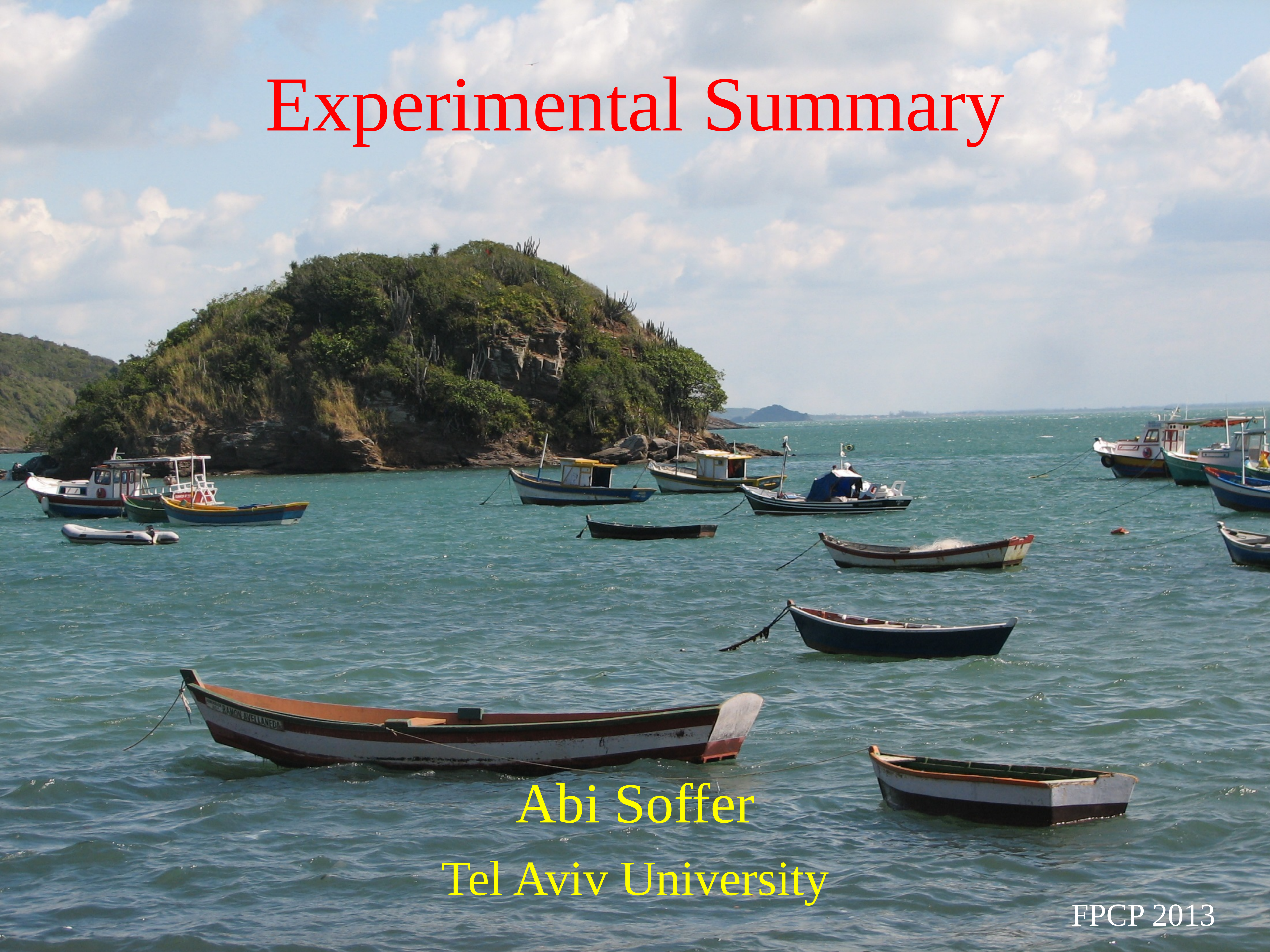
Experimental Summary



Abi Soffer
Tel Aviv University

FPCP 2013

Many talks!

- B -> D(*) tau nu and B-> tau nu — Andrzej Bozek
- B decays with significant missing energy — Youngmin Yook
- b production, both as hadron and jets — Jean Wicht
- Baryonic B decays — Marcus Ebert
- Bs and B0 –> mu mu rare decays — Jose Lazo-Flores
- Bs-> mumu and B → Xs gamma — Mikolaj Misiak
- Charged Lepton flavour violation theory — Maxim Pospelov
- Charm mixing and CPV — Alberto Reis
- Charm spectroscopy and rare decays — Diego Milanes
- Charmless 3-body B decays and gamma measurement — David London
- Charmless semi-leptomic B decays at ee colliders — Cesar A. Beleño de la Barrera
- Charmonium at ee colliders — XiaoLong Wang
- CP violation in Bs oscillations at ATLAS, CMS and Tevatron — James Walder
- CPT effects on CPV measurements — Ikaros Bigi
- D meson Physics — Cheng-Wei Chiang
- D0 mixing — Karim Trabelsi
- Dimuon charge asymmetry in p pbar collisions — Bruce Hoeneisen
- Exotic states and charmonia production — Tomasz Skwarnicki
- Gamma from ee colliders — Matteo Rama
- Highlights from BESIII — Roy Briere
- ILC Status — Taikan Suehara
- Lepton Flavour Violation — Giovanni Signorelli
- LHCb upgrade — Renaud Le Gac
- Light flavour at ee collider — Andreas Hafner
- Limits on 4th generation fermions — Andrey Ivanov
- Measurement of CP violation in Bs oscillations — Bruno de Paula
- Measurement of D0 mass and D* natural linewidth — Gabriele Simi
- Measurement of gamma from B->DK and related modes — Moritz Karbach
- Measurement of the form factors of K+- -> pi0 l+- nu — Cristina Biino
- Measurement of Theta13 — Kwong Lau
- Neutrino Physics — Mu-Chun Chen
- Numu disappearance and numu CC Inclusive cross section — Alexander Finch
- Phi2 measurement at ee colliders — Pit Vanhoefer
- Quarkonium production at LHC — Cristina Biino
- Radiative penguin at hadron machines — Kevin Stenson
- Radiative Penguins at ee colliders — Gerald Eigen
- Recent Development on CKM angles — Wei Wang
- Recent progress in lattice QCD — Rachel Dowdall
- Result on rare decays from NA62 — Paolo Massarotti
- Search for CPV in charm at ee colliders — Ryan White
- Search for light Higgs and dark gauge bosons at ee collide — Sven Vahsen
- Search for ttbar resonances — Jun Guo
- Semileptonic mixing asymmetry measurements of assl and adsl — Martino Margoni
- Sin 2 beta measurements — Riccardo de Sangro
- Status of Belle-II — Bostjan Golob
- Status of Higgs searches — Junji Tojo
- Status of SUSY searches — Anna Lipniacka
- Studies of charmless B decays, including CP violation effects — Irina Nasteva
- Studies of hadronic B decays at LHC — Neus Lopez-March
- Studies of rare FCNC b decays — Marc-Olivier Bettler
- Tau physics from ee collider — Steven Robertson
- Theory Summary — Yuval Grossman
- Three-body heavy meson decays: final state interaction — Manoel Robilotta
- Top properties — Jacob Linacre
- Unitarity triangle sides from ee colliders — Phillip Urquijo

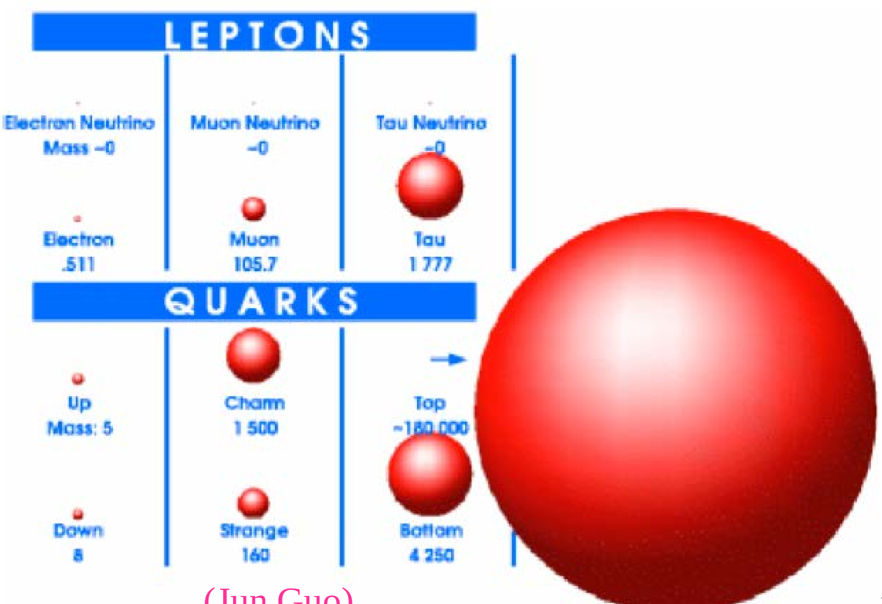
Won’t be able to cover all the results or all the talks…
Apologies if I left out your talk. Will nonetheless try to touch on all topics.
Please correct me if I got something wrong.


TOSHIBA

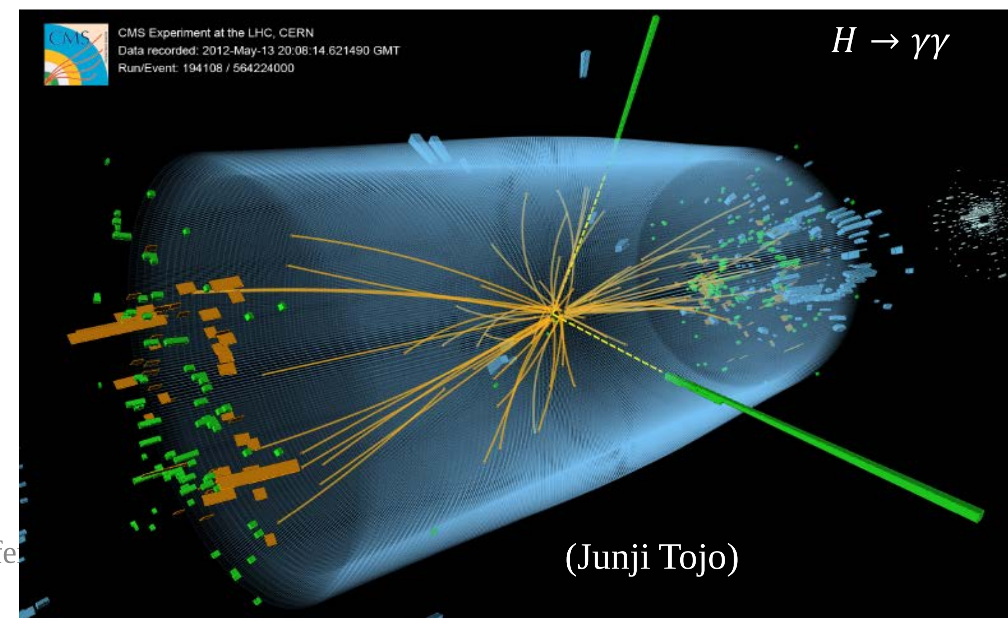
 

How is it constructed? → An idea… → Be there at the right time

What causes it? → A theory… → The right measurement



(Jun Guo)

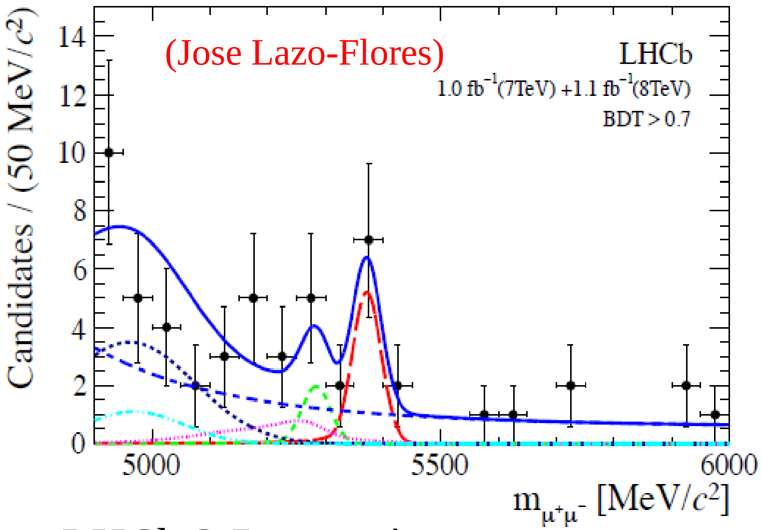


(Junji Tojo)

Some of the measurements

LHC: new era for exclusive rare decays

First evidence for $B_{(s)} \to \mu^+\mu^-$



LHCb 3.5 σ result:

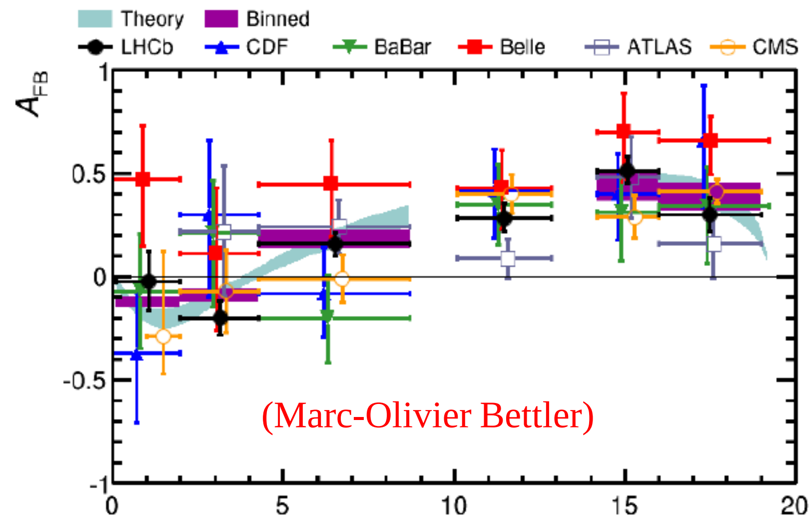
$$\overline{\mathcal{B}}_{\rm exp} = \left(3.2^{+1.5}_{-1.2}\right) \times 10^{-9}$$

