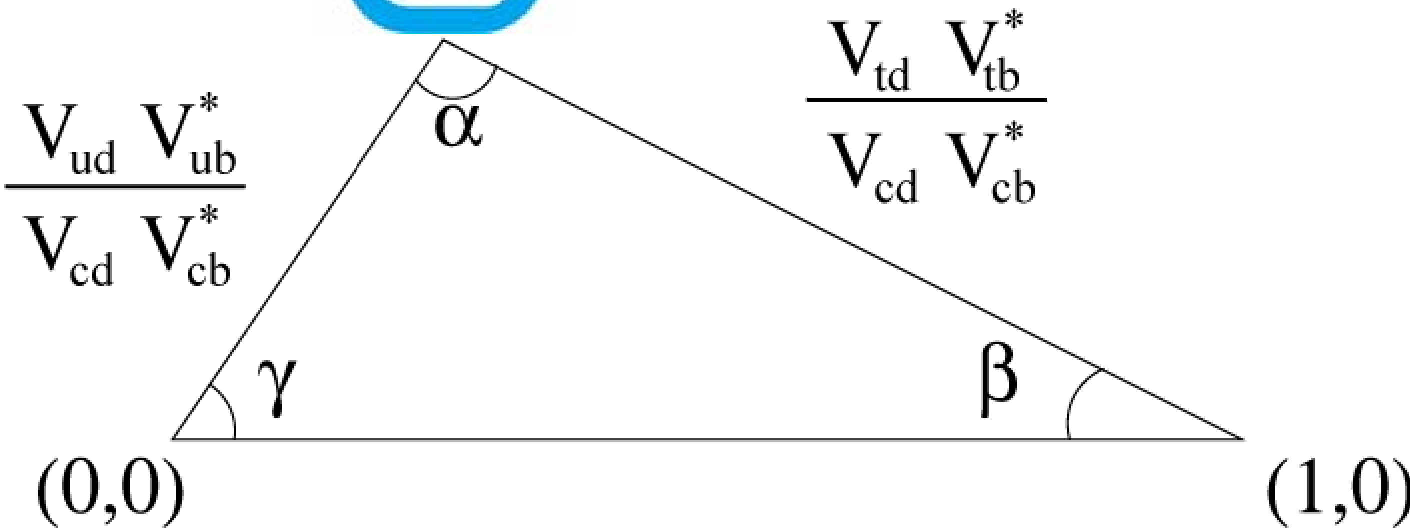
Measuring α at SuperB



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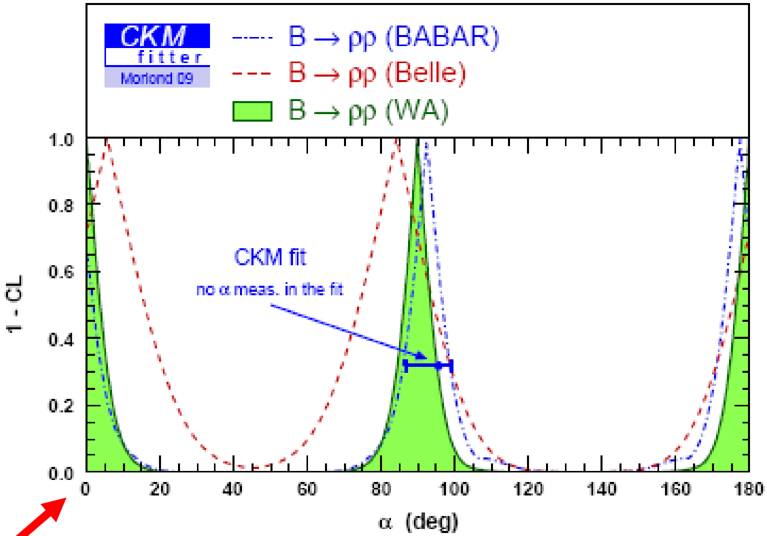
Overview

- The experimental Landscape Now
  - SU(2) $\pi\pi$, $\rho\rho$, $\rho\pi$
  - SU(3) $\rho\rho$, + $a_1\pi$ (soon)
- Projections to $75ab^{-1}$ and $250ab^{-1}$ ($1/4\ zb^{-1}$)
- Conclusions
- Relevant Past talks by AB:
  - Paris '07, Elba '08

