Report on SuperB Physics Workshop

M. Ciuchini

Facts:

- Sunday, December 11th & Monday, December 12th
- ~30-40 participants
- Only plenary sessions
- 25 speakers (-1)
- 14 theory & 9 experimental talks (2 missing)
- Invited talks from Belle, Atlas/CMS, LHCb, Tevatron

On the meeting format

- We continue with the meeting format introduced in Elba this summer: we focus on a subset of topics without covering everything. In this meeting:
  - A session dedicated to the new Bs WG
  - A session dedicated to charm following the Beijing workshop and the new LHCb result on CPV
  - A session on B physics devoted to b → s gamma (with a tail of b → sll from Elba)
  - A session devoted to impact of the LHC on SuperB phenomenological studies
  - Further talks on tau and LFV

The meeting programme

Sunday 11 December 2011	
08:30	--- Registration of Participants -
09:30	Welcome - Adrian Bevan *(Queen Mary)*
09:45	Special Topics in Bs Physics - Alexander Lenz *(CERN)* Slides
10:30	Open flavour between 5S and 6S bottomonium - Felipe Llanes-Estrada *(Complutense University of Madr*
11:00	--- coffee break ---
11:30	Line Shapes of Near-Threshold Resonances. Charmonium and Bottomonium Hybrids - Alexey Nefediev Slides
12:00	Bs Results from Belle - Alexey Drutskoy *(ITEP, Moscow)* Slides
12:30	Bs Results from the Tevatron - Martin Heck *(Kahrsruhe Institute of Technology)* Slides;
13:00	Summary of Charm Workshop Beijing - Nicola Neri *(MI)* Slides
13:30	--- lunch break ---
15:00	Time-Dependent CPV in Charm - Gianluca Inguglia *(Queen Mary University of London)* Slides
15:30	Charm results from LHCb - Walter Bonivento *(CA)* Slides
16:00	Direct CPV in D Decays - Jure Zupan *(CERN)* Slides
16:30	--- coffee break
17:00	Charm news from the Intensity Frontier Workshop - Brian Meadows *(University of Cincinnati)*
17:30	Lepton Flavour Violation in Susy Models - Cedric Weiland *(LPT Orsay)* Slides
18:00	Precision SM tests with tau decays - Emilie Passemar *(IPN Orsay)* Slides

Monday 12 December 2011	
09:00	Bottom quark mass from R(s) - Matthias Steinhauser *(KIT)* Slides
09:30	B -> Xs gamma: normalization and parameters - Paolo Gambino *(TO)*
10:00	Inclusive B -> Xs gamma photon spectrum and CP asymmetry - Mikolaj Misiak *(University of Warsaw)*
10:30	B->Xs gamma Experimental Issues - John Walsh *(PI)*
11:00	--- coffee break ---
11:30	B->K*ll Theory Update - Christoph Bobeth *(TU München - IAS/Excellence Cluster)*
12:00	B -> K*ll Theory 2 - Tobias Hurth *(CERN)*
12:30	Results from LHCb - Tim Gershon *(University of Warwick)*
13:30	--- lunch break ---
15:00	CKM with 4 Generations - Otto Eberhardt *(Karlsruhe Institute of Technology)*
15:30	LHC Results - Maurizio Pierini *(CERN)*
16:00	Little Higgs and Randall-Sundrum facing early LHC data - Monika Blanke *(Cornell University)*
16:30	Photon polarization determination of b -> s gamma - A. Tayduganov *(LAL/IN2P3)*
17:00	--- coffee break ---
17:30	New Physics in b->s Transitions - Paride Paradisi *(CERN)*
18:00	Electroweak Physics at SuperB: Update - Michael Roney *(University of Victoria)*
18:30	Closeout - John Walsh *(PI)*

Reviews & Summaries

1. Alexey Drutskoy, Belle Bs results
2. Martin Heck, Tevatron HF physics
3. Nicola Neri, Beijing Charm Workshop
4. Walter Bonivento, charm LHCb results
5. Tim Gershon, LHCb B/Bs results
6. Maurizio Pierini, SUSY searches at the LHC
   - Not discussed in the following on the basis that a summary^2 (or even summary^3) does not work well, but specific results are mentioned here and ther

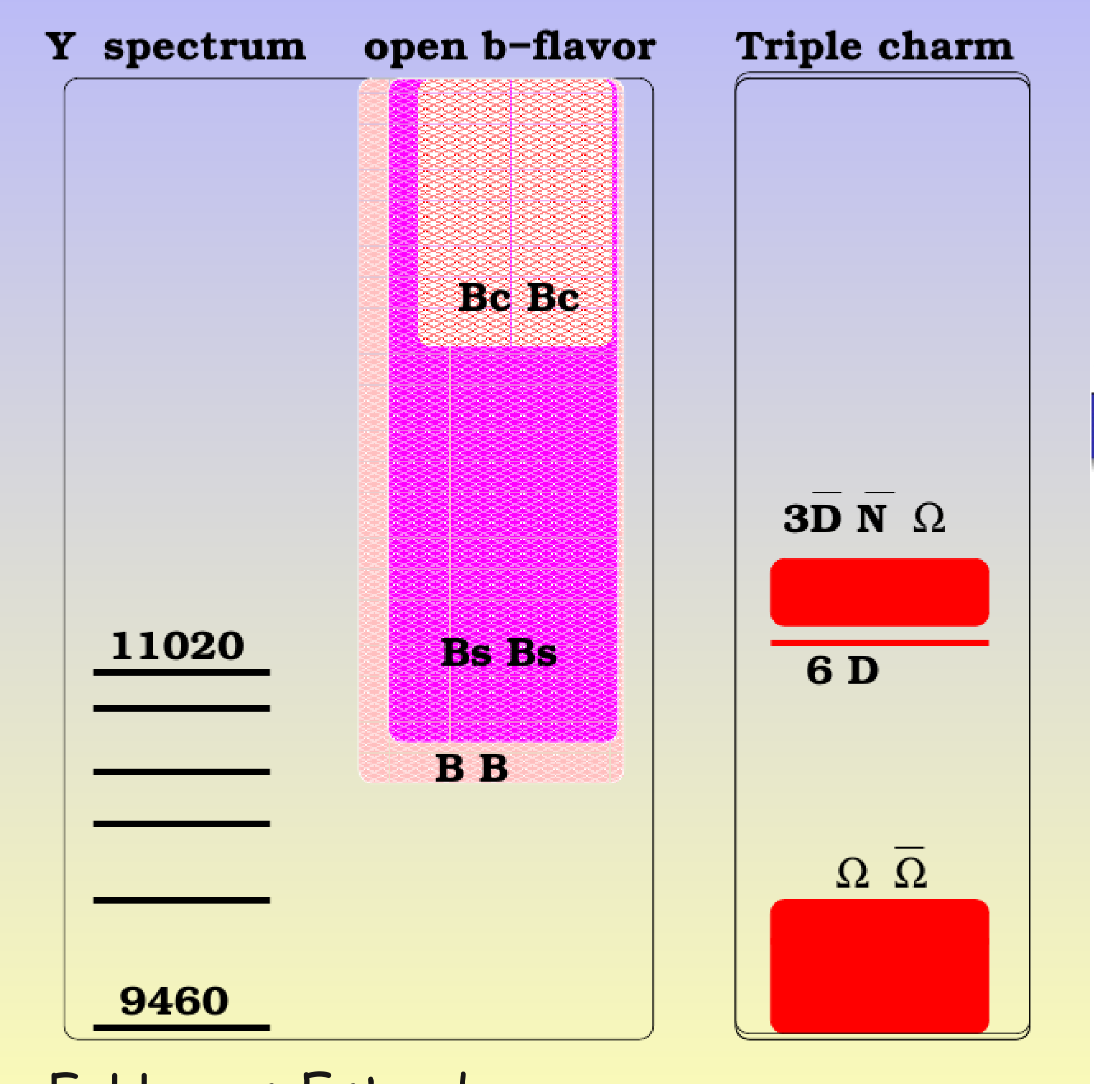
Thanks to all the speakers

Bs session

Additions to the SuperB whish-list:

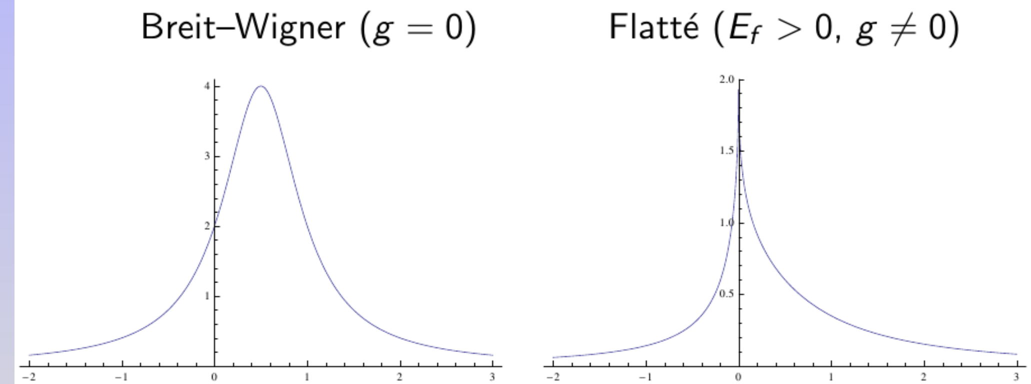
- **Precise** value of $\Delta\Gamma_s$ and ϕ_s
  - New channels like $B_s \to J/\psi\eta^{(')}, \psi f_0, \eta_c\phi, D^{(*)}K_s, D^{(*)}\phi, \phi\eta', K^0\bar{K}^0 ...$
  - Test: $2Br(B_s \to D_s^{(*)\pm} D_s^{(*)\pm}) = \Delta\Gamma^{CP}/\Gamma$ by measuring 3-body final states.
- **Precise** value of lifetimes $\tau(B_s), \tau(B_d), \tau(B^+), ...$ and ratios
- **Precise** values of the semileptonic CP asymmetries $a_{sl}^{s,d}$
  also hadronic channels like $B_s \to D_s^{(*)}\pi$
- **Precise** values of the semileptonic branching ratios B_{sl}
- **Values** for inclusive branching ratios $r(0, 1, 2 \;\; \mathrm{charm})$
- **Values** for many penguin modes to determine size of penguin pollution
  e.g. $B_s \to J/\psi K_s, K^0\bar{K}^0, \phi\phi, \eta^{(')}\eta^{(')} ...$
- **Bounds** on on $B_s \to \tau\tau$, $B \to K\tau\tau$

A. Lenz, theory introduction



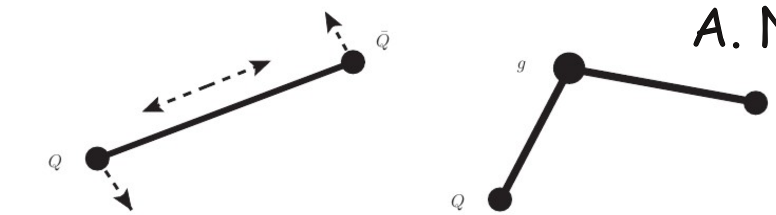
F. LLanes-Estrada

A gym for QCD: normal states, molecules, hybrids, triple charm...



QCD string approach: conventional mesons vs hybrids

A. Nefediev



Masses of S- and P-level charmonia, in GeV

State	$\eta_c(1S)$	J/ψ	$h_c(1P)$	$\chi_{c_1}(1P)$	$\chi_{c_0}(1P)$	$\chi_{c_2}(1P)$
J^{PC}	0^{-+}	1^{--}	1^{+-}	1^{++}	0^{++}	2^{++}
$^{2S+1}L_J$	$^1S_0$	$^3S_1$	$^1P_1$	$^3P_1$	$^3P_0$	$^3P_2$
Exp	2.980	3.097	3.526	3.511	3.415	3.556
Theor	2.981	3.104	3.528	3.514	3.449	3.552

