Highlights from the B-Factories

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Queen Mary, University of London

IoP HEPP 2009

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The Nobel Prize in Physics 2008

and the B FACTORIES

KEK/High Energy Accelerator Research Organization

SLAC NATIONAL ACCELERATOR LABORATORY

The Nobel Prize in Physics 2008 was awarded to

Makoto Kobayashi
High Energy Accelerator Research Organization (KEK),
Tsukuba, Japan

&

Toshihide Maskawa
Kyoto Sangyo University; Yukawa Institute for Theoretical Physics (YITP)
Kyoto University, Kyoto, Japan

and to Yoichiro Nambu, Enrico Fermi Institute, University of Chicago, IL, USA
"for the discovery of the mechanism of spontaneous broken symmetry in subatomic physics."

"for the discovery of the origin of the broken symmetry which predicts the existence of at least three families of quarks in nature"

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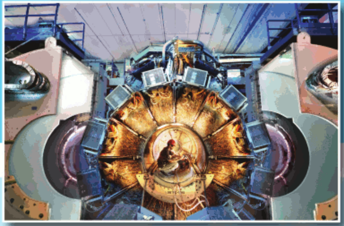
BaBar



PEP-II

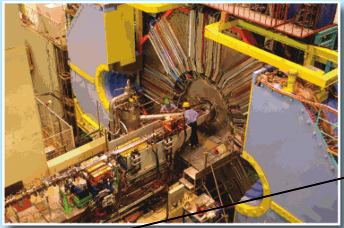
Broken Symmetries Predicted Extra Quarks

Matter and antimatter are nearly exact opposites of each other. But this near-perfect symmetry is broken in nature as we observe it. In 1972, Kobayashi and Maskawa discovered that the root of the mystery could be explained by the properties of quarks, the fundamental constituents of protons and neutrons, but only if there were three more types of quarks than had previously been observed. At that time, experimenters had seen the up, down, and strange quarks, but the charm, bottom, and top would not be discovered until later.

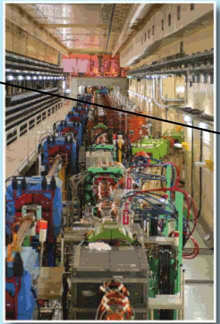
B Factory Experiments Confirmed the Predictions

Experiments at the B factories in the United States and Japan in the early 2000s made detailed investigations of billions of high-energy particles containing bottom quarks. International Collaborations at the B factories made numerous measurements of the parameters of the Cabibbo, Kobayashi, and Maskawa (CKM) mixing matrix and confirmed the precise links of these with the observed differences between matter and antimatter. The B factories each consist of an accelerator and a particle detector. At the SLAC National Accelerator Laboratory in California, USA, the PEP-II accelerator provides the collisions observed by the BaBar detector. At KEK in Tsukuba, Japan, the KEK-B accelerator supplies the Belle detector with the particles needed for these studies.

Belle



KEK-B



"Please accept our deepest respect and gratitude for the B factory achievements. In particular, the high-precision measurement of CP violation and the determination of the mixing parameters are great accomplishments, without which we would not have been able to earn the Prize."

小林誠 *(Makoto Kobayashi)*

益川敏英 *(Toshihide Maskawa)*

"Please accept our deepest respect and gratitude for the B factory achievements. In particular, the high-precision measurement of CP violation and the determination of the mixing parameters are great accomplishments, without which we would not have been able to earn the Prize."

Disclaimer

- Flavor physics is a rich and vibrant field
  - O(100) abstracts at ICHEP08.
- This talk: CKM matrix
  - Magnitude, angles and phase of the matrix.
  - Will focus on the newest results, and summaries.
  - Charm physics and hadron spectroscopy not included.
  - My apologies if I omit your favorite paper !
- Talks in parallel sessions at this conference:
  - 1B
  - 2B

Outline

- The theoretical and experimental environment.
- The angles of the Unitarity Triangle.
- The magnitude of the elements of the CKM matrix.
- Perspectives and Conclusions.

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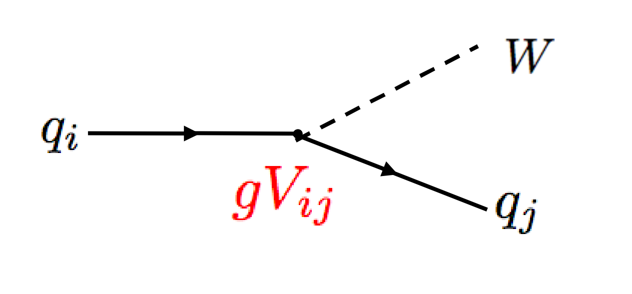
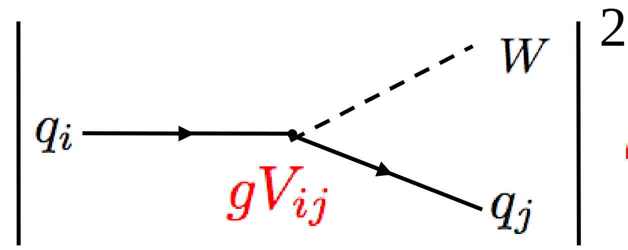
CKM Matrix



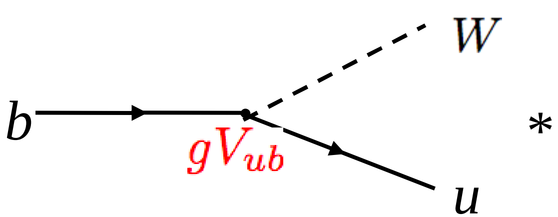
$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{td} \end{pmatrix}$$

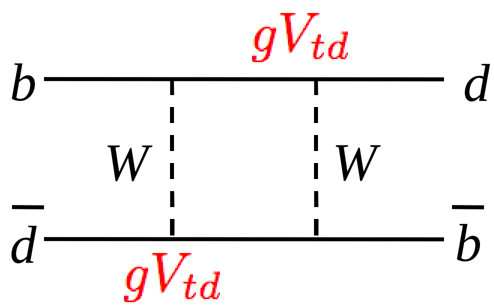
Measure magnitudes from rates:



$\sim |V_{ij}|^2$

Measure phases through interference: CP violation. Need at least two amplitudes, e.g. 2 decay amplitudes (“direct CPV”), or decay and mixing





$\sim e^{i\,\arg(V_{td}^2 V_{ub})}$

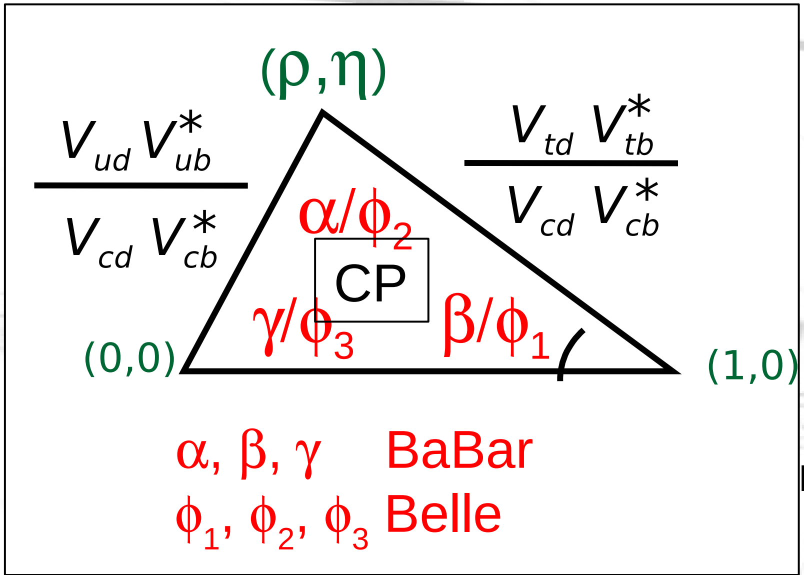
Unitarity Triangle

Unitary mixing matrix: 4 parameters (*c.f.* MNSP matrix in neutrinos)
For quarks, conventional Wolfenstein parameterization:

$$A,\ \rho,\ \eta \sim \mathcal{O}(1),\ \ \lambda \equiv \sin\theta_c \approx 0.22$$

$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \approx \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + \mathcal{O}(\lambda^4)$$

$$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$$: unitarity relation for B_d decays



$$\alpha \equiv \arg\left[-\frac{V_{td}V_{tb}^*}{V_{ud}V_{ub}^*}\right]$$: interfere b→u & mixing

$$\beta \equiv \arg\left[-\frac{V_{cd}V_{cb}^*}{V_{td}V_{tb}^*}\right]$$: interfere b→c & mixing

$$\gamma \equiv \arg\left[-\frac{V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*}\right]$$: interfere b→u & b→c

Common Definitions

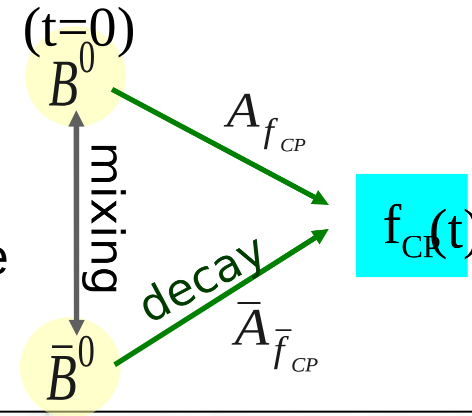
CP violation in interference between decays with and without mixing:

$$\lambda_{f_{CP}} = \eta_{CP} \frac{q}{p} \cdot \frac{\bar{A}_{\bar{f}_{CP}}}{A_{f_{CP}}}$$ ← amplitude ratio

CP eigenvalue → η_{CP}

$\frac{q}{p} \cdot \frac{\bar{A}_{\bar{f}_{CP}}}{A_{f_{CP}}} \approx e^{-2i\varphi_{CP}}$ ← *CP* phase

$\eta_{CP} = \pm 1$; $\phi_{CP} = \alpha, \beta, \gamma$



Time-dependent *CP* Observable:

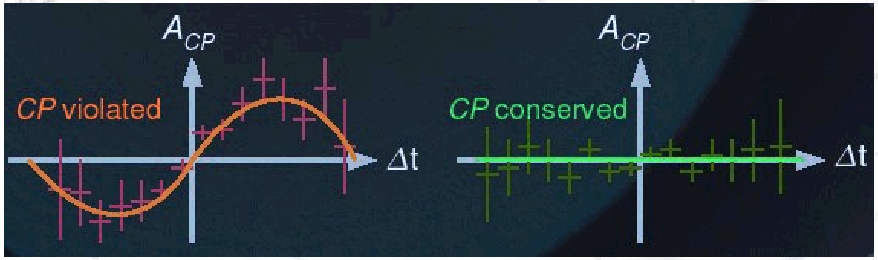
$$A_{f_{CP}}(t) = \frac{\Gamma(\bar{B}^0_{phys}(t) \to f_{CP}) - \Gamma(B^0_{phys}(t) \to f_{CP})}{\Gamma(\bar{B}^0_{phys}(t) \to f_{CP}) + \Gamma(B^0_{phys}(t) \to f_{CP})}$$
$$= C_{f_{CP}} \cdot \cos(\Delta m_{B_d} t) + S_{f_{CP}} \sin(\Delta m_{B_d} t)$$

$$C_{f_{CP}} = \frac{1 - |\lambda_{f_{CP}}|^2}{1 + |\lambda_{f_{CP}}|^2}$$

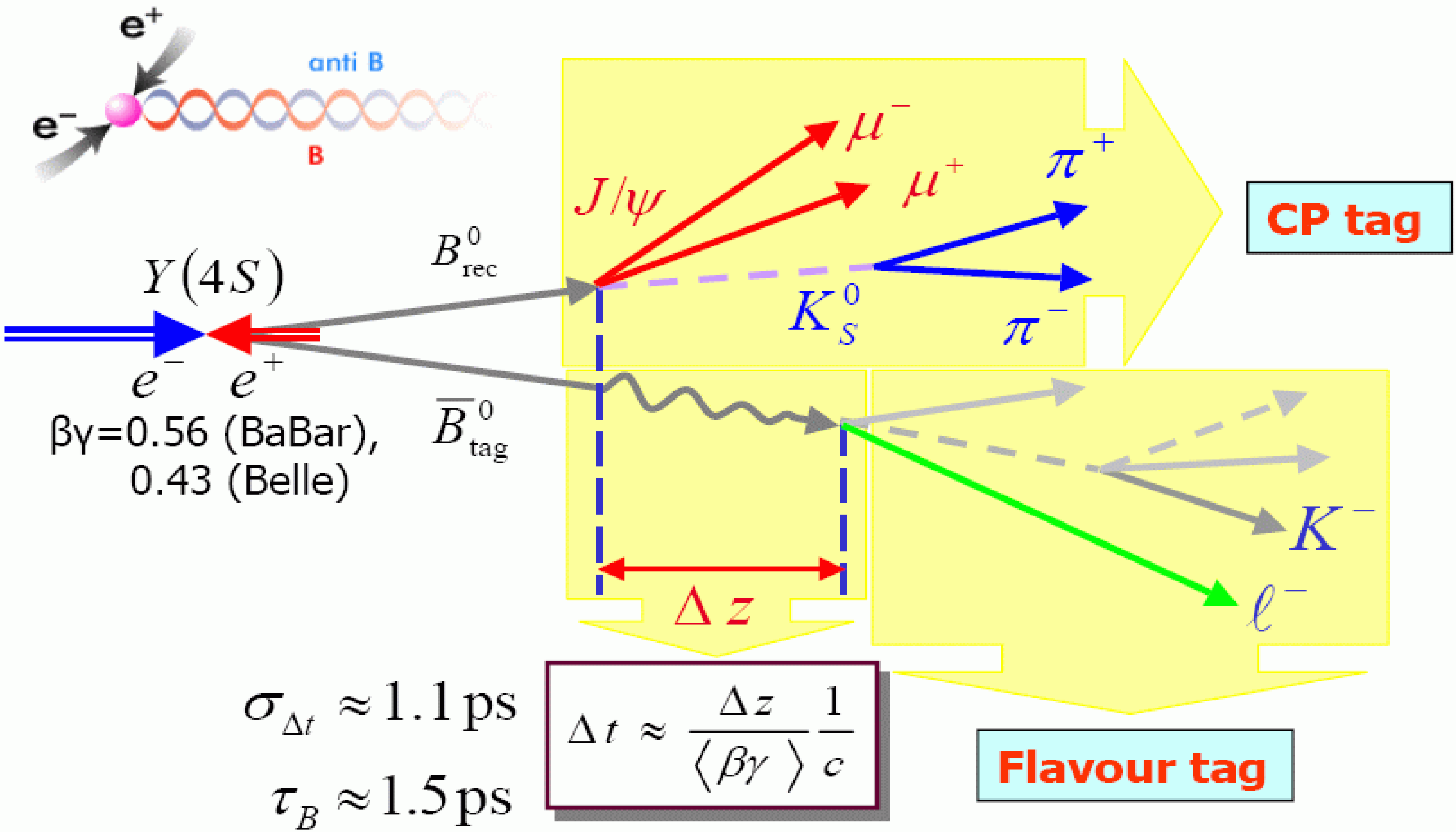
$$S_{f_{CP}} = \frac{-2\,\mathrm{Im}\,\lambda_{f_{CP}}}{1 + |\lambda_{f_{CP}}|^2}$$

$C_{fCP}=0$ $S_{fCP}=\sin 2\beta$ for $J/\psi\ K_s$

$C_{fCP}=0$ $S_{fCP}=\sin 2\alpha$ for $\pi^+\pi^-$ (if tree only)



Measuring the CP parameters

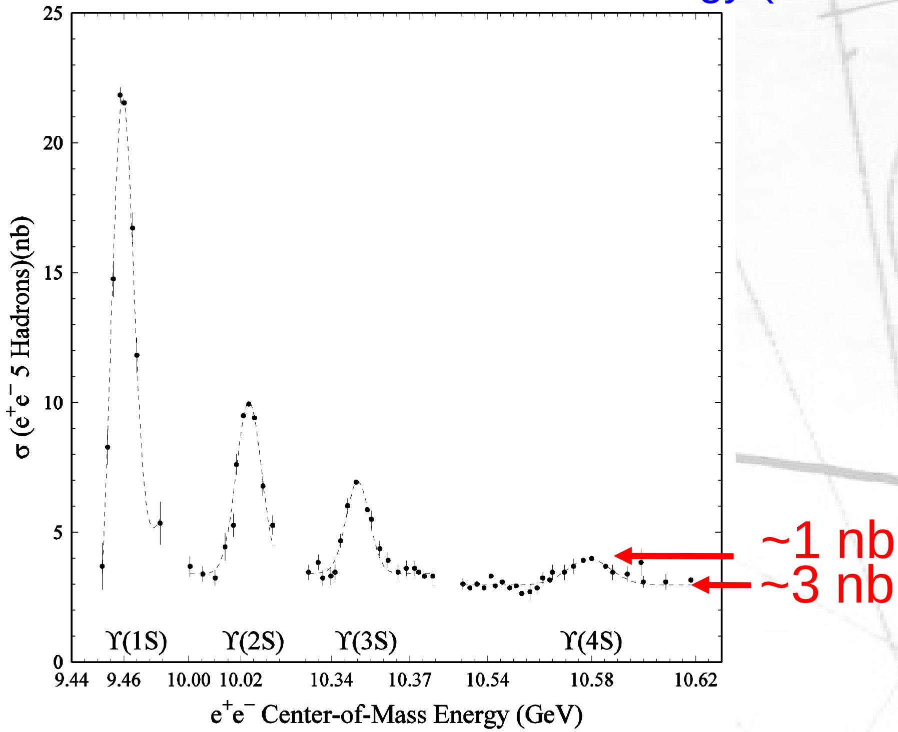


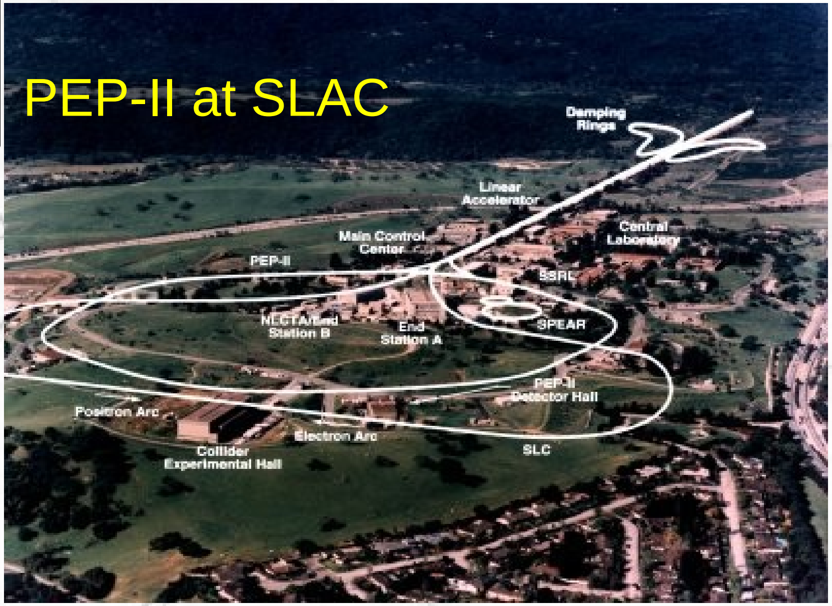
B-Factories

e^+e^- colliders @ Υ(4S) resonance

....but also run @ Υ(2S), Υ(3S) and Υ(5S)!

