Searches for Standard Model Higgs and Techniparticles in the e-ν plus heavy flavours final state at DØ

Lorenzo Feligioni

Boston University

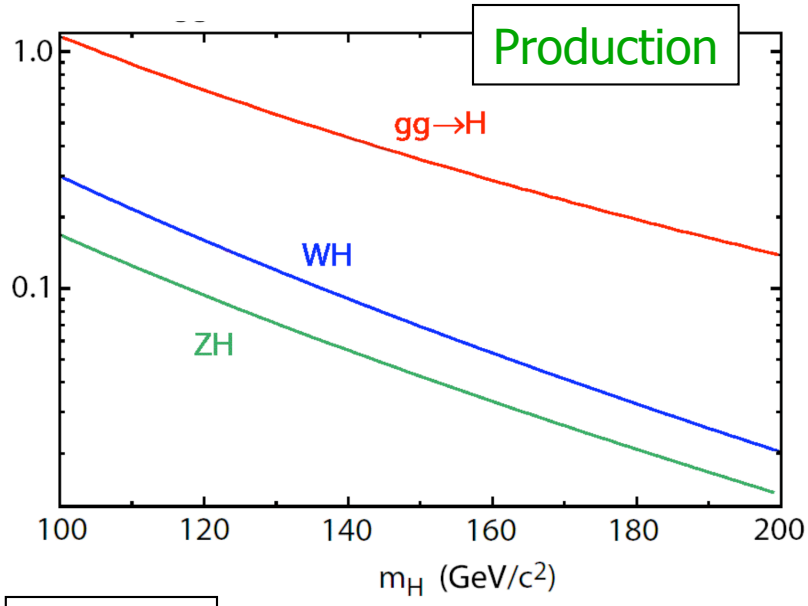
for the DØ collaboration

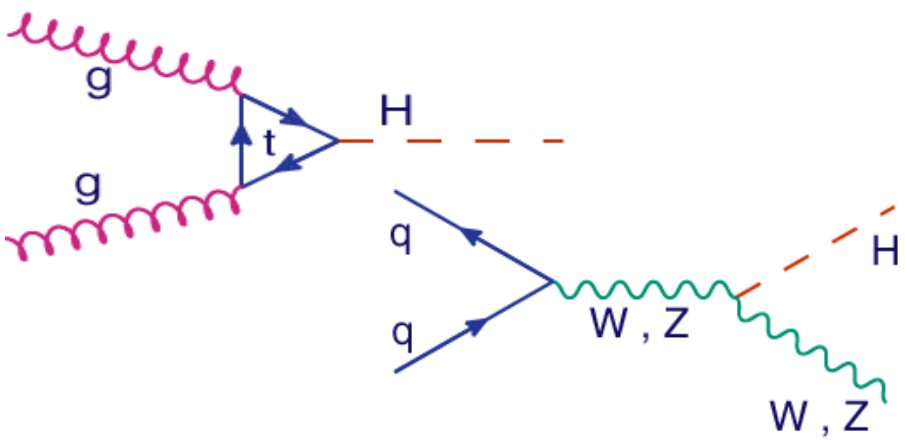
- Electroweak Symmetry Breaking Phenomenology:
  - Standard Model Higgs
  - Technicolor
- Experimental Signatures in W + heavy flavours:
  - $W\pi_T \rightarrow e\ \nu\ b\ b/c$
  - $WH \rightarrow e\ \nu\ b\ b$
- Cross Section Limits

