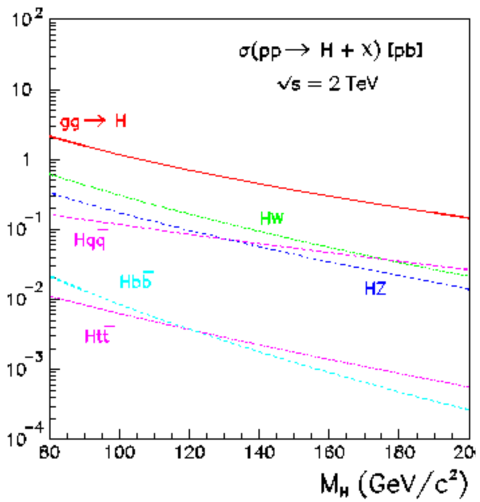
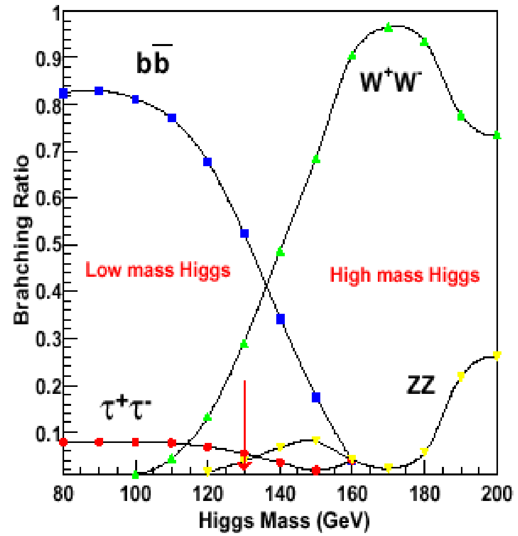
Higgs Production and Decay at the Tevatron

- gg→H dominates over all mass ranges, but huge QCD backgrounds.
- M_H<130 GeV/c^2 "Low mass Higgs".
  - H→bb with Associated production mode is the most promising. The double b-tagging together with the signature of the additional boson helps to discriminate from the background.



M(H)[GeV/c^2]	σ_H[fb]	σ_{WH}[fb]	σ_{ZH}[fb]	σ_{Hqq}[fb]
110	900	224	128	100
120	704	165	96.5	85.4
130	558	124	73.5	73.2

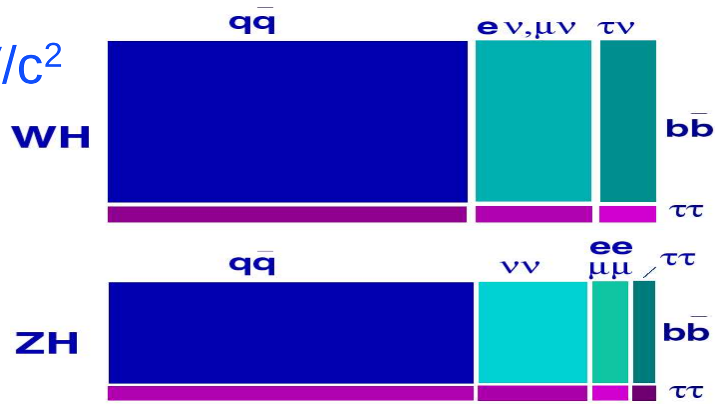


Event rates

- The initial Run II goal is to achieve a luminosity of ~ $1x10^{32}$ cm^{-2} sec^{-1}
  - 2 fb^{-1} delivered to each detector, CDF and DØ

Run	Dates	Integrated Lumi (fb^{-1})
I	1993-1996	0.1
IIa	2001-2003	~2
IIb	2004-2007	~15

M_H ~120 GeV/c^2



Process	WH	Wbb Wττ	lνbb lνττ
Events	165 fb x 15 fb^{-1} = 2475	x 0.68 = 1650 x 0.07 = 168	x 0.296 = 500 x 0.296 = 50

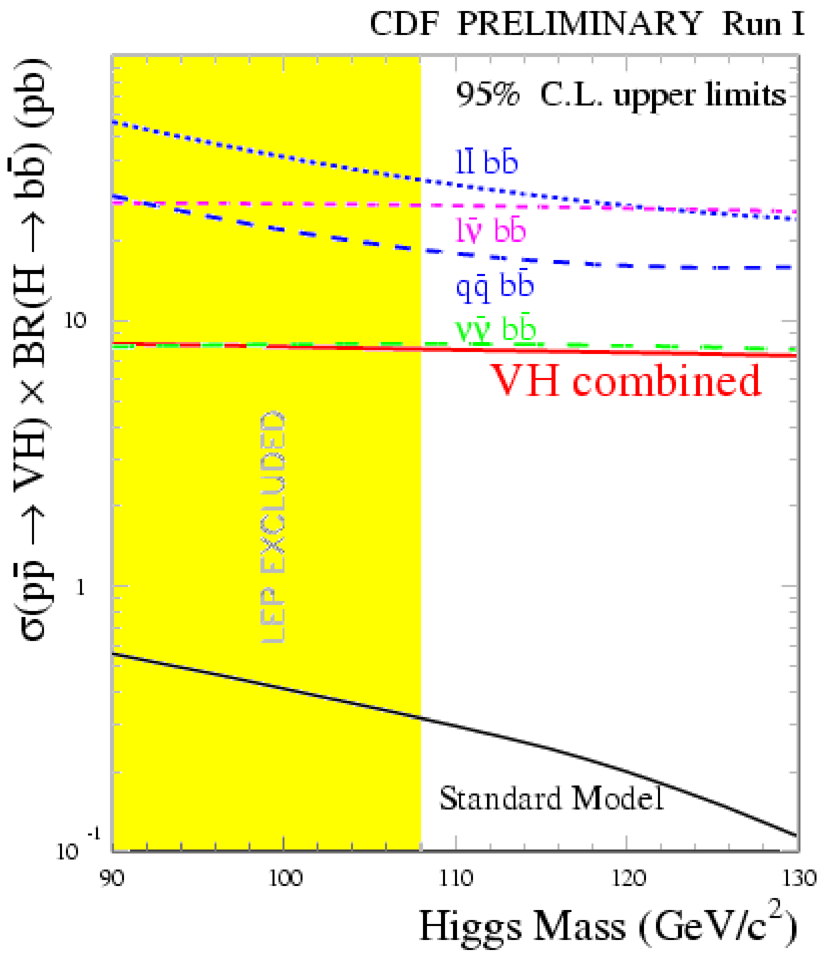
Process	ZH	Zbb Zττ	ννbb ννττ
Events	97 fb x 15 fb^{-1} = 1455	x 0.68 = 990 x 0.07 = 181	x 0.2 = 195 x 0.2 = 21

Compare to top quark discovery: 67 pb^{-1} x 5 pb = 335 tt events.

