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# FNAL D0 Experiment Support

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Sept. 26, 2007  
DOE Review



# Outline

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- Performance of upgraded detector
- Improved algorithms
- Computing model
- Challenge of high luminosity
- Manpower
- Summary



# D0 Run IIb

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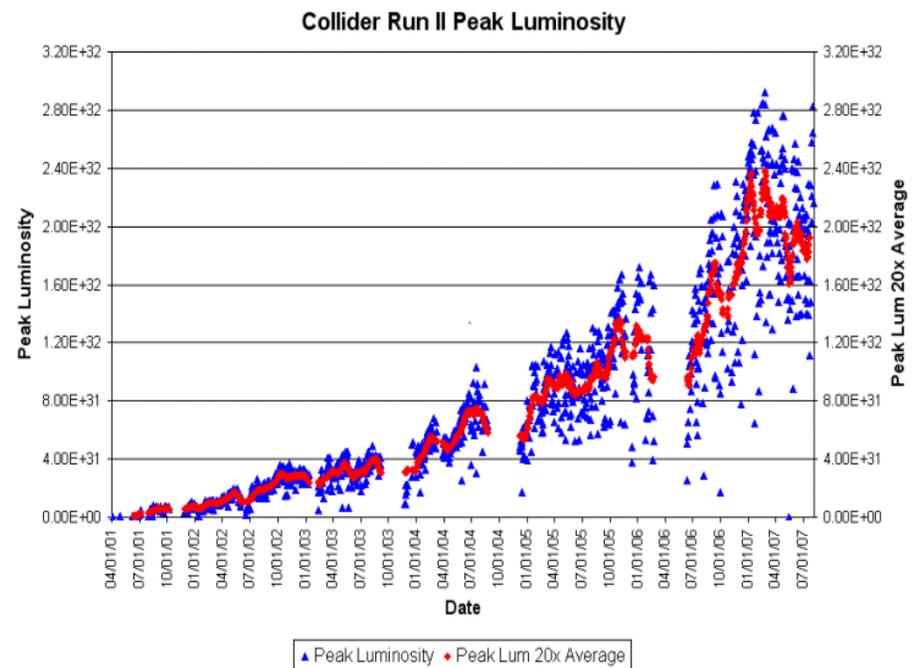
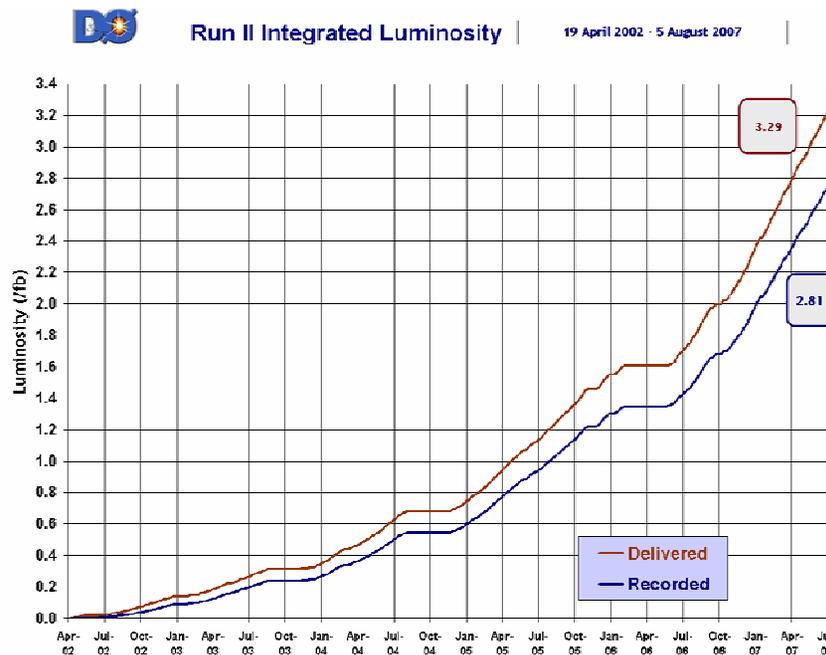
- Run IIb started June 2006.
- Run IIb has various hardware upgrade and software improvements.
- D0 has been running very well in Run IIb.
- We took data from 06/2006 to 08/2007, collected and processed  $1.45 \text{ fb}^{-1}$  data.
- D0 collaboration has 600 people, Fermilab group has 54 people. ~9%
- Fermilab group is playing leading role in many aspects of Run IIb.



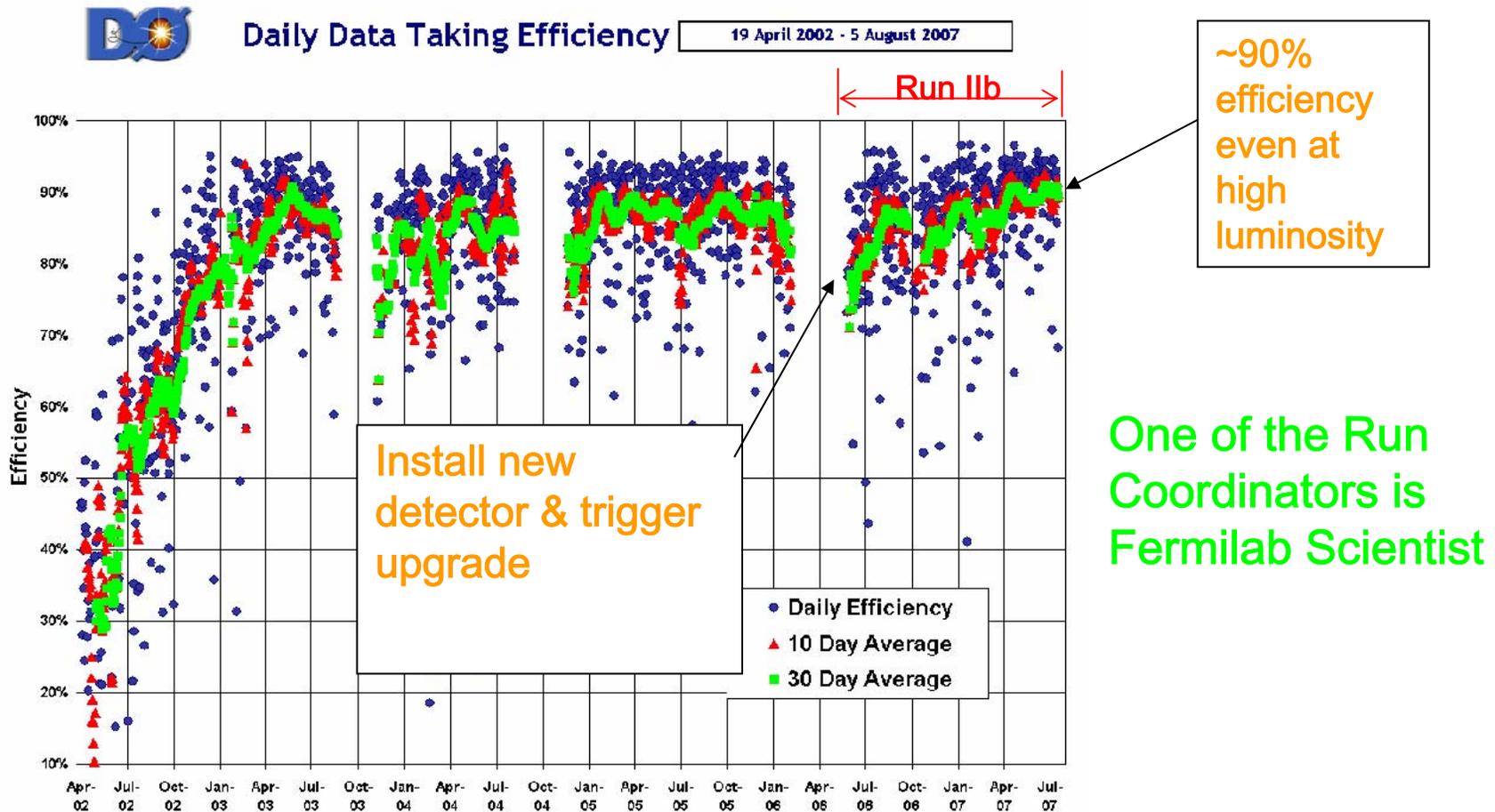
# D0 Luminosity

- Delivered and recorded integrated luminosity  
– 2.8 fb<sup>-1</sup> recorded !

