Study of the $B \rightarrow J/\psi K \pi \pi$ *decay* *and* *measurement of the* $B \rightarrow X(3872)K$ *branching fraction*

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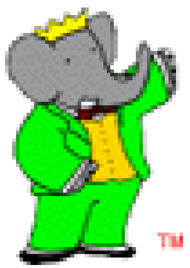
on behalf of the

BaBar Collaboration



Motivations

Charm and charmonium states can be studied in *B- Factories*

$$e^+ e^- \rightarrow \Upsilon(4S) \rightarrow B\,\overline{B}$$

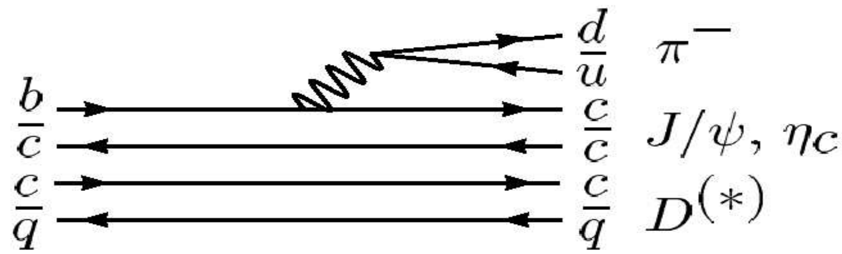
- $B \rightarrow J/\psi\, K\, \pi\, \pi$ decays relevant to understand states with high multiplicity in B decays
- Search for new charmonium states

$$B \rightarrow X_{c\,c}\, K \;,\; X_{c\,c} \rightarrow J/\psi\, \pi\, \pi$$

Motivations

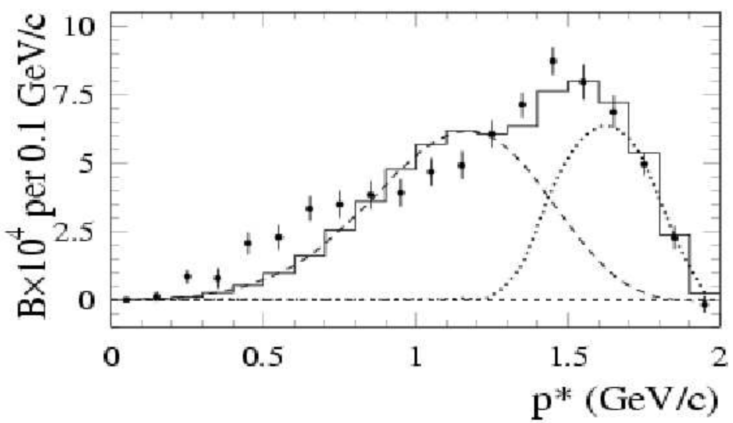
- Intrinsic charm production

  $c\bar{c}c$ in $\bar{B}$ decay final states



$B \rightarrow J/\Psi\ D\ \pi$, $D \rightarrow K\ \pi$ to explore the J/Ψ low momentum anomaly produced in inclusive $B \rightarrow J/\Psi\ X$ decays

