Run II Results
QCD and B Physics

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for the D0 collaboration

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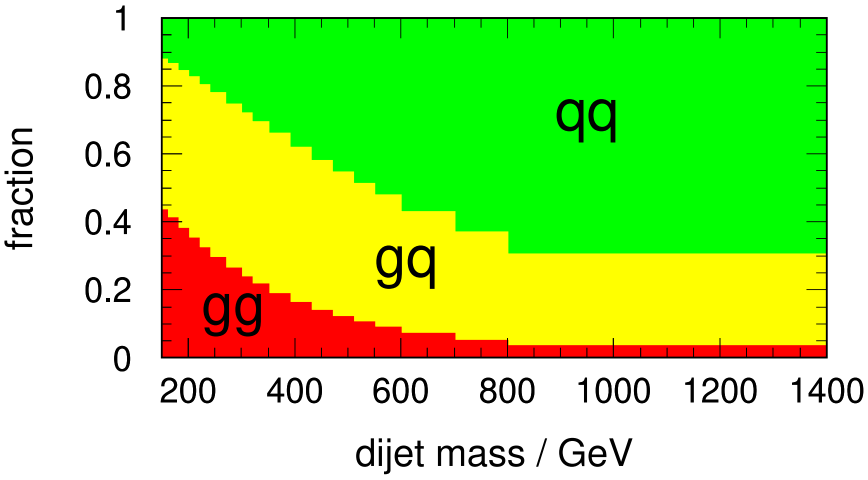
Jet Production at the Tevatron

most powerful accelerator on earth!!

- test of pQCD predictions – up to highest jet energies

- direct sensitivity to gluon at large x

  <u>dijet cross section:</u>
  significant gluon contributions
  at highest masses

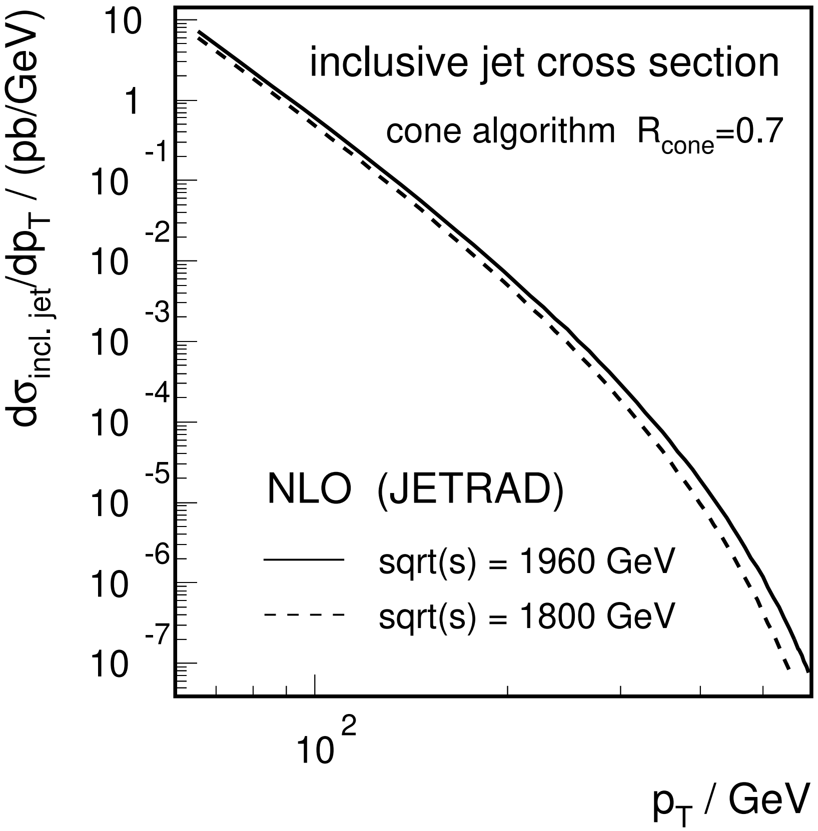


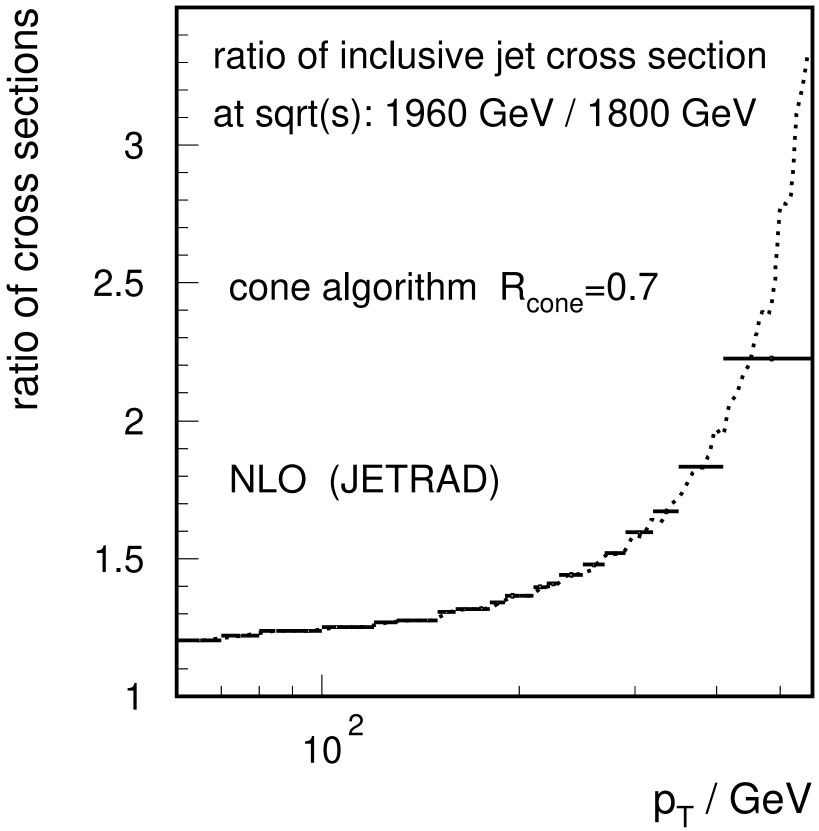
- search for new physics
  - hunting for resonances
  - at highest p_T and largest $M_{JJ} \rightarrow$ quark compositness ??