Good agreement with the SM:

$$\overline{\mathcal{B}}_{\rm SM} = (3.67 \pm 0.21) \times 10^{-9}$$

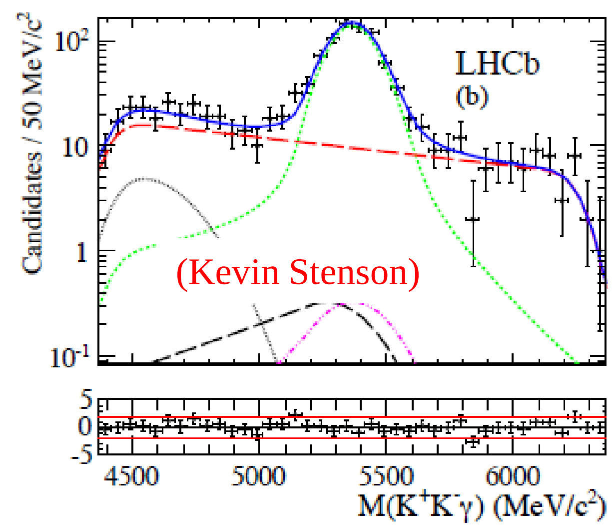
Consistent with limits from CDF, D0, ATLAS, CMS

$B_{(s)} \to h\mu^+\mu^-$



A_{FB} vs. q^2 in $B \to K^{*0}\mu^+\mu^-$

$B \to \phi\gamma$:

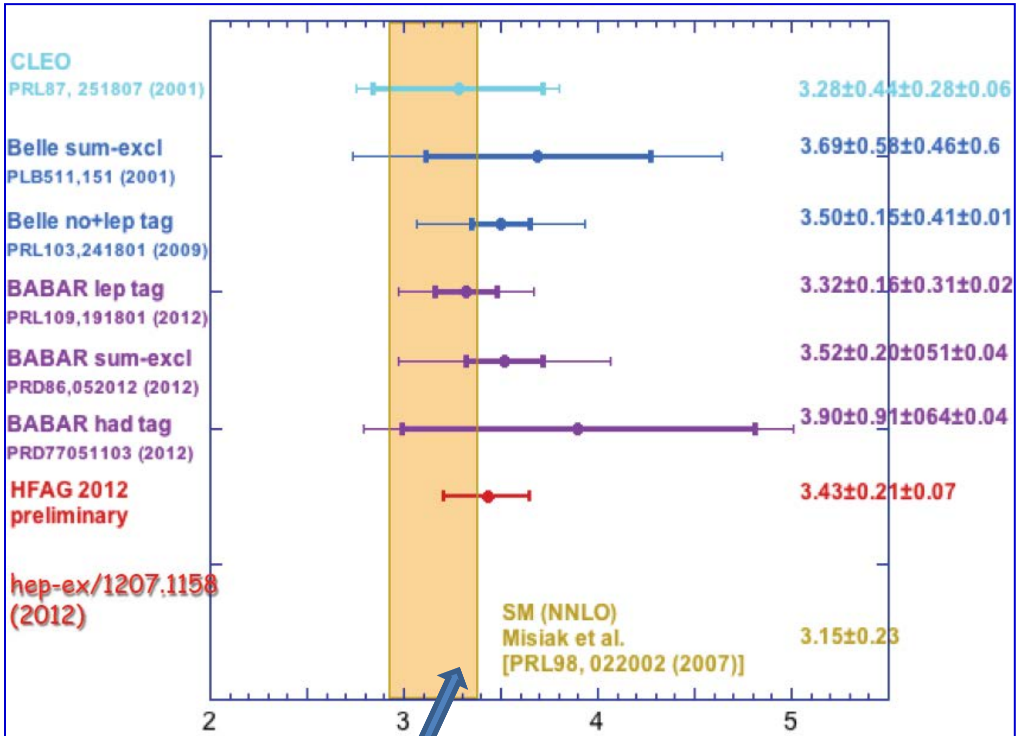


(Diego Milanes): LHCb: **BF($D^0 \to \mu^+\mu^-$)<7.6x10^{-9} @95% CL**

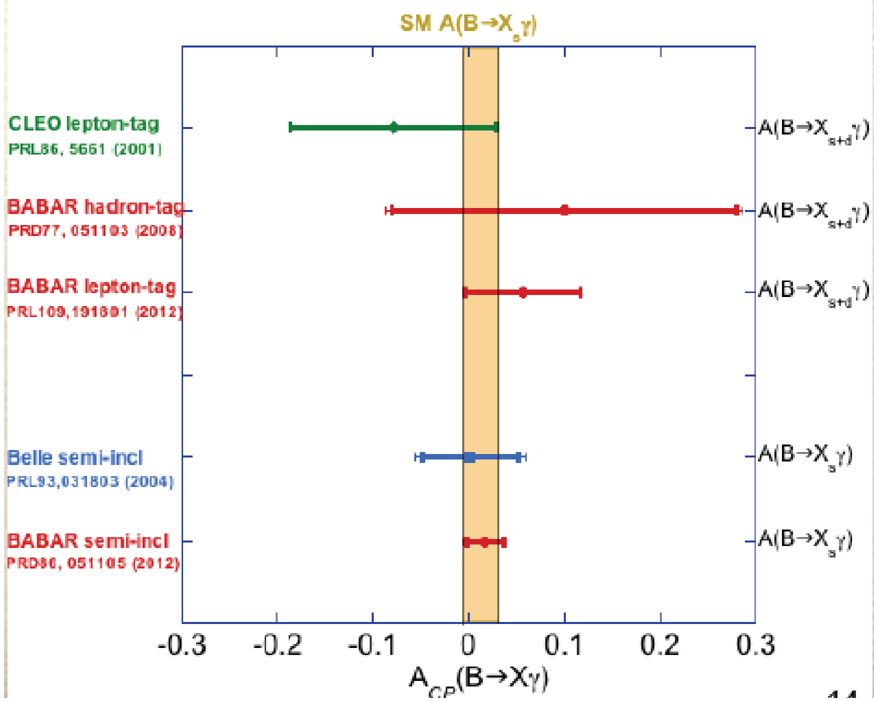
Inclusive EW penguins: B factories

(Gerald Eigen)

$BF(B \to X_s \gamma)\ [10^{-4}]$



$A_{CP}(B \to X_s\gamma)$



(Mikolaj Misiak)

Update of the SM prediction (preliminary)

$$\mathcal{B}(\bar{B} \to X_s\gamma)^{\rm SM}_{E_\gamma > 1.6\ {\rm GeV}} = (3.14 \pm 0.22) \times 10^{-4}$$

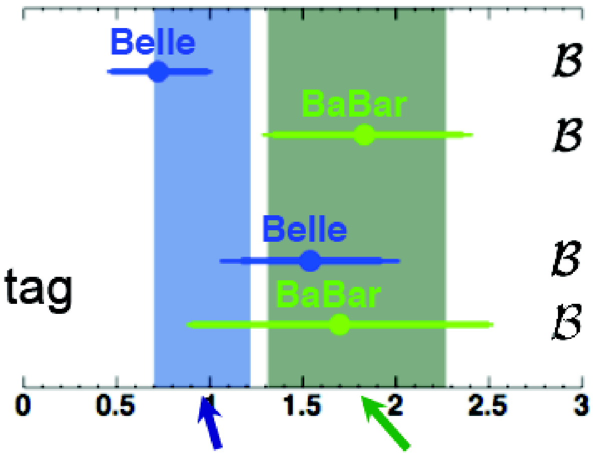
All results consistent with the SM,
→ strong NP constraints

$B \to \tau\nu$: tension with SM is gone

(Andrzej Bozek)

Hadronic tag

Semileptonic tag



$\mathcal{B} = [0.72^{+0.27}_{-0.25}(\text{stat}) \pm 0.11(\text{syst})] \times 10^{-4}$

$\mathcal{B} = [1.83^{+0.53}_{-0.49}(\text{stat}) \pm 0.24(\text{syst})] \times 10^{-4}$

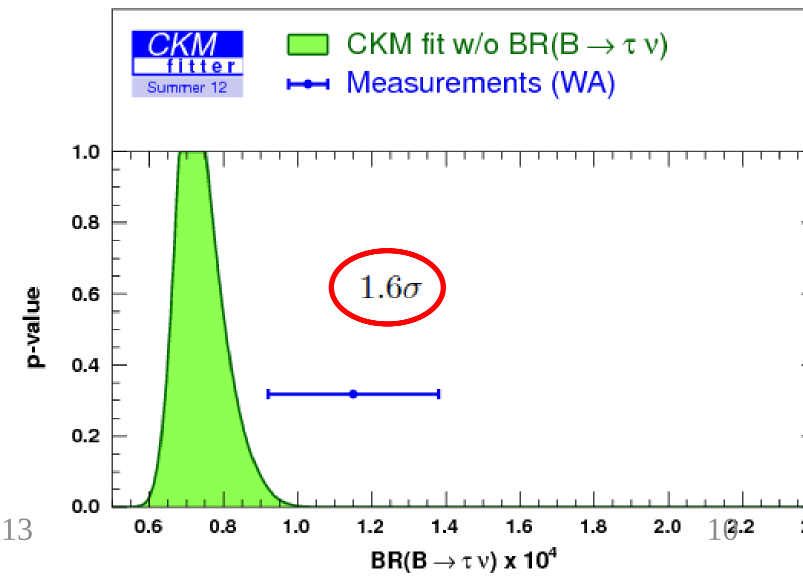
$\mathcal{B} = [1.54^{+0.38}_{-0.37}(\text{stat})^{+0.29}_{-0.31}(\text{syst})] \times 10^{-4}$

$\mathcal{B} = [1.7 \pm 0.8(\text{stat}) \pm 0.2(\text{syst})] \times 10^{-4}$

Belle combined: $\mathcal{B}$=(0.96±0.26)x10^{-4} BaBar combined: $\mathcal{B}$=(1.79±0.48)x10^{-4}

Naive world average $\mathcal{B} = (1.15 \pm 0.23) \times 10^{-4}$

Consistency with the SM:



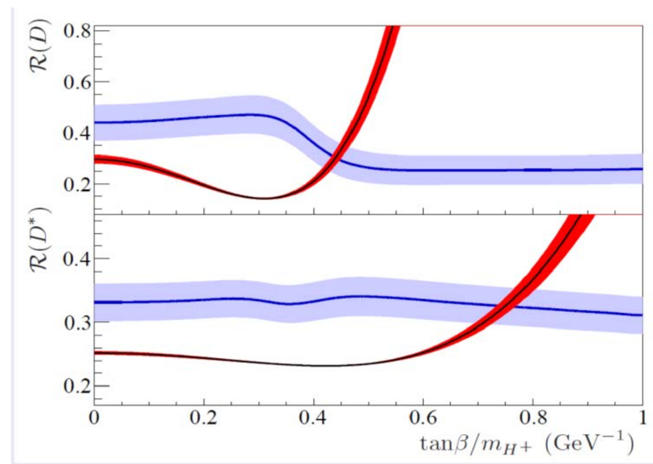
$B \to D^{(*)}\tau\nu$: tension persists

(Andrzej Bozek)

2HDM type-II (~MSSM) disfavored at >99.8%,
since $B \to D\tau\nu$ and $B \to D^*\tau\nu$ disagree on $\tan\beta/m_{H^+}$:

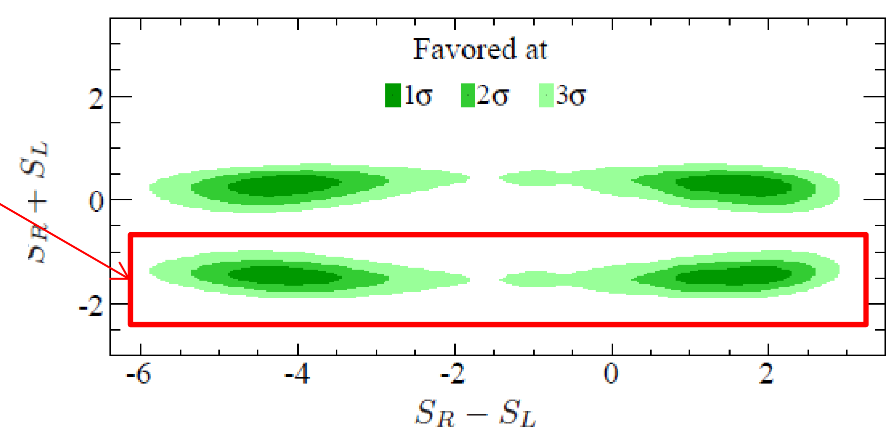
Belle and BABAR average deviation from SM

- $R(\overline{D}^*)$ 3.8σ
- $R(\overline{D})$ 2.4σ
- $R(\overline{D}^{(*)})$ 4.8σ



Allowed region in (real) parameter space for type-III 2HDM:

Excluded @ > 2.9 σ by q^2 dist.