Experimental Landscape

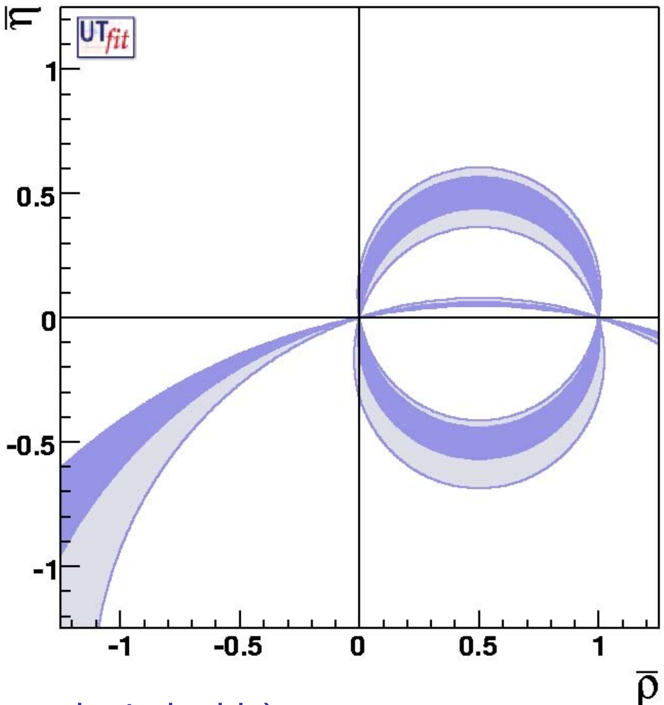
Averaging Group	direct	indirect
UTfit	$(92 \pm 7)^\circ \cup (166 \pm 2)^\circ$	92.4 ± 4.1
CKM fitter	$89.0^{+4.4}_{-4.2}$	$95.6^{+3.3}_{-8.8}$
UTfit $\rho\rho$ only	$(90 \pm 8)^\circ \cup [167, 197]^\circ$	...

- Better than 4° now
- ρρ dominates precision
- <u>BECAUSE</u> ρρ triangle is flat!



