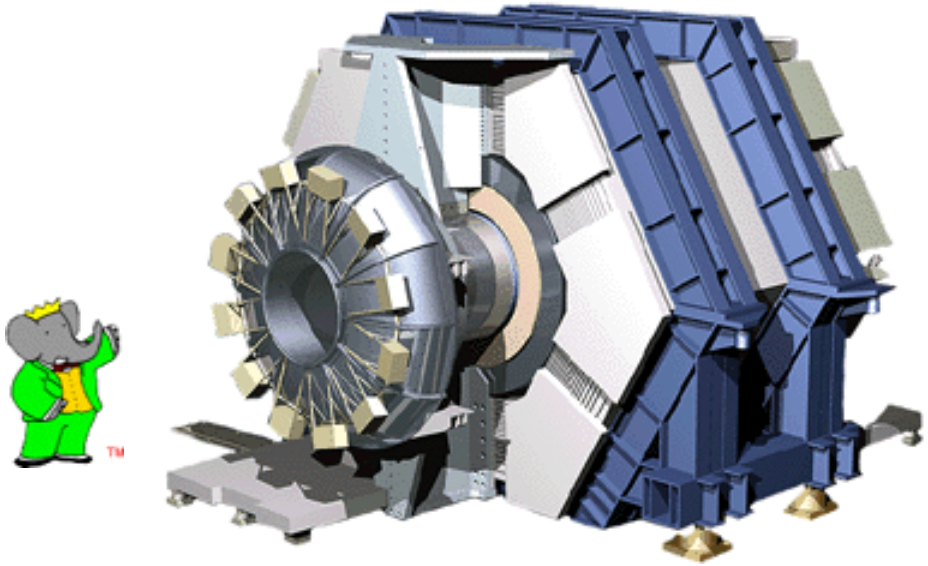
Study of B decays to open charm final states with the BaBar experiment



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Outline: BaBar physics with open charm B decays

QCD tests and precision measurements

$B \rightarrow D^* \omega \pi$

$B \rightarrow D \pi,\ D^* \pi$

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

Rare decays (annihilations, exchanges), searching for NP

$B \rightarrow D_s^{(*)} \phi$

$B \rightarrow D_s^{(*)-} D_s^{(*)+}$

γ related measurements

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

First observation of "lower vertex production"

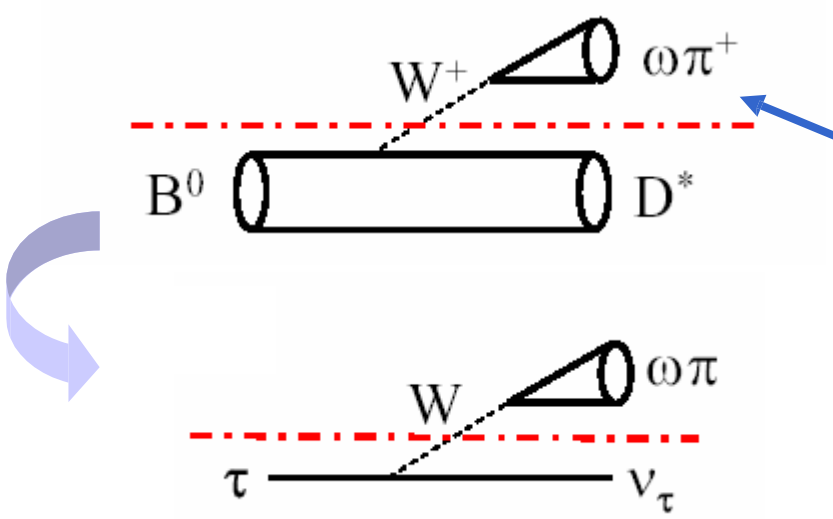
$B^- \rightarrow D_s^{(*)+} K^- \pi^-$

Baryon physics

$B^- \rightarrow \Lambda_c \bar{p} \pi^-,\ \bar{B}^0 \rightarrow \Lambda_c \bar{p}$

$B \rightarrow D^* \omega \pi$

- Measurement of the Branching Fraction
- Excellent laboratory to test factorization



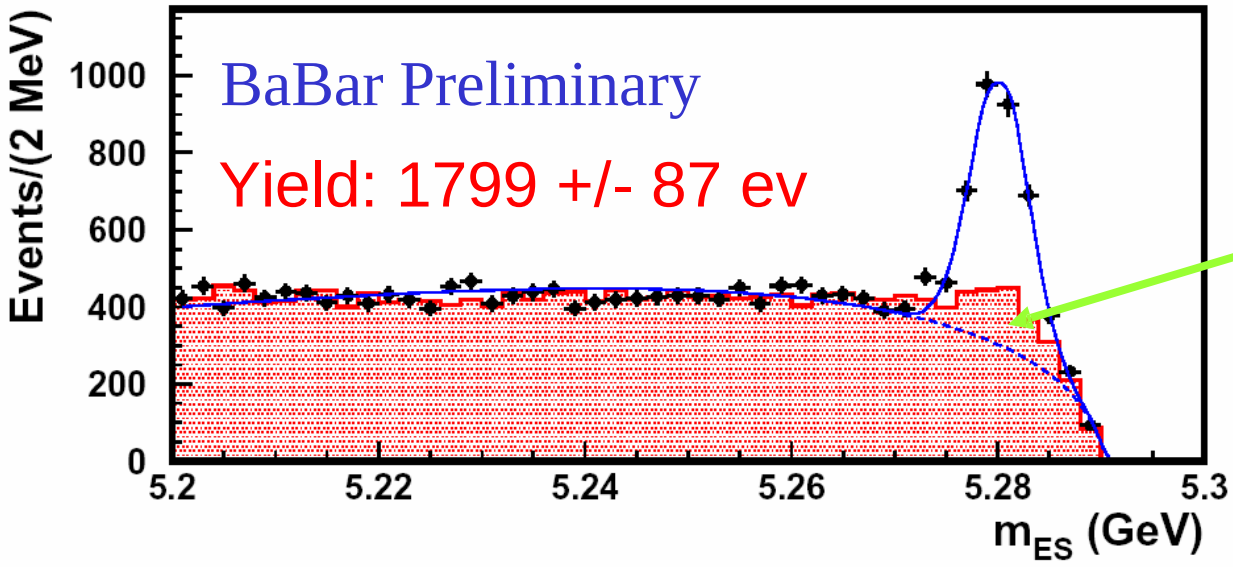
B->D*(ωπ) favored
over B->(D*ω)π

Comparison with τ decay

(Ligeti, Luke, Wise, Phys. Lett. B 507, 142, 2001)

Analysis based on 232M $B\bar{B}$

hep-ex/0604009



$D^*\pi\pi\pi\pi^0$ non-resonant contamination

$D^0 \longrightarrow K\pi, K3\pi, K\pi\pi^0$ $\quad\quad$ $\omega \longrightarrow \pi\pi\pi^0$

