



# CDF RunII実験の現状報告 2

筑波大物理

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CDF Collaboration

## -QCD

Inclusive jet cross section

Dijet mass spectrum

Charm production Cross section

## -Top

Cross section

Top mass

Single Top

## -New Particles/Phenomena

Leptoquarks

SUSY

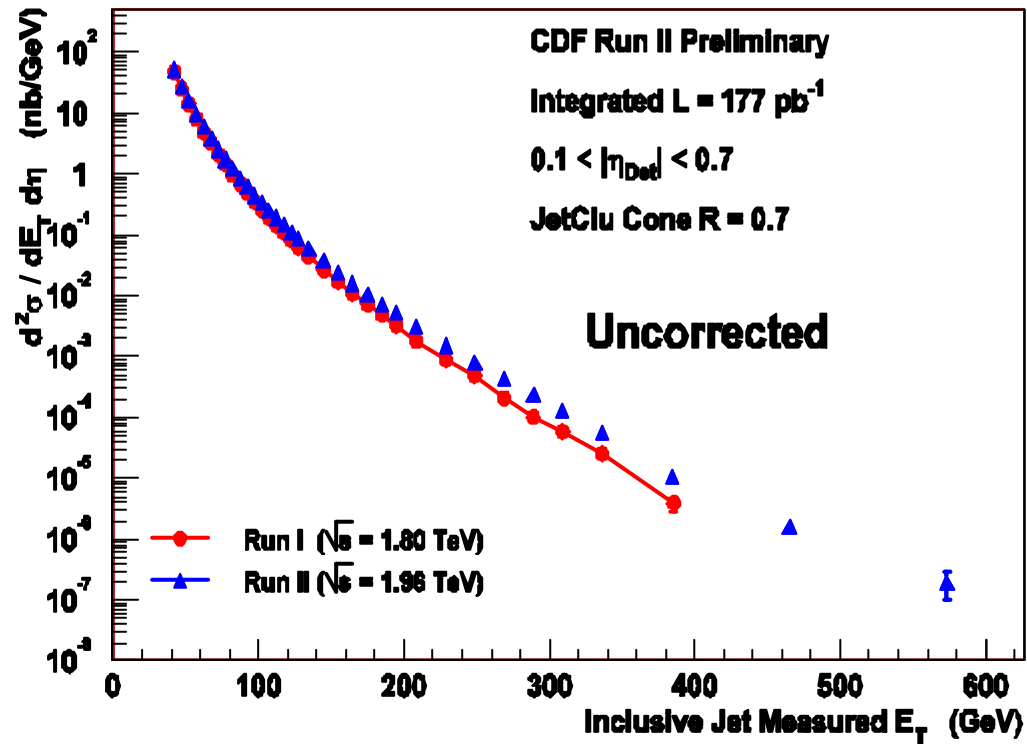
Z' / Extra dimension

## - RunII Prospects

Luminosity

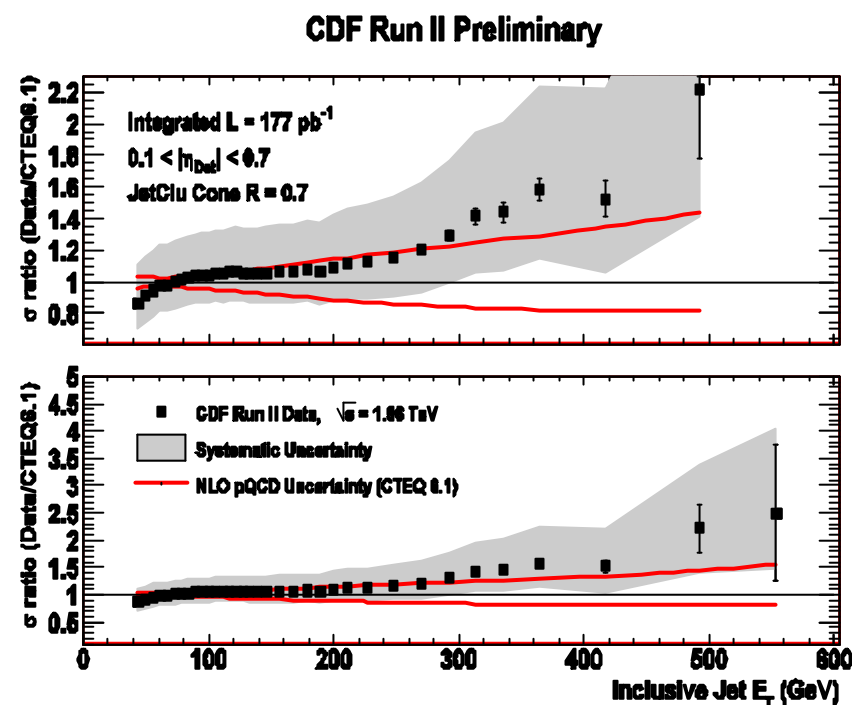
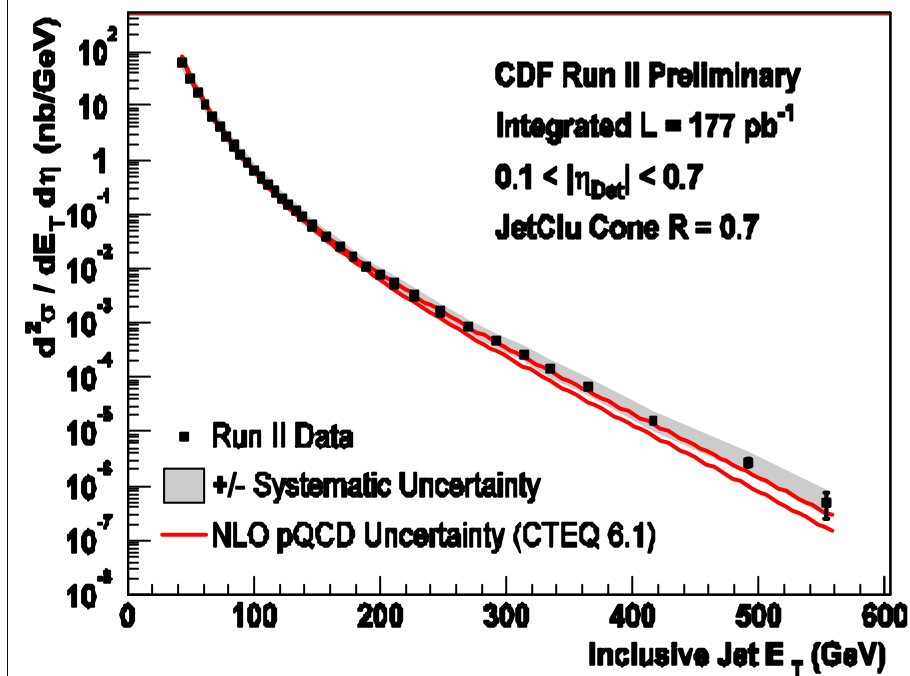
Higgs sensitivity

# Inclusive Jet Cross Section



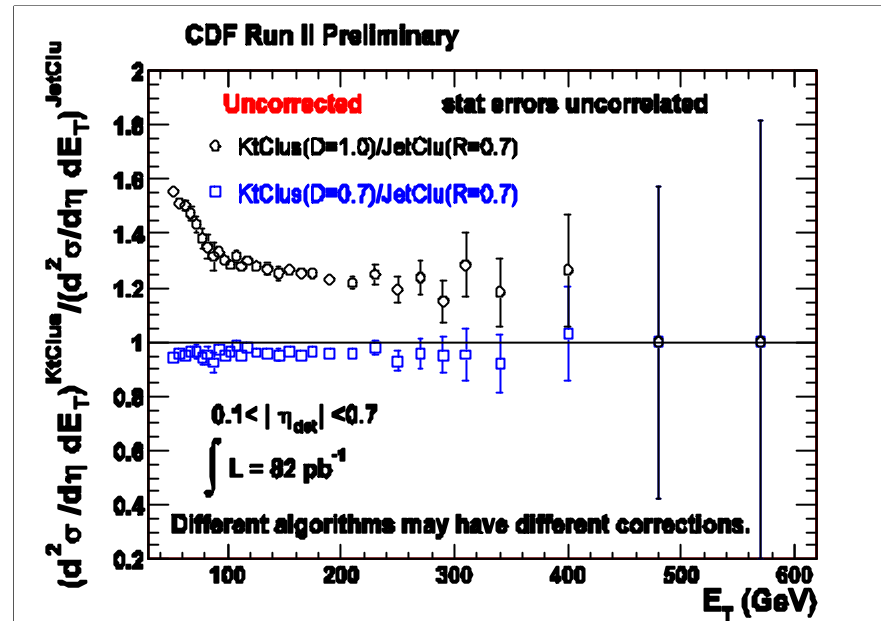
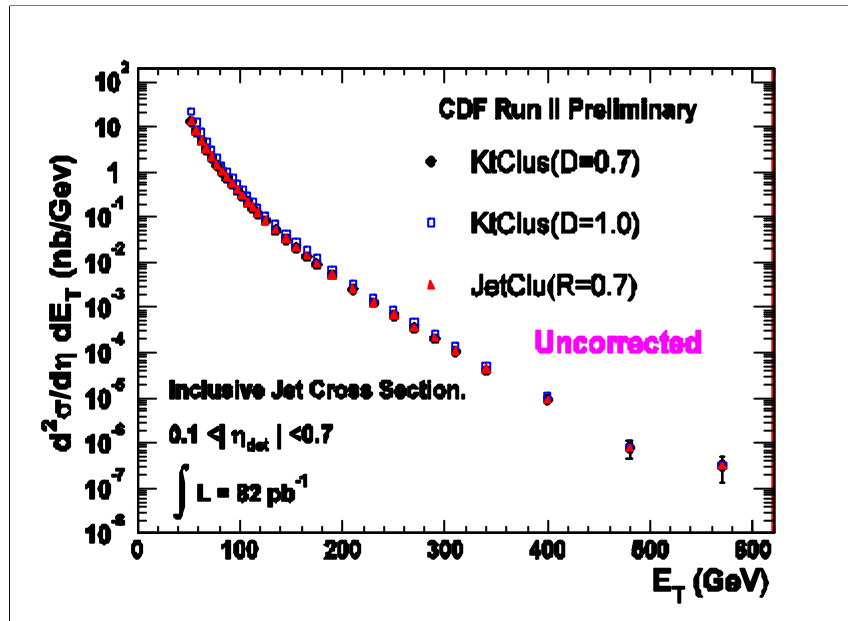
- 177 pb<sup>-1</sup> collected  
from Feb 2002 to June 2003
- Highest  $E_T$  jets ever
- Extending past Run I reach  
by almost **150 GeV**
- Reduced systematic error  
(mainly jet energy scale)  
from 5% to 3% since winter  
Expect 1% eventually