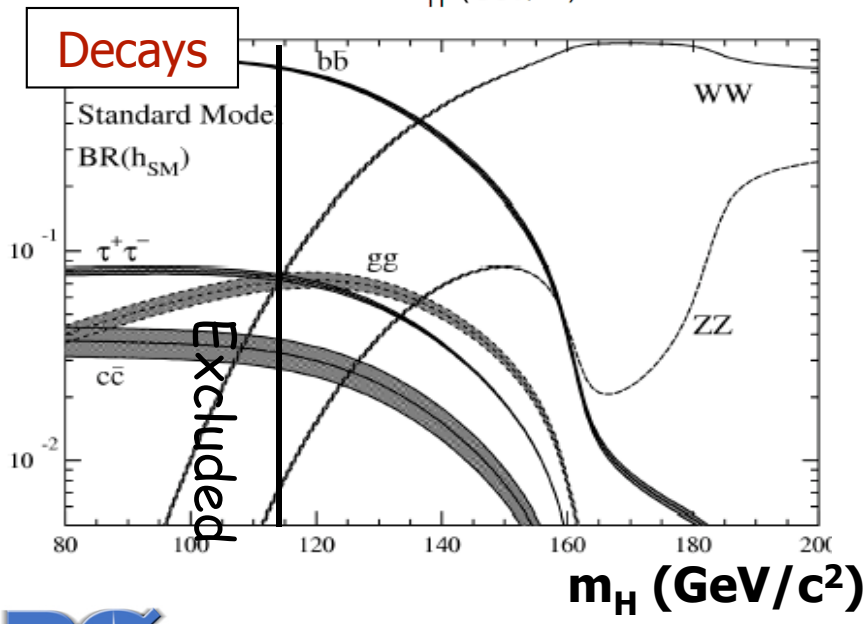
Electroweak Symmetry Breaking

- Mechanism of electroweak symmetry breaking
  - Standard Model and Supersymmetry:
    - Higgs field ⇒ Higgs boson
      - **Weakly coupled, light fundamental scalar**
  - Technicolor:
    - New strong dynamics: SU(N_{TC}) gauge theory analog to QCD
    - N^2_{TC} - 1 new gauge bosons: technigluons
    - In analogy with QCD breaking of the chiral symmetry produces Goldstone bosons (technipions):
      - 3 technipions are eaten to become W_L and Z_L
      - others could be observed at collider experiments

SM Higgs: Production and Decays







Production cross section

→ in the 1.0-0.1 pb range for gg → H

→ in the 0.2-0.02 pb range for associated vector boson production

Dominant Decays

→ bb for M_H < 135 GeV

→ WW* for M_H > 135 GeV

Search strategy:

M_H <135 GeV WH and ZH with H→bb

M_H >135 GeV gg →H WW*

SM Higgs: direct and indirect limits

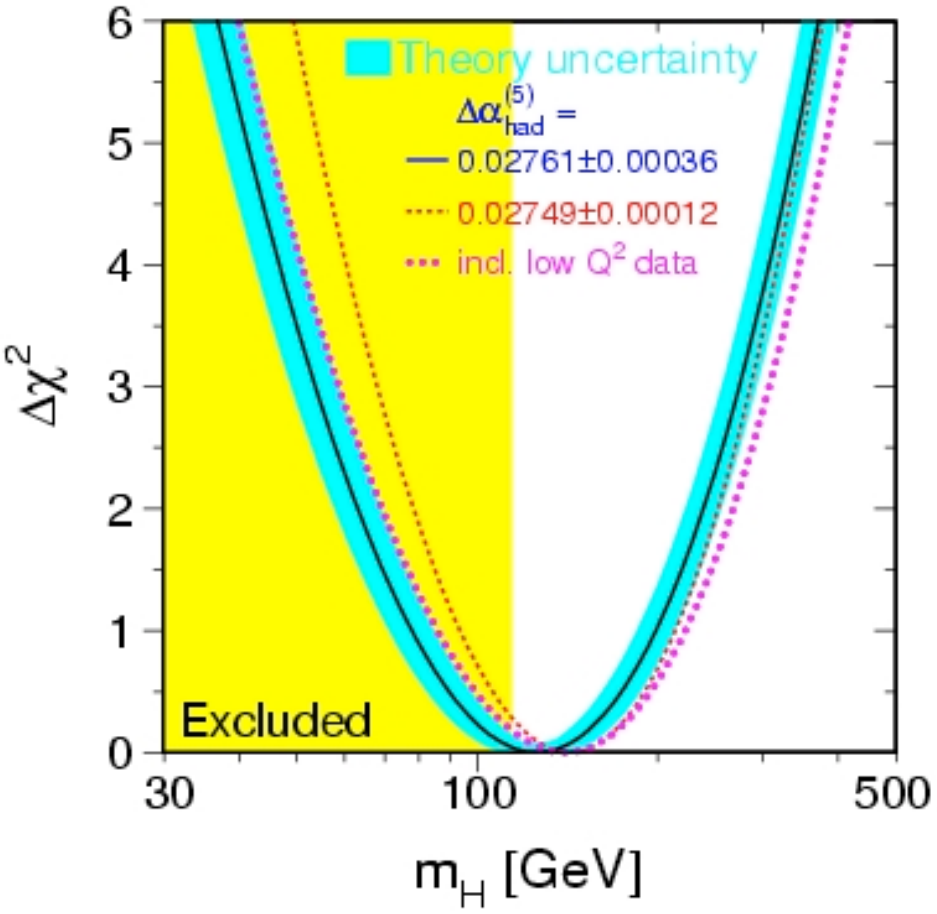
→ Direct searches at LEP

M_H >114 GeV at 95% C.L.