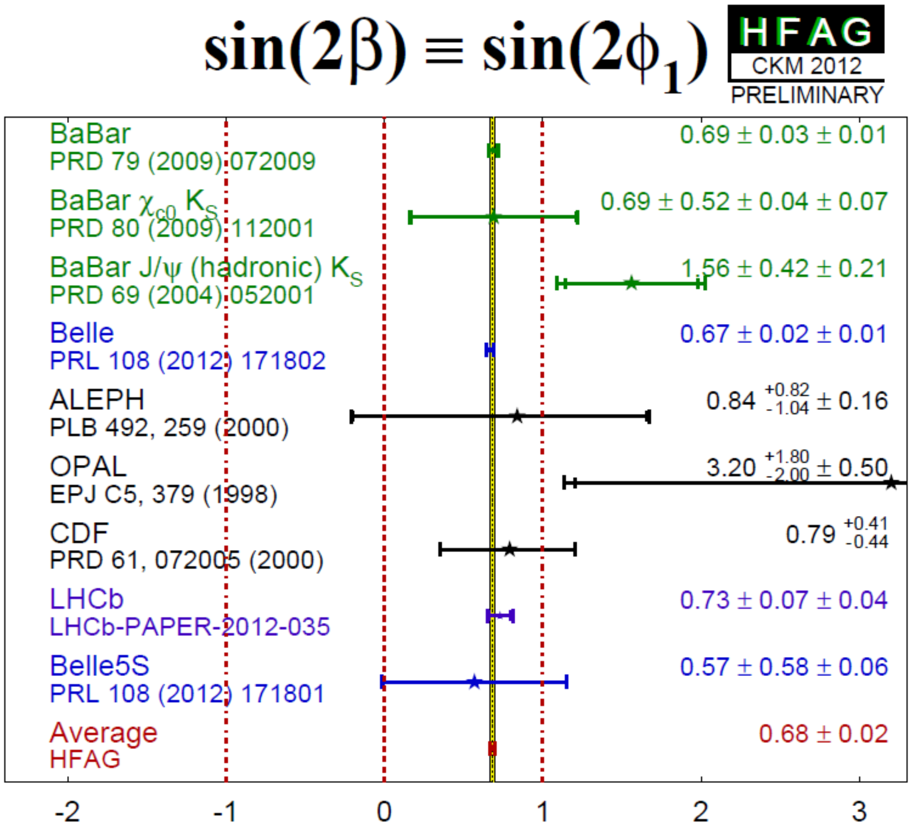


Need to verify:

- Final results from Belle expected soon.
- LHCb (with $\tau \to 3\pi\nu$ "not hopeless")

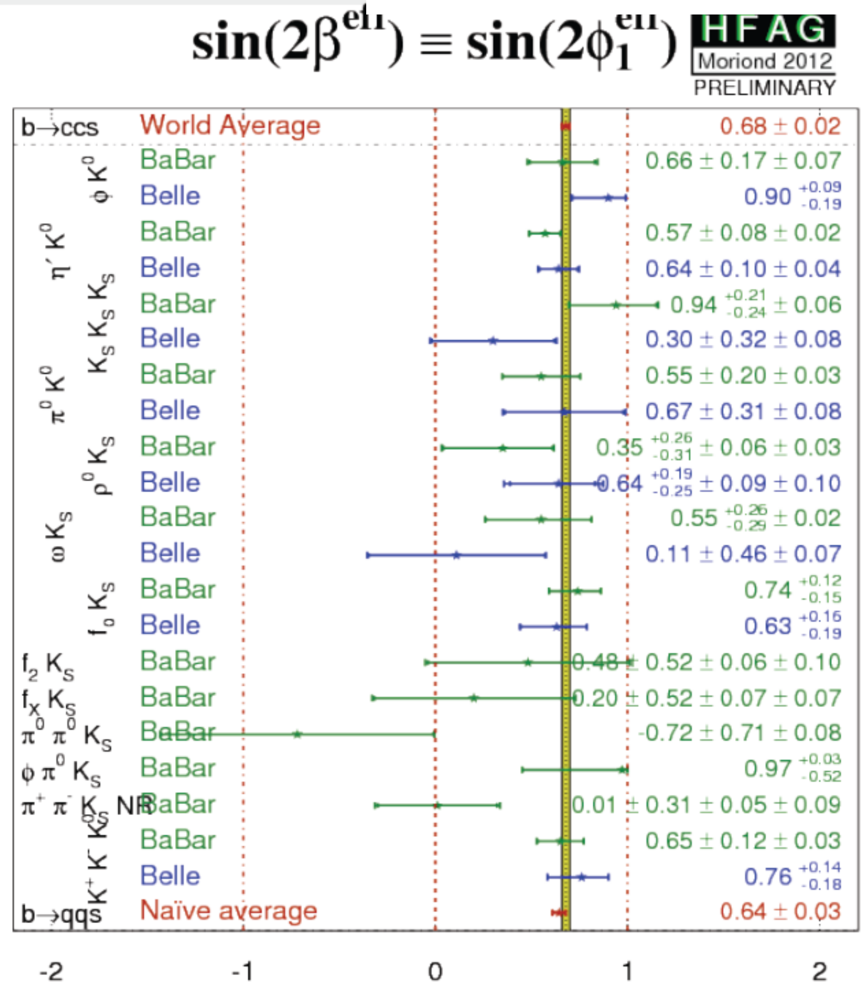
CKM angles: β (ϕ_1)

(Wei Wang)



LHCb will match B-factory sensitivity only after the upgrade (more below)

(Riccardo de Sangro) $\sin 2\beta$ in $b \to q\bar{q}s$

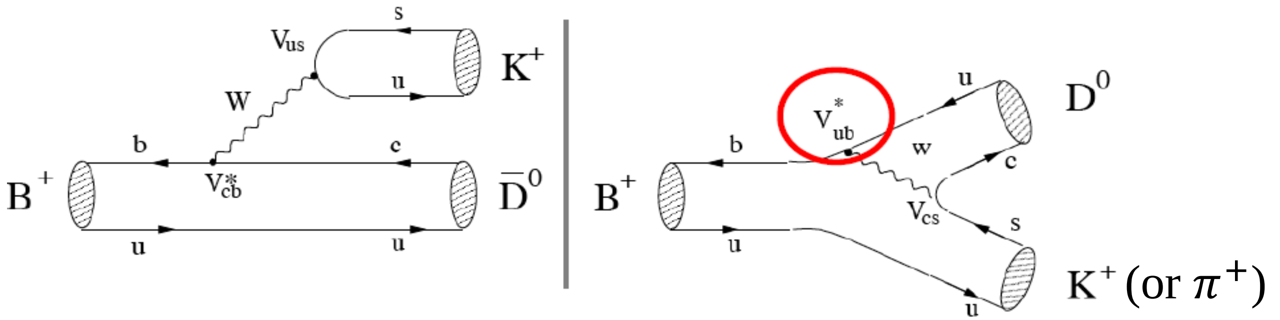


No longer tenwion with $b \to c\bar{c}s$ and

CKM angles: γ (ϕ_3)

(Matteo Rama, Moritz Karbach)

A variety of methods exploiting interference between the $B \to DK$ diagrams



BABAR:	Belle:	B-factory average:	LHCb w. 3 fb^{-1}:
$\gamma = (69^{+17}_{-16})^\circ$	$\gamma = (68^{+15}_{-14})^\circ$	$\gamma = (67 \pm 11)^\circ$	$\gamma = (67 \pm 12)^\circ$

→ Expect slow improvement at LHCb with luminosity

(Wei Wang) Suggests use of new mode: $B \to DK^*_{0,2}$

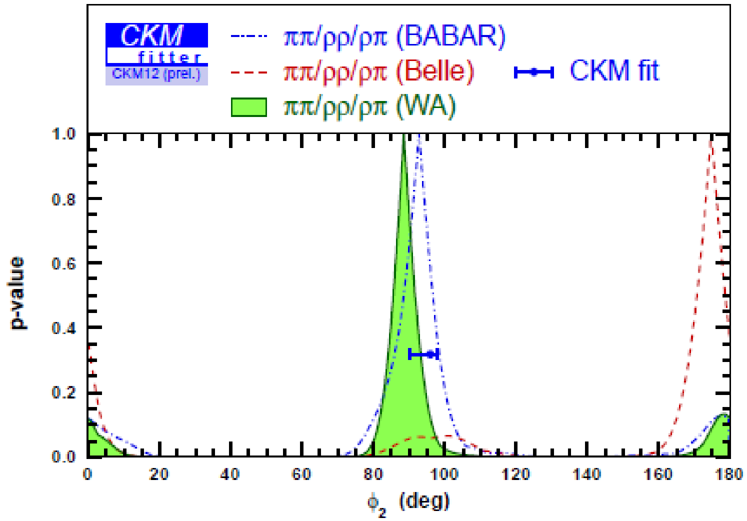
(David London) $B \to KKK$ & $\pi\pi\pi$ → $\gamma = 77^\circ \pm 3^\circ$, error << than for "flagship" $B \to DK$

- Concern over simple SU(3) breaking implementation
- David & collaborators will explore ways to study systematic error experimentally.
- Experimentalists should explore optimal binning of Dalitz plot.

CKM angles: α (ϕ_2)

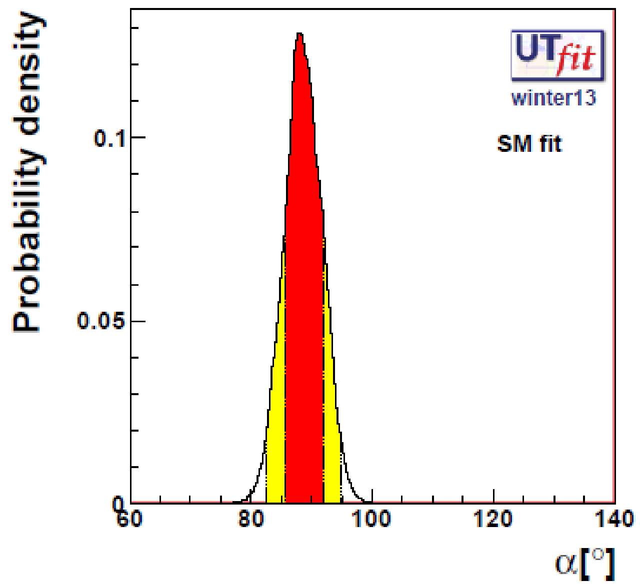
(Pit Vanhoefer)

(frequentist)



$$\phi_2/\alpha = (88.5^{+4.7}_{-4.4})^\circ$$

(bayesian)



$$\phi_2/\alpha = (88.7 \pm 3.1)^\circ$$

But note that $B \to \rho\pi$ should not be used – not robust with current statistics.
Comment: Subtract β and convert to a measurement of γ

Direct CP asymmetries in *b* & *c* decays

(Irina Nasteva) A_{CP} in $B^0_{(s)} \to K\pi$ from LHCb:

$A_{CP}(B^0) = -0.080 \pm 0.007(\text{stat}) \pm 0.003(\text{syst})$ 10.5σ

$A_{CP}(B^0_s) = 0.27 \pm 0.04(\text{stat}) \pm 0.01(\text{syst})$ 6.5σ

- First observation of direct CP violation in the B_s system.
- Most precise measurement of $A_{CP}(B^0 \to K^-\pi^+)$.
- Agreement with the SM: $\Delta = \frac{A_{CP}(B^0 \to K^+\pi^-)}{A_{CP}(B^0_s \to K^-\pi^+)} + \frac{\mathcal{B}(B^0_s \to K^-\pi^+)}{\mathcal{B}(B^0 \to K^+\pi^-)} \frac{\tau_d}{\tau_s} = 0$ H.J. Lipkin, PL**B621** (2005) 126

$$\Delta = -0.02 \pm 0.05 \pm 0.04$$

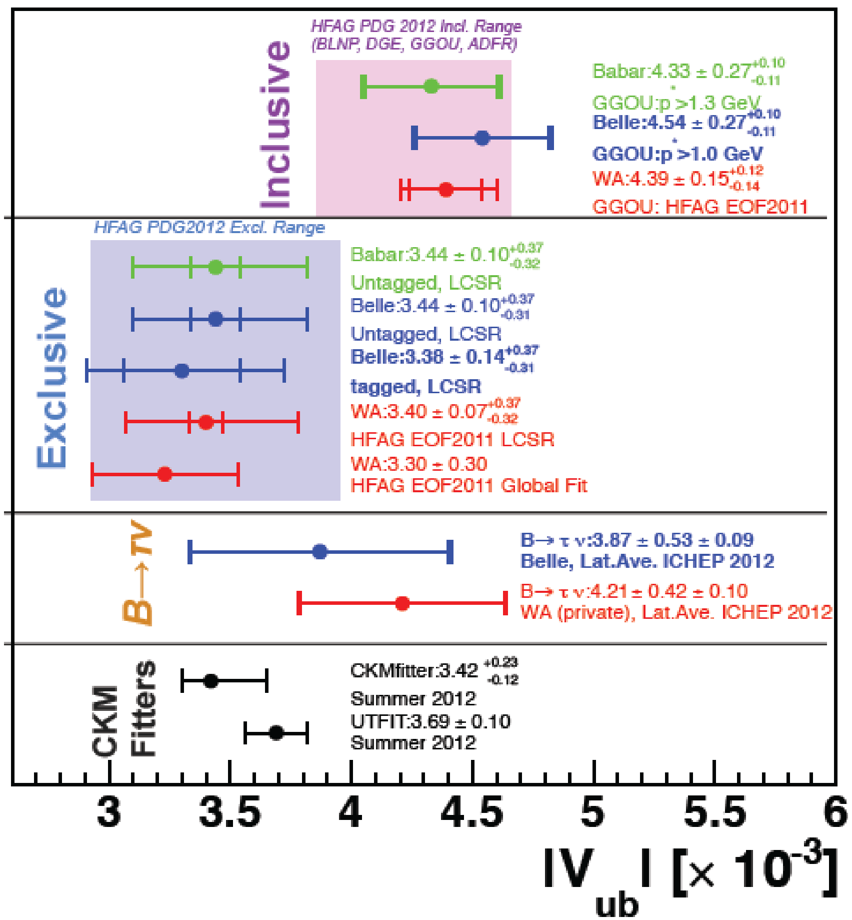
(Aberto Dos Reis) LHCb's $\Delta A_{CP} = A_{CP}(D^0 \to K^+K^-) - A_{CP}(D^0 \to \pi^+\pi^-)$ with prompt D was $(-0.82 \pm 0.21 \pm 0.11)\%$ with 0.6 fb^{-1}.
Now: $(-0.34 \pm 0.15 \pm 0.10)\%$ after adding 0.4 fb^{-1}, better reco'
After adding *D*'s from *B* decays, average is $(-0.15 \pm 0.16)\%$

