Prospects for Higgs searches at DØ

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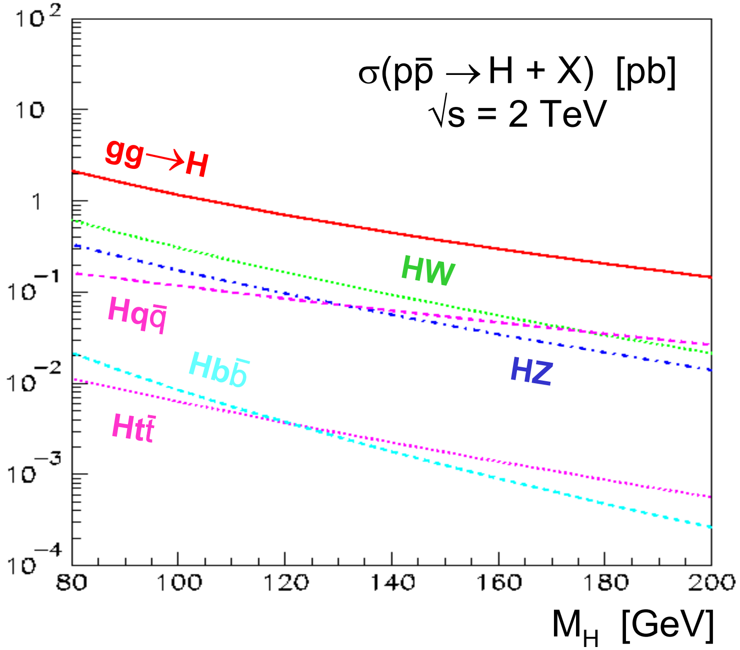
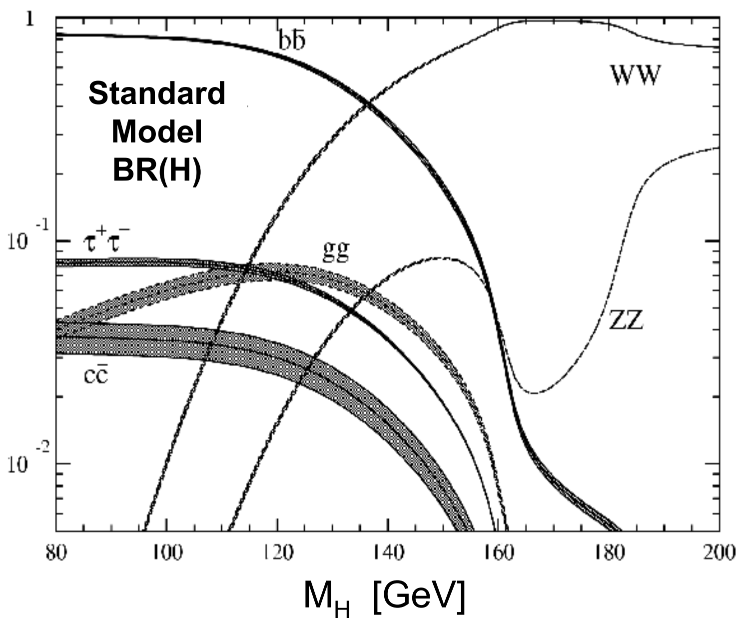
For the DØ Collaboration

- Introduction
- Earlier analysis
- DØ Run 2 detector
  - Current performance
- Standard Model Higgs
- SUSY Higgs
- Summary

Introduction

- One of the main goals at the Tevatron is to search for Higgs particles
- The SM Higgs production cross sections are not very large,1 - 0.1 pb depending on mass (M_H)
- In the context of, e.g. SUSY models the b-Higgs coupling is enhanced by ~tanβ making searches promising



