

DØ Experiment and BNL

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(for the BNL-DØ Group)

BNL DOE Review

Brookhaven National Laboratory, April 22-23, 2004

Outline

- **Overview of DØ Experiment**
- **BNL-DØ Personnel**
 - **Current Masthead**
- **Major Contributions**
 - **Software**
 - **Hardware**
- **Current Status**
 - **Snapshot of physics results in the first 250 pb⁻¹ of data**
- **Closing Remarks**



➤ Composition of the collaboration

- **638 collaborators**
 - 140 graduate students
 - 92 postdocs
- **77 institutions from 19 countries**
 - 36 US, 41 non-US
- **160+ Ph.D.'s awarded**
 - 16 Run II Ph.D.'s

➤ Run I publications (1993 – present)

- **125 physics papers published or accepted; recent additions include:**
 - “Search for large extra dimensions in monojet + E_T channel with DØ”, PRL 90 (2003).
- **additional 3 submitted, include:**
 - “An Improved Measurement of the Top Quark Mass”, Nature (2004).
 - lepton+jets: $M_{top} = 180.1 \pm 3.6$ (stat) ± 3.9 (syst) GeV/c² = 180.1 ± 5.3 GeV/c²

➤ Run II

- **40 analyses in review; 2004 DØ Publication Plan: 30 publications**
 - “Search for Doubly-charged Higgs Boson Pair Production”, (hep-ex/040415), submitted to PRL.
 - “Observation and Properties of the State $X \rightarrow J/\psi \pi^+ \pi^-$ in $p\bar{p}$ collisions at $\sqrt{s}=1.96$ TeV at DØ”, under collaboration review.



➤ **Current BNL-DØ Masthead**

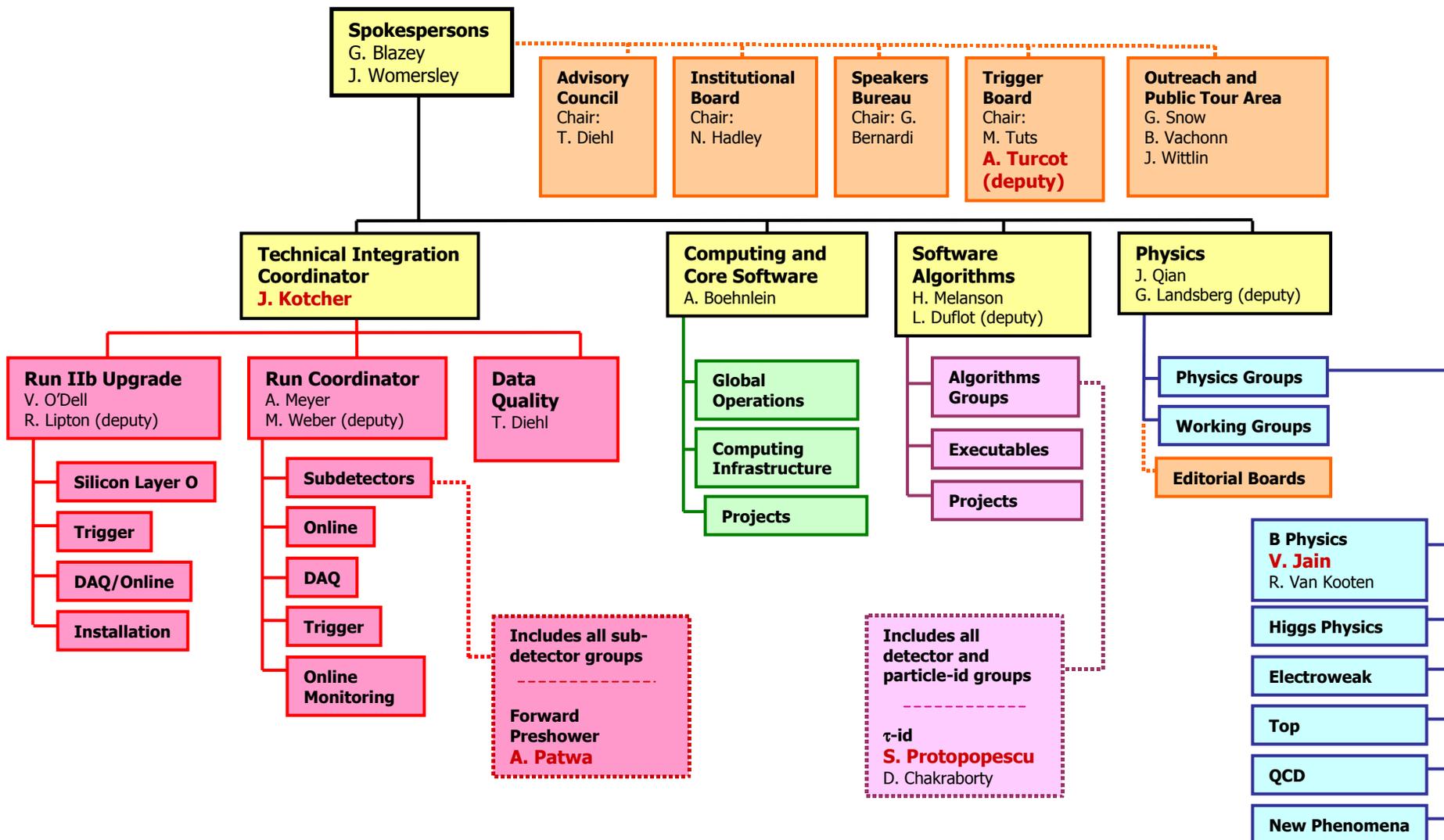
- **V. Jain, S. Kahn, J. Kotcher, A. Patwa, S. Protopopescu, S. Snyder, A. Turcot, K. Yip**
- **6 scientists >90% DØ, 2 at the >25% level**
- **1 post-doc (Patwa), remaining are full-time staff**
- **3 resident at Fermilab: Kotcher, Patwa, Turcot**

➤ **Major contributions to hardware, software and physics**

- **Key leadership roles**
 - **Jain — Co-Leader of B-physics analysis group**
 - **Kotcher — Run IIB Upgrade Project Manager (past), Run II Technical Integration Coordinator (present)**
 - **Patwa — Coordinator FPS subdetector operations and commissioning**
 - **Protopopescu — Co-Leader: offline algorithms (past), simulation software (past), tau-id group (present)**
 - **Turcot — Co-Leader: calorimeter and preshower software development (past); Co-convener of Higgs Multi-jet subgroup; Deputy Chair: Run II Trigger Board**
- **and “working” roles...**



DO Organization



BNL continues to play prominent leadership role and is heavily involved in areas of detector operation, trigger, software, and physics analysis



- **BNL playing integral contribution in management as well as hardware and software at all levels**
- **Hardware and Software Contributions**
 - **FPS commissioning and operations (Patwa)**
 - **Development of online infrastructure software (Snyder)**
 - **Run II trigger development (Turcot)**
 - **Development of L1 track trigger simulation software (Jain)**
 - **Integration of Silicon Track Trigger (Jain)**
 - **Offline infrastructure and analysis software (Jain, Protopopescu, Snyder)**
 - **Tau-id offline algorithm and trigger tools (Protopopescu, Patwa)**
 - **Offline calorimeter software (Kahn)**
 - **Software development for FPS (Patwa, Protopopescu, Turcot)**
 - **Run II management (Kotcher)**
- **Physics analyses focused on two primary topics**
 - **Searches and physics beyond the SM**
 - **Higgs (Kahn, Snyder, Turcot)**
 - **SUSY – τ channel (Patwa, Protopopescu)**
 - **Heavy Flavor Physics**
 - **B_s mixing, X(3872), lifetime studies (Jain)**
 - **K_s reconstruction (Yip)**