J/ψ low p* anomaly



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BABAR

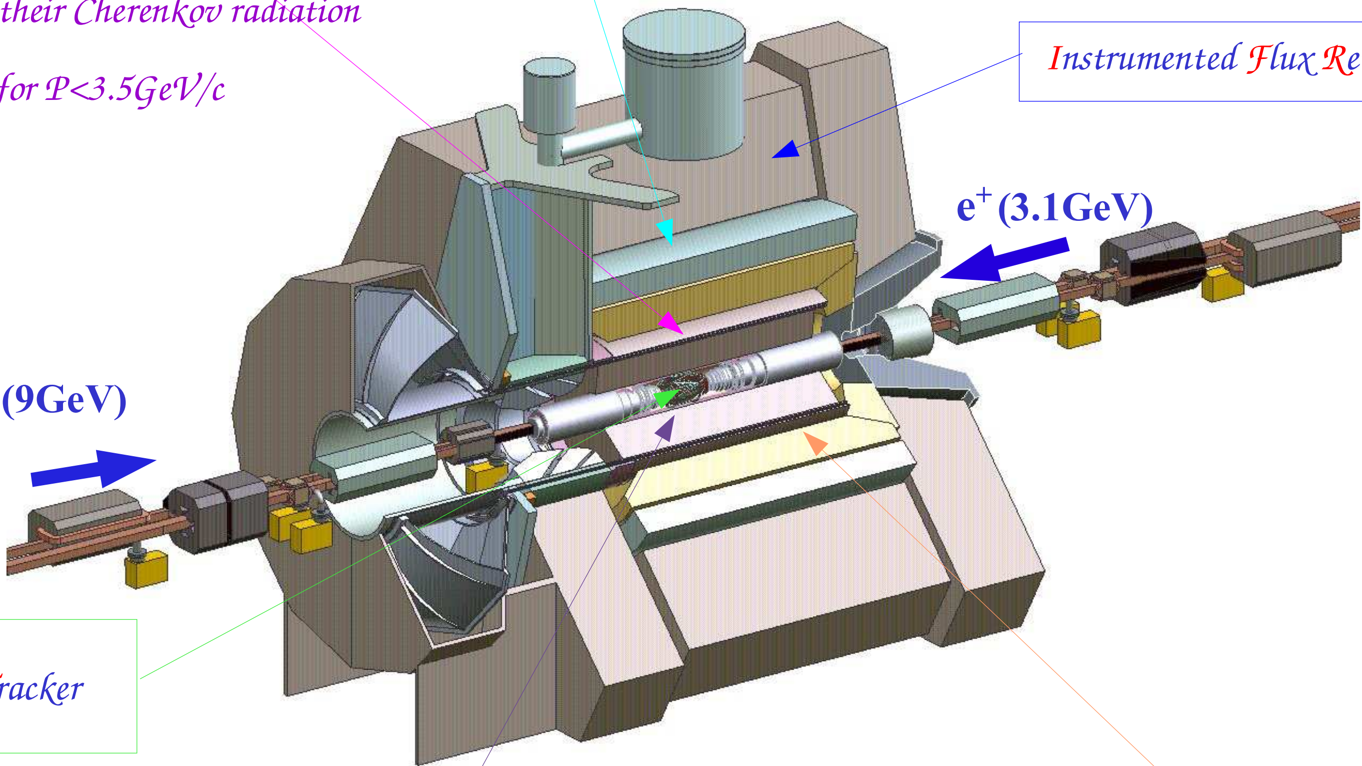
Detector of Internally Reflected Cherenkov light

1. 5T solenoid

Identifies particles by their Cherenkov radiation

K-π separation>3.4σ for P<3.5GeV/c

Instrumented Flux Return



Silicon Vertex Tracker

Measures origin of charged particle
Trajectories + dE/dx
97% efficiency

Drift CHamber

Measures momentum of charged particles + dE/dx

$\sigma(p_T)/P_T = 0.13\% P_T \oplus 0.45\%$

ElectroMagnetic Calorimeter

Measures energy of electrons and photons

$\sigma(E)/E = 1.33\% E^{-1/4} \oplus 2.1\%$

Event Selection

- J/Ψ reconstructed from pairs of *electrons* or *muons* selected with a *loose* criteria

  $J/\Psi \to e^+ e^-$: $2.95 < m_{ee} < 3.14$ GeV/ c^2 $|\cos\theta_{thrust}| < 0.8$

  $J/\Psi \to \mu^+ \mu^-$: $3.06 < m_{\mu\mu} < 3.14$ GeV/ c^2 $|\cos\theta_{thrust}| < 0.9$

  a constraint on J/Ψ candidates mass is applied

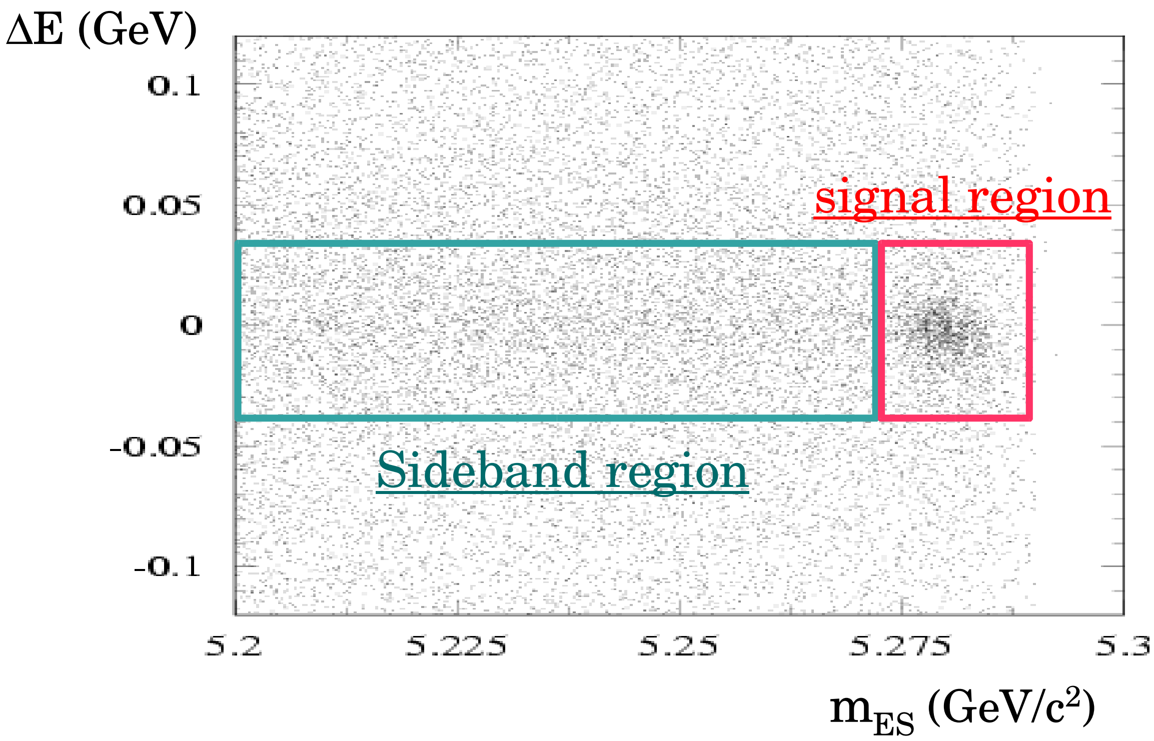
- *Kaons* identified using a *loose* criteria

