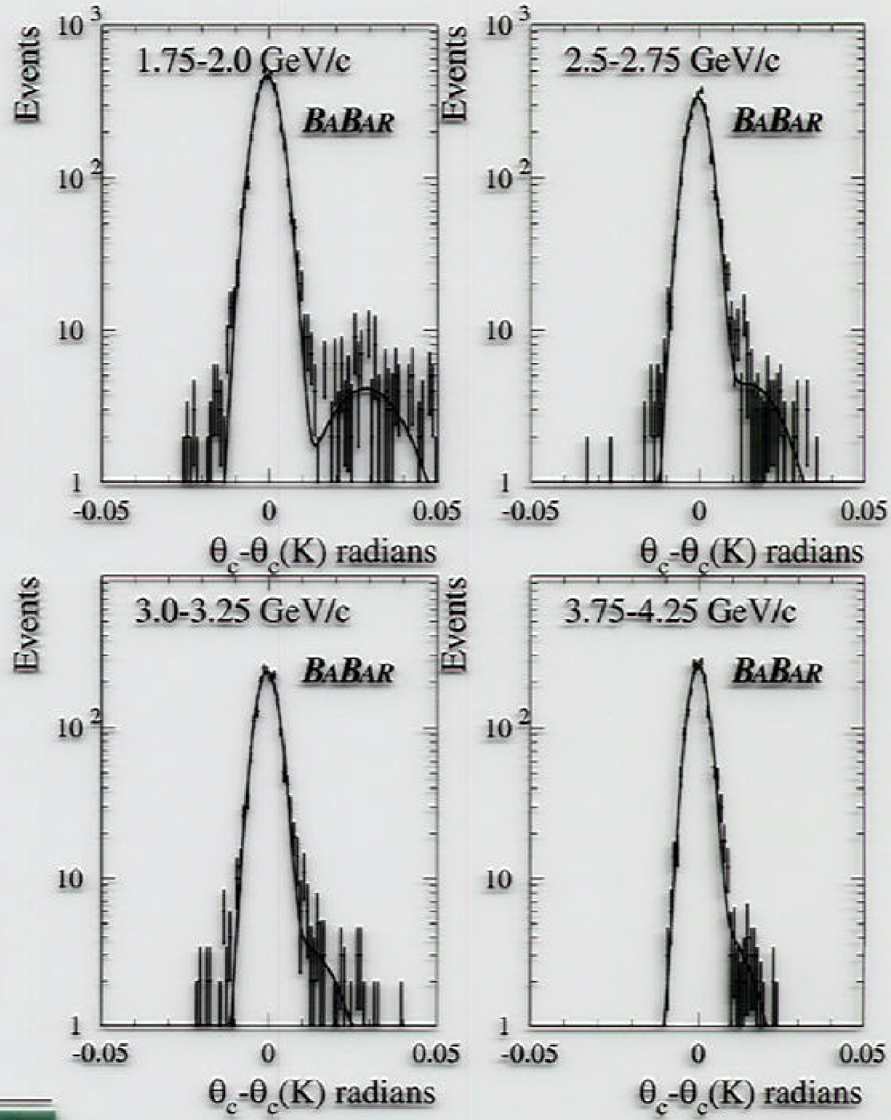
CALIBRATION OF: θ_C

Apply $\cos\theta_{\rm polar}$ angle dependent parameterization of Cherenkov angle (θ_C) systematic offset, resolution and small sattelite peaks

$\theta_C(\text{rec.}) - \theta_C(K^\pm)$ for kaons from D^{*+} control sample $\Longrightarrow$



MAXIMUM LIKELIHOOD FIT

An 8 parameter, unbinned extended likelihood fit is performed (fitted quantities in red). The PDF for event i reads ($N' \equiv \sum_k N_k$):

