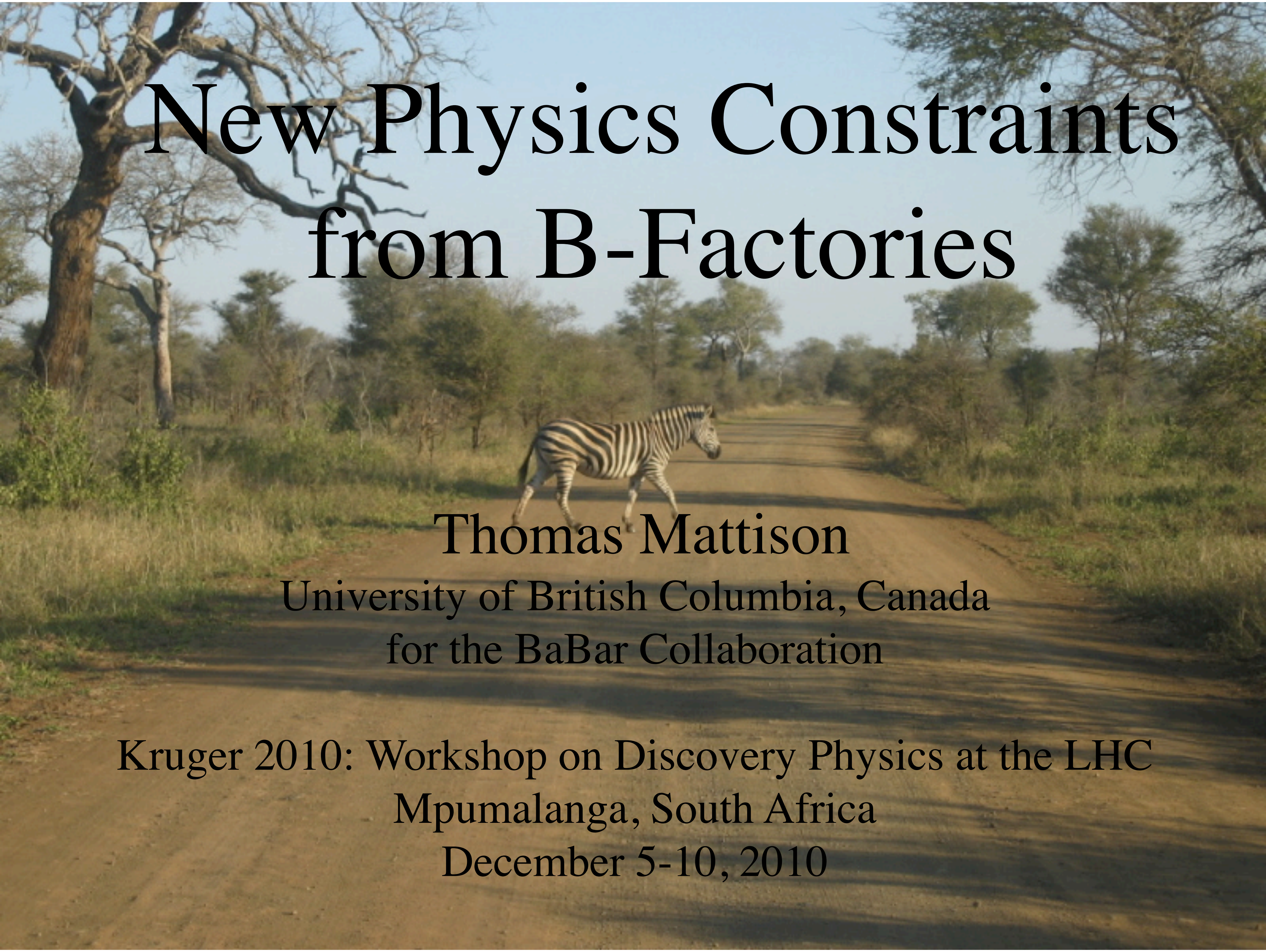

New Physics Constraints from B-Factories

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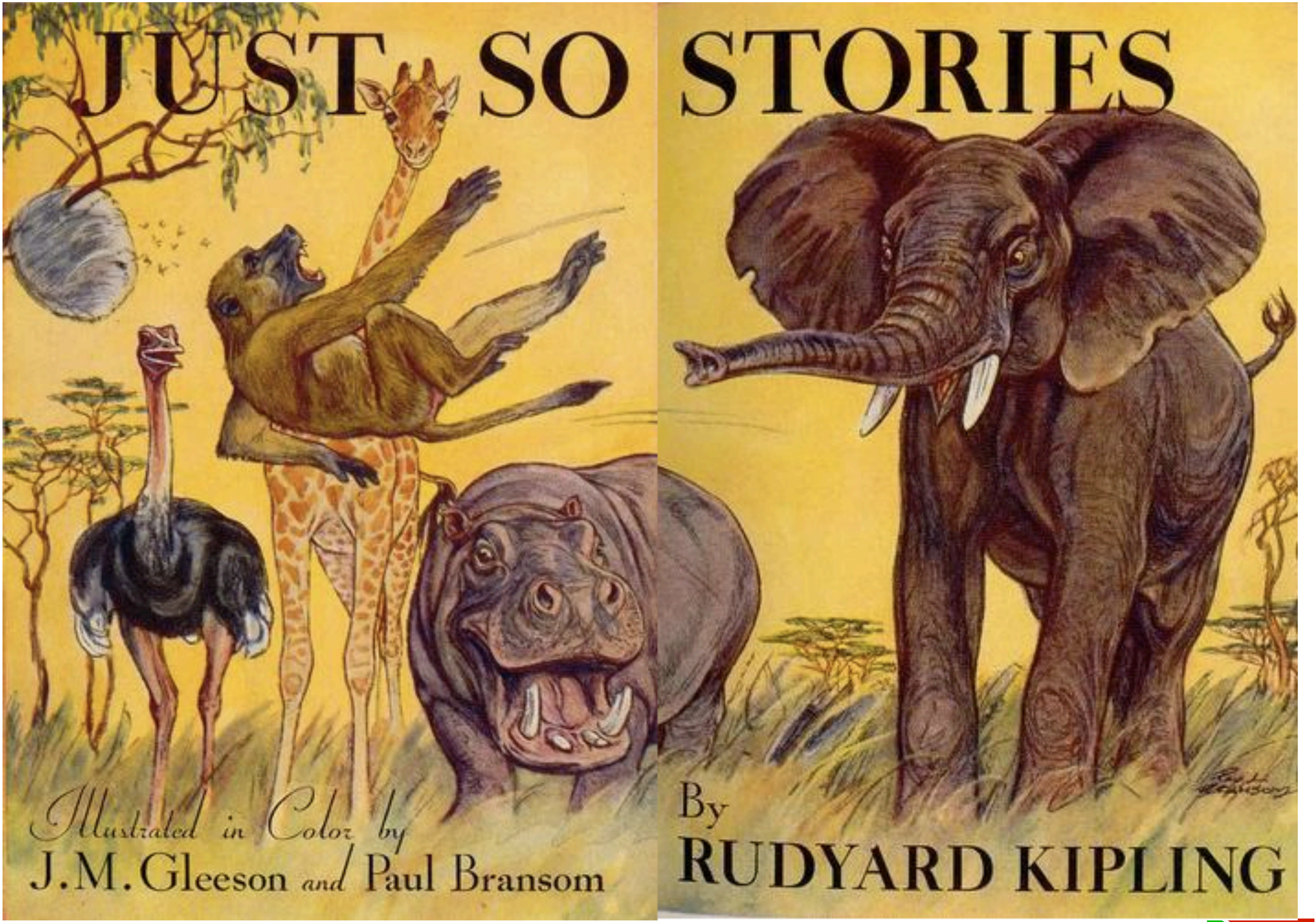
Kruger 2010: Workshop on Discovery Physics at the LHC
Mpumalanga, South Africa
December 5-10, 2010

Outline

- The Story of the B-Factories
- Constraining New Physics in the CKM Sector
- A (very) Incomplete Sample of Other Constraints
- The Future


JUST SO STORIES
Illustrated in Color by
J.M. Gleeson and Paul Bransom
By
RUDYARD KIPLING

How the B-Factories Got Their Spots

- Once upon a time, CP violation was found in the K sector. Was it part of weak interactions? Or was it new physics?
- Kobayashi and Maskawa noticed that a 3-generation quark-mixing matrix naturally allowed a complex phase that would cause CP violation (a year before the third generation started to be discovered!)
- But "everyone knew" that the B lifetime would be too short for B-mixing like the K-mixing that made CP visible. So there was no real hope of checking the KM model.

How the B-Factories Got Their Spots (2)

- “Everybody” was wrong. B’s lived much longer than expected, about as long as charmed particles.
- But “everybody knew” that still wasn’t long enough for mixing, because top quarks couldn’t weigh much more than bottom quarks, so the GIM mechanism would cause mixing to be too slow for CP violation to be seen.

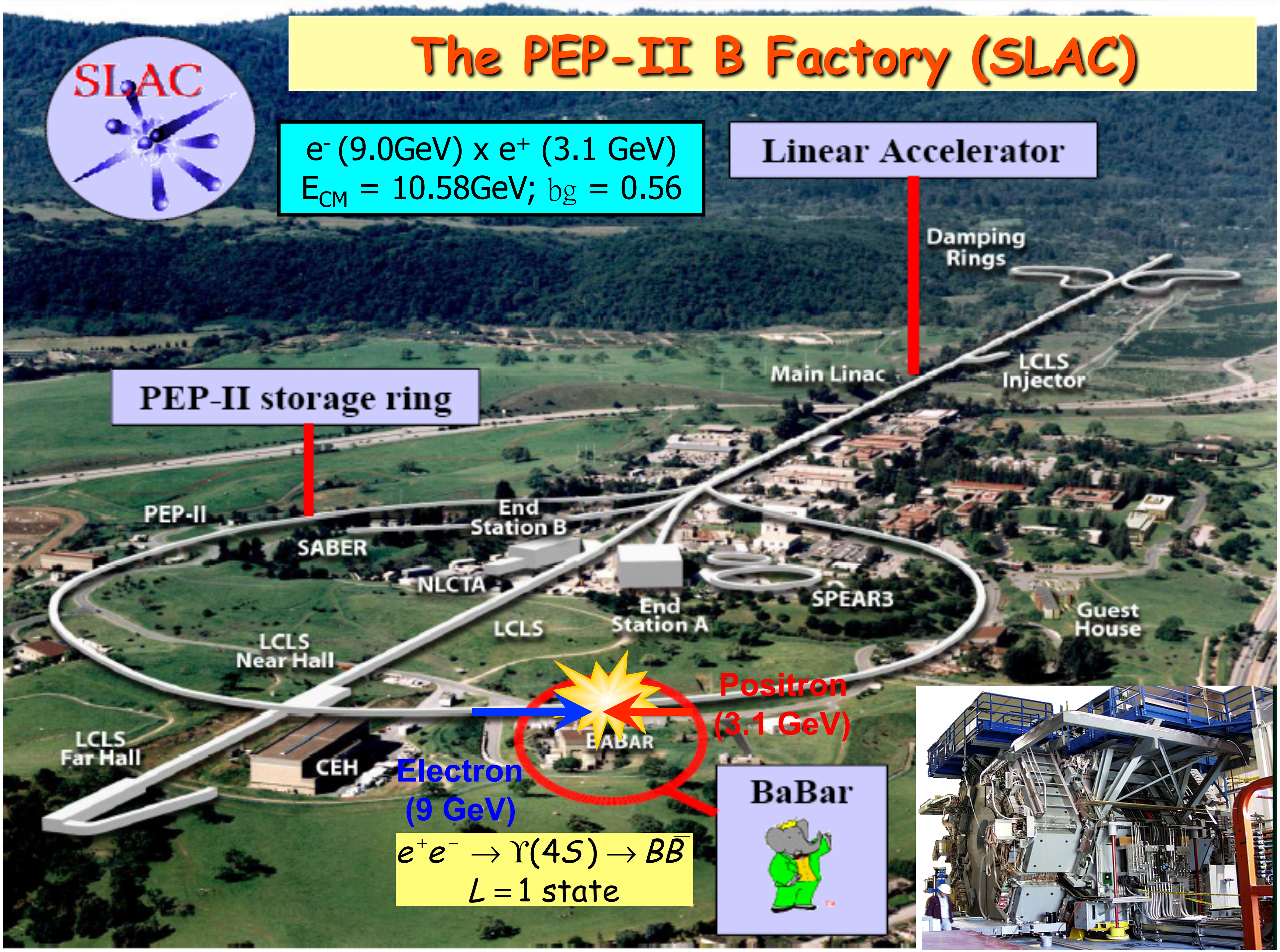
How the B-Factories Got Their Spots (3)

- “Everybody” was wrong about the top mass too. It was high enough to break the GIM mechanism, so B’s happily mixed. (There were quite a few B-mixing limits that were lower than the eventual signal!)
- And it became plausible that if you had enough B’s, you could test if Kobayashi and Maskawa were right, or if CP violation was new physics.
- So the B-factories were built to test the KM model, and it was “just so.”

The Morals of the Story

- One or two of the things that you have been told to look for at the LHC may turn out to be "just so."
- Sometimes "everybody" is wrong when they tell you what things will be like, and what will be possible or impossible.

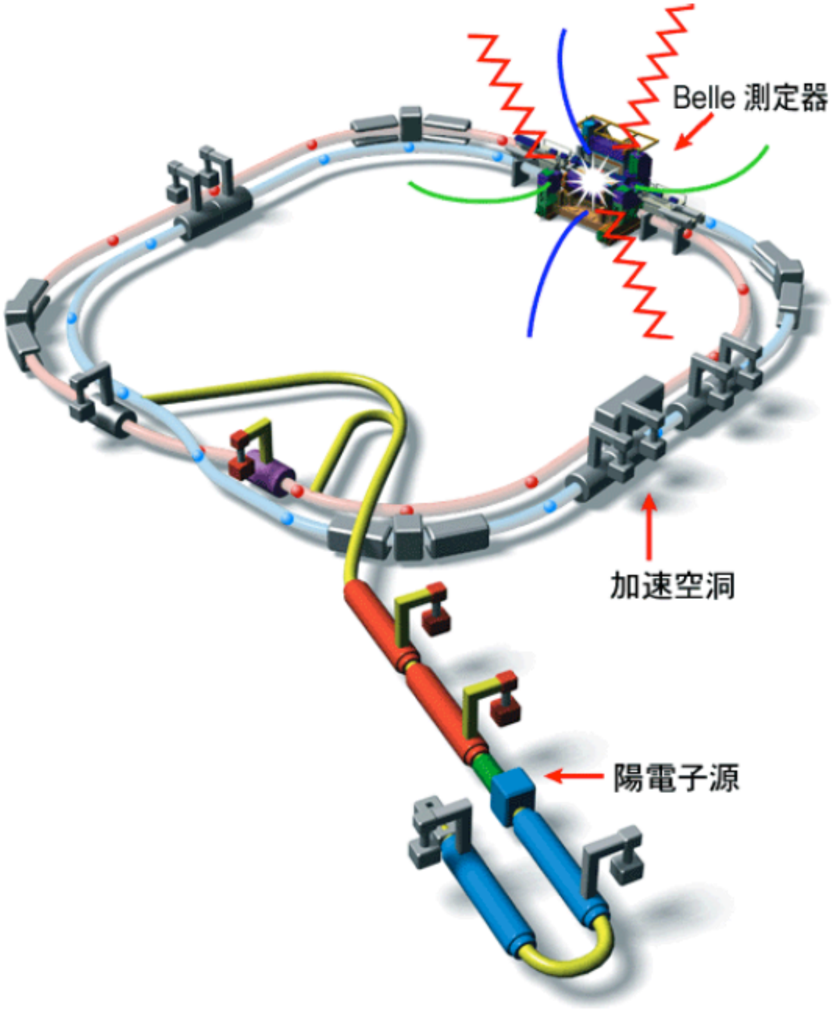
The PEP-II B Factory (SLAC)



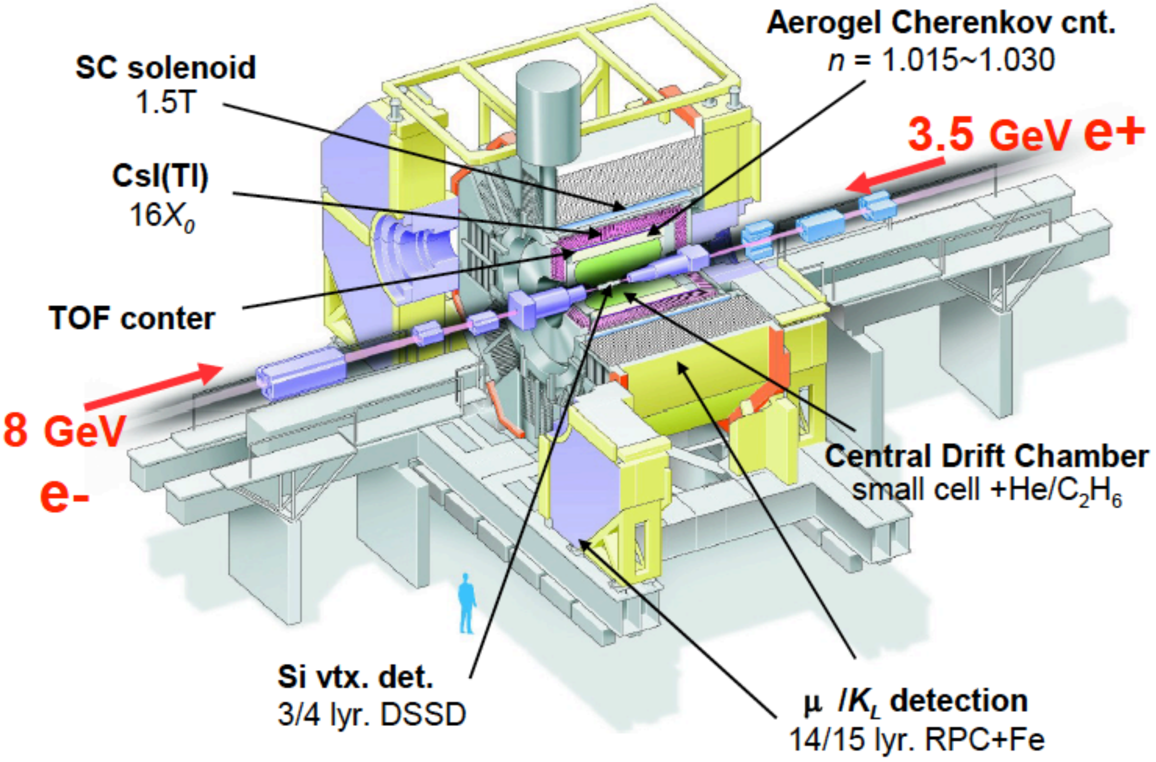
e^- (9.0GeV) x e^+ (3.1 GeV)
E_{CM} = 10.58GeV; bg = 0.56

$$e^+e^- \to \Upsilon(4S) \to B\bar{B}$$
$$L = 1 \text{ state}$$

KEKB B-factory and Belle detector



Belle detector: multi-purpose, large-solid-angle magnetic spectrometer


SC solenoid
1.5T

CsI(Tl)
$16X_0$

TOF conter

Aerogel Cherenkov cnt.
$n = 1.015 \sim 1.030$

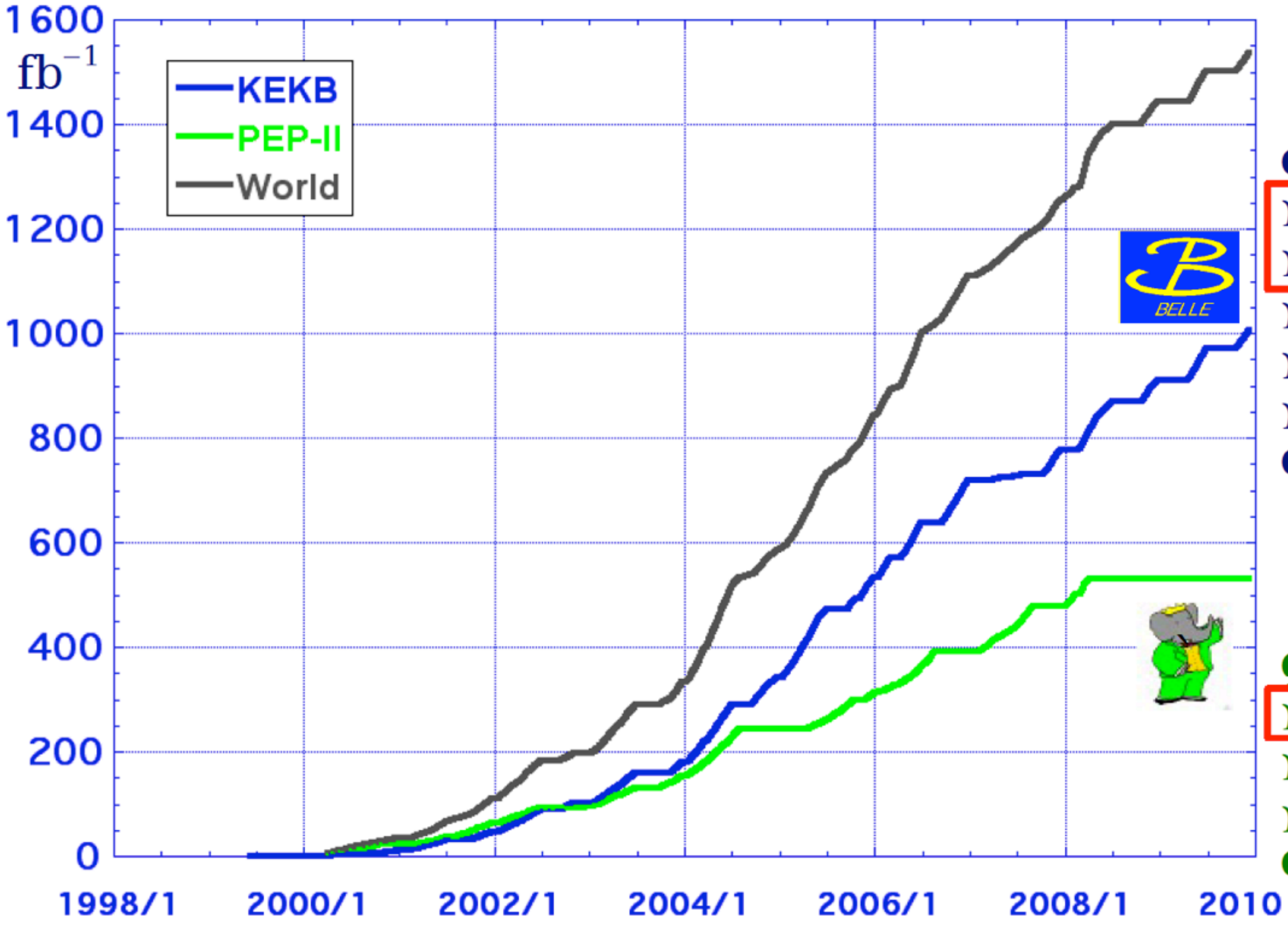
3.5 GeV e+

8 GeV e-

Central Drift Chamber
small cell +He/C_2H_6

Si vtx. det.
3/4 lyr. DSSD

μ /K_L detection
14/15 lyr. RPC+Fe



$> 1\ \mathrm{ab}^{-1}$

On resonance:

$\Upsilon(5S)$: 121 fb^{-1}

$\Upsilon(4S)$: 711 fb^{-1}

$\Upsilon(3S)$: 3 fb^{-1}

$\Upsilon(2S)$: 24 fb^{-1}

$\Upsilon(1S)$: 6 fb^{-1}

Off reson./scan

$\sim 100\ \mathrm{fb}^{-1}$

$\sim 550\ \mathrm{fb}^{-1}$

On resonance:

$\Upsilon(4S)$: 433 fb^{-1}

$\Upsilon(3S)$: 30 fb^{-1}

$\Upsilon(2S)$: 14 fb^{-1}

Off resonance:

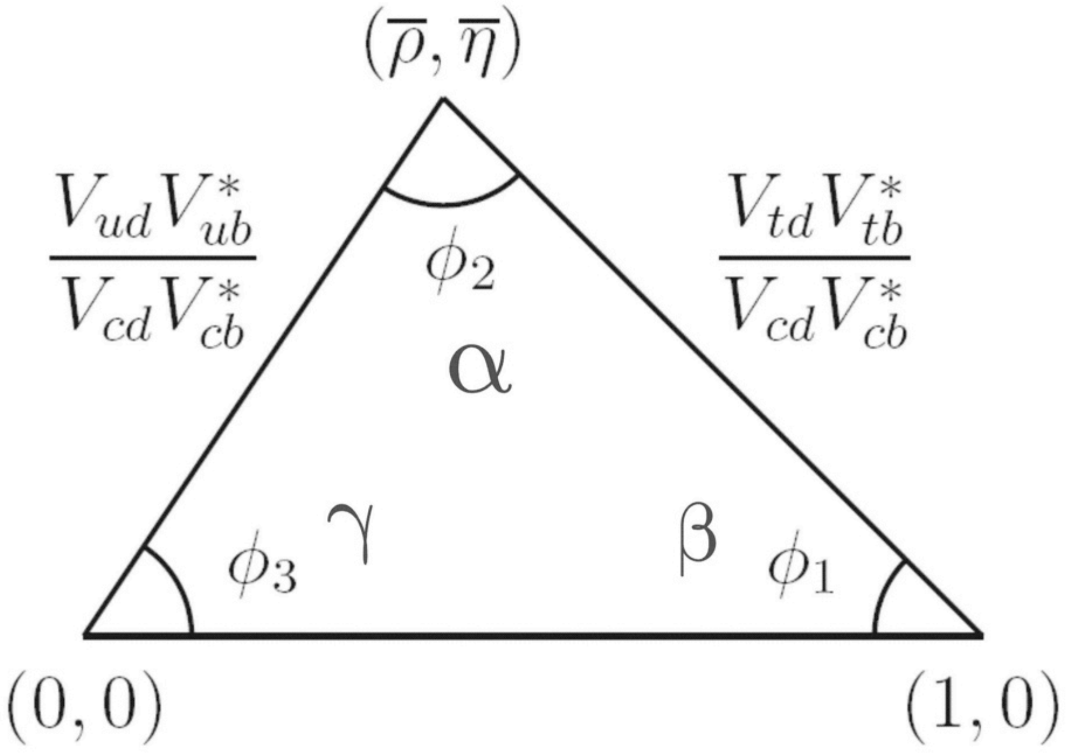
$\sim 54\ \mathrm{fb}^{-1}$

CKM Physics Constraints

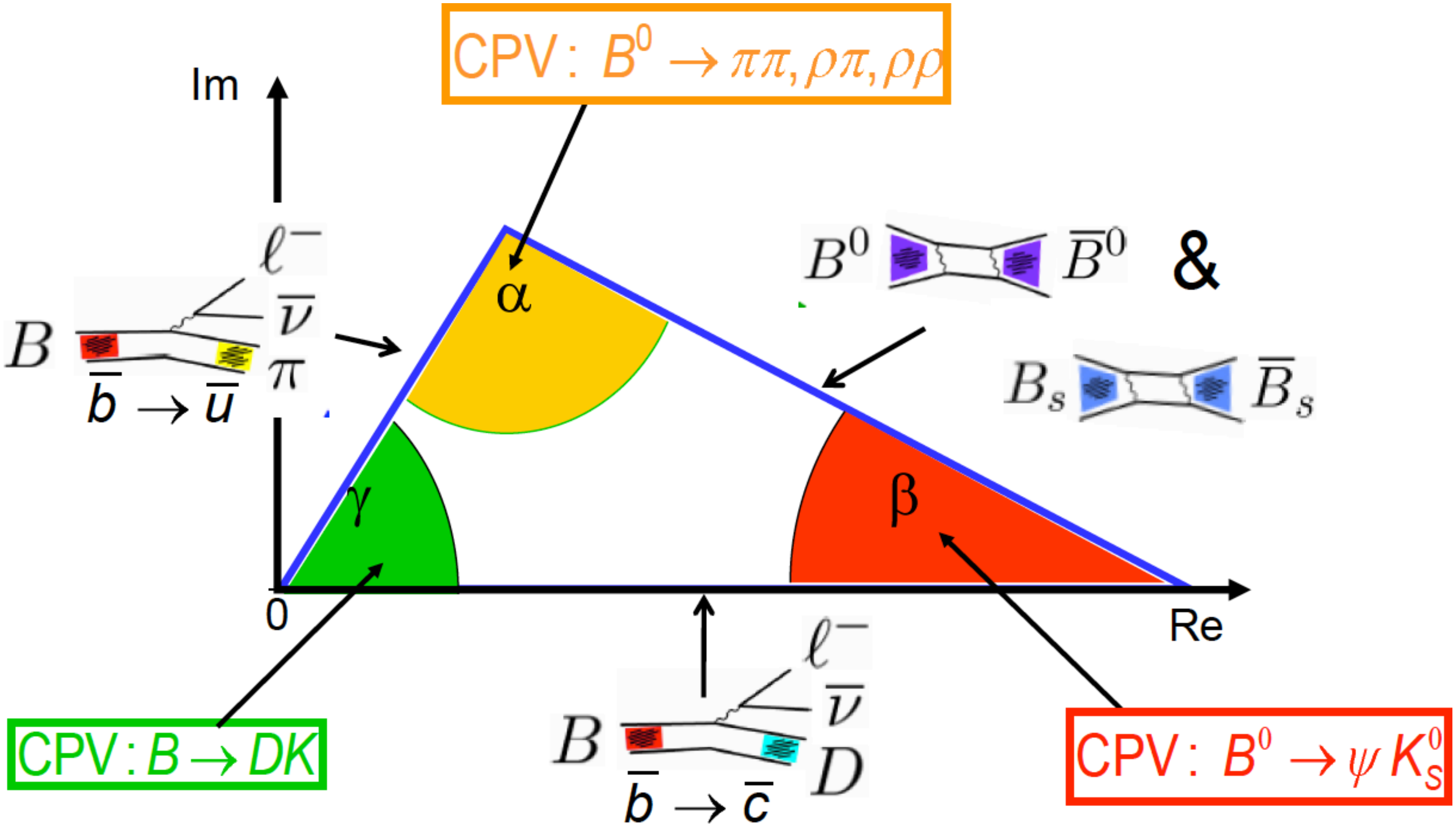
CKM Matrix and Unitarity Triangle

$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 1-\frac{\lambda^2}{2} & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{\lambda^2}{2} & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

$$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$$



Measuring the Triangle



CPV: $B^0 \to \pi\pi, \rho\pi, \rho\rho$

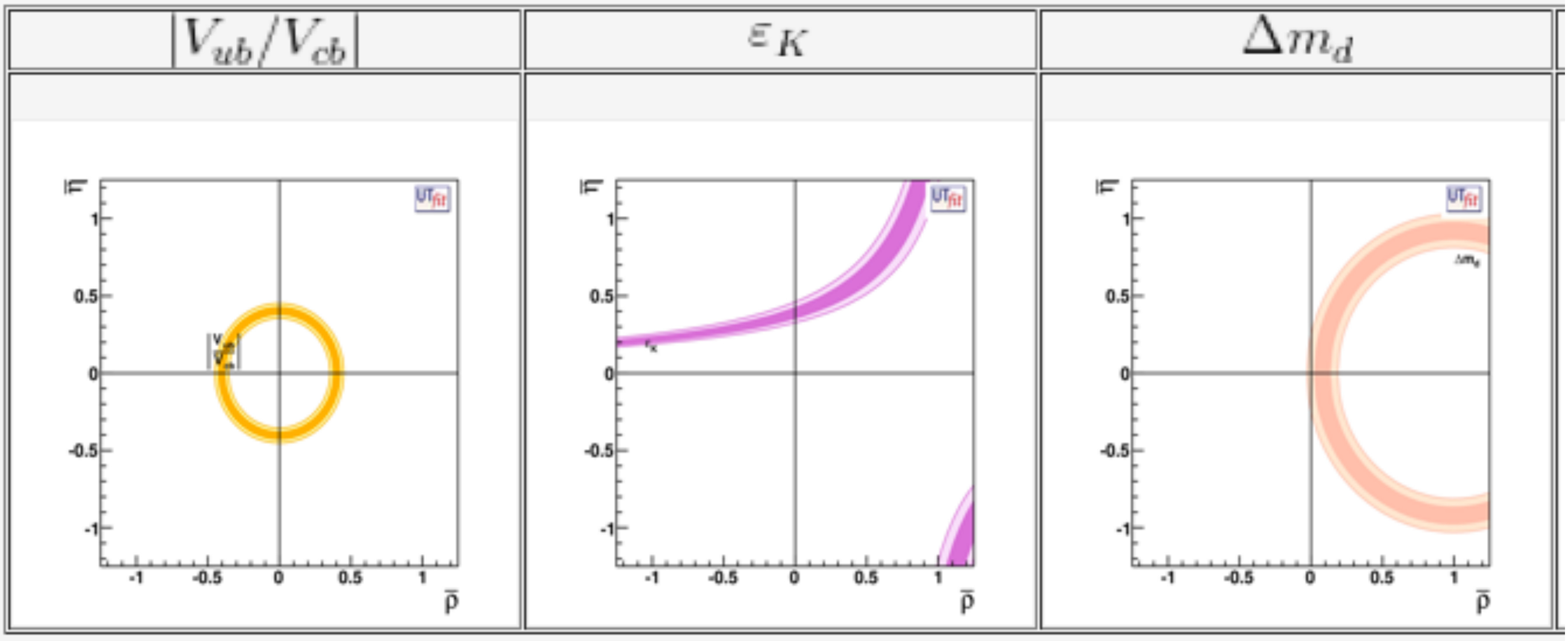
B^0 $\overline{B}^0$ &

B_s $\overline{B}_s$

CPV: $B \to DK$

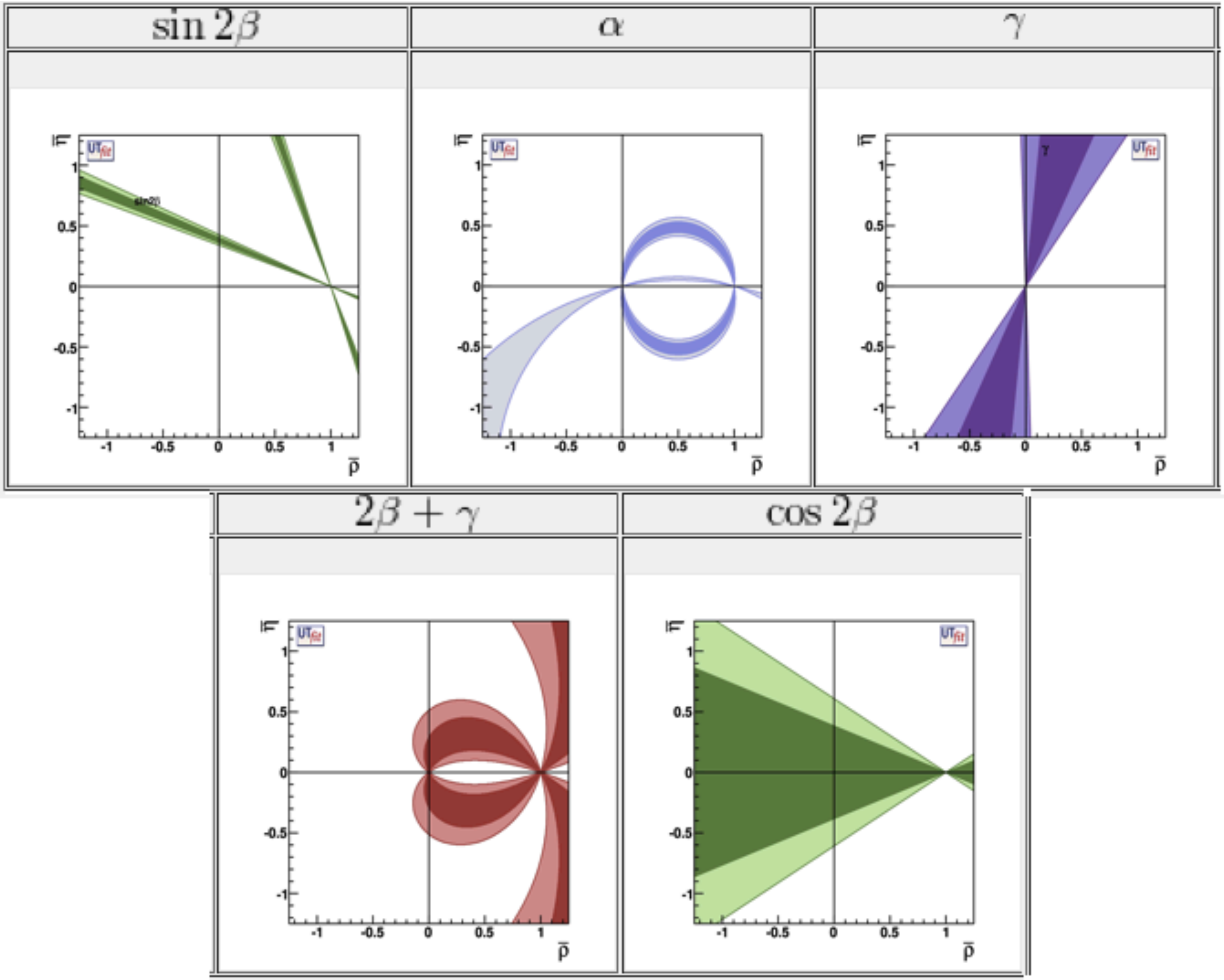
CPV: $B^0 \to \psi K_S^0$

Before the B-Factories

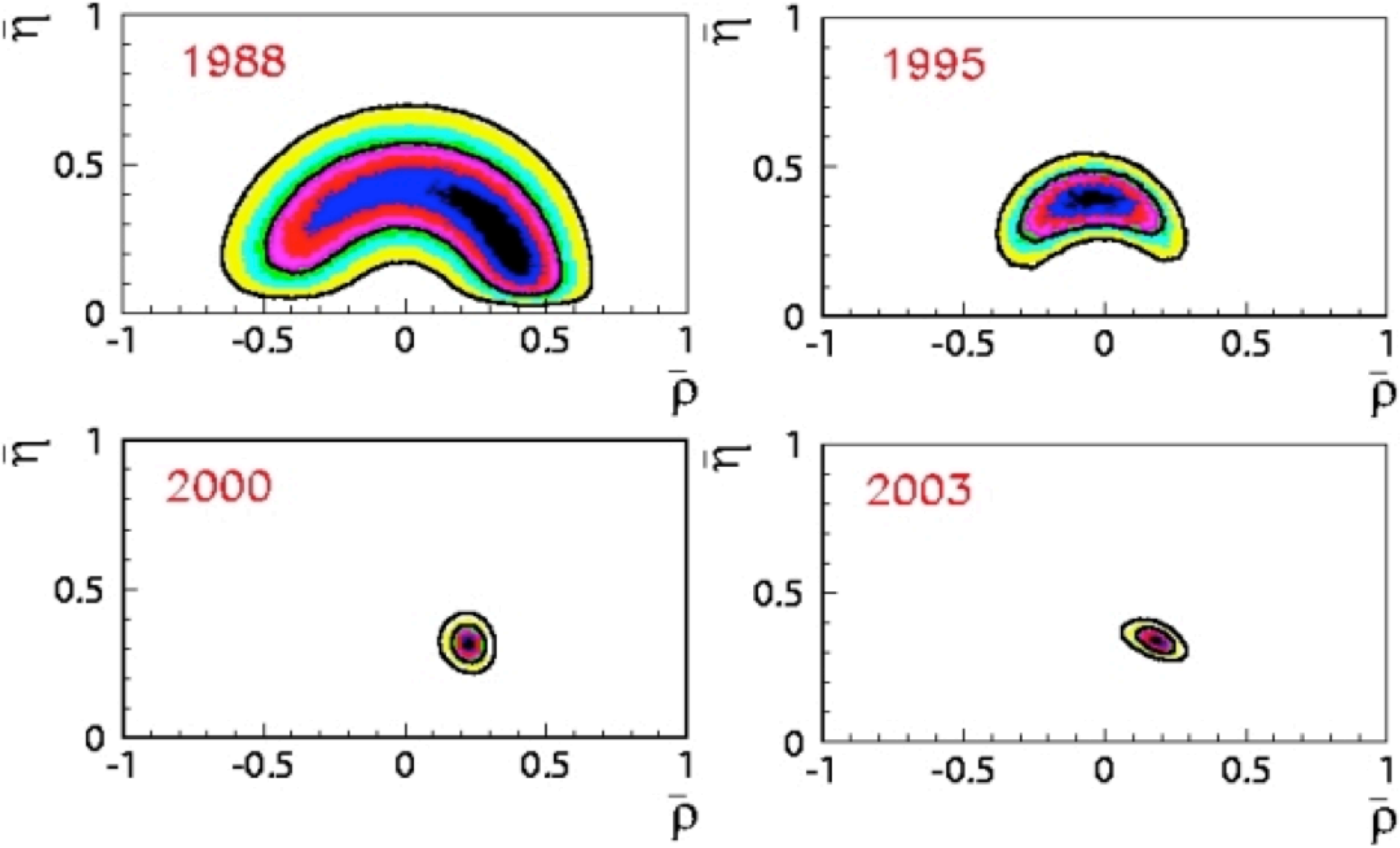


Left side from $b \rightarrow u$ branching fraction,
right side from B-mixing rate,
hyperbolas from CP violation in K system