# Inclusive Jet Cross Section vs NLO QCD



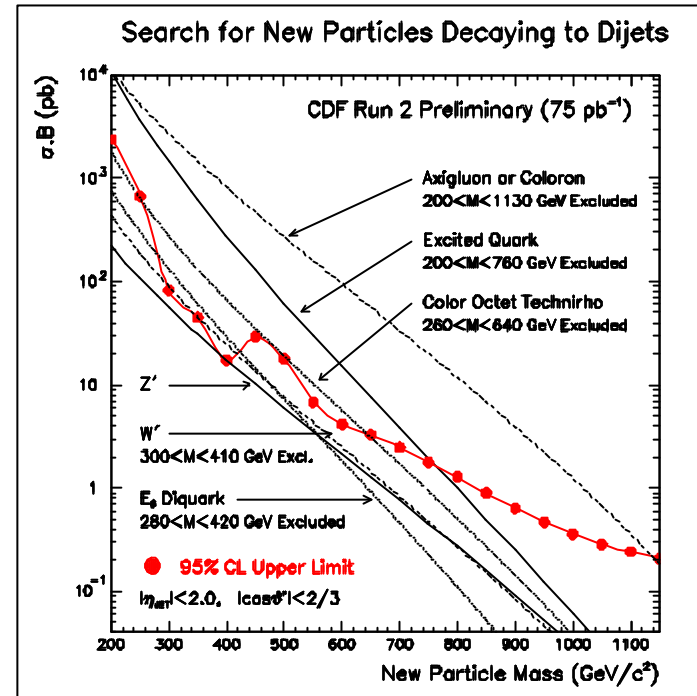
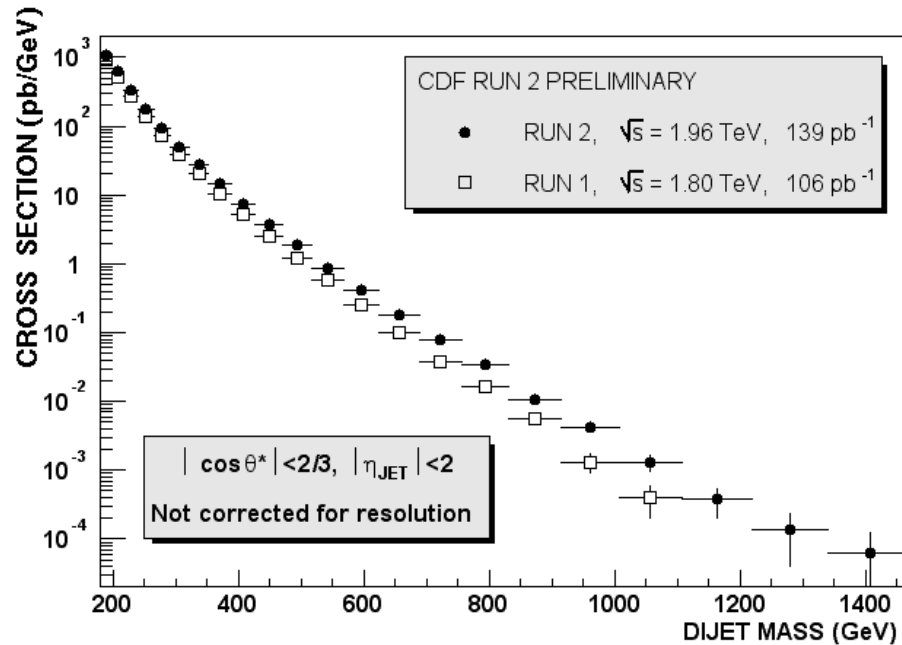
- Theoretical error dominated by PDF's
- RunII data agrees with NLO prediction within estimated errors

# Jet Algorithms and Inclusive Cross Section



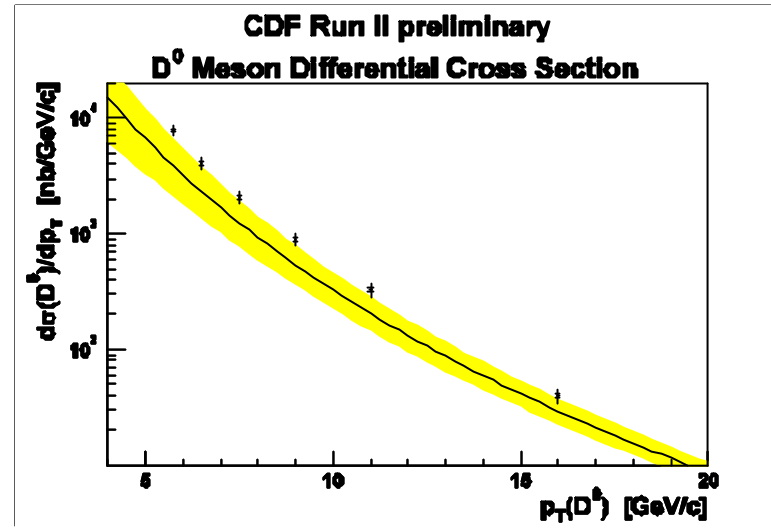
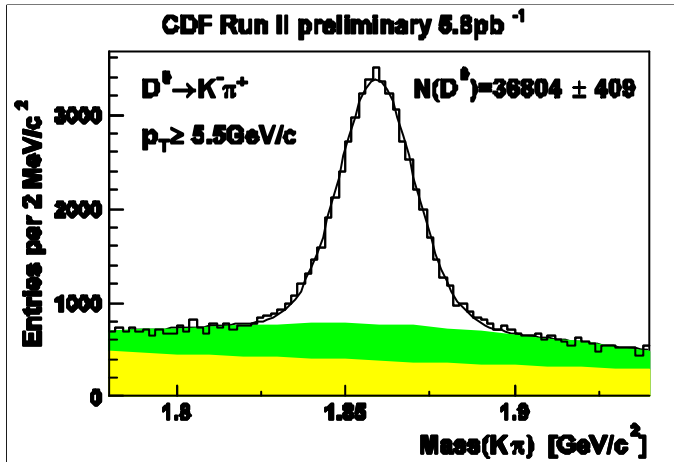
- Exploring the use of Kt algorithm
  - D0 uses Kt algorithm since Run I
- Need to understand/derive corrections for Kt clusters

# Dijet Mass Spectrum



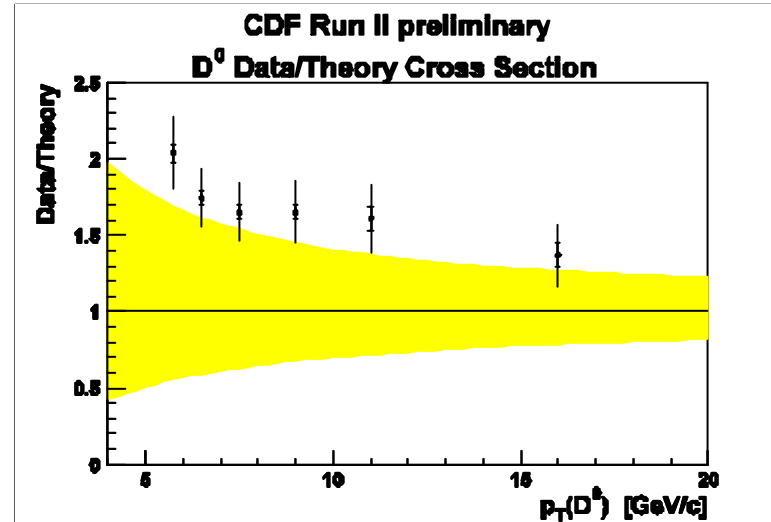
- 139  $\text{pb}^{-1}$  data sample  
larger dijet mass events than Run I
- Set upper limits for resonances in dijet mass ( $75 \text{ pb}^{-1}$ )

# Direct Charm Production



- Reconstruct  $D^0$   $K^- p^+$ 
  - $D^{*+}$   $D^0(K^- p^+) p^+$
  - $D^+$   $K^- p^+ p^+$

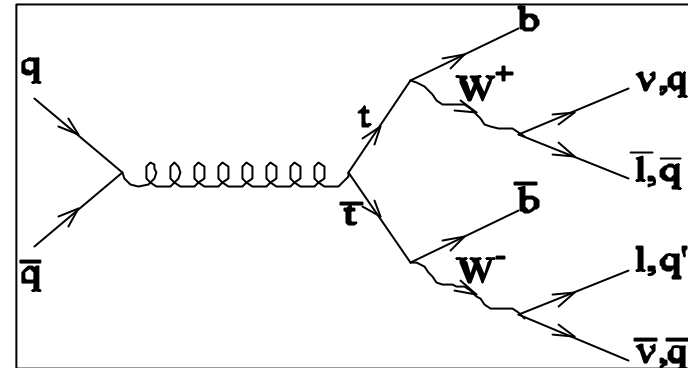
- Measured cross-sections are
  - ~ 70% higher than NLO predictions,
  - but consistent within errors



# Top Physics

## ● Pair production

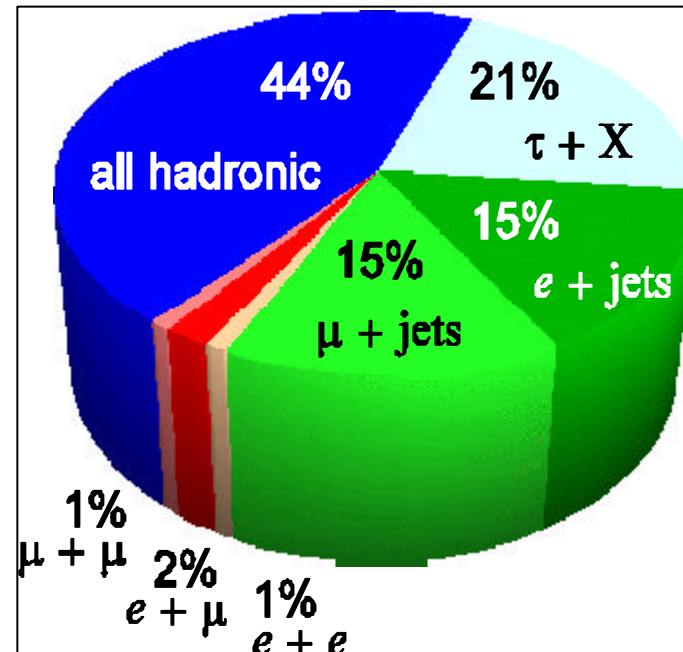
- Cross section :
  - ~ 5pb (RunI)    ~ 7pb (RunII)
- $q\bar{q}$  annihilation
  - ~ 90% (RunI)    ~ 85% (RunII)
- gluon fusion
  - ~ 10% (RunI)    ~ 15% (RunII)



