B_c at DØ: Triggering and Reconstruction

- **Outline**
  - MC studies and full simulations of triggering of semileptonic mode

Run II B Physics Workshop
Prod/Frag/Sect. Working Group Meeting
24 February 2000
Fermilab

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DØ

Monte Carlo Production

- Use PYTHIA, MCFAST and DØ Upgrade Detector resolution

  New: PMCS (DØ parameterized fast MC)
  + 457 fully GEANT simulated
  (allows use of more realistic trigger simulator)

- Increase fraction of $b \to B_c$ to 0.5, scale fractions of B_d, $B^{\pm}$, B_s, Λ_b down appropriately. Toss events with two B_c to get "away side" correct

- Use CLEO QQ and force decays:

$B_c^{\pm} \to J/\psi\, \ell^{\pm} \nu$
$\quad\quad \hookrightarrow e^+e^-$ or $\mu^+\mu^-$

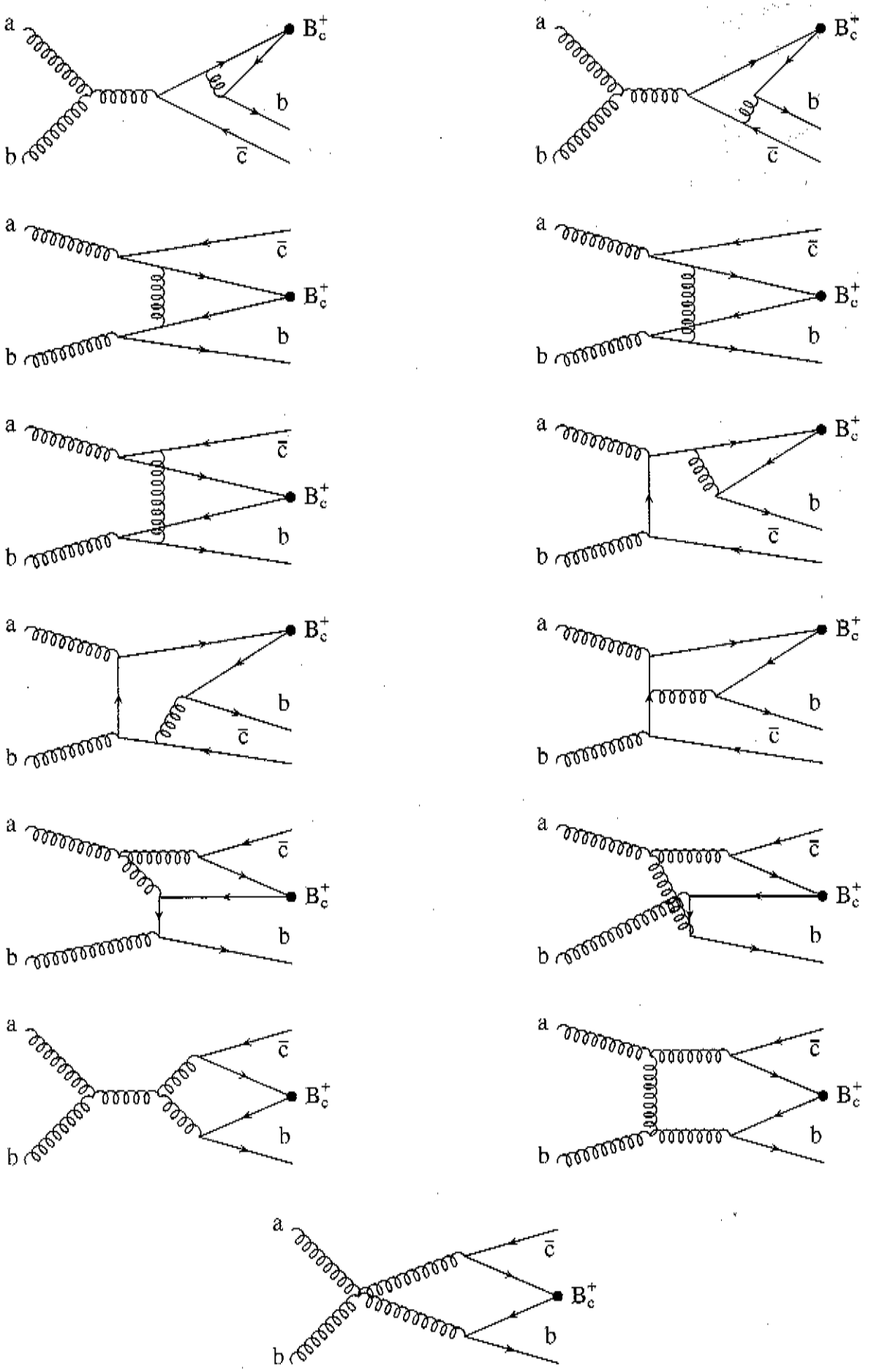
$\to J/\psi\, \pi^{\pm}$

$\to J/\psi\, D_s^{\pm}$ Planned

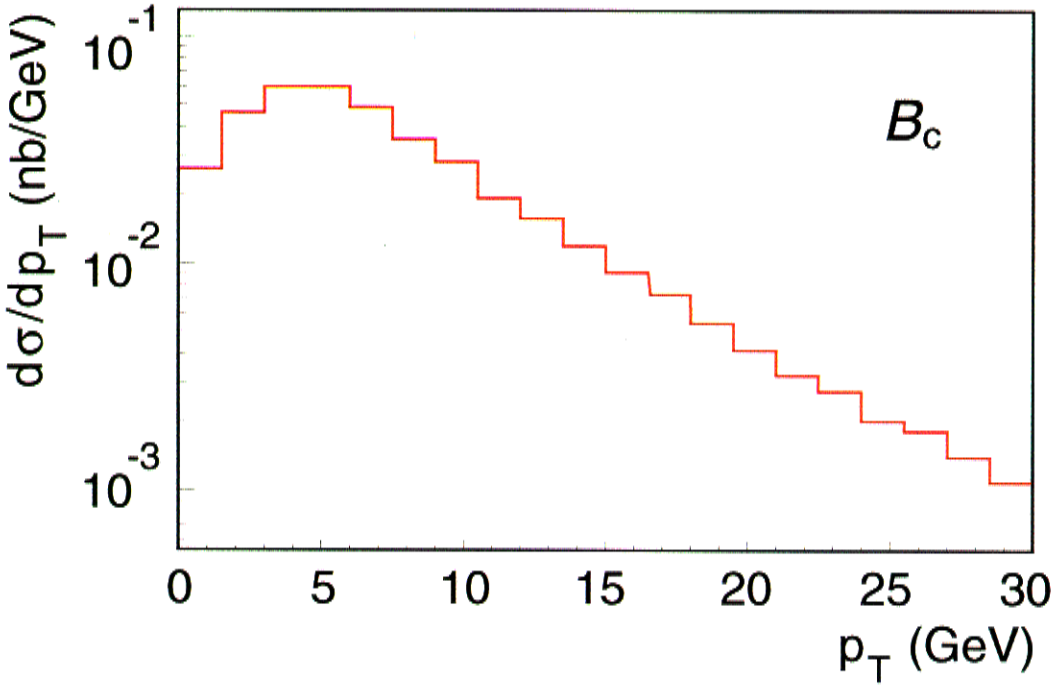
$\to B_s\, \pi^{\pm} X$ Not done, no time

