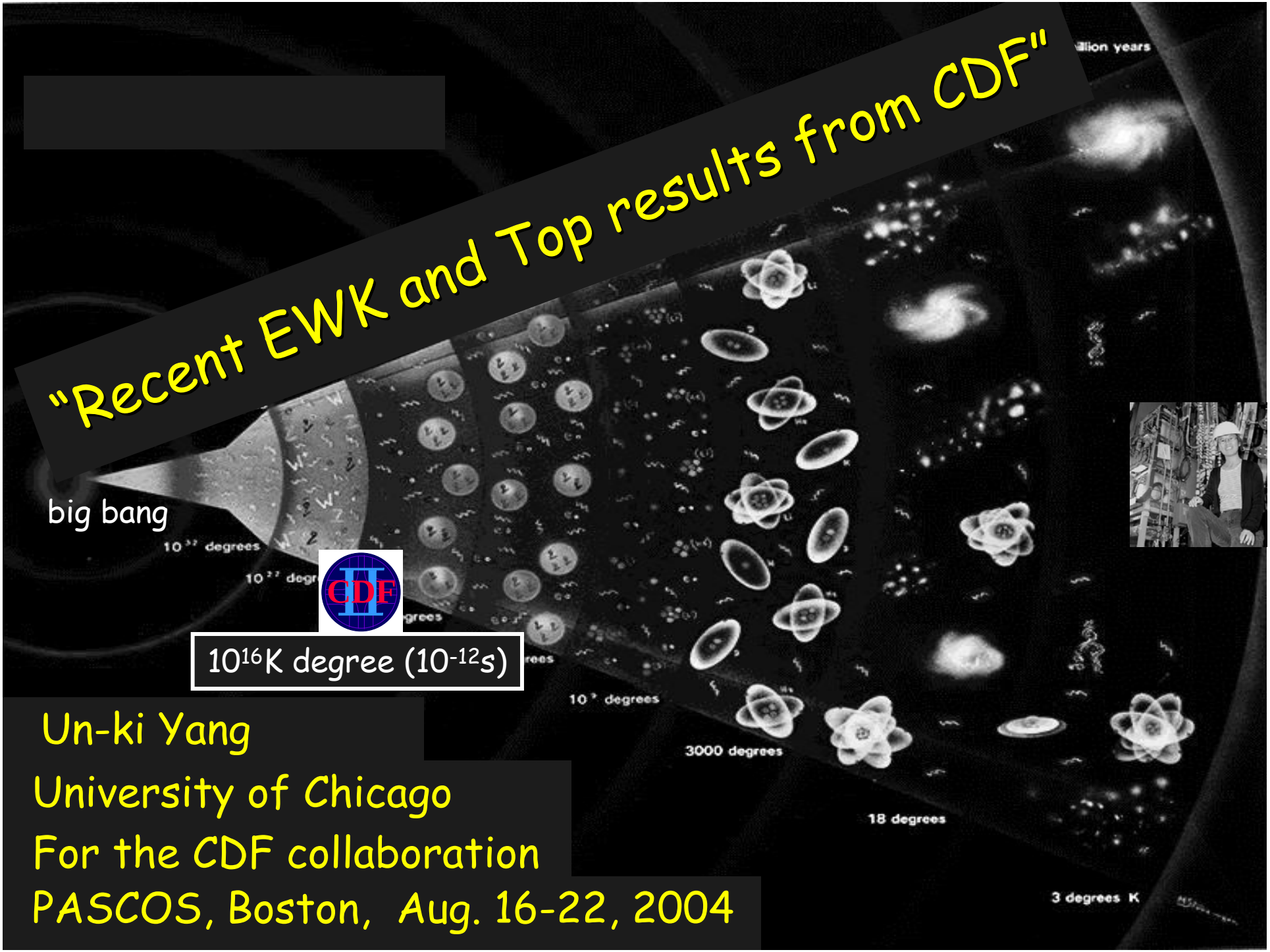
"Recent EWK and Top results from CDF"



10^{16}K degree (10^{-12}s)

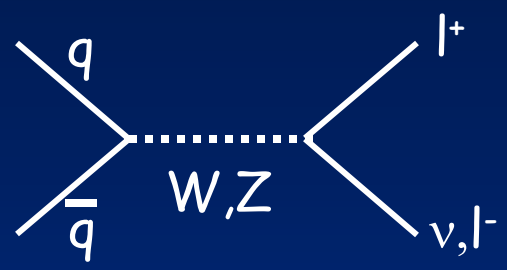
Un-ki Yang
University of Chicago
For the CDF collaboration

PASCOS, Boston, Aug. 16-22, 2004

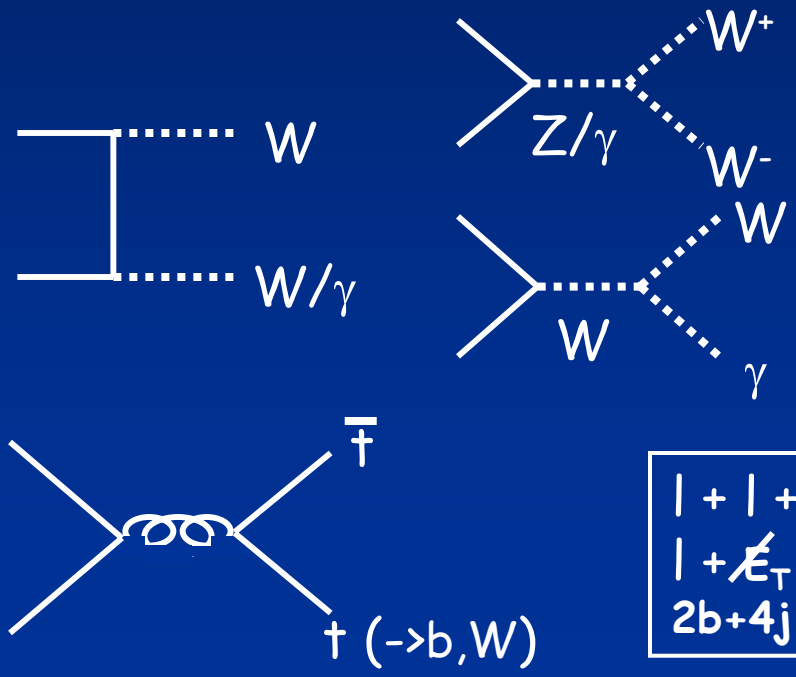
Collider Physics Program at the Tevatron

Collider spectrum

- mb → Lo-pt QCD, B physics
- nb → W, Z
  0.2Hz @ Lum=E32
- pb → Dibons, Top
- fb → Higgs, Exotics



$l + \not{E}_T (\nu)$
$l + l$



$l + l + \not{E}_T$
$l + \gamma + \not{E}_T$

$l + l + \not{E}_T + 2b$
$l + \not{E}_T + 2b + 2j$
$2b + 4j$

Evidence for beyond SM
- missing dark matter
- ν_R at very high E?

SUSY, extra-dim, GUT etc?
No clear idea where to start!

good guideline

Collider spectrum

mb → Lo-pt QCD
B physics

nb → W, Z → $l + \not{E}_T (\nu)$, $l + l$

0.2Hz @ Lum=E32

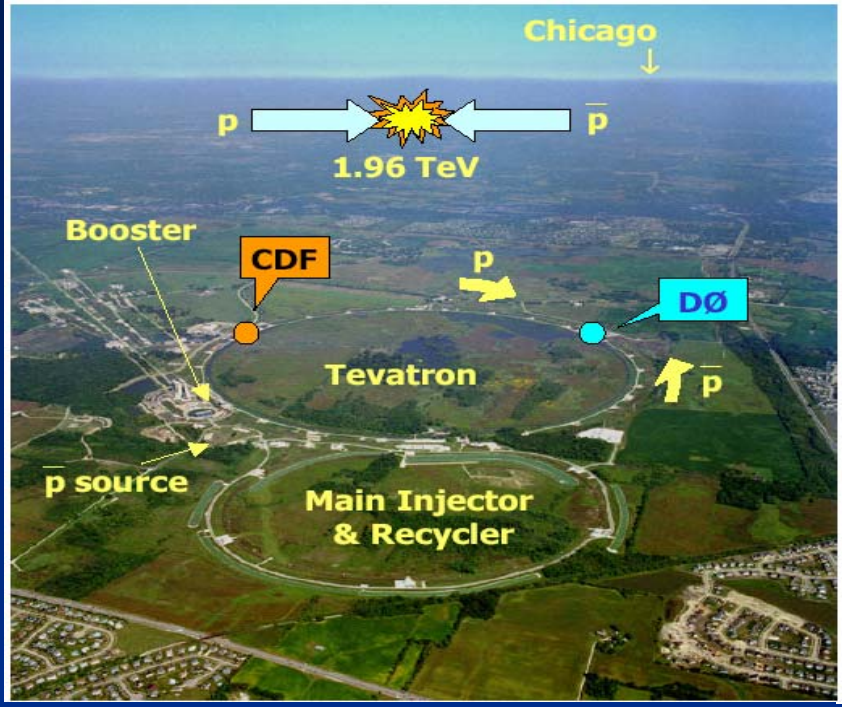
pb → Dibons
Top → $l + l + \not{E}_T$, $l + \gamma + \not{E}_T$

