Measuring γ with

$$B^0 \to D^0 K^{*0}$$

Dalitz analysis @ Babar

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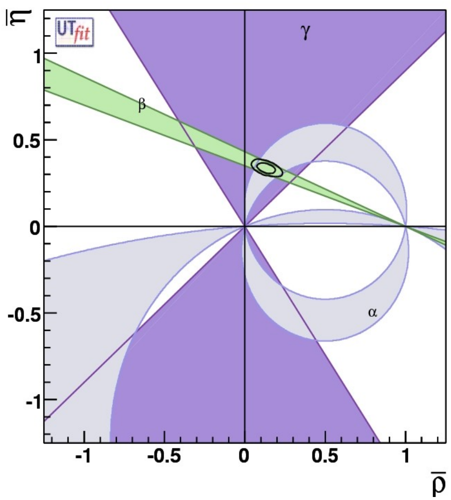
Outline

- Idea and analysis technique
- CP fit and toy-MC tests
  - Polar coordinates
  - Cartesian coordinates
- Measurement and expected sensitivity on γ with actual BaBar statistics

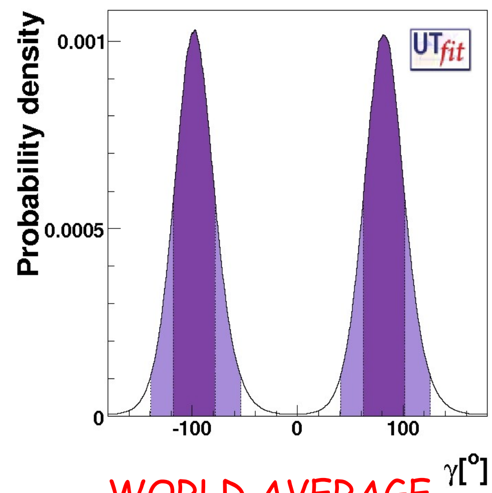
Measurements of γ

From charged $B \to D^0K$ measurements



Combination of many methods (GLW, ADS, Dalitz)

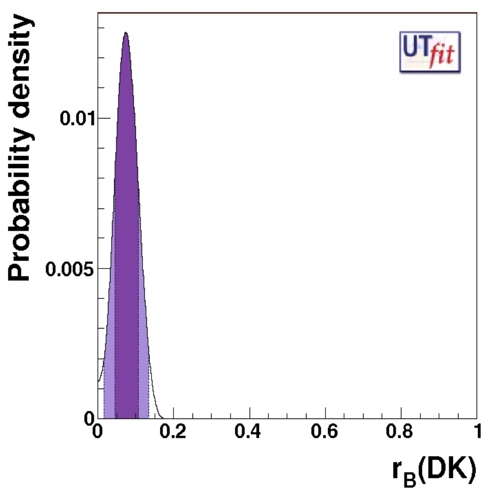
$$\gamma = (82 \pm 20)^o$$



WORLD AVERAGE

$$r_B = \left|\frac{A(V_{ub})}{A(V_{cb})}\right| = \left|\frac{A(B^+ \to D^0 K^+)}{A(B^+ \to \bar{D}^0 K^+)}\right|$$

$$r_B = 0.075 \pm 0.030$$

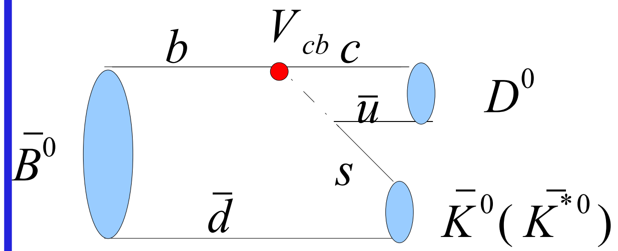


Measurements of γ with neutral B

Also in the neutral B decays phases V_{cb} and V_{ub}

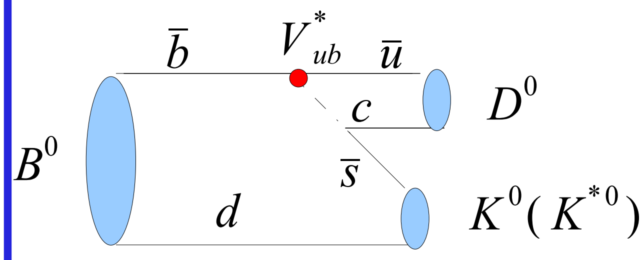
$\bar{B}^0 \to D^0 \bar{K}^0$

$\bar{B}^0 \to D^0 \bar{K}^0 (\bar{K}^{*0})$



$B^0 \to D^0 K^0$

$B^0 \to D^0 K^0 (K^{*0})$



$$r_B = \left| \frac{A(\bar{B}^0 \to D^0 K^{*0})}{A(B^0 \to D^0 K^{*0})} \right| \sim 0.4$$