## ● Decay channels

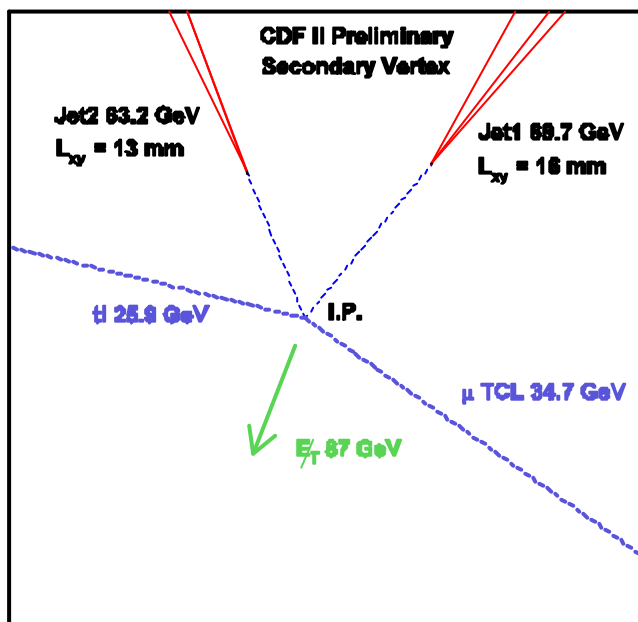
$$\text{BR}(t \rightarrow Wb) = 100\%$$

- **Dilepton**
  - ( $2W \rightarrow l\nu$ ,  $l = \epsilon, \mu$  : BR=5%)
- **Lepton+jets**
  - ( $W \rightarrow l\nu$ ,  $W \rightarrow qq'$  : BR=30%)
- All hadronic
  - (BR=44%)

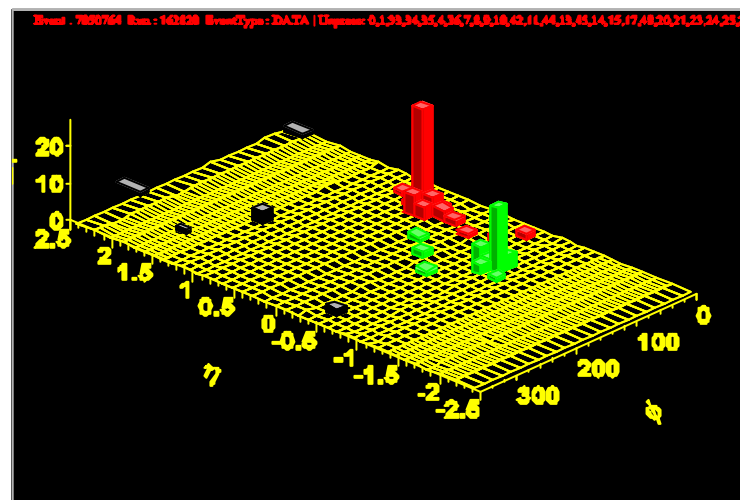
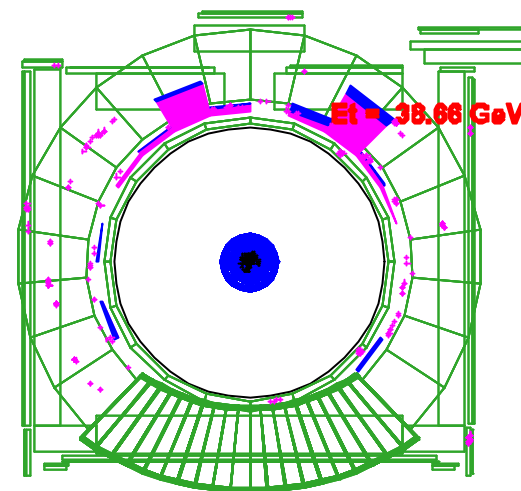


# Double B-tagged Dilepton Event

Run 162820 Event 7050764 Sun May 11 16:53:57 2003



Tue Aug 5 13:29:39 2003

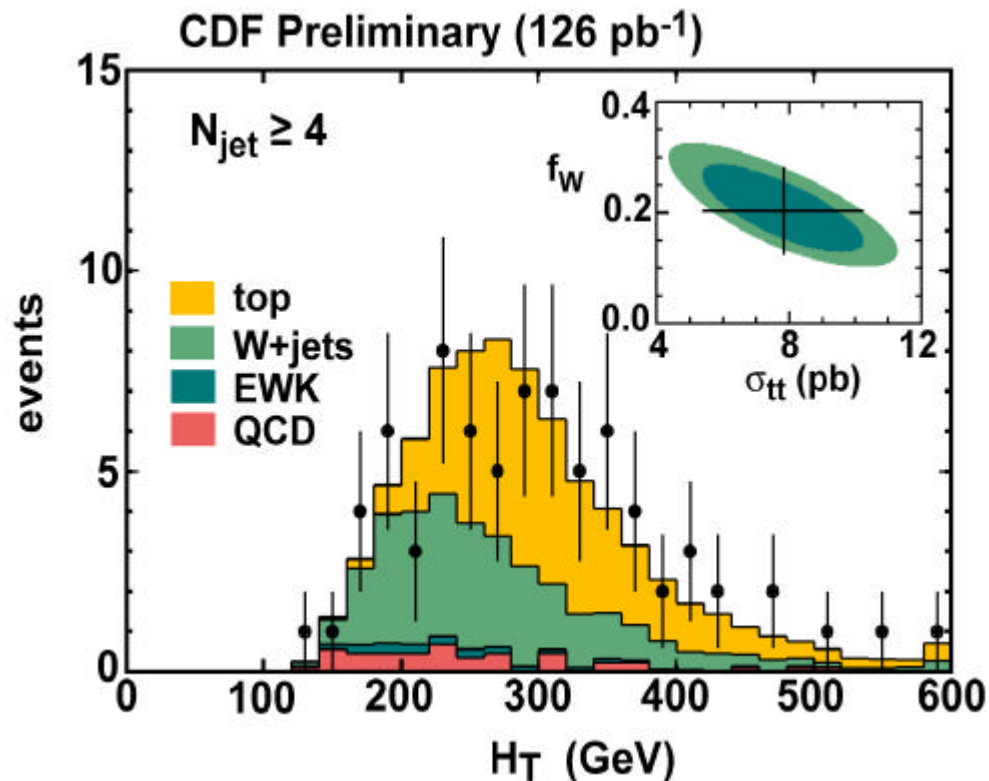


Sep 10, 2003

日本物理学会 2003年秋季大会



# Lepton+Jets Cross Section

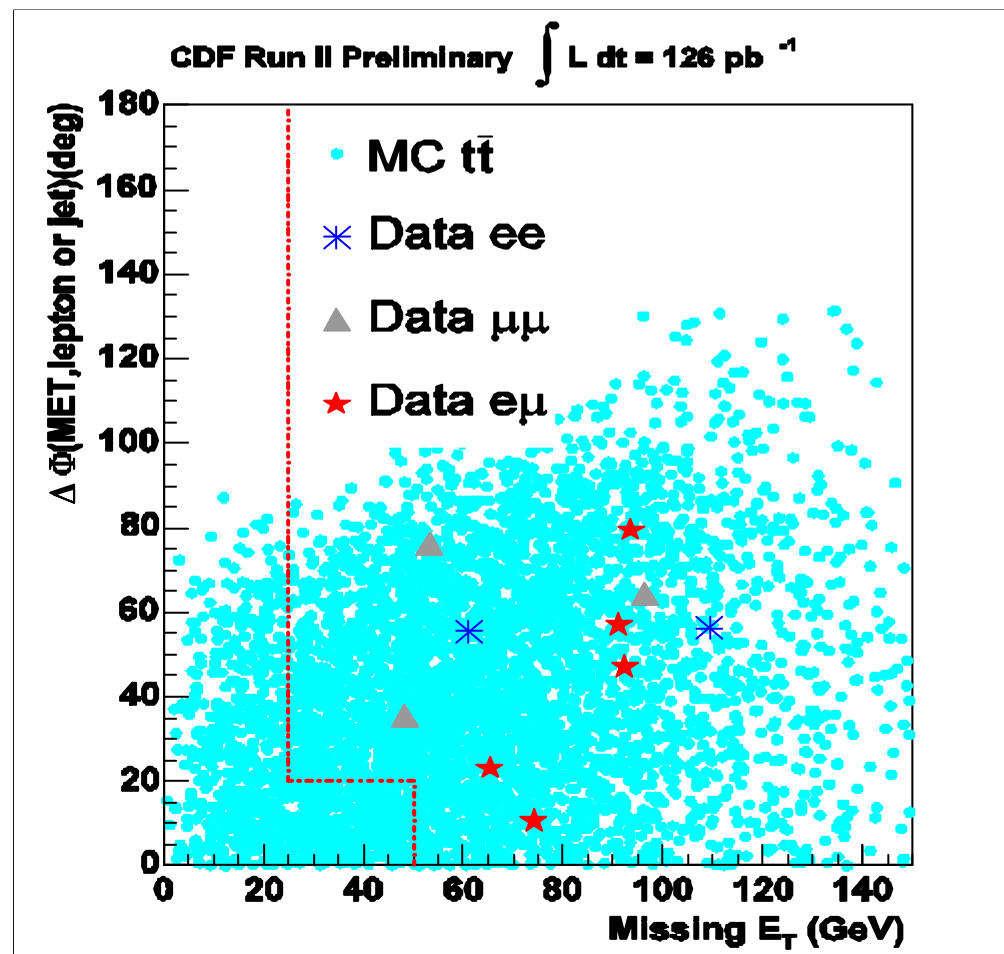


- One high- $P_T$  isolated lepton (e,  $\mu$ )
- Veto Z's, cosmics and conversions
- Large missing  $E_T$
- At least 4 or more high  $E_T$  jets
- Find 75 candidates in 107.9 pb<sup>-1</sup>
- $51 \pm 16\%$  to be top events
- Extract cross section with fit to  $H_T$  shape