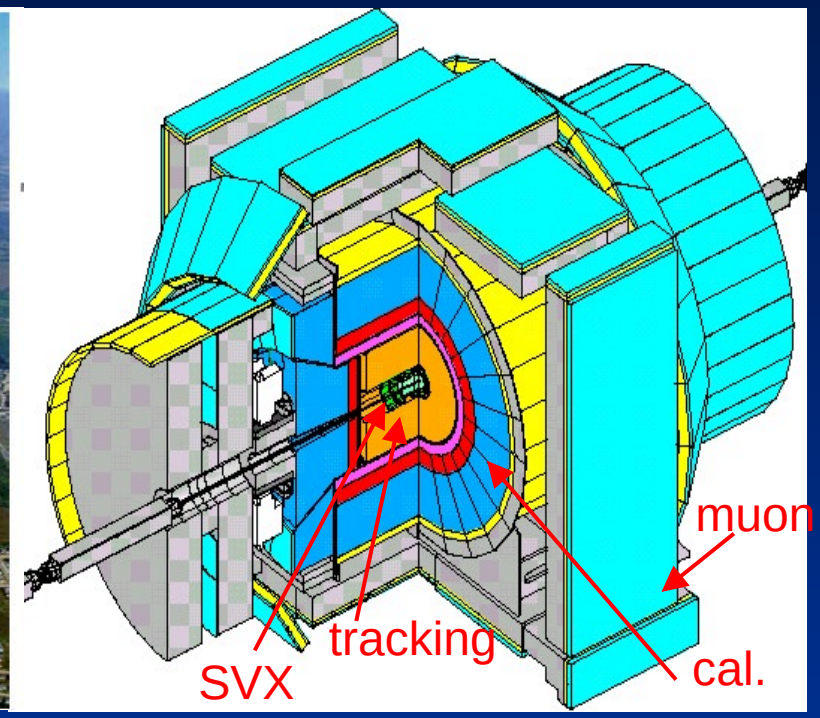
fb → Higgs
Exotics → $l + l + \not{E}_T + 2b$, $l + \not{E}_T + 2b + 2j$, $2b+4j$

D.Tsybychev's talk

- SM + non-SM
- ✓ enhance signals
- ✓ destroy SM evt property
- ➢ Explore many channels from many diff. angles

For High Energy Frontier; CDF at Fermilab

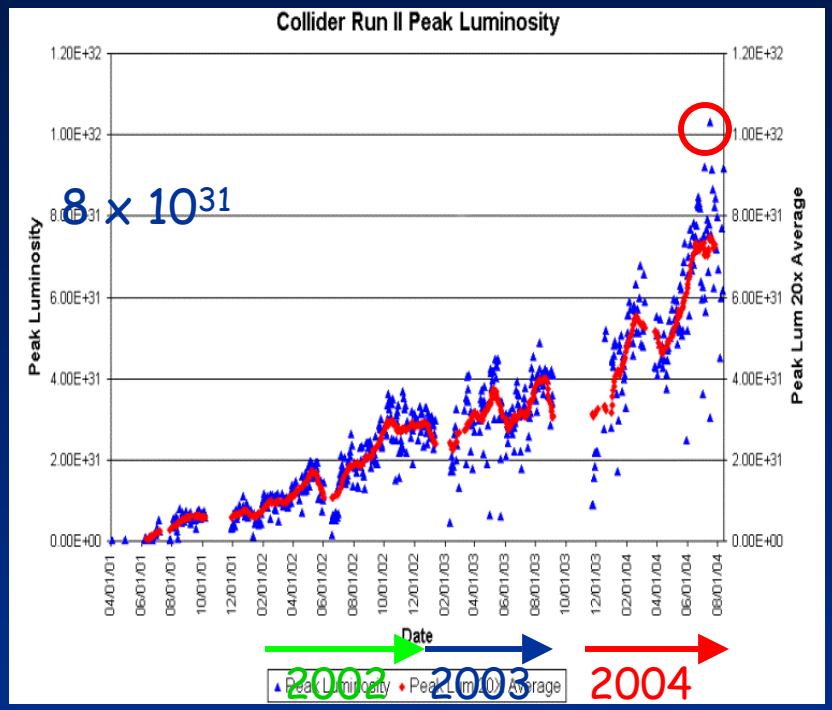


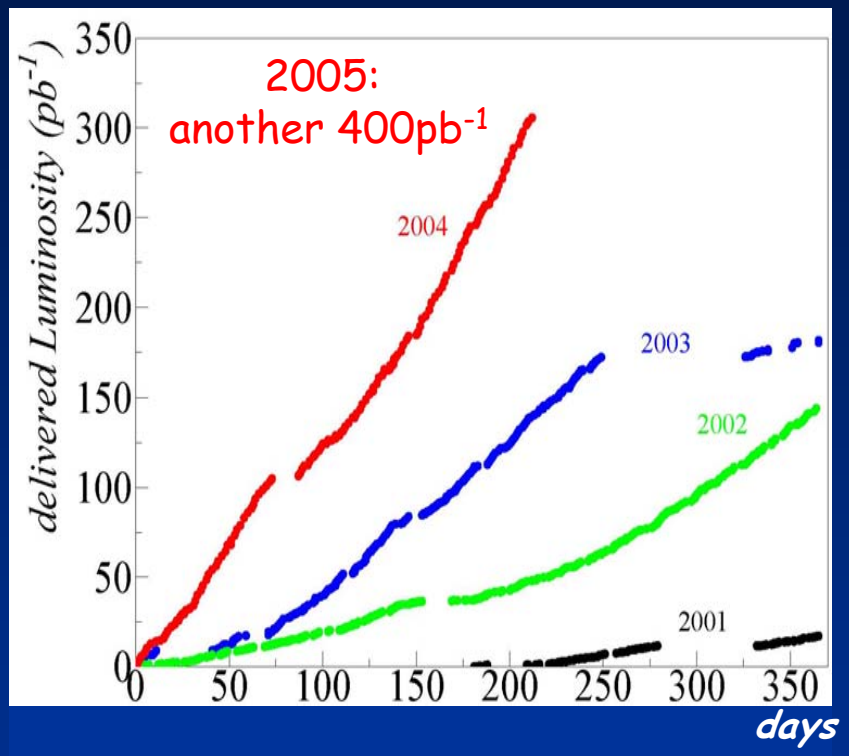


New in Run II (precision meas. and search for new physics)

- High lum. accelerator with higher beam energy (1.8 → 1.96 TeV)
- Faster detector, DAQ, and Trigger (~2M evts → write 70 evts/s)
- More coverage in SVX, muon, and calorimters
- Good identification of e,μ,τ,γ and jet