T.Munar, S.Rolli

SM Higgs Dedicated Triggers

- In the SM Higgs associated production the signature of the associated boson allows background rejection.
  - ➤ ***W H→ lν bb***
  - ➤ ***Z H → ℓlν bb,*** ν ν ***bb***
  - ➤ ***V H → qq bb***
- From the trigger point of view, channels with one high P_T lepton are not a concern.
- H W/Z→ bb jj
  - ➤ **suffer of huge QCD background. But can set competitive limits.**
  - ➤ **Run-I multijets trigger completely inadequate. (Optimized for Top searches).**
- HZ→ bb + MET: promising channel.
  - ➤ **Lower MET threshold**:
    - **Better turn-on behaviour**.
  - ➤ **Lower MET: unacceptable Rates**
  - ➤ **SVT can reduce rates.**

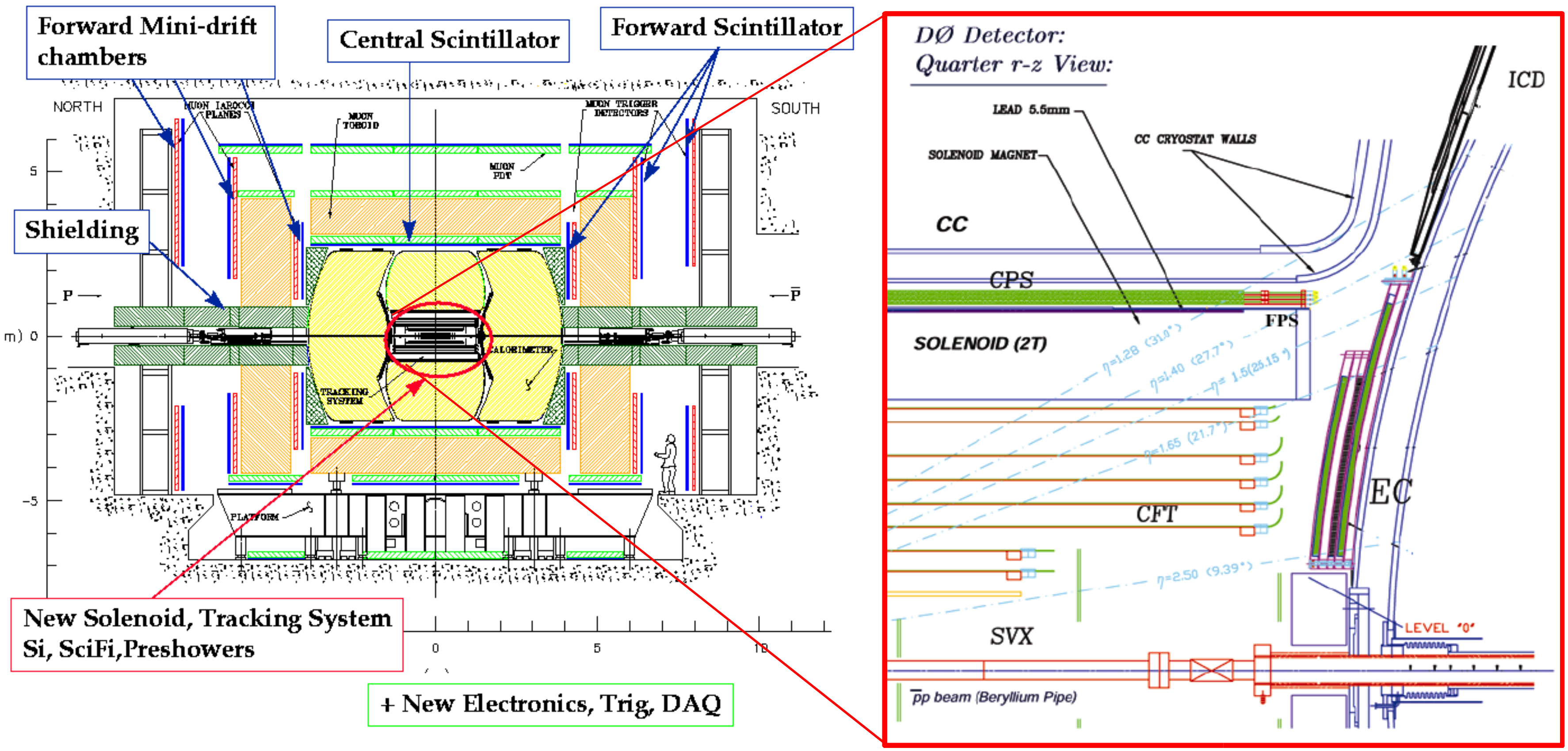


Experimental Issues At The Tevatron

- The trigger:
  - need good missing E_T as well as good lepton id at trigger level .
  - b−tagging at a trigger level is needed to exploit the hadronic decays of Z and W.
- b−tagging is essential offline as you need to tag both jets in order to reject QCD background.
- Need a good di−jet mass resolution.
- Lepton identification.