$\to B_s\, \ell^{\pm} \nu$

- Set mass to 6.40 GeV and lifetime to 0.50 ps


a
b
B_c^+
b
$\bar{c}$

Production

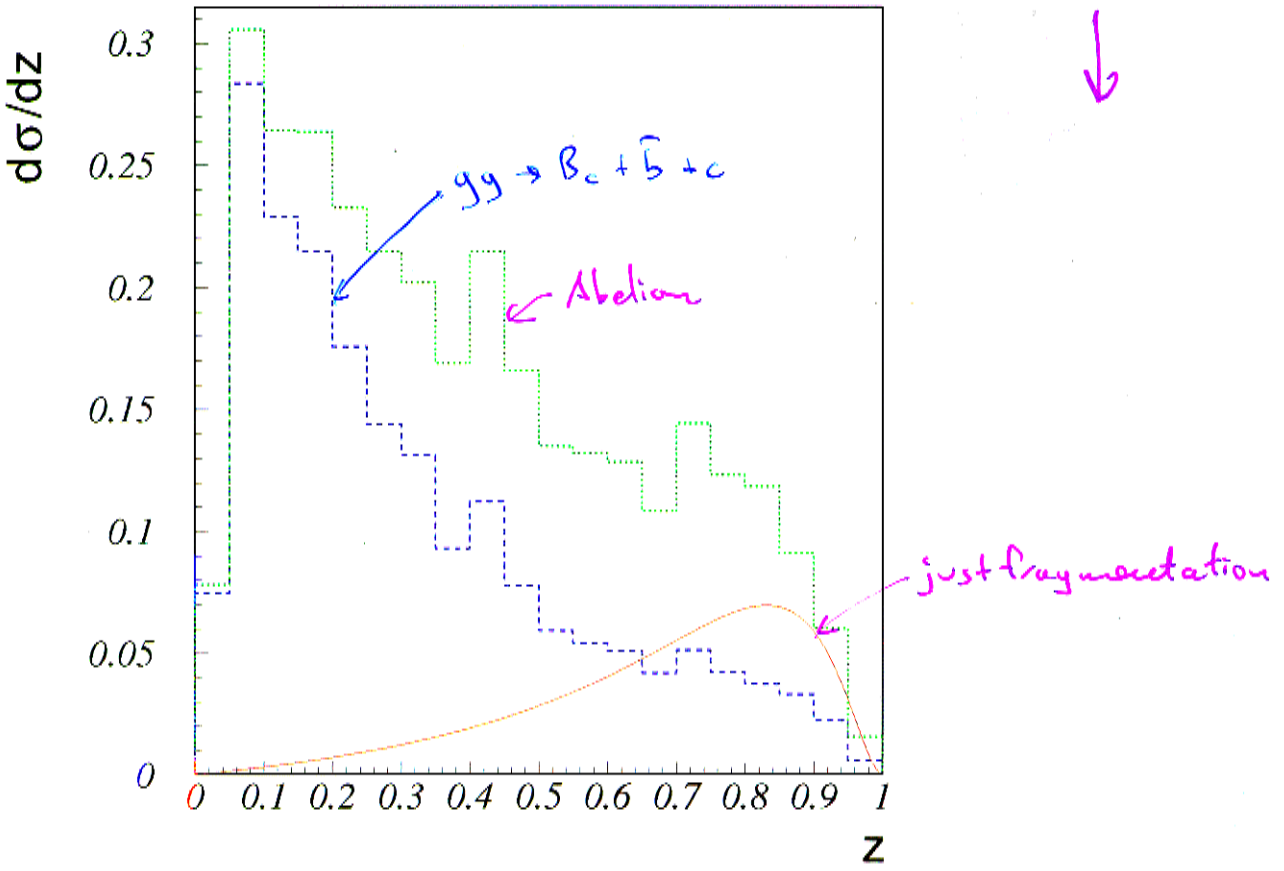


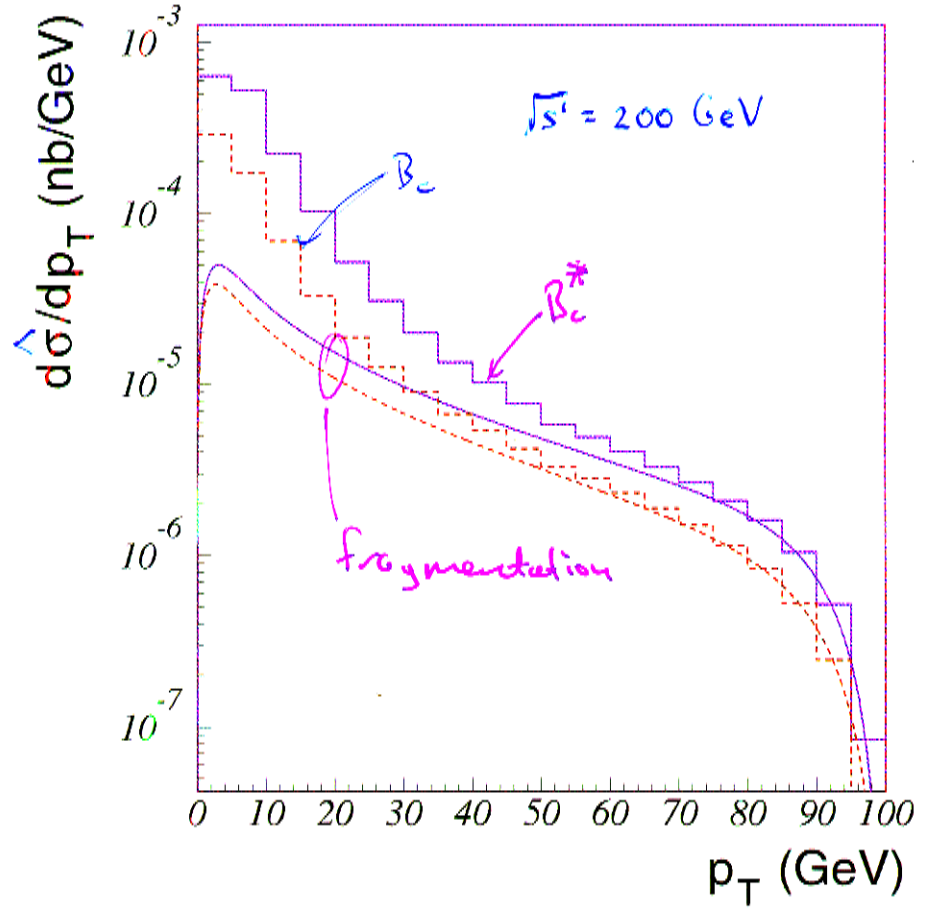
- Reweight events to theory prediction of $d\sigma/dp_T$ interfaced with PYTHIA
  - → Code from A. Berezhnoy, Likhoded et al.

