DØ Status

PAC Meeting
30th March 2007

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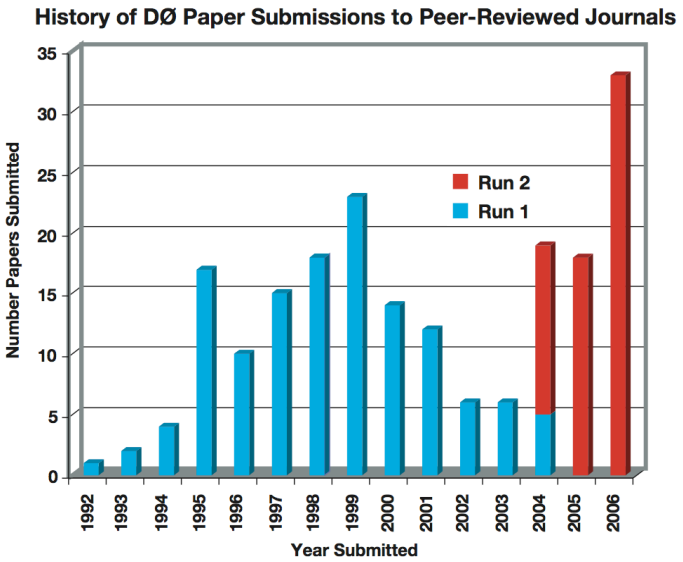
- A few highlights from the 1 fb^{-1} run IIa dataset
  - and some pointers to the future (beating √lumi)
- Status of run IIb
  - upgrades, data taking, computing
- Challenges
  - high luminosity, manpower

2006: A Very Good Year for DØ

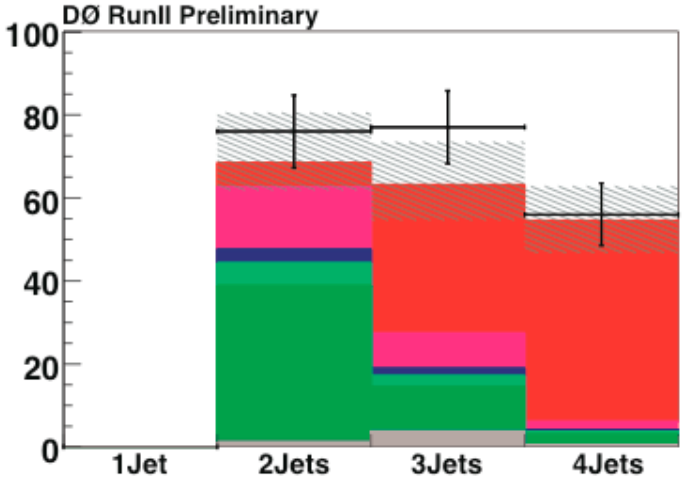
- The best ever for DØ publications
  - Including:
    - DØ B_s oscillations: PRL 97, 021802 (2006)
      - the first paper with 1 fb^{-1} from the Tevatron
      - the most cited HEP result of 2006
        - » 106 citations and counting
    - single top evidence: hep-ex/0612052
  - Many additional preliminary 1 fb^{-1} results



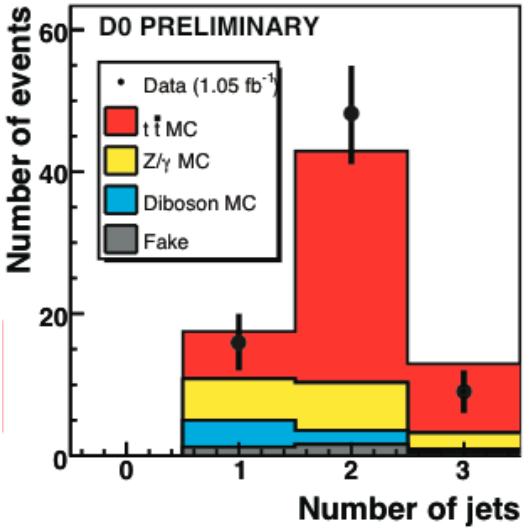
- Very successful installation and commissioning of Run IIb upgrades …..
  - Tracking and Level-1 trigger
- …… whilst maintaining high efficiency and quality data taking
- Continued developments at the forefront of exploiting the Grid

Top Physics with 1 fb^{-1}

- Lepton + jets (double b-tagged)



Di-Lepton (no b-tag)



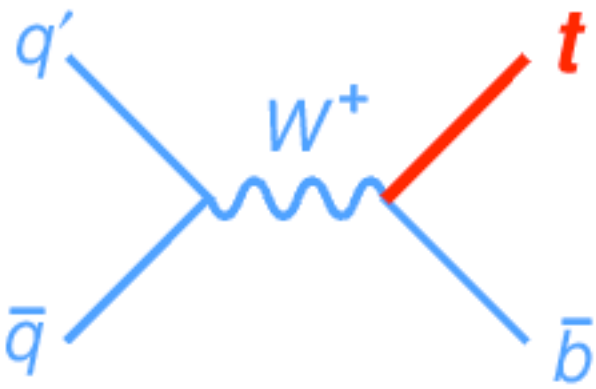
- Example measurements from lepton + jets sample

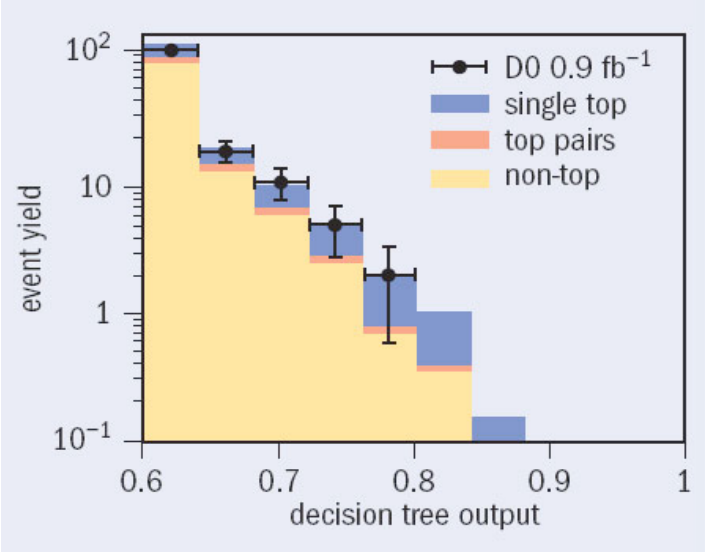
$$\sigma_{t\bar{t}+X} = 8.3^{+0.6}_{-0.5}(\text{stat})\ ^{+0.9}_{-1.0}(\text{syst}) \pm 0.5(\text{lumi})\ \text{pb}$$

M_{top}= 170.5 ± 2.4 (stat+JES) ± 1.2 (syst) GeV

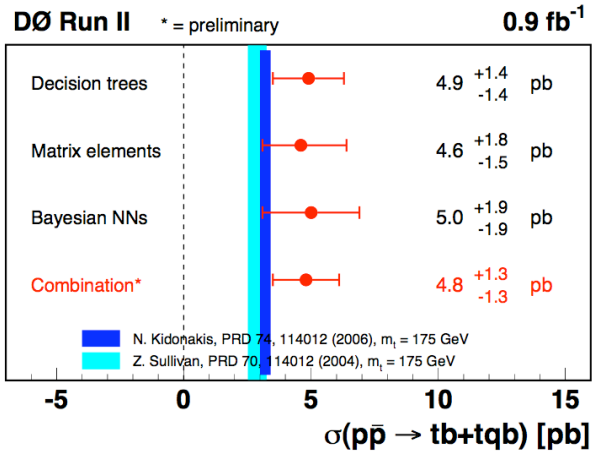
  - Further significant improvements to external jet energy scale expected soon

First Evidence for Single Top Production





- Consistent results obtained from three techniques
  - boosted decision trees, matrix elements, Bayesian NN
- Combined result:
  - 4.8 ± 1.3 pb (3.5 σ significance)
  - Consistent with SM expectations
- First direct determination of $|V_{tb}|$
  - $0.68 < |V_{tb}| < 1$ at 95% CL