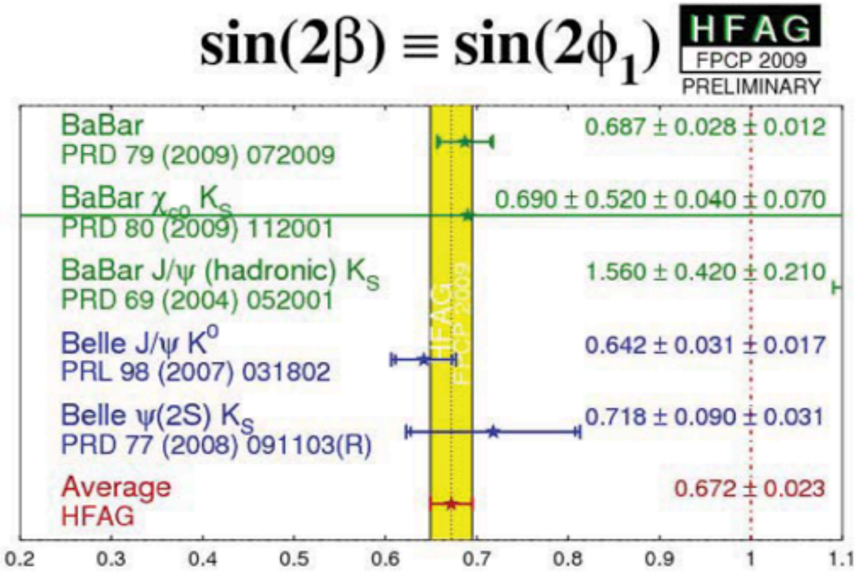
Enter the Angles



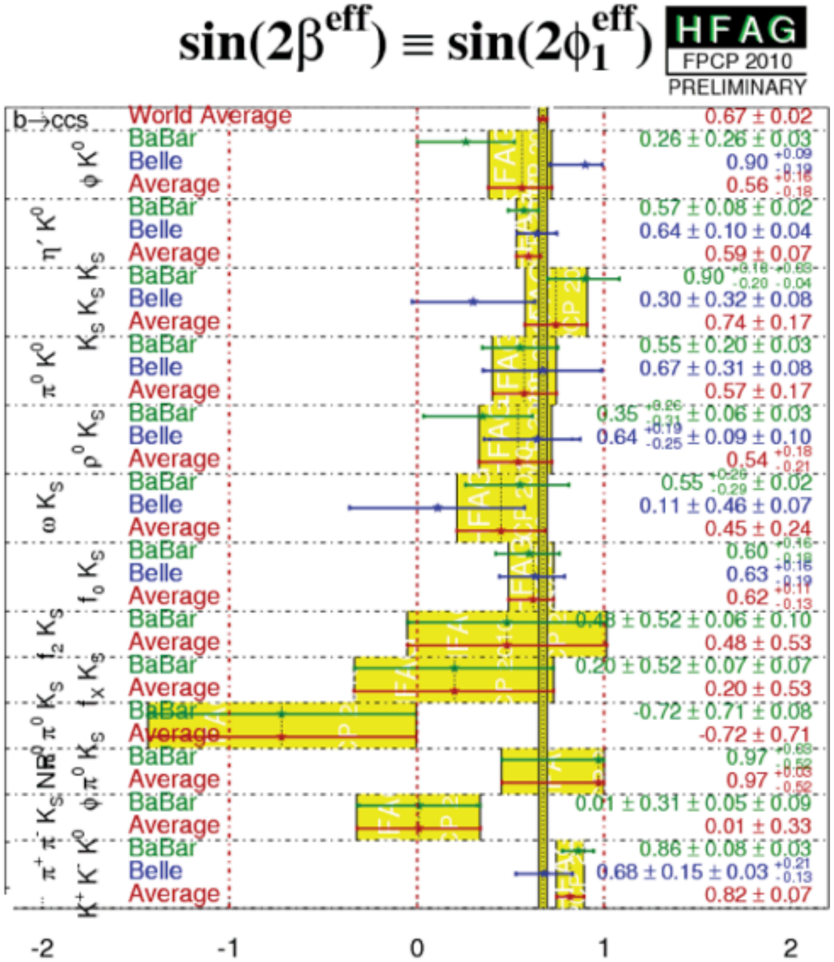
Pre B-Factory to Early B-Factory



ϕ_1 or β



sin 2β from the $b \to c\bar{c}s$ “golden” modes



Compare with Penguin modes

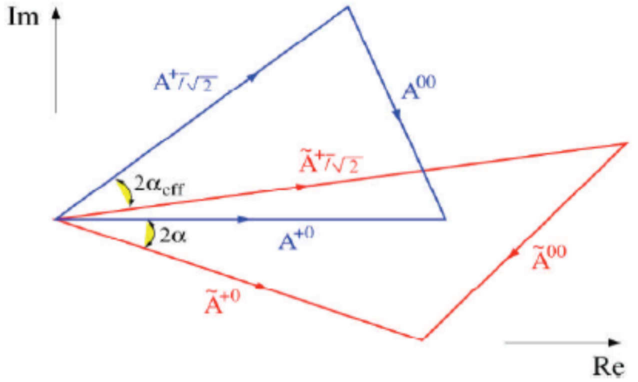
ϕ_2 or α

- Almost a precision measurement

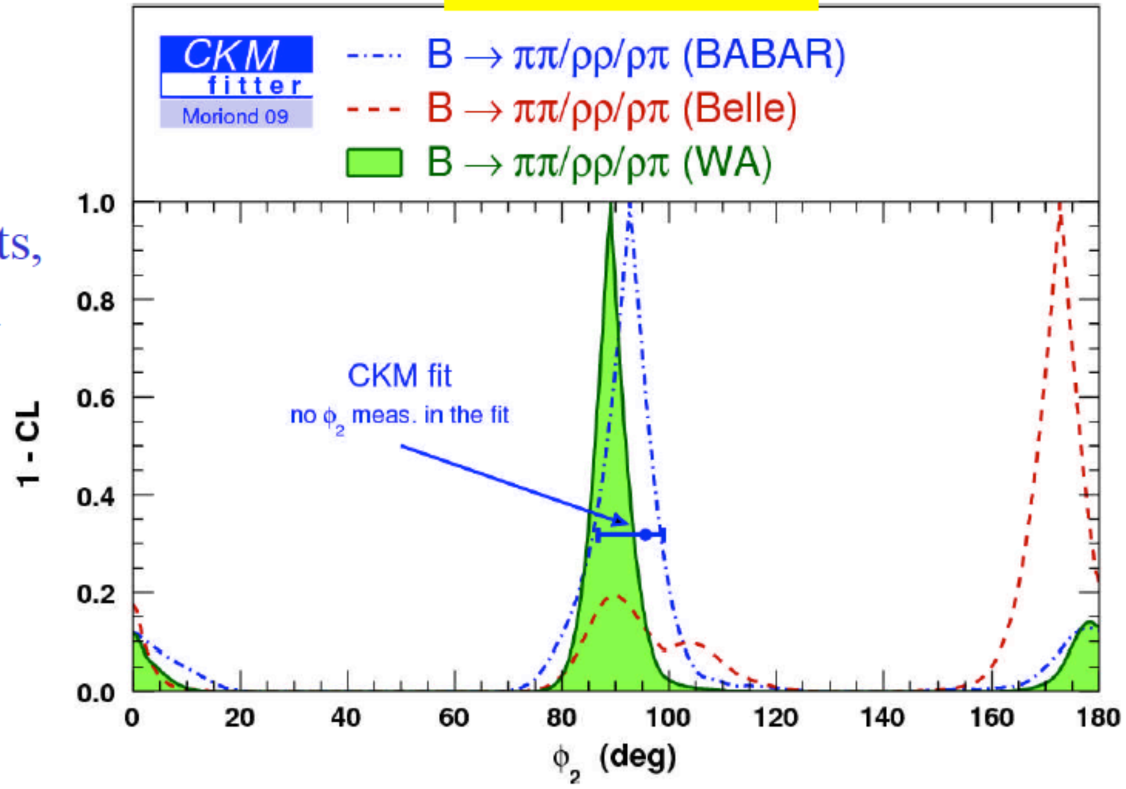
$$\phi_2 = \left(89.0^{+4.4}_{-4.2}\right)^\circ$$

- Dominated by the B→ρρ results, that rely on the isospin relation

Gronau & London, PRL 65 (1990) 3381



Current world-average



- New measured BF of $B^+ \to \rho^+\rho^0$ has stretched the base of the two isospin triangles, making them degenerate **PRL 102 (2009) 141802**

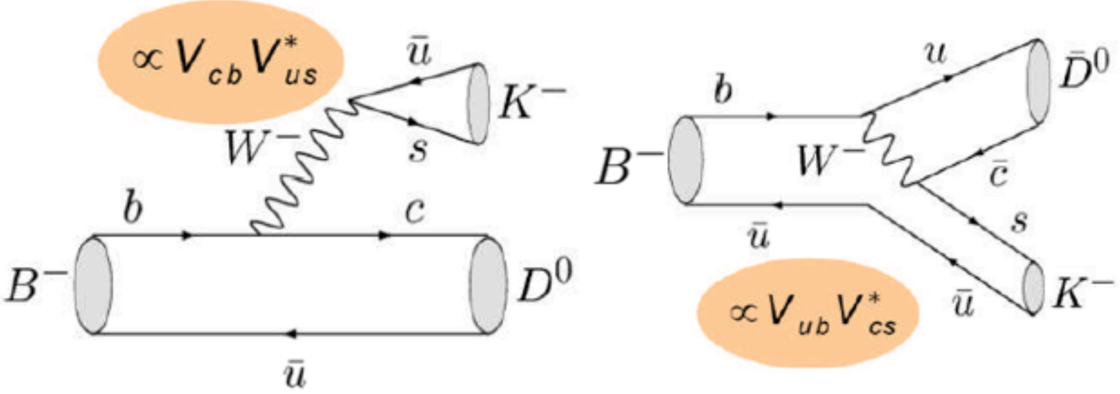
❖ Belle's final results on B→ρρ, especially $B^+ \to \rho^+\rho^0$, are eagerly awaited for

What about φ_3?

- Various methods proposed: **Gronau-London-Wyler** PLB 253 (1991) 483 PLB 265 (1991) 172

Atwood-Dunietz-Soni PRL 78 (1997) 3257 PRD 63 (2001) 036005 **Giri-Grossman-Soffer-Zupan** PRD 68 (2003) 054018

- Basic strategy is to exploit the interference between two contributing amplitudes

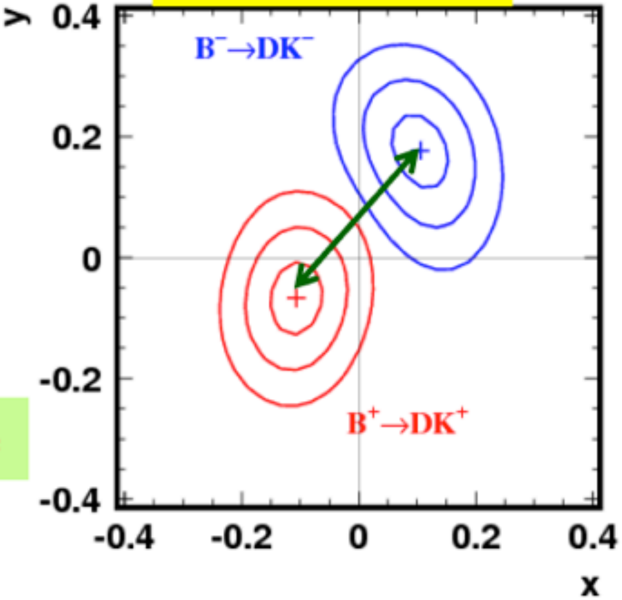


- Main bottle-neck: small signal
- Now, seems like beginning of an end?

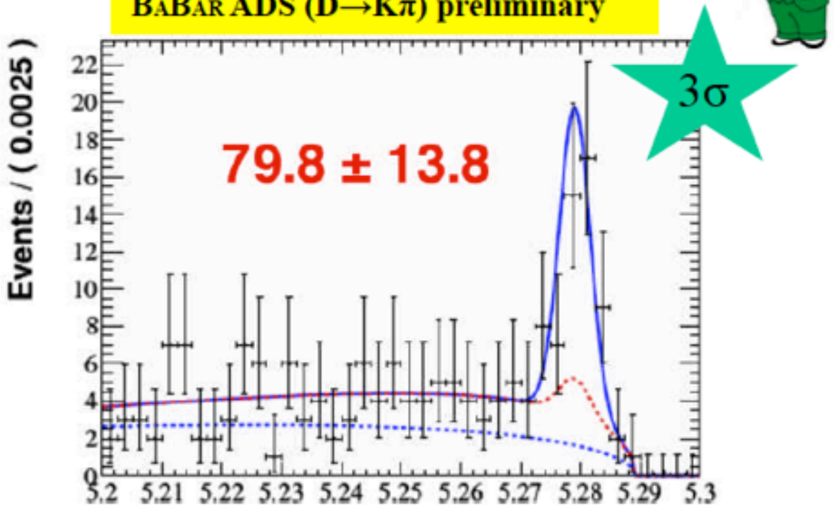
$x_\pm = r_\pm \cos(\pm\varphi_3 + \delta)$
$y_\pm = r_\pm \sin(\pm\varphi_3 + \delta)$,
r is the ratio of two amplitudes, δ is the strong phase diff. between them

3.5σ evidence

PRD 81 (2010) 112002

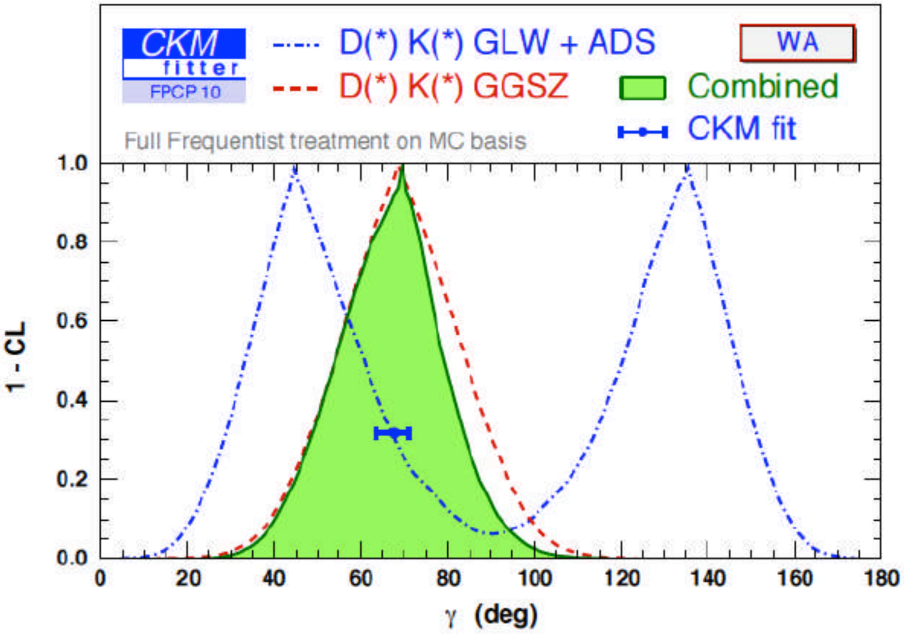


BABAR ADS (D→Kπ) preliminary

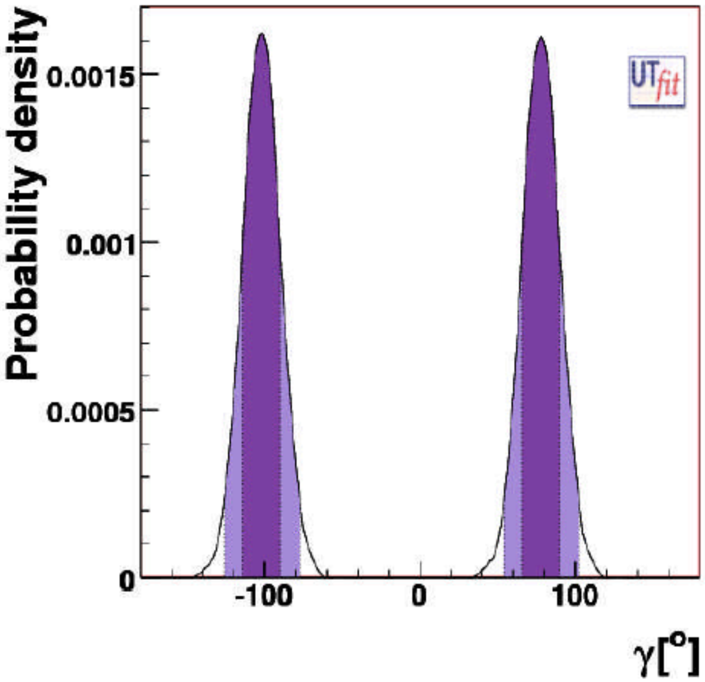


ϕ_3 or γ

Frequentist

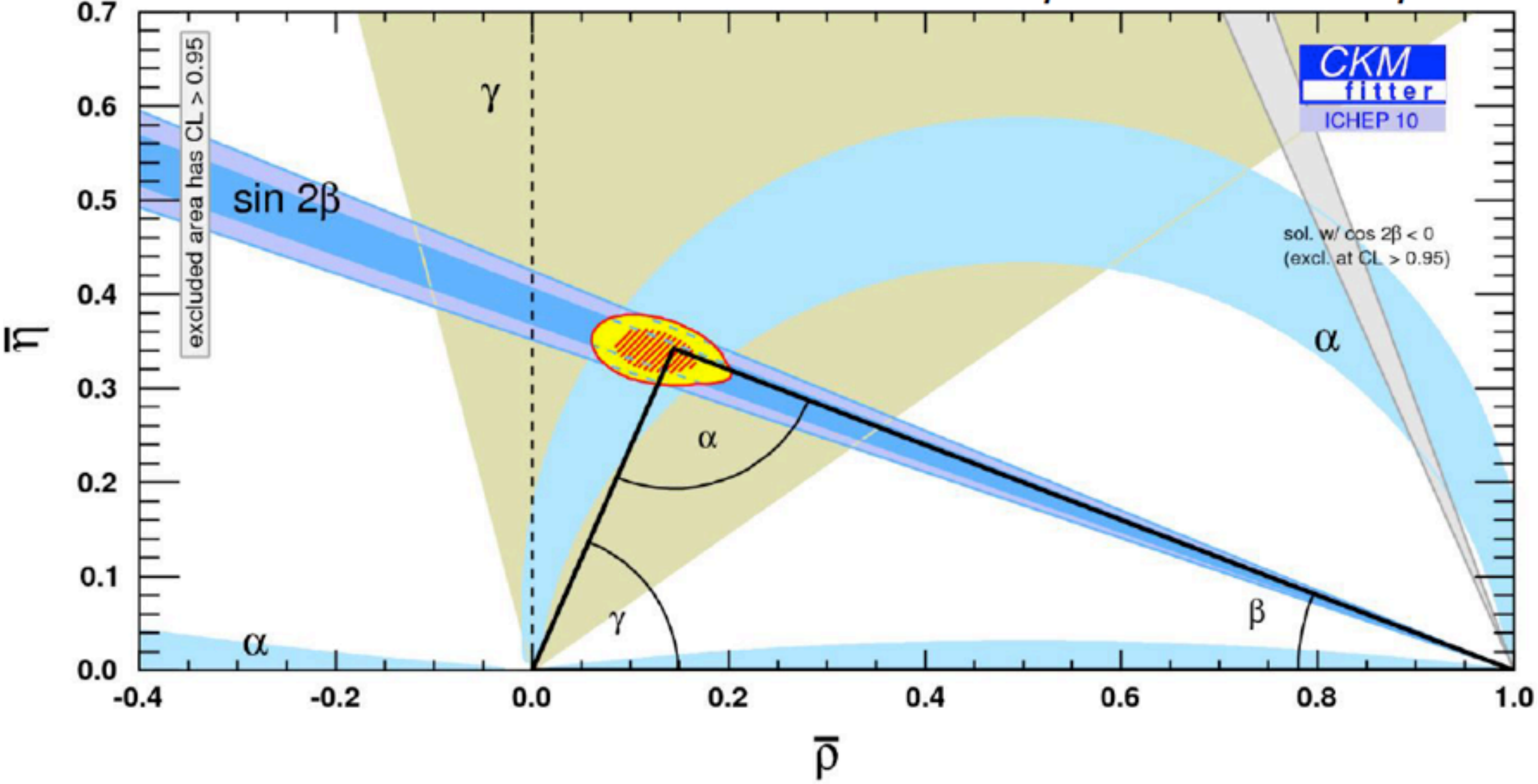


Bayesian



- Measurement: $\phi_3 = \left(70^{+14}_{-21}\right)^\circ$ frequentist vs. $\phi_3 = (74 \pm 11)^\circ$ Bayesian
- Fit prediction: $\phi_3 = \left(67.7^{+3.6}_{-4.1}\right)^\circ$ frequentist vs. $\phi_3 = (69.6 \pm 3.0)^\circ$ Bayesian

http://ckmfitter.in2p3.fr/



β $\beta = 21.1^o \pm 0.9^o \quad \sin 2\beta = 0.673 \pm 0.023 \quad (\pm 3.5\%)$

