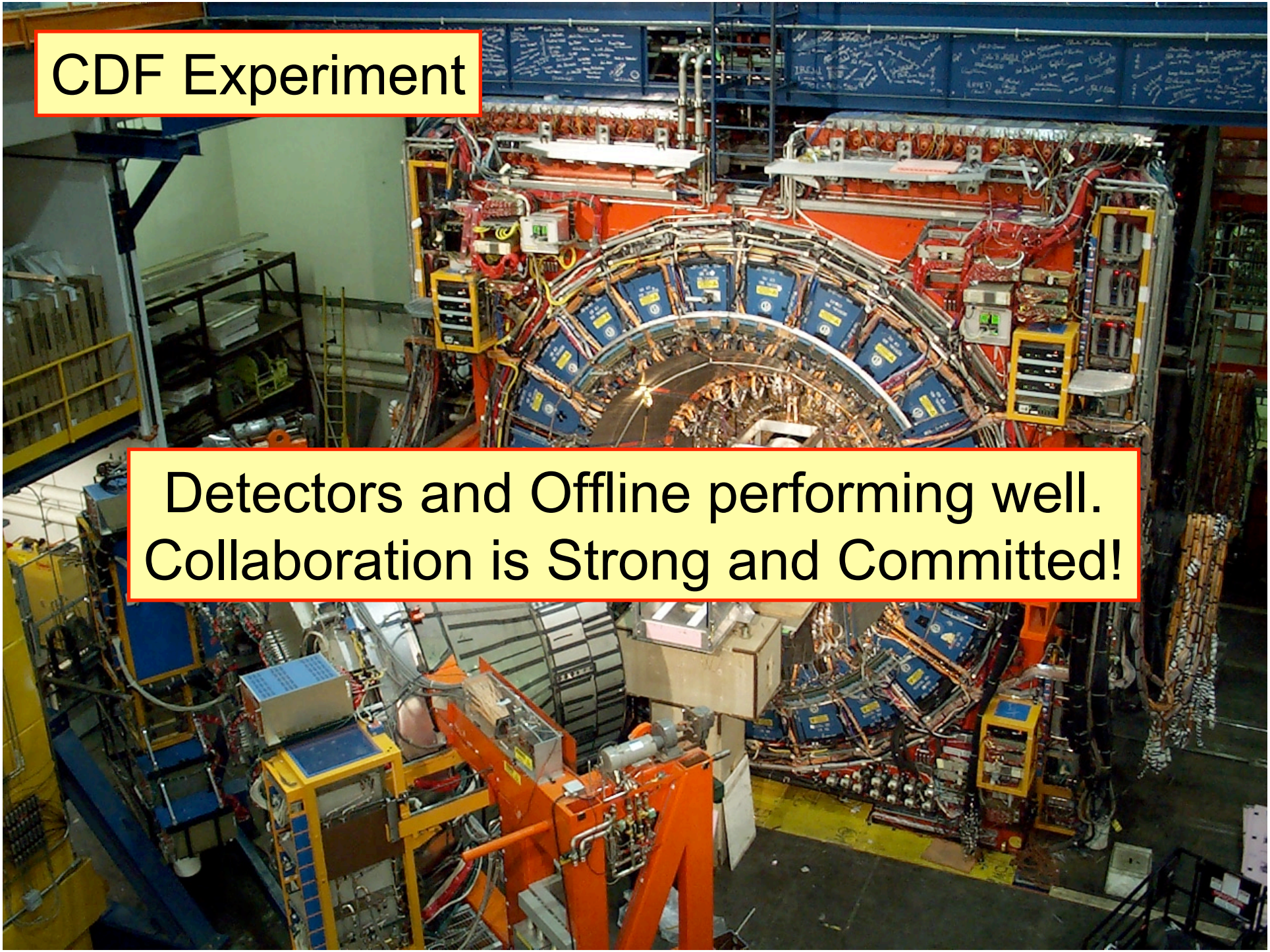
CDF Status

Rob Roser and Young-Kee Kim
on behalf of the CDF Collaboration

Physics: Highlights and Projections
(Young-Kee Kim)

The Challenge of High Luminosity and Shrinking Resources
(Rob Roser)


CDF Experiment
Detectors and Offline performing well.
Collaboration is Strong and Committed!

CDF II Physics Results

http://www-cdf.fnal.gov/physics/pub_run2/

Physics Papers	2001	First Collisions,Commissioning
	2002	First Physics Data
	2003	4
	2004	17
	Dec 8, 2005 Dec 9-23, 2005	29 7
	Total	57
NIM Papers	Total	31

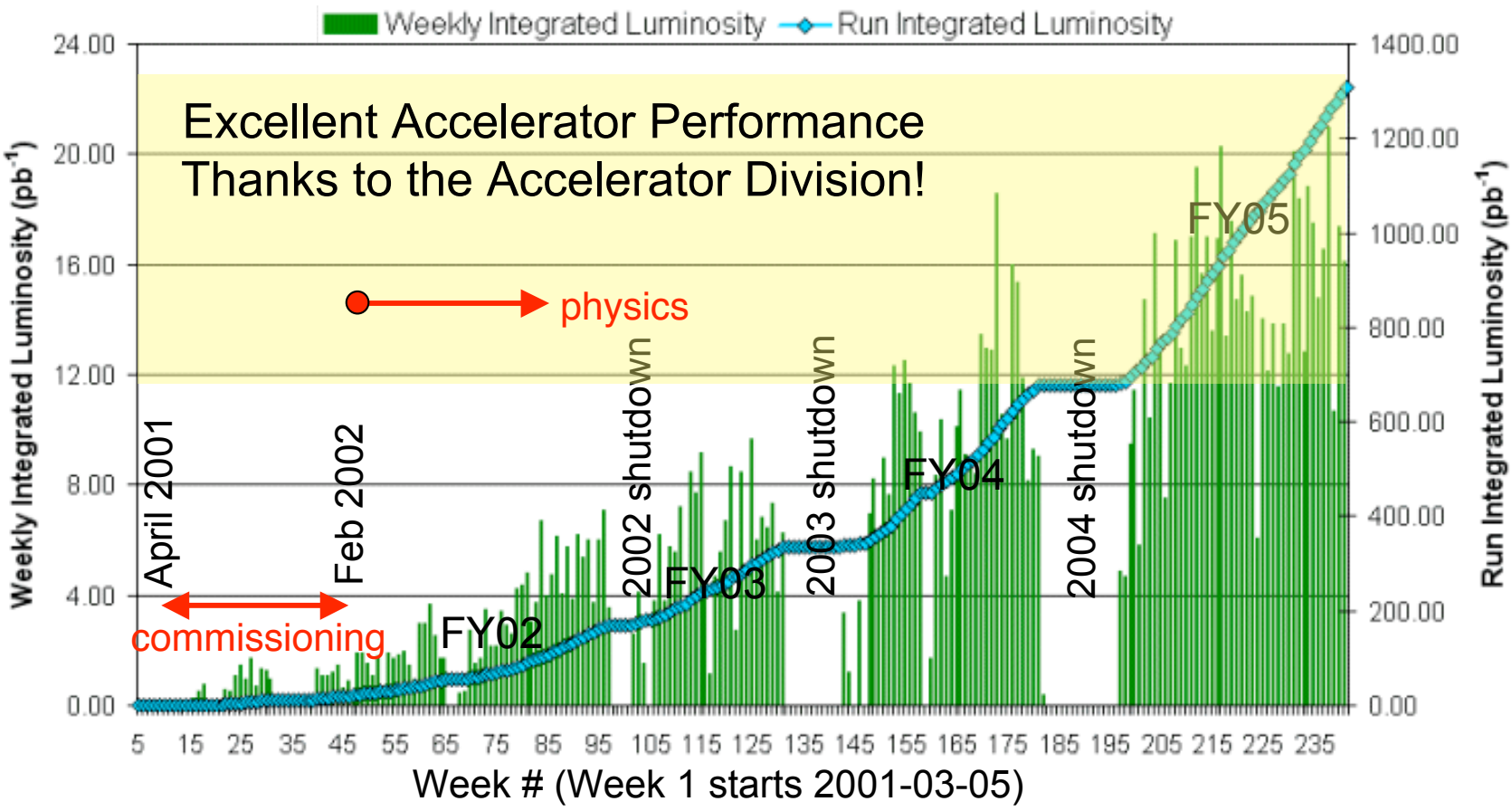
35 physics papers currently under collaboration's review

See the details in the backup slides.

Today's presentation includes some (not all) of the new results.

the others results - http://www-cdf.fnal.gov/physics/physics.html

Data delivered/recorded to date



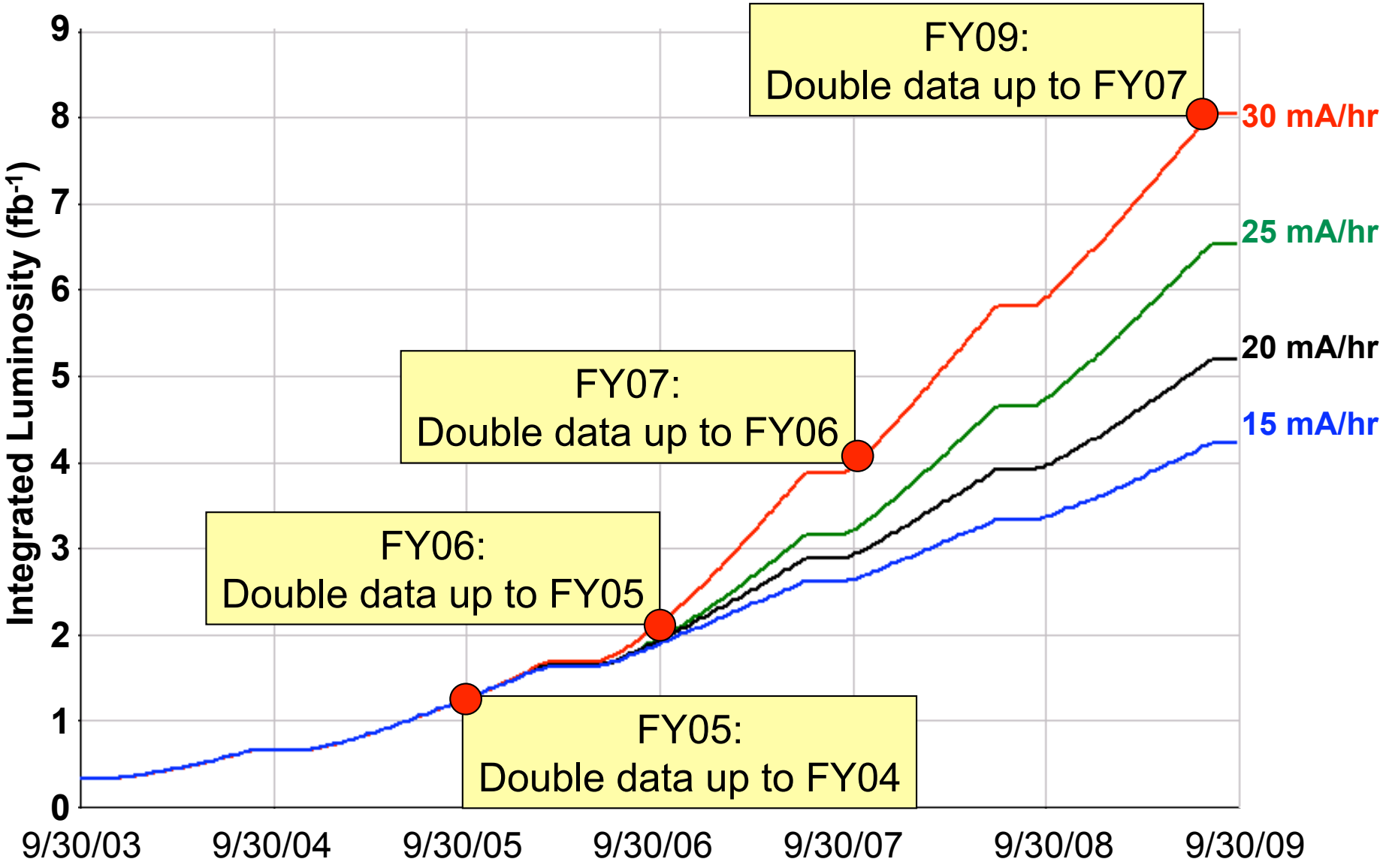
CDF: 1.44 fb^{-1} delivered, 1.15 fb^{-1} on tape

FY05 - 84% data taking efficiency

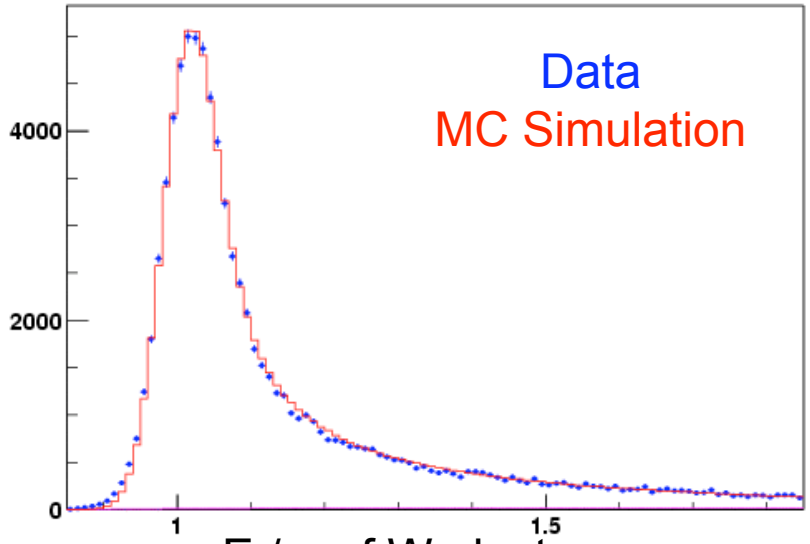
16% ineff.: ~5% Trigger/DAQ dead time, ~5% Beam conditions