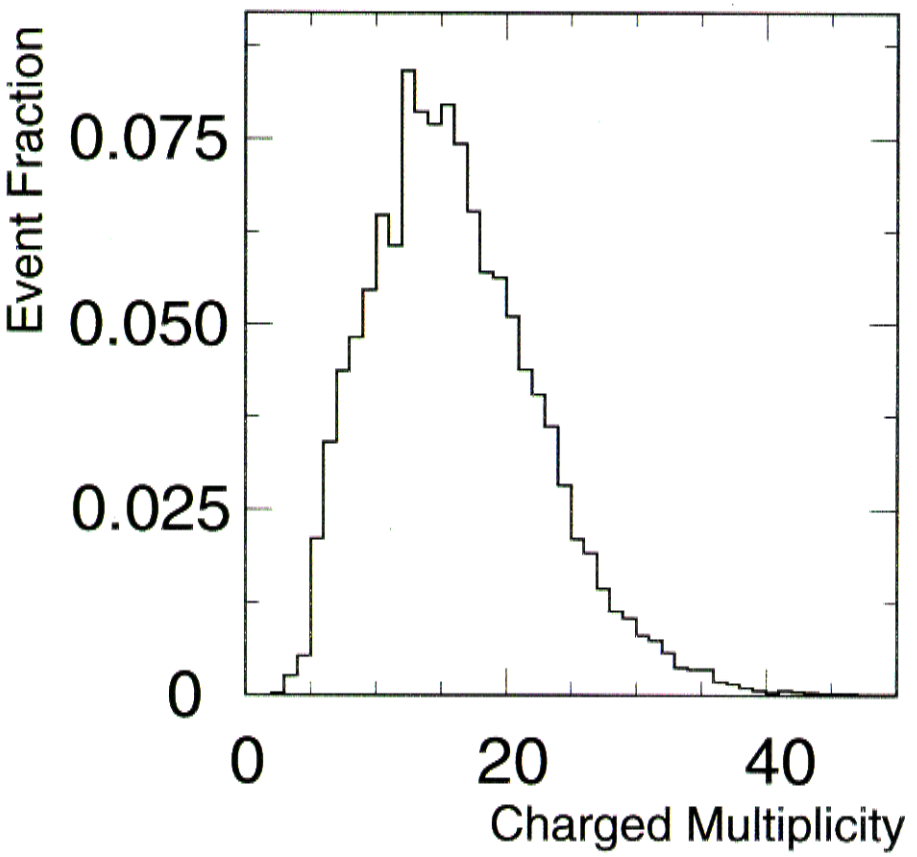
Changed

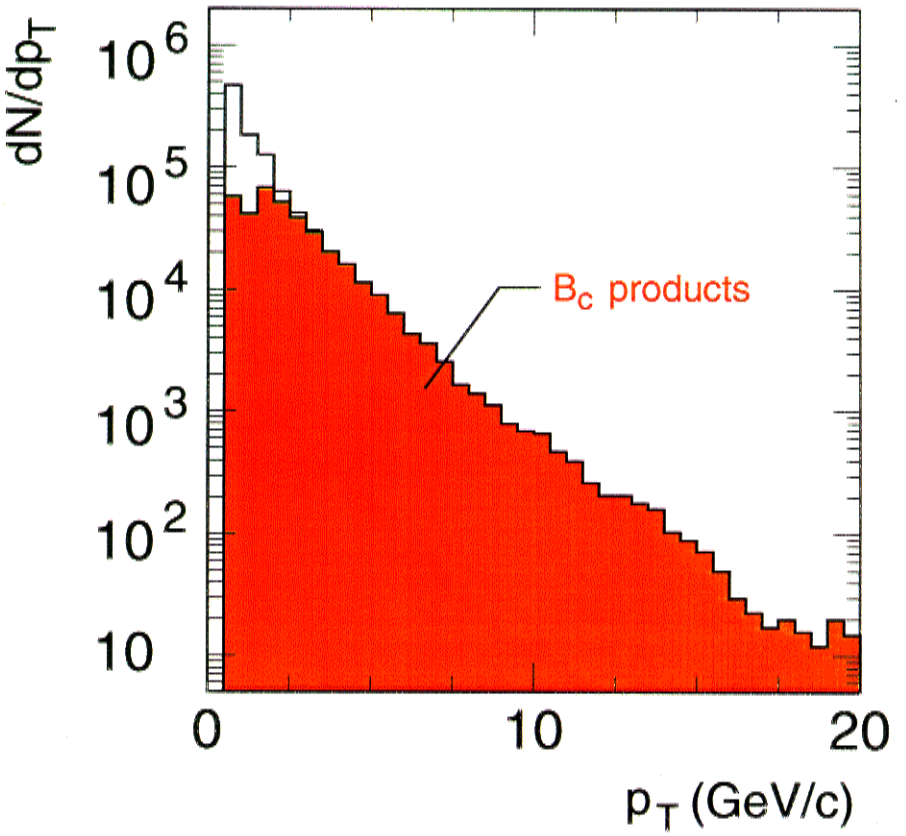
- Fragmentation as in their paper

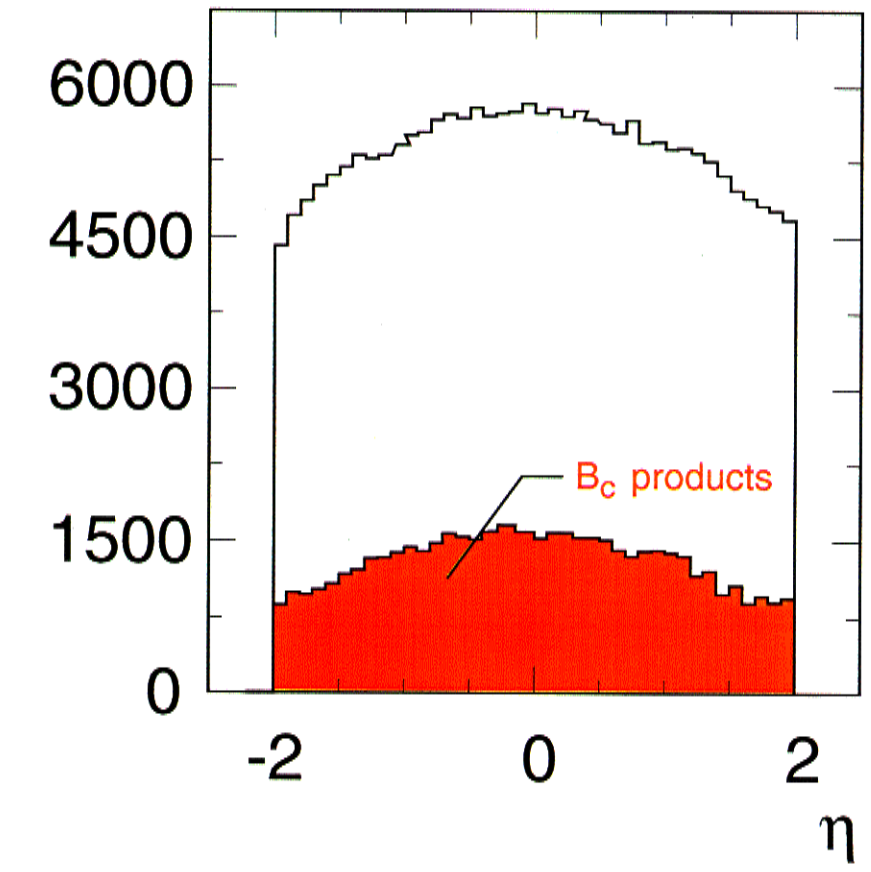
A. Likhoded

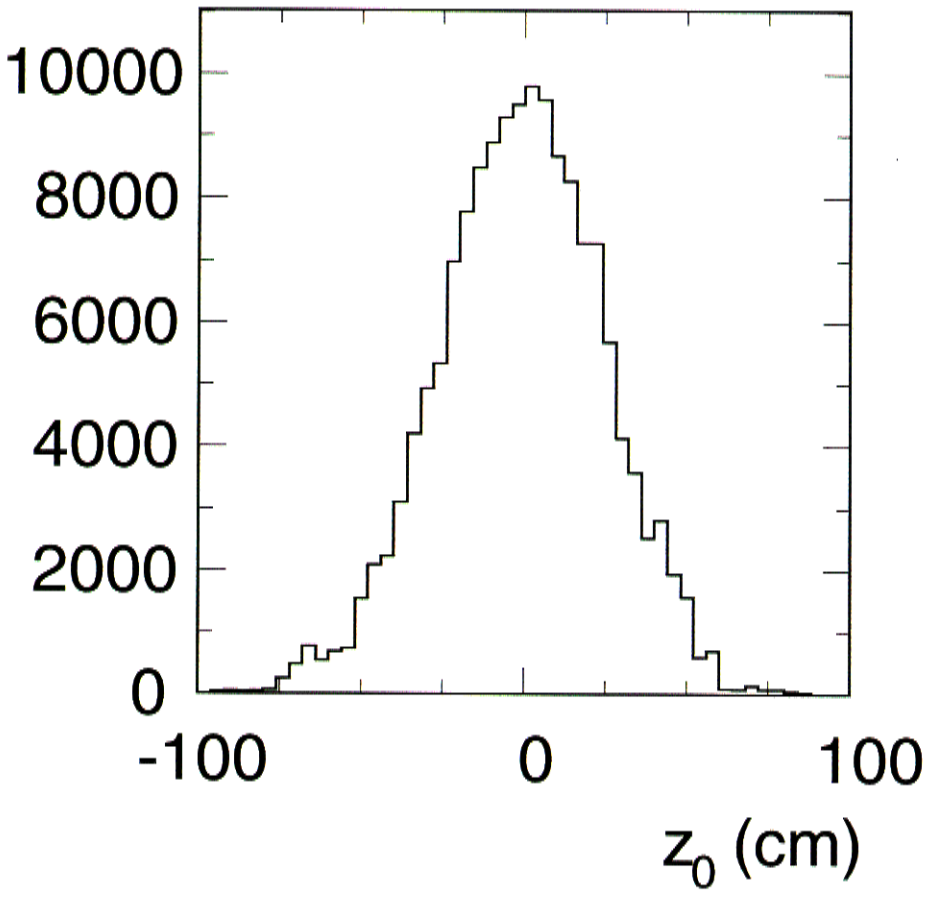

dσ/dz
0.3
0.25
0.2
0.15
0.1
0.05
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
z
gg → Bc + b̄ + c
Abelian
just fragmentation


dσ̂/dpT (nb/GeV)
10-3
10-4
10-5
10-6
10-7
0 10 20 30 40 50 60 70 80 90 100
pT (GeV)
√s = 200 GeV
Bc
Bc*
fragmentation


