Rare decays in LHCb

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On behalf of the
LHCb Collaboration

Naturalness 2014,
Weizmann Institute of
Science. Rehovot

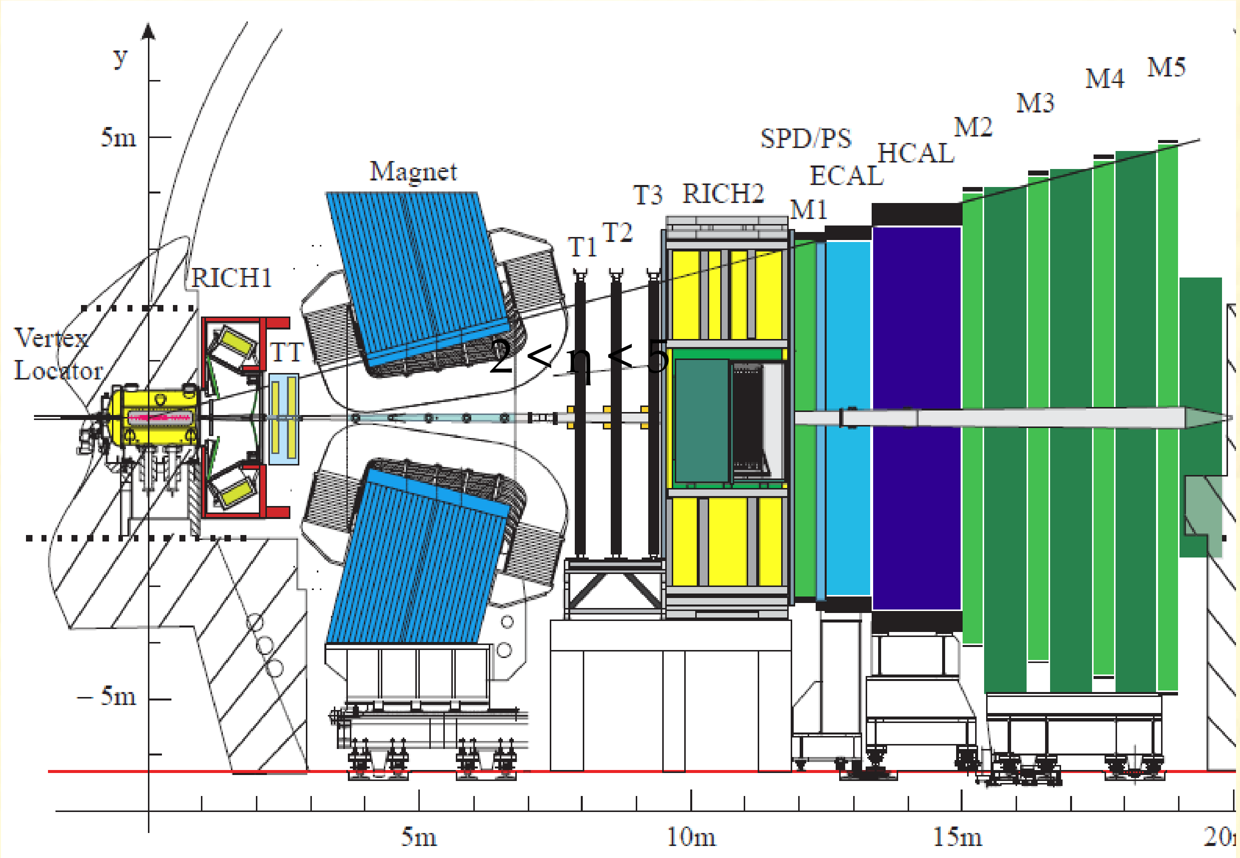
Rare Decays results from LHCb

- The LHCb experiment
  - Detector
  - Indirect searches for New Physics
- Very rare decays
  - $B_s \to \mu\mu$, $B_d \to \mu\mu$
  - Rare strange decays
  - Rare charm decays
  - Other very rare decays
- The rare decays $B \to K(*)\, \mu\mu$
  - Angular analysis
  - Lepton universality tests
- Not covered here: radiative decays

The LHCb experiment

Forward spectrometer with very precise tracking and PID

- Decay time resolution
  40 fs (B→J/ψKK)
- Invariant mass resolution
  ~23 MeV (B→μμ)
- 95% (K-π) ID efficiency
  for 5% fake rate



Efficient and flexible trigger
ε ~90% B→μμ decays

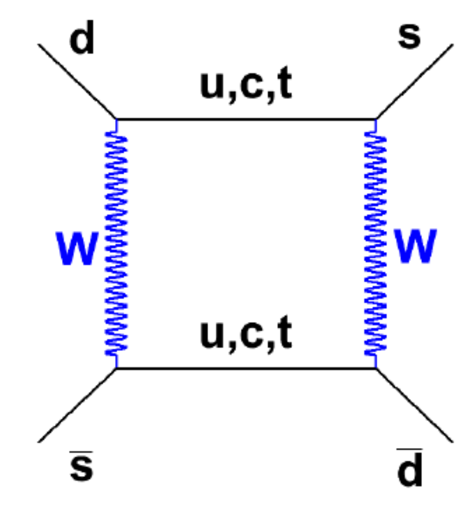
Recorded luminosity: 3 fb^{-1}

$1\ fb^{-1}$ at 7 TeV (2011)
$2\ fb^{-1}$ at 8 TeV (2012)

Also, took $13nb^{-1}$ of pA data

The LHCb experiment

- The **LHCb physics program** focuses mostly on CP violation and rare decays
- Both correspond to **indirect searches for New Physics** (i.e, new particles),
- Indirect approach has been very successful in the past
  - Neutral Currents
    (Z^0 inferred ten years before direct observation)
  - Kaon mixing
    (top-quark inferred 30 years before direct observation)



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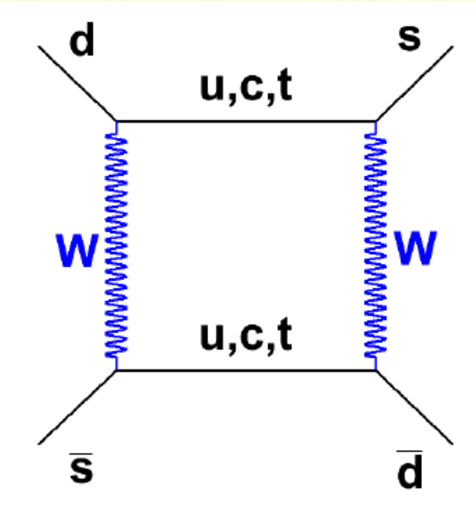
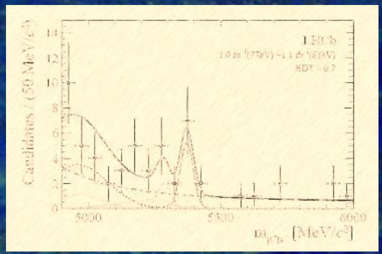
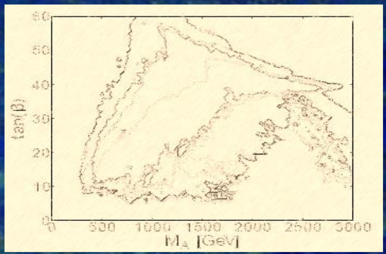


(you may also notice Earth' radius was inferred indirectly 2.3k years before direct observation…)

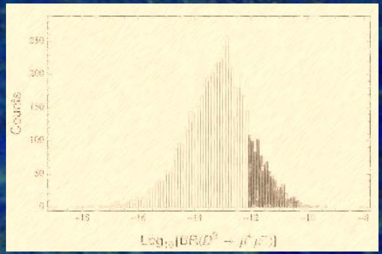
Eratosthenes

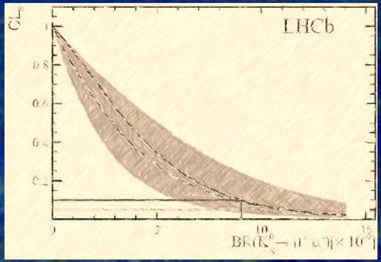
~2.3 K years till the direct observation…





VERY RARE DECAYS





$B_{s(d)} \to \mu\mu$

These decays are very supressed in SM

$BR(B_s \to \mu\mu) = (3.66 \pm 0.23) \times 10^{-9}$ $BR(B_d \to \mu\mu) = (1.06 \pm 0.09) \times 10^{-10}$

PRL 112, 101801
(time averaged)

… but can be modified by NP.

Scenario	Would point to →
$BR(B_s \to \mu\mu) >> SM$	Big enhancement from NP in the scalar sector, SUSY at high tanβ
$BR(B_s \to \mu\mu) \neq SM$	SUSY, ED's, LHT, TC2
$BR(B_s \to \mu\mu) \approx SM$	Anything (→ rule out regions of parameters space that predict sizable departures w.r.t SM)
$BR(B_s \to \mu\mu) << SM$	NP in the scalar sector, but full MSSM ruled out. NMSSM (Higgs singlet) good candidate
$BR(B_s \to \mu\mu) / BR(B_d \to \mu\mu) \neq SM$	CMFV ruled out. New FCNC independent of CKM matrix (RPV-SUSY, ED's ,etc …)

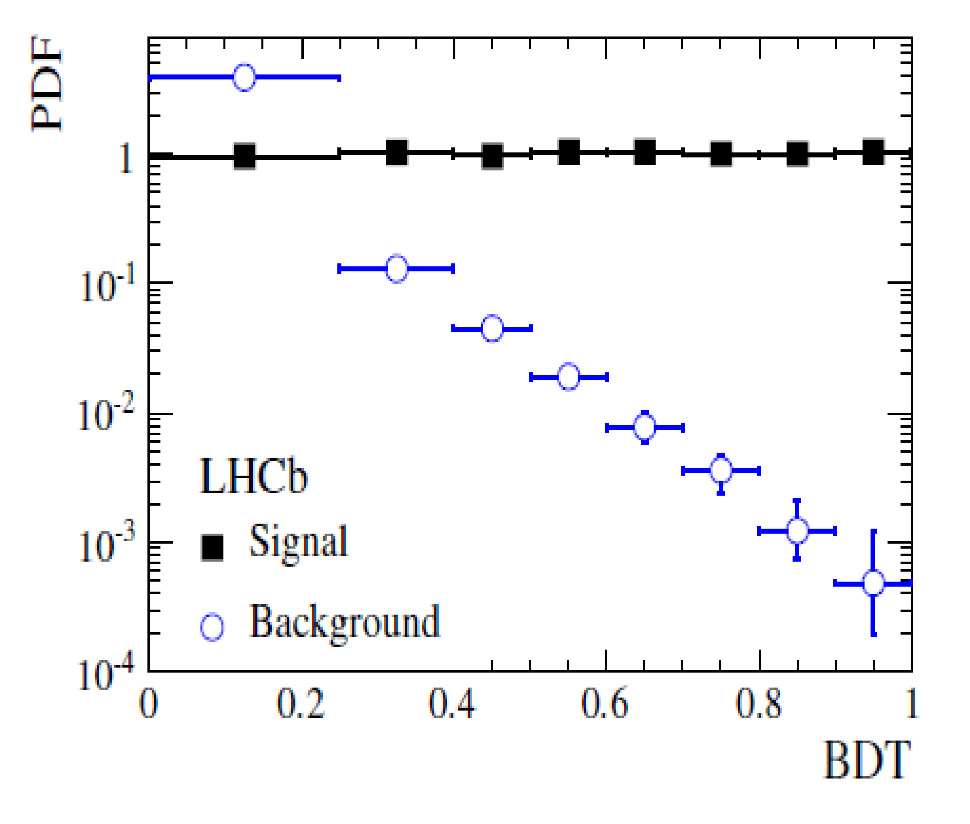
$B_{s(d)} \rightarrow \mu\mu$ (LHCb analysis strategy)

Phys. Rev. Lett. 111 (2013) 101804

I) Selection cuts in order to reduce the amount of data to analyse.

II) Classification of $B_{s,d} \rightarrow \mu\mu$ events in a 2D space

- Invariant mass of the μμ pair
- Boosted Decision Tree (BDT) combining geometrical and kinematical information about the event.



