DØ Detector Operations

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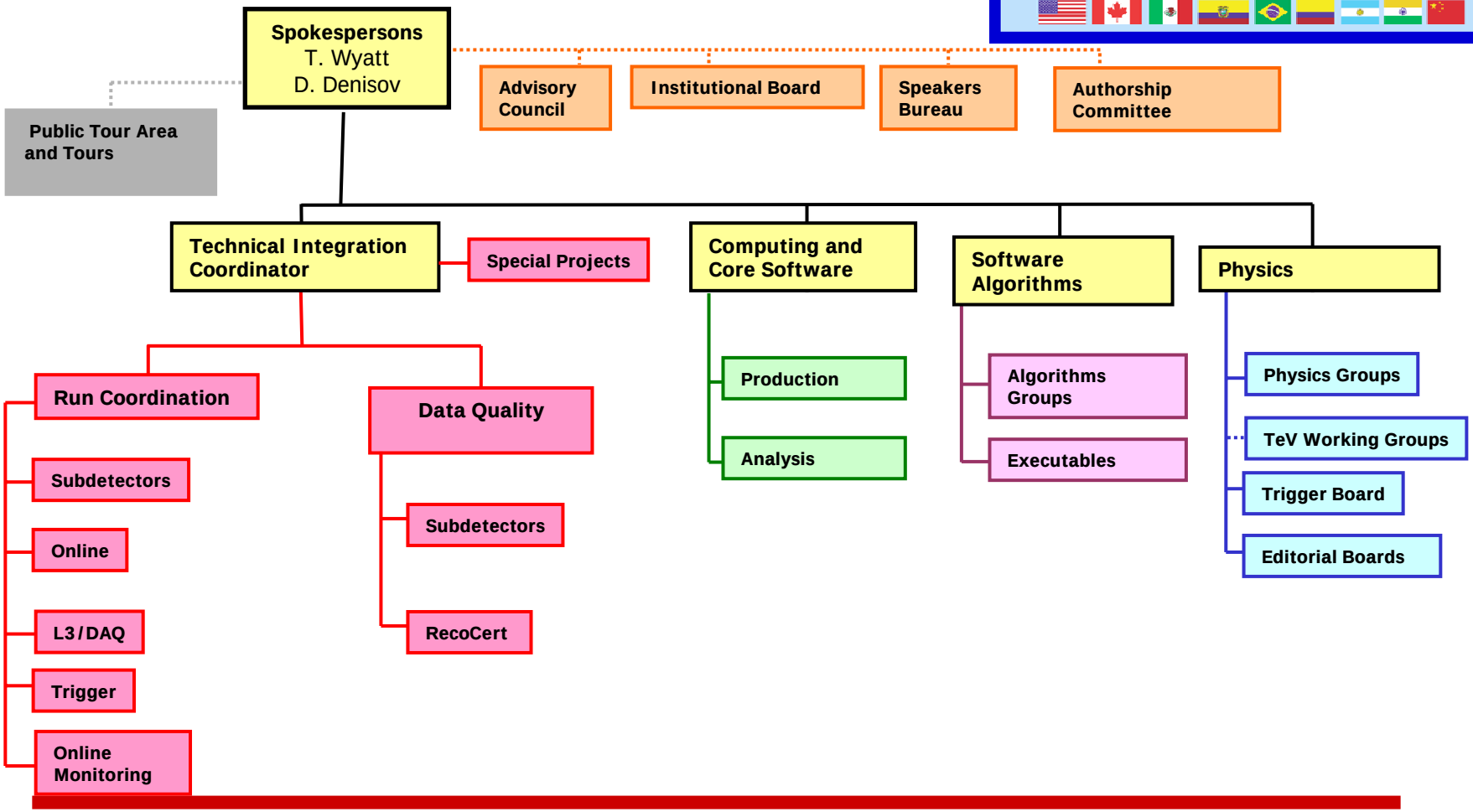
University of Rochester

DOE Tevatron Operations Review
March 27, 2007

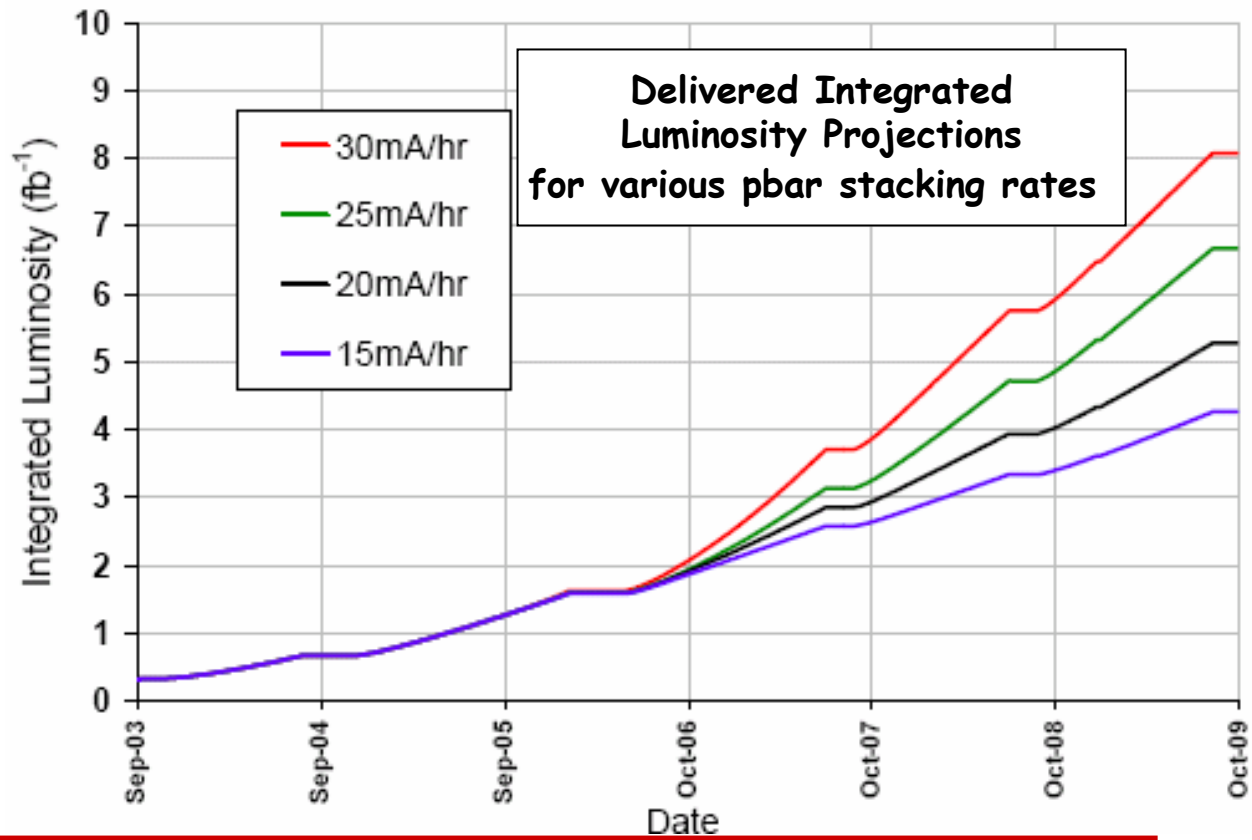
DØ Collaboration

- 575 collaborating authors from 82 institutions



Opportunity

- Tevatron and collider detectors provide an opportunity to explore uncharted territory
- Continuing efforts to effectively complete this exploration
  - Anticipate significant increases in integrated luminosity
- Maximize physics productivity
- Optimizations must be carefully planned and executed



Operating Environment

- Potentially hazardous environment
  - High voltages and currents, substantial cryogens, radiation, high magnetic fields, heights, hazardous materials (beryllium)
- Safety is a key component of effective operations
  - Each individual must take responsibility for safety
  - Management must foster an environment where the importance of safety is clearly communicated and provide the tools necessary to generate and support that environment
  - Division and Lab ES&H serve as essential resources in this effort
  - Training for all personnel
    - Employee and User Orientation
    - DØ specific Orientation
    - Drills (and safety system tests)
    - Additional training for specific activities
  - Safety considerations integrated into Detector Design and Operations Implementations
    - Operational Readiness Clearances
      - Safety assessments for various subsystems
    - Written procedures
      - For major operations
      - Toolbox meetings as appropriate
    - Job Hazard Analysis
    - Follow-up on unusual situations
    - Respond to grass roots input
  - One incident requiring first aid within the last two years

DØ Operations Team

- Run Coordinators
  - Team of two people
    - Alternate on-call status on bi-weekly basis
  - Generate run plan
  - Serve as primary operations interface to Accelerator Division
  - Facilitate smooth and efficient data acquisition
- Complete shifter coverage round the clock when in data acquisition mode
  - Currently team of five people in the control room
  - Detector subsystem shifters may be released during extended downtimes or shutdowns
  - During smooth operation, many shifters are able to get other work done in parallel with shift responsibilities
- On-call experts
  - Pager carrying support network to insure prompt expert availability
    - Minimize downtimes and inefficiencies
  - Primary and secondary pagers for each subsystem generally rotate among pool of experts

DØ Shifters

- Captain/Global Monitor serves as shift coordinator
  - Implements Run Plan
  - Serves as main control room contact
  - Monitors trigger and physics examines

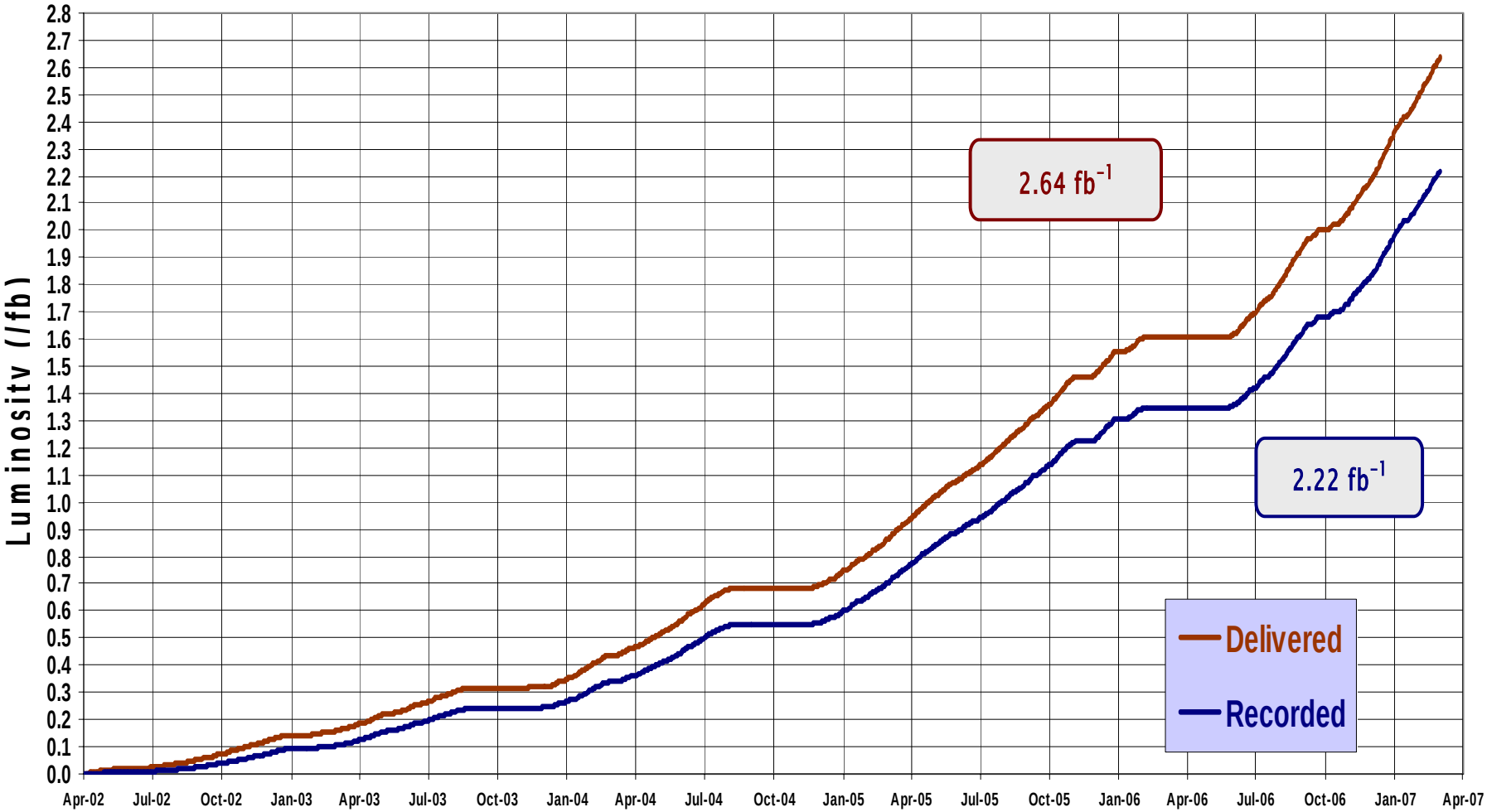
  Merged Jun 2005
- Data acquisition (DAQ) shifters
  - Devotes substantial fraction of time to operations over several months
    - Generally 42 shifts in 16 weeks
- Detector subsystems shifters
  - Monitor, calibration, and operate detector subsystems
    - Calorimeter and Muon — Merged Nov 2003
    - Silicon MicrostripTracker
    - Central Fiber Tracker