$H_T$ : Scalar sum of all the measured  $E_T$

$$7.1 \pm 2.4 \text{ (stat)} \pm 3.0 \text{ (sys) pb}$$

# Dilepton Cross Section



- 2 high  $P_T$  isolated lepton ( $e, \mu$ )
- Large missing  $E_T$
- 2 central jets

■ 10 candidate events observed

Bkg estimate :  $2.9 \pm 0.9$

$$\sigma(t\bar{t}) = 7.6 \pm 3.4 \text{ (stat)}$$

$$\pm 1.5 \text{ (syst) pb}$$

# Lepton+Track Cross Section

Dilepton is clean, but low-statistics

Require looser cuts for more acceptance

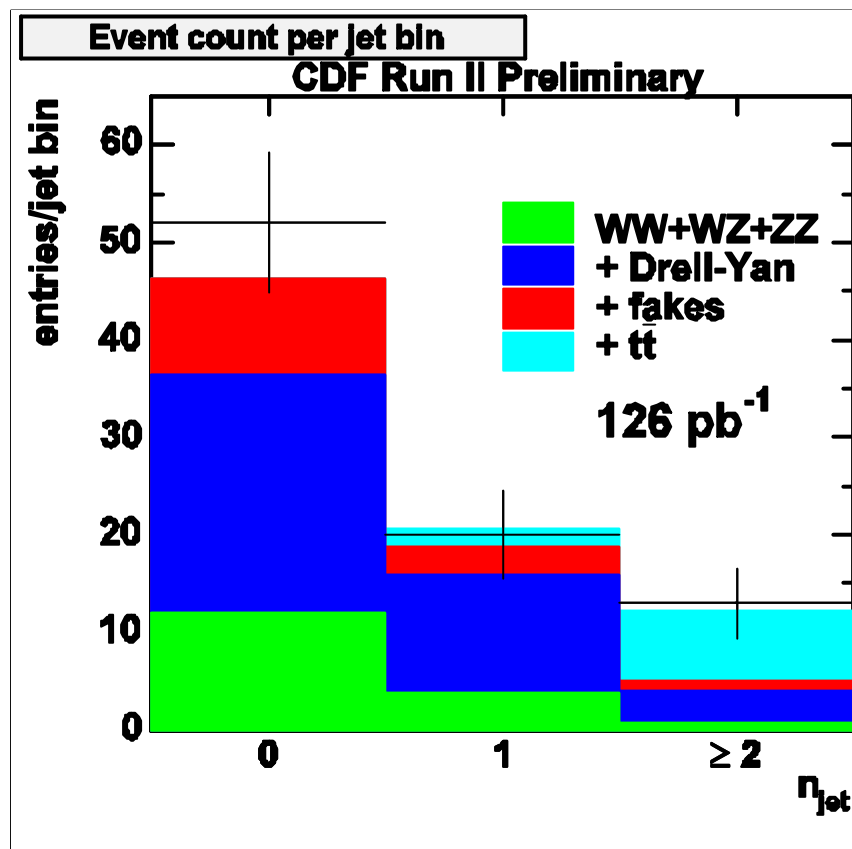
■ significant sensitivity to  $\tau$ -channel

- 1 tight lepton (e,  $\mu$ )
- 1 isolated track with  $P_T > 15 \text{ GeV}$   
in  $|\eta| < 1$
- Large missing  $E_T > 25 \text{ GeV}$
- At least 2 or more high  $E_T$  jets

Expect  $5.1 \pm 0.9$  bkg events,

Observe 13 events

$$\sigma(t\bar{t}) = 7.3 \pm 3.4 \text{ (stat)} \pm 1.7 \text{ (syst)} \text{ pb}$$



# Top Mass

- **Top mass :**

Fundamental SM parameter

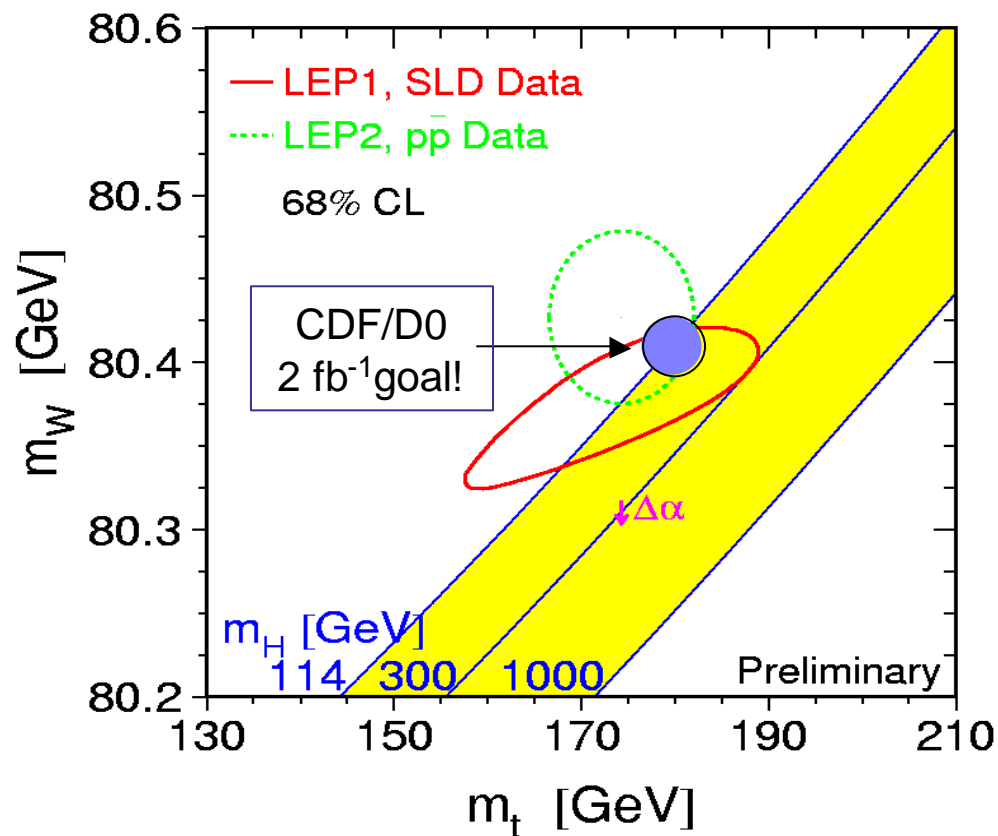
- Important for radiative corrections

Constrain  $\Delta M_h/M_h$  to 35% in RunII

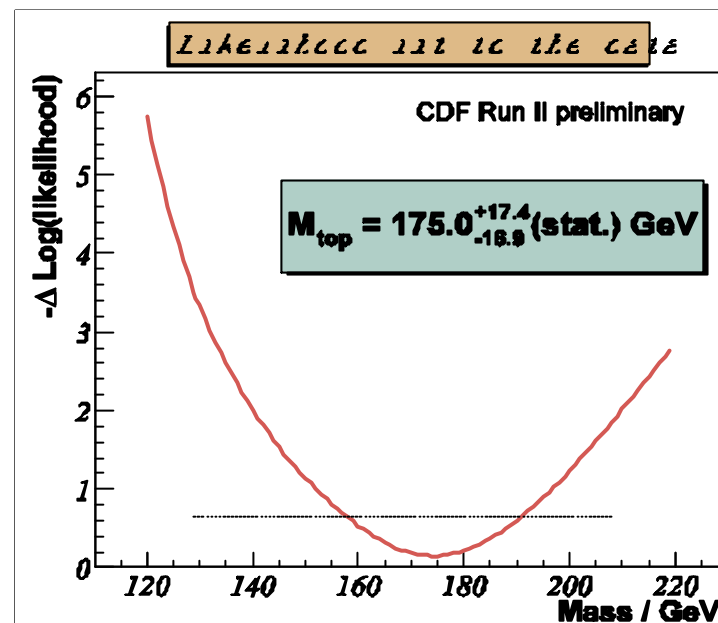
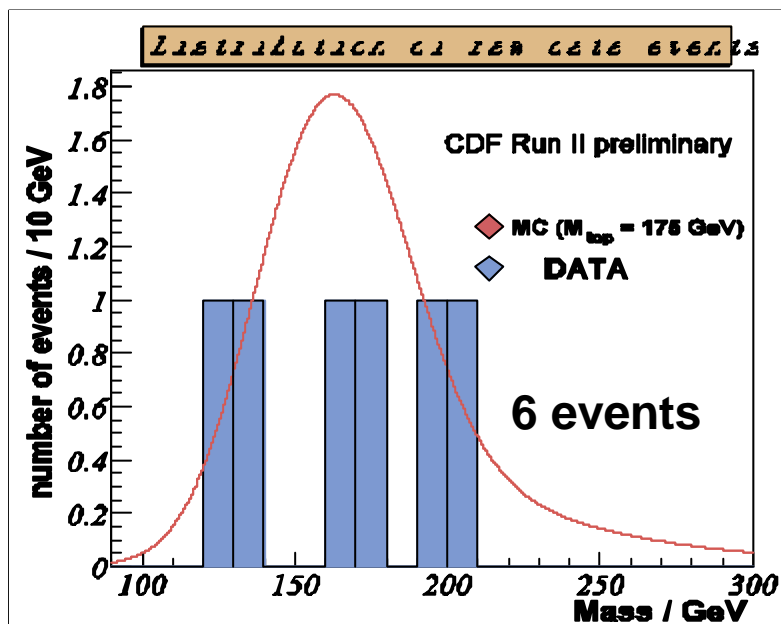
CDF RunI result (combined)

$$176.0 \pm 6.5 \text{ GeV}/c^2$$

< 3.0 in RunII (2 fb<sup>-1</sup>)



