B decays to Charm and Charmonium in BaBar

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Outline

- B decays to J/Ψ baryon-antibaryon
- $B^{\pm} \rightarrow \chi_{c0}\ K^{\pm}$
- $B \rightarrow J/\Psi\ \eta\ K$
- $B^{-} \rightarrow D^{*0}\ \ K^{*-}$
- $B \rightarrow D^{*}\ \ D^{*}$

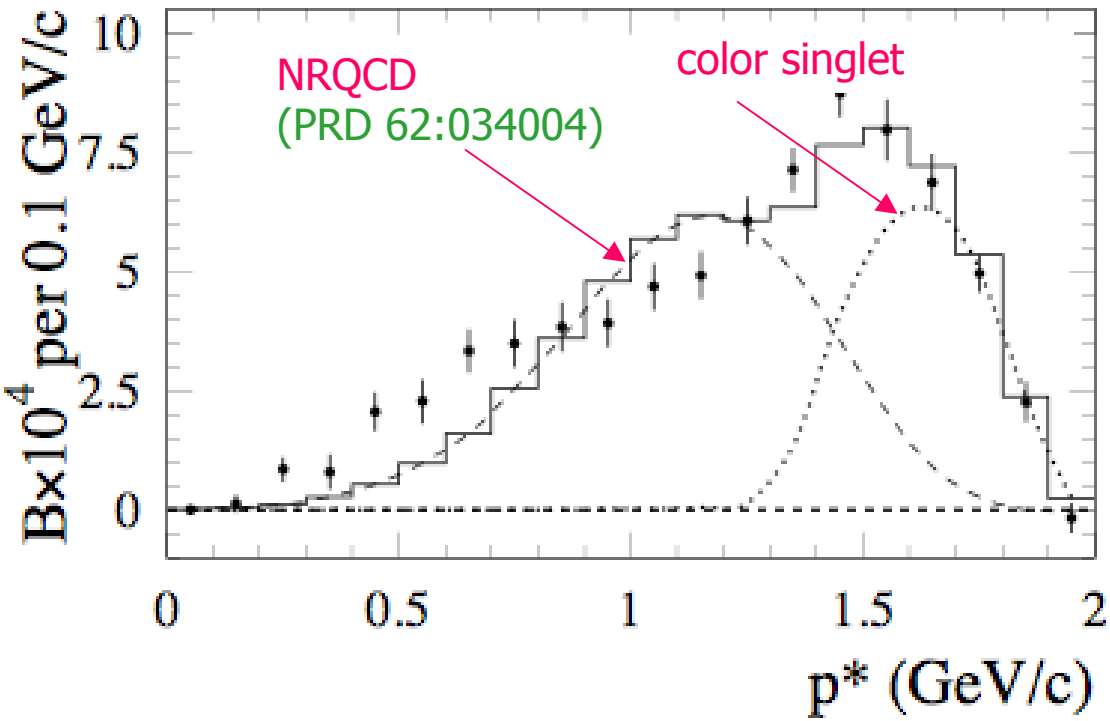
B decays to J/Ψ baryon-antibaryon

- inclusive production of J/Ψ in B decays (PRD 67:032002)
- p of J/Ψ in Y(4S) frame exhibits excess at low p* compared to NRQCD.

