Introduction a` la session Higgs

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- Deux ANR soumises,
  - SM Higgs low mass (CPPM,IPHC,LAL,LPNHE)
  - tau et Susy Higgs (IRFU,LPC)

➔ ici intro a la session Standard Model Higgs

5 points mis en avant dans l'ANR Higgs low mass:

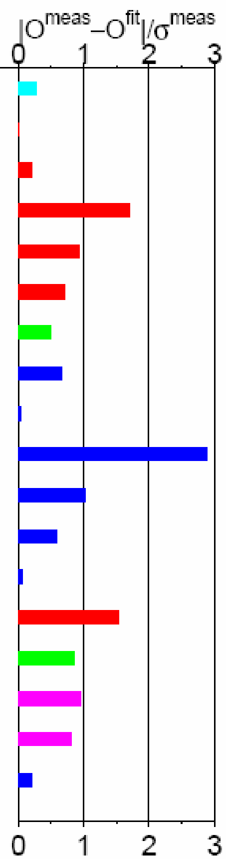
Trigger
b-tagging
Jet resolution
Comprehension/ rejection bruit de fond standard
Techniques avancees

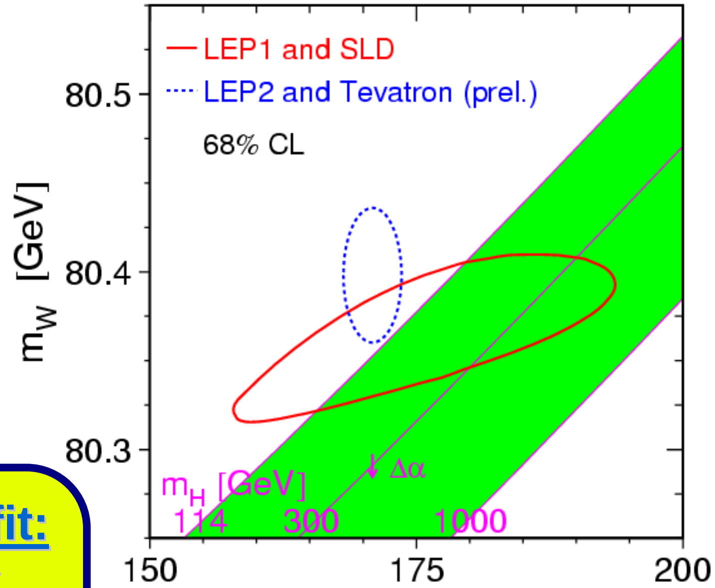
Experimental constraints on the SM Higgs Boson

Direct searches at LEP II: mH>114.4 GeV @ 95% CL

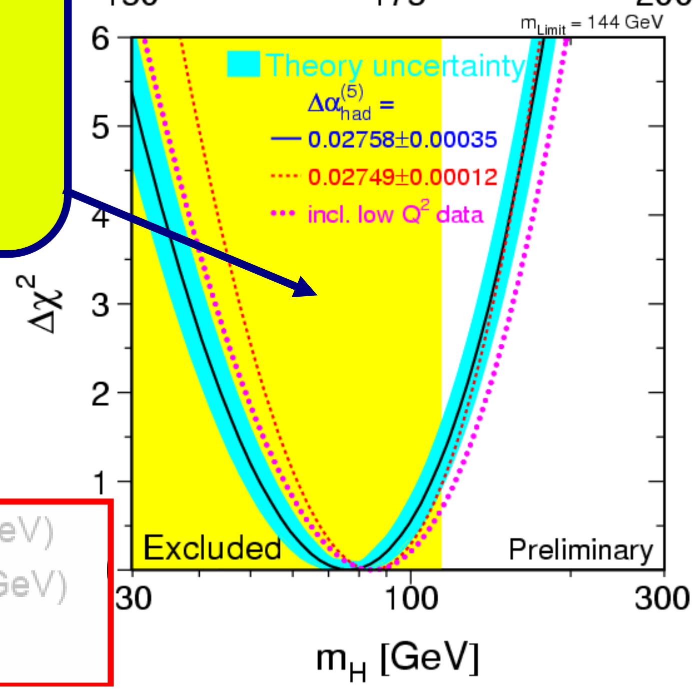
Indirect Constraints: Top, W-boson masses, EW meas.

	Measurement	Fit
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02758 ± 0.00035	0.02768
m_Z [GeV]	91.1875 ± 0.0021	91.1875
Γ_Z [GeV]	2.4952 ± 0.0023	2.4957
σ^0_{had} [nb]	41.540 ± 0.037	41.477
R_l	20.767 ± 0.025	20.744
$A^{0,l}_{fb}$	0.01714 ± 0.00095	0.01645
$A_l(P_\tau)$	0.1465 ± 0.0032	0.1481
R_b	0.21629 ± 0.00066	0.21586
R_c	0.1721 ± 0.0030	0.1722
$A^{0,b}_{fb}$	0.0992 ± 0.0016	0.1038
$A^{0,c}_{fb}$	0.0707 ± 0.0035	0.0742
A_b	0.923 ± 0.020	0.935
A_c	0.670 ± 0.027	0.668
A_l(SLD)	0.1513 ± 0.0021	0.1481
$\sin^2\theta^{lept}_{eff}(Q_{fb})$	0.2324 ± 0.0012	0.2314
m_W [GeV]	80.398 ± 0.025	80.374
Γ_W [GeV]	2.140 ± 0.060	2.091
m_t [GeV]	170.9 ± 1.8	171.3





