B decays to charm and charmonium states in BaBar

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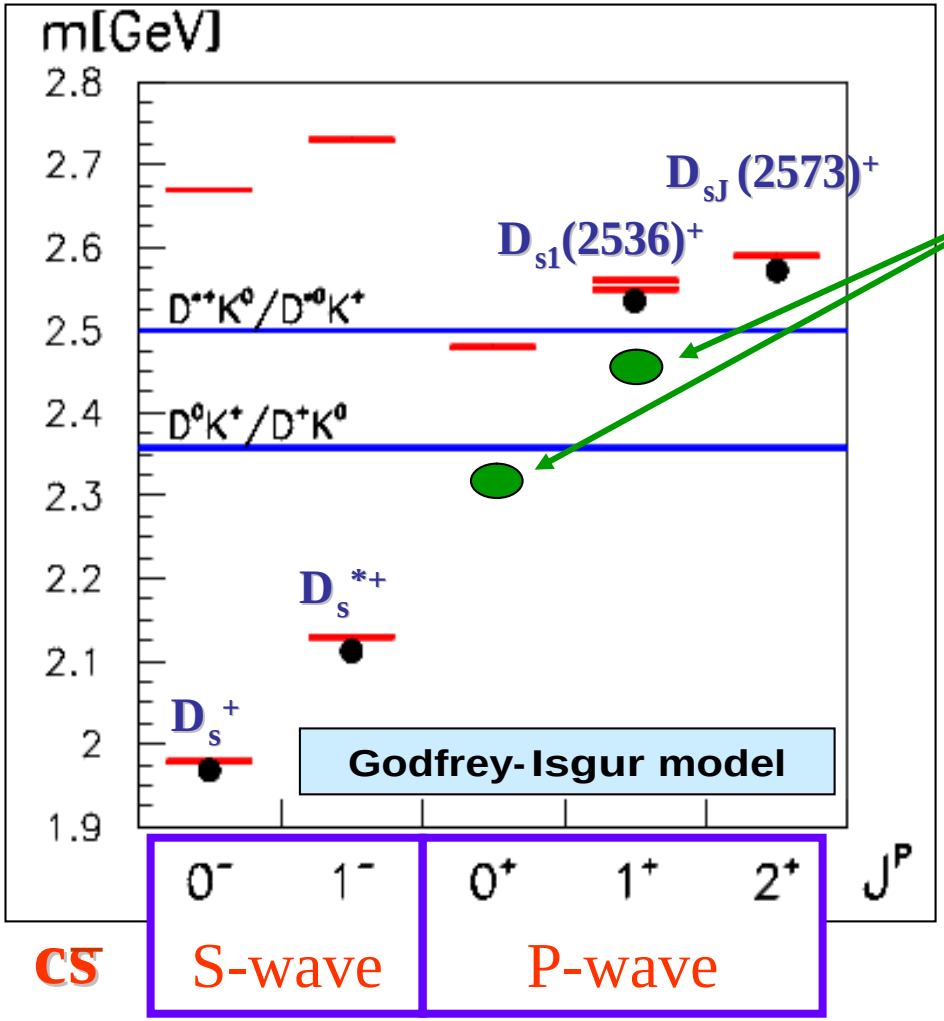
5th Rencontres du Vietnam

Outline

- Exclusive charm sector:
  - Study of $B \to D_{sJ}^{(*)} D^{(*)}$
  - Search for $B^0 \to D_s^+ \rho^-$ New result
- Exclusive charmonium sector:
  - Study of $B^- \to J/\psi K^- \pi^+ \pi^-$
  - Search for the decay $B^0 \to J/\psi \gamma$ New result

Study of $B \to D_{sJ}^{(*)} D^{(*)}$: $c\bar{s}$ spectroscopy



$D_{sJ}^*(2317)^+$, $D_{sJ}(2460)^+$

- Observation by BaBar, CLEO and Belle
- below the threshold for the $D^{(*)}K$ decay process
- **isospin violating** decay process $D_s^{(*)}\pi^0$
- and $D_{sJ}(2460)^+ \to D_s^+\gamma$
  - narrow states