- Peak luminosity  
– 287.8E30 !



# Data taking Efficiency



# Layer 0 Silicon detector



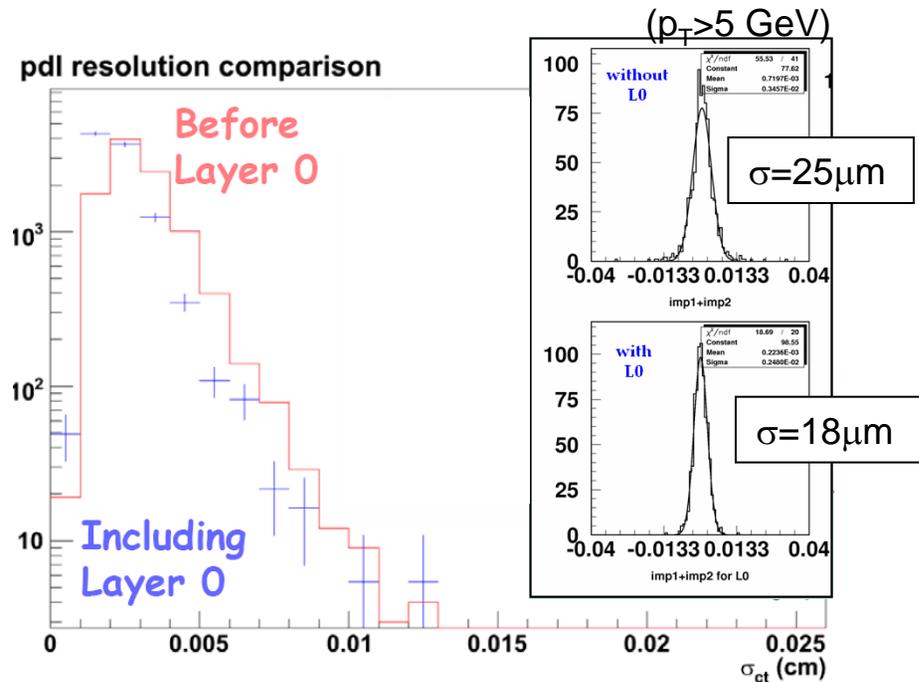
- In Run IIb, added layer of rad hard silicon detectors installed inside the Silicon Microstrip Tracker

Remarkably successful

- with 100% readout of all chips
- no significant coherent noise

More robust tracking and online pattern recognition

- The Fermilab group:
  - led electrical and mechanical design work for Layer 0
  - established techniques for effective grounding
  - developed the challenging installation procedure.
  - leads detector operation



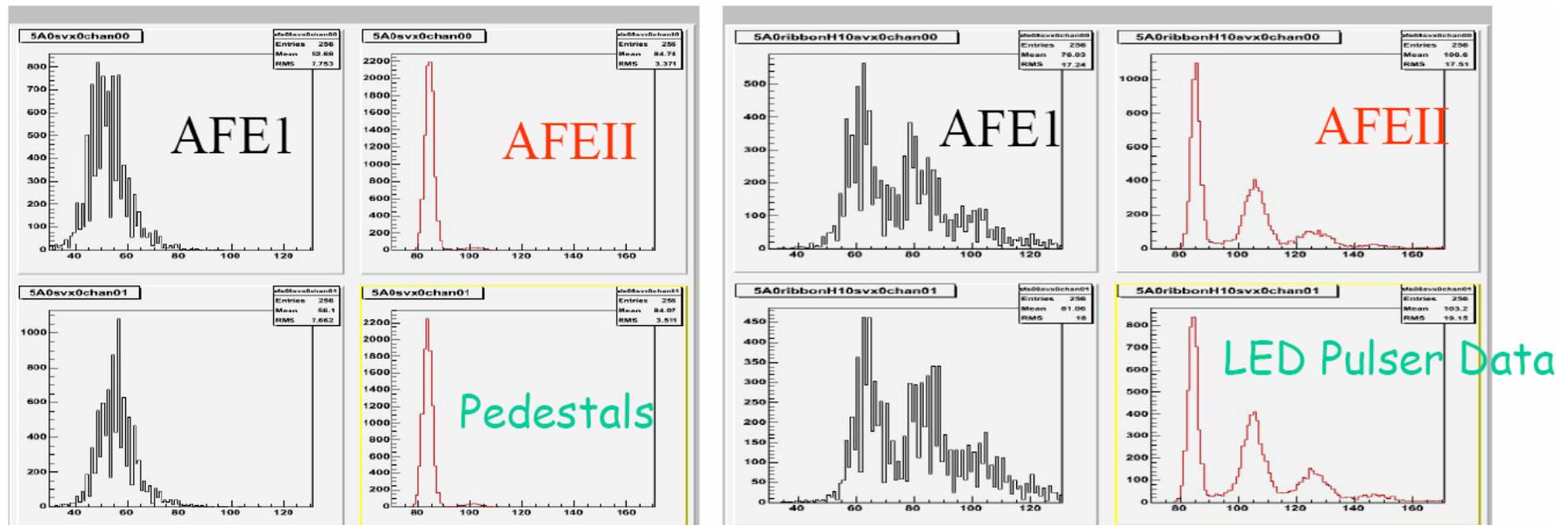
- Layer 0 was constructed in SiDet. The skilled Fermilab technical staff and equipment infrastructure was crucial to the successful construction effort.