1.0 fb^{-1} good for physics without silicon, 0.9 fb^{-1} good for physics with silicon

Projected Data Sample Growth

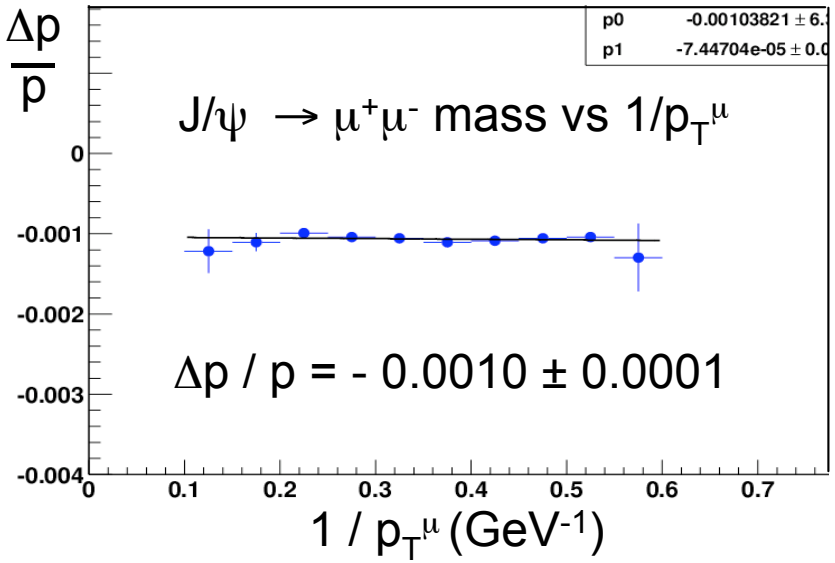


Momentum and Energy Scale Status

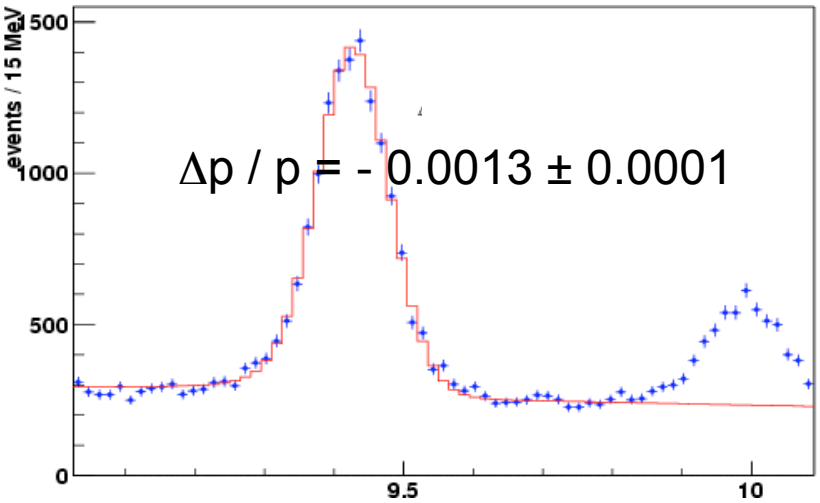


E / p of W electrons

- Understand passive material well:
  - E/p tail - data vs. simulation
  - Flatness of $J/\psi \rightarrow \mu^+\mu^-$ mass over a large p_T range
- $\Delta M_{J/\psi}$ = 0.05 MeV, ΔM_B = 0.2 MeV
- ΔM_W due to P, E scale
  - Run II current (Run Ib)
  - μ: 30 (87) MeV, e: 70 (80) MeV
  - better than Run Ib



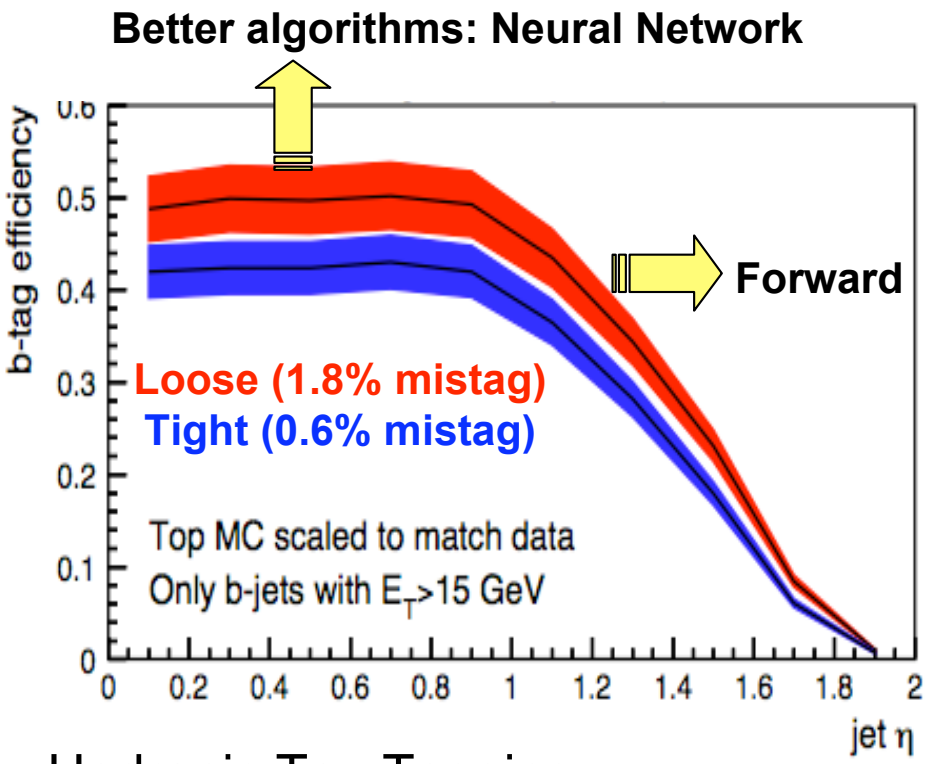
1 / p_T^{μ} (GeV^{-1})



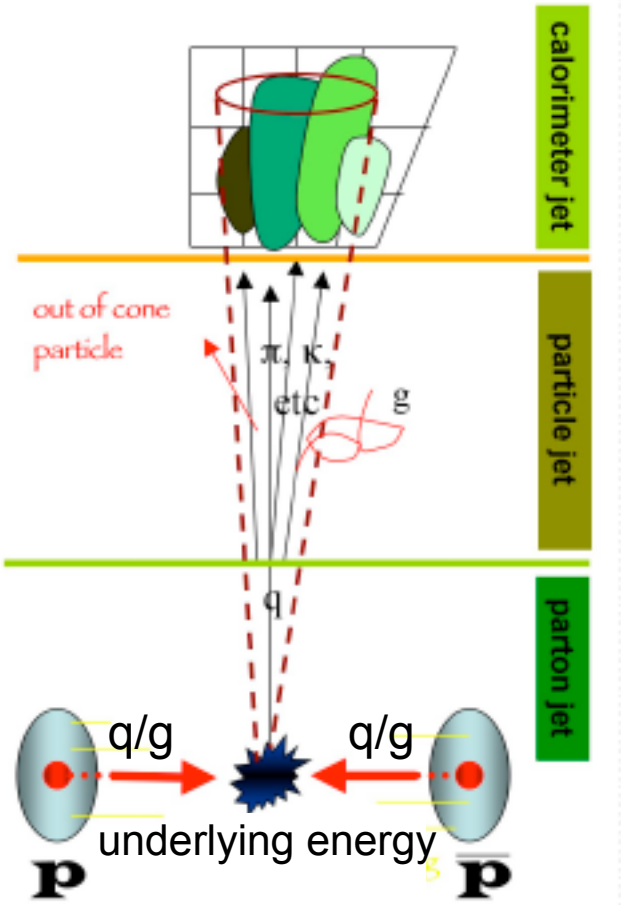
$\mu^+\mu^-$ mass (GeV) near Upsilon

Tagging and Jet Energy Calibration

- B Tagging (secondary vertex)



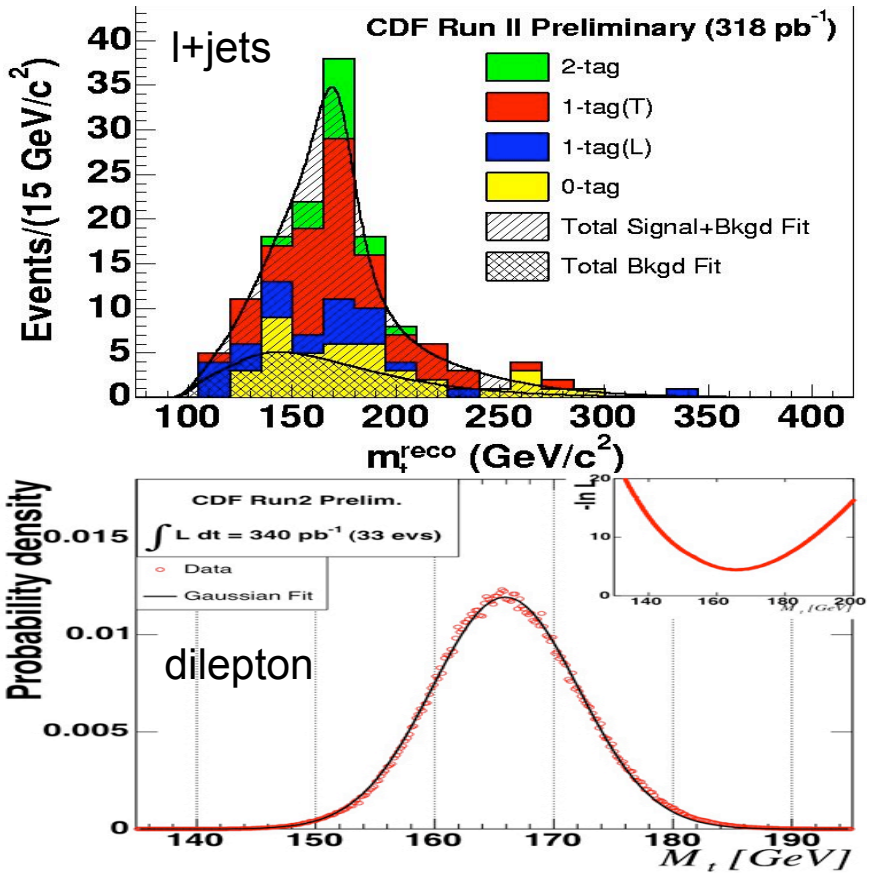
- Hadronic Tau Tagging
  - $E_{visible}$ > 30 GeV
    - ~50% efficient
    - 0.5 - 0.1% mis-identified