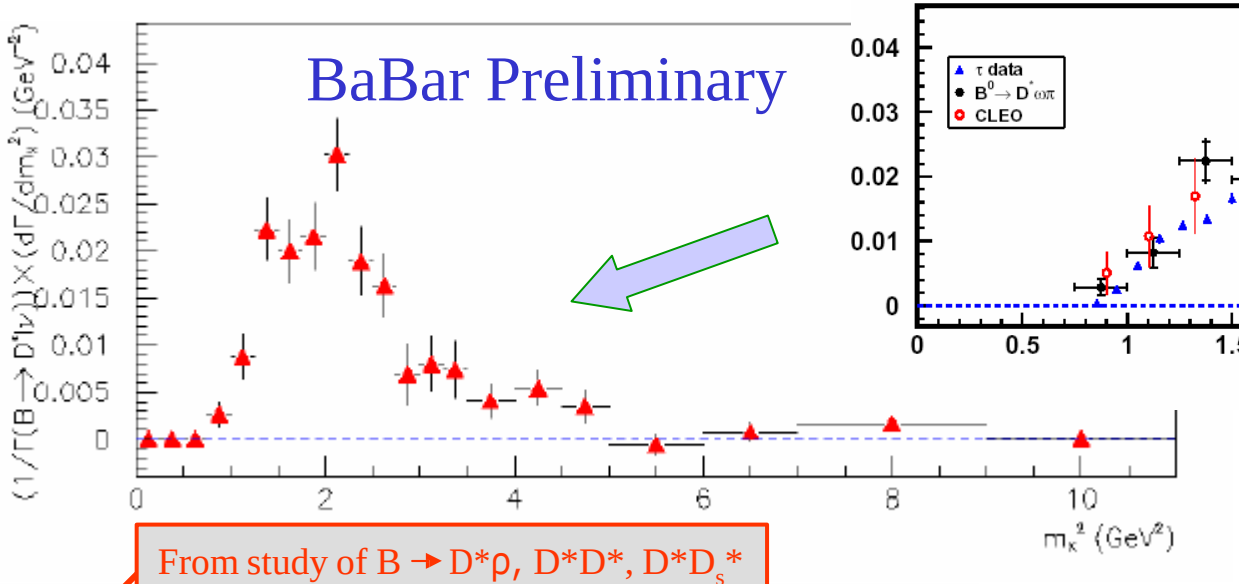
$$BR(\bar{B}^0 \longrightarrow D^{*+}\omega\pi^-) = [2.88 \pm 0.21(stat.) \pm 0.31(syst.)] \times 10^{-3}$$

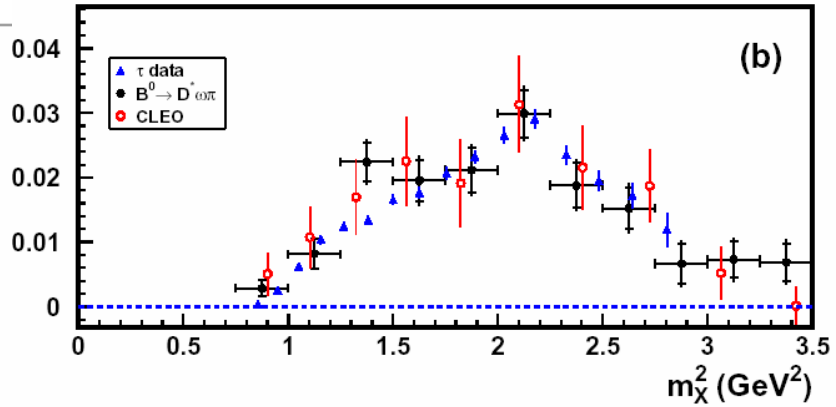
to be compared with CLEO [1] :

$[2.9 \pm 0.3(stat.) \pm 0.4(syst.)] \times 10^{-3}$

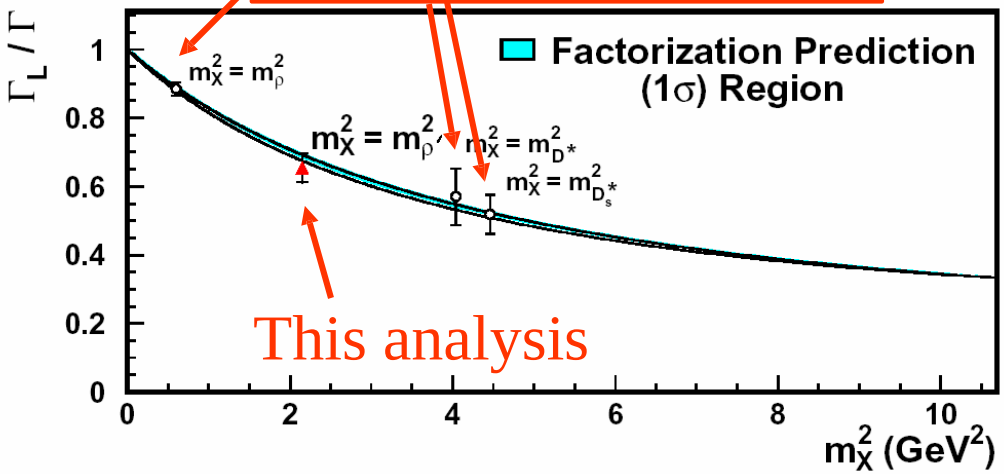
[1] Phys. Rev. D64, 092001 (2001)

Study of $m^2(\omega\pi)$ distributions





From study of $B \to D^*\rho$, D^*D^*, $D^*D_s^*$

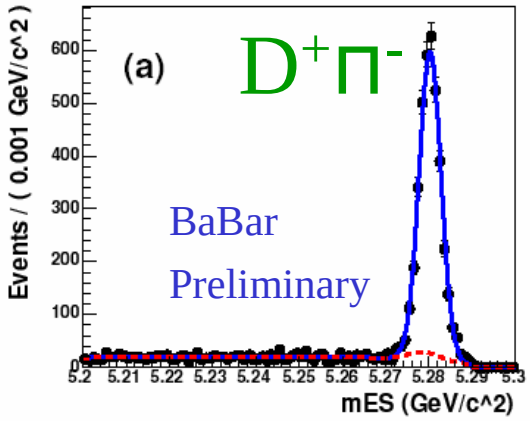


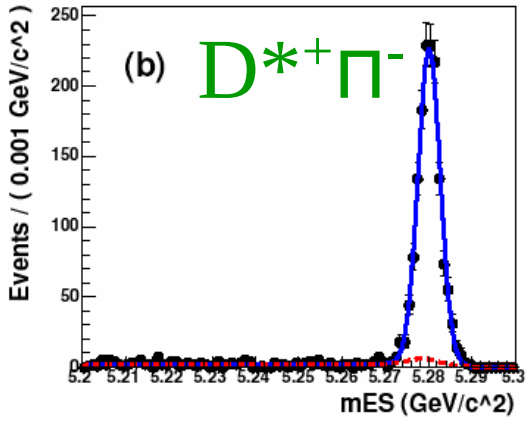
Very good agreement with factorization prediction