    } Merging spring 2007
- Operations Shifter
  - PPD Mechanical Department personnel supporting DØ operations
  - Monitor and control cryo systems and associated support
  - HVAC and safety system monitoring
- SAM shifter
  - Monitor data server status and react accordingly
  - Monitor output from data reconstruction pass

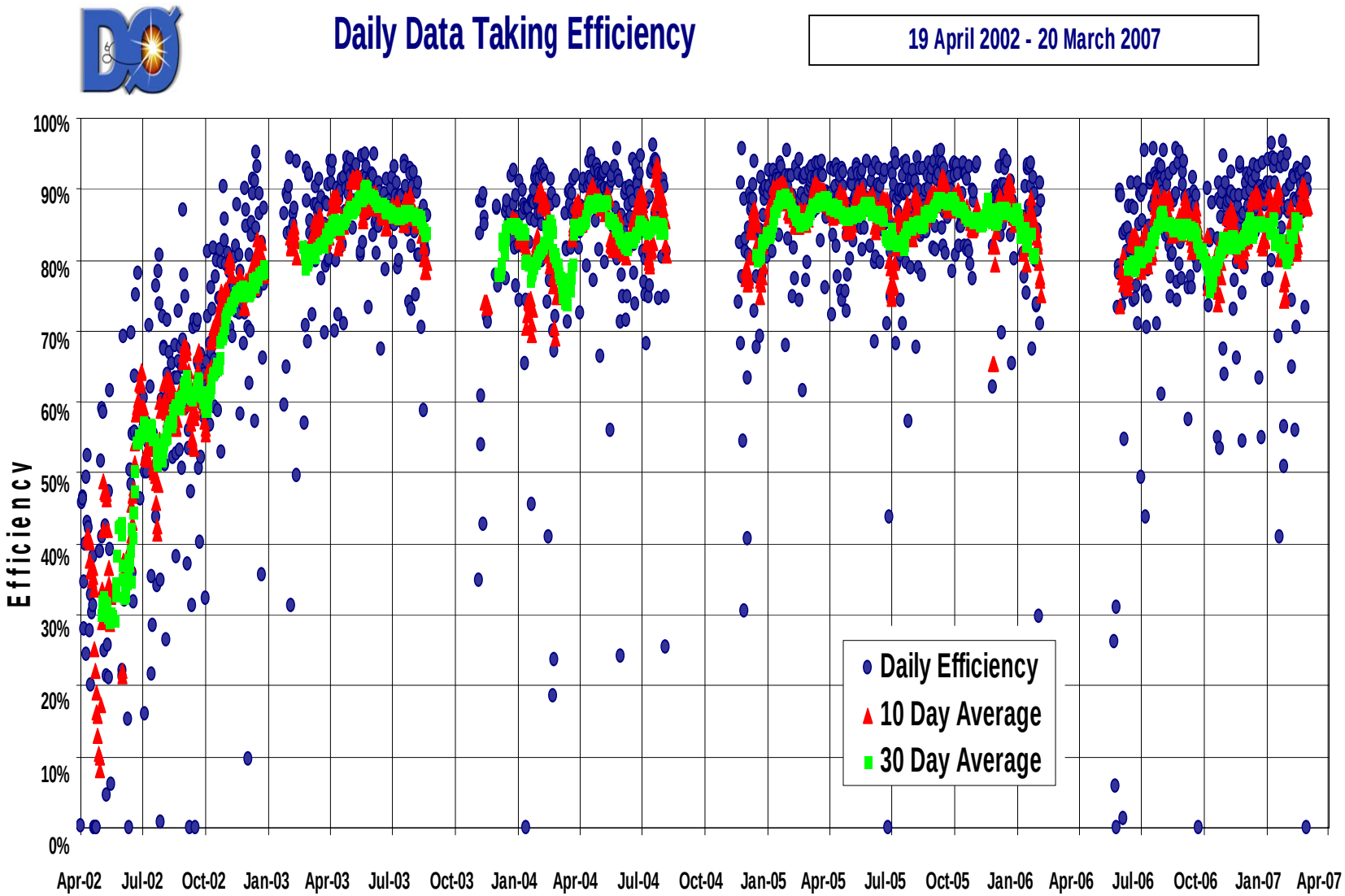
Recent Operations Performance Overview

- DØ detector had a data taking efficiency of 87% between the 2004 and 2006 shutdowns
  - 800 pb^{-1} recorded of 923 pb^{-1} delivered in 63 weeks
  - Addressed detector issues as instantaneous luminosities increased
    - Increase buffer sizes
    - Change Level 2 transfer mode to smooth out operations
    - Increased number of Level 3 nodes
    - Developed and commissioned V14 trigger list
- Shutdown in 2006 to install a suite of upgrades designed to prepare the DØ detector to effectively handle growing integrated and instantaneous luminosities
  - Tracking Upgrades
    - Layer 0 Silicon Detector
    - Enhanced front-end boards for Central Fiber Tracker (AFE II)
  - Trigger Upgrades to keep trigger rates in check
  - DAQ/Online System Upgrades to handle data rates
- DØ detector had a data taking efficiency of 84% since the 2006 shutdown (including Run IIb Upgrade commissioning)
  - 841 pb^{-1} recorded of 997 pb^{-1} delivered in 40 weeks

Delivered and Recorded Luminosity



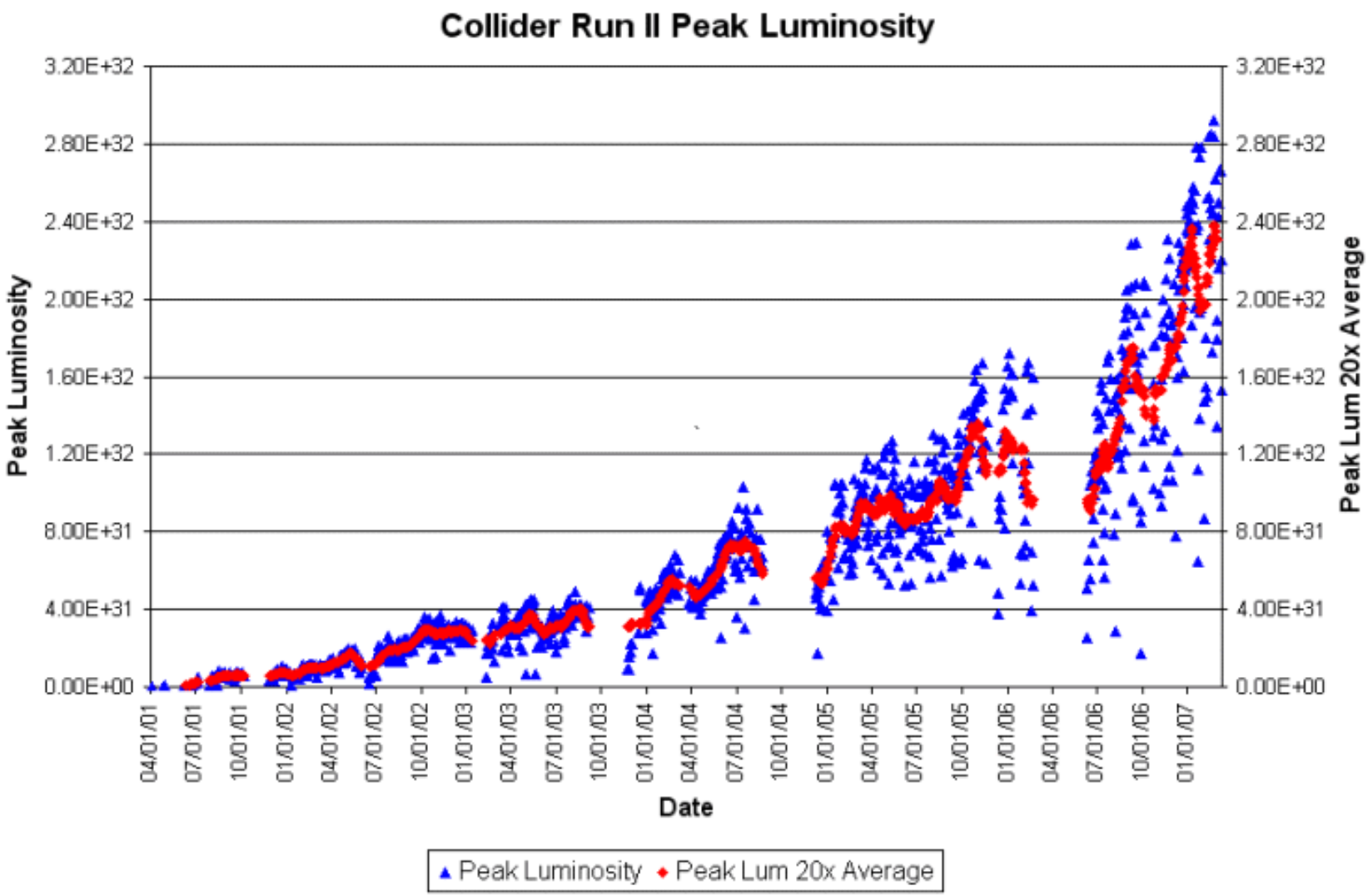
Data Taking Efficiency



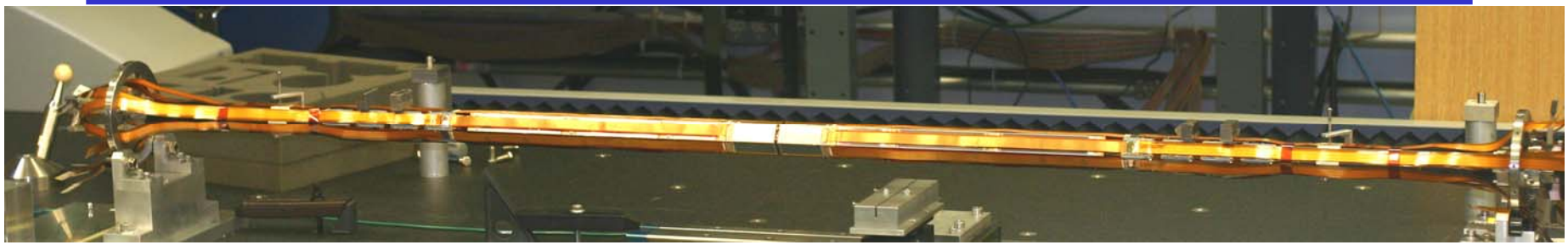
Sources of Losses

- Front End Busy due to event readout
- Begin/End Store and Begin/End Run
  - Ramping high voltages
  - Adjusting trigger prescales
- Failures/Downtimes
  - Crate resets due to lost synchronization
  - Power supply trips
  - Water drips/trips
  - HV trips
  - Noise
  - Power outages
- Shifter (and expert) experience
  - Low rate of individual failures
  - Turn-over
- Transitions for special studies/calibrations
- Operations team tracks failures and errors and addresses root cause where possible

