B Physics at the DØ Experiment

Harald Fox, Northwestern University,
for the DØ Collaboration

Content:

Improved Tracking Performance

B Cross section

B Lifetimes

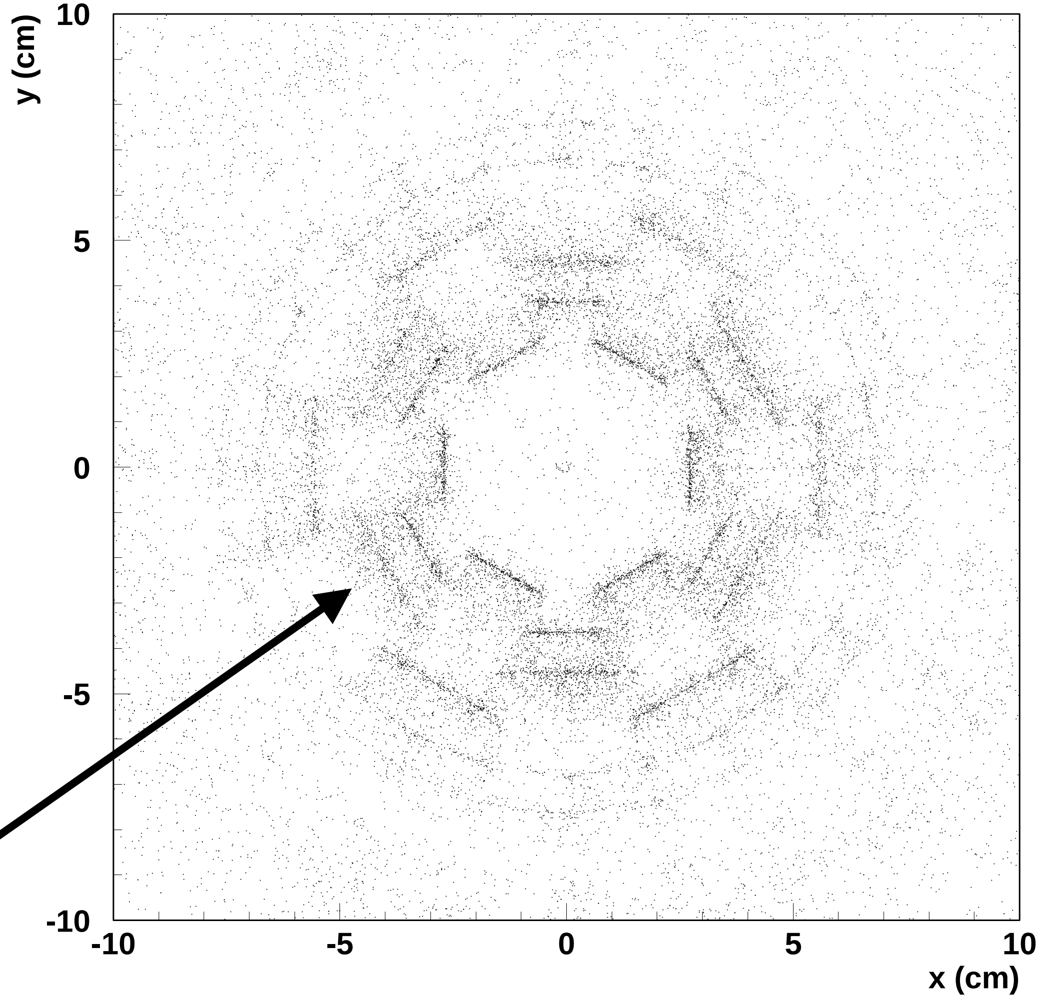
B Flavor Tagging Performance

Improved Tracking

Since low P_T tracks are very important for B physics, tracking algorithm has been improved.

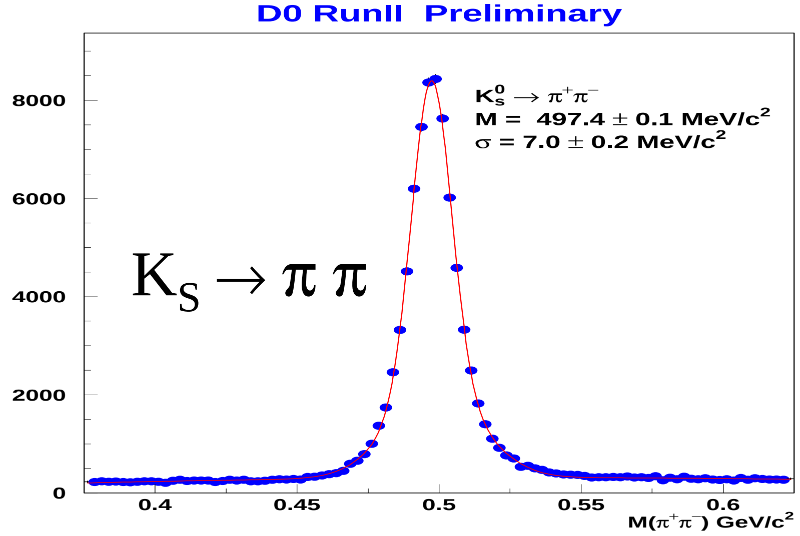
Improved performance for low P_T tracks and tracks with large impact parameter (Ks, Λ).

