Experimental Highlights

FPCP2010

Torino, Italy

A. Jawahery
University of Maryland

We have had an exciting and remarkably fruitful conference:

- 45 talks on experiments
- 13 talks on theory & interpretations
- I have tried to select some highlights to comment on. My sincere apologies to those not included.

- Having had the honor of summarizing FPCP2006, I will start with a reminder of what appeared to be, at that time, a reasonable (consensus) expectation for FPCP2008:

<u>Some of the highlights from FPCP2006</u>

- First evidence for Bs mixing
    - No info yet on its phase
- First evidence for $B \to \tau\nu$
- Hints (~2 σ) for D^0 mixing
- Indications for f_{Ds} problem
- Lattice friends declared that it's time to deliver – charm measurements to help $|V_{ub}|$ measurement
- Dreams(and some ideas) for a SuperB at 10^{36} /cm2/s – but no solution yet.

The goals- from FPCP2006

$$\sigma(|V_{ub}|) \approx 5\%$$

$$\sigma(\gamma) \approx 5 - 10^o$$

$$\sigma(\alpha) \approx 8^o$$

$$\sigma(\sin 2\beta) = 0.02$$

FPCP2010 at conclusion of
The decade of "flavor physics dominance"

The highlights of the report card includes:

- Observation of CP violation in B decays and measurement of the CKM phase via angles of CKM unitarity triangle.
  - CKM mechanism has passed the main tests, with its phase shown to be the primary source of observed CP violation effects
  - Conclusion of the CKM [O(10%)] onward to CKM [O(1%)]

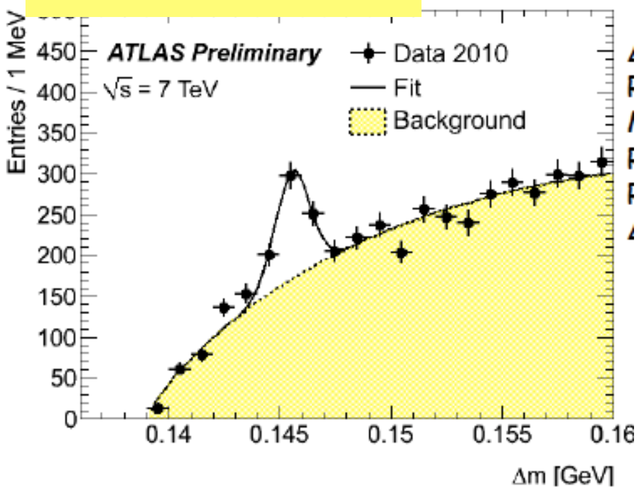
- Completed the neutral meson mixing picture:
  - Observation of Bs mixing at Tevatron
  - Observation D^0 mixing at the B factories

- Broad search for New Physics via measurements of Flavor-Changing-Neutral-Current (FCNC) processes- measured CPV in some very rare decays; SM remarkably resilient- but some hints of deviation present.

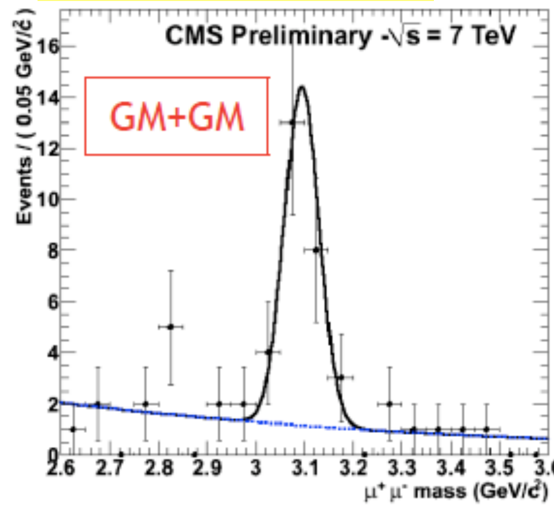
Start of Flavor Physics at LHC

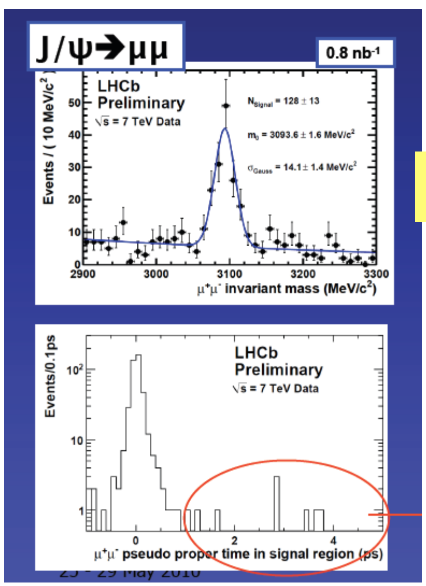
<u>Congratulation to our LHC colleagues-</u> the experiments seem ready for physics, including flavor physics- just need the data:

S. Hassani

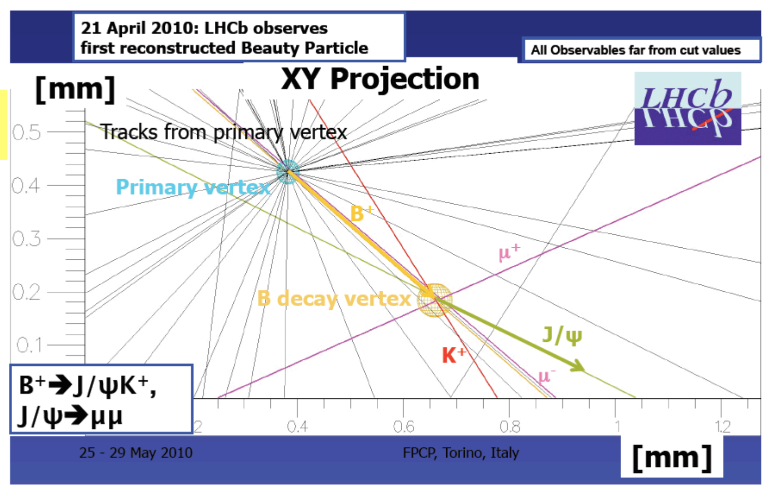


U. Langenegger

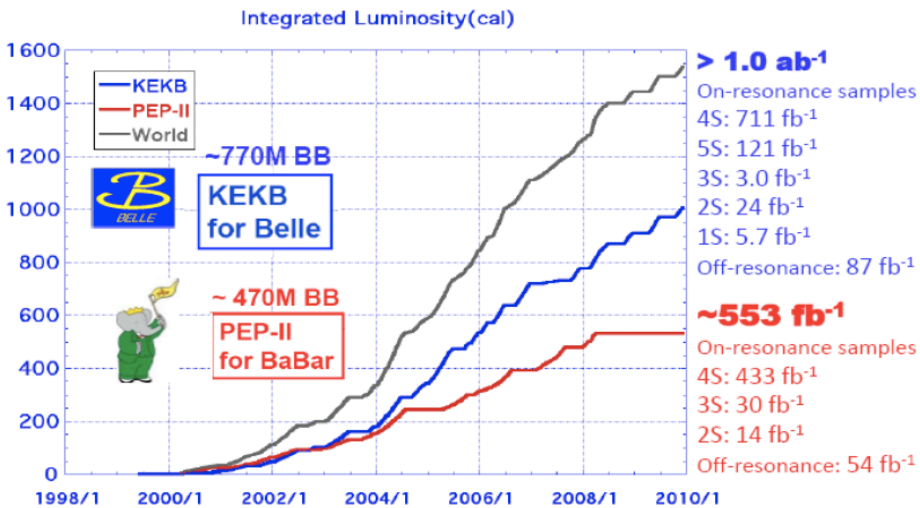


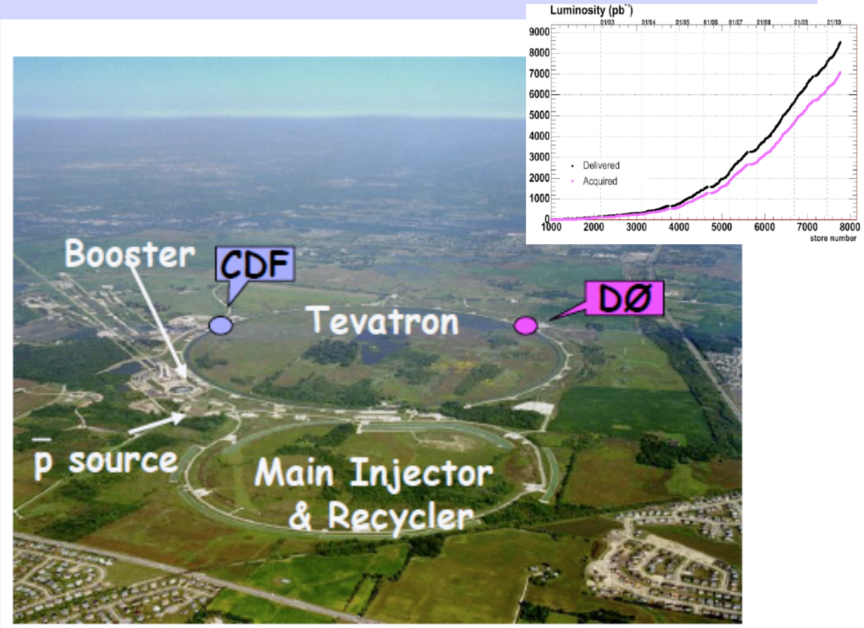


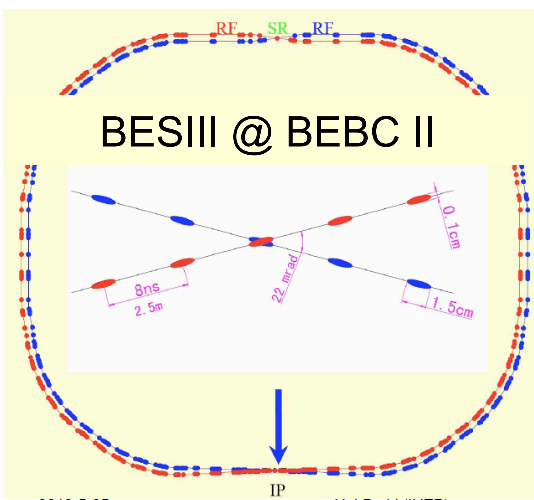
F. Muheim



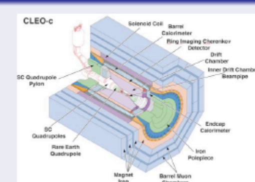
Some of the experimental Players responsible for the current results







