



A Search for Higgs Decaying to $WW^{(*)}$ at DØ

presented by

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on behalf of the DØ Collaboration

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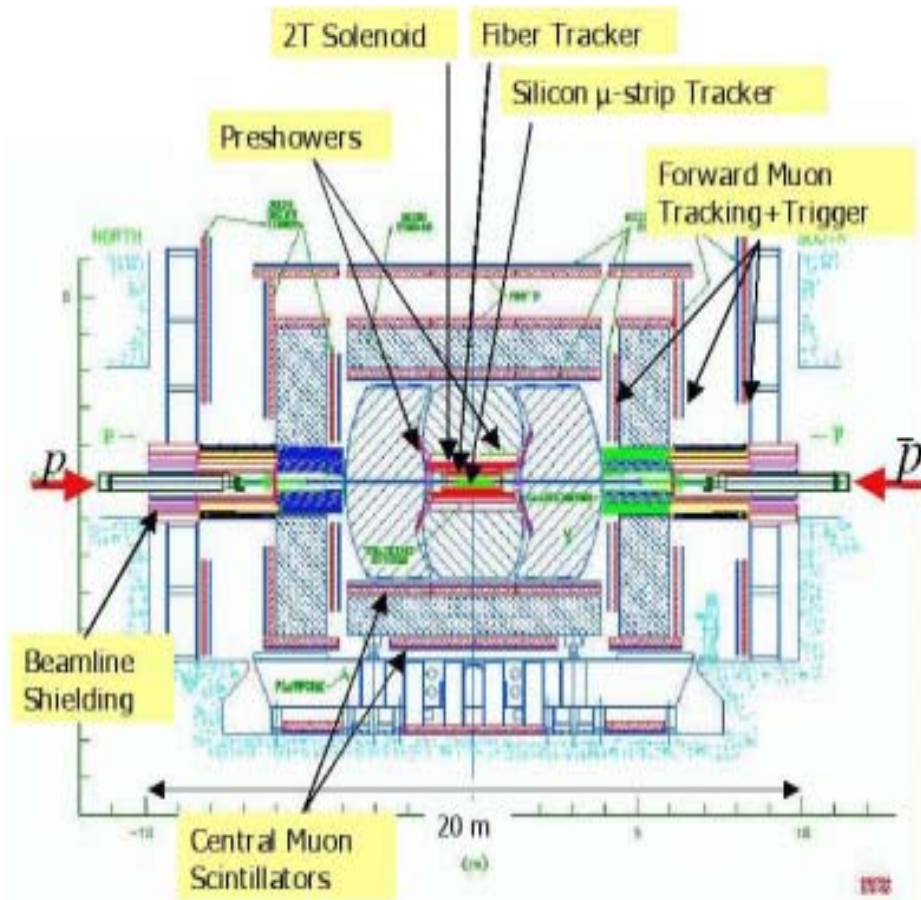


Overview

- The DØ experiment in Run II
- Why $H \rightarrow WW^{(*)}$?
- Event signature
- Selection criteria
- Comparison of Monte Carlo and data
- The $\sigma \times BR(H \rightarrow WW^{(*)})$ limit
- Conclusions



The Upgraded $D\bar{0}$ Detector



- Completely new tracking system, inside 2T magnetic field
- Inner Si vertex detector (SMT) provides b-tagging capability
- Excellent Run I calorimetry exploited in Run II
- Upgraded 3-tier trigger and data acquisition system



Higgs Searches at the Tevatron



- Search strategy:

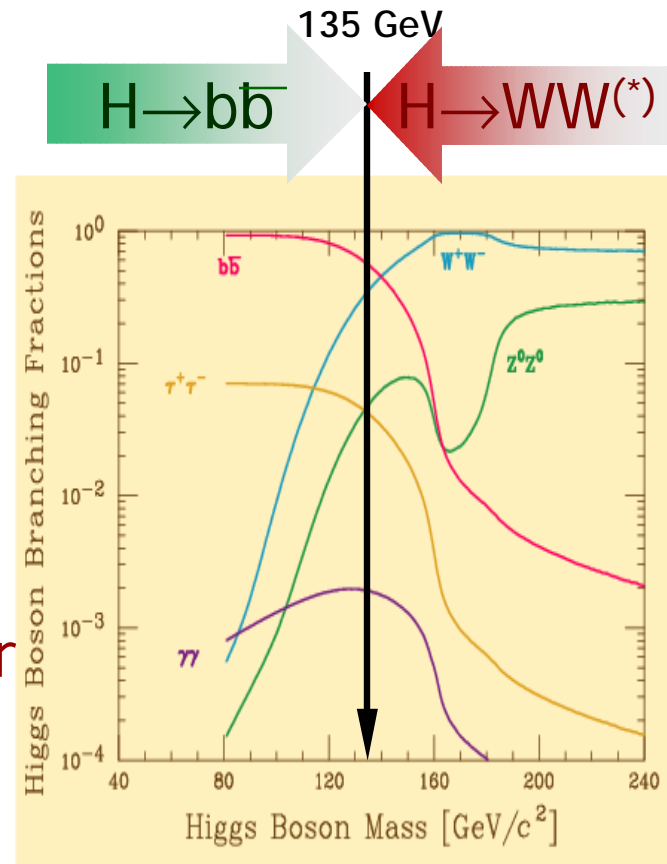
for a light Higgs ($M_H < 135$ GeV)

- use associated WH or ZH production
- dominant decay is $H \rightarrow b\bar{b}$

for a heavy Higgs ($M_H > 135$ GeV)

- use $gg \rightarrow H$ production
- dominant decay is $H \rightarrow WW^{(*)}$
- the WW leptonic signature is cleaner

