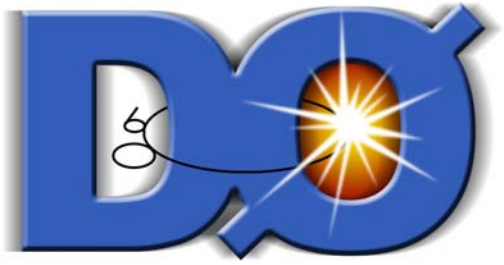
Prospects for Higgs Searches at



Gordon Watts
University of Washington
For the DØ Collaboration

2003 April Meeting
DPF

Previous Searches

The LEP & Tevatron Run I Era

15 Years of Precision Measurements

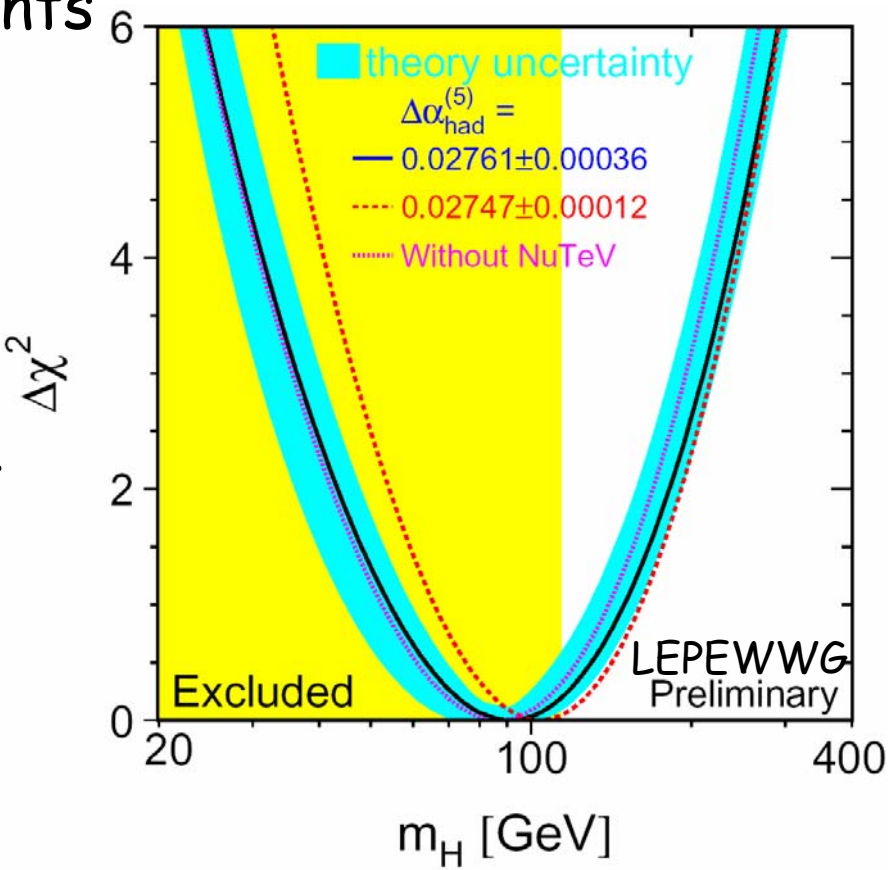
Global Fit of SM Measurements

Light SM Higgs Favored

91^{+58}_{-37} GeV/c^2

LEP Direct Searches:

$M_H > 114.4$ GeV/c^2 @ 95% CL



Run II at the Tevatron

Center Of Mass Energy Increase

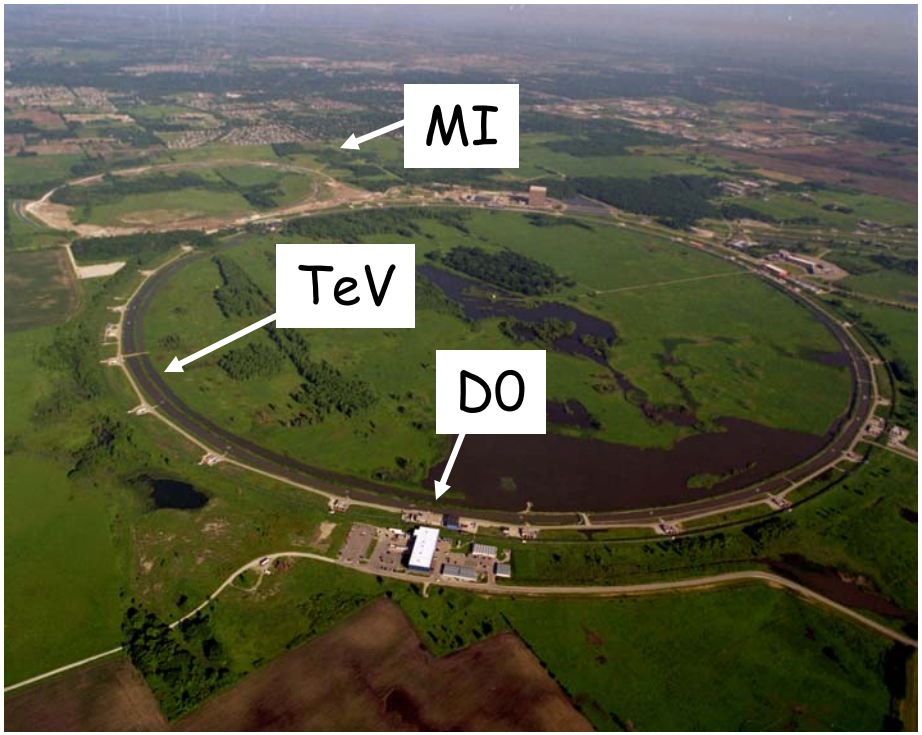
$\sqrt{s} = 1.8\,\text{TeV} \Rightarrow 1.96\ \text{TeV}$

20-30% Increase in the SM Higgs Cross Section

Accelerator Improvements

Main Injector, Recycler, etc.

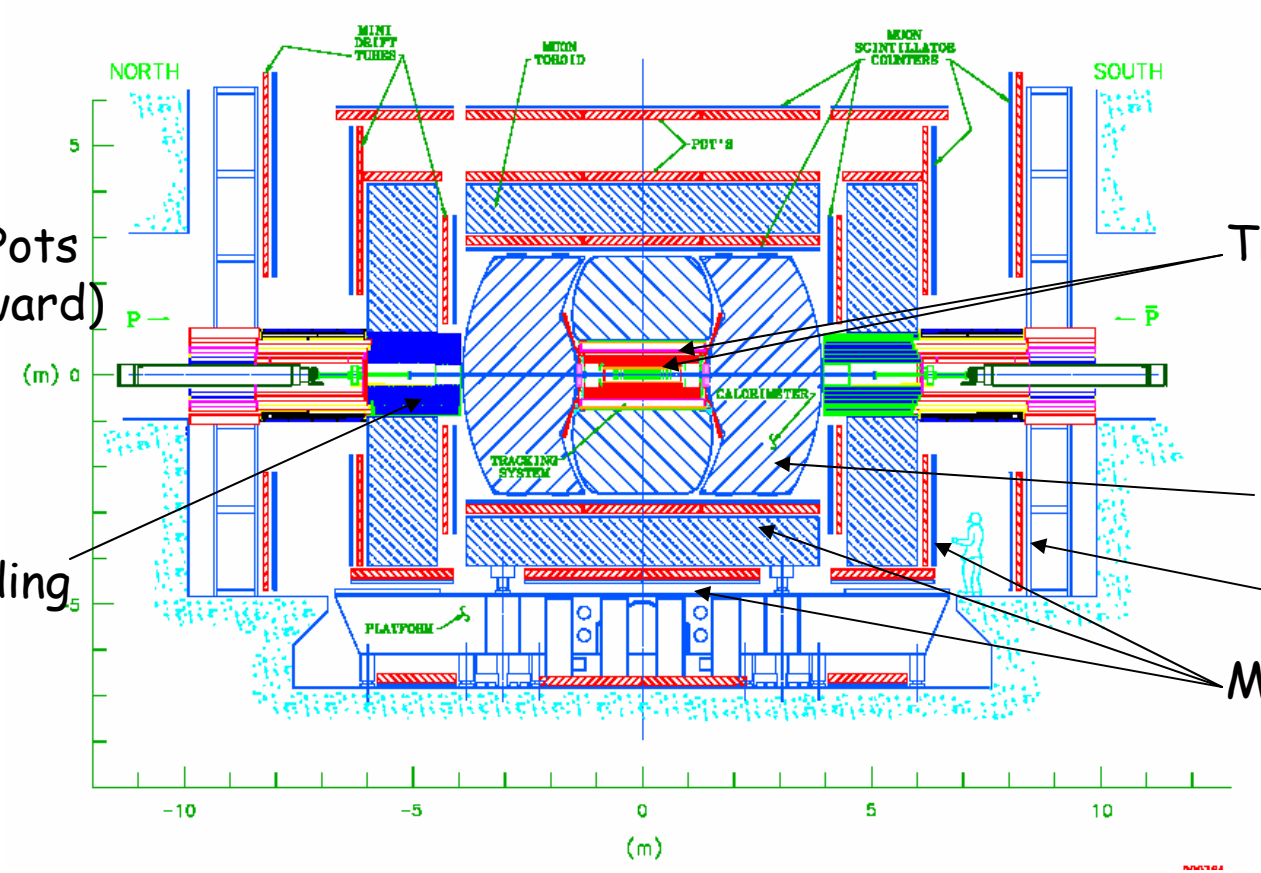
Run I Lumi 120 pb^{-1}
Run II Lumi 6-10 fb^{-1}