III) Control channels ($B \rightarrow hh$, $B \rightarrow J/\psi K$, mass sideb.) to get signal and background expectations w/o relying on simulation

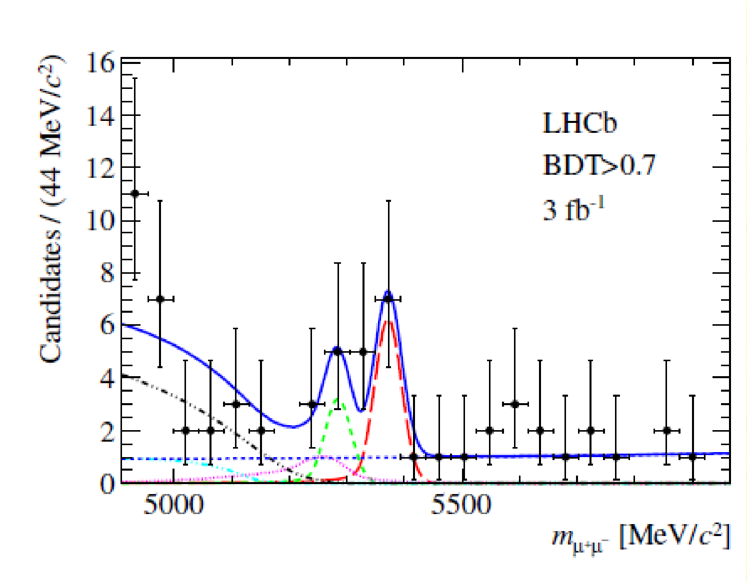
IV) Fit for signal strength : simultaneous fit of the mas spectrum in the different BDT regions

$B_{s(d)} \to \mu\mu$ (results)

Phys. Rev. Lett. 111 (2013) 101804

Full Run-I dataset analysed, giving:

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = (2.9\,^{+1.1}_{-1.0}(\text{stat})\,^{+0.3}_{-0.1}(\text{syst})) \times 10^{-9}\,,$$
$$\mathcal{B}(B^0 \to \mu^+\mu^-) = (3.7\,^{+2.4}_{-2.1}(\text{stat})\,^{+0.6}_{-0.4}(\text{syst})) \times 10^{-10}$$



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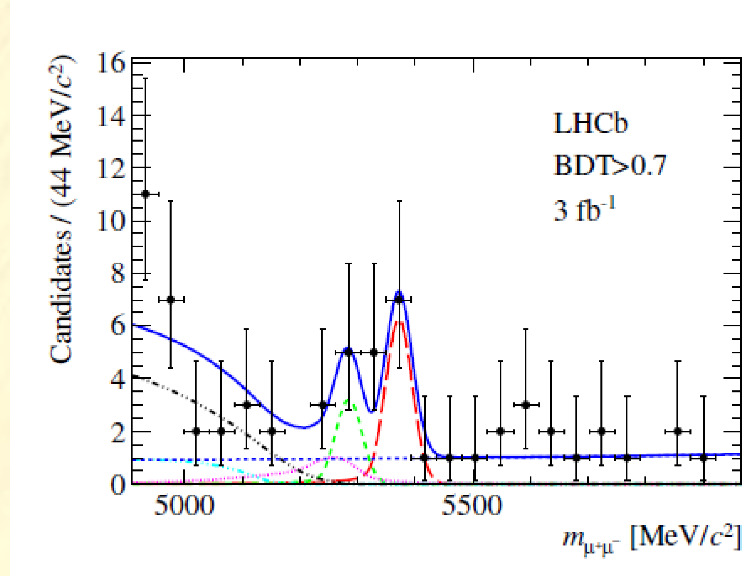


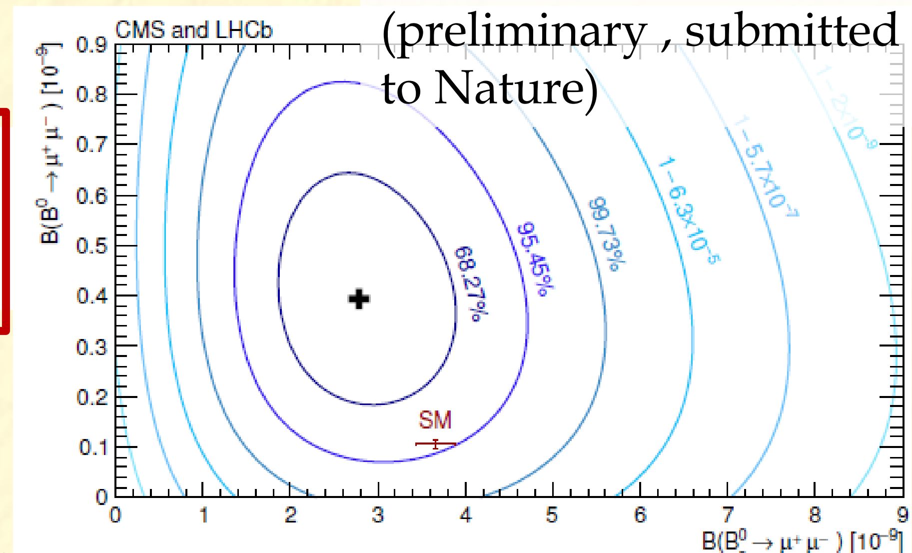
Combined with CMS (joint likelihood fit)

CMS: Phys. Rev. Lett. 111, 101805

6.2 observation of $B_s \to \mu\mu$
3.2 evidence for $B_d \to \mu\mu$

$$\mathcal{BR}(B_s \to \mu^+\mu^-) = 2.8^{+0.7}_{-0.6} \times 10^{-9}$$
$$\mathcal{BR}(B_d \to \mu^+\mu^-) = 3.9^{+1.6}_{-1.4} \times 10^{-10}$$

(preliminary , submitted to Nature)



Ratio B_s/B_d compatible with SM at 2.3σ

$B_{s(d)} \rightarrow \mu\mu$ (what does it imply?)

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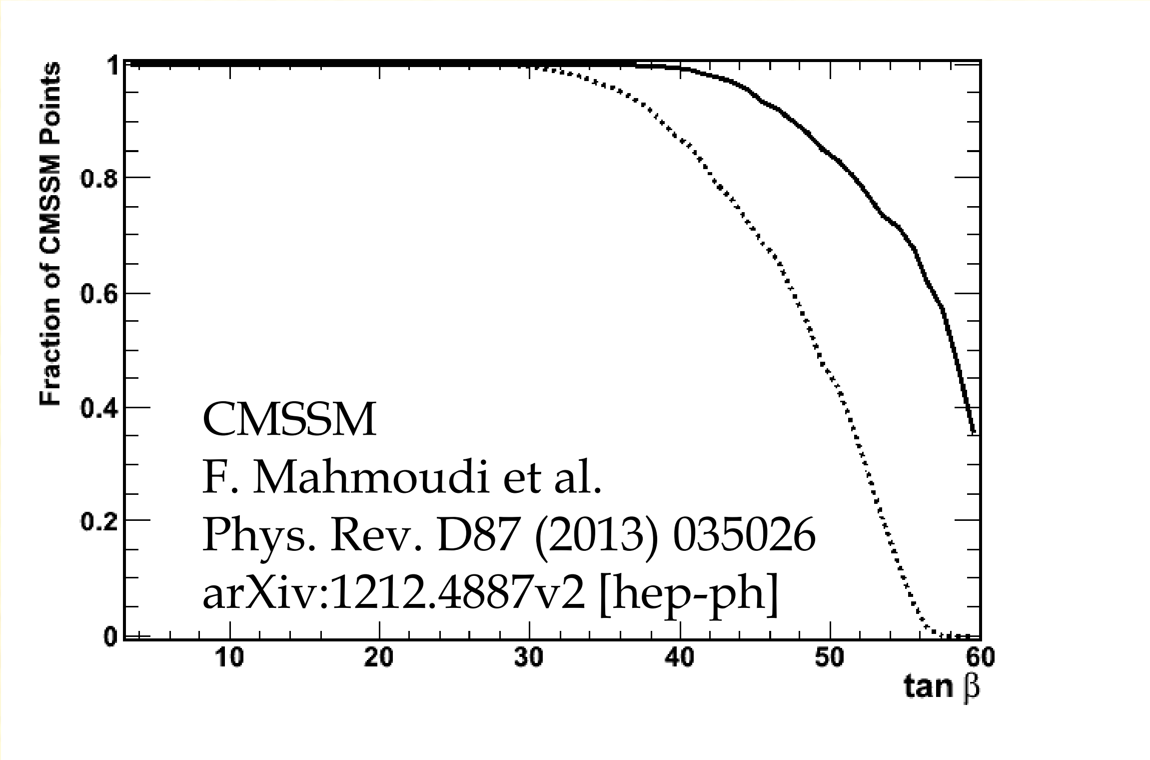
NIKHEF

$B_{s(d)} \rightarrow \mu\mu$ (what does it imply?)

Scenario	Would point to
BR(Bs→μμ) >> SM	Big enhancement from NP in the scalar sector, SUSY at high tanβ
BR(Bs→μμ) ≠ SM	SUSY, ED's, LHT, TC2
BR(Bs→μμ) ≈SM	Anything (→ rule out regions of parameters space that predict sizable departures w.r.t SM)
BR(Bs→μμ) << SM	NP in the scalar sector, but full MSSM ruled out. NMSSM (Higgs singlet) good candidate
BR(Bs→μμ) /BR(Bd→μμ) ≠ SM	CMFV ruled out. New FCNC fully independent of CKM matrix (RPV-SUSY, ED's ,etc …)

… You expect some constraints at least in SUSY at high tanβ

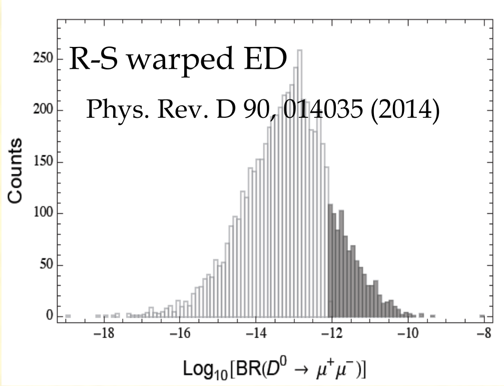
$B_{s(d)} \rightarrow \mu\mu$ (what does it imply?)



