DØ Status and Tevatron Physics Results (I)

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DOE Tevatron Operations Review

April 20/21 2007

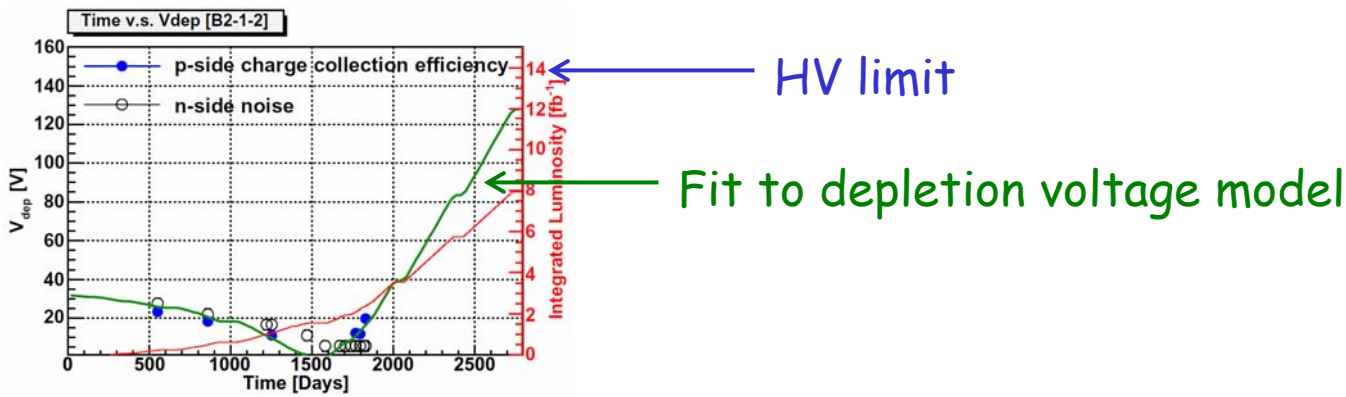
Outline

- Status of the DØ experiment
  - Data taking
  - Detector Status and RunIIb Upgrades
    - Tracking detectors
    - Trigger system
  - Computing & Analysis
- Physics highlights from Tevatron (CDF & DØ, part I):
  - Searches for New Phenomena
  - QCD
  - CP Violation studies in B(s) system
  - Electroweak Production of Top Quarks
  - SUSY Higgs Searches
- In Florencia 's talk (next): Physics highlights from Tevatron (CDF & DØ, part II):
  - Top
    - Mass
    - Production and decay properties
  - Electroweak
    - W mass and width
    - Diboson production: WZ, ZZ
  - SM Higgs Searches
    - ZH, WH, $H \rightarrow WW$
- Conclusions

- 574 scientific authors, 82 institutions in 18 countries
- FNAL: 54 authors (33 FTE) + support from PPD/CD divisions

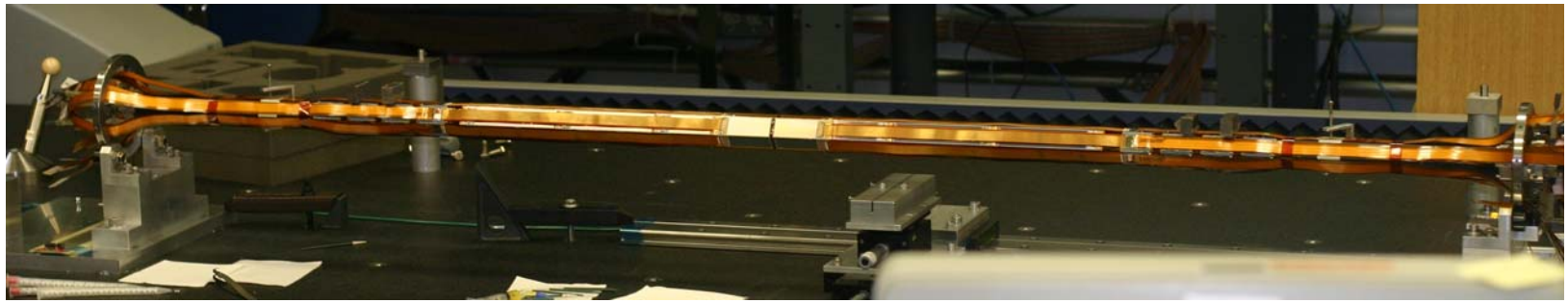
Operations and Performance

- DØ collected data for 2.33 fb^{-1} out of the total delivered luminosity of 2.76 fb^{-1}
  - 85% data taking efficiency since April 2002
- Detector aging within expectations

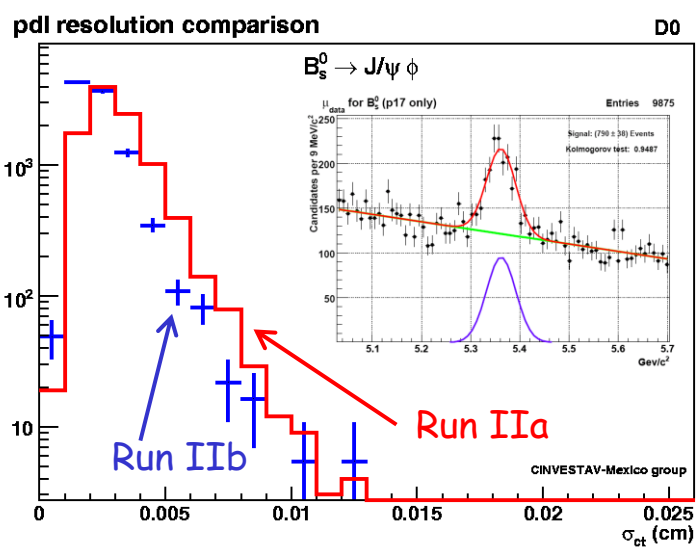


- Quick commissioning of upgrades designed to cope with high delivered and instantaneous luminosities
- Expect to maintain current level of performance in next years

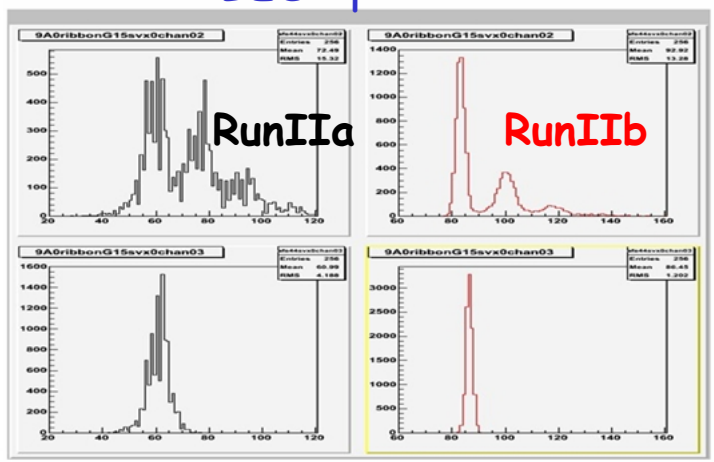
Upgrades of Tracking Detectors



- SMT Layer 0: additional layer of rad hard silicon detectors installed inside the Run IIa SMT



LED spectra

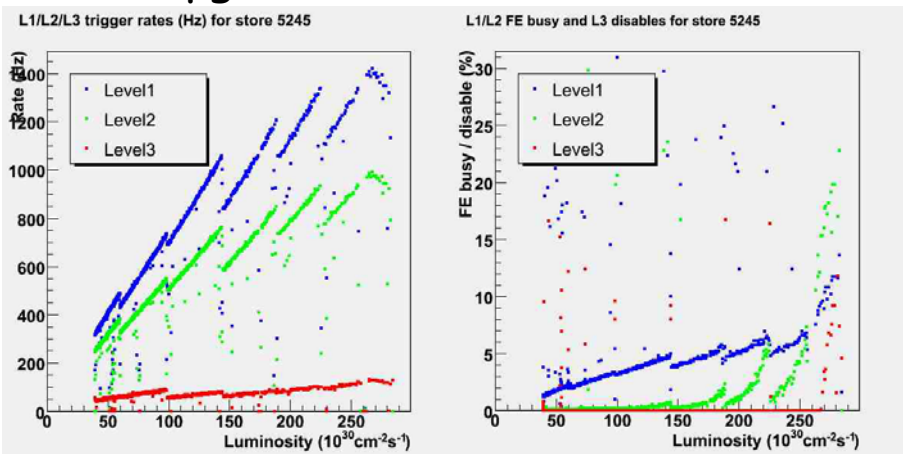


Pedestals

- AFE IIt: new analog front end for fiber tracker and preshower detectors

Trigger upgrades

- L1 Central Track Trigger
  - Replace FPGAs used for track finding (use full CTT granularity)
- L1 Calorimeter Trigger
  - Complete replacement of 10 racks of Run I electronics
  - Electron, tau and jet clustering at L1
- L1 Calorimeter Track Match upgrade
  - Match calorimeter and track objects at L1
  - Improved rejection / linearity for electrons and taus
- Use Layer 0 in L2 Silicon Track Trigger
- CPU Upgrade at L3 and increase in bandwidth to tape