Tevatron $\Rightarrow$ unique possibilities

Jet Production at $\sqrt{s} = 1960$ GeV

inclusive jet cross section at $\sqrt{s}$=1960 GeV and $\sqrt{s}$=1800 GeV





$\Rightarrow$ increase between 20% and 260%

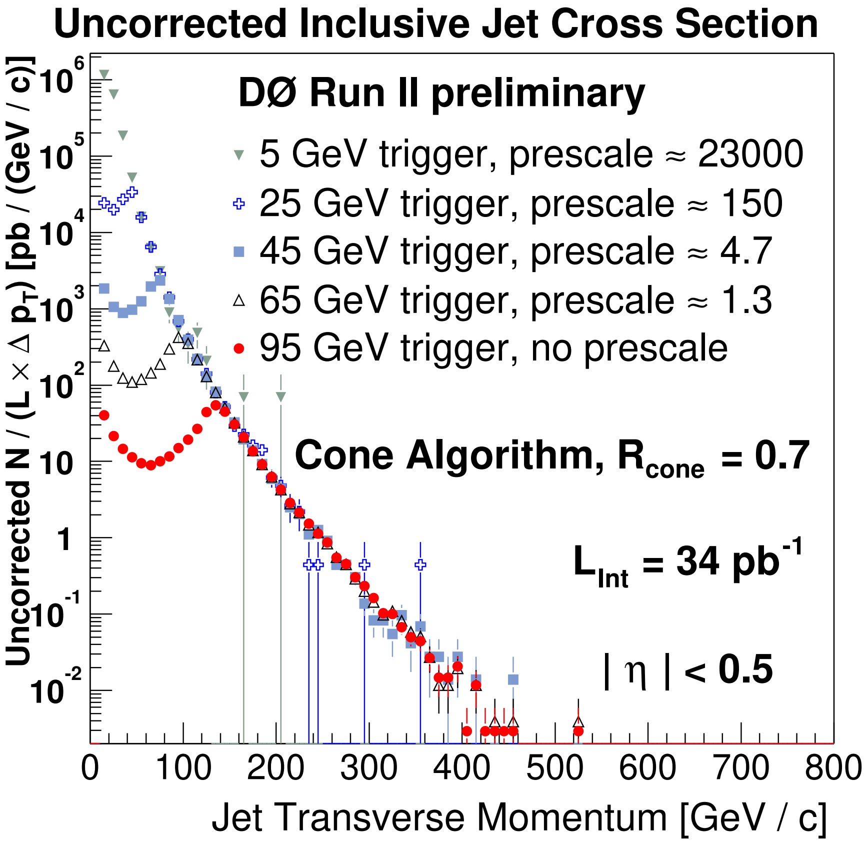
Inclusive Jet Cross Section

data sample: $\mathcal{L}_{\text{int}} = 34\,\text{pb}^{-1}$

iterative cone algorithm
using midpoints – $\Delta R_{\text{cone}} = 0.7$

event selection:
prim. vertex: $|z_{\text{vtx}}| < 50\,\text{cm}$, $N_{\text{track}} > 4$
$\not{E}_T / p_{T,\text{lead.}} < 0.7$

jet selection:
shower shapes
$|\eta| < 0.5$ (“central region”)



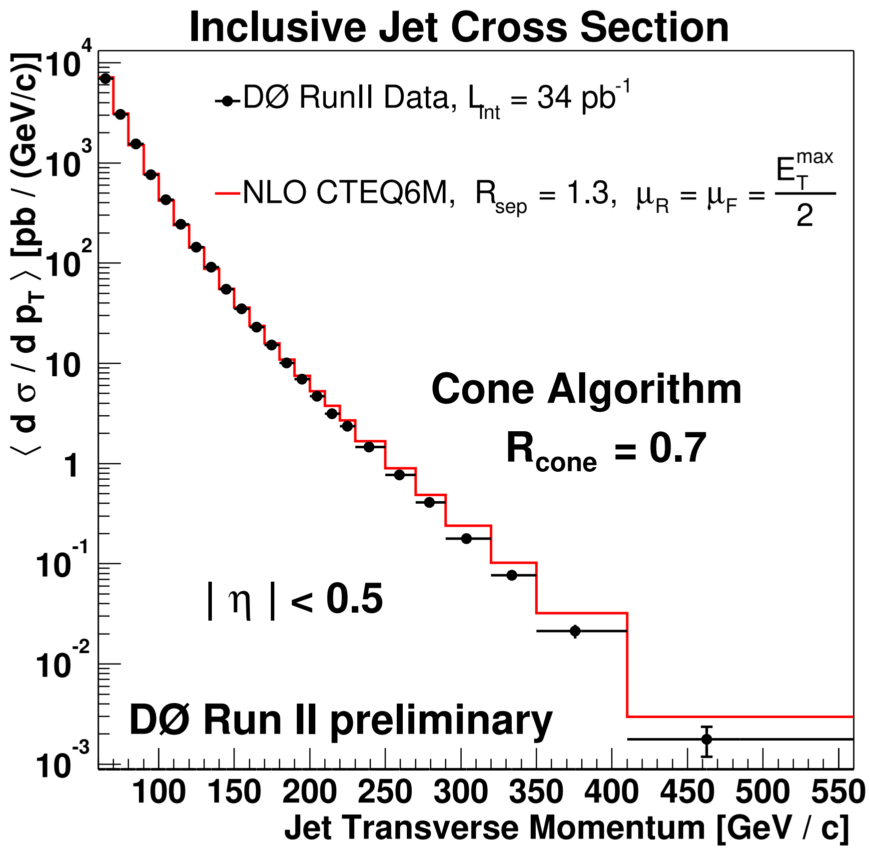
four different jet triggers cover the range $60 < p_T < 560\,\text{GeV}$

Inclusive Jet Cross Section

preliminary result:

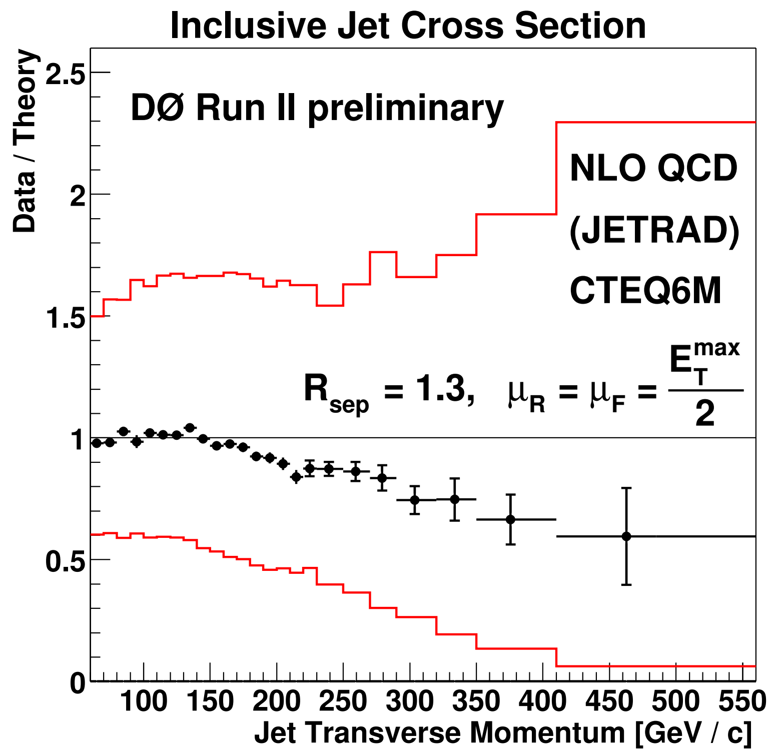
incl. jet cross section falls
more than 6 orders of magnitude
at $60 < p_T < 560\,\mathrm{GeV}$

