

Charmless B decays

at



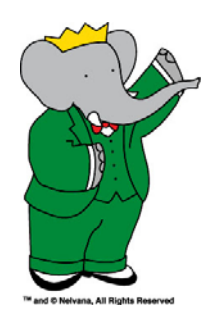
BABAR

™ and © Neivana, All Rights Reserved



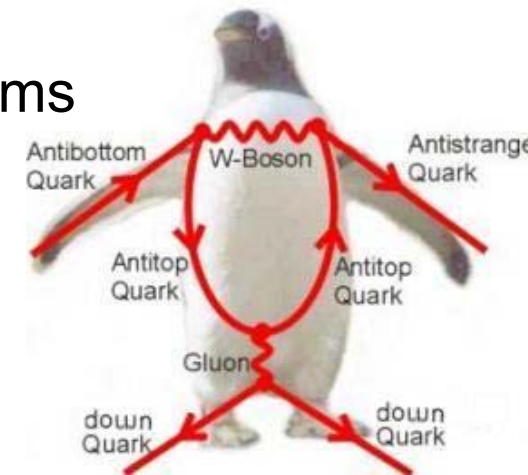
Pablo del Amo Sanchez

LPNHE (Univ. Paris VI et VII) – IN2P3 – CNRS



Motivation

- Rare decays: BF's $\sim 10^{-5} - 10^{-6}$
- Mainly **b \rightarrow s loop**, b \rightarrow u tree and b \rightarrow d loop diagrams (hence good place to look for New Physics)
- Very **rich phenomenology**:
 - **large DCPV** (direct CP violation),
 - α , γ , **loop β_{eff} vs tree β** ,
 - $K\pi$ asymmetry puzzle,
 - $B\rightarrow VV$ polarization puzzle...
- Hence will show a (personal) selection of topics...



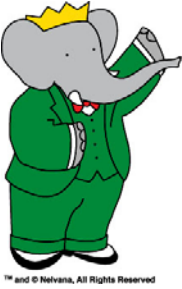
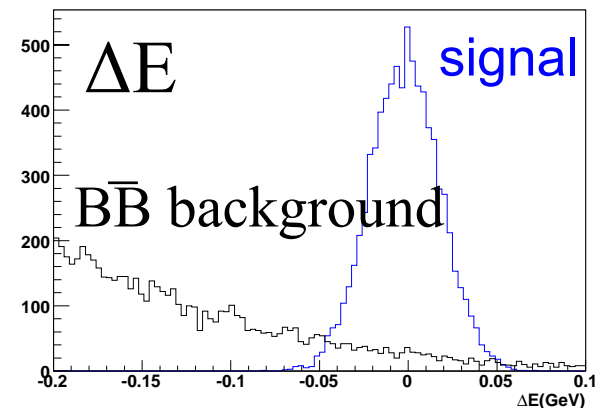
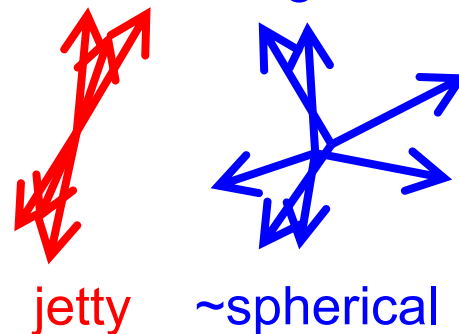
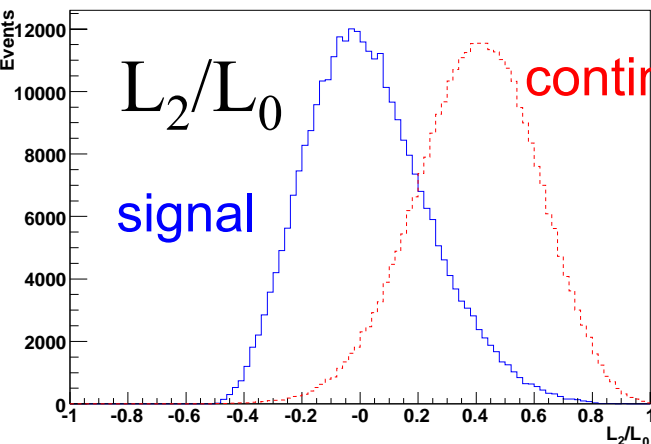
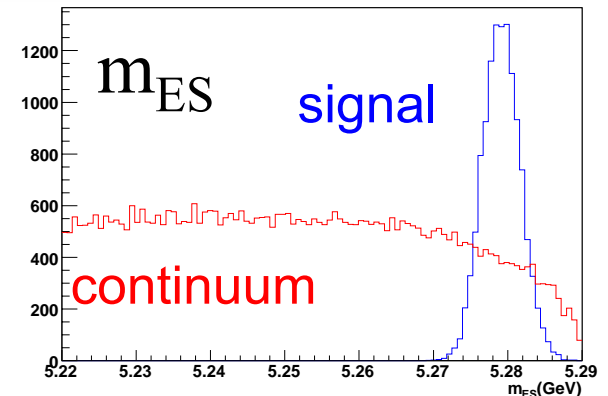
Experimental issues

- Small S/B ratio, **mostly continuum** ($e^+e^- \rightarrow q\bar{q}$, $q \neq b$) background
- Use **kinematical** and **event-shape** variables to **discriminate**:

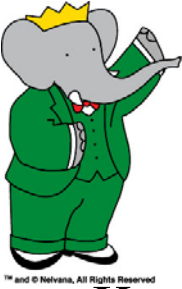
$$m_{ES} = \sqrt{(s/2 + \vec{p}_i \cdot \vec{p}_B)^2 / E_i^2 - \vec{p}_B^2}$$

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

- $m_{ES} \sim$ **mass of B**, good against continuum
- ΔE spots **misreconstructed true B events**
- $L_2/L_0 \sim$ shape of event in CM frame