L_{init} (DØ) = 2.9 10^{32} cm^{-2} s^{-1}

7.4 pb^{-1} recorded

89% efficiency

Computing

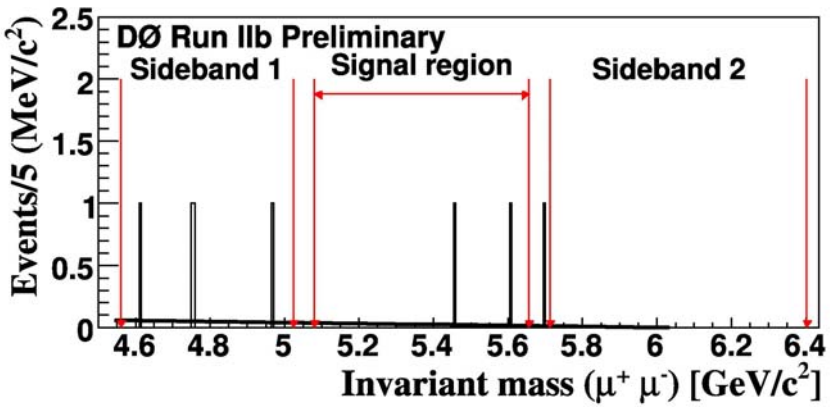
- Using dedicated facilities at Fermilab
  - Reconstruction and analysis farm, interactive analysis cluster
- And shared facilities around the world
  - Mostly non DØ dedicated CPUs
  - Access through LCG/OSG grids
  - All MC production done remotely
- Fast turnaround from data collection to analysis (1 week) to public results

First 2 fb^{-1} result from Tevatron:

$BR(B_s \rightarrow \mu\mu) < 7.1\ 10^{-8}$ (90%CL)

Data up to 1/6/07

Presented at Moriond 3/12/07



- Currently reprocessing Jun-Dec 06 data, full dataset (2.3 fb-1) available for analysis early May 07

Personpower

- MOUs
  - Institutional commitments, updated Winter 07
- Tevatron Collider Experiments Task Force
  - Assess needs for data collection, processing and analysis

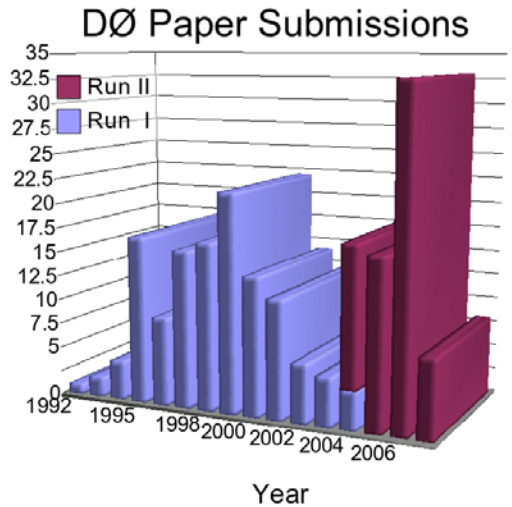
	Collider Task Force Resource Needs	
	2007	2009
Operations*	165	124
Physics Analysis‡	86 to 165	66 to 124
Collaboration Total FTE	**251 to 330**	**190 to 248**
Fraction Physics Analysis	**0.34 to 0.50**	**0.35 to 0.50**
MoU FTE Projection	**357**	**184**

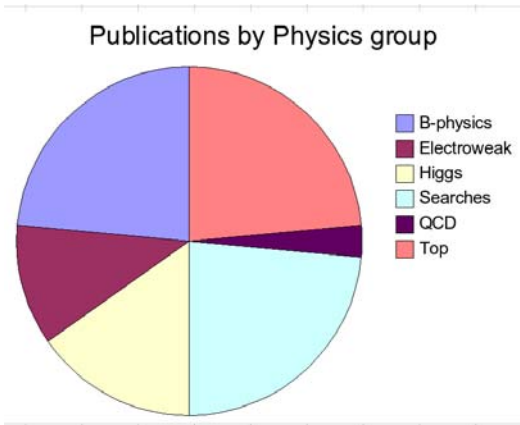
* Operations includes detector, offline, algorithms and management

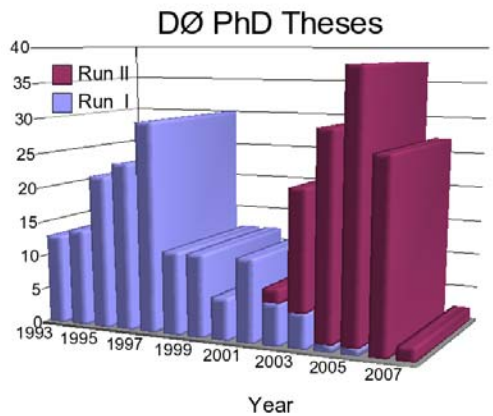
‡ Physics analysis needs: lower estimate from "core physics only"
upper estimate from need to keep "service fraction" at 50%

Physics Analysis

- 2006 Best year for DØ
  - B0s oscillations
    - PRL 97, 021802 (2006)
    - First 1fb $^{-1}$ paper from Tevatron
    - Most cited HEP results of 2006
  - Single top evidence
    - Accepted by PRL
- Many additional results with 1 fb^{-1}
- 120 more PhD theses in progress

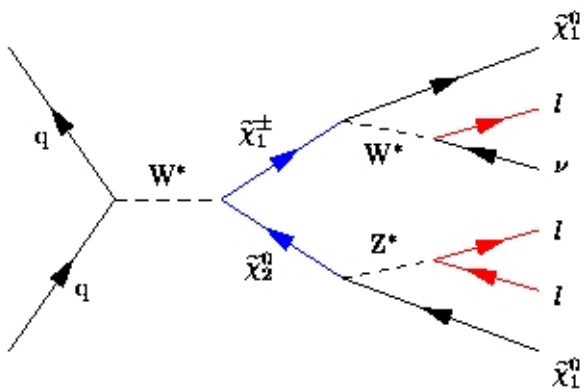


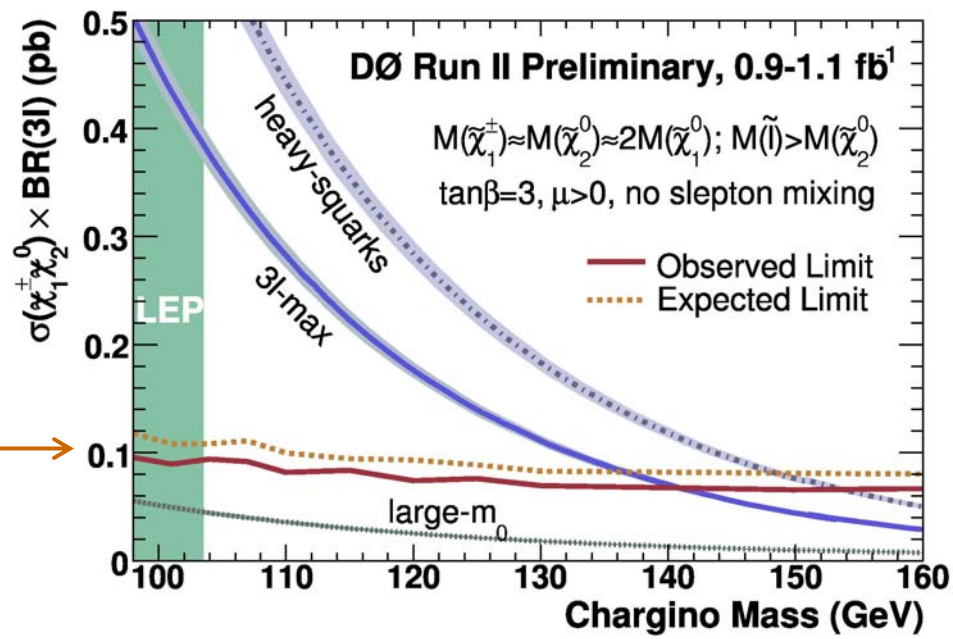




New phenomena searches with 1 fb^{-1}

- Charginos + neutralinos: trileptons + missing E_T
  - Combine various channels: ee/eμ/μμ+(e/μ/track) + like-sign ee/μμ pairs
  - Minimal requirements on 3rd lepton
    - High efficiency for small ΔM, τ decays