Cleo-c

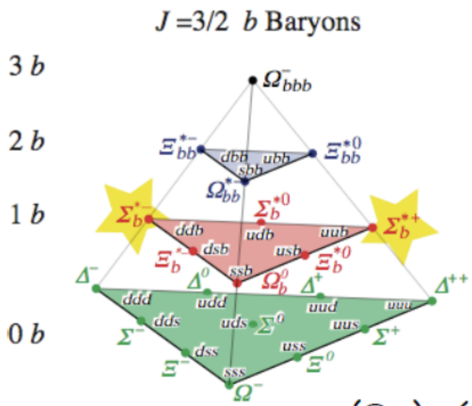


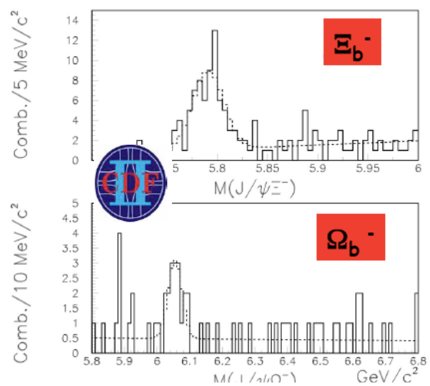
- 0.818/fb at $\psi(3770)$
  - $\star$ 2.4×10^6 D^+D^- pairs
- 0.586/fb at $\psi(4170)$
  - $\star$ 0.54×10^6 $D_s^{*\pm}D_s^{\mp}$ pairs

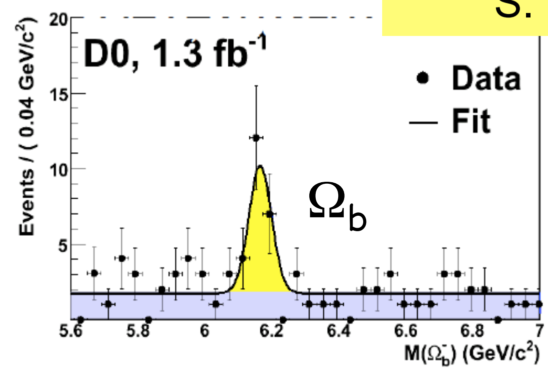
New states and spectroscopy

- Tevatron experiment have been measuring higher b-flavored states- latest are bottom baryons:Ω_b, Ξ_b, Σ^*_b

S. Donati







$m(\Omega_b^-)$: 6054.4 ± 6.8(stat.) ± 0.9(syst.) MeV/c^2

D0 Mass: 6.165 ± 0.010(stat) ± 0.013(syst) GeV/c^2

6σ difference: Stay tuned for the resolution of this issue;
Both experiments have more data to analyze

- Bottomonium system is now on a firm ground: P. Kim
  - The ground state η_b observed by BaBar in $\Upsilon(3S)\to\gamma\eta_b$, confirmed by CLEO, also seen in $\Upsilon(2S)\to\gamma\eta_b$. $\Upsilon(1^3D_J)$ confirmed – initially seen by CLEO.
  - Bottomonium polarization studies at Tevatron J. Lewis

- The charmonium-like states remain "X,Y,Z"-interpretation nowhere in sight. more data has led to an increase in confusion level; conflicting info on spin-parity of X(3872); Molecular interpretation is highly disfavored. P. Biassoni & A. Polosa

CKM parameters

- The CKM mechanism, now known to ~10% accuracy, can accommodate all experimental measurements in flavor physics; few small tensions

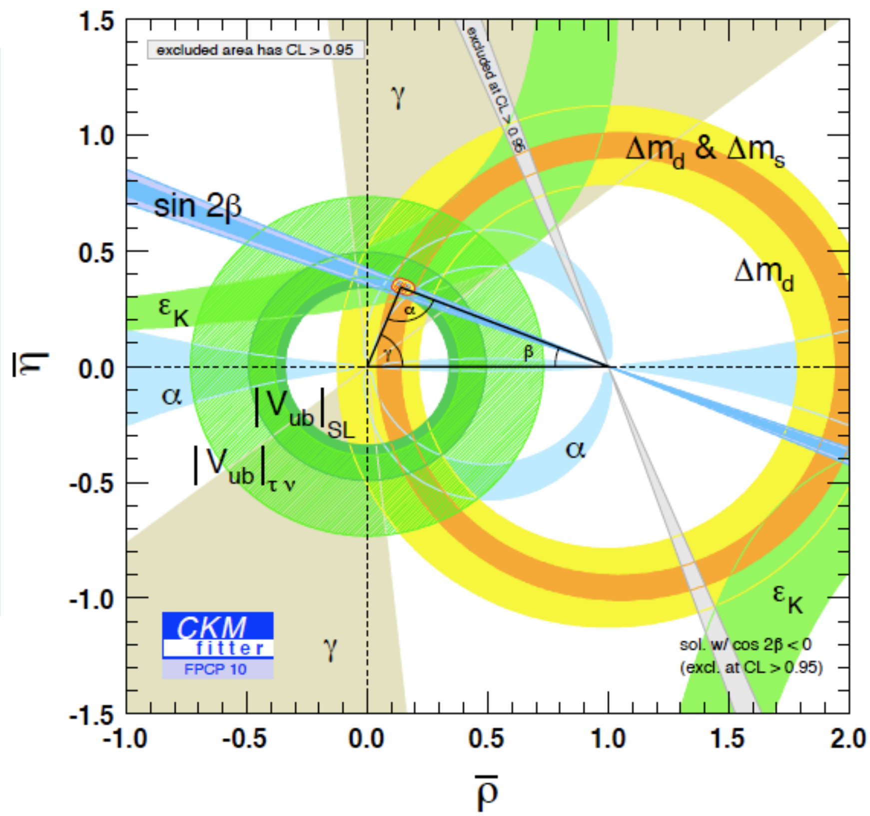
(B. Kowalewski/T.Mannel)

$\delta|V_{cb}|$ @~2%

$\delta|V_{ub}|$ @~10%

New measurements of |Vus| from K3l & K2l decays , and strange tau decays.

P. Massarotti
S. Paramesvaran



$\alpha = (92.0 \pm 3.4)^o$ *Bays.*

$\alpha = (89.0^{+4.4}_{-4.2})^o$ *Freq.*

$\beta = (21.1 \pm 0.9)^o$

$\gamma = (74 \pm 11)^o$ *Bays.*

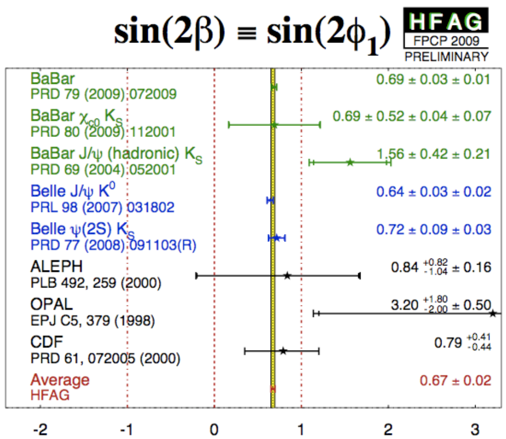
$\gamma = (73^{+22}_{-25})^o$ *Freq.*

UTFit:	$\bar{\rho} = 0.130 \pm 0.020$
	$\bar{\eta} = 0.355 \pm 0.013$
CKMFitter:	$\bar{\rho} = 0.139^{+0.027}_{-0.023}$
	$\bar{\eta} = 0.342^{+0.016}_{-0.015}$

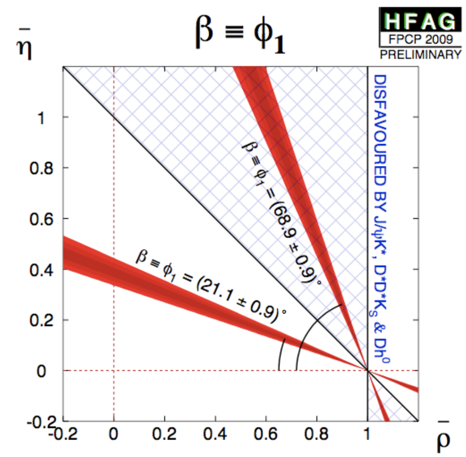
Speakers: K. Sumisawa, J. Dalseno, D. Derkach, M. Bona (UTfit), S. Decostes-Genon(CKMfitter)

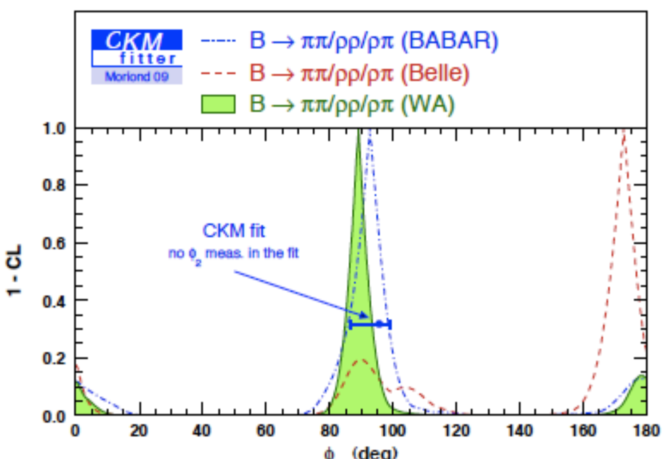
CKM parameters: α & β

- B factories have probably said their "final" word on $\alpha(\phi_2)$ & $\beta(\phi_1)$



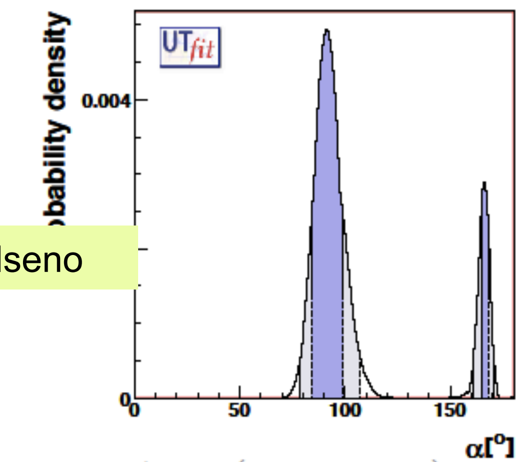
K. Sumisawa





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

J. Dalseno

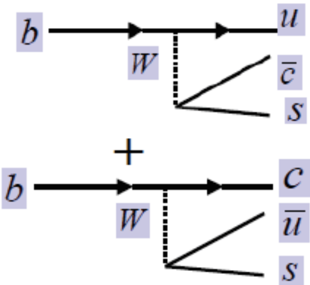


$\phi_2 = (92.0 \pm 3.4)^\circ$

CKM parameters: γ

Tree level determination of γ – key to its value in NP search

D. Derkach



$B^- \to \bar{D}^0 K^-$ $\quad A(B^- \to \bar{D}^0 K^-) = |A_1| e^{i\delta_2} e^{i\gamma}$