- *2* uncorrelated kinematic variables

$$m_{ES} = \sqrt{s/4 - p^{*2}_B}$$

$$\Delta E = E^*_B - \sqrt{s} / 2$$

used to separate signal and background



$B \to J/\psi K \pi \pi$ *Branching Fraction*

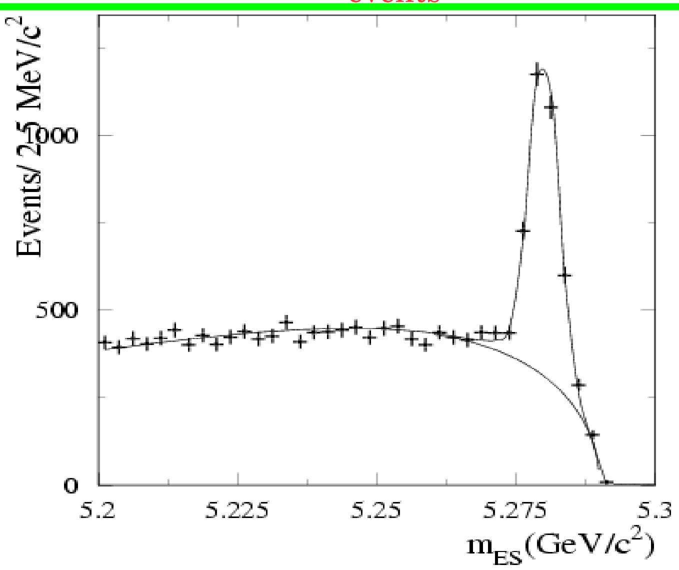
$$R = \frac{Br(B^{\pm} \to J/\psi K^{\pm} \pi^{+} \pi^{-})}{Br(B^{\pm} \to \psi(2S) K^{\pm})} = \frac{N_{events}}{N_{\psi(2S)}} \frac{\varepsilon_{\psi(2S)}}{\varepsilon} Br(\psi(2S) \to J/\psi \pi^{+} \pi^{-})$$

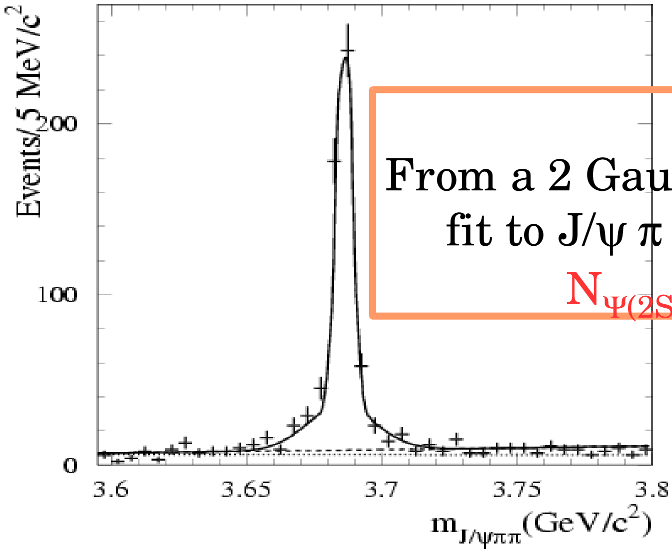
<u>to reduce systematic errors:</u>
$Br(B \to \Psi(2S)K) = (6.8 \pm 0.4)10^{-4}$
from PDG 2003

