Higgs Searches and Perspectives at the Tevatron

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Outline

SM Higgs → bb (lower mass)

WH → lνbb

ZH → ννbb

ZH → llbb

SM Higgs → WW (higher mass)

H → WW

WH → WWW

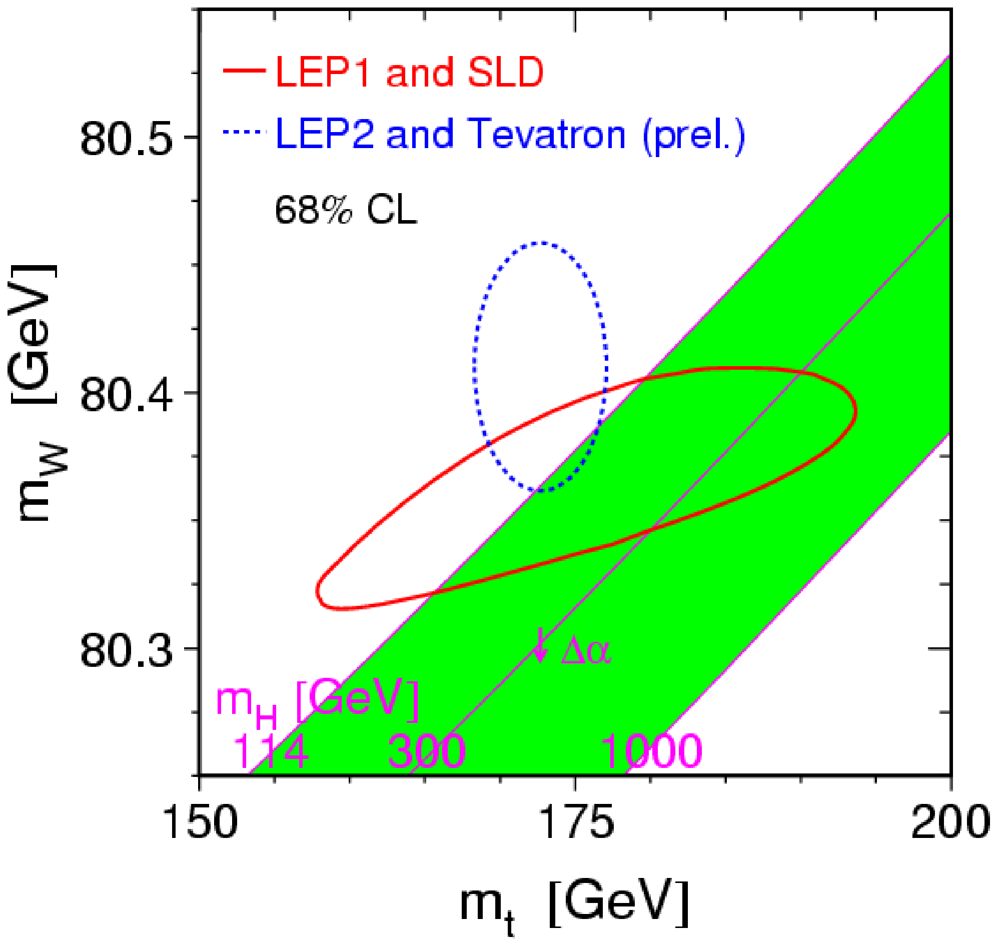
MSSM Higgs

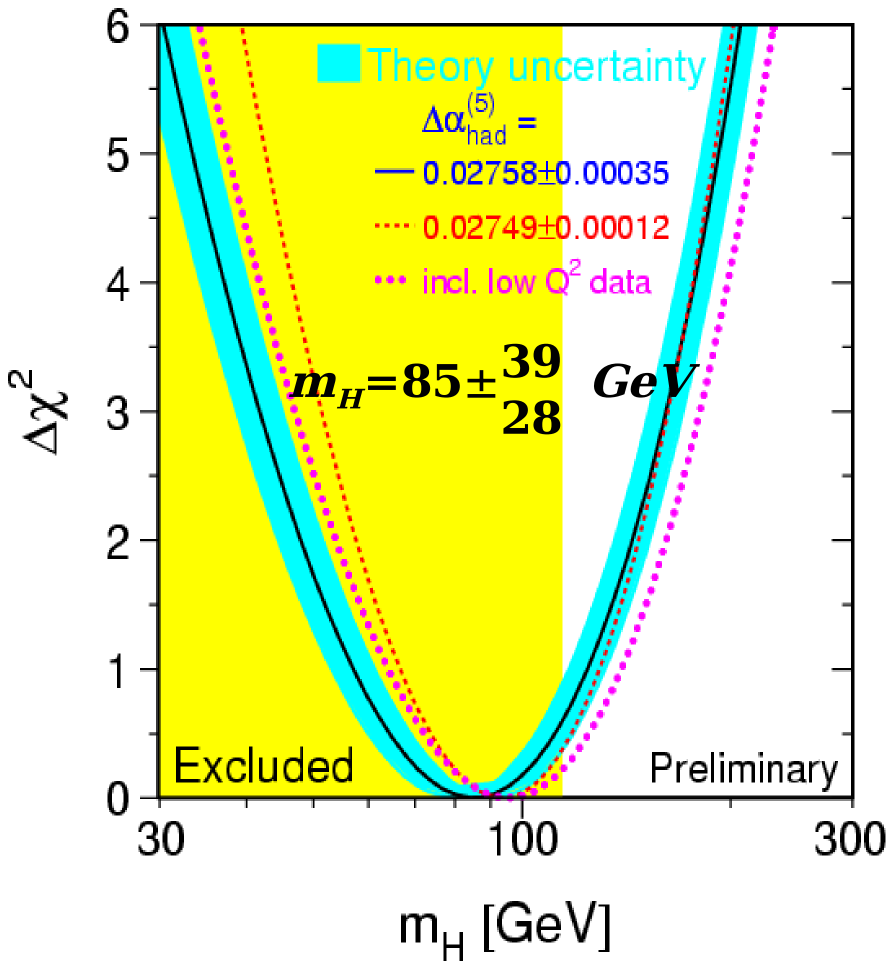
A → τ τ

Perspectives and Summary

LEP: $m_H > 114.4\ GeV\ (95\%\ CL)$

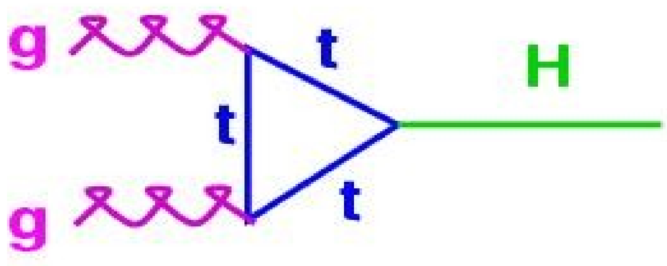
Stalking the wild Higgs

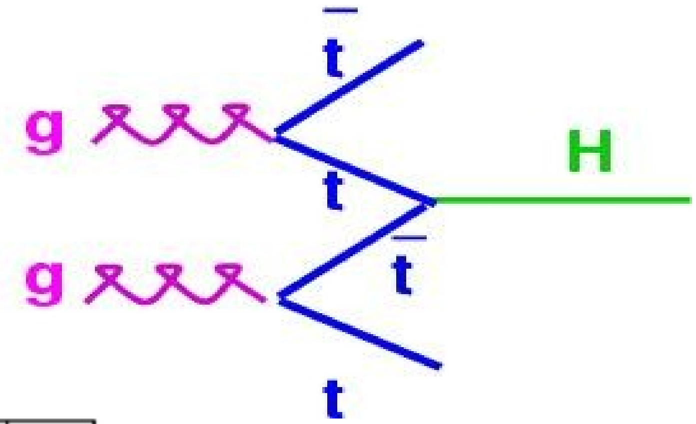


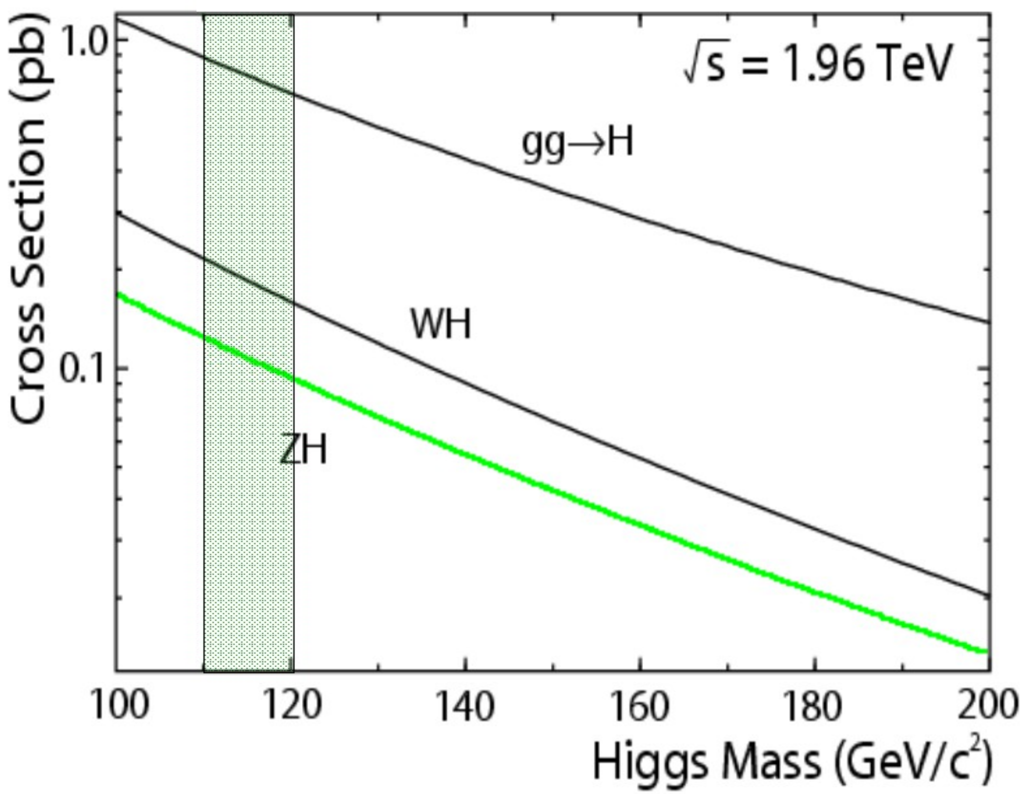


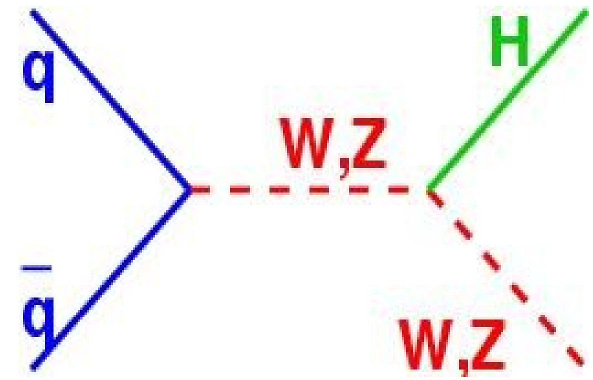
A light Higgs Boson
is in our reach..

