DØ Performance and Planned Improvements

- **Operations**
  - Collection of data
  - Detector status
  - Processing: local & remote

- **Algorithms**

- **Upgrades**

Institutions: 84 Total
  - 35 US, 49 non-US

Collaborators:
  - ~ 675 Total
  - ~ 50% from non-US institutions
  - ~ 100 post-docs
  - ~ 140 graduate students
A “100E30” Store

Factors Limiting Efficiency:
- ~3-5% front-end busy
- ~2-3% are losses due to store & run transitions
- ~5% “incidentals”

Triggers:
- L1: ~1600Hz, ~110 bits
- L2: ~800Hz, ~110 bits
- L3: ~50Hz, ~450 bits
Daily Data Taking Efficiency

19 April 2002 - 7 September 2005

Daily often above 90%
Current trends 85-90%

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Data Delivered: 1.10 fb\(^{-1}\)
Data to Tape: 0.92 fb\(^{-1}\)
Efficiency w/ all detectors: 83.6%

Thanks to the Acc. Division!
Silicon Microstrip Detector

- 4 barrel layers
- Axial + stereo strips
- H, F Disks/wedges

- 793k Channels
- S/Noise: > 10 all devices
- Cluster Efficiency: > 97%
- No fiducial loss
Radiation Hardness

- **Studied**
  - In the booster
  - In situ with HV
  - Scans of noise and efficiency

- **Depletion voltages**
  - Evolving as expected
  - For inner layer
    \[ V_{\text{depletion}} \sim V_{\text{max}} = 150\text{V} \]
    at 5—7 fb\(^{-1}\)

![Graph showing depletion voltage vs. fluence and luminosity](image)
Central Fiber Tracker & Preshowers

- Eight axial & eight stereo layers
- VLPC readout at 8K
- Performing well
  - good light yield
  - layer $\varepsilon > 98\%$
- After November 2003 shutdown
  ~ 1% of VLPC channels not functional
  - was 0.1% before November
  - a one-time event
  - water contamination in cryostat?
- Last shutdown warmed up 1 (of 2) cryostats
  - pumped out 0.5l H$_2$O
  - Upon cool down same loss rate
    BUT different channels
- Does not seriously degrade performance, but requires vigilance.
Coming out of FY04 shutdown, while attempting to ramp to full current, the solenoid quenched.

Clues:
- An additional ~8W heat load was seen on the cooling system during operation
- The south end of support cylinder shows an elevated temperature when powered
- An excess in resistance is seen in the inner coil layer
- Careful detailed review of history of temperature rise of south coil support when powered indicates that the degradation is strongly correlated with coil thermal cycles above 90K

Diagnoses: Suspect degradation of inner layer conductor joint at south end of solenoid coil.

Prescription:
- Minimize future thermal disturbances
- Limit power cycles
- Upgraded cryogenics plant to provide additional operating margin

Carefully monitored coil resistance and support temperature since beginning of FY05 run & show no further signs of degradation.

Have run stably at 4550A (rather than 4750A)
Calorimeter

- Liquid argon calorimeter with uranium absorber
  - Operating Smoothly
  - 99.9% of 55,000 channels operational
- Aggressive program to reduce noise was productive, certain types of noise down 4 orders of magnitude.
- Completed an in situ cell-by-cell calibration of EM and Had calorimeters
- Z pole resolution improves from 3.35 GeV to 2.93 GeV

Correction factors at $\eta=0.5$
Muon Systems

- **Three layers tracking & triggering**
- **Central**
  - PDTs: 98.6% of 8k tubes active
  - Scintillator: 99.8% of 630 counters active
- **Forward**
  - Scintillator:
    - 99.9% of 4608 counters active
    - Expect around 10% degradation (mainly in phototube) at 15 fb⁻¹
  - MDTs:
    - 99.7% of 50k wires active
    - one plane disabled due to broken wire.
- **Stable to 1%**
- **Highly Efficient**

*Strength of DZero*

*Efficiency: high (94%) & uniform ±2*

\[ Y = \frac{N}{L} \]

\[ \chi^2 / \text{ndf} = 58.34 / 12 \]
Overall Tracking Performance

• **Alignment: B=0 Field, verified w/ cosmics**
  - CFT: fibers positioned to ~10um
  - SMT: single element alignment ~3um in transverse plane
  - SMT-CFT relative alignment: <10um
  - Stable: <5um motion over time

• **High $p_T$ Electrons:**
  - Efficiency: ~87% for $|\eta| < 2$
  - Fakes: 1-2%

• **High $p_T$ Muons**
  - Efficiency: 98% central, 95% overall
  - Fakes: <1%
**Processing: Onsite & Remote**

- **Basic Strategy**
  1. Initial reconstruction pass at Fermilab
  2. Reprocessing & simulation offsite.