$B \to D_{sJ}^{(*)} D^{(*)}$ results

Sum over $D^{(*)(0)}$ modes

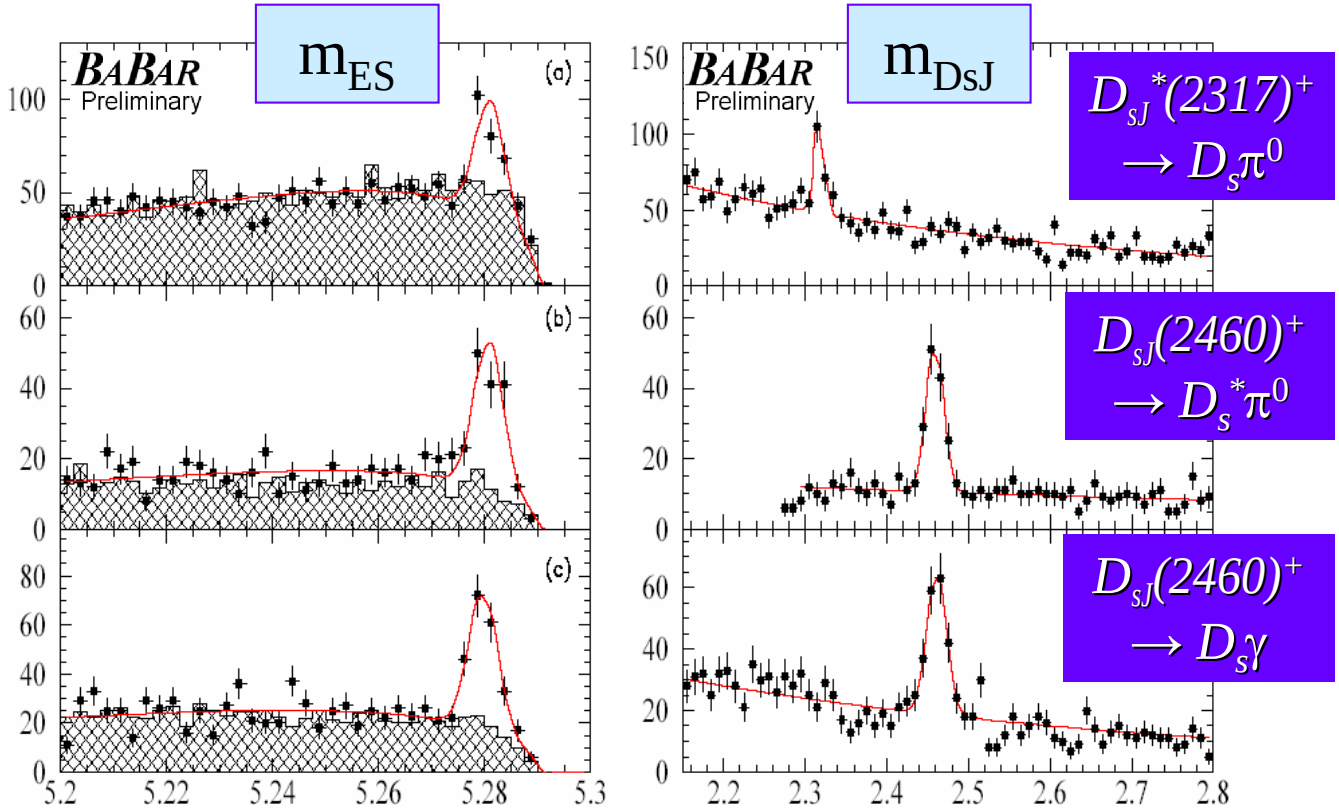
$$m_{ES} = \sqrt{s/4 - p_B^{*2}}$$

$$\Delta E = E_B^* - E_{beam}^*$$

$\sqrt{s}$ Y(4S) energy

p_B^{*2}, E_B^* B momentum and energy in the center-of-mass

Crosshatched histograms are from sidebands



Yields
113 fb^{-1}

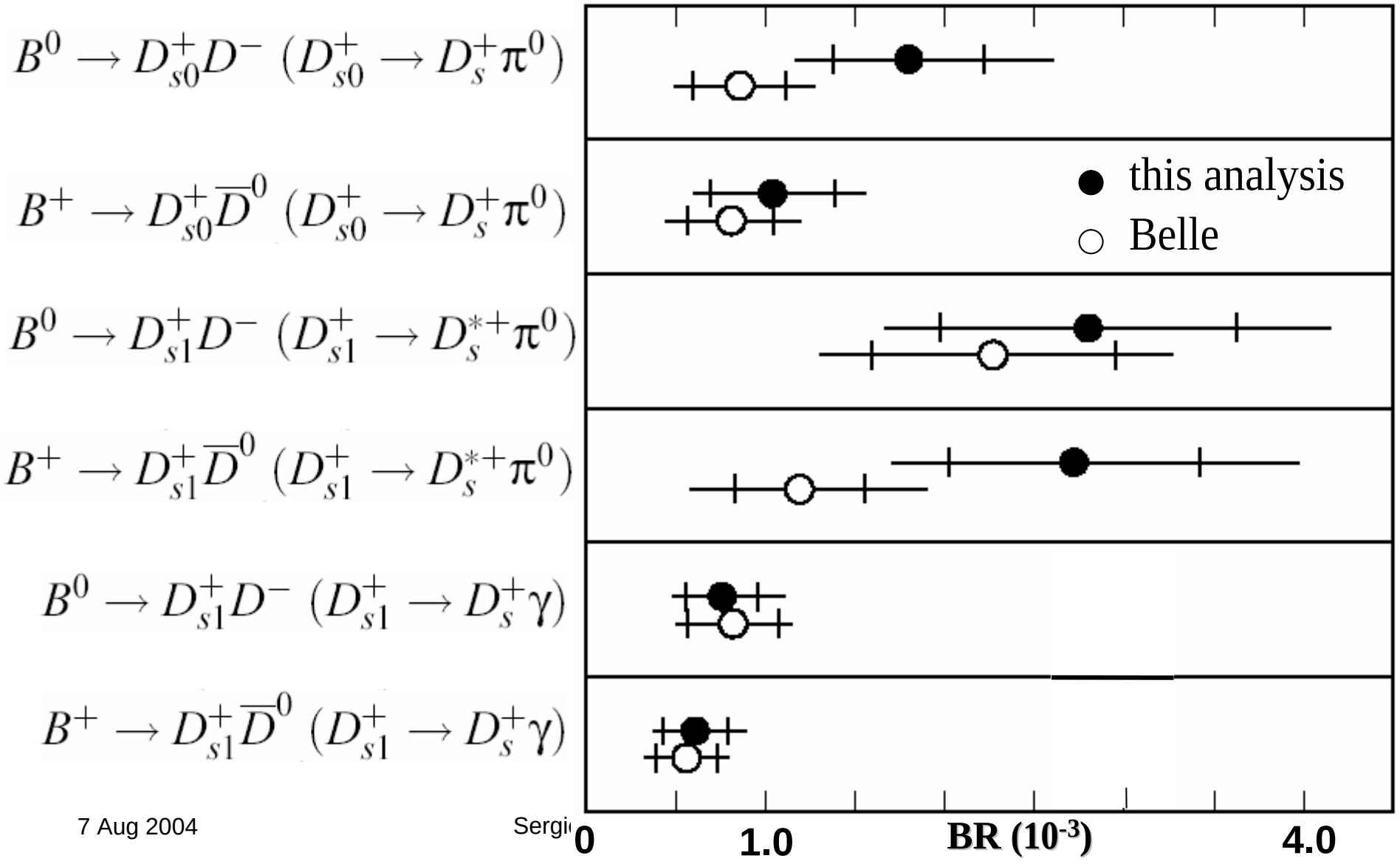
$D_{sJ}^*(2317)^+ \to D_s\pi^0$	88±17
$D_{sJ}(2460)^+ \to D_s^*\pi^0$	112±14
$D_{sJ}(2460)^+ \to D_s\gamma$	139±17

