Search for Standard Model Higgs Bosons in Association with W bosons

(CDF note 8355)

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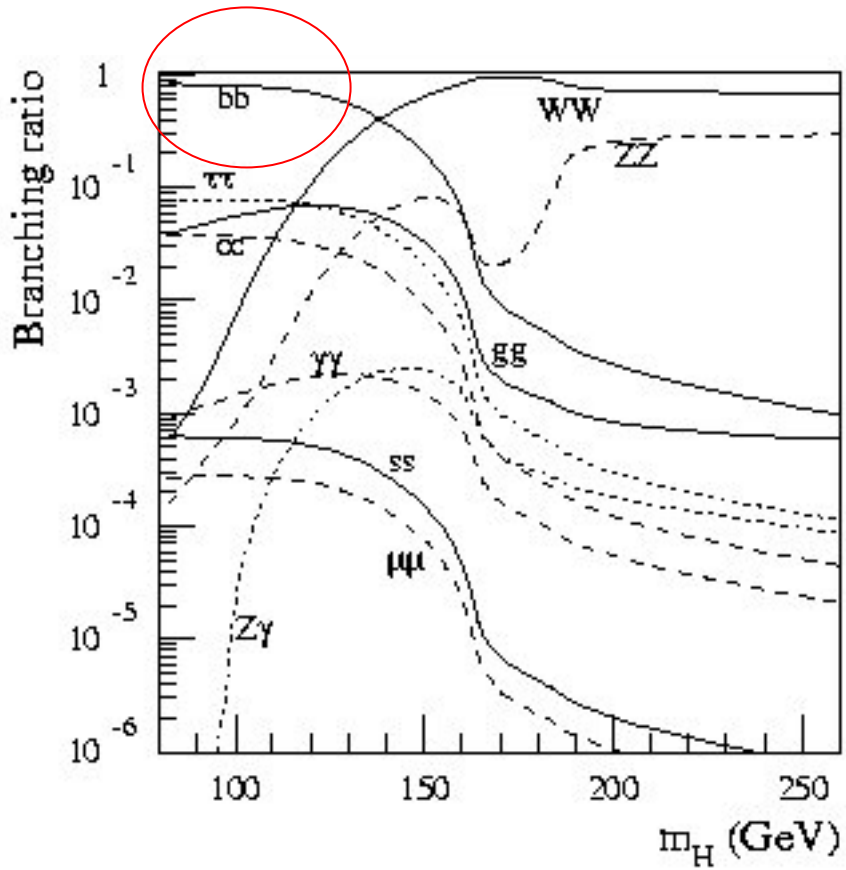
- **Motivations**
- **Data Sample**
- **B tagging**
- **Backgrounds**
- **Results**
- **Summary**

Motivations

- Higgs boson is predicted in SM and not yet observed experimentally
  - Mass constrained to [114.4,182] at 95% confidential level by LEP2 and EWK data global fits
- HW->lvbb is a promising channel
  - Last CDF analysis limited by W + c/l.f., new analysis use NN to further suppress charm and l.f. jets.



Data Sample and Event Selection

- 1 pb^{-1} of proton-antiproton collision data
  - Bhel, bhmu: 0d+0h+0i
- Event selection
  - **Exactly one ele (CEM) or one muon (CMUP/CMX), p_T/E_T > 20, iso < 0.1**
  - **Uncorrected MET > 20**
    - **No delta phi cut on MET and leading jet**
  - **Jet E_T > 15, |eta| < 2 (JetCorr06, level 4)**
    - **Signal: TL+2jet**
    - **Calibration sample for background estimation: TL+1,3,4 jets bins**
  - **Dz < 5 cm**
  - **Reject events with >1 isolated lepton and invariant mass in [76,106] to suppress Z, diboson background**
  - **Single or double SECVTX tagged events**
    - **Plus Neural Network for single tagged events**

Neurl Network b-tagging

- Builds on the SECVTX secondary vertex tagger
  - Separate b jets from c and l.f. jets
  - Two neural networks using 16 jet variables below
    - 8 variable are properties of SECVTX tag
      - # of tracks, transverse decay length and its significance
      - Fit chi2, pseudo-ctau, vertex mass,
      - Vertex pT divided by the sum of good tracks' pT
      - Vertex pass number
    - 8 variables are independent of SECVTX (for pass 1 and pass2 tracks)
      - # of good tracks, reconstructed mass
      - total pT of tracks divided by jet pT
      - Jet probability value
  - Trained on and applied to SECVTX tagged sample.

