Higgs Results From Tevatron Run II

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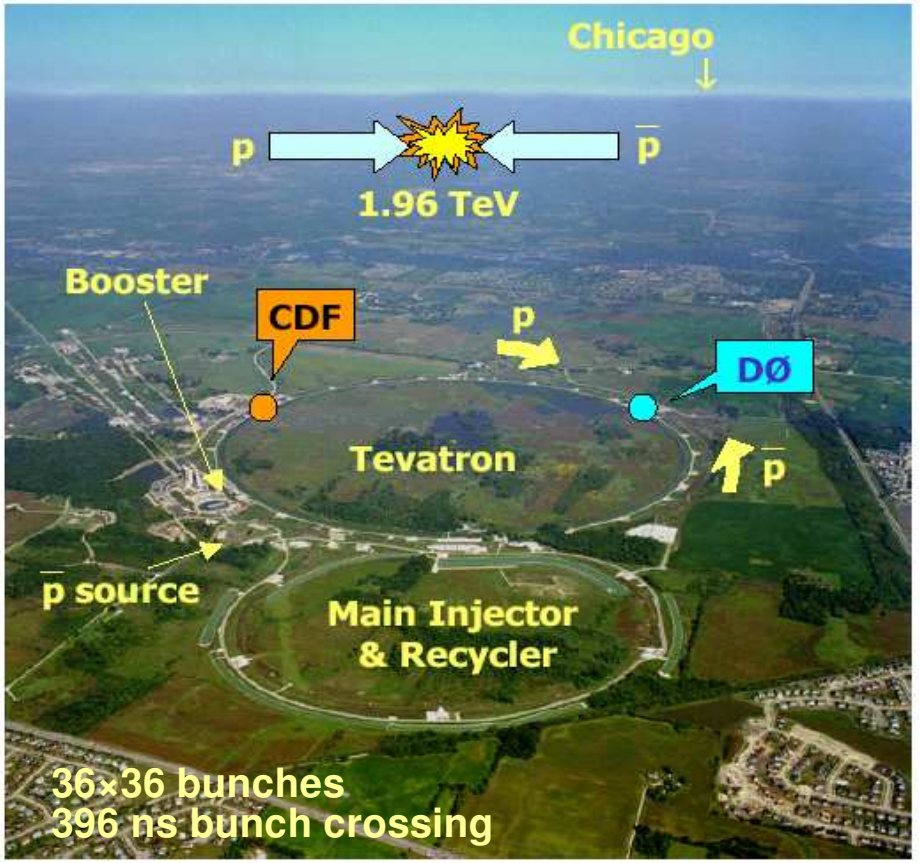
On behalf of CDF and DØ Collaborations

Many thanks to everyone who helped in the preparation of this talk

Outline

- Introduction
  - Accelerator performance
  - Experimental status
- Beyond Standard Model
  - MSSM : hbb
  - H->γγ
  - H^{++}/H^{--}
- Standard Model Higgs
  - Zb cross section
  - H->Wbb
  - H -> WW*
- Prospects for the Standard Model Higgs
- Conclusions



Tevatron Run II performance

- Instantaneous luminosity steadily rising. (more than 12 pb^{-1}/week last month)
- 2004 integrated luminosity is above the design projection

- Available for physics (summer 2004) L~400 pb^{-1} per experiment.
- Results in the following are based on a smaller sample L<200 pb^{-1}

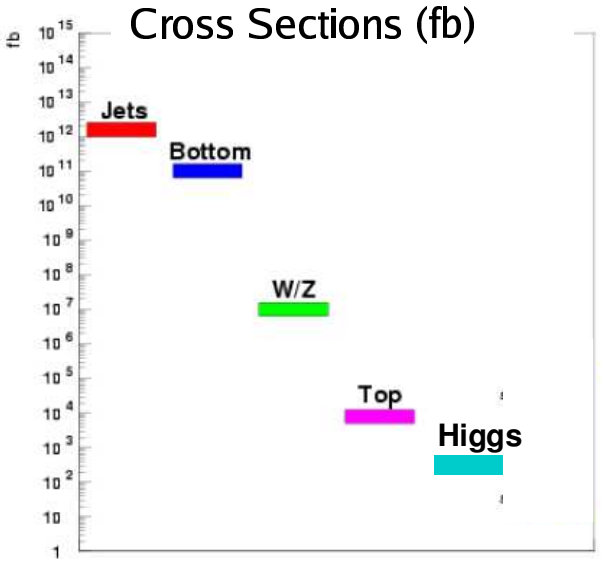
Experimental status

Still early stage of the data taking :

- Understand detector performance
- Test and improve reconstruction algorithms
- Study instrumental background:
  - jets faking leptons, photons
  - missing E_T induced by mismeasured jets
  - jets faking b-quarks
- Study physics background
  - Comparison with LO Matrix Element Monte Carlo
  - (W+jets, Z+jets, bbj, bbjj)
    - Comphep + Herwig showering
    - ALPGEN + Pythia showering

→

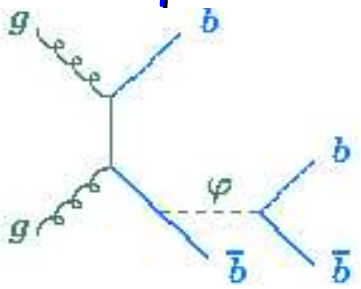
Jet energy scale
Jet energy resolution
b-tagging
Missing E_T



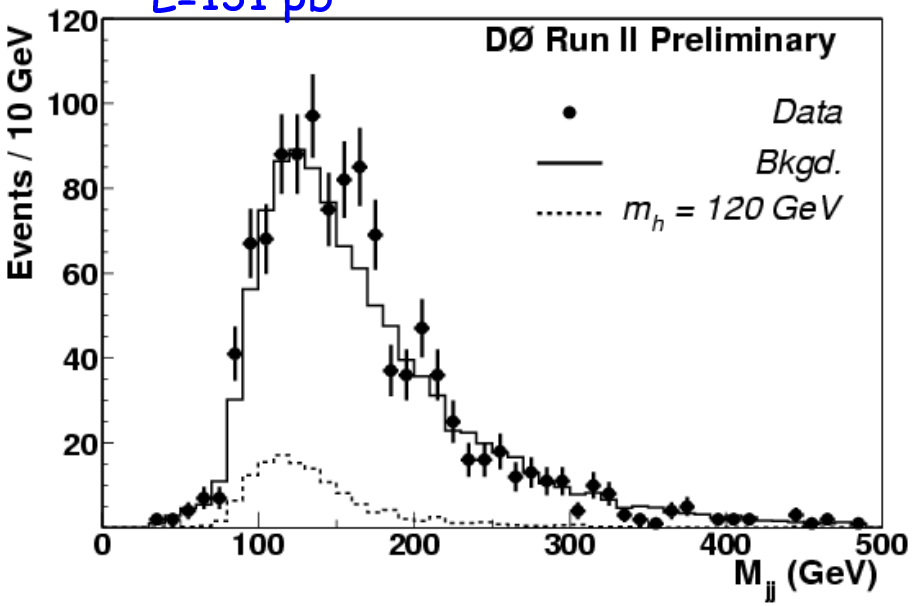
Beyond Standard Model

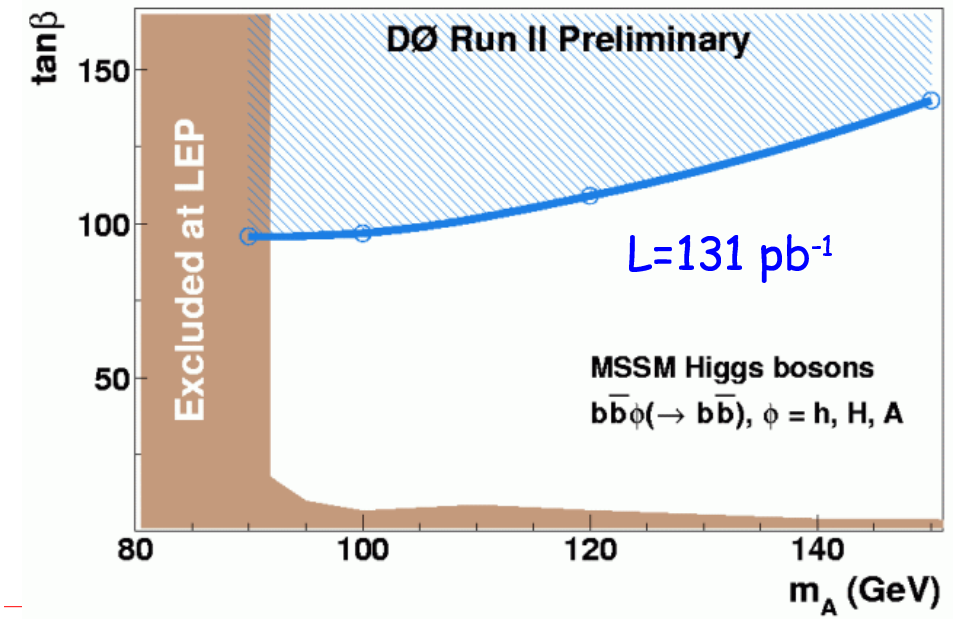
DØ: SUSY Higgs at large tan(β) (hb and hbb)

- In MSSM 5 Higgs : 3 neutral (h,H,A) and 2 charged (H^+,H^-)
  - At large tan(β) : 2 neutral almost degenerated in mass with coupling ~tan(β)
  - Enhanced production ($\sigma \sim \tan^2\beta$) of Higgs's associated with b-quarks
- Selection :
  - 3 or more jets. (E_T>45, 35, 15 GeV for m_A=100 GeV)
  - At least 3 b-tagged jets
- Efficiencies and background estimated from data



Leading jets invariant mass
L=131 pb^{-1}





DØ: Search for H->γγ

- Can be seen only if B(H->γγ) is larger than in SM
  - Fermiophobic Higgs
  - Topcolor Higgs : fermion coupling to top only
- Selection
  - 2 isolated γ
  - p_T>25 GeV, |η|<2 (CC) or 1.5<|η|<2.4 (EC)
  - $p_T^{\gamma\gamma}$>35 GeV
- Dominant uncertainty is photon miss-Id (~30%)

