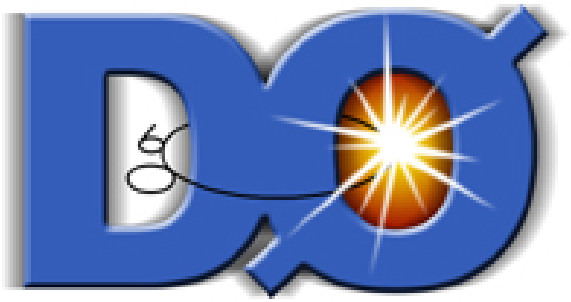


D0 Experiment
(BNL-DOE Review)

Vivek Jain, BNL

Apr. 22, 2003

- 650 collaborators, 110 graduate students, 85 post-docs
- 80 institutions, 18 countries
- Approximately half of the collaboration is from outside US
- 150 Ph.D.'s have been awarded so far

Summary of Activities of the BNL group:

- BNL group on D0:
  - V. Jain (100%)
  - S. Kahn (30%)
  - J. Kotcher (100%)
  - A. Patwa (100%)
  - S. Protopopescu (90%)
  - S. Snyder (90%)
  - A. Turcot (75%)
  - K. Yip (50%)
- Leadership Roles:
  - Manager of RunIIb Project (Kotcher)
  - Co-leader: offline algorithms (past), Simulation software (past)
    Leader: Data Tier group (present) - Protopopescu
  - Co-leader of Calorimeter and Preshower software development (Turcot)
  - Co-leader of B-physics analysis group (Jain)

- Hardware and Software Contributions:
  - FPS Commissioning and Operations (Patwa)
  - Development of Online infrastructure software (Snyder)
  - Development of L1 Track Trigger Simulation software (Jain)
  - Software development for FPS (Patwa, Protopopescu, Turcot)
  - Development of Offline Calorimeter Software (Kahn, Turcot)
  - Development of Offline infrastructure and analysis software (Jain, Protopopescu, Snyder)
  - Co-ordinator of SAM (data storage/access system) shifts (Yip)
  - Member Trigger Board (Turcot)
  - Upgrade Management (Kotcher)
- Physics Analyses Activities:
  - High Energy Frontier:
    Higgs Search (Kahn, Patwa, Snyder, Turcot)
    SUSY search - tau channel (Protopopescu)
  - Flavour Physics (Jain, Yip)

Overview of D0:

- Detector fully installed
- Remaining tasks
  - Integrating Forward Proton Detector
    (BNL is no longer involved in this project)
  - Making increasing use of track triggers
  - Silicon track trigger installed this summer
- Detector operating stably and efficiently
- Integrated $\mathcal{L}$ for the period Apr 19'02-Mar 11'03:
  Delivered: 134.9 pb^{-1}, Physics: 83.6 pb^{-1}
  Some luminosity used for commissioning, tests, calibration, etc.
- In Feb'03, Efficiency of utilizing delivered $\mathcal{L} \approx 85\%$
- Broad range of physics results presented at '03 conferences
  (40-60 pb^{-1})
- RunIIb upgrade progressing well

D0 Run II Detector - Tracking

Silicon Tracker

- Four layer barrels (double/single sided)
- Interspersed double sided disks
- 840,00 channels

Fiber Tracker

- Eight layers sci-fi ribbon doublets (z-u-v, or z
- 77,800 835um fibers w/ VLPC readout

Central Preshower

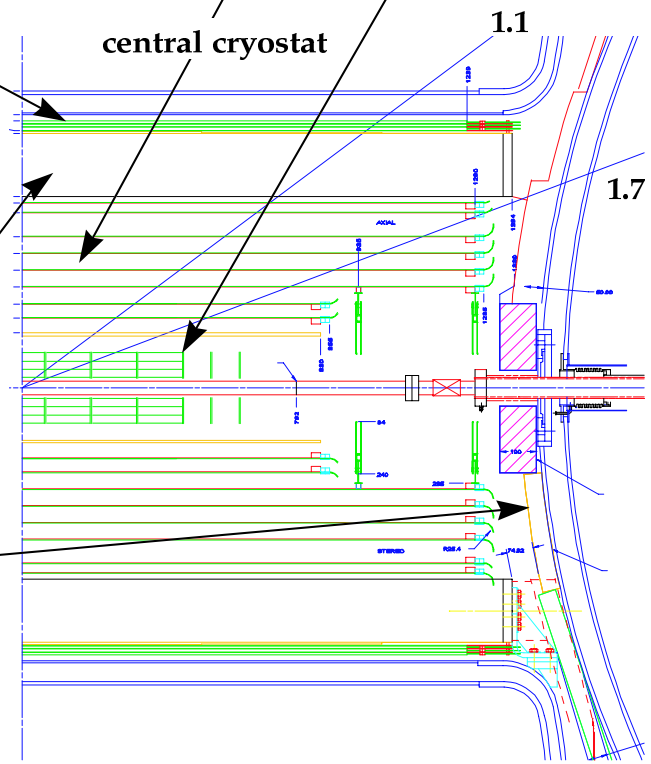
- Scintillator strips, WLS fiber readout
- 7,680 channels
- VLPC readout