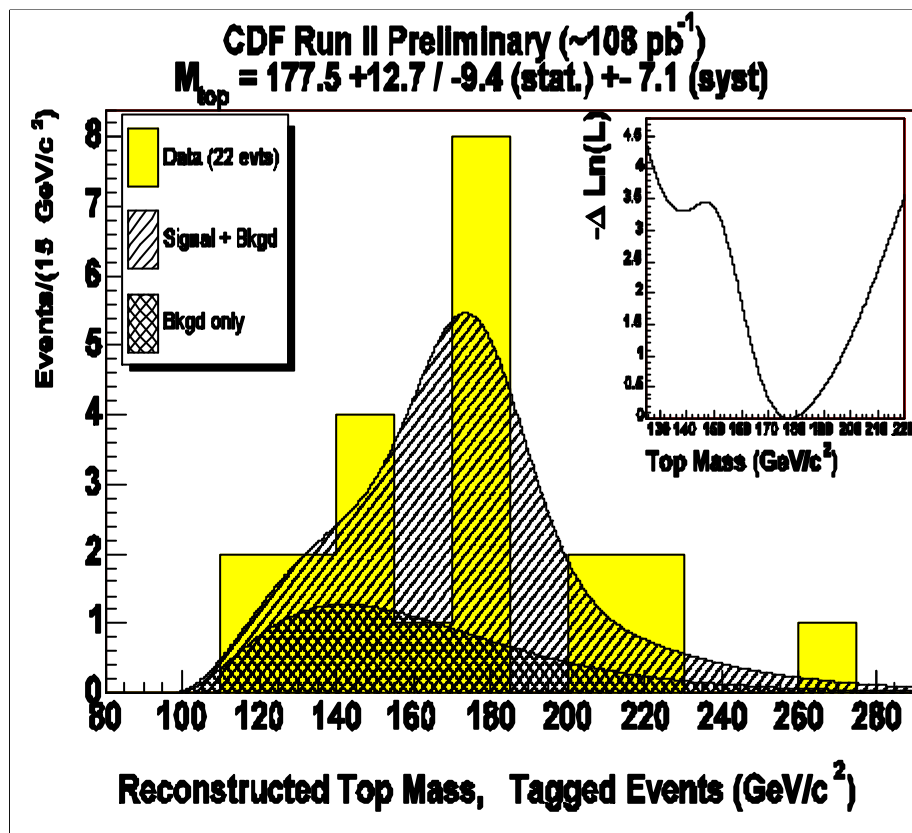
# Top Mass in Dilepton Channel



- 2 tight isolated leptons,  $E_T > 20 \text{ GeV}$ , opp. charge
- Veto Z's, cosmics
- Large  $H_T > 200 \text{ GeV}$
- Event-by-event kinematic fit

Likelihood fit  $m(t) = 175.0 + 17.4 / -16.9 \text{ (stat.)} \pm 7.9 \text{ (syst.) GeV}/c^2$

# Top Mass in Lepton+Jets Channel

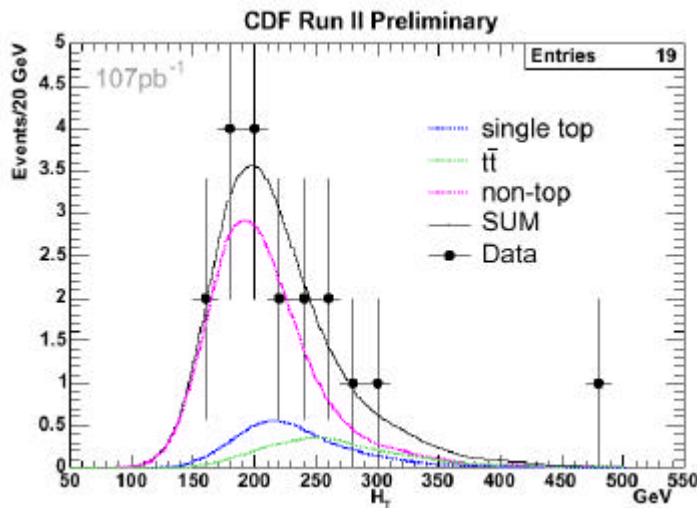
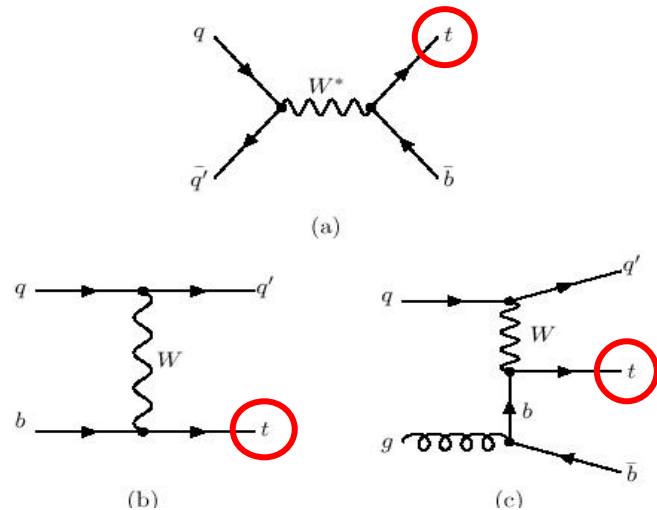


- $\sim 108 \text{ pb}^{-1}$  including silicon
- Require  $\geq 4$  jets
- **At least one b-tag**
- 2 constraint mass fit of each event
- 22 candidates events
- expect  $5.9 \pm 2.1$  bkg events

Extract  $m(t)$  using likelihood fit to simulated mass templates for signal and background

$$m(t) = 177.5 +12.7/-9.4(\text{stat}) \pm 7.1 \text{ (syst) GeV}/c^2$$

# Single Top



- $\sigma(\text{single-t}) \sim 3\text{pb}$  (1.96TeV)
- $\frac{1}{2}$  of  $t\bar{t}$  production cross section

- s-channel
- t-channel

- Direct measurement of  $|V_{tb}|$
- $\delta|V_{tb}| : 14\%$  for  $2\text{fb}^{-1}$

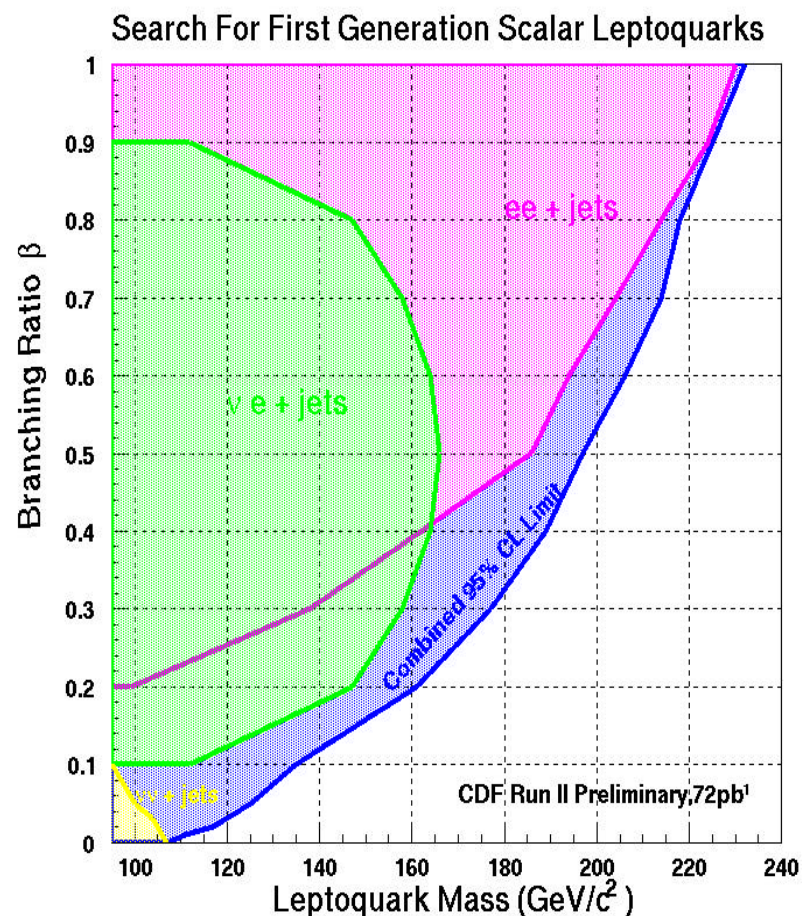
- Same signatures as SM Higgs
- associated production:  $W+2\text{jets}$

RunII preliminary results:

$$\sigma(\text{t-channel}) < 15.4\text{ pb @ 95\% C.L.}$$

$$\sigma(\text{combined}) < 17.5\text{ pb @ 95\% C.L.}$$

# Search for 1<sup>st</sup> Generation Leptoquarks

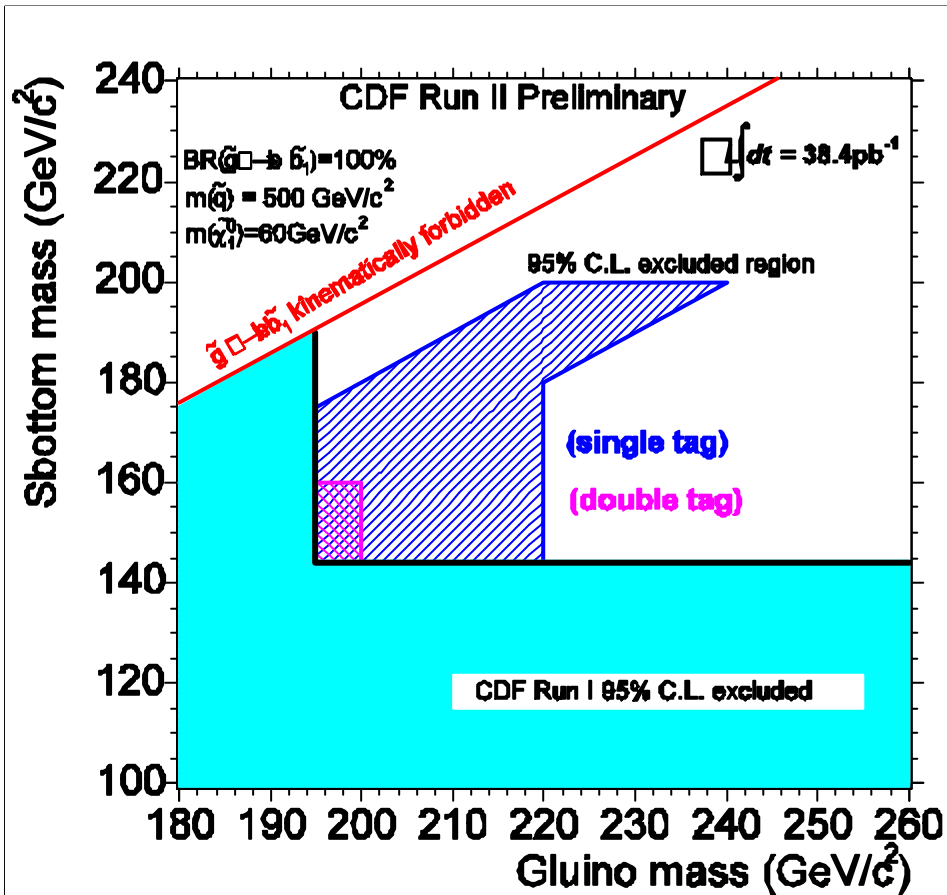


- $72\text{pb}^{-1}$  of RunII data
- Combine 3 channels to set mass limits for various  $b$  :
  - $eejj$ ,  $enjj$ ,  $nnjj$
- $m_{LQ} > 230\text{ GeV}/c^2$  @95%C.L. assuming  $b = 1$
- $m_{LQ} > 107\text{ GeV}/c^2$  @95%C.L. independent of  $b$