$e^+e^- \to$ hadrons cross section vs. energy (CLEO)





$e^+e^- \to \Upsilon(4S) \to B\bar{B}$ (~1nb)

$e^+e^- \to q\bar{q}$: main background (~3nb)

B-Factory also a charm and tau factory

B-Factories

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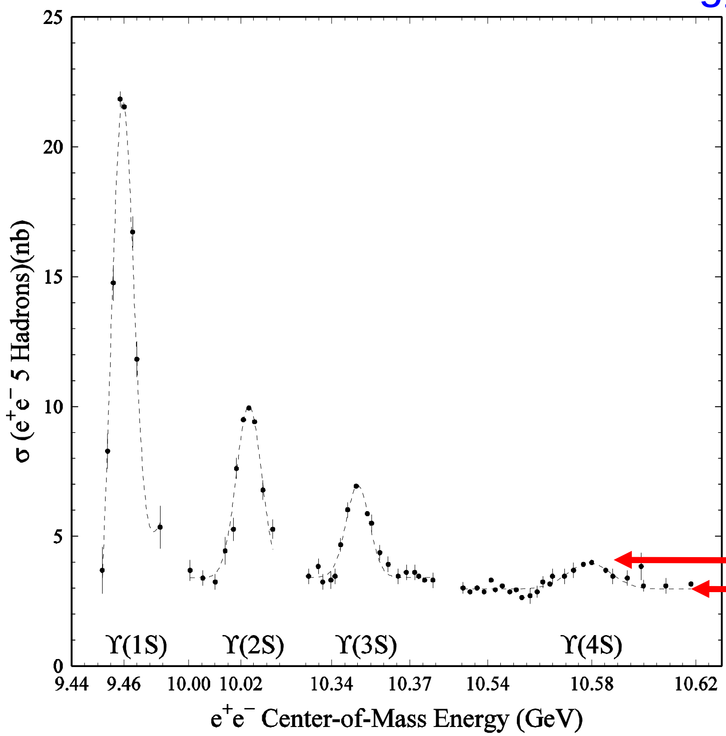
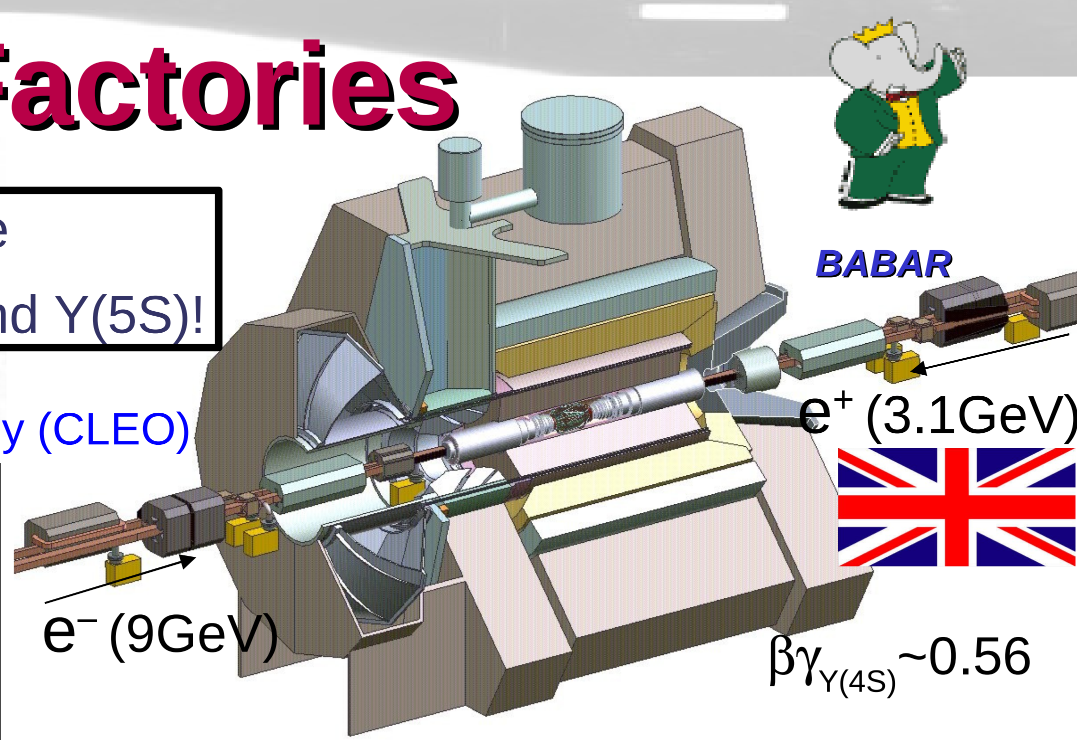
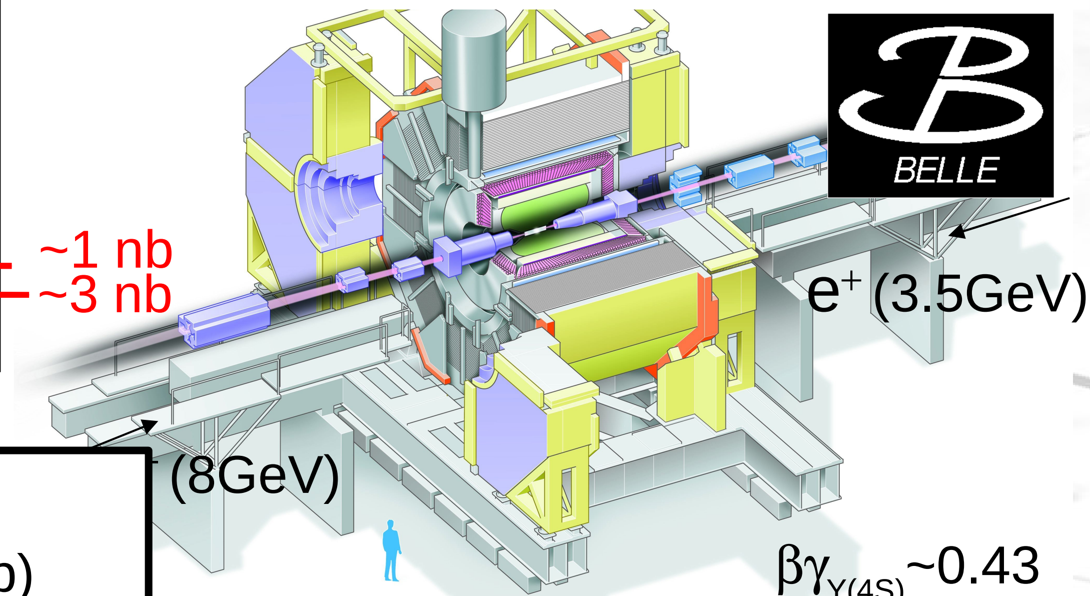






$e^+e^- \to \Upsilon(4S) \to B\bar{B}$ (~1nb)

$e^+e^- \to q\bar{q}$: main background (~3nb)

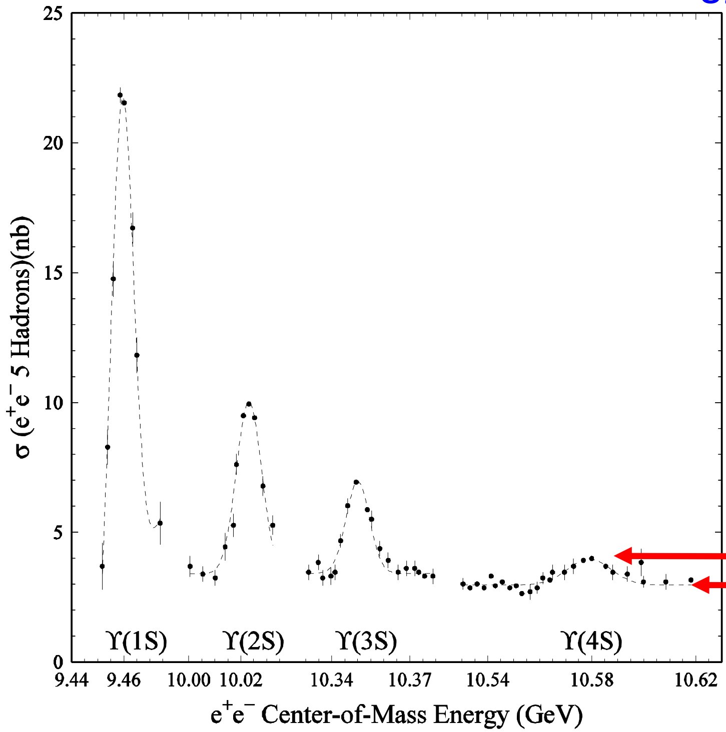
B-Factory also a charm and tau factory

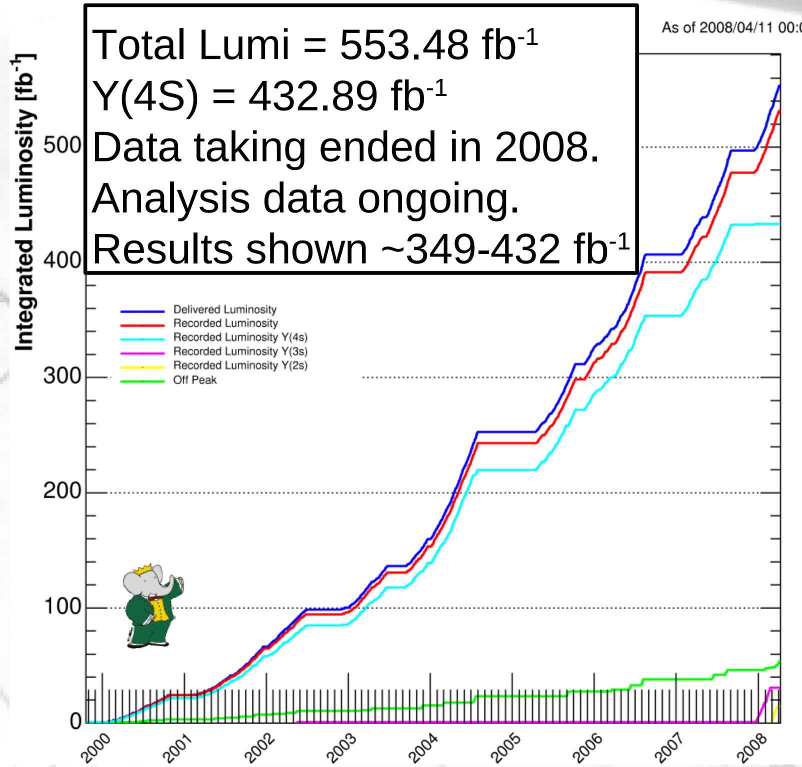
B-Factories

e^+e^- colliders @ Y(4S) resonance

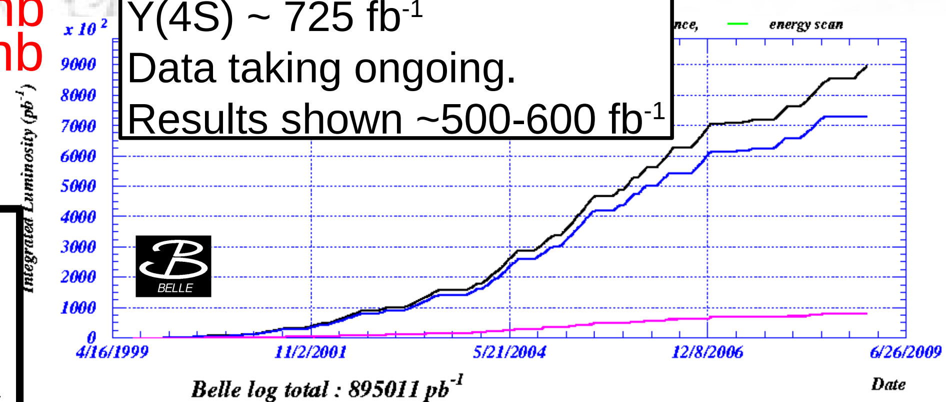
....but also run @ Y(2S), Y(3S) and Y(5S)!

$e^+e^- \rightarrow$ hadrons cross section vs. energy (CLEO)





Total Lumi = 553.48 fb^{-1}
Y(4S) = 432.89 fb^{-1}
Data taking ended in 2008.
Analysis data ongoing.
Results shown ~349-432 fb^{-1}



Total Lumi = 895.01 fb^{-1}
Y(4S) ~ 725 fb^{-1}
Data taking ongoing.
Results shown ~500-600 fb^{-1}

$e^+e^- \rightarrow Y(4S) \rightarrow B\overline{B}$ (~1nb)

$e^+e^- \rightarrow q\overline{q}$: main background (~3nb)

B-Factory also a charm and tau factory

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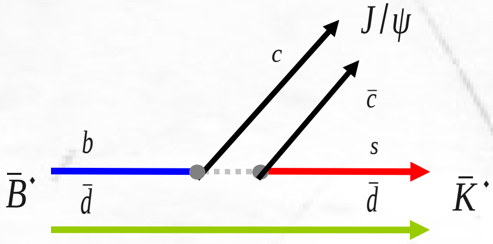
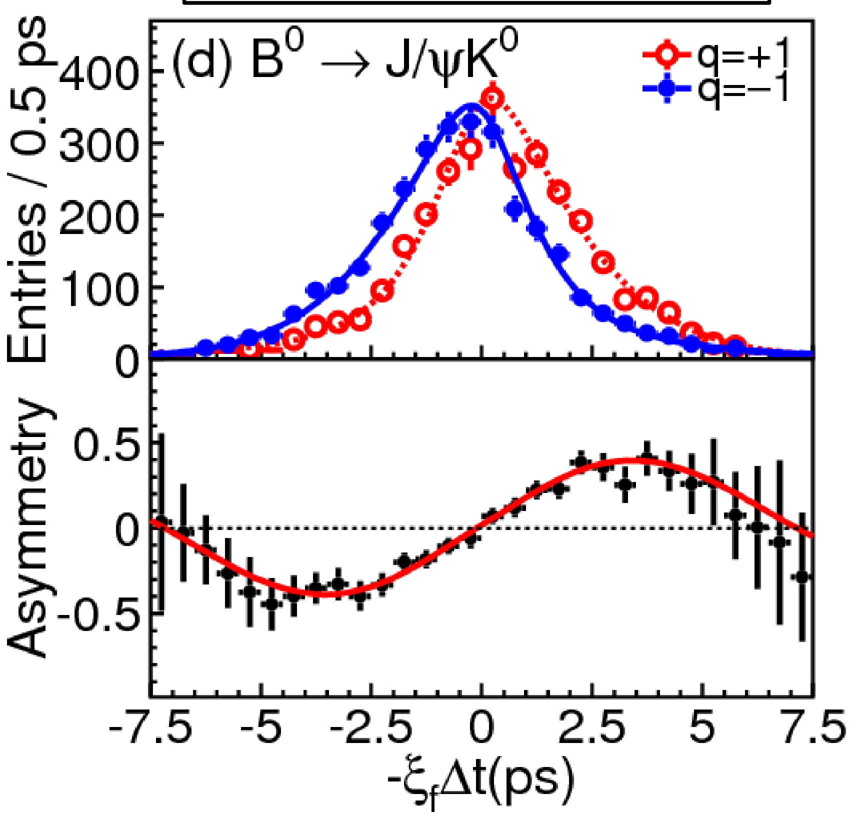
Angle β: "Golden" Channel b→c$\bar{c}$s

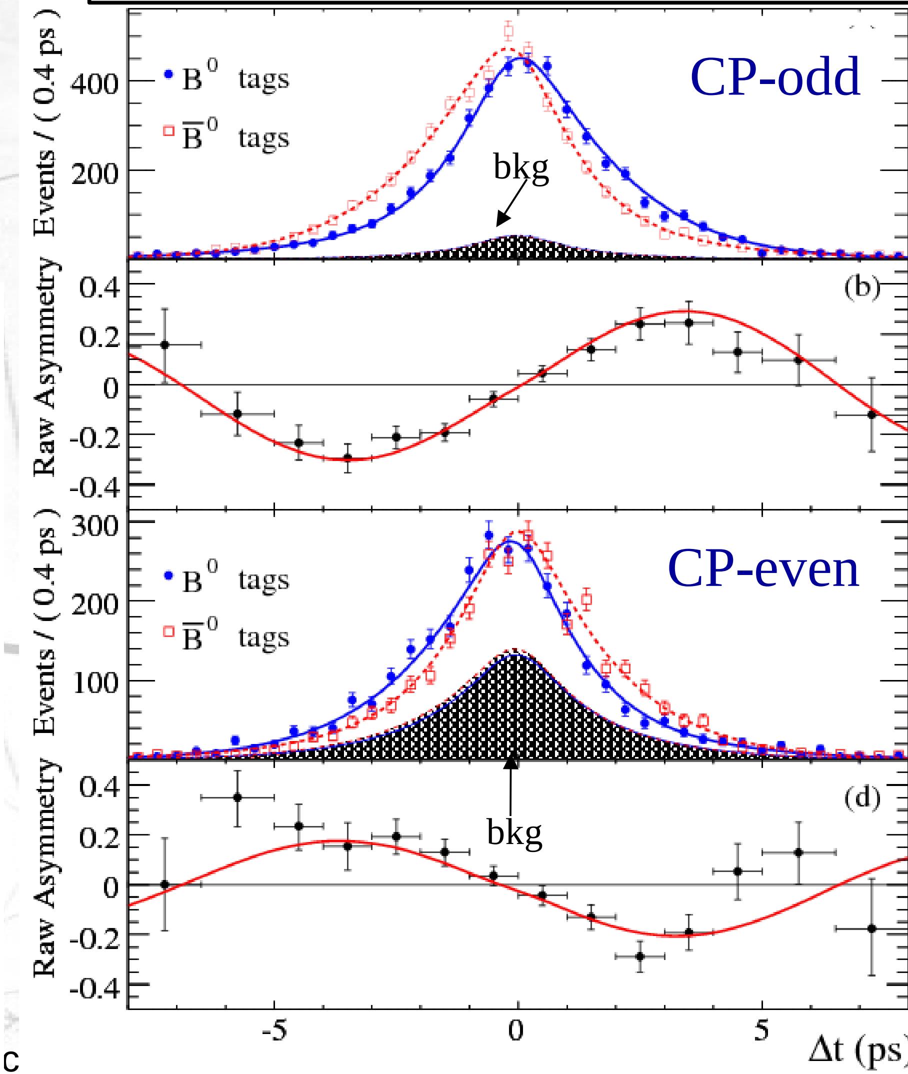


S=sin2β
C=0

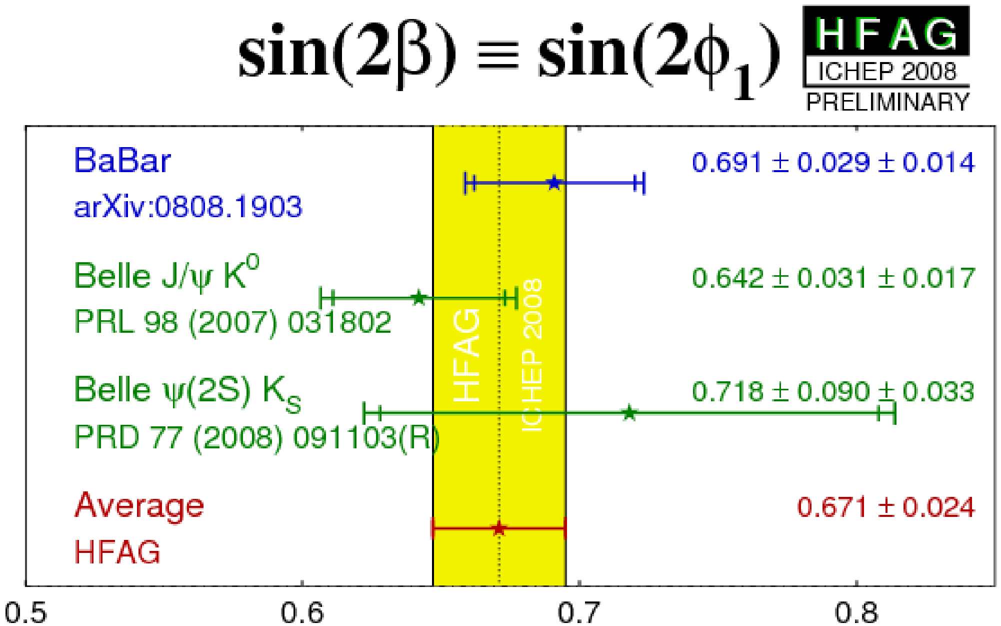
arXiv0902.1708 [hep-ex] submitted to PRD

