Towards CP violation results from DØ

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(for the DØ collaboration)

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This talk:

- Progress on CP violation measurements
- Expectations

Why do B-physics at the Tevatron?

- Producing large numbers of $b\bar{b}$ pairs:
  - $\sigma(p\bar{p} \rightarrow b\bar{b}) = 1.5\ 10^5$ nb @ 2TeV
  - $\sigma(e^+e^- \rightarrow Z^0 \rightarrow b\bar{b}) = 7$ nb
  - $\sigma(e^+e^- \rightarrow \Upsilon(4S) \rightarrow b\bar{b}) = 1$ nb

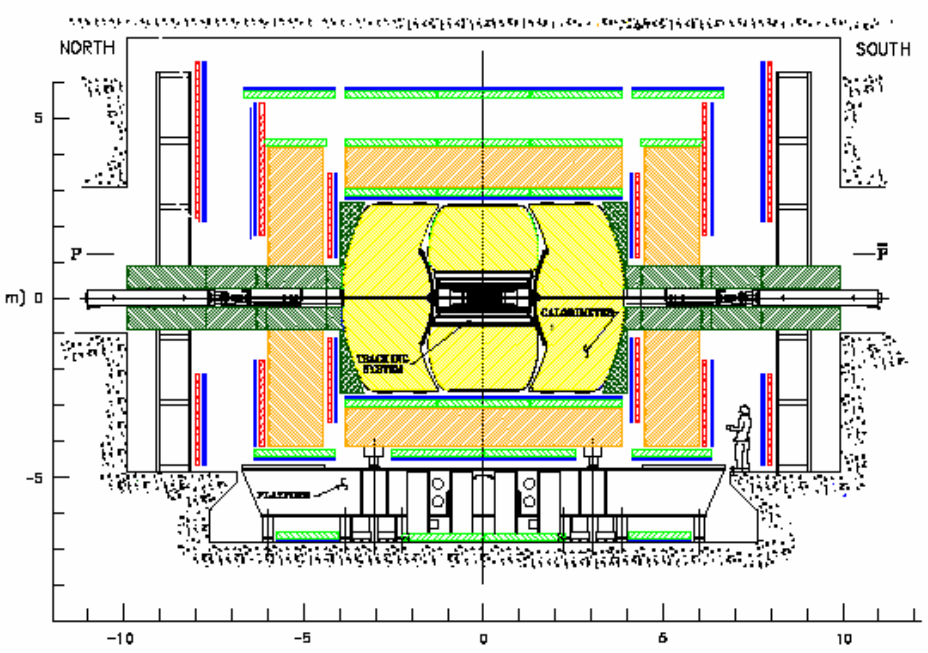
- Expect 10^{10} $b\bar{b}$ pairs/year at $4\ 10^{31}$ $cm^{-2}s^{-1}$
  - fragmenting into all B-species: B_d, B_u, B_s, Λ_b, ...
- But: much higher backgrounds, need more sophisticated triggering/event selection

Rich B-physics menu

- cross-sections: improve precision and extend p_T–range over Run I
- B hadron spectroscopy: study and discovery of new particles: B_c, Ξ_b, Ω_b, ...
- Many CP violation measurements possible
  - CKM angles from decays like
    - $B_d \rightarrow J/\psi\ K_S$
    - $B_s \rightarrow J/\psi\ \phi$
  - Mixing measurements: B_s, B_d