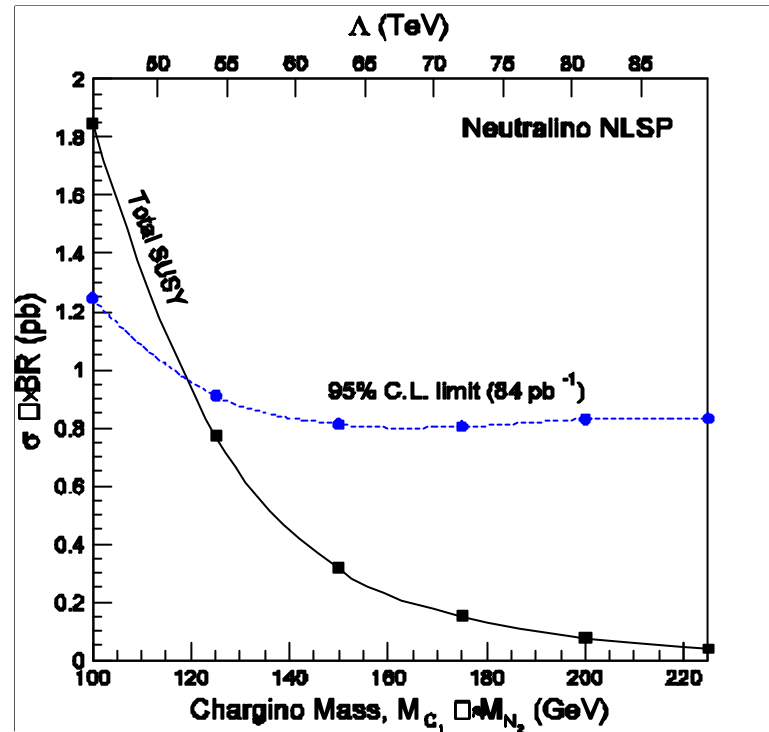
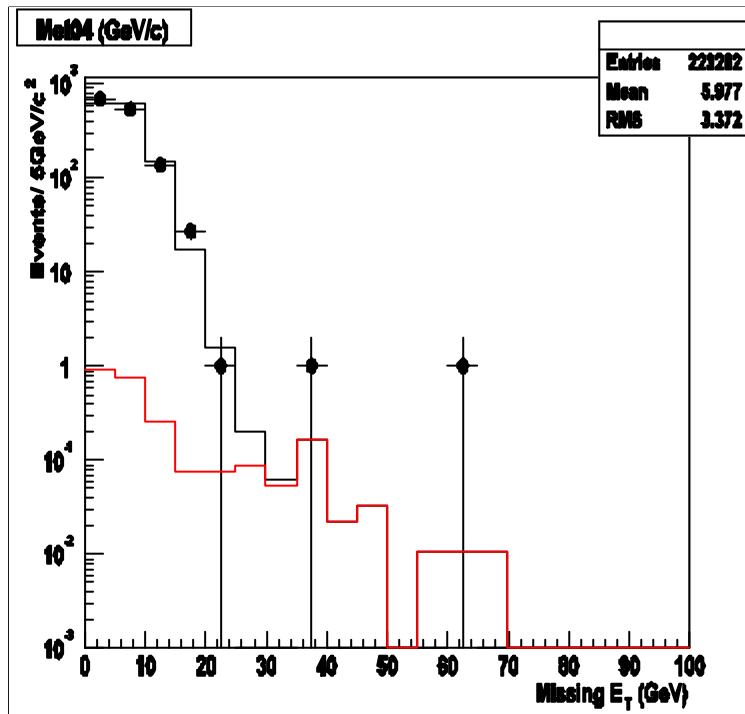
# Search for

$$\tilde{g} \rightarrow b\tilde{b}_1$$



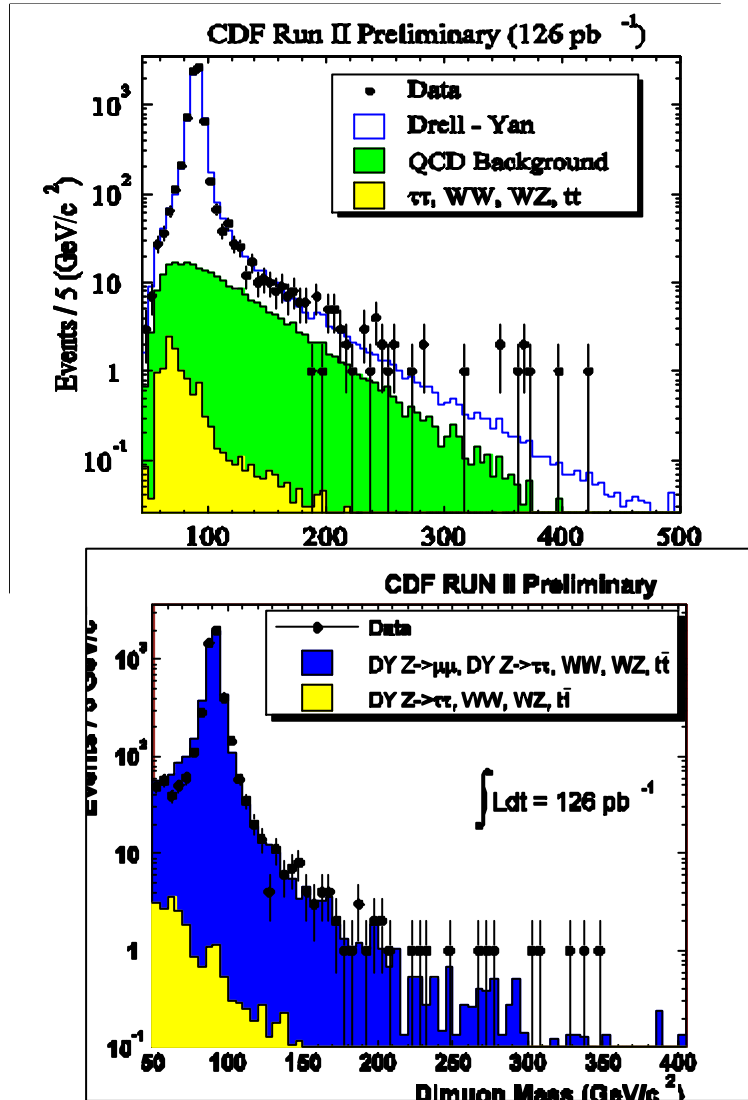
- Take advantage of the large cross sections for the production of gluinos
- signature : 4b+ missing  $E_T$   
b-jet trigger (SVT) greatly improved acceptance
- $\geq 3$  jets,  $\text{miss}E_T > 50 \text{ GeV}$ ,  
1 b-tag / 2 b-tags
- No evidence for  
gluinos pair sbottom + bottom
- Only a fraction of available data used

# Searches with $\gamma\gamma + \text{missing } E_T$



- Motivated mainly by GMSB scenario : Neutralino NLSP    Gravitino LSP + g
- Require missing  $E_T > 25\text{GeV}$     Expect 0.6 events, observe 2 events ( $84 \text{ pb}^{-1}$ )
- $M_C > 113 \text{ GeV}/c^2$  @ 95%C.L.

# High Mass Dileptons



- Search for high mass opp. sign dilepton pairs (e or  $\mu$ )

- Extra gauge bosons  $Z'$

predicted by many models  
such as E6 GUT

- Randall-Sundrum Graviton  $G$

1 extra dimension +  
spin-2 graviton

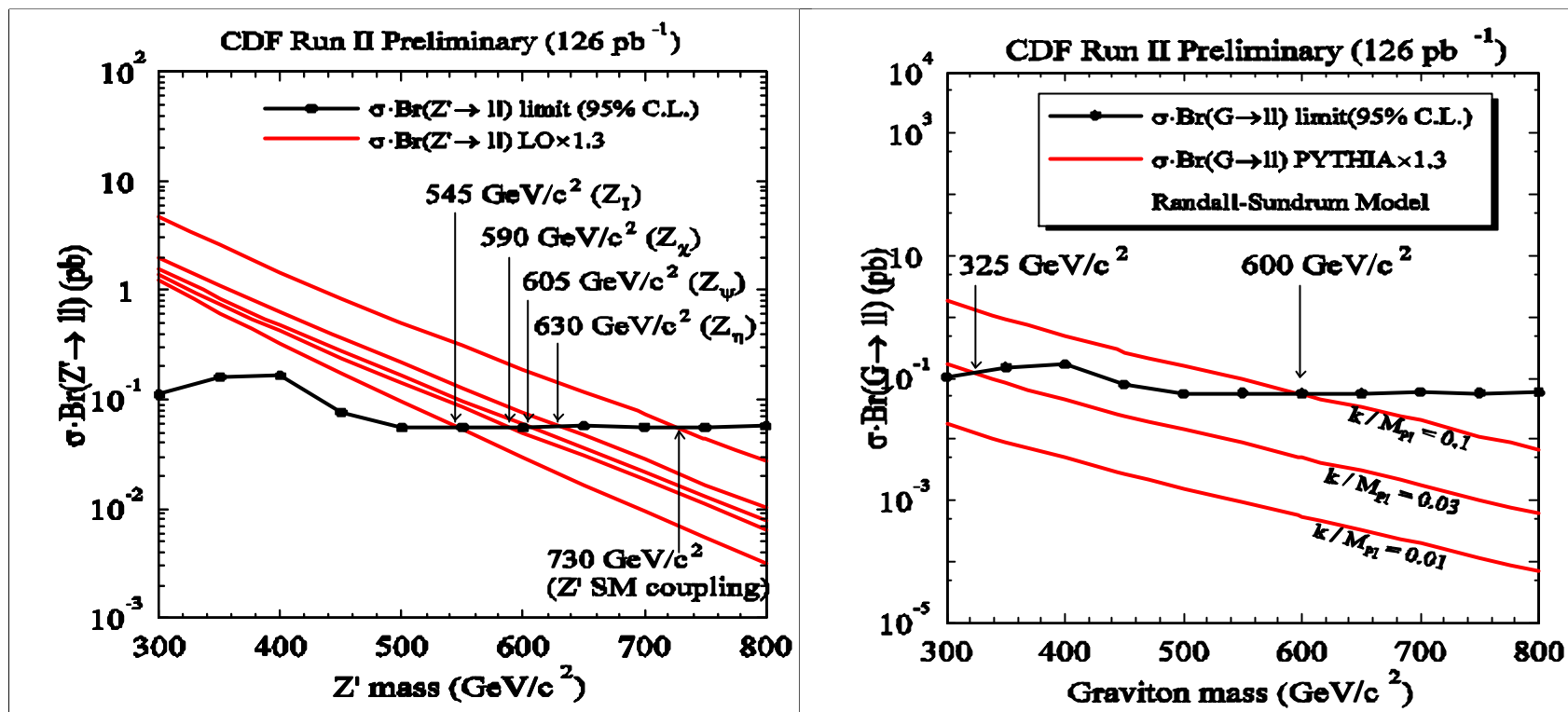
Two free parameters :

