DØ Status Report

Volker Büscher
Universität Freiburg

on behalf of the DØ Collaboration

PAC Meeting, Fermilab
December 8, 2005

– Operations
– Long-Term Planning
– Upgrade Projects
– Computing and Algorithms
– Selected Physics Highlights
DØ Detector and Operations Status

DØ: Excellent Coverage for $e, \mu, \tau$, $E_T$, $b$-tagging

- Electron acceptance $|\eta| < 3.0$
- Muon acceptance $|\eta| < 2.0$
- Silicon Precision tracking $|\eta| < 3.0$
- LAr Calorimeter $|\eta| < 4.2$

All subdetectors continue to perform very well

- Average data-taking efficiency close to 90%
- Efficiency limited by
  - 3–5% Front-End-Busy
  - 2–3% Store and run transitions
  - $<5\%$ “incidentals”
DØ Detector and Operations Status

L1 Rate < 1.6kHz
L2 Rate < 1kHz
L3 Rate < 100Hz
FEB < 5%
Inst. Luminosity

Improvements at Level 3: speedup of L3 reconstruction code, more farm nodes
Complete menu of core triggers running up to record luminosity of 160e30
Note: non-linear behaviour of L1 rate at high luminosity
  main reason: coarse granularity of track trigger, fake rates increase with occupancy
DØ Run II Dataset

Almost 1.1 fb$^{-1}$ on tape

Run II Integrated Luminosity

19 April 2002 - 6 December 2005

Thanks to the Accelerator Division!
Looking Forward

Hoping for 4 fb$^{-1}$ by end of 2007, 8 fb$^{-1}$ by end of 2009

Challenging for experiment and collaboration:

- Peak luminosities of $>300e30$ by early 2007
  → Upgrade L1 Trigger

- High radiation dose for inner layer of silicon detector
  → Add “Layer 0” silicon detector

- Most of the data to be delivered in parallel to LHC startup
  → Secure manpower to operate detector + maintain Software/Computing efforts
Manpower analysis within the Tevatron Collider Task Force

- Bottom-up analysis of FTE needs in 2007 (after completion of upgrade)
  - detailed task-by-task projection
  - 165 FTE required for Total Service (Operations, Computing, Algorithms)

- Survey of institutional commitments for 2007
  - a total of 345 FTE committed to DØ
  - service tasks can be covered with a service fraction of 50% (!)
  - leaving about 170 FTE for physics analysis

- FTE totals clearly do not tell the whole story

- Need to ensure that all critical needs are matched by institutional commitment and expertise

- Drafts of MoUs for 2006-2007 in hand, have compared with needs task-by-task
  → several areas of concern identified in Operations, Algorithms, Computing

- Issue is being addressed by management:
  - invest effort to achieve “steady-state” as soon as possible
  - task force recommendations to FNAL Director
Selection of DØ Goals for 2006

January 15  First approved analyses with an 1 fb\(^{-1}\)
March 5    Entire Run IIa dataset processed (≈1.3 fb\(^{-1}\))
June 4     Post-shutdown triggerlist online collecting cosmics
           Re-establish data collection
June 18    Recording and evaluating reconstructed data
           triggered with tracks, calorimeter, and muons
June 18    First Run IIa results (1.3 fb\(^{-1}\)) submitted for publication
July 23    Routine operation of upgrade systems
August 6   Return to 85% average data logging efficiency
October 1  Full complement AFEII production boards ready
November 19 First reports on Run IIb results
December 31 Log 2 fb\(^{-1}\) to tape
The divisions should update the laboratory staff profile required to fulfill Fermilab responsibilities to complete the Tevatron program.

Encourage the experiments and divisions to continue developing efficiencies that reduce the effective labor required to operate the Run II programs.

Continue to promote the Tevatron program to incoming Research Associates, and, starting in FY06, increase the number of CDF and DØ RA positions by two each.

