Study of Narrow D_J^0 Resonances

in the Decay of $B^- \to D^{+(*)} \pi^- \pi^-$

(Preliminary Results)

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On behalf of the

BaBar Collaboration

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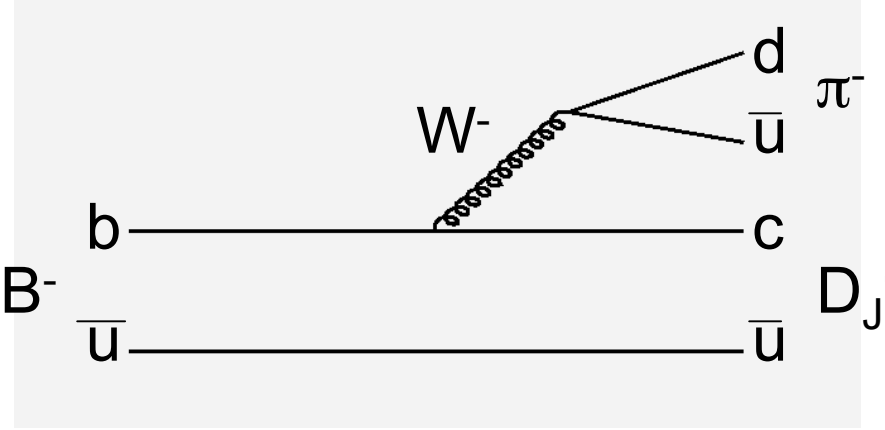
the Division of Particles and Fields

Introduction to the D_J^0 (aka D^{**0})

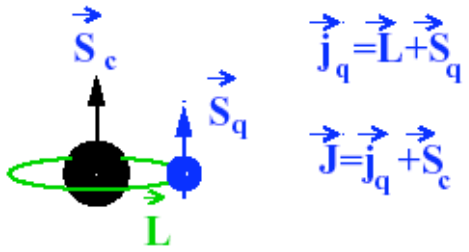
- D_J^0 is the generic name for the four orbitally excited D mesons. They consist of a charm quark and an up quark with an orbital angular momentum of L=1.
- D_J^0 is produced at BaBar through the decay of the charged B-meson.



Heavy Charm Limit

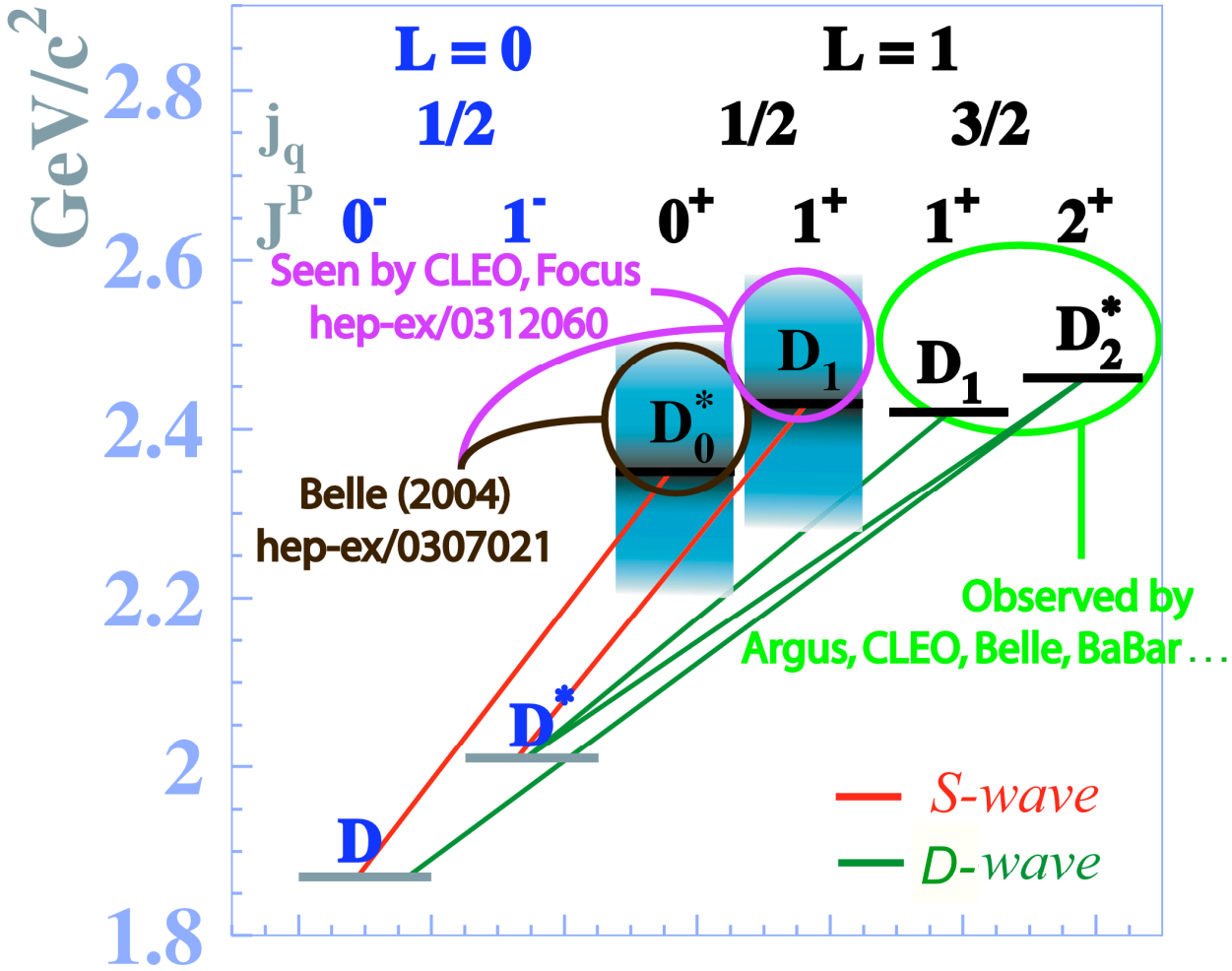
- $m_c >> \Lambda_{QCD}$
- Heavy Charm Limit
- S_c decouples
- $j_q = S_q + L$
  good quantum number
- j_q=1/2 & j=3/2
  doublets
- like hydrogen atom