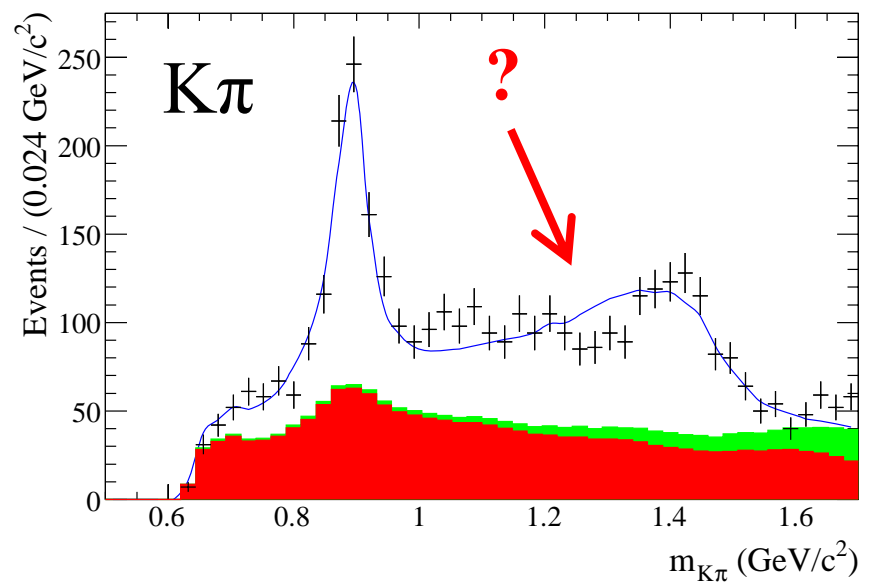
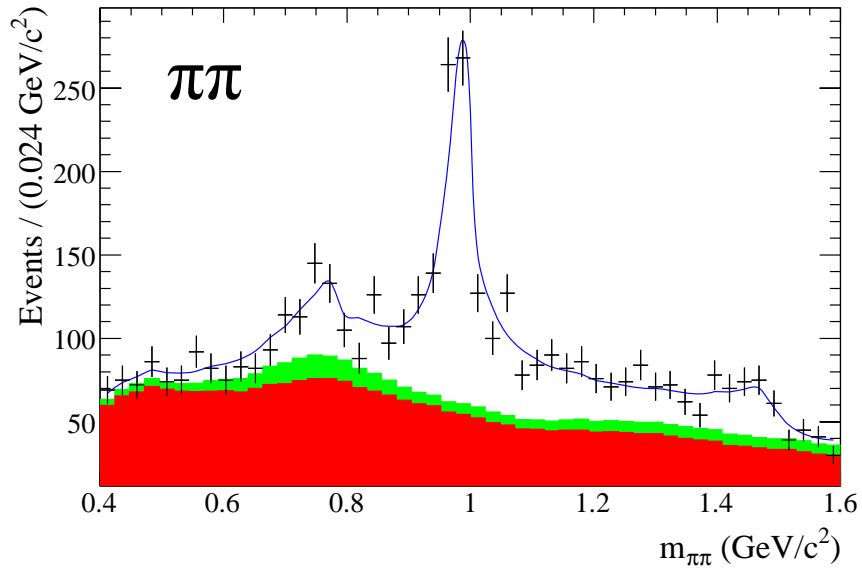


™ and © Nelvana, All Rights Reserved



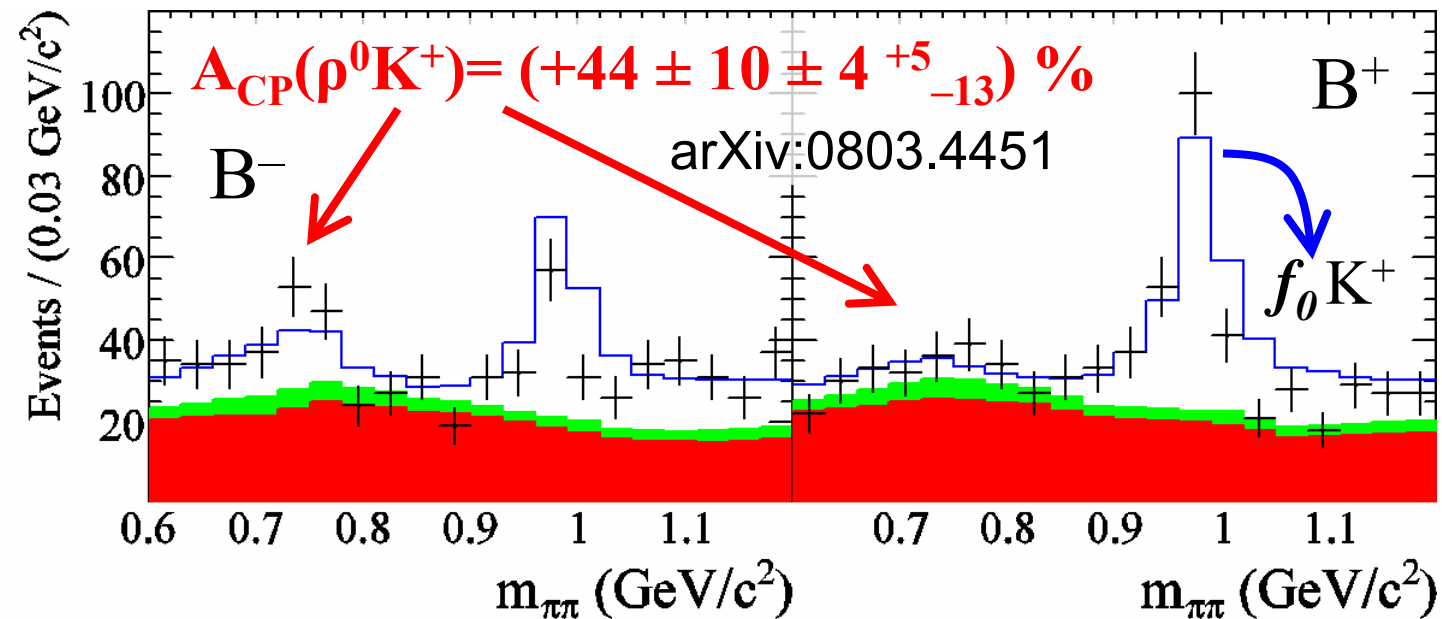
Large DCPV: $B^+ \rightarrow K^+ \pi^+ \pi^-$

- $K\pi$ asymmetry pattern not well understood: look at ρK
- **Rho wide** \rightarrow **overlaps** with other resonances (e.g. f_0) \rightarrow **interference**
- \rightarrow need **Dalitz-plot analysis** of $K^+ \pi^+ \pi^- \rightarrow$ fit relative magnitudes and **rel. phases**
- Sensitive to **DCPV** in **decay rate asym.** but also in **relative phase asym.**
- Sheds light on **$\pi\pi$ spectrum**: need $f_2(1270)K^+$ and **scalar** of mass $m = 1479 \pm 8$ MeV, width $\Gamma = 80 \pm 19$ MeV ($\sim f_0(1500)$?)