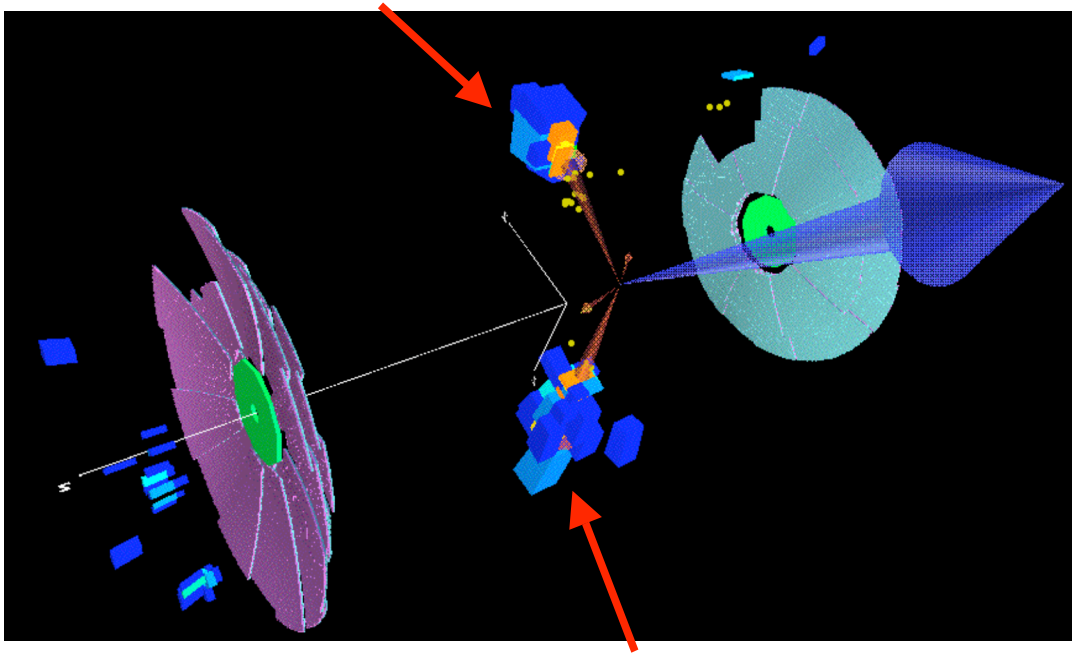
hep-ex/0612052, accepted for publication in PRL

Searches for New Phenomena with 1 fb^{-1}

- Squarks and gluinos: jets + MET

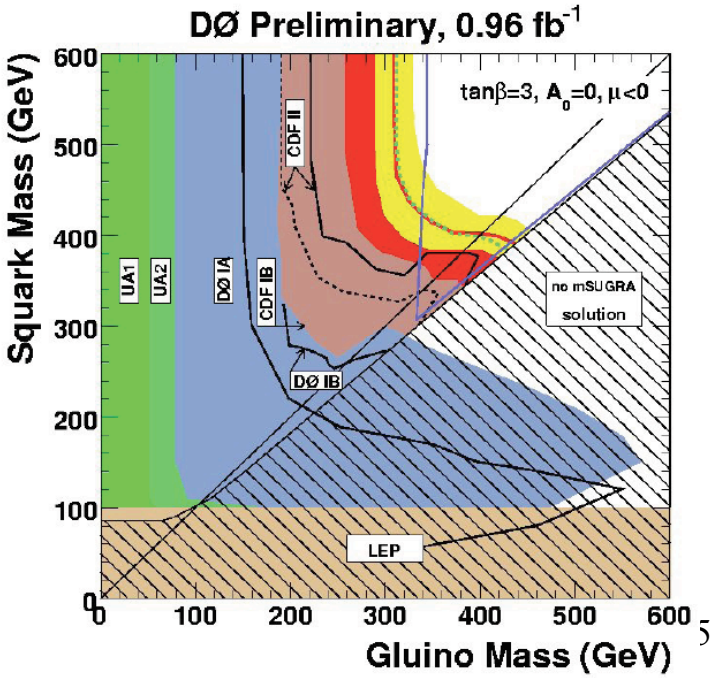
Di-jet and multi-jet event with largest MET

Jet 2: (174 GeV, -0.37, 0.12)



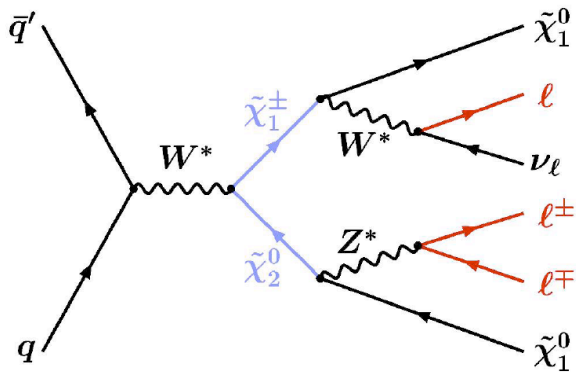
Jet 1: (282 GeV, -0.18, 1.52)