Masses of charmonium hybrids, in GeV

J^{PC}	0^{-+}	1^{-+}	1^{--}	2^{-+}
Mass	4.252	4.320	4.397	4.457

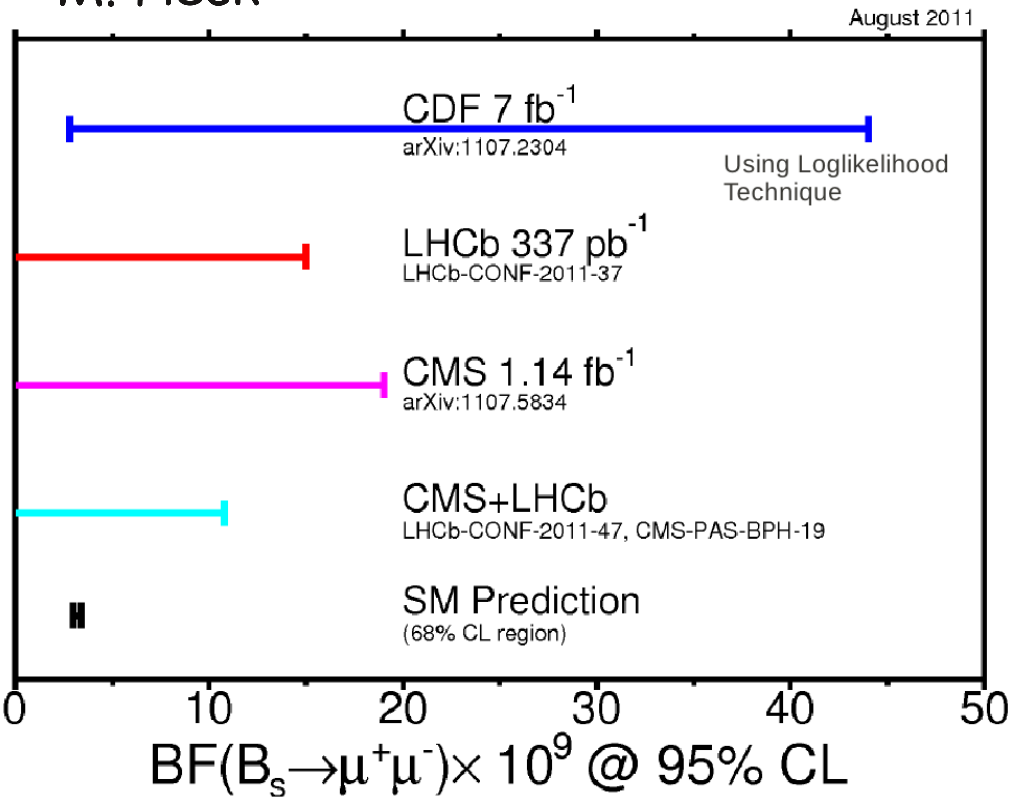
State	$\eta_b(1S)$	$\Upsilon(1S)$	$h_b(1P)$	$\chi_{b_1}(1P)$	$\chi_{b_0}(1P)$	$\chi_{b_2}(1P)$
J^{PC}	0^{-+}	1^{--}	1^{+-}	1^{++}	0^{++}	2^{++}
$^{2S+1}L_J$	$^1S_0$	$^3S_1$	$^1P_1$	$^3P_1$	$^3P_0$	$^3P_2$
Exp	9.401	9.460	9.898	9.893	9.859	9.912
Theor	9.399	9.461	9.900	9.893	9.870	9.910

Masses of charmonium hybrids, in GeV

J^{PC}	0^{-+}	1^{-+}	1^{--}	2^{-+}
Mass	11.163	11.115	11.137	11.181

Outstanding 2011 Bs results

M. Heck



$Bs \to \mu\mu$

Results from $B_s \to J/\psi\varphi$ (0.34/fb)

$$\phi_s^{J/\psi\phi} = 0.13 \pm 0.18\ (\text{stat}) \pm 0.07\ (\text{syst})\ \text{rad},$$
$$\Gamma_s = 0.656 \pm 0.009\ (\text{stat}) \pm 0.008\ (\text{syst})\ \text{ps}^{-1},$$
$$\Delta\Gamma_s = 0.123 \pm 0.029\ (\text{stat}) \pm 0.011\ (\text{syst})\ \text{ps}^{-1},$$

T. Gershon

+ serveral results from the Υ(5S) at Belle (see A. Drutskoy's talk)

First observation of the decay $B_s^0 \to K^{*0}\overline{K}^{*0}$

$$\mathcal{B}(B_s^0 \to K^{*0}\overline{K}^{*0}) = (1.95 \pm 0.47(\text{stat.}) \pm 0.51(\text{syst.}) \pm 0.29\,(f_d/f_s)) \times 10^{-5}$$

Charm session

N. Neri

Summary of the Beijing Workshop on charm physics

Discuss the benefits of the measurements made at charm threshold at existing experiments (CLEOc, BESIII) and explore the potential for those measurements in the future:

- benefits of a boosted center of mass at charm threshold at SuperB;
- impact of charm threshold measurements on other flavor physics experiments: SuperB at $\Upsilon(4S)$, Belle II, LHCb.

Summary of the summary

- Major topics of charm threshold physics are: overcome the non-perturbative QCD roadblock, test pQCD calculations and search for new physics beyond Standard Model.
- Impact of charm physics at threshold on flavor physics measurements is relevant:
  - remove Dalitz model dependency in D^0 mixing and CP violation measurements and γ/Φ_3 measurements;
  - measurement of |Vcs|, |Vcd| and $D_{(s)}$ form factors;
  - measurement of decay constants of f_D, f_{Ds};
  - searches for rare or forbidden decays;
- Systematic errors do not seem to be a roadblock for the relevant measurements and future high statistics data sample will be beneficial.

Time-dependent measurements at $D\bar{D}$ threshold: general considerations

At $\Upsilon(4S)$

- Flavor tagged D^0 through $D^{*+}\to D^0\pi^+$ decay. Flavor mistag $\approx 0.2\%$
- We denote the D* flavor tag with label lX
- D^0 can be reconstructed in flavor lX, CP, Kπ and multibody (e.g. Ks$\pi\pi$) final states. Relatively high purity due to $m(D^0)$ and $\Delta m = m(D^{*+}) - m(D^0)$
- Proper time resolution is about $\tau(D^0)/4 \approx 0.1$ ps

At $\psi(3770)$

- Coherent $D^0\bar{D}^0$ production
- Both D mesons can be reconstructed in lX, CP, Kπ and Ks$\pi\pi$ final states, with very low background
- Flavor mistag $\approx 0.2\%$ with eX, but $\approx 2\%$ with μX (large μ misid @ low p)
- Time-dependent measurements require larger CM boost compared to the $\Upsilon(4S)$ case to achieve time resolution, but reconstruction efficiency decreases with large CM boost. Need to determine the optimal boost value.

Double tags @ $\Psi(3770)$

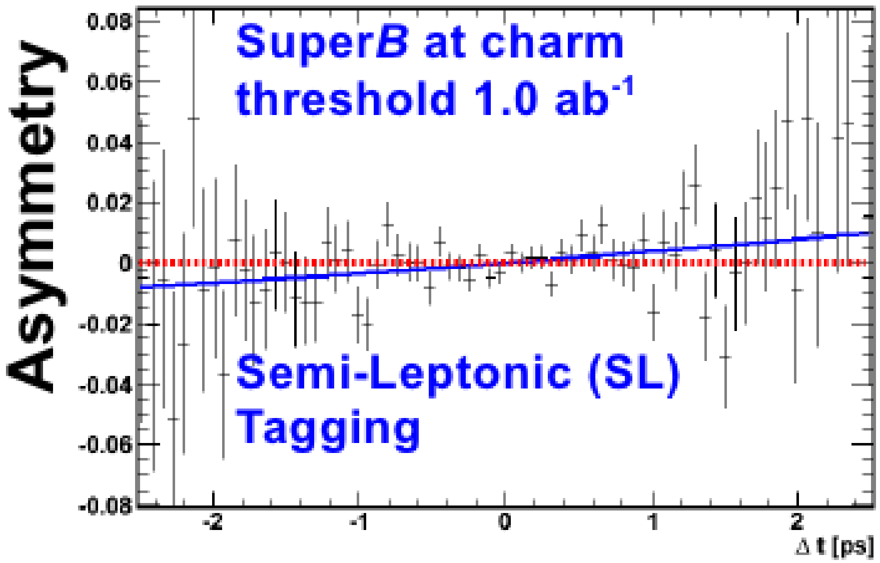
Modes with D* tag @ $\Upsilon(4S)$

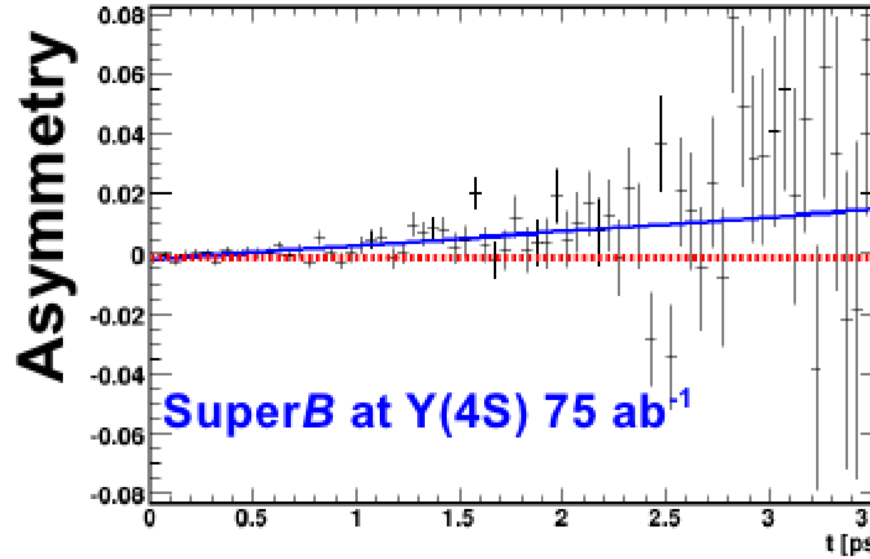
	CP–	Kπ	lX	Ks$\pi\pi$
CP+	X	X	XX	X
CP–		X	XX	X
Kπ		X	XX	X
lX			XX	XX
Ks$\pi\pi$				X

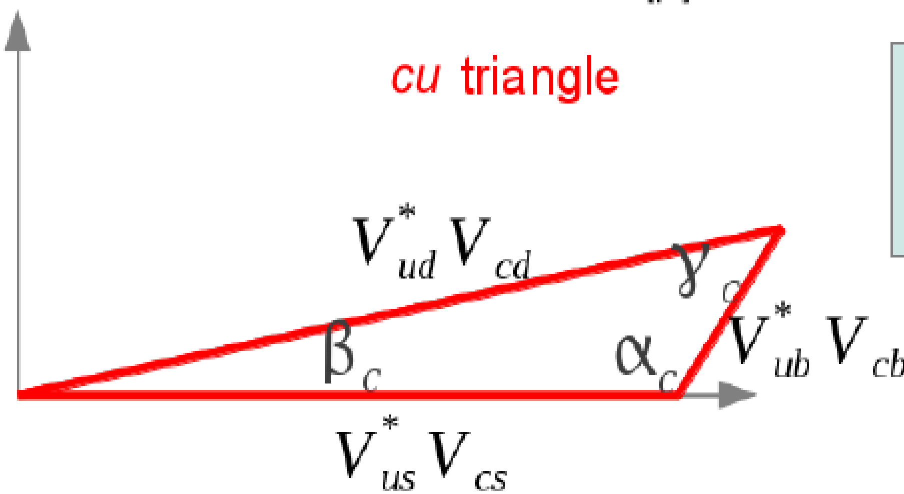
Parameter	Sensitivity @ $\Upsilon(4S)$ with time resolution, no mistag. 75 ab^{-1}
x	0.017%
y	0.008%
Arg(q/p)	0.8 deg
|q/p|	0.5%

Parameter	Best sensitivity @ $\psi(3770)$ with time resolution ($\beta\gamma$=0.56), no mistag. 0.5 ab^{-1}
x	0.11%
y	0.05%
Arg(q/p)	4.8 deg
|q/p|	3.7%

Relative effect of flavor mistag similar at $\Psi(3770)$ and $\Upsilon(4S)$







$$A^{Phys}_{D^0\to\pi^+\pi^-}(\Delta t)=\frac{\overline{\Gamma}^{Phys}(\Delta t)-\Gamma^{Phys}(\Delta t)}{\overline{\Gamma}^{Phys}(\Delta t)+\Gamma^{Phys}(\Delta t)}$$

G. Inguglia

Parameter	$\Psi(3770)$ SL	$\Psi(3770)$ SL+K	$\Upsilon(4S)$ $\pi_s^\pm$	LHCb $\pi_s^\pm$	Belle II $\pi_s^\pm$
$\delta_{\phi_{\pi\pi}} = \delta_{arg(\lambda_{\pi\pi})}$	5.7°	2.4°	2.2°	2.3°	2.8°
$\delta_{\phi_{KK}} = \delta_{arg(\lambda_{KK})}$	3.5°	1.4°	1.3°	1.4°	1.7°
$\delta_{\phi_{CP}} = \delta_{\phi_{KK}-\phi_{\pi\pi}}$	6.6°	2.8°	2.6°	2.7°	3.2°
$\delta_{\beta_{c,eff}}$	3.3°	1.4°	1.3°	1.4°	1.6°

$D^0 \to K^+ K^-$

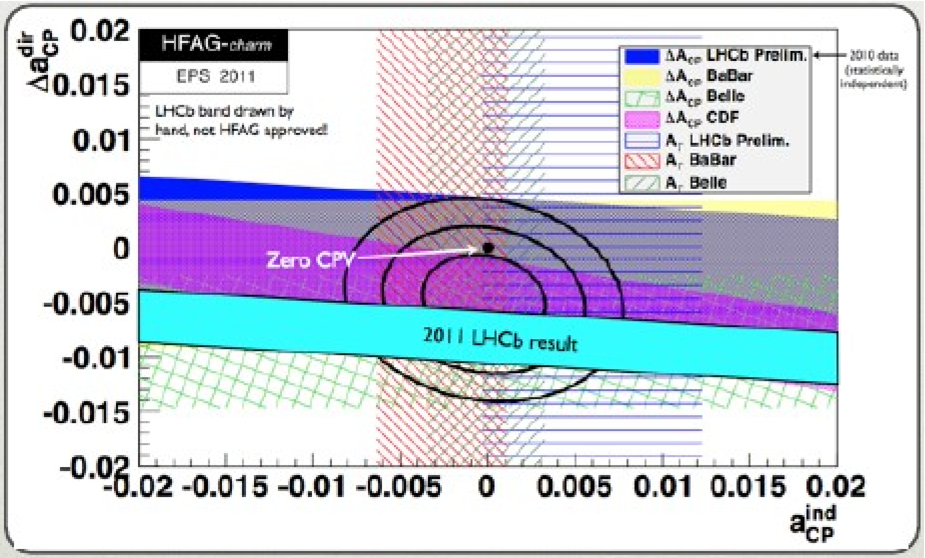
$D^0 \to \pi^+ \pi^-$

J. Zupan, direct CPV in charm

W. Bonivento

$$A_{CP}(D \to KK) - A_{CP}(D \to \pi\pi) = (-0.82 \pm 0.21 \pm 0.11)\%$$

- CPV is parametrically suppressed
  - in mixing it enters as $\mathcal{O}(V_{cb}V_{ub}/V_{cs}V_{us}) \sim 10^{-3}$
  - in SCS as $\mathcal{O}([V_{cb}V_{ub}/V_{cs}V_{us}]\alpha_s/\pi) \sim 10^{-4}$
- is it possible that it is significantly larger?