- Below 0.8 GeV/c

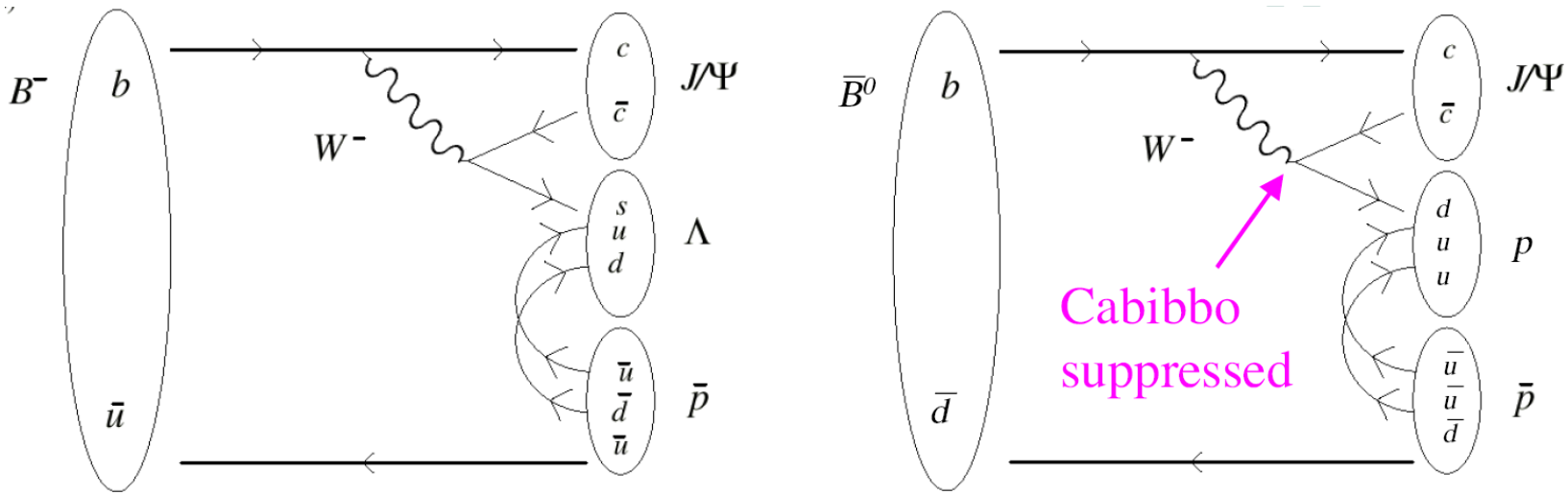
  BF of $6 \cdot 10^{-4}$
- $\sigma(p^{(\Upsilon(4S))} - p^{(B)})$ is

  0.12 GeV/c



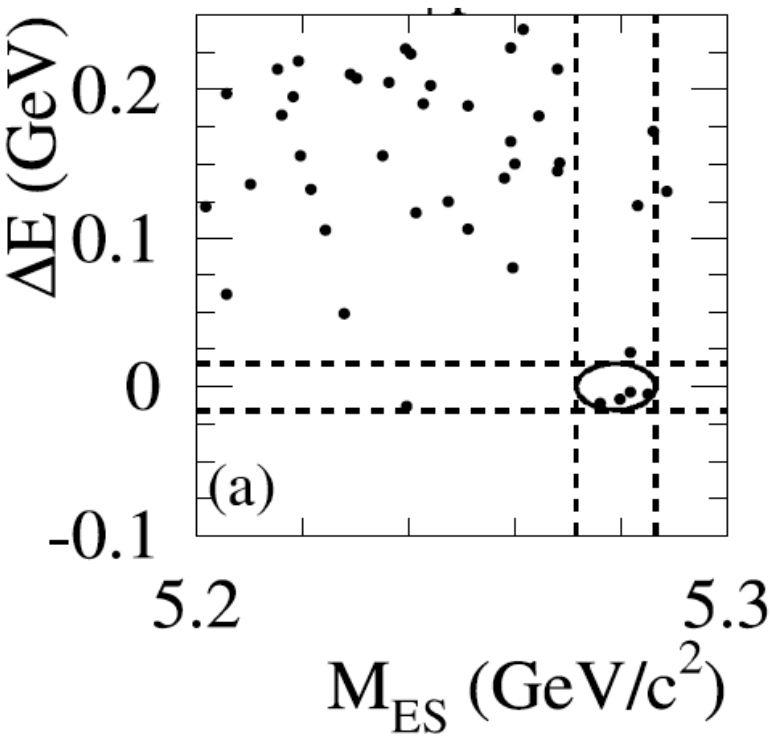
B decays to J/Ψ baryon-antibaryon

- A possible source of the excess in the p* spectrum could be B $\rightarrow$ J/ψ baryon-antibaryon (Phys Lett. B 411: 152, 1997)