Branching Ratios

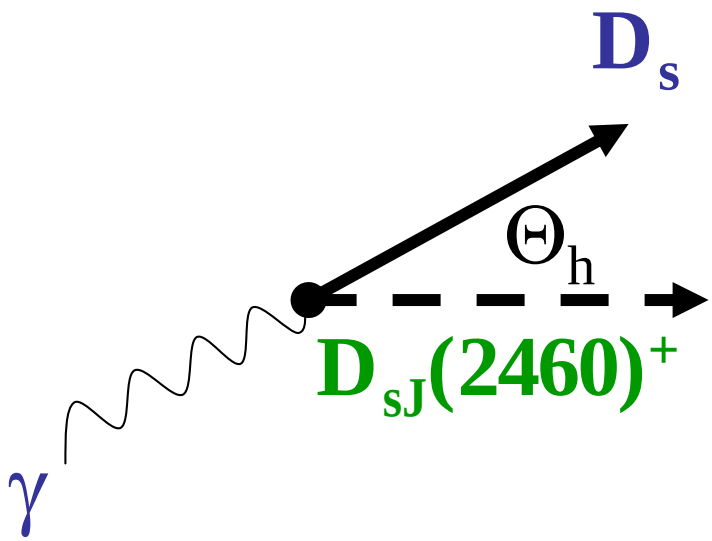
B mode	$m(D_{sJ}^+)$ yield	$\mathcal{B}(10^{-3})$	Significance
$B^0 \to D_{sJ}^{*+}(2317)D^-\ [D_s^+\pi^0]$	34.7 ± 8.0	$1.8 \pm 0.4 \pm 0.3^{+0.6}_{-0.4}$	5.5
$B^0 \to D_{sJ}^{*+}(2317)D^{*-}\ [D_s^+\pi^0]$	23.5 ± 6.1	$1.5 \pm 0.4 \pm 0.2^{+0.5}_{-0.3}$	5.2
$B^+ \to D_{sJ}^{*+}(2317)\overline{D}^0\ [D_s^+\pi^0]$	32.7 ± 10.8	$1.0 \pm 0.3 \pm 0.1^{+0.4}_{-0.2}$	3.1
$B^+ \to D_{sJ}^{*+}(2317)\overline{D}^{*0}\ [D_s^+\pi^0]$	17.6 ± 6.8	$0.9 \pm 0.6 \pm 0.2^{+0.3}_{-0.2}$	2.5
$B^0 \to D_{sJ}^{+}(2460)D^-\ [D_s^{*+}\pi^0]$	17.4 ± 5.1	$2.8 \pm 0.8 \pm 0.5^{+1.0}_{-0.6}$	4.2
$B^0 \to D_{sJ}^{+}(2460)D^{*-}\ [D_s^{*+}\pi^0]$	26.5 ± 5.7	$5.5 \pm 1.2 \pm 1.0^{+1.9}_{-1.2}$	7.4
$B^+ \to D_{sJ}^{+}(2460)\overline{D}^0\ [D_s^{*+}\pi^0]$	29.0 ± 6.8	$2.7 \pm 0.7 \pm 0.5^{+0.9}_{-0.6}$	5.1
$B^+ \to D_{sJ}^{+}(2460)\overline{D}^{*0}\ [D_s^{*+}\pi^0]$	30.5 ± 6.4	$7.6 \pm 1.7 \pm 1.8^{+2.6}_{-1.6}$	7.7
$B^0 \to D_{sJ}^{+}(2460)D^-\ [D_s^+\gamma]$	24.8 ± 6.5	$0.8 \pm 0.2 \pm 0.1^{+0.3}_{-0.2}$	5.0
$B^0 \to D_{sJ}^{+}(2460)D^{*-}\ [D_s^+\gamma]$	53.0 ± 7.8	$2.3 \pm 0.3 \pm 0.3^{+0.8}_{-0.5}$	11.7
$B^+ \to D_{sJ}^{+}(2460)\overline{D}^0\ [D_s^+\gamma]$	31.9 ± 9.0	$0.6 \pm 0.2 \pm 0.1^{+0.2}_{-0.1}$	4.3
$B^+ \to D_{sJ}^{+}(2460)\overline{D}^{*0}\ [D_s^+\gamma]$	34.6 ± 7.6	$1.4 \pm 0.4 \pm 0.3^{+0.5}_{-0.3}$	6.0