→ Precision EW fits (winter 2005)

$M_H = 126^{+73}_{-48}$ GeV

$M_H \leq 280$ GeV @ 95% C.L.



- Higgs seems to be relatively light
- Until about 2008, the Tevatron is the only place to search for Higgs, and with good chances
  - Mass range favorable to Tevatron's reach

Low Scale Technicolor Models

- Large numbers of technifermions are the natural choice for several Technicolor Models
  - Walking Technicolor
    - Evade large flavor changing neutral current
  - Topcolor-assisted Technicolor
    - Many technifermions are needed to generate hard masses for quarks and leptons
  - **Technicolor Straw Man Model (TCSM2):** K. Lane, S. Mrenna hep-ph/02110299
    - Set the scale for calculating lowest-lying bound state of lightest technifermion doublets
    - color singlet vectors (200 – 400 GeV)
      - produced in pp collisions
        - » Decays:

$\omega_T \to \gamma\pi_T$, γZ, $3\pi_T$, f f,g g

$\rho_T \to \pi_T\,\pi_T$, $W\pi_T$, $Z\pi_T$, WW, f f,g g

$\rho_T \to \pi_T\,\pi_T$, $W\pi_T$,$Z\pi_T$, WZ

    - color-singlet scalars
      - lightest technihadrons π_T^0 $\pi_T^{+/-}$
        - » Decays:

$\pi_T \to$ ff,gg ($\pi_T^0 \to bb$, $\pi_T^{+/-} \to bc$ dominate)

Previous Searches

- TCSM2 Parameters:
  - N_D : number of technifermion doublets
  - $Q_D = Q_U - 1$: technifermion charge
  - $\sin\chi$: mixing angle
  - M_V : mass parameter (it controls technifermions coupling and decay mode)
- Previous searches

CDF RunI

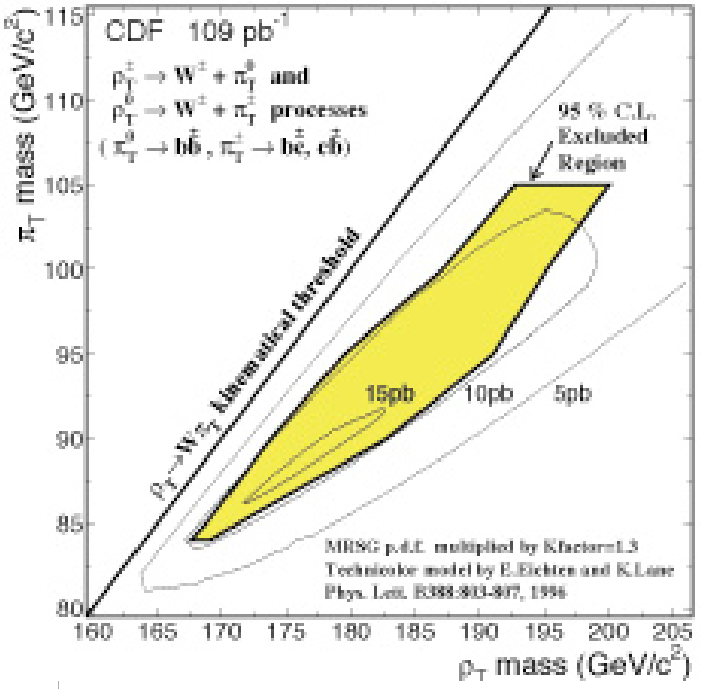
- $W\pi_T$ and $\omega_T \rightarrow \gamma\pi_T$
- $M_V = 100$