Tevatron Performace

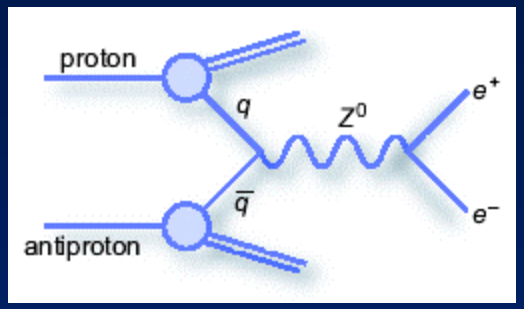


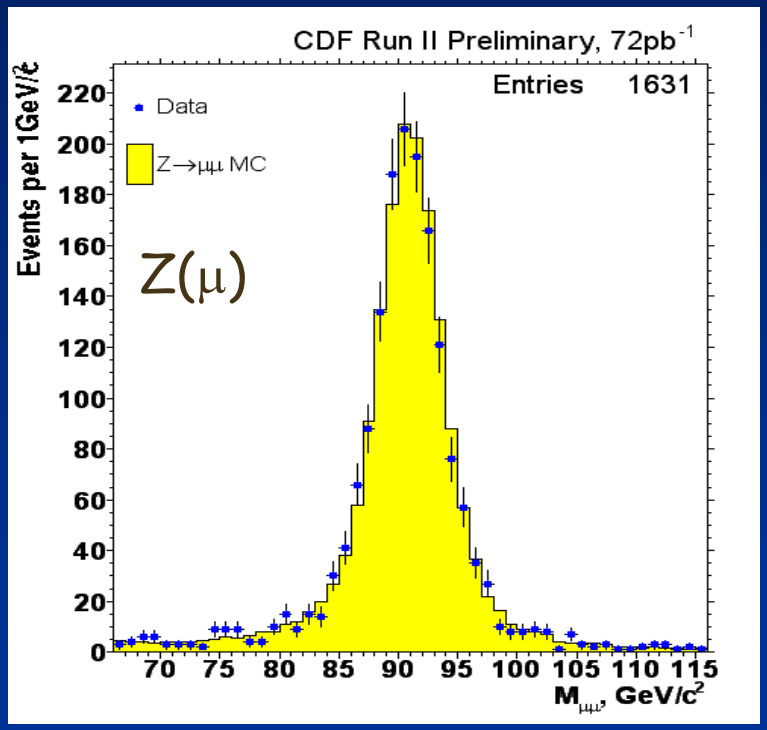


- Accelerator has been improved a lot in this year!!!
- record peak luminosity: 10.3×10^{31} cm^{-2} sec^{-1} on July 16, 2004
- Total recorded good runs: 450pb^{-1} (another 400 in 2005: ~8 x Run I)
- In this talk, results are based on ~200pb^{-1} (up to 2003)

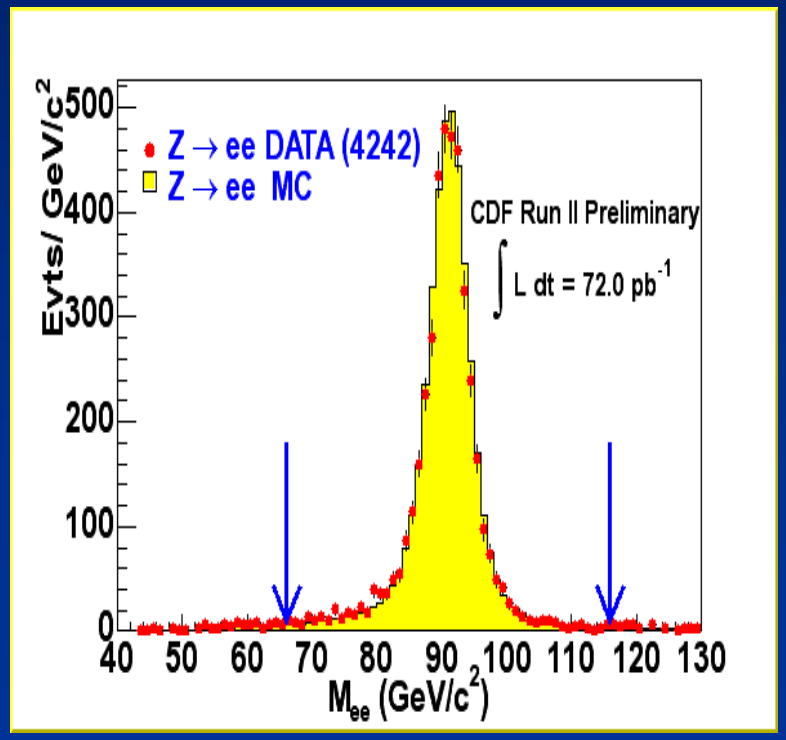
Inclusive W and Z Cross Sections

- Baseline measurements
  - ✓Precision tests on the SM
  - ✓High-pt e/muon (E/P scales, reached to 0.1%)





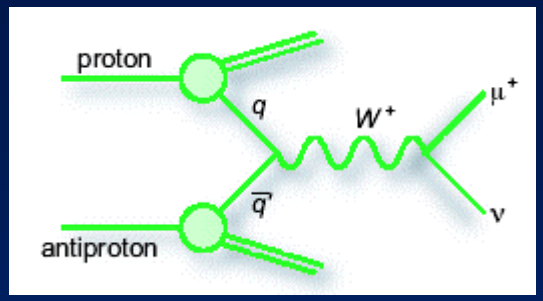
σ_Z*B(Z→ee) = 255.8 ± 3.3_{stat} ± 4.6_{syst} ± 15.2_{lum} pb



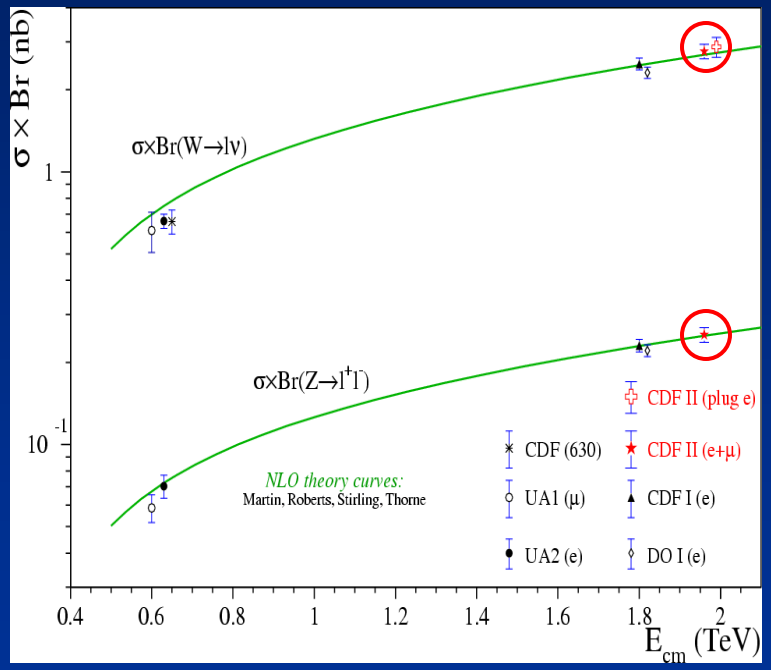
σ_Z*B(Z→μμ) = 248.0 ± 5.9_{stat} ± 7.6_{syst} ± 14.9_{lum} pb

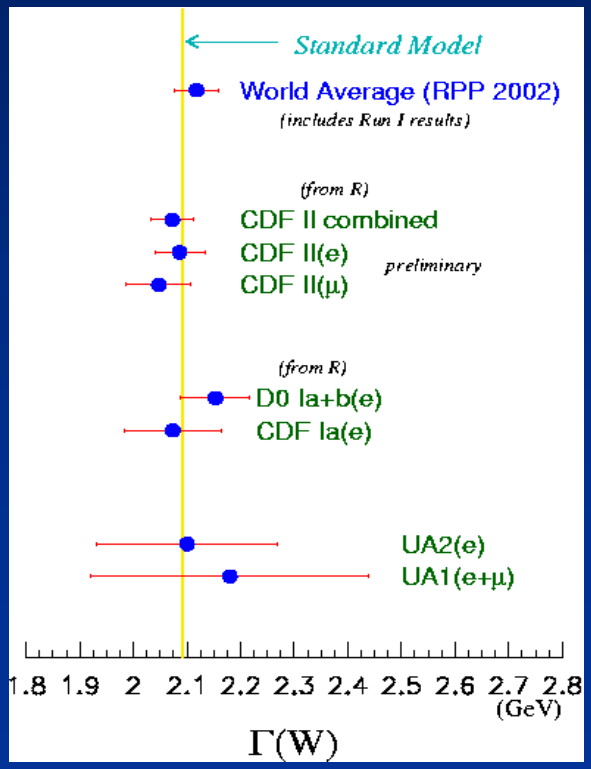
W and Z Cross Sections

- Precise W and Z cross sections (e,μ):
  - good agreement with the SM
  - R (=W(lν)/Z(ll)): 2% accuracy reached to the theorectial uncer. only with 72pb^{-1} → indirect Γ_W



