Highlights from the Tevatron

Kazuhiko HARA
University of Tsukuba

KEKPH0712
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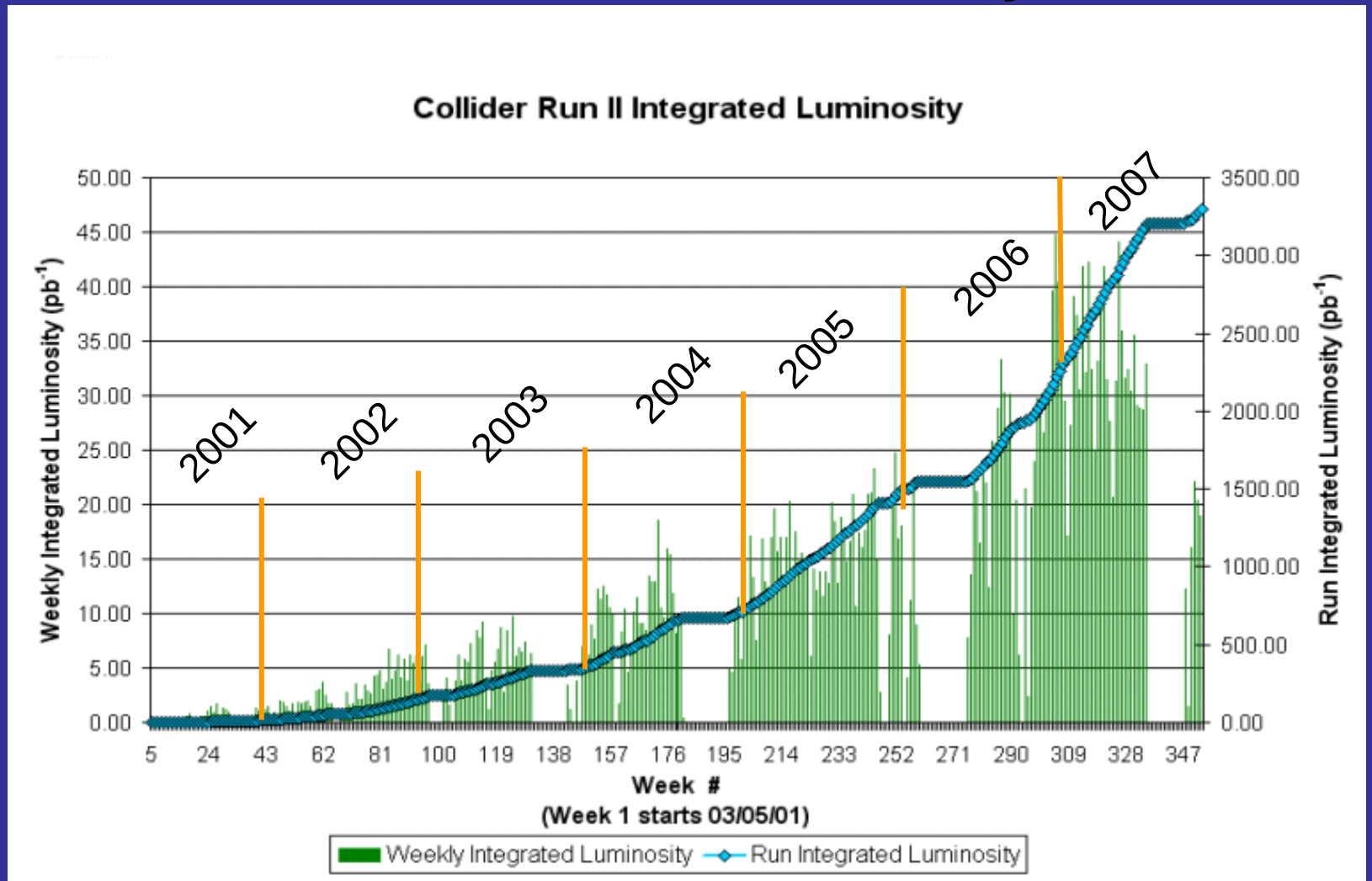
Tevatron Proton-Antiproton Collider

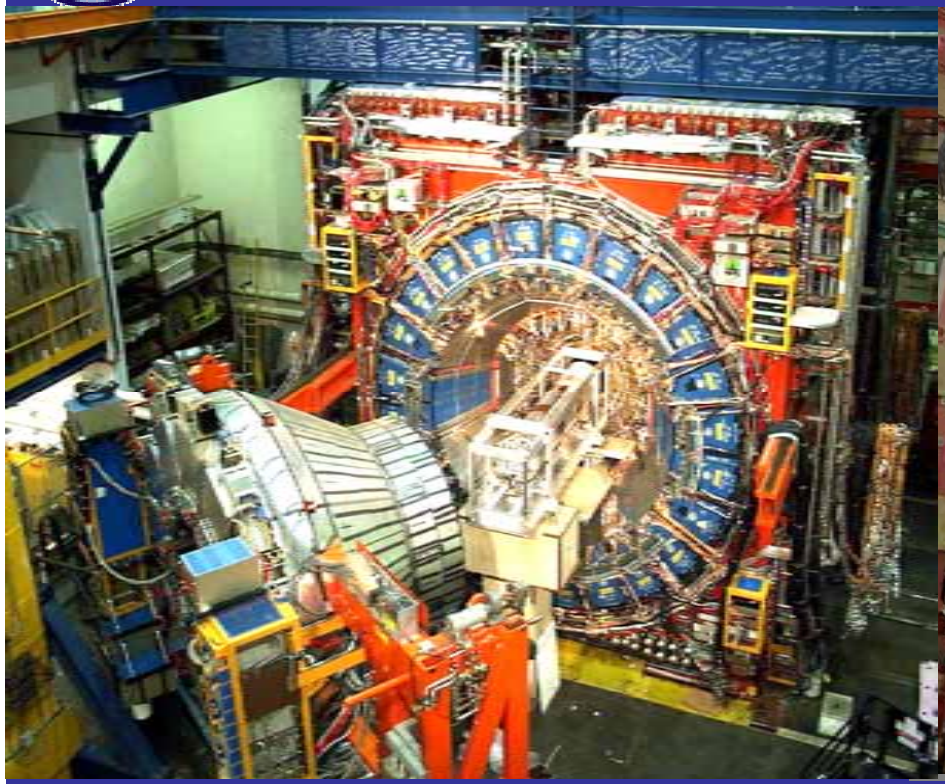
C.M.E.=1.96 TeV

Tevatron Luminosity



- ~3.3 fb^{-1} delivered (initial Run II target 2 fb^{-1} achieved)
- CDF/D0 are recording ~85% of the delivered luminosity
- Run until April 2010 (for 6-9 fb^{-1})

The Detectors



Two General-Purpose Detectors:	CDF	DØ
Electron acceptance	$\|\eta\| < 2.0$	$\|\eta\| < 3.0$
Muon acceptance	$\|\eta\| < 1.5$	$\|\eta\| < 2.0$
Silicon Precision tracking	$\|\eta\| < 2.0$	$\|\eta\| < 3.0$
Hermetic Calorimeter	$\|\eta\| < 3.6$	$\|\eta\| < 4.2$

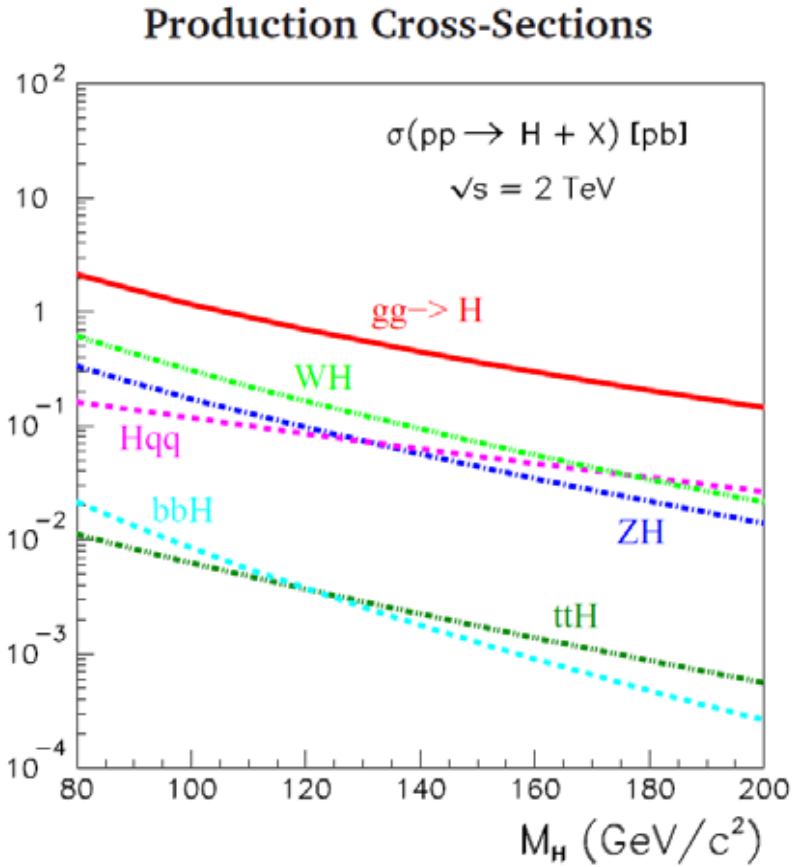
$$\eta = -\ln\tan(\theta/2)$$

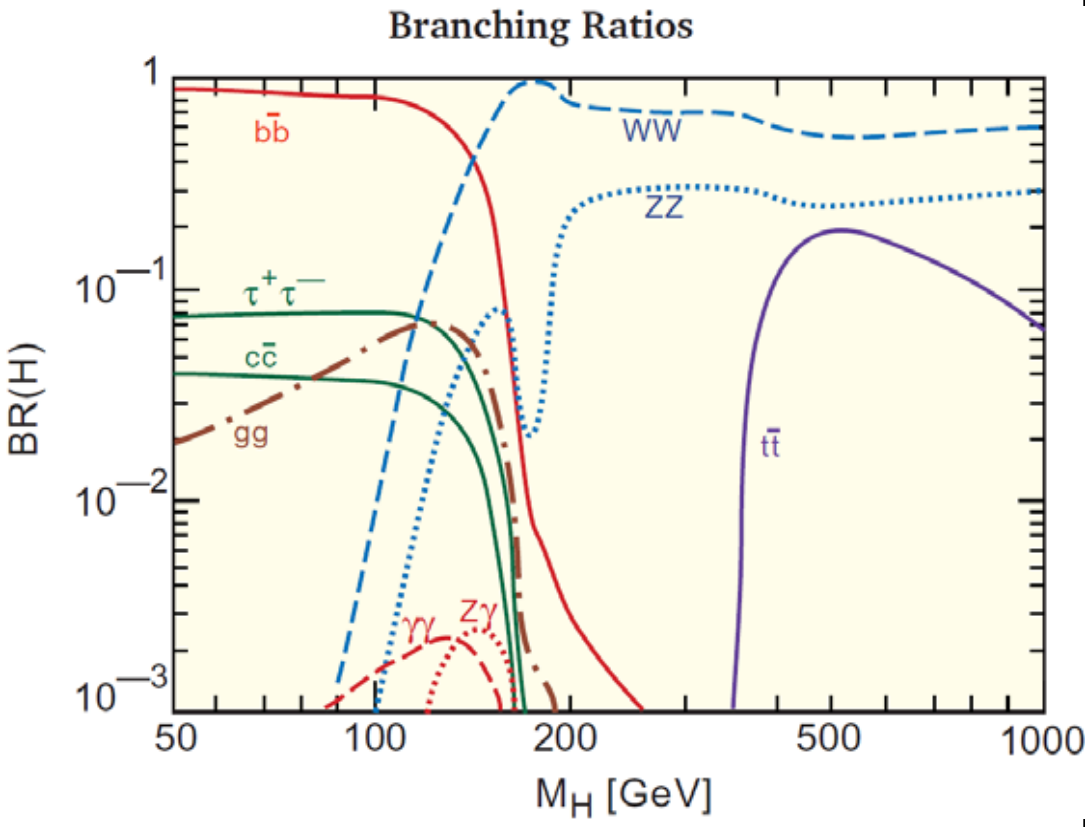
Tevatron Goals for Run II (CDF TDR)

- **Higgs Physics***
- **Properties of the Top Quark**
  - Top mass
  - σ_{tt}
  - Br $(t \rightarrow b)$ and any anomalies
  - Single top quark production*
- **Precision Electroweak Program**
  - W boson mass and width
  - Gauge boson couplings ($W\gamma$, $Z\gamma$, WW, WZ, ZZ)
  - A_{FB} of Z
- **Search for New Phenomena**
  - SUSY, Z′/ W′, Topcolor, Leptoquark, Compositeness, …
- **Precision QCD at Large Q^2**
- **Constraining the CKM Matrix**
  - CP violation in the B system
  - B_s oscillation frequency Δm_s
  - Rare B decays (B spectroscopy)

*added in beyond 2 fb^{-1} program

Higgs Boson Search at Tevatron





low-mass (m_H<135) Higgs Boson;

decay: dominantly into $b\bar{b}$ ← b tagging

production: WH, ZH ← leptonic W/Z decays provide best signature

high-mass (m_H>135) Higgs Boson;

decay: WW, ZZ ← leptonic decay enhances S/N

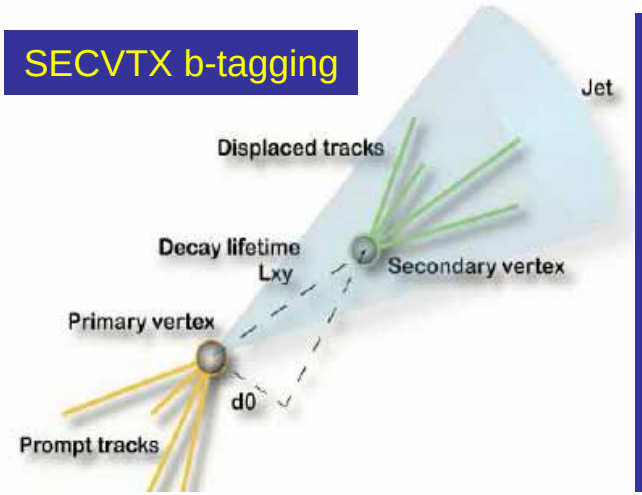
production: gg fusion

Higgs Physics

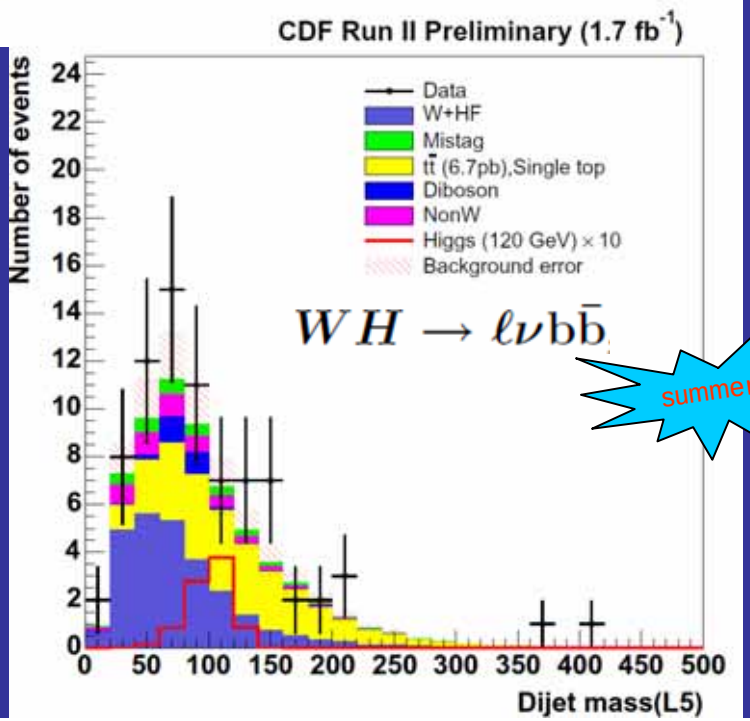
CDF Search for low-mass (m_H<135) Higgs Boson

$$WH \to \ell\nu b\bar{b},\ ZH \to \nu\bar{\nu}b\bar{b},\ ZH \to \ell^+\ell^- b\bar{b}\ (\text{with } \ell = e,\mu)$$

SECVTX b-tagging



Low signal rates in enormous backgrounds
plots are for double SECVTX b-tagged events (least BG)