$$
\begin{aligned}
&\mathcal{P}_i\left(m_{\mathrm{ES},i}, \Delta E_i, \mathcal{F}_i, \theta^+_{C,i}, \theta^-_{C,i}\right) \\
&= N_{\pi\pi}\mathcal{P}_i^{\pi\pi} + N_{b\pi\pi}\mathcal{P}_i^{b\pi\pi} + N_{KK}\mathcal{P}_i^{KK} + N_{bKK}\mathcal{P}_i^{bKK} \\
&\quad + \frac{1}{2}N_{K\pi}\left(1 + \mathcal{A}_{K\pi}\right)\mathcal{P}_i^{K^+\pi^-} + \frac{1}{2}N_{bK\pi}\left(1 + \mathcal{A}_{bK\pi}\right)\mathcal{P}_i^{bK^+\pi^-} \\
&\quad + \frac{1}{2}N_{K\pi}\left(1 - \mathcal{A}_{K\pi}\right)\mathcal{P}_i^{K^-\pi^+} + \frac{1}{2}N_{bK\pi}\left(1 - \mathcal{A}_{bK\pi}\right)\mathcal{P}_i^{bK^-\pi^+}
\end{aligned}
$$

with $\mathcal{P}^k = \mathcal{P}^k_{m_{\mathrm{ES}}}\mathcal{P}^k_{\Delta E}\mathcal{P}^k_{\mathcal{F}}\mathcal{P}^k_{\theta^+_C}\mathcal{P}^k_{\theta^-_C}$ and $\mathcal{L}_{\mathrm{tot}} \equiv e^{-N'}\prod_{i=1}^{N}\mathcal{P}_i$

$N_{\pi\pi}$	number of $B \to \pi^+\pi^-$ decays
$N_{K\pi}$	number of $B \to K^+\pi^-$ decays
$\mathcal{A}_{K\pi}$	asymmetry between $B \to K^+\pi^-$ and $B \to K^-\pi^+$ decays: $(N_{K^+\pi^-} - N_{K^-\pi^+})/(N_{K^+\pi^-} + N_{K^-\pi^+})$
N_{KK}	number of $B \to K^+K^-$ decays
$N_{b\pi\pi}$	number of background $\pi^+\pi^-$ candidates
$N_{bK\pi}$	number of background $K^\pm\pi^\mp$ candidates
$\mathcal{A}_{bK\pi}$	asymmetry between background $K^+\pi^-$ and $K^-\pi^+$ candidates
N_{bKK}	number of background K^+K^- candidates

SYSTEMATIC STUDIES

Imperfect Knowledge of PDFs

- Generous variations of PDF shape parameters:
  - within their statistical errors
  - to cover MC-data disagreements
- Use of alternate parameterizations
- PID: no charge asymmetry found in PID performance

⟹ Dominant systematic errors: Fisher shape (for background), $m_{\rm ES}$ and ΔE (signal peaks and resolution).

Cross Checks

- Validate of the fitting method: toy Monte Carlo studies with known input were performed: no bias has been found in the fit outputs within the toy statistics
- Parallel PID cut-based analysis

Comparison with ICHEP'2000 (Osaka) Results

- Bias was found in backgr. part of previous 6 parameter fit:
  - 2 background parameters: $N_{\rm bkgd}$ and f_π
  - $\rightarrow$ this implies that background consists of randomly paired tracks, so that: $f_{\pi\pi} = f_\pi^2$, $f_{K\pi} = 2f_\pi(1-f_\pi)$, $f_{KK} = (1-f_\pi)^2$.
  - This is not true. E.g, the 2-body selection criteria prefer to select $K^\pm K^\mp$ from both $s\bar{s}$ and $c\bar{c}$
  - Refit of Osaka sample (with new, substantially improved selection):

BRANCHING RATIOS FOR $B^0 \to h^+h'^-$

PRELIMINIARY

The combined 8 parameters fit yields for 16 032 events

$[N \pm \sigma(\text{stat}) \pm \sigma(\text{syst})]$

$$N_{\pi\pi} = 41 \pm 10 \pm 7$$
$$N_{K\pi} = 169 \pm 17^{+12}_{-17}$$
$$N_{KK} = 8.2^{+7.8}_{-6.4} \pm 3.3$$

