Search for Associated Higgs Boson Production with Like-Sign Leptons at DZero

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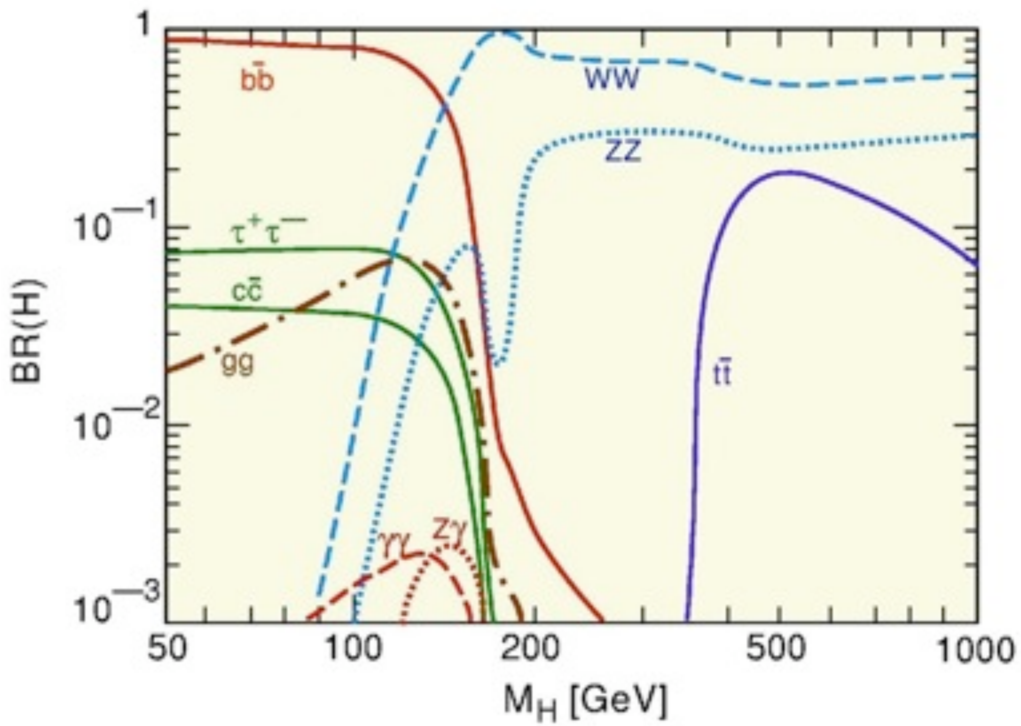
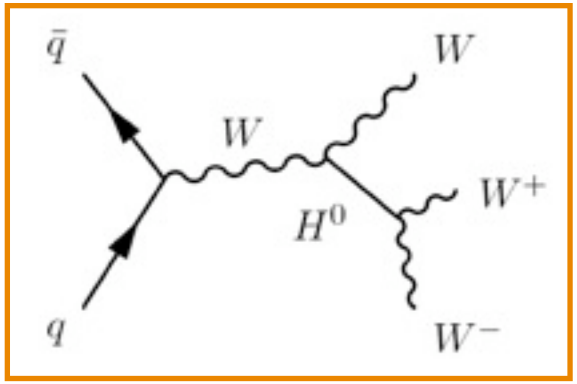
Like-Charge Signature

- $H \to WW$ dominant decay at high Higgs boson mass in SM
  - Enhanced in all region for Fermiophobic interpretation
- Associated production gives additional handle
  → Large background reduction





- Signature from WH, $H \to WW$ events
  = like-charged lepton pair + missing E_T
  - $WWW^{(*)} \to ll'\nu\nu' + X$, ll' = ee, eμ, μμ
- Presenting DZero results using 3.6 fb^{-1}

Background Processes

- Physics Background
  - Di-boson (WZ and ZZ) production with real like-charge leptons

  → Use Monte Carlo to estimate the contribution

- Instrumental Background
  - "Multijet" = fake leptons from multijet events
  - "Charge Flip" = charge mis-identification in opposite sign events (mainly from Z → ll process) due to
    - high p_T tracks with small sagitta
    - conversion and missing/fake hits in the tracker

  → Contributions estimated using Data (+ help from MC)

Event Selection

- Two high p_T Like-charge leptons from same vertex
  - Electron: electromagnetic (EM) energy cluster with a matched track, with calorimeter isolation, high EM fraction and "likelihood"
  - Muon: track in outer muon system matched with a central track, with calorimeter + tracker isolation
- Further selection using additional track quality cuts
  - Variables chosen primarily to reduce charge flip contribution → DCA, DCA significance, χ^2/ndf, and number of track hits
- Final signal-background discriminant is formed using Multivariate technique