From MC

$Br(\Psi(2S) \to J/\psi \pi \pi) =$
$(31.8 \pm 1.0)\%$
from PDG 2003

from Crystal Ball + Argus fit to the m_{ES} distribution
$N_{events} = 2540 \pm 72$





From a 2 Gaussian+flat background fit to $J/\psi \pi \pi$ mass distribution
$N_{\Psi(2S)} = 556 \pm 30$

$\mathcal{B}r(B \to J/\psi K \pi\pi)$: *Results*

	N_{events}	$N_{\Psi(2S)}$	$\varepsilon_{\Psi(2S)} / \varepsilon$	R
Default	2540 ± 72	556 ± 30	1.17 ± 0.03	1.70 ± 0.10
MC resolution	2540 ± 72	553 ± 26	1.12 ± 0.03	1.64 ± 0.09
p2 background	2540 ± 72	549 ± 30	1.15 ± 0.03	1.70 ± 0.10
argus+gauss m_{ES} fit	2445 ± 67	551 ± 26	1.19 ± 0.03	1.68 ± 0.09
Electrons	1324 ± 52	261 ± 18	1.15 ± 0.04	1.86 ± 0.15
Muons	1215 ± 48	283 ± 19	1.18 ± 0.04	1.61 ± 0.13

$$R = \frac{Br(B \to J/\psi K \pi\pi)}{Br(B \to \Psi(2S) K)} = 1.70 \pm 0.10\ (stat.) \pm 0.09\ (syst.)$$

$$Br\ (B \to J/\psi K \pi\pi) = (11.6 \pm 0.7 \pm 0.9)\ 10^{-4}$$

PDG 2003 : $Br(B \to J/\psi K \pi\pi) = (7.7 \pm 2.0)\ 10^{-4}$ (1.7σ)

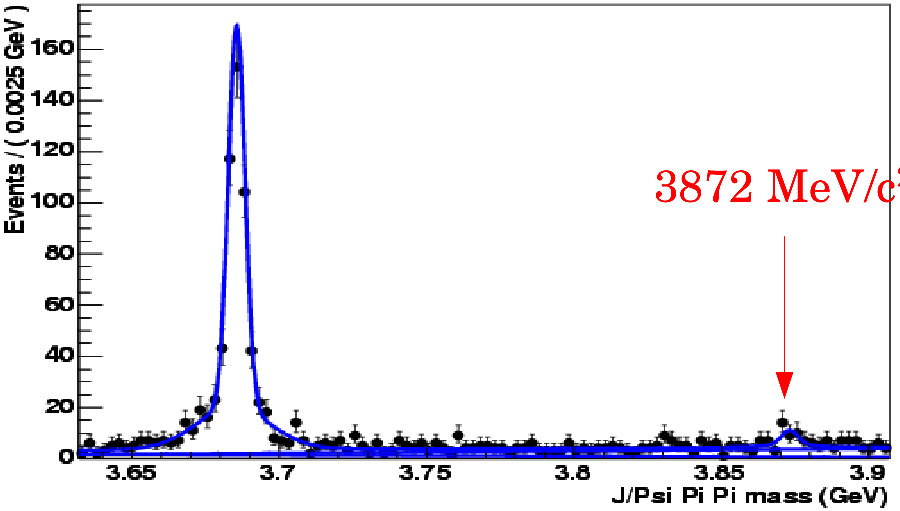
X(3872) *observation*

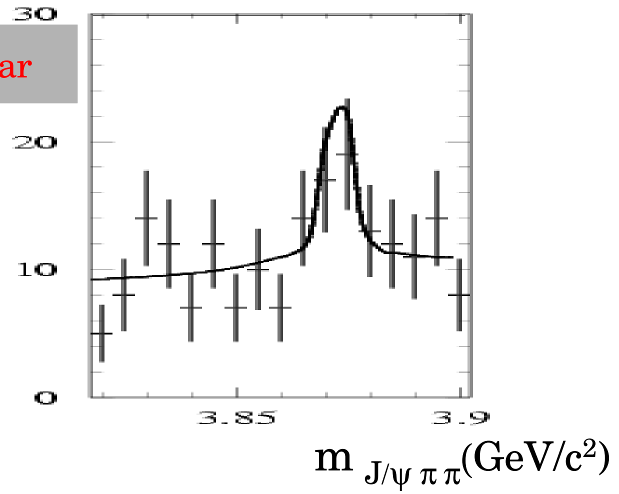
Looking at J/ψ π π mass distribution

Accumulation of events in the same spot as Belle and CDF

Mass resolution (from Ψ(2S) signal) consistent with Belle's (σ_1 = 3.1 MeV, σ_2 = 12 MeV, f_2 = 29%)