Solenoid

- 2T superconducting

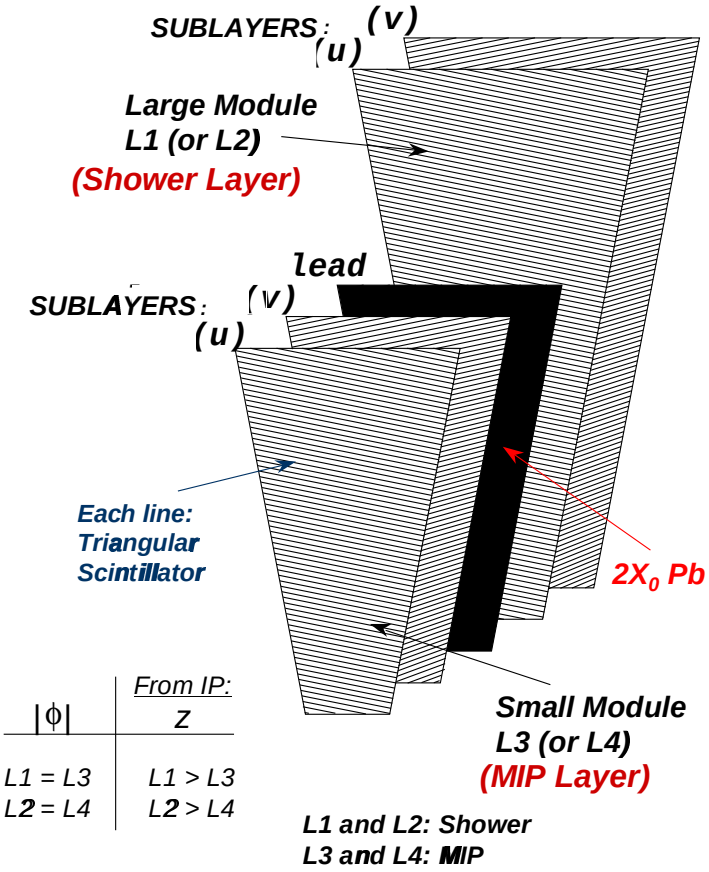
Forward Preshower

- Scintillator strips, stereo, WLS readout
- 14,968 channels
- VLPC readout



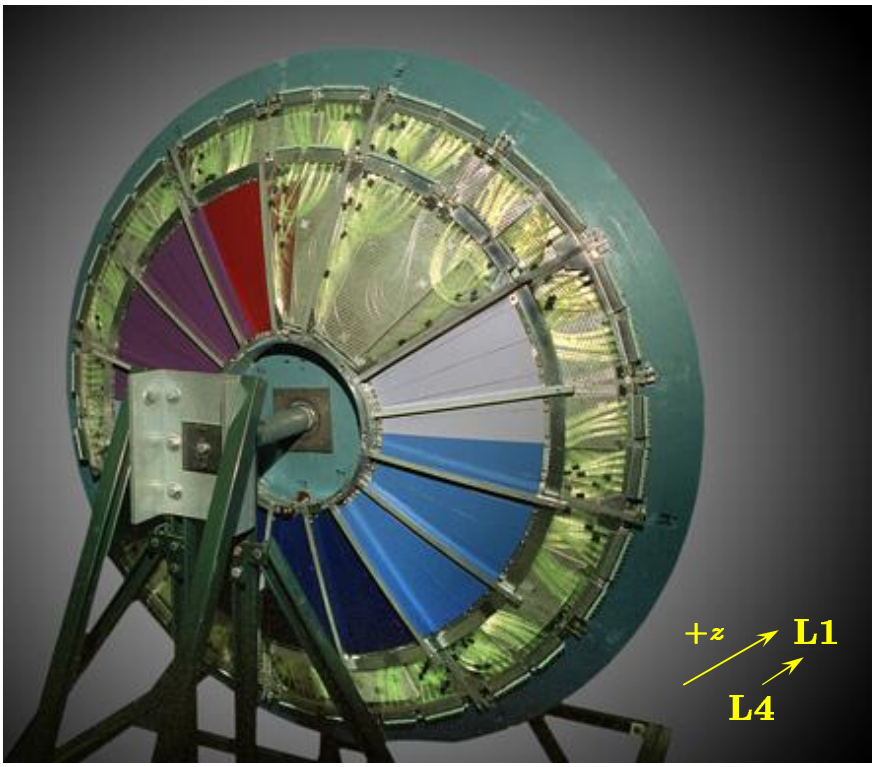
FPS Modular Design and Geometry:
Trapezoidal ϕ-Wedges and Trigger-Sectors

1 out of 16 Trigger-Sectors



$\lvert\phi\rvert$	From IP: z
L1 = L3	L1 > L3
L2 = L4	L2 > L4

L1 and L2: Shower
L3 and L4: MIP

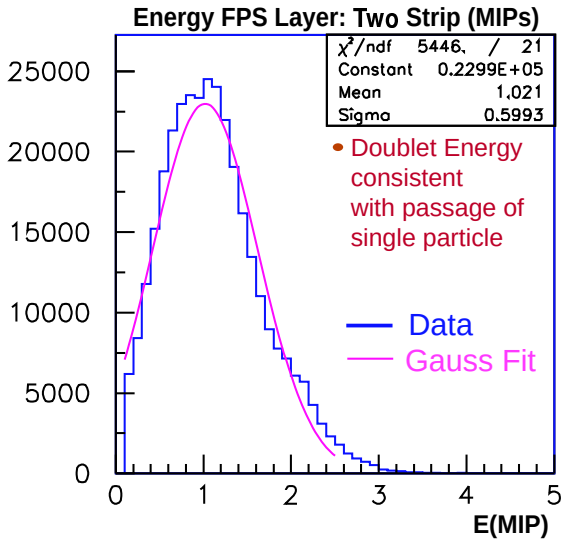


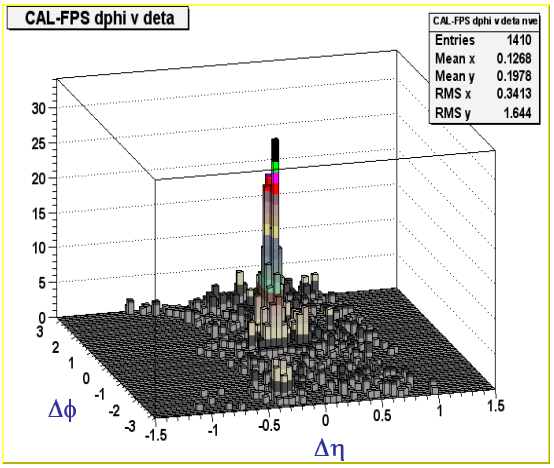
* **Successive Layers (separated in z): Rotated to prevent projective cracks**
* **Signal Processing: FPS → clear fibers → VLPC and Front-End electronics**

Forward Preshower Detector (FPS)

- Extensive forward coverage: $1.5 \leq |\eta| \leq 2.5$
- Extruded triangular scintillator strips with embedded WLS fibers; $2X_o$ Lead absorber
- Signal: Detector → clear fibers → VLPCs and Front-End electronics
- Enhances DØ's electron, photon triggering capability and offline identification
- System fully instrumented as of July 2002
- Detector commissioning fully underway
  - Performance being optimized jointly with entire DØ VLPC detectors (Central Fiber Tracker and Central Preshower)
- Offline reconstruction using matched *u*, *v* clusters and energy calibration
  - observed MIP peaks with collider data
  - cluster matching with calorimeter