- **Detector operating stably and efficiently**
 - We have $\sim 310 \text{ pb}^{-1}$ of data recorded (398 pb^{-1} delivered)
 - Some luminosity used for commissioning, tests, calibrations, etc...
 - Utilizing both on-site and off-site data processing: entire 200 pb^{-1} pre-Sept '03 shutdown data processed and available for physics studies

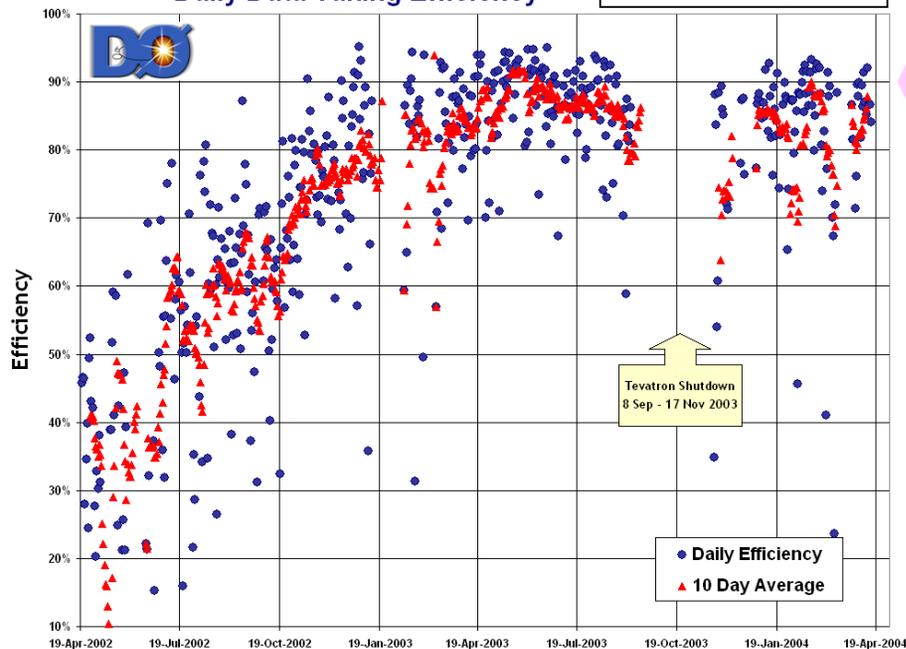
- **Present work**
 - Commissioning and integrating Silicon Track Trigger (STT) into readout
 - Integrating Forward Proton Detector (FPD)
 - Optimizing triggers for efficient data taking at higher Run II luminosities
 - Continually improving systems to enhance long-term operation and reliability

- **DØ Run II Physics program building momentum**
 - Broad range of physics results presented at Winter 2004 conferences
 - Top, Higgs, New Phenomena, Electroweak, QCD, B-physics

- **Run IIb upgrades are baselined, approved, and making excellent progress**
 - Silicon Layer Zero, Trigger, and DAQ

Daily Data Taking Efficiency

19 April 2002 - 15 April 2004



Recording physics quality data with high ($\sim 90\%$) efficiency

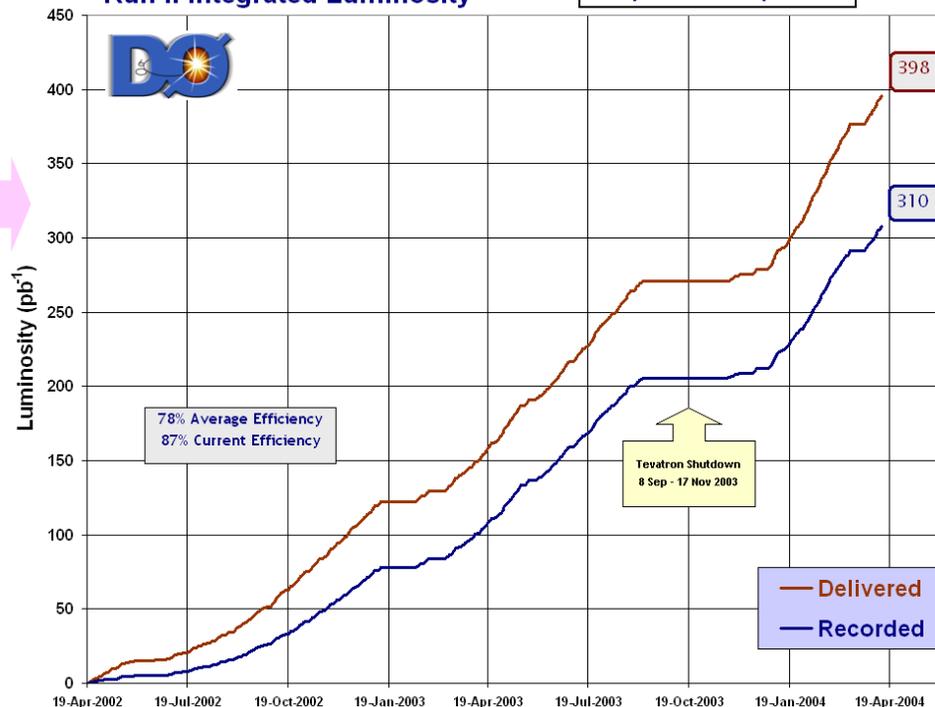
- $\sim 2 \text{ pb}^{-1}$ on typical "good" day
- $\sim 10 \text{ pb}^{-1}$ on typical "good" week (\approx Run Ia)
- Coming days... updated trigger menu will be installed for higher luminosities

$\sim 310 \text{ pb}^{-1}$ of data to tape

- $\sim \times 2.5$ Run I (125 pb^{-1})
- $150\text{--}250 \text{ pb}^{-1}$ being used in current physics analyses
- Just in the last couple of months... DØ computing systems served up to 8 billion events for analysis

Run II Integrated Luminosity

19 April 2002 - 15 April 2004



Remote International Monitoring for the DØ Experiment

Detector Monitoring data sent in real time over the internet



Fermilab 



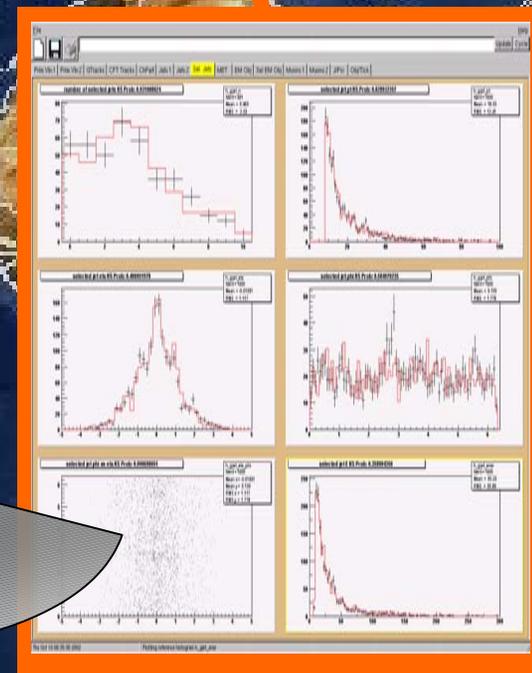
NIKHEF 
Amsterdam

DØ physicists in Europe and Asia use the internet and monitoring programs to examine collider data in real time and to evaluate detector performance and data quality.