But B^0 - B^0bar mixing... $\sin(2\beta+\gamma)$

Some evaluation:

$r_B < 0.4 @ 90\% C.L.$ — EXPERIMENTAL MEASUREMENT

$r_B = 0.26 \pm 0.16$ — PHENOMENOLOGICAL ESTIMATE

See: [BABAR Collaboration], B.~Aubert et al., Phys. Rev. D74, 031101, (2006)
and also http://ckm2005.ucsd.edu/WG/WG5/thu2/Sordini-WG5-S3.pdf

The idea

Study the decay:

$$B^0 \to D^0(\bar{D}^0)\, K^{*0}$$

$$K^{*0} \to K^+ \pi^-$$

$$D^0(\bar{D}^0) \to K_S \pi^+ \pi^-$$

$$K_S \to \pi^- \pi^+$$

$$B^0 \to K^+$$

$$\bar{B}^0 \to K^-$$

with a D^0 Dalitz analysis

$$B^0 \to D^0 K^{*0}[K^+\pi^-](V_{cb}) \;\text{ or }\; B^0 \to \bar{D}^0 K^{*0}[K^+\pi^-](V_{ub})$$

- Decay is self tagging (no time-dependent measurement)
- The ratio $r_B \sim 0.4$
- The D^0 Dalitz plot is well known. In the charged B sector, the Dalitz method gives the best error on γ

See this morning talks from F.Martinez-Vidal and A.Poluektov

Likelihood fit: the structure

CP PDF:

$$A(\bar{B}^0 \to (D^0[\to f]\bar{K}^{*0})_p) = A_{cb,p} A_f e^{i(\delta_{cb,p}+\delta_f)} + A_{ub,p} A_{\bar{f}} e^{i(\delta_{ub,p}+\delta_{\bar{f}}-\gamma)}$$

$$A(B^0 \to (\bar{D}^0[\to f]K^{*0})_p) = A_{cb,p} A_{\bar{f}} e^{i(\delta_{cb,p}+\delta_{\bar{f}})} + A_{ub,p} A_f e^{i(\delta_{ub,p}+\delta_f+\gamma)}$$

p B phase space point

$$A_f e^{i\delta_f} = f_- = f(m_-^2, m_+^2)$$

$$A_{\bar{f}} e^{i\delta_{\bar{f}}} = f_+ = f(m_+^2, m_-^2)$$

D^0 Dalitz structure

$$PDF = |f_{\mp.}|^2 + r_S^2 |f_{\pm.}|^2 + 2 k r_S (R\{f_{\mp.} f_{\pm.}^*\} \cos(\delta_S + \delta_D(m_{\mp.}, m_{\pm.}) \mp \gamma) +$$

$$- I\{f_{\mp.} f_{\pm.}^*\} \sin(\delta_S + \delta(m_{\mp.}, m_{\pm.}) \mp \gamma))$$

$$r_S^2 = \frac{\int dp |A_{ub,p}|^2}{\int dp |A_{cb,p}|^2}$$

$$k e^{i\delta_S} = \frac{\int dp\, A_{cb,p} A_{ub,p} e^{i\delta_p}}{\sqrt{\int dp |A_{cb,p}|^2 \int dp |A_{ub,p}|^2}}$$

Two body limit:

$$r_S \to r_B$$

$$k \to 1$$

See: M.Gronau,Phys.Lett. **B557**, 198-206(2003)

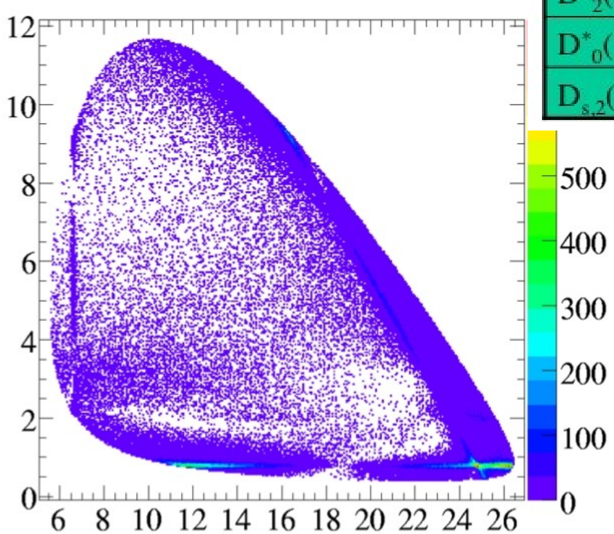
Evaluation of the k parameter

The k parameter takes into account the contributions from non-K*(892) resonance in the B decay