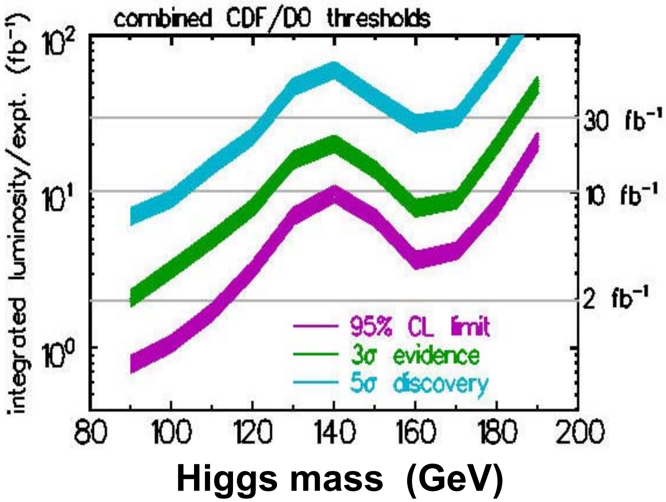


- At low $M_H \lesssim 140$ GeV the $H \to b\bar{b}$ decays are dominant and searches can be performed in W/Z associated production to handle backgrounds
- $H \to WW^{(*)} \to l^+l^-\nu\nu$ final states can be explored at higher masses
- SUSY Higgses can be searched in $bh/b\bar{b}h(\to b\bar{b})$ associated production

Tevatron Higgs Working Group studies

- In 1998 - 2000 the Tevatron Run 2 potential to discover Higgs was evaluated (HWG report, hep-ph/0010338)
- Joint effort of theorists and both experimental groups, CDF and DØ
- Simulations performed mainly using parameterized detector response
- Main conclusions
  - There is no single channel which guarantees success
  - Improved understanding of signal and background cross sections, kinematics, along with the detector performance figures, is vital
  - To maximize sensitivity advanced analysis techniques have to be employed and results from two experiments combined

- The integrated luminosity required per experiment, to either exclude a SM Higgs at 95% CL or discover it at the 3σ or 5σ level



- Goal of the on-going analysis in DØ is to evaluate in detail sensitivity to Higgs searches taking into account current/projected performance

Basic requirements

- Higgs searches are very demanding on detector performance
- Particularly important are
  - b-tagging capability
  - di-jet mass resolution
  - excellent lepton identification, efficiency, triggering, etc.
- The end result would be most dependant on the luminosity delivered by the Tevatron

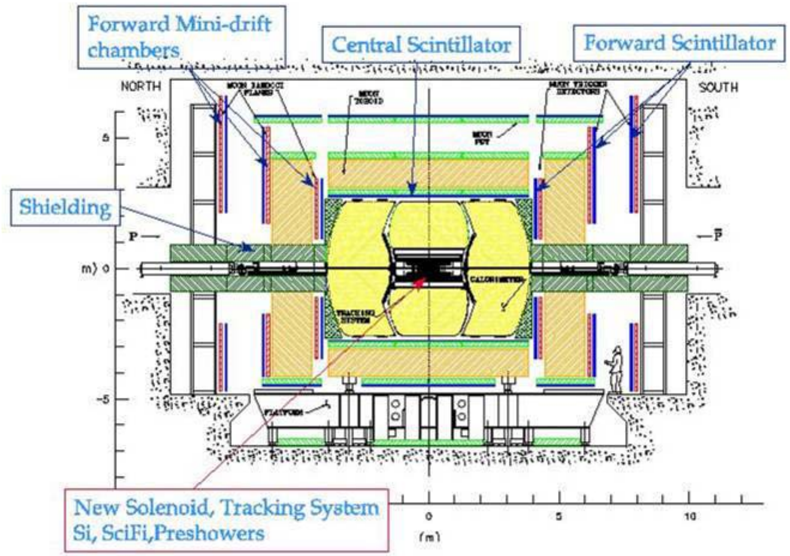
Run 1 → Run 2A → Run 2B
0.1 fb^{-1} → 2 fb^{-1} → 15 fb^{-1}

Tevatron upgrade

	Run 1B	Run 2A	Run 2B
#bunches	6x6	36x36	140x103
$\sqrt{s}$ (TeV)	1.8	1.96	1.96
typ L ($cm^{-2}s^{-1}$)	1.6×10^{30}	8.6×10^{31}	5.2×10^{32}
$\int$ Ldt (pb^{-1}/week)	3.2	17.3	105
bunch xing (ns)	3500	396	132
interactions/xing	2.5	2.3	4.8