They use web tools to report this information back to their colleagues at Fermilab.

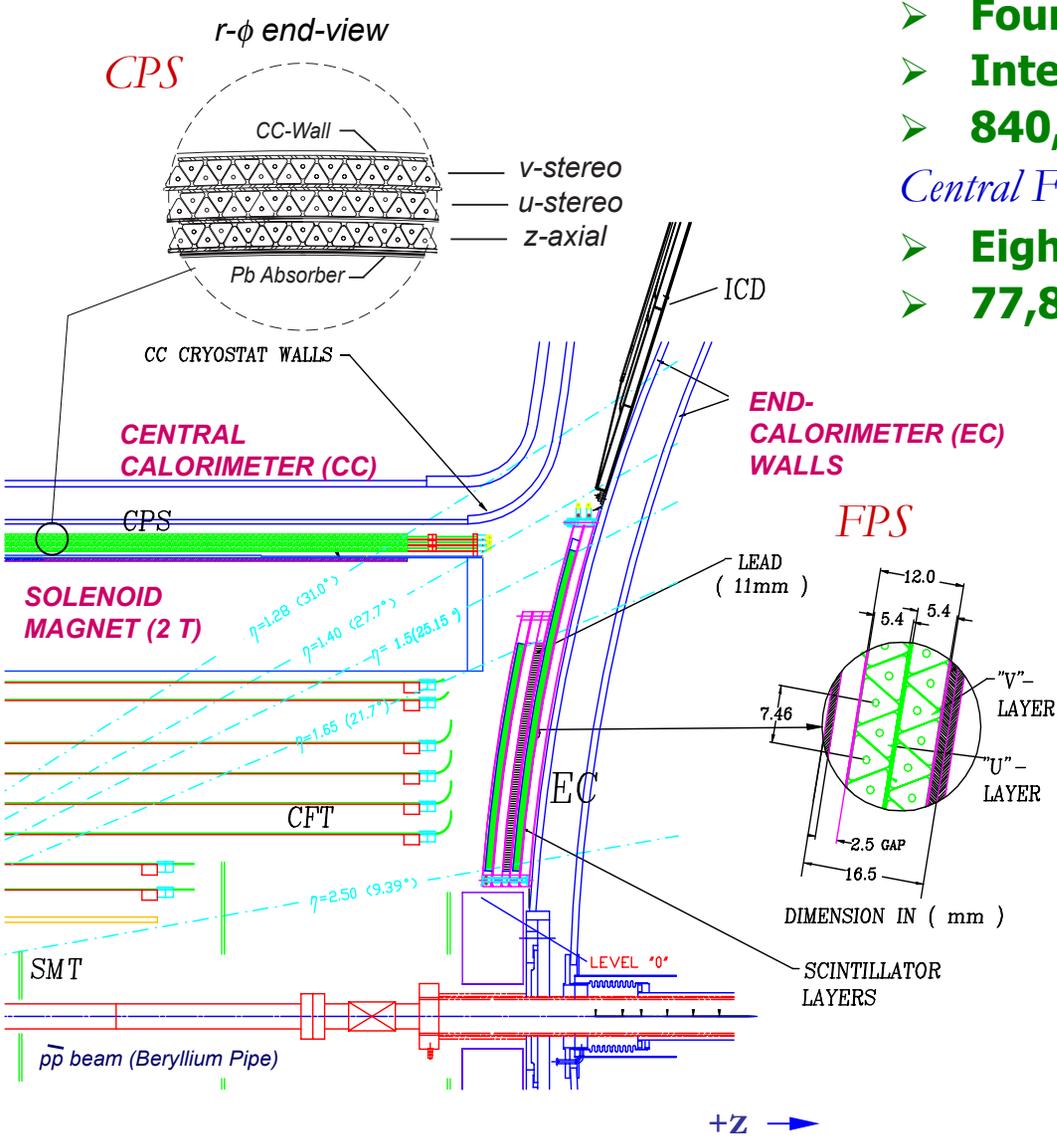


Detector



All daytime detector monitoring shifts are now run from Brazil 

Semi-quarter (r-z) view of DØ Detector



Silicon Tracker (SMT)

- **Four layer barrels (double/single sided)**
- **Interspersed double sided disks**
- **840,000 channels**

Central Fiber Tracker (CFT)

- **Eight layer sci-fi ribbon doublets (z-u, z-v)**
- **77,800 fibers using VLPC readout**

2T Solenoid

- **Encloses SMT and CFT**

Central (CPS) and Forward (FPS) Preshowers

- **Scintillator strips, WLS fibers readout**
- **axial + stereo (Central) and stereo (Forward)**
- **7,680 channels (Central)**
- **14,968 channels (Forward)**
- **VLPC readout**

BNL/SB: FPS design, software, construction, installation, operation and commissioning



+z
L1
L4



Forward Preshower

➤ Enhances DØ's electron, photon triggering capability and offline identification

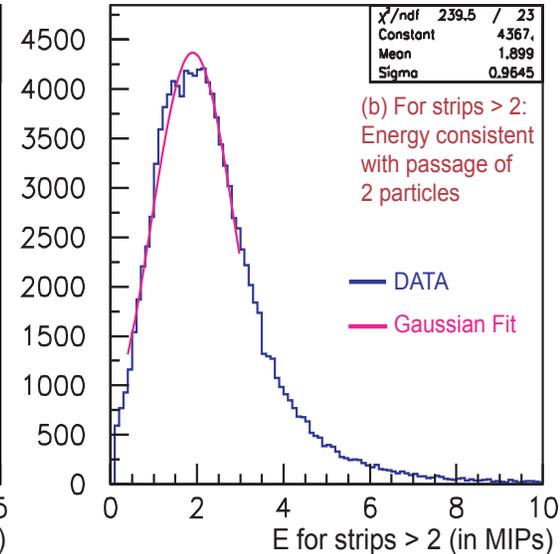
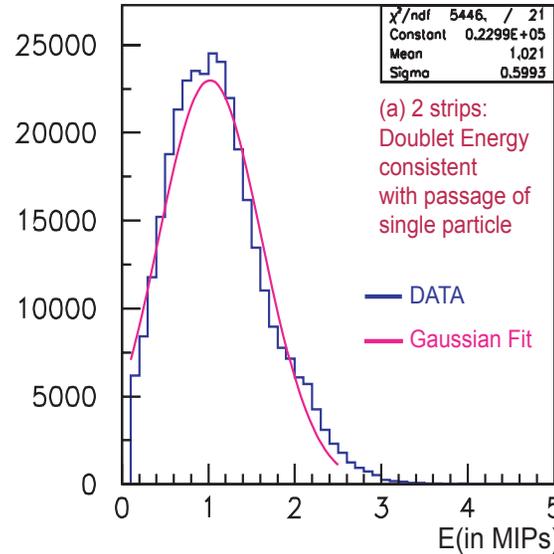
➤ System has been operating stably and in final stages of commissioning

- Performance being optimized jointly with entire DØ VLPC detectors
- FPS trigger being phased into readout

