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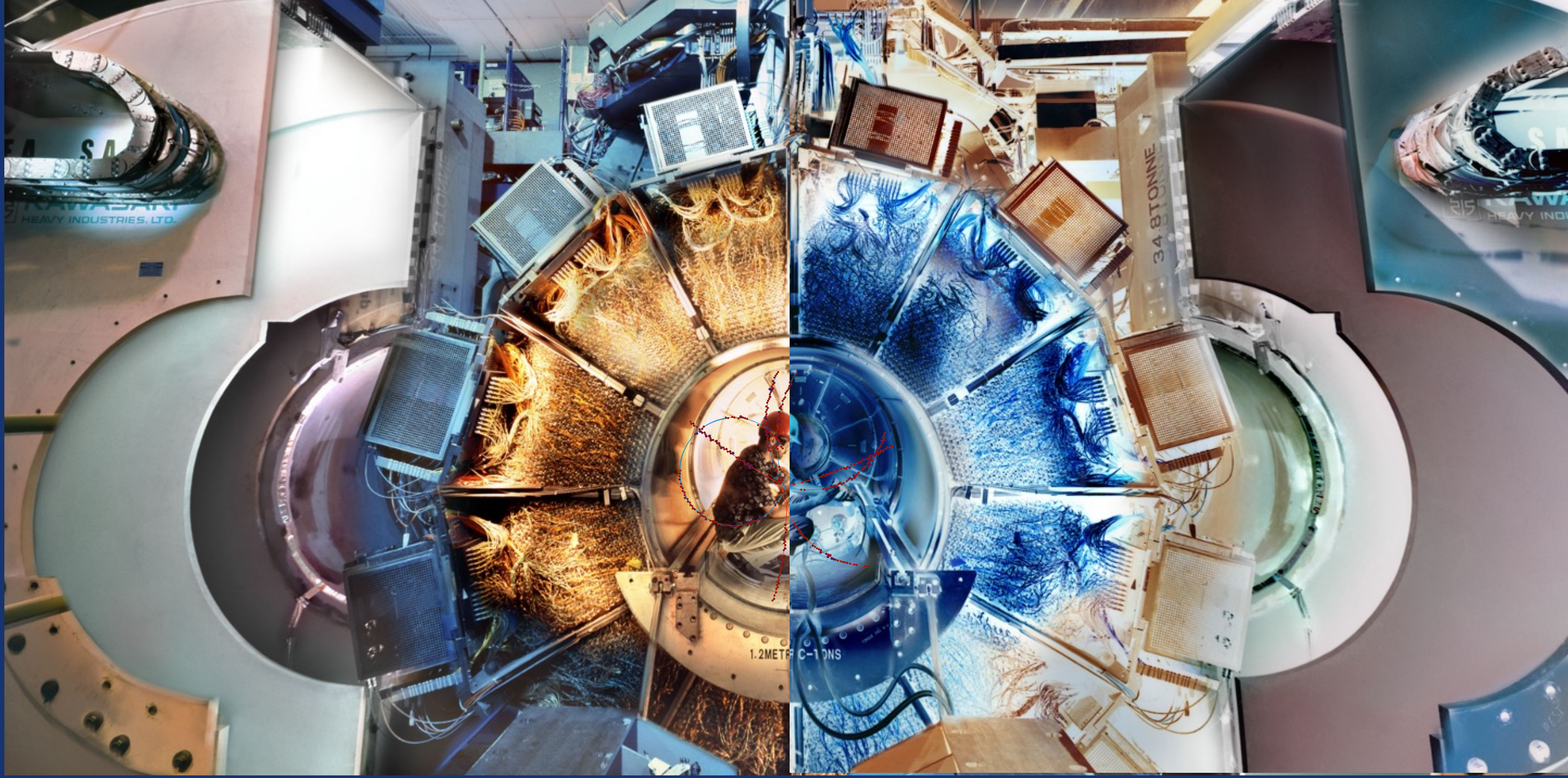
BaBar

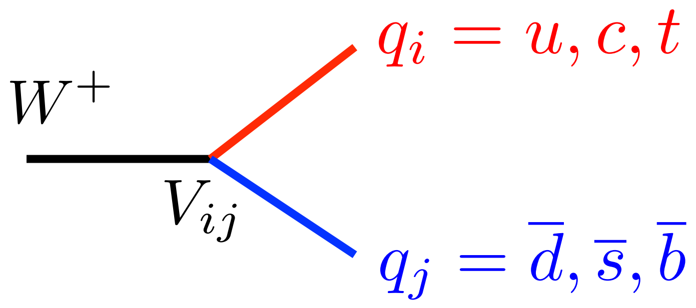


BaBar @ 30
CKM Achievements at the B Factories

Prof. Adrian Bevan a.j.bevan@qmul.ac.uk

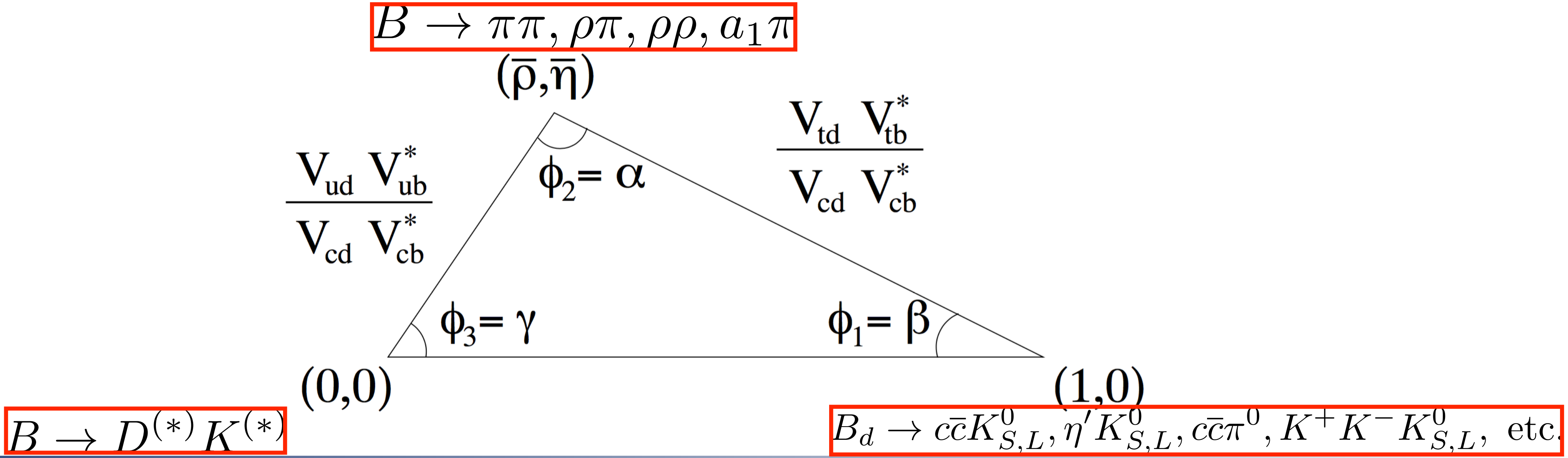
Understanding the unitarity triangle

- The turn of the century heralded an new era to test the CKM matrix



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

$$\phi_1 = \beta \equiv \arg\left[-V_{cd}V_{cb}^*/V_{td}V_{tb}^*\right]$$
$$\phi_2 = \alpha \equiv \arg\left[-V_{td}V_{tb}^*/V_{ud}V_{ub}^*\right]$$
$$\phi_3 = \gamma \equiv \arg\left[-V_{ud}V_{ub}^*/V_{cd}V_{cb}^*\right]$$



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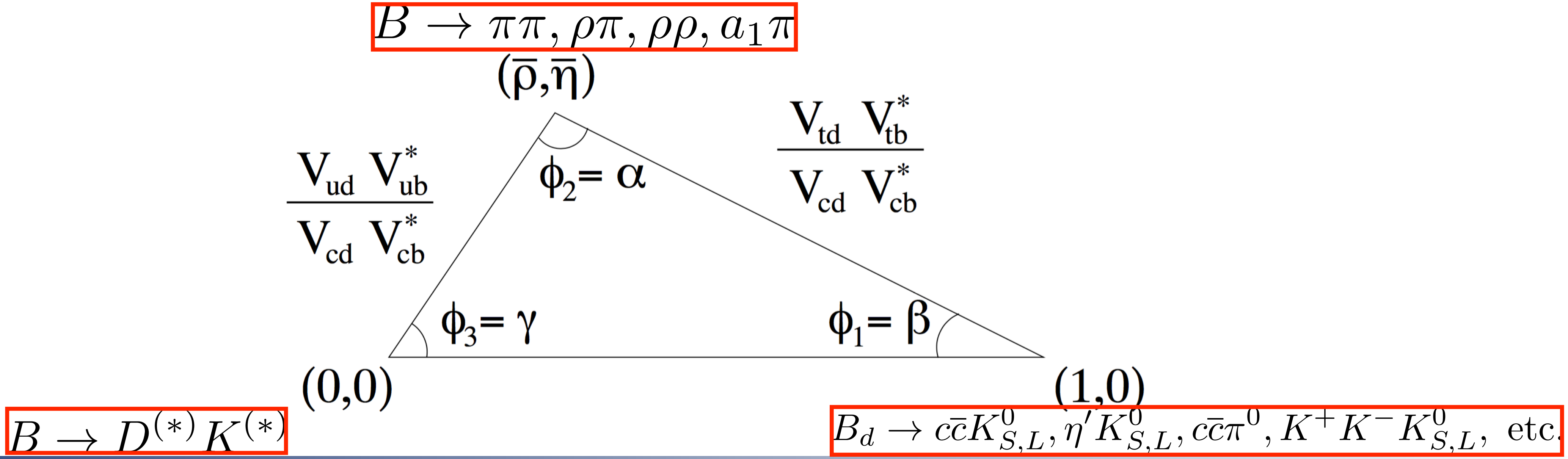
Understanding the unitarity triangle

- **The turn of the century heralded an new era to test the CKM matrix**

$$V_{CKM} = \begin{pmatrix} 1-\lambda^2/2-\lambda^4/8 & \lambda & A\lambda^3(\bar\rho - i\bar\eta)(1+\lambda^2/2) \\ -\lambda + A^2\lambda^5[1-2(\bar\rho+i\bar\eta)]/2 & 1-\lambda^2/2-\lambda^4(1+4A^2)/8 & A\lambda^2 \\ A\lambda^3[1-\bar\rho-i\bar\eta] & -A\lambda^2+A\lambda^4[1-2(\bar\rho+i\bar\eta)]/2 & 1-A^2\lambda^4/2 \end{pmatrix} + \mathcal{O}(\lambda^6)$$



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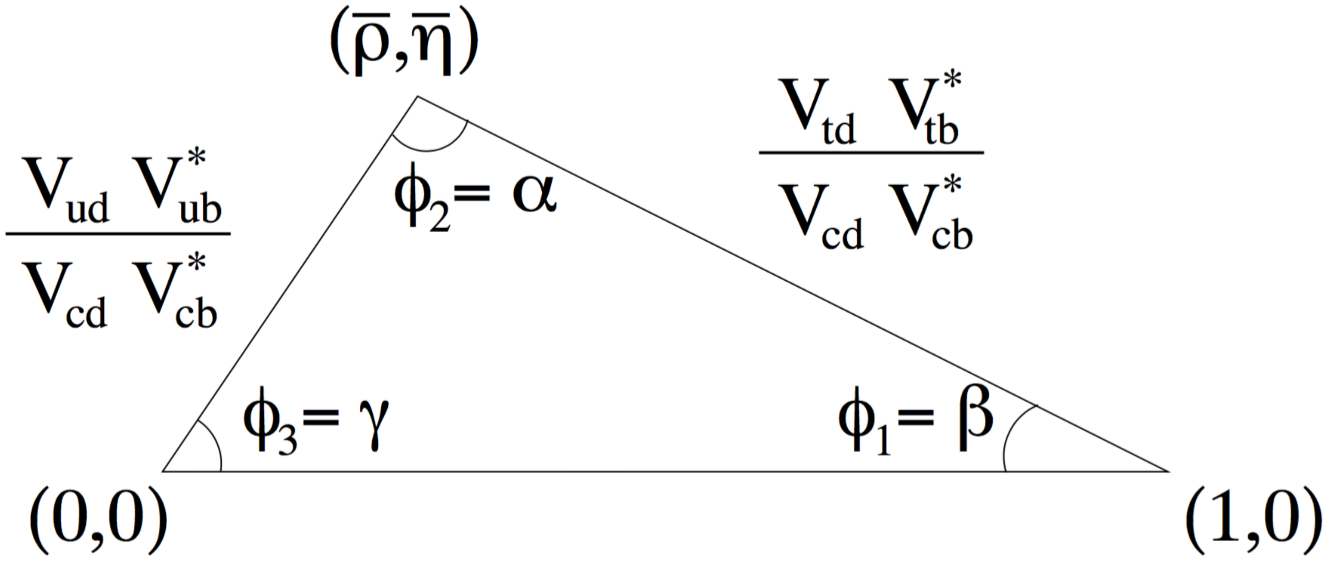
The unitarity triangle

- CP (and T) violation gives the angles of the triangle
- Semileptonic decays tell us about the length of the non-trivial sides



- This talk touches on a few highlights - there are so many results and over 600 papers from BaBar alone, and a similar number from Belle; so it is impossible to cover them all.

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Understanding the unitarity triangle

- For CP violation to be manifest we need to measure the effect of a non-zero phase difference between two or more interfering amplitudes

- Three different types of CP violation:
  - In mixing
  - In decay (direct CP violation)
  - In the interference between the two

- Measuring the sides requires:
  - Determination of decay rates
  - Deep understanding of how to interpret those as $|V_{ij}|$

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CP violation

- In the 1980's new CP violation tests were being explored
- An important paper stood out among others

NOTES ON THE OBSERVABILITY OF *CP* VIOLATIONS IN B DECAYS

I.I. BIGI

Institut für Theor. Physik der RWTH Aachen, D-5100 Aachen, FR Germany

A.I. SANDA[1]

Rockefeller University, New York 10021, USA

Received 16 June 1981

We describe a general method of exposing *CP* violations in on-shell transitions of B mesons. Such *CP* asymmetries can reach values of the order of up to 10% within the Kobayashi–Maskawa model for plausible values of the model parameters. Our discussion focuses on those (mainly non-leptonic) decay modes which carry the promise of exhibiting clean and relatively large *CP* asymmetries at the expense of a reduction in counting rates. Accordingly we address the complexities encountered when performing *CP* tests with a high statistics B meson factory like the Z^0 (and a toponium) resonance.

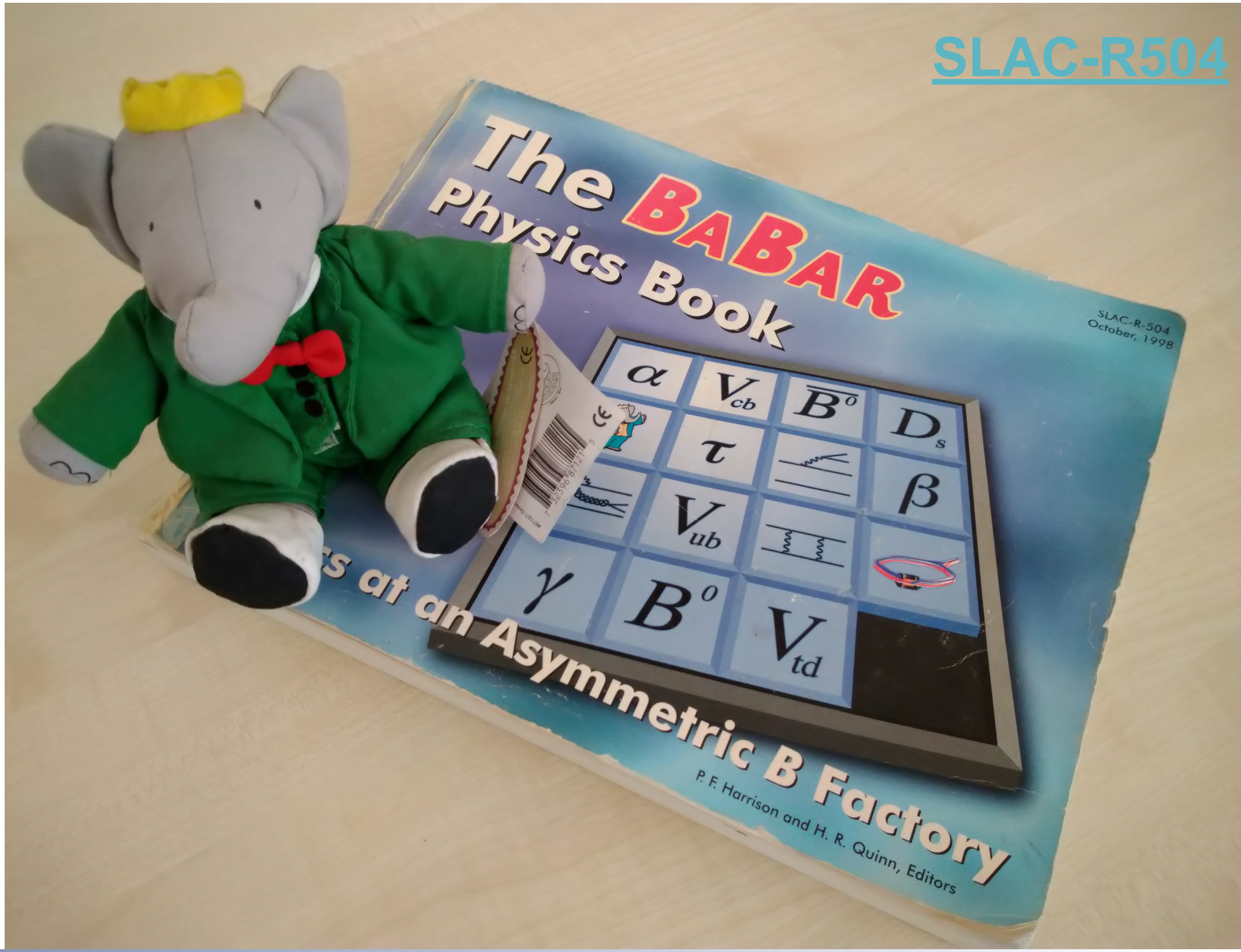
Nuclear Physics B193 (1981) 85-108

- KM, superweak and Higgs multiplet theories could all give rise to sources of CP violation.
- What description was correct?
- How do we test that?