Increase visitor budgets for outside personnel by approximately a factor of two.

In concert with the collaboration spokespeople, conduct negotiations with NSF, DOE, and foreign funding sources aimed at retaining or enhancing support for University resources in the areas of greatest risk.

Explore the possibility of contributions from the funding agencies for the creation of Tevatron Fellowships to support named university students (five each per experiment).

Similarly, explore the possibility of support from the funding agencies for the creation of Hadron Collider Fellowships to support post-docs (two each per experiment) resident at Fermilab. The three or four-year fellowships might initially focus on the Tevatron program with a transition to LHC occurring late in the second or early in the third year of the Fellowship.
The DØ Run IIb Upgrades

Suite of upgrades in preparation for large integrated and instantaneous luminosities

- Tracking Upgrades:
  - Layer 0 Silicon Detector
  - Enhanced front-end boards for Central Fiber Tracker (AFE II)

- Trigger Upgrades:
  - Level 1: Central Track Trigger, Calorimeter Trigger, Cal-Track Match
  - Level 2: Silicon Track Trigger (Layer 0), Processor Upgrade

- DAQ/Online System Upgrades

Executive Summary of Director’s Review of Upgrade Installation (October 2005):

- “Essentially ALL Hardware except AFE II is ready for installation!!!”
  (AFE II approved this year, expected to be complete Oct 2006)

- “The DØ Collaboration has achieved a status where they could have begun installation on October 31, 2005 as had been planned”

Now making best use of additional time until March 1 shutdown

- Goal: minimize duration of post-shutdown commissioning period
  → integrating upgrades into daily operations as much as possible
Upgrade of Level 1 Central Track Trigger

New electronics (larger FPGAs) make use of full granularity of Central Fiber Tracker

- Run IIa: doublet-hits only
- Run IIb: individual fibers

→ improved rejection of fake tracks (especially at high luminosity)

Split signals (2 sectors) into both Run IIa+b boards
- new electronics verified with real data
- testbed for new logic (plus special runs)

Rates and Efficiencies measured in data: significant rate reduction, efficiency ≈100%

![Diagram of Luminosity vs. Trigger Rate](image1)

![Diagram of Track Pt vs. Efficiency](image2)

**1 CTT track with \( p_T > 10 \text{ GeV/c} \)**

- Run 2A trigger
- Run 2B trigger

**Turn on curve for TTK(1,10) term**
Upgrade of Level 1 Calorimeter Trigger

- Replacing Legacy Run I system
- New functionality: clustering algorithms (FPGA)

- Running with split signals (subset of trigger towers) into both Run IIa+b electronics → full Run IIb trigger chain established
- Almost ready to operate full Run IIb system 24/7 to integrate into daily operations
Run IIb Trigger Menu

- Functionality of upgraded triggers essentially fully implemented in trigger simulation

- L1 trigger rate at 200e30 can be reduced to < 1.6kHz with same physics menu that runs at 100e30 (no efficiency loss)

- Shutdown postponed → currently working on final Run IIb triggerlist for 300e30
Silicon Layer 0 Upgrade

Radiation-hard silicon layer mounted between beampipe and current SMT

- extends lifetime of SMT
- robustness against HDI failures
- depletion voltage of DSDM detectors on inner layer projected to reach maximum at 5–7 fb⁻¹

- small radius + low mass
  → improved impact parameter resolution
- provides additional hit for pattern recognition
Status of Silicon Layer 0 Upgrade

- Detector complete, fully functional and ready to install!
- Final optical survey in progress

Sensors and analogue cables | Hybrids | Digital Cables
Layer 0 Tests and Integration

Detector performance is excellent
- No bad chips, <0.1% bad channels
- Alignment: within 2-3 $\mu$m of nominal positions
- Special provisions to minimize coherent noise:
  Ground planes on support structure, low inductance strip connections to sensors and hybrids, design minimizing capacitive couplings
- Noise measurement (operating 50% of detector): 2–2.5 ADC counts
- Cosmic ray test: MIP peak at 25–30 ADC counts $\rightarrow$ S/N is larger than 10