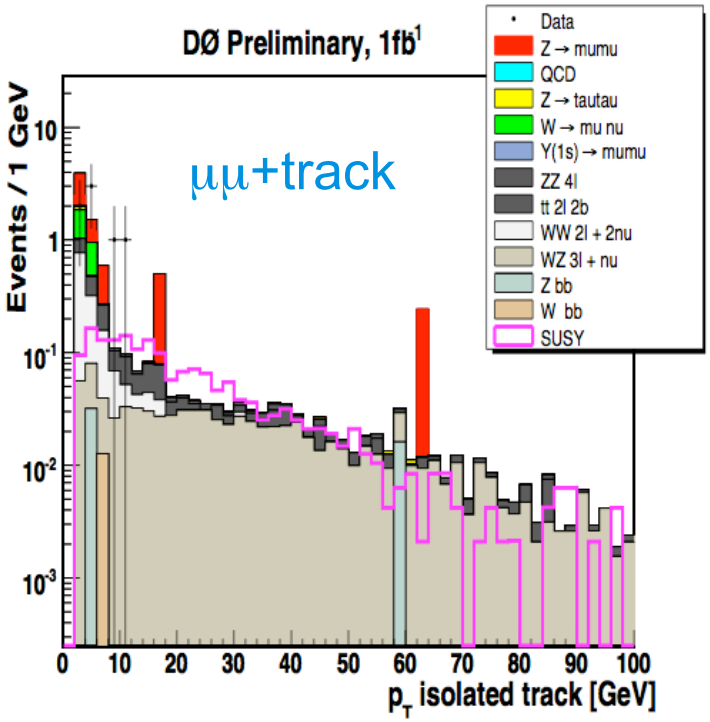
MET = 368 GeV

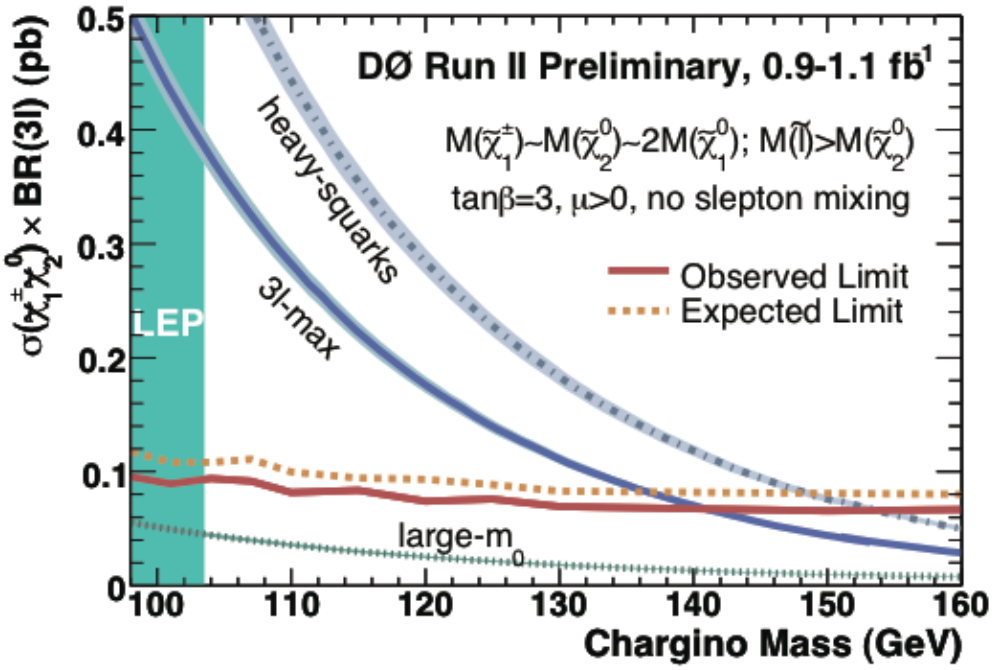


Searches for New Phenomena with 1 fb^{-1}

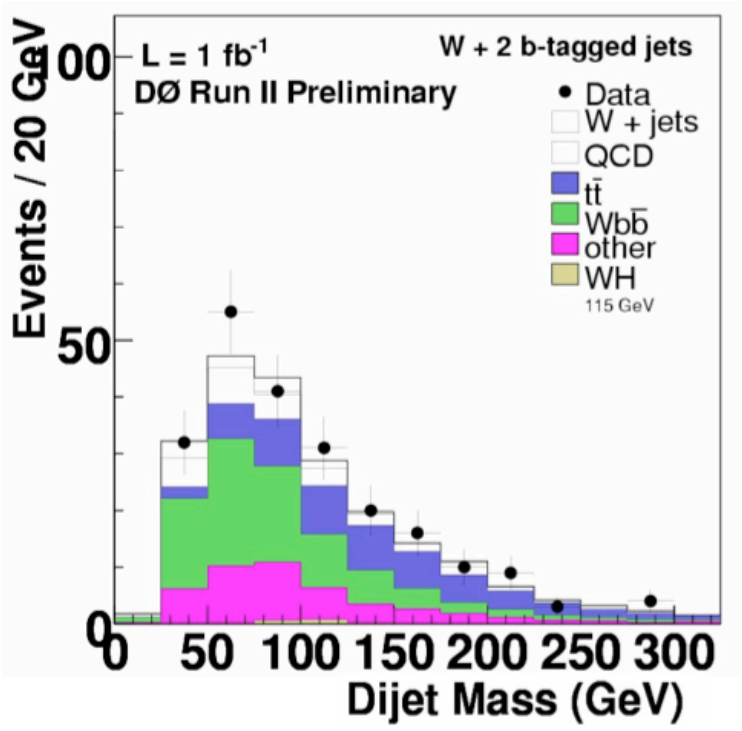
- Charginos+Neutralinos: trileptons + MET
- Combine four channels
  - ee+track, eμ+track, μμ+track, same-sign μμ
- Minimal requirements on 3rd lepton
  - Maintains high efficiency for:
    - small mass difference in SUSY cascade
    - decays to τ

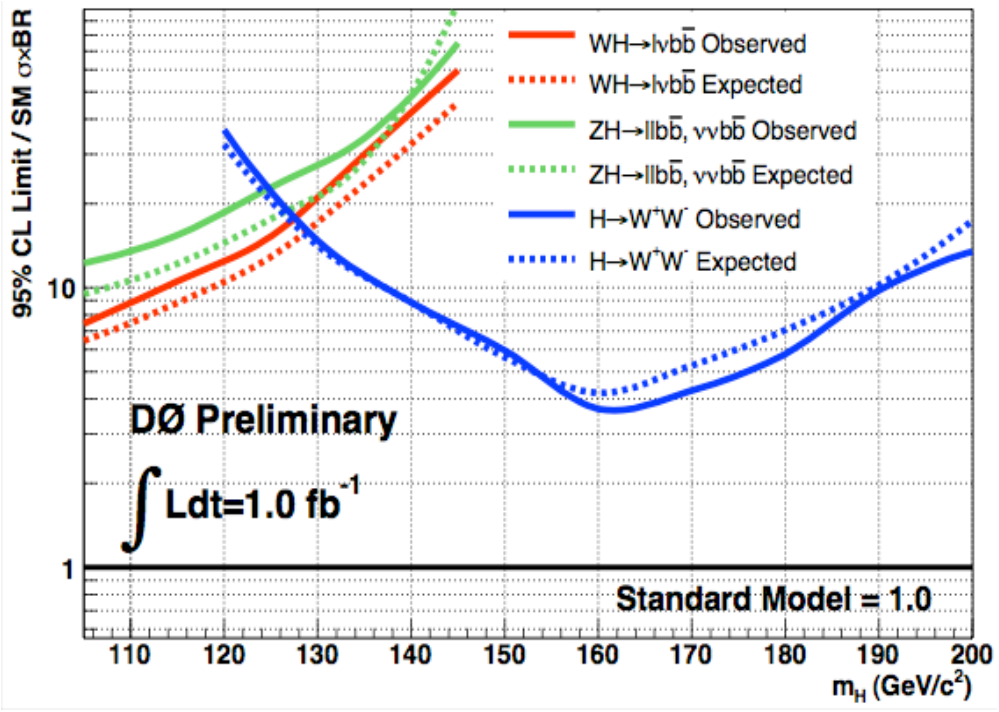






Searches for the SM Higgs Boson with 1 fb^{-1}





- Expected limits from individual channels(!) within factor 4 (8) of SM at high (low) mass.
- Overall combination of DØ limits coming soon

Beating √lumi in Searches for SM Higgs

- More efficient event pre-selections
  - OR of many triggers
  - increased lepton acceptance
  - including decays to τ
- Improved b-tagging
  - including Layer-0 silicon
- Improved di-jet mass resolution
- Use high level kinematic discriminants
  - e.g., matrix element à la single top
- Prompt combination of the two experiments

- Start to have sensitivity at 95% CL with 2–4 fb^{-1}!

CP Violation in B_s : Measurement of $\Delta\Gamma$ and ϕ_s

- Three analyses sensitive to CP violating phase in B_s decays, ϕ_s
  - time dependence of polarization amplitudes in $B_s \rightarrow J/\psi\phi$
  - like-sign di-muon charge asymmetry:

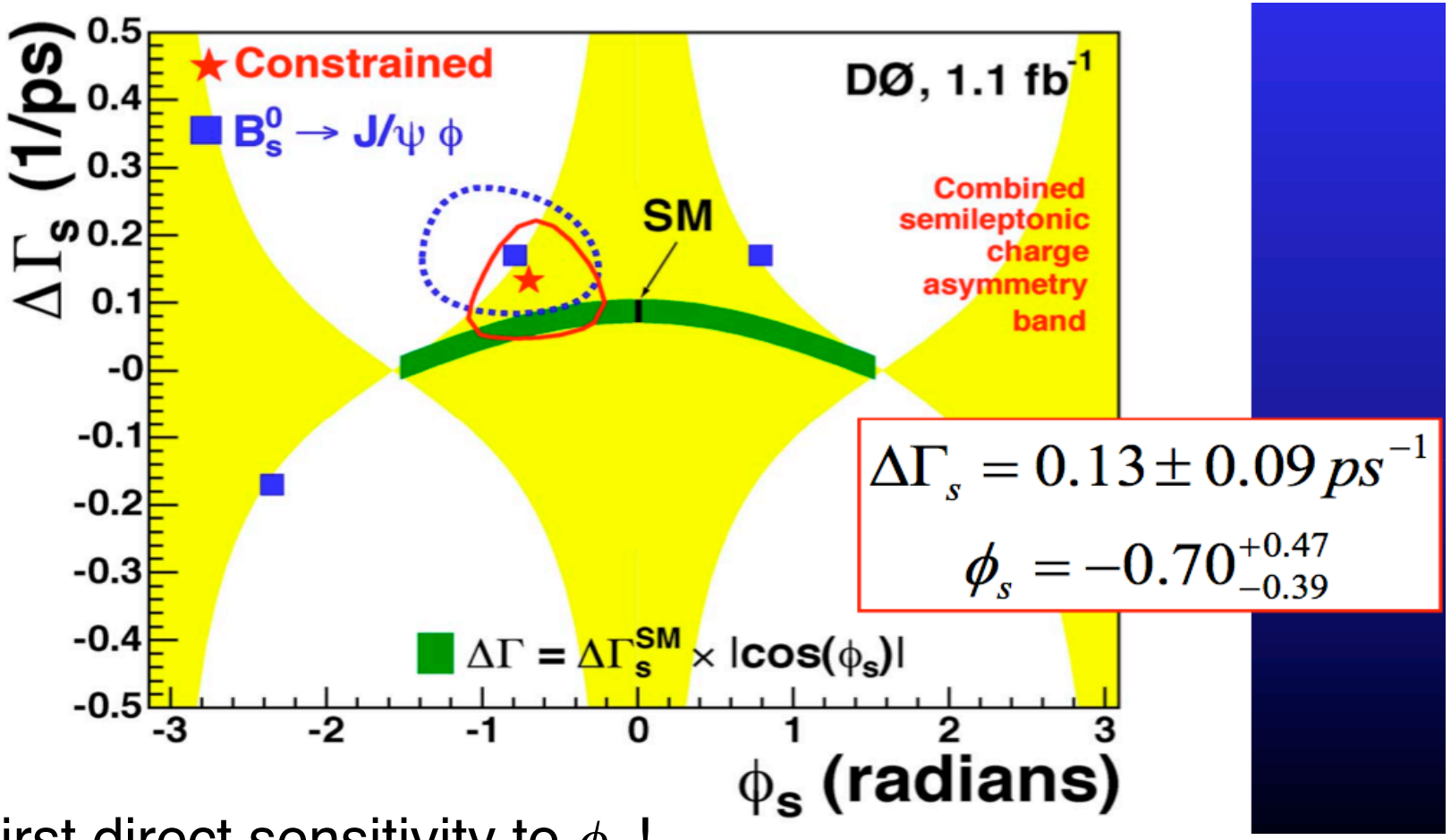
$$A_{SL} = \frac{N^{++} - N^{--}}{N^{++} + N^{--}}$$