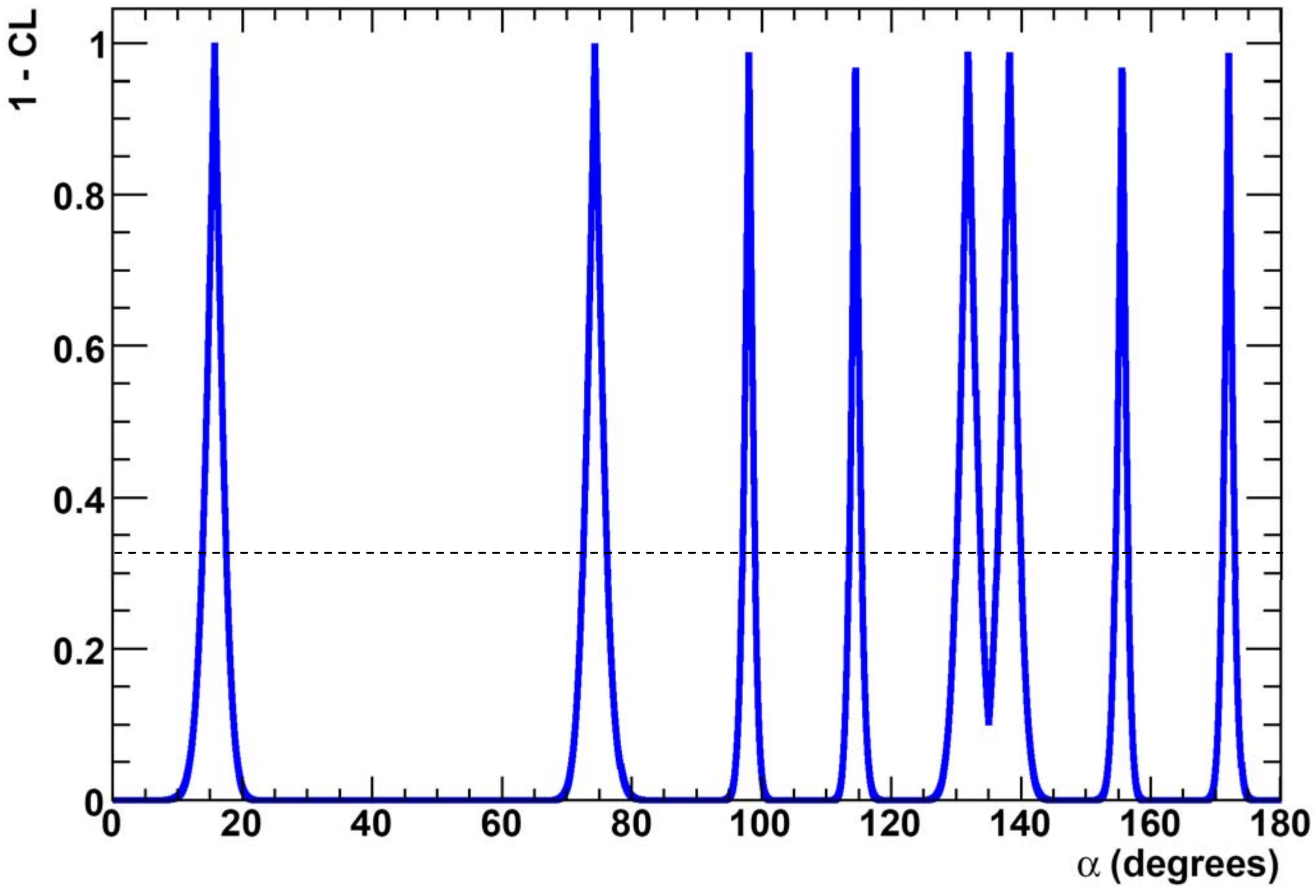
massive penguins

massive penguins



- Take care with SU(2) analysis – allows for unphysical |P/T| at π and 0.
- Experiment should correct for EWP directly (currently we don't do this).
- At high statistics different statistical interpretations of data should give the same results, so don't prefer Baysean over Frequentist or visa versa.

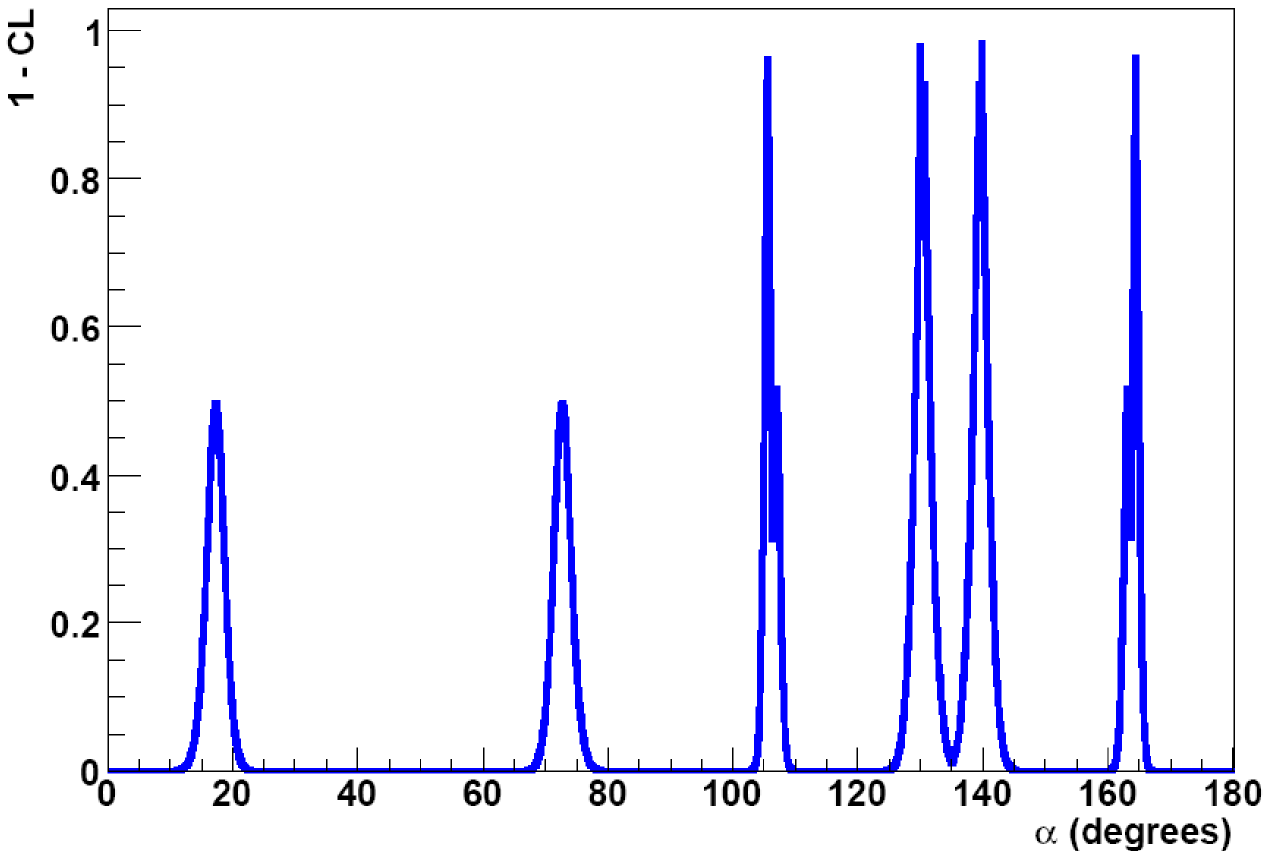
75ab^{-1}



Predictions using the GL method.