Event Fraction
0.075
0.050
0.025
0
0
20
40
Charged Multiplicity

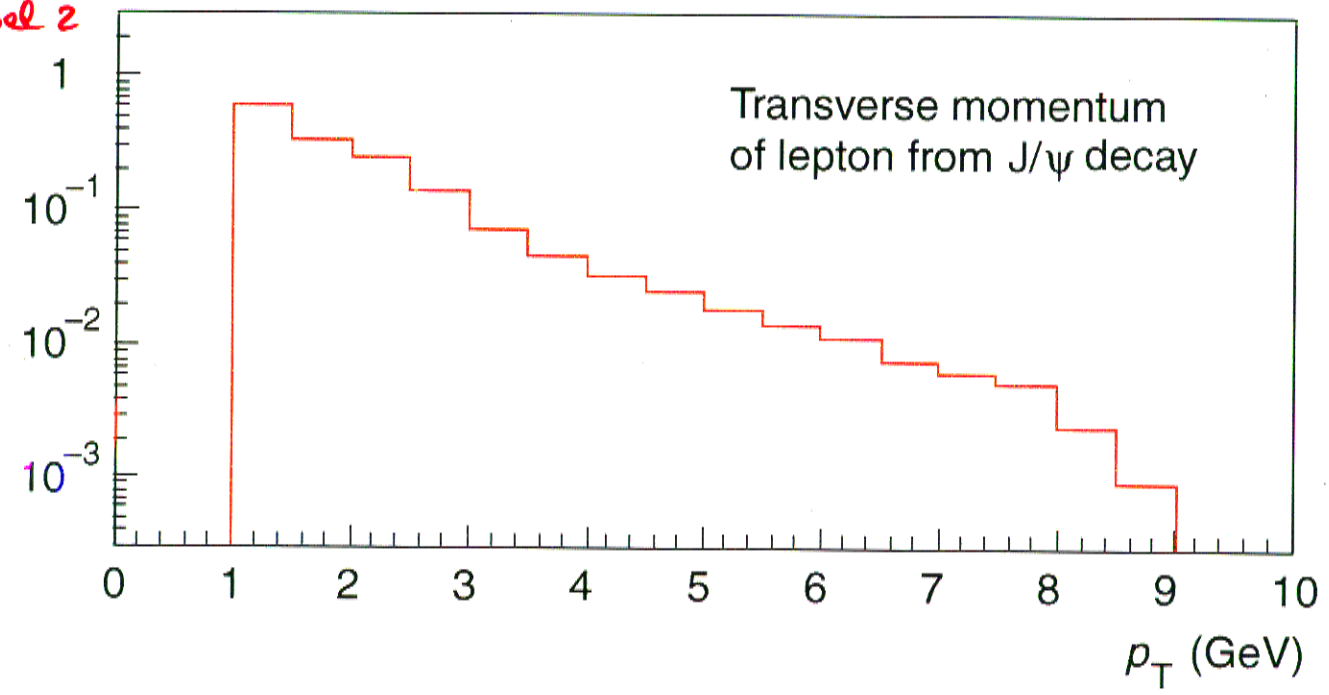

dN/dp$_T$
10^6
10^5
10^4
10^3
10^2
10
B$_c$ products
0
10
20
p$_T$ (GeV/c)


6000
4500
3000
1500
0
-2
0
2
η
B_c products


10000
8000
6000
4000
2000
0
-100
0
100
z_0 (cm)

MUON TRIGGERING

Dimuons	Level 2 Backg.	$B_c \to J/\psi \ell \nu$ Efficiency
$P_T > 2,4$ GeV	1.1 Hz	11 %
too high, ⇒ $P_T > 2,2$ GeV	272 Hz	26 %
only handle 100Hz @ Level 2		
Add SVT ??	7.6 Hz	⇒ see later



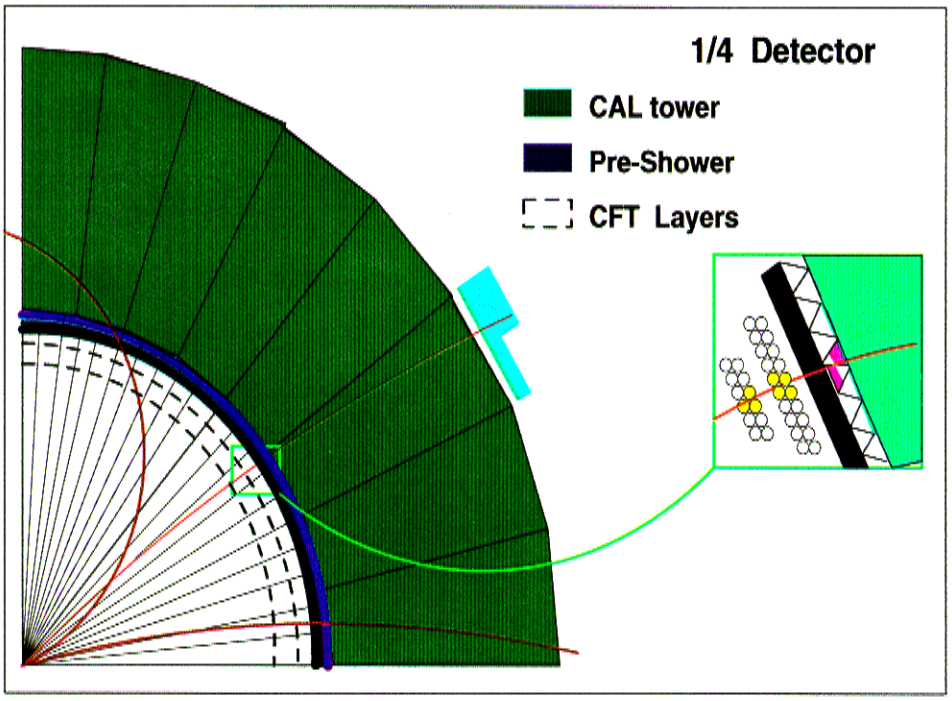
Have kinematic/geometric trigger efficiencies from MCFAST

⇒ use DØ trigger simulator on fully simulated events

⇒ first consider three muon case (IU specialty)

		Trigger Ntuple L1 Muon Trigger Efficiency
Single Muon		
MTM5 MUO(1,4,A,M)	$p_T > 4$ GeV $\|\eta\| < 1.5$ "Medium"	0.23
MTM6 MUO(1,4,A,T)	"Tight"	0.08
Di-Muon		
MTM10 MUO(2,2,A,M)	Both $p_T > 2$ GeV $\|\eta\| < 1.5$ "Medium"	0.16
MTM12 MUO(2,4,A,M)	Both $p_T > 4$ GeV $\|\eta\| < 2.0$ "Medium"	0.15