DØ Has Written ~110 pb^{-1} to tape

This talk < 60 pb^{-1}

The DØ Detector



Roman Pots (far forward)

Tracking

Calorimeter

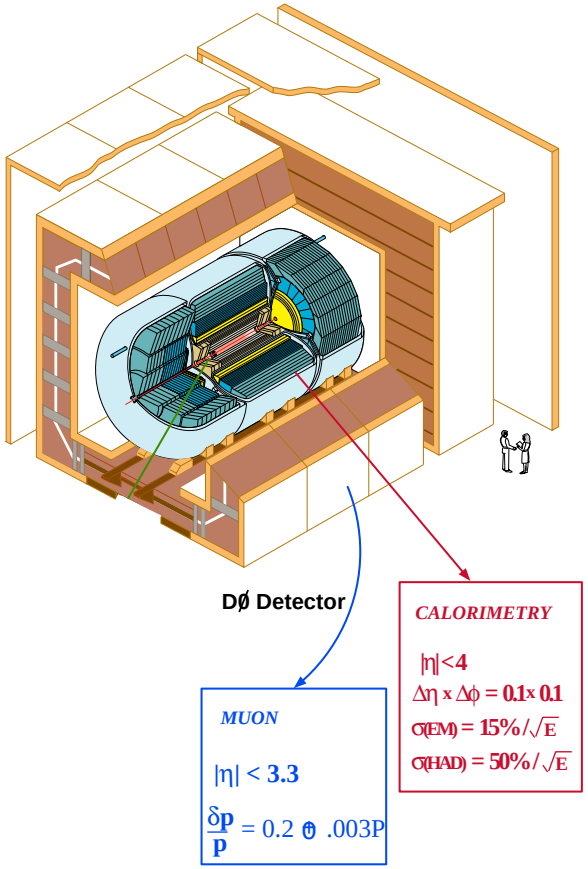
Shielding

Forward Muon

Muon

The DØ Detector

- Tracking Volume
  - Silicon Track Detector
  - Central Fiber Tracker
- High Precision LAr Calorimeter
- 4π Muon System with Absorber