Instrumental Background

- Multijet Background
  - ee and μμ channels: measure the efficiency of lepton quality cuts (e likelihood & μ isolation) in multijet enriched sample
  - eμ channel: use template fitting on electron likelihood distributions in tight-muon loose-electron sample
- Charge Flip Background
  - ee channel: parametrise charge flip rate from $Z \rightarrow ee$ events in the control region and apply to the data in search region
  - μμ channel: use two independent charge measurement (in central tracker and in muon system) to determine the fraction of charge flip events in like-charged sample of data

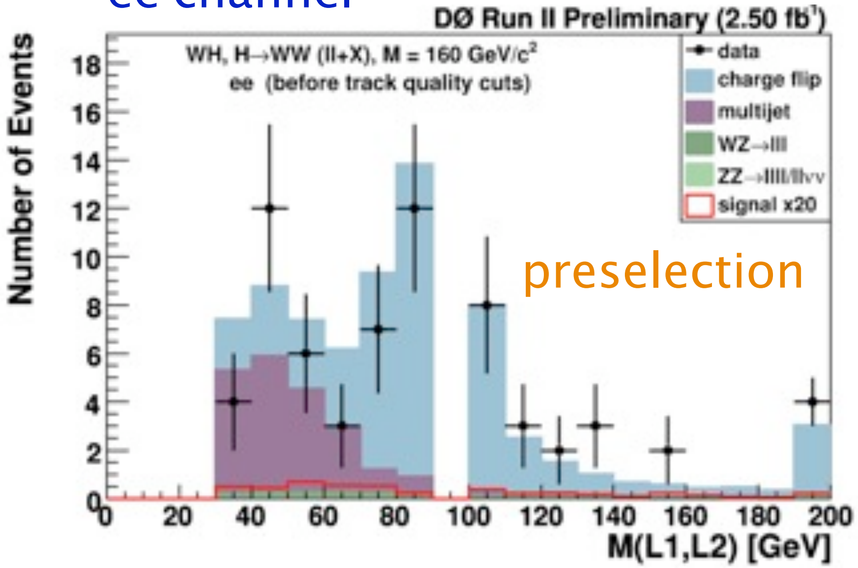
Background Composition

- Composition of selected events change after the track quality cuts
- Estimated number of background events and the shape of the background model distribution checked at each selection stage

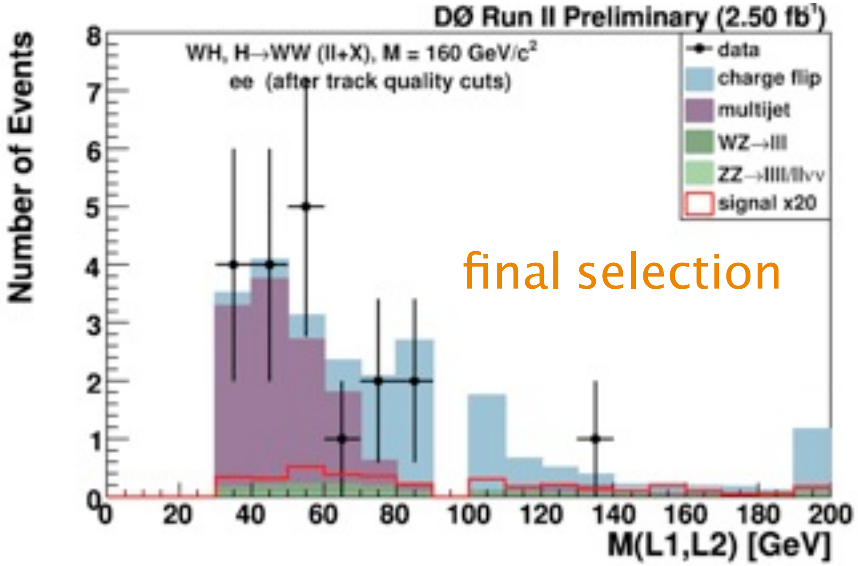
	data	expected background	signal (M=160GeV)
ee	19	23.6 ± 12.6	0.13
μμ	14	12.3 ± 7.9	0.18
eμ	35	39.2 ±3.0	0.35