  - $B_s \rightarrow \mu\upsilon D_s$ charge asymmetry ($D_s \rightarrow \phi\pi$; $\phi \rightarrow KK$)

$$A_{SL}^{unt} = \frac{N(B_s \rightarrow \mu^+ D_s) - N(B_s \rightarrow \mu^- D_s)}{N(B_s \rightarrow \mu^+ D_s) + N(B_s \rightarrow \mu^- D_s)}$$

  - These measurements rely crucially on advantages of DØ muon system:
    - high acceptance, low backgrounds, regular reversal of solenoid and toroid fields

CP Violation in B_s : Measurement of $\Delta\Gamma$ and ϕ_s



$$\Delta\Gamma_s = 0.13 \pm 0.09\, ps^{-1}$$

$$\phi_s = -0.70^{+0.47}_{-0.39}$$

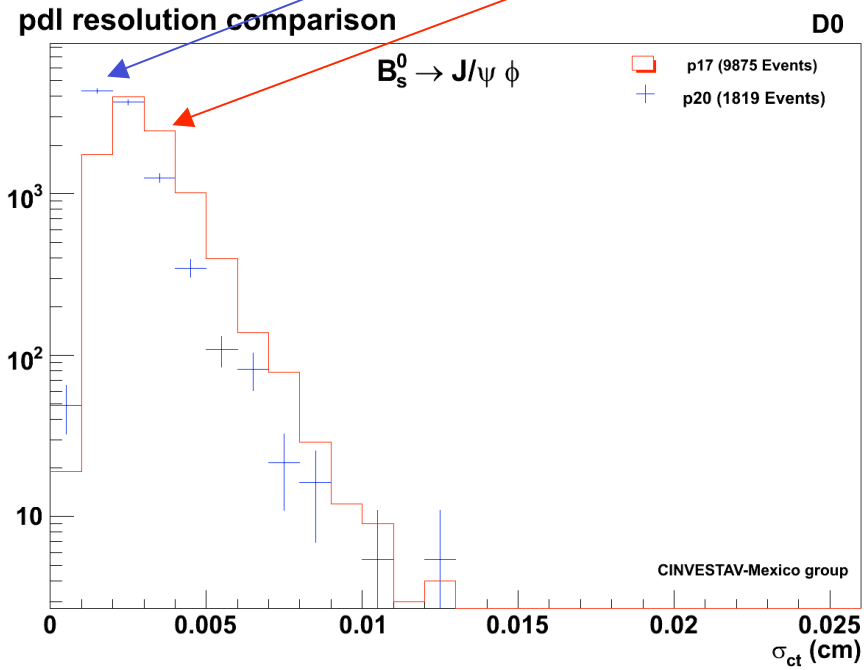
- first direct sensitivity to ϕ_s !
- beating √lumi
  - J/ψφ: include flavour tag information
  - like-sign di-muons → like-sign di-muons + φ
    - to increase B_s content

Exploiting the Run IIb Upgrades

- Tracking: Layer-0 Silicon Detector
  - 19 bad channels (out of total of 12,288 channels)
  - Signal to noise is ~15 to 1
    - No significant coherent noise
  - Improvement in decay length resolution

Run IIb (i.e., with Layer-0)

Run IIa (i.e., without Layer-0)

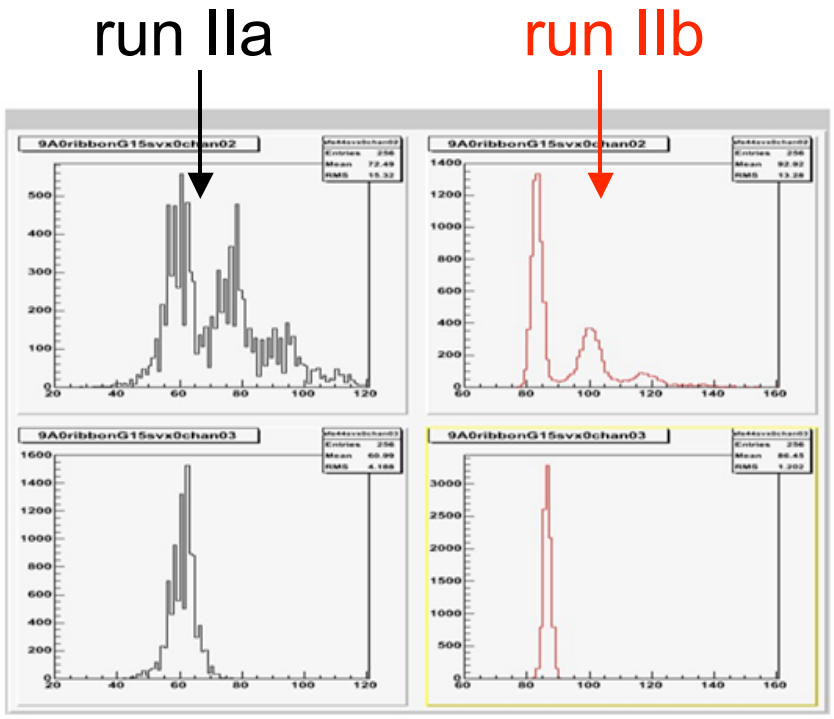


Exploiting the Run IIb Upgrades

- Tracking: AFE-IIt readout boards for fiber tracker
  - Eliminates amplifier saturation at high luminosity
  - Substantially improves pulse height resolution
    - optimization of VLPC bias voltages and reduced thresholds

❖ LED spectra

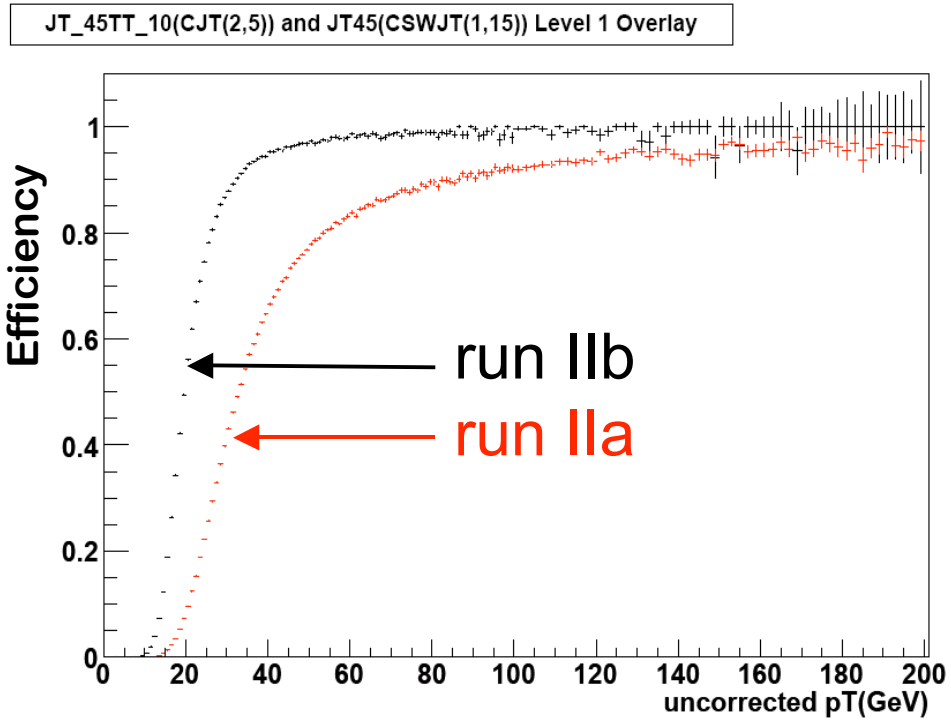
❖ pedestals



Exploiting the Run IIb Upgrades

- Level-1 Trigger: Calorimeter
  - Complete replacement of 10 racks of run I electronics
  - Allows electron, tau and jet clustering at Level-1
    - ➢ Sharper turn-on curves!