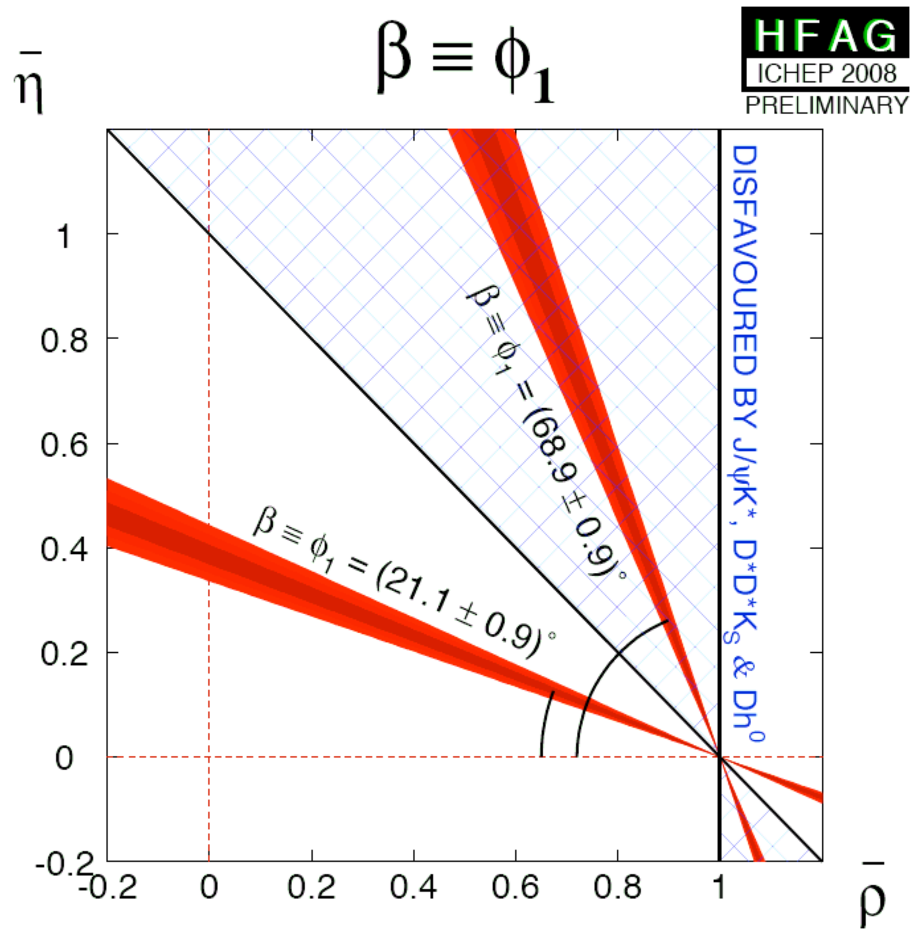
Belle: PRL**98**, 031802 (2007)





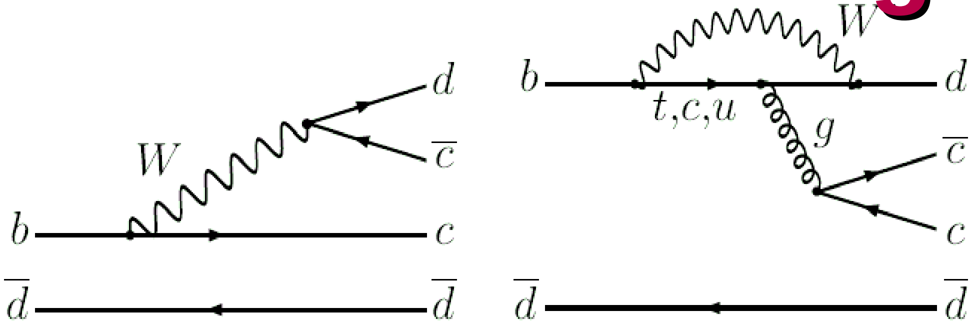
Angle β: "Golden" Channel $b \to c\bar{c}s$



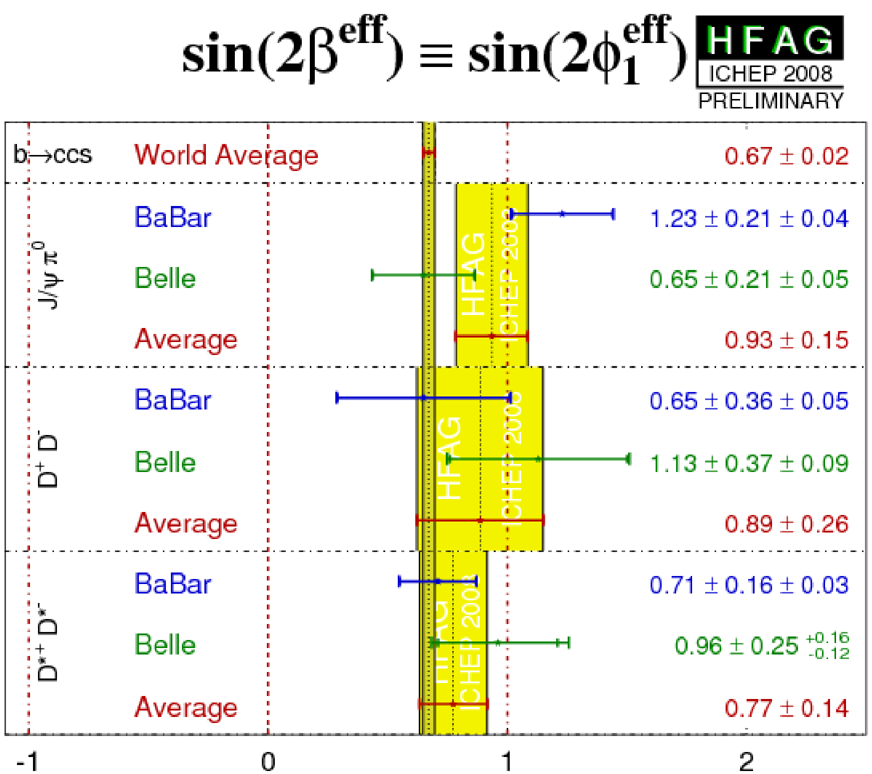


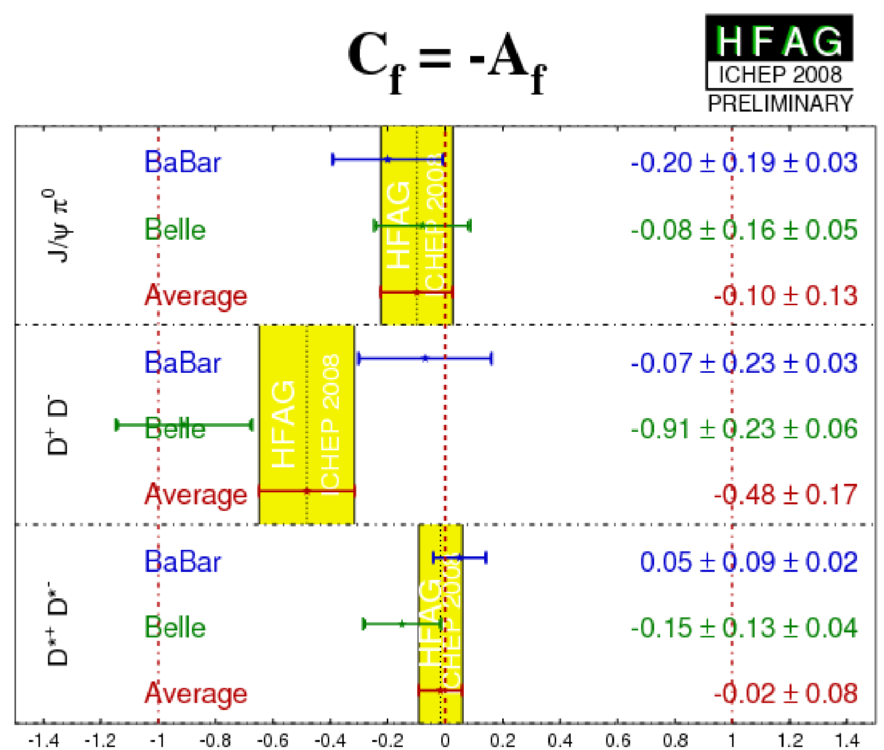
- Most precise measurements of CPV in B decays to date.
- BaBar results for the final dataset.
- Still statistically-limited measurements.
- Theoretical uncertainty for sin2β from charmonium modes below 0.01: further improvements from LHCb and Super B factories.

More on Angle β: $b \to c\bar{c}d$



Tree amplitudes Cabibbo-suppressed: potential sensitivity to penguin (loop) effects



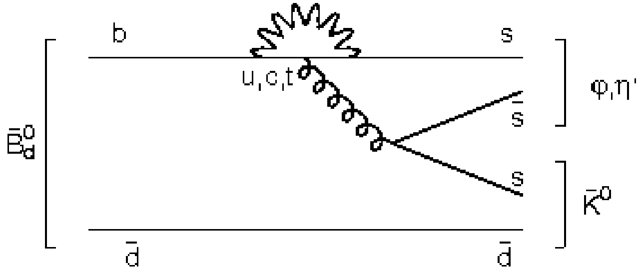


CP violation clearly established. Good agreement with golden modes.

More info needed for C in D^+D^- modes.

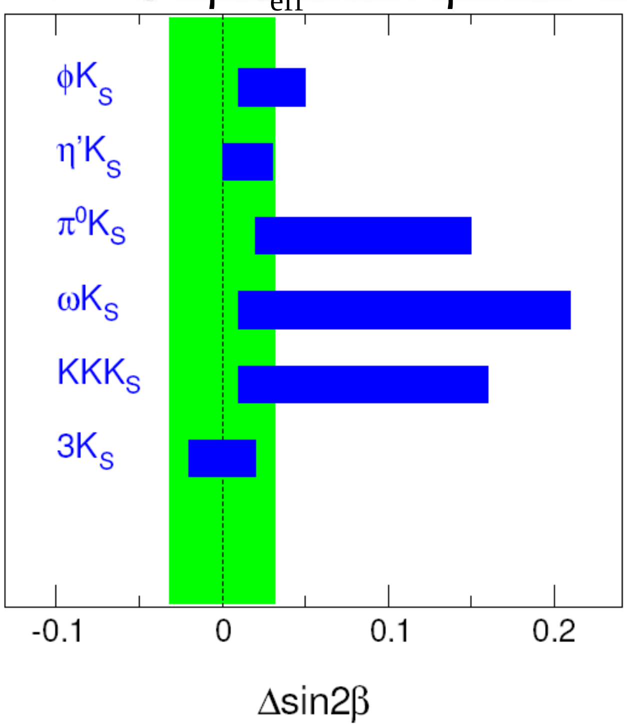
More on Angle β: b→qq̄s (penguin)

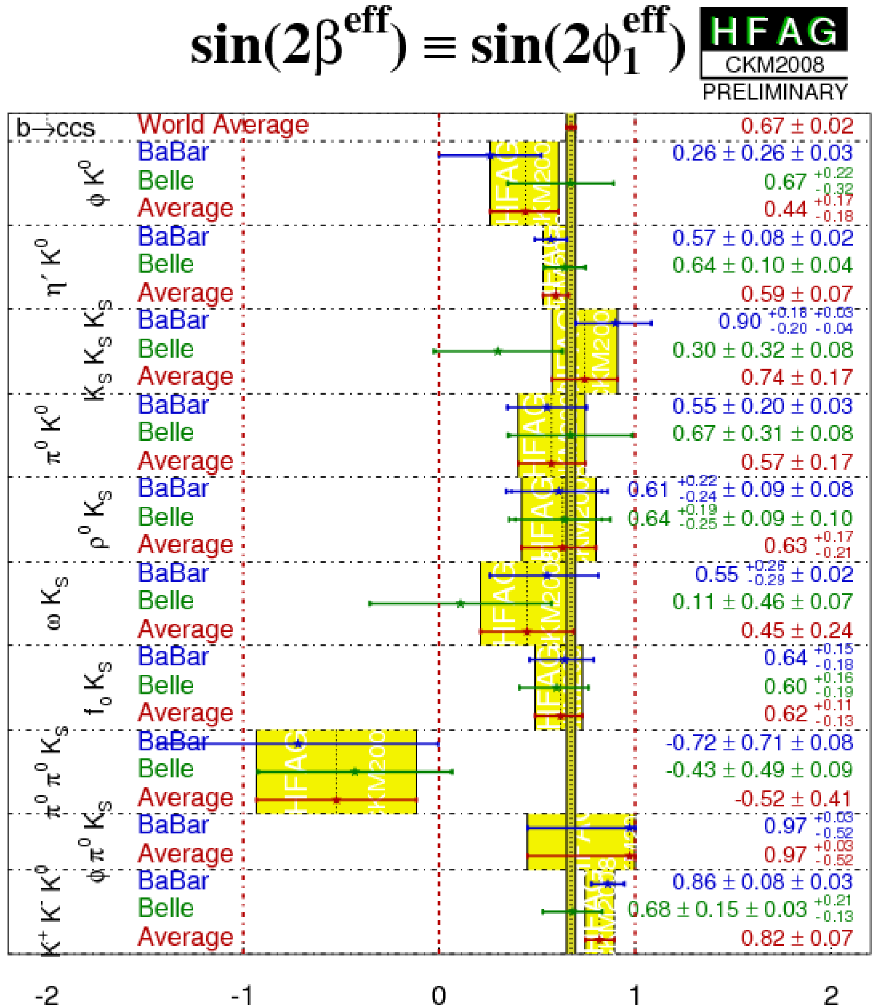
Penguin only or penguin dominated modes.



some of recent QCDF estimates

$\sin 2\beta^f_{eff} - \sin 2\beta$

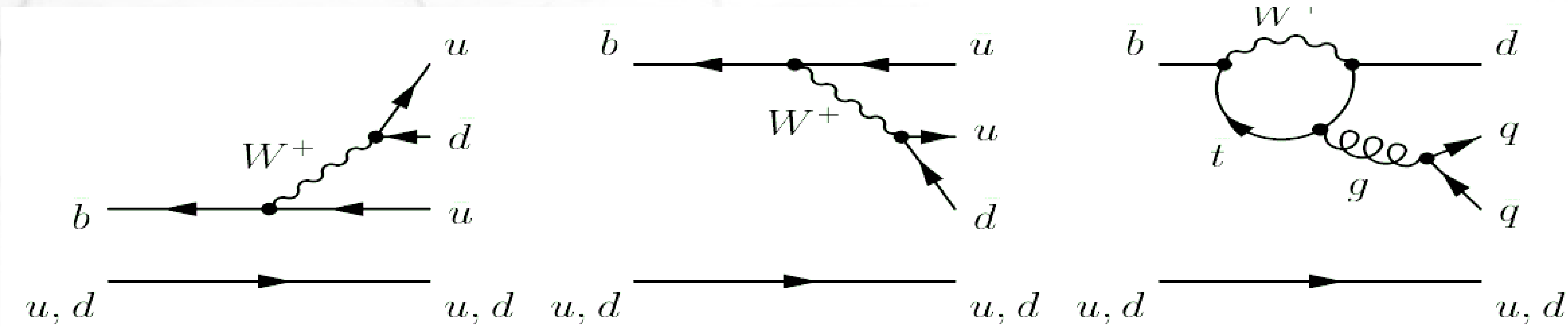




F.

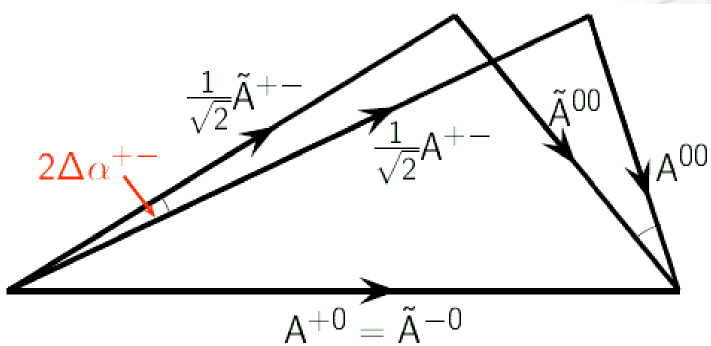
More statistics crucial for mode-by-mode studies and comparison with theory.