First measurement by BaBar

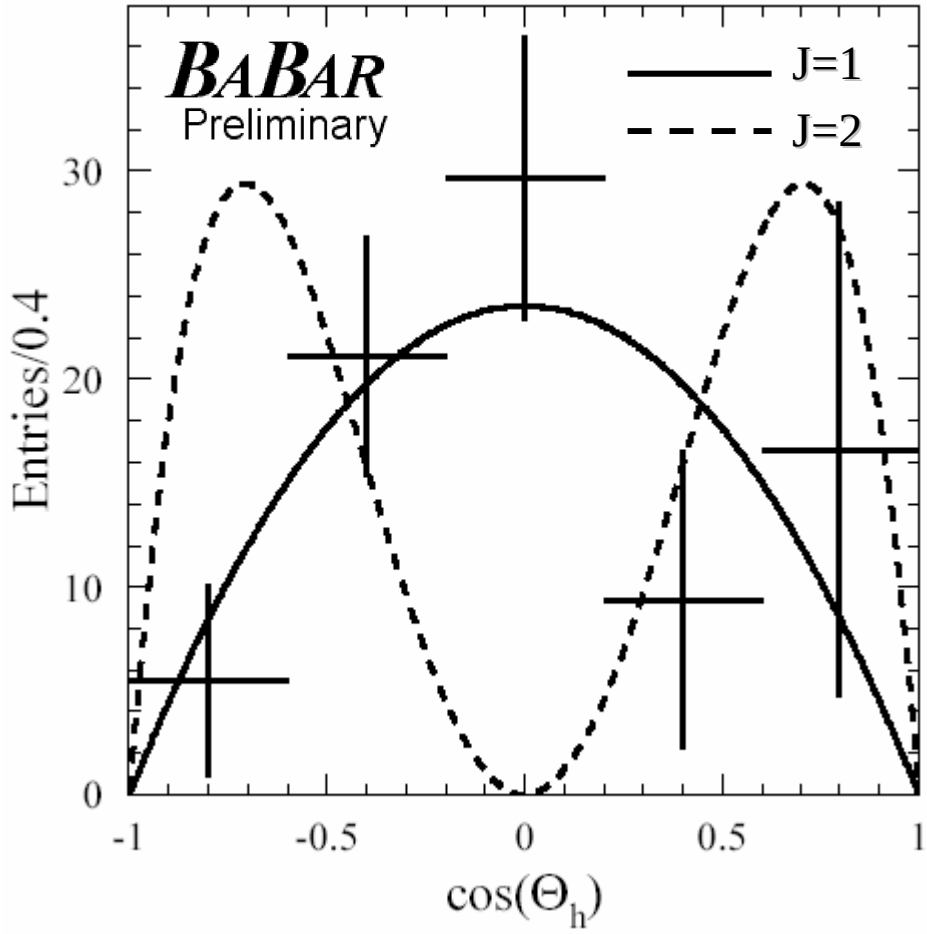
Comparison with Belle



Helicity angle of $D_{sJ}(2460)^+$



J=1 (χ^2=4.0/ 4) is preferred wrt to the J=2 (χ^2=36.4/ 4) hypothesis

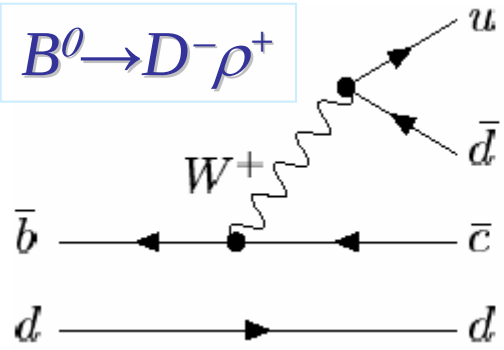


Search for $B^0 \to D_s^+ \rho^-$

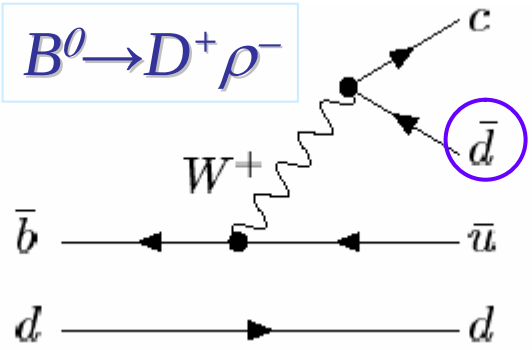
- Rare Decay: no significant signal observed yet
- Useful to measure sin(2β+γ) in $B^0 \to D^{\pm}\rho^{\mp}$, assuming SU(3) flavor symmetry, relating it to the $BR(B^0 \to D^+\rho^-)$

$$r(D\rho) = \frac{|A(B^0 \to D^+\rho^-)|}{|A(B^0 \to D^-\rho^+)|} \simeq (\tan\theta_c)\frac{f_D}{f_{D_s}}\sqrt{\frac{BR(B^0 \to D_s^+\rho^-)}{BR(B^0 \to D^-\rho^+)}}$$