$L = 1$ D-mesons



State	J^P, j
$D_0^*(j=1/2)^0$	0^+, 1/2
$D_1(2420)^0$	1^+, 3/2
$D_1(j=1/2)^0$	1^+, 1/2
$D_2^*(2460)^0$	2^+, 3/2

D_J Spectrum



- Wide Resonances: $D_0^*(j=1/2)^0$, $D_1(j=1/2)^0$
- Narrow Resonances: $D_1(2420)^0$, $D_2^*(2460)^0$

Particle Properties

State	J^P, j	Mass(MeV/c^2)	Width(MeV)	Decays (HQ Limit)
$D_0^*(j=1/2)^0$	0^+, 1/2	2308±17±15±28	276±21±18±60	Dπ (S-Wave)
$D_1(2420)^0$	1^+, 3/2	2422.2±1.8	18.9(+4.6-3.5)	$D^*\pi$ (D-Wave)
$D_1(j=1/2)^0$	1^+, 1/2	2427±26±20±15	384(+107,-75)±24±70	$D^*\pi$ (S-Wave)
$D_2^*(2460)^0$	2^+, 3/2	2458.9±2.0	23±5	$D^*\pi$, Dπ (D-Wave)

Belle, Phys. Rev. D69:112002, 2004
2004 Review of Particle Physics

Branching Fraction Ratio

$$R \equiv \frac{\mathcal{B}(B^- \to D_2^*(2460)^0 \pi^-)}{\mathcal{B}(B^- \to D_1(2420)^0 \pi^-)}$$

Neubert,
Phys. Lett. B 418, 173 (1998)

Neubert 98
R≈ 0.35

Leibovich 97
0<R<1.5

Leibovich, Legeti, Stewart, Wise,
Phys. Rev D 57, 308 (1997)

CLEO 98
R=1.8 ±0.8

Belle 03
R=0.77±0.15

Strategy - Study of $B^- \to D_J^0 \pi^-$

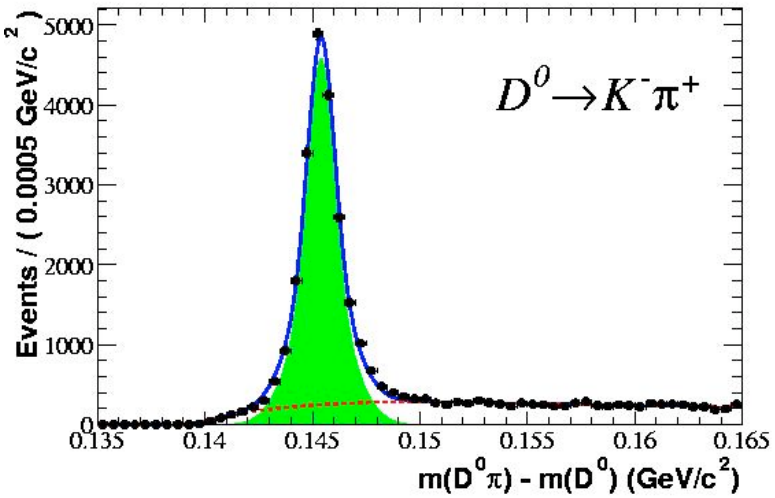
Using 88 million $B^{-/+}$ decays (81.9 fb^{-1}) collected on the Upsilon(4S) resonance:

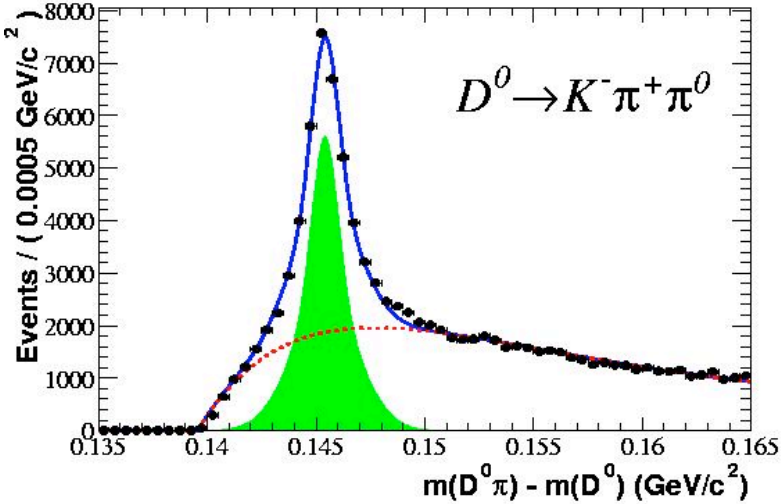
- Reconstruct:
  $B^- \to D^{*+}\pi^-\pi^-$, where $D^{*+} \to D^0\pi^+$,
  $D^0 \to K^-\pi^+, K^-\pi^+\pi^0, K^-\pi^+\pi^-\pi^+, K_S\pi^+\pi^-$
  $B^- \to D^+\pi^-\pi^-$, where $D^+ \to K^-\pi^+\pi^+, K_s\pi^+$
- Optimize cuts on event topology and mass differences: $m(D^0\pi^+)$-$m(D^0)$, $m(\pi^0)$, $m(D^0)$
- Measure branching fractions:
  Inclusive $\mathcal{B}(B^- \to D^{*+}\pi^-\pi^-)$, $\mathcal{B}(B^- \to D^+\pi^-\pi^-)$
  Exclusive $\mathcal{B}(B^- \to D_2^*(2460)^0\pi^-)$ …