- **Reconstruction Farm**
  - 15-20M event/week capacity
  - Events processed within a day or two of collection.

- **Simulation**
  - Upgraded to include realistic material & Luminosity profiles.
  - 76 M events produced since August, 2004
  - Capable of ~3M events per week
(Re)Processing

- **New reconstruction version much improved**
  - Faster
  - Grid Friendly
  - Calorimeter calibrated in situ at the cell level

- **Reprocessing first 470pb⁻¹**
  - 2004 “Pilot”: reprocessed 140pb⁻¹ remotely w/ GRID
  - Uses SamGrid (SAM+JIM), >10 offsite farms
  - Started Friday March 25, 2005
    - 795M of 986M complete
    - 671M remote
  - Should be complete by October, 2005

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Improving Electron Acceptance

- For searches, extending electron acceptance beyond central region.
- Backgrounds ~1% in CC expected to be similar in EC.
- Working to achieve lower trigger thresholds with calorimeter trigger upgrade and understand track matching in the forward regions.
τ ID and Improvements

- NN Tau ID has reached maturity within DZero
- Used to measure published σ*B(Z → ττ)
- Increasing sensitivity of searches
- Continuing to improve sensitivity

Search for \( \chi^{\pm}_1 \chi^0_2 \to 3l+X \)

DØ, 320 pb\(^{-1}\)

LEP, Chargino Searches

Trained on Z → ττ MC
Jet Energy Calibration and Improvements

- Negligible statistical uncertainties
- Factor of two improvement in systematic uncertainties in jet response related to photon purity and background estimation
- With completion of MC study out-of-cone energy loss uncertainty reduced from 2% to 0.5%
- Further improvements not shown here:
  - Jet response bias measurement at low E
  - Jet response extrapolation using Monte Carlo at high E
- Some Beneficiaries
  - Top mass in lepton+jets, cross sections
  - Single top
  - Any Search w/ jets
  - Inclusive jets...

Central jets (\(\eta=0\))

\[ E^{\text{corr}} \text{ (GeV)} \]

\[ 10 \quad 10^2 \]

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Jet Resolution & Improvements

- TrackCal Jet, an “add-on”
- Improve calorimeter jet resolution using tracks for hadron response.
- Track momentum measurements set an accurate scale for hadron response.
- Takes into account the non-linear response of individual particles in jets.

* 10% improvement in jet resolution.
* 20% improvement in MC Z resolution
• Based on NN
• Seven inputs from
  ▪ Secondary vertex tagger
  ▪ Jet impact parameter tagger
• Significant improvement
  ▪ 25% at fixed fake
  ▪ X3 less fakes at fixed efficiency

Data Measurement

Tagger
- NN
- JLIP

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Simulation and Improvements

- Improving description of material
  - Calorimeter, Cryostat, Solenoid
  - SMT volume, verified with photon conversions

Data vs. MC comparison

No of Entries 956212
No of Entries 759752
Simulation and Improvements

• Simulation of dead channels in SMT & CFT
• Overlay of zerobias events on top of MC hard scatter
  – simulate detector occupancy, noise...
  – one zerobias event per MC event
  – Taken randomly from Run II luminosity profile:

  \[ 826.3 \text{ pb}^{-1} \]

Instantaneous luminosity for each luminosity block, weighted by contribution to integrated luminosity

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2004
1) Search for Doubly-charged Higgs Boson Pair Production in the Decay to mu+mu+mu-mu- in pbarp Collisions at sqrt(s)=1.96 TeV
2) Observation and Properties of the X(3872) Decaying to J/psi pi+pi- in pbarp Collisions at sqrt(s)=1.96 TeV