- Possible enhancement by (QCD allowed):
  - Nuclear bound quarkonium (J/ψ p)
  - Baryonium (p Λ)
  - Pentaquark (J/ψ Λ)

B decays to J/Ψ baryon-antibaryon



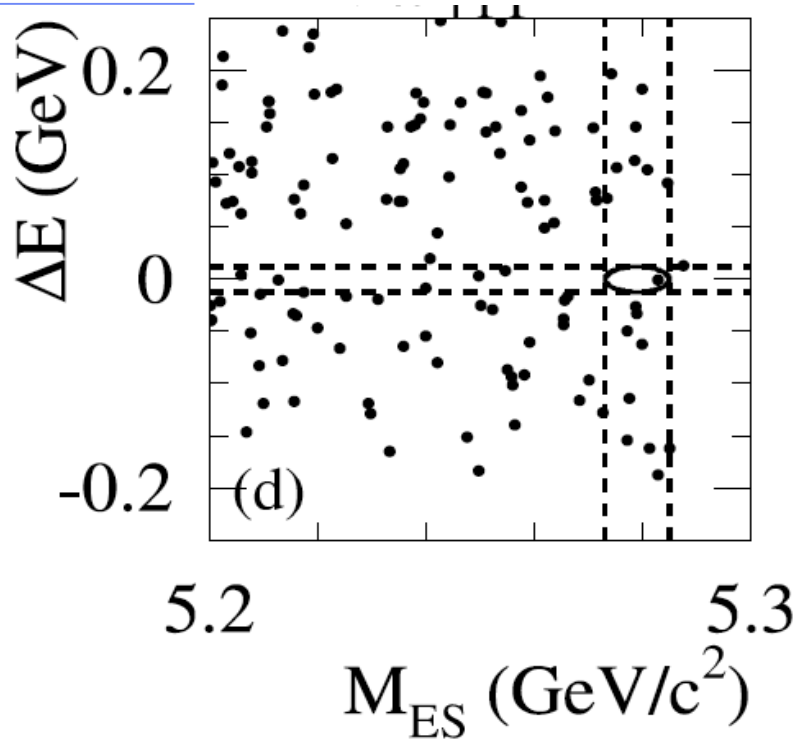
$B^+ \to J/\psi\ p\ \bar{\Lambda}$

- Observe 4 events
- Expected BG: 0.21± 0.14
- $Br(B^+ \to J/\psi\ p\ \bar{\Lambda}) = (12^{+9}_{-6}) \cdot 10^{-6}$
- Probability of BG fluctuation: $2.5 \cdot 10^{-4}$