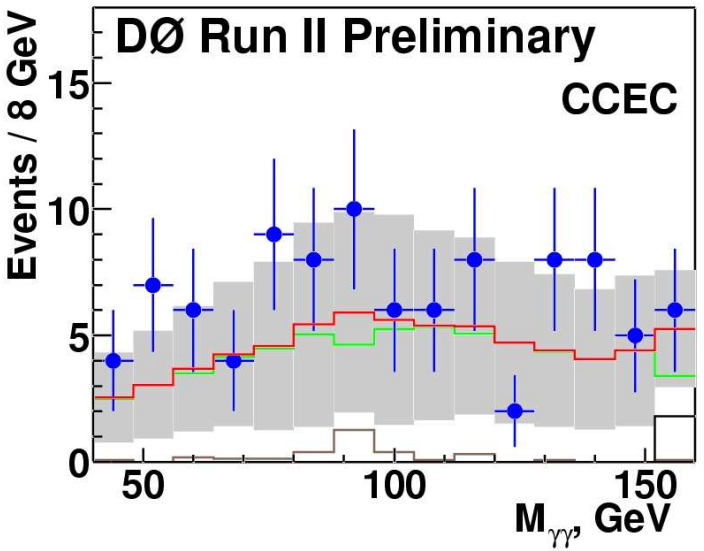
data = 97.0

bkgd = 68.8 +- 45.8

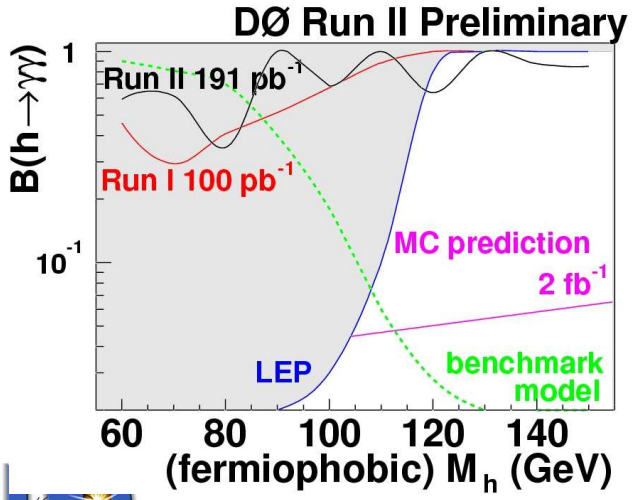
QCD = 64.0 +- 45.7

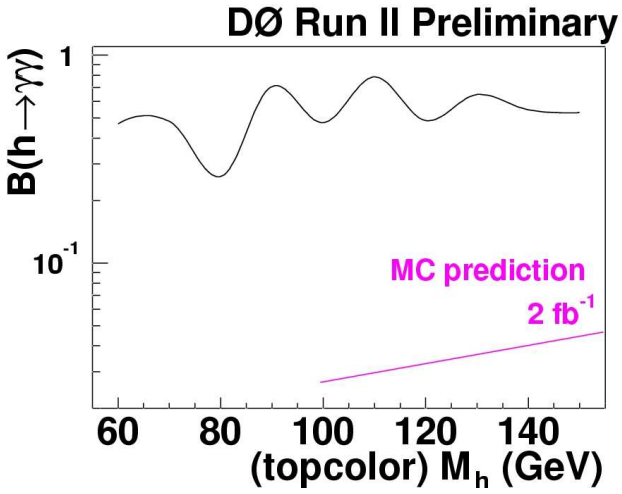
DY = 3.0 +- 3.0

γγ = 1.8 +- 0.1



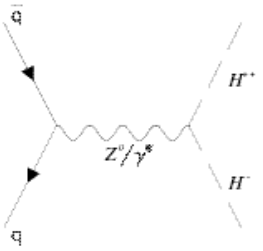
Limits on Branching ratio @95% CL.

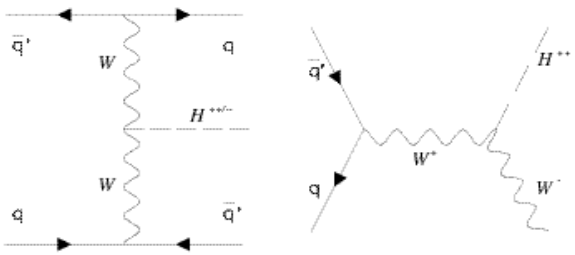




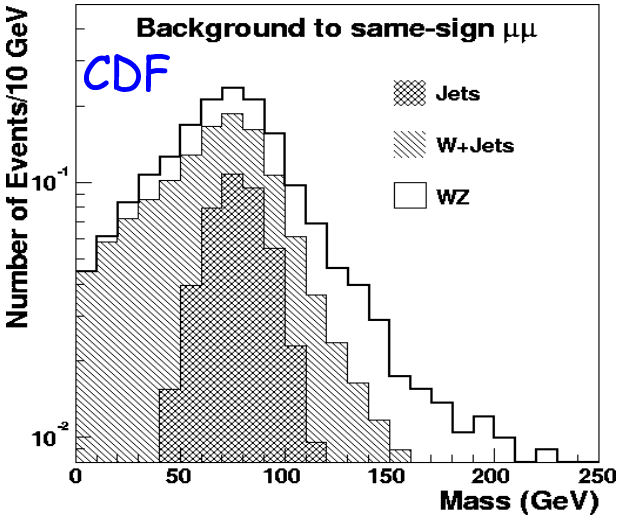
CDF, DØ: Doubly charged Higgs

- H^{++}/H^{--} decaying to two leptons are predicted
  - in model with L,R symmetry
  - models with Higgs triplet
- Selection
  - one pair of same charged leptons, isolated
  - High p_T
  - With invariant mass $M_{l^+l^+} \sim M_{H^{++}}$
- Dominant Backgrounds :
  - WZ
  - W+jets
  - QCD with leptons (Heavy Flavour)
  - Drell Yan with photon conversion for ee





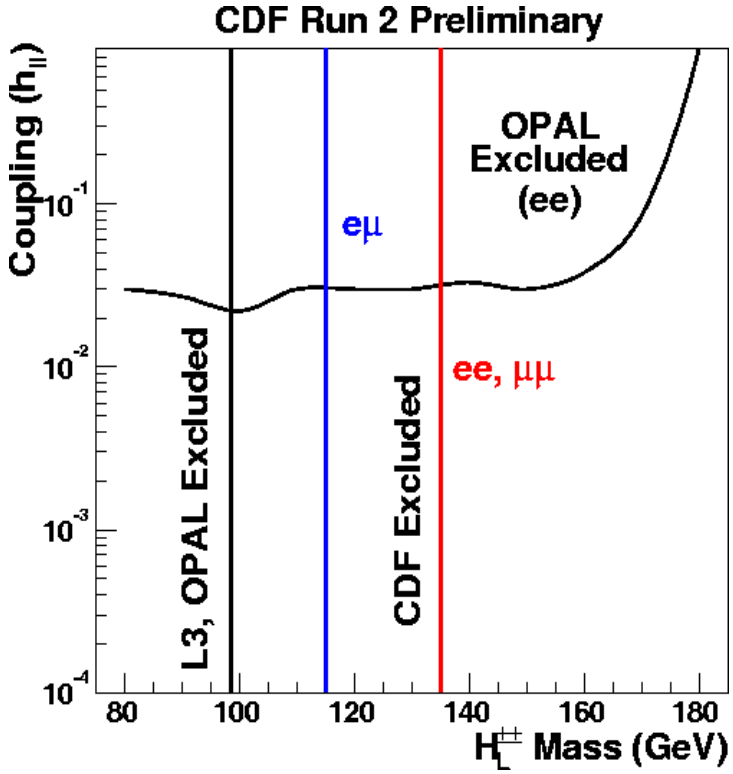
	CDF M_{ll}>80 GeV 240 pb^{-1}		DØ 106 pb^{-1}	
	Bkg	Data	Bkg	Data
ee	1.8±0.8	0		
μμ	0.8±0.6	0	1.5±0.4	3
eμ	0.9±0.4	0		



CDF, DØ: Doubly charged Higgs (2)

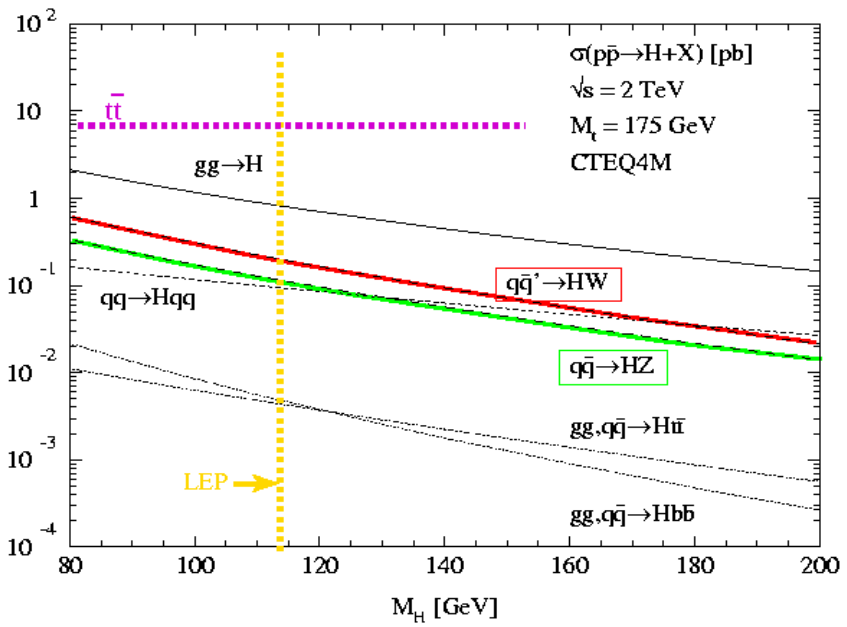
- 95% CL limit in (L,R) symmetric models

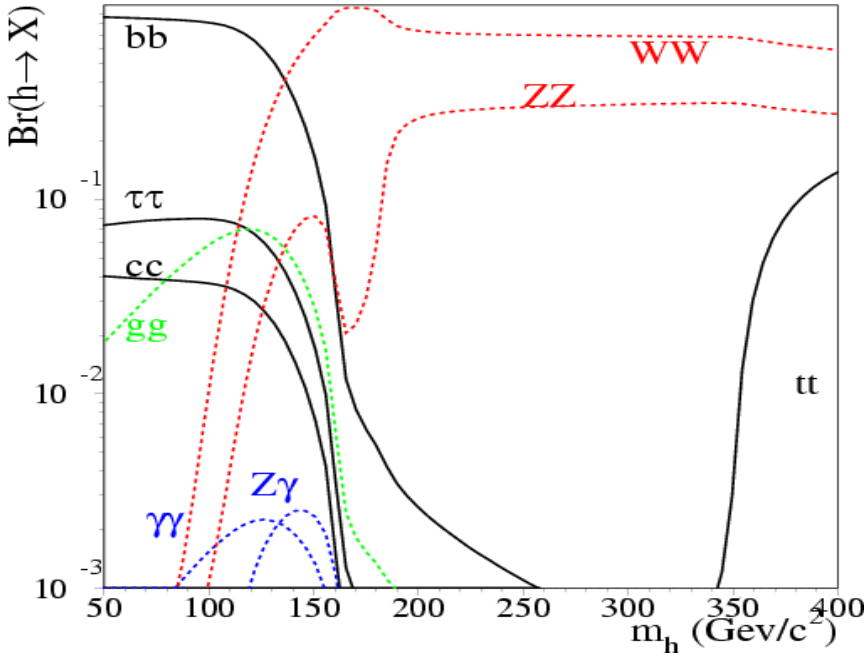
Mass Limit	CDF 240 pb^{-1}		DØ 106 pb^{-1}	
	$H_L^{\pm\pm}$	$H_R^{\pm\pm}$	$H_L^{\pm\pm}$	$H_R^{\pm\pm}$
ee	135	~102-113		
μμ	135	113	116	95
eμ	115			



Standard Model Higgs

Standard Model Higgs searches





Main signatures :

