Measurement of the Top Pair Production Cross Section in the Dilepton Decay Channel at CDF

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on behalf of
The CDF Collaboration

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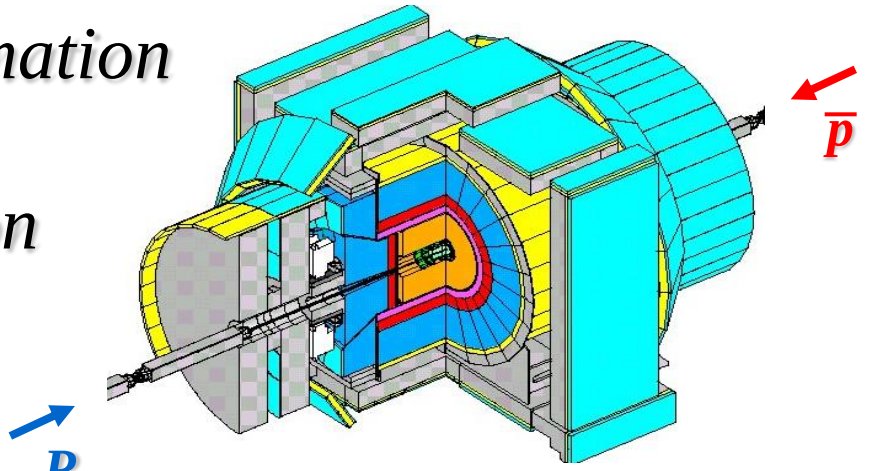
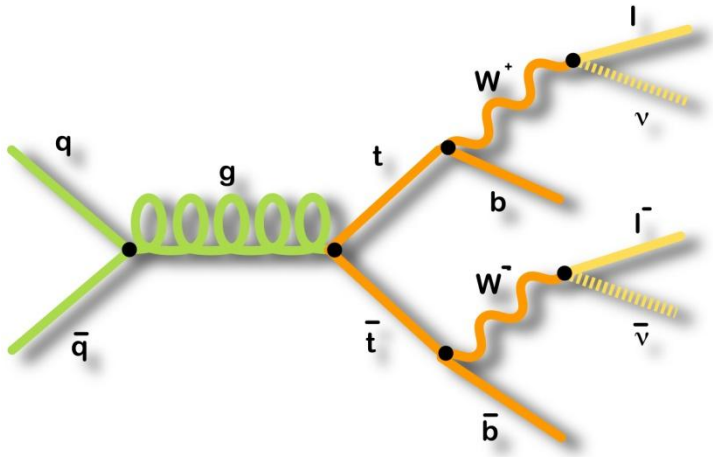


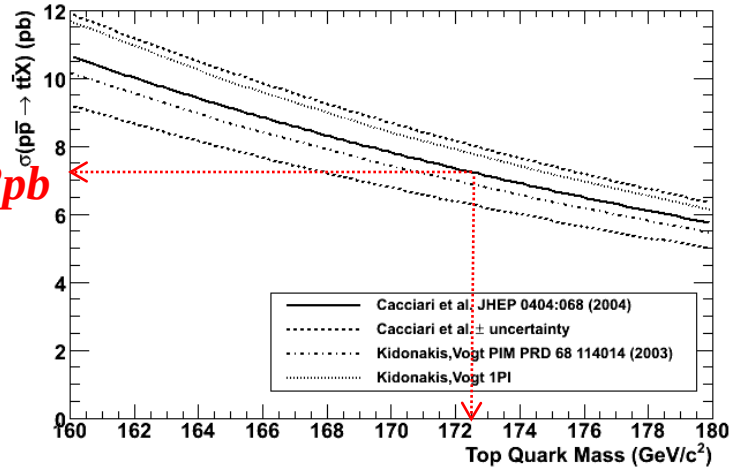
CDF II Detector

Motivation

- *Top pair decay in dilepton channel.*
  - *Dilepton(ee+eμ+μμ) channel has about 5% branching ratio in top pair decay.*
  - *The cleanest final state : Small background*
    - *Signal to Background ratio*
      - *Pre-tag ~ 2:1, b-tag ~ 15:1*
  - *Important dilepton background for New Physics searches*



- *Test of the Standard Model.*
  - *A deviation from the Standard Model prediction would indicate something new, e.g. SUSY or Higgs particles.*