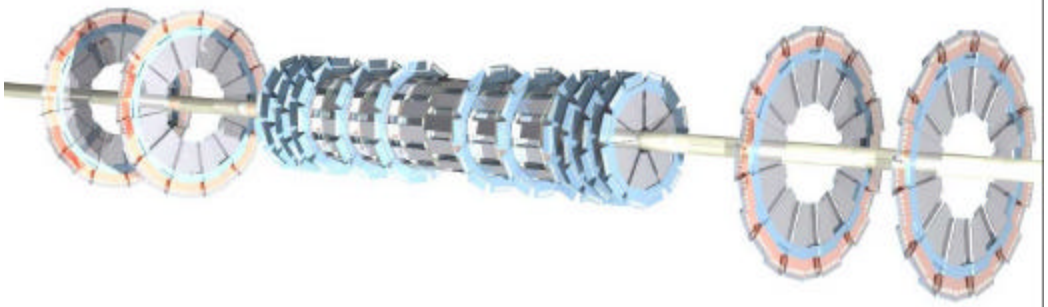
Performance of DØ

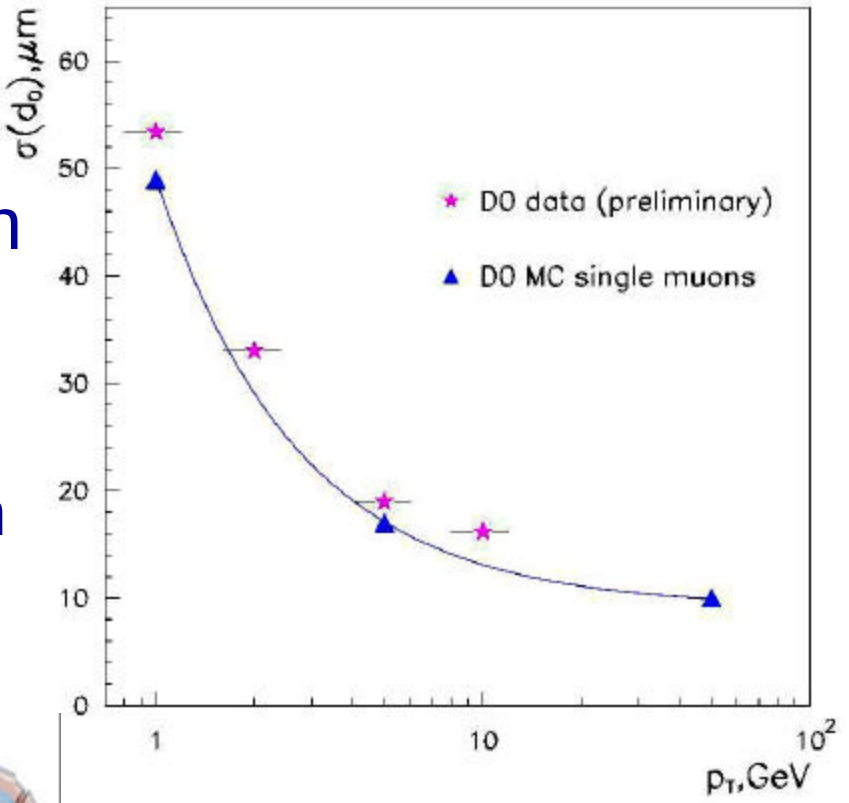
- Silicon Microstrip Tracker (SMT): 91% operational
- Central Fiber Tracker (CFT): 99% operational
- Calorimeter: 99.9% operational
- Muon system 99.5% operational
  - over entire rapidity range
- Over past year, running efficiency greatly improved
  - taking data at 50 Hz
  - June ’03 average 88%



Tracker performance

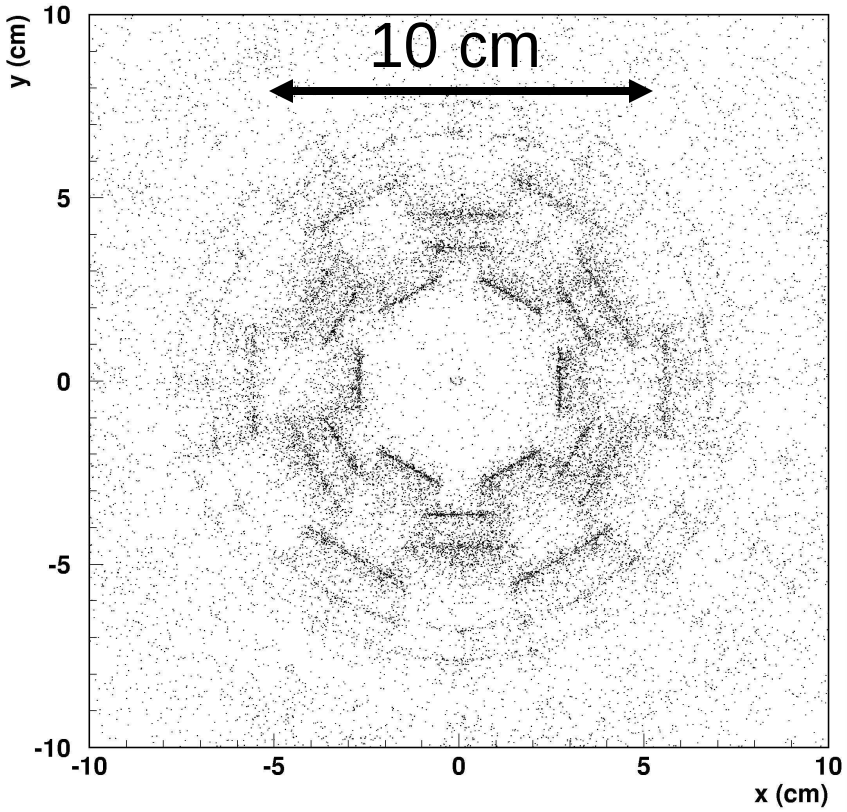
- Distance of closest approach (DCA): resolution closing in on MC
  - At p_T=1 GeV, σ(DCA)=53 μm
  - Better for higher p_T