The plan… the BaBar Physics Book

- **Great for onboarding new staff and students ahead of data taking**
  - **Introduction to the theory**
  - **Overview of the experiment**
  - **Methods: neural networks, flavour tagging etc.**
  - **β, α, γ, $|V_{cb}|$, $|V_{ub}|$, rare decays and other non-CP physics**

SLAC-R504



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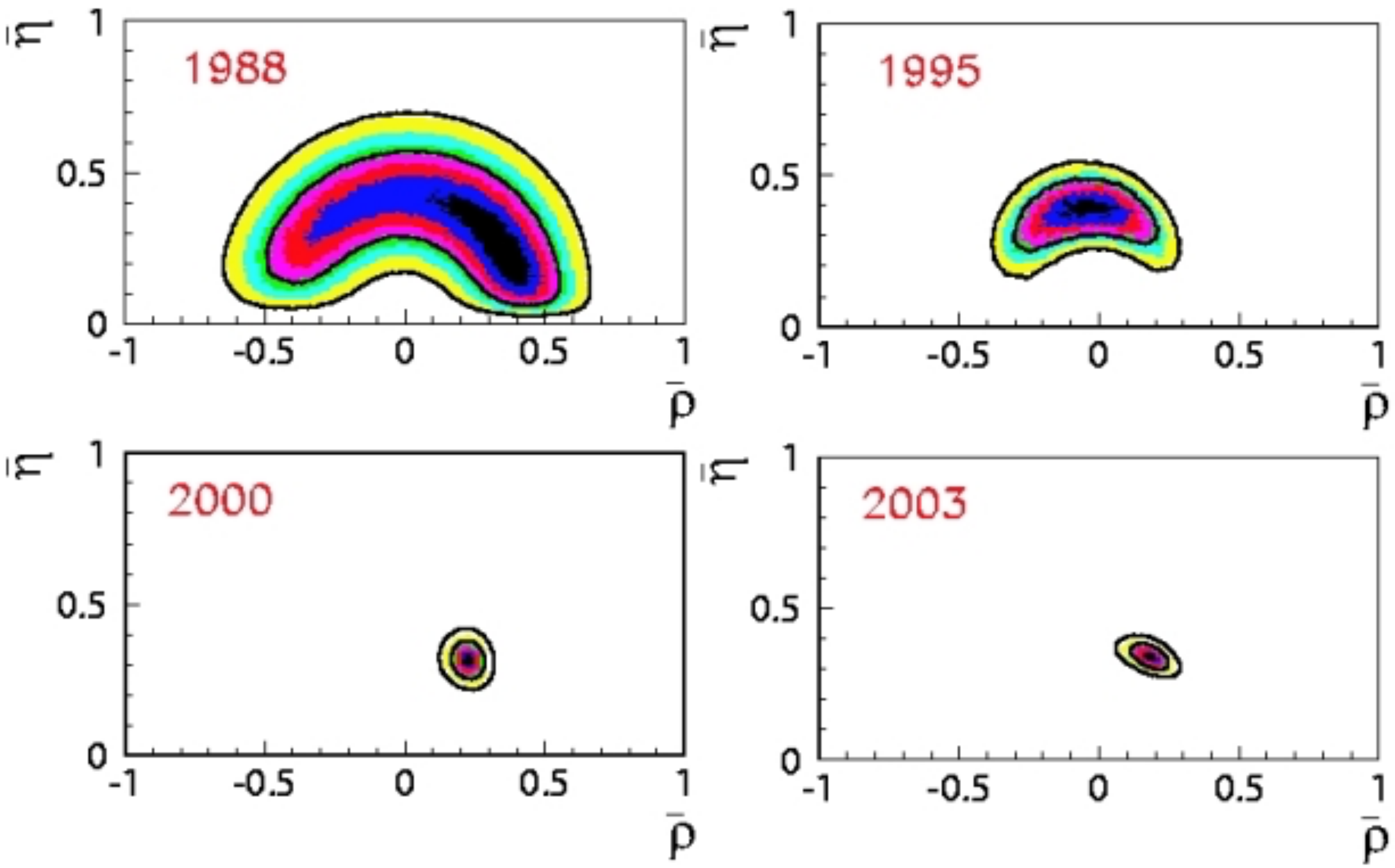
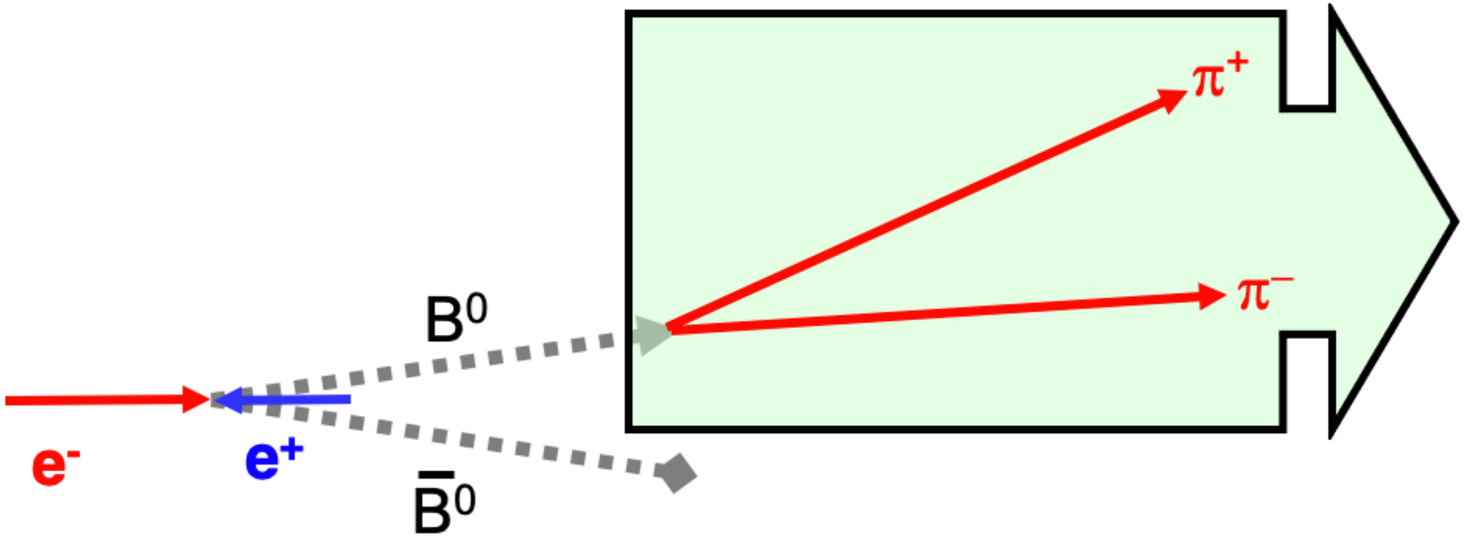
Evolution of the triangle apex

- B Factories start to have an impact in 2000 soon after starting up

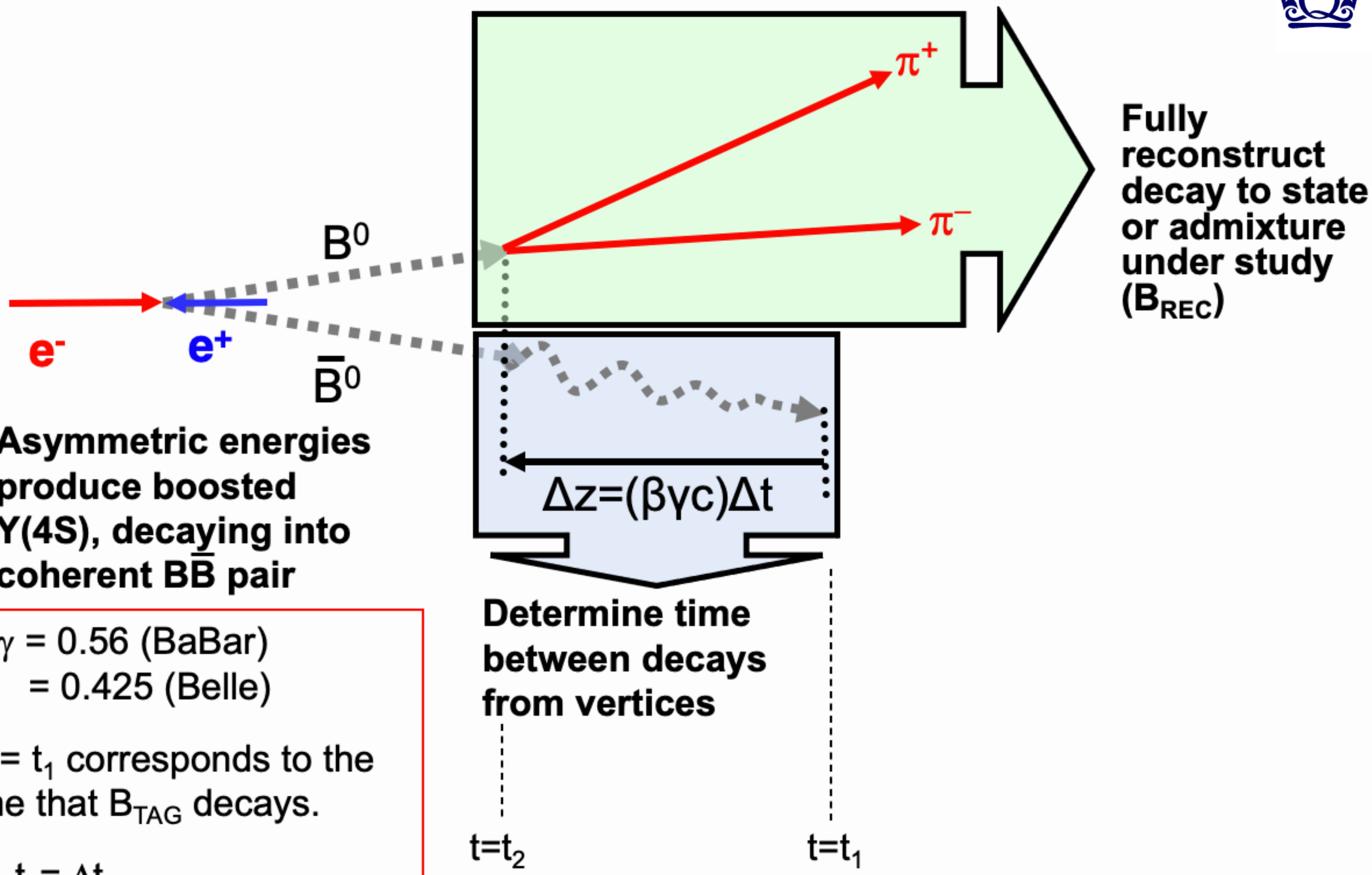


UTfit.org

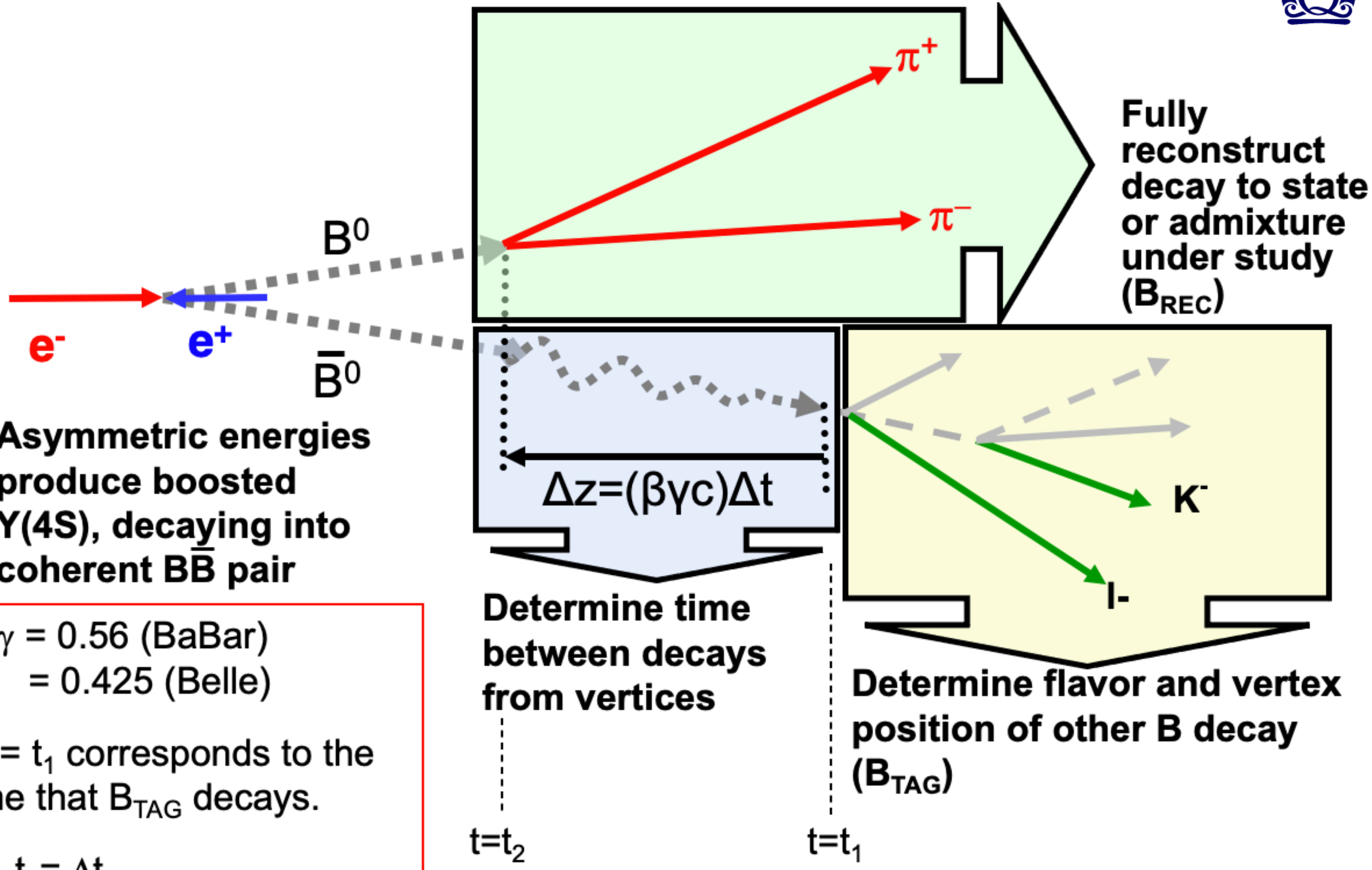


Fully reconstruct decay to state or admixture under study (B_{REC})

Asymmetric energies produce boosted Υ(4S), decaying into coherent $B\bar{B}$ pair



- $\beta\gamma = 0.56$ (BaBar)
  $= 0.425$ (Belle)
- $t = t_1$ corresponds to the time that B_{TAG} decays.
- $t_2 - t_1 = \Delta t$



Asymmetric energies produce boosted Υ(4S), decaying into coherent $B\bar{B}$ pair

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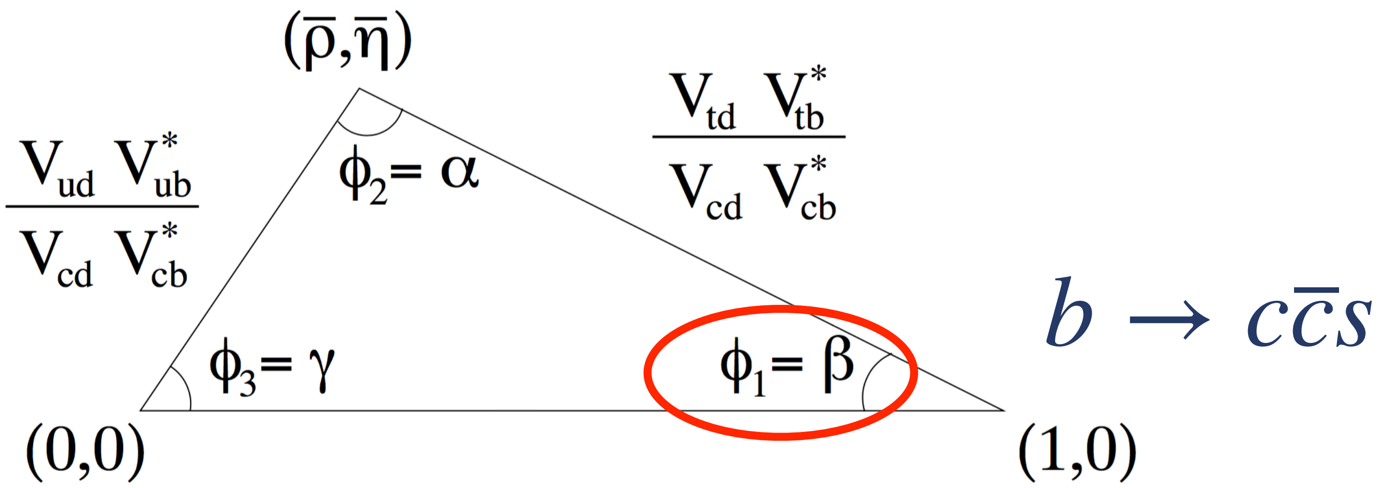
Part 1: CP violation

