SUSY2014: The 22nd International Conference on Supersymmetry and Unification of Fundamental Interactions
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Searches for BSM Physics in Rare B-decays at CMS

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on behalf of the CMS Collaboration

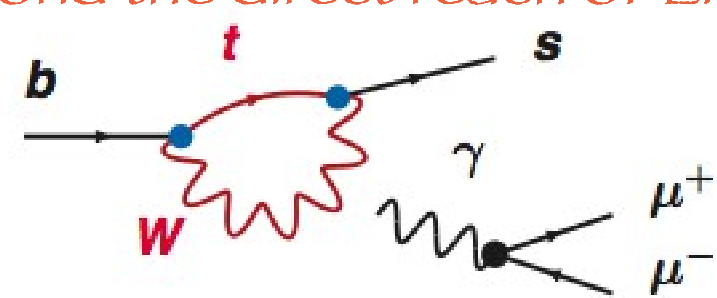
- Motivation
- $B \rightarrow \mu\mu$
- $B \rightarrow K^{(*)}\mu\mu$
- Constraints on New Physics

Motivation

Rare B decays: New Physics probes

- Search for deviations from Standard Model (SM) predictions due to virtual contributions of new heavy particles in loop processes
  - Compare experimental results with very precise SM expectations (uncertainty usually dominated by QCD)
- The most interesting processes are those that are strongly suppressed in the SM: Leptonic B-decays, FCNC ($K^{(*)}\mu^+\mu^-$) [but also LFV, CPV in B^0 mixing, c & τ]
  - New Physics (NP) could modify expectations by orders of magnitude [e.g. A. Buras, arXiv:0910.1032]

- Rare B decays can probe high scales potentially sensitive to NP beyond the direct reach of LHC:



$$\Lambda_{NP} \sim \frac{M_W}{g^2}\sqrt{\frac{16\pi^2}{|V_{ts}^* V_{tb}|}} \sim 10 \text{ TeV}$$

Rare B decays: New Physics probes

- Weak decay of hadron M into final state F described via an Effective Hamiltonian expressed by means of Operator Product Expansion:

$$A(M \rightarrow F) = \langle F | H_{eff} | M \rangle = \frac{G_F}{\sqrt{2}} \sum_i V^i_{CKM} C_i(\mu) \langle F | Q_i(\mu) | M \rangle$$

$C_i(\mu)$: Wilson Coefficients (perturbative short distance couplings)
$Q_i(\mu)$: Hadronic Matrix Elements (non -perturbative long distance effects)

- NP could modify Wilson Coefficients $C_i(\mu)$ and/or add new operators $Q_i(\mu)$

- Complementary information from different rare decays:

$B \rightarrow \mu\mu$: Scalar/Pseudoscalar interactions

$B \rightarrow K^{(*)}\mu\mu$: Vector/axial interactions

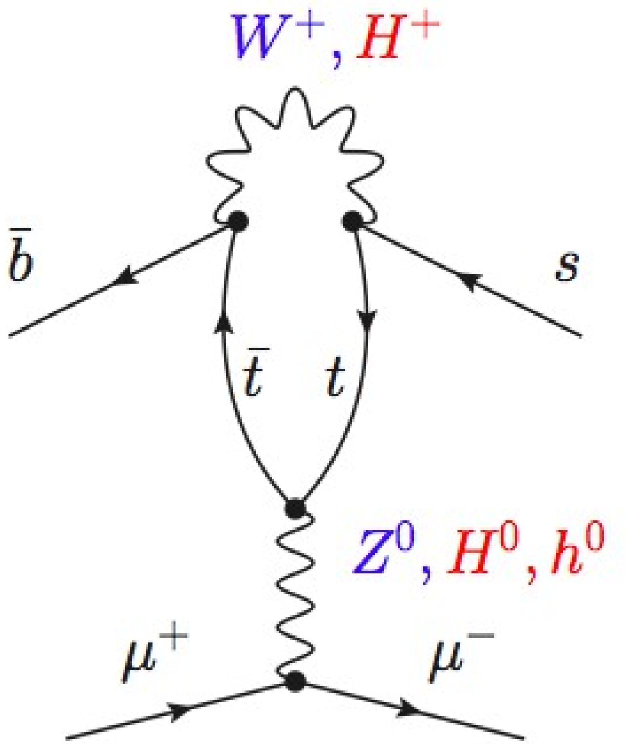
$B \rightarrow \mu^+\mu^-$

"Measurement of the $B^0_s \rightarrow \mu^+\mu^-$ branching fraction and Search for B^0 $\mu^+\mu^-$ with the CMS Experiment"

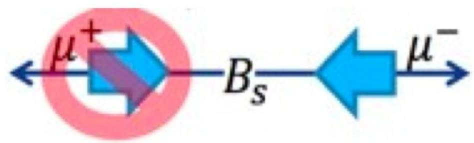
[L = 5 fb^{-1} ($\sqrt{S}$=7 TeV)+20 fb^{-1} ($\sqrt{S}$=8 TeV)]

Phys. Rev. Lett. 111, 101804 (2013)

$B \to \mu^+\mu^-$



- FCNC process forbidden at tree level,
- Helicity suppressed $\sim(m_\mu/m_B)^2$



- Cabibbo suppressed $|V_{ts(td)}|^2$
  - BR~10^{-9}: Probe the SM!

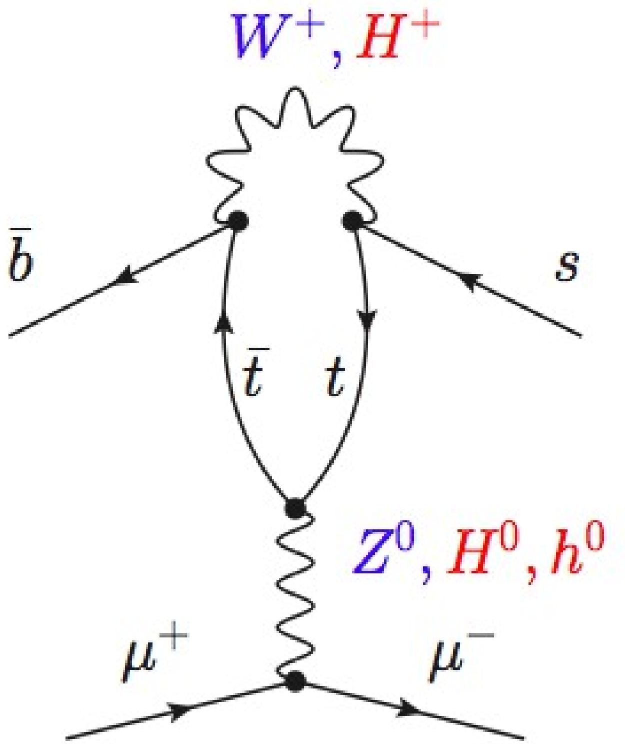
- SM: suppression of B_d over B_s ~$|V_{td}|/|V_{ts}|$:

  $BR(B_s \to \mu^+\mu^-) = (3.2 \pm 0.2)\ 10^{-9}$ [Buras et al., Eur. Phys. J C72, 2172 (2012)]

  $BR(B_d \to \mu^+\mu^-) = (0.11 \pm 0.01)\ 10^{-9}$

  Uncertainties from f_{Bs} (lattice), V_{tb}, V_{ts}, m_t, τ_{Bs}

$B \rightarrow \mu^+\mu^-$



- Golden mode to search for New Physics with scalar/pseudo-scalar interactions

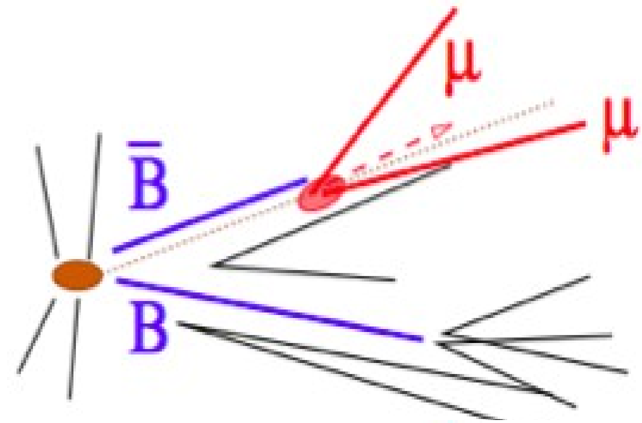
- NP scenarios in the extended Higgs sector:
  - May enhance or suppress the BR wrt SM
  - Show different tan β dependence:
    - MSSM: BR ~ $\tan^6\beta/M^4_A$
    - 2 Higgs Doublet Models: BR ~ $\tan^4\beta$

- BR($B_d \rightarrow \mu^+\mu^-$) vs BR($B_s \rightarrow \mu^+\mu^-$):

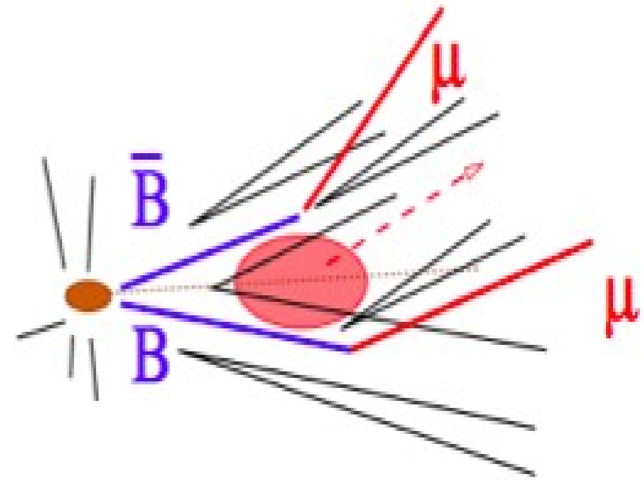
Test of Minimal Flavor Violation: general structure of SM FCNC is preserved, flavor violation depends only on CKM

$B \rightarrow \mu^+\mu^-$

- Signal:
  - Two isolated muons from a secondary vertex
  - $M(\mu^+\mu^-) \sim M(B^0_{s(d)})$
  - Momentum aligned with flight directior

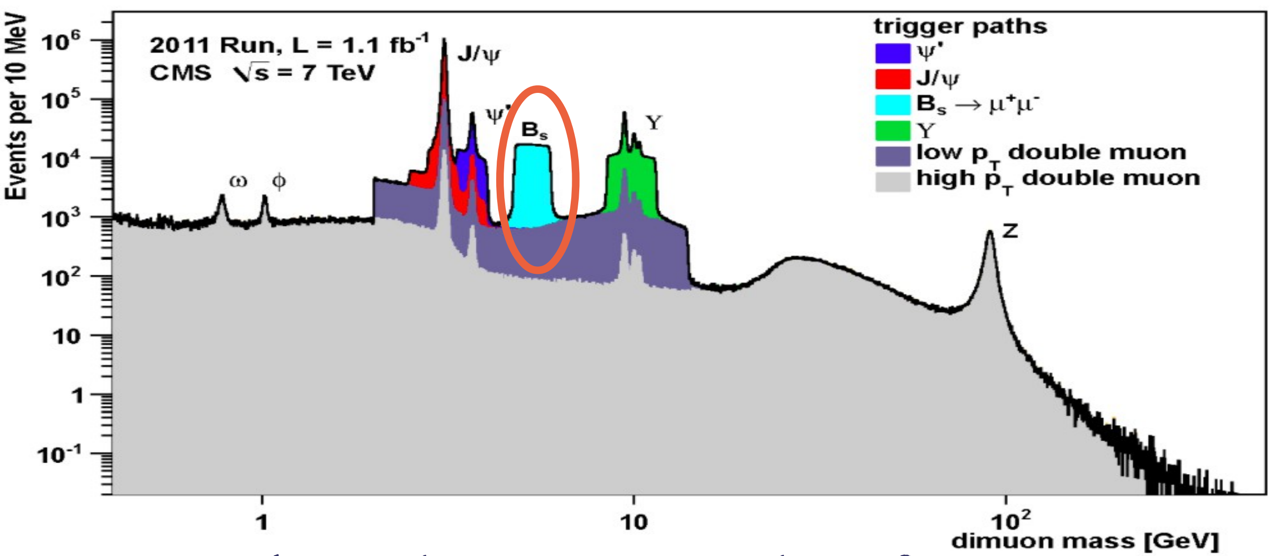


- BKG:
  - Combinatorial from uncorrelated B semileptonic decays
  - Physical:
    - Peaking $B \rightarrow hh'$ (h=misidentified K, π) ($BR \sim 10^{-7}/10^{-5}$)
    - Non Peaking $B \rightarrow h\mu\nu$, $B \rightarrow h\mu\mu$, $\Lambda_b \rightarrow p\mu\nu$



$B \to \mu^+\mu^-$

- Strategy:
  - Use of dedicated dimuon trigger path:

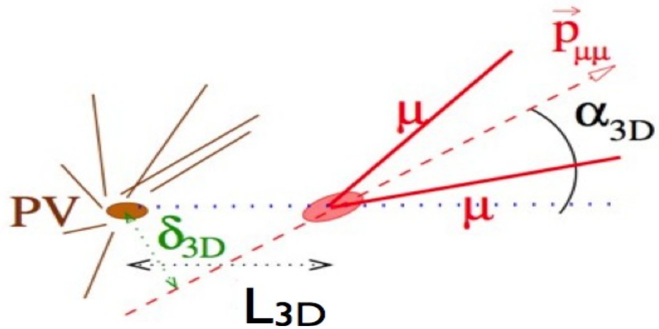


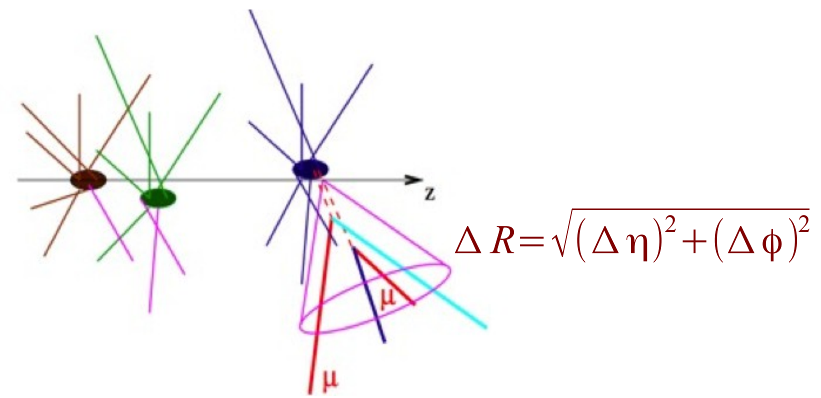
Hardware Trigger:
$P_T(\mu)>3$ GeV (few kHz)
High Level Trigger 2011 (2012):
Central region ($|\eta|<1.8$):
$P_T(\mu)>4$ (3) GeV, $P_T(\mu\mu)>3.9$ (4.9) GeV,
$4.8<M(\mu\mu)<6$ GeV
Forward region ($1.8<|\eta|<2.2$):
$P_T(\mu)>4$ GeV, $P_T(\mu\mu)>7$, Prob(VTX)>0.5%

