Hunting for New Physics in rare penguins

N.Serra

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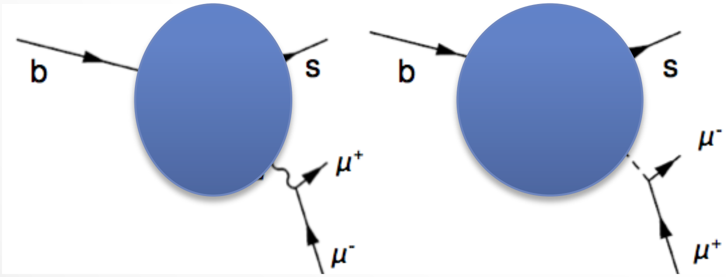
CPPM – 27/02/2012

Why flavor physics

- SM is not considered a fundamental theory
- Indirect search has often allowed us to find or understand new phenomena before the direct search (e.g. Existence of top, Existence of Atoms)
- Basic idea: look where SM predictions are accurate and where new "effective couplings" can have an impact



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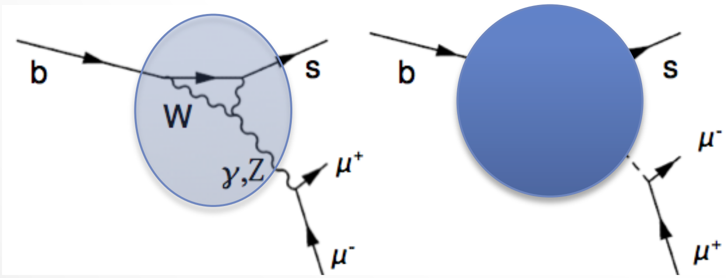

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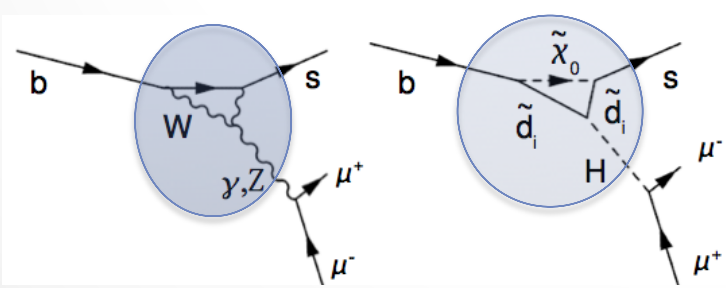
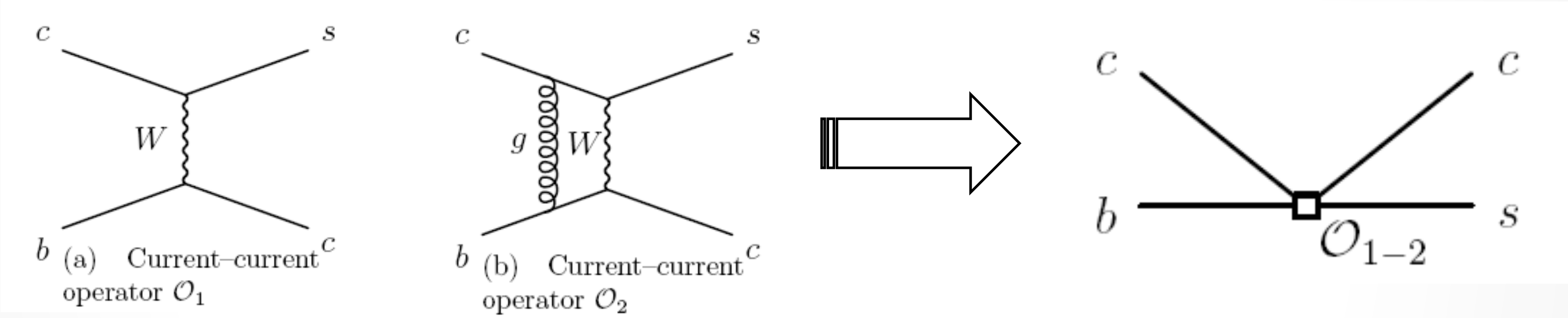


Effective Hamiltonian and OPE

B physics decays are described by an effective Hamiltonian.

$$H_{\text{eff}} = -\frac{G_F}{\sqrt{2}} V_{tb} V_{ts}^* \sum_i C_i(\mu, M_{heavy}) \mathcal{O}_i(\mu)$$



- Fermi Constant
- CMK Matrix elements
- Wilson coefficients (calculable with perturbative techniques)
- Operators which include long distance contributions

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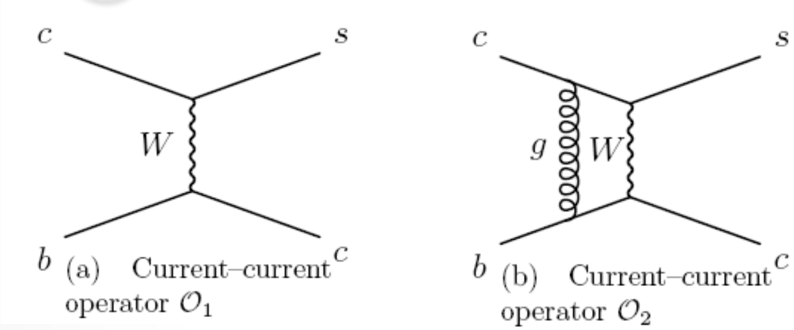

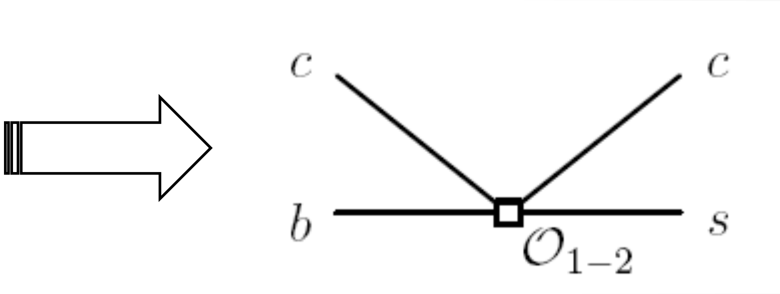

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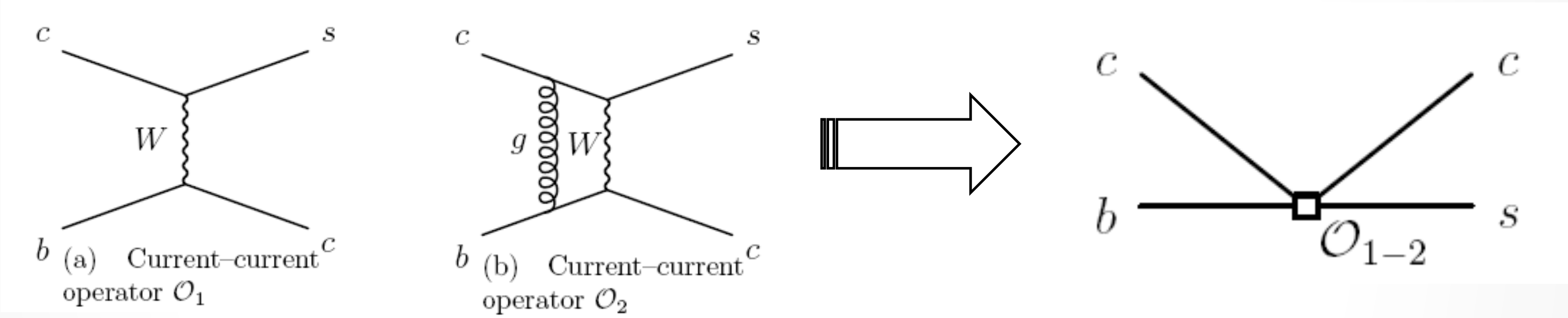

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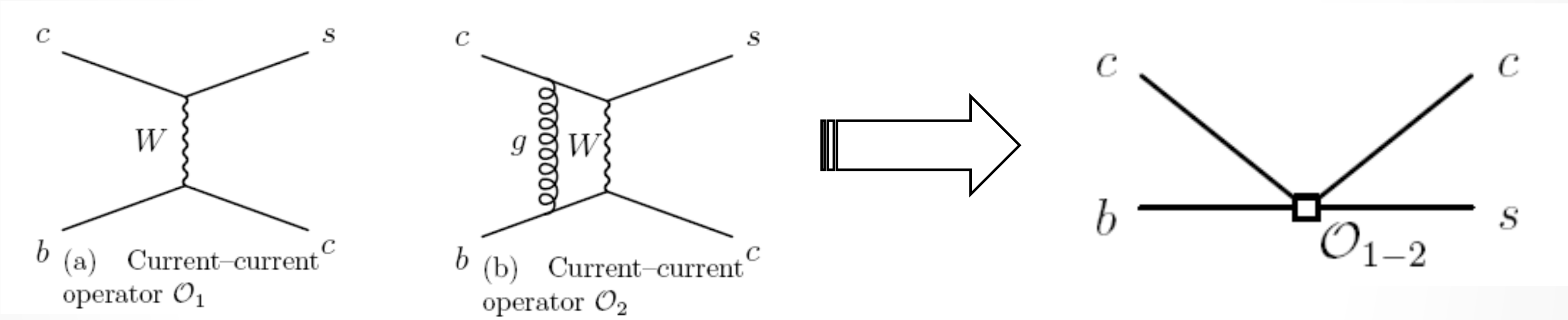

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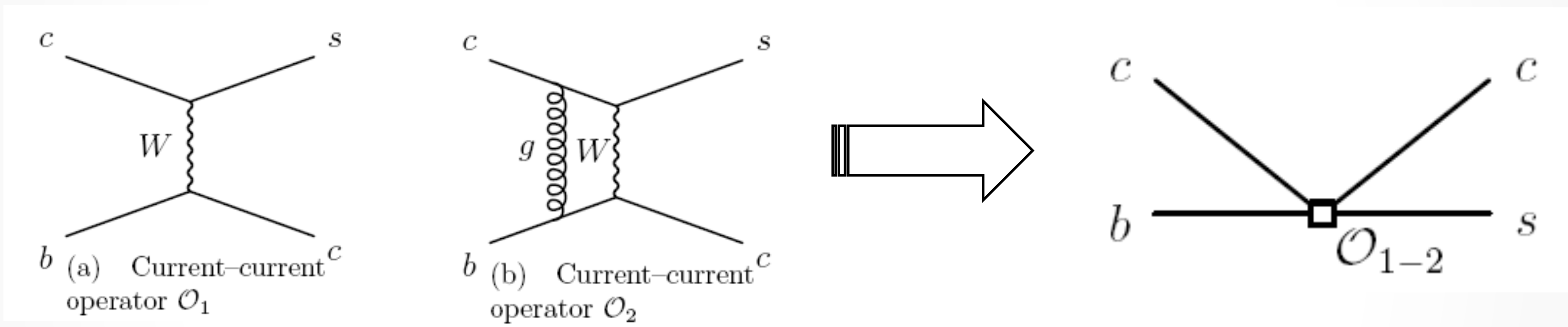

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- Operators which include long distance contributions

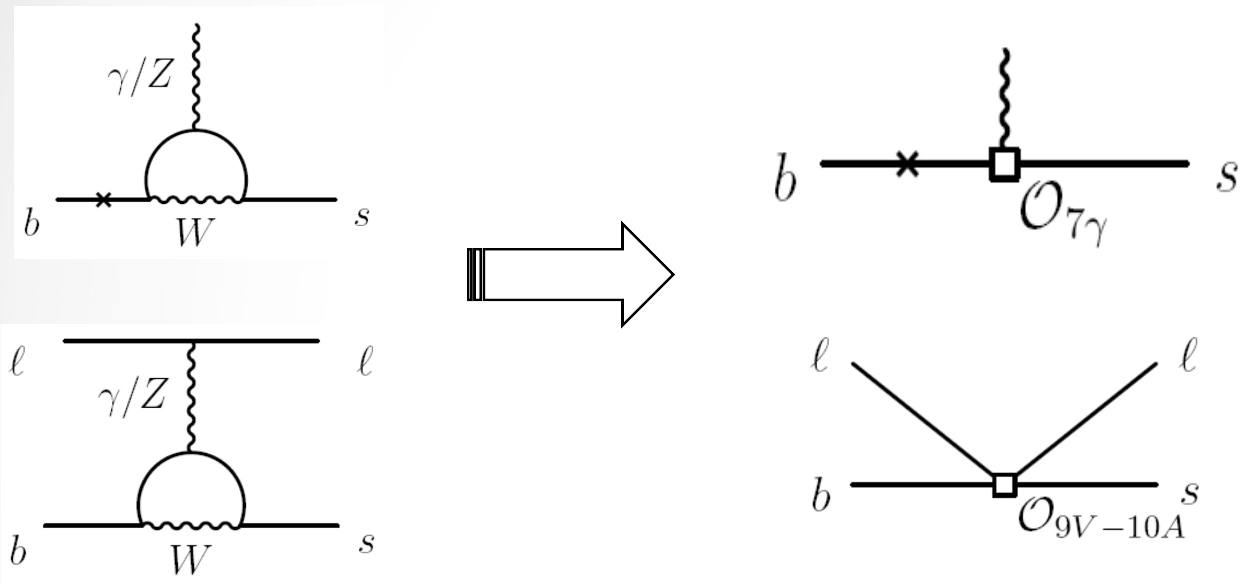
In this talk

Measurement of the branching ratio of the $B_s \rightarrow \mu\mu$ decay

Angular analysis in the $B_d \rightarrow K^*\mu\mu$ decay

Rare decays: OPE

$$H_{\rm eff} = -\frac{G_F}{\sqrt{2}} V_{tb} V_{ts}^* \sum_i C_i(\mu, M_{heavy}) \mathcal{O}_i(\mu)$$