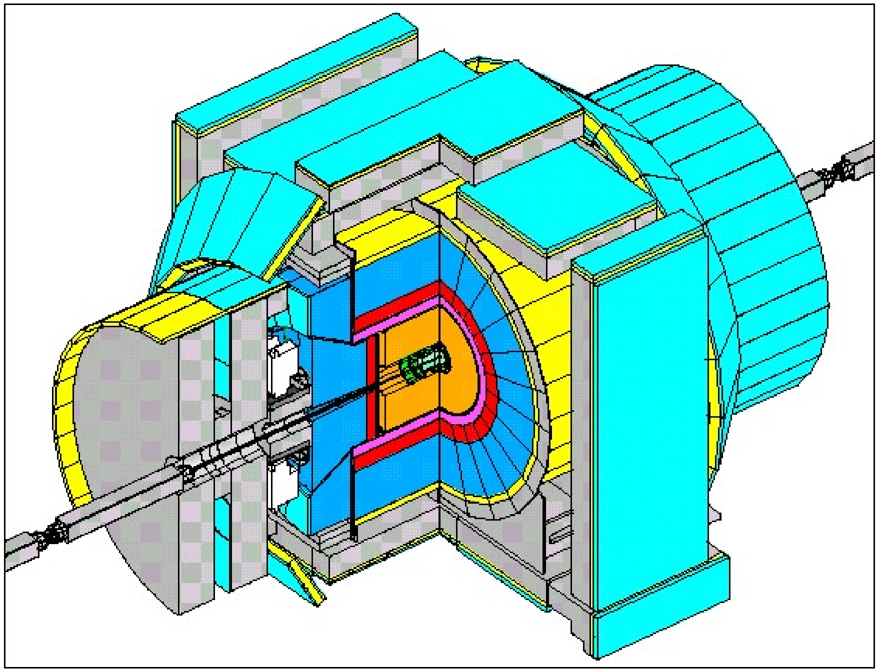
The DØ Detector

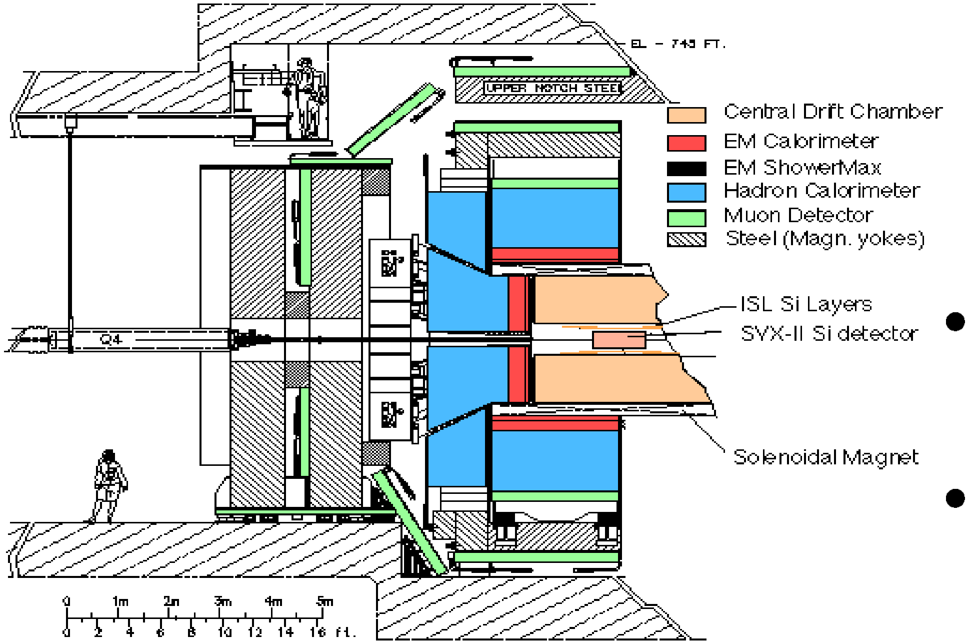
New silicon system (SMT) for b−tagging and new fibre tracker in 2T magnetic field. Preshowers for lepton id. Forward muon system upgraded, coverage out to $|\eta| < 2.0$.



The CDF Detector

- New silicon system to improve on the SVX' design used in RunI.
- Muon system coverage increased by ~50% up to $|\eta| < 1.5$

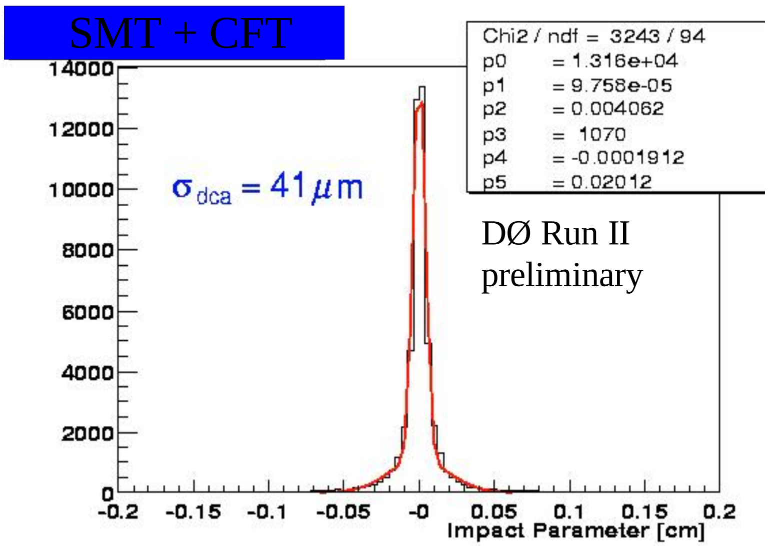


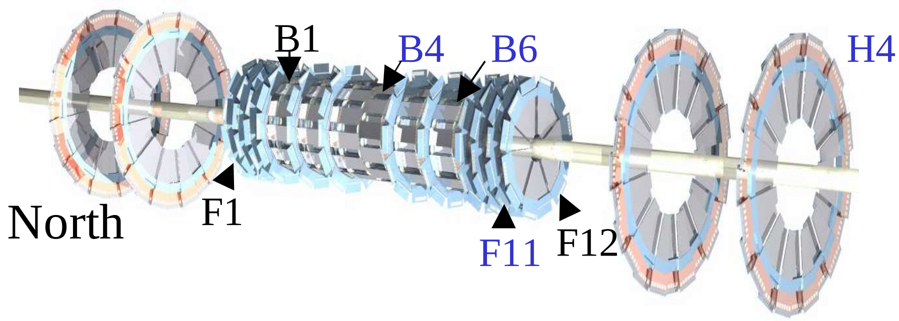


- New plug calorimeter covering $|\eta|$ 1.1 to 3.64.
- Shower max strip wire chambers to help increase purity of em id present in central and forward.

The DØ Silicon Microstrip Tracker (SMT)

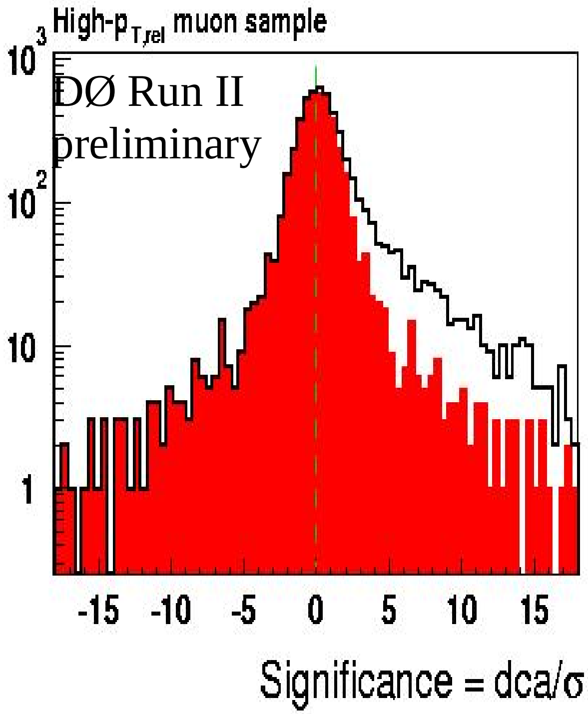
- 6 barrels with 4 layers of silicon. Single (axial) and double sided (axial + stereo).
- 12 F−disks, 6 of which attached to barrels, double sided.
- 4 H−disks for forward tracking (2 <|η|< 3).
- Allows 3D track reconstruction, using 800, 000 channels.





Information from barrels passed out to the trigger in order to give a displaced vertex trigger for b−jets (planned to be operational summer 2002).

