Results from the Dzero Experiment at the Tevatron

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Representing the Dzero Collaboration

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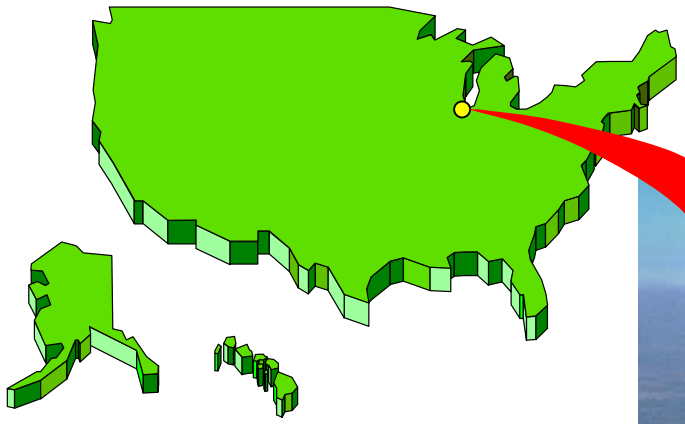
DØ in RunII

- **Center of Mass Energy = 1.96 TeV**
- **Expect 2 fb^{-1} by end of 2004 (RunIIa), 15 fb^{-1} by 2008 (RunIIb)**
- **Goals**
  - **Comprehensive study of top quark properties**
  - **Precise measurements of m_{top}, m_W, A_{FB}**
  - **Search for new phenomena (SUSY, technicolor,…)**
  - **Search for the Higgs boson**
  - **QCD (proton structure, quark compositeness)**
  - **B-physics (B_s mixing)**
- **DØ's strength is high-pT physics**
- **Requires**
  - **Measurement of leptons (e, μ), jets, missing p_T**
  - **Flavor tagging of jets**

Fermilab

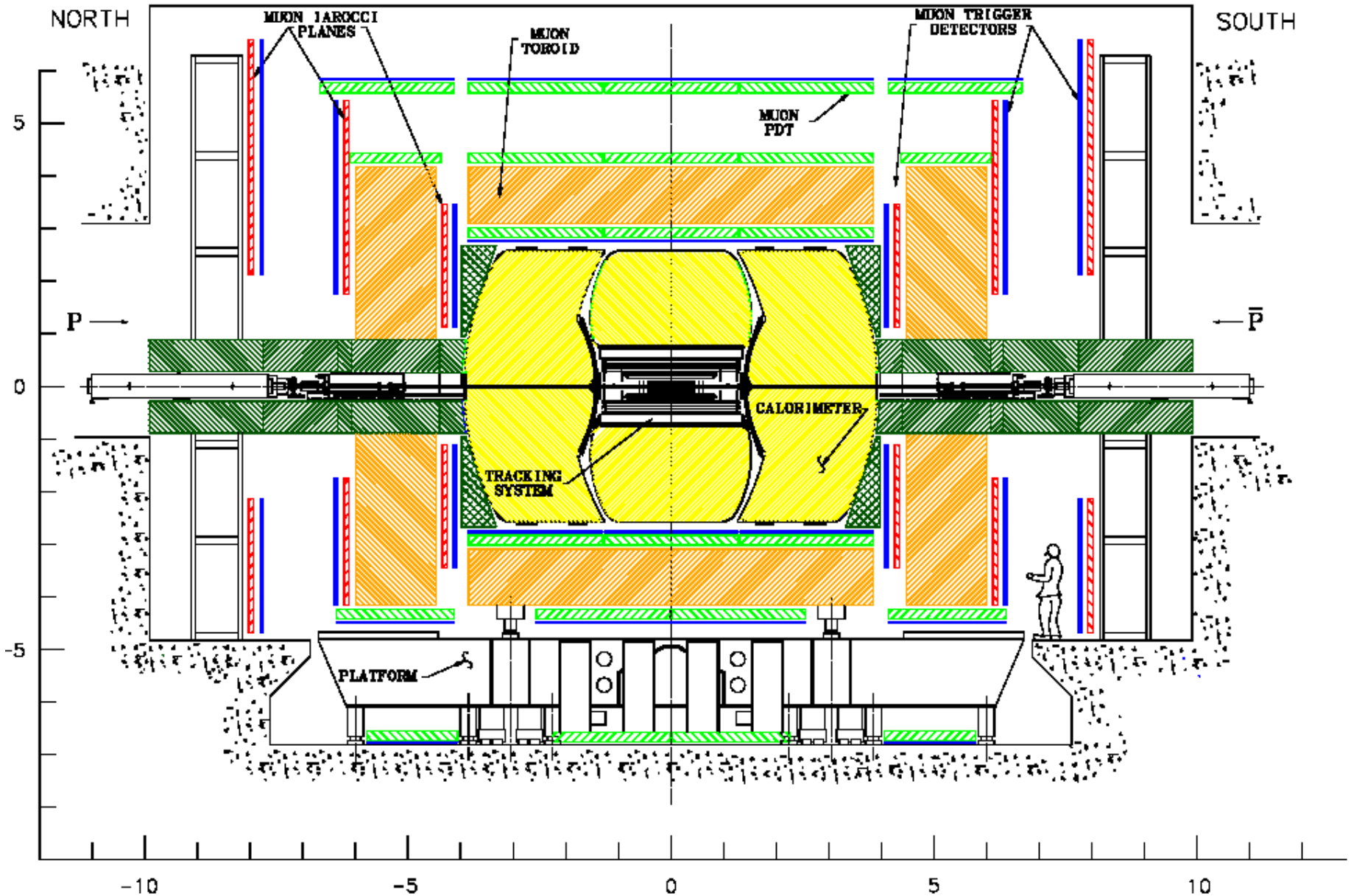


- $p\bar{p}$ collisions
- E_{com} = 1.96 TeV
- 396 ns bunch spacing
- Run II peak luminosity