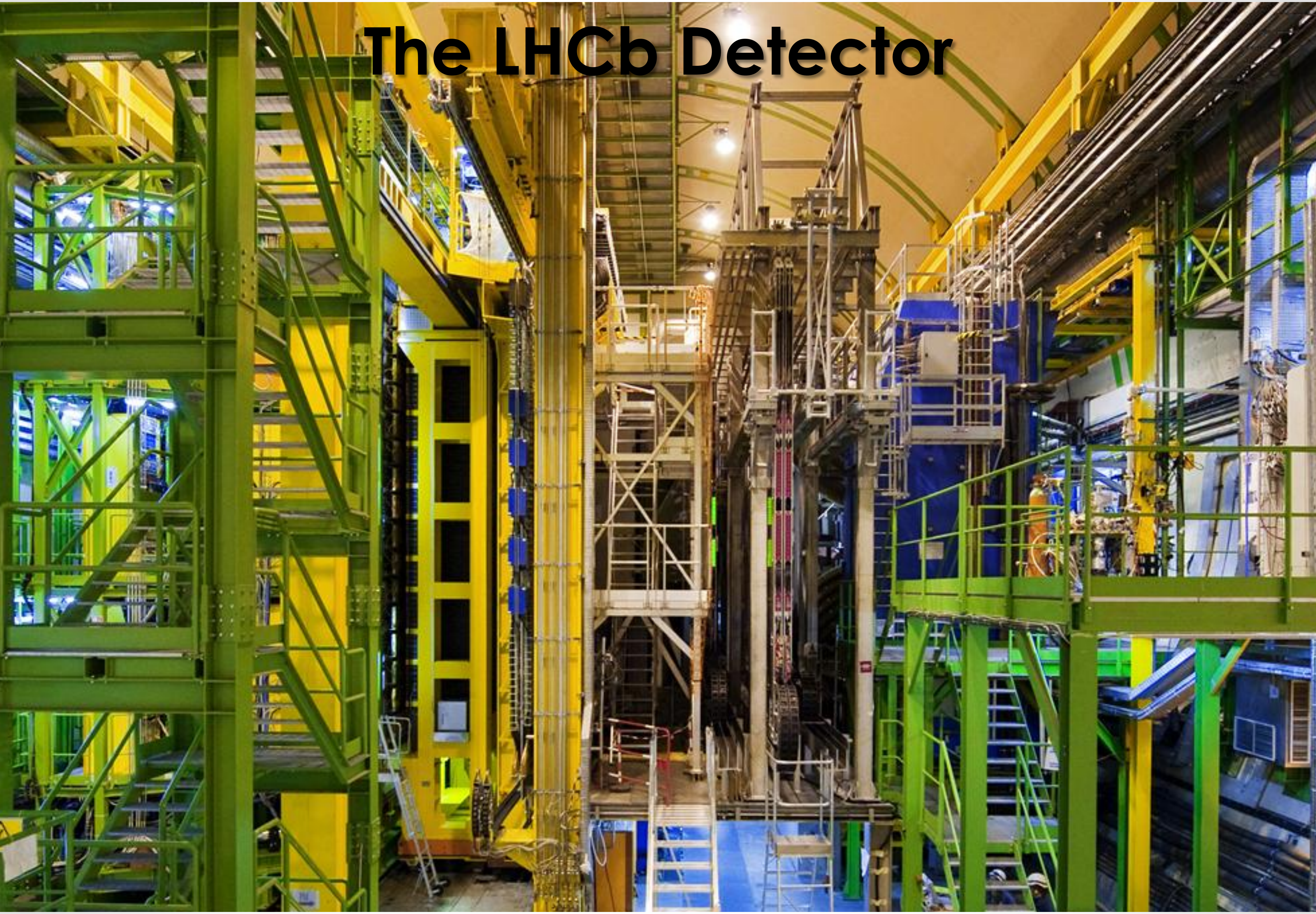
NP can contribute by modifying the Wilson coefficients or with new operators not present in the SM.

e.g. W.Altmannshofer et al., JHEP 0901:019,2009

$B^0 \to K^*\mu\mu$: $O_{7\gamma}$,O_{9V},O_{10A},O_S,O_P and also the "prime" (e.g. $O_{7\gamma}'$) counterparts
$B_s \to \mu\mu$: O_{10A},O_S,O_P

E.g. in the SM the "prime" coefficients are small and the O_S and O_P are highly suppressed.

The LHCb Detector



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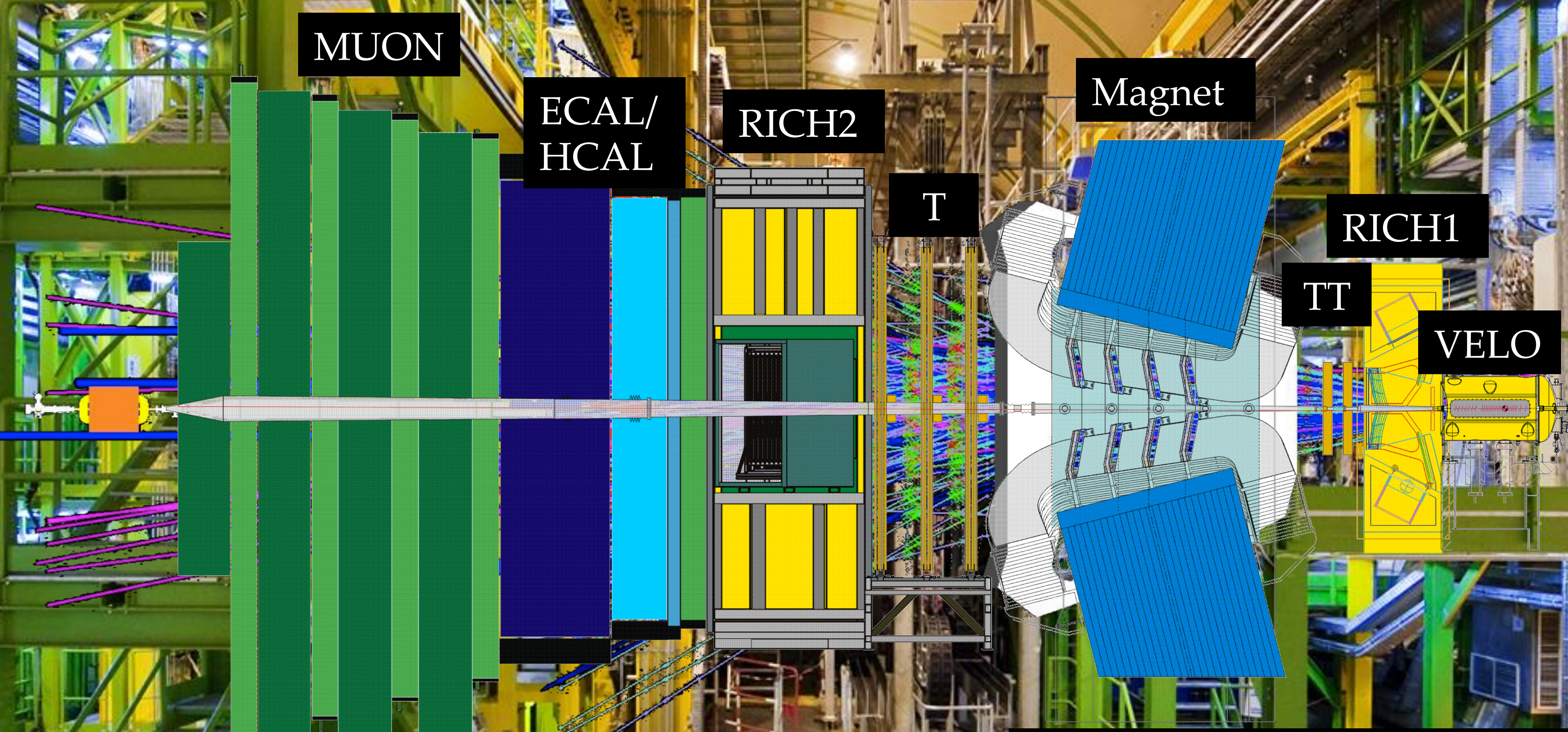

Very good momentum resolution and particle identification

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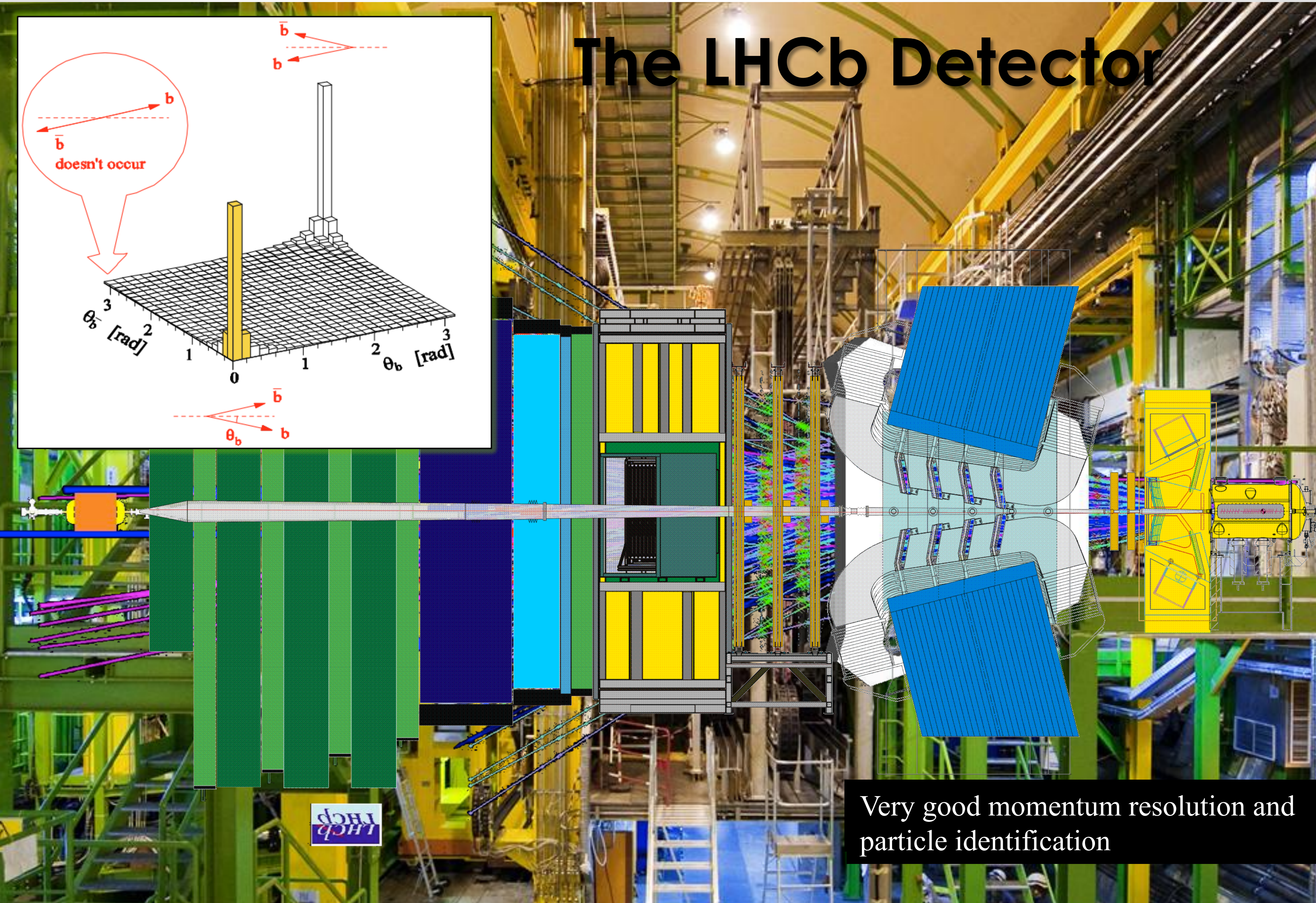

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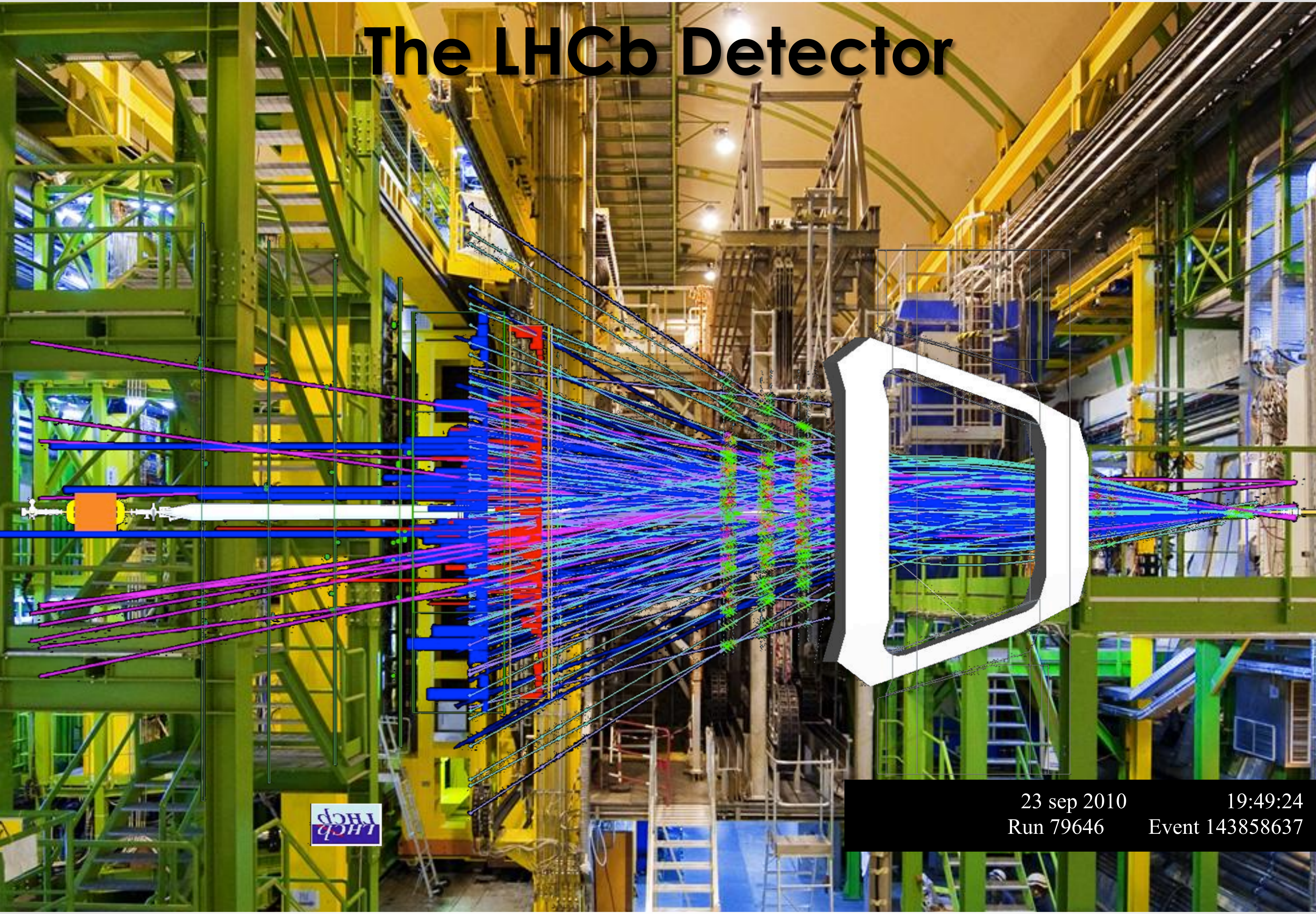