Integration into DØ Operations
- Test module in collision hall read out through full readout chain
- Now integrating monitoring tools into daily control room operations

![Histogram of Bad Channels](image1)

![Cluster Energy Distribution](image2)

- Entries: 4374
- Mean: 26.56
- RMS: 14.35
- Overflow: 54

Layer Zero Module Cluster Energy, Cosmic Muons

Cluster Energy, ADC counts
Installation of Layer 0 Detector

“Installation” in GEANT complete
- detector and passive material in GEANT
- digitization code and reconstruction geometry ready
- incorporation of new hits into pattern recognition almost complete

Procedure for installation in DØ in place and tested in dry runs
- proceeds through beampipe in Endcap calorimeter, then into SMT
- radial clearance less than 1 mm
- adequate tooling has been built and tested successfully with mockup detectors
DØ Computing Status

Reconstruction
- handled by farm at FNAL
- keeping up with data flow very well
- NEW: significant speed improvements (tracking), now roughly linear with inst. luminosity

Fixing
- second-pass reconstruction for improvements/corrections
- performed centrally

Skimming
- event streaming based on reconstructed physics objects
- performed centrally

Analysis
- NEW: deployed root-based Common Analysis Format (CAF) in summer 2005
- allowed sharing of analysis tools across all analyses
- transition completed in time for analysis of 1 fb\(^{-1}\) dataset
DØ World-Wide Computing

All Data-Handling via SAM ("data-grid"), 50 SAM Sites worldwide

Remote production activities via SAM-Grid:

- Monte Carlo: now producing >5M events per week
- Reprocessing: just completed reprocessing of 1B events
  - largest HEP activity on the grid
  - widely appreciated as shakedown in preparation for LHC
The 1 fb$^{-1}$ Dataset

Reprocessing and Fixing of 1 fb$^{-1}$ dataset complete
→ uniform dataset with latest calibration and algorithm improvements in hand

Examples of key low-level improvements:

- Improved energy resolution
  (width of $Z\rightarrow$ee peak improved by 13%)
- Vertex eff. now $\approx$100% out to $|z|=80$ cm
- Better vertex resolution, smaller tails
  → b-tagging significantly improved
MC Improvements for 1 fb$^{-1}$ Analyses

- Enhanced detail of GEANT geometry:
  coil windings, cooling pipes, SMT electronics and cabling...

- Simulating dead channels in tracking detectors, averaged over 1 fb$^{-1}$ dataset