- All ambiguities are distinct solutions at 75ab^{-1} data samples.
- Precision of solutions vary from O(0.9) – O(1.9) degrees.
- Can measure S^{00} to ~0.23 with 50ab^{-1} (not included in this projection)
- Including S^{00} will help resolve the ambiguities.

ππ



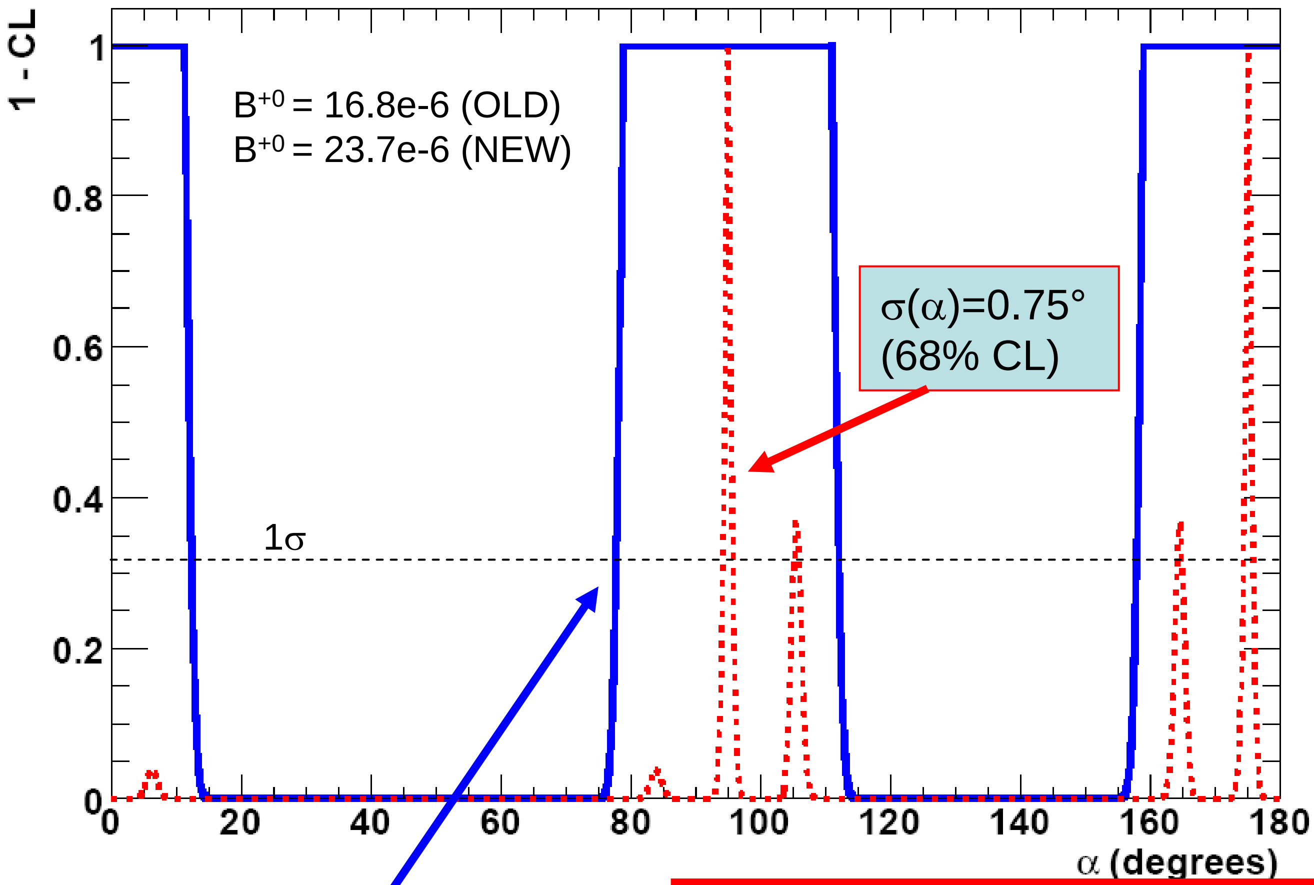
250ab^{-1}

- Prediction using $C^{00}=0$ to illustrate the effect of this parameter on ambiguities.
- Precision of central solutions is better than 1°.
- S^{00} (not included in this projection)

ρρ

SU(2)

75ab^{-1}



Ignoring S^{00} and C^{00}
Don't resolve ambiguities.