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



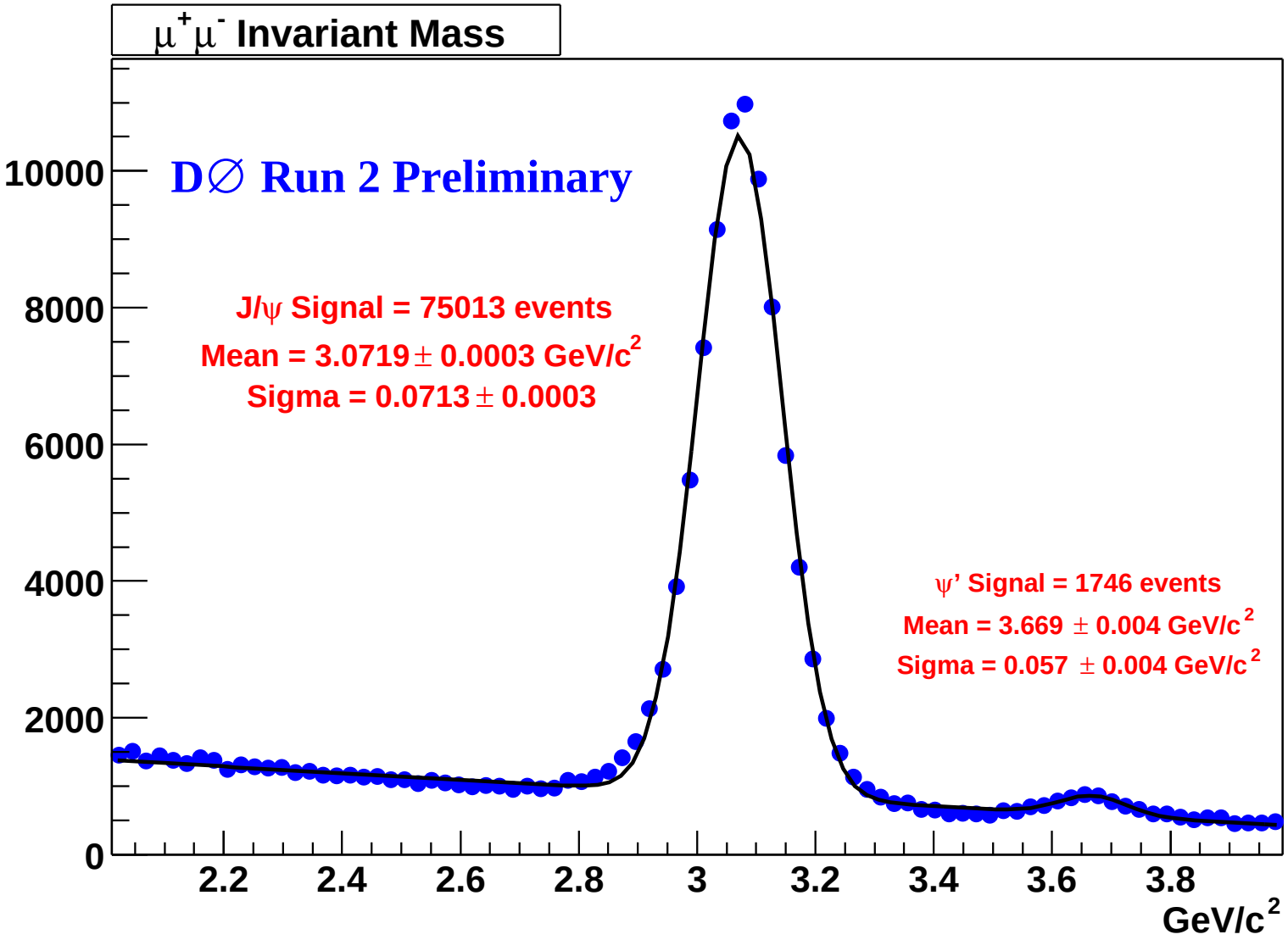


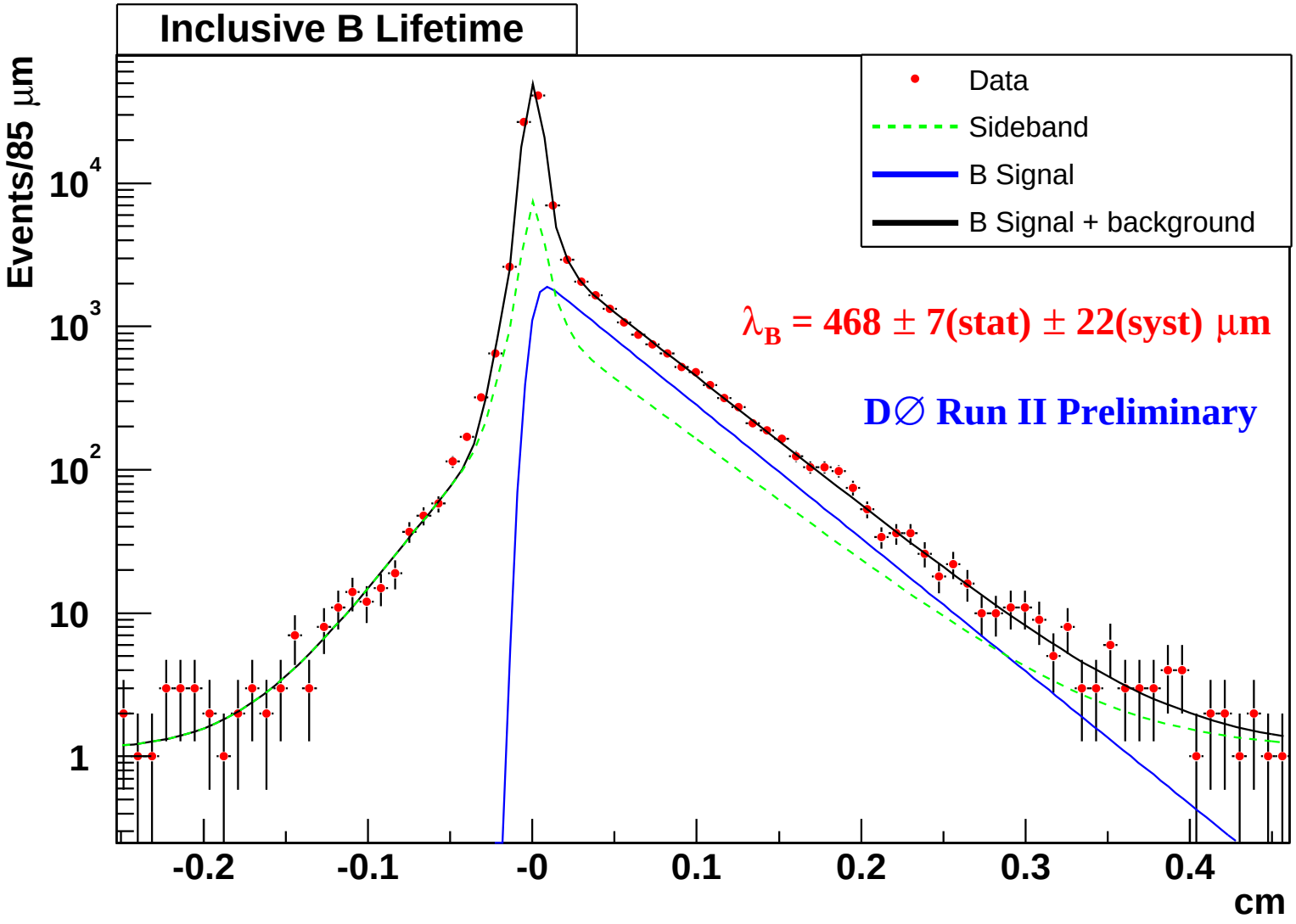
Highlights of Recent Physics Results ($\approx 40 - 60$ pb^{-1})