NN b-tagging Performance

- **90% b efficiency (after SECVTX efficiency)**
- **Reject 65% of l.f. (cut @ 0.182) jets, 50% f c jets (cut @ 0.242)**

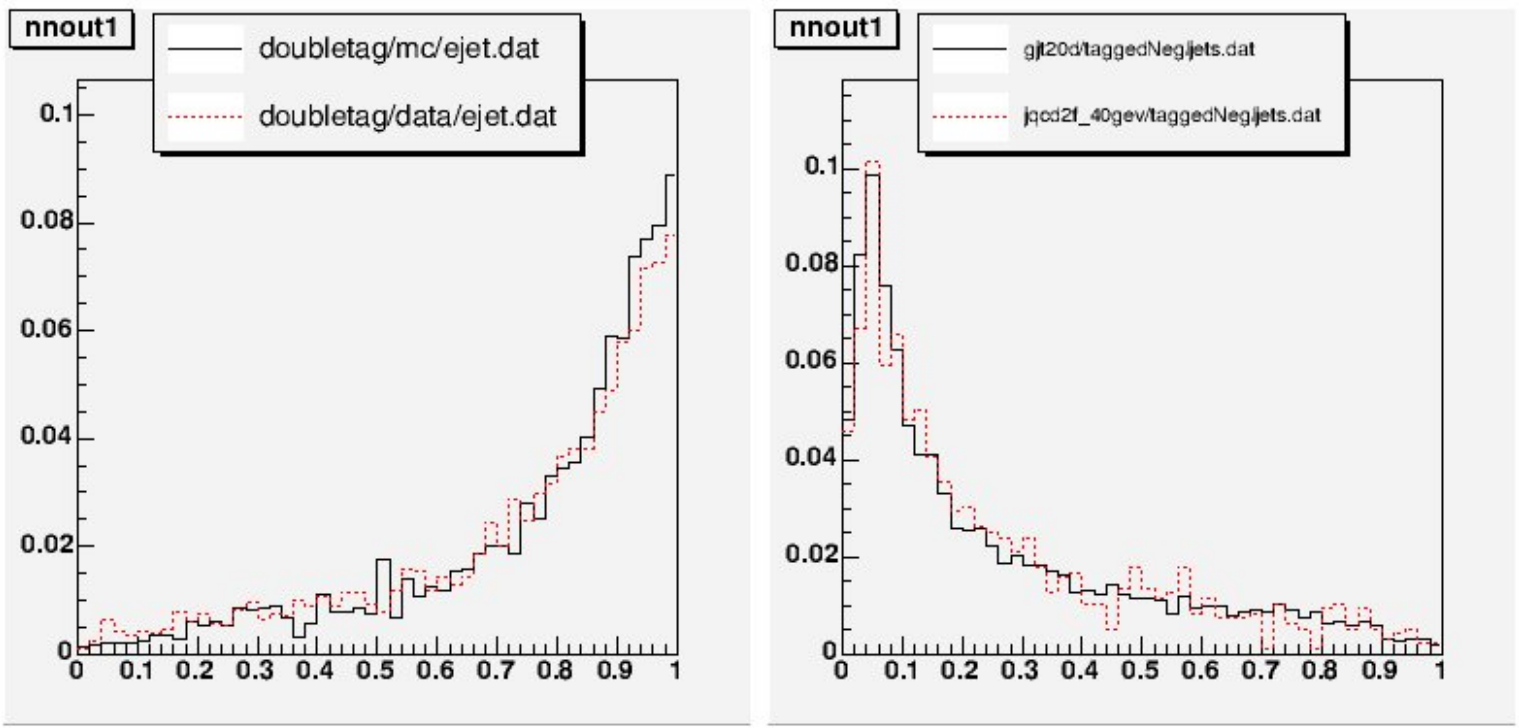


Figure 2: Comparisons of NN b-tag output in data and Monte Carlo for SECVTX-tagged heavy-flavor-enriched jets (left) and tagged light-flavor jets (right).