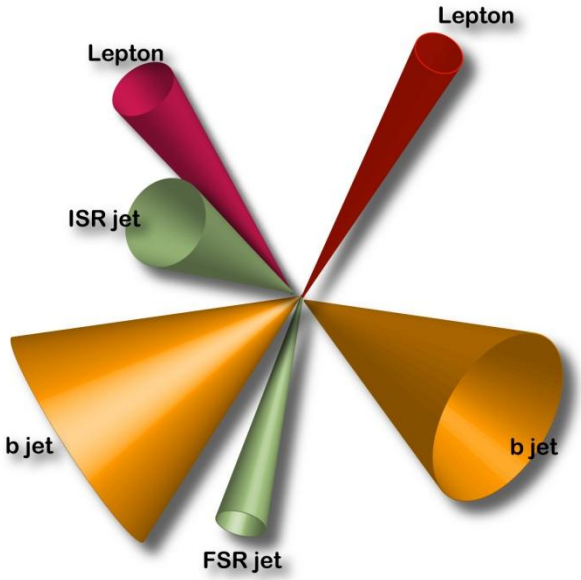
7.4±0.8pb

172.5 GeV

Dilepton Event Selection

Signal Selection

- 2 leptons : At least one tight lepton
- At least 2 tight jets.
- Minimum missing transverse energy is required.

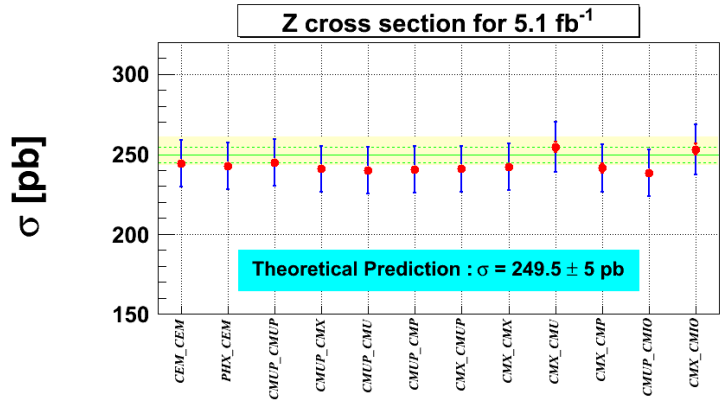


Background Rejection

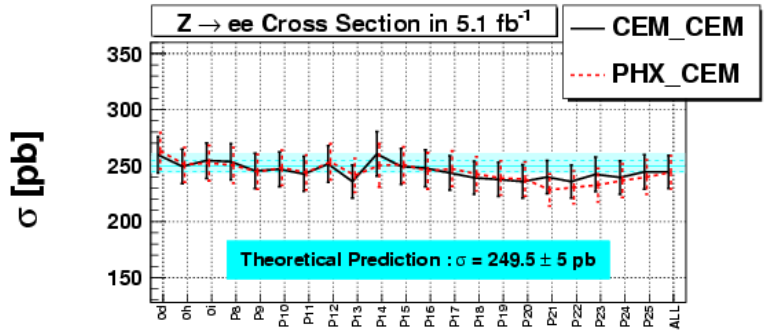
- L-cut : Angle topology cut between missing transverse energy and any lepton or jet.
- Z-veto : Missing E_T significant cut for $ee/\mu\mu$ events.
- Minimum total transverse energy(H_T) and dilepton invariant mass (M_{ll}) is required.
- Opposite charge leptons are only selected.

Z boson Cross Section Check

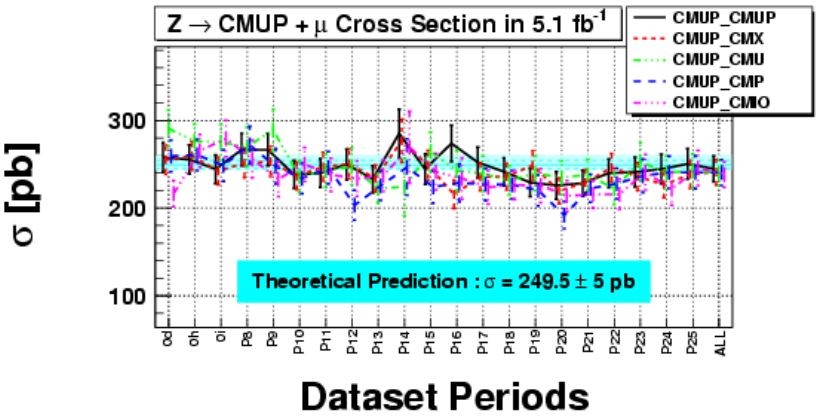
- *Z boson cross section measurement in the dielectron and dimuon events.*
  - *To validate that all of efficiencies and scale factors between data and Monte Carlo.*
  - *We observe good agreement with expected σ_Z = 249.5 pb both for ee and $\mu\mu$ categories.*