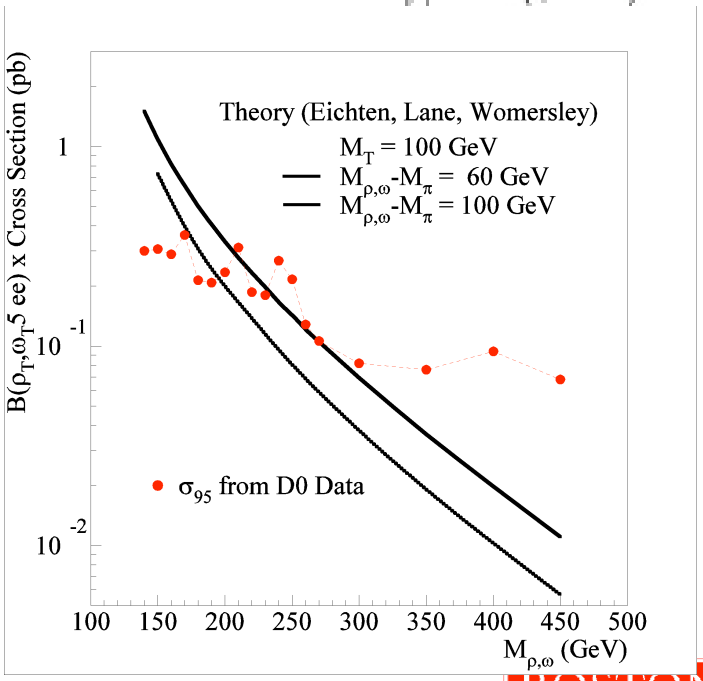
DØ RunI

- $\rho_T/\omega_T \rightarrow ee$
- $M_T = M_V = 100$ to 400
- $M(\rho_T/\omega_T) - M(\pi_T) = 60, 100$ GeV
  - $M_V = 100$ GeV $\Rightarrow W\pi_T$ channel open

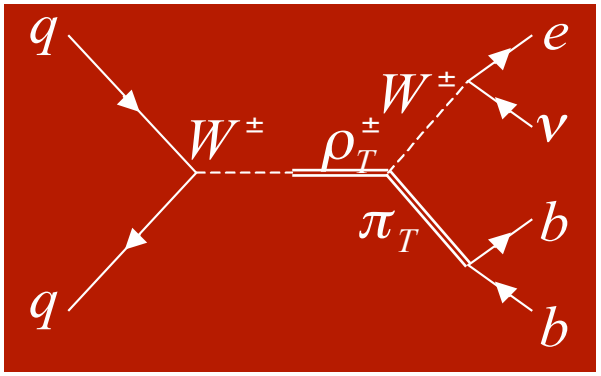
LEP

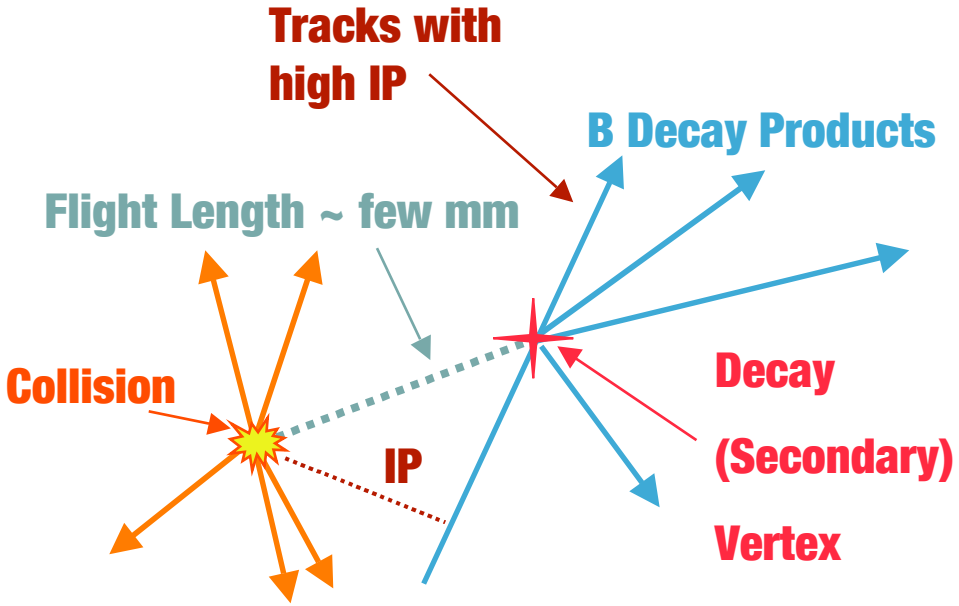
- $\rho_T \rightarrow WW$, $\rho_T \rightarrow \pi_T W$ (DELPHI)
- $M(\pi_T) = 105$ GeV $M(\rho_T) = 200$ GeV is excluded for some TCSM parameters