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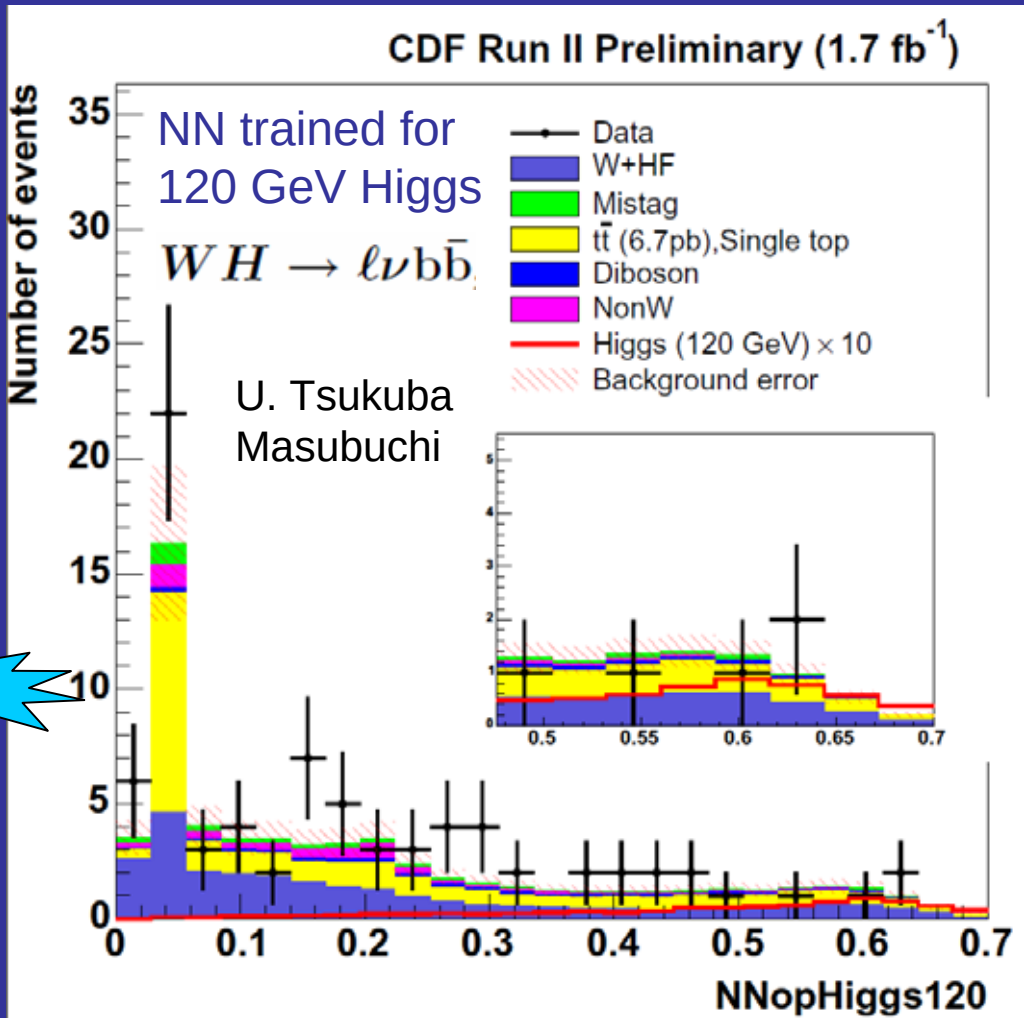
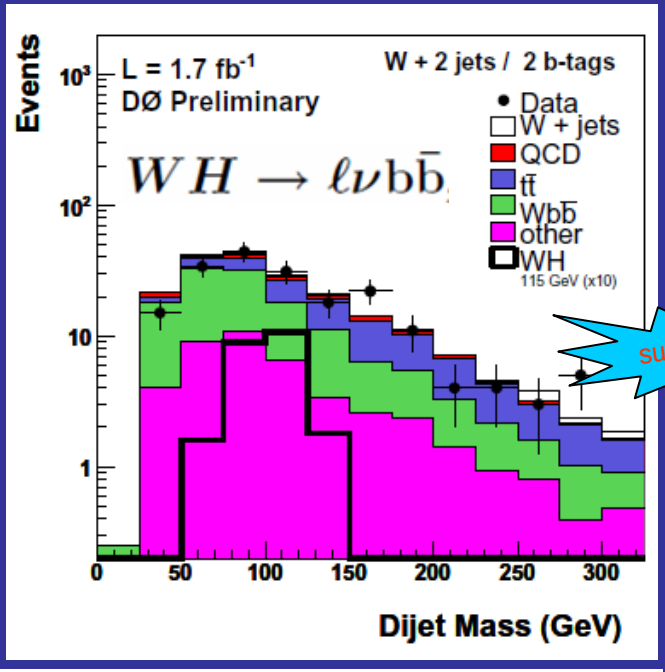


D0 Search for low-mass (m_H<135) Higgs Boson



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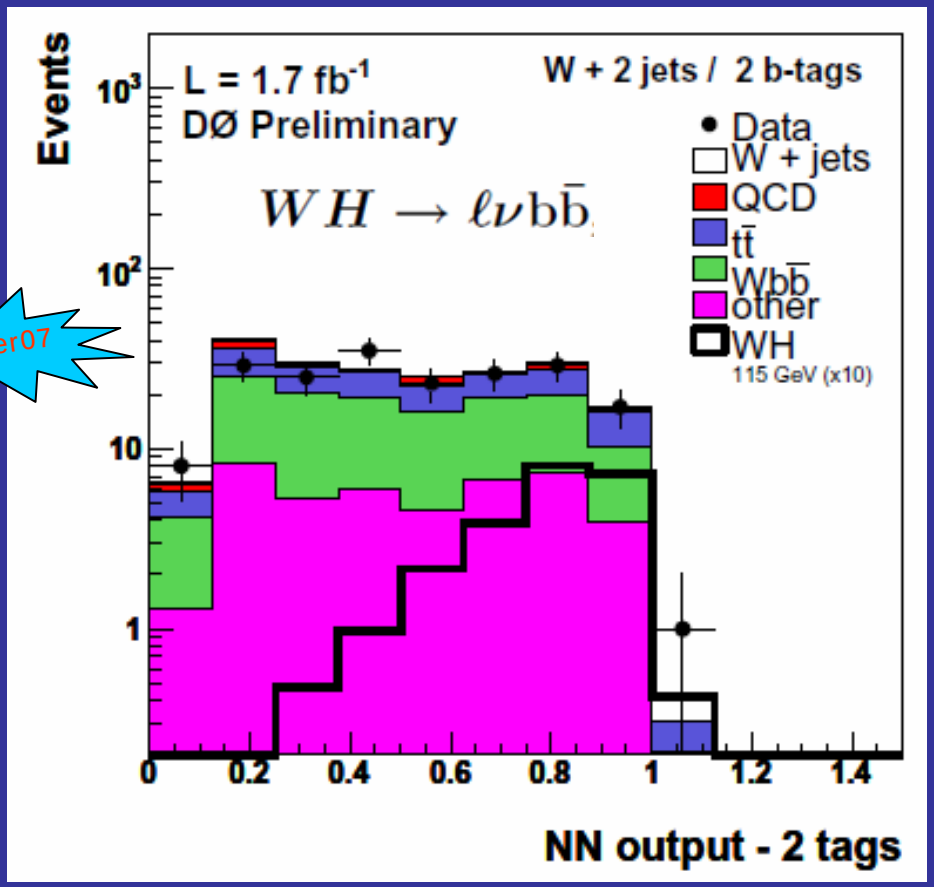
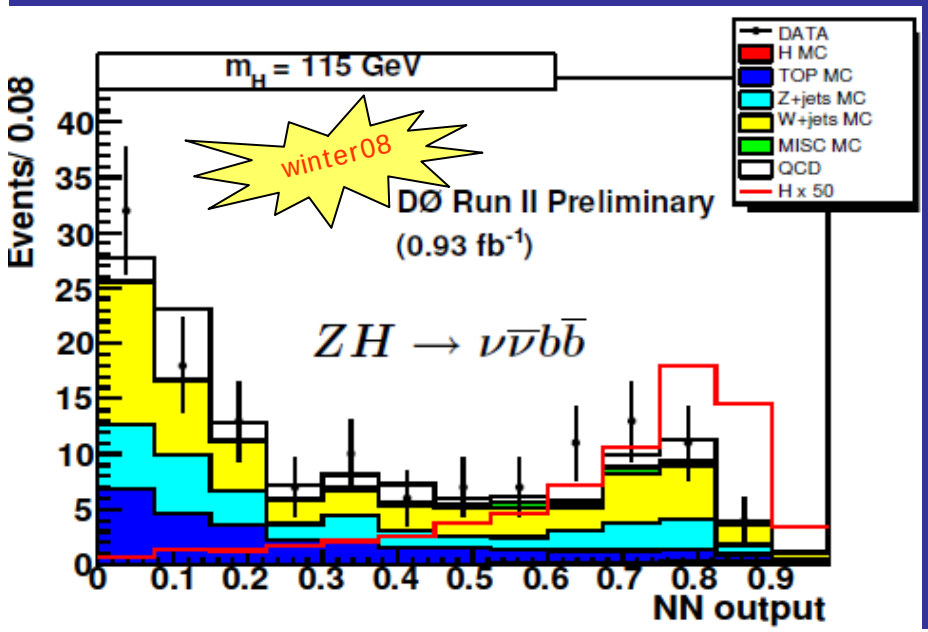




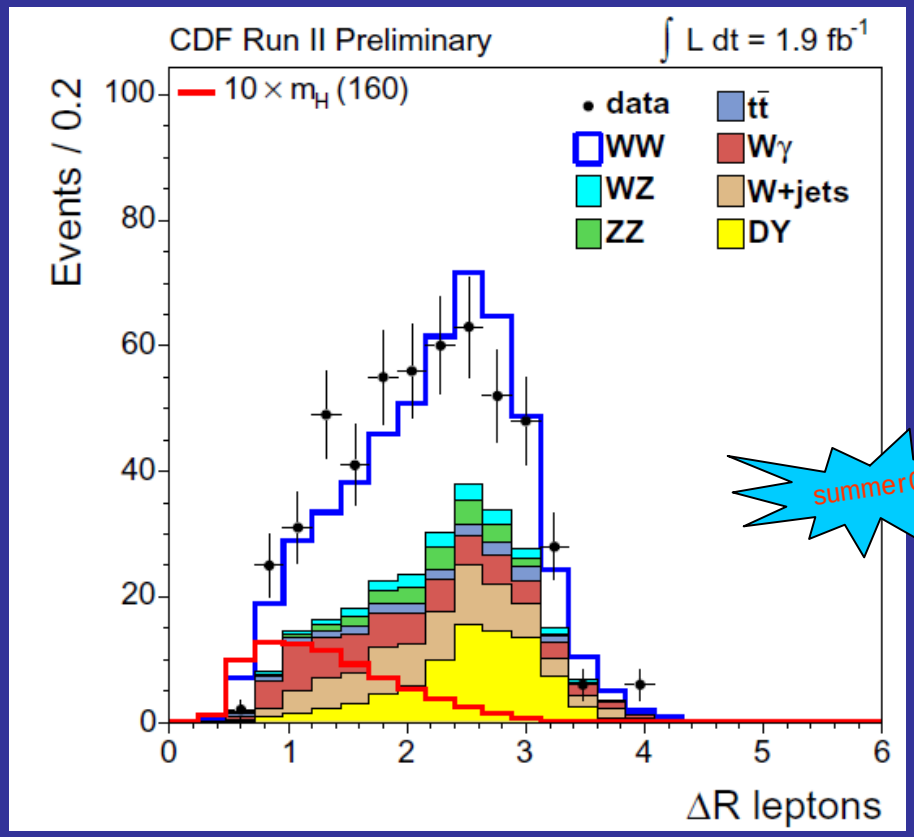
S/N＜0.1 for both experiments

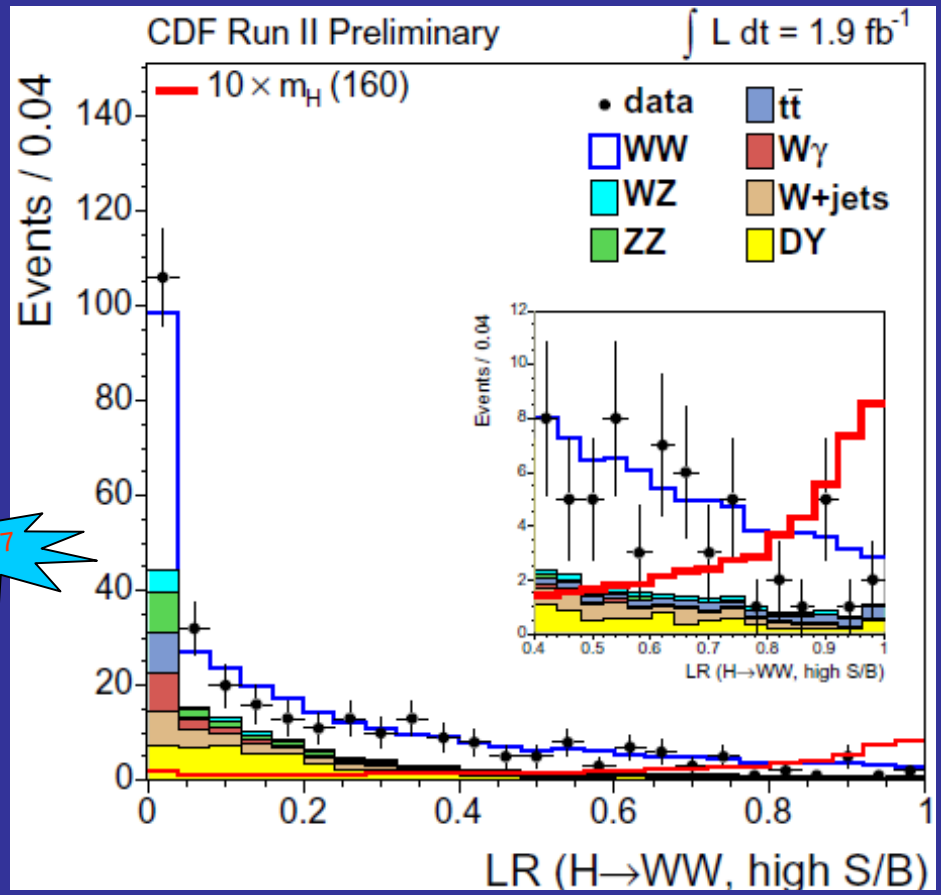
need to combine various search channels

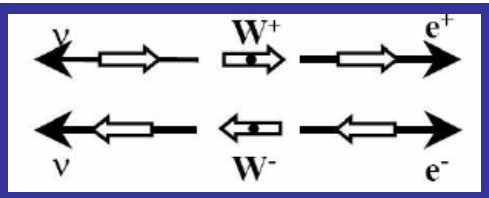
need to control systematics (JES, V+jets rate)

CDF Search for high-mass (m_H>135) Higgs Boson

$H \rightarrow WW \rightarrow l\nu l\nu$







$$\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$

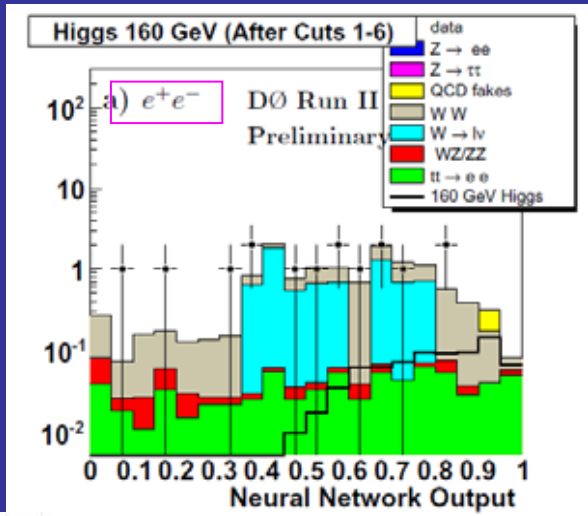
Charged leptons from Higgs decay tend to have small opening angle

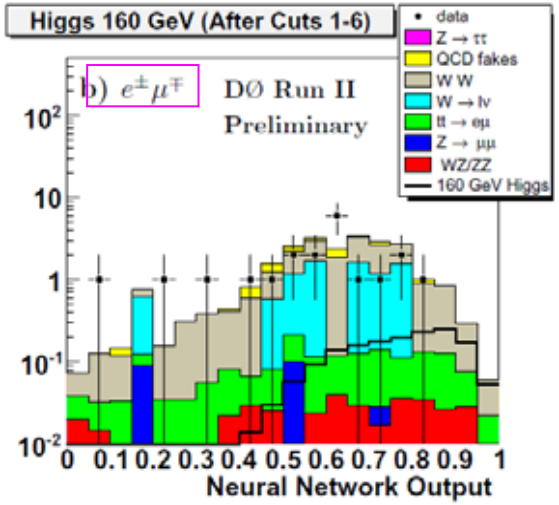
Likelihood ratio: $LR = \frac{P_H}{P_H + P_{BG}}$

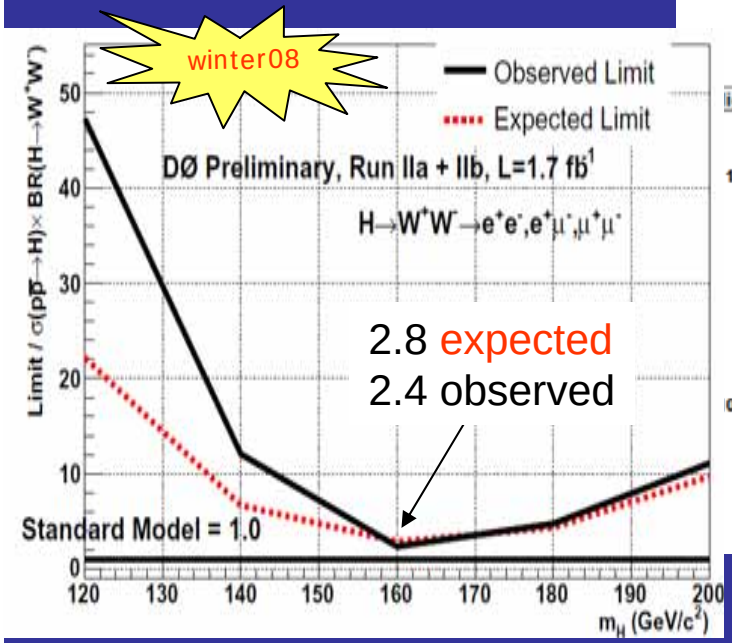
expect S/N~1.6/6 @ M_H=160 GeV

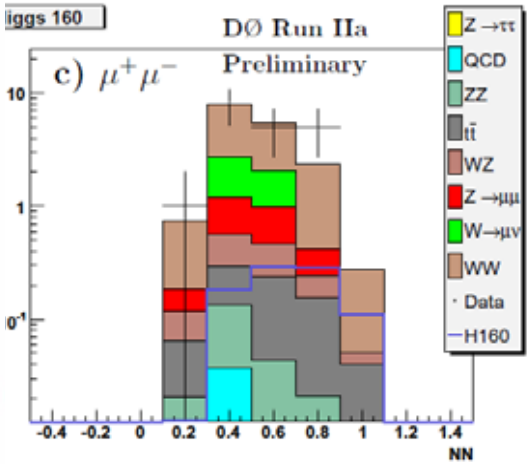
D0 Search for high-mass (m_H>135) Higgs Boson

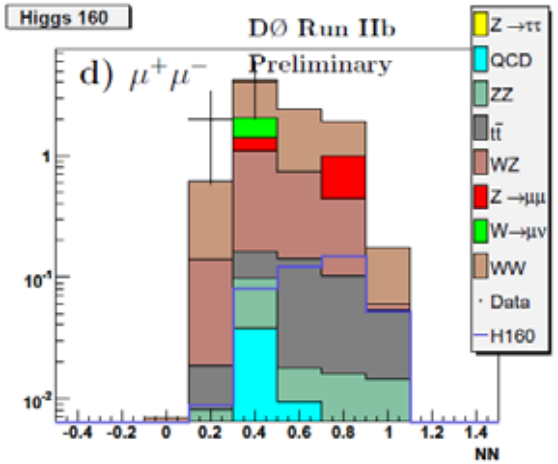
$$H \to WW^* \to ll' \ (l, l' = e, \mu)$$