WA: ΔA_{CP}=(-0.65±0.18)%

$$A_f(D \to f) = A_f^T[1 + r_f e^{i(\delta_f - \gamma)}]$$

$$\mathcal{A}_f^{\rm dir} \equiv \frac{|A_f|^2 - |\bar{A}_{\bar{f}}|^2}{|A_f|^2 + |\bar{A}_{\bar{f}}|^2} = 2r_f \sin\gamma \sin\delta_f$$

$$\Delta A_{CP} \sim 4r_f \qquad \Delta A_{CP}(\text{leading power}) = O(0.05\% - 0.1\%)$$

$$A^T(\pi^+\pi^-) = V_{cd}^* V_{ud}(T_{\pi\pi} + E_{\pi\pi}) + V_{cb} V_{ub}^* P$$

$$A^T(K^+K^-) = V_{cs}^* V_{us}(T_{KK} + E_{KK}) + V_{cb} V_{ub}^* P$$

Assumption:

P/E ~ Nc, T ~ E

$$\Delta A_{CP} \sim 0.3\% \;\; (P_{f,1})$$

$$\Gamma(\bar{B} \to X_s \gamma)_{E_\gamma > E_0} = \Gamma(b \to X_s^p \gamma)_{E_\gamma > E_0} + \left(\begin{array}{c} \text{non-perturbative effects} \\ (2 \pm 5)\% \\ \text{Benzke et al., arXiv:1003.5012} \end{array} \right)$$

Results of the SM calculations:

$$\mathcal{B}(\bar{B} \to X_s \gamma)_{E_\gamma > 1.6\ \text{GeV}} = \begin{cases} (3.15 \pm 0.23) \times 10^{-4}, & \text{MM } et\ al., \text{ hep-ph/0609232, using the 1S scheme.} \\ (3.26 \pm 0.24) \times 10^{-4}, & \text{following the kinetic scheme analysis of P. Gambino and P. Giordano in arXiv:0805.0271.} \end{cases}$$

Experiment agrees with the SM at the $\sim 1.2\sigma$ level. Uncertainties: TH $\sim 7\%$, EXP $\sim 7\%$

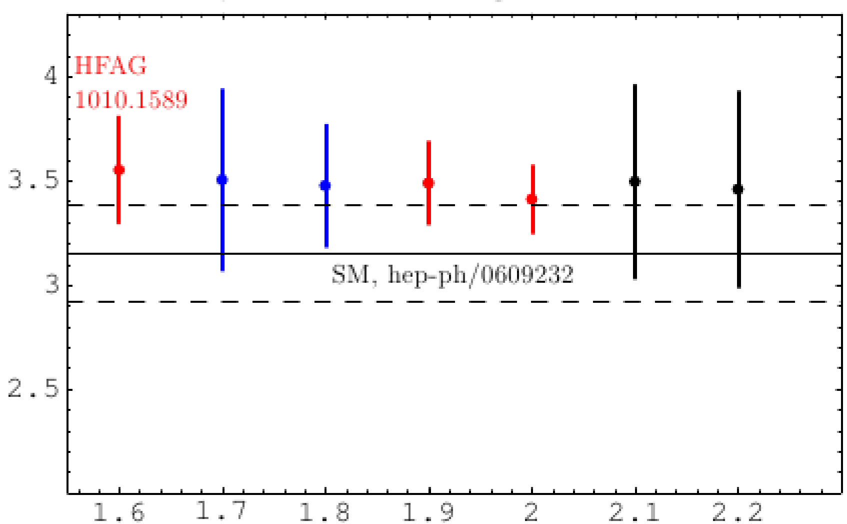
SuperB: ~3.5% ~3%

Scheme	$E_\gamma < 1.7$	$E_\gamma < 1.8$	$E_\gamma < 1.9$	$E_\gamma < 2.0$	$E_\gamma < 2.242$
Kinetic	0.986 ± 0.001	0.968 ± 0.002	0.939 ± 0.005	0.903 ± 0.009	0.656 ± 0.031
Neubert SF	0.982 ± 0.002	0.962 ± 0.004	0.930 ± 0.008	0.888 ± 0.014	0.665 ± 0.035
Kagan-Neubert	0.988 ± 0.002	0.970 ± 0.005	0.940 ± 0.009	0.892 ± 0.014	0.643 ± 0.033
Average	0.985 ± 0.004	0.967 ± 0.006	0.936 ± 0.010	0.894 ± 0.016	0.655 ± 0.037

M.Misiak

J.Walsh

Averages for each E_0 extrapolated to $E_0 = 1.6$ GeV using the HFAG factors



For theorists:

- E_{min} photon cut: motivations for reducing E_{min} at expense of experimental precision
- $A_{CP}(B \to X_s \gamma)$: how to use semi-inclusive result? Valid to compare to inclusive calculation?
- Is there general agreement on the finding of ~5% theoretical uncertainty on $A_{CP}(B \to X_s \gamma)$
- NP model predictions for $A_{CP}(B \to X_{(s+d)} \gamma)$?

For experimenters:

- Can hadron-tagged sample be used to separate $B \to X_s \gamma$ from $B \to X_d \gamma$?
- With what error can we measure $B(B \to X_s \gamma)$ using hadronic tags? Semi-leptonic tags?

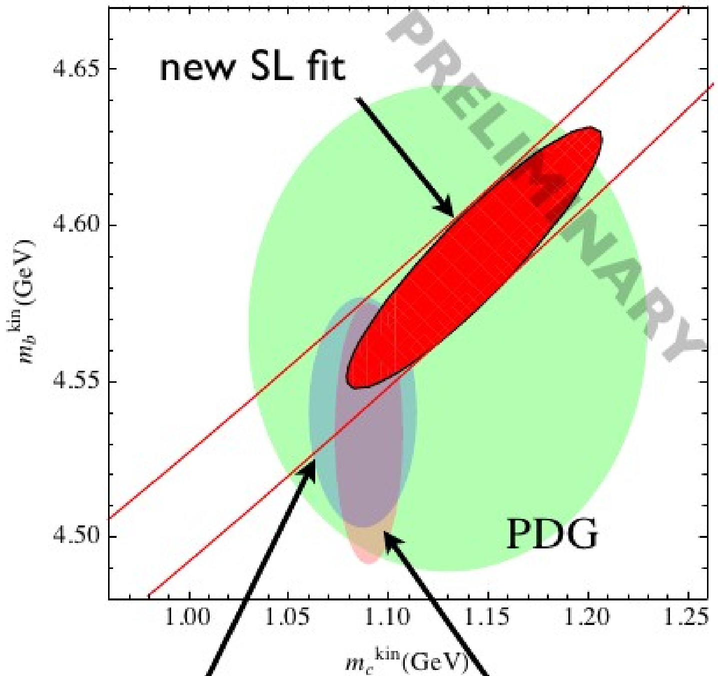
$$\mathrm{BR}_\gamma(E_0) \equiv \mathrm{BR}[B \to X_s\gamma]_{E_\gamma > E_0} = \frac{\mathrm{BR}_{c\ell\nu}}{C}\left(\frac{\Gamma[B \to X_s\gamma]_{E_\gamma > E_0}}{|V_{cb}/V_{ub}|^2\,\Gamma[B \to X_u e\bar\nu]}\right)$$

$$C = \left|\frac{V_{ub}}{V_{cb}}\right|^2 \frac{\Gamma[B \to X_c e\bar\nu]}{\Gamma[B \to X_u e\bar\nu]}$$

C=0.580(16) — Bauer et al, Manohar

C=0.546(17)$_{exp}$(16)$_{th}$ — Giordano, PG

Recent sum rules determinations converted to kin scheme



C=0.571(7)

P .Gambino

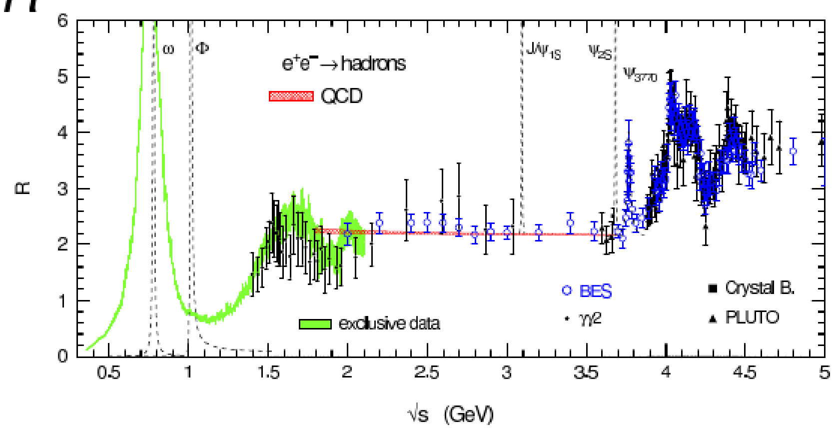
- *Dominant parametric uncertainties in BR_γ due to b,c masses, V_{cb} and local OPE power corrections. Strong correlations, semileptonic moments provide crucial information.*
- *Global fits including precise constraints on m_c and possibly m_b are the way to go. Preliminary results for C, F have >50% smaller experimental uncertainty.*
- *Inclusion of higher order effects in the fits under way, improvements in parametric uncertainty look possible.*

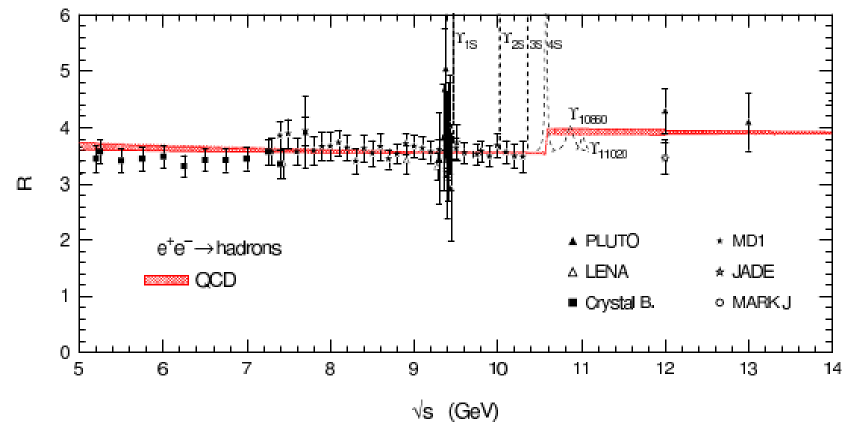
Paolo promised δBR ~2% for SuperB
Please take note!