graviton mass  $M_G$  and

coupling parameter  $k/M_{pl}$

- No significant excess

# Z' and RS gravitons

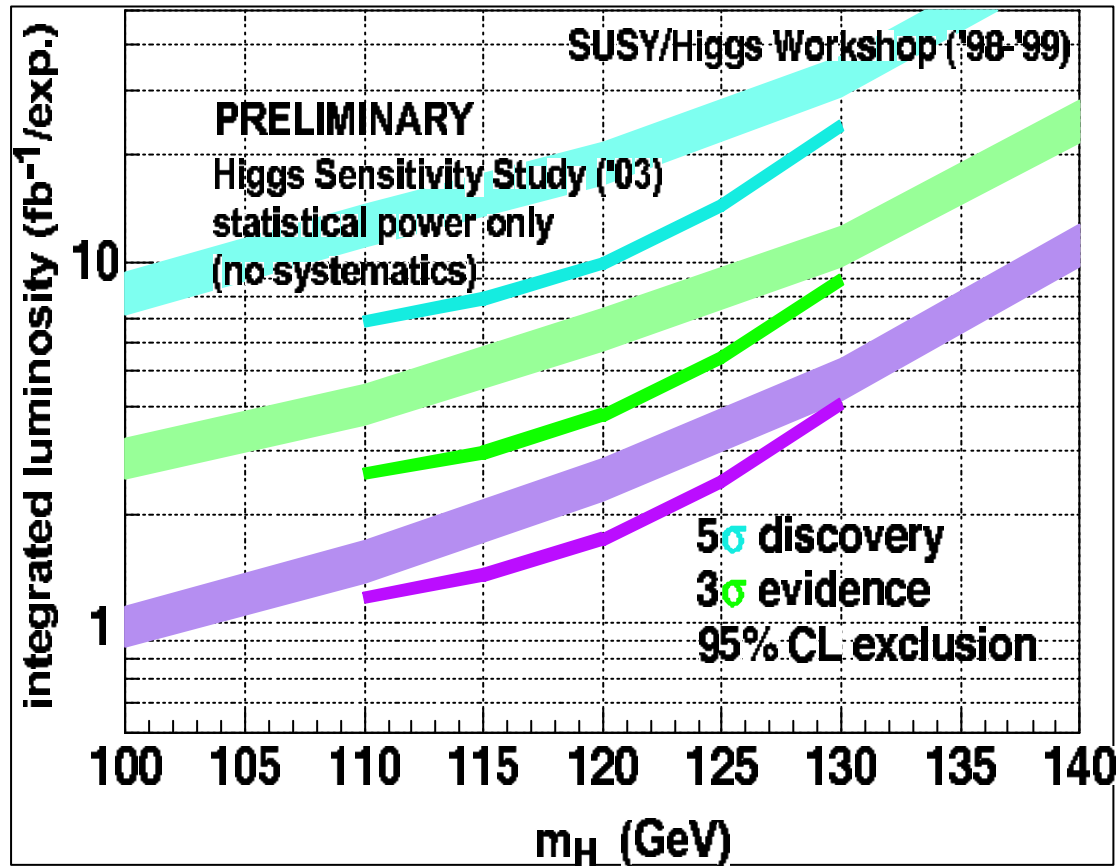


- Combined dielectron and dimuon channels
- $M_{Z'} > 545 \sim 630$  GeV/c<sup>2</sup> (95% C.L.) for various Z's within E6 models
- $M_G > 600$  GeV/c<sup>2</sup> (95% C.L.) for  $k/M_{pl} = 0.1$

# New Study of Higgs Sensitivity

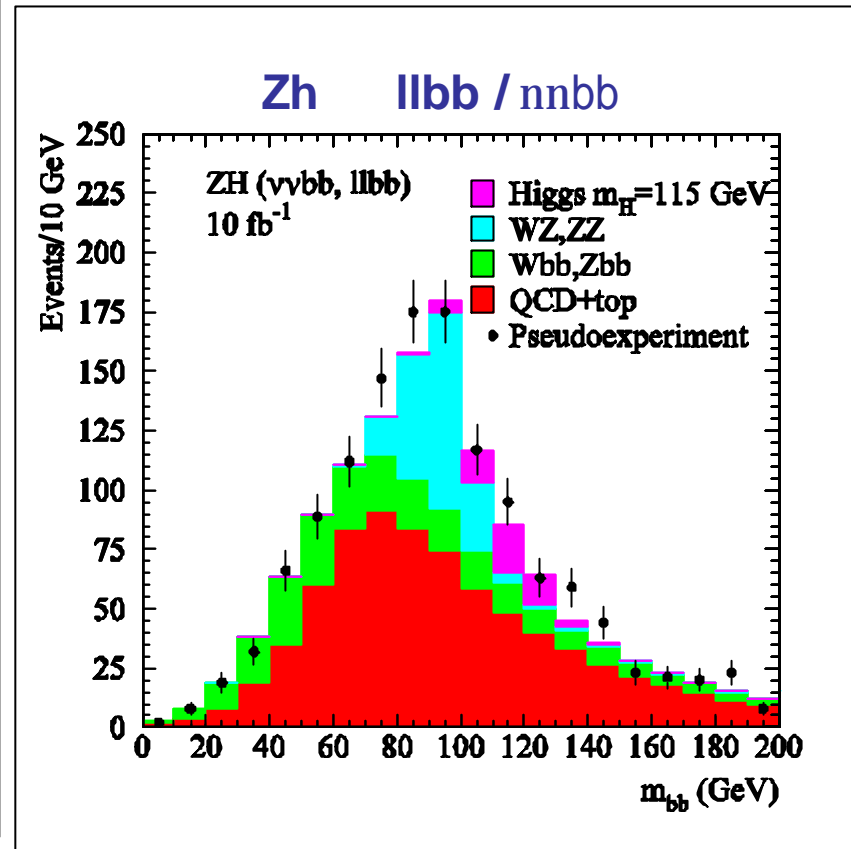
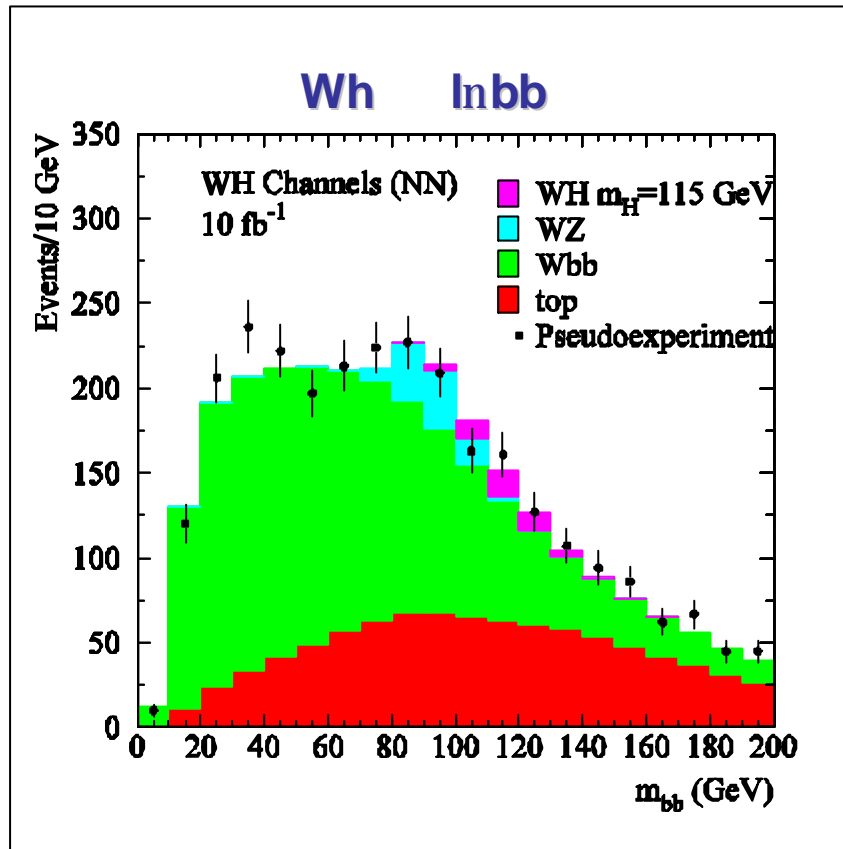
- Update the results of the previous study in 1998-1999
  - CDF and D0 now have tuned simulations
  - Event selections can now be on actual data analyses
  - Background processes known to be higher
  - New analysis techniques
- Concentrate on low mass region :  $110 < m_h < 140 \text{ GeV}/c^2$
- Concentrate on the two main channels :
  - CDF studied  $Wh \rightarrow l\nu bb$
  - D0 studied  $Zh \rightarrow \nu\nu bb$
- Results combined for both channels and experiments