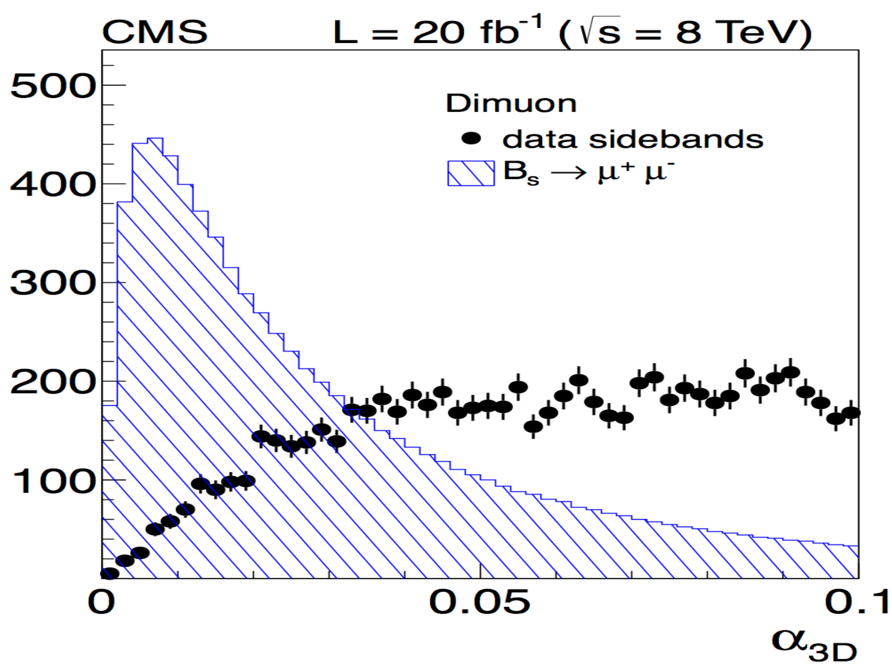
  - BDT-based muon (Mis)identification:
    - Exploits kinematic quantities, silicon-tracker fit information and combined silicon/muon track fit information
    - Studied on MC/data control samples ($B_s \to KK$, $B^0 \to \pi\pi$, $K^0 \to \pi\pi$, $\Lambda \to p\pi$, $D^* \to D^0\pi$)
    - $\varepsilon(\pi \to \mu)<0.13\%$, $\varepsilon(K \to \mu)<0.22\%$, $\varepsilon(p \to \mu)<0.15\%$

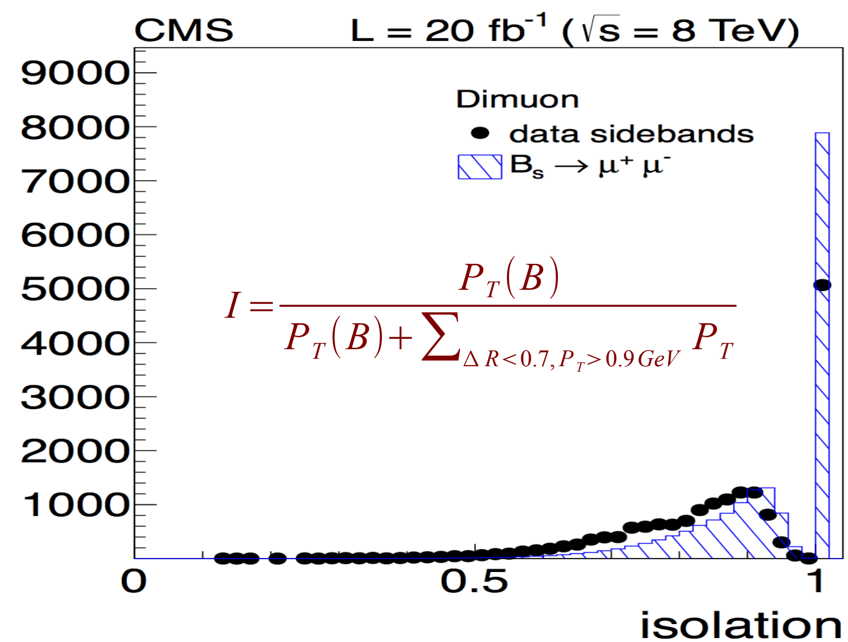
$B \to \mu^+\mu^-$

- Strategy:
  - Events selected by means of a MVA exploiting kinematic, vertexing and isolation variables









$B \rightarrow \mu^+\mu^-$

- Strategy:
  - Events selected by means of a MVA exploiting kinematic, vertexing and isolation variables
  - Measure event yields from an unbinned simultaneous fit to M(μμ)
  - BR obtained relative to the normalization channel $B^+ \rightarrow K^+ J/\psi$ to avoid systematics from cross section & luminosity, and reduce efficiency uncertainty:

$$B(B_s^0 \rightarrow \mu^+\mu^-) = \frac{Y_S}{Y_N}\frac{\epsilon_N}{\epsilon_S}\frac{f_U}{f_S} B(B^+ \rightarrow K^+ J/\psi \rightarrow K^+\mu^+\mu^-)$$

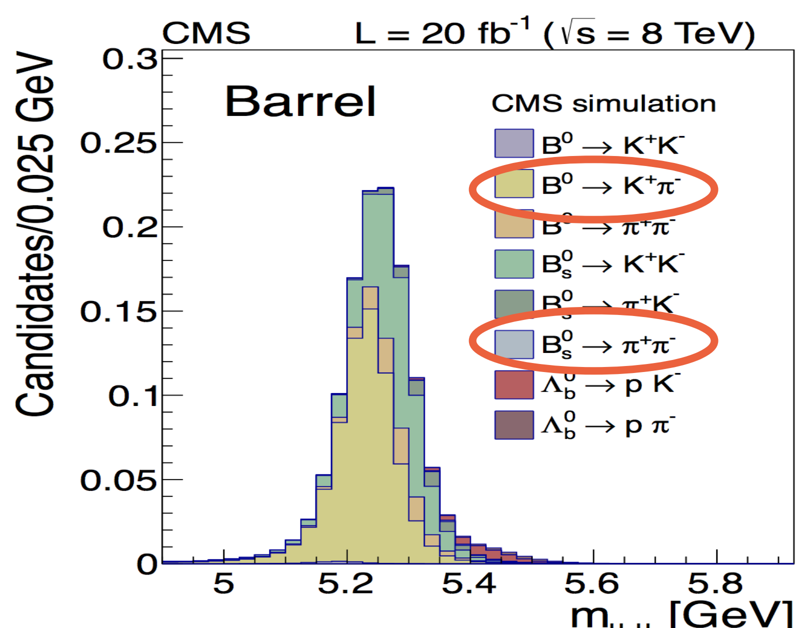
Y_S, Y_N	Signal and Normalization Yields
ϵ_S, ϵ_N	Signal and Normalization Efficiencies
$\frac{f_U}{f_S} = 0.256 \pm 0.020$	Ratio between B^+ and B^0_s fragmentation functions [LHCb, JHEP 04 (2013) 001]

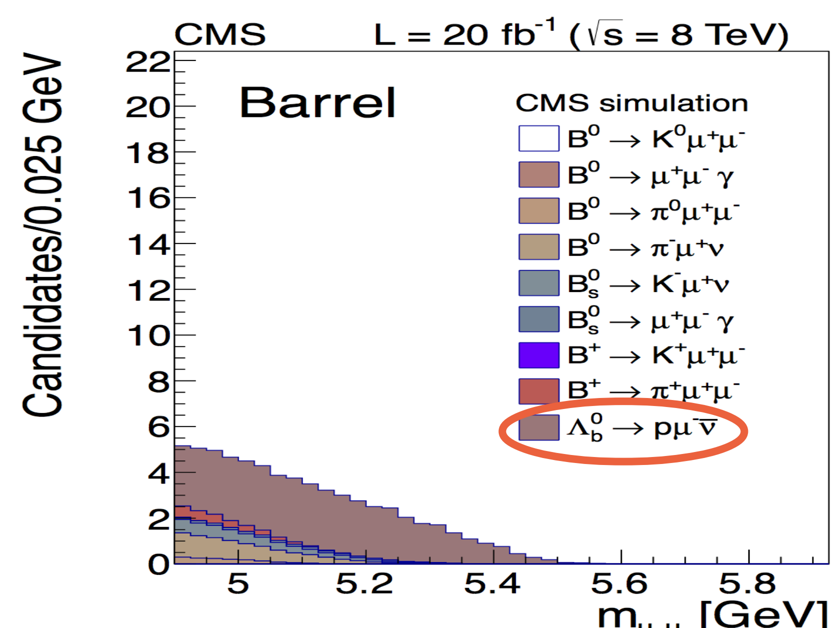
  - Data/MC agreement checked on $B_s \rightarrow J/\psi\,\varphi$ control sample

$B \to \mu^+\mu^-$

- Strategy:
  - Combinatorial BKG from Side Bands extrapolation
  - Semileptonic & Peaking BKG estimated normalizing to $B^+ \to K^+ J/\psi$

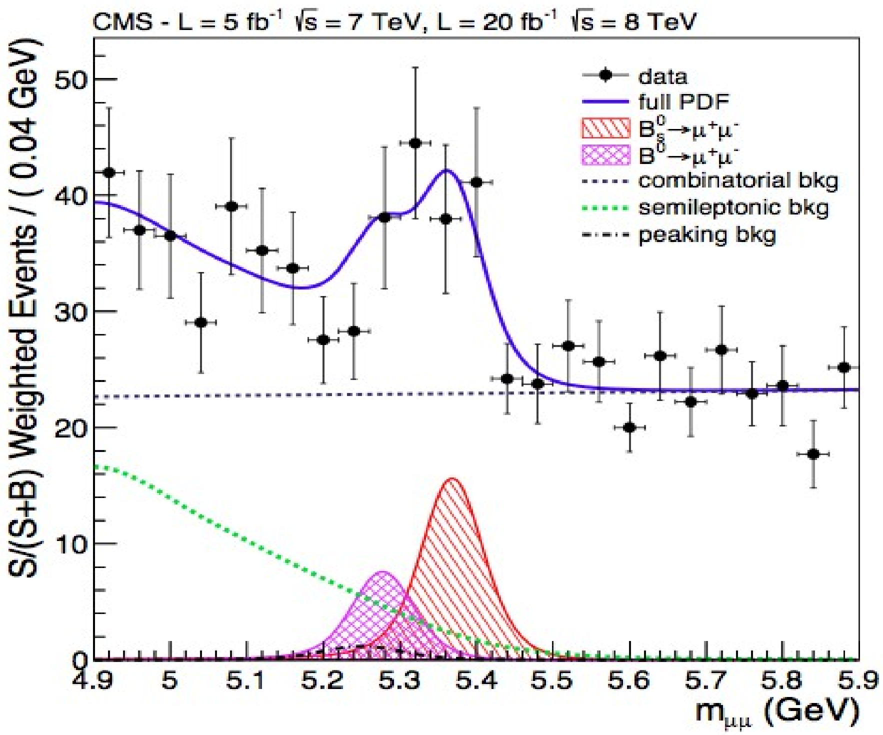
$$N(Y \to X) = \frac{BR(Y \to X)}{BR(B^+ \to K^+ J/\psi)} \frac{\epsilon(X)}{\epsilon(B^+)} \frac{f_Y}{f_U} N(B^+ \to K^+ J/\psi)$$

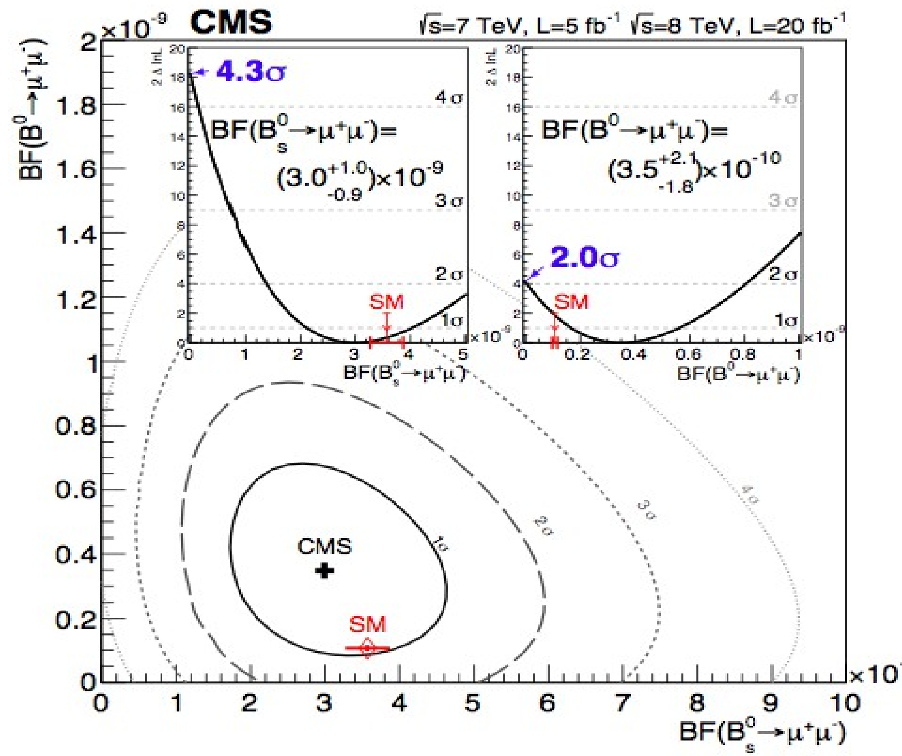




  - Peaking BKG checked with independent analysis of $B \to hh'$

$B \to \mu^+\mu^-$: Results





- Results:

  $BR(B_s \to \mu^+\mu^-) = (3.0\,^{+0.9}_{-0.8}\,(stat)\,^{+0.6}_{-0.4}\,(syst)\,10^{-9})$ (4.3 σ significance)

  $BR(B^0 \to \mu^+\mu^-) < 1.1 \times 10^{-9}$ @ 95% CL

- Systematics from muon misidentification, BR of rare BKG decays ($\Lambda_b \to p\mu\nu$) and normalization of peaking BKG

Comparison with other experiments

- ATLAS from 4.9 fb^{-1} using a BDT analysis:

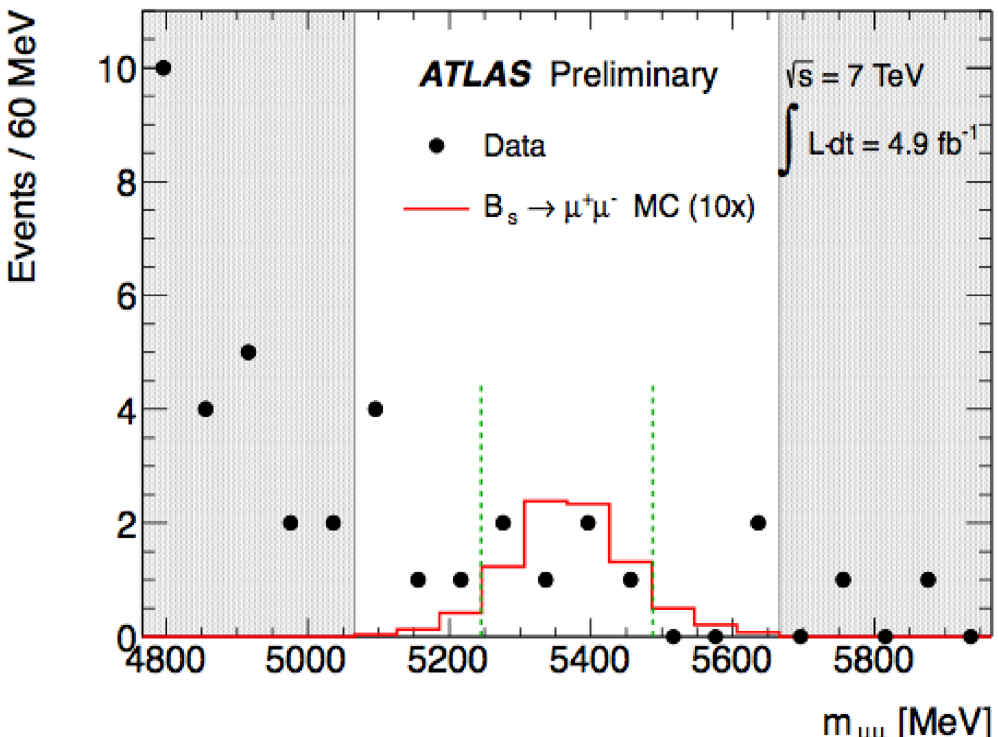
  $BR(B_s \to \mu^+\mu^-) < 1.5\ 10^{-8}$ @ 95% CL