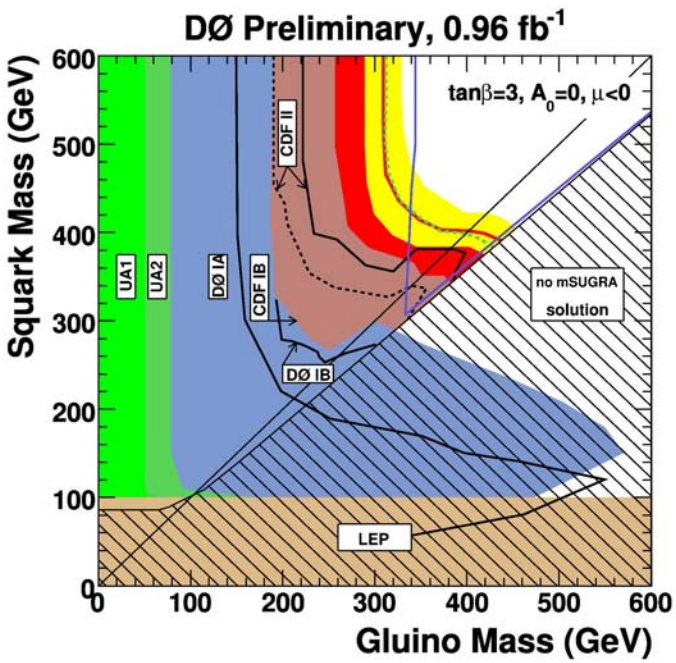


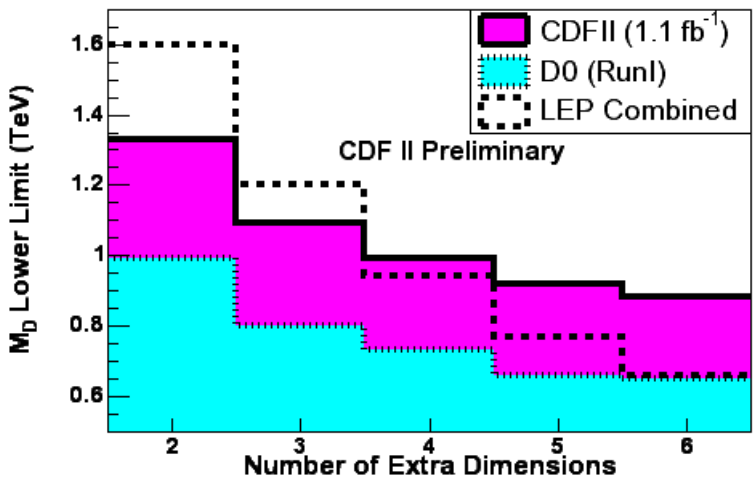


Both CDF and DØ have expected cross section limits of 100 fb

New phenomena searches with 1 fb^{-1}

- Events with jet(s) and missing E_T
  - SUSY interpretation: squarks/gluinos production
  - Extra Dimensions interpretation: graviton production

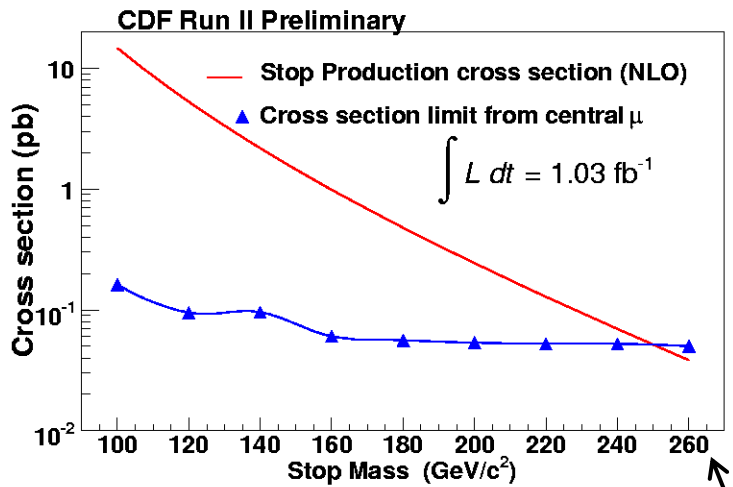




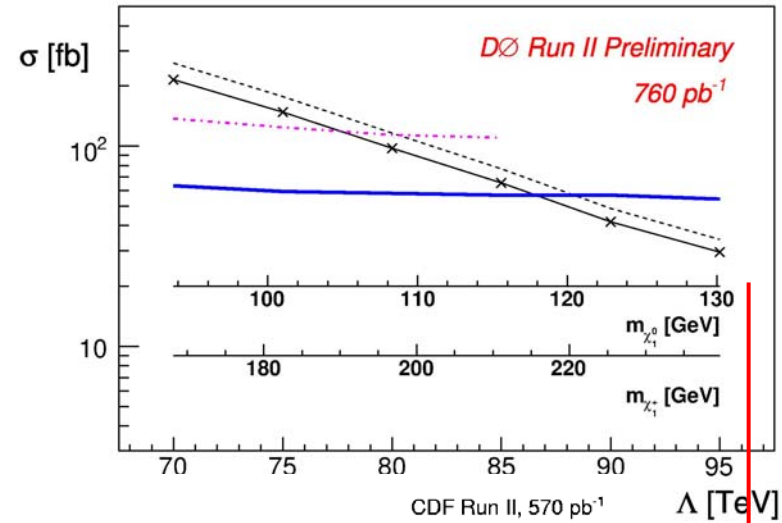
- Limits on extra dimension models also from dilepton/diphoton events
  - Explore mass range up to 800 GeV

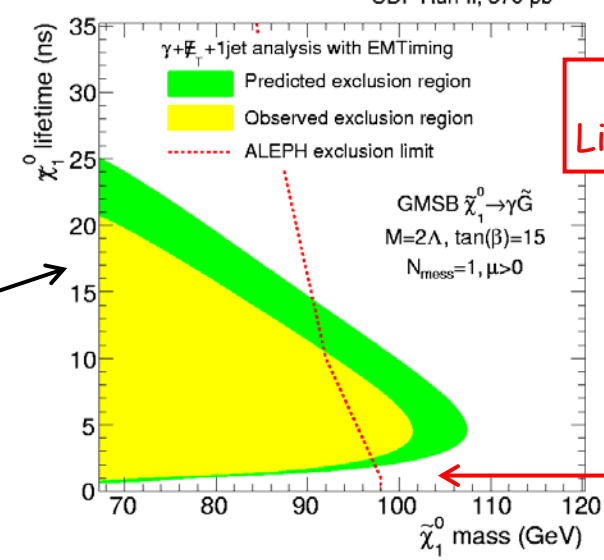
New phenomena searches with 1 fb^{-1}

- Searches in alternative SUSY breaking scenarios:
  - (quasi-) stable particles
  - GMSB (displaced vertices)



