



Charmless B decays into three charged track final states

Alexei Garmash
KEK/BINP

for the Belle Collaboration

Outline:

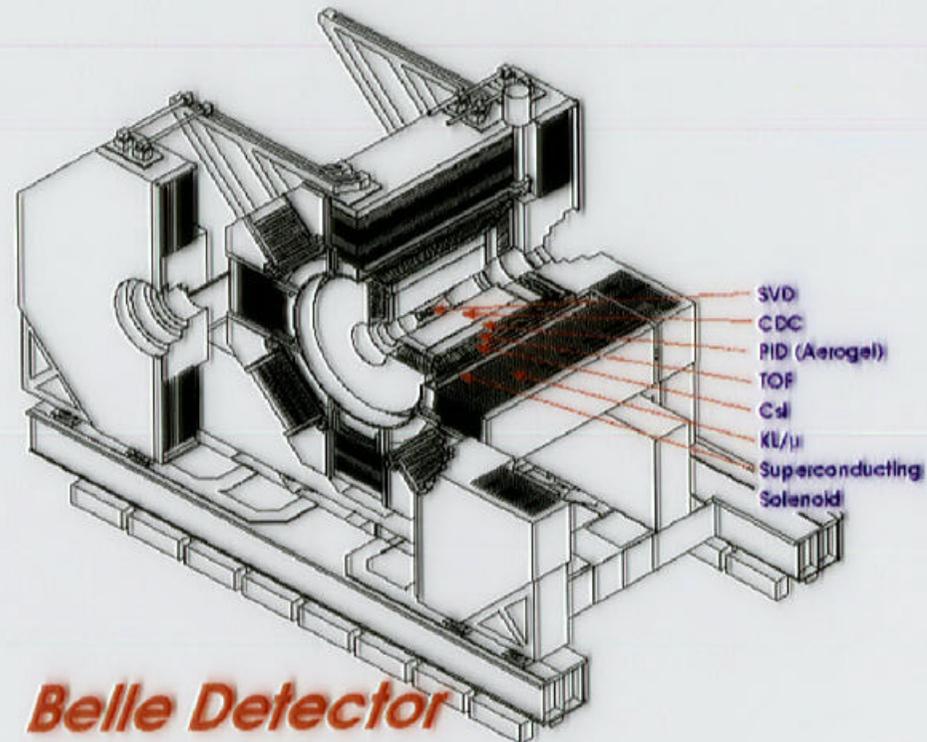
- Motivations
- Event selection
- Results on $B^+ \rightarrow K^+ \pi^+ \pi^-$
- Results on $B^+ \rightarrow K^+ K^+ K^-$
- Discussion & Conclusion



Belle Detector at KEKB

Data Set:

- 10.5 fb^{-1} at $\Upsilon(4S)$ resonance
- 0.60 fb^{-1} below $B\bar{B}$ threshold





