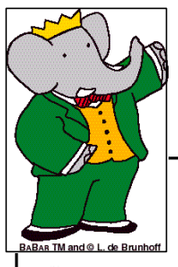
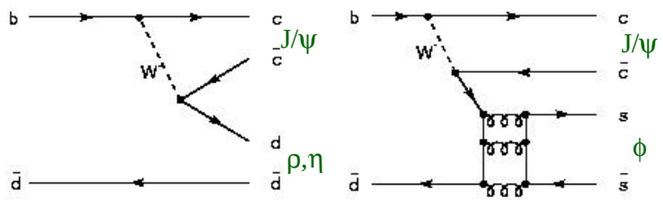
Recent Results from BaBar on Charmonium Production in B Decays



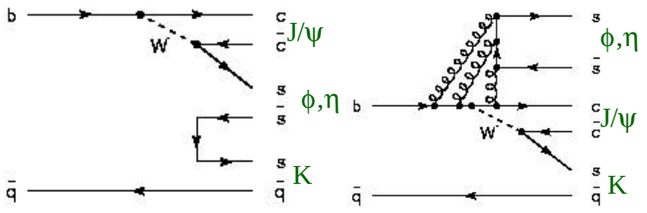
Colorado State University
Knowledge to Go Places

$B \to J/\psi\, s\bar{s}$



• *Rate of $B \to J/\psi\, f$ comparable to $B \to J/\psi\, r$ or $J/\psi\, h$ indicates the importance of rescattering diagrams*

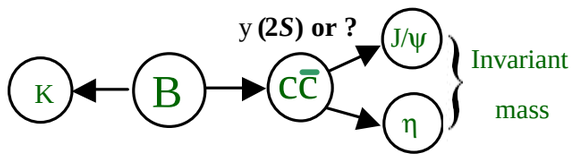
$B \to J/\psi\, s\bar{s}\, K$



• ***CLEO*** *observed* $BF(B \to J/\psi\, f\, K) = 8.8^{+3.7}_{-3.3} \times 10^{-5}$

• *$B \to J/\psi\, h\, K$ should be comparable to $B \to J/\psi\, f\, K$*

$B \to J/\psi\, h\, K$ Contributions



• $\psi(2S)\, K \to J/\psi\, h\, K$ is already possible.

• h_c ($^1P_1$ state of $c\bar{c}$, $J^{PC} = 1^{+-}$) ?

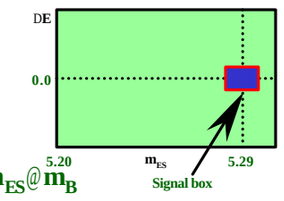
• Charmonium hybrid state ($c\bar{c}g$)?

Analysis Strategy

• ***Kinematic Variables***

Energy substituted mass $m_{ES} = \sqrt{E^{*2}_{beam} - p^{*2}_{B}}$

Energy Difference $\Delta E = E^{*}_{B} - E^{*}_{beam}$



Signal peaks at ΔE@0.0 and m_{ES}@m_B

• **# signal events = # events in signal box n_0 – # background events n_b**

• **background n_b determination**

>> Two types of background: combinatorial and peaking

>> $B \to J/\psi\, \phi\, K$ ($J/\psi\, \eta\, K$)

m_{ES} background shape from m_{ES} distributions formed by requiring J/ψ with fake lepton ID (ΔE sideband); cross checked by MC background study (η sideband).

>> $B \to J/\psi$ baryon anti–baryon

Using area outside of signal box as background area, scaling it to signal region to get average background events, cross checked by Kolmogorov test.

Branching Fraction and Upper Limit

$$BF = \frac{n_0 - n_b}{N_{BB} \times e \times f}$$

N_{BB}: number of BB events; ε: events selection efficiency; f: second branch fraction (PDG value)

upper limit N for probability 1–∈

$$\epsilon = \frac{\sum_{n=0}^{n_0} P(n; n_b + N)}{\sum_{n=0}^{n_0} P(n; n_b)}$$

$P(n; n_b)$ is Poisson distribution

Summary of the Results

• **$B \to J/\psi\, s\bar{s}$** ($\times 10^{-5}$, 90% .C.L.): (**new,** PRL accepted.)

$BF(B \to J/\psi\eta) < 2.7$ $\quad$ $BF(B \to J/\psi\eta') < 6.3$

$BF(B \to J/\psi\phi) < 0.92$**,** rescattering effect is small

• **$B \to J/\psi\, s\bar{s}$ K** ($\times 10^{-5}$):

>> *$B \to J/\psi\, f\, K$* (**improved,** PRL accepted)

$BF(B \to J/\psi\phi K^+) = 4.4 \pm 1.4 \pm 0.6$; $BF(B \to J/\psi\phi K^0) = 10.2 \pm 1.4 \pm 0.6$

>> *$B \to J/\psi\, h\, K$* (**new**)

$BF(B \to J/\psi\eta K^+) = 10.8 \pm 2.3 \pm 2.4$; $BF(B \to J/\psi\eta K^0) = 16.8 \pm 5.2 \pm 5.4$

>>no intermediate hybrid states were seen with data used for each decay mode.