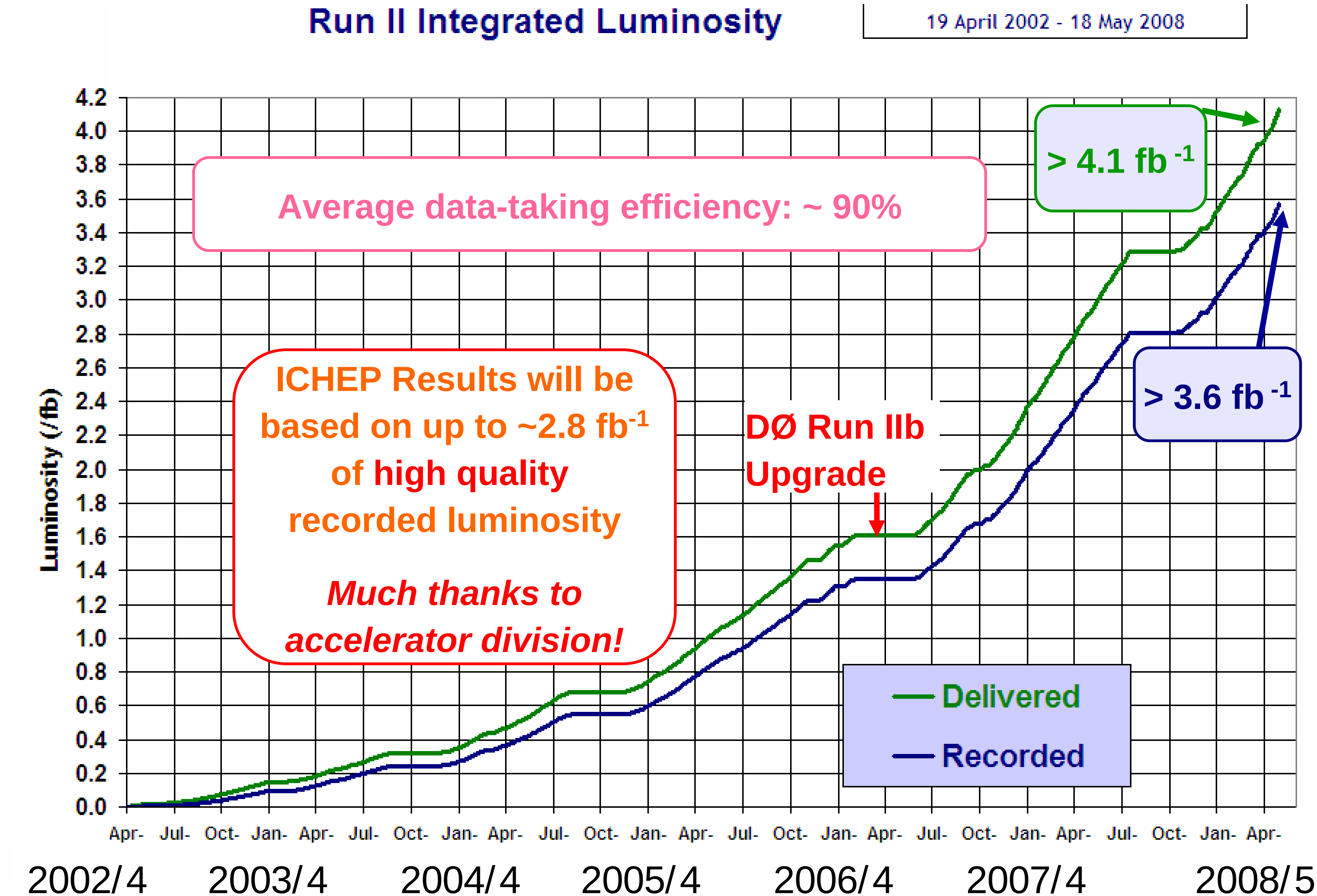
Precision EW fit:
m_H<160 GeV
<190 GeV
with
LEPII Limit



2008

– m_{top} = 172.8±1.4 GeV (171.3±1.7 GeV)
– M_H = 87 +36 -27 GeV (76 +33 -24 GeV)
- χ^2/dof = 17.2/13 (18.2/13)

Operations

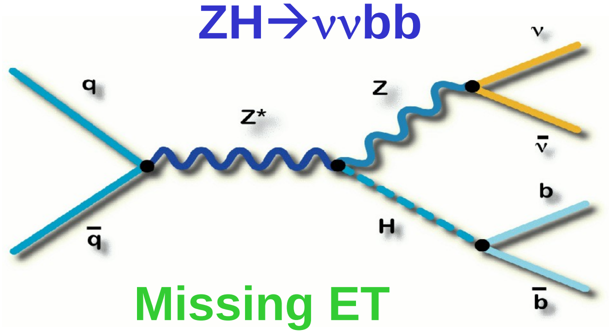

Run II Integrated Luminosity
19 April 2002 - 18 May 2008
Average data-taking efficiency: ~ 90%
> 4.1 fb -1
> 3.6 fb -1
ICHEP Results will be based on up to ~2.8 fb-1 of high quality recorded luminosity
Much thanks to accelerator division!
DØ Run IIb Upgrade
Delivered
Recorded
Luminosity (/fb)
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Apr- Jul- Oct- Jan- Apr- Jul- Oct- Jan- Apr- Jul- Oct- Jan- Apr- Jul- Oct- Jan- Apr- Jul- Oct- Jan- Apr- Jul- Oct- Jan- Apr-
2002/4 2003/4 2004/4 2005/4 2006/4 2007/4 2008/5

SM Higgs Low mass searches: datasets/ methods

WH

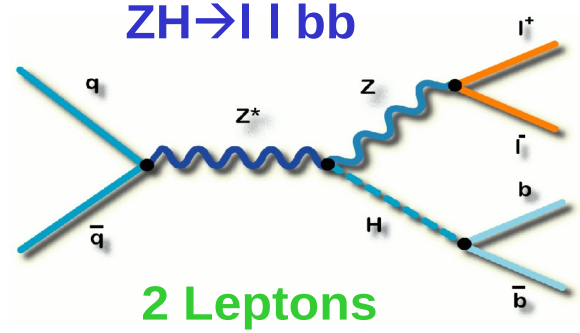
Lepton
Missing E_T
2 b-jets

ZH→ννbb



Missing ET
2 b-jets

ZH→l l bb



2 Leptons
2 b-jets

CDF	DØ	CDF	DØ	CDF / DØ
1.9 fb^{-1}	1.7 fb^{-1}	1.7 fb^{-1}	2.1 fb^{-1}	1.1 fb^{-1}
Moriond*	LP-07	LP-07	Moriond	Moriond-07

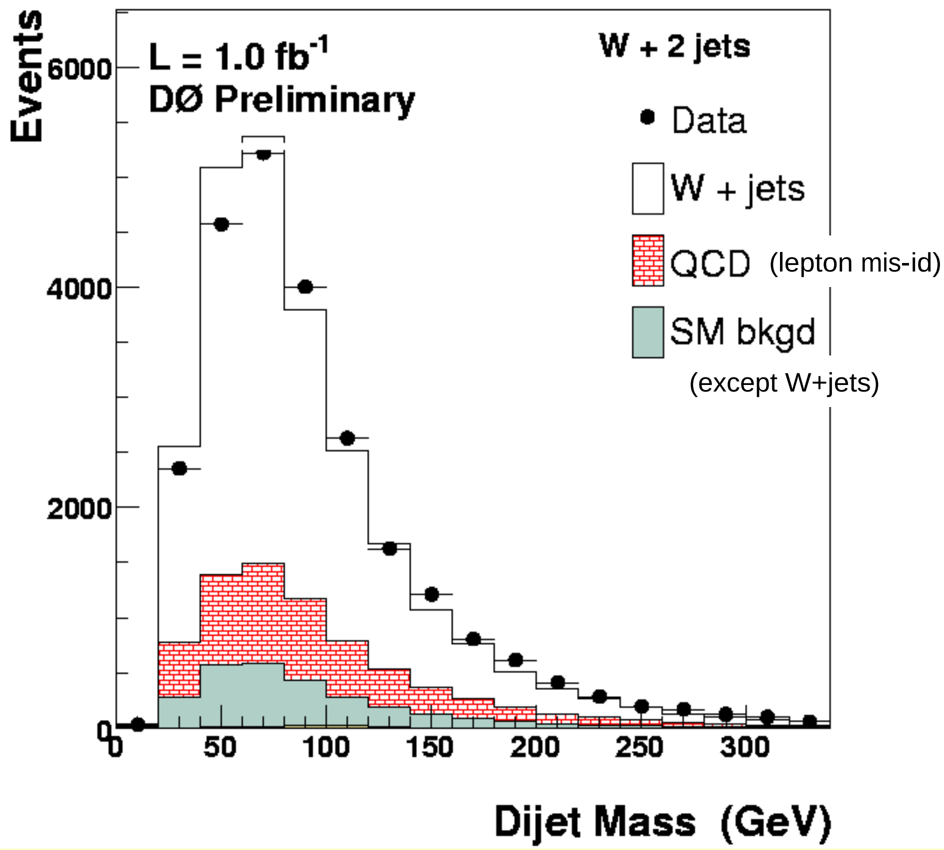
Common to all analyses: b-tagging, Jet calibration & resolution, lepton-identification, Background cross-section