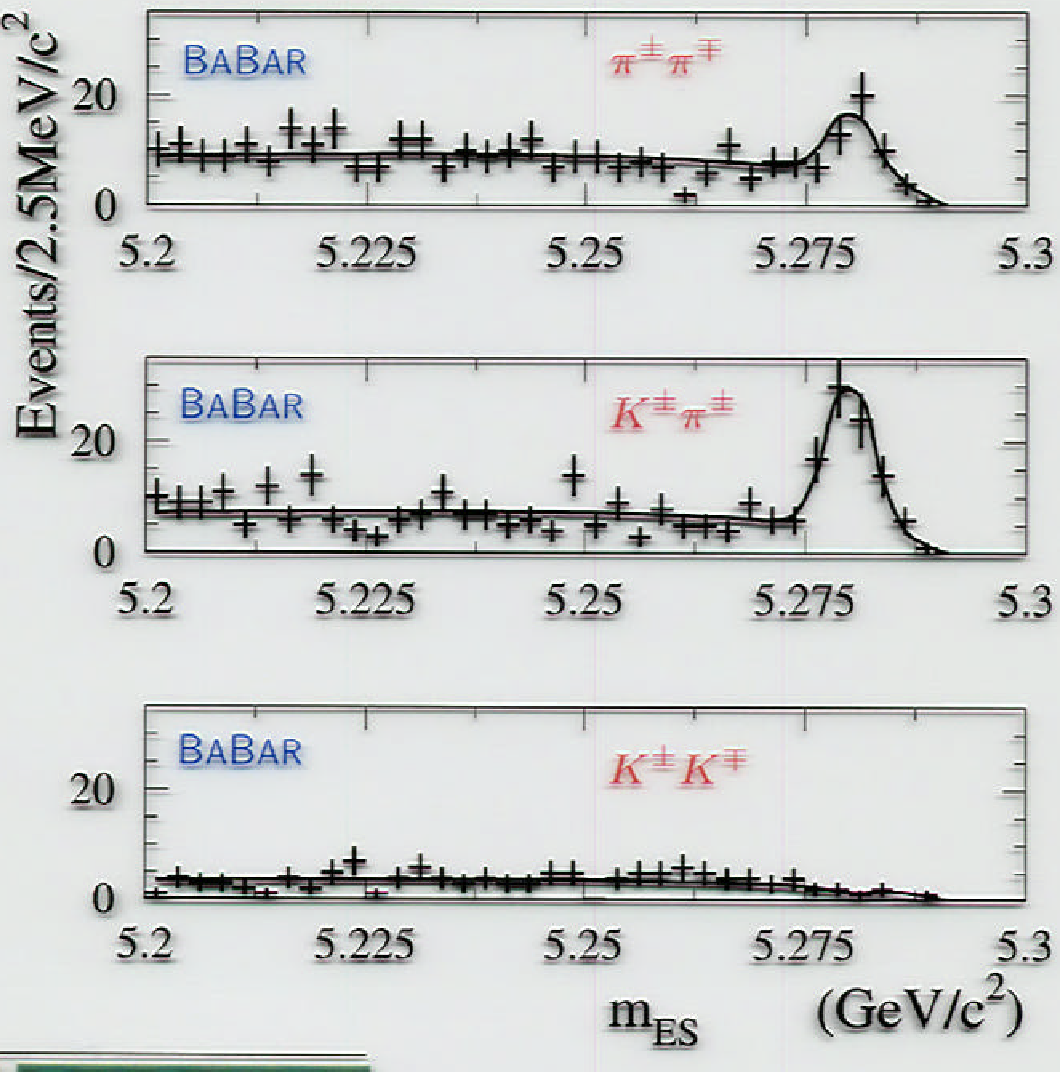
(correlations $< 15\%$)

The branching ratios are obtained via $\text{BR} = N_S/\epsilon N_{B\bar{B}}$, with $N_{B\bar{B}} = 22.5 \times 10^6$ and $\epsilon = 0.43$ (K^+K^-) - 0.45 $(\pi^+\pi^-)$.

Decay Mode	$[\text{BR} \pm \sigma(\text{stat}) \pm \sigma(\text{syst})]$ $(\times 10^{-6})$	
	BABAR	CLEO
$\pi^+\pi^-$	$4.1 \pm 1.0 \pm 0.7$	$4.3^{+1.6}_{-1.4} \pm 0.5$
$K^+\pi^-$	$16.7 \pm 1.6^{+1.2}_{-1.7}$	$17.2^{+2.5}_{-2.4} \pm 1.2$
K^+K^-	< 2.5 (90% CL)	< 1.9 (90% CL)

RESULTS

Parallel cut & dice analysis and binned likelihood fit of the m_{ES} distribution finds consistent results



MEASUREMENT OF THE $B \to J/\psi K^*$ DECAY AMPLITUDES

Properties of $B \to J/\psi K^*$ Decays:

- Decay $P \to VV$: $J^P(J/\psi) = 1^-$ and $J^P(K^*) = 1^- \Rightarrow$ $L = 0, 1, 2$ between the 2 vector mesons
- Final state $K_S^0\pi^0$ is not a pure CP eigenstate
- Parameter $R_\perp$ measures CP^- fraction

Motivation for the Analysis:

- CP measurement using $B \to J/\psi K^{*0} \to (\ell^+\ell^-)(K_S^0\pi^0)$. For $R_\perp \equiv 0,\ 1$, $J/\psi K^{*0}(K_S^0\pi^0)$ is a golden CP channel
- Test of factorization hypothesis: zero FSI implies zero or π phase shifts between amplitudes

Analysis Framework:

- Considered are the K^* final states: $(K_S^0\pi^0)^{*0}$, $(K^\mp\pi^\pm)^{*0}$, $(K_S^0\pi^\pm)^{*\pm}$, $(K^\pm\pi^0)^{*\pm}$,
- Assuming $\Delta I = 0$: all $K\pi$ final states have same amplitudes
- Using *Transversity Basis*: amplitudes are CP eigenstates

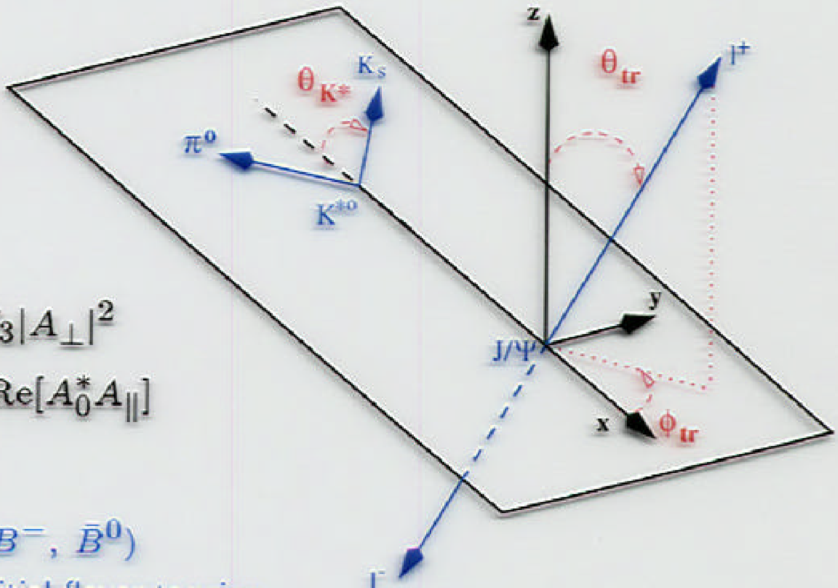
ANGULAR DISTRIBUTION

The Transversity Basis (defined in J/ψ rest frame):

- Define 3 amplitudes ($\sum_i |A_i|^2 = 1$):

$A_\parallel$: both vector mesons have parallel polarization: $\mathrm{CP} = +1$
A_0: both vector mesons have longitudinal polarization: $\mathrm{CP} = +1$
$A_\perp$: both vector mesons have perpendicular polarization: $\mathrm{CP} = -1$.
In particular: $|A_\perp|^2 \equiv R_\perp$.

- After removal of global phase, 2 phases left: $\phi_\parallel$, $\phi_\perp$



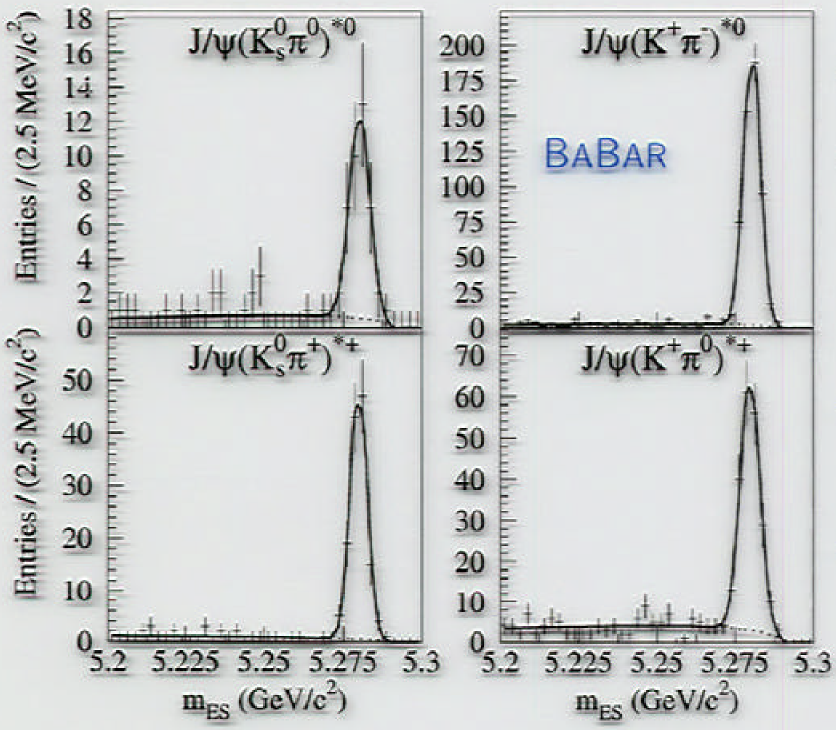
Angular distribution:

$$g(\cos\theta_{\mathrm{tr}}, \cos\theta_{K^*}, \phi_{\mathrm{tr}})$$
$$= f_1|A_0|^2 + f_2|A_\parallel|^2 + f_3|A_\perp|^2$$
$$+ f_4\xi\mathrm{Im}[A_\parallel^* A_\perp] + f_5\mathrm{Re}[A_0^* A_\parallel]$$
$$+ f_6\xi\mathrm{Im}[A_0^* A_\perp]$$

$\xi = +1\ (-1)$ for B^+, B^0 (B^-, $\bar{B}^0$)
$\xi = 0$ for CP mode without initial flavor tagging

$B \to J/\psi K^*$ CANDIDATE SELECTION

- $J/\psi \to \ell^+\ell^-$: vertex two identified leptons and apply mass cut
- K_S^0: vertex 2 tracks, apply mass cut, require minimum flight length and that the K_S^0 origins from the interaction point
- K^*: formed from $K\pi$ combinations within K^* mass cut
- $B \to J/\psi K^*$: apply cut on K^* helicity angle, $\cos\theta_{K^*}$, (reducing (self) cross feed) and energy difference ΔE

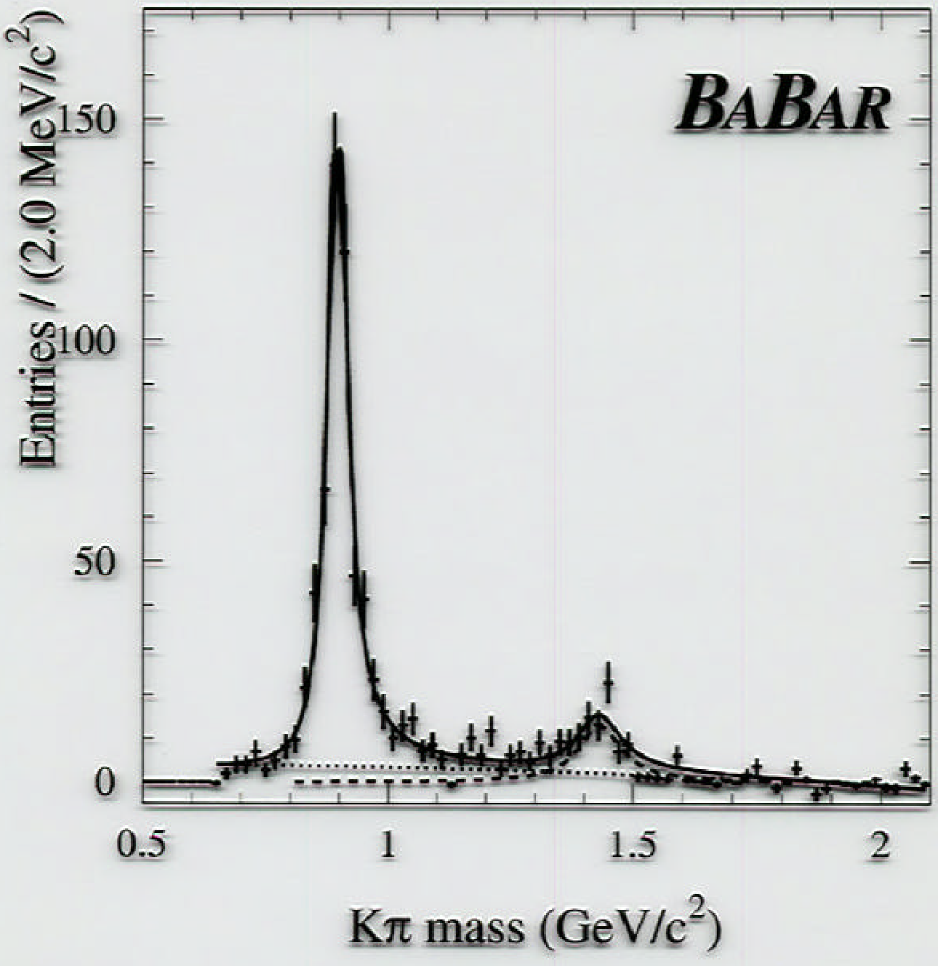


Selection Efficiencies:	
$J/\psi(K_S^0\pi^0)^{*0}$	9.9%
$J/\psi(K^\mp\pi^\pm)^{*0}$	23.9%
$J/\psi(K_S^0\pi^\pm)^{*\pm}$	17.2%
$J/\psi(K^\pm\pi^0)^{*\pm}$	13.8%
$K\pi$ feed thru:	$<$ 2.6%
Self feed thru:	$<$ 13.2%

K^* MASS SPECTRUM

Signal contributions may arise from the heavier K^* excitations $K_0^*(1430)$, $K_2^*(1430)$, and non-resonant $K\pi$ production

Background subtracted $m_{K^\pm\pi^\mp}$ spectrum:



THE AMPLITUDE FIT

Unbinned Maximum Likelihood Fit exploiting $m_{\rm ES}$ and the angular information of the event.