$B^+ \rightarrow K^+ \pi^+ \pi^-$ (cont'd)

- Helps with (poorly known) $K\pi$ spectrum: $K_2^{*0}(1430)$ present, LASS best description of S-wave, but not perfect?
- $A_{CP}(K^{*0}\pi^+) \sim 0$ (as expected in SM); DCPV hint in $f_2(1270)K^+$
- Babar: $B^+ \rightarrow \rho^0 K^+$, evidence of DCPV at 3.7σ

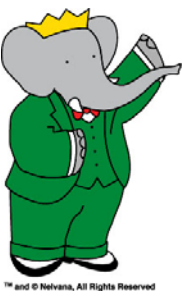


Good agreement with some theory predictions[†] and with Belle:

$$A_{CP} = (30 \pm 11^{+11}_{-5})\%$$

(AIP Conf.Proc. **814**:680)

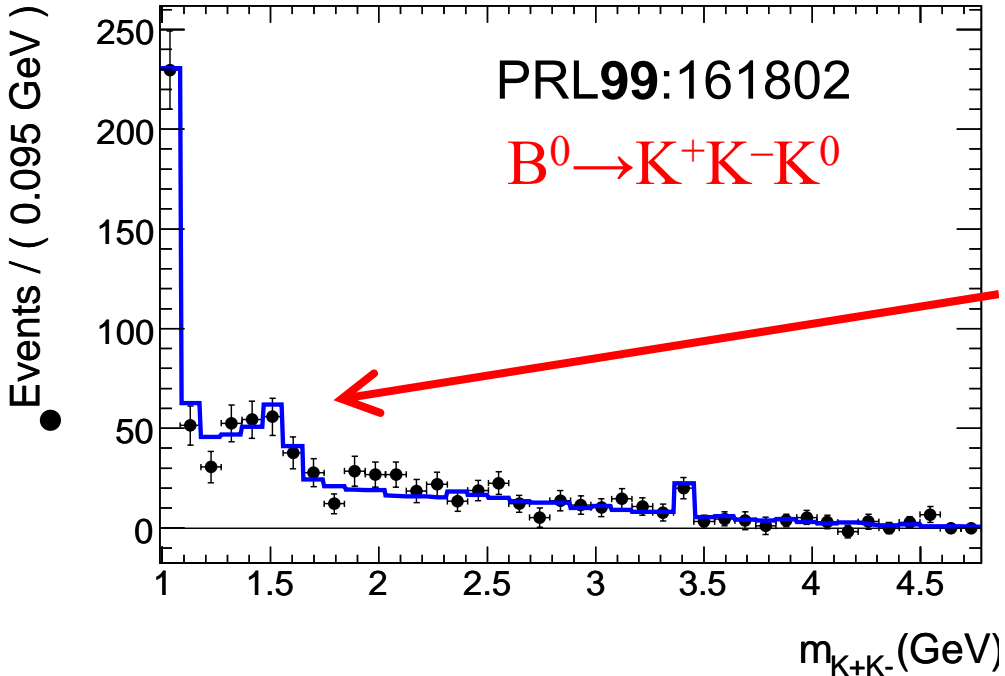
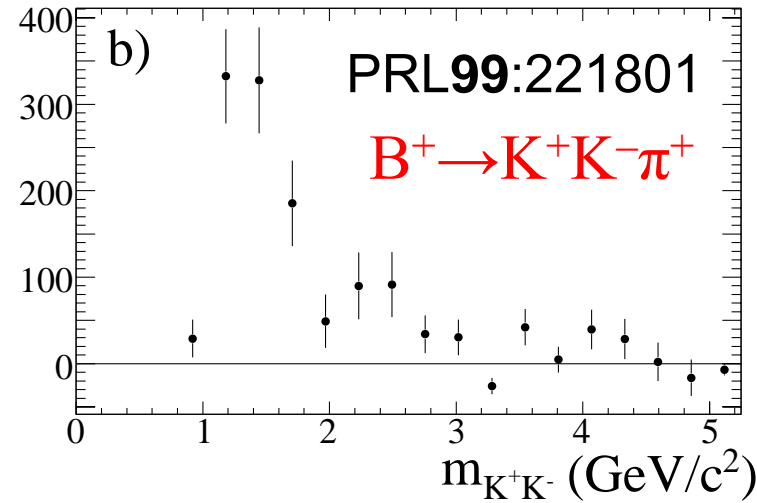




KK S-wave: $K^+K^-\pi^+$ & $K^+K^-K^0$

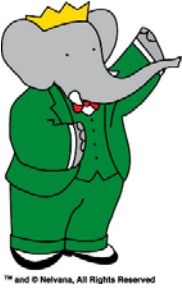


- Recent observation of $B^+ \rightarrow K^+K^-\pi^+$:
 $BF = (5.0 \pm 0.5 \pm 0.5) \times 10^{-6}$
 (429 \pm 43 events, 9.6 σ)
- Broad peak at $\sim 1.5 \text{ GeV}/c^2$ in KK mass
- No $\Phi \rightarrow$ peak not coming from $s\bar{s}$?