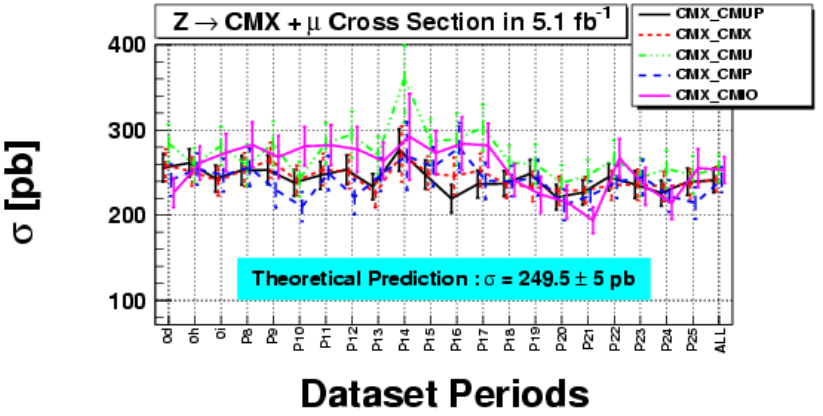


All Dilepton Categories



ee Dilepton Categories

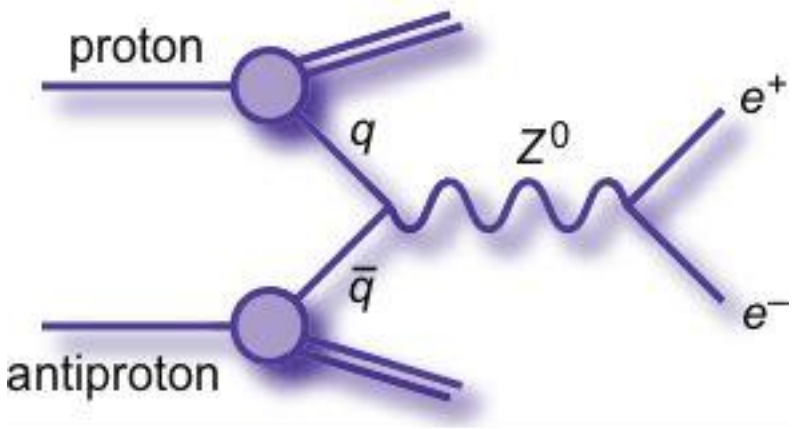




μμ Dilepton Categories

Type of Backgrounds

- *Use both data and MC for background estimates*
  - *Fully estimated from MC*
    - *Diboson : WW, WZ, ZZ*
    - *Drell-Yan/Z→ττ*
    - *Wγ*
  - *Use both Data and MC*
    - *Drell-Yan/Z→ ee, μμ*
  - *Fully estimated from Data*
    - *Fakes (Mostly coming from W+jets events)*



Signal & Background Systematics

For the pre-tagged events

Source	Systematic Error (%)
Lepton ID	2.2
MC Generator	1.9
ISR/FSR	1.3
PDF's	0.6
CR	1.2
Jet corrections	3.3
Total	4.8

For the b-tagged events

Source	Systematic Error (%)
Lepton ID	2.2
MC Generator	1.9
ISR/FSR	1.3
PDF's	0.6
CR	1.2
Jet corrections	3.3
b-tagging	4.1
Total	6.3

Signal Candidate Composition in 5.1 fb^{-1}

Before b-tagging events

CDF II preliminary (5.1 fb^{-1})