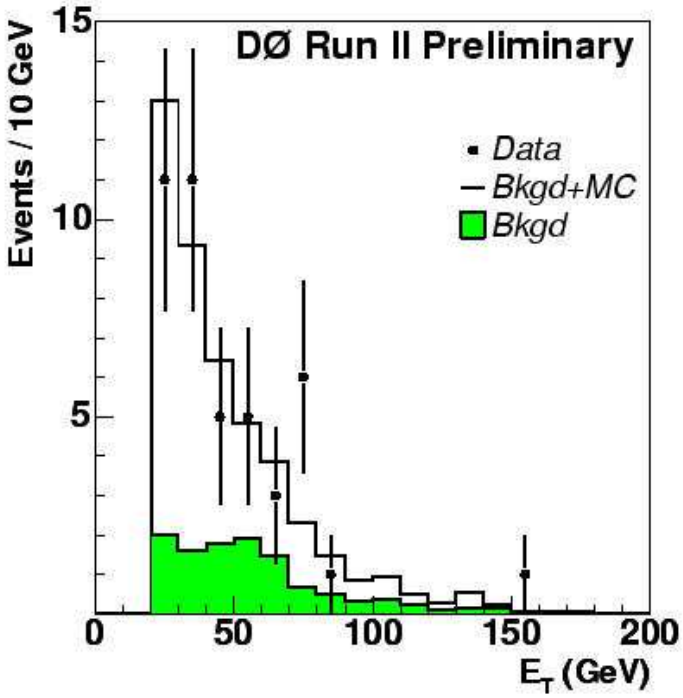
- For Mh < 130 GeV
  - Associated production with W or Z. Leptonic decay of W or Z.
    - Wbb : eν bb, μν bb
    - Zbb : ee bb, μμ bb, νν bb,
- For Mh > 130 GeV .
  - gg->H->WW* production followed by leptonic decays
  - eνeν, μνμν, eνμν

DØ: Z(ee/μμ)b production

- Measurement of the ratio (Z+b)/(Z+j)
  - Study background for ZH production
  - Probe the b-quarks PDF
- Signature
  - 2 isolated high Pt leptons.
  - Dilepton Mass~ 91 GeV
  - One jet tagged as b.
- Background estimated from Data
  - QCD faking isolated leptons
  - Light quark mis-tag
- Main systematics
  - b-tagging efficiency (16%)
  - Jet energy scale (10%)
  - Background estimation (6%)

ee channel 152 pb^{-1}

μμ channel 185 pb^{-1}



- Results for jet E_T>20 GeV, $|\eta|$<2.5

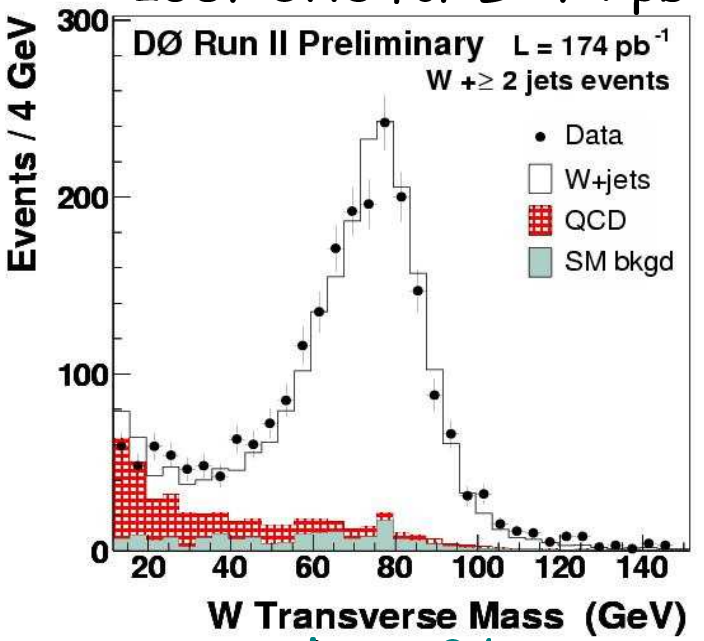
  $\sigma(Z+b)/\sigma(Z+j)=0.024\pm0.005(stat)^{+0.005}_{-0.004}(syst)$

- Good agreement with NLO expectation ~0.02. hep-ph/0312024

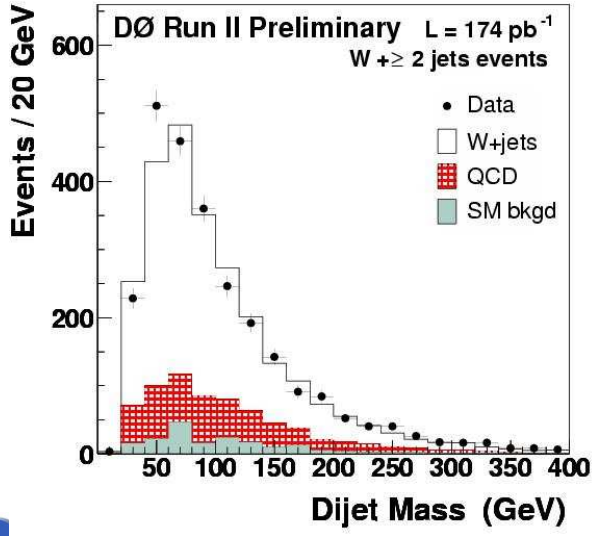
DØ: WH->Wbb electron channel only

- First preselection
  - Central isolated e. p_T>20 GeV
  - Missing E_T > 25 GeV
  - ≥2 jets: E_T>20, Gev $|\eta|$<2.5
- Background
  - W+jets production
  - QCD faking isolated electron
  - top pair production

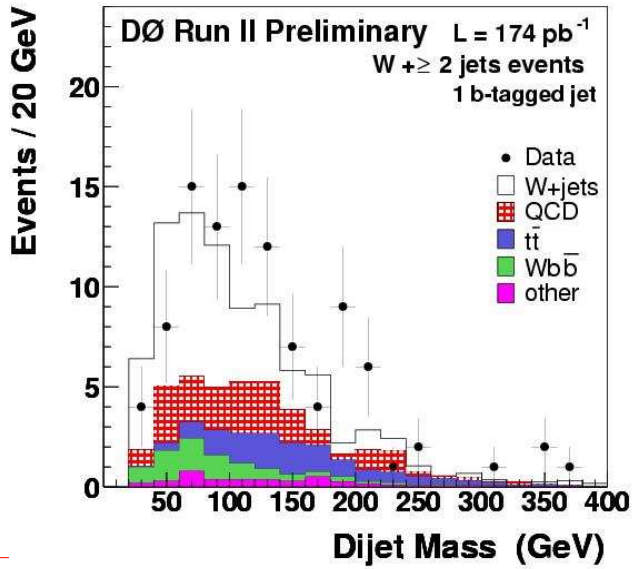
2587 evts for L=174 pb^{-1}



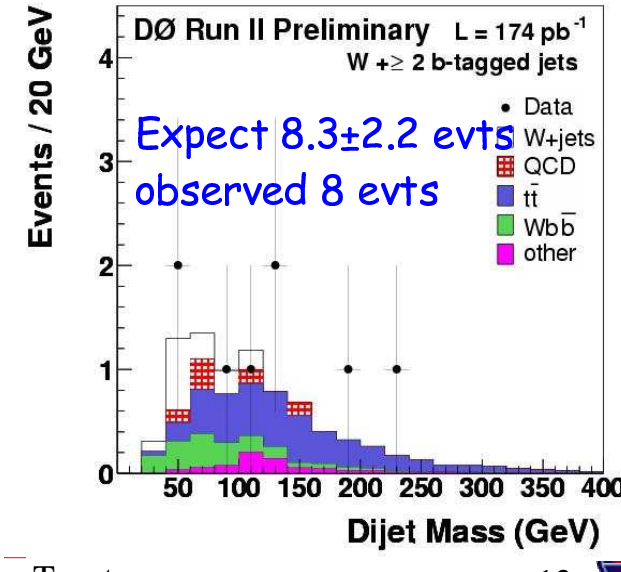
no b-tag requirement



at least 1 b-tag



at least 2 b-tag



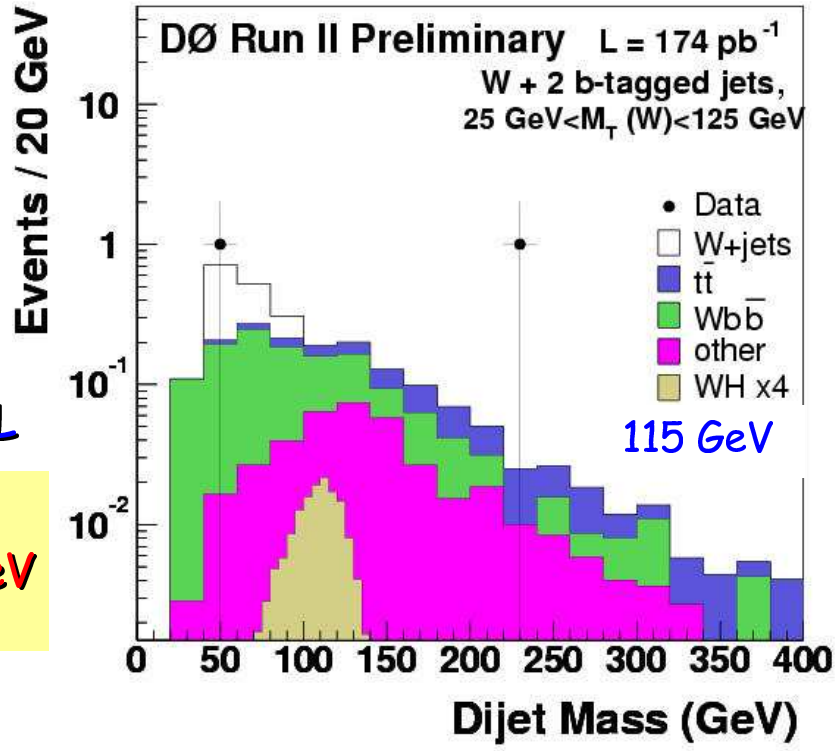
DØ: WH->Wbb electron channel only (2)

- Final Cuts
  - Cut on jet multiplicity to reduce top background
  - Cut on W transverse mass to reduce QCD background
- Final selection
  - Expected 2.5±0.5 events
  - Observed 2 events

Wbb	Wc(c)	Wjj	tt+t	Others
1.4±0.4	0.3±0.1	0.10±0.03	0.6±0.2	0.10±0.03

- Systematics on Higgs production
  - Jet energy scale 14%
  - Jet ID 7%
  - Trigger-electronID 5%
  - EM scale 5%
  - MC simulations 15%