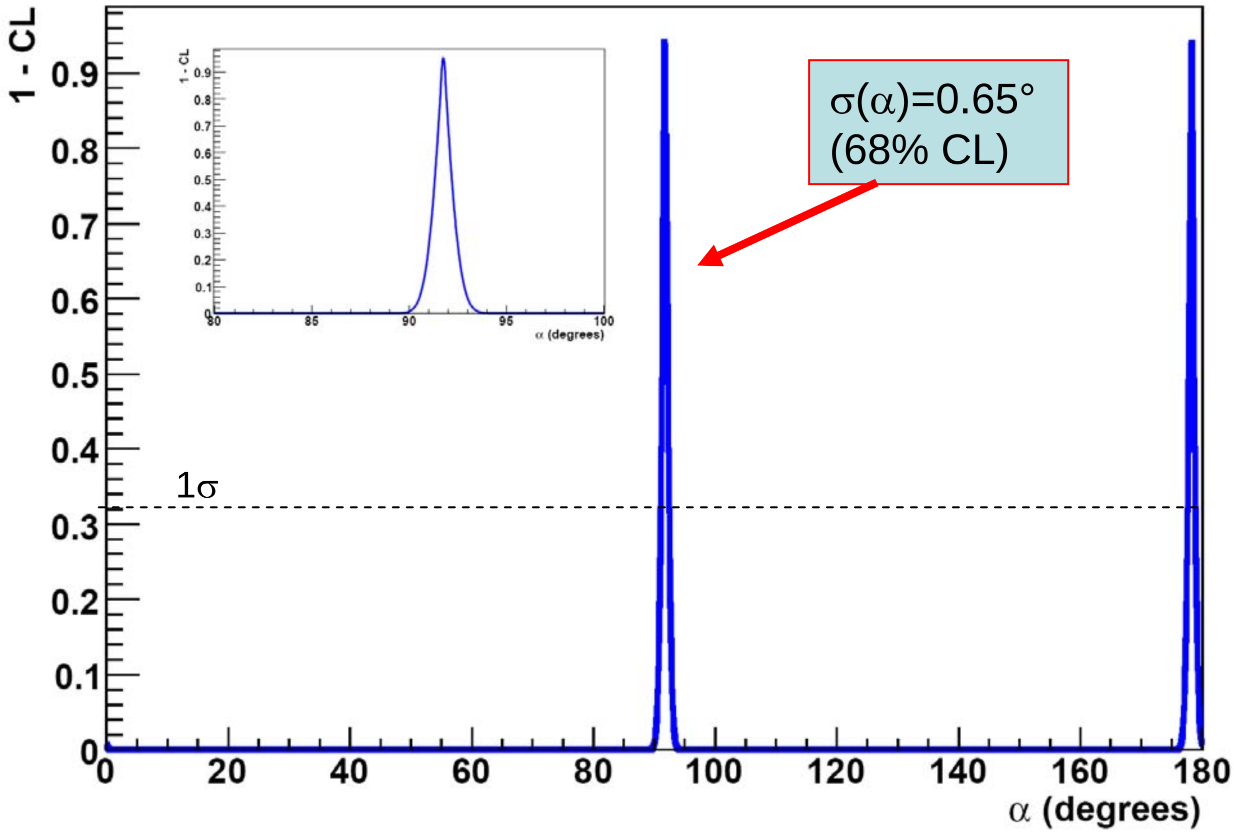
Using S^{00} and C^{00} we obtain the red curve with the OLD $\rho^+\rho^0$ branching fraction.

With the new $\rho+\rho0$ branching fraction we obtain only the central solution from each grouping

ρρ

SU(2)