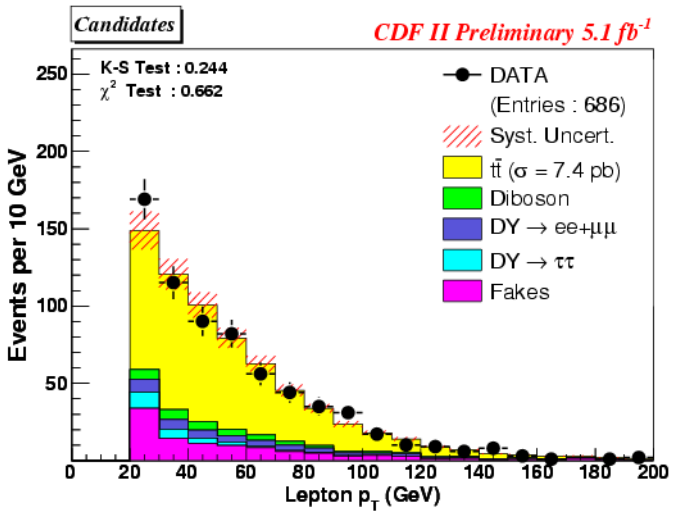
$t\bar{t}$ Signal Events per Dilepton Flavor Category				
Source	ee	$\mu\mu$	eμ	$\ell\ell$
WW	3.08±0.64	2.68±0.56	5.96±1.21	11.72±2.36
WZ	1.56±0.25	0.98±0.16	0.93±0.16	3.48±0.55
ZZ	1.02±0.79	0.82±0.64	0.42±0.33	2.25±1.75
Wγ	0.42±0.44	0.00±0.00	0.00±0.00	0.42±0.44
DY$\rightarrow \tau\tau$	2.88±0.55	2.97±0.56	6.42±1.16	12.26±2.18
DY$\rightarrow ee + \mu\mu$	11.54±2.22	8.40±1.62	2.45±1.09	22.40±3.24
Fakes	7.23±2.29	12.85±4.22	33.20±10.25	53.27±14.70
Total background	27.73±4.28	28.69±5.04	49.38±10.85	105.80±17.24
$t\bar{t}$ ($\sigma = 7.4$ pb)	54.65±2.65	54.92±2.65	127.55±6.10	237.13±11.30
Total SM expectation	82.38±6.63	83.61±7.46	176.93±16.80	342.92±28.30
Observed	74	96	173	343

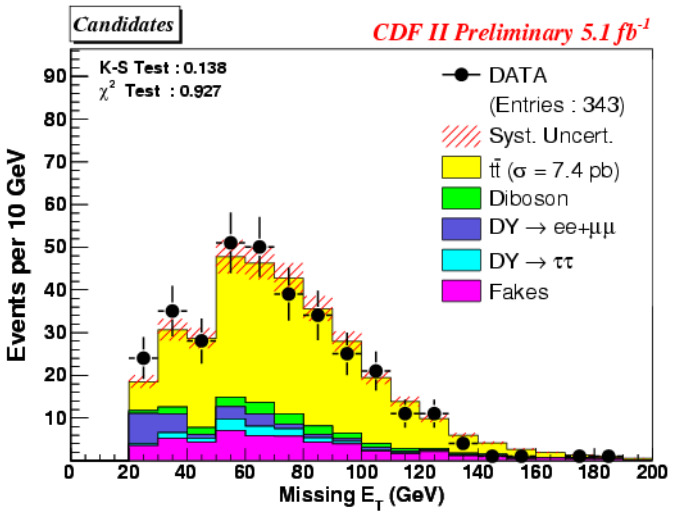
Signal b-tagged events

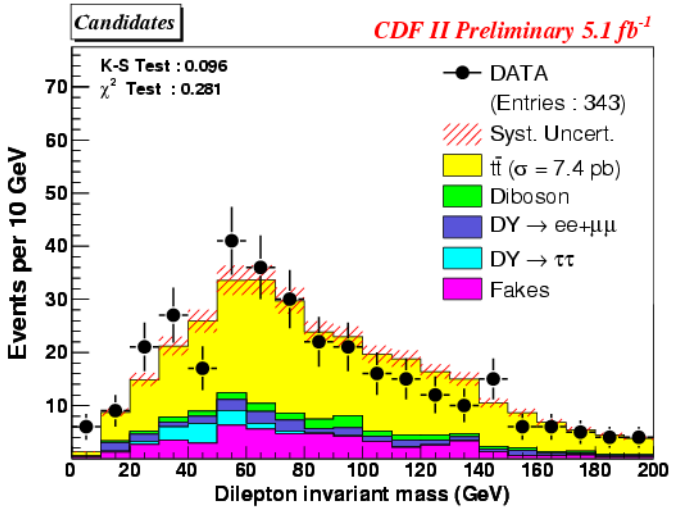
CDF II preliminary (4.8 fb^{-1})