(Ryan White, Aberto Dos Reis) All CP asymmetries in charm decays are consistent with 0

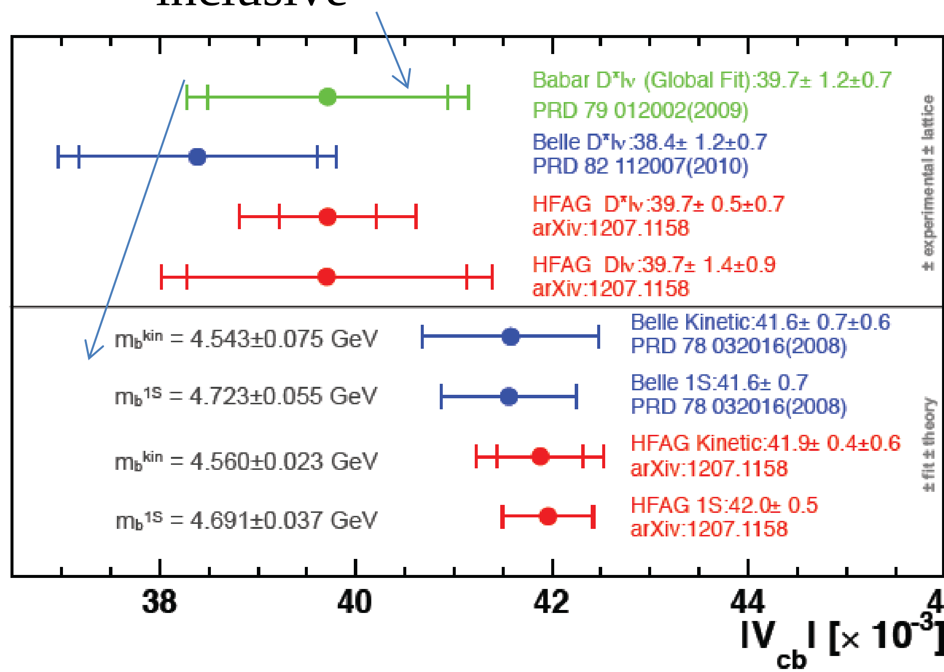
CKM sides: inclusive-exclusive tension persists

(Phillip Urquijo, Cesar Beleno)

V_{ub}



V_{cb} exclusive
inclusive



(Christina Biino)

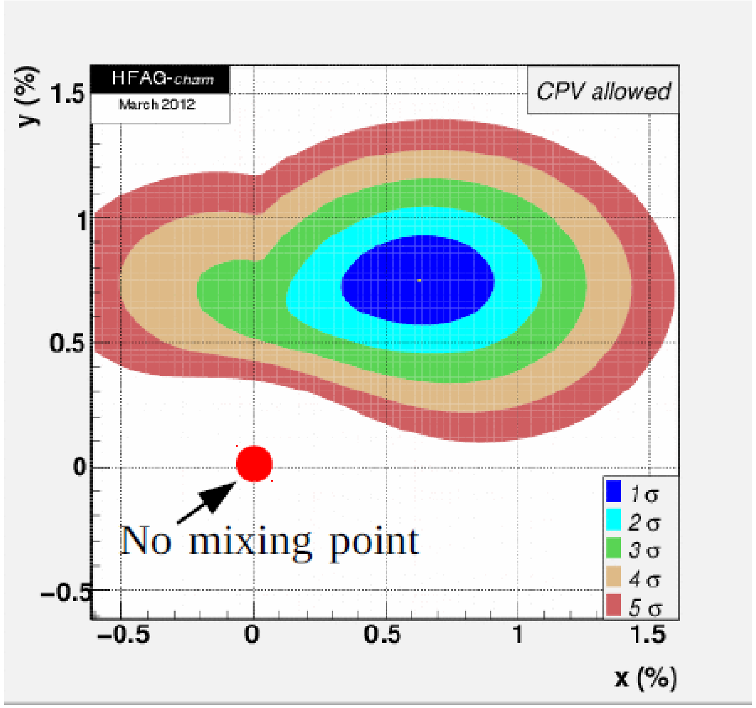
$K^+ \rightarrow \pi^0 l^+ \nu$ analysis at NA48 ~done.

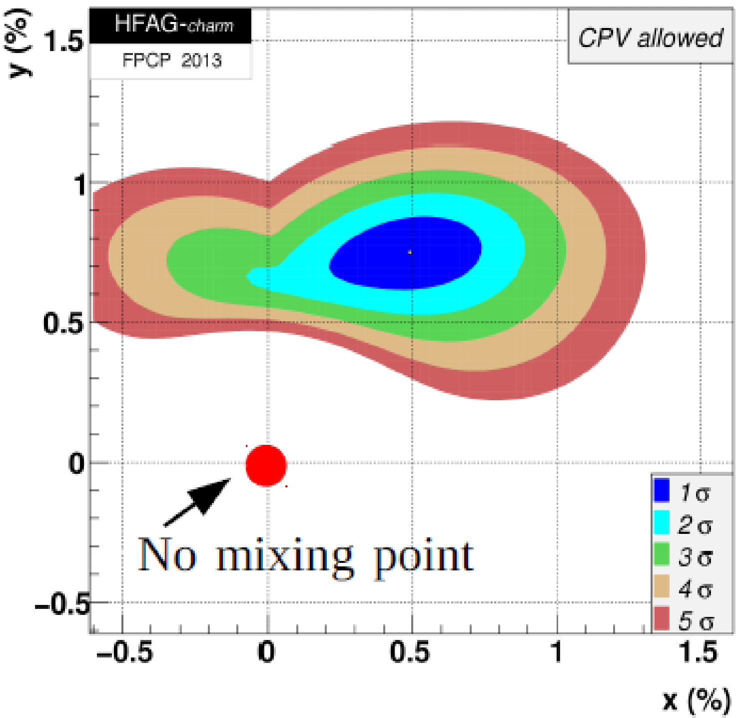
V_{us} extraction soon.

$D^0 - \overline{D}^0$ mixing

(Karim Trabelsi)

FPCP 2012	FPCP 2013





FPCP 2012:

$$x = \left(0.63\ ^{+0.19}_{-0.20}\right)\%$$

$$y = (0.75 \pm 0.12)\%$$

FPCP 2013:

$$x = \left(0.49\ ^{+0.17}_{-0.18}\right)\%$$

$$y = (0.75 \pm 0.09)\%$$

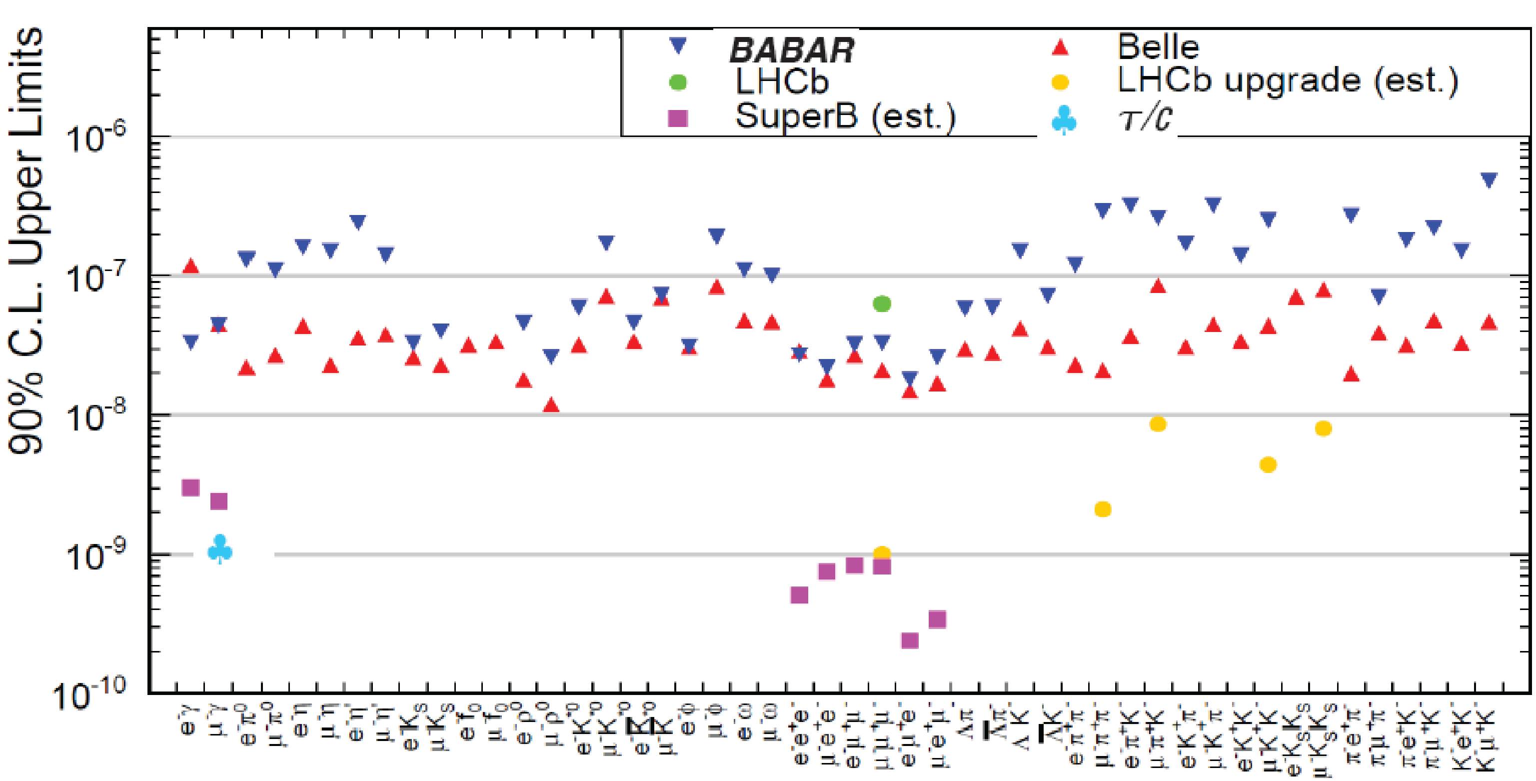
τ decays

(Steve Robertson): CPV in $\tau \to K_S \pi \nu$

A_Q = (-0.36± 0.23 ± 0.11)%
SM prediction: (0.36 ± 0.01)%

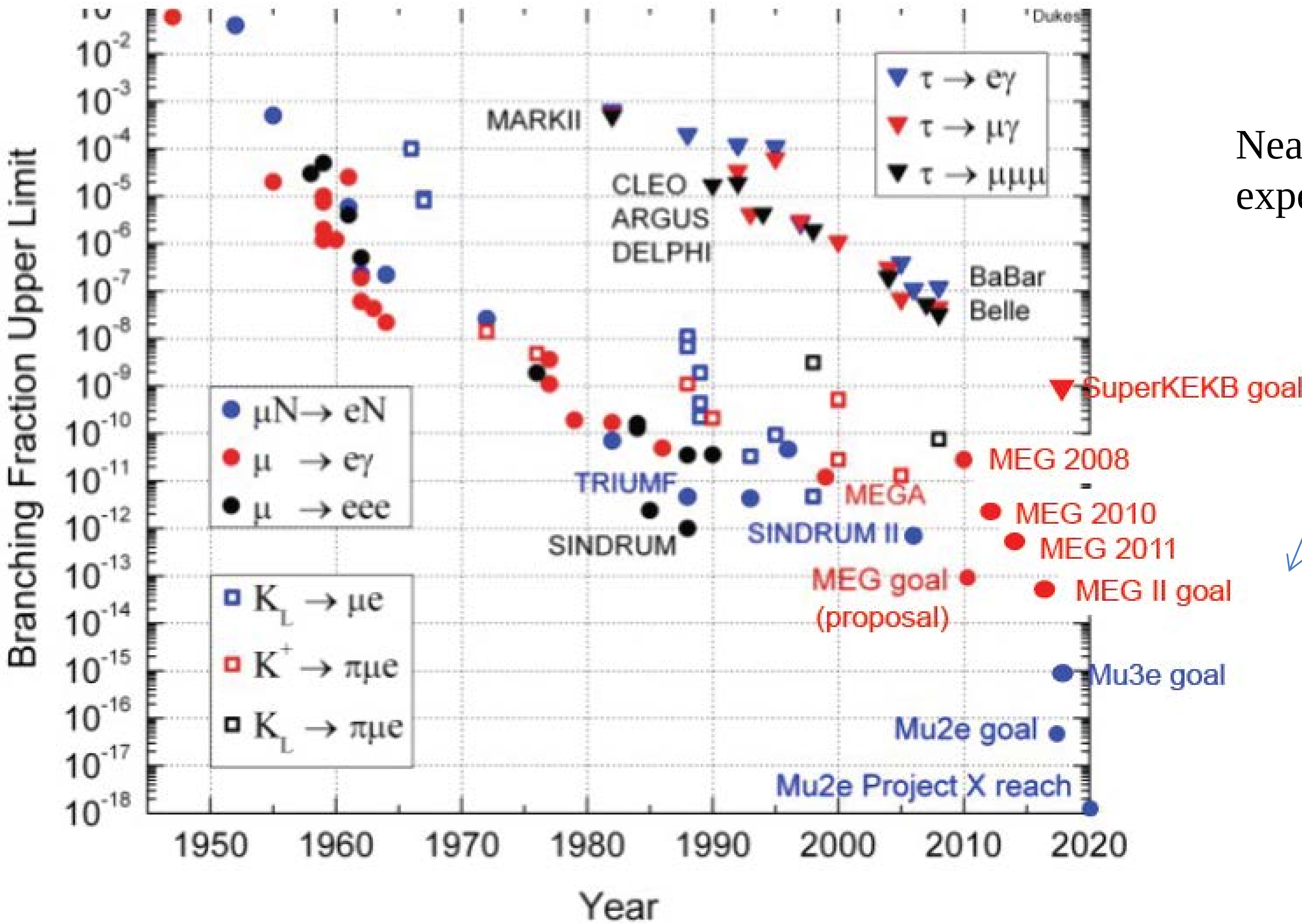
~2.8σ tension with SM prediction

(Giovanni Signorelli): LFV in τ decays



LFV in μ & K decays

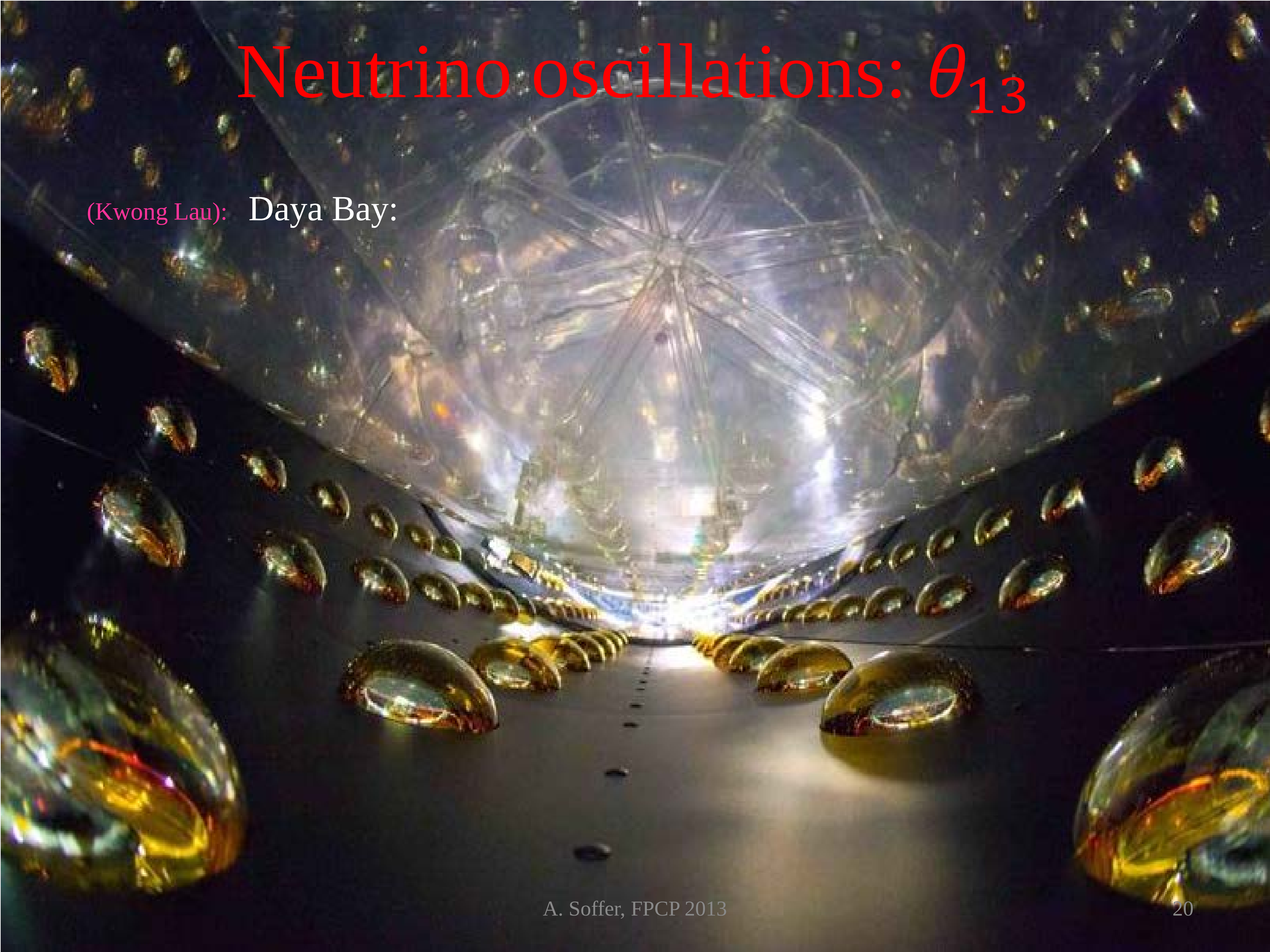
(Giovanni Signorelli):



Near-future experiments

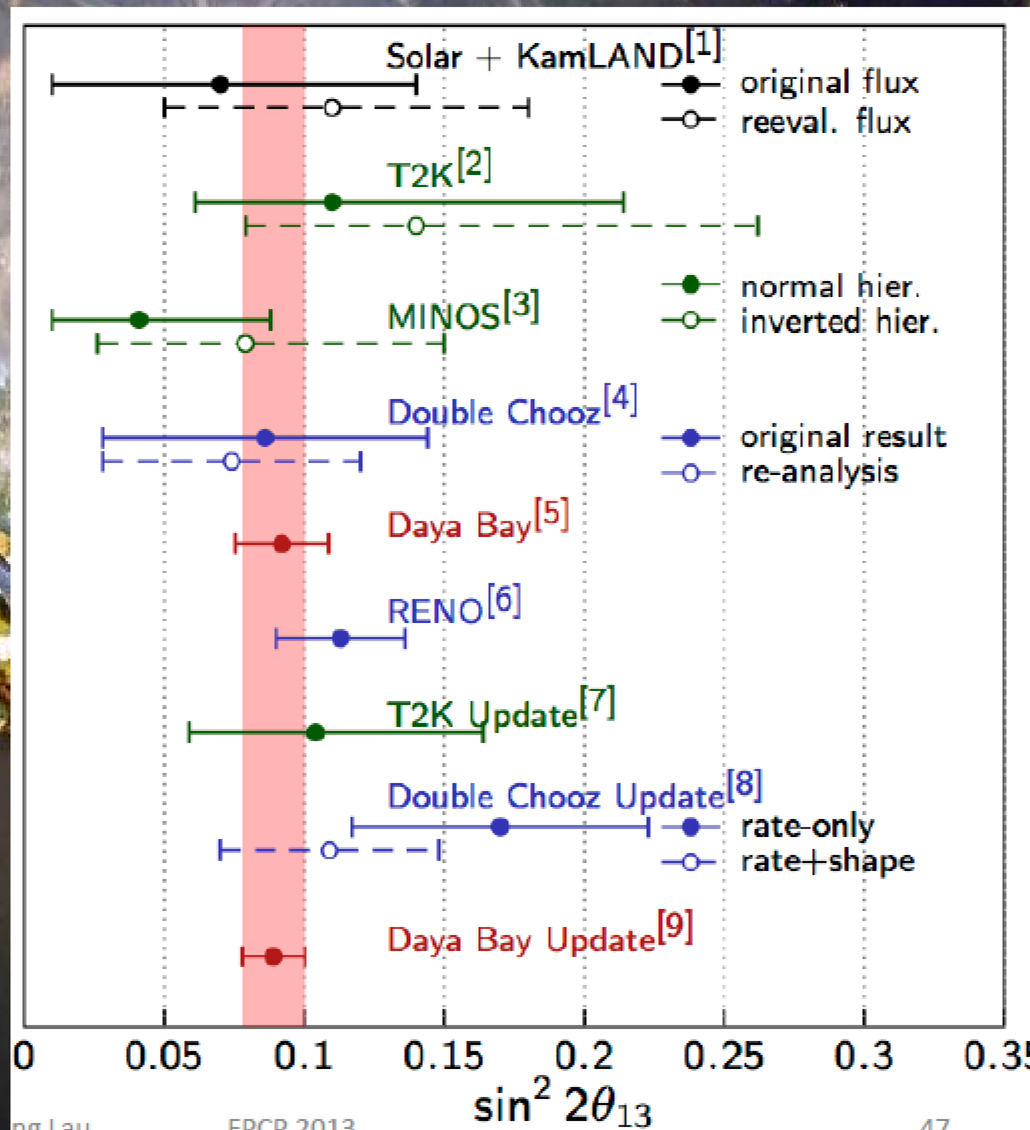
Neutrino oscillations: θ_{13}

(Kwong Lau): Daya Bay:



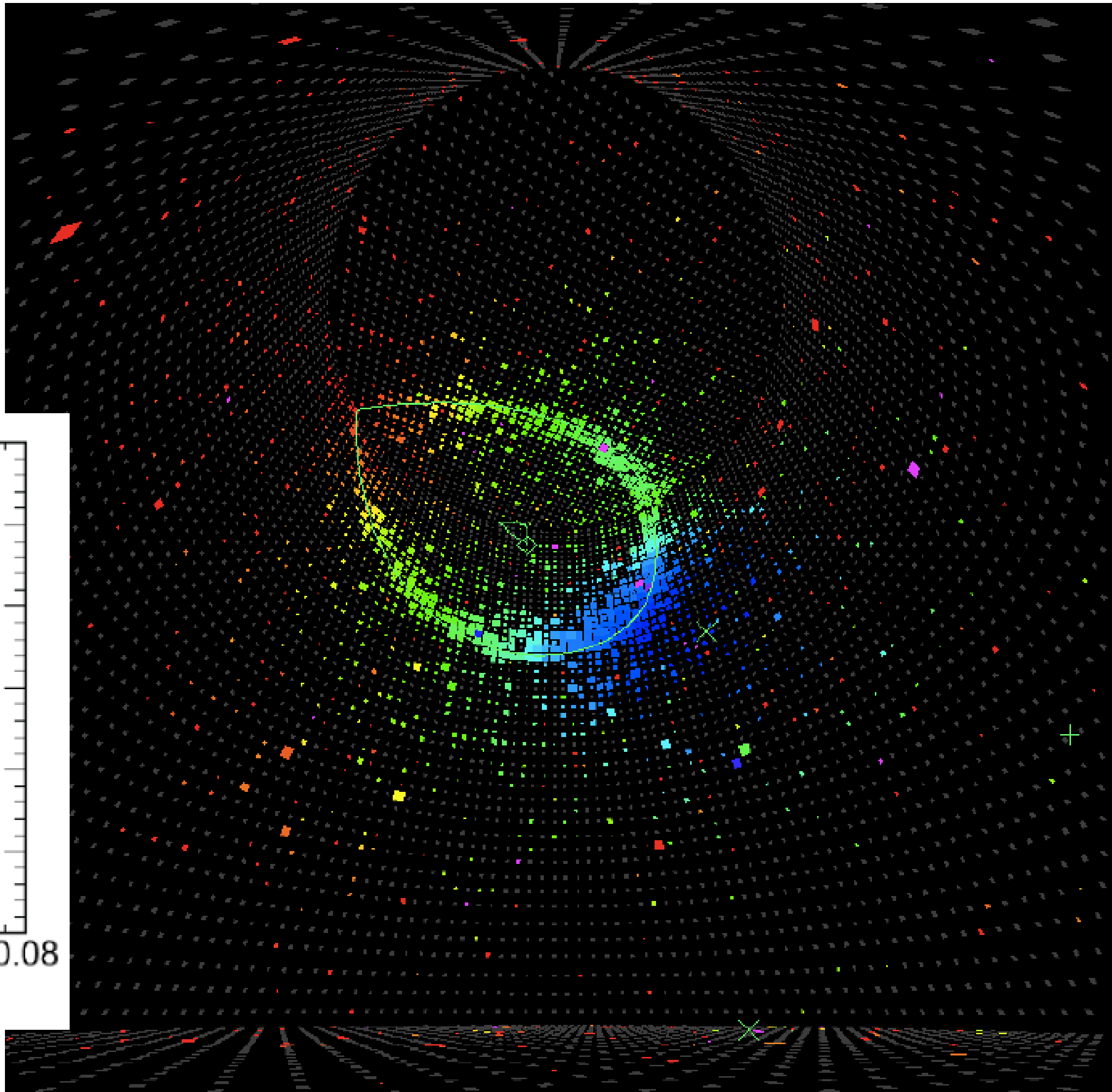
Neutrino oscillations: θ_{13}

(Kwong Lau): Results:

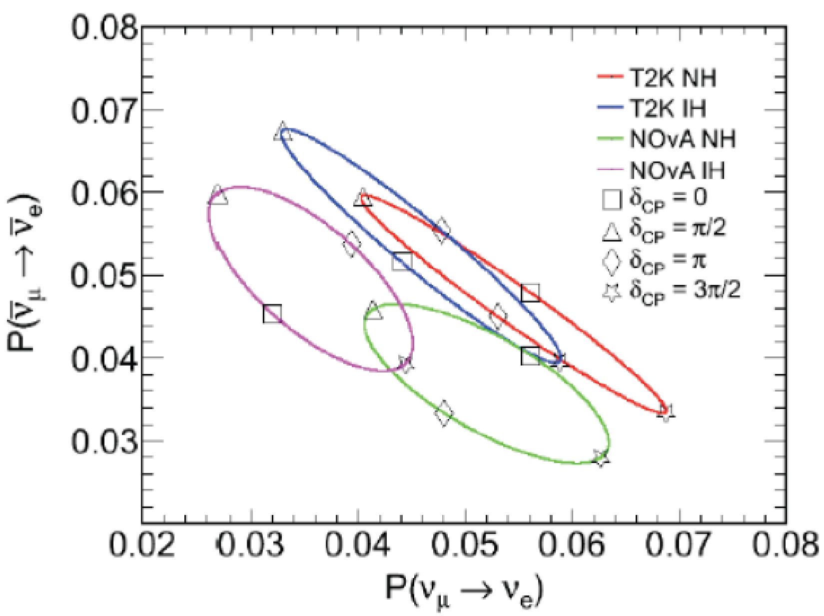


T2K $\nu_\mu \to \nu_e$ candidate #11

(Alex Finch):