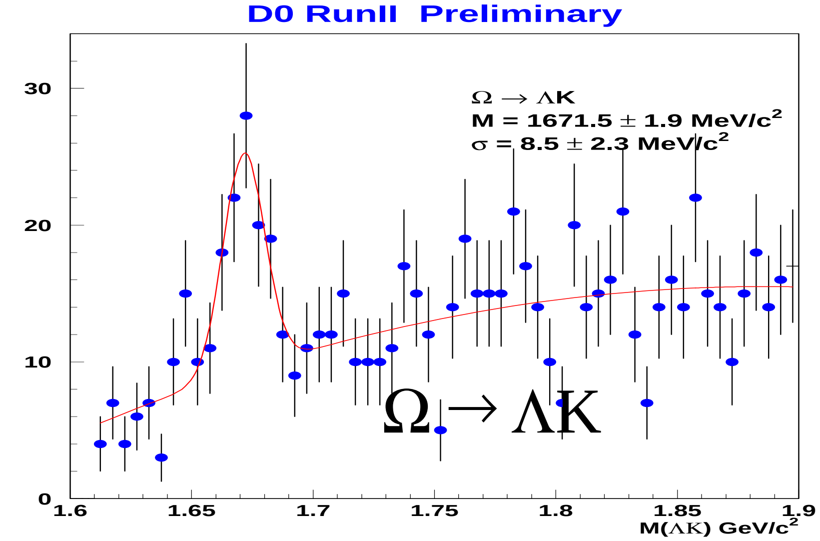
X-Y vertex location of $\gamma \to e^+e^-$

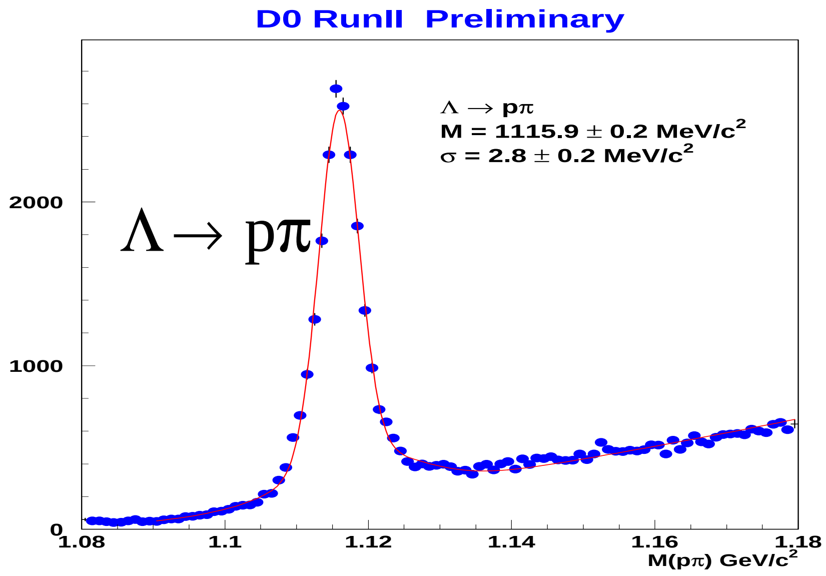


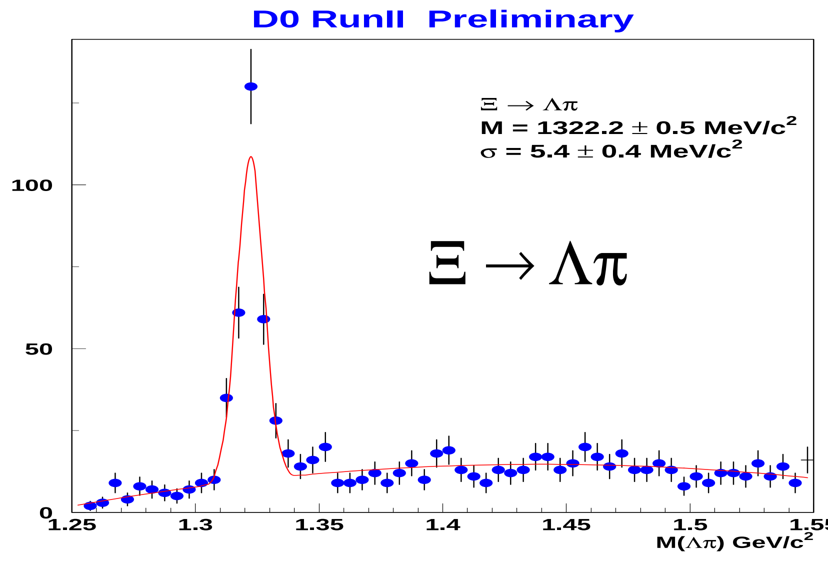
Silicon modules

Results with new Tracking









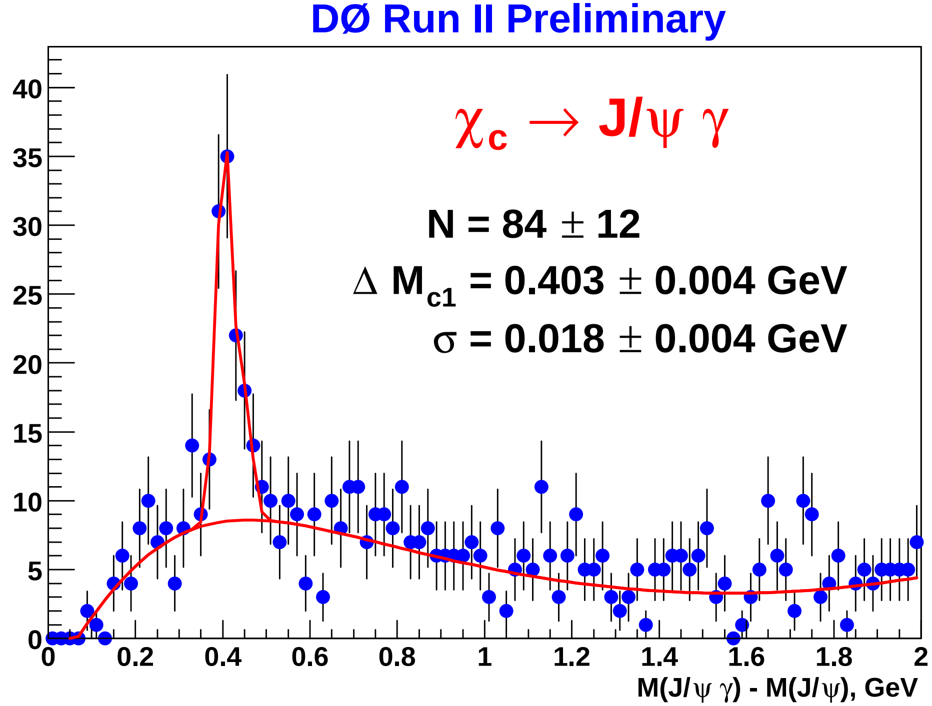
$\chi_c \to J/\psi\,\gamma$

According to CDF Run I measurement:
fraction of J/Ψ from χ_c:
$(27.4 \pm 1.6 \pm 5.2)$ %
$\varepsilon_\gamma \approx 0.4\%$ with $p^\gamma_T > 1$ GeV
Expect ~ 80 events