$m_H < 166\ GeV\ (95\%\ CL)$



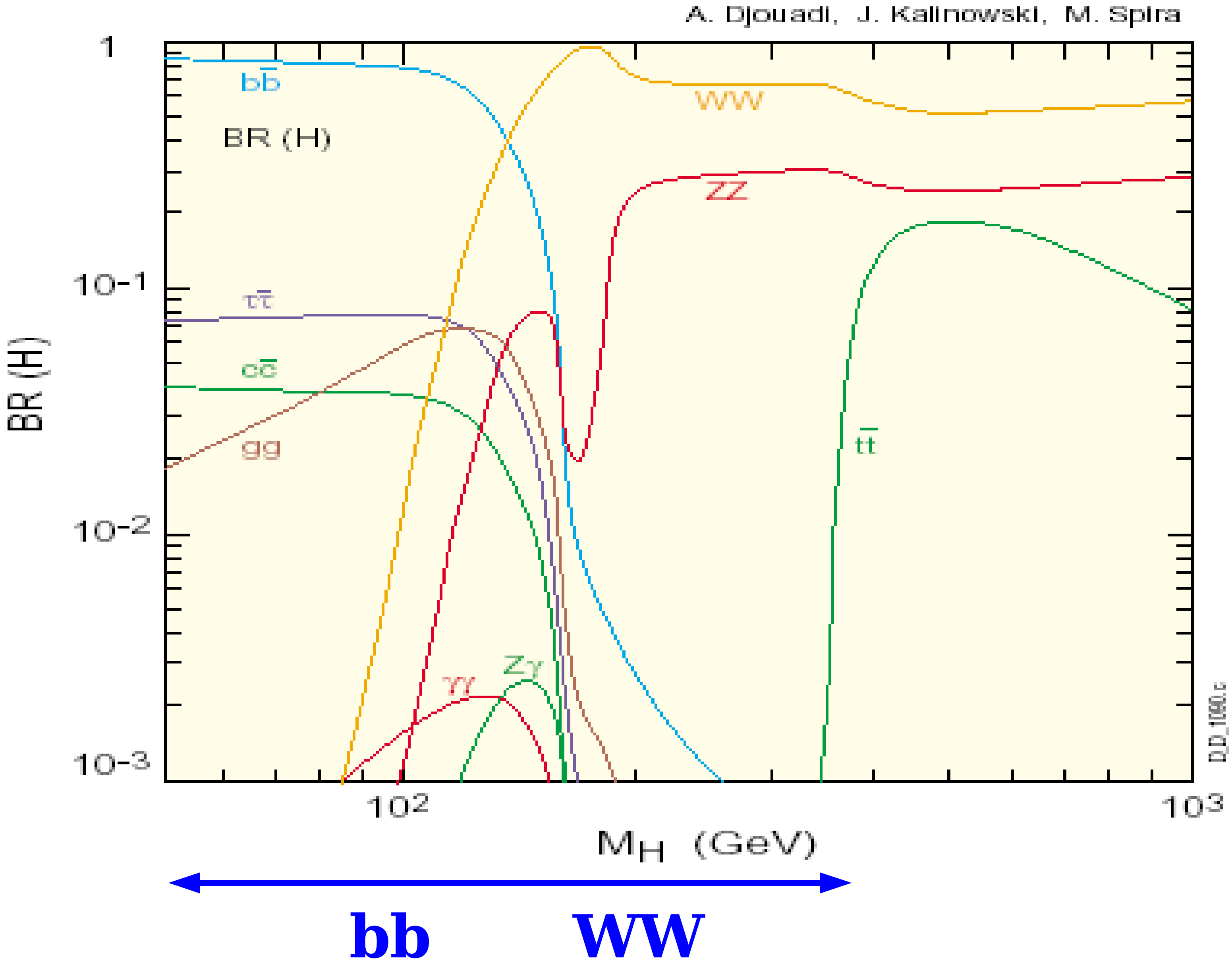




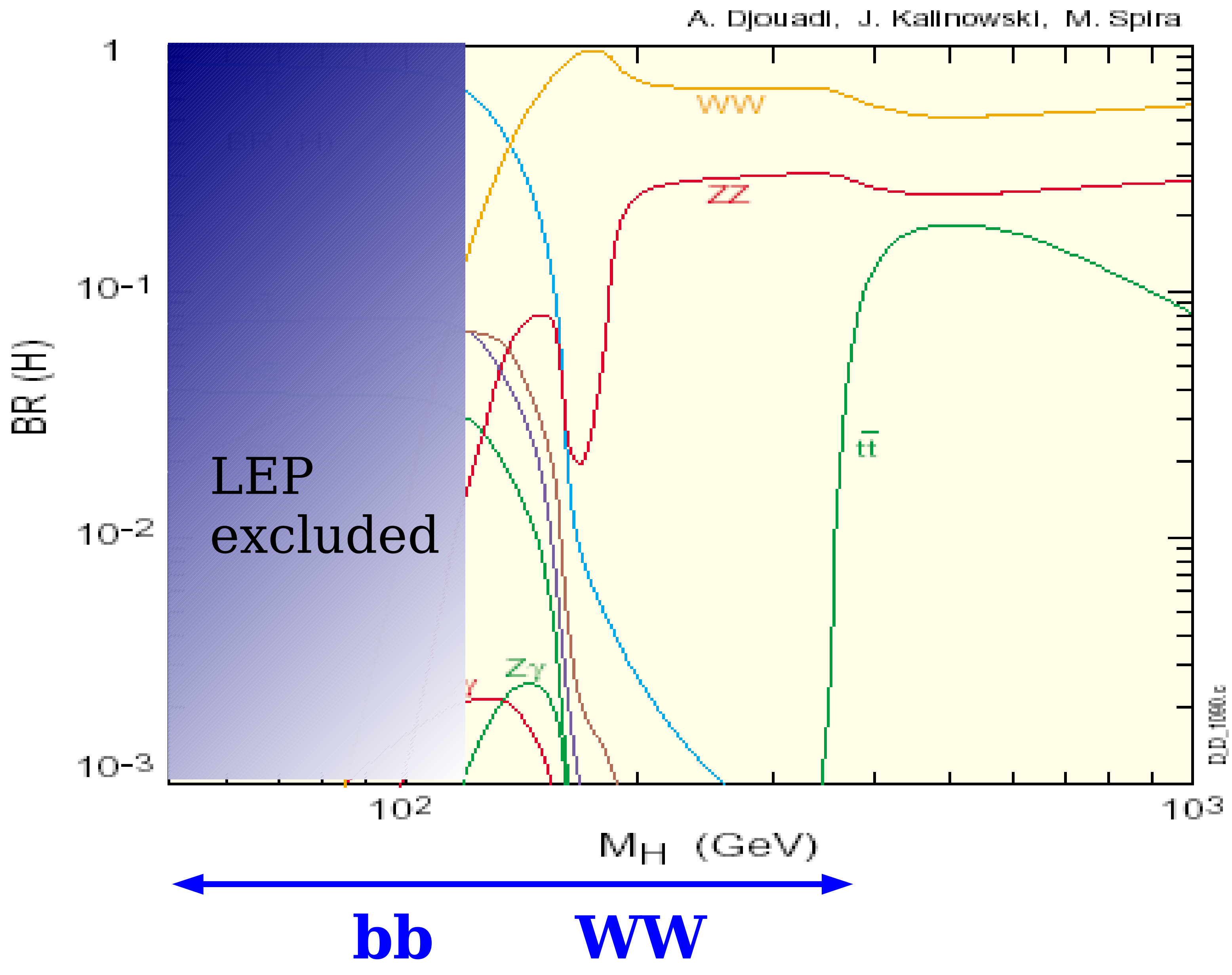


~one in 10^{12} $p\bar{p}$ events will be a Higgs boson

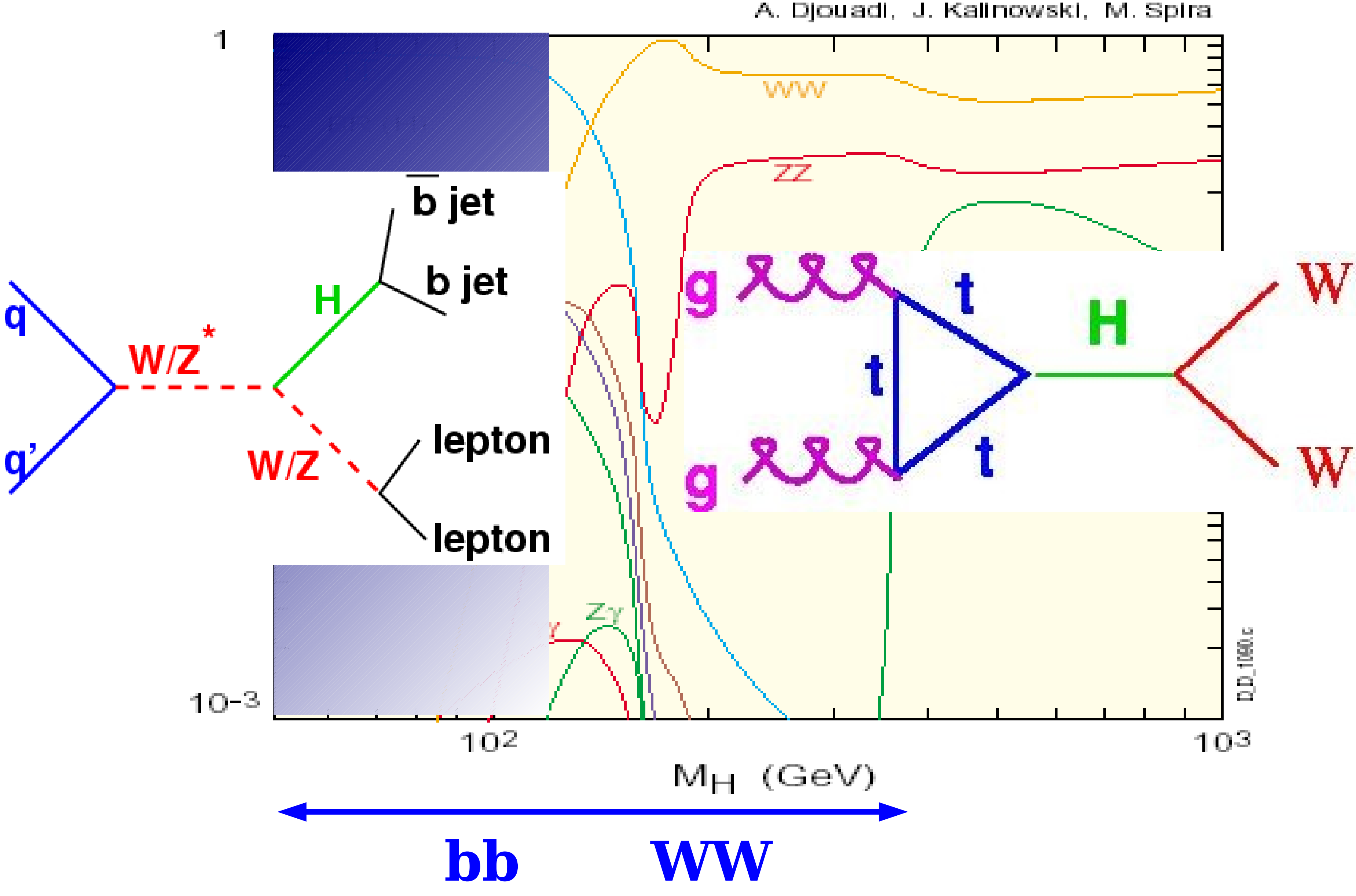
Branching Fractions:



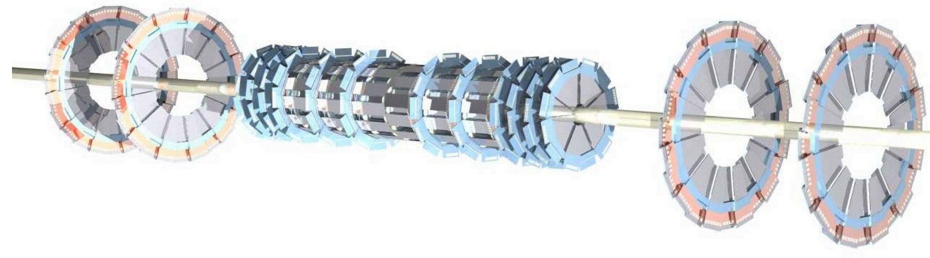
Branching Fractions:



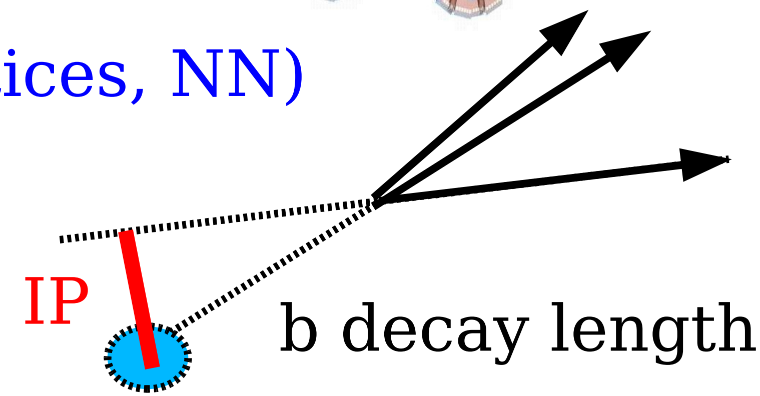
Branching Fractions:



Tools:



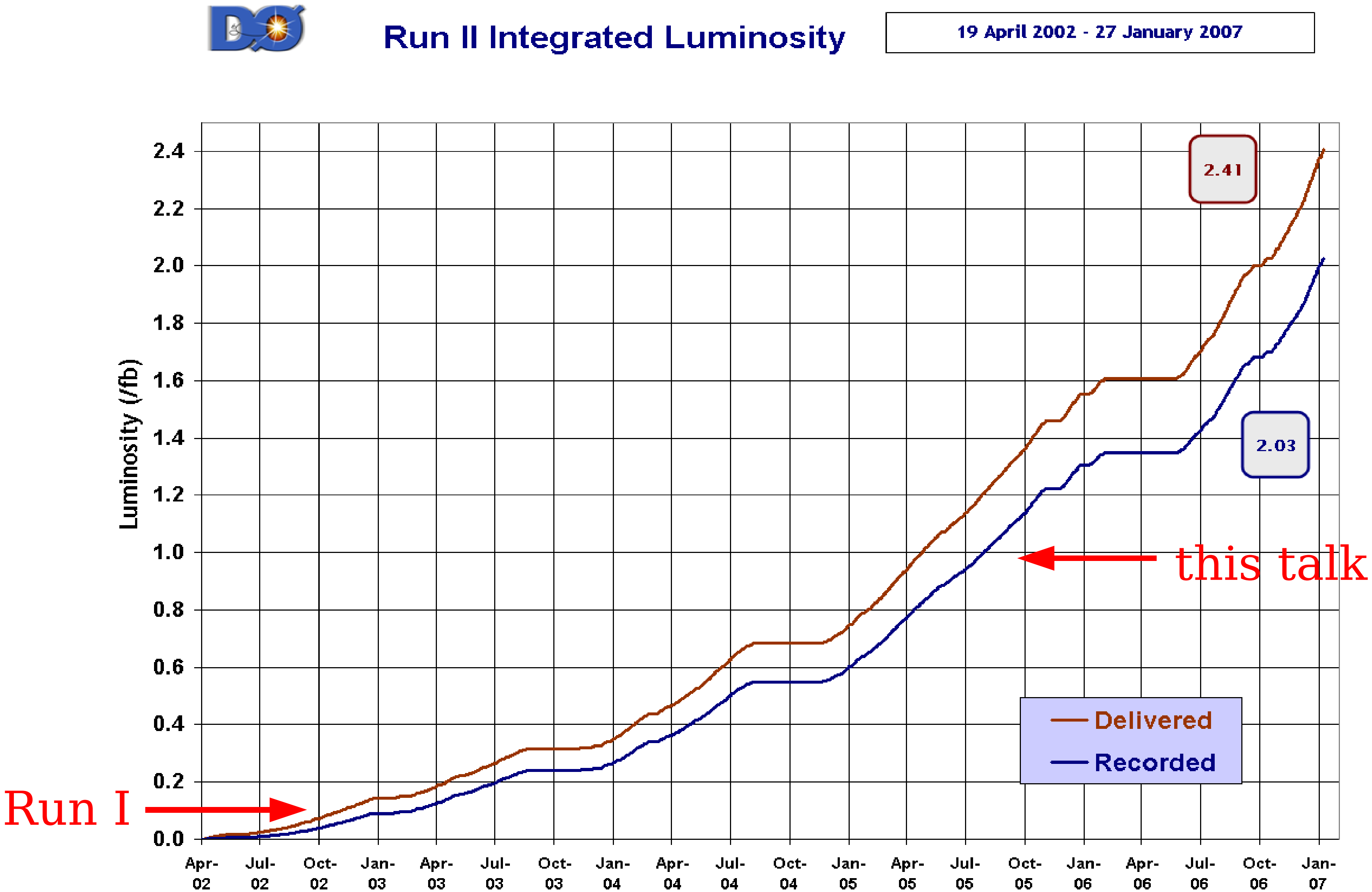
- Jet reconstruction
- B tagging (IP, muons, sec. vertices, NN)
- Electron identification
- Muon identification
- Missing transverse energy



require excellent trigger and detector performance

Backgrounds:

- Electroweak background (W, Z, WW, WZ, top)
  kinematic distributions using Monte Carlo
  normalised with (N)NLO calculations
- QCD and instrumental background taken from
  data using control samples



Run II Integrated Luminosity
19 April 2002 - 27 January 2007
Luminosity (/fb)
2.41
2.03
Delivered
Recorded
this talk
Run I
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
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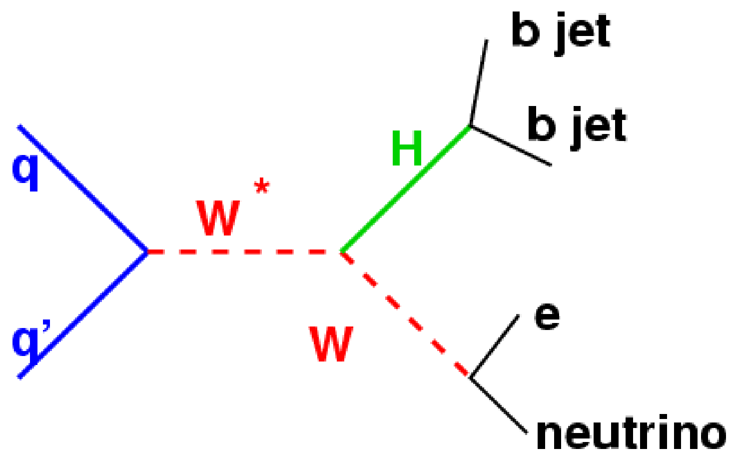
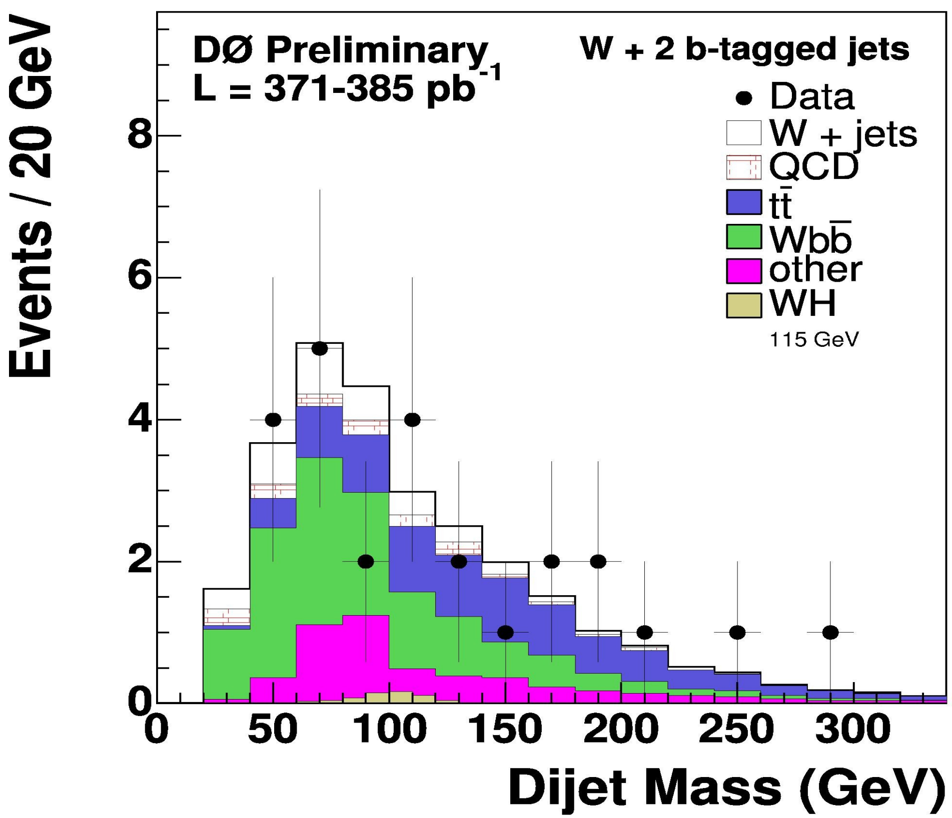
$WH \rightarrow l\nu bb$



- Selection
  - two tagged b-jets
  - lepton with $E_T > 20$ GeV
  - $E_T^{miss} > 25$ GeV

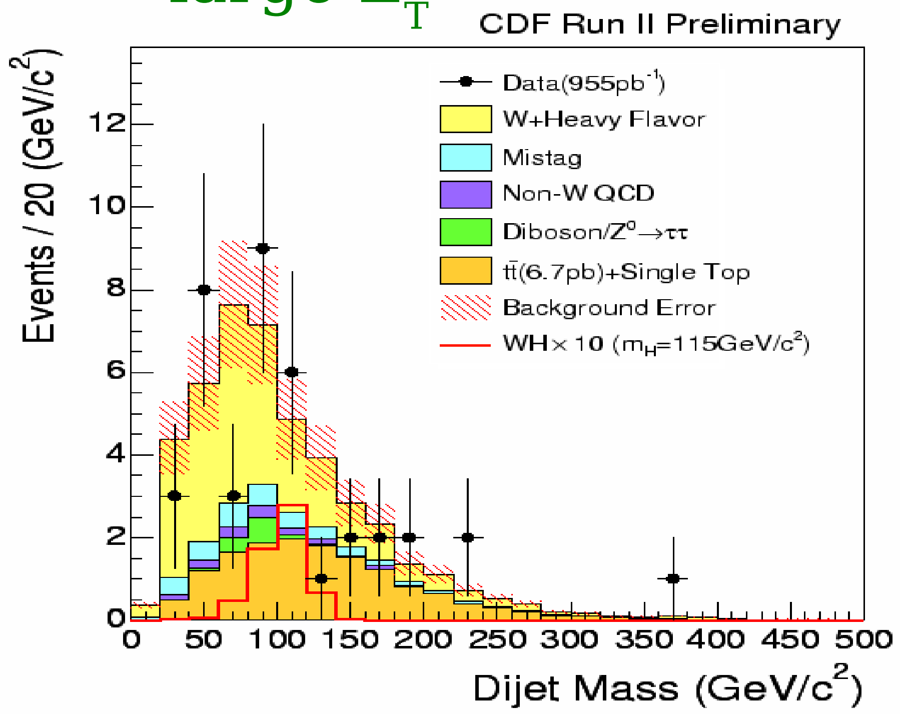


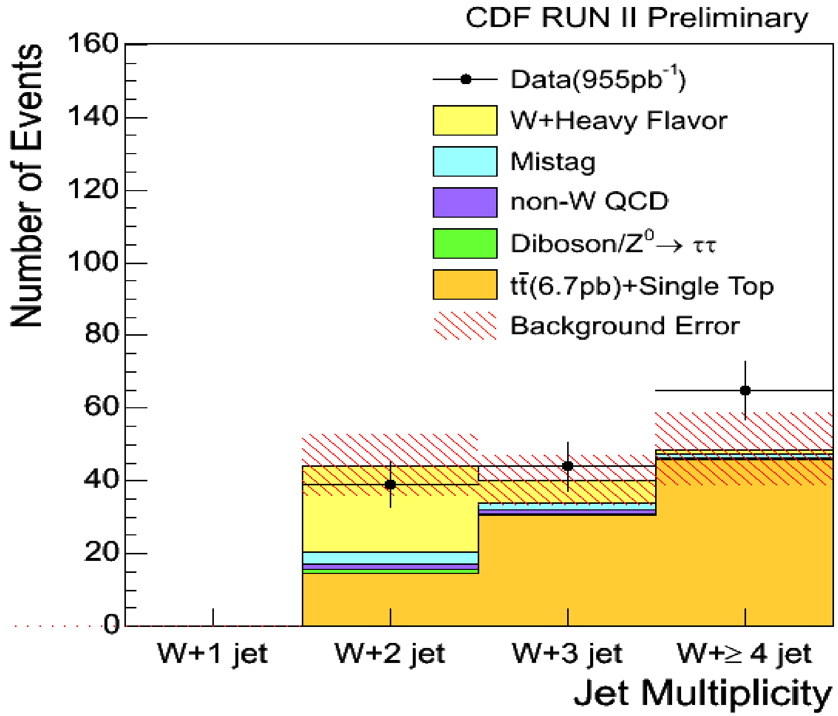
M_H=115 GeV, 90<M_{jj}<140 GeV

- 6 events observed
- 9.3 ± 1.8 background predicted
- 0.28 ± 0.06 signal predicted
- σ_{95}=2.4 pb

WH→lνbb

- muon and electron channel combined:
  - 1 or 2 NN tagged b-jets
  - electron or muon with high p_T
  - large E_T^{miss}