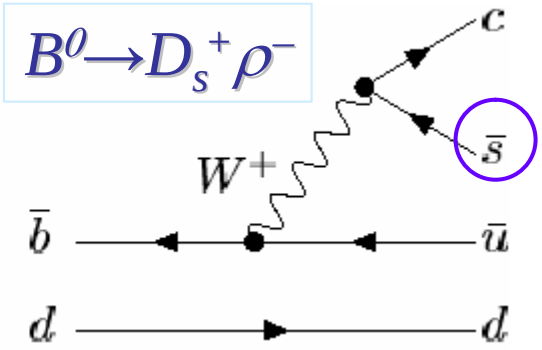
$B^0 \to D^-\rho^+$



$B^0 \to D^+\rho^-$

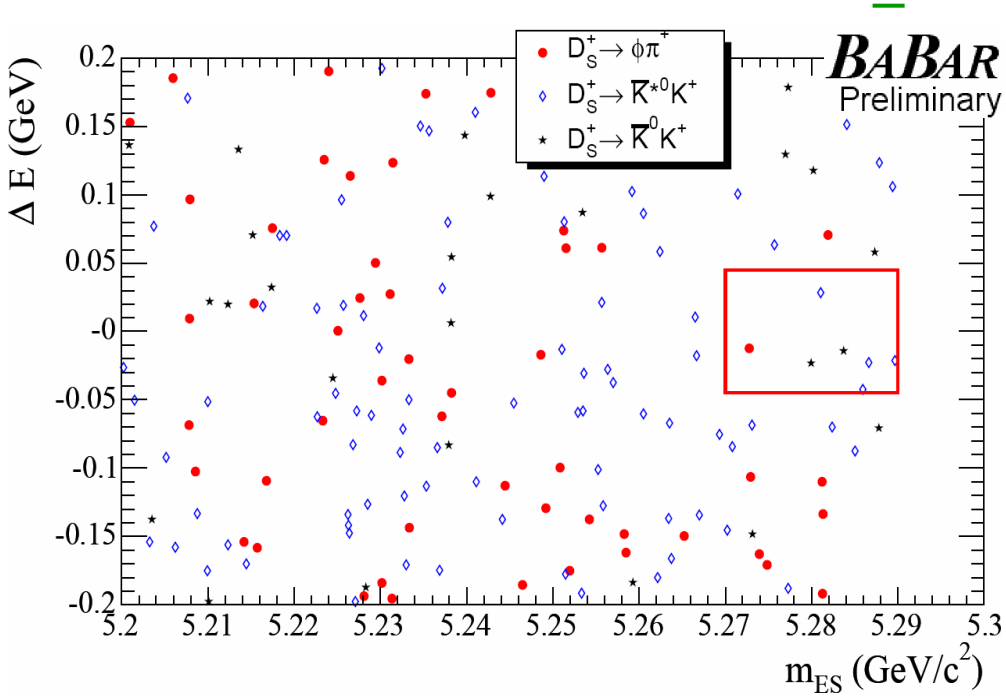


$B^0 \to D_s^+\rho^-$



$B^0 \to D_s^+ \rho^-$ results

Decay mode	ε	n_{obs}	n_{bkg}
$D_s^+ \to \phi\pi^+$, $\phi \to K^+K^-$	3.4%	1	2.2
$D_s^+ \to K^{*0}K^+$, $K^{*0} \to K^+\pi^-$	1.4%	4	3.1
$D_s^+ \to K^0K^+$, $K_s \to \pi^+\pi^-$	2.1%	2	1.1



Data sample
90 x 10^6 BB

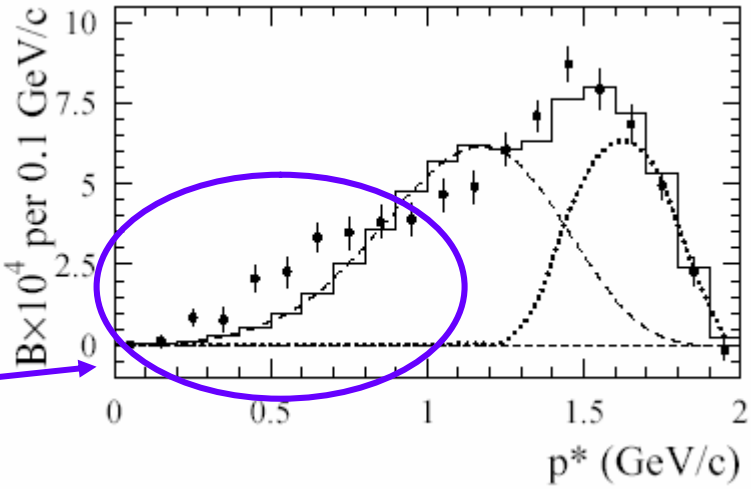
Observed signal compatible with expected background mainly from $D_s^{*+}\rho^-$, $D_s^{*+}\pi^-$, $D_s^+\rho^0$

$BR(B^0 \to D_s^+ \rho^-) < 2.5 \cdot 10^{-5}$ (90% C.L.)

$r(D\rho) < 0.01$ (90% C.L.)

Study of $B^- \to J/\psi K^- \pi^+ \pi^-$ decay

- Analysis relevant to search new charmonium states
  - Confirm Belle and CDF observation of a resonance at the mass of 3872 MeV decaying into $J/\psi\pi^+\pi^-$
  - Study the properties of this state X(3872) looking at the di-pion mass spectrum
  - Search for $h_c(3526)$ $1P_1\ c\bar{c}$?
- Investigate intrinsic charm production:
  - J/ψ low p^* anomaly observed in inclusive decays