Background Estimation

- **Main background contributions**
  - **Ttbar production**
    - **NLO PYTHIA (Xs = 6.7pb, m = 175GeV/c^2)**
  - **Non-W multijet (QCD)**
    - **Iso-MET method**
  - **W+jets production**
    - **W+l.f.**
      - **Tagging rate is measured in jet sample binned in phi, eta, pT and track multiplicity**
    - **W+h.f.**
      - **Heave Flavor fraction of Wbb, wcc, wc estimated from Alpgen sample (x1.5 scale factor to match to data)**

$$N_{W+HF} = f_{HF} \cdot \epsilon_{\text{tag}} \cdot [N_{\text{pretag}} \cdot (1 - f_{\text{non}-W}) - N_{\text{EWK}}]$$

- **Other small backgrounds**
  - **Simgle top, diboson, Z->tautau**
  - **Estimated with MC sample**
    - **Use theoretical Xs number**
    - **Fully simulated PYTHIA sample to derive acceptance**

Background Summary Table

Jet Multiplicity	1jet	2jet	3jet	$\geq$4jet
Observed Events (pretag)	94009	14583	2361	646
Mistag	139.7 ± 27.3	53.9 ± 10.7	15.5 ± 3.1	4.1 ± 0.8
$Wb\bar{b}$	306.8 ± 106.9	144.5 ± 49.3	29.9 ± 9.7	6.4 ± 2.5
$Wc\bar{c}$	63.1 ± 22.0	43.0 ± 14.7	8.7 ± 2.8	1.9 ± 0.8
Wc	185.7 ± 47.2	34.3 ± 9.0	3.4 ± 0.9	0.6 ± 0.2
$t\bar{t}$ (6.7 pb)	6.8 ± 1.2	42.0 ± 6.6	84.8 ± 12.8	98.6 ± 14.3
Single Top	16.3 ± 1.7	22.9 ± 2.3	4.7 ± 0.5	0.8 ± 0.1
Diboson/$Z \rightarrow \tau\tau$	12.0 ± 2.2	14.0 ± 2.3	4.0 ± 0.9	1.0 ± 0.3
Non-W QCD	80.0 ± 13.6	37.1 ± 7.7	11.5 ± 2.6	5.4 ± 1.2
Total Background	810.5 ± 140.6	391.6 ± 66.6	162.5 ± 18.8	118.7 ± 14.9
Observed	857	418	177	137

Table 1: Estimated background contributions to the single-tagged (exactly one tag) W+jets sample, after the NNBTAG filter has been applied.