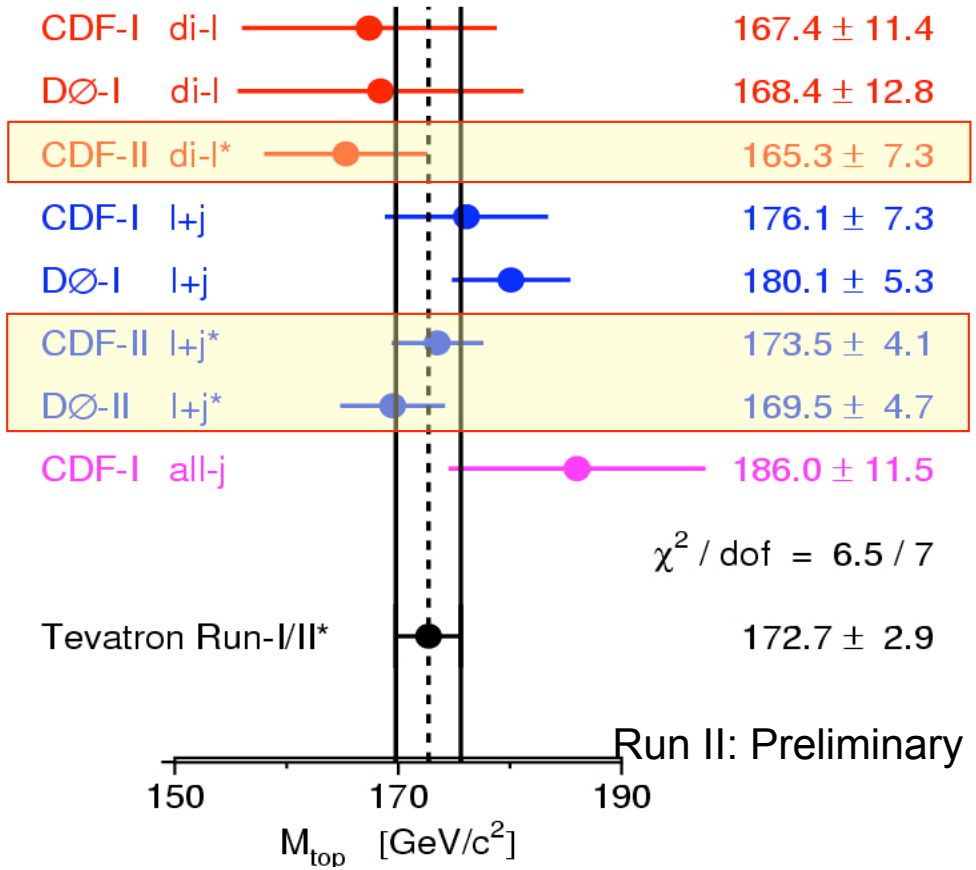


$\Delta E_{jet}/E_{jet}$ 3.5% at 50 GeV
2.6% at 100 GeV
2.8% at 200 GeV

About to submit to NIM: hep-ex/0510047

Top Mass Measurements

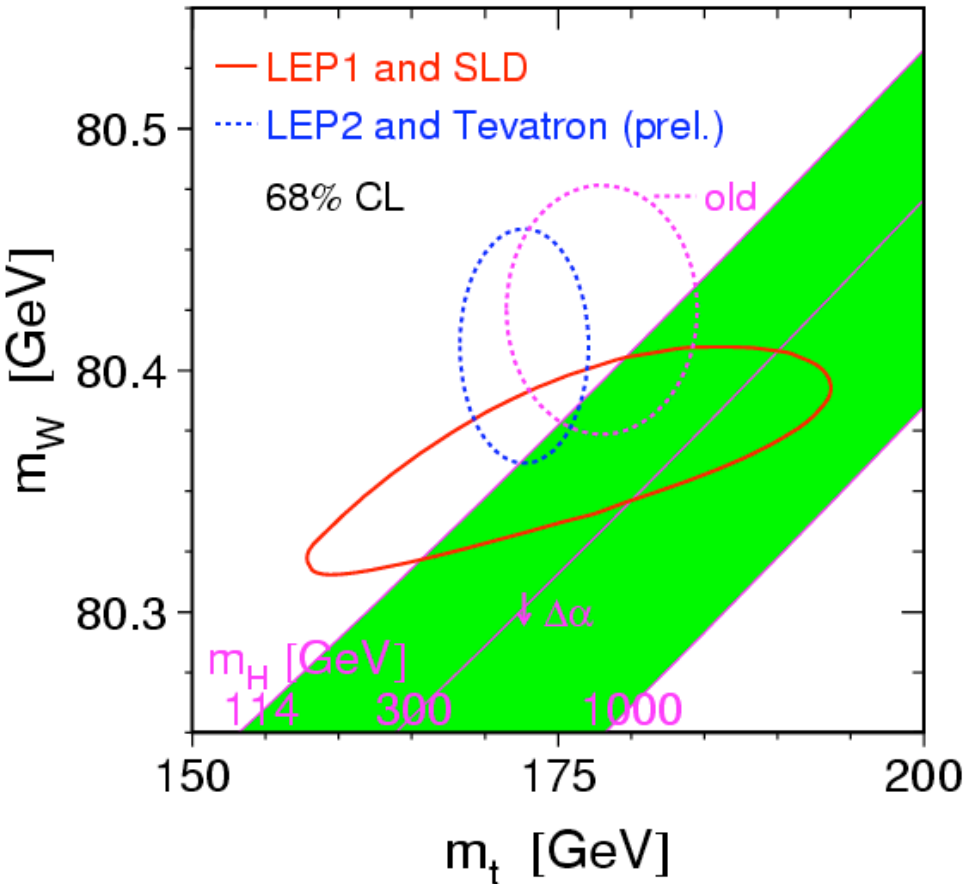


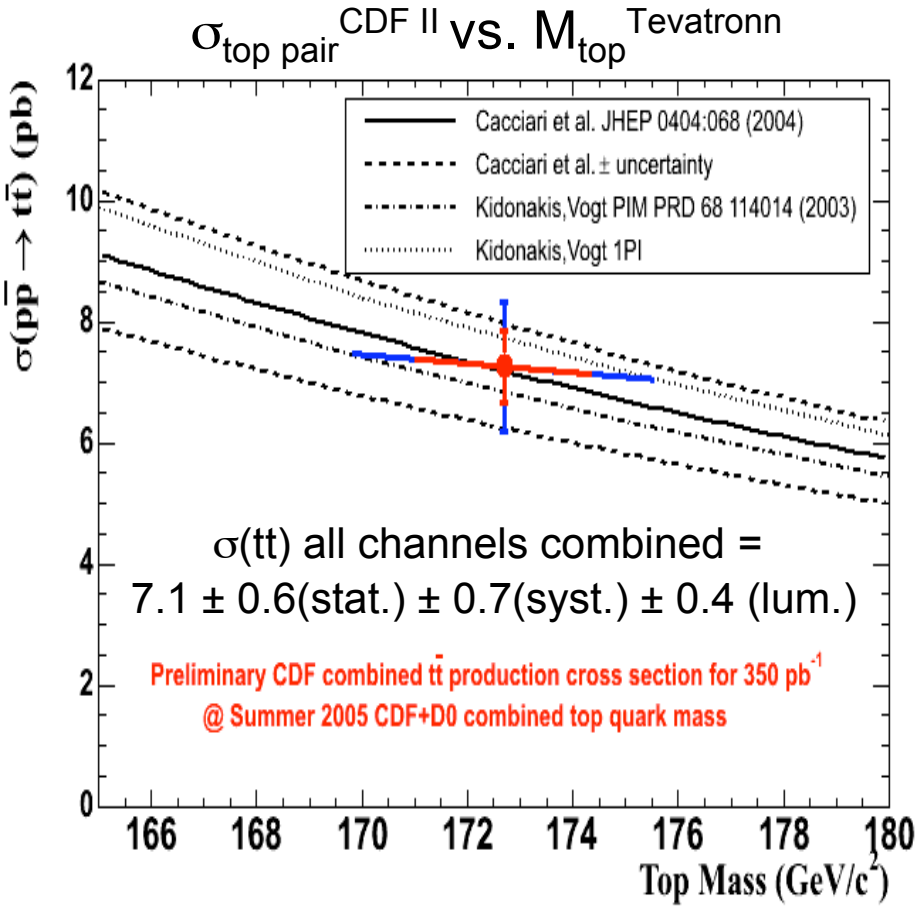


- lepton+jets (2 methods): 3 papers accepted/submitted
  - $173.5\ ^{+3.9}_{-3.8}$ GeV (template), $173.2\ ^{+4.1}_{-4.0}$ GeV (matrix element)
  - Single best measurement, better than Run I CDF+D0 measurements
- dilepton (4 methods): 2 papers will be submitted within a month

$M_{top}^{\text{CDF II combined}} = 172.2 \pm 3.7$ GeV (~2% accuracy)

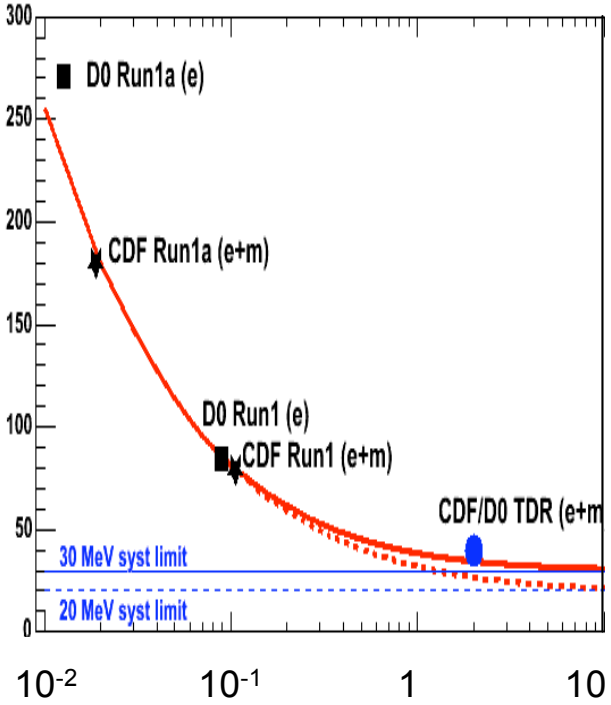
Top Mass and Production Cross-section





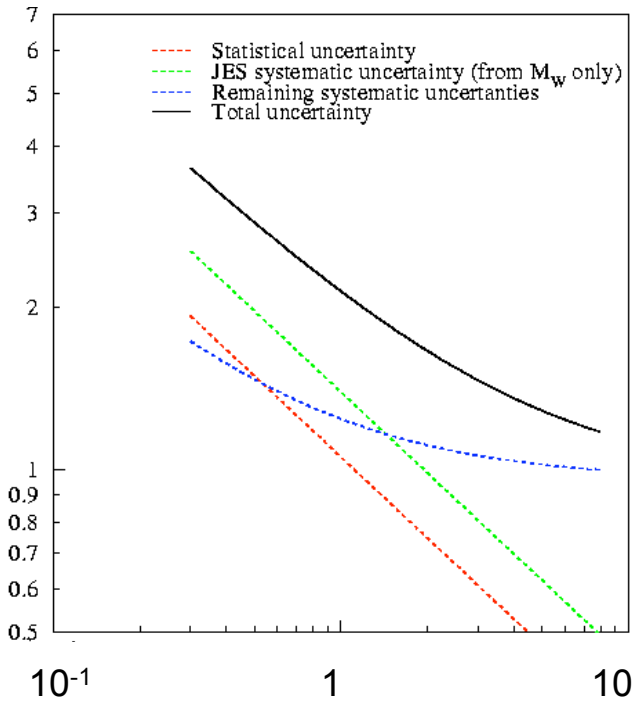
Electroweak Projections

ΔM_W [MeV]



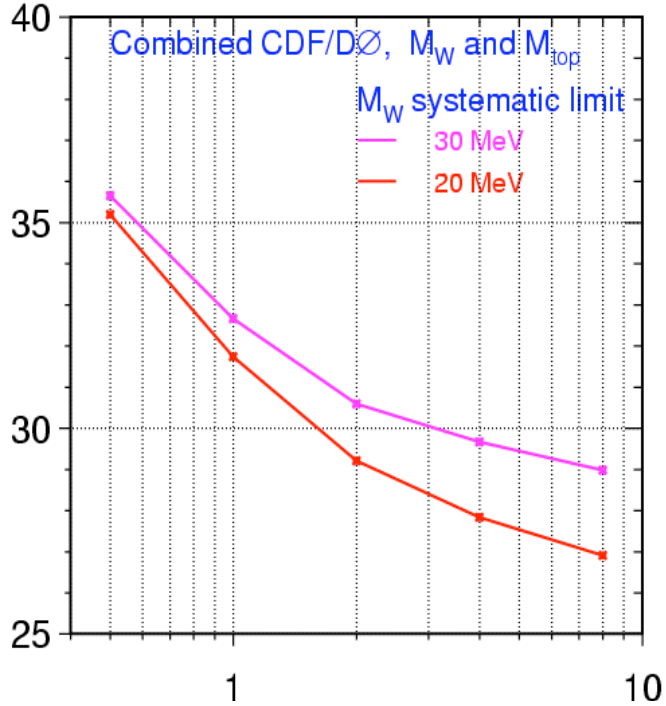
Luminosity / Experiment [fb^{-1}]

ΔM_{Top} [GeV]



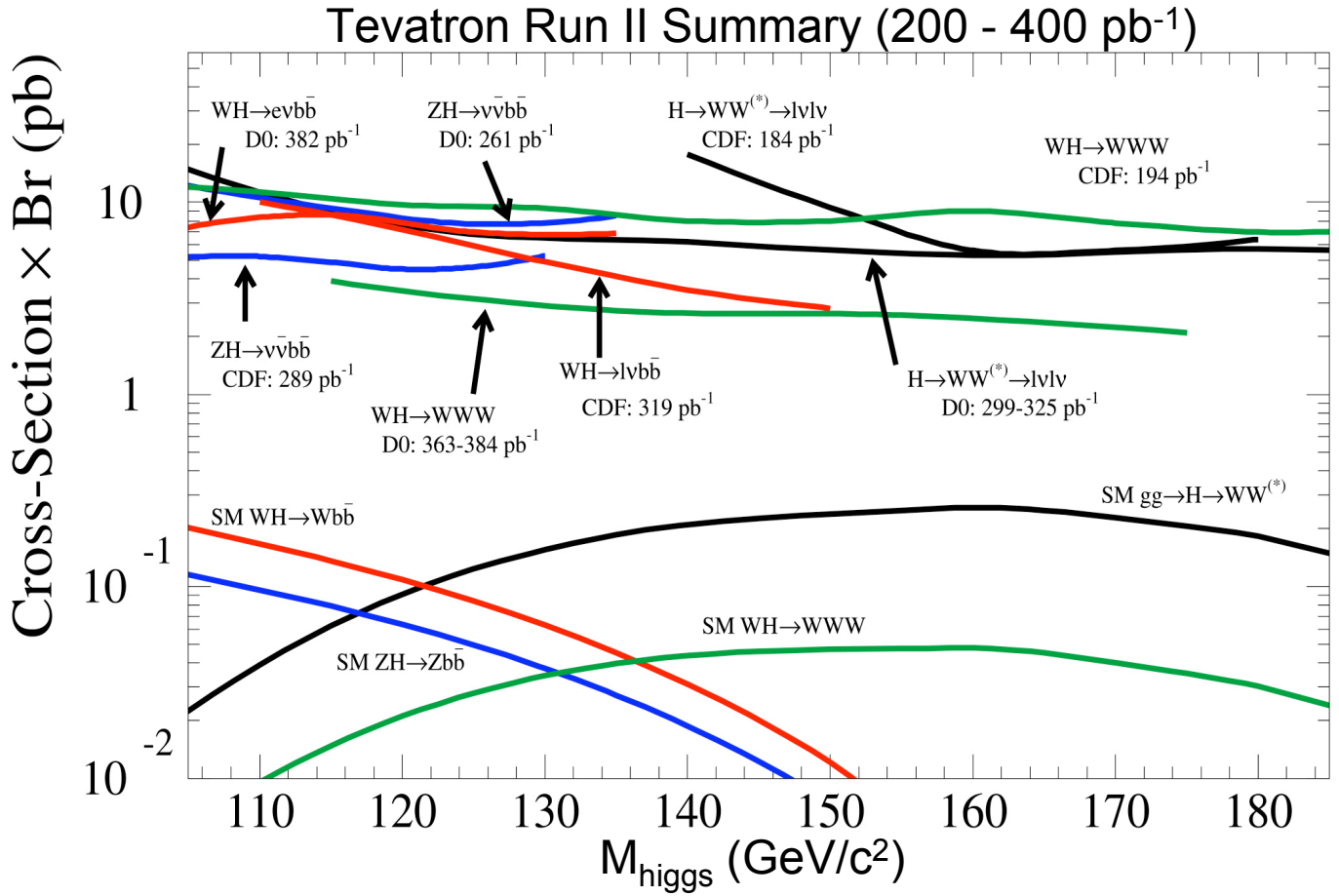
Luminosity / Experiment [fb^{-1}]