b−Tagging in Data



μ + Jet triggers,

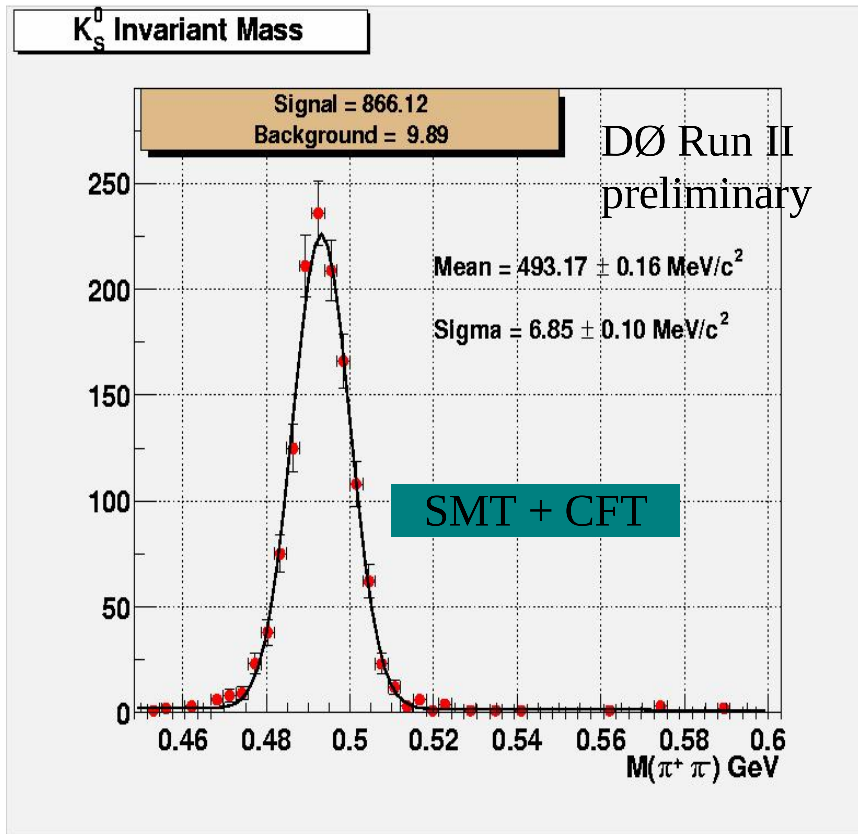
μ associated w/ jet

($dR < 0.7$)

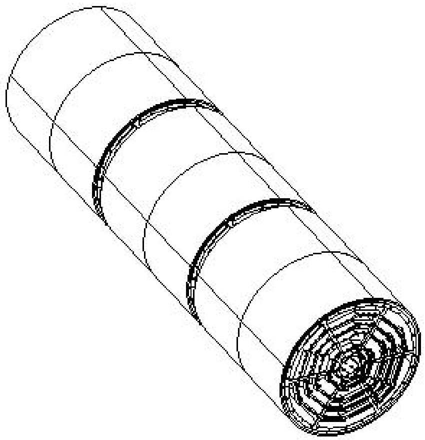
$p_T^{rel} > 1.5$ GeV

Enhanced in b-jet Content

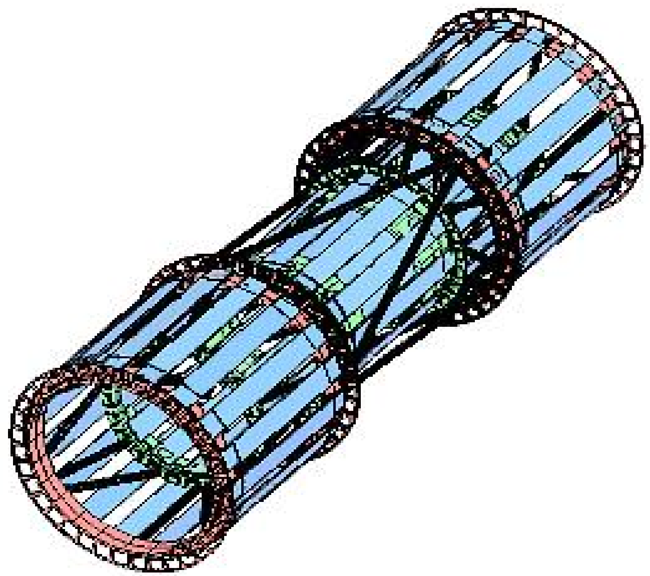
• Feb., March data



CDF Silicon Tracker

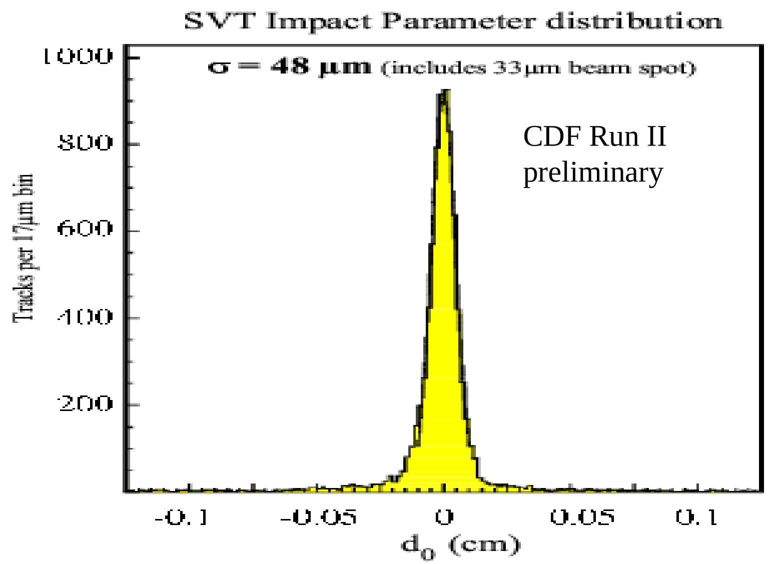


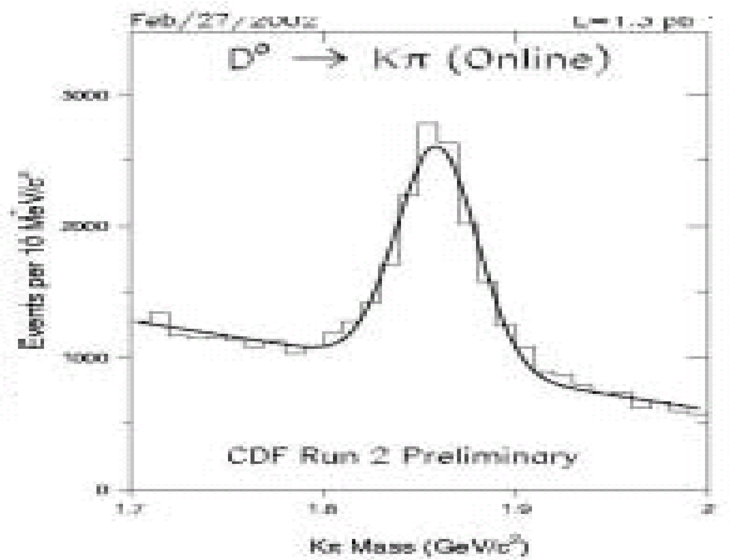
- 3 components: Layer 00, SVX II and ISL
- L00 single sided layer placed on the beampipe (r ~ 1.5 cm).
- SVX II consists of 3 barrels, 5 layers of double sided silicon, $|\eta| < 1$.
- ISL; 1 layer of double sided silicon in central and 2 layers $1 < |\eta| < 2$.



Silicon Vertex Tracker

- SVT displaced vertex trigger.
- Provides track fitting and pattern recognition in transverse plane.
- Operational and working close to expectations.
- Trigger requires 2 tracks with d > 100 μm.