SM Higgs decay



For a heavy Higgs $H \rightarrow WW^{()}$ offers a cleaner decay signal*

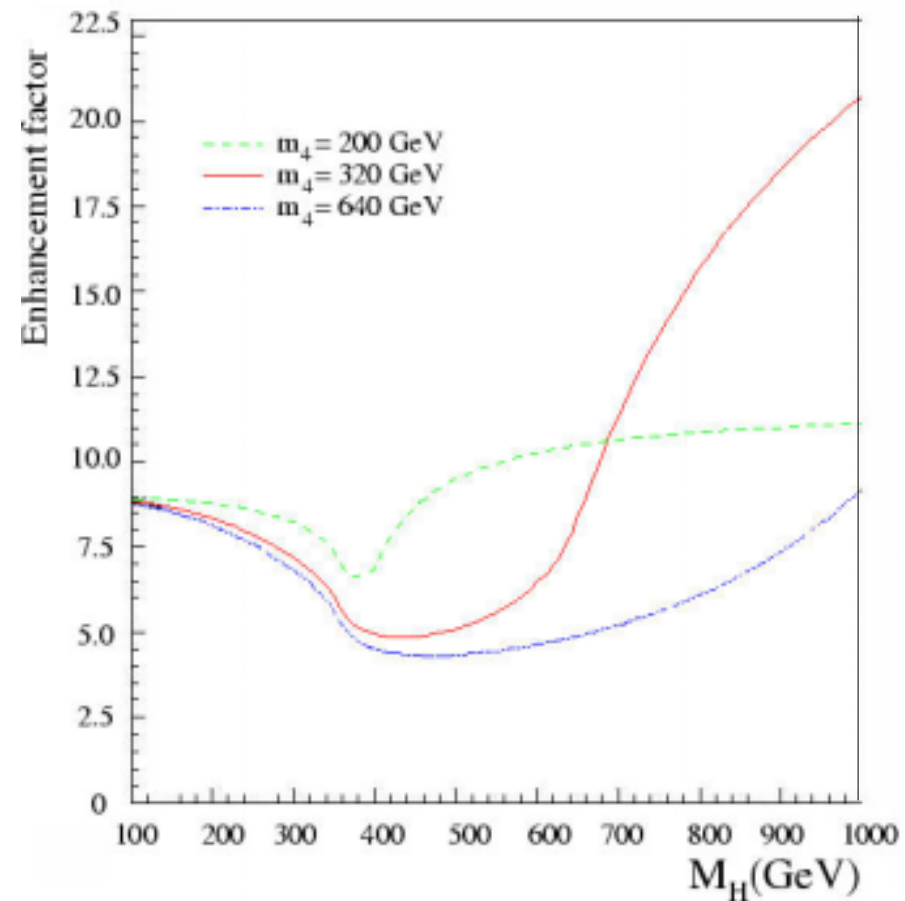


Cross-Section Enhancement From Extra Generations



- Extra quark generations could increase production cross section significantly
- Enhancement factor depends on Higgs and quark masses
- A factor of 8.5 is expected for a 4th generation, $m_4=320$ GeV

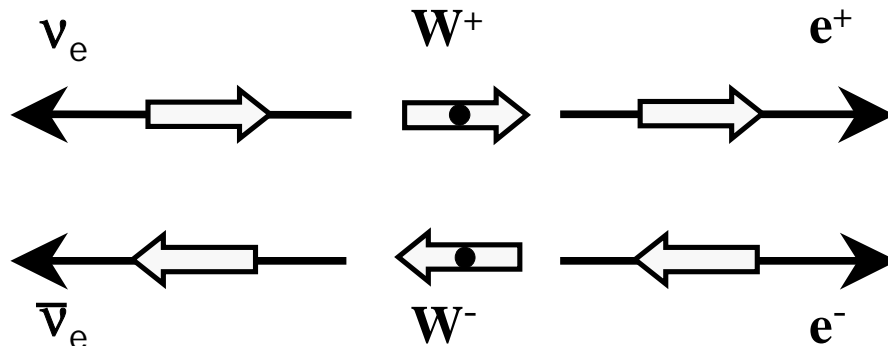
E. Arik et al, SN-ATLAS-2001-006





$H \rightarrow WW^{(*)}$: Experimental Signature

- Higgs mass reconstruction not possible due to two neutrinos
- Spin correlations suppress background:



Look for small opening angle between leptons $\Delta\phi(l\bar{l})$

→ WW comes from spin 0 Higgs
 ⇒ leptons prefer to point in the same direction

- Event signature: 2 high p_T leptons + missing E_T
- Search for excess in the leptonic decay modes: $e\nu\nu$, $e\mu\nu$ and $\mu\mu\nu$



Data and Monte Carlo Samples

- Analysed data collected between April 2002 and September 2003
- Final integrated luminosities of 177 pb^{-1} (ee), 158 pb^{-1} (e μ) and 147 pb^{-1} ($\mu\mu$) for each final state
- Removed runs with hardware failures and incomplete luminosity information
- Monte Carlo events were generated using Pythia or ALPGEN followed by a full detector simulation
 - rates normalized to NLO cross section values;
 - events overlaid with an average of 0.8 minimum bias events.



Event Selection

Event selection includes:

- Require two oppositely charged isolated leptons $l = e, \mu$
 - ee : $p_T(e_1) > 12 \text{ GeV}, p_T(e_2) > 8 \text{ GeV}$
 - $e\mu$: $p_T(e) > 12 \text{ GeV}, p_T(\mu) > 8 \text{ GeV}$
 - $\mu\mu$: $p_T(\mu_1) > 20 \text{ GeV}, p_T(\mu_2) > 10 \text{ GeV}$
- Missing E_T greater than: 20 GeV ($ee, e\mu$); 30 GeV ($\mu\mu$)
- Removal of mass resonances:
 - $12 \text{ GeV} < m(e, e) < 80 \text{ GeV}$
 - $m(\mu, \mu) > 20 \text{ GeV}$ and $|m(\mu, \mu) - m_Z| > 15 \text{ GeV}$
- Azimuthal opening angle: $\Delta\phi(e, e) < 1.5$; $\Delta\phi(e/\mu, \mu) < 2.0$
- Jet veto \Rightarrow rejects energetic jets:
 - $ee, e\mu$: $E_{T1} < 90 \text{ GeV}$ or $E_{T1} < 50 \text{ GeV}, E_{T2} < 30 \text{ GeV}$
 - $\mu\mu$: $E_{T1} < 60 \text{ GeV}, E_{T2} < 30 \text{ GeV}$