Plot for the Samples' Compositons

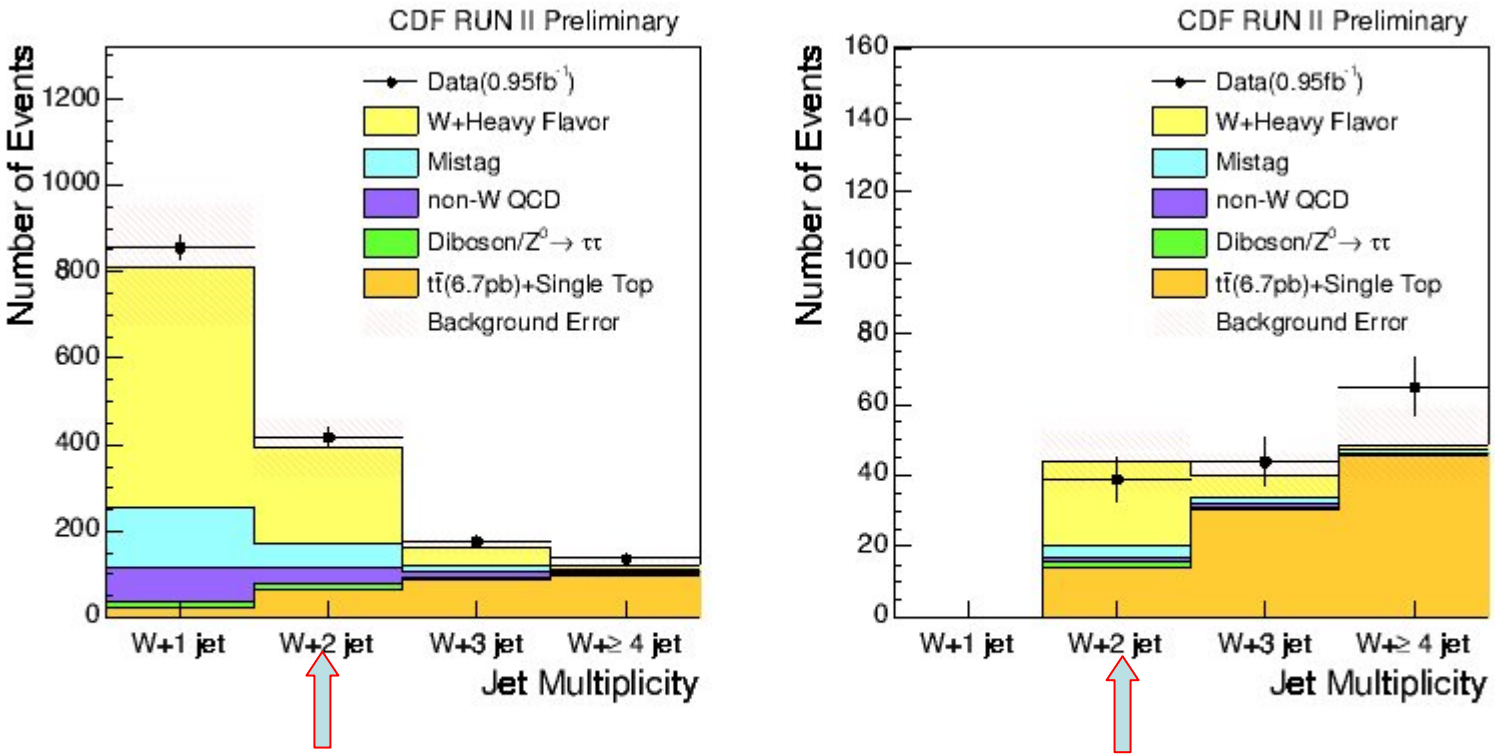
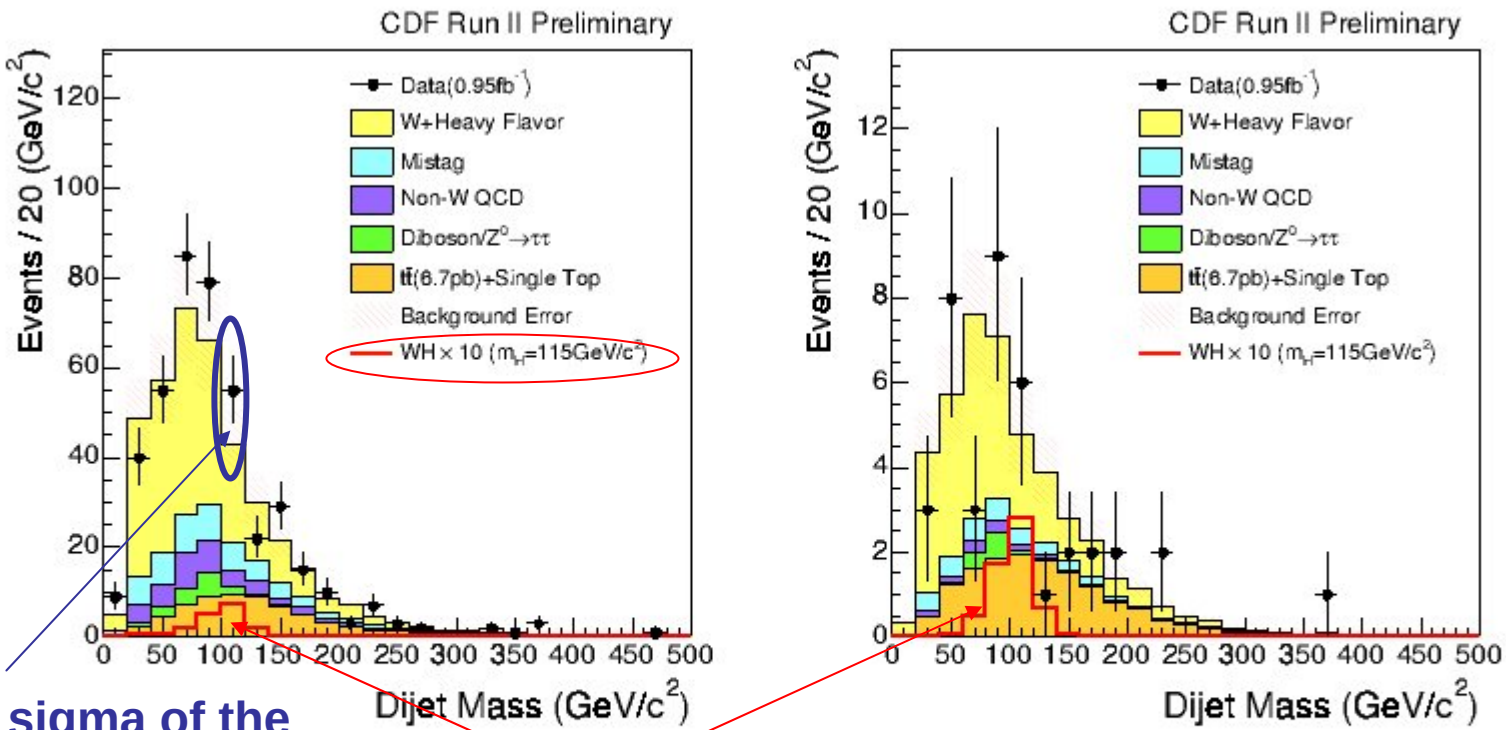


Figure 3: Number of events as a function of jet multiplicity in the single-tagged sample (left) and double-tagged sample (right).