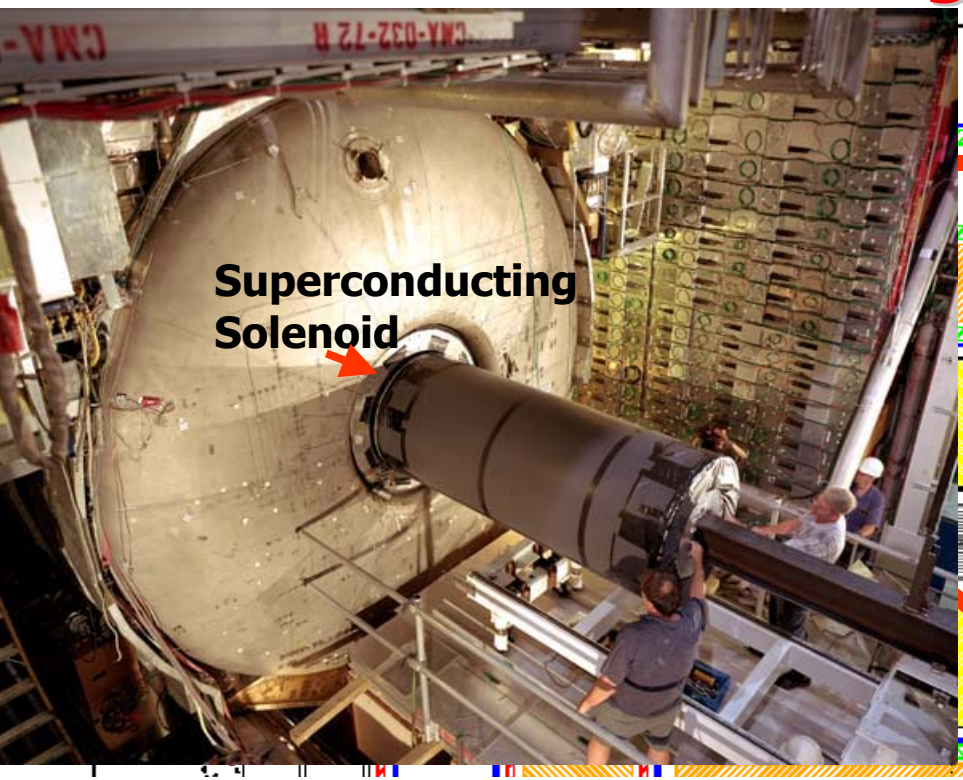
→ now: 2.1×10^{31} $cm^{-2}s^{-1}$

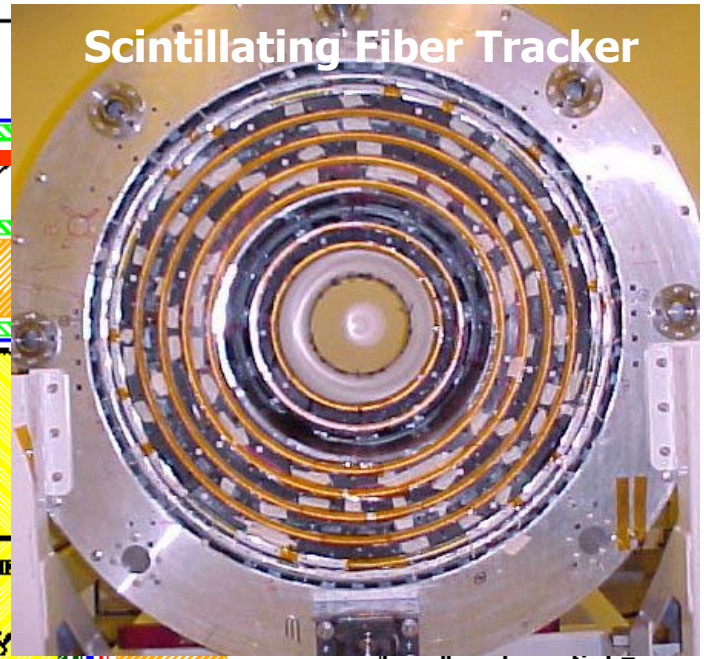
→ goal: 8.6×10^{31} $cm^{-2}s^{-1}$

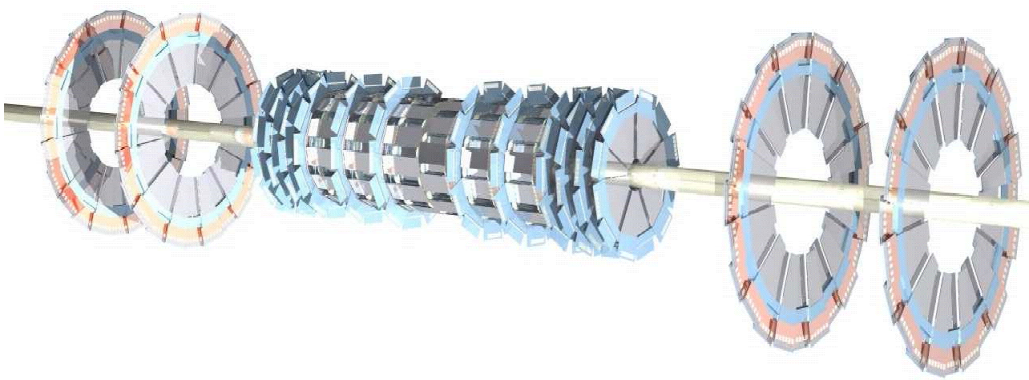
D0 RunII Detector



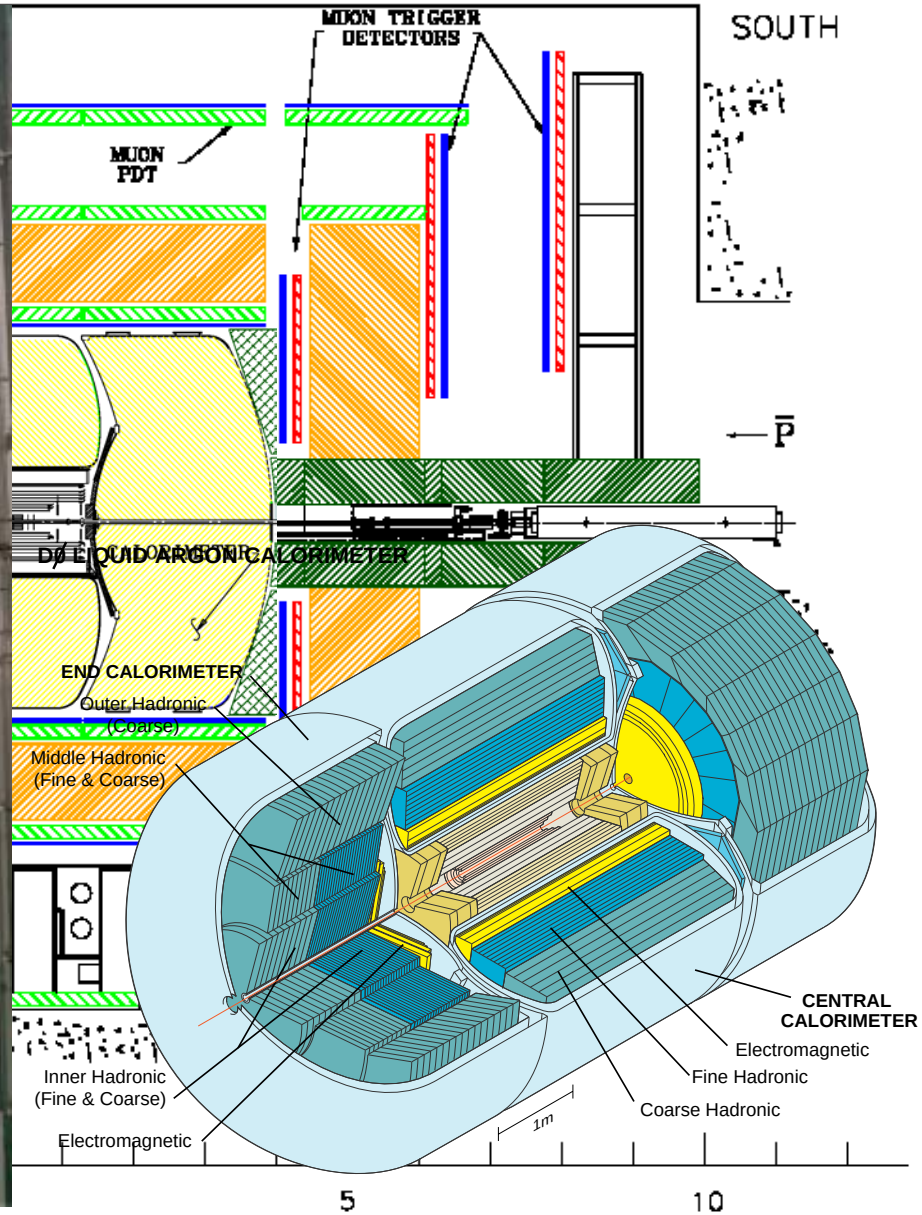
Tracking System



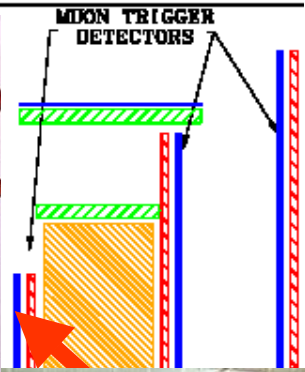


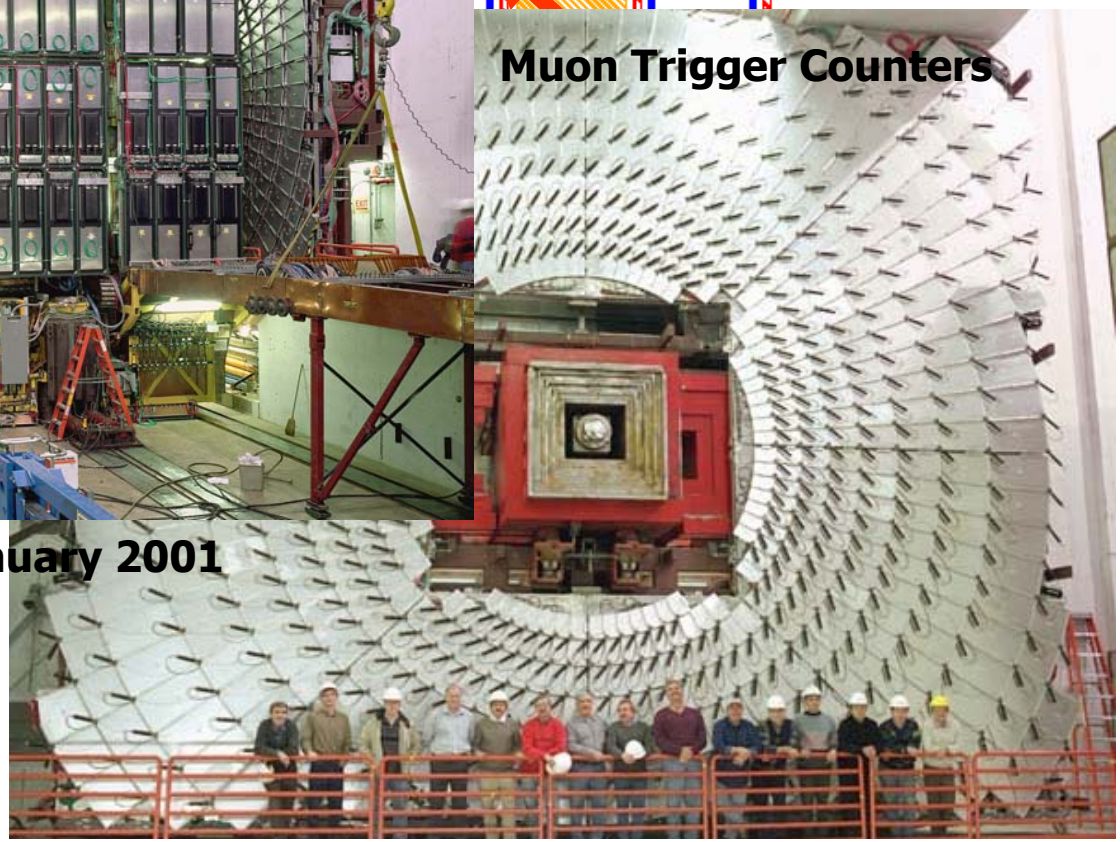


Calorimeter



Muon System



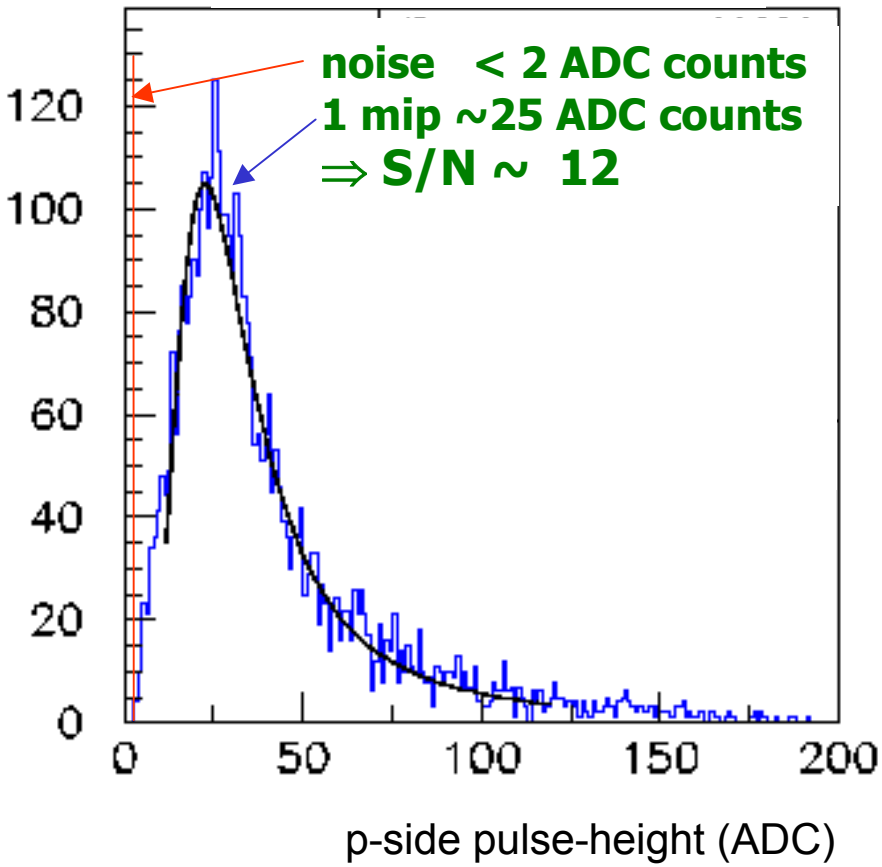


DØ Detector in Collision Hall, January 2001

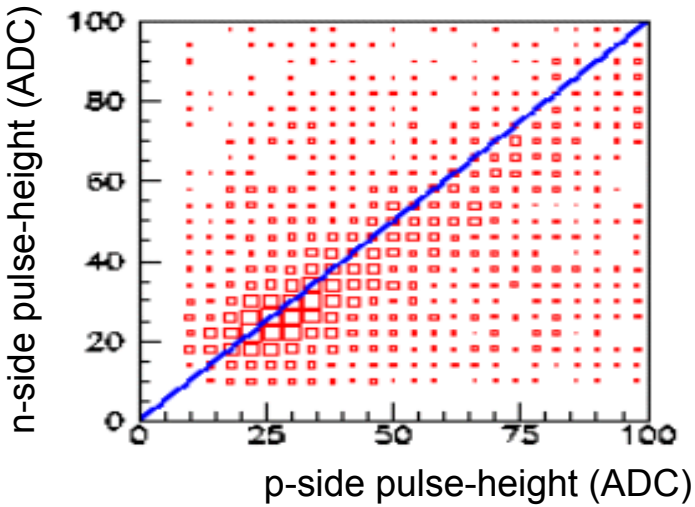
Detector Performance

- **Silicon Tracker**

Silicon cluster charge

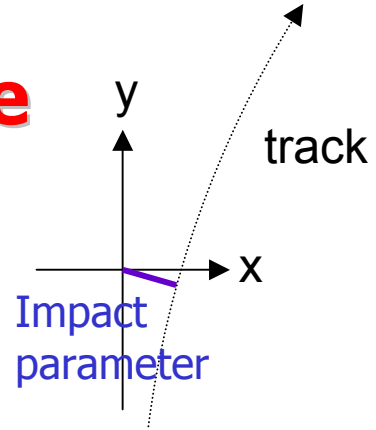


Charge correlation between p and n-side of a silicon detector



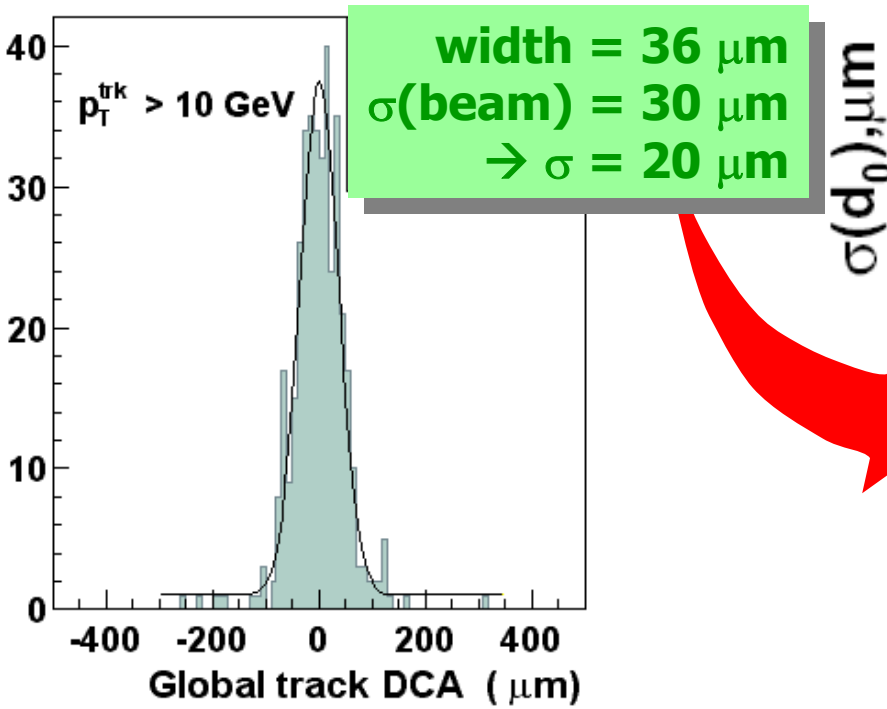
Hit efficiencies >97%

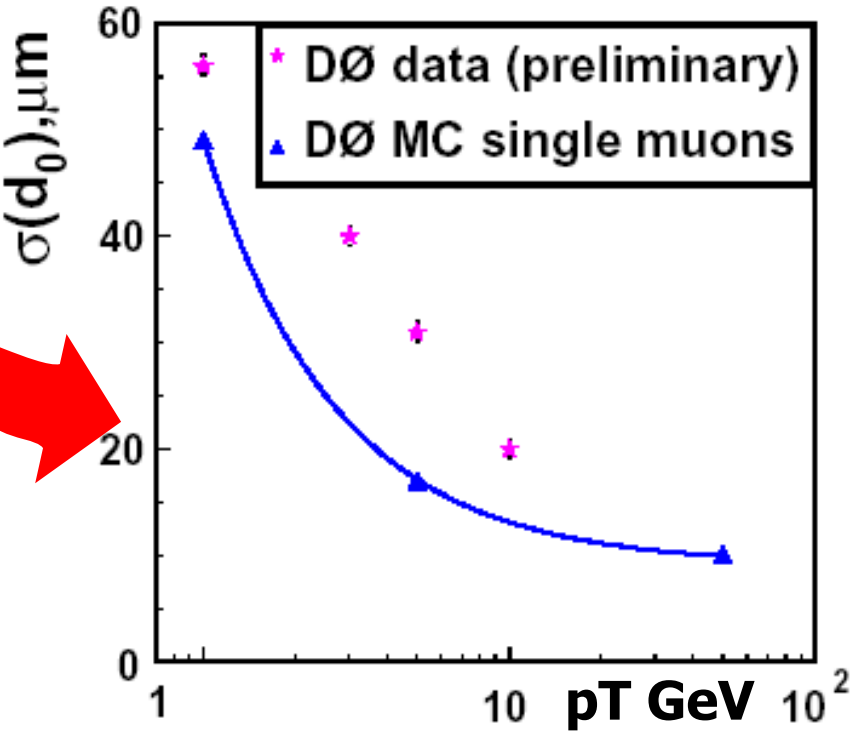
Detector Performance



- **Impact Parameter Resolution**

Survey-only alignment constants



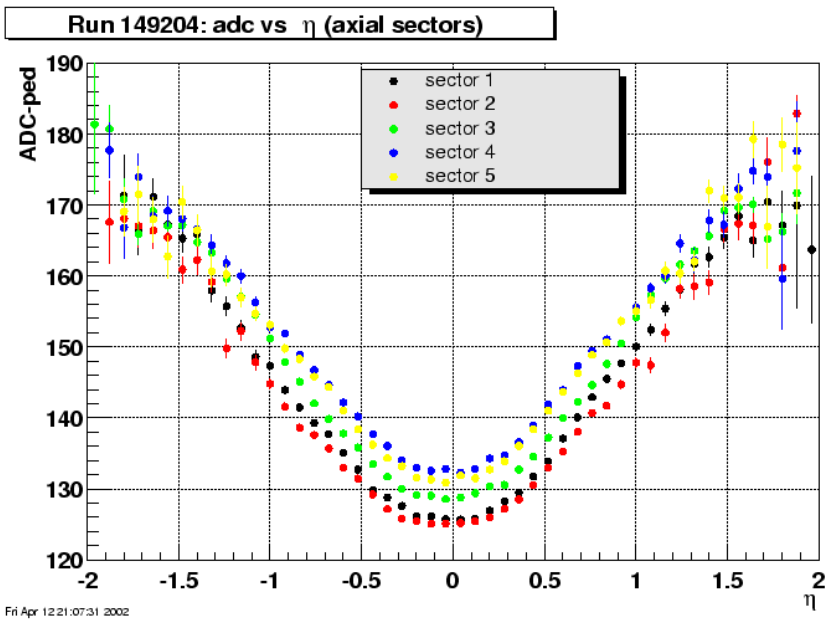


significant improvement expected from alignment with data in near future

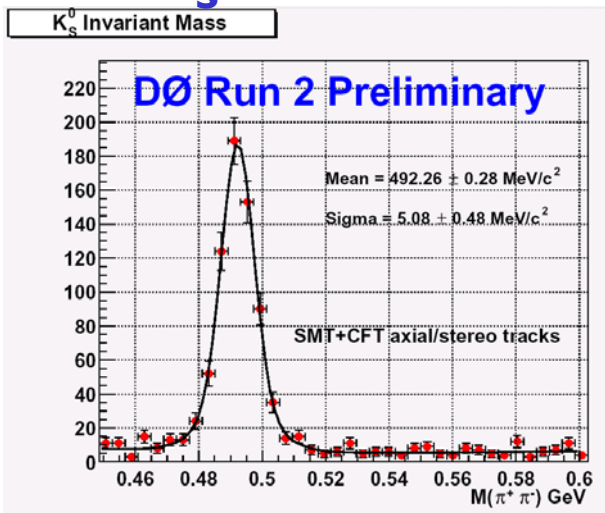
Detector Performance

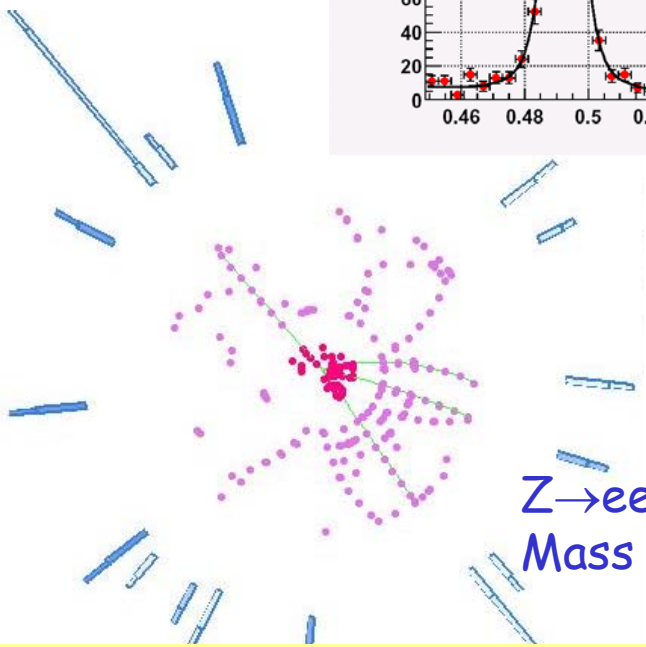
- **Fiber Tracker**

light yield vs pseudorapidity η



$K_s^0 \to \pi^+\pi^-$





Z→ee candidate
Mass 89.9GeV/c^2

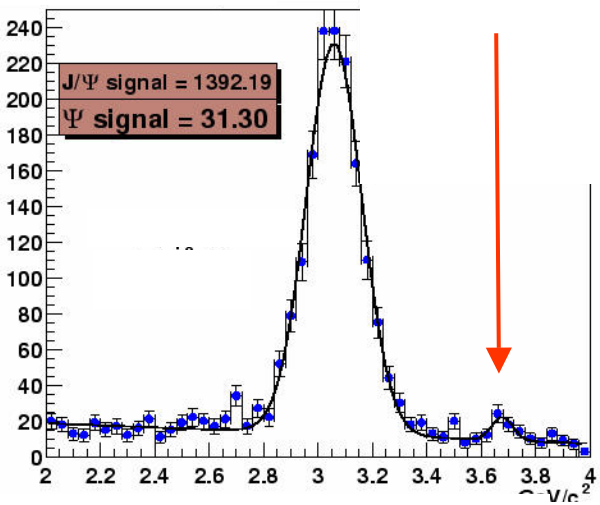
Hit efficiency ¼ 98%

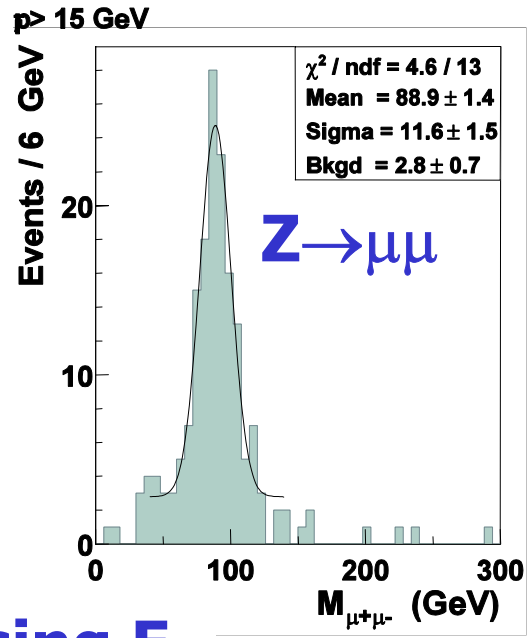
All tracking detectors working as expected

Detector Performance

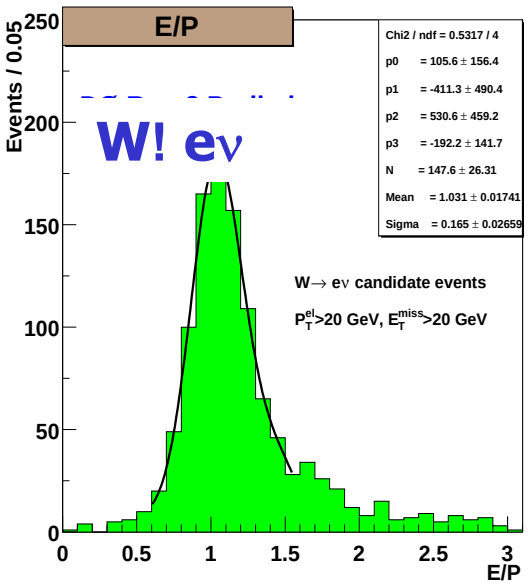
- **Muons**

J/ψ and ψ′

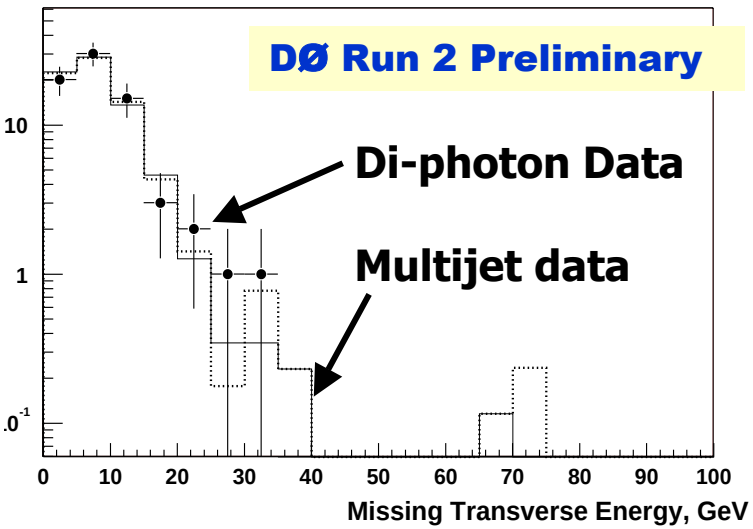