Cuts
optimised for
each final
state

\Rightarrow Beat down Z/γ^* , W +jets, WW & $t\bar{t}$ backgrounds

Signal acceptance is $\sim 0.02 - 0.2$ depending on the Higgs mass/final state

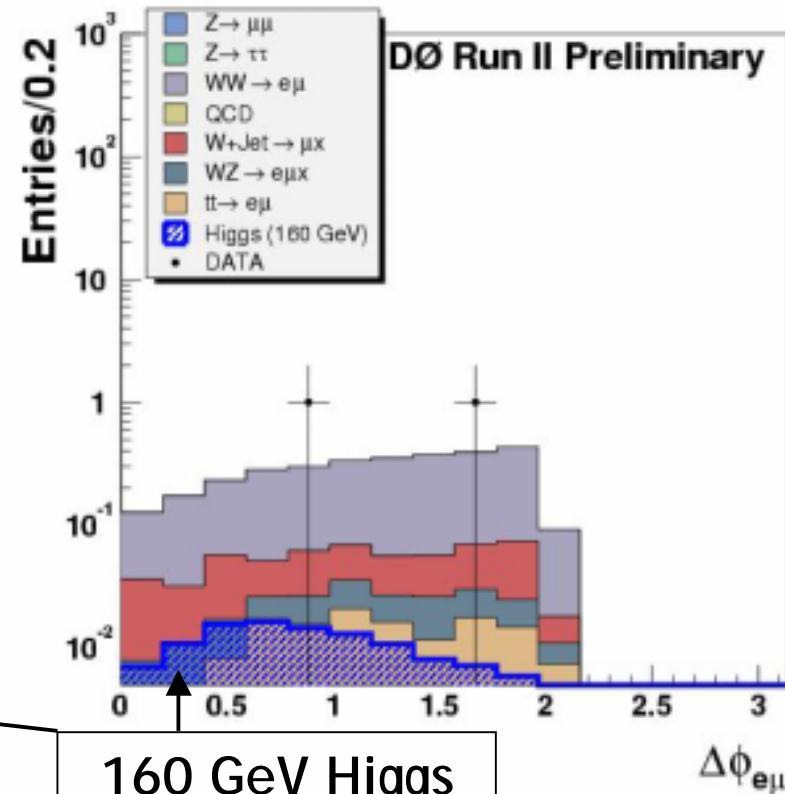
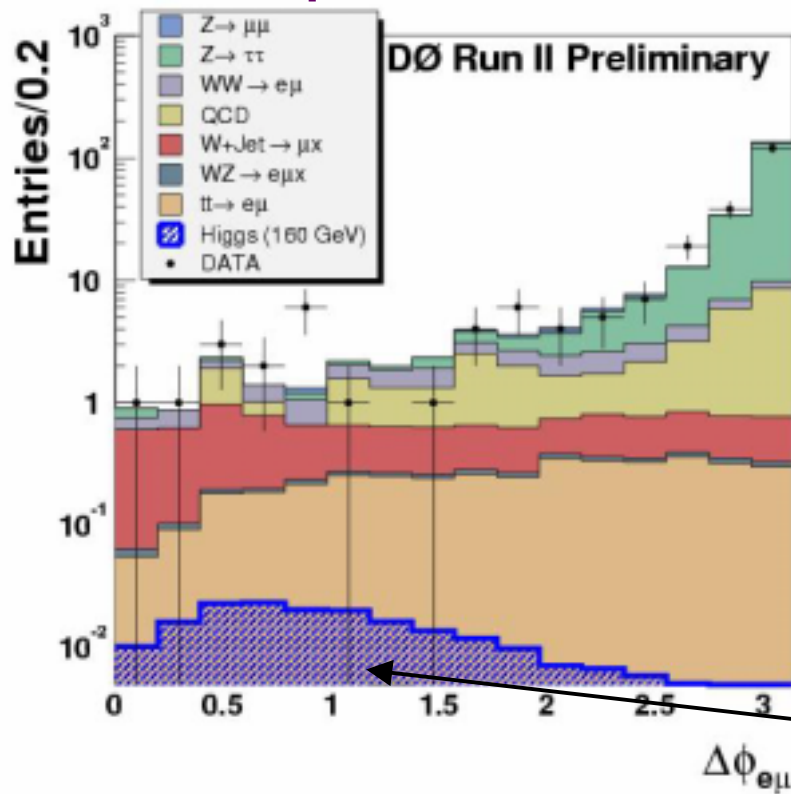