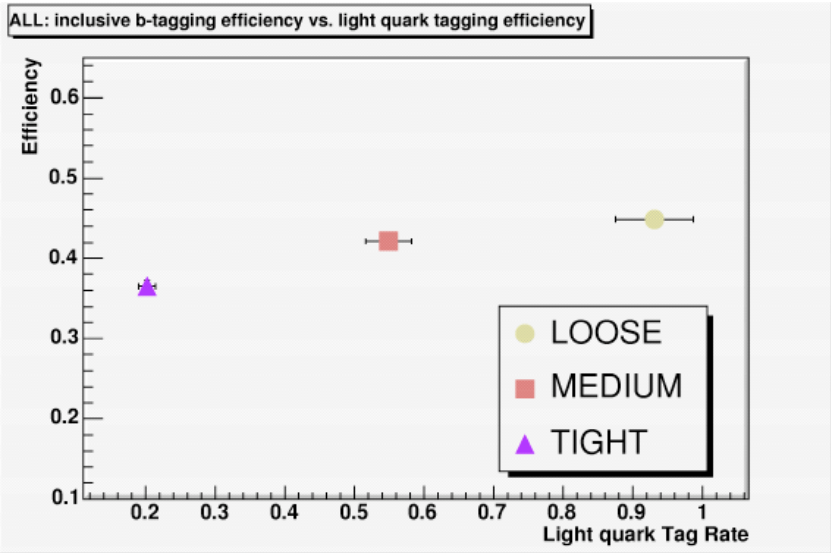


W+Heavy Flavours Events Selection





- One reconstructed Primary Vertex
- One isolated electron
  - veto on the presence of another electrons suppress Z contamination
- Missing E_T > 20 GeV
  - eliminates multi-jets (QCD)
- Two calorimeter jets
  - Veto on a third jet, suppresses tt background
- B-tagging
  - At least one jet has to be associated with a Secondary Vertex (W π_T)
  - Two jets associated with high Impact Parameter tracks (WH)



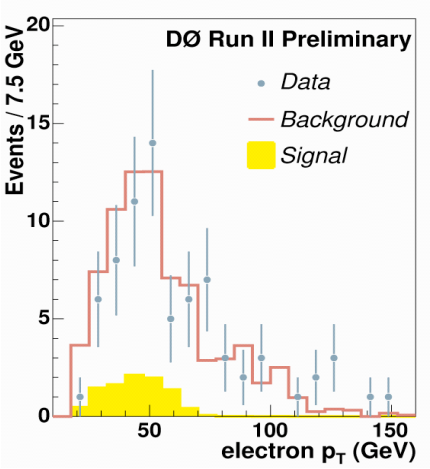
$W\pi_T$ Searches: single b-tag

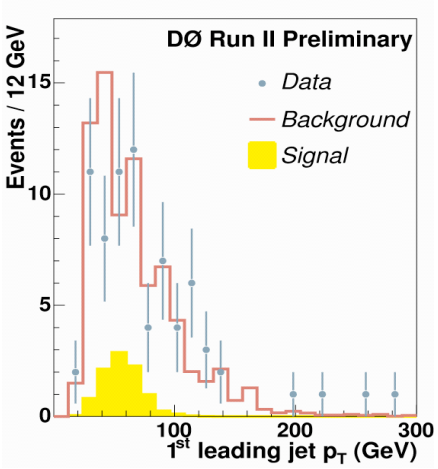
$M(\pi_T)$ = 105 GeV $M(\rho_T)$=200 GeV

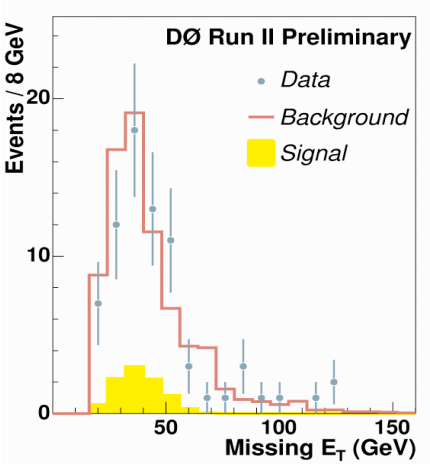
Cross sections ($W\rightarrow e\nu$), M_V=200:

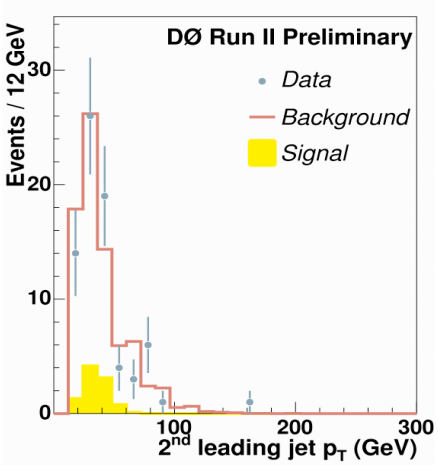
- $W\pi_T^{+/-}$ ~ 3.7 pb
- $W\pi_T^{0}$ ~ 2.9 pb