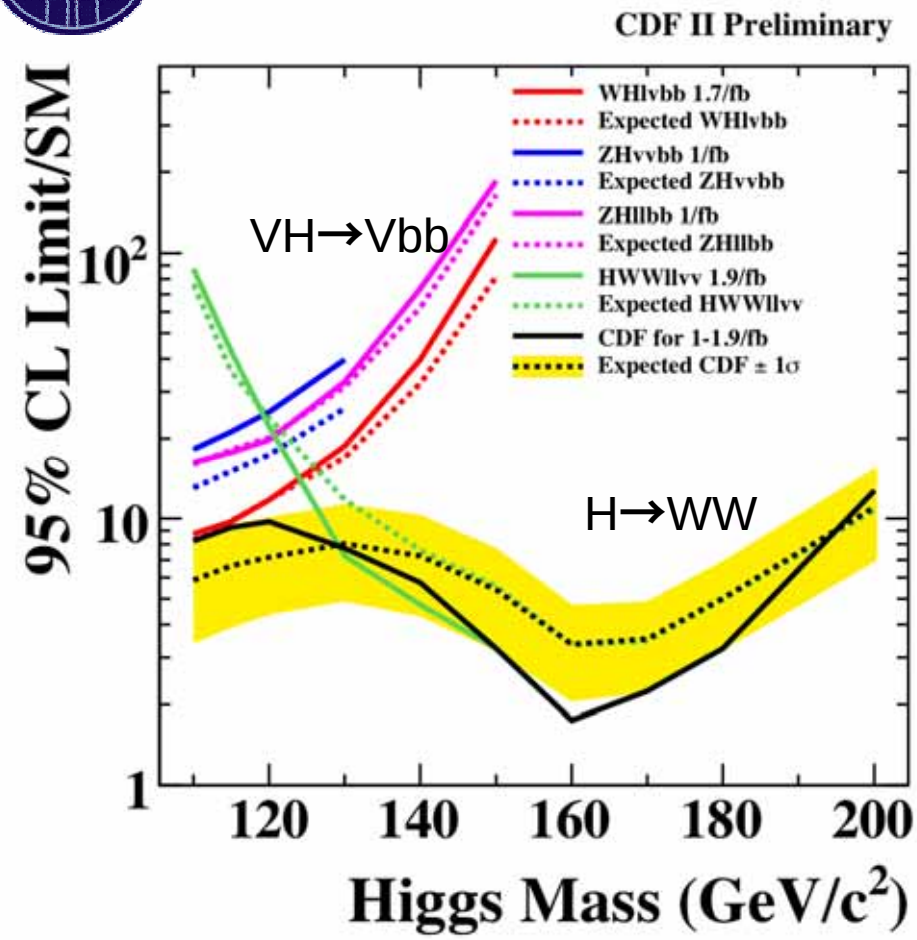


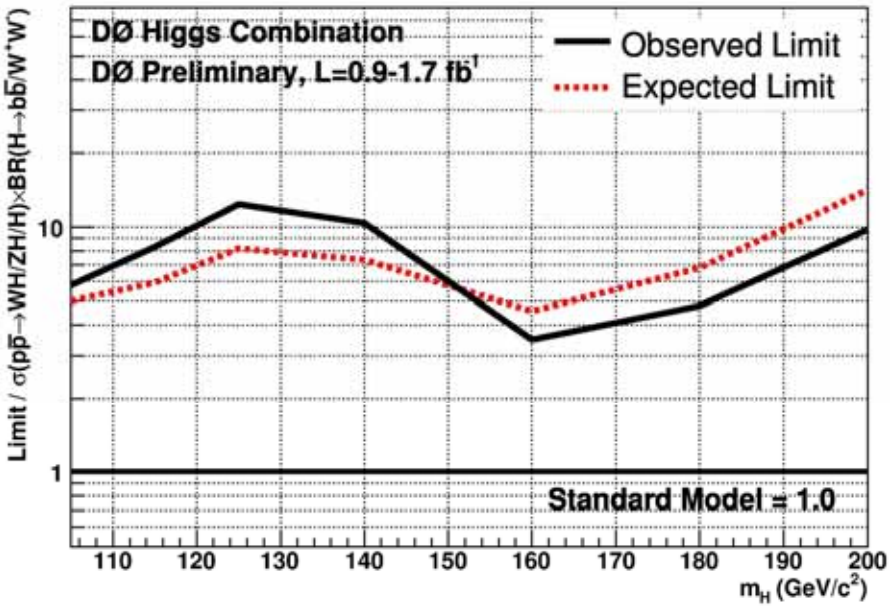


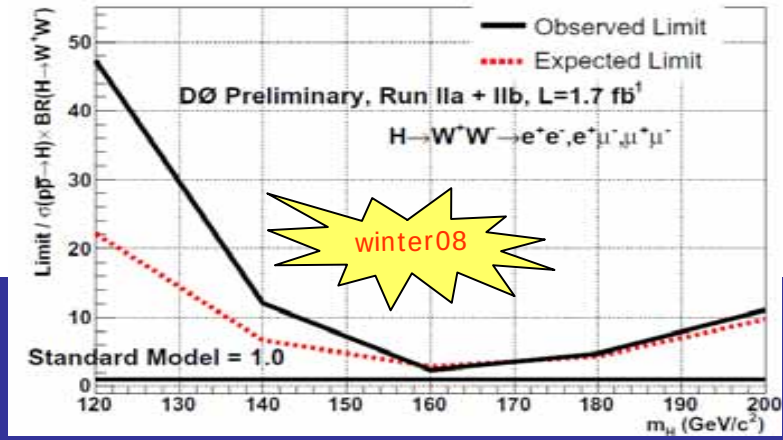


SM Higgs Sensitivities

summer07







Combined SM Higgs Search

Summer 2007

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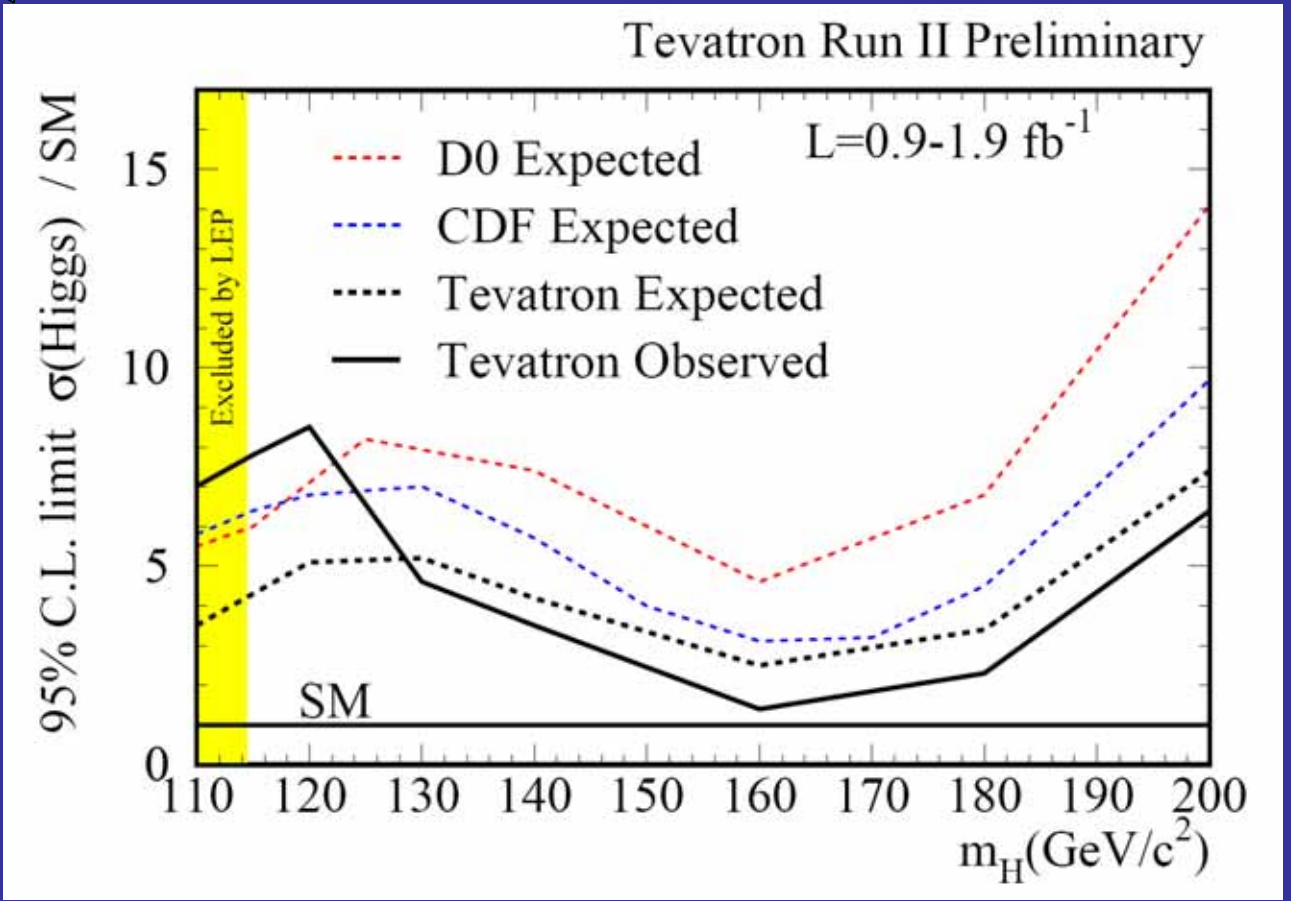
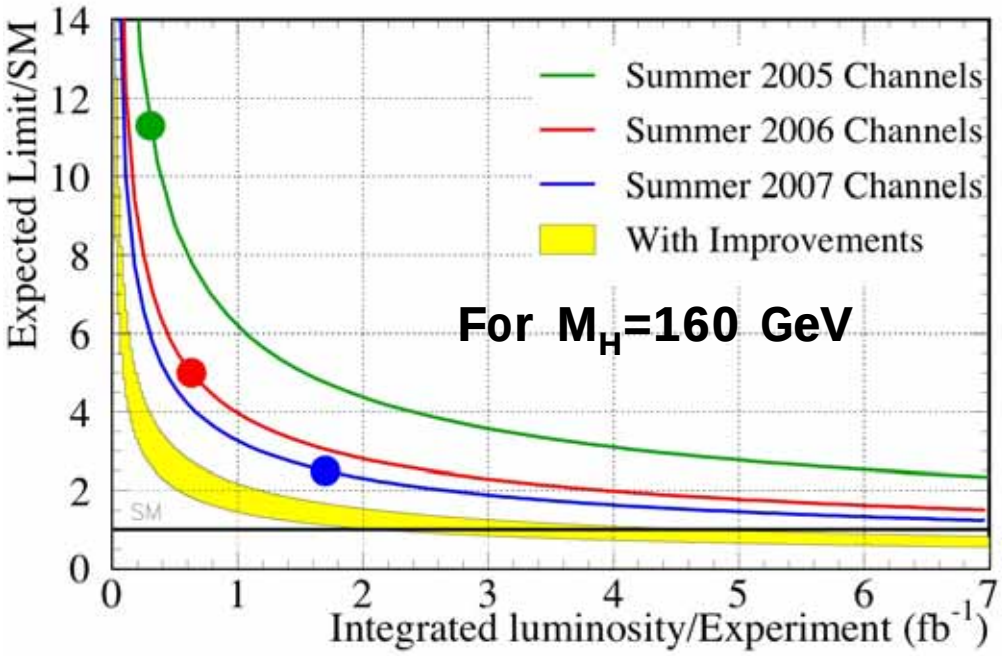
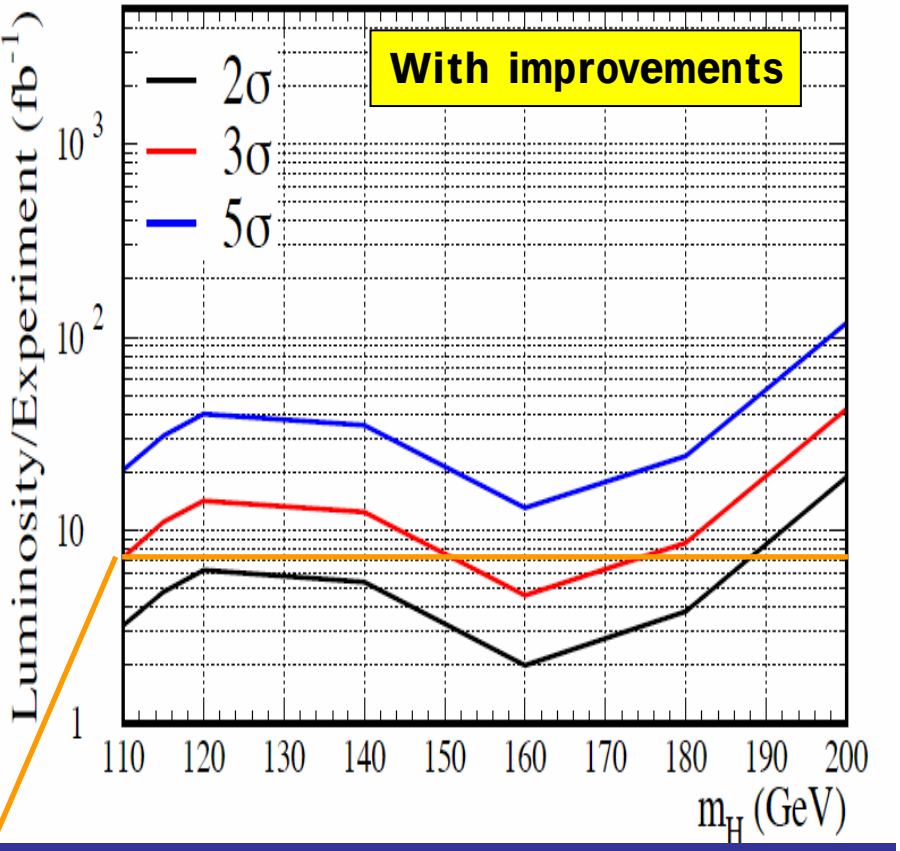
Combining 28 NN/LR/mass distributions
Without D0 update for Winter2008



Prospect for SM Higgs Search





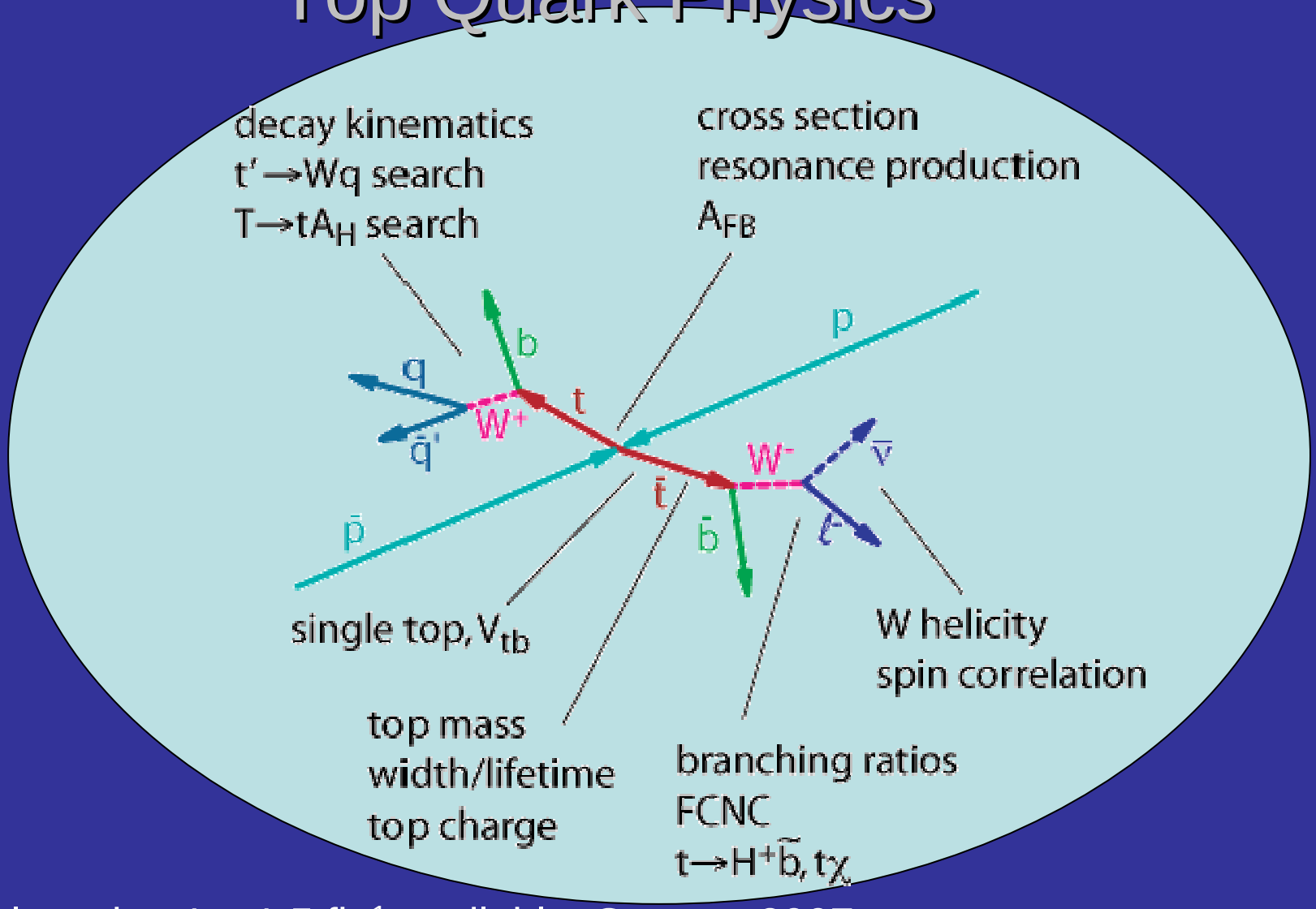
Improvements: Demonstrated 1.5-2.5 increase in sensitivity