T2K and NOvA will have some sensitivity to δ, if its value is good



Charm

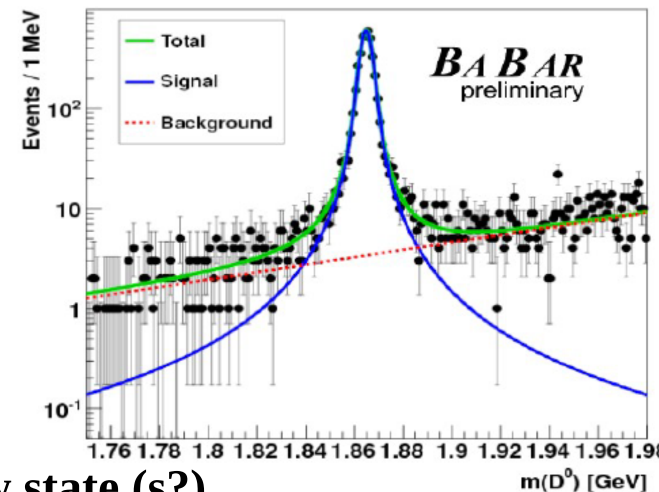
(Gabriele Simi):

Precision measurement of charm parameters

$M(D^0) = 1864.841 \pm 0.048 \pm 0.062$ MeV/c^2

$\Delta m = m(D^*) - m(D^0) = 145425.8 \pm 0.5 \pm 1.8$ keV/c^2

$\Gamma(D^*) = 83.3 \pm 1.3 \pm 1.4$ keV/c^2



(Diego Milanes): Excited charm mesons at LHCb , **new state (s?)**

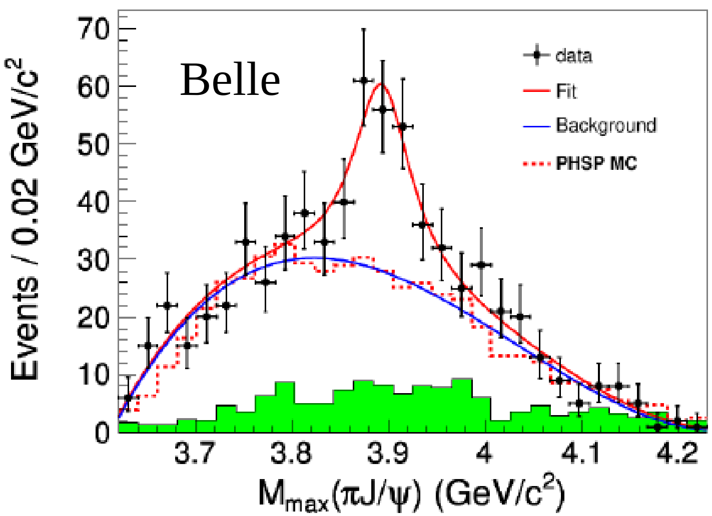
New

LHCb Preliminary
LHCb-PAPER-2013-026

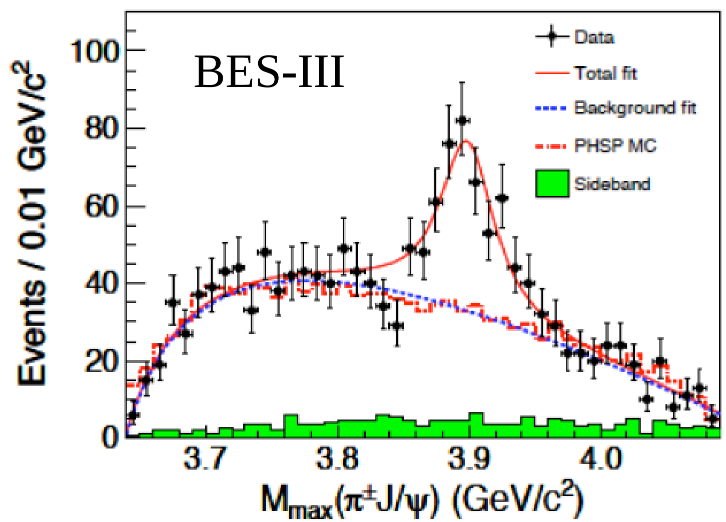
	Resonance	Final state	Mass (MeV)	Width (MeV)	Significance
Unnatural parity	$D_1(2420)^0$	$D^{*+}\pi^-$	$2419.6 \pm 0.1 \pm 0.7$	$35.2 \pm 0.4 \pm 0.9$	
Natural parity	$D_2^*(2460)^0$	$D^{*+}\pi^-$	$2460.4 \pm 0.4 \pm 1.2$	$43.2 \pm 1.2 \pm 3.0$	
Seen only in $D^*\pi$, 1^- 2S $D_1(2618)$	$D_J^*(2650)^0$	$D^{*+}\pi^-$	$2649.2 \pm 3.5 \pm 3.5$	$140.2 \pm 17.1 \pm 18.6$	24.5 (15.9)
Natural parity	$D_J^*(2760)^0$	$D^{*+}\pi^-$	$2761.1 \pm 5.1 \pm 6.5$	$74.4 \pm 3.4 \pm 37.0$	10.2 (6.0)
Seen by BaBar, unnatural parity 0^-	$D_J(2580)^0$	$D^{*+}\pi^-$	$2579.5 \pm 3.4 \pm 5.5$	$177.5 \pm 17.8 \pm 46.0$	18.8 (13.1)
Unnatural parity, 1^- like 1D $D_1(2796)$	$D_J(2740)^0$	$D^{*+}\pi^-$	$2737.0 \pm 3.5 \pm 11.2$	$73.2 \pm 13.4 \pm 25.0$	7.2 (4.7)
NEW compatible with unnatural par.	$D_J(3000)^0$	$D^{*+}\pi^-$	2971.8 ± 8.7	188.1 ± 44.8	9.0 (3.7)
Natural parity	$D_2^*(2460)^0$	$D^+\pi^-$	$2460.4 \pm 0.1 \pm 0.1$	$45.6 \pm 0.4 \pm 1.1$	
Natural parity, 2^- like 1D $D_2(2801)$	$D_J^*(2760)^0$	$D^+\pi^-$	$2760.1 \pm 1.1 \pm 3.7$	$74.4 \pm 3.4 \pm 19.1$	17.3 (5.5)
NEW	$D_J^*(3000)^0$	$D^+\pi^-$	3008.1 ± 4.0	110.5 ± 11.5	21.2 (12.4)
Natural parity	$D_2^*(2460)^+$	$D^0\pi^+$	$2463.1 \pm 0.2 \pm 0.6$	$48.6 \pm 1.3 \pm 1.9$	
Natural parity, 2^- like 1D $D_2(2801)$	$D_J^*(2760)^+$	$D^0\pi^+$	$2771.7 \pm 1.7 \pm 3.8$	$66.7 \pm 6.6 \pm 10.5$	18.8 (8.3)
NEW	$D_J^*(3000)^+$	$D^0\pi^+$	3008.1 (fixed)	110.5 (fixed)	6.6 (5.1)

New $Z_c^+(3900)$ in $Y(4260) \to J\psi\pi\pi$?

(XiaoLong Wang)

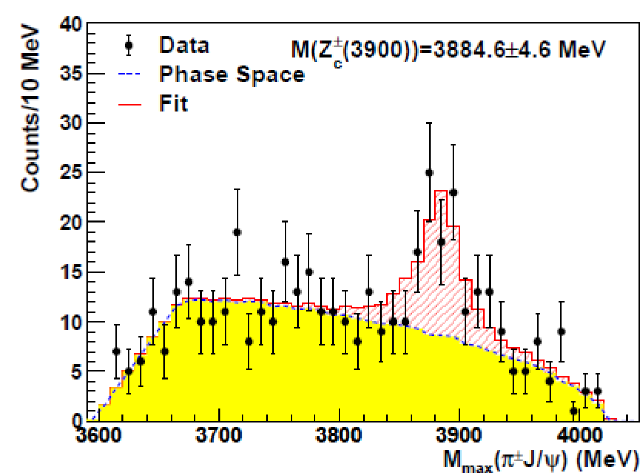


(Roy Briere)



Waiting for partial-wave analysis,
off-resonance search.

Xiao et al, using CLEO $\psi(4160)$ data:



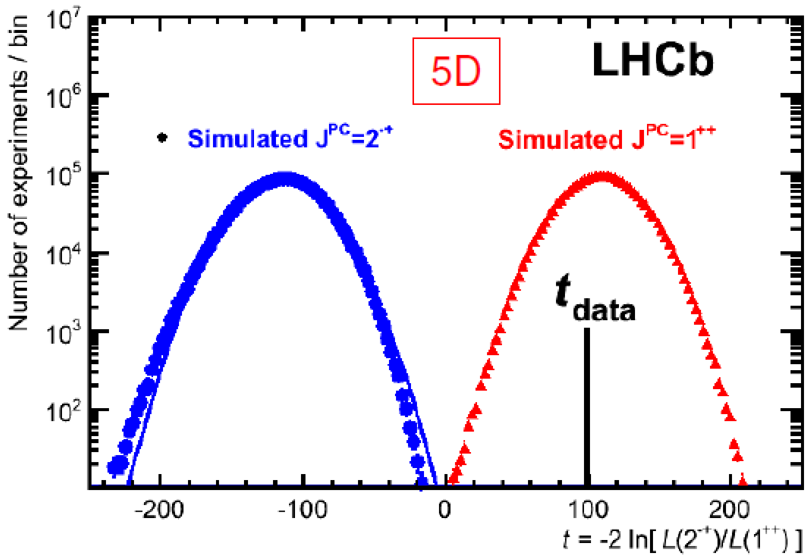
If real, what is it? Related to Z_b^+?...

Note: Y(4260) broad, but not seen in exclusive $D\bar{D}X$ decays.
BES-III should measure inclusive $Y(4260) \to DX$

$J^{PC}=1^{++}$ for X(3872)

(Tomasz Skwarnicki)

LHCb has fewer events than previous analyses, but does a more detailed 5D fit:



Molecular interpretation favored.
I don't think it requires $m_X < m_D + m_{D^*}$) – e.g., α and neutron emission.

LHCb could significantly contribute to all exotica with J/ψ , e.g., $Z^+(3440)$

CPV and mixing in B_d and B_s

(Bruno Souza de Paula) LHCb results from $B_s \to J/\psi K^+K^-$ and $J/\psi\pi^+\pi^-$ (most precise)

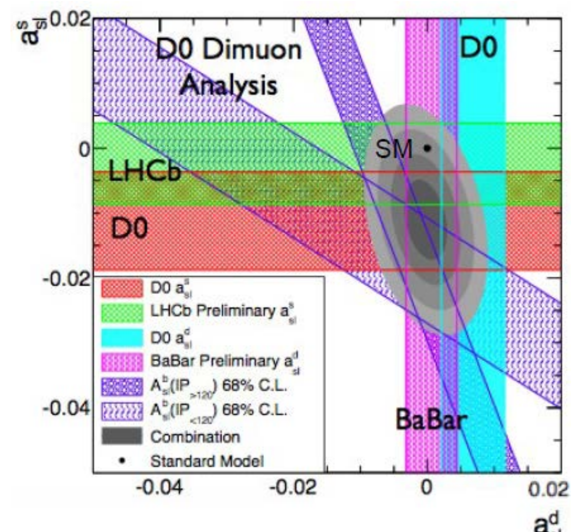
$$\begin{aligned}
\phi_s &= 0.01 \pm 0.07 \text{ (stat)} \pm 0.01 \text{ (syst) rad},\\
\Gamma_s &= 0.661 \pm 0.004 \text{ (stat)} \pm 0.006 \text{ (syst) ps}^{-1},\\
\Delta\Gamma_s &= 0.106 \pm 0.011 \text{ (stat)} \pm 0.007 \text{ (syst) ps}^{-1}.
\end{aligned}$$

(James Walder): Also from ATLAS, CMS, D0, CDF

(Bruce Hoeneisen):

D0's $A_{sl} \propto N(\mu^+\mu^+) - N(\mu^-\mu^-)$ is 3.9 σ from 0, disagrees with SM.
New: contamination from CPV in mixing-decay interference.
If the effect is ~twice its estimated value, A_{sl} goes below ~3 σ.