Electron Triggering



- Use preshower info plus fiber tracker

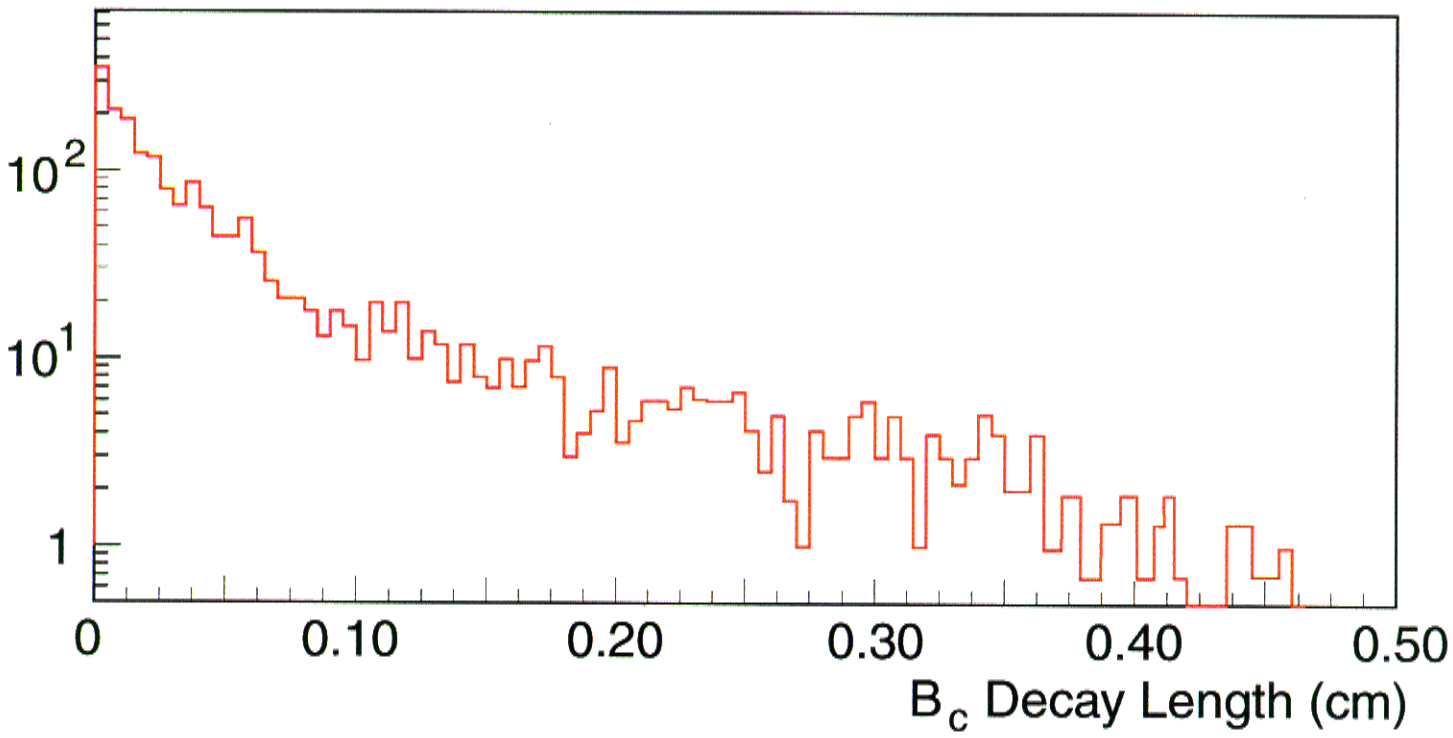
Grannis, Lucotte

Cut	J/ψ		Dijet					
			2-10 GeV		10-20 GeV		20-40 GeV	
Total processed	2818		773		990		520	
	match	no	match	no	match	no	match	no
L1 pass CCEM twr cut	1472	1472	156	156	489	489	353	352
L1 pass $E_{\rm had}$ cut	1378	1378	156	156	449	449	136	136
L1 pass CFT/CPS cut	839	839	21	21	230	230	116	116
L1 pass CFT-CAL match cut	839	608	21	13	230	144	116	80
L1 events passed	839	608	21	13	230	144	116	80
L2 pass CAL-CPS match	434	380	3	1	54	37	40	34
L2 pass di-e isol.	416	362	2	0	31	19	21	17
L2 pass di-e mass cut	361	320	2	0	23	16	10	9
L2 events passed	361	320	2	0	23	16	10	9

- Have to work harder to keep backgrounds down! Take the efficiency as 12.8%

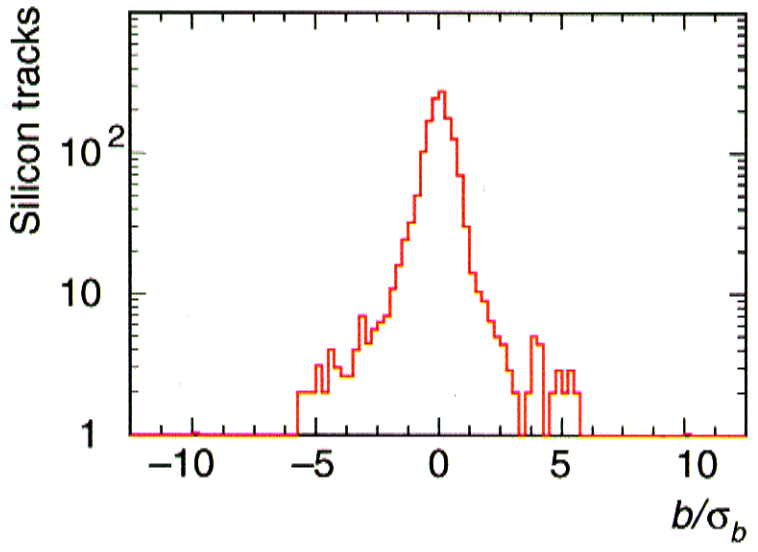
Vertex Silicon/Track Trigger?

- Generated with a lifetime of 0.50 ps
  (c.f. 1.5-1.6 ps of other B mesons)



- Decay resolution of ~ 100 μm expected

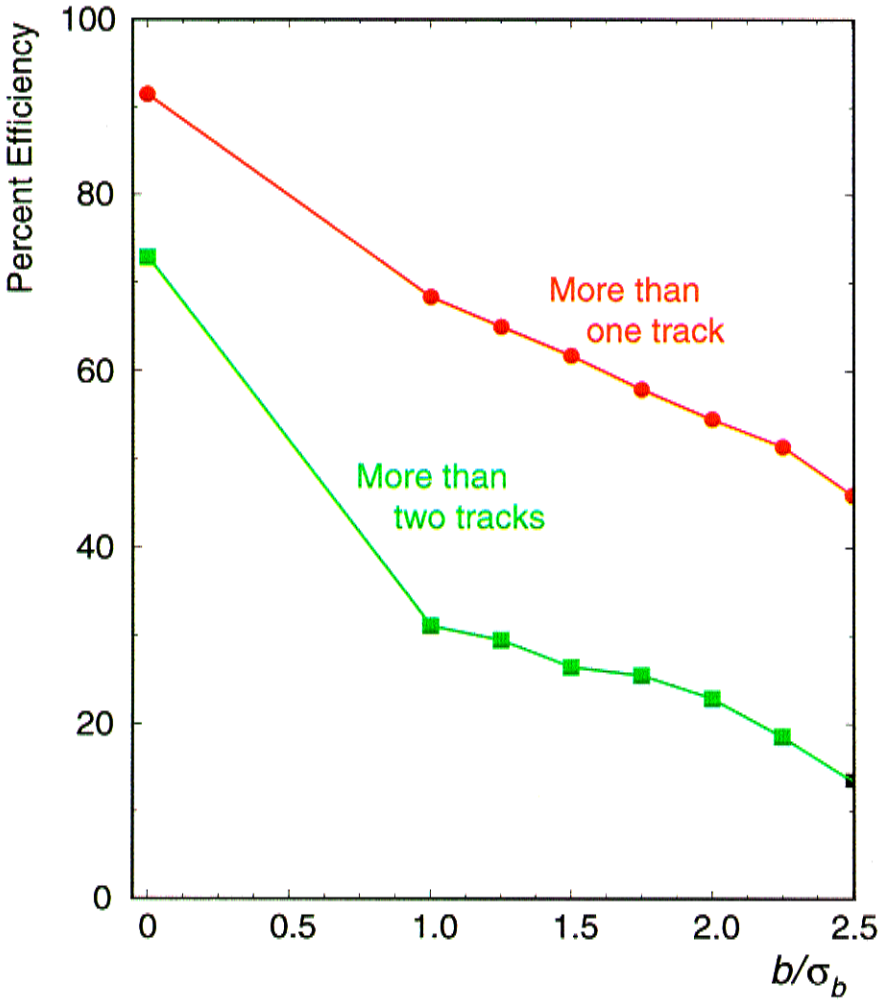
Vertex trigger help?



