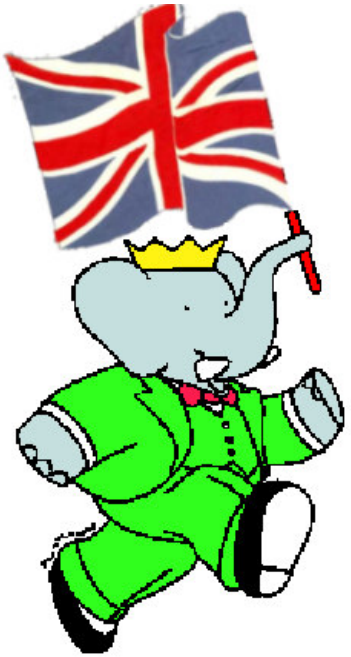


Time dependent Dalitz Plot analysis of $B^0 \to K_S \pi^+ \pi^-$

Jelena Ilic

University of Warwick

Talk outline

- 3 body decays - Dalitz plot
- Motivation
- Backgrounds
- Self Cross Feed
- Results
- Conclusion

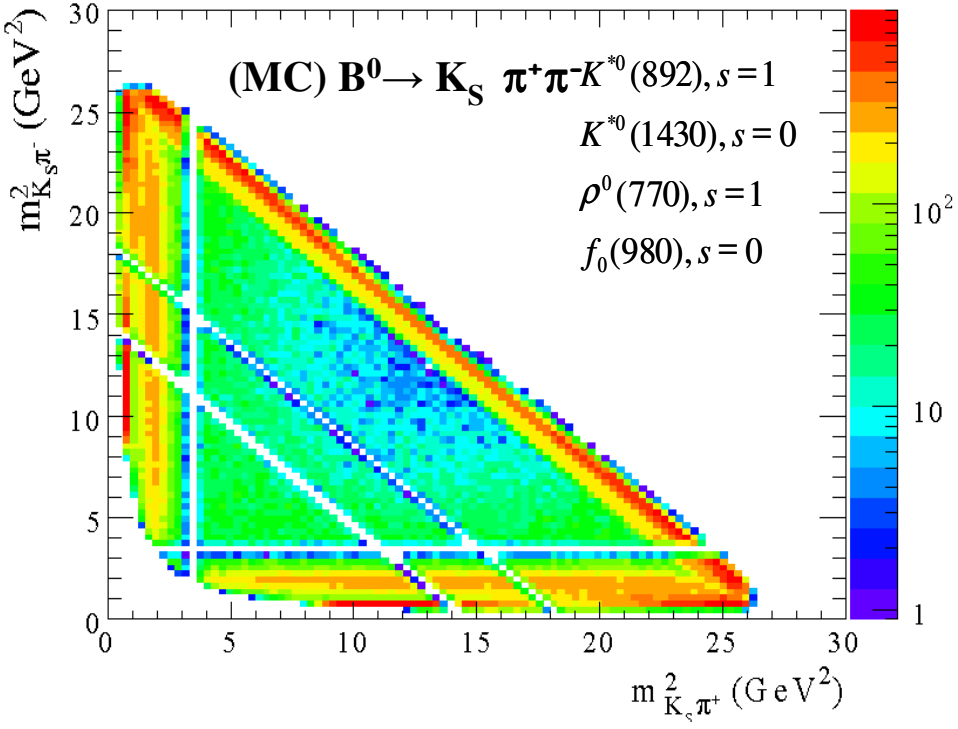
3 body decays - Dalitz Plot

4 vectors	12
conservation laws	-4
meson masses	-3
free rotation	-3
total	**2**

- Usual choice : m_{12}^2 m_{23}^2 or m_{13}^2 invariant mass of combined ij particle
- Decay rate:

$$\Gamma \propto |M|^2 dm_{12}^2 dm_{23}^2$$ (M – invariant amplitude)

Dalitz plot - visualisation of the 3 body phase space



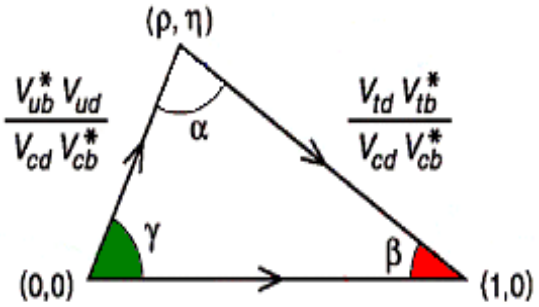
- Interfering Q2B modes
  - DP analysis is sensitive to their relative phases
  - This allows to measure $2\beta_{eff}$ in penguin dominated modes rather than just S or $\sin(2\beta_{eff})$.
  - Interfering tree and penguin diagrams~information on CKM angle γ