ΔM_{Higgs} / M_{higgs} [%]



Luminosity / Experiment [fb^{-1}]

Standard Model Higgs Searches

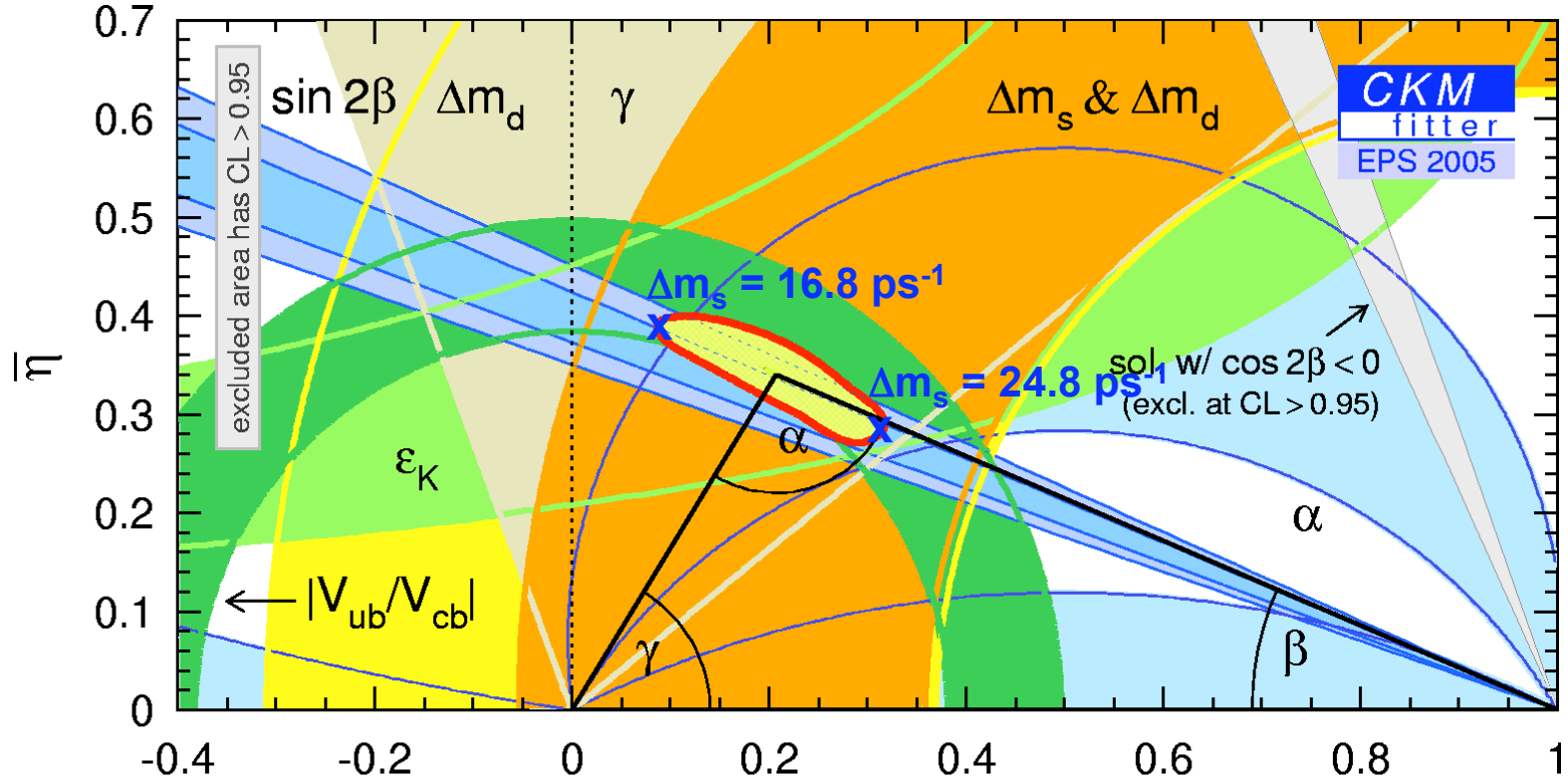


CDF currently focusing on improving sensitivities (x10):
Jet energy resolution (~70%), b-tagging acceptance (~10%) and efficiency (~50%), lepton acceptance (80~150%), analysis technique (~75%), …

We are in the half way. By summer 06, expect x5 sensitivity, x3 - x5 statistics.

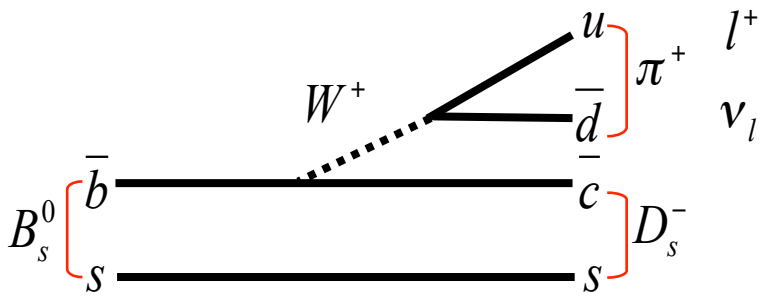
Observing B_s Mixing

CKM Fit Result: $\Delta m_s = 18.3\ ^{+6.5}_{-1.5}\ ps^{-1}$ (1σ), $18.3\ ^{+11.4}_{-2.7}\ ps^{-1}$ (2σ)

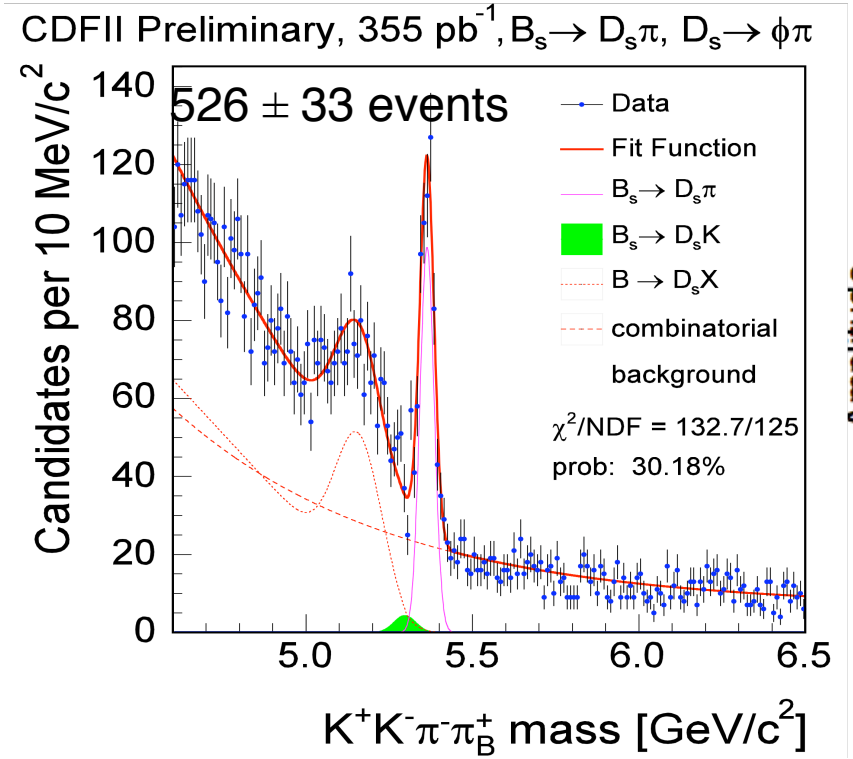


Lower limit on Δm_s → from Δm_d; from $\Delta m_d/\Delta m_s$

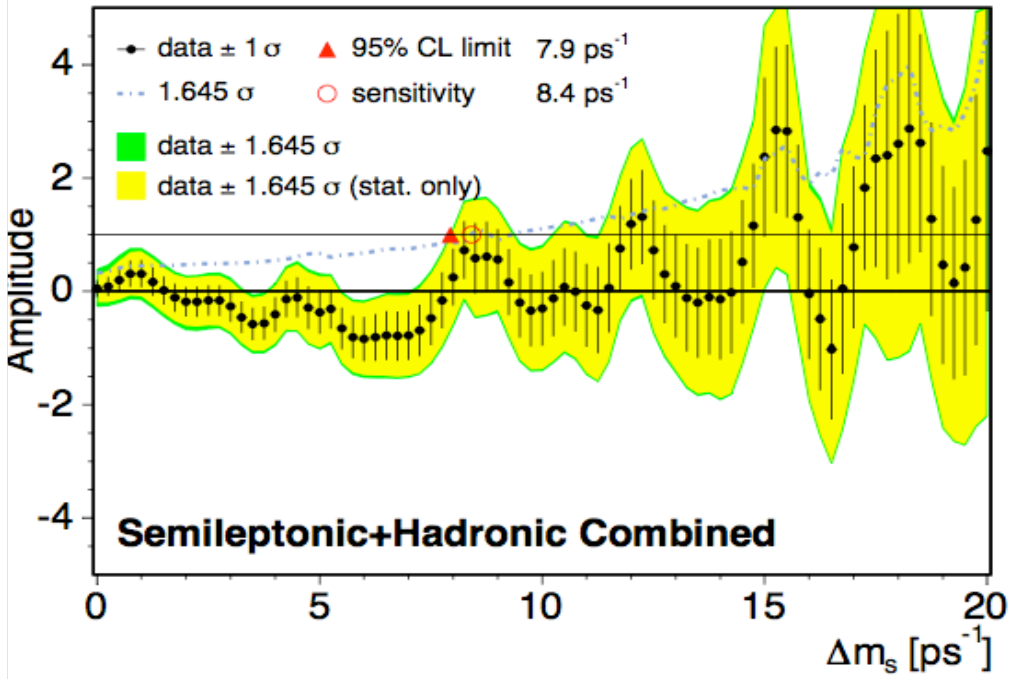
B_s Mixing Analysis: Winter 2005



~900 signal events with $B_s \rightarrow D_s\pi$, $D_s l\nu$
where $D_s \rightarrow K^*K$, $\phi\pi$, $\pi\pi\pi$



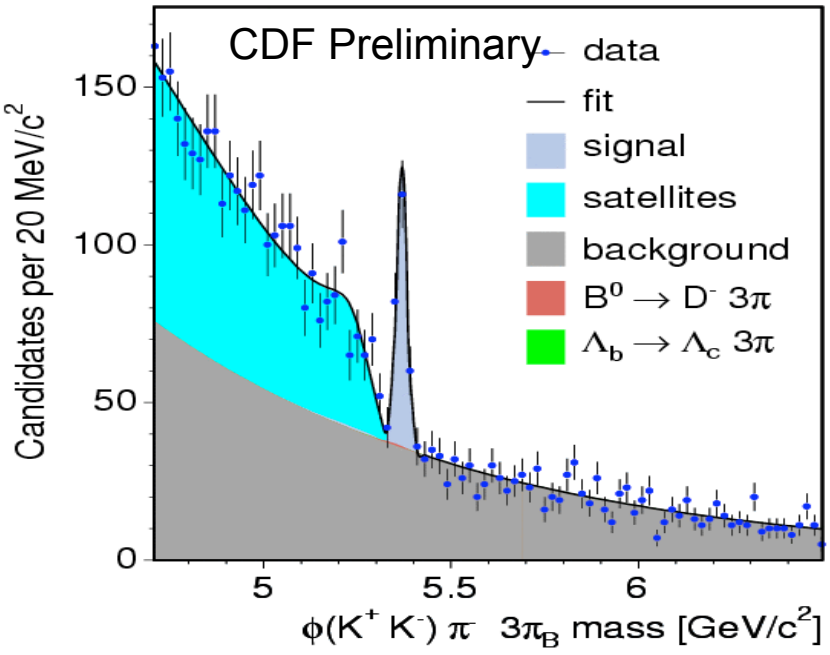
With 355 pb^{-1}
CDF 95%CL Limit: 7.9 ps^{-1}
CDF Sensitivity 8.4 ps^{-1}