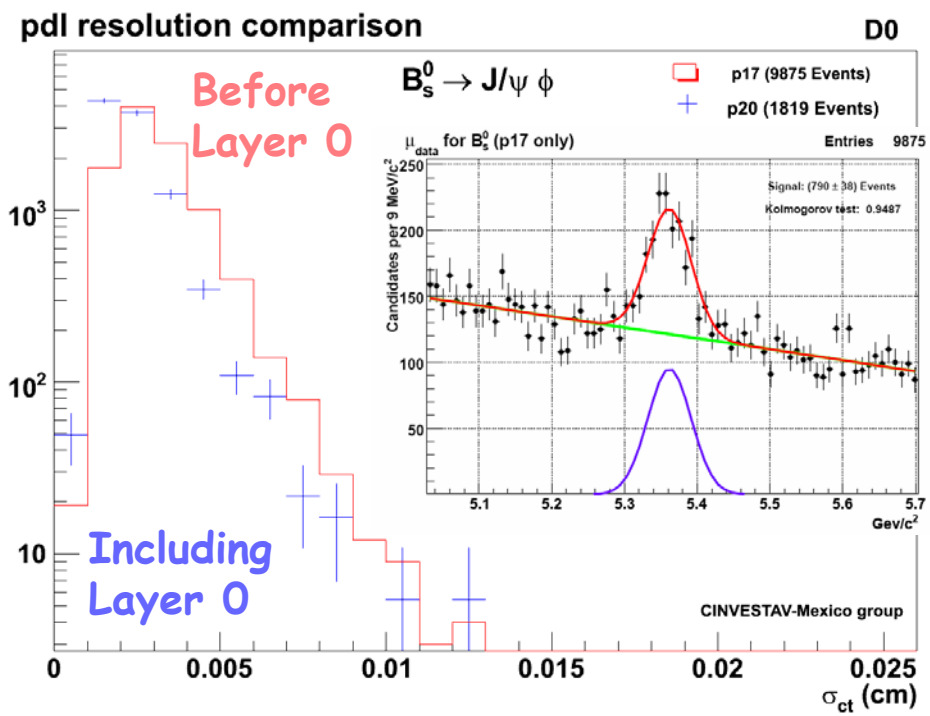
Peak Luminosity



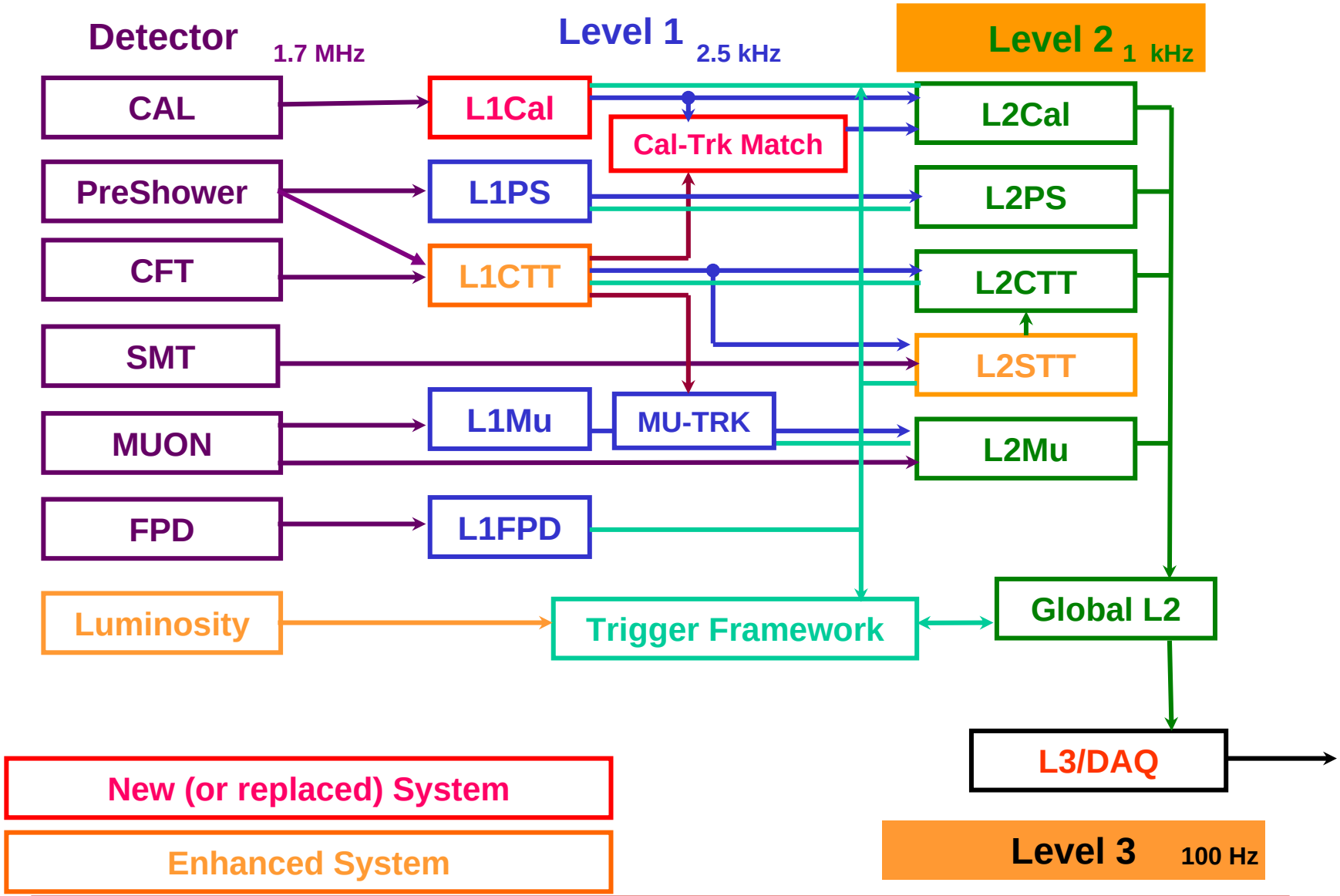
Layer 0 Silicon Detector



- Additional layer of rad hard silicon detectors installed inside the Run IIa Silicon Microstrip Tracker
  - More robust tracking and online pattern recognition
  - Improves impact parameter resolution
  - Readout is error free
  - 19 bad channels (out of total of 12,288 channels)
  - Signal to noise is ~15 to 1
  - No significant coherent noise

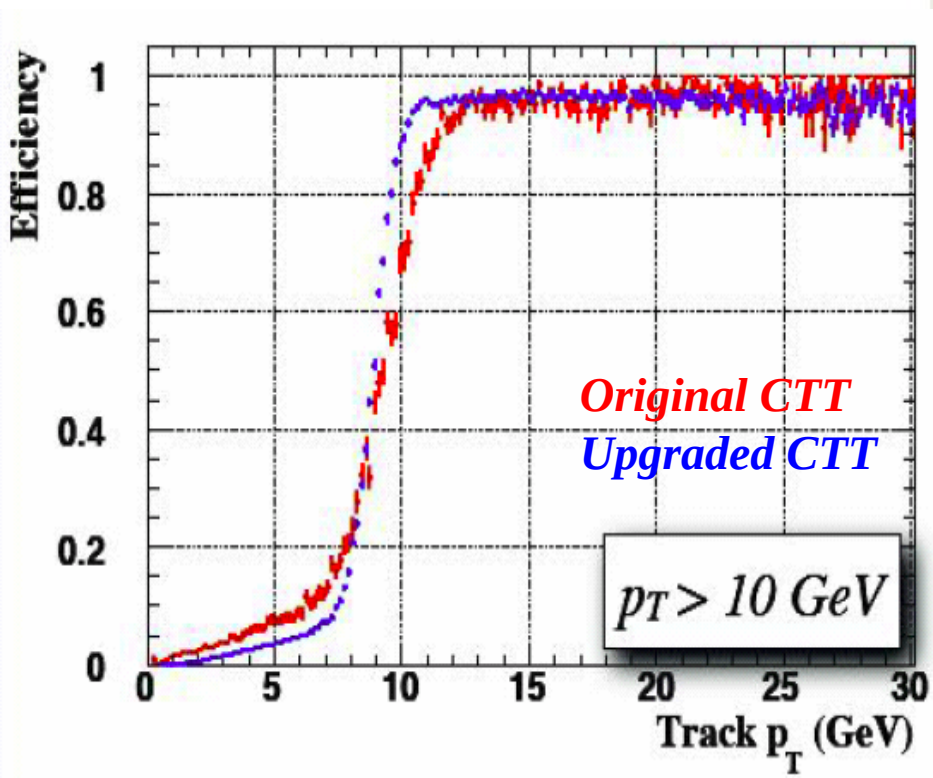


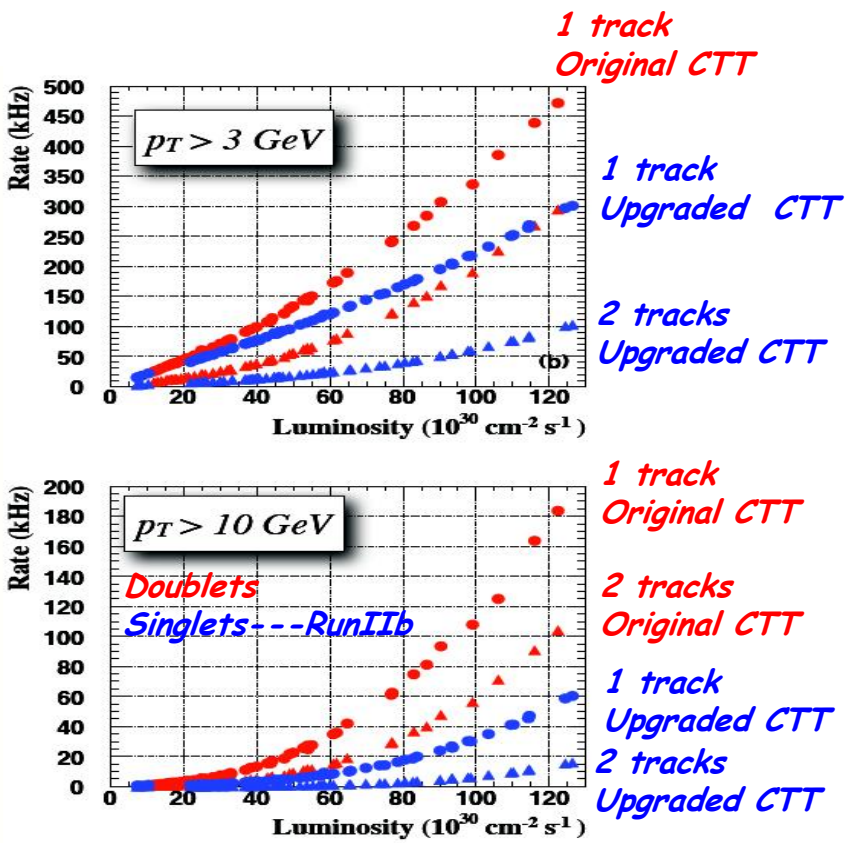
DØ Run IIb Trigger System



Level 1 Central Track Trigger Upgrade

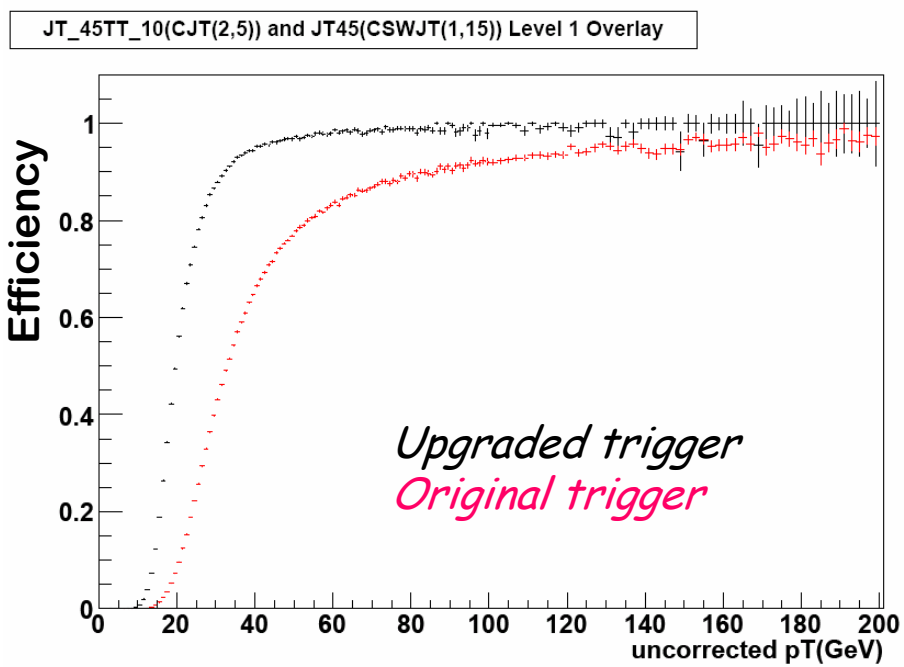
- Sharpens turn-on curves and improves fake rejection capability of CTT by making use of full granularity of Central Fiber Tracker