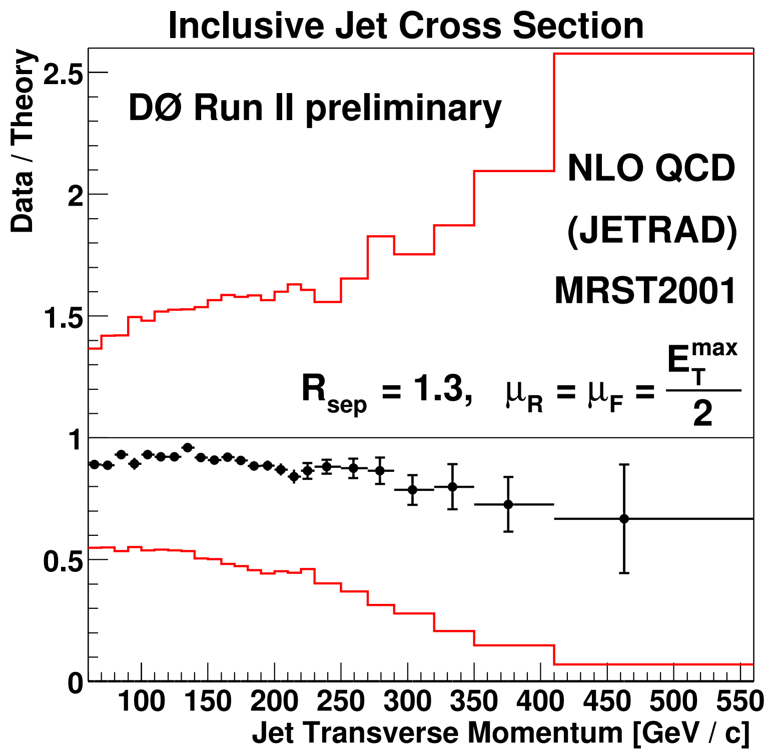
data: incl. stat. & syst. uncertainties
but not (correlated):
energy scale uncertainty
integr. luminosity $\pm 10\%$



$\Rightarrow$ well reproduced by theory: NLO (JETRAD)

Inclusive Jet Cross Section





$\Rightarrow$ large uncertainties due to uncertainty in the jet energy scale

$\Rightarrow$ **data are well-described by NLO**

Dijet Cross Section

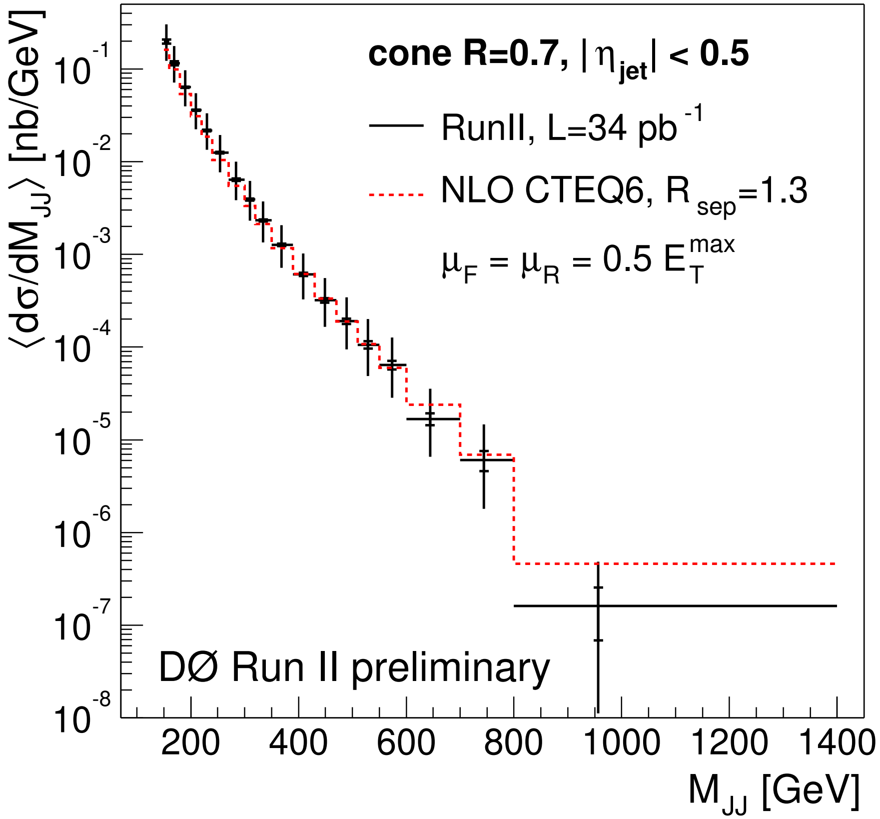
data sample: $\mathcal{L}_{\text{int}} = 34\,\text{pb}^{-1}$

iterative cone algorithm
using midpoints – $\Delta R_{\text{cone}} = 0.7$

event selection:
prim. vertex: $|z_{\text{vtx}}| < 50\,\text{cm}$, $N_{\text{track}} > 4$
$\not{E}_T / p_{T,\text{lead.}} < 0.7$

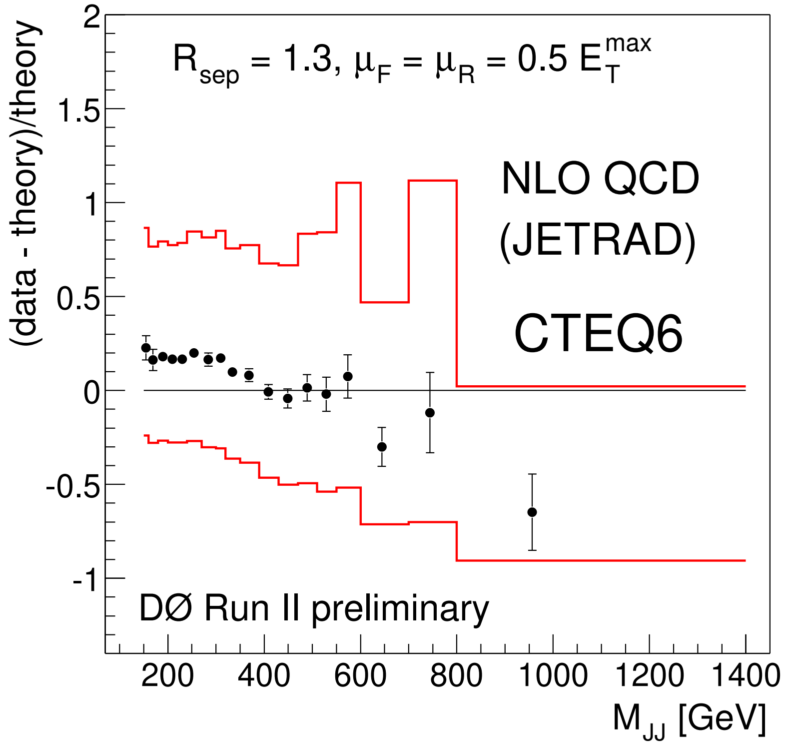
jet selection: shower shapes
two (or more) jets
two leading jets: $|\eta| < 0.5$