$\int \mathcal{L}\, dt$ = 238 pb^{-1}









Data	74

Sources of Background

Physics Background

tt	15
Single top	4
W+ Heavy Flavors	33
WZ	1
Z→ee	2
total	55

Instrumental Background

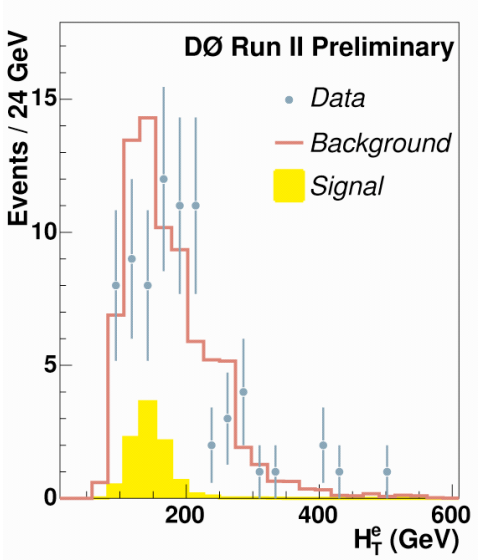
QCD	7
W + light quarks	11

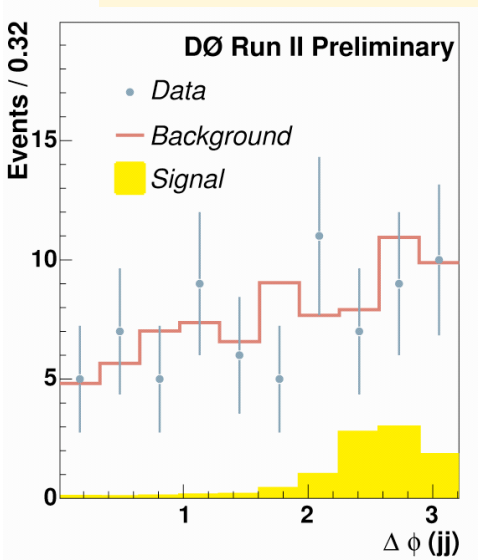
Tot Backd	73 ± 19
Expected Signal	9.1 ± 1.3

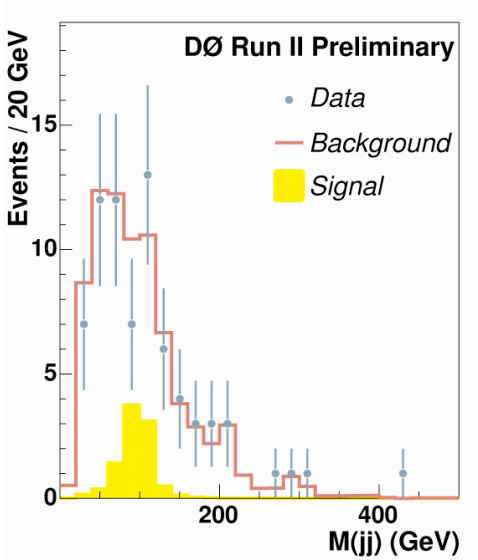
$W\pi_T$ Optimization

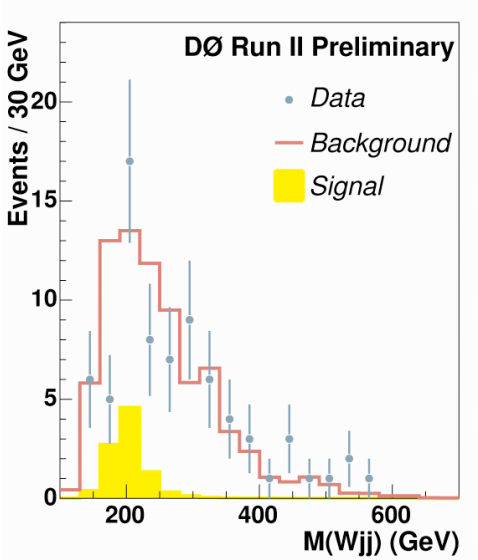
$\int \mathcal{L}\, dt$ = 238 pb^{-1}

- H_T^e (electron p_T + Σ jet p_T)
- $p_T(jj)$ (p_T of the dijet system)
- $\Delta\phi(jj)$
- M(jj) (invariant mass of the dijet system)
- M(Wjj) (invariant mass of the W + dijet system)