2005
1) Search for Supersymmetry with Gauge-Mediated Breaking in Diphoton Events at DZero
3) Measurement of Dijet Azimuthal Decorrelations at Central Rapidities in pbarp Collisions at sqrt(s)=1.96 TeV
4) Measurement of the B_s^0 Lifetime in the Exclusive Decay Channel B_s^0->J/psi phi
5) A Search for the Flavor-Changing Neutral Current Decay B_s^0->mu+ mu- in pbarp Collisions at sqrt(s)=1.96 TeV
6) Measurement of the Ratio of B+ and B0 Meson Lifetimes
7) Measurement of the Lambda-B Lifetime in the Decay Lambda-B -> J/psi Lambda With the D0 Detector
8) A Search for Wbb and WH Production in pbarp Collisions at sqrt(s)=1.96 TeV
9) Measurement of the WW Production Section in pbarp Collisions at sqrt(s)=1.96 TeV
10) A Measurement of the Ratio of Inclusive Cross Sections pbarp->Zb/pbarp->Zj at sqrt(s)=1.96 TeV
11) A search for anomalous heavy-flavor quark production in association with W bosons
12) First measurement of sigma(ppbar->Z)xBr(Z->tau tau) at sqrt(s)=1.96 TeV
13) Search for first-generation scalar leptoquarks in ppbar collisions at sqrt(s)=1.96 TeV
14) Study of Zgamma events and limits on anomalous ZZgamma and Zgammagamma couplings in pbarp collisions at sqrt(s)=1.96 TeV
15) Measurement of inclusive differential cross sections for Upsilon(1S) production in ppbar collisions at sqrt(s)=1.96 TeV
16) Measurement of the p-barp -> Wgamma +X Cross section and Limits on Anomalous WWgamma Couplings at sqrt(s)=1.96 TeV
17) Search for Randall-Sundrum Gravitons in Dilepton and Diphoton Final States
18) Search for right-handed W bosons in top quark decay
20) Production of WZ Events in p-bar collisions at $\sqrt{s}=1.96$ TeV and Limits on Anomalous WWZ Couplings
21) Search for neutral supersymmetric Higgs bosons in multijet events at $\sqrt{s}=1.96$ TeV
22) Search for supersymmetry via associated production of charginos and neutralinos in final states with three leptons
23) Search for single top quark production in p-bar collisions at $\sqrt{s}=1.96$ TeV
24) Measurement of the lifetime difference in the Bs system
25) Measurement of semileptonic branching fractions of B mesons to narrow D** states
26) Search for large extra spatial dimensions in dimuon production at DZero
27) Measurement of the $t\bar{t}$ cross section in p-bar collisions at $\sqrt{s}=1.96$ TeV using kinematic characteristics of lepton plus jets events
28) Measurement of the $t\bar{t}$ cross section in p-bar collisions at $\sqrt{s}=1.96$ TeV using lepton plus jets events with lifetime $b$-tagging
29) Measurement of the $t\bar{t}$ production cross section in p-bar collisions at $\sqrt{s}=1.96$ TeV in dilepton final states
30) Search for the Higgs Boson in $H\rightarrow WW(\ast)$ Decays in p-bar collisions at $\sqrt{s}=1.96$ TeV
31) The Upgraded D0 Detector

Thirty(+1) Run II Papers

Luminosity: $\sim 0.3-0.4\text{fb}^{-1}$ as much as $0.6\text{fb}^{-1}$
Twenty-six in Draft or Review
Conference Results: 61 Approved

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Preparation for “200E30+” Stores

- **Layer Zero detector** - an inner layer of silicon
  - Mitigate tracking losses due to radiation damage and detector aging
  - Provide more robust tracking and pattern recognition for higher luminosities
  - Improve impact parameter resolution

- **Trigger/DAQ Upgrades**
  - Complete upgrade program to keep trigger rates down as luminosity increases
  - L1 upgrades (Calorimeter, Central Track Trigger, Cal Trk-Match)
  - L2 upgrades (Silicon Track Trigger, L2 $\beta$ processors)
  - DAQ/Online (Upgrade L3 processing power, database & host servers, control systems)