* BNL group played a major role in these results

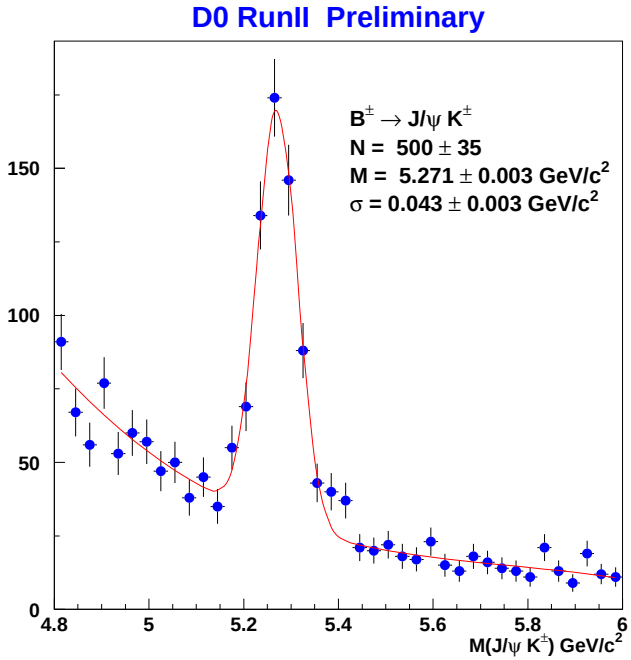
- B physics *
  - Goals: B_s mixing, Beauty Baryons, Rare decays, sin(2β) ...
- τ Identification - $Z \rightarrow \tau^+\tau^-$*
  - τ can be used in SUSY and Higgs searches
- Higgs Search *
  - First step towards W/Z ($\rightarrow$ leptons) + H($\rightarrow b\bar{b}$) is to understand W/Z + di-jets
  - Novel technique for inclusive jet based triggering
- Top Physics
  - Top cross-section at $\sqrt{s} = 1.96$ TeV
  - Improved top mass measurement using Run I data
- Electroweak Physics
  - Z$\rightarrow \mu^+\mu^-$ cross-section at $\sqrt{s} = 1.96$ TeV
- QCD
  - Di-jet cross-section at $\sqrt{s} = 1.96$ TeV
    Probe of proton structure, quark compositeness, etc.

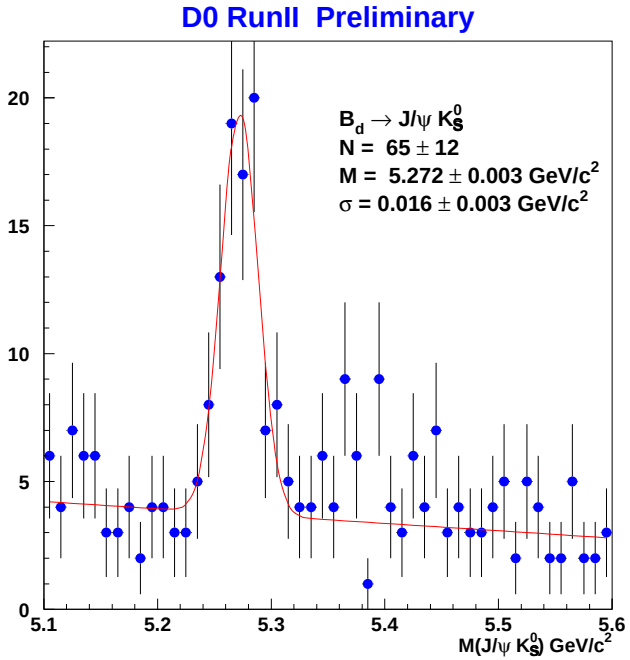
Vertex $J/\Psi \rightarrow \mu^+\mu^-$ and measure inclusive B lifetime