- β=φ_1



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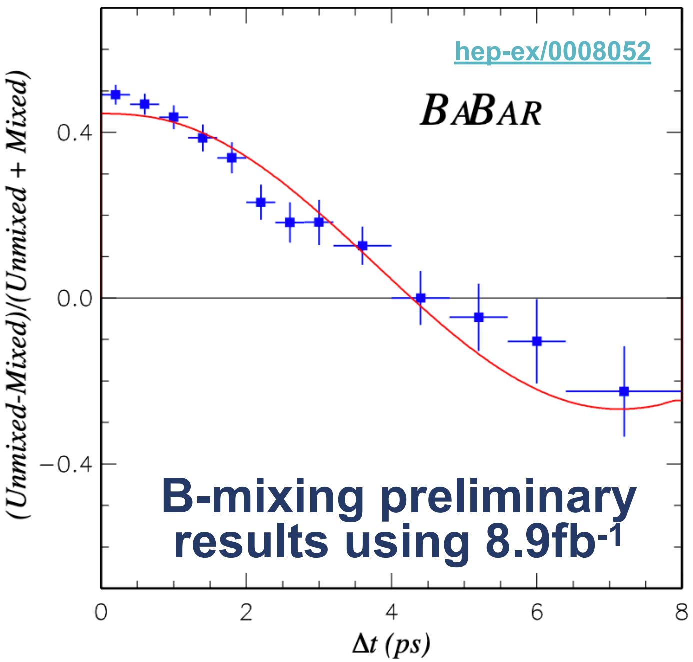
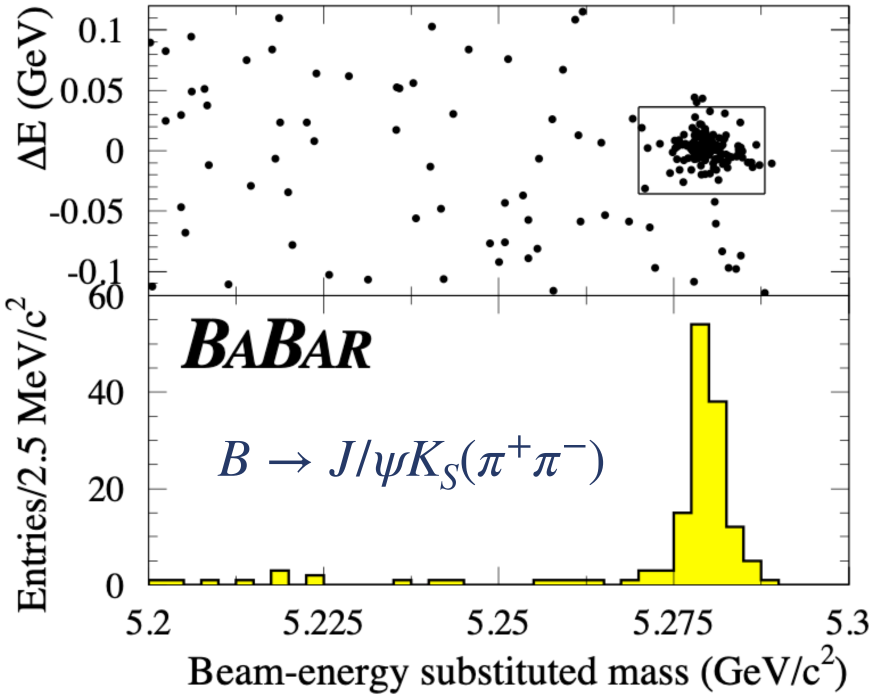
The golden mode: $B^0 \to J/\psi K^{(*)0}$

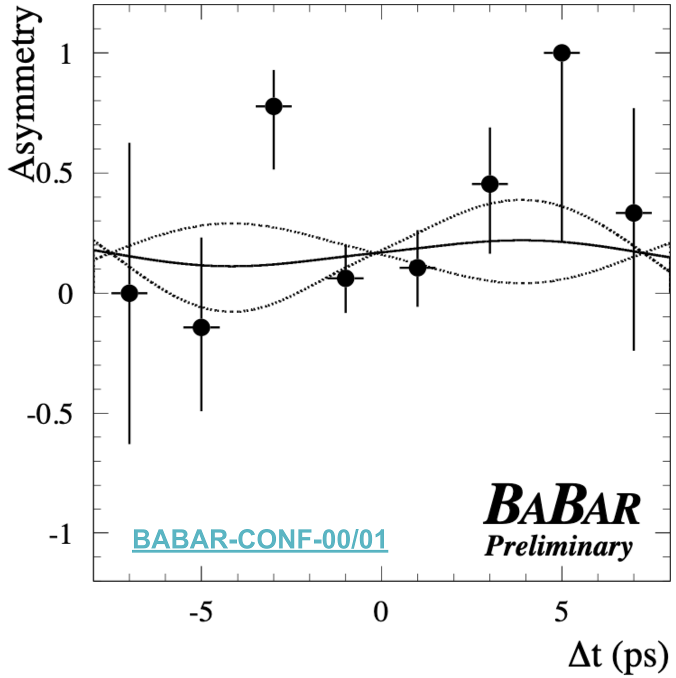
- **Preliminary results 14 months after data taking started**

ICHEP, Osaka 2000: $sin(2\beta) = 0.12 \pm 0.37(stat) \pm 0.09(syst)$



B-mixing preliminary results using 8.9fb^{-1}





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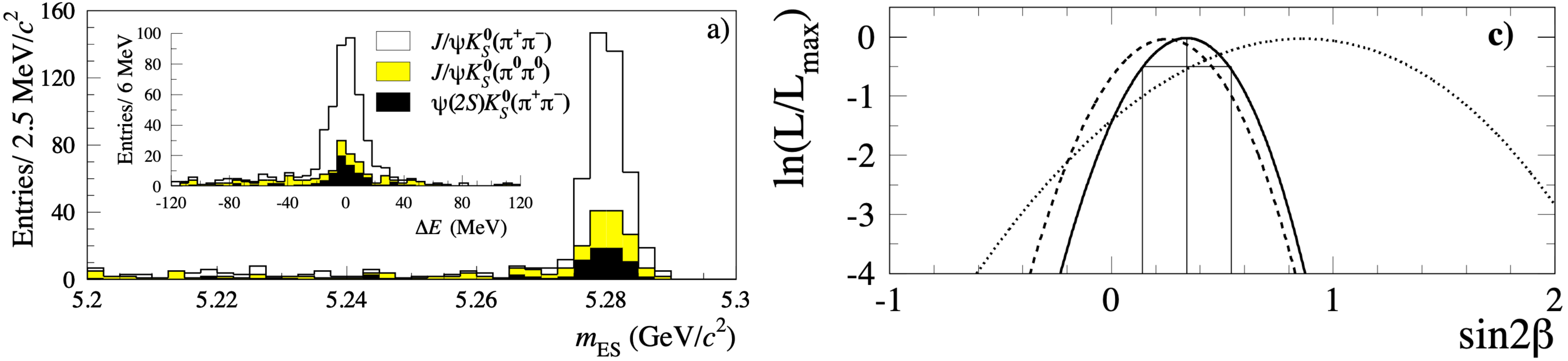
The golden mode: $B^0 \rightarrow J/\psi K^{(*)0}$

- First paper Feb 2001 using 23×10^6 neutral B meson pairs

$$sin(2\beta) = 0.34 \pm 0.20(stat) \pm 0.05(syst)$$



Phys.Rev.Lett.86:2515-2522,2001

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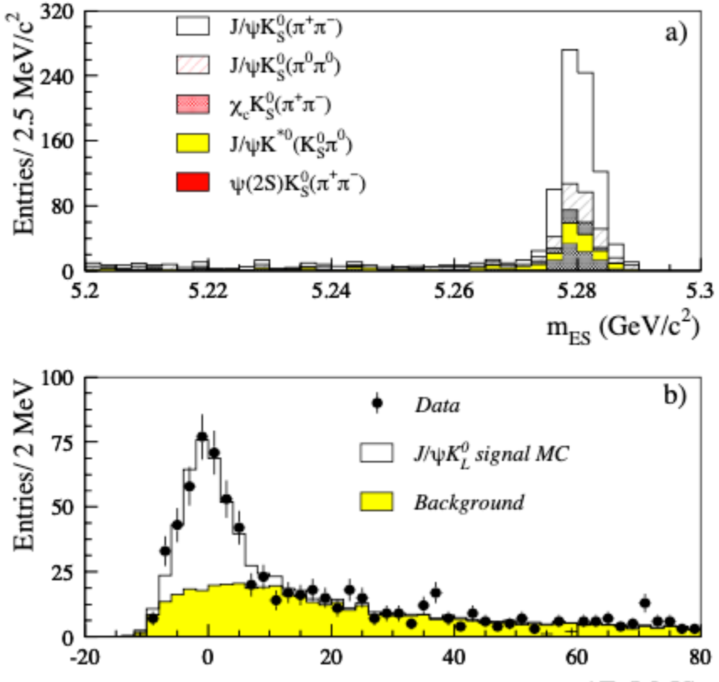
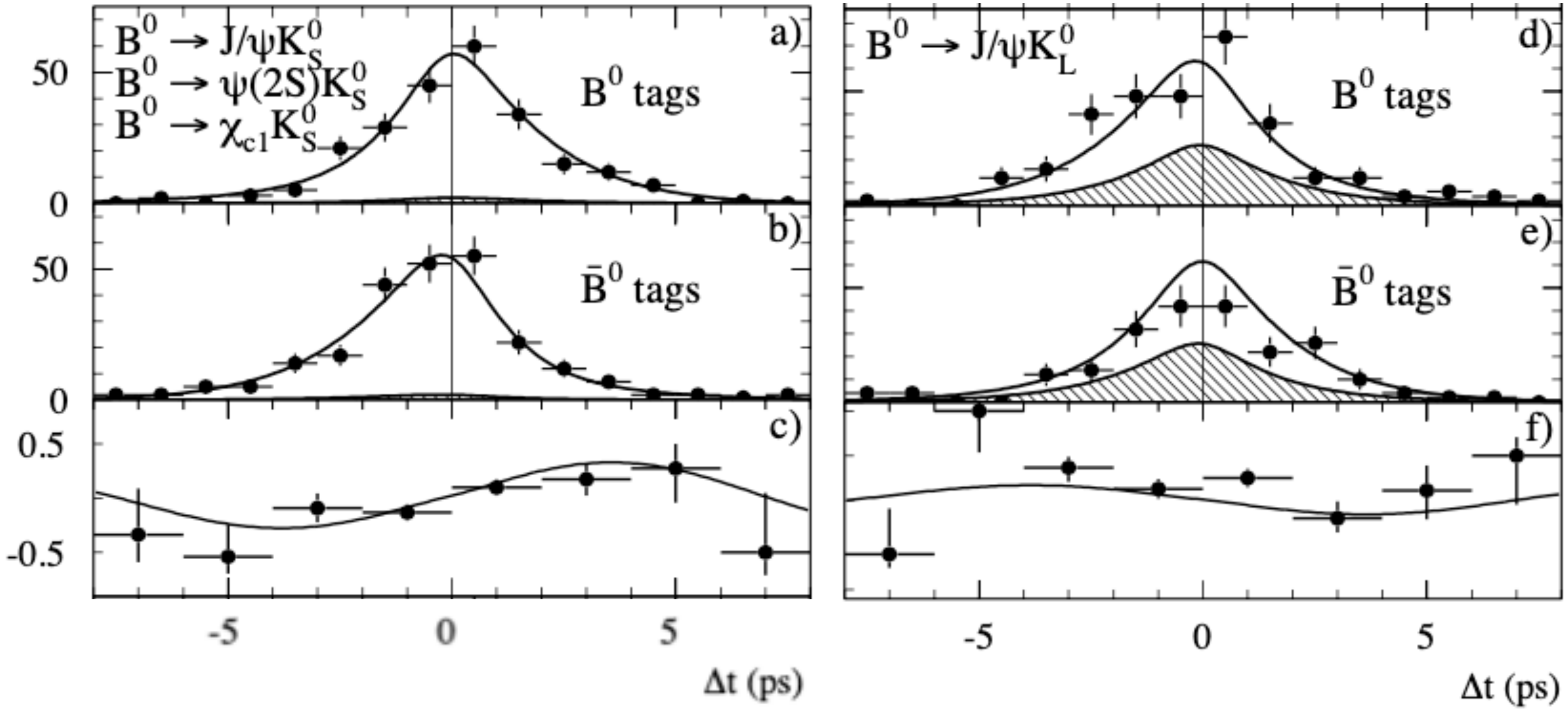
The golden mode: $B^0 \to J/\psi K^{(*)0}$

- **Quickly discovered CP violation in B decays: July 6th 2001; a few weeks over 2 years after data taking started**

EPS, 2001: $sin(2\beta) = 0.59 \pm 0.14(stat) \pm 0.05(syst)$





Using 32fb^{-1}

Phys.Rev.Lett.87:091801,2001

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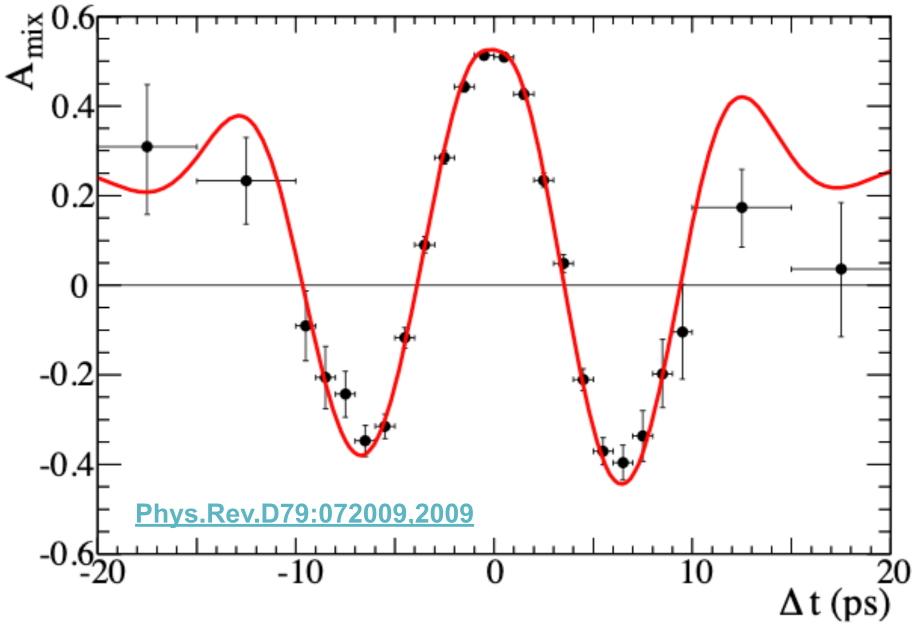
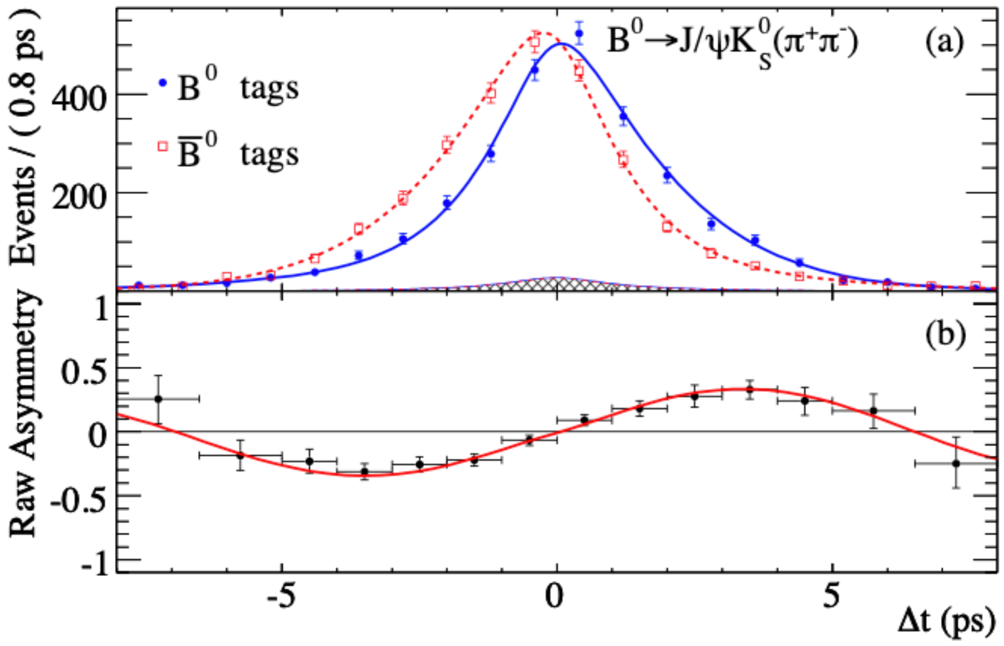
The golden mode: $B^0 \to J/\psi K^{(*)0}$

Final result: 2008 - but not the end of golden mode studies!

$$sin(2\beta) = 0.687 \pm 0.028(stat) \pm 0.012(syst)$$



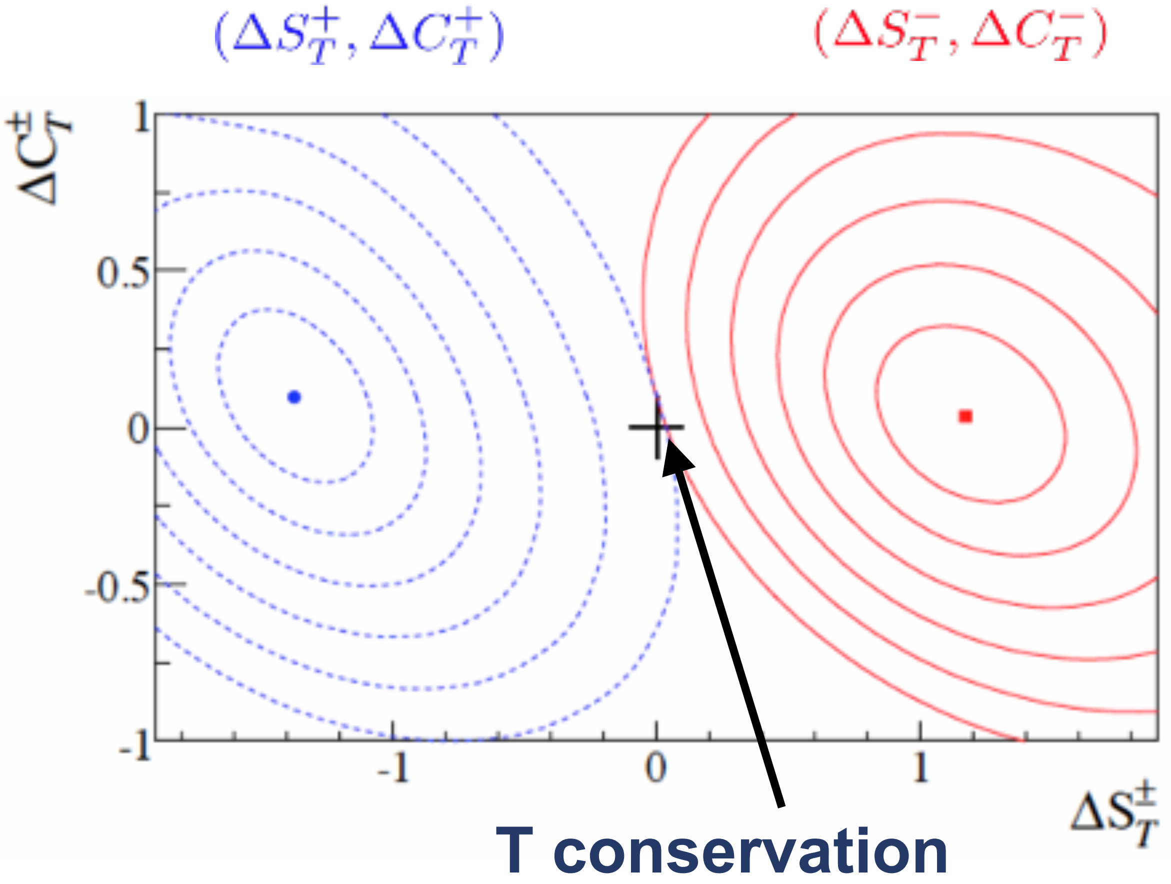


Using 425.7fb^{-1}

T-violation studies

- **Compare different CP and flavour filter modes to construct T, CP and CPT asymmetries**
- **T is broken (and measures $\pm 2\sin(2\beta)$)**