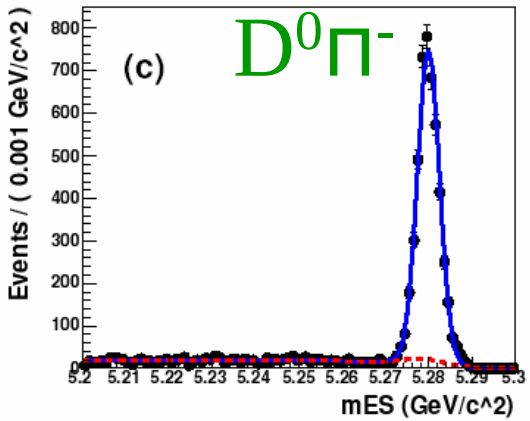
$B \to D \pi, D^* \pi$

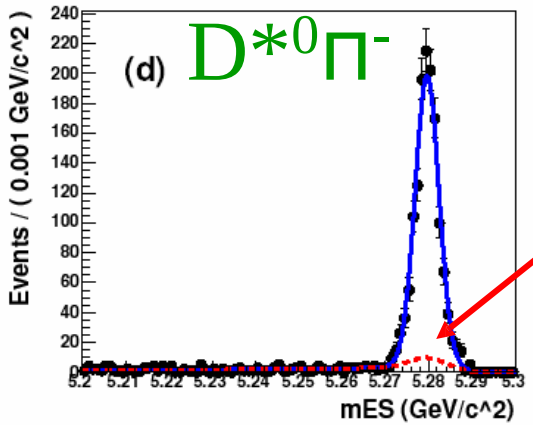
Analysis based on 65M $B\bar{B}$

BABAR-PUB06/046









Branching fractions

mode	$\mathcal{B}$ $(\times 10^{-3})$
$\overline{B}^0 \to D^+\pi^-$	$2.63 \pm 0.05 \pm 0.22$
$\overline{B}^0 \to D^{*+}\pi^-$	$2.79 \pm 0.08 \pm 0.18$
$B^- \to D^0\pi^-$	$4.90 \pm 0.08 \pm 0.23$
$B^- \to D^{*0}\pi^-$	$5.52 \pm 0.17 \pm 0.43$

Peaking background subtracted (~ 2-4% of the signal, depending on the mode)

Analysis of the difference in the I=1/2 and I=3/2 strong phases

$$\cos\delta = \frac{3\Gamma(D^-\pi^+) + \Gamma(D^0\pi^-) - 6\Gamma(D^0\pi^0)}{4|\mathcal{A}_{1/2}\mathcal{A}_{3/2}|},$$

$$|\mathcal{A}_{3/2}|^2 = \Gamma(D^0\pi^-),$$

$$|\mathcal{A}_{1/2}|^2 = \frac{3}{2}[\Gamma(D^-\pi^+) + \Gamma(D^0\pi^0)] - \frac{1}{2}\Gamma(D^0\pi^-).$$

Cosines of the difference δ in I=1/2, I=3/2 strong phases

$$\cos\delta = 0.860 \pm 0.007^{+0.029}_{-0.028}$$

(B→ Dπ)

$$\cos\delta = 0.917 \pm 0.018^{+0.059}_{-0.051}$$

(B→D*π)

A δ≠0 is an indication of interaction in the final state

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

Analysis based on 231M $B\bar{B}$

BABAR-PUB06/057

Analysis based on partial reconstruction

One B fully reconstructed

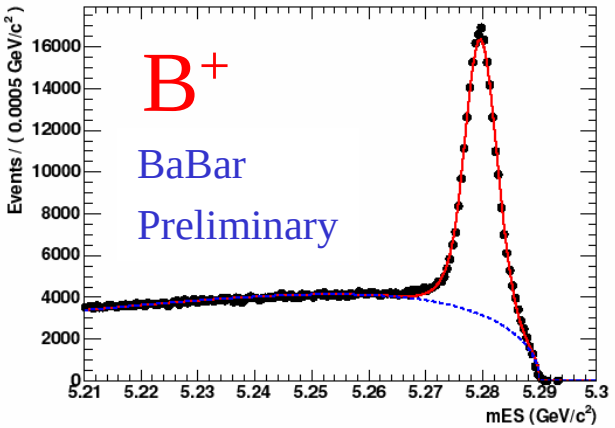
$B^+ \rightarrow D^{(*)0}\pi^+, D^{(*)0}\rho^+, D^{(*)0}a_1^+$

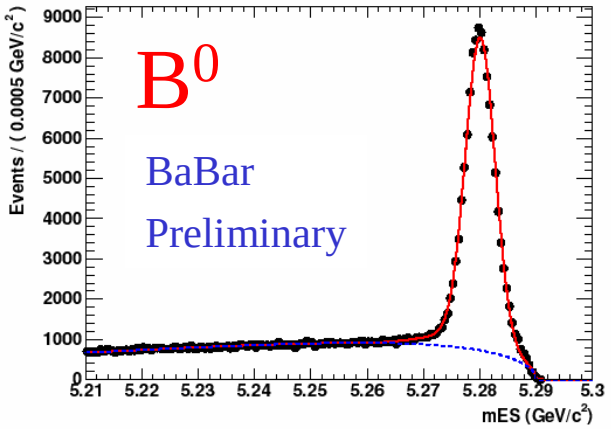
$B^0 \rightarrow D^{(*)-}\pi^+, D^{(*)-}\rho^+, D^{(*)-}a_1^+$

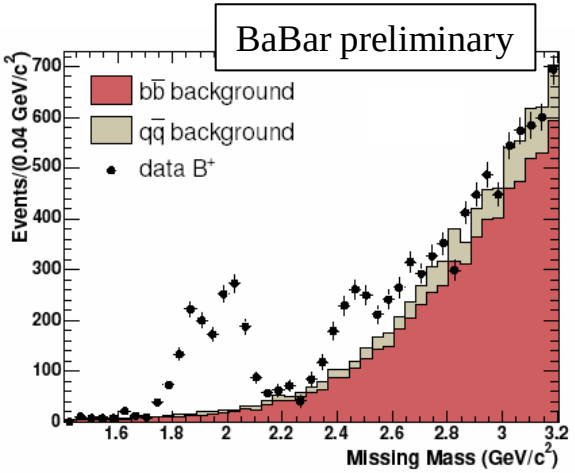
The recoiling $B \rightarrow X\pi$

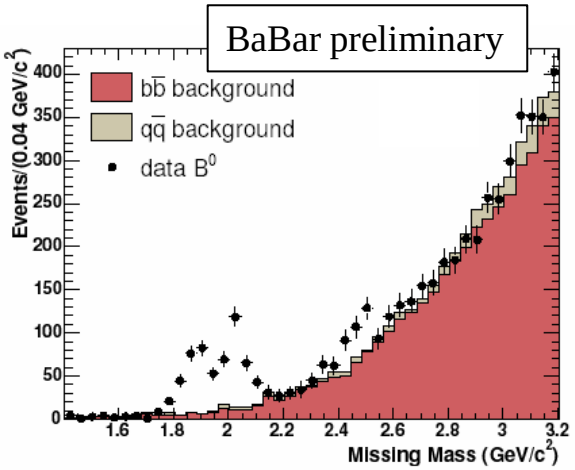
m_x reconstructed using energy-momentum conservation

