University of Glasgow
Experimental Particle Physics

Eduardo Rodrigues

Glasgow PPE Seminar, 2nd October 2008

Highlights from CKM 2008

Working groups

WG I	Precise determination of V_{ud} and V_{us}
WG II	Determination of V_{ub}, V_{cb}, V_{cs} through inclusive / exclusive semileptonic B and D decays
WG III	Rare B, D and K decays
WG IV	Lifetimes, mixing and the corresponding phases
WG V	γ (ϕ_3) and related measurements
WG VI	Angles from penguin dominated $B_{(s,d)}$ decays

V_{ud} and V_{us}

Methods

V_{ud} from :

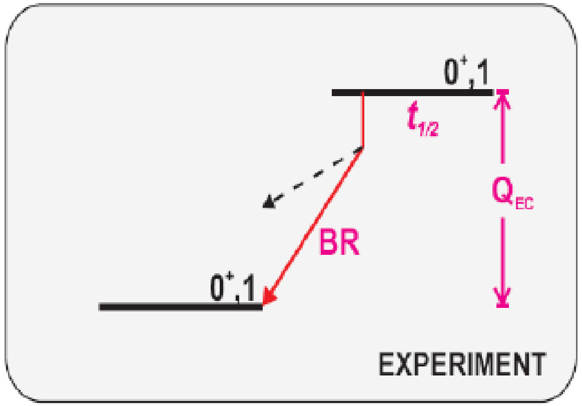
- ❑ Nuclear beta decays
- ❑ Neutron beta decays

V_{us} from:

- ❑ Kaon decays
- ❑ Hadronic τ decays

V_{ud} from nuclear β-decay (1/2)

Towner



$$ft = \frac{K}{G_V^2 \langle \tau_+ \rangle^2}$$

f = statistical rate function $f(Z, Q_{ec})$

$t = t_{1/2}/BR =$ partial half life

$\langle \tau_+ \rangle$ = isospin ladder operator matrix element
$= \sqrt{2}$ for isospin $T = 1$ states

MASTER EQUATIONS

$$\text{CVC}: \ \mathcal{F}t = ft(1+\delta'_R)(1-(\delta_C-\delta_{NS})) = \text{constant}$$

$$V_{ud}^2 = \frac{K}{2G_F^2 \overline{\mathcal{F}t}(1+\Delta_R)} \qquad \frac{K}{(\hbar c)^6} = \frac{2\pi^3 \hbar \ln 2}{(m_e c^2)^5}$$

where

ft = experimental nuclear ft values.

$\overline{\mathcal{F}t}$ = average corrected ft values (13 cases).

G_F = weak interaction coupling constant (from muon lifetime).

Nucleus-independent component Δ_R
Nucleus-dependent component δ'_R
Nuclear-structure-dependent component δ_{NS}

$$\left.\begin{array}{r}\Delta_R\\ \delta'_R\\ \delta_{NS}\end{array}\right\} = \text{calculated radiative correction.}$$

~4%

δ_C = calculated isospin symmetry breaking correction.

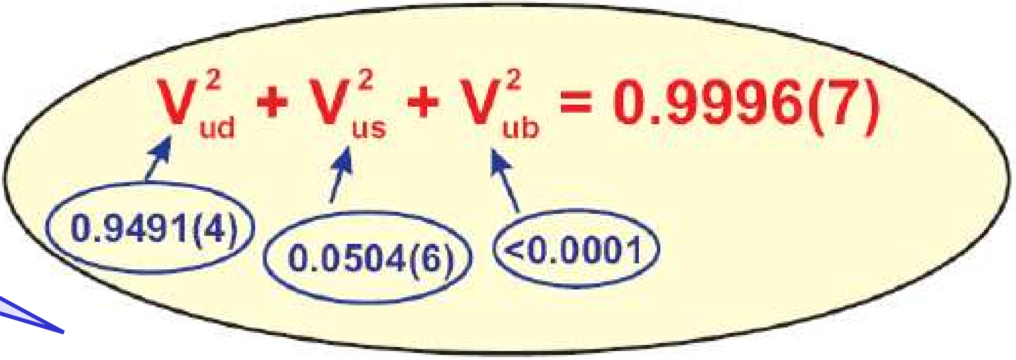
V_{ud} from nuclear β-decay (2/2)

Towner

$V_{ud} = 0.97425 \pm 0.00023$

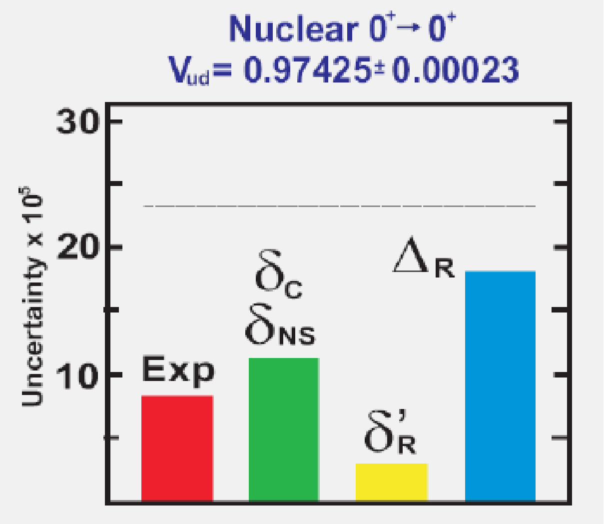
Compare:
neutron $V_{ud} = 0.9746 \pm 0.0019$
pion $V_{ud} = 0.9749 \pm 0.0026$

Superallowed β-decays yield most precise values!

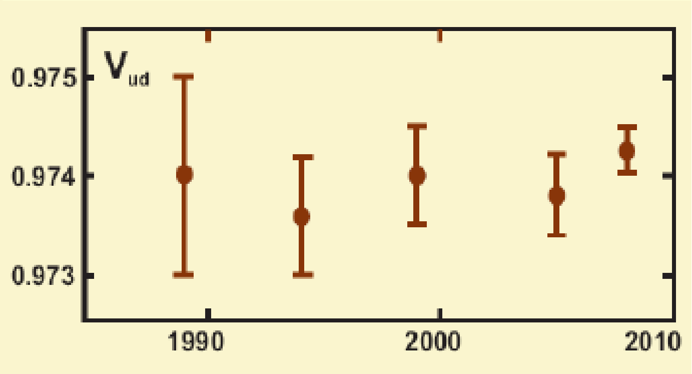


$$\underbrace{V_{ud}^2}_{0.9491(4)} + \underbrace{V_{us}^2}_{0.0504(6)} + \underbrace{V_{ub}^2}_{<0.0001} = 0.9996(7)$$

CKM unitarity to 0.07% !



Robust experimental value …



V_{us} from semi-leptonic Kaon decays (1/3)

Extraction of V_{us}

$$\Gamma(K_{l3(\gamma)}) = \frac{C_K^2 G_F^2 M_K^5}{192\pi^3} S_{EW} |V_{us}|^2 |f_+^{K^0\pi^-}(0)|^2 I_{K\ell}(\lambda_{+,0}) (1+\delta^K_{SU(2)}+\delta^{K\ell}_{em})^2$$

with $K = K^+, K^0$; $\ell = e, \mu$ and $C_K^2 = 1/2$ for K^+, 1 for K^0

Inputs from theory:

S_{EW}	Universal short distance EW correction (1.0232)
$\delta^K_{SU(2)}$	Form factor correction for strong SU(2) breaking
$\delta^{K\ell}_{em}$	Long distance EM effects
$f_+^{K^0\pi^-}(0)$	Hadronic matrix element at zero momentum transfer (t=0)

Talk by Neufeld

Talks by Flynn and Simula

CT

Inputs from experiment:

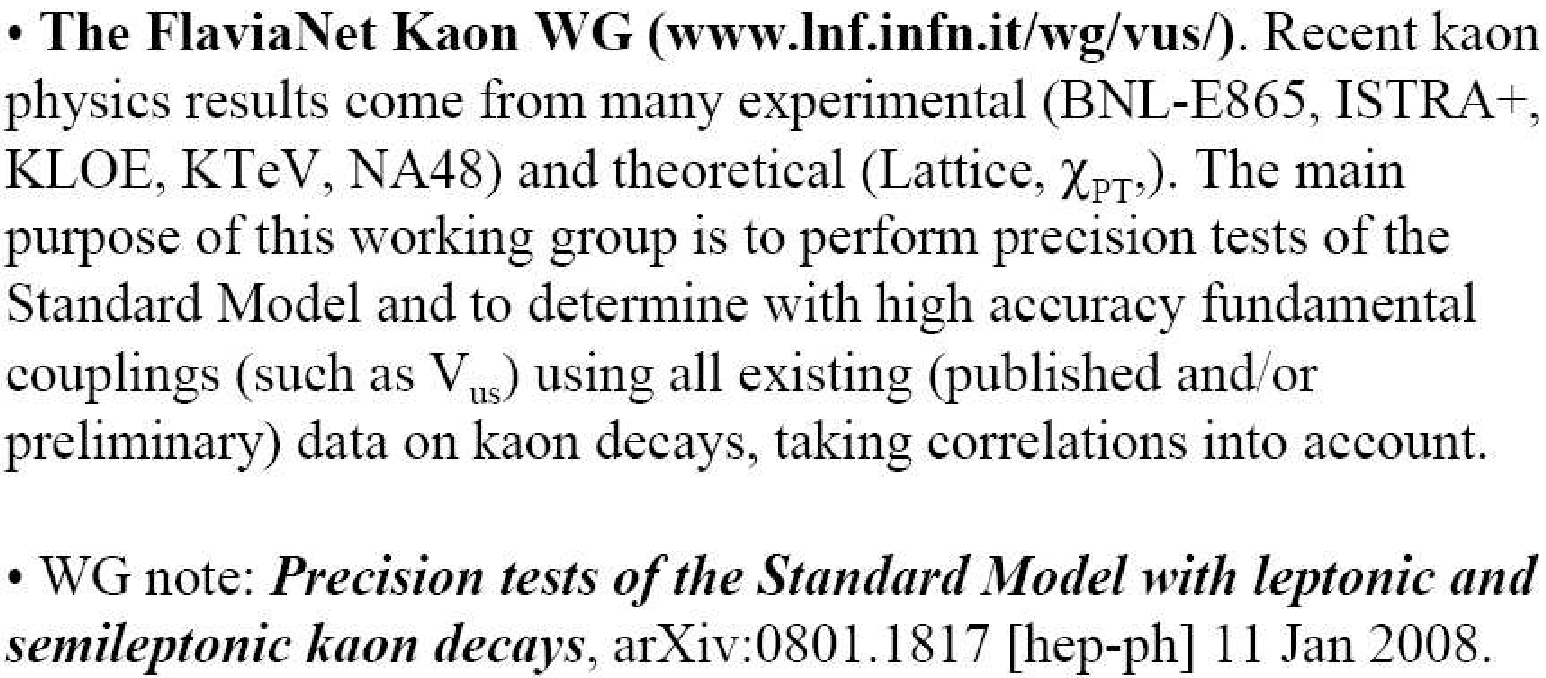
$\Gamma(K_{l3(\gamma)})$	Branching ratios with well determined treatment of radiative decays; lifetimes
$I_{K\ell}(\lambda)$	Phase space integral: λ's parameterize form factor dependence on t: K_{e3}: only λ_+ $K_{\mu3}$: need λ_+ and λ_0