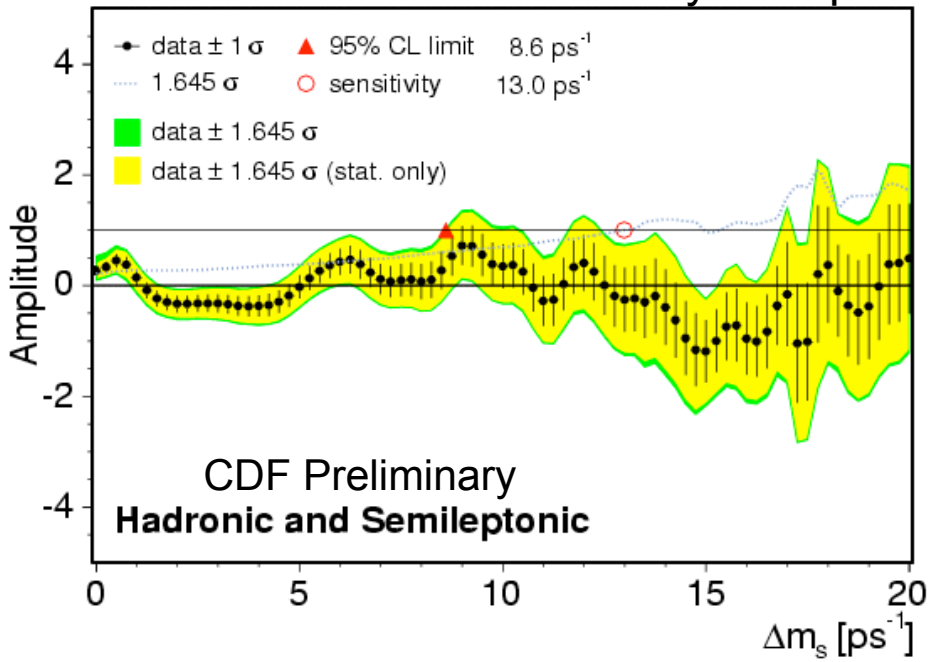


B_s Mixing Analysis: Fall 2005

- Hadronic modes
  - Improved taggers (better calibrations, NN for jet charge)
  - Improved vertex resolution (important for larger Δm_s)
  - Added a new decay mode $B_s \rightarrow D_s\, 3\pi$ (10% increase)
- Semileptonic modes
  - 2-track Silicon Vertex Trigger - x2 statistics

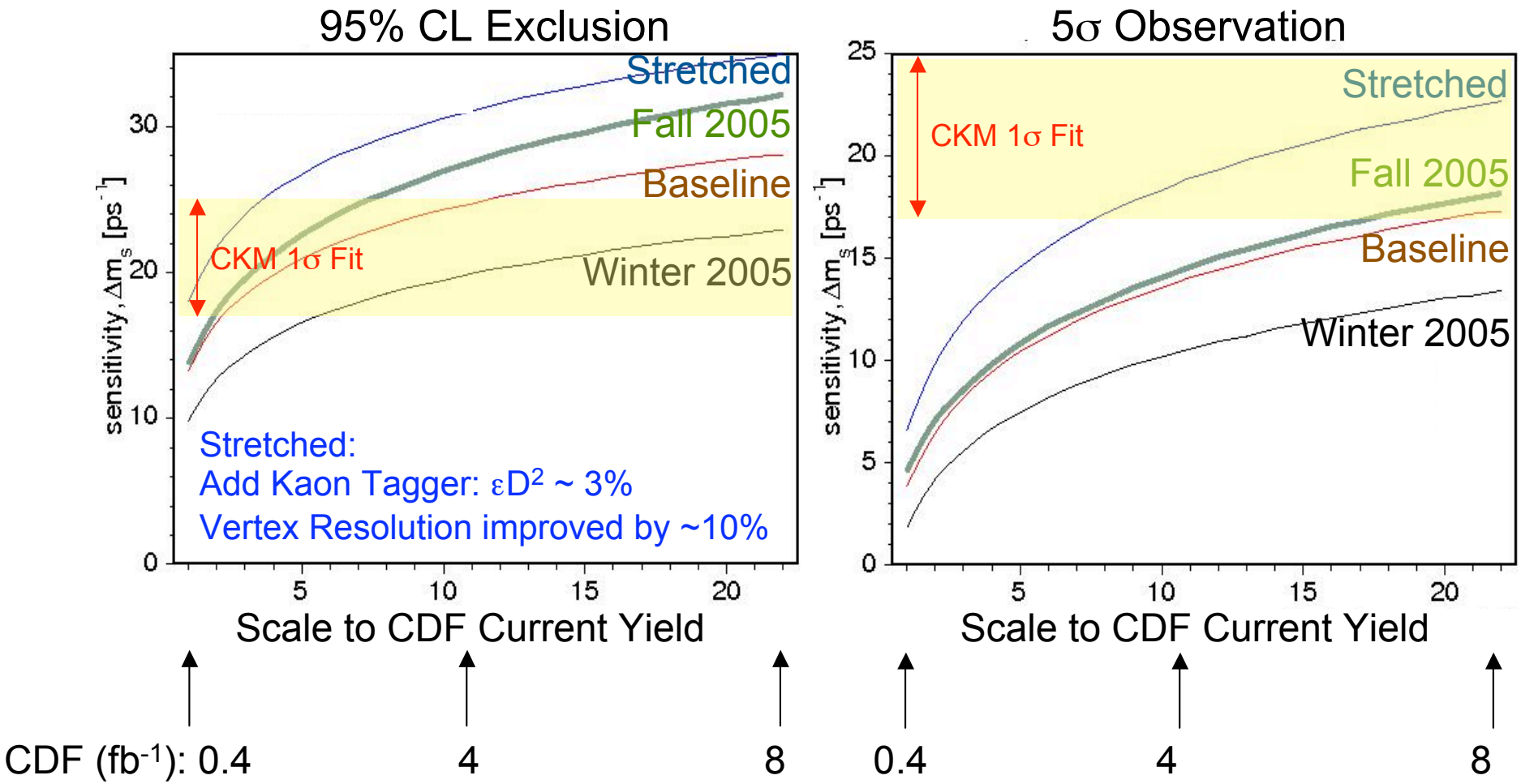
With 355 pb^{-1}
CDF 95%CL Limit: 8.6 ps^{-1}
CDF Sensitivity 13.0 ps^{-1}





With new CDF results, the world limit moved from 14.4 ps^{-1} to 16.6 ps^{-1}.

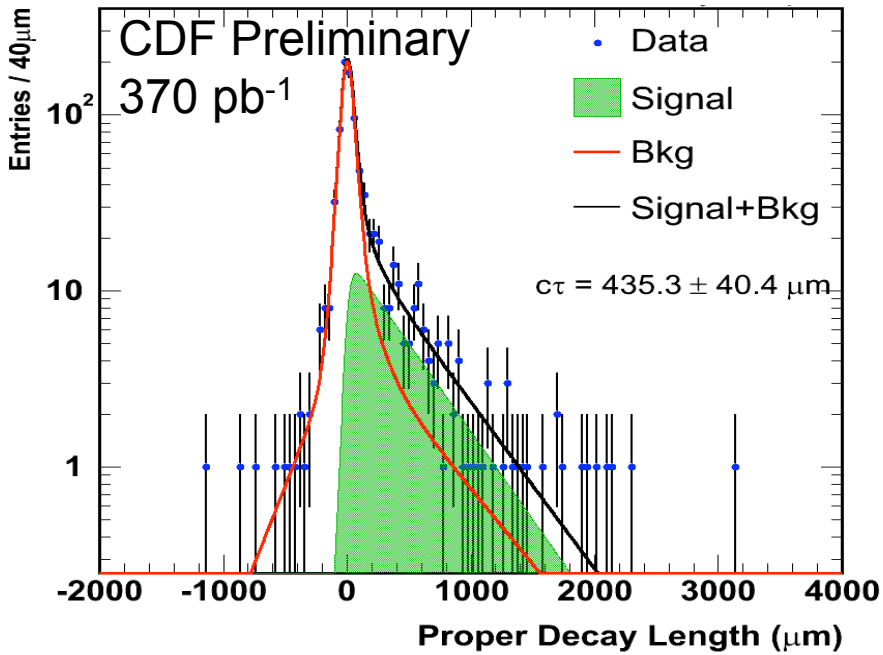
CDF Δm_s Sensitivity Projections



Sensitivity in the semileptonic mode is limited to lower values of Δm_s.
Higher values of Δm_s are only accessible in the hadronic mode.

Lifetimes

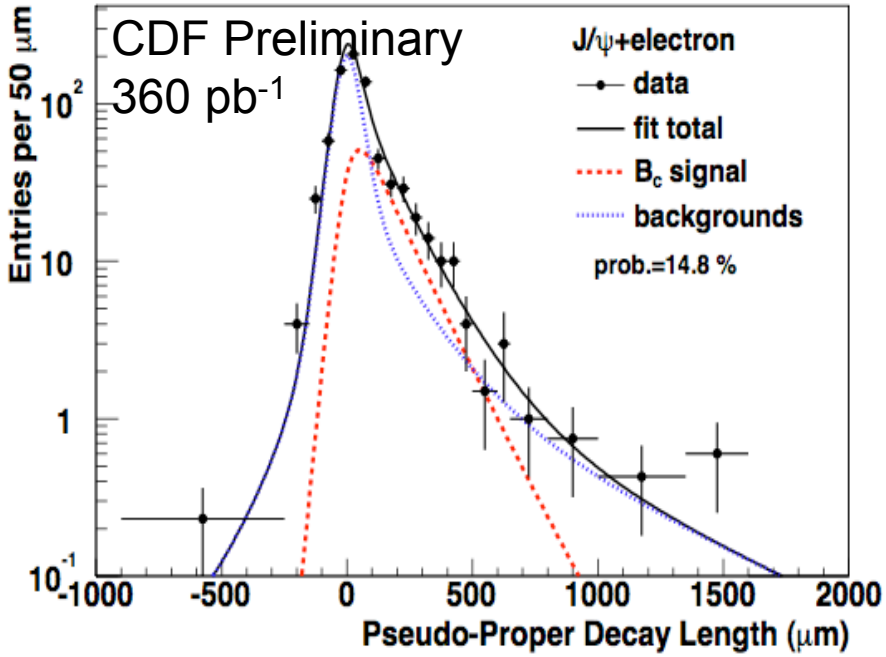
- $\Lambda_b^0 \rightarrow J/\psi\ \Lambda^0$



$\tau = 1.45 \pm 0.13 \pm 0.02$ ps

Single best measurement
in a fully reconstructed decay mode

- $B_c^0 \rightarrow J/\psi\ e\nu$



$\tau = 0.474\ ^{+0.073}_{-0.066} \pm 0.033$ ps

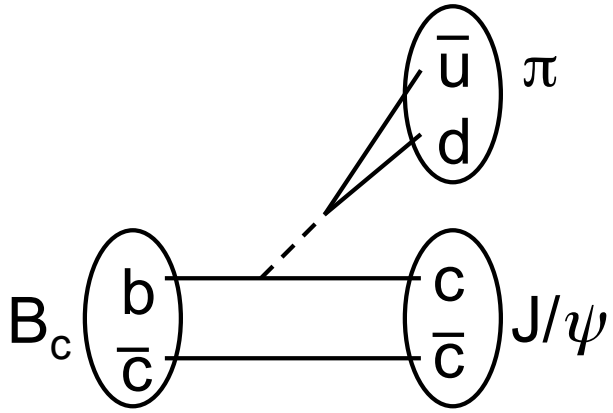
World's best

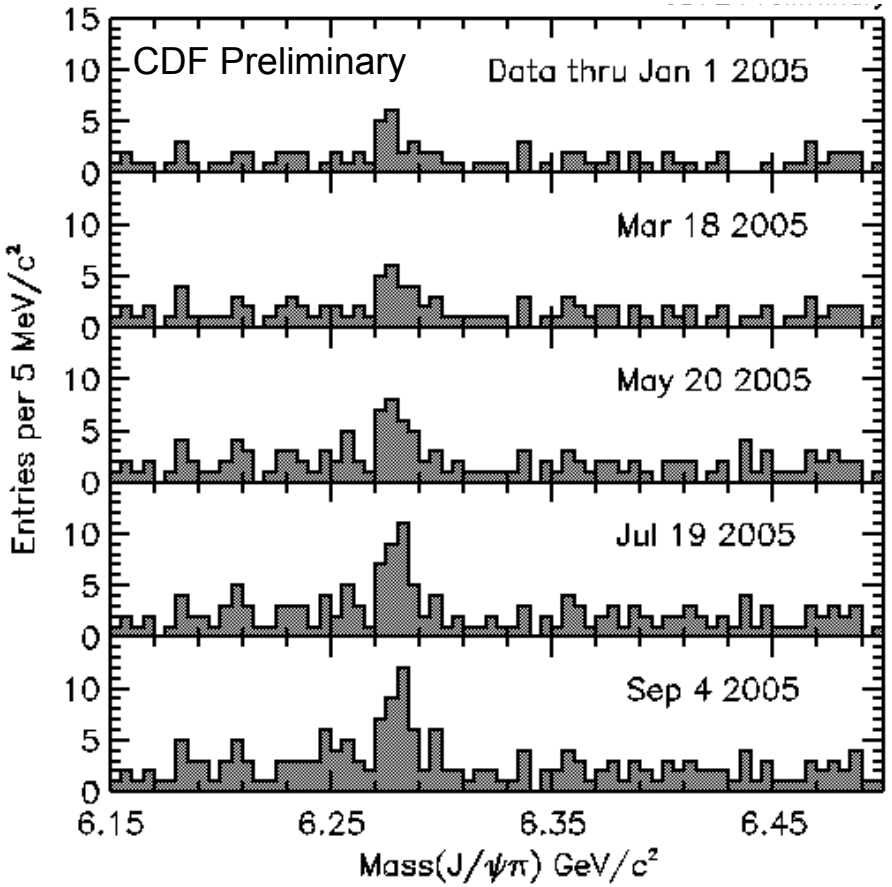
CDF are making competitive and world leading measurements
for all the heavier B hadrons.