(Martino Margoni):
New BABAR results (most precise) on A_{sl} for B_d.
Other than the D0 A_{sl}, all results are consistent with SM:



Production charge asymmetry at LHC

(Jacob Linacre)

Tevatron Forward-backward asymmetry for $t\bar{t}$ in tension with SM
ATLAS & CMS can measure a related quantity:

(Jean Wicht)

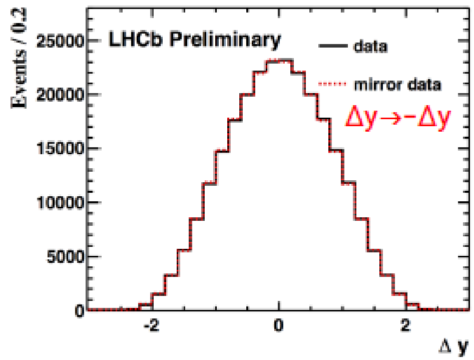
$$A_C = \frac{N(|y_t| > |y_{\bar{t}}|) - N(|y_t| < |y_{\bar{t}}|)}{N(|y_t| > |y_{\bar{t}}|) + N(|y_t| < |y_{\bar{t}}|)}$$

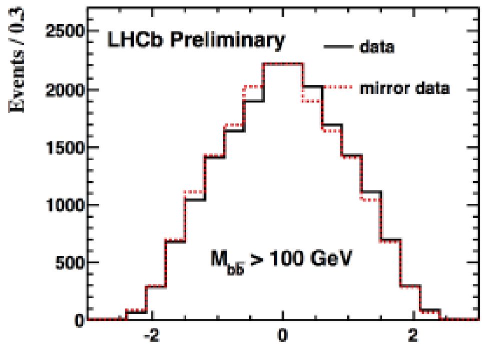
LHC measurements consistent with SM ($A_C \simeq 0.006$):

$A_C = 0.004 \pm 0.015$ (CMS l+jets)

$A_C = 0.029 \pm 0.023$ (ATLAS, l+j and dilepton combined) ATLAS-CONF-2012-057

$b\bar{b}$ asymmetry from LHCb is consistent with SM





$$A_{\rm FB}^{b\bar{b}} = (0.5 \pm 0.5\ ({\rm stat}) \pm 0.5\ ({\rm syst}))\%$$

$$A_{\rm FB}^{b\bar{b}}(M_{b\bar{b}} > 100\ {\rm GeV}) = (4.3 \pm 1.7\ ({\rm stat}) \pm 2.4\ ({\rm syst}))\%$$

∃ Models that accommodate both Tevatron & LHC results

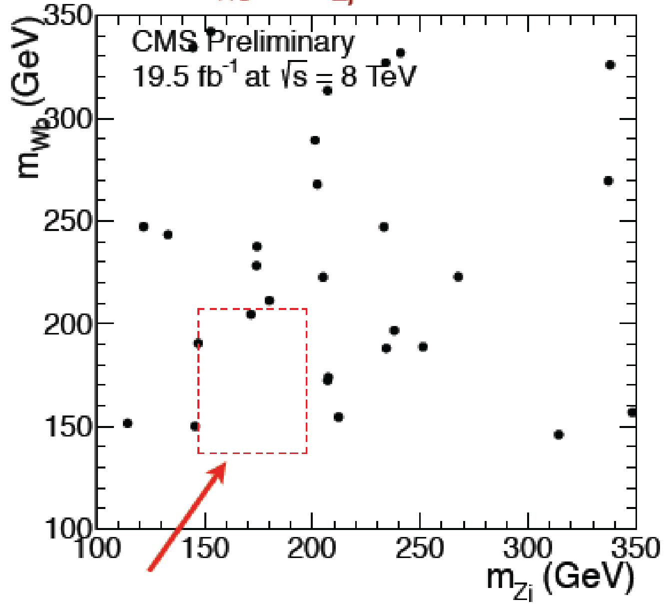
Top couplings and anomalous decays

(Jacob Linacre)

CMS search for $t \to Zq$

$\mathcal{B}(t \to Zq) <$ **0.07% (95% CL)**

m_{Wb} vs m_{Zj} distribution



1 event in signal box

CMS: Ratio of $\dfrac{B(t\to Wb)}{B(t\to Wq)}$

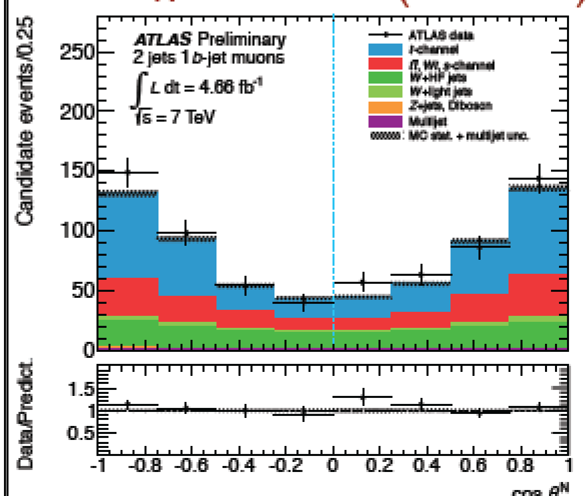
$$\mathcal{R} = 1.023^{+0.036}_{-0.034} \text{ (stat+syst)}$$

$$\mathcal{R} > 0.945 \text{ at } 95\% \text{ CL}$$

$$|V_{tb}| > 0.972 \text{ at } 95\% \text{ CL}$$ (using $\mathcal{R} = |V_{tb}|^2$)

ATLAS search for CP-violating imaginary coupling:

$\cos\theta_N$ distribution (reco level)



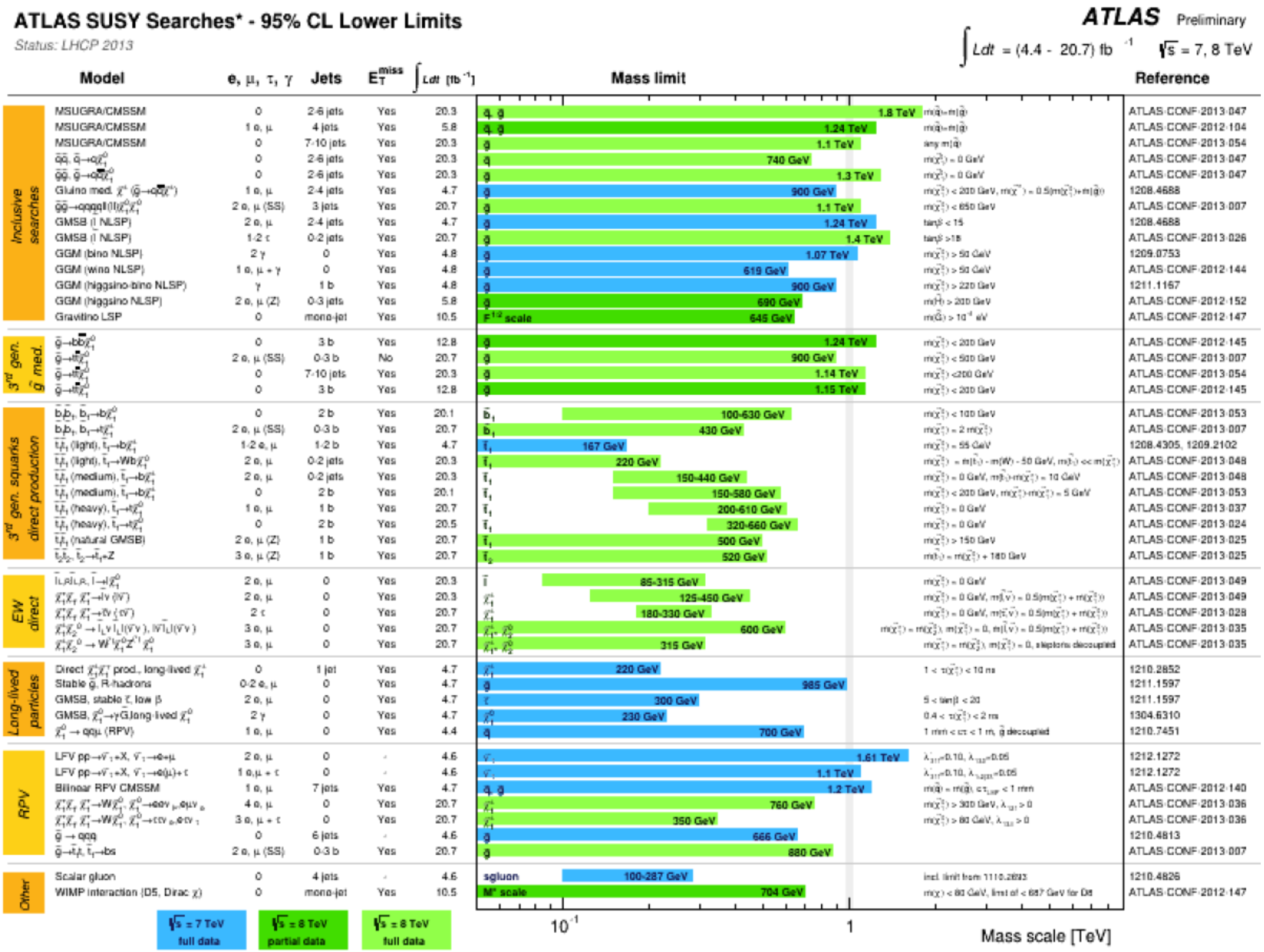
A^N_{FB} = 0.03 ± 0.07

Im(g_R) ∈ [-0.20, 0.30] at 95 % CL (P=0.9)

first experimental limits on Im(g_R)

SUSY limits (similar list from CMS)

(Anna Lipniacka)

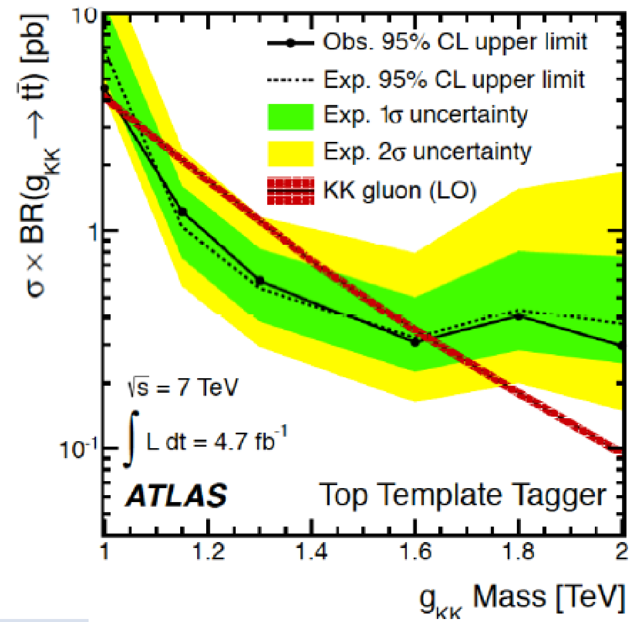


More flavor-related searches

(Andrew Ivanov)

4th generation

Mass, Dominant Decay	Limit @ 95% C.L.	Experiment, Channel
m(t′), t′ → Wb	> 656 GeV	ATLAS, l+jets
m(t′), t′ → Ht	>~850 GeV	ATLAS, l+jets
m(t′), t′ → Zt	> 625 GeV	CMS, l+jets
m(t′,b′), t′, b′ → Wq	> 350 GeV	ATLAS, OS dilepton
m(b′), b′ → Wt	> 760 GeV	CMS, multi-lepton
m(b′), b′ → Zb	> 660 GeV	CMS, multi-lepton
Inclusive t′, b′	> 685 GeV	CMS, multi-channel
m(t′), SU(2) singlet	> 640 GeV	ATLAS, l+jets
m(b′), SU(2) singlet	> 590 GeV	ATLAS, SS dilepton
m(t′), SU(2) doublet	> 790 GeV	ATLAS, l+jets
m(t′), t′ → tg	> 794 GeV	CMS, l+jets



(Jun Guo)

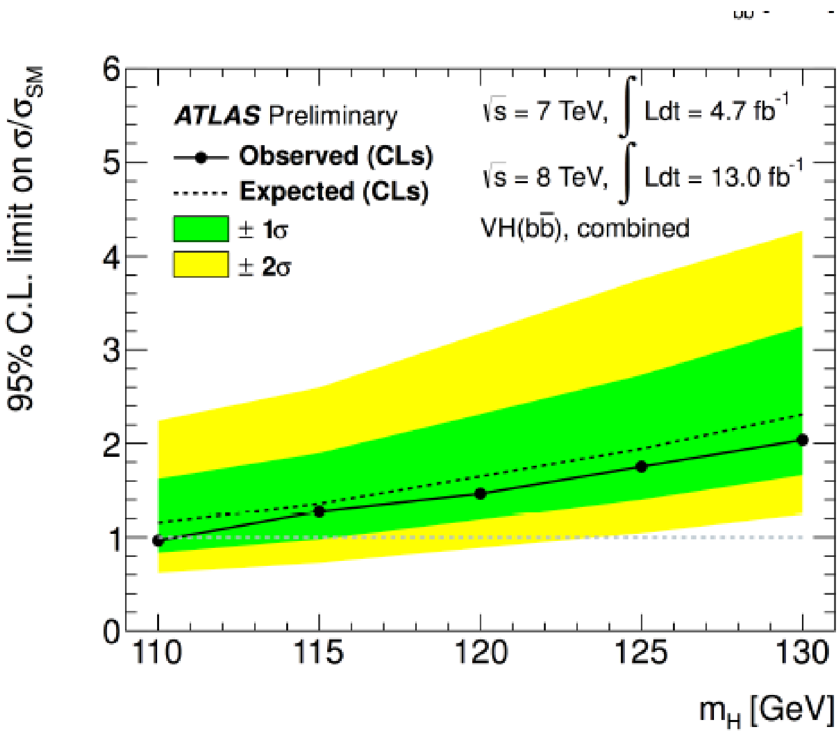
$t\bar{t}$ resonance, e.g., KK-gluon

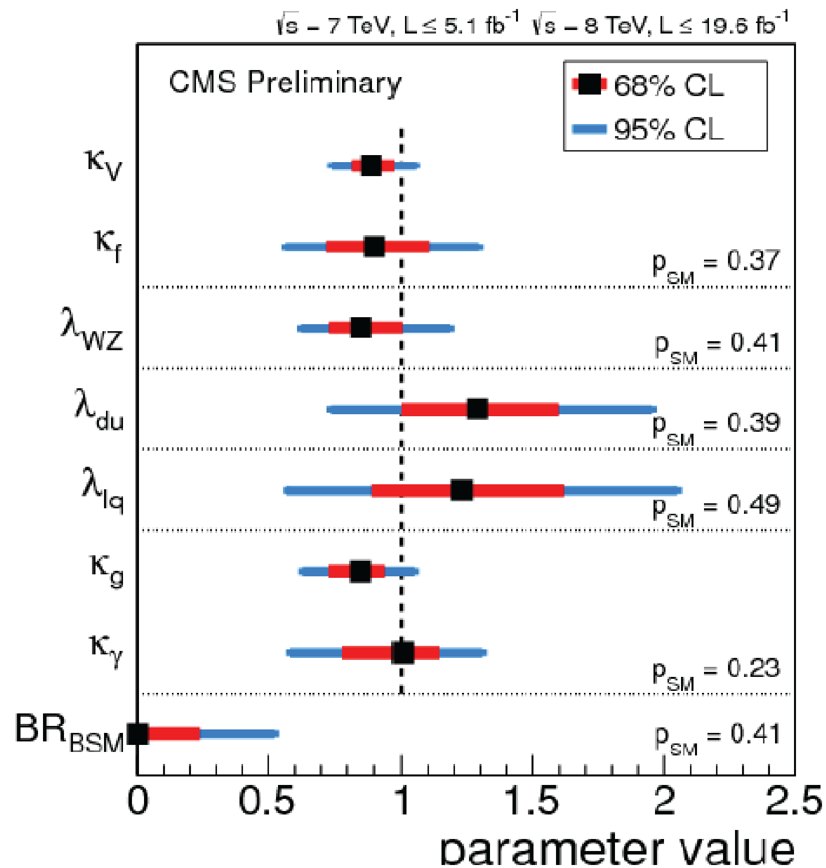
Higgs at ~125 GeV

(Junji Tojo)