Differences: instrumental bckd, multivariate techniques

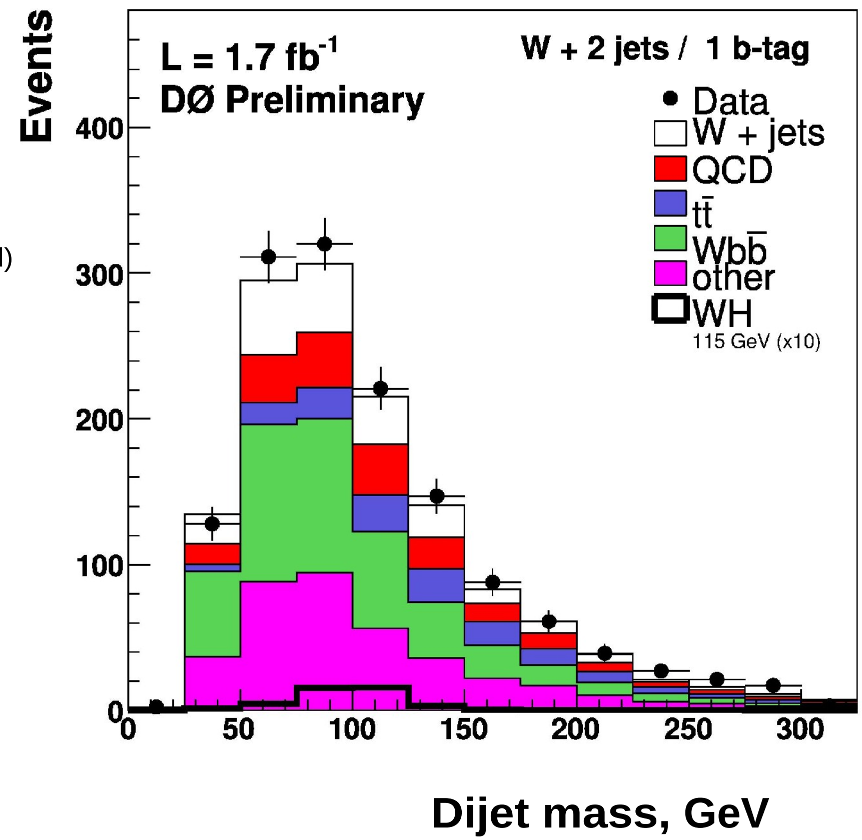
WH→lν bb (l= e,μ): effect of b-tagging

Starting from a W+ 2 jet selection, apply NN_btagging

Pre-tag



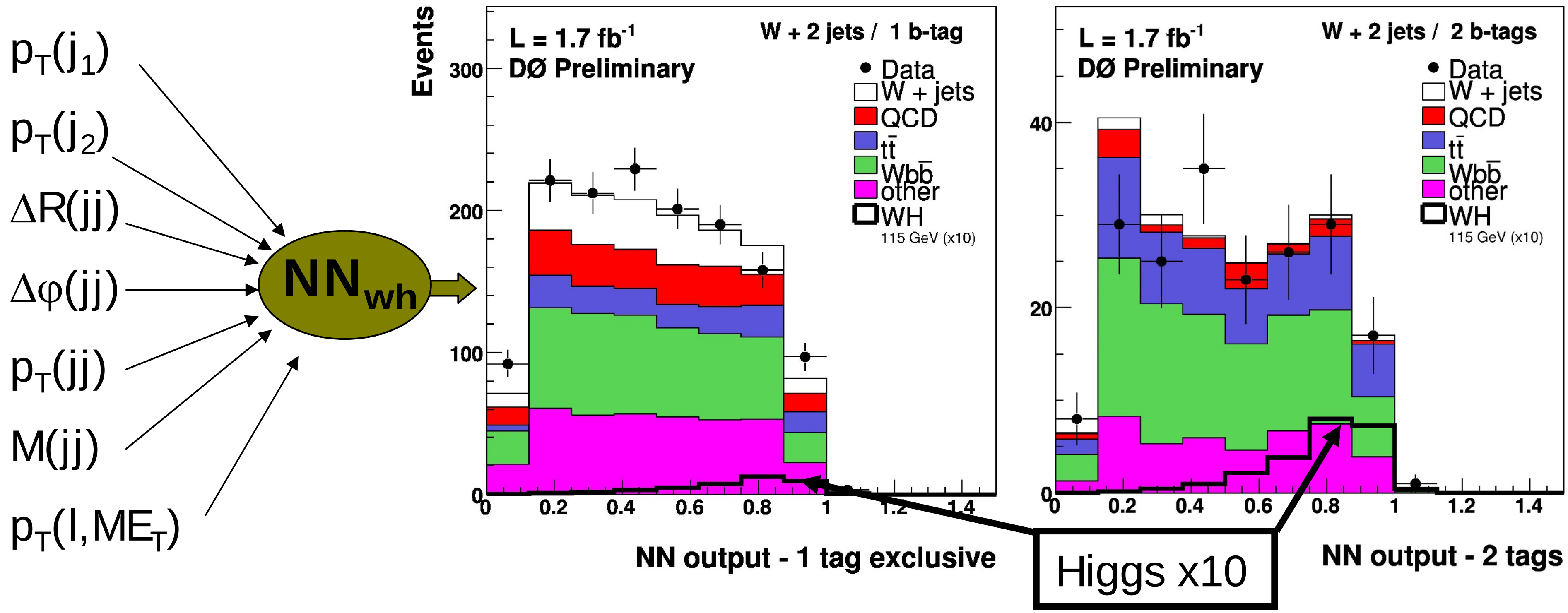
Exclusive single tag



Reweight to data eta, phi, delta-eta and delta-phi of jets in ALPGEN, before b-tagging