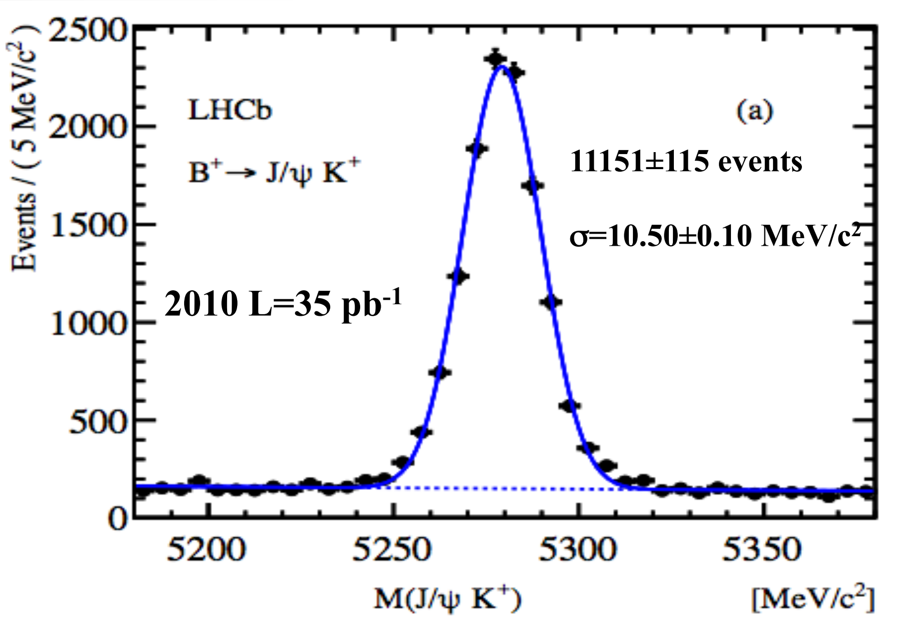
Resolution and PID

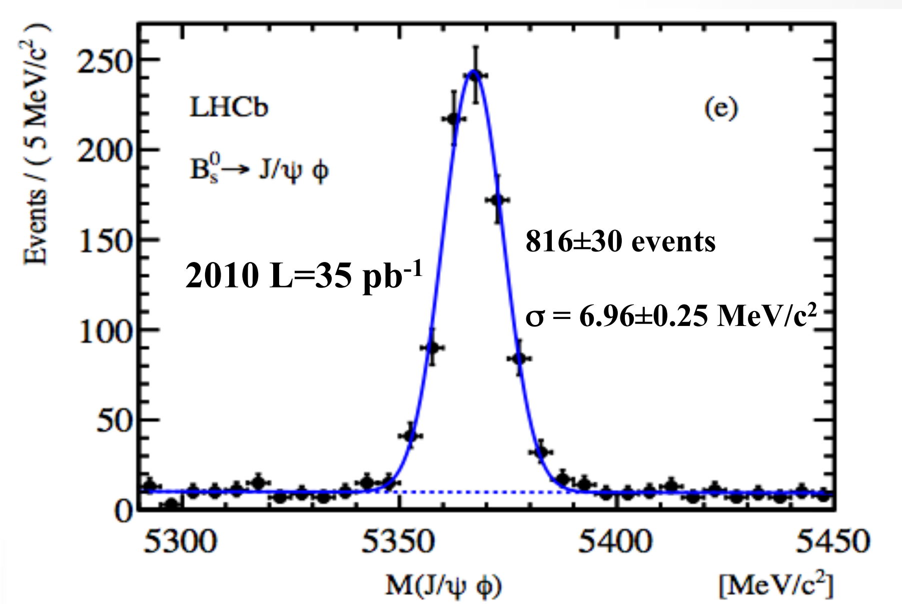
Mass resolution is based on precise momentum measurement with LHCb magnet and tracker: $\Delta p/p \sim 0.3\%$ up to 100 GeV/c (also very good PID)

Quantity	LHCb measurement	Best previous measurement	PDG fit
$M(B^+)$	5279.38 ± 0.35	5279.10 ± 0.55 [4]	5279.17 ± 0.29
$M(B^0)$	5279.58 ± 0.32	5279.63 ± 0.62 [4]	5279.50 ± 0.30
$M(B_s^0)$	5366.90 ± 0.36	5366.01 ± 0.80 [4]	5366.3 ± 0.6
$M(\Lambda_b^0)$	5619.19 ± 0.76	5619.7 ± 1.7 [4]	–
$M(B^0) - M(B^+)$	0.20 ± 0.20	0.33 ± 0.06 [15]	0.33 ± 0.06
$M(B_s^0) - M(B^+)$	87.52 ± 0.32	–	–
$M(\Lambda_b^0) - M(B^+)$	339.81 ± 0.72	–	

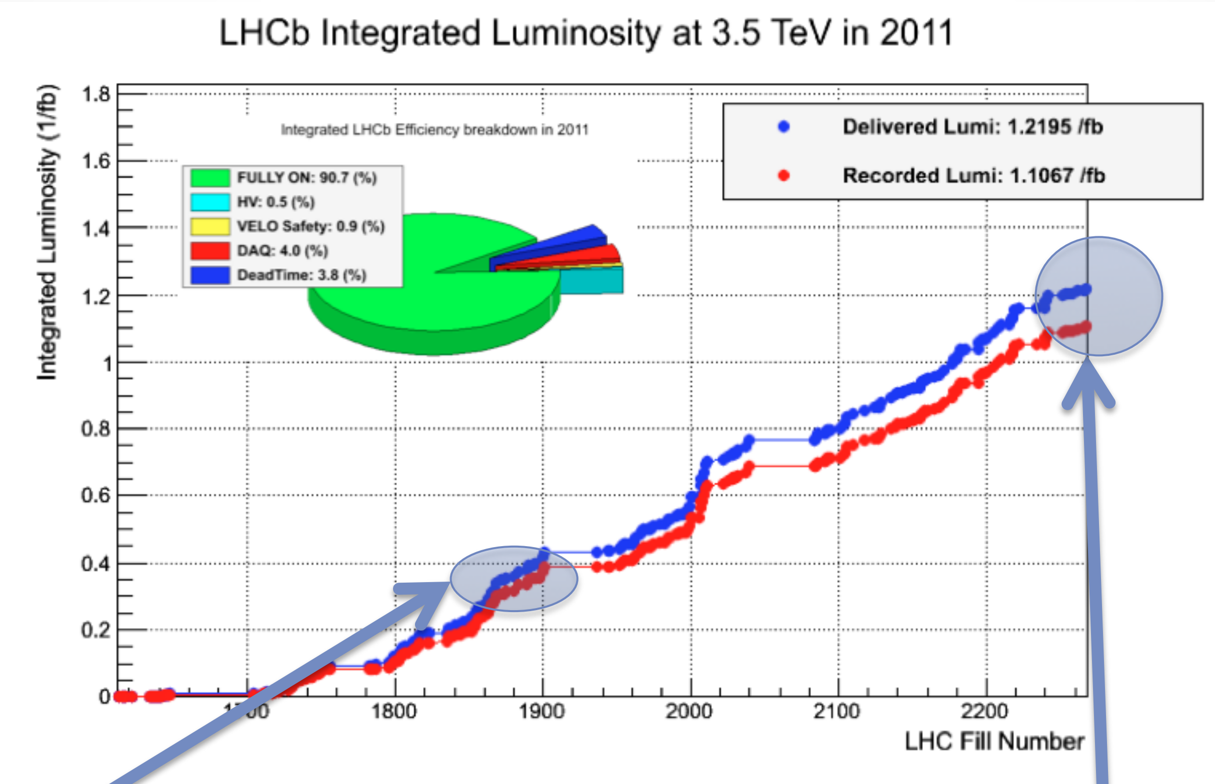
With 2010 data!

Physics Letters B 708 (2012) 241-248





Data taking



This what you will see in this talk

2011: 1.1 fb^{-1}

This is what you will see at spring conferences

Branching ratio: $B_s \rightarrow \mu\mu$

Very rare decay, since it a FCNC and also helicity suppressed.

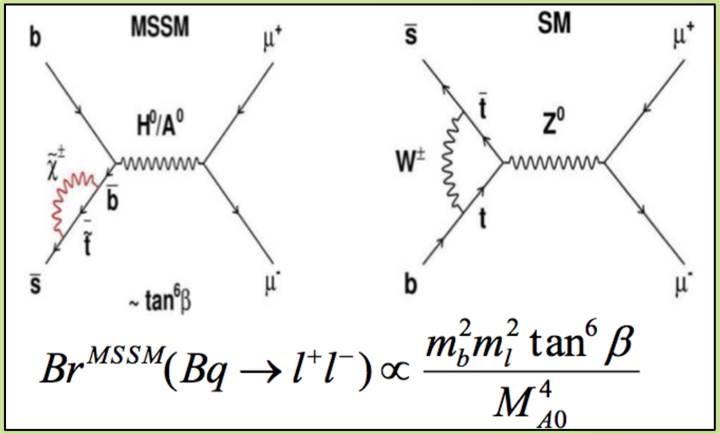
SM prediction:

$$BR(B_s \rightarrow \mu^+\mu^-) = (3.2 \pm 0.2) \cdot 10^{-9}$$

$$BR(B_d \rightarrow \mu^+\mu^-) = (1.1 \pm 0.1) \cdot 10^{-10}$$

A.J. Buras arxiv:1012.1447

E.Gamiz et al. Phys. Rev. D 80 (2009) 104503



Very sensitive probe for NP, since extended Higgs sector can enhance it (e.g. in MSSM BR is proportional to $\tan^6\beta$).

From: A.Buras, arXiv:1012.1447

	AC	RVV2	AKM	δLL	FBMSSM	$SSU(5)_{RN}$	LHT	RSc	4G	2HDM	RHMFV
$B_s \rightarrow \mu^+\mu^-$	★★★	★★★	★★★	★★★	★★★	★★★	★	★	★★★	★★★	★★

★★★ Large NP effects
★★ Small NP effects
★ No NP effects

$B_s \rightarrow \mu\mu$ in MSSM

- Branching ratio sensitive to several NP model

$$BR(B_s \to \mu\mu)_{SM} = (3.2 \pm 0.2)\cdot 10^{-9}$$

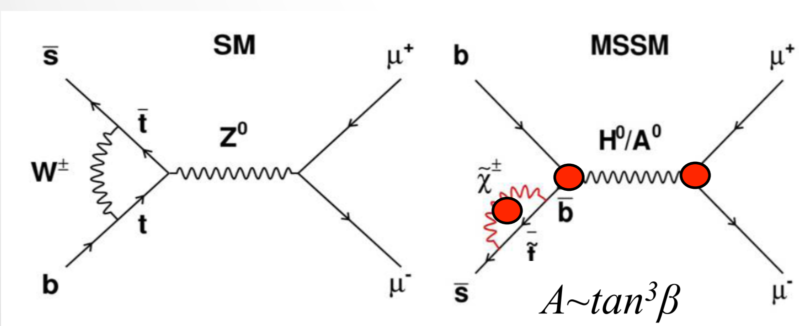
- BR strongly enhanced in MSSM at large tan(β): prop to $\tan^6(\beta)$

A.Buras, G.Isidori, P.Paradisi
Phys.Lett.B694:402-409,2011

$$R_{B\ell\ell} = \frac{\mathcal{B}^{\rm SUSY}(B_q \to \ell^+\ell^-)}{\mathcal{B}^{\rm SM}(B_q \to \ell^+\ell^-)} = (1+\delta_S)^2 + \left(1 - \frac{4m_\ell^2}{M_{B_q}^2}\right)\delta_S^2 ,$$

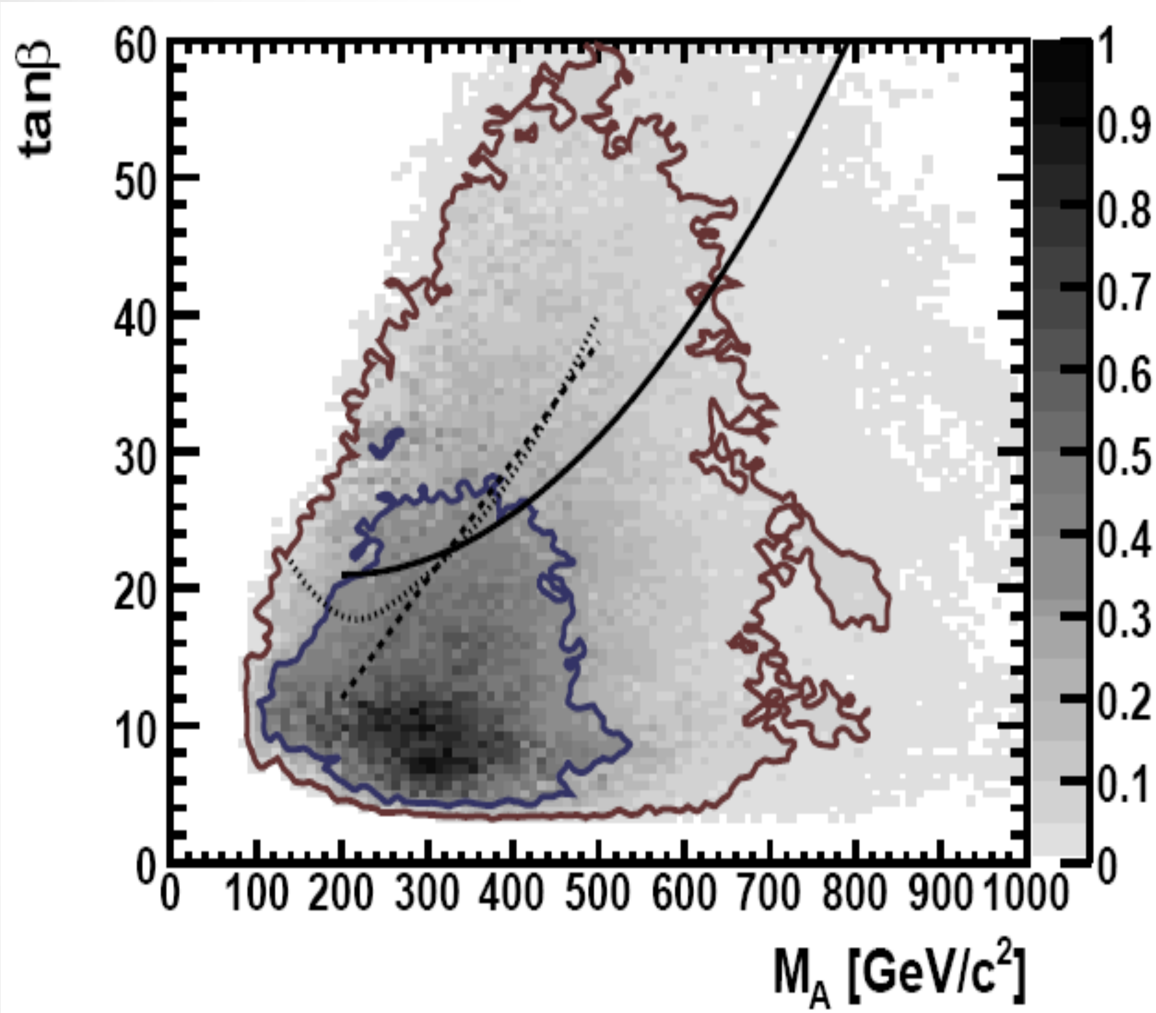
$$\delta_S = \frac{\pi \sin^2\theta_w M_{B_q}^2}{\alpha_{\rm em} M_A^2 C_{10A}(m_t^2/M_W^2)} \frac{\epsilon_Y \lambda_t^2 \tan^3\beta}{[1+(\epsilon_0+\epsilon_Y\lambda_t^2)\tan\beta][1+\epsilon_0\tan\beta]}$$

G.Isidori & P.Paradisi , Phys.Lett.B639:499-507,2006.