Scalars at $\sim 1.5 \text{ GeV}/c^2$ also in $B^0 \rightarrow K^+K^-K^0$ and $B^+ \rightarrow K^+K^+K^-$:
 $m = 1539 \pm 20 \text{ MeV}$, $\Gamma = 257 \pm 33 \text{ MeV}$

$B \rightarrow KKK$ modes dominated by non-resonant which is not uniform in phase space



β_{eff} (loop $b \rightarrow s$) vs β (tree $b \rightarrow c$)



NP in $b \rightarrow s$ loop? c.f. $A_{\text{CP}}(\Delta t)$ of $b \rightarrow c$ tree

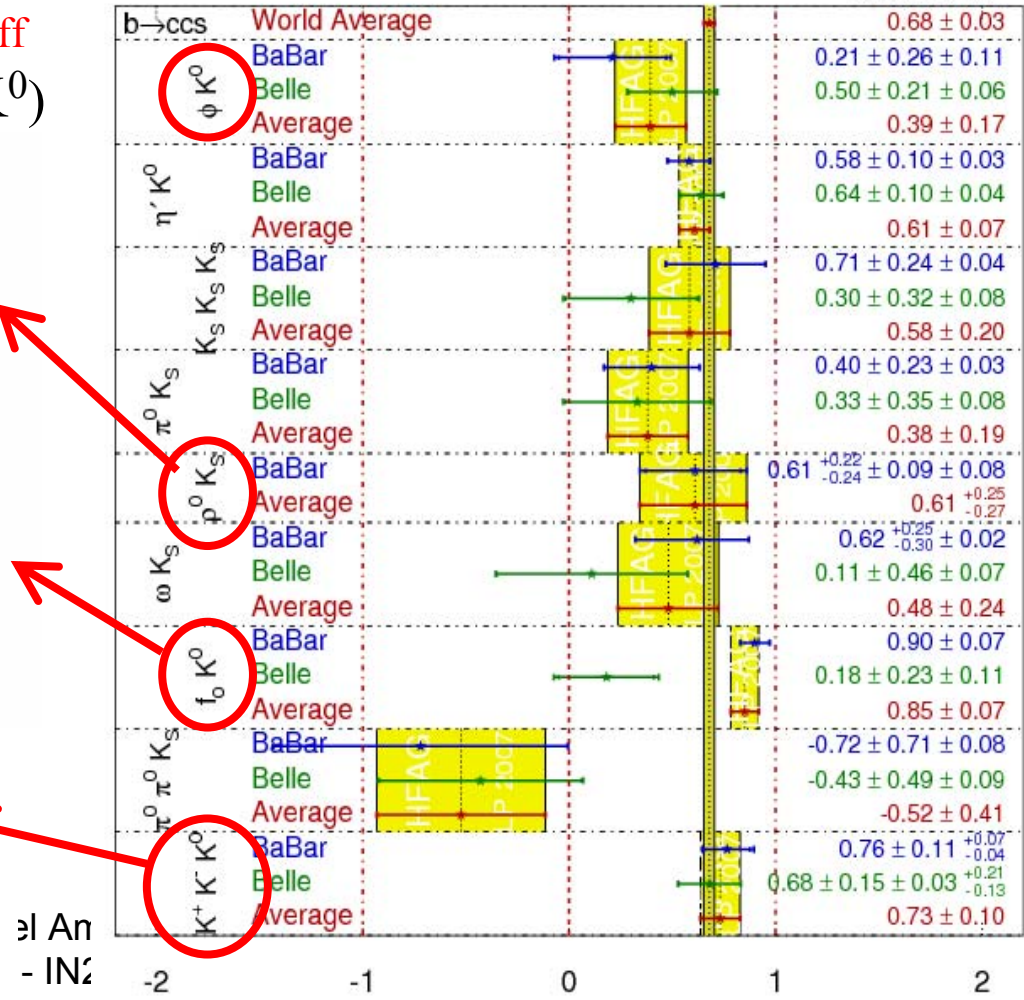
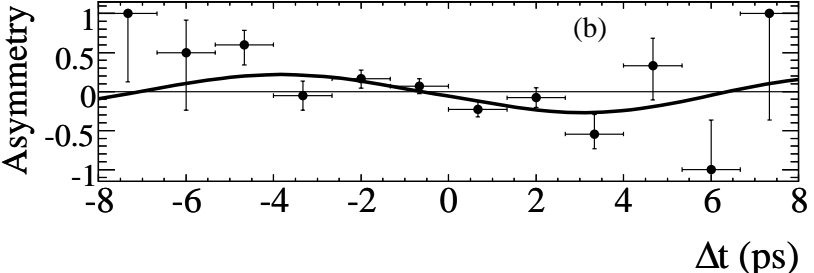
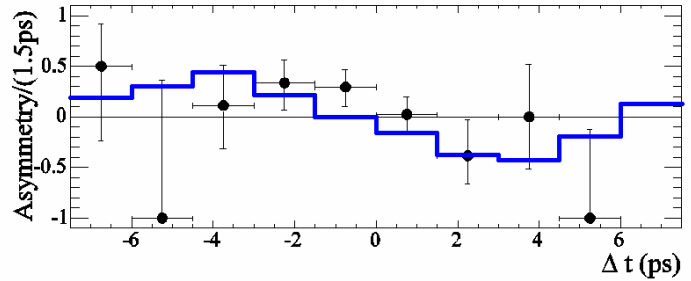
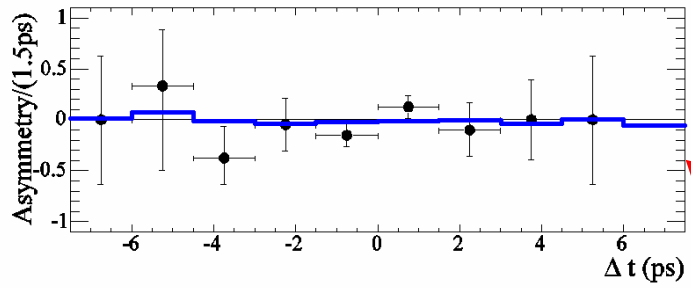
$$\sin(2\beta^{\text{eff}}) \equiv \sin(2\phi_1^{\text{eff}})$$

HFAG
LP 2007
PRELIMINARY

Dalitz extracts β_{eff} instead of $\sin 2\beta_{\text{eff}}$

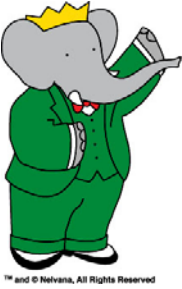
\rightarrow exclude $\pi/2 - \beta_{\text{eff}}$ at 4.5σ ($K^+K^-K^0$)