- NN/ME discriminants
- extended lepton acceptance
- NN b-tagger
- include (yet) unused triggers

7 fb^{-1}:

- exclude all masses <188 GeV at 2σ
- 3σ sensitivity in [150-170] GeV

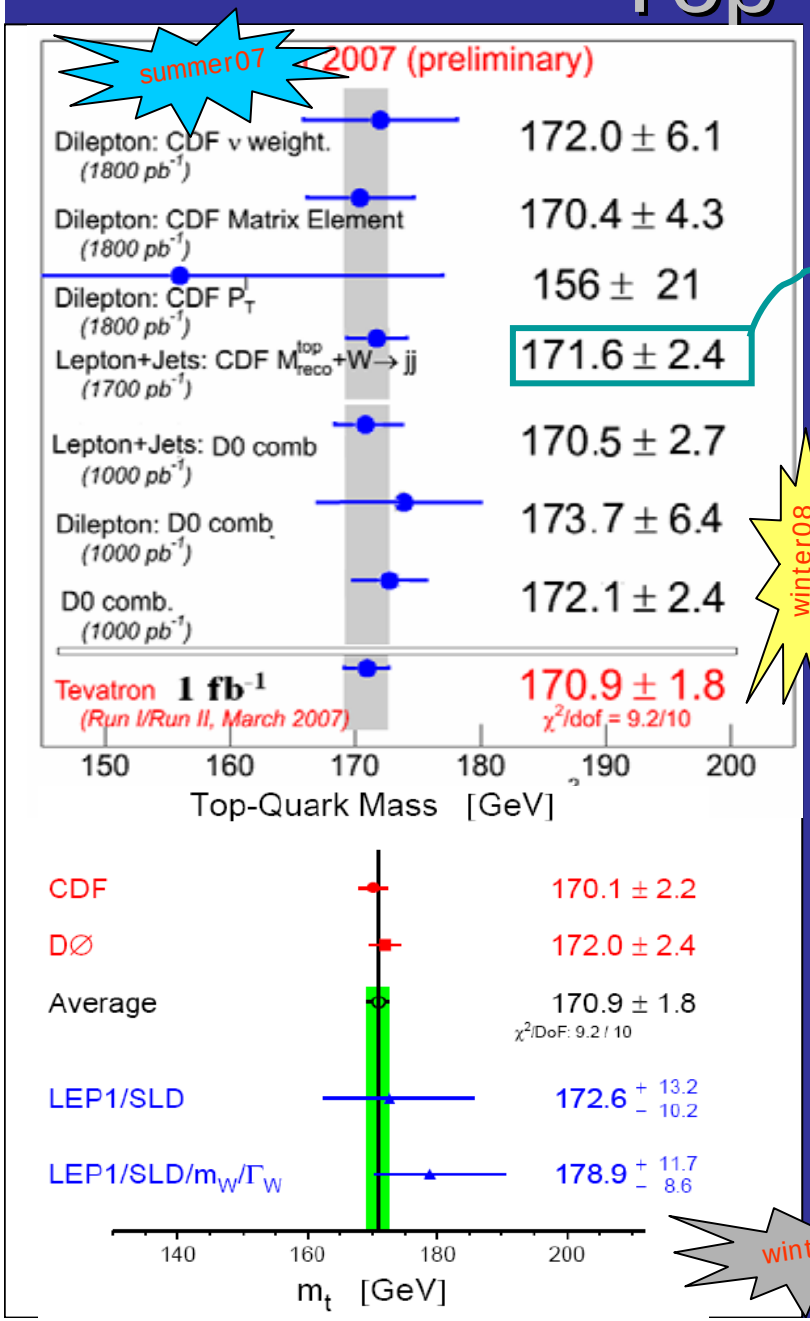
Top Quark Physics



~30 results using 1 – 1.5 fb^{-1} available: Summer2007
(updating for Winter2008 using ~2.5 fb^{-1})

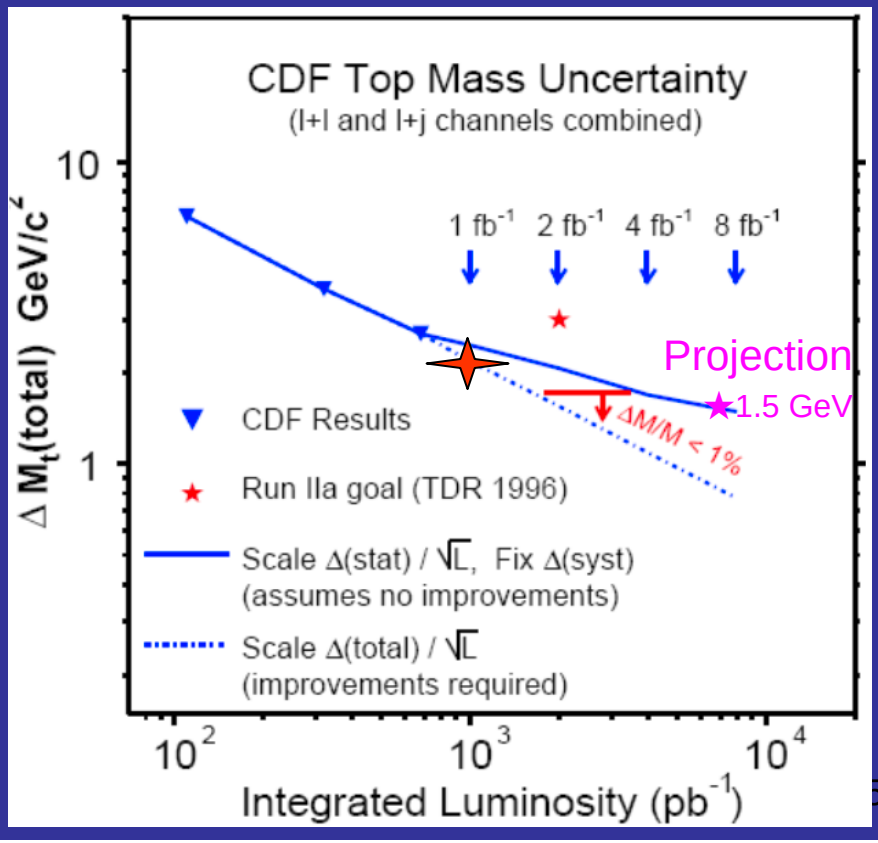
So far the data are consistent with SM

Top Quark Mass

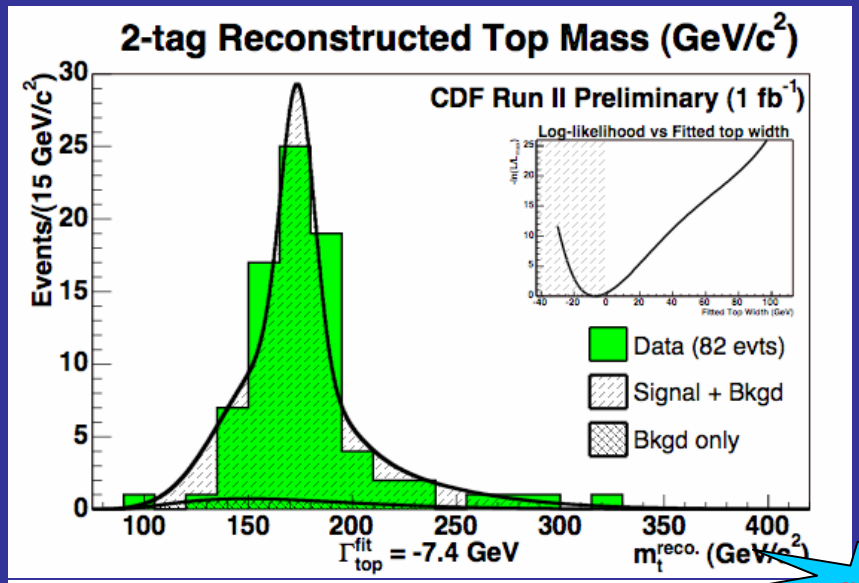


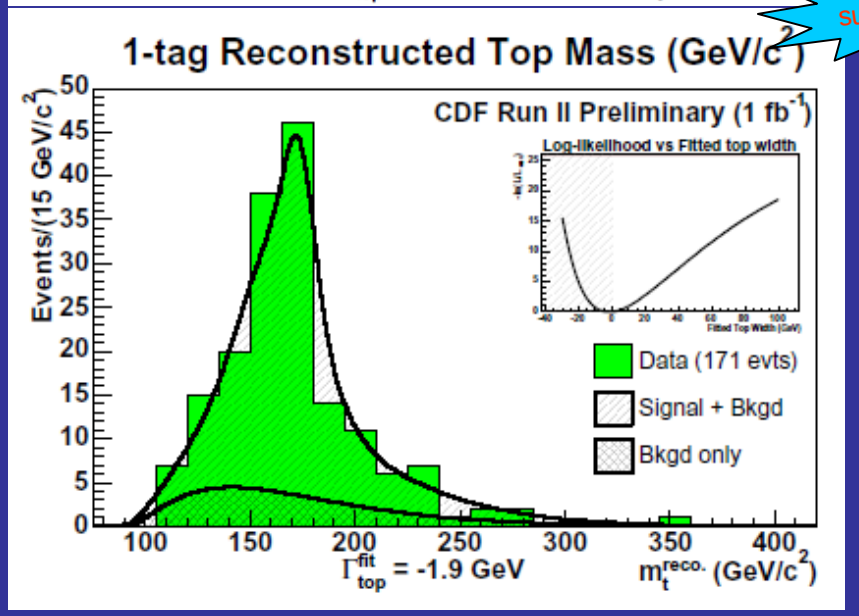
Systematics GeV/c²
In CDF Lepton+Jets

b-jet energy scale	0.6
Residual JES	0.6
Background JES	0.4
ISR	0.4
FSR	0.2
Parton Distribution Functions	0.2
Generators	0.3
Background Shape	0.2
Background composition	0.2
QCD modeling	0.1
Monte Carlo statistics	0.1
TOTAL	1.1



Top Quark Width





$\Gamma_t < 12.7\text{GeV}$ @ 95% CL

$M_t = 175$ GeV

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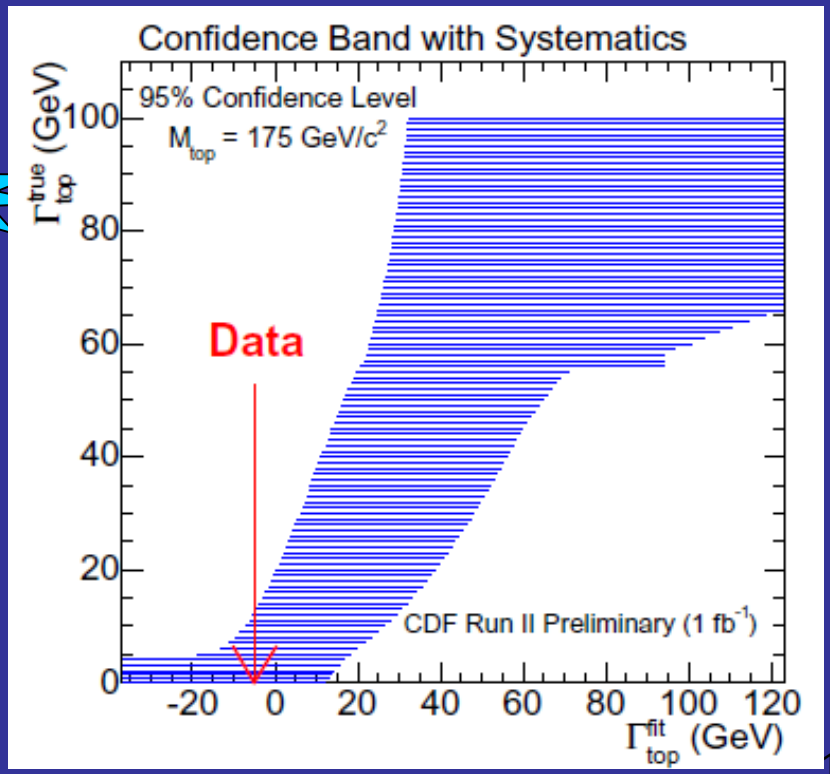
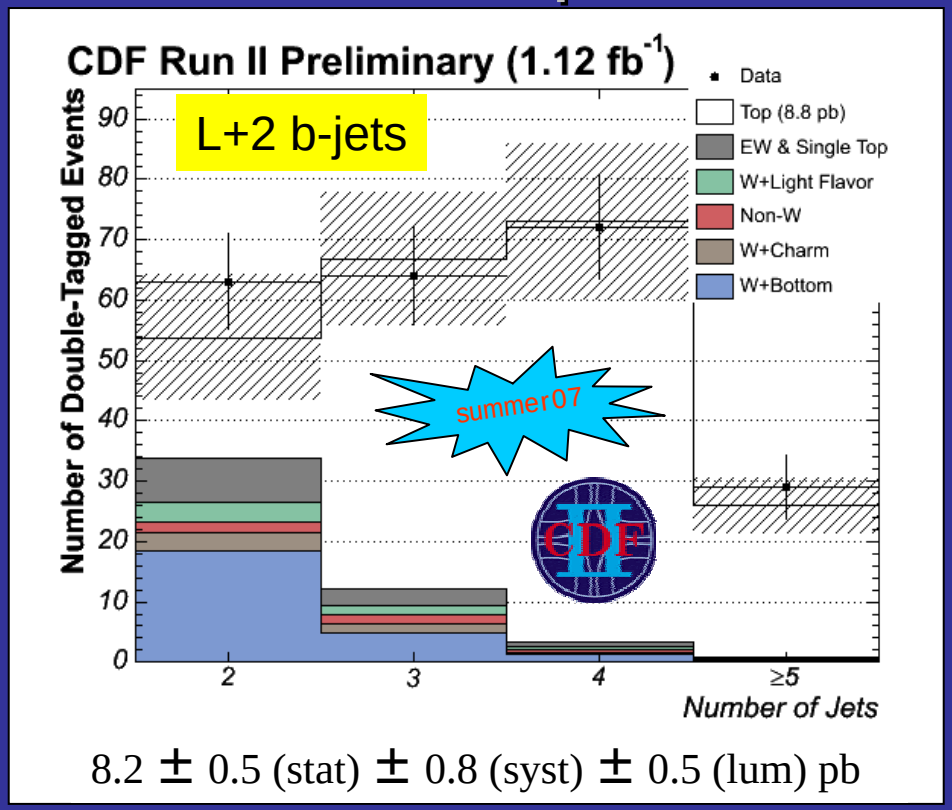
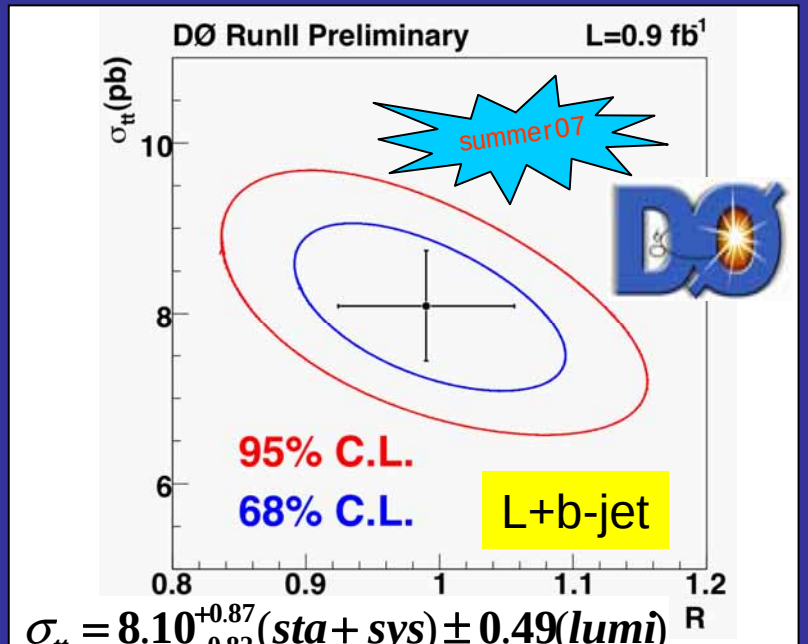


Top Cross Section and R



8.2 ± 0.5 (stat) ± 0.8 (syst) ± 0.5 (lum) pb



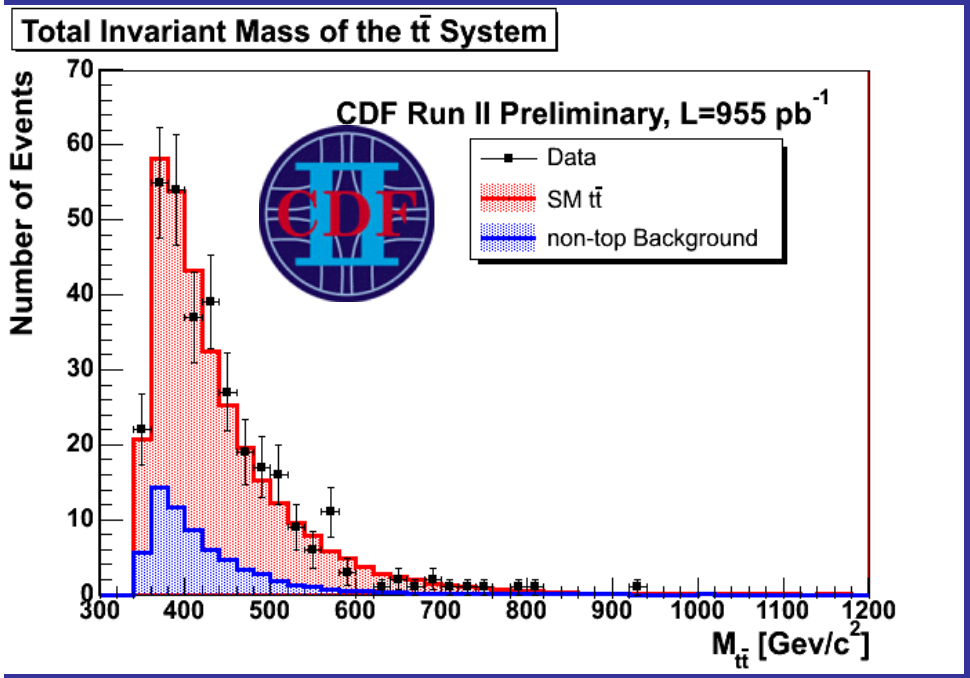
$\sigma_{tt} = 8.10^{+0.87}_{-0.82}(sta+sys) \pm 0.49(lumi)$