Parameter	Result
$\Delta S_T^+ = S^-_{\ell^-, K_L^0} - S^+_{\ell^+, K_S^0}$	$-1.37 \pm 0.14 \pm 0.06$
$\Delta S_T^- = S^+_{\ell^-, K_L^0} - S^-_{\ell^+, K_S^0}$	$1.17 \pm 0.18 \pm 0.11$
$\Delta C_T^+ = C^-_{\ell^-, K_L^0} - C^+_{\ell^+, K_S^0}$	$0.10 \pm 0.14 \pm 0.08$
$\Delta C_T^- = C^+_{\ell^-, K_L^0} - C^-_{\ell^+, K_S^0}$	$0.04 \pm 0.14 \pm 0.08$



Phys. Rev. Lett. 109, 211801 (2012)

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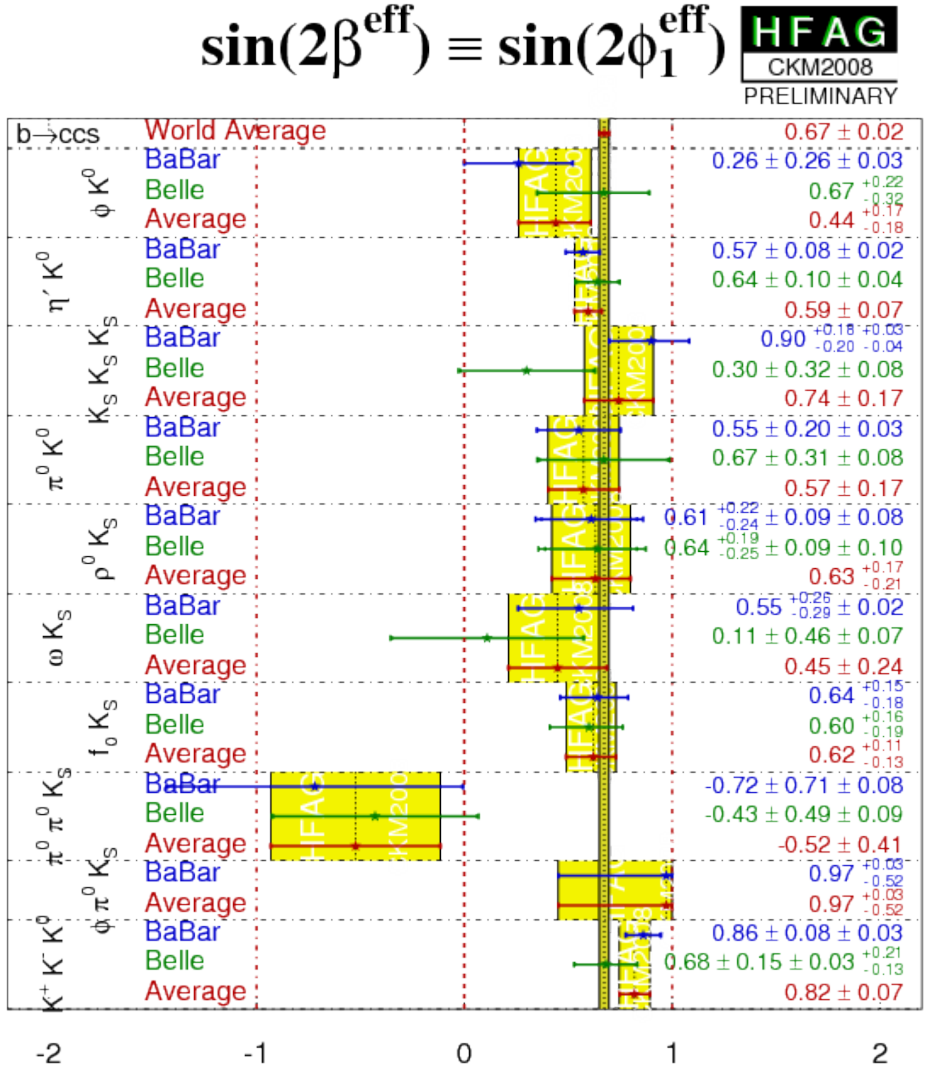
Adrian Bevan

Throwing in a curveball

- **Penguin modes measuring $sin2\beta$ generated a lot of interest in the early days: was there new physics around the corner?**

- **Belle's 2003 $B \rightarrow \phi K_S$ result sparked a new wave of non-golden mode studies.**



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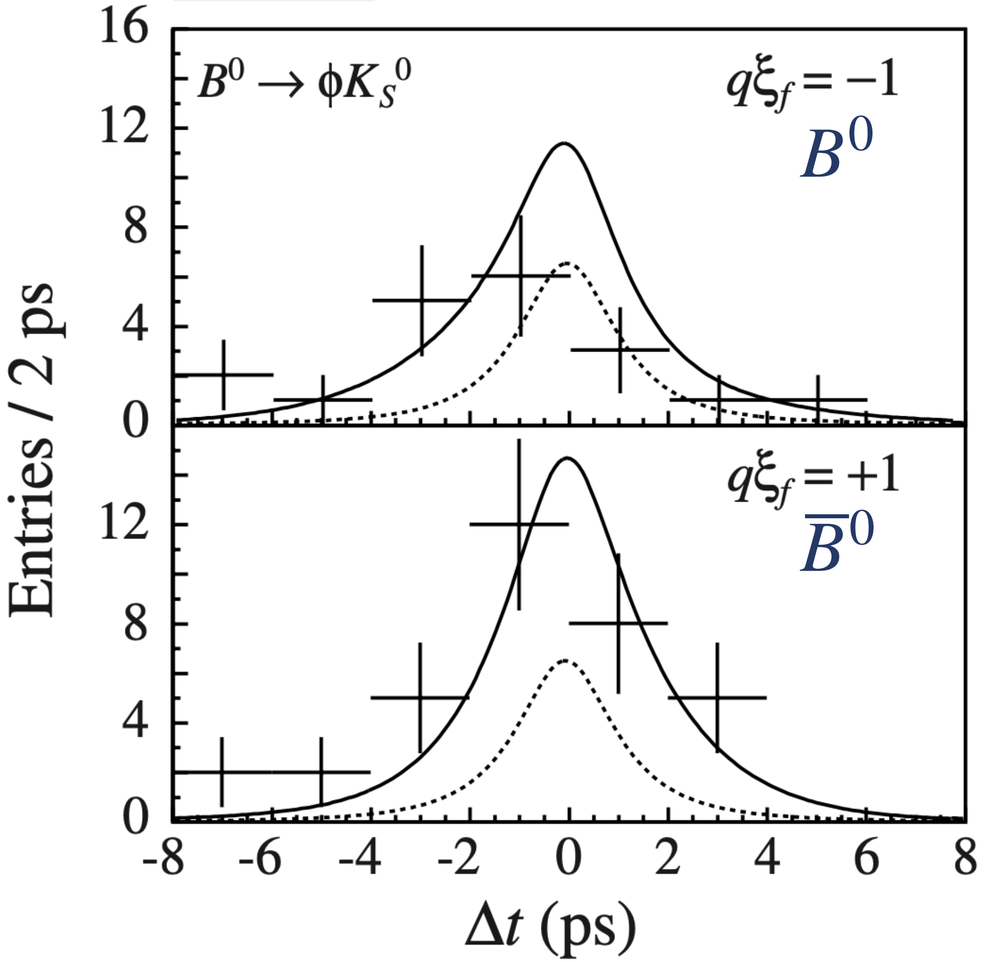
$B \to \phi K_S$ @ Belle

$$sin2\beta = -0.73 \pm 0.64 \pm 0.22$$

- 2.1σ deviation from $c\bar{c}s$ at the time
- As we learned on BaBar, extra care is required when doing time-dependent analyses of small data sets:
  - Yields - see Poisson fluctuations from continuum background reflected in signals
  - Time-dependent parameters can have non-gaussian errors



K. Abe et al., Phys.Rev.D 67 (2003) 031102

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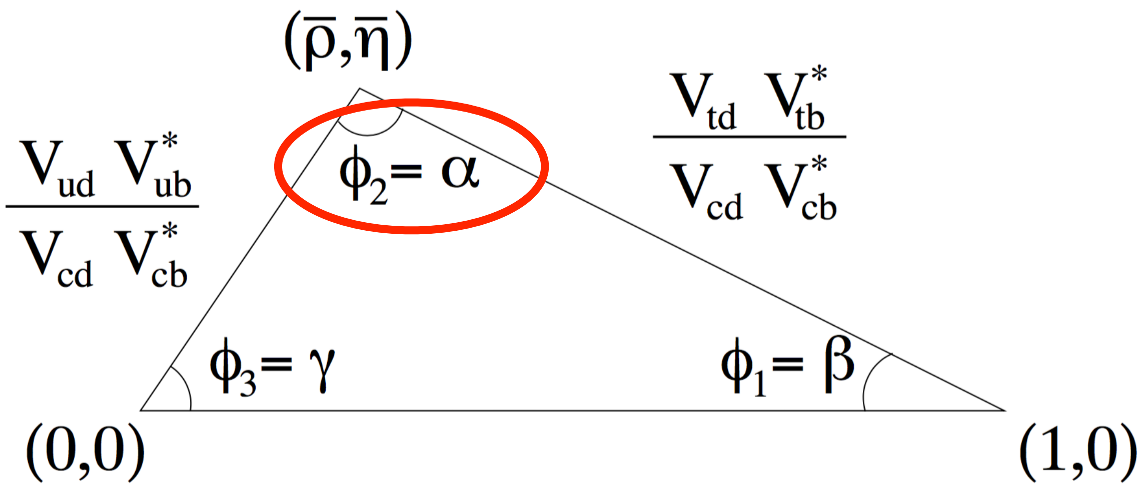
Part 1: CP violation

- $\alpha = \phi_2$

$$b \to u\bar{u}d$$



- More complicated to interpret results as these are combinations of tree and penguin modes

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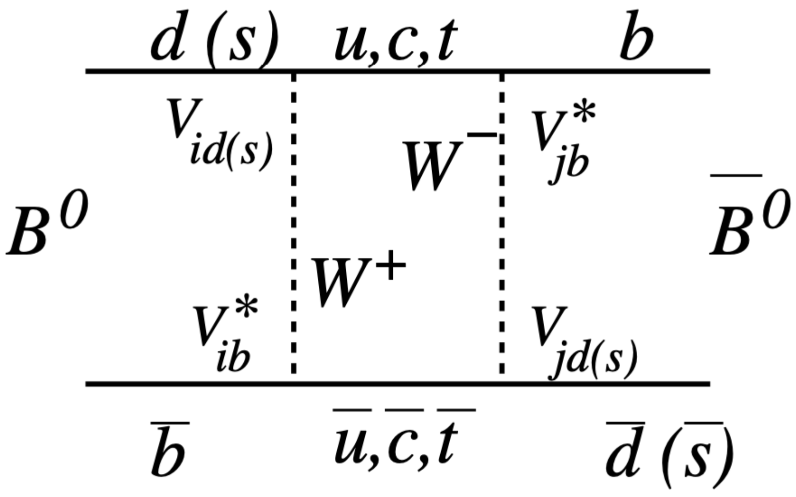
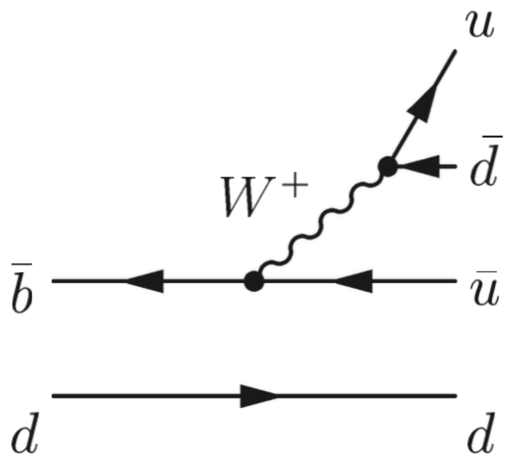
$B \to \pi\pi$

- **Main focus in the first few years of data taking**





$$S = \sin 2\alpha$$
$$C = 0$$

Interference between box and tree diagrams gives us α

Just like $\sin 2\beta$ **with** $J/\psi K^0_S$

… but

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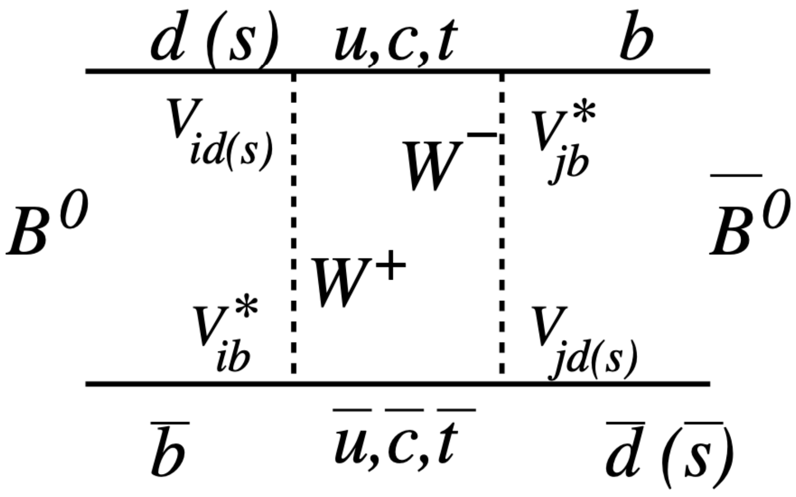
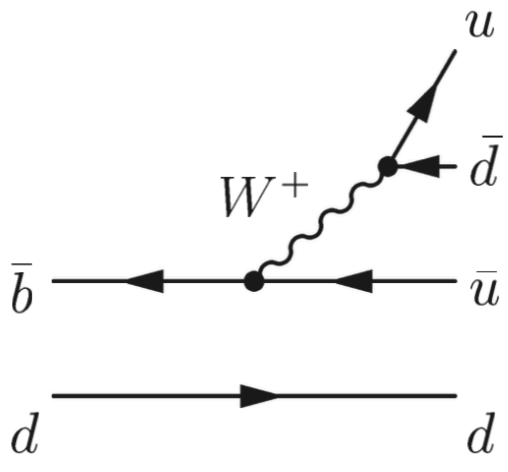
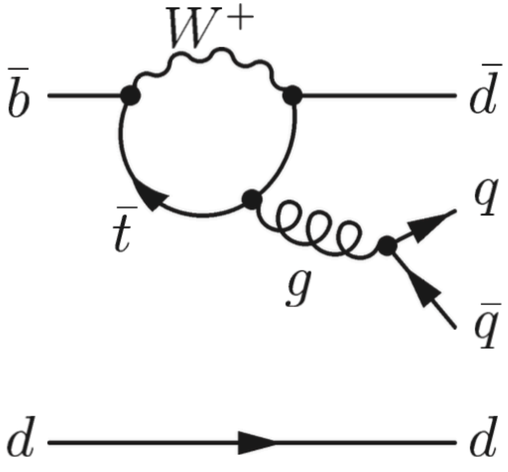
$B \to \pi\pi$

- **Main focus in the first few years of data taking**







$$S = \sqrt{1 - C^2} \sin 2\alpha_{eff}$$
$$C \propto \sin(\delta)$$
$$\delta = \delta_P - \delta_T$$

"Penguin pollution" complicates extraction of α

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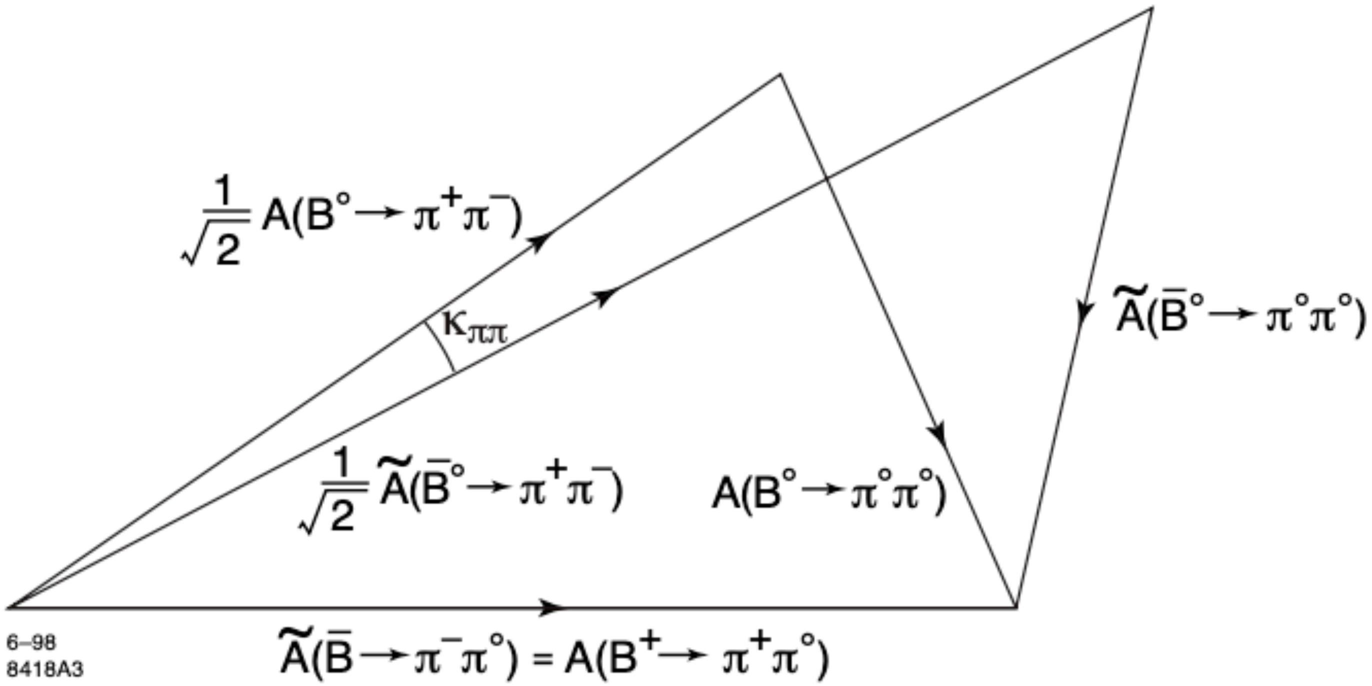
Gronau-London I-spin analysis