Data vs. Monte Carlo: Opening Angle, $\Delta\phi_{e\mu}$

After basic
event preselection

$e\mu$ Final State

After final
event selection

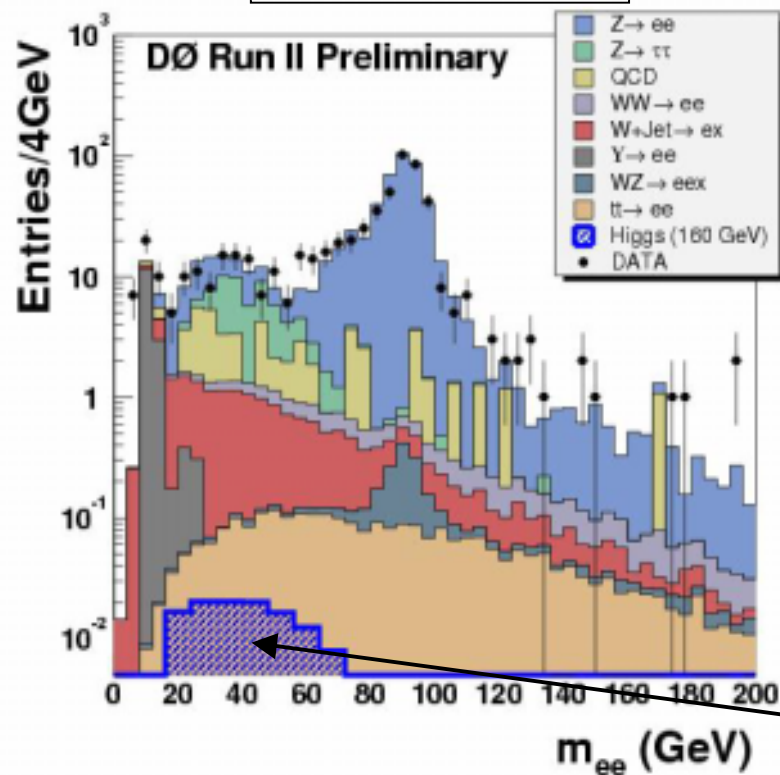




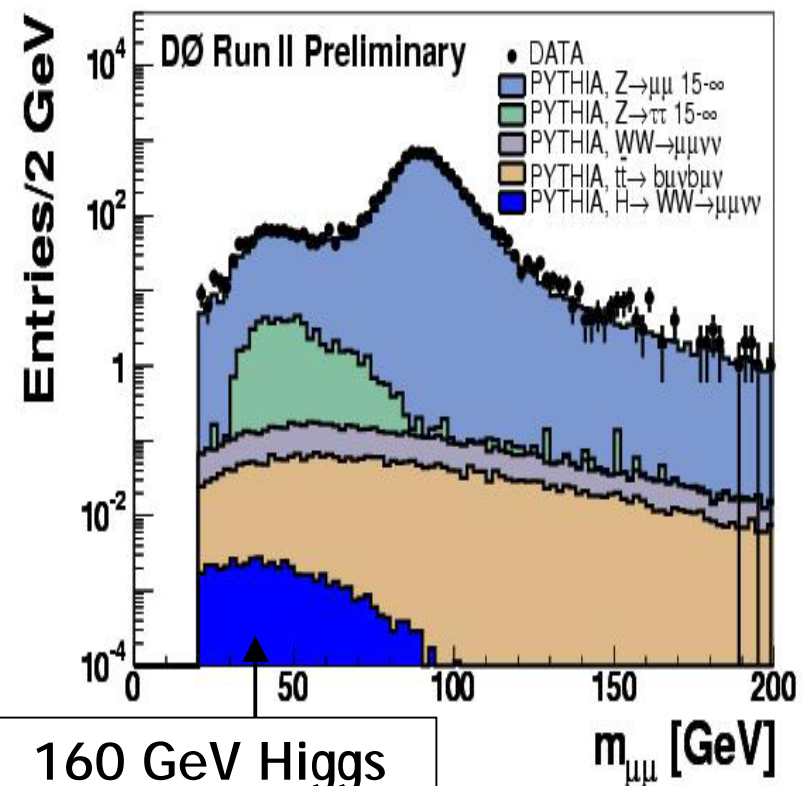
Data vs. Monte Carlo: Dilepton Invariant Mass