  TOTAL 26%



- Results : limits on production @95% CL

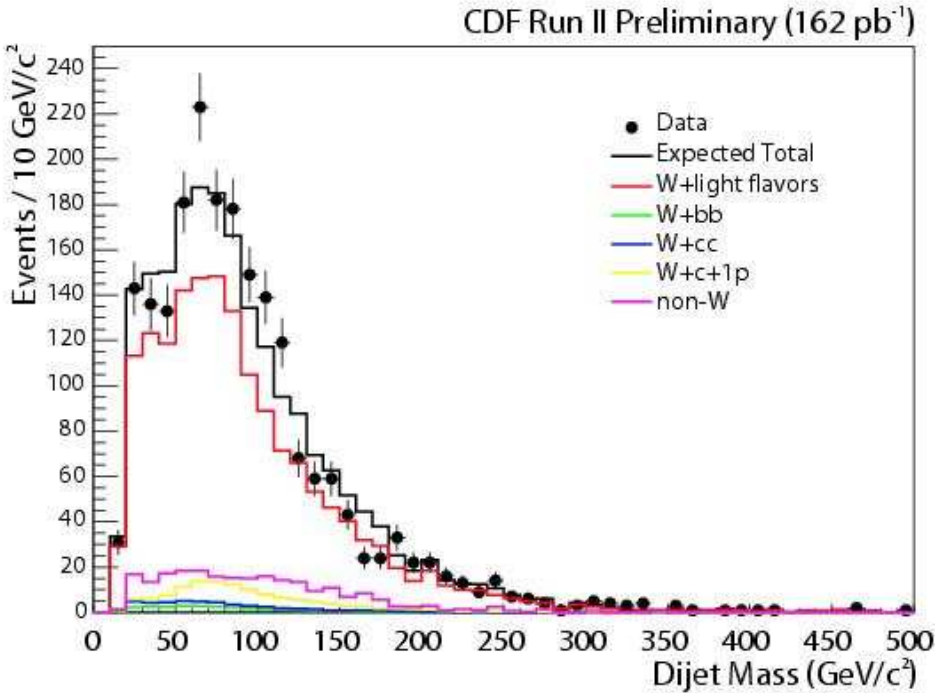
σ(Wbb)<20.3 pb

σ(WH)xB(H->bb) <12.4 pb for m_H=115 GeV

CDF: WH->Wbb

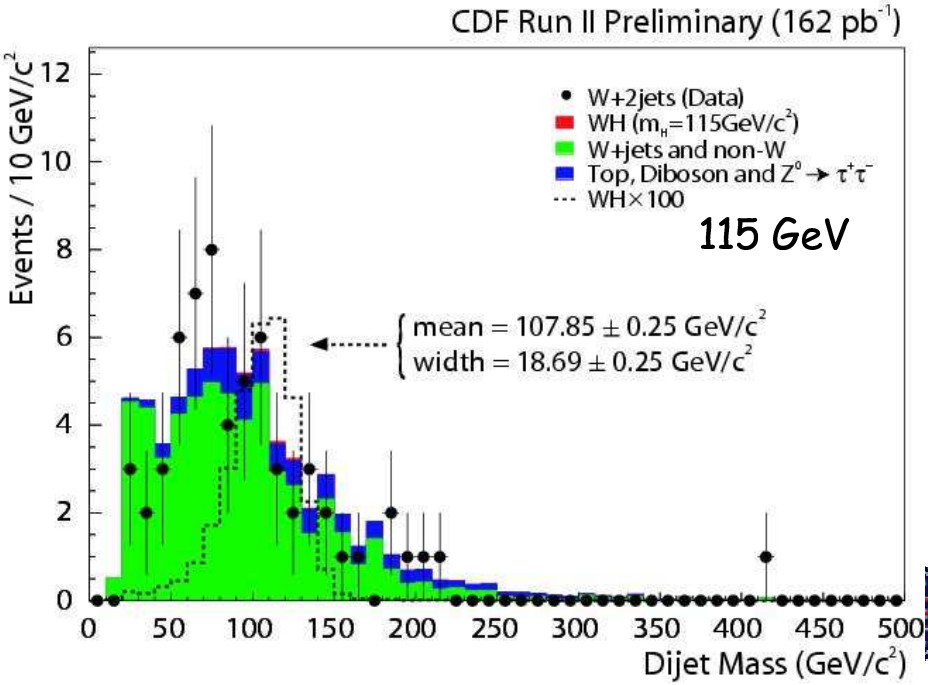
- Selection
  - Central isolated e/μ. p_T>20 GeV
  - Missing E_T > 20 GeV
  - =2 jets: E_T>15, |η|<2
  - Dileptons veto, extra jet veto

2072 evts for L=162 pb^{-1}



- With at least on b-tag
  - 61 ± 5 expected
  - 62 observed

Mistags	Wc(c)	Wbb	tt+t	Others
14±2	13±3	12±2	9±1	13±2



HW->Wbb in CDF

- Systematics on Higgs production
  - ISR/FSR 19%
  - B-tagging 8.6%
  - Lepton ID 5%
  - Jet energy scale 3%
  - PDF 1%
  - Trigger 0.7%

  TOTAL 22%

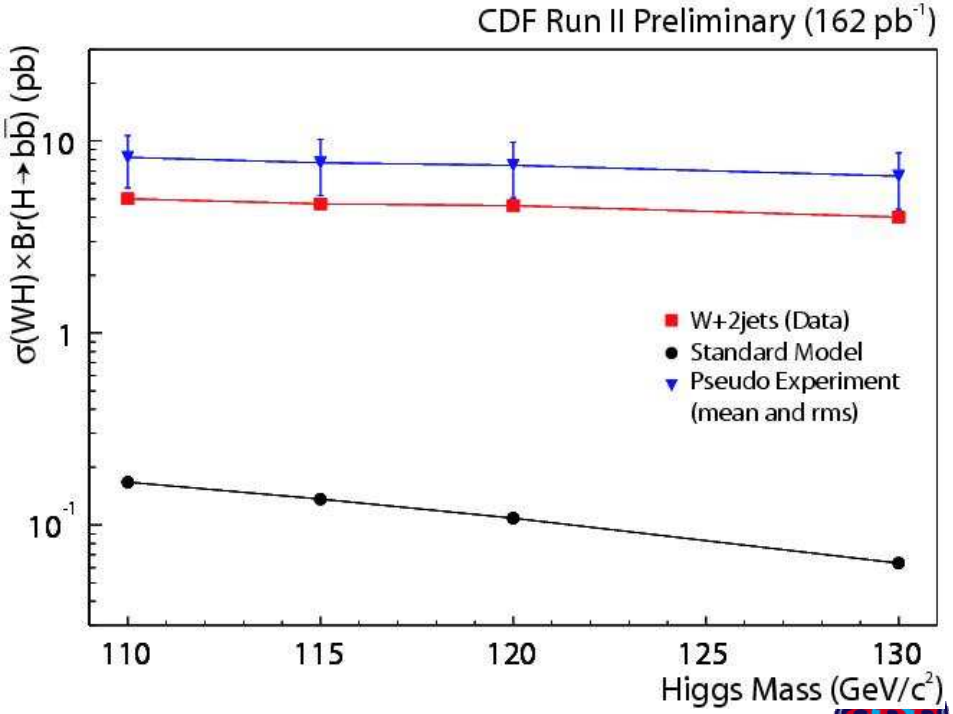
- Limits on production @95% CL

$\sigma(WH) \times B(H \to bb) < 5$ pb for $m_H = 115$ GeV

exceeds CDF's Run I limit :

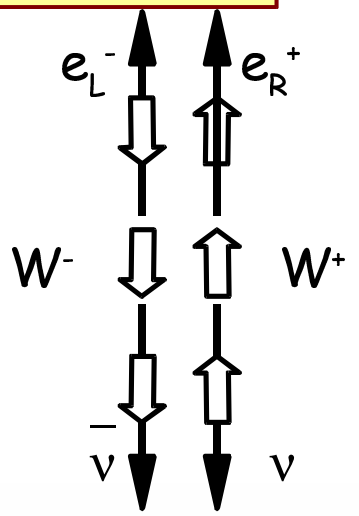
14-19 pb for m_H = 70 -120 GeV

[PRL 79, 3819(1997)]

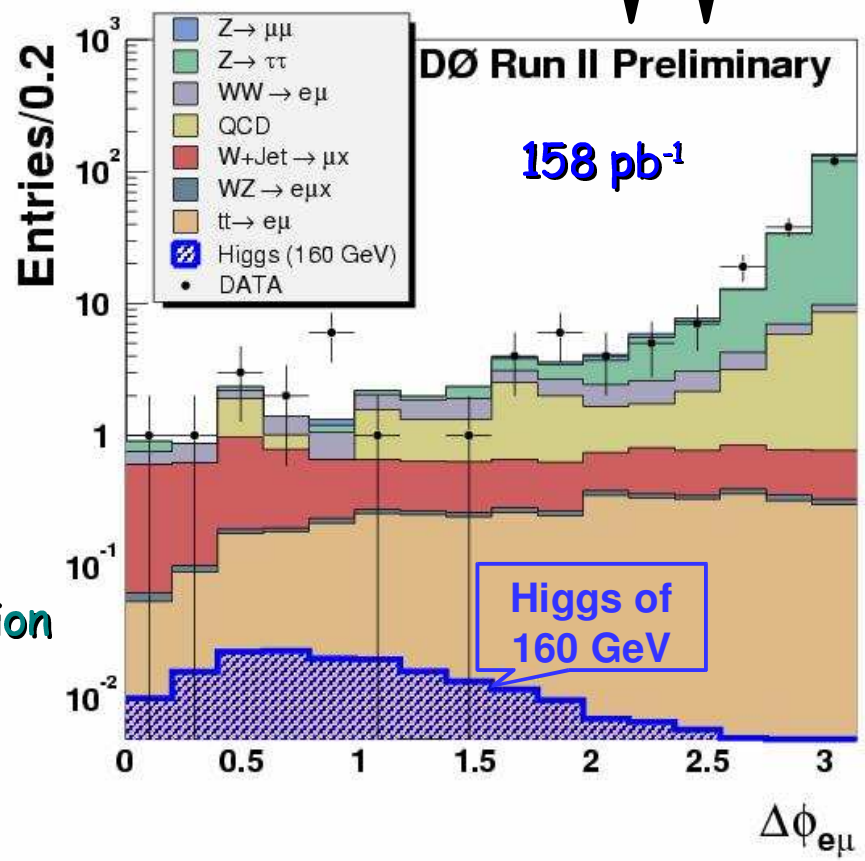


H->WW* Production

- Signature :
  - 2 isolated, high Pt leptons
  - large missing E_T
  - spin correlation : The charged leptons tend to be collinear
    - low di-leptons mass
    - small $\Delta\phi$ (l^+l^-)
- Backgrounds
  - electroweak WW production
  - Drell Yann Z/γ +jets faking missing E_T
  - W+ jets faking electrons
  - diboson production : ZZ, WZ



DØ eμ channel:
after preselection



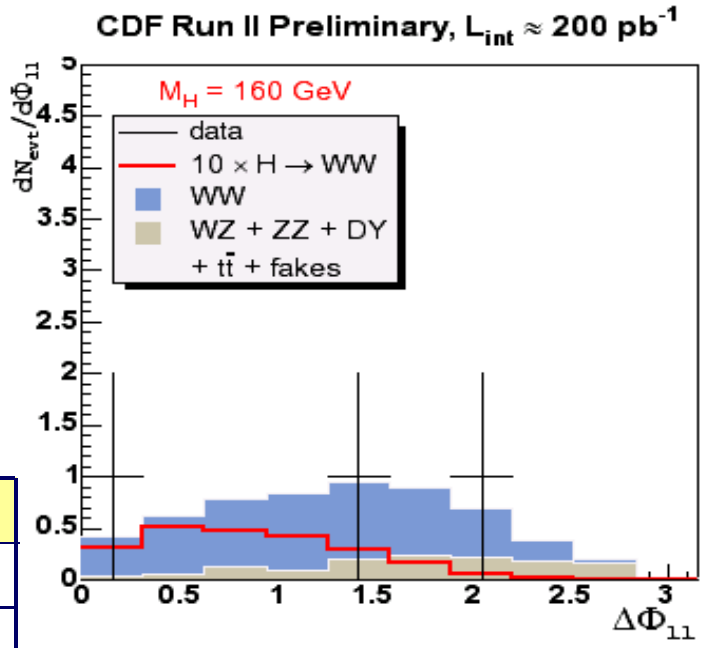
H->WW* Production (2)

CDF

- All channel together L~200 pb^{-1}
- Dilepton Mass < 0.5 x m_H,
- Fit $\Delta\phi$ (l^+l^-) distribution to derive limit

DØ

- 3 separate analysis. L~160 pb^{-1}
- $\Delta\phi(e,\mu)<2.0$, $\Delta\phi(\mu,\mu)<2.0$, $\Delta\phi(e,e)<1.5$



	DØ ee	DØ eμ	DØ μμ	CDF l^+l^-
Observed	2	2	5	3
Expected	2.7 ± 0.4	3.1 ± 0.>3	5.3 ± 0.6	4.7 ± 0.5