Hunt for a resonant peak in 2jet bin



< 1 sigma of the bkg fluctuation

WH signal

Figure 5: Dijet invariant mass spectrum in tagged W+2-jet events, afer requiring either exactly 1 SECVTX tag passing the NNBTAG filter (left) or double SECVTX tags (right).

Acceptance

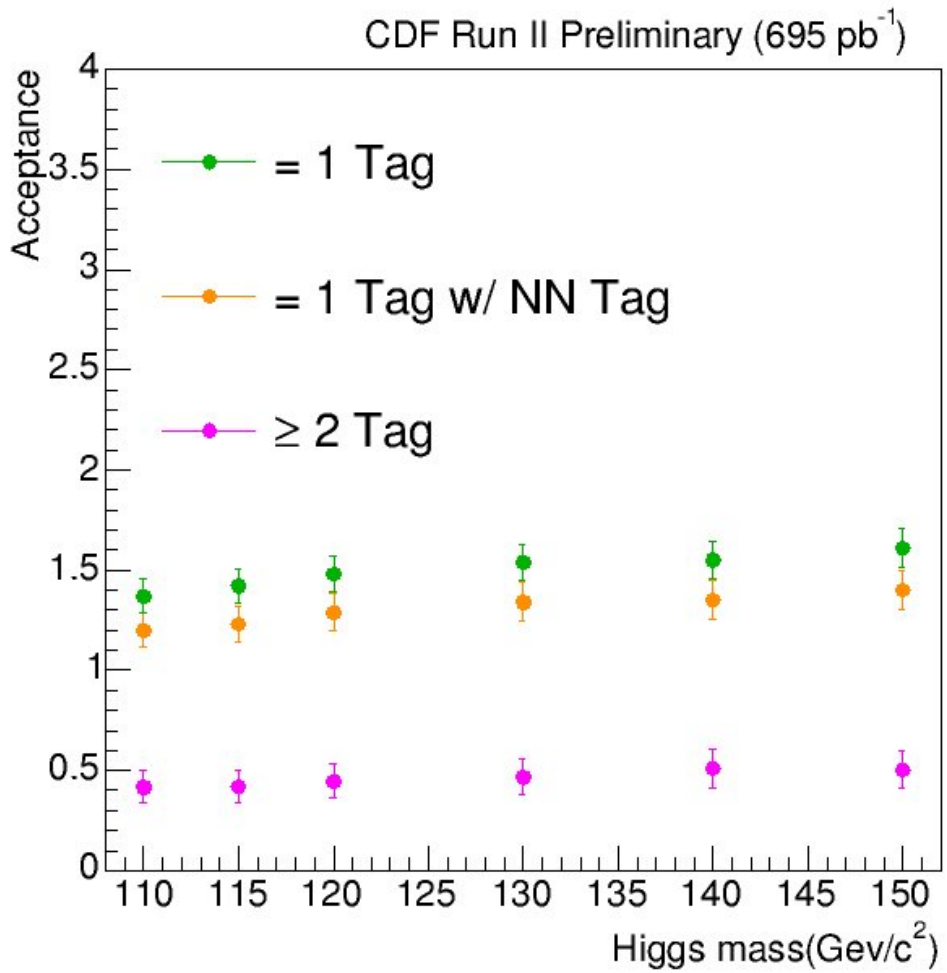


Figure 4: WH signal acceptance as a function of Higgs boson mass for the different b-tagging selections. Phoenix electron reconstruction is not included in this acceptance.

Final Result

- Limit on # of Higgs boson events are derived using a binned likelihood method following Poisson statistics (best result to combine single-tagged and double tagged events)
- Use PYTHIA sample for the acceptance of WH->lvbb
  - Include trigger efficiency, lepton ID, scale factor in the acceptance
- The 95% confidential level Xs upper limit

$$\int_0^{s_{up}} L(s)ds \Big/ \int_0^{\infty} L(s)ds = 0.95$$

3.9 to 1.3 pb for H-mass hypotheses [110,150] GeV/c^2

Systematic Uncertainties

- Heavy Flavor fraction
- JES:
  - 2.3% (1 tag)
- ISR/FSR:
  - 1.5% (3.5% MC statistic), total 3.9%
- Lepton ID, trigger efficiency:
  - 2%, 1%
- PDF
  - 1.7%