$B^- \to D^0 K^-$ $\quad A(B^- \to D^0 K^-) = |A_2| e^{i\delta_1}$

B- → (D→F)K-
F=common to D0 & anti D0

$$A[B^+ \to (D \to f)K^+] \propto 1 + r_B e^{i(\delta+\gamma)}$$
$$A[B^- \to (D \to f)K^-] \propto 1 + r_B e^{i(\delta-\gamma)}$$

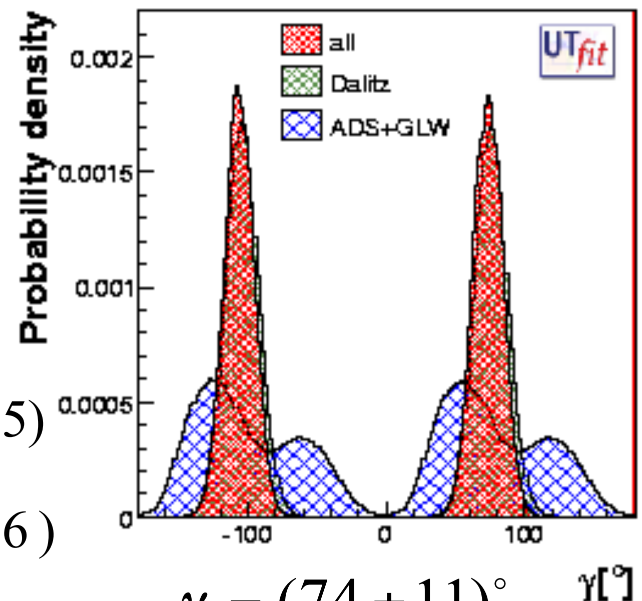
Solve for γ, & $r_B = (|A_1| / |A_2|)$

$\delta = (\delta_1 - \delta_2)$

13#

$$r_B(D^0K^+) = (0.106 \pm 0.016) \quad r_B(D^{*0}K^+) = (0.113 \pm 0.025)$$

$$r_B(D^0K^{*+}) = (0.11 \pm 0.07) \quad r_B(D^0K^{*0}) = (0.26 \pm 0.076)$$



$$\gamma = (74 \pm 11)^\circ$$

The Dalitz Method (GGSZ) dominate the current information on γ

- Uncertainties are still statistics limited
- Modeling error due to treatment of the D→$K_s\pi\pi$-Dalitz plot (amplitudes and phases) accounts for ~3°-7°

γ using $B^+ \rightarrow DK^+$ (+cc) (GGSZ method)

Parameter	68.3% CL	95.4% CL
γ (°)	68^{+15}_{-14} {4, 3}	[39, 98]
r_B (%)	9.6 ± 2.9 {0.5, 0.4}	[3.7, 15.5]
r^*_B (%)	$13.3^{+4.2}_{-3.9}$ {1.3, 0.3}	[4.9, 21.5]
κr_s (%)	$14.9^{+6.6}_{-6.2}$ {2.6, 0.6}	< 28.0
δ_B (°)	119^{+19}_{-20} {3, 3}	[75, 157]
δ^*_B (°)	-82 ± 21 {5, 3}	[−124, −38]
δ_s (°)	111 ± 32 {11, 3}	[42, 178]

Parameter	1σ interval	2σ interval	Systematic error	Model uncertainty
ϕ_3	$(78.4^{+10.8}_{-11.6})^\circ$	$54.2^\circ < \phi_3 < 100.5^\circ$	3.6°	8.9°
r_{DK}	$0.160^{+0.040}_{-0.038}$	$0.084 < r_{DK} < 0.239$	0.011	$^{+0.050}_{-0.010}$
r_{D^*K}	$0.196^{+0.072}_{-0.069}$	$0.061 < r_{D^*K} < 0.271$	0.012	$^{+0.062}_{-0.012}$
δ_{DK}	$(136.7^{+13.0}_{-15.8})^\circ$	$102.2^\circ < \delta_{DK} < 162.3^\circ$	4.0°	22.9°
δ_{D^*K}	$(341.9^{+18.0}_{-19.6})^\circ$	$296.5^\circ < \delta_{D^*K} < 382.7^\circ$	3.0°	22.9°

BaBar obtains

$\gamma = (68^{+15}_{-14} \pm 4 \pm 3)^\circ$

(from DK−, D*K−, DK*−)

Belle obtains

$\varphi_3 = (78^{+11}_{-12} \pm 4 \pm 9)^\circ$

(from DK− & D*K−)

•BaBar measurement includes both D→Ksπ+π− & D→KsK+K- and a new more accurate modeling of the Dalitz plot- including K-matrix treatment of S-wave components

•Belle measurement uses the Isobar model for DP

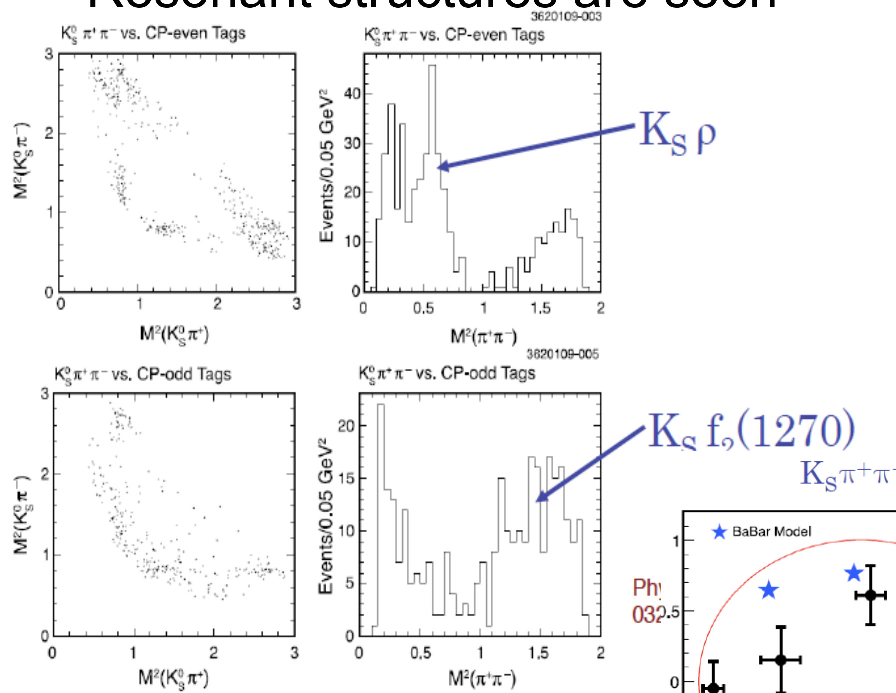
➢ Uncertainties due to D decay modeling can be ultimately reduced using measurements by CLEO-c of the D strong phase – model independent approach.

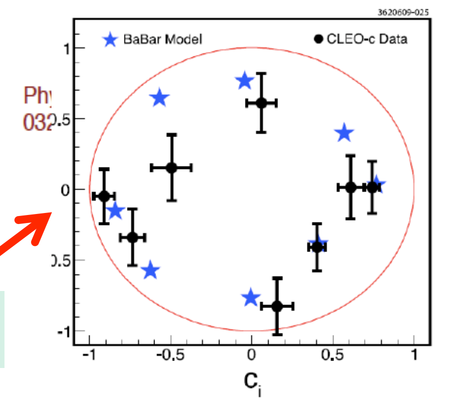
γ measurements - CLEO-c contribution

C. Thomas

- CLEO-c uses coherently produced D^0D^0(bar) pairs to determine average cos(δ) and sin(δ) in bins of DP; Allows for a model independent- binned- treatment of DP in gamma measurements
- Statistical error of CLEO-c replaces modeling errors- to improve with more data from BESS-III

Resonant structures are seen





Compared with BaBar model

LHCb- as the custodian of the γ measurement in the next few years- can reach an accuracy of ~2°. CLEO-c/BESS-III results will help limit modeling error in these measurements to ~ 1.7° (for D->Ks$\pi\pi$)

CKM parameters: $|V_{cb}|$ & $|V_{ub}|$

•Non-zero $|V_{ub}|$ established by CLEO & ARGUS ~2 decades ago

•The magnitude and phases are now measured- but precision measurement (1% for $|V_{cb}|$ and 5% $|V_{ub}|$) remains elusive & seems to be left to the next generation of experiments & theoretical calculations.

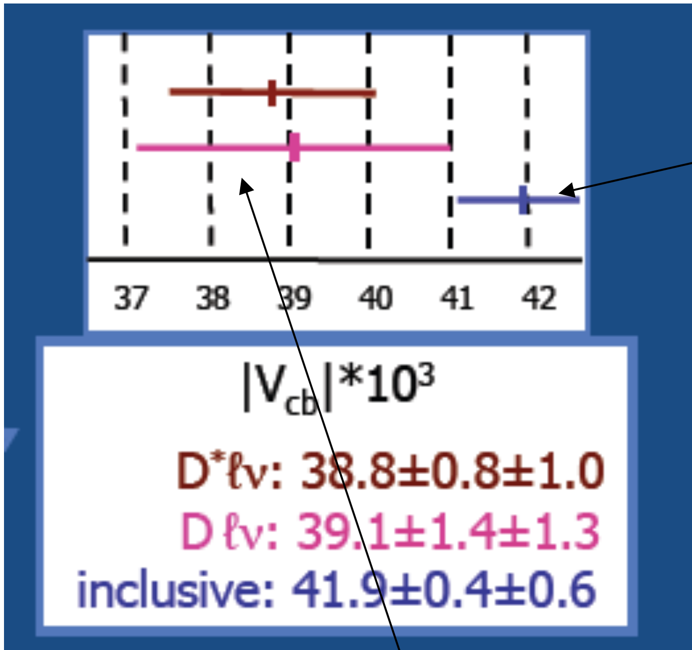
•Both $|V_{cb}|$ and $|V_{ub}|$ are critical to future flavor physics measurements and the search for New Physics in flavor processes.

- •|Vcb| is the dominant source of uncertainty in calculation of rare kaon decays: $K \rightarrow \pi\nu\nu$
- •|Vub| is a key to constraining the CKM parameters free of NP contributions.
- •Both are now dominated by theoretical uncertainties.

•Do we have a way of checking the validity of the theoretical (systematic) uncertainties?