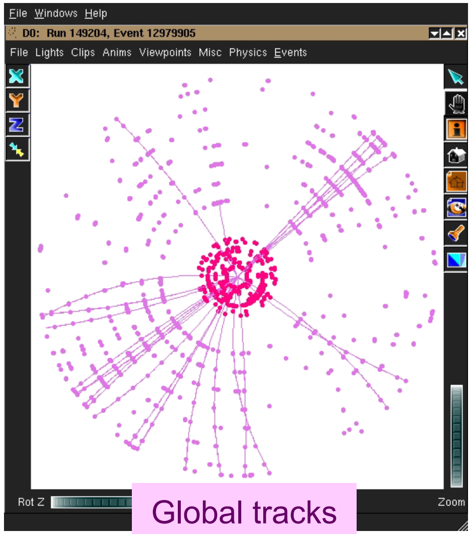
DØ Run 2 detector

- DØ has undergone major upgrades
  - New tracking devices, Silicon (SMT) and Fiber (CFT) placed in 2 T magnetic field
  - Calorimeter supplemented with the preshower detectors
  - Significantly improved muon system
  - New forward proton spectrometer
  - Entirely new DAQ and trigger systems to handle high event rate
  - New software to cope with the data



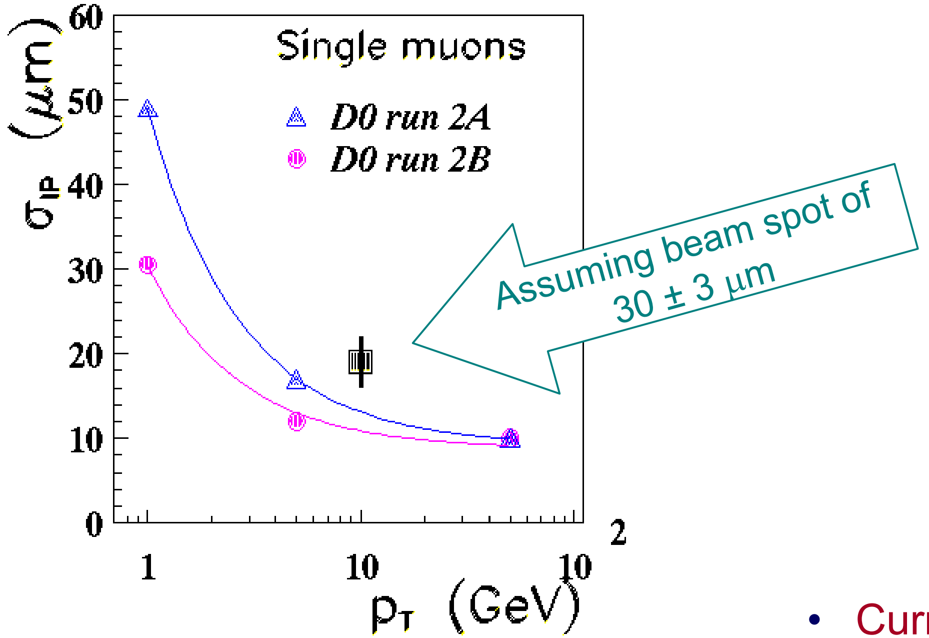
- A few subsystems are in the final stages of commissioning

- To fully explore the physics potential in Run 2B DØ is making
  - New Silicon tracker with innermost layer at 1.78 cm (c.f. 2.71 in Run 2A)
  - New calorimeter and track triggers
  - Many other improvements



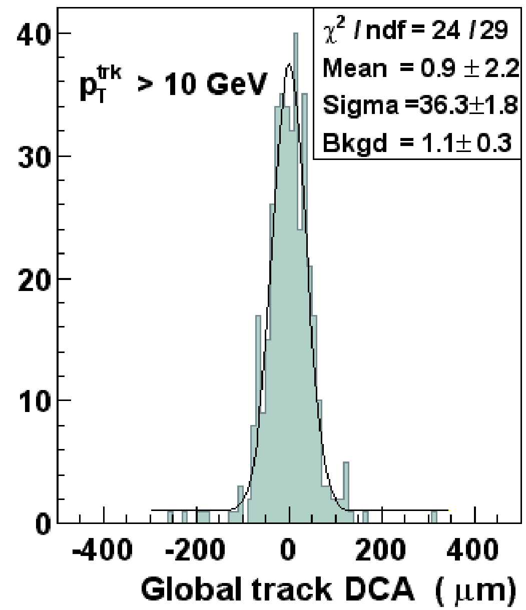
b-tagging (1)

- Crucial to keep signal efficiency high and suppress non-b jets
- Efficiency/fake rates determined by Impact Parameter (IP) resolution