Distributions after basic event preselection

ee Final State



$\mu\mu$ Final State



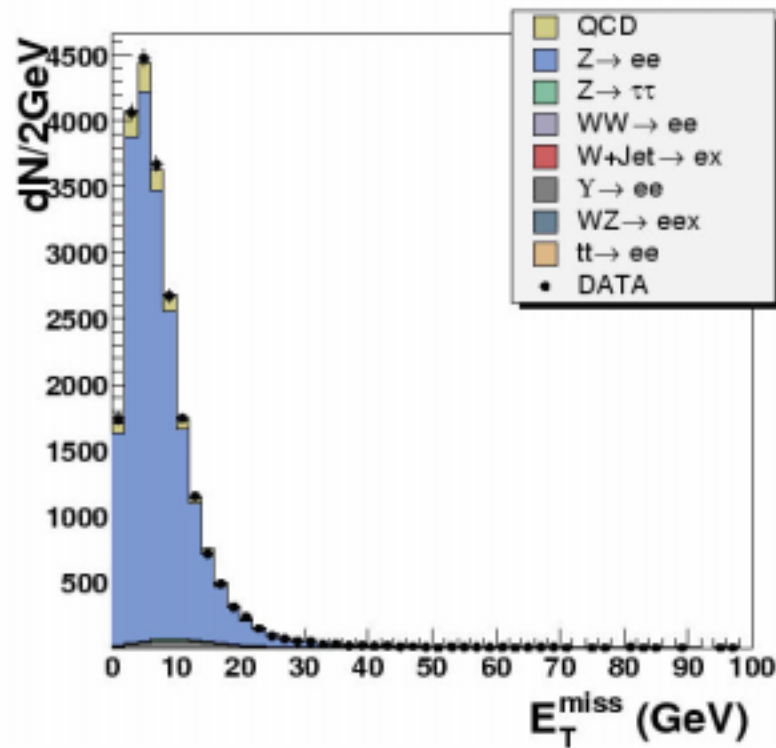
160 GeV Higgs



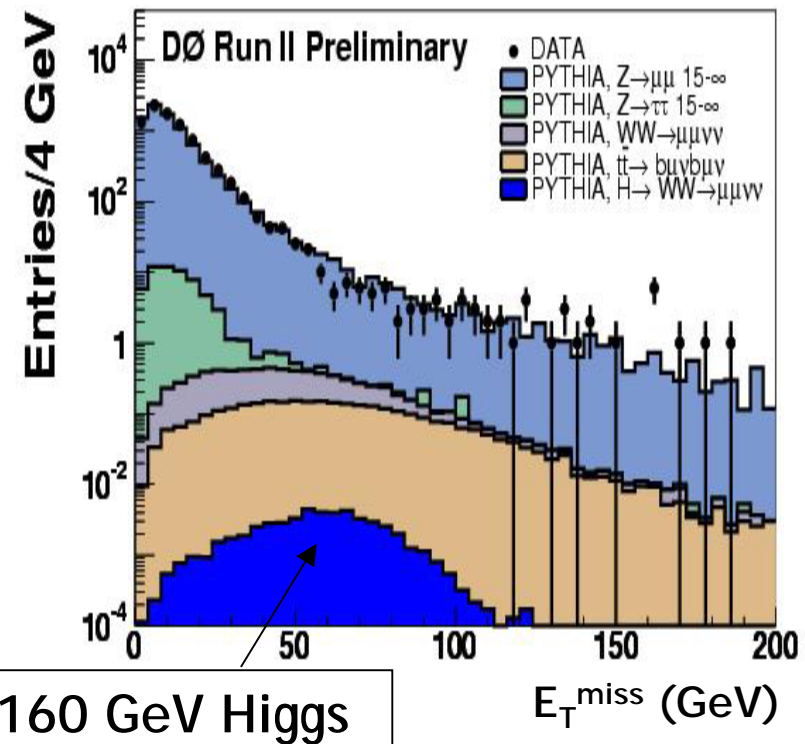
Data vs. Monte Carlo: Missing E_T

Distributions after basic event preselection

ee Final State



$\mu\mu$ Final State





Data vs. Monte Carlo



Source	$ll' = e^+e^-$ $L = 177 \text{ pb}^{-1}$	$ll' = e\mu$ $L = 158 \text{ pb}^{-1}$	$ll' = \mu\mu$ $L = 147 \text{ pb}^{-1}$
$tt \rightarrow blvbl'\nu$	0.06 ± 0.01	0.13 ± 0.01	0.03 ± 0.003
$WZ^- \rightarrow ll' + X^-$	0.04 ± 0.01	0.11 ± 0.01	
$\Upsilon \rightarrow e^+e^-$	0.00 ± 0.01		
$WW \rightarrow l\nu l'\nu$	1.17 ± 0.02	2.51 ± 0.05	1.28 ± 0.03
W+jets	1.24 ± 0.07	0.34 ± 0.02	
QCD/W+jets			0.02 ± 0.02
QCD	0.00 ± 0.50	0.00 ± 0.20	
$Z/\gamma^* \rightarrow e^+e^-$	0.10 ± 0.10		
$Z/\gamma^* \rightarrow \mu^+\mu^-$		0.00 ± 0.05	3.90 ± 0.60
$Z/\gamma^* \rightarrow \tau^+\tau^-$	0.00 ± 0.10	0.00 ± 0.10	0.00 ± 0.00
Total Background Sum	2.70 ± 0.40	3.10 ± 0.30	5.30 ± 0.60
Expected Signal for SM Higgs ($M_H = 160\text{GeV}$)	0.073 ± 0.002	0.111 ± 0.004	0.085 ± 0.001
Data	2	2	5



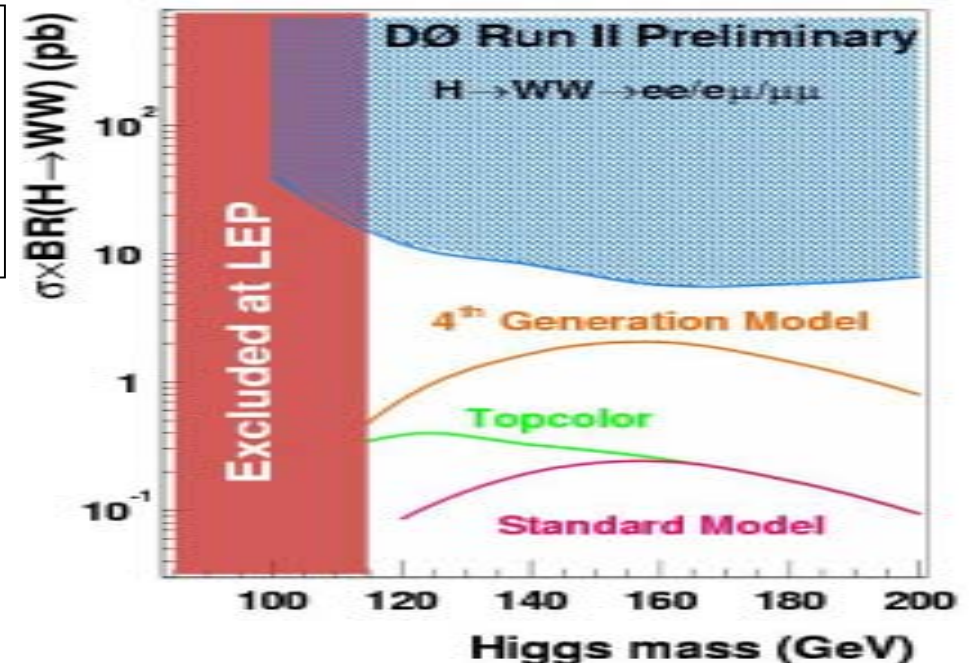
The $H \rightarrow WW^{(*)}$ Cross-Section Limit

- Cross-section limits have been calculated at 95% C.L. in each leptonic channel by counting events
- Combine likelihood functions from each channel to obtain overall result
- Upper limit on $\sigma \times \text{BR}(H \rightarrow WW^{(*)})$ set:

$\sigma \times \text{BR}(H \rightarrow WW)$ lies between 6.6 and 40.1 pb, depending on M_H