events at final selection

ee channel



preselection



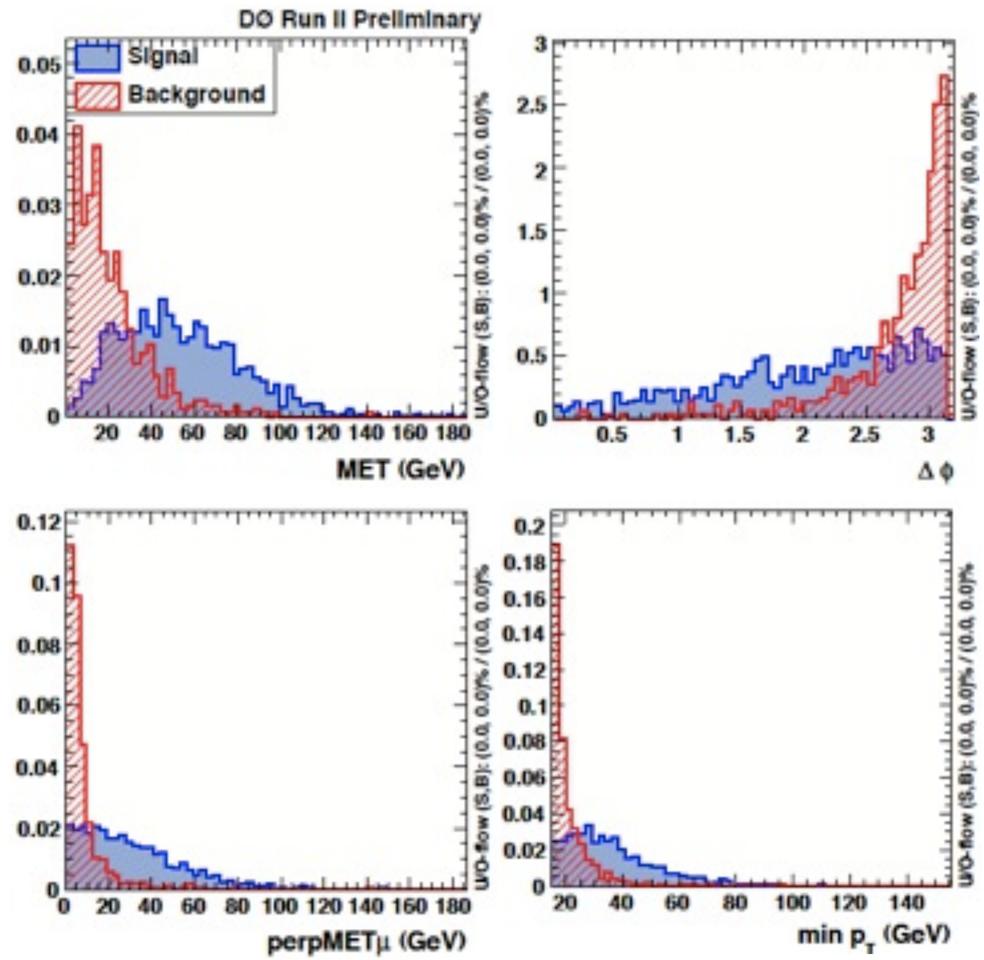
final selection

Multivariate Analysis

- Form discriminant using few powerful kinematic variables
  → Optimised against charge flip for ee and μμ, multijet for eμ

- Input variables
  - missing E_T (MET)
  - component of MET ⊥ to muon (perp MET)
  - azimuthal separation ($\Delta\varphi$)
  - trailing lepton p_T

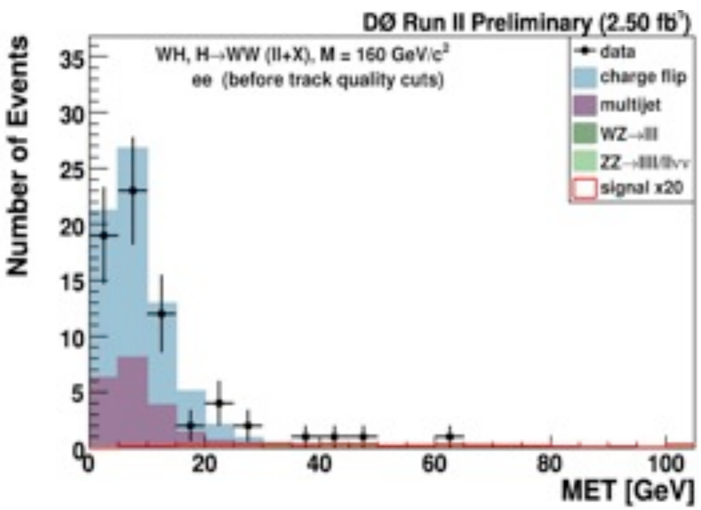
normalised input variable distribution for signal and background (multijet) in eμ channel