- •Will exclusive vs inclusive approach remain a viable method?
- •Can (validated) Lattice QCD meet the challenge in the era of CKM[O(1%)]?

|Vcb|: Inclusive vs Exclusive measurments



B. Kowalewski
T. Mannel

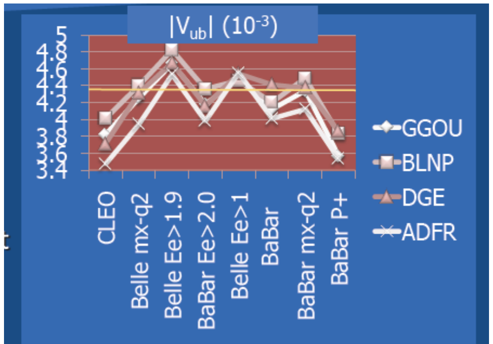
<u>Inclusive:</u>
~2% Error-
Different theory approaches-
1S and Kinetic methods- agree.
With higher level corrections,
a 1% accuracy is within reach

Exclusive:
Error dominated by LQCD calculation of form factors
Any way to check this independently? Perhaps charm decays?

Exclusive vs Inclusive "tension" @ 2.3 σ
While this "tension" persist- it's difficult to assign a 2% (or 1%) error to $|V_{cb}|$

$|V_{ub}|$: Inclusive vs Exclusive Measurements

B. Kowalewski
T. Mannel



Would be prudent to increase theory error on $|V_{ub}|$ averages to allow for this change. PDG2010 quotes

$|V_{ub}| = (4.27 \pm 0.15_{exp} \pm 0.19_{th} \pm 0.30_{add}) \times 10^{-3}$

Inclusive: the Latest analysis: Belle's analysis with a large fraction of the spectrum (~90%) covered- with Ee>1.0 GeV)

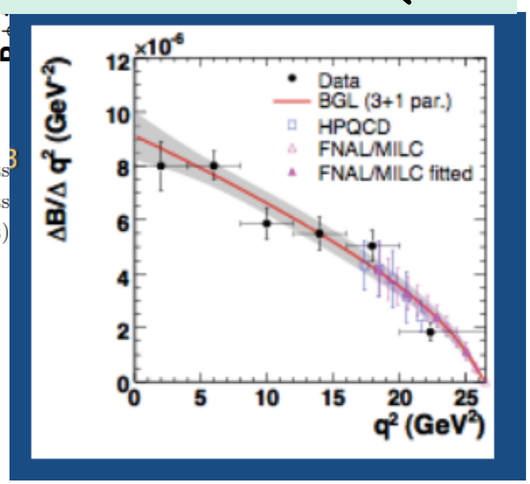
Recent NNLO calculation lead to ~8% change to BLNP based results

Exclusive: Latest in this area- BaBar results: Simultaneous fit of $B \to \pi l \nu$ to data & LQCD

Simultaneous fit to data and lattice

$$|V_{ub}| = (3.05 \pm 0.29) \times 10^{-3} \quad \text{FNAL/MILC (6 points)}$$
$$|V_{ub}| = (2.88 \pm 0.29) \times 10^{-3} \quad \text{FNAL/MILC (3 points)}$$
$$|V_{ub}| = (2.93 \pm 0.37) \times 10^{-3} \quad \text{FNAL/MILC (1 point)}$$
$$|V_{ub}| = (3.01 \pm 0.35) \times 10^{-3} \quad \text{HPQCD (1 point)},$$

precision @ 10%



Exclusive vs Inclusive tension @ 2.7 σ

- $B \to \pi \ell \nu$ — 2.95 ± 0.31 — Latest combined fit to data, lattice
- $b \to u \ell \nu$ — 4.37 ± 0.39 — PDG2010 average; error inflated to account for NNLO result

2.7σ apart

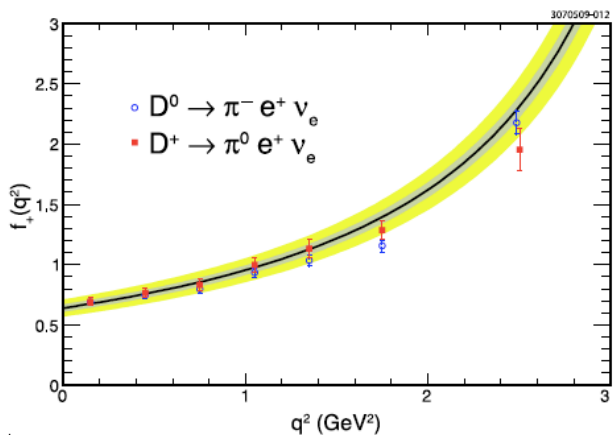
5% error does not seem within reach - Even 10% is difficult to justify as long as the tension persists.

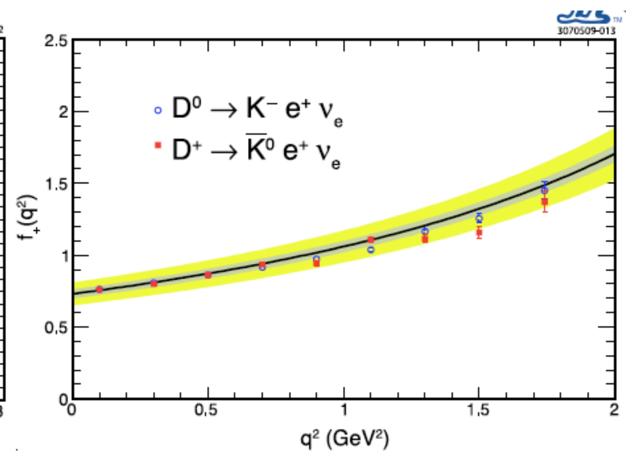
Can semileptonic Charm decays help validate LQCD calculation & help $|V_{ub}|$ measurement

K. Ecklund

$$\frac{d\Gamma\left(D\to P\ell\nu\right)}{dq^2}=\frac{G_F^2\left|V_{cq}\right|^2 P_P^3}{24\pi^3}\left\{\left|f_+(q^2)\right|^2+O(m_l^2)\right\}$$

Precise measurements of the form factors from B factories and CLEO-c to compare with theoretical calculations





- Data in agreement with LQCD band
- Experimental errors are far smaller than LQCD errors
- Will these comparisons lead to more reliable errors in SL B decay form factors?
  - Despite the significant improvement in the experimental data in SL charm decays, the benefit to B decays – as promised- is yet to emerge.

Search for New Physics

New results on B_s mixing

Key Observable in the B_s system

$$|B_{sH}\rangle = p|B_s\rangle - q|\bar{B}_s\rangle$$

$$|B_{sL}\rangle = p|B_s\rangle + q|\bar{B}_s\rangle$$

$$\Delta M_s = M_H - M_L \approx 2|M_{12}|$$

$$\Delta\Gamma_s = \Gamma_H - \Gamma_L \approx 2|\Gamma_{12}|\cos\varphi_{12}$$

$$a_{SL}^S = \frac{\Delta\Gamma_s}{\Delta M_s}\tan\phi_{12}$$

Experimental measurements at Tevatron:
$\Delta\Gamma$ & ϕ_s from time-dependent angular analysis of $Bs \rightarrow J/\psi\phi$
A_{sl} from charge asymmetries of single semileptonic rates

New Measurements:
New A_{SL} from D0 using di-muon events (5.8/fb)
New ϕ_s from CDF based on (5.2/fb)

B_s mixing: New D0 measurement of Charge Asymmetry in Leptons

G. Brooijmans

The basic observation

- $A \equiv \frac{N^{++} - N^{--}}{N^{++} + N^{--}} = (+0.564 \pm 0.053)\%$
  - 3.7×10^6 like-sign dimuon events
- $a \equiv \frac{n^{+} - n^{-}}{n^{+} + n^{-}} = (+0.955 \pm 0.003)\%$
  - 1.5×10^9 single muon events

Both related to A_{SL}

$$A = K A^b_{sl} + A_{bkg}$$
$$a = k A^b_{sl} + a_{bkg}$$

The tasks is to determine A_{bkg}, a_{bkg} & related asymmetries and K and k

Using data: they determine the fraction of various components of background sources and the related charge asymmetry of each component

Background has significant charge asymmetry- dominated by kaon punch through- determined and checked with data & consistent with MC

$(1-f_{bkg})$	f_K	f_π	f_p
$(58.1\pm1.4)\%$	$(15.5\pm0.2)\%$	$(25.9\pm1.4)\%$	$(0.7\pm0.2)\%$
	$a_K f_K$	$a_\pi f_\pi$	$a_p f_p$
	$(+0.854 \pm 0.018)\%$	$(+0.095 \pm 0.027)\%$	$(+0.012 \pm 0.022)\%$
	$A_K F_K$	$A_\pi F_\pi$	$A_p F_p$
	$(+0.828 \pm 0.035)\%$	$(+0.095 \pm 0.025)\%$	$(+0.000 \pm 0.021)\%$

(Statistical uncertainties only)

New D0 measurement

G. Brooijmans

Combing the two measurements –taking into account their correlation-

$$A^b_{sl} = (-\,0.957 \pm 0.251\ (stat) \pm 0.146\ (syst))\ \%$$

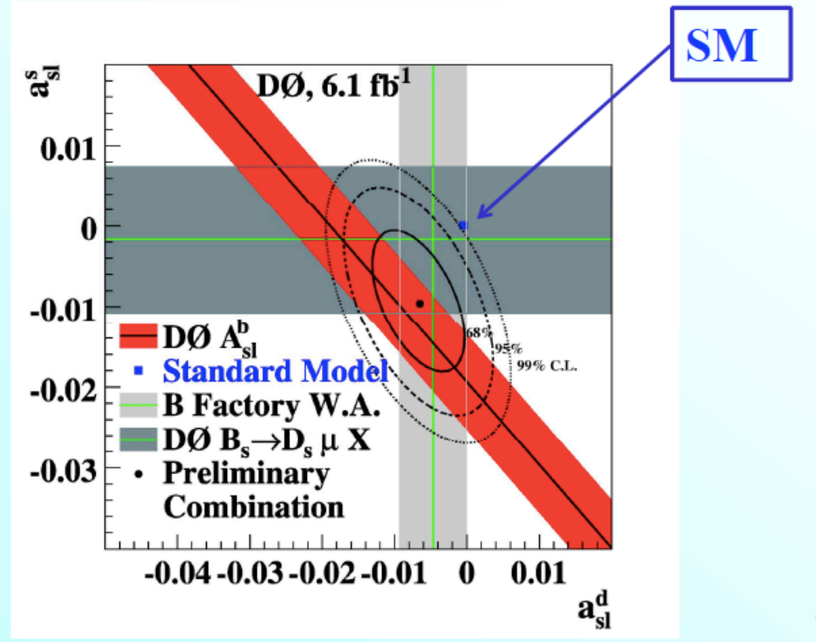
3.2 sigma away from SM

$$A^b_{sl}(SM) = (-2.3^{+0.5}_{-0.6}) \times 10^{-4}$$

Accounting for the B_d component using the B factory measurement of a^d_{sl}=-0.47+/-0.46