all channels

- Agrees well with predictions from NLO calculations





Conclusions

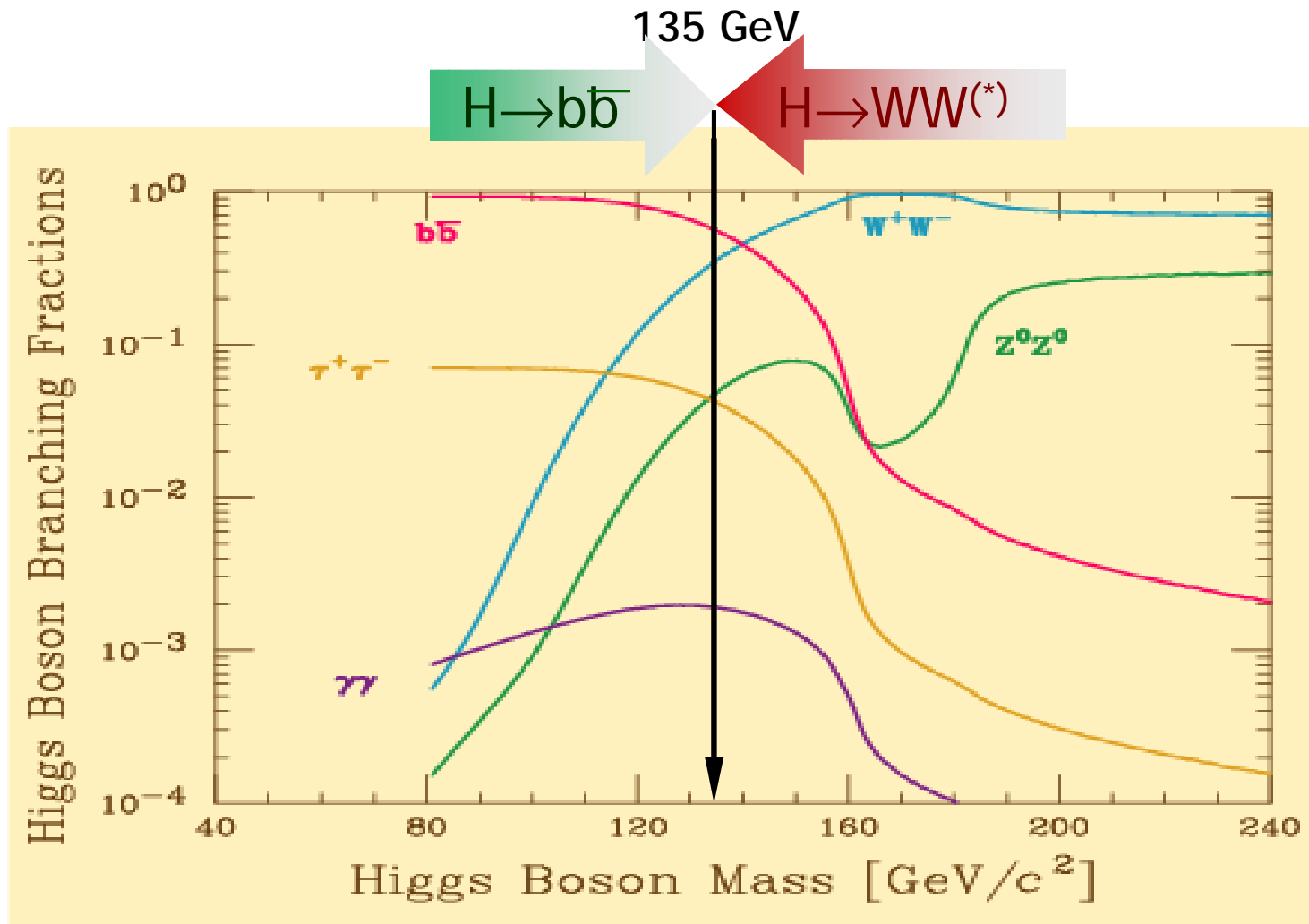
- DØ has performed a search for $H \rightarrow WW^{(*)}$ in leptonic final states using 147-177 pb^{-1} of Run II data
- Comparison between data and Monte Carlo looks good
- The number of events observed is consistent with expectations from Standard Model backgrounds
- An upper limit on $\sigma \times \text{BR}(H \rightarrow WW^{(*)})$ of between 6 and 40 pb has been set
 - result is highly consistent between all three channels
- We look forward to improving the measurement with more data and higher statistics.