- Run 2B SMT design performs much better at low p_T which is of relevance for b-tagging capability

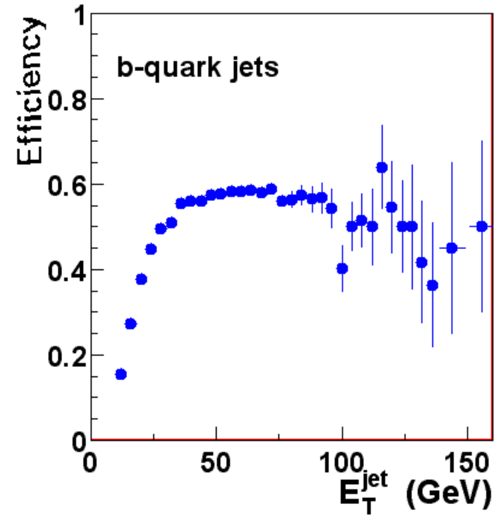
- Measured IP resolution after 1st pass in SMT alignment



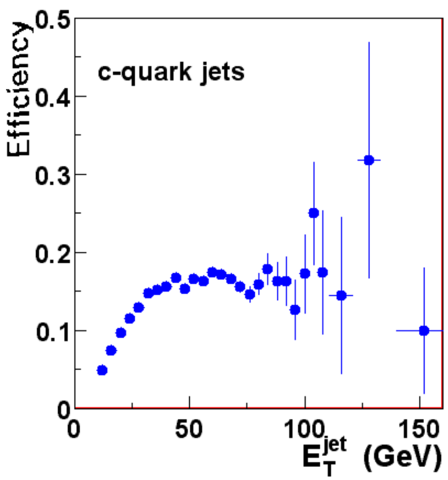
- Current performance is approaching Run 2A design figure

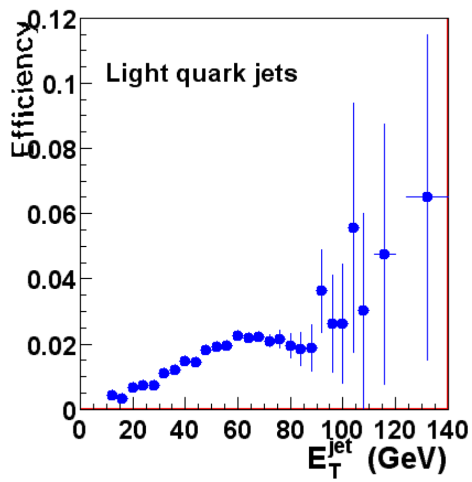
b-tagging (2)

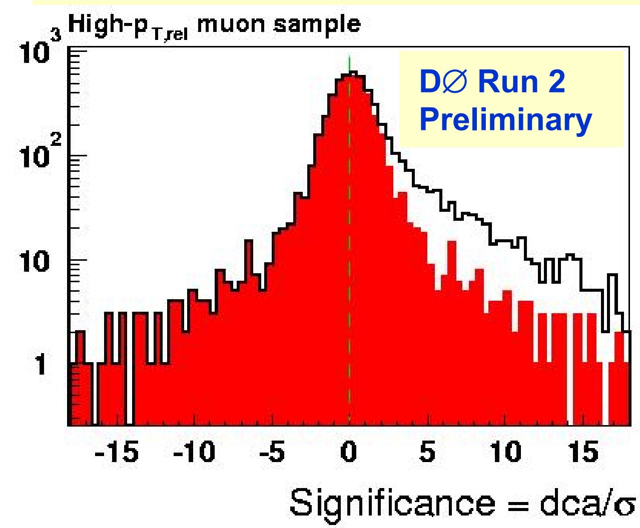
- Run 2A detailed simulations
  - Not fully optimized yet
- Preliminary results indicate
  - b-tagging efficiency as high as 60% can be achieved
  - Mis-tagging rate for c-jets is less than 15 - 20% depending on E_T, while light quark rate can be kept at a few percent level