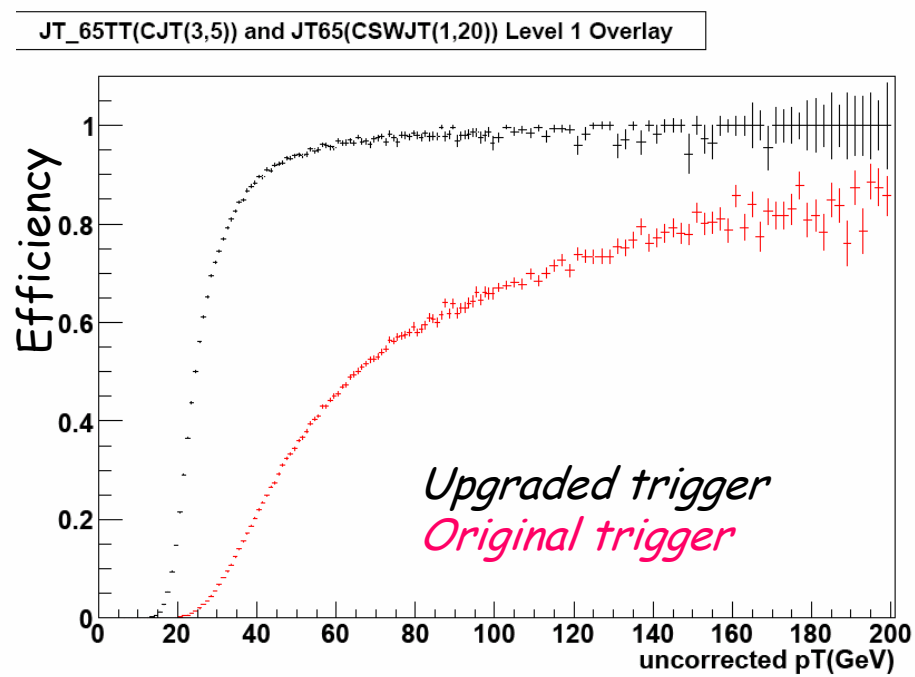




Level 1 Calorimeter Trigger Upgrade

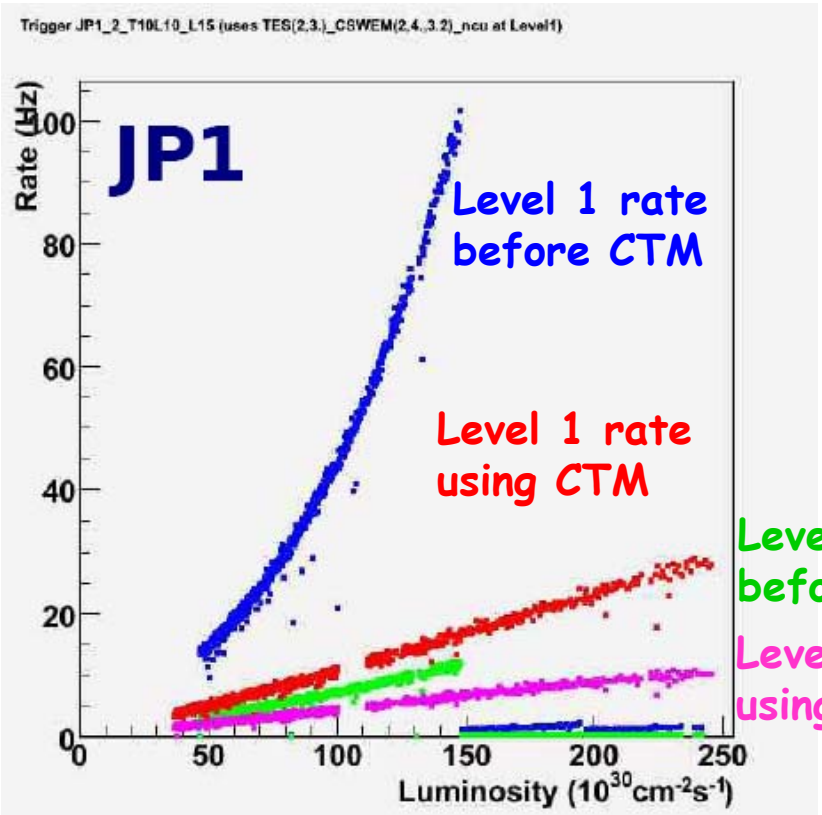
- Sharpens trigger turn-on curves
- Provides electron, jet, and tau ID at Level 1
- Replaced ten racks of Run I calorimeter trigger electronics

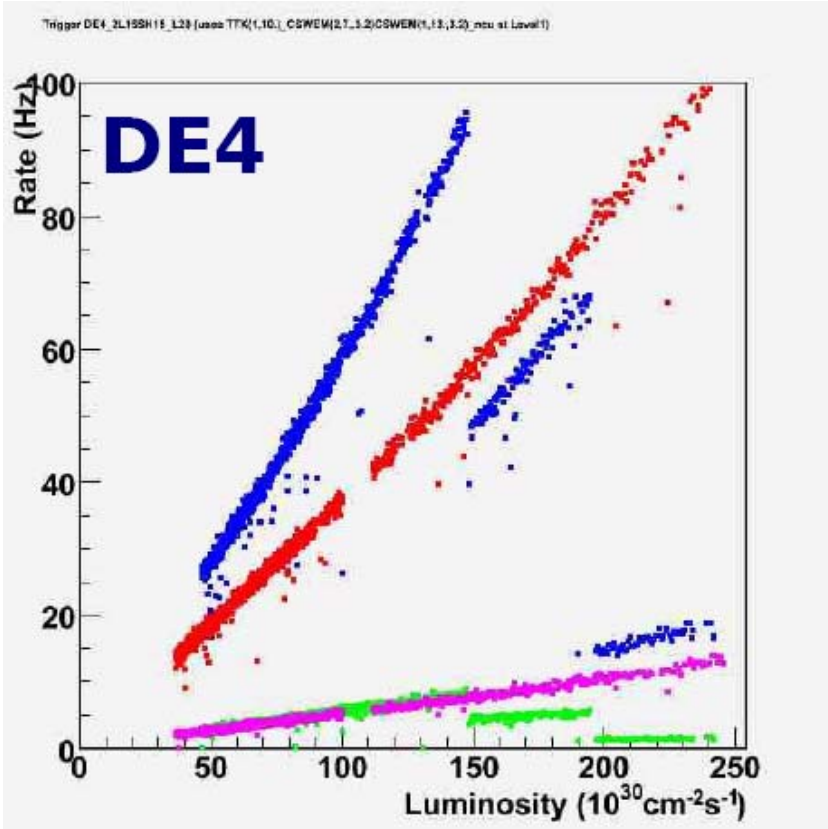




Level 1 Calorimeter Track Match Trigger

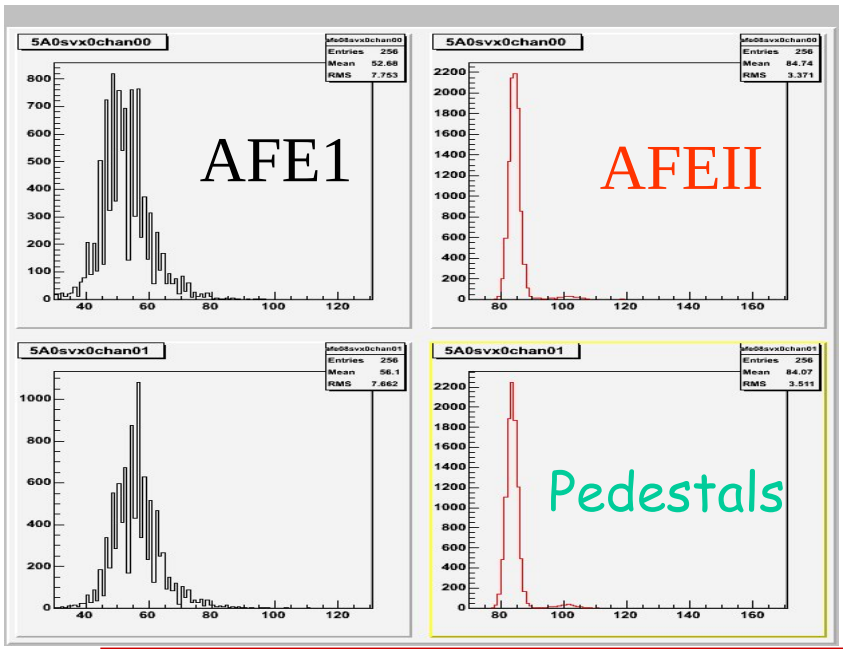
- New capability to match calorimeter and track objects at Level 1
  - Improved rejection and tau triggering capability
  - Improves linearity as a function of luminosity
  - Complete implementation required change in trigger timing

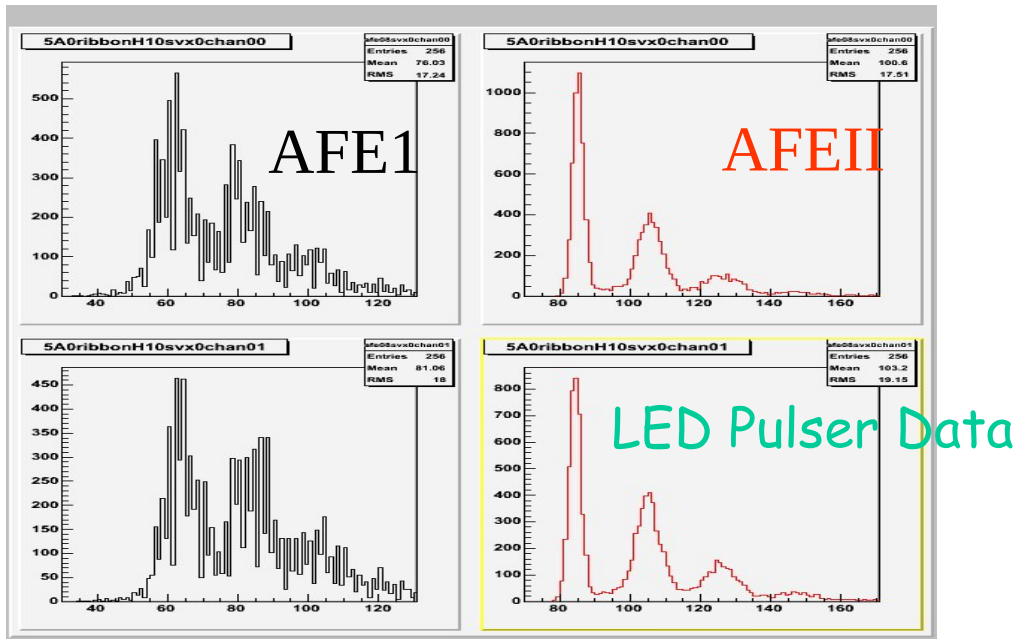




Fiber Tracker (and Preshower) Readout Upgrade

- Analog Front End II (AFEII)
  - Eliminates amplifier saturation anticipated at high instantaneous luminosity
  - Provide additional enhancements to make detector more robust
  - Facilitates optimization of bias voltages and reduced thresholds
  - Plug compatible with original AFE to allow adiabatic installation during brief accesses
    - 198 boards total
    - 42 boards still to be installed – primarily for preshower detectors





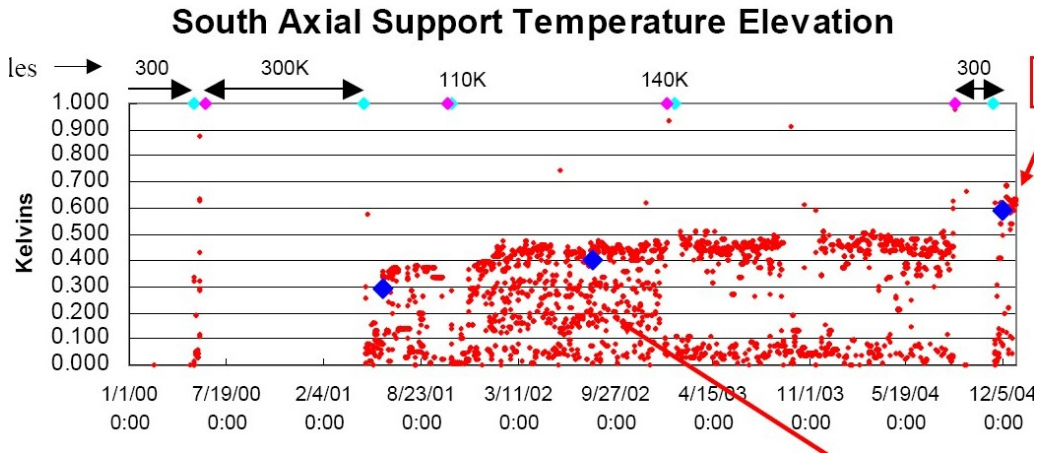
Additional Enhancements

- Level 3 Trigger
  - Re-commissioned dual ethernet Level 3 readout
  - 120 additional Level 3 farm nodes
  - Improved level 3 tracking code about to go online
- Enhanced data logger capabilities