Higgs multijets Trigger

	Level 2		Offline b-tag rates	
	Eff (%)	Rate (Hz) (JET-20)	1 SECVTX	2 SECVTX
			Eff (%)	Eff (%)
RUN-I $N_{clu}\geq4$ SumEt>125 $E_T\geq15$Gev	24.6	--	--	3.4
RUN-II Calorimetry $N_{clus}\geq3$ SumEt>70 E_T>10GeV	77.6	17.0	34.2	10.2
Calorimetry + 1 SVT d0>100 μm	38.3	2.8	26.5	9.5
Calorimetry + 2 SVT d0>100 μm d1>80 μm	30.6	1.0	26.3	9.4

Efficiencies and Rates with SVT cuts x 1.3 due to improved geometrical acceptance

Double b-tag acceptance improves by a factor 3 respect Run-I

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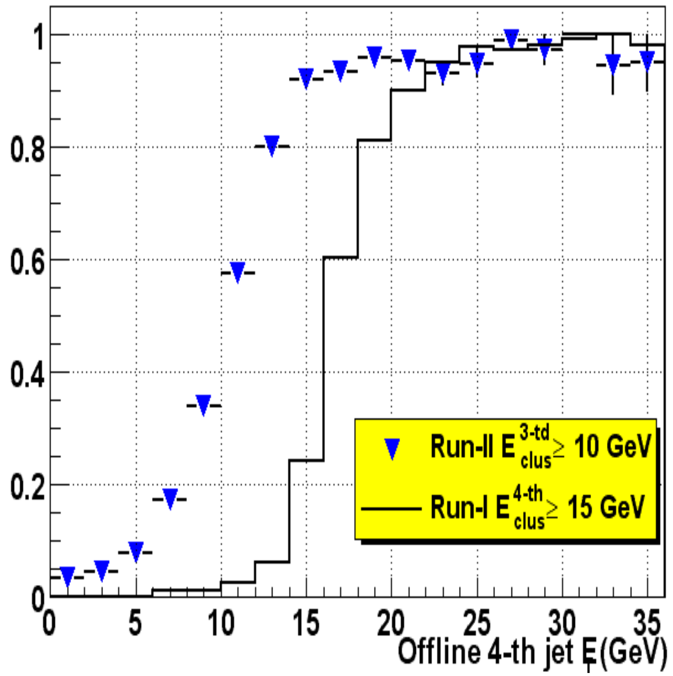
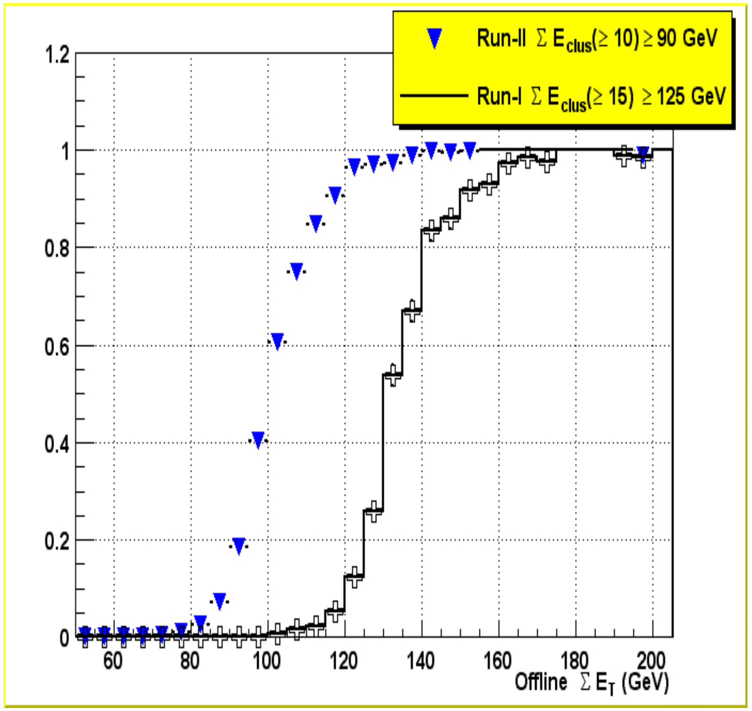
HW→bbqq Turn-on curves



4-th Jet



SumEt

T.Munar, S.Rolli

Higgs HZ→bbνν

	Level 2		Offline b-tag rates	
	Eff (%)	Rate (Hz) (JET-20)	1 SECVTX	2 SECVTX
			Eff (%)	Eff (%)
RUN-I MET>35 GeV	**24.6**	**--**	**--**	**5.6**
RUN-II Calorimetry MET>15 GeV	**77.6**	**234**	**34.8**	**7.7**
Calorimetry + 1 SVT d0>100 μm	**38.3**	**21.5**	**26.6**	**7.5**
Calorimetry + 2 SVT **d0>100 μm** d1>80 μm	**30.6**	**1.45**	**19.4**	**7.1**

When SVT cuts are applied, a factor x 1.3 can be applied due to SVXII Run-II increased geometric acceptance.

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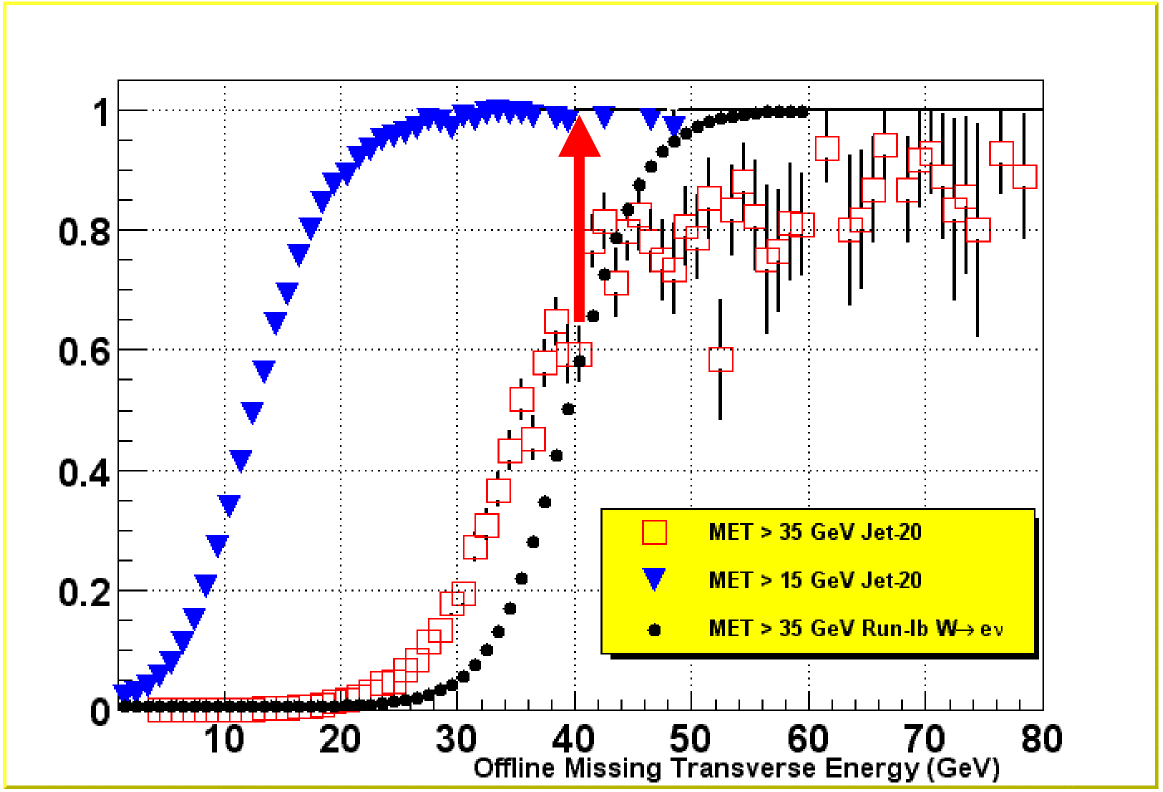
HZ→bbνν MET Turn-on