Prompt γγ+missing E_T

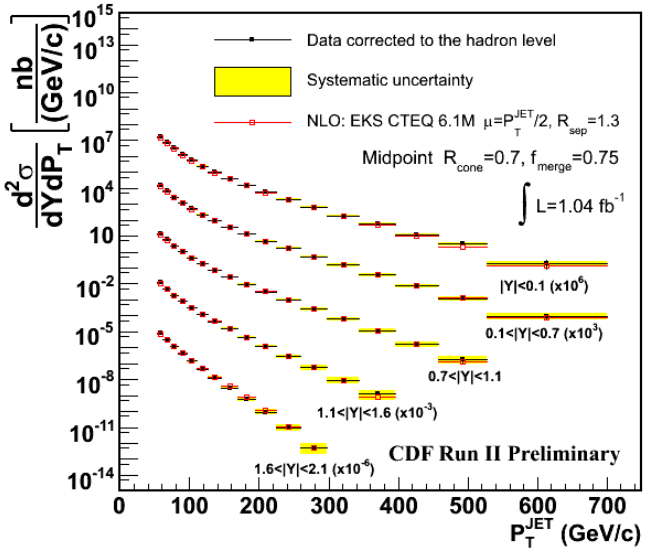


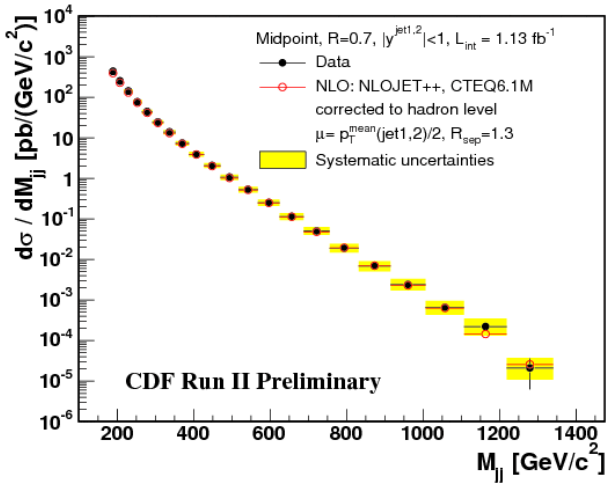


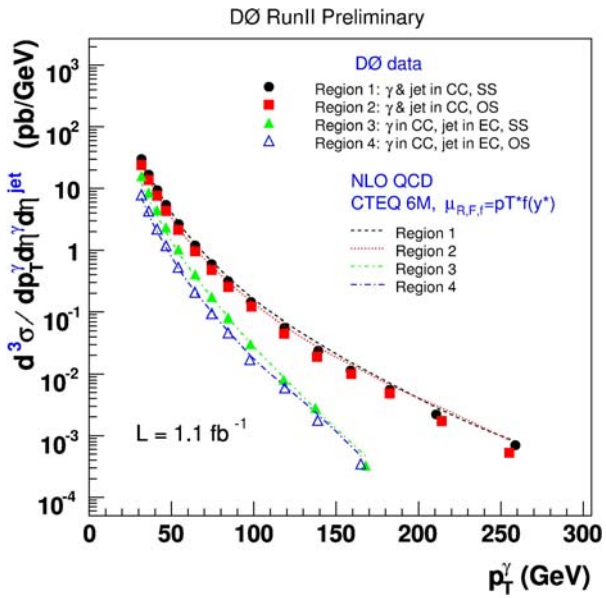
Cover small Lifetime region

- GMSB results from CDF using timing information in COT, TOF and calorimeter

QCD Results

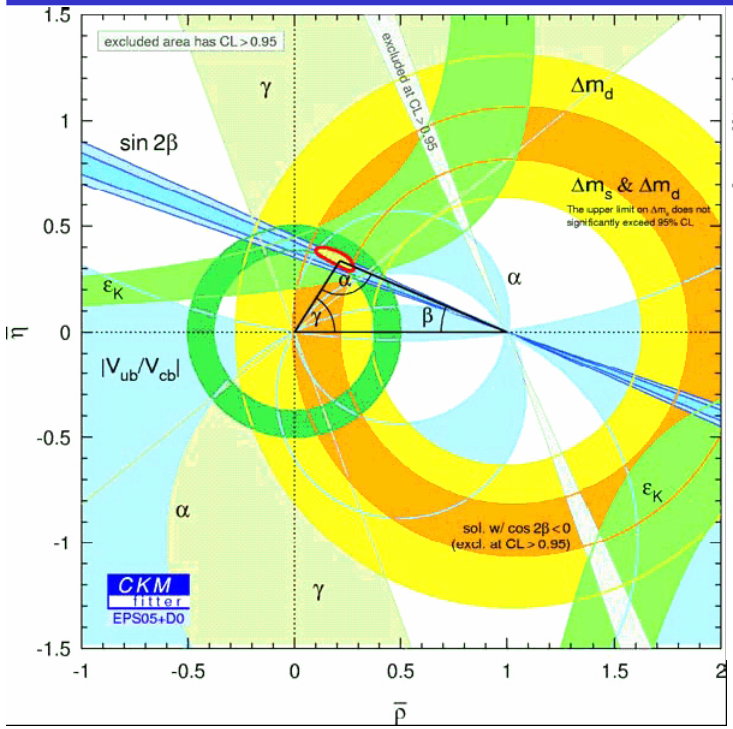


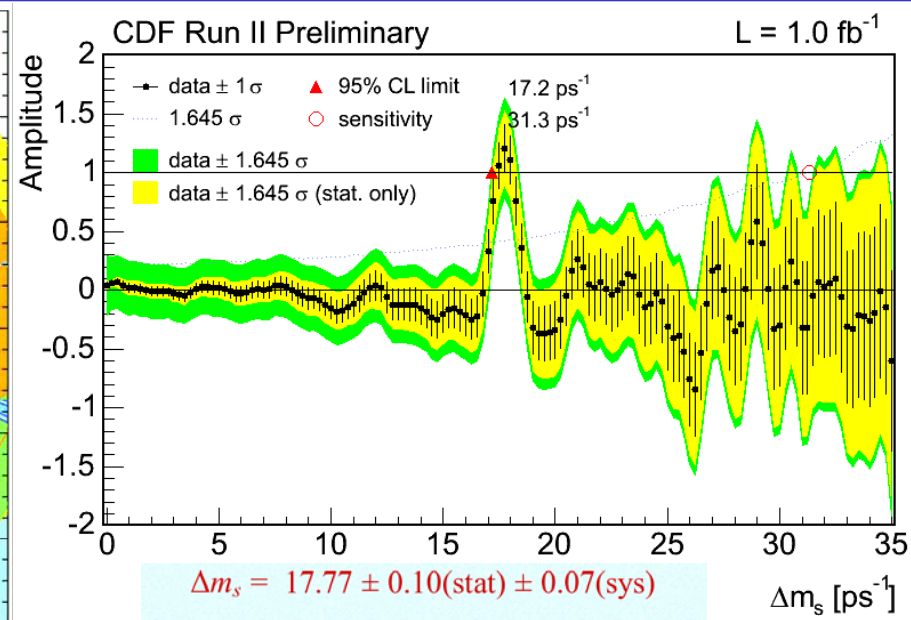




- Dijet invariant mass spectrum measured up to 1.3 TeV
- Measurements of double/triple differential cross sections for jets/γ+jets
- All in agreement with QCD predictions

B_s Mixing and impact on CKM Matrix





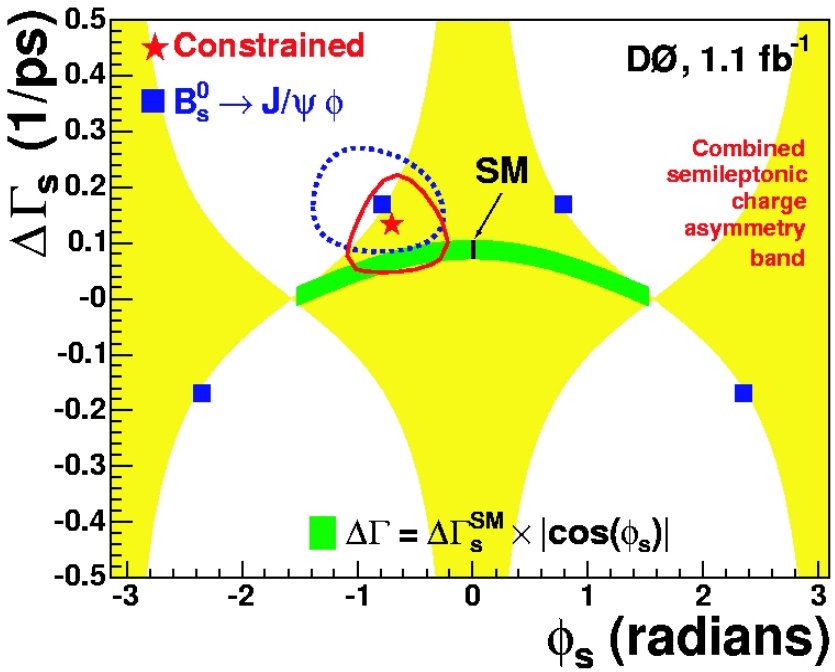
$$\Delta m_s = 17.77 \pm 0.10(\text{stat}) \pm 0.07(\text{sys})$$

