Charmless three-body $B \to Khh$ decays

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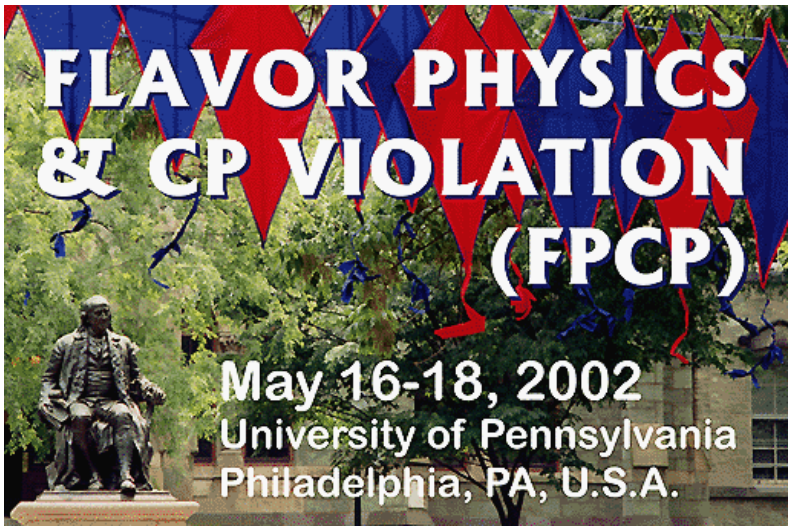
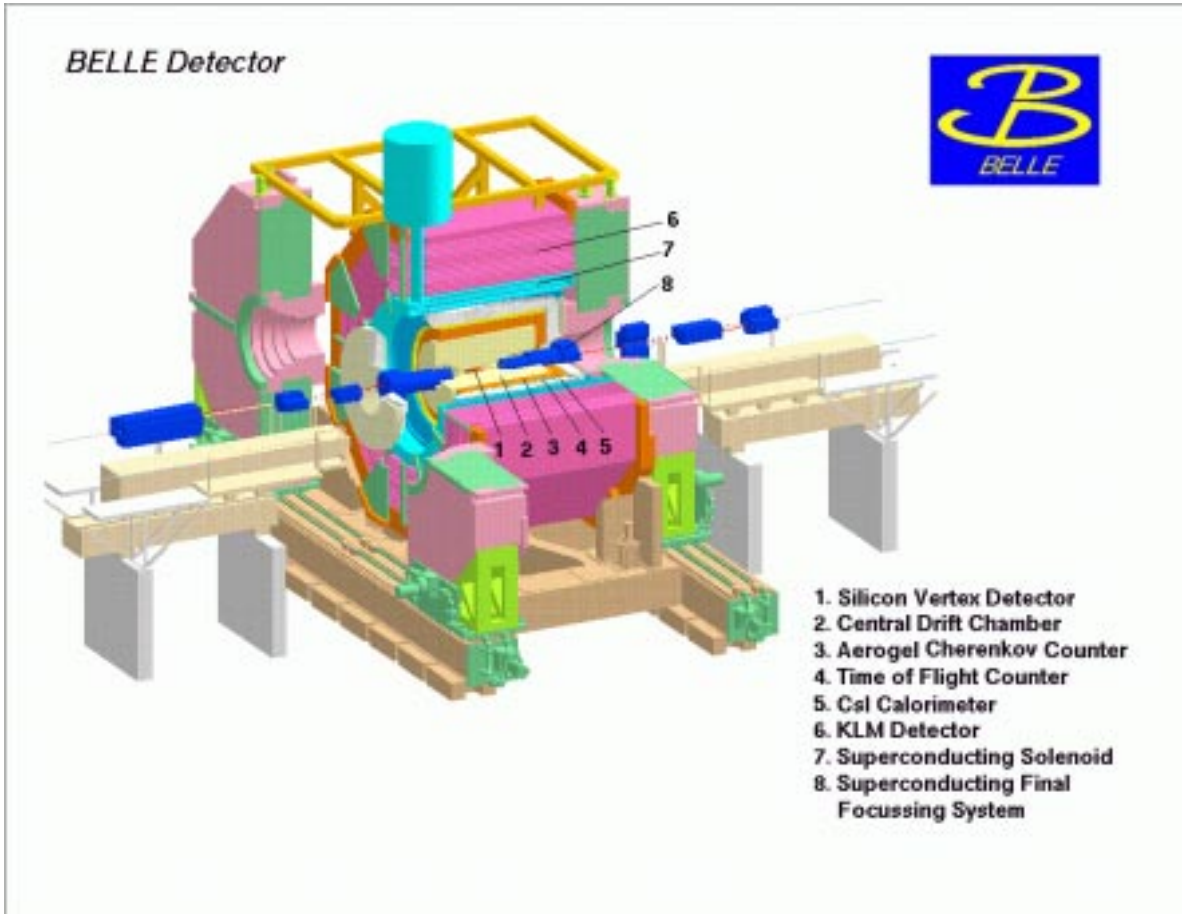
on behalf of the

Belle Collaboration



Outline:

- Introduction
- Results
- Summary
- Conclusion

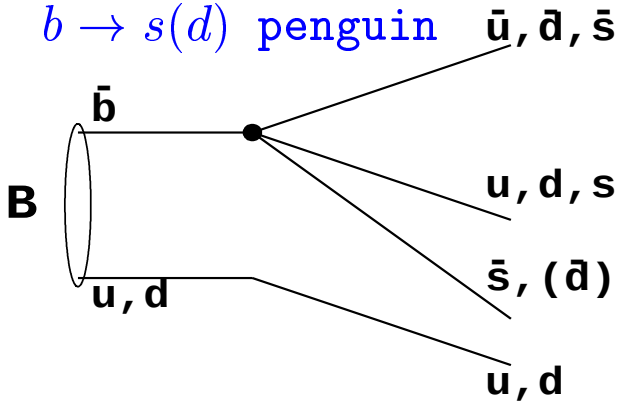


Most of the results are obtained with $\mathcal{L} = 43.1\ fb^{-1}$ (45.4×10^6 $B\bar{B}$ pairs)

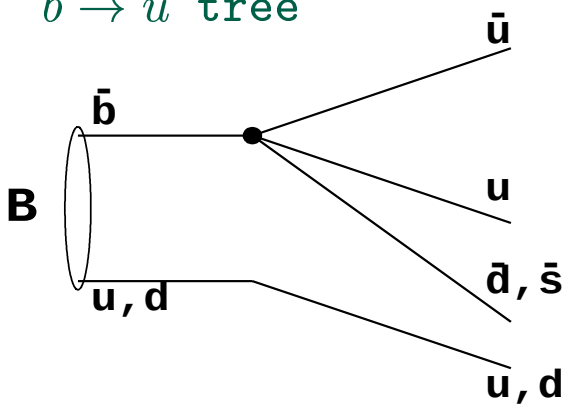
Introduction

The dominant contributions to charmless three-body B decays are expected to come from the $b \to s(d)$ penguins and $b \to u$ tree transitions