Motivation

- Study CP violation effects

Standard Model ~ CKM matrix ~ couples the quarks with the weak force carriers

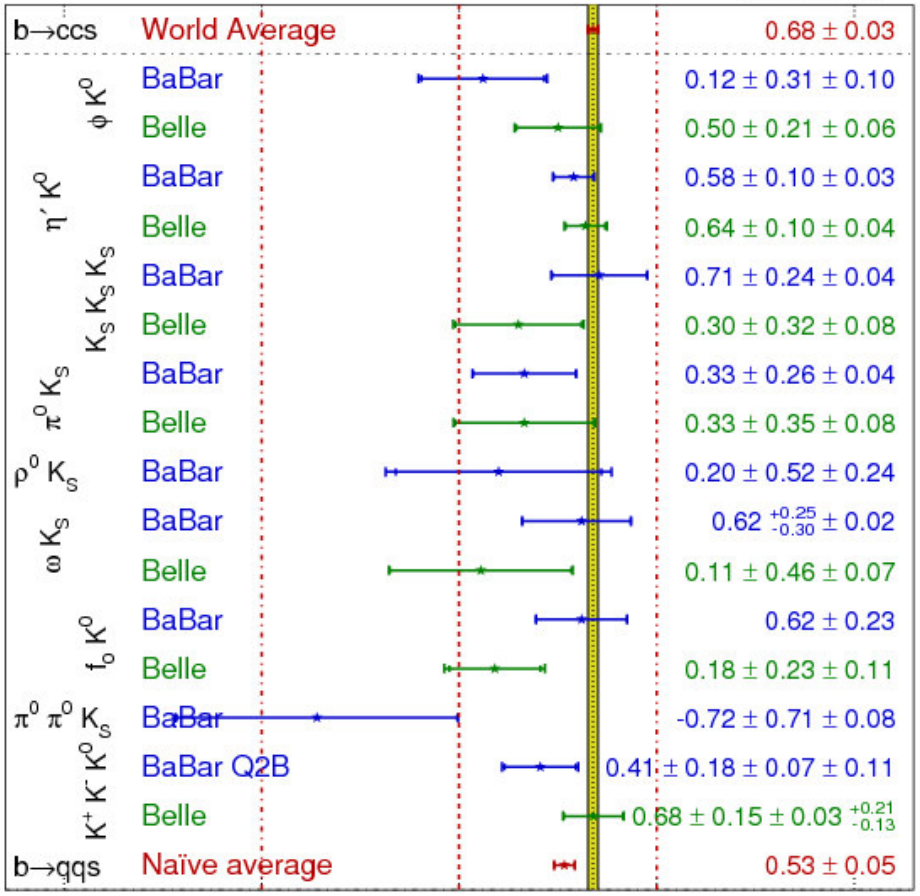
$$V_{CKM} = \begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix}$$



- measurement of the angle β in b→sqqbar

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

HFAG Moriond 2007 PRELIMINARY

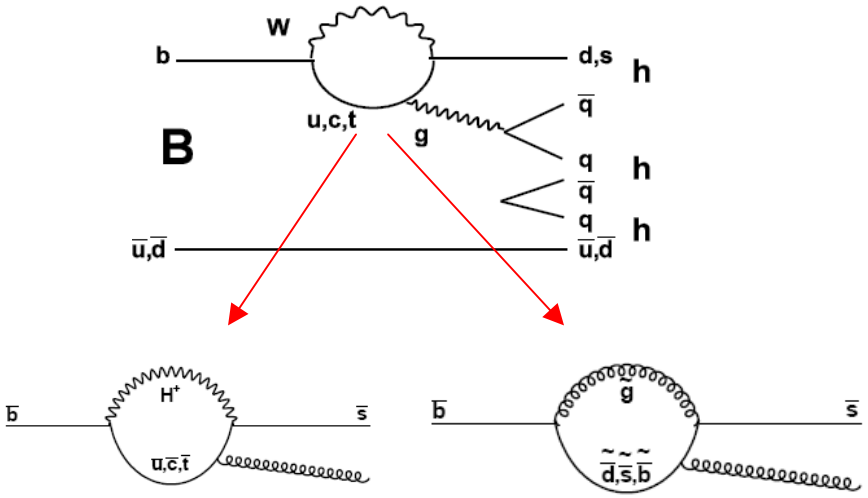


- constraint on the angle γ

M. Ciuchini, M.Perini and L.Silvestrini, Phys.Rev. D **74** (2006) 051301

M. Gronau, D. Pirjol, A. Soni and J. Zupan, Phys.Rev. D **75** (2007) 014002

- New Physics?