Γ_W = 2.0788 ± 0.0414 GeV

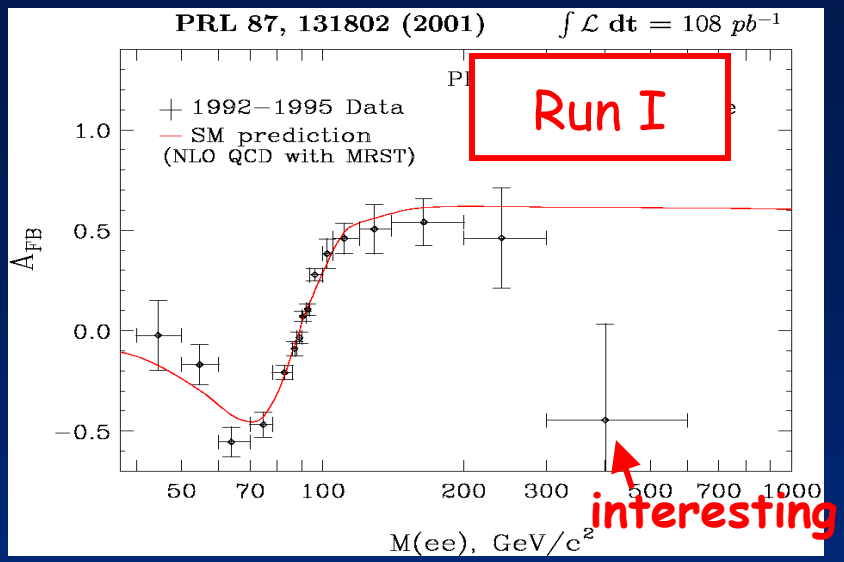


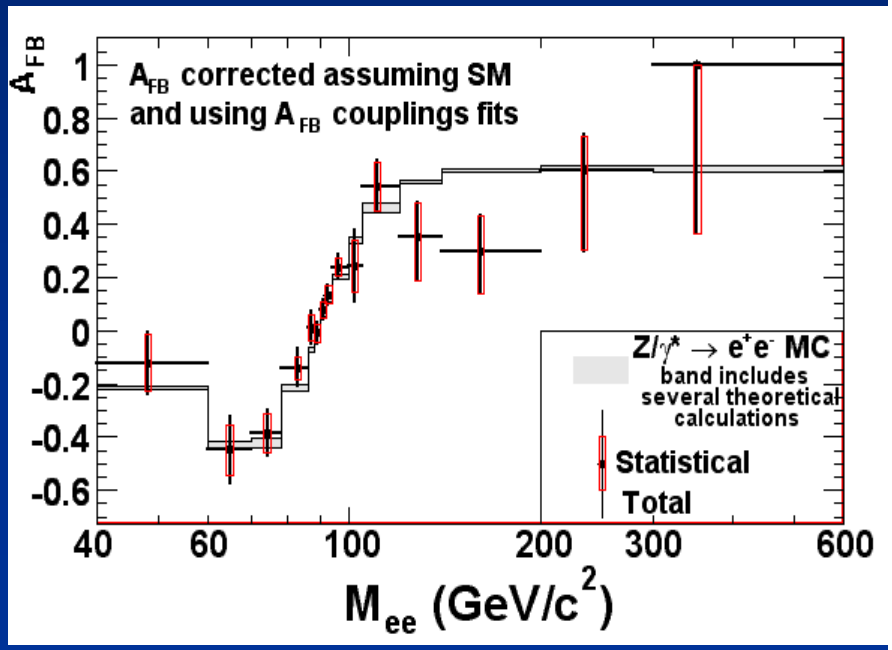


σ_W*B(W→e,μν) = 2777 ± 10_{stat} ± 52_{syst} ± 167_{lum} pb

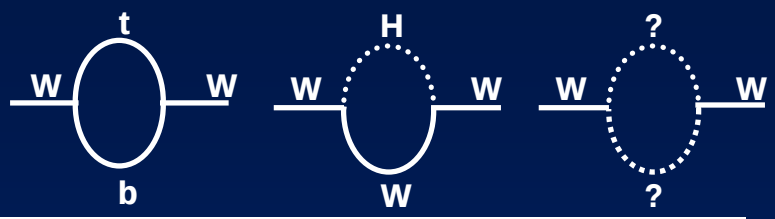
FB asym. in $\gamma/Z^0 \rightarrow e^+e^-$

- FB asym: interference between Z and γ
  - Direct probe of Z and γ couplings
  - New resonance could destroy interference (indirect search for high mass state)
- Run II
  - With $72pb^{-1}$, good agreement with the SM at Z mass region.
  - Ready to look for high mass region with $450pb^{-1}$

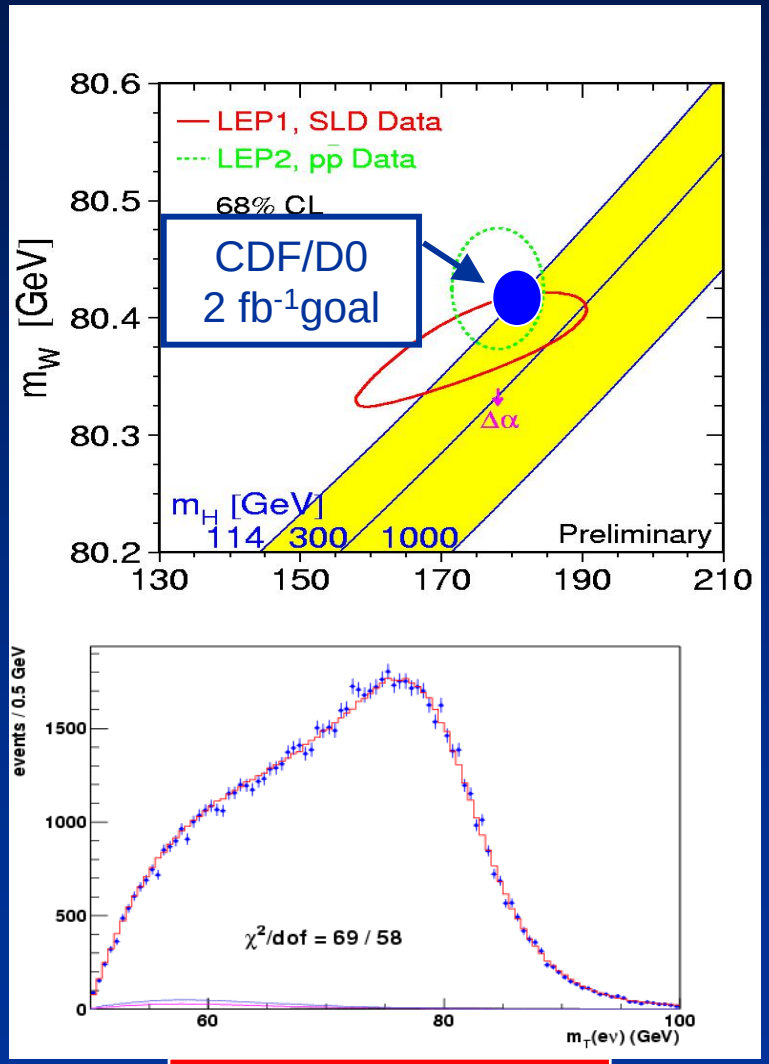




W mass

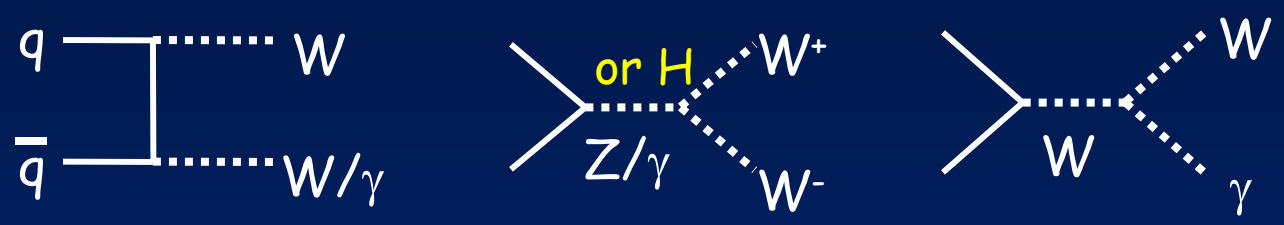


- M(W) and M(top) are very sensitive to M(Higgs) and new particles via radiative corrections
- Run II W mass analysis (fit using transverse mass, Mt)
  - Requires precise understanding of energy scale (<0.1%), Pt(W): very complicated!
  - With 200pb^{-1}, dominated by systematics
  - Plan to release M(W) result (δM~50 MeV) in next year with double statistics.
  - Will be the best single-experiment measurement