Fit with fixed $M\chi_{c1}$-$M\chi_{c2}$ = 46 MeV but float relative contributions

Cuts:

1. Track $p_T > 2.0$ GeV on tracks from J/Ψ
2. $p_T^\gamma > 1.0$ GeV



B Jet Cross Section

Measured in Run I: 2-3 times higher in the central region than predictions

Data:

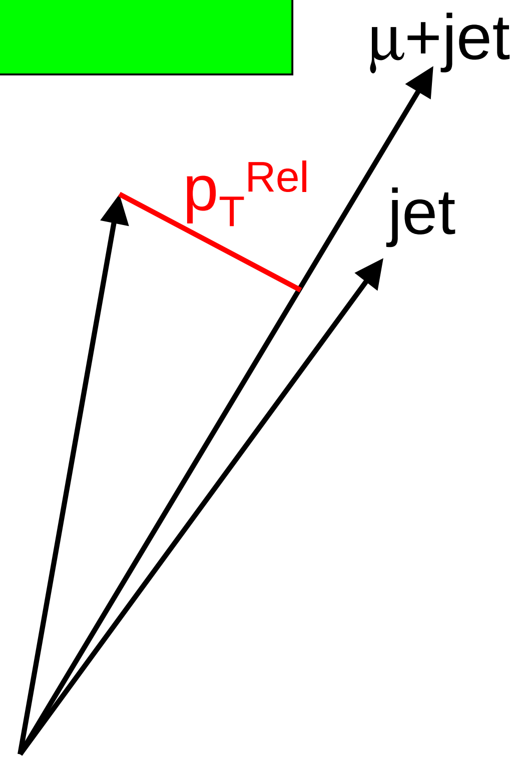
02/28/02-05/10/02 :

($3.4\ pb^{-1}$)

Strategy:

Measure μ+jet cross-section

Extract b-content using P_T^{Rel}



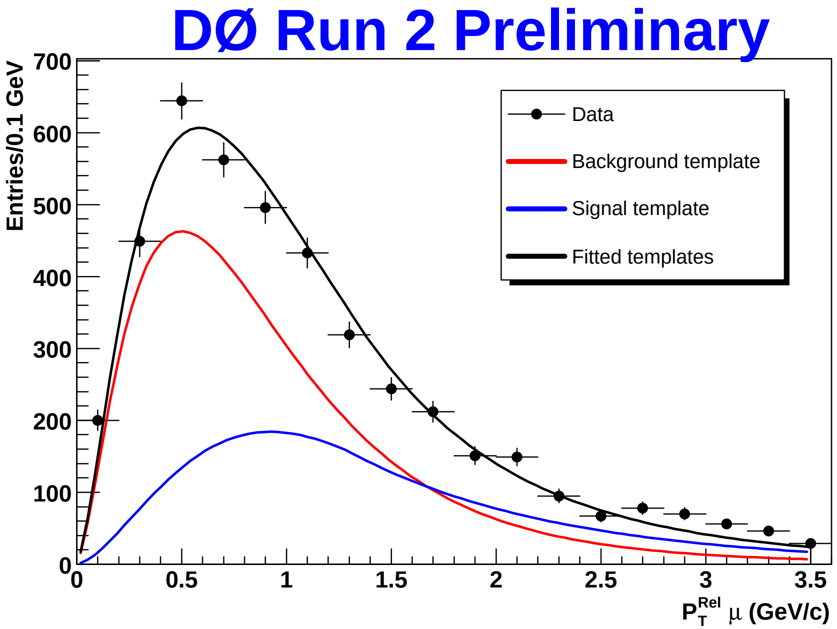
Data selection & kinematic cuts:

- $p_T^{\mu} > 6$ GeV/c, $|\eta^{\mu}| < 0.8$ (Muon P_T measured in muon system only)
- 0.5 cone jet
- $|\eta^{jet}| < 0.6$
- $E_t^{corr} > 20$ GeV
- $\delta R(jet,\mu) < 0.7$

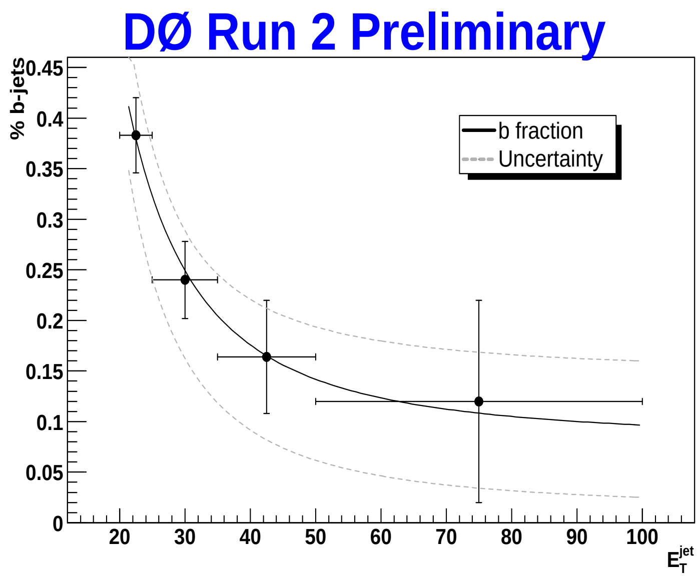
B Jet Cross Section

Obtain B jet cross section from μ +jets cross section:
Fit data to P_T^{rel} distribution of b-jets and background in bins of E_T (cannot distinguish $c \to \mu X$ and decays in flight so only fit b, non-b).