M_{belle}=(3872.0±0.8)MeV/c^2





Mass Measurement using *unbinned maximum likelihood fit* to m_{ES} and $m_{J/\Psi\pi\pi}$

4 PDF components :

signal, Ψ(2S) , B → J/ψ K π π,

combinatorial background

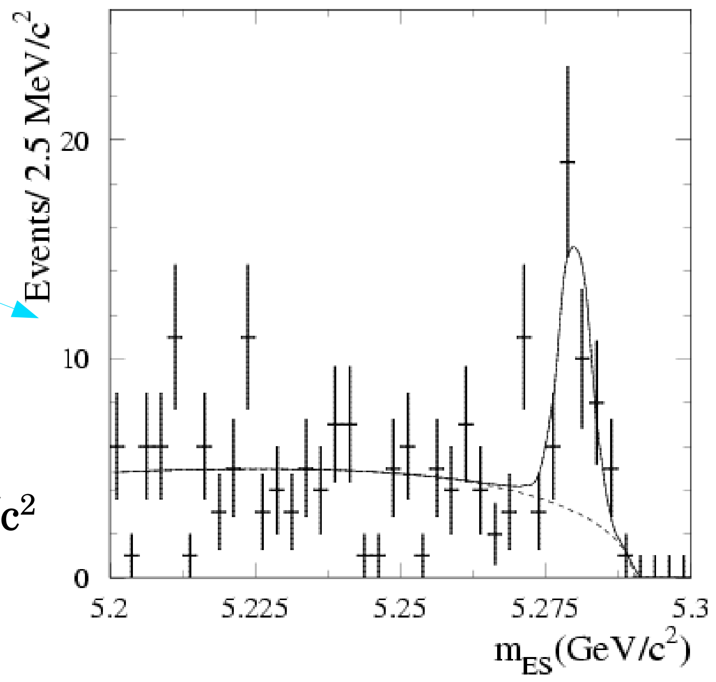
We measure mass difference w.r.t. the Ψ(2S): it allows us to neglect systematics errors on the absolute mass scale

$M_{X(3872)}$= (3873.4 ±1.4) MeV/c ^{2}

Br (B →X(3872)K) : *Strategy* (*I*)

- Define signal region : $3862 < m_{J/\Psi\pi\pi} < 3882$ MeV/c² (~ 95% of the signal) and estimate efficiency by applying the same cut to the Ψ(2S) : $\varepsilon = (92 \pm 1)\%$

- Estimate combinatorial background in the $m_{J/\Psi\pi\pi}$ signal region from a CB+Argus fit to the m_{ES} distribution : $N_{comb} = 22.0 \pm 4.3$.



- Estimate peaking background in 2 regions:

  symmetric sideband : $15 < |m_{J/\Psi\pi\pi} - 3872| < 45$ MeV/c²

  low sideband : $3760 < m_{J/\Psi\pi\pi} < 3840$ MeV/c²

  and take difference as systematic error

  $N_{peak} = 10.5 \pm 3.2 \pm 2.4$

- Count the number of the events in signal region with $m_{ES} > 5.27$ GeV/c² : $N_{data} = 63$

Br (B → X(3872)K) : *Strategy* *(II)*

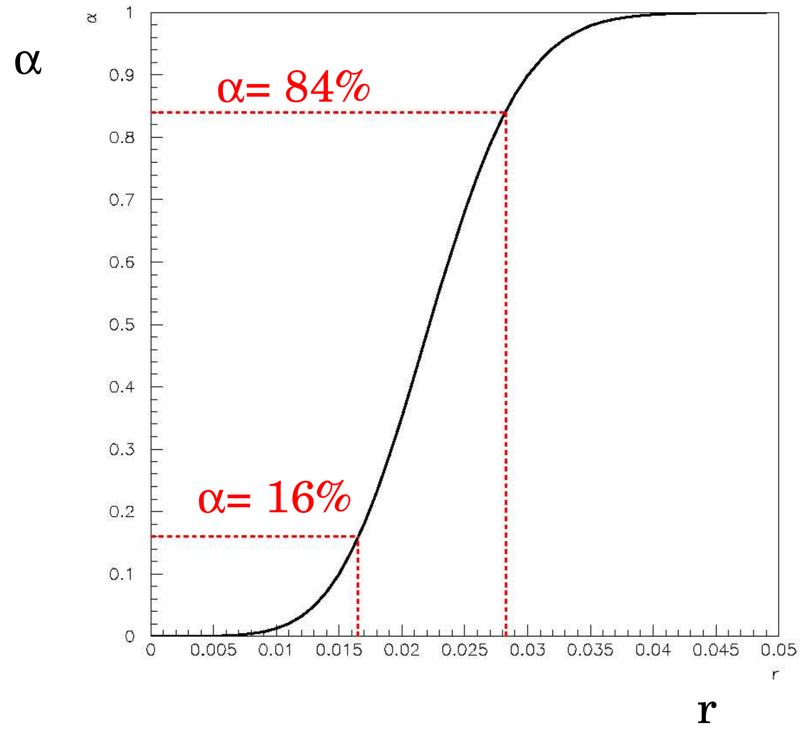
Estimate with a TOY- MC the fraction of times α that the number of events expected from signal+bkg exceeds N_{data}, under a given assumption for