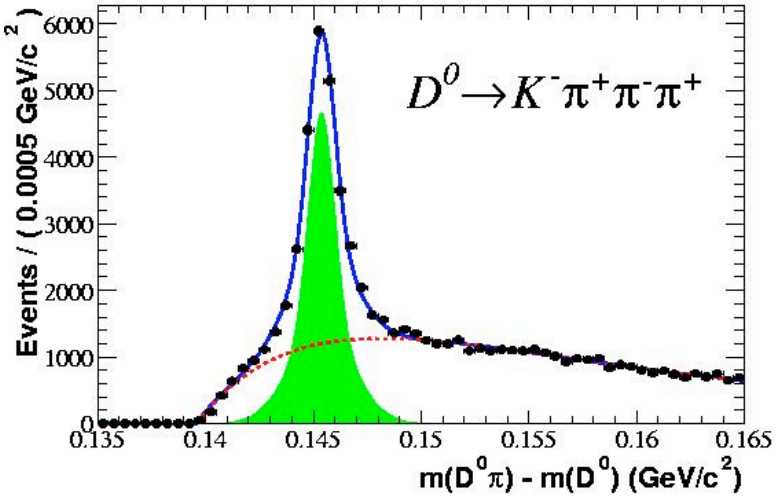
$m(D^0\pi^+)$-$m(D^0)$ Mass Spectrum, $B^- \to D^{*+}\pi^-\pi^-$

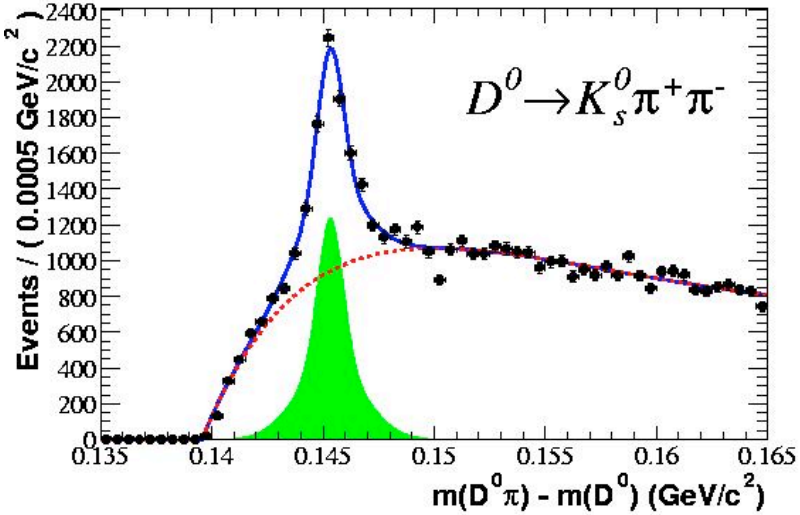
$m(D^0\pi^+)$-$m(D^0)$ within 2.6 - 3.0 MeV of PDG (depends on D^0 decay mode)