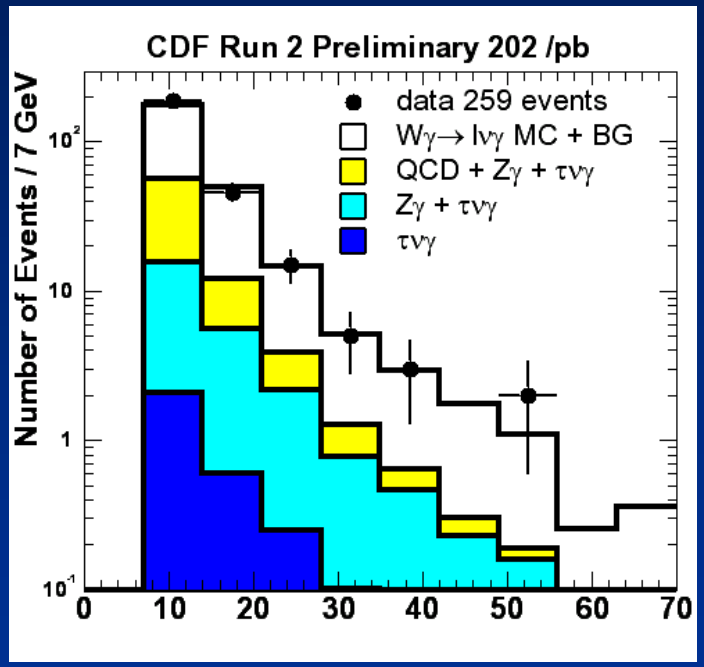


W(e) mass fit using Mt

Diboson productions: WW,Wγ



- Direct test of trilinear gauge couplings (WWZ, WWγ)
  → study anomalous coupling
- Good baseline toward Higgs search in H->WW
- New physics signal in l+l+ E_T (or l+γ + E_T) without any jet?
- With 200 pb^{-1}, good agreement with the SM: more data



e,μ $\sigma(p\bar{p} \rightarrow WW) = 14.3^{+5.6}_{-4.9} \pm 1.6 \pm 0.9\ pb$

e,μ +track : $= 19.4 \pm 5.1 \pm 3.5 \pm 1.2\ pb$

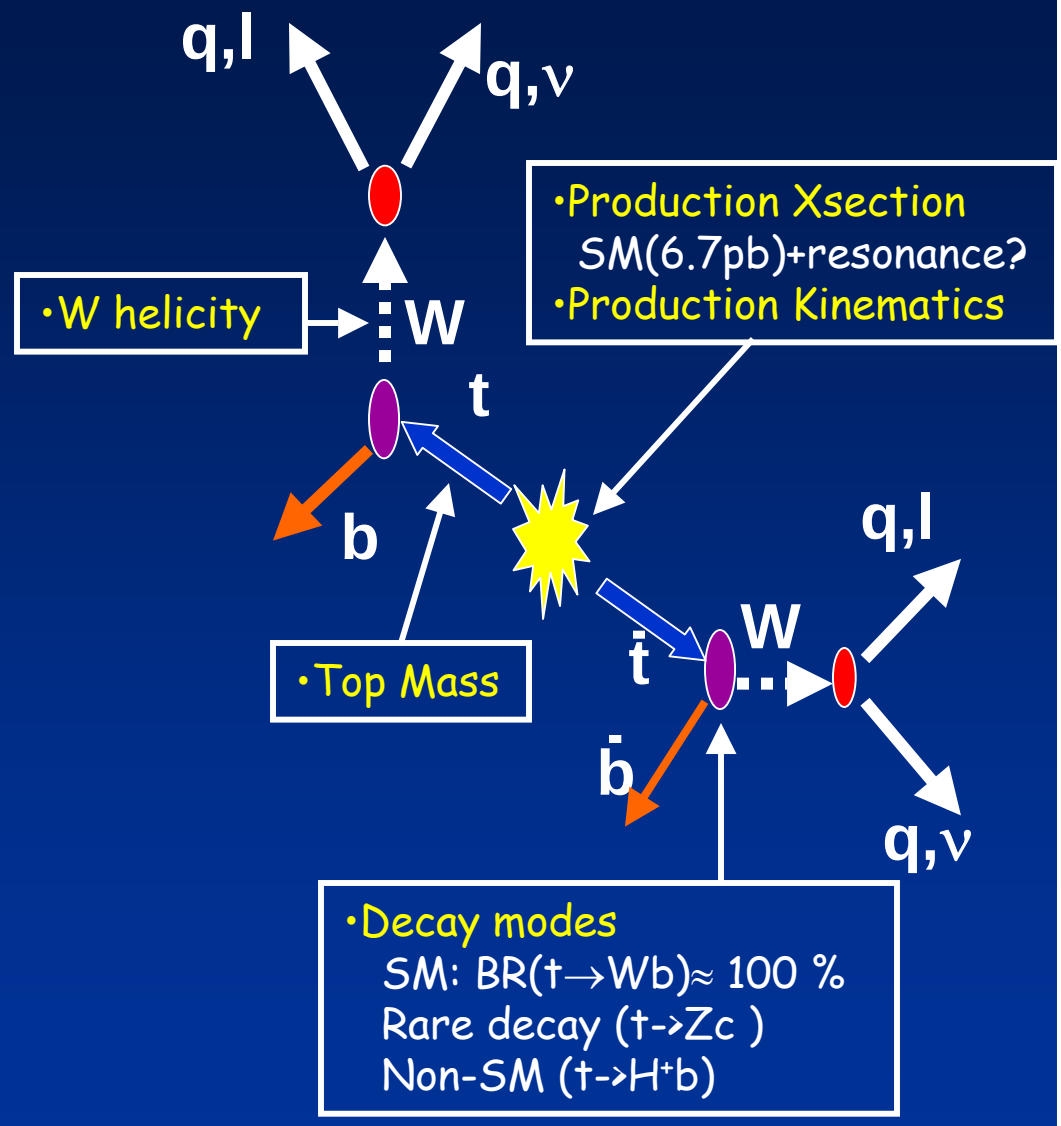
(SM: 12.5pb)

σ (Wγ)×BR(W→lν) = $19.7^{\pm}1.7^{\pm}2.0^{\pm}1.1$ pb

(SM:19.3± 1.4 pb)

Top production and decay

- Top quark is still the most mysterious particle, even with great success of the SM
- Origin of the large top mass (Yukawa coupling ~1) is different from those of the light quarks? → a gateway to new physics
- Provide many interesting measurements to search for new physics signals
- Fully explore top quark physics potential as much as possible in many ways!!!