- Using overlay of zero-bias data for modelling of detector noise, multiple interactions
| 1. | Search for Doubly-charged Higgs Boson Pair Production in the Decay to \( \mu^+\mu^+\mu^-\mu^- \) in p\( \bar{p} \) Collisions at \( \sqrt{s} = 1.96 \) TeV |
| 2. | Observation and Properties of the \( X(3872) \) Decaying to \( J/\psi \) \( \pi^+\pi^- \) in p\( \bar{p} \) Collisions at \( \sqrt{s} = 1.96 \) TeV |
| 3. | Search for Supersymmetry with Gauge-Mediated Breaking in Diphoton Events at DZero |
| 4. | Measurement of Dijet Azimuthal Decorrelations at Central Rapidities in p\( \bar{p} \) Collisions at \( \sqrt{s} = 1.96 \) TeV |
| 5. | Measurement of the \( B_s^0 \) Lifetime in the Exclusive Decay Channel \( B_s^0 \rightarrow J/\psi \phi \) |
| 6. | A Search for the Flavor-Changing Neutral Current Decay \( B_s^0 \rightarrow \mu^+\mu^- \) in p\( \bar{p} \) Collisions at \( \sqrt{s} = 1.96 \) TeV |
| 7. | Measurement of the Ratio of \( B^+ \) and \( B^0 \) Meson Lifetimes |
| 8. | Measurement of the Lambda-B Lifetime in the Decay \( \Lambda_B \rightarrow J/\psi \Lambda \) With the D0 Detector |
| 9. | A Search for \( W^+b \) and \( WH \) Production in p\( \bar{p} \) Collisions at \( \sqrt{s} = 1.96 \) TeV |
| 10. | Measurement of the WW Production Cross Section in p\( \bar{p} \) Collisions at \( \sqrt{s} = 1.96 \) TeV |
| 11. | A Measurement of the Ratio of Inclusive Cross Sections p\( \bar{p} \rightarrow Zb \)/p\( \bar{p} \rightarrow Zj \) at \( \sqrt{s} = 1.96 \) TeV |
| 12. | A search for anomalous heavy-flavor quark production in association with \( W \) bosons |
| 13. | First measurement of \( \sigma(pp\bar{p} \rightarrow Z\gamma)\cdot\text{Br}(Z\rightarrow\tau\tau) \) at \( \sqrt{s} = 1.96 \) TeV |
| 14. | Search for first-generation scalar leptoquarks in p\( \bar{p} \) collisions at \( \sqrt{s} = 1.96 \) TeV |
| 15. | Study of Z\( \gamma \) events and limits on anomalous ZZ\( \gamma \) and Z\( \gamma \)\( \gamma \) couplings in p\( \bar{p} \) collisions at \( \sqrt{s} = 1.96 \) TeV |
| 16. | Measurement of inclusive differential cross sections for \( \Upsilon(1S) \) production in p\( \bar{p} \)bar collisions at \( \sqrt{s} = 1.96 \) TeV |
| 17. | Measurement of the p\( \bar{p} \rightarrow W\gamma + X \) Cross section and Limits on Anomalous WW\( \gamma \) Couplings at \( \sqrt{s} = 1.96 \) TeV |
| 18. | Production of WZ Events in p\( \bar{p} \) Collisions at \( \sqrt{s} = 1.96 \) TeV and Limits on Anomalous WWZ Couplings |
| 19. | Search for neutral supersymmetric Higgs bosons in multijet events at \( \sqrt{s} = 1.96 \) TeV |
| 20. | Measurement of the \( t\bar{t} \) cross section in pp collisions at \( \sqrt{s} = 1.96 \) TeV using kinematic characteristics of lepton plus jets events |
| 21. | Measurement of the \( t\bar{t} \) cross section in p\( \bar{p} \) collisions at \( \sqrt{s} = 1.96 \) TeV using lepton plus jets events with lifetime b-tagging |
| 22. | Search for supersymmetry via associated production of charginos and neutralinos in final states with three leptons |
| 23. | Search for Randall-Sundrum Gravitons in Dilepton and Diphoton Final States |
| 24. | Search for right-handed W bosons in top quark decay |
| 25. | Search for single top quark production in p\( \bar{p} \) collisions at \( \sqrt{s} = 1.96 \) TeV |
| 26. | Measurement of the \( t\bar{t} \) production cross section in p\( \bar{p} \) collisions at \( \sqrt{s} = 1.96 \) TeV in dilepton final states |
| 27. | Search for large extra spatial dimensions in dimuon production at DZero |
| 28. | Measurement of semileptonic branching fractions of B mesons to narrow D** states |
| 29. | Measurement of the lifetime difference in the Bs system |
| 30. | Search for the Higgs Boson in \( H \rightarrow WW(*) \) Decays in p\( \bar{p} \) Collisions at \( \sqrt{s} = 1.96 \) TeV |
| 31. | The Upgraded D0 Detector |
| 32. | Measurements of the isolated photon cross section in p\( \bar{p} \) Collisions at \( \sqrt{s} = 1.96 \) TeV |