Fraction of points from a flat scan which survive $B_s \rightarrow \mu\mu$ constraint

Rare charm decays: $D^0 \to \mu\mu$

Phys.Lett. B725 (2013) 15-24



SM prediction: $BR(D^0 \to \mu\mu) < 1.6\text{x}10^{-11}$
(Precision depends on knowledge of $BR(D^0 \to \gamma\gamma)$)

BSM physics (RPV, ED's) can enhance it up to the 10^{-10} level

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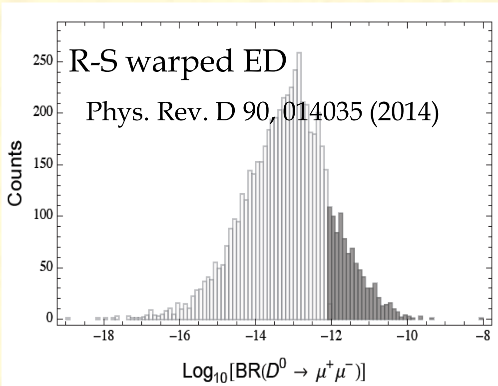

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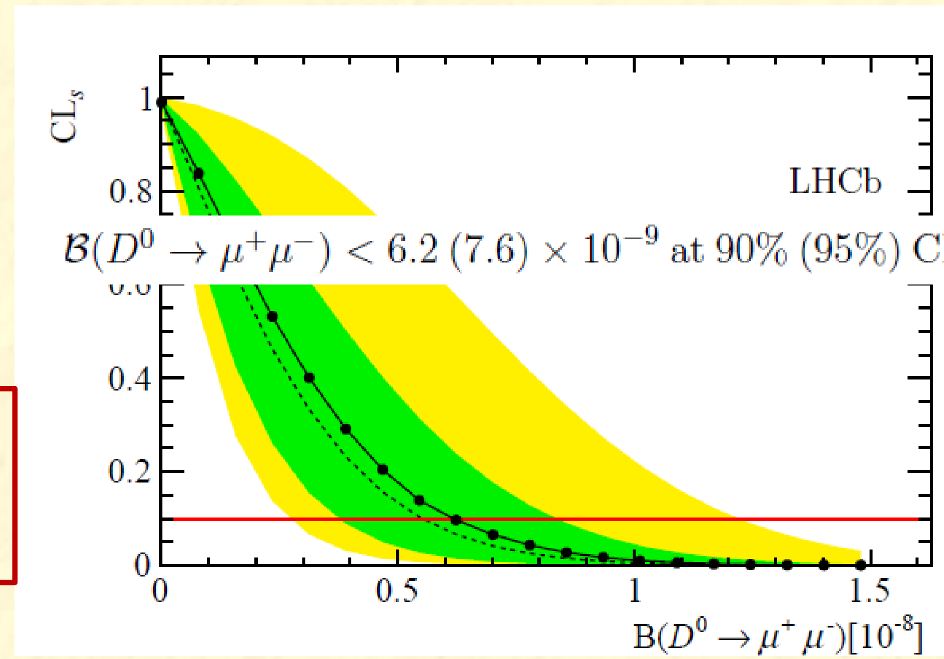

$BR(D^0 \to \mu\mu) < 6.2(7.6) \times 10^{-9}$ @ 90(95) $\%CL_s$

Potential to reach more interesting region with LHCb upgrade

Other rare charm decays

	Run –I	Run- II	Upgrade	Status
$D^+_{(s)} \to \pi^+\mu^+\mu^-$	Few 10^{-8}	Fewer 10^{-8}	Few 10^{-9}	1/3 Run-I arXiv:1304.6365, Phys. Lett. B 724 (2013) 203-212
$D^+_{(s)} \to \pi^-\mu^+\mu^+$	Few 10^{-8}	Fewer 10^{-8}	Few 10^{-9}	1/3 Run-I arXiv:1304.6365, Phys. Lett. B 724 (2013) 203-212
$D^+_s \to K^+\mu^+\mu^-$	Few 10^{-7}	Fewer 10^{-7}	Few 10^{-8}	Work ongoing
$D^0 \to h^+h'^-\mu^+\mu^-$	Few 10^{-7}	Fewer 10^{-7}	Few 10^{-8}	Work ongoing
$\Lambda^+_c \to p\mu^+\mu^-$	Few 10^{-7}	Fewer 10^{-7}	Few 10^{-8}	Work ongoing
$D^0 \to \mu\, e$	Few 10^{-8}	Fewer 10^{-8}	Few 10^{-9}	Work ongoing
$\sigma(A_{CP} D^0 \to \phi\gamma)$	~10%	5%	?	Work ongoing

Rare strange decays: introduction

- Minimal Flavour Violation motivated by search of NP ~ TeV
- But if NP > few TeV, non-MFV scenarios become very interesting
- In such contest rare decays of strange particles are very important : $s \rightarrow d$ transitions have the strongest CKM suppression (i.e, strongest suppression of SM "background")

$$A = A_0 \left[c_{SM} \frac{1}{M_W{}^2} + c_{NP} \frac{1}{\Lambda^2} \right]$$

c_{SM} ↑ $\sim V_{ts} V_{td} \sim 10^{-4}$

From G. Isidori @ Rare'n'Strange

LHCb can explore rare decays of **K_S and hyperons**: Big effective kaon flux $\sim 10^{13}$ K_S /y

Rare strange decays: $K_S \to \mu\mu$

- SM prediction: $BR(K_S \to \mu\mu) = (5.1 \pm 1.5) \times 10^{-12}$
  JHEP 0401 (2004) 009
- $K_S \to \mu\mu$ sensitive to different physics than $K_L \to \mu\mu$
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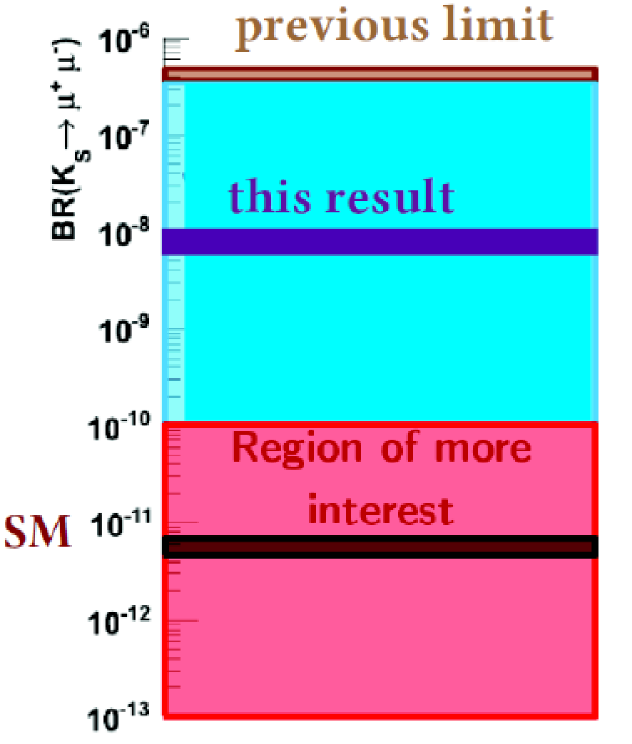
- If NP is found in NA62, then limits of $K_S \to \mu\mu$ in the 10^{-11}-10^{-12} range useful to understand its nature



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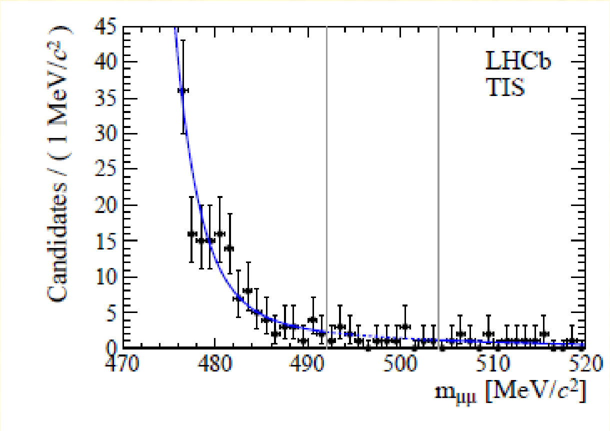

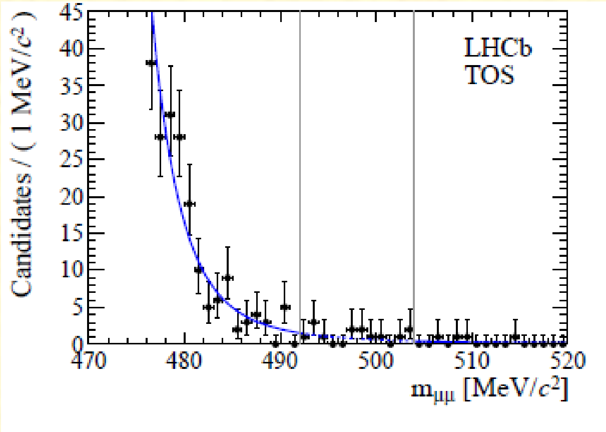

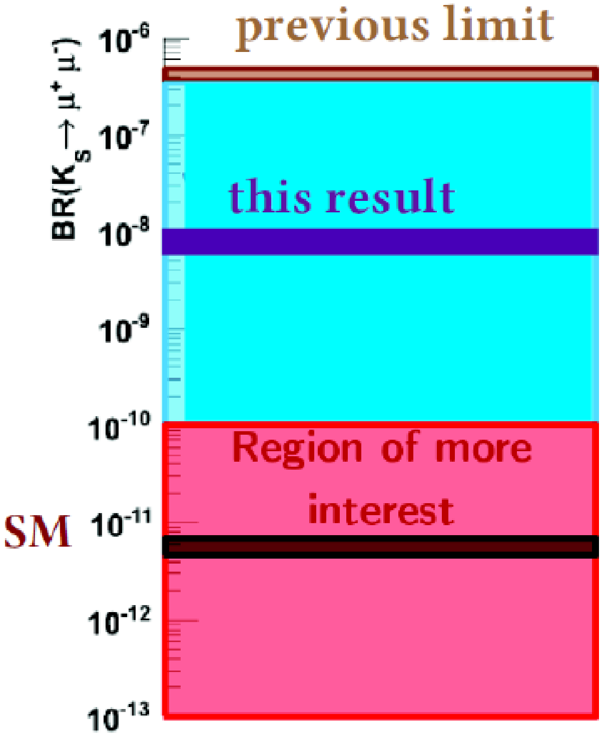

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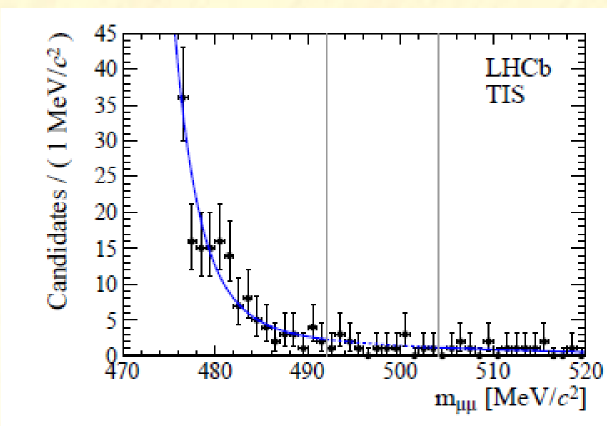
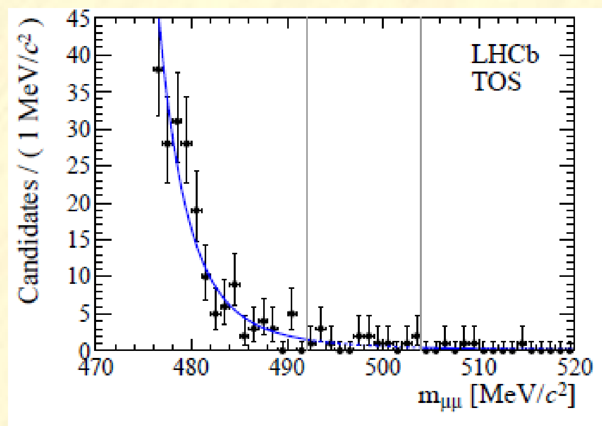
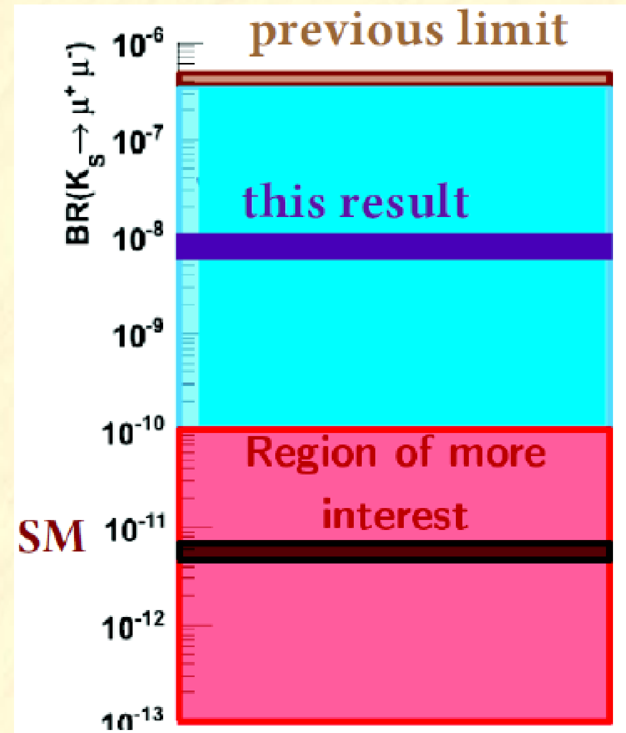
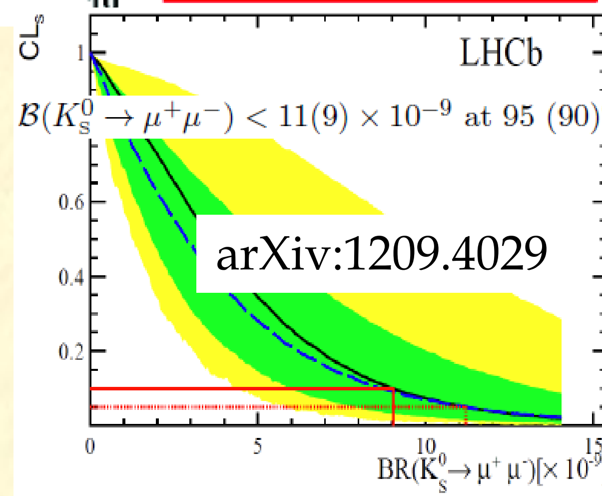