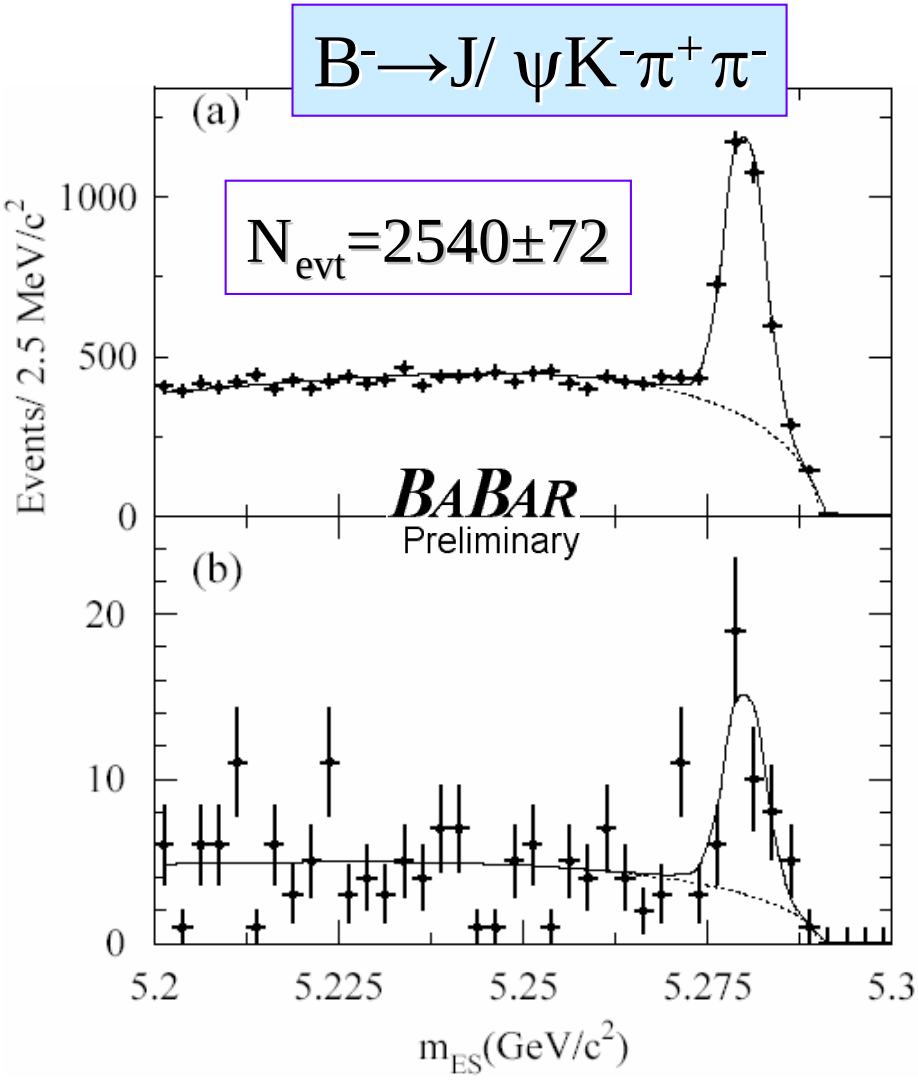
Phys.Rev.D67:032002,2003

$B^- \to J/\psi K^- \pi^+ \pi^-$ branching ratio

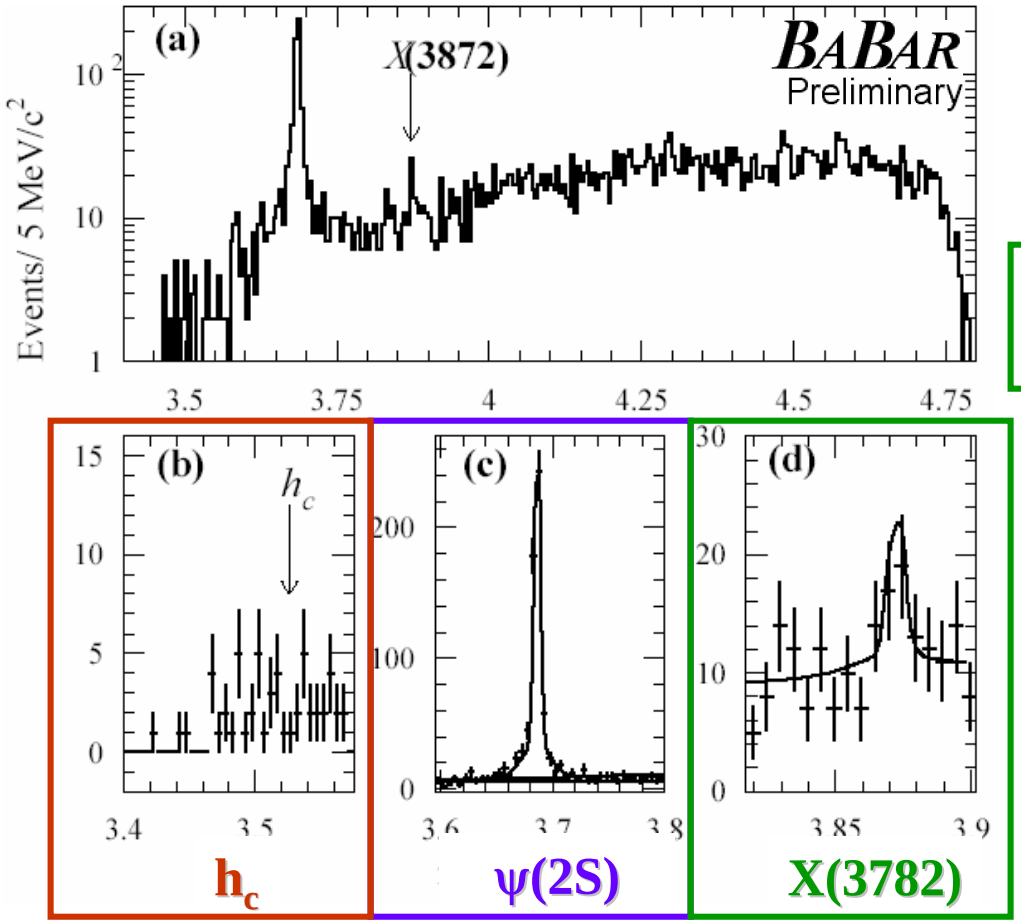
Analysis performed on 117 x 10^6 $B\bar{B}$