Tagging in μ+jet data sample: muon p_T^{rel} > 1.5 GeV wrt the jet



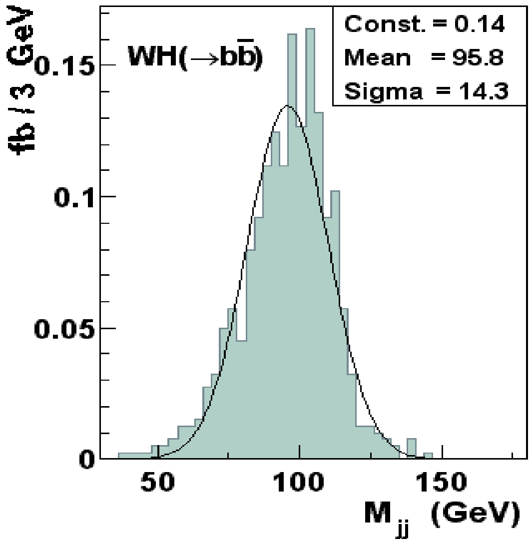




$W(\to e\nu/\mu\nu)H(\to b\bar{b})$ associated production

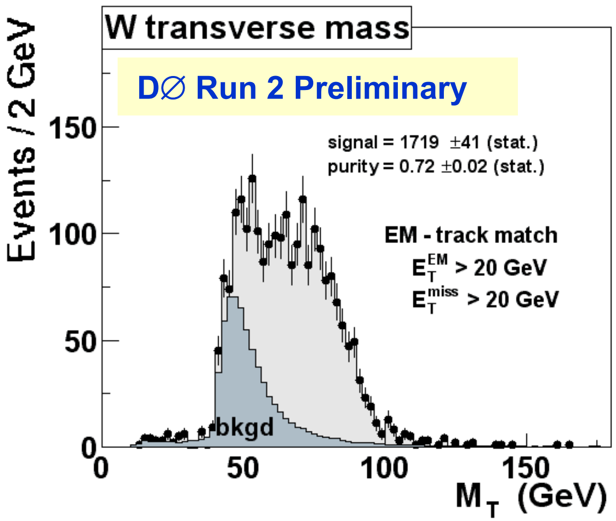
- Final states are characterized by
  - Isolated lepton, e or μ
  - Two b-jets
  - Missing E_T
- Signal acceptance/rate based on detailed simulations
- Detailed background studies are underway
- Example of M_h=115 GeV
- Selections similar to HWG; in particular
  - $E_T(e/\mu) > 20$ GeV in $|\eta| < 2.5$
  - $E_T(\text{jet1/2}) > 15$ GeV in $|\eta| < 2$ and tagged as b-jets

- Two leading jets mass spectrum



- Get relative resolution $\sigma/M \approx 15\%$
  - Calorimeter response correction only
  - Close to HWG assumptions
- Expected number of signal events comparable to HWG estimations of 4 events per fb^{-1}