❖ e.g. 45 GeV jet trigger

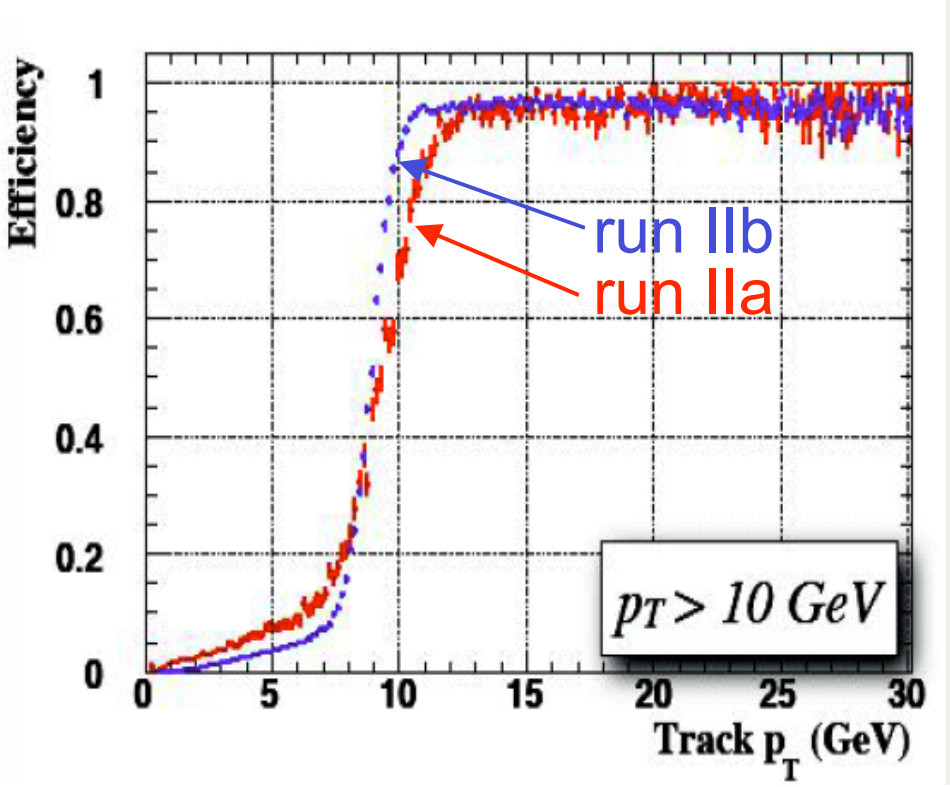


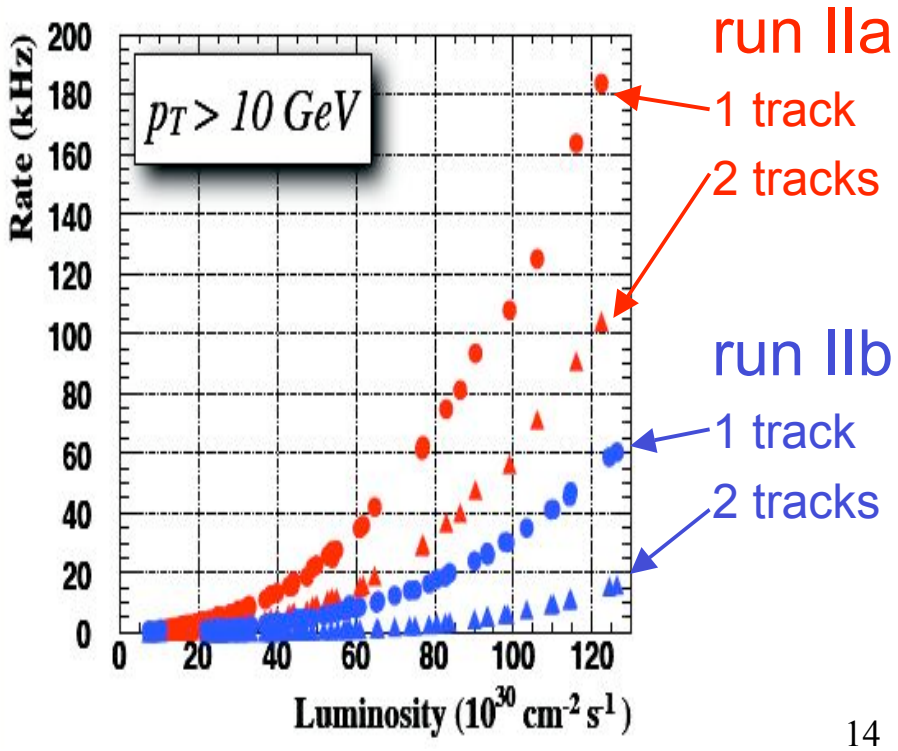
Exploiting the Run IIb Upgrades

- Level-1 Trigger: Tracking
  - More sophisticated algorithm requiring larger FPGAs

➢ sharper turn-on

lower fake rates

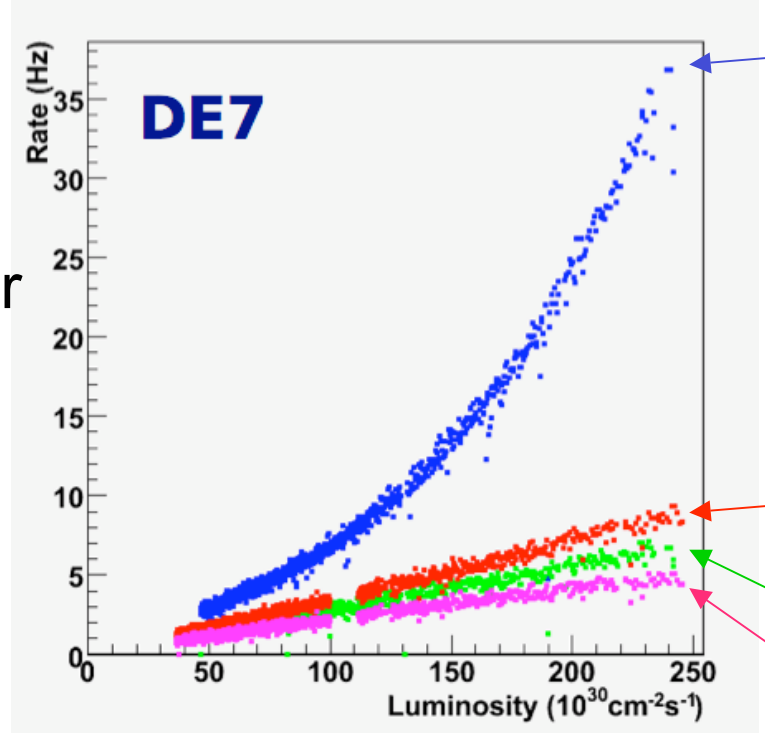




Exploiting the Run IIb Upgrades

- Level-1 Trigger: Calorimeter-Track Matching
  - Entirely new capability for DØ at Level-1
    - formerly available only at Level-2
  - ➢ Improved rejection and linearity with luminosity