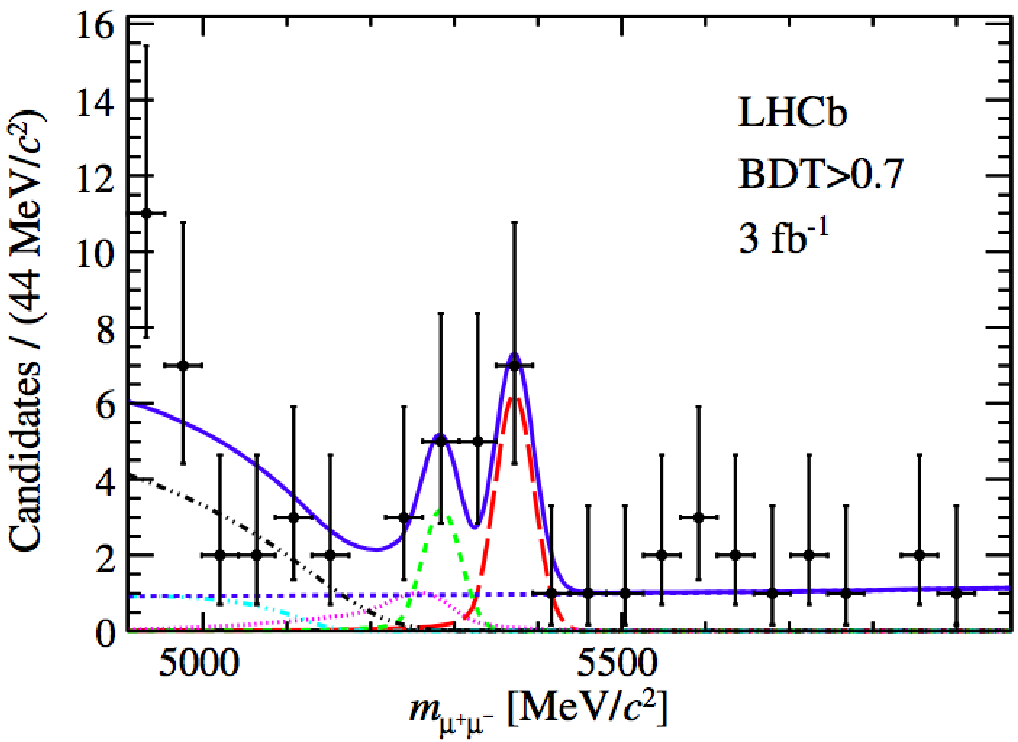
- LHCb from 3 fb^{-1} using a BDT analysis:

  $BR(B_s \to \mu^+\mu^-) = 2.9^{+1.1}_{-1.0}\ 10^{-9}$ (4.0 σ significance)

  $BR(B^0 \to \mu^+\mu^-) < 7.4 \times 10^{-10}$ @ 95% CL

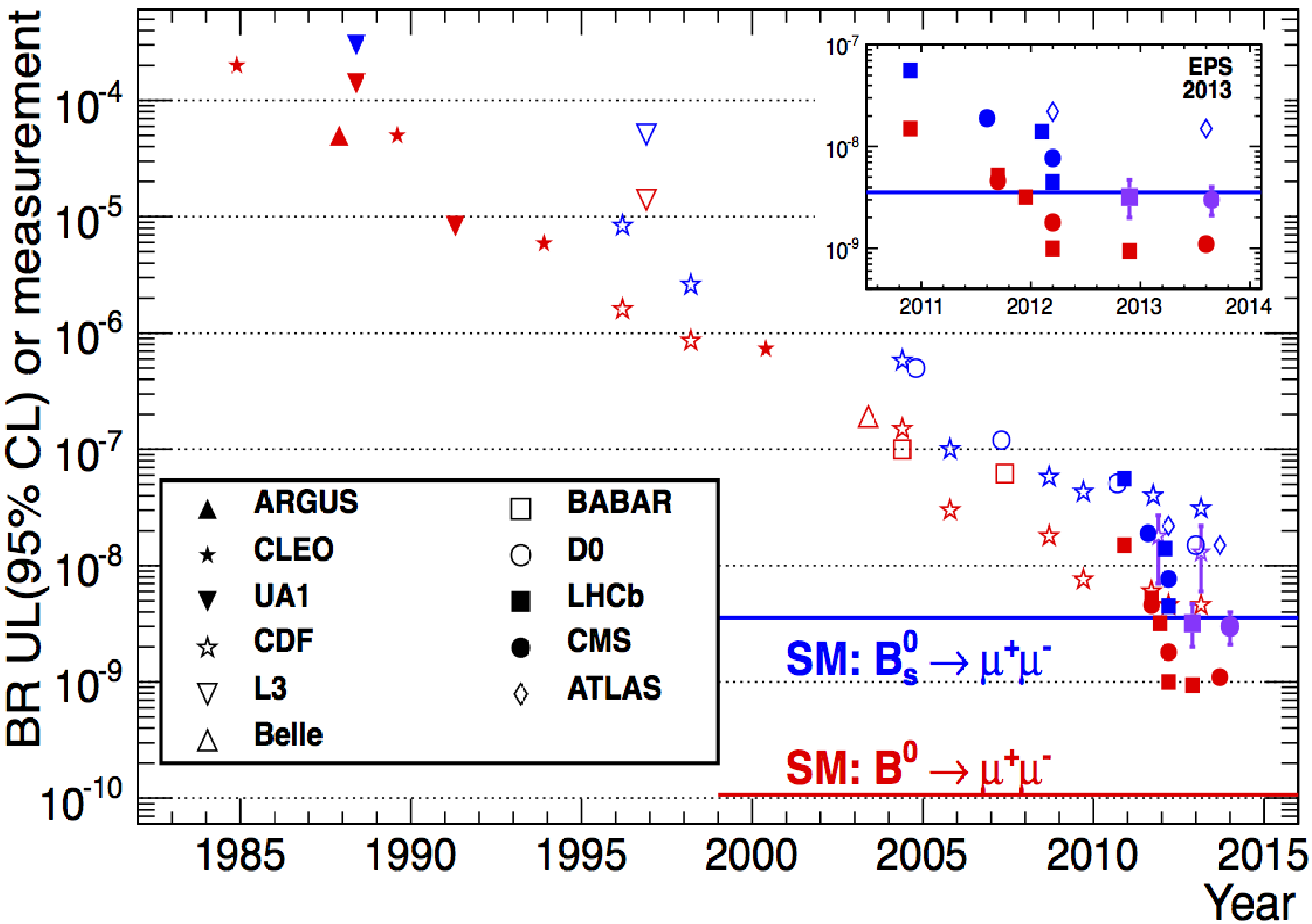
[ATLAS-CONF-2013-076]
[LHCb: PRL 111, 101805 (2013)]





Comparison with other experiments

History of a long search



$B^0 \to \mu^+\mu^-$:

Let's wait for next LHC Runs

$B \to \mu^+\mu^-$: Combination

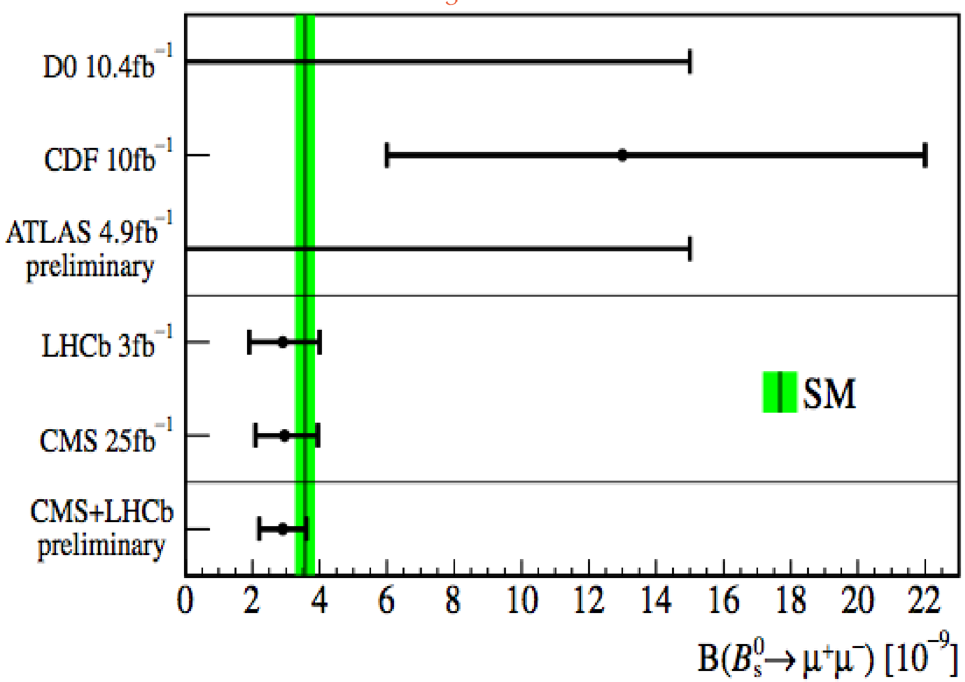
CMS-PAS-BPH-13-007
LHCb-CONF-2013-012

- Preliminary CMS+LHCb combination
  - Taking into account correlation from f_s/f_u [LHCb, JHEP 04 (2013) 001]

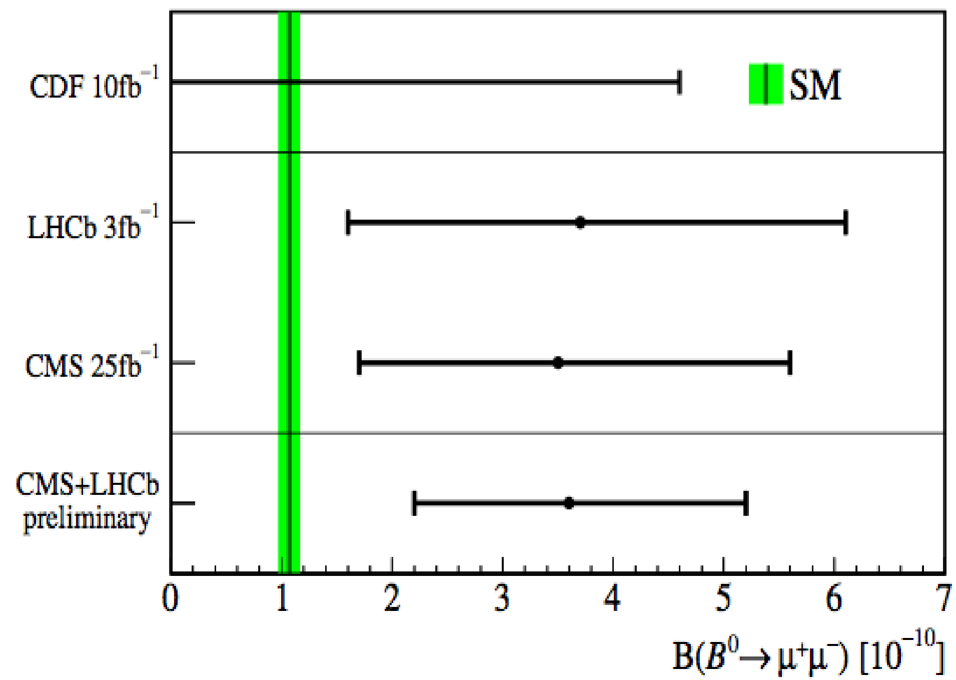
$BR(B_s \to \mu^+\mu^-) = (2.9 \pm 0.7)\ 10^{-9}$ (>5 σ significance)

$BR(B^0 \to \mu^+\mu^-) = (3.6\ ^{+1.6}_{-1.4})\ 10^{-10}$ (<3 σ significance)

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

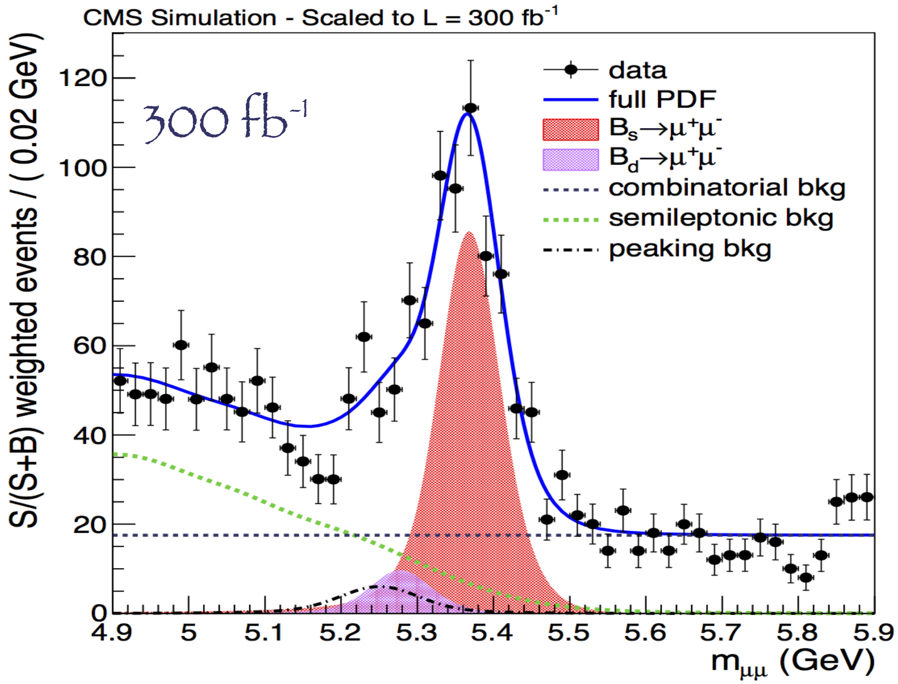


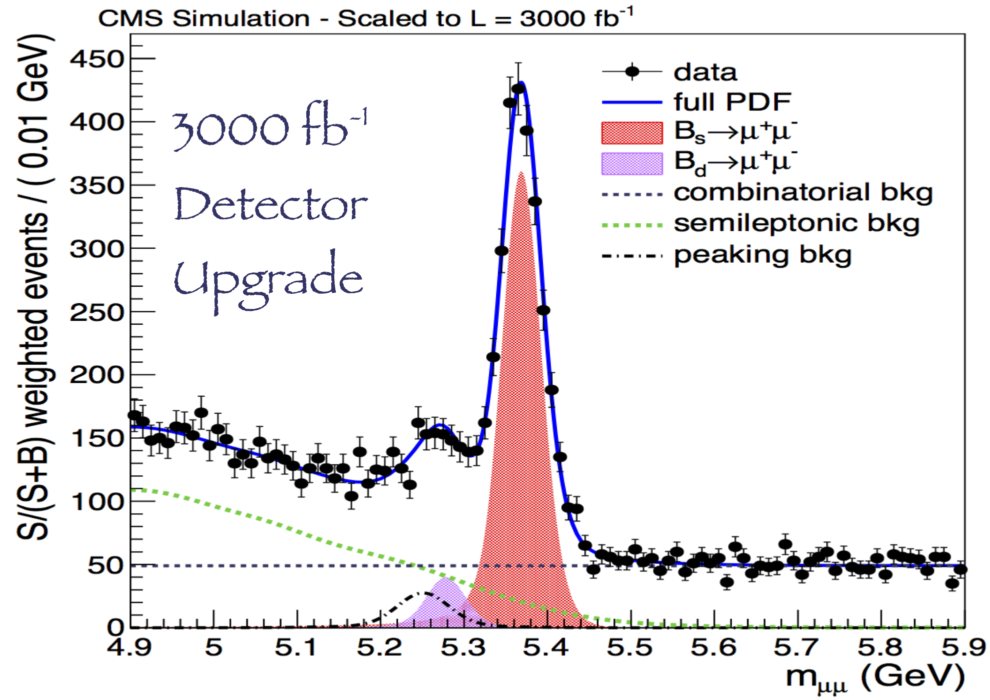
$B^0 \to \mu^+\mu^-$



What Next on $B \rightarrow \mu^+\mu^-$?