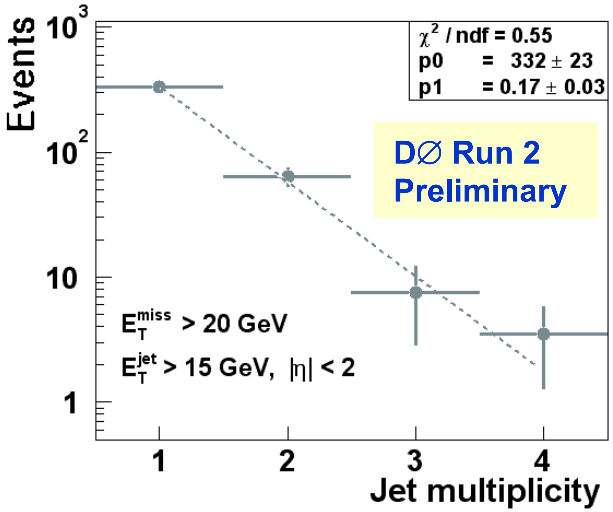
W's in data

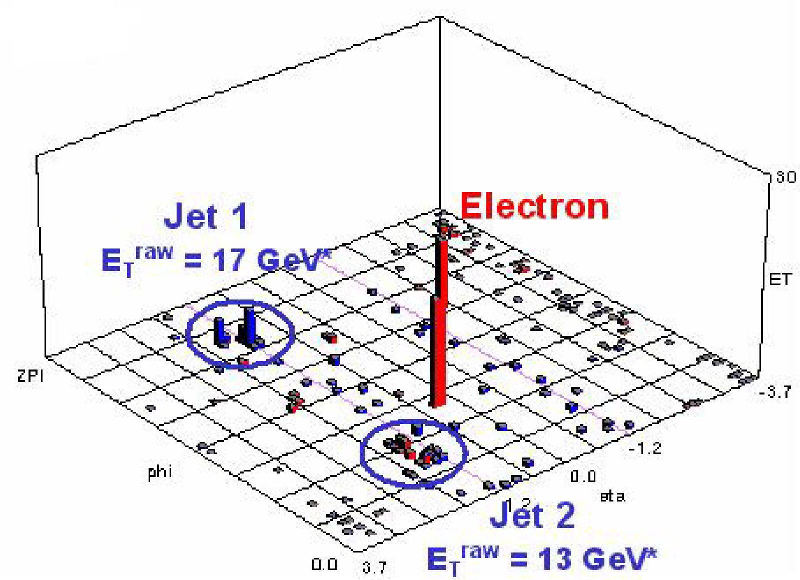


W transverse mass spectrum in e + missing E_T inclusive sample

… and a W + 2jet Higgs candidate (just for fun!)

W + jets inclusive sample





* Jet E_T corrections will be large

$Z(\to ee/\mu\mu/\nu\nu)H(\to b\bar{b})$ associated production

$Z(\to ee/\mu\mu)H(\to b\bar{b})$

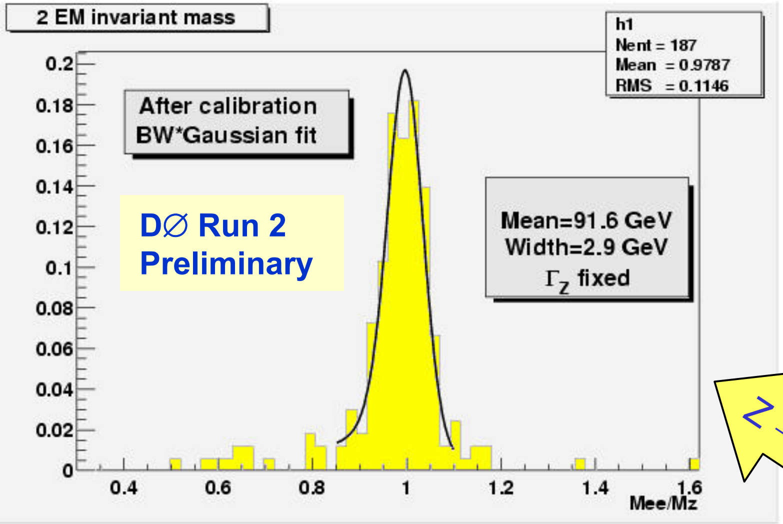
- Final states are characterized by
  - Two isolated leptons, e or μ
  - M_{l+l-} consistent with M_Z
  - Two b-jets

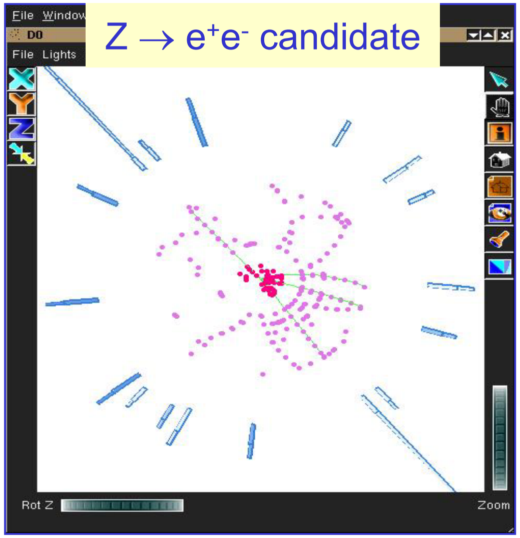
$Z(\to \nu\nu)H(\to b\bar{b})$

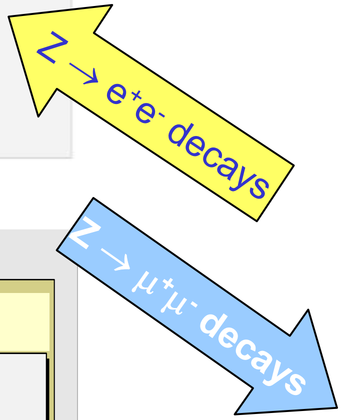
- Final states with
  - large missing E_T
  - Two b-jets