Talks by Sciascia, Sibidanov, Wanke

Talk by Passemar

Sciascia

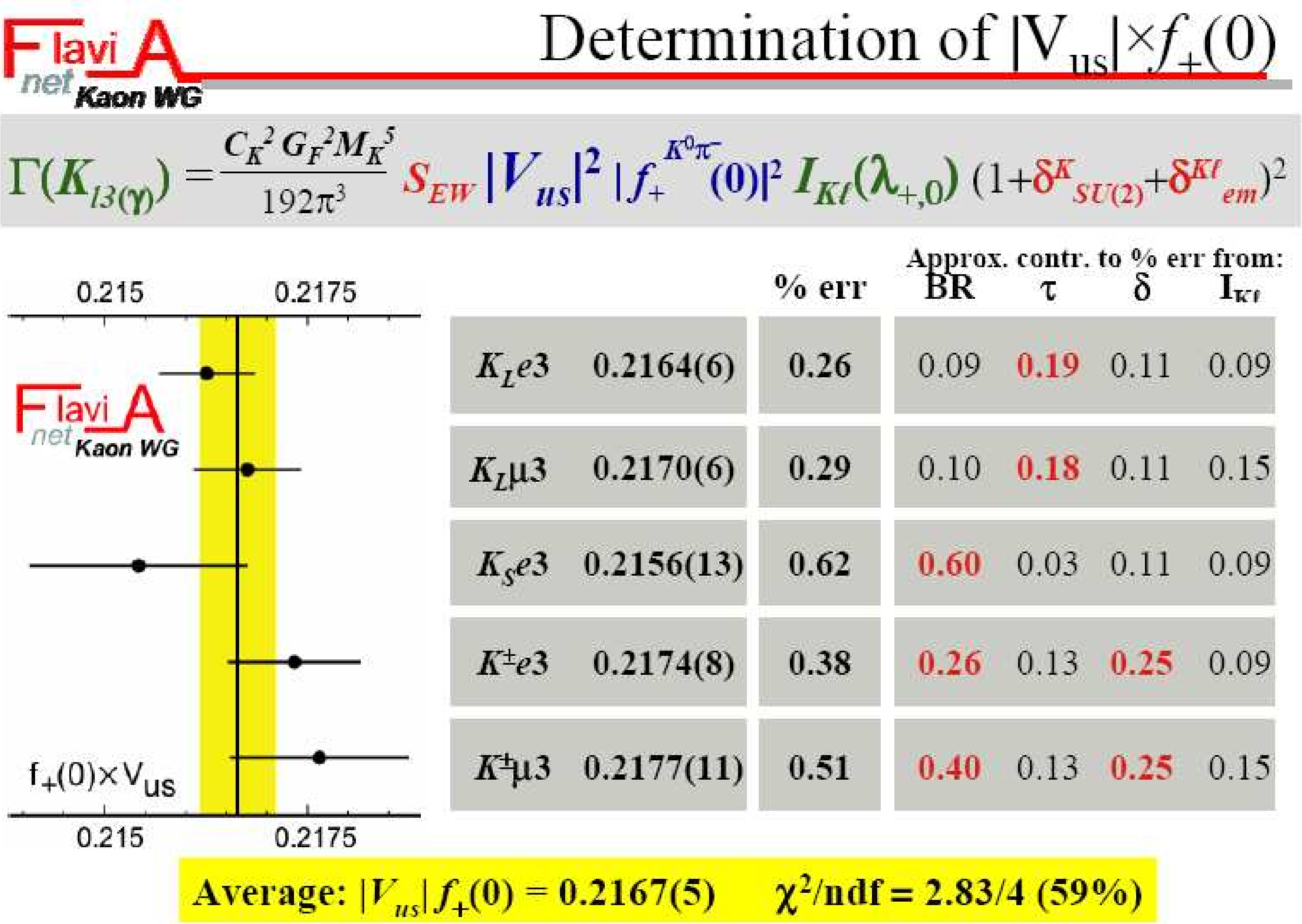
The FlaviaNet Kaon working group



- **The FlaviaNet Kaon WG (www.lnf.infn.it/wg/vus/)**. Recent kaon physics results come from many experimental (BNL-E865, ISTRA+, KLOE, KTeV, NA48) and theoretical (Lattice, χ_{PT},). The main purpose of this working group is to perform precision tests of the Standard Model and to determine with high accuracy fundamental couplings (such as V_{us}) using all existing (published and/or preliminary) data on kaon decays, taking correlations into account.

- WG note: ***Precision tests of the Standard Model with leptonic and semileptonic kaon decays***, arXiv:0801.1817 [hep-ph] 11 Jan 2008.

V_{us} from semi-leptonic Kaon decays (3/3)



Determination of $|V_{us}|\times f_+(0)$

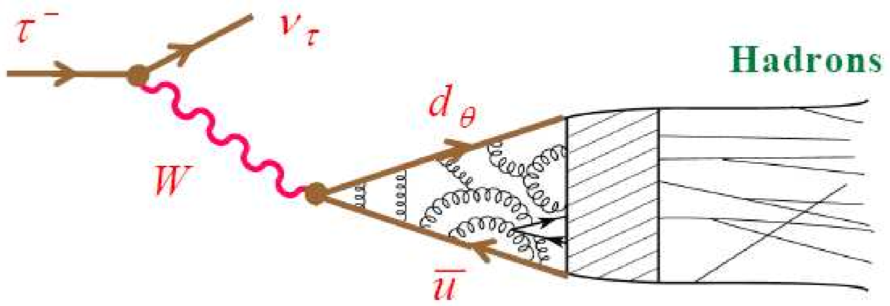
$$\Gamma(K_{l3(\gamma)}) = \frac{C_K^2 G_F^2 M_K^5}{192\pi^3} S_{EW} |V_{us}|^2 |f_+^{K^0\pi^-}(0)|^2 I_{K\ell}(\lambda_{+,0}) (1+\delta^K_{SU(2)}+\delta^{K\ell}_{em})^2$$

		% err	Approx. contr. to % err from: BR	τ	δ	$I_{K\ell}$
K_Le3	0.2164(6)	0.26	0.09	0.19	0.11	0.09
$K_L\mu3$	0.2170(6)	0.29	0.10	0.18	0.11	0.15
K_Se3	0.2156(13)	0.62	0.60	0.03	0.11	0.09
$K^\pm e3$	0.2174(8)	0.38	0.26	0.13	0.25	0.09
$K^\pm\mu3$	0.2177(11)	0.51	0.40	0.13	0.25	0.15

Average: $|V_{us}| f_+(0) = 0.2167(5)$ $\chi^2/\text{ndf} = 2.83/4$ (59%)

V_{us} from hadronic τ decays (1/2)

Pich



$$R_\tau \equiv \frac{\Gamma\left(\tau^- \to \nu_\tau + \mathrm{Hadrons}\right)}{\Gamma\left(\tau^- \to \nu_\tau\, e^- \bar{\nu}_e\right)}$$

$$R_\tau = N_C\, S_{\mathrm{EW}} \left(1 + \delta_{\mathrm{P}} + \delta_{\mathrm{NP}}\right) = R_{\tau,V} + R_{\tau,A} + R_{\tau,S}$$

$$R_\tau^{kl}(s_0) \equiv \int_0^{s_0} ds \left(1 - \frac{s}{s_0}\right)^k \left(\frac{s}{m_\tau^2}\right)^l \frac{dR_\tau}{ds}$$

$$|V_{us}|^2 = \frac{R^{00}_{\tau,S}}{\dfrac{R^{00}_{\tau,V+A}}{|V_{ud}|^2} - \delta R^{00}_{\tau,\mathrm{th}}}$$

The τ could give the most precise V_{us} determination

- From present τ data one gets:

$$\boxed{|V_{us}| = 0.2165 \pm 0.0026_{\mathrm{exp}} \pm 0.0005_{\mathrm{th}}}$$

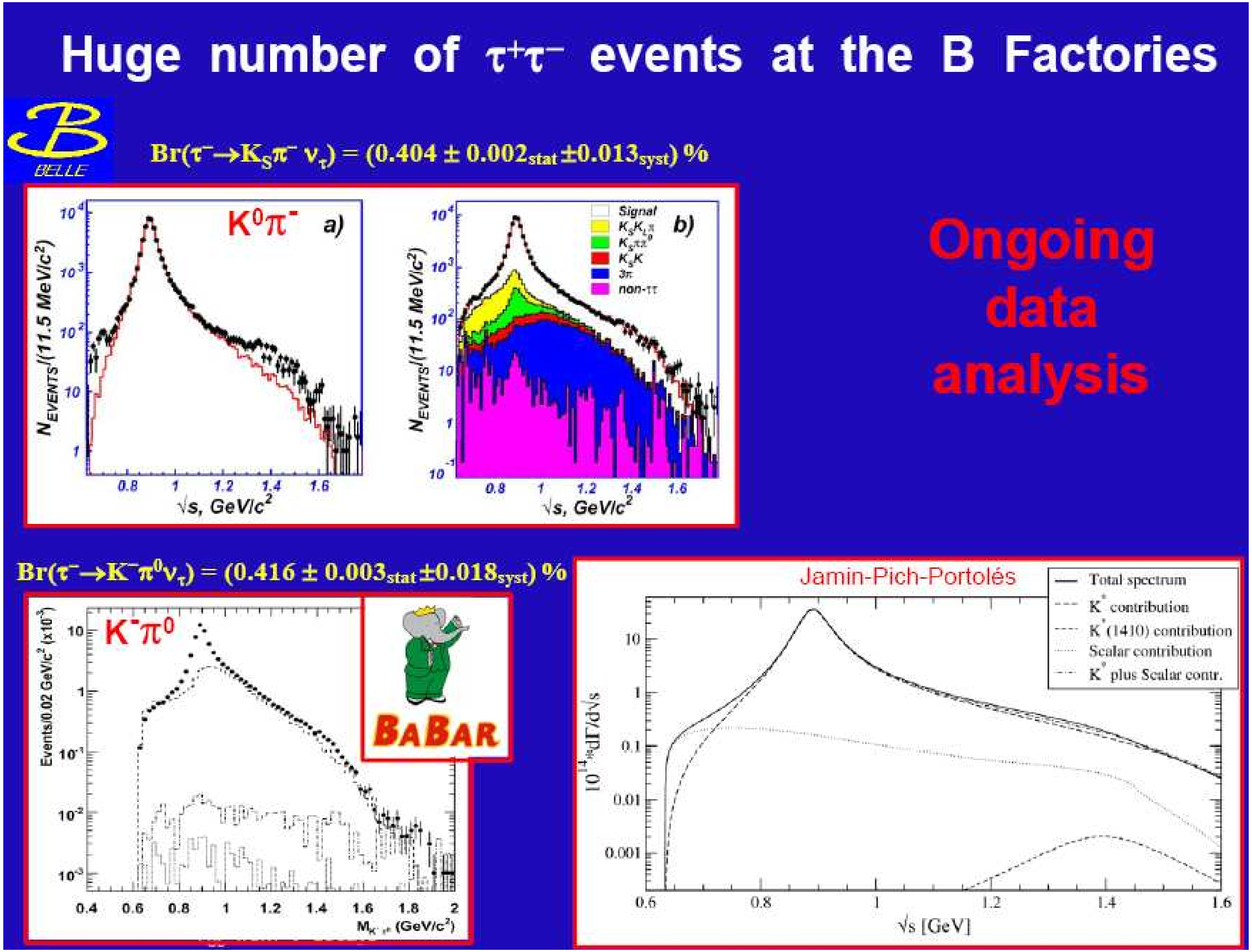
- Accuracy similar already to K_{l3}:

$$|V_{us}| = 0.2233 \pm 0.0024 \qquad [f_+(0) = 0.97 \pm 0.01]$$

Interesting challenge for the B Factories & BESIII

V_{us} from hadronic τ decays (2/2)