$b \to s(d)$ penguin



$b \to u$ tree

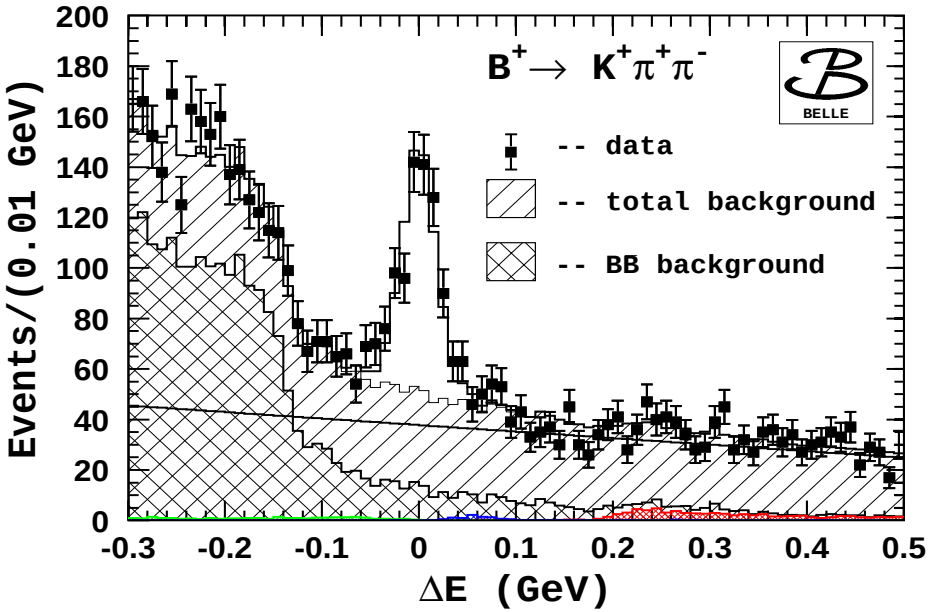


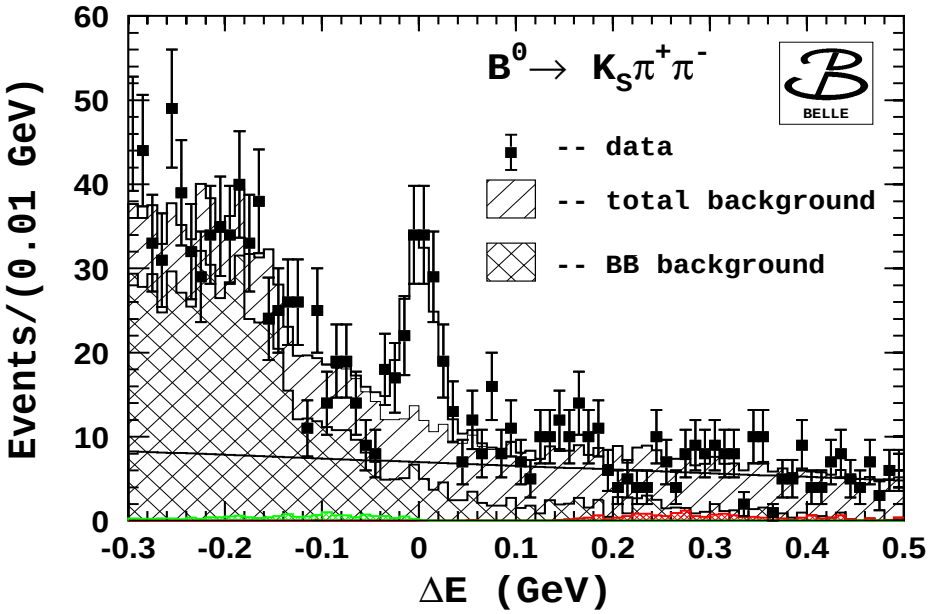
$b \to s$ transition contributes to only final states with odd number of kaons (s quarks): $K\pi\pi$, KKK

$b \to u$ tree and $b \to d$ penguin transitions contributes to final states with even number of kaons (s quarks): $\pi\pi\pi$, $K\bar{K}\pi$. The contribution to states with odd number of kaons is Cabibbo suppressed

''*wrong flavor*'' final states such as $K^+K^+\pi^-$ and $K^-\pi^+\pi^+$ are expected to be negligibly small ($\sim 10^{-11}$) in SM $\to$ good test of physics beyound the SM

Results: $B^{+(0)} \to K^{+(0)}\pi^+\pi^-$





Fit components:

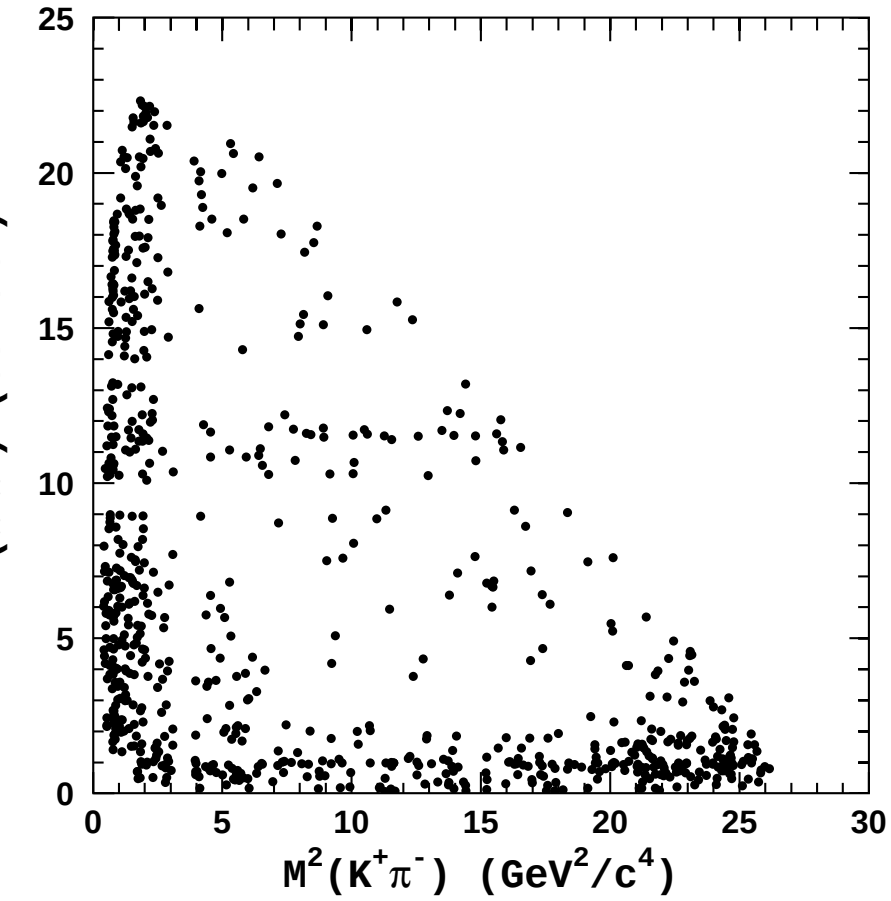
- ✓ Signal: double Gaussian with fixed mean and widths
- ✓ Continuum: linear function
- ✓ $B\bar{B}$ background: shape fixed from MC; normalization free
- ✓ Rare B background (fixed):
  - ◇ $B \to hh$: red histogram
  - ◇ $B \to \eta' K \to (\gamma\pi^+\pi^-)K$: green histogram
  - ◇ $B^+ \to \rho^0\pi^+ \to (\pi^+\pi^-)\pi^+$: blue histogram

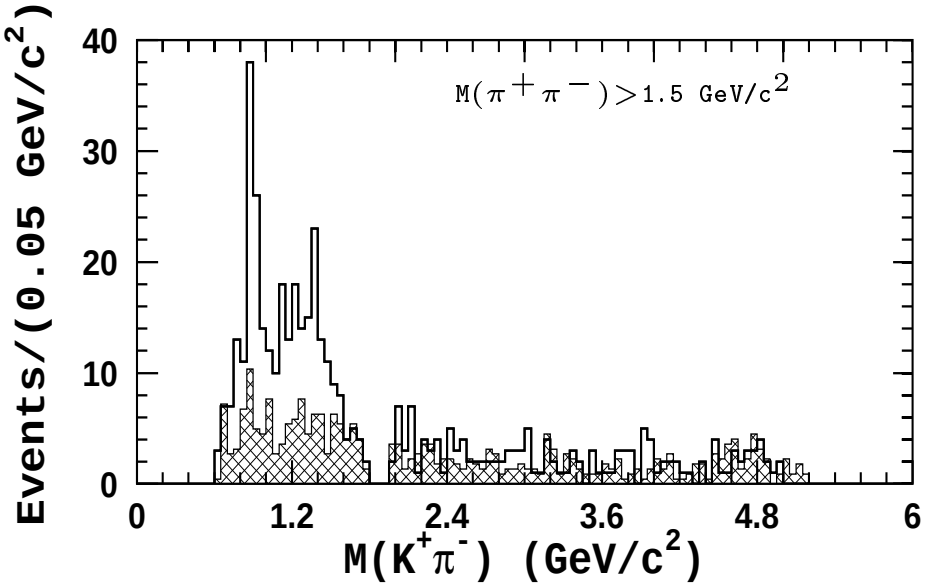
Fit Results:

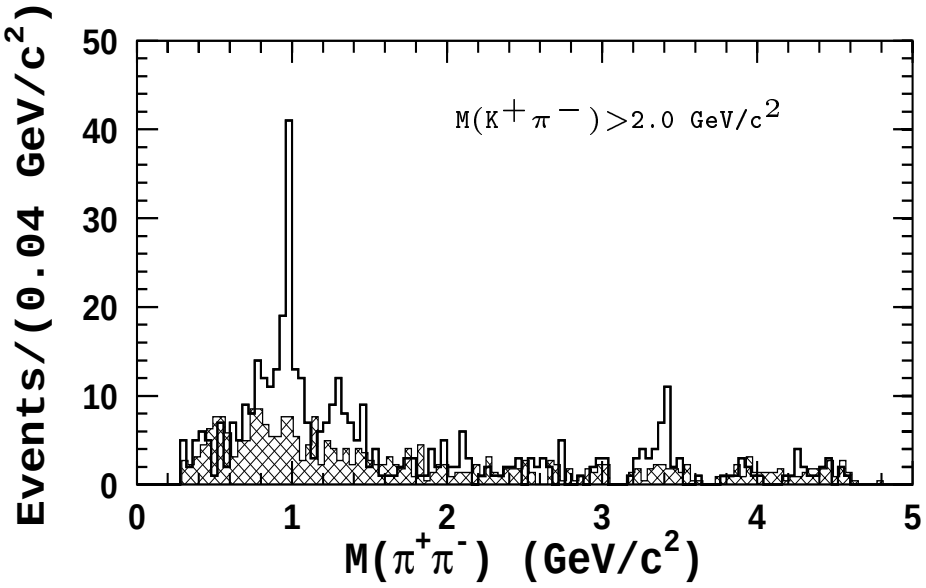
$\mathbf{N}(K^+\pi^+\pi^-) = 463 \pm 32$

$\mathbf{N}(K_S\pi^+\pi^-) = 94.7 \pm 14.4$

Results: $B^+ \to K^+\pi^+\pi^-$

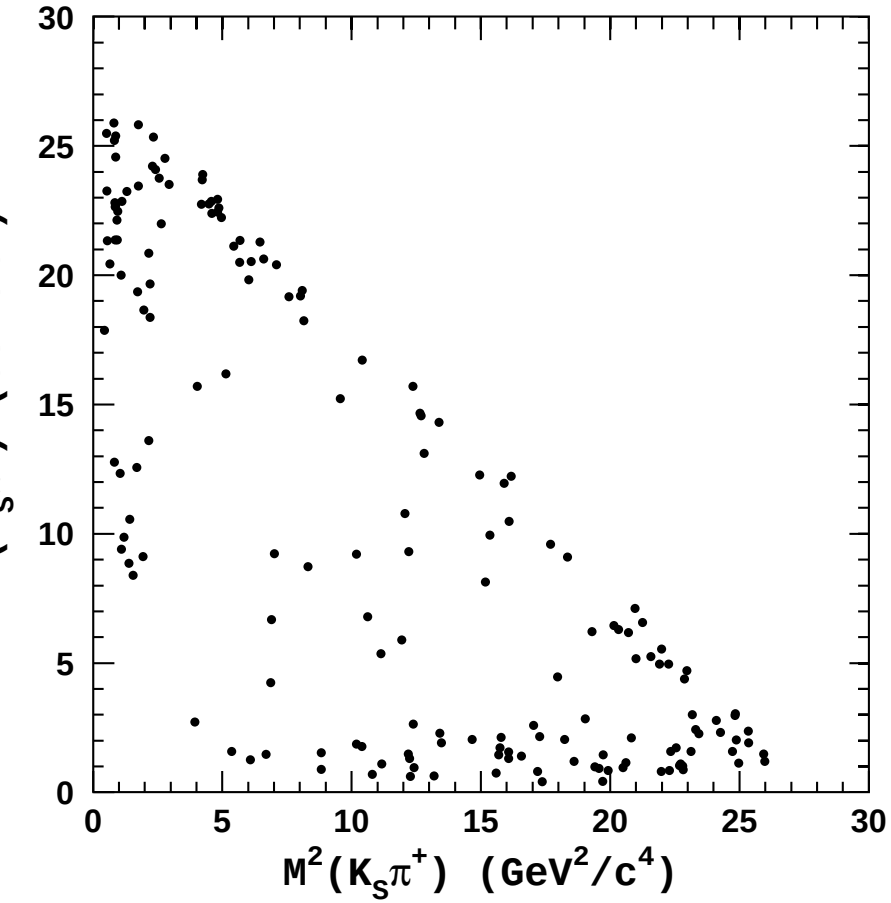


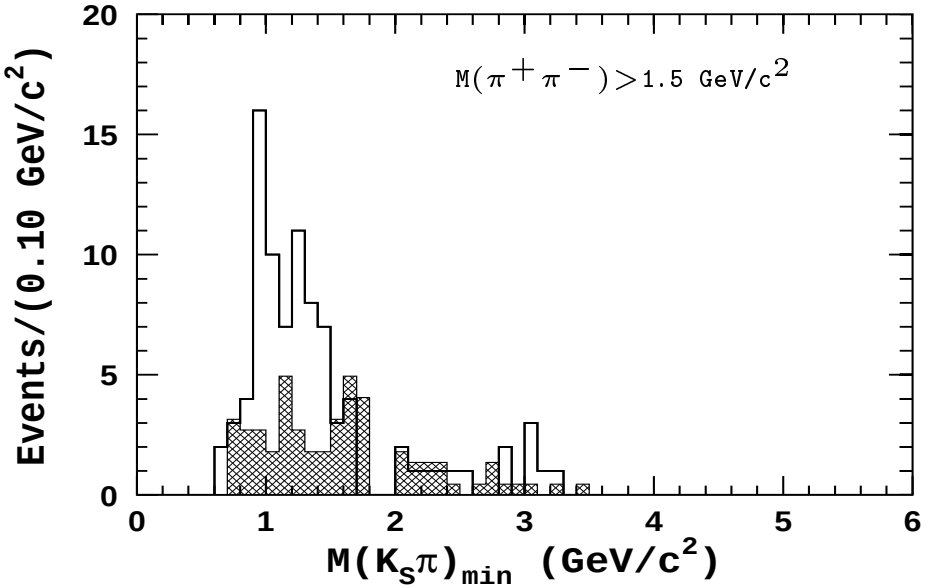


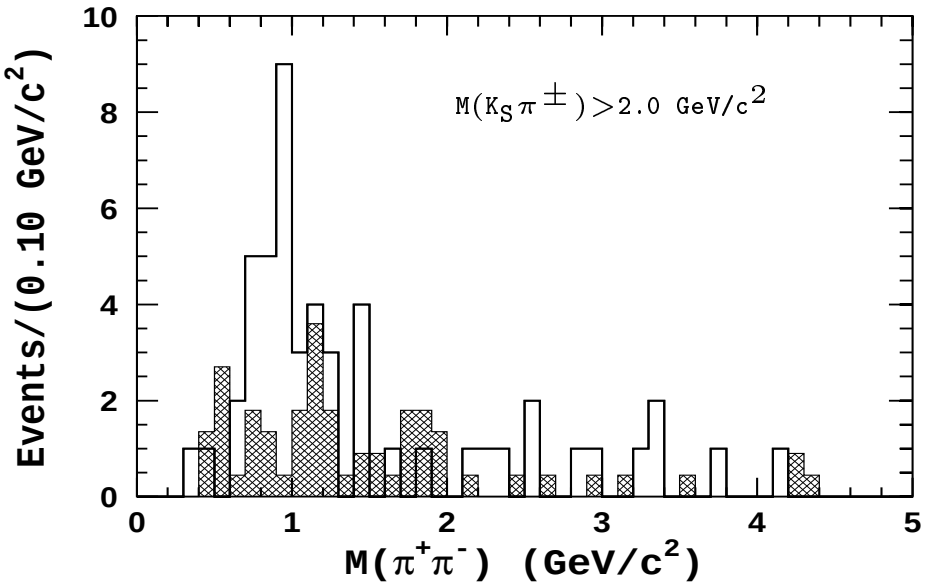


- open histograms - B signal region;
- hatched histograms - background estimation from the ΔE sidebands.