$$r = \frac{Br\,(B \to X(3872)K)\; Br(X(3872) \to J/\psi\pi\pi)}{Br\,(B \to \Psi(2S)\,K)} = (1.89 \pm 0.61)\ \%$$

$Br(B \to \Psi(2S)K) = (6.8 \pm 0.4)10^{-4}$
from PDG 2003

Probability of absence of signal is
$\alpha(0) = 5.4 \times 10^{-4}$ (3.5 σ)

Belle result : r = (1.92 ± 0.42) %



$B \to X(3872)K$ *Branching Fraction*

<u>Systematics errors</u> (already included in TOY- MC) from

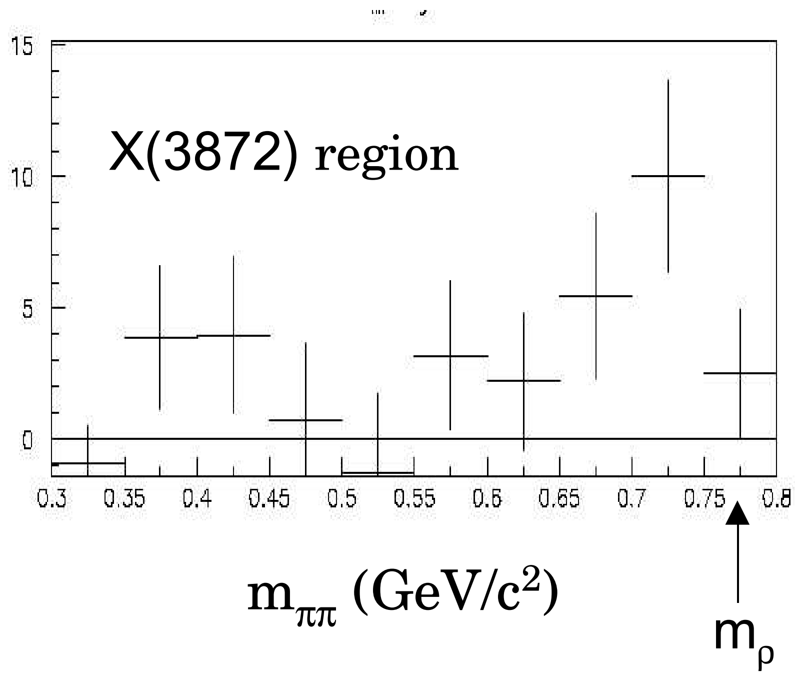
- Peaking background determination
- Partial Branching Ratios
- Normalization sample statistics
- Argus background parametrization
- $M_{J/\Psi\pi\pi}$ resolution