$BR(K_S \to \mu\mu) < 9(11) \times 10^{-9}$ @90(95)%CL_s

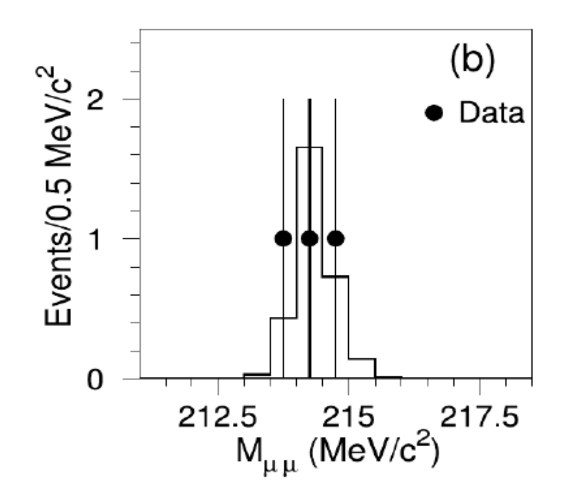




Rare strange decays: prospects

- LHCb will keep being world leading on $K_S \to \mu\mu$
- **Most interesting region** ($BR(K_S \to \mu\mu) < 10^{-10}$) might be achievable with LHCb upgrade (**requires trigger developments**)
- Sensitivity to other decays under investigation:

- **$\Sigma \to p\mu\mu$**: aim to confirm /reject Hyper CP anomaly



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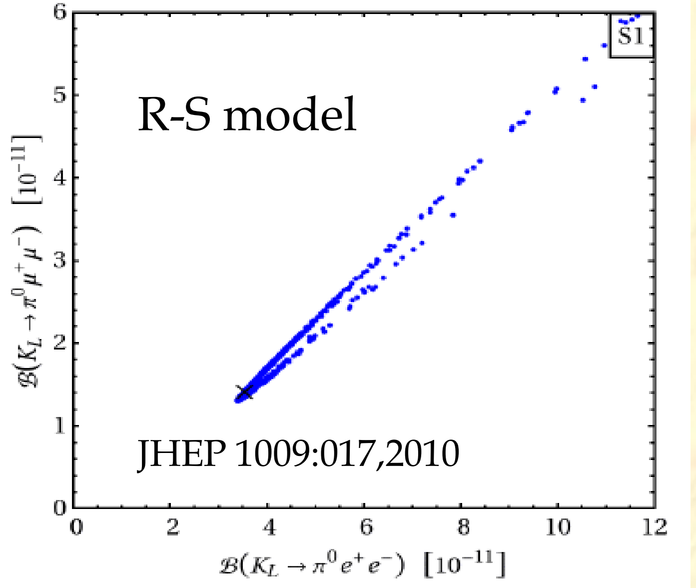

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- Other possibilities under investigation: $K_S \rightarrow \pi\pi\mu\mu$, $K_S \rightarrow \mu\mu\mu\mu$, electron modes…

Rare strange decays: prospects

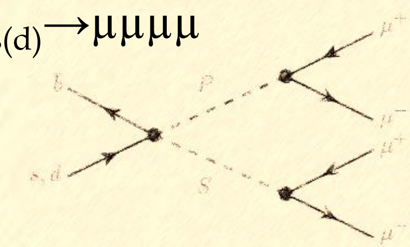
LHCb can do kaon/hyperon physics

However, in many cases, looking for a given channel will require us to develop triggers

If you have some idea of a new interesting channel please shout

Other very rare decays @ LHCb

$B_{s(d)} \rightarrow \mu\mu\mu\mu$



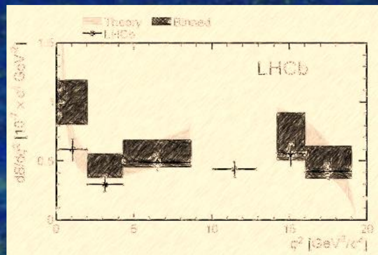
Decay	Main BSM test	95% upper limit
$B_s \rightarrow \mu\mu\mu\mu$	Some SUSY scenarios	$<1.6 \times 10^{-8}$ (PRL. 110, 211801)
$B_d \rightarrow \mu\mu\mu\mu$	Some SUSY scenarios	$<6.6 \times 10^{-9}$ (PRL. 110, 211801)
$\tau \rightarrow \mu\mu\mu$	LFV (ex: LHT)	$<5.6 \times 10^{-8}$ (arXiv:1409.8548) (still below B-factories sensitivity)
$B_s \rightarrow e\mu$	RPV, Pati-Salam LQ…	$<1.4 \times 10^{-8}$ (PRL 111 141801)
$B_d \rightarrow e\mu$	RPV, Pati-Salam LQ…	$<3.7 \times 10^{-9}$ (PRL 111 141801)
$B \rightarrow X\mu^+\mu^+$	4^{th} gen. Majoranas	See Phys. Rev. D 85, 112004

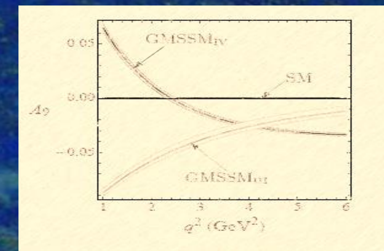
$M_{LQ}(B_s^0 \rightarrow e^\pm \mu^\mp) > 106 \text{ TeV}/c^2$

$M_{LQ}(B^0 \rightarrow e^\pm \mu^\mp) > 127 \text{ TeV}/c^2$

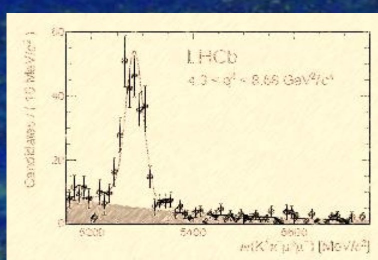
A good example of flavour physics accessing high energy scales

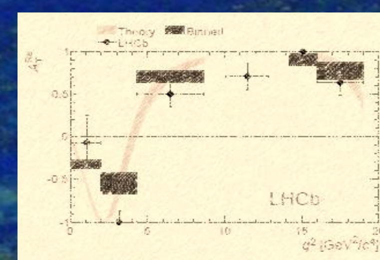
(arXiV references in backup)





$B_d \to K^*(\to K\pi)\,\mu\mu$





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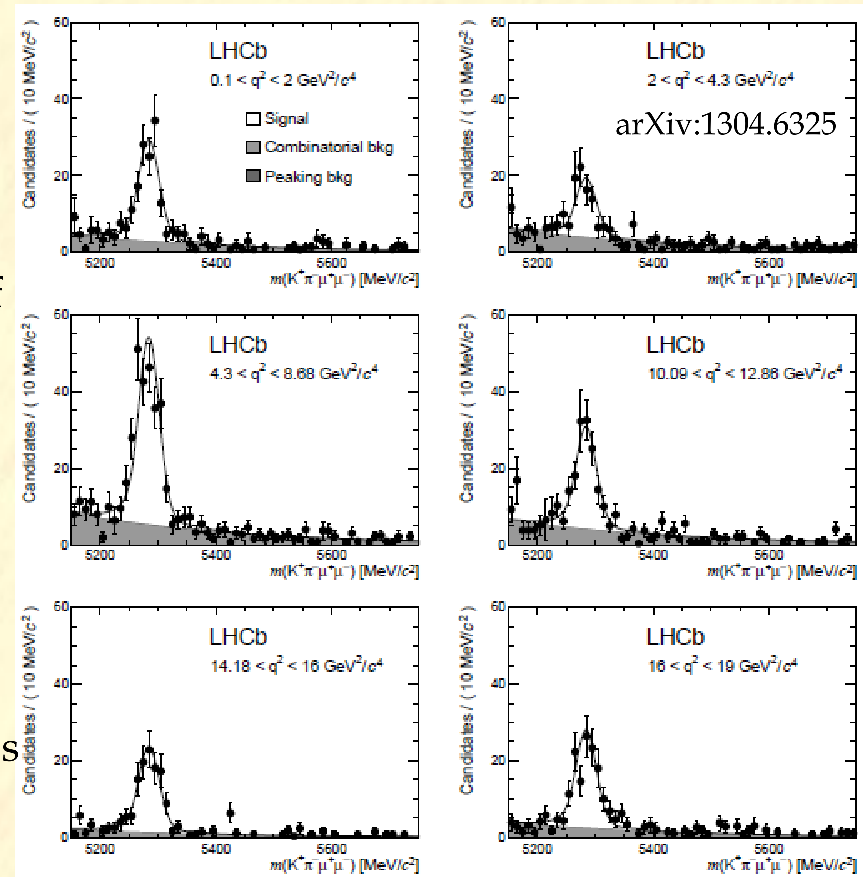
$B_d \rightarrow K^*(\rightarrow K\pi)\ \mu\mu$

- We select events using a BDT and special vetoes for specific backgrounds

- Correct (in an event-by event basis) for the effect of reconstruction/selection/trigger using simulation

    - Validated on data via control channels (mainly $B_d \rightarrow J/\psi(\mu\mu)\ K^*(K\pi)$)

- Fit yields and angular distributions for observables in bins of q^2 (dimuon invariant mass squared)



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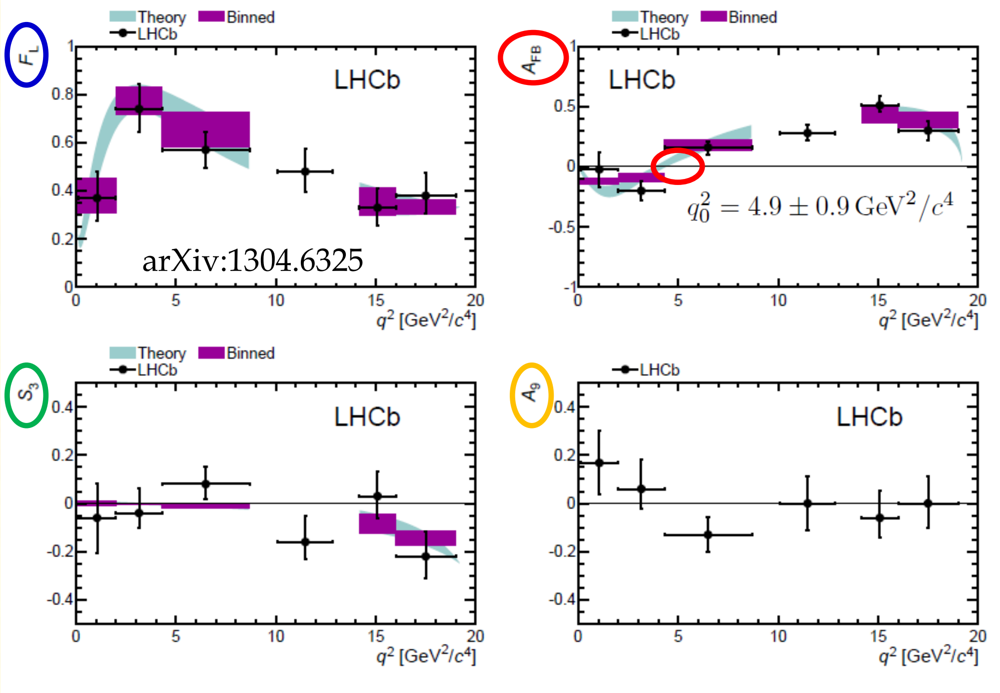
$$\frac{1}{\mathrm{d}\Gamma/\mathrm{d}q^2}\frac{\mathrm{d}^4\Gamma}{\mathrm{d}q^2\,\mathrm{d}\cos\theta_\ell\,\mathrm{d}\cos\theta_K\,\mathrm{d}\hat{\phi}} = \frac{9}{16\pi}\Big[F_\mathrm{L}\cos^2\theta_K + \frac{3}{4}(1-F_\mathrm{L})(1-\cos^2\theta_K) - F_\mathrm{L}\cos^2\theta_K(2\cos^2\theta_\ell-1) + \frac{1}{4}(1-F_\mathrm{L})(1-\cos^2\theta_K)(2\cos^2\theta_\ell-1) + S_3(1-\cos^2\theta_K)(1-\cos^2\theta_\ell)\cos 2\hat{\phi} + \frac{4}{3}A_\mathrm{FB}(1-\cos^2\theta_K)\cos\theta_\ell + A_9(1-\cos^2\theta_K)(1-\cos^2\theta_\ell)\sin 2\hat{\phi}\Big]$$