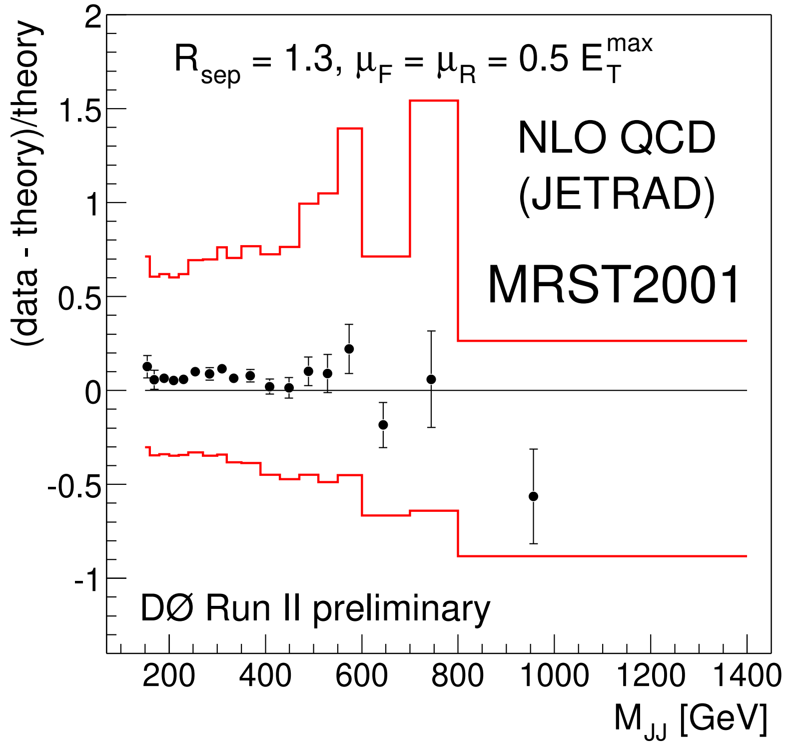
dijet x-sect. falls 6 orders of magnitude
over $150\,\text{GeV} < M_{\text{JJ}} < 1400\,\text{GeV}$



⇒ well reproduced by theory: NLO (JETRAD)

Dijet Cross Section





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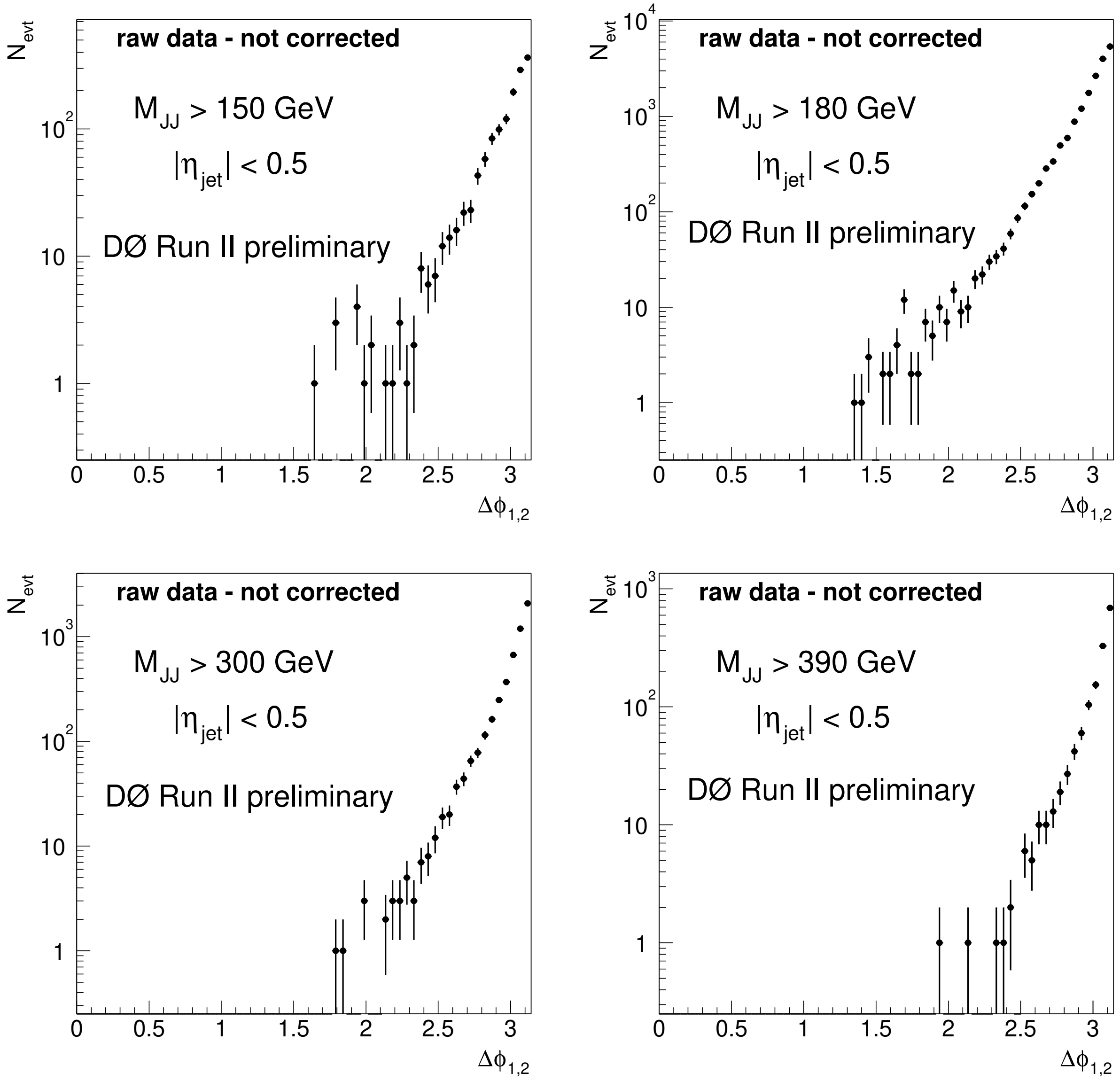
Dijet Cross Section – Delta Phi



Delta Phi distribution (uncorrected)