- **Electrons**



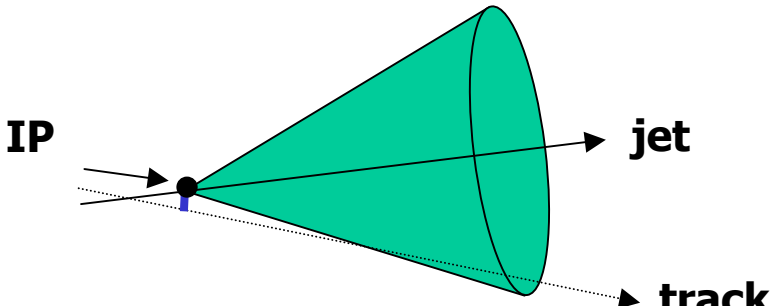
- **Missing E_T**



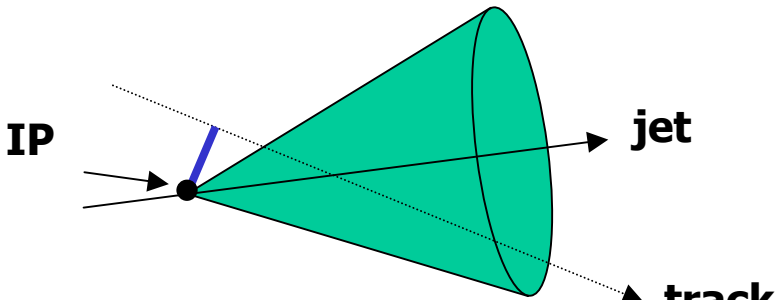
Detector performance consistent with expectations!

Identyfying b-quarks

- **Signed impact parameter**

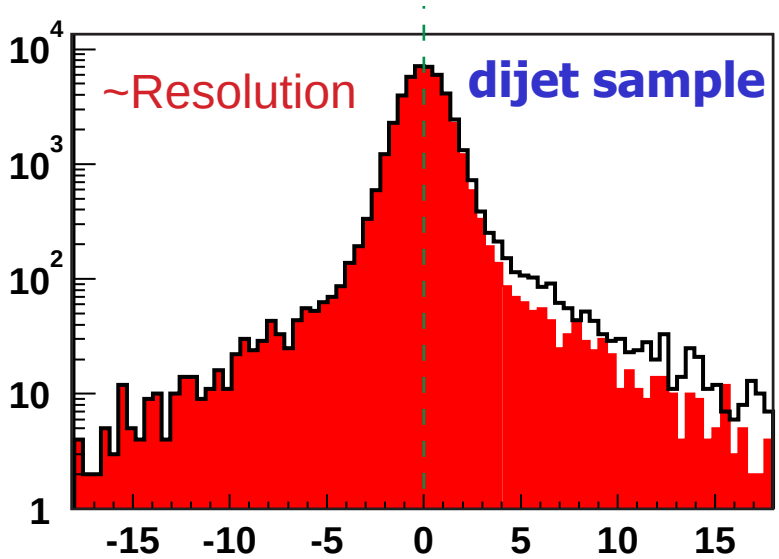


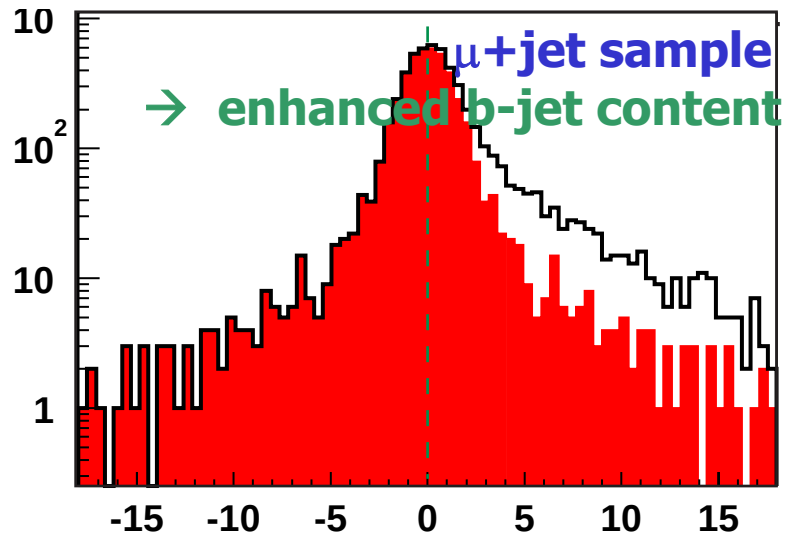
Impact parameter < 0 (resolution)



Impact parameter > 0 (secondary decay vertex)

→ **Reconstruct secondary vertex**
→ **Also use semileptonic decays**





Significance = dca/σ

RunII Data and First Physics Results

- **Delivered luminosity about 50 pb^{-1}**
- **Mostly used to commission detector**
  - **Now complete**
- **First results from about 10 pb^{-1} of physics quality data**
  - **New center of mass energy $\rightarrow$ measure cross sections**
  - **Exploit our High pT Physics capabilities at the energy frontier**
- **See also talks in parallel sessions**
  - **include results from both RunI and RunII**

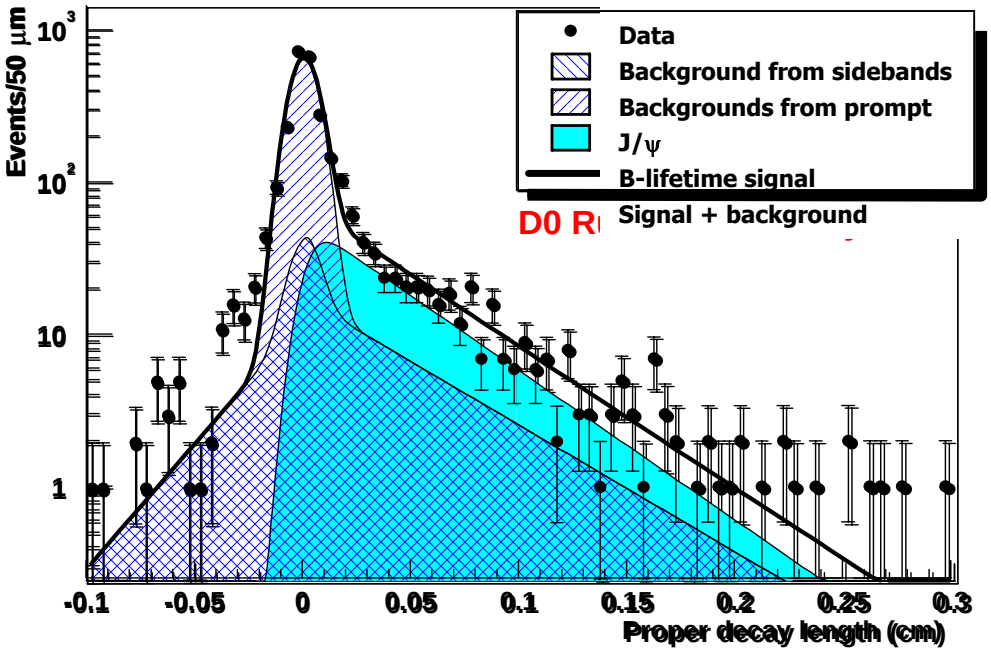
Dzero talks during the parallel sessions

- **Jet measurement with the KT method (Ursula Bassler)**
- **Minireview on Low Scale Gravity and ED at HERA/LEP/Tevatron (Gregorio Bernardi)**
- **Photon and Jet Physics at DØ (Marek Zielinski)**
- **Search for SUSY at the Tevatron (Vishnu Zutshi)**
- **W boson mass and width measurements (Sarah Eno)**
- **Top physics at the Tevatron (Ia Iasvilli)**
- **The DØ tracking system for Run II (George Ginther)**
- **The DØ detector for Run II (Levan Babukhadia)**