**32 Publications plus 9 in final stages of review**

**62 Conference Results**
Inclusive single muon triggers down to $p_T > 3$ for $|\eta| < 2.0$

→ Large sample of flavor-tagged semi-leptonic $B_s$ candidates (0.61 fb$^{-1}$):

about 4200 $B_s \rightarrow D_s \mu X$ with $D_s \rightarrow \Phi \pi$ and $D_s \rightarrow K^* K$ (34k before tagging)

Opposite-side flavor tagging:

- Muon or electron, jet charge, secondary vertex charge and $p_T$, event charge
- all combined into single likelihood ratio: $\epsilon D^2 = (1.94 \pm 0.14 \pm 0.09) \%$

Reminder: Significance = 
\[
\sqrt{\frac{S \epsilon D^2}{2}} e^{-0.5(\Delta m_s \sigma_t)^2} \sqrt{\frac{S}{S+B}}
\]
B_s Mixing Results

Numerous improvements in the pipeline:

- more channels: D_s plus electron (signal in hand)
- refined flavor tagging
- use event-by-event dilution for limit setting
- unbinned amplitude fit
- more statistics

Expecting sensitivity between 12 and 14 ps^{-1} in 1 fb^{-1} from D_s+lepton alone
Bs Mixing Run IIb Projections

- Expecting to extend sensitivity well beyond Standard Model prediction
  - will require inclusion of hadronic channels (in progress)
  - Layer 0 Upgrade will improve VPDL resolution
  - Securing computing resources to reconstruct additional 50 Hz dedicated to B physics
    - request for funding from IU and UO pending approval
    - recommissioning retired farms from FNAL and UO

---

Integrated Lumi for Observation at 3\(\sigma\) in fb

- Hadronic
- Layer 0
- Semileptonic + BW upgrade

\(\sigma(\tau) \sim 150\) fs
\(\sigma(\tau) \sim 75\) fs

\(\Delta m_s [ps^{-1}]\) from global fits 95% C.L. region
“Bread and Butter” Physics

Results available for full set of EW processes
- important backgrounds to rare signals at Tevatron and LHC
- studying (differential) cross sections, asymmetries to extract information on PDFs, anomalous couplings etc.

Example: W/Z+jets production
- major background to Top and Higgs signals
- several new generators on the market: alpgen, CKKW-Pythia, Sherpa
- first results available for alpgen, more to follow soon
- working in close collaboration with theorists
Measurement of the W mass

Analysis in progress, no approved results available yet

- last pass at calorimeter calibration and new improved MC provide solid basis for high-precision results

Current DØ estimates for uncertainty on $m_W$ (stat+syst):

- From $M_T$ Fit, central electrons only, 200 pb$^{-1}$: ±120 MeV
- Extrapolation to 2 fb$^{-1}$: ±48 MeV
  (Error dominated by electron energy scale uncertainties)
The Search for Single Top Production

Single top cross section: direct measurement of $V_{tb}$

**Winter 2005 publication (230 pb$^{-1}$):**
- s-channel: $\sigma < 6.4$ pb (expected: 4.5 pb)
- t-channel: $\sigma < 5.0$ pb (expected: 5.8 pb)

**Summer 2005 prel. (370 pb$^{-1}$):**
- s-channel: $\sigma < 5.0$ pb (expected: 3.3 pb)
- t-channel: $\sigma < 4.4$ pb (expected: 4.3 pb)

1 fb$^{-1}$ analysis in preparation for Moriond

Expect to achieve 3$\sigma$ sensitivity by summer
Properties of the Top Quark

Towards measurements of the complete set of quantum numbers

Top Charge: preliminary results sent to PANIC 2005

- Charge consistent with $2/3e$, $4/3e$ excluded at 94% CL

![Graph showing the reconstructed top charge distribution with data points and theoretical predictions.](image)
Properties of the Top Quark

Towards measurements of the complete set of quantum numbers

Top Charge: preliminary results sent to PANIC 2005
- Charge consistent with $2/3e$, $4/3e$ excluded at 94% CL