Example: P_T^{rel} for jets with
20 GeV < E_T < 25 GeV



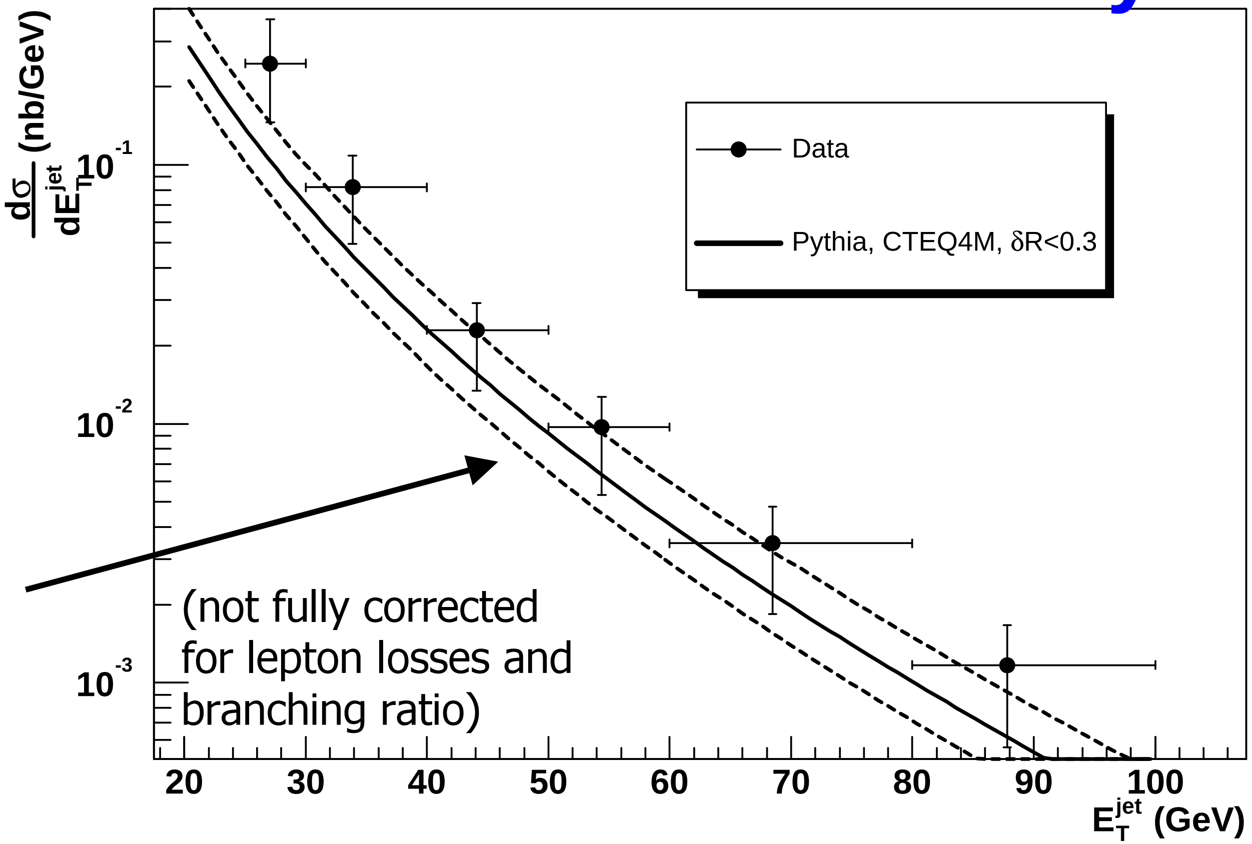
B fraction as a function of Jet E_T:



B Jet Cross Section

- Deconvolution of jet energy resolution.
- Jet Energy Scale is the dominant error.
- Uncertainty:
  - b quark mass
  - Renormalization / factorization scale
  - pdf's
  - Fragmentation function (NLO + Pythia)