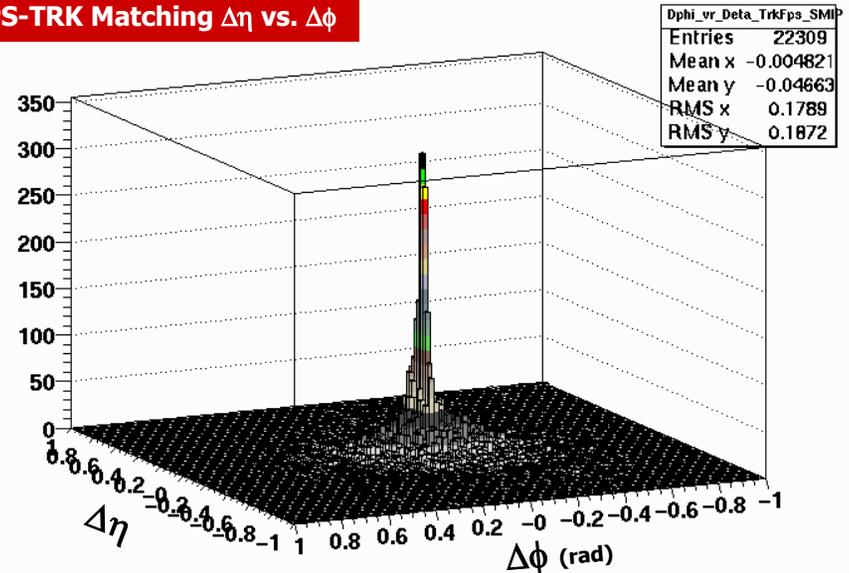
➤ Offline reconstruction using matched u,v clusters and energy calibration

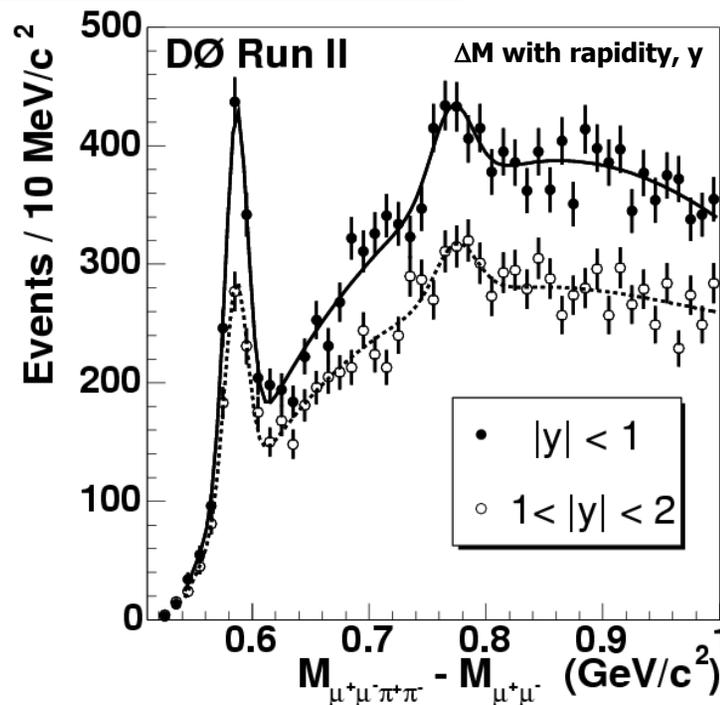
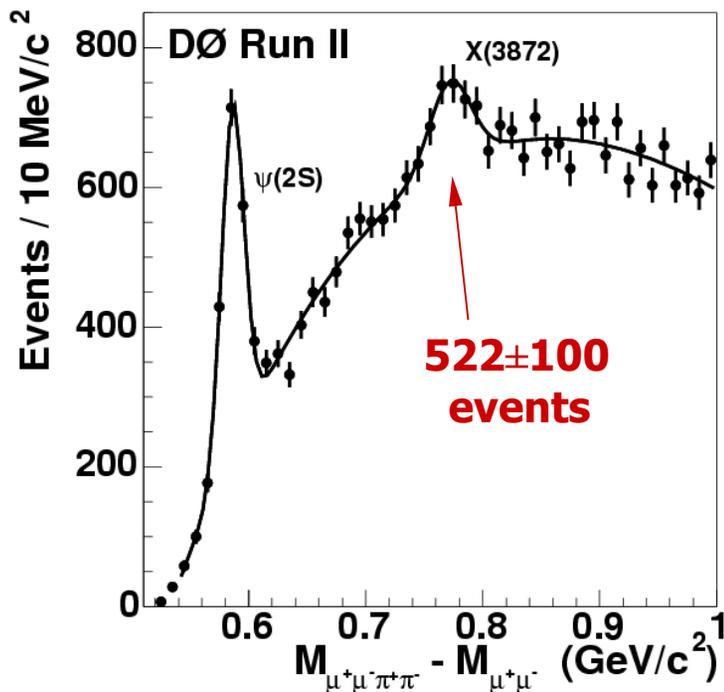
- MIP peaks with collider data → calibration
- Cluster matching with DØ inner tracking

MIP Energy in FPS Layer – (a) two strips and (b) > two strips



FPS-TRK Matching $\Delta\eta$ vs. $\Delta\phi$



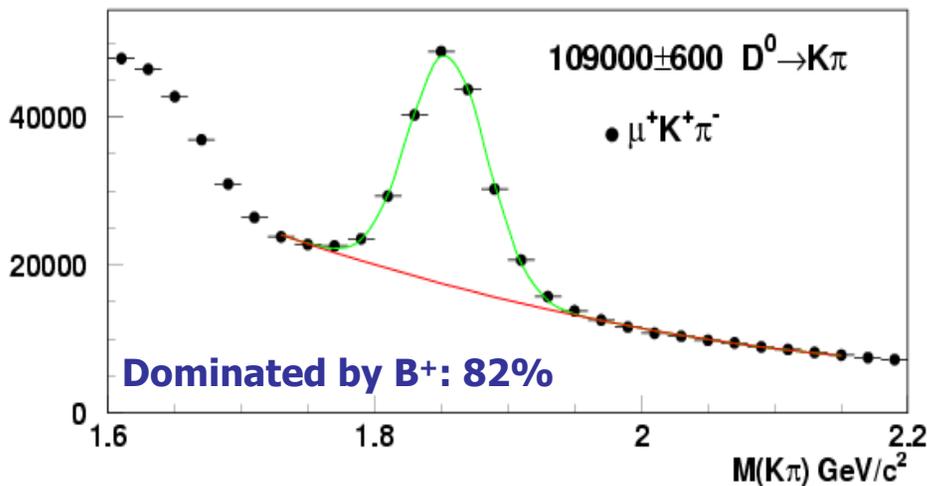


$\Delta M = 0.7749 \pm 0.0031$ (stat) ± 0.003 (syst) GeV/c^2

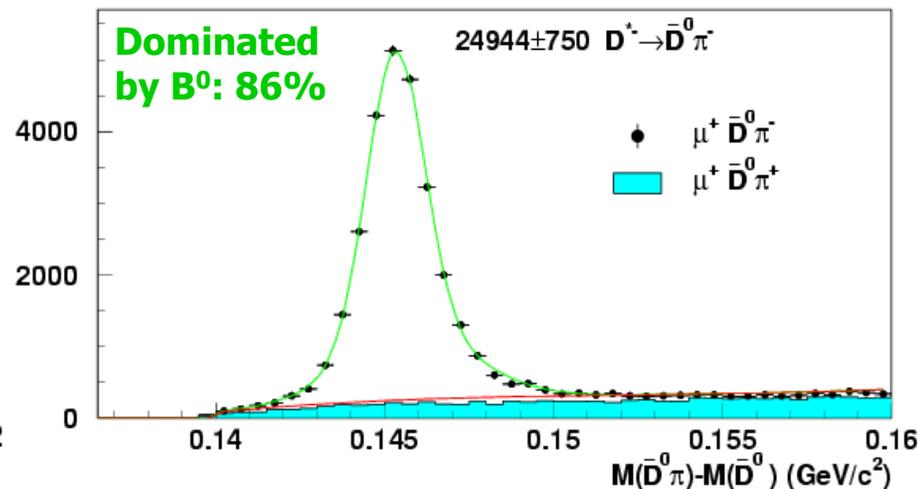
- **Last Summer, Belle discovered new state**
 - $X \rightarrow J/\psi \pi^+ \pi^-$, where $J/\psi \rightarrow \mu^+ \mu^-$
 - Belle's discovery confirmed by CDF and DØ
- **Production of X with $\psi(2S)$ compared using different variables**
 - e.g., looking at rapidity, y , results appear to be consistent with $\psi(2S)$
- **What kind of particle is the X?**
 - Charmonium, D-meson molecule, ...