BaBar Preliminary



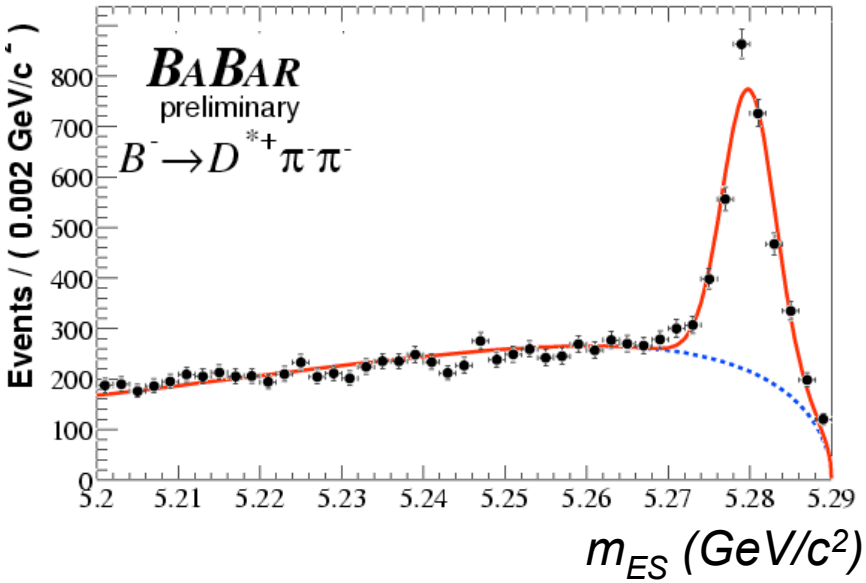


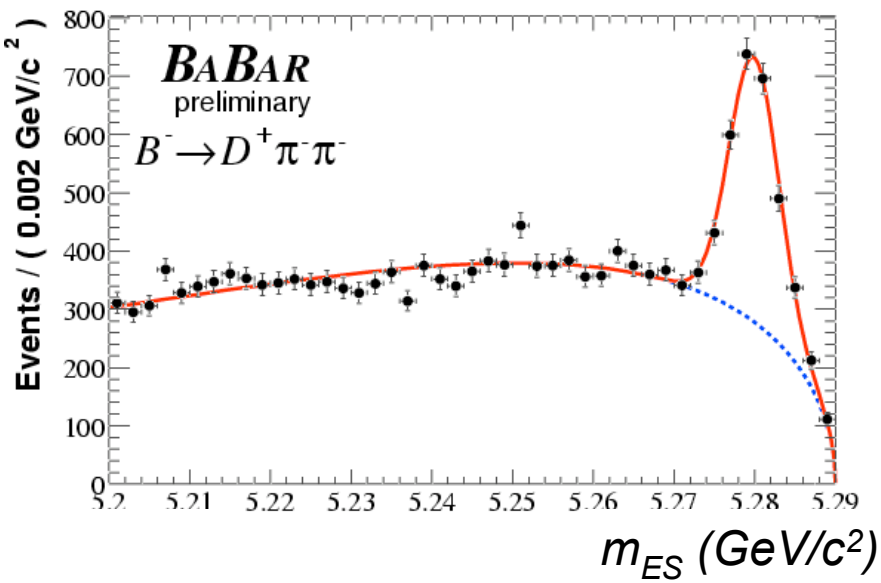




B Reconstruction

$$m_{\mathrm{ES}} = \sqrt{(E^*_{\mathrm{beam}})^2 - (\sum_i \mathbf{p}^*_i)^2}$$

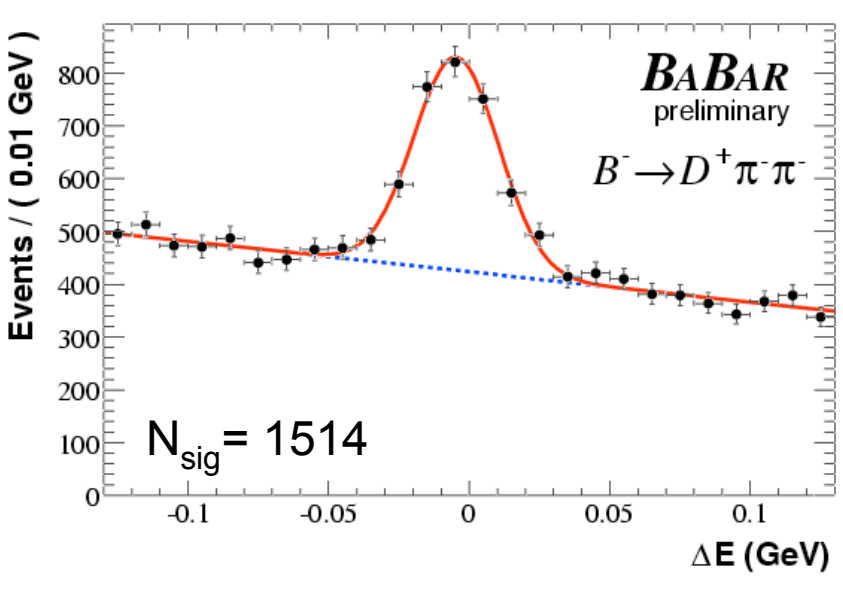


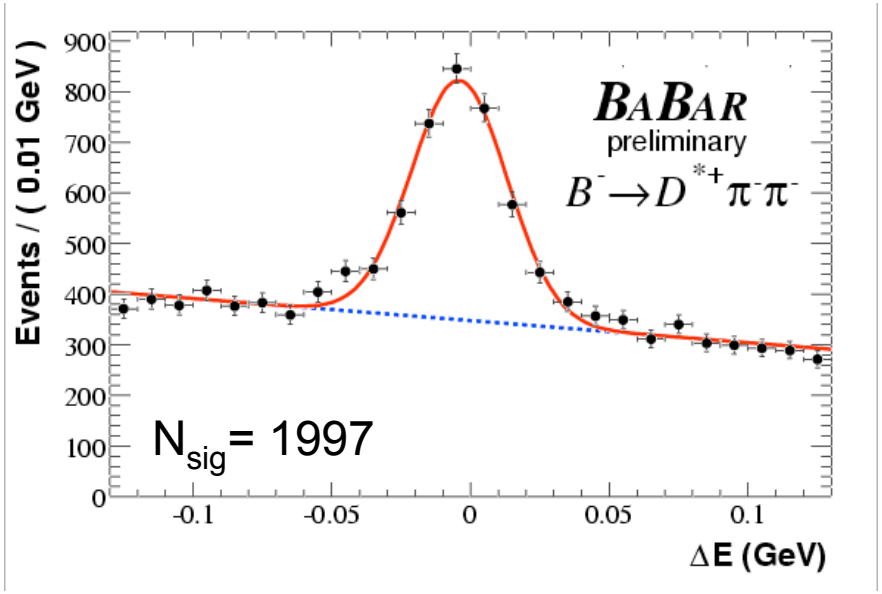


88 million $B^{-/+}$ decays (81.9 fb^{-1})