Yield extracted from missing mass spectra

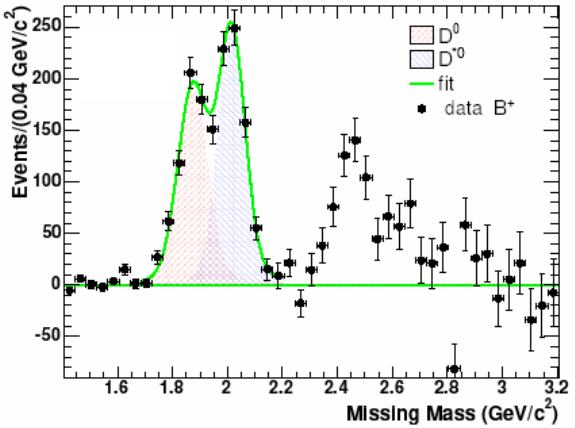


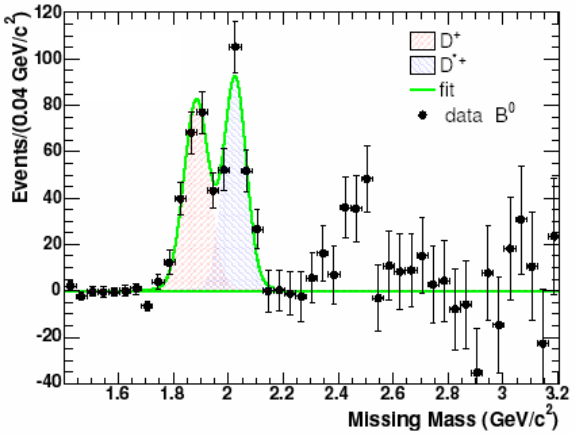






Missing mass spectra





Background subtracted

decay mode	Yield	$\mathcal{B}(10^{-3})$
$B^- \to D^0\pi^-$	677 ± 32	$4.49 \pm 0.21 \pm 0.23$
$B^- \to D^{*0}\pi^-$	774 ± 33	$5.13 \pm 0.22 \pm 0.28$
$B^- \to D^{**0}\pi^-$	829 ± 78	$5.50 \pm 0.52 \pm 1.04$
$\overline{B}^0 \to D^+\pi^-$	248 ± 19	$3.00 \pm 0.23 \pm 0.23$
$\overline{B}^0 \to D^{*+}\pi^-$	245 ± 19	$2.97 \pm 0.23 \pm 0.24$
$\overline{B}^0 \to D^{**+}\pi^-$	192 ± 54	$2.32 \pm 0.65 \pm 0.88$

Many systematics cancel out in the ratio

$$\mathcal{B}(B^- \to D^{*0}\pi^-)/\mathcal{B}(B^- \to D^0\pi^-) = 1.14 \pm 0.07 \pm 0.04,$$
$$\mathcal{B}(B^- \to D^{**0}\pi^-)/\mathcal{B}(B^- \to D^0\pi^-) = 1.22 \pm 0.13 \pm 0.23,$$
$$\mathcal{B}(\overline{B}^0 \to D^{*+}\pi^-)/\mathcal{B}(\overline{B}^0 \to D^+\pi^-) = 0.99 \pm 0.11 \pm 0.08,$$
$$\mathcal{B}(\overline{B}^0 \to D^{**+}\pi^-)/\mathcal{B}(\overline{B}^0 \to D^+\pi^-) = 0.77 \pm 0.22 \pm 0.29.$$

$B \rightarrow D_s^{(*)} \phi$

Analysis based on 234M $B\bar{B}$

hep-ex/0512028

Predictions for Branching Fractions in SM: O(10^{-6})

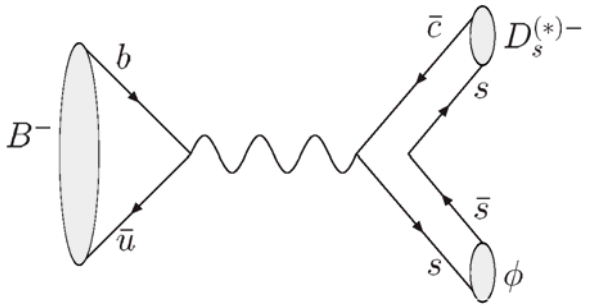
In some MSSM with R-parity violation: BR O(10-4)

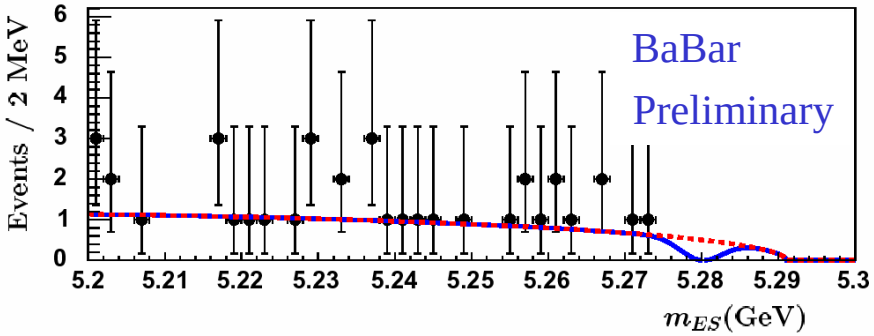
(Phys. Lett. B 540, 241, (2002))

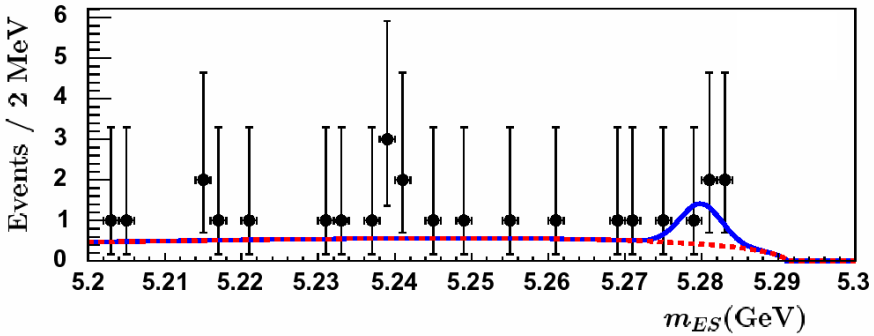
Sensitive to new physics

$$\mathcal{B}(B^- \rightarrow D_s^- \phi) < 1.9 \times 10^{-6}$$
$$\mathcal{B}(B^- \rightarrow D_s^{*-} \phi) < 1.2 \times 10^{-5}$$