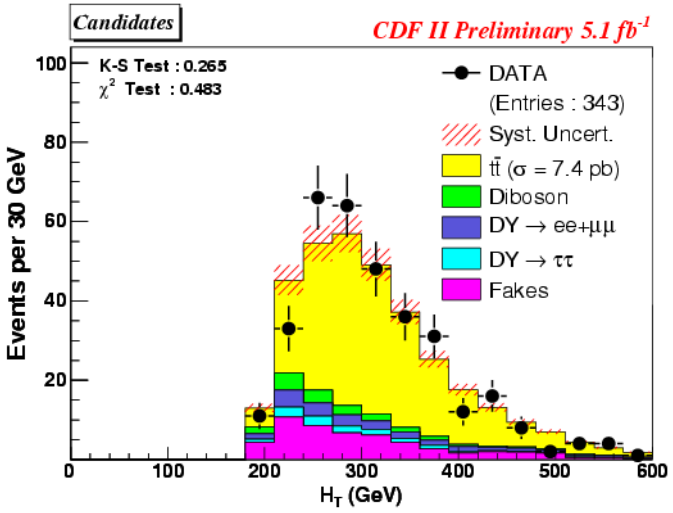
$t\bar{t}$ Signal Events with the tight SecVtx b-tag				
Source	ee	$\mu\mu$	eμ	$\ell\ell$
WW	0.08±0.03	0.09±0.04	0.21±0.06	0.37±0.10
WZ	0.02±0.01	0.03±0.01	0.03±0.01	0.08±0.02
ZZ	0.08±0.06	0.07±0.06	0.02±0.02	0.17±0.14
DY+LF	0.51±0.05	0.60±0.05	0.28±0.03	1.39±0.12
DY+HF	0.51±0.04	1.41±0.11	0.37±0.03	2.28±0.18
Fakes	1.17±0.48	0.90±0.39	3.39±1.12	5.46±1.59
Total background	2.36±0.51	3.10±0.46	4.29±1.13	9.75±1.68
$t\bar{t}$ ($\sigma = 7.4$ pb)	30.22±1.91	29.63±1.87	70.10±4.38	129.96±8.10
Total SM expectation	32.59±2.32	32.73±2.25	74.39±5.42	139.71±9.66
Observed	22	44	71	137