[CMS PAS FTR-13-022]





Year	L (fb^{-1})	No. of B_s^0	No. of B^0	$\delta\mathcal{B}/\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	$\delta\mathcal{B}/\mathcal{B}(B^0 \to \mu^+\mu^-)$	B^0 sign.	$\delta\frac{\mathcal{B}(B^0\to\mu^+\mu^-)}{\mathcal{B}(B_s^0\to\mu^+\mu^-)}$
now	20	16.5	2.0	35%	>100%	0.0–1.5 σ	>100%
2018	100	144	18	15%	66%	0.5–2.4 σ	71%
2021	300	433	54	12%	45%	1.3–3.3 σ	47%
2023	3000	2096	256	12%	18%	5.4–7.6 σ	21%

- Expected number of events assuming SM BRs
- HI-LHC: Inner tracker with improved granularity & muon detector with extended coverage

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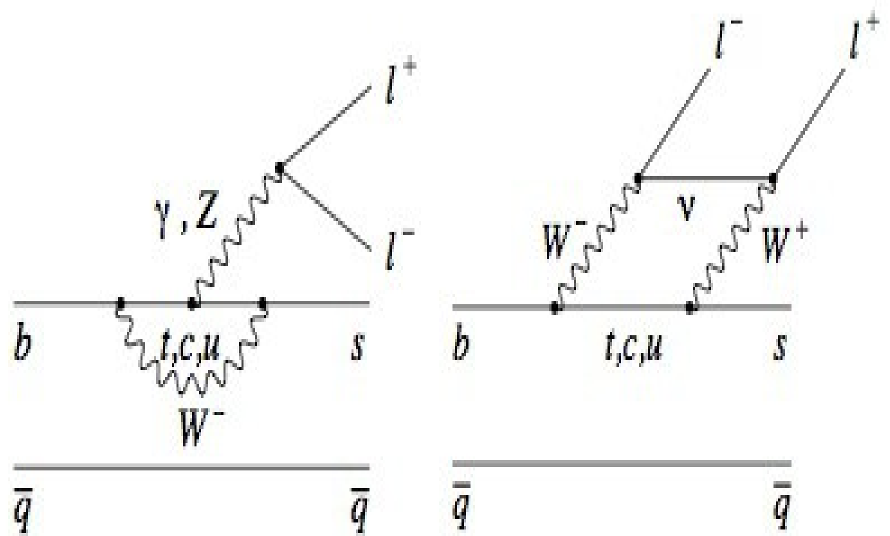
$B^0 \rightarrow K^{*0}\mu^+\mu^-$

"Angular analysis and branching fraction measurement of the decay $B^0 \rightarrow K^{*0}\mu^+\mu^-$ "

[L = 5.2 fb^{-1} ($\sqrt{S}$=7 TeV)]

Phys. Lett. B 727, (2013) 77-100

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

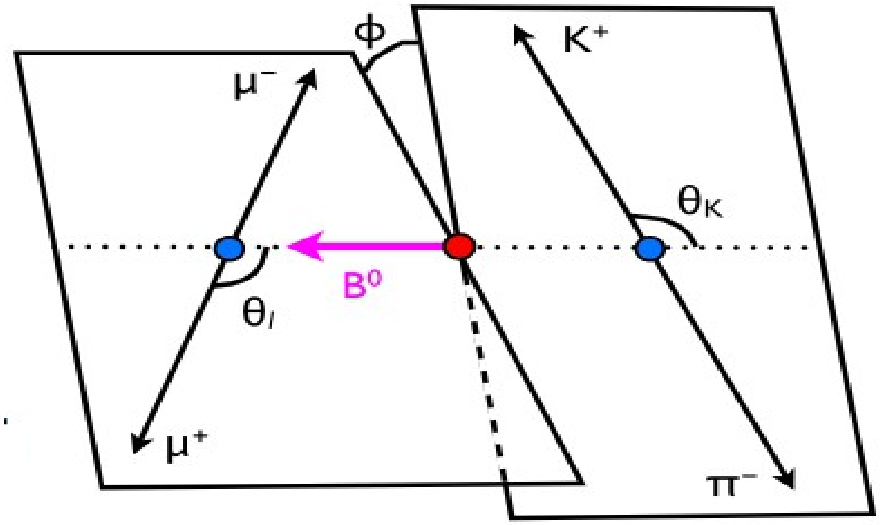


FCNC process forbidden at tree level, BR~10^{-6}: Probe the SM!

- Sensitive to the effects of NP in photon, vector and axial-vector couplings which can enter at the same order as SM contributions
- Complementary information to $B \to \mu^+ \mu^-$

- Amplitudes expressed using OPE in terms of:
  - Hadronic Form Factors (accuracy ~20%) [A. Barucha et al. arXiv 1004.3249]
  - Wilson coefficients C^{eff}_7, C^{eff}_9, C^{eff}_{10} [A. Ali et al.,PRD 61 074024, Z. Phys. C 67 417]
  - Clean theoretical predictions expecially at low $q^2=m^2(\mu^+\mu^-)$
  - Experimentally clean signature

$B \to K^{*}\mu^{+}\mu^{-}$



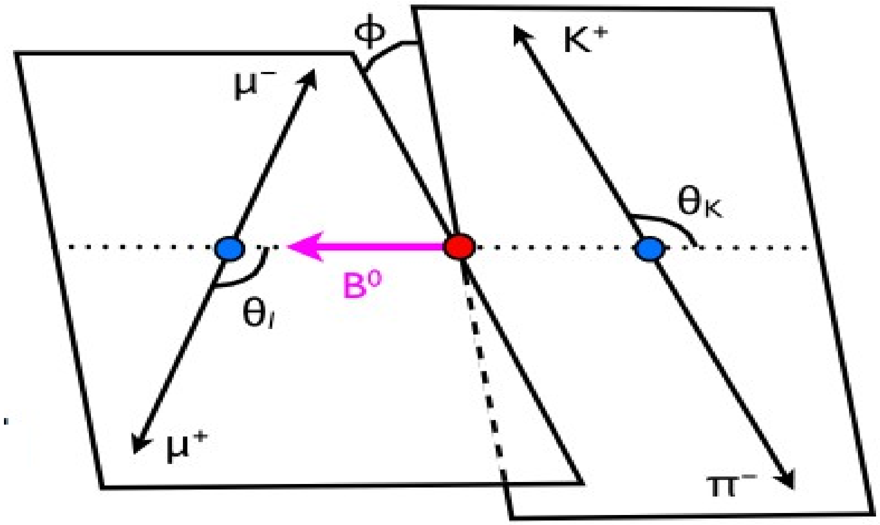
- Kinematics of the decay $B \to V\mu^{+}\mu^{-}$ (V=K*, φ, ρ) determined by three angles:
  - θ_l, θ_K, ϕ
- Event Yields reconstructed in bins of $q^2=m^2(\mu^+\mu^-)$

- Differential Amplitude:

$$\frac{1}{\Gamma}\frac{d^3\Gamma}{d\cos\theta_K\, d\cos\theta_l\, dq^2} = \frac{9}{16}\Bigg\{\left[\frac{2}{3}F_S + \frac{4}{3}A_S\cos\theta_K\right](1-\cos^2\theta_l) + (1-F_S)\Big[2F_L\cos^2\theta_K(1-\cos^2\theta_l) + \frac{1}{2}(1-F_L)(1-\cos^2\theta_K)(1+\cos^2\theta_l) + \frac{4}{3}A_{FB}(1-\cos^2\theta_K)\cos\theta_l\Big]\Bigg\}.$$

- Observables Include:
  - Differential Branching Ratio dB/dq^2
  - A_{FB} (forward-backward muon asymmetry)
  - F_L (fraction of longitudinally polarized K*)

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



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- Differential Amplitude:

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- F_S: Fraction of spinless Kπ (S-wave) combination
- A_S: Interference amplitude between S-wave and P-wave decays
  - F_S=0.01±0.01, A_S=-0.10±0.01 fitted on the $B^0 \to K^* J/\psi$ control sample

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

- Strategy:
  - Measure event yield Y_S, A_{FB} and F_L from an unbinned simultaneous fit to $M(K\pi\mu\mu)$, $\cos(\theta_K)$ and $\cos(\theta_l)$ in bins of q^2
  - dB/dq^2 obtained relative to the normalization channel $B^0 \to K^* J/\psi$:

$$\frac{dB(B^0 \to K^{*0} \mu^+ \mu^-)}{dq^2} = \frac{Y_S}{Y_N} \frac{\epsilon_N}{\epsilon_S} B(B^0 \to K^{*0} J/\psi \to K^{*0} \mu^+ \mu^-)$$

Y_S, Y_N Signal and Normalization Yields

ϵ_S, ϵ_N Signal and Normalization Efficiencies

$$PDF(M, \cos\theta_K, \cos\theta_l) = Y_S \cdot S(M) \cdot S(\cos\theta_K, \cos\theta_l) \cdot \epsilon(\cos\theta_K, \cos\theta_l)$$ Signal

$$+ Y_{Bc} \cdot B_C(M) \cdot B_C(\cos\theta_K) \cdot B_C(\cos\theta_l)$$ Combinatorial

$$+ Y_{Bp} \cdot B_P(M) \cdot B_P(\cos\theta_K) \cdot B_P(\cos\theta_l)$$ Peaking BKG from $B^0 \to K^* J/\psi(\psi')$

Y_S, Y_{Bc}, Y_{Bp} Event Yields

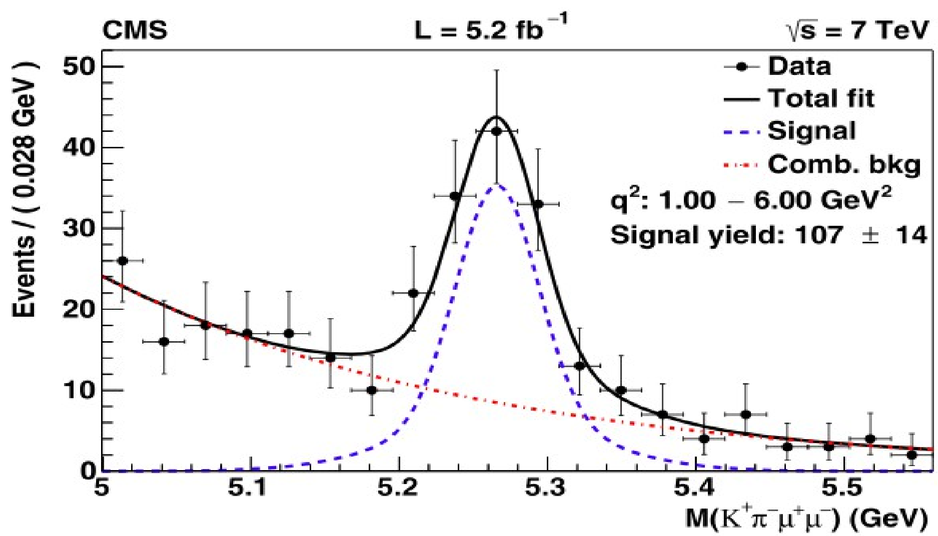
$S(\cos\theta_K, \cos\theta_l), \epsilon(\cos\theta_K, \cos\theta_l)$ Signal 2D angular shape and efficiency

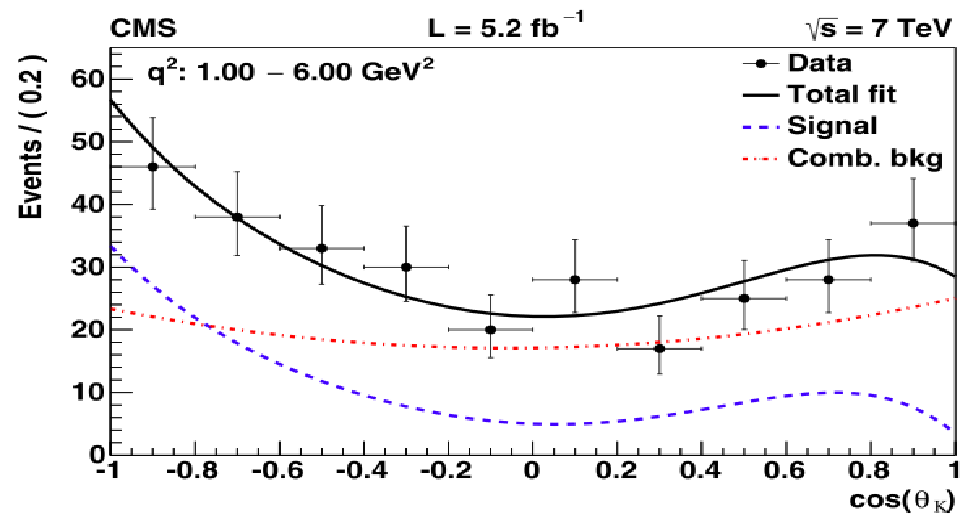
$S(M), B_C(M), B_P(M)$ Mass PDFs

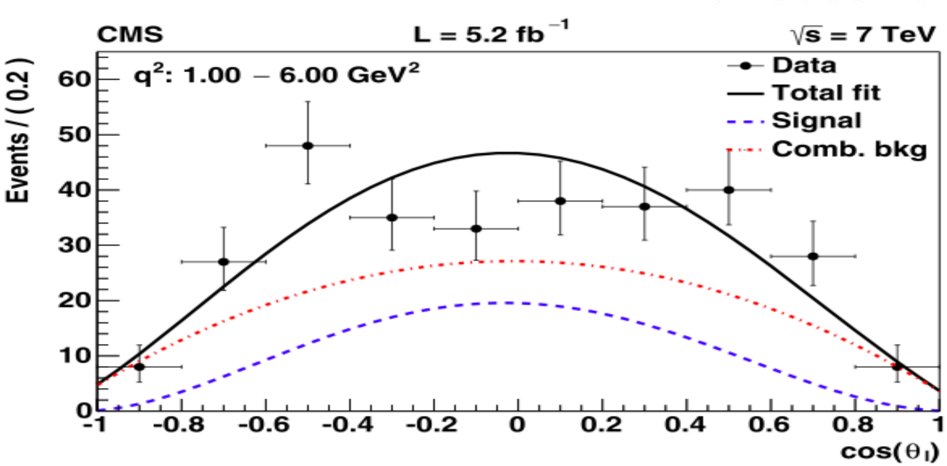
$B_C(\cos\theta_{K(l)}), B_P(\cos\theta_{K(l)})$ Angular BKG PDFs

$B \rightarrow K^{*}\mu^{+}\mu^{-}$

- Strategy:
  - Measure dBR/dq^2, A_{FB} and F_L from an unbinned simultaneous fit to $M(K\pi\mu\mu)$, $\cos(\theta_K)$ and $\cos(\theta_l)$ in bins of q^2