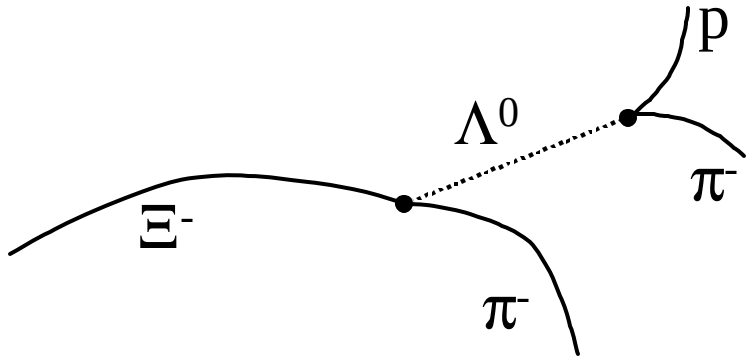


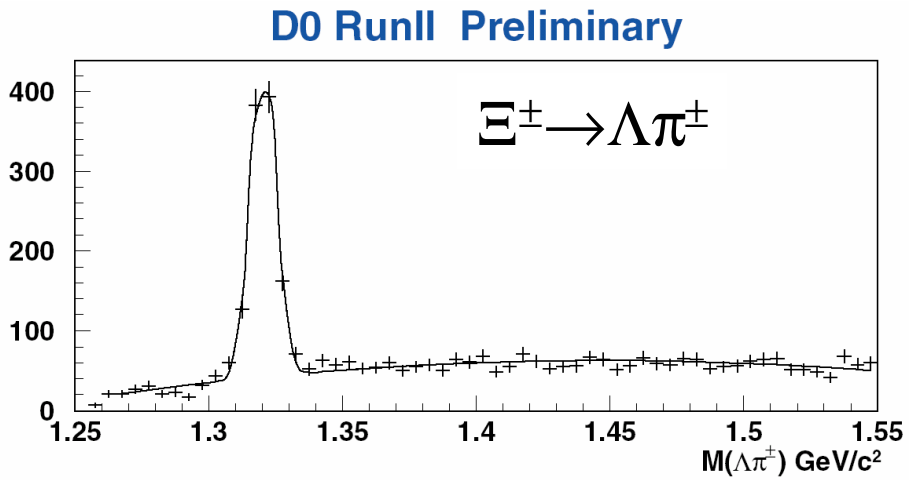
Tracker feats

- photon conversions:



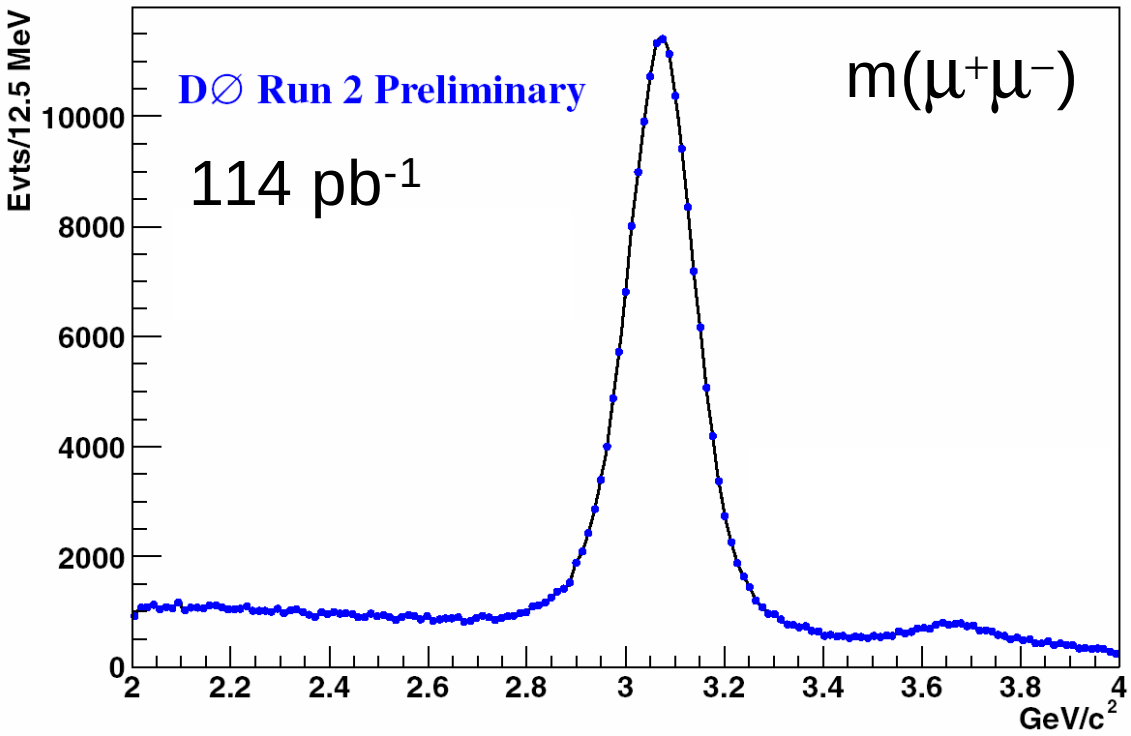
- Ξ^- decay:





Today's B sample

- 114 pb^{-1} taken with dimuon trigger
  - requires muon scintillator coincidence at L1
- At the Tevatron, a J/ψ trigger yields a lot of B's: 15-20%



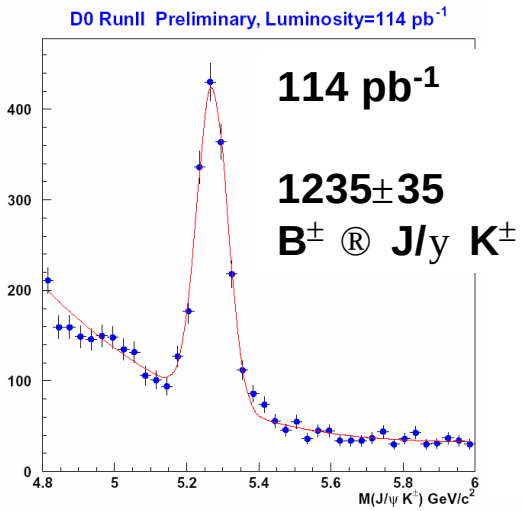
All J/ψ modes suffer from (implicit) |p| cut in L1 muon trigger

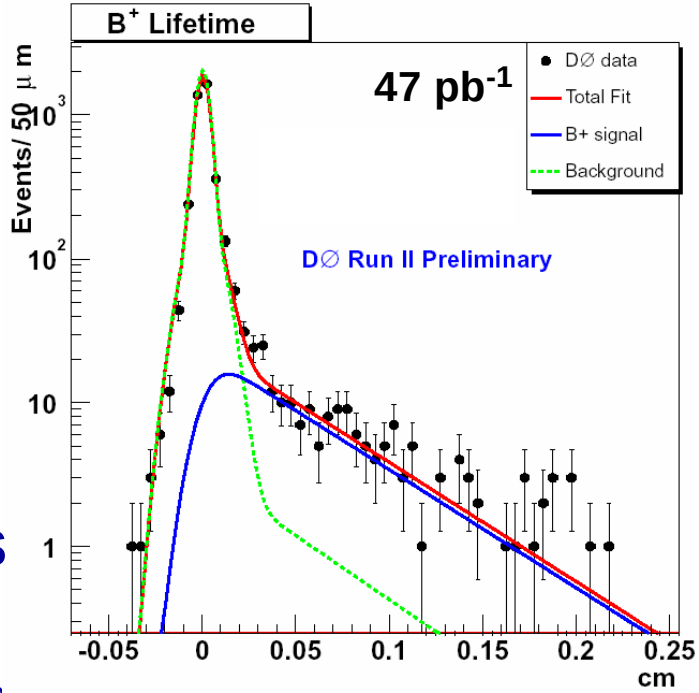
Awaiting trigger completion
(see later slides)

- Current baseline Tevatron plan: 2 fb^{-1} at the end of 2005

Baseline lifetime measurement: $B^{\pm} \rightarrow J/\psi\ K^{\pm}$

- Combining J/ψ and one track
  - we have only limited K/π separation using dE/dx from the SMT
- Lifetime fit to $c\tau$ distribution, use
  - Gaussian for combinatorics
  - exp. convoluted with Gaussian for B bkg
  - exp. convoluted with Gaussian for B^+ signal