- $\Delta E = E^*_B - E^*_{beam}$
- $M_{ES} = \sqrt{(E^*_{beam})^2 - (p^*_B)^2}$

in $\Upsilon(4S)$ frame

B decays to J/Ψ baryon-antibaryon

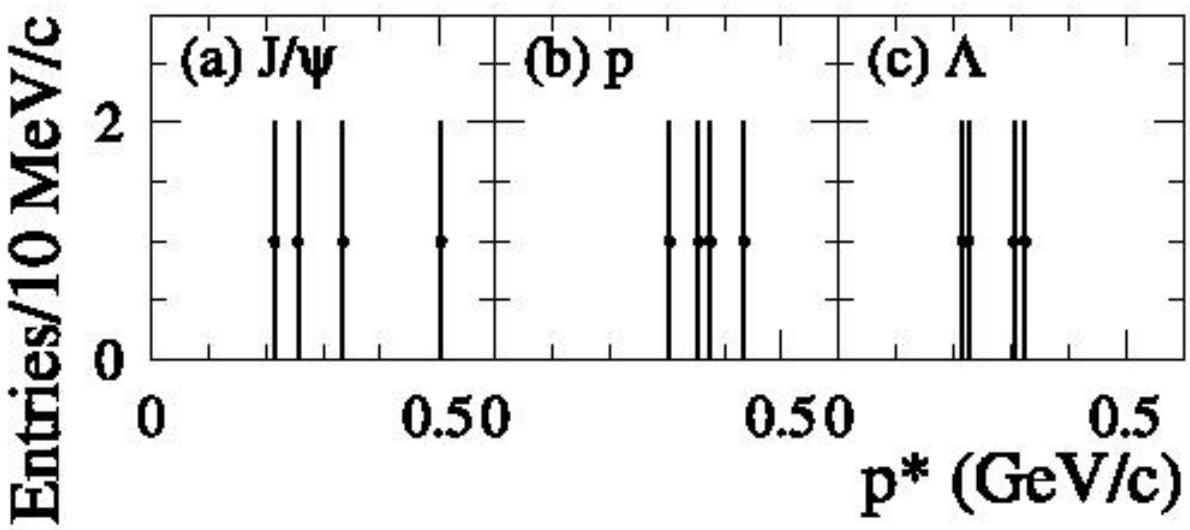


$B^0 \rightarrow J/\psi\ p\ \bar{p}$

- Observe 1 event
- Expected BG: 0.64± 0.17
- $Br(B^0 \rightarrow J/\psi\ p\,\bar{p}) < 1.9 \cdot 10^{-6}$ (90 % C.L.)

B decays to J/Ψ baryon-antibaryon

$B^+ \rightarrow J/\psi \; p \; \bar{\Lambda}$



- No peak in p* distributions (no QCD exotics)

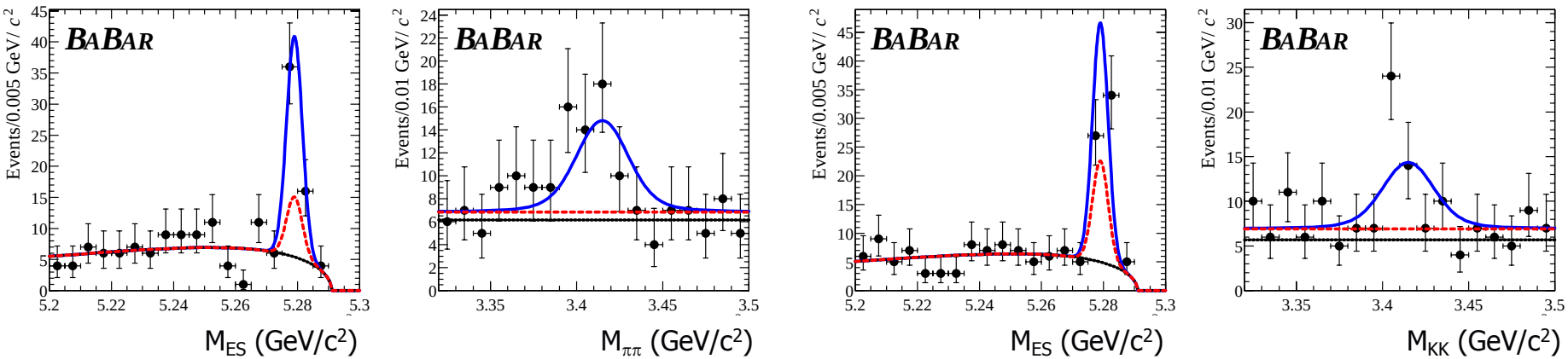
PRL 90, 231801 (2003).

$B^{\pm} \to \chi_{c0}\ K^{\pm}$

- $B^{\pm} \to \chi_{c0}\ K^{\pm}$ vanishes in factorization approximation
- NRQCD calculations predict BR comparable to that of $B^{\pm} \to \chi_{c1}\ K^{\pm} \Rightarrow (6.5 \pm 1.1) \cdot 10^{-4}$
- Contributions from $B^{\pm} \to D_S^{(*)}\ D^{(*)} \to \chi_{c0}\ K^{\pm}$ rescattering amplitudes could produce $BR(B^{\pm} \to \chi_{c0}\ K^{\pm})$ in the range $(1.1 - 3.5) \cdot 10^{-4}$ (Phys Lett. B 542: 71, 2002)
- Possible channel for measuring UT angle γ (Phys Lett. B 539: 67, 2002)
- Already seen by BELLE:
  - $BR(B^{\pm} \to \chi_{c0}\ K^{\pm}) = (6.0^{+2.1}_{-1.8} \pm 1.1) \cdot 10^{-4}$