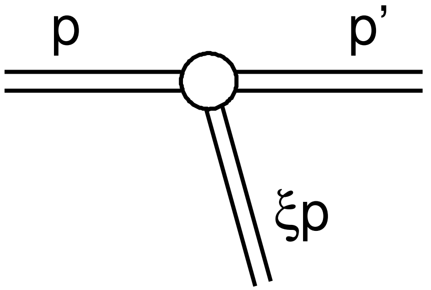
$\Delta\phi_{1,2}$ is sensitive to additional p_T in the dijet event – outside the two leading jets

theory: contributions beyond leading order

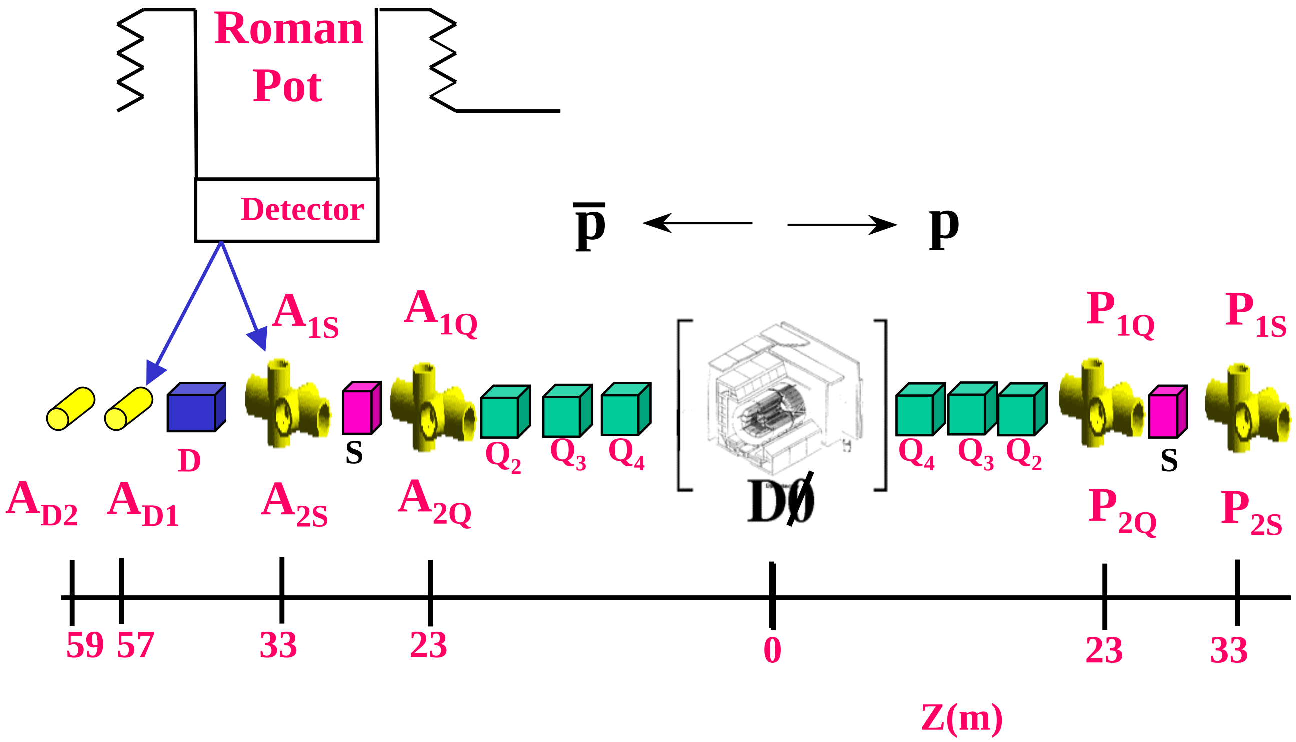
$\Rightarrow$ dijet system is better balanced in azimuthal angle at higher masses

Forward Proton Detector

⇒ detect protons in diffractive events



$$t = (p - p')^2$$
$$p' = x_l\, p$$
$$\xi = 1 - x_l$$



dipoles & quadrupoles:
sensitive to different kinematic regions in ξ and t

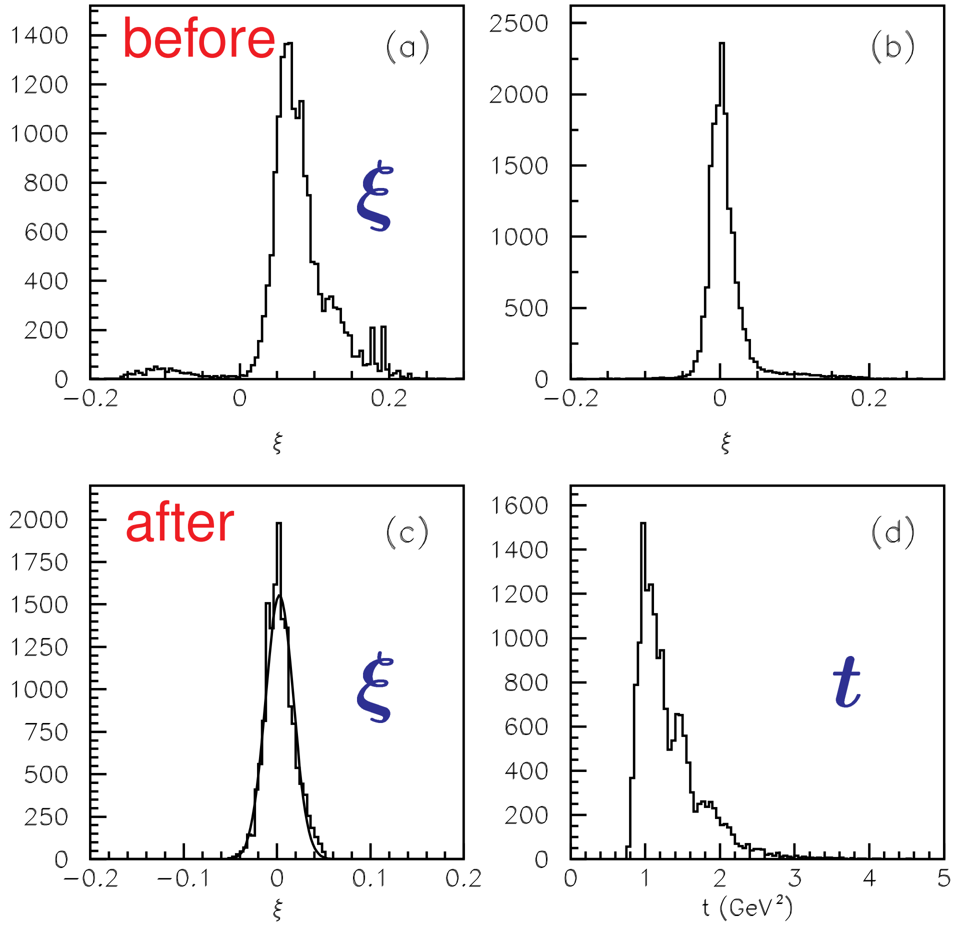
⇒ 10 (of 18) pots now integrated into DAQ