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

- B_s mixing results consistent with CKM picture of CP violation
  - Look for new physics in other parameters of B_s mixing and rare processes

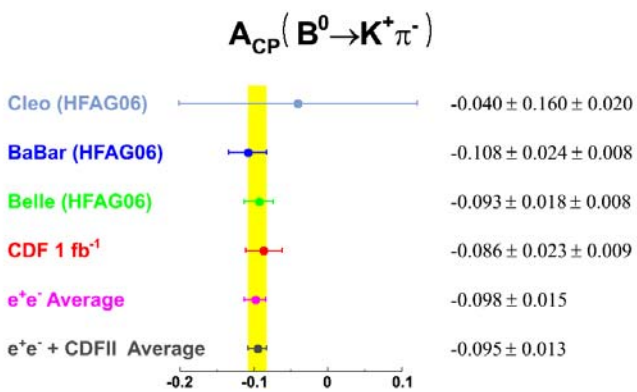
CP Violation in B_s Mixing

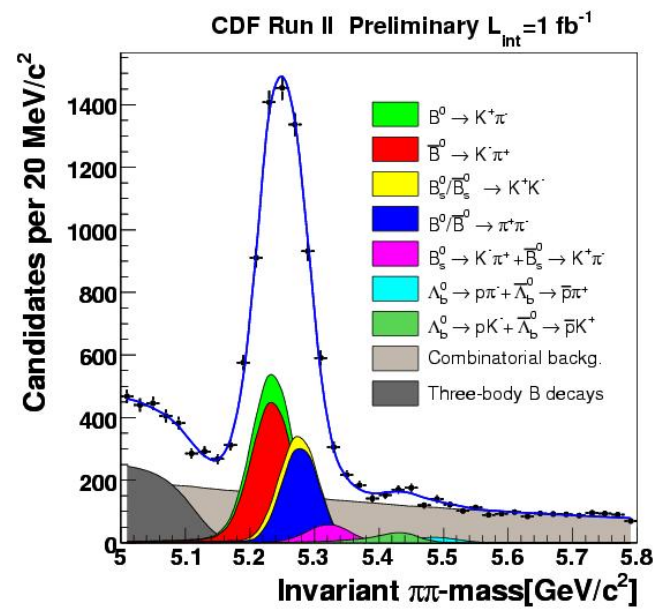
- All parameters of B_s mixing measured at Tevatron:
  - Measurements of $\Delta\Gamma_s$
    - $BR(B_s \to D_s^{(*)} D_s^{(*)})$+$B_s$ lifetime, polarization+lifetime in $J/\psi\phi$
  - Measurements of Φ_s
    - Polarization+lifetime for $J/\psi\phi$, charge asymmetry in dimuon events and $B_s \to D_s \mu X$
- First direct measurement of Φ_s, sensitivity to new physics
- Sensitivity to new physics also in branching ratios of rare decays ($B_s \to \mu\mu$)



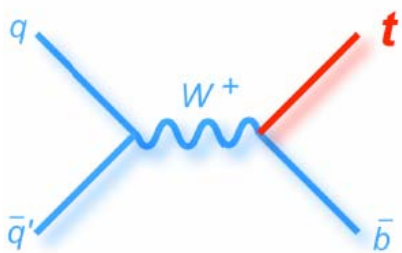
Rare Decays and CP Violation in $B_{(s)} \to h^+h^-$

- CDF displaced vertex trigger
  - collect large sample of two body decays of b-hadrons
  - (first) measurements of branching ratios
- CP violation studies for $B_d \to K\pi$
  - competitive with BaBar and Belle
- Unique possibility
  - CP violation studies in $B_s \to K\pi$:
    - $A_{CP}(B_s \to K\pi) = 0.39 \pm 0.15 \pm 0.08$
    - 2.5 σ different from 0

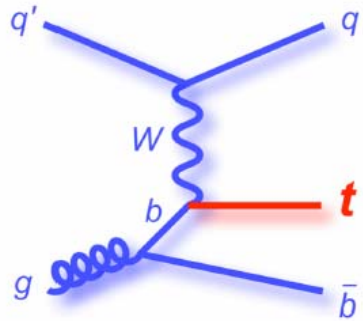




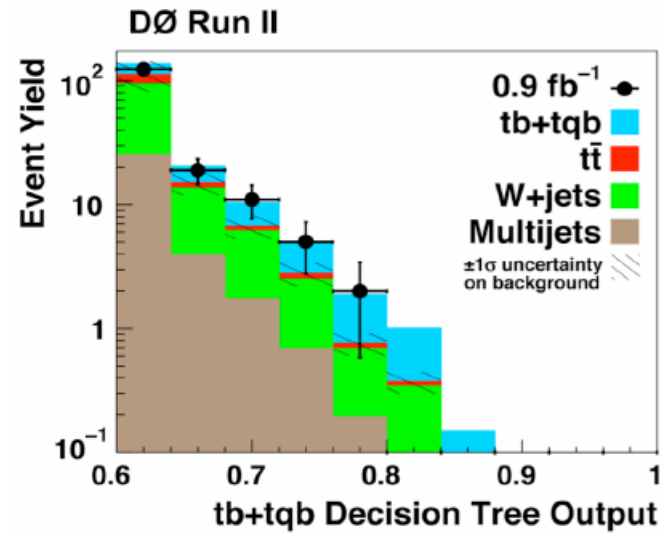
Electroweak Production of Top Quarks at DØ



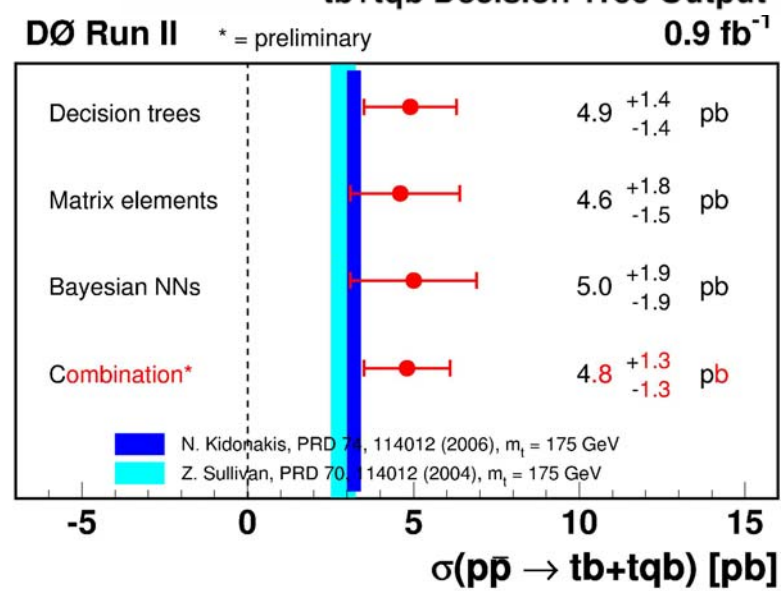
s-channel (tb)



t-channel (tqb)

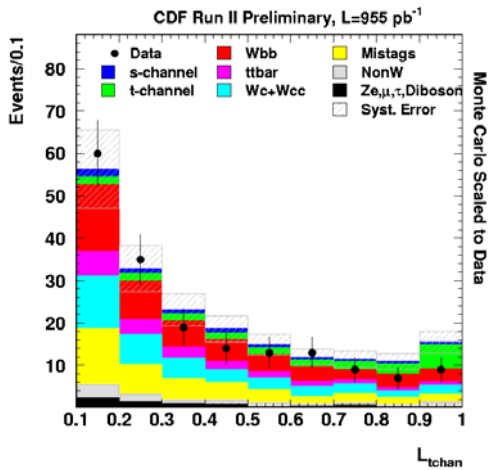


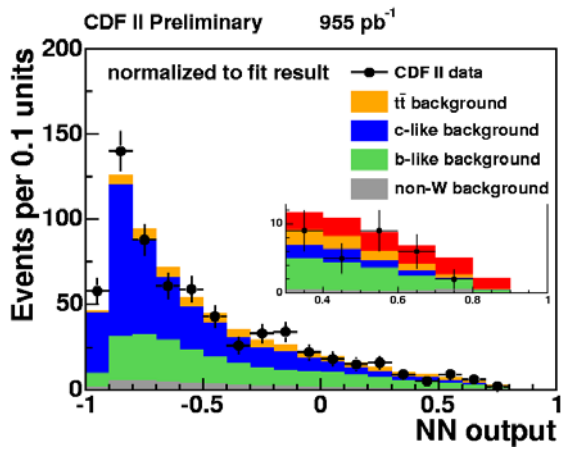
- Consistent results obtained with 3 techniques:
  - Boosted Decision Trees
  - Neural Networks
  - Matrix Elements
- Combined result
  - σ=(4.8±1.3)pb
    - 3.5 σ significance
    - First evidence
- First determination of V_{tb}:
  - $0.68<|V_{tb}|<1$ at 95%CL