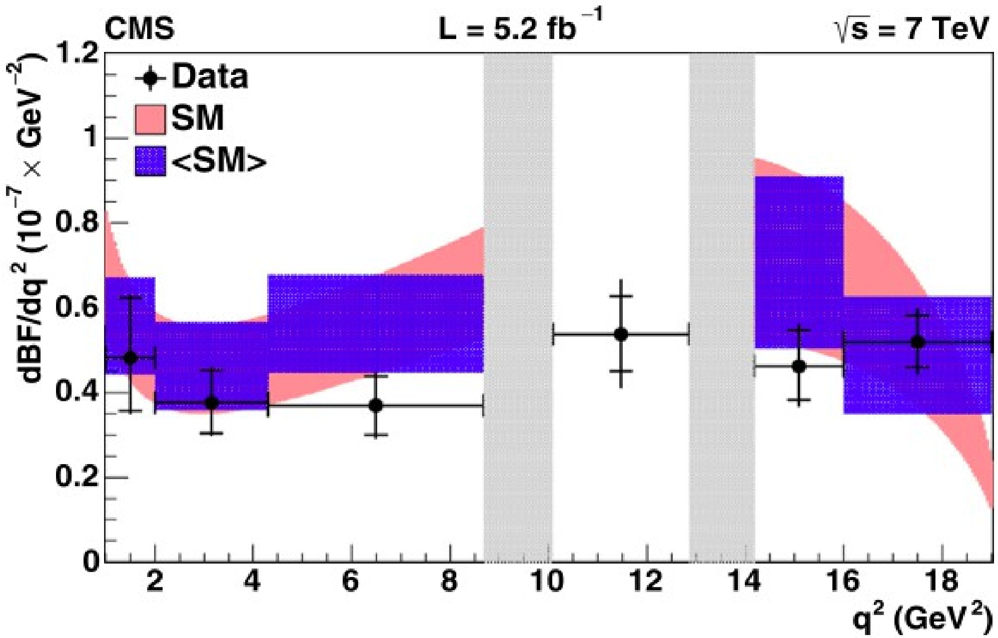


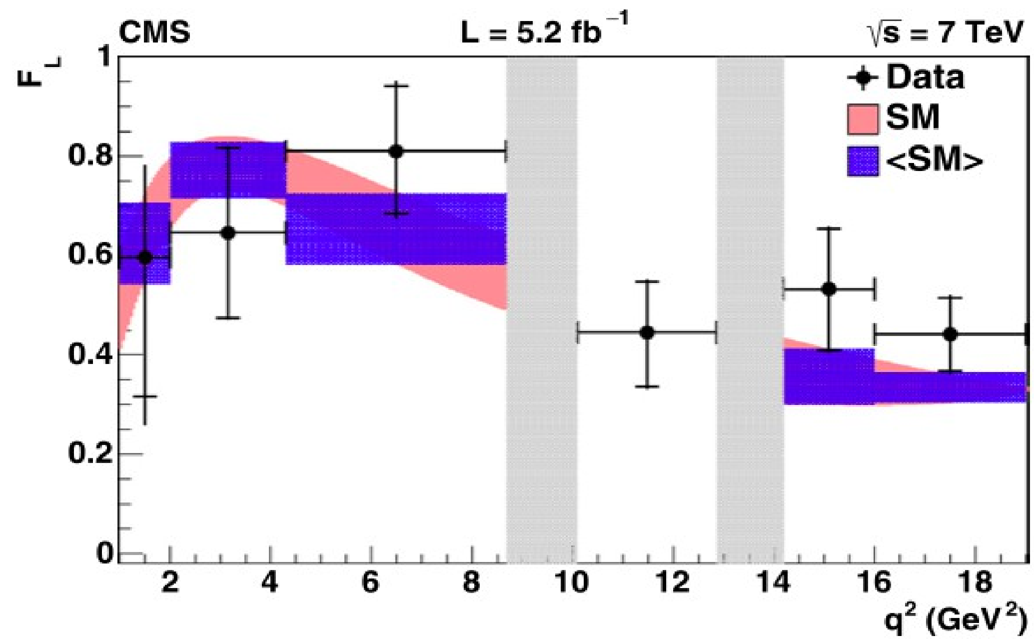


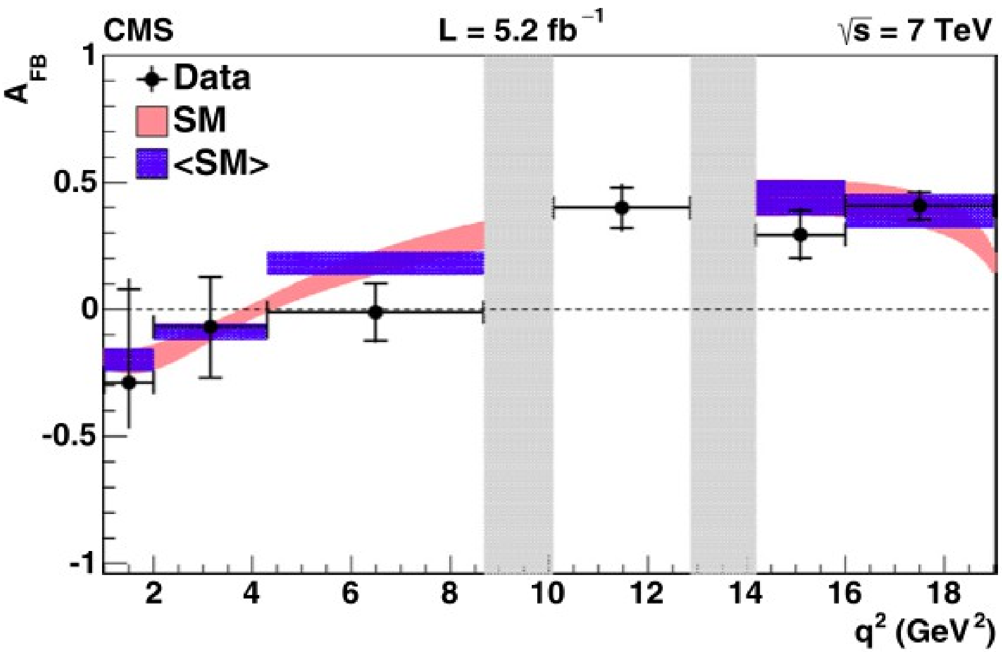


- B flavor tagging from $K\pi$ charge
- BKG PDFs:
  - Combinatorial from MC
  - Peaking parameterized on MC
  - $B \rightarrow K^{*}J/\psi(\psi')$

$B \to K^{*}\mu^{+}\mu^{-}$: Results



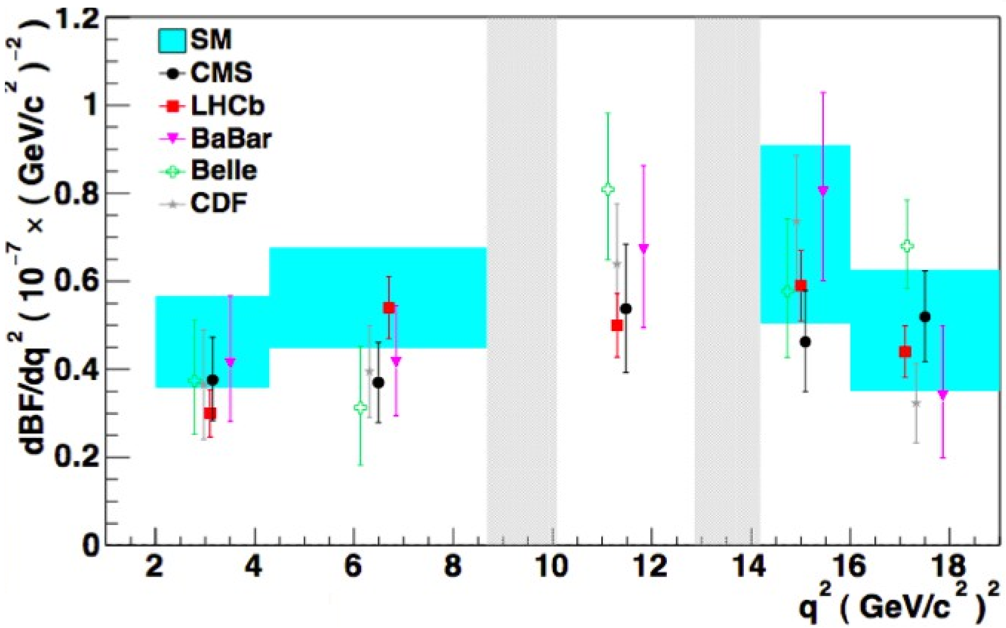


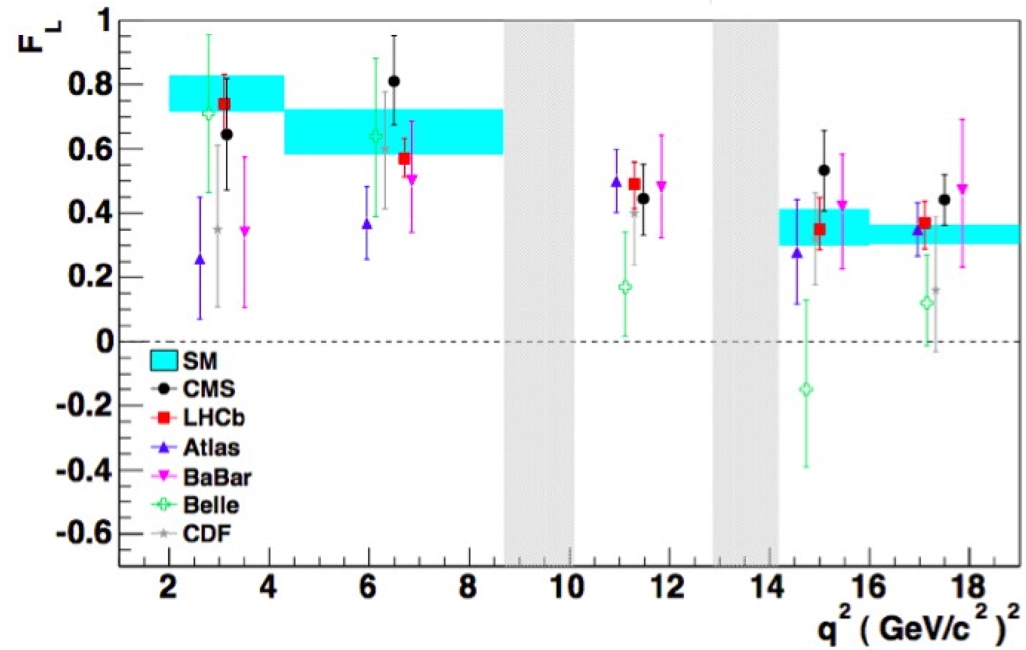


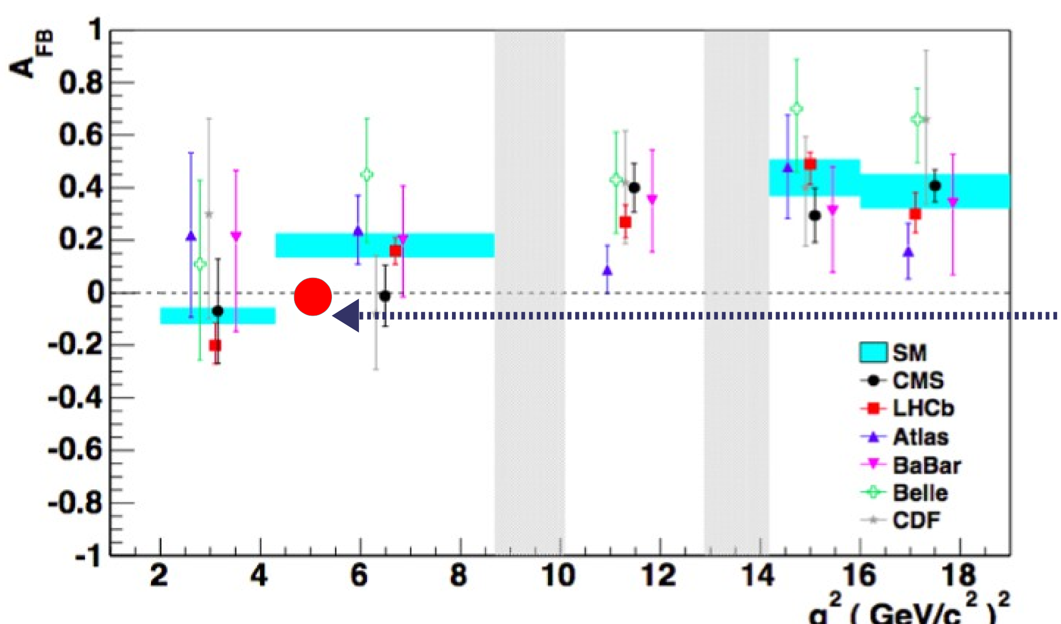
Results consistent with SM

- Theoretical and experimental errors comparable
- Systematics from Peaking BKG mass shape, $\cos(\theta_{l,K})$ BKG shape and S-wave contribution

Comparison with other experiments







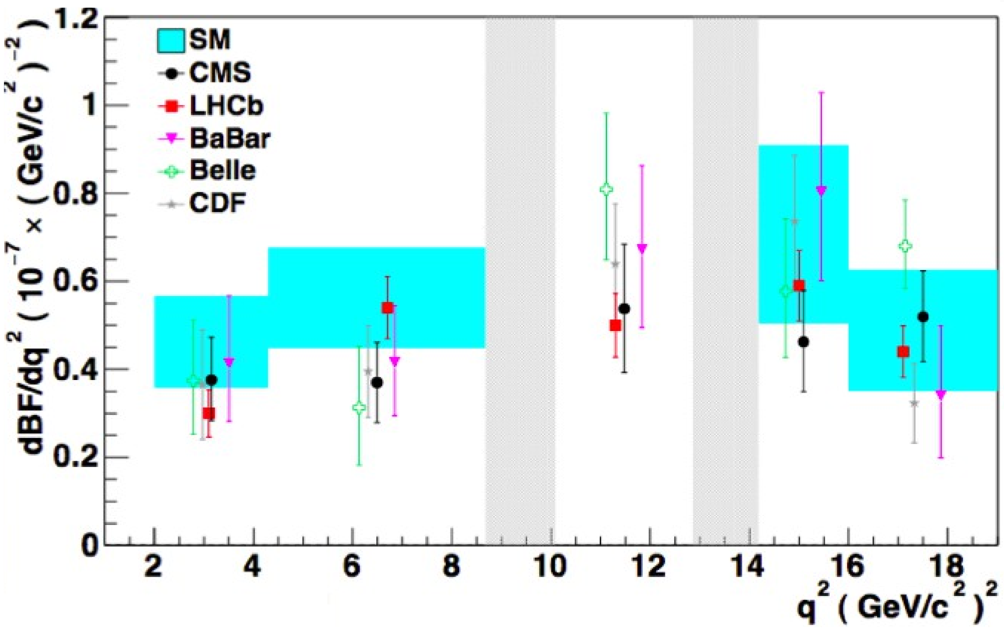
- LHCb measures the position of the zero-crossing point theoretically clean [JHEP 1308 131]:

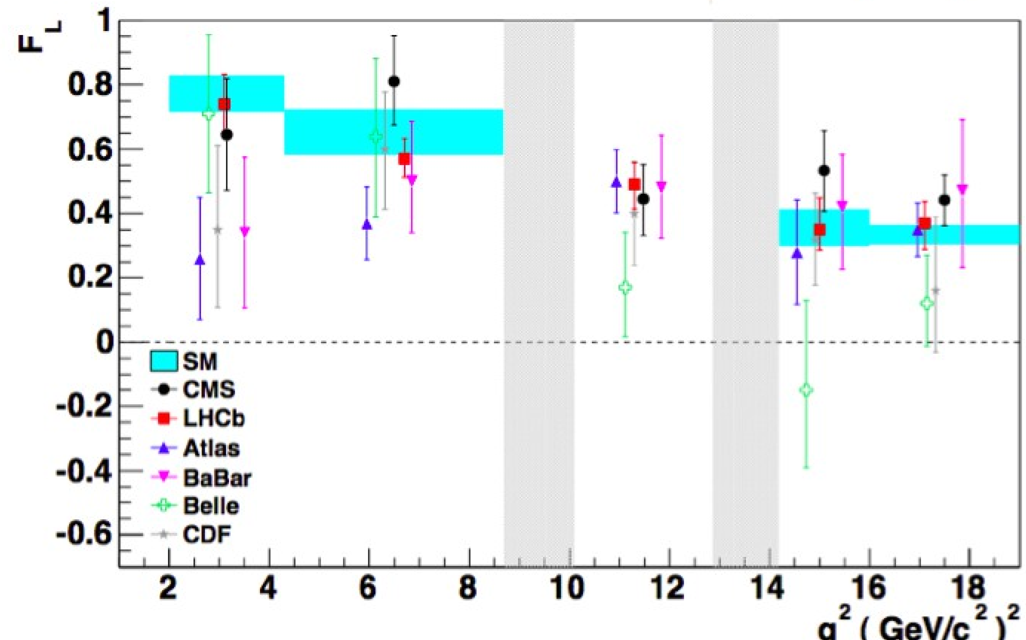
  q_0^2=4.9 ±0.9 GeV^2

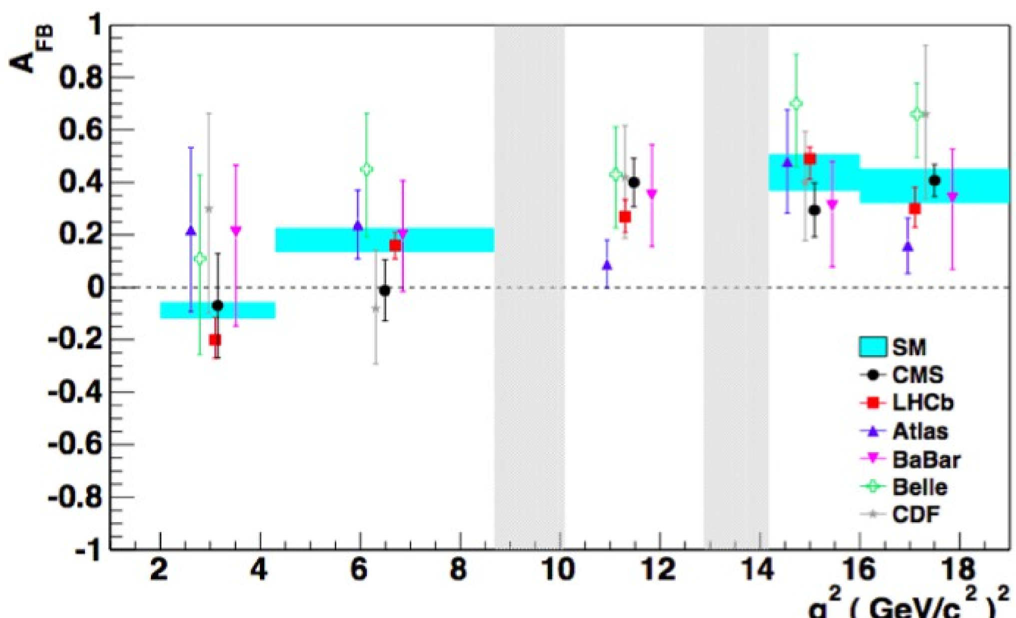
  In agreement with the SM

  [e.g. M. Beneke et al., Eur. Phys. J C47, 625]

Comparison with other experiments







What Next from CMS?