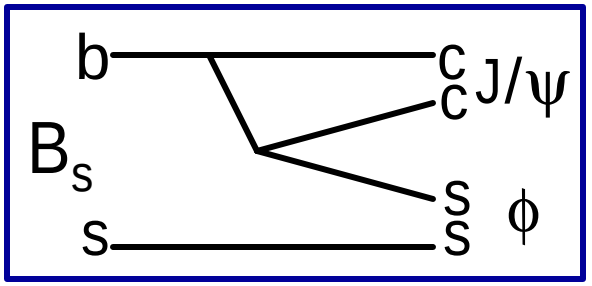


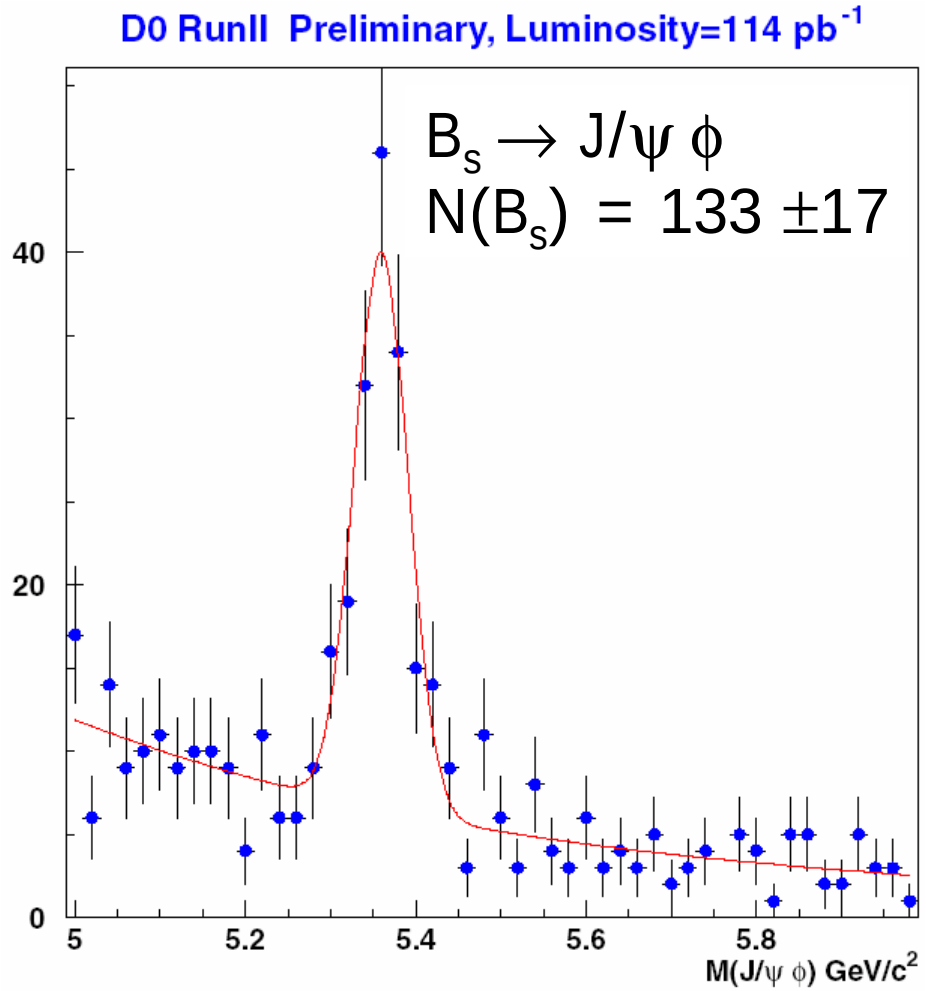


- Result: $\langle\tau\rangle = 1.761 \pm 0.24$ (stat) ps
- Compare PDG: $\langle\tau\rangle = 1.671 \pm 0.018$ ps

Decays for CKM angles:

$B_s \rightarrow J/\psi\,\phi$





- CP violation in this channel allows measurement of CKM angle β_s

$$\beta_s \equiv \arg\left(-\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*}\right)$$

- Effect expected to be small (few %), but directly proportional to η (Wolfenstein param.)
- Lifetime fits are in progress
  - see LeptonPhoton03 !