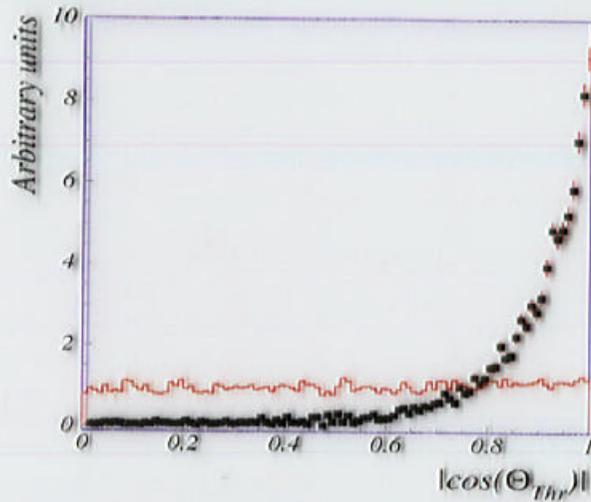
Motivations



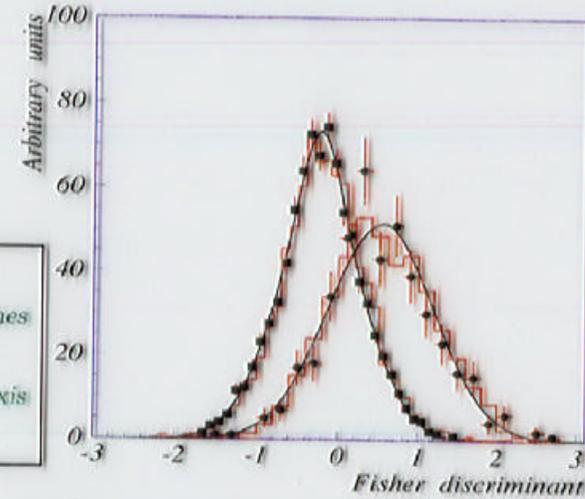
- *A lot of new results on two-body charmless B decays came from CLEO Collaboration*
- *Study of penguin $b \rightarrow sq\bar{q}$ transitions (resulting in the odd number of kaons in final state)*
- *Good K/π separation capability of the Belle detector in a wide momentum region allows a study of three particle final state without any assumption on intermediate mechanism*
- *Search for New Physics (SUSY ...)*



Event Selection



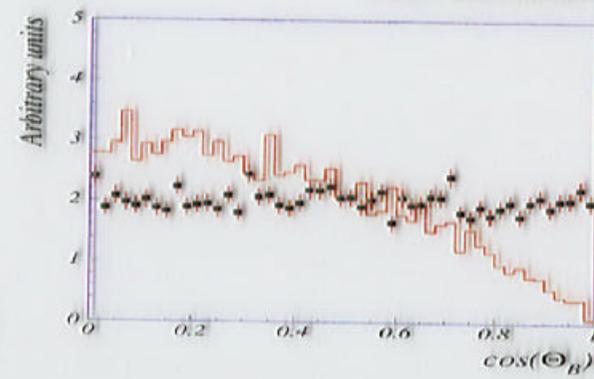
- Fisher Discriminant:**
- momentum flows in 9 cones around B decay axis
 - angle between B decay axis and beam axis



θ_{Thr} - angle between B decay axis and that for the rest of the event

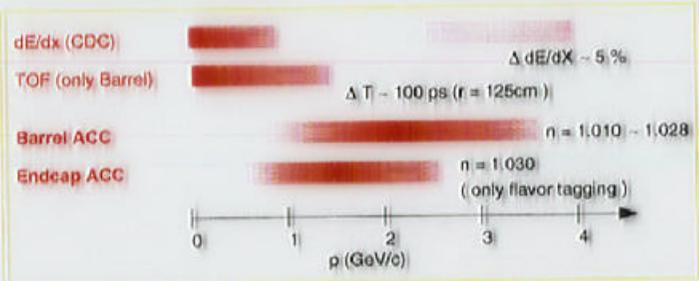
$$\mathcal{LR} = \frac{\mathcal{L}_S}{\mathcal{L}_S + \mathcal{L}_B}$$

$$\mathcal{L}_i = \mathcal{L}_i(\mathcal{F}) \times \mathcal{L}_i(\cos(\theta_B))$$