- Simplifying monitoring and controls interfaces
- Automated monitoring and control
  - HV ramping at store transitions
  - Silicon Microstrip Tracker heartbeat trigger enhancements
  - Detection of synch loss and recovery
  - Flagging of alarm conditions and detector state transitions
    - Guidance associated with alarms to provide shifters with immediate assistance in addressing situations
- Improving documentation
- Enhanced diagnostic tools

Some Potential Detector Issues to Watch

- Protecting the solenoid coil—need to keep the coil cold



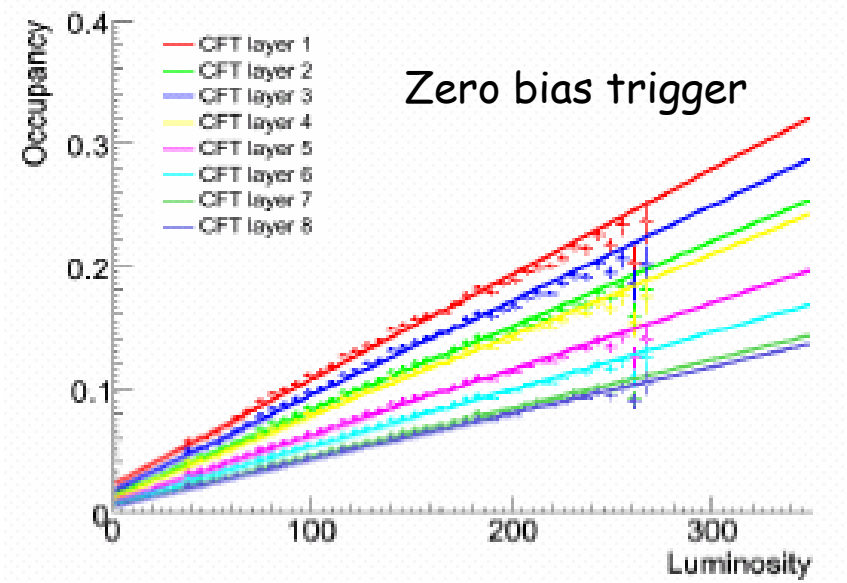
- Monitor radiation damage
  - Silicon Microstrip Tracker
  - Luminosity Monitors
- Minimizing beam losses and impact of beam losses
  - Muon readout failures
  - Muon power supplies failures
- Minimizing calorimeter noise

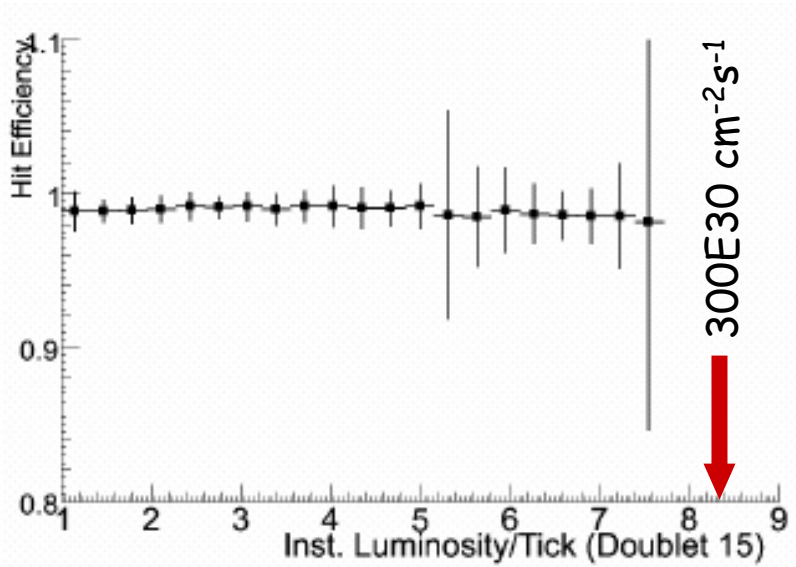
Instantaneous Luminosity Challenge

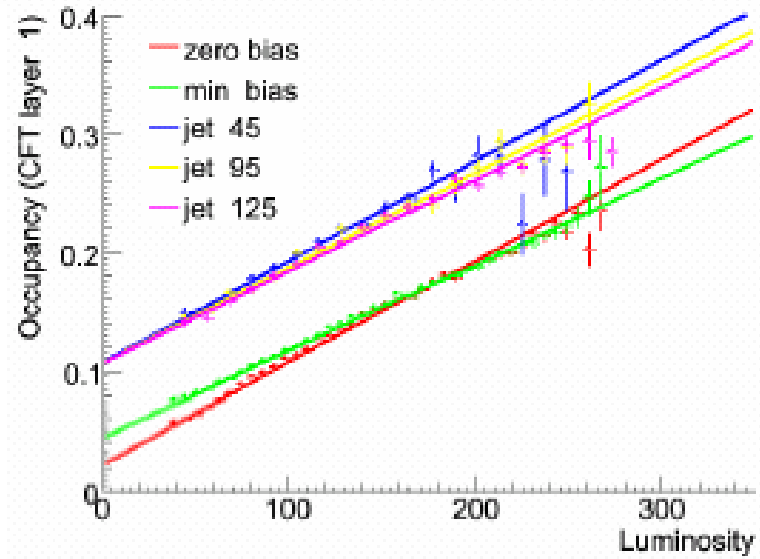
- No substantial additional detector upgrades anticipated
- Evaluating performance (to maximize physics yield) while instantaneous luminosities increase
  - Detector Performance
    - Occupancies in Central Fiber Tracker
    - Monitoring calorimeter baseline subtraction
  - Trigger refinements
    - Level 2 trigger menu
    - Level 3 tracking efficiency/reconstruction time tradeoff
  - DAQ performance
    - Event size due to occupancies
    - Data rates
  - Offline reconstruction algorithms and object IDs
    - Reconstruction times

Central Fiber Tracker Performance

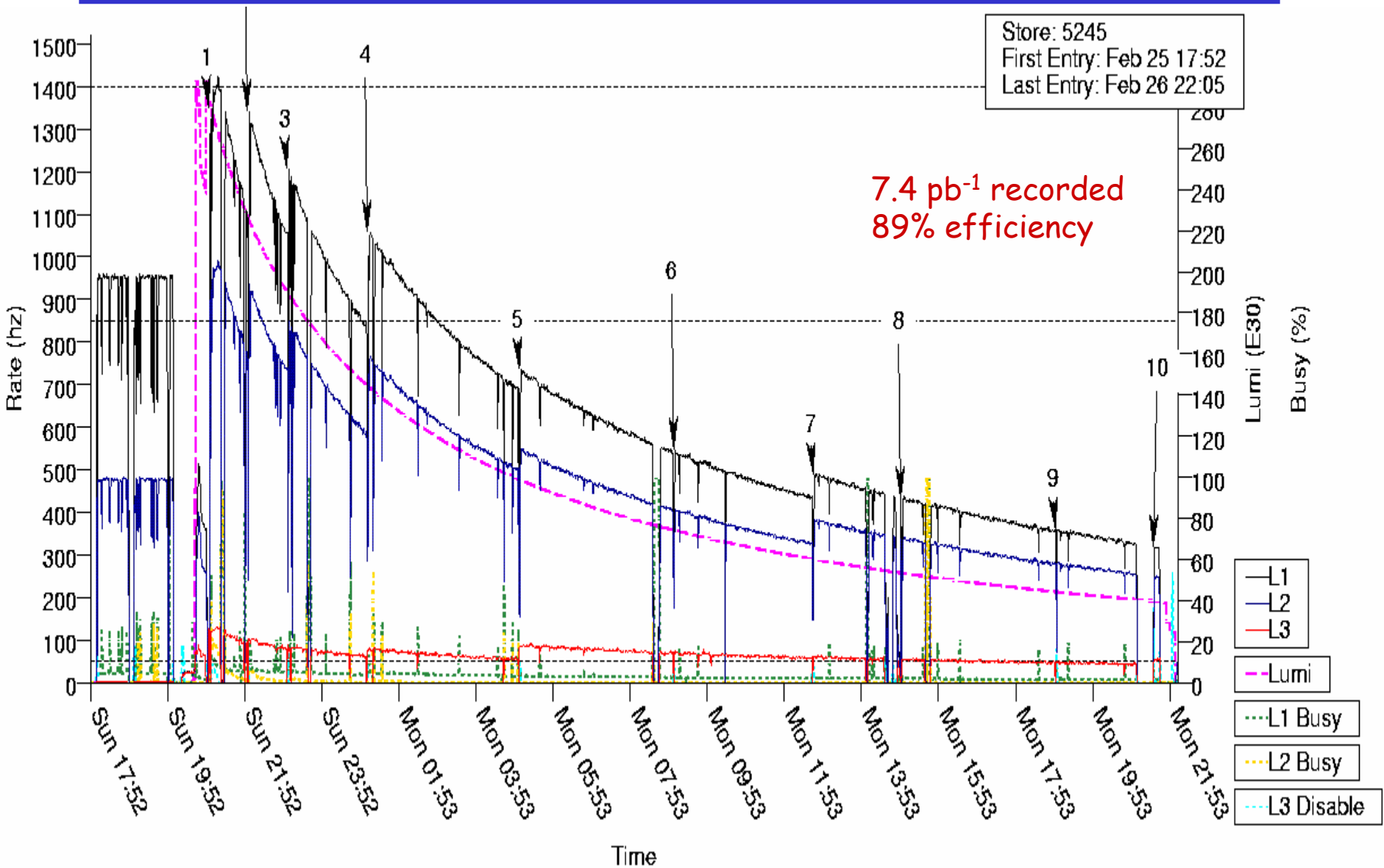
- CFT occupancy rises linearly with instantaneous luminosity
  - Trigger and reconstruction challenges
- Probability of finding hit on track remains stable







Current Record Initial Luminosity Store



Effort Reports

- Management requests accounting of effort invested in DØ by collaborators
  - "FTE" is fraction of collaborators total work effort
    - Not necessarily strongly coupled to 40 hour work week

	2005 "FTE"	2006 "FTE"
Operations (including shifts and Run IIb activities)	107	91
Computing	35	30
Algorithms	74	65
Management (Spokes and institutions)	14	14
Physics Analysis	214	207
Collaboration Total	443	407
Fraction of Effort Devoted to Physics Analysis	**0.48**	**0.51**