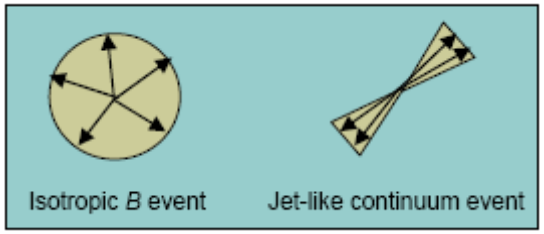
Background

- Continuum

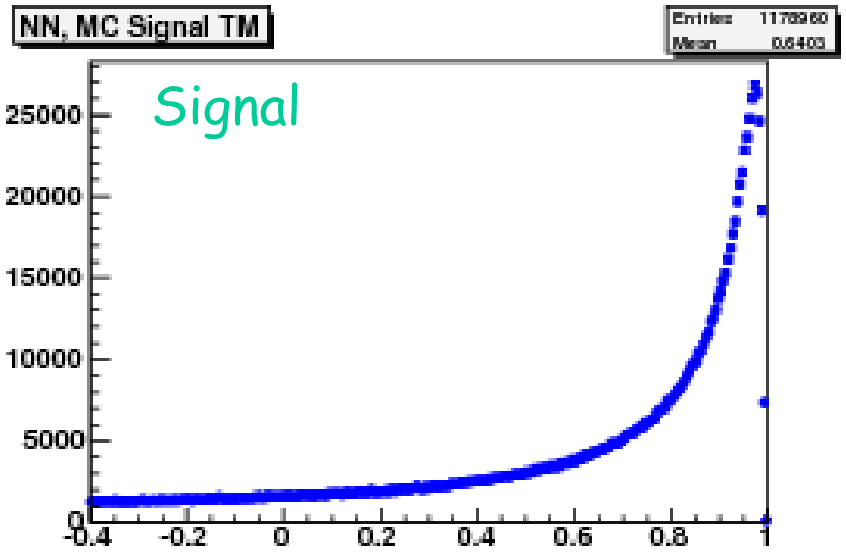
  $e^+e^- \rightarrow$ qqbar (q=light quark)

