B physics results from 2011 summer conferences

Justine Serrano - CPPM

(Bias) choice of topic:

•Rare decays: $B_s \to \mu^+\mu^-$, $B \to K^*\mu^+\mu^-$

•CPV & B_s mixing: $B_s \to J/\psi\ \varphi$

•Radiative: $B_s \to \varphi\ \gamma$ and $B_d \to K^*\ \gamma$

•Hadronic : $B_{(s)} \to D_{(s)}K$

•Semileptonic: $B \to D(^*)\tau\upsilon$

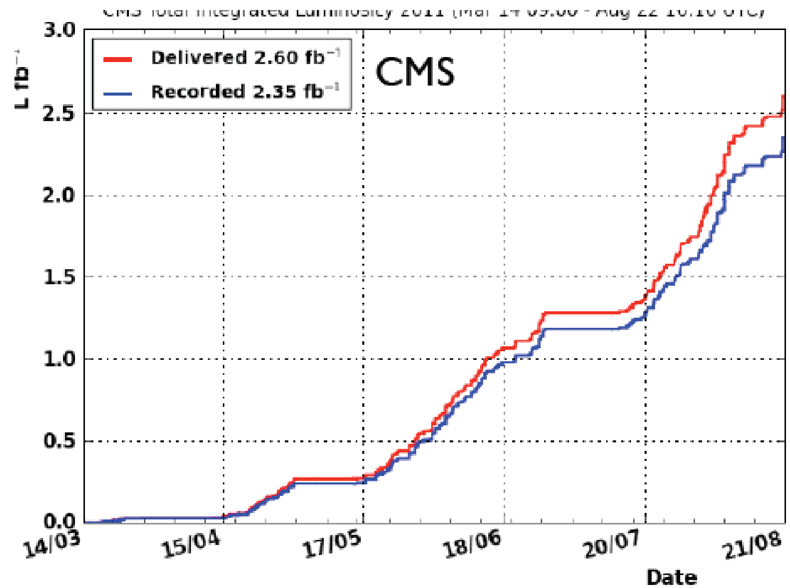
séminaire CPPM

24 octobre 2011

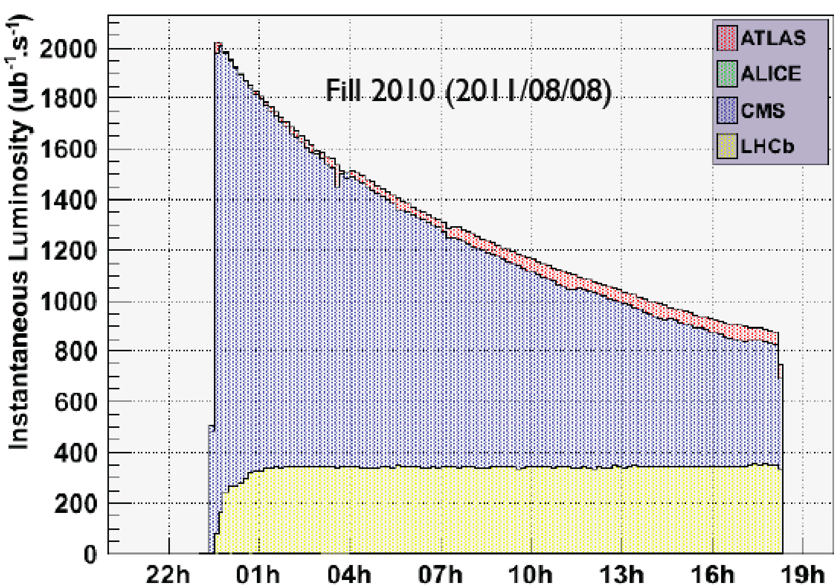
Where to find beauty ?

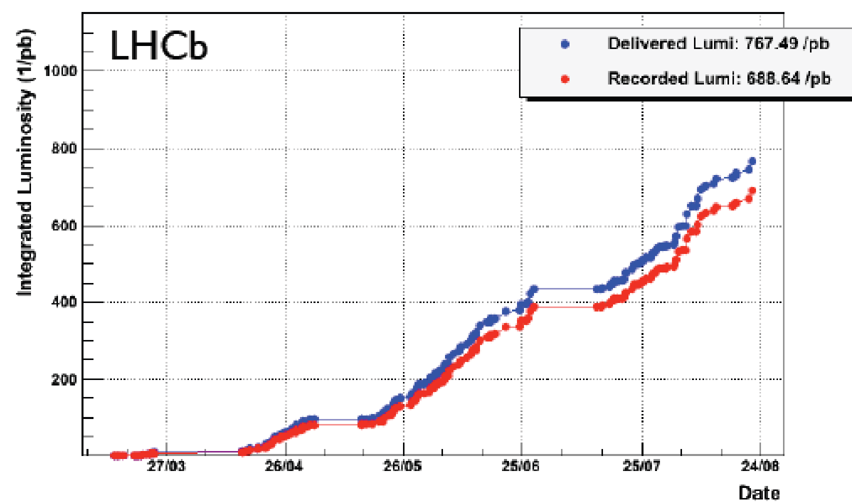
	L(fb^{-1})	σ_{acc} (μb)	$b\bar{b}$ produced/10^9
ATLAS/CMS[1]	2.5	75	190
LHCb[2]	0.7	75	52
CDF/D0[3]	9.5	2.8	26
Belle+BaBar	832+426	0.0011	1.4

Small but clean!



LHCb luminosity levelling





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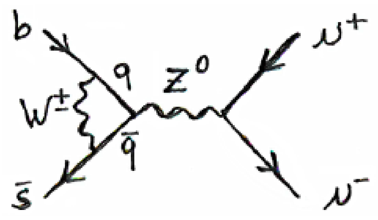
Rare decay: $B_{s/d} \to \mu^+\mu^-$

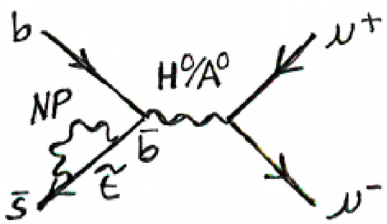
- FCNC and helicity suppressed decays



- Precise SM prediction:
  - $BR(B_s \to \mu^+\mu^-) = (3.2 \pm 0.2) \times 10^{-9}$
  - $BR(B_d \to \mu^+\mu^-) = (1.1 \pm 0.1) \times 10^{-10}$

- BR very sensitive to new physics

$$\mathrm{Br}_{\mathrm{MSSM}}(B_q \to \ell^+\ell^-) \propto \frac{M_b^2 M_\ell^2 \tan^6\beta}{M_A^4}$$



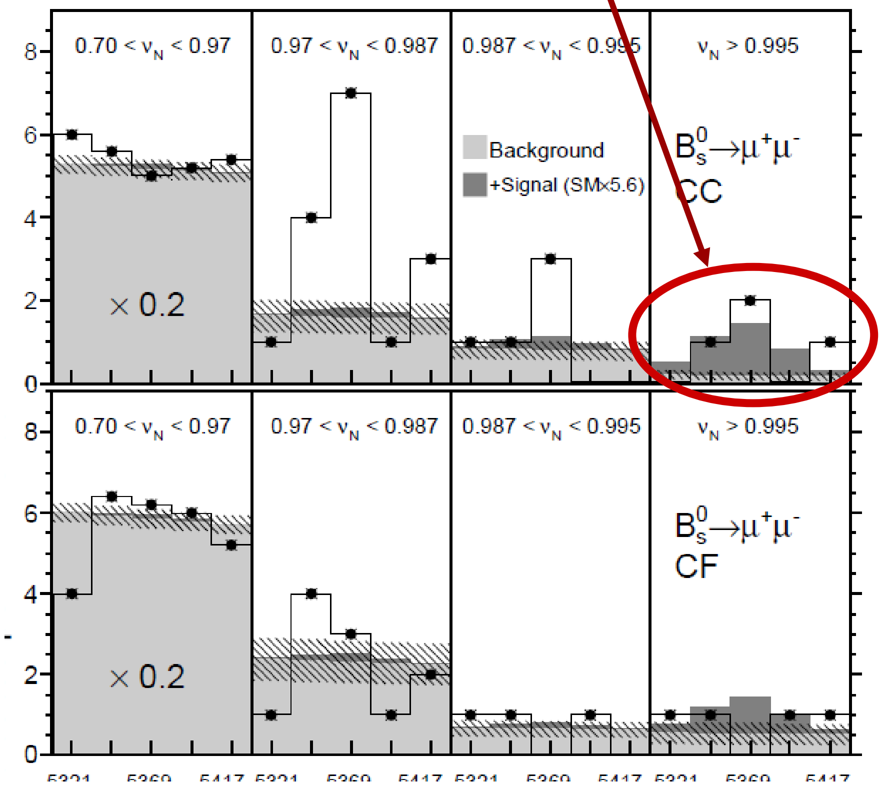
- Analysis done at hadronic collider (Tevatron and LHC)
- Cut based or more sophisticated multi variate approach
- Blind analysis
- Statistics is crucial!

New result from CDF ($7fb^{-1}$)

- Few days before EPS: CDF report a hint

arXiv:1107.2304v2

Bs mass region in bin of neural network

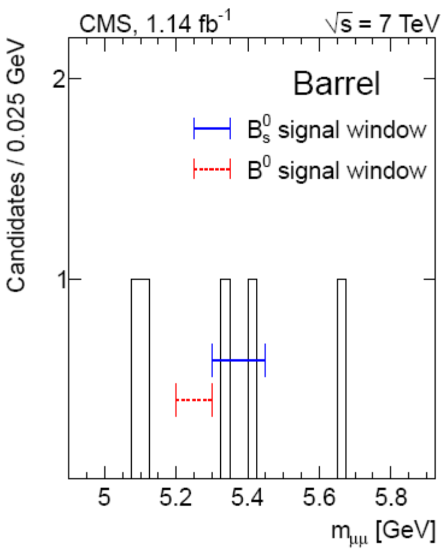


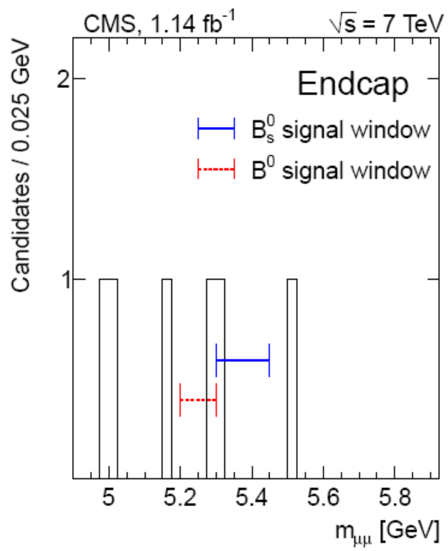
p-value background + SM Br: 1.9%

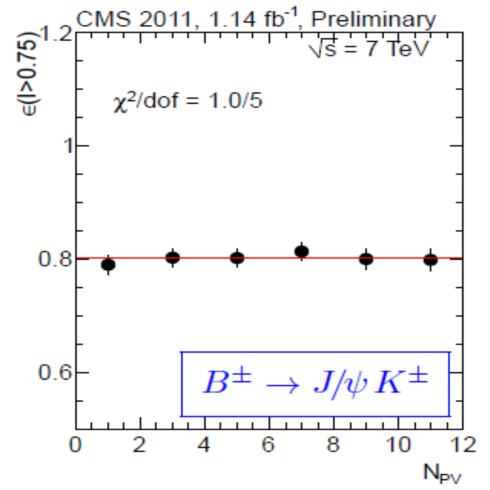
$Br_{CDF}(B_s \to \mu\mu) = 1.8^{+1.1}_{-0.9} \times 10^{-8}$ $BR(B_d \to \mu^+\mu^-) < 6.0 \times 10^{-9}$ @95%CL