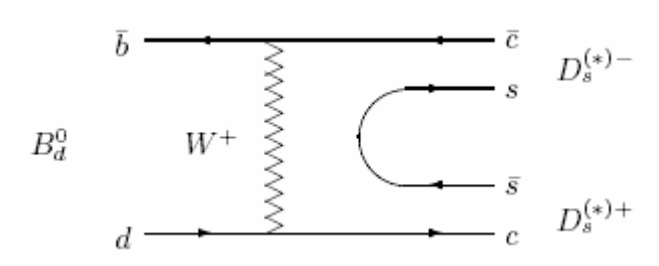
@ 90% CL







$B \rightarrow D_s^{(*)-} D_s^{(*)+}$



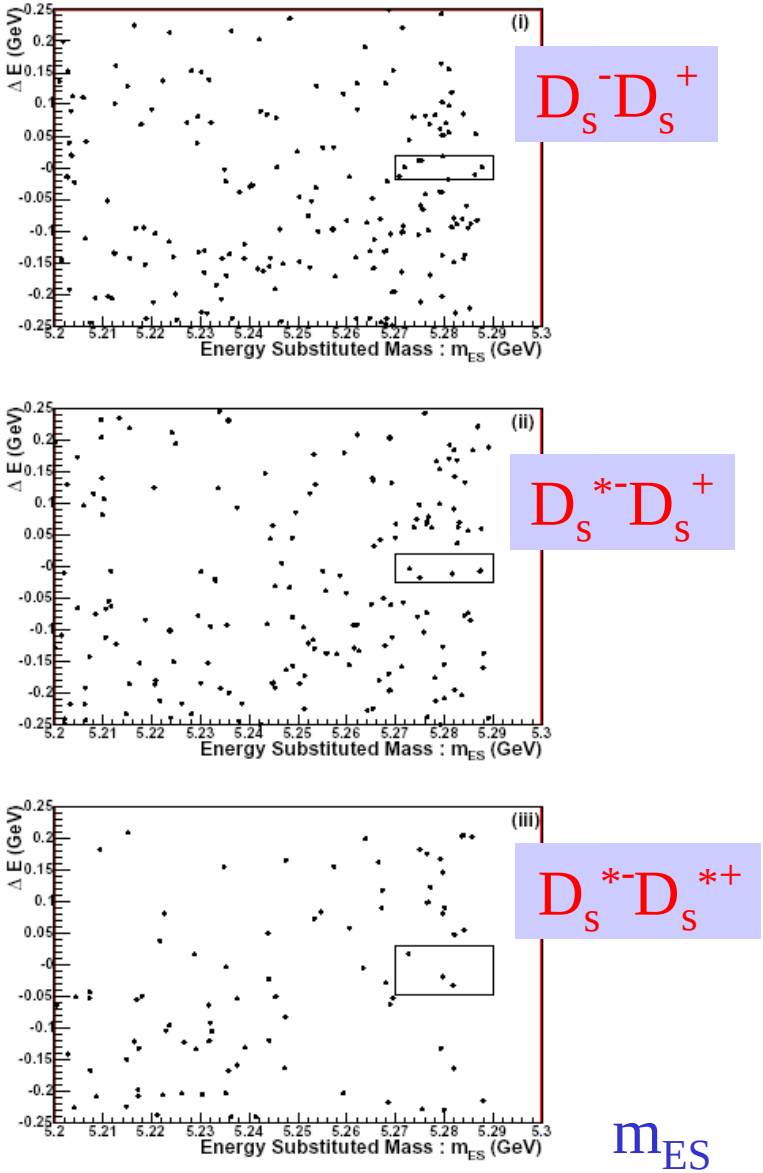
Predictions for Branching Fractions are very small O(10^{-4}) in Standard Model

only limits with the present data

$$\mathcal{B}(B^0 \rightarrow D_s^- D_s^+) < 1.0 \times 10^{-4},$$
$$\mathcal{B}(B^0 \rightarrow D_s^{*-} D_s^+) < 1.3 \times 10^{-4},$$
$$\mathcal{B}(B^0 \rightarrow D_s^{*-} D_s^{*+}) < 2.4 \times 10^{-4}.$$

@ 90% CL

hep-ex/0510051



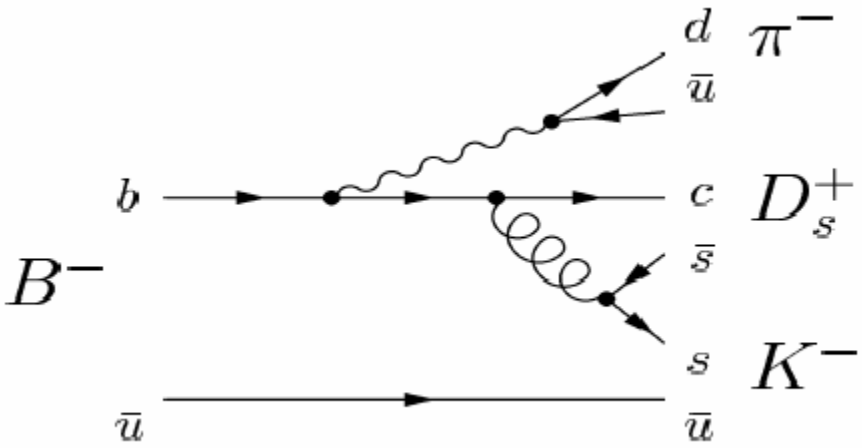
$B^- \rightarrow D_s^{(*)+} K^- \pi^-$

BABAR-CONF06/009

Example of D_s lower-vertex production *("correlated production")*

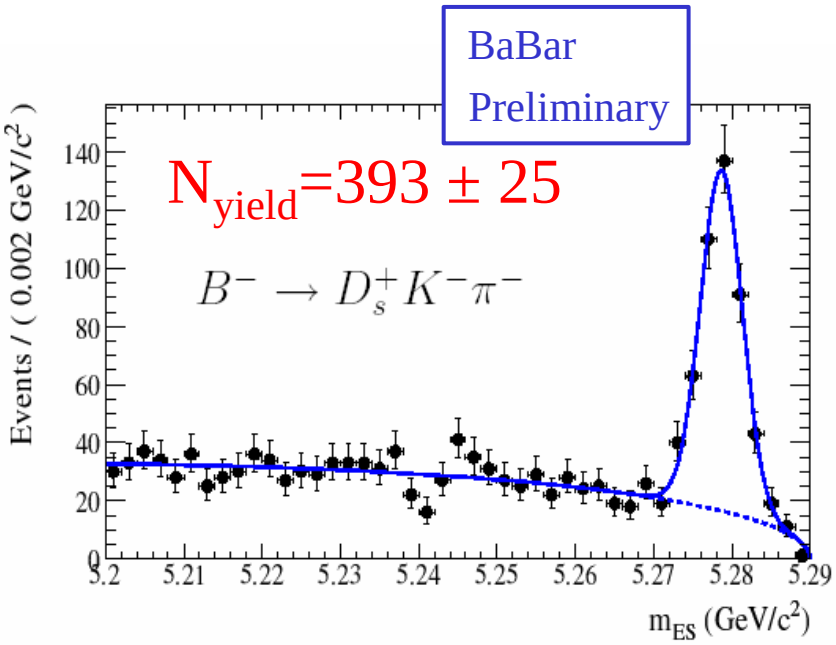
No exclusive decay of this kind had been observed yet