BR($B^- \to J/\psi K^- \pi^+ \pi^-$)= $(116 \pm 7 \pm 9) \cdot 10^{-5}$

If we look into the X(3872) mass window:
$3862 < m(J/\psi \pi^+ \pi^-) < 3882$MeV



$J/\psi\pi^+\pi^-$ mass spectrum



$N_{\psi(2S)} = 556 \pm 30$

$m_{X(3782)} = 3873.4 \pm 1.4$ MeV/ c^2

No evidence of h_c found
Set an upper limit

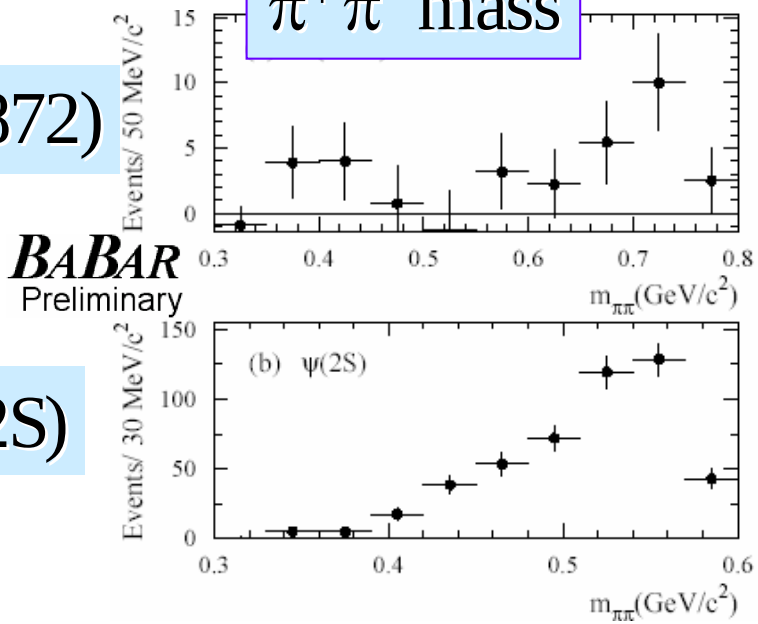
$BR(B^- \to h_c K^-) \cdot BR(h_c \to J/\psi\pi^+\pi) < 3.4 \cdot 10^{-6}$ (90% C.L.)

$BR(B^- \to X(3872)K^-) \cdot BR(X(3872) \to J/\psi\pi^+\pi^-) = (1.28 \pm 0.41) \cdot 10^{-5}$

Same behavior with events concentrated near the kinematic limit. Statistic too small to allow a clear conclusion on the presence of the strongly suppressed isospin violating decay $X(3872) \rightarrow J/\psi\rho$

X(3872)

$\pi^+\pi^-$ mass



ψ(2S)

Intrinsic charm production would need (**PRD64,071501**)

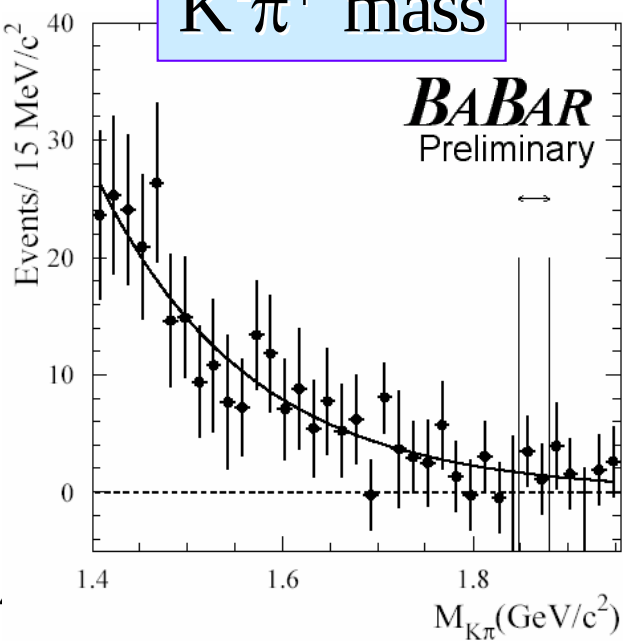
$BR(B^- \rightarrow J/\psi D^0\pi^-) \sim 10^{-4}$

Set the upper limit:

$\mathbf{BR(B^- \rightarrow J/\psi D^0\pi^-) < 5.2 \cdot 10^{-5}}$

(90% C.L.)