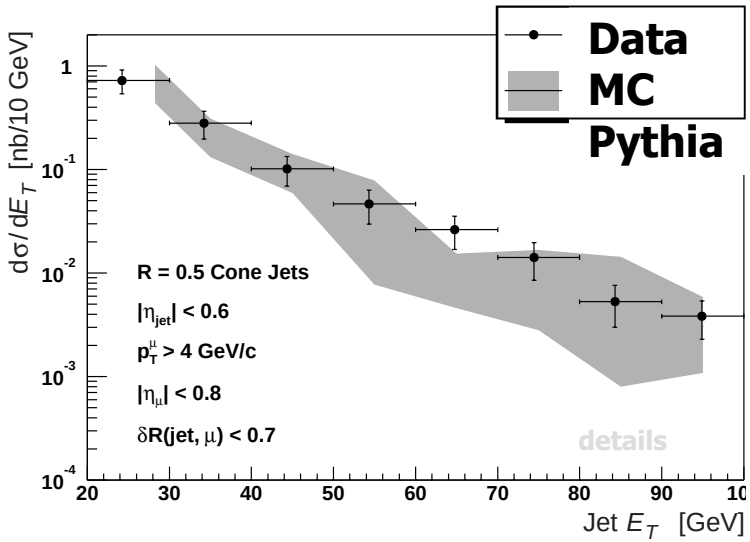
- **+… a few more talks by CDF speakers which include Dzero RunII results.**

B-Mesons

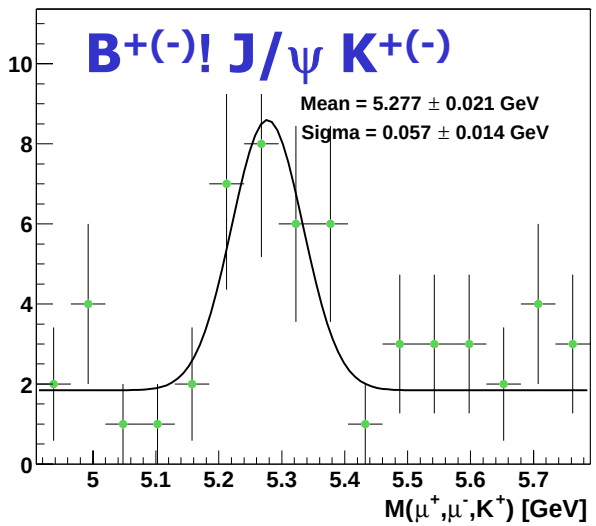
Average B Lifetime (B! J/ψ+X)



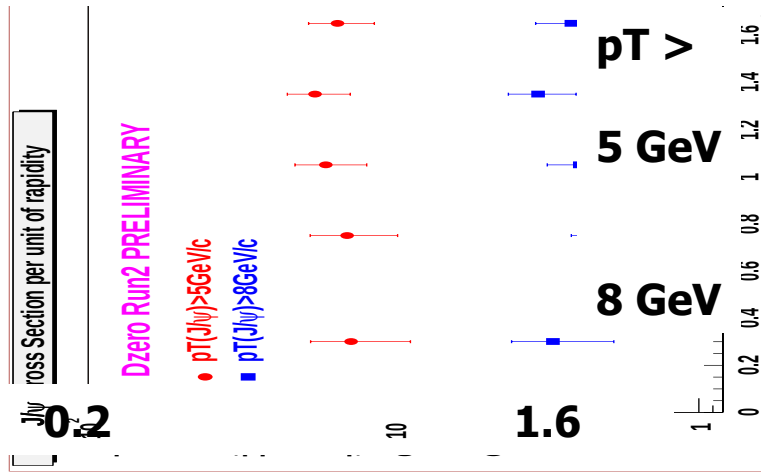
μ+jet Production Cross Section



B+(-)! J/ψ K+(-)

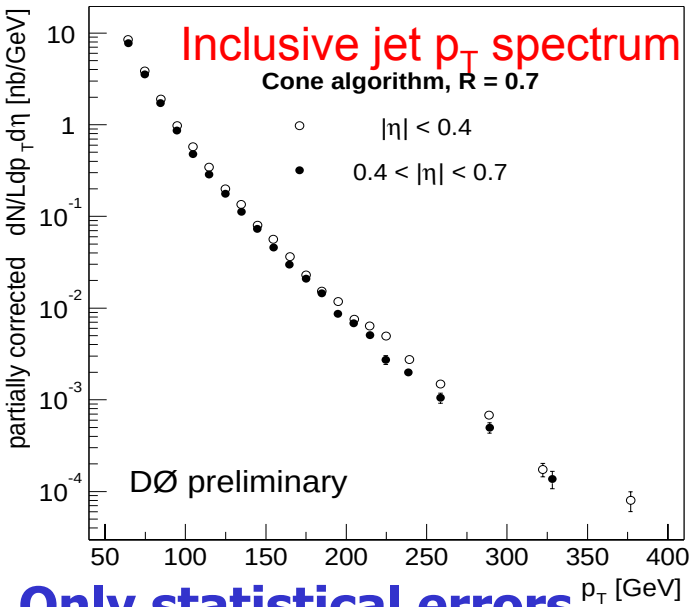


J/ψ production cross section as a function of pseudo rapidity



Jets Physics

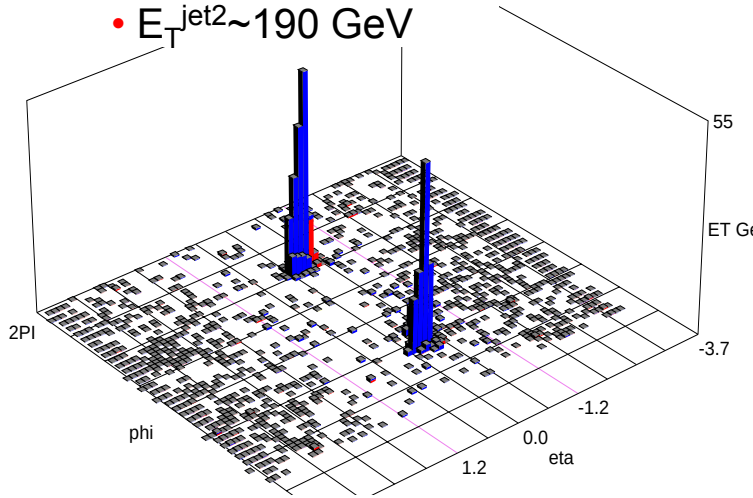
- **At √s=1.96 TeV, cross section 2x larger compared to 1.8 TeV (Run I) for jets with p_T > 400 GeV**

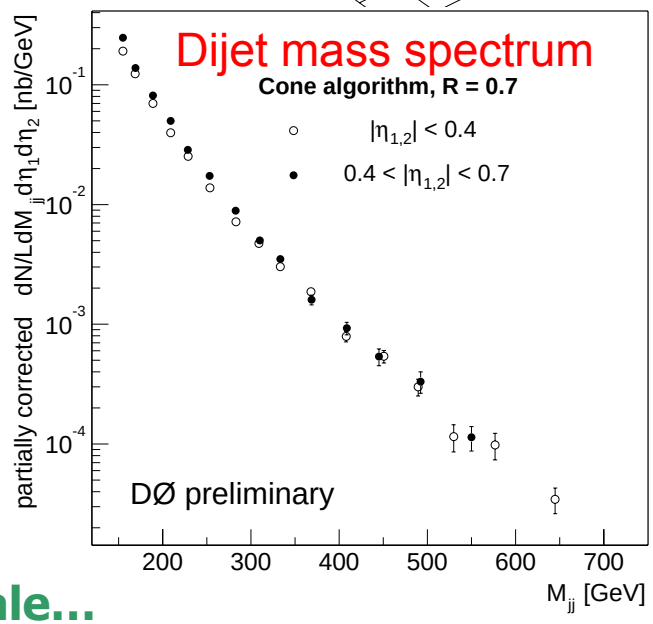


Luminosity 5.8 pb^{-1}

2-jet event

- E_T^{jet1}~230 GeV
- E_T^{jet2}~190 GeV

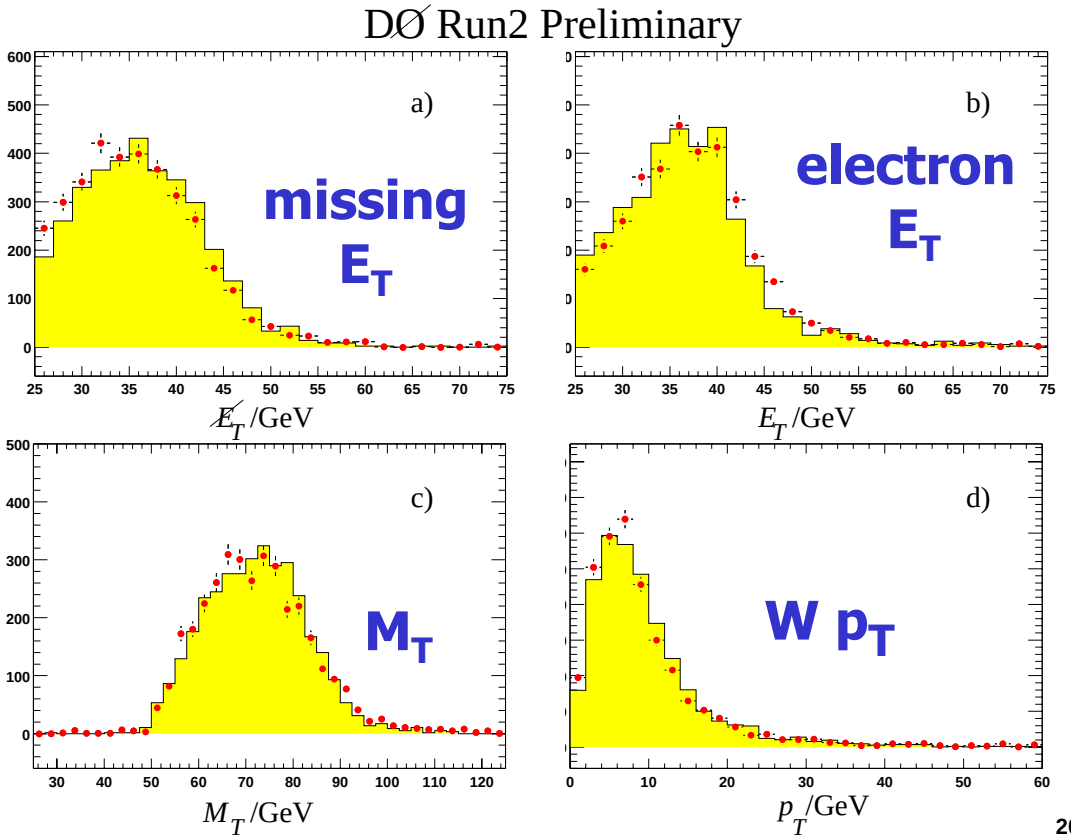




- **Only statistical errors**
- **Preliminary jet energy scale**
- **Not fully corrected**
  (for unsmearing, efficiencies)
- **In the works:**
  - **expanded η range, Improved energy scale…**

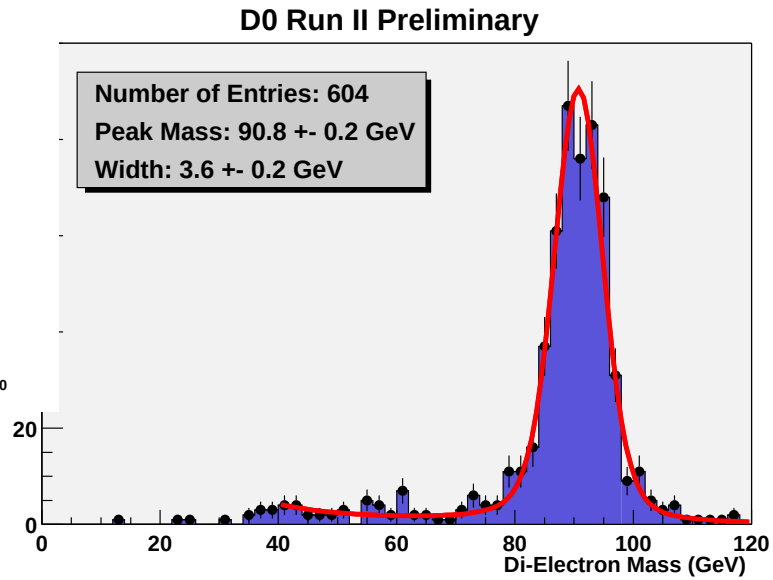
W and Z boson production

W(! eν) event characteristics



Red dots: Data
Yellow filled histogram: MC

Z!ee

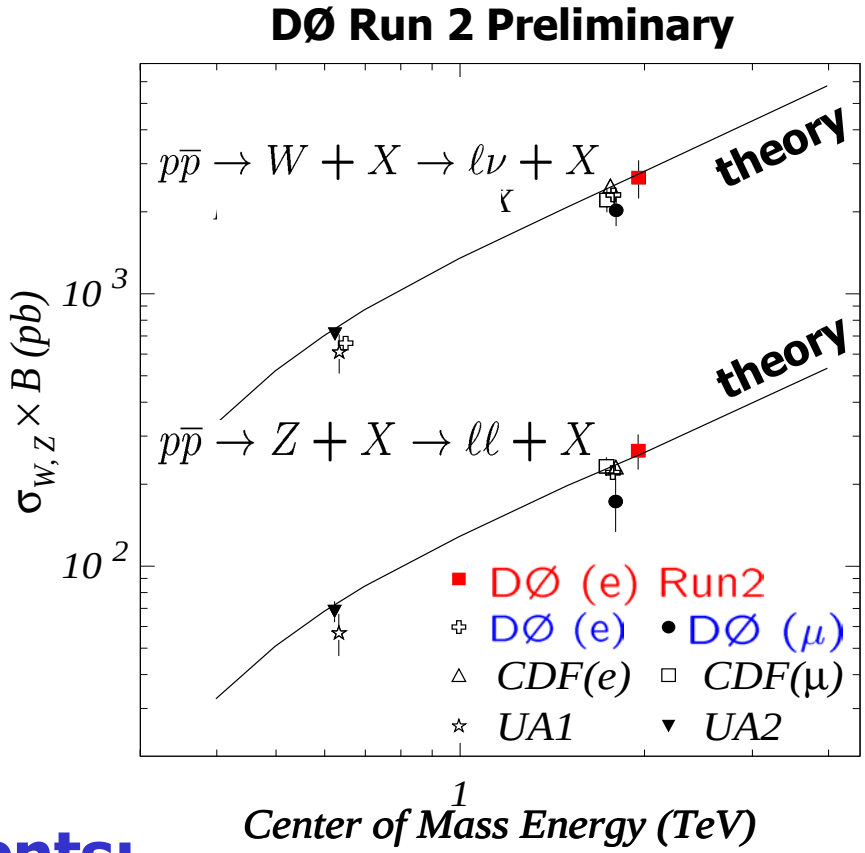


Distributions modeled well by MC

Invariant mass (GeV)