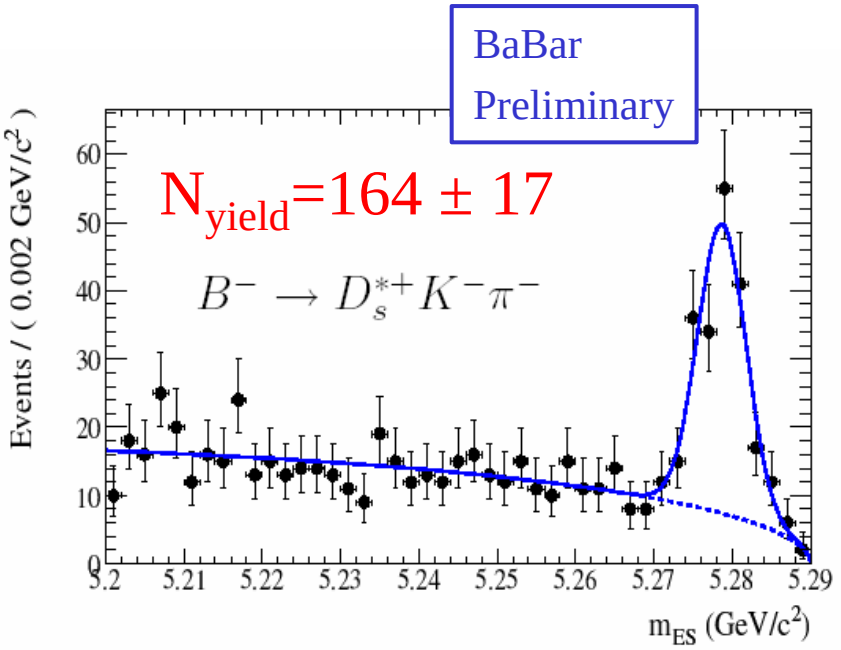
In this class of decays, the $\bar{B}^0 \rightarrow D_s^+ \bar{K}^0 K^-$ is very interesting for time-dependent CP asymmetry and Sin(2β+γ)



Existing limits by ARGUS and CLEO

Experiment	Decay Mode	Upper limit (@90% *C.L.*)
ARGUS	$B^- \rightarrow D_s^+ K^- \pi^-$	8×10^{-4}
	$B^- \rightarrow D_s^{*+} K^- \pi^-$	12×10^{-4}
CLEO	$B^- \rightarrow D_s^+ K^- \pi^-$	5×10^{-4}
	$B^- \rightarrow D_s^{*+} K^- \pi^-$	6.8×10^{-4}





In the D_s channel, peaking background components due to B^- charmless and charmonium decays with the same set of particles in the final state

Estimated and subtracted: N_{signal}=370 ± 26

Branching fractions extracted

$$\mathcal{B}(B^- \to D_s^+ K^- \pi^-) = (1.88 \pm 0.13 \pm 0.41) \cdot 10^{-4} \qquad (14.2\ \sigma)$$

$$\mathcal{B}(B^- \to D_s^{*+} K^- \pi^-) = (1.84 \pm 0.19 \pm 0.40) \cdot 10^{-4} \qquad (9.6\ \sigma)$$

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

Analysis based on 234M $B\bar{B}$

Update of a previous result with x2.7 more data

hep-ex/0604017

Decay mode relevant for γ analyses ($R_{CP\pm}$)

$$\mathcal{R}_{CP\pm} = 2\frac{\Gamma(B^- \to D^0_{CP\pm}K^{*-}) + \Gamma(B^+ \to D^0_{CP\pm}K^{*+})}{\Gamma(B^- \to D^0 K^{*-}) + \Gamma(B^+ \to \bar{D}^0 K^{*+})}$$

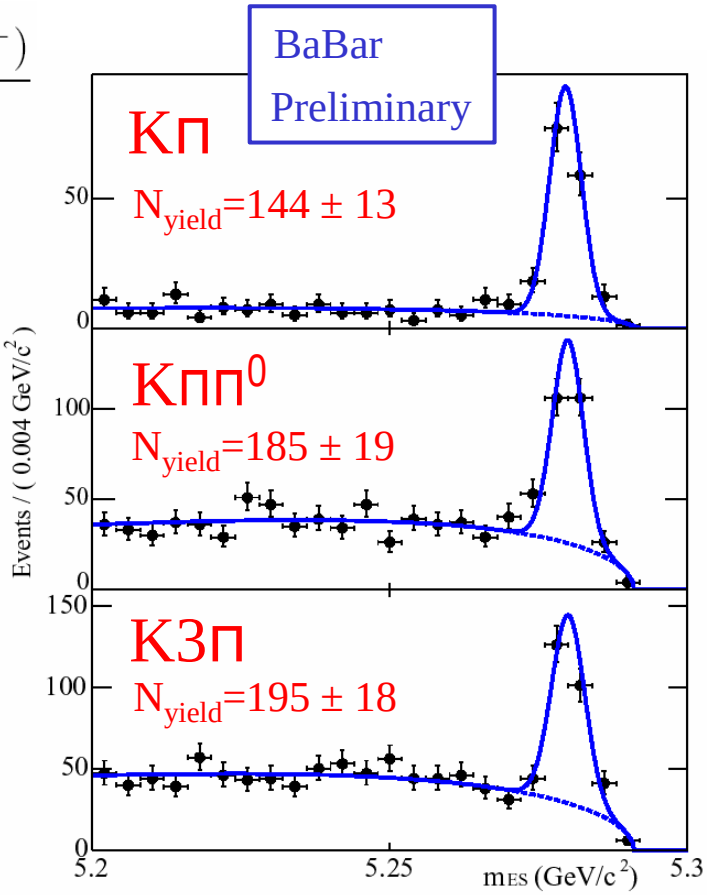
$$\mathcal{R}_{CP\pm} = 1 \pm 2 r_B cos\delta cos\gamma + r_B^2$$