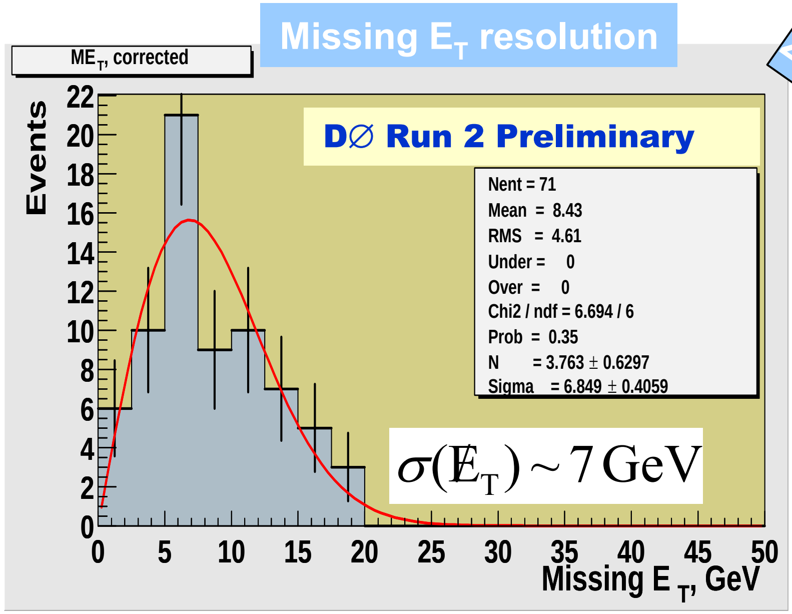
- In both cases the signal acceptance and rate calculations are based on detailed simulations
- Detailed background studies $Zjj/c\bar{c}/b\bar{b}$, ZZ, $t\bar{t}$, QCD are underway
- Selection criteria similar to HWG
- Higgs mass resolution and expected number of events are similar to $WH(\to b\bar{b})$ case and HWG estimations of 4.7 events per fb^{-1}

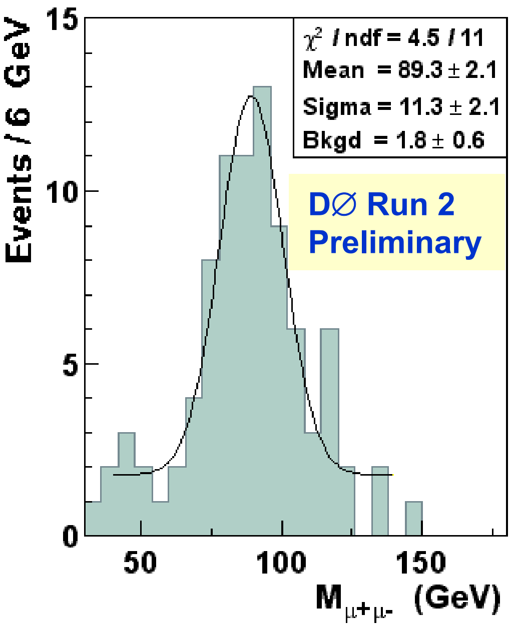
Z(→ee/μμ), missing E_T resolution in data











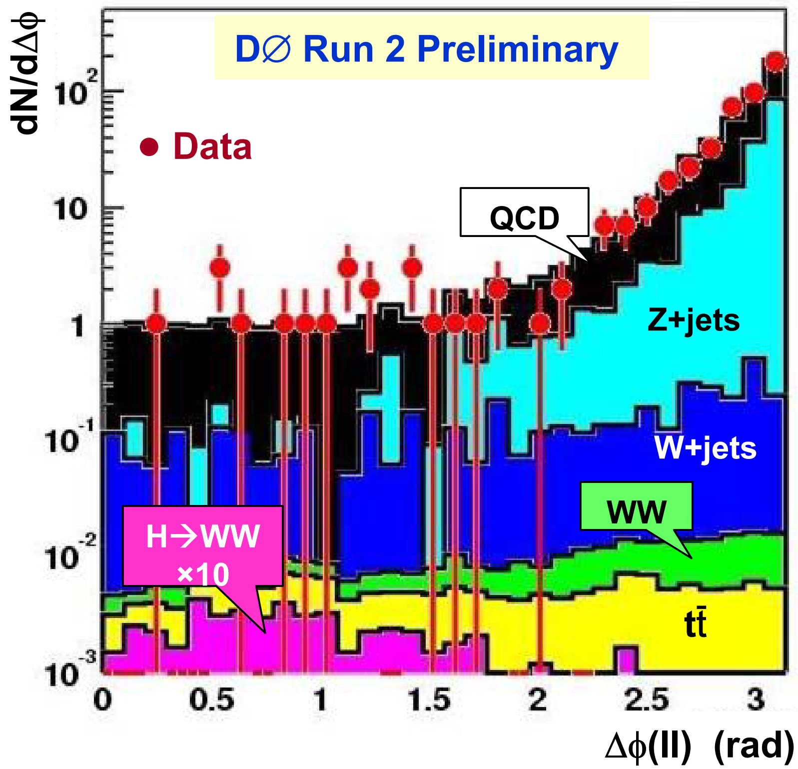
$H \to WW^{(*)} \to l^+l^-\nu\nu$ final states