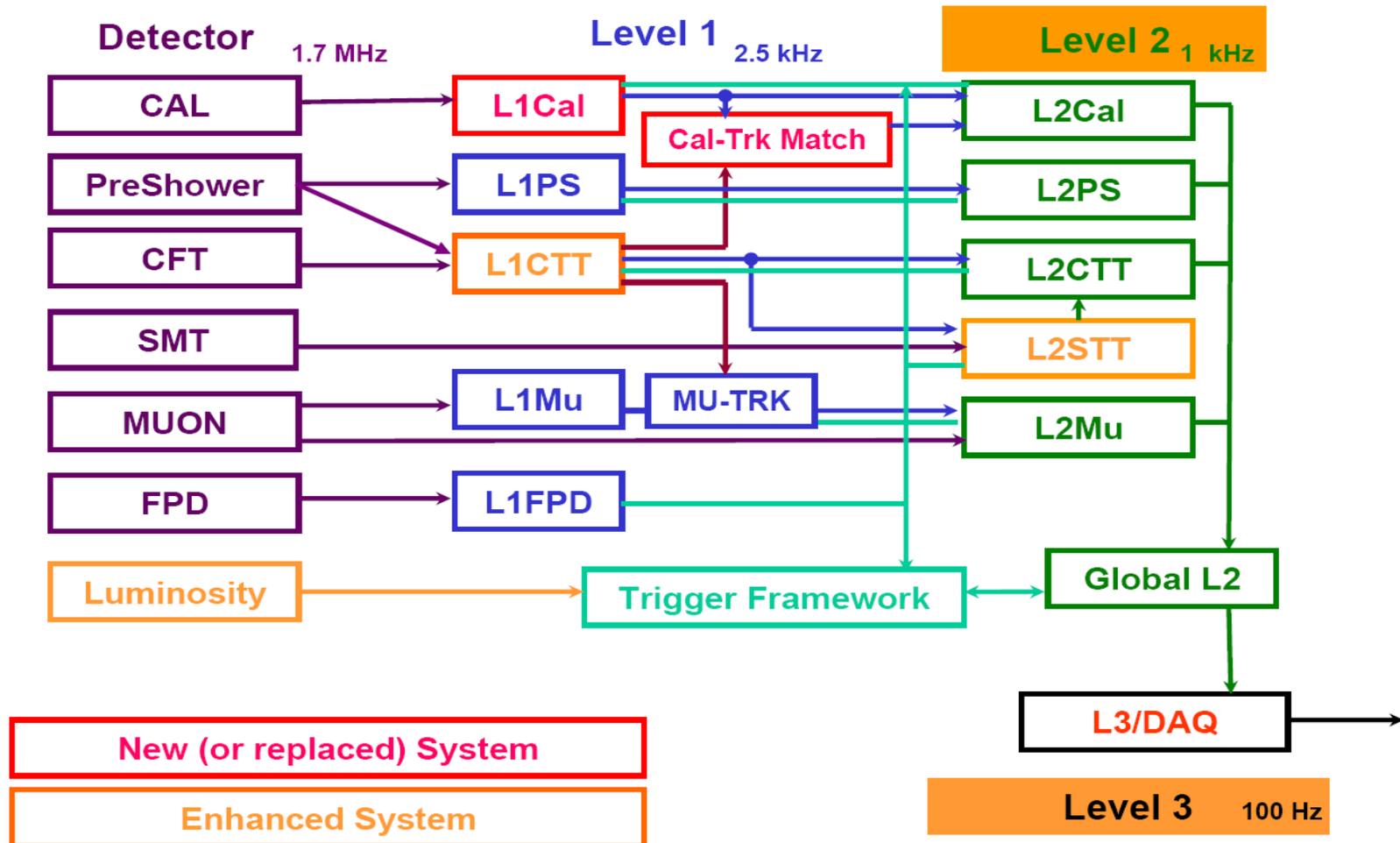
# Fiber Tracker Readout Upgrade

- Analog Front End II (AFEII) Total 198 boards
  - Eliminates amplifier saturation anticipated at high luminosity
  - Provide additional enhancements to make detector more robust
  - Facilitate optimization of Bias voltages and reduced thresholds

AFEII project was primarily performed by Fermilab personnel.  
Installation and commissioning by Notre Dame group & Fermilab.



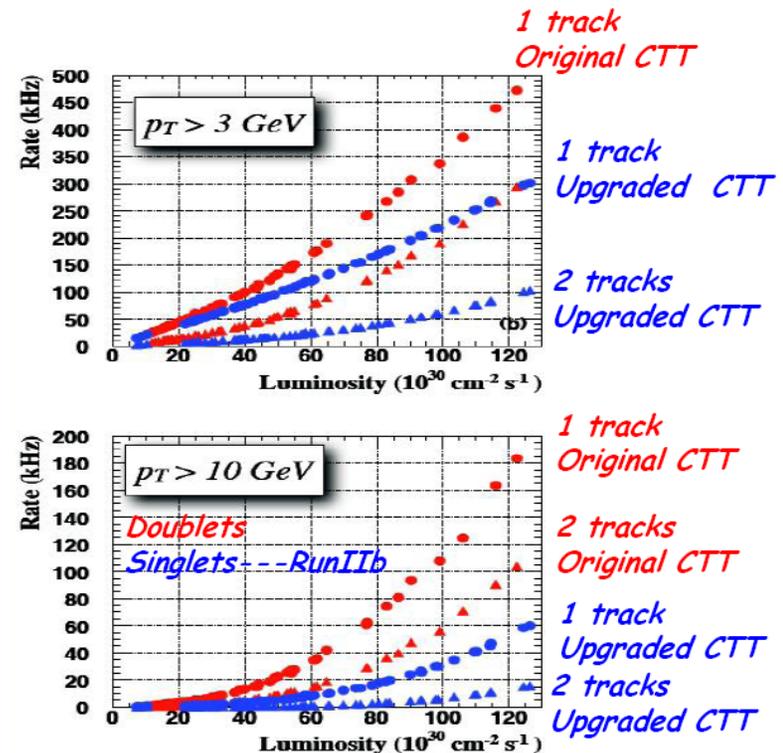
# D0 Run IIb trigger system



# Level 1 Track Trigger Upgrade



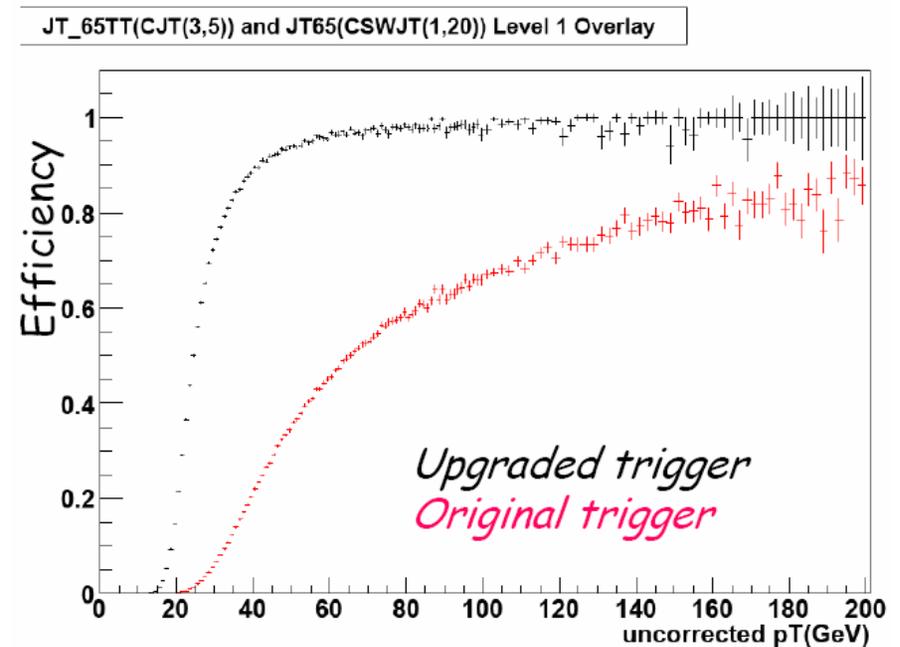
- L1 tracker trigger upgrade
  - Sharpens turn-on curves
  - improves fake rejection capability of CTT by making use of full granularity of Central Fiber Tracker
- L1CTT upgrade project was co-led by Fermilab scientist
- Fermilab group made many important contributions to the design, as well as the implementation and installation.