Back-up Slides



SM Higgs Decay Modes



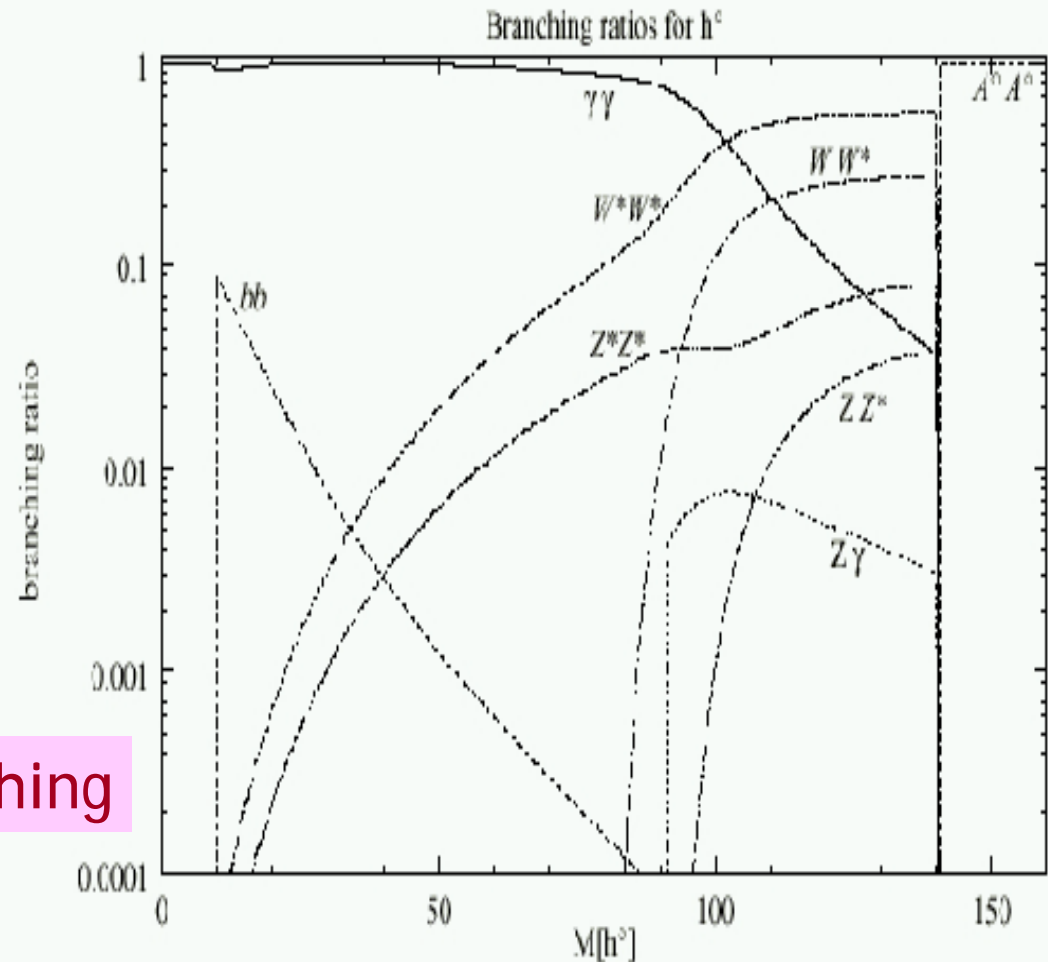


Suppressed Couplings to b, τ

L. Brucher, R. Santos, hep-ph/9907434

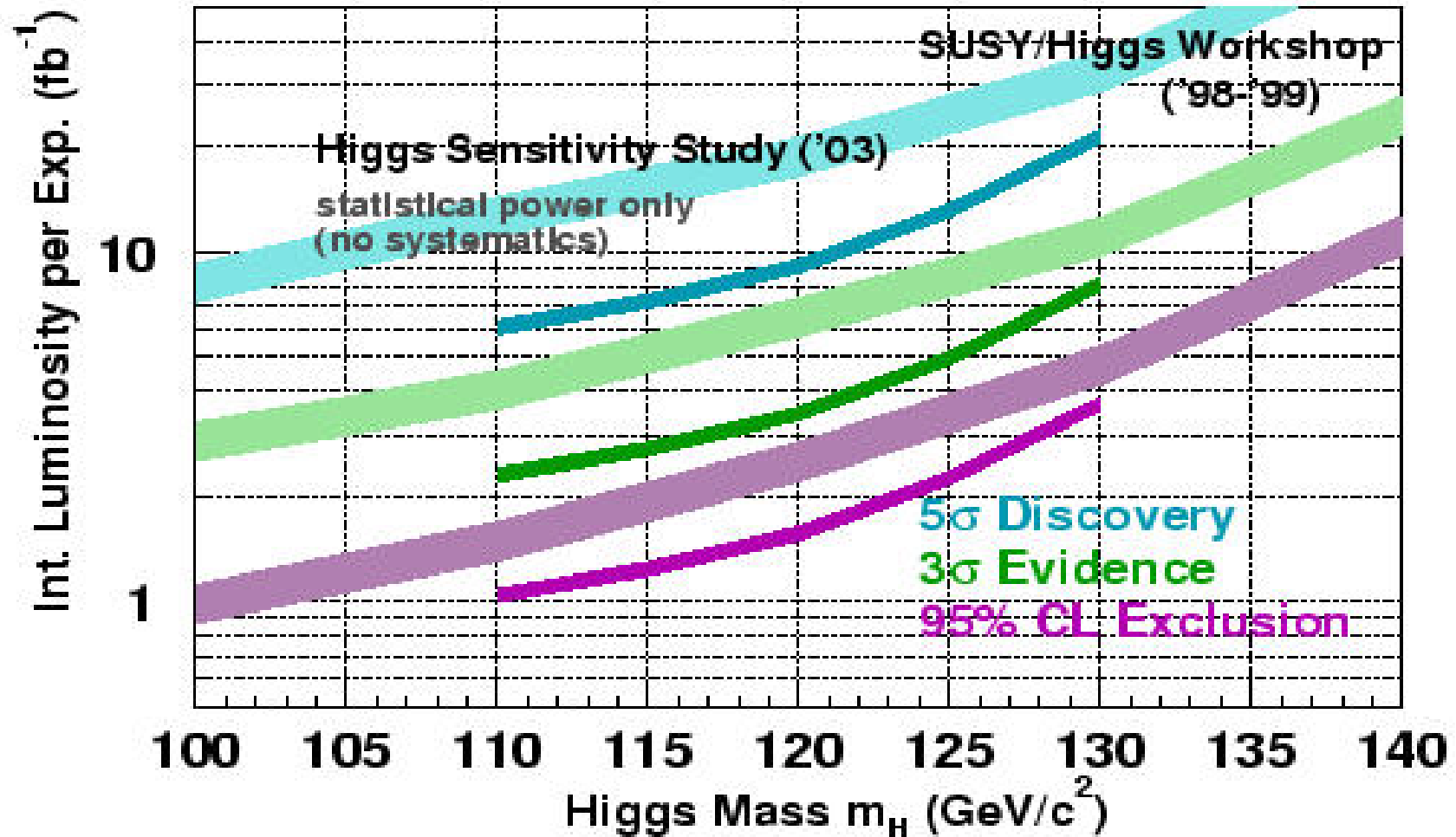
- Occurs beyond the SM in Top Color or Fermiophobic Higgs models