Results: $B^0 \to K_S\pi^+\pi^-$

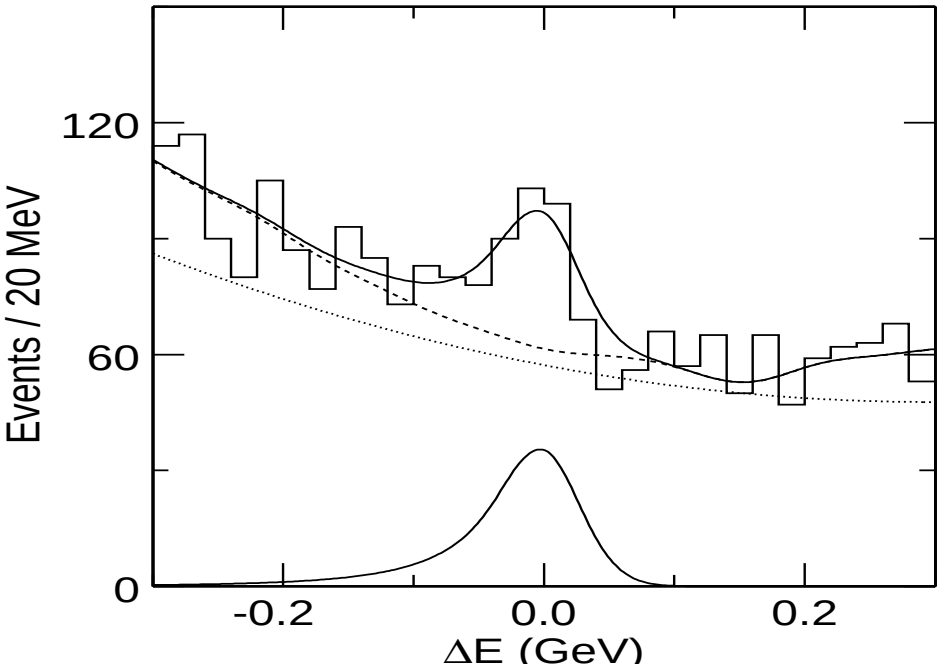






- open histograms - B signal region;
- hatched histograms - background estimation from the ΔE sidebands.

Results: $B^0 \to K^+\pi^-\pi^0$



dashed line - total background level

dotted line - continuum background

Large combinatorial background from low momentum π^0

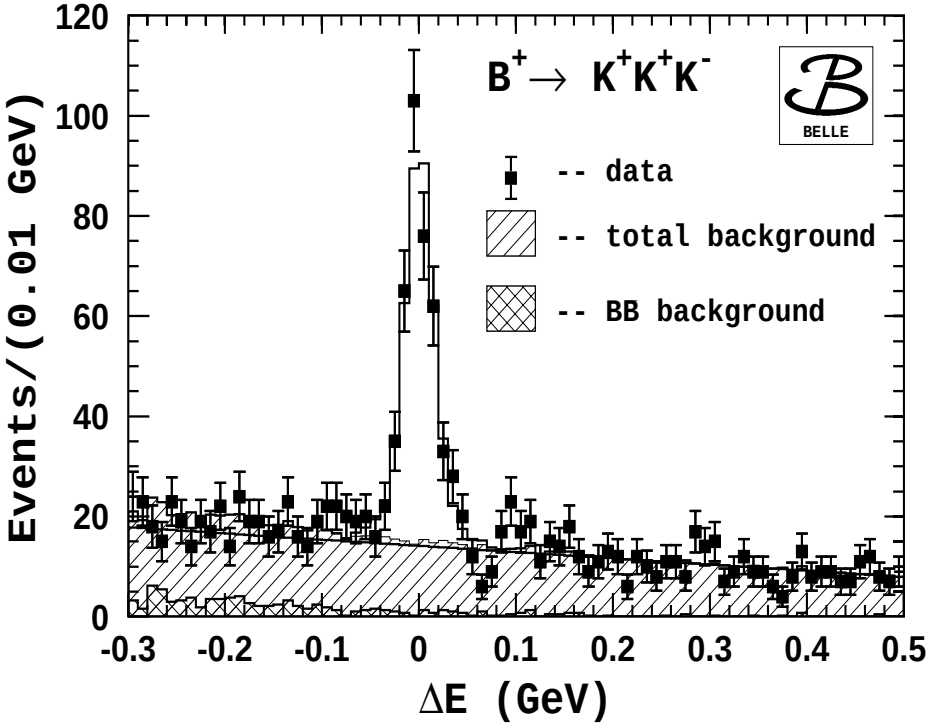
Complicated $B\bar{B}$ background shape

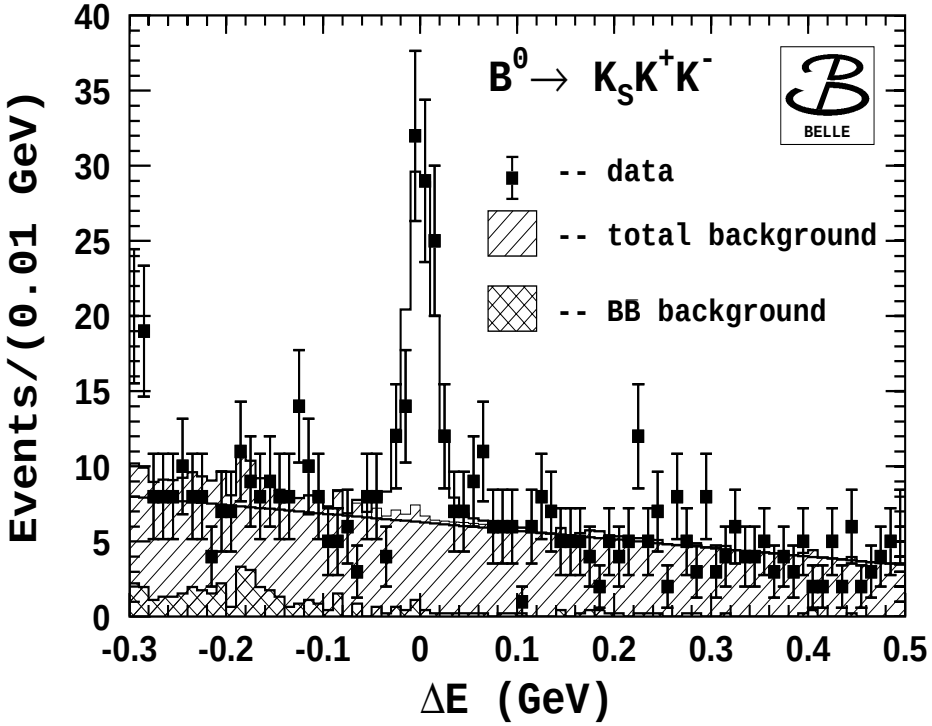
Fit Results:

$\mathbf{N(K^+\pi^-\pi^0) = 173 \pm 30}$

Analysis of quasi-two-body intermediate states is in progress

Results: $B^{+(0)} \to K^{+(0)} K^+ K^-$



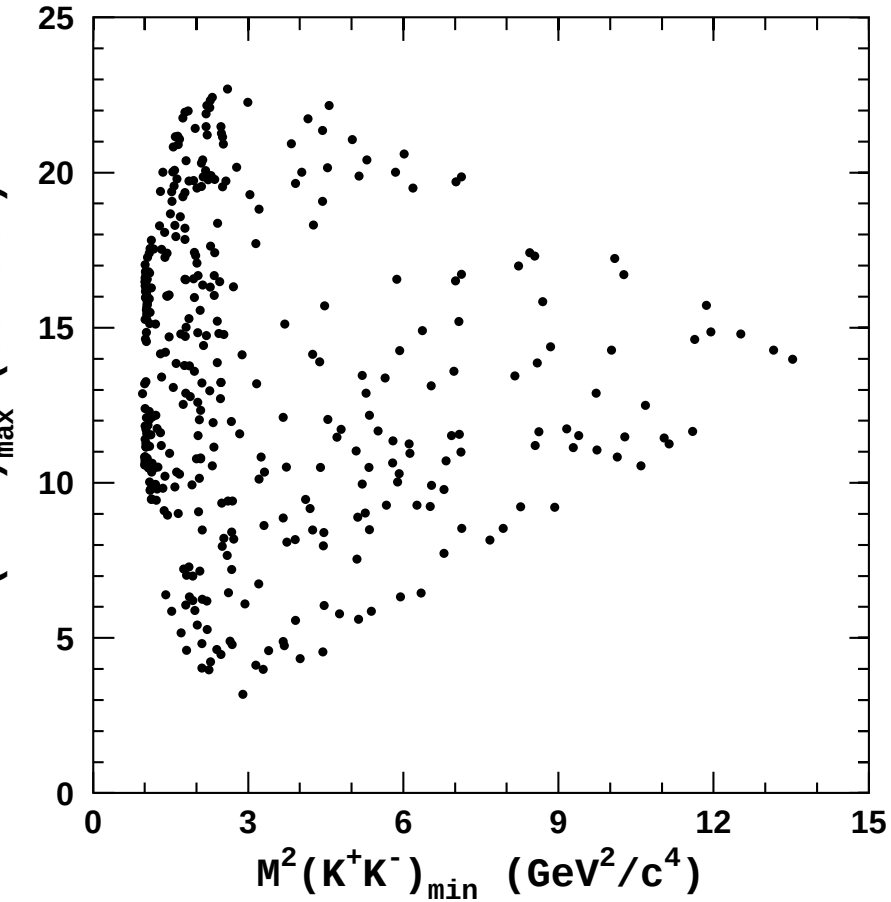


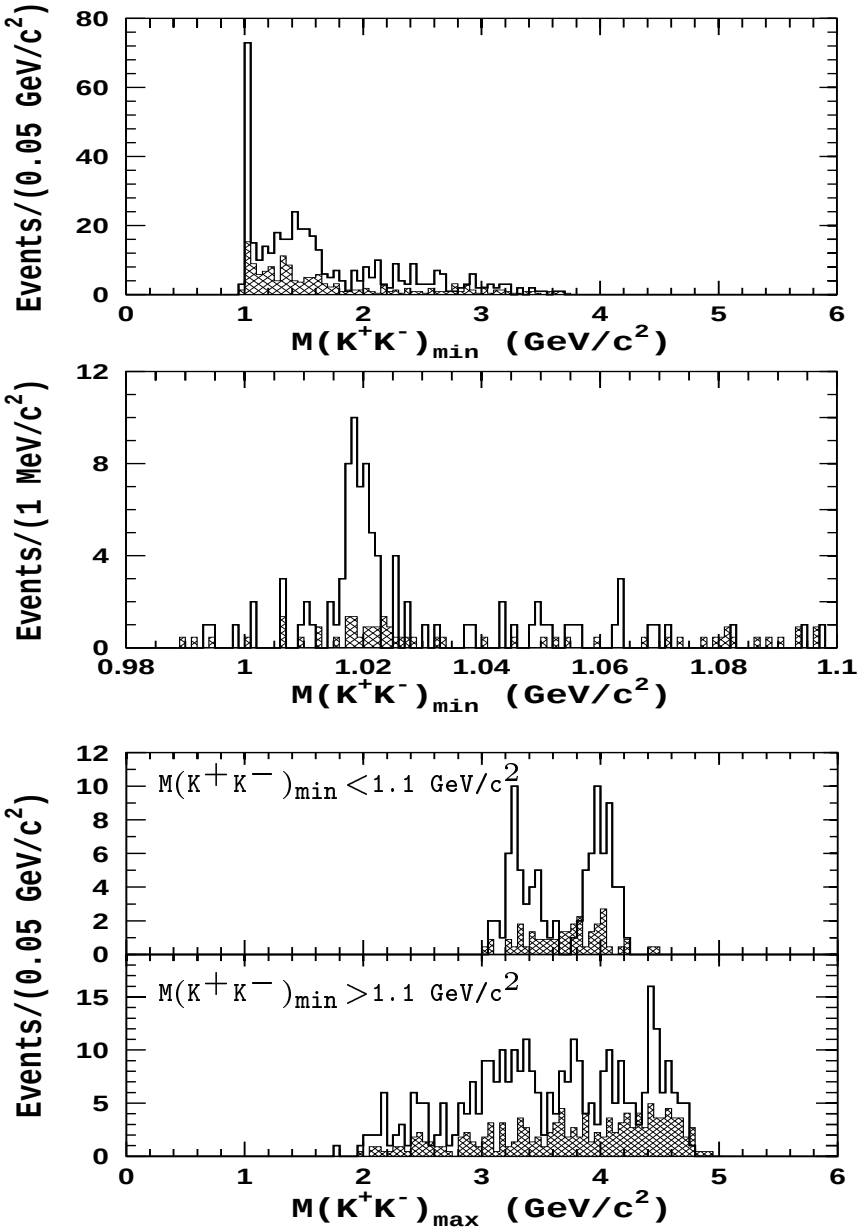
No background from rare B decays found

Fit Results:

$$\mathrm{N}(K^+K^+K^-) = 289 \pm 20$$
$$\mathrm{N}(K_S K^+ K^-) = 88.8 \pm 11.8$$