Pre-tag Kinematic Plots of Candidates

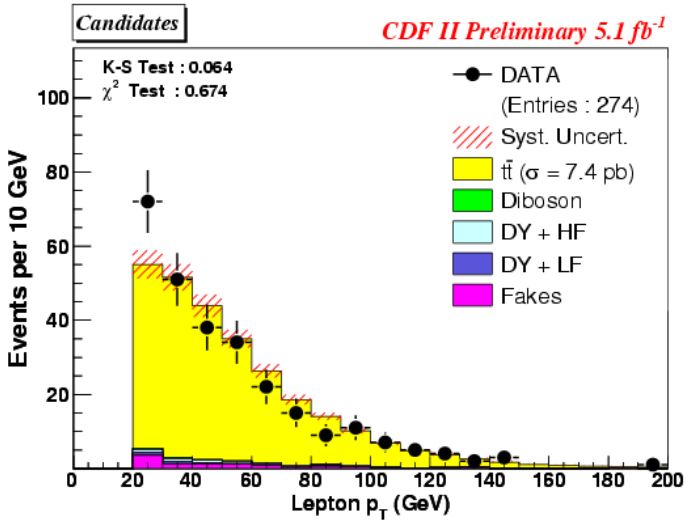


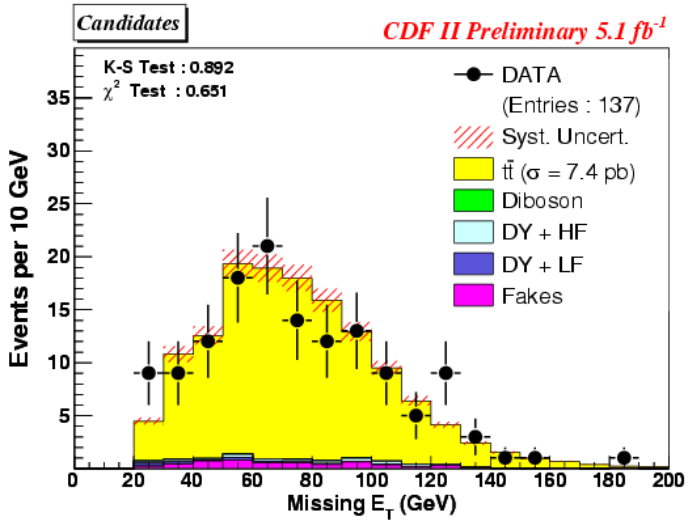


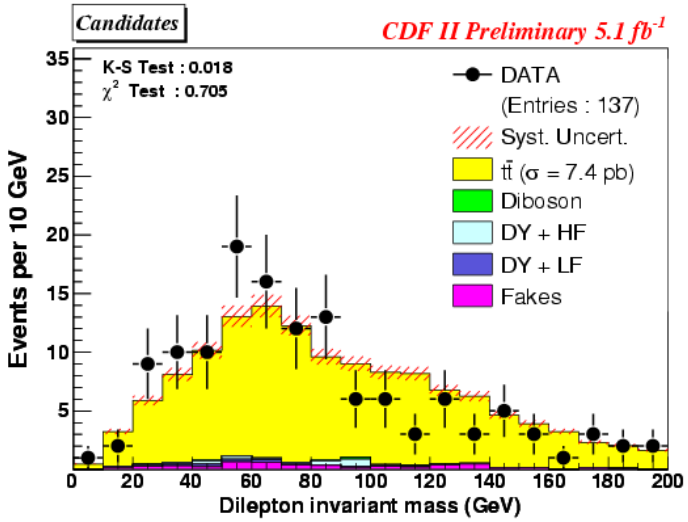


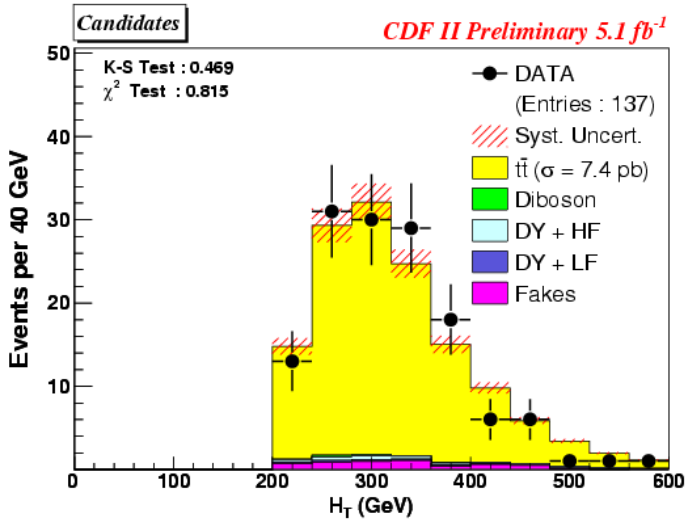


b-tag Kinematic Plots of Candidates









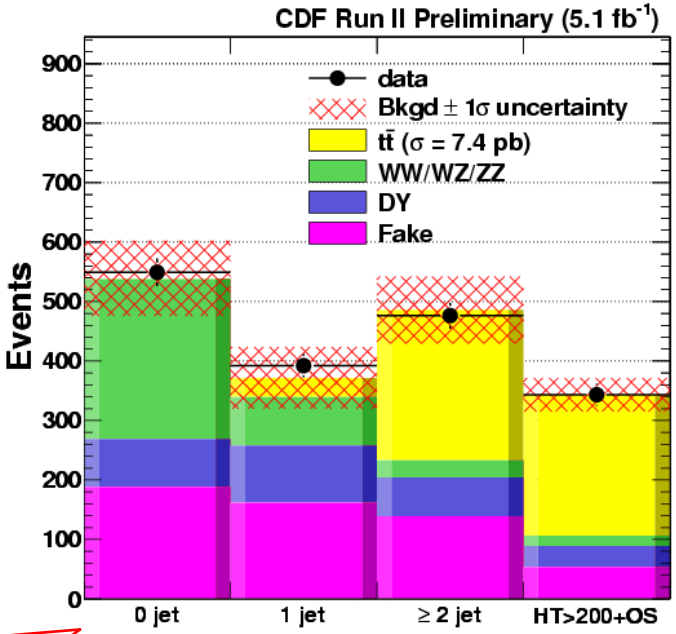
Calculation of Cross Section

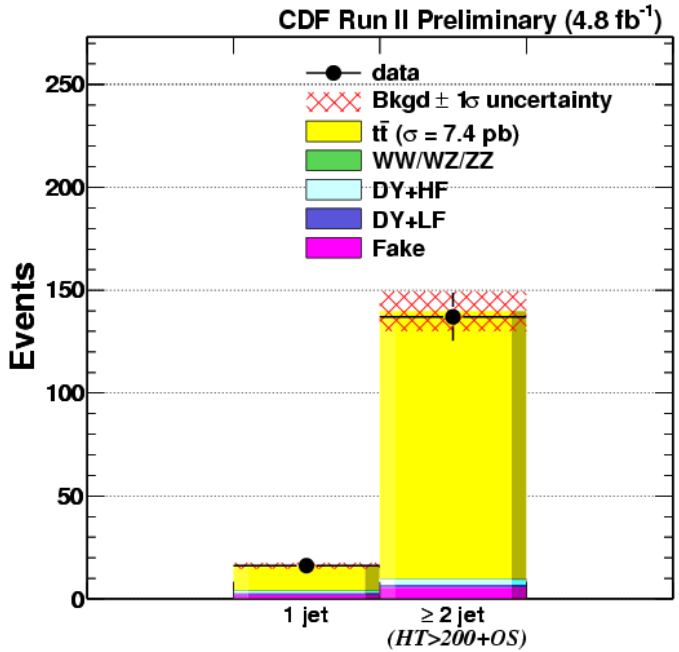
- *The Top pair production Cross Section* σ_{tt}

$$\sigma_{t\bar{t}} = \frac{N_{Observed} - N_{Background}}{Acceptance \times Luminosity}$$

- *Cross Section Numerator*
  - $N_{Background} = Acc * \sigma * Lum * SF$
- *Cross Section Denominator*
  - $Acceptance * Luminosity = \sum_i A_i * L_i$, *where* $A_i = A_{l_1 l_2} * C_{l_1 l_2}$
  - ***Pre-tag :*** *Raw ttbar MC acceptance :* $A_{ttop25} = (0.756 \pm 0.004)\ \%$
    For 5.1 fb^{-1} *denominator :* $A*L = 32.047 \pm 0.149\ pb^{-1}$
  - ***b-tag :*** *Raw ttbar MC acceptance :* $A_{ttop25} = (0.461 \pm 0.003)\ \%$