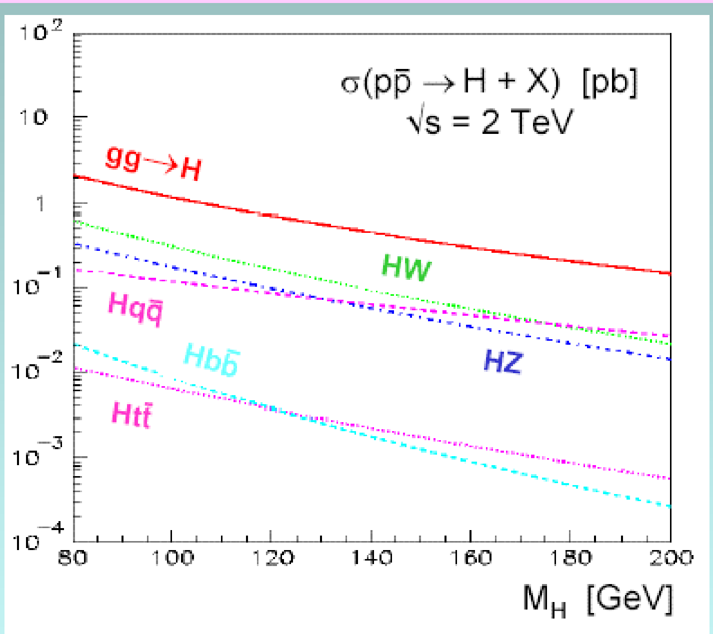


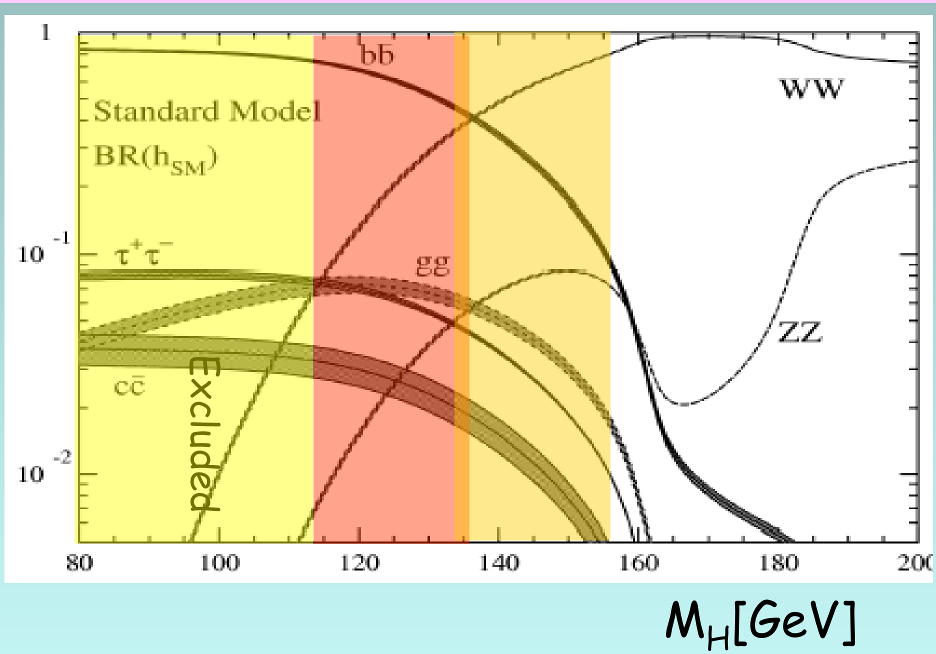
With MET>15 the Turn-on plateau is reach for $MET^{offline}$ >30 GeV

For cuts $MET^{offline}$>40 an efficiency increase of **1.4** can be reached.

Higgs Decays

Search strategies are a function of Decay Channel and Production Channel





Low Mass Higgs Searches

$$m_H < 135\ GeV$$
$$ZH,\ WH\quad H \to b\bar{b}$$

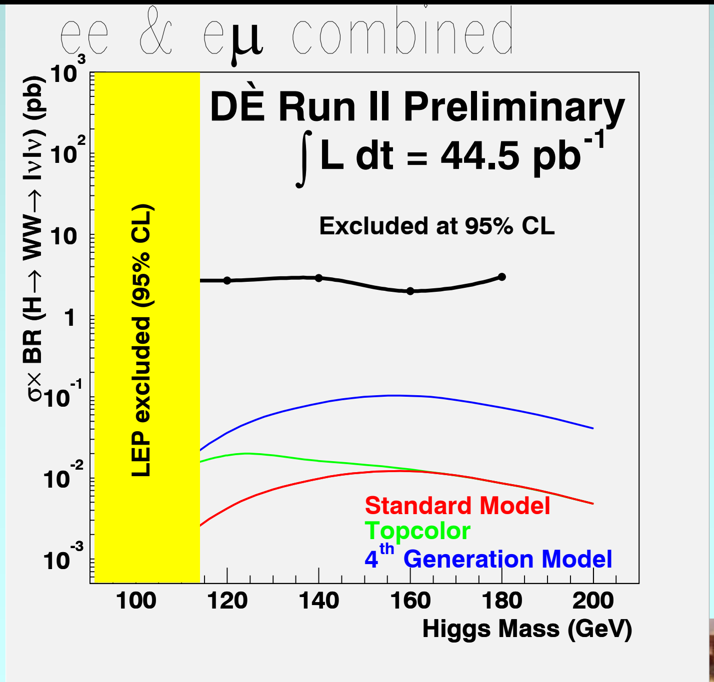
High Mass Higgs Searches

$$m_H > 120\ GeV$$
$$gg \to H \to WW^*$$

$H \to WW^* \to \ell^+ \ell^- \nu \nu$

- Search for high mass Higgs
  - SM extensions enhance the production cross section
- Signal: dileptons + $\not{E}_T$
- Bkgd: Z/γ^*, WW, tt, W/Z + j, QCD
- Opening angle between leptons is useful discriminating variable
  - Two leptons tend to move in parallel due to spin correlation of Higgs boson decay products
- Excluded cross section together with expectations from SM Higgs production and alternative models. →

	ee	eμ	μμ
(pb^{-1})	44	34	48
Total Background	0.7 ± 1.4	0.9 ± 1.5	0.3 ± 0.1 (stat)
Observed events	**0**	**1**	**1**