# Level 1 Cal Trigger Upgrade



- L1 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



- Fermilab scientist was a key player in the installation, commissioning & operation.
- The D0 electrical support group were intimately involved in the successful and timely installation.

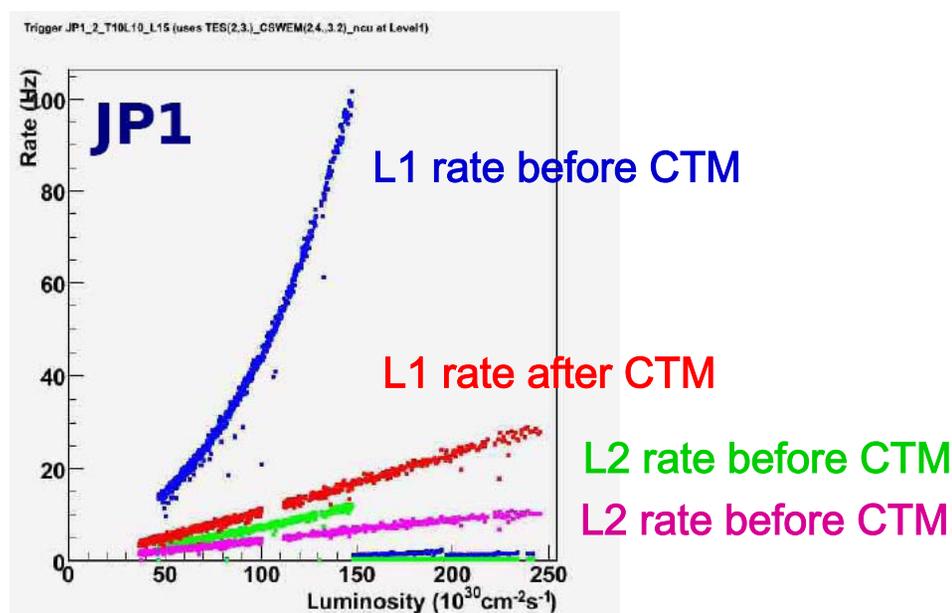


# L1 Cal Track Match Trigger

- New capability to match calorimeter & track objects at L1
  - Improved rejection and tau triggering capability
  - Improved linearity as a function of luminosity
  - Complete implementation required change in trigger timing

Fermilab is a key player in the maintenance and operation

Low  $p_T$  di-electron  
trigger



# D0 Online and Global Monitoring



- Fermilab group manages D0 online computer system
  - design, installation and operations
  - 170 new Level 3 nodes were added to handle high luminosity
    - 48 nodes added Oct. 2006
    - 122 nodes added May 2007
- Fermilab group is responsible for D0 slow control system
  - High Voltage, Low Voltage, monitoring, alarms, interface between operators and hardware, ...
- Fermilab physicist co-leads the global monitoring in control room.





# Improved Algorithms

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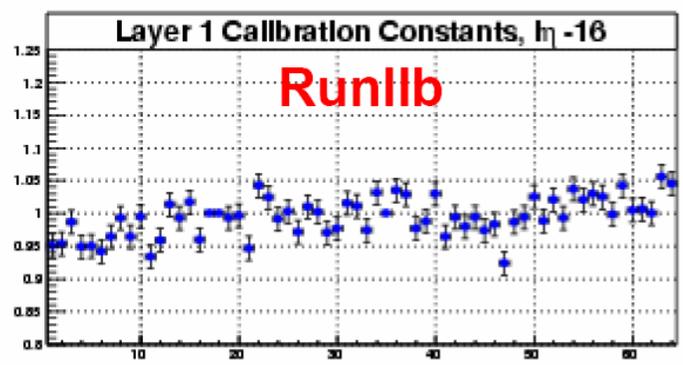
- A new version of reconstruction program delivered in Jan, 2007.
- Based on the studies of first few months RunIIb data.
- **The reconstruction program effort is led by Fermilab scientist.**
- New calorimeter calibration for both EM and HAD calorimeters
- ICD calibrations
- Improved tracker alignment
- Lowered CFT ADC count cut with new AFEII
- Lorentz shift correction for layer 0
- Tracking  $P_T$  threshold increased to 450 MeV
- Luminosity DB access from D0reco
- Luminosity tick information into the event and stored in TMB
- New version of muonT0's
- Much more robust, very few crashes
- Removed occupancy dependent  $P_T$  thresholds in tracking

# Improved Algorithms



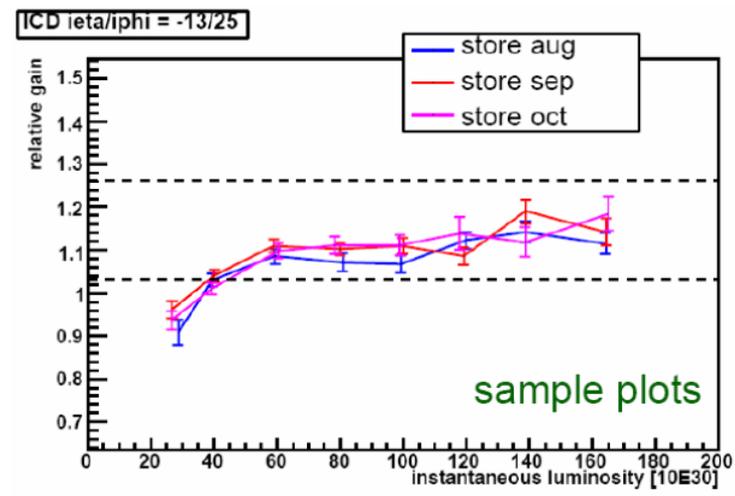
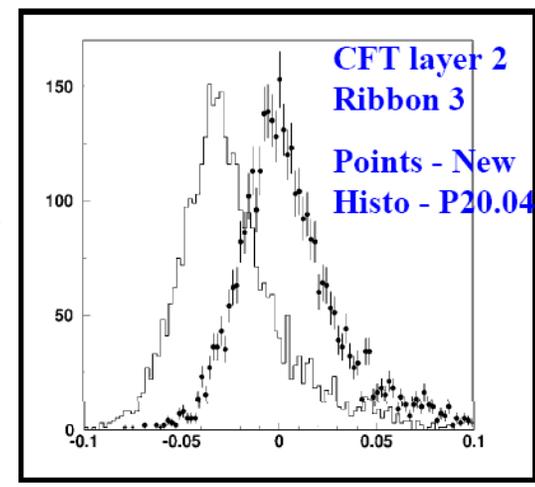
Calorimeter new calibration