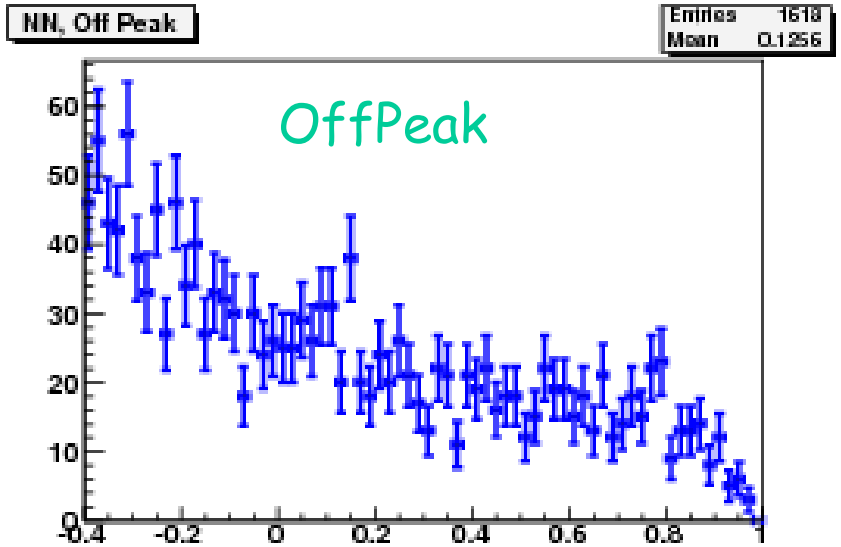
  Dominant background

Use events topology



Combine topological variables to form a NN





Use kinematical variables

- Energy substituted mass
- Energy difference

$$m_{ES} = \sqrt{E_x^2 - \vec{p}_B^2}$$

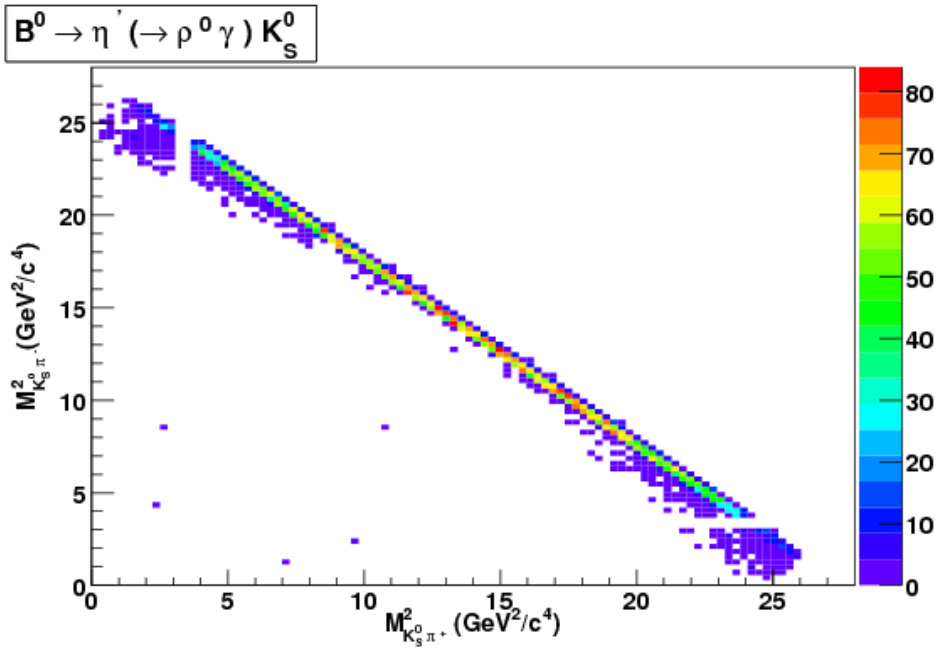
$$\Delta E = E_B - E_x \qquad E_x = \frac{1}{2}\sqrt{s}$$

Sqrt(s) - Invariant mass of e^+e^- system

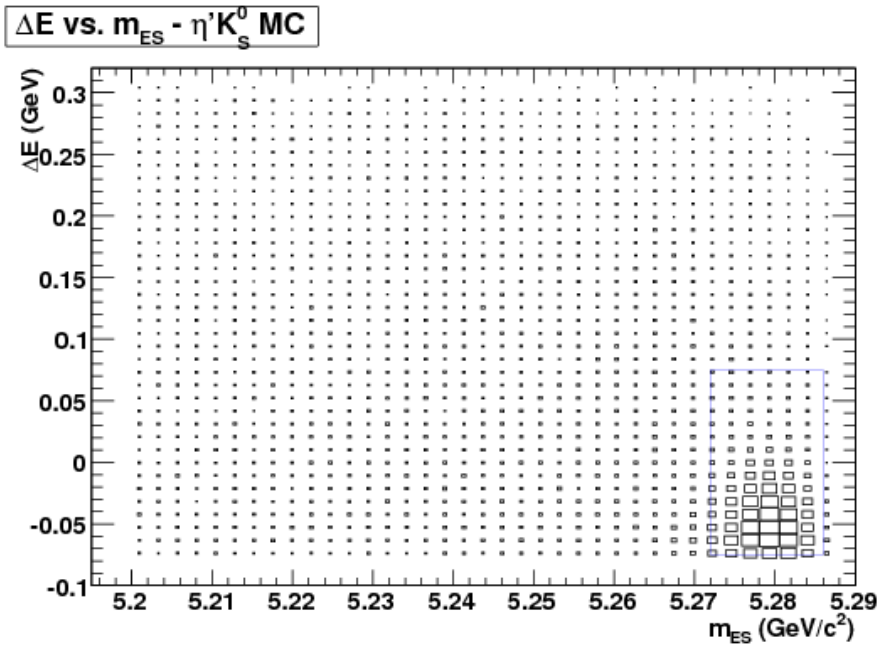
Background

- BBbar
  - B decay events
  - Final state is not a product of charmless B meson decay to $K_S\pi^+\pi^-$

- Study using both generic and exclusive MC samples
- find dominant decay modes (peaking background)
- combinatorial background



Mode	Number of events
$B^0 \to D^-(\to K^0_S\pi^-)\pi^+$	3377 ± 60
$B^0 \to J/\psi(\to l^+l^-)K^0_S$	1803 ± 43
$B^0 \to \psi(2S)K^0_S$	142 ± 13
$B^0 \to \eta' K^0_S$	37 ± 16
$B^0 \to a_1^{\pm}\pi^{\mp}$	7.3 ± 0.7
$B^0 \to D^{*-}(\to D\pi)\pi^+$	43.8 ± 2.5
$B^0 \to D^- h^+$; $B^0 \to D^-\mu^+\nu_\mu$	281 ± 20
$B^0 \to D^{*-}\rho^+$	34.5 ± 4.6
$B^0 \to \{\text{neutral generic decays}\}$	114 ± 7
$B^+ \to \{\text{charged generic decays}\}$	282 ± 11