$B^0 \rightarrow K_S \pi^+ \pi^-$
 arXiv:0708.2097



$\Delta \ln |A|$
 $- \ln |Z|$

$B \rightarrow a_1 h$ and α



- TD $B^0 \rightarrow a_1(1260)\pi$ measured $\alpha_{\text{eff}} = (78.6 \pm 7.3)^\circ$ (PRL98:181803)
- Loop diagram pollution $\rightarrow \alpha_{\text{eff}} \neq \alpha$
- Bound $\Delta\alpha = |\alpha - \alpha_{\text{eff}}|$ from SU(3) (PRD73:057502)
 \rightarrow need BFs of $B \rightarrow a_1(1260)K$, $B \rightarrow K_1(1270)\pi$, $B \rightarrow K_1(1400)\pi$

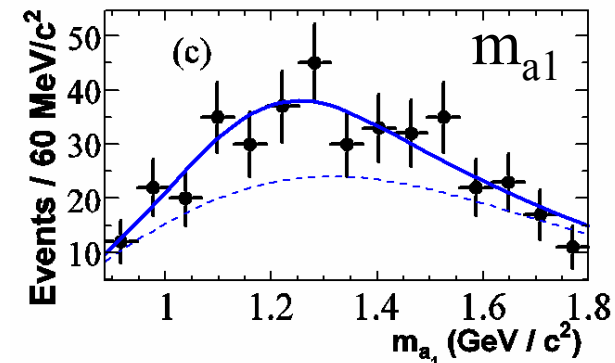
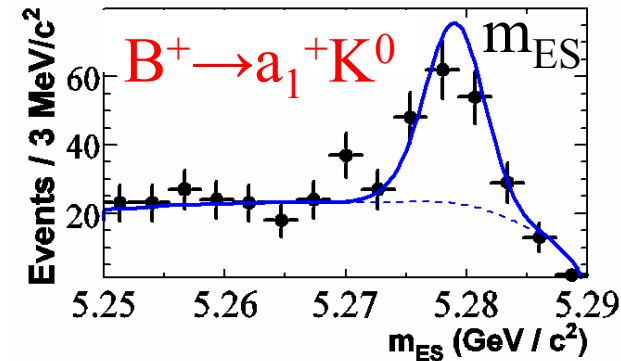
- **Observed** $B^0 \rightarrow a_1(1260)^- K^+$ (5.1σ),
(PRL100:051803) $B^+ \rightarrow a_1(1260)^+ K^0$ (6.2σ)

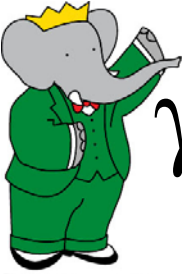
$$\text{BF}(B^0 \rightarrow a_1(1260)^- K^+) \times \text{BF}(a_1^- \rightarrow \pi^+ \pi^- \pi^-) =$$

$$= (8.2 \pm 1.5 \pm 1.2) \times 10^{-6}$$

$$\text{BF}(B^+ \rightarrow a_1(1260)^+ K^0) \times \text{BF}(a_1^+ \rightarrow \pi^+ \pi^+ \pi^-) =$$

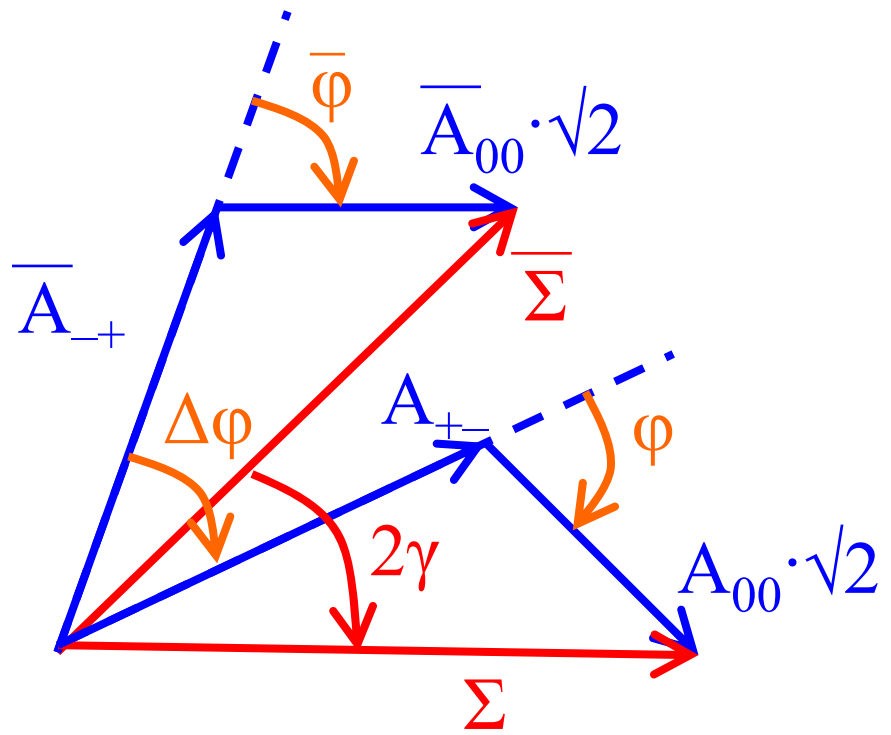
$$= (17.4 \pm 2.5 \pm 2.2) \times 10^{-6}$$



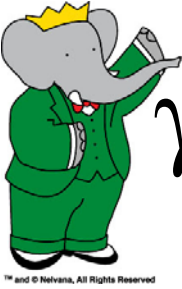


γ (CPS): $B^0 \rightarrow K^+ \pi^- \pi^0, B^0 \rightarrow K_S \pi^+ \pi^-$

- Phase between tree and loop diagrams in $B \rightarrow K\pi\pi$ is γ .
 - γ from $K^{*+}\pi^- - K^{*0}\pi^0$ interference in $K^+\pi^-\pi^0$ (CPS PRD74:051301 & GPSZ PRD75:014002)
- Cancel loop diagrams using isospin:

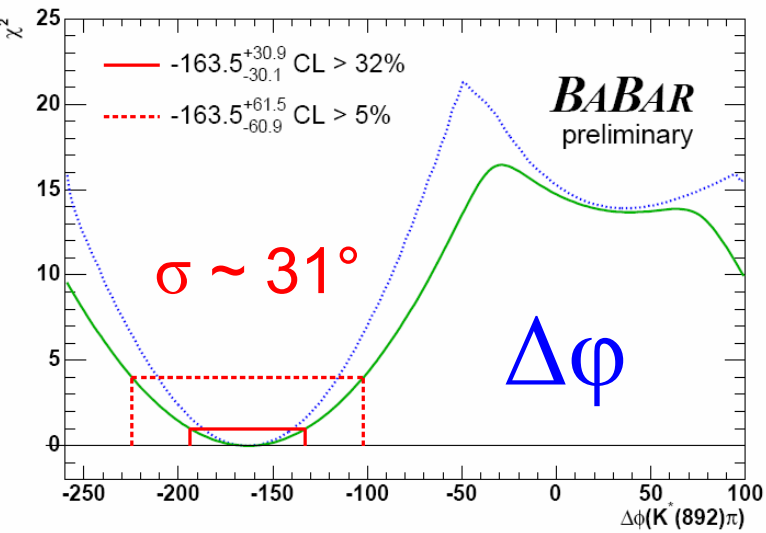


- A_{ij} = Amplitude ($B^0 \rightarrow K^{*i}\pi^j$)
 - $\Sigma = A_{-+} + A_{00} \cdot \sqrt{2}$
 - angle between $\bar{\Sigma}$ and Σ is 2γ (in the absence of EW loop diagrams)
- need $|A_{ij}|$ and rel. phases $\phi, \bar{\phi}, \Delta\phi$
- need Dalitz analysis of $B^+ \rightarrow K^+ \pi^- \pi^0$ and $B^0 \rightarrow K_S \pi^+ \pi^-$

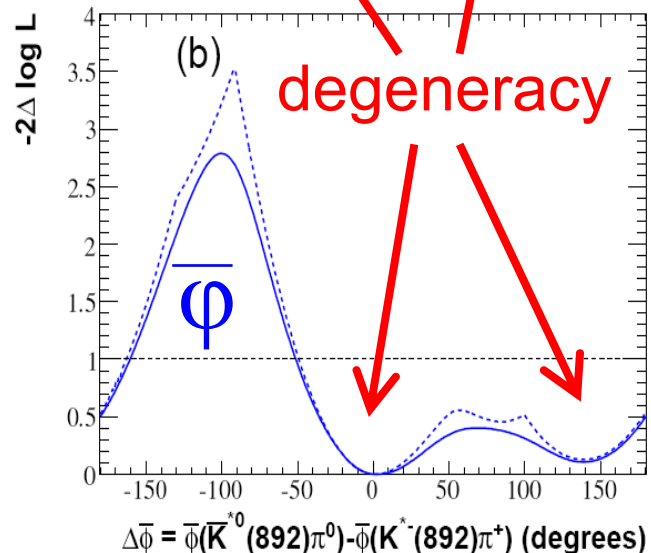
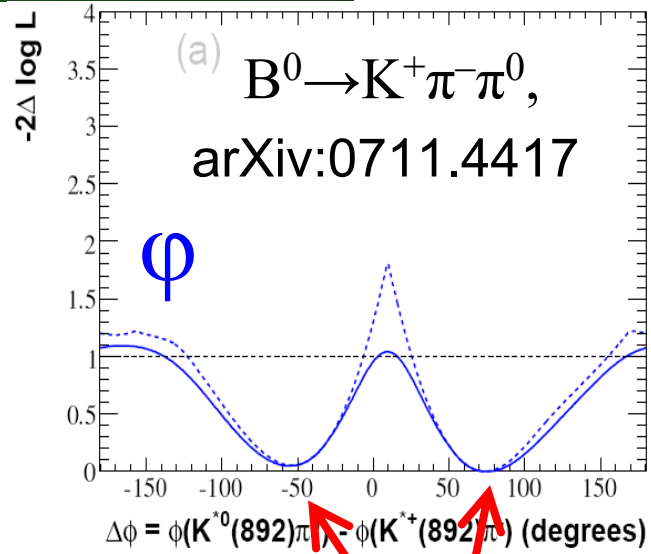


γ (CPS): $B^0 \rightarrow K^+ \pi^- \pi^0, B^0 \rightarrow K_S \pi^+ \pi^-$

- $|A_{ij}| \leftrightarrow$ BFs, so well measured, small errors
- $\Delta\phi$ measured in Dalitz $B^0 \rightarrow K_S \pi^+ \pi^-$
 → only 1 min in likelihood, reasonable error $\sim 31^\circ$
- $\phi, \bar{\phi}$ measured in Dalitz $B^0 \rightarrow K^+ \pi^- \pi^0$
 → likelihood has 2 minima within $\sim 1\sigma$
- weak constraint on γ

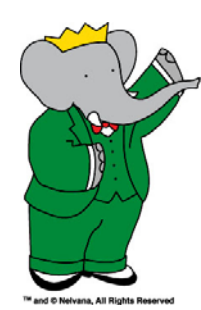


Updating
 $B^0 \rightarrow K^+ \pi^- \pi^0$
 analysis with
 more stats!



$B^0 \rightarrow K_S \pi^+ \pi^-$, arXiv:0708.2097

Pablo del Amo Sanchez,
 LPNHE - IN2P3 - CNRS



Conclusions



- BaBar is exploring many interesting topics in Charmless B decays:

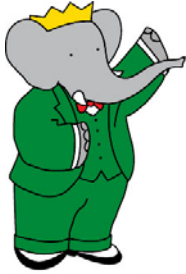
Large DCPV: $B^+ \rightarrow K^+ \pi^+ \pi^-$ (3.7σ in $\rho^0 K^+$)

scalar and NR in KK: $B^+ \rightarrow K^+ K^- \pi^+$ & $B^0 \rightarrow K^+ K^- K^0$

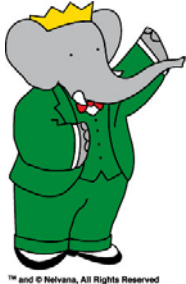
β_{eff} from $B^0 \rightarrow \rho^0 K_S, f_0 K_S, \Phi K^0$ & high mass $K^+ K^- K^0$

γ via CPS – GPSZ: $B^+ \rightarrow K^+ \pi^- \pi^0, B^0 \rightarrow K_S \pi^+ \pi^-$

...among many others!