DØ Run 2 Preliminary



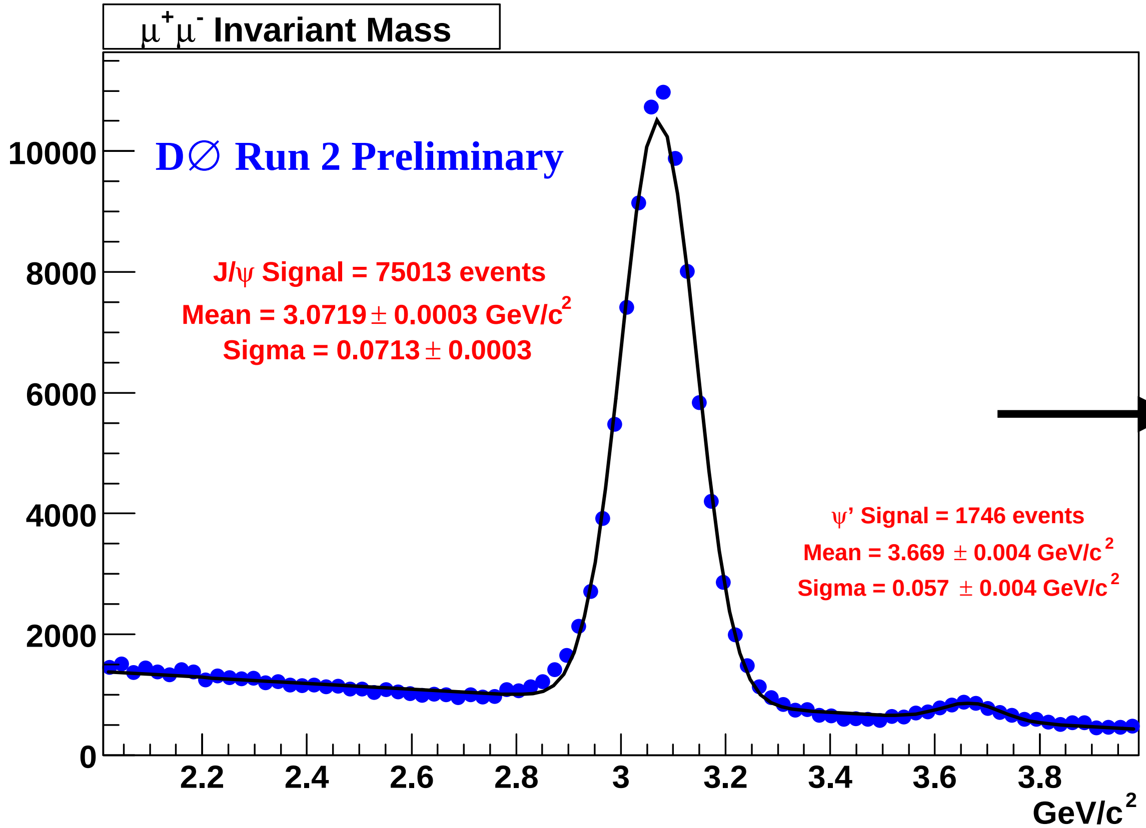
Consistent with Run I result

Data Sample

For now focusing on $J/\Psi \rightarrow \mu^+\mu^-$ sample

- Useful for calibration
- Easy trigger and provides lots of B's

L~ 40 pb^{-1}



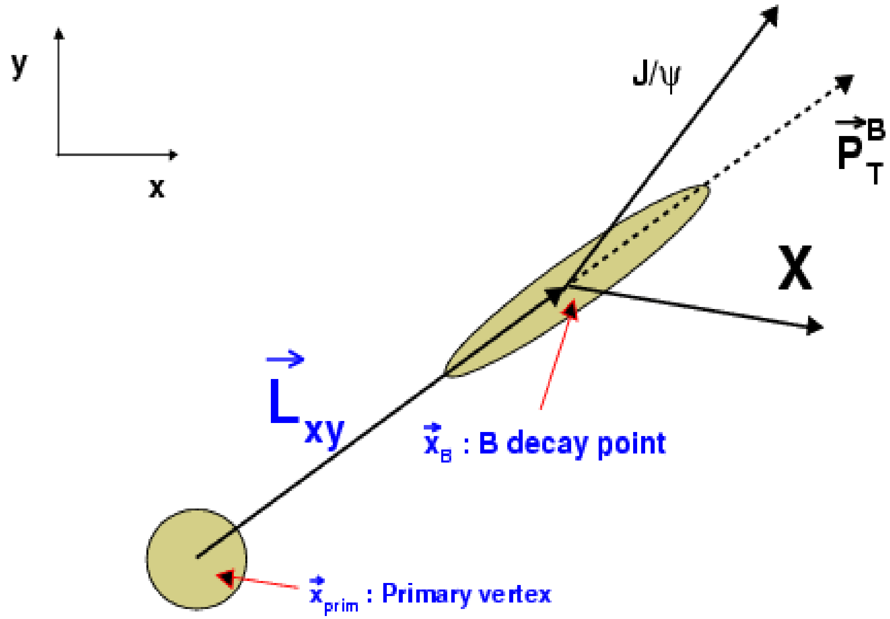
75,000*0.17

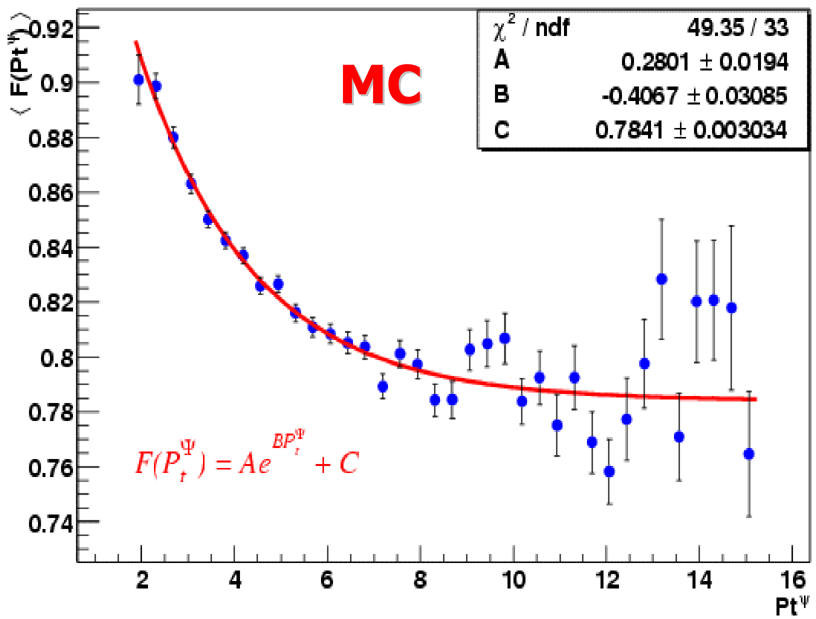
~13,000 b's

Inclusive B Lifetime

J/ψ Sources $\begin{cases} (c\bar{c}) \text{ states (prompt)} \\ B \to J/\psi\, X \end{cases}$

Difference $\begin{cases} \text{Prompt} & \sim \text{PV} \\ J/\psi(B) & \sim \text{SV} \end{cases}$