FPD Alignment

detector performs as designed
(good efficiency / resolution)

have observed
diffractive and elastic events

$\Rightarrow$ alignment:
using elastic scattering data



$\Rightarrow$ good prospects for measurements of diffractive cross sections

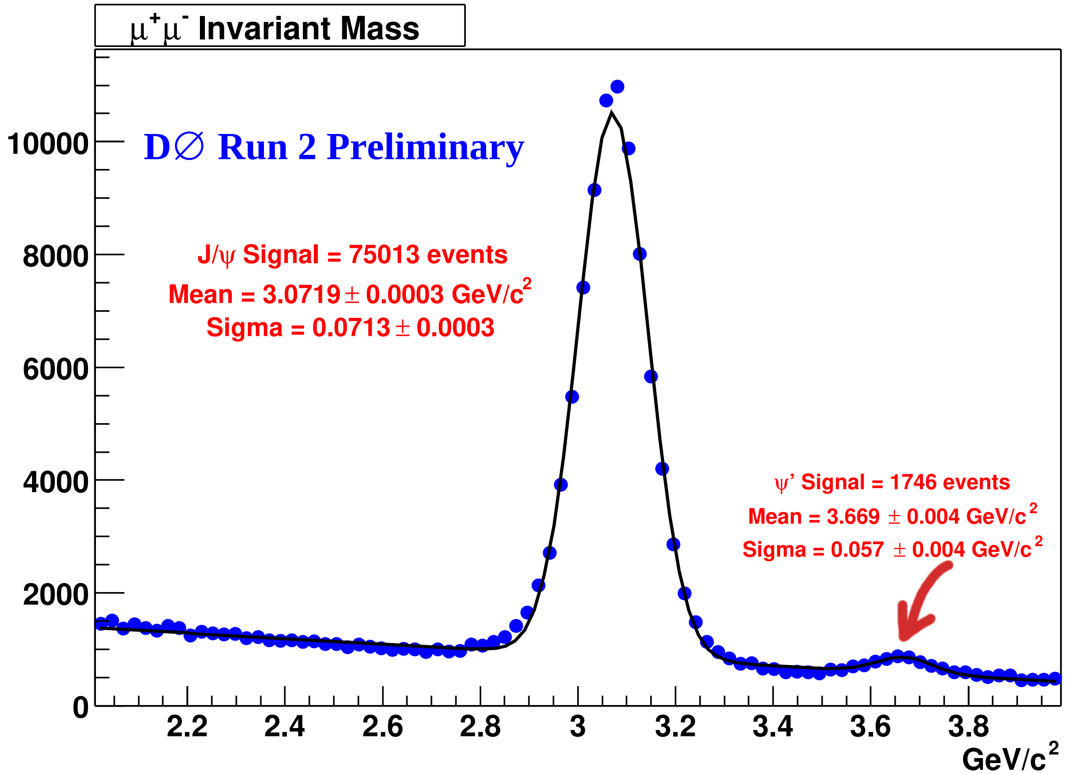
B Physics

high inclusive b production cross section
$\Rightarrow$ precise study of rare B hadron decay modes

- J/ψ dimuon mass peak
- average and charged B lifetime
- exclusive decays / B_s and Λ_b production
- flavor tagging (prospects: mixing and CP violation)

J/ψ Dimuon Mass Peak

Results presented here use $J/\psi \to \mu^+\mu^-$ sample



- unprescaled trigger
- clean signal
- large number of B mesons

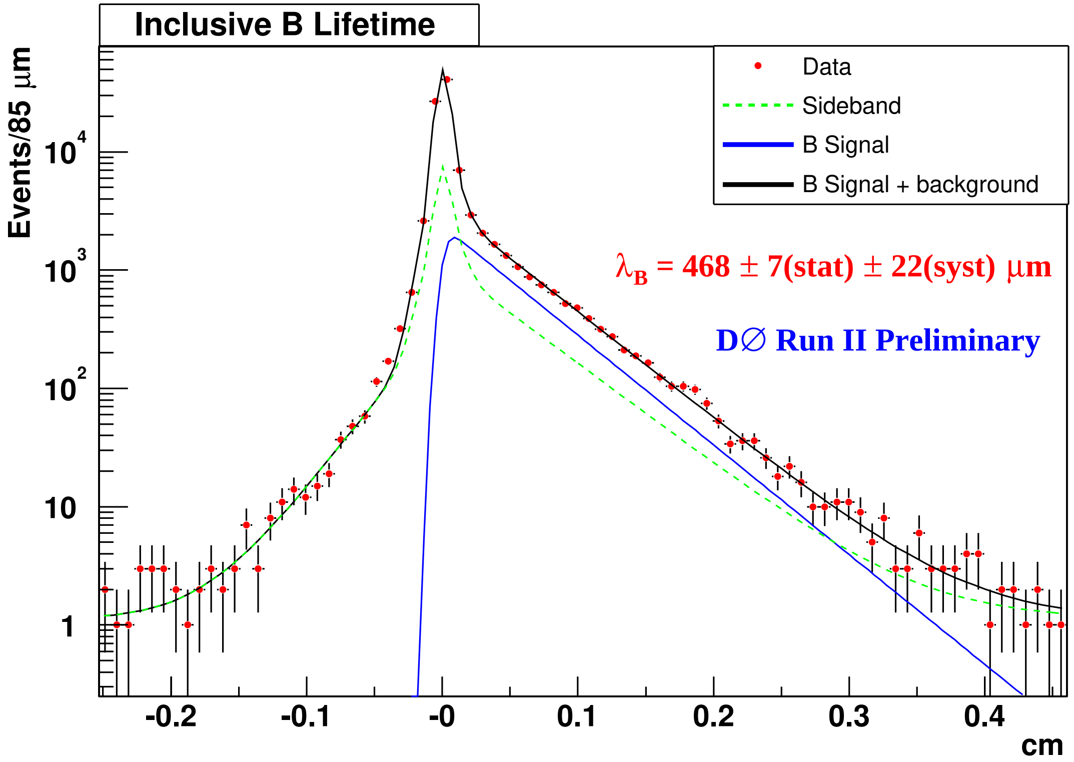
$|\eta_{\mu^\pm}| < 2.4$

$\mathcal{L}_{\text{int}} = 40\,\text{pb}^{-1}$

$\approx$ 75,000 J/ψ events

calibration not yet finalized $\longrightarrow$ fitted J/ψ mass not in agreement with PDG value