AMPLITUDES: SIGNAL

Acceptance corrected, normalized signal PDF for event i:

$$g_{\rm obs}(\vec{\omega}_i) = \frac{g(\vec{\omega}_i) \cdot \epsilon(\vec{\omega}_i)}{\langle \epsilon \rangle}$$

$\epsilon(i)$: event efficiency

$\langle \epsilon \rangle$: efficiency averaged over angular space

$$\langle \epsilon \rangle = \int g \cdot \epsilon = \sum_{j=1}^{6} A_j^2 \eta_j \qquad (\eta_j = \int f_j \cdot \epsilon)$$

η_j : obtained from MC simulation (channel dependent)

AMPLITUDES: BACKGROUND (BG)

- Non $B \to J/\psi K^*$ BG: define "projected" $g_{\rm B}(\vec{\omega}_i)$, similar to $g_{\rm obs}(\vec{\omega}_i)$, with B_i the background amplitudes
- (S)CF BG is amplitude dependent: correct the η_i for this bias

B - MASS

The PDFs for $m_{\rm ES}$ are a Gaussian for signal and the ARGUS function for background.

THE COMPLETE LIKELIHOOD

The final log likelihood (x is signal fraction within $5.2 \leq m_{\mathrm{ES}} \leq 5.3$):

$$\begin{aligned}\log L &= \sum_{i=1}^{N_{\mathrm{obs}}} \log\Big(x \cdot \mathrm{Gauss}(m_{\mathrm{ES},i}) \cdot g_i(\vec{\omega}) \\ &\quad + (1-x) \cdot \mathrm{ARGUS}(m_{\mathrm{ES},i}) \cdot g_{\mathrm{B},i}(\vec{\omega}) \Big) \\ &= N_{\mathrm{obs}} \log \left(\sum_{i=1}^{6} \eta_i \left[x A_i^2 + (1-x) B_i^2 \right] \right) = \mathcal{N}\end{aligned}$$