$$A^b_{sl} = (0.506 \pm 0.043)a^d_{sl} + (0.494 \pm 0.043)a^s_{sl}$$

$$a^s_{sl} = (-1.46 \pm 0.75)\%$$

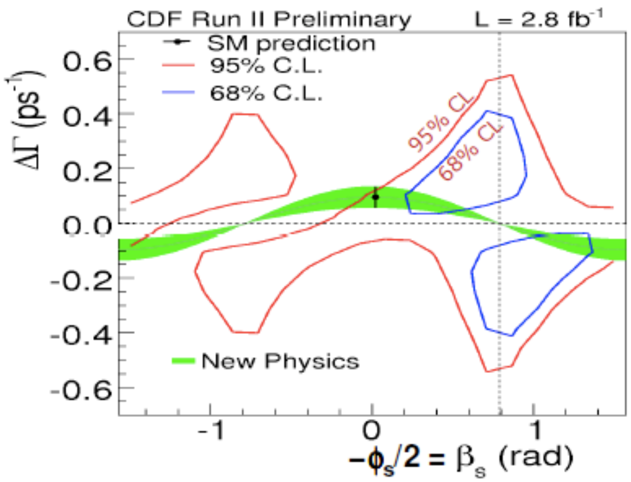


"Tension" with SM is clear. Need confirmation. CDF acceptance is smaller and somewhat suffers from the inability to reverse the B field direction

Measurement of B_s mixing phase (old results)

Using time-dependent angular analysis of $B_s \rightarrow J/\psi\phi$

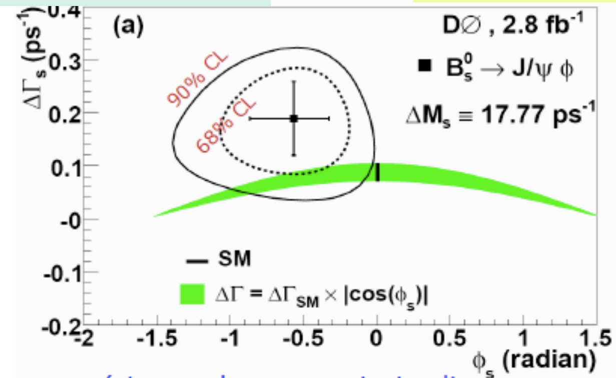
A. Chandra



$$-\phi_s / 2 = \beta_s = [0.28, 1.29] \ rad$$

PRL 100, 161802 (2008)

Probability of SM = 7.0% ~1.8σ



(strong phases constrained)

$$\phi_s = -0.57 ^{+0.24}_{-0.30} (stat) ^{+0.07}_{-0.02} (syst) \ rad$$

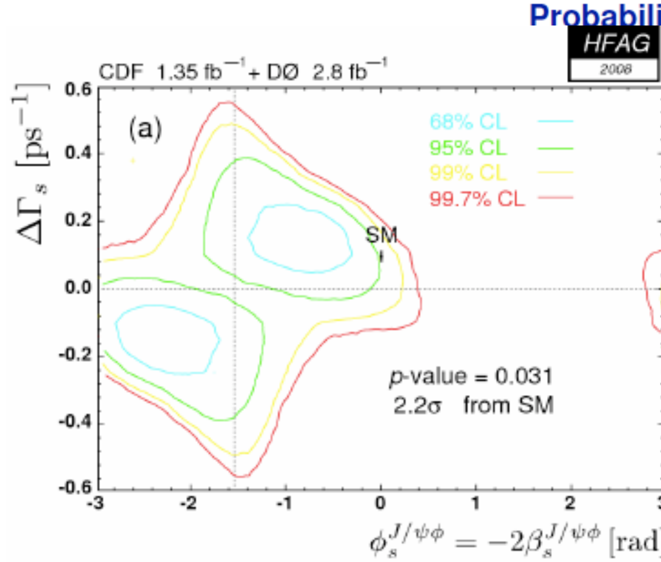
$$\Delta\Gamma_s = 0.19 \pm 0.07 (stat) ^{+0.02}_{-0.01} (syst) \ ps^{-1}$$

$$\overline{\tau_s} = 1.52 \pm 0.05 (stat) \pm 0.01 (syst) \ ps$$

PRL 101, 241801 (2008)

Probability of SM = 6.6% ~1.8σ 6

Combined Tevatron result:
A 2.2 sigma deviation from SM

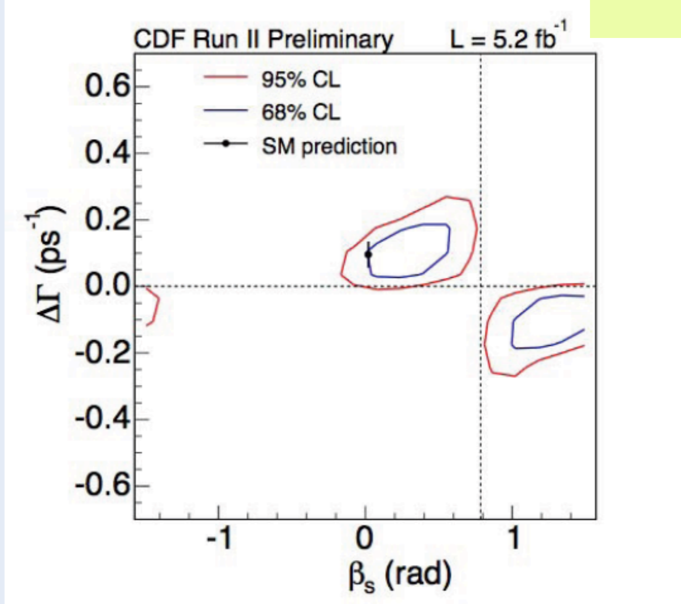


Measurement of B_s mixing phase (new results)

L. Oakes

- CDF's new measurement with 5.2/fb
  - Data within 1 sigma of SM
- This result goes in opposite direction from A_{sl}

- D0 will update their measurement soon.



Coverage adjusted 2D likelihood contours for β_s and $\Delta\Gamma$

P-value for SM point: 44% (0.8σ deviation)

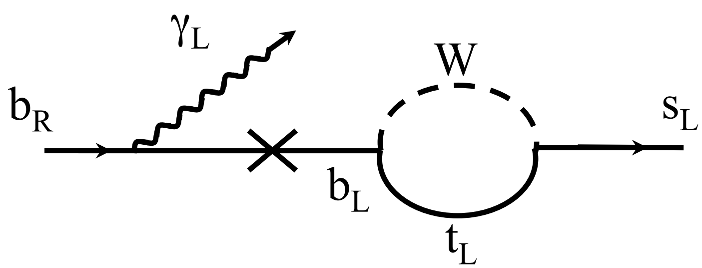
An interesting related contribution from Sheldon Stone:

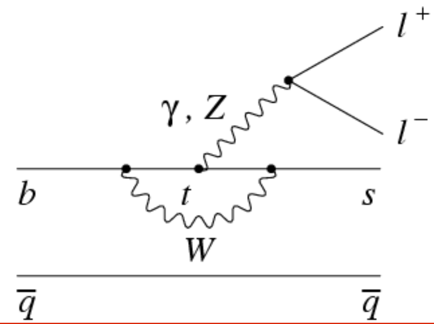
S-waves are ubiquitous, they appear whenever looked for, & must be taken into account in $B_s \rightarrow J/\psi\ \phi$ measurements of amplitudes, phases, & CP violation

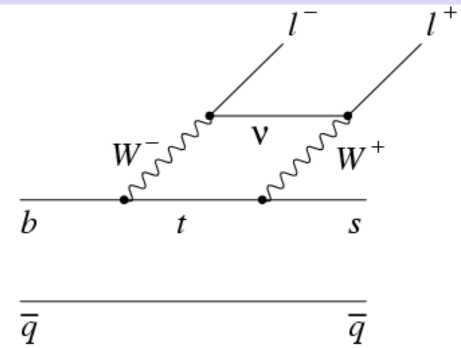
CDF analysis allows for S-wave component- and set a limit on it.

Belle searched for $B_s \rightarrow J/\psi f^0$ & set a limit on Br.(See R. Louvot)

Other New Physics searches with FCNC observables



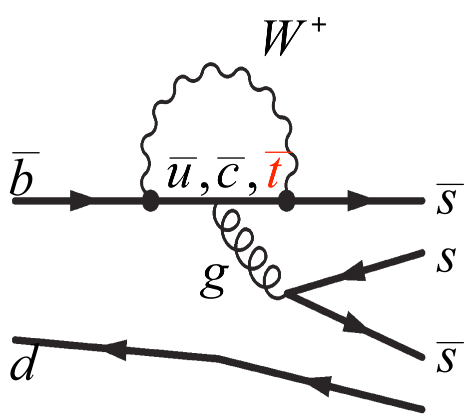




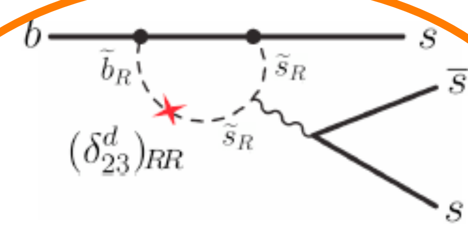
- Photon helicity in b→$\gamma_L s$ (γ left-handed in SM) – probe of right handed currents
- Direct CP violation – nearly zero in SM
- In B→Kll- q^2 dependence of the rate; FB asymmetry, CPV in FB asymmetry

Search for modification of Wilson coefficients C7, C9, C10 & new operators

- Sensitive to charged higgs mass and couplings



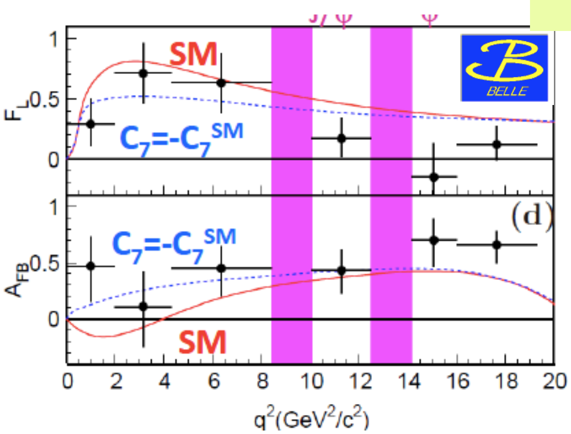
Observable: Rates, CPV, polarization,..

