SuperB sensitivity to $\delta_{K\pi}$

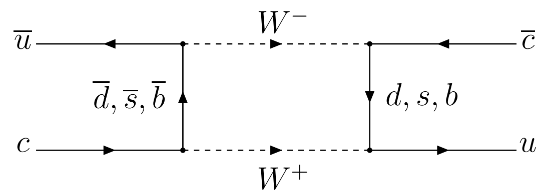
- Mixing is a transition from a particle to its antiparticle. It occurs when the flavour eigenstates (D^0, $\overline{D}^0$) produced in decays are not the same as the mass eigenstates (D_1, D_2) which move through space.

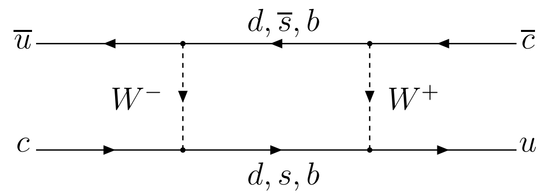
- We parametrise mixing by the normalised mass and width differences of the mass eigenstates:

$$\begin{aligned} \Delta M &= m_1 - m_2 \\ \Delta\Gamma &= \Gamma_1 - \Gamma_2 \\ \Gamma &= (\Gamma_1 + \Gamma_2)/2 \\ x &= \Delta M/\Gamma \\ y &= \Delta\Gamma/2\Gamma. \end{aligned}$$

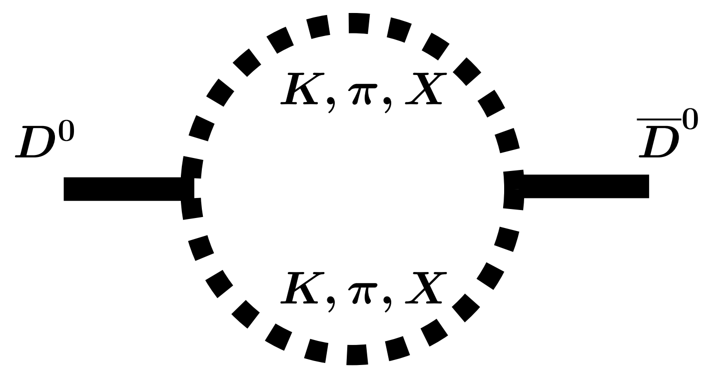
- Mixing is strongly suppressed in charmed mesons; the Standard Model predicts a very tiny ($x, y < 10^{-4}$) effect from calculable short-distance effects.

Short-distance





Long-distance



Measurements

- Many different mixing measurements. Concentrate on three channels:
  - $D^0 \to KK, \pi\pi, K\pi$. Allows the measurement of y_{CP}, equal to y if CP is conserved.
  - $D^0 \to K\pi$. Because of the unknown strong phase $\delta_{K\pi}$ between direct and mixed decays, this channel gives us rotated quantities

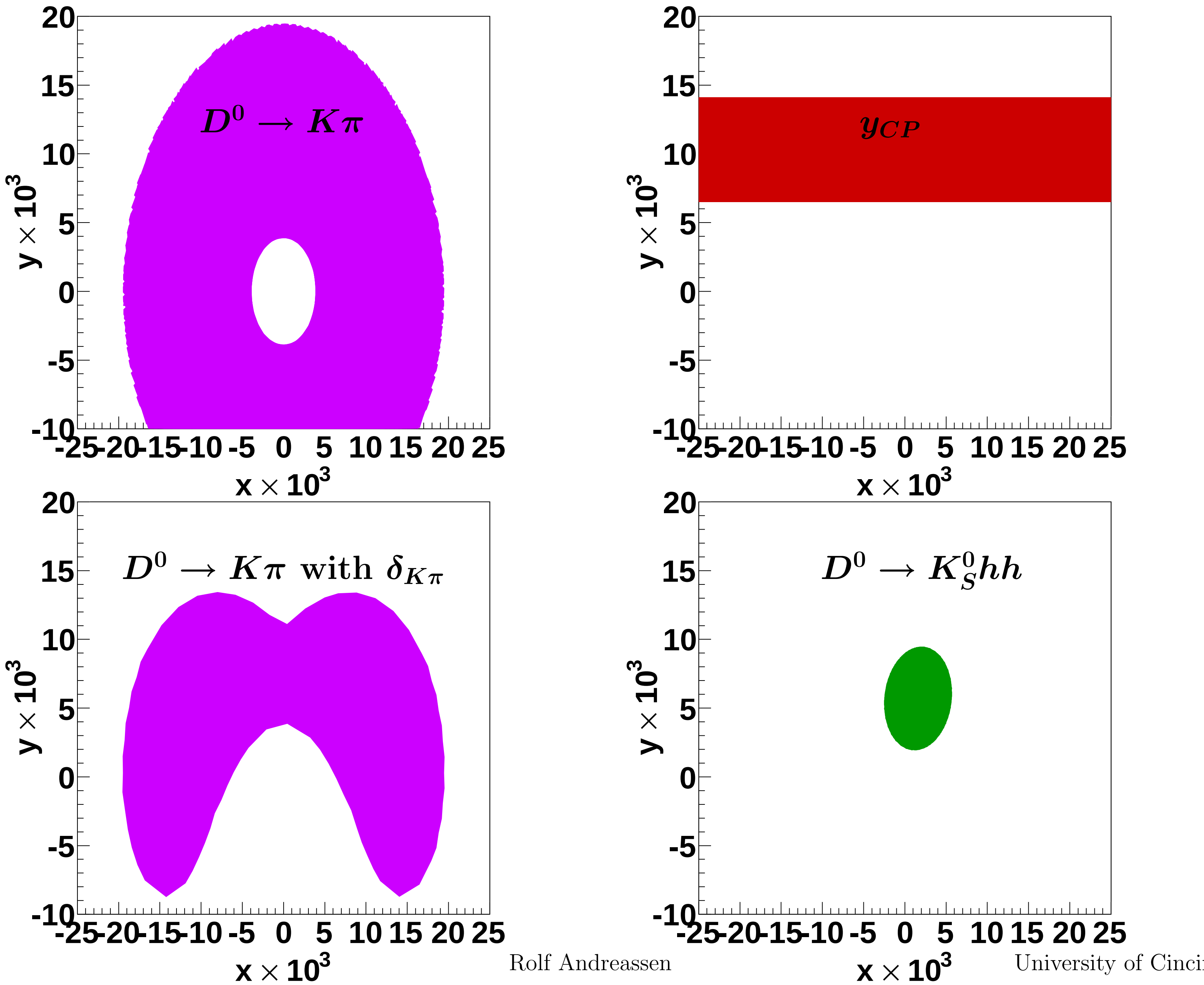
$$\begin{aligned} x' &= x \cos\delta_{K\pi} - y \sin\delta_{K\pi} \\ y' &= y \cos\delta_{K\pi} + x \sin\delta_{K\pi}. \end{aligned}$$