$B_d \rightarrow K^*(\rightarrow K\pi)\,\mu\mu$

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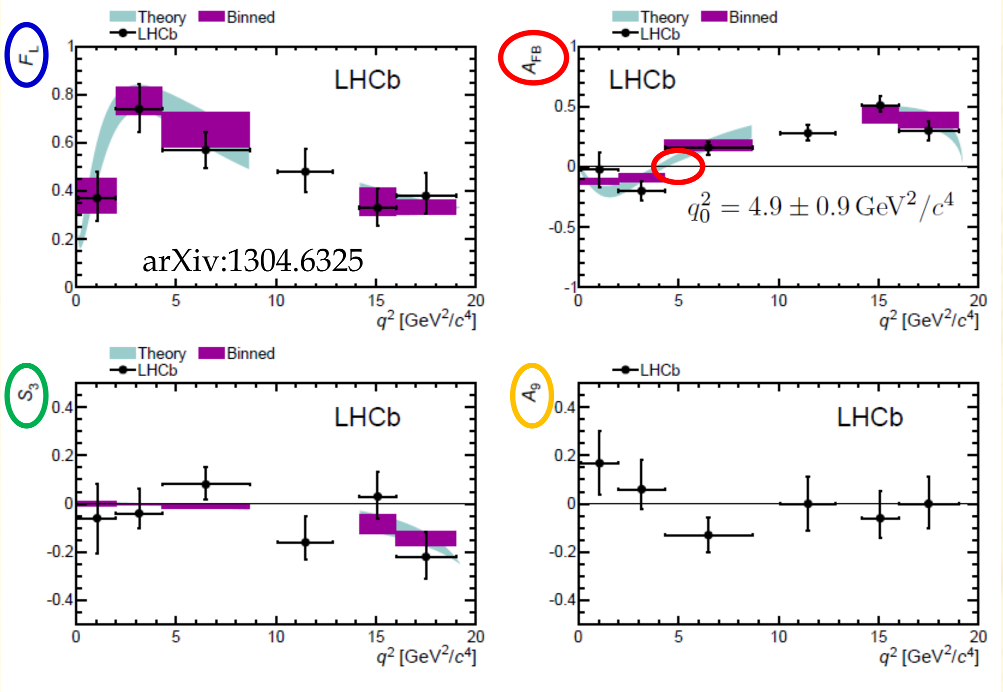
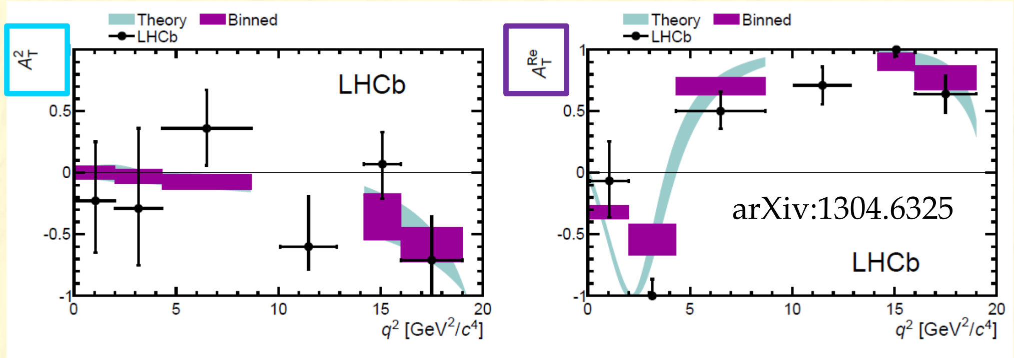
$$\frac{1}{\mathrm{d}\Gamma/\mathrm{d}q^2}\frac{\mathrm{d}^4\Gamma}{\mathrm{d}q^2\,\mathrm{d}\cos\theta_\ell\,\mathrm{d}\cos\theta_K\,\mathrm{d}\hat{\phi}} = \frac{9}{16\pi}\Big[F_L\cos^2\theta_K + \frac{3}{4}(1-F_L)(1-\cos^2\theta_K) - F_L\cos^2\theta_K(2\cos^2\theta_\ell-1) + \frac{1}{4}(1-F_L)(1-\cos^2\theta_K)(2\cos^2\theta_\ell-1) + S_3(1-\cos^2\theta_K)(1-\cos^2\theta_\ell)\cos 2\hat{\phi} + \frac{4}{3}A_{FB}(1-\cos^2\theta_K)\cos\theta_\ell + A_9(1-\cos^2\theta_K)(1-\cos^2\theta_\ell)\sin 2\hat{\phi}\Big]$$



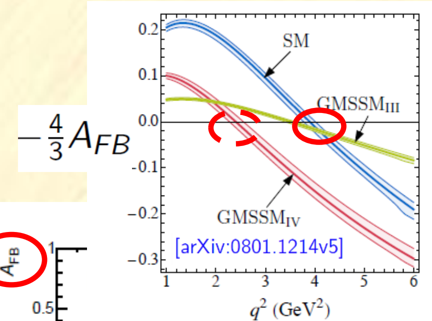
You can also **reparameterize** the fit pdf to get some cleaner observables:

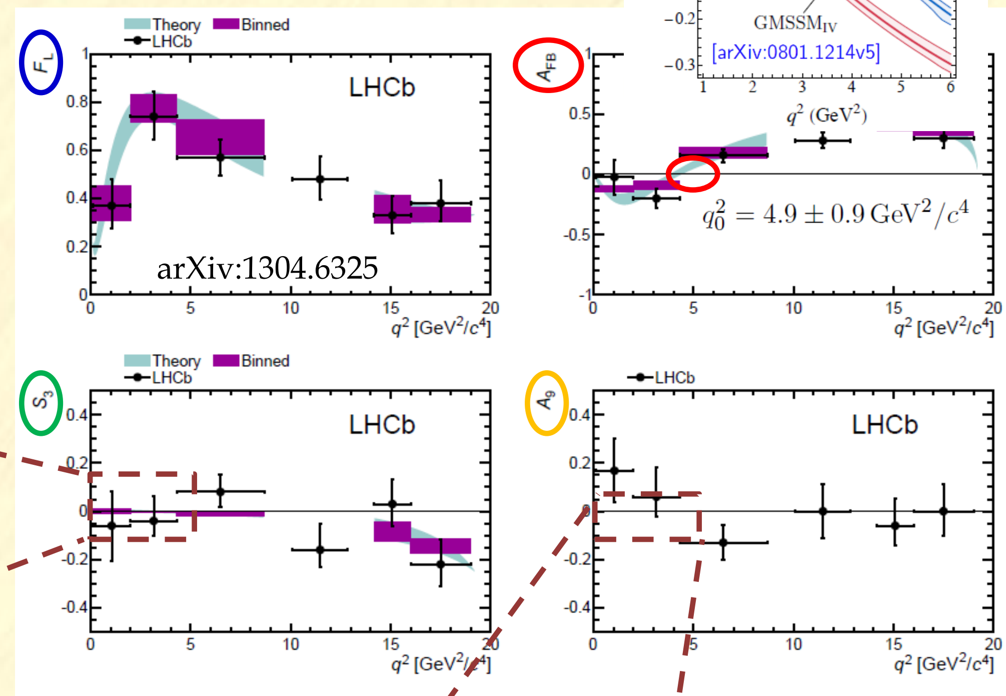
$$A_{FB} = \frac{3}{4}(1-F_L)A_T^{Re} \quad \text{and} \quad S_3 = \frac{1}{2}(1-F_L)A_T^2$$

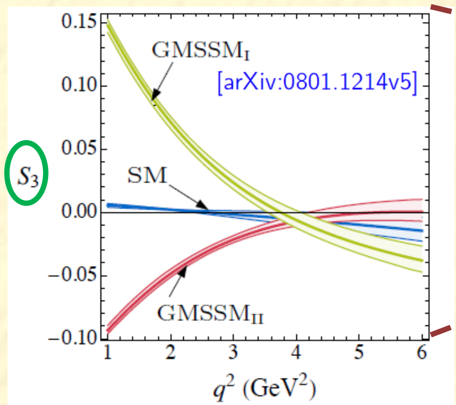


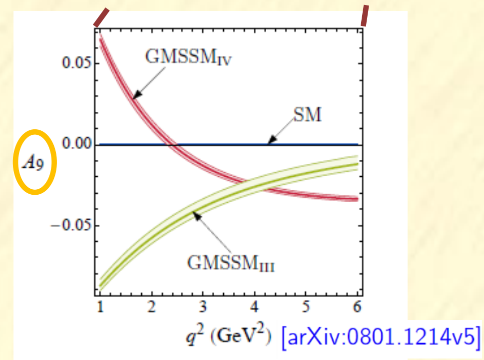
$B_d \to K^*(\to K\pi)\,\mu\mu$

… And then you can compare to models









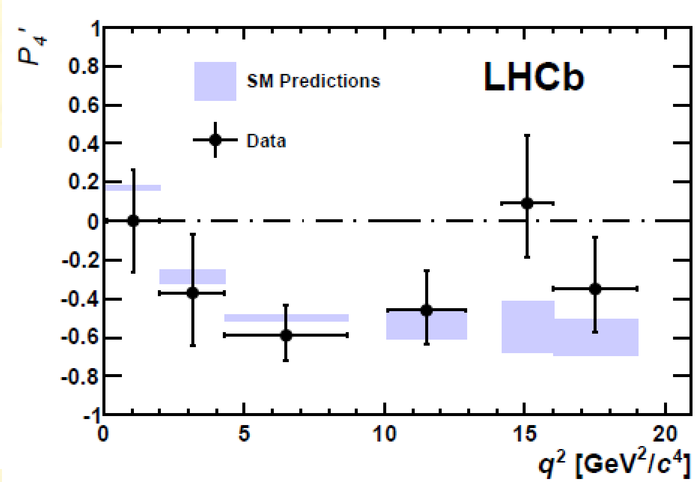
$B_d \to K^*(\to K\pi)\,\mu\mu$

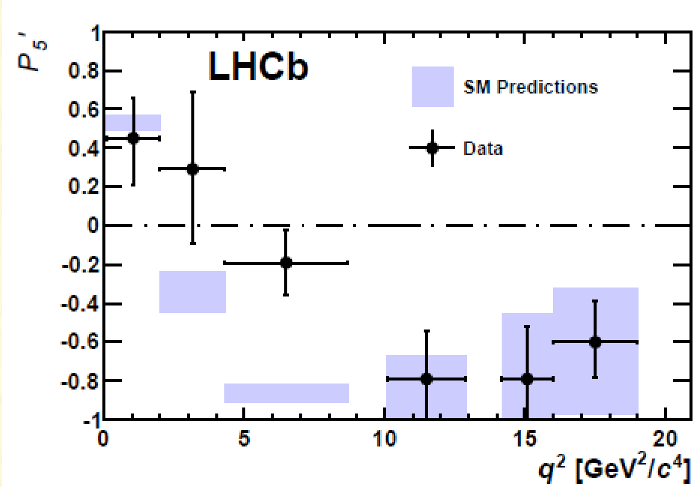
Phys. Rev. Lett. 111, 191801

PDF can also be parameterized to minimize form factors uncertainties

$$\frac{1}{\mathrm{d}\Gamma/dq^2}\frac{\mathrm{d}^4\Gamma}{\mathrm{d}\cos\theta_\ell\,\mathrm{d}\cos\theta_K\,\mathrm{d}\phi\,\mathrm{d}q^2} = \frac{9}{32\pi}\Big[\frac{3}{4}(1-F_{\mathrm{L}})\sin^2\theta_K + F_{\mathrm{L}}\cos^2\theta_K + \frac{1}{4}(1-F_{\mathrm{L}})\sin^2\theta_K\cos 2\theta_\ell$$
$$- F_{\mathrm{L}}\cos^2\theta_K\cos 2\theta_\ell + S_3\sin^2\theta_K\sin^2\theta_\ell\cos 2\phi$$
$$+ S_4\sin 2\theta_K\sin 2\theta_\ell\cos\phi + S_5\sin 2\theta_K\sin\theta_\ell\cos\phi$$
$$+ S_6\sin^2\theta_K\cos\theta_\ell + S_7\sin 2\theta_K\sin\theta_\ell\sin\phi$$
$$+ S_8\sin 2\theta_K\sin 2\theta_\ell\sin\phi + S_9\sin^2\theta_K\sin^2\theta_\ell\sin 2\phi\Big],$$