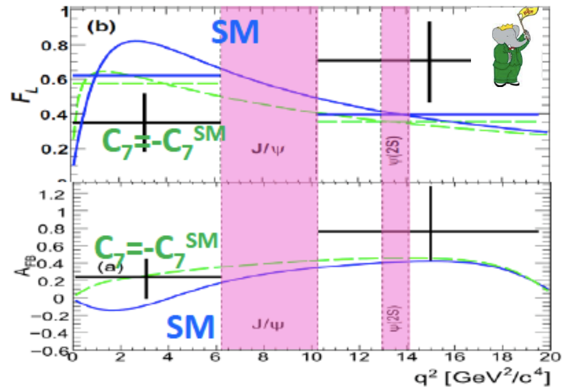


Radiative decays

• B→K(*)l+l- provides a number of powerful observable for probing NP- through measurements of wilson coefficients

H. Nakayama





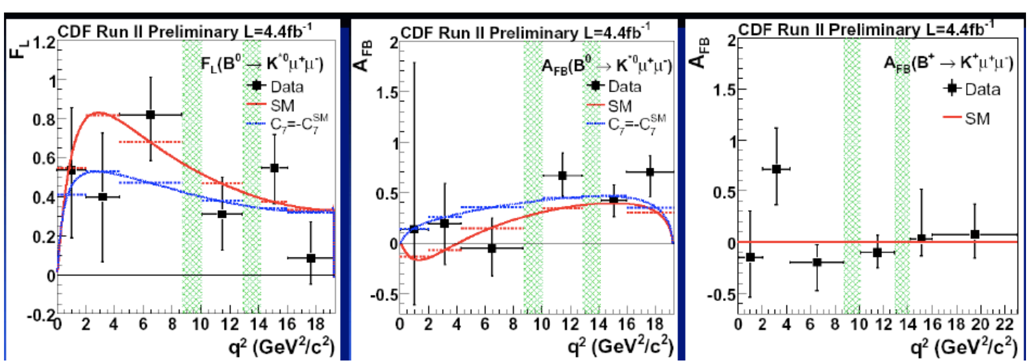
$$\frac{3}{4}F_L(1-\cos^2\theta_{Bl})+\frac{3}{8}(1-F_L)(1+\cos^2\theta_{Bl})+A_{FB}\cos\theta_{Bl}$$

Data slightly favors the flipped C7 scenario- not supported by Belle's recent inclusive measurement : B->Xsll

The new CDF measurement is consistent with SM

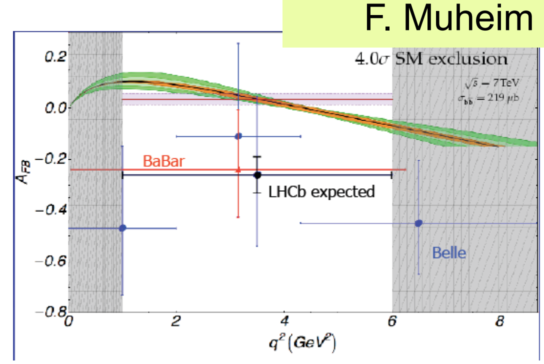
They have also seen: Bs→ϕμ+μ−

M. Aoki

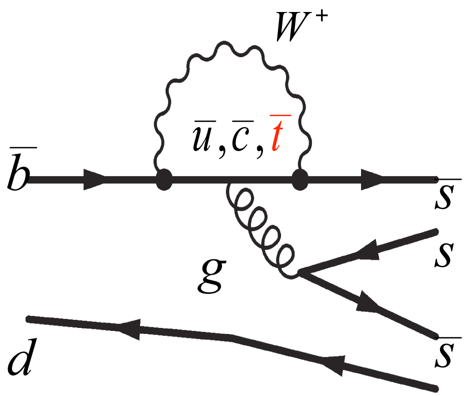


LHCB sensitivity at 1/fb

F. Muheim

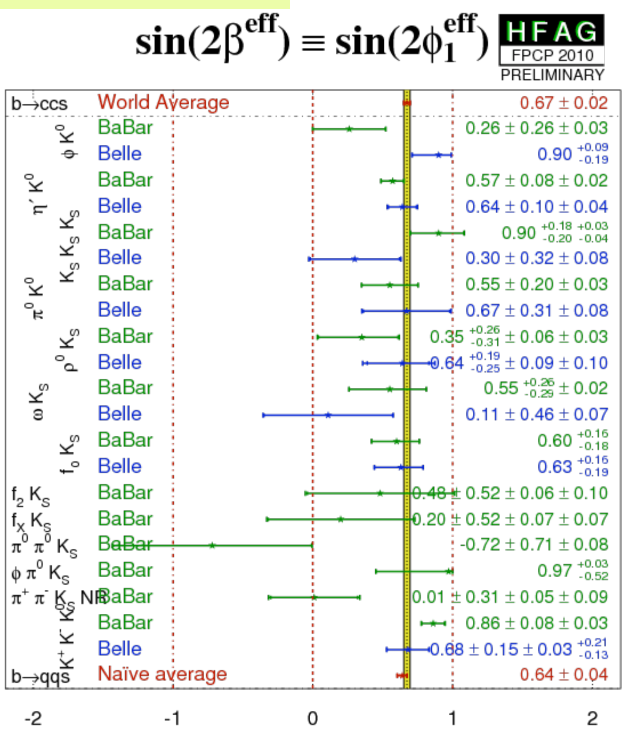


gluonic penguin



- In SM: Time-Dependent CP violation: S ~ sin2β
- Looking for a ΔS=S-sin2β, sensitive to new CPV phases.
- Must understand SM predictions for ΔS
    - QCD calculations
    - Comprehensive measurements of many channels and the use of symmetries to relate them.

K. Sumisawa

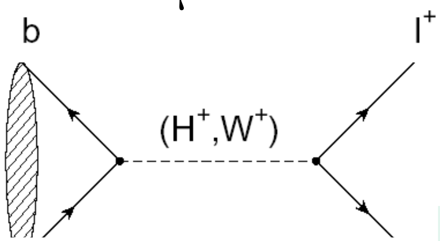


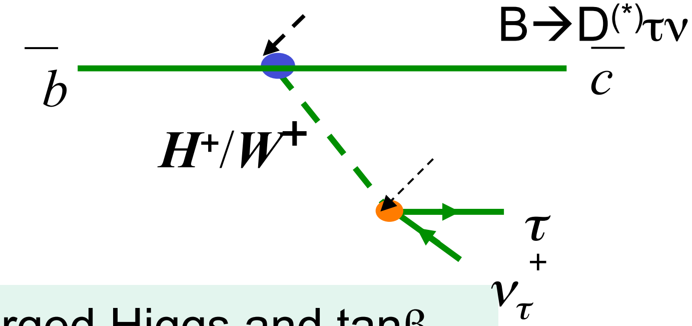
The "naïve average" is now consistent with SM.
No significant progress reported on theoretical determination of ΔS
Crucial if these channels are to serve as tools for NP searches.

B→τ ν & B→τD(*)ν

A. Bozek

B→μν &B→τν



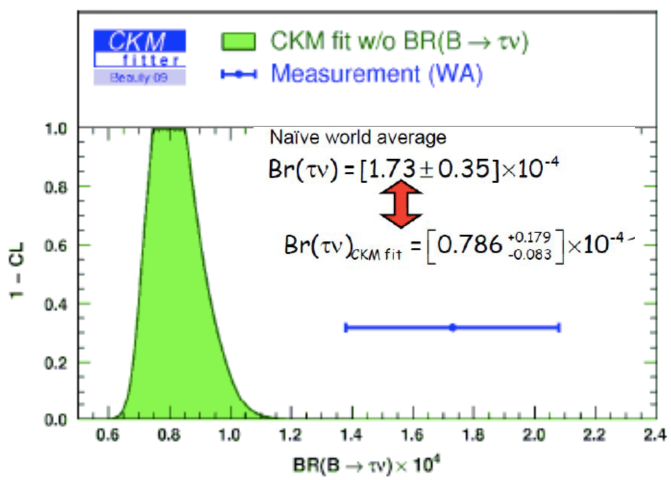


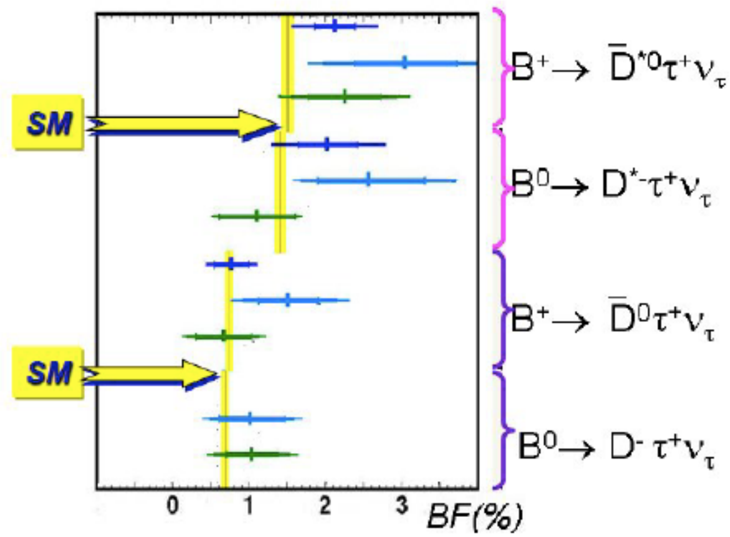
Sensitive to charged Higgs and tanβ

$$\mathrm{BR}(B\to\tau\nu)=\mathrm{BR}_{SM}(B\to\tau\nu)\left(1-\frac{m_B^2}{M_H^2}\tan^2\beta\right)$$