- **Novel technique to measure $\tau(B^+)/\tau(B^0)$**
 - **Divide $B^+ \rightarrow D^0\mu X$ and $B^0 \rightarrow D^*\mu X$ each into 7 time intervals**
 - **Measure ratio of events in time bins**

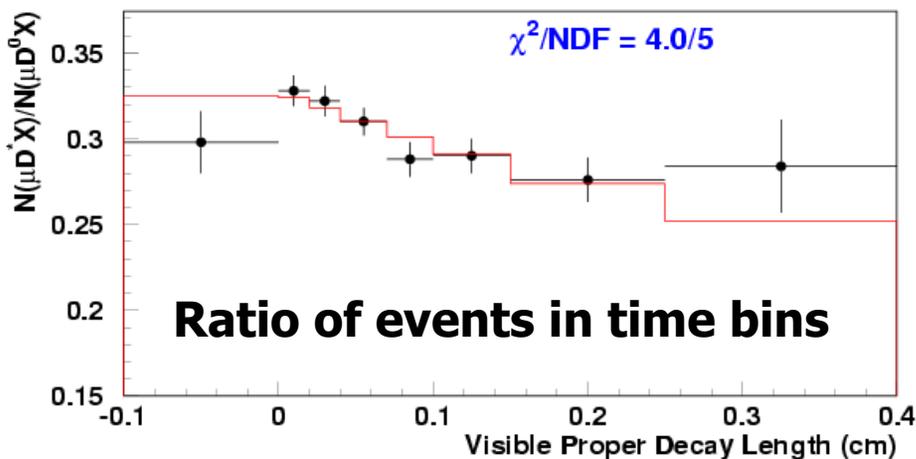
DØ RunII Preliminary, Luminosity=250 pb⁻¹



DØ RunII Preliminary, Luminosity = 250 pb⁻¹



DØ RunII Preliminary, Luminosity = 250 pb⁻¹



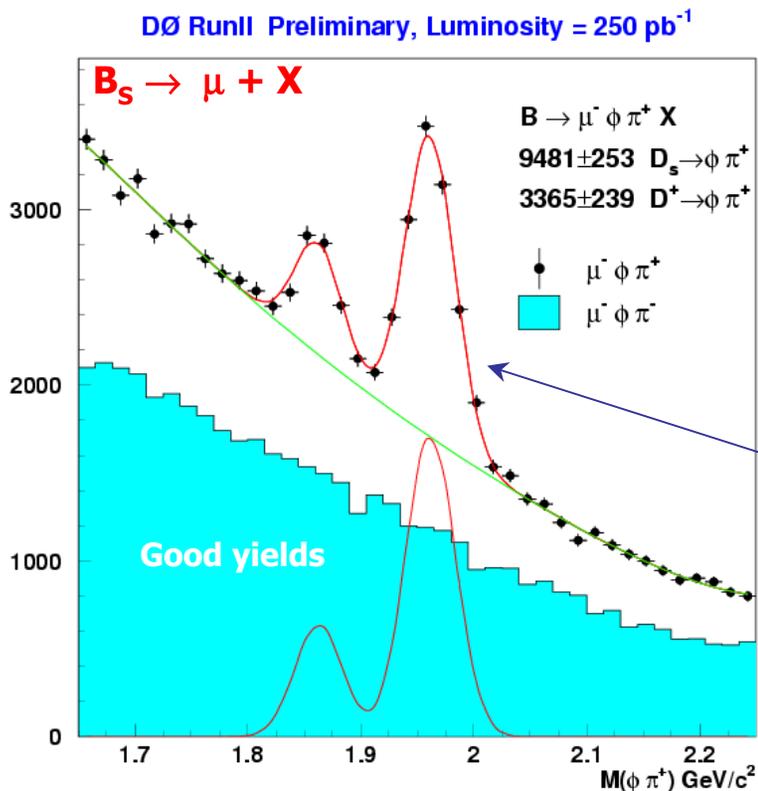
Ratio = 1.093 ± 0.021 ± 0.022

... and one of the more precise results

- Use $D^* + \mu$ sample to measure B_d Mixing (opposite μ to tag flavor)

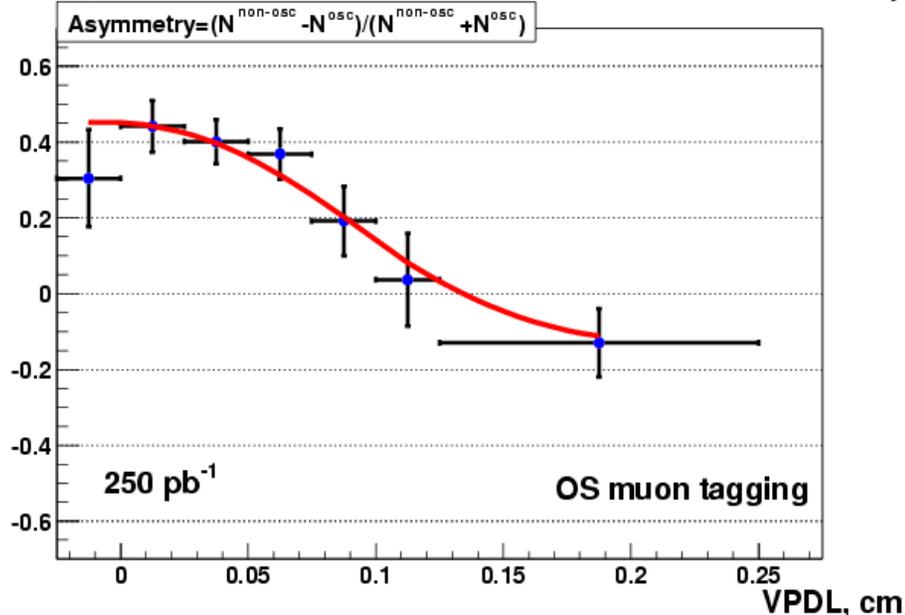
$$\Delta m_d = 0.506 \pm 0.055 \pm 0.049 \text{ ps}^{-1}$$