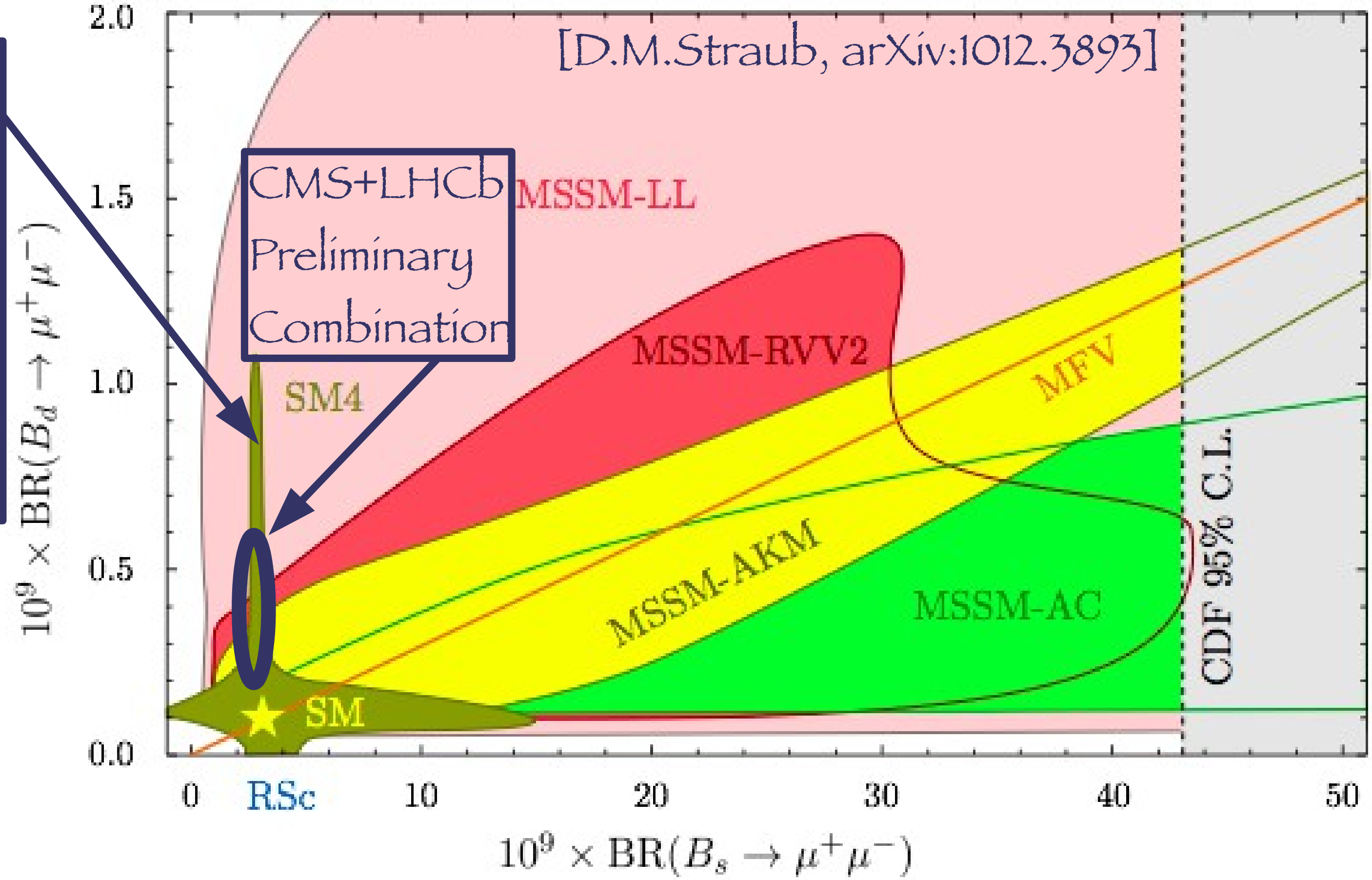
- Results of 8 TeV data analysis expected soon:
  - dB/dq^2, F_L, A_{FB}, A_{FB} zero crossing-point
  - Use of new angular variables with small Form-Factor dependence

Constraints on NP

Constraints from $B \rightarrow \mu^+\mu^-$

SM4: SM with a 4[th] generation

MFV: Flavor Violation governed only by CKM matrix

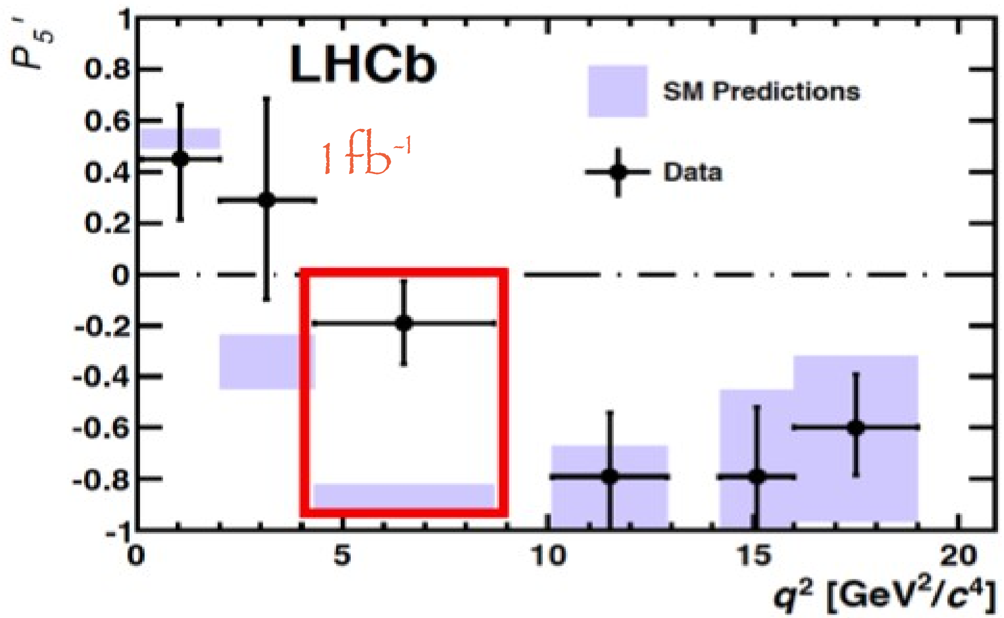


- $BR(B_d)/BR(B_s)$ extremely sensitive probe of NP

- Result in agreement with SM [0.4 σ for B_s and 1.7 σ for B_d]
- The focus now is on $BR(B_d)$ and on the ratio $BR(B_s)/BR(B_d)$
- LHCb (after upgrade): measure ratio @ 35% with 50 fb^{-1}

LHCb $B \to K^* \mu^+\mu^-$: Hint of NP?

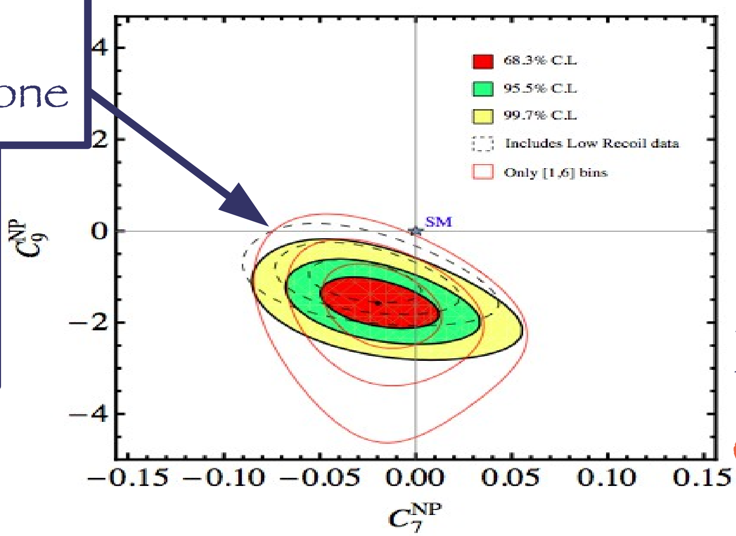
- Variables free from Form Factor contributions [JHEP 05, 137 (2013)]



- 3.7 σ discrepancy in P'_5 in $4.3<q^2<8.68$ GeV^2 [PRL 111, 191801 (2013)]
- Possible interpretation as a NP contribution to Wilson coefficient C_9

Low q^2 $K^*\mu^+\mu^-$ bins alone

3.9σ discrepancy wrt SM



Combined analysis from $K^*\mu\mu$, $B \to X_s\gamma$, $X_s\mu\mu$, $K^*\gamma$, $B_s \to \mu\mu$

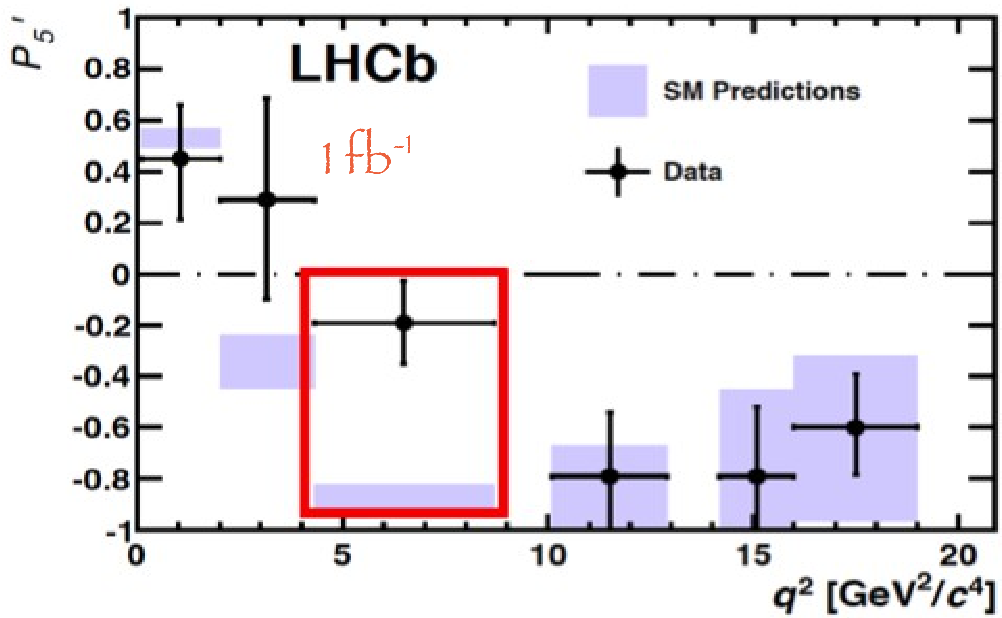
[S. Descotes-Genon et al., PRD 88, 074002]

Difficult to explain with SUSY

Consistent with a Z' with m~7 TeV

LHCb $B \rightarrow K^* \mu^+\mu^-$: Hint of NP?

- Variables free from Form Factor contributions [JHEP 05, 137 (2013)]



- 3.7 σ discrepancy in P'_5 in $4.3<q^2<8.68$ GeV^2 [PRL 111, 191801 (2013)]
- Possible interpretation as a NP contribution to Wilson coefficient C_9

- Resulting C_9^{NP} would imply an inclusive BR($B \rightarrow X_s l^+l^-$) suppression of ~ 25% in $1<q^2<6$ GeV^2 and $q^2>14.4$ GeV^2
- Recent BaBar BR($B \rightarrow X_s l^+l^-$) result in the high-q^2 region shows a ~ 2 σ excess wrt SM prediction in both the $X_s\mu^+\mu^-$ and $X_s e^+e^-$ channels
  - ➔ **LHCb effect not confirmed by BaBar** [PRL 112, 211802]

Conclusions

Conclusions

- Rare B decays are an excellent laboratory for the search for physics beyond the SM
- In the last few years several new measurements from LHC & B-Factories experiments released with impressive experimental precision
- Almost all the results are in agreement with expectations but some tension is present in some sectors (i.e. $B \rightarrow K^{*}\mu\mu$, $\tau\nu$, $D^{(*)}\tau\nu$,...)
- Strong constraints on NP models from flavor measurements

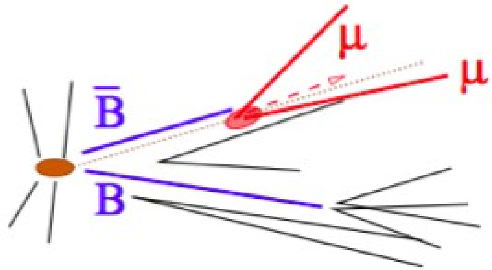
- Rich program of measurements is expected from LHC/Belle II experiments in the coming years
  - **Chances to discover/understand NP in flavor sector in the near Future?**

Backup

$B \to \mu^+\mu^-$

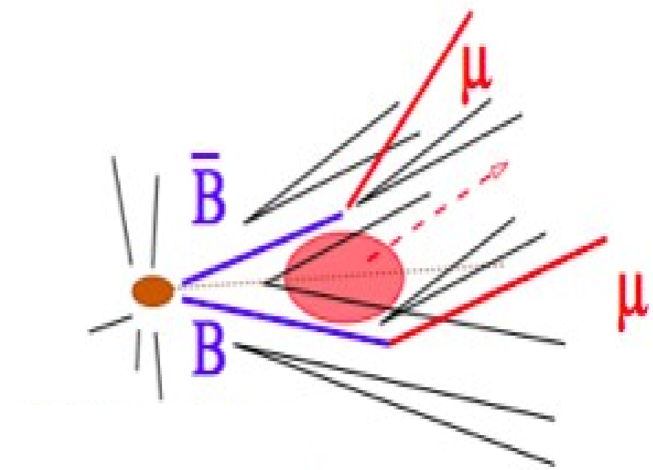
- Signal: two isolated muons from a secondary vertex

Measurement performed on 25 fb^{-1}



Trigger on dimuons 2011(2012)
Central:
$p_T^{\mu}>4.0$ (3.0) GeV, $p_T^{\mu\mu}>3.9$(4.9) GeV, $4.8<m^{\mu\mu}<6.0$ GeV
Forward: $p_T^{\mu}>4.0$ GeV, $p_T^{\mu\mu}>7.0$ GeV, vProb> 0.5%

- BKG:
  - Combinatorial
  - Physical:
    - Uncorrelated B semileptonic decays
    - Peaking $B \to hh'$ (h=K, π) (BR~$10^{-5}/10^{-7}$)
    - Non Peaking $B_s \to K\mu\nu$, $\Lambda_b \to p\mu\nu$