Pich



Huge number of $\tau^+\tau^-$ events at the B Factories

$Br(\tau^- \to K_S \pi^- \nu_\tau) = (0.404 \pm 0.002_{stat} \pm 0.013_{syst})\ \%$

Ongoing data analysis

$Br(\tau^- \to K^- \pi^0 \nu_\tau) = (0.416 \pm 0.003_{stat} \pm 0.018_{syst})\ \%$

Jamin-Pich-Portolés

D^0 mixing
and
CP violation

D^0 : mixing and CP violation

Golowich

Standard Model :

- Estimate of y_D ~10^{-2} but hadronic corrections tricky
- x_D more problematic to calculate

New Physics :

- Many models can yield sizable x_D, but not all
- Charm mixing data will provide contraints

D^0 : mixing

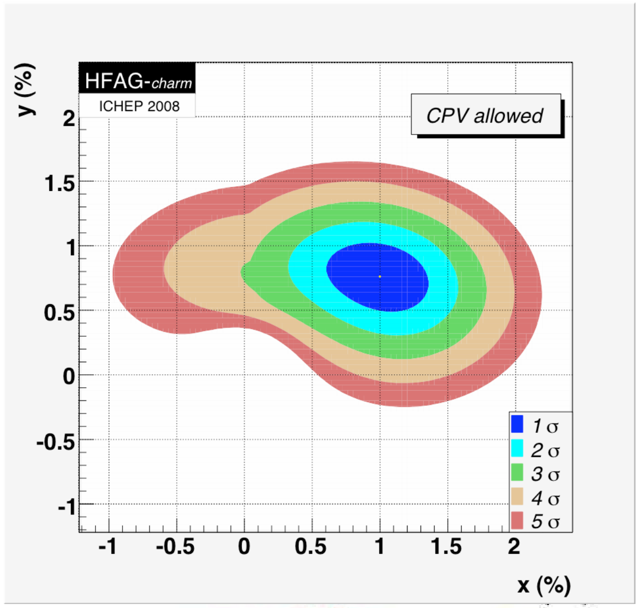
Coleman

- It took ~30 years to find evidence for D^0 mixing
- First evidence announced at Rencontres de Moriond in March 2007

- … and now the “no mixing” scenario is excluded at ~10σ !

- Results from several experiments

- Absolute values of x_D and y_D ~ 1% compatible with SM predictions



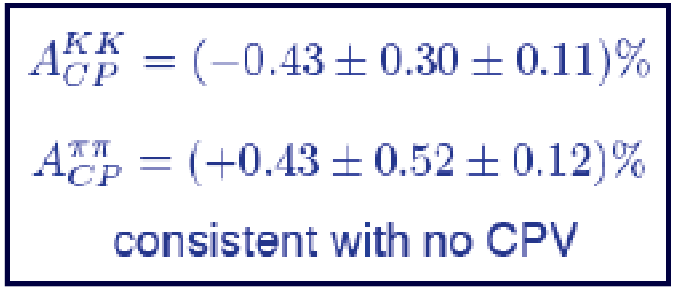
$x = 1.00\pm^{0.24}_{0.25}$ % 3.4σ

$y = 0.76\pm^{0.17}_{0.18}$ % 4.1σ

D^0 : CP violation

Staric

- **No evidence found up to now !**



$$A_{CP}^{KK} = (-0.43 \pm 0.30 \pm 0.11)\%$$

$$A_{CP}^{\pi\pi} = (+0.43 \pm 0.52 \pm 0.12)\%$$

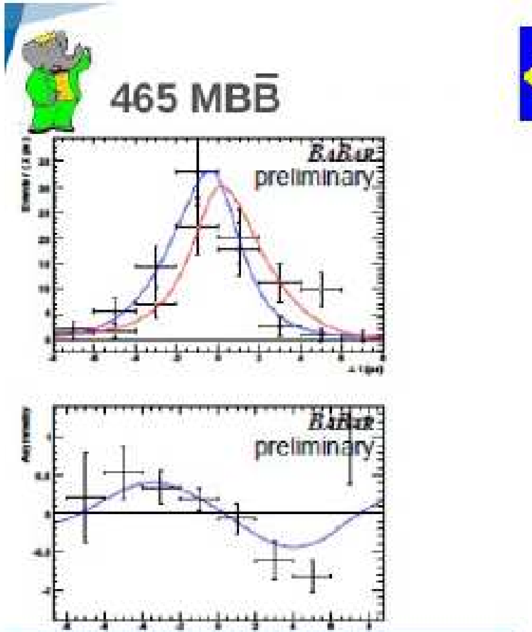
consistent with no CPV

- **Many decay modes used in searches**
- **Most stringent constraints from decays to CP eigenstates (KK, $\pi\pi$) and with Dalitz analyses of 3-body charge-conjugate states ($\pi^+\pi^-\pi^0$)**

β angle

$B^0 \to K_s K_s K_s$

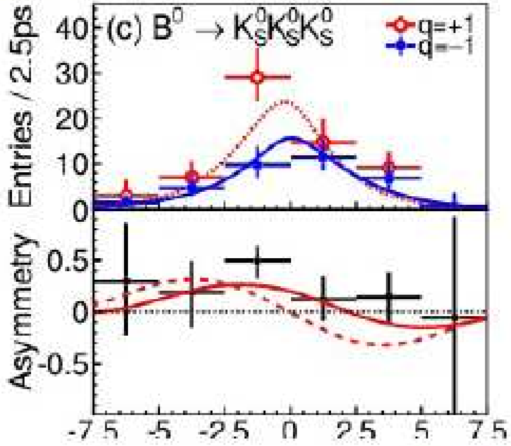
Fujikawa



465 MB$\bar{B}$

PRL 98 (2007) 031802

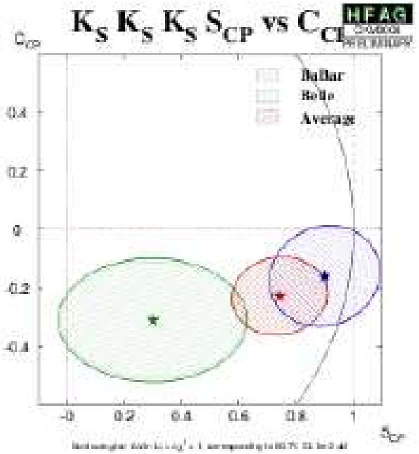
535 MB$\bar{B}$



(preliminary)

BABAR RESULTS

NEW FOR CKM2008



$C_{CP} = -\mathcal{A}$

BaBar	$-0.16 \pm 0.17 \pm 0.03$
Belle	$-0.31 \pm 0.20 \pm 0.07$
Average	-0.23 ± 0.13

$\sin 2\phi_1^{\mathrm{eff}} = -\mathcal{S}$

BaBar	$0.90 \pm ^{0.20}_{0.18} \pm ^{0.04}_{0.03}$
Belle	$0.30 \pm 0.32 \pm 0.08$
Average	0.74 ± 0.17

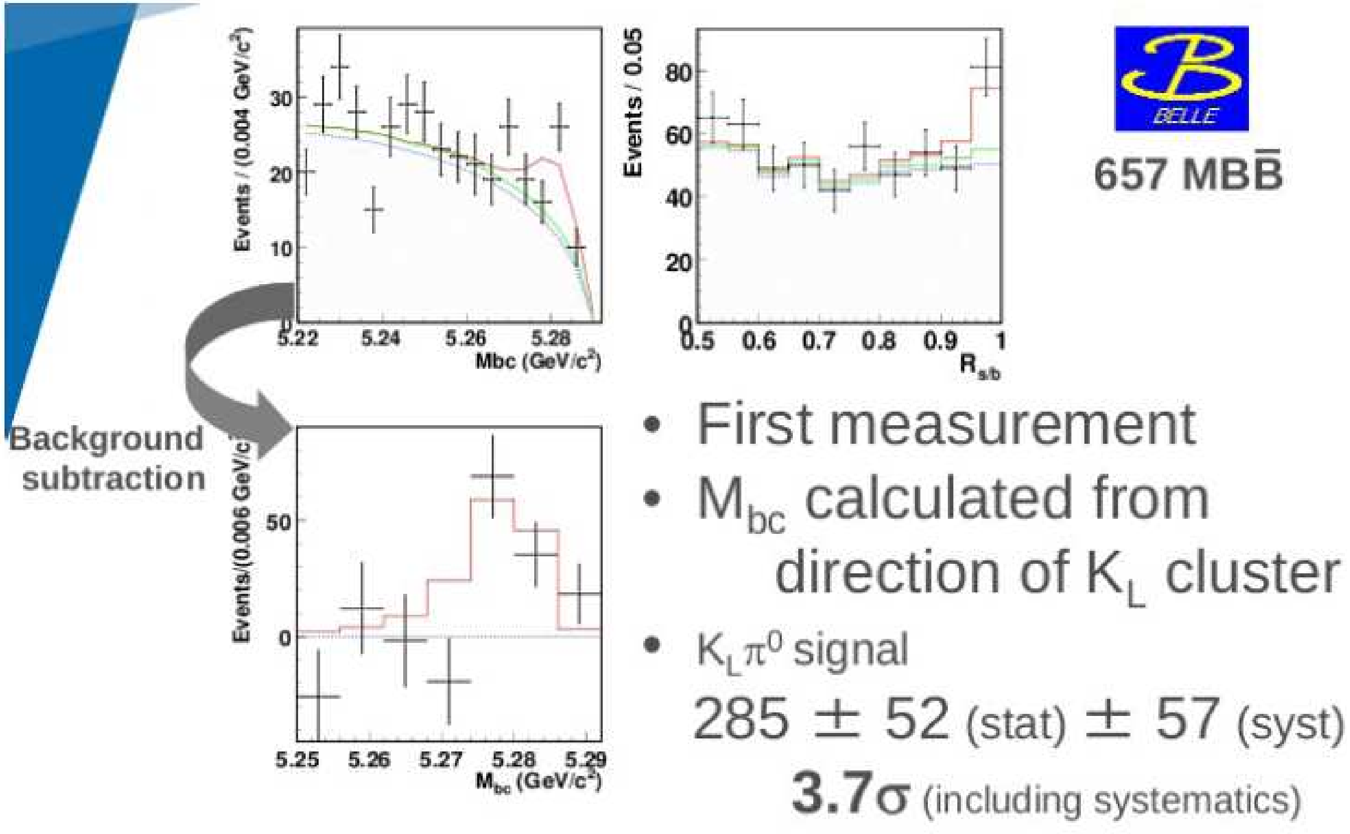
Other analyses include:

Dalseno / Fujikawa / Gaz / Virto

- $B^0 \to \phi K_s$
- $B^0 \to \eta' K_s$
- $B^0 \to K_S \pi^0$
- $B^0 \to K_L \pi^0$

Golden modes!