250ab^{-1}

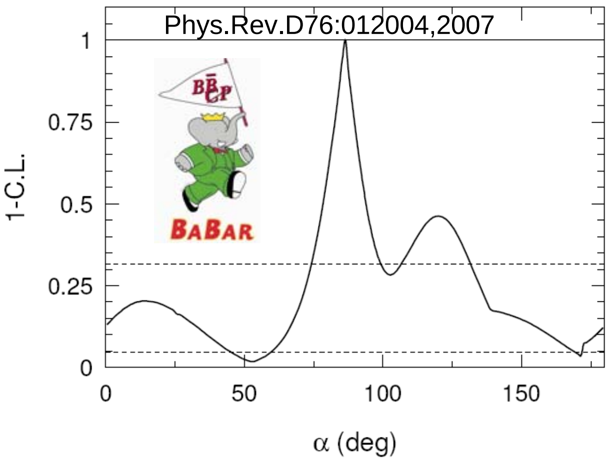


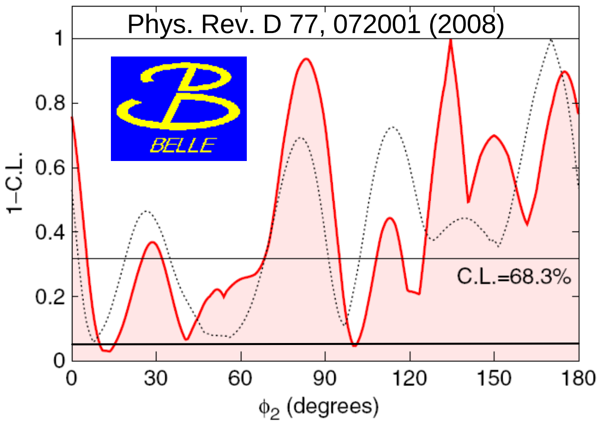
- Using the new $\rho^+\rho^0$ branching fraction WA removes the ambiguities seen in the previous slide.
- Only slight improvement in error on α when going to 250ab^{-1}.
- This analysis will be systematics limited at this luminosity.

- SuperB will need to work on the analysis technique to reduce $\sigma(\alpha)$ beyond 0.65°:
  - SCF, DCSD interference, Fit Bias are the main culprits.

ρπ

- Many parameters fitted to a complex Dalitz structure: Hard to make definite predictions now.
  - The dominant role of ρπ is to reduce ambiguity.





- Currently:
  - Useful 1σ constraint.
  - Almost no constraint at 2σ.
  - No constraint at 3σ.
- Will select a solution (based on current data, most probably the SM solution).
- Will improve overall precision slightly.
- *Conservatively* Ignore the effects of ρπ on the precision of α and just assume we are able to select with certainty the SM solution.
- **This mode plays a very important role!**

Limiting uncertainties at Super-B

SU(2)

- ππ

$$\sigma_{\pi\pi}(\alpha) = 0.9 \sim 1.9\ (\text{expt})\ \pm\ (\text{th.})$$

  - ΔI=5/2 amplitudes to test for.
  - SU(2) breaking in $\pi^0-\eta-\eta'$ mixing.
  - Should be dominated by experimental uncertainty.

See the following Refs. (not an exhaustive list) for more details on sources of theoretical uncertainty: Gronau and Zupan PRD**71** 074017 (2005); Gardner PRD**72** 034015 (2005); hep-ph/9906269; Botella et al. PRD**73** 071501 (2006) …

- ρρ

$$\sigma_{\rho\rho}(\alpha) = 0.75\ (\text{expt})\ \pm 0.4\ (\text{EWP})$$

  - I=1 amplitudes to test for.
  - ΔI=5/2 amplitudes to test for.
  - ρ-ω mixing to include in $\rho^+\rho^0$ and $\rho^0\rho^0$ measurements.
  - SU(3) method has a precision of O(2)°: Limited by theory uncertainties.

75ab^{-1}

- ρπ

$$\sigma_{\rho\pi}(\alpha) = ^{+45}_{-13}\ \ (\text{Currernt BaBar Error})$$

  - Too complicated to make sensible projections for at the moment.

- Experimental precision of ~1° is achievable.
- *Essential to have control of all theoretical uncertainties so that the worst case scenario is comparable to or better than experiment.*

Combination

SU(2)

- $\rho\pi$ TDDP not included → this will select one of the solutions (assume $\alpha \sim \pi/2$ is selected).

- The precision of $\pi\pi$ and $\rho\rho$ IAs will be comparable at the % level.
  - Differences in central value will help resolve ambiguities.
  - This is a function of C^{00}, S^{00} simultaneously for both $\pi\pi$ and $\rho\rho$.
  - Neglected the fact that we can measure S^{00} to a precision of ~0.23 with $50ab^{-1}$ using photon conversions (see Ishino et al. hep-ex/0703039). This will help a little in resolving ambiguities.

- There is room for improvement:
  - The measurement of S^{+-} and C^{+-} for $\rho\rho$ will be systematically limited using the current methods.
    - These limitations can probably be overcome with some thought. Given the data it is reasonable to assume a sub 0.5° measurement is possible.
    - Fitting lepton tagged events only should overcome the systematic error limitation and result in a similar precision on α to that quoted here.