Average B Lifetime



$B \to J/\psi \; X$

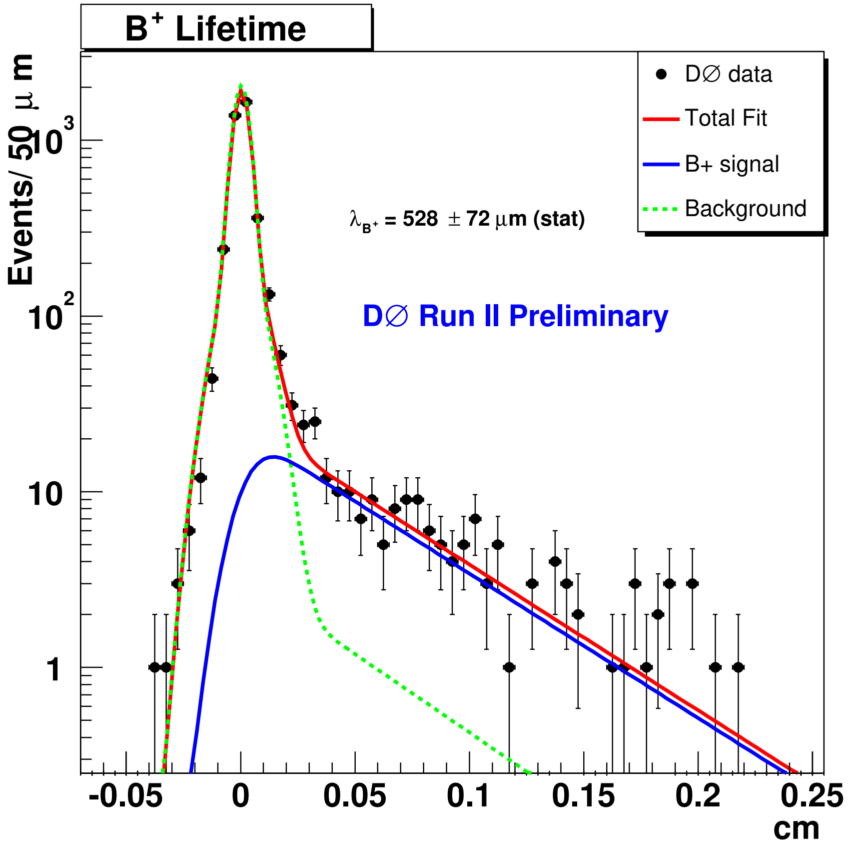
measure B lifetime:
transverse decay
length method

B hadron not fully
reconstructed
$\Rightarrow$ involves MC model
($\to$ dominant syst. uncert.)

$$\langle \tau \rangle = 1.561 \pm 0.024\,(\text{stat.}) \pm 0.074\,(\text{syst.}) \quad \text{ps}$$

$$\langle \tau \rangle = 1.564 \pm 0.014 \text{ ps} \quad \text{(PDG)}$$

B^+ *Lifetime*



$B^+ \to J/\psi\ K^\pm$

fully reconstructed

$\to$ no hadronization uncertainties

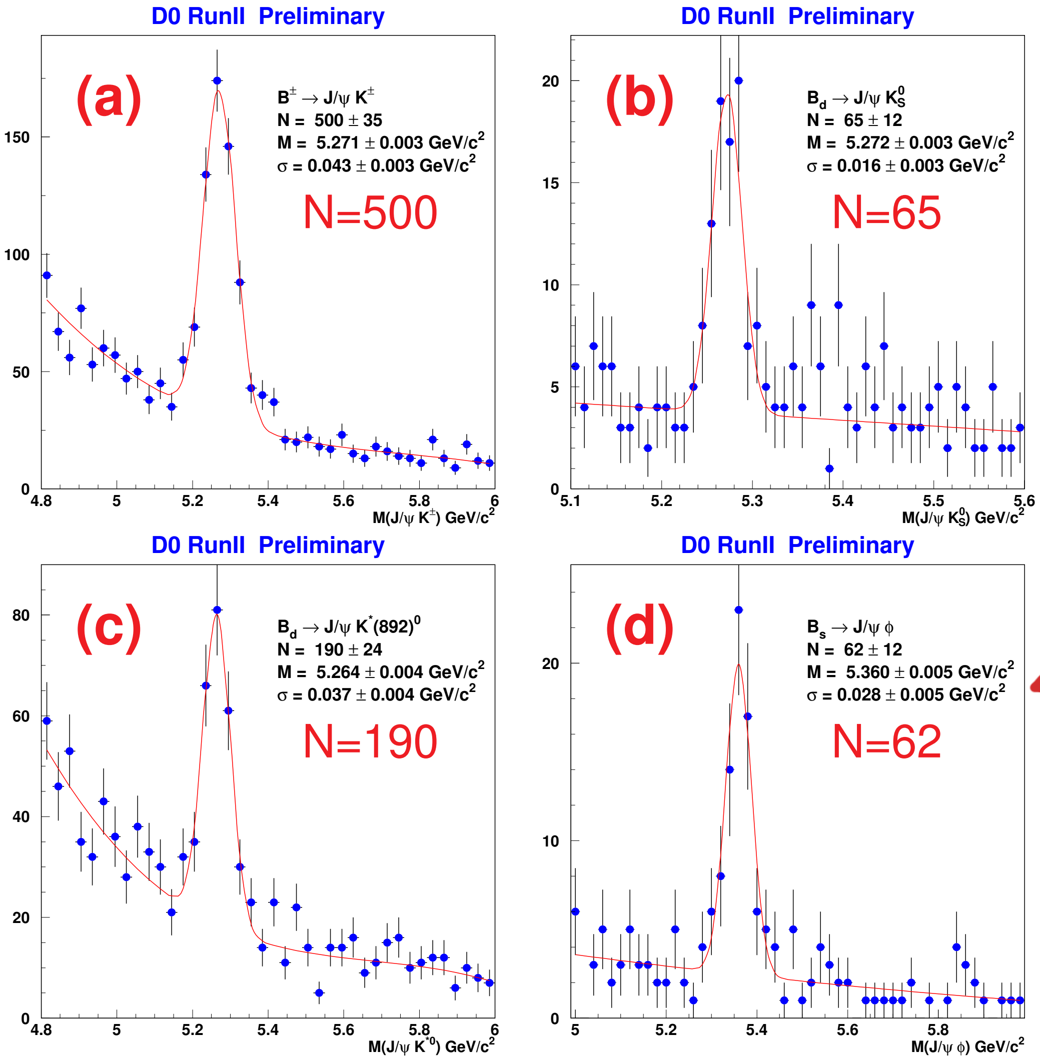
background from right-hand sideband

Result:

$\langle\tau\rangle = 1.76\ \pm 0.24\,(\text{stat.})$ ps

$\langle\tau\rangle = 1.674\ \pm 0.018$ ps (PDG)