Concerning quark masses:

M. Steinhauser

R^{exp}





- m_c and m_b from moments $(n = 1, 2, 3, (4))$
- direct determination of $\overline{\text{MS}}$ quark mass
- $m_b(10\text{ GeV}) = 3610 \pm 10_{\text{exp}} \pm 12_{\alpha_s} \pm 3_{\text{th}}$ MeV
  $\alpha_s(M_Z) = 0.1189 \pm 0.0020$

  exp: 50% from $\Gamma_{ee}\ \Upsilon(1S), \ldots, \Upsilon(4S)$
  50% from $\sqrt{s} > M_\Upsilon(4S)$
- 1 week of SuperB running above $\Upsilon(4S)$ could be sufficient to clarify the situation in the “bottom threshold region” and even improve the accuracy
- $R(s)$ at the 1% level below $\Upsilon(4S)$ (e.g. $\sqrt{s} = 10.52$ GeV)
  ⇨ competitive α_s value between τ and Z

Back to B → Xs γ: other observables

isospin asymmetry

$$\Delta_{0-} = [\Gamma(\bar{B}^0 \to X_s\gamma) - \Gamma(B^- \to X_s\gamma)]/[\Gamma(\bar{B}^0 \to X_s\gamma) + \Gamma(B^- \to X_s\gamma)]$$

can be used to constrain some uncomputable $\alpha_s \frac{\Lambda}{m_b}$ corrections

M.Misiak

SM estimate [Benzke, Lee, Neubert, Paz, arXiv:1012.3167]: $A_{X_s\gamma} = \frac{\Gamma(\bar{B}\to X_s\gamma) - \Gamma(B\to X_{\bar{s}}\gamma)}{\Gamma(\bar{B}\to X_s\gamma) + \Gamma(B\to X_{\bar{s}}\gamma)}$

$$A^{\rm SM}_{X_s\gamma} \simeq \mathrm{Im}\left(\frac{V^*_{us}V_{ub}}{V^*_{ts}V_{tb}}\right)\pi \left|\frac{C_1^{\rm their}}{C_7}\right| \left[\frac{\tilde{\Lambda}^u_{17}-\tilde{\Lambda}^c_{17}}{m_b} + \frac{40\alpha_s}{9\pi}\frac{m_c^2}{m_b^2}\left(1 - \frac{2}{5}\ln\frac{m_b}{m_c} + \frac{4}{5}\ln^2\frac{m_b}{m_c} - \frac{\pi^2}{15}\right)\right]$$

$$\simeq \left(1.15\,\frac{\tilde{\Lambda}^u_{17}-\tilde{\Lambda}^c_{17}}{300\ \mathrm{MeV}} + 0.71\right)\% \in [-0.6\%, +2.8\%] \quad \text{using} \begin{cases} -330\ \mathrm{MeV} < \tilde{\Lambda}^u_{17} < +525\ \mathrm{MeV} \\ -9\ \mathrm{MeV} < \tilde{\Lambda}^u_{17} < +11\ \mathrm{MeV} \end{cases}$$

Despite the uncertainties, $A_{X_s\gamma}$ provides constraints on models with non-minimal flavour violation. Such models are also constrained by:

$$A_{X_{(s+d)}\gamma} = \frac{\Gamma(\bar{B}\to X_{(s+d)}\gamma) - \Gamma(B\to X_{(\bar{s}+\bar{d})}\gamma)}{\Gamma(\bar{B}\to X_{(s+d)}\gamma) + \Gamma(B\to X_{(\bar{s}+\bar{d})}\gamma)} \qquad (A^{\rm SM}_{X_{(s+d)}\gamma} \simeq 0)$$

J.Walsh

$A_{CP}(B \to X_{(s+d)}\gamma)$

- Extrapolation from BaBar gives error of ~ $(\pm 1_{stat} \pm 1_{syst})\%$

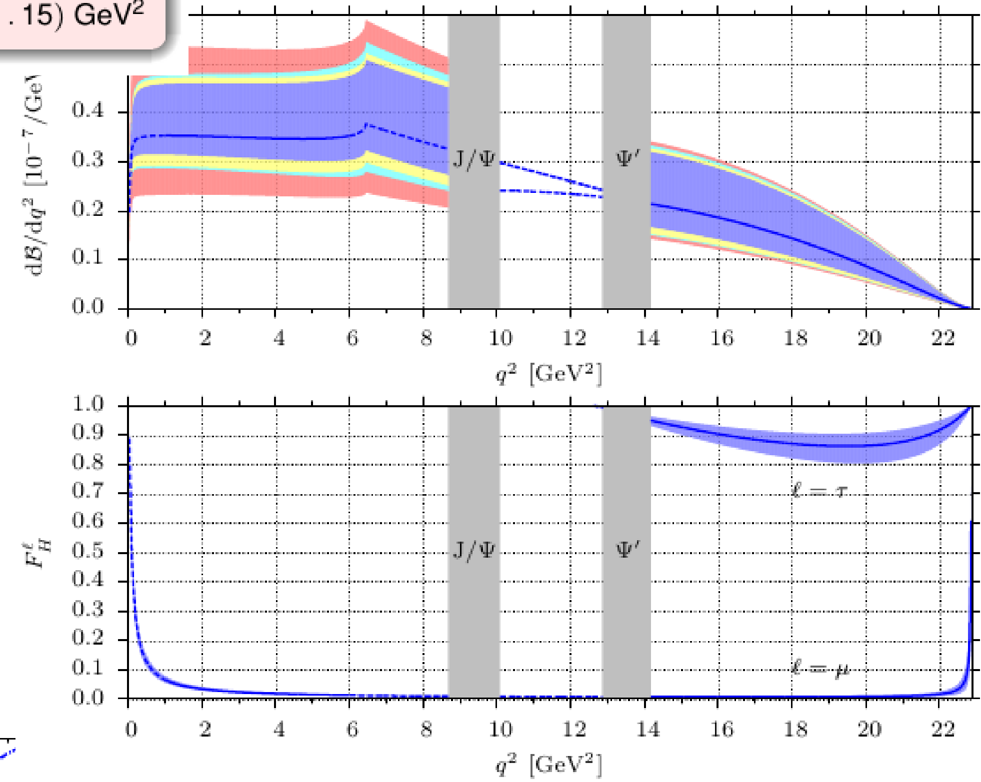
q^2 - REGIONS IN $b \to s + \bar{\ell}\ell$	$K^{(*)}$-ENERGY IN B-REST FRAME: $E_{K^{(*)}} = (M_B^2 + M_{K^{(*)}}^2 - q^2)/(2\,M_B)$	
q^2-region	low-q^2: $q^2 \ll M_B^2$	high-q^2: $q^2 \sim M_B^2$
$K^{(*)}$-recoil	large recoil: $E_{K^{(*)}} \sim M_B/2$	low recoil: $E_{K^{(*)}} \sim M_{K^{(*)}} + \Lambda_{QCD}$
theory method	QCDF, SCET: $q^2 \in [1, 6]$ GeV^2	OPE + HQET: $q^2 \geqslant (14 \ldots 15)$ GeV^2

C. Bobeth

Summary of
$b \to s\,\ell^+\ell^-$ Workshop
at DESY June 15-17, 2011

form factor
sub-leading Λ_{QCD}
CKM
short-distance

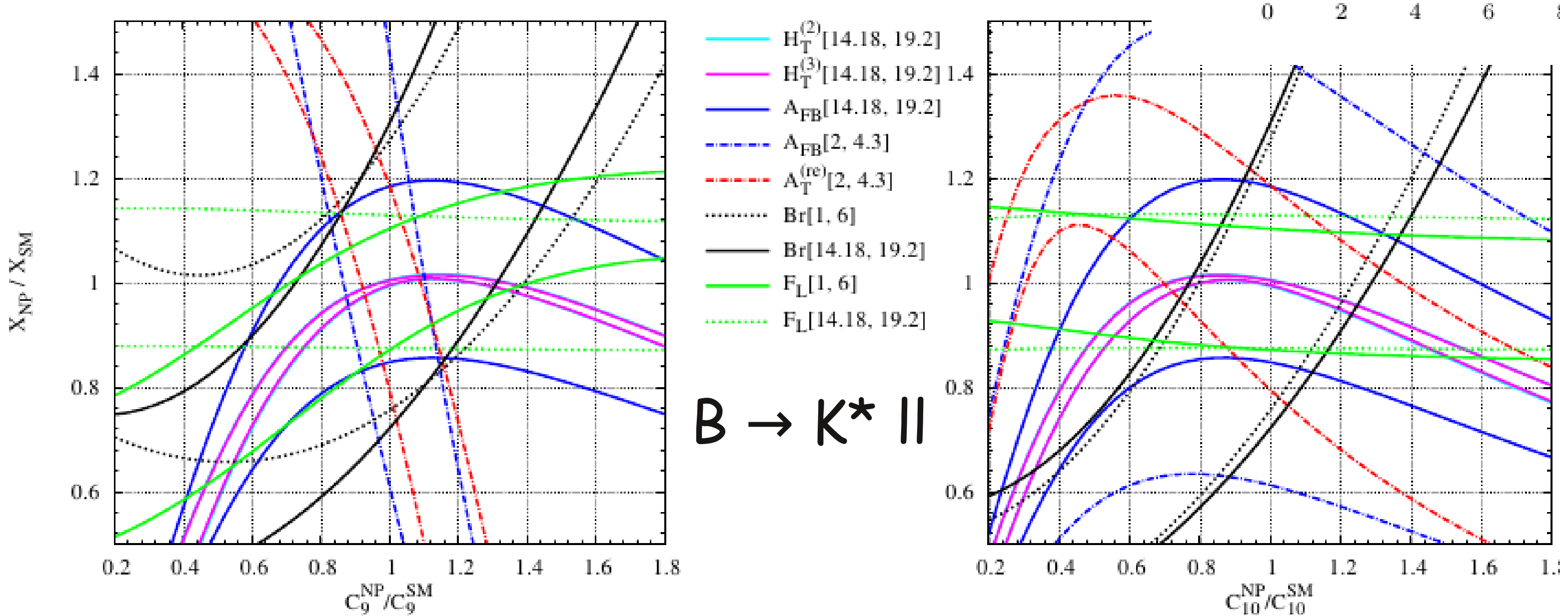
B → K ll

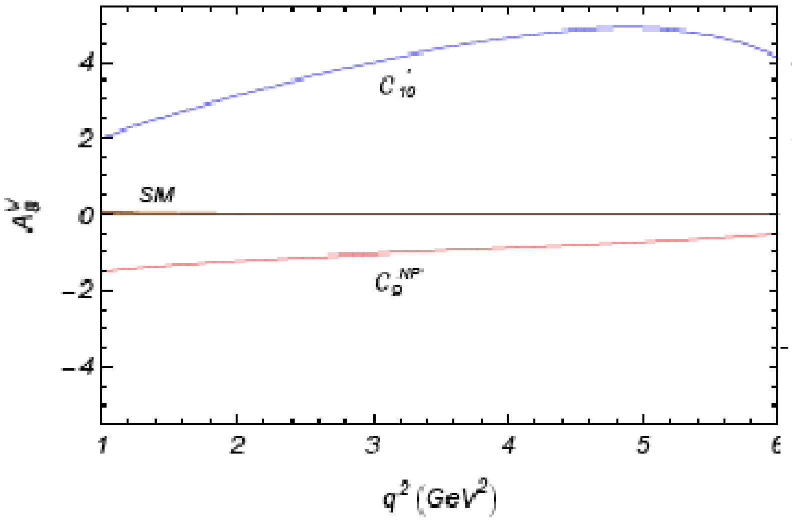


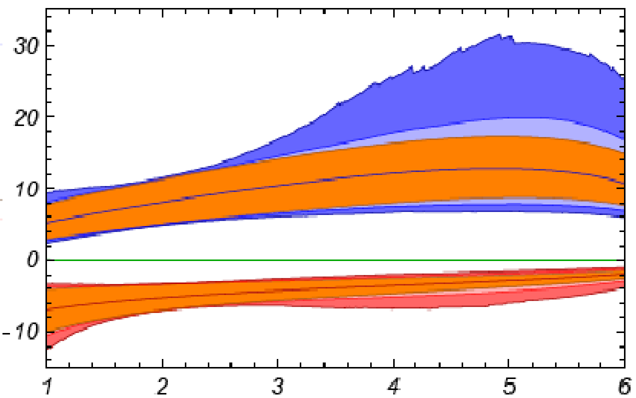
Optimised Observables at high-q^2

$$H_T^{(1)} = \frac{\sqrt{2} I_4}{\sqrt{-I_2^c\,(2 I_2^s - I_3)}} = sgn(f_0) \cdot 1$$

$$H_T^{(2)} = \frac{I_5}{\sqrt{-2 I_2^c\,(2 I_2^s + I_3)}} = 2\,\frac{\rho_2}{\rho_1}, \qquad H_T^{(3)} = \frac{I_6}{2\sqrt{(2 I_2^s)^2 - I_3^2}} = 2\,\frac{\rho_2}{\rho_1}$$