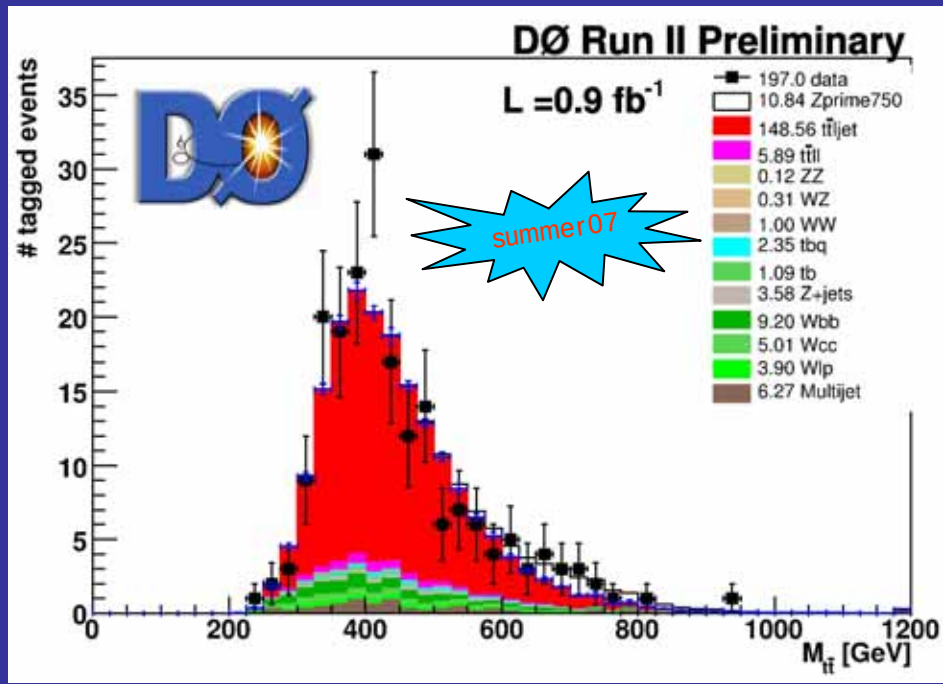
$$\sigma_{theory}(\bar{p}p \to t\bar{t}) \approx 6.7 \text{ pb}$$

$$R = \frac{BR(t \to Wb)}{BR(t \to Wq)} = |V_{tb}|^2$$

assuming 3 generations

$M_{t\bar{t}}$ and Z′

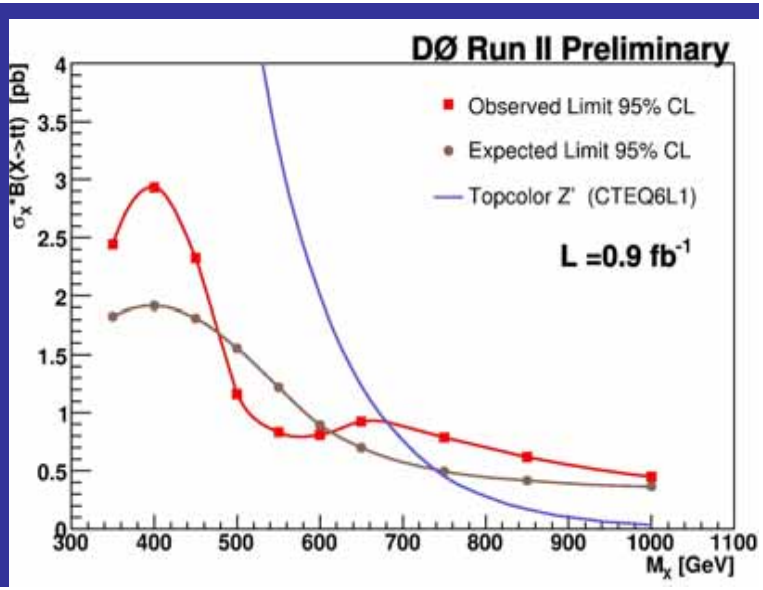




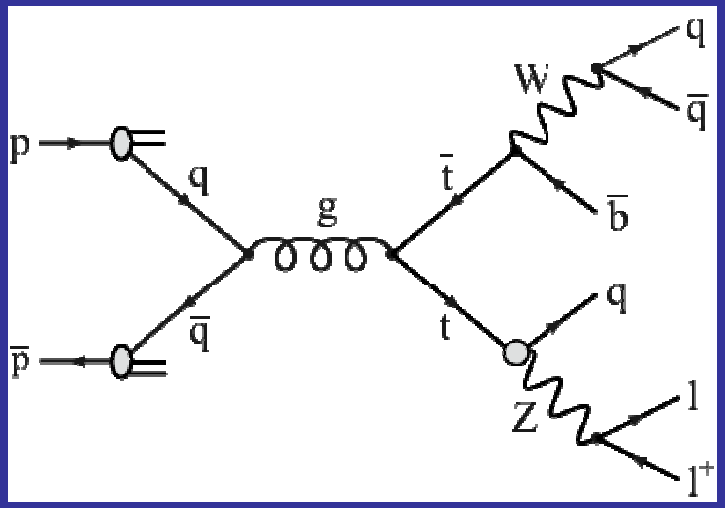
Limits on narrow tt̄ resonance production

For Technicolor leptophobic Z′
(Harris, Hill, Parke hep-ph/9911288)

CDF : $M_{Z'}$ > 720 GeV (95%CL)
D0: $M_{Z'}$ > 680 GeV (95% CL)



Top FCNC

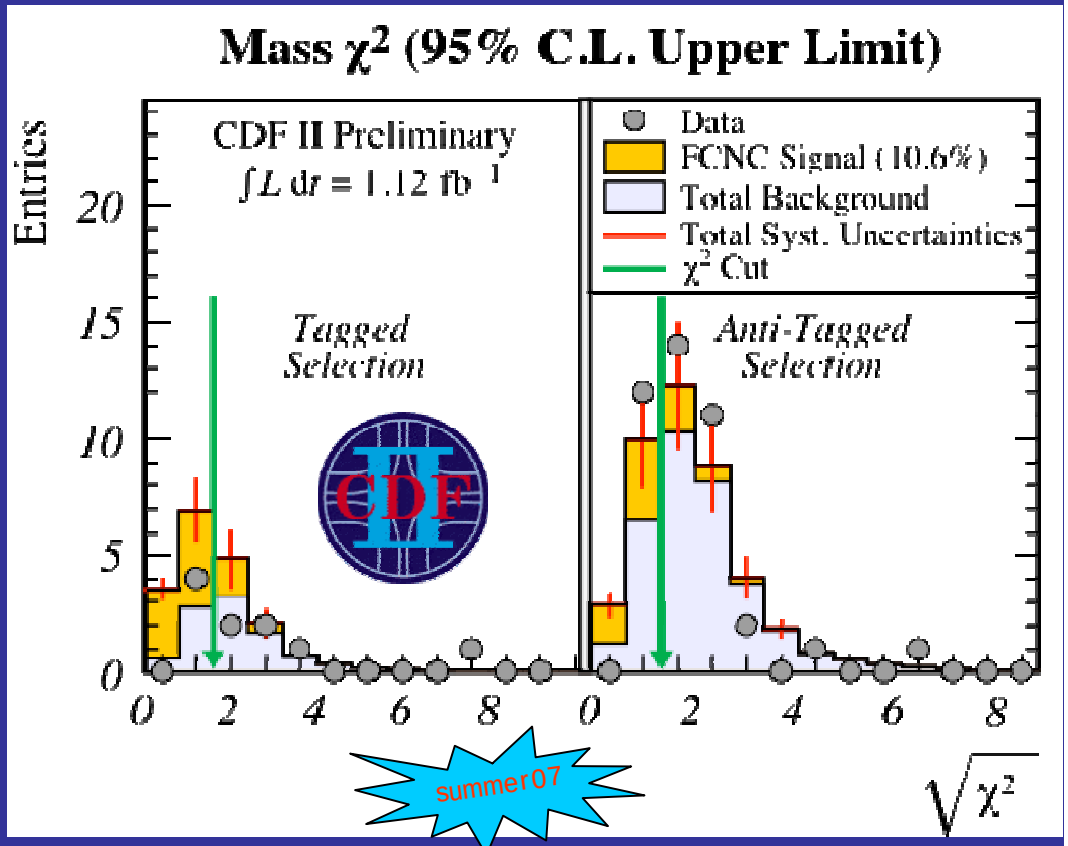


In SM BR(t→Zq) = O(10^{-14})
cf. BR(b →sγ)= O(10^{-4})
BSMs predict up to O(10^{-2})
LEP limit BR(t→Zq)<13.7%

- Z+4j events
- divide to tagged and anti-tagged selections
- calculate mass χ^2 for bkg (Z+jets, tt) suppression

CDF sees no excess in 1 fb^{-1}

$$BR(t \to Zq) < 10.6\%@95\%C.L.$$

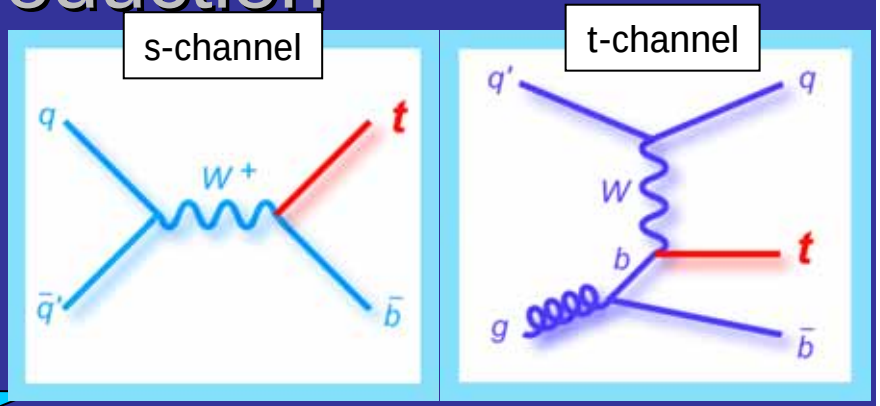


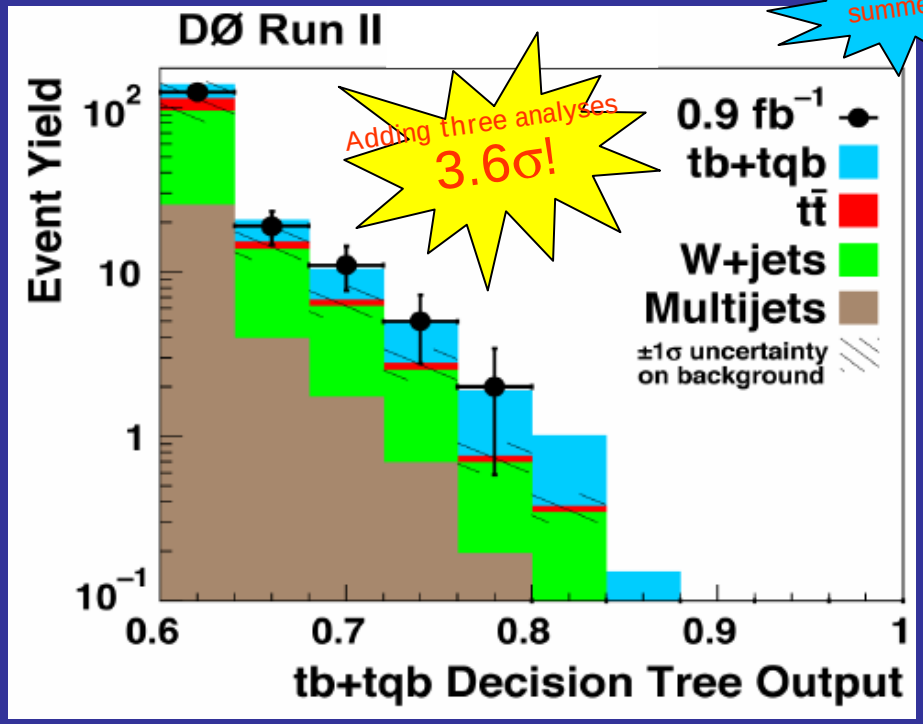
$$\chi^2 = \left(\frac{m_{W,\mathrm{rec}} - m_{W,\mathrm{PDG}}}{\sigma_{W,rec}}\right)^2 + \left(\frac{m_{t\to Wb,\mathrm{rec}} - m_{t,\mathrm{PDG}}}{\sigma_{t\to Wb}}\right)^2 + \left(\frac{m_{t\to Zq,\mathrm{rec}} - m_{t,\mathrm{PDG}}}{\sigma_{t\to Zq}}\right)^2$$

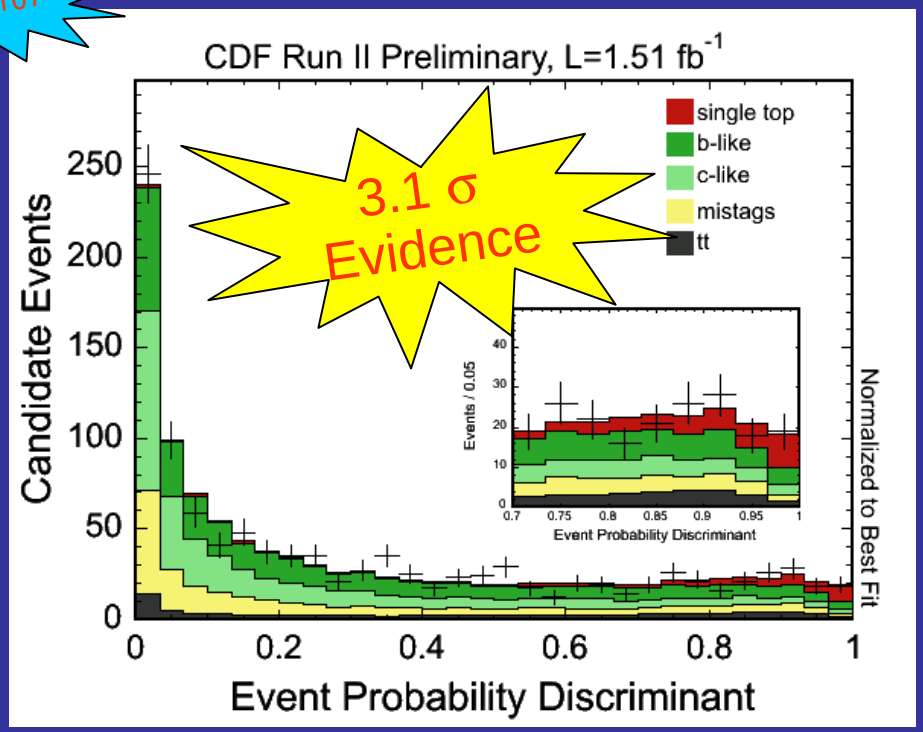
Single Top Production

$|V_{tb}| = 1.02 \pm 0.18\ (\text{expt}) \pm 0.07\ (\text{theory})$

$|V_{tb}| = 1.3 \pm 0.2$





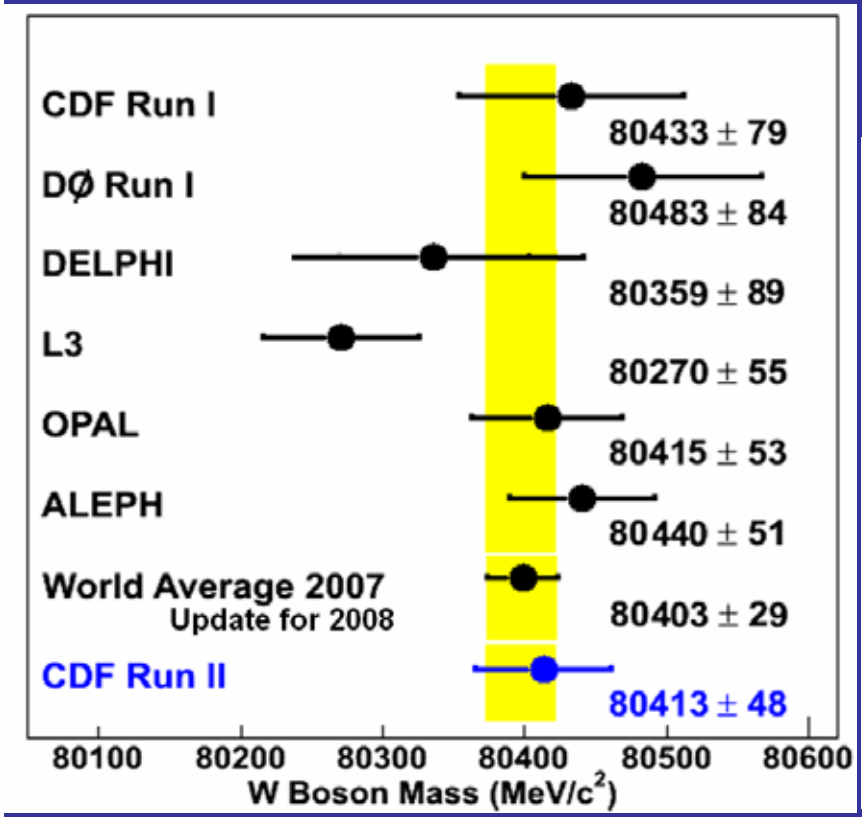


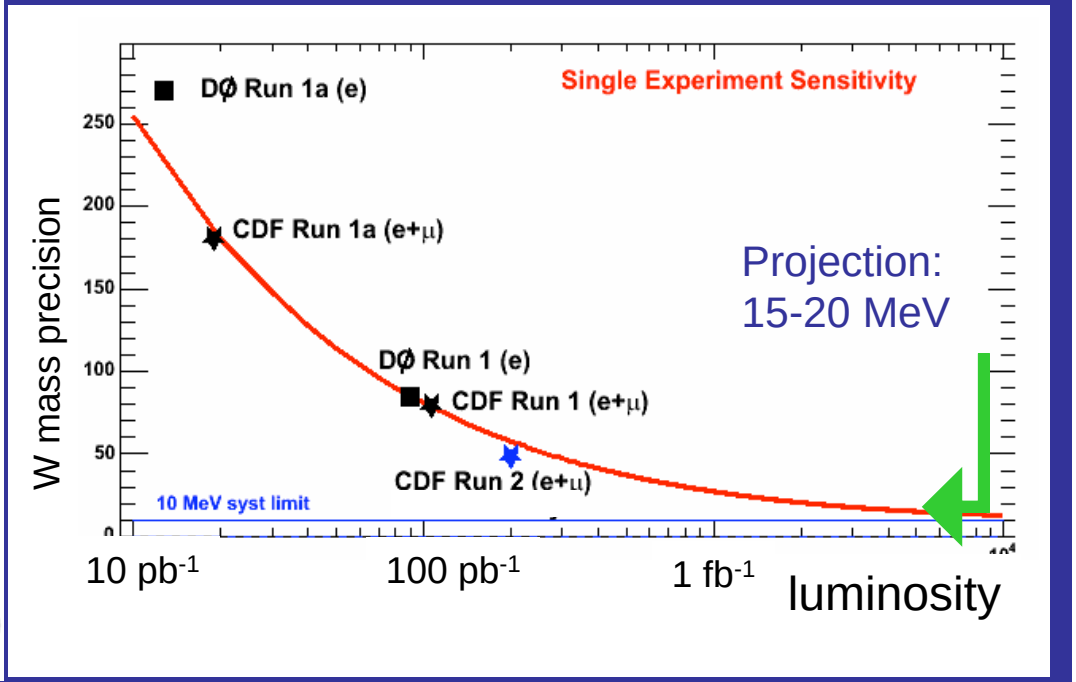
$\sigma_{s+t} = 4.7 \pm 1.3$ pb
$\sigma_s = 1.0$, $\sigma_t = 4.0$ pb