WH→lν bb (l= e,μ): Neural Net and Limits

Use neural network to separate signal from background
Fit the NN output



- **Limit @ M_H= 115 GeV (LP '07)**

σ_{95}/ SM, L= 1.7 fb^{-1}= 9 (exp)/ 11(obs)

CDF L= 1.9 fb^{-1}= 7(exp)/ 8 (obs)

Future improvements (short term):
include forward electrons and 3 jets sample. Improve NN with more backgd rejection and use Matrix Element approach

$H \rightarrow WW^* \rightarrow l\nu l\nu$

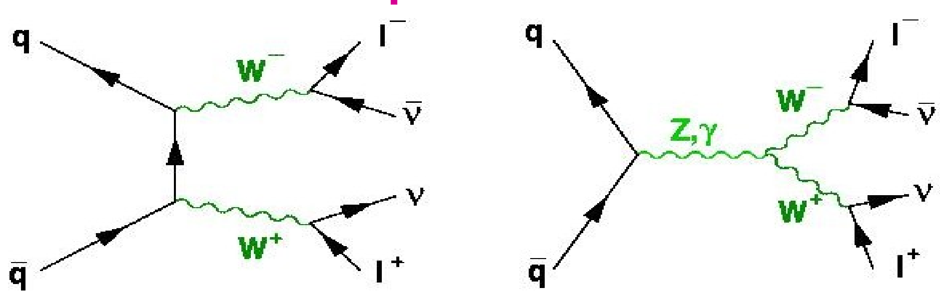
Selection Strategy:

- Presection: lepton ID, isolation,trigger, opposite charge leptons
- Remove QCD and $Z \rightarrow l^+ l^-$: $\cancel{E}_T > 20$ GeV
- Higgs Mass Dependent Cuts: Invariant Mass (M_{l+l-}); Min. Transverse Mass
  Sum of lepton p_T^l and E_T ($\Sigma\, p_T^l + E_T$)
- Anti tt(bar) cut: $H_T = \Sigma\, P_T^{jet} < 100$ GeV, or less than 2 jets
- Spin correlation in WW pair: $\Delta\phi(l,l) < 2.0$