Self Cross Feed

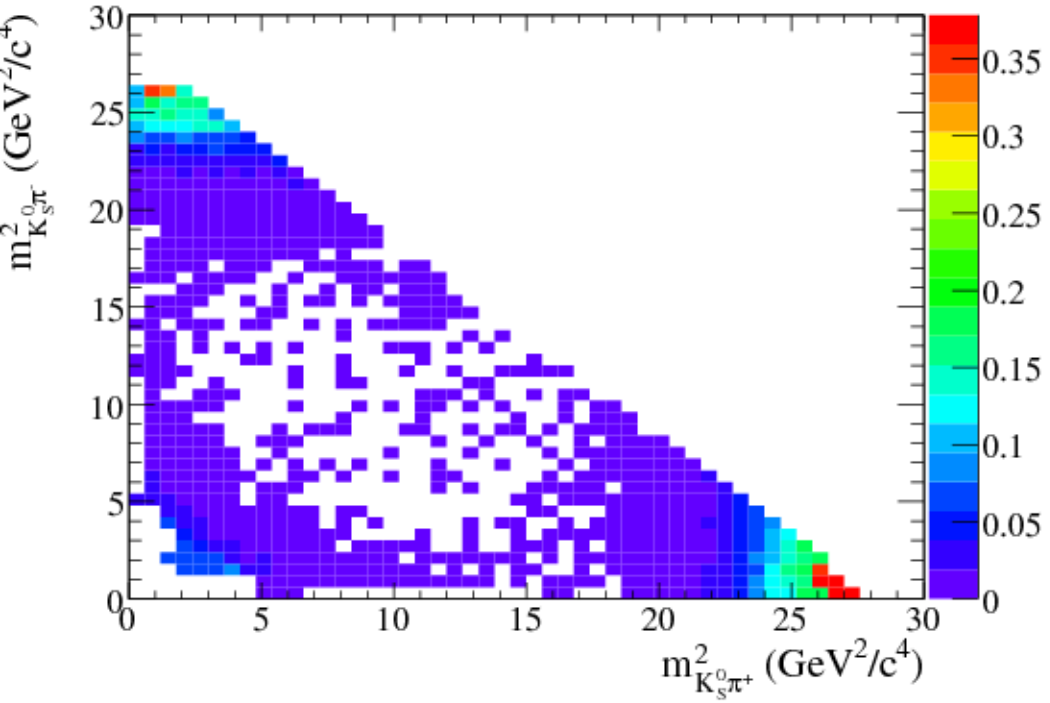
- Self Cross Feed

  Misreconstructed signal events (one or more particles actually from decay of other B in event)

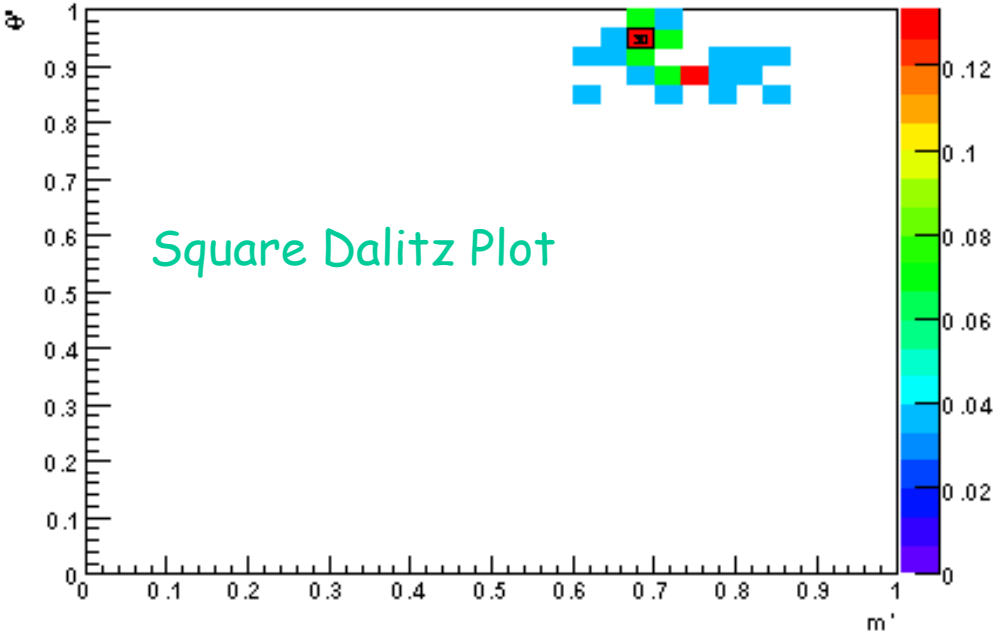
  ~1%

$$d_{\text{migration}} = \sqrt{(m^2_{13_{MC}} - m^2_{13_{\text{reco}}})^2 + (m^2_{23_{MC}} - m^2_{23_{\text{reco}}})^2}$$