HFAG WA

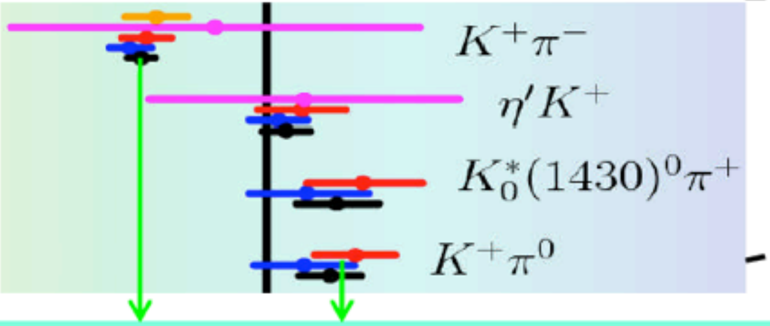
α $\alpha = (89^{+4.4}_{-4.2})^o$

γ $\gamma = (73^{+19}_{-24})^o_{CKMfit}$ or $\gamma = (74 \pm 11)^o_{UTfit}$ ← updated

$$21.1 + 89 + 73 = 183.1(\pm 10 - 20)$$

Direct CP violation

Nature 452 (2008) 332

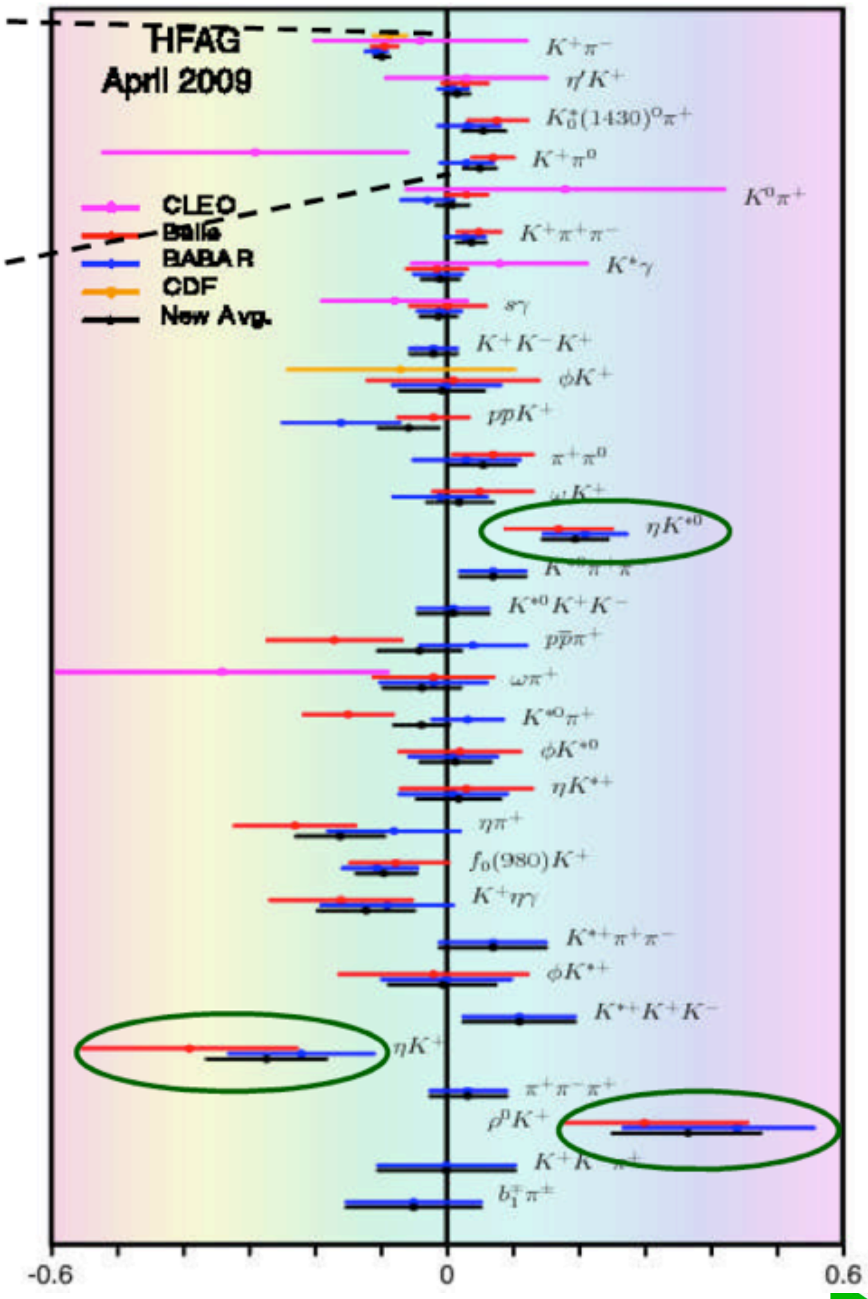


$\Delta A_{K\pi} = A_{CP}(K^+\pi^0) - A_{CP}(K^+\pi^-) = +0.144 \pm 0.029$

- ☐ Both decay channels occur via the same diagrams at tree level ➡ $\Delta A_{K\pi}$ should be zero
- ➢ Possible interpretation within the SM and with new physics
- ✓ Precise measurement of the $K^0\pi^0$ mode will be useful to check isospin relation

Gronau, PLB 627 (2005) 82

- ☐ Interesting ~3σ evidences found: $B^0 \to \eta K^{*0}$, $B^+ \to \eta K^+$ and $\rho^0 K^+$ (circled) $B^0 \to \rho^+\pi^-$ and $B^+ \to D^{(*)0}K^+$



$|V_{ub}|$ summary

Measurement	Experiment	V_{ub}
Inclusive	Belle	0.00441 ± 0.00024
Inclusive	*BABAR*	0.00431 ± 0.00035
Exclusive $\pi \ell \nu$	Belle	0.00343 ± 0.00033
Exclusive $\pi \ell \nu$	*BABAR*	0.00326 ± 0.00054

Longstanding inclusive/exclusive discrepancy remains.
For example, comparing Belle inclusive with
Belle exclusive the difference is 2.3σ

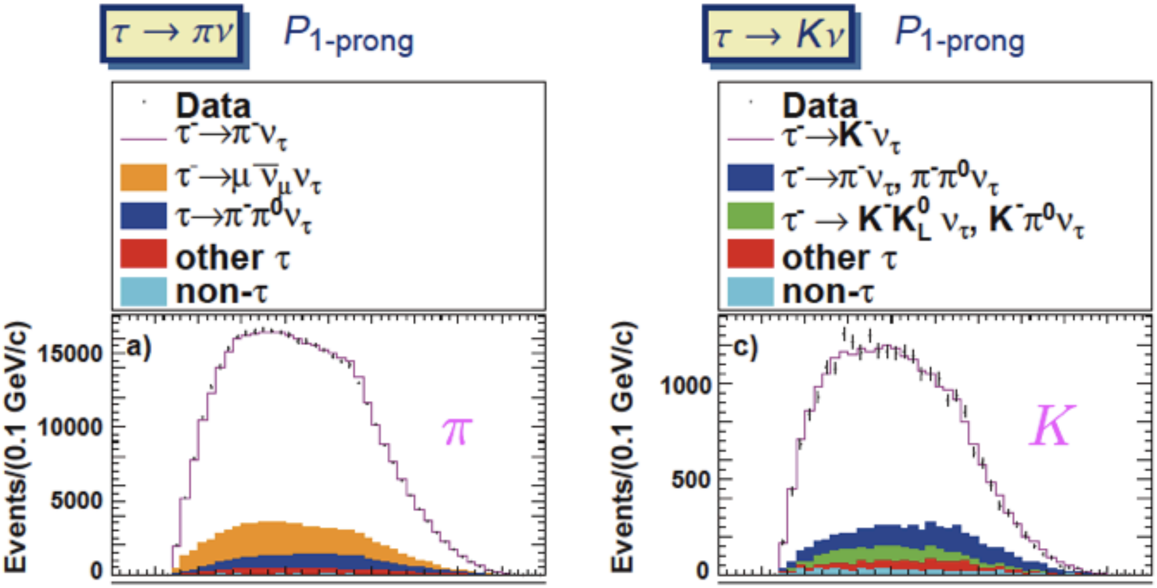
$|V_{us}|$ from tau decays

BABAR Measure in exclusive τ decays with 467 fb^{-1}

$$R_{K/\pi} \equiv \frac{\mathcal{B}(\tau^- \to K^- \nu_\tau)}{\mathcal{B}(\tau^- \to \pi^- \nu_\tau)}$$

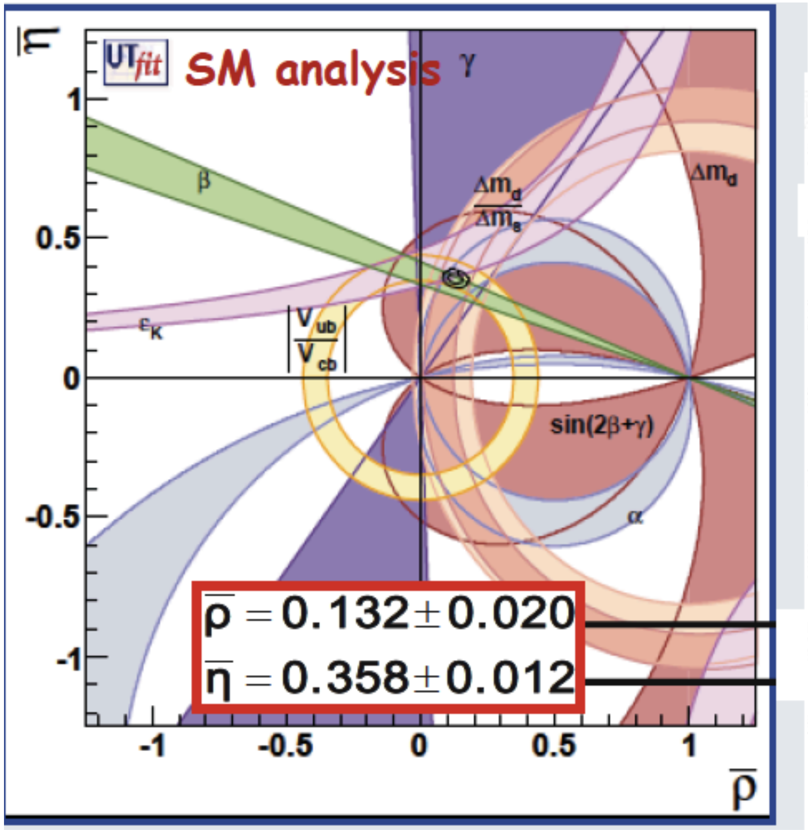
$$= 0.06531 \pm 0.00056 \pm 0.00093$$

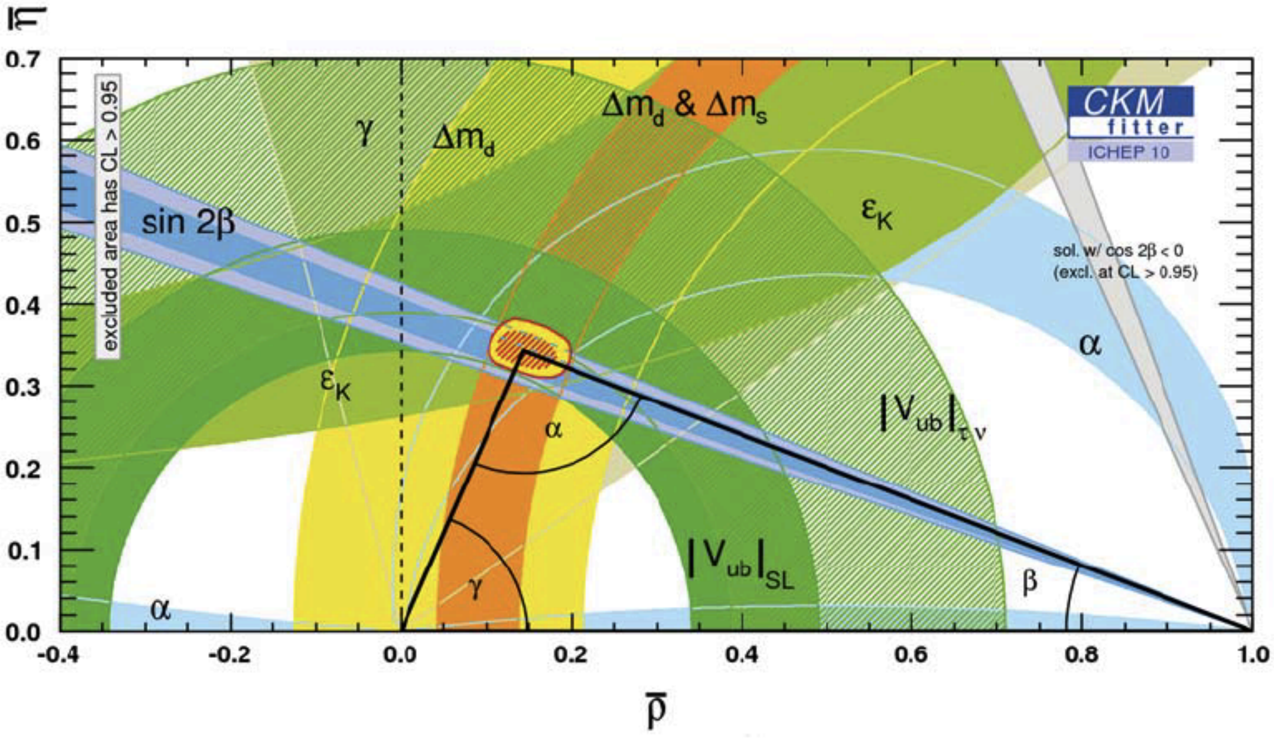
$$= \frac{f_K^2 |V_{us}|^2 \left(1 - \frac{m_K^2}{m_\tau^2}\right)^2}{f_\pi^2 |V_{ud}|^2 \left(1 - \frac{m_\pi^2}{m_\tau^2}\right)^2} (1 - \delta_{LD})$$



CM momentum of π or K (0 to 5 GeV)

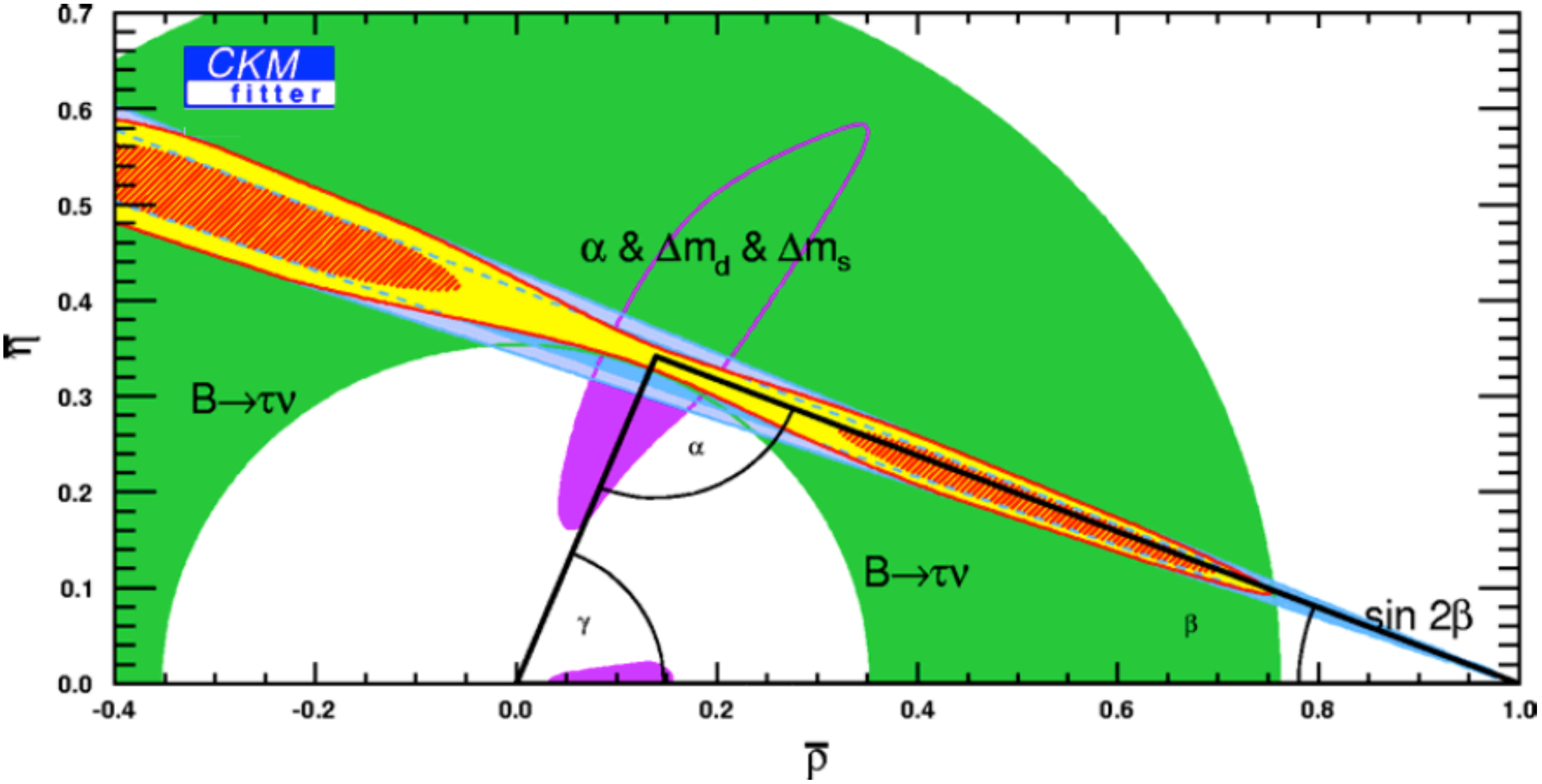
- Avoids absolute strange decay constant (f_K^2), replacing with ratio to pion. Use $f_K/f_\pi = 1.189 \pm 0.007$ and $\delta_{LD} = 0.0003 \pm 0.0044$
- Result is: $|V_{us}| = 0.2255 \pm 0.0024$





Both UTfit and CKMfitter identify $\sin 2\beta$ ($2.6\sigma/2.6\sigma$) and $\mathcal{B}(B \to \tau\nu)$ ($3.2\sigma/2.8\sigma$) as areas of discrepancy. Global consistency from CKMfitter at 2σ

$\sin(2\beta)$ and $B^+ \to \tau\nu$ vs CKM



Stephane T'Jampens for CKMfitter group, ICHEP 2010: "The combination $\sin(2\beta)$ and $B \to \tau\nu$ favors 2 solutions in contradiction with the other inputs. One cannot accommodate both inputs simultaneously in the global fit... The global fit is accommodated keeping $f_{Bd}^2 \times B_{Bd}$ constant while increasing f_{Bd} to fit $B \to \tau\nu$."

Other New Physics Constraints

A Very Incomplete Sampling

- Rare B-decays
  - $B \to \tau\nu$ already mentioned (& T.M. parallel)
  - M. Margoni parallel: $B \to X_{s,d}\gamma$ & $B \to X_{s,d}\ell^+\ell^-$
- Neus Lopez-March parallel: light scalar search in Υ(nS)
- Rare tau and charm decays
- Unexpected charming mesons

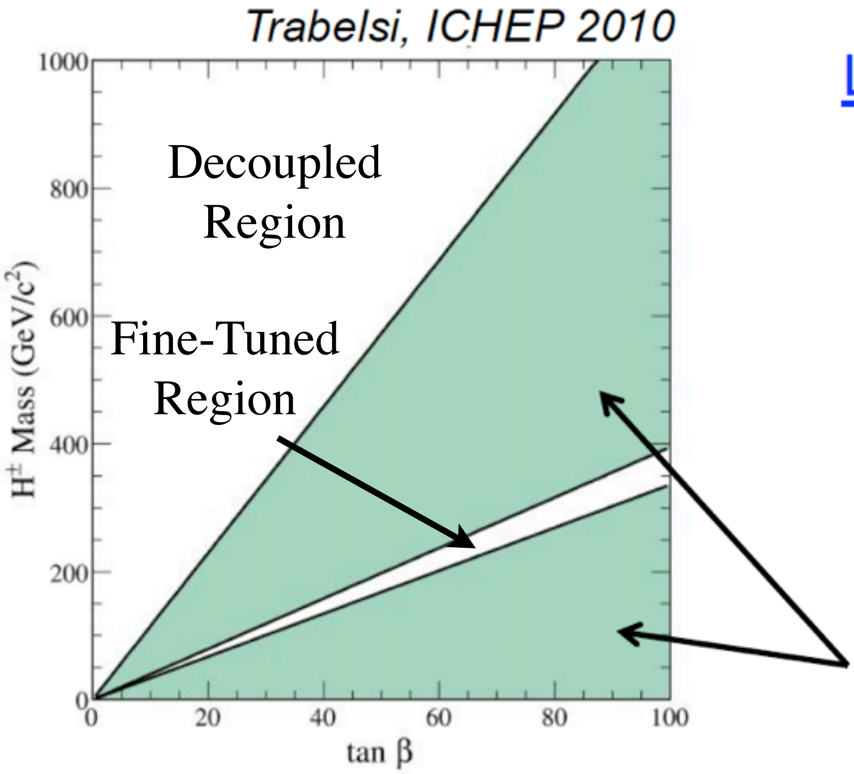
Charged Higgs Limit from $B \to \tau\nu$

Average $\mathcal{B}(B \to \tau\nu) = (1.68 \pm 0.31) \times 10^{-4}$

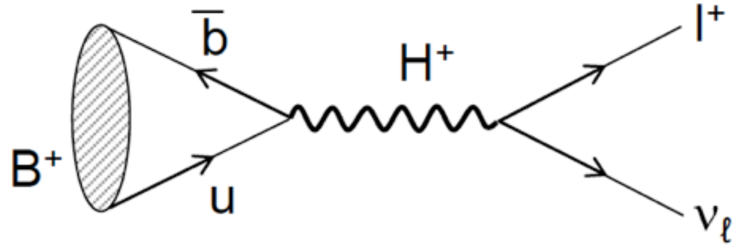
Theory $\mathcal{B}(B \to \tau\nu) = (1.20 \pm 0.25) \times 10^{-4}$

using f_B (HPQCD), $|V_{ub}|$ incl. HFAG

Trabelsi, ICHEP 2010



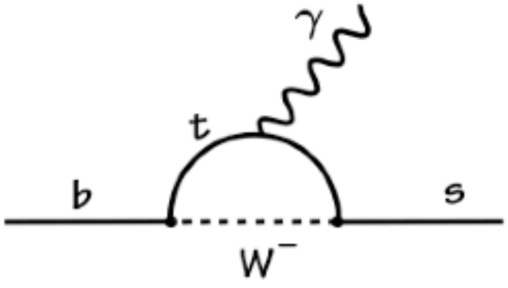
Limits on charged Higgs (2HDM II)

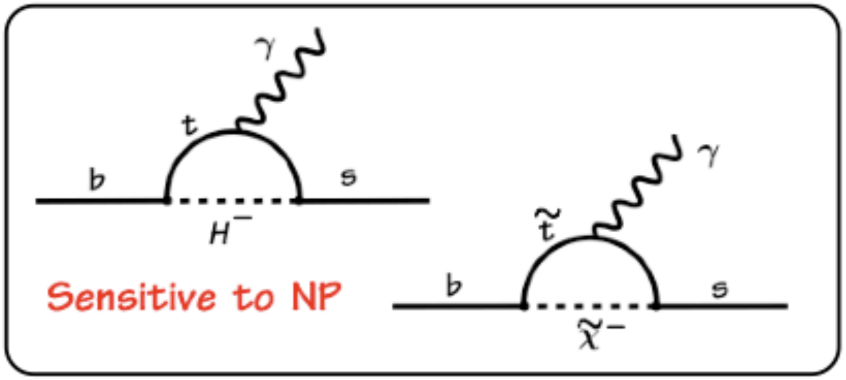


$$\mathcal{B}(B \to \tau\nu) = \mathcal{B}_{SM} \times \left(1 - \frac{m_B^2}{m_{H^+}^2} \tan^2\beta\right)^2$$