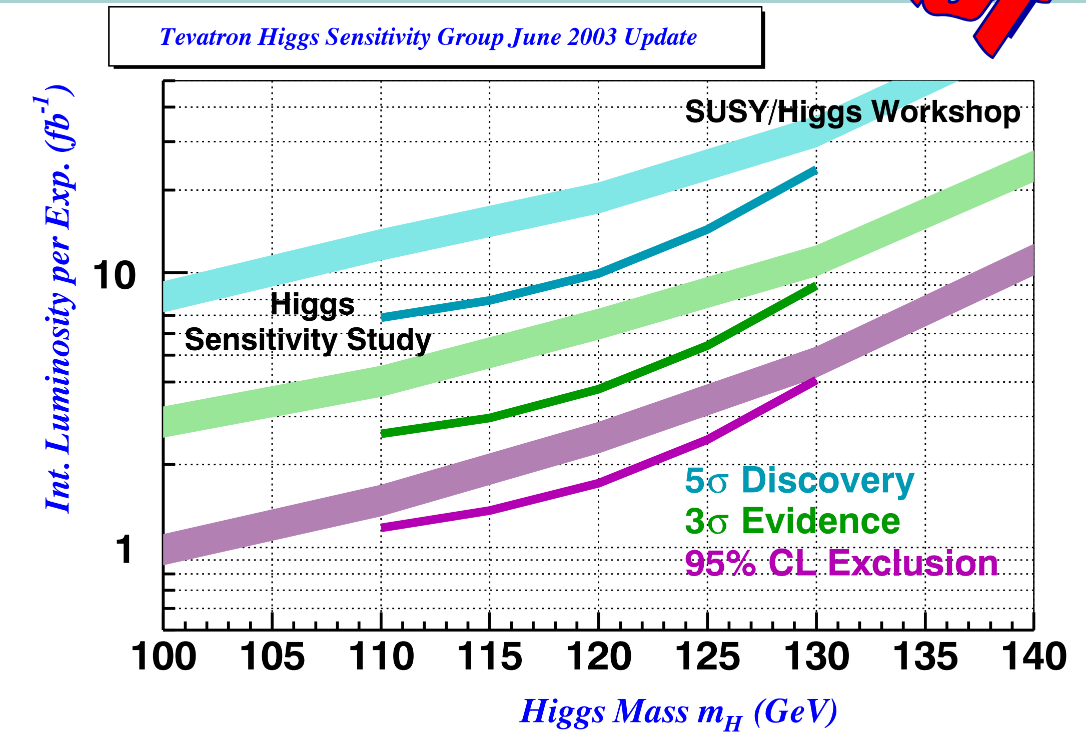
Future Prospects

- Near term: expect at least doubling of analyzed data for late summer conferences
- Long term: reaching 4-8 fb^{-1} by FY09
  - Detector upgrades for FY06 (Si, trigger)

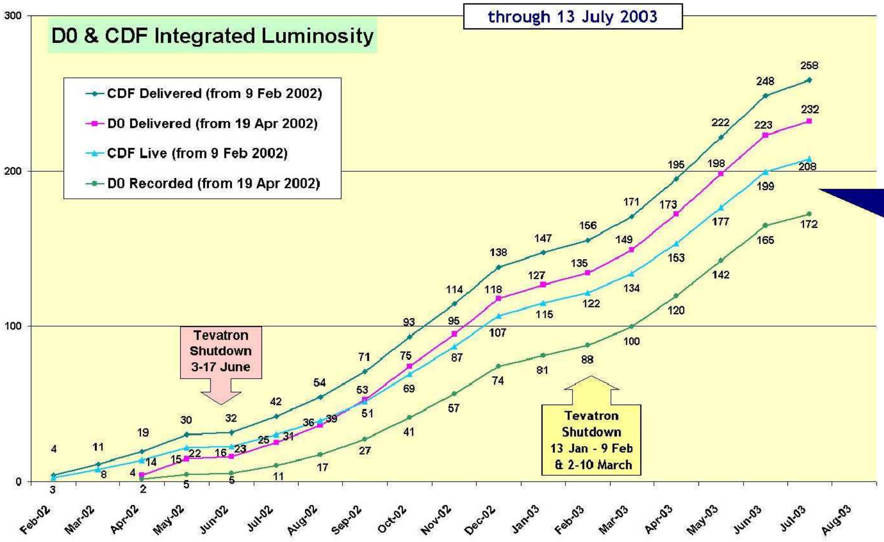
SUSY/Higgs Workshop:

hep-ph/0010338

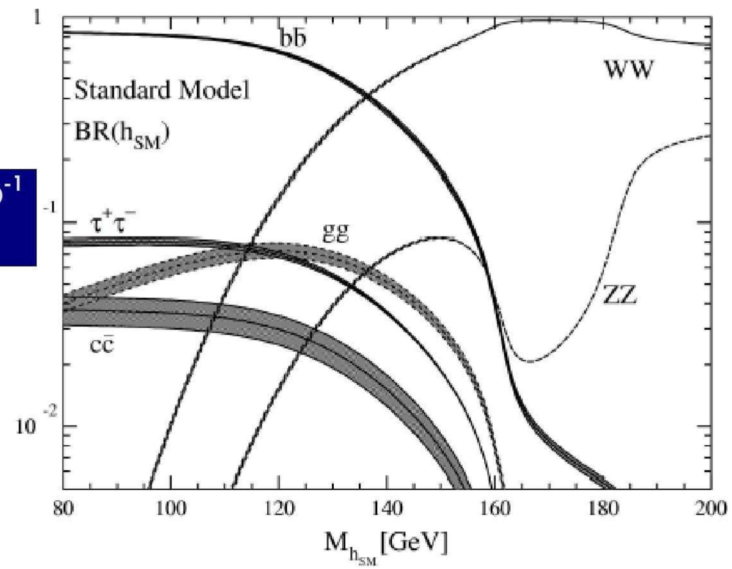
Tevatron Higgs Sensitivity Group: June 24, 2003
- $WH \rightarrow l\nu bb$
- $ZH \rightarrow \nu\nu bb$
- Improvement due mainly to sophisticated analysis techniques