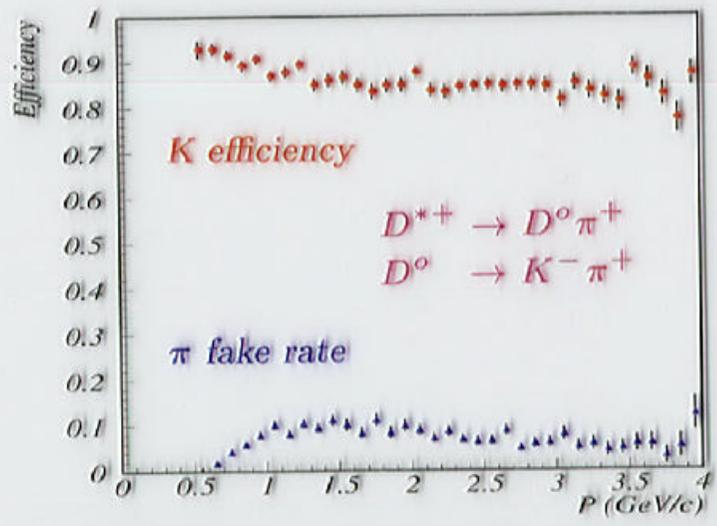


Event Selection



dE/dx + ToF + ACC combined

$$PID(K) = \frac{\mathcal{L}(K)}{\mathcal{L}(K) + \mathcal{L}(\pi)}$$



Beam constrained mass

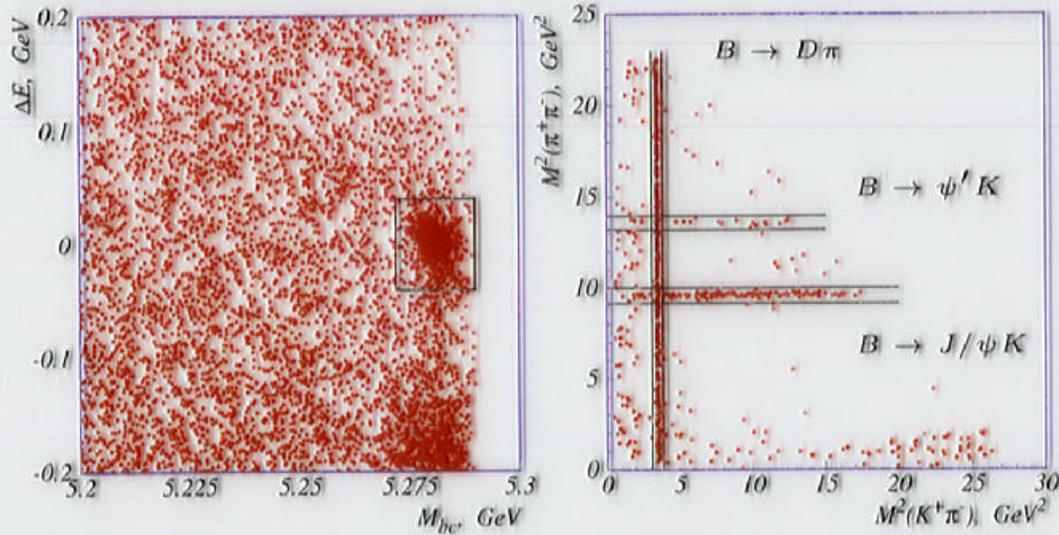
$$M_{bc} = \sqrt{[E_{beam}^*]^2 - \left[\sum_i p_i^* \right]^2}$$

Energy difference

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



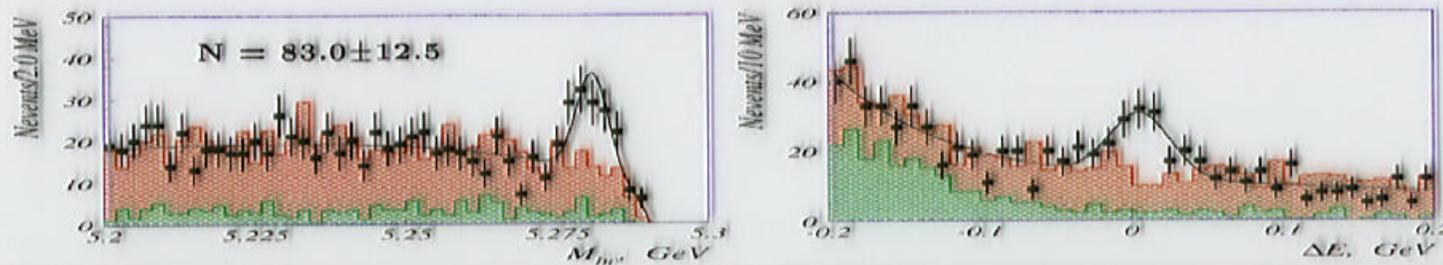
$B^+ \rightarrow K^+ \pi^+ \pi^-$



Vetoed candidates:

- $\bar{D}^0 \rightarrow K^+ \pi^-$: ± 100 MeV
- $J/\psi \rightarrow \mu^+ \mu^-$: ± 70 MeV
- $\psi' \rightarrow \mu^+ \mu^-$: ± 50 MeV

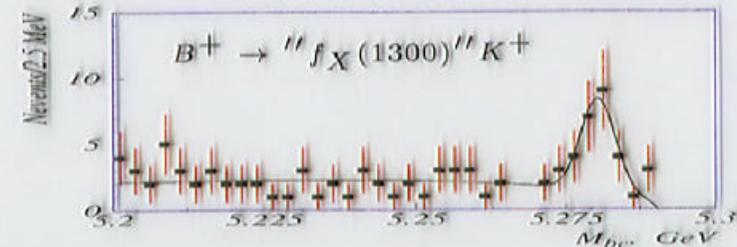
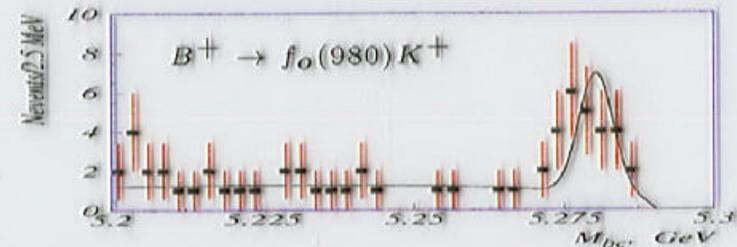
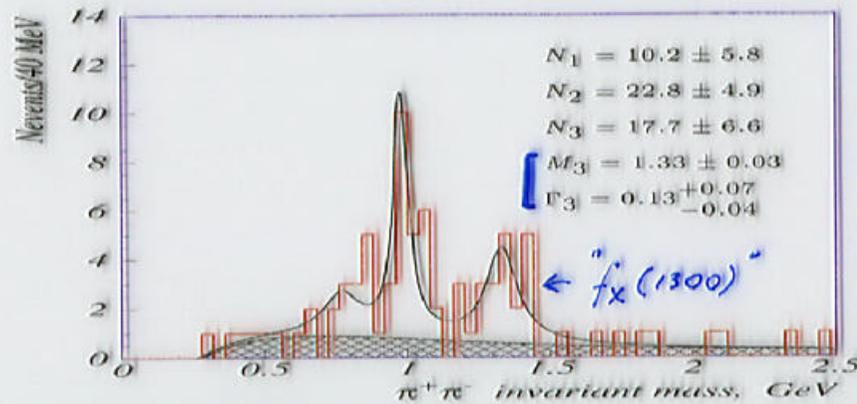
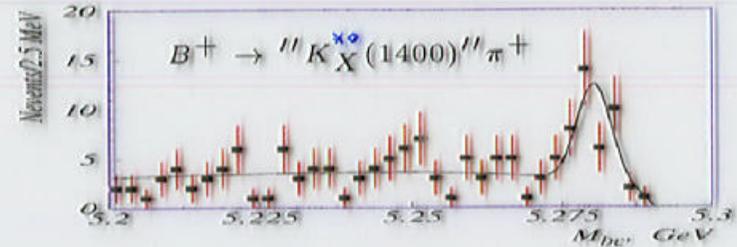
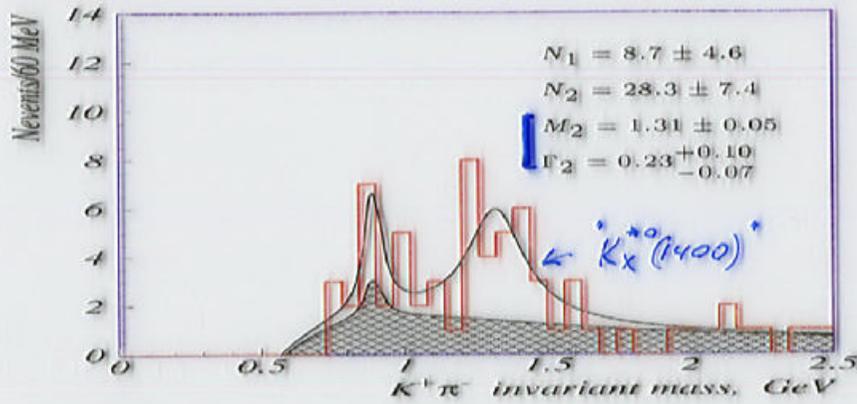
M_{bc} and ΔE distributions after D , J/ψ and ψ' veto