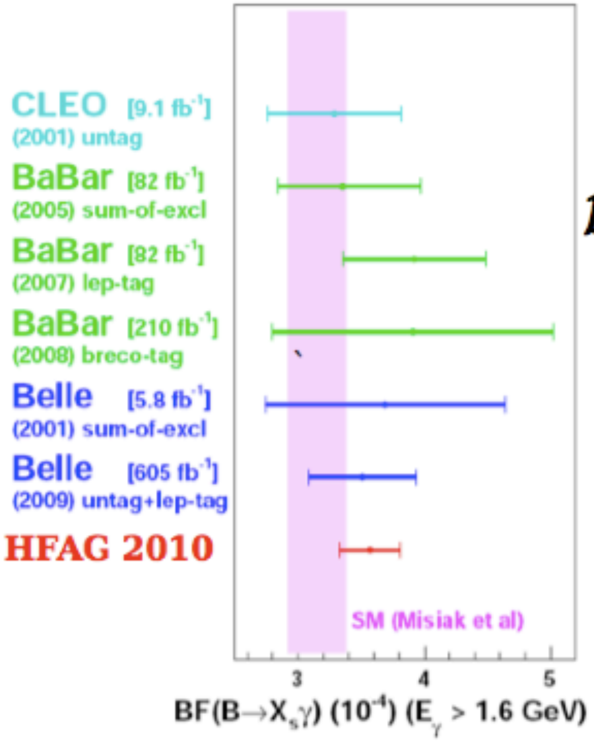
excluded at 95% CL

$B \to X_s\gamma$





Sensitive to NP



SM Prediction (Misiak):

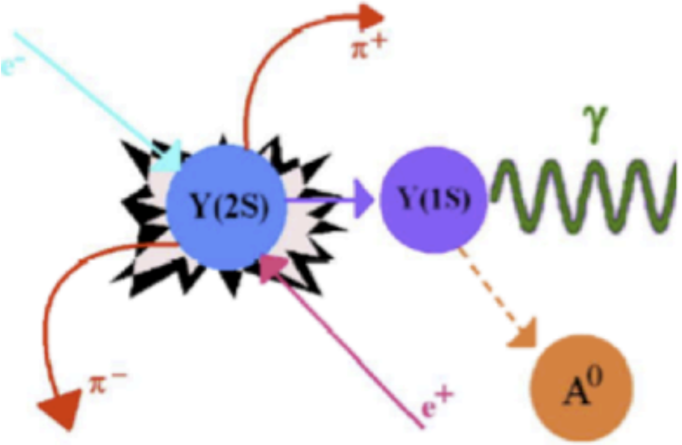
$\mathcal{B}_{SM}(B\to X_s\gamma)=(3.15\pm0.23)\times10^{-4}$

HFAG Average:

$\mathcal{B}(B\to X_s\gamma)=(3.55\pm0.26)\times10^{-4}$

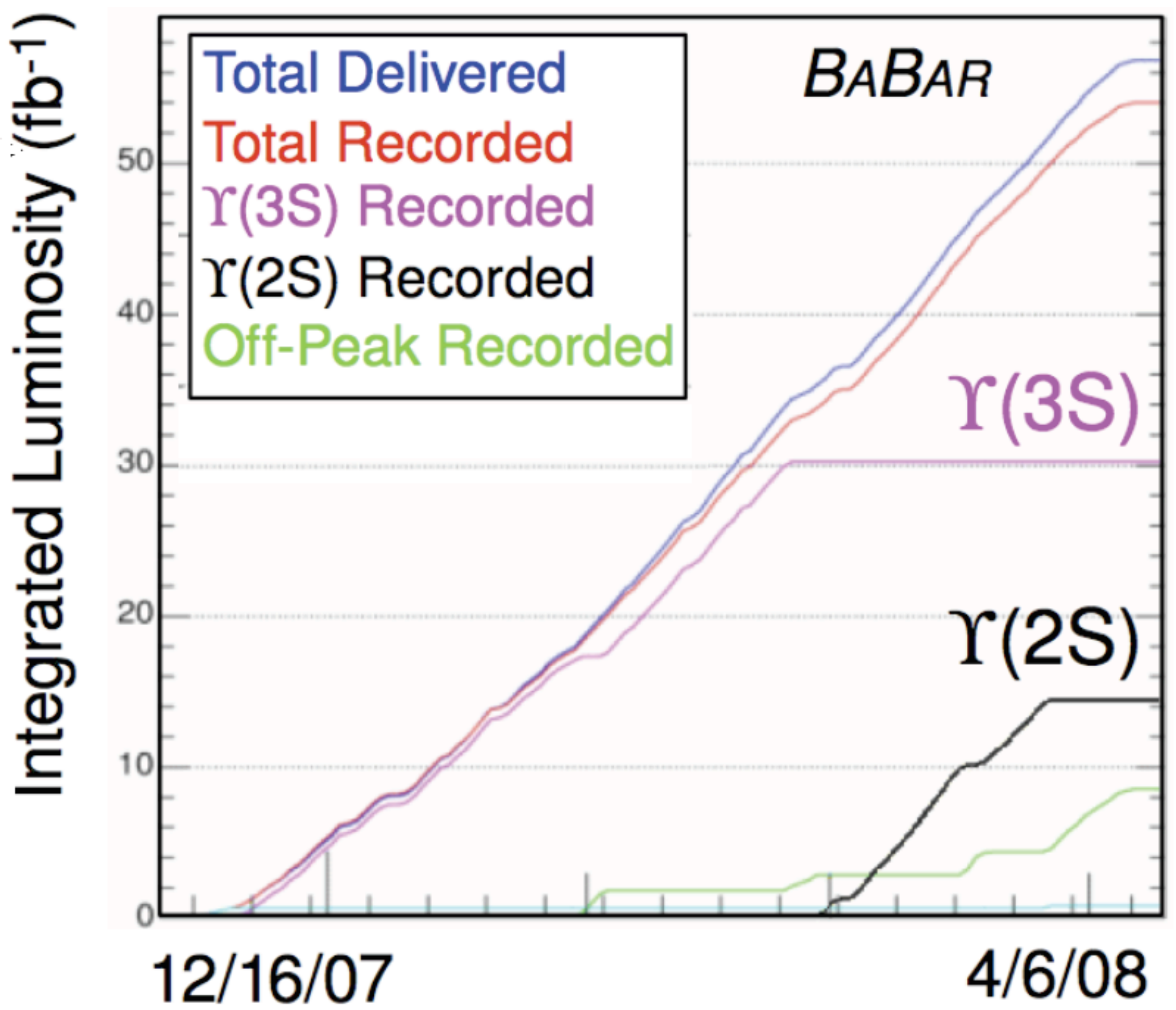
...all for $E(\gamma)>1.6$GeV

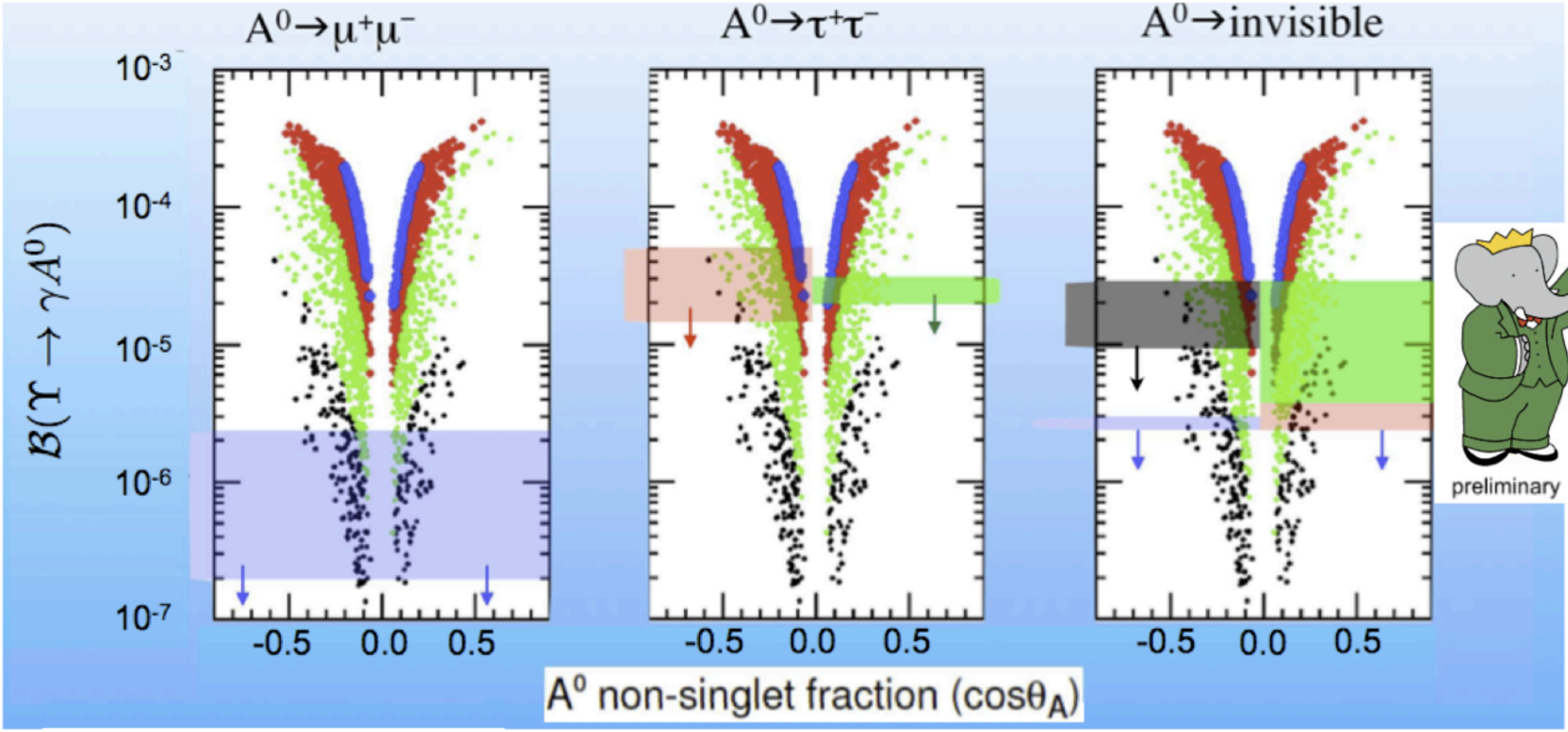
$\Upsilon(nS) \rightarrow \gamma$+Exotic!



- With the unprecedented number of Upsilon events, we can search for exotic particles directly produced in the decay.

- BaBar has performed searches in:
  - $\Upsilon(2,3S) \rightarrow \gamma\mu^+\mu^-$, $\Upsilon(3s) \rightarrow \gamma\tau^+\tau^-$
    - look for a peak in $m(l^+l^-)$ spectrum
  - $\Upsilon(3S) \rightarrow \gamma$+Invisible
    - look for peak in the "missing mass"
  - $\Upsilon(2S) \rightarrow \pi^+\pi^-\Upsilon(1S)$, $\Upsilon(1S) \rightarrow \gamma$+Invisible
    - missing mass + recoil mass
- Searches are sensitive to things like: light pseudoscalar Higgs, light DM, or heavy photon decays.


Integrated Luminosity (fb^{-1})
0
10
20
30
40
50
Total Delivered
Total Recorded
Υ(3S) Recorded
Υ(2S) Recorded
Off-Peak Recorded
BABAR
Υ(3S)
Υ(2S)
12/16/07
4/6/08



$m_{A0} < 2m_\tau$

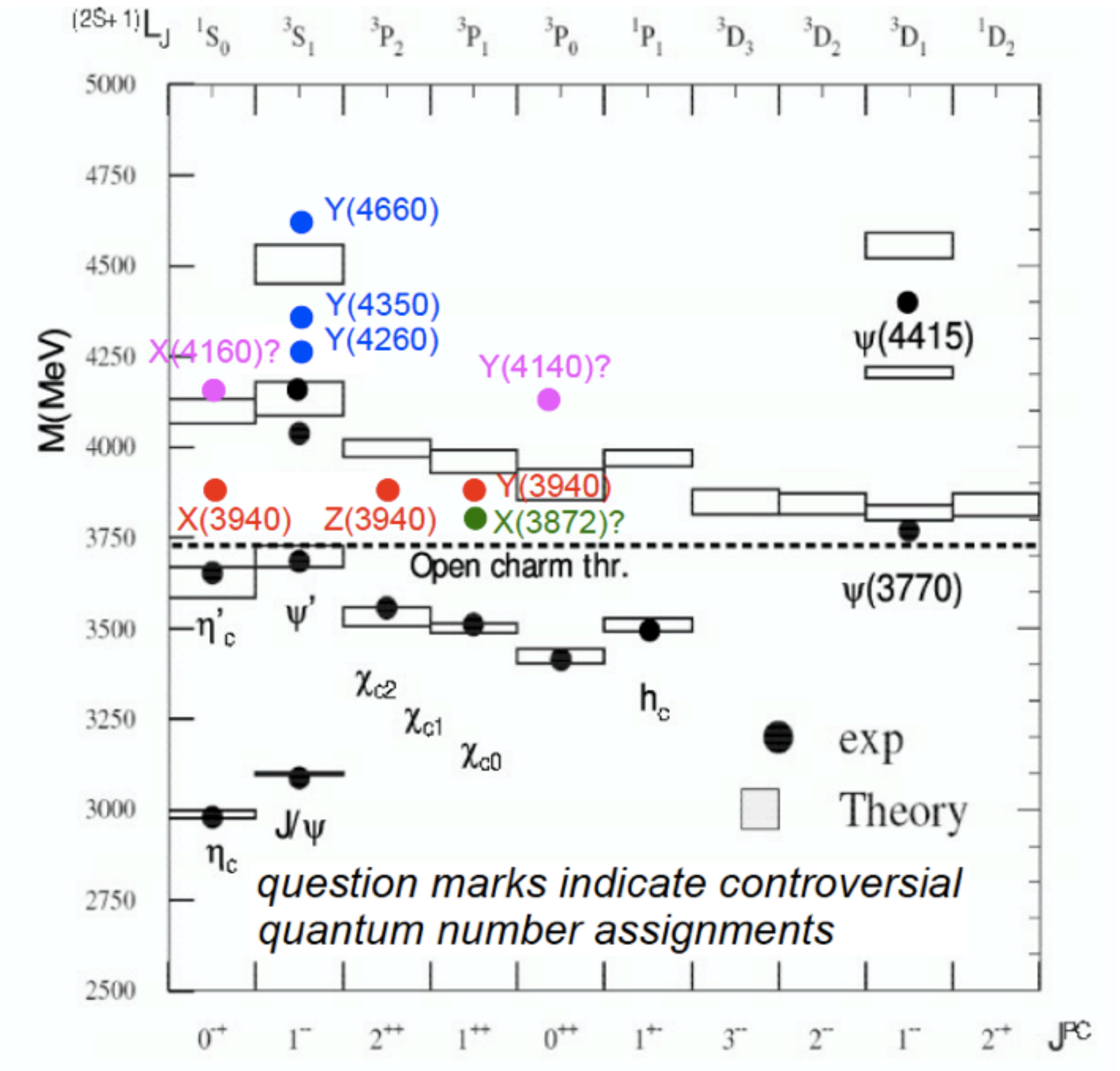
$2m_\tau < m_{A0} < 7.5$ GeV

7.5 GeV $< m_{A0} < 8.8$ GeV

8.8 GeV $< m_{A0} < 9.2$ GeV

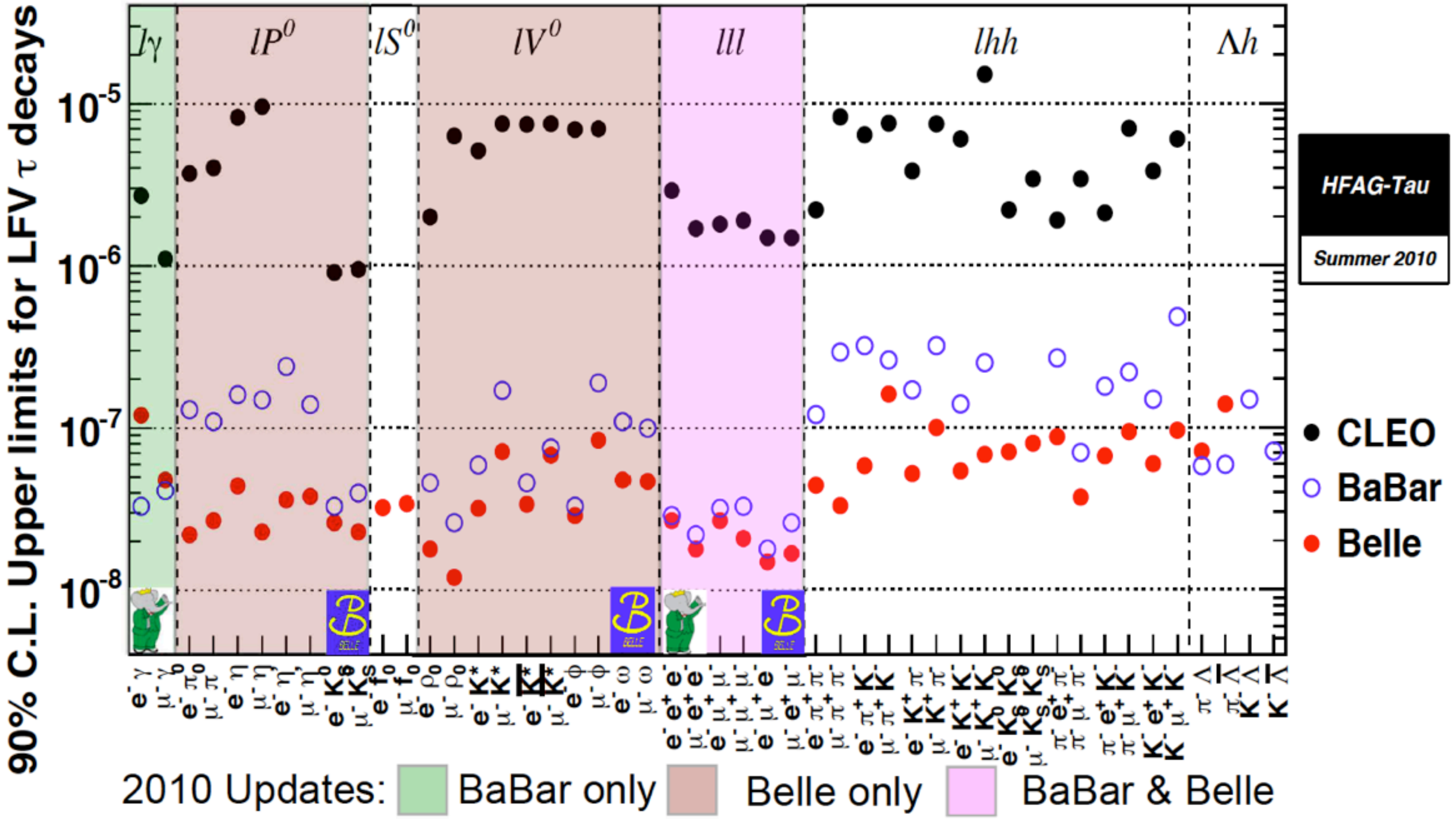
Several states do not fit well in the standard charmonium scheme:

- masses far from predictions;
- too narrow;
- non-standard decay modes;



question marks indicate controversial quantum number assignments

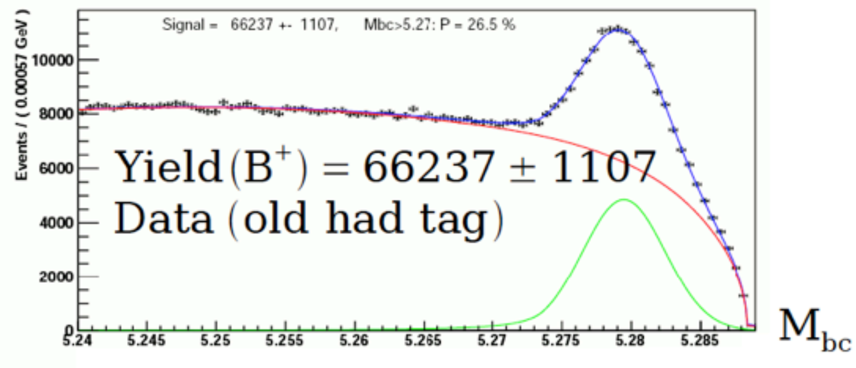
Summary of LFV in τ decays



BaBar: ''Two years after the end of the data taking, BaBar continues to exploit its rich dataset, more results will be coming...'' (Alessandro Gaz)

Belle:

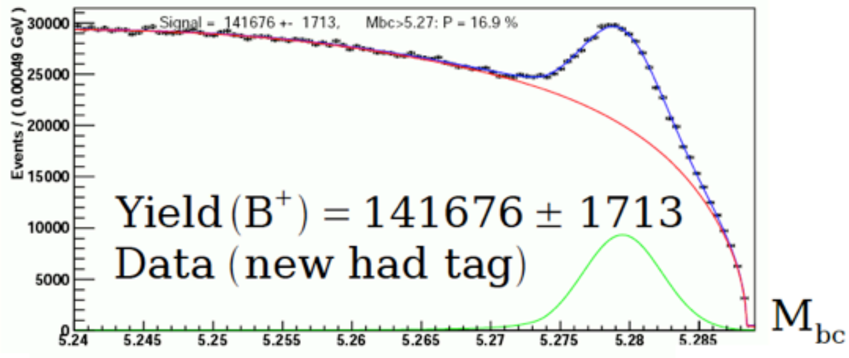
- reprocessed data sample with improved tracking efficiency
- none of the results shown for rare B decays use full data sample yet
- hadronic tag efficiency improved: effective luminosity improved by factor ~ ×2



$\mathrm{Yield}(B^+) = 66237 \pm 1107$

Data (old had tag)

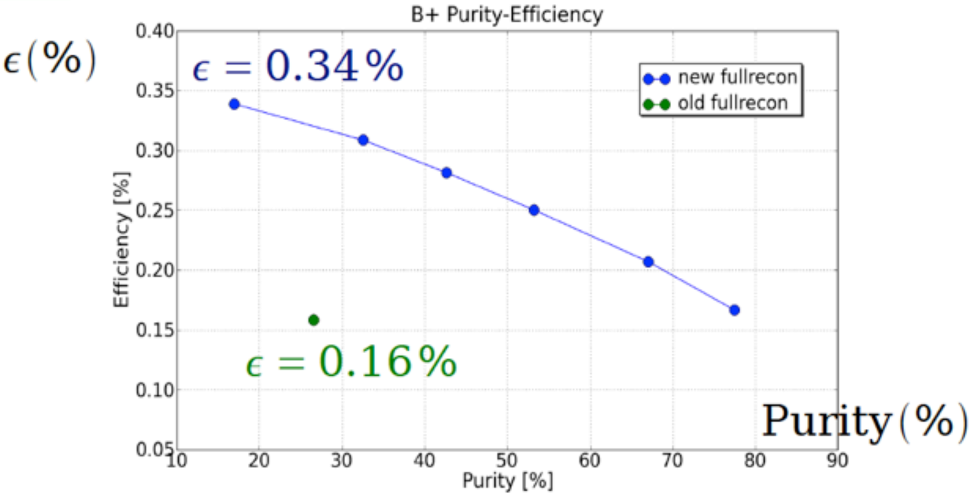
M_{bc}



$\mathrm{Yield}(B^+) = 141676 \pm 1713$

Data (new had tag)

M_{bc}



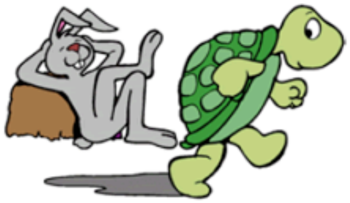
$\epsilon(\%)$

$\epsilon = 0.34\,\%$

$\epsilon = 0.16\,\%$

Purity (%)

⇒ new results coming soon !