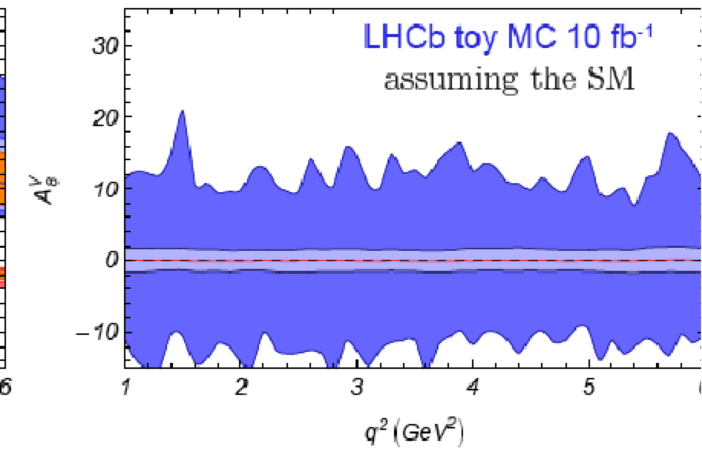






$|\mathcal{C}_9^{\rm NP}| = 2, \quad \phi_9^{\rm NP} = \frac{\pi}{2}$, red bands

$|\mathcal{C}'_{10}| = 3, \ \phi'_{10} = \frac{\pi}{2}$, blue bands

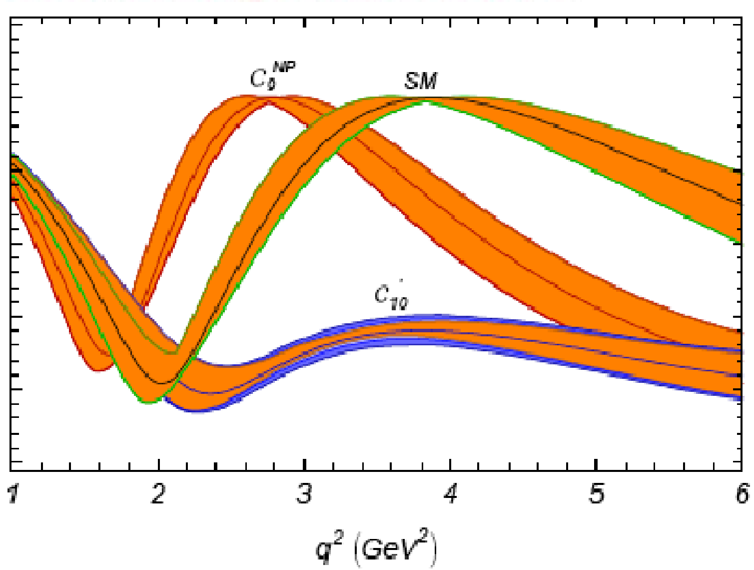


$$A_8^V = \frac{J_8 - \bar{J}_8}{J_8 + \bar{J}_8}$$

T. Hurth, CPV in B → K* ll

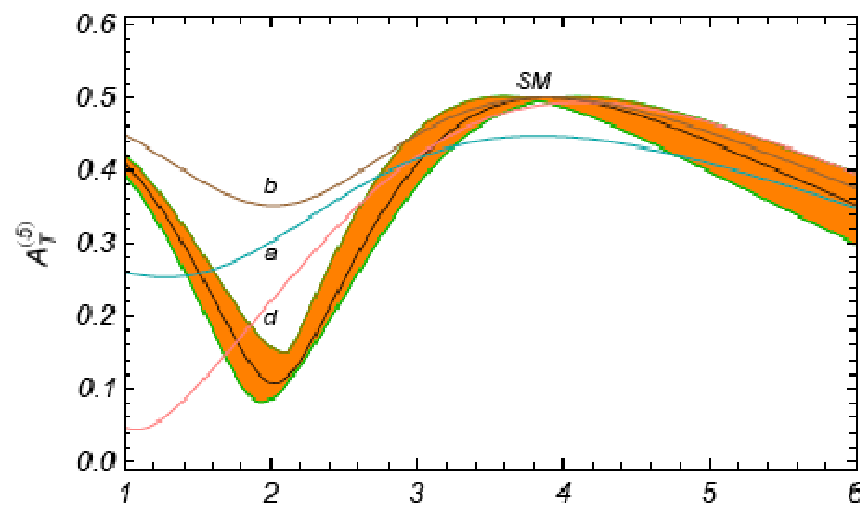
$A_7 \ A_8 \ A_9$ **favored**

First nontrivial sensitivity to CP phases most probably in CP conserving observables



NP in $\mathcal{C}'_{10} = 3e^{i\frac{\pi}{8}}$ and $\mathcal{C}_9^{\rm NP} = 2e^{i\frac{\pi}{8}}$

$A_T^{(5)}$



$(a) \quad (\mathcal{C}_7^{\rm NP}, \mathcal{C}'_7) = (0.26e^{-i\frac{7\pi}{16}}, 0.2e^{i\pi})$

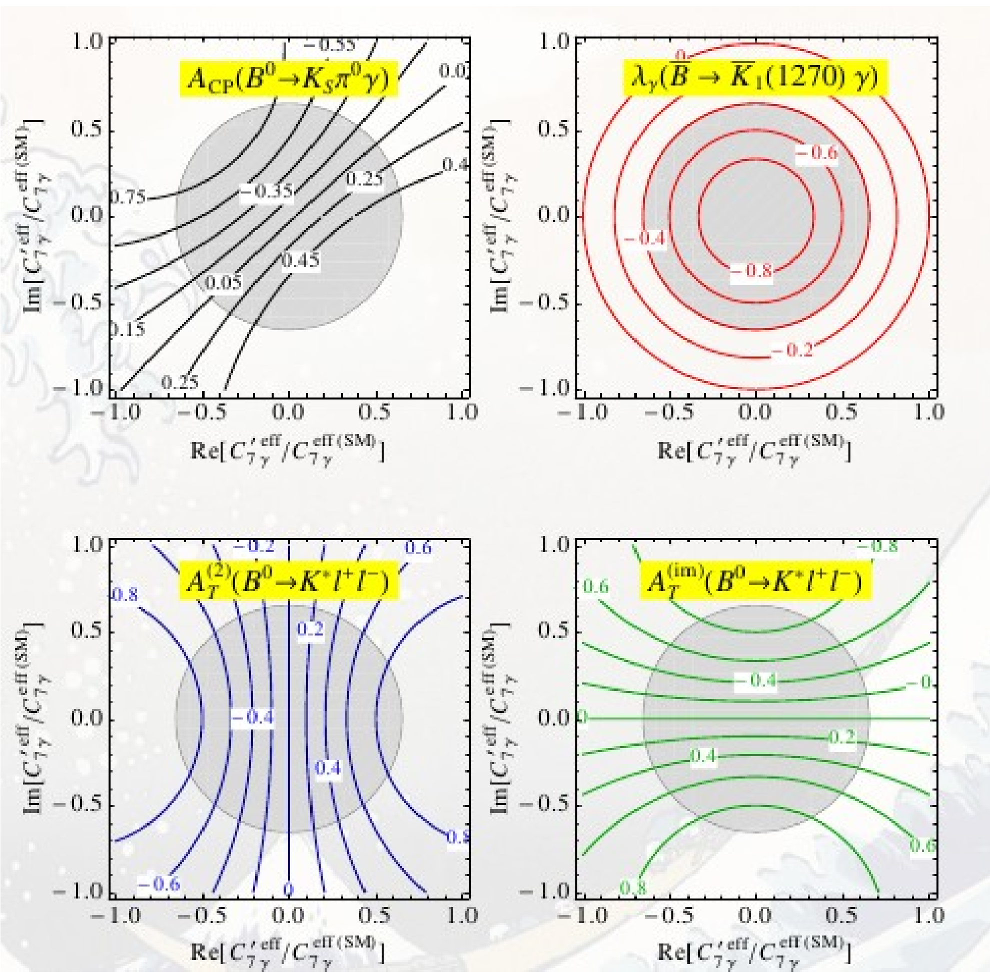
$(b) \quad (0.07e^{i\frac{3\pi}{5}}, 0.3e^{i\frac{3\pi}{5}})$

$(d) \quad (0.18e^{-i\frac{\pi}{2}}, 0)$

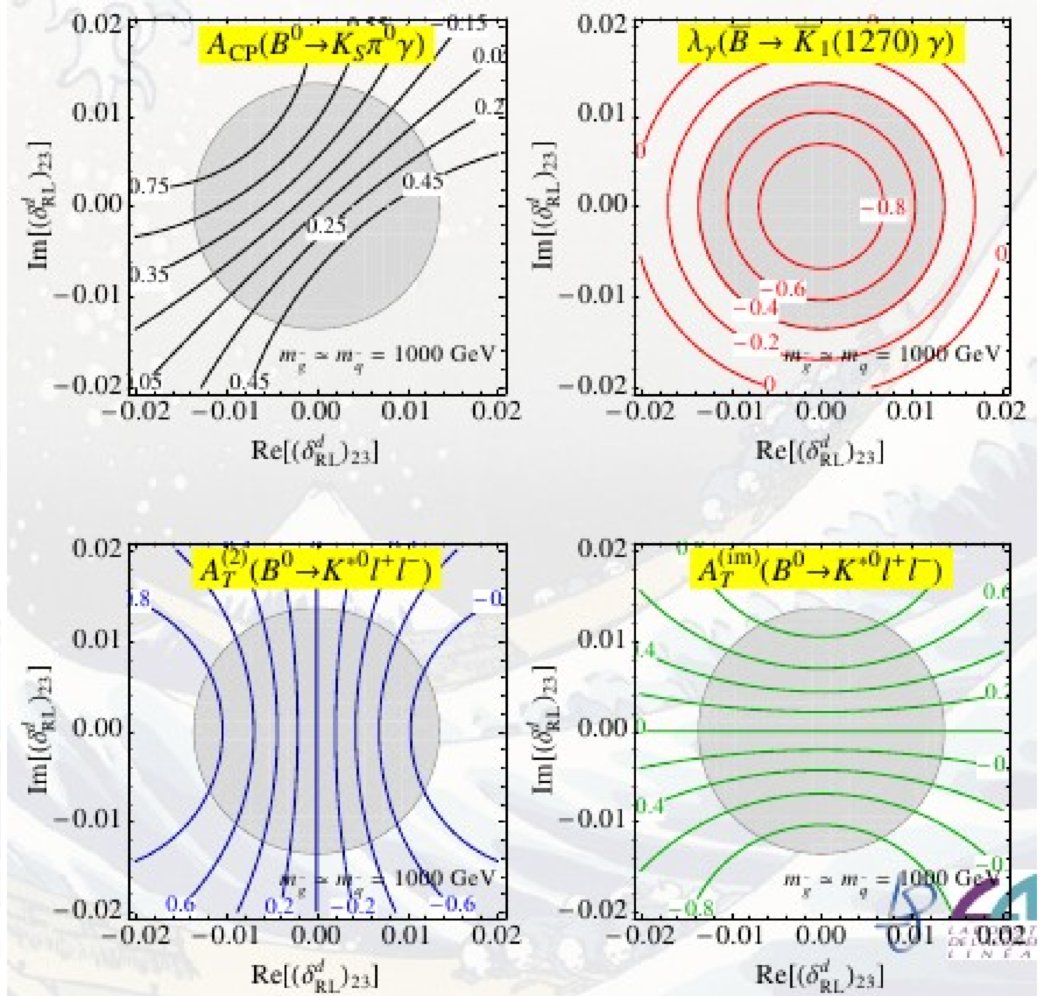
Photon polarization determination: 3 methods

A. Tayduganov

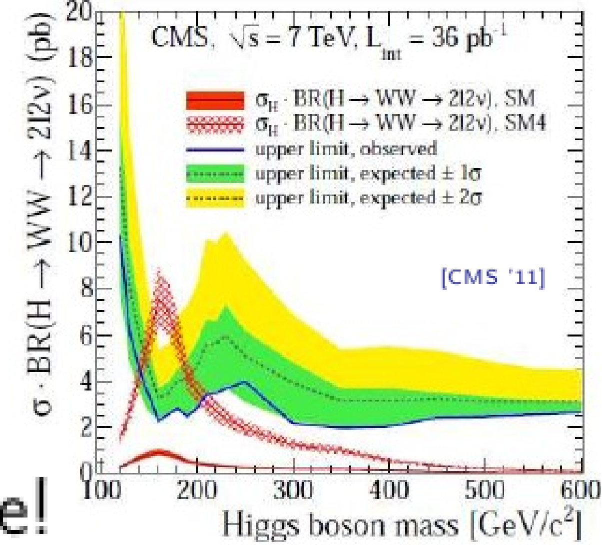
1. Time-dependent CP-asymmetry in SuperB golden channel $B^0 \to K^{*0}(\to K_S\pi^0)\gamma$ [Atwood et al., Phys.Rev.Lett.79('97)]
2. Transverse asymmetries in $B^0 \to K^{*0}(\to K^-\pi^+)\ell^+\ell^-$ [Kruger&Matias, Phys.Rev.D71('05);Becirevic&Schneider, Nucl.Phys.B854('11)]
3. K_1 three-body decay method in $B \to K_1(\to K\pi\pi)\gamma$ [Gronau et al., Phys.Rev.Lett.88, Phys.Rev.D66 ('02)]



$m_{\tilde{g}} \simeq m_{\tilde{q}} = 1000$ GeV



$$V_{CKM4} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} & V_{ub'} \\ V_{cd} & V_{cs} & V_{cb} & V_{cb'} \\ V_{td} & V_{ts} & V_{tb} & V_{tb'} \\ V_{t'd} & V_{t's} & V_{t'b} & V_{t'b'} \end{pmatrix}$$



O. Eberhardt, CKM fit in SM4

The SM4 is still alive!

→ Maybe ruled out by tomorrow, 2 p.m.?