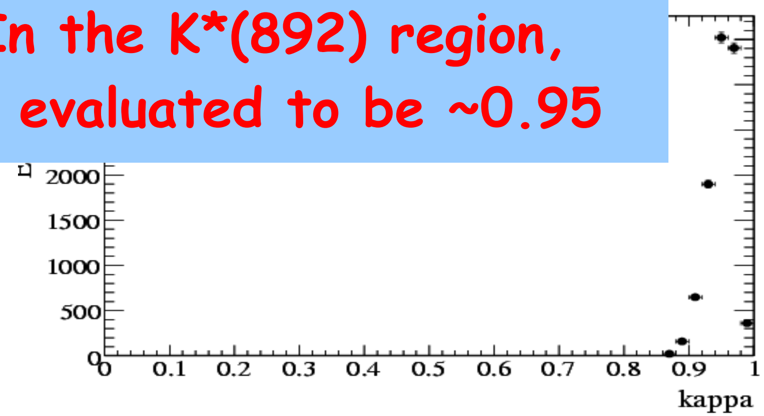
$$k\, e^{i\delta_S} = \frac{\int dp\, A_{cb,p} A_{ub,p} e^{i\delta_p}}{\sqrt{\int dp |A_{cb,p}|^2 \int dp |A_{ub,p}|^2}}$$

10K different B Dalitz models: amplitudes varied of +-30% and always different random choice of strong phases
(Ds,2(2573) amplitude varied of +- 200%)

	Mass (GeV/c_2)	Width (GeV/c_2)	J^P	A_{Vcb}	A_{Vub}
$K^*(892)$	0.89166	0.0508	1^-	1	0.4
$K^*_0(1430)$	1.412	0.294	0^+	0.3	0.12
$K^*_2(1430)$	1.4256	0.0985	2^+	0.15	0.06
$K^*(1680)$	1.717	0.322	1^-	0.2	0.08
$D^*_2(2460)$	2.461	0.046	2^+	1	0
$D^*_0(2308)$	2.308	0.276	0^+	1	0
$D_{s,2}(2573)$	2.572	0.015	2^+	0	0.17



In the K*(892) region, k evaluated to be ~0.95

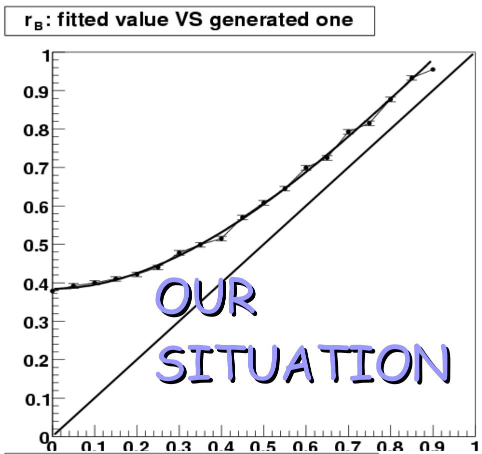


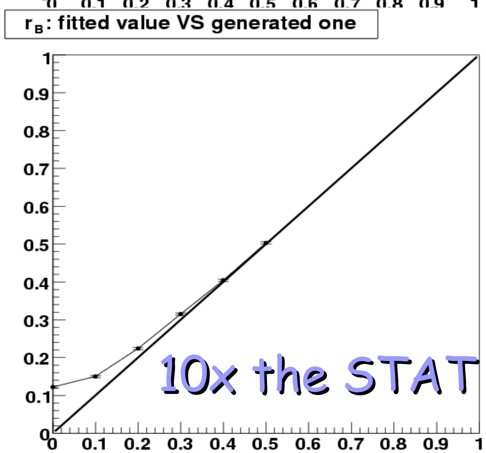
See: F.Polci,M.-H.Schune and A.Stocchi hep-ph/0605129