W and Z Boson production cross section

- **Data Sample:**
  - Luminosity ¼ 7.5 pb^{-1}
  - 9205 W candidates
  - 328 Z candidates



- **Cross section measurements:**

$$\sigma_Z \times B(Z \to ee) = 266 \pm 20_{stat} \pm 20_{syst} \pm 27_{lumi} \text{ pb}$$

$$\sigma_W \times B(W \to e\nu) = 2.67 \pm 0.06_{stat} \pm 0.33_{syst} \pm 0.27_{lumi} \text{ nb}$$

W and Z Boson production cross section

- **Ratio of cross sections**

$$R = \frac{\sigma_W \times B(W \to e\nu)}{\sigma_Z \times B(Z \to ee)} = 10.0 \pm 0.8_{stat} \pm 1.3_{syst}$$

- **W boson width**

$$R = \frac{\sigma_W \times B(W \to e\nu)}{\sigma_Z \times B(Z \to ee)} = \frac{\sigma_W \times \Gamma(W \to e\nu)}{\sigma_Z \times B(Z \to ee)\Gamma_W}$$

  - **Using σ(W)/σ(Z) from theory and B(Z! ee) from LEP**

$$\Gamma_W = 2.26 \pm 0.18_{stat} \pm 0.29_{syst} \pm 0.04_{theory} \text{ GeV}$$

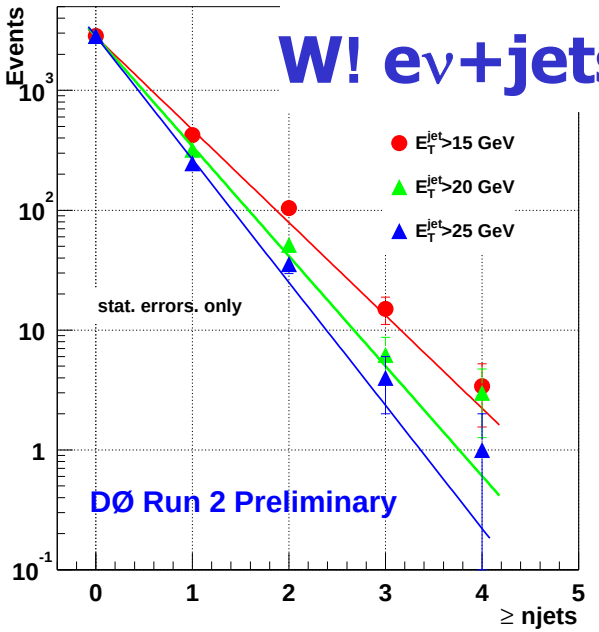
  - **In good agreement with world average:**

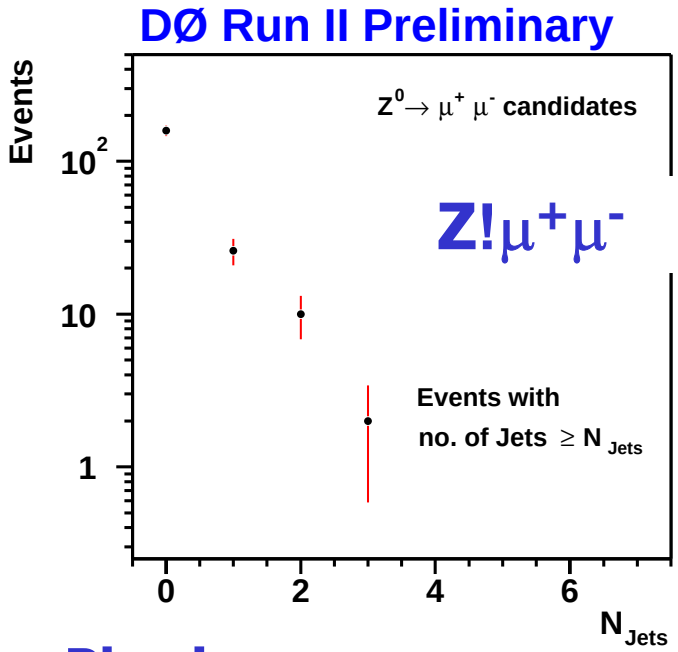
Γ_W = 2.135§0.069 GeV

First results at 1.96 TeV

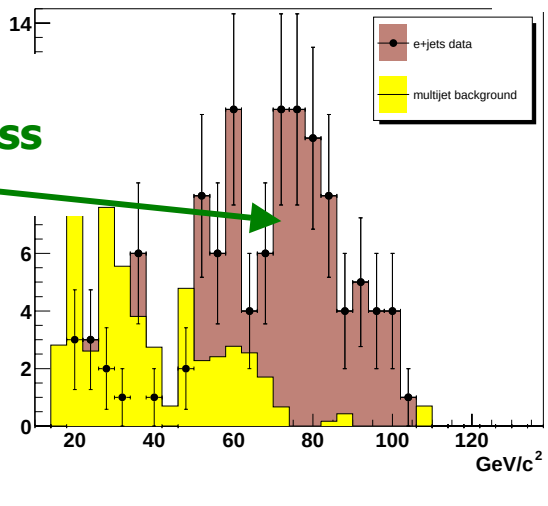
W/Z boson + multijet events

- **Jet multiplicity distributions**





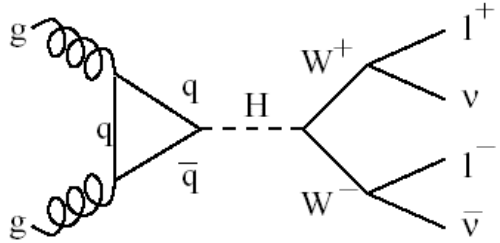
W+≥ 2jets Transverse mass spectrum



- **Top Physics:**
  W+≥3jets, Z+≥2jets
- **Higgs Physics:**
  W/Z +≥ 2jets

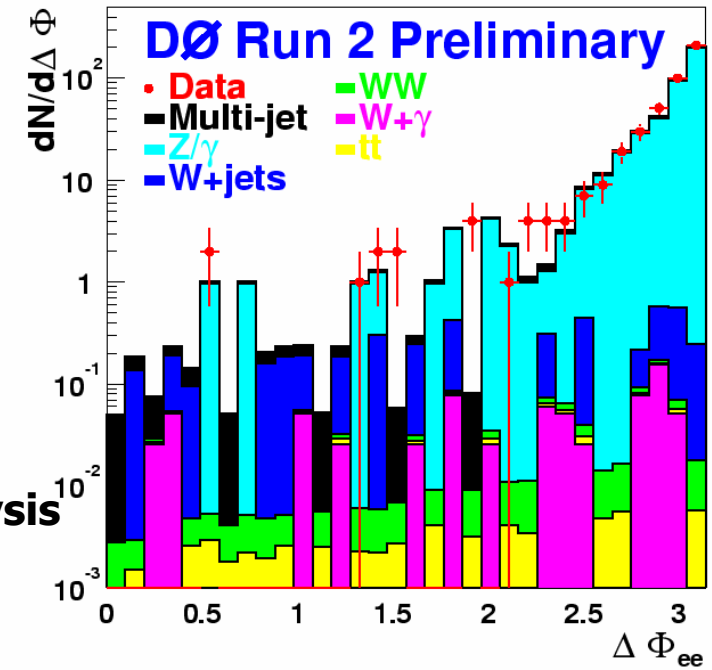
- **Need excellent b-jet identification**
  - **Secondary vertex recons.**
  - **Soft leptons in jets**

H ! WW



- **Why H ! WW at low luminosities?**
  - **4th fermion family enhances SM Higgs cross sections by a factor of ¼ 8.5 for Higgs mass between 100-200 GeV**
  - **Fermiophobic Higgs: B(H! WW) >98% for $m_H \geq 100$ GeV**
- **Search for ee+$\not{E}_T$ events**
- **Understand Backgrounds for SM Higgs Search**

Azimuthal opening angle between the leptons



luminosity 8.8 pb^{-1}

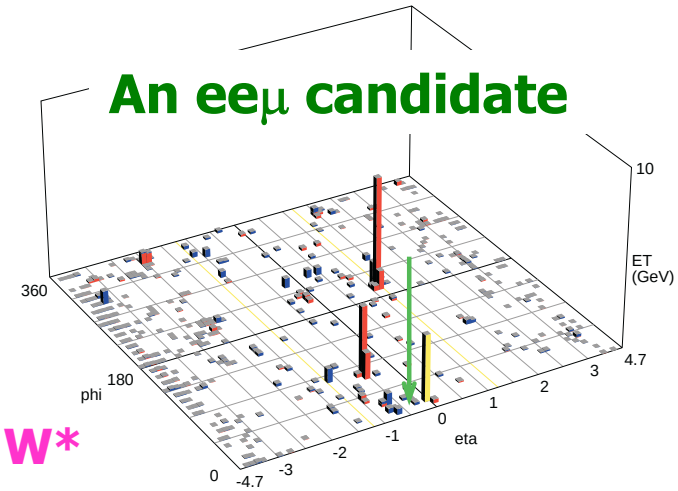
Require good e^+e^-

Observed events in our data and estimated backgrounds are in good agreement.

Develop tools necessary for analysis Of larger data sets.

Search for Phenomena beyond the SM

- **Many Analyses in progress:**
  - **Likesign dielectrons**
  - **Jets+Missing Et**
  - **Tri-lepton signatures**
    - **One of cleanest signatures of SUSY chargino+neutralino production via W***
- **GMSB SUSY**



$$p\bar{p} \rightarrow gauginos \rightarrow W, Z, \gamma + \chi_1^0 \chi_1^0$$

$$\rightarrow \gamma\gamma + \tilde{G}\tilde{G} + \chi\chi$$

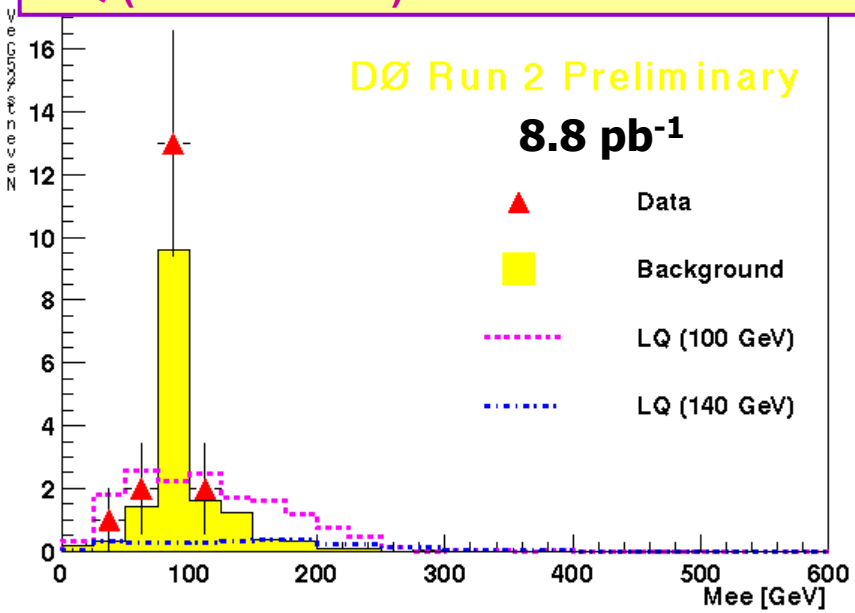
⇒**inclusive search for $\not\!\!E_T$ + X**

- **Limit:**
- **Sensitiv** $\sigma < 0.9pb \quad @95\% \quad CL$ **points**

Leptoquarks

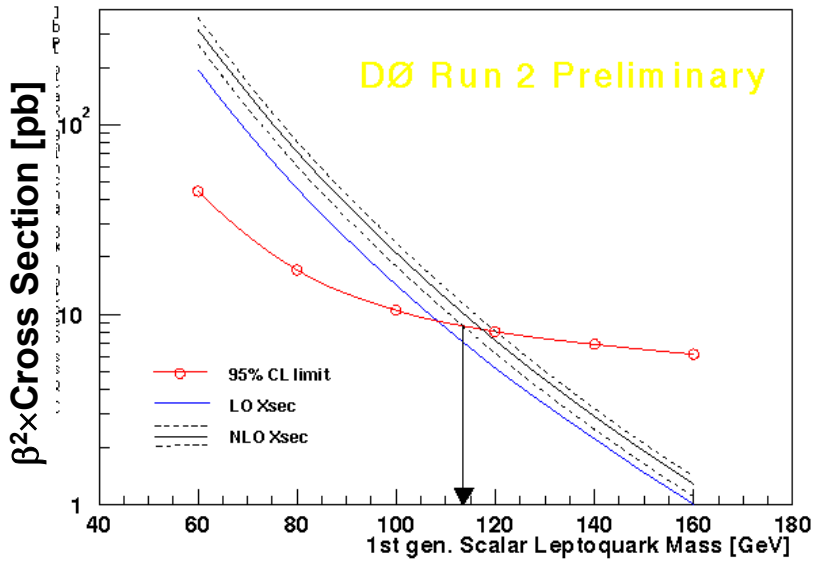
- particles with properties of both quarks and leptons; restore symmetry between the two
- Signature: eejj events

Data :	18 events
Background :	15.3 ± 5.3 events
LQ (m = 100 GeV) :	15.4 ± 2.0 events
LQ (m = 140 GeV) :	3.1 ± 0.3 events



6 candidates after removing Z

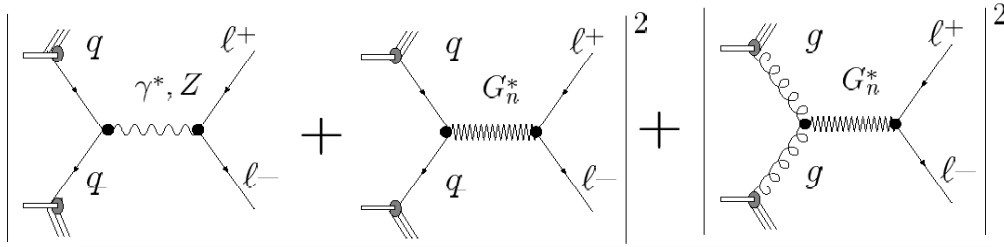
$M_{LQ} > 113$ GeV/c^2 at 95% CL, for $\beta=1$