Exclusive B Decays



(a) $B^{\pm} \to J/\psi\, K^{\pm}$

(b) $B_d \to J/\psi\, K^0_s$

(c) $B_d \to J/\psi\, K^*$

(d) $B_s \to J/\psi\, \phi$

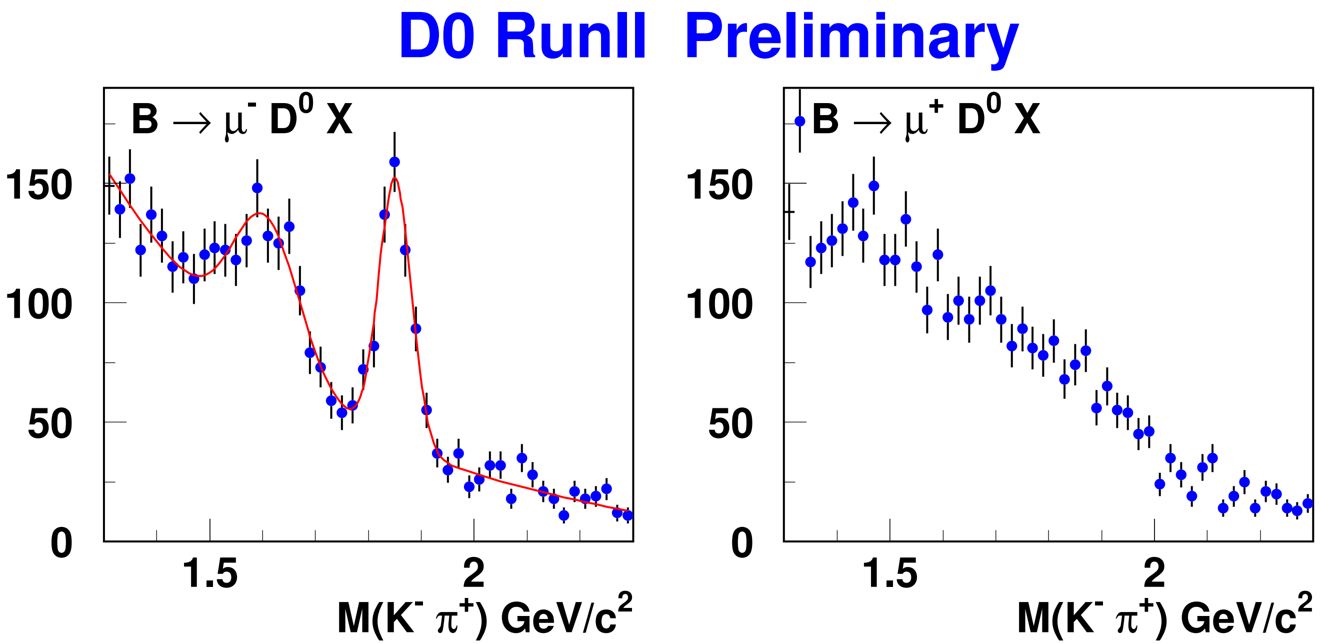
<u>new B hadron at D0:</u>
62 fully reconstructed B_s

→ not accessible
at B factories

golden channel for
CP violation in B_s system
(very small in SM)

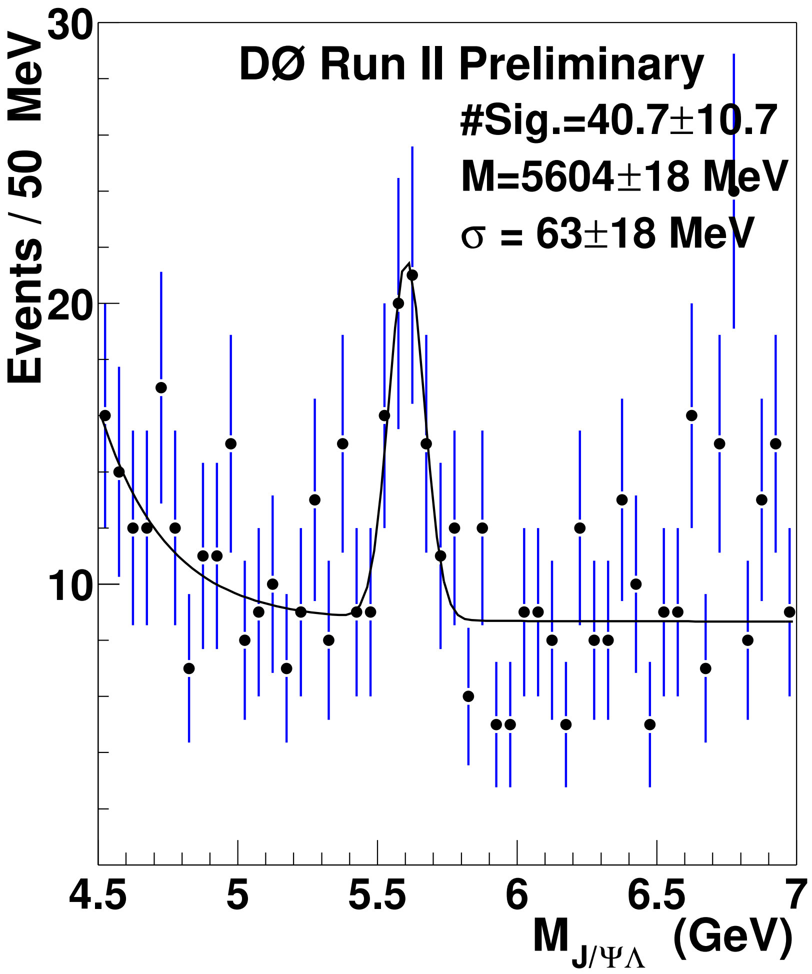
Semileptonic B Decays

$$B \to \mu^{\pm} D^0 X \quad , \qquad D^0 \to K^- \pi^+$$



selecting identified muons plus two additional tracks ($q_1 \cdot q_2 < 0$)

$\Rightarrow \quad \approx$ 400 events / pb^{-1}



B baryon:

fully reconstructed $\rightarrow \Lambda_b \rightarrow J/\psi\ \Lambda$

$\rightarrow$ **not accessible at B factories**

discrepancy with theory
in lifetimes $\tau(\Lambda_b)\,/\,\tau(B^0)$

$\Rightarrow$ mass measurement

B Flavor Tagging

measurement of mixing and CP violation in neutral B meson decays
requires: tag the flavor of the B meson at it's time of production
$\rightarrow$ use reconstructed $B^{\pm}$ mesons to determine performance

opposite side tags: soft muon tag & jet charge tag

tagging performance $\propto \ \epsilon D^2$

efficiency:

$$\epsilon = \frac{N_{\text{correct}} + N_{\text{wrong}}}{N_{\text{correct}} + N_{\text{wrong}} + N_{\text{notag}}}$$

Dilution:

$$D = \frac{N_{\text{correct}} - N_{\text{wrong}}}{N_{\text{correct}} + N_{\text{wrong}}}$$

Tag	soft muon	jet charge
efficiency ϵ (%)	8.2$\pm$ 2.2	55.1$\pm$ 4.1
dilution D (%)	63.9 $\pm$30.1	21.1 $\pm$10.6
ϵD^2 (%)	3.3 $\pm$ 1.8	2.4 $\pm$ 1.7

$\Rightarrow$ RunII B-Physics Workshop 2000: 3.1% 4.7%

hep-ph/0201071

Conclusion and Outlook

- **great progress:** high-quality data — interesting physic results
  inclusive jet and dijet cross section
  Λ_b and B_s signals have been established
  B exclusive decays / average & charged B lifetime / flavor tagging

- **improved understanding of the detector:**
  improved jet energy scale / extend jet analyses to higher η
  B physics program: more calibration / track & silicon triggers

- **more luminosity:** summer conferences: $\mathcal{L}_{\text{int}} >$ Run I
  take full advantage of higher cross section at increased Run II CM energy
  explore highest p_T and M_{JJ} regions $\rightarrow$ high-x gluon, new physics
  more statistics for rare B decays, precise cross sections,
  BR measurements, B_s, Λ_b lifetimes / estimations of B_s-mixing reach

unique opportunities at Tevatron $\Longrightarrow$ lots of important results