E.g., 7 GeV
di-electron trigger



Level-1 before cal-track match

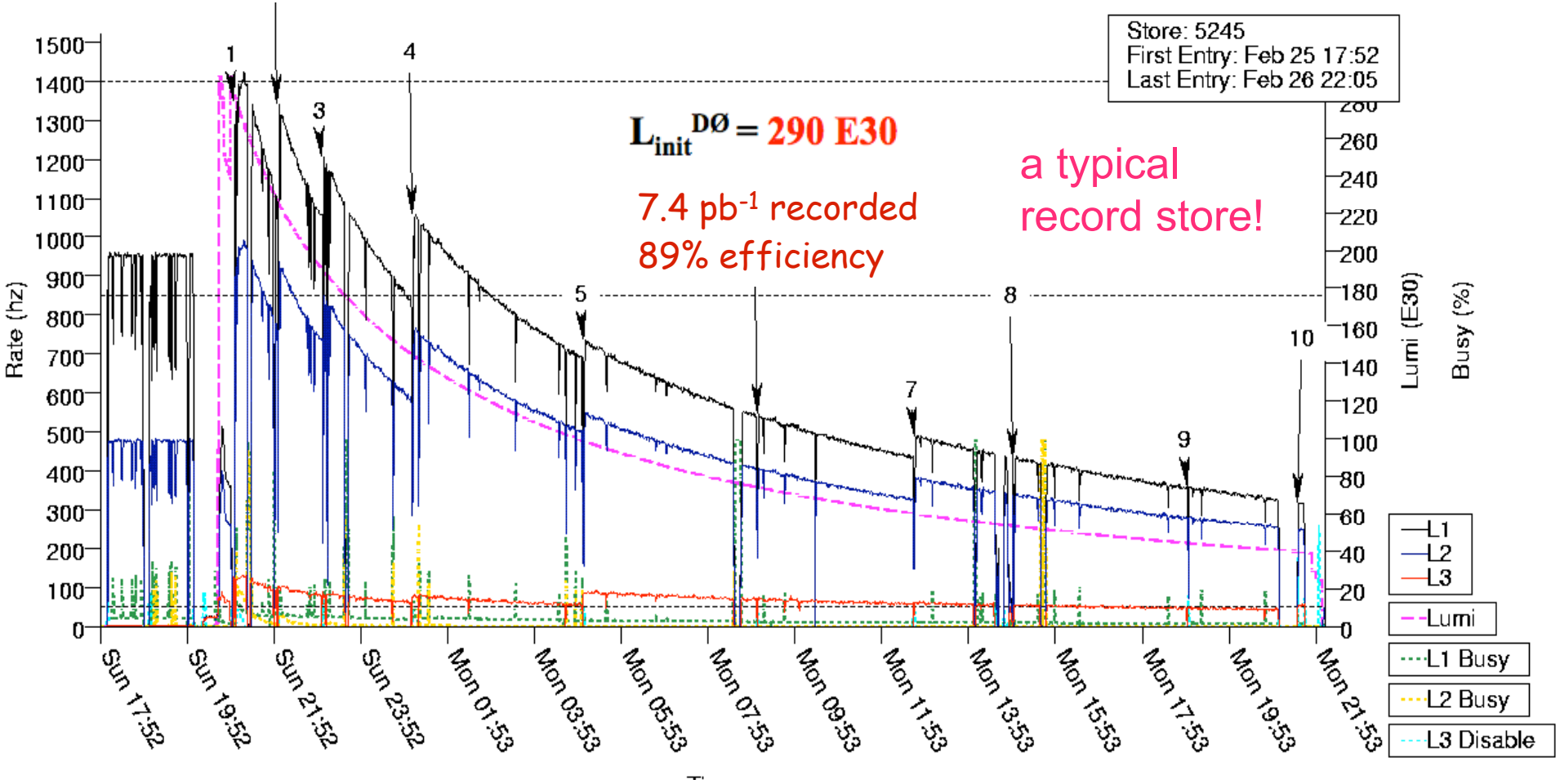
Level-1 after cal-track match

Level-2 before

Level-2 after

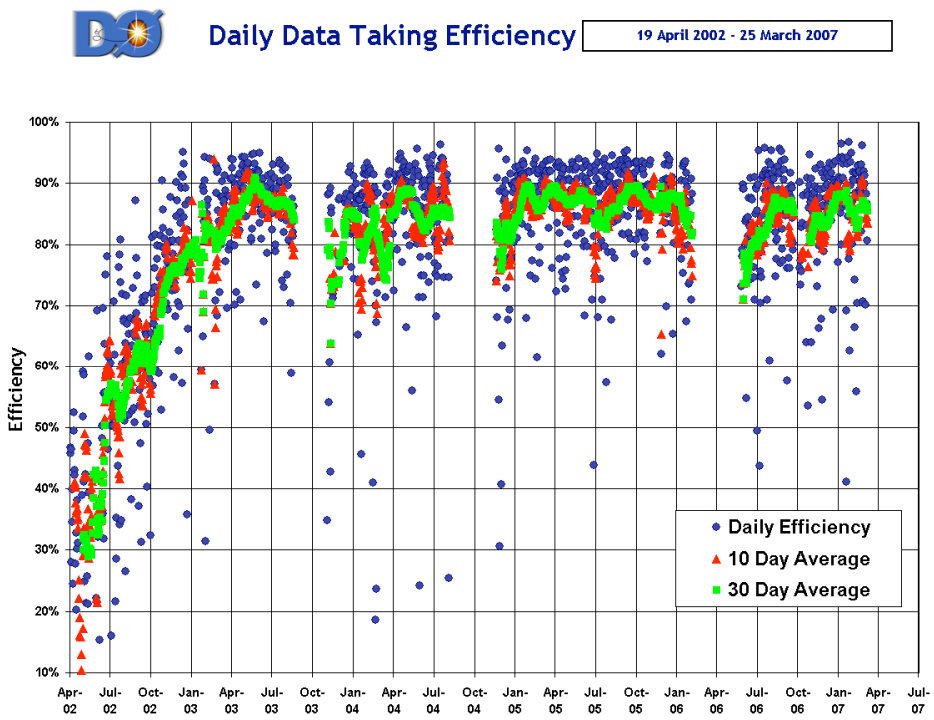
Exploiting the Run IIb Upgrades

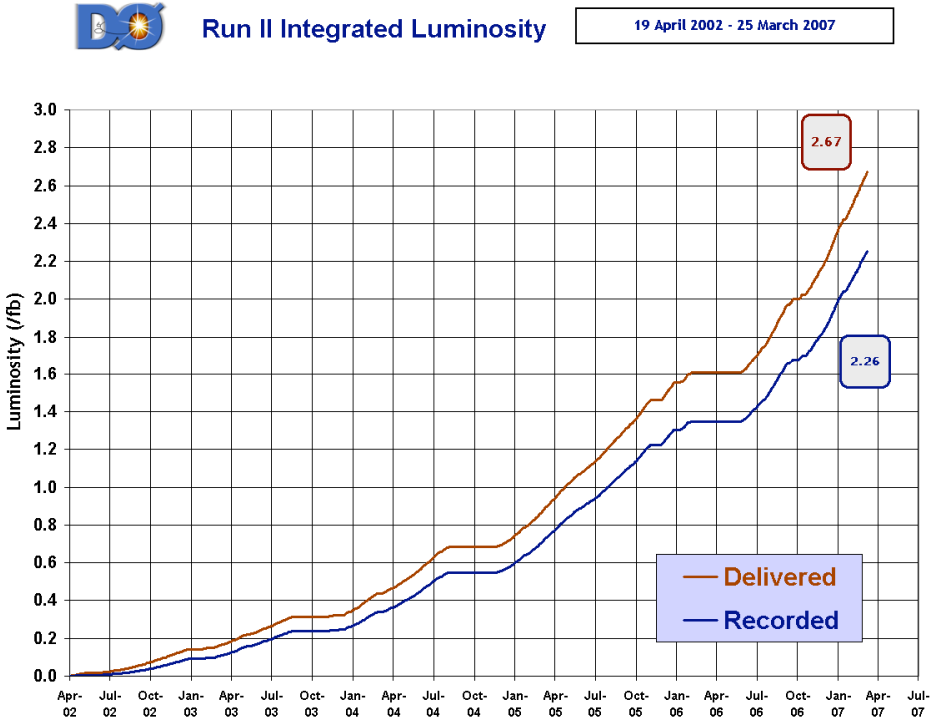
- Trigger list design



- Level-1 rate within 1.5 kHz at 290E30
  - High p_T trigger menu runs essentially un-prescaled at this luminosity!