Inclusive Branching Fractions

$$\Delta E = \sum_i \sqrt{m_i^2 + (\mathbf{p}_i^*)^2} - E_{\mathrm{beam}}^*$$





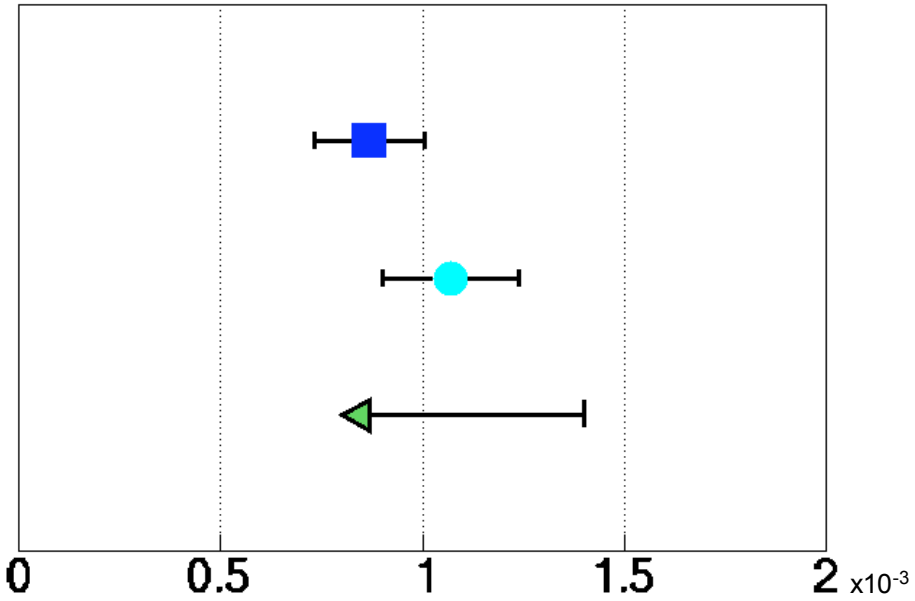
$\mathcal{B}(B^- \to D^{*+}\pi^-\pi^-) = (1.22 \pm 0.05 \pm 0.18) \times 10^{-3}$

$\mathcal{B}(B^- \to D^{+}\pi^-\pi^-) = (0.87 \pm 0.04 \pm 0.13) \times 10^{-3}$

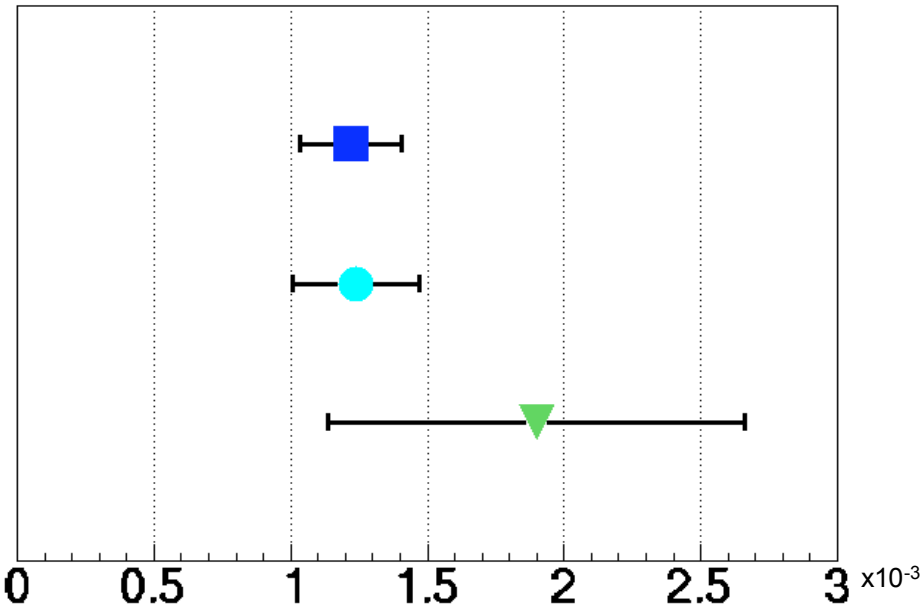
Inclusive Branching Fractions Comparison