Possibility to test (rule out) a large part of the phase space of the MSSM

$B_s \rightarrow \mu\mu$: Constraing NP



Allowed parameter space from fit in non-univ Higgs mass (NUHM):

O.Buchmueller et al. [*Eur.Phys.J.C64:391-415,2009*]

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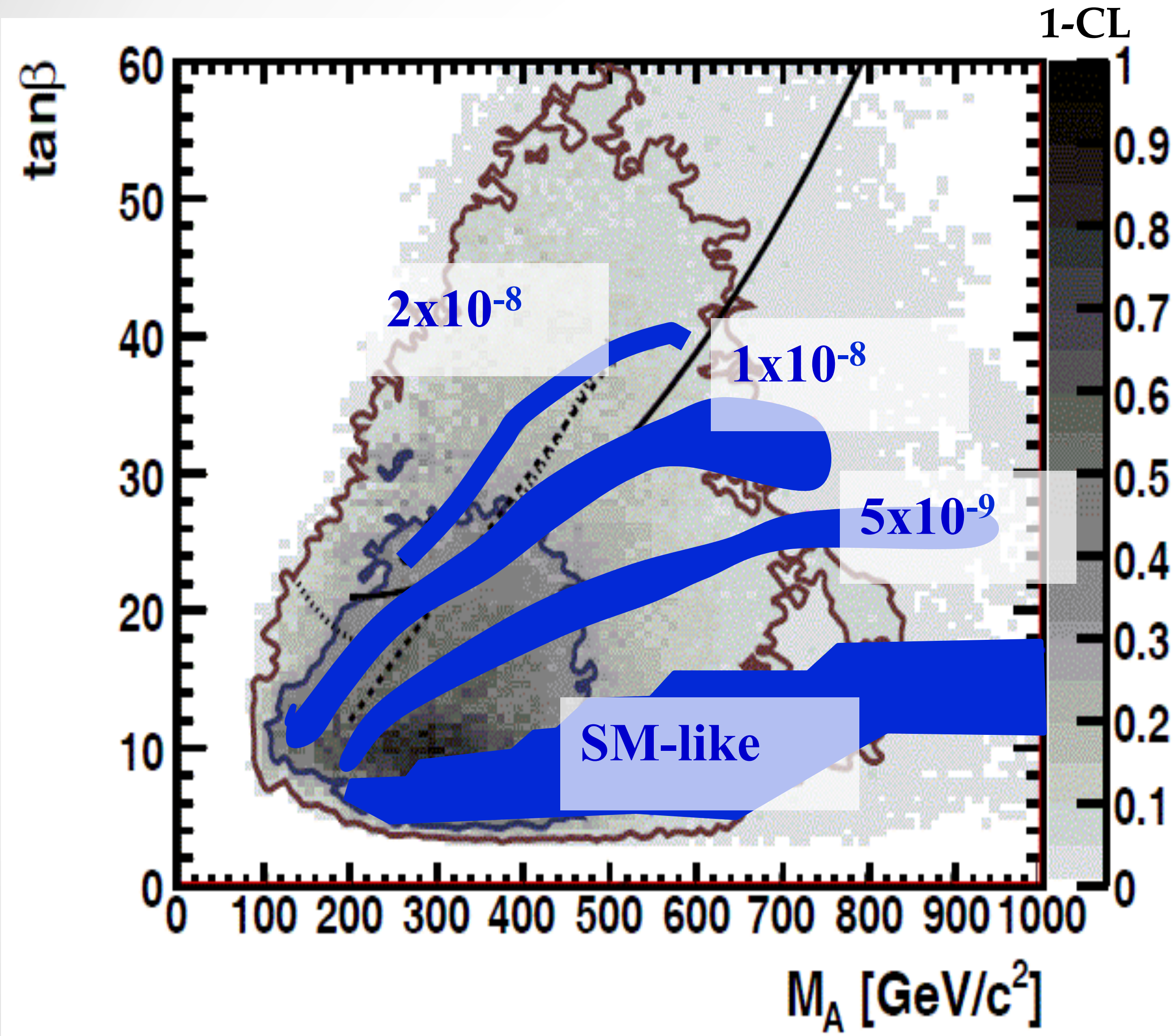

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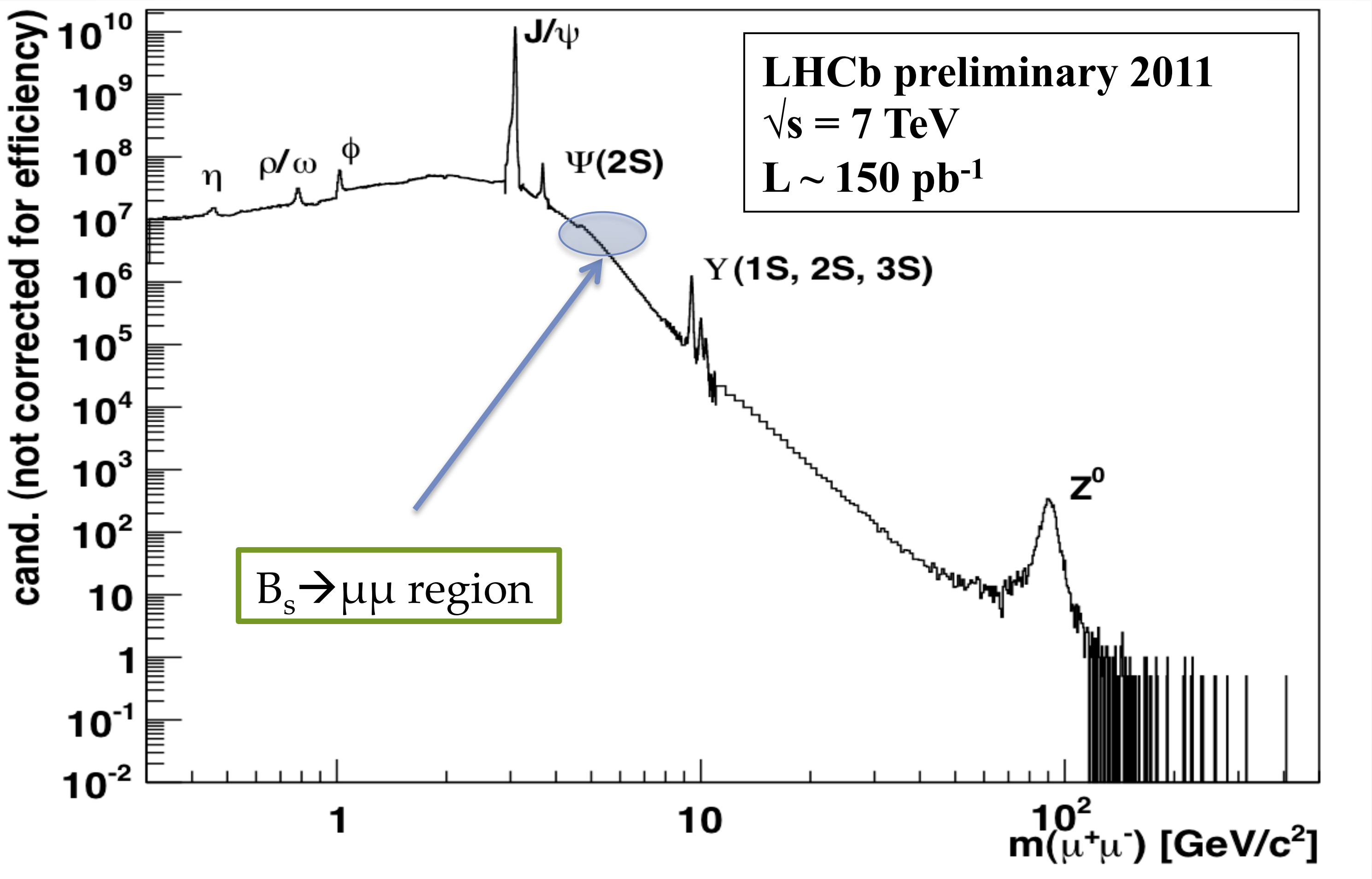
Dimuon invariant mass



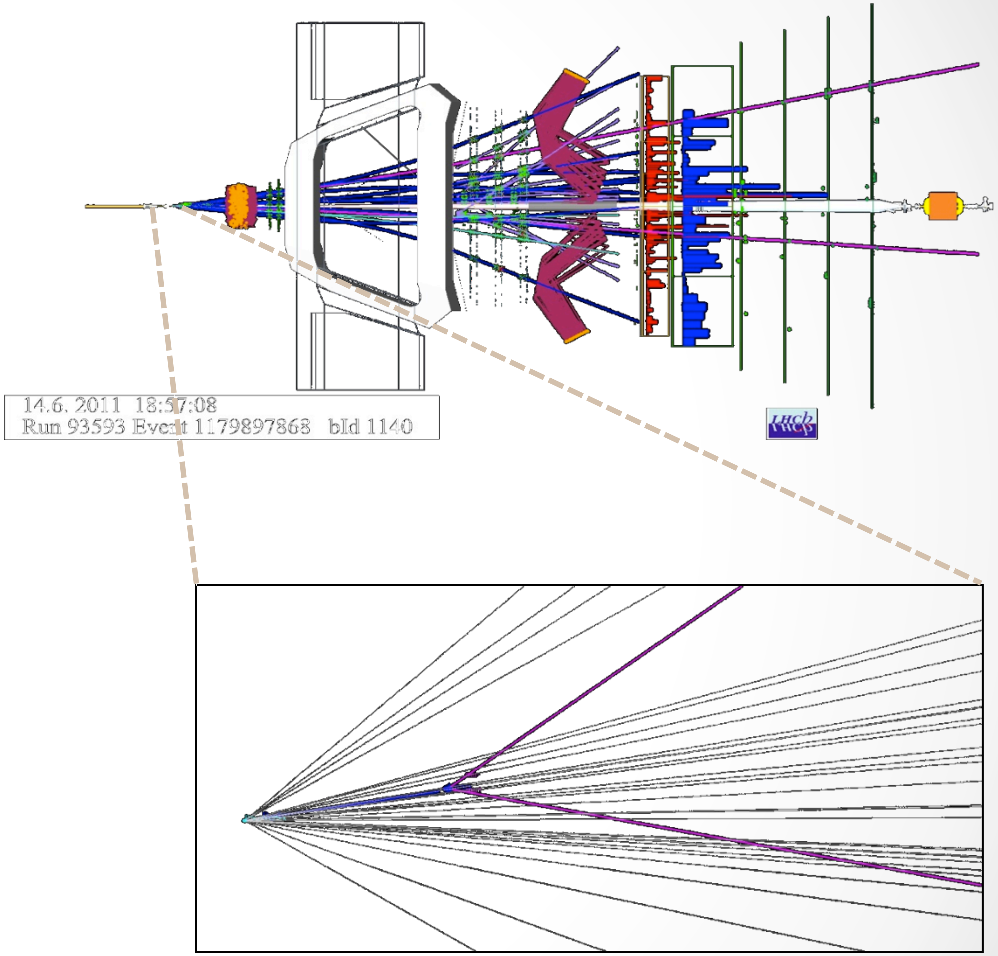
Selection

Invariant Mass

Kinematic / geometrical:

1) B lifetime
2) IP $_{\mu}$, IPS$_{\mu}$, $p_{T,\mu}$, min($p_{T,\mu}$)
3) DOCA 2 muons
4) μ and B isolation

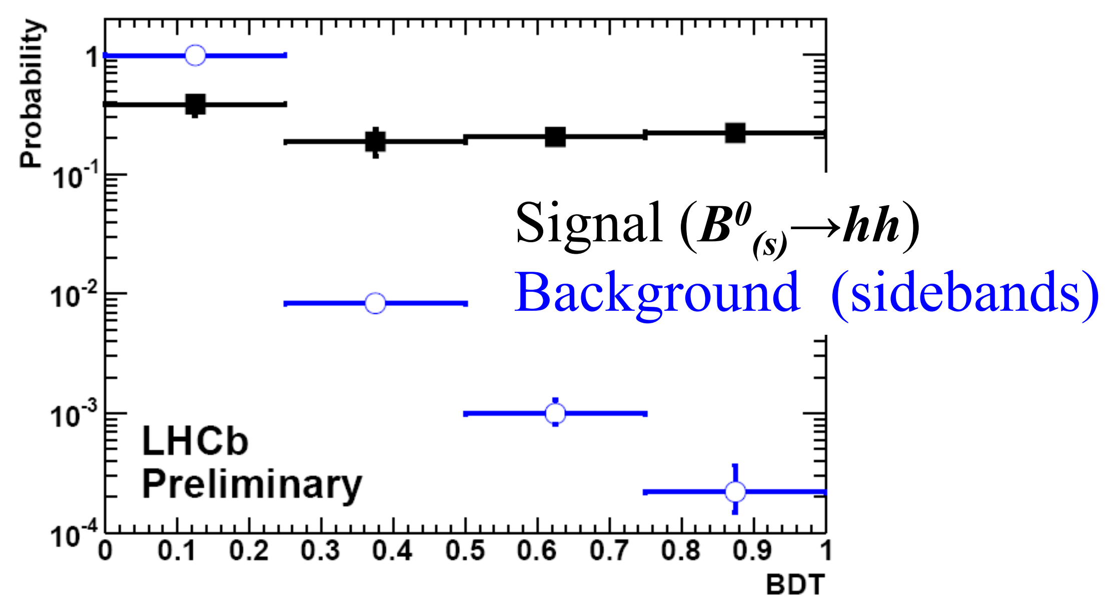
➢ Boosted Decision Tree - BDT

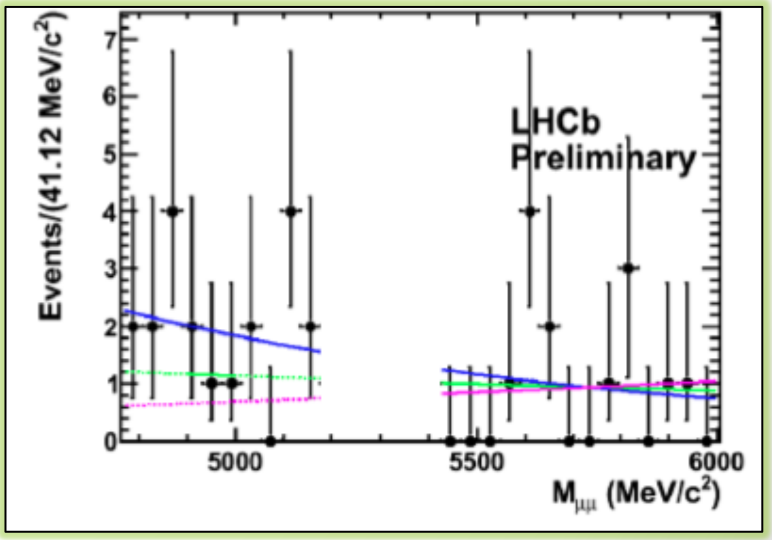


Analysis strategy

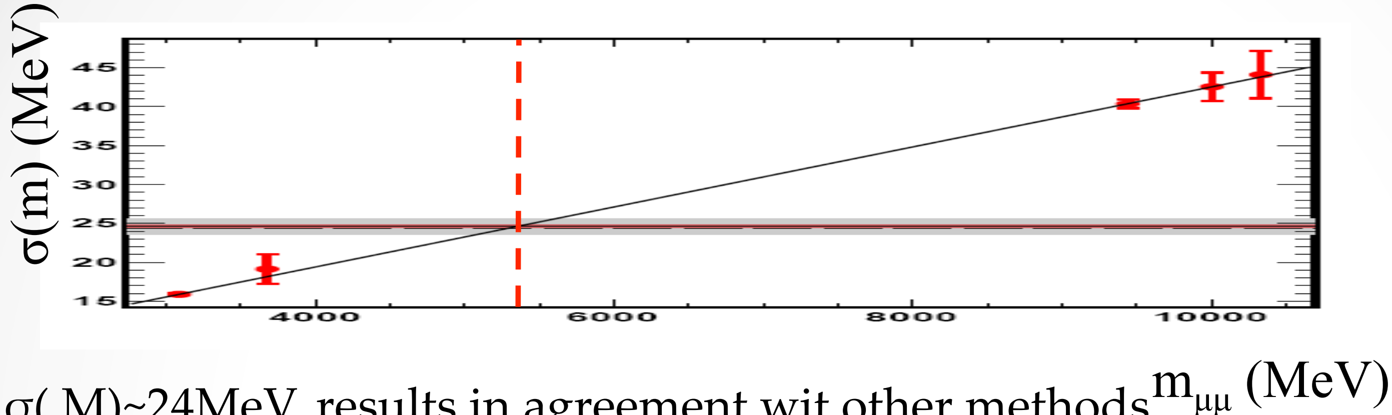
LHCb already published a limit with 2010 data (PLB), analysis strategy similar:

- Blind analysis
- BDT (9 variables) trained on MC for signal and background
- Background calibrated with sidebands, Signal with control channels ($B \to hh$, $J/\psi \to \mu\mu$…)
- Normalization with $B^+ \to J/\psi K^+$ *(using LHCb measured fs/fd)*

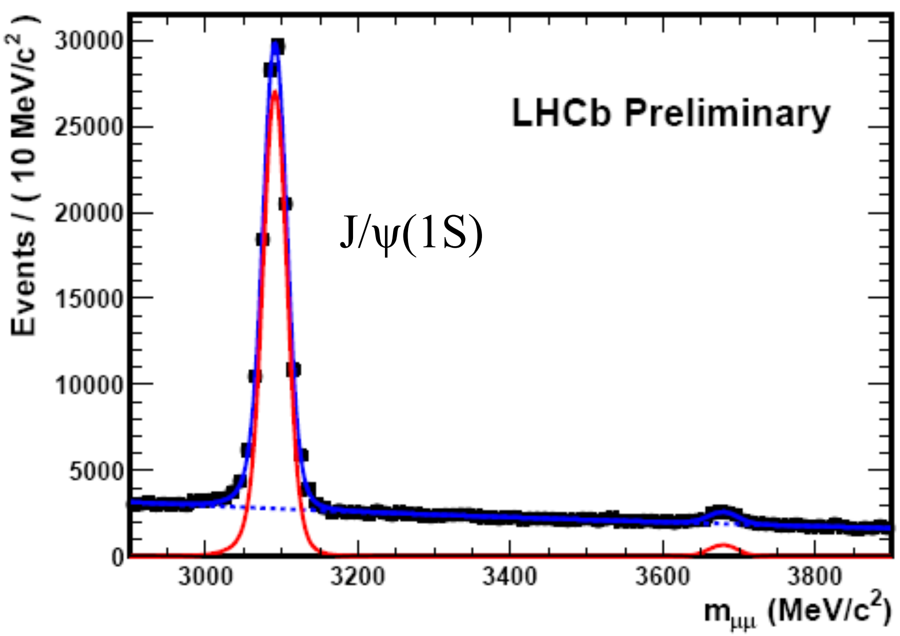


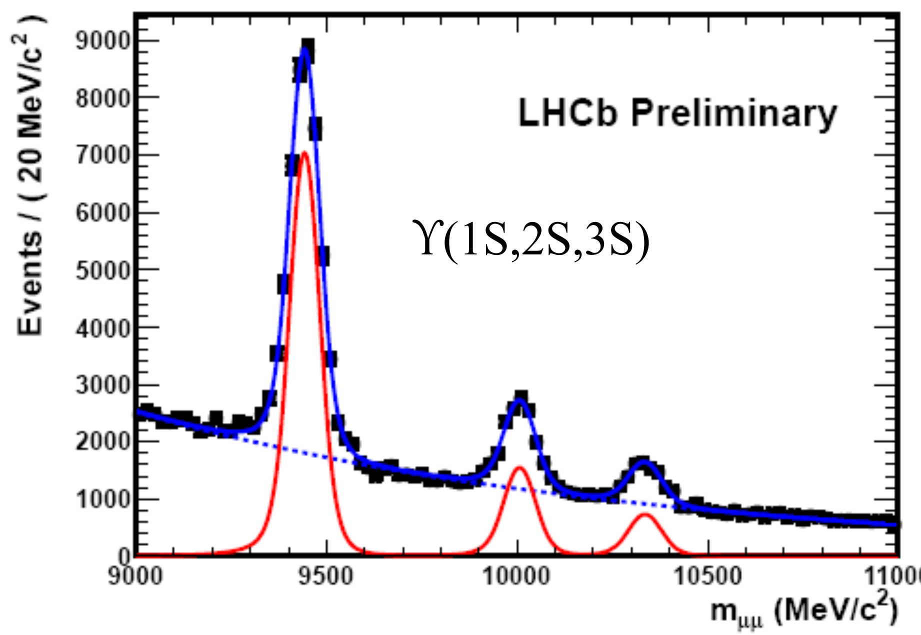


Invariant mass calibration



σ(M)~24MeV, results in agreement wit other methods

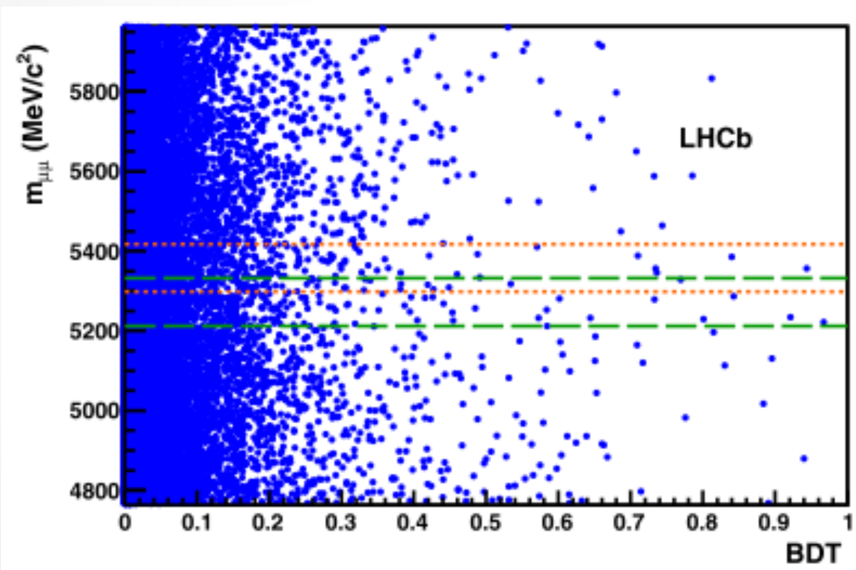




Opening the Box

Inside the Box

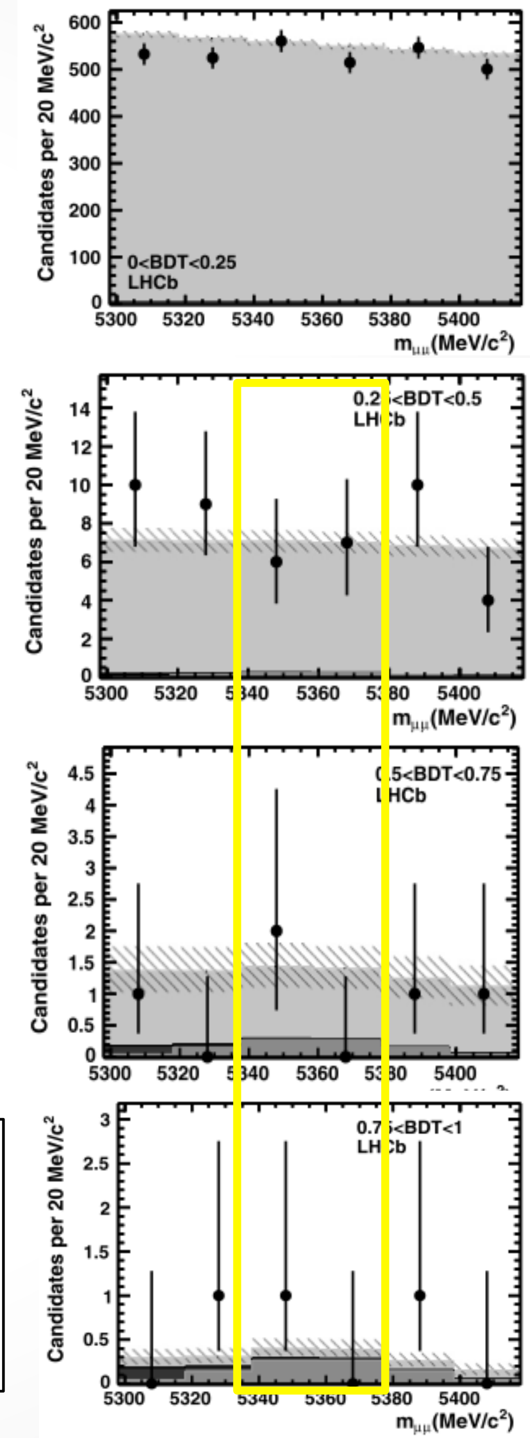
- Observe 11 events, expect:
  - *~9.5 background*
  - *~1.2 SM*



Less background

Less background

Expected $B^0_s \to \mu\mu$ yield (SM)



Measuring the BR

$$\mathrm{BR}(B_s^0 \to \mu^+\mu^-) = \mathrm{BR}(B_q \to X)\frac{f_q}{f_s}\frac{\epsilon_X}{\epsilon_{\mu\mu}}\frac{N_{\mu\mu}}{N_X}$$

- normalization channels:
  - $B^+ \to J/\psi K^+$
  - $B^0 \to K^+\pi^-$
  - $B_s^0 \to J/\psi\varphi$

Needed fs/fd!
fs/fd → P,eta,energy dependent
We needed to measure this at LHCb

Belle: BR$(B_s \to J/\psi\phi) = 1.15\times 10^{-3} \pm 25\%$
R. Louvot, arXiv:0905.4345v2

Before LHCb fs/fd uncertainty ~13%
(*PDG, a.o.: CDF, Phys.Rev.D77:072003,2008*)

fs/fd main systematic uncertainty on the branching ratio

How to measure fd/fs

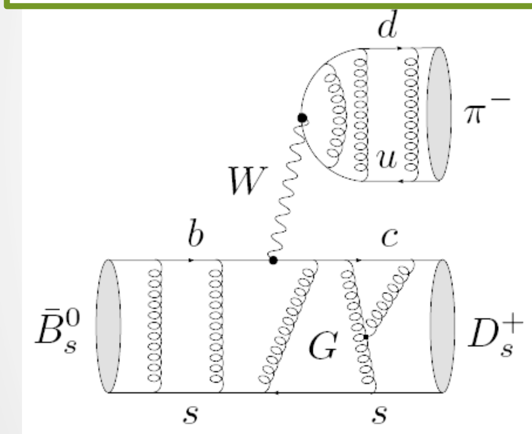
$$\frac{N_s}{N_d} = \frac{f_s}{f_d} \frac{\varepsilon(B_s \to \text{something})}{\varepsilon(B_d \to \text{something else})} \frac{BR(B_s \to \text{something})}{BR(B_d \to \text{something else})}$$

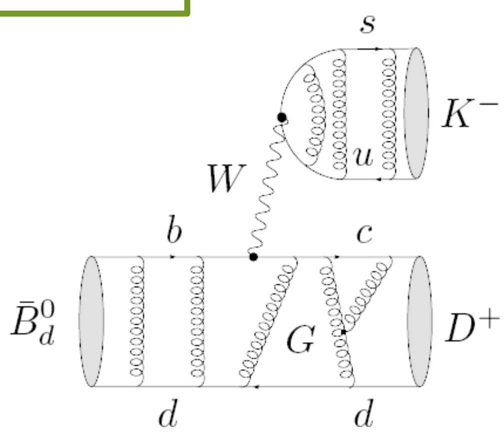
You just need to invert this formula! ☺

How to measure fd/fs (I)

- Theoretically well understood
  - U-spin related
  - Pure T diagram
  - Factorization working well

- Experimentally clean





$$\frac{N_{D_s\pi}}{N_{D_dK}} = \frac{f_s}{f_d}\frac{\epsilon_{D_s\pi}}{\epsilon_{D_dK}}\frac{\mathrm{BR}(\bar{B}_s^0 \to D_s^+\pi^-)}{\mathrm{BR}(\bar{B}_d^0 \to D^+K^-)}$$

$$\frac{f_s}{f_d} = 0.971\left|\frac{V_{us}}{V_{ud}}\right|^2\left(\frac{f_K}{f_\pi}\right)^2\frac{\tau_{B_d}}{\tau_{B_s}}\frac{1}{N_a N_F}\frac{\varepsilon_{D^-K^+}}{\varepsilon_{D_s^-\pi^+}}\frac{N_{D_s^-\pi^+}}{N_{D^-K^+}}$$

*R. Fleischer, **N. Serra**, N. Tuning*
Phys.Rev.D82:034038,2010

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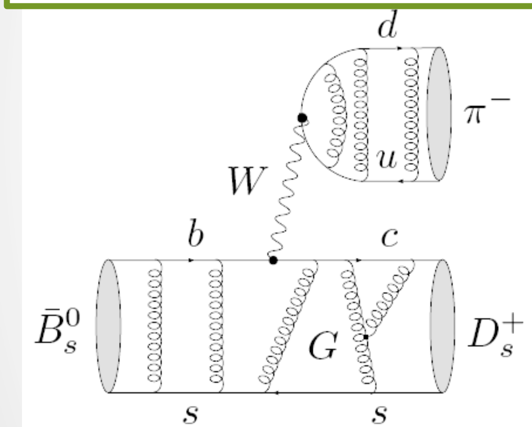