- $B_s \to K^* K^*$
  (mixing angle measurement)



657 MB$\bar{B}$

- First measurement
- M_{bc} calculated from direction of K_L cluster
- $K_L \pi^0$ signal

  285 ± 52 (stat) ± 57 (syst)

  3.7σ (including systematics)

γ angle

γ from tree-level decays

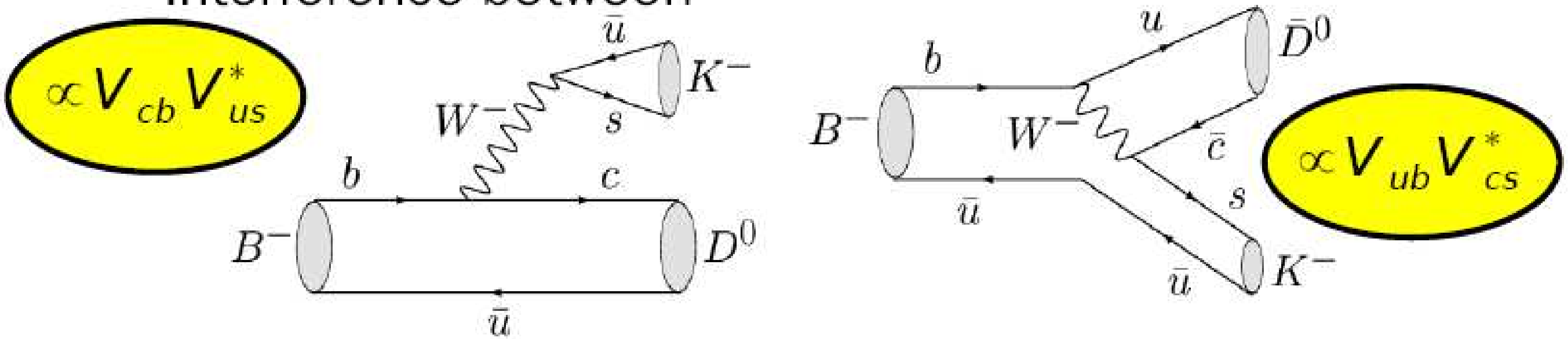
Active field!

1.Unitarity Angle Gamma	T.Gershon
2. Gamma from charged B decays at Babar	V.Tisserand
3. Belle results for phi_3 measurements	A.Bondar
4. Gamma from neutral B decays at Babar	V.Sordini
5. Time-dependent CP asymmetry in B0->$D^{*-}\pi^{+}$	M.Iwabuchi
6. CLEO_c Impact on ADS Determination of gamma	J.Libby
7. CLEO_c Impact on gamma from B->DK, D->$K_S\pi\pi$	J.Rademacker
8. Measuring weak phases using B->D*V modes	R.Sinha
9. Test of flavor SU(3) symmetry and weak phase gamma from B->Kp	C-W.Chang
10.Gamma from UTFIT	V.Sordini
11.Gamma from CKM fitter	K.Trabelsi
12.Time dependent measurements of gamma at LHCb	A.Carbone
13.Gamma at LHCb with ADS/GLW strategies	A.Powell
14.Gamma at LHCb:Dalitz fit and global precision	G.Wilkinson
15.Prospects for gamma (phi_3) at the SuperKEKB	P.Krokovny
16. Prospects for gamma at Super Flavor Factory	F.Martinez-Vidal

How to measure γ

Gershon

- Focus on theoretically pristine measurement
  - Interference between



$\propto V_{cb} V^{*}_{us}$

$\propto V_{ub} V^{*}_{cs}$

- colour allowed
- final state contains D^0

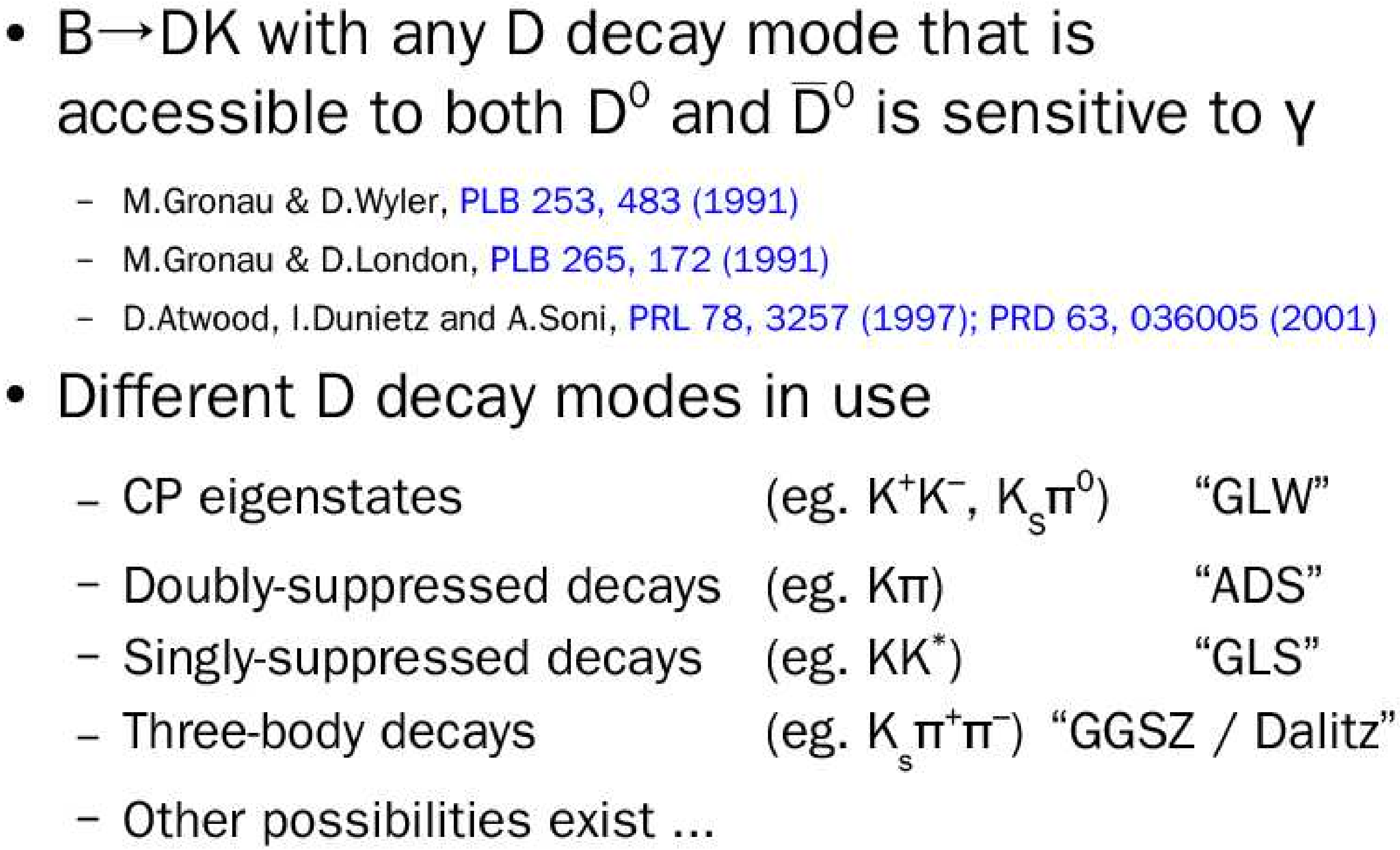
- colour suppressed
- final state contains $\bar{D}^0$

Relative magnitude of suppressed amplitude is r_B

Relative weak phase is $-\gamma$, relative strong phase is δ_B

$B \rightarrow D\,K$: many modes for a given method

Gershon



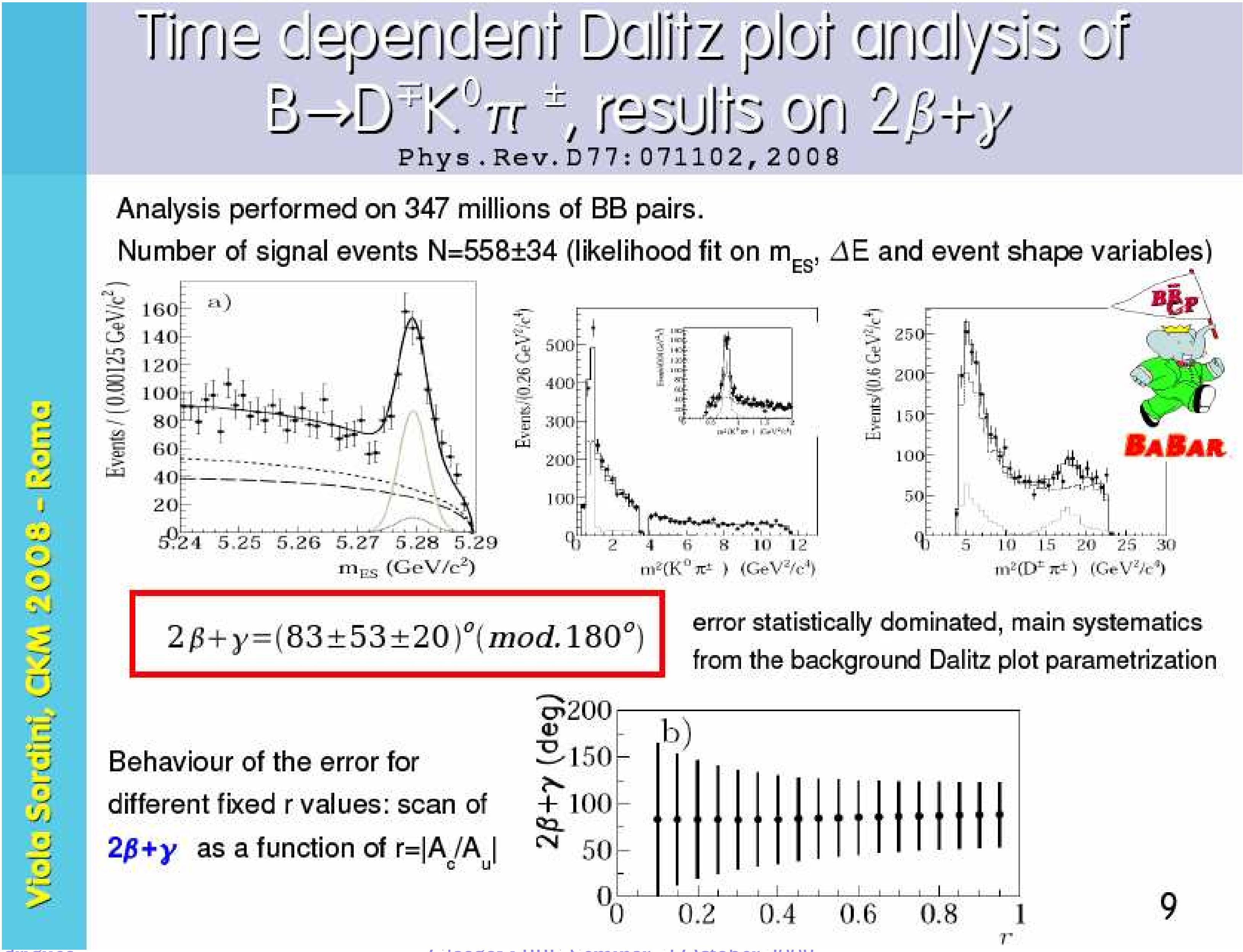
- B→DK with any D decay mode that is accessible to both D^0 and $\overline{D}^0$ is sensitive to γ
  - M.Gronau & D.Wyler, PLB 253, 483 (1991)
  - M.Gronau & D.London, PLB 265, 172 (1991)
  - D.Atwood, I.Dunietz and A.Soni, PRL 78, 3257 (1997); PRD 63, 036005 (2001)
- Different D decay modes in use

– CP eigenstates	(eg. K^+K^-, $K_s\pi^0$)	“GLW”
– Doubly-suppressed decays	(eg. $K\pi$)	“ADS”
– Singly-suppressed decays	(eg. KK^*)	“GLS”
– Three-body decays	(eg. $K_s\pi^+\pi^-$)	“GGSZ / Dalitz”

  - Other possibilities exist …

An example from BaBar …

Sordini



Time dependent Dalitz plot analysis of $B\to D^{\mp}K^0\pi^{\pm}$, results on $2\beta+\gamma$

Phys.Rev.D77:071102,2008

Analysis performed on 347 millions of BB pairs.