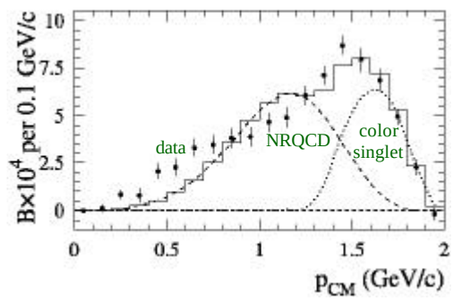
• **$B \to J/\psi$ baryon anti-baryon** ($\times 10^{-6}$): (PRL Vol.90 No.23)

$BF(B^+ \to J/\psi p\bar{\Lambda}) = 12^{+9}_{-6}$

90% C. L. Upper Limit for $B^0 \to J/\psi p\bar{p}$: 1.9

no intermediate QCD exotic resonances were seen

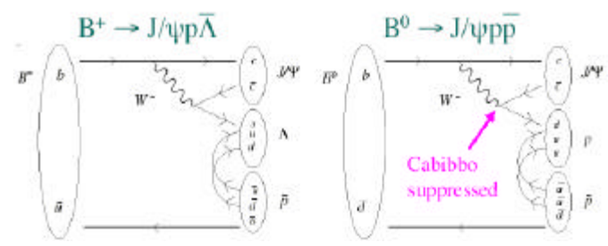
Inclusive J/ψ momentum spectrum (after removing heavier charmonium states)



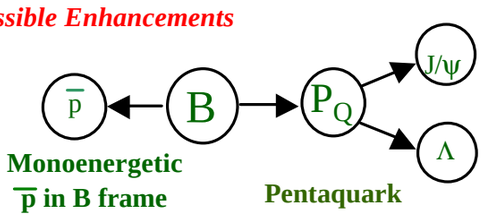
• An excess of J/ψ meson s at low momentum in the e^+e^- center mass frame.

• Is *$B \to J/\psi$ baryon antibaryon* a possible source?

$B \to J/\psi$ baryon anti-baryon



Possible Enhancements



Monoenergetic $\bar{p}$ in B frame $\quad$ **Pentaquark**

• Search for Pentaquark and QCD exotics including baryonium or nucleon bound charmonium

Backgrounds with $B \to J/\psi\, s\bar{s}$ (K)

• Combinatoric $\gamma\gamma$ background in $\eta \to \gamma\gamma$ mode

>> π^0 mass veto to reject γ from π^0

>> γ helicity angle cut in η frame.

• Continuum background

>> thrust angle θ_T is used to suppress this background.

• $B \to J/\psi$+X events background

>> the main source of the background, this causes peaking background in m_{ES} distribution for $B \to J/\psi\, \eta$ with $\eta \to \pi^+\pi^-\pi^0$

Selection criteria and backgrounds for $B \to J/\psi$ baryon anti-baryon

• Signal ellipse is $[(m_{ES} - M_B)/\sigma_m]^2 + [\Delta E/\sigma_E]^2 < S^2$, for neutral mode S=2.4, charge mode S=2.2.

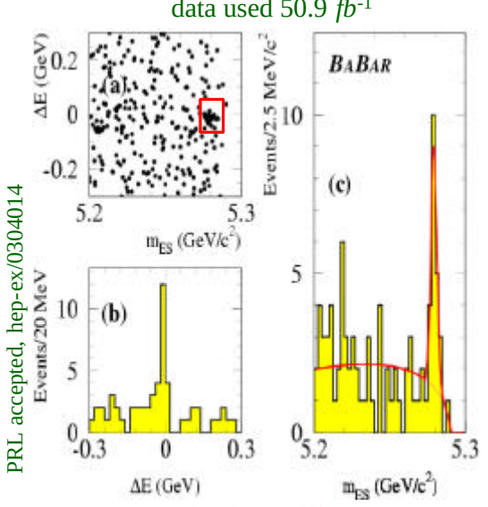
• Geometrical vertex fits are used to select B candidate.