Tevatron Collider Task Force

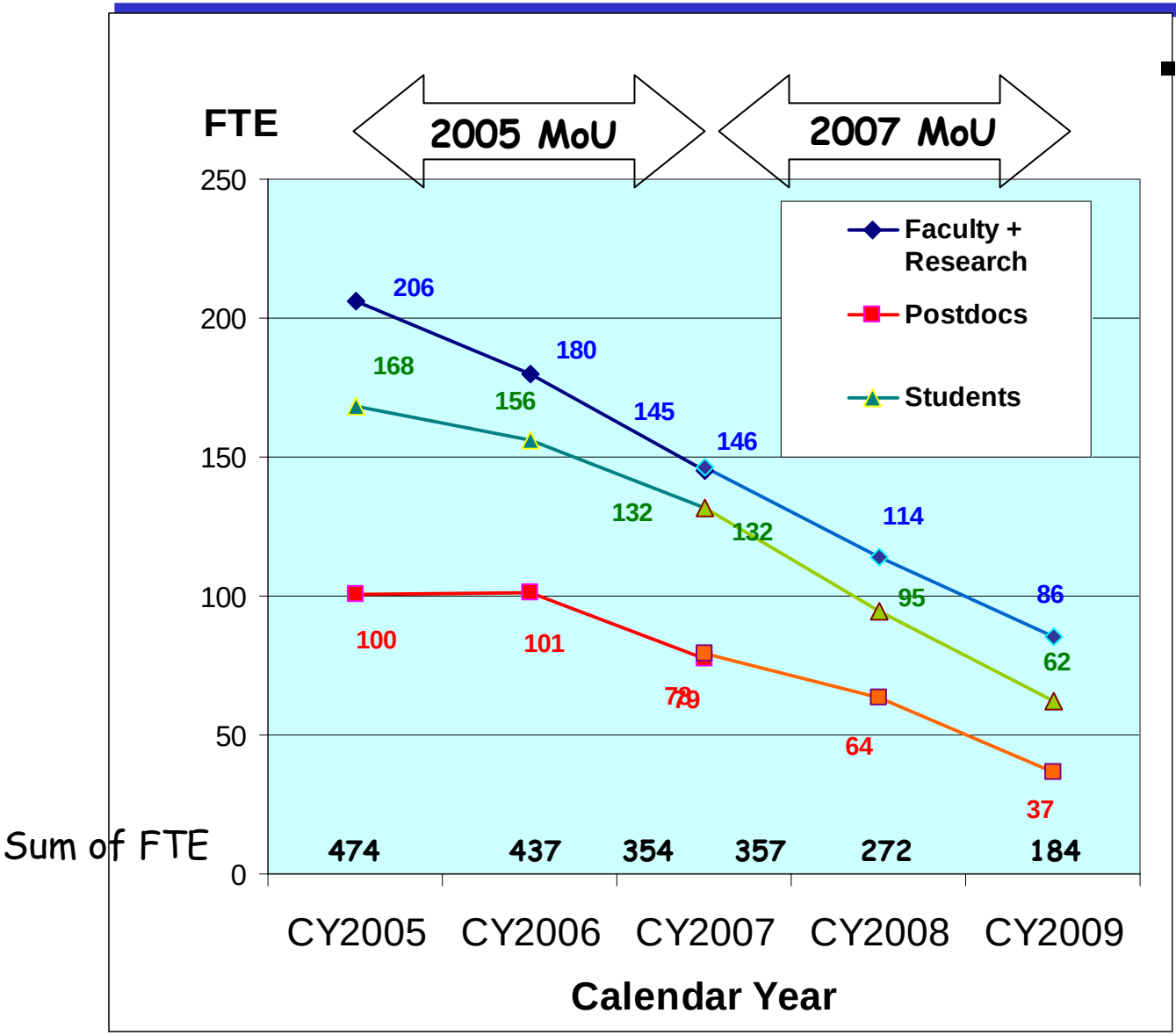
- During the fall of 2005, the Tevatron Collider Task Force evaluated personnel needed to operate CDF and DØ through 2009 and perform physics analysis in a timely fashion
  - Bottoms-up estimates for operations and offline analysis personnel needs
- Our estimate was that 190 to 248 collaborator FTEs would be required to operate the detector, reconstruct the data and produce physics results in 2009
  - In addition, 26 FTE of PPD technical support and 14 FTE of CD central support required

Comparing Resources and Needs

	Effort Report		Collider Task Force	
	"FTE"		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	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 numbers includes contributions to Run IIb Upgrade activities

MoU Estimates of FTE Effort on DØ



- DØ Management uses MoUs with Institutional Board Reps to identify and track our key resources (personnel), and make projections regarding future availability of such resources
  - Provides opportunity to match tasks to individuals

Outlook

- Successful detector operation, and effective and timely reconstruction and analysis of the resulting data is not just a matter of head count and FTEs
  - Requires the proper distribution (and physical location) of skill sets, experience and interests
- Significant effort from the collaboration and the support from the Lab and agencies are essential to assure that sufficient manpower continues to be available to fully exploit this exciting physics program
  - Excellent training ground for students and post-docs
  - Major investments already made—small additional investments could yield substantial additional physics results
  - Continue streamlining to improve efficiency
    - Reduce shift burden
    - Addressing reliability issues as they arise
    - Automation of monitoring

Summary of DØ Detector Operations

- Accelerator complex is performing well
- Recorded Run II data accumulating at a rate of more than a fb^{-1} per year, and the rate continues to increase
- Anticipate Run II delivered luminosity in the range of 6 to 8 fb^{-1} by the end of 2009
- Challenges on the horizon
  - Increasing integrated and instantaneous luminosities
  - Maintaining effective operations as pressure increases on the available effort pool
- DØ Detector is operating safely, reliably, and efficiently
  - Efficient turn-on after shutdown for RunIIb upgrade installation
  - Additional layer of silicon microstrip detector performing well
  - Benefiting from the suite of trigger and data acquisition upgrades
    - Highest priority triggers run unprescaled at highest peak luminosities delivered to date
  - Results are available in timely manner
- Looking forward to very productive running in 2008 and 2009!

Effort Reports

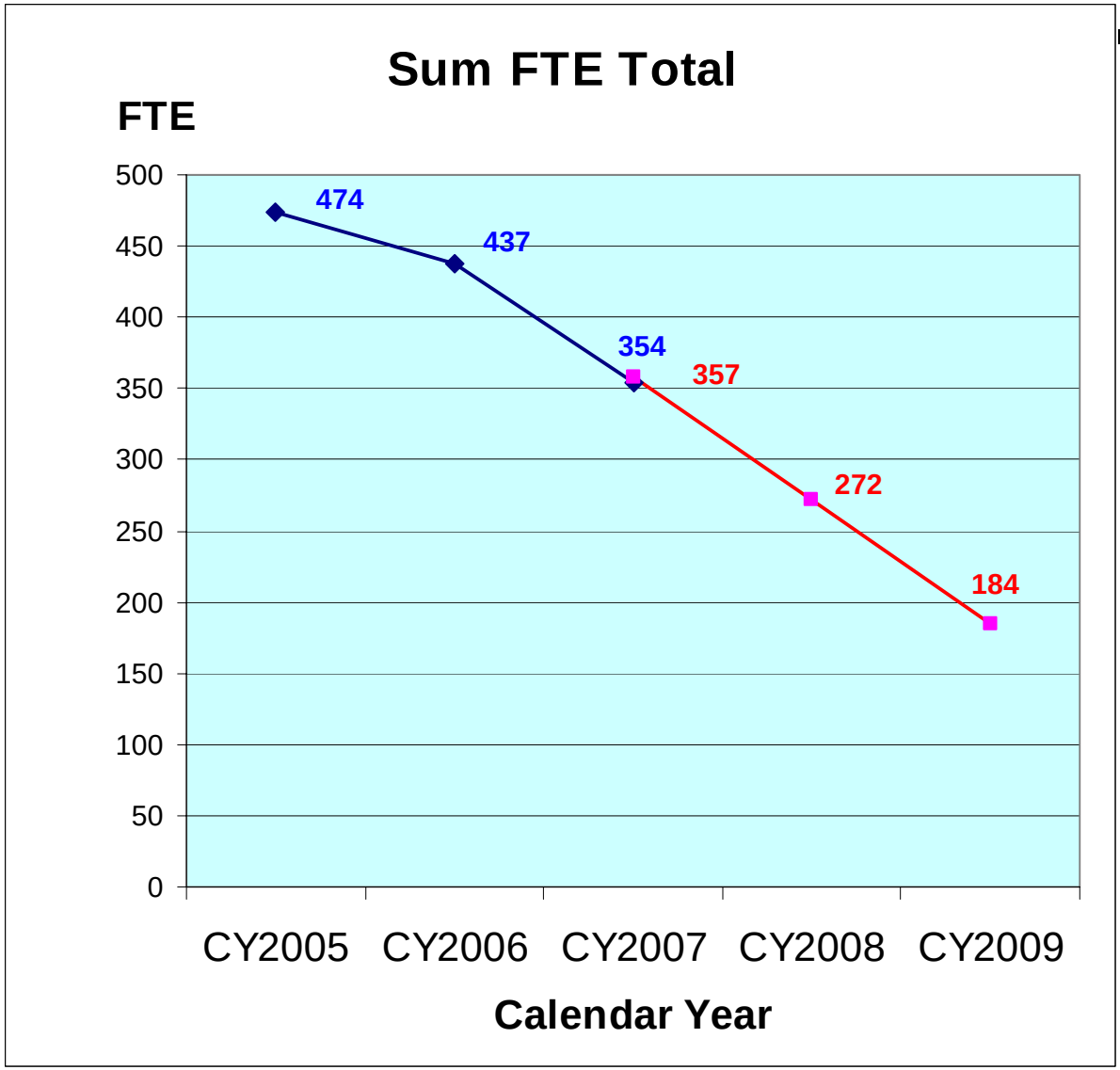
- Management requests accounting of effort invested in DØ by collaborators
  - "FTE" is fraction of collaborators total work effort
    - Not necessarily strongly coupled to 40 hour work week
  - Valuable tool for monitoring experiment resources

	2005 "FTE"	2006 "FTE"
Post Doc	94	94
Professor	94	81
Scientist	80	72
Student	171	158
Univ. Technical Support	4	2
Collaboration Total	443	407

Tevatron Collider Task Force—Operations Needs

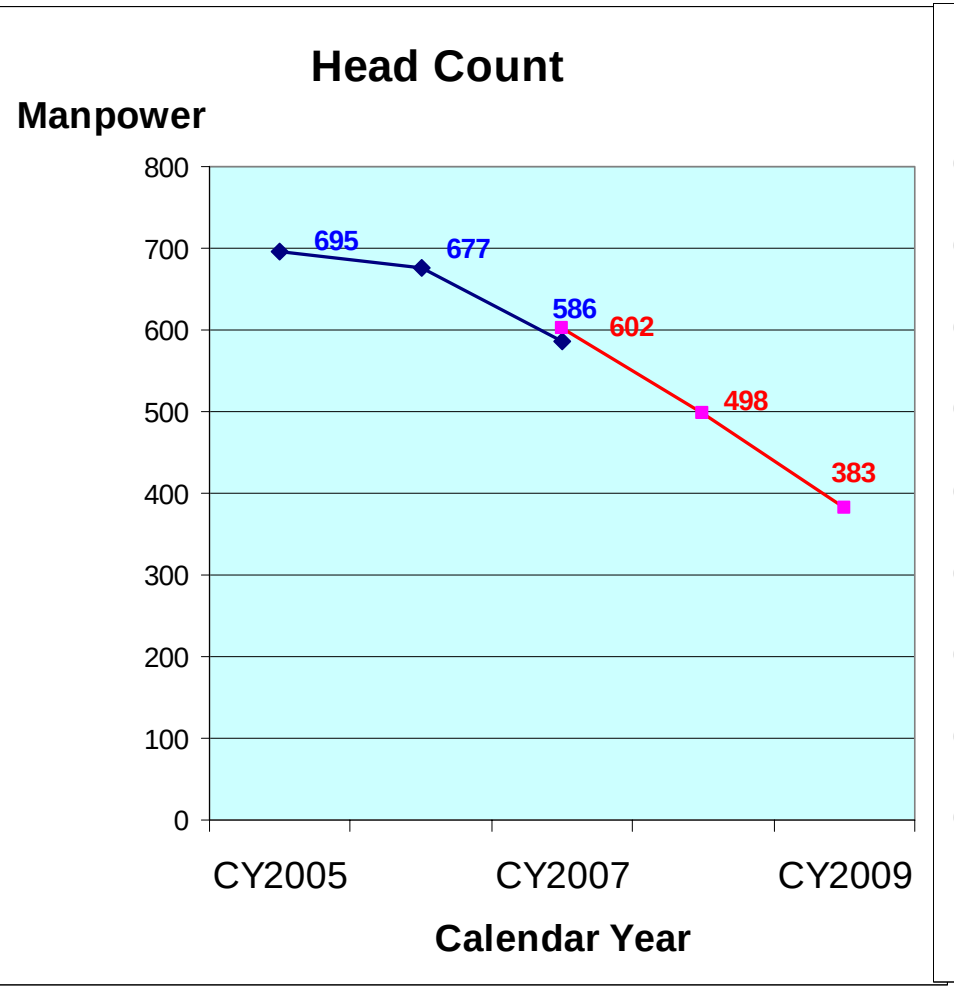
	Head Count	FTE
Operations Management	5	3.0
Alarms and Controls	3	2.0
Online and Data Acquisition	4	1.6
Data Quality Monitoring	14	4.0
Silicon Microstrip Tracker	8	3.0
Central Fiber Tracker	8	2.9
Calorimeter	10	3.6
Muon Detectors	17	8.9
Luminosity Detector	4	1.8
Trigger	4	0.7
Level 1 Trigger	11	4.0
Level 2 Trigger	10	2.1
Level 3	5	0.9
Infrastructure Support	3	0.6
Subtotal	106	39.0
Collaboration Shift Effort		28.4
Technical Support—includes Ops Shifter	32	26.0