Angle α



Tree | Color-suppressed | "Penguin" loop

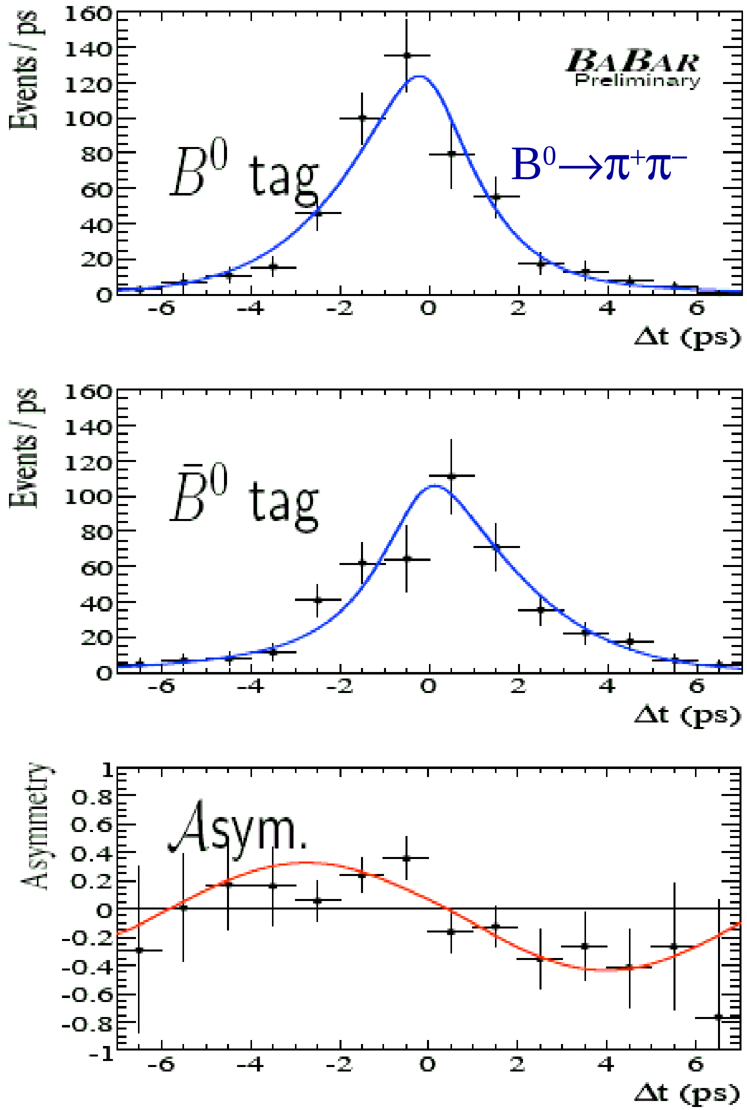
- Time-dependent CPV in b→u transitions.
- Problem: 2-3 amplitudes, additional interference.
  - "Penguin" pollution: $S_{\rm eff} = \sqrt{1 - C^2} \times \sin(2\alpha - 2\Delta\alpha)$
- Isospin analysis to measure Δα.
  - 4-fold ambiguity in Δα.
  - Small branching fractions.
- Most useful modes:
  - B→ρρ, ππ, ρπ

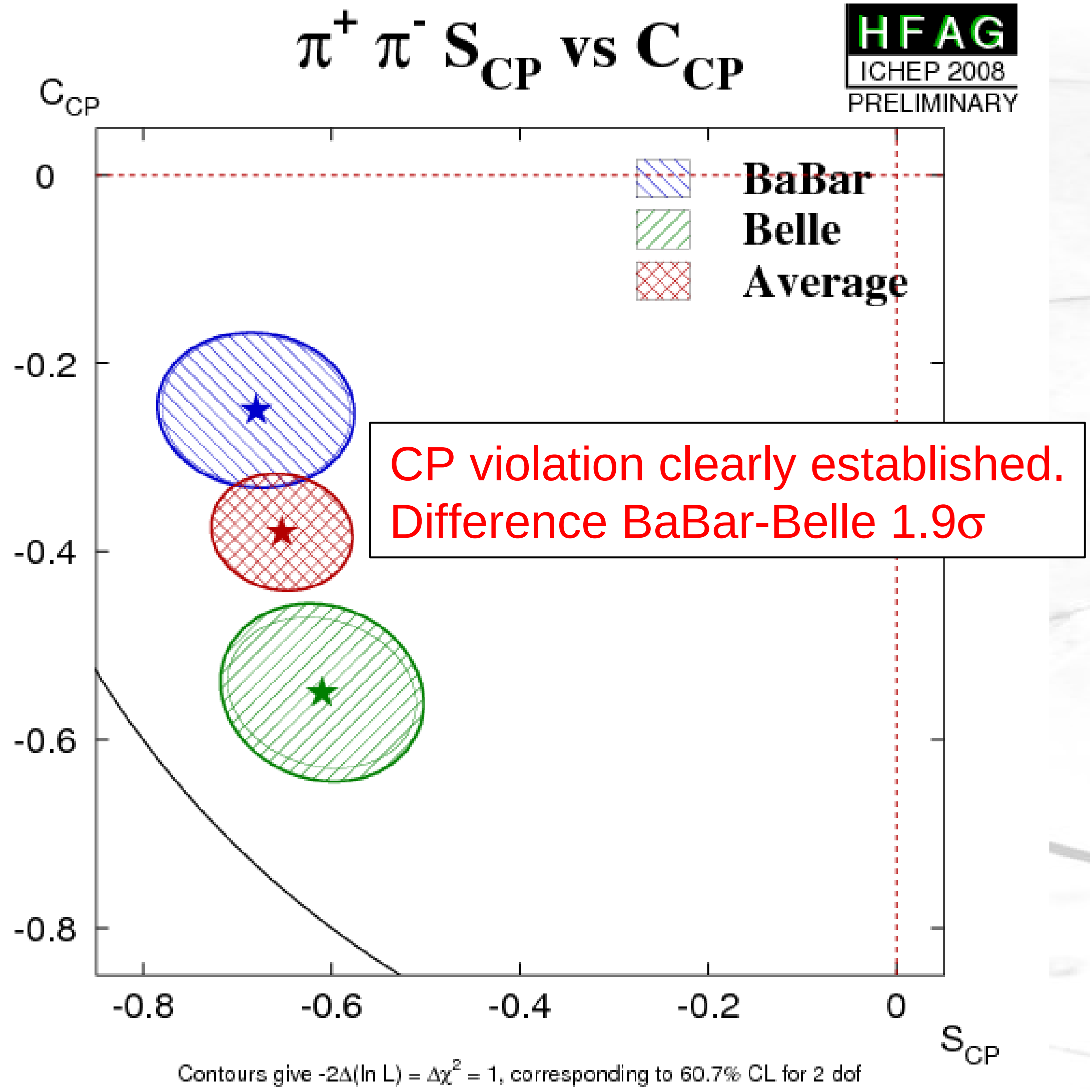


Gronau, London, PRL**65**, 3381 (1990)

α from B→ππ

From BaBar:
$B^0 \to \pi^+\pi^-$, $\pi^0\pi^0$ (arXiv:0807:4226)



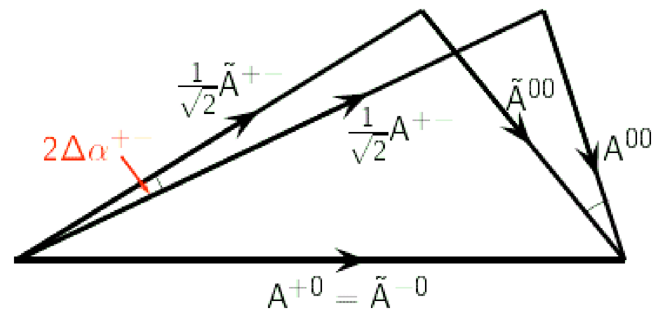


CP violation clearly established.
Difference BaBar-Belle 1.9σ

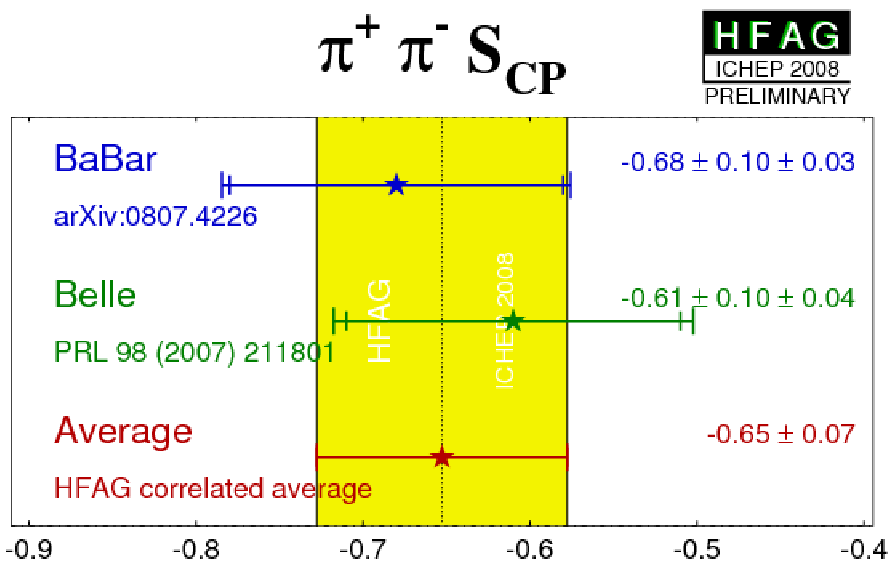
Interpretation

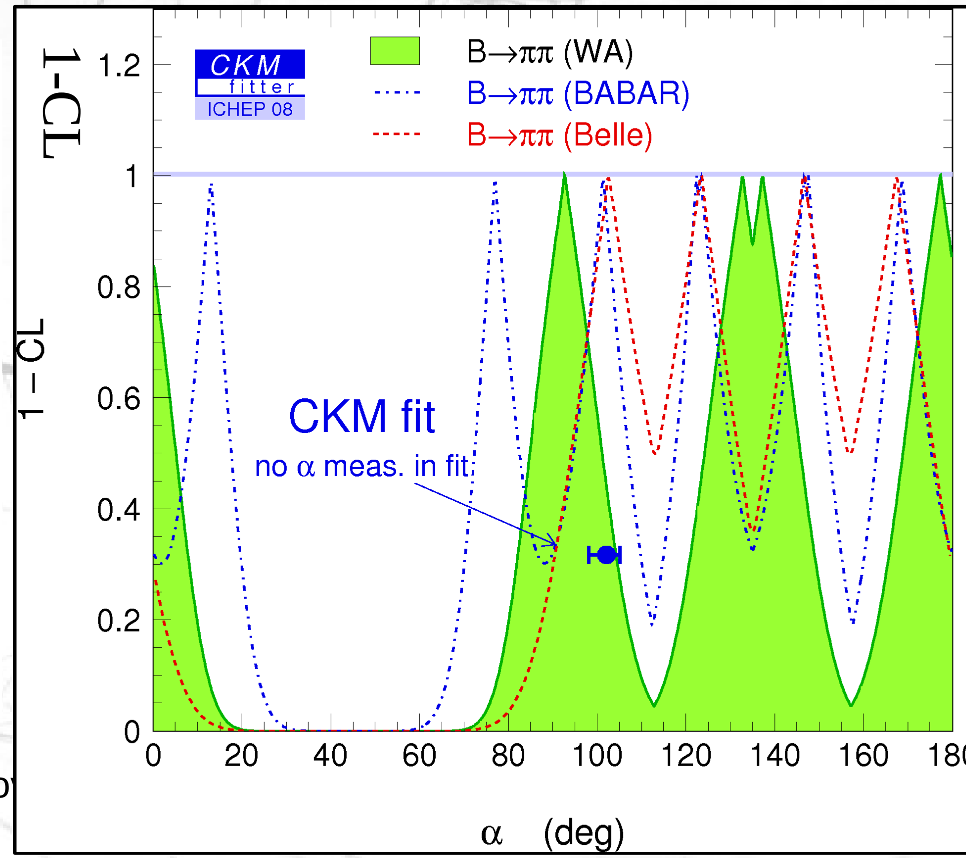
BABAR
arXiv:0807:4226

	$\mathcal{B}(10^{-6})$	C
$\pi^+\pi^-$	$5.5 \pm 0.4 \pm 0.3$	$-0.25 \pm 0.08 \pm 0.02$
$\pi^+\pi^0$	$5.02 \pm 0.46 \pm 0.29$	–
$\pi^0\pi^0$	$1.83 \pm 0.21 \pm 0.13$	$-0.43 \pm 0.26 \pm 0.05$

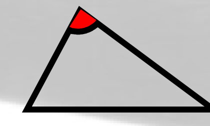


$B(\pi^0\pi^0) \sim B(\pi^+\pi^-)$: $\Delta\alpha$ could be large

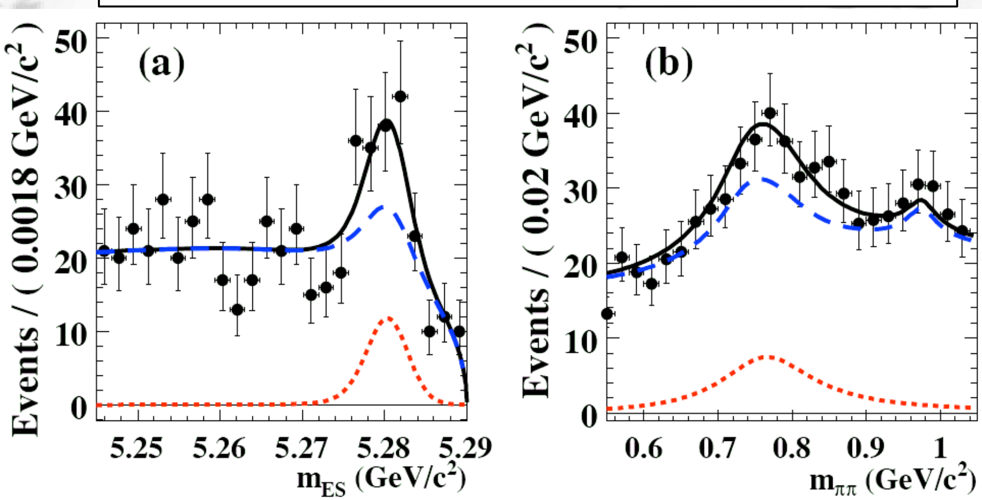




α from B→ρρ



BaBar (PRD78,071104) : $B^0 \to \rho^0\rho^0$



$$\mathcal{B} = (0.92 \pm 0.32 \pm 0.14) \times 10^{-6}$$

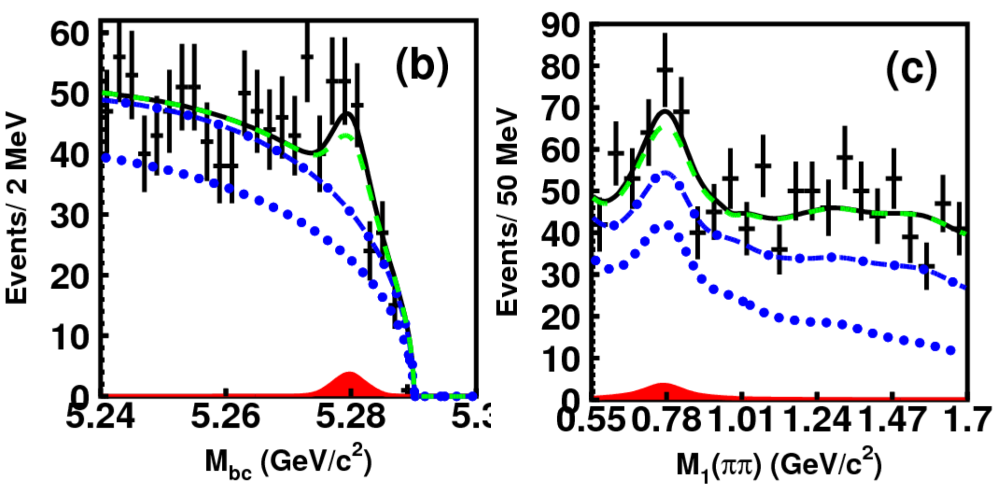
$$f_L = 0.75^{+0.11}_{-0.14} \pm 0.04$$

$$S^{00} = +0.3 \pm 0.7 \pm 0.2$$

$$C^{00} = +0.2 \pm 0.8 \pm 0.3$$

3.1σ evidence for $\rho^0\rho^0$

Belle(PRD78,111102): $B^0 \to \rho^0\rho^0$ $\mathcal{B} = (0.4 \pm 0.4 \pm 0.2) \times 10^{-6}$



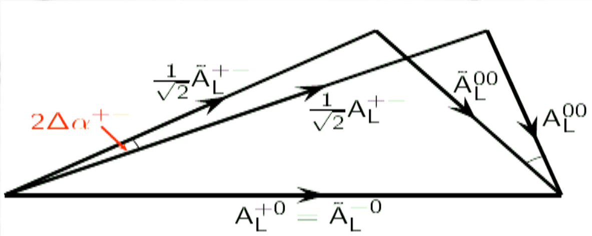
World averages:

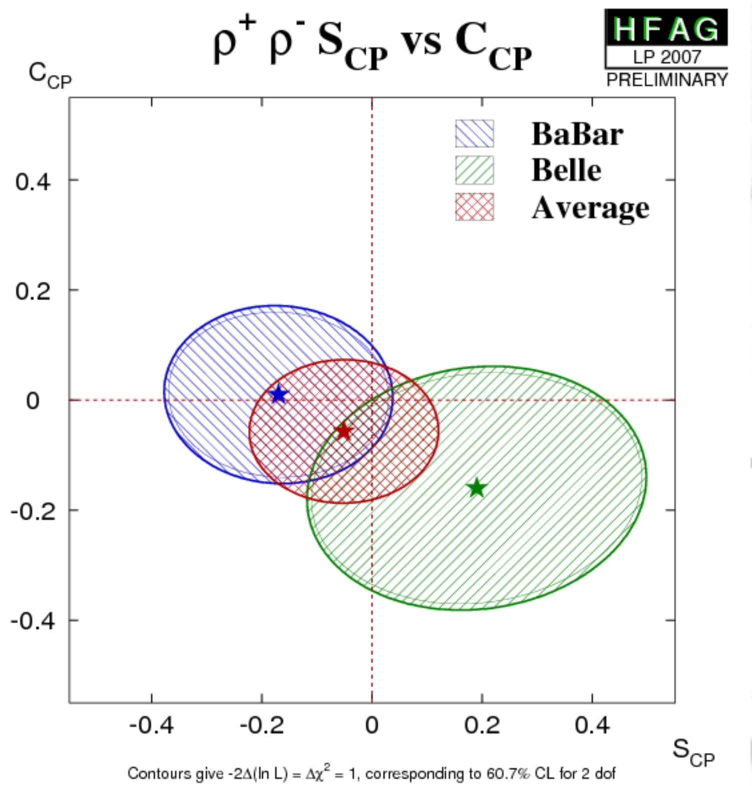
$$\mathcal{B}_{\rho 0 \rho 0} = (0.72 \pm 0.28) \times 10^{-6}$$

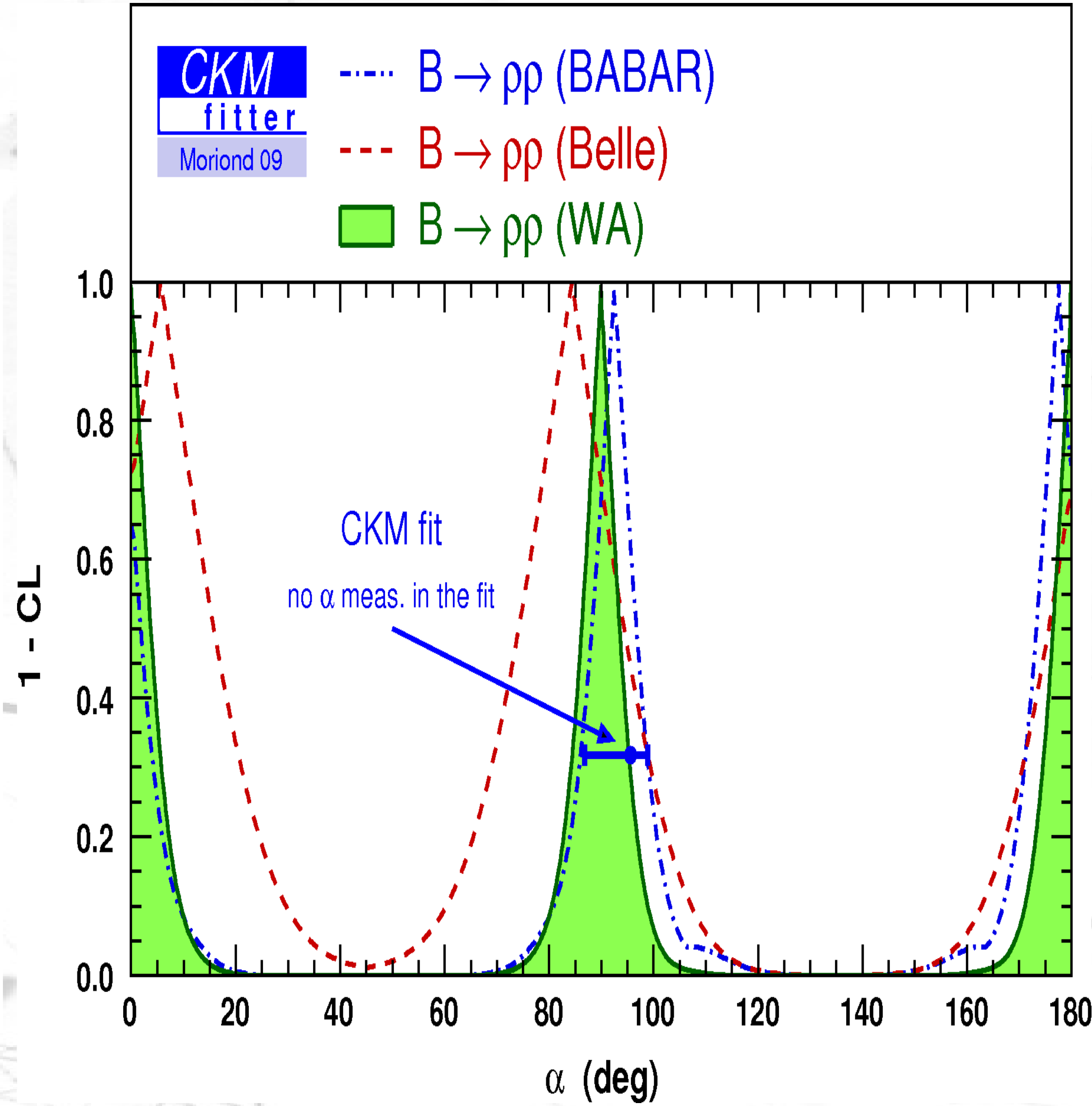
$$\mathcal{B}_{\rho + \rho -} = (24.2 \pm 3.2) \times 10^{-6}$$