The DØ Upgrade

Added a 2T Magnetic Field

Track p_T, Lepton ID, Jet Calibrations

New Silicon Detector & Central Tracking Detector

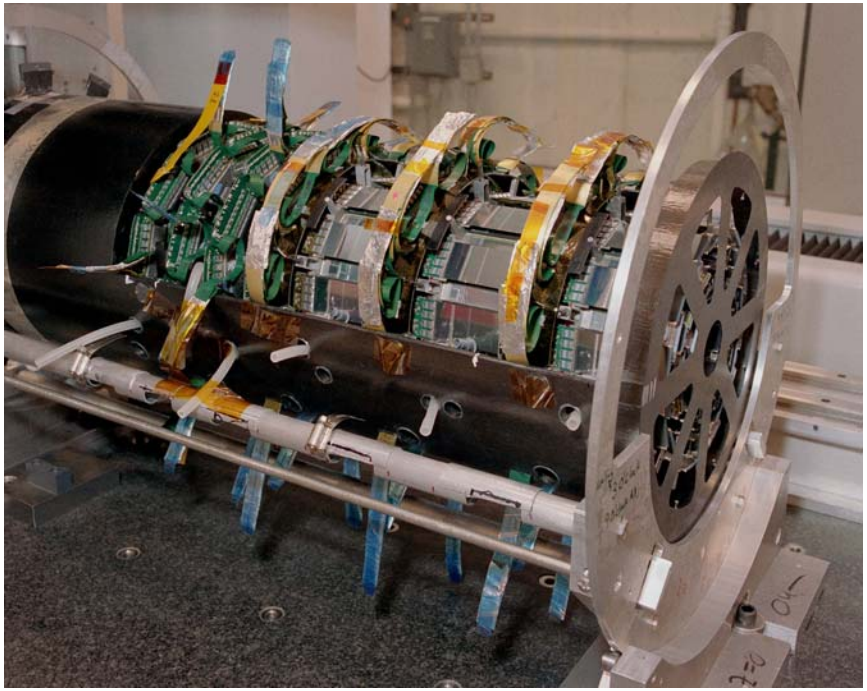
Displaced Vertex ID, Tracking

Preshower Detector

Improved electron ID

Trigger/DAQ Upgrade

Better Efficiency for difficult signals



Finding the Higgs will require all components of the detector

Regularly collect > 85% of data delivered by the Tevatron

The Higgs in Run II

1 Indirect Measurements

Further Constrain the SM

$\delta M_t < 2.5$ GeV/c^2

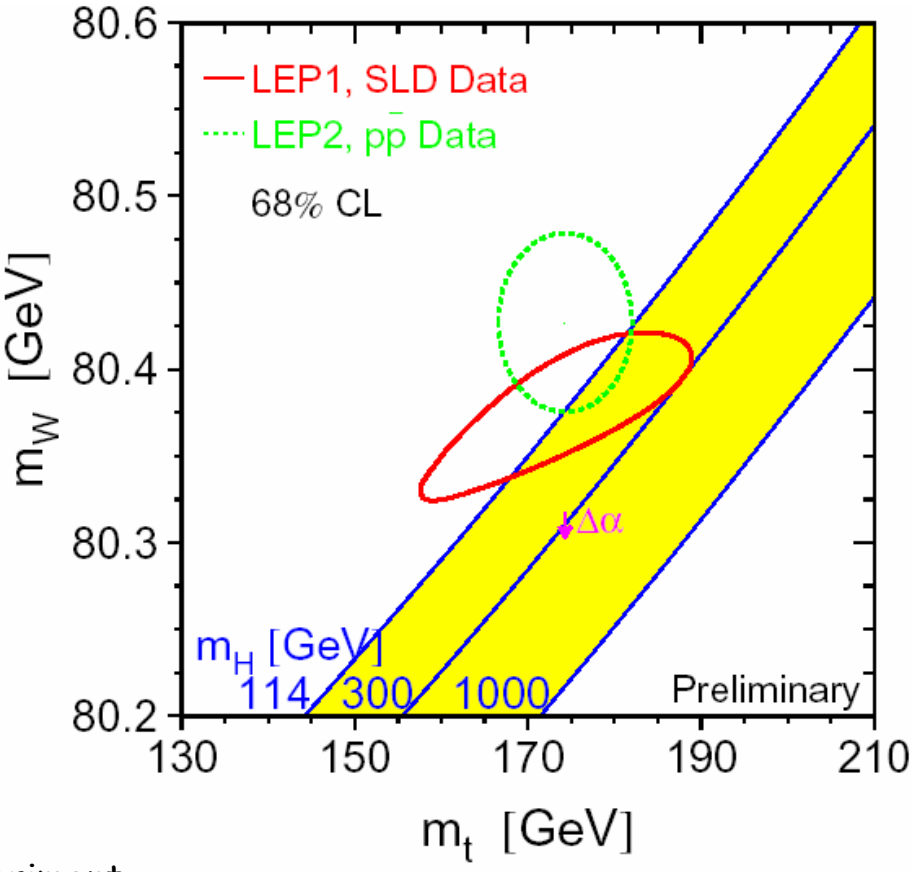
Currently 5.1 GeV/c^{2*}

$\delta M_W < 40$ MeV/c^2

Currently 59 MeV/c^{2*}

2 Direct Searches

The rest of this talk…



*these are combined, Run II predictions are per experiment

Higgs Decays

Search strategies are a function of Decay Channel and Production Channel

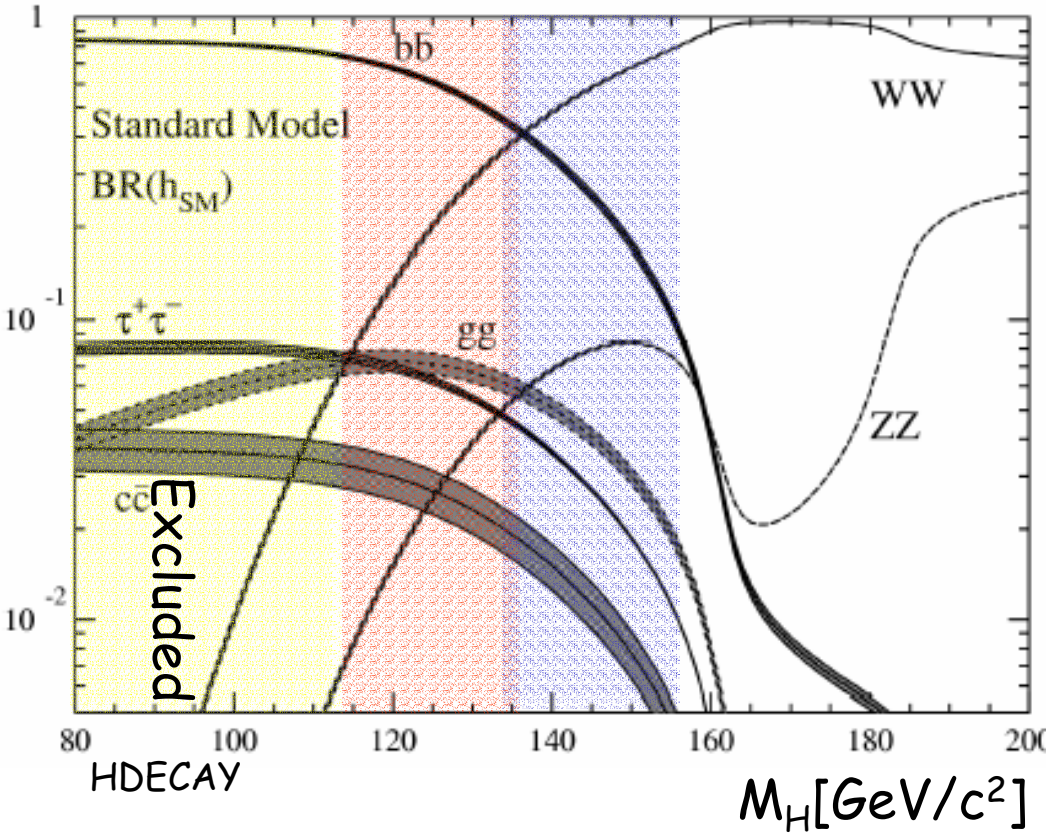
Nominal Mass Reach Spans Two Decay Modes