$K^-\pi^+$ mass



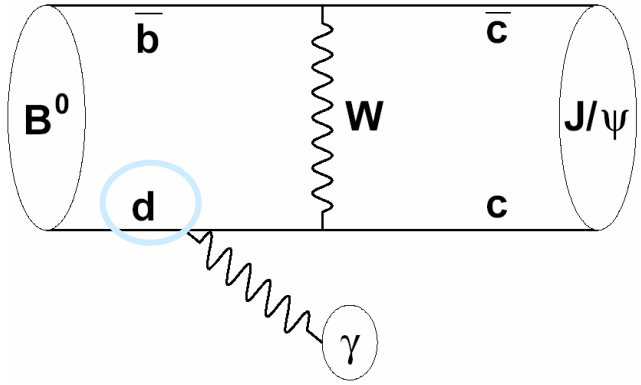
Search for the decay $B^0 \rightarrow J/\psi\gamma$

- Very rare decay! Expected:

  $BR(B^- \rightarrow J/\psi\gamma) \sim 10^{-9}$

  Lu, Wang, Yang
  Eur.Phys.J.C34:291-296,2004

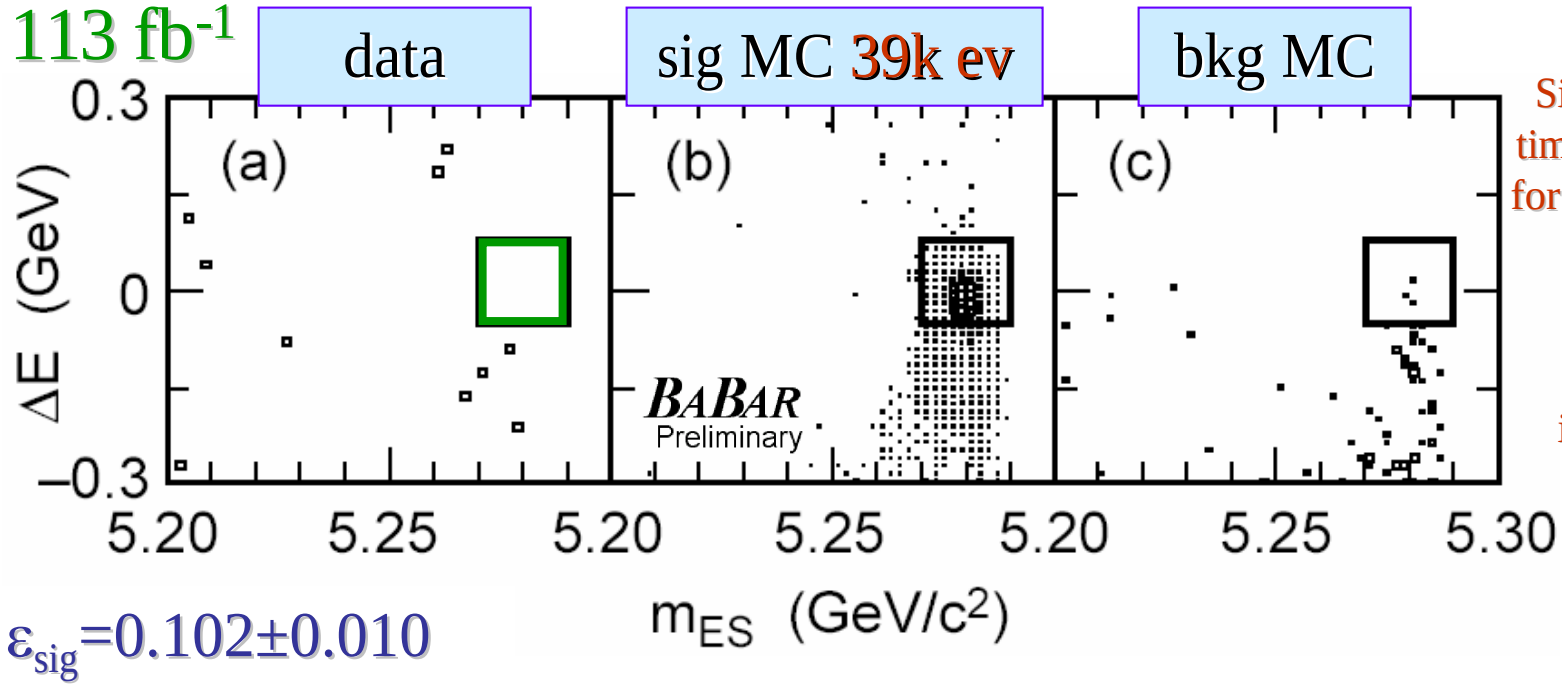
- Probe for new effects beyond the SM
- Leading order contribution from the diagram:
- No prior search for this decay mode



$B^0 \to J/\psi\gamma$ results

Data sample

113 fb^{-1}



Simulated many times data statistic for bkg estimation.

generic BB

~700 fb^{-1}

inclusive J/ψ

~400 fb^{-1}

ε_{sig}=0.102±0.010

Observed 0 events when 0.71 are expected from background (mainly $B^0 \to J/\psi\pi^0$ and $B^0 \to J/\psi K^0_L$)

$BR(B^0 \to J/\psi\gamma) < 1.6 \cdot 10^{-6}$ (90% C.L.)

Conclusions

- New results from BaBar in the exclusive B charm and charmonium sector
- Branching fractions for $B \to D_{sJ}^{(*)} D$ and $B \to D_{sJ}^{(*)} D^*$ (first measurement), and helicity angle study for $D_{sJ}(2460)^+$
- Observation and study of $X(3872) \to J/\psi \pi^+ \pi^-$
- Upper limit set on observation of the $h_c(3526)$ and of the decay $B \to J/\psi D^0 \pi$
- Upper limit set on the channel $B^0 \to J/\psi \gamma$ and $B^0 \to D_s^+ \rho^-$