$\sigma_{s+t} = 3.0 \pm 1.2$ pb
$\sigma_s = 1.1$, $\sigma_t = 1.9$ pb

W Mass

CDF PRL paper accepted



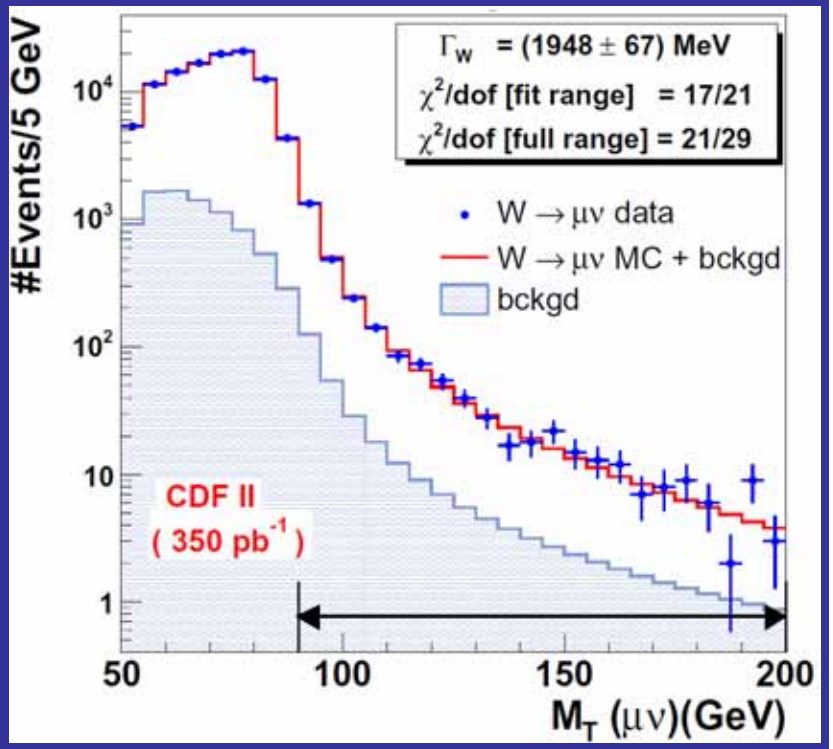


No update since 2006 summer

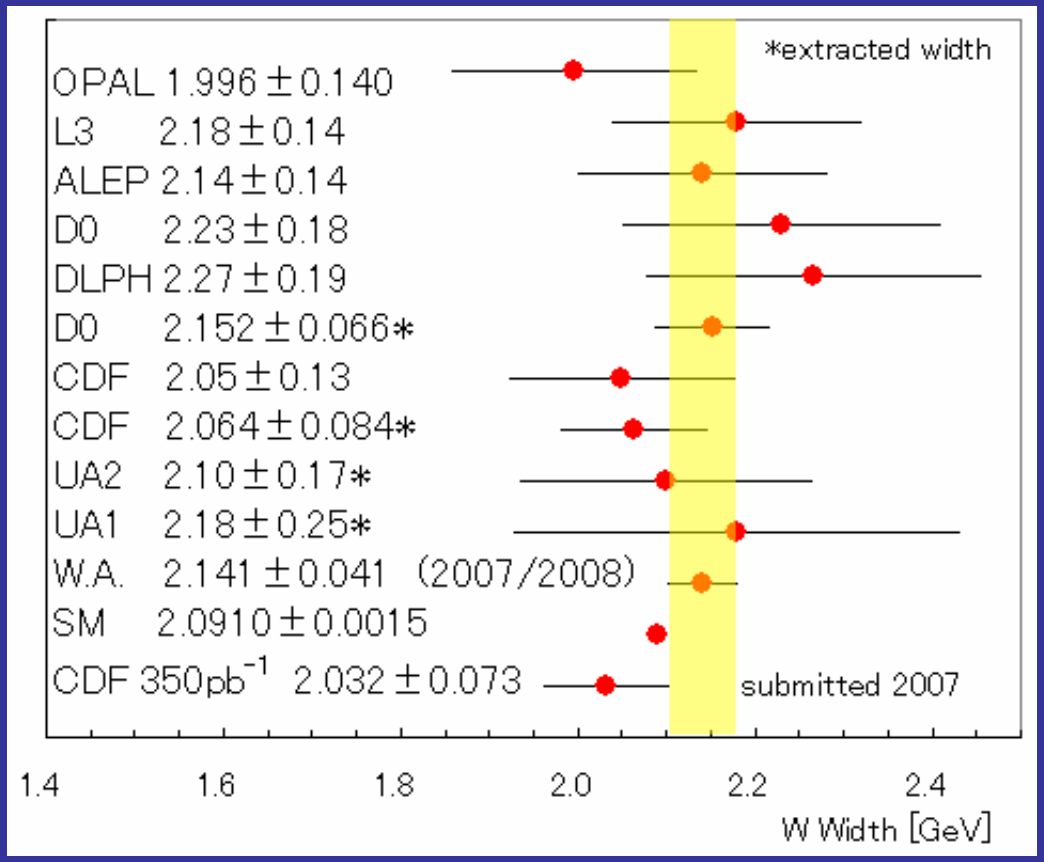
No D0 Run II result, yet

W Width

CDF PRL paper submitted



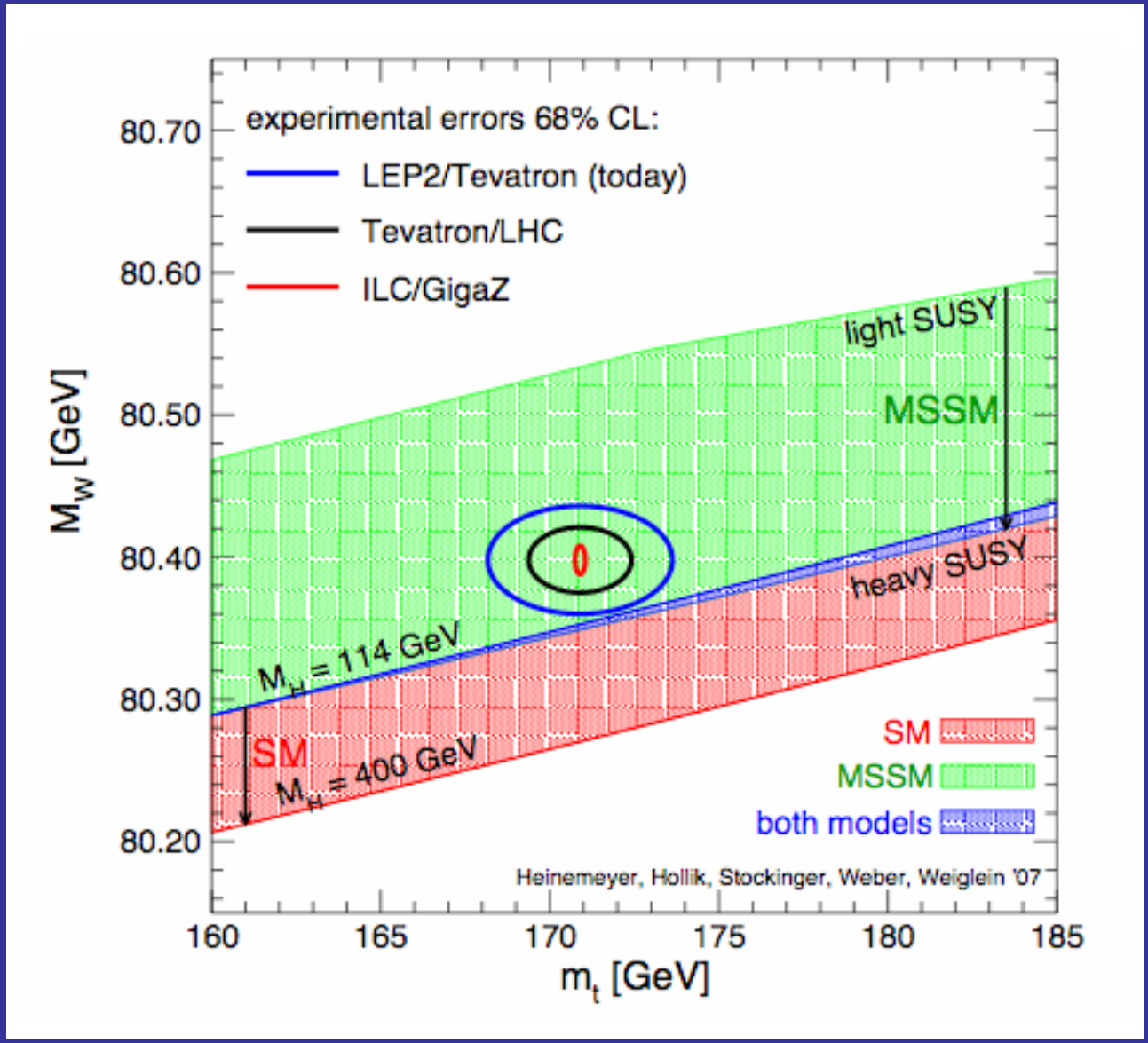
(2007 winter)



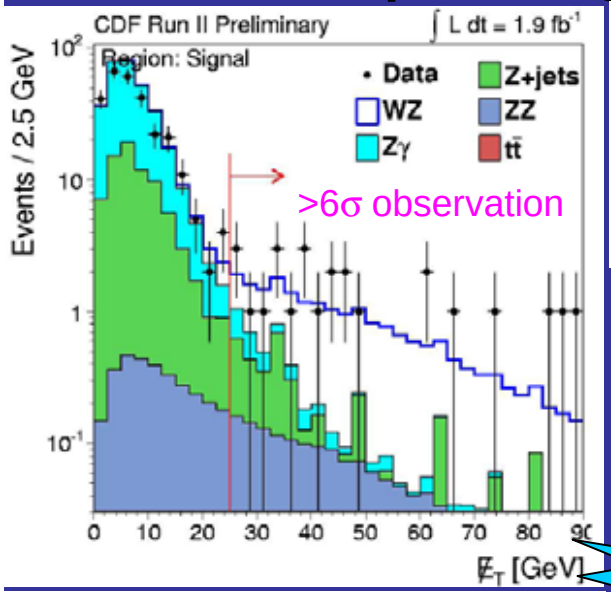
PDG 2007 and update for 2008

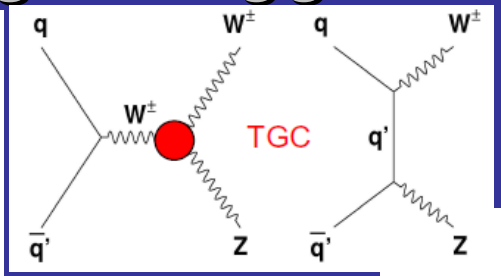
*extracted: $$R = \left[\frac{\sigma_W}{\sigma_Z}\right]\frac{[\Gamma(W \to l\nu)]/\Gamma_W}{[B(Z \to ll)]}$$

W and Top Mass in MSSM

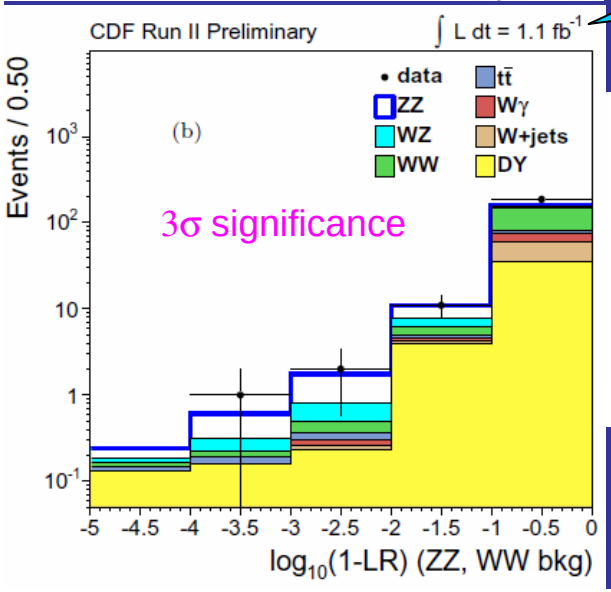


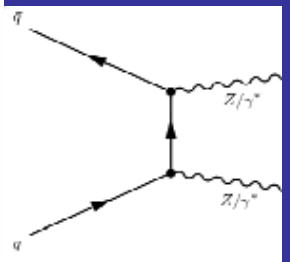
Di-boson Cross Sections: Exploring to Higgs and New Physics