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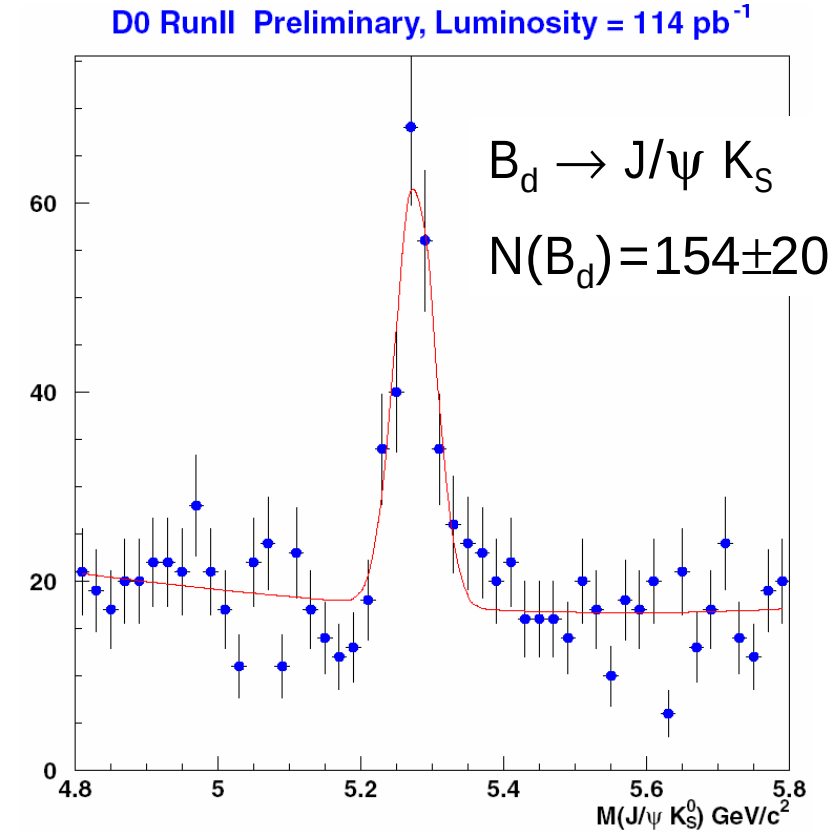
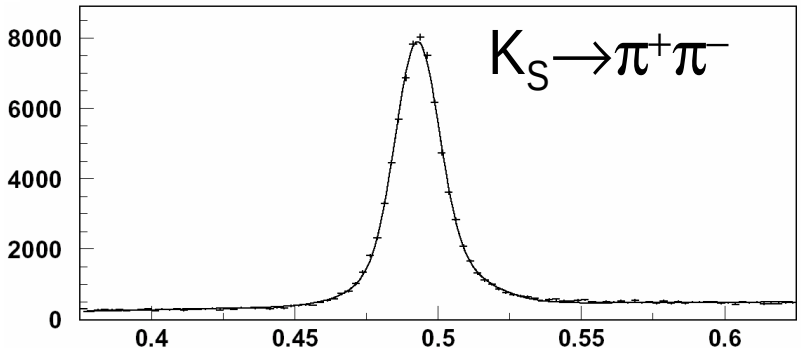
Decays for CKM angles: $B_d \rightarrow J/\psi\ K_S$





- B_d mass formed from mass-constrained K_S and J/ψ
- $\sin(2\beta) = \dfrac{A(B_d) - A(\overline{B_d})}{A(B_d) + A(\overline{B_d})}$
- Accurate measurement requires:
  - initial-flavour tagging
  - trigger completion

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Initial Flavour Tagging

- Jet charge tag: sum of charge of tracks in opposite-side jet
- Soft muon tag: use opposite-side muon charge
- Using exclusively reconstructed $B^+ \rightarrow J/\psi\, K^+$ sample

	Results using 47 pb^{-1}	jet charge	soft muon
signal + bkg	# events	181	218
	# correct tags	66	13
	# wrong tags	48	5
for B signal	efficiency ε [%]	55.1 ± 4.1	8.2 ± 2.2
	dilution D [%]	21.0 ± 10.6	63.9 ± 30.1
	tagging power εD^2 [%]	2.4 ± 1.7	3.3 ± 1.8