Status of Data Taking

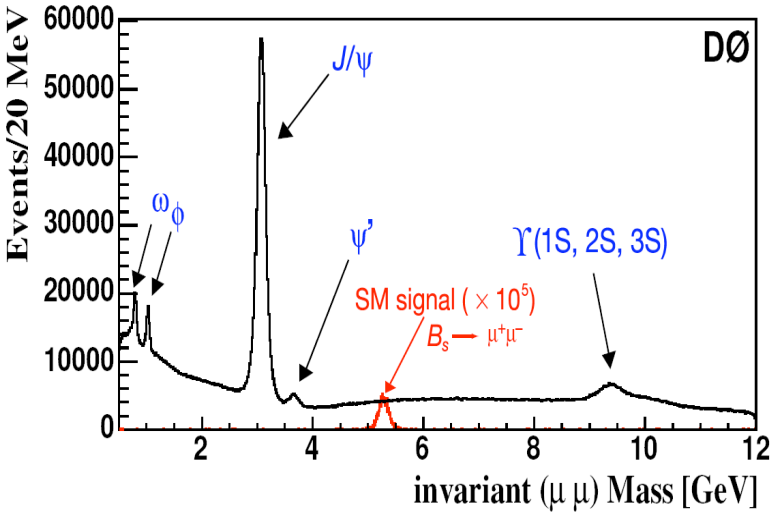


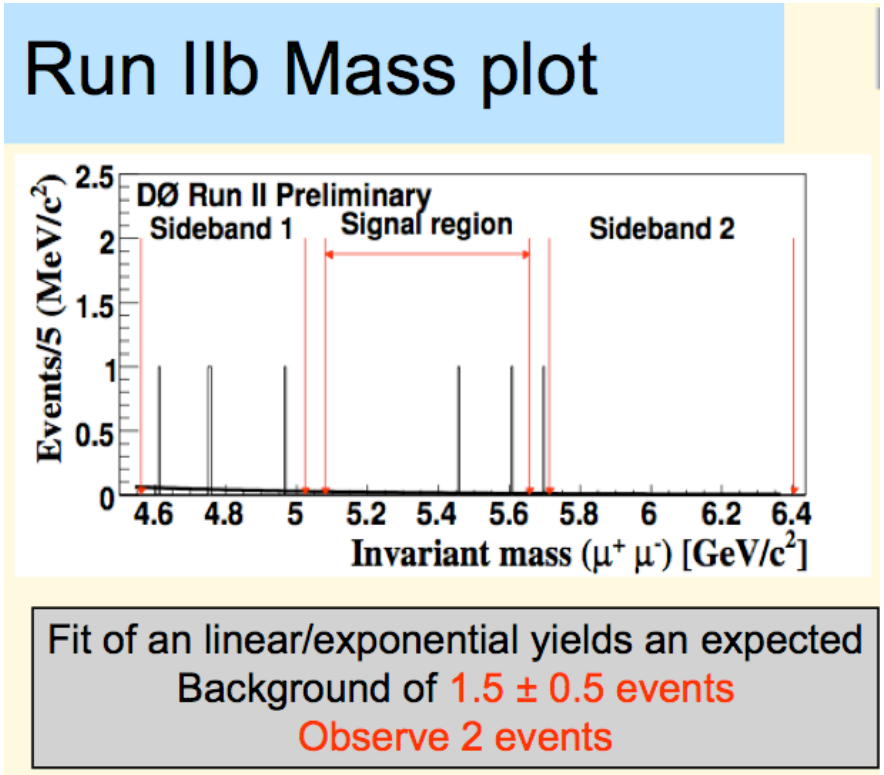


- November 2004 → February 2006
  - 800 pb^{-1} recorded of 923 pb^{-1} delivered in 63 weeks
    - 87% efficiency
- June 2006 → March 2007
  - 841 pb^{-1} recorded of 997 pb^{-1} delivered in 40 weeks
    - 84% efficiency not withstanding substantial commissioning effort

Exploiting the Run IIb Upgrades

- The first 2 fb^{-1} physics result from the Tevatron
  - Br($B_s \rightarrow \mu\mu$) < 7.1 x 10^{-8} (90% CL)
    - world's best limit





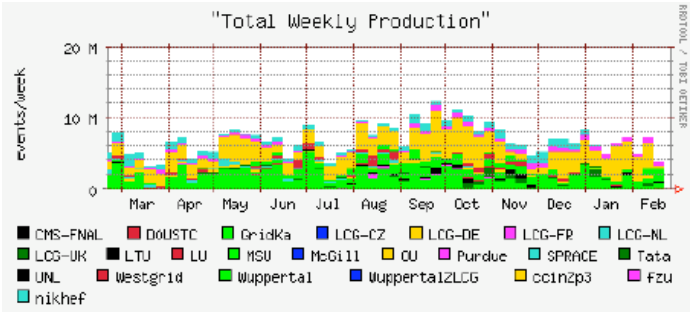
  - N.B
    - Includes data taken up to Jan 6th 2007
    - Shown at Moriond March 12th 2007
    - Data reconstructed using preliminary calibration and alignment

Improved Reconstruction of Run IIb Data

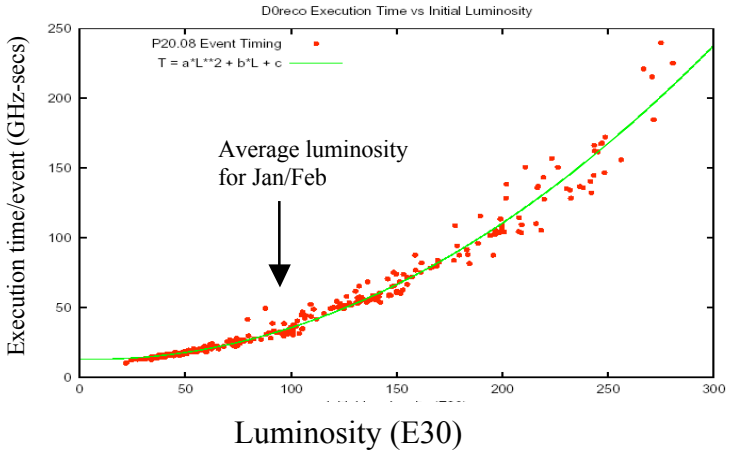
- Reduced thresholds for Central Fiber Tracker
- Improved tracker alignment
  - Final alignment and Lorentz angle correction for Layer-0
  - Remove systematic distortions ("telescoping")
- Removal of occupancy-dependent p_T cut in tracking
- New calibration for both EM and HAD calorimeters
- Luminosity database access
  - allows the addition of Luminosity tick-by-tick information into the events
- Much more robust
  - crashes and dead loops almost eliminated!

- Being used for:
  - Reconstruction of data collected from January 2007
  - Re-reconstruction of data collected June–December 2006 on the Grid

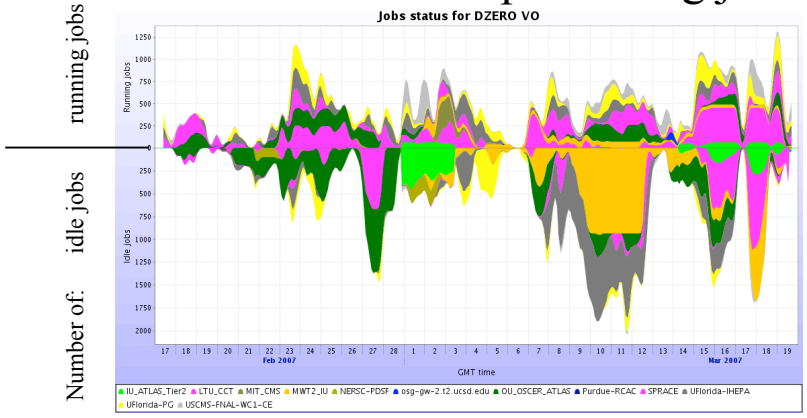
Computing



- Monte Carlo production
  - Mainly using SAM(Grid) on DØ-specific sites
  - 2.5 THz sustained 24/365 in 2006!
    - 80% in Europe (CCIN2P3, GridKa, etc)
- First pass reconstruction
  - dedicated CPU farm at Fermilab runs with 80% efficiency
  - farm about to double in size
  - expect to keep up with incoming data(~4M events/day) if initial luminosity is regularly 300E30



Number of OSG reprocessing jobs



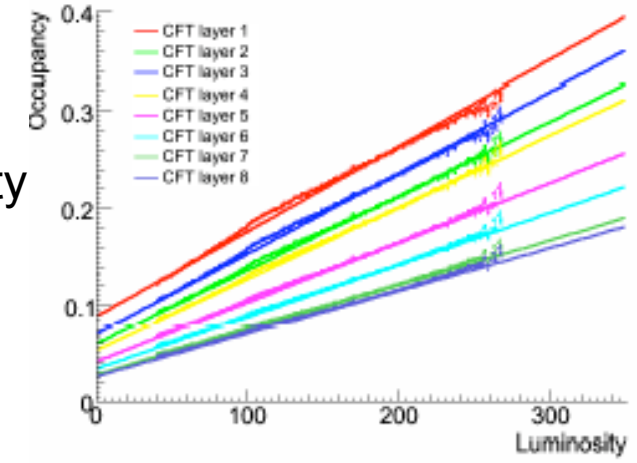
- Re-processing of June – December 2006 data
  - 500 M events — aim to finish by early May 2007
  - include “generic” OSG sites and non-expert submitters
    - difficult to sustain constant high rate, but improving

Tracking at High Luminosity

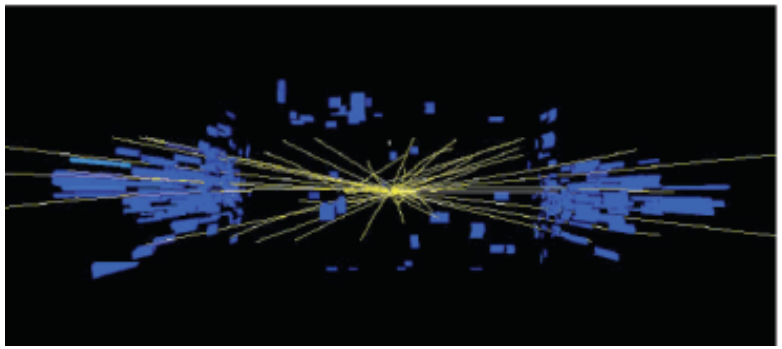
- DØ central tracker had to fit into a compact volume
- Central Fiber Tracker (CFT) designed for L=200E30 at 132 ns bunch spacing (108 bunches)
- Now running at L=300E30 and 396 ns (36 bunches)
  - i.e., occupancies factor 4-5 times original design