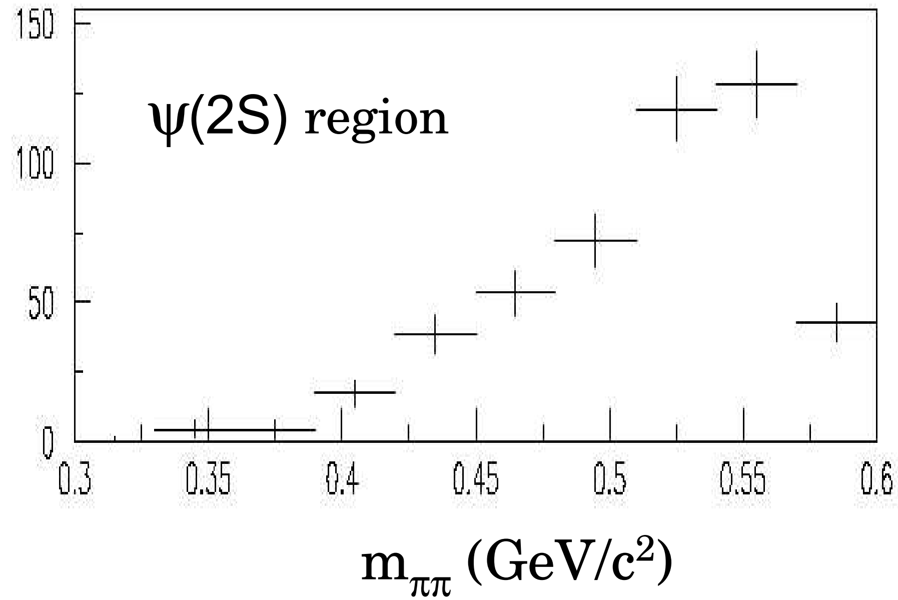
$$Br(B \to X(3872)\,K)\,Br(X(3872) \to J/\psi\,\pi\pi) = (1.28 \pm 0.41)10^{-5}$$

Di-pion System

The di- pion invariant mass is also good discriminator among hypotheses on the nature of X(3872):

if charmonium then X(3872) $\rightarrow J/\psi\ \rho$ is excluded because is an isospin- violating process

