Search for exotics in the rare decay $B \to J/\psi K K K$ @ BABAR

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Motivation

Three body decay 
Cabibbo and color suppressed
Predicted $B^+ \to J/\psi K^+$

Possibility to proceed as quasi 2-body decay

Transition $B \to \psi(2S)$ promising place to search for $\psi(2S)$ exotic states

If any $\psi(2S)$ exists, it is expected below 4.3 GeV/c^2 (2D threshold)

Analysis strategy @ BABAR

- e^+e^- collider, 424 fb^-1 integrated lumi., run @ $E_{cm} = 10.56$ GeV
- $J/\psi$ mass constraint, reconstructed to $e^+e^-$ and $\mu^+\mu^-$
- $K^+$ reconstructed to $K^0 K^+$ in $[1.004;1.034]$ GeV/c^2
- $\phi$, reconstructed to $\pi^+\pi^-$ in $[0.485;0.515]$ GeV/c, no PID
- 860 000 generated MC events, EVGens, PHSP model:
- MC simulations used to validate the fit procedure
- $\phi$ and $J/\psi$ are 2 vectors, then can be polarized. MC simulations for 2 extreme cases are generated (100% transv- and long-polarized) to evaluate effects on the efficiency change

Kinematic variables:

- $m_{bc} = \sqrt{E^2_{beam} - p^2_{beam}}$
- $\Delta E = E^*_{beam} - \sqrt{s}$

Goals of this analysis

- Measure the Branching Fraction (BF) of:
  - $B^+ \to J/\psi K K^+$ in all $K K^+$ range available, [0.98, 1.69] GeV/c^2
  - $B^+ \to J/\psi K K^+$ in all $K K^+$ range available, [0.98, 1.69] GeV/c^2
  - $B^+ \to J/\psi K'$ in the $K K'$ range [1.004;1.034] GeV/c^2, where $\phi$ lies
  - $B^+ \to J/\psi K$ in the $K K$ range [1.004;1.034] GeV/c^2, where $\phi$ lies

- Search for $B^+ \to J/\psi K'$: no signal expected $bd \to \psi(2S)$ with rescattering of $\phi$ into $\psi(2S)$

- Search for resonant states in the invariant mass distributions:
  $J/\psi KK$, $J/\psi K K^+$ (charged and neutral B channels)

Unbinned maximum likelihood $m_{bc}$ fit
Best $B$ candidate with $\Delta E$ minimum, $|\Delta E| = 30$ Mev for $B^+$, $|\Delta E| = 25$ MeV for $B^0$

Observation of:

- $B^+ \to J/\psi K K'$, $B^+ \to J/\psi K K^+$, $B^0 \to J/\psi \phi K^0$, $B^0 \to J/\psi \phi K^0$

Significance >5s for all these decay modes

Approach followed for searching new resonances in $J/\psi$, $J/\psi K$, $K K K$

- Mass resolution at $J/\psi$ mass threshold: 2 MeV/c^2
- Additional selection cut $m_{bc}>527$: signal box, small background.
- Purity of $B^+$ sample: 89.2%; purity of $B^0$ sample: 82.0%
- Efficiency study in all inv mass range: loss of efficiency at the threshold, due to the very low momentum kaons
- Fit function: sum of 2 incoherent Breit-Wigner (BW) functions + PHSP.
- The fit function is weighted by 2D-efficiency map from the MC
- PHSP Dalitz plots. We fit the Dalitz projections: mass and width fixed
- No main structure observed: in $J/\psi$ inv mass enhancements <2$\sigma$
- $\chi^2$ of the fit is better when adding 2 BWs to PHSP.

Complicated decay dynamics in the system of $J/\psi$ due to the presence of 2 vectors.

We would need a full Dalitz plot analysis and more statistics for best understanding

Results

- $m_{bc}$ distribution

Channel Fit $x(4140)$ $x(4270)$ fit

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<tr>
<th>Channel</th>
<th>$B^+$</th>
<th>$B^0$</th>
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<tbody>
<tr>
<td>$B^+ \to J/\psi K K^+$</td>
<td>$x(4140)$</td>
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Conclusions

- New BF measurements performed for the first time
- $K^+$ non-resonant contribution to $B^0 \to J/\psi K K^+$
- UL at 90% c.l for $B^+ \to J/\psi K K^+$
- UL for the existence of the $X(4140)$ and the $X(4270)$

[1] previously addressed at JGU University of Mainz, DE