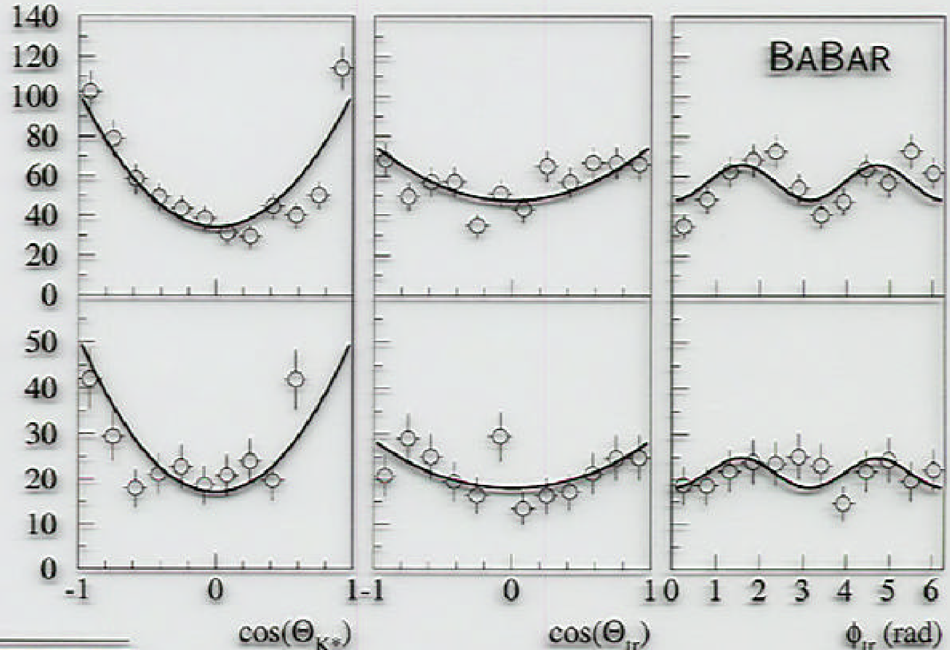
The likelihood is extended by the normalization condition:

$$\mathcal{N} = N_{\mathrm{obs}} \left(|A_0|^2 + |A_{\|}|^2 + |A_{\perp}|^2 \right)$$

Illustration only:

Acceptance corrected 1D projections of the 3 angles & fit results

Top: without π^0
Bottom: with π^0

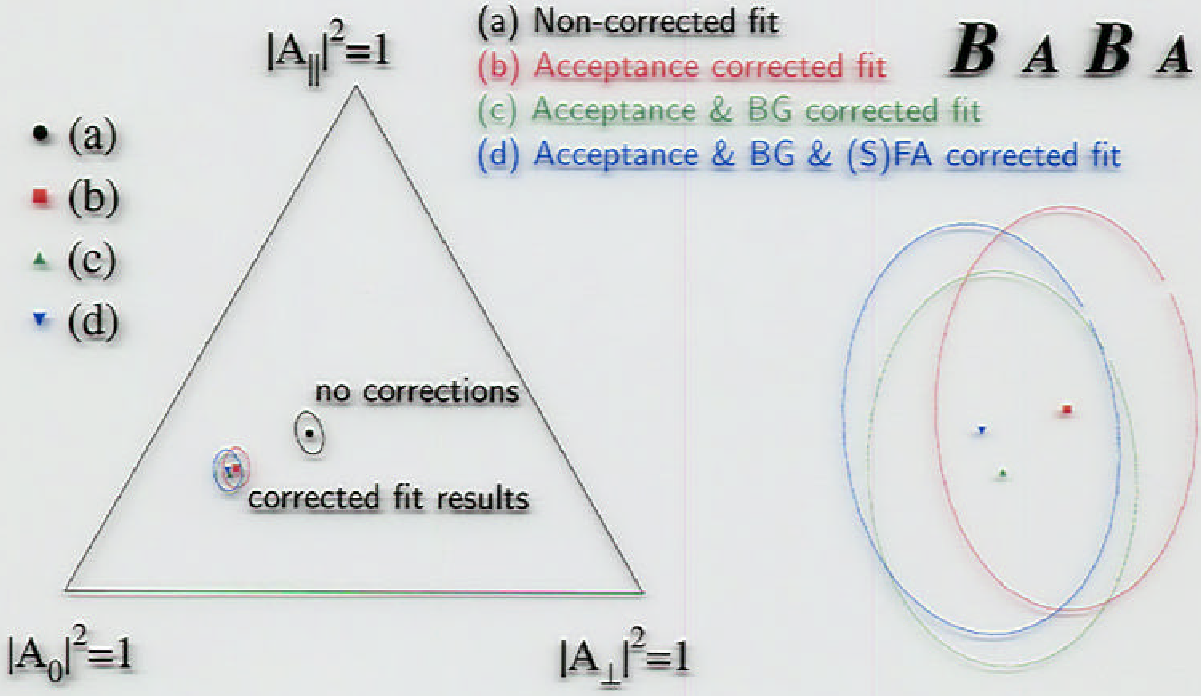


SYSTEMATIC EFFECTS

Systematics are dominated by

- Heavy K^* excitations (shifts observed when including higher mass region in the fit)
- MC statistics.