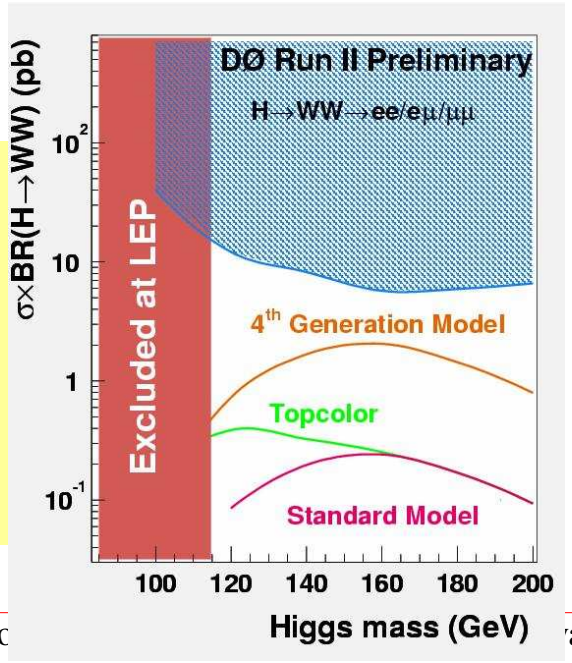
Limits on production @95% CL

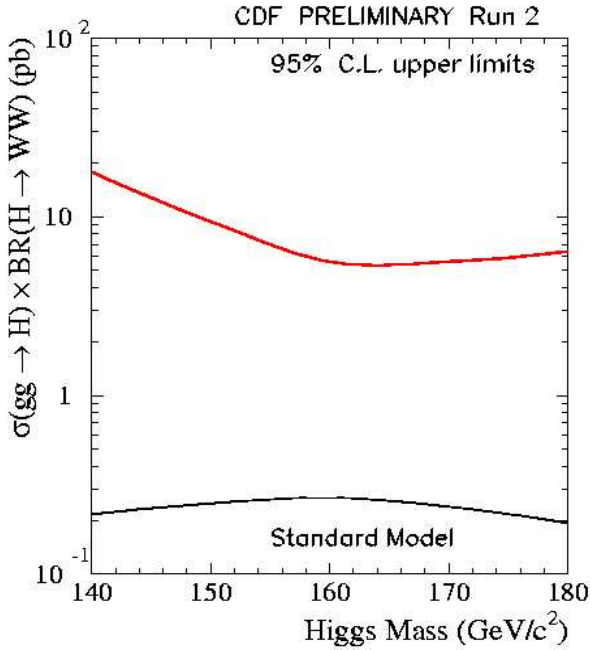
CDF :

σxB(H->WW) <5.6 pb for m_H=160 GeV

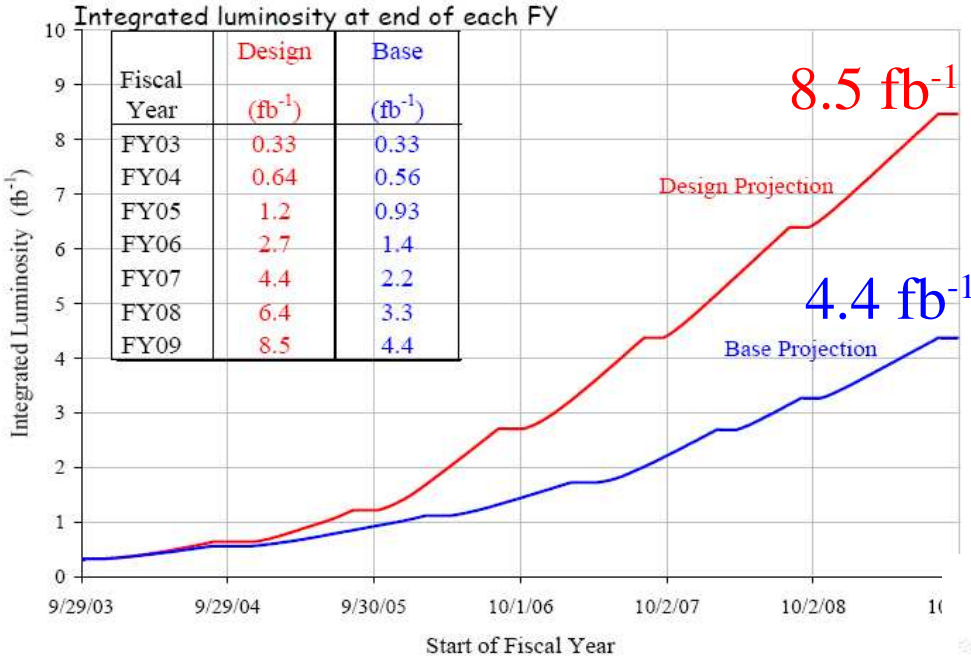
DØ:

σxB(H->WW) <5.7 pb for m_H=160 GeV





Higgs prospects vs luminosity prospects



Fiscal Year	Design (fb^{-1})	Base (fb^{-1})
FY03	0.33	0.33
FY04	0.64	0.56
FY05	1.2	0.93
FY06	2.7	1.4
FY07	4.4	2.2
FY08	6.4	3.3
FY09	8.5	4.4

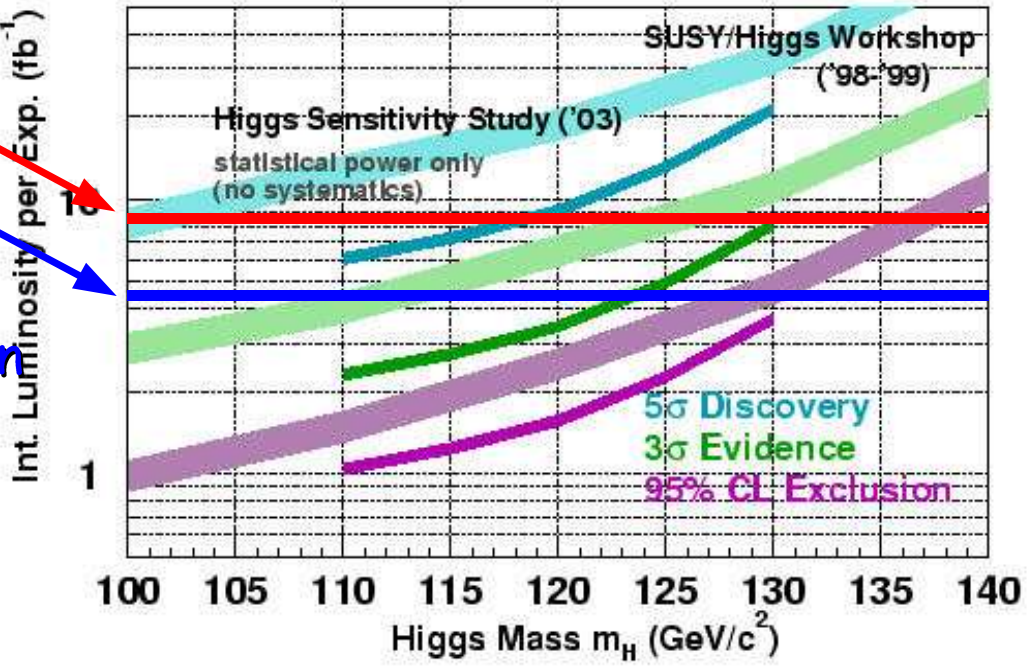
- Design projection = challenging
  - 8.5 fb^{-1} by end of 2009
- Base projection= conservative
  - schedule slippage
  - under-performance

  4.4 fb^{-1} by end of 2009

Tevatron Higgs Sensitivity Study 2003

2009 8.5 fb^{-1}

2009 4.4 fb^{-1}



- Base projection

Range 115-130 covered for exclusion

3σ evidence up to ~125 GeV.

- Design projection

3σ evidence up to 130 GeV

5σ discovery up to 120 GeV

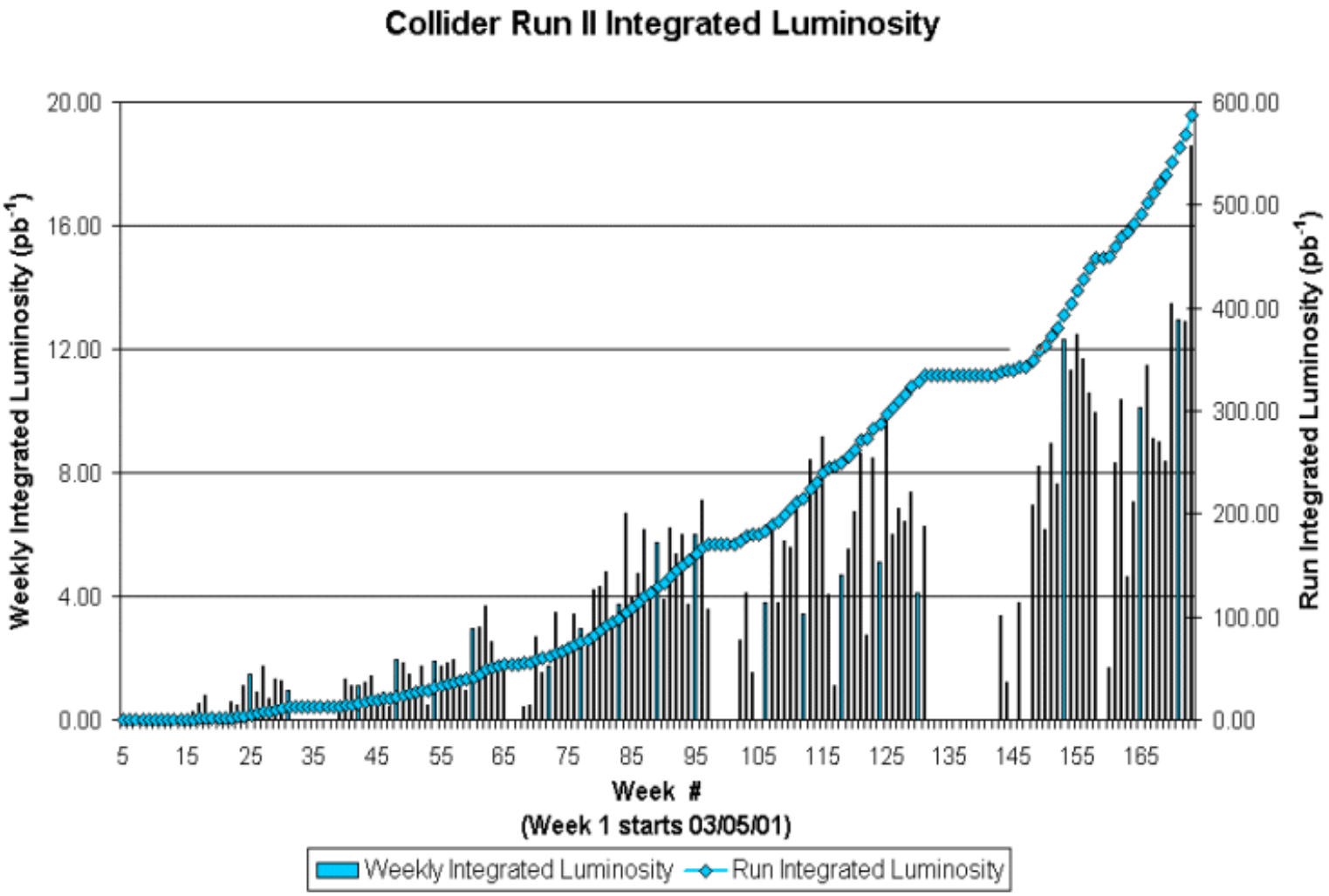
Conclusions

- Only a few hundred pb^{-1} analyzed (~half the data on tape)
- But already impressive results which demonstrate the :
  - understanding of background processes
  - understanding of detector response.
- The hunt for Higgs has started.
- More will come very soon.