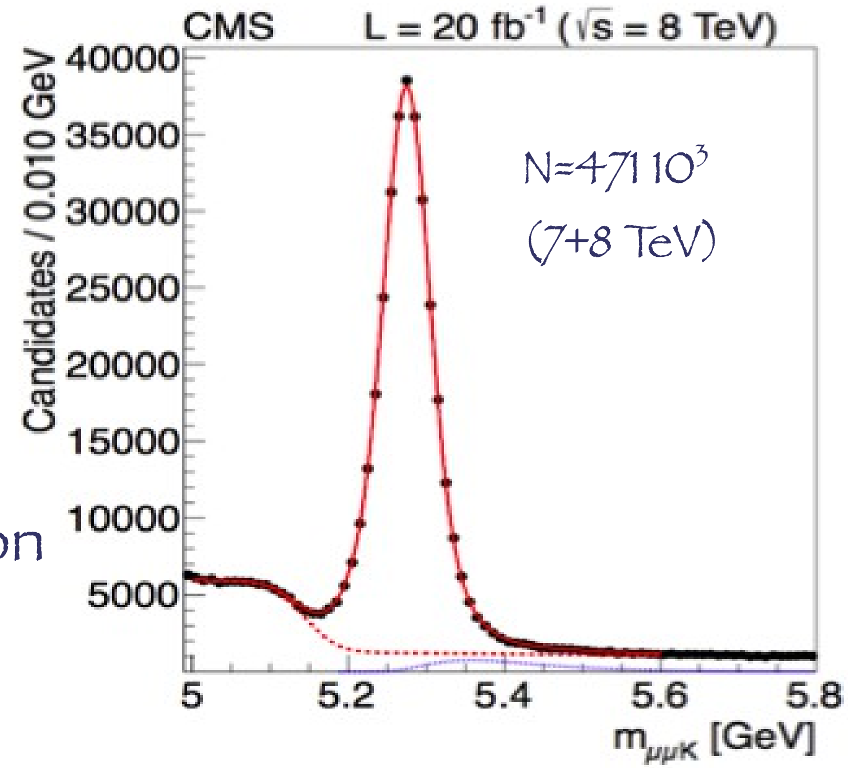
- Strategy:
  - BDT-based muon (Mis)identification studied on MC/data control samples ($B_s \to KK$, $B^0 \to \pi\pi$, $K^0 \to \pi\pi$, $\Lambda \to p\pi$, $D^* \to D^0\pi$)
  - Peaking BKG checked with independent analysis of $B \to hh'$

$\mathcal{B} \to \mu^+\mu^-$

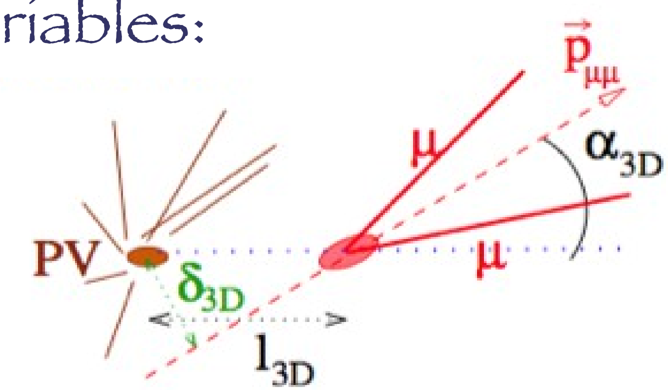
PRL 111, 101804 (2013)

- BR measured relative to normalization channel $B^+ \to J/\Psi\, K^+$ to reduce systematics:

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = \frac{N_S}{N_{obs}^{B^+}} \frac{f_u}{f_s} \frac{\varepsilon_{tot}^{B^+}}{\varepsilon_{tot}} \mathcal{B}(B^+)$$



- Events selected by means of a MVA exploiting kinematic, vertexing and isolation variables:



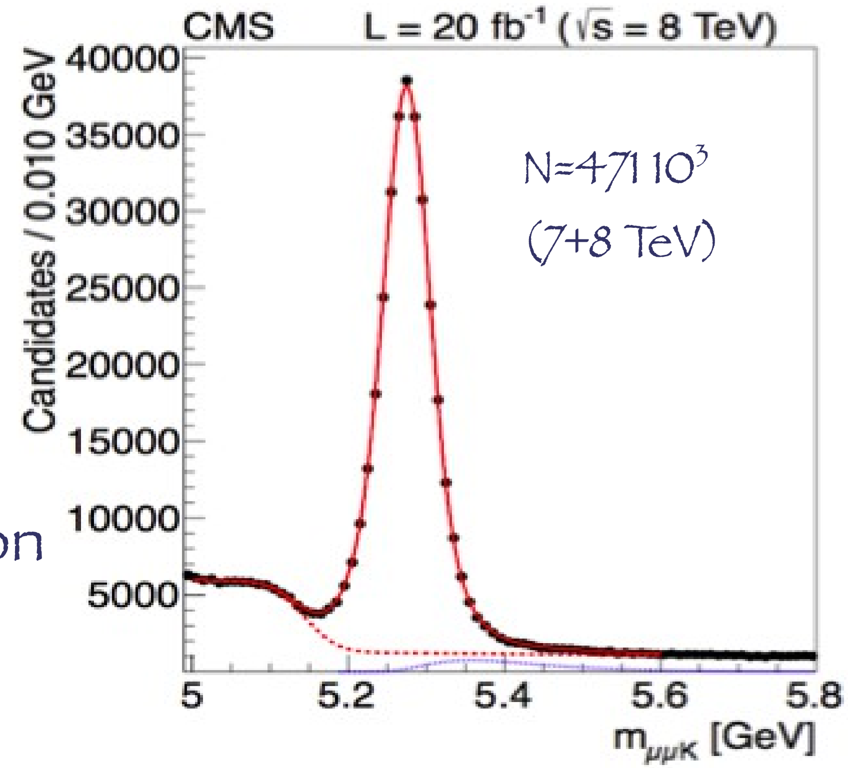
- Data/MC agreement checked on $B^+ \to J/\Psi\, K^+$, $B_s \to J/\Psi\, \varphi$ control samples

$B \to \mu^+\mu^-$

PRL 111, 101804 (2013)

- BR measured relative to normalization channel $B^+ \to J/\Psi\, K^+$ to reduce systematics:

$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = \frac{N_S}{N^{B^+}_{\rm obs}} \frac{f_u}{f_s} \frac{\varepsilon^{B^+}_{\rm tot}}{\varepsilon_{\rm tot}} \mathcal{B}(B^+)$$



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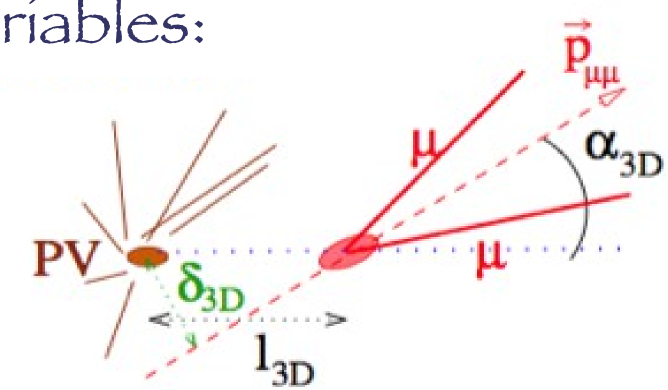
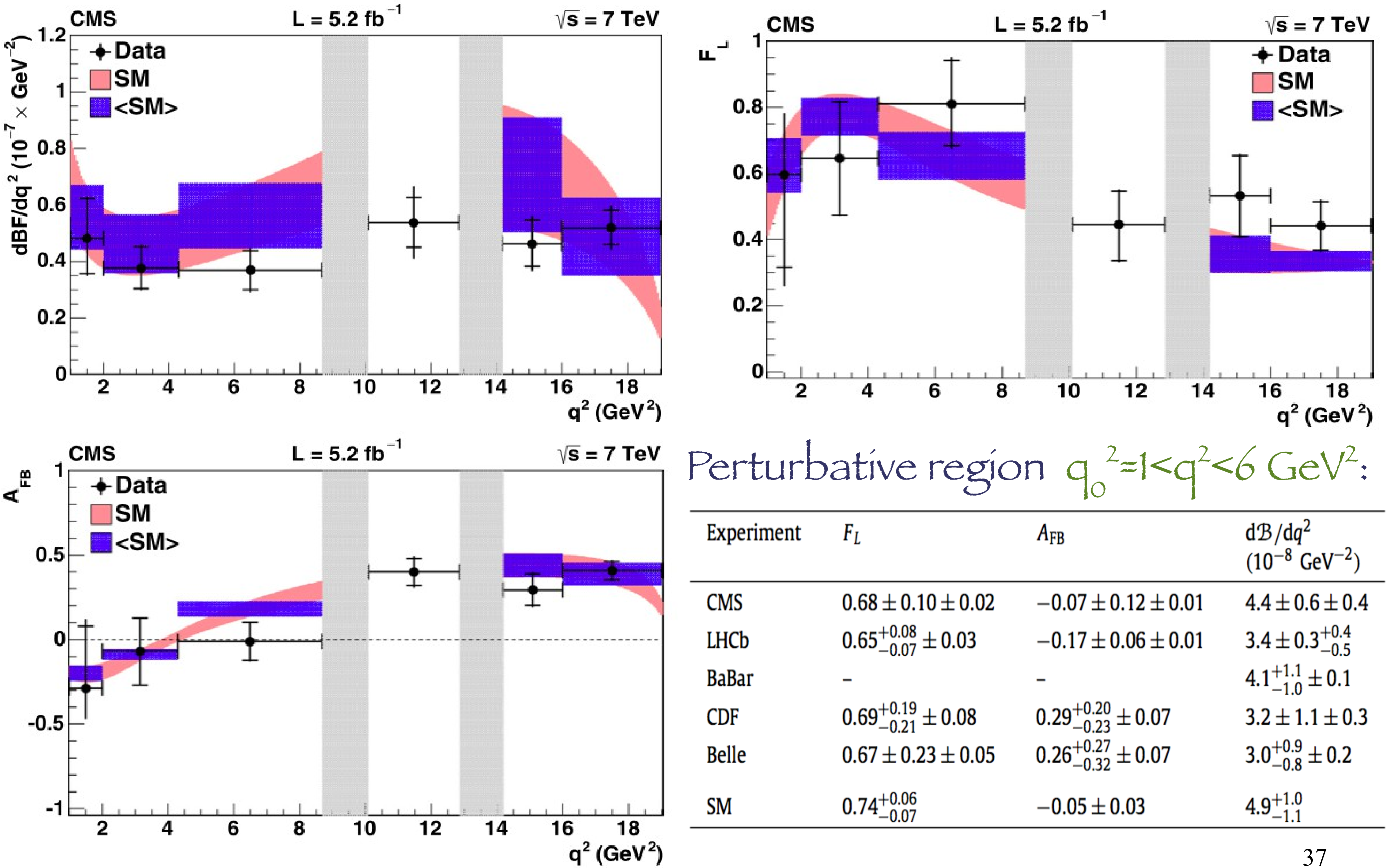


- Data/MC agreement checked on $B^+ \to J/\Psi\, K^+$, $B_s \to J/\Psi\, \varphi$ control samples

$B \to K^*\mu^+\mu^-$: Results

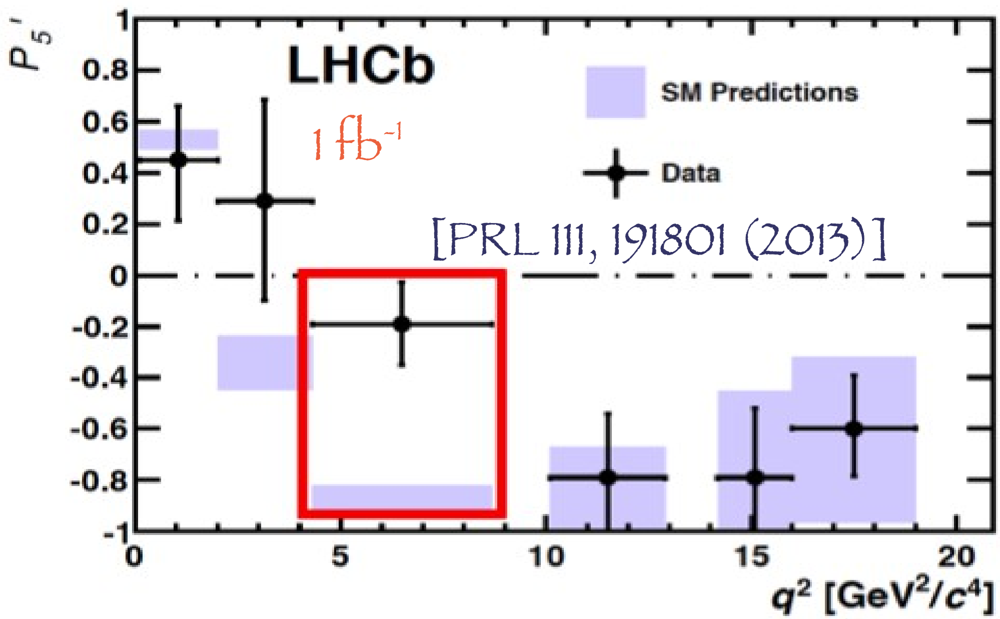


Perturbative region $q_0^2 = 1 < q^2 < 6$ GeV^2:

Experiment	F_L	A_{FB}	$d\mathcal{B}/dq^2$ (10^{-8} GeV^{-2})
CMS	$0.68 \pm 0.10 \pm 0.02$	$-0.07 \pm 0.12 \pm 0.01$	$4.4 \pm 0.6 \pm 0.4$
LHCb	$0.65^{+0.08}_{-0.07} \pm 0.03$	$-0.17 \pm 0.06 \pm 0.01$	$3.4 \pm 0.3^{+0.4}_{-0.5}$
BaBar	–	–	$4.1^{+1.1}_{-1.0} \pm 0.1$
CDF	$0.69^{+0.19}_{-0.21} \pm 0.08$	$0.29^{+0.20}_{-0.23} \pm 0.07$	$3.2 \pm 1.1 \pm 0.3$
Belle	$0.67 \pm 0.23 \pm 0.05$	$0.26^{+0.27}_{-0.32} \pm 0.07$	$3.0^{+0.9}_{-0.8} \pm 0.2$
SM	$0.74^{+0.06}_{-0.07}$	-0.05 ± 0.03	$4.9^{+1.0}_{-1.1}$

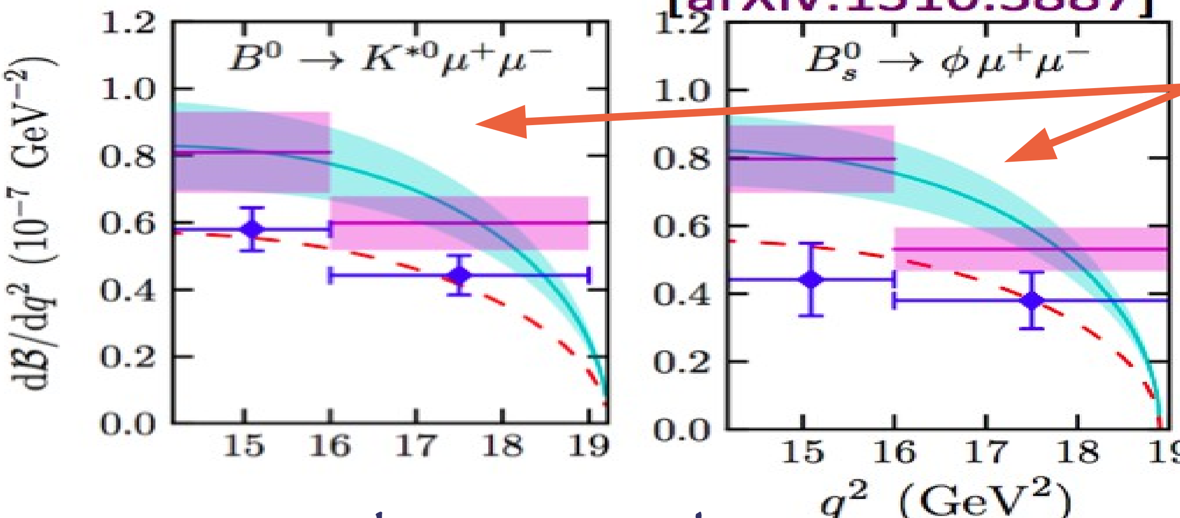
$B \rightarrow K^* \mu^+\mu^-$: Hint of NP?