$$P'_{i=4,5,6,8} = \frac{S_{j=4,5,7,8}}{\sqrt{F_{\mathrm{L}}(1-F_{\mathrm{L}})}}$$





Local discrepancy with SM prediction of 3.7σ

LEE-corrected SM p-value of this analysis is 0.5%

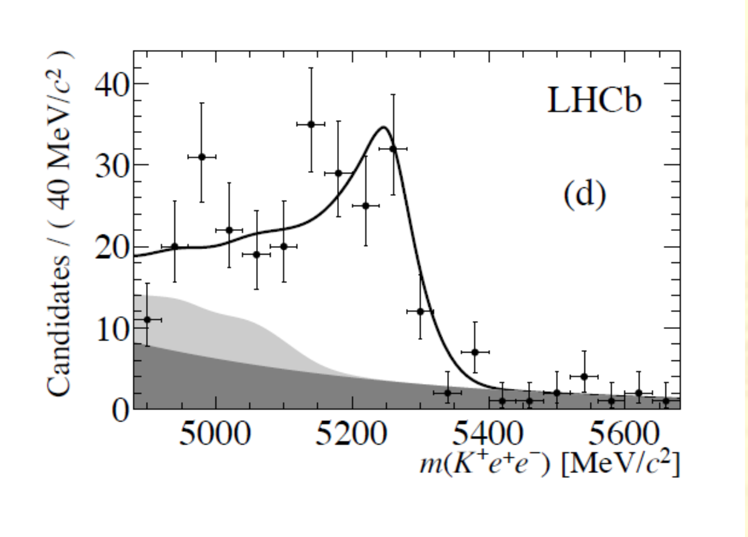
Experimental precision will keep improving
Work ongoing in the theory community (SM/NP) to better understand this bin

Phys. Rev. Lett. 113, 151601

Lepton Universality

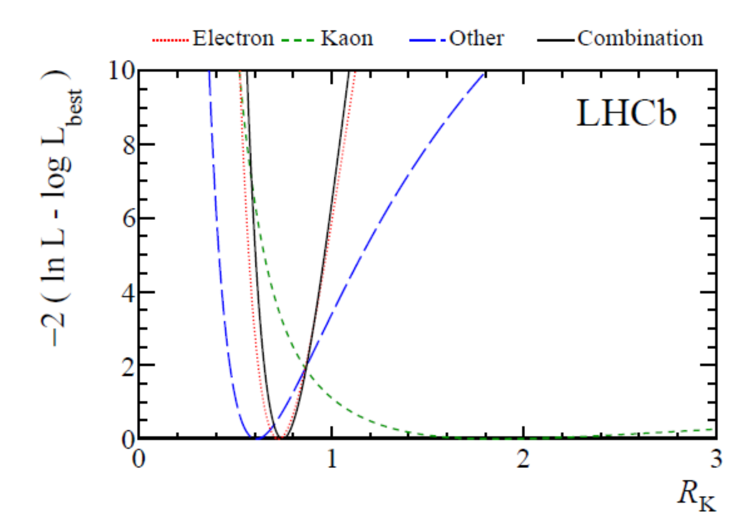
LHCb performed a lepton universality test in $B^+ \to K^+ \ell^+ \ell^-$ with full Run-I dataset

$$R_K = \frac{BF(B^+ \to K^+ \mu^+ \mu^-)}{BF(B^+ \to K^+ e^+ e^-)} = 0.745^{+0.090}_{-0.074}(\text{stat}) \pm 0.036(\text{syst})$$



Result deviates **2.6σ** from SM prediction of $R_K = 1$
Result with m_{ll} at the J/ψ resonance consistent with 1

Work ongoing to test lepton universality in $K^* \ell^+ \ell^-$ and $\Phi \ell^+ \ell^-$ models



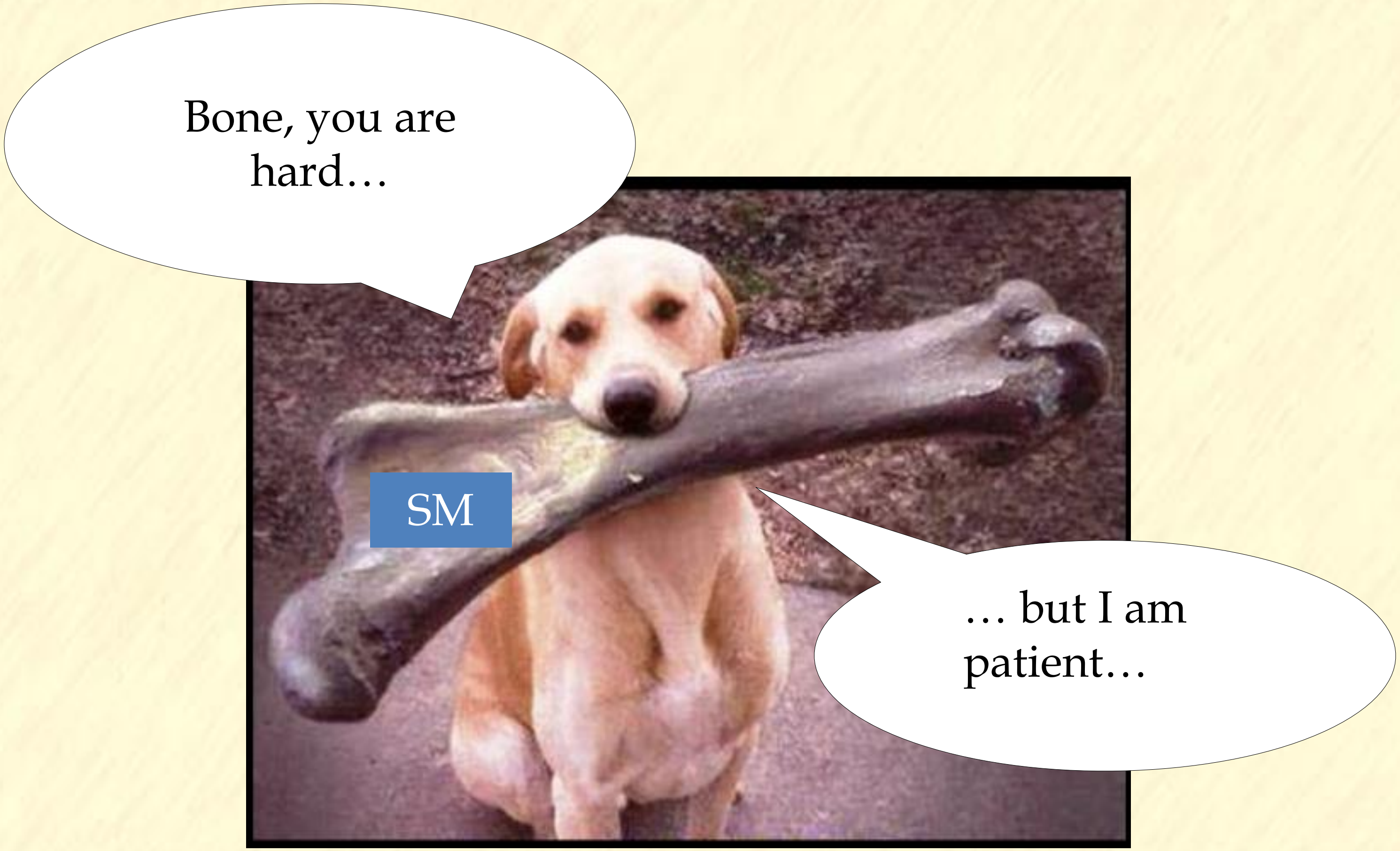
Results on b→sll

Measurement	Luminosity	Reference
BR($B^+ \to \pi^+\mu^+\mu^-$)	1 fb^{-1}	JHEP 12 (2012) 125
BR($B_d \to K^* e^+ e^-$)	1 fb^{-1}	JHEP 05(2013) 159
$B_d \to K^*\mu^+\mu^-$, angular analysis (I) (A_{FB}, F_L, S_3…)	1 fb^{-1}	JHEP 1308 (2013) 131
$B_s \to \Phi\mu^+\mu^-$, angular analysis	1 fb^{-1}	JHEP 1307 (2013) 084
BR($\Lambda_b \to \Lambda\mu^+\mu^-$)	1 fb^{-1}	PLB 725 (2013) 25
Resonance searches in $B^+ \to K^+\mu^+\mu^-$	3 fb^{-1}	PRL 111, 112003 (2013)
$B_d \to K^*\mu^+\mu^-$, angular analysis (II) (P'_i)	1 fb^{-1}	PRL 111, 191801 (2013)
$B \to K^{(*)}\mu^+\mu^-$, BR and Isospin Asymmetry	3 fb^{-1}	JHEP 06 (2014) 133
$B \to K\mu^+\mu^-$, A_{FB}, F_H	3 fb^{-1}	JHEP 05 (2014) 082
$B \to K l^+ l^-$ Lepton universality	3 fb^{-1}	PRL 113, 151601 (2014)
$B \to K^{(*)}\mu^+\mu^-$ CP asymmetries	3 fb^{-1}	JHEP 09 (2014) 177
BR($B^+ \to hhh\mu^+\mu^-$)	3 fb^{-1}	JHEP 1410 (2014) 064

(arXiV references in backup)

Conclusions

- $B_{s(d)} \rightarrow \mu\mu$ full Run-I dataset analysed, also combined with CMS Run-I data
    - $B_s \rightarrow \mu\mu$ significance is 6.2σ.
    - First evidence for $B_d \rightarrow \mu\mu$ (3.2σ) . Ratio B_d/B_s within SM at 2.3σ Level
- Results and prospects for rare strange and cham decays presented
    - Study rare kaon/hyperon decays require trigger work. **If you have ideas of interesting channels, shout asap**
- $B_d \rightarrow K^* \mu\mu$ angular analysis using 1/3 of Run-I data. LEE-corrected SM p-value is 0.5% when analysing P' observables.
- Lepton universality tests on $B^+ \rightarrow K^+ \ell^+ \ell^-$ within SM prediction at 2.6σ