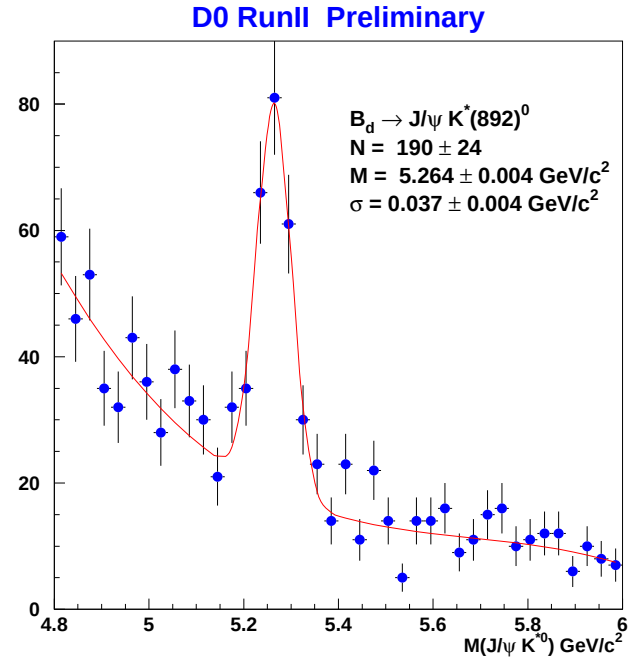


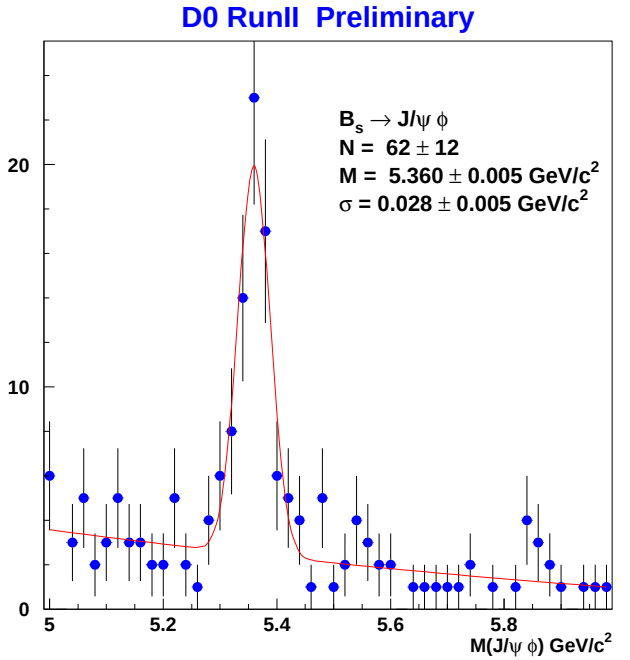


CDF Run I result: $460 \pm 11\mu$ m





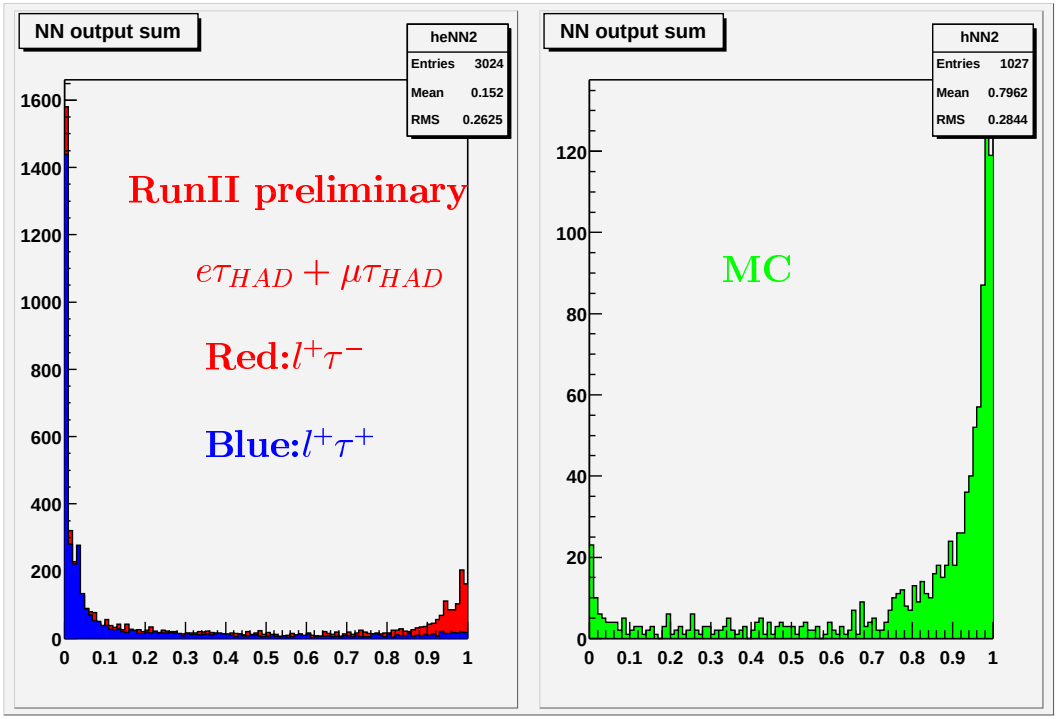




Next: Reconstruct hadronic and semi-leptonic B decays

$Z \to \tau\tau$ in RunII Data

Select events with good e and μ and 1-prong τ candidates.
Use Neural Network to identify τ's.