- Then apply advanced analysis technique, Neural Net+Matrix element

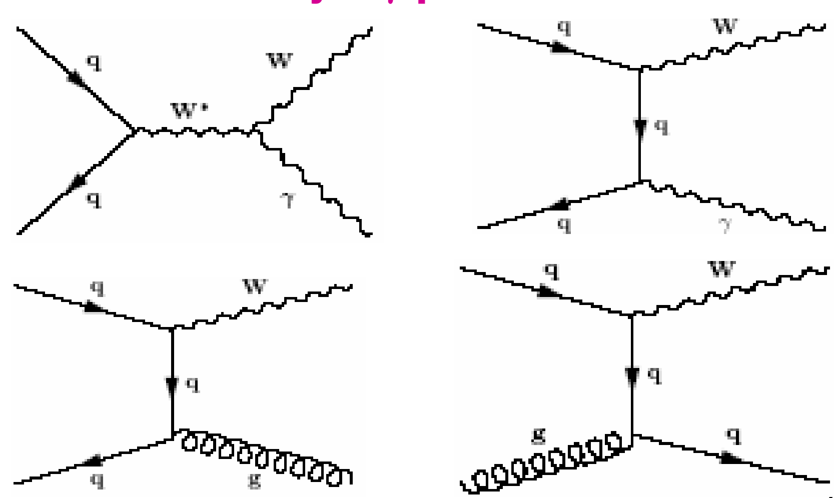
Major backgrounds

WW production

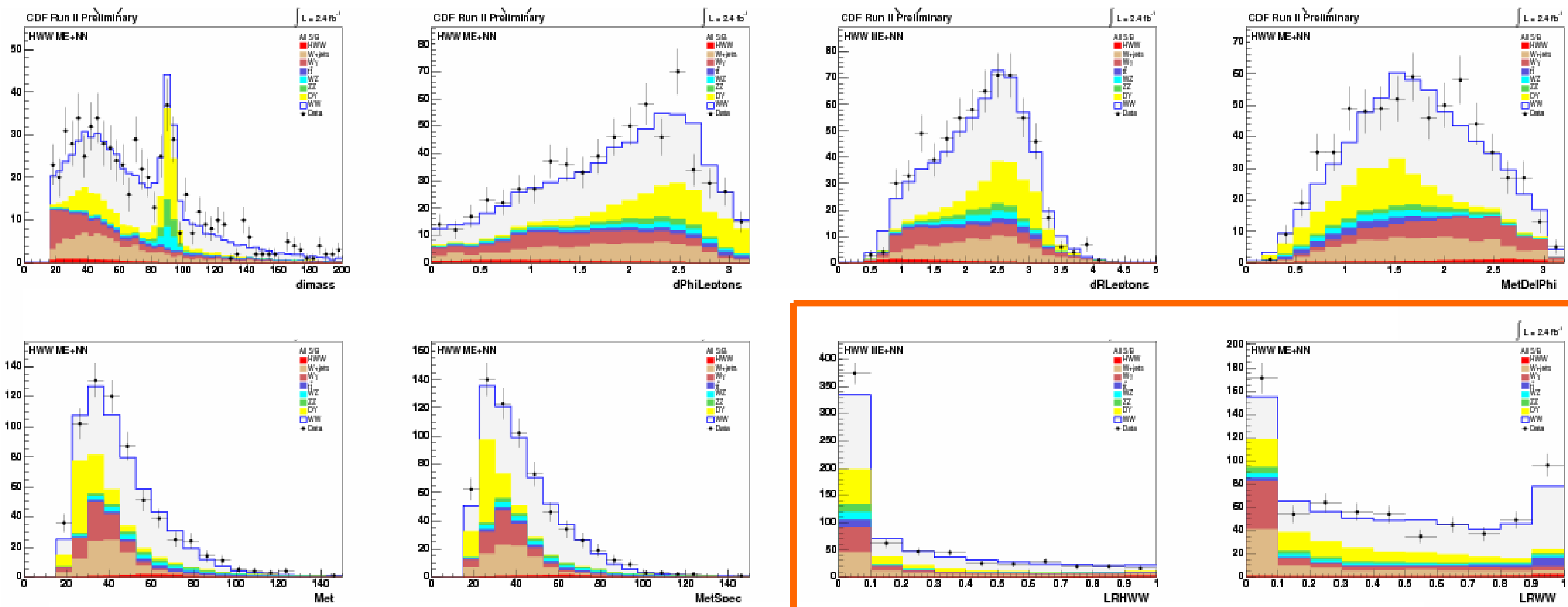


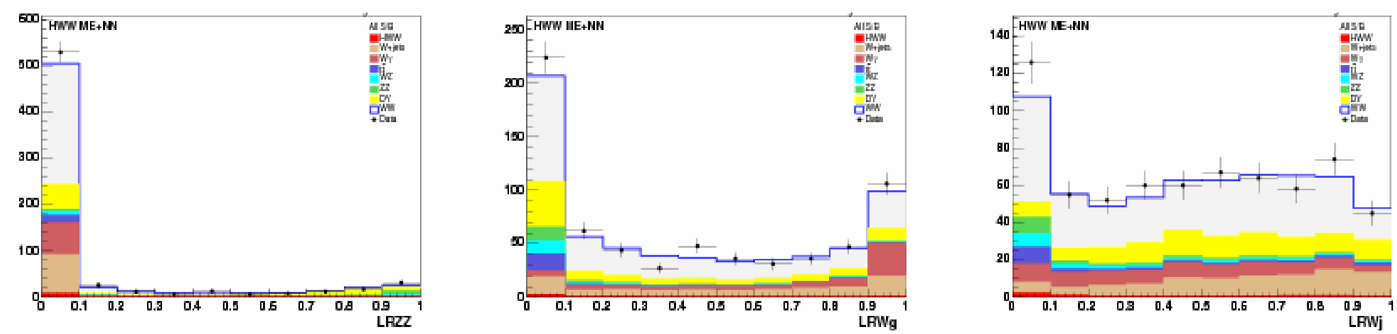
Now measured at the Tevatron by both expts.
in agreement with NLO calculation: ~13.5 pb

W + jet/γ production:



Neural Network Input Variables / Matrix Elements





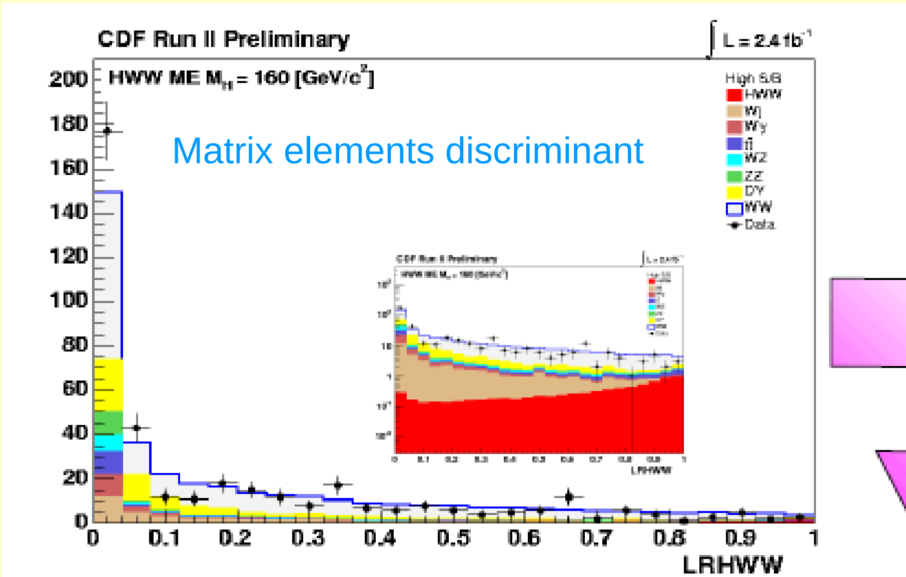
5 Matrix Elements discrim.

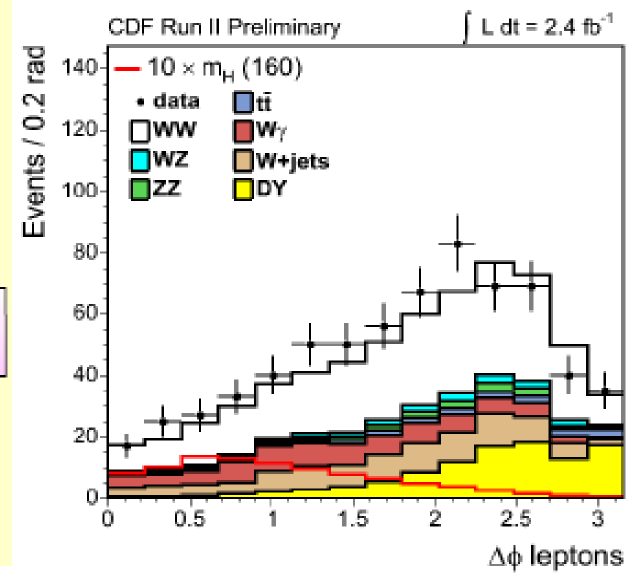
$$P_m(x_{obs}) = \frac{1}{<\sigma_m>}\int \frac{d\sigma_m^{th}(y)}{dy}\epsilon(y)G(x_{obs},y)dy$$

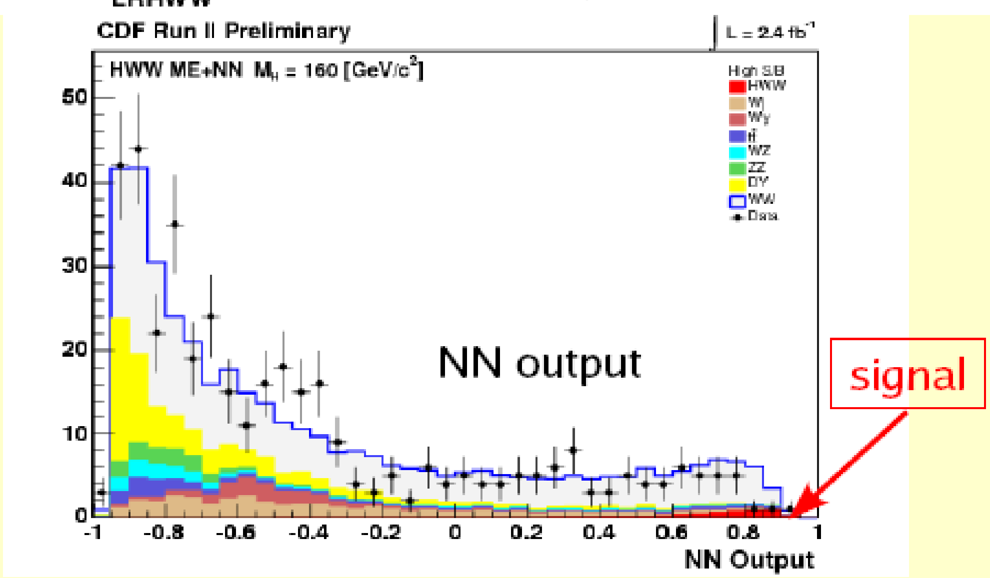
$$LR_H(x_{obs}) \equiv \frac{P_H(x_{obs})}{P_H(x_{obs}) + \Sigma_i k_i P_i(x_{obs})}$$

Matrix Elements + Neural Net → Final Discriminant

- ME calculated from lepton 4-vectors and missing transverse energy is used as an input to NN together with several kinematic distributions