⇒ tougher than

B_d^0 $B^{\pm}$

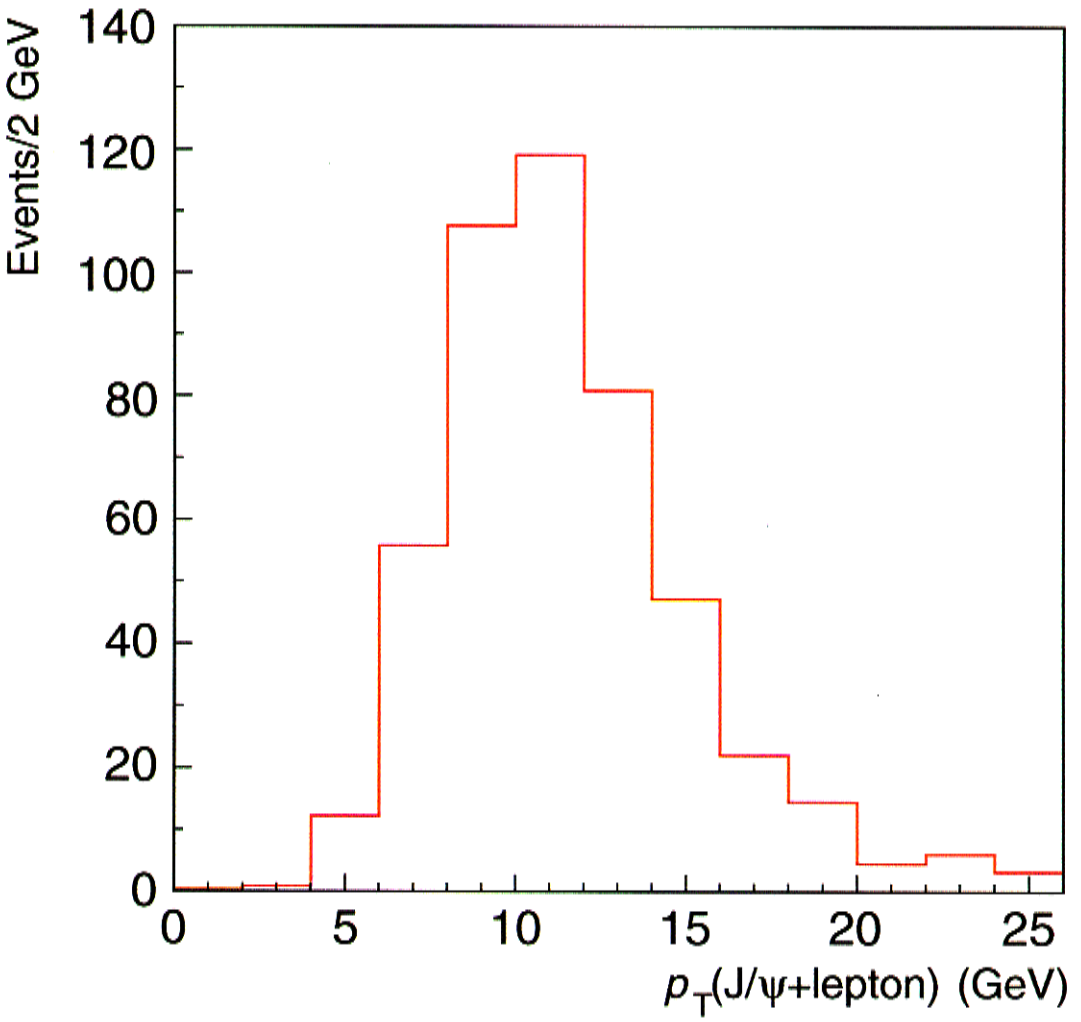
because of shorter lifetime!