$\phi$ -intercalibration



New alignment for tracker

ICD gain is luminosity dependent

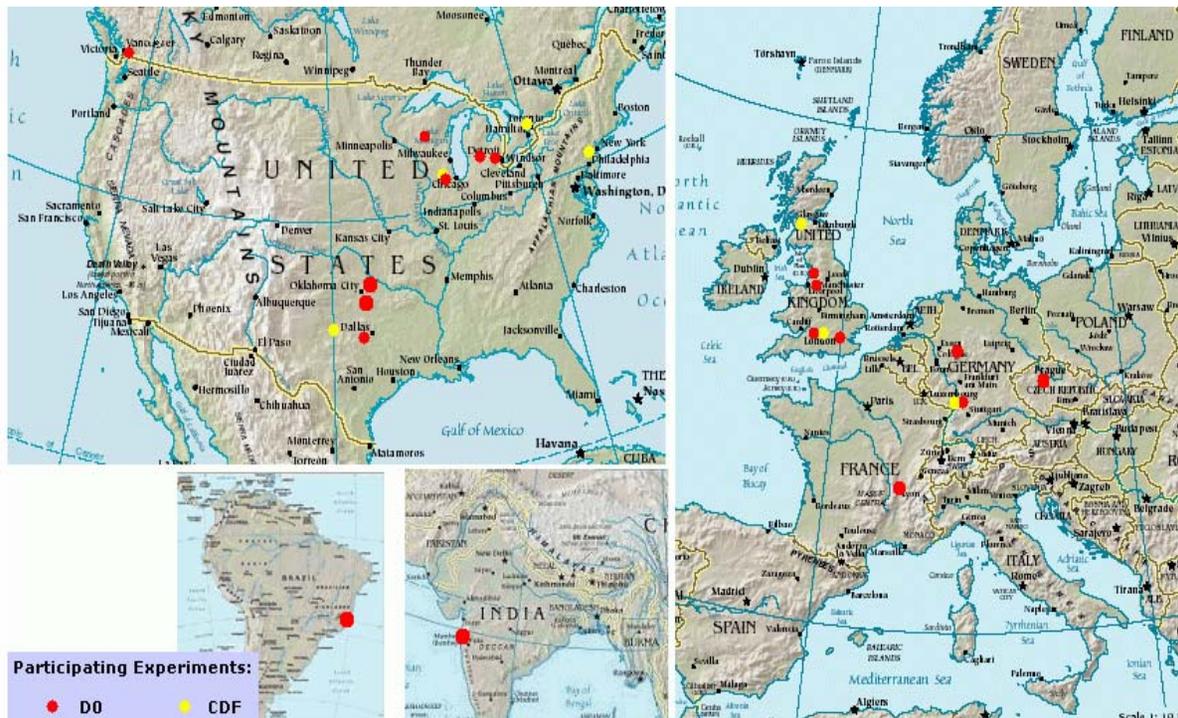


a luminosity dependent example



# D0 Computing Model

- Distributed computing, moving toward automated use of common tools on grid
- Grid computing (dedicated + opportunistic resources)



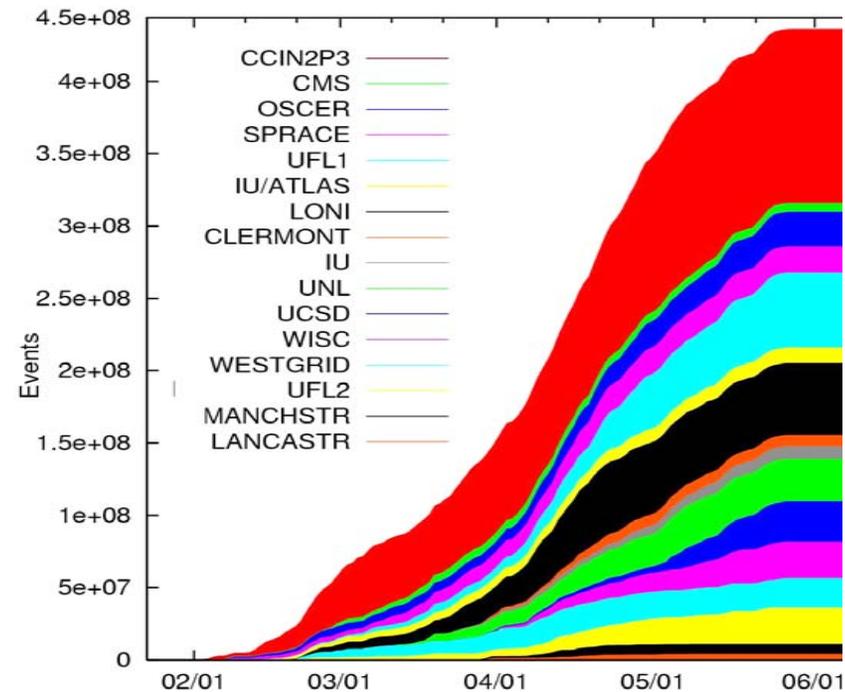
## Data and MC production:

- scalable
- opportunistic resources
- working with OSG, LCG and FermiGrid



# Data Reprocessing

- We reprocessed all Run IIb data taken in 2006 with improved algorithms.
- 90 TB of data reconstructed using fully distributed, opportunistic resources, from Feb. to May 2007.
- Total 485 M events
- Reprocessing done at
  - OSG (11 sites)
  - LCG (3 sites)
  - CCIN2P3 (France)
  - Westgrid (Canada)
  - D0 local farm (Fermilab)

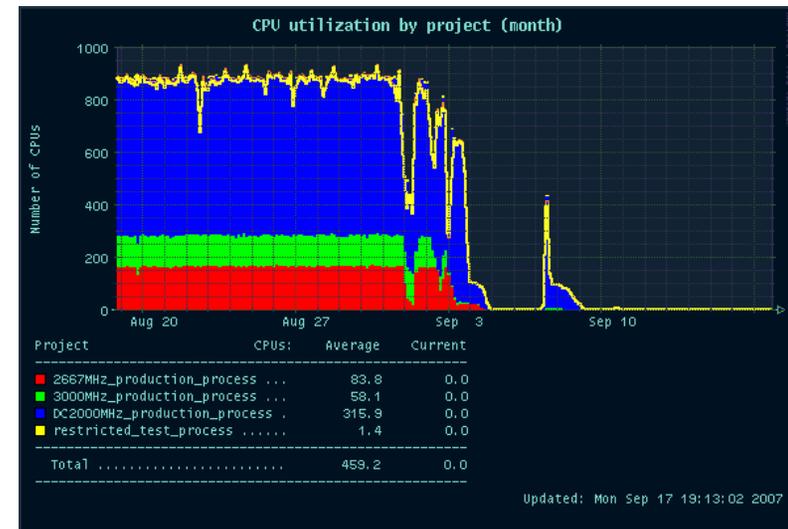
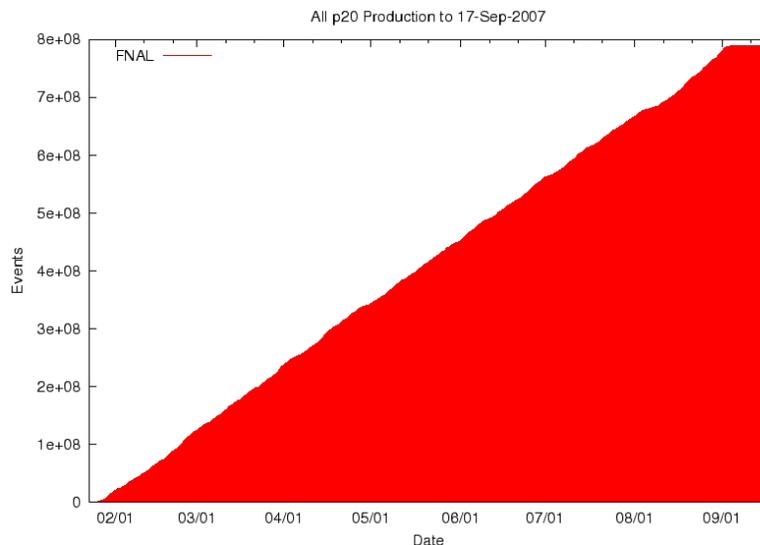


# Data Production



- All 2007 data are processed at FNAL local farm, by Fermilab Scientist.