Low Mass Higgs Searches

$$m_H < 135 GeV/c^2$$
$$H \rightarrow b\bar{b}$$

High Mass Higgs Searches

$$m_H > 120 GeV/c^2$$
$$H \rightarrow WW^*$$



Higgs Production

Gluon Fusion

$gg \rightarrow H \quad \sigma \sim 1pb$

No Good at Low Mass

Overwhelmed by QCD background

Good at High Mass

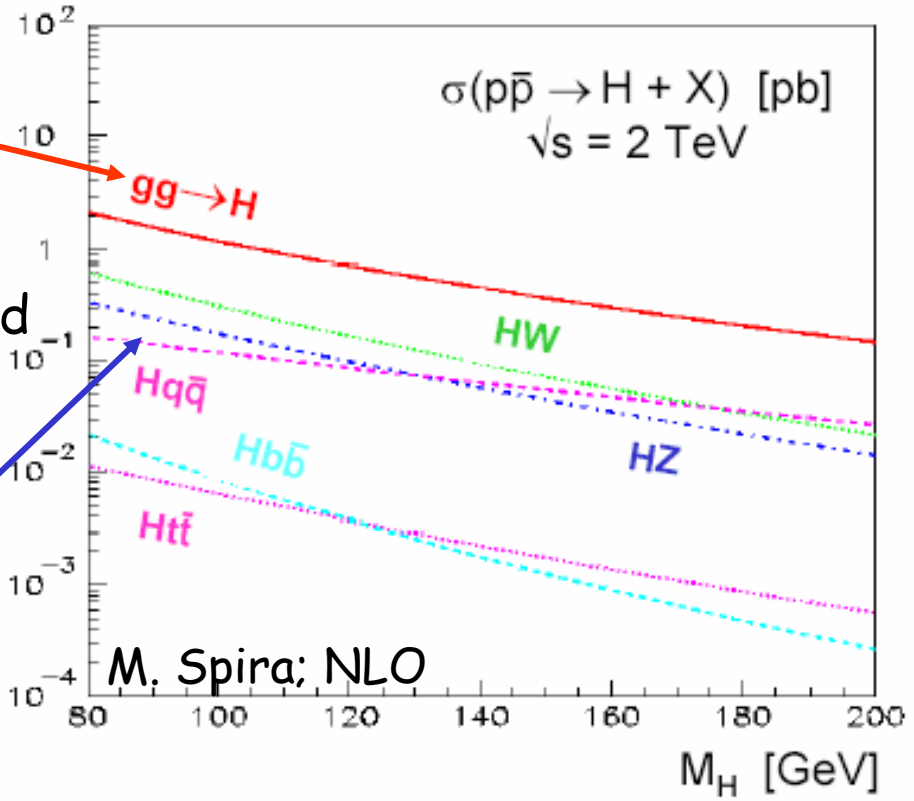
$H \rightarrow WW^*$

Associated Production

$ZH, WH \quad \sigma \sim 0.1pb$

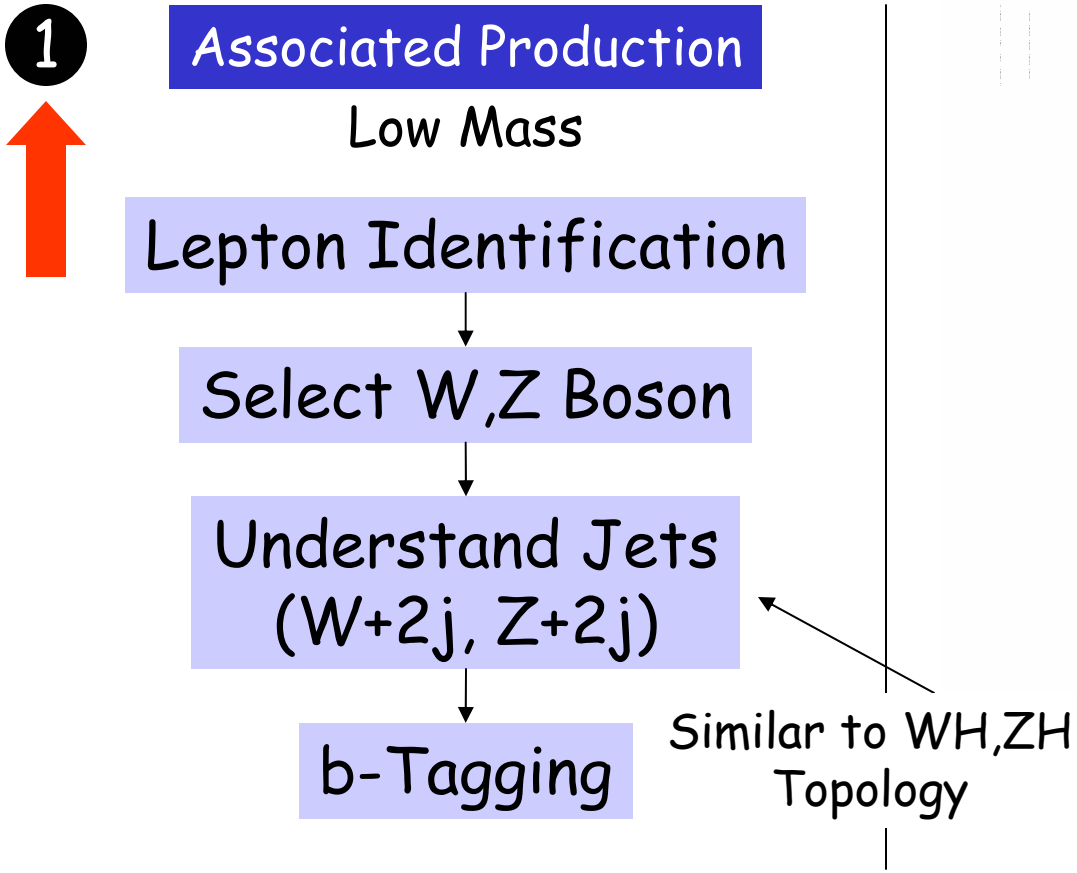
Good at Low Mass

$H \rightarrow bb$



SM Higgs Searches At DØ

SUSY Higgs Searches at End of talk



Electron ID

Trigger on EM Object

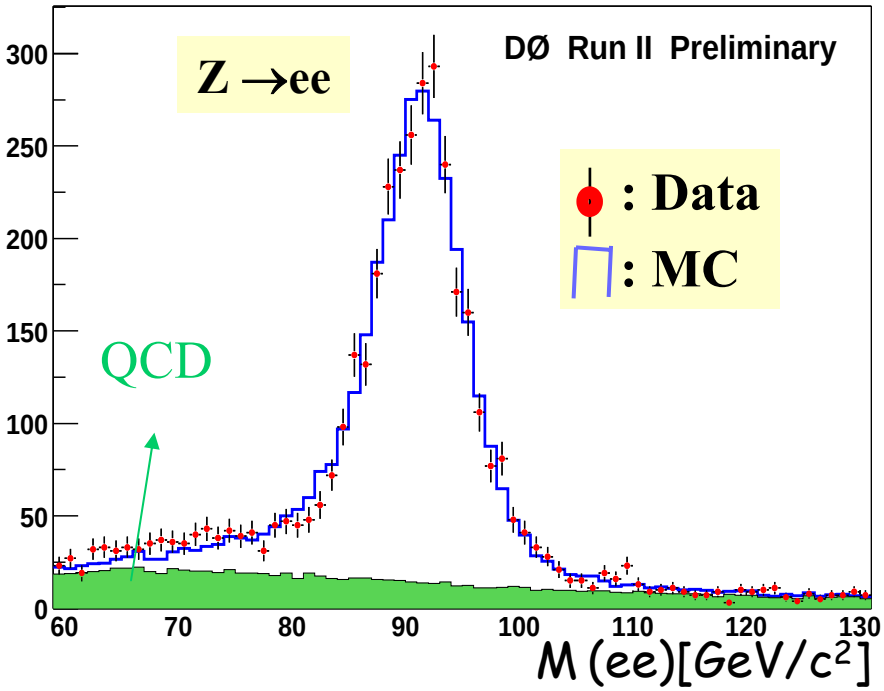
Calorimeter EM Object

p_T>20 GeV/c Quality Cuts

Matching Track

M (ee)

Pythia MC



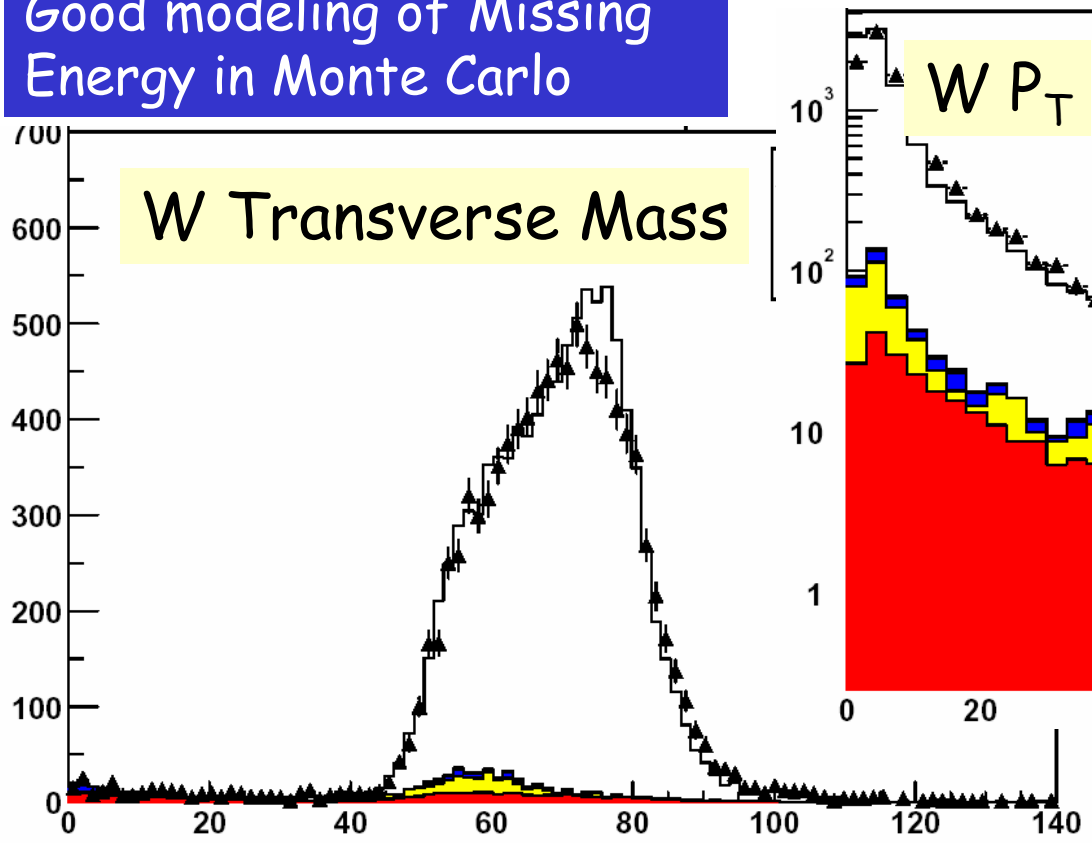
35 pb^{-1} of data

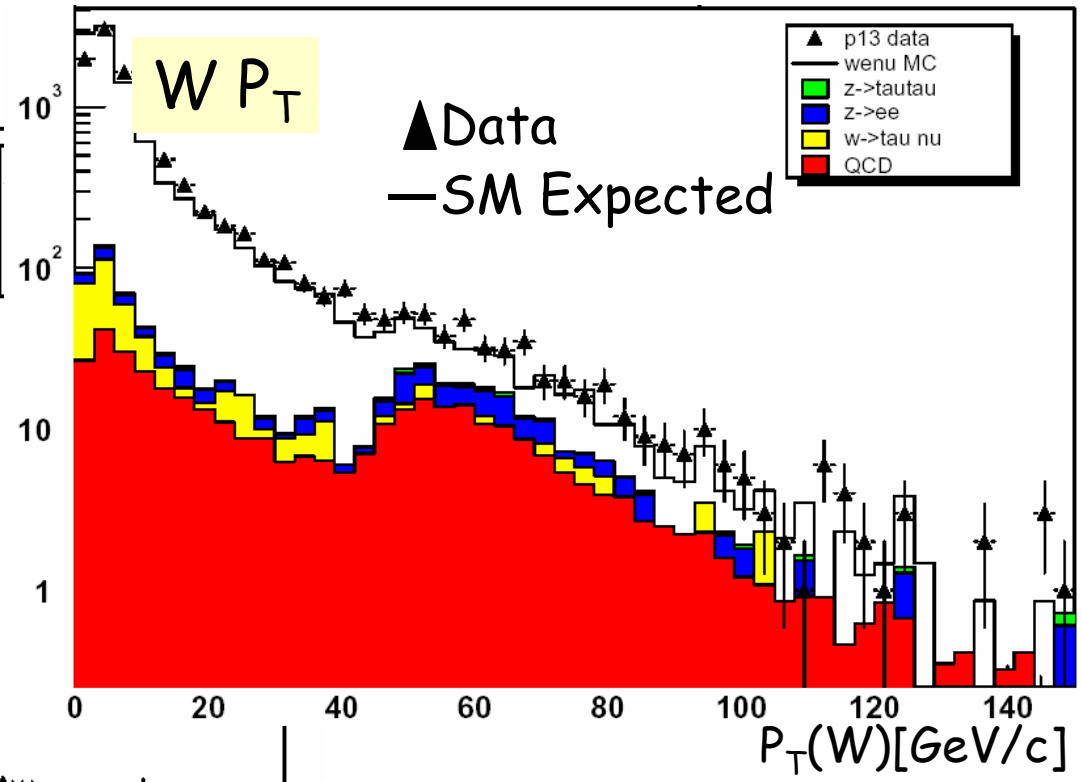
See U14.02 for more!