Preliminary

$\mathcal{B}(B^- \to D^+ \pi^- \pi^-)$



$\mathcal{B}(B^- \to D^{*+} \pi^- \pi^-)$



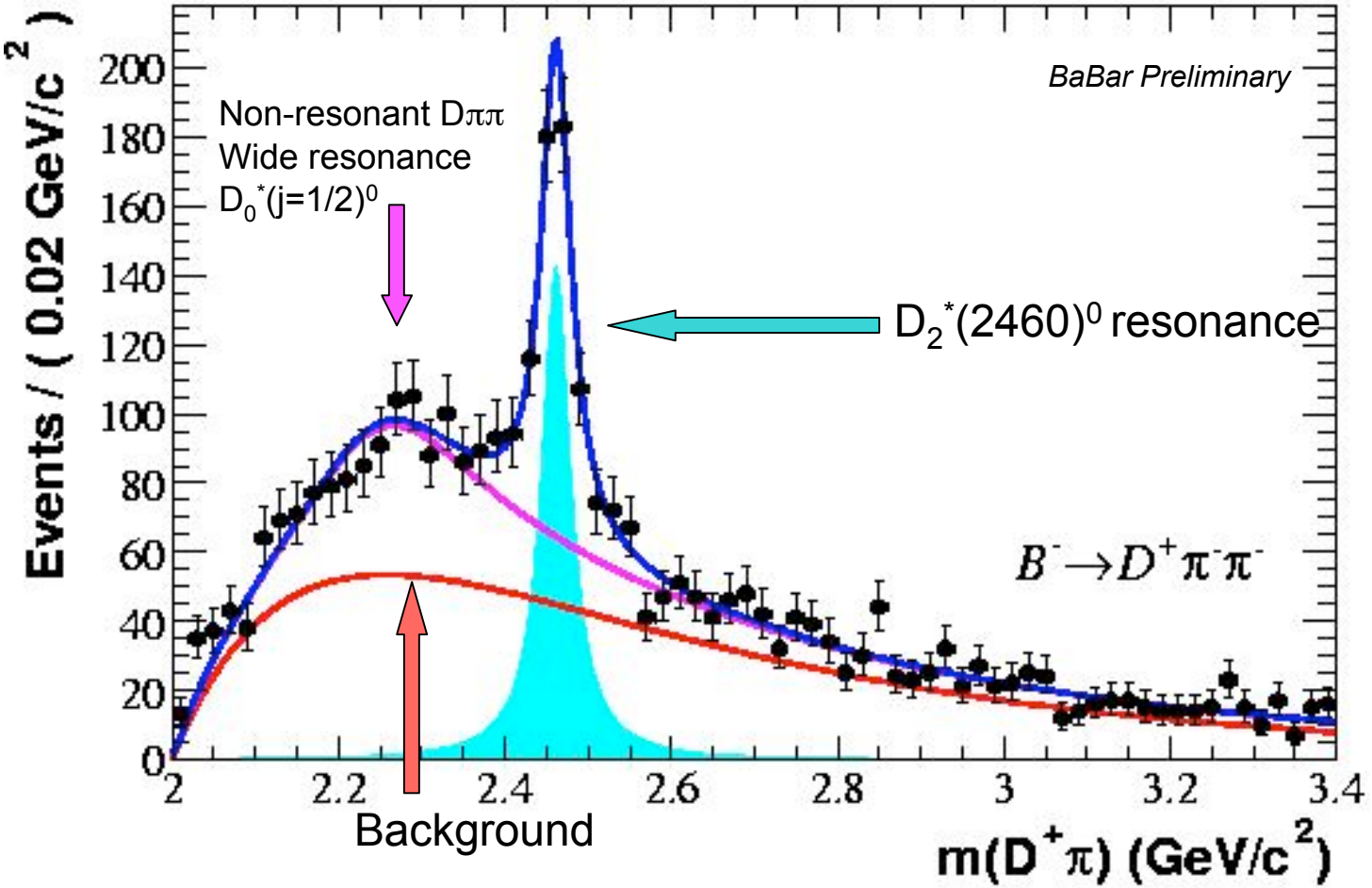
	BaBar	Belle	CLEO
$\mathcal{B}(B^- \to D^{*+} \pi^- \pi^-)$ (10^{-3})	1.22±0.05±0.18	1.24±0.08±0.22	1.9±0.7±0.3
$\mathcal{B}(B^- \to D^+ \pi^- \pi^-)$ (10^{-3})	0.87±0.04±0.13	1.02±0.04±0.15	<1.4 (90% C.L.)

Phys. Rev. D69:112002, 2004

CLEO CONF 99-6 (1999)

Dπ Mass Spectrum

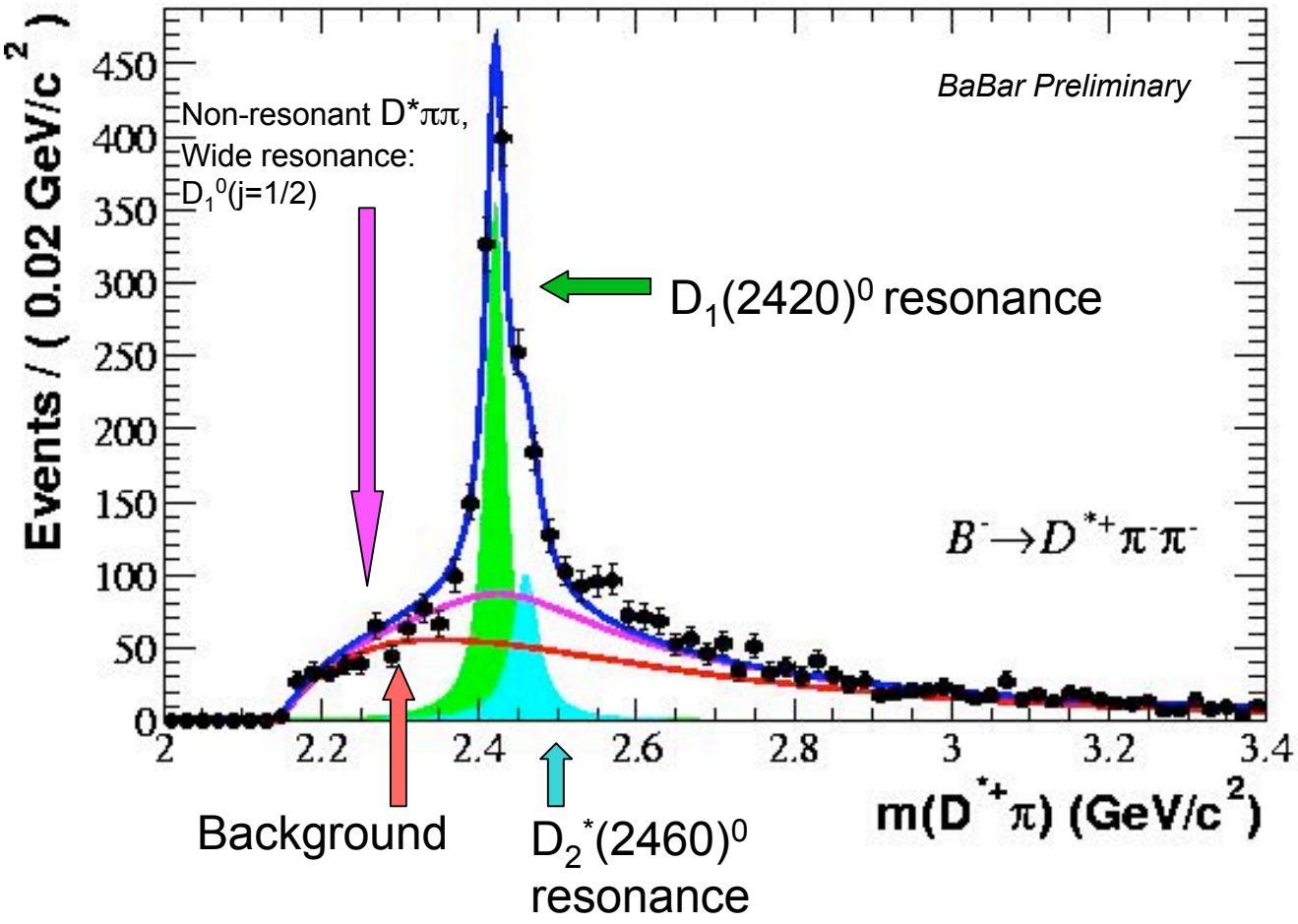
Expected Resonances: $D_2^*(2460)^0$, $D_0^*(j=1/2)^0$