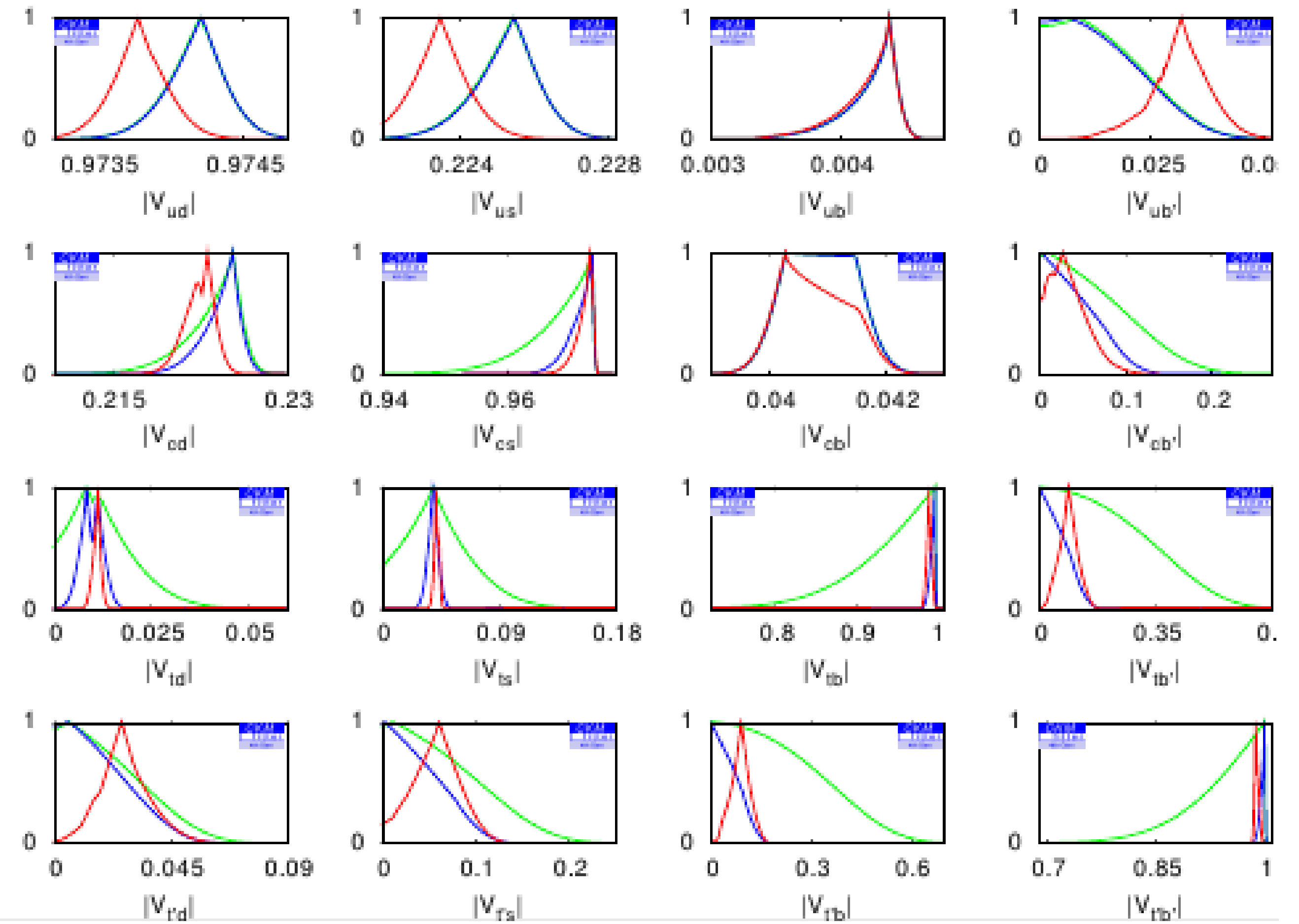
"Direct" constraints

$m_{t'} \in [450, 900]$ GeV

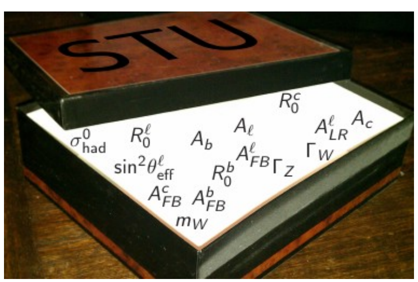
$m_{b'} \in [428, 900]$ GeV

$m_{\ell_4} \in [100, 900]$ GeV

$m_{\nu_4} \in [46, 900]$ GeV



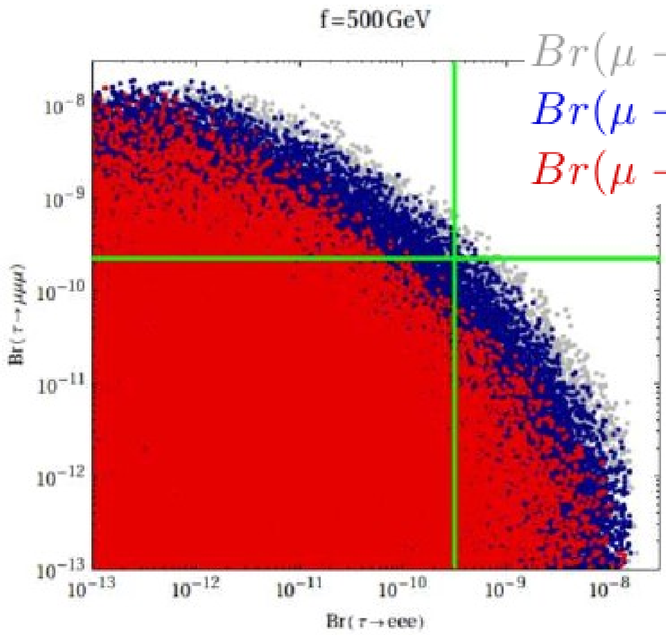
Electroweak constraints



Flavour constraints

- $B_s \to \mu^+\mu^-$
- A_{sl}, ΔM_{B_d}, ΔM_{B_s}
- ϵ_K
- $R(b \to s\gamma)$

M. Blanke



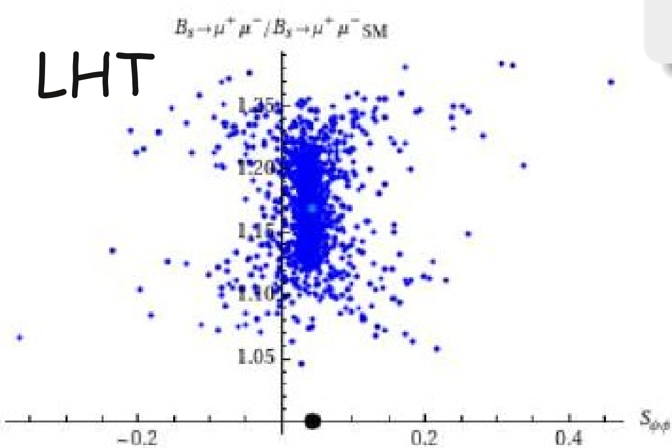
$Br(\mu \to e\gamma) < 1.2 \cdot 10^{-11}$
$Br(\mu \to e\gamma) < 2.4 \cdot 10^{-12}$
$Br(\mu \to e\gamma) < 10^{-13}$

MEG results

	LHT	RSc
CP asymmetries $S_{\psi\phi}$, A^s_{SL}	++	++(+)
rare B decays: $B_{s,d} \to \mu^+\mu^-$, $B \to X_s \nu\bar{\nu}$, ...	+	−
$b \to s\gamma$ and $b \to s\ell^+\ell^-$	−	++
rare K decays: $K \to \pi\nu\bar{\nu}$, $K \to \pi\ell^+\ell^-$, ...	+++	+++
deviations from MFV relations	++	++
LFV $\tau \to \mu$ transitions	+++	+++
LFV $\tau \to e$ transitions	+++	++

LHCb results

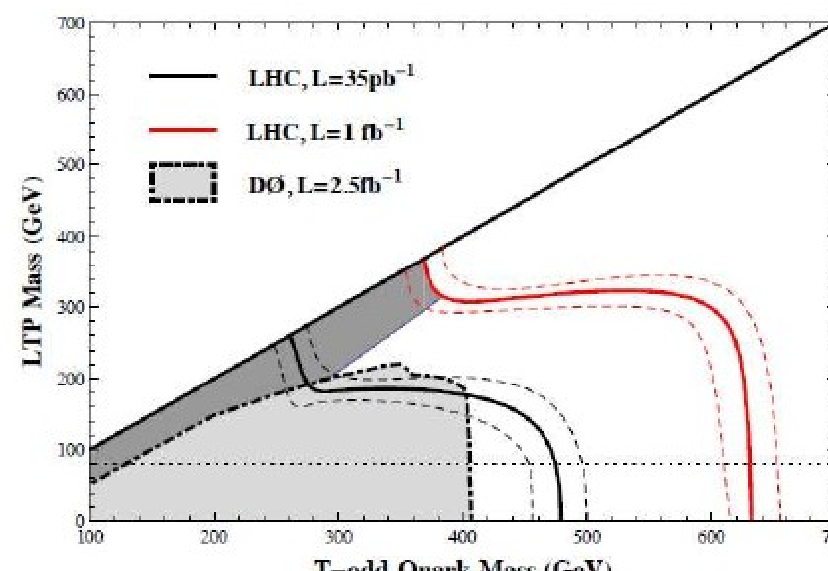
LHT



from jets+MET searches (LHC)

$m^i_H \gtrsim 600$ GeV

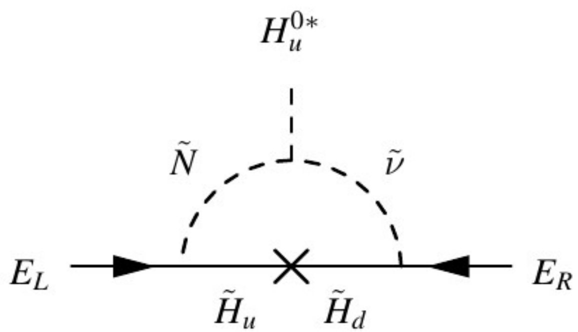
LHT & RSc unscathed



in principle any Bs mixing phase possible
however RSc naturally predics moderate effects
very small effects in Br(Bs,d → μ+ μ−)

Higgs-mediated cLFV

- $M_{\tilde{N}} \sim 1$TeV $\Rightarrow$ New contribution, dominant in the SUSY Inverse Seesaw model



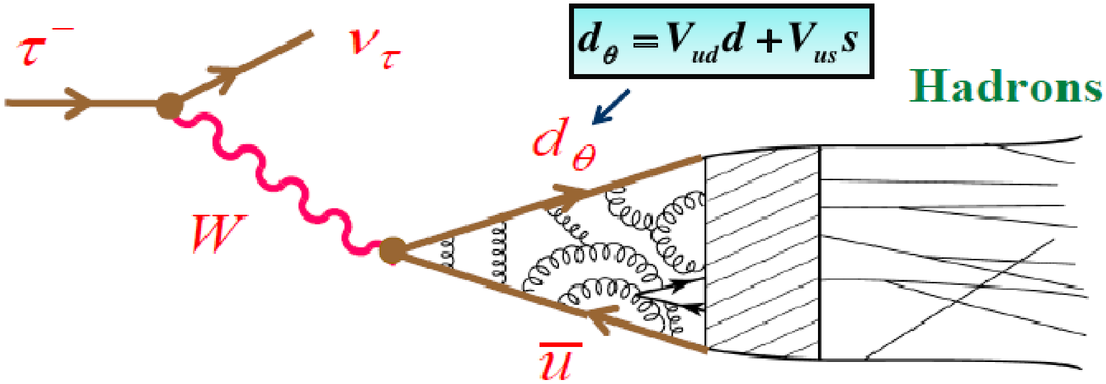
C. Weiland

Point	$\tan\beta$	$m_{1/2}$	m_0	$m^2_{H_U}$	$m^2_{H_D}$	A_0	μ	m_A
CMSSM-A	10	550	225	$(225)^2$	$(225)^2$	0	690	782
CMSSM-B	40	500	330	$(330)^2$	$(330)^2$	-500	698	604
NUHM-C	15	550	225	$(652)^2$	$-(570)^2$	0	478	150

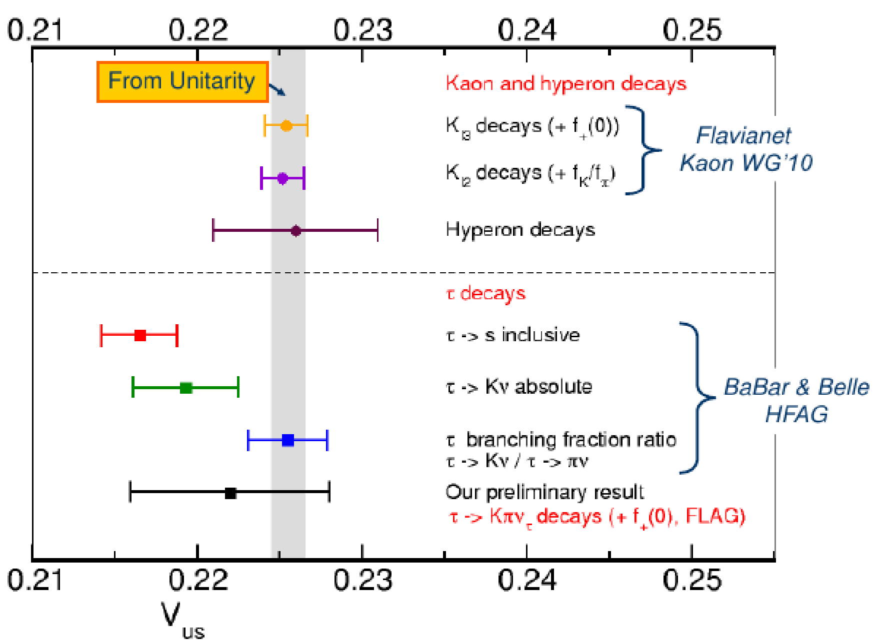
LFV Process	Present Bound	Future Sensitivity	CMSSM-A	CMSSM-B	NUHM-C
$\tau \to \mu\mu\mu$	2.1×10^{-8}	8.2×10^{-10}	1.5×10^{-14}	1.5×10^{-10}	1.0×10^{-10}
$\tau^- \to e^-\mu^+\mu^-$	2.7×10^{-8}	$\sim 10^{-10}$	1.5×10^{-14}	1.5×10^{-10}	1.0×10^{-10}
$\tau \to eee$	2.7×10^{-8}	2.3×10^{-10}	3.5×10^{-19}	3.6×10^{-15}	2.4×10^{-15}
$\mu \to eee$	1.0×10^{-12}		6.8×10^{-21}	6.5×10^{-17}	4.7×10^{-17}
$\tau \to \mu\eta$	2.3×10^{-8}	$\sim 10^{-10}$	8.6×10^{-14}	1.3×10^{-9}	5.8×10^{-10}
$\tau \to \mu\eta'$	3.8×10^{-8}	$\sim 10^{-10}$	4.7×10^{-15}	4.1×10^{-10}	4.1×10^{-11}
$\tau \to \mu\pi^0$	2.2×10^{-8}	$\sim 10^{-10}$	1.9×10^{-16}	3.2×10^{-12}	1.3×10^{-12}
$B_d^0 \to \mu\tau$	2.2×10^{-5}		2.9×10^{-14}	3.3×10^{-9}	3.4×10^{-10}
$B_d^0 \to e\mu$	6.4×10^{-8}	1.6×10^{-8}	1.3×10^{-16}	1.4×10^{-11}	1.5×10^{-12}
$B_s^0 \to \mu\tau$			8.3×10^{-13}	9.7×10^{-8}	9.8×10^{-9}
$B_s^0 \to e\mu$	2.0×10^{-7}	6.5×10^{-8}	3.7×10^{-15}	3.9×10^{-10}	4.3×10^{-11}
$h \to \mu\tau$			1.4×10^{-7}	1.0×10^{-6}	3.0×10^{-5}
$A, H \to \mu\tau$			3.7×10^{-5}	5.1×10^{-4}	6.4×10^{-5}