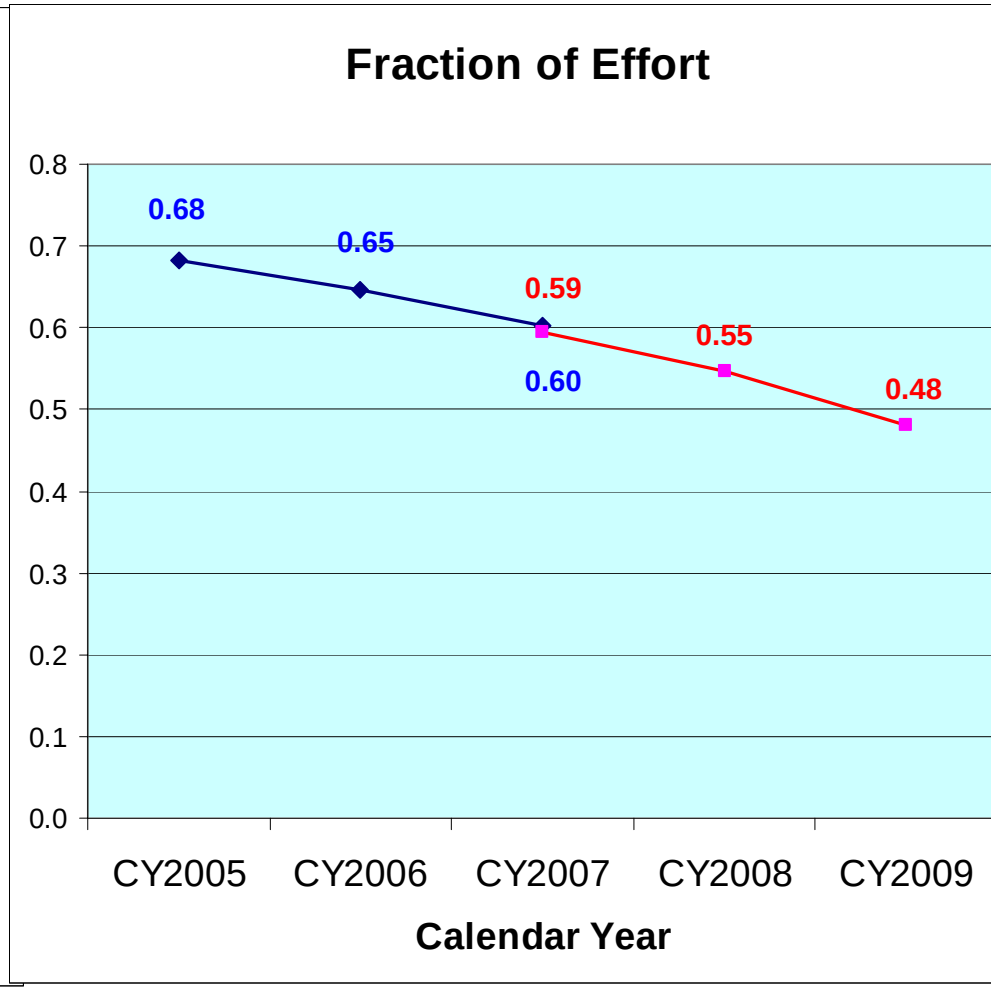
MoU Estimates of Total FTE Effort on DØ



- FTE units reported in MoUs appear to track with units used in Effort Reports
  - Total FTE in 2005 Effort Reports was 443 FTE (as compared to 474 anticipated in the MoU)
  - Total FTE in 2006 Efforts Reports was 407 FTE (as compared to 437 anticipated in the MoU)

MoU "Heads Count" and "Fractional Effort on DØ"

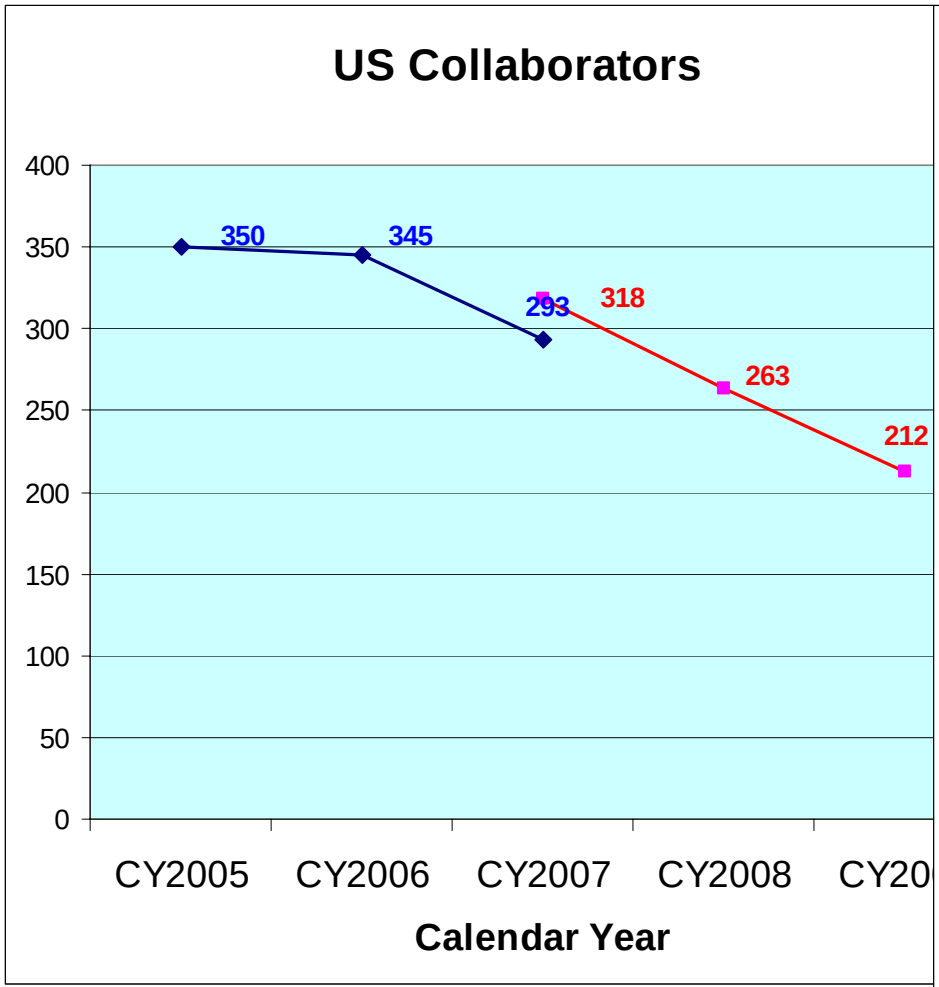


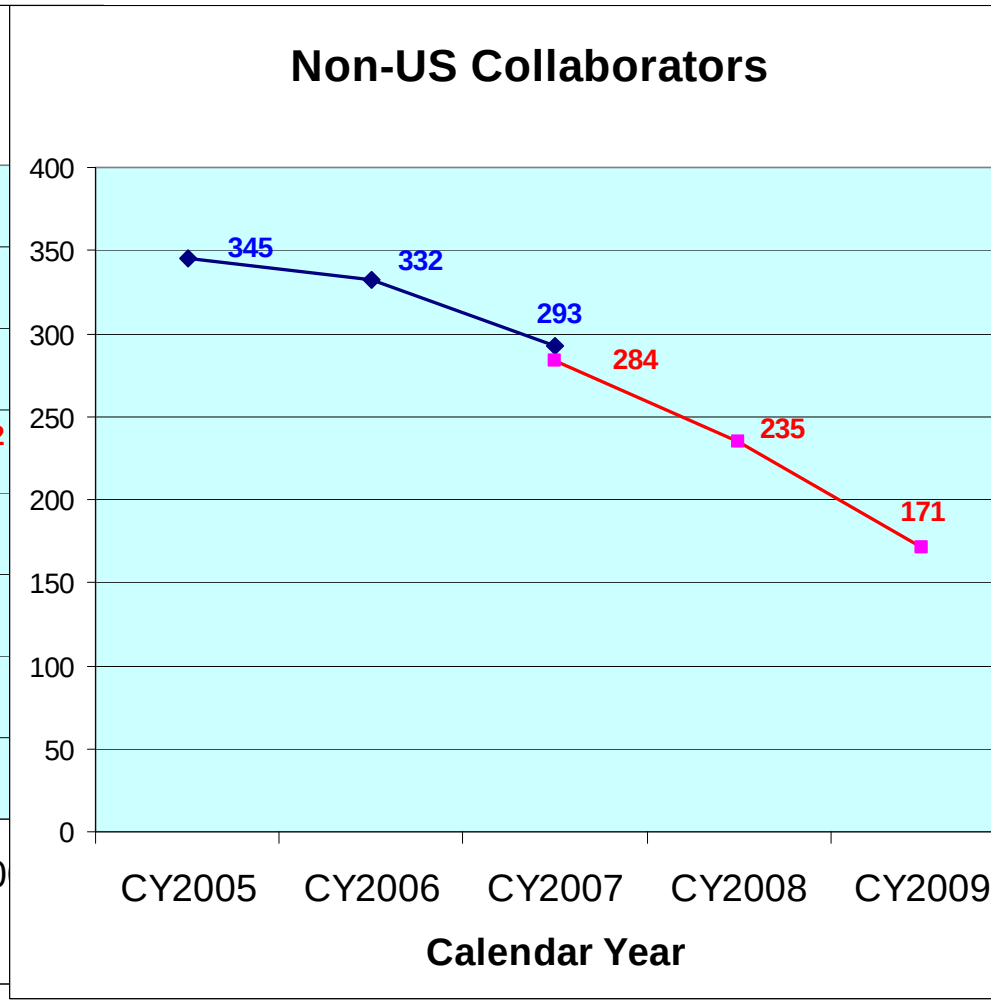


Head count decreasing more gently than FTE count

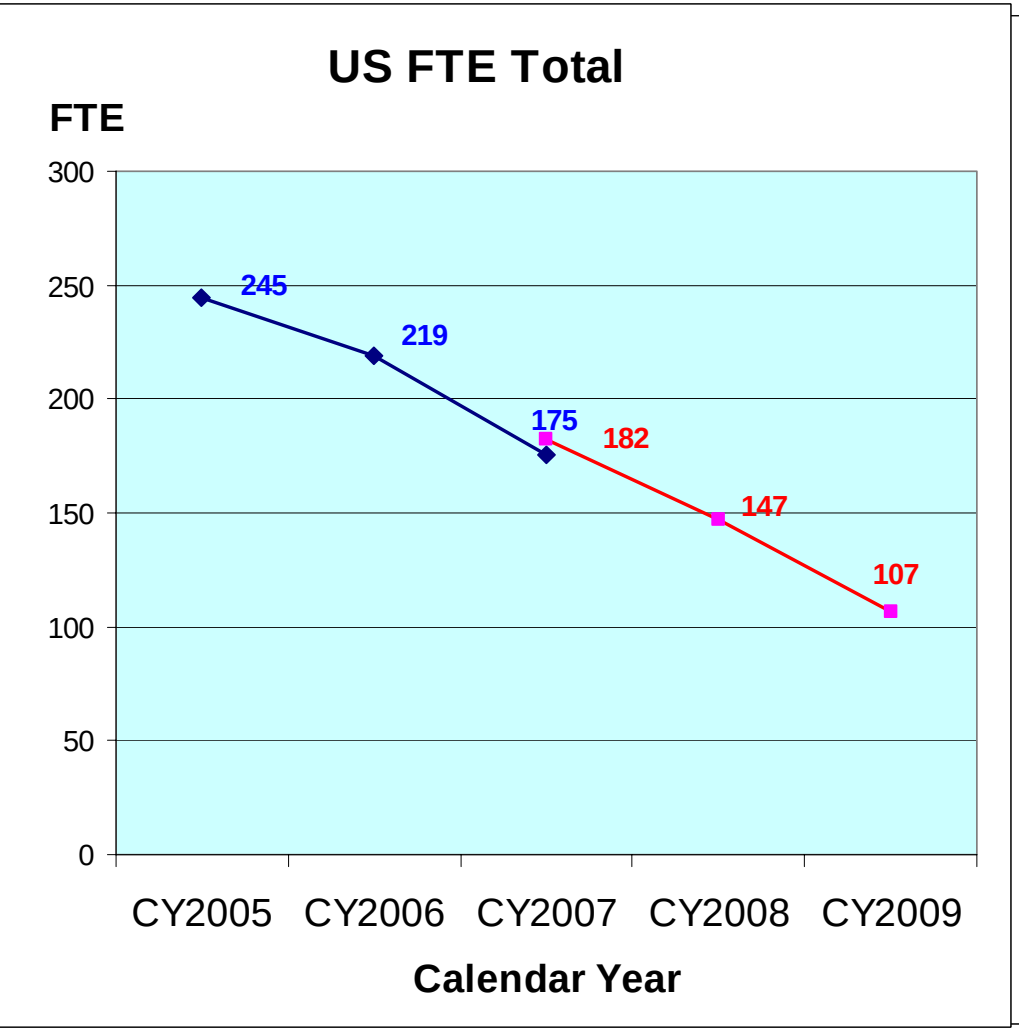
Average fraction of time collaborators spend on DØ