Number of signal events N=558±34 (likelihood fit on m_{ES}, ΔE and event shape variables)

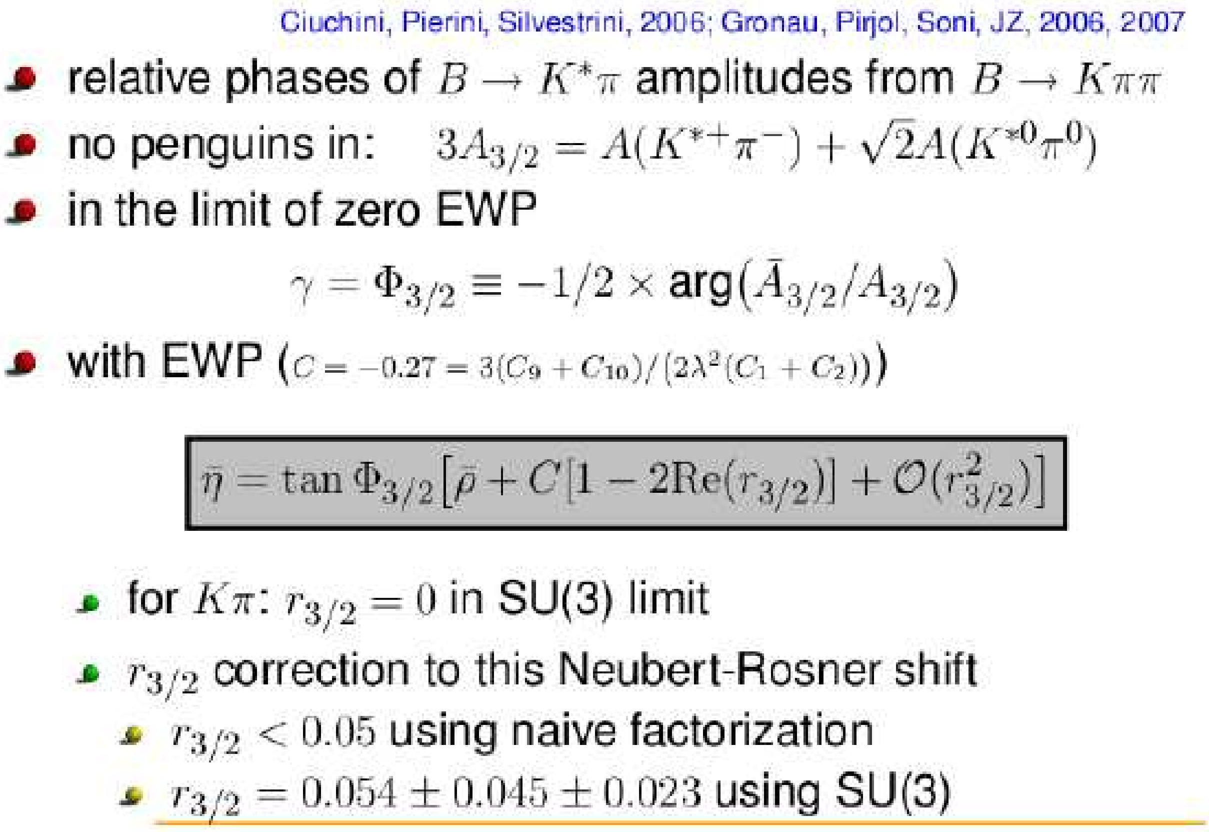
$$2\beta+\gamma=(83\pm53\pm20)^o(mod.180^o)$$

error statistically dominated, main systematics from the background Dalitz plot parametrization

Behaviour of the error for different fixed r values: scan of $2\beta+\gamma$ as a function of $r=|A_c/A_u|$

B → Kππ : Dalitz analyses

Zupan / Lathan



Ciuchini, Pierini, Silvestrini, 2006; Gronau, Pirjol, Soni, JZ, 2006, 2007

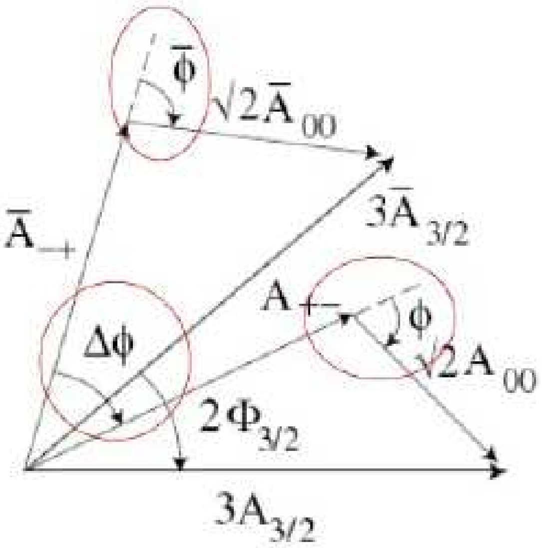
- relative phases of $B \to K^*\pi$ amplitudes from $B \to K\pi\pi$
- no penguins in: $3A_{3/2} = A(K^{*+}\pi^-) + \sqrt{2}A(K^{*0}\pi^0)$
- in the limit of zero EWP

$$\gamma = \Phi_{3/2} \equiv -1/2 \times \arg(\bar{A}_{3/2}/A_{3/2})$$

- with EWP ($C = -0.27 = 3(C_9 + C_{10})/(2\lambda^2(C_1 + C_2))$)

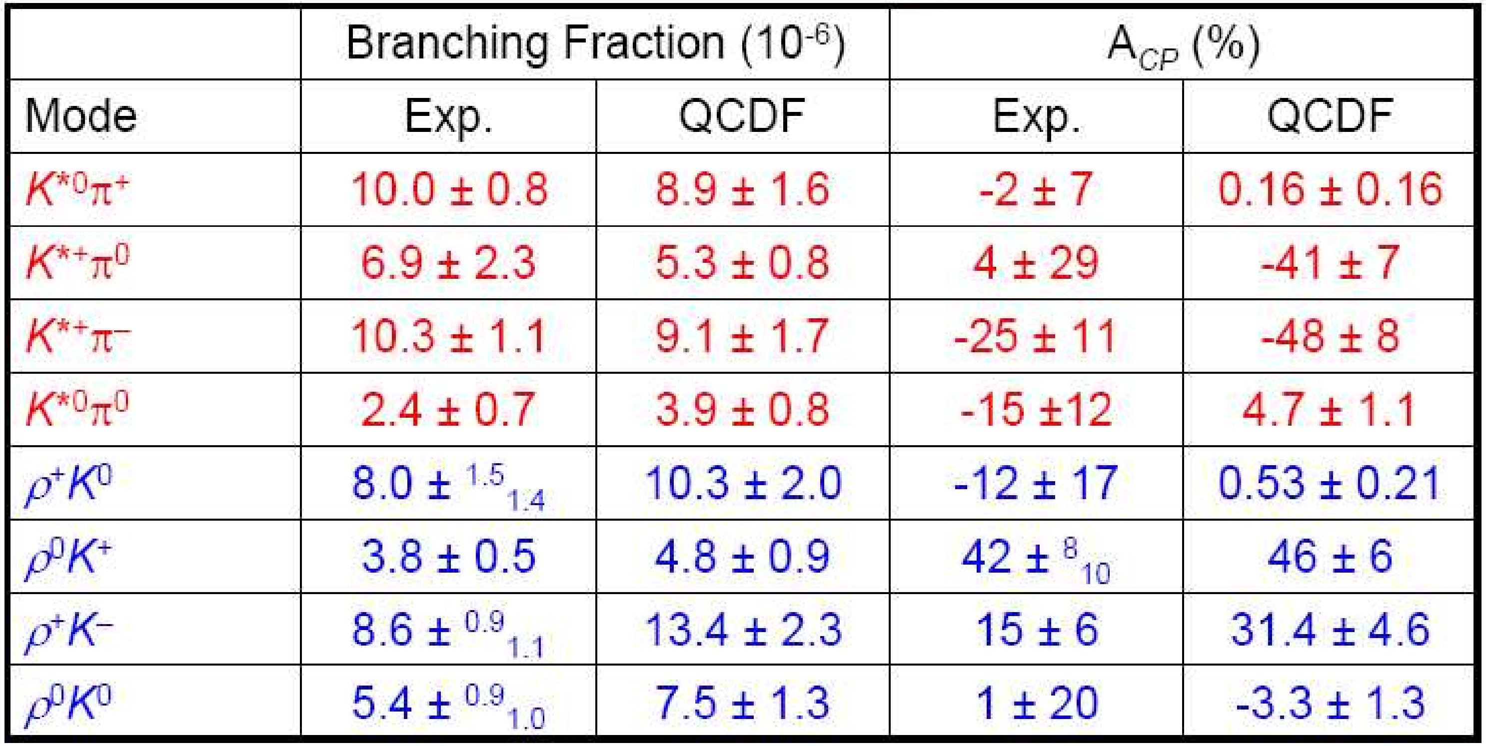
$$\boxed{\bar{\eta} = \tan\Phi_{3/2}\big[\bar{\rho} + C[1 - 2\mathrm{Re}(r_{3/2})] + \mathcal{O}(r_{3/2}^2)\big]}$$

- for $K\pi$: $r_{3/2} = 0$ in SU(3) limit
- $r_{3/2}$ correction to this Neubert-Rosner shift
  - $r_{3/2} < 0.05$ using naive factorization
  - $r_{3/2} = 0.054 \pm 0.045 \pm 0.023$ using SU(3)



