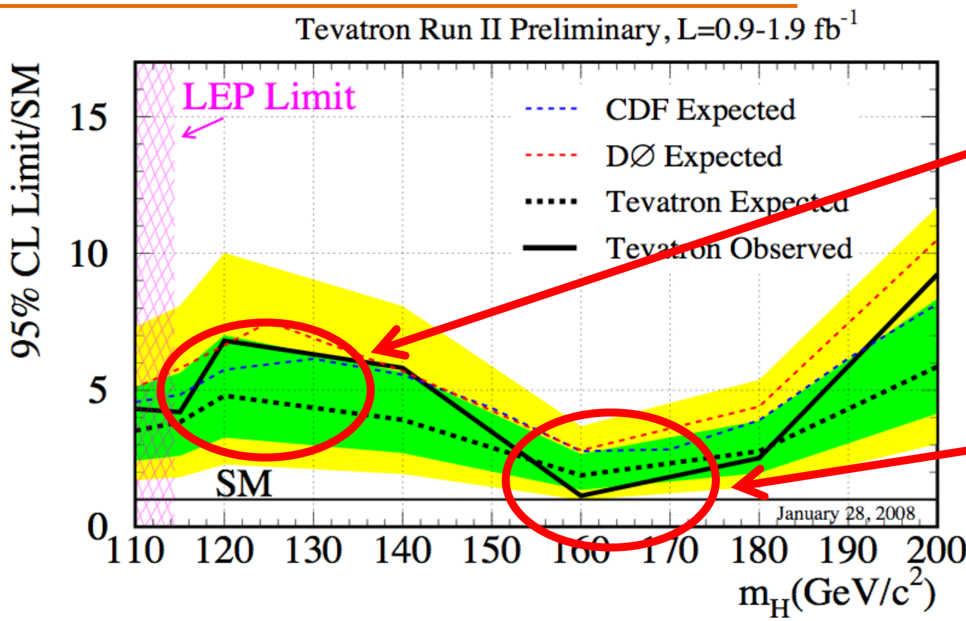
Summary and Tevatron Results

- Search for the Standard Model Higgs boson (*WH*) channel using 1.9fb^{-1} dataset collected at CDF
- Use three *b* flavor tagging categories (ST+ST, ST+JP, 1NNtag)
- Apply NN discriminant instead of dijet mass
- No evidence of Higgs signal ➔ Set upper limit

$$\sigma(p\bar{p} \to WH) \times BR(H \to b\bar{b}) < 1.4 - 0.9\text{pb@95\%C.L.}$$

~ 10 times higher than SM in low mass region

Tevatron Combined Result

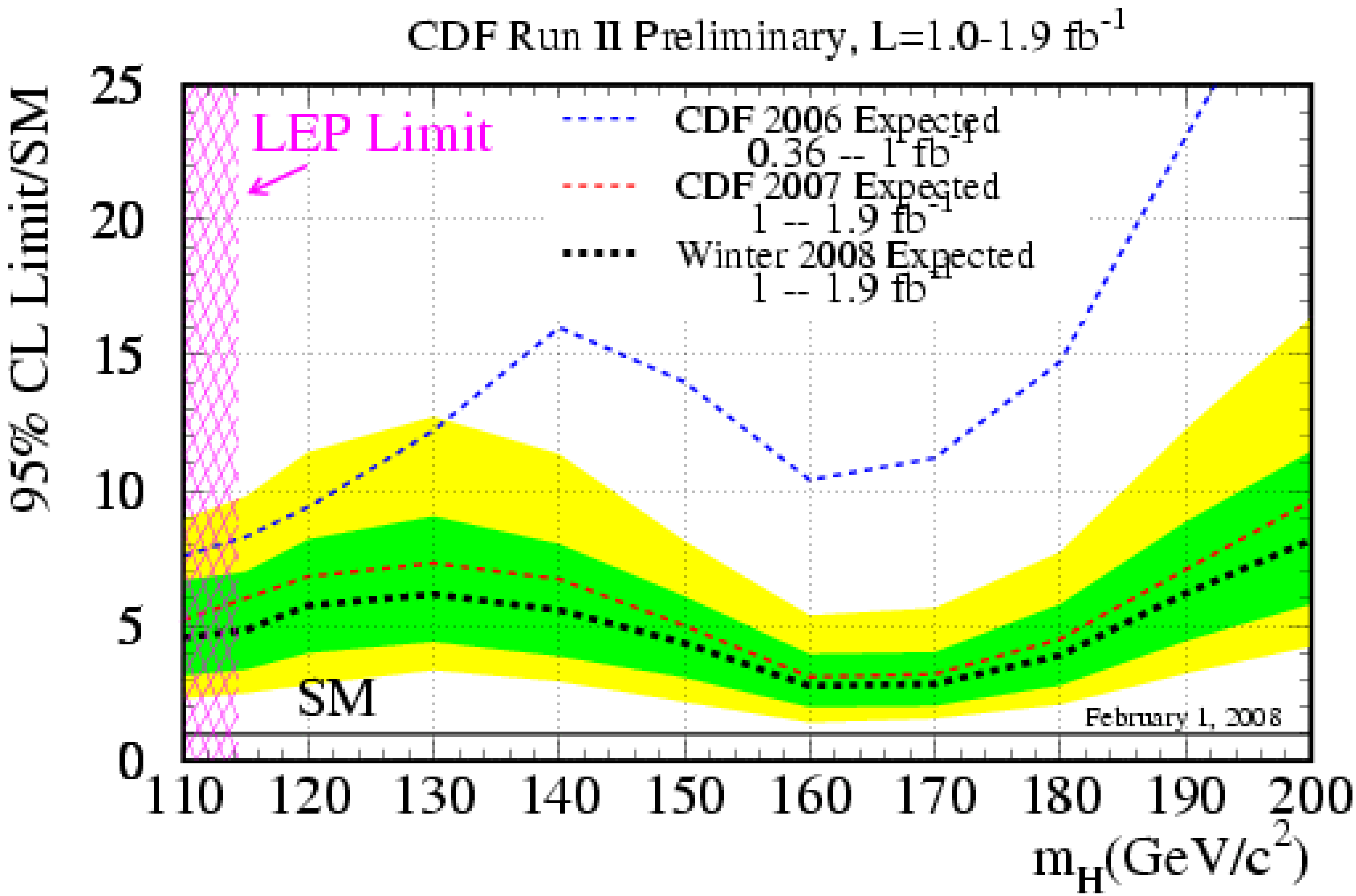


M_h = 115 (120) GeV
~ 3.8 (4.8) expected
~ 4.2 (6.8) observed

M_h = 160 GeV
~ 1.9 expected
~ 1.1 observed

BACK UP

CDF Sensitivity progression



Future Prospect