$B^{\pm} \to \chi_{c0}\ K^{\pm}$

- χ_{c0} decay to K^+K^- and $\pi^+\pi^-$
- Unbinned Max. Likelihood fit to M_{ES} and $m\chi_{c0}$

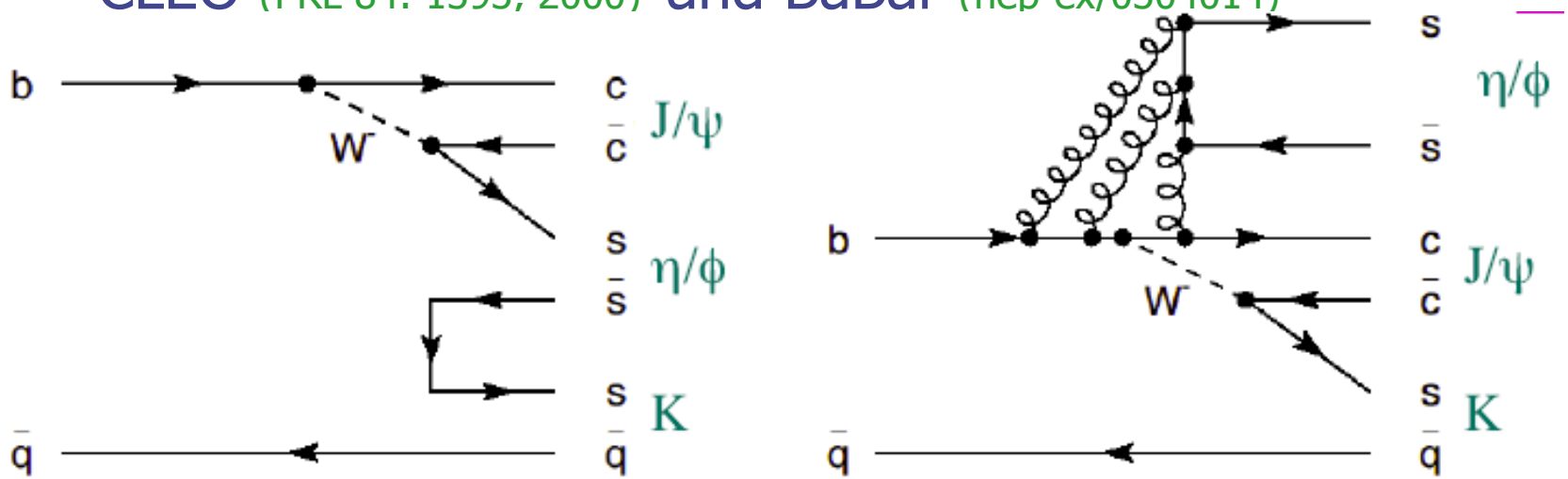


- $BR(B^{\pm} \to \chi_{c0}\ (\pi^+\pi^-)K^{\pm}) = (1.32^{+0.28}_{-0.27} \pm 0.09) \cdot 10^{-4}$
- $BR(B^{\pm} \to \chi_{c0}\ (K^+K^-)K^{\pm}) = (1.49^{+0.36}_{-0.34} \pm 0.11) \cdot 10^{-4}$

- $BR(B^{\pm} \to \chi_{c0}\ K^{\pm}) = (2.7 \pm 0.7) \cdot 10^{-4}$ (prelim.)

$B \to J/\psi\ \eta\ K$

- First observation of color-suppressed B decay modes with hidden strangeness, $s\bar{s}$, in $B \to J/\psi\ \phi\ K$
  CLEO (PRL 84: 1393, 2000) and BaBar (hep-ex/0304014)