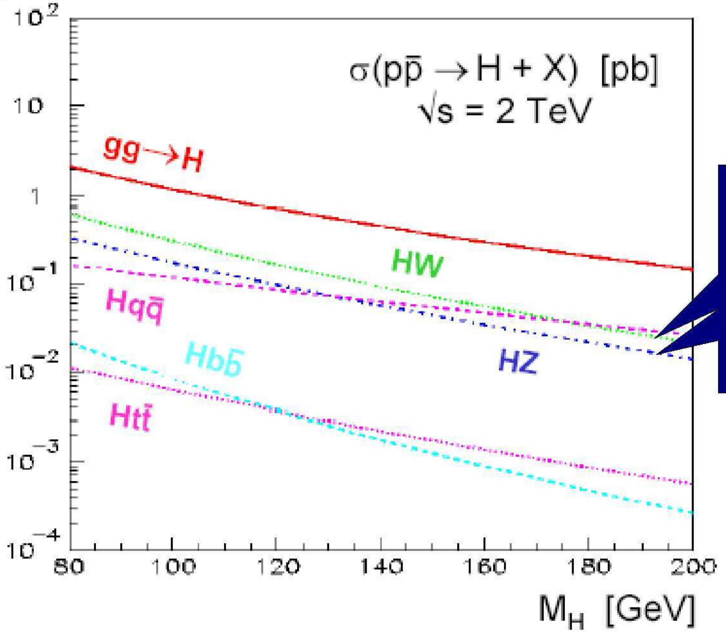


Tevatron Luminosity and Prospects

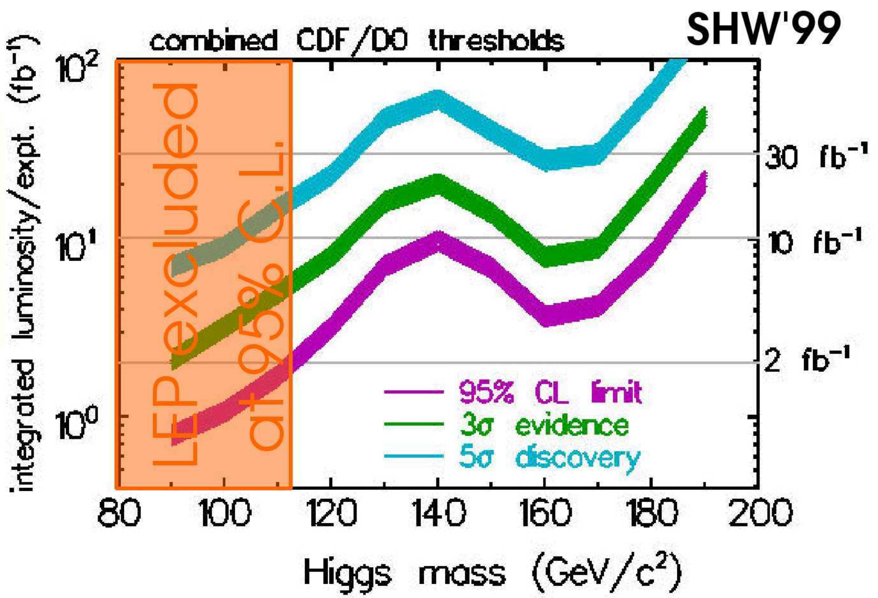


170 – 210 pb^{-1} recorded





use HZ and HW with H→ bb,WW and Z→ ll, Z→ $\nu\nu$, W→ lν



SM Higgs Search at the Tevatron

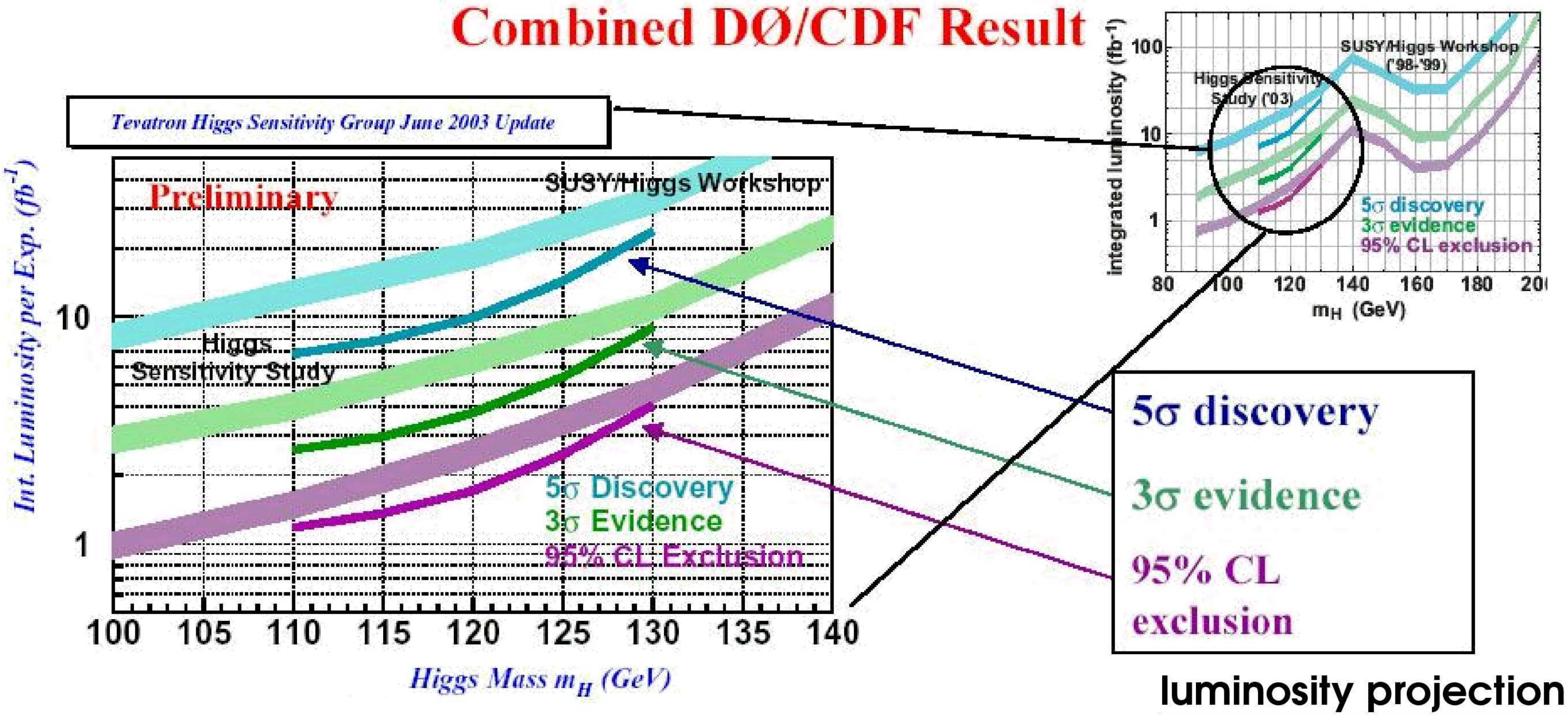
Improved Understanding due to Data

Process	*SHW 1999*	*Xsec '03*	*Ratio*	*Analysis '03*	*Ratio*	*comment*
HZ (115 GeV)	**3.15**	**3.82**	**1.22**	**2.86**	**0.91**	
HW (115 GeV)	**2.39**	**2.78**	**1.16**	**2.08**	**0.87**	
Zbb	4.34	1.73	0.4	1.99	0.46	from CDF data
Wbb	9.45	3.59	0.38	4.34	0.46	from CDF data
ZZ	1.82	2.36	1.3	2.93	1.61	PYTHIA 6.125 + K=1.34
WZ	1.45	1.79	1.45	1.84	1.27	PYTHIA 6.125 + K=1.34
tt	3	6.53	2.18	5.48	1.83	average of NLO calc.
qtb	0.31	0.8	2.62	0.68	2.22	NLO calc.
tb	4.7	0.49	0.1	0.35	0.08	NLO calc
QCD	25.06	17.3	0.69	11.16	0.45	from current study
total bgd	**50.11**	**34.59**		**28.77**		
Significance	**0.78**	**1.12**		**0.92**		

nr. events for 1 fb^{-1}

- **assumes mostly running with Run-IIB silicon tracker**
- **assumes Jet-Mass resolution of 10%,**
  SHW 1999 CAL reso. assumption met in Run-IIA
- **improvement mainly from sophisticated analysis techniques**
- **~50% less luminosity needed compared to 1999 with updated Xsec**
- **~28% less luminosity needed with realistic trigger efficiency,**
  QCD ... Bgd from data compared to SHW '99

SM Higgs Search at the Tevatron



luminosity projection (fb^{-1})

year	*baseline*	*design*
2003	0.28	0.3
2004	0.59	0.68
2005	0.98	1.36
2006	1.48	2.24
2007	2.11	3.78
2008	3.25	6.15
2009	4.41	8.57

- combined ll, νν, lν channels
- no systematics included
- no h → WW channel; impacts m_H > 125 GeV