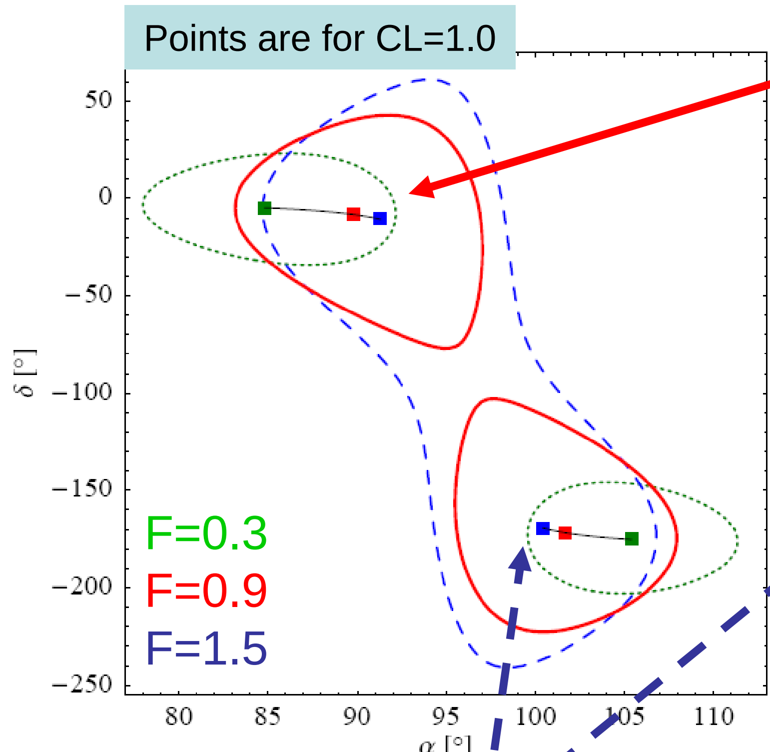
  - These extrapolations assume the published tagging performance Q~30%. The final performance has Q~33%.

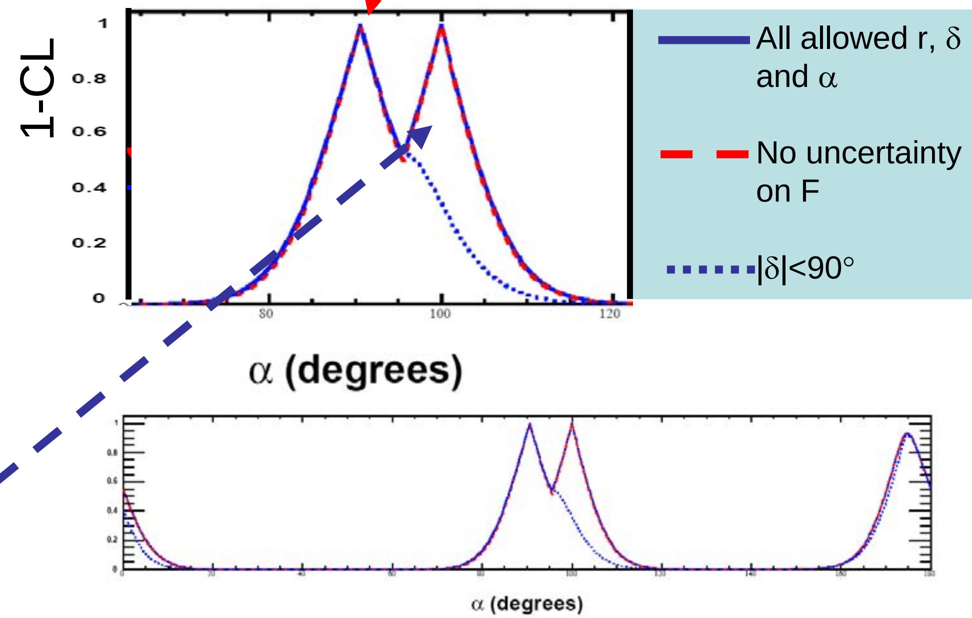
SU(3) based methods: ρρ

- Relate $K^{*0}\rho^{+}$ to the penguin contribution in $\rho^{+}\rho^{-}$ (**BGRS**):
  - Gives a precise determination of α: independent of B^{+0}.