CP fit: polar coordinates

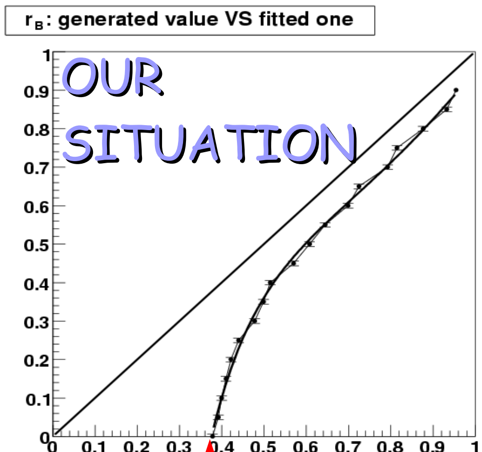
Linearity problem: due to the likelihood dependence on r_B,, one tends to fit a bigger r_B than the “true” one and then to underestimate the error on γ

r_B fit vs r_B gen





r_B gen vs r_B fit



0.38 !!!

Very difficult to convert!!

Test made assuming ~35 signal events and a realistic amount of background

CP fit: cartesian coordinates

$$x_{\pm} = r_B \cos(\delta \pm \gamma)$$

$$y_{\pm} = r_B \sin(\delta \pm \gamma)$$

Cartesian coordintaes, used in the D^0K^- Dalitz analysis, they solve the linearity problem

Problems when performing the fit in cartesian coordinates due to the poor statistics: the variables do not have Gaussian behaviour. Biases.

FROM TOY MC STUDIES..

	OUR CONFIGURATION	10x the STAT
μ_{x+}^{PULL}	-0.52 ± 0.005	-0.04 ± 0.05
σ_{x+}^{PULL}	0.82 ± 0.03	0.97 ± 0.04
μ_{x-}^{PULL}	-0.07 ± 0.05	-0.02 ± 0.05
σ_{x-}^{PULL}	0.78 ± 0.04	0.99 ± 0.04
μ_{y+}^{PULL}	-0.18 ± 0.05	-0.05 ± 0.06
σ_{y+}^{PULL}	0.79 ± 0.04	1.1 ± 0.04
μ_{y-}^{PULL}	0.40 ± 0.05	-0.03 ± 0.05
σ_{y-}^{PULL}	0.79 ± 0.04	1.03 ± 0.04

And still problems in the case of 45 signal only events...due to the statistics! We expect ~35 events, and background..

μ and σ of pull distributions

Measurement at ~350 fb^{-1}

- CP fit problems due to low statistics
- The situation will eventually improve when performing a simultaneous fit with a measurement of r_B

With a 350 fb^{-1} (Babar available statistics):

for the moment perform the *measurement of gamma as a scan in* r_B (likelihood scan of gamma for each value of r_B).