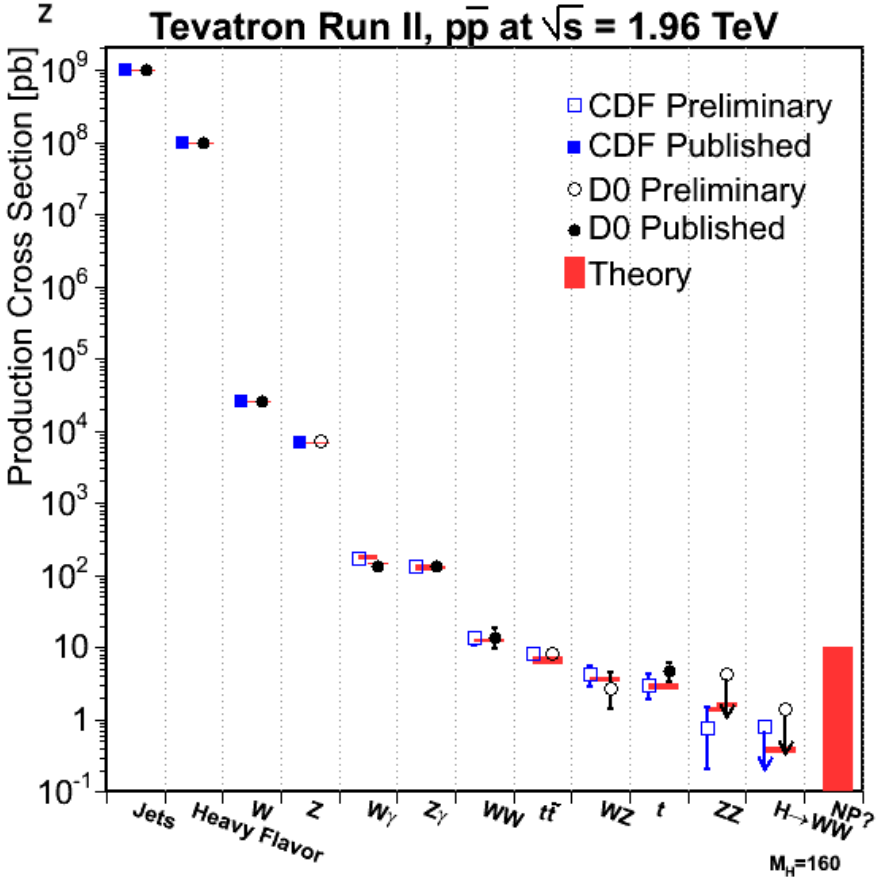


summer07

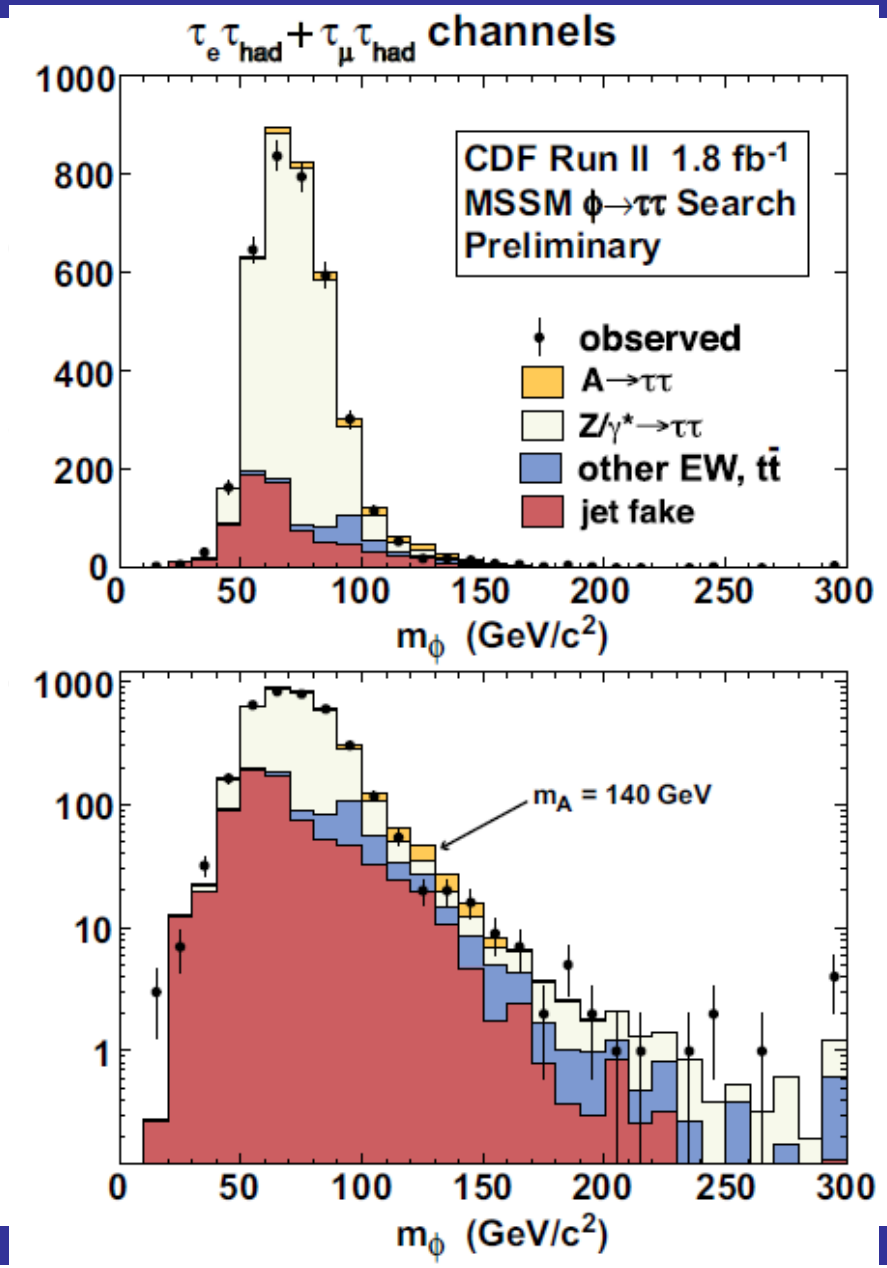


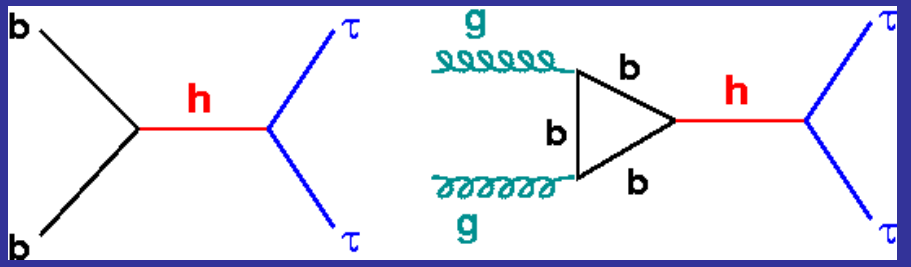


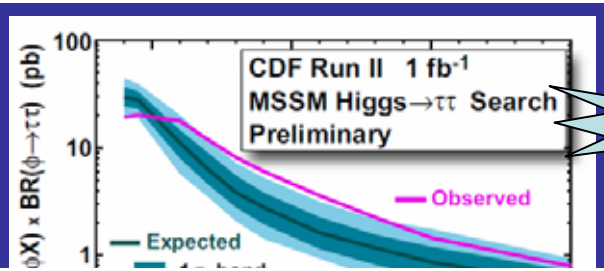
no ZZZ or ZZγ TGC



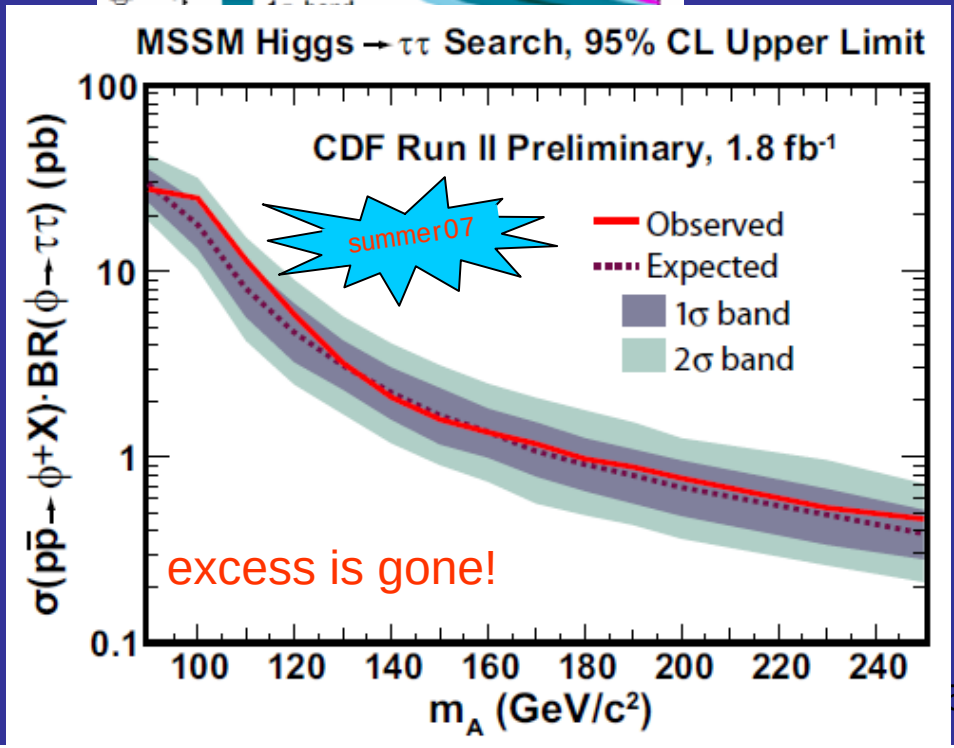
ττ channels (MSSM Higgs?)



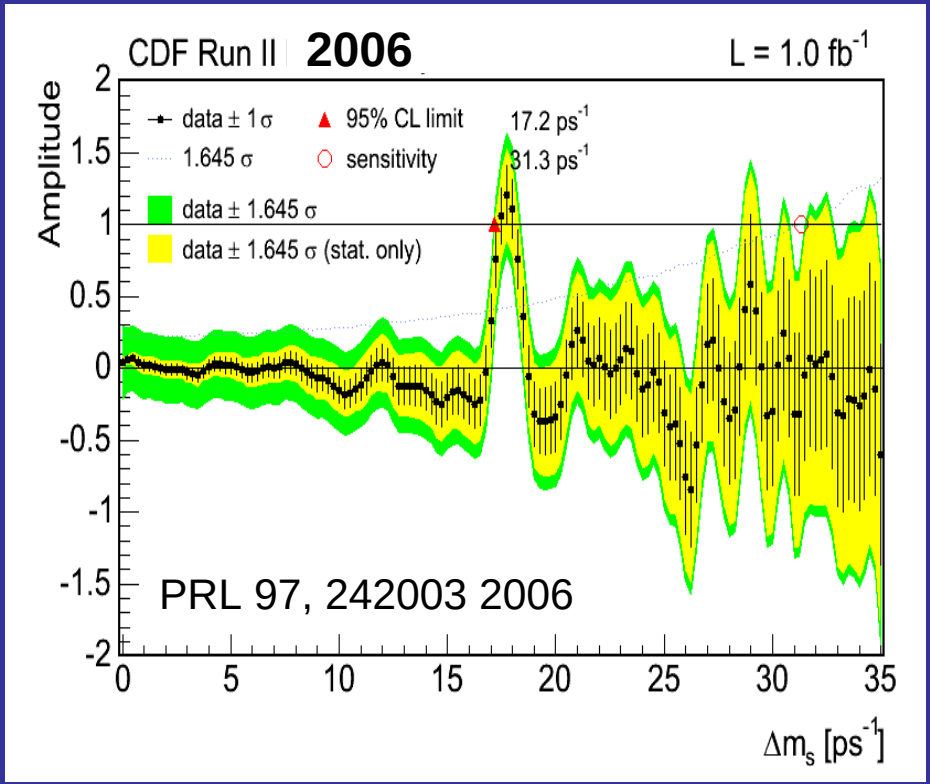


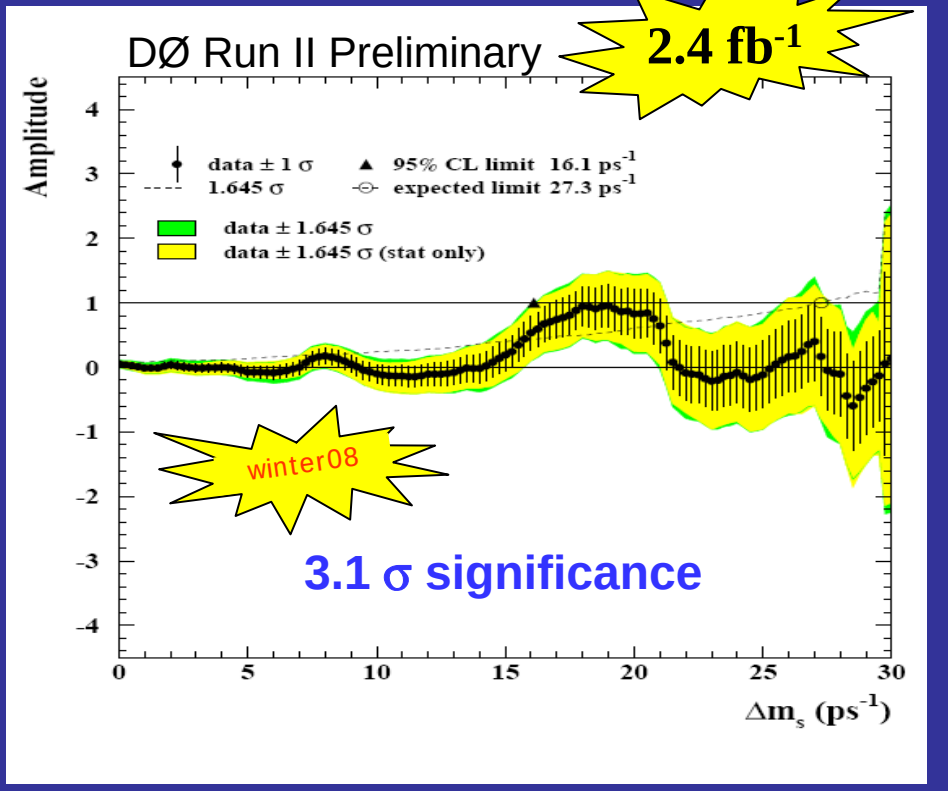


winter07



B_s Mixing and Δm_s





CDF: $\Delta m_s = 17.77 \pm 0.10\ (\text{stat}) \pm 0.07\ (\text{syst})\ \text{ps}^{-1}$

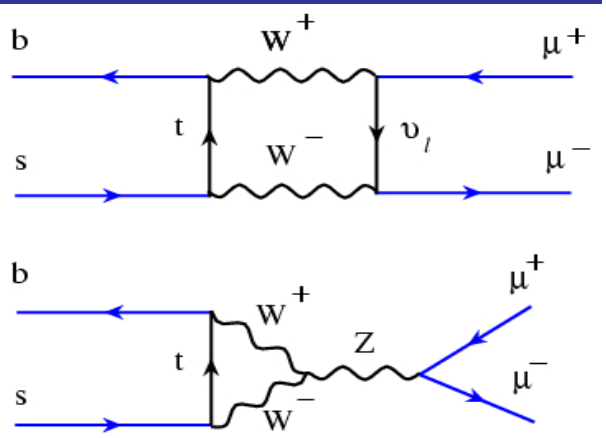
DØ: $\Delta m_s = 18.56 \pm 0.87\ \text{ps}^{-1}$

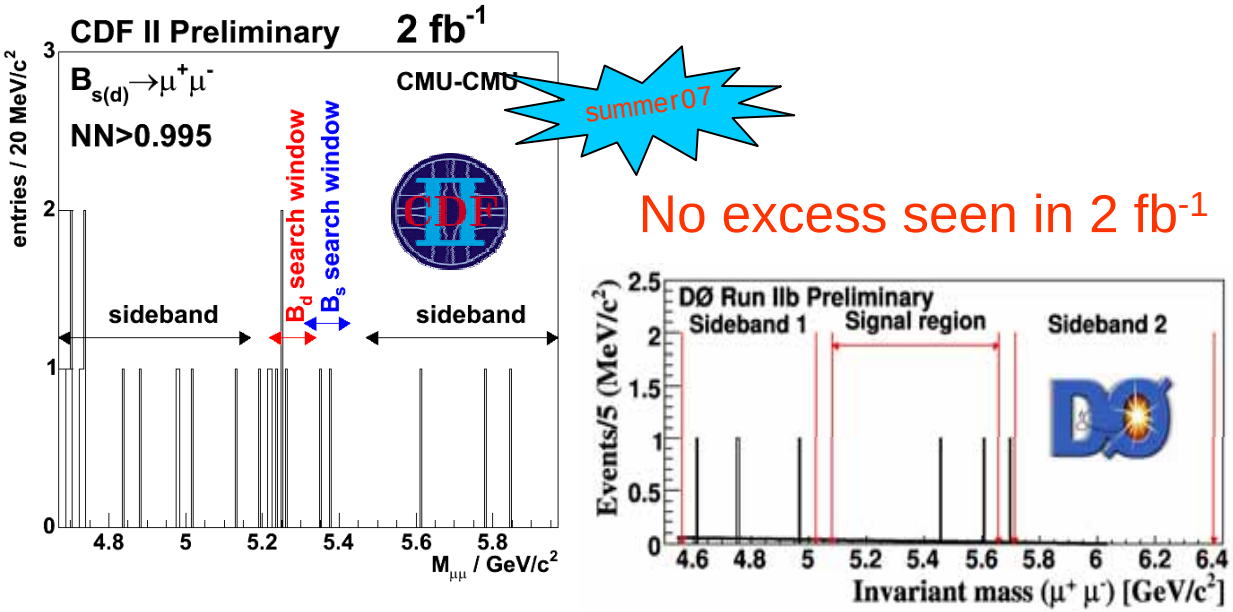
CDF: $|V_{td}/V_{ts}| = 0.2060 \pm 0.0007\ (\text{exp})\ ^{+0.0081}_{-0.0060}\ (\text{theor})$

Theoretical uncertainty ~ 10 x Experimental uncertainty

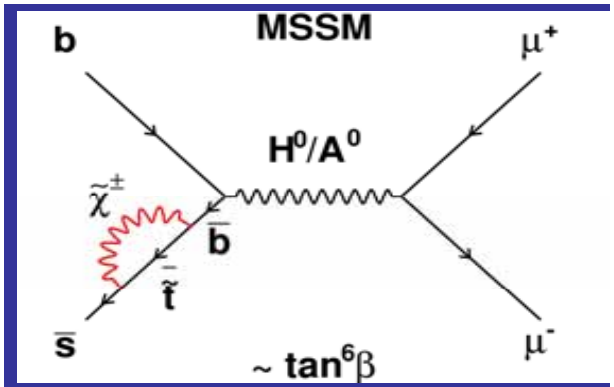
$B_s \rightarrow \mu\mu$

- In SM $B_s \rightarrow \mu\mu$ is suppressed (FCNC)
  - SM predicts $BR(B_s \rightarrow \mu^+\mu^-) \approx 3.5\times10^{-9}$
- SUSY can enhance BR (@large tanβ)