W Boson

$W \rightarrow e\nu$

Good modeling of Missing Energy in Monte Carlo





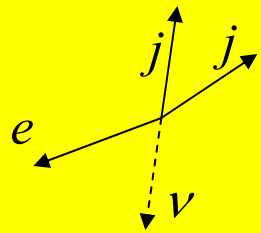
SM Expected includes W(eν), W(tν), Z(ττ), Z(ee), QCD

See Talk by D. Meder

G. Watts APS 2003

Understanding W+Jets

Important for both Top and Higgs



$W \to e/\mu\nu$

MC:
Statistical and Jet Energy Scale Systematic Errors

Normalized by area

Isolated electron:

$p_T > 20GeV/c \quad |\eta| < 0.8$

Missing Energy:

$\not{E}_T > 25GeV$

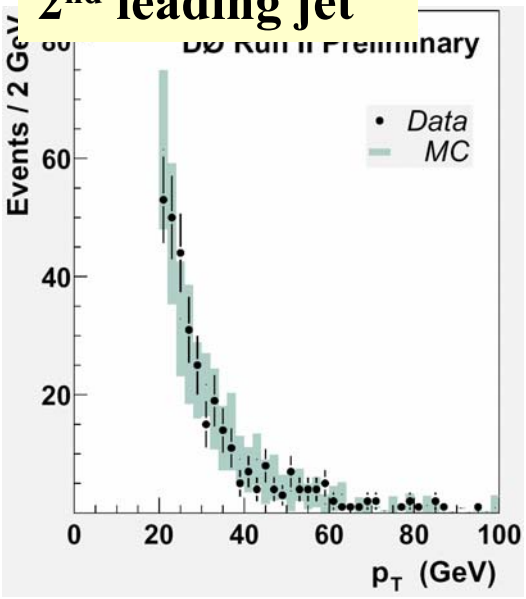
Jets:

$p_T > 20GeV/c$

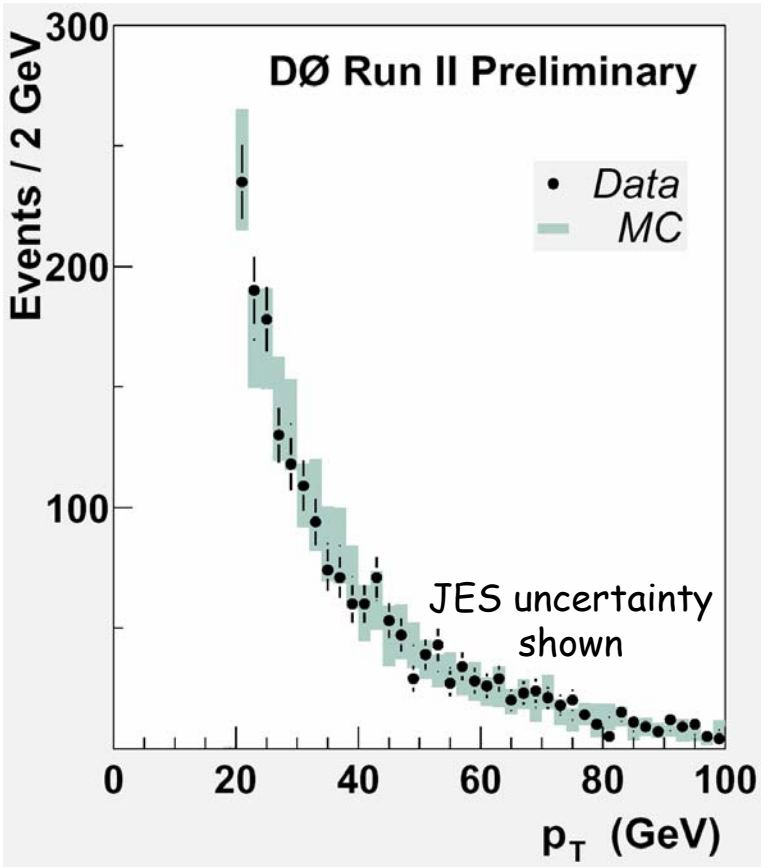
$|\eta| < 2.5$

Pythia Used for Signal and Background

2nd leading jet

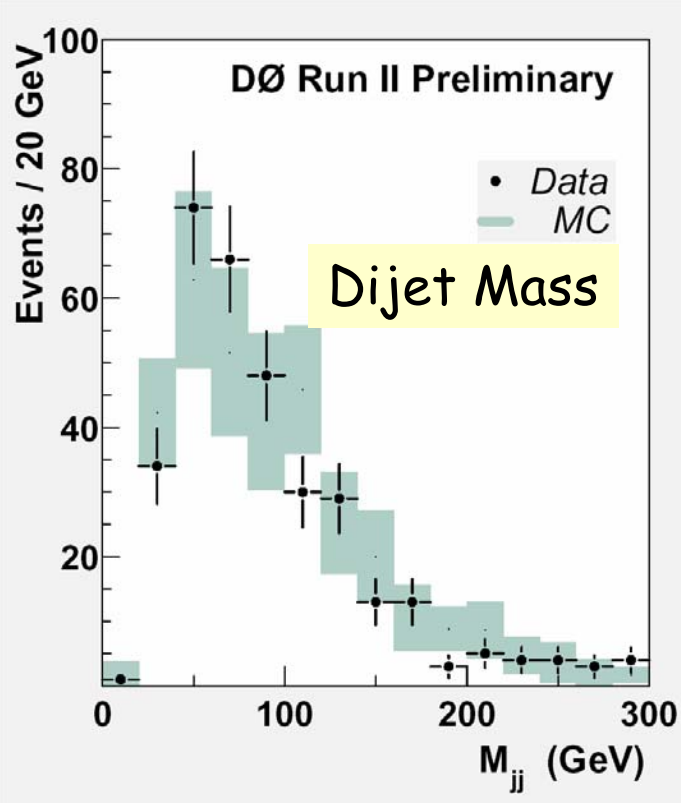


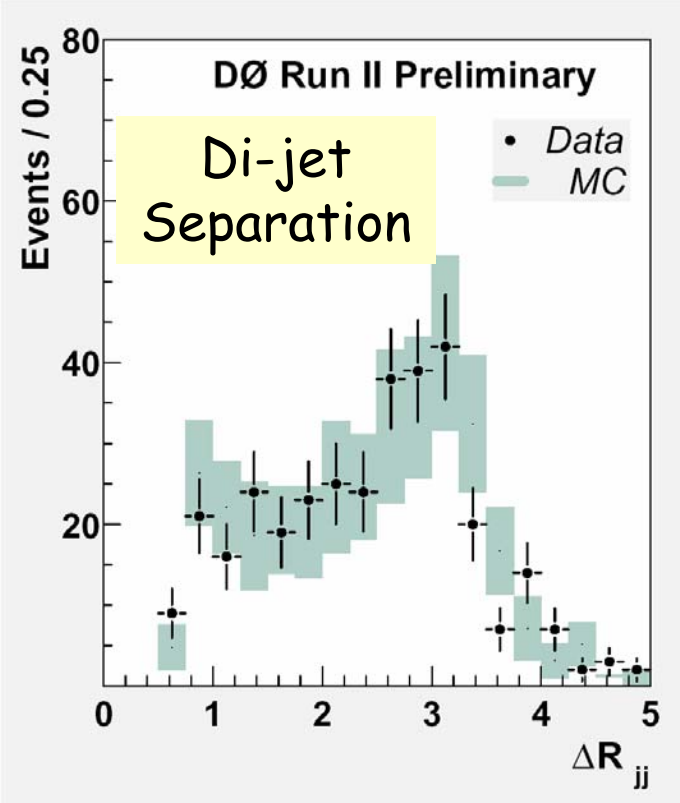
1st leading jet **W(e/μν)+jets**



Jet Properties in W+jets

$W \to e\nu$
$W \to \mu\nu$
Combined

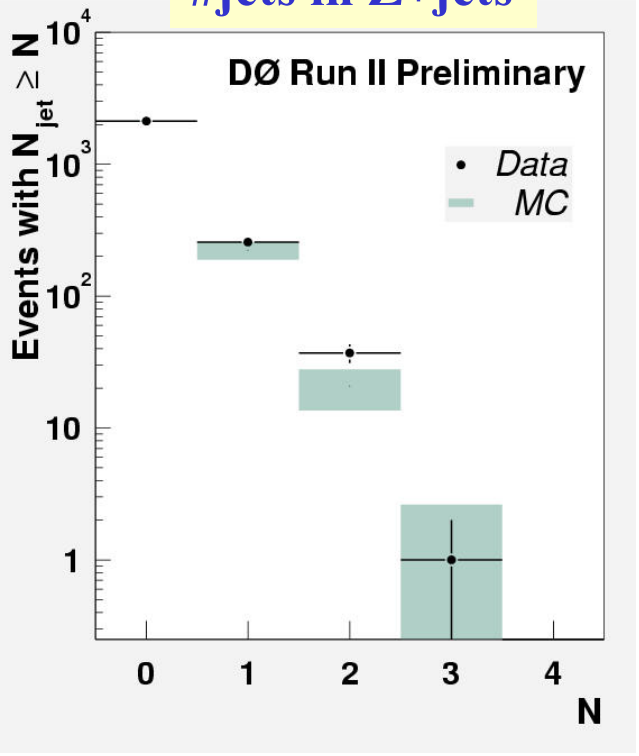




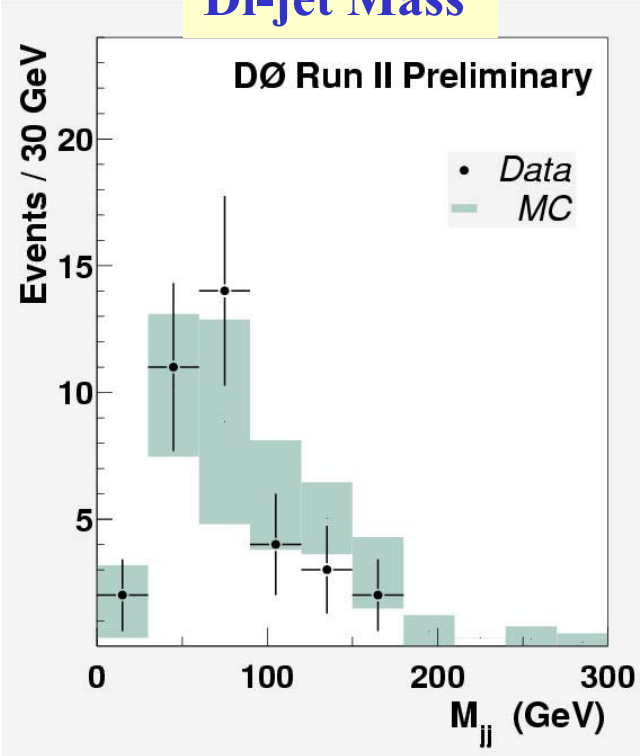
Pythia, Alpgen used to model all signal and background processes

Jets in Z+Jets

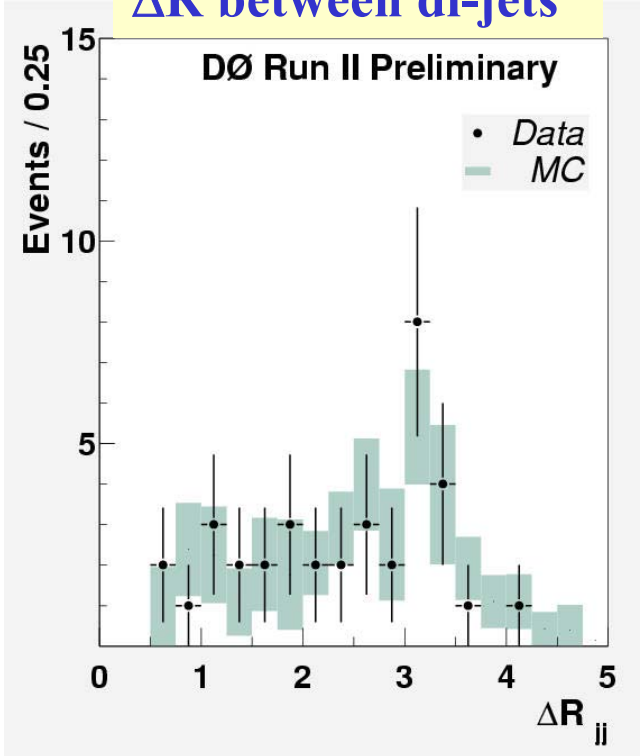
#jets in Z+jets



Di-jet Mass



ΔR between di-jets

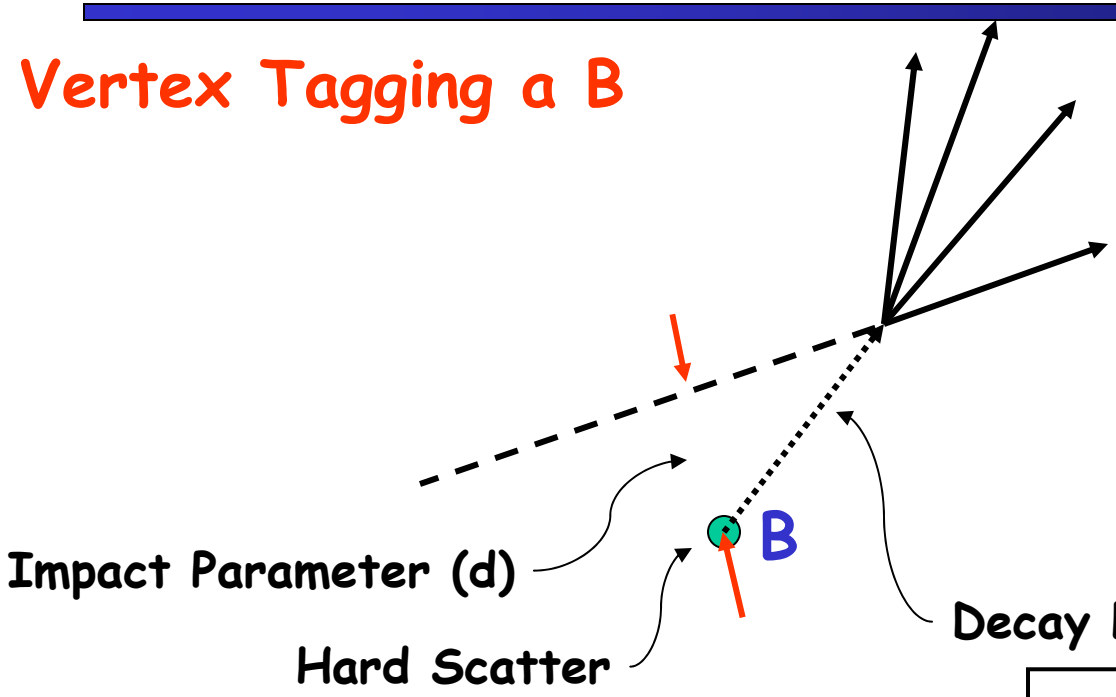


Pythia used to generate both signal and background processes

See talk by M. Buehler

Tagging a B

Vertex Tagging a B

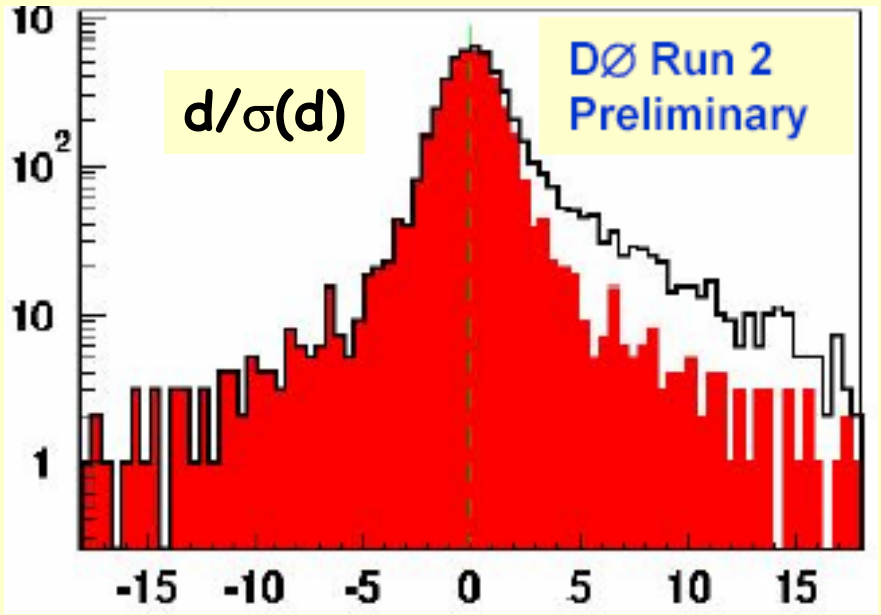


- Top, Higgs contain b-quark jets
  - Most backgrounds do not
- Jets look like any light quark jet
- Other than contain a B meson
  - Has finite life time
  - Travels some distance from the vertex before decaying
    - ~ 1mm
    - With charm cascade decay, about 4.2 charged tracks