- **SU(2) gives us a way to constrain penguin pollution and extract α**



Need branching ratio and CP asymmetries of:

$$B_d \to \pi^+\pi^-$$
$$B_u^\pm \to \pi^\pm\pi^0$$
$$B_d \to \pi^0\pi^0$$

M. Gronau, D. London, Phys. Rev. Lett. 65, 3381

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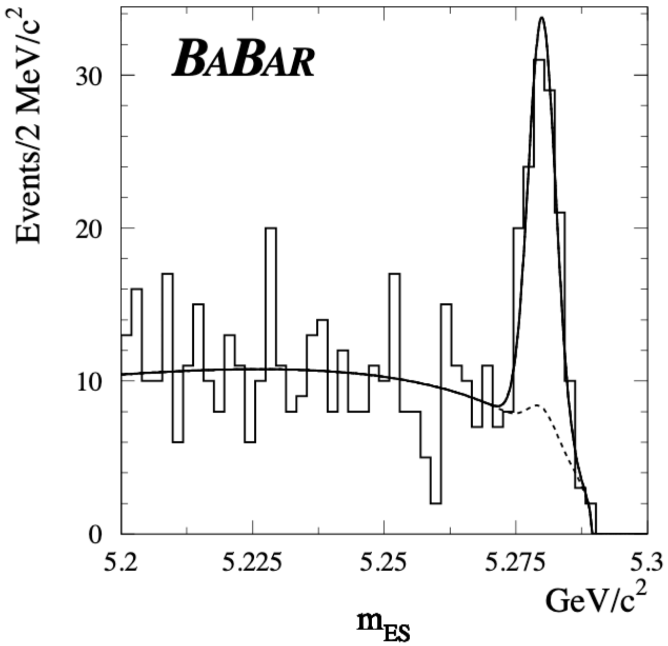
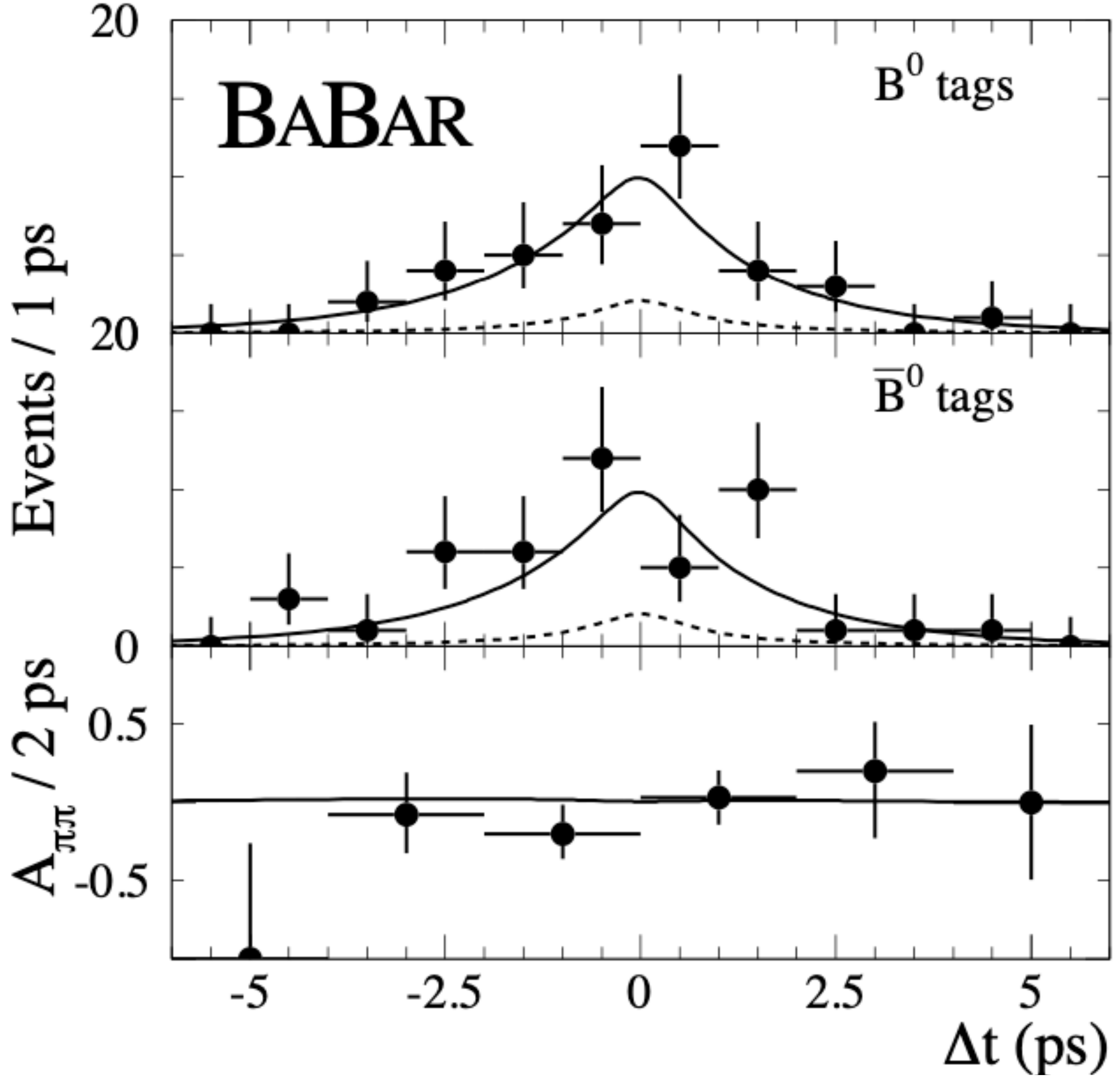
$B \to \pi\pi$ (2002, BaBar)

- $B_d^0 \to \pi^+\pi^-$ gives S and C
- Clean two-track final state



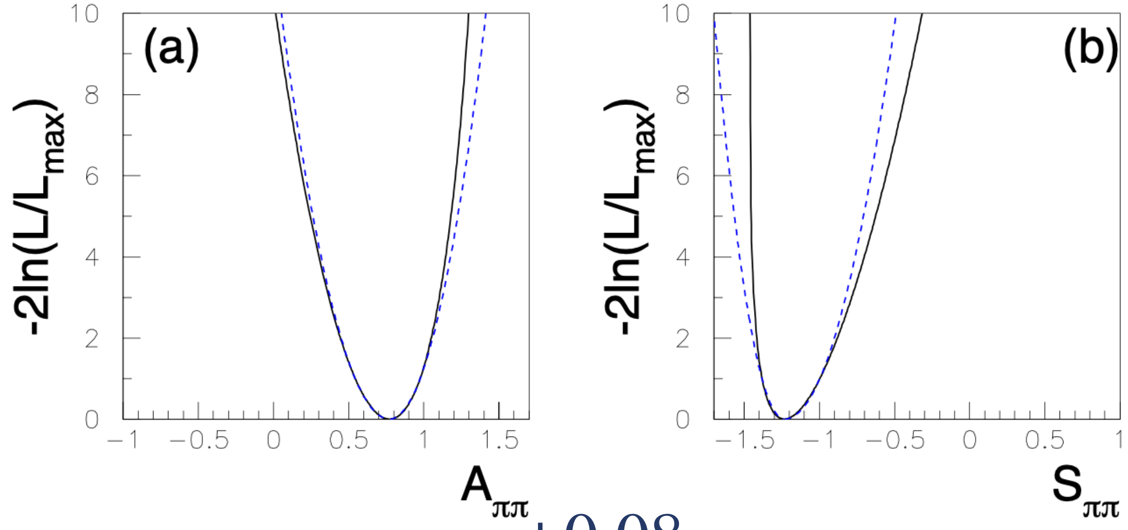
$$S = -0.01 \pm 0.37 \pm 0.07$$
$$C = -0.02 \pm 0.29 \pm 0.07$$

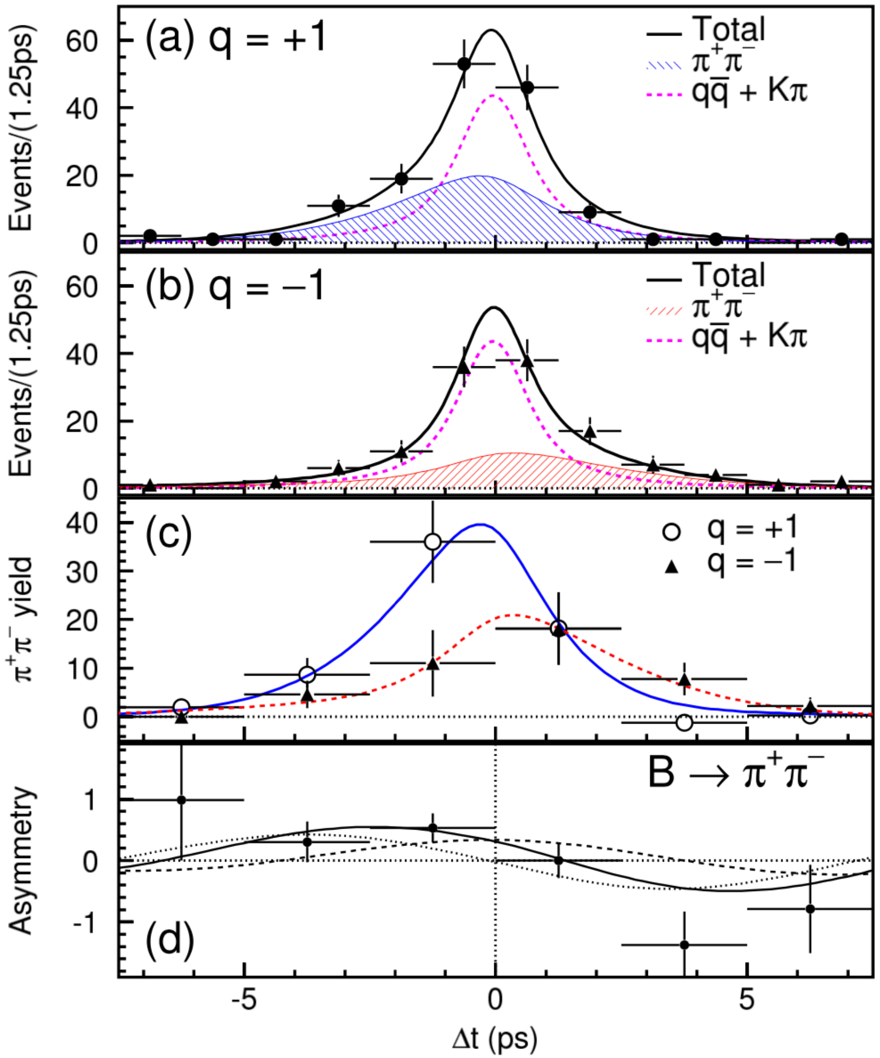


Phys.Rev.Lett. 89 (2002) 281802

$B \to \pi\pi$ (2003, Belle)

- $B_d^0 \to \pi^+\pi^-$ gives S and C
- 'Perfect' signal event dominated
- Drove the fitted values unphysical





$$S = -1.23 \pm 0.41^{+0.08}_{-0.07}$$
$$A_{\pi\pi} = +0.77 \pm 0.27 \pm 0.08 \; [= -C]$$

Phys.Rev.D 68 (2003) 012001

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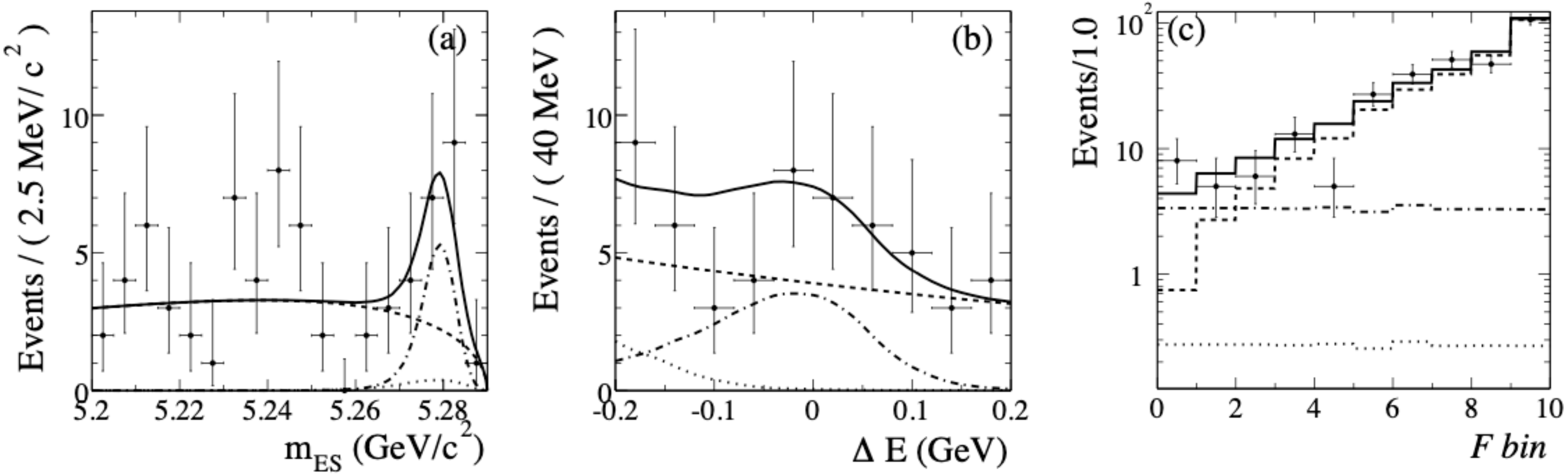
$B \rightarrow \pi\pi$ (2003)

- $B_d^0 \rightarrow \pi^0\pi^0$ is the key to extracting α, but was much larger than expected
- Proof that penguins were large in $B \rightarrow \pi\pi$ …



Phys.Rev.Lett.91:241801,2003

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$B \to \rho\pi$

Phys.Rev.Lett.91:201802,2003

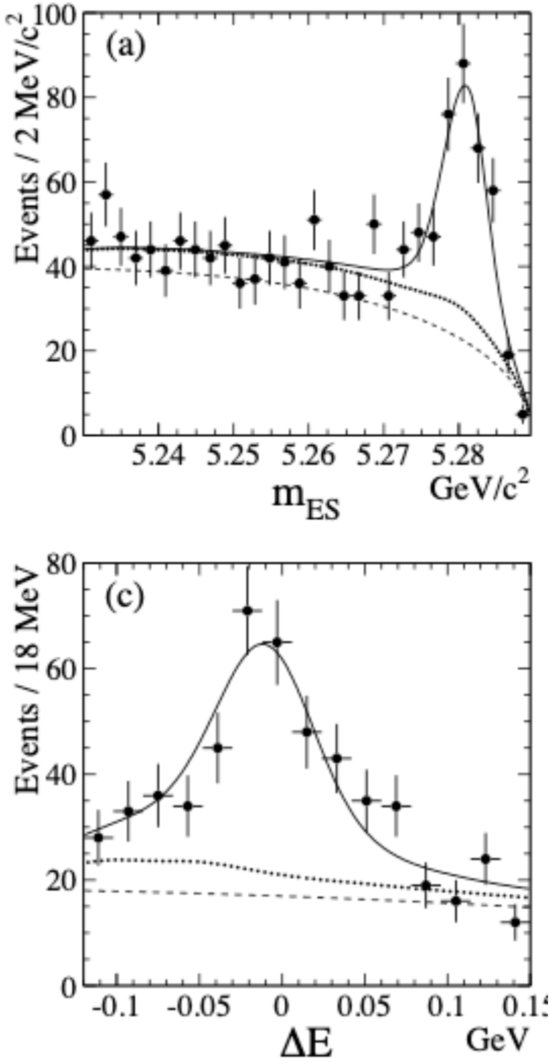
- **Initial measurements took a quasi 2 body approach to extracting α from $\rho\pi$**

- **Measure $A_{CP}, S, C, \Delta S, \Delta C$**

$$f_{\pm}(\Delta t) = (1 \pm \mathcal{A}_{CP})\frac{e^{-|\Delta t|/\tau}}{4\tau}[(S \pm \Delta S \sin(\Delta m_d \Delta t) - (C \pm \Delta C)\cos(\Delta m_d \Delta t)]$$

- **ρK final state analysed simultaneously**

$$A_{CP}^{\rho\pi} = -0.18 \pm 0.08 \pm 0.03\,, \quad A_{CP}^{\rho K} = 0.28 \pm 0.17 \pm 0.08\,,$$
$$C_{\rho\pi} = \quad 0.36 \pm 0.18 \pm 0.04\,, \quad S_{\rho\pi} = 0.19 \pm 0.24 \pm 0.03\,.$$
$$\Delta C_{\rho\pi} = 0.28^{+0.18}_{-0.19} \pm 0.04\,, \quad \Delta S_{\rho\pi} = 0.15 \pm 0.25 \pm 0.03$$



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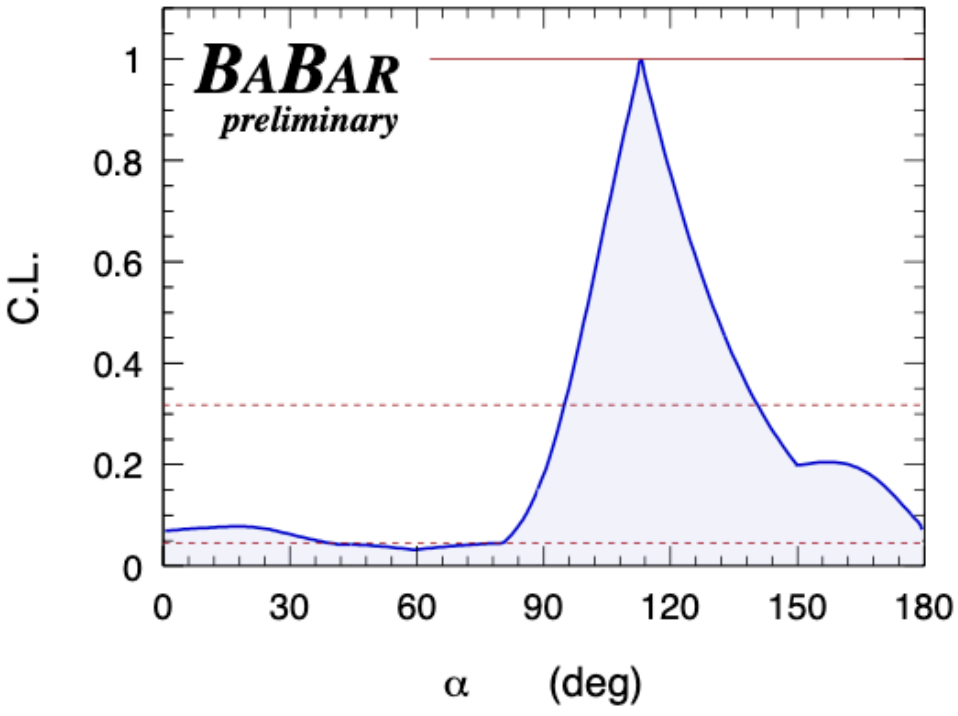
$B \to \rho\pi$