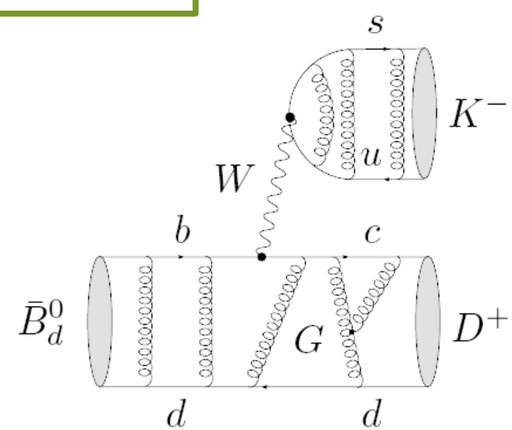

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How to measure fd/fs (II)

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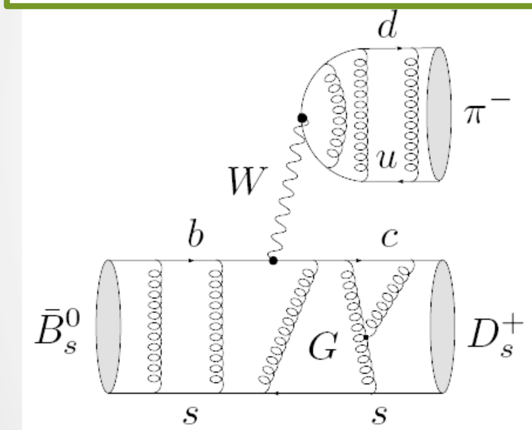
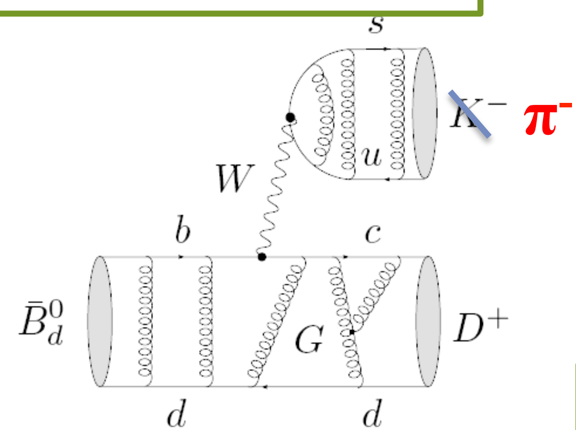
  - ~~Pure T diagram~~ → T dominated diagram
  - Factorization working well

- Experimentally clean





R. Fleischer, ***N. Serra***, *N. Tuning*
Phys.Rev. D83:014017, 2011.

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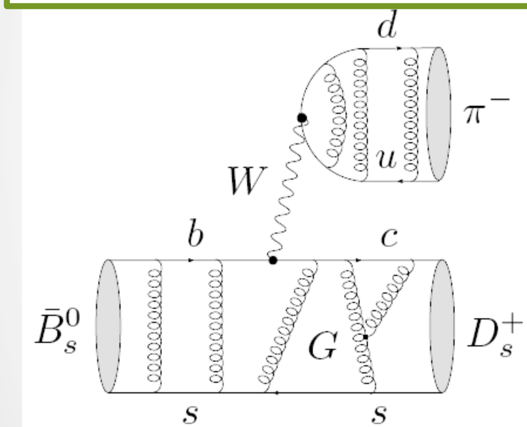
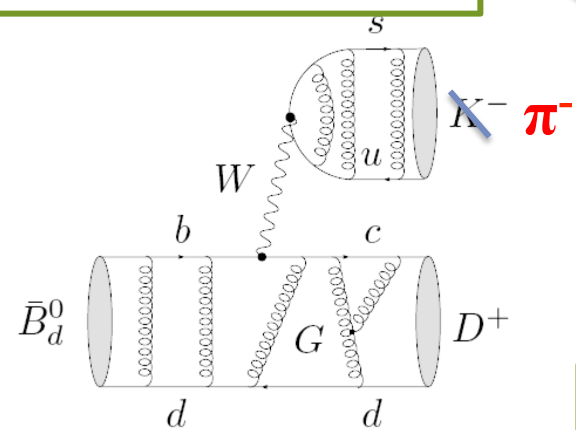
$$\mathcal{N}_E \equiv \left|\frac{T}{T+E}\right|^2$$





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Phys.Rev. D83:014017, 2011.

$$\frac{N_{D_s\pi}}{N_{D_d\pi}} = \frac{f_s}{f_d}\frac{\epsilon_{D_s\pi}}{\epsilon_{D_d\pi}}\frac{\mathrm{BR}(\bar{B}_s^0 \to D_s^+\pi^-)}{\mathrm{BR}(\bar{B}_d^0 \to D^+\pi^-)}$$

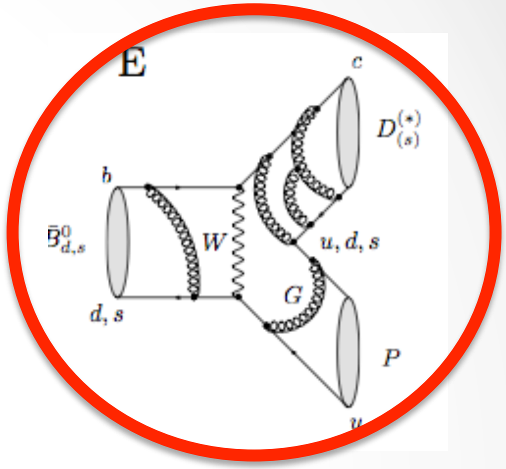
$$\frac{f_s}{f_d} = 0.982\frac{\tau_{B_d}}{\tau_{B_s}}\frac{1}{N_a N_F N_E}\frac{\varepsilon_{D^-\pi^+}}{\varepsilon_{D_s^-\pi^+}}\frac{N_{D_s^-\pi^+}}{N_{D^-\pi^+}}$$

R. Fleischer, **N. Serra**, N. Tuning
Phys.Rev.D82:034038,2010

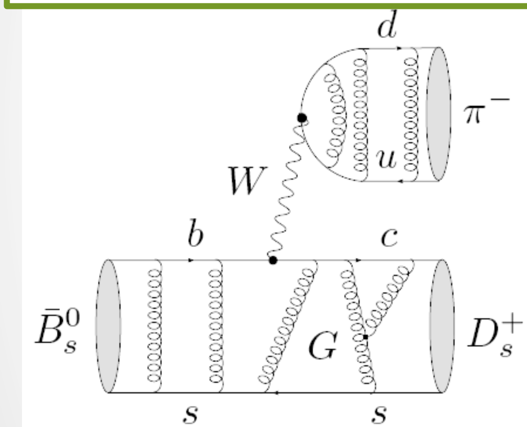
How to measure fd/fs (II)

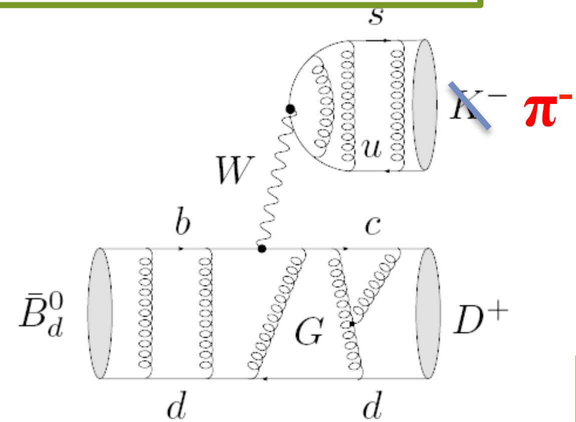
- Theoretically well understood
  - U-spin related
  - ~~Pure T diagram~~ → T dominated diagram
  - Factorization working well

- Experimentally clean



$$\mathcal{N}_E \equiv \left|\frac{T}{T+E}\right|^2$$





R. Fleischer, **N. Serra**, N. Tuning
Phys.Rev. D83:014017, 2011.

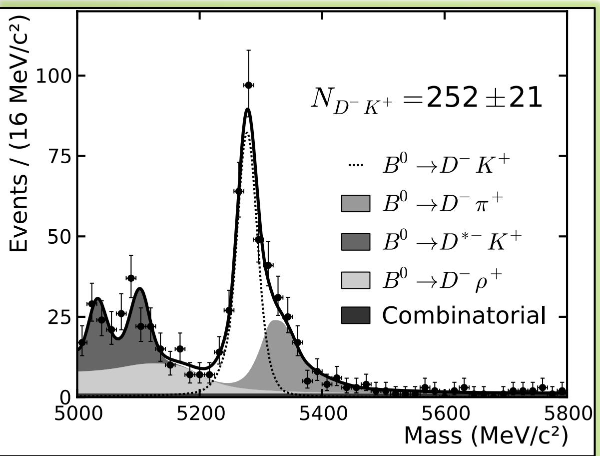
$$\frac{N_{D_s\pi}}{N_{D_d\pi}} = \frac{f_s}{f_d}\frac{\epsilon_{D_s\pi}}{\epsilon_{D_d\pi}}\frac{\mathrm{BR}(\bar{B}^0_s \to D_s^+\pi^-)}{\mathrm{BR}(\bar{B}^0_d \to D^+\pi^-)}$$

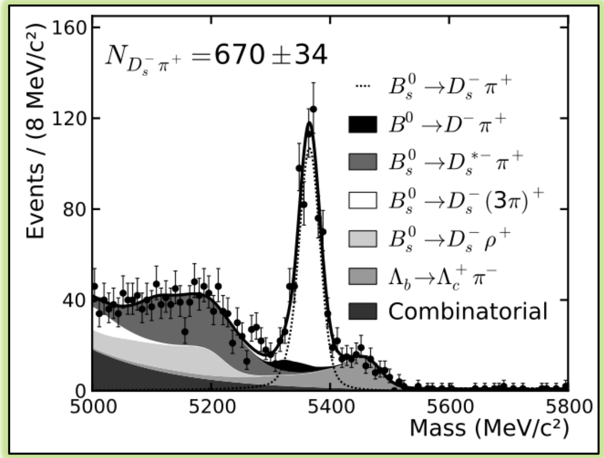
→

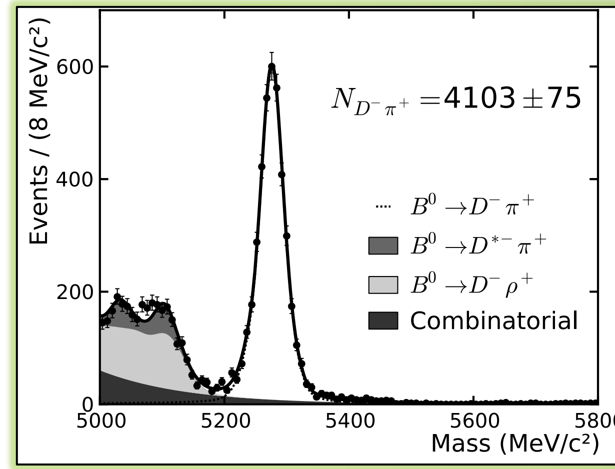
$$\frac{f_s}{f_d} = 0.982\,\frac{\tau_{B_d}}{\tau_{B_s}}\,\frac{1}{N_a N_F N_E}\,\frac{\varepsilon_{D^-\pi^+}}{\varepsilon_{D_s^-\pi^+}}\,\frac{N_{D_s^-\pi^+}}{N_{D^-\pi^+}}$$

R. Fleischer, **N. Serra**, N. Tuning
Phys.Rev.D82:034038,2010

fd/fs at LHCb







$$f_s/f_d = 0.253 \pm 0.017^{\text{stat}} \pm 0.017^{\text{syst}} \pm 0.020^{\text{theor}}$$

Physical Review Letters, Vol.107, No.21, 2011

With the present dataset at LHCb (~1fb^{-1}) we can improve the factorization tests!

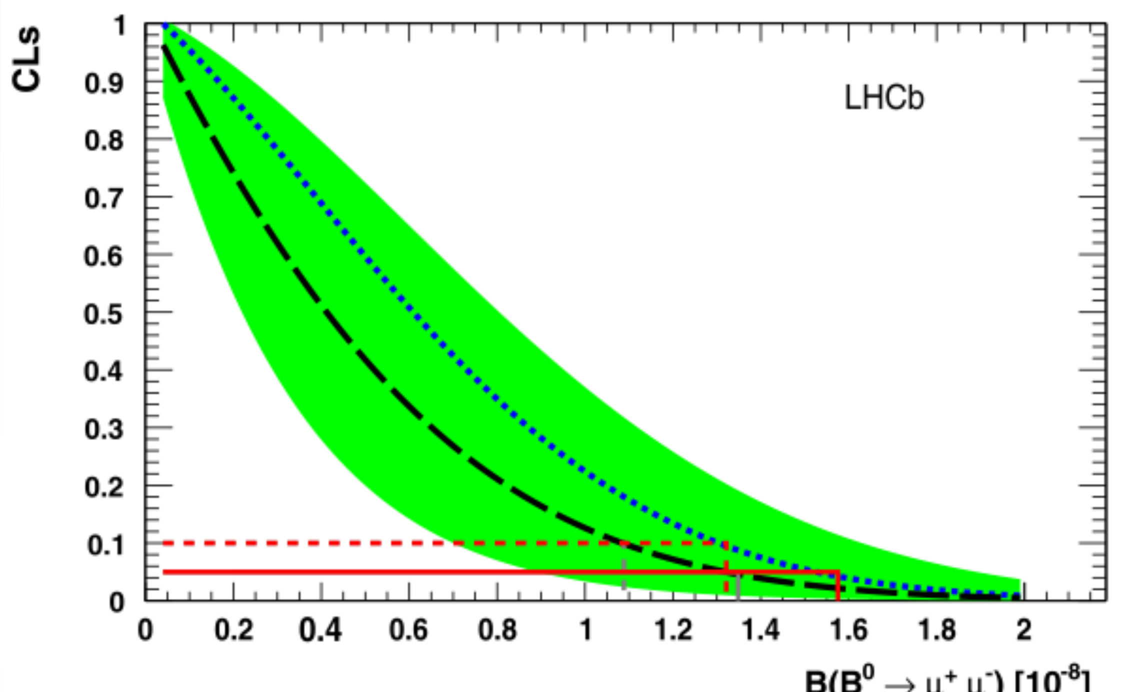
We do the same measurement with semi-leptonic B decays