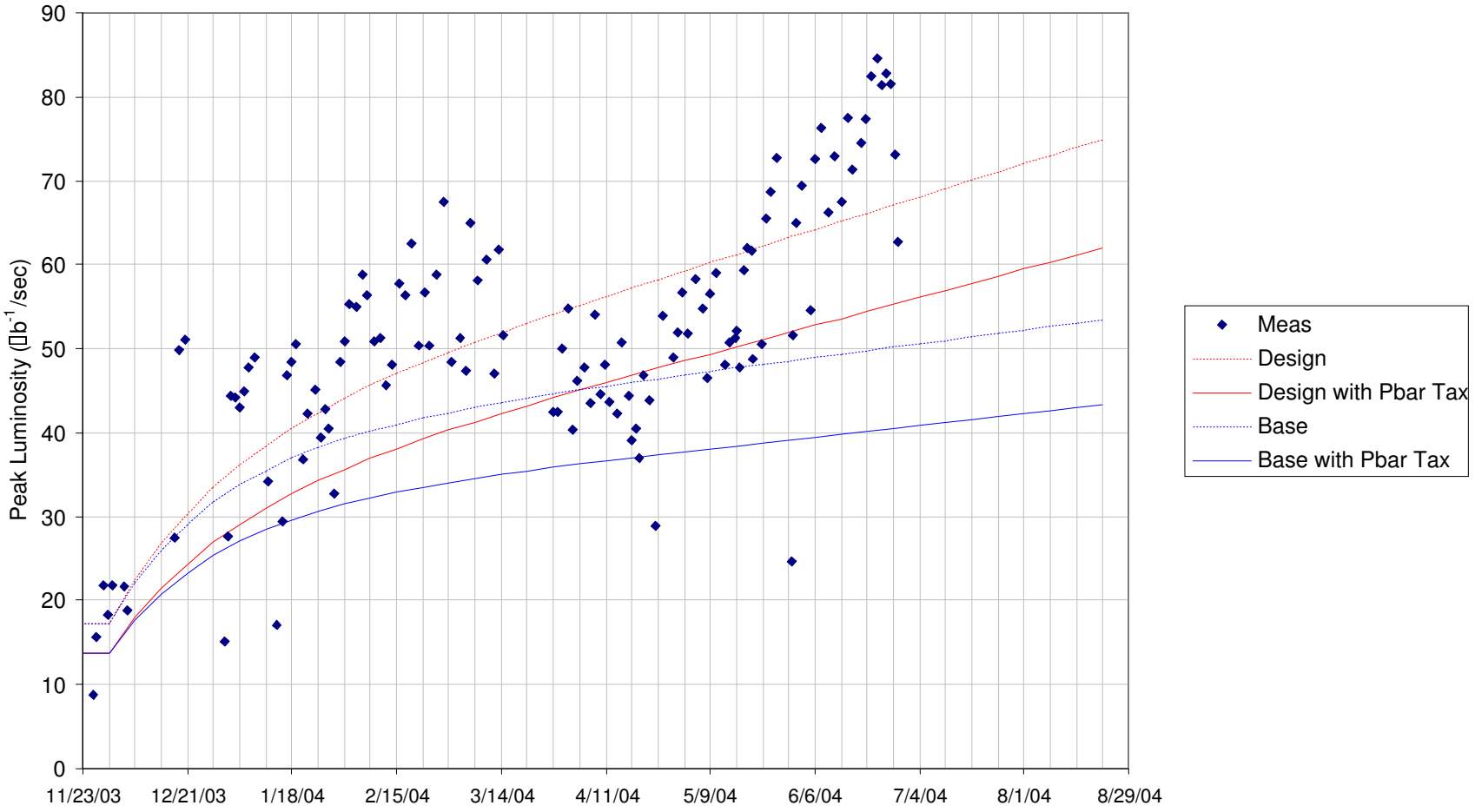
- Search for the Standard Model Higgs is very challenging but if Tevatron and experiments keep improving their performance we can explore an interesting range of Higgs Masses.