$(B^- \to D_2^*(2460)^0\pi^-) \times (D_2^*(2460)^0 \to D^+\pi^-) = (0.29 \pm 0.02 \pm 0.05) \times 10^{-3}$

$D^*\pi$ Mass Spectrum

Expected Resonances: $D_1^0(j=1/2)$, $D_1(2420)^0$, $D_2^*(2460)^0$

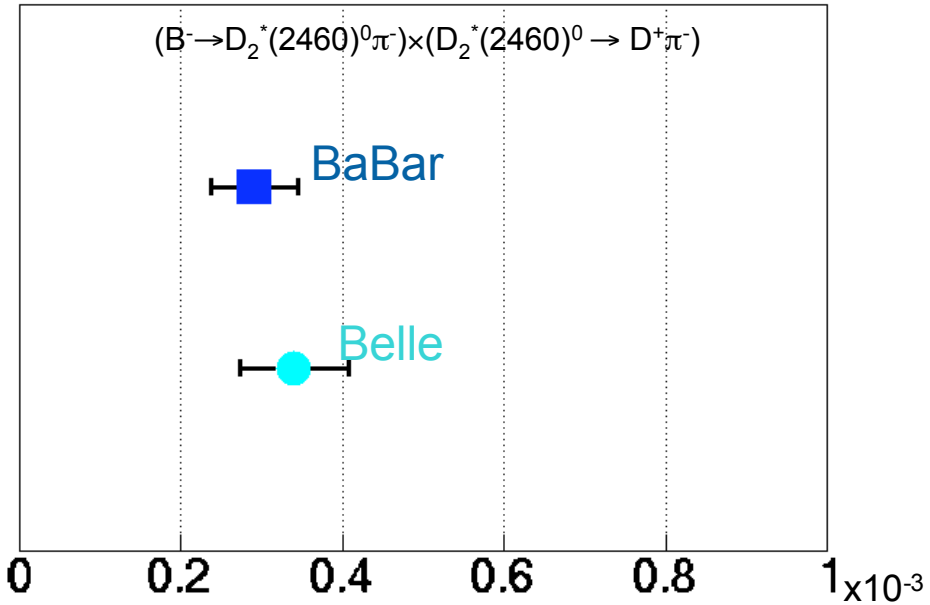


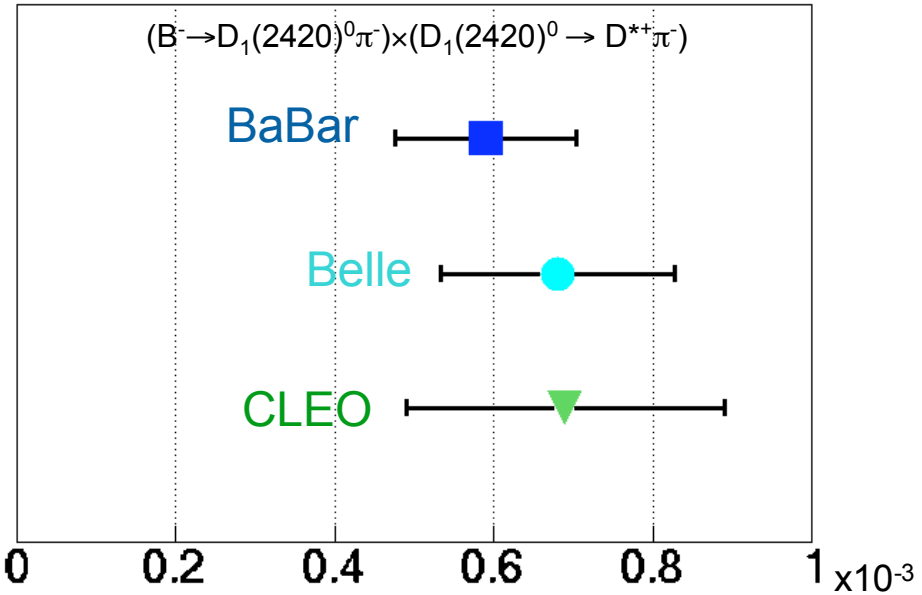
$(B^- \to D_1(2420)^0\pi^-) \times (D_1(2420)^0 \to D^{*+}\pi^-) = (0.59 \pm 0.03 \pm 0.11) \times 10^{-3}$