- **Evolving to a Dalitz analysis approach required new tools**

$$|\mathcal{A}_{3\pi}^{\pm}(\Delta t)|^2 = \frac{e^{-|\Delta t|/\tau_{B^0}}}{4\tau_{B^0}}\Big[|\mathcal{A}_{3\pi}|^2 + |\overline{\mathcal{A}}_{3\pi}|^2 \mp \left(|\mathcal{A}_{3\pi}|^2 - |\overline{\mathcal{A}}_{3\pi}|^2\right)\cos(\Delta m_d \Delta t)$$
$$\pm 2\mathrm{Im}\left[\overline{\mathcal{A}}_{3\pi}\mathcal{A}_{3\pi}^*\right]\sin(\Delta m_d\Delta t)\Big] ,$$

ICHEP 2004, BABAR-CONF-04/38, SLAC-PUB-10658



- **where**

$$|\mathcal{A}_{3\pi}|^2 \pm |\overline{\mathcal{A}}_{3\pi}|^2 = \sum_{\kappa\in\{+,-,0\}} |f_\kappa|^2 U_\kappa^{\pm} + 2\sum_{\kappa<\sigma\in\{+,-,0\}}\left(\mathrm{Re}\left[f_\kappa f_\sigma^*\right]U_{\kappa\sigma}^{\pm,\mathrm{Re}} - \mathrm{Im}\left[f_\kappa f_\sigma^*\right]U_{\kappa\sigma}^{\pm,\mathrm{Im}}\right)$$

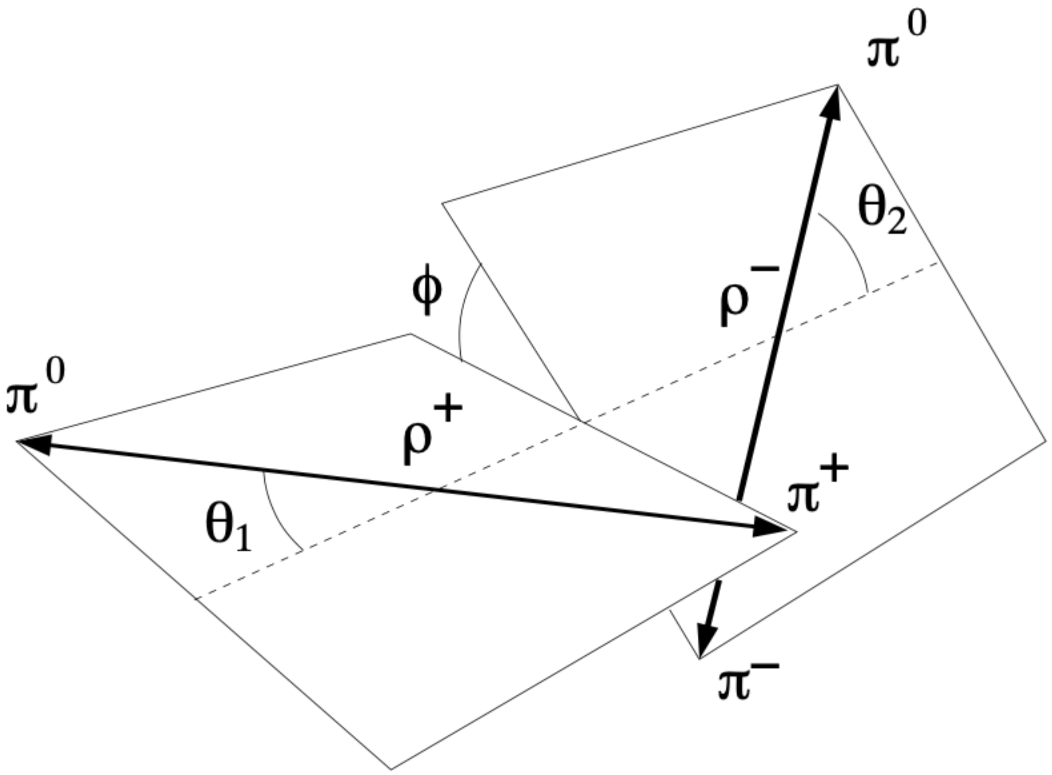
$$\mathrm{Im}\left(\overline{\mathcal{A}}_{3\pi}\mathcal{A}_{3\pi}^*\right) = \sum_{\kappa\in\{+,-,0\}} |f_\kappa|^2 I_\kappa + \sum_{\kappa<\sigma\in\{+,-,0\}}\left(\mathrm{Re}\left[f_\kappa f_\sigma^*\right]I_{\kappa\sigma}^{\mathrm{Im}} + \mathrm{Im}\left[f_\kappa f_\sigma^*\right]I_{\kappa\sigma}^{\mathrm{Re}}\right) ,$$

with

$$U_\kappa^{\pm} = |A^\kappa|^2 \pm |\overline{A}^\kappa|^2 ,$$
$$U_{\kappa\sigma}^{\pm,\mathrm{Re(Im)}} = \mathrm{Re(Im)}\left[A^\kappa A^{\sigma *} \pm \overline{A}^\kappa \overline{A}^{\sigma *}\right] ,$$
$$I_\kappa = \mathrm{Im}\left[\overline{A}^\kappa A^{\kappa *}\right] ,$$
$$I_{\kappa\sigma}^{\mathrm{Re}} = \mathrm{Re}\left[\overline{A}^\kappa A^{\sigma *} - \overline{A}^\sigma A^{\kappa *}\right] ,$$
$$I_{\kappa\sigma}^{\mathrm{Im}} = \mathrm{Im}\left[\overline{A}^\kappa A^{\sigma *} + \overline{A}^\sigma A^{\kappa *}\right] .$$

$B \to \rho\rho$

- **Hints that penguins might be small (and longitudinally dominated) for $\rho\rho$ existed …**



More challenging variant than $\pi\pi$, but SU(2) isospin analysis works

Longitudinal (CP even) and transverse (CP admixture) components to study

Longitudinal component dominates:

$$S_{\rm long} = -0.17 \pm 0.20({\rm stat})^{+0.05}_{-0.06}({\rm syst})$$
$$C_{\rm long} = 0.01 \pm 0.15({\rm stat}) \pm 0.06({\rm syst})$$

Phys.Rev.D76:052007,2007

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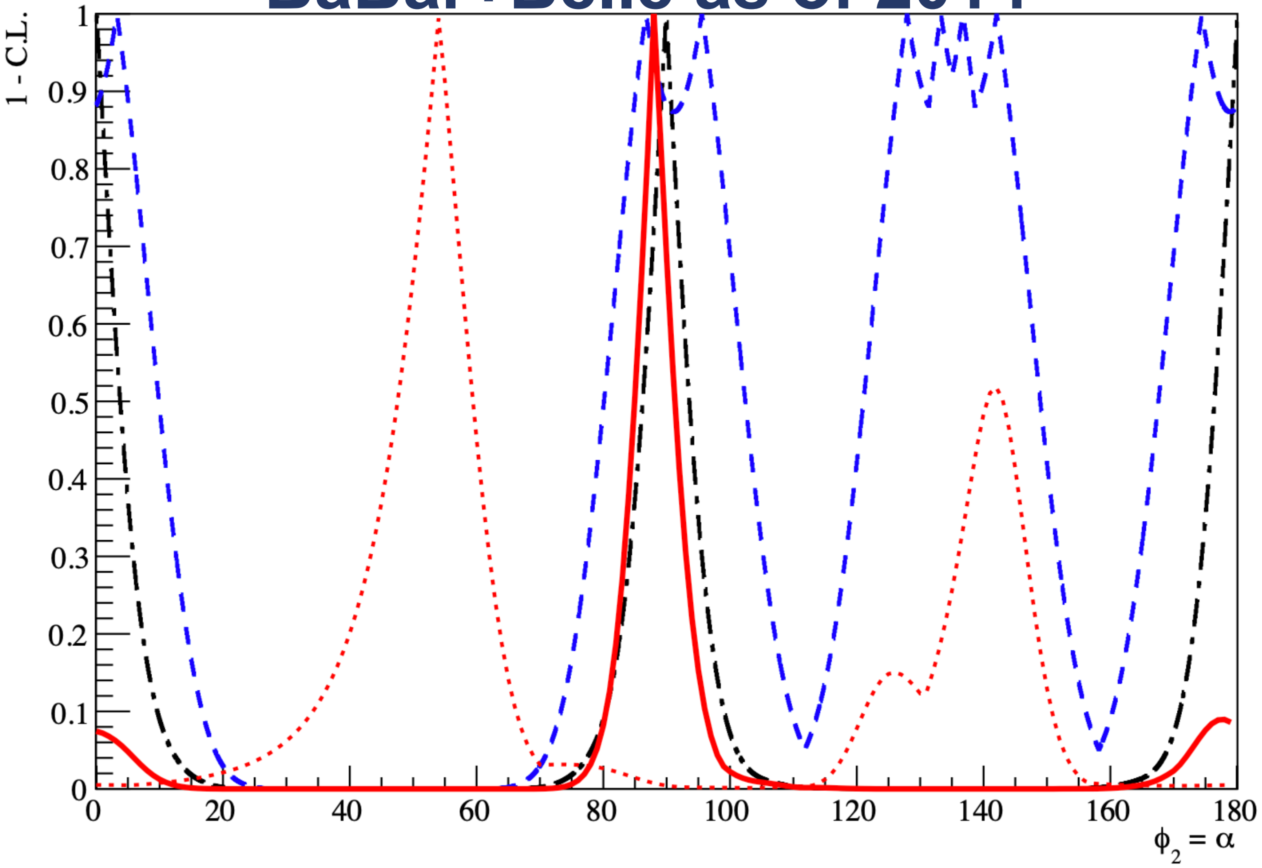
Constraining α

- **Combinations of these three approaches are used to determine the angle**

BaBar+Belle as of 2014



Each approach plays a role:

- **precision is dominated by $\rho\rho$**
- **both $\pi\pi$ and $\rho\pi$ lift ambiguity**

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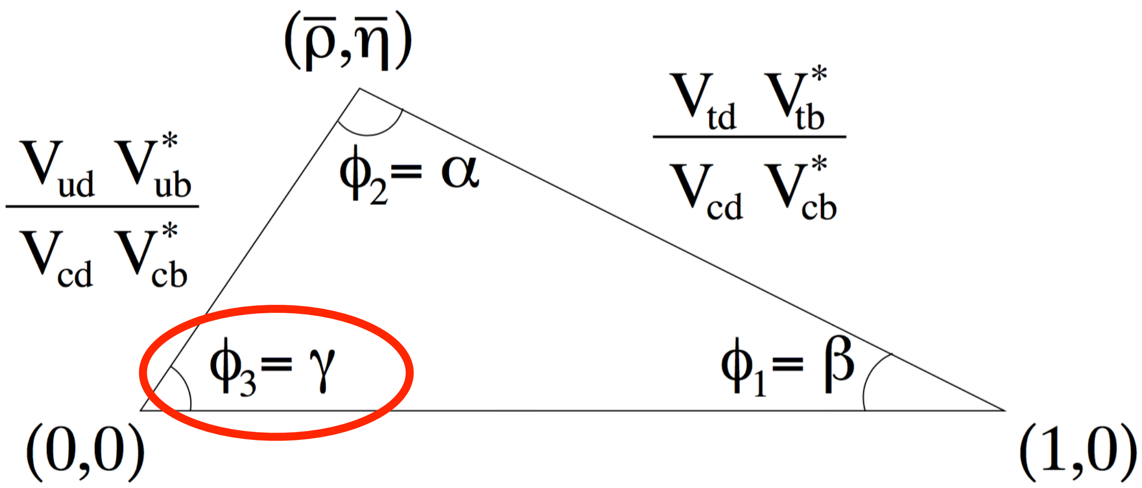
Part 1: CP violation

- $\gamma=\varphi_3$
- Focus was on combinations of measurements to constrain γ



$b \rightarrow c$ **interfering with** $b \rightarrow u$

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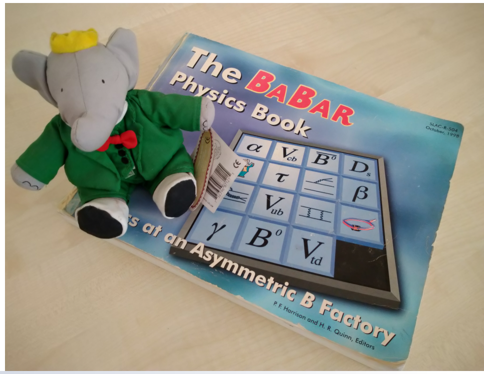
Measuring γ

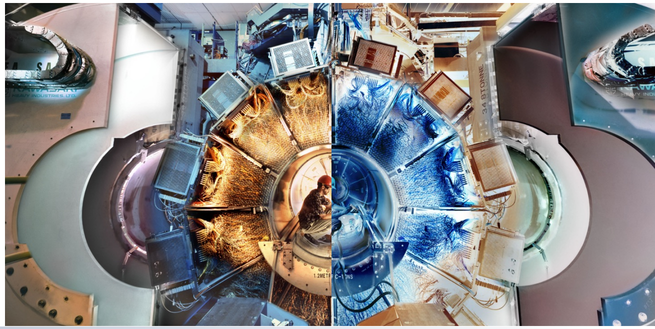
- **Lots of different ideas on how to measure needed exploration**
  - **Triangle relations among decay amplitudes**
  - $B^{\pm} \to DK^{\pm}$ **and related decays**
  - **Amplitude relations for** $B_{u,d} \to \pi K$ **decays**
  - **Partial reconstruction of** $B_d \to D^{(*)}\pi$ **to extract** $\sin(2\beta+\gamma)$
  - $B_s - \overline{B}_s$ **mixing**



Measuring γ

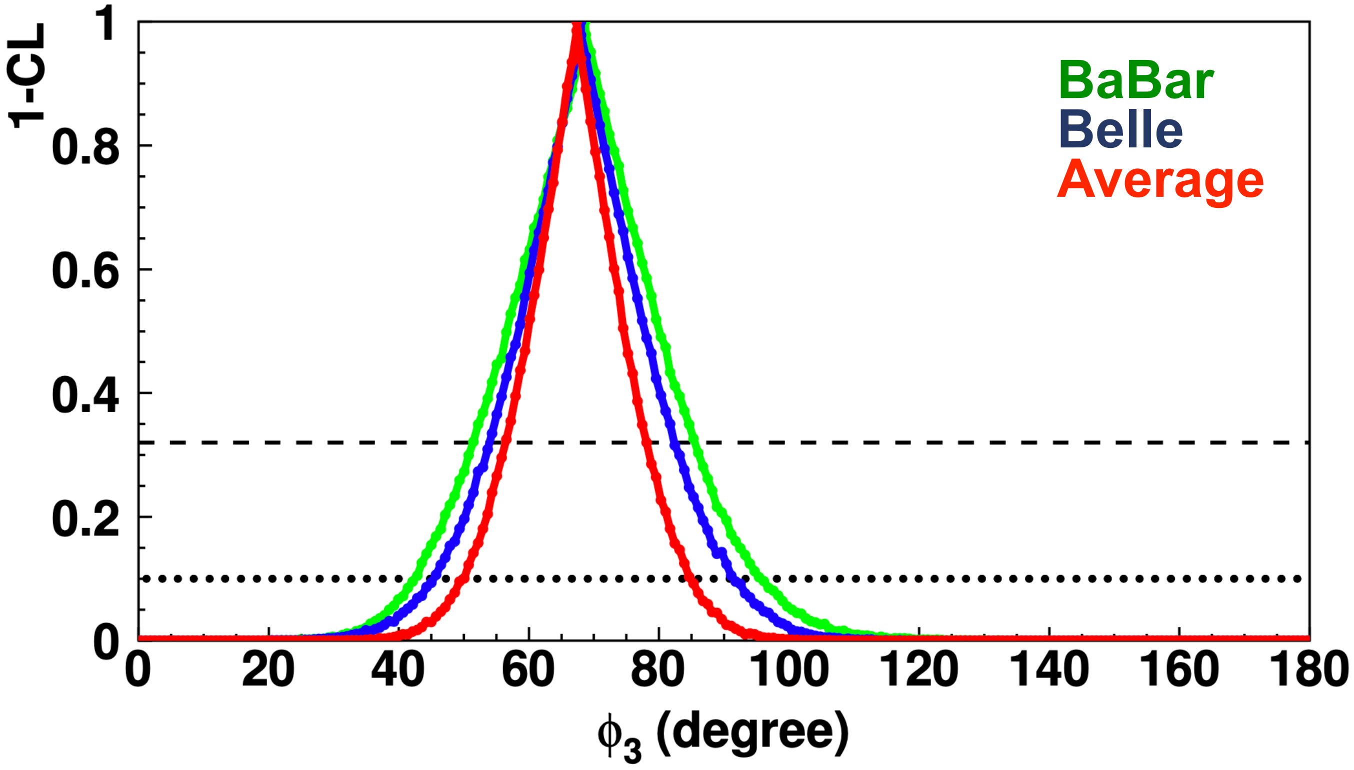
- Lots of different ideas on how to measure needed exploration
  - Triangle relations among decay amplitudes
  - $B^{\pm} \rightarrow DK^{\pm}$ and related decays
  - Amplitude relations for $B_{u,d} \rightarrow \pi K$ decays
  - Partial reconstruction of $B_d \rightarrow D^{(*)}\pi$ to extract $\sin(2\beta + \gamma)$
  - ~~$B_s - \overline{B}_s$ mixing (no $\Upsilon(5S)$ running)~~

LHCb did a great job of measuring B_s mixing @ the LHC



Measuring γ

- Lots of different ideas on how to measure needed exploration
  - For example: $B \to D^{(*)}K^{(*)}$ resulted in $\gamma = (69 \pm 17)^{\circ}$