Similar to what is done in D(*)pi for $\sin(2\beta+\gamma)$ *!!!*

TOY-MC with r_B fixed

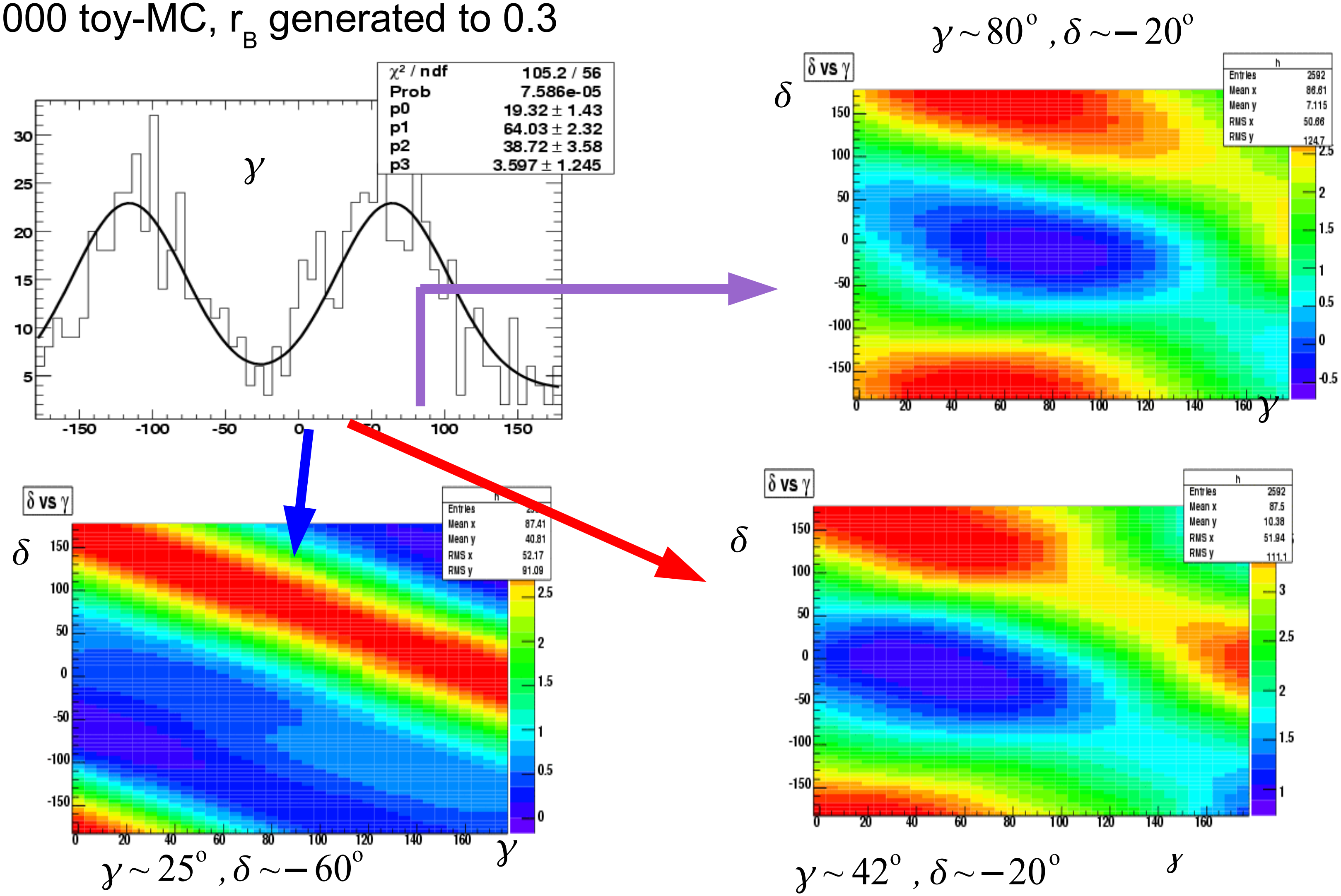
Coverage test for γ :
(65+-2)% for rB=0.40
(65+-2)% for rB=0.35

% of cases in which:

$$|LogL()-LogL(\gamma=\gamma_{GEN})|<1.$$

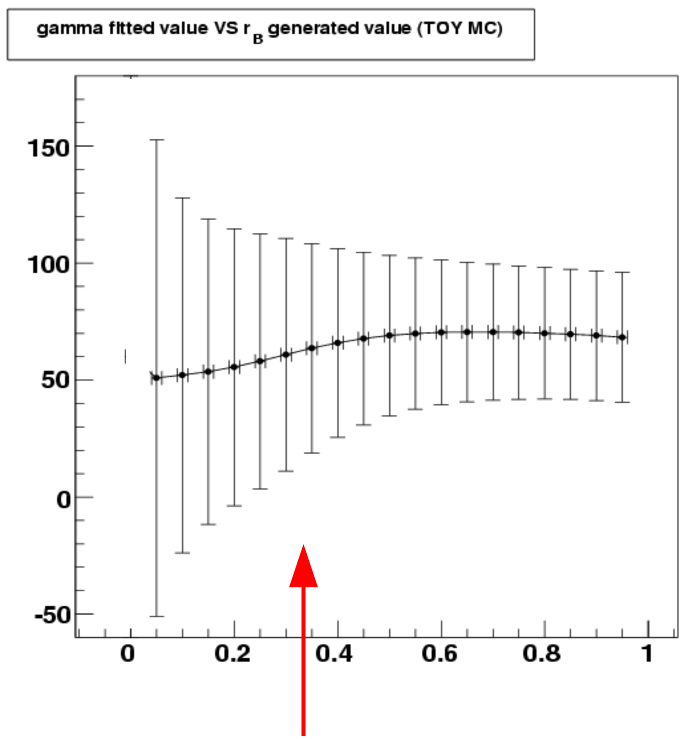
Different toy-MC (r_B=0.3)