CFT occupancy by layer as function of luminosity

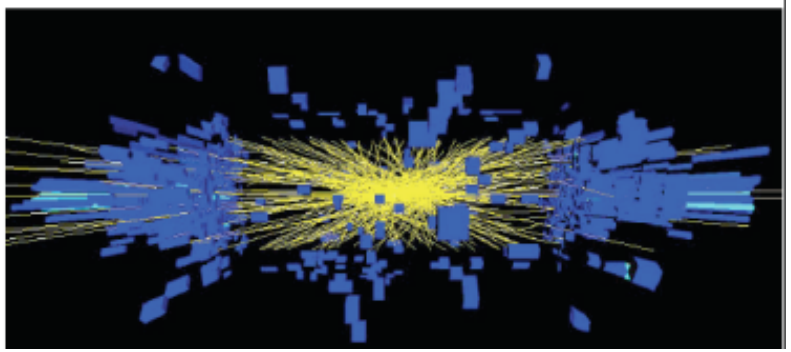
(global physics trigger mix)



A zero bias event @ 60E30 cm^2s^{-1}

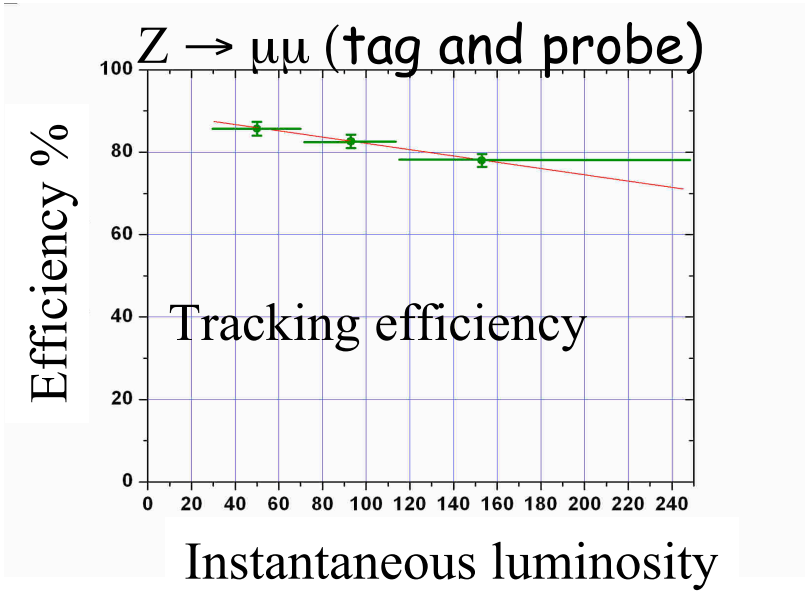


... and @ 240E30 cm^2s^{-1}



Tracking at High Luminosity

- Loss in offline tracking efficiency observed with current algorithms



- At Level-3 trigger the challenge is even more severe
  - factor 100 less time per event for reconstruction
- Very significant collaboration effort currently devoted to understanding limitations of current algorithms and attempting to develop improvements
- DØ expects to complete preliminary studies and recommend a strategy for mitigation on timescale of 2 months

Manpower: Needs and Availability

- MOUs
  - institutional commitments
  - updated summer 2005 and winter 2007
- Effort Reports
  - for each individual, for each activity
  - collected annually in December/January
- Tevatron Collider Experiment Task Force
  - assess needs for data collection, processing and analysis
  - recommended actions to address gaps between needs and available manpower
  - report Jan 2006

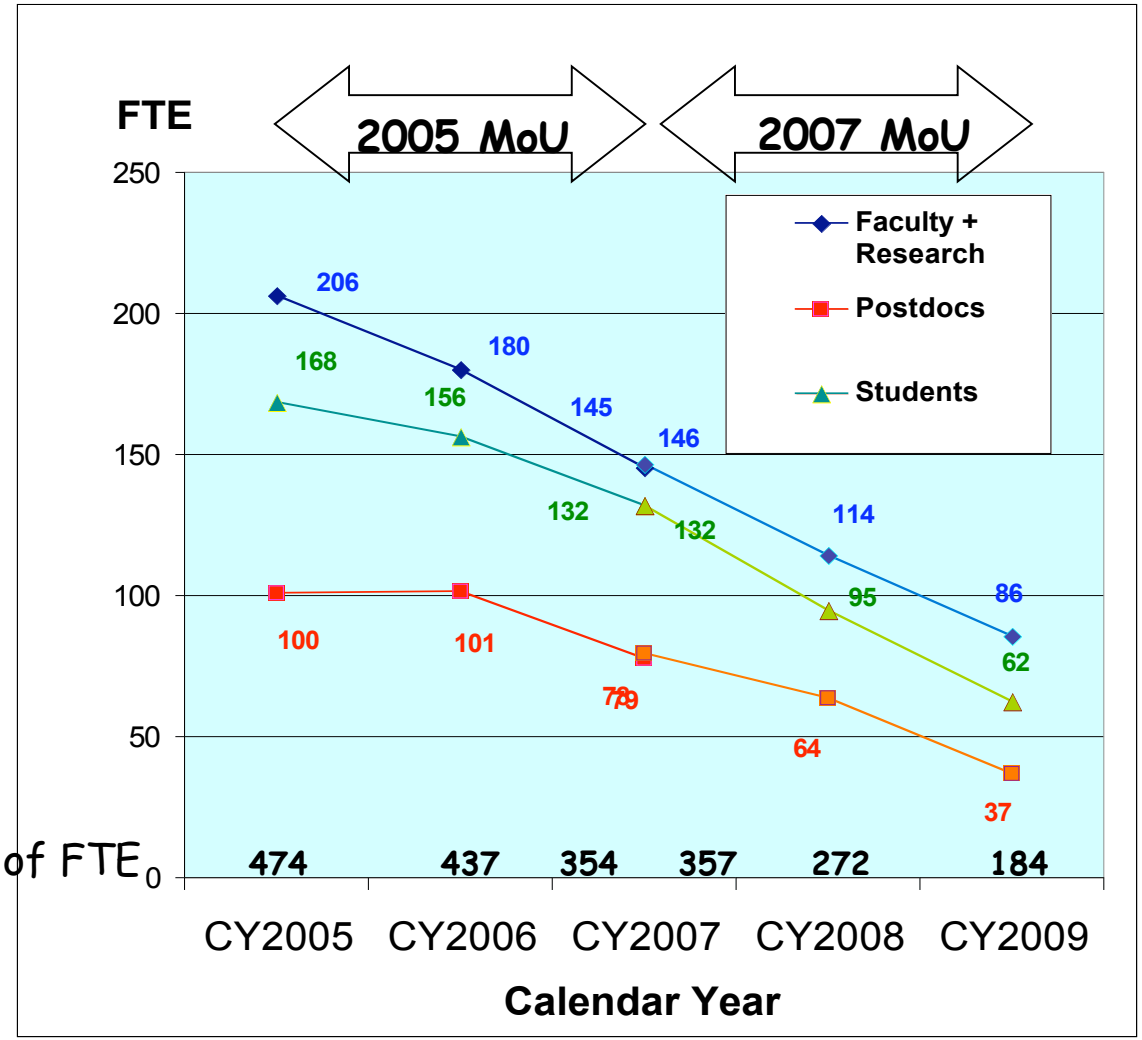
Manpower: Needs and Availability

	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%

Manpower: Needs and Availability



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

Meeting the Challenge of 2009

- Maintain high quality in data collection, reconstruction and analysis by:
  - Making most efficient possible use of available FTEs
    - Merge control room shifts
    - Improve automated monitoring and action
    - Improve automation of production computing
    - Further development of Common Analysis Format
      - including common tools for measuring and applying efficiencies for standard physics objects
      - including common pre-selections for analyses sharing a given final state
    - N.B. all of the above require investment of effort now to reap rewards later
  - Increasing the number of available FTEs!
    - Requires concerted effort by the collaboration and Fermilab

Summary and Conclusions

- Very successful current physics programme
  - many “first”s and “world’s best”s for DØ in 2006
- Huge potential for 6–8 fb^{-1}
  - including direct and indirect sensitivity to Higgs
- Strong desire by DØ to run through 2009 to realise this potential
- High luminosity and 2009 manpower are serious challenges
  - Require a serious response from DØ and Fermilab
  - Together we expect to face these challenges successfully