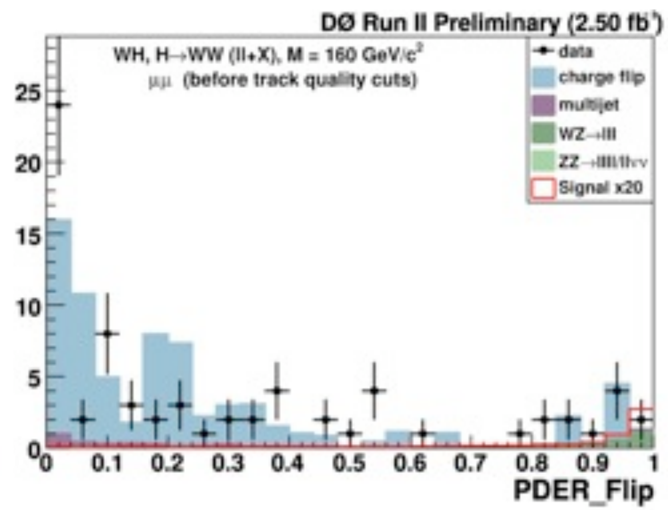


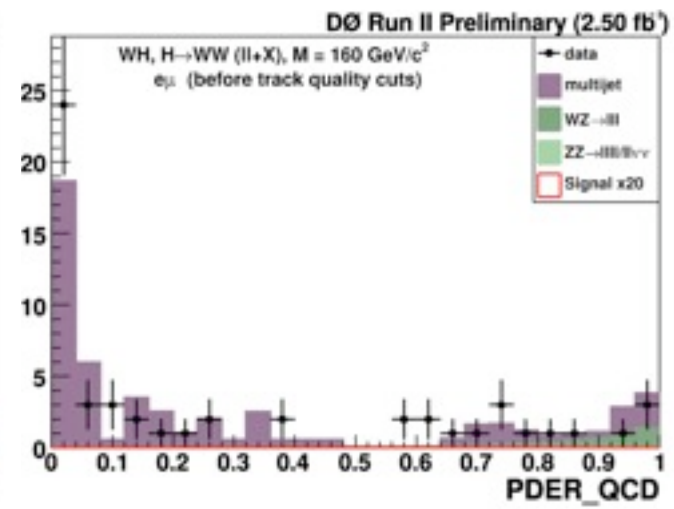
Multivariate Discriminants

ee channel | μμ channel | eμ channel

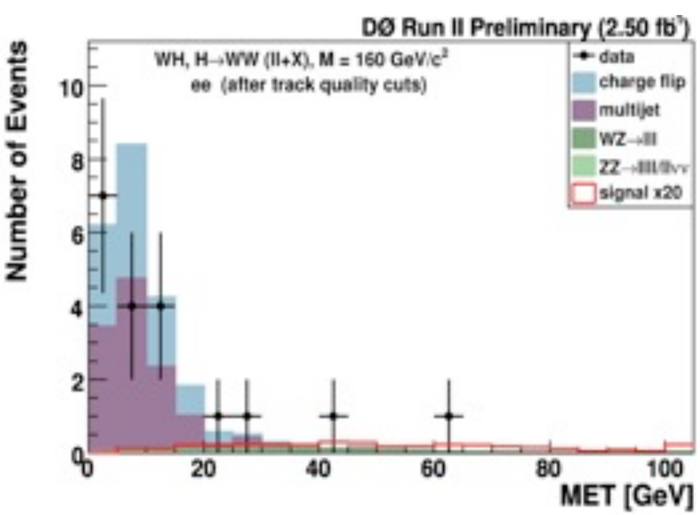
preselection

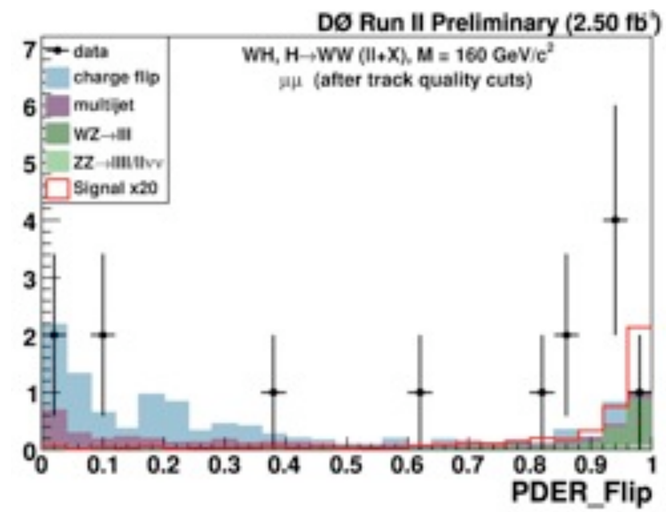


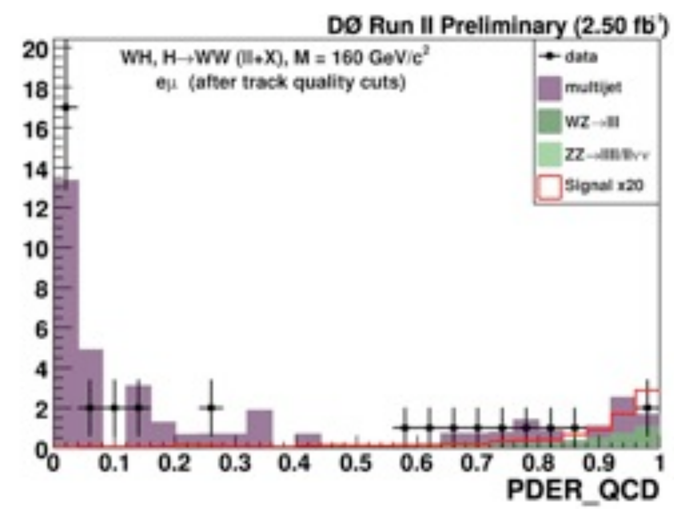




final selection

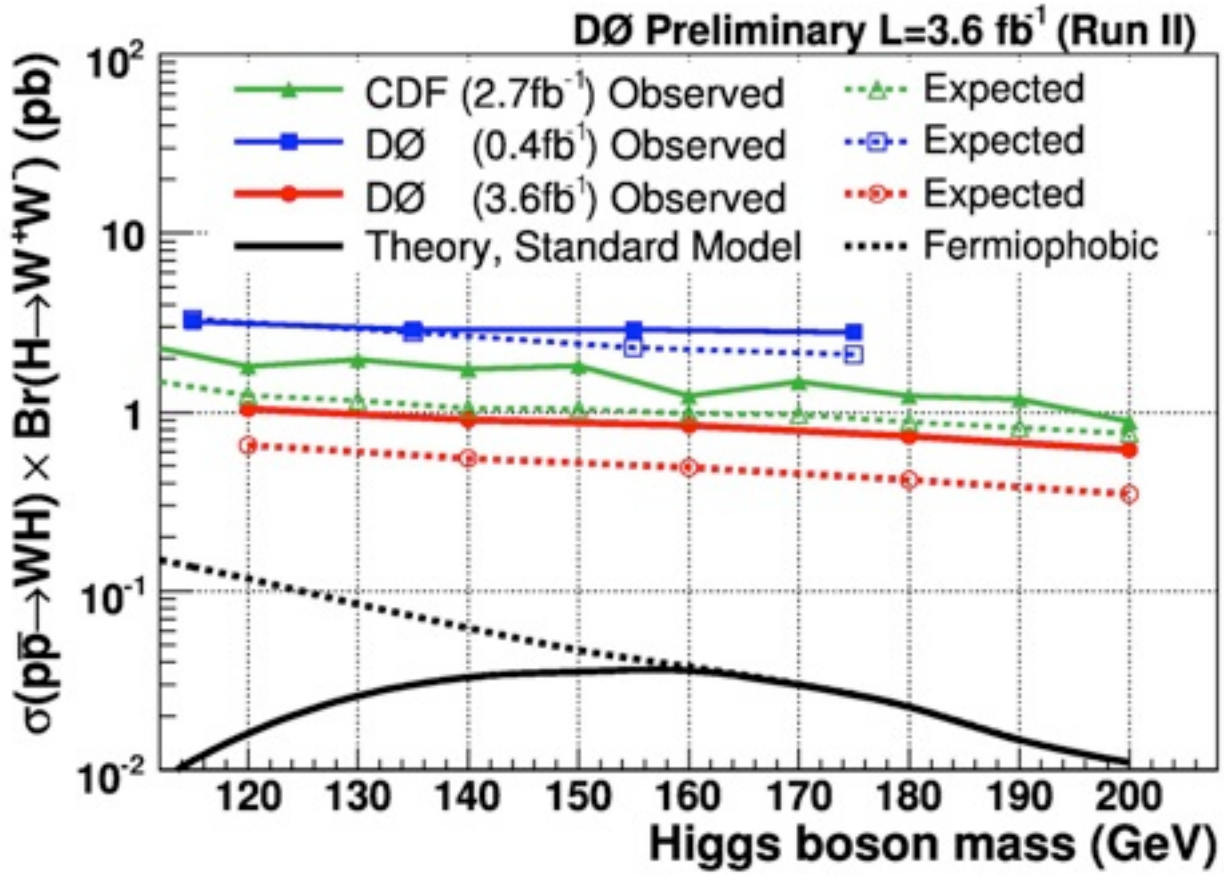






Cross Section Limit

- Preliminary results from winter 2009 using Run II data
- Cross section limits (ratios to SM prediction) at $M_H = 160$ GeV
  - 10.7 x SM (exp)
  - 18.4 x SM (obs)



- Further improvements expected from exploiting other variables and optimising the discriminant against di-boson and increasing the signal acceptance

Back Up

back up

Background Composition

TABLE I: The number of predicted and observed events before and after the track quality cuts. The signal event yields are based on the standard model Higgs boson production cross section and the decay branching ratio. For