Results: $B^+ \to K^+K^+K^-$





- open histograms - B signal region;
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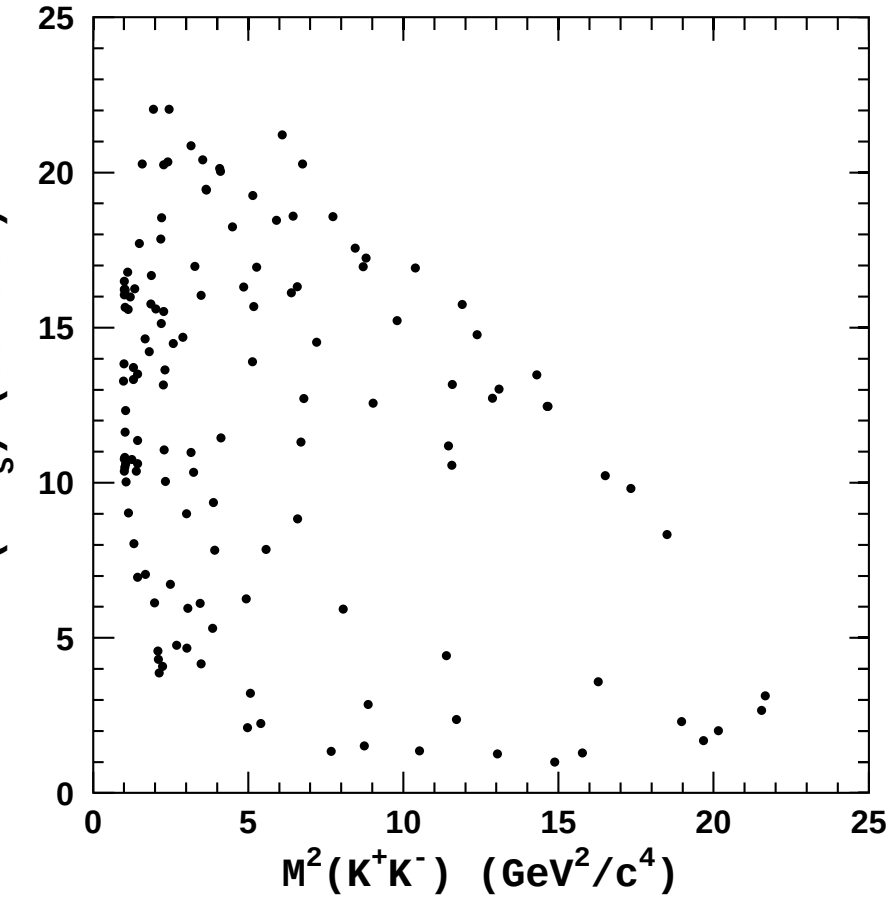
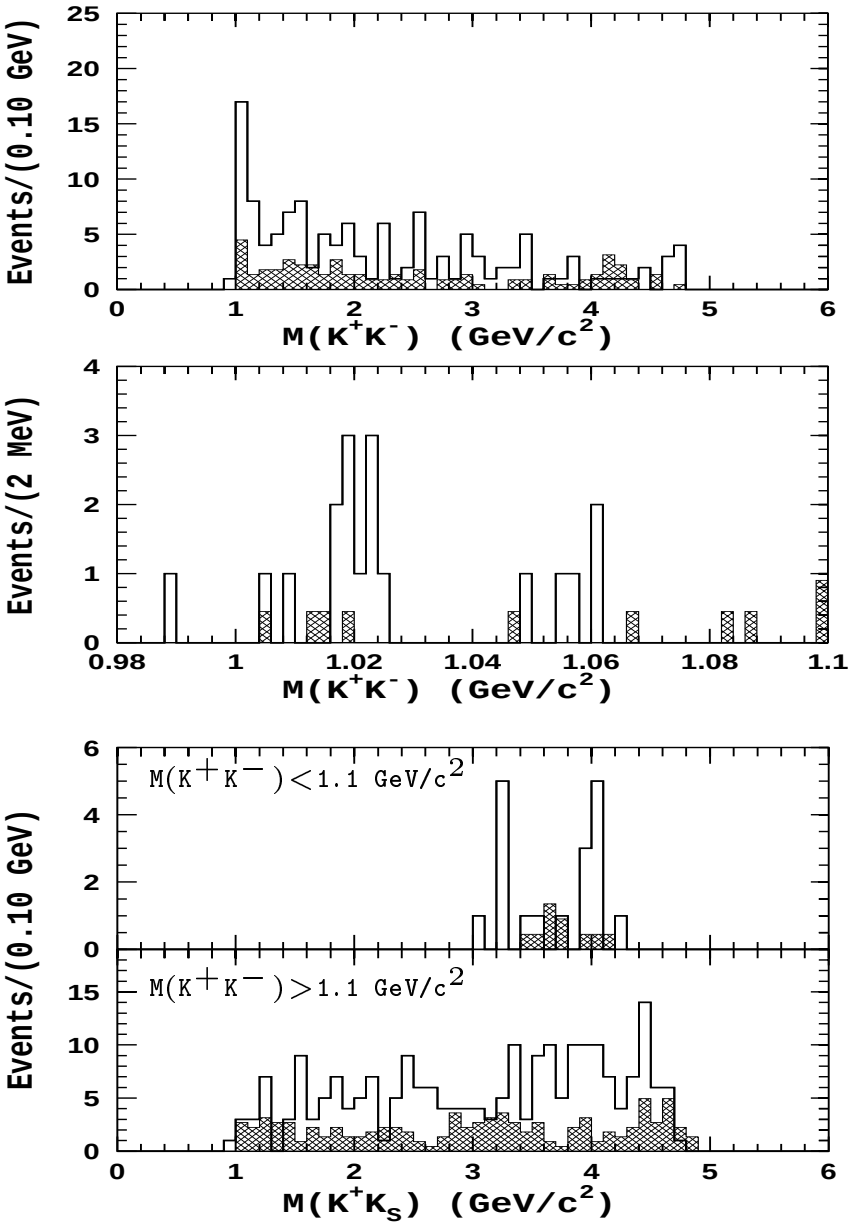
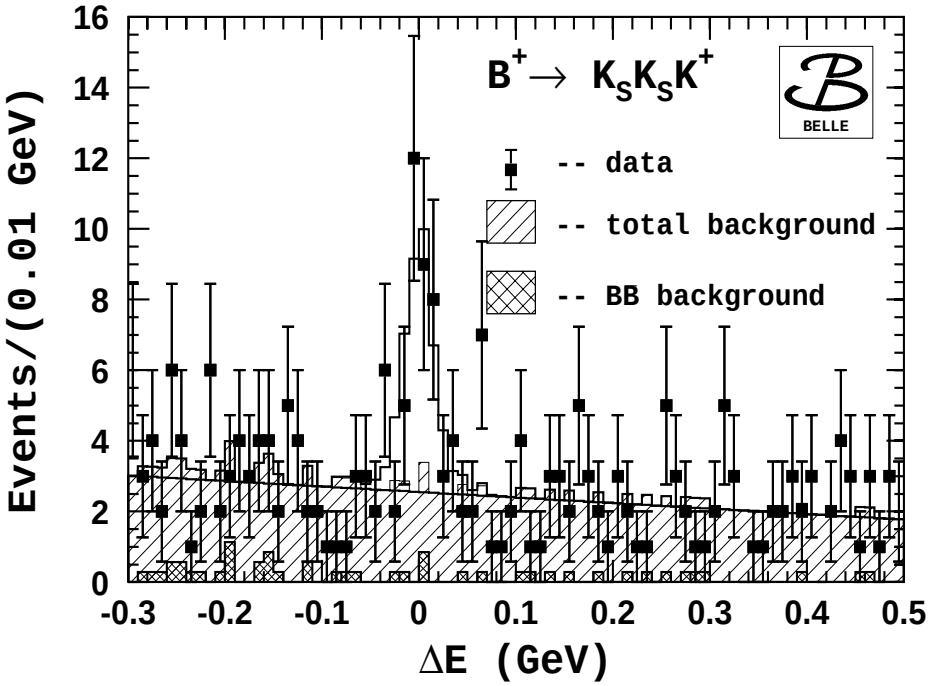
Results: $B^0 \to K_S K^+ K^-$

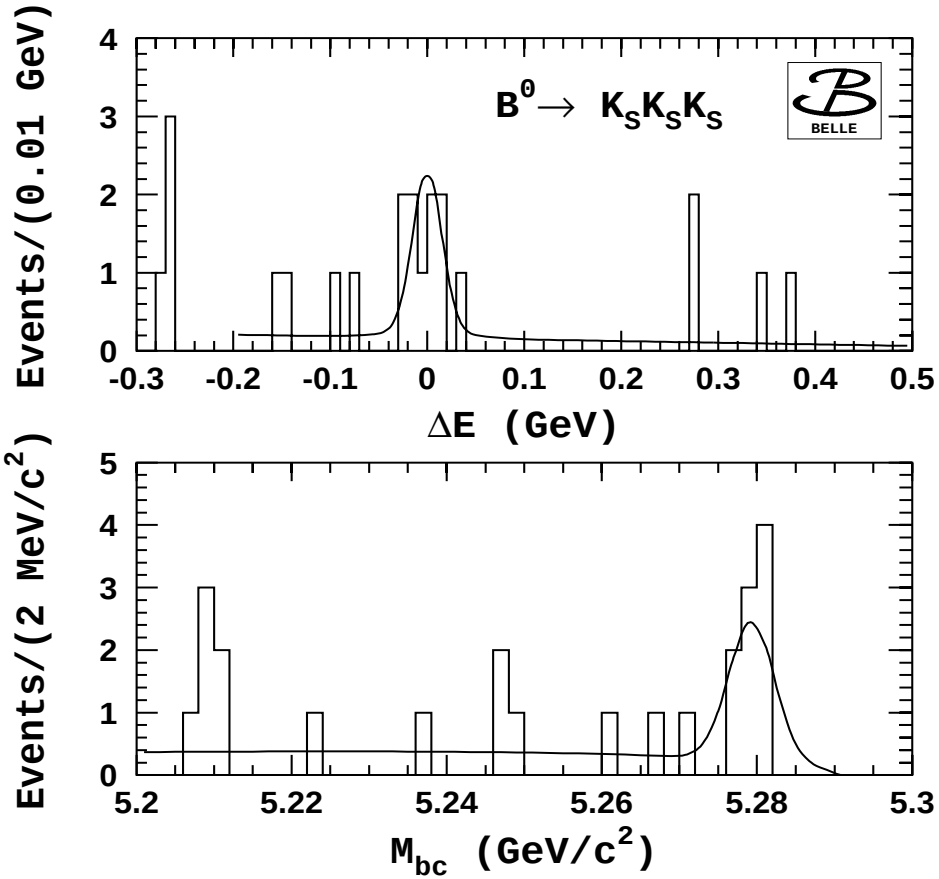




- open histograms - B signal region;
- hatched histograms - background estimation from the ΔE sidebands.