$B(\rho^0\rho^0) << B(\rho^+\rho^-)$

Interpretation

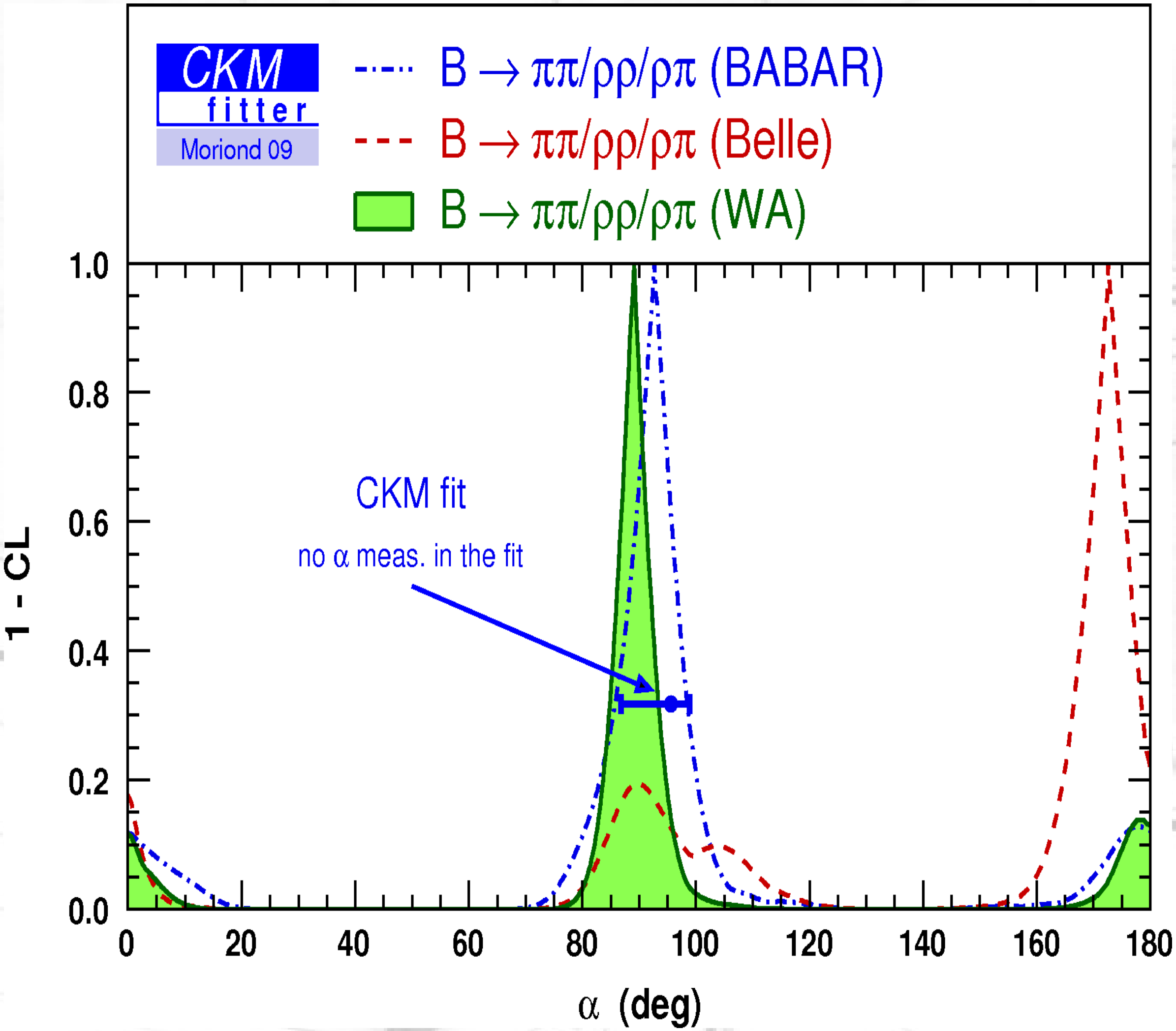






$\sigma(\alpha_{eff})$~6°, $\Delta\alpha$<14.16°

Summary of α

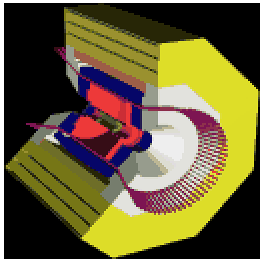


$\alpha \in [83.5 ; 94.0]^{o}$ @ 68% CL

Angle γ

- Hardest angle of all to tackle
  - $\gamma = -\arg(V_{ub})$, and V_{ub} is small
- Direct CPV in $B \to D^{(*)0} K^{(*)}$ decays
  - 3-body Dalitz Decays (Giri,Grossman,Soffer,Zupan)
    $D^0 \to K_s \pi^+ \pi^-$
  - CP eigenstates (Gronau,London,Wyler)
    $D^0 \to \pi\pi, KK, \ldots$
  - Doubly Cabibbo-suppressed (Atwood,Dunietz,Soni)
    $D^0 \to K^+ \pi^-$ vs $D^0 \to K^- \pi^+$
- Several complementary techniques
  - Time-dependent CPV in $B^0 \to D^{(*)}\pi$, $D^{(*)}\rho$
    Measures $\sin(2\beta+\gamma)$
- Key parameter: r_B, ratio of $|A(b \to u)/A(b \to c)|$

CLEO-c



Difficult, statistics-limited measurements! Combination of constraints:

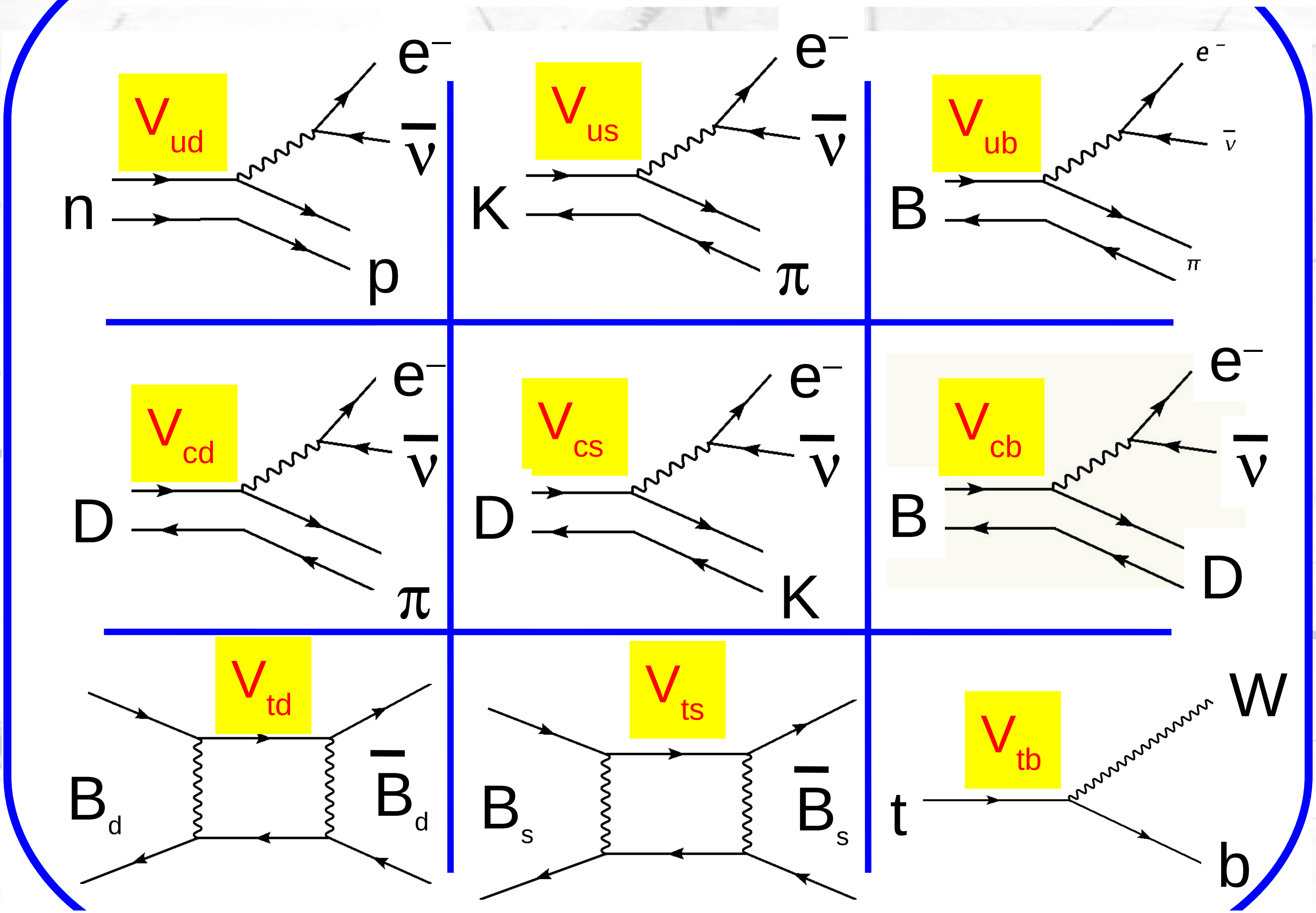
$\gamma = (70 \pm 28)^0$, uncertainty of $\sim 28^o$. Larger statistics needed (LHCb, SuperB)

Outline

- The theoretical and experimental environment.
- The angles of the Unitarity Triangle.
- The magnitude of the elements of the CKM matrix.
- Perspectives and Conclusions.

CKM matrix elements magnitudes

- Fundamental parameters of the Standard Model
- They cannot be predicted but can be measured



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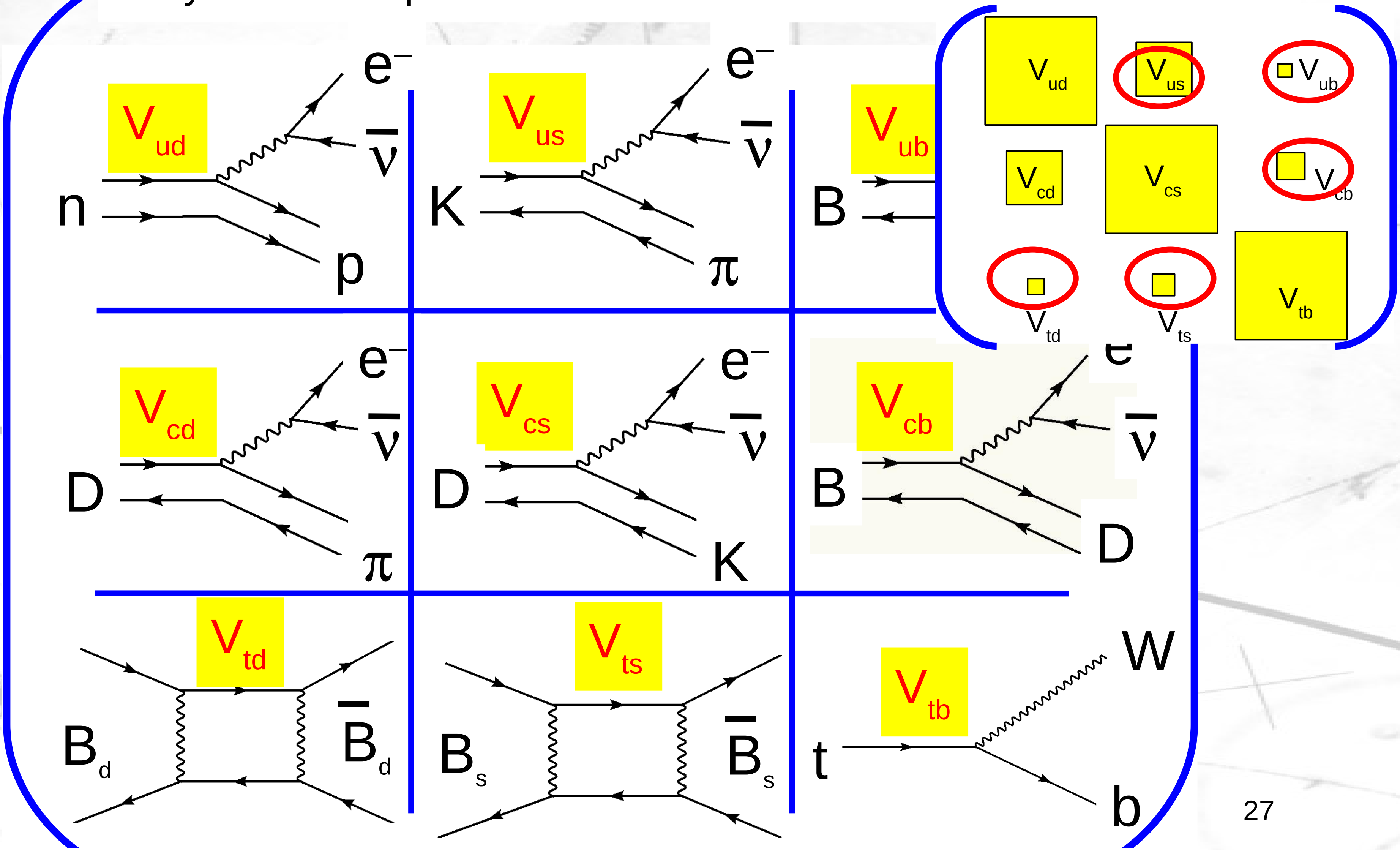
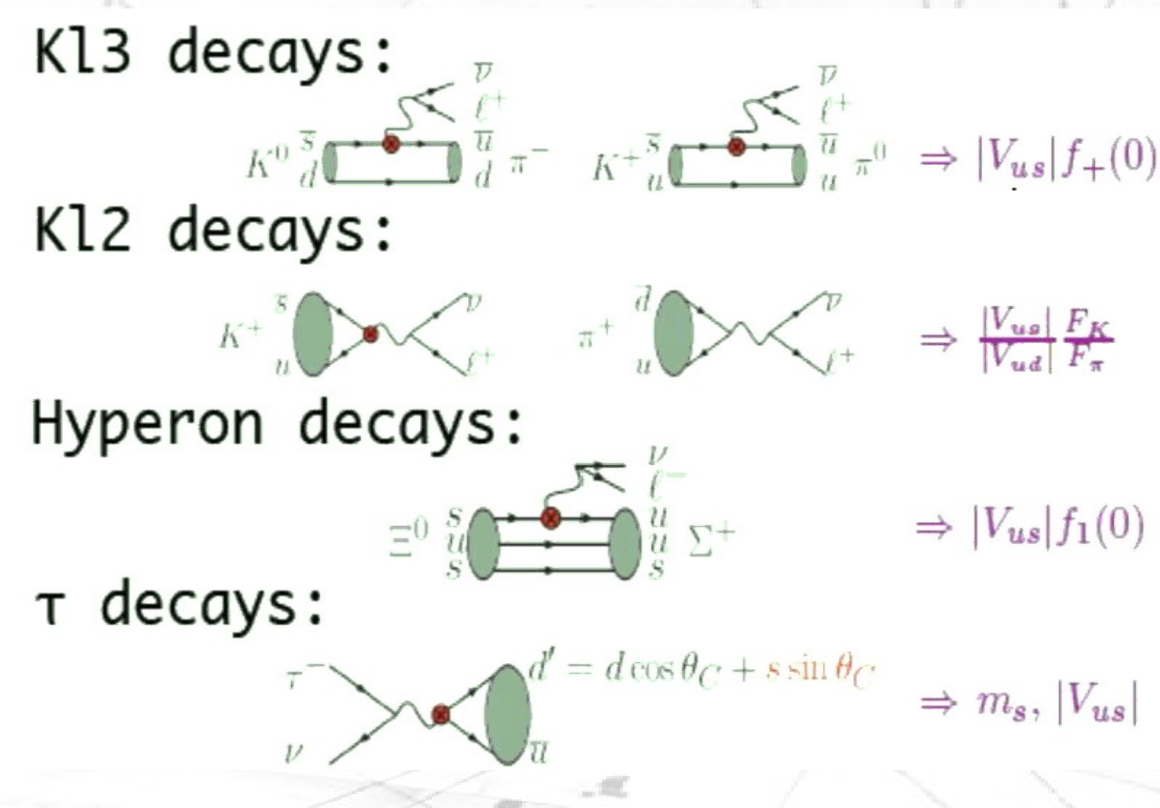
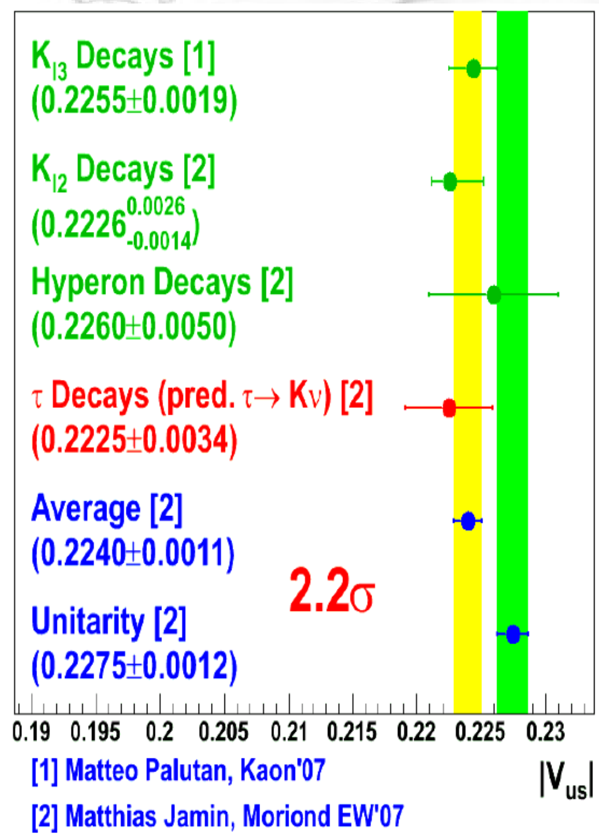


$|V_{us}|$ from τ decays

- Preferred method to extract is $|V_{us}|$ is from $K_{\ell 3}$,$K_{\ell 2}$ decays.
- But $|V_{us}|$ can be extracted from τ decays in final states with kaons.
- However, $|V_{us}|$ ~3σ below $|V_{us}|$ from $K_{\ell 3}$,$K_{\ell 2}$
- Possibly due to convergence of the OPE series (arXiv:0807.3195 [hep-ph])