Used the ADS, GLW and GGSZ methods to determine γ from DK final states

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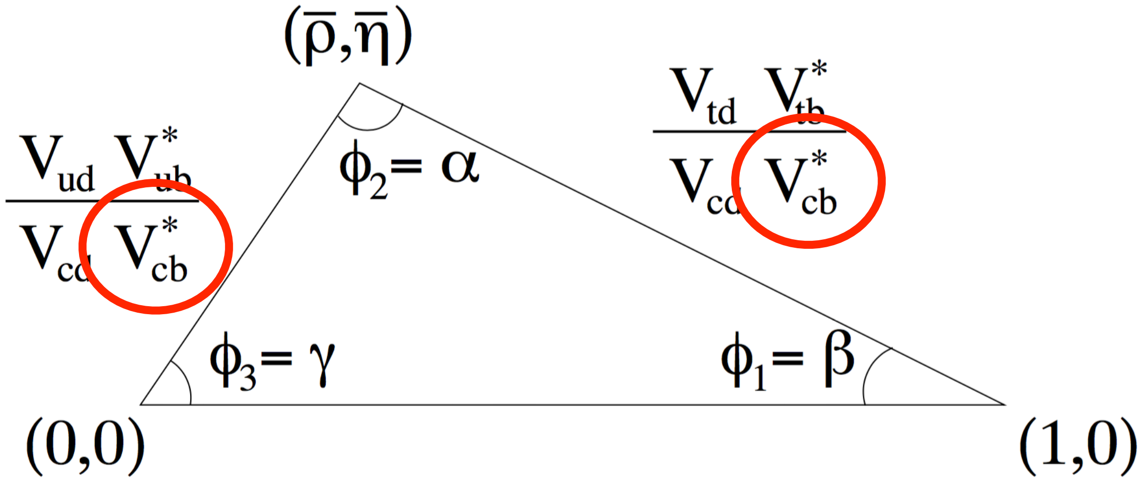
Part 2: sides

- $|V_{cb}|$



$$b \to X_c \ell \nu$$

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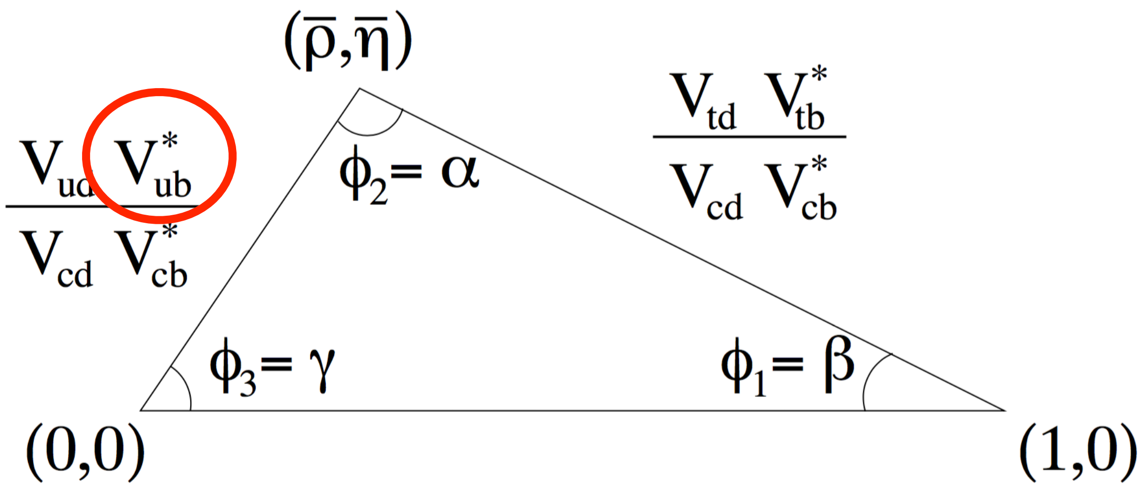
Adrian Bevan

Part 2: sides

- $|V_{ub}|$



$$b \to X_u \ell \nu$$

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Queen Mary University of London

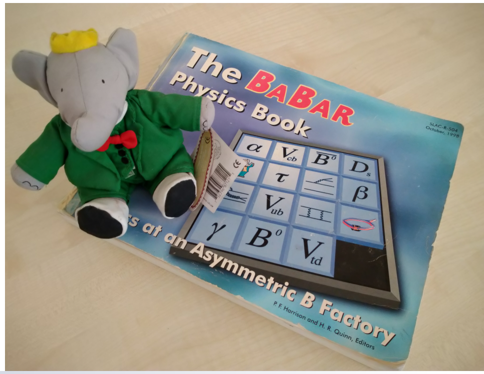
Measuring the sides

- **Detailed pre-data taking studies concluded attainable precisions of:**

$$|V_{cb}| = \ldots \pm 0.0004 \pm 0.0012 (\pm 1\% \pm 3\%)$$

$$|V_{ub}| = \ldots \pm 0.0001 \pm 0.0004 (\pm 2.5\% \pm 10\%)$$

- **Theoretical uncertainties should dominate**



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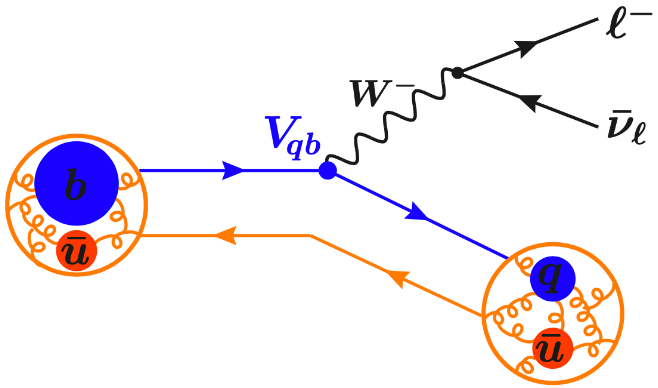
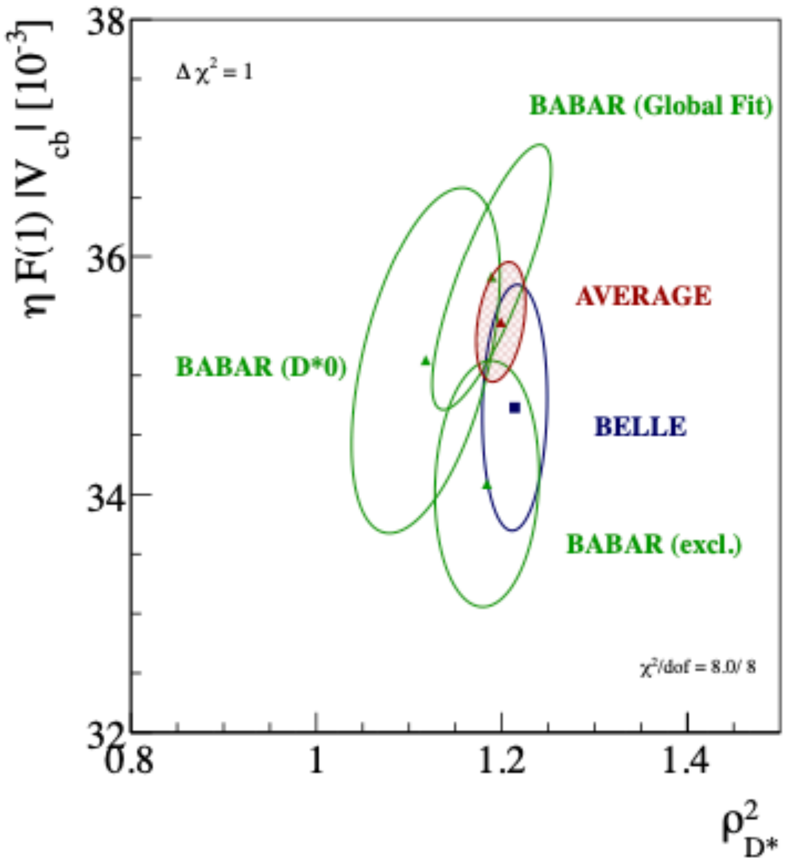
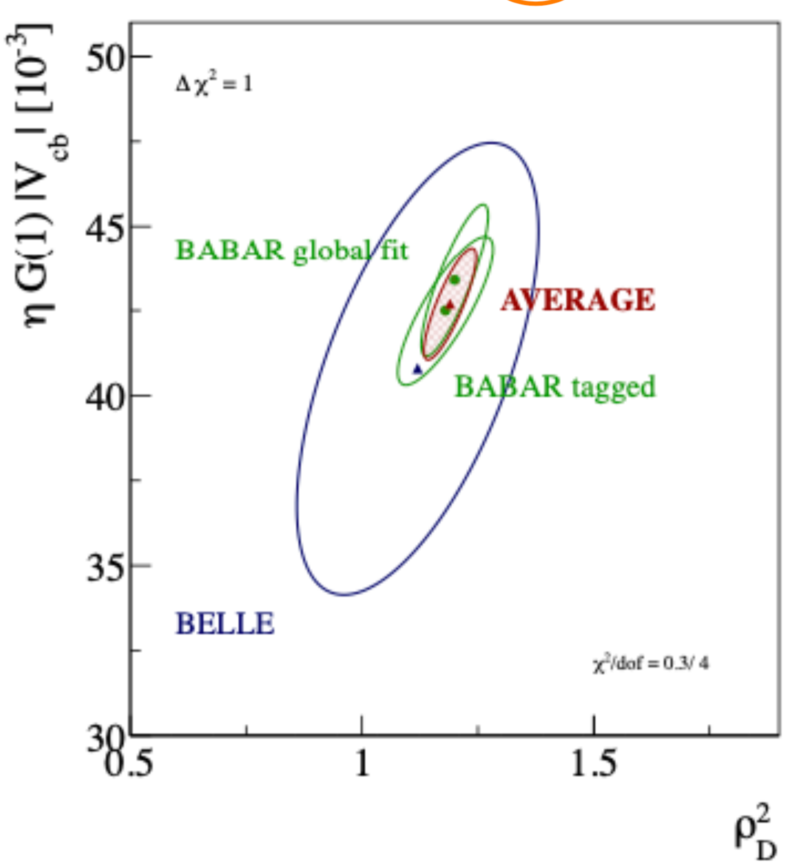
Measuring the sides

- HQET used for $|V_{cb}|$ measurement







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Measuring the sides

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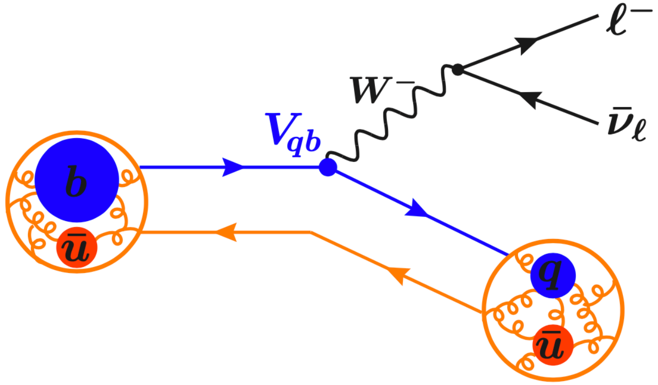

- B Factory average (2014)

$$|V_{cb}|_{\mathrm{excl}} = [39.04\ (1 \pm 0.014_{\mathrm{exp}} \pm 0.019_{\mathrm{th}})] \times 10^{-3}$$
$$|V_{cb}|_{\mathrm{incl}} = [42.01\ (1 \pm 0.011_{\mathrm{exp}} \pm 0.014_{\mathrm{th}})] \times 10^{-3}$$

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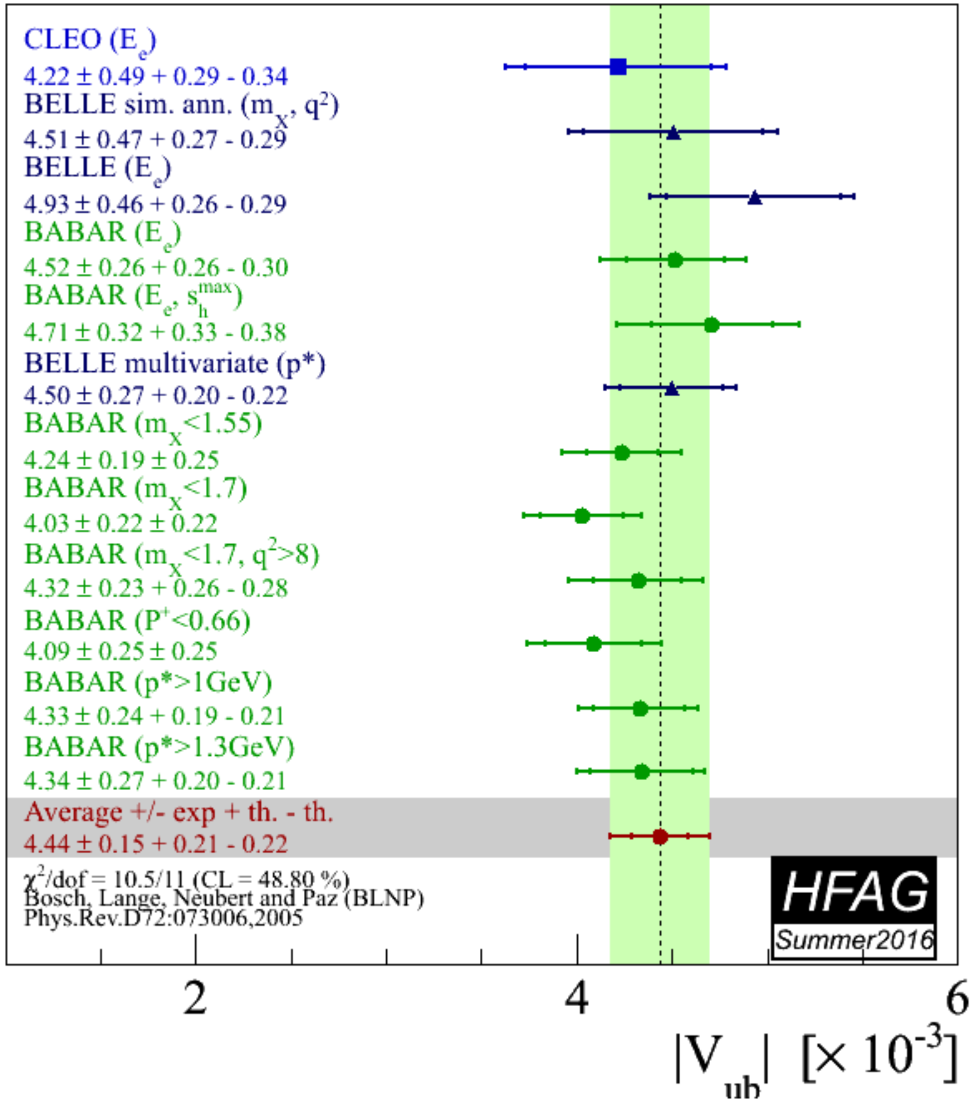
Measuring the sides

- Different schemes for extracting $|V_{ub}|$ were used
  - Huge intellectual endeavour to perform inclusive and exclusive measurements
  - Overall precision better than anticipated in the Physics book
  - BLNP results (2016) shown



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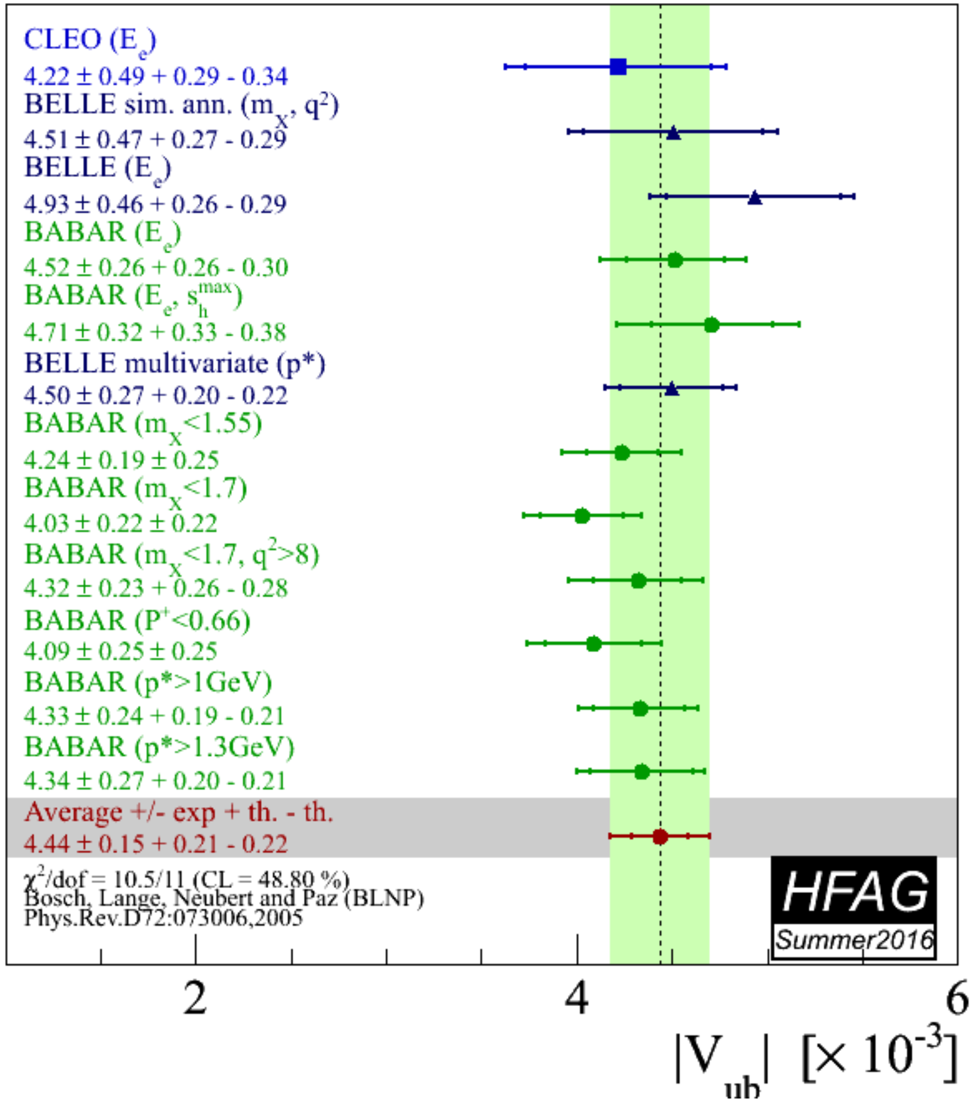
Measuring the sides

- **Different schemes for extracting $|V_{ub}|$ were used**
  - **Huge intellectual endeavour to perform inclusive and exclusive measurements**
  - **Overall precision better than anticipated in the Physics book**
  - **B Factory average (2014):**

$$|V_{ub}|_{\rm excl} = [3.23\ (1 \pm 0.05_{\rm exp} \pm 0.08_{\rm th})] \times 10^{-3}$$