Results: $B^{+(0)} \to K^0 K^0 K^{+(0)}$





No background from rare B decays found

Fit Results: $\mathrm{N}(K_S K_S K^+) = 27.5 \pm 6.7$

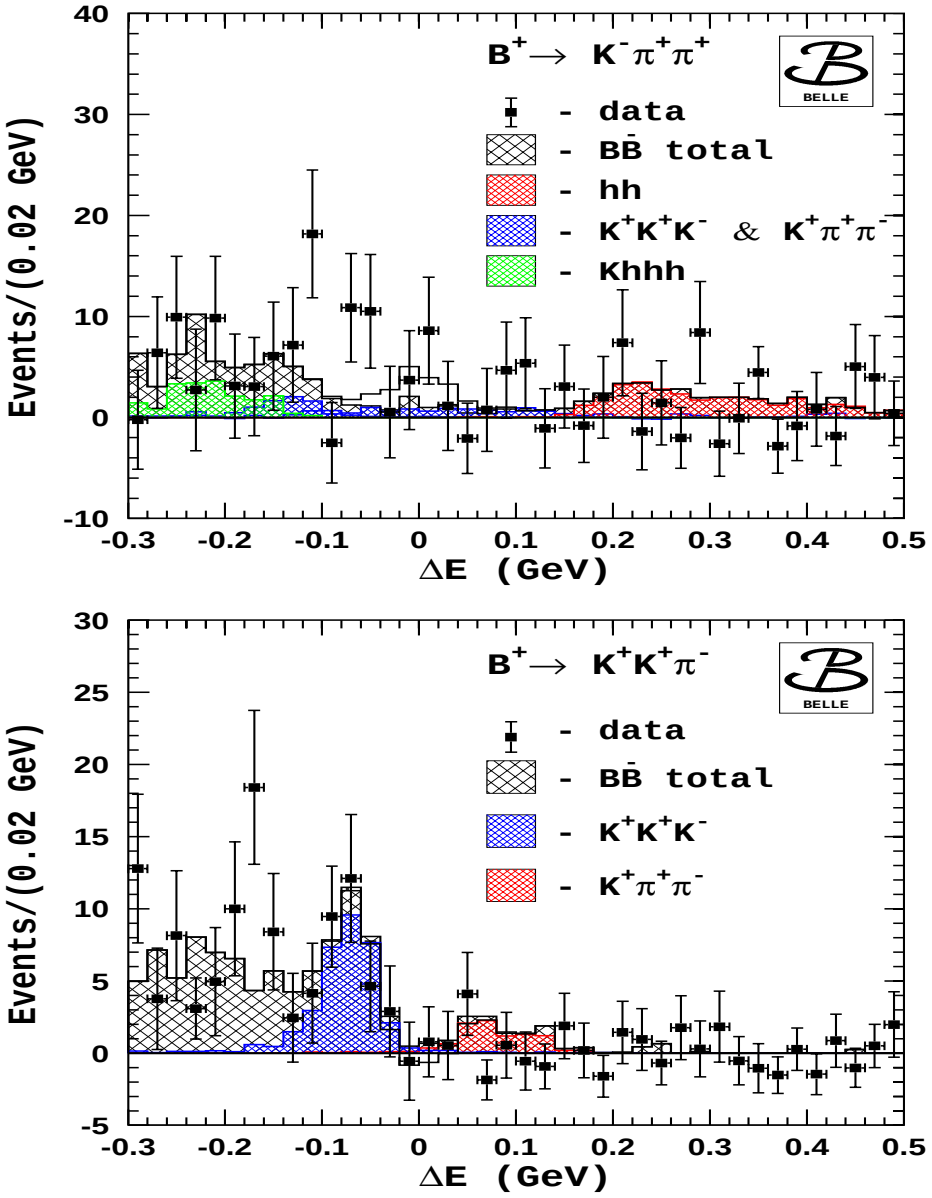
significance $= 5.2\sigma$

$\mathrm{N}(K_S K_S K_S) = 8.4^{+3.6}_{-2.9}$

significance $= 4.0\sigma$

First Observation !!!

Results: $B^+ \to K^-\pi^+\pi^+$ & $B^+ \to K^+K^+\pi^-$



Analysis method:

- ✓ subdivide ΔE into bins (20 MeV)
- ✓ extract signal yield in each ΔE bin from the fit to the corresponding $M_{\rm bc}$ distribution
- ✓ fit resulting ΔE distribution

Fit components:

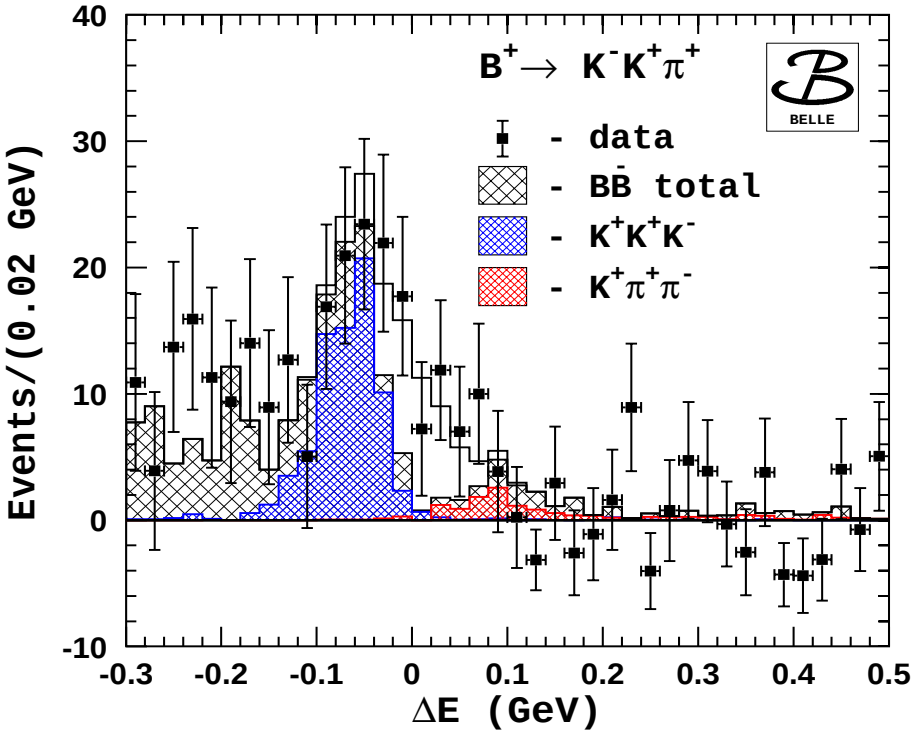
- Signal: shape fixed from $B^+ \to \bar{D}^0\pi^+$ data; normalization - free
- $B\bar{B}$ generic: fixed from MC
- Rare Background:
  - $B \to hh$, $B \to Khh$, $B \to Khhh$ fixed from signal MC

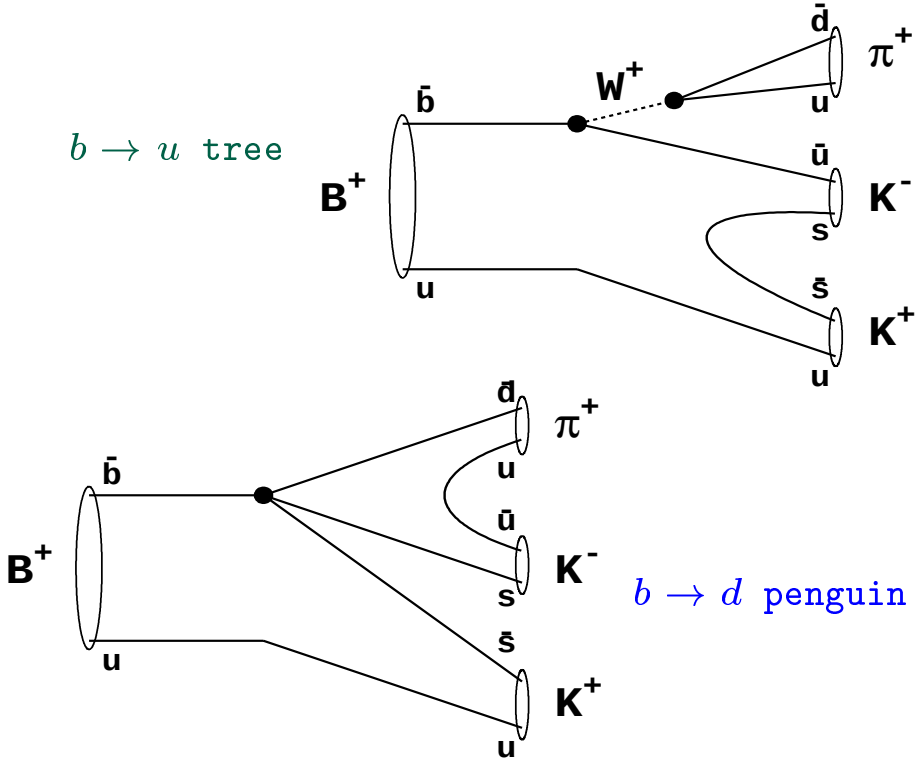
Fit results:

$$\mathbf{N}(K^-\pi^+\pi^+) = 14 \pm 12$$

$$\mathbf{N}(K^+K^+\pi^-) = -4.7 \pm 9.0$$

Results: $B^+ \to K^+K^-\pi^+$



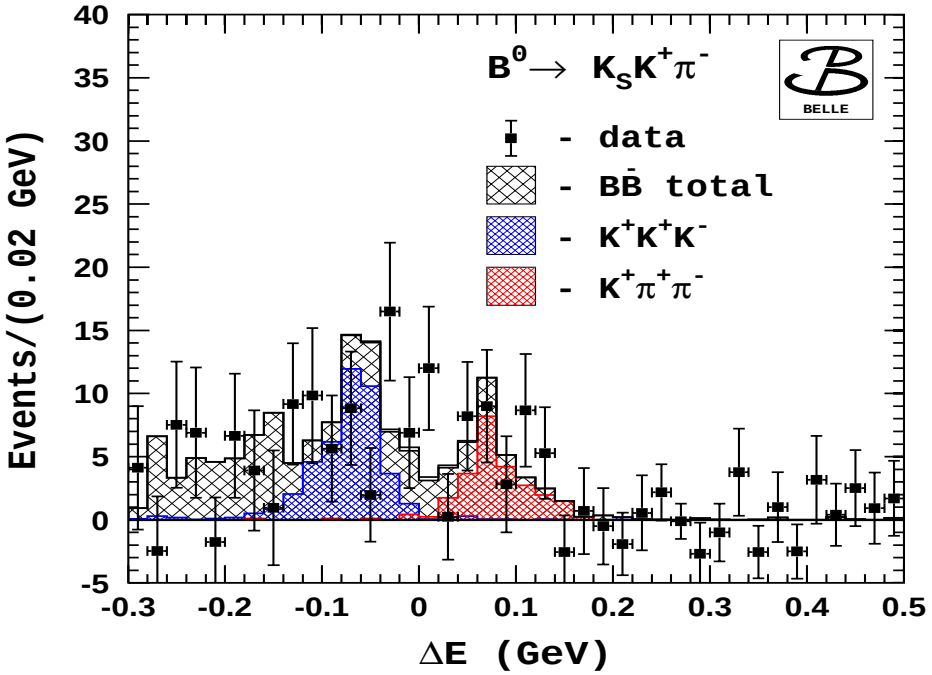


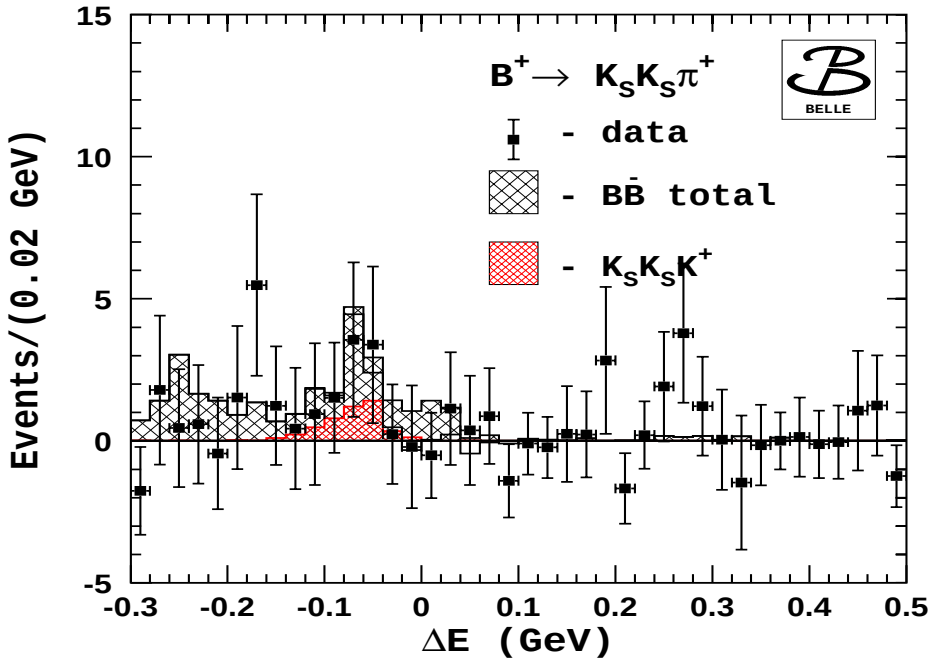
Fit results:

$\mathrm{N}(K^+K^-\pi^+) = 49 \pm 15$

Evidence for $b \to u$ in $B^+ \to K^+K^-\pi^+$?

Results: $B^0 \to K_S K^{\pm}\pi^{\mp}$ & $B^+ \to K_S K_S \pi^+$





Fit Results:

$\mathrm{N}(K_S K^{\pm}\pi^{\mp}) = 1.2 \pm 11$

$\mathrm{N}(K_S K_S \pi^+) = -6.4 \pm 8.1$

First Result

Summary

Three-body branching fractions

Mode	Efficiency, %	Yield, events	$\mathcal{B}, 10^{-6}$ (43fb^{-1})	$\mathcal{B}, 10^{-6}$ (29fb^{-1})	
$K^+\pi^-\pi^+$	21.1	463 ± 32	59.3 ± 4.1	$55.6 \pm 5.8 \pm 7.7$	*
$K^0\pi^-\pi^+$	5.23	94.7 ± 14.4	41.7 ± 7.2	$53.2 \pm 11.3 \pm 9.7$	**
$K^+\pi^-\pi^0$	11.6	$173^{+30.5}_{-29.6}$	–	$47.1 \pm 8.2 \pm 6.3$	***
$K^+K^+K^-$	22.2	289 ± 20	35.8 ± 2.5	$35.3 \pm 3.7 \pm 4.3$	*
$K^0K^+K^-$	7.10	88.8 ± 11.8	32.3 ± 4.8	$34.8 \pm 6.7 \pm 6.5$	**
$K_SK_SK^+$	5.76	27.5 ± 6.7	13.1 ± 3.2	–	
$K_SK_SK_S$	3.86	$8.2^{+3.5}_{-2.9}$	$5.5^{+2.3}_{-1.9}$	–	
$K^+K^-\pi^+$	13.8	49 ± 15	$9.1 \pm 2.8 (< 14)$	< 12	*
$K^+K^+\pi^-$	14.2	-4.7 ± 9	< 2.0	< 3.2	*
$K^-\pi^+\pi^+$	17.0	14 ± 12	< 5.4	< 7.0	*
$K^0K^\pm\pi^\mp$	4.53	1 ± 11	< 9.2	< 13.4	**
$K_SK_S\pi^+$	5.31	-6.4 ± 8.1	< 3.3	–	

PRELIMINARY

* published in Phys. Rev. D65:092005, 2002

** to be submitted to PRL

*** preliminary result

Conclusion

- A number of branching fraction of B mesons decays to three-body charmless final states have been measured
- The $K_S K_S K^+$ and $K_S K_S K_S$ three-body final states have been observed for the first time; evidence for the $K^+ K^- \pi^+$; first result on $K_S K_S \pi^+$
- A number of quasi-two-body final states have been observed: $K^*(892)^0 \pi^+$, $f_0(890) K^+$ (first $B \to SP$ decay), etc.
- The extraction of quasi-two-body branching fractions requires the full amplitude analysis of the Dalitz plot
- Analysis of three-body final states provides new possibilities for the study of CP violation in B decays