~4M events/day



- Running at ~90% efficiency
- Loss of efficiency due to
  - Scheduled downtimes
  - Nodes under repair
  - Occasional power failure



# Data Production

- All Run IIb data reconstruction is completed.
- Total 1255 M events (Run IIb).

- 485 M events taken 2006;  
- 770 M events taken 2007  
( all by Fermi Scientist.)

Lead by Fermilab scientist  
and with support from  
Computing Division Grid  
Dept. and system admins

40 M events by  
Fermi Scientist

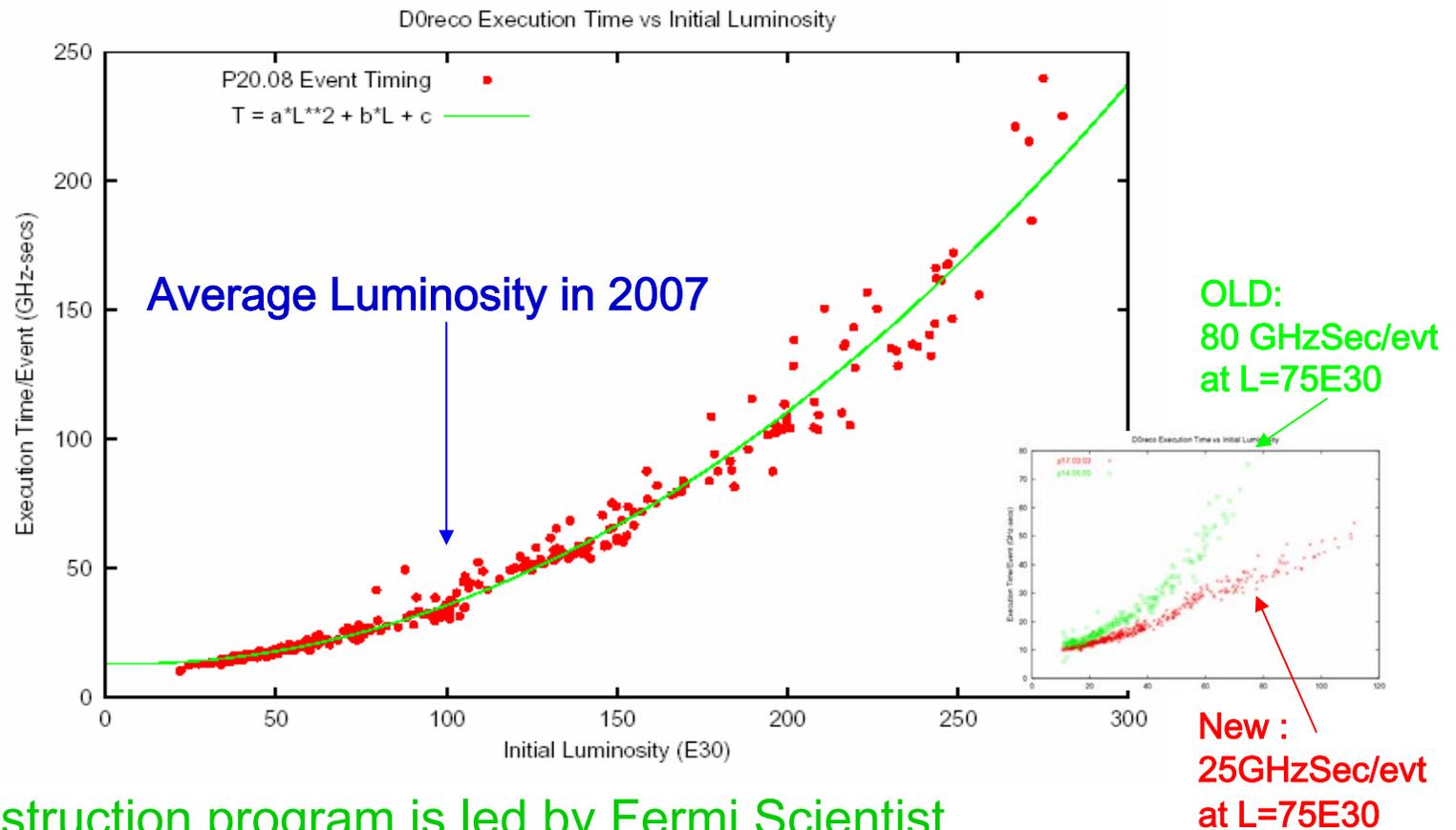
- Recently just finished moving data production from local stand-alone production farm to Grid.
- Run data production on D0 central computing cluster (CAB) using SamGrid tool to submit production jobs through Fermilab Grid facility.
- Old local farm CPU will move to D0 central computing cluster.

Fermi CD system  
admin.