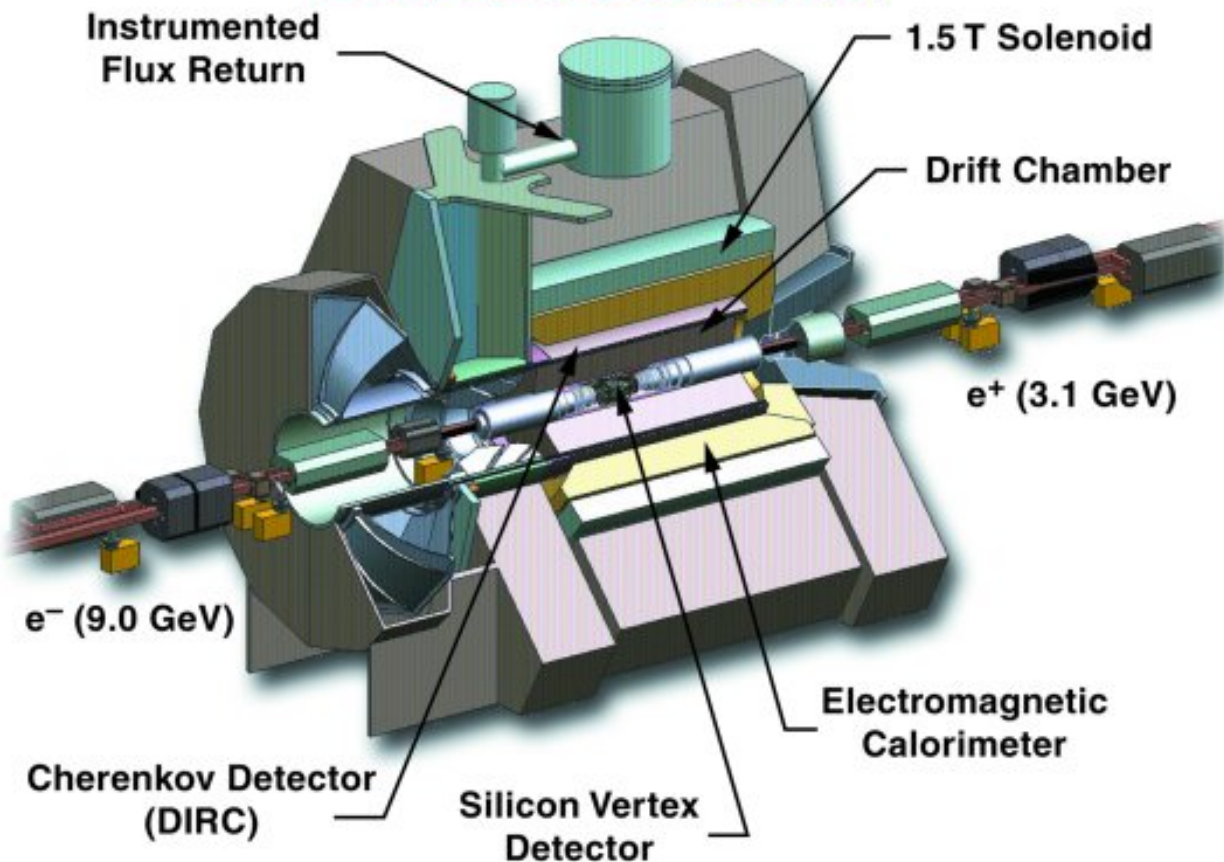
BACK UP SLIDES



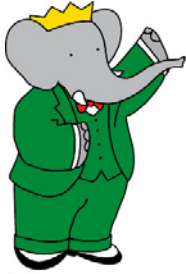
The BaBar experiment



BABAR Detector



- Asymmetric energies:
boost $\beta\gamma = 0.56$
- $\sqrt{s} = 10.58 \text{ GeV}$
 $= m(Y(4S)) \approx 2 m(B^0)$
so $e^+e^- \rightarrow Y(4S) \rightarrow B\bar{B}$
- SVT: 100 μm resolution
in $\Delta z \sim \beta\gamma c\tau = 250 \mu\text{m}$
- SVT: good eff
for low p_t tracks
- PID from DIRC essential
for tagging
- Belle experiment similar