Combination of hadronic and semileptonic modes

$$f_s/f_d = 0.267^{+0.021}_{-0.020}$$

LHCb Collaboration, LHCb-CONF-2011-034

$B_s \to \mu\mu$ Results

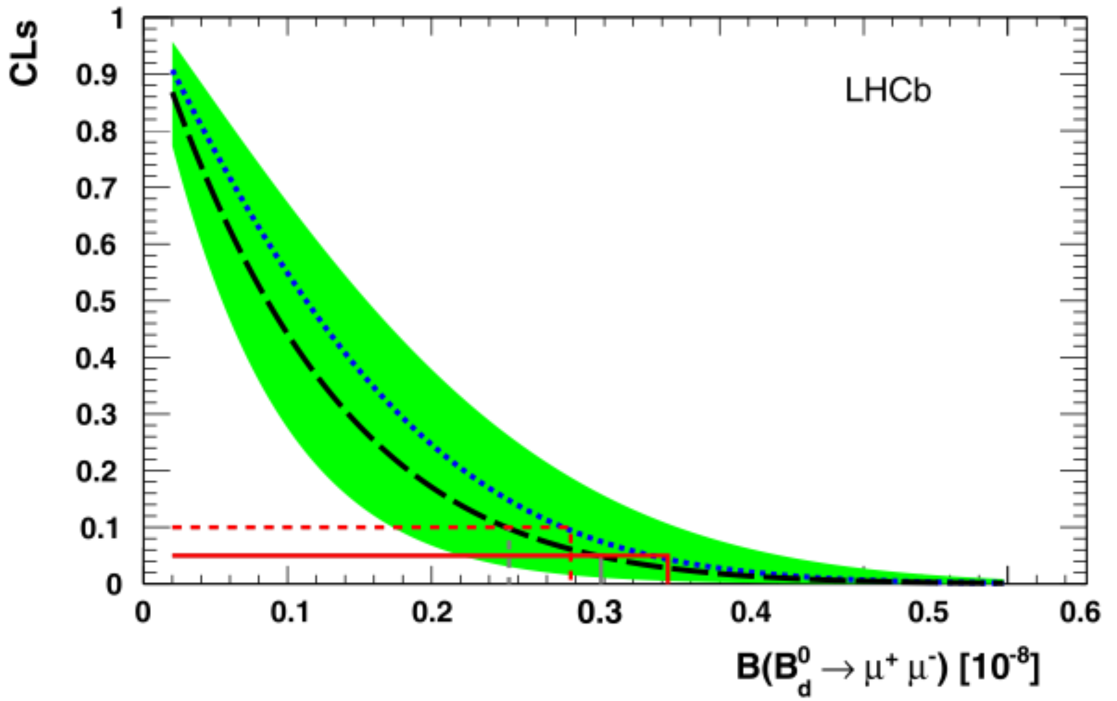


Expected and observed limits on the $B_s^0 \to \mu^+\mu^-$ branching fraction for the 2011 data and for the combination of 2010 and 2011 data. The expected limits are computed allowing the presence of $B_s^0 \to \mu^+\mu^-$ events according to the SM branching fraction.

		at 90% CL	at 95% CL	CL_b
2011	expected limit	1.1×10^{-8}	1.4×10^{-8}	
	observed limit	1.3×10^{-8}	1.6×10^{-8}	0.95
2010 + 2011	expected limit	1.0×10^{-8}	1.3×10^{-8}	
	observed limit	1.2×10^{-8}	1.4×10^{-8}	0.93

LHCb Coll., Phys. Lett. B 708 (2012) 55–67

$B_d \rightarrow \mu\mu$ Results



Expected and observed limits on the $B^0 \rightarrow \mu^+\mu^-$ branching fraction for 2011 data and for the combination of 2010 and 2011 data. The expected limits are computed in the background only hypothesis.

		at 90% CL	at 95% CL	CL_b
2011	expected limit	2.5×10^{-9}	3.2×10^{-9}	
	observed limit	3.0×10^{-9}	3.6×10^{-9}	0.68
2010 + 2011	expected limit	2.4×10^{-9}	3.0×10^{-9}	
	observed limit	2.6×10^{-9}	3.2×10^{-9}	0.61

LHCb Coll., Phys. Lett. B 708 (2012) 55–67

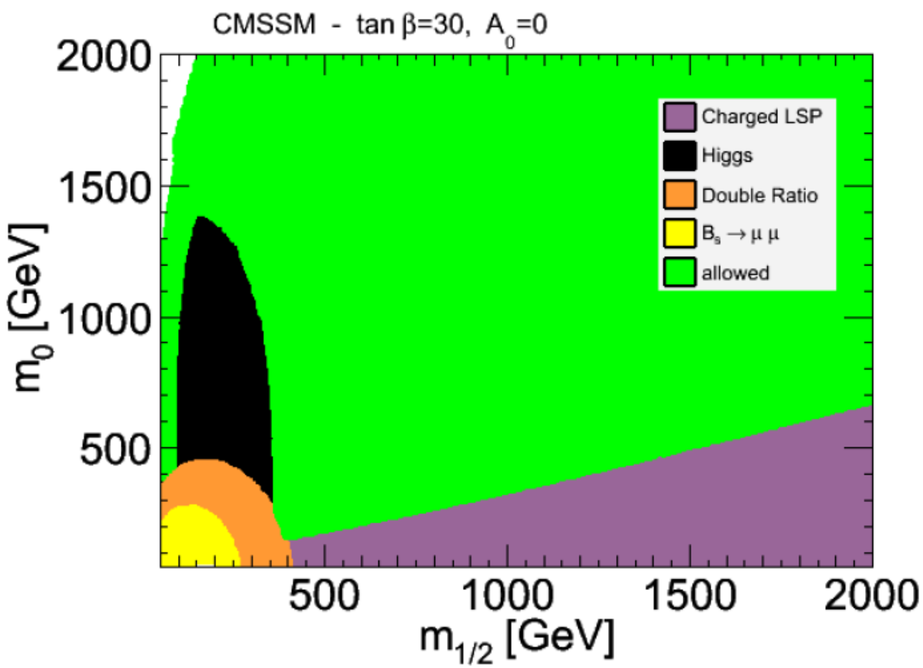
Implications ($B_s \rightarrow \mu\mu$) I

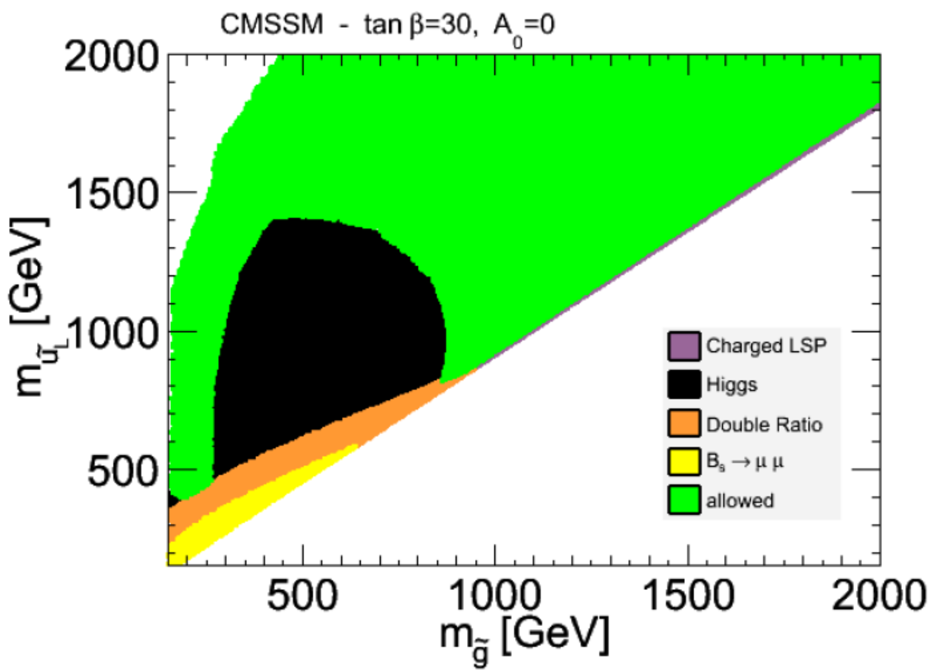
Implications in CMSSM

A.Akeroyd, F. Mahmoudi,
D.Martinez Santos
arXiv:1108.3018

Allowed
Excluded by $B^0_s \rightarrow \mu\mu$
Excl by $B^0_s \rightarrow \mu\mu$, $B^+ \rightarrow \tau\upsilon$, $D_{(s)}^+ \rightarrow \mu\upsilon$

$\tan\beta = 30$





CMSSM, see: O.Buchmueller et al. Eur.Phys.J.C64:391-415,2009

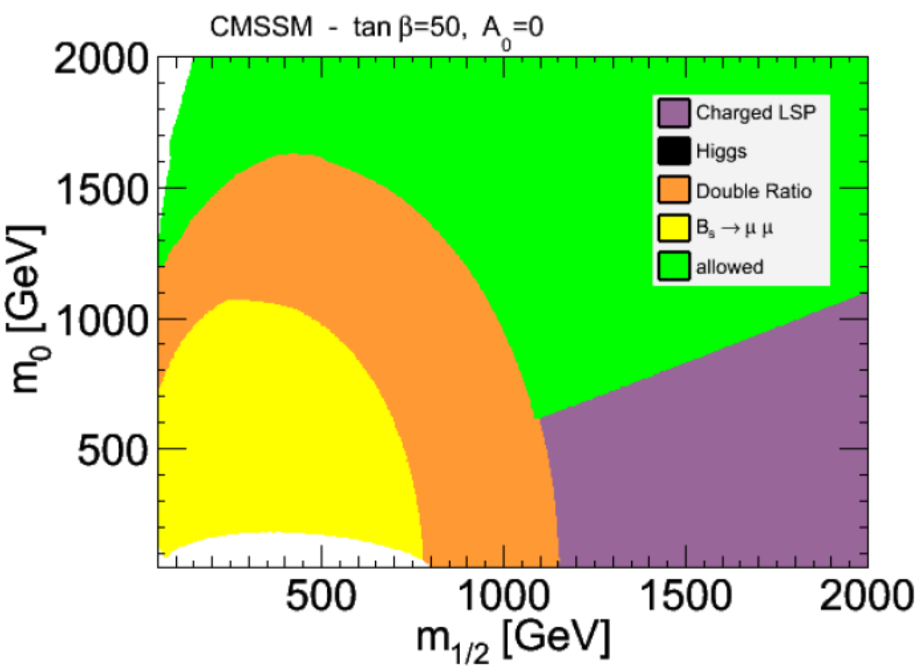
Implications ($B_s \rightarrow \mu\mu$) II

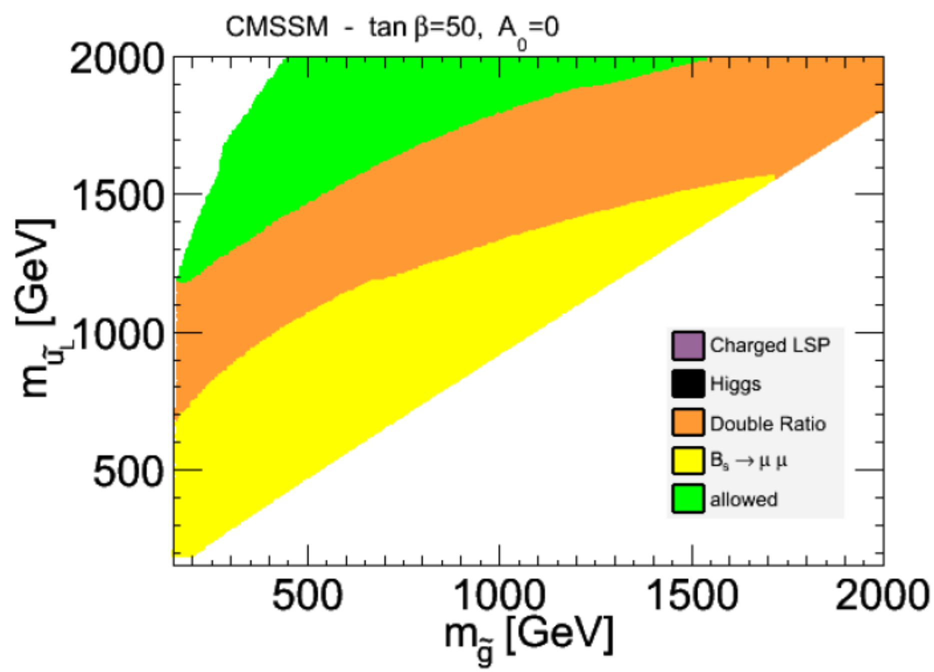
Implications in CMSSM

A.Akeroyd, F. Mahmoudi, D.Martinez Santos
arXiv:1108.3018

- Allowed
- Excluded by $B^0_s \rightarrow \mu\mu$
- Excl by $B^0_s \rightarrow \mu\mu$, $B^+ \rightarrow \tau\upsilon$, $D_{(s)}^+ \rightarrow \mu\upsilon$