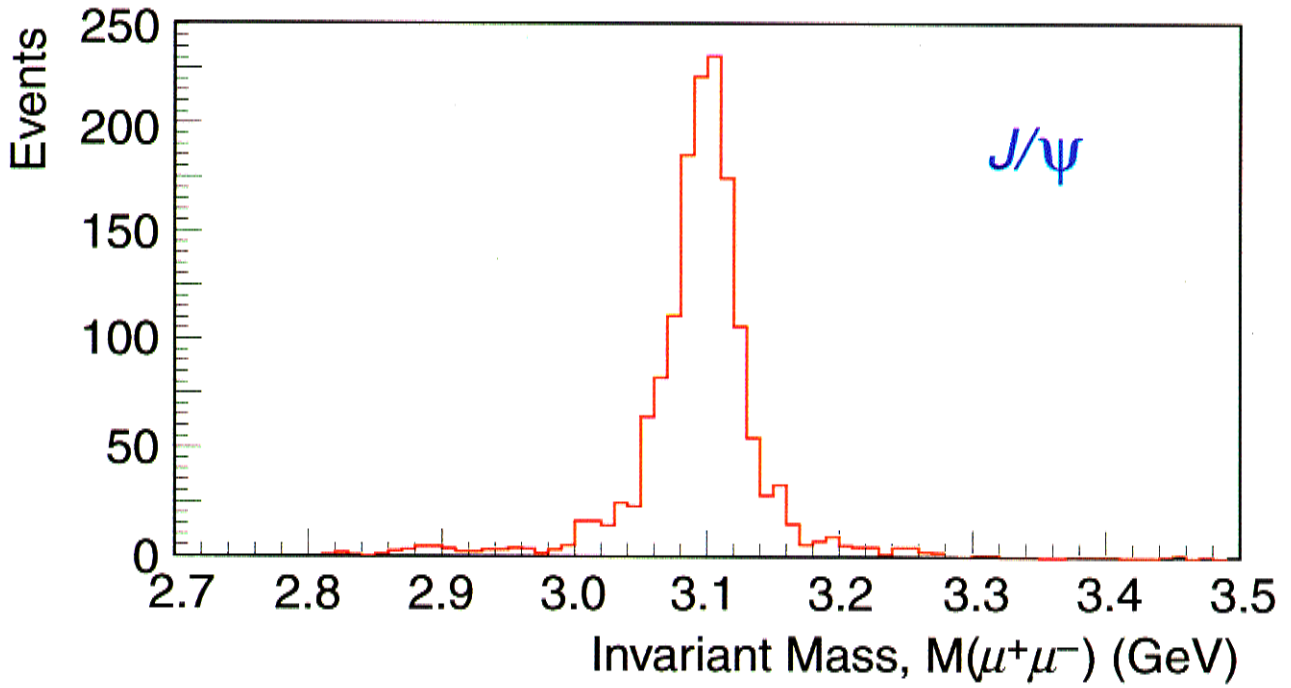


- For same background rate, efficiency ~2.5 times lower than comparable

$B^0 \rightarrow J/\psi K_S^0$

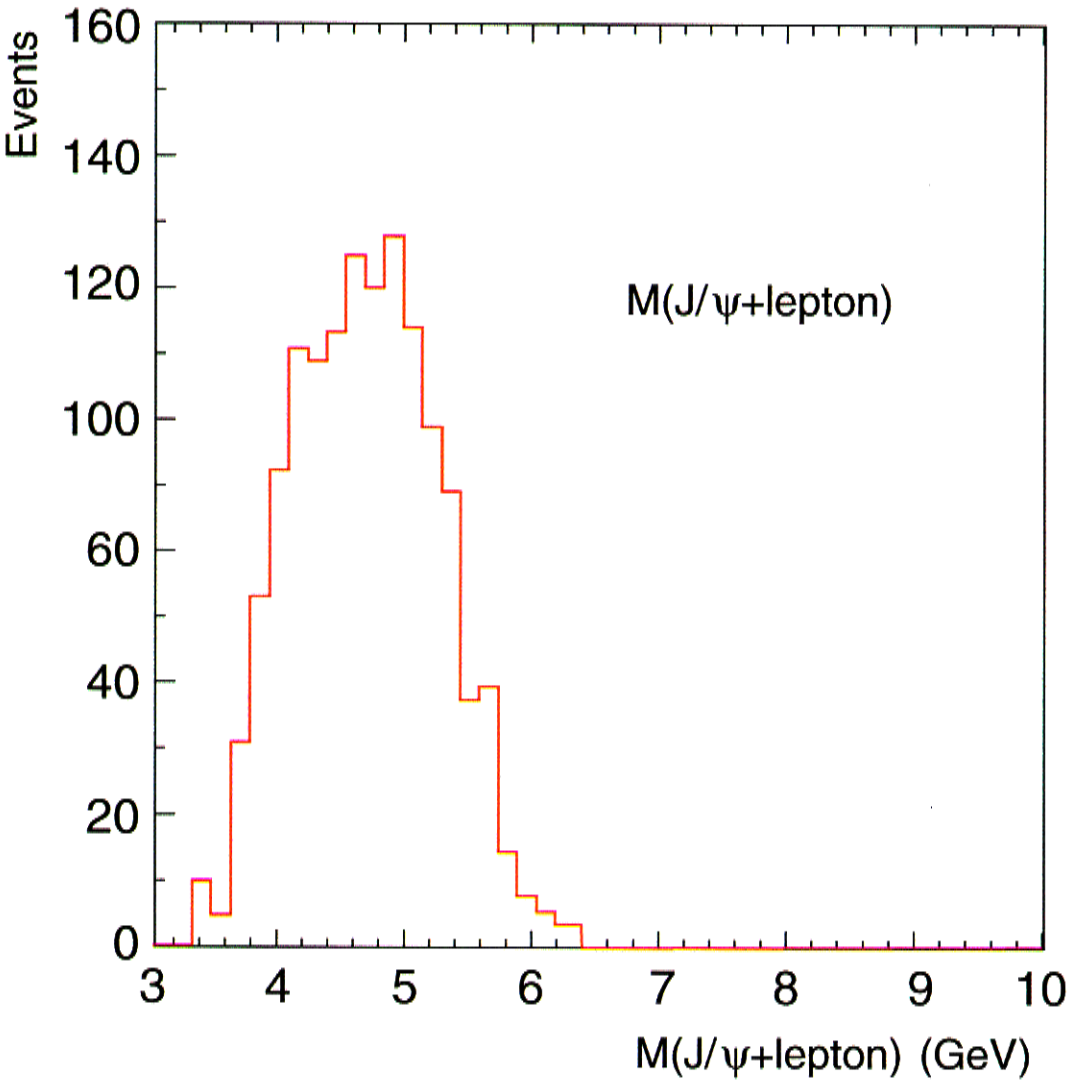
- Kinematic quantities to reduce backgrounds:





- Resolution σ_M ~ 30 MeV, more radiative tails for e^+e^-

- Invariant mass of tri-lepton system (missing neutrino shifts mass down)



- gives mass info (e.g. CDF Monte Carlo templates)

Some Numbers

$$\frac{\sigma(B_c^+)}{\sigma(\bar{b})} = 1.3 \times 10^{-3} \quad \text{c.f.} \quad \frac{\sigma(B^+)}{\sigma(\bar{b})} = 0.378 \pm 0.022$$

$$Br(B_c^+ \to J/\psi \ell \nu) = 2.5\% \text{ (theory)}$$

c.f.

$$Br(B^+ \to J/\psi X) \approx 1\%$$

$$Br(B^0 \to J/\psi K^0) = 8.9 \times 10^{-4}$$

$$Br(B^+ \to J/\psi K^+) = 1.0 \times 10^{-3}$$

Easiest: measurement from CDF:

$$\frac{\sigma(B_c^+) \cdot Br(B_c^+ \to J/\psi \ell \nu)}{\sigma(B^+) \cdot Br(B^+ \to J/\psi K^+)} = 0.132 \pm 0.031 \pm \begin{matrix} 0.032 \\ 0.020 \end{matrix}$$

Conclusions & To Do

- Without the "mixed" lepton final state (needs trigger optimizing),

  ~600 fully reconstructed $B_c^{\pm} \to J/\psi \ell^{\pm} \nu$ in $2\,fb^{-1}$

  $\Rightarrow$ Sample for good physics

- Check vertex trigger

- Look at other channels

  $J/\psi\,\pi^{\pm}$, B_s $\Rightarrow$ easy extension