λ_B through λ_ψ :

$$\lambda_B = L_{xy} \frac{M^\Psi}{P_T^\Psi \langle F(P_T^\Psi) \rangle}$$

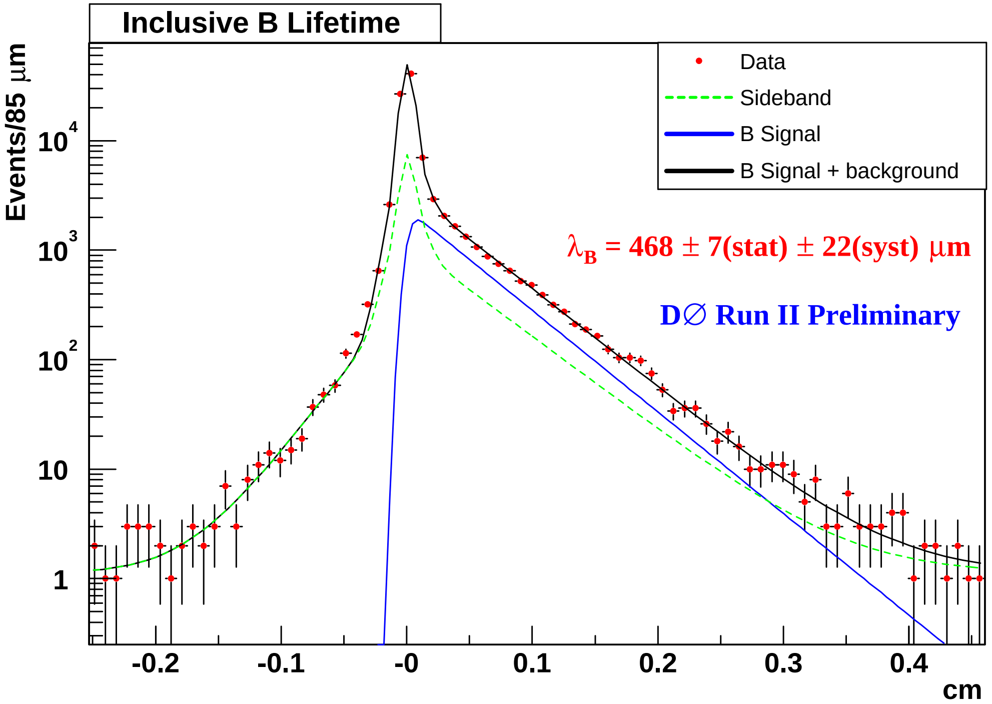
$$\langle F(P_T^\Psi) \rangle = \frac{M_\Psi}{M_B} \frac{P_T^B}{P_T^\Psi}$$

Correction factor
B->ψ from MC

Inclusive B Lifetime

Fit the λ_B distribution in sideband windows to extract the background shape (g+g+e+c).

Fit the data in the J/ψ signal window to background + prompt production (g+g) + exponential with fixed resolution.



$<\tau>$ = 1.561 ± 0.024 (stat) ±0.074 (sys) ps

$<\tau>$ = 1.564 ± 0.014 ps (PDG)

B fraction: 17.3 ± 0.5 %

Dominant Uncertainty:

Correction factor	16 μm 0.053 ps
Fitting Bias (MC)	13 μm 0.043 ps

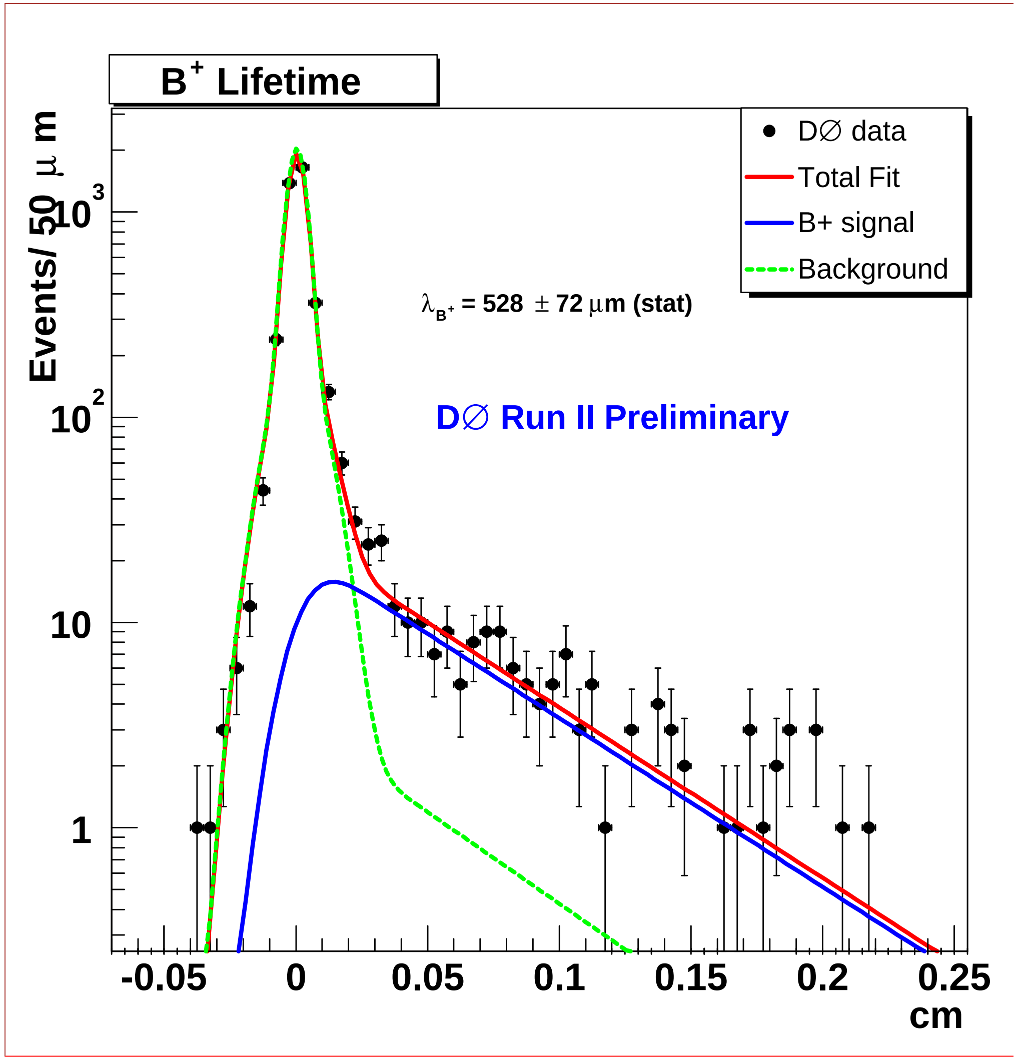
Charged B Lifetime

Fully reconstructed B so no need for a correction factor:

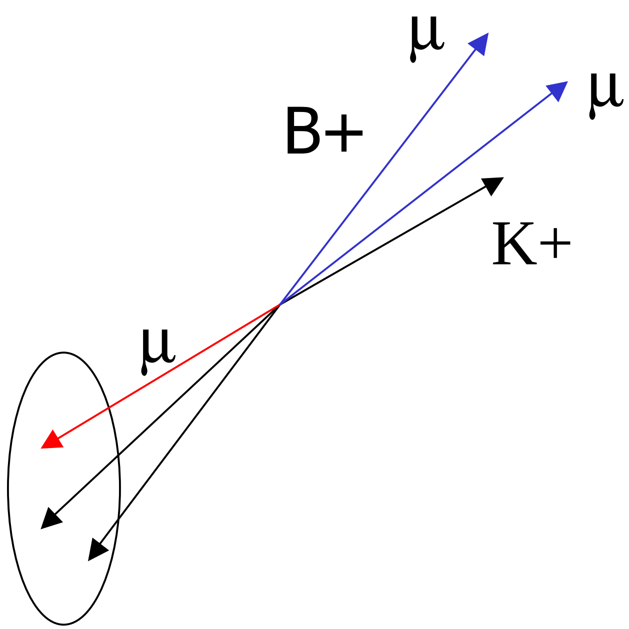
$$\boxed{\lambda = L_{xy}\frac{M(B)}{P_T(B)}}$$

The background shape is extracted from the high mass sideband. The data is fitted to background + prompt production (g+g) + exponential with fixed resolution + 12% residual B contamination.

<τ>=1.76±0.24 (stat) ps
<τ>=1.674±0.018 ps (PDG)



Flavor Tagging



$$Q = \frac{\sum p_{T,i} * q_i}{\sum p_{T,i}}$$

Use charged B sample to determine the flavor tagging performance.

Soft Muon Tag:
Muon $\Delta R > 2.0$ from B^+
Muon $P_T > 1.9$ GeV/c
Charge of μ with highest $P_T \Rightarrow$ B-tag

Jet Charge Tag:
Choose tracks opposite of the reconstructed B^+ close (2cm) to the primary vertex
Only events with $|Q|>0.2$ are used as tags

Tagging Power

Significance of a mixing measurement: proportional to εD^2

$$\varepsilon\text{: Efficiency} = \frac{N_{correct} + N_{wrong}}{N_{corrrect} + N_{wrong} + N_{notag}}$$

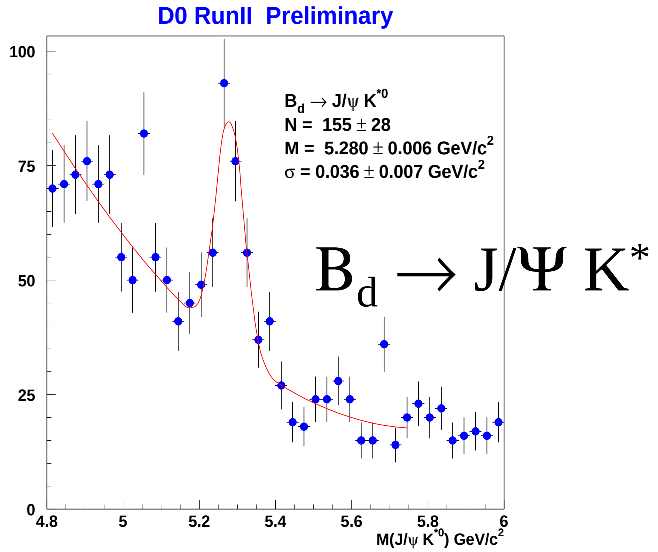
$$\text{D: Dilution} = \frac{N_{correct} - N_{wrong}}{N_{correct} + N_{wrong}}$$

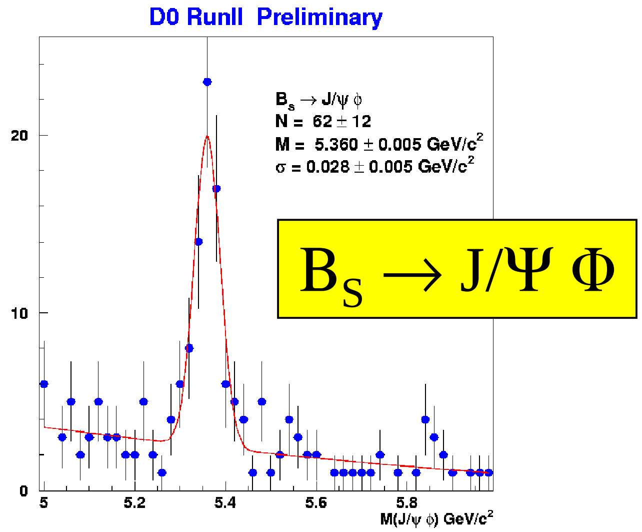
Jet Charge Tag	Soft Muon Tag
$N_{right} = 66$	$N_{right} = 13$
$N_{wrong} = 48$	$N_{wrong} = 5$
$\varepsilon = 55.0 \pm 4.1\%$	$\varepsilon = 8.2 \pm 2.2\%$
$D = 21.1 \pm 10.6\ \%$	$D = 63.9 \pm 30.1\%$
$\varepsilon D^2 = 2.4 \pm 1.7\%$	$\varepsilon D^2 = 3.3 \pm 1.8\ \%$