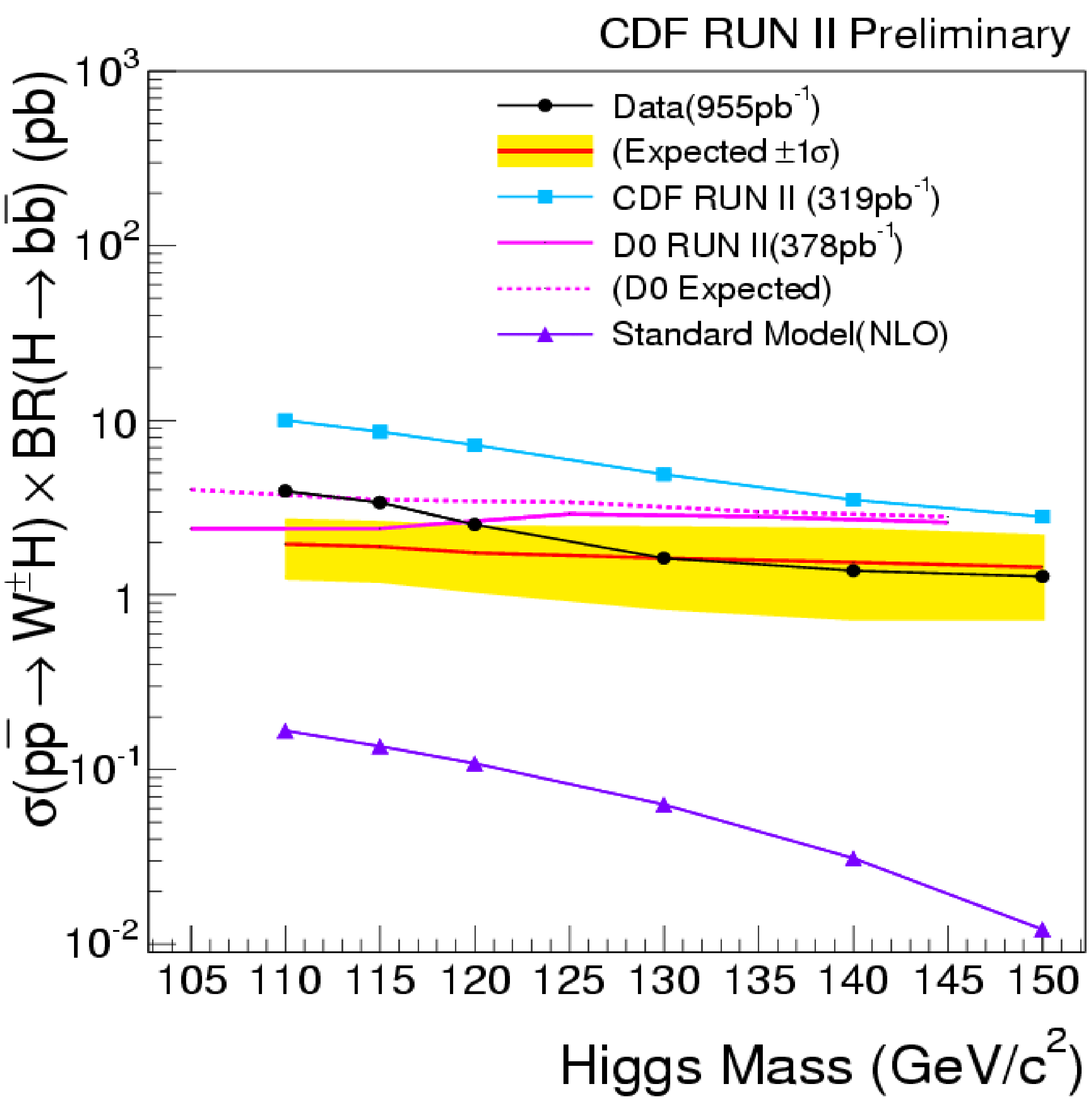


- main backgrounds:

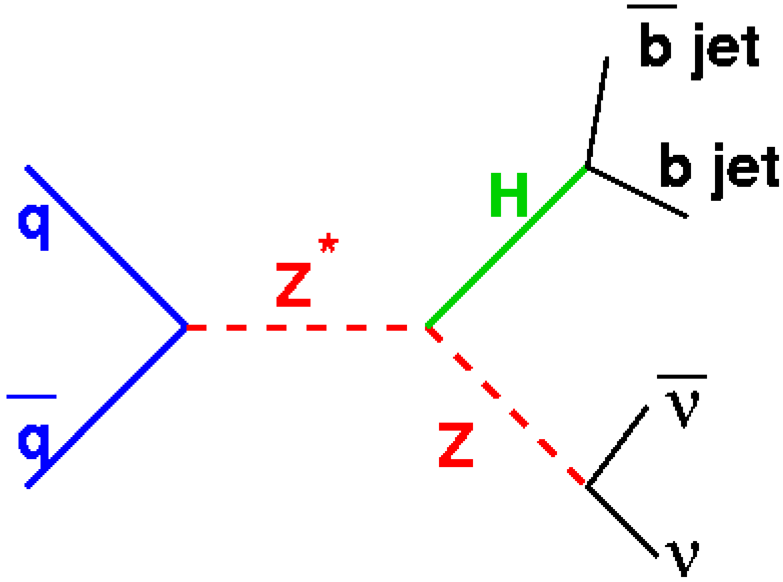
  W+heavy flavour jets
  top pairs
  di-bosons (WZ, WW etc.)

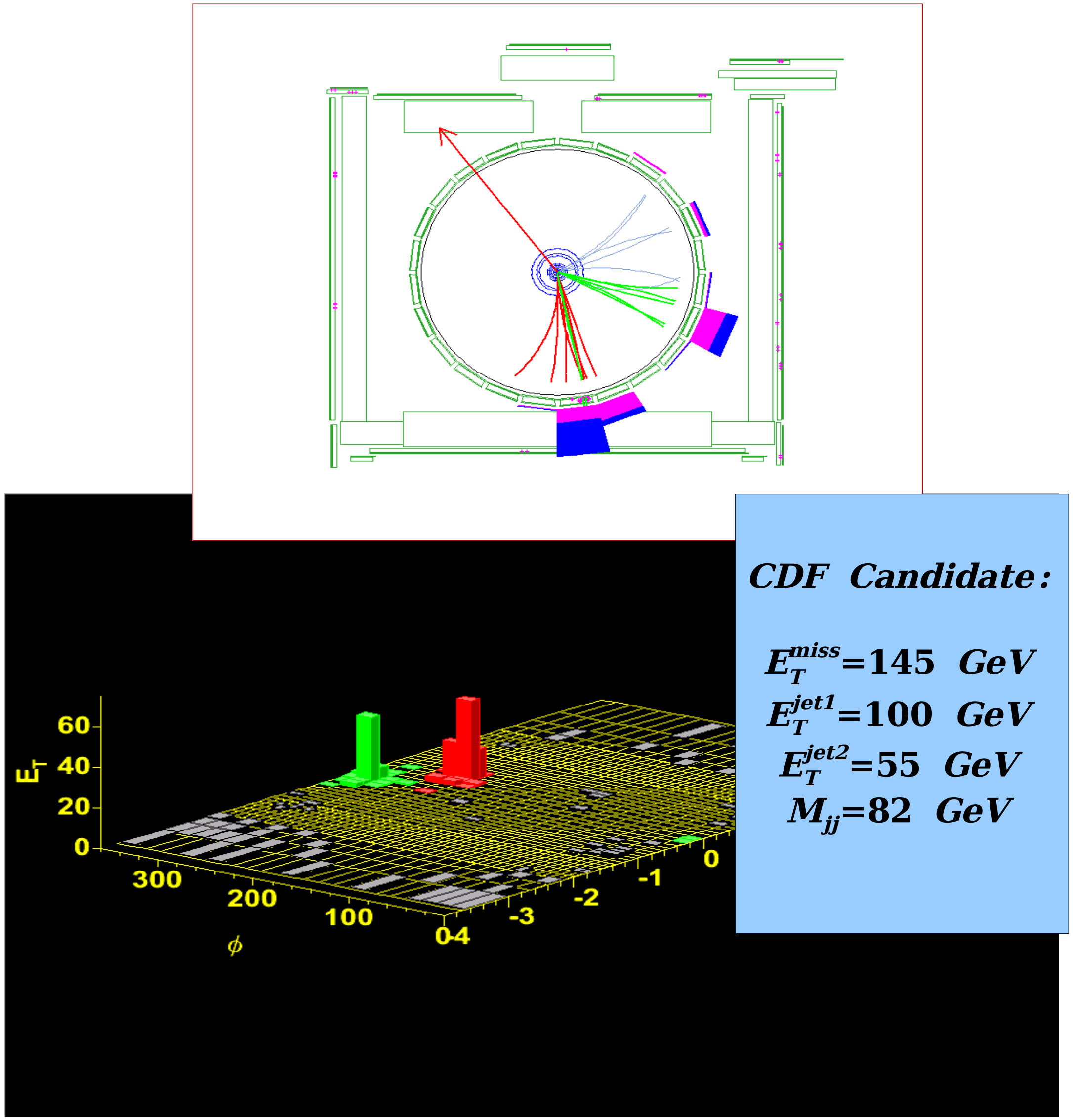
Cross-section Limits

Source	Uncertainty (%)	
	= 1tag w/ NNtag	≥ 2tag
Lepton ID	∼2%	
Trigger	< 1%	
ISR	1.8%	4.3%
FSR	3.2%	8.6%
PDF	1.7%	2.0%
JES	2.3%	3.0%
b-tagging	5.3%	16%
Total	7.2%	19.1%



$ZH \rightarrow \nu\nu bb$

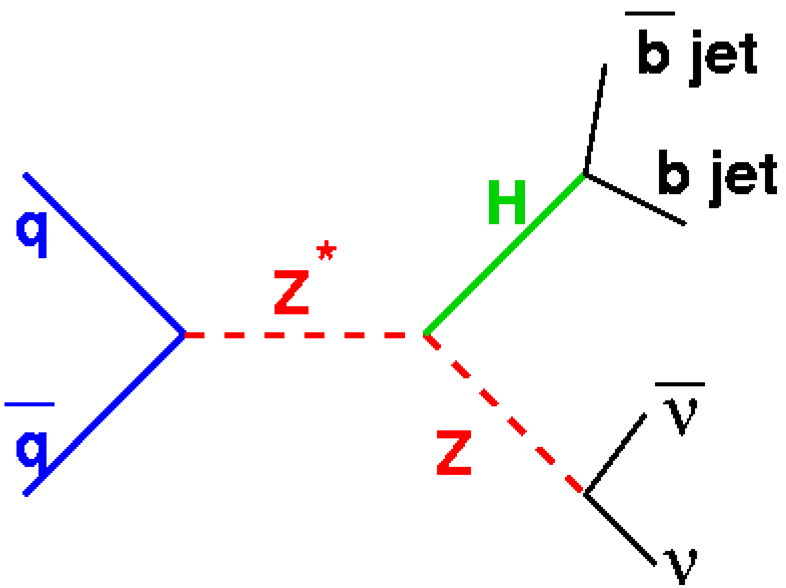


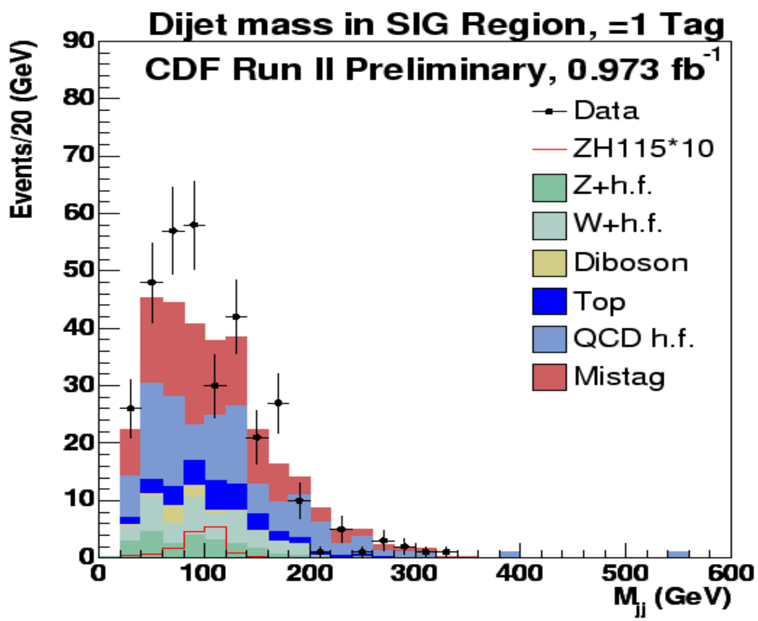


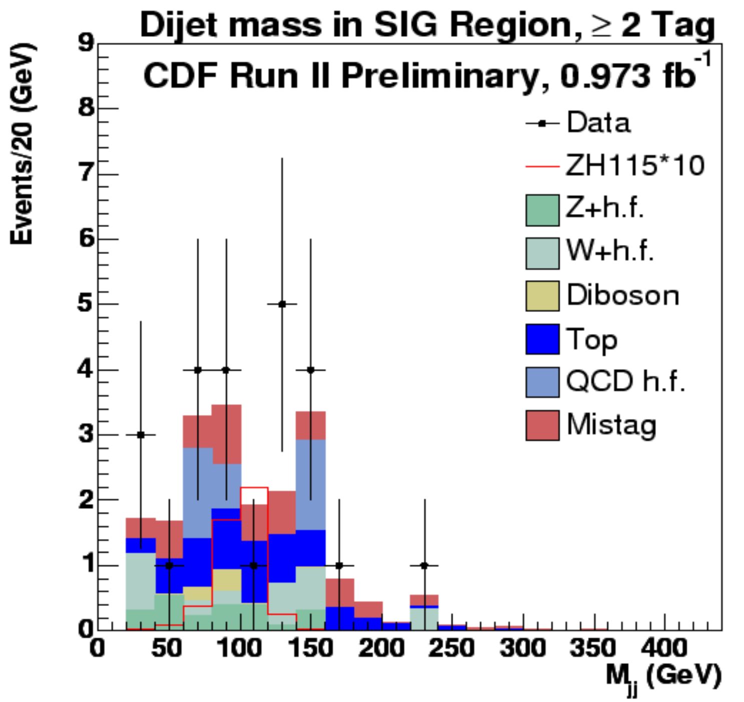
Selection:

- $\geq$ 1 tagged b-jets
- two jets with E_T > 35/20 GeV
- E_T^{miss} > 55 GeV

ZH → ννbb





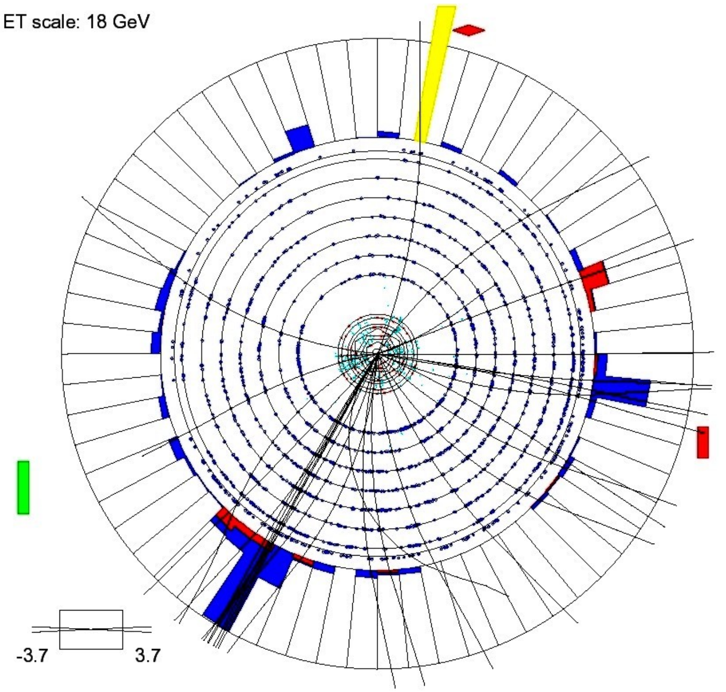


Backgrounds :

- W+heavy flavour jets
- Z +heavy flavour jets
- di-bosons
- misidentified b jets
- top pairs

ZH → ννbb

L=261 pb^{-1}



Selection:

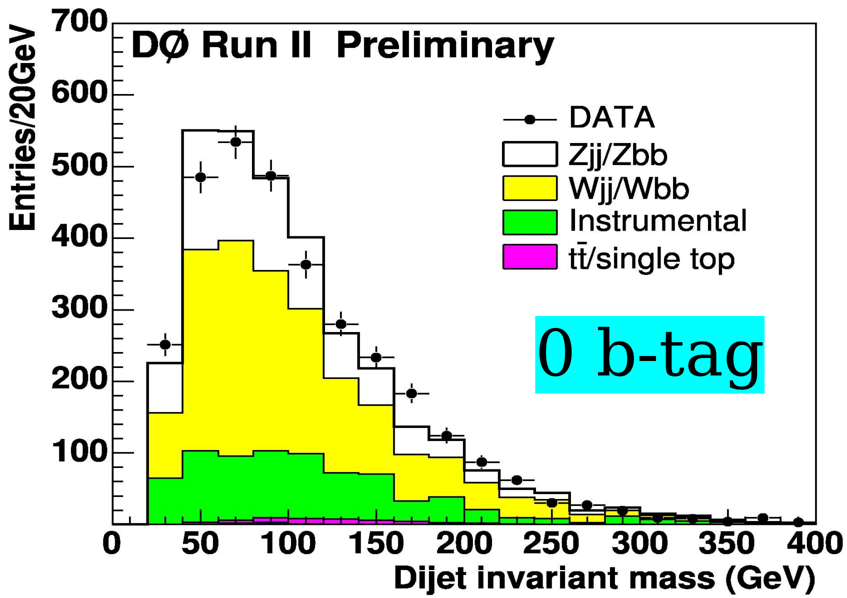
- two or three jets with E_T > 20 GeV
- E_T^{miss} > 50 GeV
- leading jets acoplanar
- Sum of scalar jet E_T<240 GeV

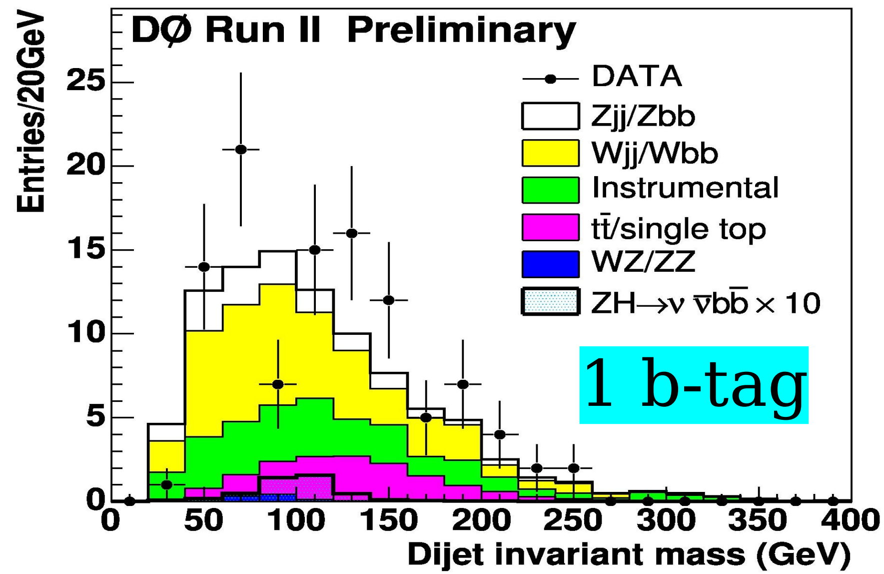
Two (exclusive) samples:

(i) two tagged b jets – signal efficiency 0.43%

(ii) one tagged b jet - signal efficiency 0.42%

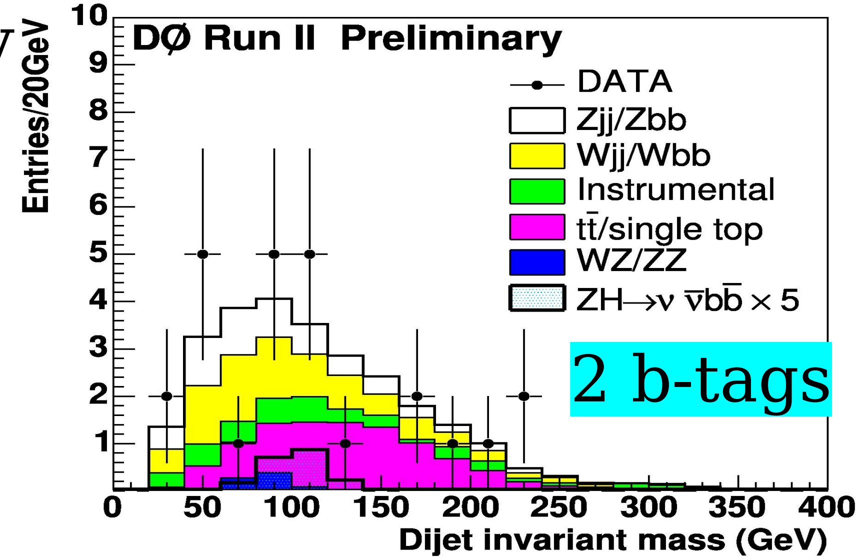
ZH → ννbb



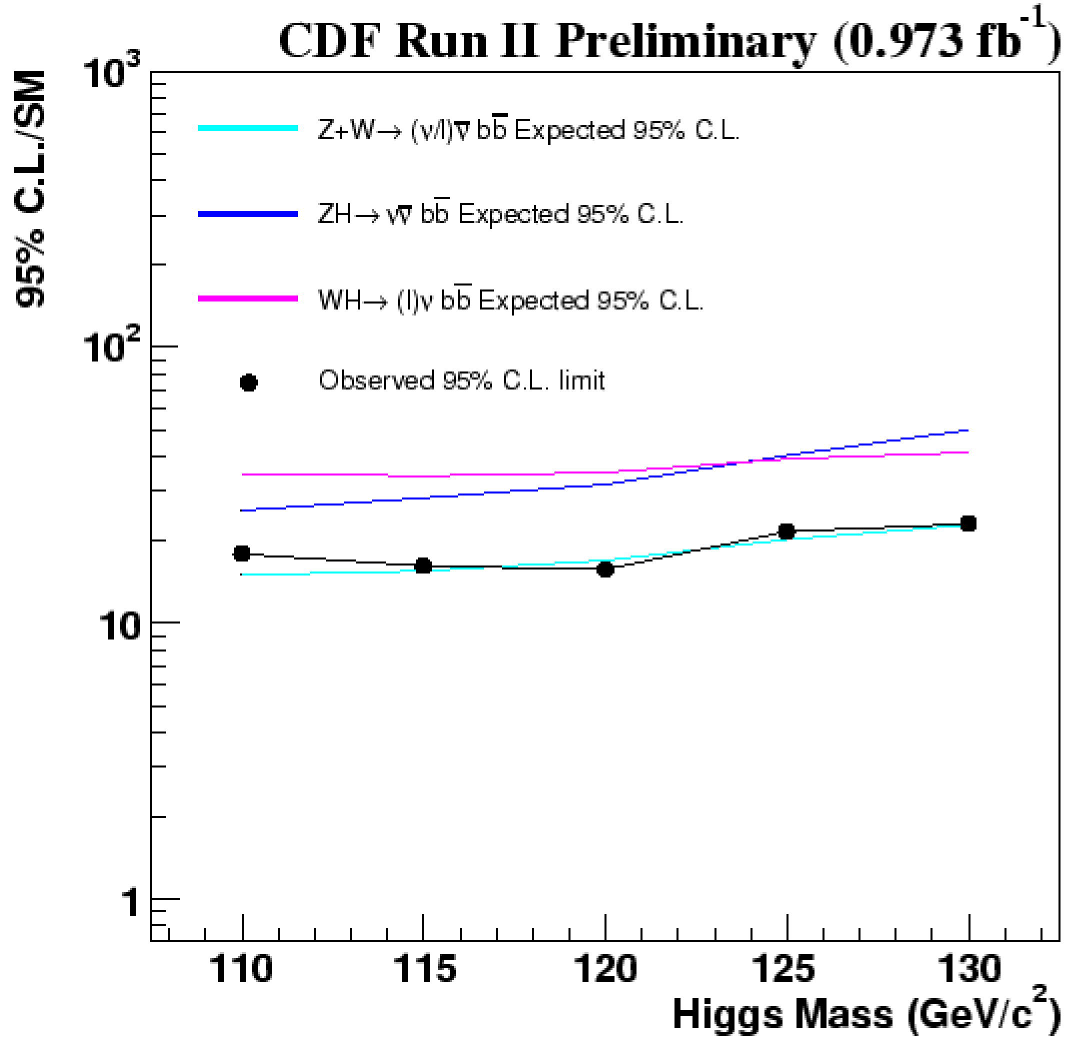


M_H=115 GeV, 80<M_{jjl}<130 GeV

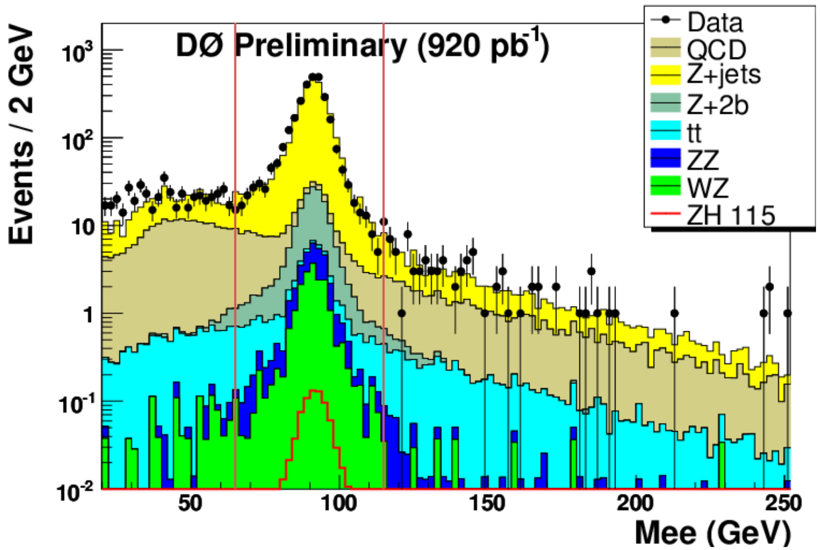
- 11 (double tagged) events observed
- 9.4 ± 1.8 bg predicted
- 0.21/0.15 (ZH/WH) signal expected
- σ_{95}=3.2 pb (ZH)

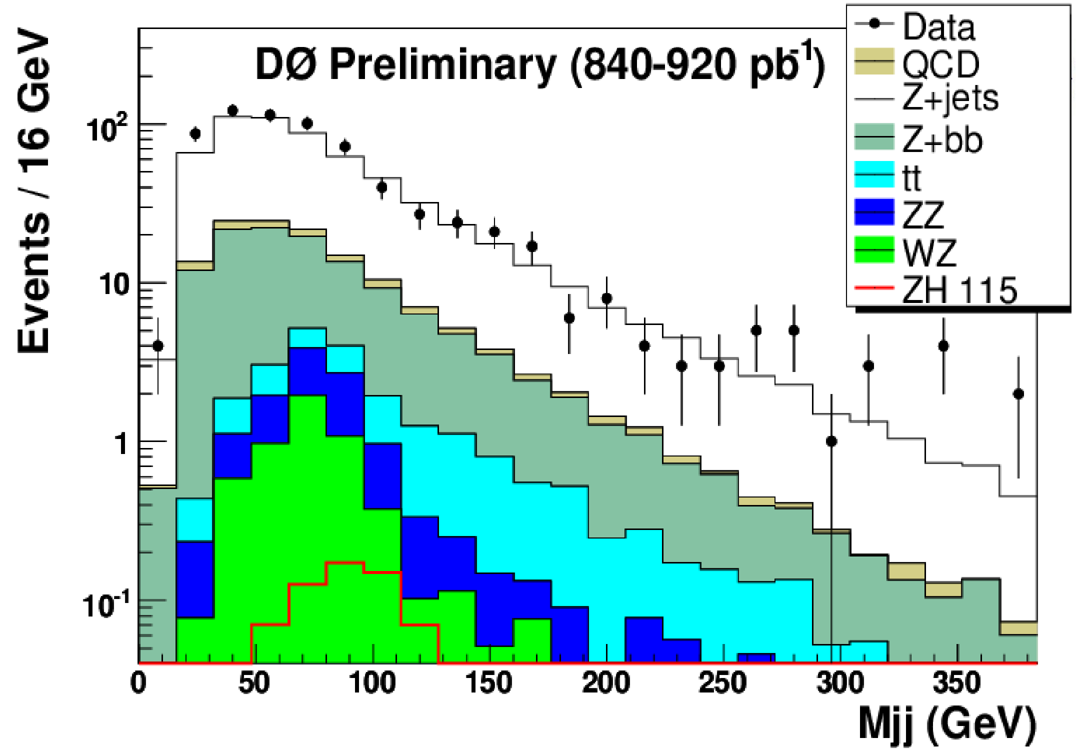


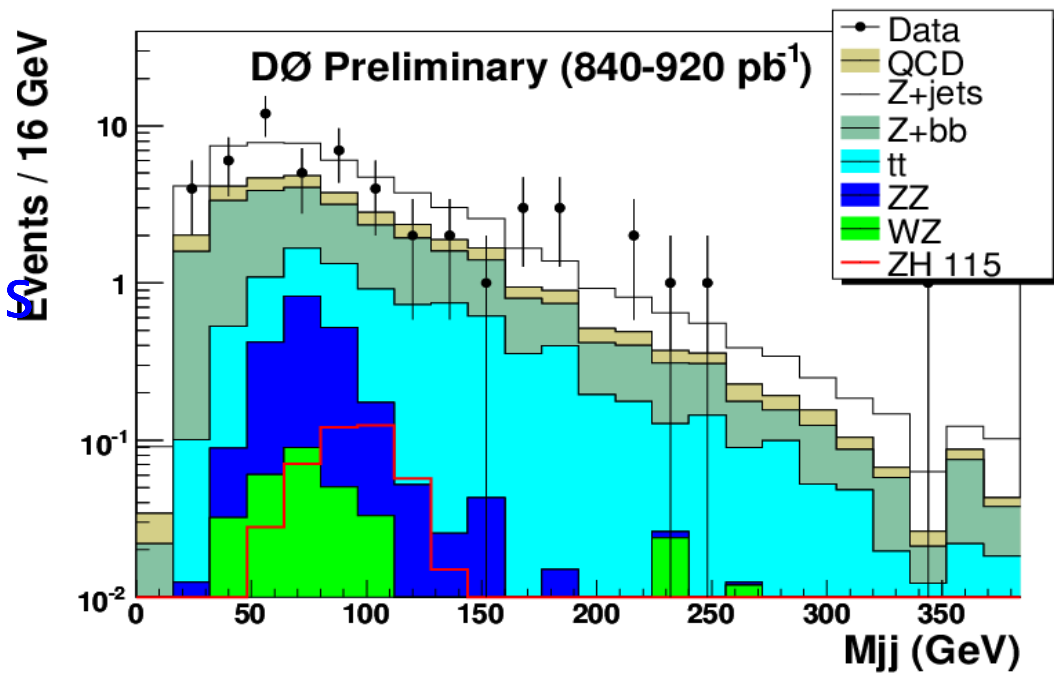
Limit still a factor 10 away from SM
..a long way to go