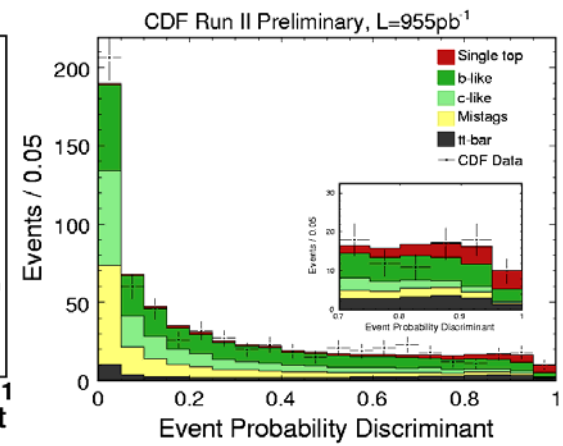


Electroweak Production of Top Quarks at CDF

- CDF: 3 analyses
  - Likelihood, neural network and matrix element based





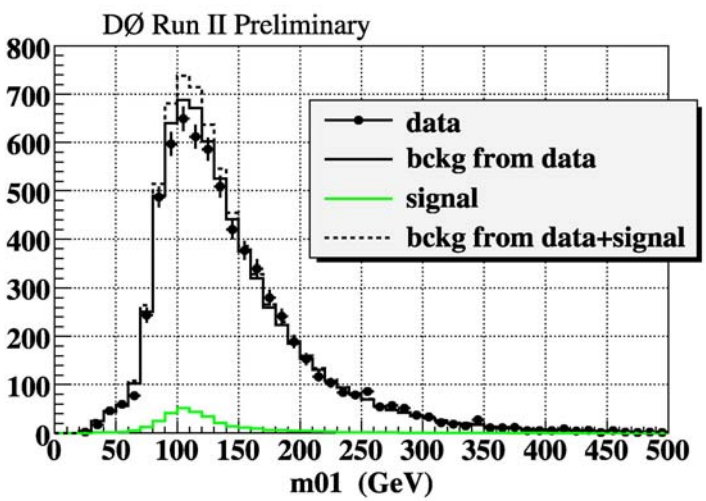


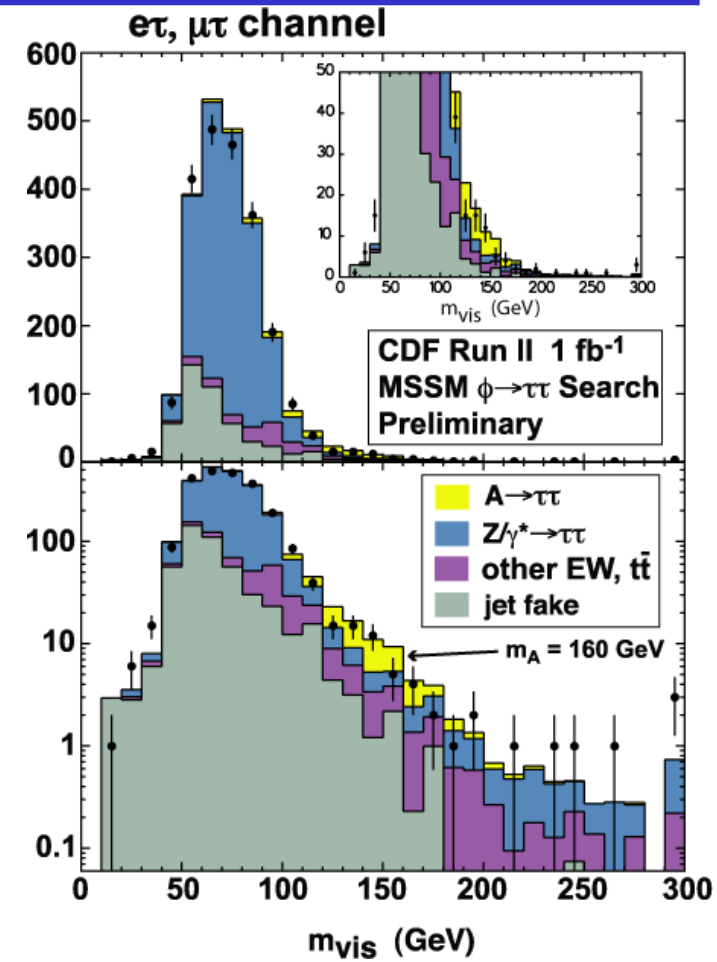
Expected 2.0 σ sensitivity	2.6σ	2.5σ
No evidence of signal	No evidence of signal	2.3σ evidence
σ_{s+t} < 2.7 pb at 95%CL	σ_{s+t} < 2.6 pb at 95%CL	$\sigma_{s+t}=(2.7^{+1.5}_{-1.3})$pb

- More data available for both experiments: turn initial evidence into observation soon

Higgs Searches (SUSY)

- SUSY Higgs at large tanβ
  - Search for b(b)H production
    - 3 or 4 b-tagged jets in final state (DØ)
  - Search for $A \to \tau\tau$
    - eh, μh, and eμ final states in CDF
    - DØ : μh final state



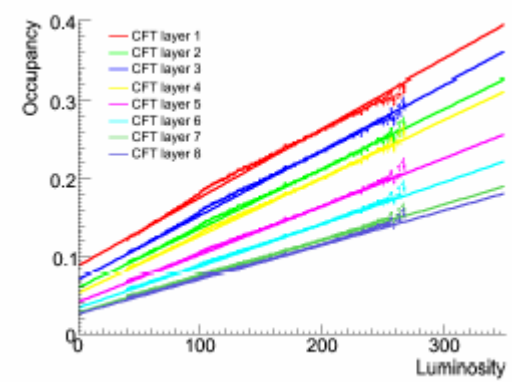


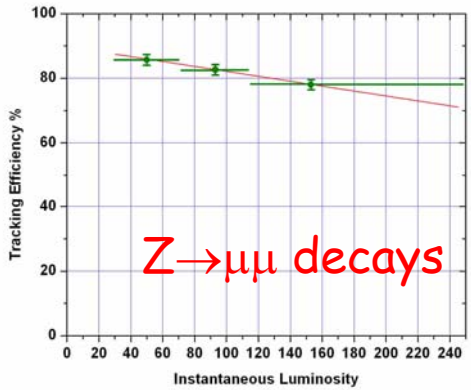
- Excess in eτ,μτ observed by CDF
- No excess in DØ data (similar sensitivity) and in CDF eμ data

BACKUP SLIDES

Tracking at High Luminosity

- D0 Tracker built to fit into compact volume
  - Currently working at instantaneous luminosities 4-5 times larger than in original design
- Loss in offline tracking efficiency observed with current algorithms
  - Already addressed more severe problem at L3

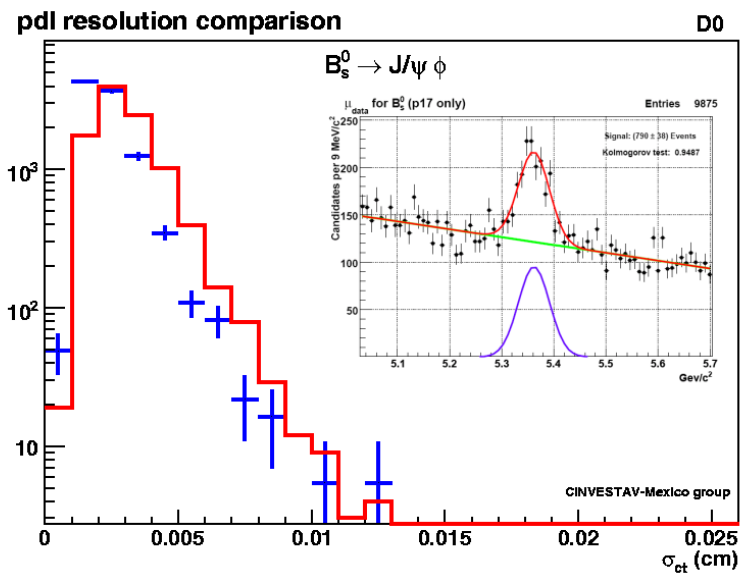




- Significant collaboration effort devoted to understand limitations of current algorithms and development of improvements
  - Expect complete preliminary studies within 2 months