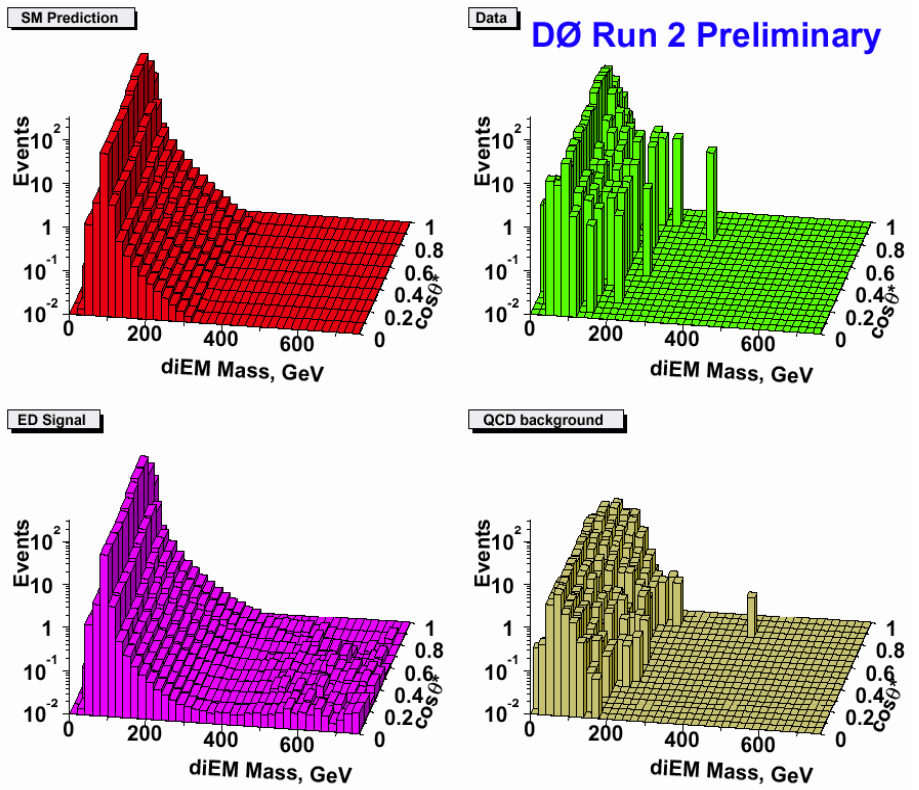
Consistent with our Run I result

Extra Dimensions

- **Search for large extra spatial dimensions via virtual graviton effects**
- **e^+e^-, $\gamma\gamma$ and $\mu^+\mu^-$ events**



- **Run2 Preliminary Limit:**
  - **Ms(GRW) > 0.92 TeV (ee,$\gamma\gamma$)**
- **DØ Run I limits:**
  - **Ms(GRW) > 1.2 TeV**

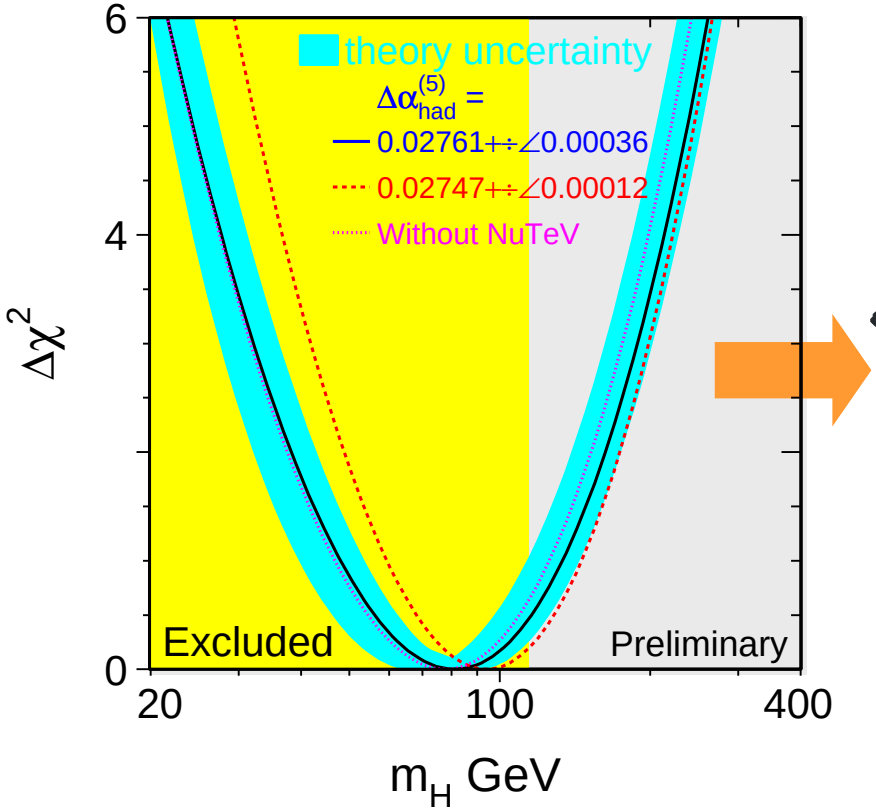


Future Prospects

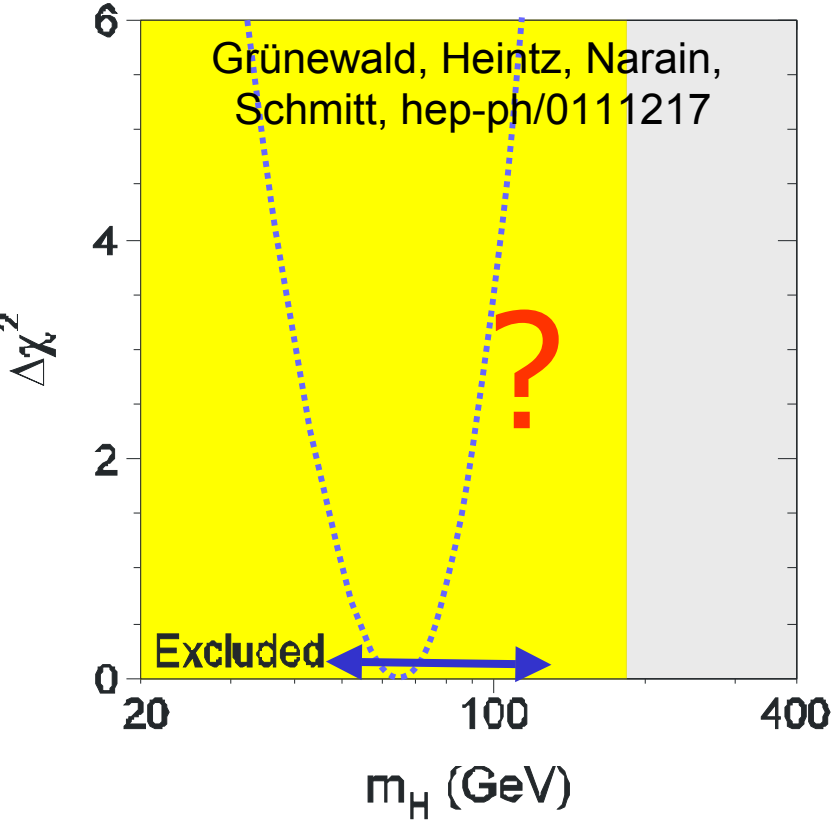
- Continue to Search for New Physics
  - SUSY, strong dynamics, others…
- Rich program of B-physics
- Measure W/Z Properties (A_{FB}, W mass to 30 MeV)
- Comprehensive study of Top quark Properties ($2fb^{-1}$)
  - Cross section(7%), Mass (2 GeV)
  - spin correlations, charge, top-gauge boson couplings
- Precision measurements of Top quark and W Boson mass
  $\Rightarrow$ constrain the Higgs Boson
- Direct Searches for the Higgs Boson
  - Run IIa: M_H & 115 GeV
  - Run IIb: M_H & 180 GeV or see signal
- With 15 fb^{-1}
  - δm_t ¼ 1 GeV, δm_W ¼ 15 MeV, δA_{FB} ¼ 2 £ 10^{-4}

Can we exclude the SM?

summer 2002



¼ 2008



- **current central values**
- **$\delta\Delta\alpha^{(5)}_{had}(M_Z^2) = 10^{-4}$, δM_W = 20 MeV, δm_t = 1 GeV**
- **could lead to inconsistency within SM framework**

Thanks to my collaborators…

Institutions:

33 US, 40 non US

Collaborators:

334 from US

312 from non US institutions

Conclusion

- **First physics results at 1.96 TeV**
  - W and Z production cross sections
  - First generation LQ limits, Limit on Large Extra Dimensions
  - Lay foundation towards measurement of:
    - B lifetime, b-quark cross sections, jet cross sections
    - Many High p_T analyses in progress awaiting more luminosity

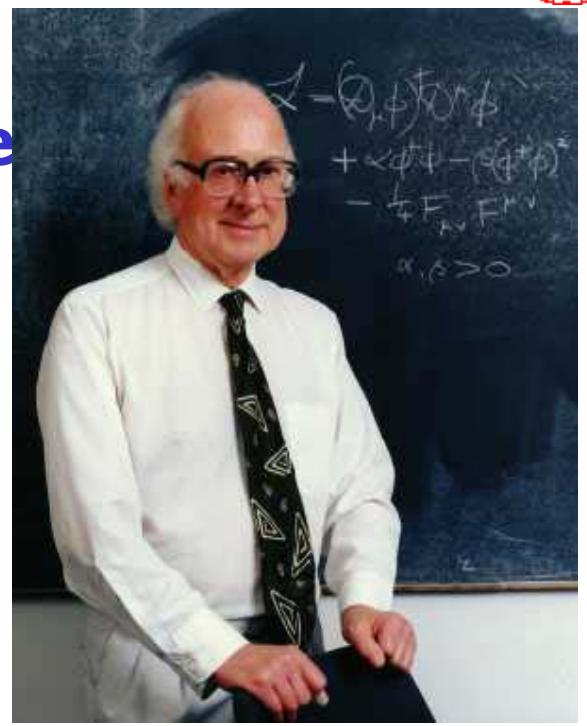
- **Enormous progress made over the last year**
  - detector performance optimization
  - developing analysis tools

- **Improvements in store:**
  - optimization of event reconstruction and selection procedures
  - Triggers and DAQ performance,
  - calibration, and alignment of the detectors

- **Looking forward to collecting large integrated luminosity !**

Outlook

- **We are curious to see where it le**



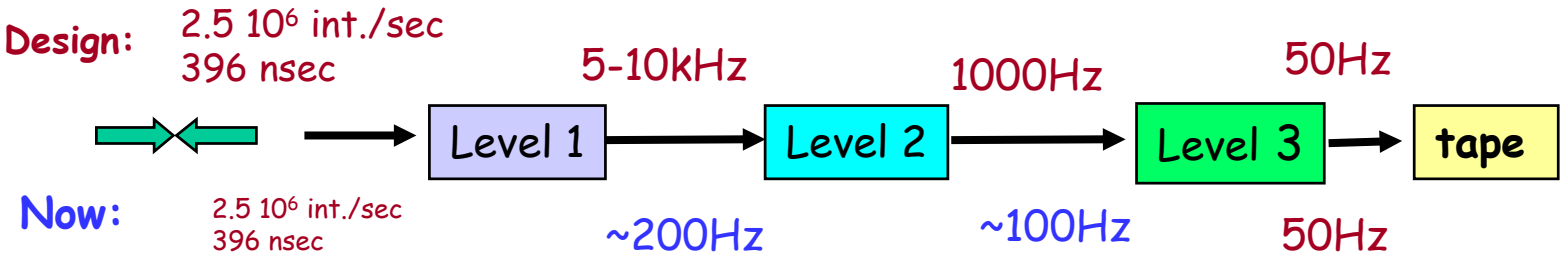
Prof. Peter Higgs

Status details

All subdetectors operational & reading out

All electronics, fronts ends, trigger & DAQ hardware installed

Remaining: tuning up of the trigger/DAQ system



Changed to new modern L3/DAQ system this year (done)

Commissioning and tuning up this system
VERY COMPLEX and high bandwidth system
Expect full rate by middle of fall of 2002

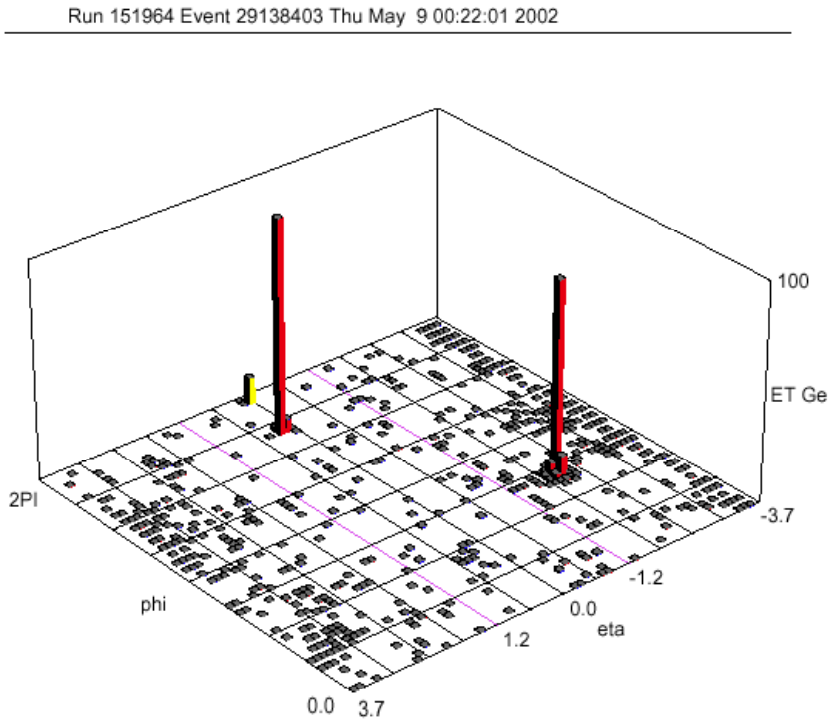
Large effort

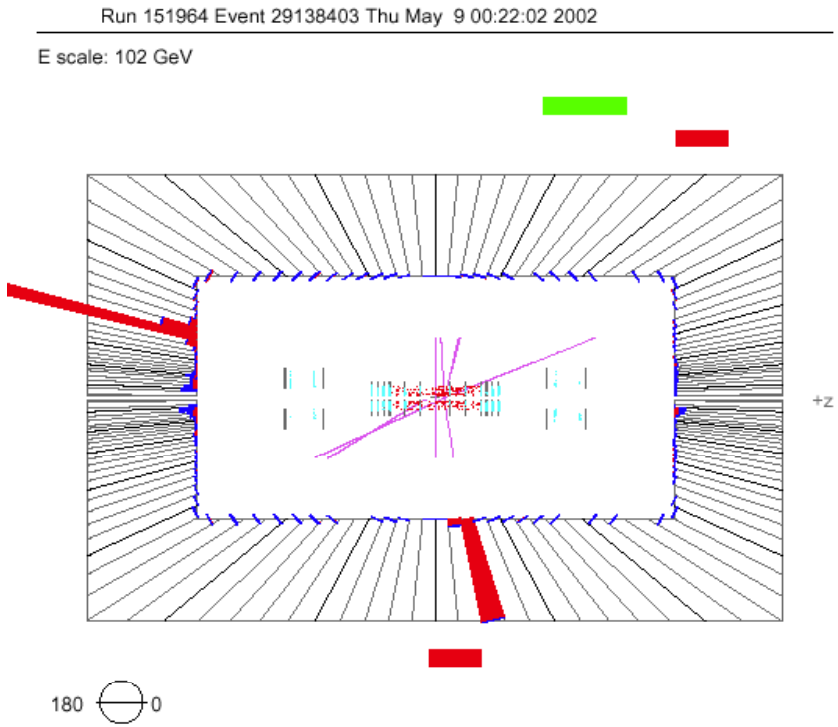
Data taking continues
No loss of physics at current luminosities