Smaller systematics arise from background, model, tracking, PID

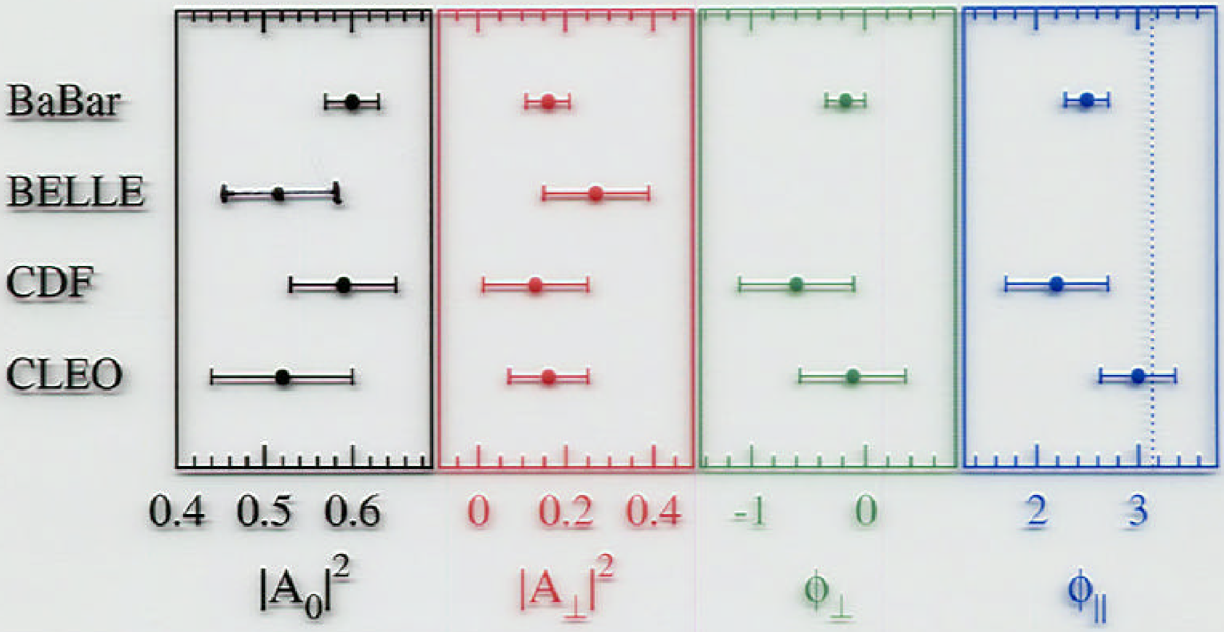


RESULTS

Signal Amplitudes ($\pm\sigma_{\rm stat} \pm \sigma_{\rm sys}$):

$$|A_0|^2 = 0.597 \pm 0.028 \pm 0.008$$
$$|A_\perp|^2 = 0.160 \pm 0.032 \pm 0.036$$
$$|A_\parallel|^2 = 0.243 \pm 0.034 \pm 0.033$$
$$\phi_\perp = (-0.17 \pm 0.16 \pm 0.06) \text{ rad}$$
$$\phi_\parallel = (2.50 \pm 0.20 \pm 0.07) \text{ rad} \quad (\Longrightarrow \text{FSI ?})$$

Dominant longitudinal component. Small P wave. For $\sin 2\beta$ with $J/\psi(K^0_S\pi^0)^{*0}$, the dilution is: $D_\perp = (1-2|A_\perp|^2) = 0.68 \pm 0.10$



CONCLUSIONS

- BABAR advances towards the finalization of the analyses using the full RUN 1999-2000 data set of $21\ \mathrm{fb}^{-1}$

- The data quality has been found within the design requirements

- First, preliminary results have been presented on the
  - Measurement of the branching fractions of $B^0 \to h^+h'^-$ final states ($h = \pi, K$)
  - Measurement of the $B \to J/\psi K^*$ decay amplitudes

- The results obtained are in agreement with published values, though the precision dominates the previous measurements on all above quantities

- We are looking forward to the forthcoming unblinding of the remaining rich variety of charmless B decays

BABAR