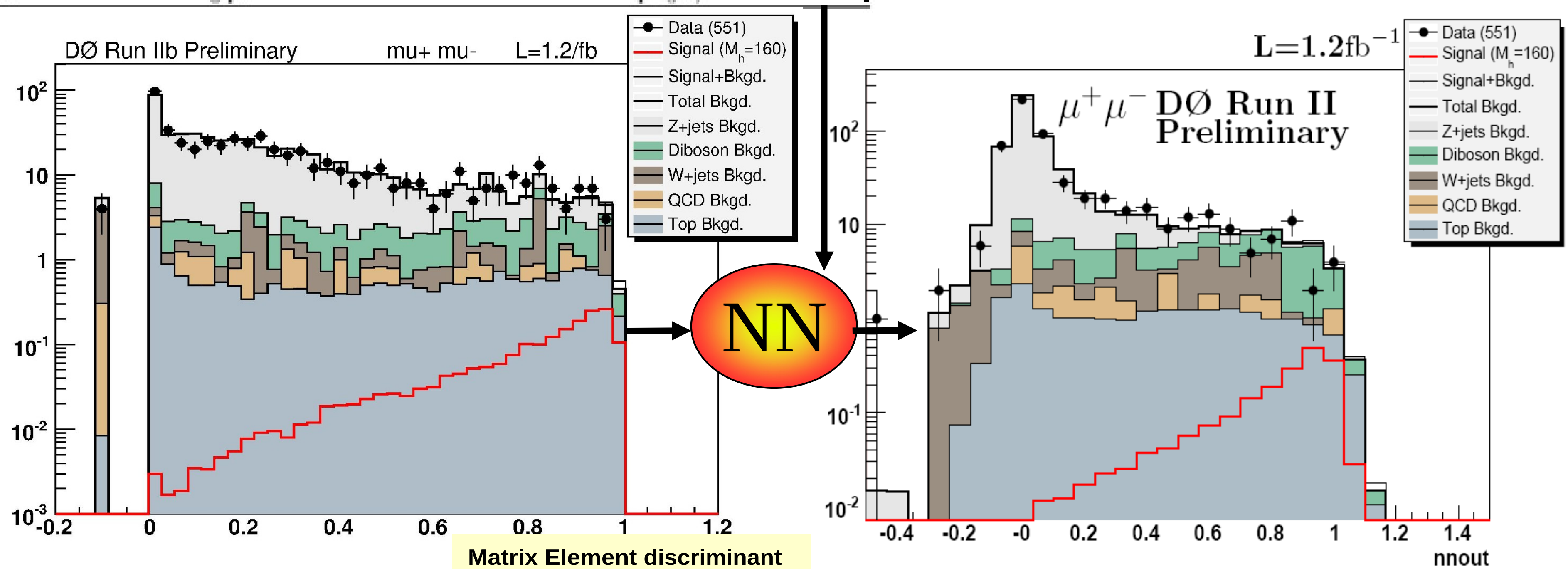
H → WW* → lν lν : Neural Nets + ME

$\mu\mu$ NN Analysis Variables	
Scaled $\not{E}_T$	$\not{E}_T^{\text{Scaled}}$
Invariant mass of the two muons	$M_{\mu\mu}$
Missing E_T	$\not{E}_T$
Sum of the p_T's of all 0.5 cone jets with $p_T >$ 6 GeV	H_T^{all}
$H \to WW$ vs. WW ME discriminant	ME_{disc}
p_T of the $\mu\mu$ system	$p_T(\mu_1 + \mu_2)$
Smaller of the two muon-$\not{E}_T$ transverse masses	M_T^{min}
p_T of the leading p_T muon	$p_T(\mu_1)$
Azimuthal angle between the $\not{E}_T$ and the second-leading p_T muon	$\Delta\phi(\mu_2, \not{E}_T)$
$\log_{10}$ of the sum of the muon scaled (track+cal) isolations	$\log_{10}$(scalediso $\mu_1 + \mu_2$)
Event scalar E_T	SE_T
Azimuthal angle between the two muons	$\Delta\phi(\mu_1, \mu_2)$
Worst of the two muon qualities (loose,medium,tight)	$\min(\mu_1^{\text{qual}}, \mu_2^{\text{qual}})$
Azimuthal angle between the $\not{E}_T$ and the leading p_T muon	$\Delta\phi(\mu_1, \not{E}_T)$
p_T of the second-leading p_T muon	$p_T(\mu_2)$

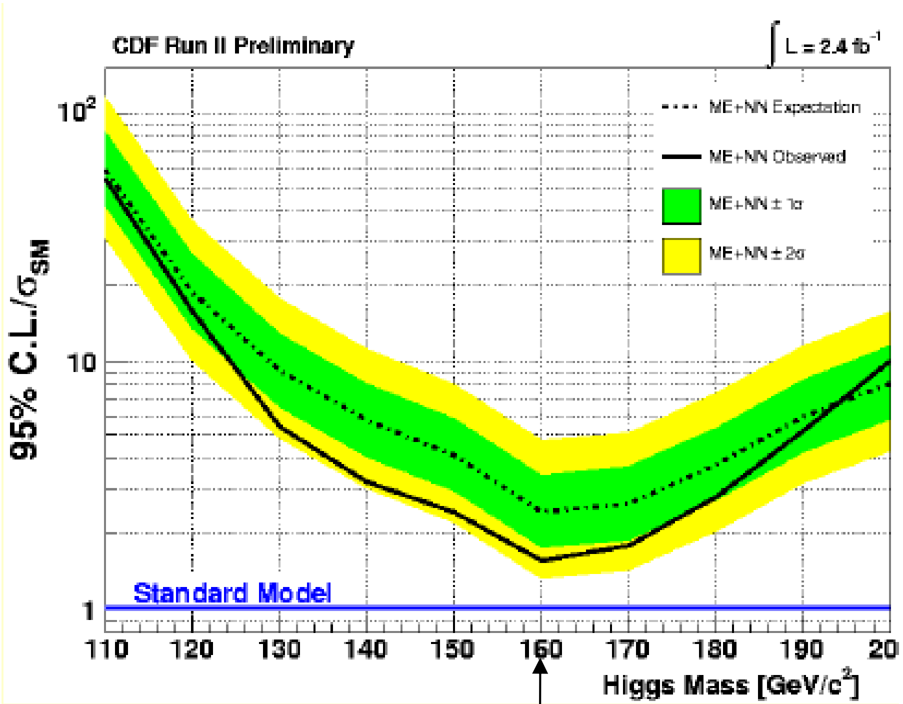
DØ uses more kinematic variables and H->WW vs. WW Matrix Element calculation as input to NN.