SCF events fraction



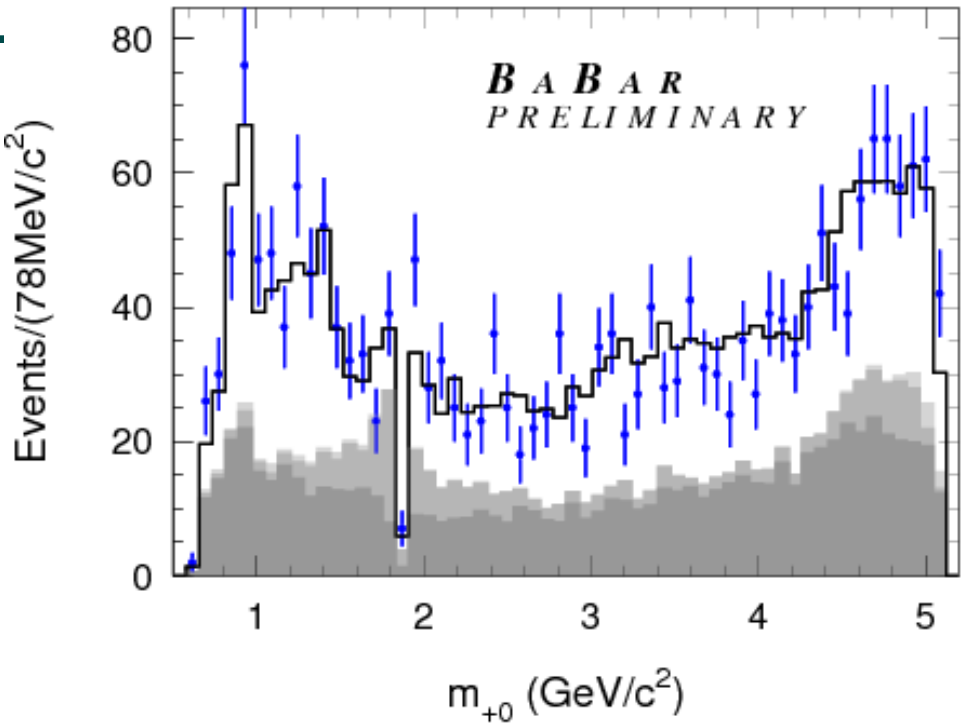
SCF events migration probability

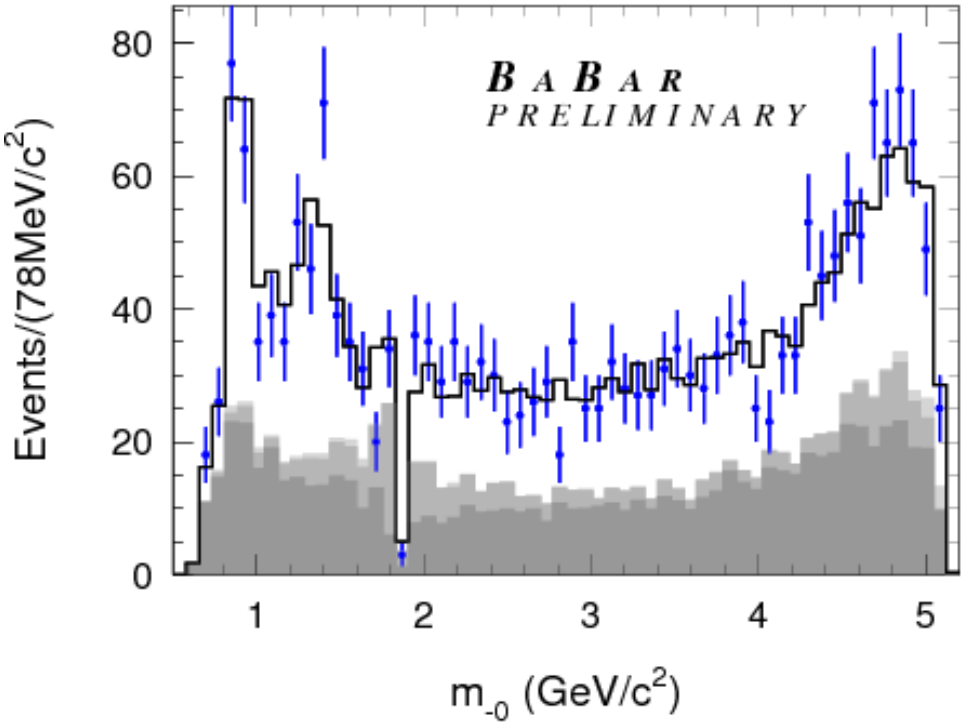


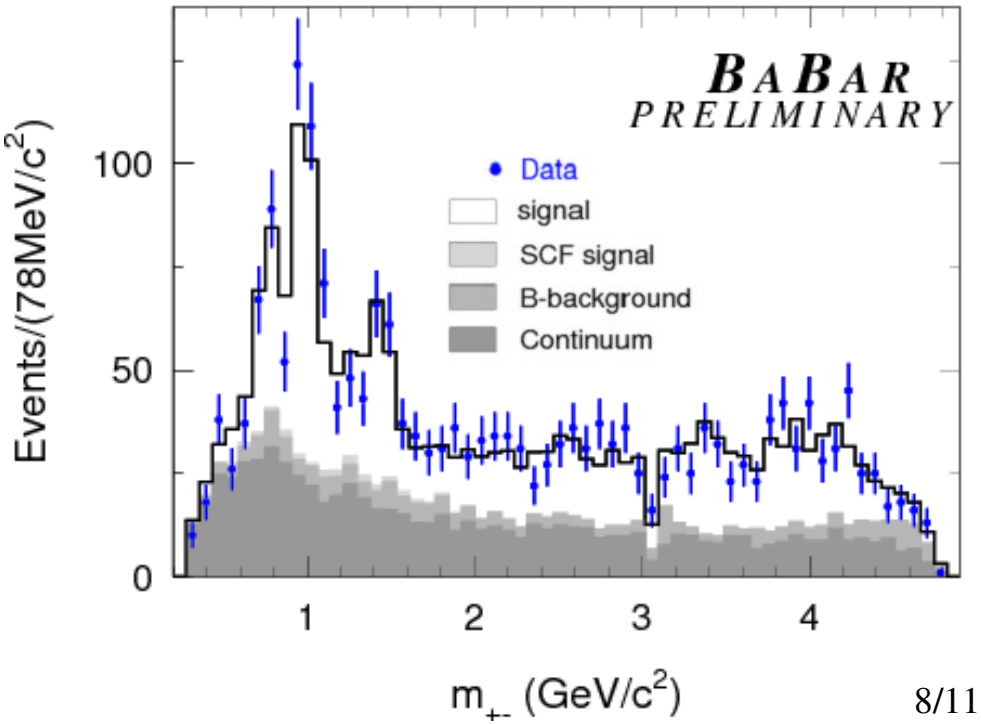
Results

- (383 ± 3)10^6 BBbar decays
  - 22525 candidates
  - $B \to K_S \pi^+ \pi^-$ signal yield: 2172±70

arXiv: 0708.2097 [hep-ex]







Results

- Resonances' relative magnitudes and phases

arXiv: 0708.2097 [hep-ex]

Resonance Name	$\lvert c_\sigma \rvert$	ϕ[degrees]	$\lvert \overline{c}_\sigma \rvert$ ($\lvert \overline{c_{\overline{\sigma}}} \rvert$)	$\overline{\phi}$[degrees]