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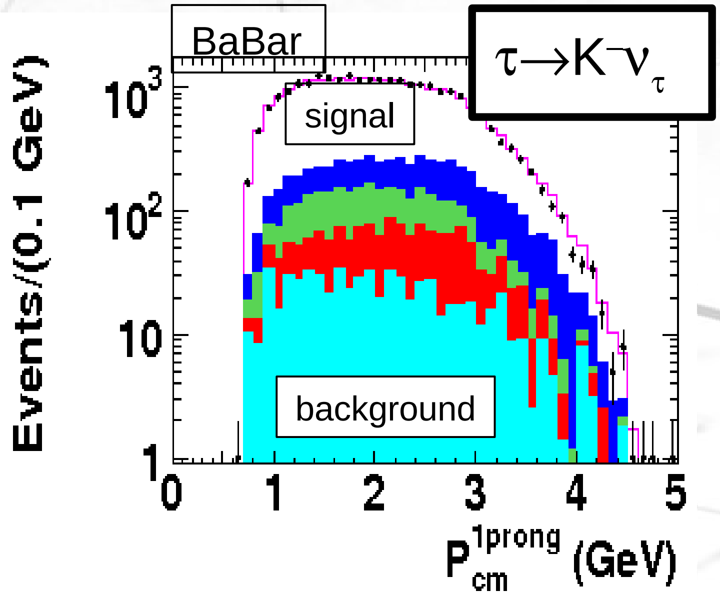
BaBar measurement:

$$\frac{\mathcal{B}(\tau^- \to K^- \nu_\tau)}{\mathcal{B}(\tau^- \to \pi^- \nu_\tau)} = \frac{f_K^2 |V_{us}|^2}{f_\pi^2 |V_{ud}|^2} \frac{\left(1 - \frac{m_K^2}{m_\tau^2}\right)^2}{\left(1 - \frac{m_\pi^2}{m_\tau^2}\right)^2} = 0.06531 \pm 0.00056 \pm 0.00093$$



Using $f_K/f_\pi = 1.189 \pm 0.007$ from

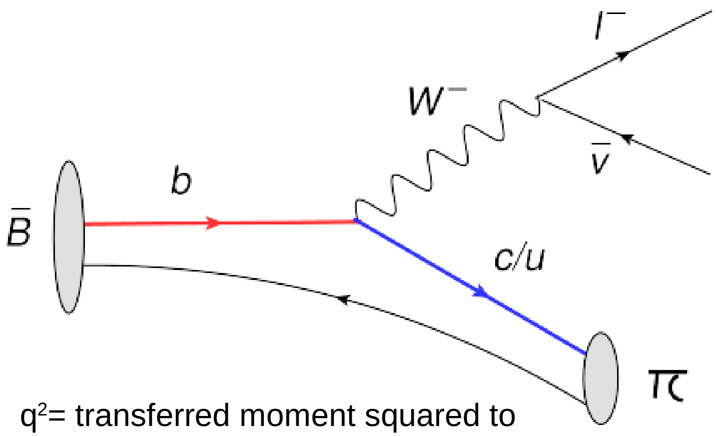
E.Follana *et al.* Phys. Rev. Lett. 100, 062002 (2007)

$|V_{us}| = 0.2255 \pm 0.0023$

Consistent with $|V_{us}|$ from $K_{\ell 3}, K_{\ell 2}$

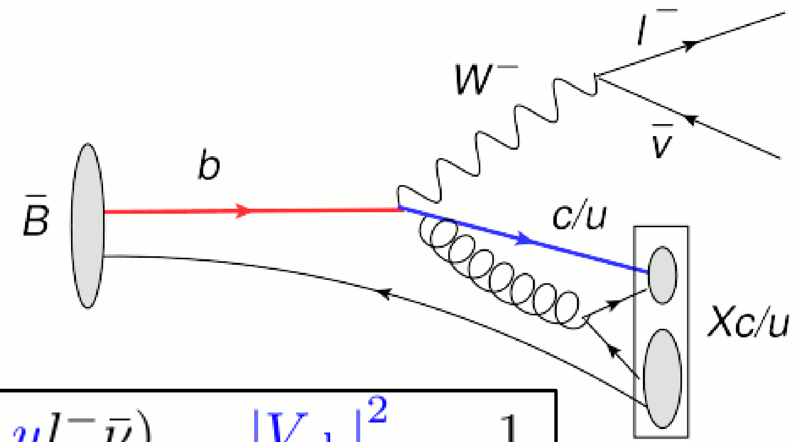
Semileptonic B decays

Exclusive final state



q^2= transferred moment squared to the $\ell\nu$

Inclusive final state



$$\frac{\Gamma(b \to u l^- \bar{\nu})}{\Gamma(b \to c l^- \bar{\nu})} = \frac{|V_{\rm ub}|^2}{|V_{\rm cb}|^2} \simeq \frac{1}{50}$$

$$d\Gamma/dq^2 = \frac{G_F^2 |V_{\rm qb}|^2}{192\pi^3} \, |f_+(q^2)|^2$$

Experimentally:
good signal/background but proportional to form factor. Need Lattice QCD.

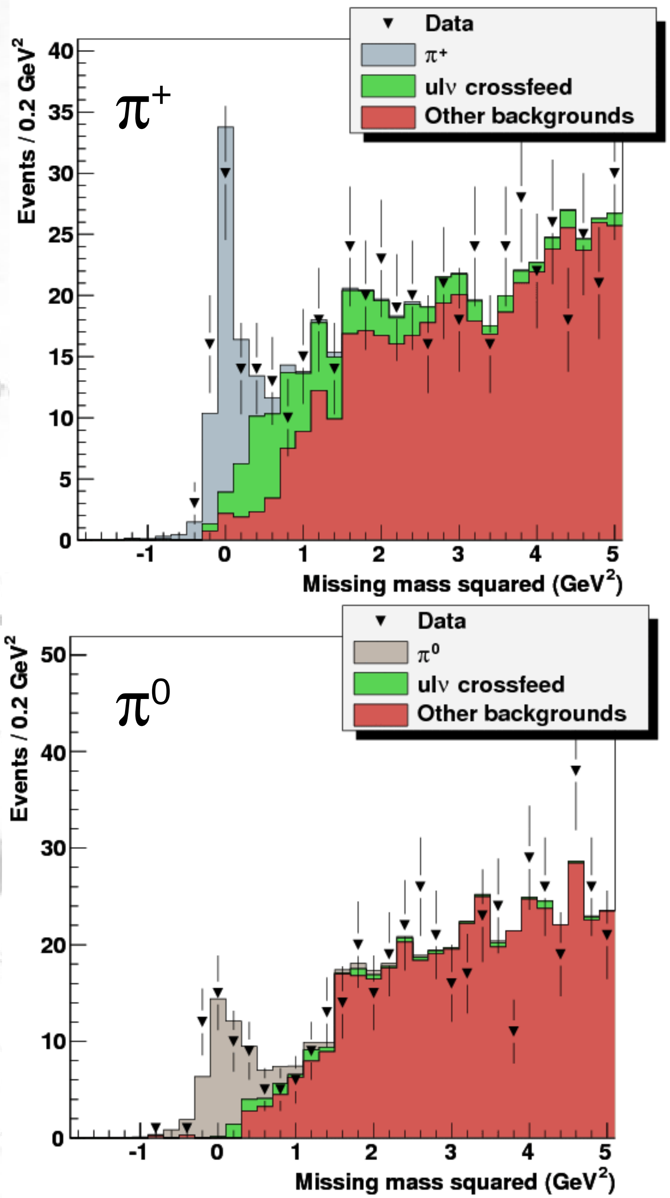
$$\Gamma = \frac{G_F^2 |V_{\rm qb}|^2}{192\pi^3} m_b^5 (1 + \cdots)$$

Total width easy to compute but, in b→u, kinematic cuts are essential to reduce b→c background.

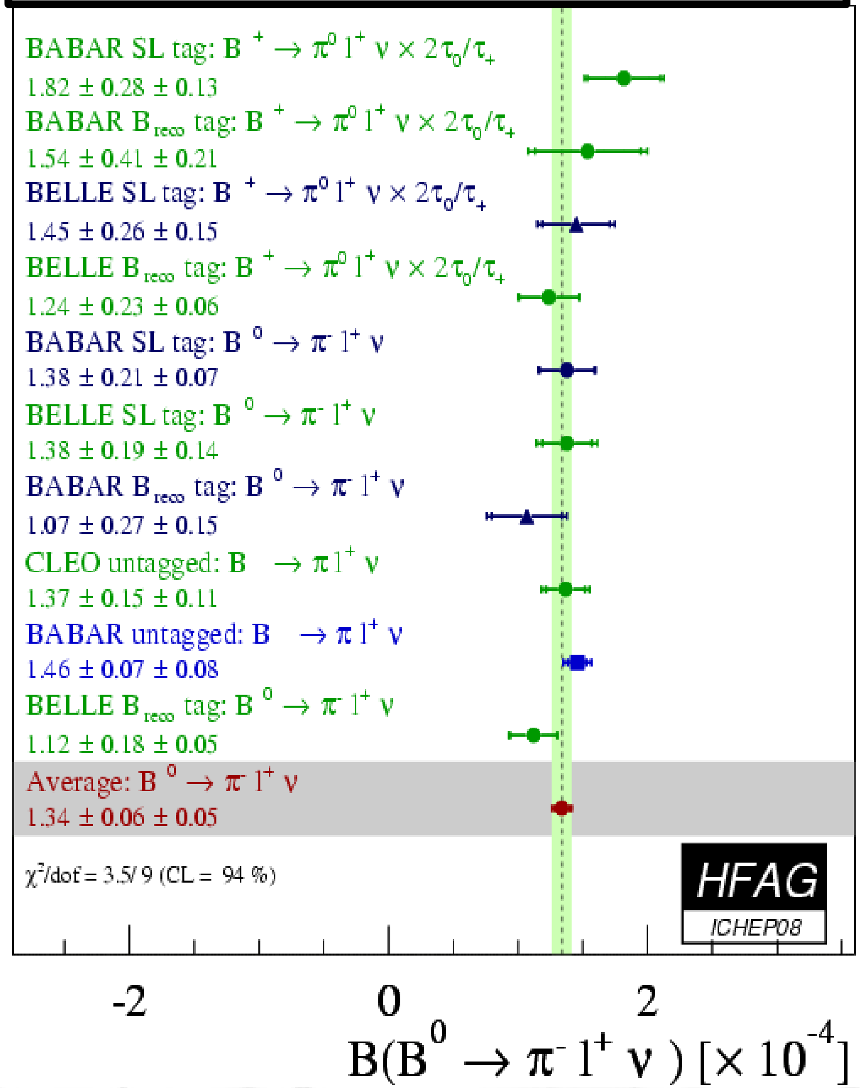
Exclusive and inclusive decays have different strength, complementary!

$|V_{ub}|$ from $B \to \pi \ell \nu_\ell$ decays

Belle, arXiv:0812.1414 [hep-ex]



$\mathcal{B}\ (B^0 \to \pi^- \ell^+ \nu_\ell) = (1.34 \pm 0.06 \pm 0.05) \times 10^{-4}$



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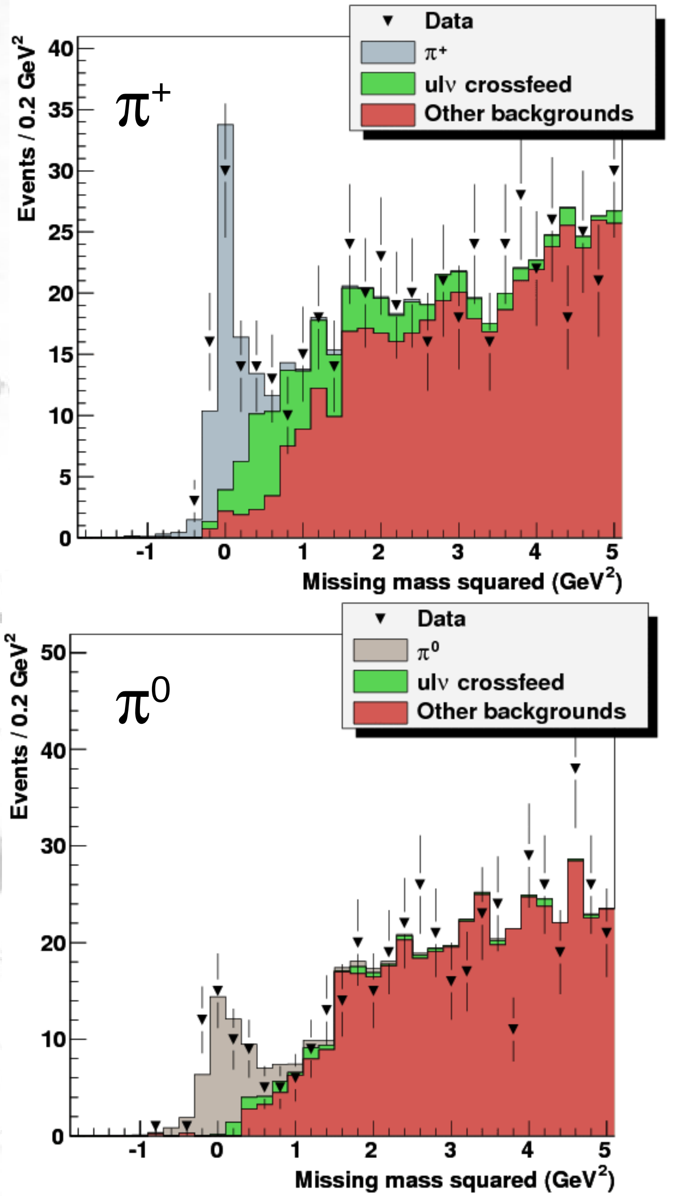
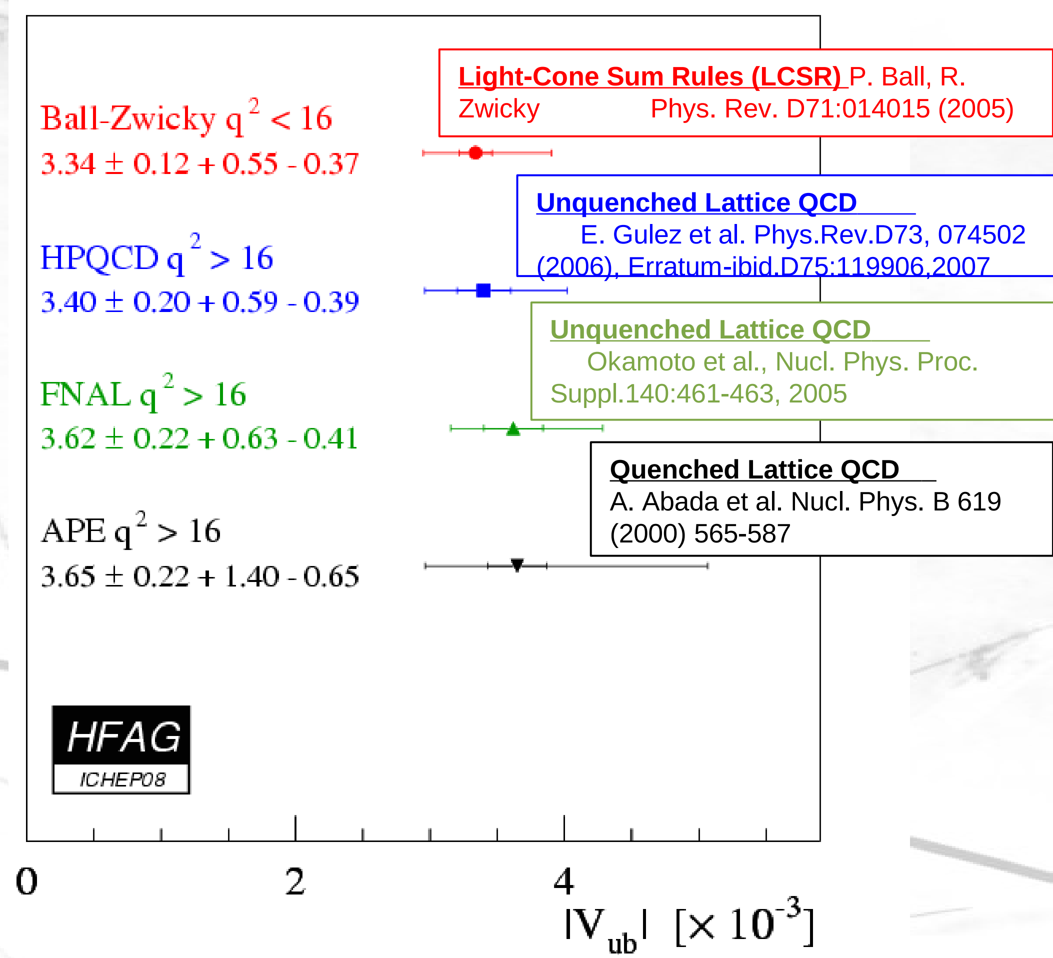


$|V_{ub}|$ using different theoretical methods



Theory lags behind experiments

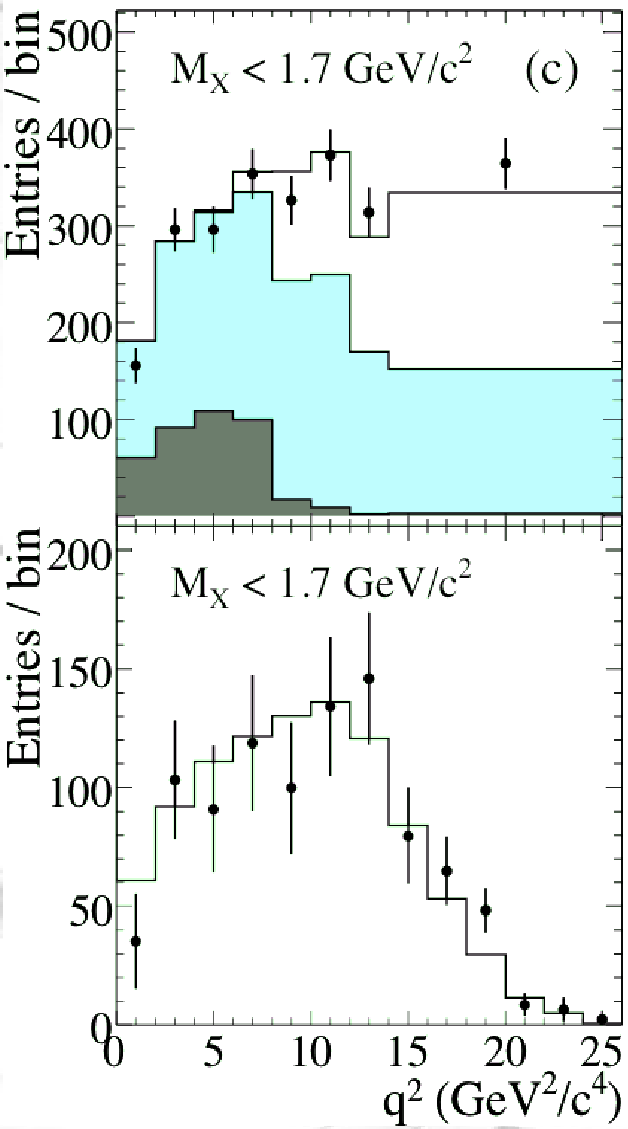
$\delta|V_{ub}|/|V_{ub}|^{\,exp} \sim 5\%$

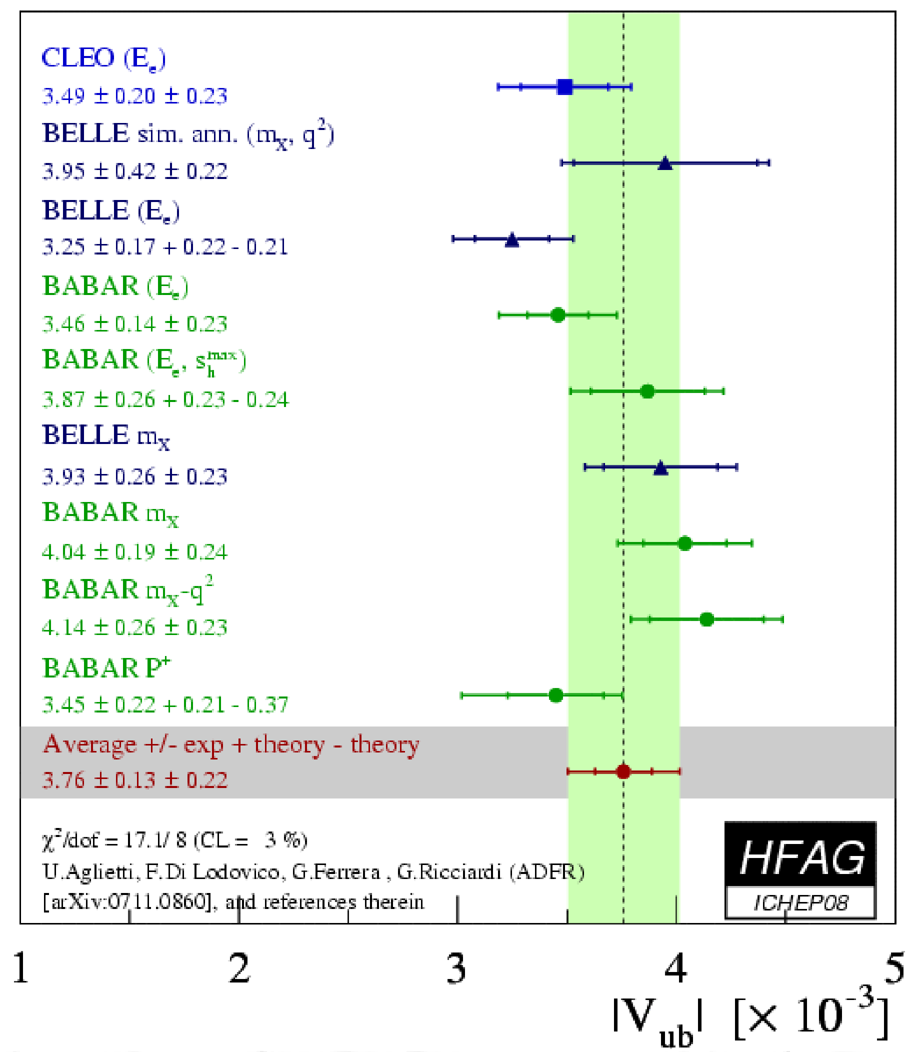
$\delta|V_{ub}|/|V_{ub}|^{\,f+(0)} \sim {}^{+17\%}_{-11\%}$ (e.g HPQCD & FNAL)

$|V_{ub}|$ from $B \to X_u \ell \nu_\ell$ decays

Analyses apply different kinematic cuts to suppress the $b \to c$ background.