  - $D^0 \to K_S\pi\pi$. This analysis requires an amplitude model for the Dalitz plot, but because $K^0_S\rho$ is a CP eigenstate (and therefore has known strong phase) we can measure the phase at every point relative to this intermediate state, and extract x and y directly.
- By running at charm threshold, we can produce coherent $D^0\overline{D^0}$ pairs, and measure $\delta_{K\pi}$, which allows us to extract x and y from the $K\pi$ channel.
- BaBar results (and one CLEO):

$$\begin{aligned} y_{CP} &= (1.03 \pm 0.33 \pm 0.19)\% \\ x'^2_{K\pi} &= (-0.022 \pm 0.030 \pm 0.021)\% \\ x_{K^0_S hh} &= (0.16 \pm 0.23 \pm 0.12 \pm 0.08)\% \end{aligned}$$

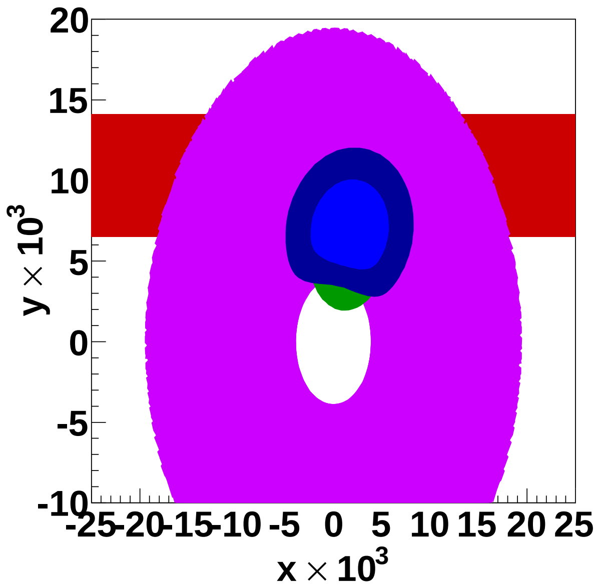
$$\begin{aligned} \cos\delta_{K\pi} &= 1.1 \pm 0.35 \pm 0.07 \\ y'_{K\pi} &= (0.97 \pm 0.44 \pm 0.31)\% \\ y_{K^0_S hh} &= (0.57 \pm 0.20 \pm 0.13 \pm 0.07)\% \end{aligned}$$

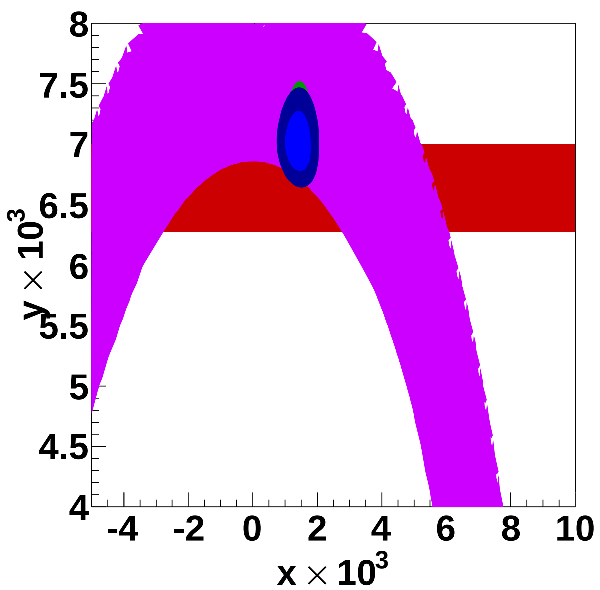
Contours in (x, y) space



Combining the results

- 'CKM-like' fitter uses χ^2 of all results to arrive at best contour.
- For hypothetical SuperB contour, assume that all errors scale as $1/\sqrt{N}$ and that SuperB has 100 times the data of *BABAR* .
- Take fit to *BABAR* results as central value, and perturb individual measurements around this by their hypothetical errors.