Backup Slides

- **Insert backup slides after this page**

The Most Massive Candidate event



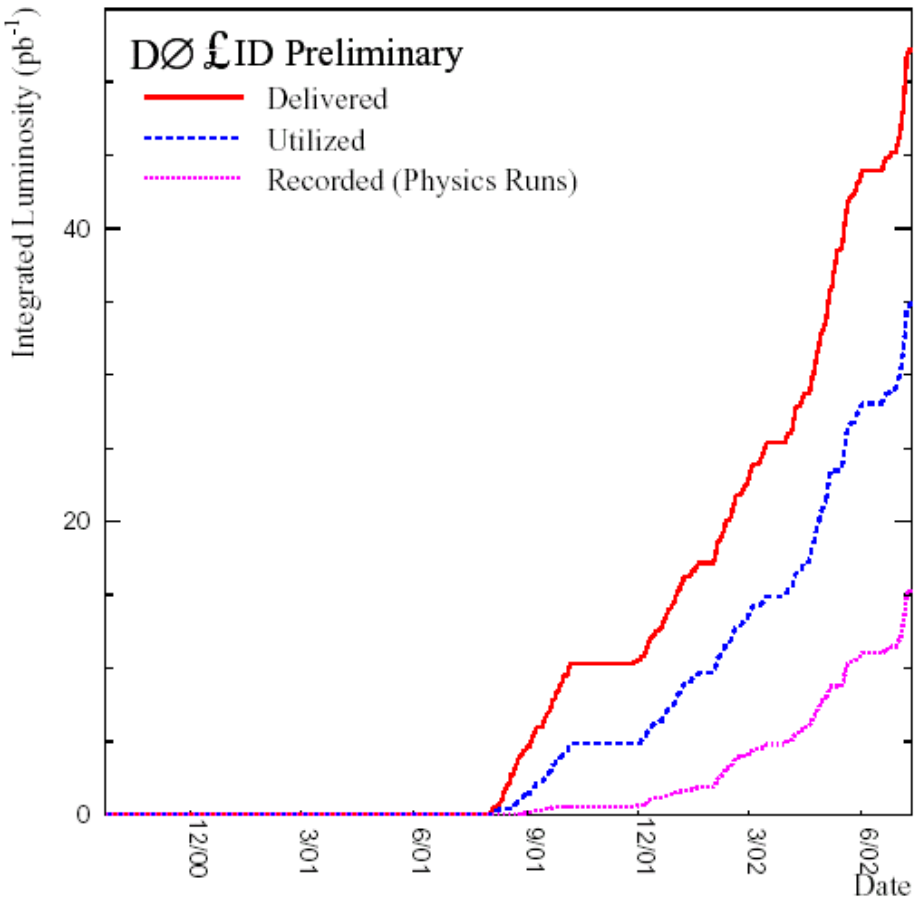


EM1	EM2
E_T = 120.3 GeV η = 0.10 φ = 5.27 No track match	E_T = 106.2 GeV η = -2.10 φ = 2.19 No track match

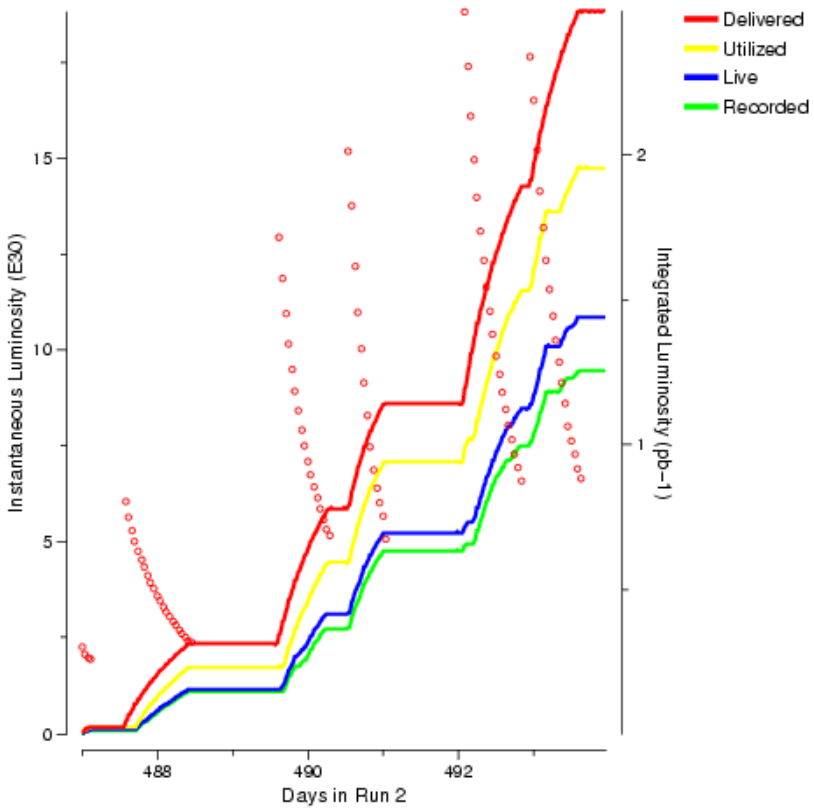
M(diEM) = 377 GeV; cosθ* = 0.77; ME_T = 12.6 GeV;

Luminosity

Total Run 2 luminosity delivered & used

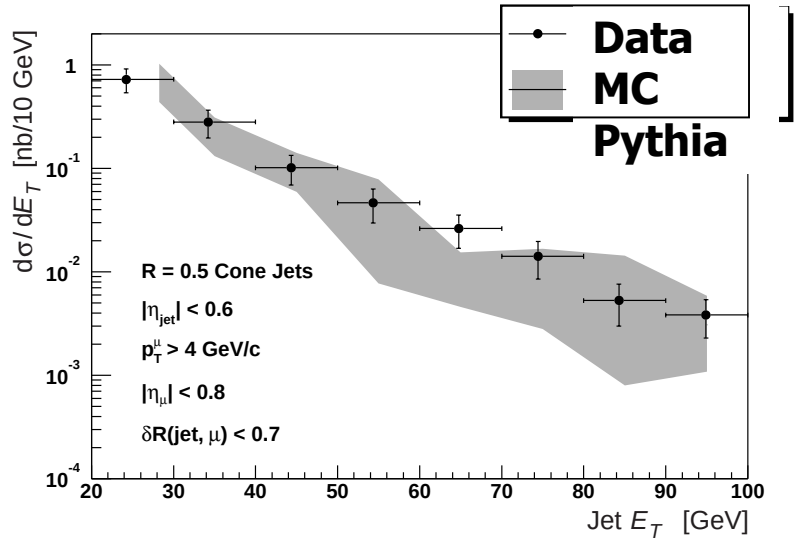


A snapshot: July 1 to July 6, 2002

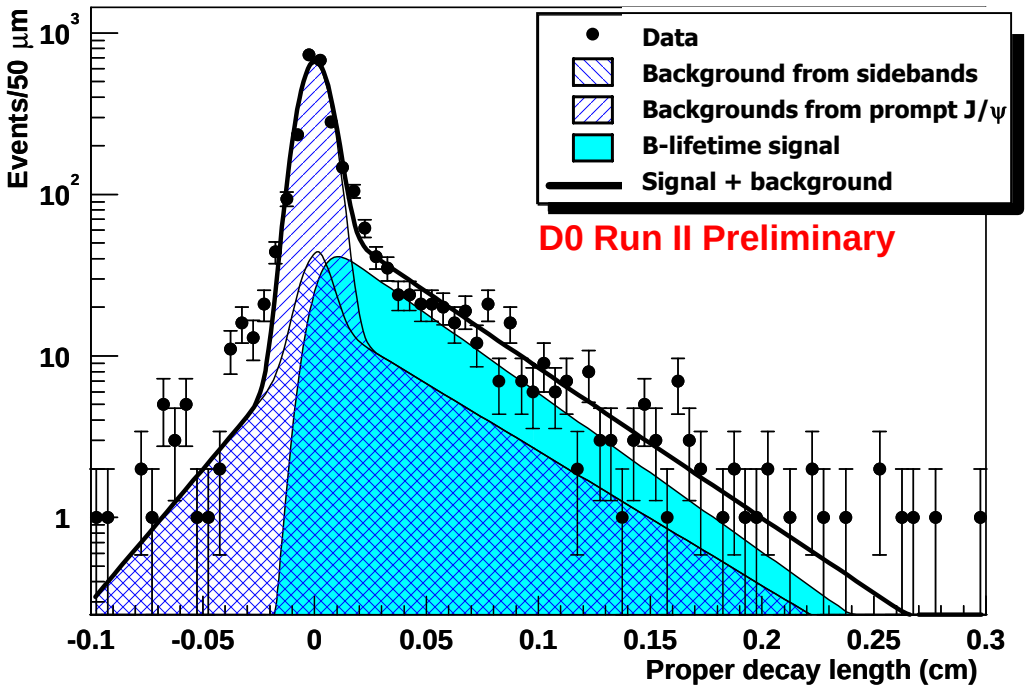


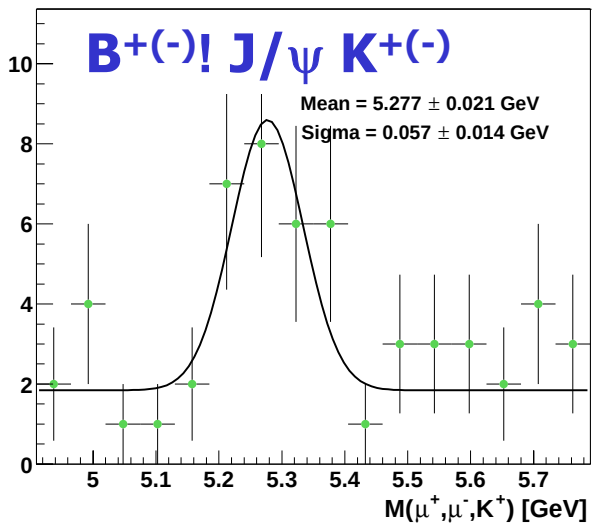
B-Mesons

b-quark Production Cross Section



Average B Lifetime (B! J/ψ+X)

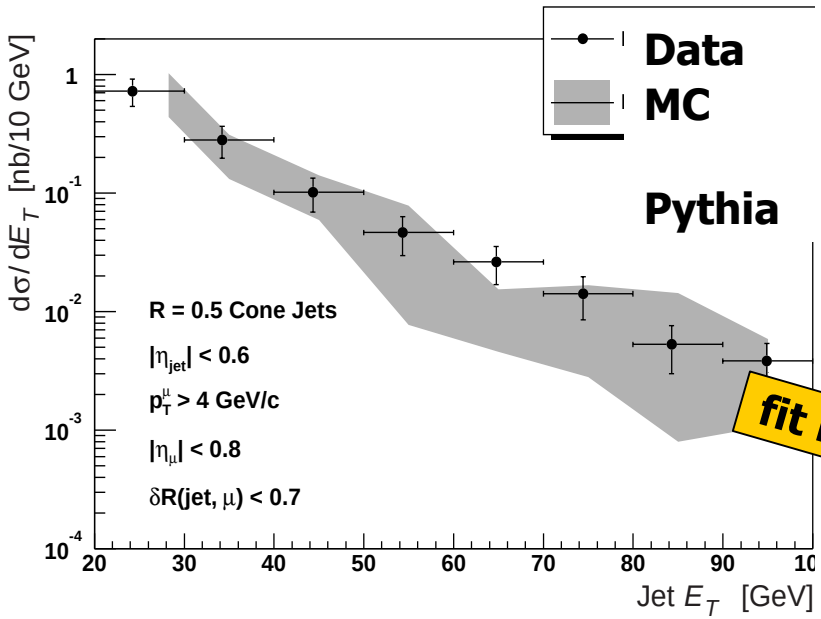




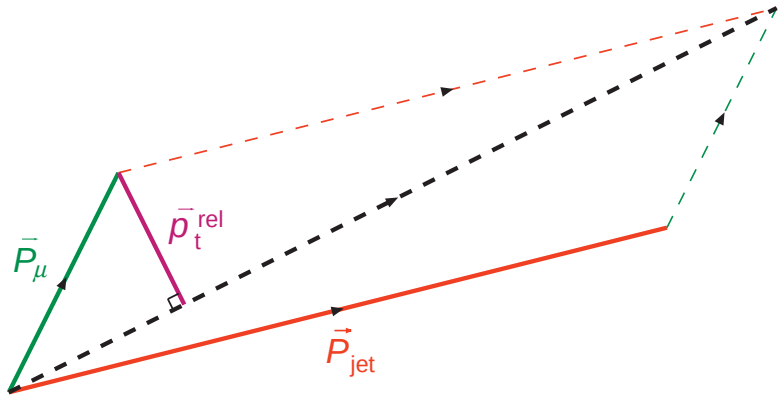
Also have measured J/ψ cross sections out to pseudorapitidy of 1.6