First result from CMS (1.14 fb^{-1})

- Cut based analysis
- Optimized on MC, cross check on data
- Effect of pile up has been carefully studied







CMS-PBH-11-002

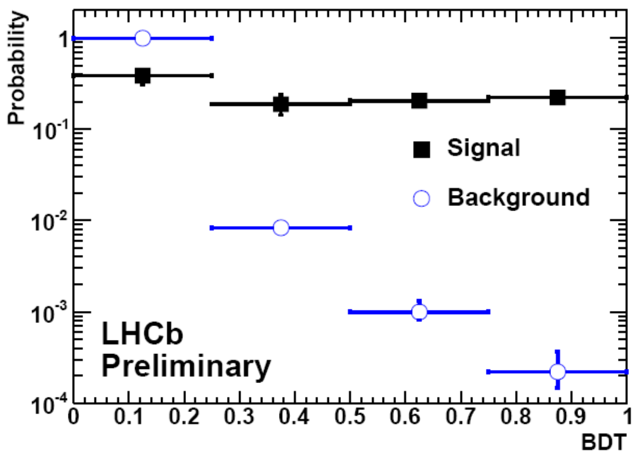
this is B→hh (N^{exp}_{peak})

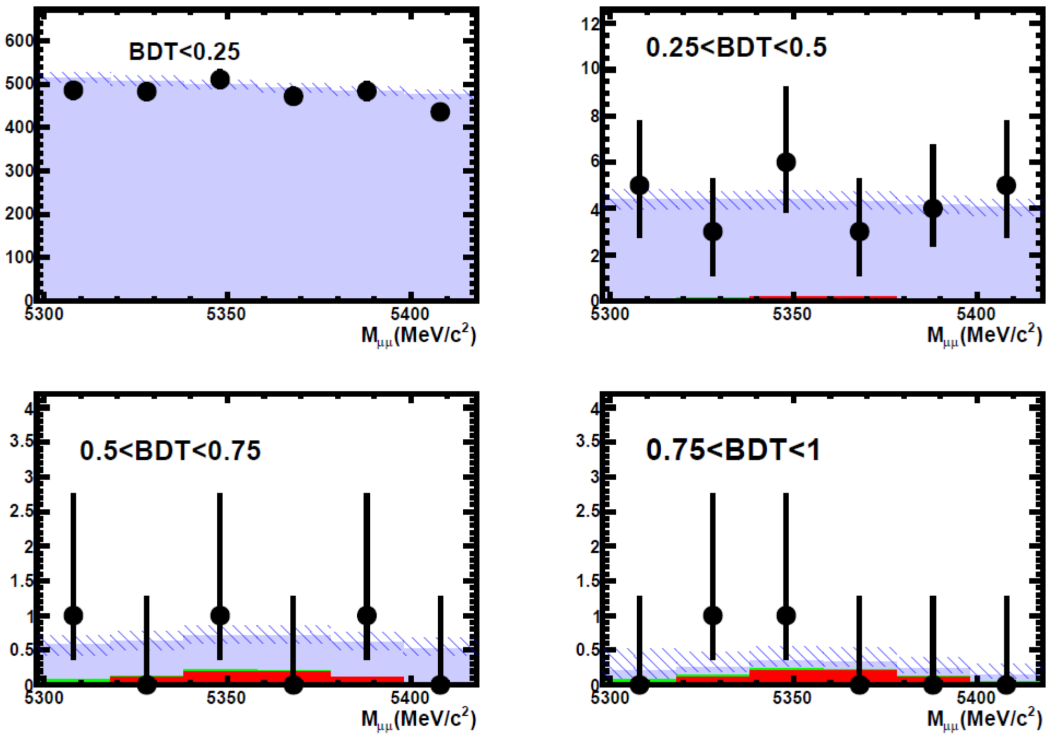
	Barrel	Endcap
N^{exp}_{signal}	0.80 ± 0.16	0.36 ± 0.07
N^{exp}_{bg}	0.60 ± 0.35	0.80 ± 0.40
N^{exp}_{peak}	0.07 ± 0.02	0.04 ± 0.01
N_{obs}	2	1

$BR(B_s \to \mu^+\mu^-) < 1.9 \times 10^{-8}$ @95% CL
$BR(B_d \to \mu^+\mu^-) < 4.6 \times 10^{-9}$ @95% CL

LHCb (300pb^{-1})

- Use a boosted decision tree combining 9 geometrical and kinematical variables
- Extensive use of data to calibrate the PDF





Combinatorial bkg

Misid bkg

Signal SM

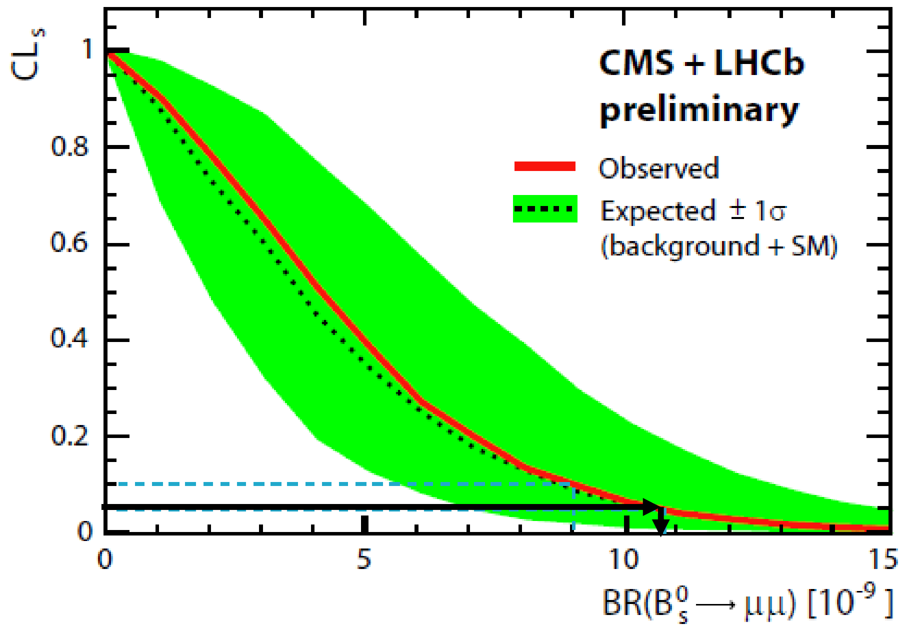
Data

LHCb-CONF-2011-037

$BR(B_s \to \mu^+\mu^-) < 1.3 \times 10^{-8}$ (1.6×10^{-8}) @ 90 (95)% CL

$BR(B_d \to \mu^+\mu^-) < 4.2 \times 10^{-9}$ (5.1×10^{-9}) @ 90 (95)% CL

LHCb+CMS

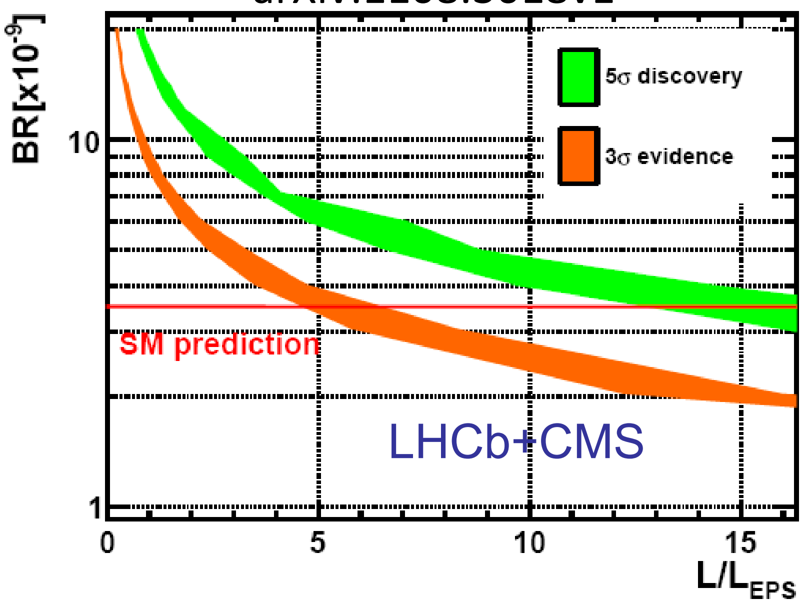


LHCB-CONF-2011-047

$BR(B_s \to \mu^+\mu^-) < 11 \times 10^{-9}$ @ 95% CL (about 3.4 x SM)

p-value background + SM BR: 55%

arXiv:1108.3018v1



Conclusion:

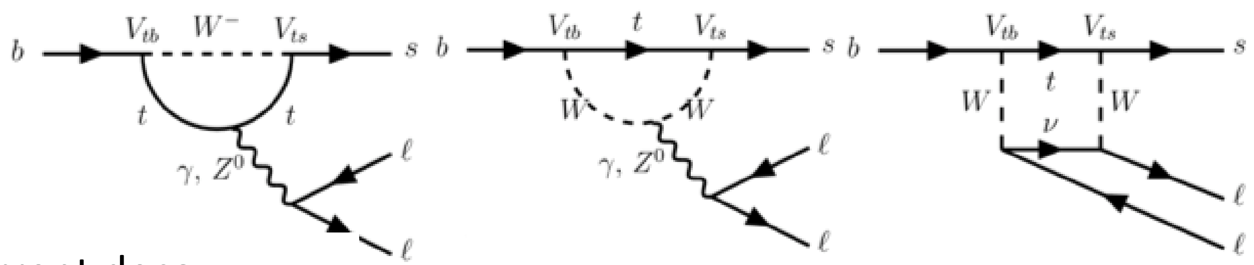
Hint of excess seen by CDF not confirmed by LHC

CMS sensitivity is equivalent to LHCb with ~5 times the statistics

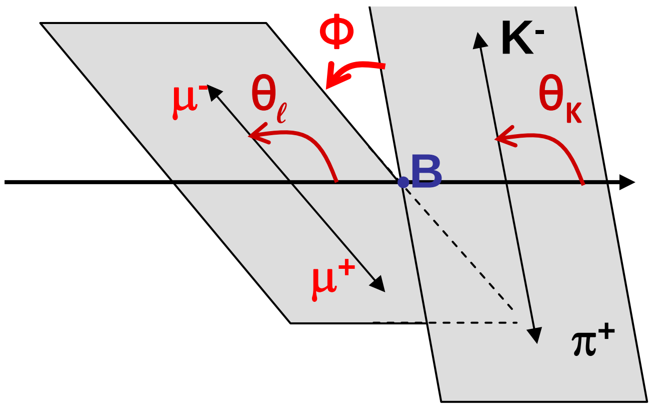
LHCb+CMS could claim a 3σ evidence next winter

We are waiting for ATLAS results

B→K*μμ



Flavour changing neutral current decay :
BR = (3.3 ±1.0) 10^{-6}



System described by
Invariant mass of the dimuon system q^2
3 angles to describe the decay