- Expect BR($B \to J/\psi\ \eta\ K$) comparable to

BR($B \to J/\psi\ \phi\ K$) = $(4.4 \pm 1.4 \pm 0.5) \cdot 10^{-5}$

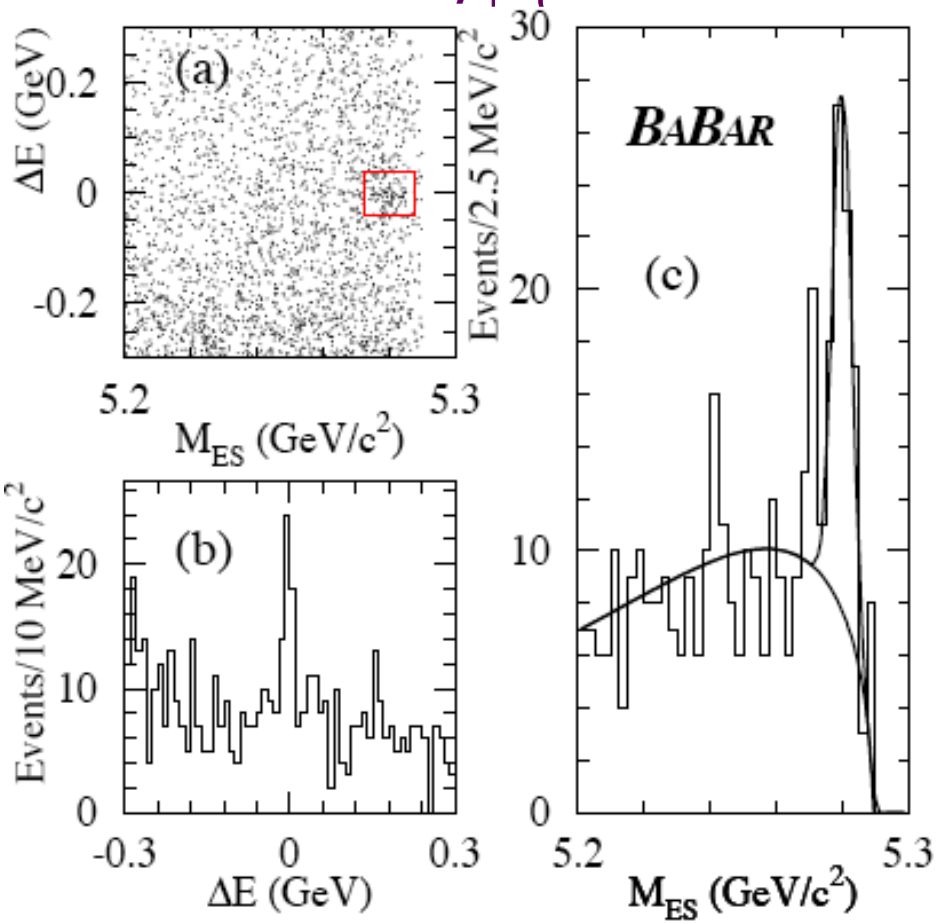
$B \rightarrow J/\psi\ \eta\ K$ feed-down

- From $B \rightarrow \Psi(2s)\ K \rightarrow J/\psi\ \eta\ K$
  - BR of $(2.1 \pm 0.2) \cdot 10^{-5}$
  - $J/\psi\ \eta$ in a relative P-wave state
- From h_c if $J/\psi\ \eta$ form an S-wave resonance
  - $J^{PC}=1^{+-}$
  - But probably too light
- Charmonium hybrids ($c\bar{c}g$) in the good mass range
  (hep-ph/0305285)

$B \to J/\psi\ \eta\ K$

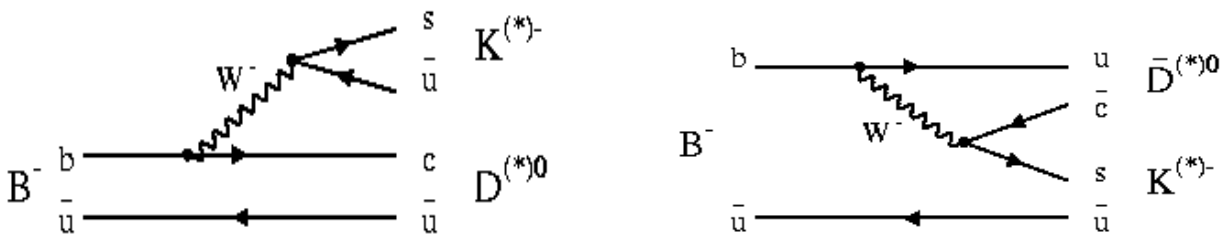
- $BR(B^{\pm} \to J/\psi\ \eta\ K^{\pm}) =$
  $(10.8 \pm 2.3 \pm 2.4) \cdot 10^{-5}$
- $BR(B^{0} \to J/\psi\ \eta\ K^{0}) =$
  $(16.8 \pm 5.2 \pm 5.4) \cdot 10^{-5}$
- Rates comparable to $J/\psi\ \Phi\ K$
  (hep-ex/0307032)