# Higgs Sensitivity



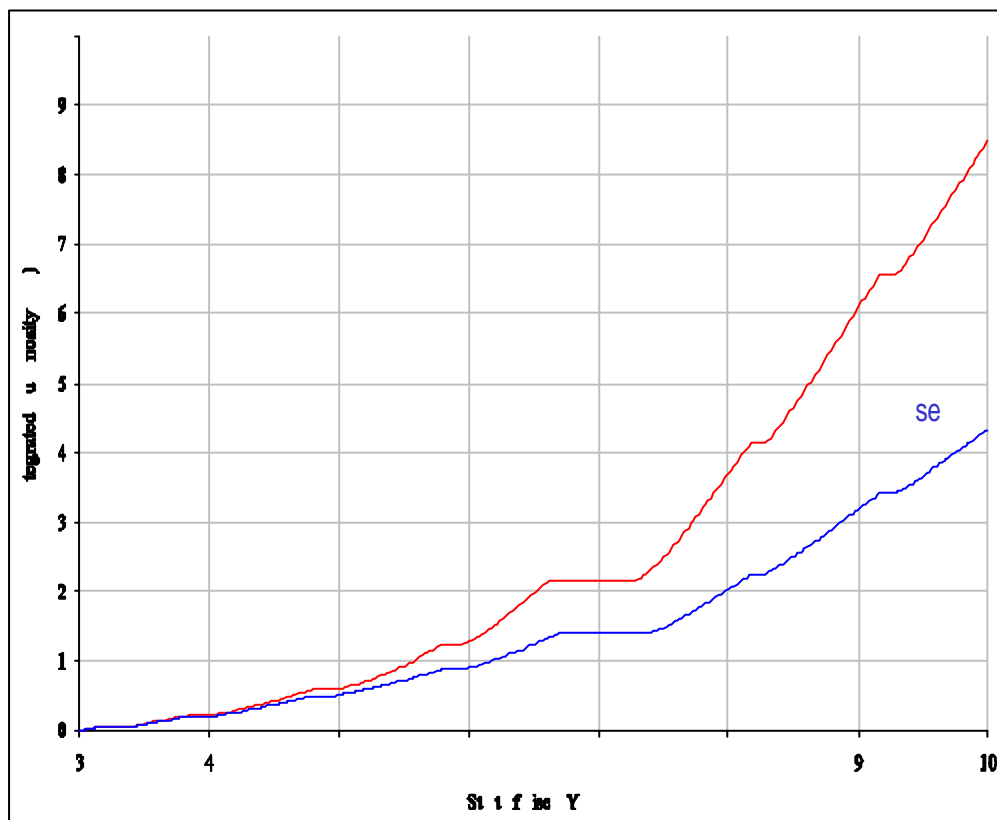
- No systematics included
- New study supports old study
- b-tagging is almost as good as assumed
  - effect of silicon radiation damage?
- dijet mass resolution
  - ~ 10%
- This result is not final : joint report will be released soon

# SM Higgs Signals



- Signal will not be dramatic...
- Need to control systematic errors on dijet mass shape

# Integrated Luminosity Expectations

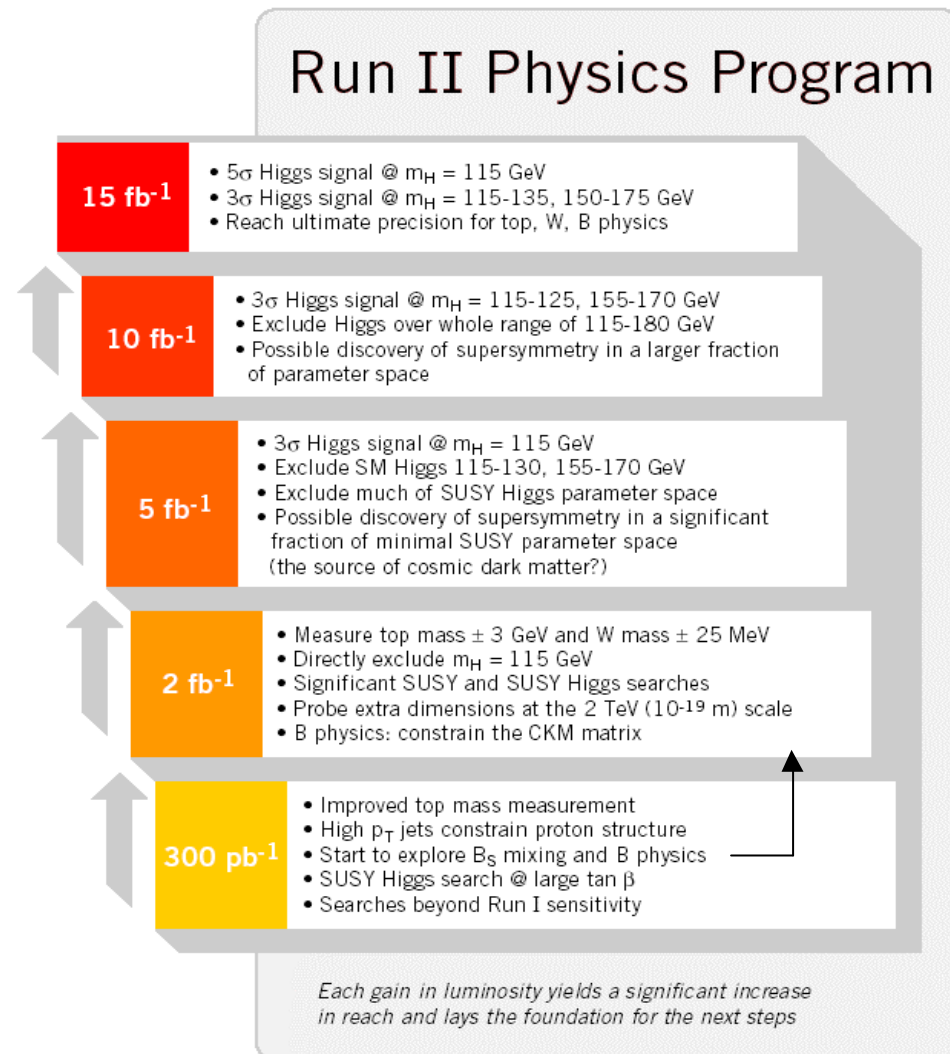


- Recycler and electron cooling since FY 2006
- Design projection :  
8.6 fb<sup>-1</sup> by end of FY 2009
- Base Projection :  
4.4 fb<sup>-1</sup> by end of FY 2009
- Plan for detector upgrades in FY 2006  
“RunIIb” : Trigger, DAQ, ...



# RunII Physics Program

Each gain in luminosity yields a significant increase in reach and lays the foundation for the next steps

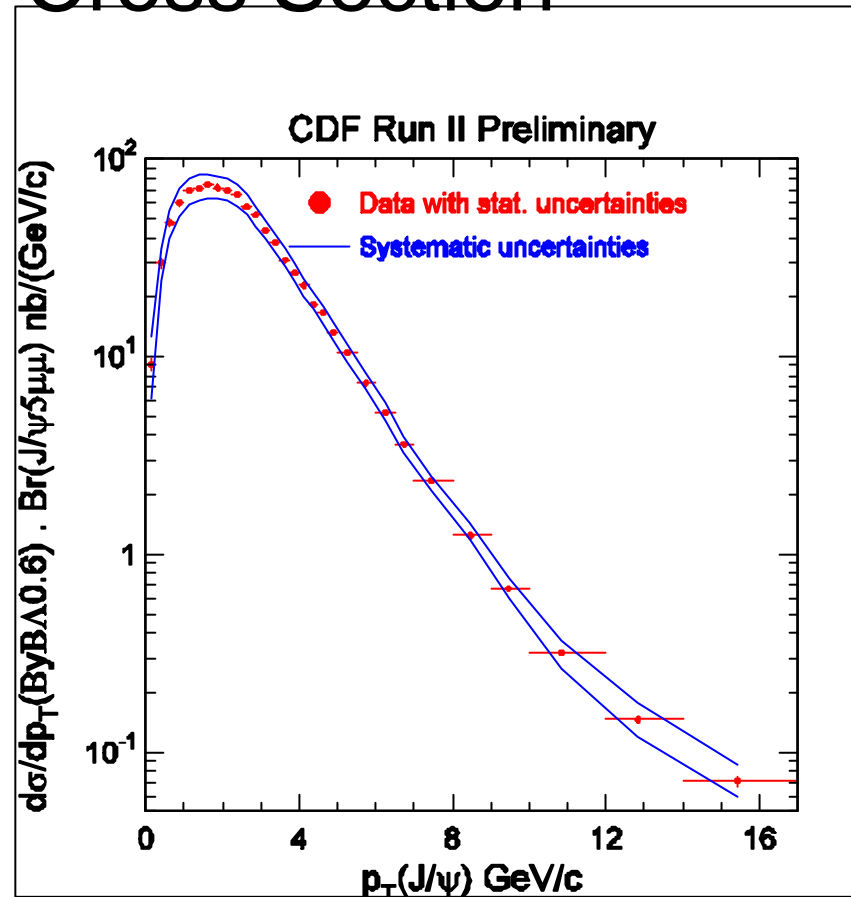
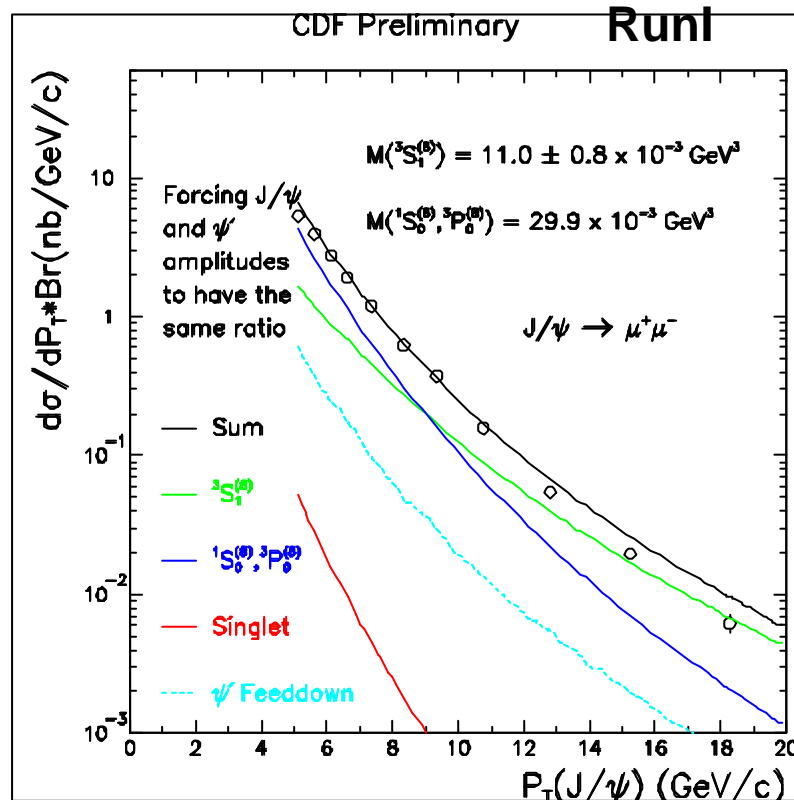


# Summary

- Highest  $E_T$  jets observed
- New Top measurements
  - Cross section, Top mass
- Search for new phenomena
  - Direct search mass limits on  $Z'$
- More SUSY results will be available soon
- Appears to be positive about Higgs search
- Need more data !

# Backup slides

# J/ψ Production Cross Section



- Taking the beam energy increase into account, RunII results support RunI results.