the ee channel, the control region used to parameterize the charge flip rate is excluded. Statistical and systematic uncertainties have been combined.

	ee channel		$\mu\mu$ channel		$e\mu$ channel	
	preselection	final	preselection	final	preselection	final
$WZ \to \ell\nu\ell\ell$	2.41 ± 0.17	1.76 ± 0.12	3.27 ± 0.23	2.42 ± 0.17	6.99 ± 0.49	5.18 ± 0.36
$ZZ \to \ell\ell\ell\ell$	0.53 ± 0.04	0.37 ± 0.03	0.58 ± 0.04	0.43 ± 0.03	1.17 ± 0.08	0.87 ± 0.06
multijet	20.2 ± 10.2	11.8 ± 11.2	4.4 ± 5.0	3.0 ± 4.2	48.5 ± 4.4	33.2 ± 3.0
charge flip	49.2 ± 7.4	9.7 ± 5.8	65.2 ± 6.5	6.5 ± 6.7	- ± -	- ± -
total background	72.3 ± 12.6	23.6 ± 12.6	73.5 ± 8.2	12.3 ± 7.9	56.7 ± 4.4	39.2 ± 3.0
data	66	19	71	14	54	35
$WH(160) \to \ell\ell jj$	0.137	0.101	0.164	0.128	0.334	0.255
$WH(160) \to \ell\ell\ell$	0.047	0.035	0.069	0.055	0.129	0.098

Cross Section Limits

TABLE III: The expected(observed) production cross section limits (pb) for individual channels and for the combination.