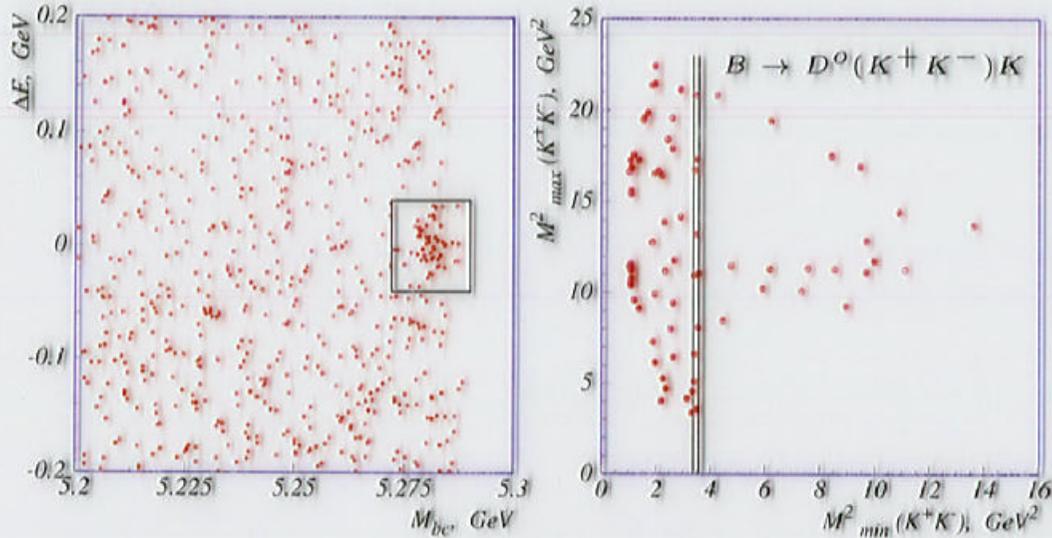
$B^+ \rightarrow K^+ \pi^+ \pi^-$

Invariant mass spectra for candidates from the B signal box





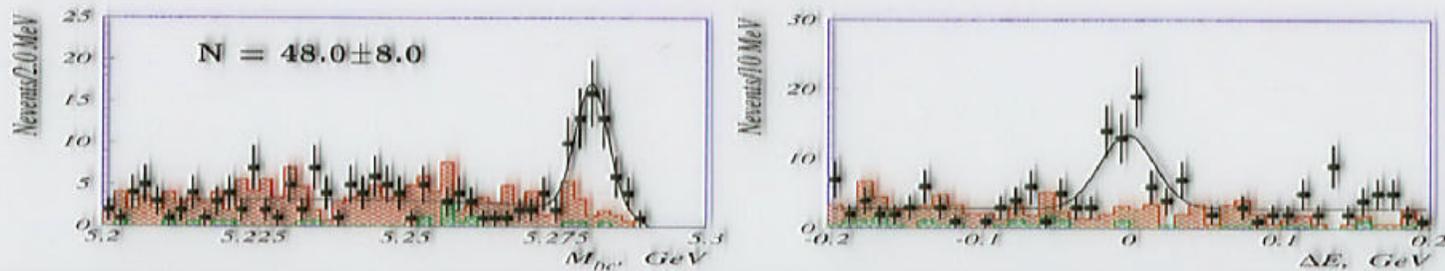
$B^+ \rightarrow K^+ K^+ K^-$



Vetoed candidates:

- $D^0 \rightarrow K^+ K^-$: ± 25 MeV

M_{bc} and ΔE distributions after D veto

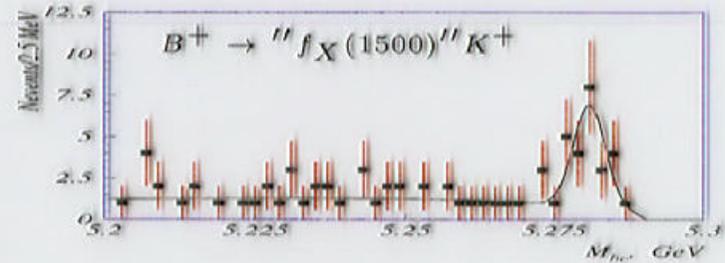
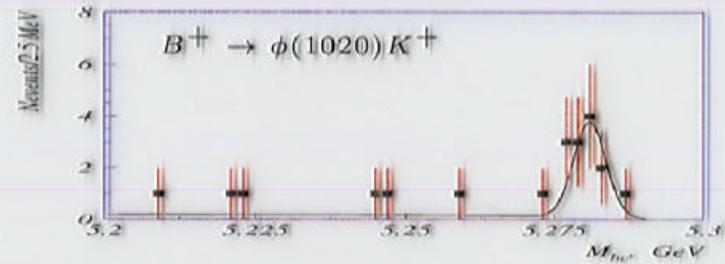
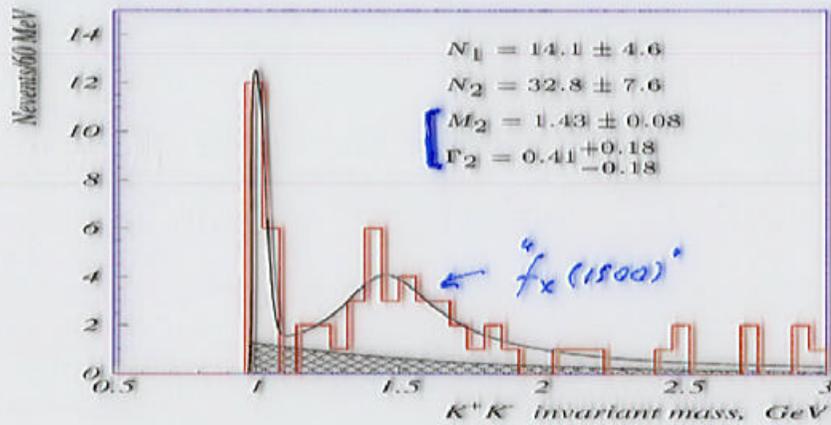