raw numbers

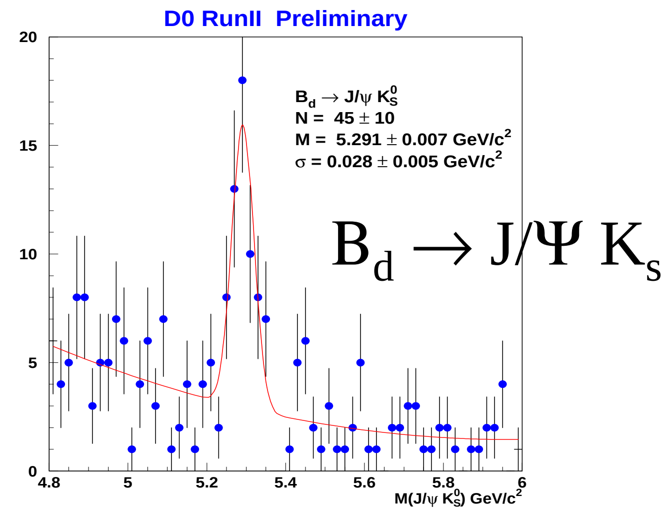
corrected for background

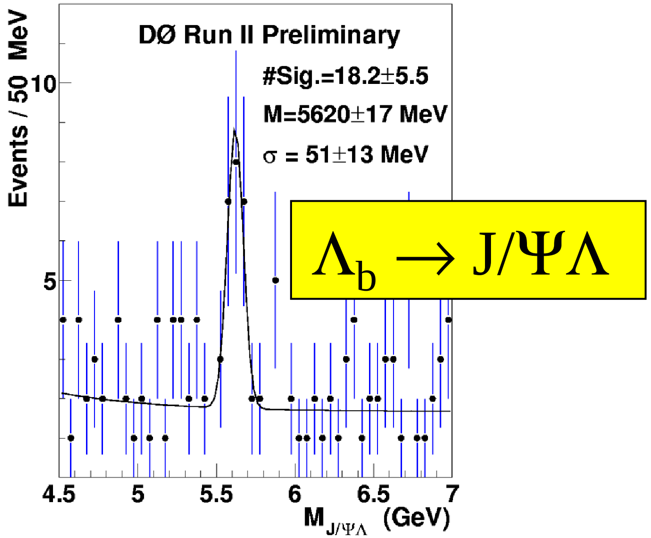
Towards Sin(2β)





Combine J/Ψ with K_S, Φ or Λ and require decay length significance > 3.0



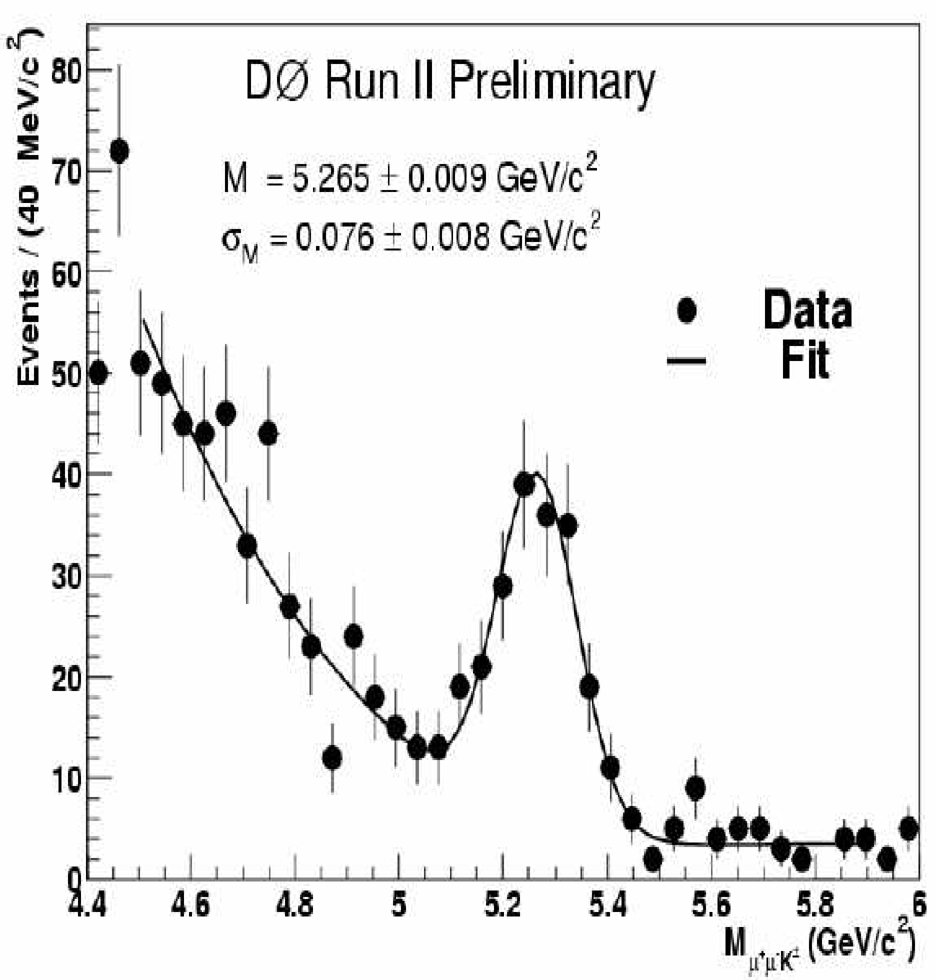


Conclusion

- D0 has made significant progress in tracking and understanding of the data.
- We have good results on basic quantities such as masses, lifetimes, cross sections.
- We start to understand flavor tagging.
- More interesting things to come:
  - B_s mixing
  - CP violation in B_d
  - CP violation in B_s

Charged B

$B^{+-} \rightarrow J/\Psi\ K^{+-}$



Cuts (J/ψ):

1. Muons with opp. charge
2. $p_T(\mu) > 2.0$ GeV
3. SMT hits ≥ 1
4. χ^2 on J/ψ vertex < 10
5. $2.8 < m(J/\psi) < 3.3$

Cuts (Charged B):

1. χ^2 for K < 10
2. Total $\chi^2 < 20$
3. Kaon hits ≥ 3
4. $p_T(K) > 2.0$ GeV
5. Collinearity>0.9
6. B decay length > 0.3mm