- One of the more precise Tevatron results



B_d oscillations

DØ Run II Preliminary



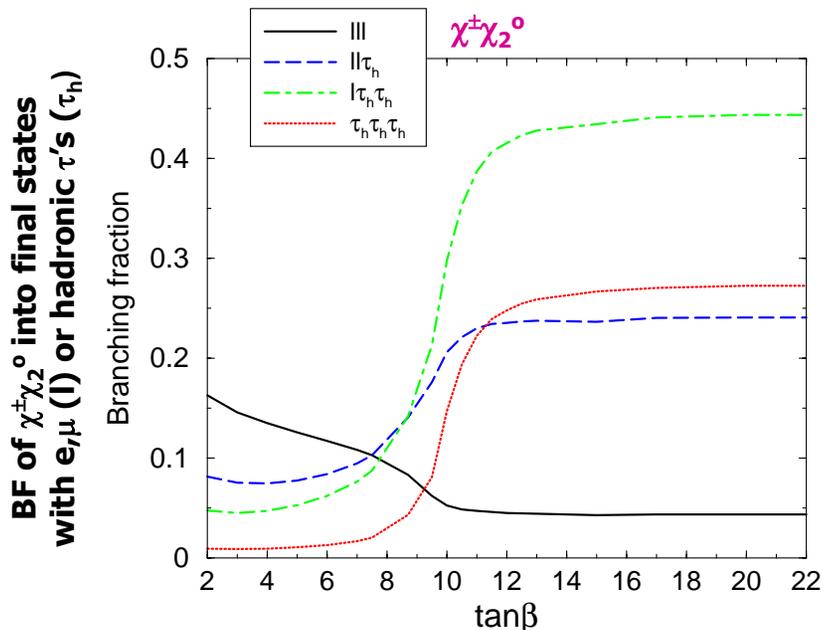
- B_s mixing: much faster

$$\Delta m_s > 14.4 \text{ ps}^{-1}$$

- Semi-leptonic: large yields but proper time resolution is an issue
- Hadronic mode: low yields but better resolution

- Studies actively progressing

➤ **Detecting τ 's critical in any SUSY search in multi-lepton final states**



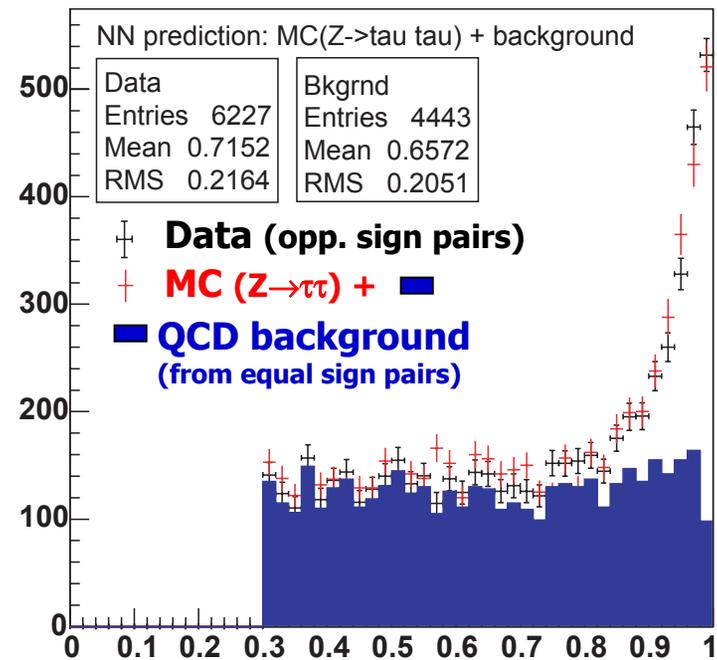
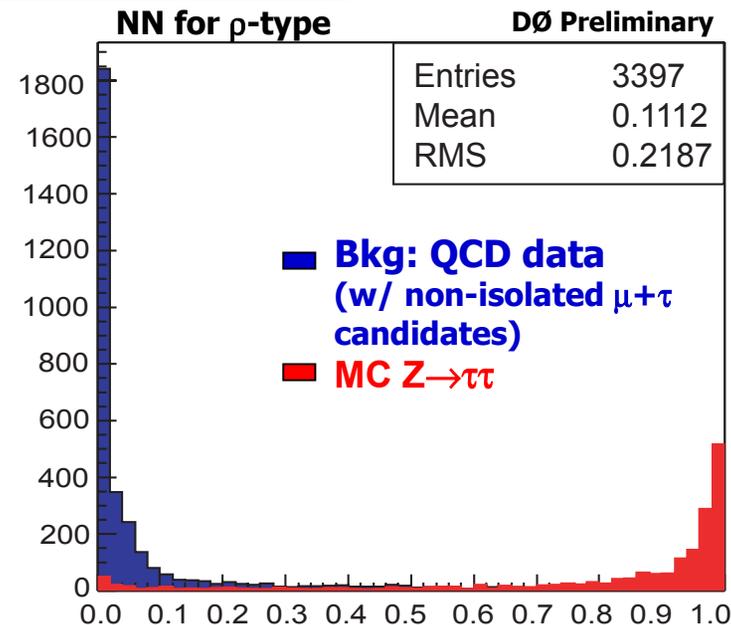
➤ **For $\tan\beta \geq 8$, final states dominated by τ 's**

➤ **Use Neural Networks (NN) to identify τ 's**

- variables that measure jet narrowness, calorimeter and track isolation, and track multiplicity
 - NN per decay type: π , ρ , 3-prong
- richest channels are $W \rightarrow \tau\nu$ and $Z \rightarrow \tau\tau$
 - essential step for understanding τ -id

➤ **Apply offline selections and measure NN**

- Background: NN \rightarrow 0.0, Signal: NN \rightarrow 1.0

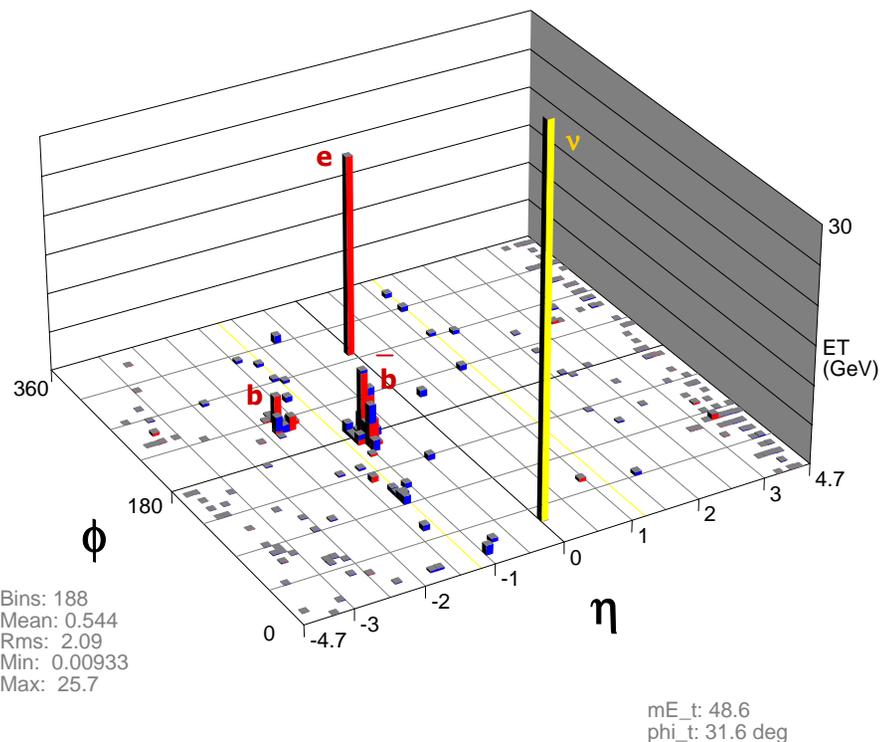
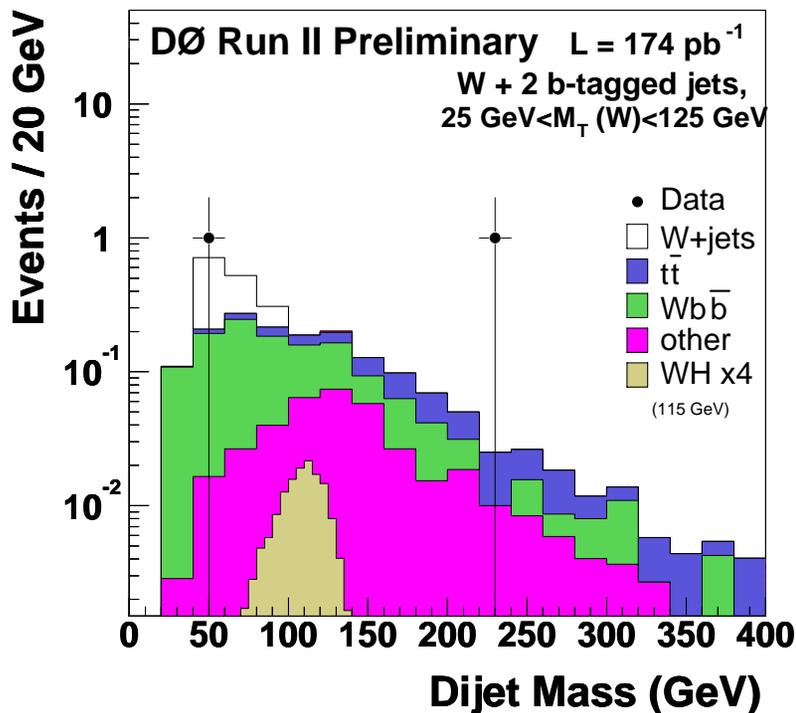