ZH → llbb



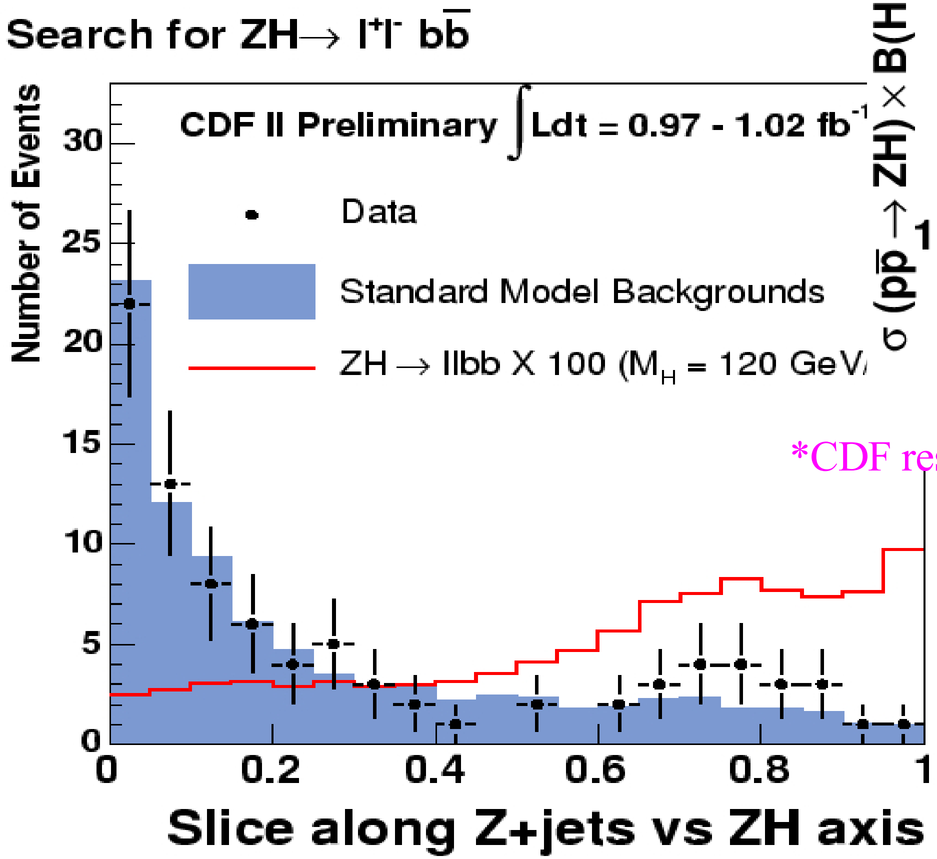


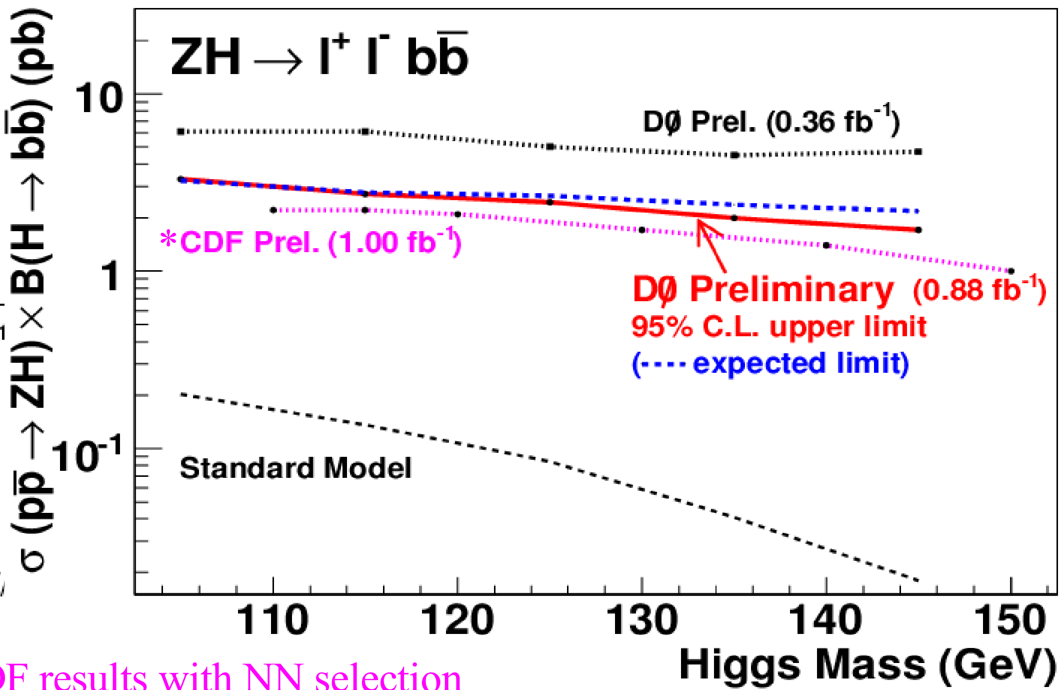


Dominated by background

advanced analysis techniques

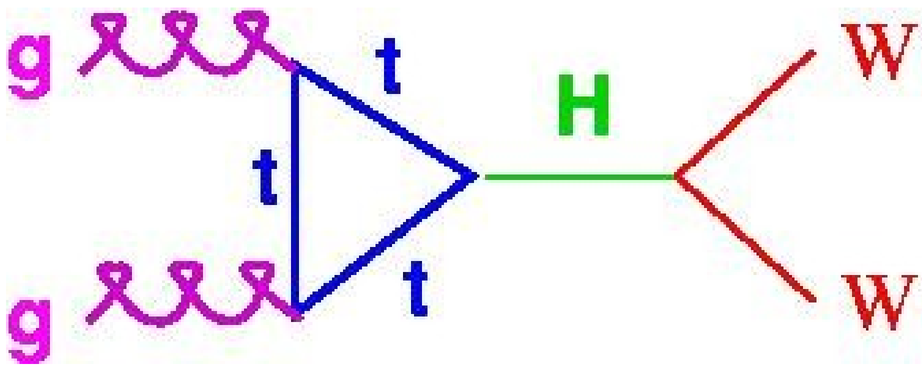
multivariate analysis → CDF

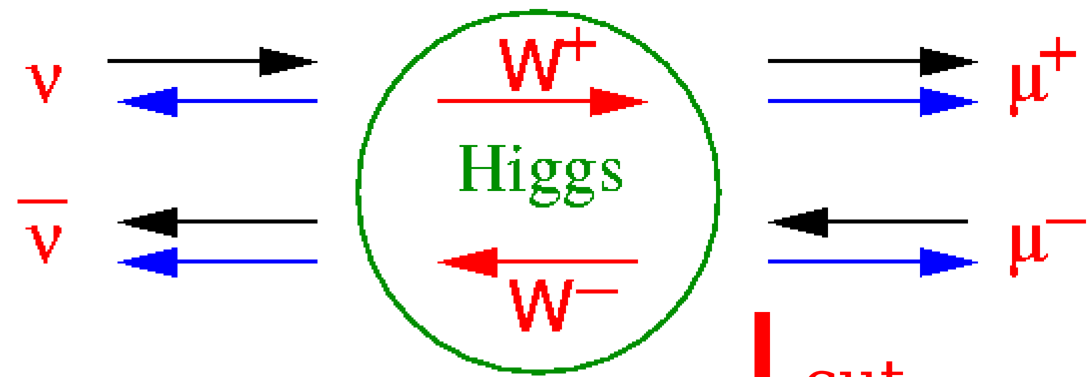


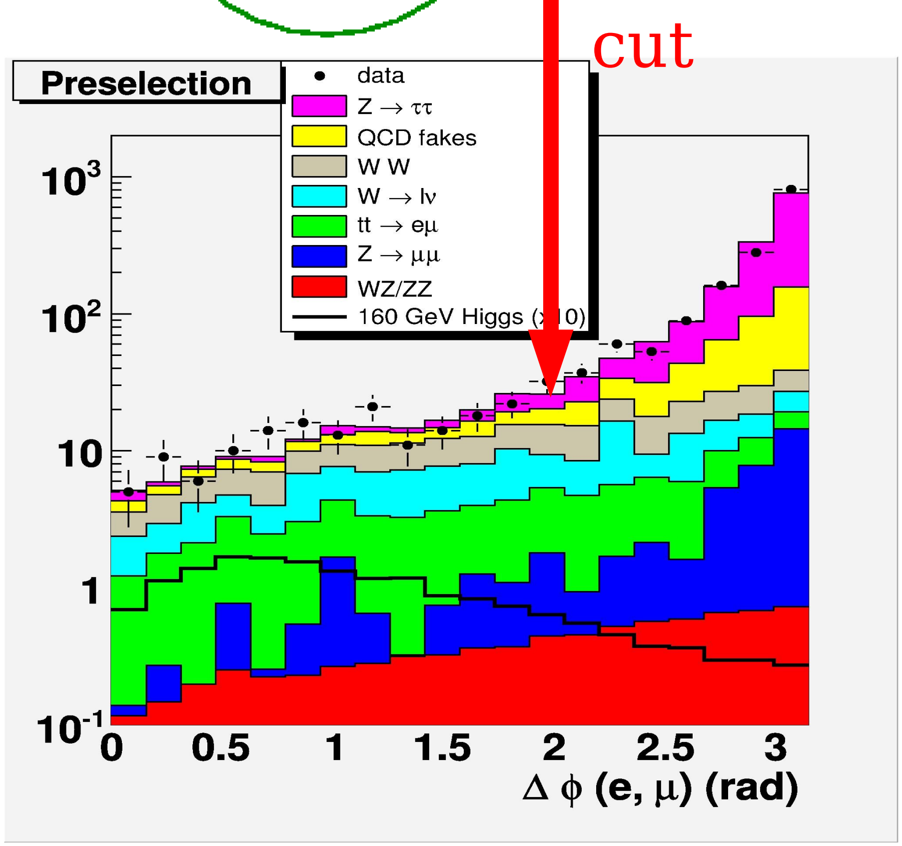


*CDF results with NN selection

H → WW → eνeν, μνμν, eνμν



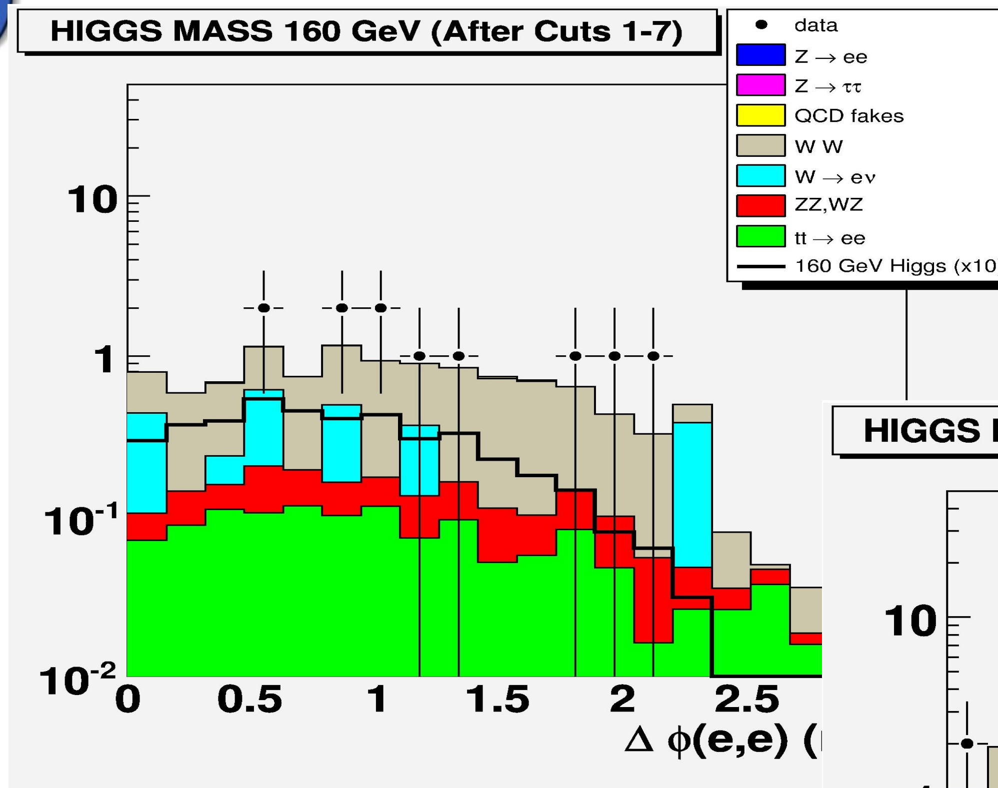


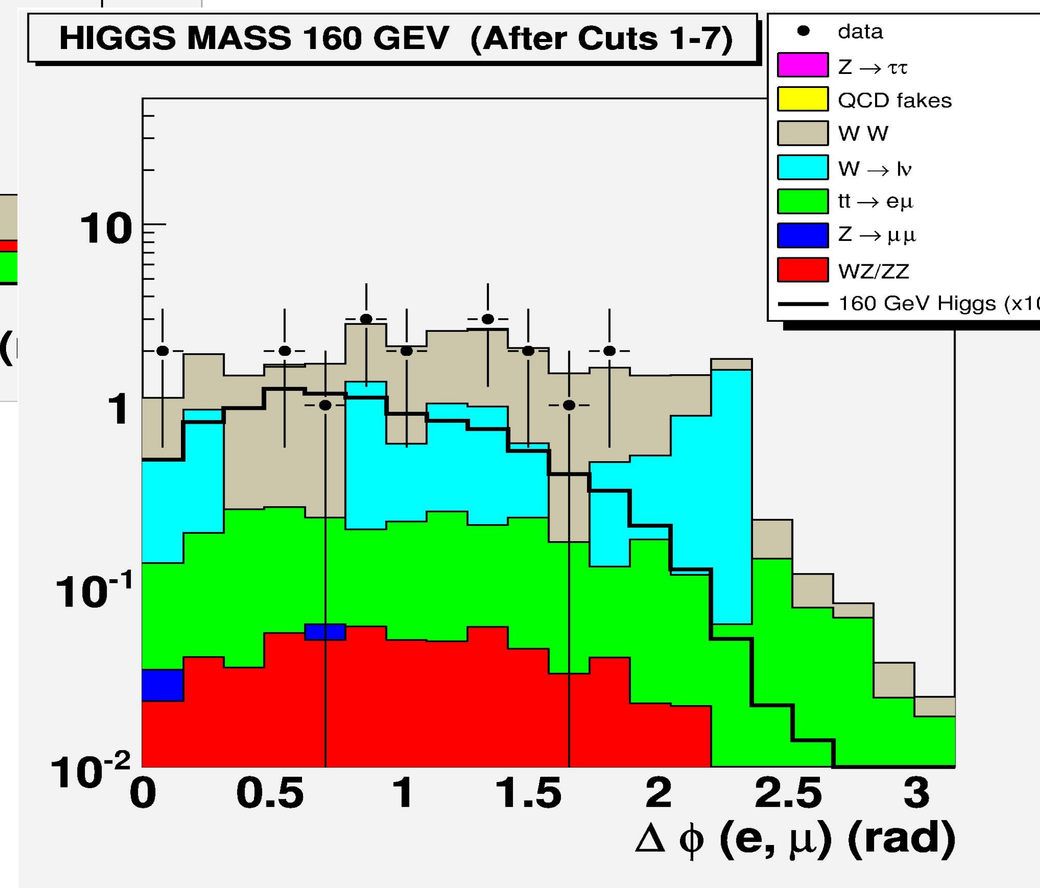


Selection:

- two leptons with $p_T > 15/10$ GeV
- $E_T^{miss} > 20$ GeV
- $\Delta\phi_{ll} < 2$

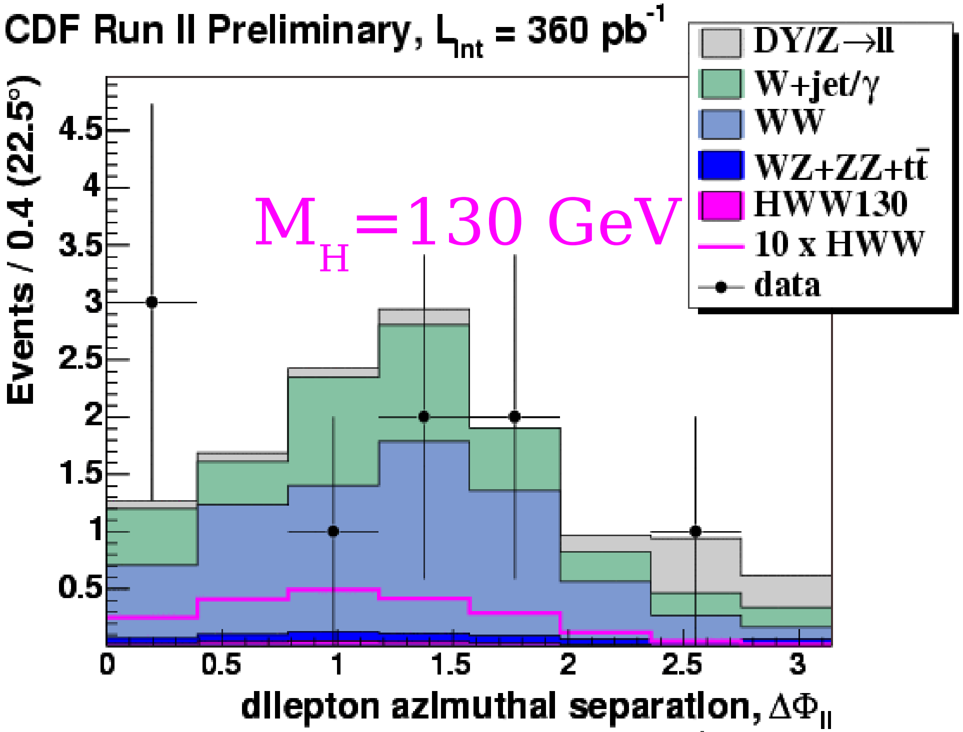
+ mass dependent cuts

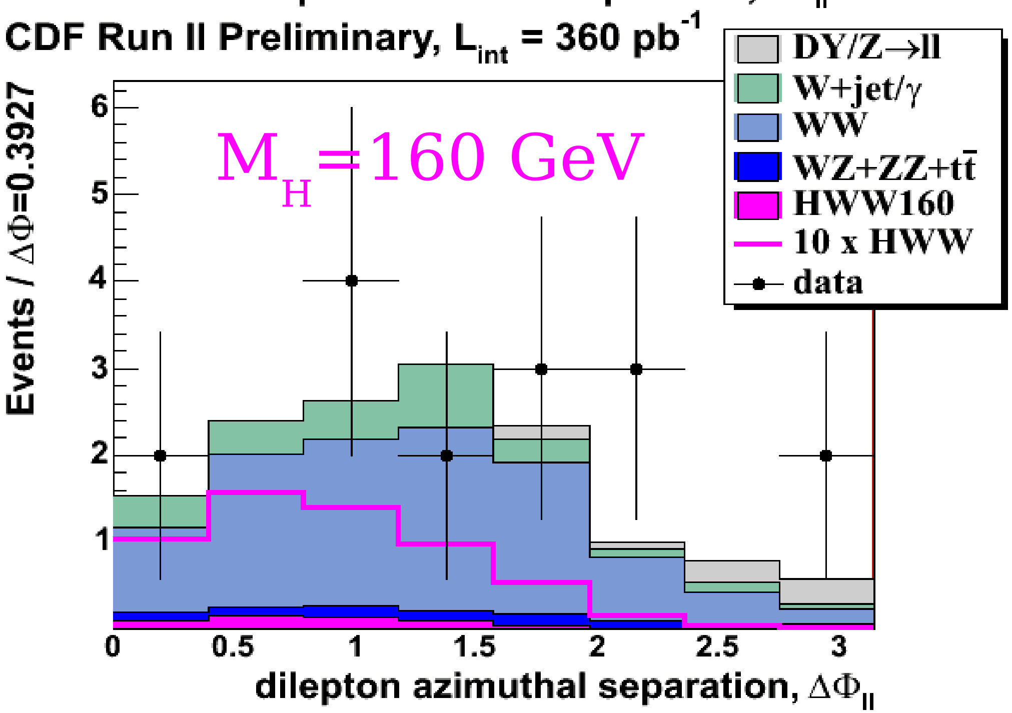




M_H=120 GeV

- 31 events observed
- 32.7 ± 2.3 (stat) predicted
- σ_{95}(obs)=6.3 pb

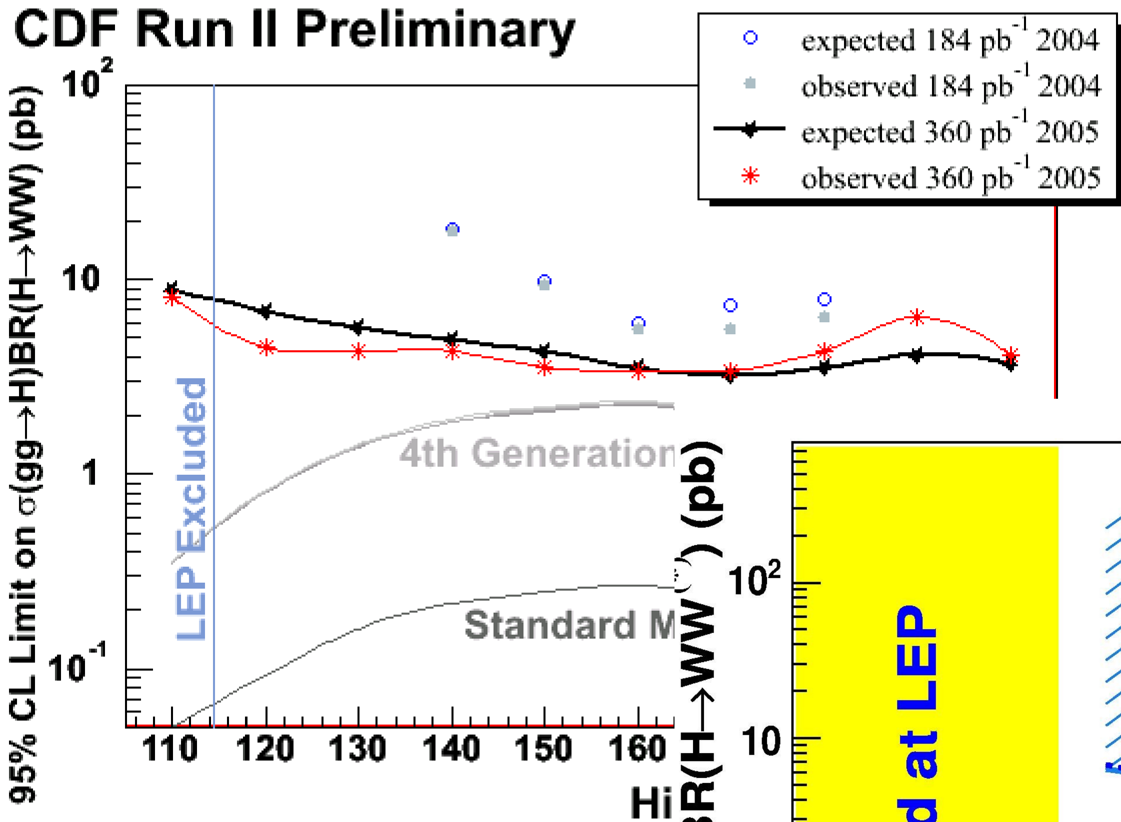


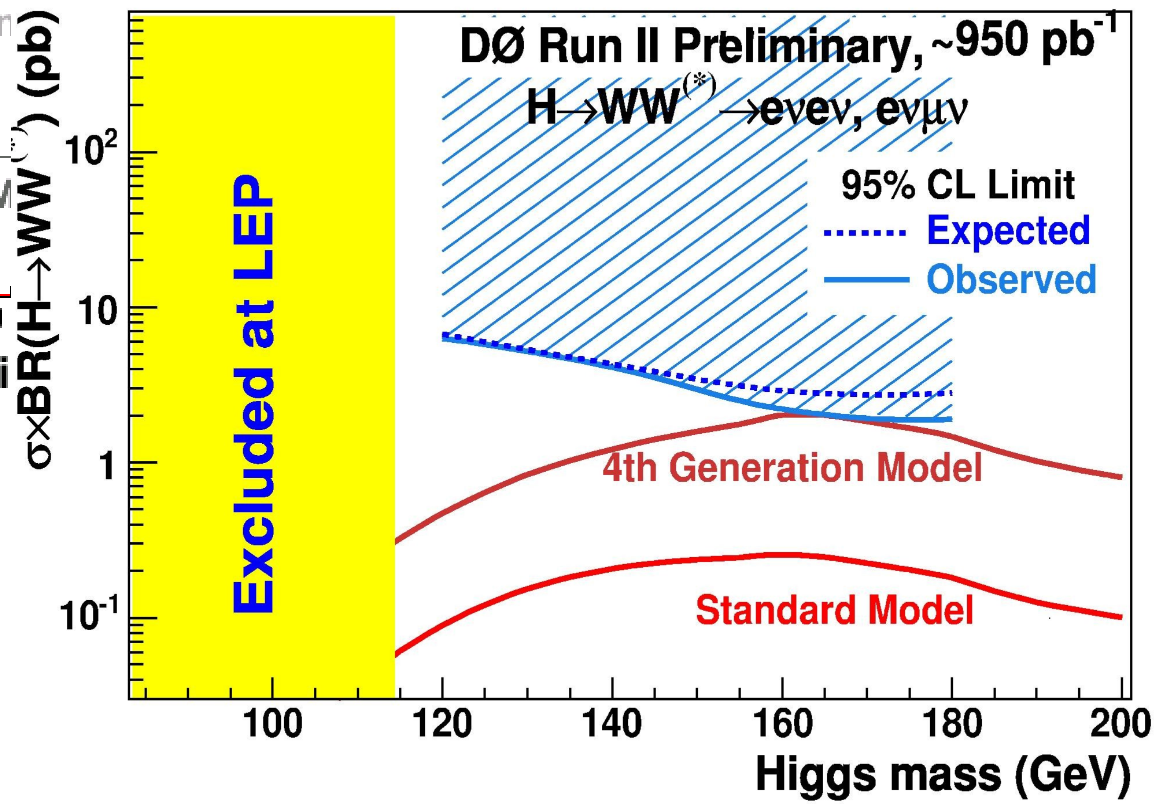


Selection:

- two leptons with p_T>20/10 GeV
- $E_T^{miss} > M_H/4$
- $16 < M_{ll} < M_H/2\text{-}5$ GeV

$\Delta\phi_{ll}$ distribution fitted to extract 95% CL limit

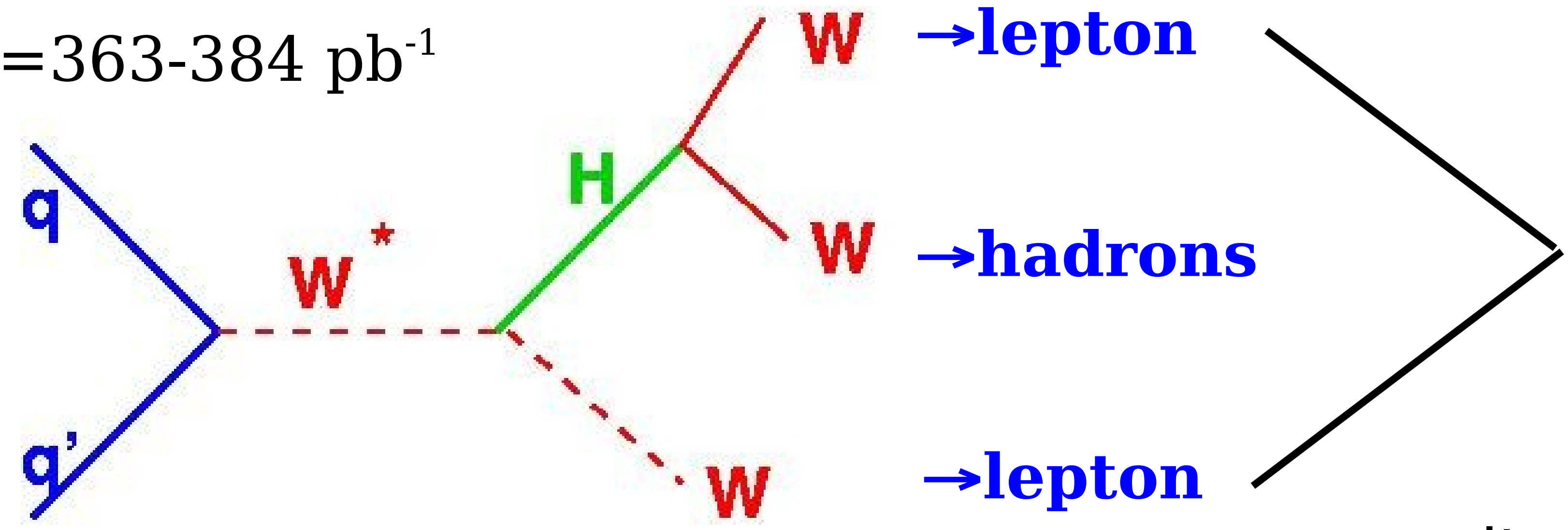




DØ also uses shape information for limit setting (LEP CL$_s$ method)

WH→ WW* → lν l'ν qq

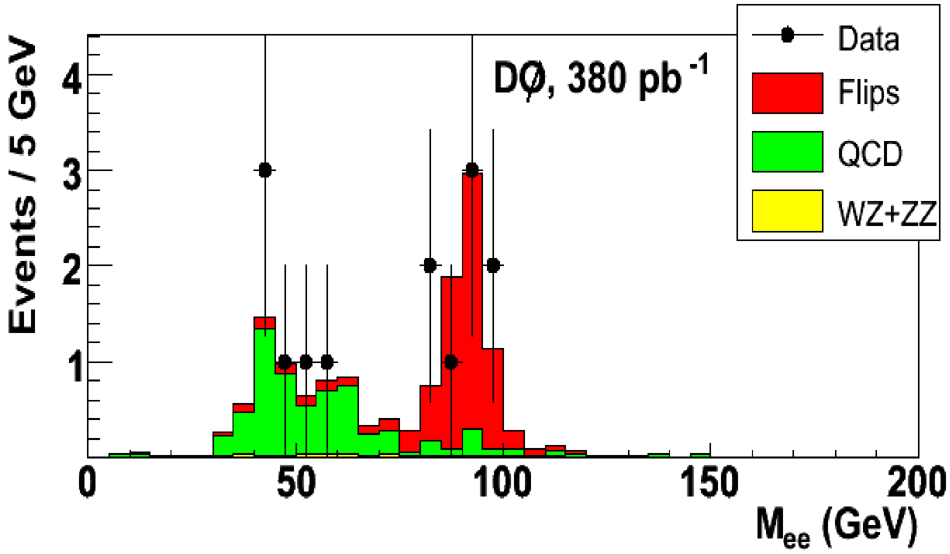
L=363-384 pb^{-1}



di-electron

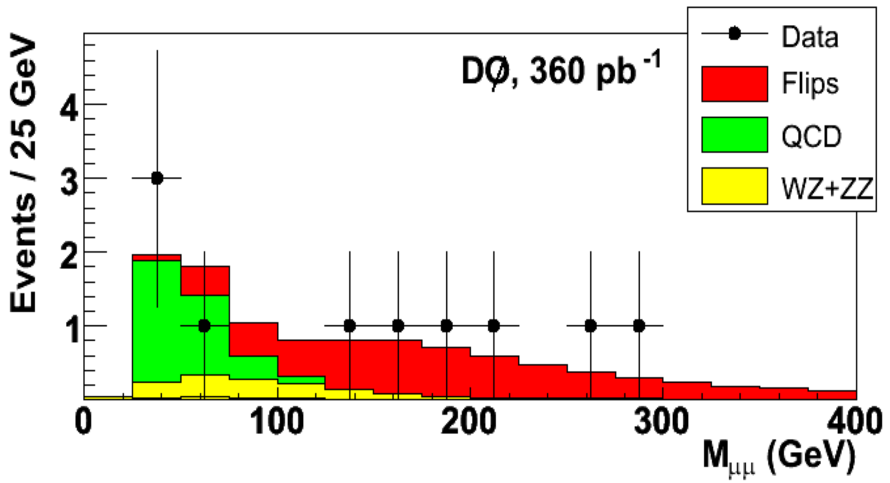
Selection:

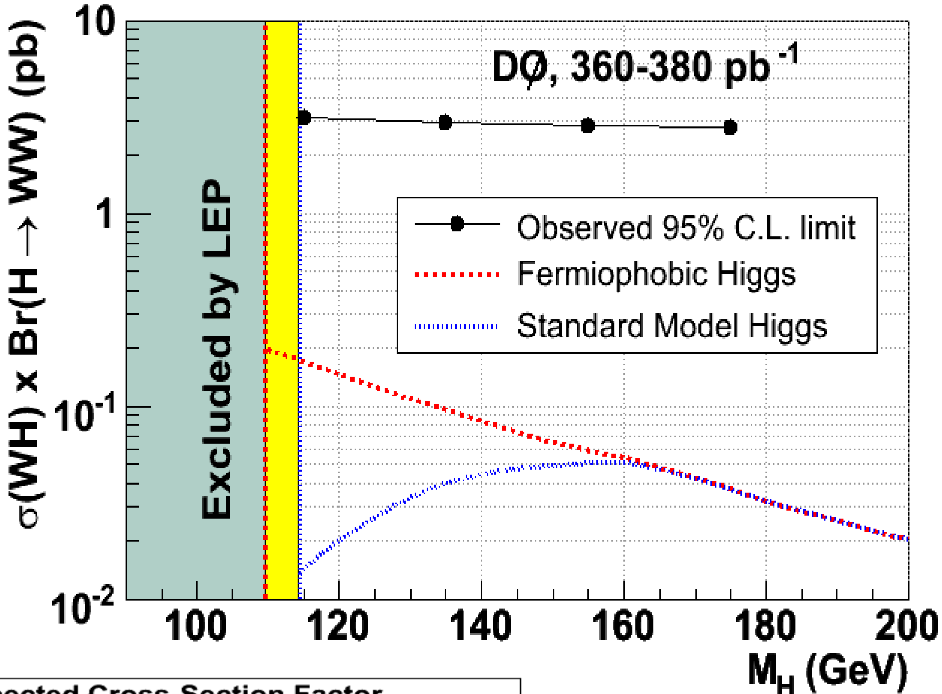
- two isolated leptons (electrons,muons)
- both leptons have p_T > 15 GeV
- E_T^{miss} > 20 GeV