Several algorithms under development

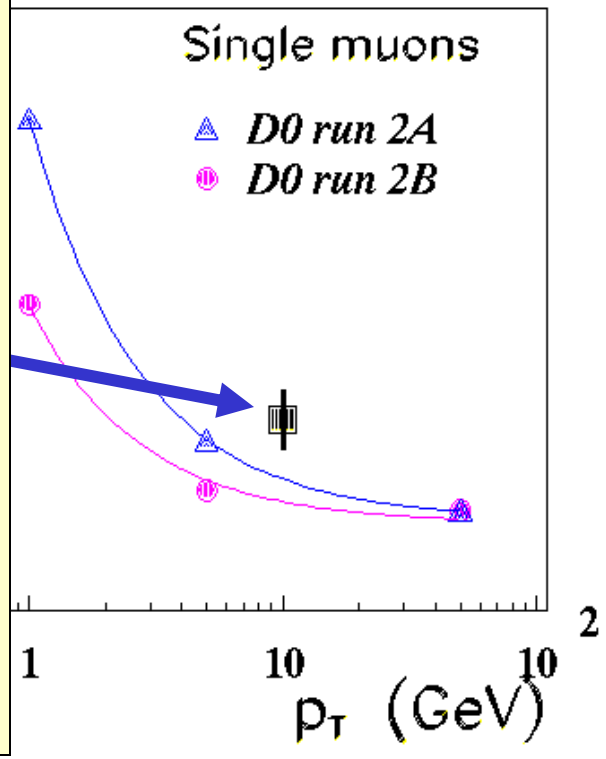
Impact Parameter Resolution	$d/\sigma(d)$
Decay Length Resolution	$L_{xy}/\sigma(L_{xy})$

B-Quark ID



See Talk By Y. Mutaf

solution as the function of P_T



SM Higgs Searches At DØ

Gluon Fusion

High Mass

Lepton Identification

↓

Select W Bosons

↓

Apply cuts to remove backgrounds

↓

Apply Mass Window Cut

$H \rightarrow WW^{*} \rightarrow l^{+}l^{-}\nu\bar{\nu}$

Major SM Backgrounds include Z/y*, WW, $t\bar{t}$, W/Z+jets, and QCD

Results from ee, $e\mu$, and $\mu\mu$ channels → New for DPF

Lepton cuts similar to previous analysis

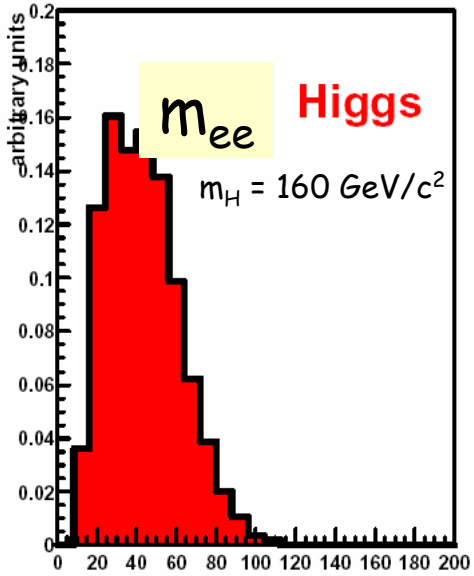
Mass Window Cut

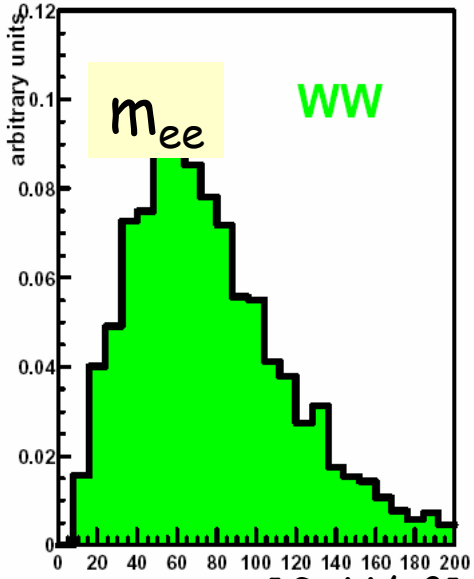
2 neutrinos → Can't Determine m_H

Cut on m_{ll} and $\not\!\!E_T$

$\Delta\Phi_{ll}$
- Higgs: spin correlations in WW* decay keep leptons in parallel
- Z/y* and QCD: leptons tend to be back to back

More details in talk P. Tamburello.





(other backgrounds not shown)

Production Limits

The ee and eμ Channels

ee

Expected: 0.7 ± 1.4 ± 0.1

ε_{signal} : ~8%

Observed: 0

For MH=120

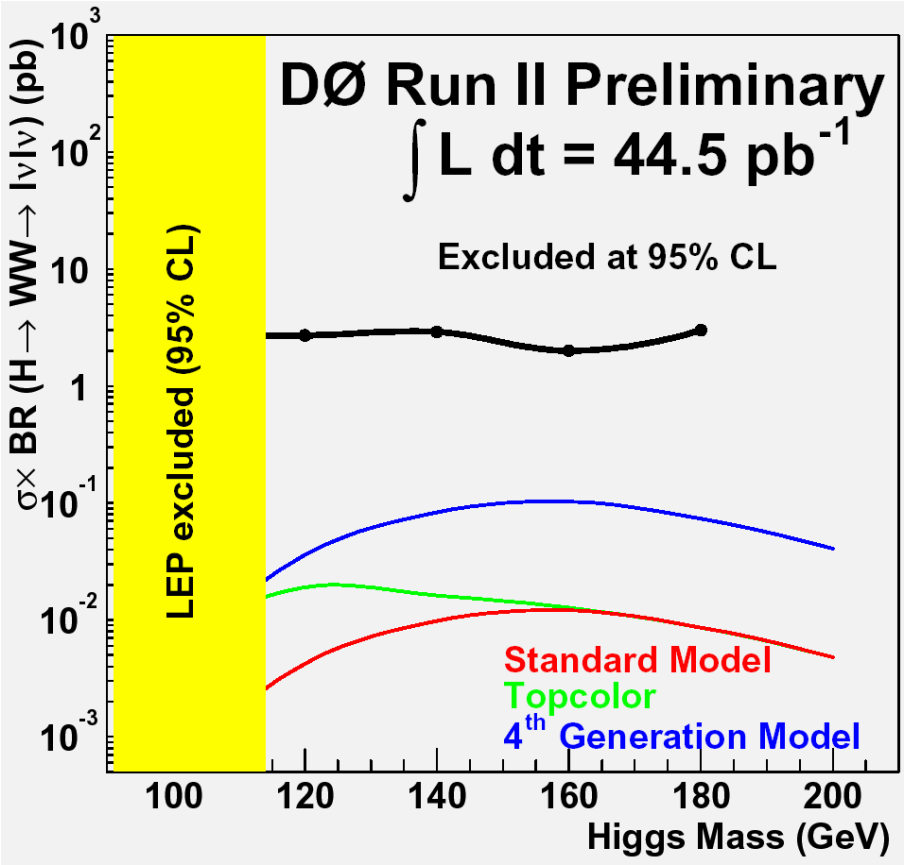
eμ

Expected: 0.9 ± 1.5 ± 0.1

ε_{signal} : ~12%

Observed: 1

For MH=120



$H \rightarrow WW^* \rightarrow \mu^+\mu^-\nu\bar{\nu}$

Expected: 0.32 ± 0.01 (stat)
Observed: 1
ε_{sig}: 14.6 ± 0.6% (stat)
m_H=160GeV/c^2