$f_0(980)K^0_S$	4.0	0.0	2.8 ± 0.7	-88.6 ± 21.3
$\rho^0(770)K^0_S$	0.10 ± 0.02	58.6 ± 16.4	0.09 ± 0.02	21.3 ± 21.2
$f_0(1300)K^0_S$	1.9 ± 0.4	117.6 ± 22.6	1.1 ± 0.3	-15.2 ± 23.8
Nonresonant	3.0 ± 0.6	13.8 ± 14.3	3.7 ± 0.5	-16.2 ± 17.3
$K^{*+}(892)\pi^-$	0.136 ± 0.021	-60.7 ± 18.5	0.113 ± 0.018	102.6 ± 22.9
$K^{*+}(1430)\pi^-$	4.9 ± 0.7	-82.4 ± 16.8	7.1 ± 0.9	79.2 ± 20.5
$f_2(1270)K^0_S$	0.011 ± 0.004	62.9 ± 23.3	0.010 ± 0.003	-73.9 ± 27.8
$\chi_{c0}(1P)K^0_S$	0.34 ± 0.15	68.7 ± 31.1	0.40 ± 0.11	154.5 ± 28.6

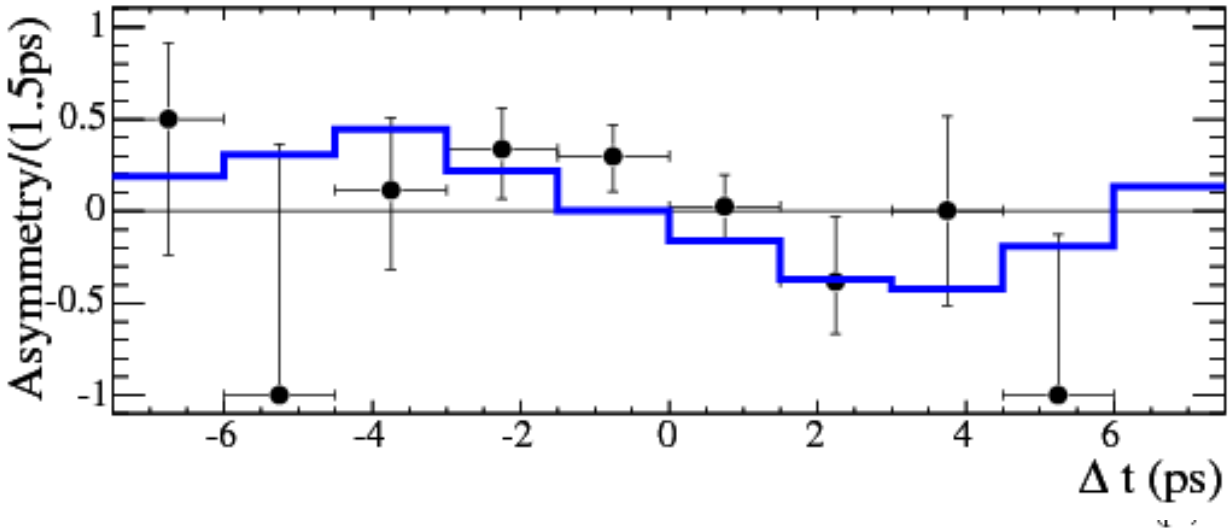
- Mixing phase, direct and mixing-induced CP asymmetries