D^0 reconstructed in Kπ, Kππ, $K\pi\pi^0$

K^{*-} in $K_s^0\pi^-$

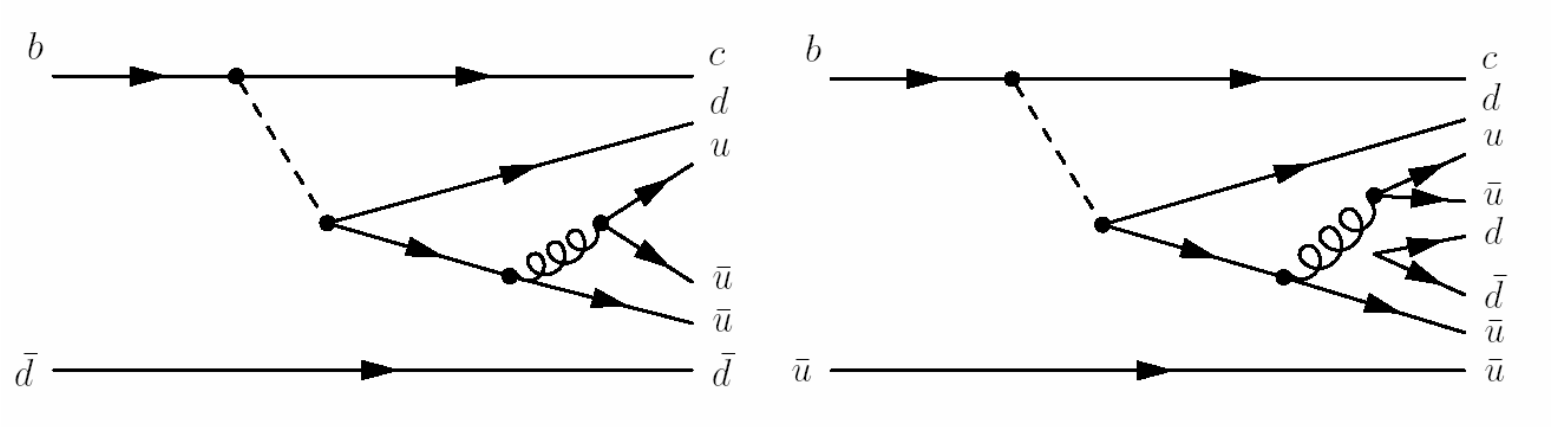
	$K^-\pi^+$	$K^-\pi^+\pi^0$	$K^-\pi^+\pi^-\pi^+$
Yield	144 ± 13	185 ± 19	195 ± 18
Efficiency	13.30%	4.60%	8.99%
$\mathcal{B}(B^- \to D^0 K^{*-})$	5.15±0.47	5.65±0.57	5.24±0.49

$BR(B^- \to D^0 K^{*-}) = (5.29 \pm 0.30 \pm 0.34) \times 10^{-4}$



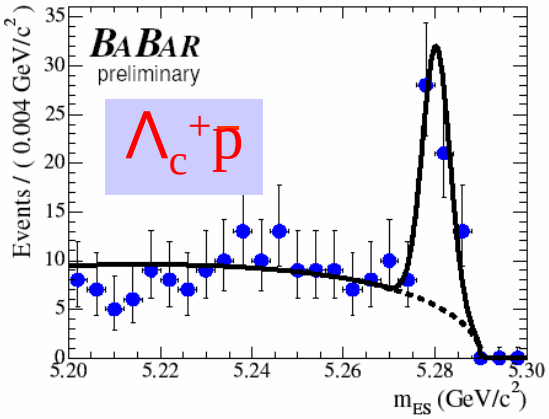
$B^- \to \Lambda_c \bar{p}\pi^-$, $\bar{B}^0 \to \Lambda_c \bar{p}$

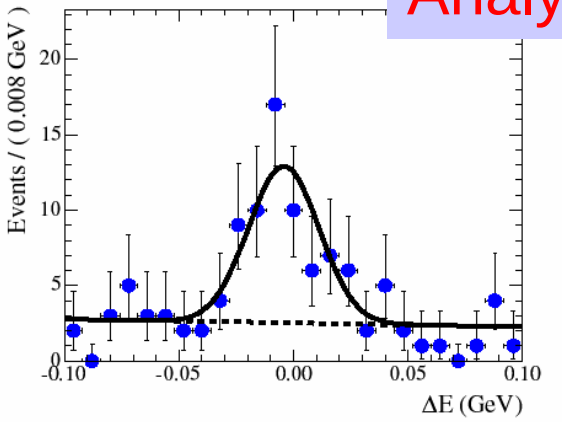
- Theoretical interest in the suppression of baryonic 2-body wrt 3-body decays
- In the 3-body decay, Belle found hint of baryon-antibaryon invariant mass peaking near threshold



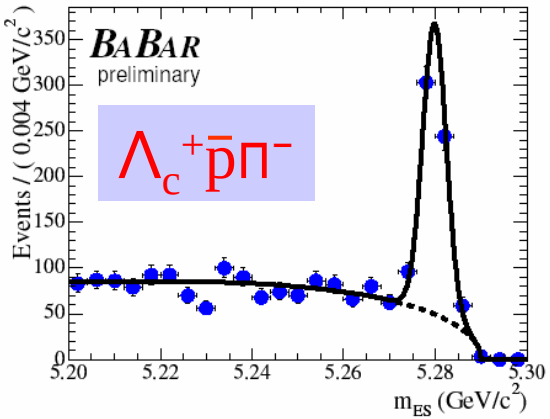
Analysis based on 232M $B\bar{B}$

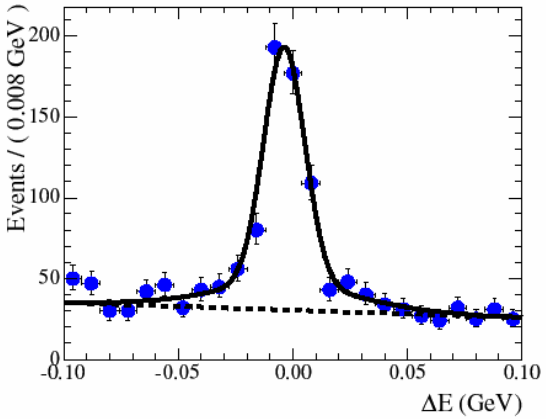
hep-ex/0607055





$N_{yield}=50 \pm 8$





$N_{yield}=571 \pm 34$

$\Lambda_c \to pK\pi$ BF

$$\mathcal{B}(\overline{B}^0 \to \Lambda_c^+ \overline{p}) = (2.15 \pm 0.36 \pm 0.13 \pm 0.56) \times 10^{-5}$$

$$\mathcal{B}(B^- \to \Lambda_c^+ \overline{p}\pi^-) = (3.53 \pm 0.18 \pm 0.31 \pm 0.92) \times 10^{-4}$$

4σ higher than the Belle measurement!