$B^+ \rightarrow K^+ K^+ K^-$



Invariant mass spectra for candidates
from the B signal box

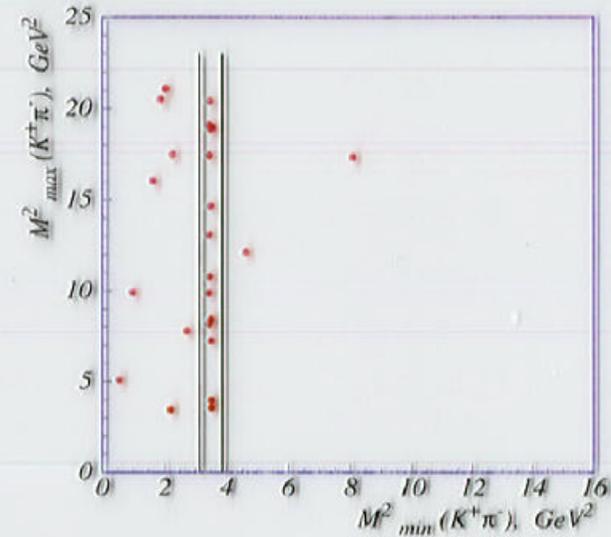




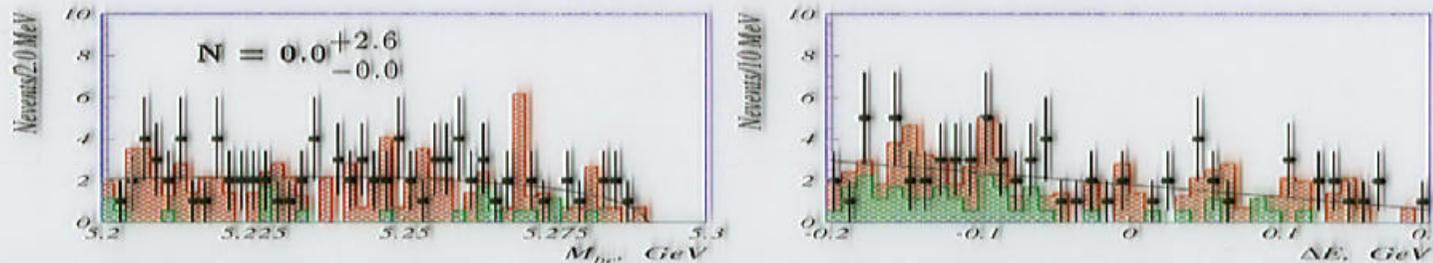
$B^+ \rightarrow K^+ K^+ \pi^-$

- in the SM the expected branching ratio is $\sim 10^{-11}$
- SUSY gives $\sim 10^{-7}-10^{-8}$
- from $b \rightarrow c$ transitions we expect to observe the Cabibbo suppressed decay
 $B^+ \rightarrow \bar{D}^0 K^+, \bar{D}^0 \rightarrow K^+ \pi^-$

$$\begin{aligned} \text{Br}(B^+ \rightarrow \bar{D}^0 K^+) / \text{Br}(B^+ \rightarrow \bar{D}^0 \pi^+) &= \\ &= 0.055 \pm 0.014 \pm 0.005 \text{ [CLEO(1998)]} \\ &= 0.077 \pm 0.009 \pm 0.006 \text{ [Belle(2001)]} \end{aligned}$$



M_{bc} and ΔE distributions after D veto





Summary of the results

$$\mathcal{B}r(B^+ \rightarrow X h^+) \times \mathcal{B}r(X \rightarrow h^+ h^-) = \frac{N_X}{N_{D\pi}} \times \mathcal{B}r(B^+ \rightarrow \bar{D}^0 \pi^+) \times \mathcal{B}r(\bar{D}^0 \rightarrow K^+ \pi^-) \times \frac{1}{\epsilon}$$

PRELIMINARY

Mode	ϵ	Yield	Significance, σ	$\mathcal{B}r(10^{-6})$	90%UL(10^{-6})	Note
$K^+ \pi^- \pi^+$	0.94	83.0 ± 12.5	8.60	$64.8 \pm 10.0 \pm 7.0$	—	1
$K^+ K^+ K^-$	0.72	48.0 ± 8.0	9.30	$36.5 \pm 6.1 \pm 5.5$	—	2
$K^- \pi^+ \pi^+$	0.94	$7.8^{+6.2}_{-5.5}$	—	—	< 12.8	3
$K^+ K^+ \pi^-$	0.83	$0.0^{+2.6}_{-0.0}$	—	—	< 5.20	4
$K^+ K^- \pi^+$	0.83	$9.7^{+6.6}_{-5.9}$	—	—	< 17.0	5

1) CLEO2: $< 2.8 \times 10^{-5}$ (NR); BaBar: $< 5.4 \times 10^{-5}$ (NR); DELPHI: $< 3.3 \times 10^{-4}$ (NR); ARGUS: $< 3.3 \times 10^{-4}$ (NR)