Summary of K*π and ρK analyses

Lathan



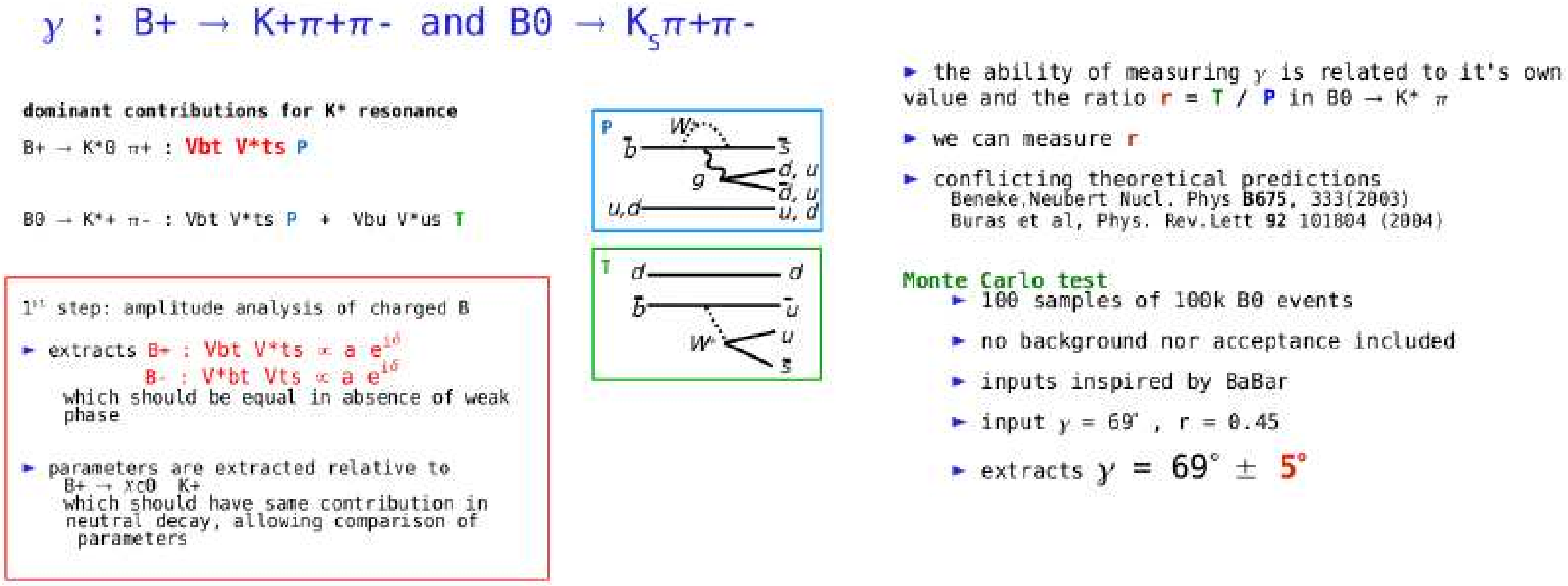
	Branching Fraction (10^{-6})		A_{CP} (%)	
Mode	Exp.	QCDF	Exp.	QCDF
$K^{*0}\pi^{+}$	10.0 ± 0.8	8.9 ± 1.6	-2 ± 7	0.16 ± 0.16
$K^{*+}\pi^{0}$	6.9 ± 2.3	5.3 ± 0.8	4 ± 29	-41 ± 7
$K^{*+}\pi^{-}$	10.3 ± 1.1	9.1 ± 1.7	-25 ± 11	-48 ± 8
$K^{*0}\pi^{0}$	2.4 ± 0.7	3.9 ± 0.8	-15 ±12	4.7 ± 1.1
$\rho^{+}K^{0}$	$8.0 \pm {}^{1.5}_{1.4}$	10.3 ± 2.0	-12 ± 17	0.53 ± 0.21
$\rho^{0}K^{+}$	3.8 ± 0.5	4.8 ± 0.9	$42 \pm {}^{8}_{10}$	46 ± 6
$\rho^{+}K^{-}$	$8.6 \pm {}^{0.9}_{1.1}$	13.4 ± 2.3	15 ± 6	31.4 ± 4.6
$\rho^{0}K^{0}$	$5.4 \pm {}^{0.9}_{1.0}$	7.5 ± 1.3	1 ± 20	-3.3 ± 1.3

Experimental numbers from HFAG Summer 2008, QCDF predictions from Chang et al., arXiv:0807.4295v3

B → Kππ : LHCb developments

Guerrer

- $B^0 \rightarrow K\pi\pi^0$ will be difficult → use a different method
- One nominal year of LHCb data on $B^+ \rightarrow K\pi\pi$
  - 2 orders of magnitude more events than the B factories!



γ : $B+ \rightarrow K+\pi+\pi-$ and $B0 \rightarrow K_S\pi+\pi-$

dominant contributions for K* resonance

$B+ \rightarrow K^*0\ \pi+$: **Vbt V*ts** P

$B0 \rightarrow K^*+\ \pi-$: Vbt V*ts P + Vbu V*us T

1st step: amplitude analysis of charged B

- extracts B+ : Vbt V*ts $\propto a\, e^{i\delta}$
  B- : V*bt Vts $\propto a\, e^{i\delta}$
  which should be equal in absence of weak phase
- parameters are extracted relative to
  $B+ \rightarrow \chi c0\ \ K+$
  which should have same contribution in neutral decay, allowing comparison of parameters

- the ability of measuring γ is related to it's own value and the ratio r = T / P in $B0 \rightarrow K^*\ \pi$
- we can measure r
- conflicting theoretical predictions
  Beneke,Neubert Nucl. Phys **B675**, 333(2003)
  Buras et al, Phys. Rev.Lett **92** 101804 (2004)

Monte Carlo test

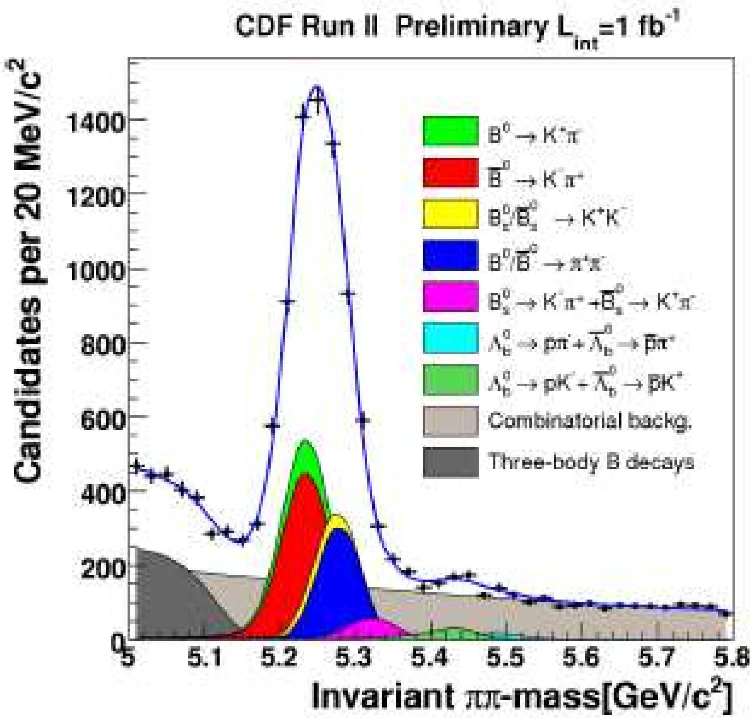
- 100 samples of 100k B0 events
- no background nor acceptance included
- inputs inspired by BaBar
- input $\gamma = 69^\circ$, $r = 0.45$
- extracts $\gamma = 69^\circ \pm 5^\circ$

B $\rightarrow$ hh : some results from CDF

Volpi

Determination of sample composition provides

1. Observation of new Bhh mode: Bs→Kπ
2. First observation of Λ_b→ph decays: Λ_b →pπ and Λ_b→pK
3. Unique sample of B_s→KK
4. B-factories-like samples of B_d →ππ and B_d→Kπ



A wealth of measurements is extracted

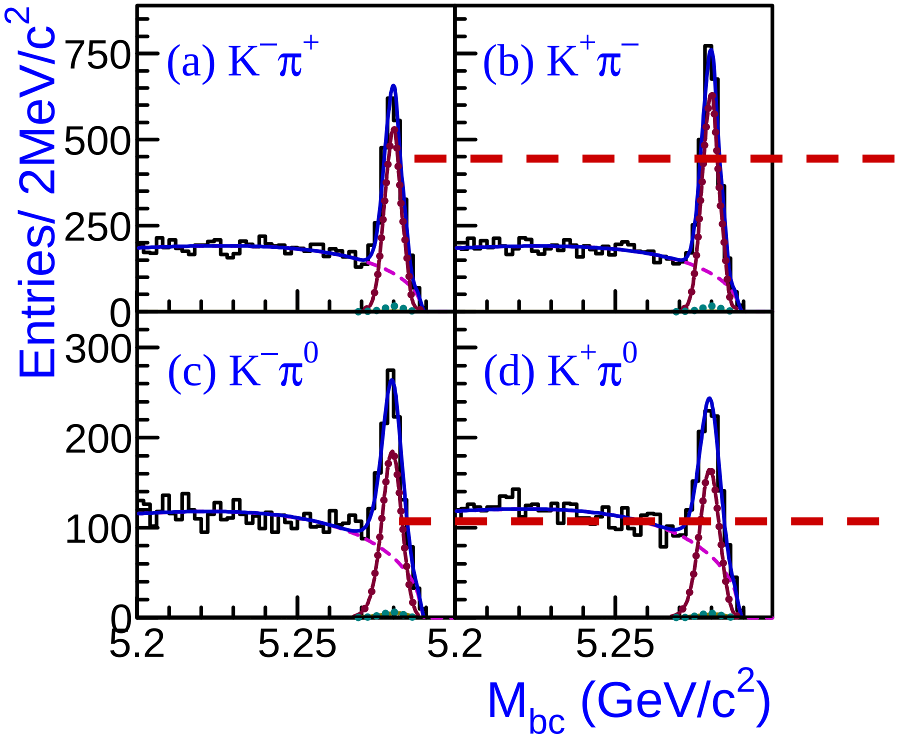
1. BR(B_s→Kπ) and ACP(B_s→kπ)
2. Improved BR(B_s→KK)
3. BR(Λ_b→pπ) and ACP(Λ_b→pπ)
4. BR(Λ_b→pK) and ACP(Λ_b→pK)

Constraints on gamma!

All BR are measured relative to the reference mode B_d → Kπ to cancel common systematic uncertainties

$B \to hh$: direct CP asymmetries

Lin



$K^+\pi^-$: -0.094±0.018±0.008 (4.7σ)

$K^+\pi^0$: 0.07±0.03±0.01 (2.3σ)

$\pi^+\pi^0$: 0.07±0.06±0.01

Acp($K^+\pi^-$) - Acp($K^+\pi^0$)

➔-0.164±0.037@4.4σ

Nature 452, 332 (2008)

$$A_{cp}(K^+\pi^-) = \begin{cases} -0.107 \pm 0.016 \; {}^{+0.006}_{-0.004} & \textbf{BaBar} \\ -0.094 \pm 0.018 \pm 0.008 & \textbf{Belle} \\ -0.086 \pm 0.023 \pm 0.009 & \textbf{CDF} \\ -0.04 \pm 0.16 \pm 0.02 & \textbf{CLEO} \end{cases}$$

$$\Rightarrow -0.098 \; {}^{+0.012}_{-0.011} \; @ \; 8.1\sigma \quad \textbf{AVG}$$

$$A_{cp}(K^+\pi^0) = \begin{cases} +0.030 \pm 0.039 \pm 0.010 & \textbf{BaBar} \\ +0.07 \pm 0.03 \pm 0.01 & \textbf{Belle} \\ -0.29 \pm 0.23 \pm 0.02 & \textbf{CLEO} \end{cases}$$