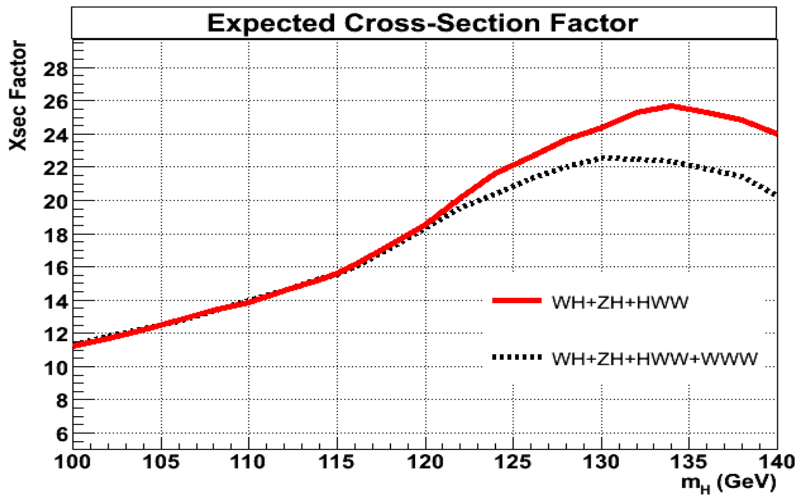


WH → WWW*

di-muon

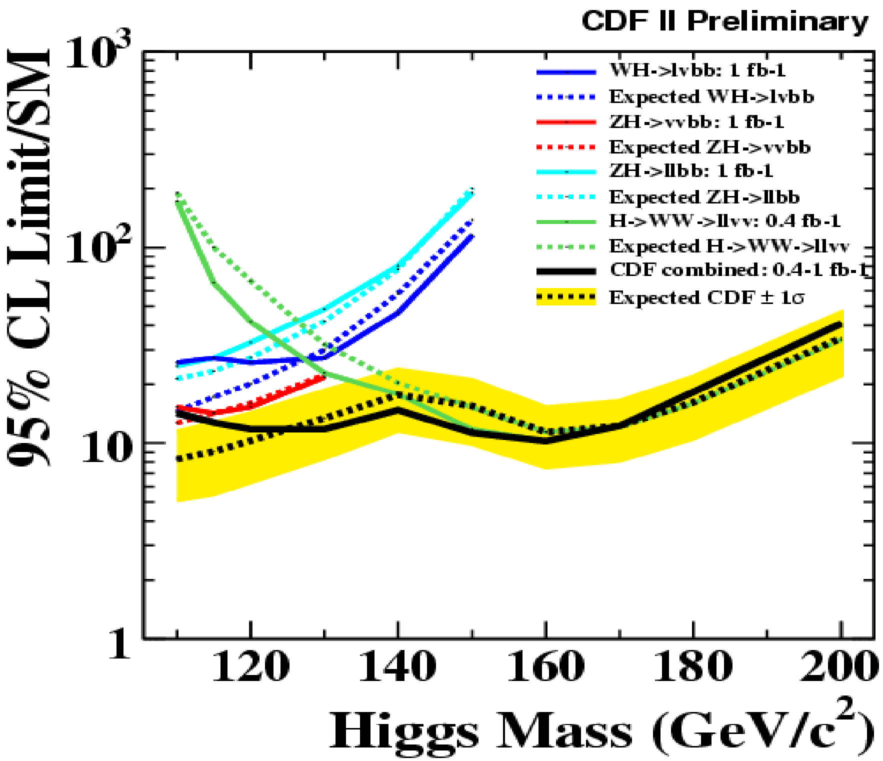


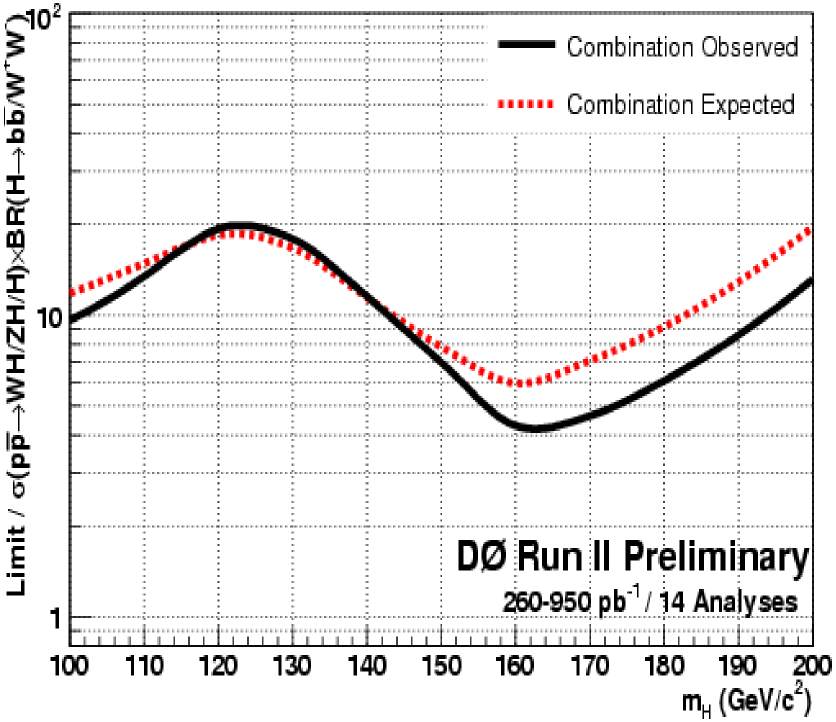


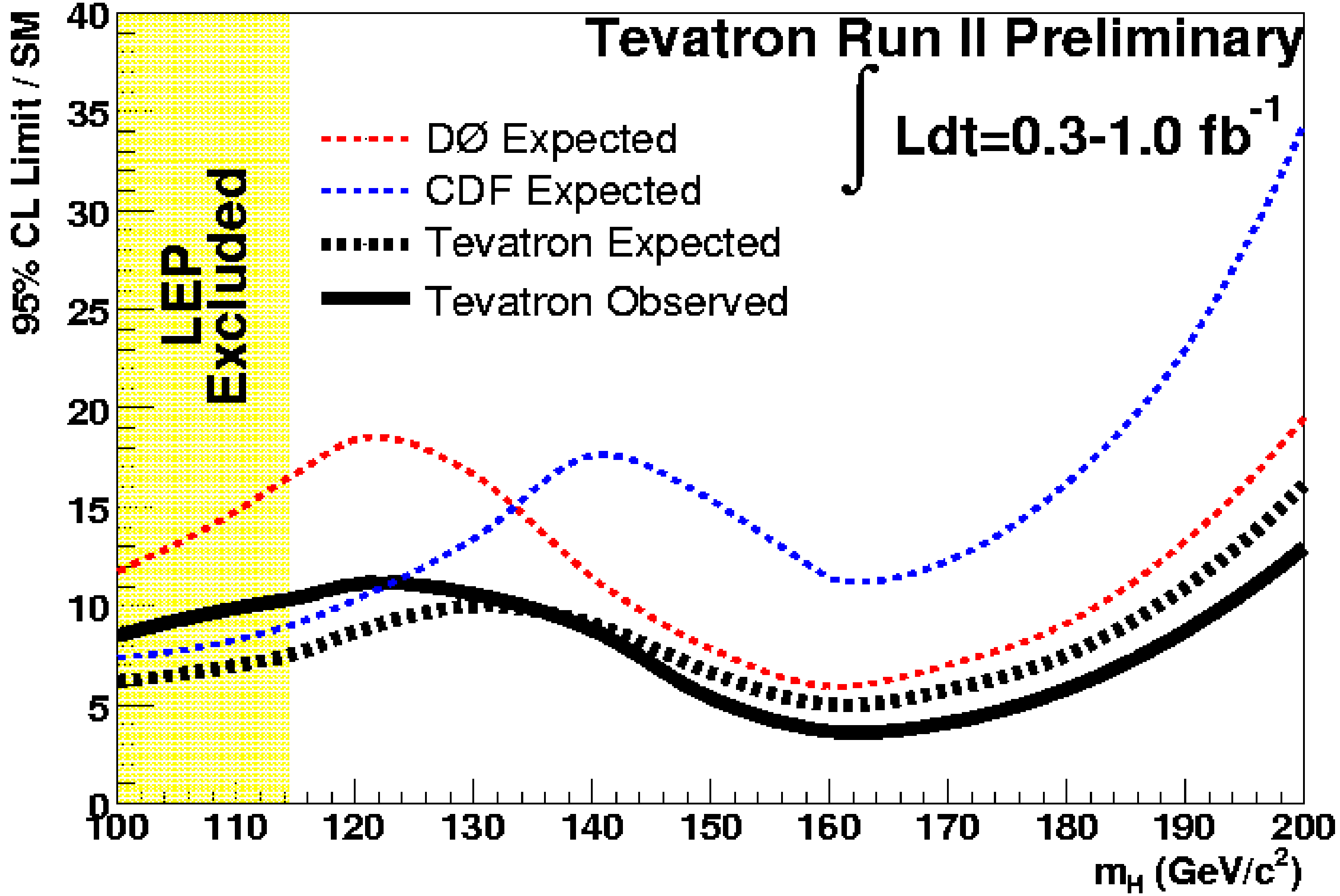


Important
in intermediate
mass range

The bottom line…







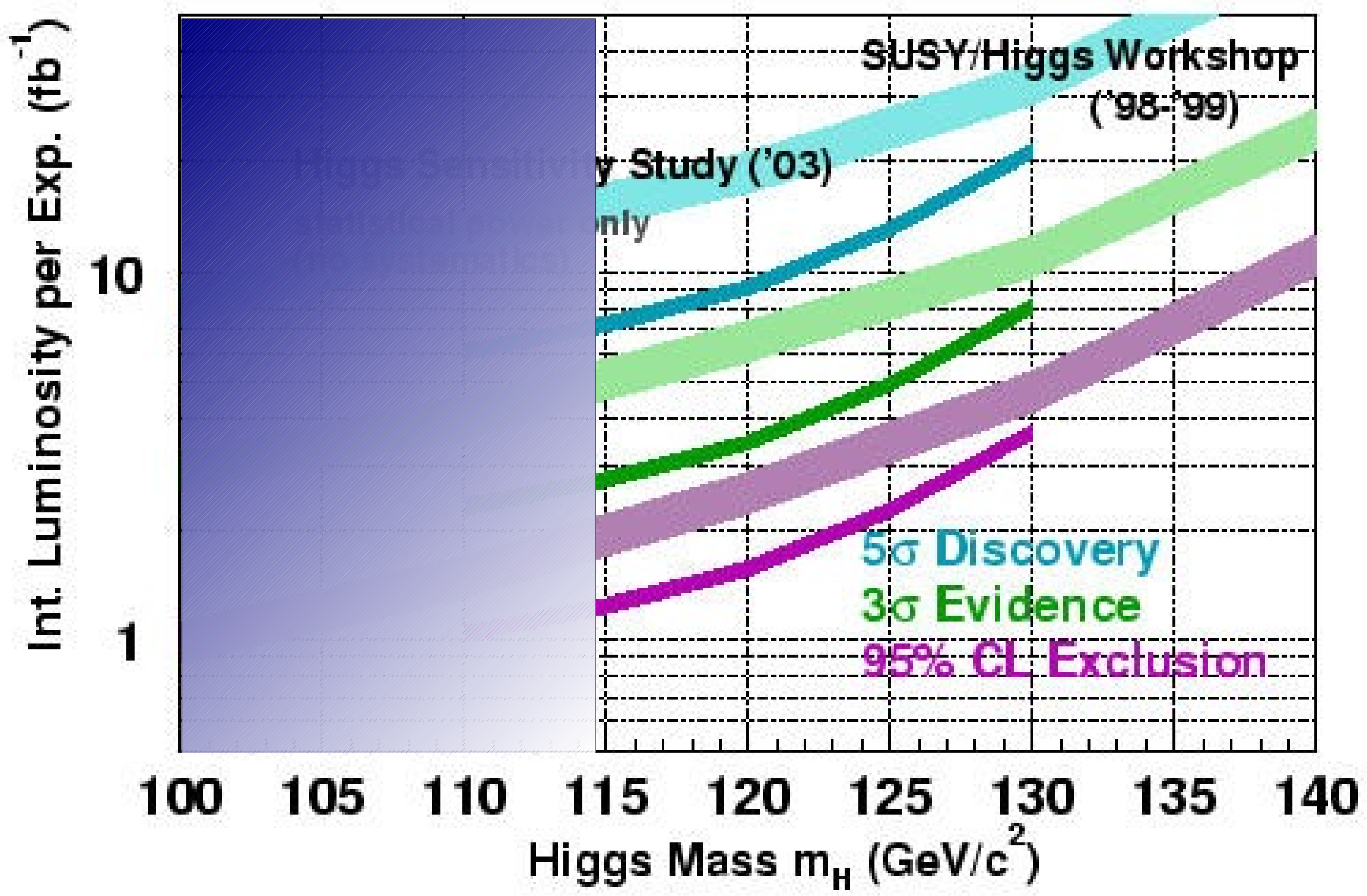
At time of combination: CDF added WH,ZH at 1 fb^{-1}

DØ added WW at 1 fb^{-1}

similar systematics

Perspectives

only statistical uncertainties



Current sensitivities are lower

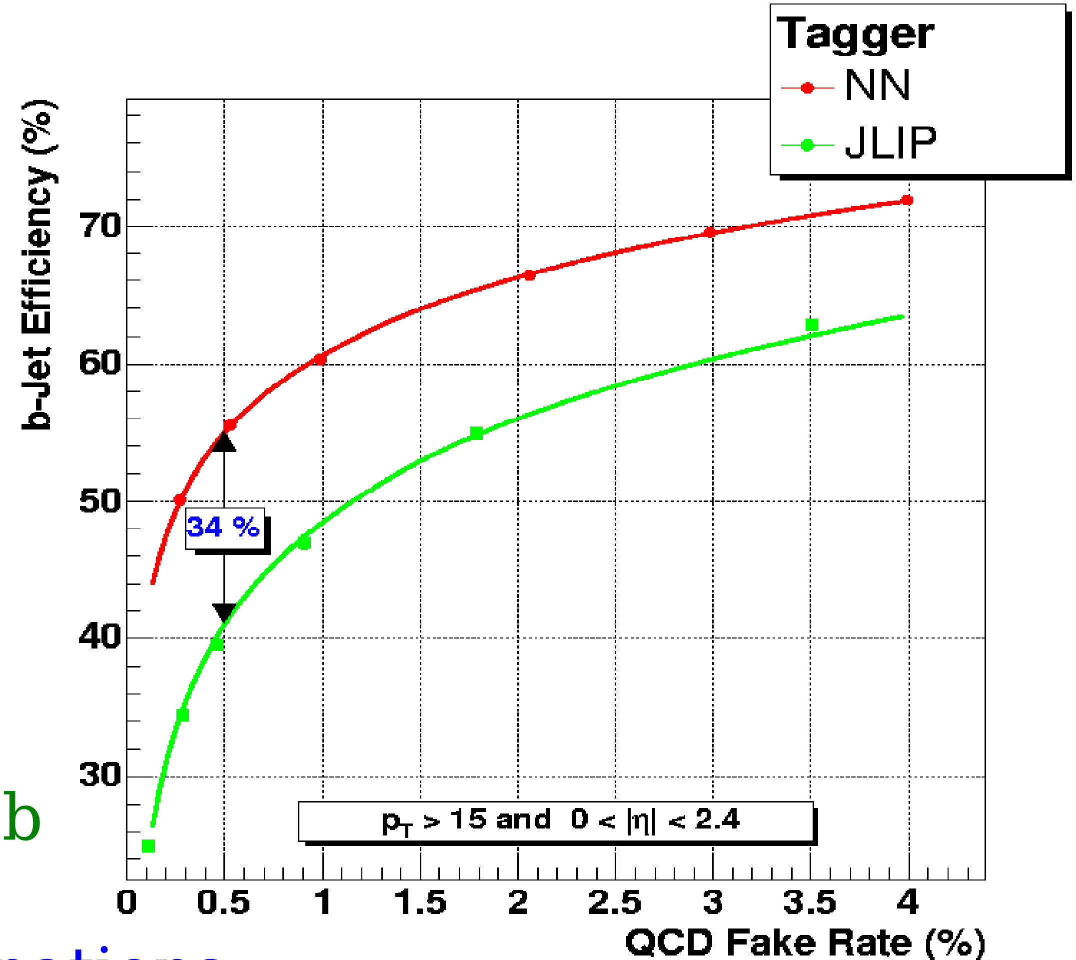
A long list of ongoing improvements

- Neural Net B tagging

- Di-jet mass resolution

  typically 14% ® 10%
  in Higgs mass window

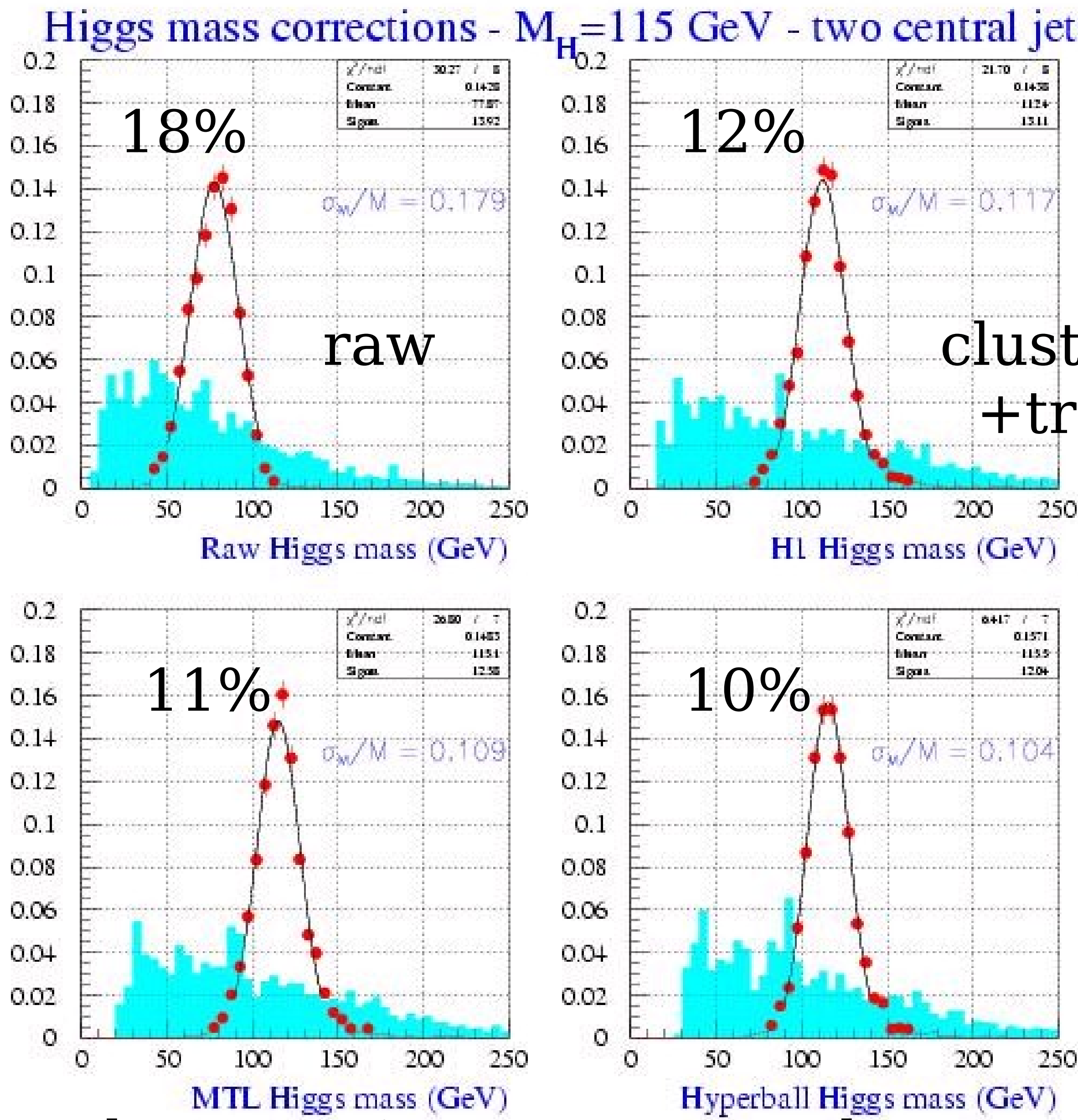
- More channels, e.g.
  - WH → WWW
  - ZH →llbb
  - WH → tau(→ hadrons)ν bb



- Channel/Experiment Combinations

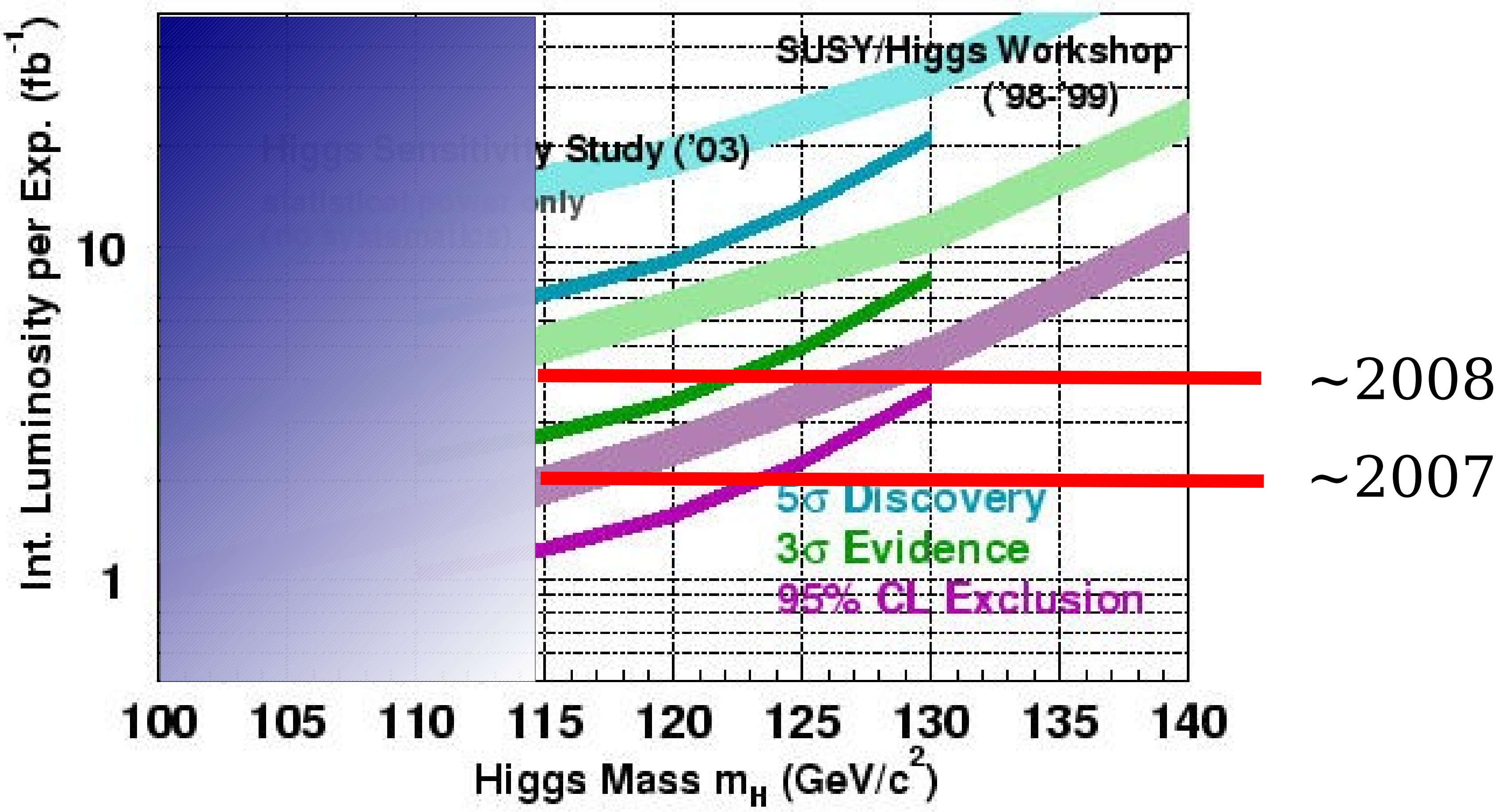
- More data, better techniques,reduced systematics

Higgs Sensitivity Study '03



b correction Neural Network

Higgs Sensitivity Study (2003)



Currently very good Tevatron performance

Minimal Supersymmetric Standard Model (MSSM)

Two Higgs doublets lead to five physical Higgs states

2 neutral Higgs Bosons (CP even): h, H
1 neutral Higgs Boson (CP odd): A
2 charged Higgs Bosons: H^{+-}

tan β: ratio of Higgs vev's;
determines couplings, branching ratios

MSSM Higgs Searches

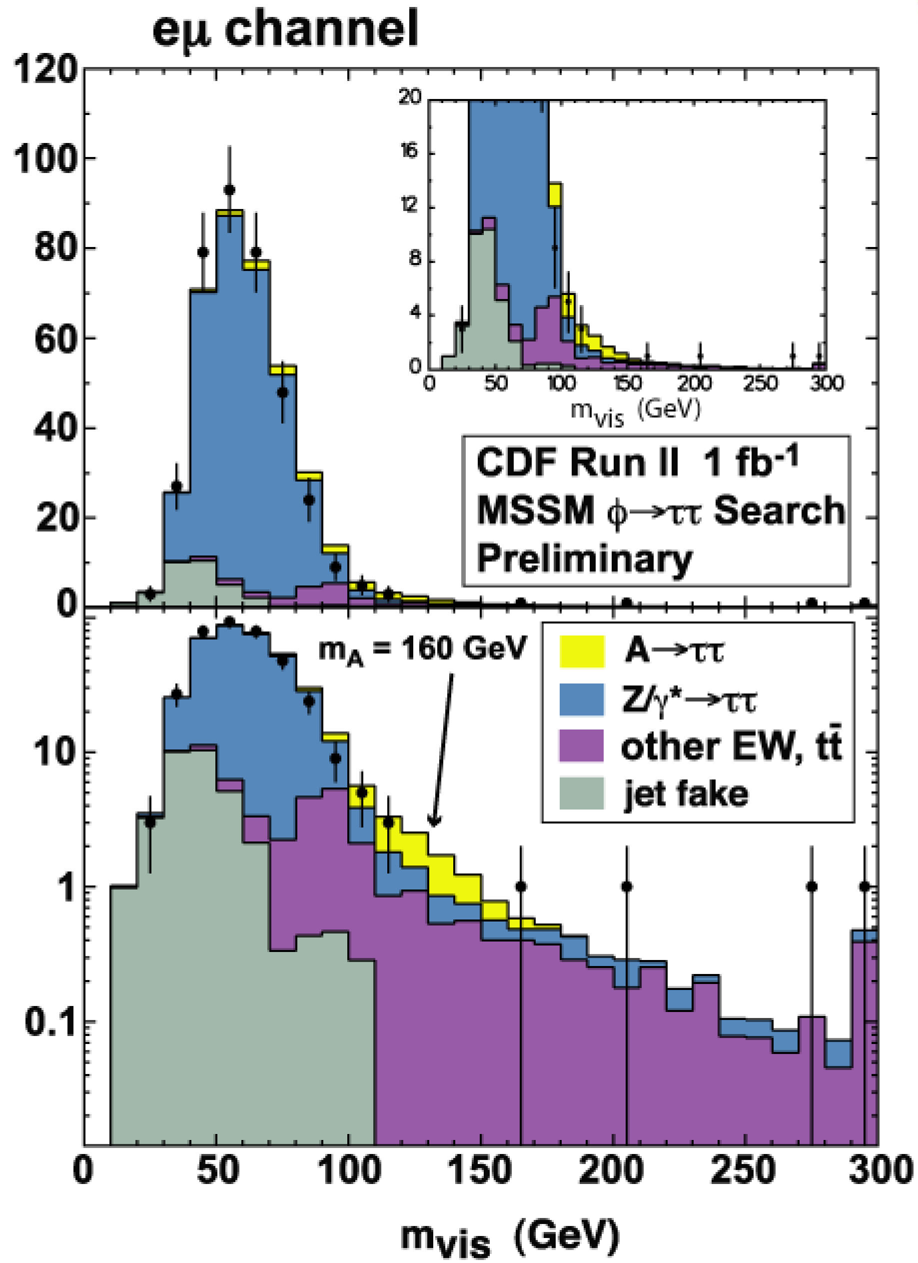
- cross-section enhanced with $\tan^2\beta$