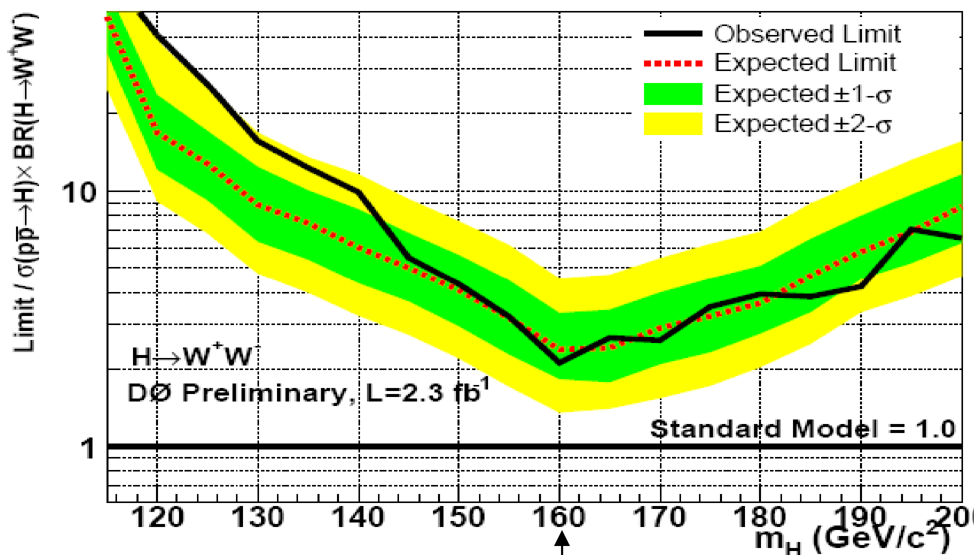
NN trained for each Higgs mass in 5 GeV steps, for each channel

Final ME+NN output used for setting limits



H → WW* → lν lν : Limits





Expected Limit / SM ~ 2.6
Observed Limit / SM ~ 1.6

Expected Limit / SM ~ 2.4
Observed Limit / SM ~ 2.2

Systematics: ZH-llbb / CDF vs DØ

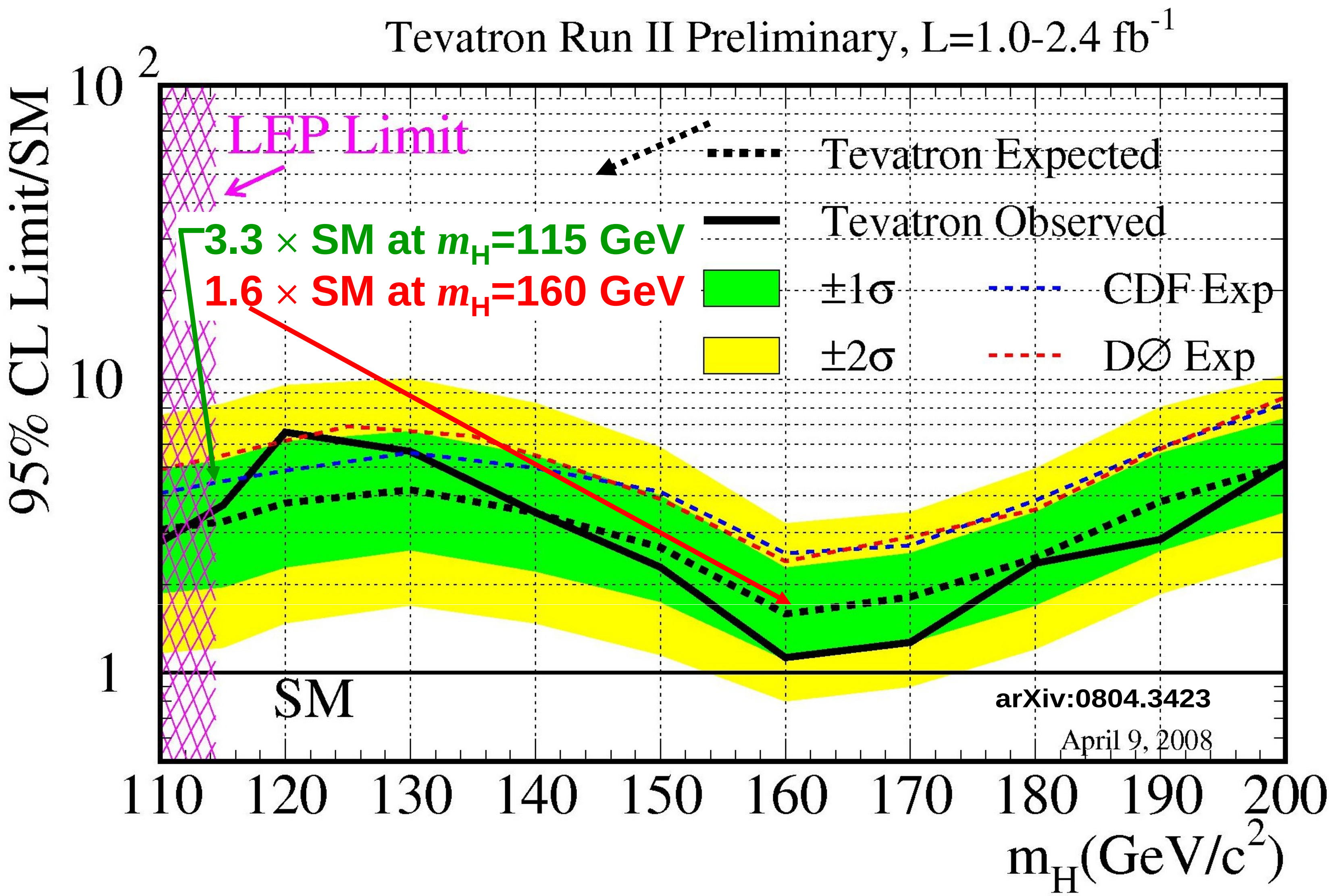
CDF: Double Tag (DT) $ZH \to \ell\ell b\bar{b}$ Analysis

Contribution	Fakes	Top	WZ	ZZ	$Z+b\bar{b}$	$Z+c\bar{c}$	Z+mistag	ZH
Luminosity ($\sigma_{\mathrm{inel}}(p\bar{p})$)	0	4	4	4	4	4	0	4
Luminosity Monitor	0	5	5	5	5	5	0	5
Lepton ID	0	1	1	1	1	1	0	1
Fake Leptons	50	0	0	0	0	0	0	0
Jet Energy Scale (shape dep.)	0	$^{+0.1}_{-0.1}$	0	$^{+0.5}_{-3.0}$	$^{+3.1}_{-7.8}$	$^{+8.7}_{-0}$	0	$^{+0.3}_{-1.2}$
Mistag Rate	0	0	0	0	0	0	24	0
B-Tag Efficiency	0	16	16	16	16	32	0	16
$t\bar{t}$ Cross Section	0	20	0	0	0	0	0	0
Diboson Cross Section	0	0	20	0	0	0	0	0
$\sigma(p\bar{p} \to Z + HF)$	0	0	0	0	40	40	0	0
ISR (shape dep.)	0	0	0	0	0	0	0	$^{+4.6}_{+0.6}$
FSR (shape dep.)	0	0	0	0	0	0	0	$^{+5.3}_{+3.7}$