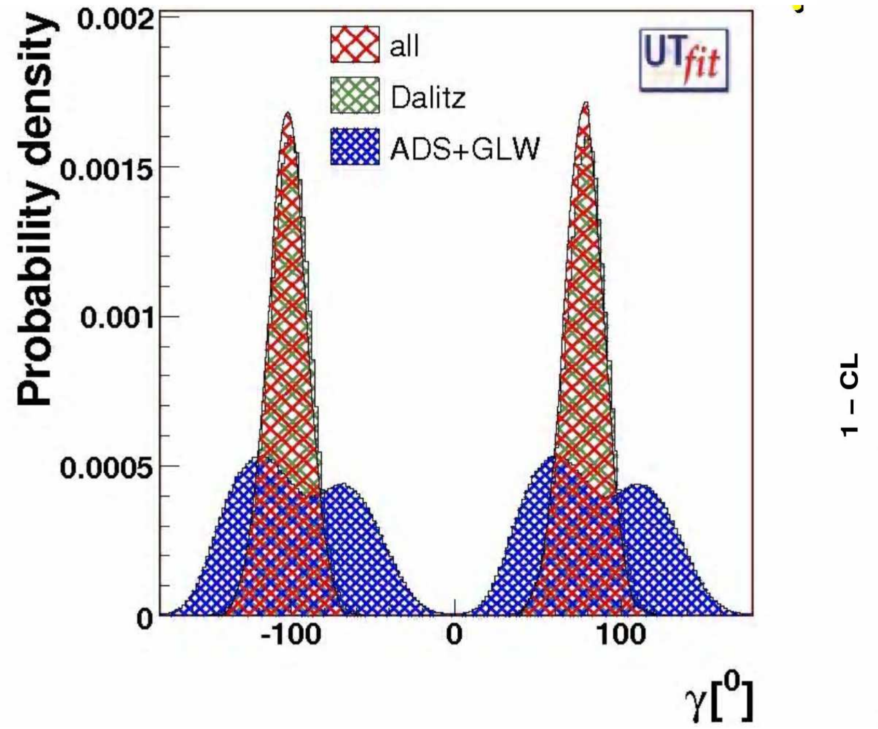
$$\Rightarrow +0.050 \pm 0.025 \; @ 2.0\sigma \quad \textbf{AVG}$$

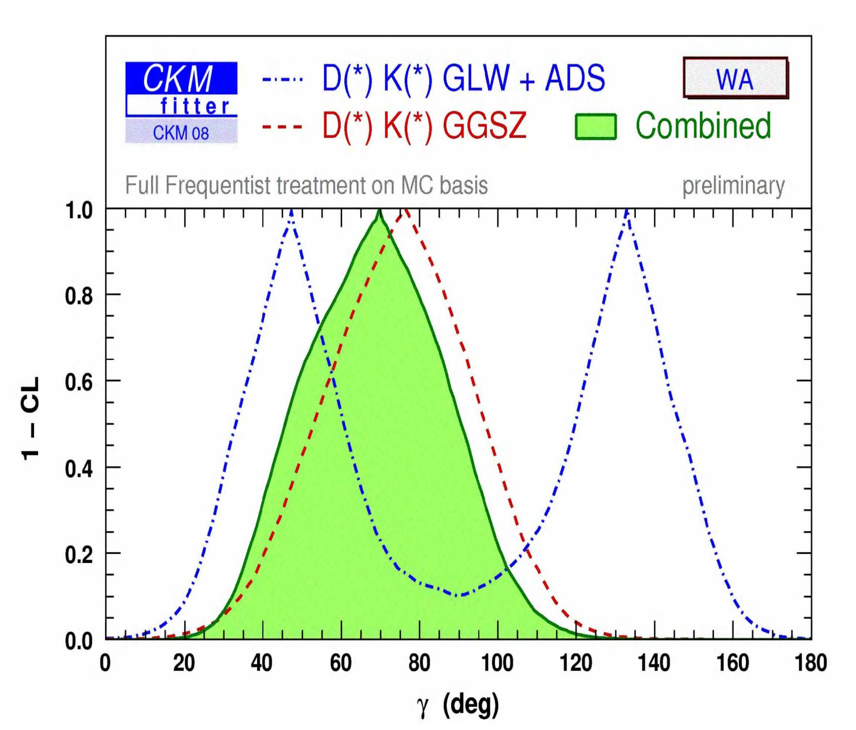
$$\Delta A_{K\pi} = A_{cp}(K^+\pi^-) - A_{cp}(K^+\pi^0)$$
$$= -0.147 \pm 0.028 \; @ \; 5.3\sigma$$

γ: UT$_{\text{fit}}$ versus CKM$_{\text{fitter}}$

Sordini

Trabelsi





$$\gamma = (78 \pm 12)^\circ, [2\sigma] = (54^\circ, 100^\circ)$$

$$\gamma = (70^{+27}_{-29})^\circ, [2\sigma] = (29^\circ, 113^\circ)$$

Rare B decays

Methods

- $b \to s/d\,\gamma$, inclusive and exclusive
- $b \to s\, l^+ l^-$, inclusive and exclusive
- $b \to \mu^+ \mu^-$

b $\rightarrow$ s/d γ : theory

Greub

- ❑ **Provides stringent bounds on many models of New Physics**

First estimate at NNLO

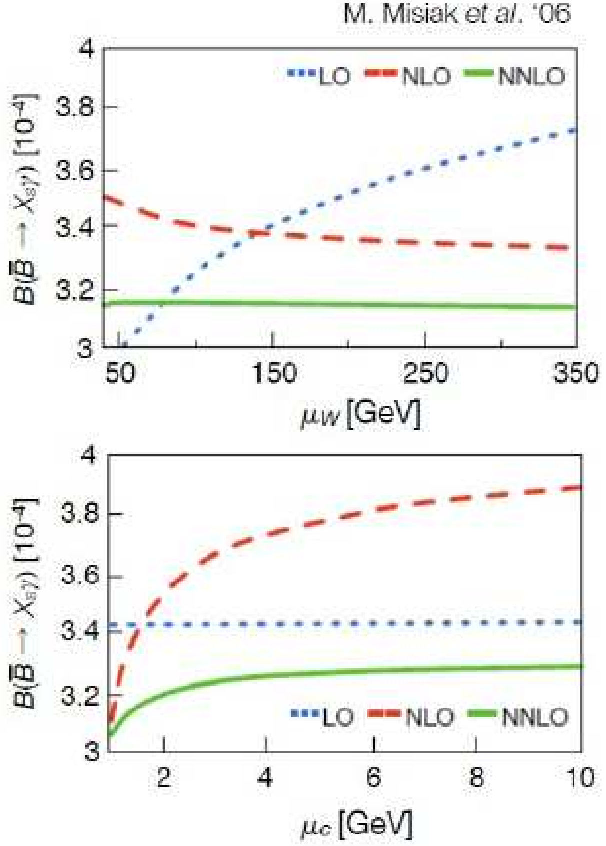
$$\mathcal{B}(\bar{B} \to X_s\gamma)^{E_\gamma > 1.6\,\mathrm{GeV}}_{\mathrm{NNLO}} = (3.15 \pm 0.23) \times 10^{-4}$$

To be compared to

$$\mathcal{B}(\bar{B} \to X_s\gamma)^{E_\gamma > 1.6\,\mathrm{GeV}}_{\mathrm{exp}} = (3.52 \pm 0.23 \pm 0.09) \times 10^{-4}$$

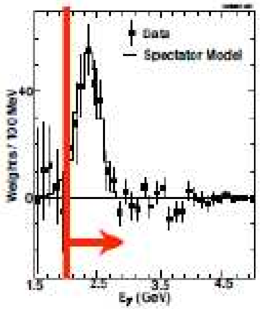
Inclusion of NNLO corrections leads to a notable reduction of renormalization scale dependences.

Most pronounced effect occurs for charm quark mass scale that was main source of uncertainty at NLO.


M. Misiak *et al.* '06

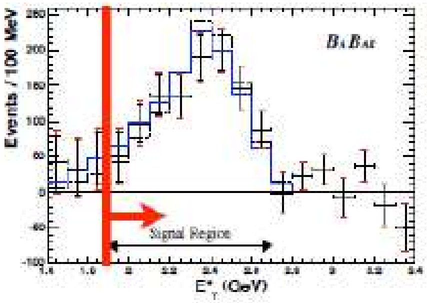
$b \to s/d\,\gamma$: inclusive measurements

Gardi / Limosani



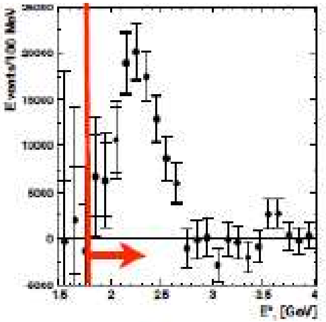
CLEO
9.1/fb ON
4.4/fb OFF
$E_\gamma > 2.0$ GeV

PRL87, 251807
(2001)



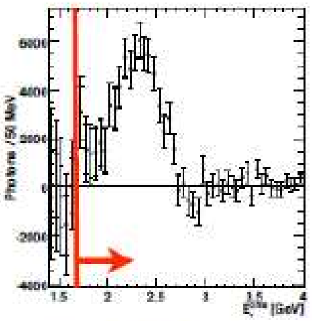
BABAR
81.5/fb ON
9.6/fb OFF
$E_\gamma > 1.9$ GeV

PRL97, 171803
(2006)



Belle
140/fb ON
15/fb OFF
$E_\gamma > 1.8$ GeV

PRL93, 061803
(2004)



Belle
605/fb ON
68/fb OFF
$E_\gamma > 1.7$ GeV

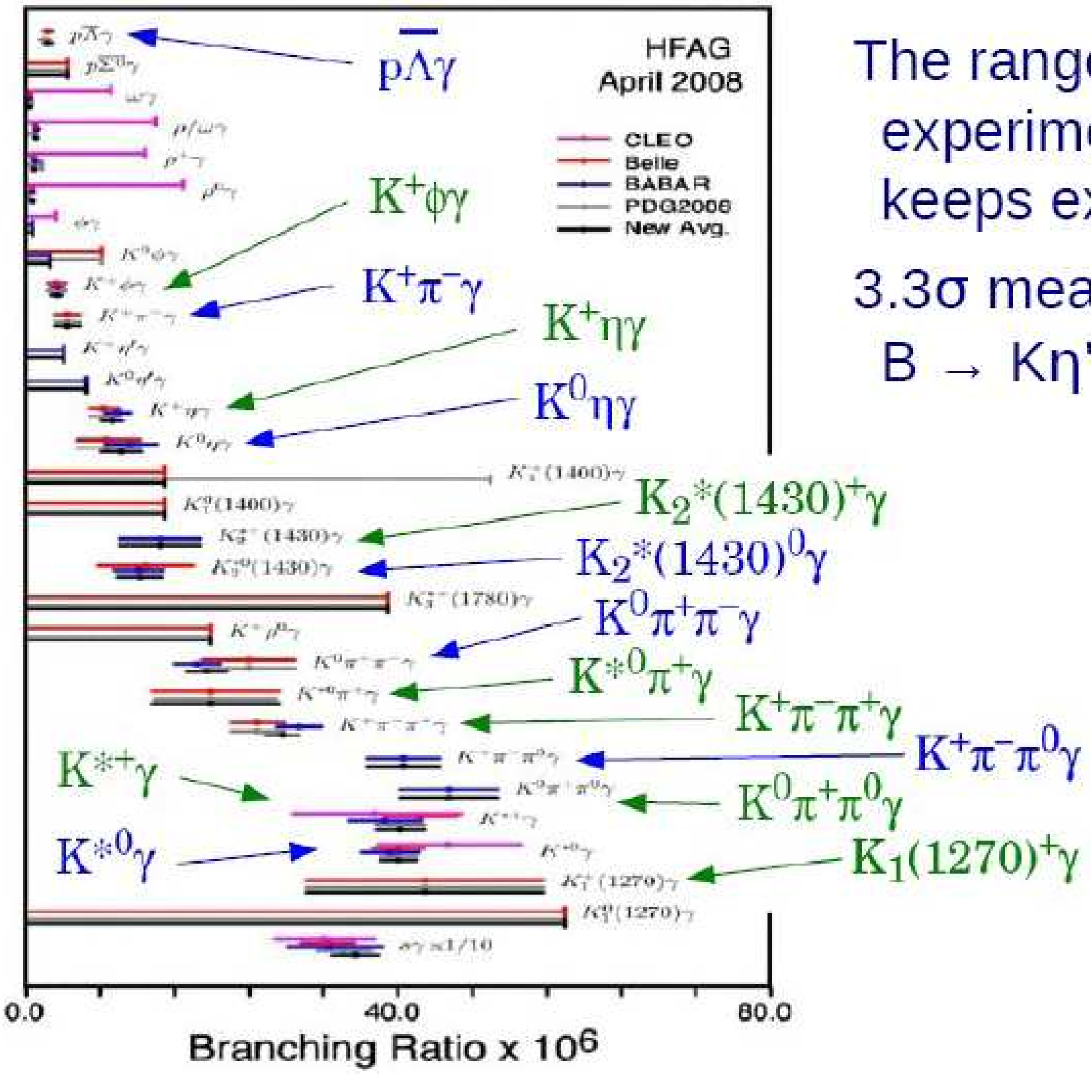
arXiv:0804.1580
(2008)