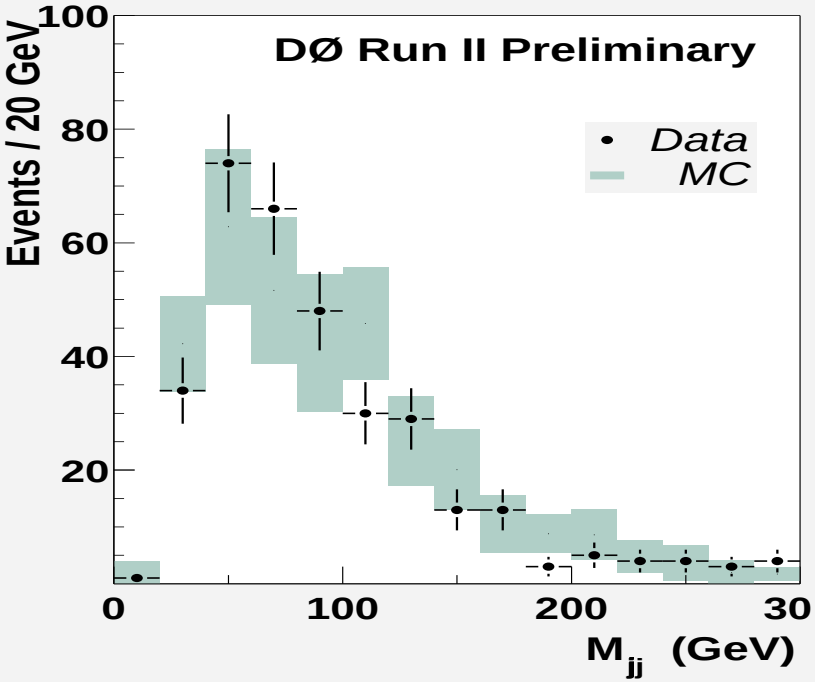


NN output NN ouput

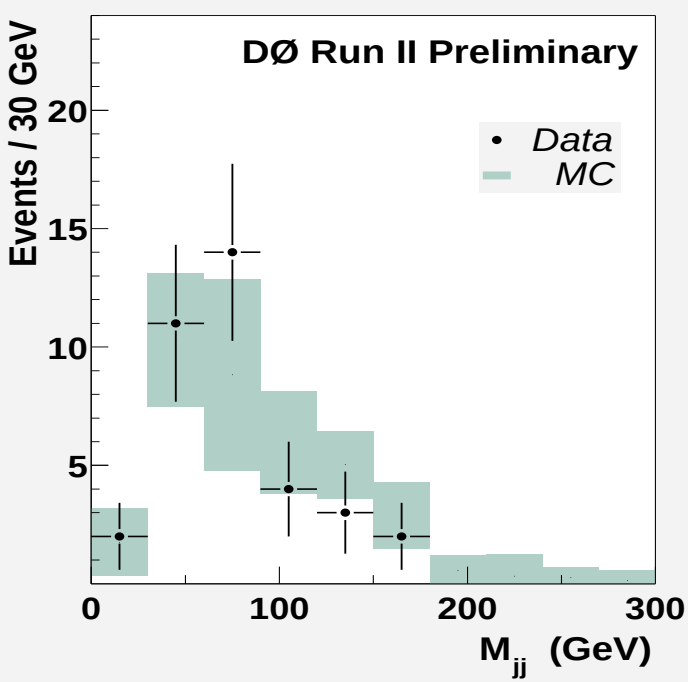
NN uses calorimeter and track energy distributions as inputs

Di-jet mass (in W/Z+jets sample)

W+jets



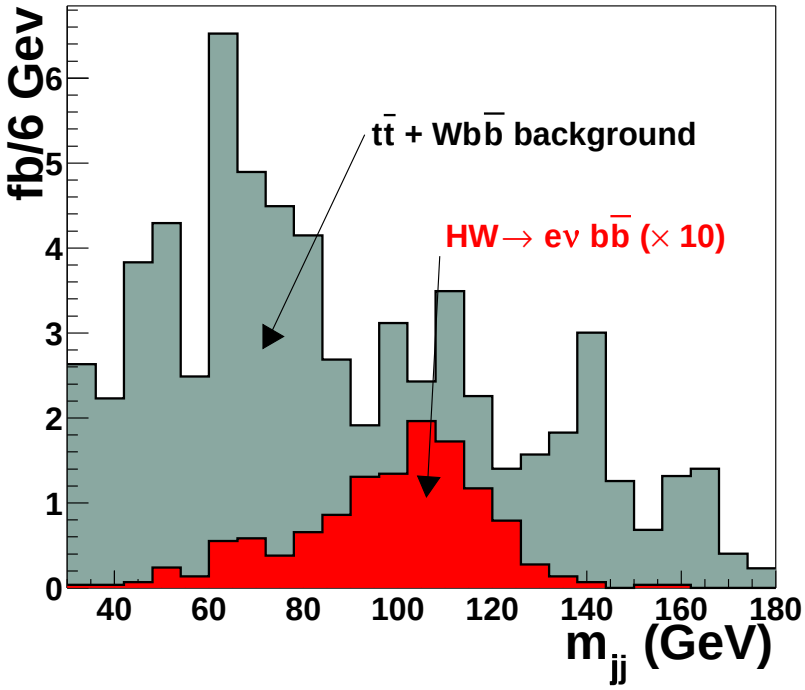
Z+jets

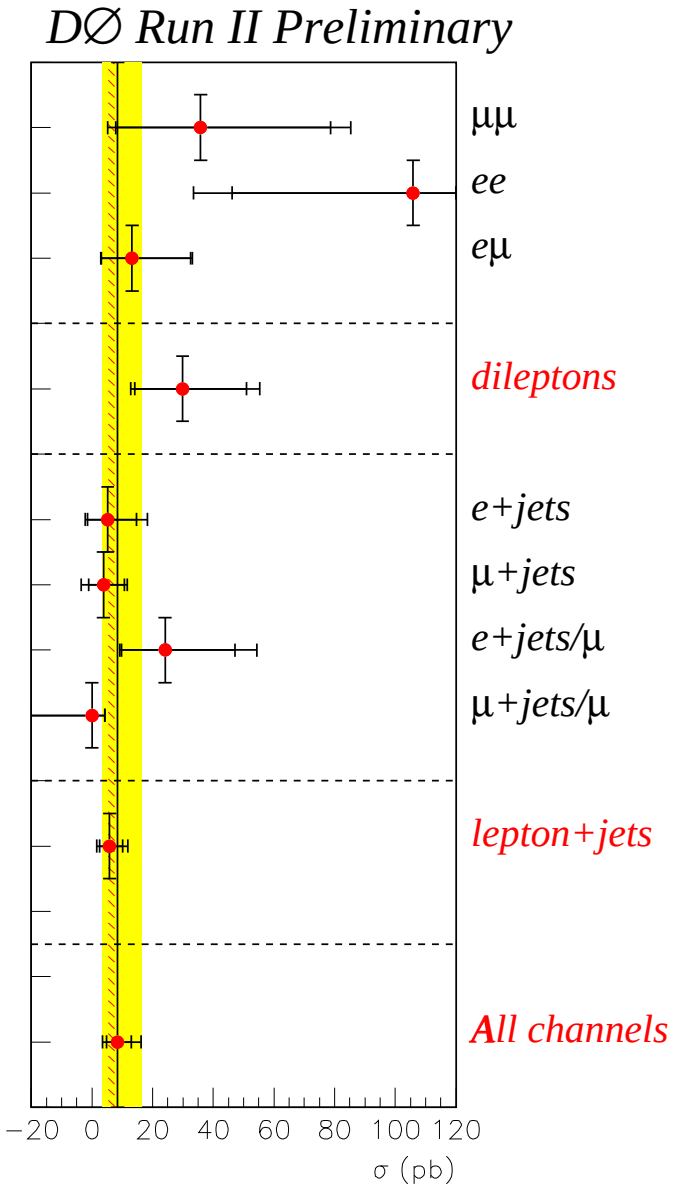


Next step is to understand b-tagging of jets

Di-jet mass (in W/Z+jets sample) - contd.