Observation of $B_c \rightarrow J/\psi\,\pi$

Evidence with 360 pb^{-1}
hep-ex/0505076

Observation with ~800 pb^{-1}



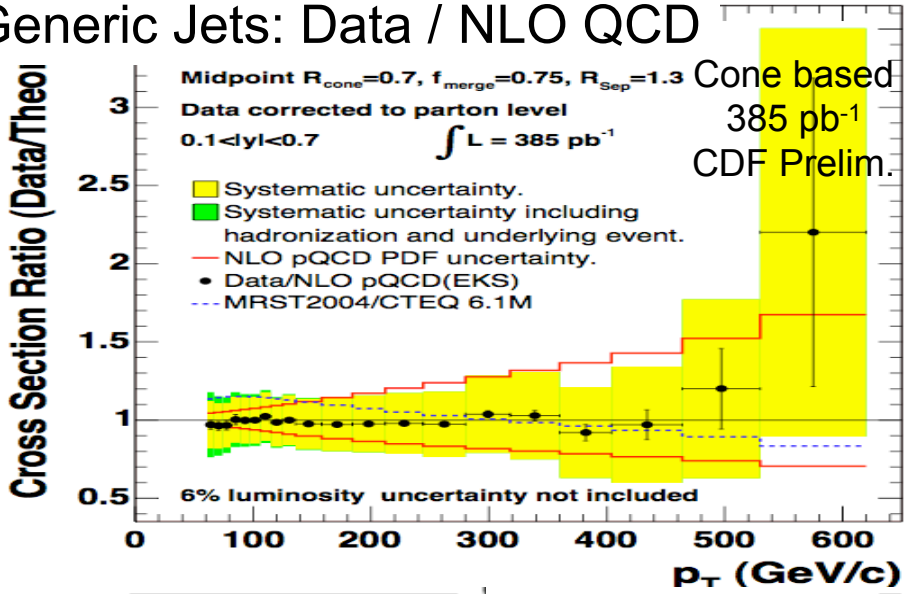


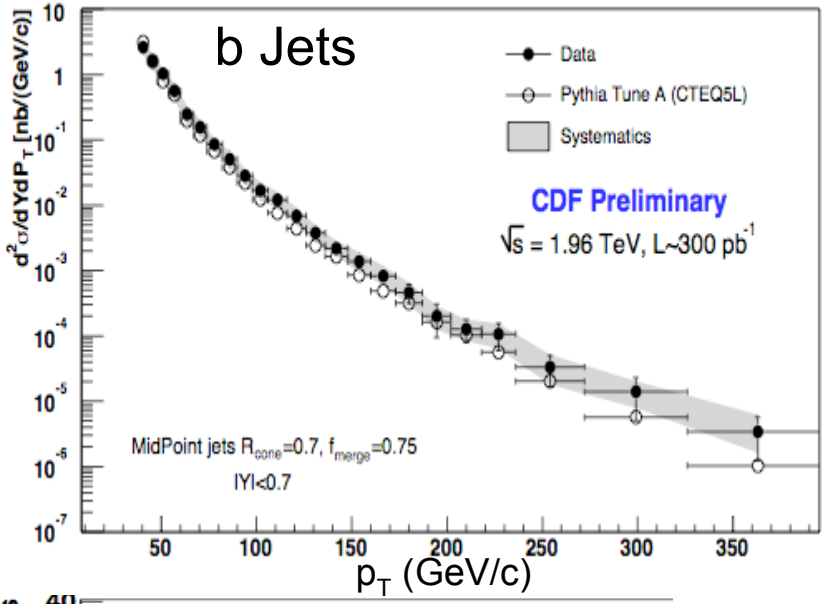
With 0.8 fb^{-1}, CDF M(B_c) = 6275.2 ± 4.3 (stat.) ± 2.5 (syst.) MeV
Lattice QCD Cal. M(B_c) = 6304 ± 12 $^{+18}_{-0}$ MeV [hep-lat/0411027]

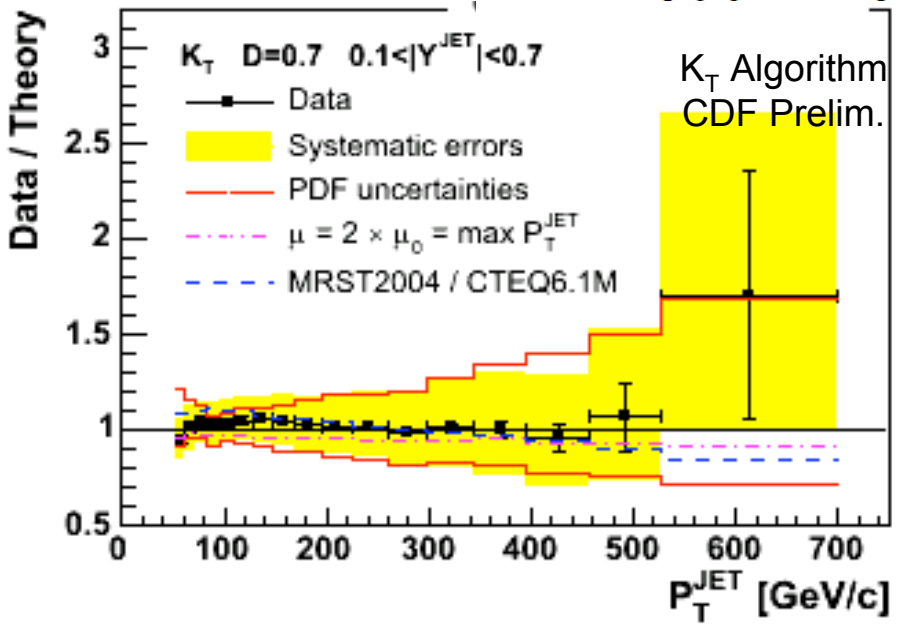
Used data up to Sept. 4, 2005 and approved as of Nov. 10, 2005.
Demonstrates physics results with data through Feb. 06 by next summer.

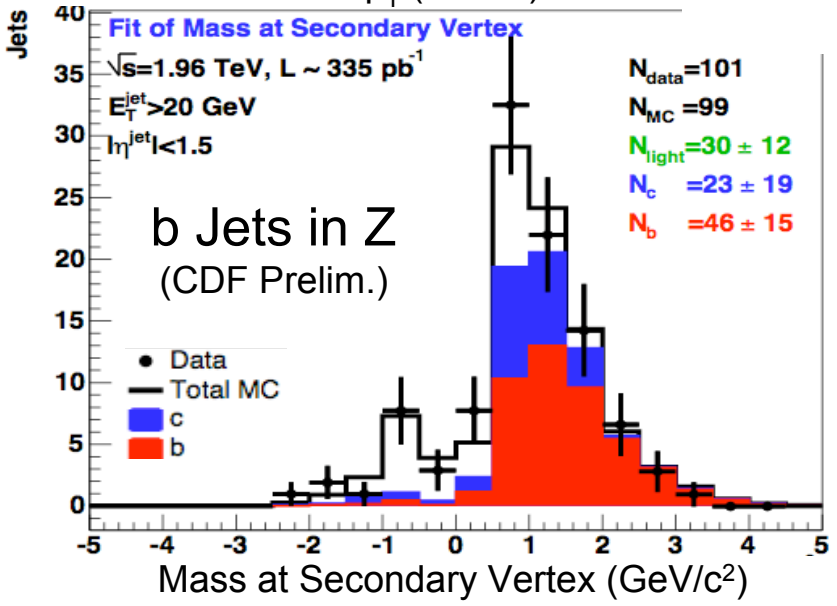
QCD Measurements

Generic Jets: Data / NLO QCD







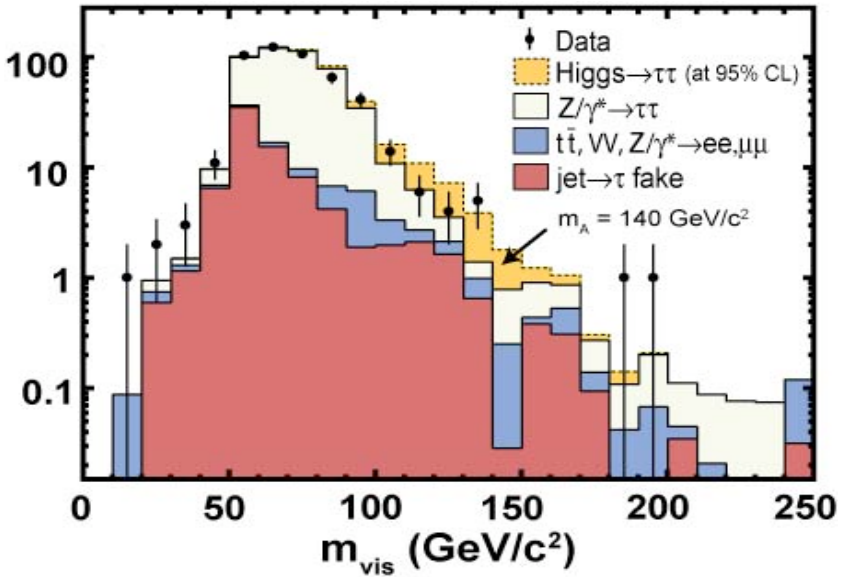


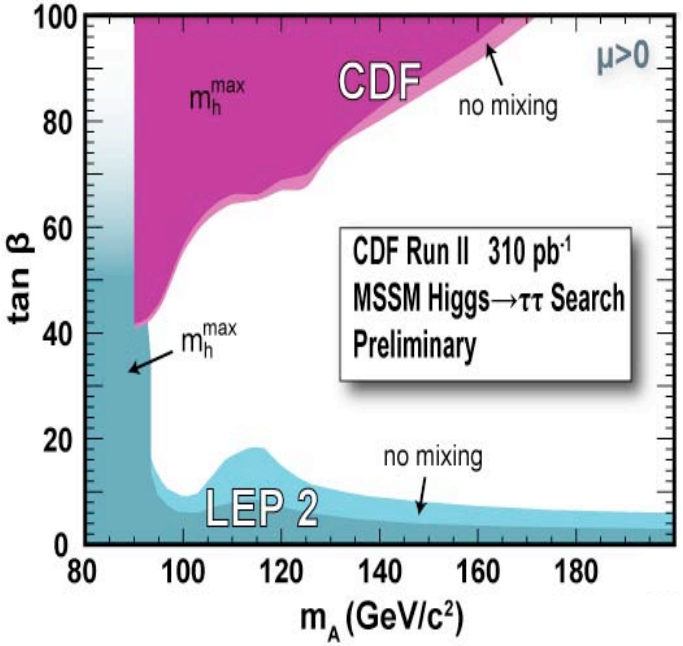
MSSM Higgs Searches

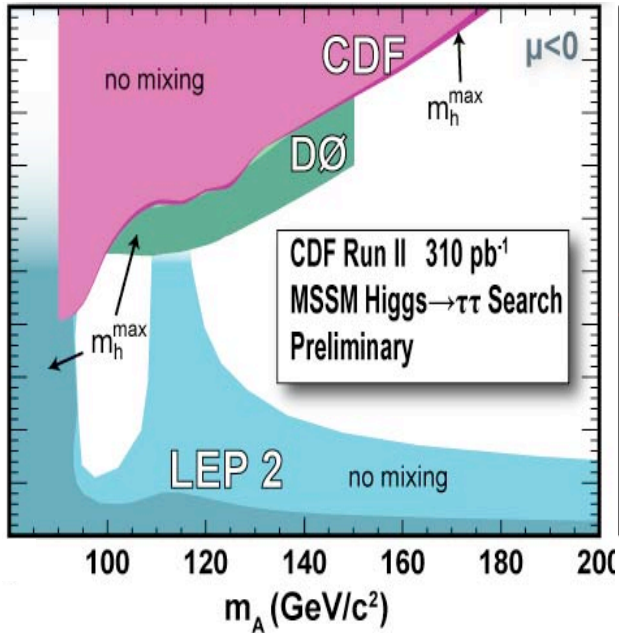
h/A/H → ττ

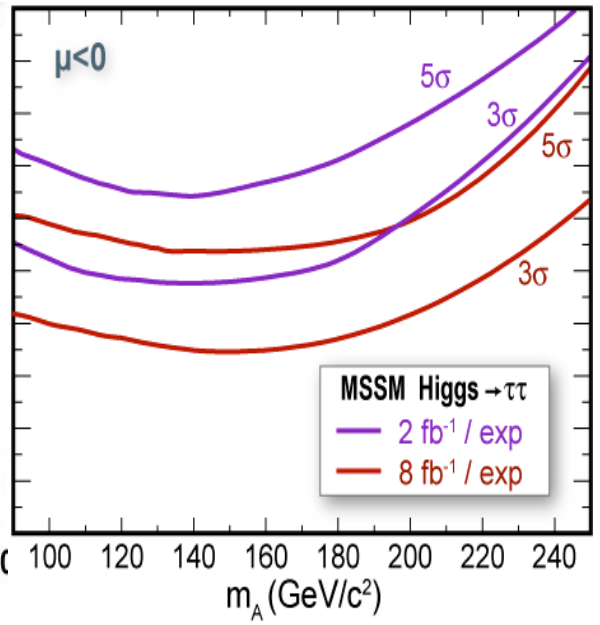
Accepted by PRL, hep-ex/0508051

$|\mu|$ = 200 GeV
M_2 = 200 GeV
$M_{gluino} = 0.8\ M_{SUSY}$
M_{SUSY} = 1 TeV, $X_t = \sqrt{6}\ M_{SUSY}$ (m_h^{max})
M_{SUSY} = 2 TeV, X_t = 0 (no-mixing)