Resonances	$2\beta_{eff}$ (degrees)	C	S
$f_0(980)K^0_S$	$89^{+22}_{-20} \pm 5 \pm 8$	$0.35 \pm 0.27 \pm 0.07 \pm 0.04$	$-0.94\ ^{+0.07+0.05}_{-0.02-0.03} \pm 0.02$
$\rho^0(770)K^0_S$	$37^{+19}_{-17} \pm 5 \pm 6$	$0.02 \pm 0.27 \pm 0.08 \pm 0.06$	$0.61\ ^{+0.22}_{-0.24} \pm 0.09 \pm 0.08$
$K^*(892)\pi$		$-0.18 \pm 0.10 \pm 0.03 \pm 0.03$	

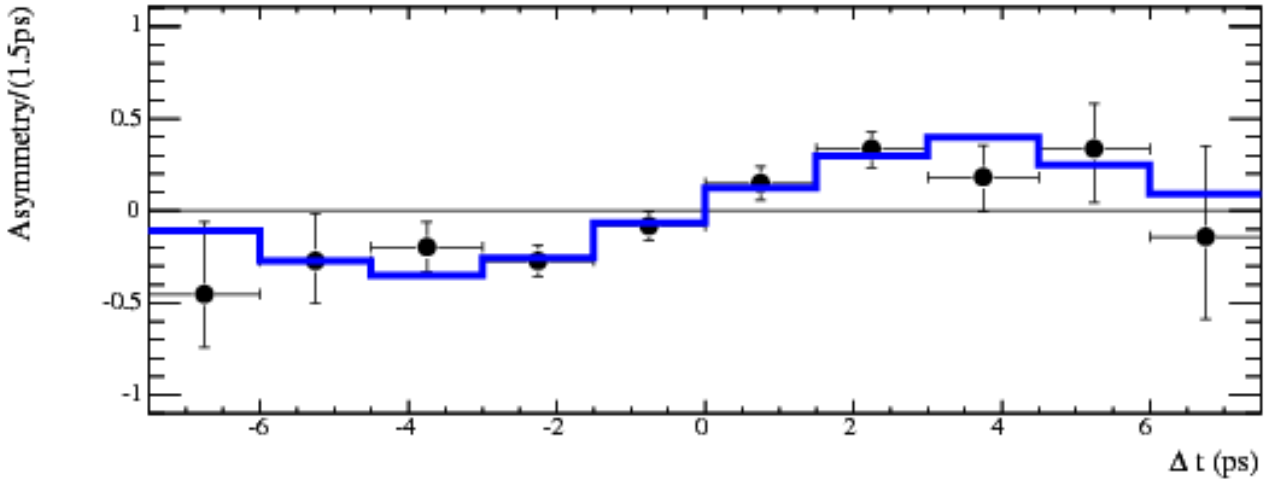
Results

arXiv: 0708.2097 [hep-ex]

- Δt asymmetry



- $f_0(980)K^0_S$ region



- $\rho^0(770)K^0_S$ region

Conclusion

- First Time Depenedent Dalitz plot analysis of $B \to K_S \pi^+ \pi^-$ decays
- Allows measurement of $2\beta_{eff}$ for $f_0(980)K_S$ and $\rho(770)K_S$
- Improved statistical accuracy
- Direct CP asymmetries ~ consistent with 0
- Time dependent asymmetries coefficients *S* measured
  - $S(f_0(980))$ compatible with previous BaBar measurament;It is above $b \to ccs$ expectation in contrast to most $b \to qqs$ analysis
  - $S(\rho^0(770))$ consistent with charmonium measurament of $\sin(2\beta)$
  - Small errors a natural consequence of DP analysis with central value of S close to physical boundary
- Relative phases and magnitudes for different resonances measured
- Measurements of relative phases of $K^*\pi$ allow constraint on gamma using CPS/GPSZ theoretical method