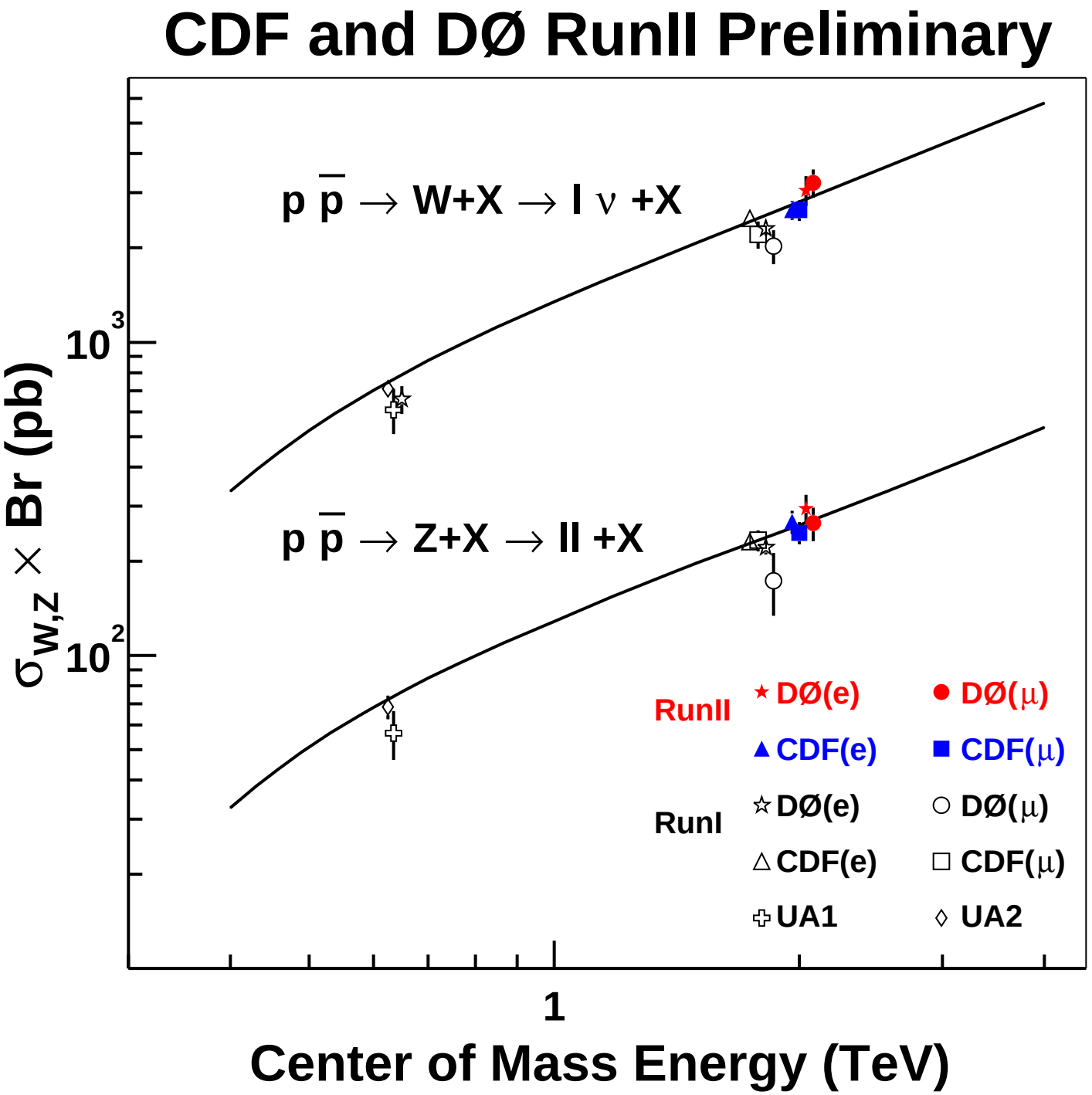
MC expectation for a 115 GeV Higgs



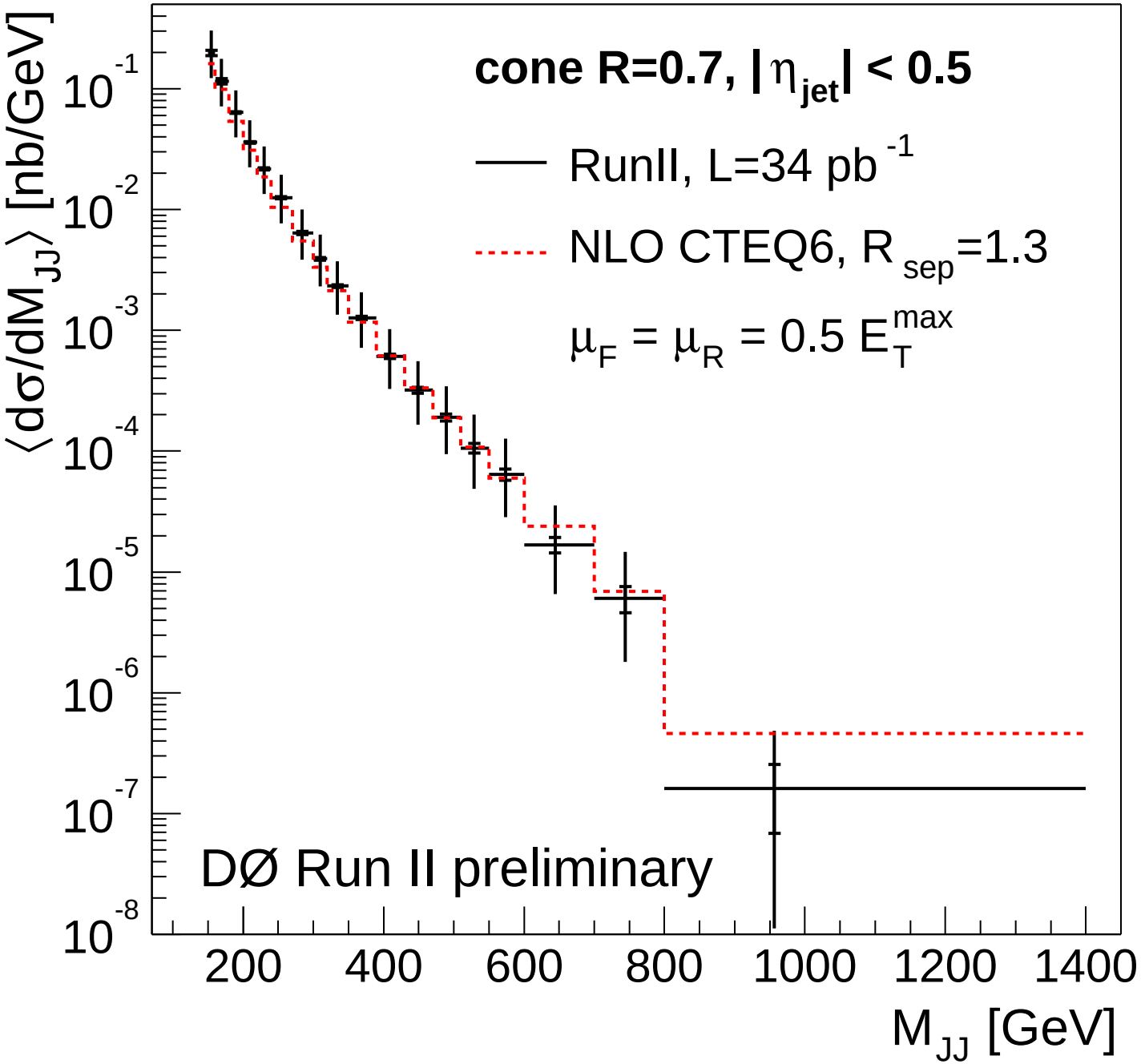


$$\sigma_{t\bar{t}} = [8.5\ ^{+4.5}_{-3.6}(\text{stat})\ ^{+6.3}_{-3.5}(\text{syst})\ \pm 0.8(\text{lumi})]\ \text{pb}$$

At $\sqrt{s} = 1.96$ TeV, Predictions between 6.7-7.5 pb


CDF and DØ RunII Preliminary
p p̄ → W+X → l ν +X
p p̄ → Z+X → ll +X
σW,Z × Br (pb)
10^3
10^2
1
Center of Mass Energy (TeV)
RunII
DØ(e)
DØ(μ)
CDF(e)
CDF(μ)
RunI
DØ(e)
DØ(μ)
CDF(e)
CDF(μ)
UA1
UA2

Di-jet cross-section



RunIIb Upgrade

- Collect > 6 fb^{-1} for Higgs/SUSY/New Phenomena Searches
- Expected to start in Oct. 2006 - Project Manager: Kotcher
- Silicon
  - Six layer device - all single sided sensors
  - Ready for installation May '06, ready-for-beam Oct '06
  - Replace current Silicon with a more rad-hard version
  - Current detector designed for 2 fb^{-1} -
    Most radiation hard technology available at that time
- Trigger Upgrade
  - In Run IIb, instantaneous $\mathcal{L} = 2 - 4 \times 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
  - Lead to unacceptable increase in rates, especially at Level 1
  - Improving Level 1 rejection in CAL, CTT, CAL-Track match
  - Modest upgrades to,
    Level 2 Silicon Track Trigger - to accomodate new Si detector
    Level 2 β processors - additional processors
- Upgrades to DAQ/Online systems for long-term, high rate running
- \$20.62M baselined cost for DOE equipment funds
  Includes all labor, contingency, and overheads

D0 Regional Analysis Center

- Easy availability of all reconstructed data
- Propose 5 regional analysis centers (RAC) in the US
  in addition to FNAL
- Data to be easily accessible to all collaborators
  Tools can be adapted from the proposed D0 GRID
- (Minimal) Design Parameters for a RAC
  - Store 15% of reco. data in DST format $\approx$ 150kB/event
  - Entire DST on disk allows one to pick interesting events
    Possible only if there are ≥ 6 RAC's
  - Store 100% of reco. data in compressed
    thumbnail (TMB) format $\approx$ 10kB/event
  - Sufficient computing power:
    re-reconstruct the DST set in 0.5 yr
    OR cycle through the entire TMB set in 10 days