➤ Several studies in progress for different decay modes of the Higgs

WH → evb \bar{b}

- Using 174 pb⁻¹ of data
- Require e, E_T, two b-tagged jets
- 25 GeV < M_T(W) < 125 GeV
- No events in 85 < m(jj) < 135 GeV
- $\sigma(\text{WH}) \times \text{B}(\text{H} \rightarrow \text{b}\bar{\text{b}}) < 12.4 \text{ pb}$ at 95% CL for m_H = 115 GeV

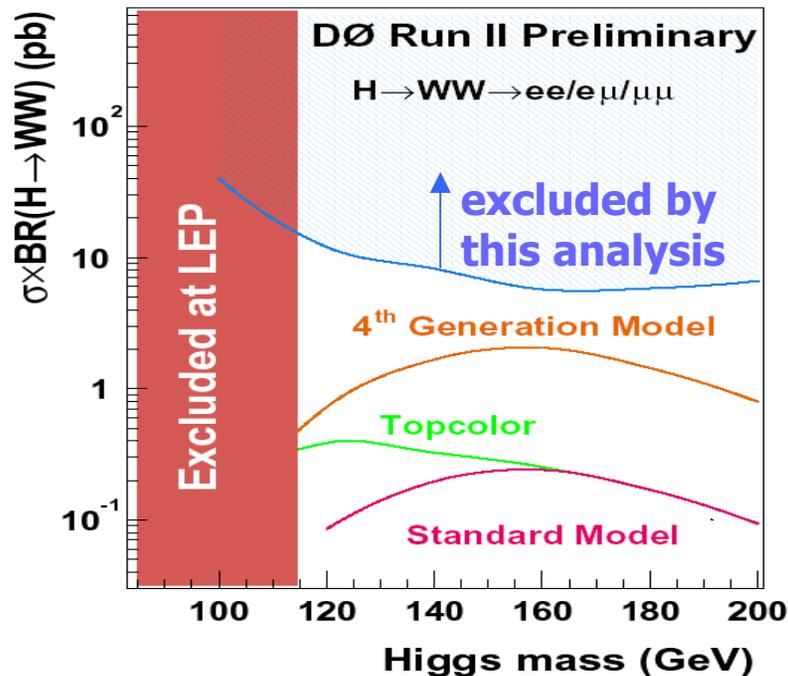
Run 174426 Event 7077298 Fri Mar 5 20:33:38 2004



Run II evb \bar{b} candidate

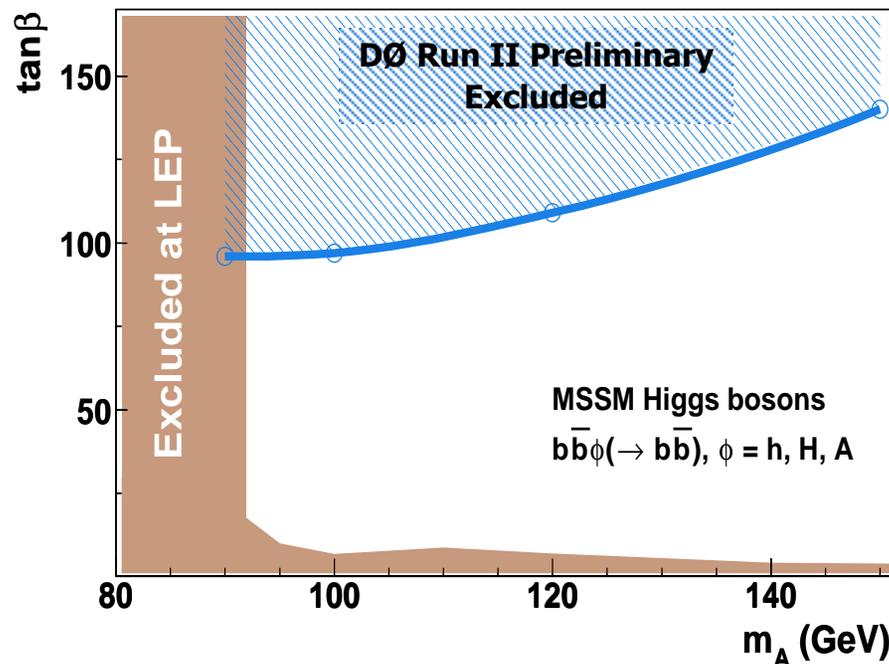
H \rightarrow WW \rightarrow (e μ) ν (e μ) ν search

- New Higgs search topology
- 147-177 pb⁻¹ of data
- Require leptons (l_i), \cancel{E}_T , $\Delta\phi(l_i l_j) < 1.5 - 2.0$, veto jets
- With 2.5 fb⁻¹, will approach SM