    For 4.8 fb^{-1} *denominator :* $A*L = 17.569 \pm 0.238\ pb^{-1}$

$t\bar{t}$ Dilepton Cross Section





For pre-tag

$$\sigma_{t\bar{t}} = 7.40 \pm 0.58(stat) \pm 0.63(syst) \pm 0.45(lumi)\ pb$$

For b-tag

$$\sigma_{t\bar{t}} = 7.25 \pm 0.66(stat) \pm 0.47(syst) \pm 0.44(lumi)\ pb$$

Summary and Future Prospect

- *We have measured the top pair production cross section for M_{top}=172.5 GeV in dilepton channel using 5.1 fb^{-1} of data.*
  - *The results are consistent with the standard model : no new physics is founded yet.*

$$\sigma_{t\bar{t}} = 7.40 \pm 0.58(stat) \pm 0.63(syst) \pm 0.45(lumi)pb$$ *(For pre-tag)*

$$\sigma_{t\bar{t}} = 7.25 \pm 0.66(stat) \pm 0.47(syst) \pm 0.44(lumi)pb$$ *(For b-tag)*

- *This is the first measurement statistical uncertainty turn to be smaller than systematic uncertainty in dilepton channel.*
- *Considering to use multivariate technique to improve signal to background ratio and reduce systematic uncertainty.*