Top electroweak coupling: any hint of V+A contribution? → W-Helicity

Combined results from $t+j$ and dilepton channels:

$$ f^+ = 0.04 \pm 0.11 \text{ (stat)} \pm 0.06 \text{ (syst)} \rightarrow f^+ < 0.25 \text{ at 95% C.L.} $$
Properties of the Top Quark

Towards measurements of the complete set of quantum numbers

Top Charge: preliminary results sent to PANIC 2005
- Charge consistent with $2/3e$, $4/3e$ excluded at 94% CL

Top electroweak coupling: any hint of $V+A$ contribution? → W-Helicity

Combined results from l+jets and dilepton channels:
$$f^+ = 0.04 \pm 0.11 \text{ (stat)} \pm 0.06 \text{ (syst)} \rightarrow f^+ < 0.25 \text{ at 95% C.L.}$$

Top electroweak coupling: $V_{tb}$ from $R=\text{BR}(t \rightarrow Wb)/\text{BR}(t \rightarrow Wq)$

Simultaneous measurement of $R$ and $t\bar{t}$ cross section
$$R=1.03^{+0.19}_{-0.17} \rightarrow |V_{tb}| > 0.80 \text{ at 95% C.L.}$$

Top Spin: measurement in progress
Measurement of the Top Mass

New preliminary mass measurement using matrix element technique (320 pb\(^{-1}\))

Significant improvement: in-situ calibration of jet energy scale using \(W \rightarrow qq\)

Result:

\[ m_{\text{top}} = 169.5 \pm 4.4(\text{stat} + \text{JES}) \pm 1.7(\text{syst}) \text{ GeV} \]

(JES scale factor = 1.034 \pm 0.034)

New Tevatron combination (TEVEWWG):

\[ m_{\text{top}} = 172.7 \pm 1.7(\text{stat}) \pm 2.4(\text{syst}) \text{ GeV} \]

Implications for mass of SM Higgs boson:

\[ M_H = 91^{+45}_{-32} \text{ GeV} \]

\[ M_H < 186 \text{ GeV at 95% C.L.} \]
Currently finalizing improved jet energy calibration
- based on latest calorimeter calibration
- improved photon identification → less background
- MC studies to understand possible bias from background contamination
- numerous refinements in calibration procedure

Goal: uncertainty < 2.5% (for 50 GeV jets in central region)
- closure tests are within 2% (preliminary)

Focus is now shifting towards high-precision calibration of b-jets
Measurement of the Top Mass

Projection of error on top mass for remainder of Run II:

- Normalizing stat. and syst. error to current performance at 300 pb$^{-1}$
- Irreducible syst. uncertainty of ±1.1 GeV (±1 GeV correlated across experiments)

→ Projected error of 1.4 (1.2) GeV with 4 fb$^{-1}$ (8 fb$^{-1}$)!

Projected systematic errors on $m_t$

<table>
<thead>
<tr>
<th>Source</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>JES $p_T$ dependence</td>
<td>± 0.35</td>
</tr>
<tr>
<td>B-jet energy scale</td>
<td>± 0.7</td>
</tr>
<tr>
<td>Signal Modeling (gluon rad.)</td>
<td>± 0.4</td>
</tr>
<tr>
<td>Background Modeling</td>
<td>± 0.4</td>
</tr>
<tr>
<td>MC calibration</td>
<td>± 0.4</td>
</tr>
<tr>
<td>Trigger</td>
<td>± 0.1</td>
</tr>
<tr>
<td>PDF’s</td>
<td>± 0.3</td>
</tr>
<tr>
<td>Total</td>
<td>± 1.1</td>
</tr>
</tbody>
</table>
Search for the Standard Model Higgs Boson

Recent results from DØ:

- \( WH \to WWW \) in like-sign dileptons (370 pb\(^{-1}\), prel.)
- \( WH \) in electron channel (382 pb\(^{-1}\), prel.)
- \( ZH \to \nu\nu b\bar{b} \) (261 pb\(^{-1}\), prel.)
- \( H \to WW \) (325 pb\(^{-1}\), accepted by PRL)

Second-generation analyses with 1 fb\(^{-1}\) dataset in progress
Algorithm Improvements for 1 fb$^{-1}$ Analyses

B-Tagging using neural network

- Combining information from secondary vertex and jet impact parameter tagger
- Significant Improvement: efficiency increase by 34% (at fake rate of 0.5%)
- Further improvements expected from new vertexing

Jet energy measurement using tracks

- Tracking detectors provide precise measurement of low-momentum particles
- Combining with cal. information leads to 10% improvement in jet energy resolution
- Expecting further improvements from measurement of single pion response and further tuning of the algorithm
Shortcomings in current analyses understood, improvements ready and demonstrated to be sufficient for WH/ZH/H→WW:

- b-tagging: Neural-Network tagging, efficiency increase 34% per jet → factor 1.8!
- mass resolution: “TrackCalJets”, improvement >20% 
- missing channels and acceptance: add isolated tracks, forward leptons, ZH→ ℓℓbb 
- multivariate techniques 
- combining channels, experiments: TEVNPHWG and procedures in place
Search for SUSY Higgs Bosons

- MSSM predicts at least one light Higgs boson → ideal for searches at Tevatron
  - can use re-interpretation of SM Higgs searches
  - in addition: dedicated SUSY Higgs searches in large $\tan\beta$-region

- Large $\tan\beta$: $hbb$-coupling enhanced
  → large cross-sections for $h(b\bar{b})$ production
  → both $h \rightarrow b\bar{b}$ and $h \rightarrow \tau\tau$ are accessible

- Search for $hb(b) \rightarrow b\bar{b}b(b)$ published (260 pb$^{-1}$), analyses with $h \rightarrow \tau\tau$ in progress
- Combined analyses promise significant reach in ($\tan\beta, m_A$)-plane

\[ h \rightarrow b\bar{b} \quad \text{and} \quad h \rightarrow \tau\tau \]

\[ \mu = -200 \text{ GeV}, \quad M_t = 200 \text{ GeV}, \quad m_g = 0.8 M_{\text{SUSY}} \]
\[ M_{\text{SUSY}} = 1 \text{ TeV}, \quad \chi_\mu = \sqrt{6} M_{\text{SUSY}} (m_h^{\max}), \quad \chi_\tau = 0 \text{ (no-mixing)} \]
Search for Supersymmetry – Squarks/Gluinos

- DØ search sets new limits in squark/gluino mass plane
- Have reached sensitivity beyond Run I and LEP limits
- Run IIb projection: can probe squark masses up to about 400 GeV
Search for Supersymmetry – Squarks/Gluinos

- \( \bar{q}q \) candidate event
  \( (E_T = 354 \text{ GeV}, p_T^{j1} = 264 \text{ GeV}, p_T^{j2} = 106 \text{ GeV}) \)

- DØ search sets new limits in squark/gluino mass plane
- Have reached sensitivity beyond Run I and LEP limits
- Run IIb projection: can probe squark masses up to about 400 GeV
Search for Charginos and Neutralinos

- Production cross section (electroweak) relatively small
  → need clean leptonic signature to suppress backgrounds

- Golden channel: $\tilde{\chi}^\pm \tilde{\chi}_2^0 \rightarrow 3\ell + E_T$

- Experimental Challenge: low-$p_T$ leptons
  → need multilepton triggers with low thresholds
  → need efficient lepton identification at low $p_T$

- Analysis Strategy:
  - two identified leptons ($e$, $\mu$, $\tau$) plus isolated track

---

**Diagram Description**

- $\tilde{\chi}^\pm$ and $\tilde{\chi}_2^0$ decay to $3\ell + E_T$
- $q'$, $W^*$, $Z^*$, $\nu$, $1^\pm$