SUSY bbh \rightarrow bbbb search

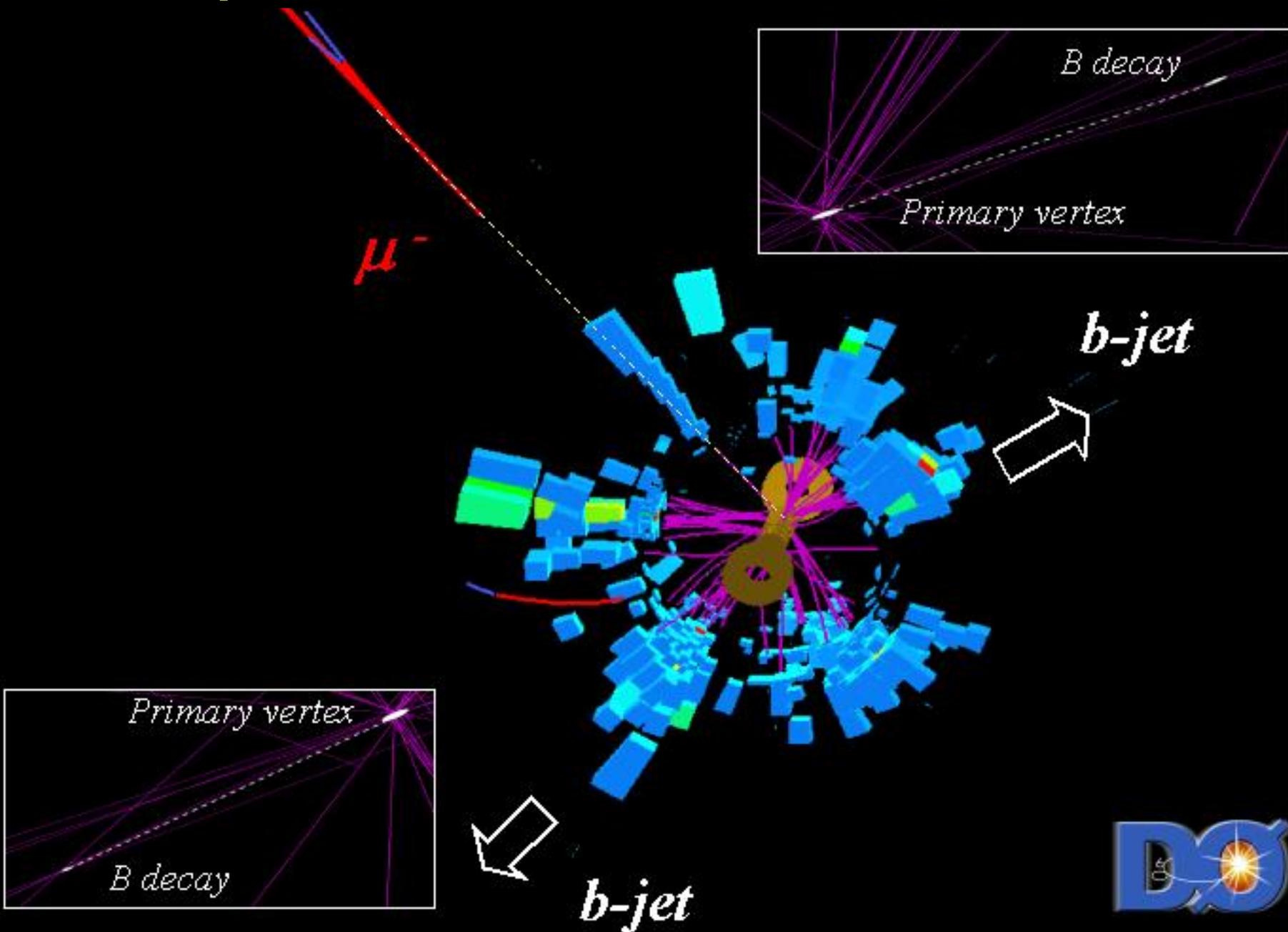
- 131 pb⁻¹ of data
- Require ≥ 3 b-tagged jets
- With 2 fb⁻¹, will be sensitive to $\tan\beta \sim 35$ and $m_A \sim 100$ GeV



Also analyses progressing in H \rightarrow $\tau\tau$, Non-SM H \rightarrow $\gamma\gamma$...

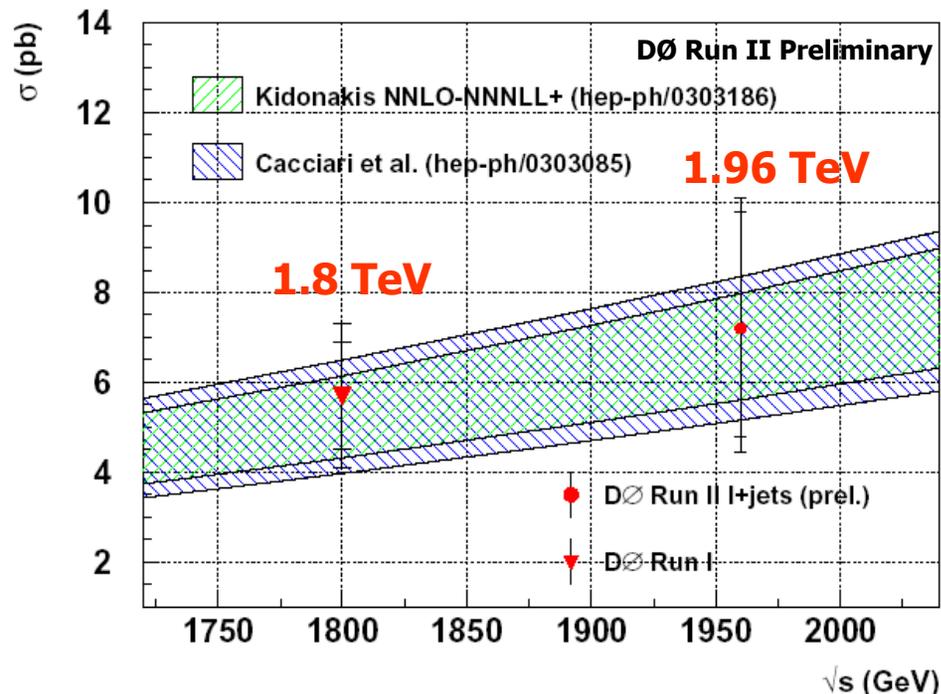
Run II top candidate

Lepton + jets



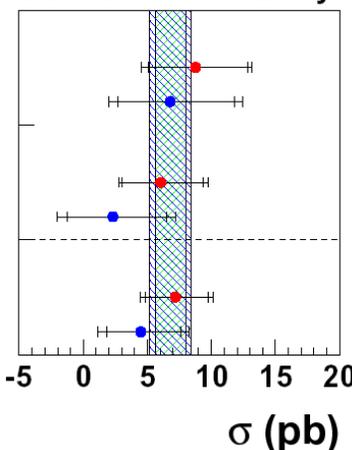
- **Currently top can only be observed at the Tevatron**
- **Coming soon...**
 - **Top all-jets measurement**
 - **New limits on single top**
- **Also,**
 - **Run II mass measurement (using Run I technique) due later this year**
 - **anticipated statistical error 6-8 GeV**

Measured cross section consistent with QCD



Run II (e,μ) + jets

DØ Run II Preliminary



$$8.8^{+4.1}_{-3.7} (stat) \ ^{+1.6}_{-2.1} (sys) \pm 0.57 (lumi) \text{ pb}$$

$$6.0^{+3.4}_{-3.0} (stat) \ ^{+1.6}_{-1.6} (sys) \pm 0.39 (lumi) \text{ pb}$$

$$7.2^{+2.6}_{-2.4} (stat) \ ^{+1.6}_{-1.7} (sys) \pm 0.47 (lumi) \text{ pb}$$



- **Run II physics program is fully underway and DØ is taking quality data**
 - **At high efficiency**
 - **Strong emphasis on Run II publications**

- **Detector commissioning is nearing completion**
 - **Subsystems are performing well and operating stably**
 - **FPS commissioning in its final stages**
 - **Continually improving systems for long-term performance and reliability**

- **Brookhaven-DØ group continues to make critical contributions to DØ on many fronts**
 - **Management and leadership**
 - **Software and hardware**
 - **Physics analyses**