The Future

B-Factories: The Sequels

- Many measurements are still statistics-limited, and many systematics can be reduced by larger control samples
- Some measurements could be done in new ways with lower systematics if sufficient statistics were available
- Discoveries at LHC are likely to have multiple possible explanations; precision low-energy experiments are likely to be useful in deciding which is right
- Both the KEKB/BELLE and PEP-II/BaBar communities are pursuing next-generation accelerators and detectors

Can It Be Done?

- PEP-II and KEK-B had fairly conservative parameters, except the number of bunches was much higher than in previous machines, and KEK-B's crossing-angle.
- RF power, beam instabilities, vacuum problems, and machine-induced backgrounds make it hard to imagine further increases in beam current.
- Stronger focusing is technically possible, but was thought to require short bunches not feasible in a storage ring
- P. Raimondi's "crab-waist" scheme combined with a large crossing angle circumvents this, allowing far higher luminosity with currents no higher than PEP-II or KEK-B.

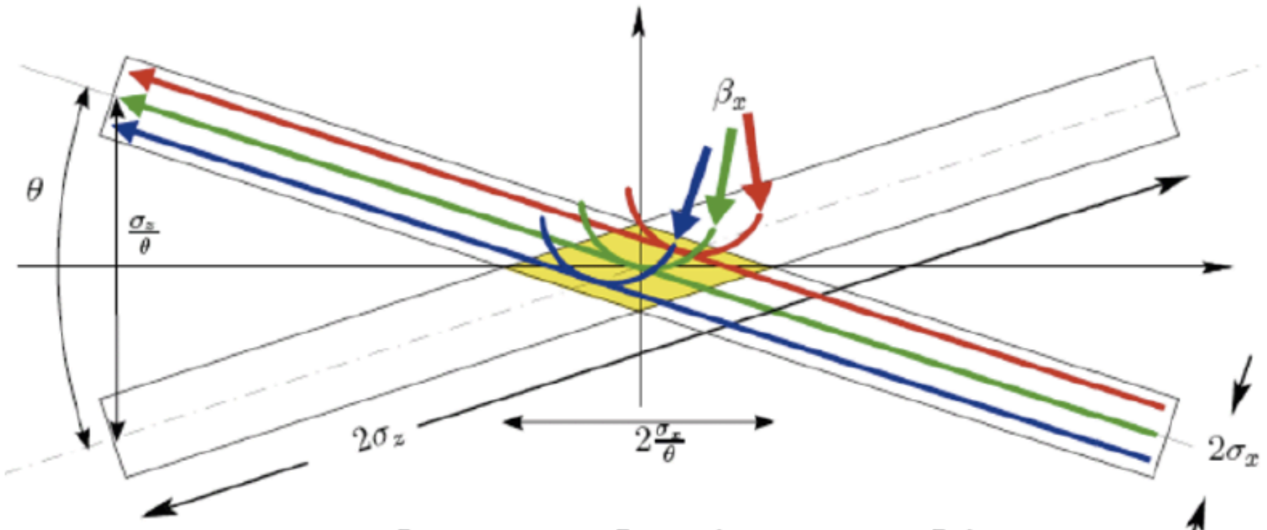
Crossing angle IR with large angle (DAFNE,KEKB)

Crab waist scheme (Frascati, DAFNE)

Very low IR vertical and horizontal beta functions (ILC)

Low horizontal and vertical emittances (Light sources)

Ampere beam currents (PEP-II, KEKB)

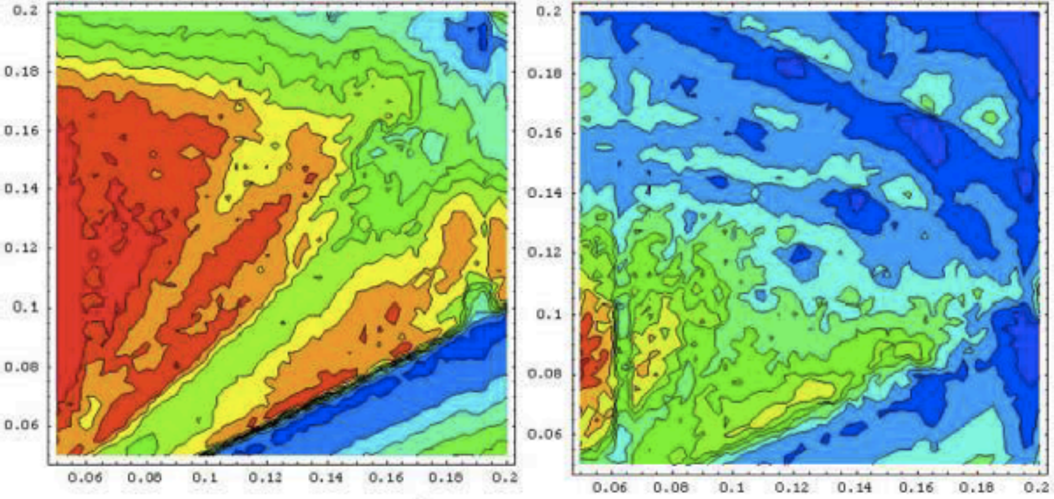


crab waist idea (Raimondi)

crab waist test at Dafne

luminosity scan in the tunes plane performed for DAFNE in the Siddharta configuration

Red: max. luminosity **Blue**: minimum



Crab ON → $0.6/\theta$

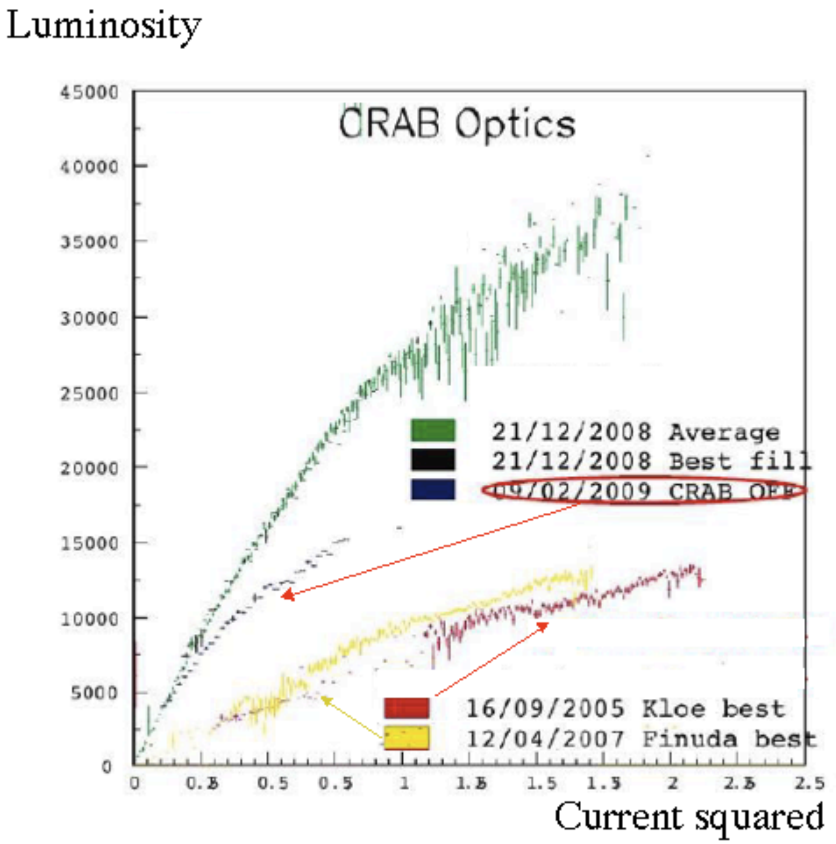
$L_{max} = 2.97 \times 10^{33}\ cm^{-2}s^{-1}$

$L_{min} = 2.52 \times 10^{32}\ cm^{-2}s^{-1}$

Crab OFF

$L_{max} = 1.74 \times 10^{33}\ cm^{-2}s^{-1}$

$L_{min} = 2.78 \times 10^{31}\ cm^{-2}s^{-1}$



with the crab waist:

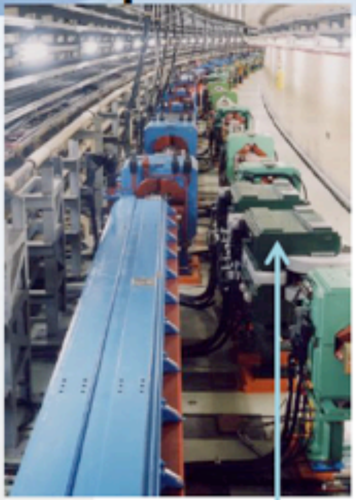
- many X-Y betatron resonances disappear or become weaker
- good working area is significantly enlarged (→ larger integrated luminosity)

When the crab waist is turned off:

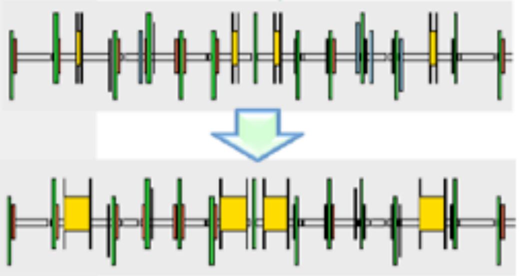
- beam size increases
- luminosity drops down

SuperKEKB collider

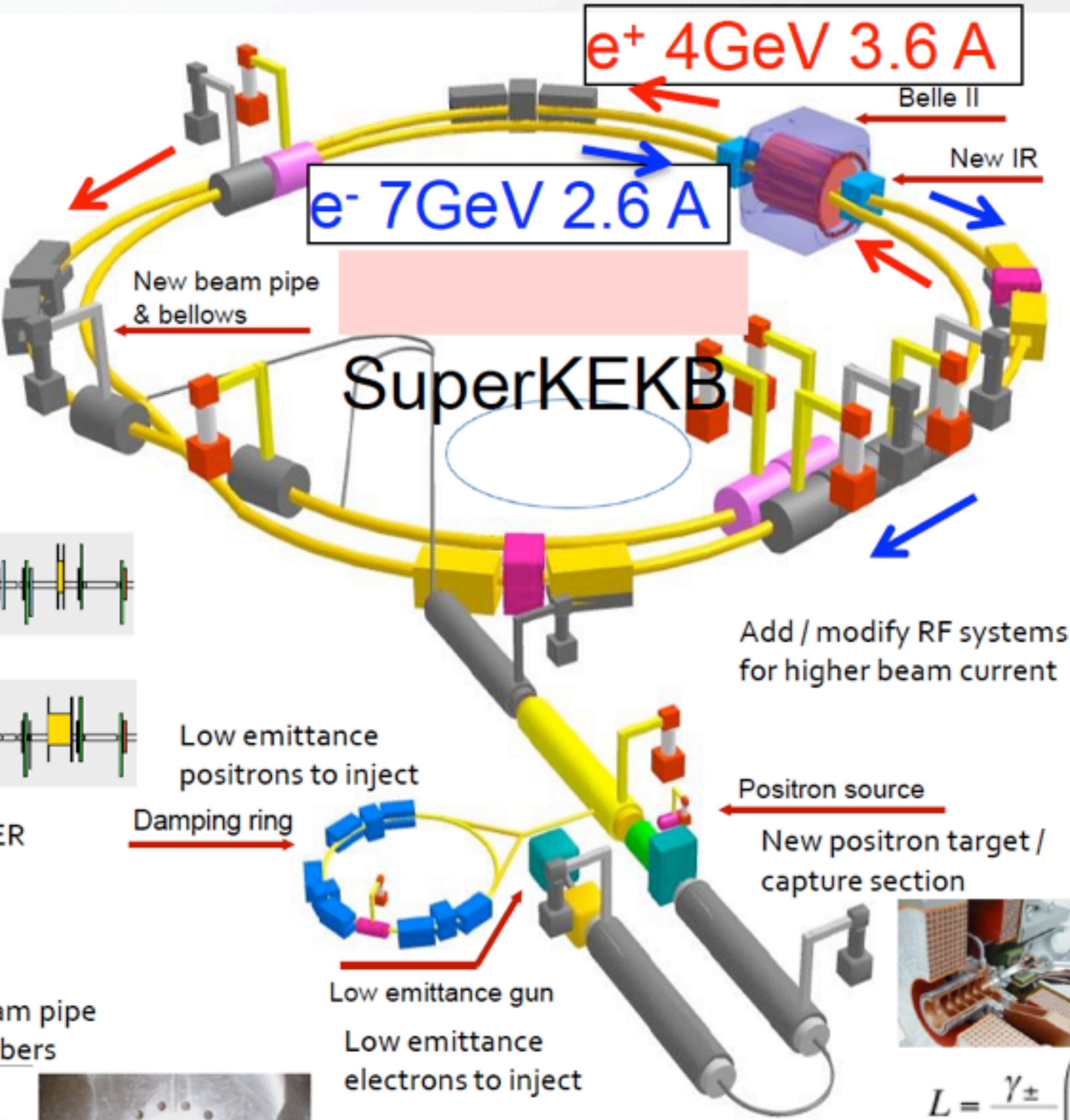
Contribution ID: 561
The SuperKEKB accelerator status



Replace short dipoles with longer ones (LER)

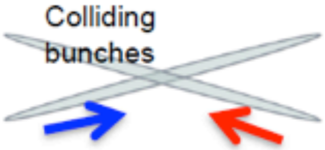


Redesign the lattices of HER & LER to squeeze the emittance

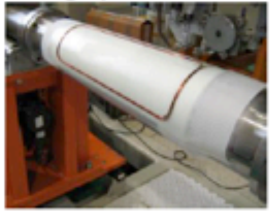


Add / modify RF systems for higher beam current

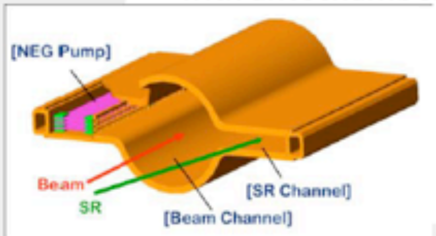
New positron target / capture section

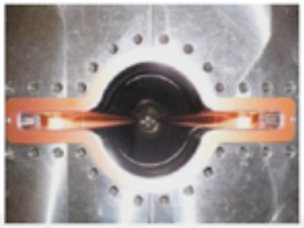


New superconducting /permanent final focusing quads near the IP



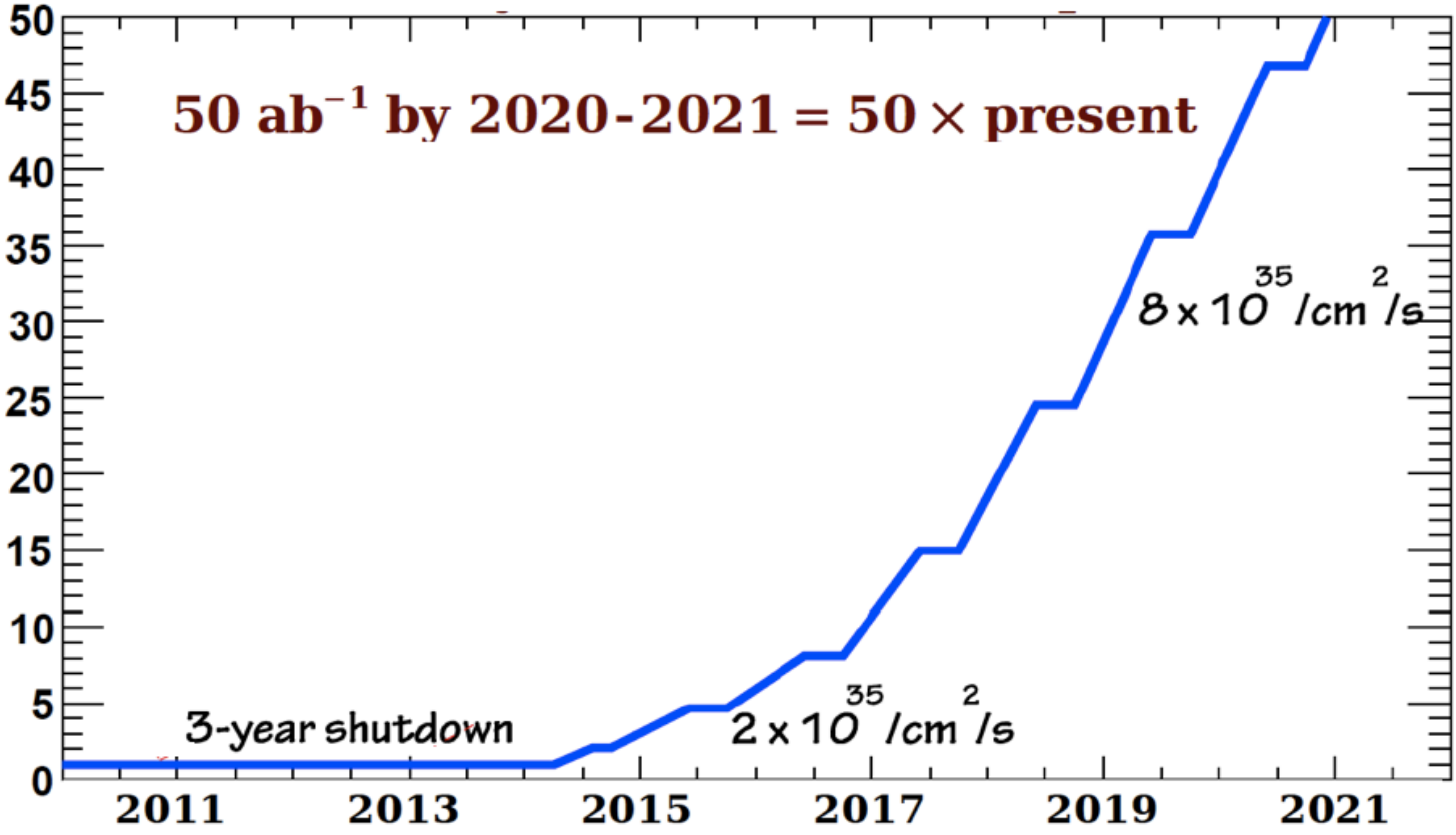
TiN-coated beam pipe with antechambers





$$L = \frac{\gamma_{\pm}}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\boxed{\frac{I_{\pm}\xi_{\pm y}}{\beta_y^*}}\left(\frac{R_L}{R_y}\right)$$

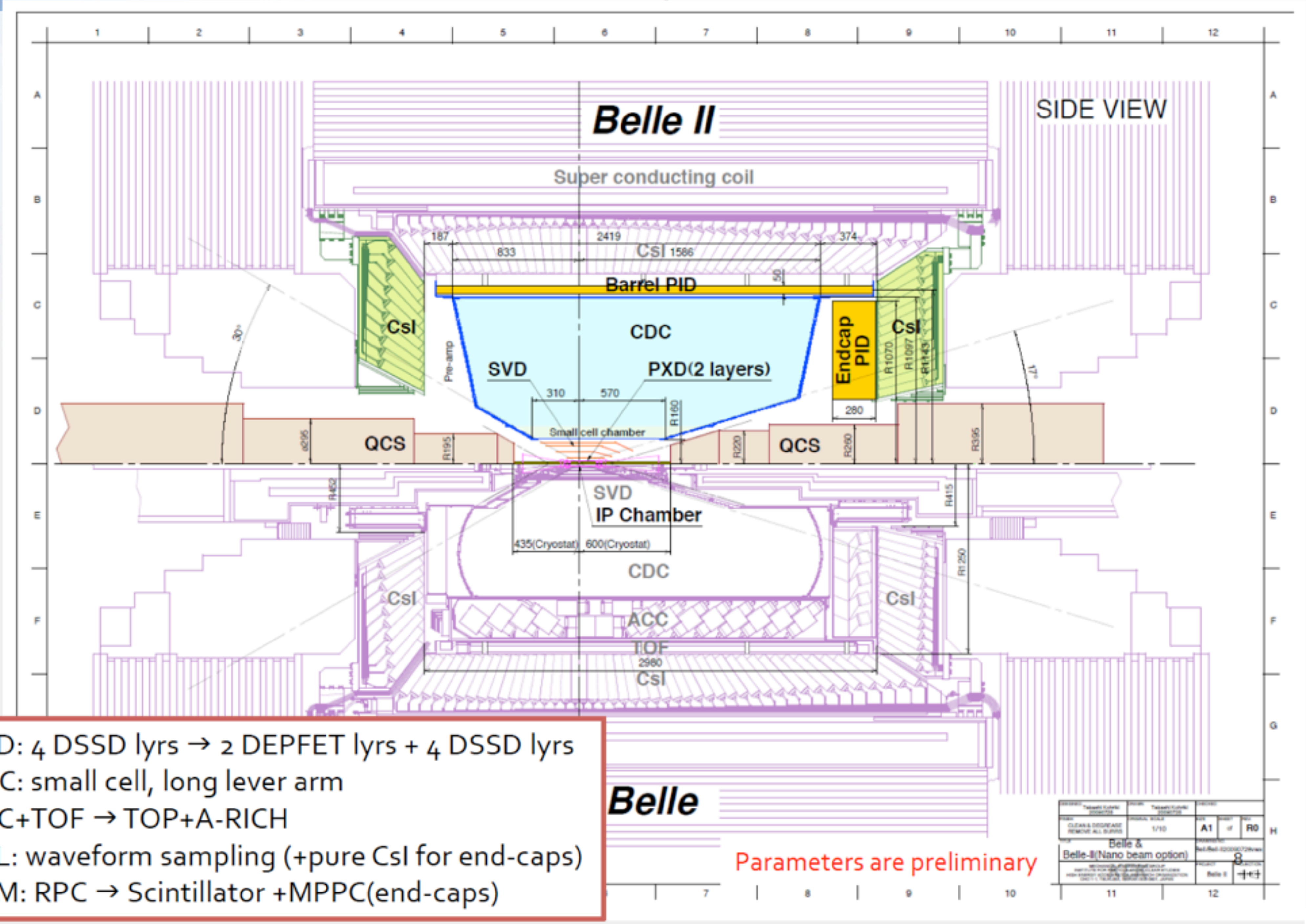
Target: L = $8\times10^{35}/\text{cm}^2/\text{s}$



KEKB upgrade has been approved*

100 oku yen(88.6M euros)FY 2010-2012

Belle II Detector (in comparison with Belle)



SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling (+pure CsI for end-caps)
KLM: RPC → Scintillator +MPPC(end-caps)

Parameters are preliminary

SuperB in Italy

- Frascati Laboratory proposes to host a SuperB machine in Italy
- SLAC and US DOE have pledged PEP-II machine components and BaBar detector components
- Sites have been identified, local support has been good, and national support also seems to be good, but project is not completely approved (yet).