• Background events are mostly combinatorial $B\bar{B}$ events

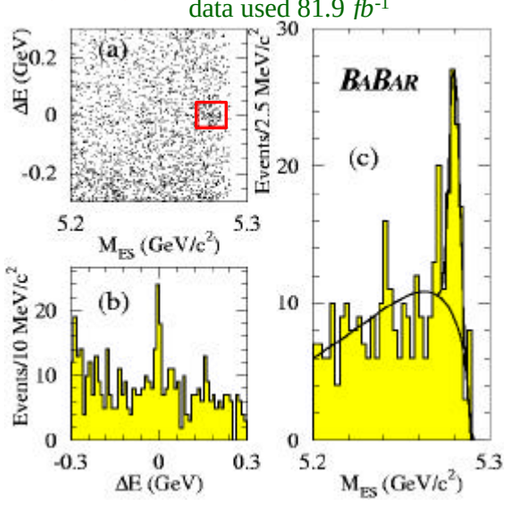
• No peaking background in the signal region of either of ΔE or m_{ES}

Results (data)

$B \to J/\psi\, \phi\, K^+$ data used 50.9 *fb*$^{-1}$



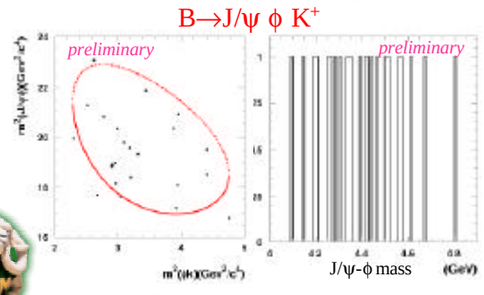
$B \to J/\psi\, \eta\, K^+$ data used 81.9 *fb*$^{-1}$



PRL accepted, hep-ex/0304014

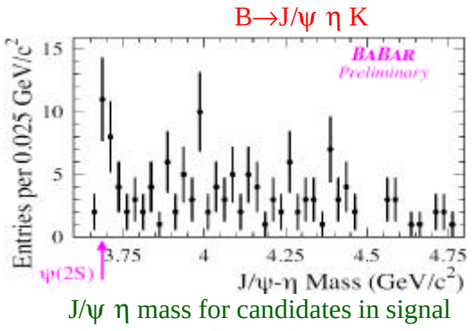
Hep-ex/0307032, will be submitted to PRL

$B \to J/\psi\, \phi\, K^+$



Dalitz plots and J/ψ φ mass for 23 candidates in signal box

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



J/ψ η mass for candidates in signal box only

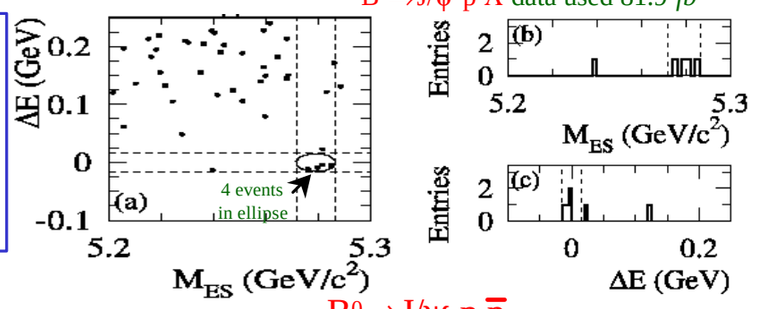
Results (data)

4 events observed with expected background of 0.21±0.14

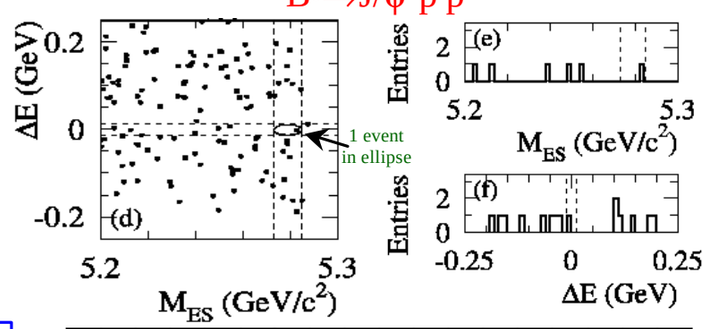
1 event observed with expected background of 0.64±0.17

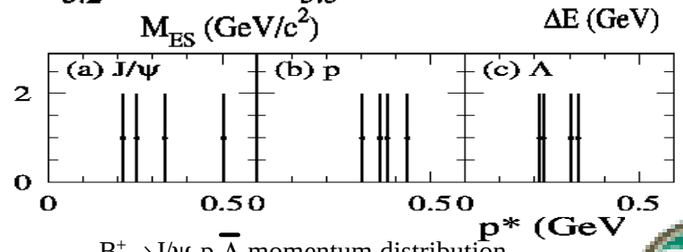
No peaks were found in p* distributions

$B^+ \to J/\psi\, p\, \bar{\Lambda}$ data used 81.9 *fb*$^{-1}$



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





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

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