# Data reconstruction CPU



- Reconstruction CPU usage

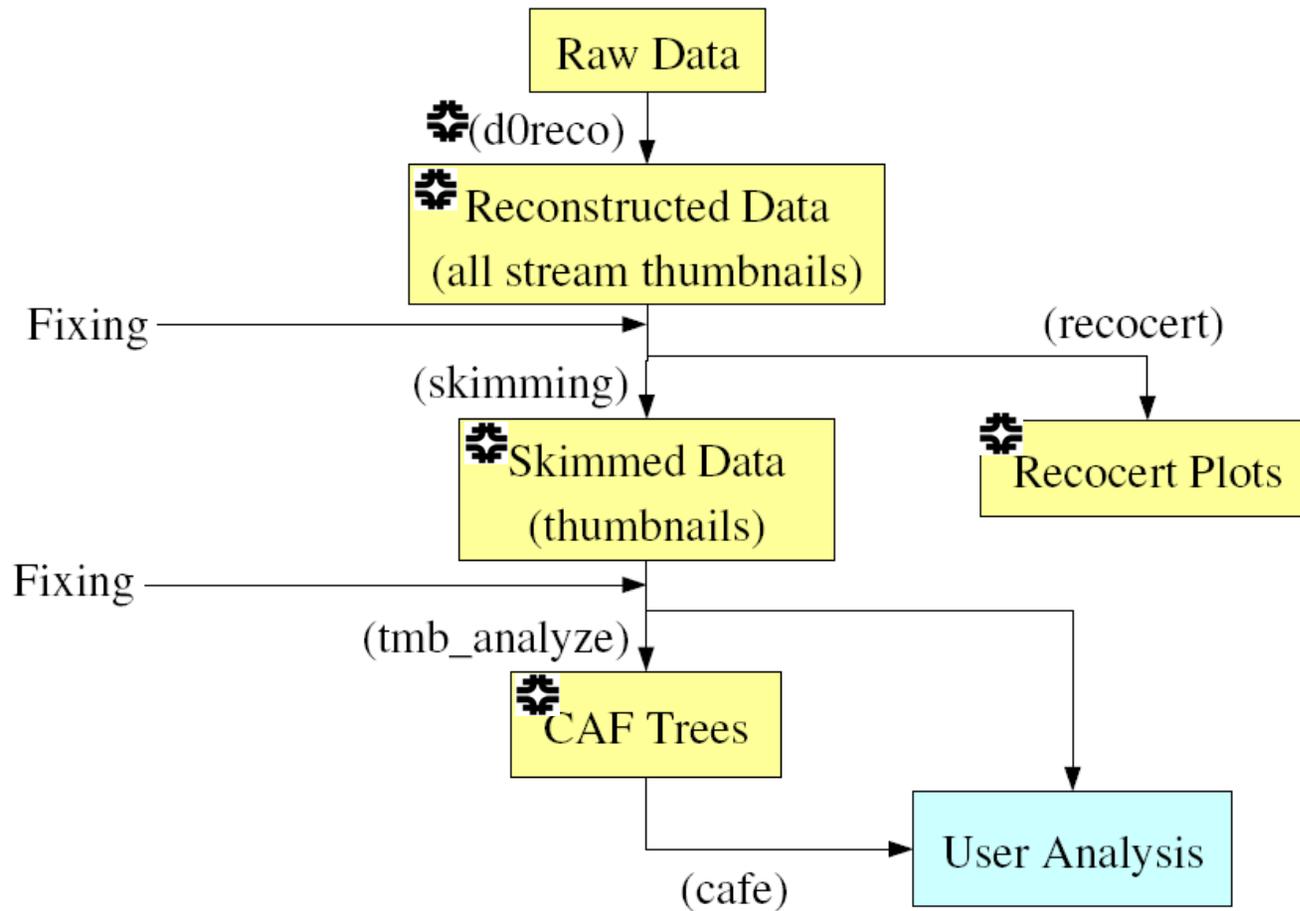


Reconstruction program is led by Fermi Scientist.

# D0 Data Processing Chain



## Data Processing Chain





# D0 Analysis Model

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- All reconstructed events are stored in compressed format.
- Then skimmed according to trigger & offline cuts.
- Make Common Analysis Format tree (ROOT tree) for skimmed data.
- Users use CAF-tree to do analysis.
- Currently all data are available for users in CAF-tree format.
- Total **2.8 fb<sup>-1</sup>** data available for physics analysis. (RunIIa + RunIIb)
- **All above processing are done by Fermilab scientists, except reprocessing.**

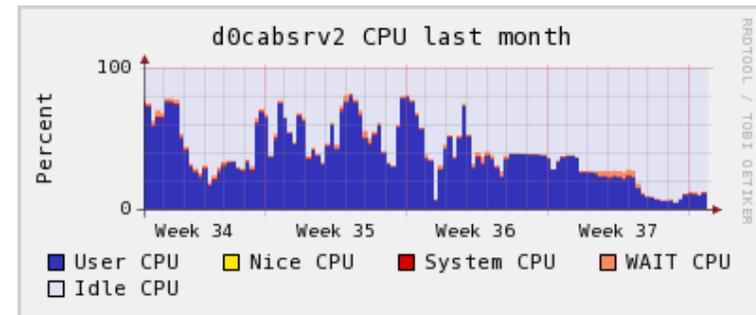


# D0 CAB clusters

- D0 central analysis cluster (CAB) is for D0 physics analysis.
- CAB is part of Fermilab Grid Facility.
- Now both data production and analysis jobs run on CAB.

- It consists:

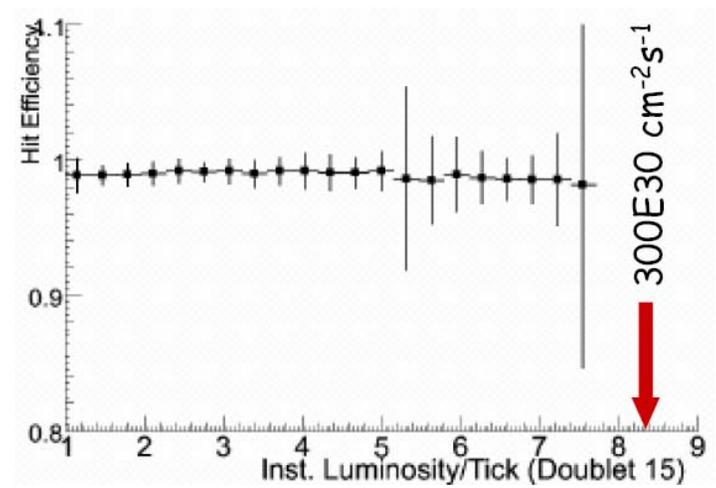
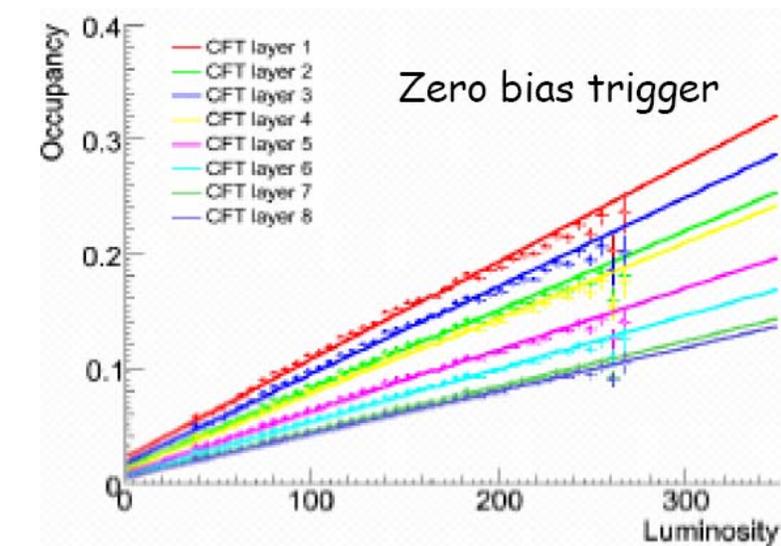
- Cab1: 460 nodes
- Cab2: 400 Nodes
- Total 3.096 THz CPU
- Will add old production farm nodes into cab next month
- Newly purchased nodes will replace retiring nodes
- New nodes will be dual-processors, quad-core!
  - increased CPU for handling high luminosity and more data