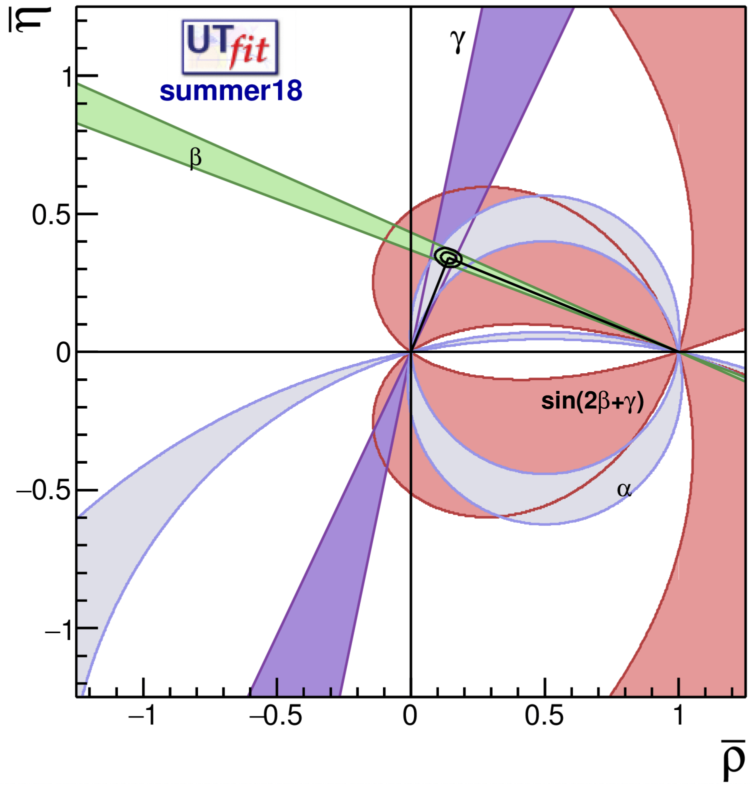
$$|V_{ub}|_{\rm incl} = [4.42\ (1 \pm 0.045_{\rm exp} \pm 0.034_{\rm th})] \times 10^{-3}$$



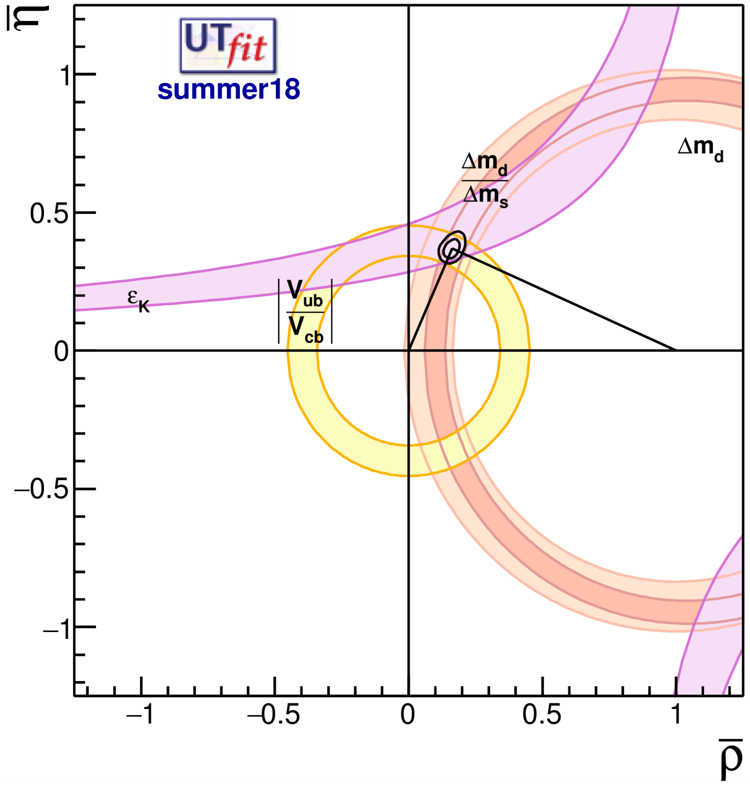
Summing it all up

- **The triangle closes**

Angles only



Sides only

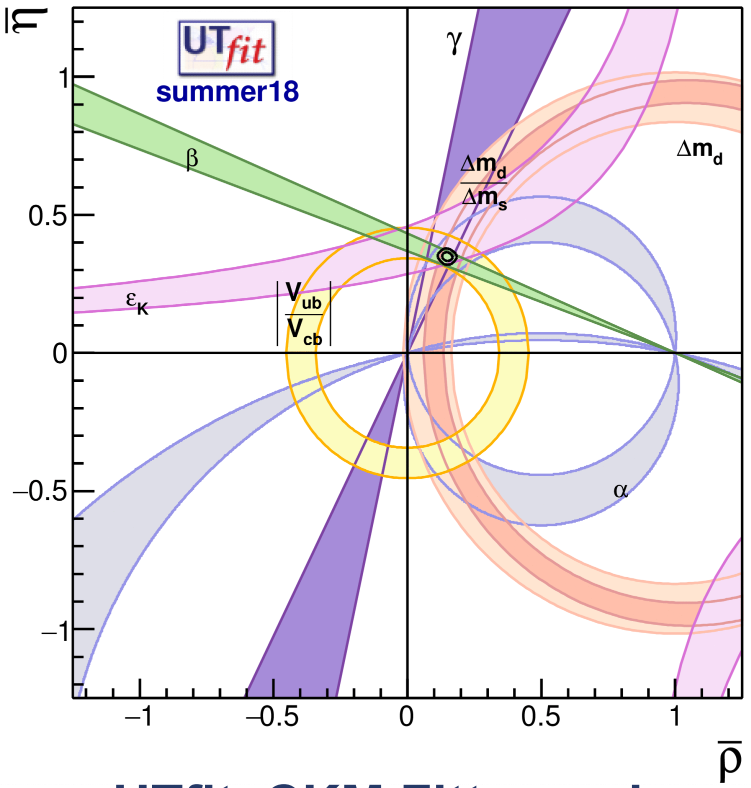


These results are from UTfit, CKM Fitter and a scan method have been used to check closure of the triangle - all methods broadly agree

Summing it all up

- The triangle closes

All constraints



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Summing it all up

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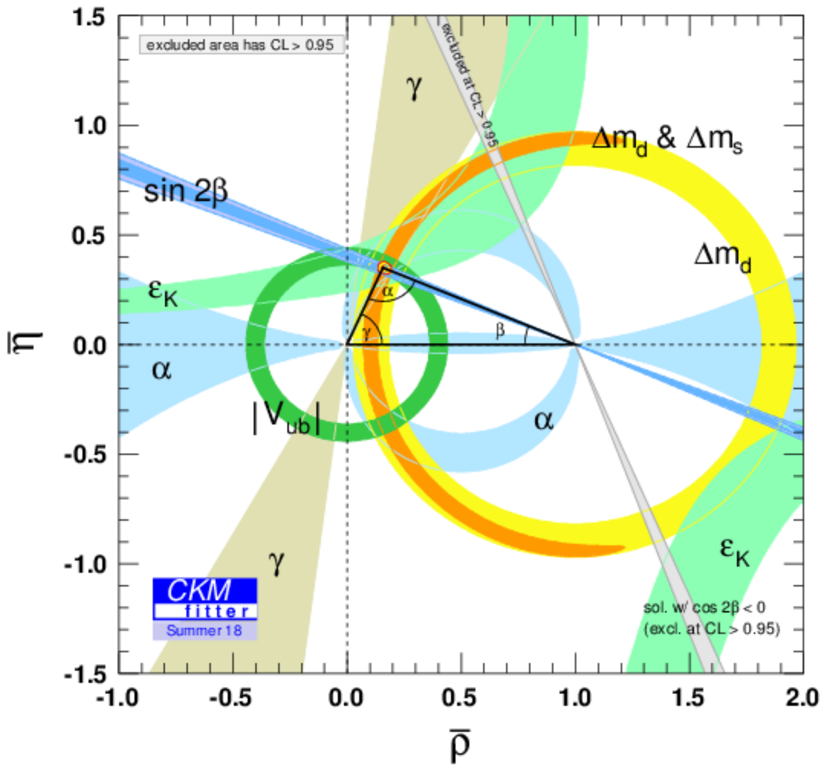

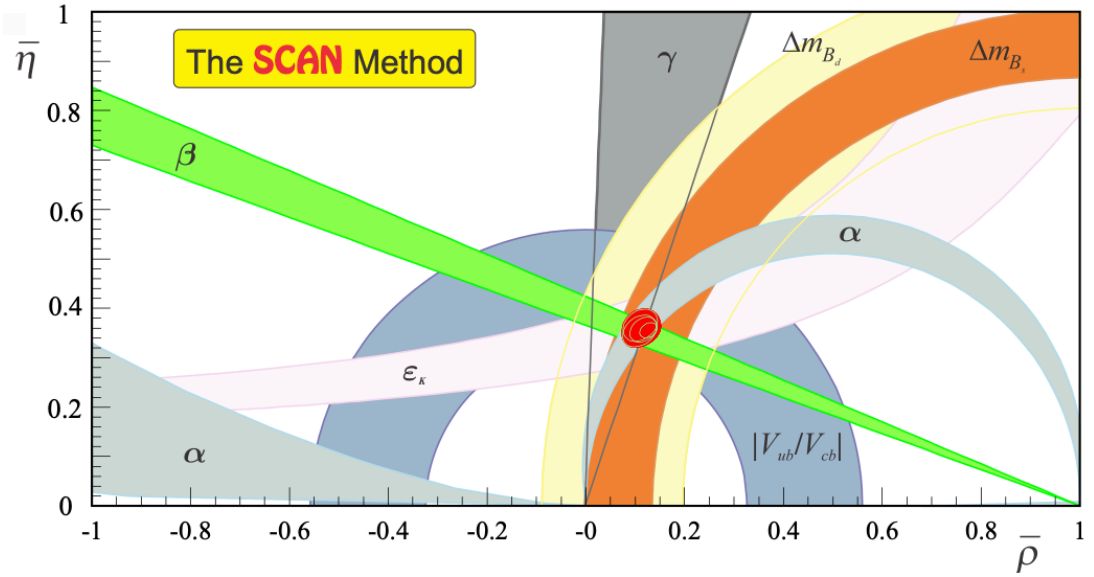

G. Eigen et al., CALT 68-2902

These results are from UTfit, CKM Fitter and a scan method have been used to check closure of the triangle - all methods broadly agree

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Summing it all up

- The triangle closes
- CKM provides the standard model description of CP violation
- Kobayashi and Maskawa were awarded the Nobel Prize in 2008

CP-Violation in the Renormalizable Theory of Weak Interaction

Makoto KOBAYASHI and Toshihide MASKAWA

Department of Physics, Kyoto University, Kyoto

(Received September 1, 1972)

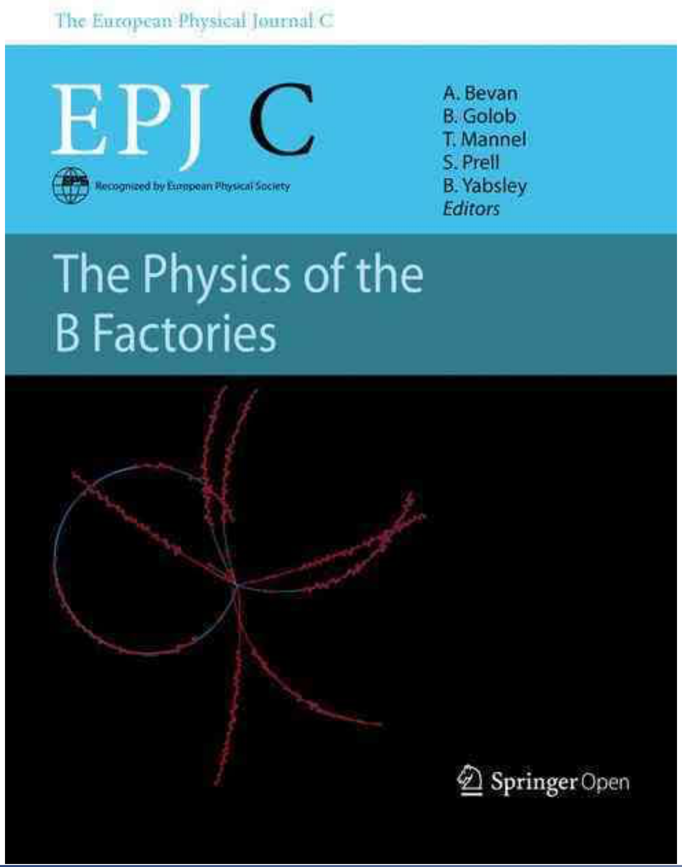
In a framework of the renormalizable theory of weak interaction, problems of *CP*-violation are studied. It is concluded that no realistic models of *CP*-violation exist in the quartet scheme without introducing any other new fields. Some possible models of *CP*-violation are also discussed.

M. Kobayashi and T. Maskawa, Prog. Theor. Phys 49, 652 (1973).

2008

Deep reflection …

- **172 authors from the global community came together to reflect on the work we did on BaBar and Belle for the Physics of the B Factories book**



arXiv:1406:6311
Eur. Phys. J. C74 (2014) 3026

Deep reflection …

- **172 authors from the global community came together to reflect on the work we did on BaBar and Belle for the Physics of the B Factories book**

Foreword

"The Physics of the *B* Factories" describes a decade long effort of physicists in the quest for the precise determination of asymmetry — broken symmetry — between particles and anti-particles. We now recognize that the matter we see around us is the residue — one part in a billion — of the matter and antimatter that existed in the early universe, most of which annihilated into the cosmic background radiation that bathes us. But the question remains: how did the baryonic matter-antimatter asymmetry arise? This book describes the work done by some 1000 physicists and engineers from around the globe on two experimental facilities built to test our understanding of this phenomenon, one at the SLAC National Accelerator Laboratory in California, USA, and a second at the KEK Laboratory, Tsukuba, Japan, and what we have learned from them in broadening our understanding of nature.

Why is our universe dominated by the matter of which we are made rather than equal parts of matter and antimatter? This question has puzzled physicists for decades. However, this was not the question we addressed when we wrote the paper on *CP* violation in 1972. Our question was whether we can explain the *CP* violation observed in the *K* meson decay within the framework of the renormalizable gauge theory. At that time, Sakharov's seminal paper was already published, but it did not attract our attention. If we were aware of the paper, we would have been misled into seeking a model satisfying Sakharov's conditions and our paper might not have appeared.

In our paper, we discussed that we need new particles in order to accommodate *CP* violation into the renormalizable electroweak theory, and proposed the six-quark scheme as one of the possible ways introducing new particles. We thought that the six-quark scheme is very interesting, but it was just a possibility. The situation changed when the tau-lepton was found and it was followed by the discovery of the Upsilon particle. The existence of the third generation became reality. However, it was still uncertain whether the mixing of the six quarks is a real origin of the observed *CP* violation. Theoretical calculation of *CP* asymmetries in the neutral *K* meson system contains uncertainty from strong interaction effects. What settled this problem were the *B* Factories built at SLAC and KEK.

These *B* Factories are extraordinary in many ways. In order to fulfill the requirements of special experiments, the beam energies of the colliding electron and positron are asymmetric, and the luminosity is unprecedentedly high. It is also remarkable that severe competition between the two laboratories boosted their performance. One of us (M. Kobayashi) has been watching the development at KEK very closely as the director of the Institute of Particle and Nuclear Studies of KEK for a period of time. As witnesses, we appreciate the amazing achievement of those who participated in these projects at both laboratories.

The *B* Factories have contributed a great deal to our understanding of particle physics, as documented in this book. In particular, thanks to the high luminosity far exceeding the design value, experimental groups measured mixing angles precisely and verified that the dominant source of *CP* violation observed in the laboratory experiments is flavor mixing among the three generations of quarks. Obviously we owe our Nobel Prize to this result.

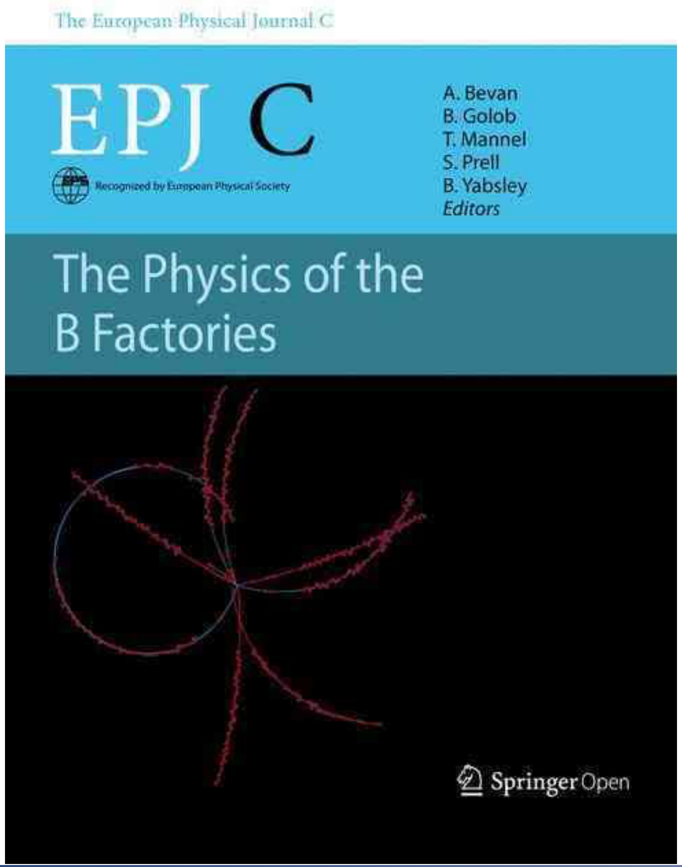
Now we are awaiting the operation of the next generation Super *B* Factories. In spite of its great success, the Standard Model is not an ultimate theory. For example, it is not thought to be possible for the matter dominance of the universe to be explained by the Standard Model. This means that there will still be unknown particles and unknown interactions. We have a lot of theoretical speculations but experimental means are rather limited. There are great expectations for the Super *B* Factories to reveal a clue to the world beyond the Standard Model.

Makoto Kobayashi
Honorary Professor Emeritus
KEK

Toshihide Maskawa
Director General
Kobayashi-Maskawa Institute for the Origin of Particles and the Universe
Nagoya University

Deep reflection …

- **172 authors from the global community came together to reflect on the work we did on BaBar and Belle for the Physics of the B Factories book**



Completed just in time for the 50th anniversary of the discovery of CP violation in 2014

@ 50 years of CP violation

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Summary

- The quest to discover CP violation in B decays was quickly completed
- We turned to understanding what that meant and searching for patterns that did not fit the Standard Model
- … and we found anomalies; some of those anomalies remain open questions today …

Summary

- The quest to discover CP violation in B decays was quickly completed
- We turned to understanding what that meant and searching for patterns that did not fit the Standard Model
- … and we found anomalies; some of those anomalies remain open questions today
- Everything related to tests of the CKM matrix points to the KM mechanism working exceedingly well
- Both BaBar and Belle continue to publish results

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