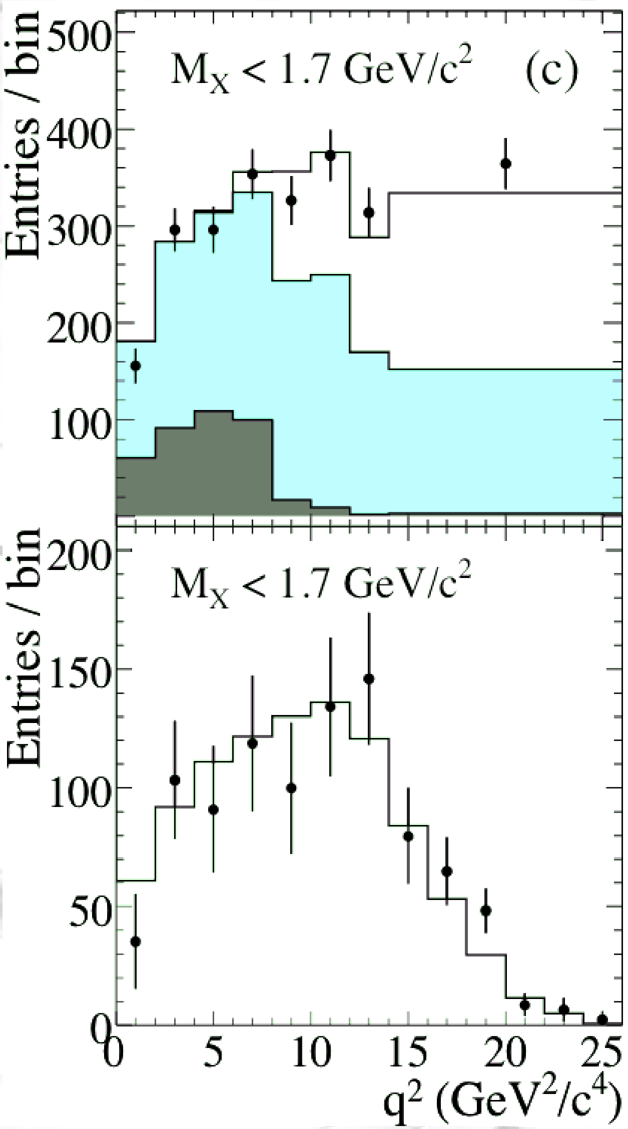
BaBar PRL100:171802 (2008)

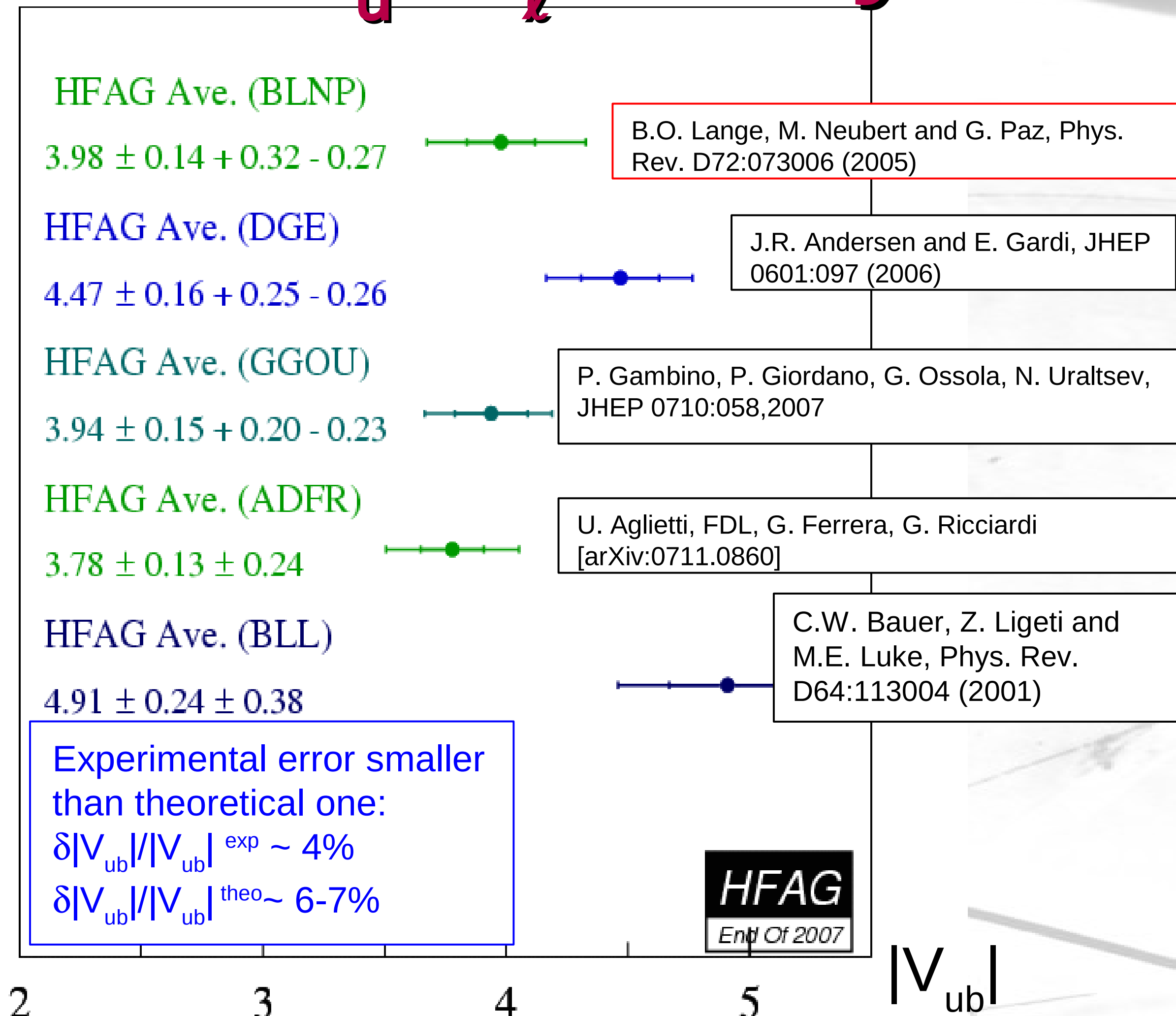




$|V_{ub}|$ from $B \to X_u \ell \nu_\ell$ decays

BaBar PRL100:171802 (2008)





Experimental error smaller than theoretical one:

$\delta|V_{ub}|/|V_{ub}|^{exp} \sim 4\%$

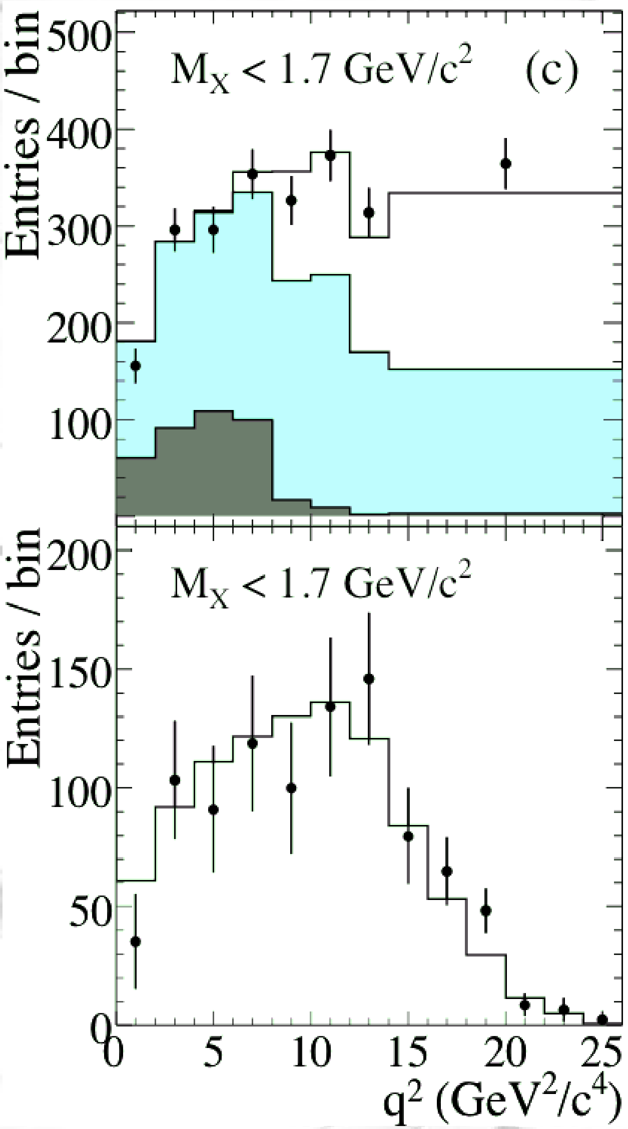
$\delta|V_{ub}|/|V_{ub}|^{theo} \sim 6\text{-}7\%$

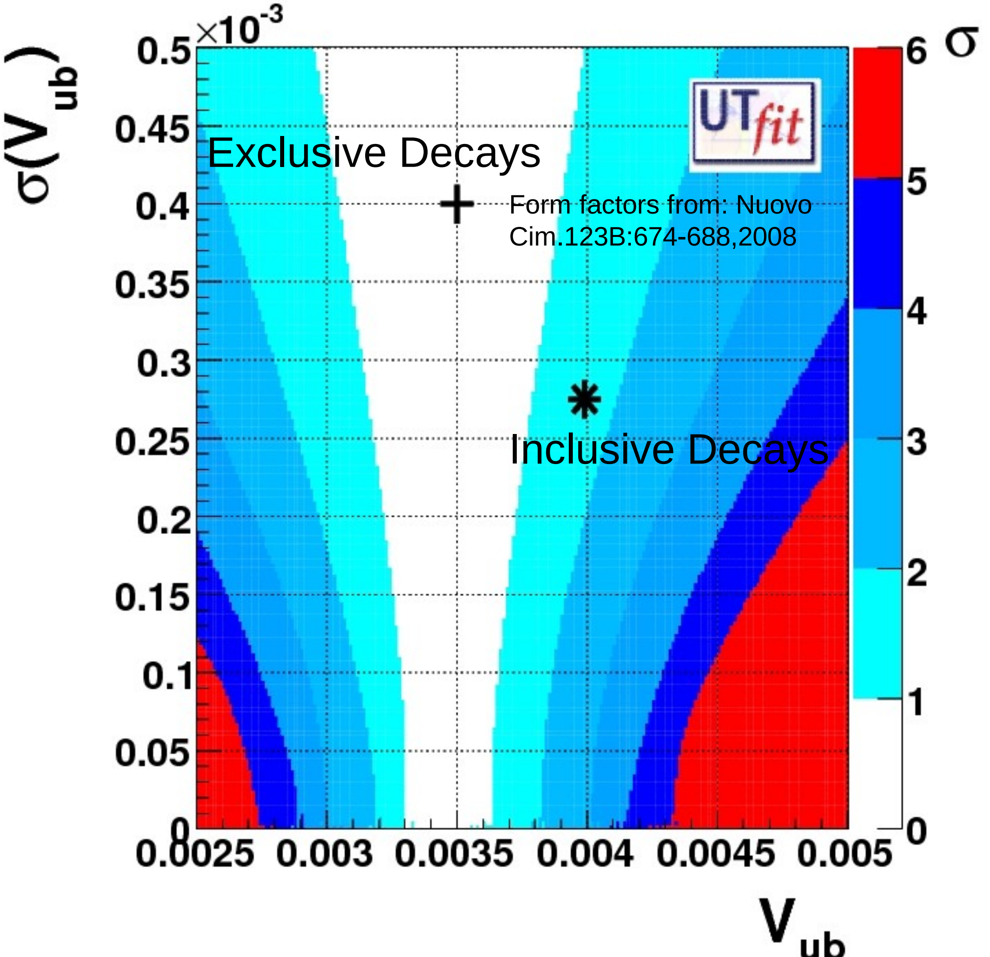
$|V_{ub}|$ from inclusive decays higher than from exclusive decays being investigated.

$|V_{ub}|$ from exclusive decays consistent with indirect predictions from $\sin 2\beta$.

$|V_{ub}|$ from $B \to X_u \ell \nu_\ell$ decays

BaBar PRL100:171802 (2008)





$|V_{ub}|$ from inclusive decays higher than from exclusive decays being investigated.
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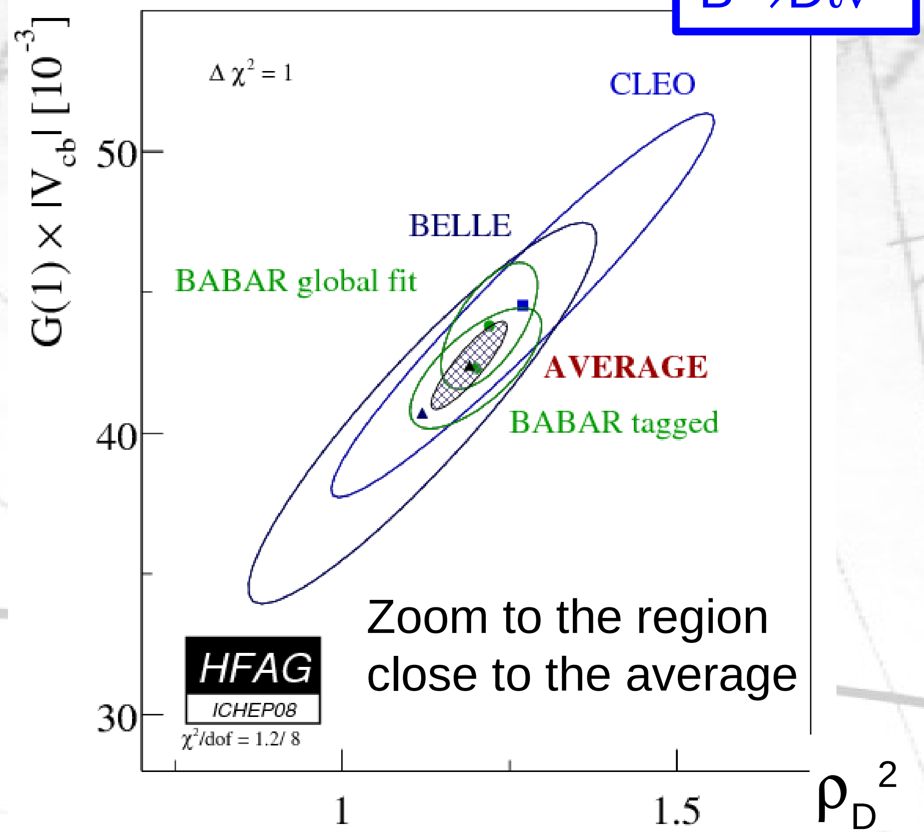
$|V_{cb}|$ from $B \to D^{(*)} \ell \nu_\ell$ decays

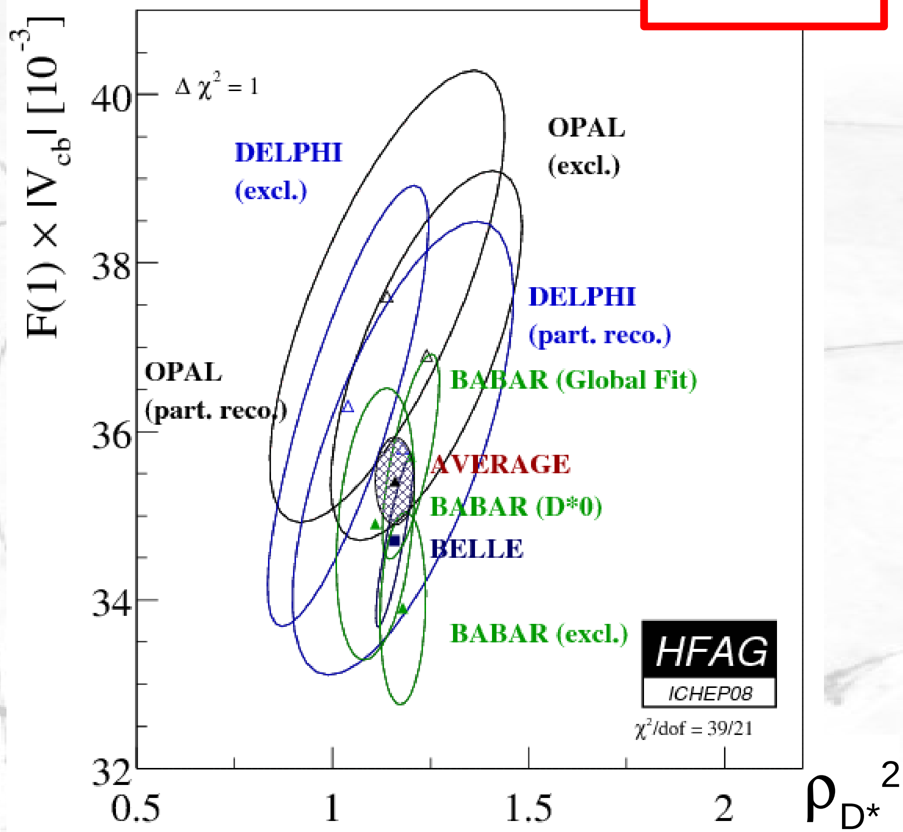
G(1) form factor, ρ_D slope

$B \to D \ell \nu$



F(1) form factor, ρ_{D^*} slope

$B \to D^* \ell \nu$



$G(1)|V_{cb}| = (42.9 \pm 1.6) \times 10^{-3}$

for $G(1) = 1.074 \pm 0.018 \pm 0.016$

(M.Okamoto et al NPPS 140, 461 (2005))