$0.35ab^{-1}$

α~90° is preferred for |δ|<90°





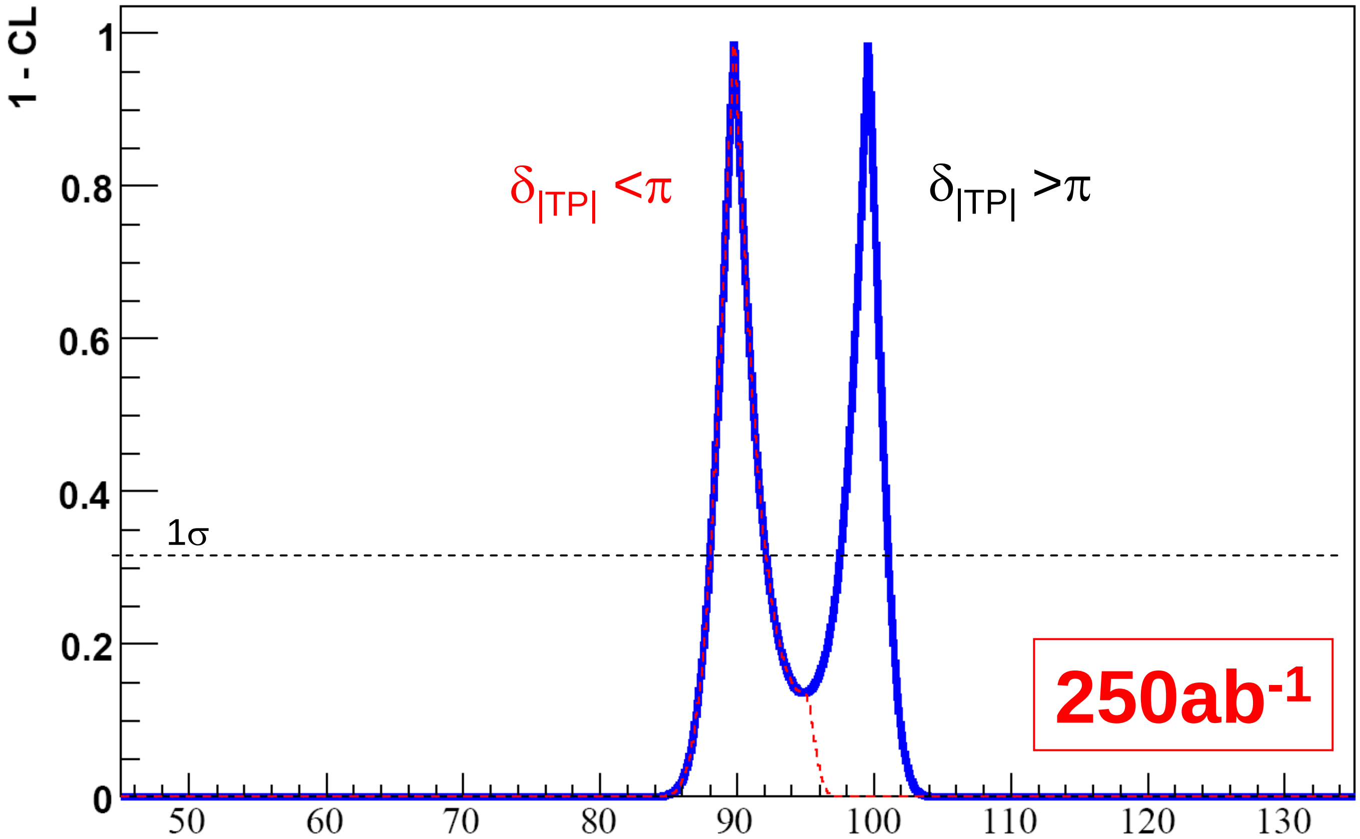
α~100° is preferred for |δ|>90°

σ(α)~7°(expt.)±1.5 °(th.)

Beneke et al., Phys.Lett. B638 (2006) 68-73

SU(3) based methods: ρρ

SU(3)



- Precise determination of α with a few degrees uncertainty.
- Ultimate precision depends on systematic limitations in S^{+-} and C^{+-}.

Other SU(3) based methods

- $a_1\pi$:
  - $\sigma(\alpha_{eff})$~7°
  - Need $K_1\pi$ and $a_1\pi$ branching fractions to constrain penguins using SU(3).
    - It doesn't matter what value $\delta\alpha$ is in this mode – it WILL be measurable at SuperB, so we will be able to use this in our α determination.
  - Will have all of the ingredients from current B-factories to extrapolate this method to higher luminosities during the TDR period…
- $a_1\rho$, $\omega\rho$, $b_1\rho$, … Looked for … nothing seen so far!
- What about a_1a_1?
  - If found what can we do with it? This modes is also related to polarisation puzzle!

Conclusions

- Note: These estimates are extrapolated form the current B-factories.
- % level measurement is achievable, as sub-% level measurement is quite possible from the experimental side.
  - … can theory do the same?
- There is clearly room for improvement.
  - Also need to look at how SuperB Detector Geometry affects precision. Can we make further optimisations to help this measurement.
- What are the prospects of improving the theoretical control of SU(2) and SU(3) uncertainties? [See Jure]
- Are there higher order effects that would hamper an α version of the ΔS measurement?
- α @ SuperB will be a game of $\pi\pi$, $\rho\rho$, $\rho\pi$, $a_1\pi$, + …