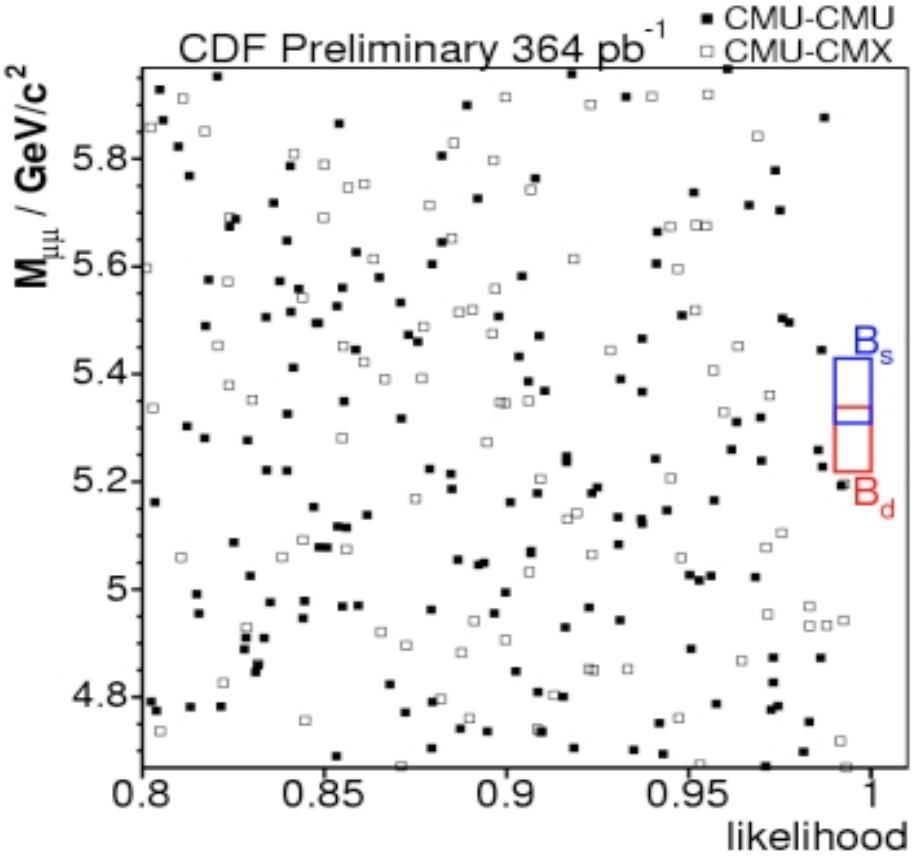
New Physics Searches via Rare Decays

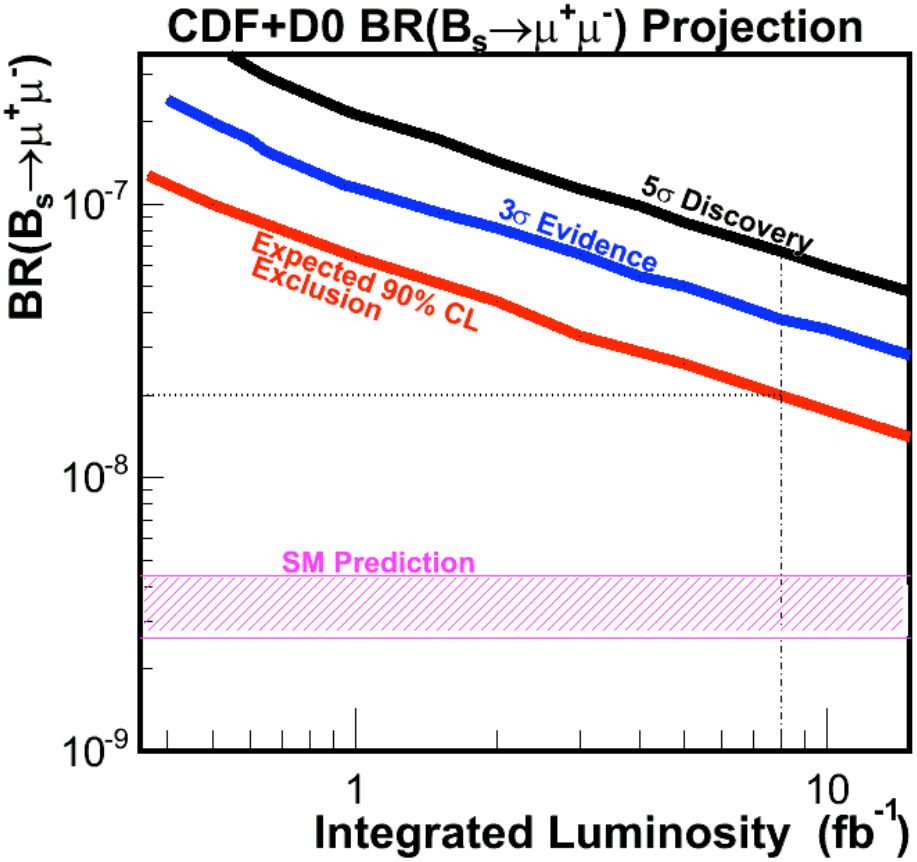
CDF Limits:

$Br(B_s \rightarrow \mu\mu) < 2.0 \times 10^{-7}$ at 95% CL - world's best

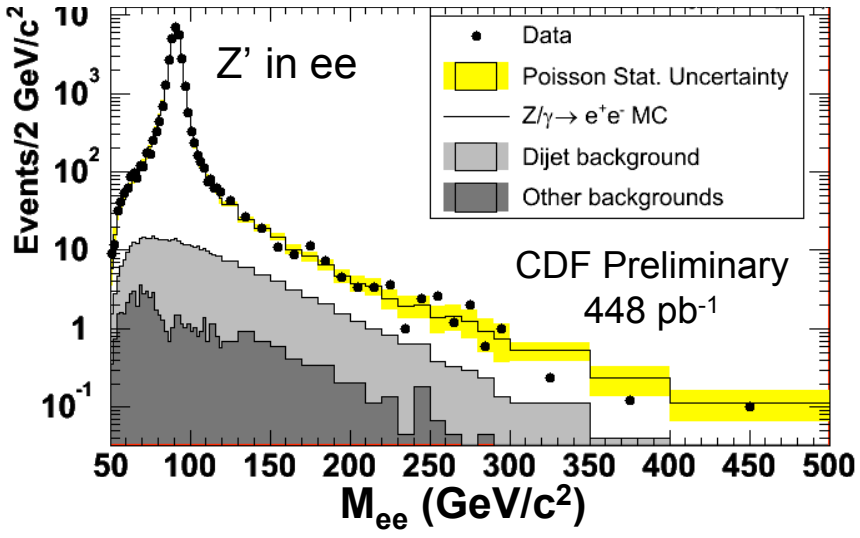
$Br(B_d \rightarrow \mu\mu) < 5.1 \times 10^{-8}$ at 95% CL - world's best

Phys. Rev. Lett. 95, 221805 (2005)





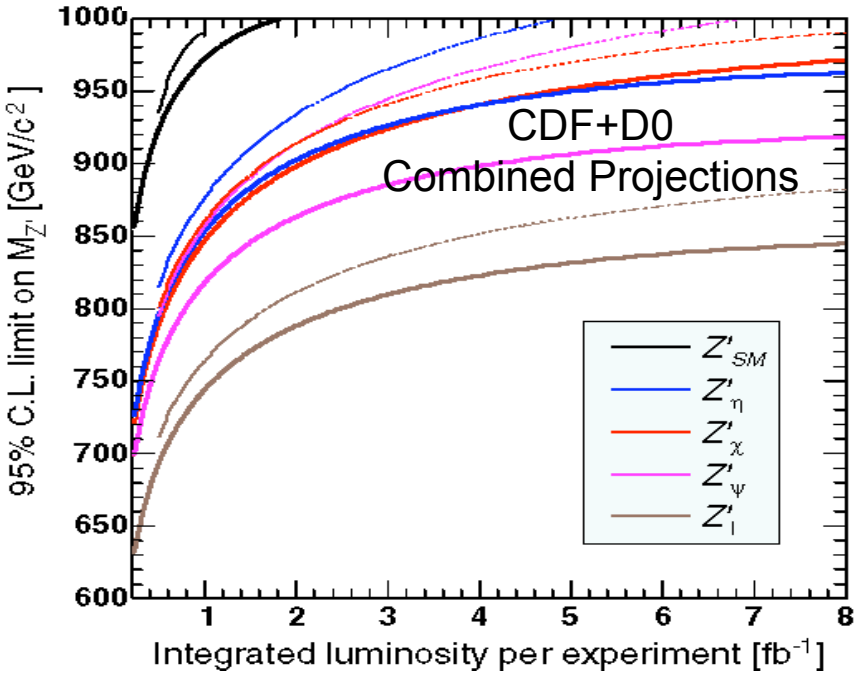
Could Find New Physics in Standard Model Samples?

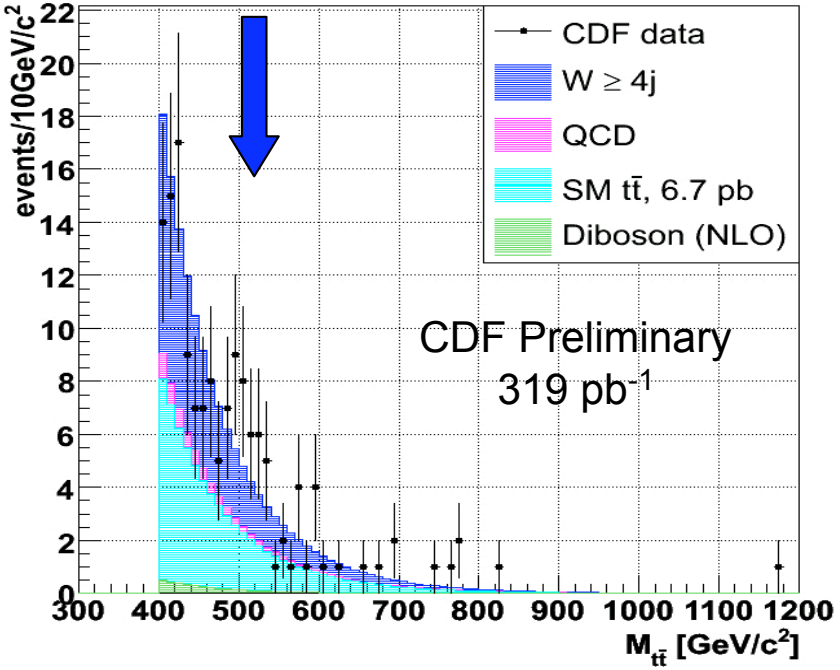


X → e^+e^-, $\mu^+\mu^-$, $\gamma\gamma$ mass spectrum
(paper in preparation)

Excited muon in $\mu\mu\gamma$
(paper in preparation)

X → top pair mass spectrum
(paper in preparation)





1 fb^{-1} Physics Challenge

Data taking Period	Total Lum. (pb^{-1})	Data processed	Ntuples made	Physics results
2/2002 - 8/2004	320-550	2004	2004	Spring 2005
adding 12/2004 - 3/2005	430-680	7/2005	9/2005	
adding 3/2005 - 5/2005	540-810	8/2005	9/2005	
adding 5/2005 - 7/2005	640-910	9/2005	9/2005	
adding 7/2005 - 8/2005	700-960	10/2005	10/2005	Winter 2006
adding 9/2005	750-1010	11/2005	11/2005	
adding 10/2005	800-1060	12/2005	12/2005	
adding 11/2005	850-1110	1/2006	1/2006	
adding 12/2005	900-1160	2/2006	2/2006	
adding 1/2006	950-1210	3/2006	3/2006	
adding 2/2006	1000-1260	4/2006	4/2006	Summer 2006

Concluding Remarks

- CDF experiment is operating well. Better than ever!
  - Typical data taking efficiencies in the mid 80%'s with increasing inst. Luminosity and Run IIb commissioning
  - All detectors are in excellent conditions
  - Stable offline software
  - Established fast calibrations, data processing scheme
  - Good detector simulation
  - MC production at remote sites
- Challenging ahead…
  - x2 higher instantaneous luminosity
  - x8 higher integrated luminosity
  - Resources going down
- CDF Strategies in preparation for the future
  - Planning ahead: we have been identifying those areas that need further development and are beginning to address them immediately. Goal is to complete the work by early 2006.