$B^{\pm} \to J/\psi\ \eta\ K^{\pm}$ data



$B^- \to D^{*0} \; K^{*-}$

- Decays $B \to D^{(*)} \; K^{(*)}$ for extraction of UT angle γ
- Via interference of charged B decaying into common final states:

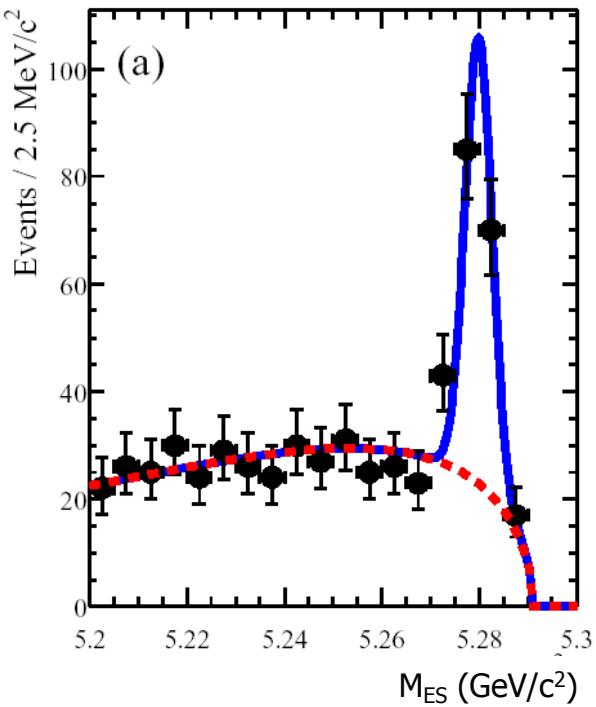


- CP effect may be small (Cabibbo/Color suppression)
- Vector-Vector B decays: helicity amplitudes interference

$B^- \to D^{*0} \; K^{*-}$ can give information on γ (PRL 80: 3706, 1998)

$B^- \to D^{*0} K^{*-}$

- Preliminary results



- $86 \cdot 10^6$ $B\bar{B}$ pair / 79 fb^{-1}
- $D^{*0} \to D^0 \pi^0$, $D^0 \gamma$
- $D^0 \to K^- \pi^+$, $K^- \pi^+ \pi^0$, $K^- \pi^+ \pi^+ \pi^-$
- $K^{*-} \to K_S \pi^-$
- $BR(B^- \to D^{*0} K^{*-}) = (8.3 \pm 1.1 \pm 1.0) \cdot 10^{-4}$

- Longitudinal polarization fraction $\Gamma_L / \Gamma = (0.86 \pm 0.06 \pm 0.03)$
- Consistent with expectations from factorization, HQET