  - High bandwidth (> 1 Gbps) connections to the outside world
- D0-BNL group proposes to expand the
  RHIC-ATLAS computing center to become a RAC for D0

- Initial expenditure in FY2004
  - For Run IIa, need 45 TBytes/year
  - $510K to provide 45 Tbytes of disk, 50 processors and the necessary infrastructure
  - $300K 2 FTE's for the necessary system maintainence and D0 software support
- In FY 2005
  - $374K for additional equipment to keep up with new data
  - $312K for 2 FTE's for system and D0 software support
- In FY 2006
  - $329K for additional equipment to keep up with new data
  - $324K for 2 FTE's for system and D0 software support
- See detailed Cost Estimate $\rightarrow$
- In Run IIb , data rates and storage requirements will increase

Conclusions

- Run IIa producing physics quality data
- Run IIb upgrade is underway
- Propose establishing Regional Analysis Center for D0 at BNL
- BNL group is making very important contributions to D0:
  Hardware, Software, Physics Analyses, and Management

Category 1: Support Similar to RHIC and ATLAS					
- parts of many people					
	Effort (FTE)	Unit/cost ($K)	FY04 ($K)	FY05 ($K)	FY06 ($K)
Management& Planning	0.10				
Infrastructure:LAN,WAN,DNS,backup,security,etc.	0.40				
Interactive CPU cycles	0.25				
Large scale disk	0.25				
Total	1.00	150	150	156	162
Category 2: Support specific to D0 - single specific person					
D0 software environ.	0.20				
D0 remote access (SAM)	0.30				
D0 resource/prod. manag.	0.55				
Total	1.00	150	150	156	162
Capital items					
Yr 1: 50 CPU's, 2 systems, 45 TB, 1 Switch, 6 Servers					
Linux Farm		2	100	100	100
Disk Server		5	10	5	5
Disk Array		5	214	135	85
Switch		60	60	20	20
Infrastructure Servers		12	4	4	4
Overhead		8.8%	35	23	19
Total			431	287	233
MST+					
Personal Support		7.5	15	16	16
Licenses & software		15	15	15	15
Space/power, etc.		5	5	5	5
Sub Cap procurements		2%	9	6	5
Computing Equip maintainence		4%	17	29	38
Overhead on above		12%	18	17	17
Total			79	87	96
Integrated Capacity					
CPU's (Number)			50	100	150
CPU Capacity (SPECint95)			5481	14181	27991
Disk Capacity (TBytes)			45	90	135
TOTAL Cost	2.0		810k	687k	653k