No excess seen in 2 fb^{-1}

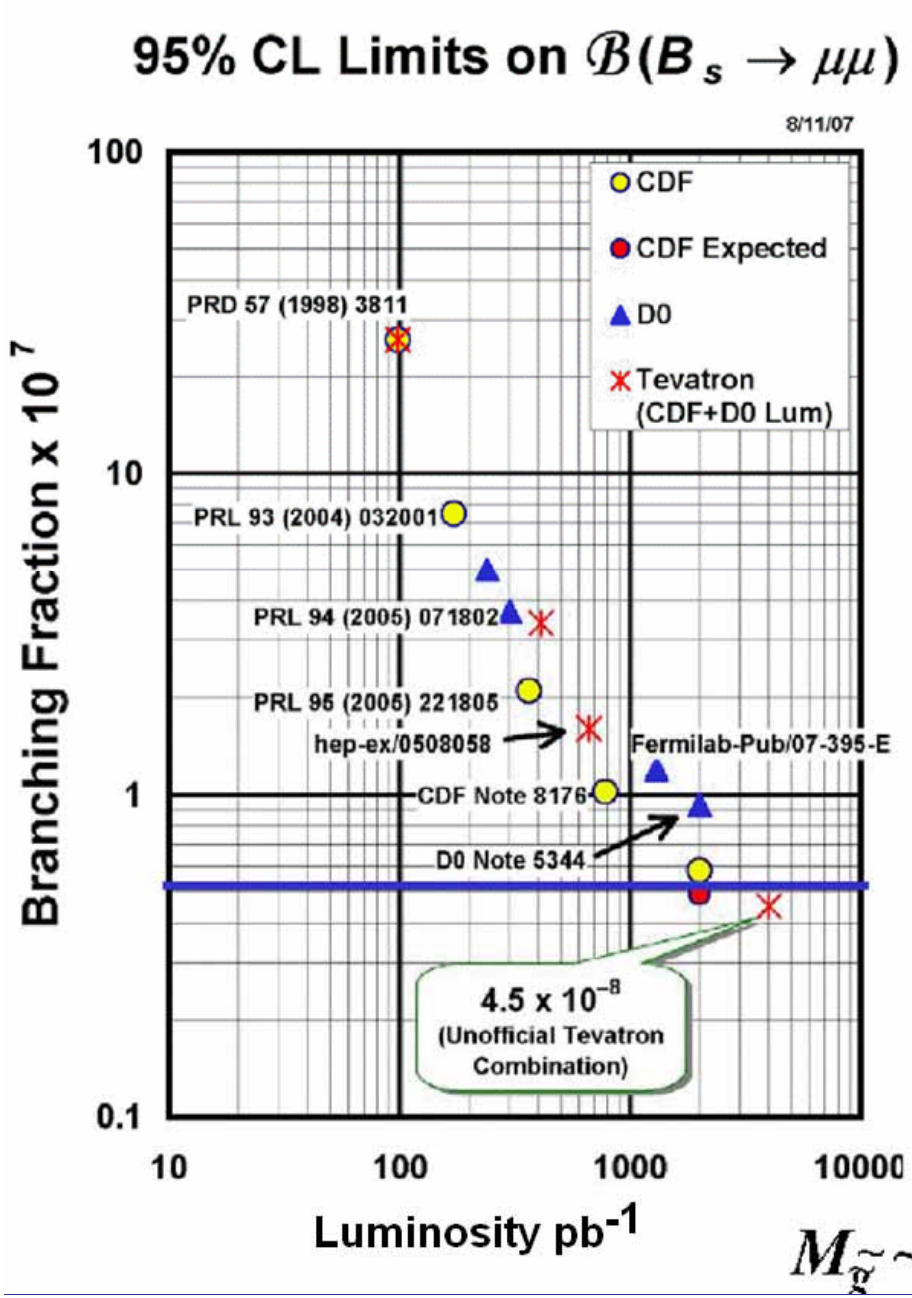


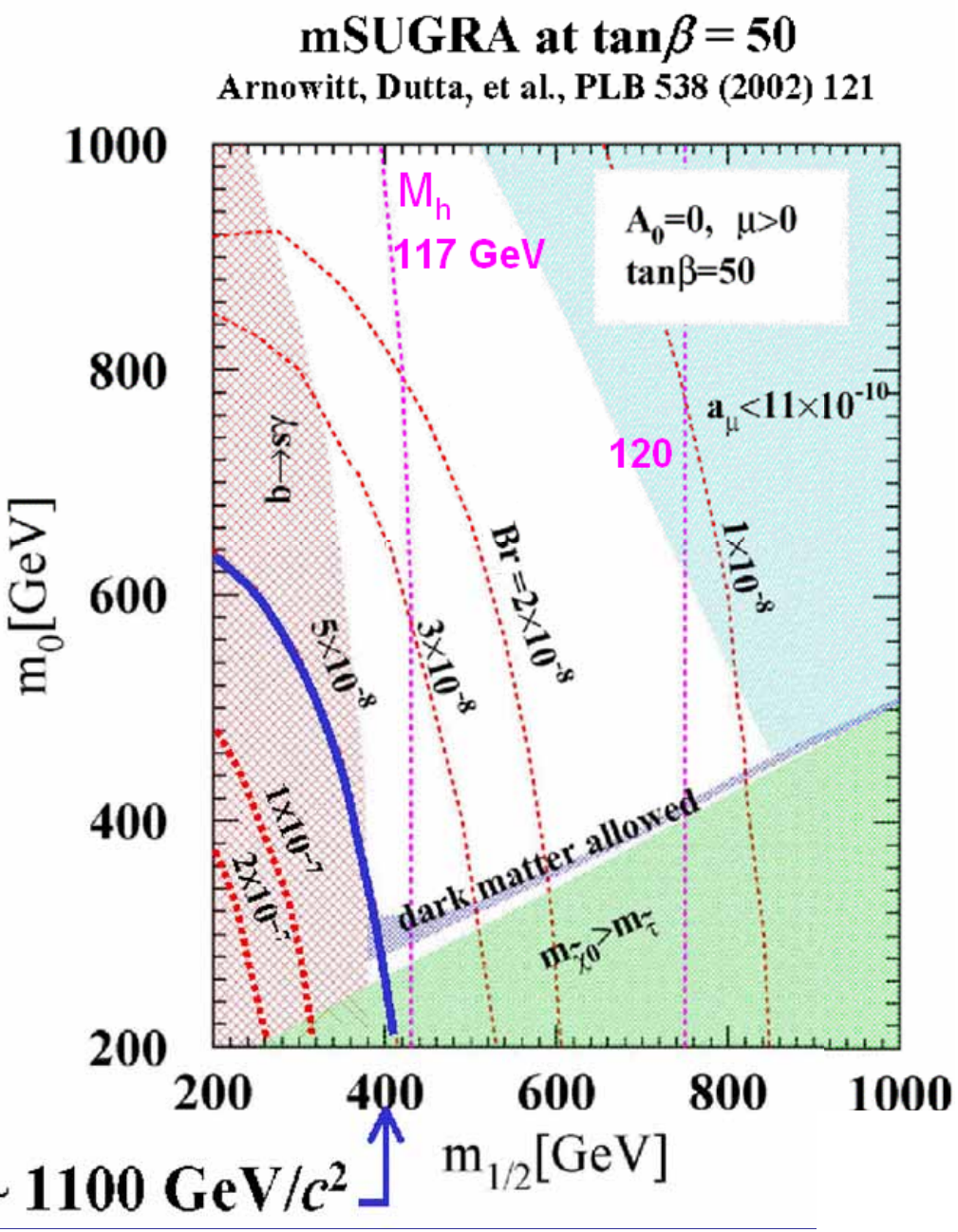
$BR(B_s \rightarrow \mu\mu) < 5.8\times10^{-8}$

$BR(B_s \rightarrow \mu\mu) < 9.3\times10^{-8}$

@95%C.L

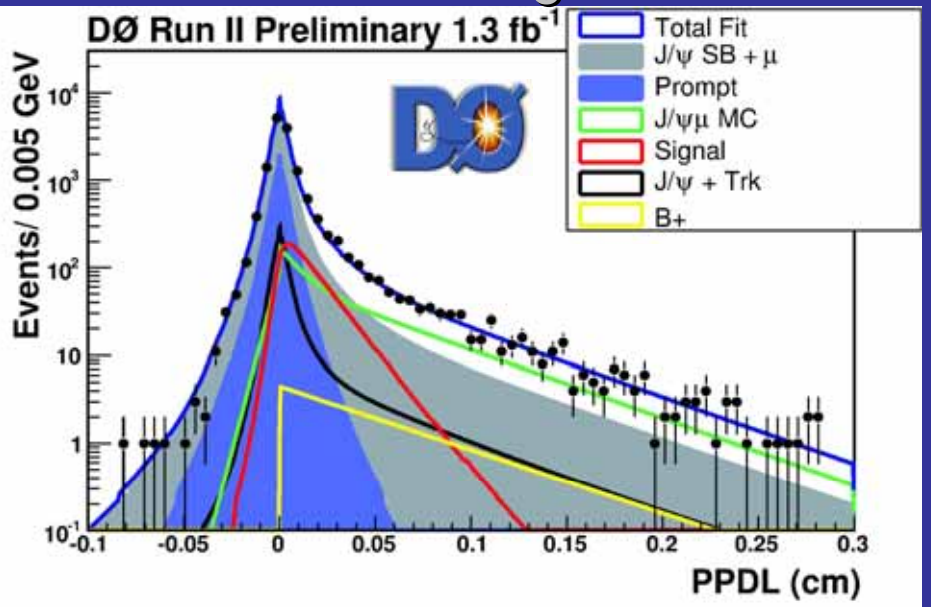
$\mathcal{B}(B_s \to \mu\mu)$ and Cosmological Connection





$M_{\tilde{g}} \sim 1100\ \text{GeV}/c^2$

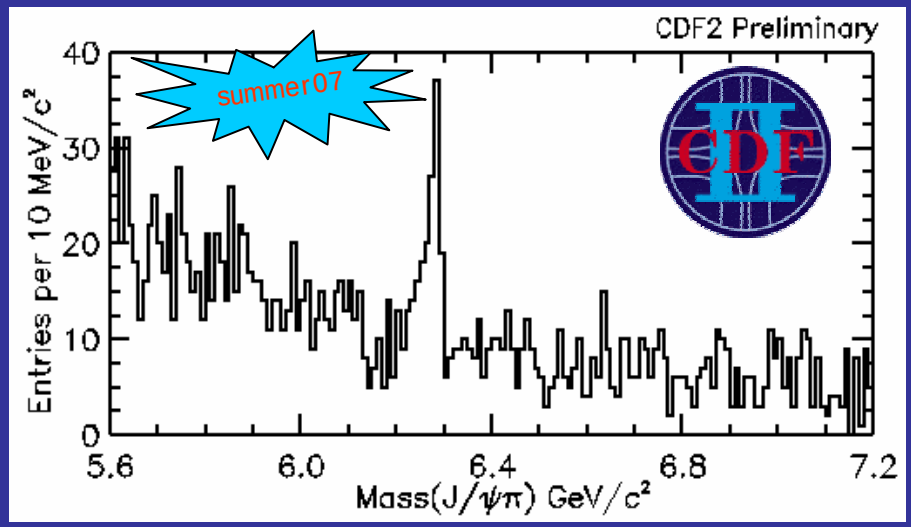
B_c Lifetime and Mass



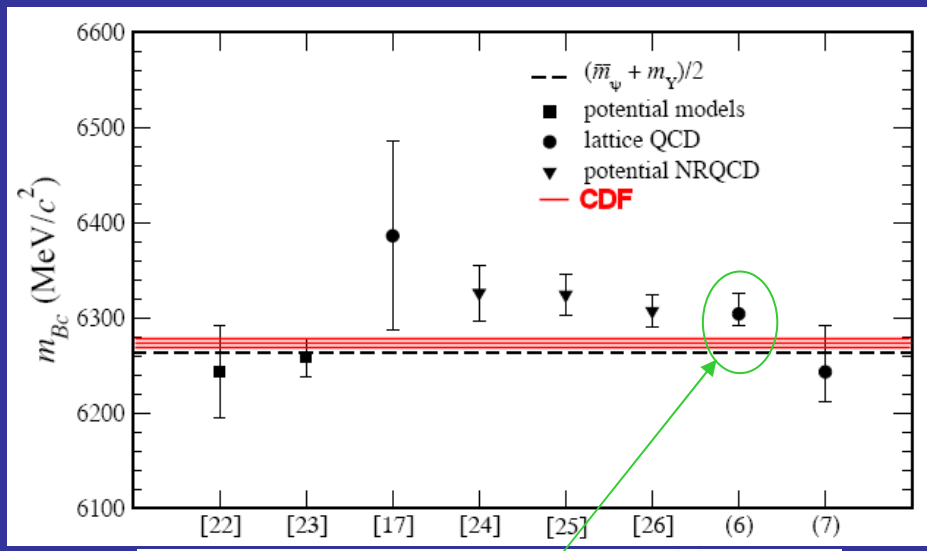
$$\tau(B_c^{\pm}) = 0.444^{+0.039}_{-0.036}\,(\text{stat})^{+0.039}_{-0.034}\,(\text{sys})\ \text{ps}$$

Theory: 0.48 ± 0.05 ps
V. Kiselev hep-ph/0308214

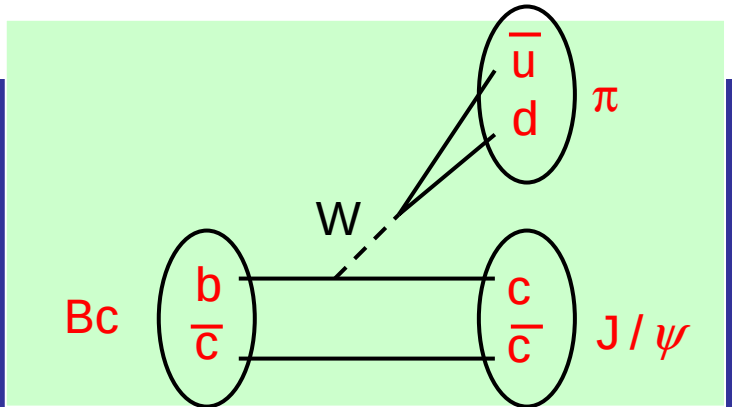
winter08



Mass(Bc) = 6274.1 ± 3.2 ± 2.6 MeV/c²

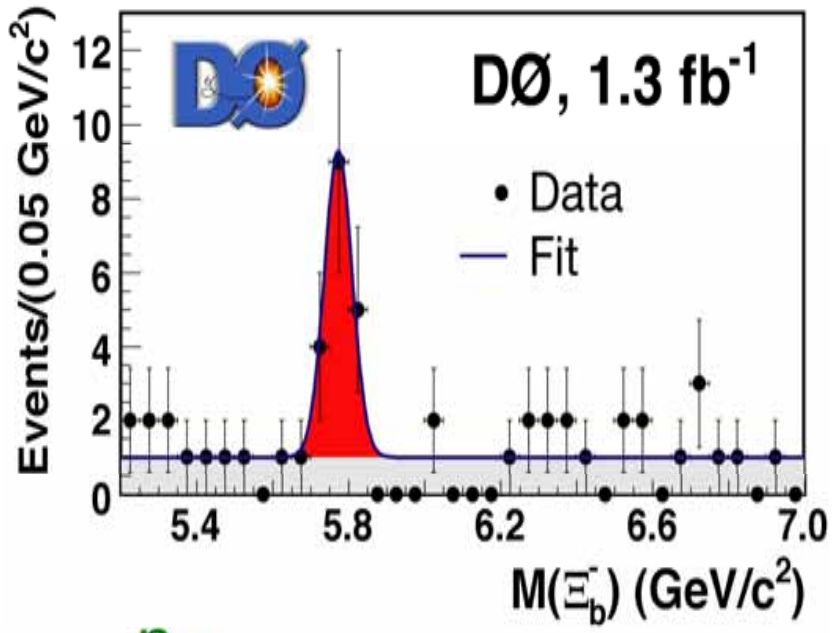


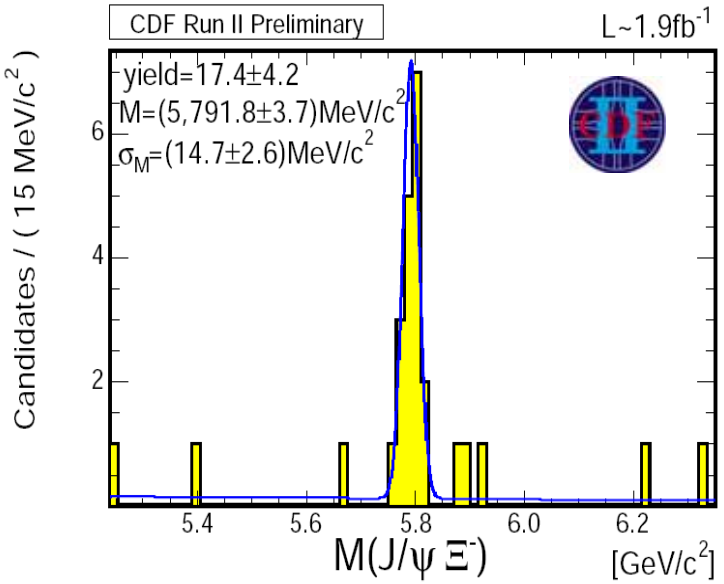
$$M(B_c^-) = 6304 \pm 12\ ^{+18}_{-0}\ \text{MeV}$$

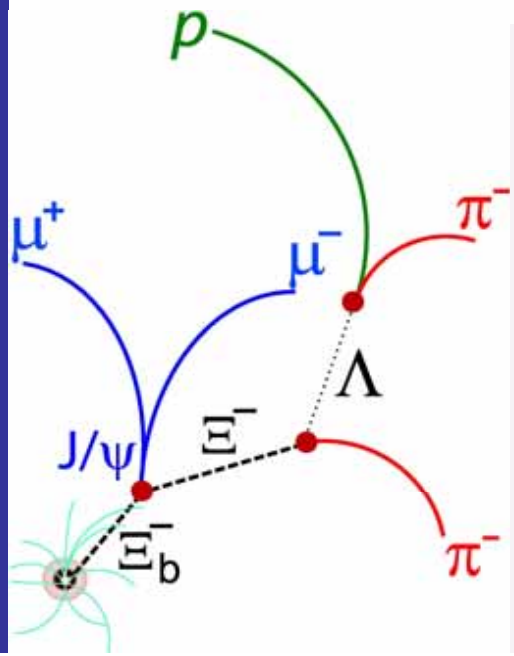


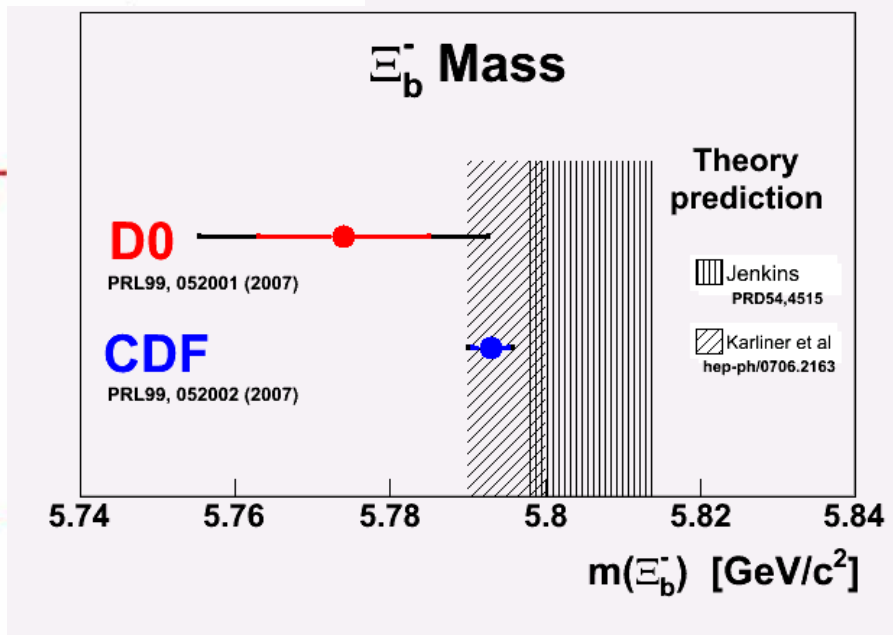
Ξ_b Discoveries

summer 07









SUMMARY

- **Approaching to the SM Higgs detection**

  3σ evidence for Higgs of 110 GeV, 150-175 GeV

  or, exclude Higgs <190 GeV

  with further analysis improvements and luminosity reach of 7 fb^{-1}

- **Top properties are being explored. No hints of beyond the SM physics, yet.**
- **Achieved initial Run II precision goals on M_t, M_W, Δm_s Improving further.**

The Tevatron continues to provide exciting data.

Will run till 2010.