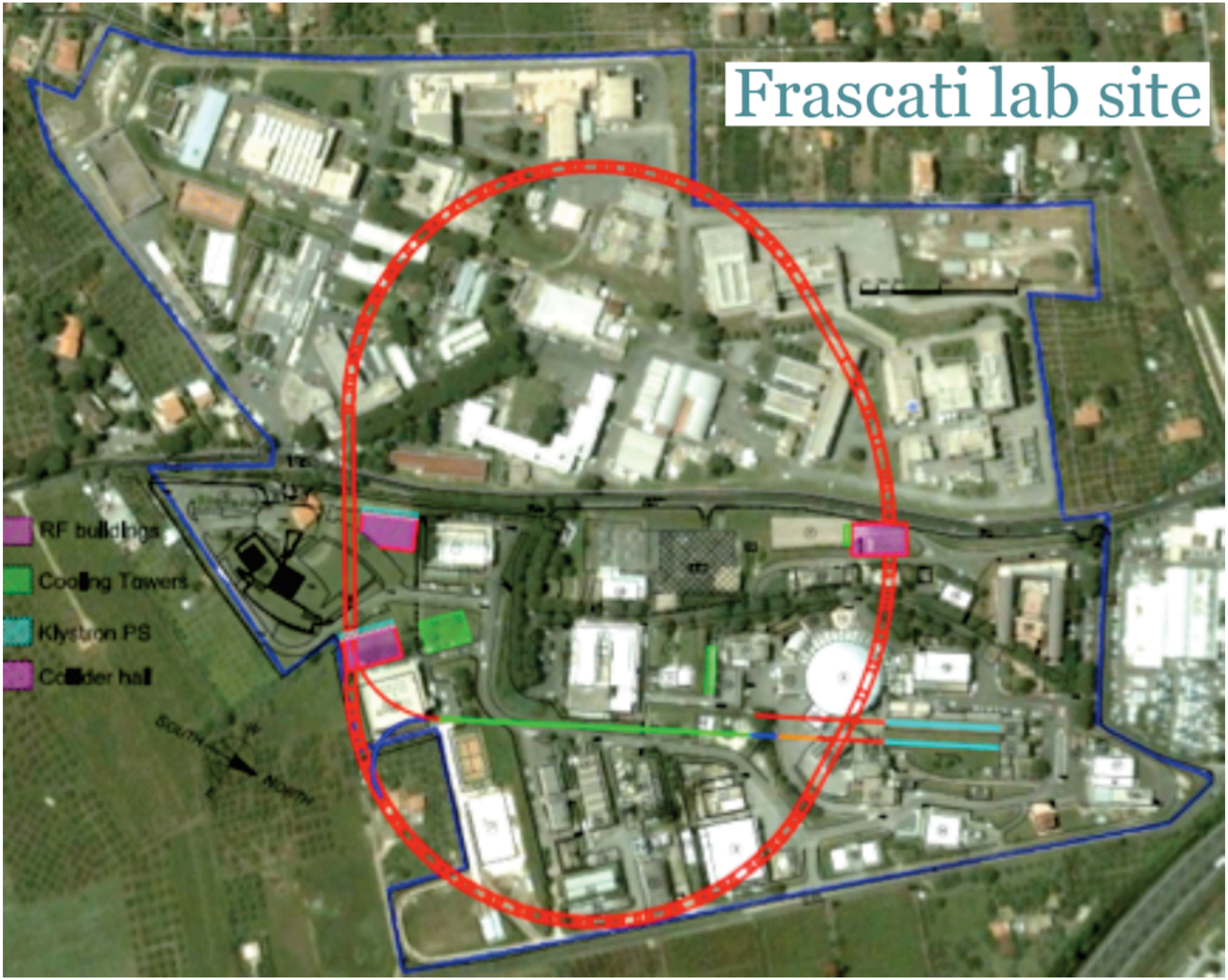
The TDR phase has started. The detector and machine TDR are currently expected to be released in 2011

- MoU signed between INFN and France, Russia (BINP) and US (SLAC). Letter of commitment from Canada (IPP)

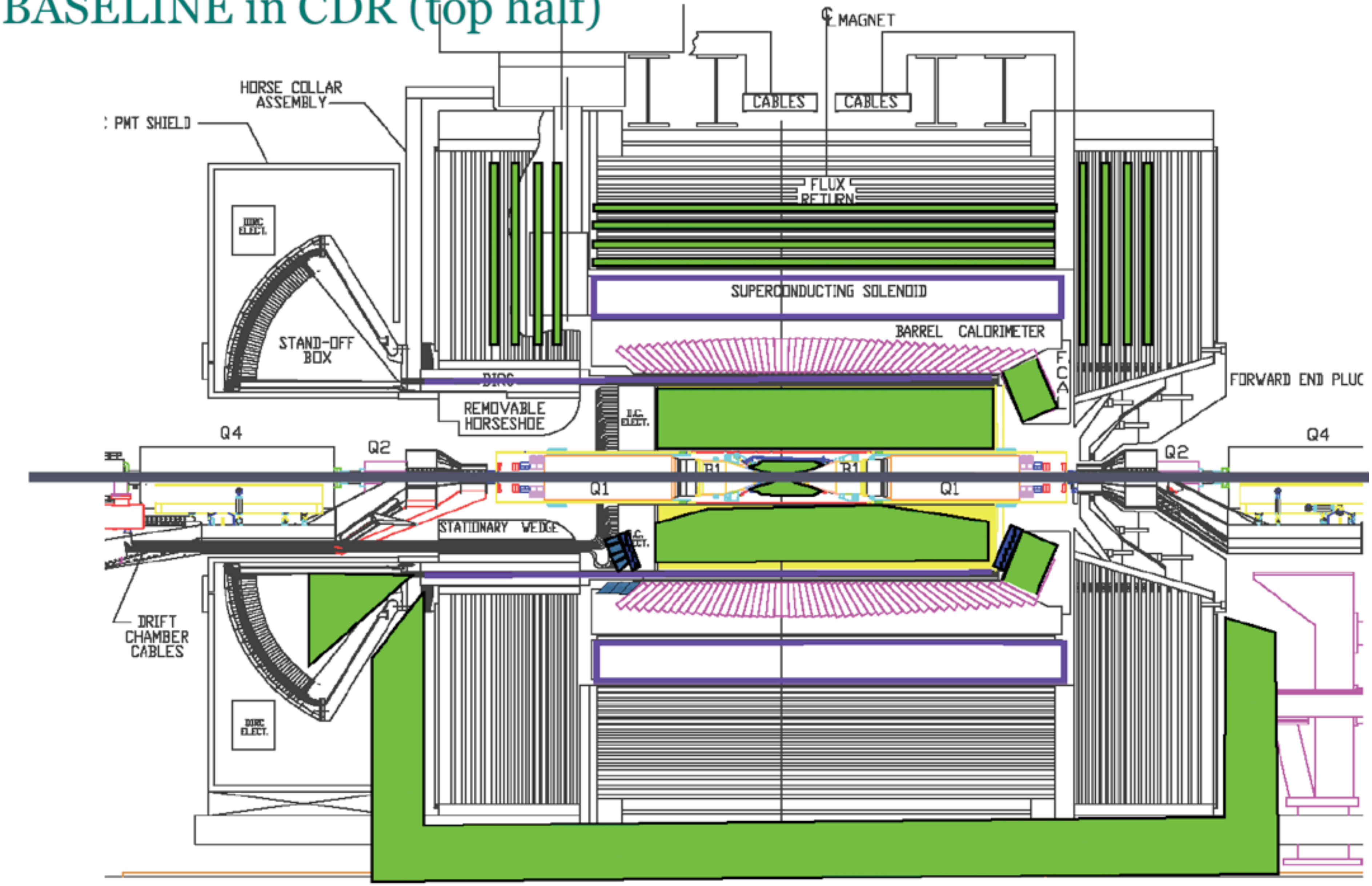
The Italian Minister of Research has presented the project to the Italian Government. The project is inserted as flagship project in the Italian National Research Plan 2010-2012. Government decision expected soon

Joint agreement of mutual financial support of a fusion research reactor (IGNITOR) in Russia and the SuperB project in Italy signed by Prime Ministers Berlusconi and Putin.

Frascati lab site



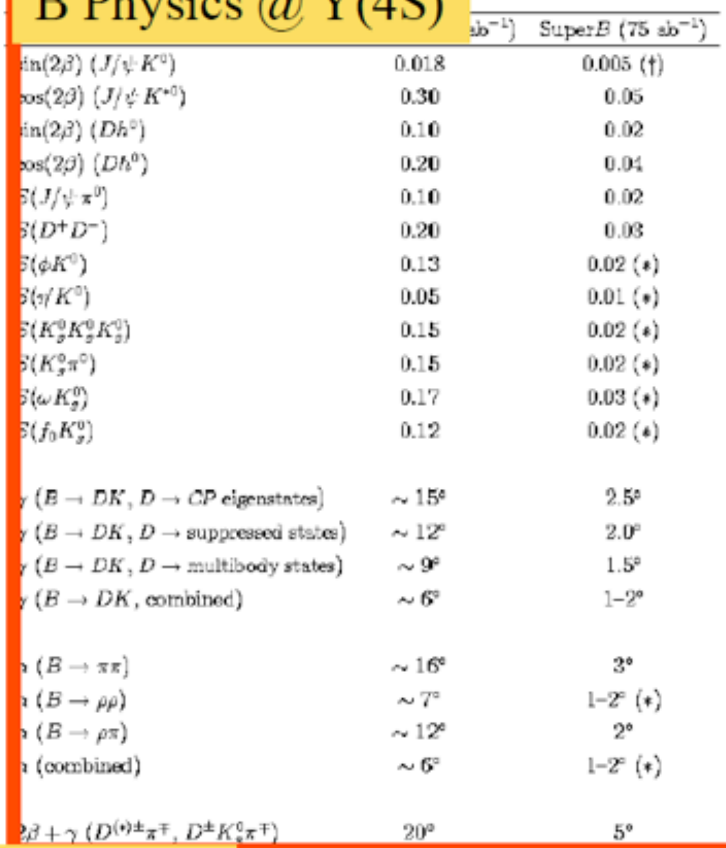
BASELINE in CDR (top half)



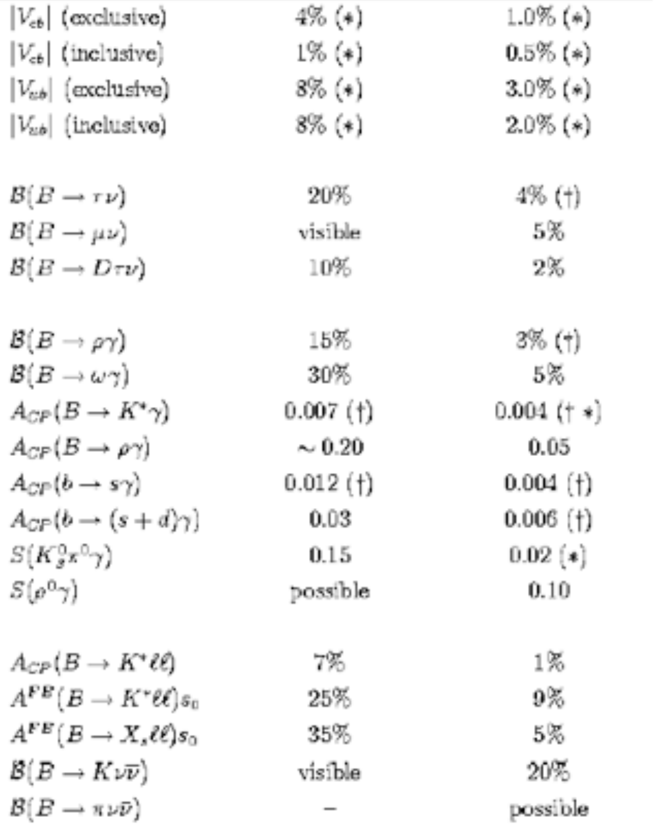
OPTIONS (Bottom half)

Green items are new; others are reused from BaBar

B Physics @ Y(4S)

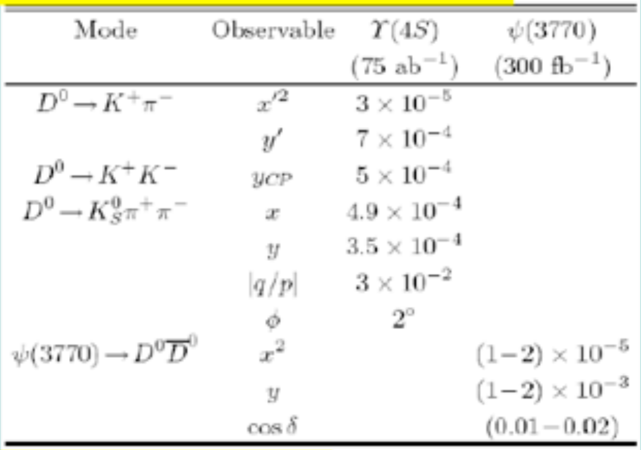


	ab^{-1})	Super$B$ (75 ab^{-1})
in(2β) $(J/\psi K^0)$	0.018	0.005 (†)
os(2β) $(J/\psi K^{*0})$	0.30	0.05
in(2β) (Dh^0)	0.10	0.02
os(2β) (Dh^0)	0.20	0.04
$(J/\psi \pi^0)$	0.10	0.02
(D^+D^-)	0.20	0.03
(ϕK^0)	0.13	0.02 (∗)
$(\eta' K^0)$	0.05	0.01 (∗)
$(K^0_S K^0_S K^0_S)$	0.15	0.02 (∗)
$(K^0_S \pi^0)$	0.15	0.02 (∗)
(ωK^0_S)	0.17	0.03 (∗)
$(f_0 K^0_S)$	0.12	0.02 (∗)
$(B \to DK, D \to CP$ eigenstates)	$\sim 15^\circ$	2.5°
$(B \to DK, D \to$ suppressed states)	$\sim 12^\circ$	2.0°
$(B \to DK, D \to$ multibody states)	$\sim 9^\circ$	1.5°
$(B \to DK$, combined)	$\sim 6^\circ$	1–2°
$(B \to \pi\pi)$	$\sim 16^\circ$	3°
$(B \to \rho\rho)$	$\sim 7^\circ$	1–2° (∗)
$(B \to \rho\pi)$	$\sim 12^\circ$	2°
(combined)	$\sim 6^\circ$	1–2° (∗)
$\beta + \gamma$ $(D^{(*)\pm}\pi^\mp, D^\pm K^0_S \pi^\mp)$	20°	5°



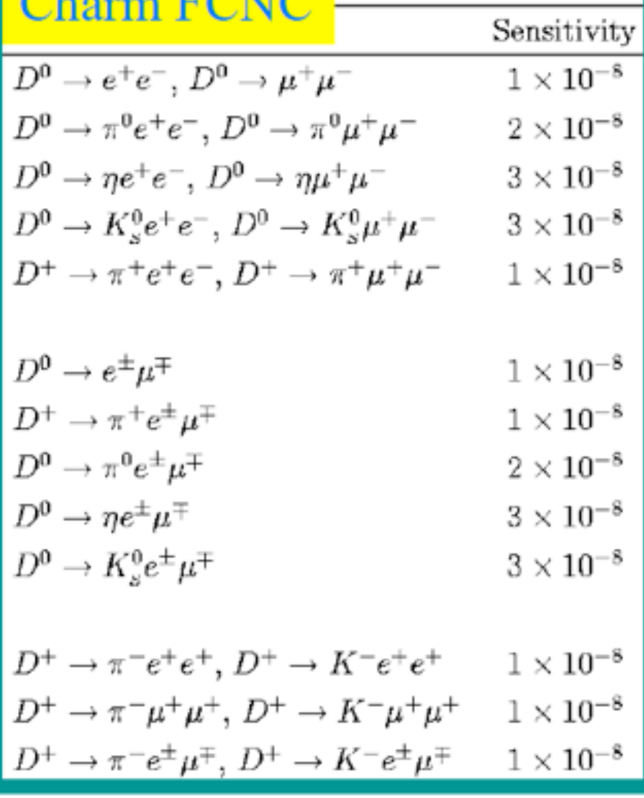
Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$\lvert V_{cb}\rvert$ (exclusive)	4% (∗)	1.0% (∗)
$\lvert V_{cb}\rvert$ (inclusive)	1% (∗)	0.5% (∗)
$\lvert V_{ub}\rvert$ (exclusive)	8% (∗)	3.0% (∗)
$\lvert V_{ub}\rvert$ (inclusive)	8% (∗)	2.0% (∗)
$\mathcal{B}(B \to \tau\nu)$	20%	4% (†)
$\mathcal{B}(B \to \mu\nu)$	visible	5%
$\mathcal{B}(B \to D\tau\nu)$	10%	2%
$\mathcal{B}(B \to \rho\gamma)$	15%	3% (†)
$\mathcal{B}(B \to \omega\gamma)$	30%	5%
$A_{CP}(B \to K^*\gamma)$	0.007 (†)	0.004 († ∗)
$A_{CP}(B \to \rho\gamma)$	~ 0.20	0.05
$A_{CP}(b \to s\gamma)$	0.012 (†)	0.004 (†)
$A_{CP}(b \to (s+d)\gamma)$	0.03	0.006 (†)
$S(K^0_S \pi^0 \gamma)$	0.15	0.02 (∗)
$S(\rho^0\gamma)$	possible	0.10
$A_{CP}(B \to K^*\ell\ell)$	7%	1%
$A^{FB}(B \to K^*\ell\ell)s_0$	25%	9%
$A^{FB}(B \to X_s\ell\ell)s_0$	35%	5%
$\mathcal{B}(B \to K\nu\bar{\nu})$	visible	20%
$\mathcal{B}(B \to \pi\nu\bar{\nu})$	–	possible

Charm mixing and CP



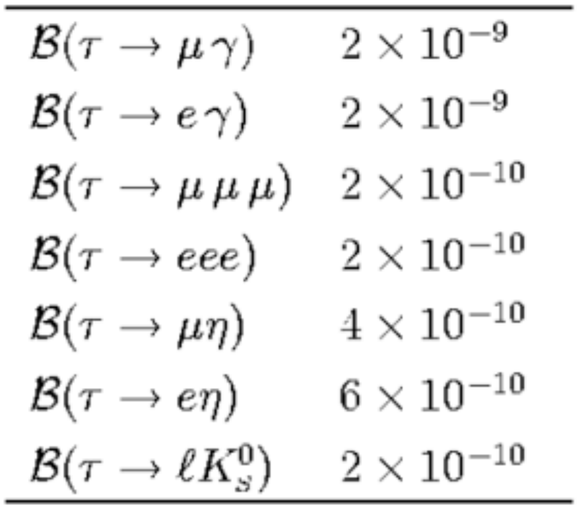
Mode	Observable	$\Upsilon(4S)$ (75 ab^{-1})	$\psi(3770)$ (300 fb^{-1})
$D^0 \to K^+\pi^-$	x'^2	3×10^{-5}	
	y'	7×10^{-4}	
$D^0 \to K^+K^-$	y_{CP}	5×10^{-4}	
$D^0 \to K^0_S\pi^+\pi^-$	x	4.9×10^{-4}	
	y	3.5×10^{-4}	
	$\lvert q/p\rvert$	3×10^{-2}	
	ϕ	2°	
$\psi(3770) \to D^0\overline{D}^0$	x^2		$(1-2) \times 10^{-5}$
	y		$(1-2) \times 10^{-3}$
	$\cos\delta$		$(0.01-0.02)$