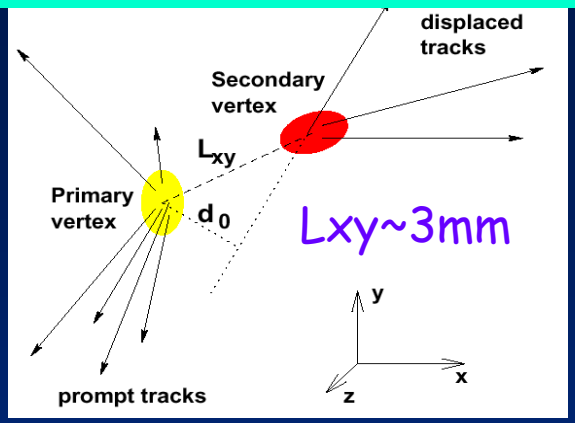


✓Single top: direct |Vtb|

Top Cross Section in lepton-jet

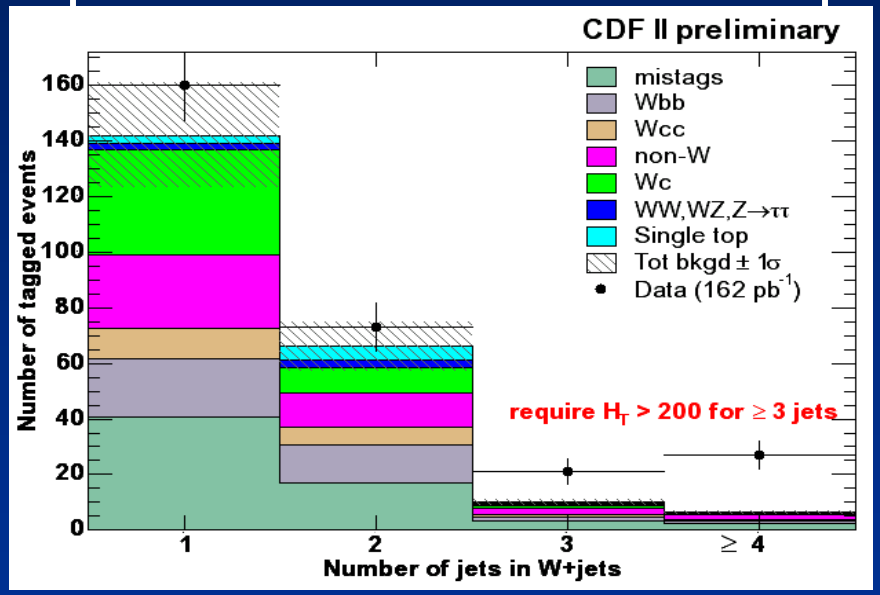
- Signature: 1 hi-Pt e/μ (>20 GeV), >=3 jets (one b-tag), large $\not\!\!E_T$ (>20GeV)

single tag 52%, false tag: 0.5%



Counting exp.

Each bkgd: using MC and data

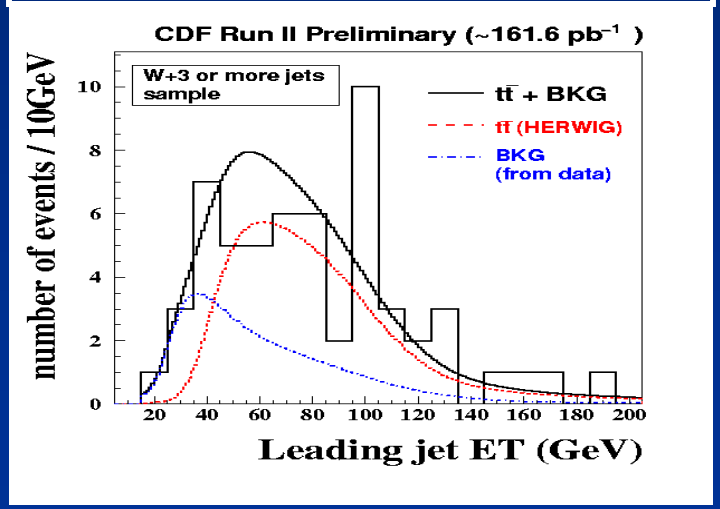


control ⟷ signal

$$\sigma(tt) = 5.6^{+1.2}_{-1.0}(stat) \pm 0.8\ pb$$

Leading jet Et

Bkgd: using diff shapes



$$\sigma(tt) = 6.7 \pm 1.1(stat) \pm 1.6\ pb$$

Top Cross Sections

Top pair events (multi-objects)

Dilepton ($l\nu\ l\nu\ bb$): 2 hi-Pt e/μ,

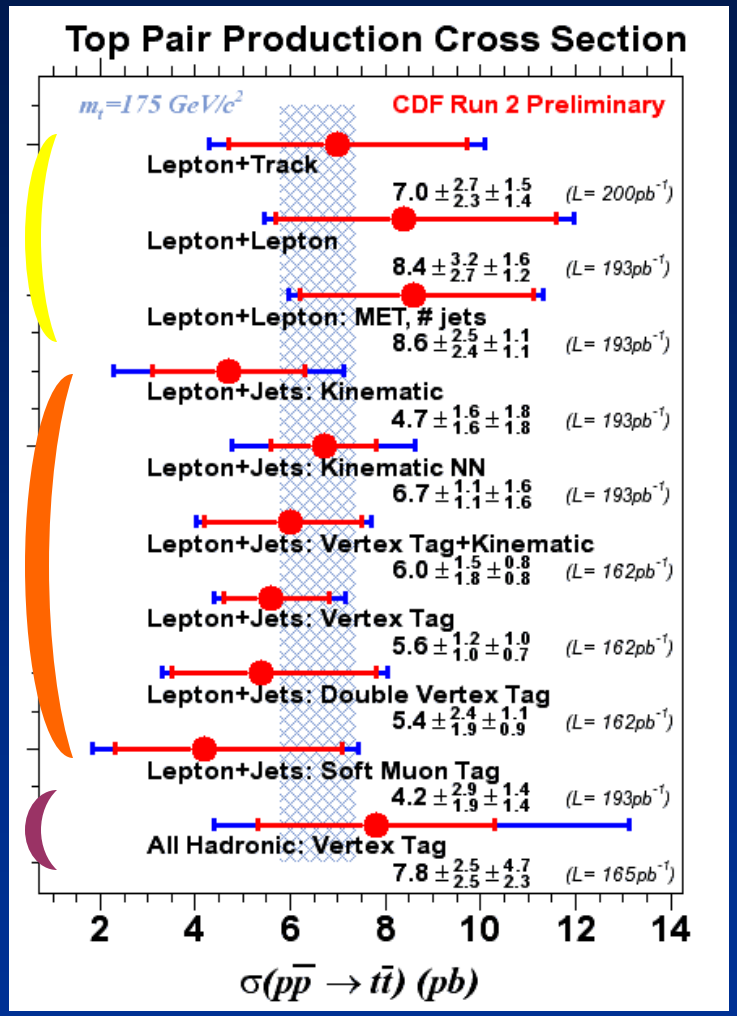
2 bjets, large $\not{E}_T$ (5%) : no b-tag

Lepton+Jets ($l\nu\ qq\ bb$) : 1 hi-Pt e/μ,

4 jets (2 b's), large $\not{E}_T$ (30%) : Lxy, soft lepton (SLT) for b-tag

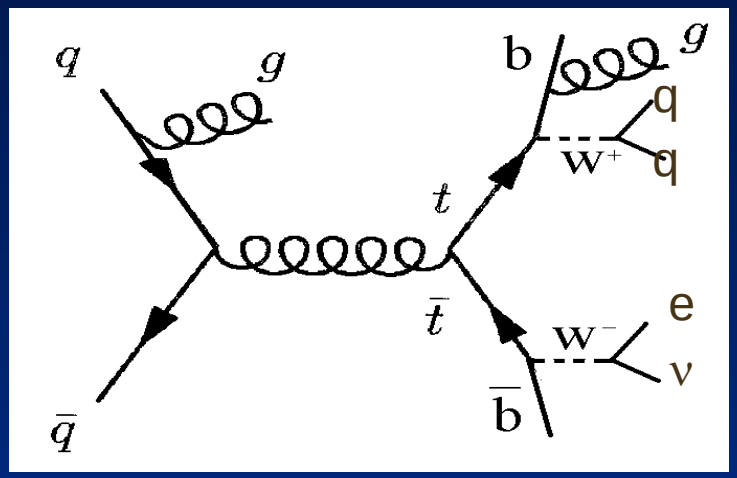
All-hadronic ($qq\ qq\ bb$): 6 jets (44%)

- Good agreement with the SM in many channels (based counting exp. and kinematic shapes)
- Dominated by the statistical uncertainty