Couplings are consistent with SM only:

Decays to vector bosons well established.
No sensitivity yet @ SM level to fermions.
E.g., $b\bar{b}$ coupling limits:

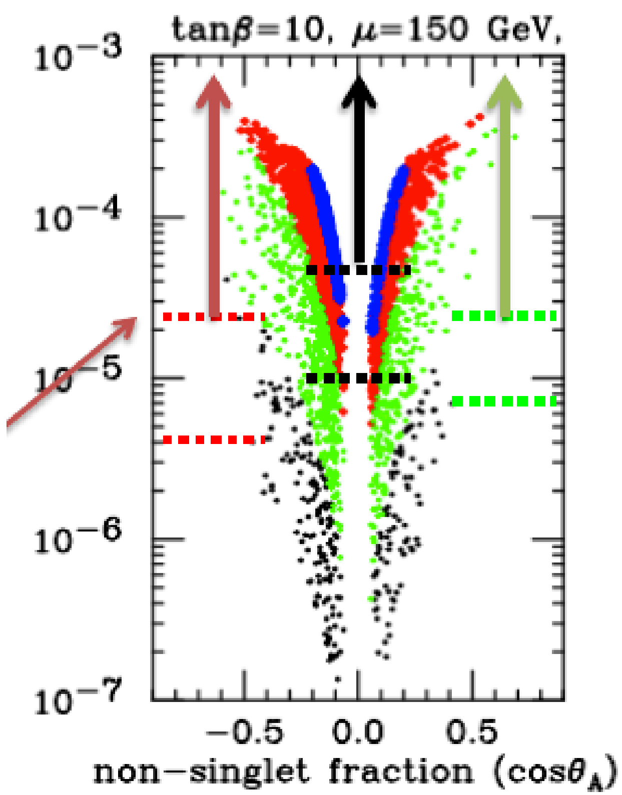




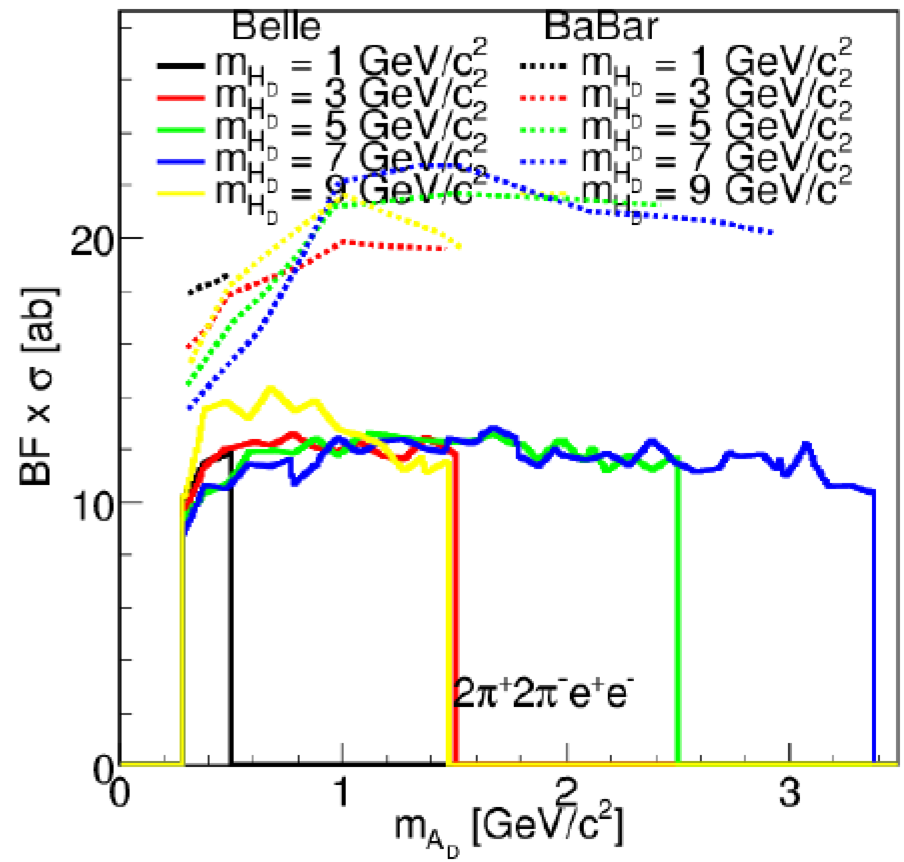
Light Higgs and dark photons

(Sven Vahsen)

nMSSM parameter space
highly restricted by B factories

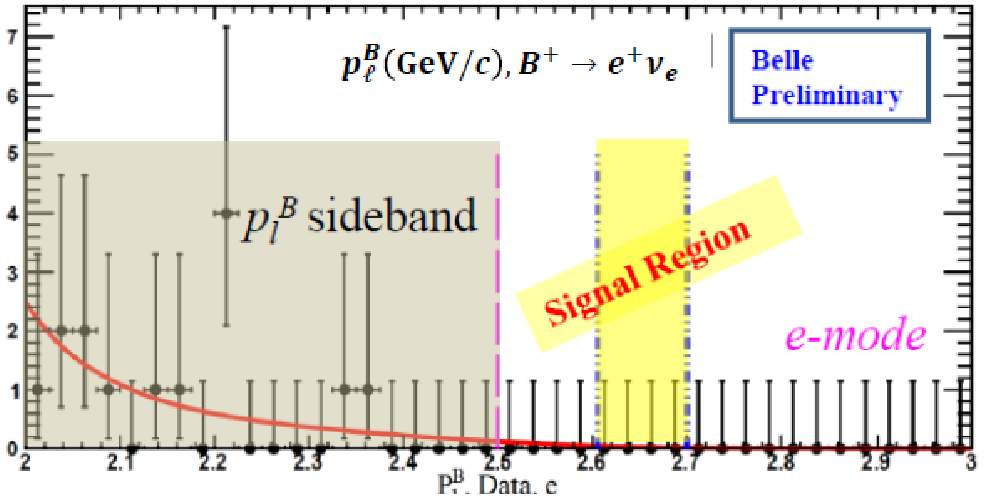


Dark photon: Belle halves limits production in Higsstrahlung scenario



Limits on suppressed decays with neutrinos

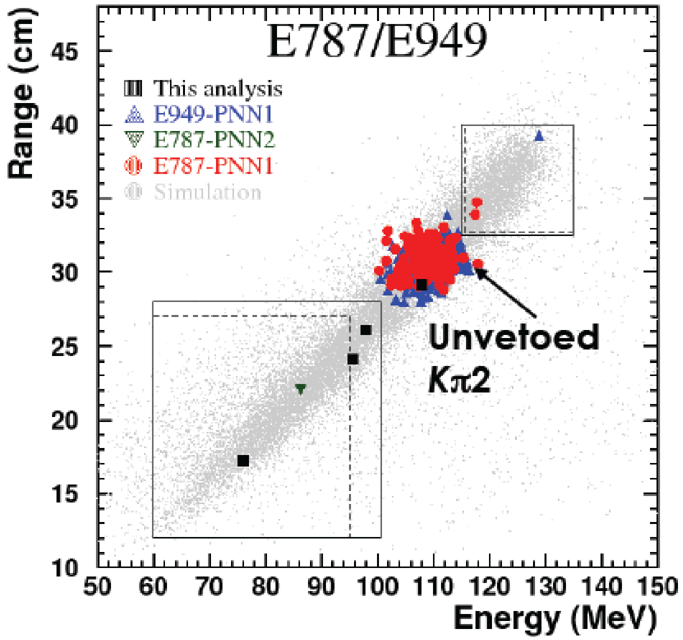
(Youngmin Yook) New $B \to l\nu$ limits from Belle



(Paolo Massarotti)

$K^+ \to \pi^+\nu\bar{\nu}$ limit from E787/E949

$BR(K^+ \to \pi^+\nu\bar{\nu}) = (1.73^{+1.15}_{-1.05}) \times 10^{-10}$



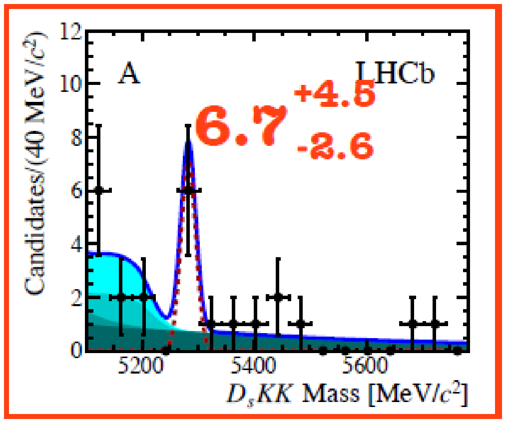
No inconsistency with SM detected

Hadronic decays and production

(Neus Lopez March)

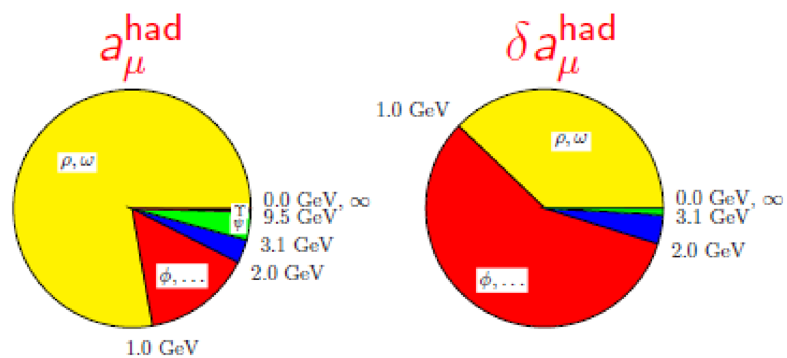
Hadronic B decays @ LHCb

$B^+ \to D_s^+ \Phi$



(Andreas Hafner)

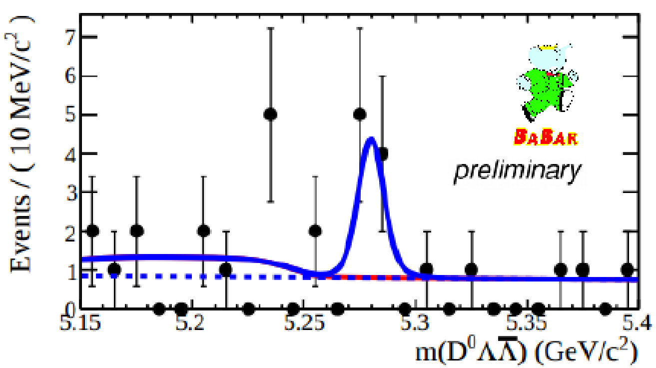
Hadronic contributions to $g-2$



[PR 477, 1 (2009).]

(Marcus Ebert)

Baryonic B decays @ BABAR



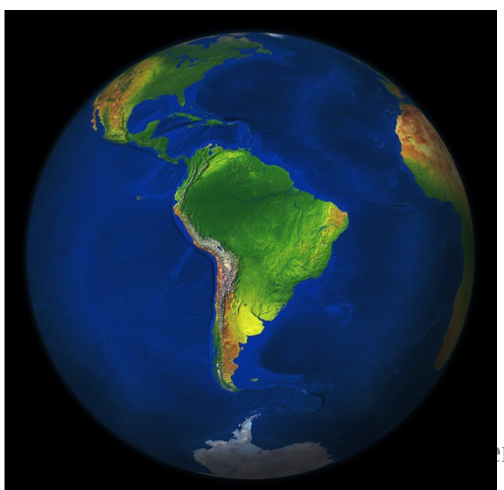
$$a_\mu^{had}(K^+K^-) = 216.3 \pm 2.7 \pm 6.8$$
$$\downarrow$$
$$a_\mu^{had}(K^+K^-) = 229.5 \pm 1.4 \pm 2.2$$

calculation only based on BABAR 2013 data!

Experimental snapshot

- SM appears fully established
- No clear sign of physics beyond the SM
- But several $3\sigma - 4\sigma$ discrepancies persist
  - $A_{FB}^{t\bar{t}}$(Tevatron) , inclusive A_{sl}^{s} (D0), $B \to D^{*}\tau\nu$ (B factories)…
    - (Talks by Jean Wicht, Martino Margoni, Bruce Hoeneisen, Andrzej BOZEK)
- Others have disappeared
  - $\Delta A_{CP}^{D^o}$ (LHCb), and maybe inclusive A_{sl}^{s} (D0)
    - (Talk by Alberto Dos Reis, Bruce Hoeneisen)
- What does nature have in store for us in the coming decade?...

Pedro Álvares Cabral
Brazil 1500



Robert Falcon Scott
Antarctica 1912

Things are exciting now

- LHC experiments are in full swing
- B factories still productive (31/28 BABAR/Belle papers in 2012)
- Neutrino experiments having new results
- Etc.…

Getting even more exciting soon

- LHC 13 TeV – 2014
- NA62 sensitivity to $K^+ \rightarrow \pi^+ \nu\bar{\nu}$ ~ current CKM – 2017
- LHCb upgrade – 2018
- Belle-II – 2018
- New LFV expts. (Mu2e, COMET) – 2022
- T2K, NOvA may glimpse at CPV
- Maybe ILC on the horizon

- Encourage Chinese HEP community to compete with Italy & Russia for τ-charm factory – role of mid-size facilities in LHC era.

Thank you for the wonderful conference.
See you in Marseille