Both processes are now well established

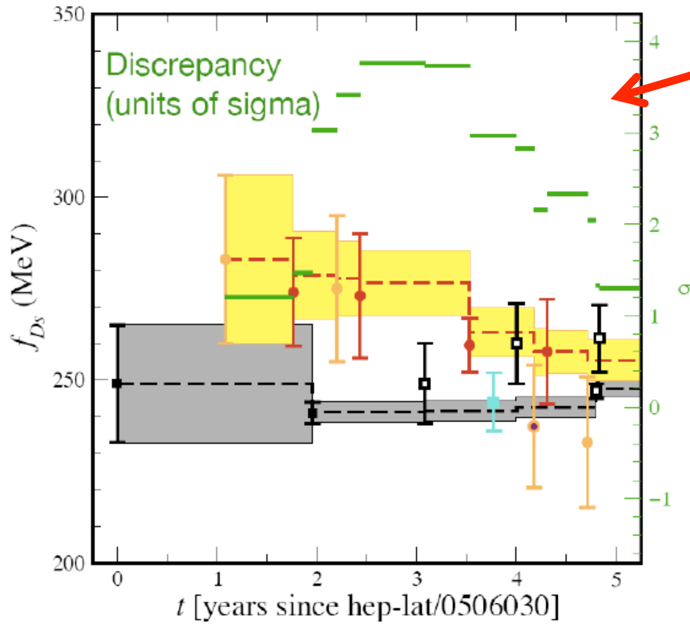
Some (~2 sigma) tension with SM in B→τν





The D_s Decay constant (f_{Ds})

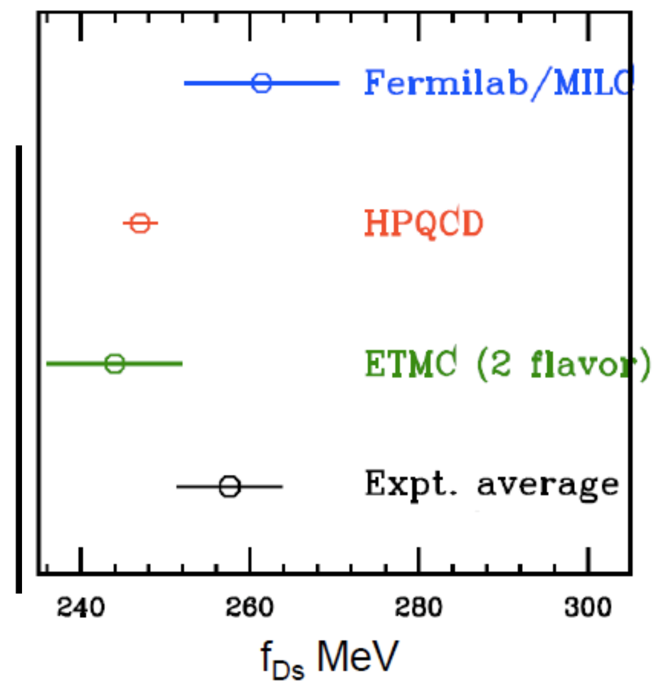
S. Stone



History of data vs LQCD
(Kronfeld)

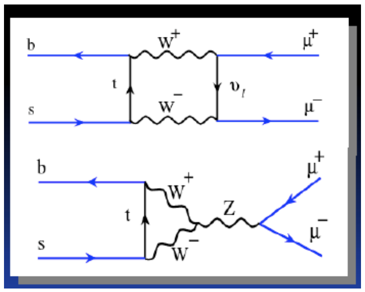
The discrepancy now resolved:
with new experimental measurements by CLEO, Belle and BaBar, in both Ds→μν and τν and new lattice calculations

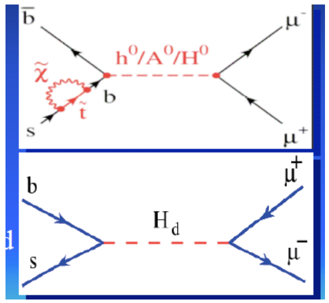
Experiment	Mode	$\mathcal{B}$	$f_{D_s^+}$ (MeV)
CLEO-c [12]	$\mu^+\nu$	$(5.65 \pm 0.45 \pm 0.17) \times 10^{-3}$	$257.6 \pm 10.3 \pm 4.3$
Belle [13]	$\mu^+\nu$	$(6.38 \pm 0.76 \pm 0.57) \times 10^{-3}$	$274 \pm 16 \pm 12$
Average	$\mu^+\nu$	$(5.80 \pm 0.43) \times 10^{-3}$	261.5 ± 9.7
CLEO-c [12]	$\tau^+\nu\ (\pi^+\overline{\nu})$	$(6.42 \pm 0.81 \pm 0.18) \times 10^{-2}$	$278.0 \pm 17.5 \pm 3.8$
CLEO-c [14]	$\tau^+\nu\ (\rho^+\overline{\nu})$	$(5.52 \pm 0.57 \pm 0.21) \times 10^{-2}$	$257.8 \pm 13.3 \pm 5.2$
CLEO-c [15]	$\tau^+\nu\ (e^+\nu\overline{\nu})$	$(5.30 \pm 0.47 \pm 0.22) \times 10^{-2}$	$252.6 \pm 11.2 \pm 5.6$
BaBar [16]	$\tau^+\nu\ (e^+\nu\overline{\nu})$	$(4.54 \pm 0.53 \pm 0.40 \pm 0.28) \times 10^{-2}$	$233.8 \pm 13.7 \pm 12.6$
Average	$\tau^+\nu$	$(5.58 \pm 0.35) \times 10^{-2}$	255.5 ± 7.5
Average	$\mu^+\nu + \tau^+\nu$		257.5 ± 6.1



Search for $B_s \to \mu^+\mu^-$

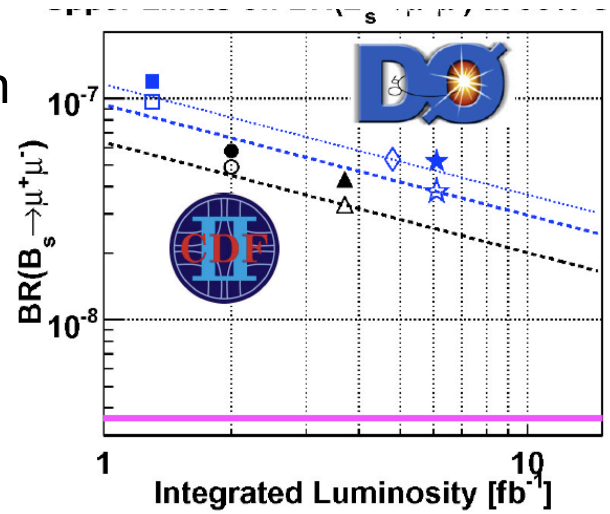
- An important process for NP search in flavor physics- highly suppressed in SM and enhanced in most NP models.



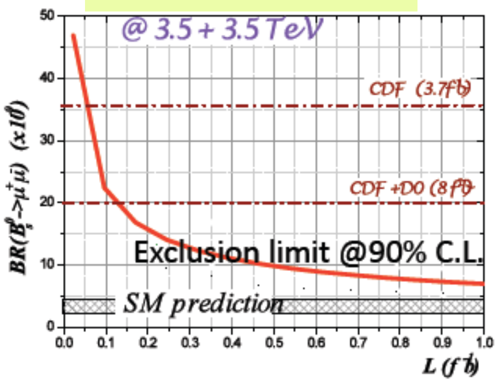


A. Aoki

Current Tevatron 95% C.L. limits

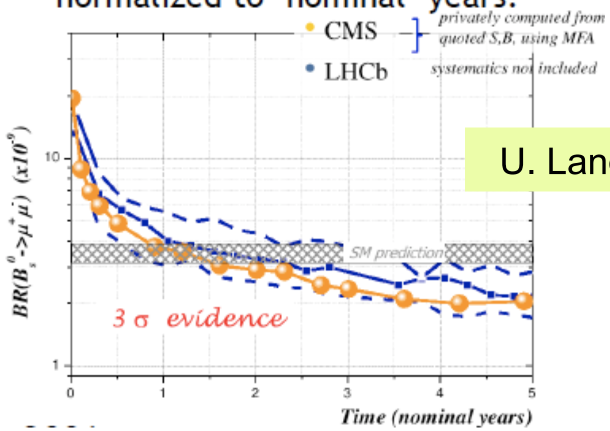


F. Muheim



LHC- projections

normalized to 'nominal' years:



U. Langenegger

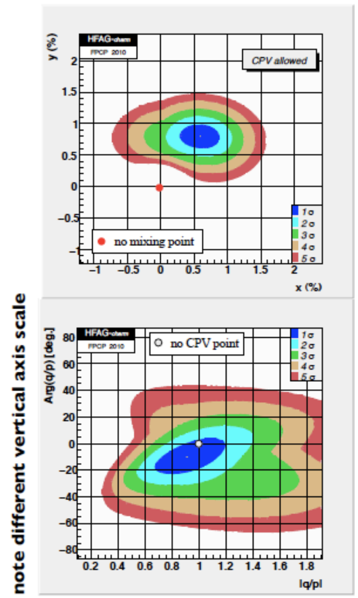
10/fb for 5σ observation

D mixing and CP violation

N. Neri

D0 mixing is solidly established
No evidence for CPV yet

The new BaBar measurements with 3-body modes has benefited from improved DP modeling that also benefited the measurement of angle γ



HFAG averages including new BaBar $K_S\pi^+\pi^-$ + $K_SK^+K^-$ results:

- *sizable improvement in mixing contours*
- *noticeable effect on x parameter value*

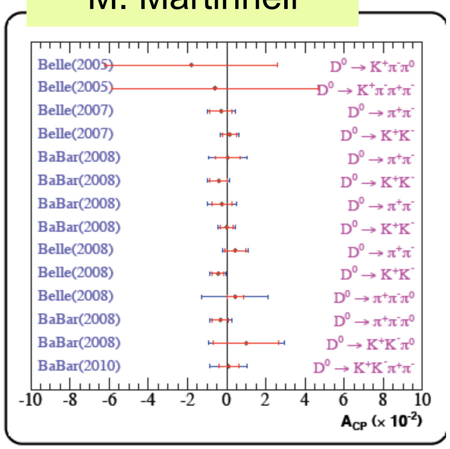
EPS 2009	FPCP 2010
$x = (0.976 \pm 0.249)\%$	$x = (0.59 \pm 0.20)\%$
$y = (0.833 \pm 0.160)\%$	$y = (0.80 \pm 0.13)\%$
$\lvert q/p\rvert = 0.866 \pm 0.160$	$\lvert q/p\rvert = 0.91^{+0.19}_{-0.16}$
$\varphi = -0.148 \pm 0.126$ rad	$\varphi = -10^{+9.3}_{-8.7}$ deg
	($\varphi = -0.175^{+0.162}_{-0.152}$ rad)

Mixing significance still exceeding 10.2σ

No CPV point is within 1σ contour

A broad set of channels in D0, D+ and Ds has been studied for Direct CP asymmetry- no CPV effect observed.