 Rolf Andreassen University of Cincinnati

Sensitivity to $\delta_{K\pi}$

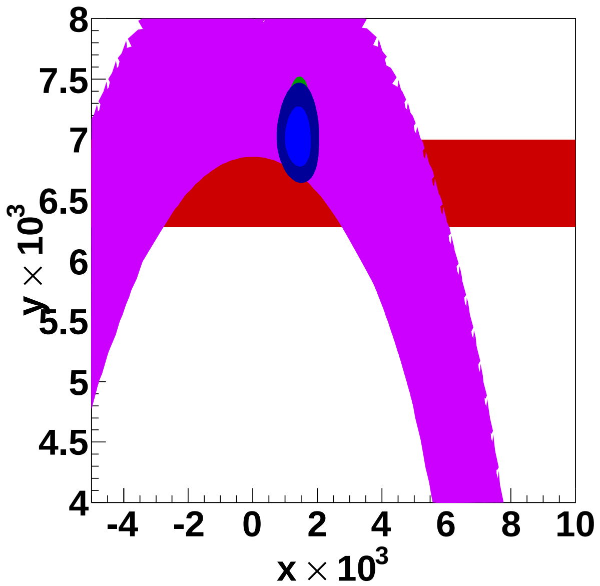
- Suppose we run SuperB at charm threshold long enough to improve the CLEO $\cos\delta_{K\pi}$ measurement by a factor 10.
- This has practically no effect on mixing sensitivity.

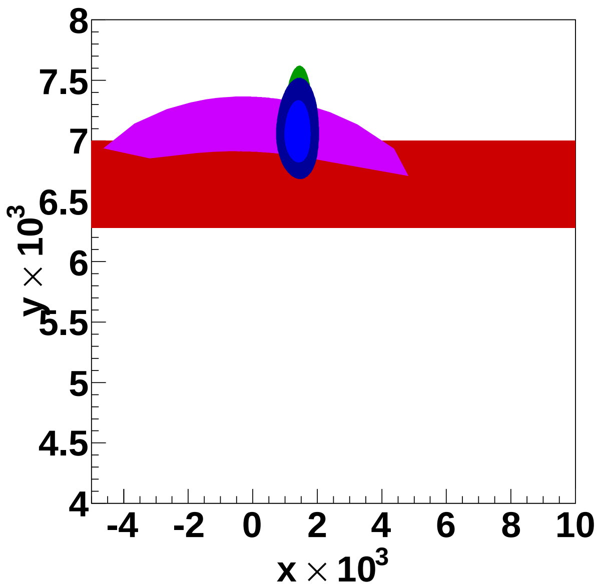
Input	x $[\times 10^3]$	y $[\times 10^3]$	$\cos\delta_{K\pi}$
BaBar	1.68 ± 2.67	6.94 ± 2.06	0.83 ± 0.73
BaBar+CLEO	1.67 ± 2.67	6.85 ± 1.63	1.00 ± 0.43
Plain SuperB	1.39 ± 0.26	7.00 ± 0.14	0.98 ± 0.10
Threshold $\cos\delta = 1.0$	1.40 ± 0.27	7.00 ± 0.15	0.99 ± 0.02
Threshold $\cos\delta = 0.5$	2.29 ± 0.23	7.48 ± 0.18	0.62 ± 0.03
Threshold $\cos\delta = 0.0$	-1.58 ± 0.26	0.80 ± 0.20	0.41 ± 0.03

- $\delta_{K\pi}$ measurement may still be of interest for its own sake.
- $D^0 \to K_S\pi\pi$ with SuperB statistics already has strong sensitivity to $\delta_{K\pi}$ by fixing what sector of the (x, y) space you occupy.

Visualisation

- **Adding a $\cos\delta$ result enormously reduces the purple $K\pi$ annulus.**
- **But with almost no effect on the mixing contour!**





Conclusions and caveats

- **SuperB can have good sensitivity to $\delta_{K\pi}$ ($\sim$ factor 3 better than CLEO) from $D^0 \to K^0_S hh$, without a charm threshold run.**
- **Mixing is not the best argument for a threshold run.**
- **Point to note: $D^0 \to K\pi$ analysis is simpler than $D^0 \to K^0_S hh$ - no amplitude analysis required.**
- **The study assumed that systematic errors would scale along with statistical ones. If error from amplitude model of $D^0 \to K^0_S hh$ analysis is not reducible, sensitivity will degrade.**