- Mass reconstruction not possible due to missing neutrinos
  - Cluster transverse mass is correlated to Higgs mass

$$M_C = \sqrt{p_T^2(\ell\ell) + m^2(\ell\ell)} + \not{E}_T$$

- Background processes
  - WW, $t\bar{t}$, W/Z+jets, QCD/instrumental
- Can probably suppress most of them except for "irreducible" WW
- Employ spin correlations
  - $\Delta\phi$(ll) variable is particularly useful
- Current di-electron data analysis in preliminary stages

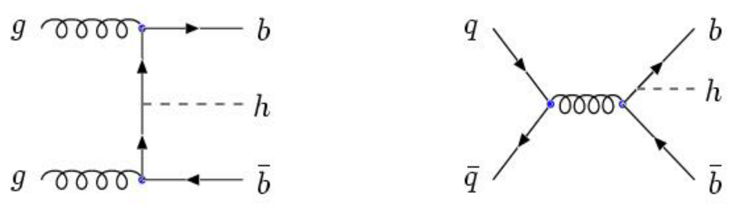
$\Delta\phi$ distribution after basic electron ID requirements and kinematical cuts
$p_T > 20$ GeV in $|\eta| < 2.5$



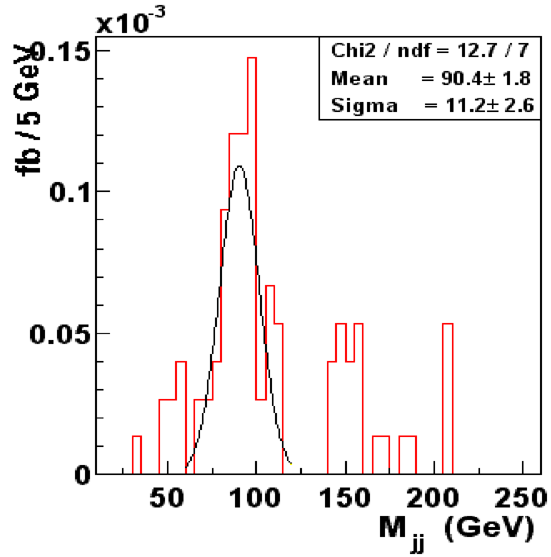
- Extracting the Higgs signal will not be an easy task

Higgs associated production with b

- In SUSY models b-h (=h, H, A) couplings are enhanced by tanβ so the cross sections could be large
- Search for Higgs in 4b final states



- Background processes
  - QCD multi-jet, $t\bar{t}$, $Zb\bar{b}$, $Wb\bar{b}$
- Example of M_h = 120 GeV
  - E_T(jet1) > 55 GeV, E_T(jet2) > 40 GeV
  - E_T(jet3/4) > 30 GeV, $|\eta|$ < 2
  - Require at least 3 b-tags per event
- Consider all permutations (events rate is normalized to 3.7 fb)



- Obtain relative resolution $\sigma/M \approx 12\%$
  - No jet calibration applied
- Started recently to look at $gb \rightarrow bh$ channel which has an order of magnitude larger cross section

Summary

- Further understanding of previous analyses based on fast MC simulations (HWG) is underway
- Performance of upgraded DØ detector is encouraging and we are on our way to doing excellent physics
- Even with Run 2A data we can make significant impact on non-standard Higgs searches
- Need full Run 2 luminosity of ~ 15 fb^{-1} for Higgs discovery

Higgs searches will form the central part of the DØ physics program