2) CLEO2: $< 3.8 \times 10^{-5}$ (NR); DELPHI: $< 2.0 \times 10^{-4}$; ARGUS: $< 3.5 \times 10^{-4}$

3) CLEO2: $< 5.6 \times 10^{-5}$ (NR) 4) OPAL: $< 8.79 \times 10^{-5}$ (NR)

5) CLEO2: $< 7.5 \times 10^{-5}$ (NR)

(NR – non-resonant)



Summary of the results

PRELIMINARY

Mode	ϵ	Yield	Significance, σ	$\mathcal{B}r(B \rightarrow Xh) \times \mathcal{B}r(X \rightarrow hh)(10^{-6})$	Note
$K^{*0}(892)\pi^+$	0.70	$11.4_{-3.9}^{+4.6}$	2.8	< 11.6 90% CL	1
$"K_X^{*0}(1400)"\pi^+$	0.67	$26.0_{-7.1}^{+7.7}$	5.2	$23.8_{-5.1}^{+5.6} \pm 5.8$	2
$\rho^0(770)K^+$	0.51	$5.7_{-3.9}^{+4.6}$	1.6	< 13.5 90% CL	3
$f_0(980)K^+$	0.60	$16.9_{-5.0}^{+5.6}$	4.9	$16.4_{-4.2}^{+4.9} \pm 2.8$	4
$"f_X(1300)"K^+$	0.60	$17.5_{-5.4}^{+6.0}$	4.8	$18.8_{-4.6}^{+5.3} \pm 4.3$	—
$"f_X(1500)"K^+$	0.45	$17.6_{-5.0}^{+5.7}$	5.5	$25.1_{-5.8}^{+6.6} \pm 4.3$	—

- 1) $\mathcal{B}r(B^+ \rightarrow K^{*0}(892)\pi^+)$ **This Work:** $< 17.4 \times 10^{-6}$; CLEO2: $< 16 \times 10^{-6}$; Babar: $< 28 \times 10^{-6}$
- 2) ARGUS: $\mathcal{B}r(B^+ \rightarrow K_2^+(1430)\pi^+) < 6.8 \times 10^{-4}$
- 3) $\mathcal{B}r(B^+ \rightarrow \rho^0(770)K^+)$ **This Work:** $< 13.5 \times 10^{-6}$; CLEO2: $< 17 \times 10^{-6}$; Babar: $< 29 \times 10^{-6}$
- 4) $\mathcal{B}r(B^+ \rightarrow f_0(980)K^+)$ **This Work:** $(16.4_{-4.2}^{+4.9} \pm 2.8) \times 10^{-6}$; CLEO: $< 80 \times 10^{-6}$



Discussion & Conclusion

Our attempt to interpret the observed structures in $h^+ h^-$ mass spectra takes into account:

- *observed states should have $J^P = 0^+$ or 2^+ since decays of 0^- , 1^+ and 1^- mesons with appropriate masses to $\pi\pi$, $K\pi$ and $K\bar{K}$ are forbidden or significantly suppressed*
- *the significant signal is observed in $B^+ \rightarrow f_0(980)K^+$*

With present statistics the angular distribution analysis could not resolve between 0^+ and 2^+ intermediate states.

Phenomenological estimations made within the factorization approach give

- *production of tensor mesons (2^+) in penguin B decays is expected to be highly suppressed ($\text{Br}(B^+ \rightarrow f_2(1270)K^+) \sim 5 \times 10^{-8}$; C. S. Kim, B. H. Lim and Sechul Oh, hep-ph/0101292)*
- *production of scalar mesons (0^+) in penguin B decays could be enhanced ($\text{Br}(B^+ \rightarrow K_0^*(1430)\pi^+) \sim 45 \times 10^{-6}$; V. Chernyak, hep-ph/0102217)*

From this we can conclude that the observed structures in various $h^+ h^-$ invariant mass spectra between 1300 and 1500 MeV could have a significant scalar component.