Top Mass Measurement

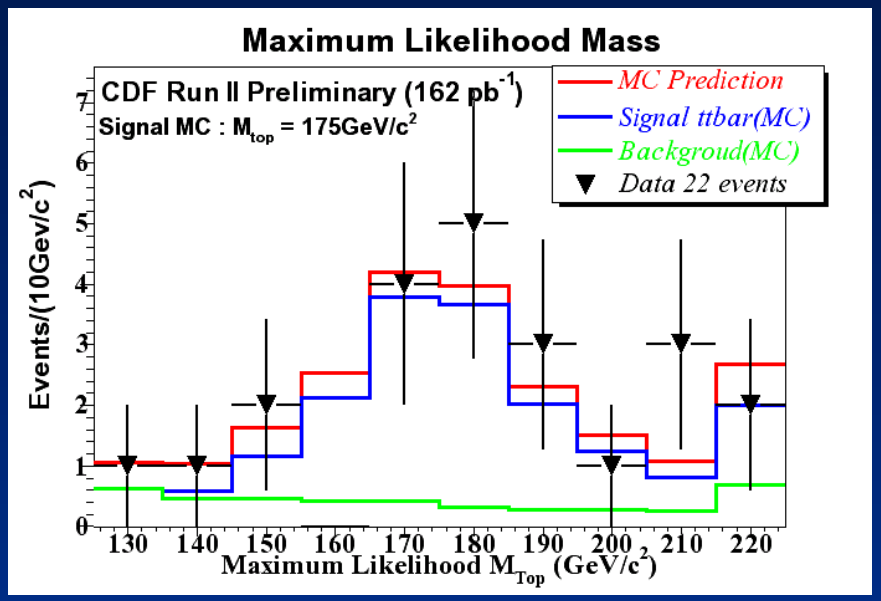
One hi-Pt lepton, 4 jets (at least one b-tag), large $\not{E}_t$

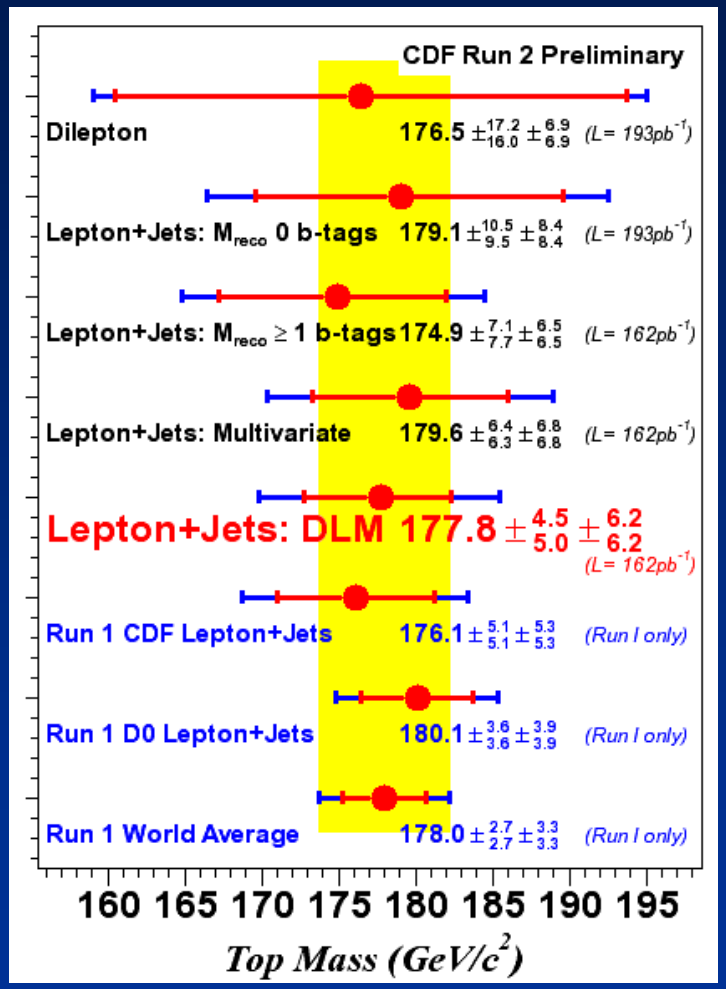


- Why so challenging?
  not just a calculation of M(W+b) !!!
  - missing neutrino
  - confusion in ID (additional jet from ISR/FSR, b-tag: not 100%)
  - jet energy scale

- Method: reconstruct Mtop with 2 constraints, $M(W^+)=M(W^-)$, $M(t)=M(\bar{t})$
  - Take the best combination over all 12 combinations
  - Use all combinations(12) weighted by the diff. cross section (full kinematic info): dependence on $t\bar{t}$ event kinematics?

Top mass measurements
for diff channels in many ways

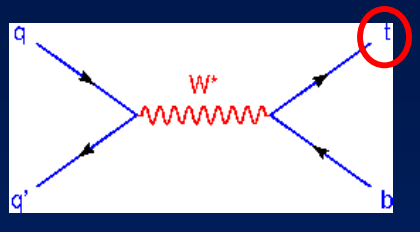


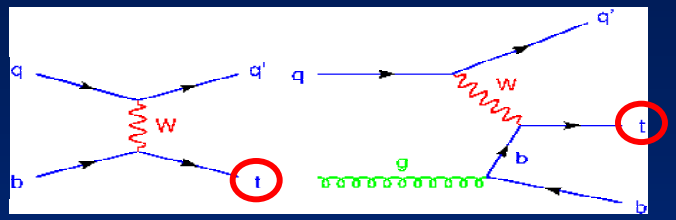


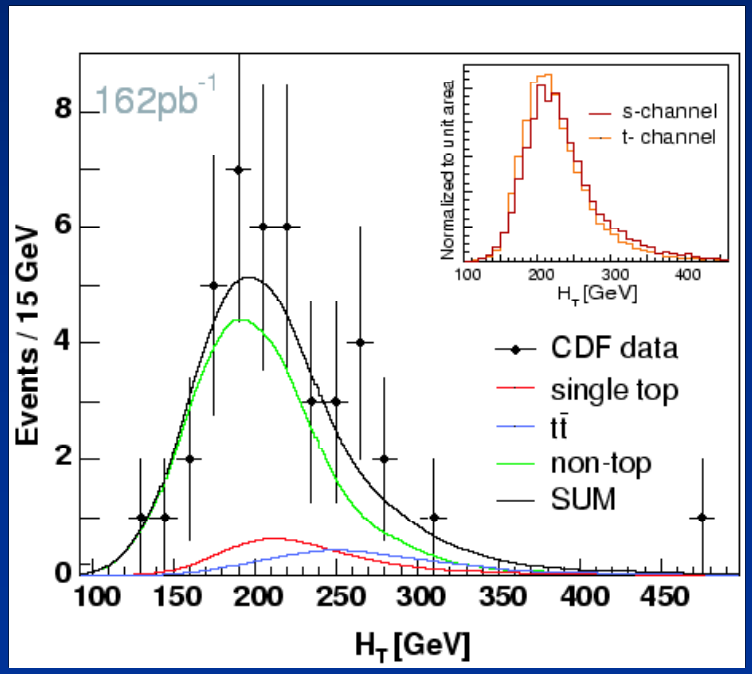
- Prospect: $\delta m_{top} \approx$ 2-3 GeV with 2fb^{-1}
  improved jet energy scale
  - Accurate detector simulation (jets)
  - γ +jet Et, Z+jet balance, W mass from top
  - Z→bb mass for b-jets

Single Top production

- Direct measurement of Vtb
- Sensitive to new physics
  - new charged gauge boson, anomalous couplings, FCNC
- Signal: W+2jets (with one b-tag)
  - σ(single)<3pb, very small
  - sandwitch between tt and non-top
- Upper limit 95% C.L.:
  - t-ch< **10.1** pb
  - s-ch< **13.6** pb
  - Comb< **17.8** pb
- Expect observation with 2fb^{-1}