Same-side tag being worked on

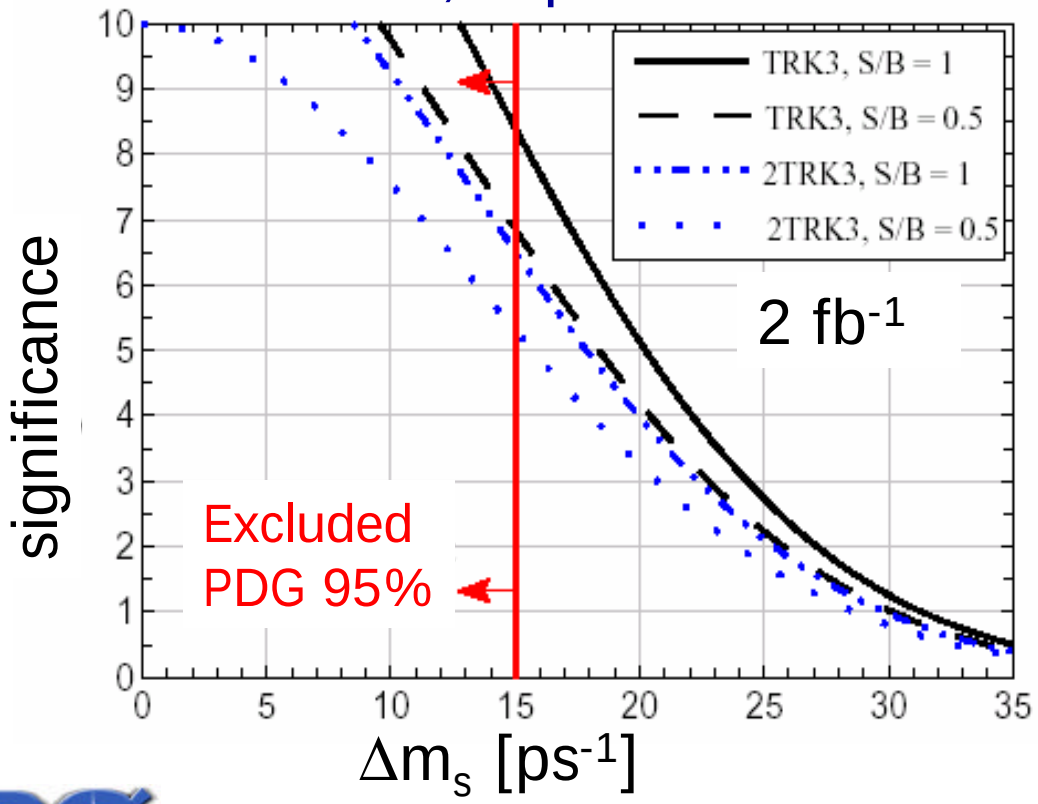
(errors are statistical)

Efficiency: $\varepsilon = (N_{right} + N_{wrong}) / N_{all}$

Dilution: $D = (N_{right} - N_{wrong}) / (N_{right} + N_{wrong})$

B_s mixing: Δm_s

- Δm_s reach in hadronic channel: $B_s \rightarrow D_s^{(*)} \pi$
  - used soft muon tag
  - proper time res. used: 75 fs, reco. effiency 15%
  - in 2 fb^{-1}, expect 1300-1900 events (single-μ trigger)



With 2 fb^{-1}, can make 3σ measurement to Δm_s of ~23 ps^{-1}

- also looking into semileptonic channel

Reach determined by vertexing resolution and trigger efficiencies

Trigger completion

- CTT: L1 Central Track Trigger
  - Track finding at L1, allows match with muon system
  - Effectively allows lowering p_T threshold on muon triggers
  - Coming online **now**! (installed, running tests)
- STT: L2 Silicon Track Trigger
  - Displaced track trigger allowing b-tagging at L2
  - Expected after the summer