$|V_{cb}| = (39.7 \pm 1.4_{exp} \pm 0.9_{theo}) \times 10^{-3}$

$F(1)|V_{cb}| = (35.97 \pm 0.53) \times 10^{-3}$

for $F(1) = 0.924 \pm 0.012 \pm 0.019$

(J.Laiho) arXiv:0710.1111 [hep-lat]

$|V_{cb}| = (38.7 \pm 0.6_{exp} \pm 0.9_{theo}) \times 10^{-3}$

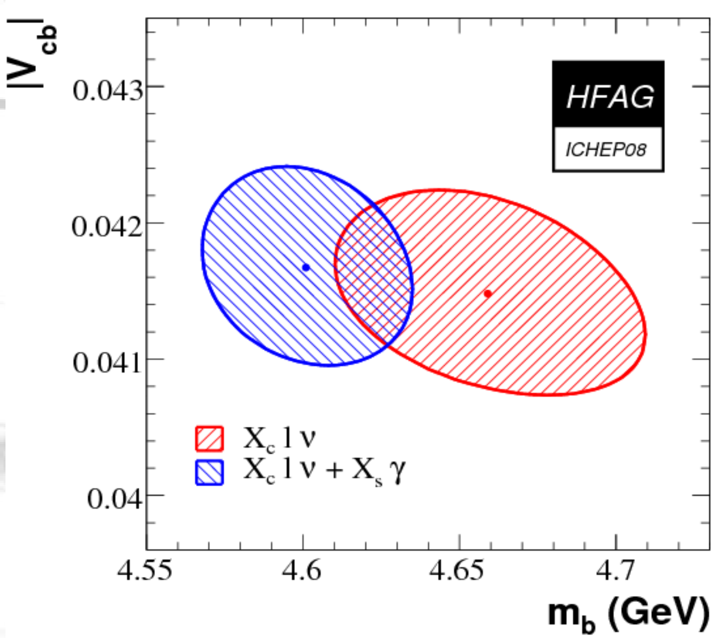
Inclusive $B \to X_c \ell \nu_\ell$ decays

Moments are related to $|V_{cb}|$, m_b, m_c and non-perturbative parameters

Lepton moments: $\langle E^n_\ell \rangle = \frac{1}{\Gamma} \int (E_\ell - \langle E_\ell \rangle)^n \frac{d\Gamma}{dE_\ell} dE_\ell$

Hadronic mass moments: $\langle m^n_X \rangle = \frac{1}{\Gamma} \int m^n_X \frac{d\Gamma}{dm_X} dm_X$

Similarly for photon energy moments for $b \to s\gamma$



Calculations in "kinetic" scheme (Benson, Bigi, Gambino, Mannel, Uraltsev, Nucl. Phys. B665:367)

Fit to > 60 moments: DELPHI, CLEO, BaBar, Belle, CDF

$|V_{cb}| = (41.67 \pm 0.43_{fit} \pm 0.08_{\tau_B} \pm 0.58_{theory}) \times 10^{-3}$

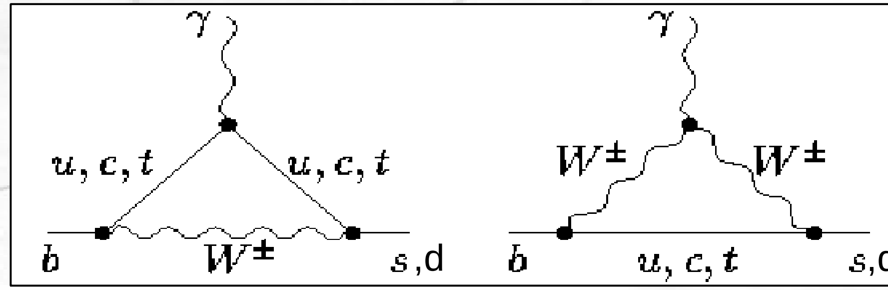
$m_b = 4.601 \pm 0.034$ GeV

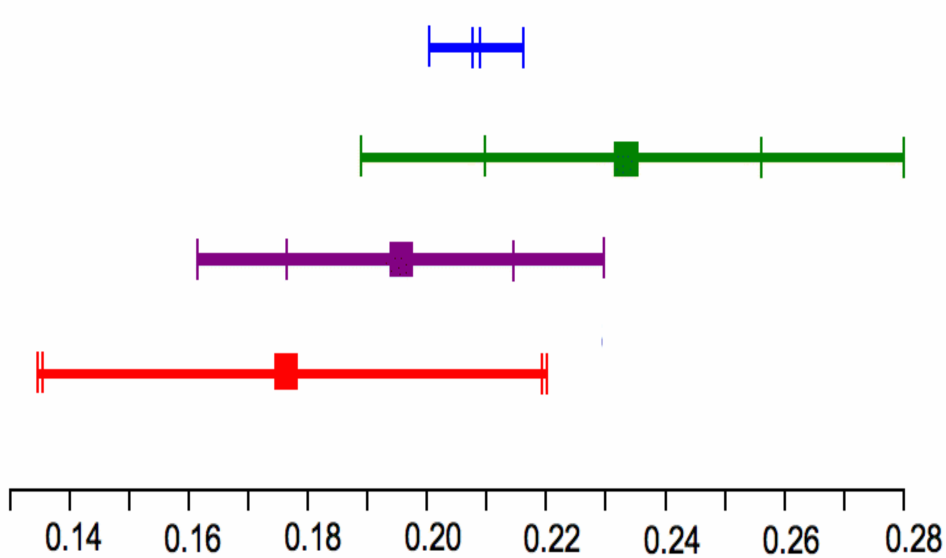
+ other fitted parameters

Difference between exclusive and inclusive $|V_{cb}|$ determinations ~2.3σ

$|V_{td}|/|V_{ts}|$ from $b\to d\gamma/b\to s\gamma$

Complementary to B_s-mixing (from Tevatron) : different experimental and theoretical issues (penguin decays with respect to box diagrams), but statistically limited.





B mixing (C. Amsler et al., Phys. Lett B667, 1 (2008)

|Vtd/Vts| = 0.209 ±0.001 ±0.006

BaBar exclusive PRD78, 112001 (2008)

|Vtd/Vts| = 0.233 ±0.025 ±0.022

Belle exclusive Belle, PRD101, 111801 (2008)

|Vtd/Vts| = 0.195 ±0.020 ±0.015

BaBar inclusive BaBar, arXiv:0807.4975 [hep-ex]

|Vtd/Vts| = 0.177 ±0.043 ±0.001

Limited final states used.
Not included in the theo. error.

(first error experiment, second theory)

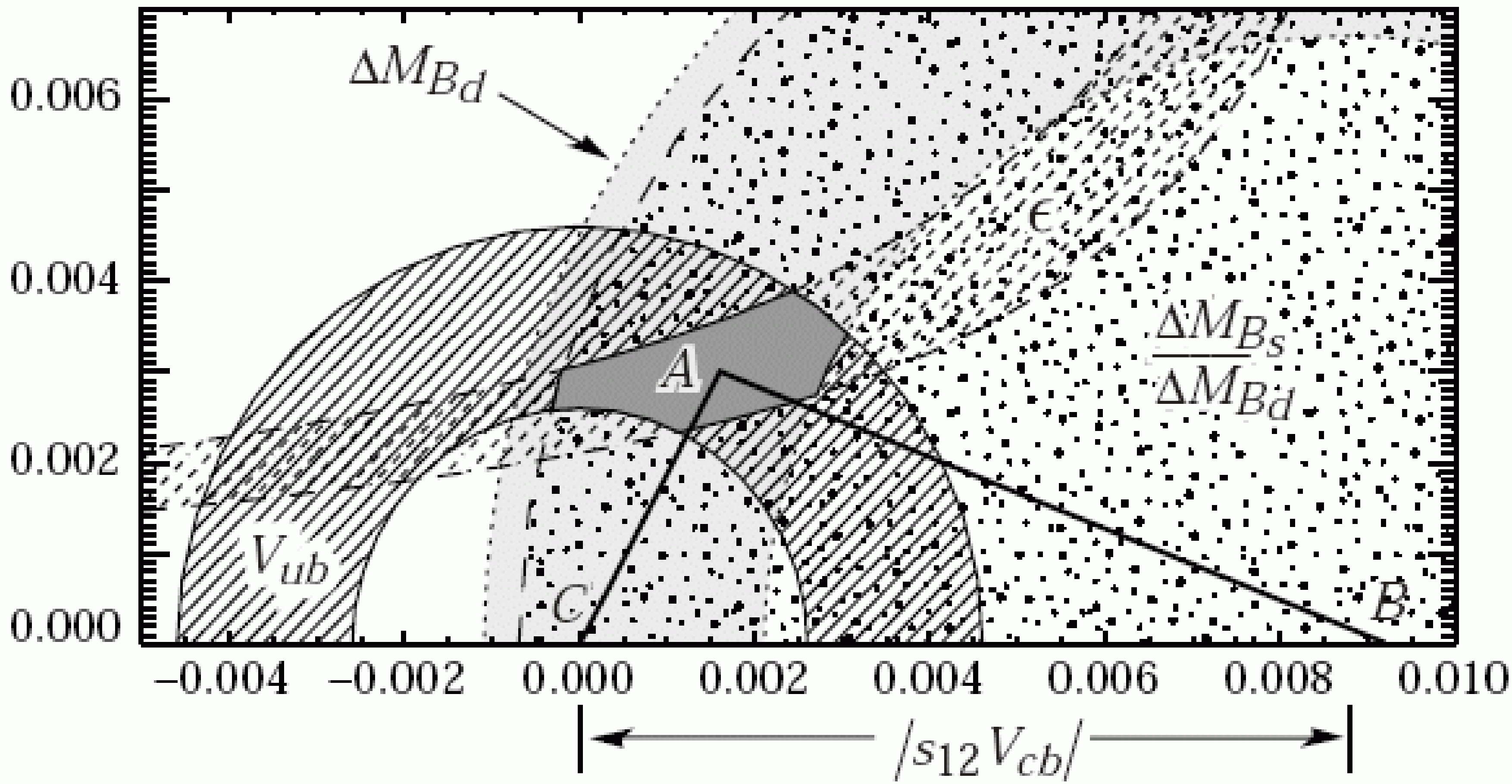
Theoretical computations: A. Ali, H. Asatrian, C. Greub
A. Ali, E. Lunghi and Parkhomenko
P. Ball, G. Jones, R. Zwicky

Outline

- The theoretical and experimental environment.
- The angles of the Unitarity Triangle.
- The magnitude of the elements of the CKM matrix.
- Perspectives and Conclusions

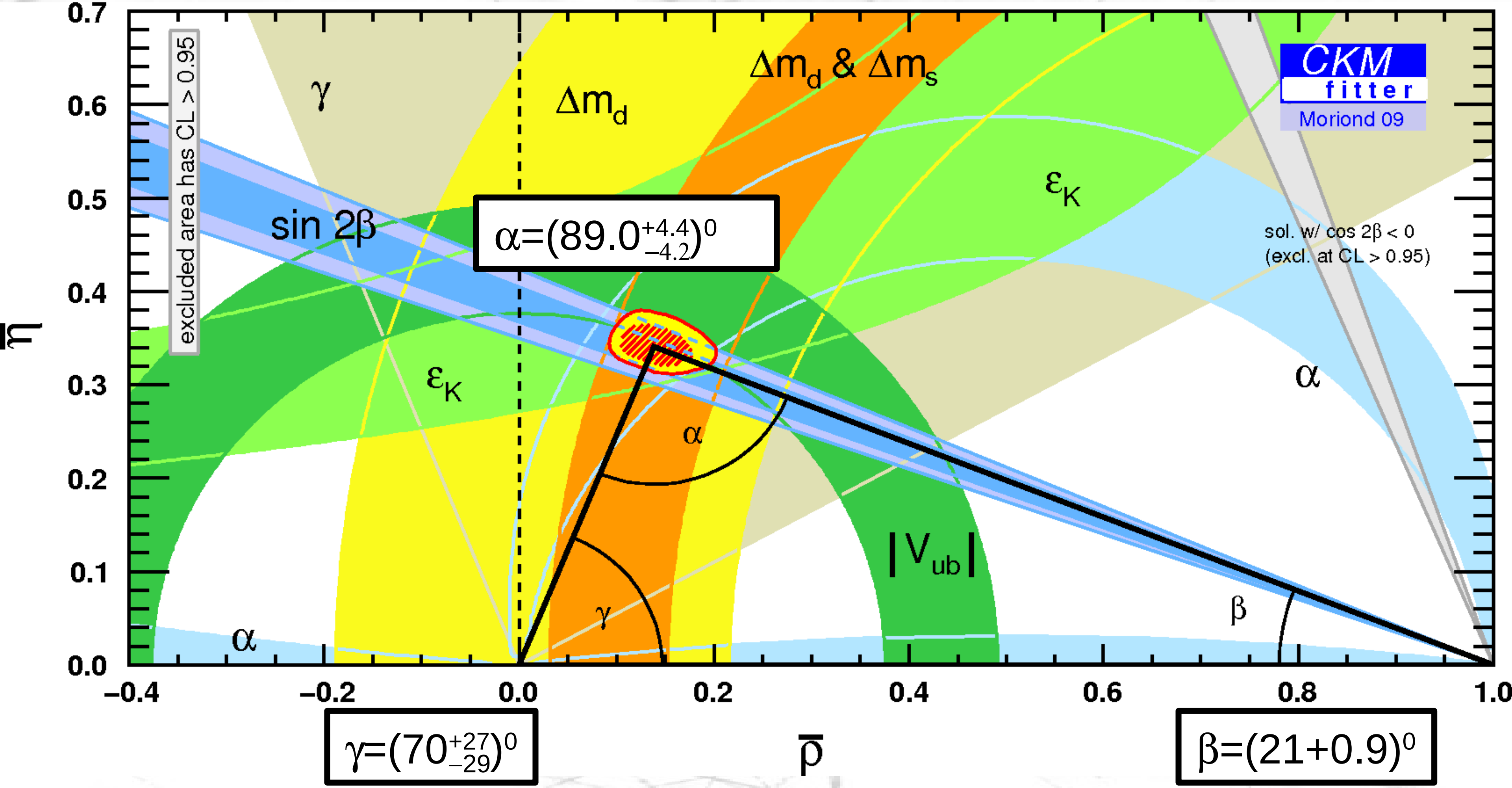
How we were... ca March 2000

PDG 2000



These results do not include the ones from the B-Factories.
BaBar and Belle started to take data in 1999.
First results presented at the Summer conferences in 2000.

How we are... in 2009!



$\alpha=(89.0^{+4.4}_{-4.2})^0$

$\gamma=(70^{+27}_{-29})^0$

$\beta=(21+0.9)^0$

A Lesson from Quarks

Zhi-zhong Xing, ICHEP08

CKM quark mixing:

$$\mathbf{V} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \begin{pmatrix} c_{13} & 0 & s_{13} \\ 0 & e^{-i\delta} & 0 \\ -s_{13} & 0 & c_{13} \end{pmatrix} \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Exp. steps: θ_{12} → θ_{23} → θ_{13} → δ new physics ?

$\sim$ 13° $\sim$ 2° $\sim$ 0.2° $\sim$ 65°   unitarity ?

MNS lepton mixing:

$$\mathbf{V} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \begin{pmatrix} c_{13} & 0 & s_{13} \\ 0 & e^{-i\delta} & 0 \\ -s_{13} & 0 & c_{13} \end{pmatrix} \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} e^{i\rho} & 0 & 0 \\ 0 & e^{i\sigma} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Exp. steps: θ_{23} → θ_{12} → θ_{13} → $\delta/\rho/\sigma$ new physics ?

$\sim$ 45° $\sim$ 34°   <10° $\sim$? ? ?   unitarity ?

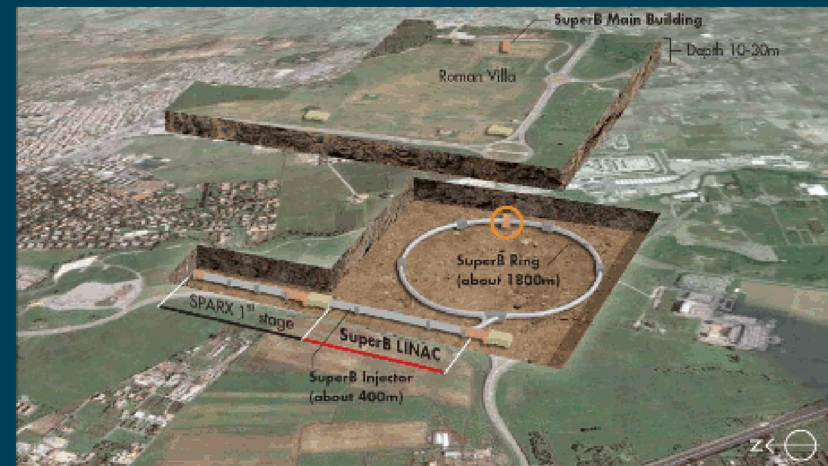
known theta_13: a turning point to the era of precision measurements

SuperB *(In a Nutshell)*

Adrian Bevan, MoriondEW 2009

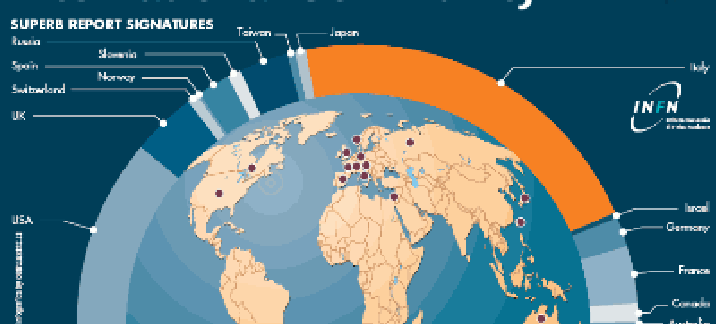
Site: Tor Vergata Campus (Rome II)

- Asymmetric energy e^+e^- collider
- Low emittance operation (like LC)
- Polarised beams
- Luminosity 10^{36} $cm^{-2}s^{-1}$
    - $75ab^{-1}$ data at the $\Upsilon(4S)$
    - Collect data at other $\sqrt{s}$
    - Start data taking as early as 2015



- Crab Waist technique developed to achieve these goals

- International Community



Geographical distribution of CDR signatories.

Precision B, D and τ decay studies and spectroscopy

- New Physics in loops
    - 10 TeV reach at $75ab^{-1}$
    - Rare decays
    - ΔS CP violation measurements
- Lepton Flavour & CP Violation in τ decay
- Light Higgs searches
- Dark Matter searches

http://www.pi.infn.it/SuperB/

Conclusions

- High-precision measurements from the B-factories (final dataset from BaBar ~500M B). Belle continues operations to O(1000M decays)
  - Overall, excellent agreement between sides and angles of the Unitarity Triangle.

    But a few tantalizing hints.
  - Nontrivial constraints on the flavor of new physics.
- Still statistics limited.

  $\sigma(\beta) \sim 2^o$; theory errors below 1^o.

  $\sigma(\alpha) \sim 10^o$; limited by measurements of penguin pollution.

  $\sigma(\gamma) \sim 15^o$; limited by statistics and theory.

  $\sigma(|V_{ub}|) \sim 7^o$; the real limitation is from theory errors.
- CPV measurements in the B system will continue to provide important insights and constraints on the flavor structure of physics within and beyond the Standard Model.