Support slides

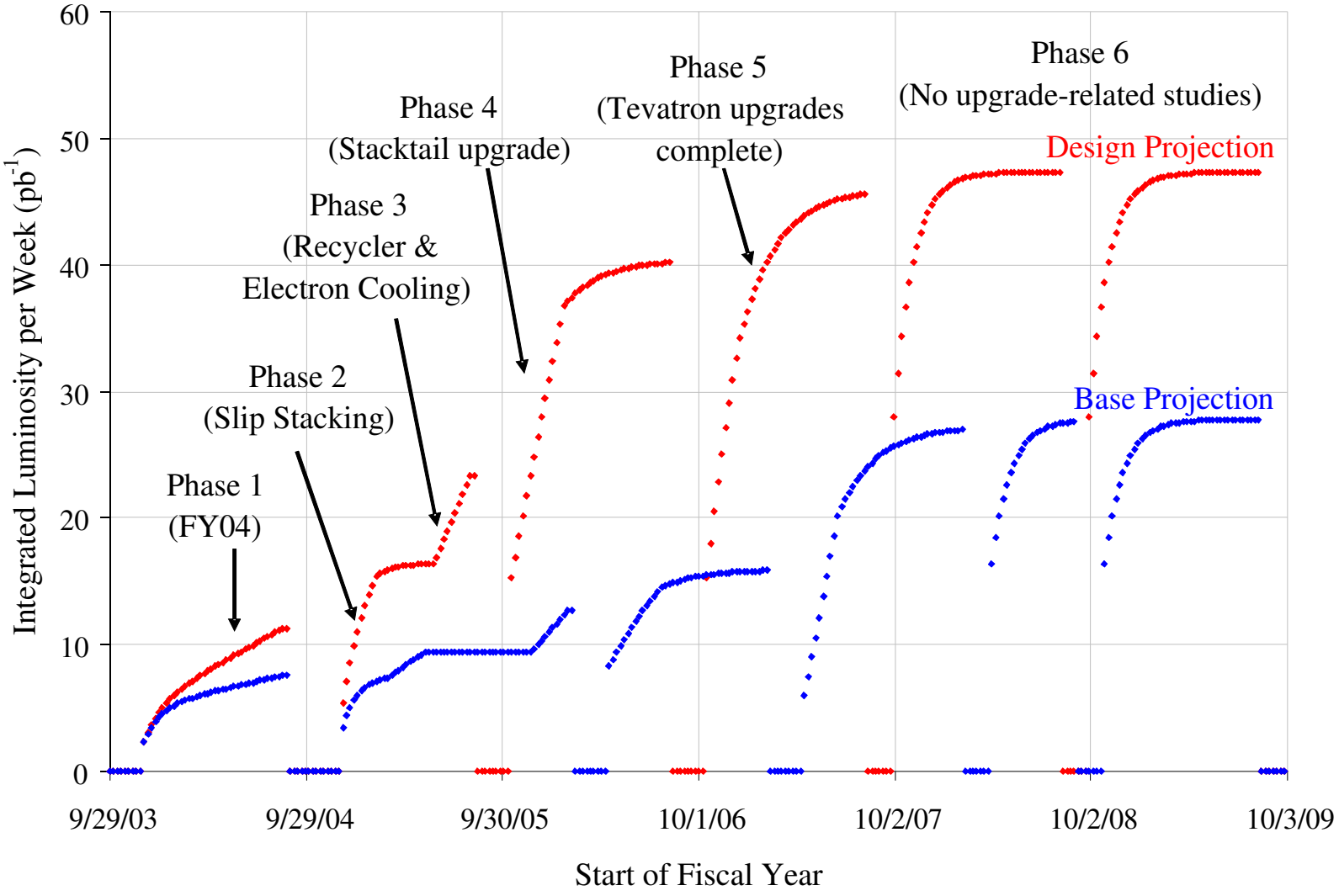
Run II integrated luminosity



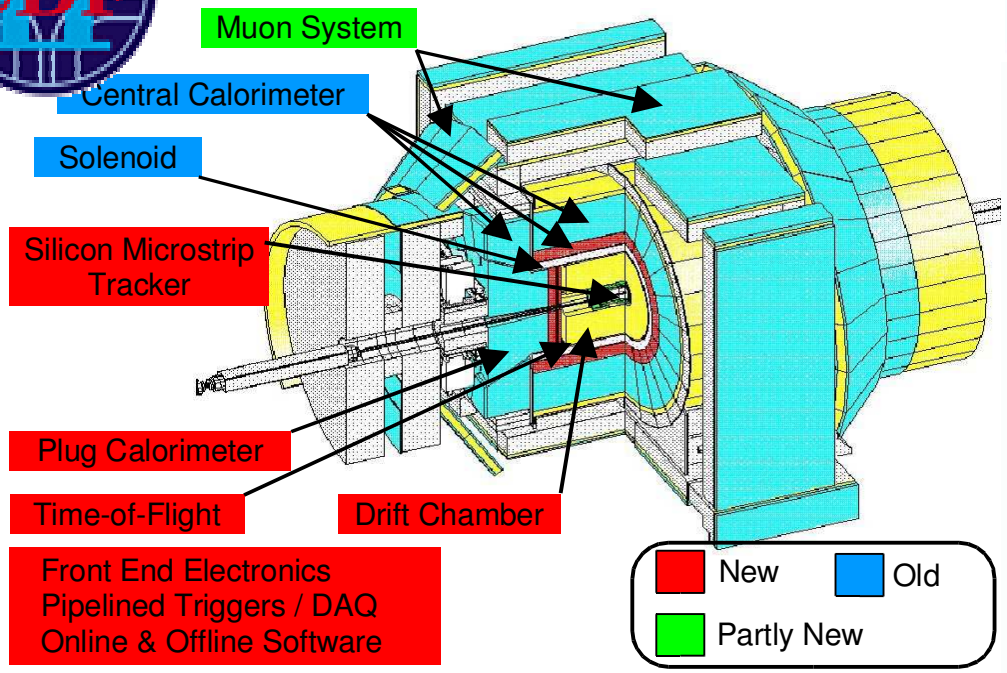
Peak luminosity

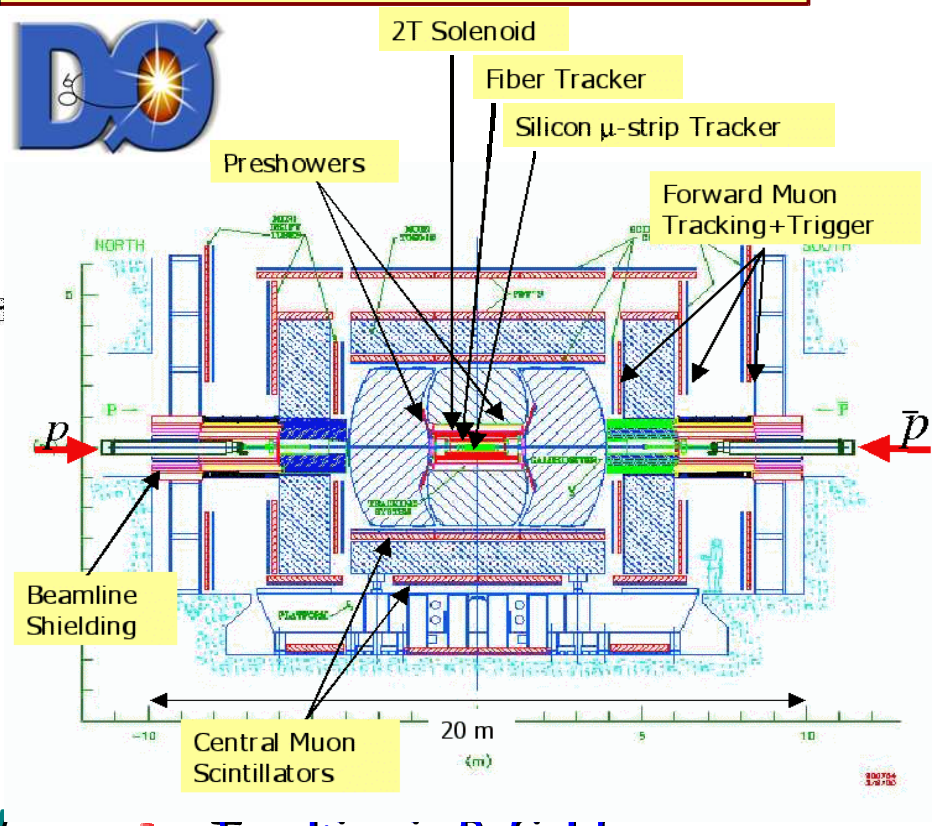


Tevatron luminosity upgrades



Tevatron Experiments





New

- silicon detector
- Drift chamber
- TOF PID system

Upgraded

- Calorimeter
- DAQ/trigger
- displaced-vertex trigger

New

- Tracking in B-field
- Silicon detector
- fiber tracker

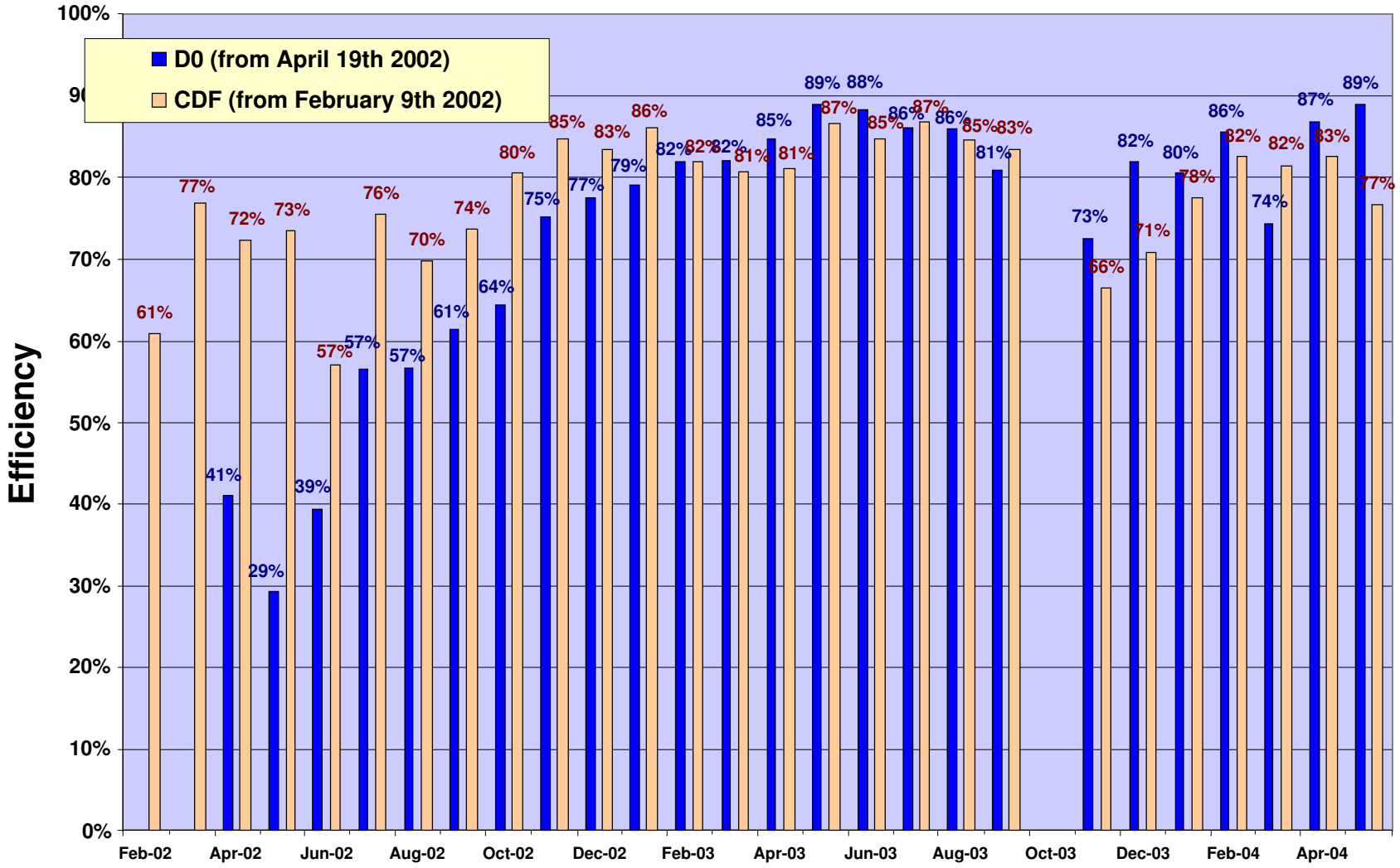
Upgraded

- Calorimeter, muon system
- DAQ/trigger
- (displaced-vertex trigger soon)

Monthly efficiency D0 - CDF

D0 & CDF Data Taking Efficiency

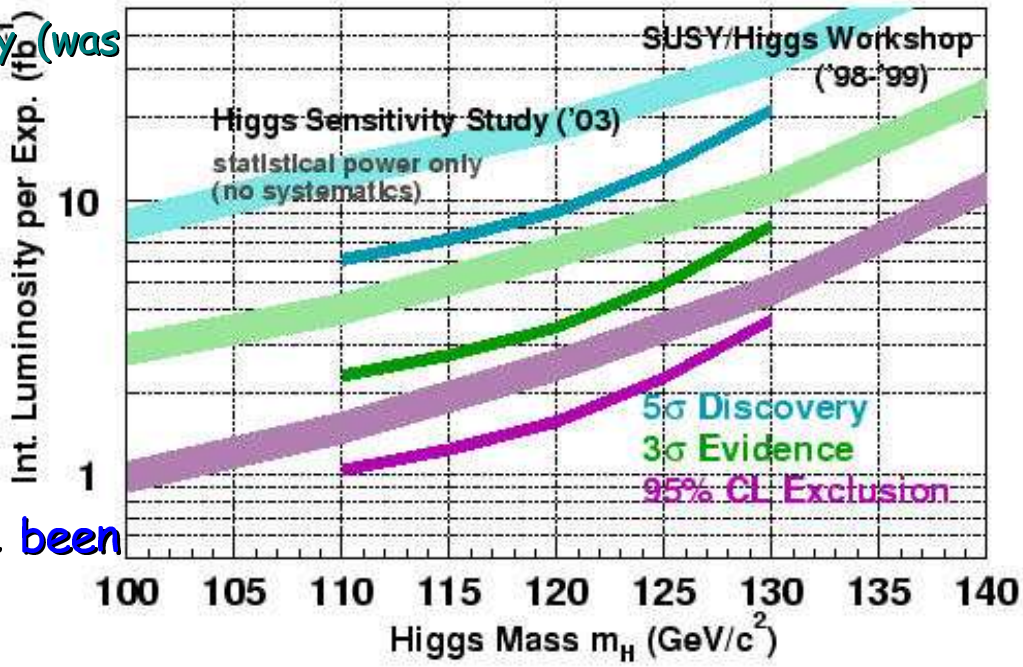
through May 31 2004



Standard Model Higgs Prospects

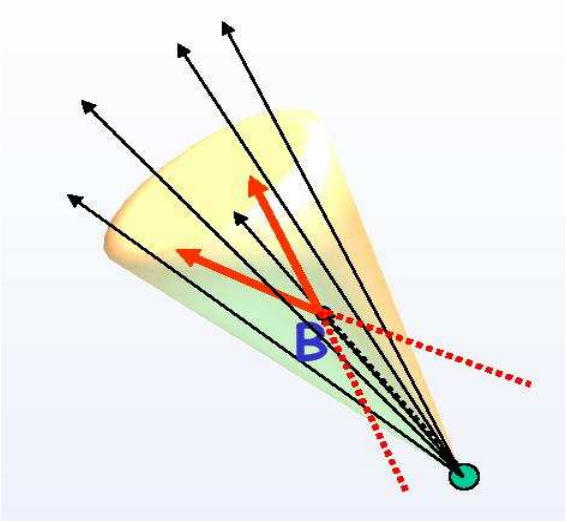
Tevatron Higgs Sensitivity Study 2003 (Fermilab pub 03-320-E)

- New with respect to SUSY/Higgs Workshop 98 (hep/ph 0010338)
  - Full Geant simulation of detector (was fast MC)
  - Run II b sillicon detectors performance
  - Use full mass shape to derive sensitivity (was window mass)
  - neural network
  - 396 ns bunch crossing (->5 minimum bias)
  - QCD bkg using RunII available data
  - Assume 10% m_{bb} mass resolution
  - Does not include WW* channel
- Caveat
  - Sillicon detectors full upgrades have been canceled.
  - Impact not assessed yet.



b-jet tagging

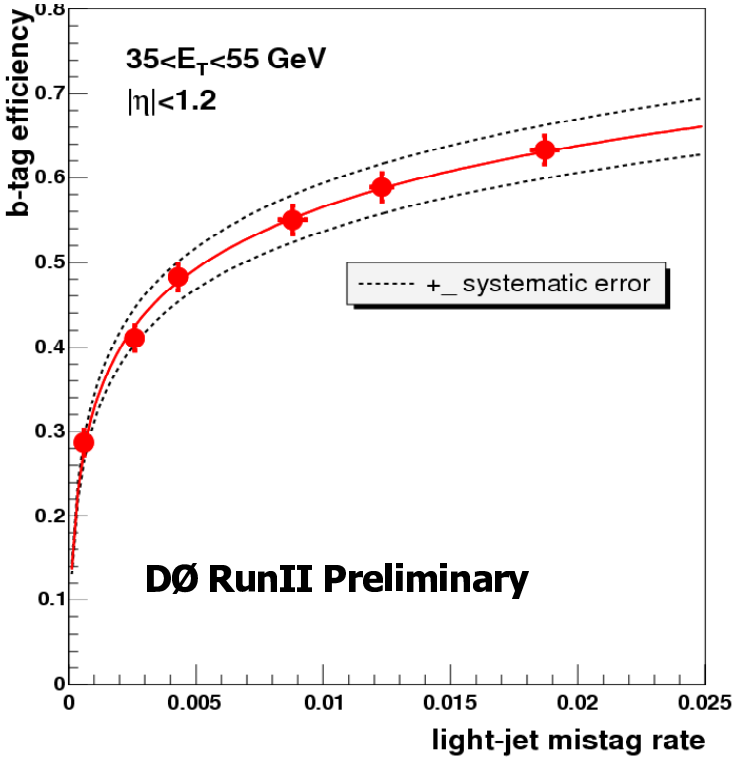
- Essential for H→bb searches



- Can make use of the track impact parameter (IP) measurements or secondary vertex reconstruction
- CDF: performance of sec. vtx. algorithm (after kinematics cuts)
  - ~50% b-tag efficiency for ~0.6% light quark mis-tag rate in $|\eta| < 1$