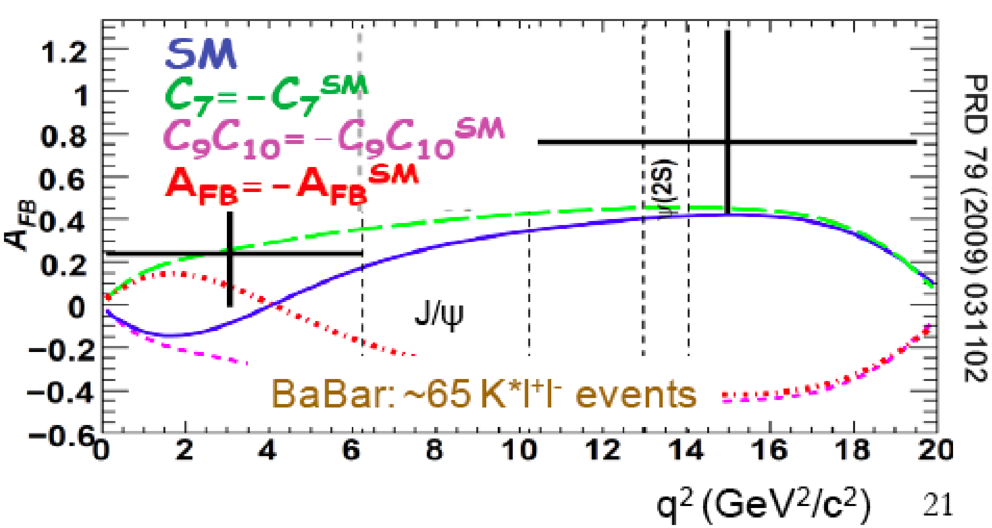
Probe of the helicity structure of BSM physics
First measurement : A_{FB} as function of q^2

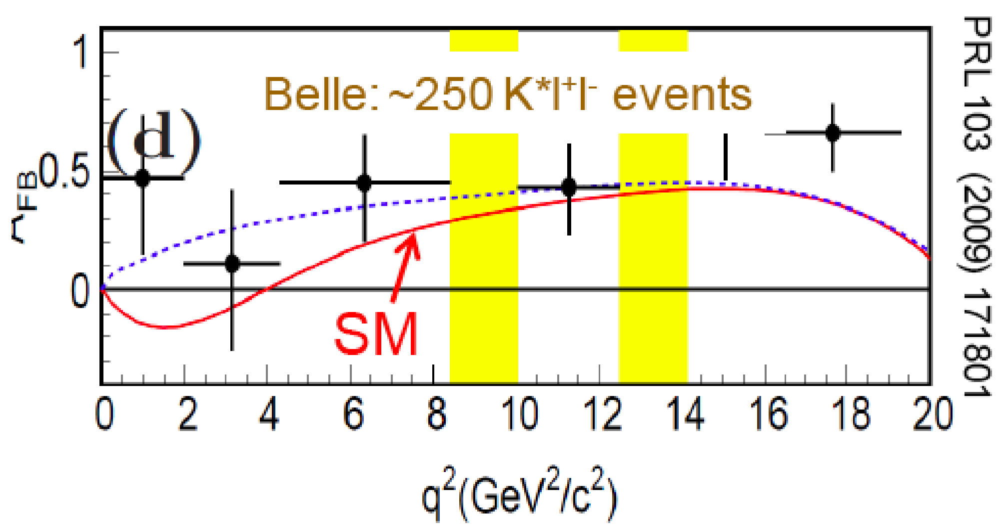
$$A_{\rm FB}(q^2) = \frac{\left.\frac{\mathrm{d}N}{\mathrm{d}q^2}\right|_{\cos\theta_l>0} - \left.\frac{\mathrm{d}N}{\mathrm{d}q^2}\right|_{\cos\theta_l<0}}{\left.\frac{\mathrm{d}N}{\mathrm{d}q^2}\right|_{\cos\theta_l>0} + \left.\frac{\mathrm{d}N}{\mathrm{d}q^2}\right|_{\cos\theta_l<0}}$$

$$\frac{1}{\Gamma}\frac{\mathrm{d}^2\Gamma}{\mathrm{d}\cos\theta_\ell\,\mathrm{d}q^2} = \frac{3}{4}F_L(1-\cos^2\theta_\ell) + \frac{3}{8}(1-F_L)(1+\cos^2\theta_\ell) + A_{FB}\cos\theta_\ell$$

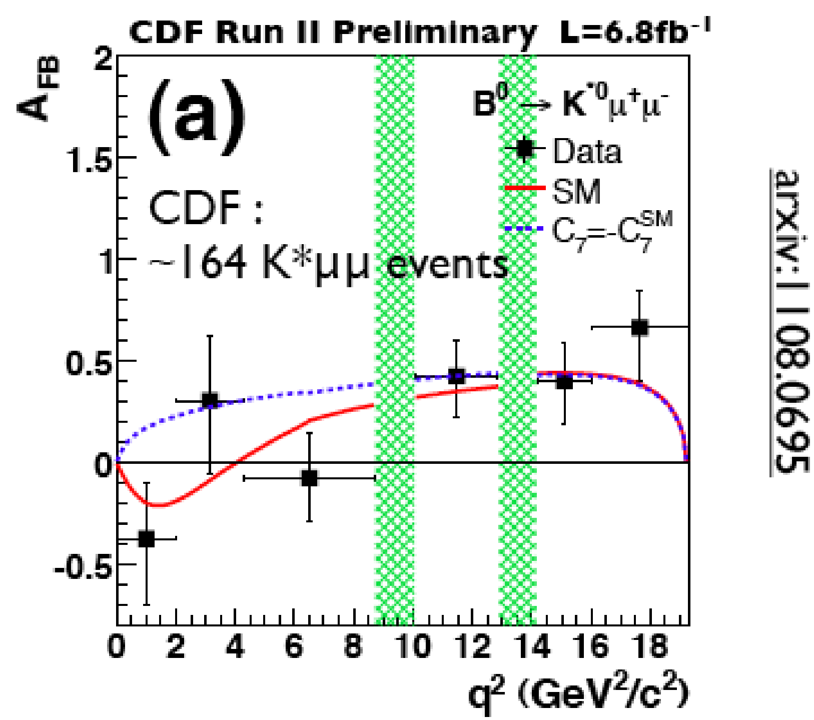
$$\frac{1}{\Gamma}\frac{\mathrm{d}^2\Gamma}{\mathrm{d}\cos\theta_K\,\mathrm{d}q^2} = \frac{3}{2}F_L\cos^2\theta_K + \frac{3}{4}(1-F_L)(1-\cos^2\theta_K)$$

B→K*μμ: B factories and tevatron

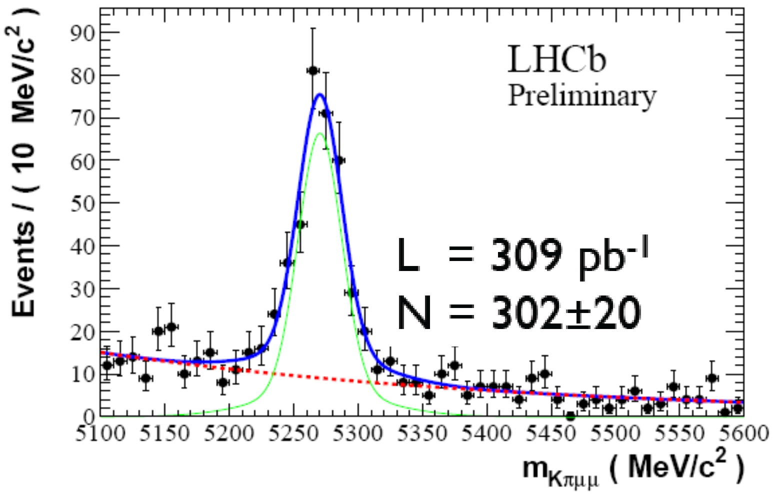




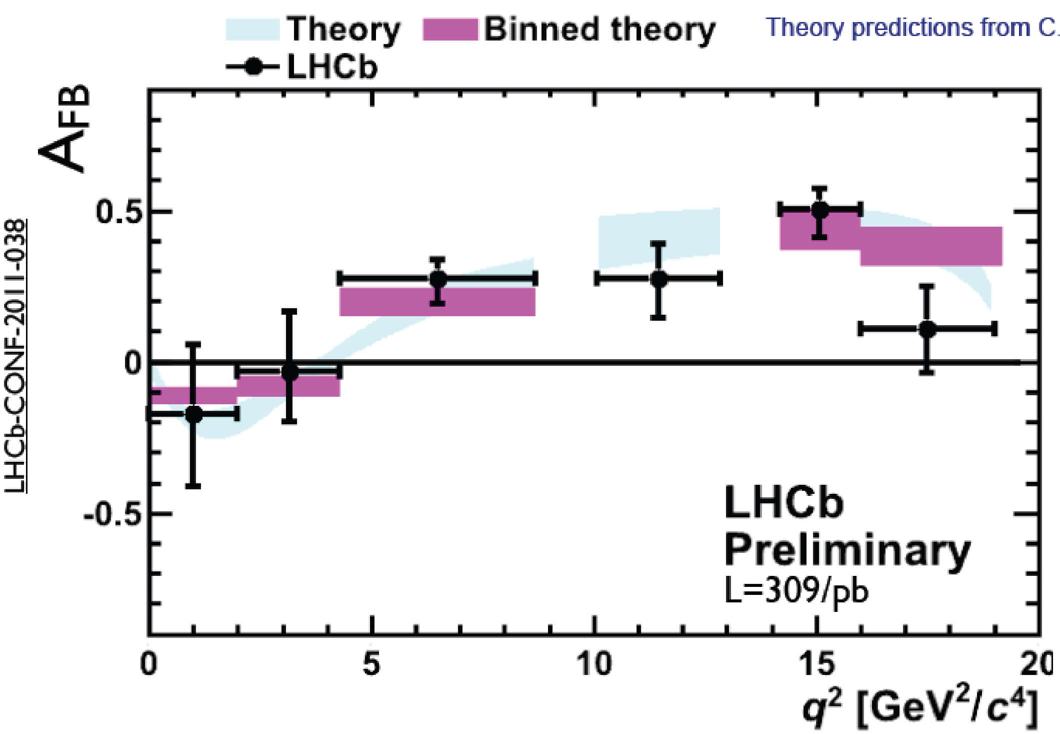
CDF (EPS2011) : 6.8 fb-1



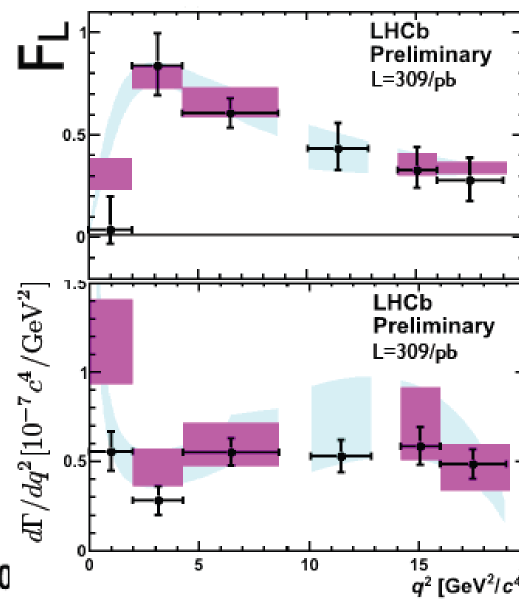
B→K*μμ: LHCb



- using *simultaneous* fit to 1-dim projections of θ_k and θ_l
- Systematic uncertainties small, and generally statistics limited
- Data in excellent agreement with SM predictions at current l
  level of precision.