- Expect large increase in J/ψ yield

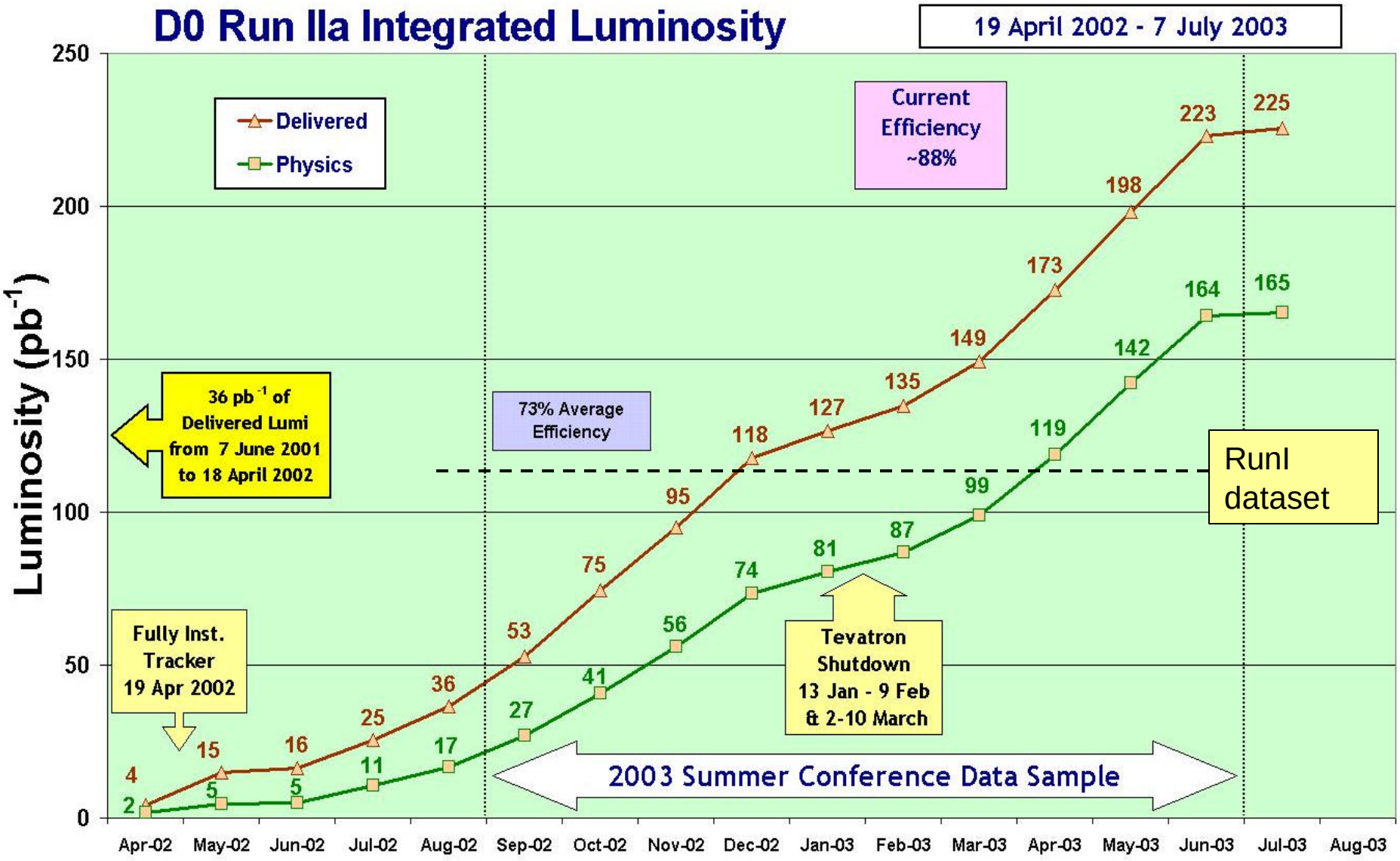
Conclusions

- B's in 114 pb^{-1} sample have been studied
- Results promising: compatible with expectations

- With more data and completed trigger, DØ will make accurate CP violation measurements

Stay tuned!

Back-up slides


D0 Run IIa Integrated Luminosity
19 April 2002 - 7 July 2003
Delivered
Physics
Current Efficiency ~88%
Luminosity (pb-1)
250
200
150
100
50
0
36 pb-1 of Delivered Lumi from 7 June 2001 to 18 April 2002
73% Average Efficiency
RunI dataset
Fully Inst. Tracker 19 Apr 2002
Tevatron Shutdown 13 Jan - 9 Feb & 2-10 March
2003 Summer Conference Data Sample
4
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Aug-03

Flavour tagging: Jet charge

Algorithm:

- Remove daughter tracks from the reconstructed B
- Remove tracks w. 2D impact parameter greater than 0.2 cm
- Remove tracks with $|\, z(\mathrm{DCA}) - z(\mathrm{PV}) \,| > 2.0$ cm
- Use remaining tracks in φ window opp. B to calculate the jet charge Q (weighing tracks with p_T)
- Events with $|Q|>0.2$ are "tagged"

- Efficiency = $(N_{right} + N_{wrong})/ N_{all}$
- Dilution = $(N_{right} - N_{wrong})/ N_{all}$

(using 47 pb^{-1})

# of events	181
# of events with correct tag	66
# of events with wrong tag	48
Raw efficiency (%)	63.0±3.6
Raw dilution (%)	15.8±8.3
Estimated # of signal events	114
Purity	63.0
Estimated efficiency of signal events (%)	55.1±4.1
Estimated dilution of signal events (%)	21.0±10.6
Estimated e×D^2 of signal events (%)	2.4±1.7

- Errors only statistical
- Errors in fractions of signal, bgd events in mass window (from fit) are ignored

Flavour tagging: Soft muon tag

Algorithm:

- must have $?R > 2.0$ separation from reconstructed B
- must have $p_T > 1.9$ GeV
- charge of highest-p_T muon in event gives (opposite-side) B-tag

(using 47 pb^{-1})

# of events	218
# of events with correct tag	13
# of events with wrong tag	5
Raw efficiency (%)	8.3±1.9
Raw dilution (%)	44.4±21.1
Estimated # of signal events	12.8
Estimated # of bgd events	5.2
Estimated efficiency of signal events (%)	8.2±2.2
Estimated dilution of signal events (%)	63.9±30.1
Estimated $e \times D^2$ of signal events (%)	3.3±1.8

- Errors only statistical
- Errors in fractions of signal, bgd events in mass window (from fit) are ignored

$B^+ \rightarrow J/\psi\ K^+$ mass plots

- Mass spectrum used for lifetime fit:
  - mass 5.254 GeV ± 8 MeV
  - 179 signal events
- Mass spectrum with add'l lifetime cut:
  - 96 signal events