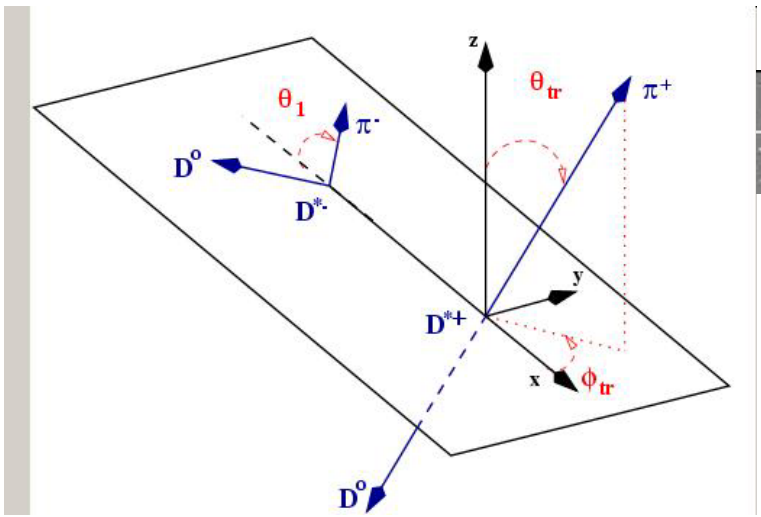
(Phys Lett. B 89: 105, 1979)

$B \rightarrow D^* \; D^*$

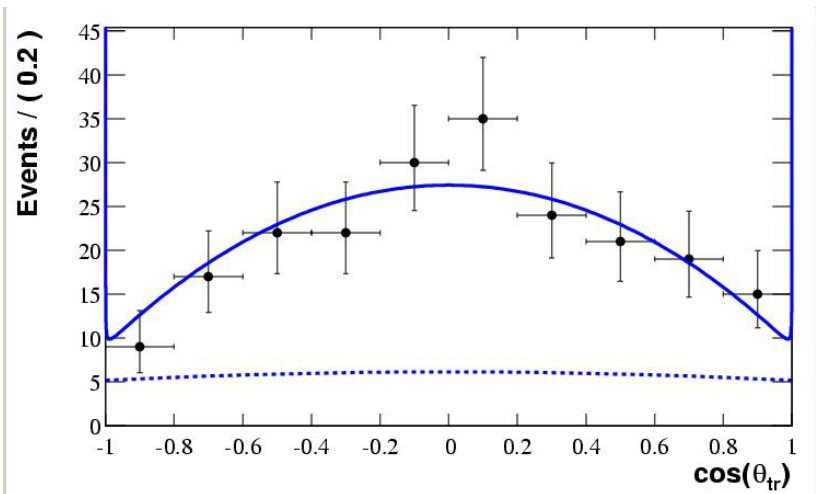
- $B^0 \rightarrow D^* D^*$: Cabibbo suppressed
  - Tree for measurement of UT angle β
  - Penguin expected to be $< 10\ \%$ (SM)
- Vector-Vector decay: not pure CP eigenstate
  - Angular moment L=0,1,2
  - Analysis in transversity frame: 3 amplitudes
    - A_0 CP even
    - $A_{||}$ CP even
    - $A_\perp$ CP odd
  - CP odd fraction $R_\perp = |A_\perp|^2 / (|A_0|^2 + |A_{||}|^2 + |A_\perp|^2)$

$B \rightarrow D^* \; D^*$

- 1D Angular distribution in transversity frame



$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_{tr}} = \frac{3}{4}(1-R_\perp)\sin^2\theta_{tr} + \frac{3}{2}R_\perp\cos^2\theta_{tr}$$



81 fb^{-1} (hep-ex/0307032)

$R_\perp = 0.063 \pm 0.055 \pm 0.009$

Used for CP analysis

$B \rightarrow D_{sJ}\, D^{(*)}$

- D_{sJ} (2317) and D_{sJ} (2460) by BaBar in $c\bar{c}$
- Belle observed $B \rightarrow D_{sJ}$ (2317) $D^{(*)}$ and $B \rightarrow D_{sJ}$ (2460) $D^{(*)}$ with 90 fb^{-1} (FPCP 2003)
- BaBar analysis still ongoing
- See precedent talk by J.C. Wang

Conclusions

- Observation of $B \rightarrow J/\Psi\ p\ \Lambda$
- $B \rightarrow J/\Psi\ \eta\ K$ rate as expected
- BR($B^{\pm} \rightarrow \chi_{c0}\ K^{\pm}$)
- BR and polarization in $B^{-} \rightarrow D^{*0}\ K^{*-}$
- CP-odd fraction for $B^{0} \rightarrow D^{*}D^{*}$
- More analysis and data coming