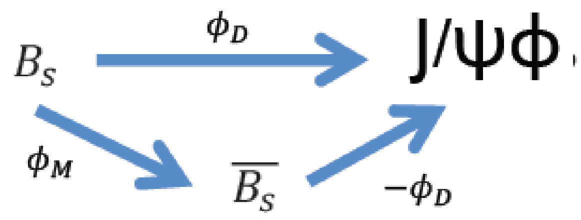


Theory predictions from C.Bobeth *et al.*, arXiv:1105.0376v2



CP violation: $B_s \to J/\psi\ \varphi$

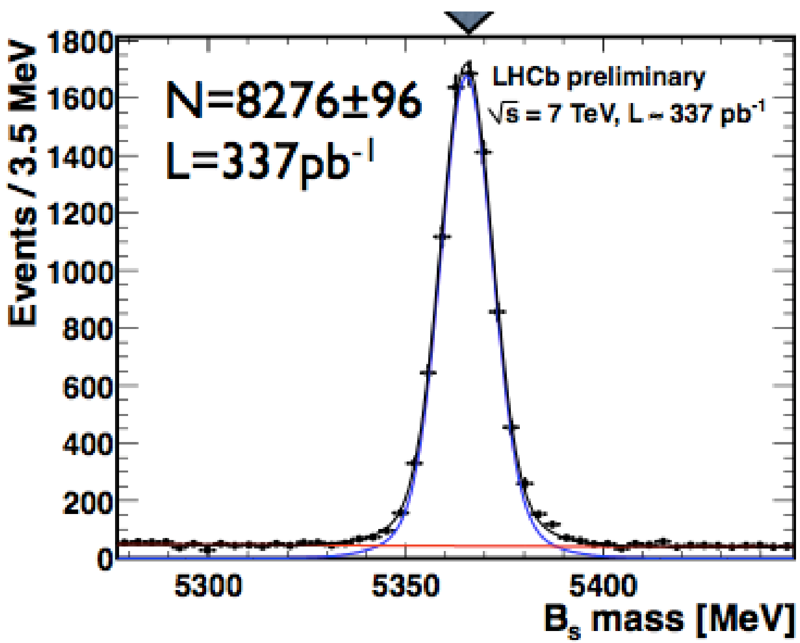
Interference between mixing and decay gives rise to
CP violating phase $\phi_s = \phi_M - 2\,\phi_D$

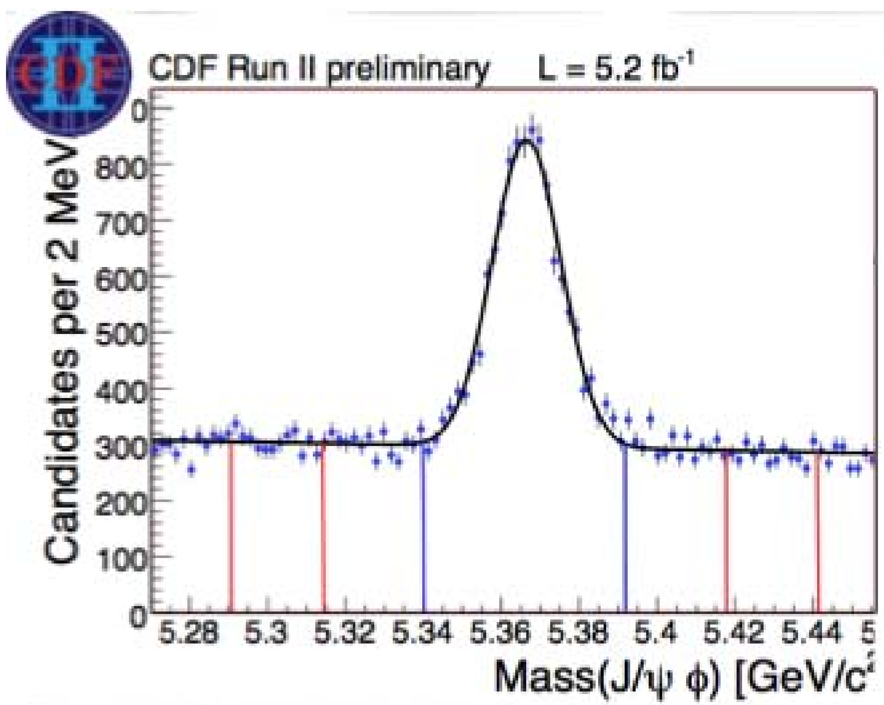


$$\phi_s \overset{SM}{=} -2\beta_s \equiv -2\arg\left(-\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*}\right) = -0.0363 \pm 0.0016\,\mathrm{rad}$$

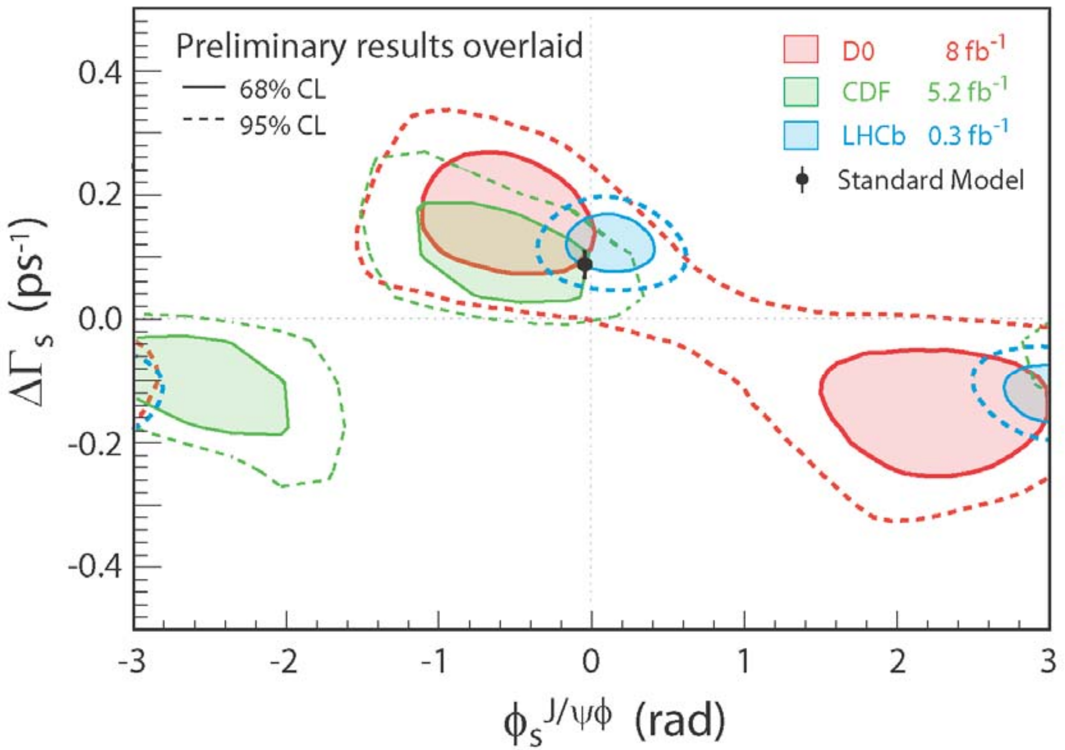
Complex analyses :

- time dependent
- Flavour tagging
- full angular analysis for J/ψ φ(B->VV decay)
- should measure at the same time Γ_s and Φ_s

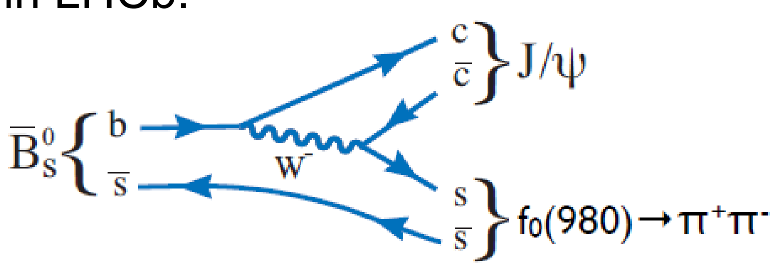




$B_s \to J/\psi\ \varphi$: results



Also in LHCb:



$$\phi_s^{J/\psi f_0} = -0.44 \pm 0.44\ (\mathrm{stat}) \pm 0.02\ (\mathrm{syst})$$

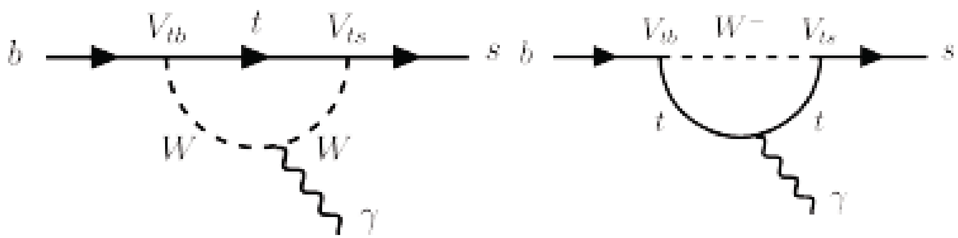
Simultaneous fit to both samples:

LHCb Preliminary

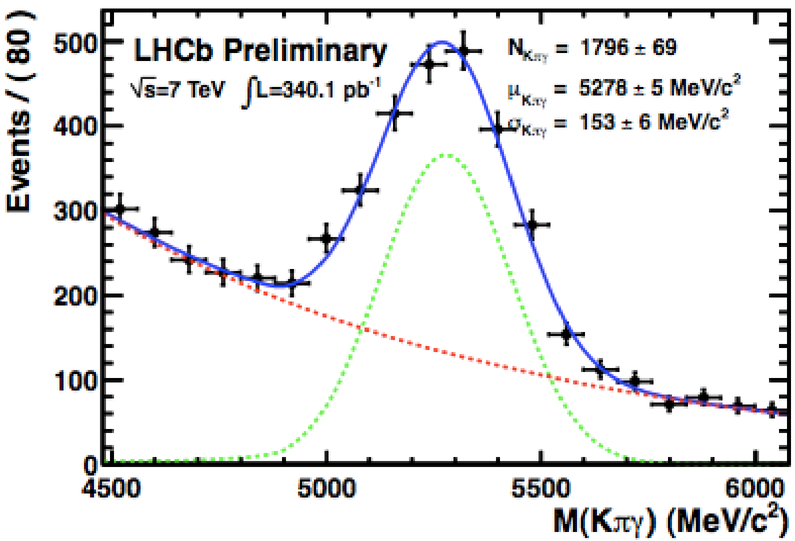
$\phi_s = 0.03 \pm 0.16 \pm 0.07$ rad

LHCb-CONF-2011-056

$B_s \to \varphi\,\gamma$ and $B_d \to K^*\,\gamma$



LHCb-CONF-2011-055

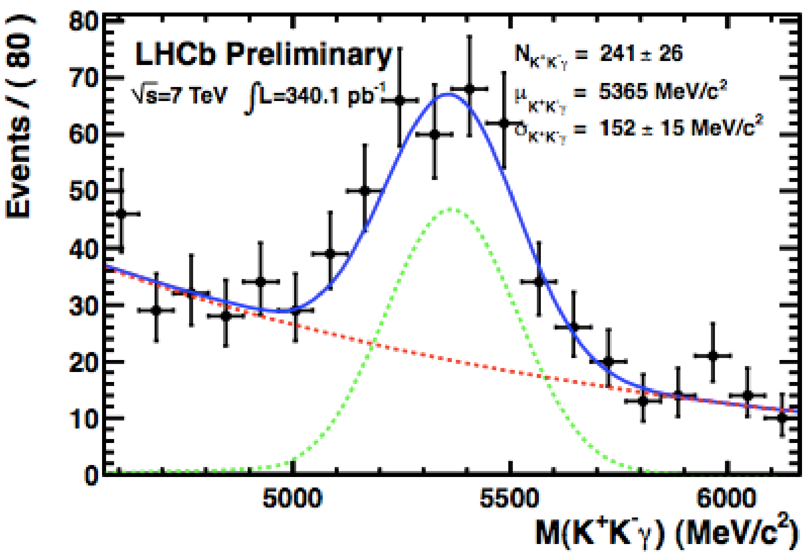


Previously (Belle, Babar, CLEO):

$$\frac{\mathcal{B}(B^0 \to K^{*0}\gamma)}{\mathcal{B}(B_s^0 \to \phi\gamma)} = 0.7 \pm 0.3$$