Charm FCNC



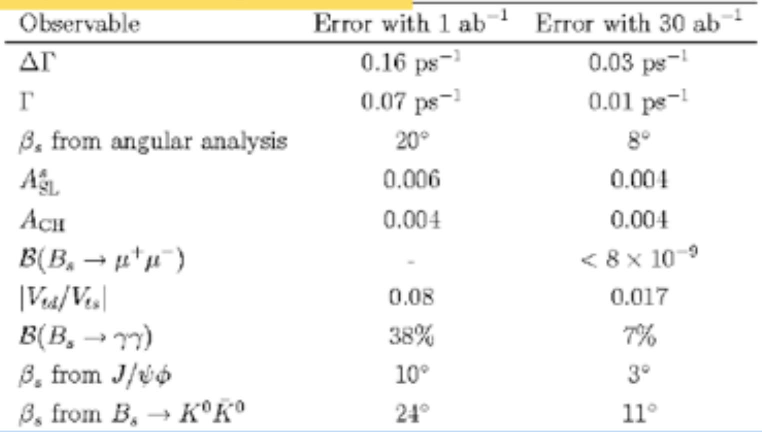
	Sensitivity
$D^0 \to e^+e^-$, $D^0 \to \mu^+\mu^-$	1×10^{-8}
$D^0 \to \pi^0 e^+e^-$, $D^0 \to \pi^0\mu^+\mu^-$	2×10^{-8}
$D^0 \to \eta e^+e^-$, $D^0 \to \eta\mu^+\mu^-$	3×10^{-8}
$D^0 \to K^0_S e^+e^-$, $D^0 \to K^0_S\mu^+\mu^-$	3×10^{-8}
$D^+ \to \pi^+ e^+e^-$, $D^+ \to \pi^+\mu^+\mu^-$	1×10^{-8}
$D^0 \to e^\pm\mu^\mp$	1×10^{-8}
$D^+ \to \pi^+ e^\pm\mu^\mp$	1×10^{-8}
$D^0 \to \pi^0 e^\pm\mu^\mp$	2×10^{-8}
$D^0 \to \eta e^\pm\mu^\mp$	3×10^{-8}
$D^0 \to K^0_S e^\pm\mu^\mp$	3×10^{-8}
$D^+ \to \pi^- e^+e^+$, $D^+ \to K^- e^+e^+$	1×10^{-8}
$D^+ \to \pi^-\mu^+\mu^+$, $D^+ \to K^-\mu^+\mu^+$	1×10^{-8}
$D^+ \to \pi^- e^\pm\mu^\mp$, $D^+ \to K^- e^\pm\mu^\mp$	1×10^{-8}

τ Physics



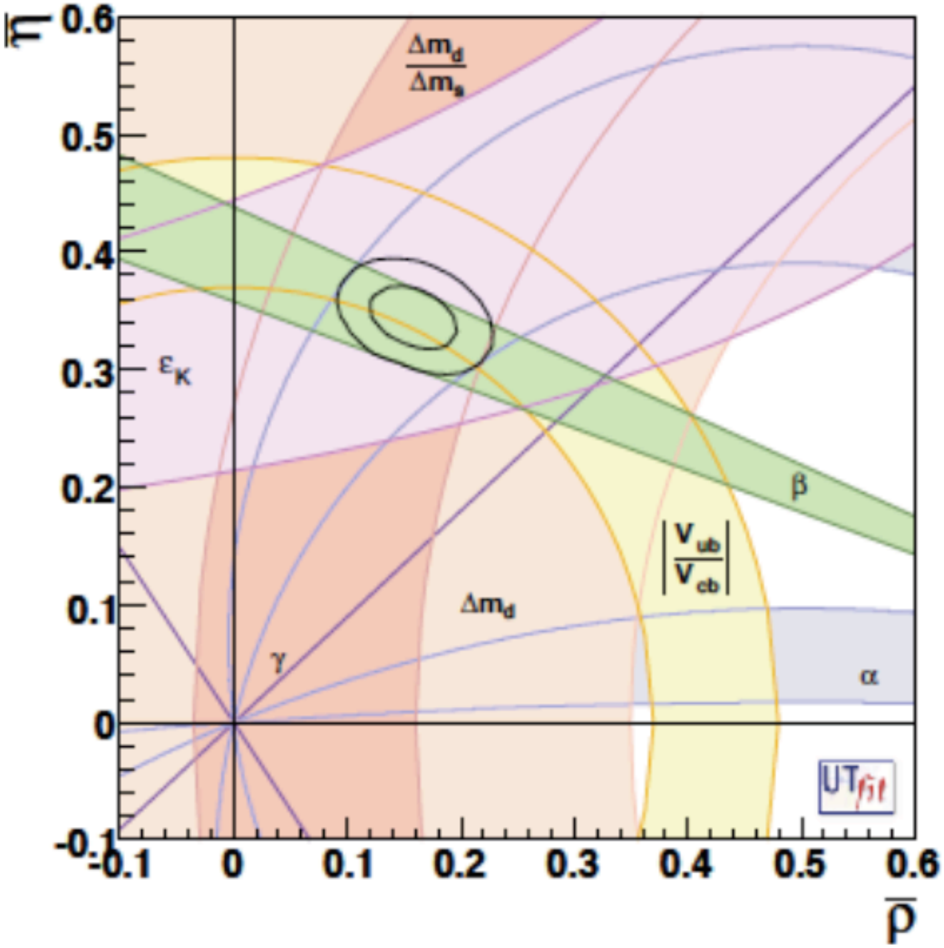
	Sensitivity
$\mathcal{B}(\tau \to \mu\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to e\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to \mu\mu\mu)$	2×10^{-10}
$\mathcal{B}(\tau \to eee)$	2×10^{-10}
$\mathcal{B}(\tau \to \mu\eta)$	4×10^{-10}
$\mathcal{B}(\tau \to e\eta)$	6×10^{-10}
$\mathcal{B}(\tau \to \ell K^0_S)$	2×10^{-10}

B$_s$ Physics @ Y(5S)

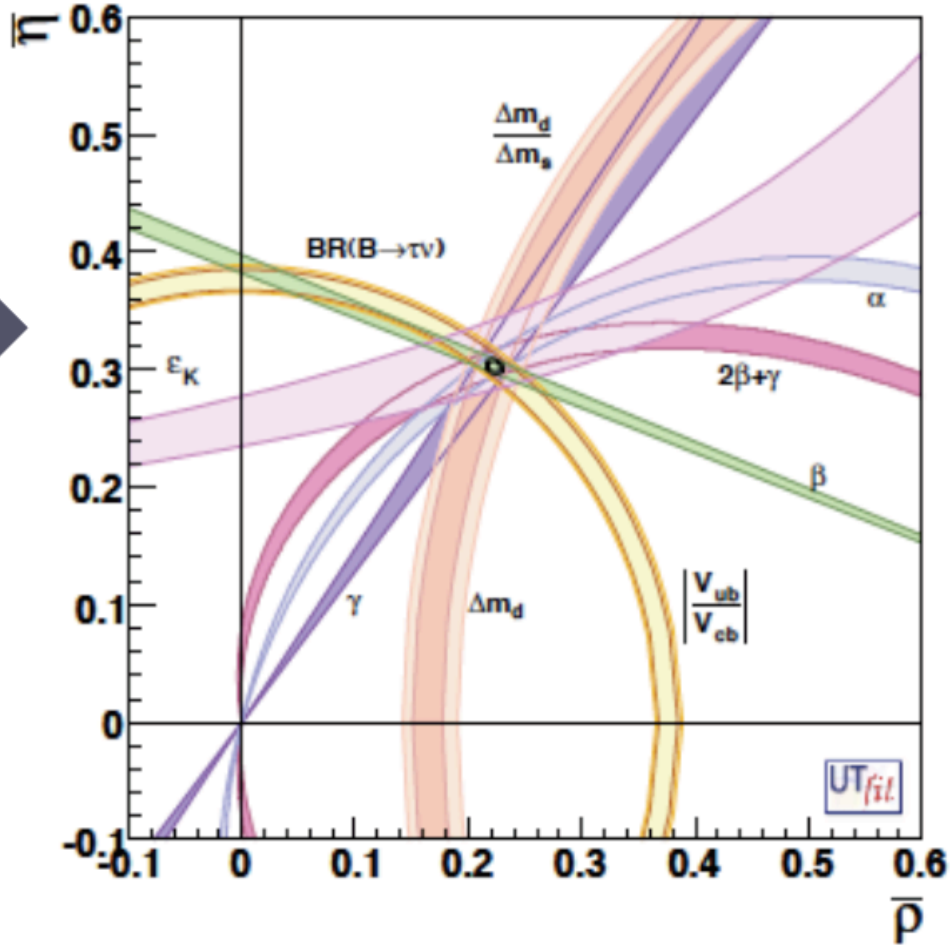


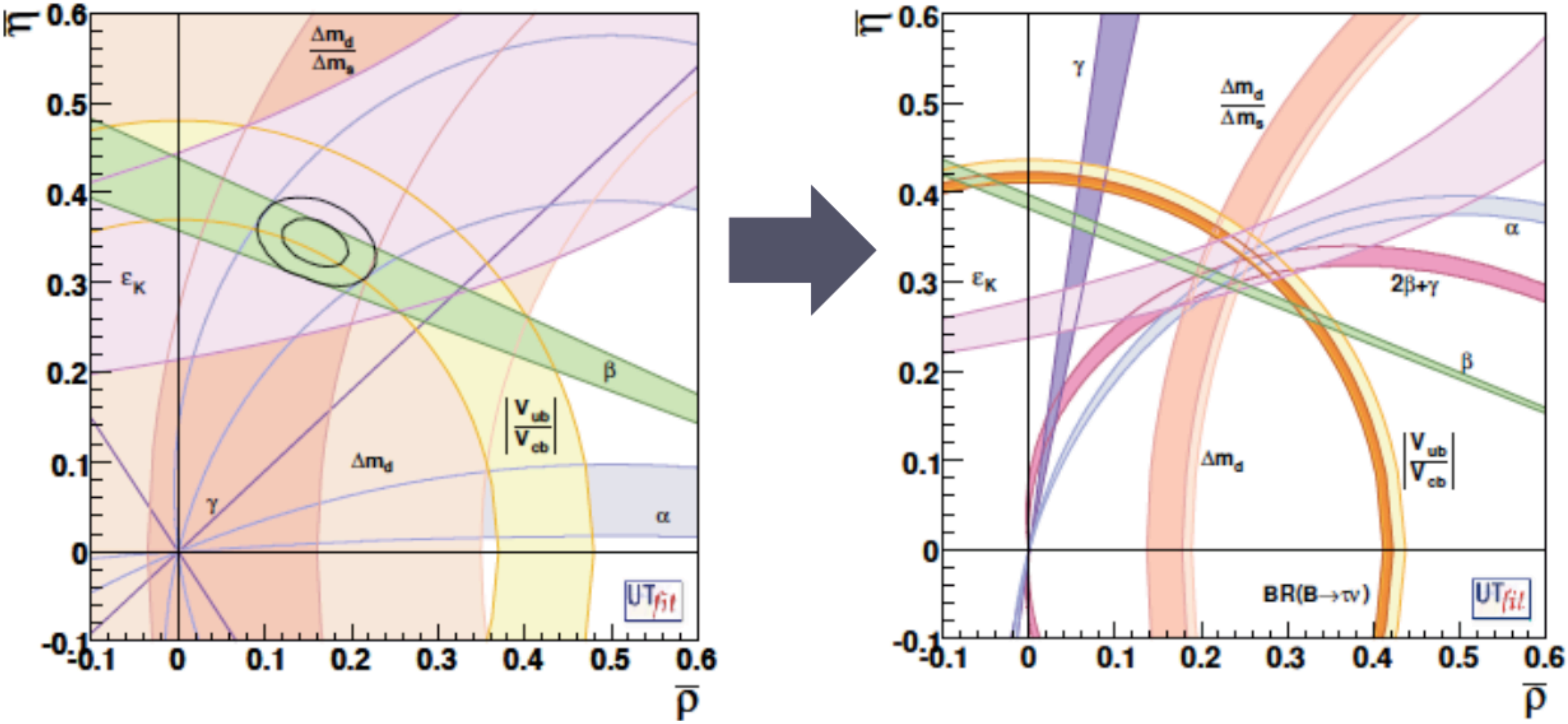
Observable	Error with 1 ab^{-1}	Error with 30 ab^{-1}
$\Delta\Gamma$	0.16 ps^{-1}	0.03 ps^{-1}
Γ	0.07 ps^{-1}	0.01 ps^{-1}
β_s from angular analysis	20°	8°
$A^s_{\rm SL}$	0.006	0.004
$A_{\rm CH}$	0.004	0.004
$\mathcal{B}(B_s \to \mu^+\mu^-)$	-	$< 8 \times 10^{-9}$
$\lvert V_{td}/V_{ts}\rvert$	0.08	0.017
$\mathcal{B}(B_s \to \gamma\gamma)$	38%	7%
β_s from $J/\psi\phi$	10°	3°
β_s from $B_s \to K^0\bar{K}^0$	24°	11°

ρ = 0.163 ± 0.028
η = 0.344± 0.016



ρ = ± 0.0028
η = ± 0.0024





$\bar{\eta}$
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
$\bar{\rho}$
$\frac{\Delta m_d}{\Delta m_s}$
ε_K
β
$\left|\frac{V_{ub}}{V_{cb}}\right|$
Δm_d
γ
α
UTfit
$\bar{\eta}$
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
$\bar{\rho}$
γ
$\frac{\Delta m_d}{\Delta m_s}$
ε_K
α
$2\beta+\gamma$
β
Δm_d
$\left|\frac{V_{ub}}{V_{cb}}\right|$
BR($B\to\tau\nu$)
UTfit

$e^+e^- \rightarrow \mu^+\mu^-$ @ $\sqrt{s}$=10.58GeV

Diagrams	Cross Section (nb)	A_{FB}	A_{LR} (Pol = 100%)
$\lvert Z+\gamma \rvert^2$	1.01	0.0028	-0.00051

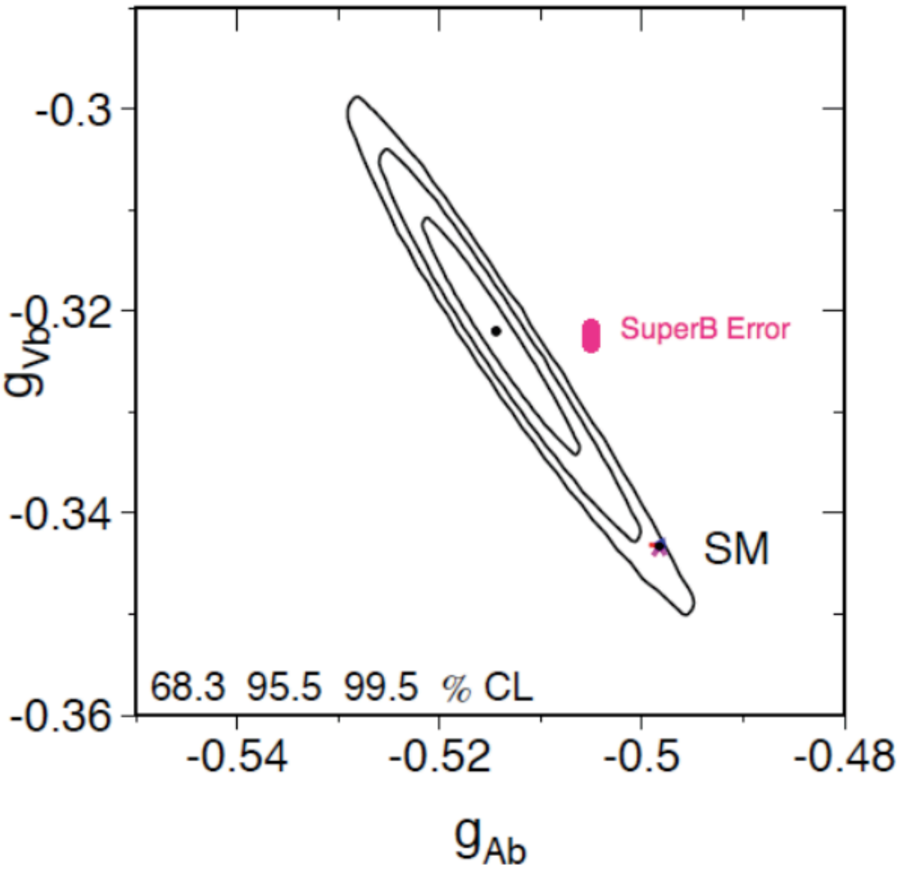
$\sigma_{ALR} = 5\mathrm{x}10^{-6}$ ➔ $\sigma_{(\sin 2\theta \mathrm{eff})} = 0.00018$

SLC A_{LR} $\sigma_{(\sin 2\theta \mathrm{eff})} = 0.00026$

relative stat. error of 1.1% (pol=80%)
require <~0.5% systematic error on beam polarisation

- SM: -0.34372 +0.00049-.00028
- A_{FB}^{b}: -0.3220±0.0077

- with 0.5% polarization systematic and 0.3% stat error gives a SuperB error of ±0.0021



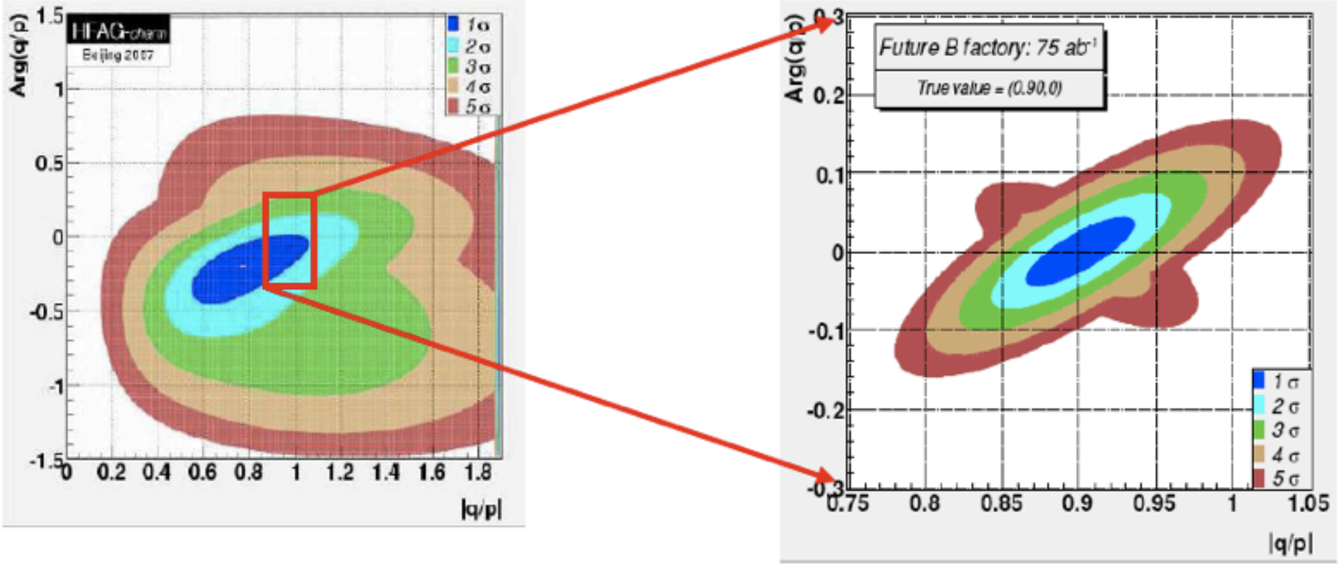
CPV in charm decays

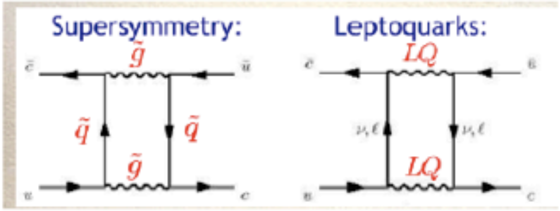
Measurement of D oscillations opens **new window** to search of CPV in charm.

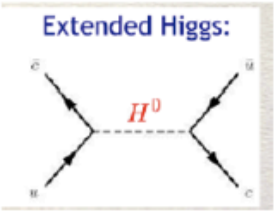
Observation of CPV would provide **unequivocal NP signals**

- D mixing observed by BaBar, CDF and Belle
- Size of charm sample at SuperB reduces errors by an order of magnitude

Mode	Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$D^0 \to K^+K^-$	y_{CP}	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
$D^0 \to K^+\pi^-$	y'_D	$2\text{–}3 \times 10^{-3}$	7×10^{-4}
	x'^2_D	$1\text{–}2 \times 10^{-4}$	3×10^{-5}
$D^0 \to K^0_S\pi^+\pi^-$	y_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
	x_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
Average	y_D	$1\text{–}2 \times 10^{-3}$	3×10^{-4}
	x_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}







Plus, possibility of running @ $\Psi(3S)$: **in 4 months ~0.3ab^{-1} → 1000x CLEO-c, 10x BESIII !!**

Conclusion

- The B-Factories have been a smashing success in their decade of running, meeting or exceeding their goals
- No unambiguous flaws in the CKM Model have been found, although there may be a few hints of new physics
- B-Factories have done a lot more than CP-physics as well
- The portents are good for a new generation of B-Factories with up to 100 times the luminosity, as companions to LHC