M. Martinneli



A. Kamenik

A_{CP} in	Belle (%)	Cleo (%)	HFAG WA (%)	A_{CP}^{SM} (%)
$D^+ \to K_S\pi^+$	$-0.71\pm0.19\pm0.20$	$-1.3\pm0.7\pm0.3$	-0.72 ± 0.26	$-0.332^\dagger$
$D_s^+ \to K_S\pi^+$	$+5.45\pm2.50\pm0.33$	$+16.3\pm7.3\pm0.3$	$+6.5\pm2.5$	$+0.332$
$D^+ \to K_SK^+$	$-0.16\pm0.58\pm0.25$	$-0.2\pm1.5\pm0.9$	-0.09 ± 0.63	-0.332
$D_s^+ \to K_SK^+$	$+0.12\pm0.36\pm0.22$	$+4.7\pm1.8\pm0.9$	$+0.28\pm0.41$	$-0.332^\dagger$

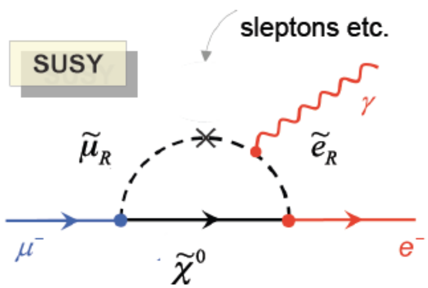
Charge Lepton Flavor Violation

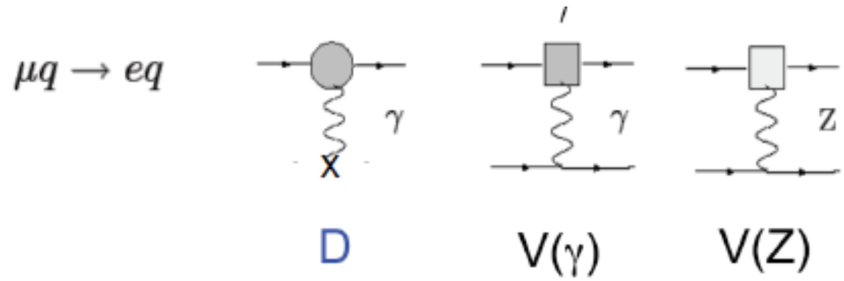
V. Cirigliano, C. Voena,
Y. Miyazaki, Y. Kuno

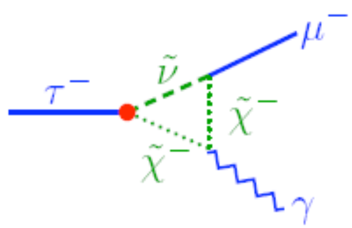
CLFV is a clear signature of New Physics:

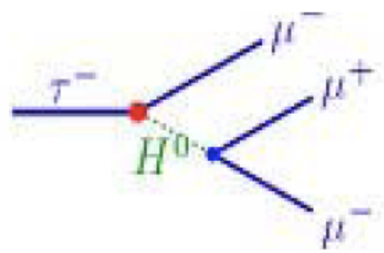
- Highly suppressed in SM- Br~ 10^{-54}; Most NP models predict measureable effects

e.g. $\mu \rightarrow e\gamma$, $\mu \rightarrow e$ coversion, $\tau \rightarrow \mu\gamma$ $\tau \rightarrow \mu\mu\mu$,….









Establishing the pattern of CLFV is important to determining the source of lepton flavor breaking. These are not redundant processes- each probe different aspect of the LFV transition

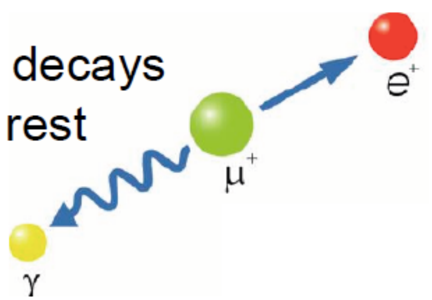
Some of the predictions are within the reach of current or planned experiments.

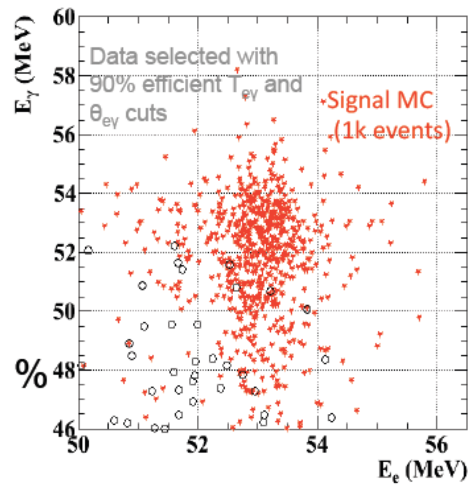
LFV -current status

V. Cirigliano, C. Voena,
Y. Miyazaki, Y. Kuno

MEG at PSI: muon decay at rest $\mu \rightarrow e\gamma$

μ^+ decays
at rest





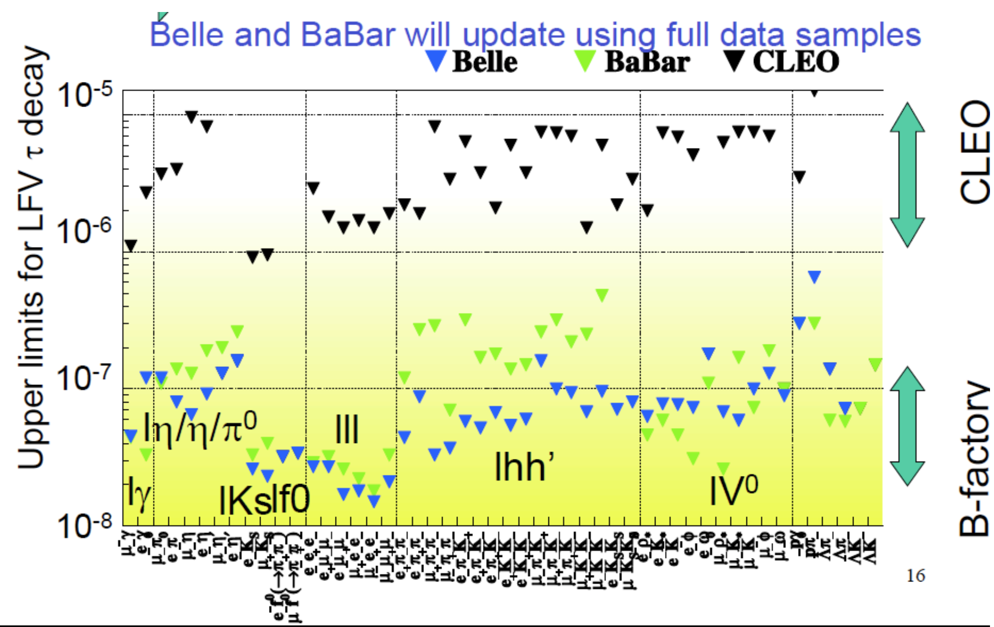
$$BR(\mu^+ \rightarrow e^+\gamma) < 2.8 \cdot 10^{-11} @ 90\% C.L.$$

Best limit (MEGA 2001)
$B(\mu \rightarrow e\gamma) < 1.2 \times 10^{-11}$ @90% cl.

Ultimate expected MEG limit
at $O(0^{-13})$ – runs in 2011

Current data on tau: (90% c.l. limits)
$B(\tau \rightarrow \mu\gamma) < 4.5 \times 10^{-8}$ (Belle)
$< 4.4 \times 10^{-8}$ (BaBar)

Super-B-factories can reach $\sim 10^{-9}$
Within the range of many NP models



Experimental outlook for Flavor Physics

M. Tecchio, C. Lazzeroni

Kaon Physics: Ultimate goals is measurement of:

$K^+ \rightarrow \pi^+ \nu\nu$ $K_L \rightarrow \pi^0 \nu\nu$ $K_L \rightarrow \pi^0 e^+ e^-$ $K_L \rightarrow \pi^0 \mu^+ \mu^-$

Among the most precisely calculated processes

- Near future:
  - NA62 at CERN aiming for $K^+ \rightarrow \pi^+ \nu\nu$ @Br~10^{-10} (SM)
  - KOTO at JPARC aiming for $K_L \rightarrow \pi^0 \nu\nu$ @ BR~$0.2.10^{-10}$ (SM)
- At proposal level:
  - P993 at FNAL (project X)- precision measurement of $K^+ \rightarrow \pi^+ \nu\nu$

Charge Lepton Flavor Violation:

V. Cirigliano, C. Voena, Y. Miyazaki, Y. Kuno

- $\mu \rightarrow e\gamma$ @10^{-13} MEG at PSI (~2012)
- $\mu N \rightarrow eN$ (Al) @10^{-16} Mu2e at FNAL & COMET at Jparc (proposal level)
- PRISM aiming for 10^{-18} sensitivity- R&D stage.
- Tau LFV @<10^{-9} Super B Factories

Experimental outlook for Flavor Physics (2)

F. Muheim, F. Machefert,
T. Kuhr, ,U. Wienands,

B Physics:

- Immediate future dominated by Tevatron, LHCB & analysis of Belle and BaBar data. CMS and ATLAS will contribute to $B \rightarrow \mu+\mu-$.
- LHCB upgrade is aimed at enabling it to run at 10^{33}/cm2/s and then to ($2x10^{33}$/cm2/s).
- Impressive physics reach. Most promising areas are likely to be measurement of the ange γ & exclusive decays in all B hadrons, and radiative decays.

- e^+e^- Super Flavor Factories @ instantaneous lumi ~10^{36}/cm2/s: Will allow for comprehensive measurements of all B decay channels as well as charm & tau decays- important for studying the pattern of deviation from SM & precision CKM (- dreaming for 1%- with major theory input)

  - **A solution is now in hand for reaching 10^{36}/cm2/s**
  - Very low emittance beams (ILC like)
  - Large piwinski angle
  - Small vertical beta*
  - Crab-waist (for Frascati Super B)- verified with tests at DAPHNE
  - Similar currents to PEP-II/KEK-B
  - Polarized beam (one beam)- important to tau LFV studies

Summary of Summary

Many thanks to all the speakers for the excellent talks and the discussions at this great meeting.

It has been very stimulating and lots of fun.

The results shown here and their potential implications have demonstrated that the field remains as exciting as ever: With the conclusion of the “flavor dominated decade” and the start of the LHC era, the field of flavor physics is now entering its precision era: a powerful companion to LHC in uncovering Physics Beyond the SM. But we need to turn into reality the new planned/ proposed experiments.

.

Many many thanks to our hosts

Fabrizio Bianchi (Chair), Diego Gamba, Paolo Gambino, Ezio Menichetti, Roberto Mussa, Mario Pelliccion

For the great meeting

&

Excellent hospitality