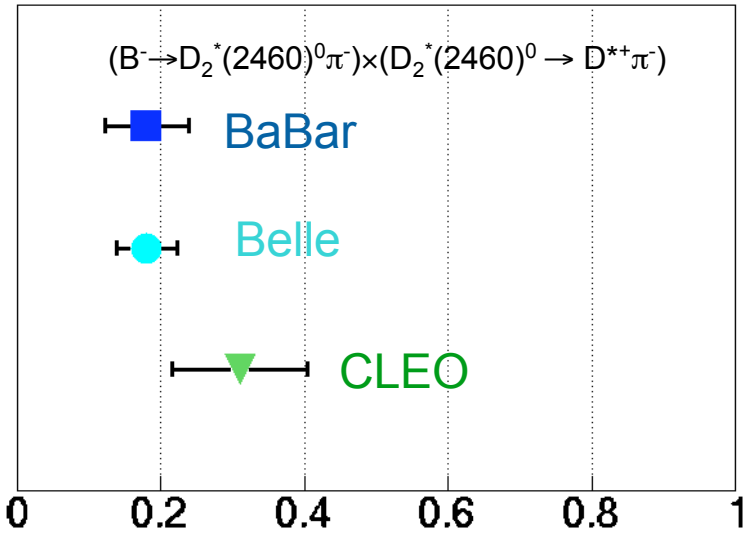
$(B^- \to D_2^*(2460)^0\pi^-) \times (D_2^*(2460)^0 \to D^{*+}\pi^-) = (0.18 \pm 0.03 \pm 0.05) \times 10^{-3}$

Exclusive Branching Fraction Comparison

(Preliminary)







Belle Phys. Rev. D69:112002, 2004

CLEO CONF 99-6 (1999)

Branching Fraction Ratio R

BaBar

0.80 ±0.07 ±0.16

Belle

0.77±0.15

CLEO

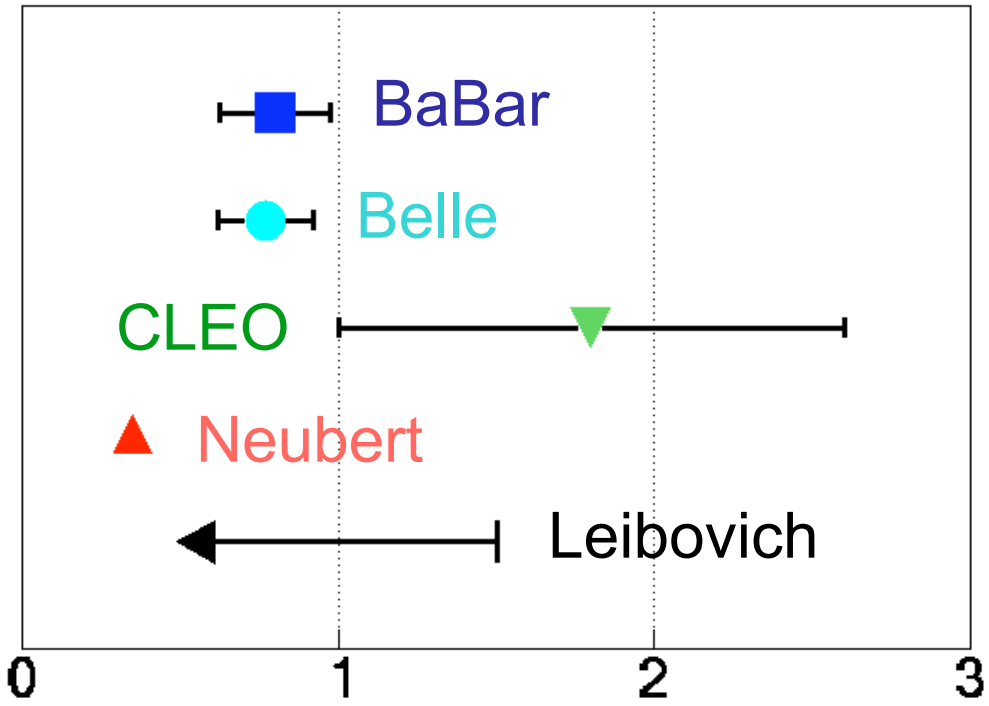
1.8 ±0.8

Neubert

R≈0.35

Leibovich

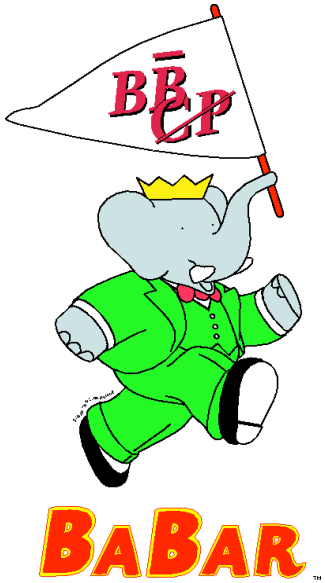
0<R<1.5



Systematic Uncertainties

Correlated	
Uncertainties on tracking efficiency	
bachelor pions	3.5%
all other tracks	1.3%
Uncertainties on Particle ID (kaon eff)	2.5%
Efficency difference among the res. and nonres. decay:	
K^- modes	(3-4)%
K_S modes	(8-13)%
Multiple B candidates	(2-15)%
B-counting	1.1%
D^{*+} branching fractions for $D^{*+}\pi^-\pi^-$	0.7%
Uncorrelated	
π^0 efficiency	7.7%
$K_S{}^0$ efficency	3%
D^0 and D^+ branching fractions	(2.3-6.2)%
Monte Carlo statistics	(1.5-5.2)%
$K^0 \rightarrow K_S{}^0 \rightarrow \pi^-\pi^+$ branching fraction	0.4%
Systematic Uncertainties on Exclusive BF	
Uncertainties in the description of the wide resonances	(4.5-11.8)%
Peaking background from wrong π and real D_J	4%
Uncertainty in $D_1(2420)^0$ and $D_2^*(2460)^0$ fit	(0.3-7.4)%

Summary / Future Plans



- Present inclusive and exclusive $\mathcal{B}$'s and $\mathcal{B}$ ratio R.
  Details found at hep-ex/0308026
- $\mathcal{B}$ results are consistent with CLEO, Belle
- R is consistent with Belle
- Continuing to study the wide resonances via full Dalitz and angular analysis