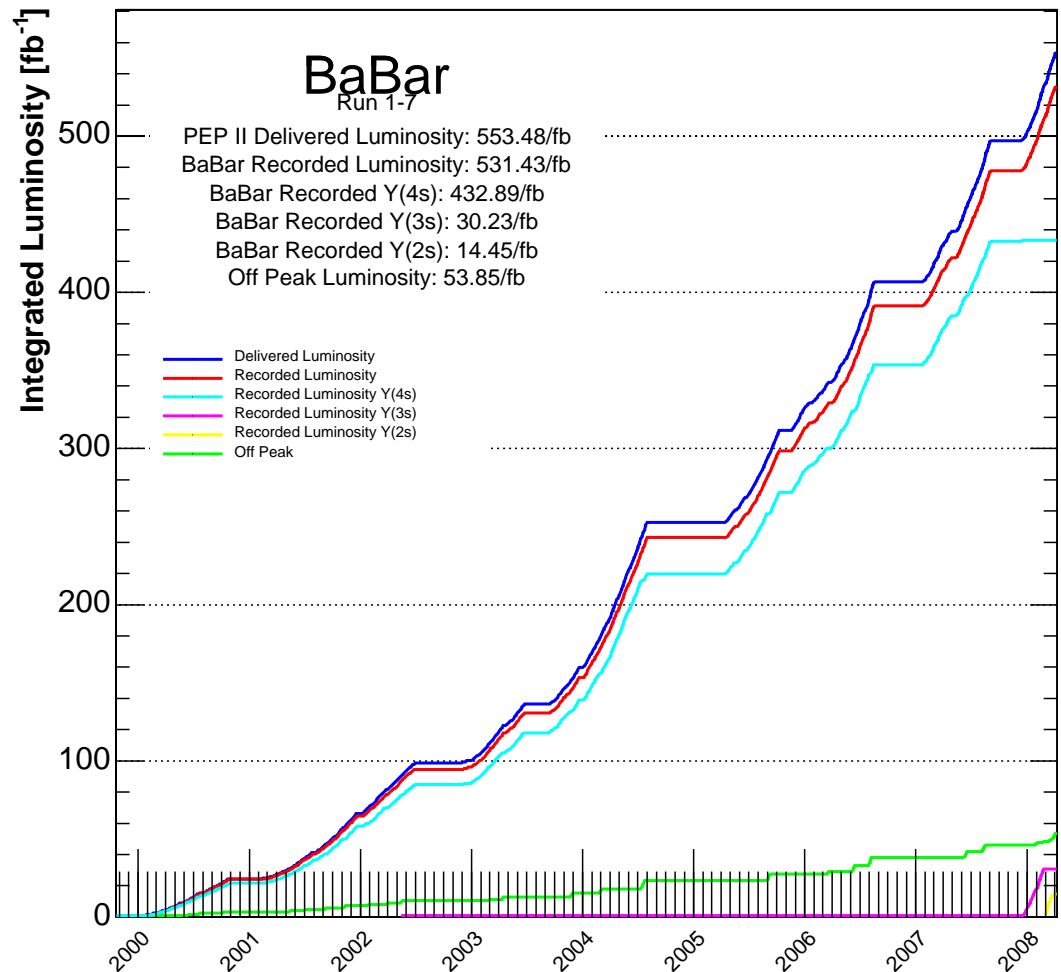


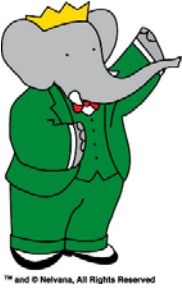
The BaBar experiment



- Y(4S) data taking ended Dec 2007: ~ 465 M BB
- Have recorded ~ 30/fb on Y(3S) and ~ 15/fb on Y(2S)
- Routinely collect data 40 MeV below Y(4S) peak for background characterization
- Finished running on 8th April

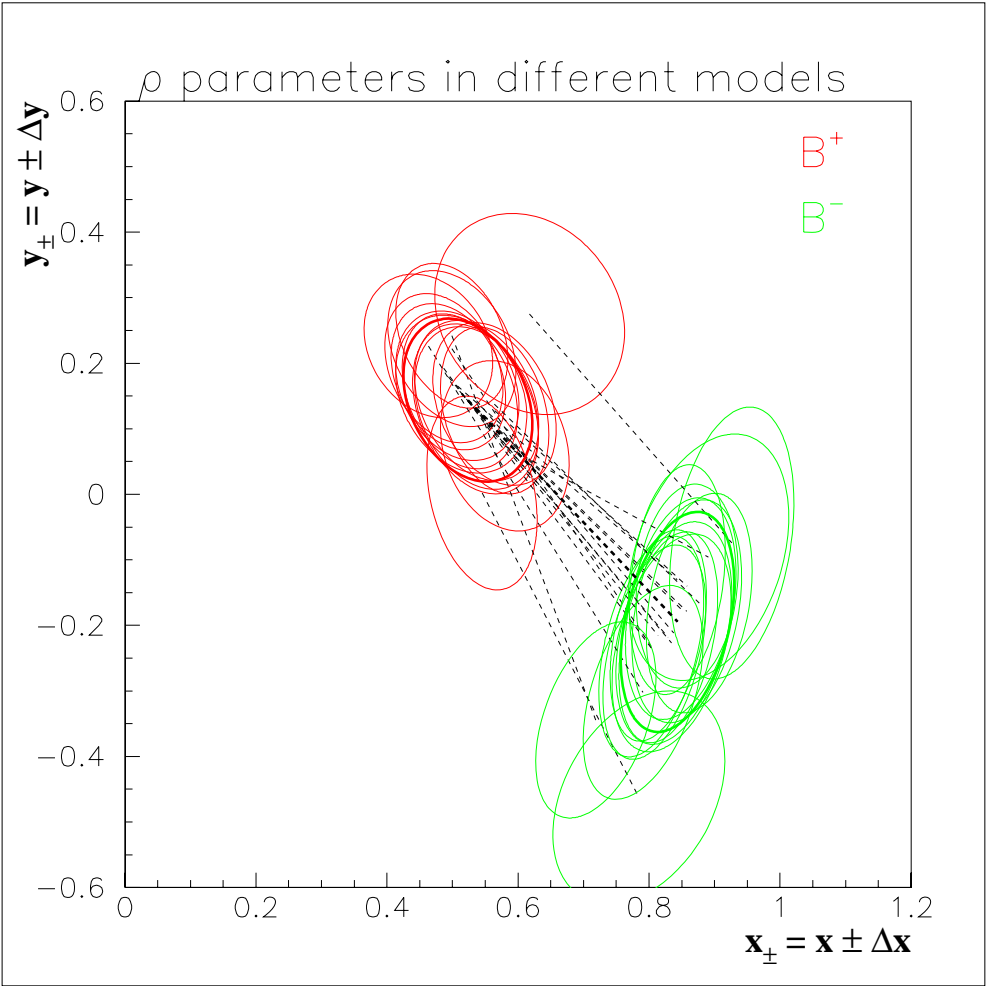
As of 2008/04/11 00:00





™ and © Nelvana, All Rights Reserved

$\rho^0 K^+$ DCPV significance



“Dalitz” analysis

- 2 degrees of freedom in $B \rightarrow P_1 P_2 P_3$, usually $m^2_{P_1 P_2}$ and $m^2_{P_1 P_3}$:
3 daughters x 3 p comp – 4 (E, p conservation) - 3 Euler angles

Resonances, bands of constant m^2_{12} , m^2_{23} or m^2_{13}

Overlap \rightarrow interference

\rightarrow sensitive to relative phase

Observe intensity $|A|^2$,

with $A \sim \sum c_i BW_i$ (Isobar)

c_i characterize model

so $|A|^2 \sim c_k^* c_l BW_k^* BW_l$

$k, l > 1$ lift degeneracies

Ideal to measure phases!

Dalitz Plot