~1000 toy-MC, r_B generated to 0.3



On a toy-MC

On a chosen toy-MC. Central γ value for different, fixed, r_B



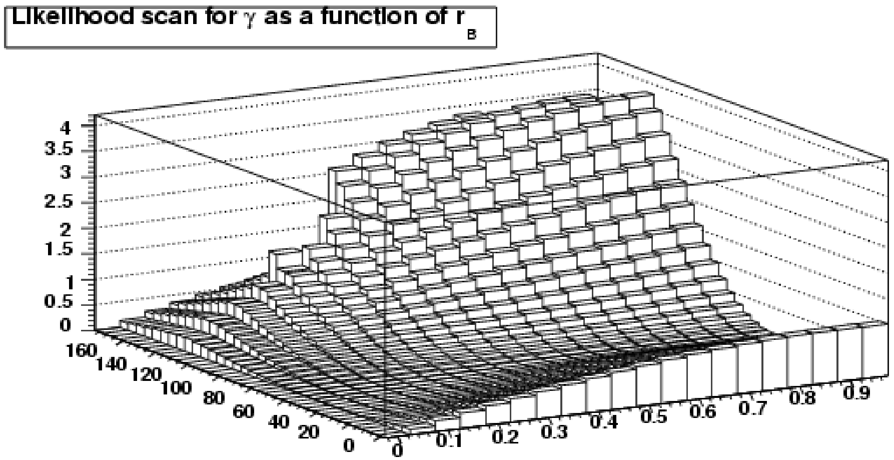
Stable central value. Error bars are the errors from the fit

HOW A MEASUREMENT WOULD LOOK LIKE..

OTPUT OF THE MEASUREMENT

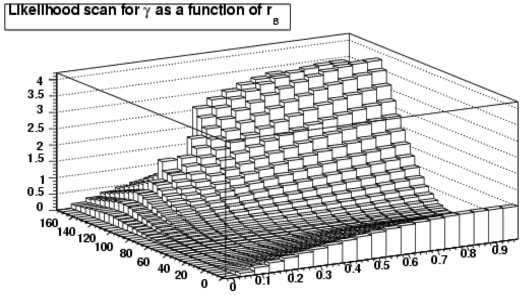
Scan of γ wrt r_B

For each fixed r_B, we make a likelihood scan for γ



On a toy-MC

If we combine the likelihood so obtained with a fake r_B measurement



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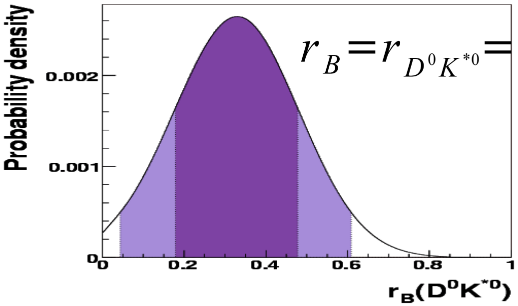
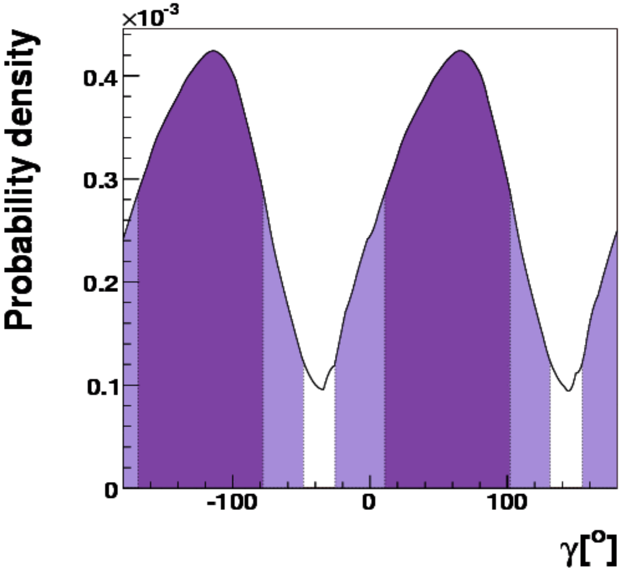


$r_B = r_{D^0K^{*0}} = 0.35 \pm 0.15$

We obtain:

=



$\sigma_\gamma \sim 46^o$

On different toy-MC, with r_B generated to 0.35:

$\sigma_\gamma \sim 50^o$

Conclusions

- We propose a new method of measuring γ using $B^0 \rightarrow D^0 K^{*0}$
- With ~350 fb^{-1} (Babar avalilable stat) scan gamma vs r_B
- If combined with an r_B=0.35+-0.15 γ error ~50^o
- More stat will solve CP-fit problems
- Final B-factories stat and combined with an r_B measurement, will be competitive with charged B results (..if r_B is not 0.2!!)