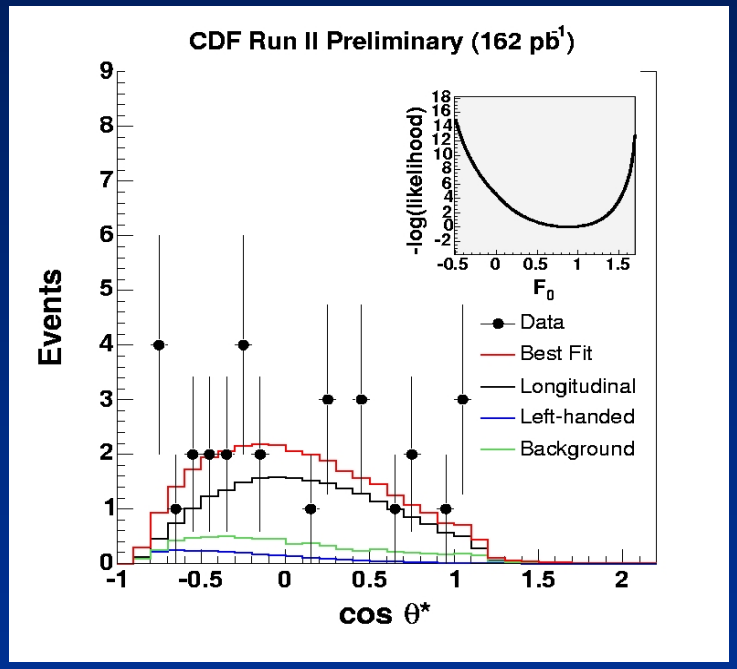


W helicity in $t\bar{t}$ events

- W from top decay has a long. pol. due to heavy top

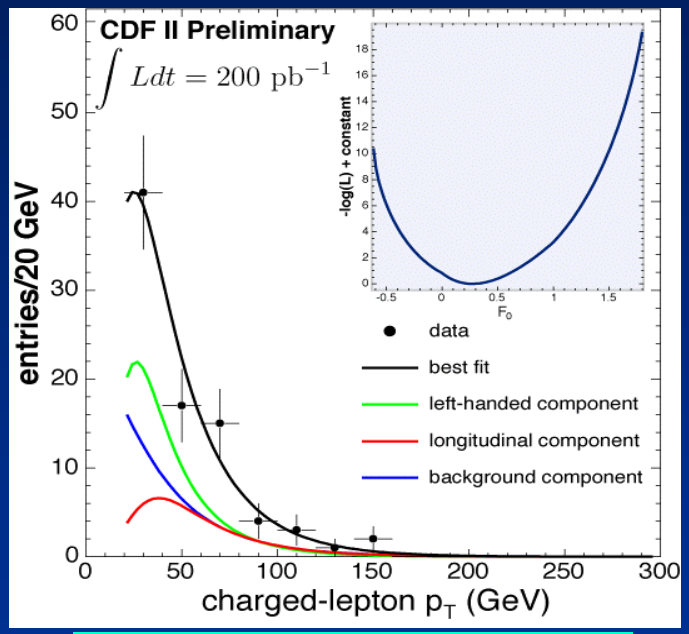
$$F_0(long) = \frac{1}{1+2(m_W/m_t)^2} = 0.70$$

- Angle between lepton (in W rest) and W.
- Lepton Pt



$$F0 = 0.89^{+0.30}_{-0.34}(stat) + 0.17(sys)$$

(lepton-jet channel)

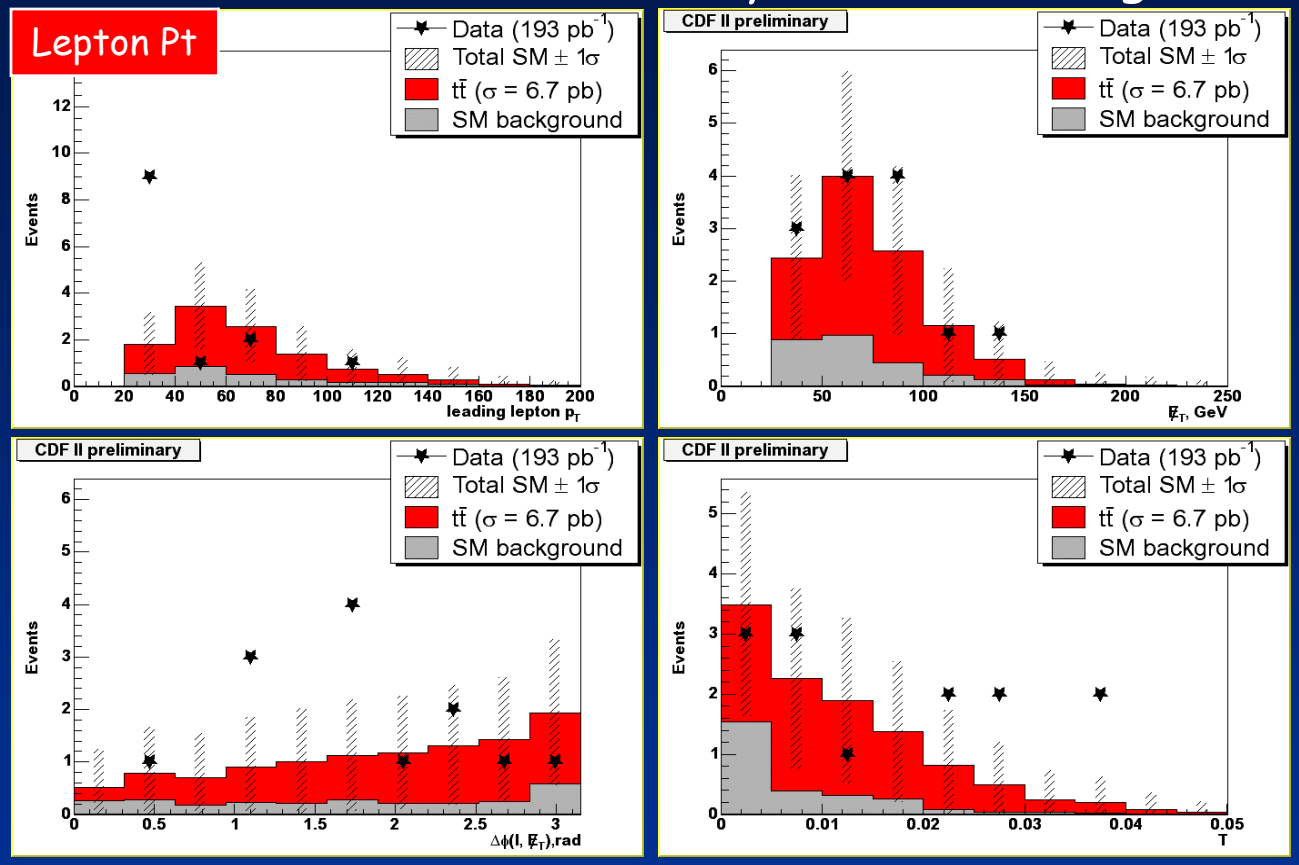


$$F0 = 0.27^{+0.35}_{-0.21}(stat + sys)$$

(lepton-jet + dilepton)
mainly due to low-pT lepton excess in dilepton channel

Kinematic properties in dilepton

Four kinematic variables chosen *a priori* to test against SM



- Prob. of consistency with SM (KS test) = 1.0-4.5%
  - due to excess in low-p_T leptons; most likely fluctuation of top
- Waiting for more data and checking out same hints in other channels…

Many other interesting results in progress

- Productions
  - Search for high mass particles decaying into top pair
  - Search for t'
  - Top quark spin
- Decays
  - Ratio of branching ratios: sensitive to non-SM top decays

    BR(t->Wb)/(t->Wq) :

    BR(dilepton)/(lepton-jet)
  - Search for Charged Higgs, H+ from top decay

    (t->H+b, H+->tau-nu, csbar)
  - Tau-dilepton channel (tau could come from H+)

See http://www-cdf.fnal.gov/physics/physics.html

Prospects for EWK and top physics

- Performance of the Tevatron collider has been improved a lot !!!
- CDF future now looks very bright
  - ✓ Many results for the 1st round of publications (2 PRL, 19 papers under internal reviews from EWK/top)
  - ✓ ~ 800pb^{-1} to analyze by next year
  - ✓ Toward precision measurements and search for new physics in many ways from many different angles!!!
- Coherent studies of the high-energy collider physics, neutrino, and cosmology would be essential for our understanding toward a unified picture of nature