**Histograms**

- DØ, 320 pb$^{-1}$
- Eel selection

<table>
<thead>
<tr>
<th>Leading Lepton</th>
<th>Next-to-Leading Lepton</th>
<th>3rd Lepton</th>
</tr>
</thead>
<tbody>
<tr>
<td>M(slepton) = 116 GeV</td>
<td>M(neutralino2) = 110 GeV</td>
<td>M(chargino) = 106 GeV</td>
</tr>
</tbody>
</table>

- Events / 2 GeV
- $p_T^3$ (GeV)
- Data, Z/$\gamma$, QCD, W + jet / $\gamma$, WW, WZ, ZZ, $t\bar{t}$, SUSY
Published analysis constrains SUSY beyond LEP chargino limits:

- **3l-max scenario:** $m_{\tilde{\chi}^\pm} > 117$ GeV
- **heavy-squarks scenario:** $m_{\tilde{\chi}^\pm} > 132$ GeV

**High tan$\beta$-region very challenging**
Search for Charginos and Neutralinos

Run IIb projections (assuming some analysis improvements):

- $3\ell$-max scenario: will probe $m_{\tilde{\chi}^\pm} > 200$ GeV
- large-$m_0$ scenario: sensitive up to $m_{\tilde{\chi}^\pm} \approx 150$ GeV

High $\tan\beta$-region very challenging
Supersymmetry and $B_S \rightarrow \mu^+ \mu^-$

SM prediction: $\text{BR}(B_S \rightarrow \mu^+ \mu^-) = 3.8 \times 10^{-9}$

SUGRA: enhancement $\sim (\tan \beta)^6$

$\rightarrow$ significant at high $\tan \beta$: $\text{BR} = O(10^{-7})$

$\rightarrow$ complementary to trilepton search

- Tevatron: large production rate for $B_S$
- Selection: two isolated muons, displaced vertex

![Graph and diagrams showing SM prediction and SUGRA enhancement](image-url)
Supersymmetry and $B_S \rightarrow \mu^+ \mu^-$

Results (limits at 95% C.L.):

- **DØ** (300 pb$^{-1}$): $4.3 \pm 1.2$ expected, 4 observed → $\text{BR}(B_S \rightarrow \mu^+ \mu^-) < 3.7 \times 10^{-7}$
- **CDF** (364 pb$^{-1}$): $1.5 \pm 0.2$ expected, 0 observed → $\text{BR}(B_S \rightarrow \mu^+ \mu^-) < 2.0 \times 10^{-7}$

**TEVNPHWG Combination:** $\text{BR}(B_S \rightarrow \mu^+ \mu^-) < 1.5 \times 10^{-7}$

- DØ result will be updated with 1 fb$^{-1}$ by Moriond
- **Projection for Run IIb:** sensitivity will approach $10^{-8}$
  → will test large part of SUGRA parameter space

Dedes, Dreiner, Nierste, Richardson
(hep-ph/0207026)
Conclusions

- Detector operating very well, close to 1.1 fb\(^{-1}\) accumulated so far
- Long-term planning to maintain efficient operation while LHC is ramping up
- Run IIb Layer 0 and trigger upgrades ready to install
  - currently integrating parallel slices into operations
  - expect a 14-week shutdown no later than March 1, 2006
- Calibration/Reconstruction/Simulation mature
- Reprocessing completed, 1 fb\(^{-1}\) dataset being analyzed
- Wealth of physics results, 30 publications within one year
- Potential for measurements/discoveries that will advance the field in several key areas

\[ \delta M_t = 1.2 \text{ GeV}, \]
\[ \delta M_W = 24 \text{ MeV}, \text{ world avg} \]
\[ \text{(LEP2 + } \delta M_W = 30 \text{ MeV(Tevatron), no LEP/TeV correlations)} \]