More data, lower the photon energy cut

"Matching" between experiment and theory at an energy cut-off of 1.6 GeV.
But theorists recommend to use a cut-off at 1.8 GeV ...

b → s/d γ : exclusive decay measurements

Nishida



The range of experimental results keeps expanding

3.3σ measurement of B → Kη'γ the latest

$b \to s/d\,\gamma$: direct CP and isospin asymmetries

Nishida

Charge asymmetry

$$A_{CP} = \frac{\Gamma(\bar{B} \to \bar{K}^* \gamma) - \Gamma(B \to K^* \gamma)}{\Gamma(\bar{B} \to \bar{K}^* \gamma) + \Gamma(B \to K^* \gamma)}$$

Isospin asymmetry

$$\Delta_{0+} = \frac{\Gamma(B^0 \to K^{*0}\gamma) - \Gamma(B^+ \to K^{*+}\gamma)}{\Gamma(B^0 \to K^{*0}\gamma) + \Gamma(B^+ \to K^{*+}\gamma)}$$

BaBar	BaBar
$-0.009 \pm 0.017 \pm 0.011$	$0.029 \pm 0.019 \pm 0.016 \pm 0.018$
BELLE	BELLE
$-0.015 \pm 0.044 \pm 0.012$	$0.034 \pm 0.044 \pm 0.026 \pm 0.025$

This number becomes interesting in comparison with measurement in $B \to K^{(*)} l^+ l^-$

$b \to s/d\ l^+l^-$

Feldmann / Hurth / Lunghi

A_{FB} :

- ❑ Calculations to fixed-order NNLO
- ❑ SM predictions with 5-15% errors

Rates and amplitudes:

- ❑ Theoretically safe region: $1 < q^2 < 6$ GeV^2
- ❑ Experiments strongly encouraged to focus on this window
  (e.g. Babar goes down to 0.1 GeV^2)

New observables :

- ❑ Good exp. resolution
- ❑ Small theor. uncertainties

Old

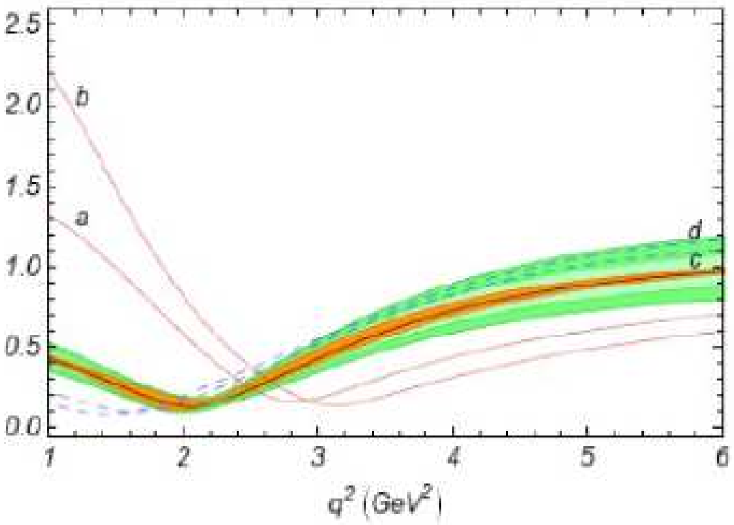
$$A_T^{(1)} = \xcancel{\frac{-2\mathrm{Re}(A_\parallel A_\perp^*)}{|A_\perp|^2 + |A_\parallel|^2}} \qquad A_T^{(2)} = \frac{|A_\perp|^2 - |A_\parallel|^2}{|A_\perp|^2 + |A_\parallel|^2}$$

New

$$A_T^{(3)} = \frac{|A_{0L}A_{\parallel L}^* - A_{0R}^* A_{\parallel R}|}{\sqrt{|A_0|^2 |A_\perp|^2}} \qquad A_T^{(4)} = \frac{|A_{0L}A_{\perp L}^* - A_{0R}^* A_{\perp R}|}{|A_{0L}^* A_{\parallel L} + A_{0R}A_{\parallel R}^*|}$$

$b \to s/d\ l^+l^-$: $A_T^{(3)}$ in different SUSY models

Hurth / Patel



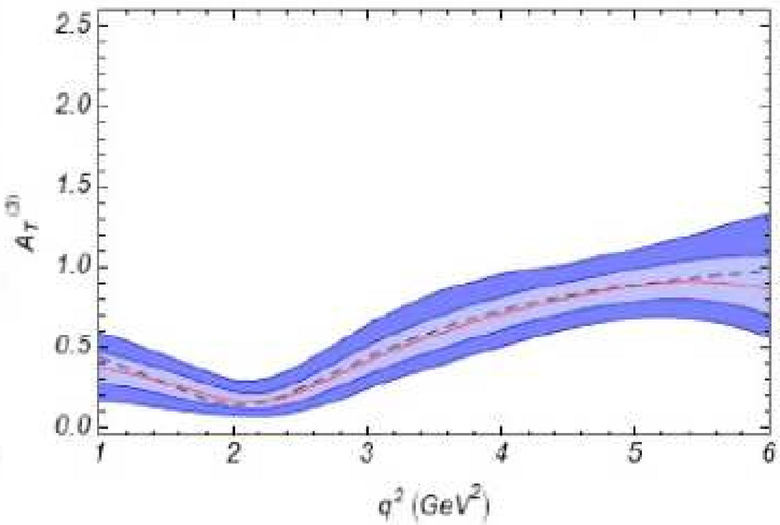
Theoretical uncertainty

Light green

5% Λ / m_b corrections

Dark green

10% Λ / m_b corrections



Exp uncertainty at LHCb

Light blue

1σ contour at 10 fb-1 @ LHCb

Dark blue

2σ contour at 10 fb-1 @ LHCb

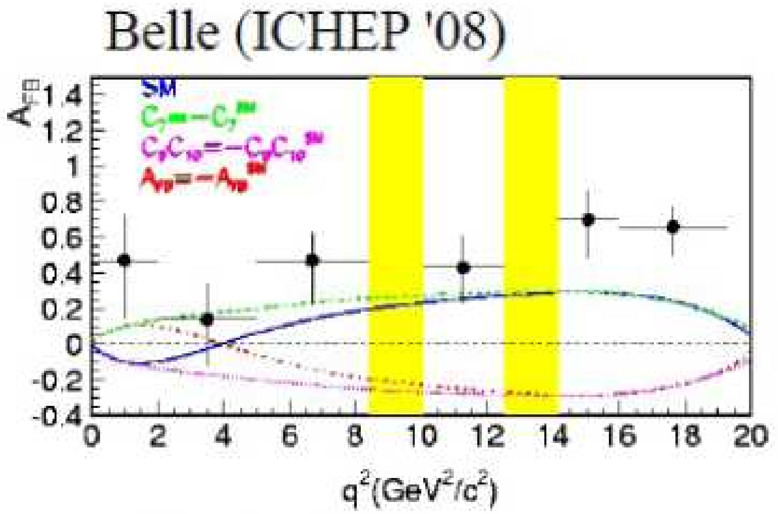
B → K* l^+l^- : forward-backward asymmetry

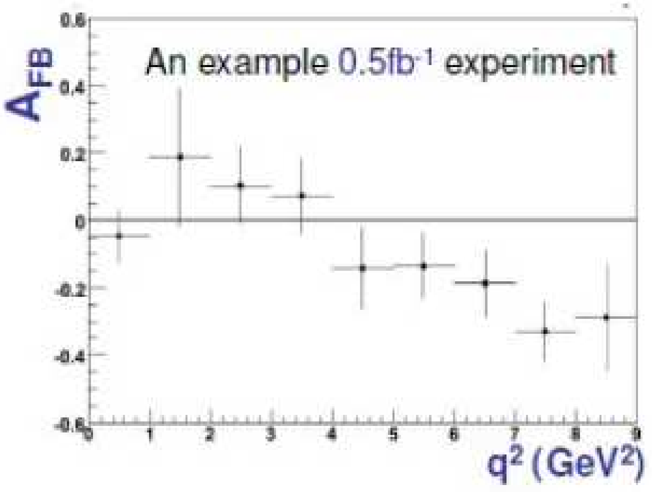
Schilling / Patel

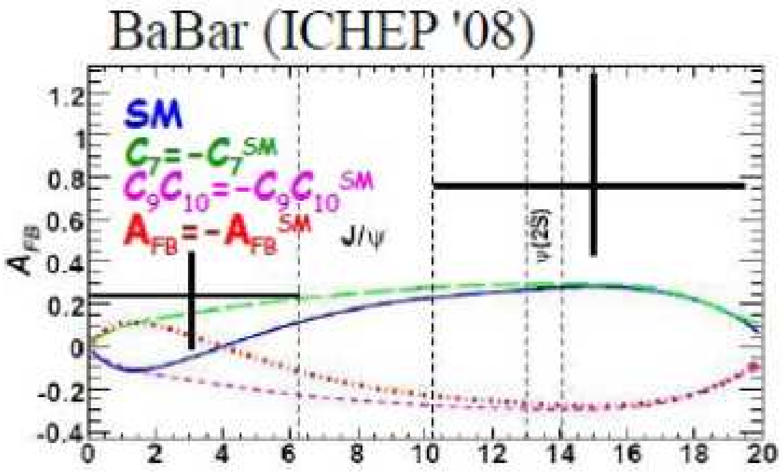
Results are compatible with SM but are certainly interesting!

Great prospects for LHCb to resolve this.

Expect O(2k) events in 2009







Conclusions and Outlook

- Many many updates and new techniques presented

- Impressive achievements by BaBar, Belle and CDF

- Unitarity of 1st row of CKM matrix confirmed to 0.07%

- Particular focus on complementary measurements of γ
- Still only known to about 10-30 degrees

- LHCb is finally in the spotlight ;-)