- Study additional variables free from FF contributions [JHEP 05, 137 (2013)]



- 3.7 σ discrepancy in P'_5 in $4.3<q^2<8.68$ GeV^2
- Possible interpretation as a NP contribution to Wilson coeff. C9
- Analysis of the full 3 fb^{-1} statistics in progress

[arXiv:1310.3887]

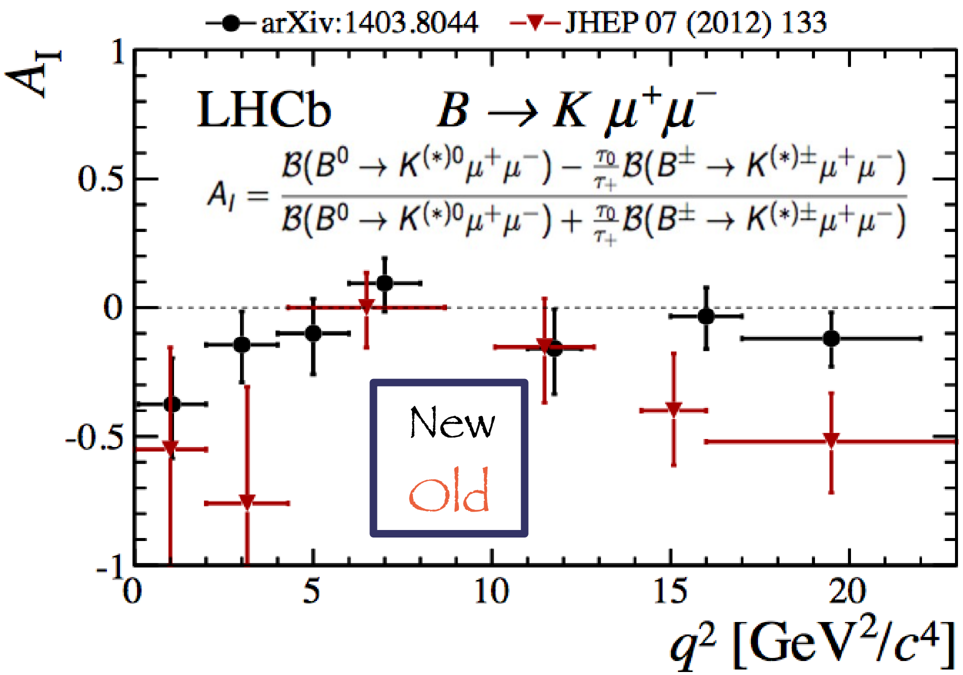


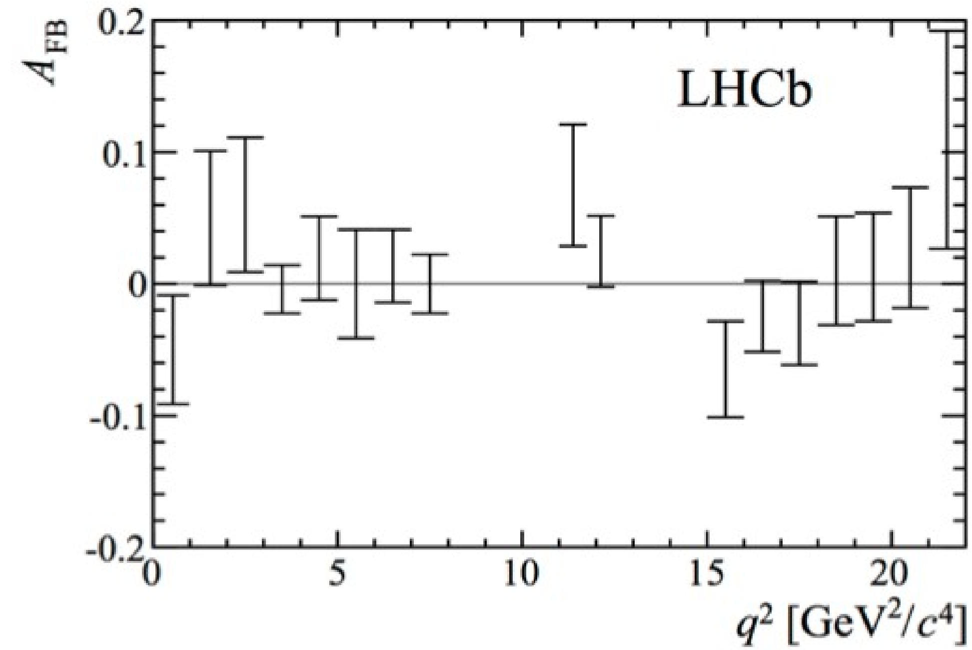
- P'5 tension correlated with other minor tensions (too small BRs)
- Difficult to explain with SUSY
- Consistent with a Z' with m~7 TeV
  - Measure other $B \rightarrow K\mu\mu$ decays

$B \to K \mu^+\mu^-$

[LHCb-Paper-2014-006]

- $K^* \mu^+\mu^-$ tension motivates studies of A_I, A_{FB}



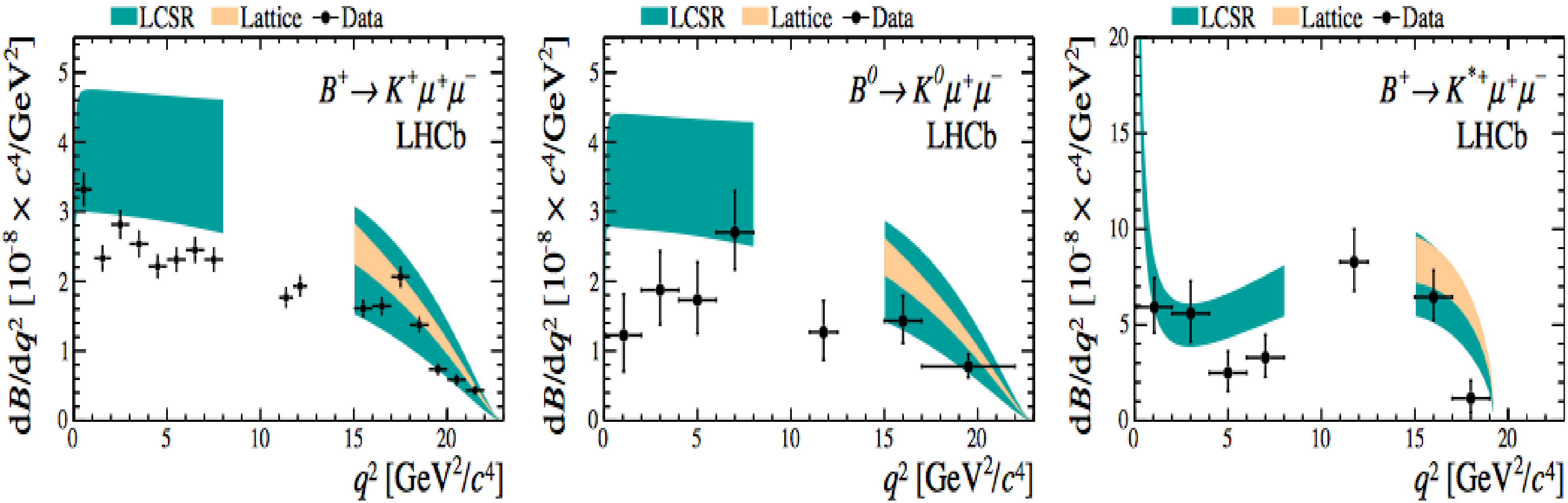


- Update of previous A_I measurement (4.4 σ discrepancy integrated on q^2) is now in agreement with SM
  - Improvements in efficiency ratio ε(Kμμ)/ε(J/ψK)
  - $\mathcal{B}(J/\psi K^0)/\mathcal{B}(J/\psi K^+)$ correction applied vs K momentum
- A_{FB} in agreement with SM

$B \to K \mu^+\mu^-$

[LHCb-Paper-2014-006]

- $K^* \mu^+\mu^-$ tension motivates studies of differential BRs

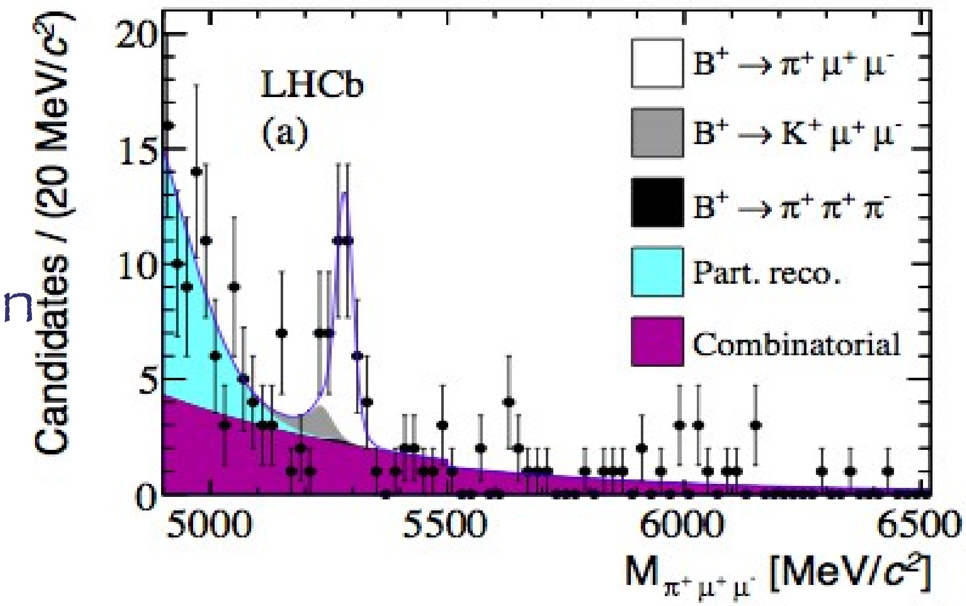


Decay mode	Measurement	Prediction
$B^+ \to K^+\mu^+\mu^-$	$8.5 \pm 0.3 \pm 0.4$	10.7 ± 1.2
$B^0 \to K^0\mu^+\mu^-$	$6.7 \pm 1.1 \pm 0.4$	9.8 ± 1.0
$B^+ \to K^{*+}\mu^+\mu^-$	$15.8\ ^{+3.2}_{-2.9} \pm 1.1$	26.8 ± 3.6

- All the results are "consistent" with SM at <2.2 σ
- But all of them are lower than the predictions...

What Next on $K^{(*)}\ \mu^+\mu^-$ & friends?

- Measurements of related $b \to d\mu\mu$ channels are welcome to reveal information on Minimal Flavor Violation nature of New Physics

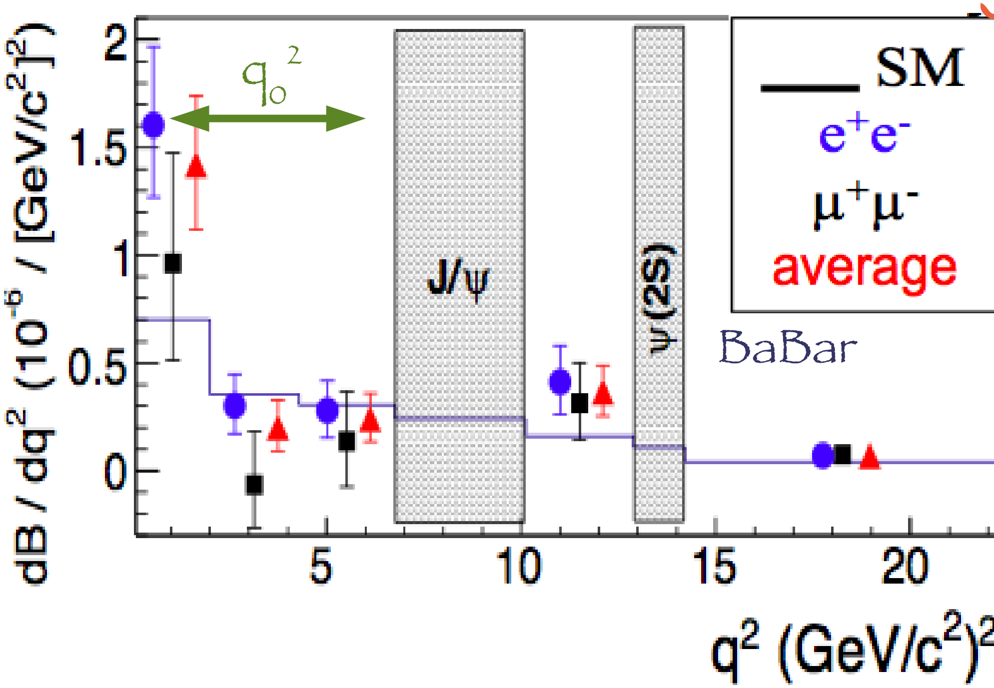


LHCb: $BR(B^+ \to \pi^+\mu^+\mu^-) = (2.4 \pm 0.6 \pm 0.2)10^{-8}$ in agreement with MFV

[JHEP 12, 125 (2012)]

- $BR(B^+ \to \pi^+\mu^+\mu^-)/BR(B^+ \to K^+\mu^+\mu^-)$ would provide a comparison of $|V_{td}|/|V_{ts}|$ from penguin processes and box processes ($\Delta m_s/\Delta m_d$)
- Improve theoretically very clean measurements of semi-inclusive $B \to X_{s/d}ll$, ($X_{s/d}\gamma$)

BaBar $B \to X_s l^+ l^-$ [PRL 112, 211802]



- Perturbative region q_0^2=1<q^2<6 GeV^2:

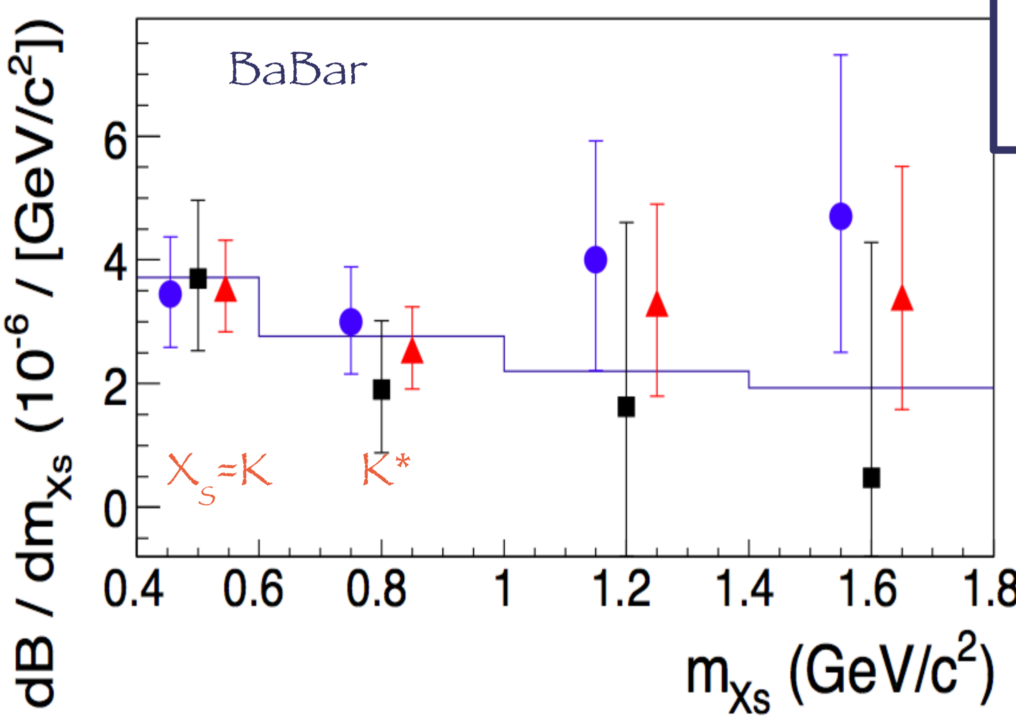
$BR=(1.60\ ^{+0.41}_{-0.39}\ ^{+0.17}_{-0.13}\ \pm 0.18)10^{-6}$

In agreement with SM $(1.59\pm0.11)10^{-6}$

- q^2 region above ψ(2S) :

$BR=(0.57\ ^{+0.16}_{-0.15}\ ^{+0.03}_{-0.02}\ \pm 0.0)10^{-6}$

~2 σ above SM $(0.24\pm0.07)10^{-6}$



➔ LHCb effect not confirmed by BaBar