LHCb result:

$$\frac{\mathcal{B}(B^0 \to K^{*0}\gamma)}{\mathcal{B}(B_s^0 \to \phi\gamma)} = 1.52 \pm 0.15(\mathrm{stat}) \pm 0.10(\mathrm{syst}) \pm 0.12(f_s/f_d)$$

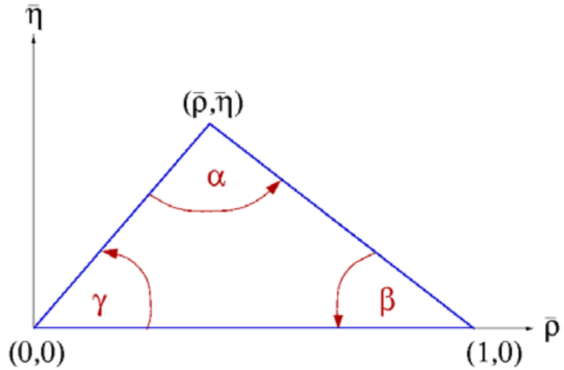


SCET predicts 1.0 ± 0.2 for this ratio

[Ali et al., EPJ C55:577 (2008)]

Next : measure CP asymmetries

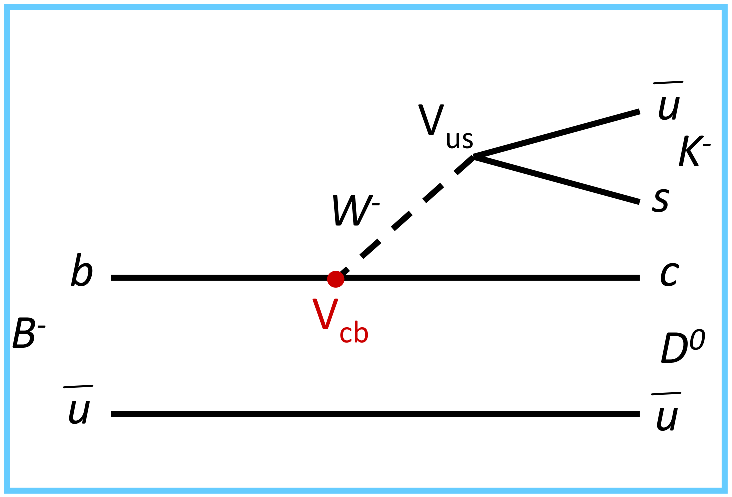
Measurement of the UT angle γ



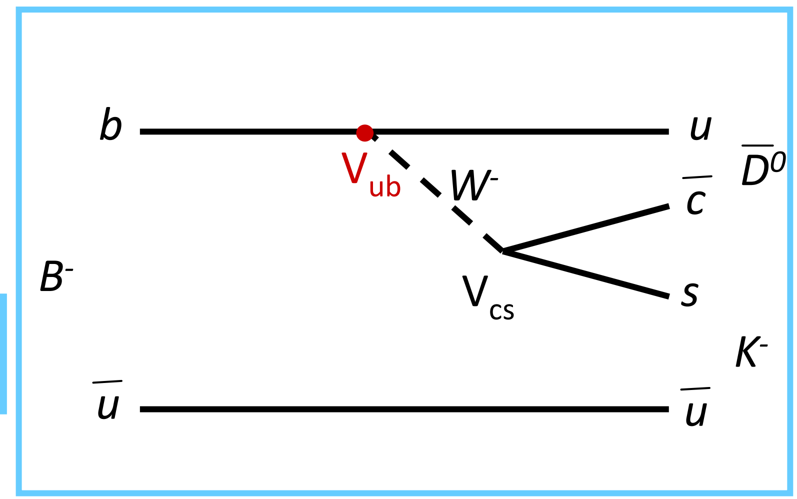
It's the less well known angle

$\sigma_\alpha \sim 6°$
$\sigma_\beta \sim 1°$
$\sigma_\gamma \sim 11°$

Interferences between *b*→*c* and *b*→*u* transitions



Relative magnitude r_B
relative phase δ_B-γ

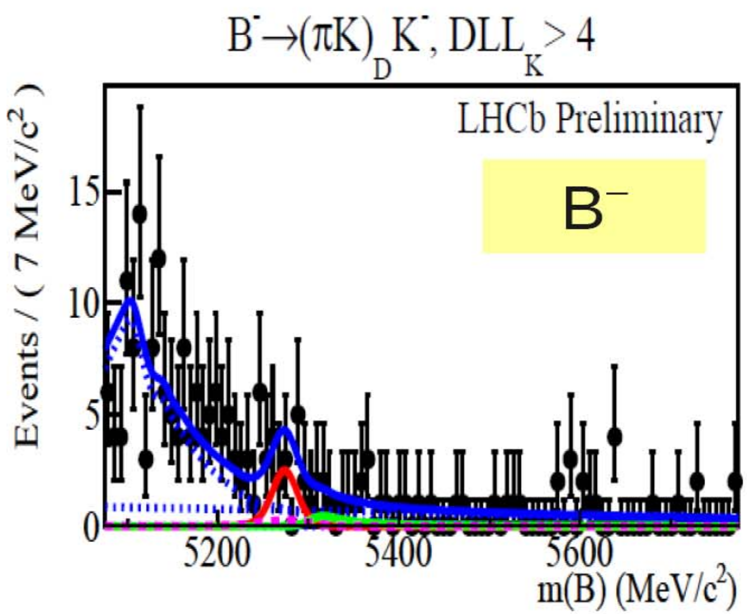


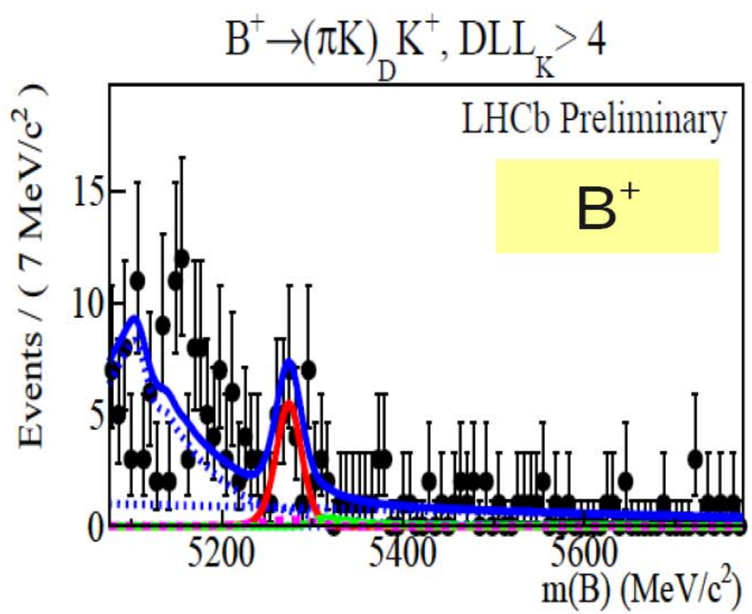
Same final state, 3 techniques :

- GLW (Gronau, London, Wyler) : use a CP mode for the D^0 decay *Physics Letters B 265(1-2), 172 – 176*
- ADS (Atwood, Dunietz, Soni) : use D^0 CA($K^- \pi^+$) mode for the V_{ub} decay and D^0 DCS($K^+\pi^-$) for the V_{cb} decay *Phys. Rev. Lett. 78(17), 3257–3260*
- Dalitz GGSZ (Giri, Grossman, Soffer, Zupan) : use the $D^0 \rightarrow K_S \pi \pi$ or $K_S KK$ decays *Phys. Rev. D 68(5), 054018.*

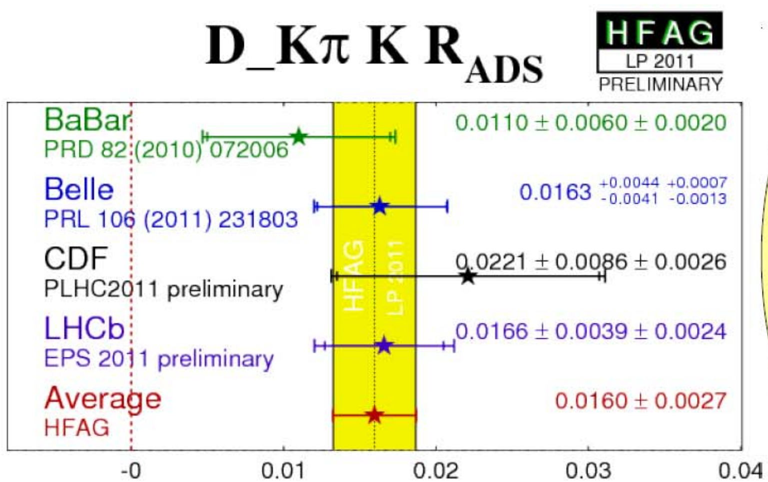
γ from B →DK, D → Kπ (ADS)

LHCb-CONF-2011-044



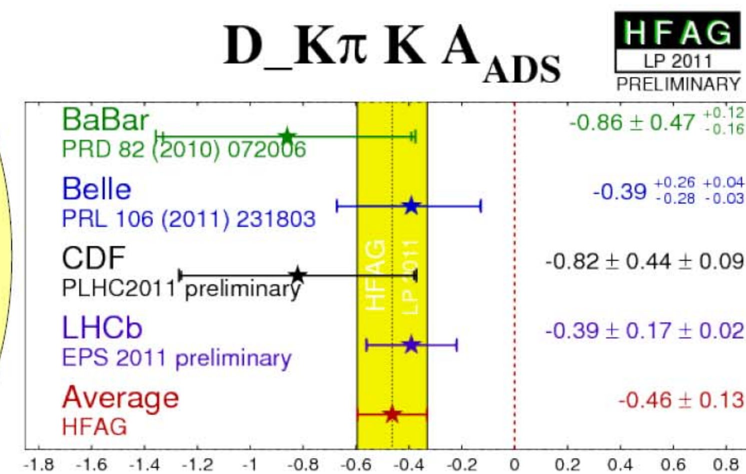


Ratio to favoured modes:



All new results in last 2 years

Asymmetry:

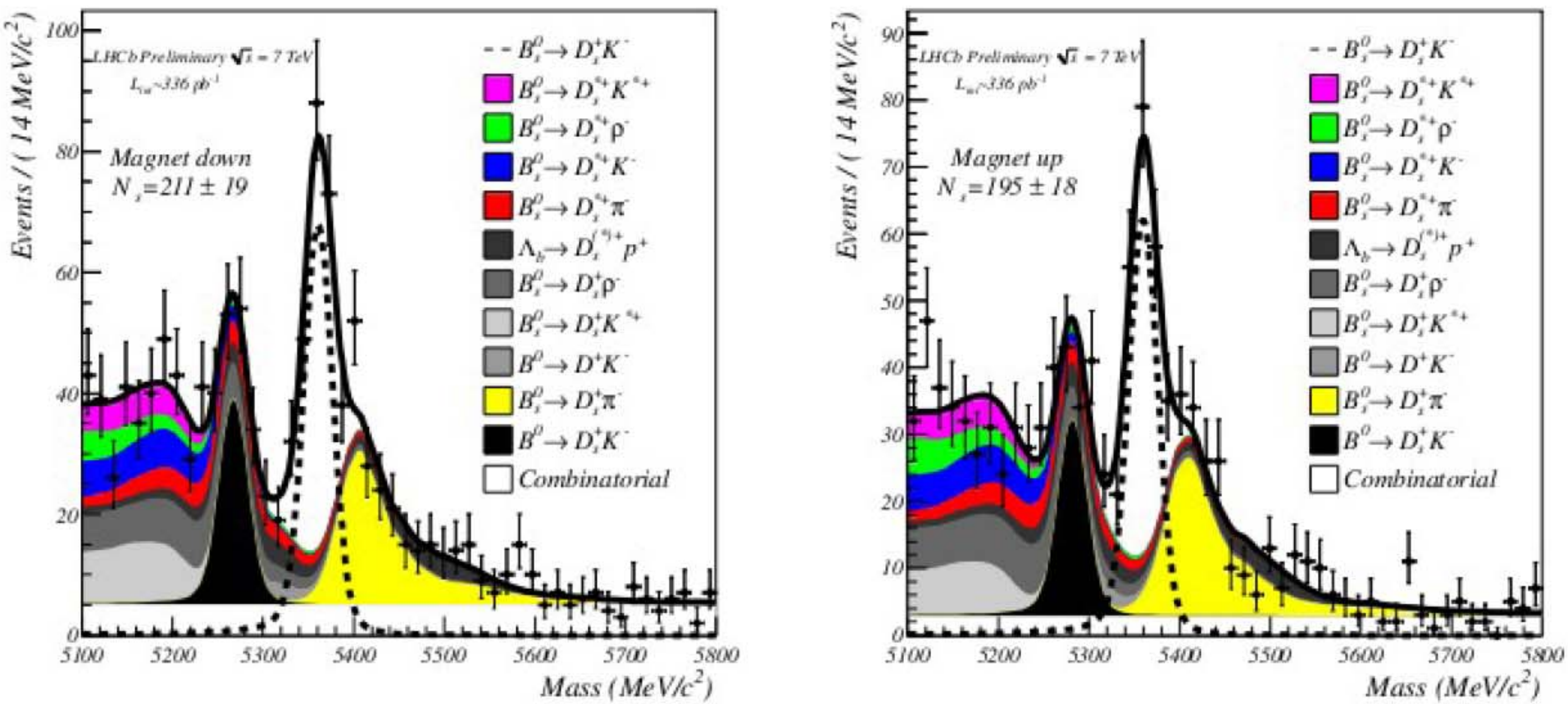


γ from $B_s \to D_s K$

Time dependent analysis of the $B_s \to D_s K$ decays

LHCb-CONF-2011-057

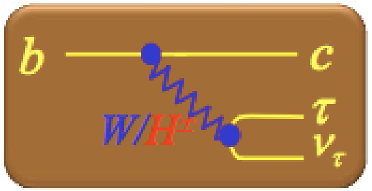
This summer : measure the BR (split by magnet polarity)



$$B\left(B_s \to D_s^{\mp} K^{\pm}\right) = \left(1.97 \pm 0.18\,(stat)\,^{+0.19}_{-0.20}\,(syst)\,^{+0.11}_{-0.10}\,(f_s/f_d)\right) \times 10^{-4}$$

Very promising for future γ measurement

Search for charged Higgs in B →D(*)τυ



Ratio of τ to μ,e could be reduced/enhanced significantly

$$R(D) \equiv \frac{\mathcal{B}(B \to D\tau\nu)}{\mathcal{B}(B \to D\ell\nu)}$$

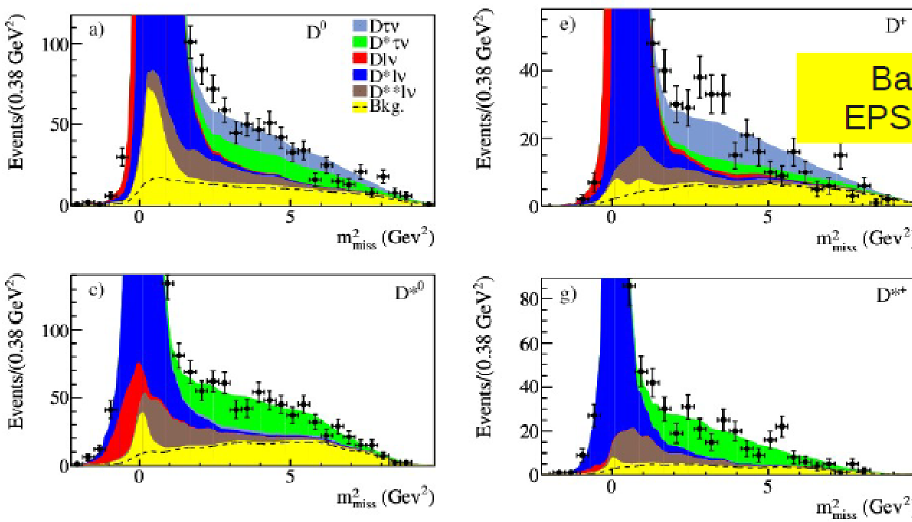
$B^- \to D^0\tau^-\nu$

$\bar{B}^0 \to D^+\tau^-\nu$

BaBar experiment
EPS 2011 preliminary

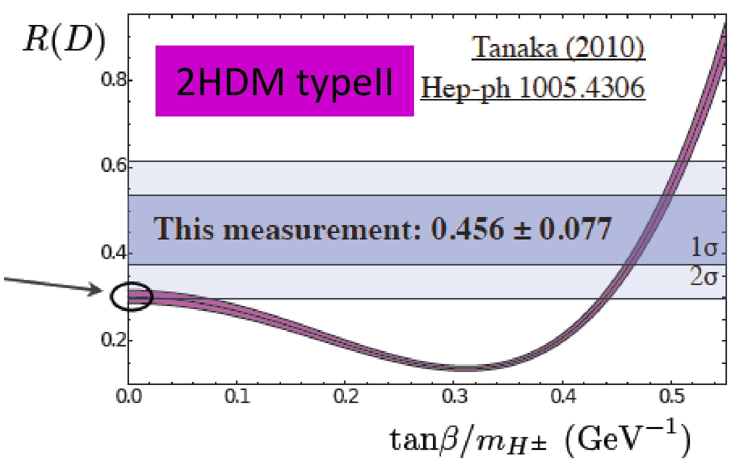
$B^- \to D^{*0}\tau^-\nu$

$\bar{B}^0 \to D^{*+}\tau^-\nu$



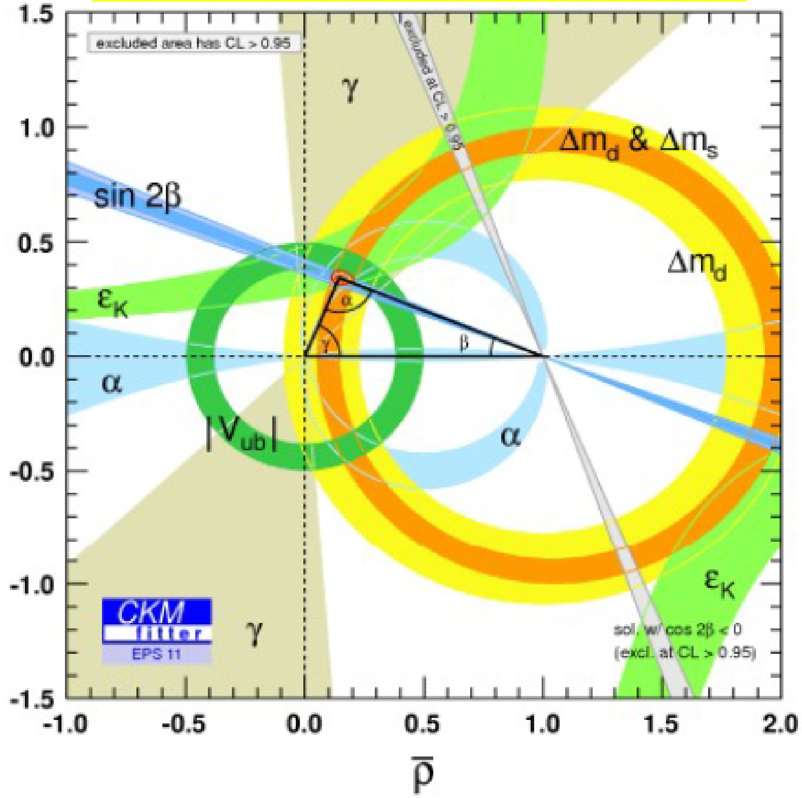
$R(D) = 0.456 \pm 0.053 \pm 0.056$		$R^{SM}(D) = 0.31 \pm 0.02$	
$R(D^*) = 0.325 \pm 0.023 \pm 0.027$		$R^{SM}(D^*) = 0.25 \pm 0.07$	

1.8 σ excess over SM

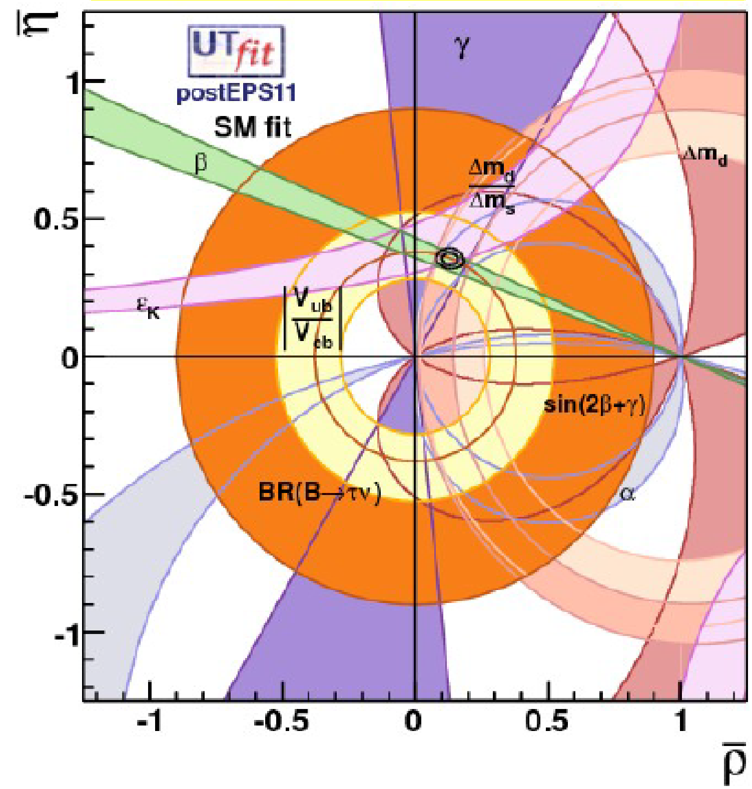


Global CKM fit

http://ckmfitter.in2p3.fr



http://www.utfit.org



$$\bar{\rho} = 0.144^{+0.027}_{-0.018} \; (CKMfitter) = 0.132 \pm 0.020 \; (UTfit)$$

$$\bar{\eta} = 0.343 \pm 0.014 \; (CKMfitter) = 0.353 \pm 0.014 \; (UTfit)$$

Overall good consistency with the standard model

Some tensions between V_{ub} inclusive/exclusive, sin2β, B $\rightarrow \tau\upsilon$

Conclusion

A lot of impressive results from

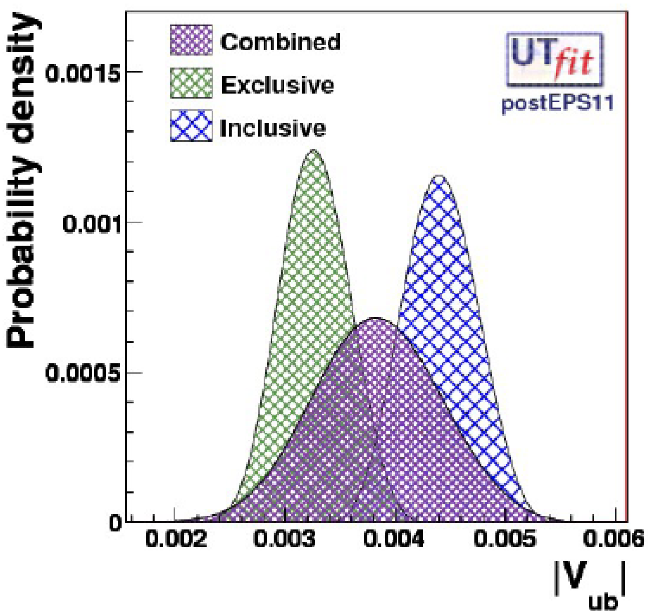
The open space for new physics is reducing!