Same diameter as a golf ball
“200E30” Strawman Trigger List

- Current Trigger good to ~120E30
- Upgrade Trigger Task Force
- Estimate
  - Includes only L1cal upgrades
  - Further improvements anticipated from L1CTT and L1caltrack
- Rates projected to 200e30 using data:
  - Pre-upgrade: 2800 Hz
  - Upgraded: 1400 Hz
  - Efficiency equal or better
  - Implemented @ shutdown

limit for 5% front-end busy
Run IIb Upgrade Current Status

- **Layer Zero**
  - Completed. All channels read out
  - Technical Readiness Review (TRR) scheduled for Sept. 16
  - Cooling and clearance tests remain
  - Installation mockups successful, fine tuning procedures
  - Software ready.

- **Trigger/DAQ Upgrades**
  - L1 all hardware in hand and bench tested
    - L1CTT system tests have been completed and TRR held.
    - L1Cal system tests well advanced and TRR held.
    - L1 Cal-Trk Match has made a full integration vertical slice.
  - L2 upgrades hardware in hand
    - β processors tested at DZero and UVa
    - STT TRR towards end of September.
  - DAQ/online essentially complete

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Comments on Upgrade

- The upgrades are ready to install
  - In two cases, the collaboration has had the chance to hold full reviews
  - The rest of the subprojects will also be reviewed – but no showstoppers
- The RunIIb project phenomenally successful! A technically challenging project finishing within a couple of months of the original forecast two years ago.
- Especially in the last few months many people have been working extremely hard to bring the projects to installation readiness.
- DZero ready to install upgrades Oct 31st:
  - Improves quality/efficiency of DZero data and collection
  - Allows experts to move on to physics commissioning and analysis
Looking forward - other initiatives

- **New electronics for central fiber tracker (AFE II)**
  - Helps tracking efficiency in high luminosity/occupancy environment.
  - Approved early ‘05.
  - Different timescale - completion late 2006
- **Have submitted a proposal to improve Bs mixing reach.**
  - Measurement is statistically limited.
  - L3 bandwidth
  - 50 Hz store average limited by computing budget
  - Have submitted a proposal to DOE for additional offsite reconstruction CPU
- **Located at IndianaU and UofOklahoma**
  - 50% match by the institutions
Experimental and Analysis Plan

• Each December upper management proposes a set of major goals for the experiment. The CY05 goals focused on
  – Completion of the upgrades
  – Preparation of the full Run IIa data set for CY06 presentation and publication
  – Increased automation/efficiency for long term data preparation and analysis

• Highlights of late CY05 goals:
  – July:
    • Reprocessing well underway.
    • Implementation of Common Analysis Format
  – August/September:
    • Complete upgrade elements.
  – October:
    • Preliminary version new jet calibration.
  – November:
    • Processing and Reprocessing of entire 1fb⁻¹ data set complete with improved calibration/tracking
    • Automated certification of all object definitions.
Conclusions

- The DØ detector is working well at ~90% efficiency
- World-wide processing keeping pace
- Algorithms and simulation reaching maturity and improved sensitivity.
- Publishing at a healthy rate (up to 600 pb⁻¹)
- Preparing for the future.
  - Operational Efficiency
  - Upgrades
- The collaboration is enthusiastic about the nearly 1.0 fb⁻¹ data to tape and the prospects more.

On the operational side both experiments are ready and preparing for the full run – we have the means – next you’ll hear we have the will.
Details on Prospects for $B_s$ Mixing

- **New Layer-Zero silicon improves decay length resolution 30%**
- **Bandwidth increase will increase statistics threefold**
- **Improved triggering with STT and invariant mass at L3**
- **Add hadronic $B_s$ decays**
  - Trigger on flavor-tagging
  - Excellent proper time resolution since full reconstructed
- **Analysis Techniques**
  - Add more decay channels $D_s \rightarrow K_s^0 K, K^* K^*, 3\pi$
  - Improve boost estimate (semileptonic modes)
  - Improve opposite-side flavor tag (now $\varepsilon D^2 \sim 2\% \rightarrow 2.5\%$)
  - Add same-side flavor tag ($\varepsilon D^2 \sim 1.5-2\%$) by summer
  - Un-binned likelihood fit: event-by-event resolution and purity

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