Silicon Layer 0

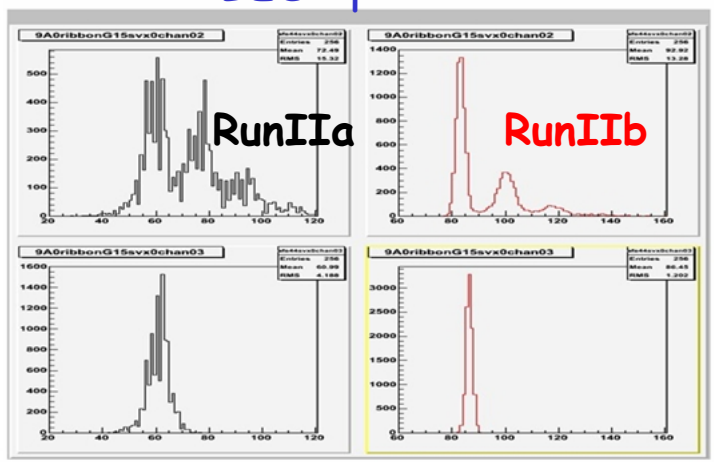
- Additional layer of rad hard silicon detector installed inside the RunIIa SMT
  - More robust tracking and pattern recognition
  - Improves b-tagging
  - Readout error free
  - 0.15% bad channels
  - S/N is ~15/1
  - No significant coherent noise
  - Used in 2nd pass of data reconstruction



AFE IIt Readout Boards for CFT

- New analog front end for fiber tracker and preshower detectors
  - Eliminates amplifier saturation at highest instantaneous luminosities
  - Substantially improves pulse height resolution
  - Facilitates optimization of bias voltage and reduction of thresholds
  - 166/198 boards installed in brief accesses (CFT and central preshower complete)
  - Provides timing information which could be used to improve pattern recognition at highest luminosities

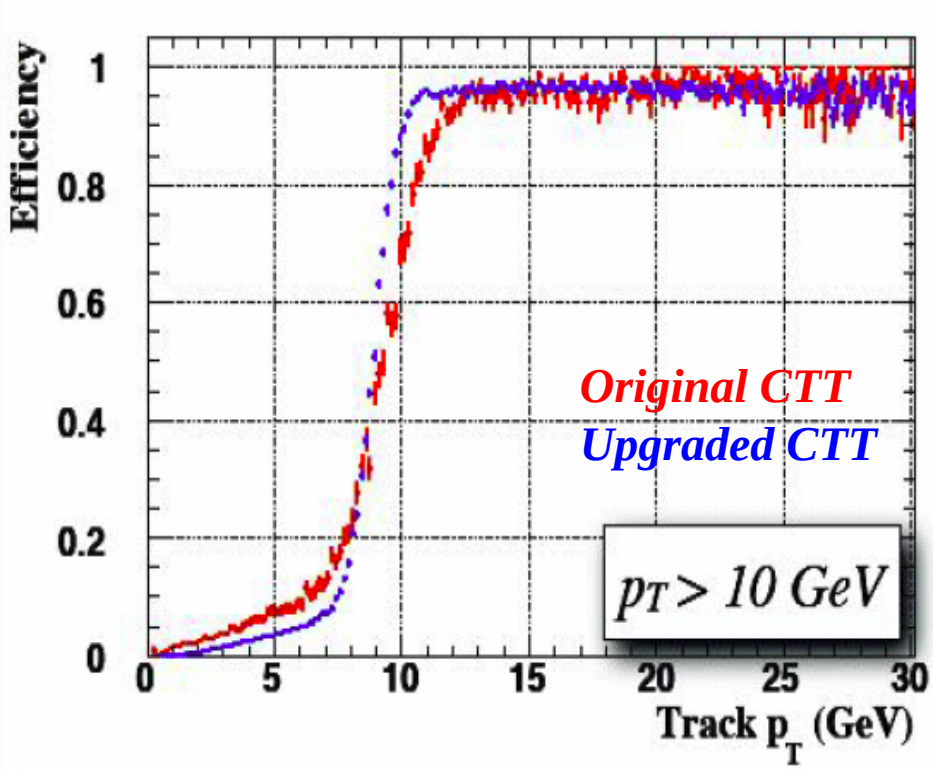
LED spectra

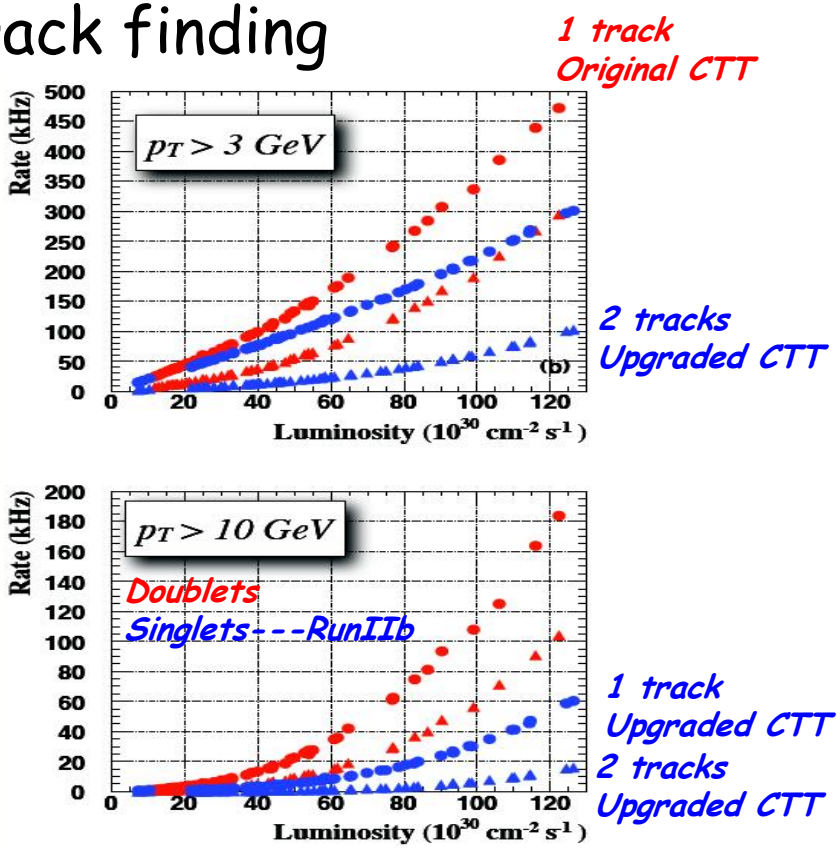


Pedestals

Upgrade of L1 Track Trigger

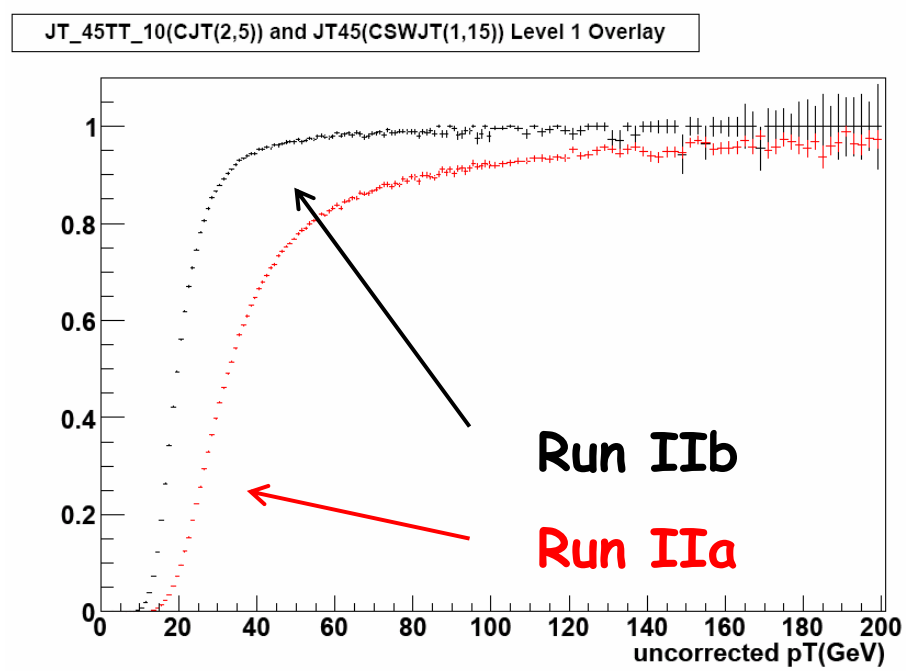
- Use full granularity of CFT to:
  - Sharpen turn-on curves
  - Improve rejection of fake tracks
- Replaced FPGAs used for track finding