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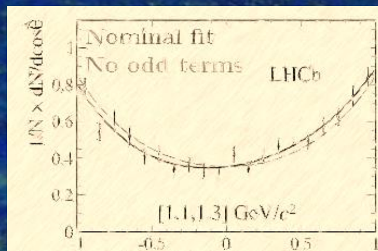
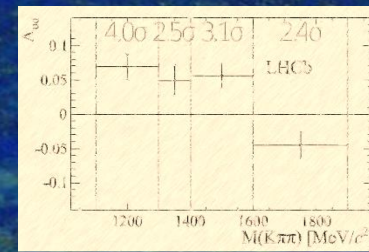
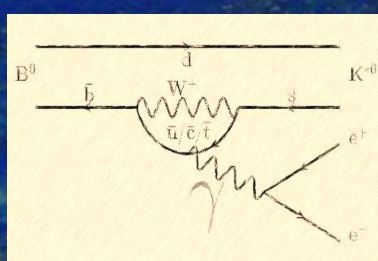
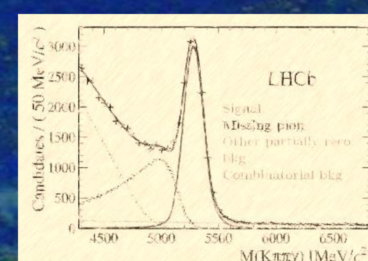




RADIATIVE DECAYS

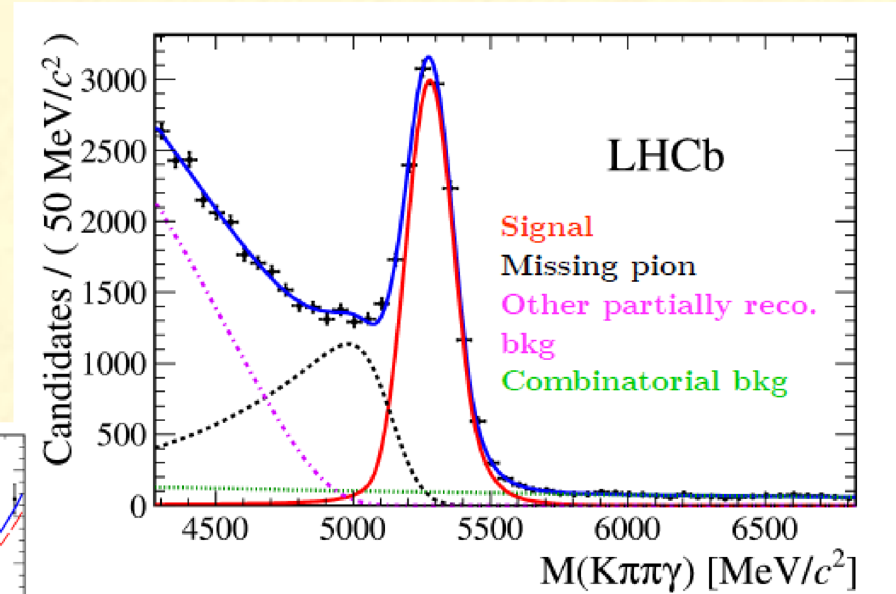


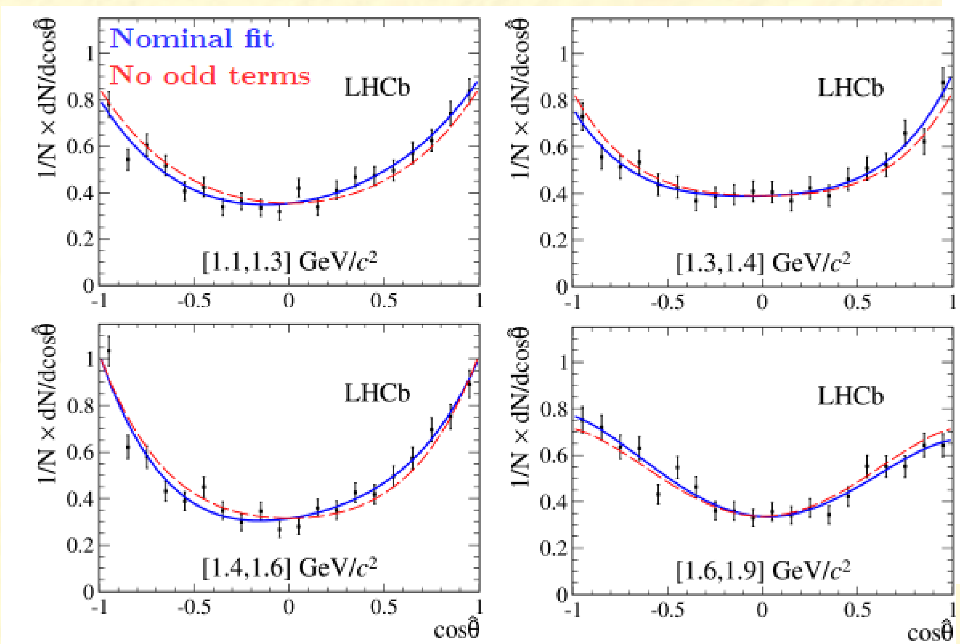


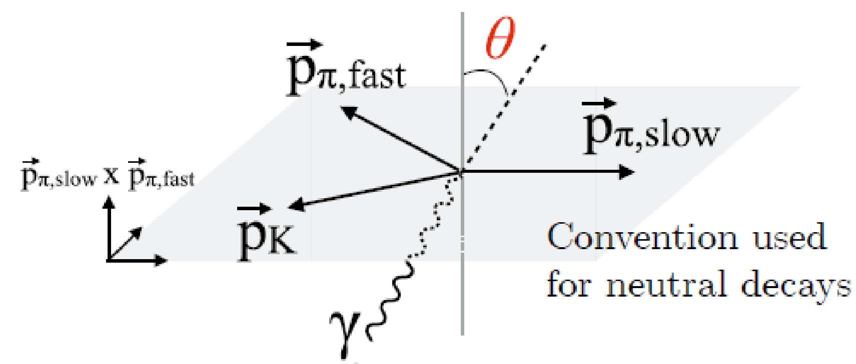
$B^+ \to K^+\pi^-\pi^+\gamma$

PRL 112, 161801 (2014)

- Full dataset analysed
- ~14k signal events in $M_{K\pi\pi}$ [1.1,1.9] GeV
- First measurement of non-zero photon polarization in b→sγ transitions







Prospects on $B_d \to K^* ee$ and $B_s \to \Phi\gamma$

Angular analysis of $B_d \to K^* ee$ ongoing.

Electron channel allows to go to very low q^2, where photon pole contribution dominates

3 fb^{-1} Sensitivity from toy-MC

	F_L	A_T^{Re}	$A_T^{(2)}$	A_T^{Im}
σ^{stat}	0.07	0.17	0.25	0.25
σ^{syst}	0.03	0.05	0.05	0.05

Time dependent analysis of $B_s \to \Phi\gamma$ is ongoing. Allows to extract photon polarization

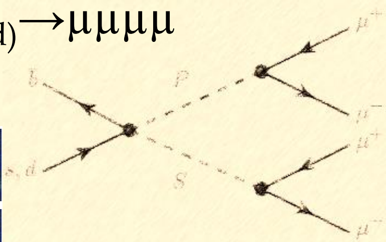
$$\Gamma(t) = |A|^2 e^{-\Gamma_s t}\left(\cosh\frac{\Delta\Gamma_s t}{2} - \mathcal{A}^{\Delta}\sinh\frac{\Delta\Gamma_s t}{2}\right)$$

$$\mathcal{A}^{\Delta} = 0.047 \pm 0.025 \pm 0.015_{\alpha_S}$$

Run-I expected sensitivity: ~0.3

Other very rare decays @ LHCb

$B_{s(d)}\to\mu\mu\mu\mu$



Decay	Main BSM test	95% upper limit
$B_s\to\mu\mu\mu\mu$	Some SUSY scenarios	$<1.6\times10^{-8}$ (arXiv:1303.1092)
$B_d\to\mu\mu\mu\mu$	Some SUSY scenarios	$<6.6\times10^{-9}$ (arXiv:1303.1092)
$\tau\to\mu\mu\mu$	LFV (ex: LHT)	$<5.6\times10^{-8}$ (arXiv:1409.8548) (still below B-factories sensitivity)
$B_s\to e\mu$	RPV, Pati-Salam LQ…	$<1.4\times10^{-8}$ (LHCb-PAPER-2013-030)
$B_d\to e\mu$	RPV, Pati-Salam LQ…	$<3.7\times10^{-9}$ (LHCb-PAPER-2013-030)
$B\to X\mu^+\mu^+$	4th gen. Majoranas	See arXiv:1201.5600

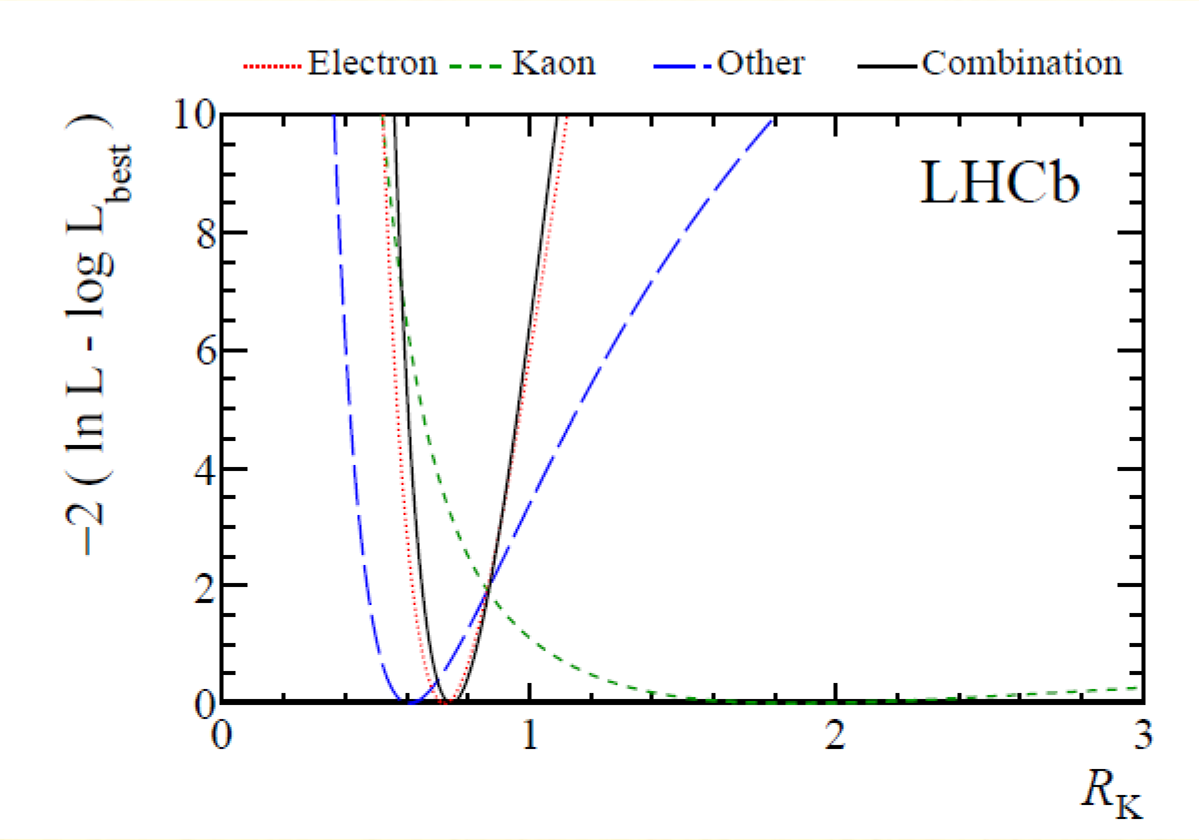
$$M_{\rm LQ}(B_s^0\to e^\pm\mu^\mp) > 106\ \ {\rm TeV}/c^2$$

$$M_{\rm LQ}(B^0\to e^\pm\mu^\mp) > 127\ \ {\rm TeV}/c^2$$

A good example of flavour physics accessing high energy scales

Results on b→sll

Measurement	Luminosity	Reference
BR($B^+ \to \pi^+ \mu^+ \mu^-$)	1 fb^{-1}	[arXiv:1210.2645]
BR($B_d \to K^* e^+ e^-$)	1 fb^{-1}	[arXiv:1304.3035]
$B_d \to K^* \mu^+ \mu^-$, angular analysis (I) (A_{FB}, F_L, S_3…)	1 fb^{-1}	[arXiv:1304.6325]
$B_s \to \Phi \mu^+ \mu^-$, angular analysis	1 fb^{-1}	[arXiv:1305.2168]
BR($\Lambda_b \to \Lambda \mu^+ \mu^-$)	1 fb^{-1}	[arXiv:1306.2577]
Resonance searches in $B^+ \to K^+ \mu^+ \mu^-$	3 fb^{-1}	[arXiv:1307.7595]
$B_d \to K^* \mu^+ \mu^-$, angular analysis (II) (P'_i)	1 fb^{-1}	[arXiv:1308.1707]
$B \to K^{(*)} \mu^+ \mu^-$, BR and Isospin Asymmetry	3 fb^{-1}	[arXiv:1403.8044]
$B \to K \mu^+ \mu^-$, A_{FB}, F_H	3 fb^{-1}	[arXiv:1403.8045]
$B \to K l^+ l^-$ Lepton universality	3 fb^{-1}	[arXiv:1406.6482]
$B \to K^{(*)} \mu^+ \mu^-$ CP asymmetries	3 fb^{-1}	[arXiv:1408.0978]
BR($B^+ \to hhh \mu^+ \mu^-$)	3 fb^{-1}	[arXiv:1408.1137]