$W\pi_T$ Cross Section Limit

$\int \mathcal{L}\, dt = 238\ pb^{-1}$

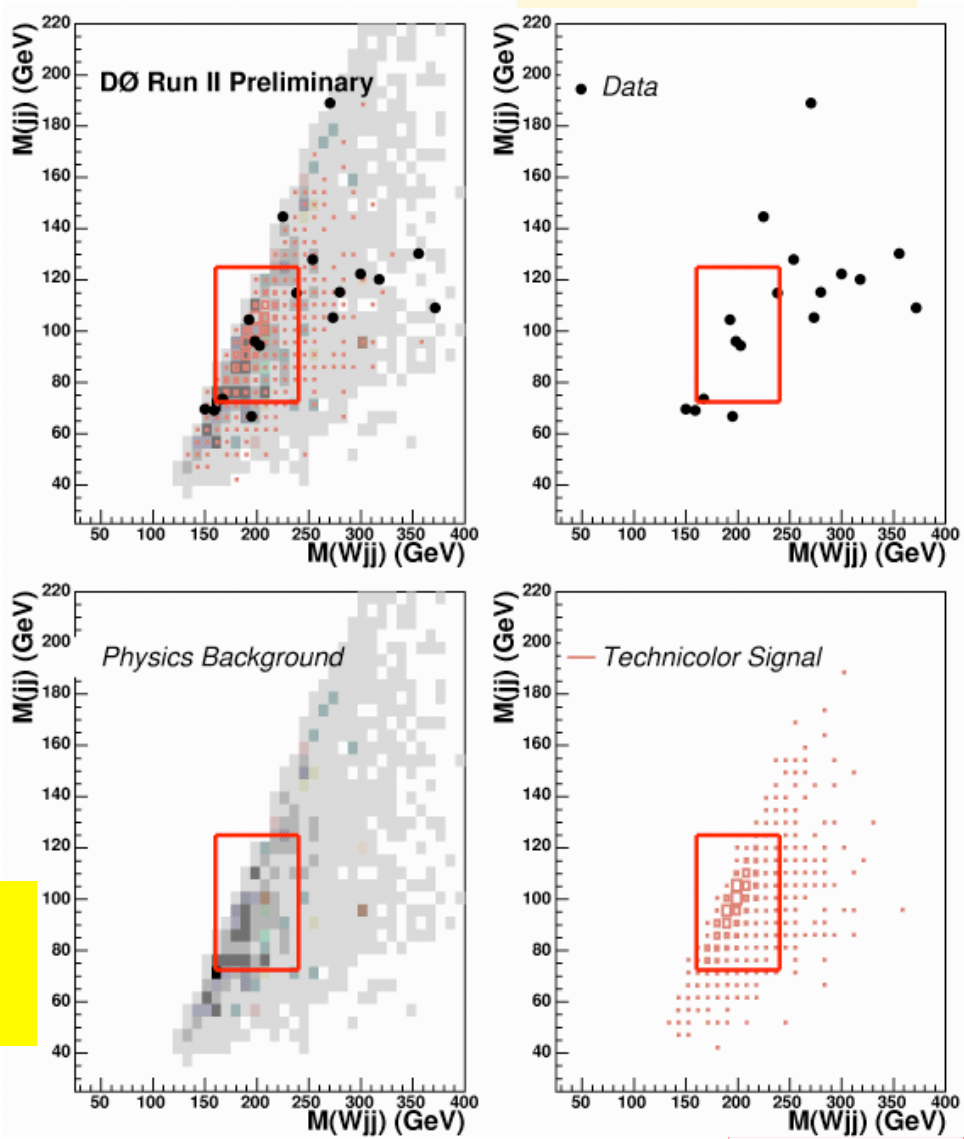
Optimization cuts

- $\Delta\phi(jj) > 2.2$
- $p_T(jj) > 75$ GeV
- $H_T^e < 200$ GeV
- Mass Window

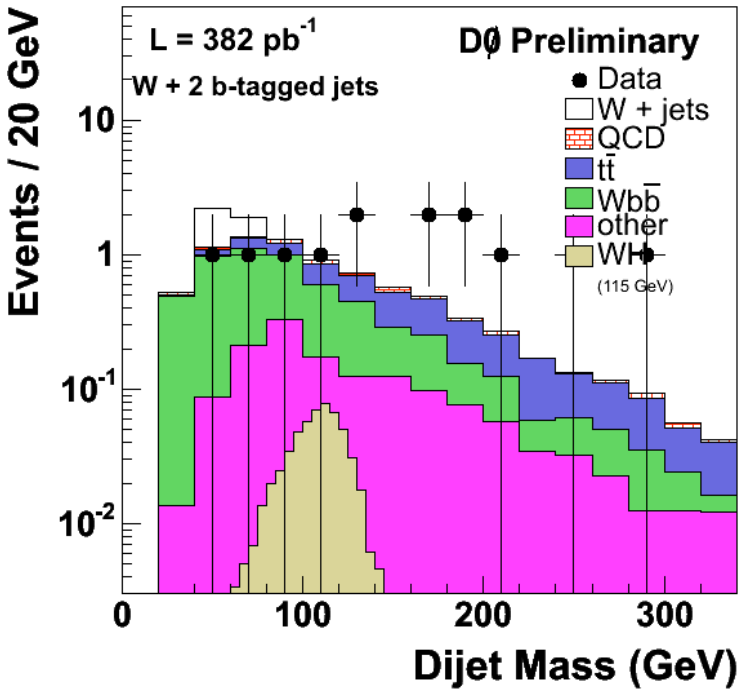
	data	background	signal
Baseline + $\Delta\phi$	28	28.3±7.1	7.5±1.1
+ $p_T(jj)$	22	24.7±6.2	7.4±1.1
+ H_T^e	17	18.3±4.6	7.2±1.1
+ mass window	4	6.6±1.6	6.2±0.9

$W\pi_T$ $M(\rho_T) = 200$ GeV $M(\pi_T) = 105$ GeV

$\Rightarrow$ 95% C.L. upper limit 6.4 pb



Wbb and WH searches : Double Tag

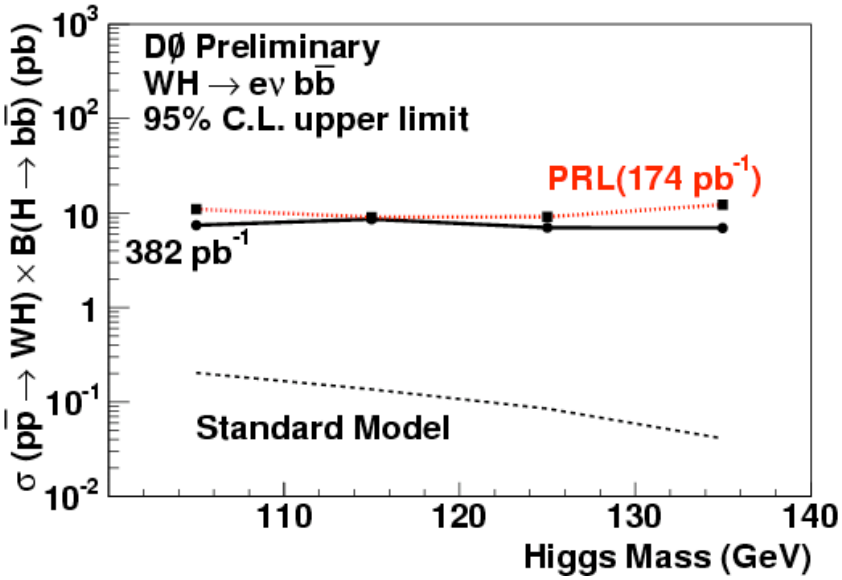


- Count in 85 – 135 GeV mass window;
  - Observe 4 evts., expect 2.5±0.6
- Estimated bkgd. sample composition

WH	Wbb	tt+t	WZ	others
0.1	1.1	1.0	0.2	0.14

95% CL upper limit on WH production of 6.9 - 8.6 pb for Higgs masses of 105-135 GeV

(previous 9.0 – 12.2 pb)



- Observe 13 evts., expect 10.2±2.4
  - Estimated background composition

Wbb	QCD	W/Zjj	tt+t	Others
4.3±1.0	0.4±0.2	1.6±0.4	3.4±0.8	0.5±0.1

Wbb 95% CL upper limit of 4.6 pb

Summary

- DØ has begun to search for new physics in the W+2 jets channel
  - W(eν) H : preliminary update to previous PRL result.
    - (result with 174 pb-1 published in PRL 94, 091802)
  - W(eν) π_T: approaching sensitivity for unexplored TCSM phase space
    - Full dataset is being analyzed
    - Fast Monte Carlo simulation will establish new exclusion region