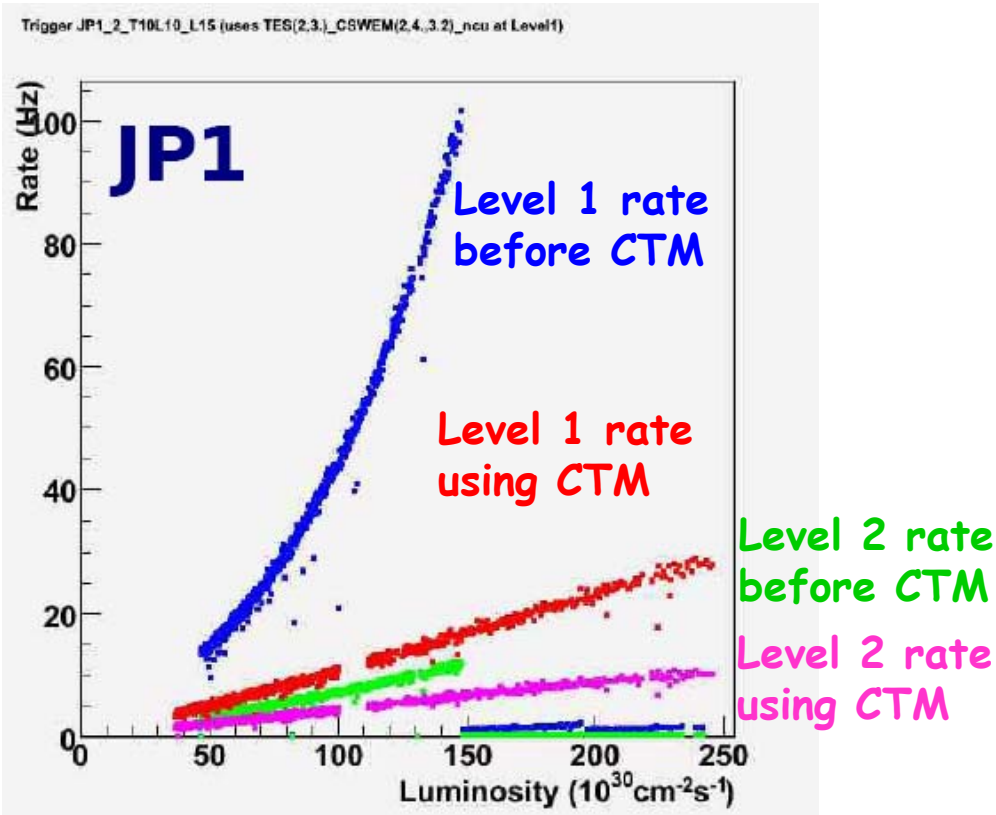
Upgrade of L1 Calorimeter Trigger

- Complete replacement of 10 racks of Run I electronics
- Electron, tau and jet clustering at Level 1
  - Sharper turn-on curves, reduced rates
- Used for physics quality data taking from 2nd store of Run IIb



Level 1 Calorimeter Track Match

- New capability to match calorimeter and track objects at Level 1
  - Improved rejection and tau triggering capability
  - Improves linearity as a function of luminosity
  - Complete implementation required change in trigger timing



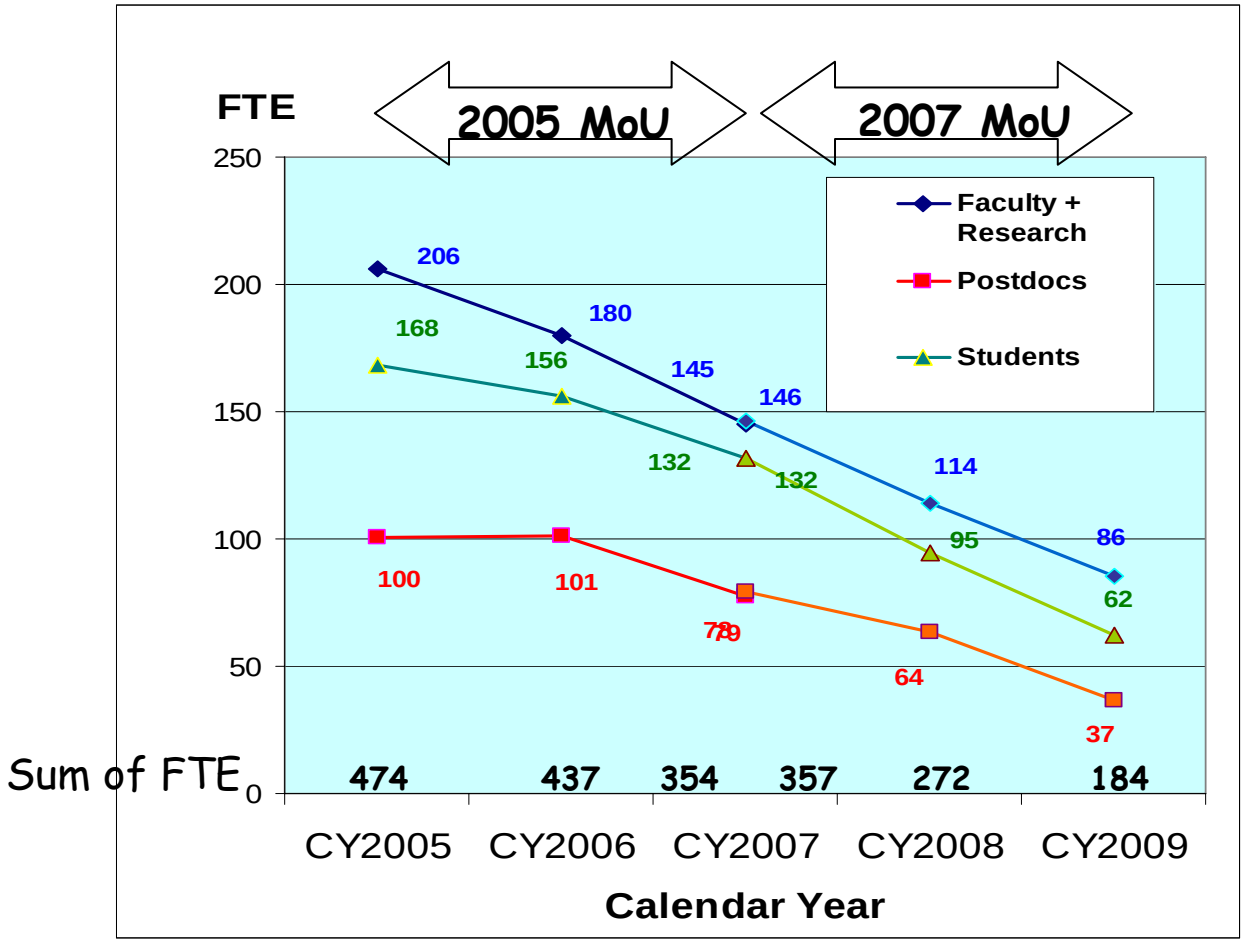
Personpower Needs/Projections

	Effort Report "FTE"		Collider Task Force Resource Needs	
	2005	2006	2007	2009
Operations*	107	91	68	68
Computing	35	30	32	25
Algorithms	74	65	55	21
Management	14	14	10	10
Physics Analysis‡	214	207	86 to 165	66 to 124
Collaboration Total FTE	**443**	**407**	**251 to 330**	**190 to 248**
Fraction Physics Analysis	**0.48**	**0.51**	**0.34 to 0.50**	**0.35 to 0.50**
MoU FTE Projection	**474**	**437**	**357**	**184**

* Operations category of Effort Report includes Run IIb Upgrade activities

‡ Physics analysis needs: lower estimate from "core physics only"
upper estimate from need to keep "service fraction" at 50%

Personpower needs/availability



- Student and postdoc FTEs fall somewhat faster than faculty and research scientist FTEs