Ratio of the two BFs

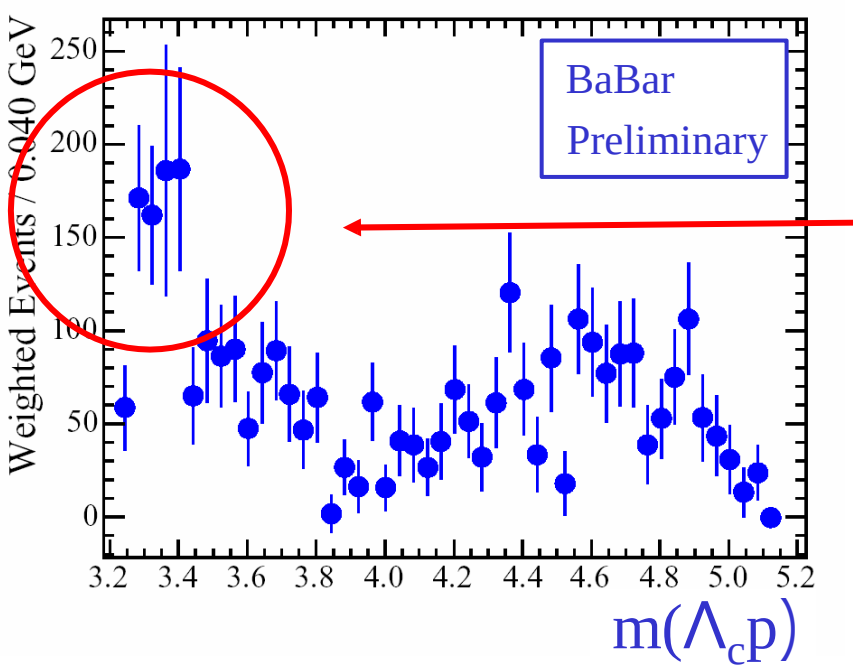
$$\frac{\mathcal{B}(B^- \to \Lambda_c^+ \bar{p}\pi^-)}{\mathcal{B}(\bar{B}^0 \to \Lambda_c^+ \bar{p})} = 16.4 \pm 2.9 \pm 1.4$$

- Theory:

$$\frac{BF(B^- \to \Lambda_c^+ \bar{p}\pi^-)}{BF(\bar{B}^0 \to \Lambda_c^+ \bar{p})} \sim 10$$

Cheng, J. Korean Phys. Soc. 45, S245 (2004)

Analysis of baryon-antibaryon mass in the 3-body mode



Also in BaBar data, in the 3-body decay there is an enhancement in the baryon-antibaryon mass distribution near threshold (quasi-resonance?)

Summary

- We have measured the Branching Fractions for several exclusive B decays to open charm final states. Many of them are precision measurements and tests of QCD.
- Many measurements more precise than the PDG values.
- Quest for rare decays, searching for new physics

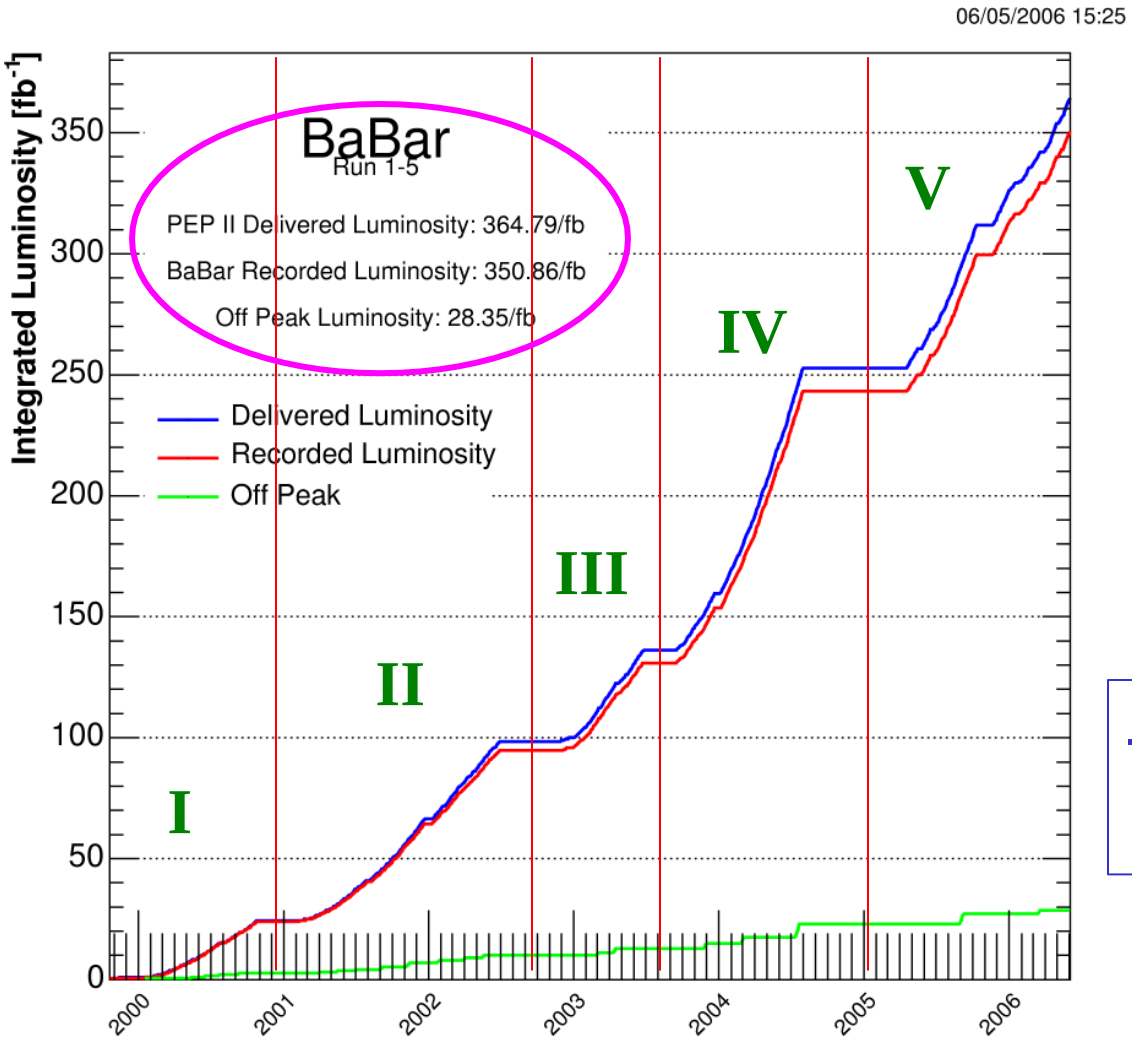
  More stringent limits!
- First observations!

$$B^- \rightarrow D_s^{(*)+} K^- \pi^- \qquad B^- \rightarrow D_s^{+} K^- \pi^-$$

- New results in charm baryon physics

Backup slides

Integrated data sample to date



Project Run 5
at 415 fb^{-1} delivered
by August 21

Belle:
peak: 1.627 x 10^{34} cm^{-2} sec^{-1}
integral: 624 fb-1

Total Babar Logged To Date: 370 /fb

PEP-II PEAK LUMI 1.124 x 10^{34} cm^{-2} sec^{-1}