DØ: Double Tag (DT) $ZH \to \ell\ell bb$ Analysis

Contribution	WZ/ZZ	Zbb/Zcc	Zjj	$t\bar{t}$	QCD	ZH
Luminosity	6.1	6.1	6.1	6.1	0	6.1
EM ID/Reco eff.	4	4	4	4	0	4
Muon ID/Reco eff.	4	4	4	4	0	4
Jet ID/Reco eff.	2	1.5	2	1.5	0	1.5
Jet Energy Scale (shape dep.)	4	8	11	2	0	2
B-tagging/taggability	8	8	9	7	0	7
Cross Section	7	0	0	18	0	6
Heavy-Flavor K-factor	0	30	15	0	0	0
Instrumental-ZH-2	0	0	0	0	50	0

Post-Moriond 2008



Observed limit at m_H= 160 Gev: 1.1 x SM (3.6 @ 115 GeV)

➔Very close to excluding a 160 GeV SM Higgs. @ ICHEP: ~ 3 fb^{-1}

Sensitivity and Projections – MH = 115 GeV

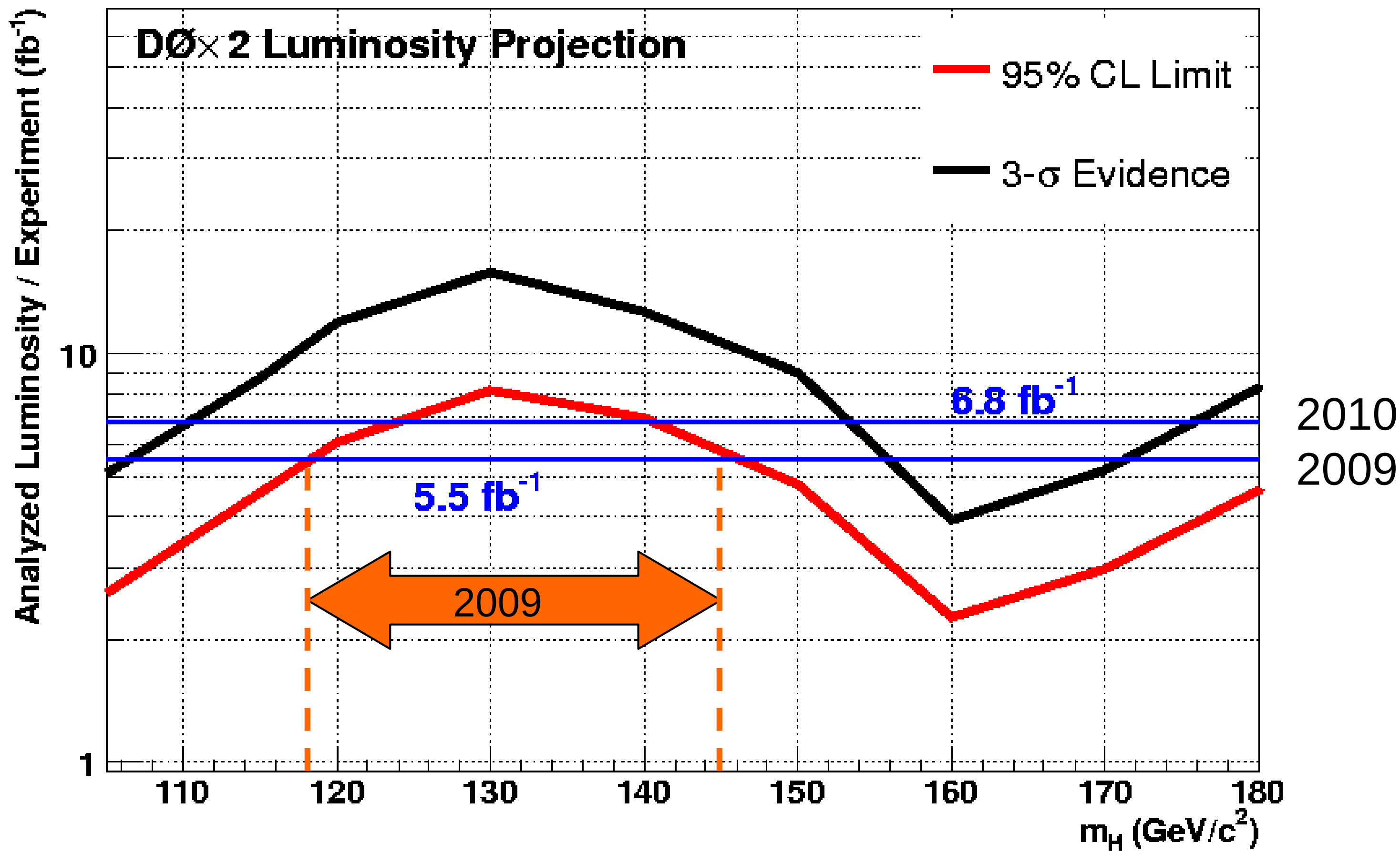
- Since 2005, our analysis sensitivity has improved by a factor of 1.7 well beyond improvement expected from sqrt(luminosity)
  - Acceptance/kin. phase space/Trigger efficiency
  - Asymmetric tagging for double b-tags
  - b-tagging improvements (NN b-tagging)
  - improved statistical techniques/event NN discriminant

  → for channel with largest effort applied (WH) factor was 2.1

- For 2010, we estimate that we will gain an additional factor of 2.0 beyond improvement expected from sqrt(luminosity)
  - b-tagging improvements
    - Layer 0 (~8% per tag efficiency increase) @D0
    - add semileptonic b-tags (~5% per tag efficiency increase)
  - Di-jet mass resolution (18% to 15% in s(m)/m)
  - increased lepton efficiency (10% per lepton)
  - improved/additional multivariate techniques (~20% in sensitivity)

Expected Higgs sensitivity in 2009/ 2010

Assumes two experiments



By the time LHC produces Higgs Physics (end 2009), precision EW meas. + Tevatron might allow SM Higgs only with mass between 118 and 145 GeV, definitely only a light Higgs boson, which will take some time to be found at LHC (> 1 fb^{-1}) → LHC/Tevatron complementarity H→ γγ vs H→ bb

Conclusion

Sensitivity of Higgs analyses is constantly progressing almost linearly with Luminosity, i.e. much better than sqrt(L)

2008 should allow us to go beyond LEP w.r.t SM Higgs, in particular at 160 GeV

D0-France-Higgs could contribute more, more “mutualisation” of the efforts could be an option.

We must make a common effort this fall to take advantage of our proximity in space and interest.

2008 -2009 must teach us how well we perform at low mass, with the golden WZ/ ZZ ($Z \rightarrow bb$) benchmark

For Higgs, 2009-2011 will be the most exciting years.