Not covered: spectroscopy, charmless B decay, Vub, Vcb, α, β, anomalous dimuon charge asymmetry, LFV, …

backup

UTfit

Observable	Prediction	Measurement	Pull (σ)
γ [°]	69.6 ± 3.1	74 ± 11	-0.4
α [°]	85.4 ± 3.7	91.4 ± 6.1	-0.8
$\sin 2\beta$	0.771 ± 0.036	0.654 ± 0.026	$+2.6$
$\lvert V_{ub}\rvert$ [10^{-3}]	3.55 ± 0.14	3.76 ± 0.20	-0.9
$\lvert V_{cb}\rvert$ [10^{-3}]	42.69 ± 0.99	40.83 ± 0.45	$+1.6$
ε_K [10^{-3}]	1.92 ± 0.18	2.23 ± 0.010	-1.7
$BR(B \to \tau\nu)$ [10^{-4}]	0.805 ± 0.071	1.72 ± 0.28	-3.2
Δm_s [ps^{-1}]	17.77 ± 0.12	18.3 ± 1.3	-0.4
β_s[°]	1.08 ± 0.04	Tevatron average	$+2.1$
$\Delta\Gamma_s$ [ps^{-1}]	0.11 ± 0.02		
$A_{\mu\mu}$ [10^{-4}]	-1.7 ± 0.5	-95.7 ± 29.0	$+3.2$



Méthode d'analyse

- Calibration des fonctions de vraisemblance en utilisant les données
  - Bruit de fond: sidebands
  - Signal: échantillons de contrôle

- Normalisation à un canal connu pour obtenir le rapport d'embranchement

$$\mathrm{BR} = \mathrm{BR}_{\mathrm{cal}} \times \frac{\epsilon_{\mathrm{cal}}^{\mathrm{REC}} \epsilon_{\mathrm{cal}}^{\mathrm{SEL|REC}} \epsilon_{\mathrm{cal}}^{\mathrm{TRIG|SEL}}}{\epsilon_{\mathrm{sig}}^{\mathrm{REC}} \epsilon_{\mathrm{sig}}^{\mathrm{SEL|REC}} \epsilon_{\mathrm{sig}}^{\mathrm{TRIG|SEL}}} \times \frac{f_{\mathrm{cal}}}{f_{B_q^0}} \times \frac{N_{B_q^0 \to \mu^+\mu^-}}{N_{\mathrm{cal}}} = \alpha_{\mathrm{cal}} \times N_{B_q^0 \to \mu^+\mu^-}$$

Evalués avec le MC, crosscheck sur les données

Mesuré dans les données avec $J/\psi \longrightarrow \mu^+\mu^-$

Fraction d'hadronisation

- Résultats:
  - Calcul de la limite en utilisant la méthode frequentiste modifiée CLs en bin the masse invariante et de MVA

Avec 1.14 fb^{-1}, CMS obtient:

BR($B_s \to \mu^+\mu^-$) < 1.9 x10^{-8} @ 95% CL

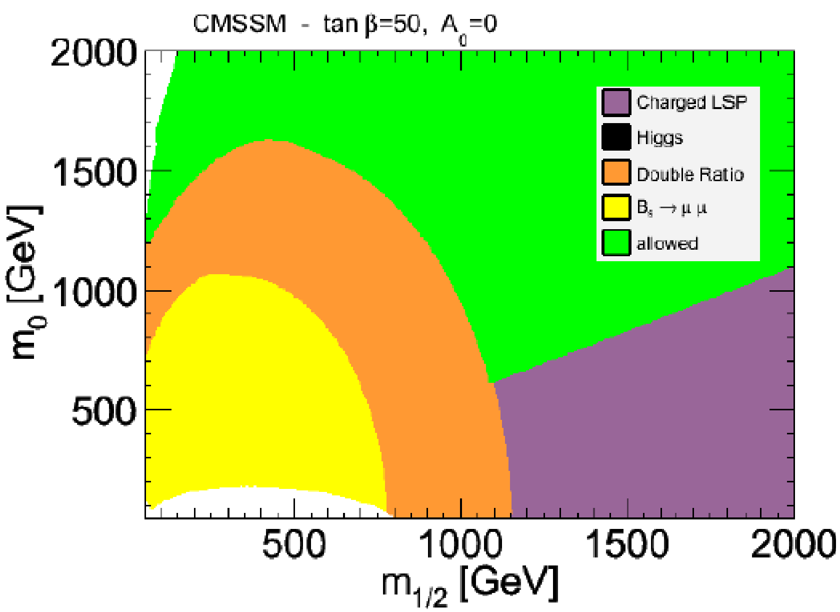
BR($B_d \to \mu^+\mu^-$) < 4.6 x10^{-9} @ 95% CL

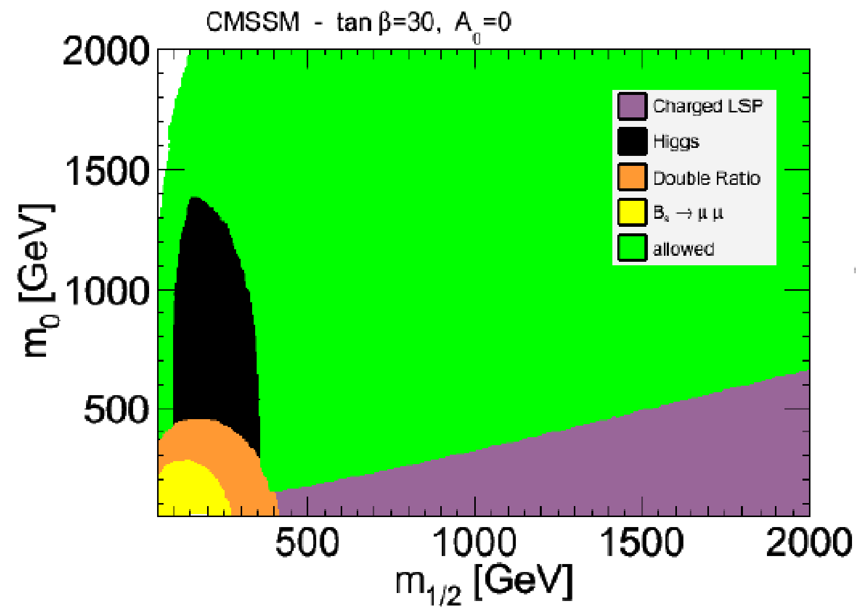
Combiné avec LHCb →

LHCb-CONF-2011-047

BR($B_s \to \mu^+\mu^-$) < 1.08 x10^{-8}

Exemple de contraintes dans le cadre du CMSSM (*F.Mahmoudi et al, arXiv:1108.3018*):





La limite actuelle sur BR($B_s \to \mu^+\mu^-$) impose de fortes contraintes sur la masse des particules supersymetriques à grand tanβ

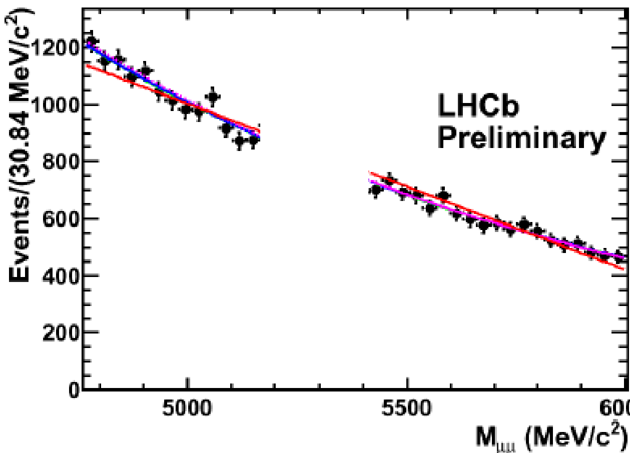
Background expectation I

- Combinatorial background expectation extracted from a fit to the mass sidebands in bins of BDT
- Systematics evaluated using different fit functions and ranges