48.4 pb^{-1}

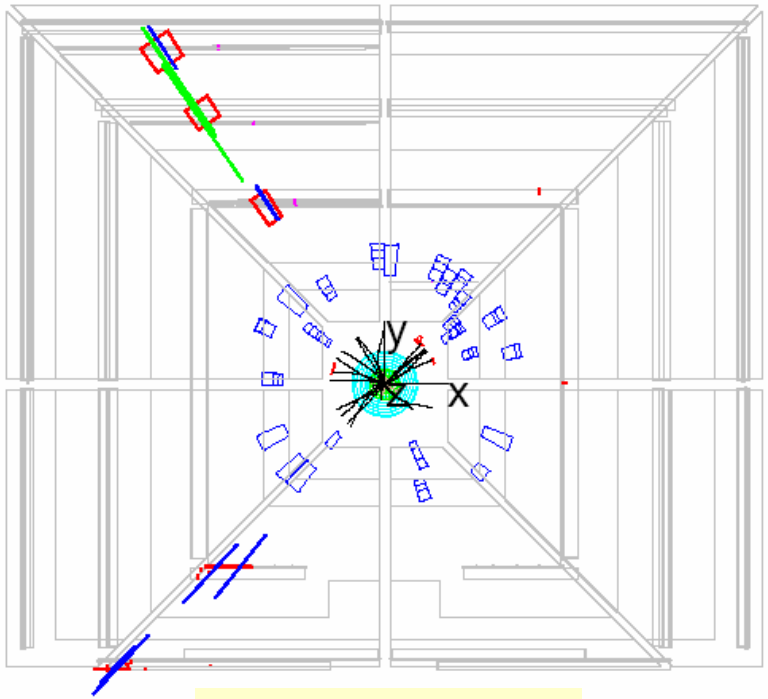
Run 163305
Event 3024474

μ #1 p_T = 23.7 GeV/c
μ #2 p_T = 33.7 GeV/c

$\not\!\!E_T$ = 45.7 GeV

$\Delta\Phi_{\mu\bar{\mu}}$ = 1.84

$m_{\mu\mu}$ = 52.5 GeV/c^2



Beam-pipe View

More details in talk P. Tamburello.

Non Standard Model Higgs Searches

- Ongoing
  - H^{++}
  - $hb\bar{b}$ at high tan β
    - Talk by A. Haas on Monday
- Two Photon - $H \to \gamma\gamma$
  - SM Decay Process
  - Decay mode in SM extensions that suppress Higgs Fermi coupling
    - Fermiphobic Higgs
    - Top Color Higgs

$H \rightarrow \gamma\gamma$

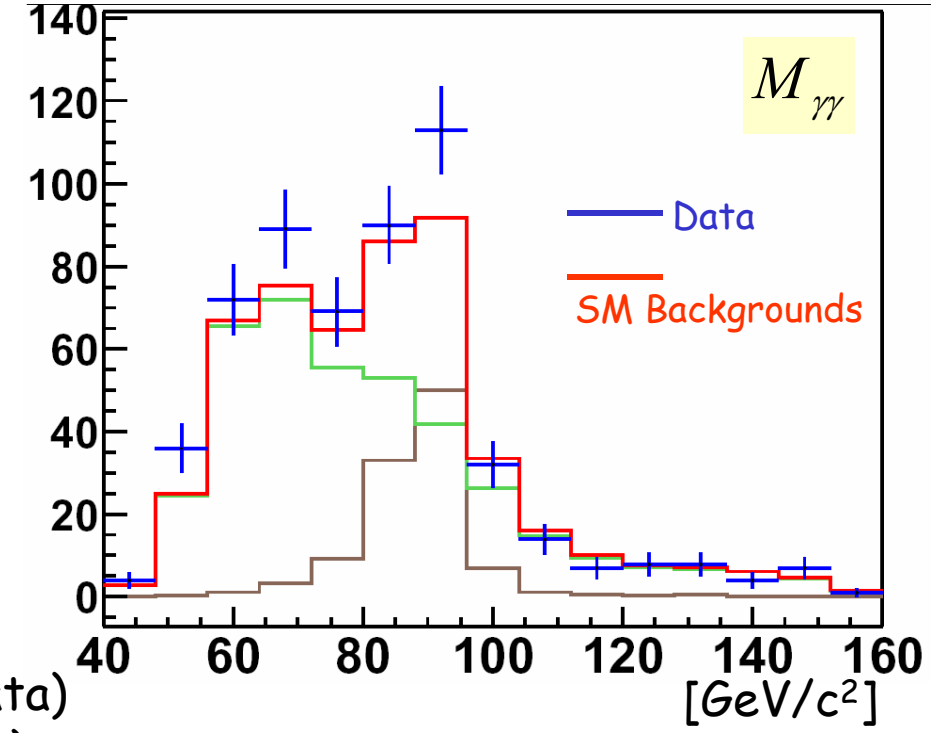
Require 2 Isolated EM

$p_T > 25GeV/c$

No Track (photon)

SM Backgrounds

Drell-Yan, Z/g(ee), QCD



L=51.8 pb^{-1}

QCD Background (data)

DY Background (data)

Look Specifically at the Top Color Higgs

Results

Cross over at

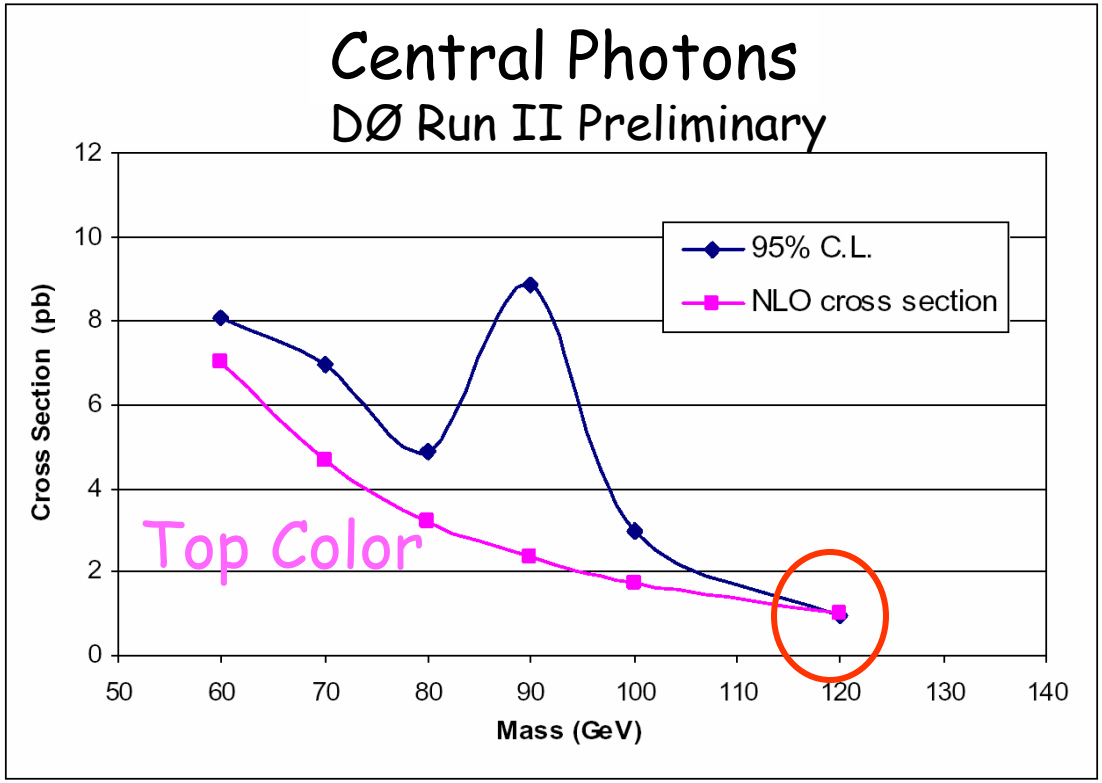
M_H = 120 GeV/c^2

BR($h \rightarrow \gamma\gamma$)=1

With more data will be sensitive to other exotic Higgs Models

Mass Window Cut

Pythia used for Signal



See talk by A. Melnitchouk

Conclusions

- Analysis Efforts for the Higgs search are well under way
  - Results for the first 50 pb^{-1} reported here
  - We can clearly see the pre-cursors for the Higgs search
- Next Steps at DØ
  - Improved object ID efficiencies
  - b-quark tagging algorithm maturity
  - Steady progress on di-jet mass resolutions
- What to watch for at Fermilab
  - More Luminosity!
- Prospects for Discovery
  - DØ has work to do in btagging, di-jet resolutions and tau to achieve the working groups levels.
    - Dijet mass distribution will require the most work.
  - Joint CDF/DØ group put together to study all of this now.