Increased $H \rightarrow WW^{(*)}$ branching





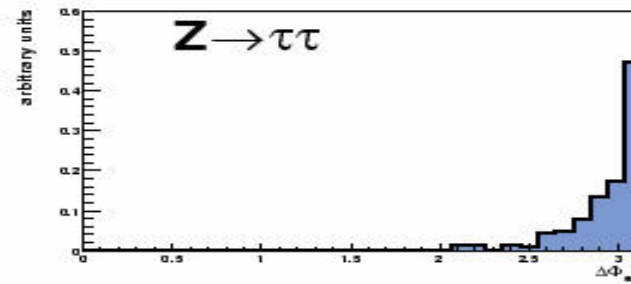
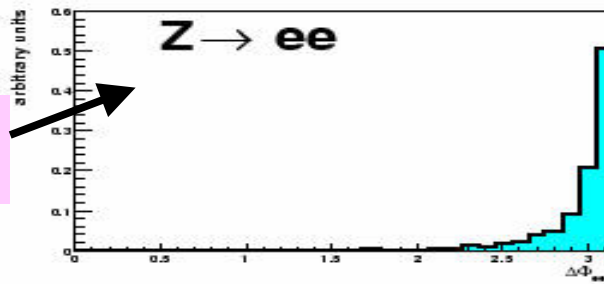
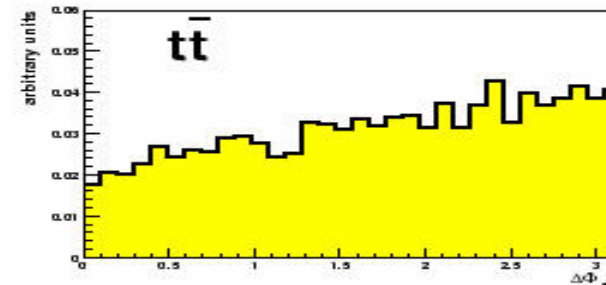
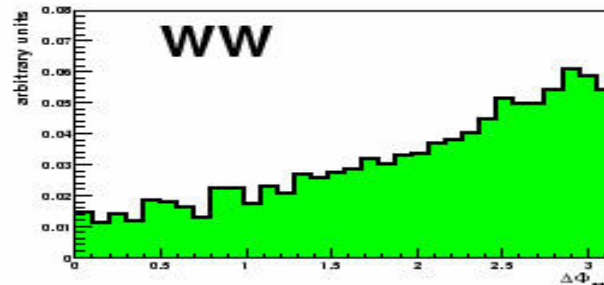
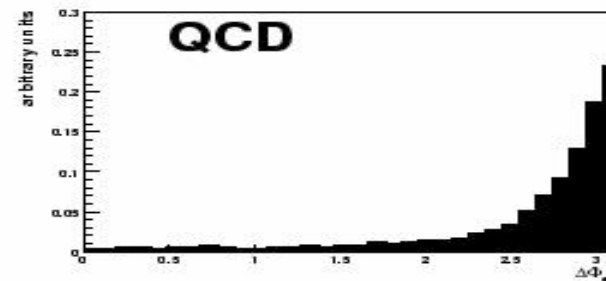
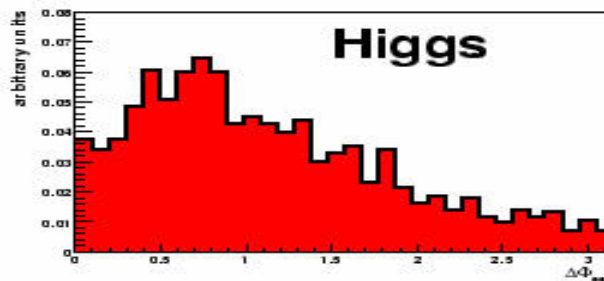
Higgs Sensitivity Reach





Azimuthal Opening Angle: $\Delta\phi_{ll}$

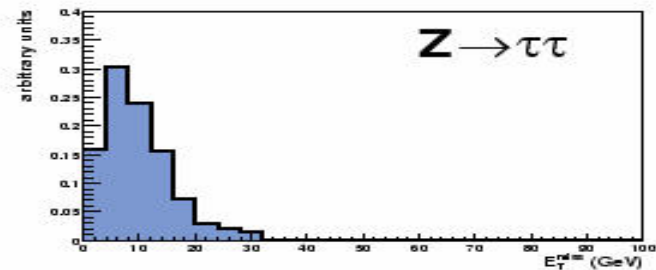
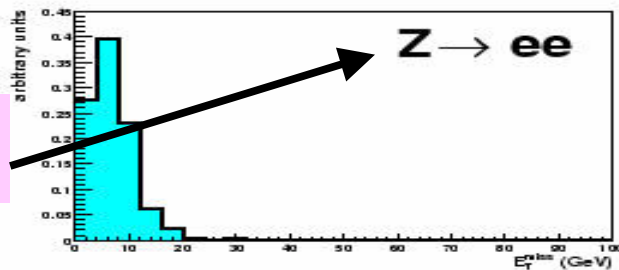
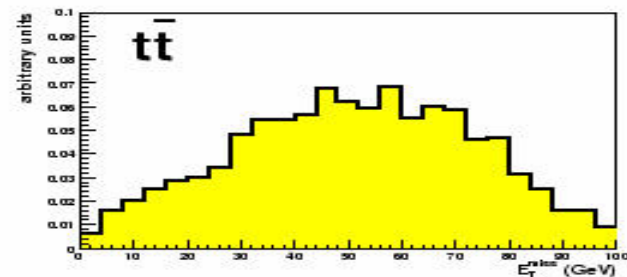
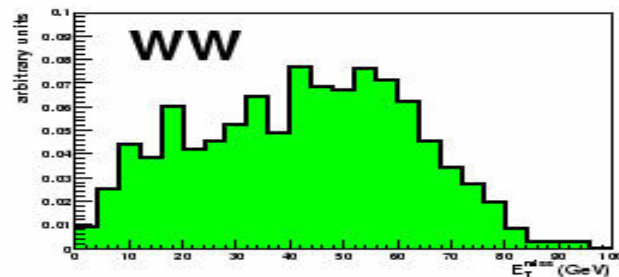
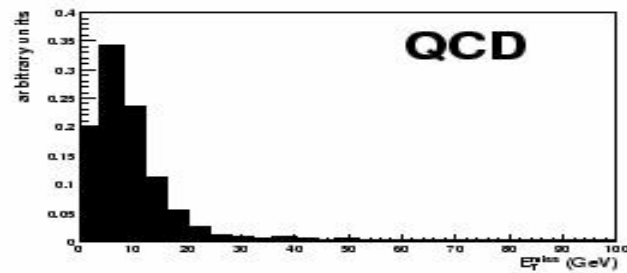
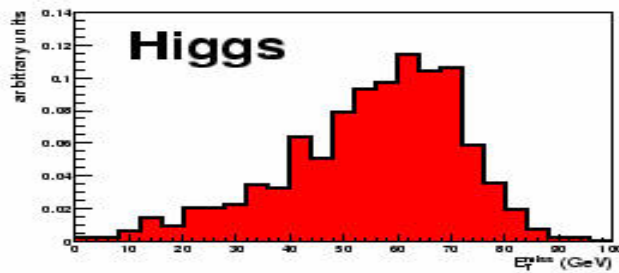
An example: e^+e^- final state MC





Missing E_T

An example: e^+e^- final state MC



Main background