BDT<0.25

B_s=2968±69

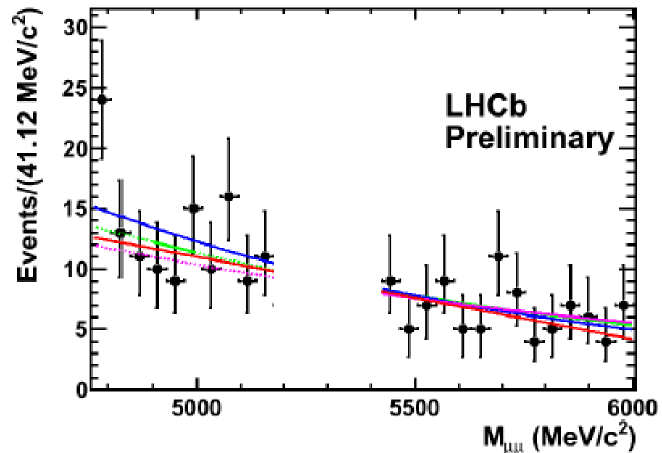
B_d=3175±72



0.25<BDT<0.5

B_s=25.0±2.5

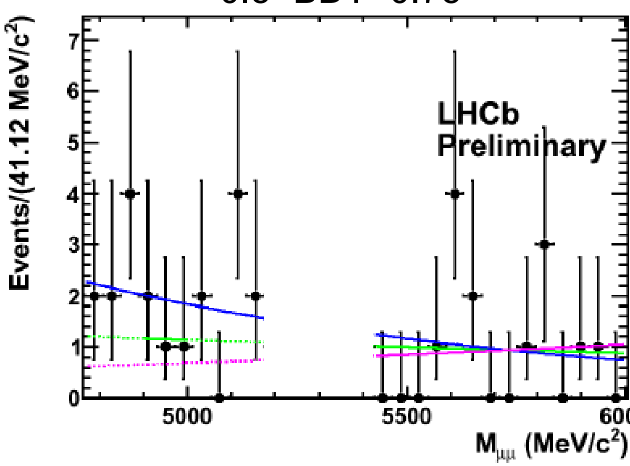
B_d=26.6±2.5



0.5<BDT<0.75

B_s=3.0±0.9

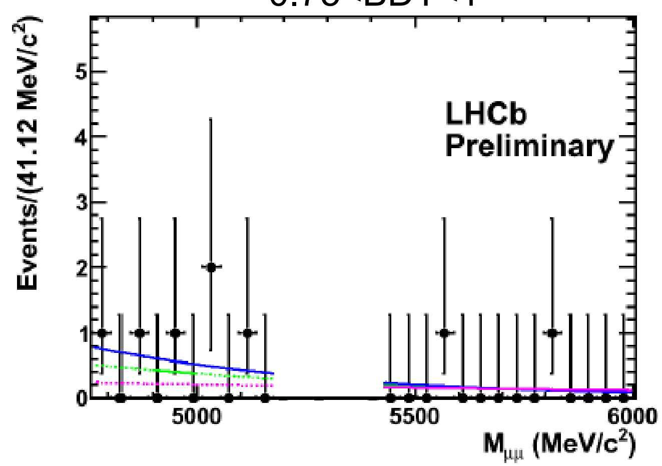
B_d=3.1±0.8



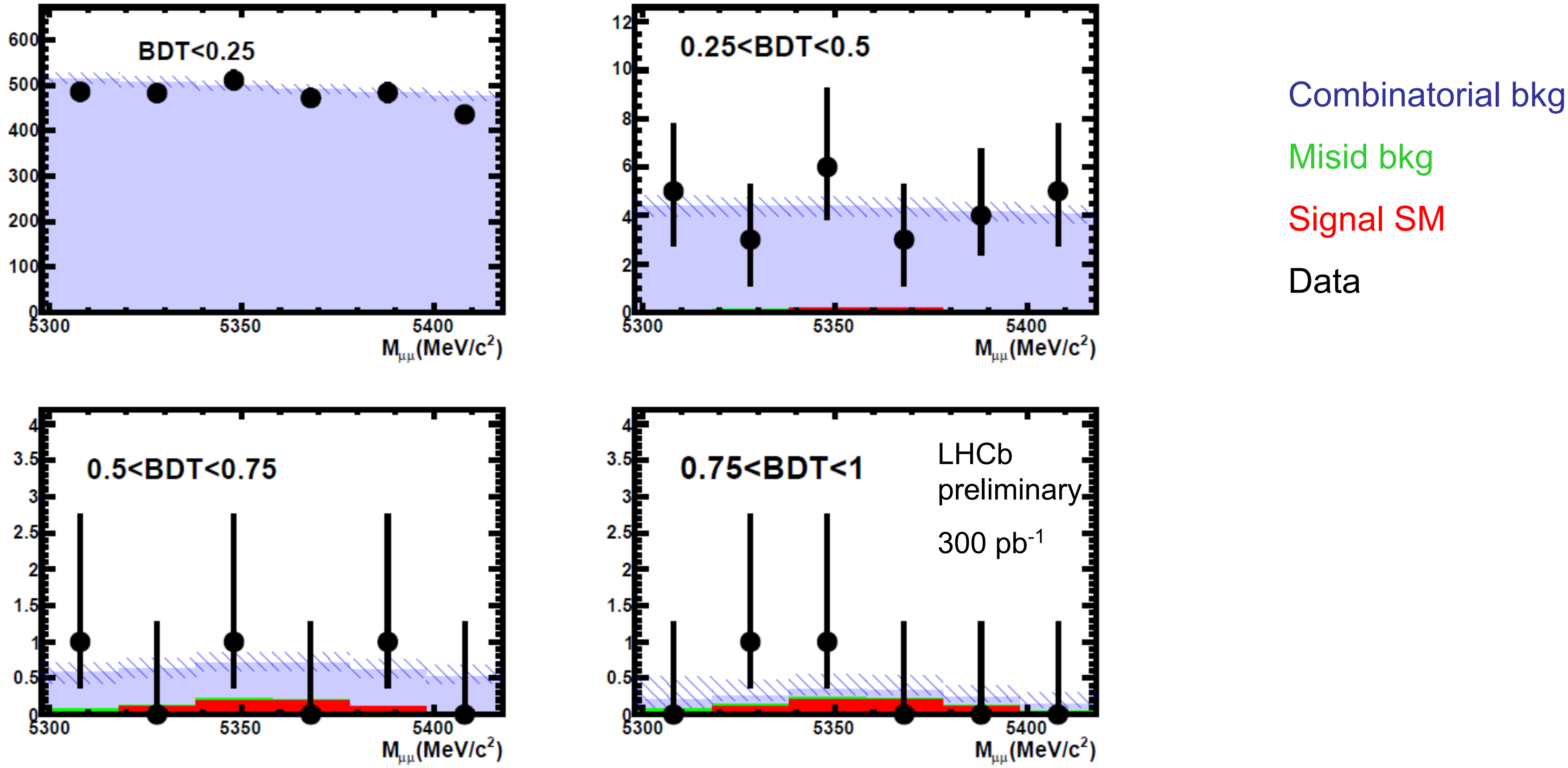
0.75<BDT<1

B_s=0.7±0.4

B_d=0.7±0.4



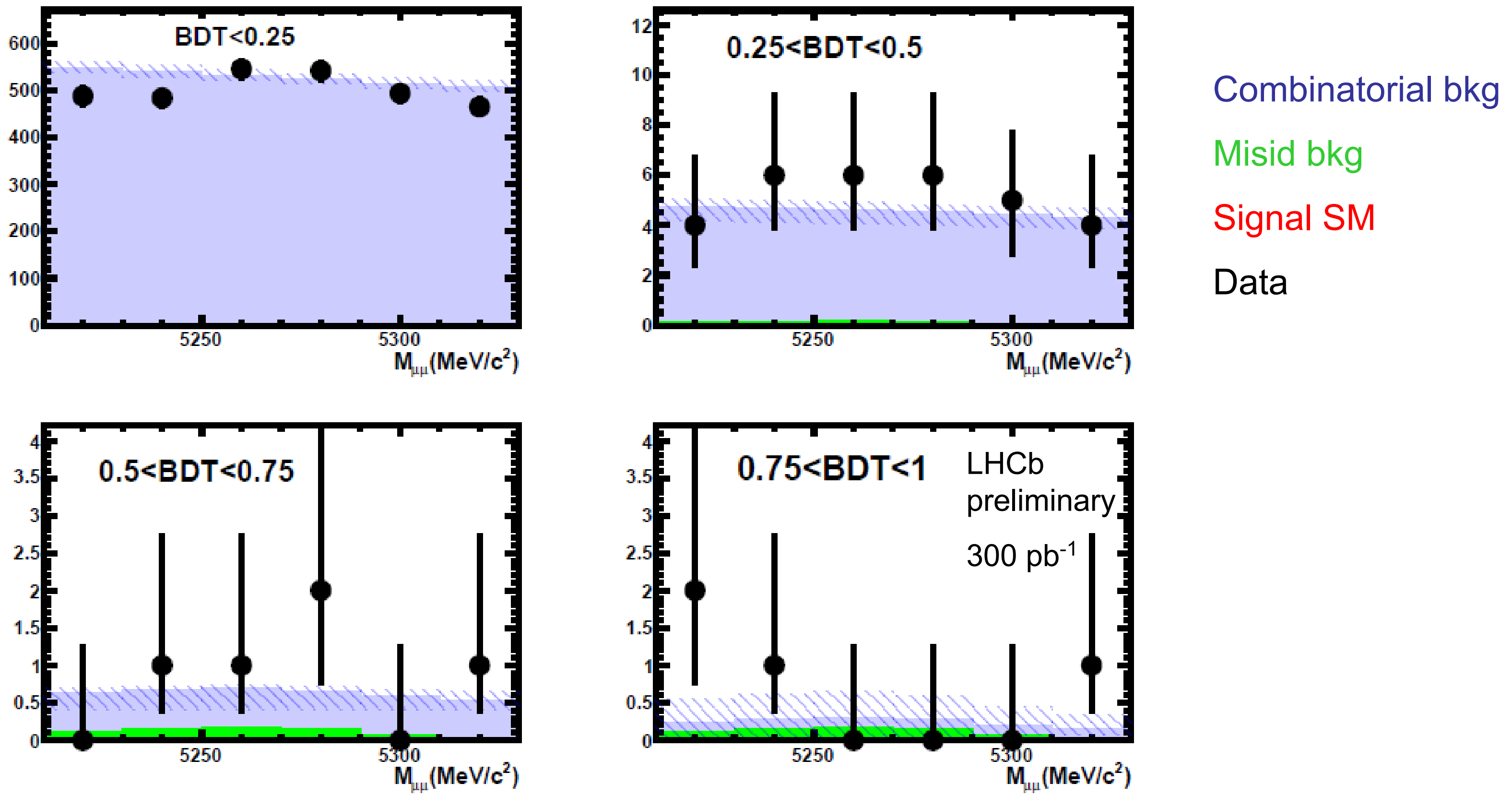
B_s region



	BDT<0.25	0.25<BDT<0.5	0.5<BDT<0.75	0.75<BDT
Exp.combinatorial	2968 ± 69	25 ± 2.5	2.99 ± 0.89	0.66 ± 0.40
Exp. SM signal	1.26 ± 0.13	0.61 ± 0.06	0.67 ± 0.07	0.72 ± 0.07
Observed	2872	26	3	2

misID background : 0.01±0.011 per bin

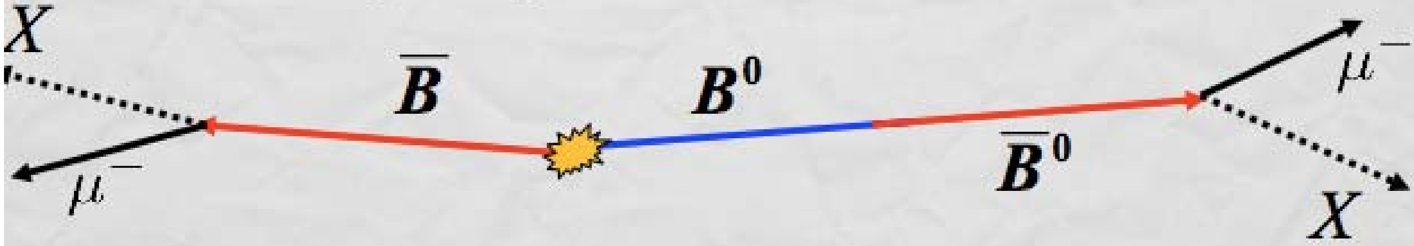
B_d region



	BDT<0.25	0.25<BDT<0.5	0.5<BDT<0.75	0.75<BDT
Exp.combinatorial	3175 ± 72	26.6 ± 2.5	3.1 ± 0.8	0.7 ± 0.4
Exp. MisID	0.6± 0.1	0.6± 0.1	0.6± 0.1	0.6± 0.1
Observed	3025	31	5	4

$B_{(s)}$ mixing : search for NP

In flavor-symmetric p̄p->b̄b, like-sign leptons arise from HF decays only if flavor oscillations occur.



SM predicts small asymmetry between numbers of ++ and -- muons from B. Enhancement implies NP in mixing.

- DØ: Evidence for anomalous dimuon charge asymmetry, (6 fb^{-1},PRL **105**, 081801 (2010))
  3.2σ deviation from $A^b_{sl}(SM) = (-0.023^{+0.005}_{-0.006})\%$

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Non-CP violating charge asymmetry measured directly in data

Update

- Increased statistics: 6.1 $fb^{-1} \rightarrow$ 9.0 fb^{-1}
- Improved muon selection (higher efficiency, lower background from $K \rightarrow \mu$, $\pi \rightarrow \mu$)
- Improved analysis technique
- From *b*'s? Study dependence of asymmetry on muon impact parameter

$$A^{\rm raw} = \frac{N(\mu^+\mu^+) - N(\mu^-\mu^-)}{N(\mu^+\mu^+) + N(\mu^-\mu^-)}$$

Constrain backg. ← Reduce syst.

$$a^{\rm raw} = \frac{n(\mu^+) - n(\mu^-)}{n(\mu^+) + n(\mu^-)}$$

Inclusive single muons

Mostly background

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DØ Update 9.0 fb^{-1} arXiv:1106.6308, sub. to PRD

$$A^b_{sl} = (-0.787 \pm 0.172 \pm 0.093)\%$$

Now a 3.9σ deviation from SM prediction

Central value closer to zero, still consistent with 6 fb^{-1} result