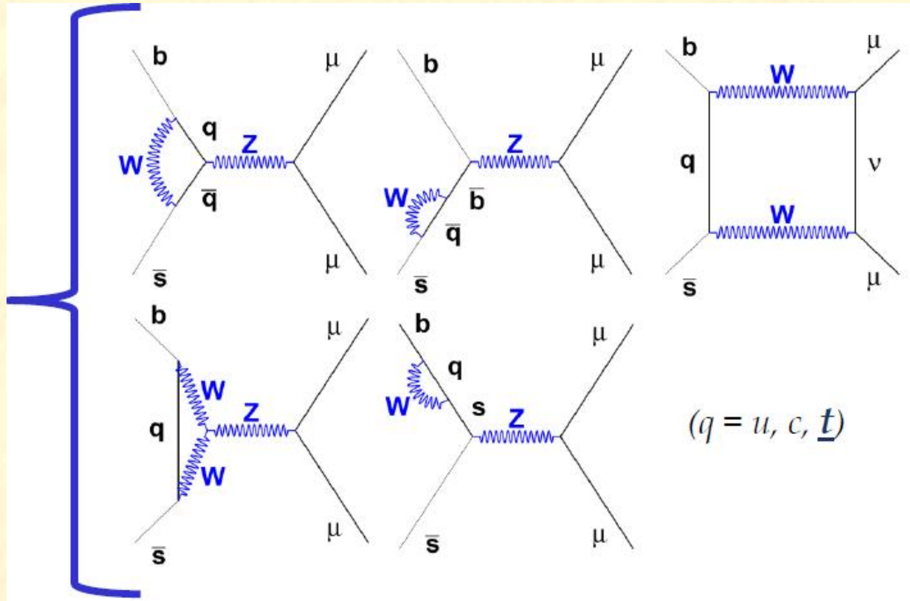

Electron
Kaon
Other
Combination
LHCb
$-2(\ln L - \log L_{best})$
R_K
0
2
4
6
8
10
0
1
2
3

$B_{s(d)} \rightarrow \mu\mu$

These decays are very supressed in SM

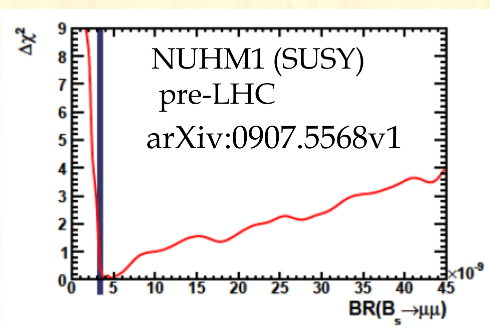
$BR(B_s \rightarrow \mu\mu) = (3.54 \pm 0.30)\times10^{-9}$
$BR(B_d \rightarrow \mu\mu) = (1.07 \pm 0.10)\times10^{-10}$

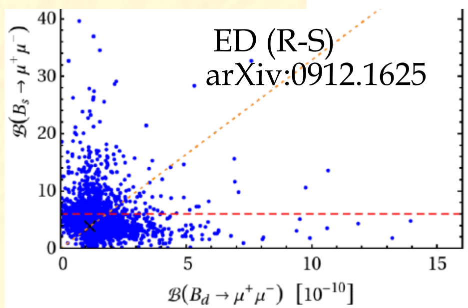
Eur. Phys. J. C72 (2012) 2172, arXiv:1208.0934. *(time averaged)*



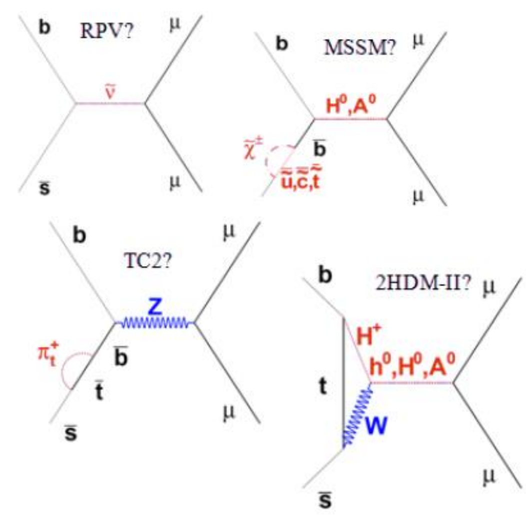
(note also the high TH precision)

But several NP models could sizably modify those values, sometimes by orders of magnitude.





+?



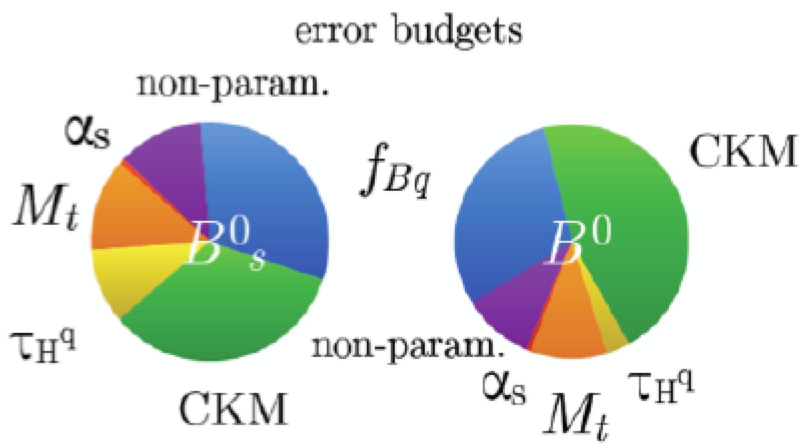
→ *Whatever we measure, it impacts NP searches*

$BR(B_s^0 \to \mu^+\mu^-) = (3.66 \pm 0.23) \times 10^{-9}$ (6.3%)
$BR(B^0 \to \mu^+\mu^-) = (1.06 \pm 0.09) \times 10^{-10}$ (8.5%)

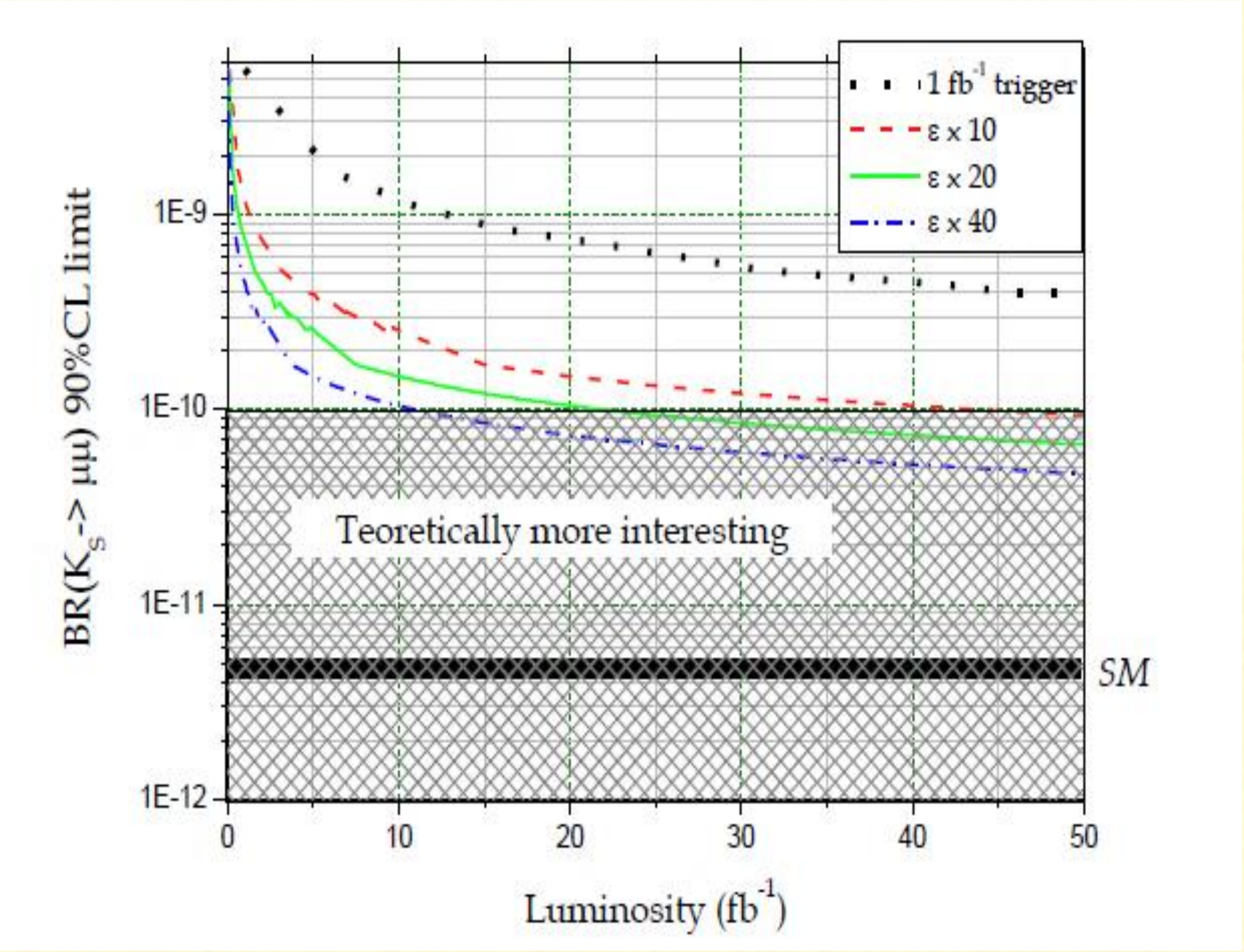
Bobeth et al. '13

	f_{B_q}	CKM	τ_H^s	M_t	α_s	other param.	non-param.	$\sum$
$B_s^0 \to \mu^+\mu^-$	4.0%	4.3%	1.3%	1.6%	0.1%	< 0.1%	1.5%	6.4%
$B^0 \to \mu^+\mu^-$	4.5%	6.9%	0.5%	1.6%	0.1%	< 0.1%	1.5%	8.5%

- $f_{B_s} = 227.4(4.5)$ MeV [FLAG '13, arXiv:1310.8555]
- V_{cb} from recent inclusive fit [Gambino, Schwanda '13, arXiv:1307.4551]
- $f_{B_d} = 190.5(4.2)$ MeV [FLAG '13, arXiv:1310.8555]



The uncertainty of CKM matrix elements is now larger than the uncertainty on $f_{Bs,d}$


1 fb^{-1} trigger
ε x 10
ε x 20
ε x 40
1E-9
1E-10
1E-11
1E-12
0
10
20
30
40
50
Teoretically more interesting
SM
BR(K_s-> μμ) 90%CL limit
Luminosity (fb^{-1})