- masses nearly degenerate

use tau final states:

- branching Higgs to tau pairs ~ 10 %

- combine $H \rightarrow \tau\tau$ and $H \rightarrow bb$



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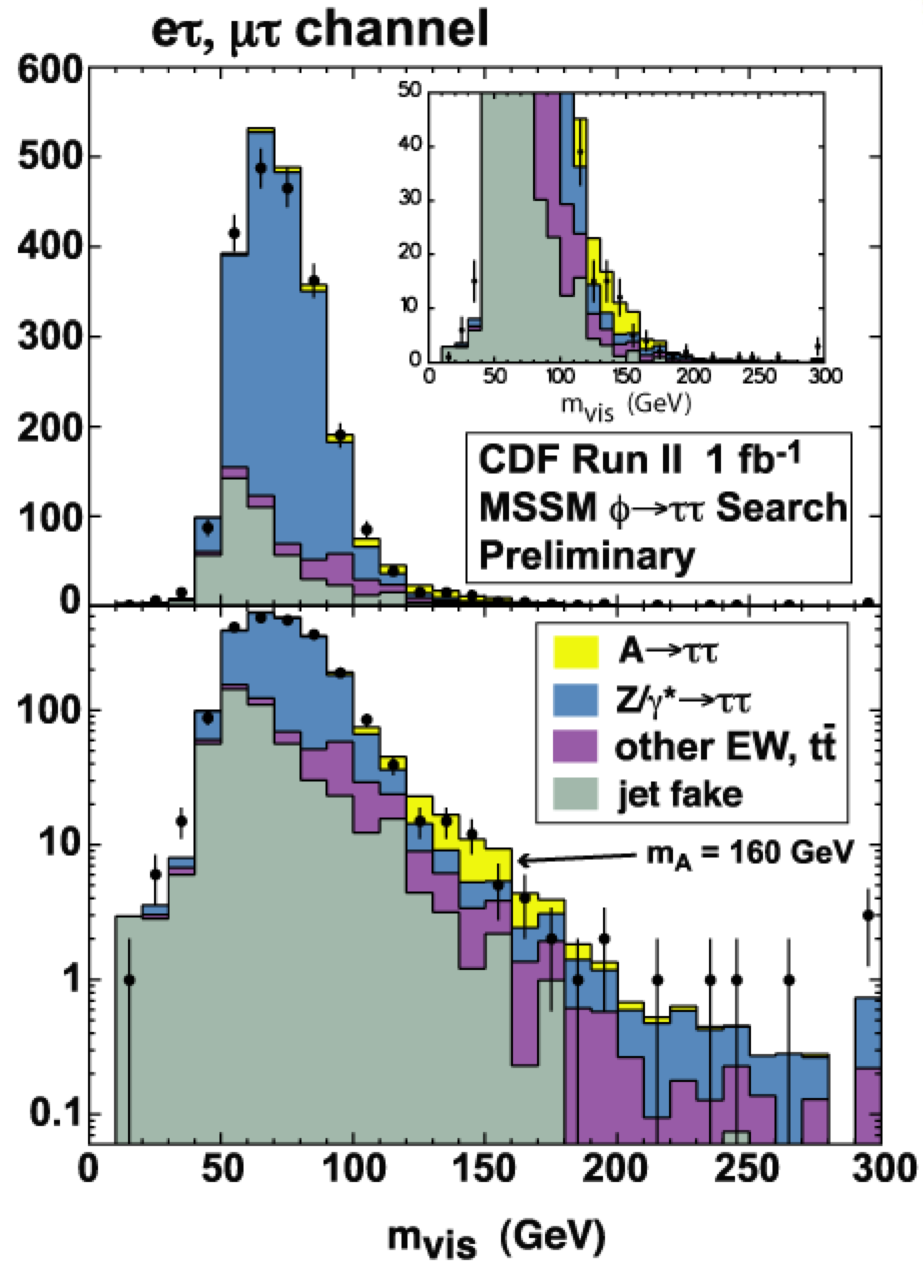
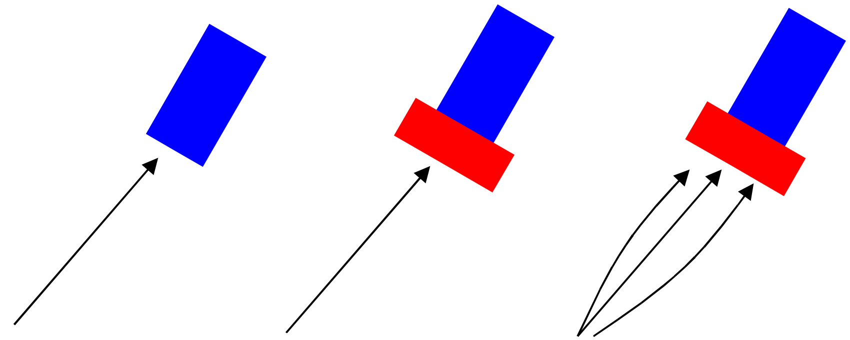
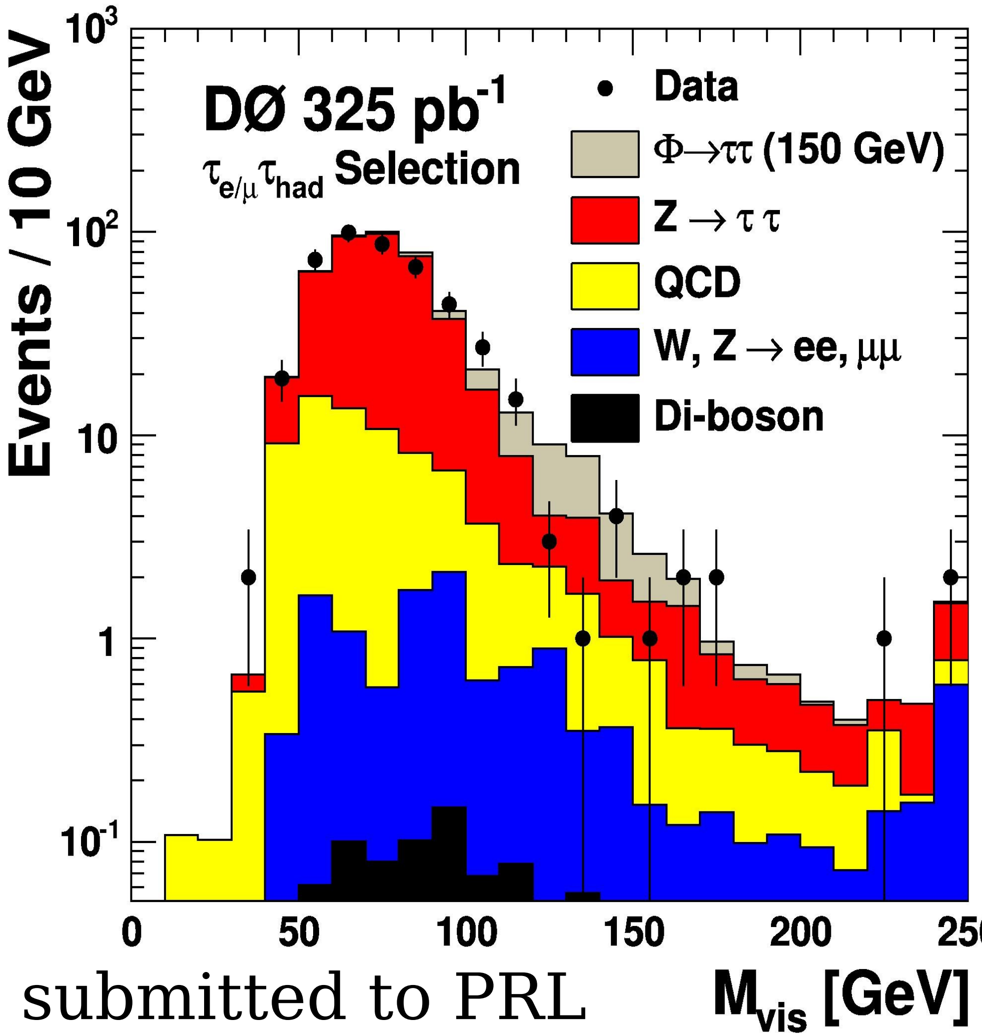
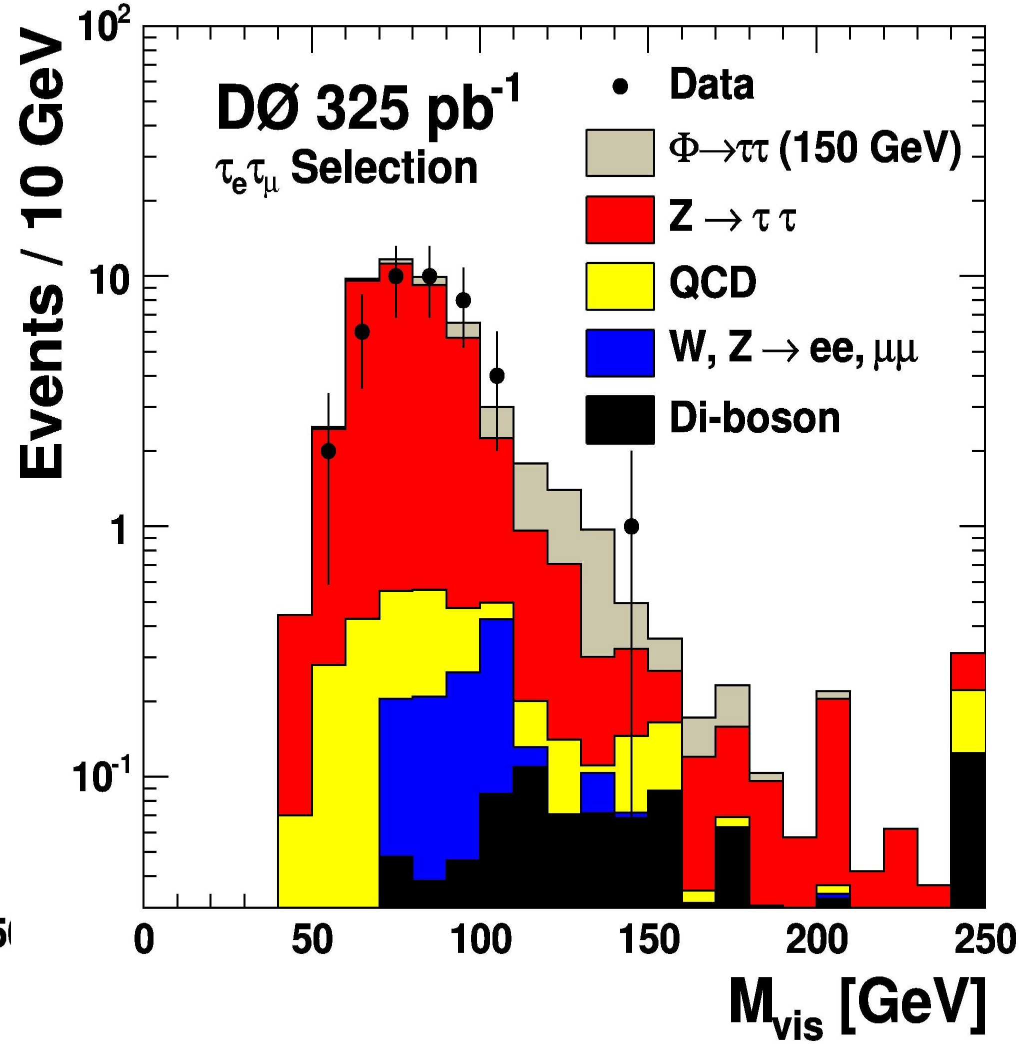


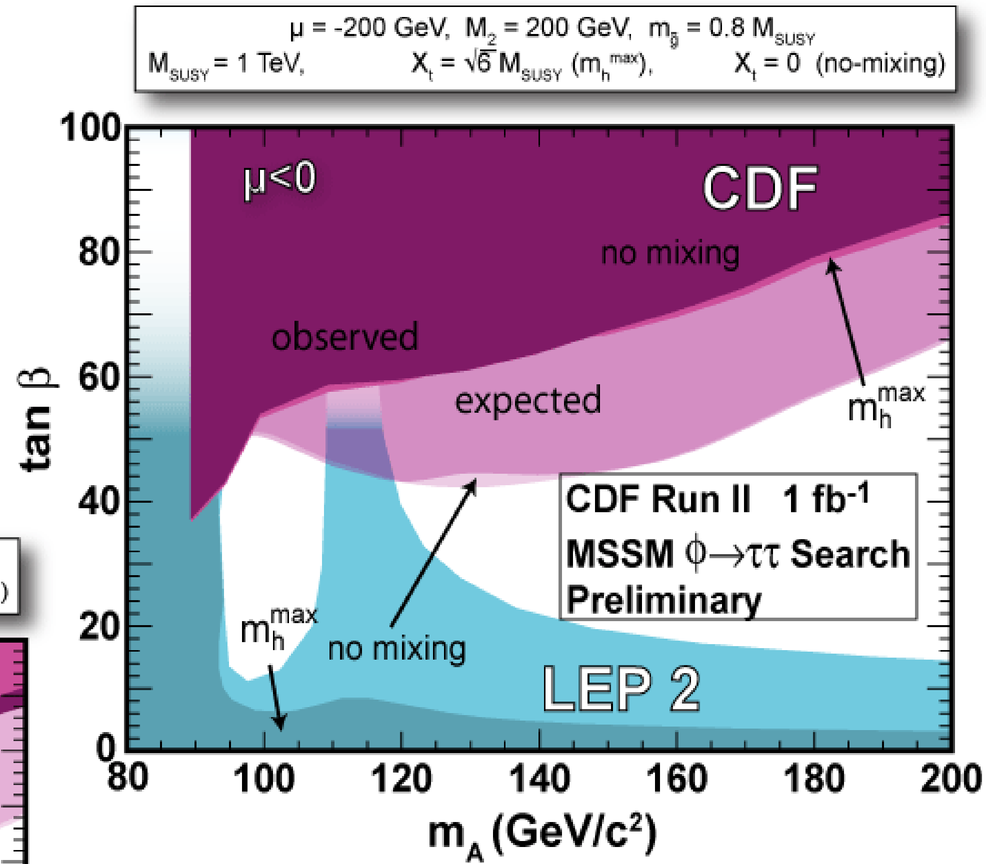


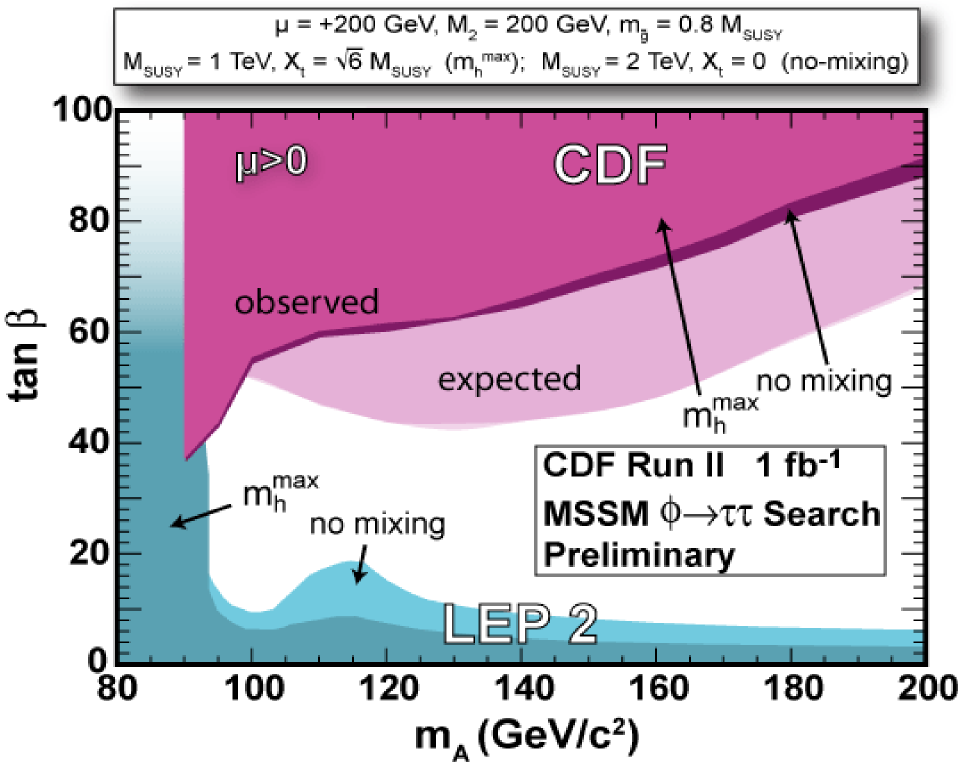
tau(e)tau(μ)
tau(e)tau(h)
tau(μ)tau(h)





submitted to PRL





Dzero result imminent

What can we learn from the Tevatron for the LHC ?

- The Tevatron will have evidence for a low mass Higgs if it exists:
  →now is a good time to join the Tevatron.

- The main challenges are trigger efficiencies, calibrations and QCD backgrounds which need to be mainly taken from the data.

- The LEP limit setting methods are designed for low background, small systematics experiments
  → further studies needed