# High Luminosity

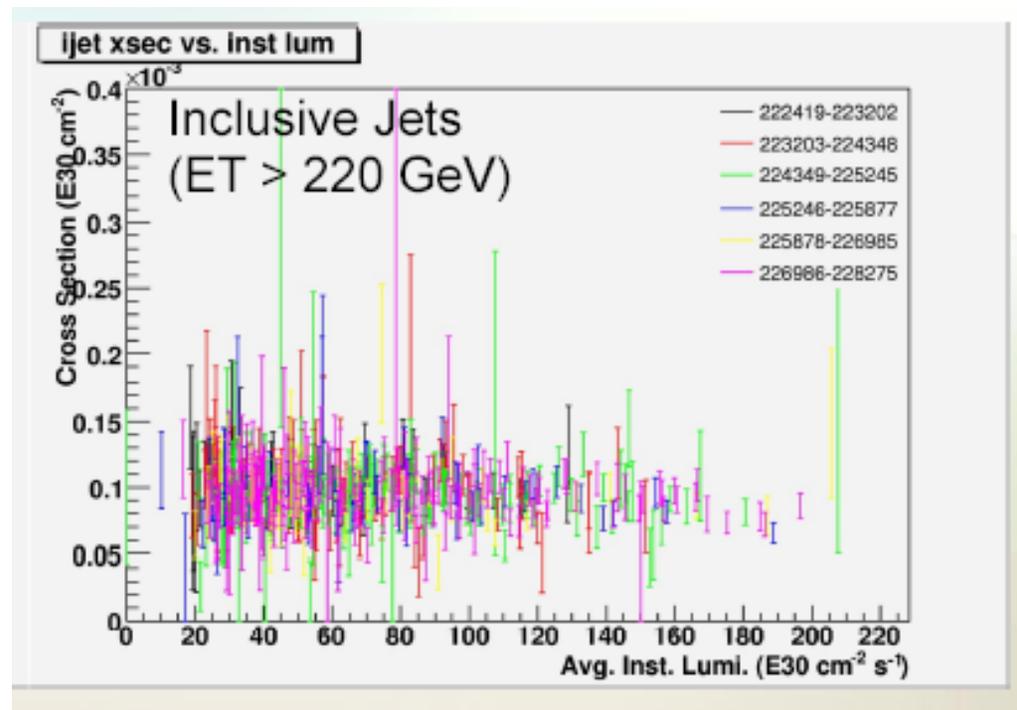
- CFT occupancy rises linearly with instantaneous luminosity
  - trigger & reconstruction challenge
    - Fake tracks
    - Fake vertex
  - probability of finding hit on track remains stable





# High Luminosity

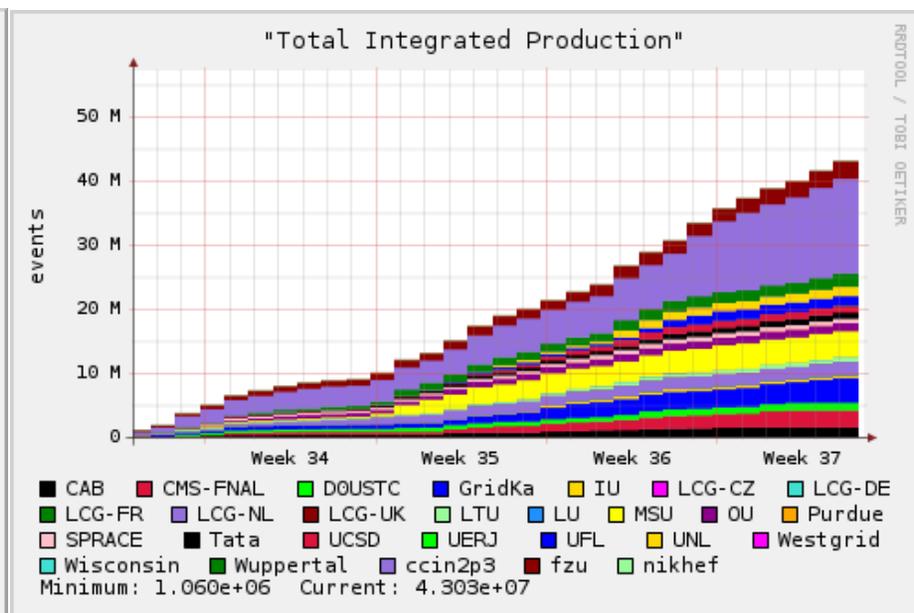
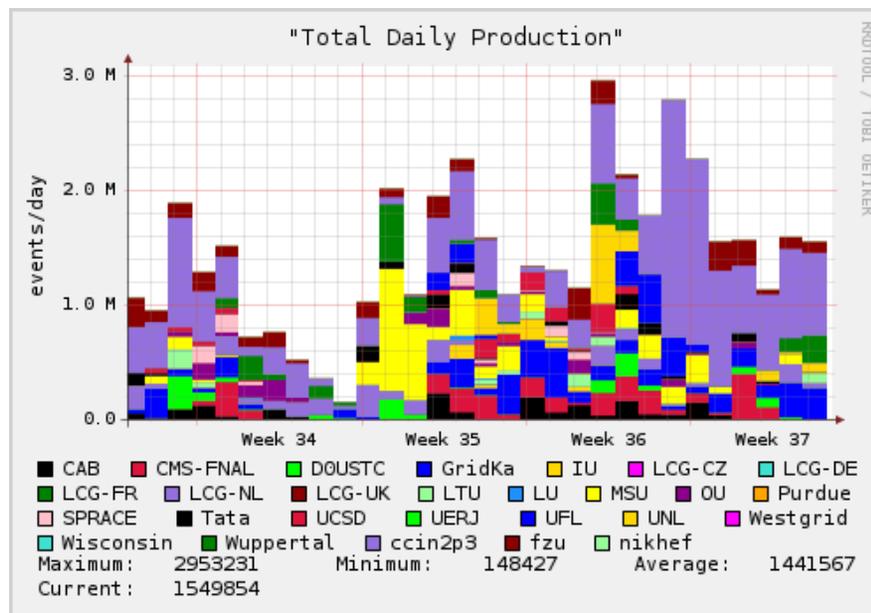
- Jet cross section shows no instantaneous luminosity effects





# MC Production

- Generating ~10-13M events/week
- Opportunistic computing on Grid
- MC jobs run at 27 sites
- Fermi Guest Scientist leads the MC production





# Current Manpower

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- Physicists :
  - Total 54 people .
  - Total: 33.2 FTE (from the effort report summary) + 4 newly hired

Activities	FTE
Algorithms	3.2
Computing & Core Software	4.8
Operations	12.5
Physics	8.8
Miscellaneous	3.9
Total	33.2

- Postdocs: 8 Research Associates, 1 Lederman Fellow.

# Technical Support for Operations

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- **Electrical Support:**
  - **3.6 FTE Electrical Engineers and Engineering Physicists**
    - Electronics, power supplies, management
    - Silicon Layer 0, CFT readout boards (AFEII)
  - **5.75 FTE Electrical Techs**
    - Power supplies
    - Protection systems, Air and water control
    - AC power, Construction Coordinator
    - AFEII boards
- **Mechanical Support:**
  - **2 Mechanical Engineers**
    - Cryo systems for solenoid, calorimeter, CFT
    - Silicon cooling system
    - Gas systems for Muon tracking systems
  - **9 Technicians and Specialists**
    - Supervises all technicians, operations shifters
    - Building manager; gas systems, fabrications
    - 4 on operation shifts

# Technical Support for computing

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- Computing support (computer professionals):
  - 3 FTE for network and window support
  - 9 people from CD system management group (part time)
  - 2 FTE for data handling
- Total technical support:
  - electrical + mechanical + computing = ~25 FTE



# Future Effort

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- Will continue play significant role in D0.
- Recently added:
  - 1 senior scientist (PPD/D0 Dept. Head)
  - 1 Wilson Fellow
  - 2 new postdocs,
  - 4 postdoc openings (3 in PPD and 1 in CD).
- The technical support manpower to continue at current level.
- The physicists manpower projection:
  - 2008: 28 FTE
  - 2009: 25 FTE
  - This is just a very rough estimate.



# Summary

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- D0 performs well in Run IIb.
- New detector and upgrades work well in high luminosity environment.
- 2.8 fb<sup>-1</sup> data are reconstructed with new algorithms, skimmed and available for physics analysis.
- D0 computing successfully moved to Grid world, using distributed, opportunistic resources.
- Fermilab group is playing a leading role in many aspects of Run IIb.