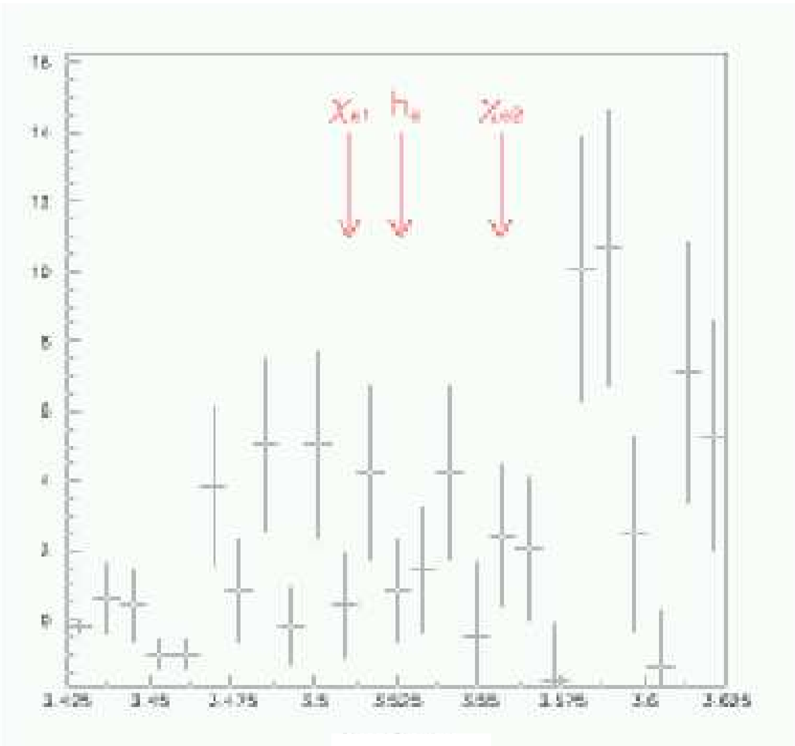




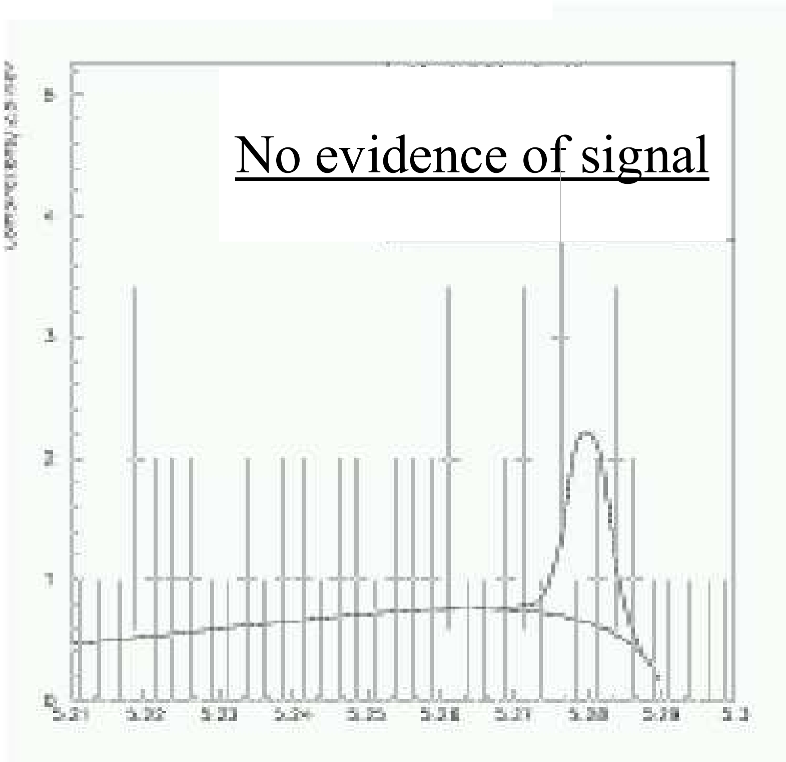
Search for B $\rightarrow h_c$K

- Same strategy as for the X(3872) search
- Same width (± 10 MeV) of the mass window centered at 3526.14 MeV/c^2

Br(B → h_c K) Br(h_c → J/ψ π π) < 3.4 x 10^{-6} @ 90% *C.L* .



$m_{J/\Psi\pi\pi}$ distribution



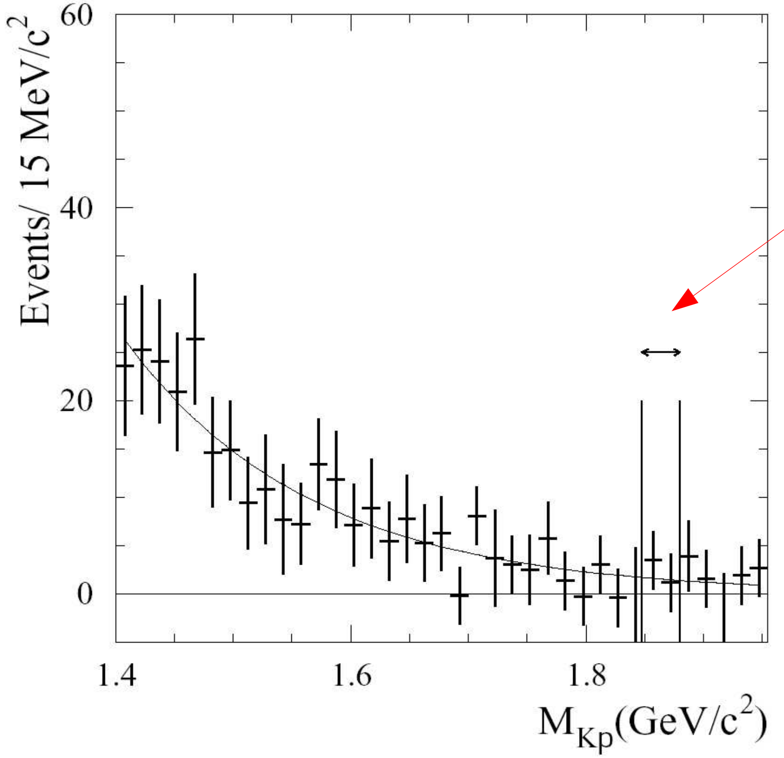
m_{ES} distribution in the signal $m_{J/\Psi\pi\pi}$ window for hc

Search for B $\rightarrow$ J/ψ D π

- Intrinsic charm production?

To justify the J/Ψ low p* anomaly would need Br(B $\rightarrow$ J/Ψ D π) ~ 10^{-4} (hep- ph/0101162)
If D $\rightarrow$ K π the final state is the same as B $\rightarrow$ J/ψ K π π

- Look at $m_{K\pi}$ sideband subtracted distribution



3σ mass window

σ = 5.4 MeV

Br(B $\rightarrow$ J/ψ D π) < 4.3 x 10^{-5} @ 90%*C.L.*

Intrinsic charm strongly constrained

Summary

Several competitive results

	This analysis	Present Best
$Br(B \to J/\psi K \pi \pi)$	$(1.16 \pm 0.11)10^{-3}$	$(0.77 \pm 0.20)10^{-3}$
$Br(B \to X(3872)K)Br(X(3872) \to J/\psi\pi\pi)$	$(1.28 \pm 0.41)10^{-5}$	$(1.42 \pm 0.31)10^{-5}$
$M_{X(3872)}$	(3873.4 ± 1.4) MeV	(3872.0 ± 1.4) MeV
$Br(B \to h_c K) Br(h_c \to J/\psi \pi \pi) <$	3.1×10^{-6}	none
$Br(B \to J/\psi D^0 \pi) <$	4.3×10^{-5}	none

and the $m_{\pi\pi}$ distribution in $X(3872) \to J/\psi\pi\pi$ confirms Belle