Concluding Remarks

- Looking forward to Summer 2006 conferences
  - Results with x3 increase in statistics over Summer 2005
  - Report on > 10 x Run I Luminosity !!
- The upcoming years will be an exciting time with increasing statistics
  - Discovery through searches
  - Discovery through precision experiments
  - CDF Experience:
    - With ~4 pb^{-1}, Top limits set
    - With ~20 pb^{-1}, Evidence paper out!
    - With ~65 pb^{-1}, Discovery paper out!
  - Hoping for new evidence/discovery with ~1 fb^{-1}
  - New physics could appear with every factor of 3~4.
- CDF is committed to operating well and analyze the data through 2009.

Backup Slides

Tracking and High p_T Lepton Status

- COT Tracking
  - Alignment: wire positions aligned better than 10 μm
  - Efficiency: 99.6% (isolated tracks), > 96% (non-isolated tracks)

- Silicon Tracking
  - Alignment: internal - 5 μm, w.r.t. COT < 10 μm
  - Efficiency: 94% with *r*-ϕ, 83% with *r*-ϕ and *z*
  - Misidentified: 0.5% - 1.5%

- High p_T Electron Identification
  - Efficiency: 82-93%, Misidentified jets: ~10^{-4}
- High p_T Muon Identification
  - Efficiency: 93%, Misidentified jets: ~10^{-4}

- Numbers are stable with time, instantaneous luminosity up to 10^{32} $cm^{-1}s^{-1}$.

Publications: Top Physics

- Published / submitted
  - Top mass in l+jets (template)
  - Top mass in l+jets (temp + ME)
  - Top mass in l+jets (ME)
  - Top $\rightarrow H^+ b$
  - Top branching ratio
  - W helicity
  - tt-bar production in tau + lepton
  - tt-bar x-sec using kinematics
  - tt-bar x-sec using SLT b-tagging
  - Kinematics in tt-bar in dilepton
  - tt-bar x-sec using Kinematics and secondary vertex b-tagging
  - Single top
  - tt-bar x-sec in di-lepton
- Under collaboration's review
  - Anomaly in W+b-jets
  - Top mass in l+jets (multivariate)
  - Top mass in dilepton (template)
  - Top mass in dilepton (ME)
  - tt-bar x-sec combined
  - tt-bar mass
  - tt-bar x-sec with secondary vertex and jet probability
  - tt-bar/WW/Z$\rightarrow\tau\tau$ x-sec with dileptons
  - tt-bar x-sec in missing Et +jets
  - tt-bar x-sec in all hadronic channel

Publications: Bottom Physics

- Published / submitted
  - Lambda_b → Lambda_c + π
  - B_s/B Branching fraction ratio
  - B mass
  - $B_s \rightarrow J/\psi + \pi$
  - B_d, $B_s \rightarrow \mu\mu$
  - Lambda_b → Kp, πp
  - Semileptonic moment
  - B_s lifetime difference
  - $B_s \rightarrow \phi\phi$ etc
  - D^0 relative Br and CP asymmetry
  - J/ψ and B x-sec
  - $B_s \rightarrow \mu\mu$ branching ratio
  - X(3872) observation
  - Br($D^0 \rightarrow \mu\mu$)
  - Charm x-sec
  - D_s D^+ mass difference
- Under collaboration's review
  - Cascade pentaquark
  - D_1 and D_2
  - B → hh and CP violation
  - X(3872) di-pion mass
  - $B_s \rightarrow \psi(2s) + \phi$
  - Ratio of Λ_b Br's
  - Semileptonic B lifetime
  - B_c lifetime in J/ψ + e
  - Br($B_s \rightarrow D_s \pi$, $D_s 3\pi$)
  - $D^0 \rightarrow K \pi$ wrong sign anal

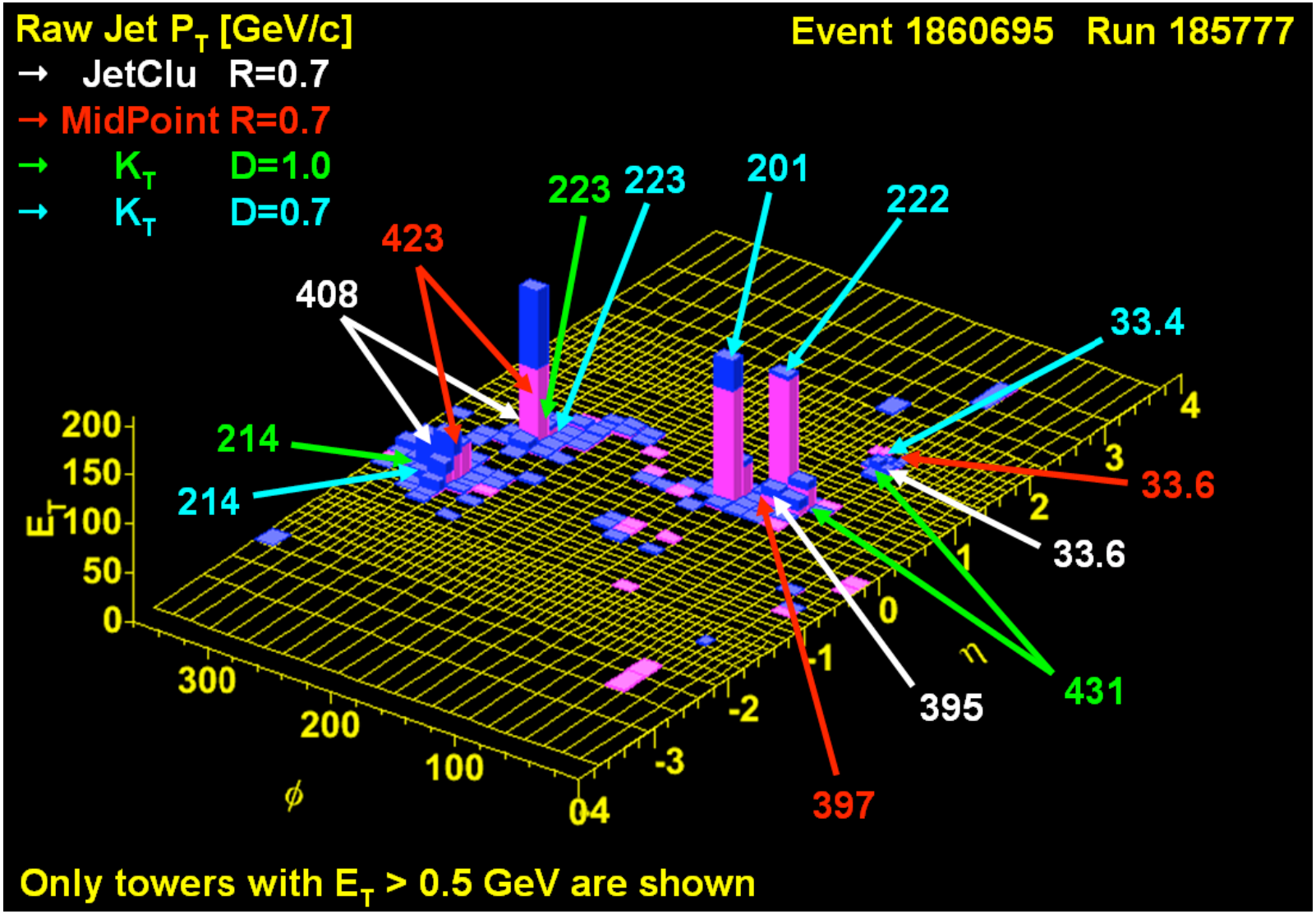
Publications: New Phenomena

- Published / Submitted
  - Monopole searches
  - Search for h/A/H $\rightarrow \tau\tau$
  - High mass dilepton
  - 1st generation lepto-quark
  - High mass di-τ
  - Lepto-quark in missing Et + dijet
  - Excited electron
  - Diphoton + missing Et
  - H^{++} search in dilepton
  - Stable H^{++} search
- Under collaboration's review
  - 2nd generation lepto-quark
  - Gluino/Sbottom search
  - WH $\rightarrow l\nu bb$ search
  - Higgs to WW search
  - W' $\rightarrow e\nu$ search
  - WH $\rightarrow$ WWW* search
  - Stop $\rightarrow$ charm + LSP
  - High mass di-photon
  - Lepton+photon+missingEt
  - Z' using mass and angular distribution
  - Sneutrino to e/μ
  - Excited muon
  - Stop in RPV SUSY

Publications: Electroweak and QCD

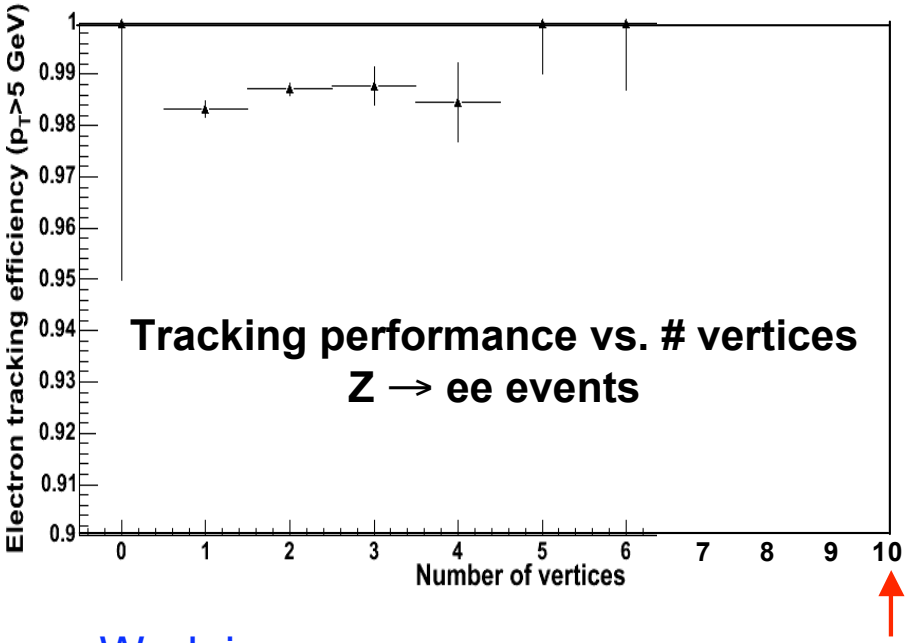
- Published / submitted
  - W and Z x-sec (PRL)
  - ZZ+WZ x-sec
  - W Charge asymmetry
  - WW x-sec
  - W and Z x-sec (PRD)
  - Forward-backward asymmetry in dielectron
  - W / Z + photon x-sec
  - Diphoton x-sec
  - Jet shapes
  - Jet x-sec with cone algorithm
- Under collaboration's review
  - W mass
  - $Z \rightarrow \tau(e)\,\tau(h)$
  - Jet x-sec with K_T algorithm
  - W/Z (2jets) + photon
  - B-jet x-sec
  - Forward jet x-sec with K_T algorithm
  - Z + b-jet x-sec
  - 2-particle correlation in jets

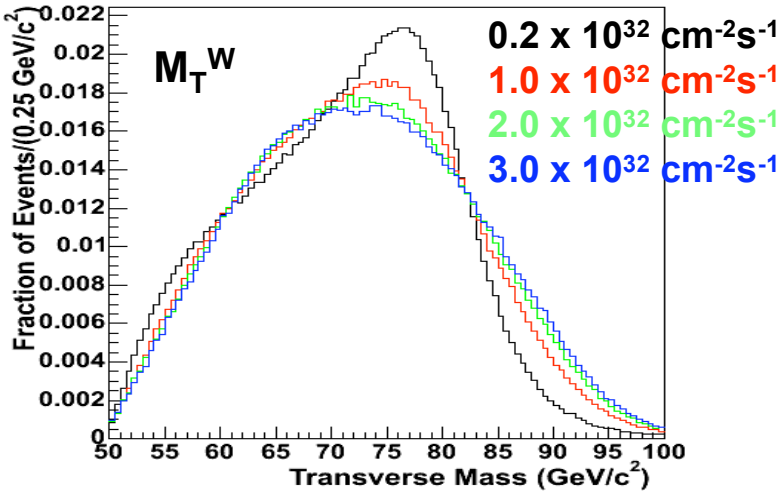
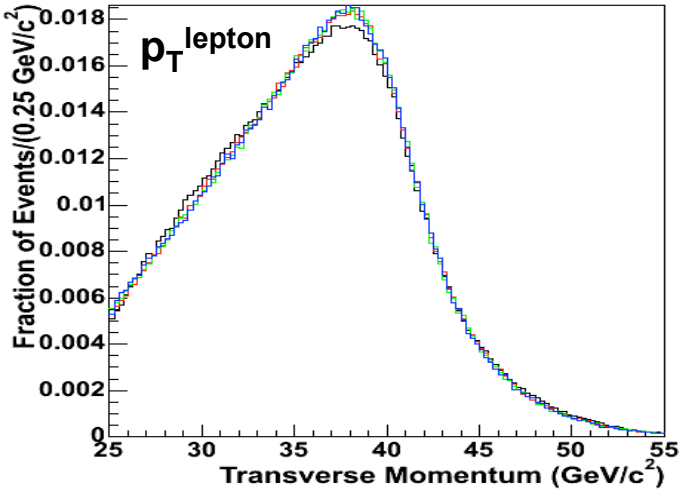
Jet Algorithms



High Lum. Impact on Reconstruction / Physics

- Understanding Tracking, B-tagging Performance at 3 x 10^{32} $cm^{-2}s^{-1}$
  - < # of interactions > ~ 10
  - Data
    - vs primary vertices
    - vs bunch-by-bunch lum.
  - MC + multiple interactions



  - Work in progress

- Developing Analysis Techniques
  - W Mass