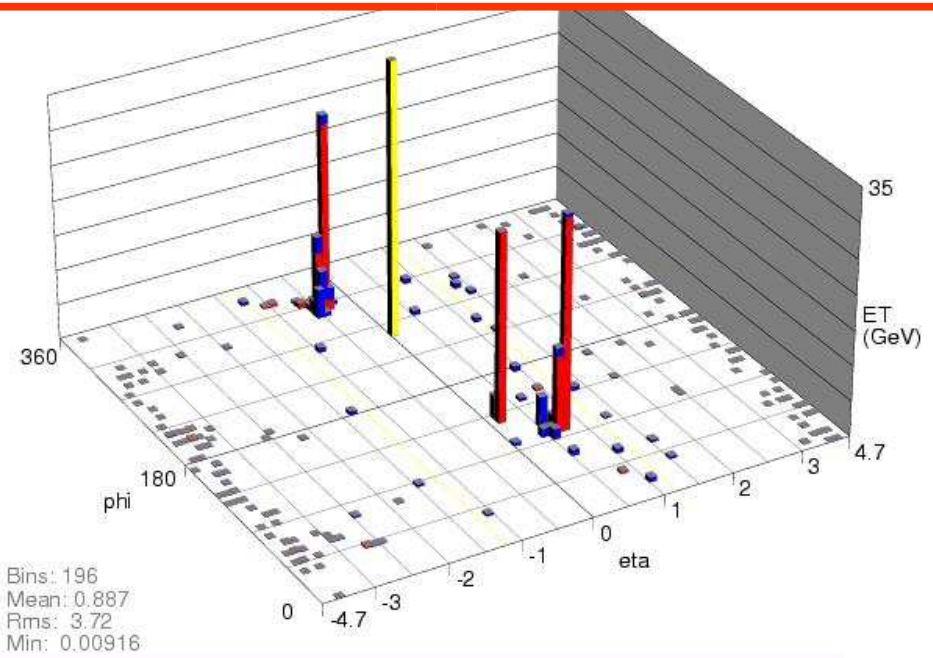
DØ in Run II is able to b-tag up to $|\eta| < 2.5$

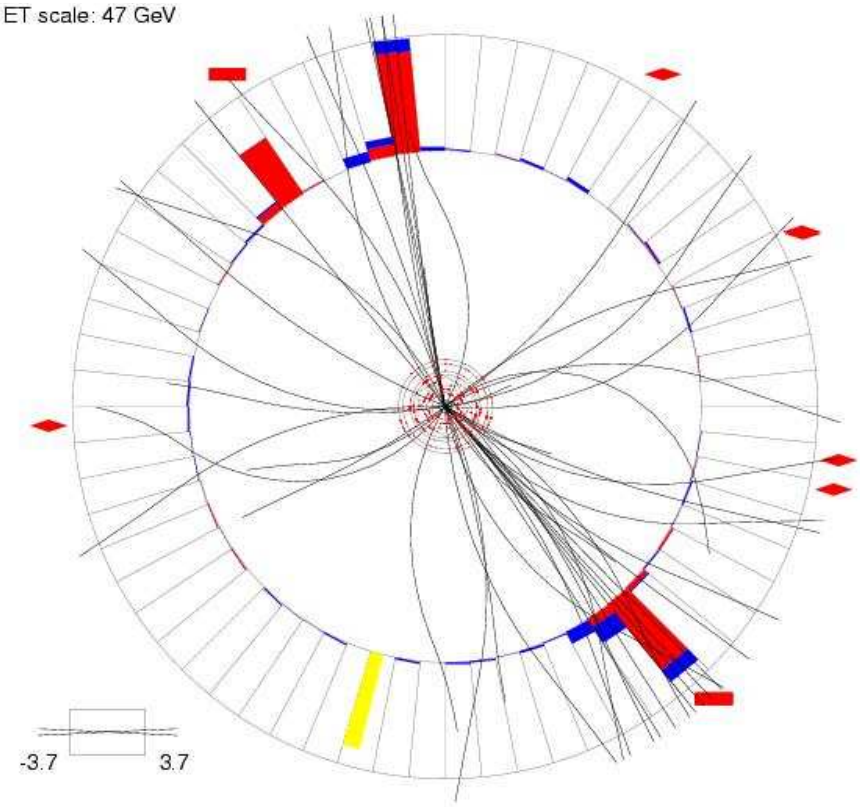
b-tagging efficiency vs light quark mis-tag rate

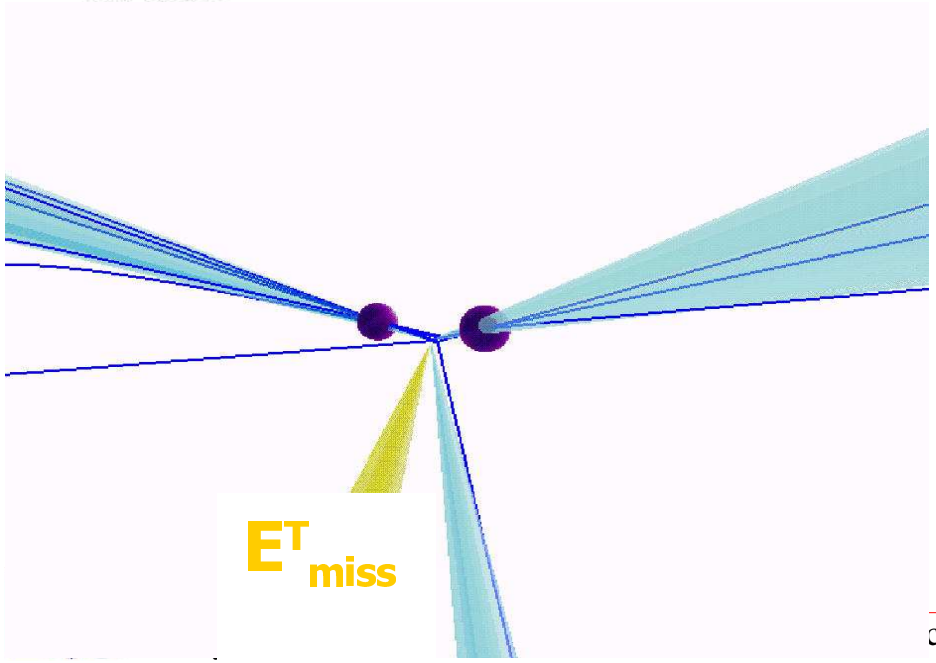


Both experiments are demonstrating good b-tagging capabilities

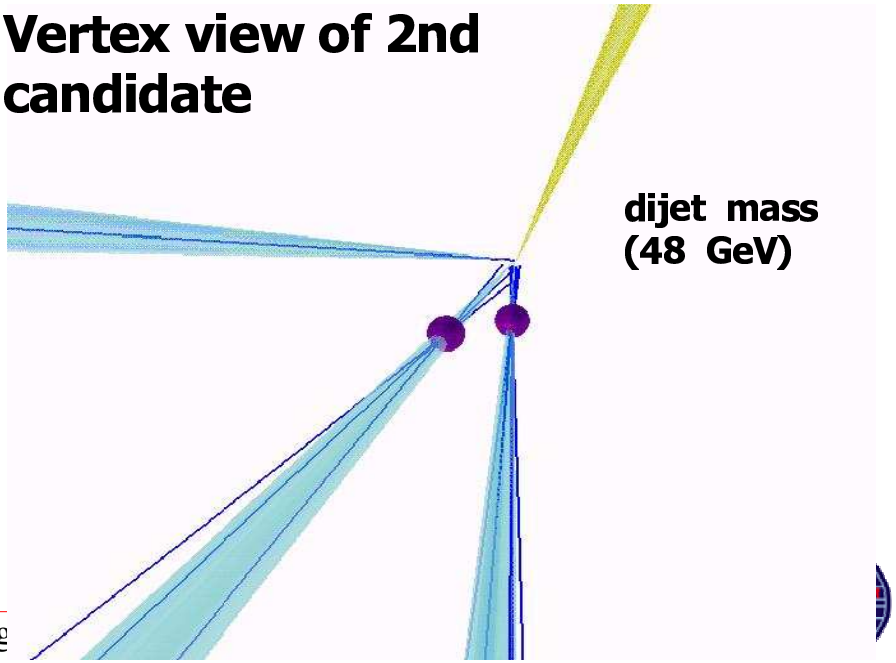
3 views of high dijet mass (220 GeV) Wbb (WH) candidate





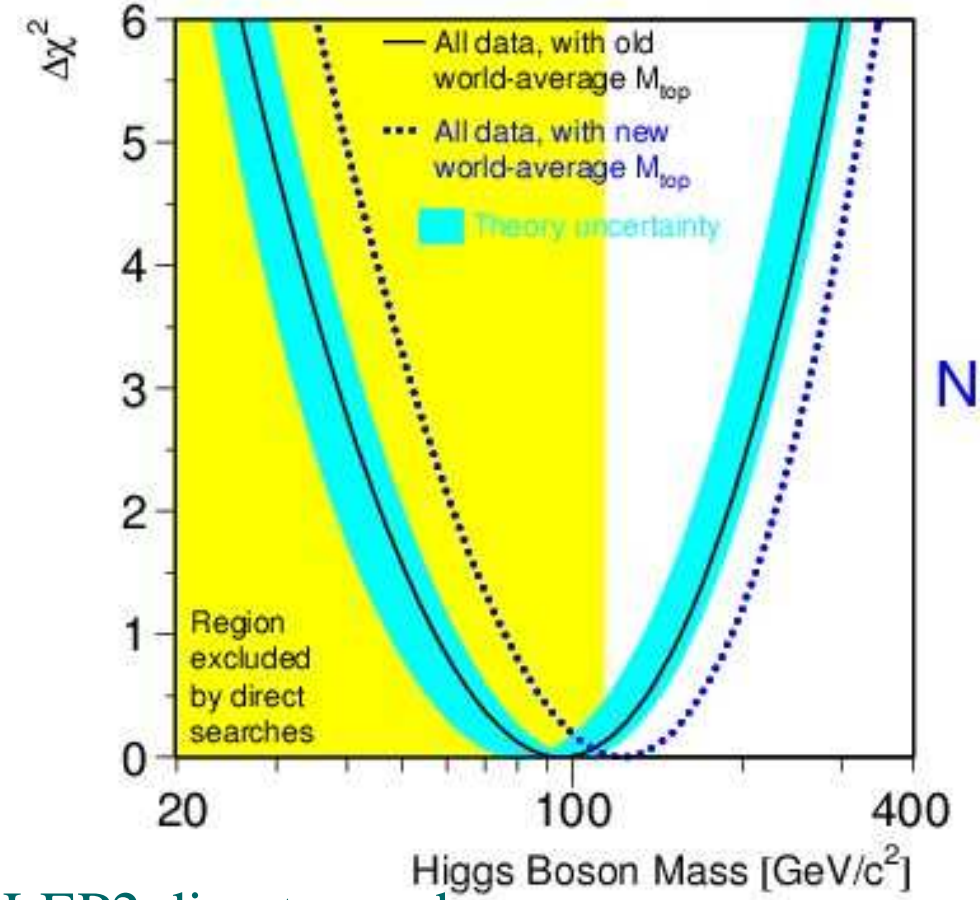


Vertex view of 2nd candidate



Precision electroweak data:

Constrain M_H in the MSM



Old:

$M_{top} = 174.3 \pm 5.1$ GeV

$\log M_H = 1.98^{+0.21}_{-0.22}$

$M_H = 96^{+60}_{-38}$ GeV

or < 219 GeV (95% CL)

New:

$M_{top} = 178.0 \pm 4.3$ GeV

$\log M_H = 2.07^{+0.20}_{-0.21}$

$M_H = 117^{+67}_{-45}$ GeV

or < 251 GeV (95% CL)

(Procedure as in hep-ex/0312023!)

LEP2 direct searches:

- $M_H > 114.4$ GeV @ 95% CL