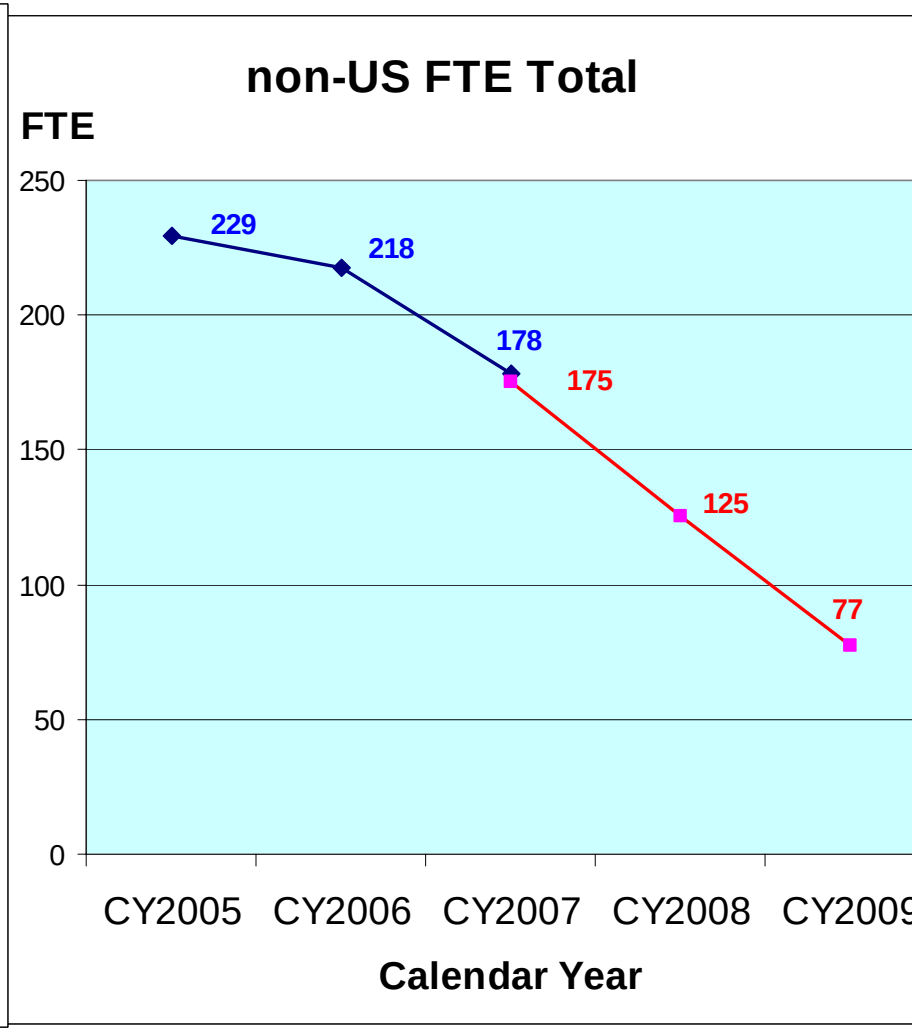
MoU Estimates of "Head Count" on DØ



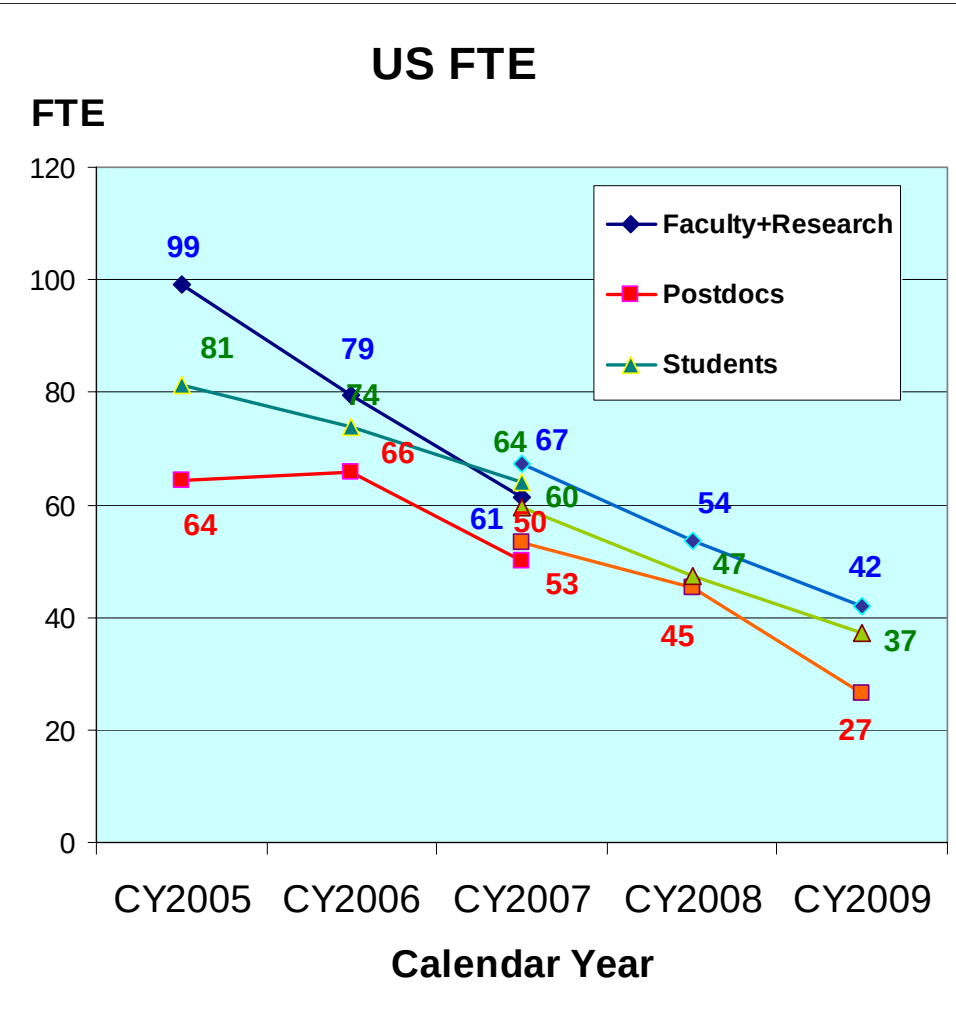


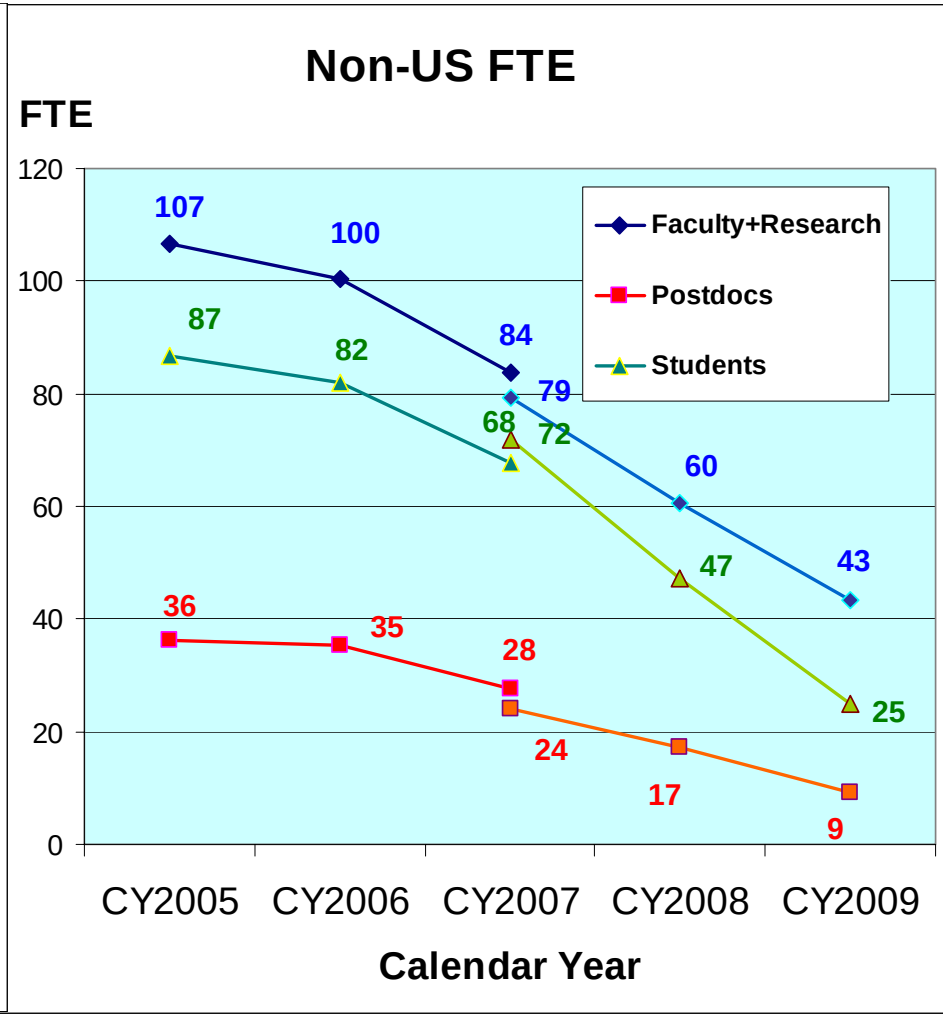
MoU Estimates of FTE Effort on DØ





MoU Estimates of FTE Effort on DØ





Fractional decline in participation is largest for non-US students and postdocs

PPD Support for DØ

- PPD support for DØ includes
  - DØ Experiment Department
  - DØ Operations Group from the Mechanical Department
  - DØ Support Group from the Electrical Engineering Department
  - Colliding Beams Experiment Group from the Electrical Engineering Department
  - Additional support for special projects

DZERO Experiment Department
L. Stutte, Head
(H. Fisk, Deputy Department Head)
R. Lipton, Deputy Department Head
D. Denisov, Associate Head - Detector
H. Greenlee, Associate Head - Computing
G. Gutierrez, Associate Head - Physics Support
A. Juste, Associate Head - Physics Support
B. Klima
(W. Merritt)
V. O'Dell
J. Womersley, L

Admin. Support
(S. Wright, Ldr.)
(H. Bruch)
(C. Johnson)

Physics Support
(G. Gutierrez, Co-Ldr.)
(A. Juste, Co-Ldr.)
M. Aoki, RA
S. Desai, RA
W. Fisher, LF
S. Fu, RA
N. Naimuddin, RA
B. Sanghi, RA
M. Verzocchi, WF
M. Wang, RA
M. Weber, RA

Computing
(H. Greenlee, Ldr.)
A. Jonckheere
(S. Fuess)

Desktop Support
G. Cisko, Ldr.
R. Cantal
E. Podschweit

Online
F. Bartlett, Ldr.
W. Lee
N. Oshima
G. Savage
V. Sirotenko
T. Yasuda

Detector
(D. Denisov, Co-Ldr.)
(R. Lipton, Co-Ldr.)
R. Angstadt
(A. Bross)
S. Cihangir
W. Cooper
T. Diehl
S. Gruenendahl
A. Ito
P. A. Kasper
D. Lincoln

Guest Scientist
T. Christoudias
Y. Liu
H. Mao
R. Mommsen

March 1, 2007

Solenoid

- Warmed-up during 2004 shutdown to perform maintenance
- After cooldown, solenoid quenched when ramped towards full field
- Decided to select new operating point at 96% of design value to provide operating margin
  - Operating current reduced from 4750 to 4550 amps
- Upon detailed investigation, identified limitation as due to degradation of inner layer conductor joint on south end
  - clear evidence that room temperature excursions degrade the joint
  - Plan to keep solenoid coils < 90K
  - Additional cooling capacity possible should need develop
    - Additional cold compressor should give 0.1K headroom