B-quark Production Cross Section

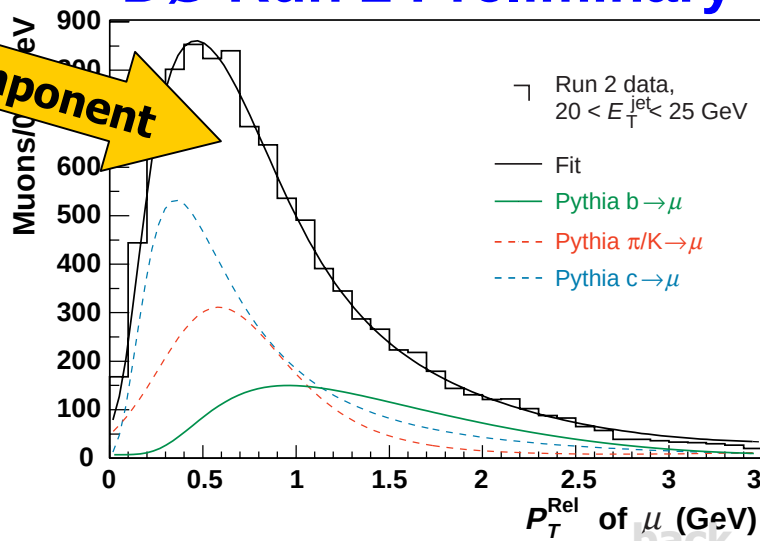
μ+jet Cross Section



fit b component



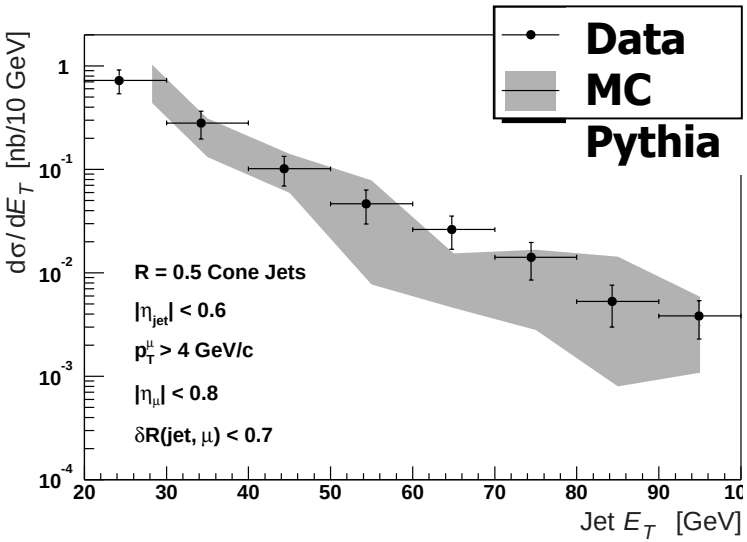
DØ Run 2 Preliminary

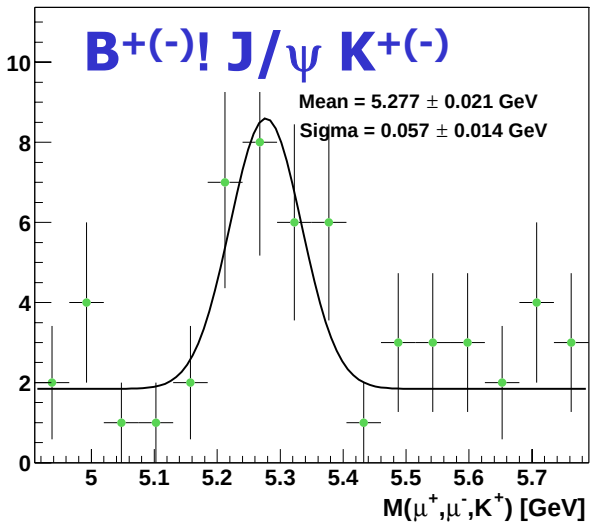


back

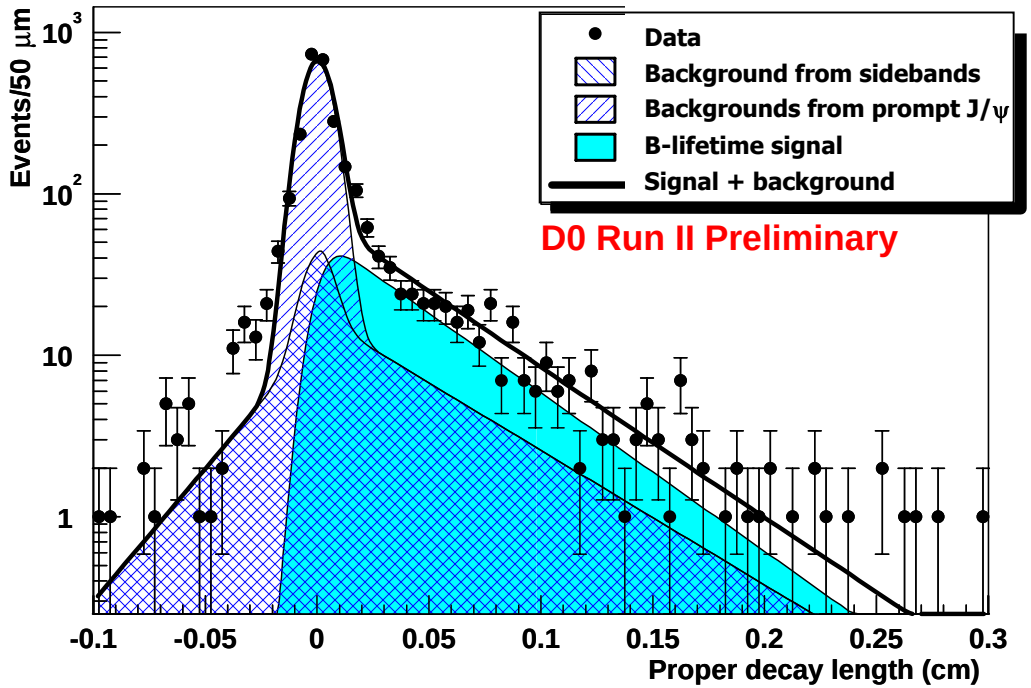
B-Mesons

b-quark Production Cross Section



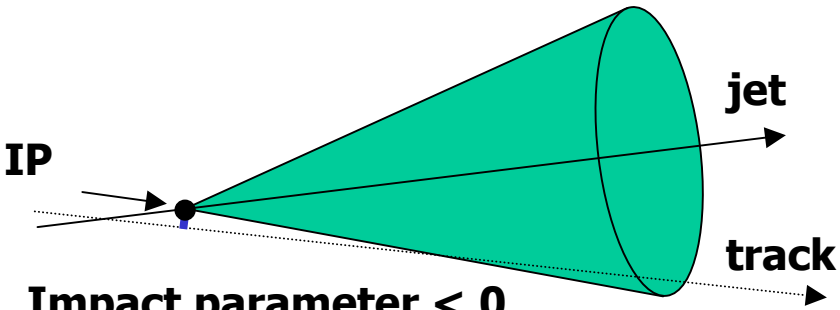


Average B Lifetime (B! J/ψ+X)

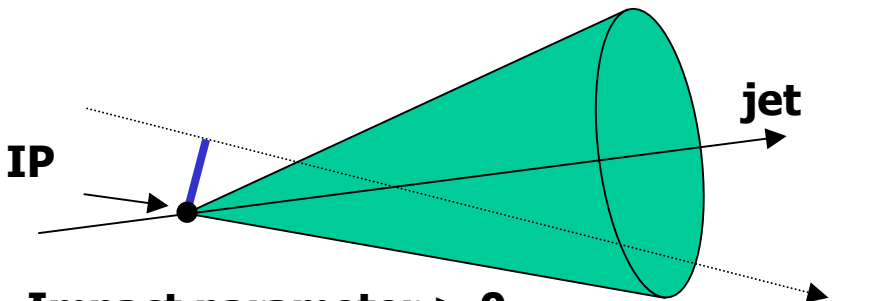


Identyfying b-quarks

- **Signed impact parameter**



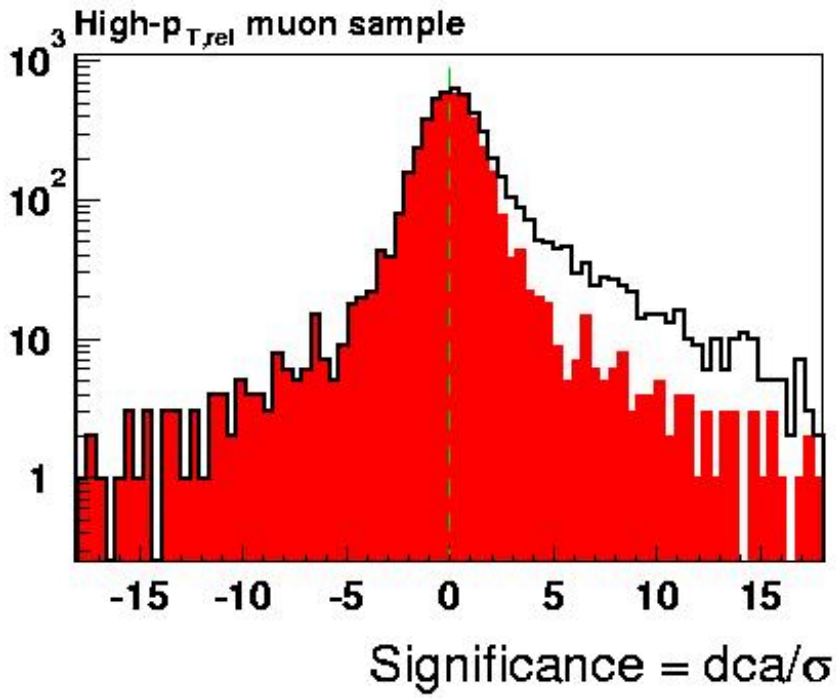
Impact parameter < 0 (resolution)



Impact parameter > 0 (secondary decay vertex)

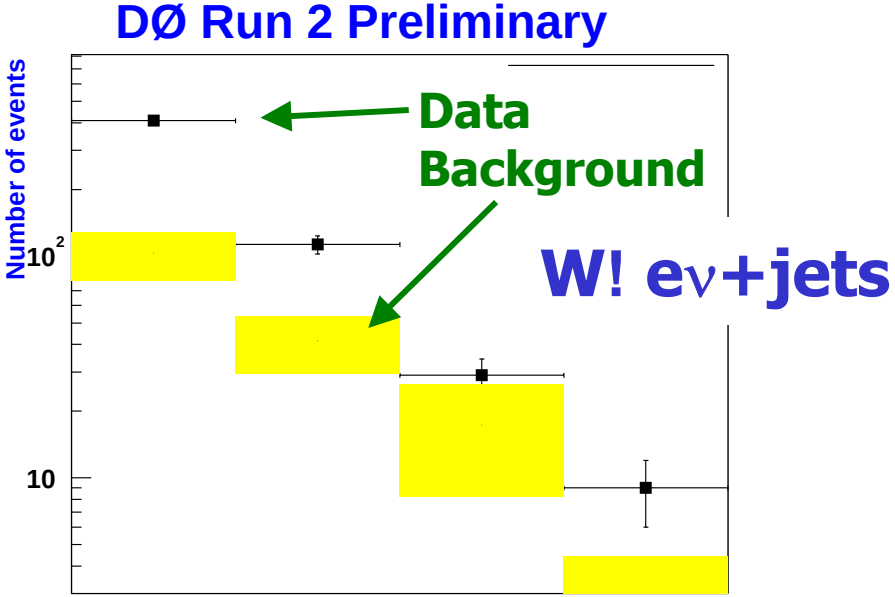
→ **Reconstruct secondary vertex**
→ **Also use semileptonic decays**

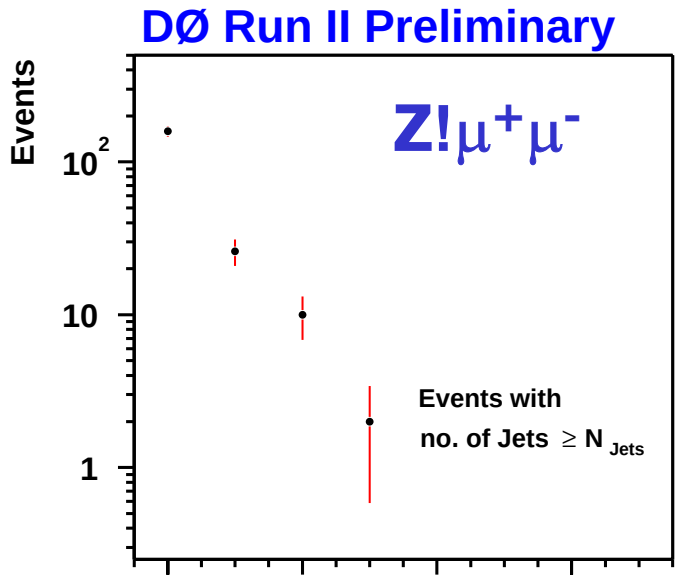
μ+jet data sample
muon p_T^{rel} > 1.5 GeV wrt jet
→ **enhanced b-jet content**



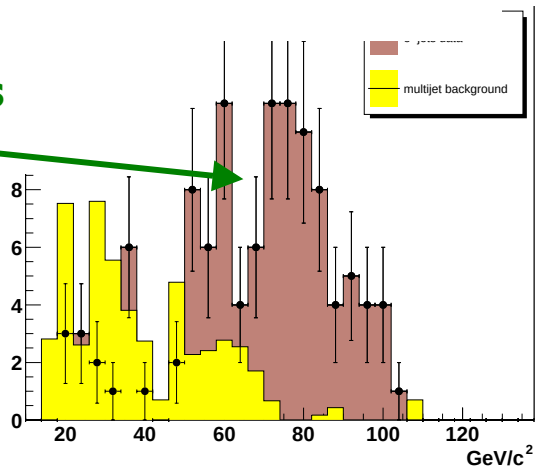
W/Z boson + multijet events

- **Jet multiplicity distributions**





W+≥ 2jets
Transverse mass spectrum



- Top Physics: W+≥3jets, Z+≥2jets
- Higgs Physics: W/Z +≥ 2jets

- Need excellent b-jet identification
  - Secondary vertex recons.
  - Soft leptons in jets