Precision SM tests with hadronic τ decays

E. Passemar



- Extraction of $\alpha_s(m_\tau)$: competitive
- Extraction of $|V_{us}|$:



CP violating asymmetry ~3σ from the SM!

$$A_Q = \frac{\Gamma\left(\tau^+ \to \pi^+ K_S^0 \bar{\nu}_\tau\right) - \Gamma\left(\tau^- \to \pi^- K_S^0 \nu_\tau\right)}{\Gamma\left(\tau^+ \to \pi^+ K_S^0 \bar{\nu}_\tau\right) + \Gamma\left(\tau^- \to \pi^- K_S^0 \nu_\tau\right)}$$

$$A_{Q\,\exp} = \left(-0.45 \pm 0.24_{stat} \pm 0.11_{syst}\right)\%$$

BaBar'11

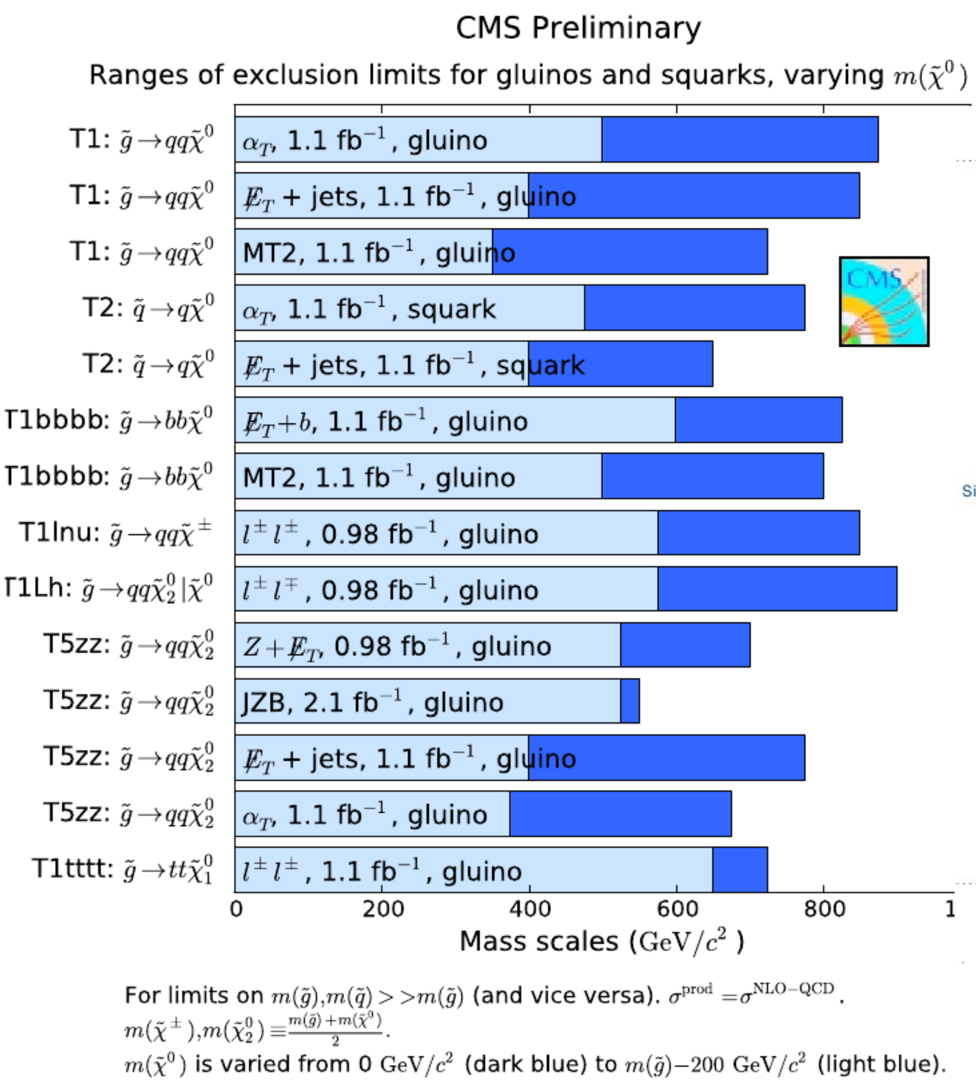
– Experimental measurement requires precise hadronic parametrization of the form factors $f_+(s), f_0(s)$
  - Use integrated $\tau \to K\pi\nu_\tau$ invariant mass $\Gamma_{\tau \to K\pi\nu_\tau}$ (*dispersive method*!)
  - FB asymmetries ⇨ disentangle vector and scalar form factors

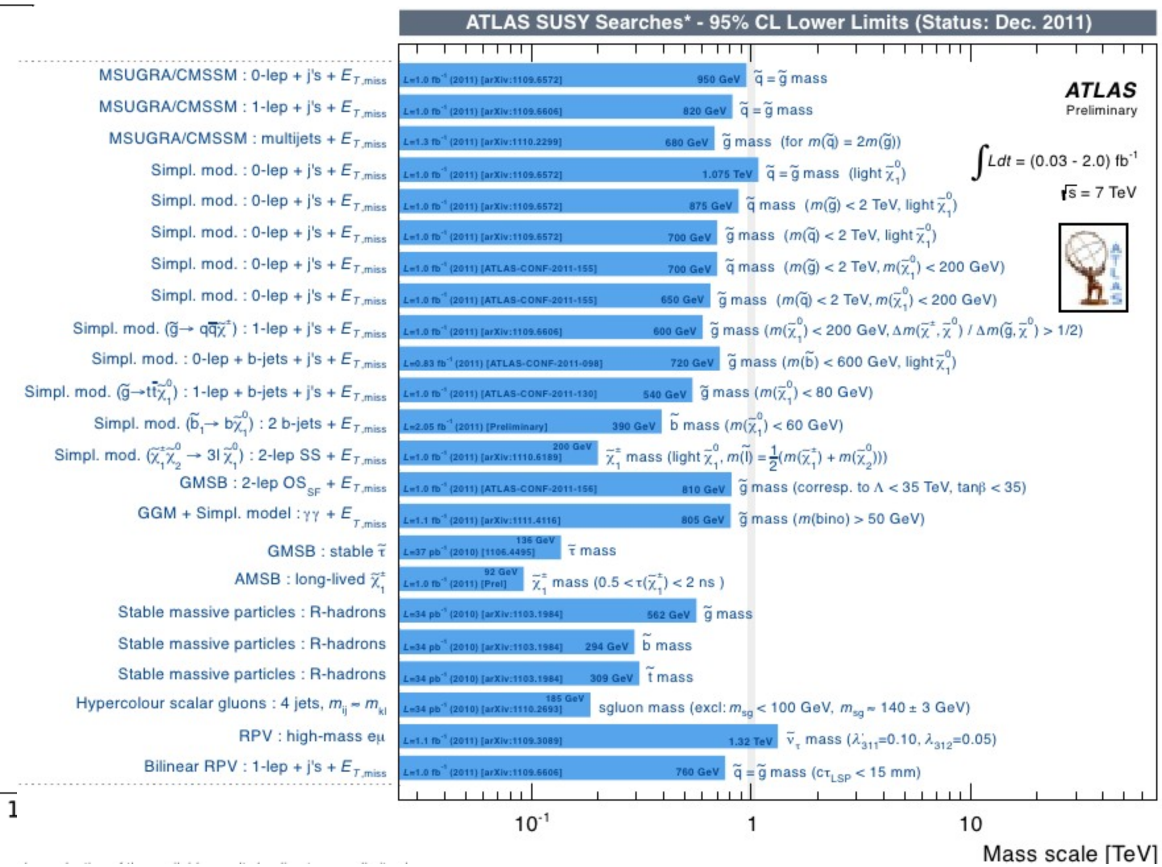
$$A_{FB} = \frac{d\Gamma(\cos\theta) - d\Gamma(-\cos\theta)}{d\Gamma(\cos\theta) + d\Gamma(-\cos\theta)}$$

SUSY

The Simplified Models

M. Pierini





Conclusion

We think that the workshop was successful:

- Short and focused
- Lively
- With the right number of people

- Thanks to everybody (particularly the secretariat for assistance on Sunday!)
- Physics continues at the Collaboration Meeting...

Backup

Belle measurements of B_s^0 decays with 23.6 fb^{-1} (<2011)

B_s^0 decay mode	Branching fraction, $\times 10^{-3}$	Rel. B^0 mode	Br. fraction, $\times 10^{-3}$
$B_s^0 \to D_s^- \pi^+$	$3.67\ ^{+0.35}_{-0.33}\ ^{+0.43}_{-0.42} \pm 0.49\ (f_s)$	$B^0 \to D^- \pi^+$	2.68 ± 0.13
> $B_s^0 \to D_s^{*-} \pi^+$	$2.4\ ^{+0.5}_{-0.4} \pm 0.3 \pm 0.4\ (f_s)$	$B^0 \to D^{*-} \pi^+$	2.76 ± 0.13
> $B_s^0 \to D_s^- \rho^+$	$8.5\ ^{+1.3}_{-1.2} \pm 1.1 \pm 1.3\ (f_s)$	$B^0 \to D^- \rho^+$	7.6 ± 1.3
> $B_s^0 \to D_s^{*-} \rho^+$	$11.9\ ^{+2.2}_{-2.0} \pm 1.7 \pm 1.8\ (f_s)$	$B^0 \to D^{*-} \rho^+$	6.8 ± 0.9
$B_s^0 \to D_s^{-/+} K^{+/-}$	$0.24\ ^{+0.12}_{-0.10} \pm 0.03 \pm 0.03\ (f_s)$	$B^0 \to D^{-/+} K^{+/-}$	0.20 ± 0.06
> $B_s^0 \to \phi \gamma$	$(5.7\ ^{+1.8}_{-1.5}\ ^{+1.2}_{-1.1}) \times 10^{-2}$	$B^0 \to K^*(892)^0 \gamma$	$(4.01 \pm 0.20) \times 10^{-2}$
$B_s^0 \to K^+ K^-$	$(3.8\ ^{+1.0}_{-0.9} \pm 0.5 \pm 0.5\ (f_s)) \times 10^{-2}$	$B^0 \to K^+ \pi^-$	$(1.94 \pm 0.06) \times 10^{-2}$
$B_s^0 \to D_s^+ D_s^-$	$(1.03\ ^{+0.39}_{-0.32}\ ^{+0.26}_{-0.25}) \times 10$	$B^0 \to D_s^+ D^-$	$(0.72 \pm 0.08) \times 10$
> $B_s^0 \to D_s^{*+} D_s^-$	$(2.75\ ^{+0.83}_{-0.71} \pm 0.69) \times 10$	$B^0 \to D_s^{*+} D^-$	$(0.80 \pm 0.11) \times 10$
> $B_s^0 \to D_s^{*+} D_s^{*-}$	$(3.08\ ^{+1.22}_{-1.04}\ ^{+0.85}_{-0.86}) \times 10$	$B^0 \to D_s^{*+} D^{*-}$	$(1.77 \pm 0.14) \times 10$
> $B_s^0 \to J/\psi\, \eta$	$(3.32 \pm 0.87\ ^{+0.32}_{-0.28} \pm 0.42(f_s)) / 10$	$B^0 \to J/\psi\, K^0$	$(8.71 \pm 0.32) / 10$ [/3]
> $B_s^0 \to J/\psi\, \eta'$	$(3.1 \pm 1.2\ ^{+0.5}_{-0.6} \pm 0.38(f_s)) / 10$	$B^0 \to J/\psi\, K^0$	$(8.71 \pm 0.32) / 10$ [/3]
> $B_s^0 \to X^- \ell^+ \nu$	$(10.2 \pm 0.8 \pm 0.9) \times 10$	$B^0 \to X^- \ell^+ \nu$	$(10.33 \pm 0.28) \times 10$