m_H (GeV)	120	140	160	180	200
ee	2.64 (3.46)	2.21 (2.89)	1.78 (2.37)	1.77 (2.35)	1.51 (2.03)
$\mu\mu$	1.98 (3.95)	1.71 (3.54)	1.65 (3.40)	1.57 (3.17)	1.53 (2.72)
$e\mu$	1.39 (1.47)	1.11 (1.13)	1.00 (1.04)	0.88 (0.90)	0.78 (0.79)
Run IIb combined	0.95 (1.61)	0.78 (1.31)	0.70 (1.18)	0.64 (1.04)	0.56 (0.90)
Run IIa + IIb	0.65 (1.04)	0.55 (0.91)	0.49 (0.84)	0.42 (0.73)	0.35 (0.62)

TABLE IV: The expected(observed) production cross section limits in terms of the ratio to the standard model cross section for individual channels and for the combination.

m_H (GeV)	120	140	160	180	200
ee	130.7 (170.9)	52.8 (69.0)	38.7 (51.5)	61.7 (81.9)	105.6 (142.0)
$\mu\mu$	97.9 (195.5)	40.8 (84.6)	35.8 (73.9)	54.5 (110.4)	93.0 (189.7)
$e\mu$	68.9 (72.9)	26.4 (27.1)	21.8 (22.7)	30.8 (31.5)	54.8 (55.1)
Run IIb combined	47.0 (79.9)	18.6 (31.3)	15.1 (25.6)	22.2 (36.3)	39.0 (63.2)
Run IIa + IIb	32.2 (51.6)	13.2 (21.7)	10.7 (18.4)	14.6 (25.5)	24.4 (43.0)