$Bf\,(B_s^0 \to \gamma\gamma) < 8.7 \times 10^{-6}$ (90% *CL*)

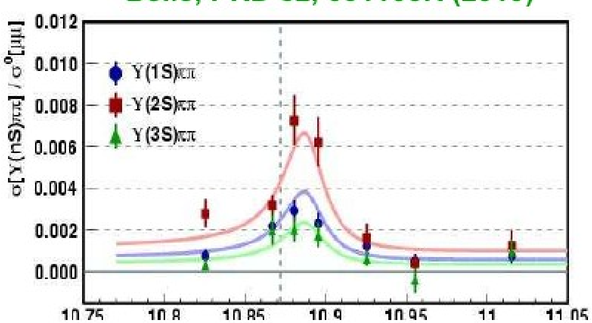
> - first measurement, > - unpublished *FM*

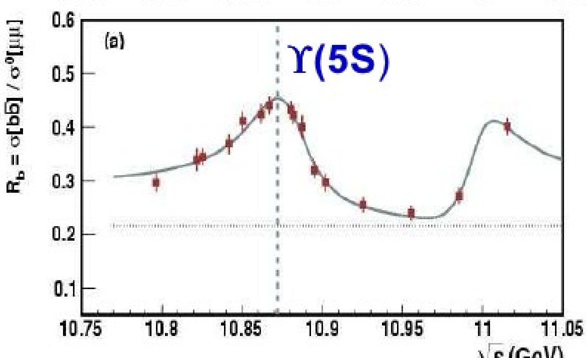
$$\frac{\Delta\Gamma_s^{CP}}{\Gamma_s} \approx \frac{Bf\,(B_s \to D_s^{(*)+} D_s^{(*)-})}{1 - Bf\,(B_s \to D_s^{(*)+} D_s^{(*)-})/2}$$

Mode	Y(events)	*Bf* (%)
$D_s^+ D_s^-$	$33.1\ ^{+6.0}_{-5.4}$	$0.58\ ^{+0.11}_{-0.09} \pm 0.13$
$D_s^{*+} D_s^*$	$44.5\ ^{+5.8}_{-5.5}$	$1.8 \pm 0.2 \pm 0.4$
$D_s^{*+} D_s^{*-}$	$24.4\ ^{+4.1}_{-3.8}$	$2.0 \pm 0.3 \pm 0.5$
Sum	$102.0\ ^{+9.3}_{-8.6}$	$4.3 \pm 0.4 \pm 1.0$

$\Delta\Gamma_s^{CP} / \Gamma_s$ $(9.0 \pm 0.9 \pm 2.2)\,\%$

Belle, PRD 82, 091106R (2010)





Position shifted ~2.5 σ (stat)

	Γ(MeV)
$\Upsilon(5S) \to \Upsilon(1S)\pi^+\pi^-$	$0.59 \pm 0.04 \pm 0.09$
$\Upsilon(5S) \to \Upsilon(2S)\pi^+\pi^-$	$0.85 \pm 0.07 \pm 0.16$
$\Upsilon(5S) \to \Upsilon(3S)\pi^+\pi^-$	$0.52^{+0.20}_{-0.17} \pm 0.10$

Belle preliminary, arXiv:1110.2251, 121.4 fb^{-1}

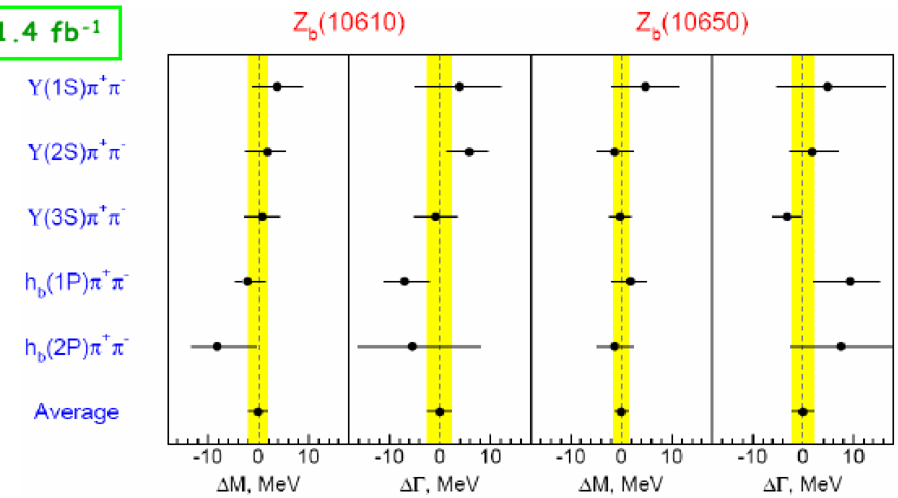
Average over 5 channels

$\langle M_1 \rangle = 10607.2 \pm 2.0$ MeV

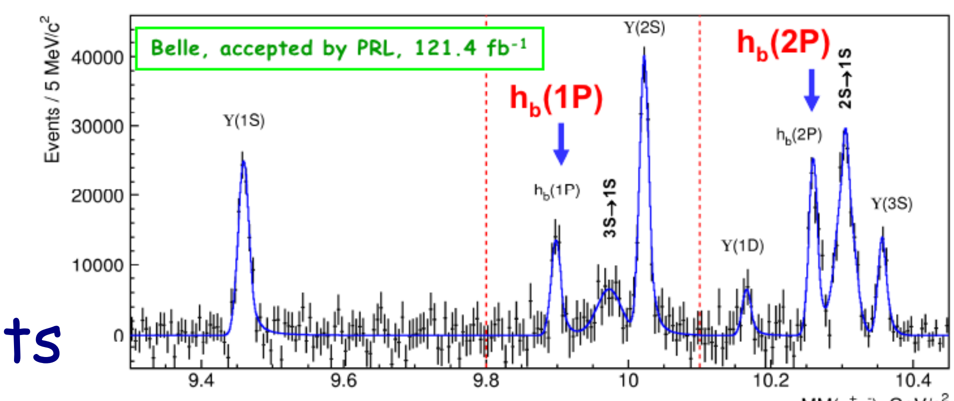
$\langle \Gamma_1 \rangle = 18.4 \pm 2.4$ MeV

$\langle M_2 \rangle = 10652.2 \pm 1.5$ MeV

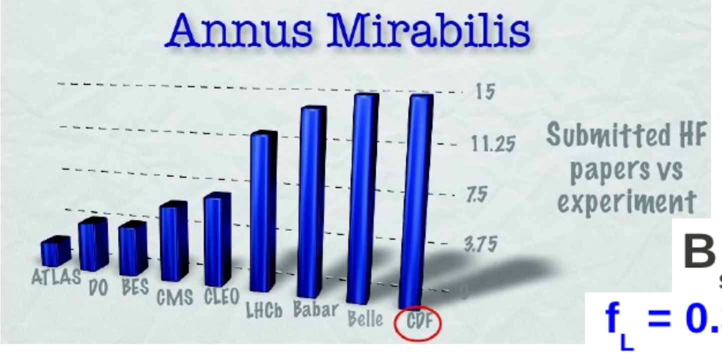
$\langle \Gamma_2 \rangle = 11.5 \pm 2.2$ MeV



A. Drutskoy



Bs results

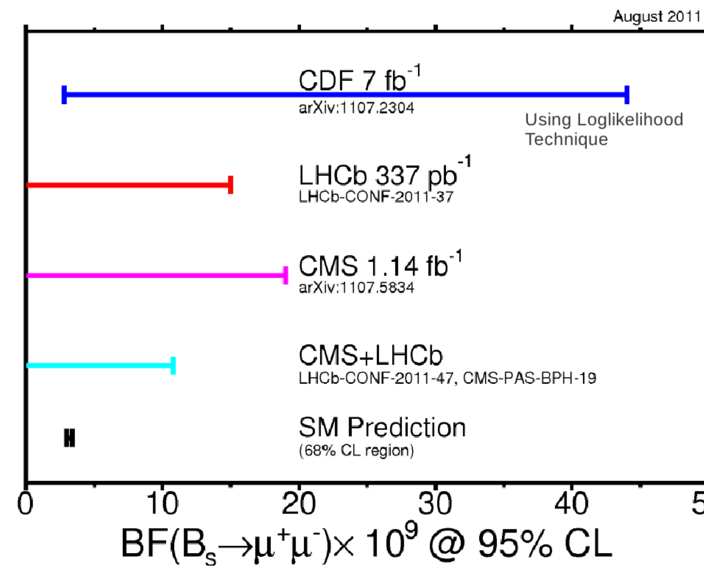


M. Heck

$B_s \to \Phi\Phi$ – Polarization

f_L = 0.348 ± 0.041 (stat) ± 0.021 (sys)

f_T = 0.652 ± 0.041 (stat) ± 0.021 (sys)



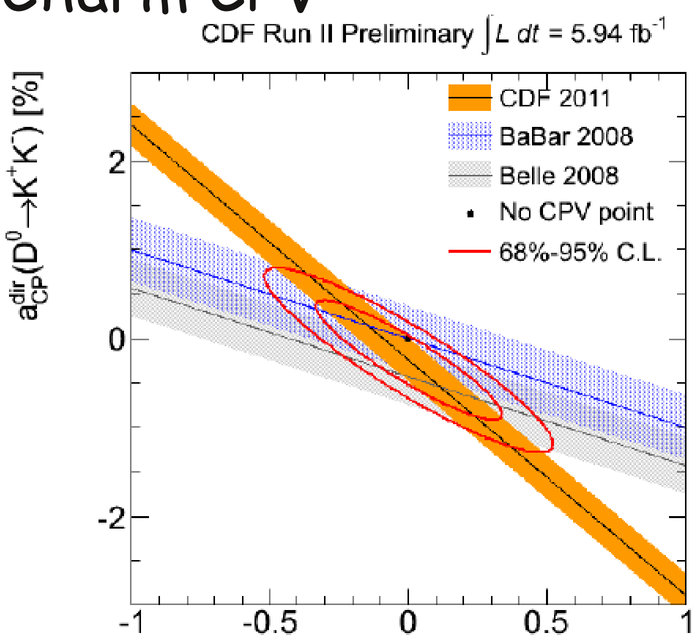
$B_s \to \pi\pi$

$BR(B_s \to \pi\pi) = (0.57 \pm 0.15\ (stat) \pm 0.10\ (sys)) \times 10^{-6}$

$0.05 < BR(B^0 \to KK) \times 10^6 < 0.46$ @90% confidence level

$Bs \to \mu\mu$

Charm CPV

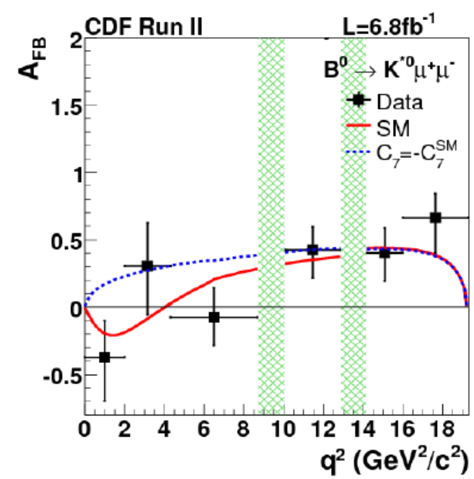


$A_{CP}(D^0 \to \pi^-\pi^+) = [\ 0.22 \pm 0.24\ (stat) \pm 0.11\ (sys)\ ]\%$

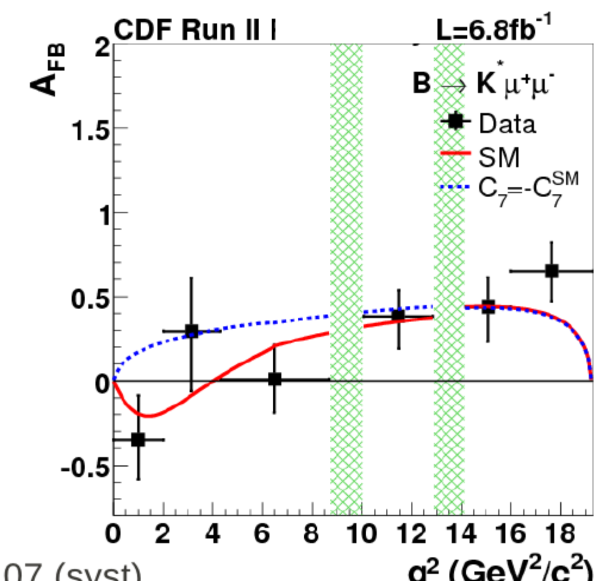
$A_{CP}(D^0 \to K^-K^+) = [\ -0.24 \pm 0.22\ (stat) \pm 0.10\ (sys)\ ]\%$

CDF doesn't see hints for any deviation.

Neutral only



Charged and Neutral



$AFB(1 < q^2 < 6) = 0.29^{+0.20}_{-0.23}$ (stat) ± 0.07 (syst)

$B \to K^* \mu\mu$