$\tan\beta = 50$



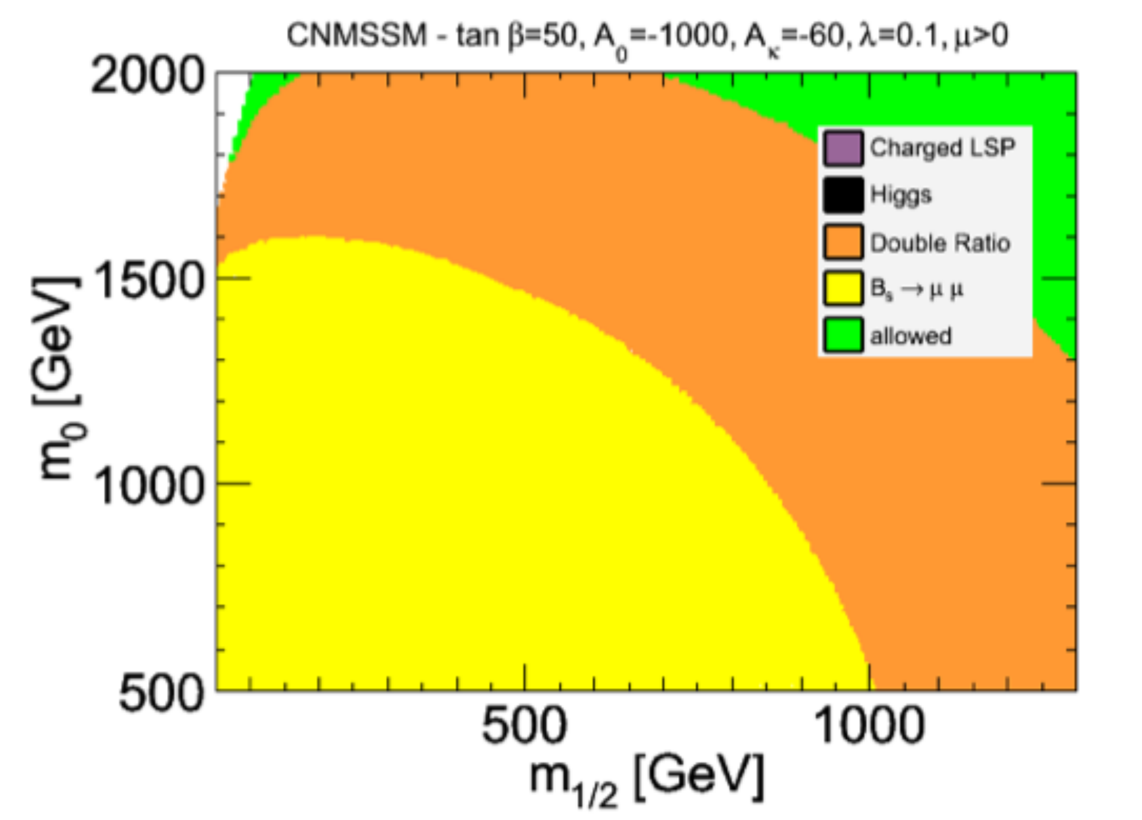


CMSSM, see: O.Buchmueller et al. Eur.Phys.J.C64:391-415,2009

Implications ($B_s \rightarrow \mu\mu$) III

Implications in CMSSM
Particularly nice case ☺

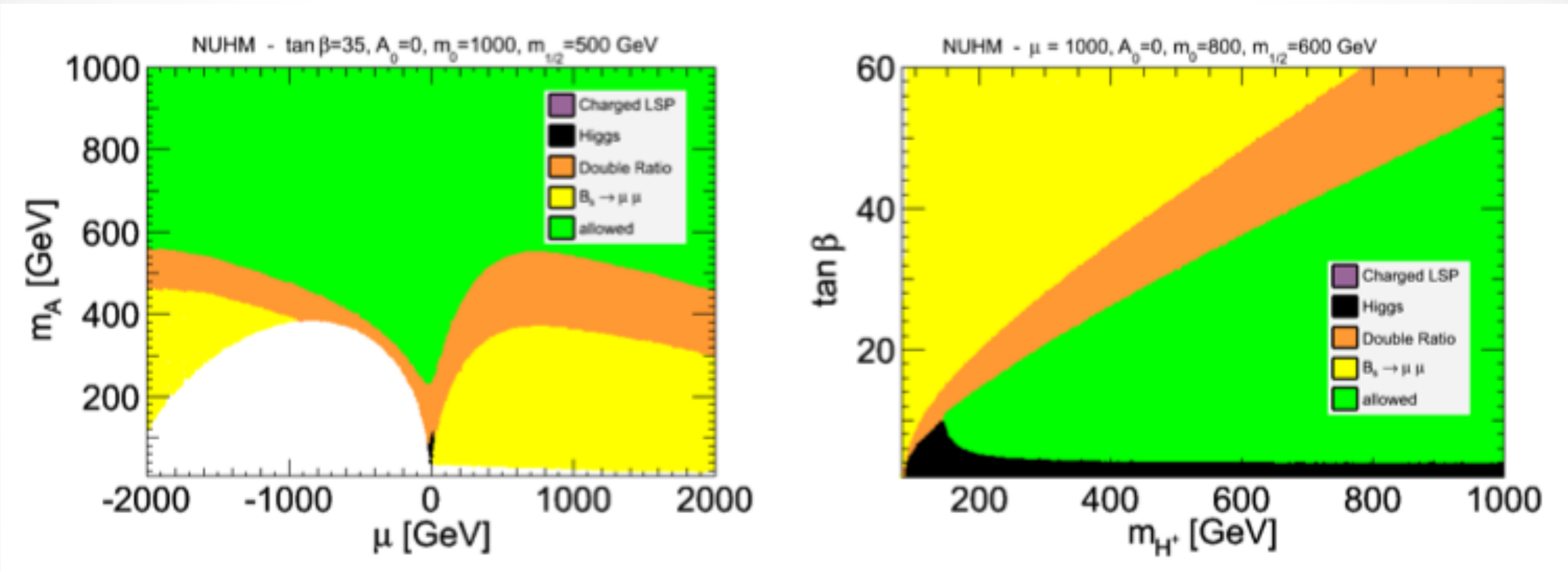
A.Akeroyd, F. Mahmoudi,
D.Martinez Santos
arXiv:1108.3018



Implications ($B_s \to \mu\mu$) IV

Another example NUHM

A.Akeroyd, F. Mahmoudi,
D.Martinez Santos
arXiv:1108.3018

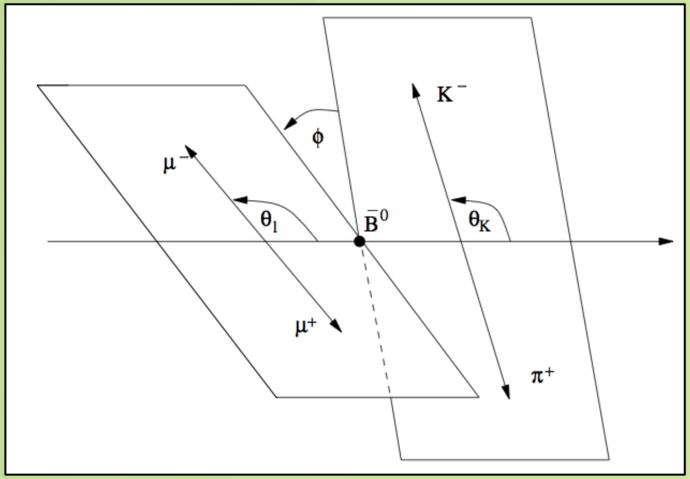


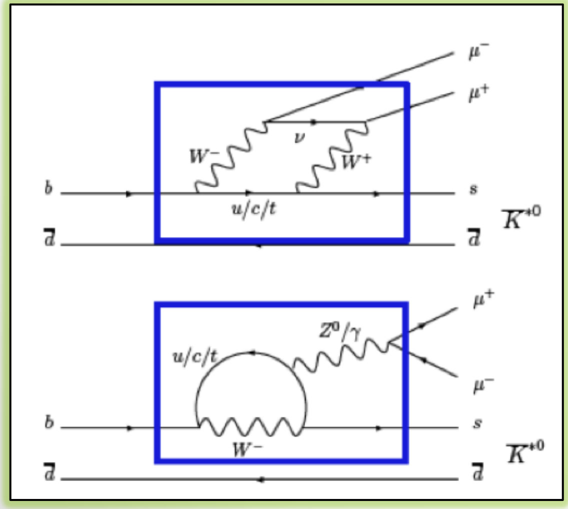
One nice thing of flavour physics is that it allow to constrain several class of models. But the real power of flavour physics are correlations, i.e. combining the different channels.

Search for $B_d \rightarrow K^* \mu\mu$

The $B_d \rightarrow K^*\mu\mu$ is described by three angles and the dimuon invariant mass

SM diagram for $B_d \rightarrow K^* \mu\mu$

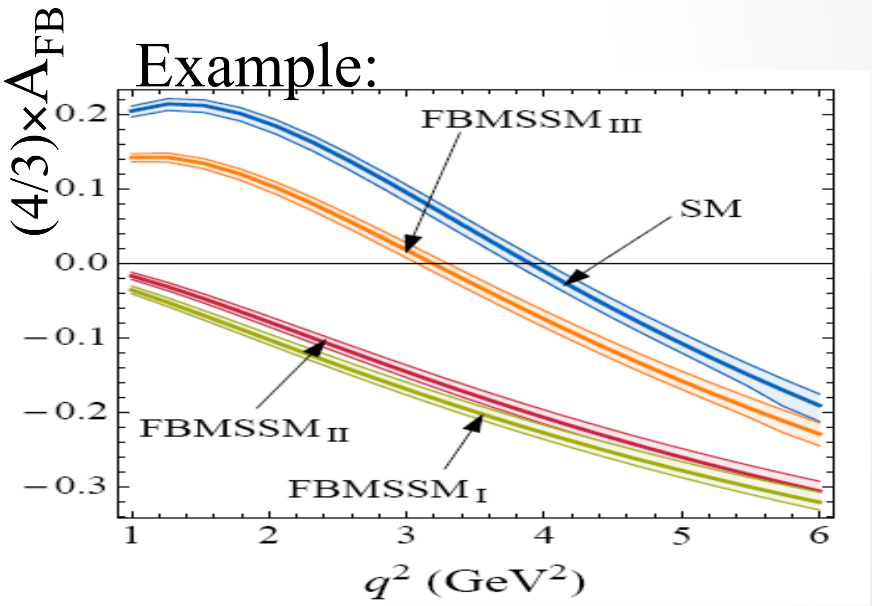




Several observable sensitive to NP, the most known is the AFB

$$AFB = \frac{N(\cos\vartheta > 0) - N(\cos\vartheta < 0)}{N(\cos\vartheta > 0) + N(\cos\vartheta < 0)}$$

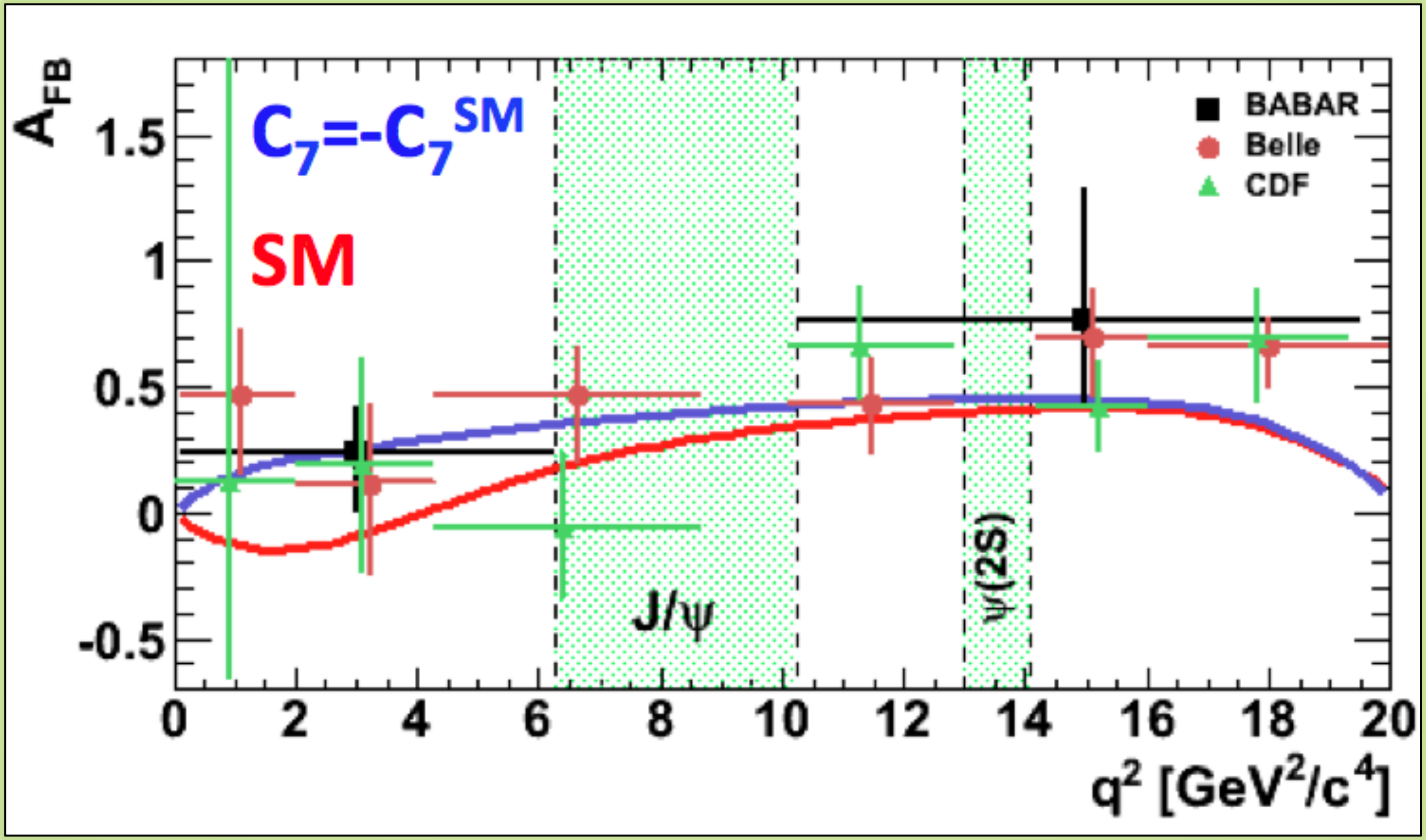
NP contribution can alter this observable



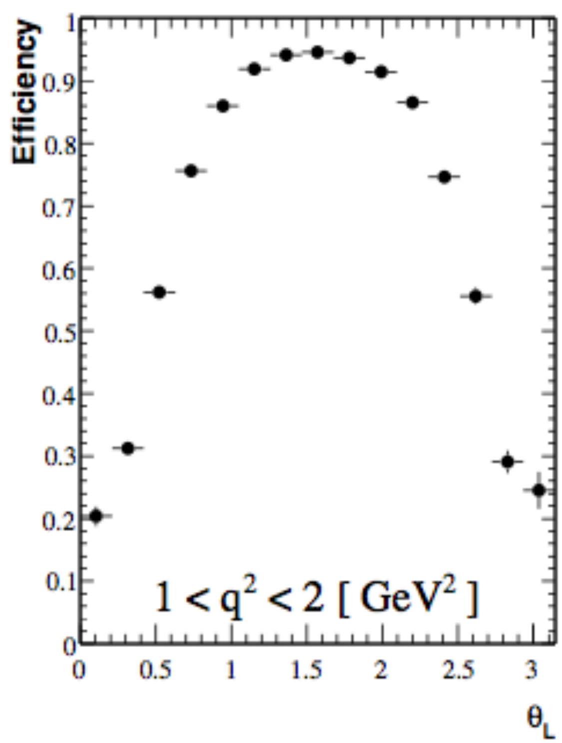
W. Altmannshofer et al., JHEP 0901:019,200

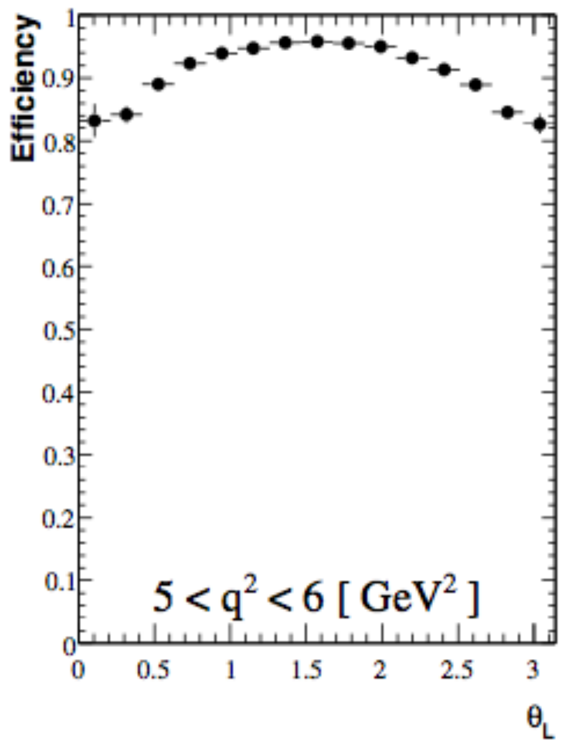
Before LHCb

Situation before LHCb measurement for $B_d \rightarrow K^*\mu\mu$ (BaBar,Belle, CDF)



Acceptance Corrections



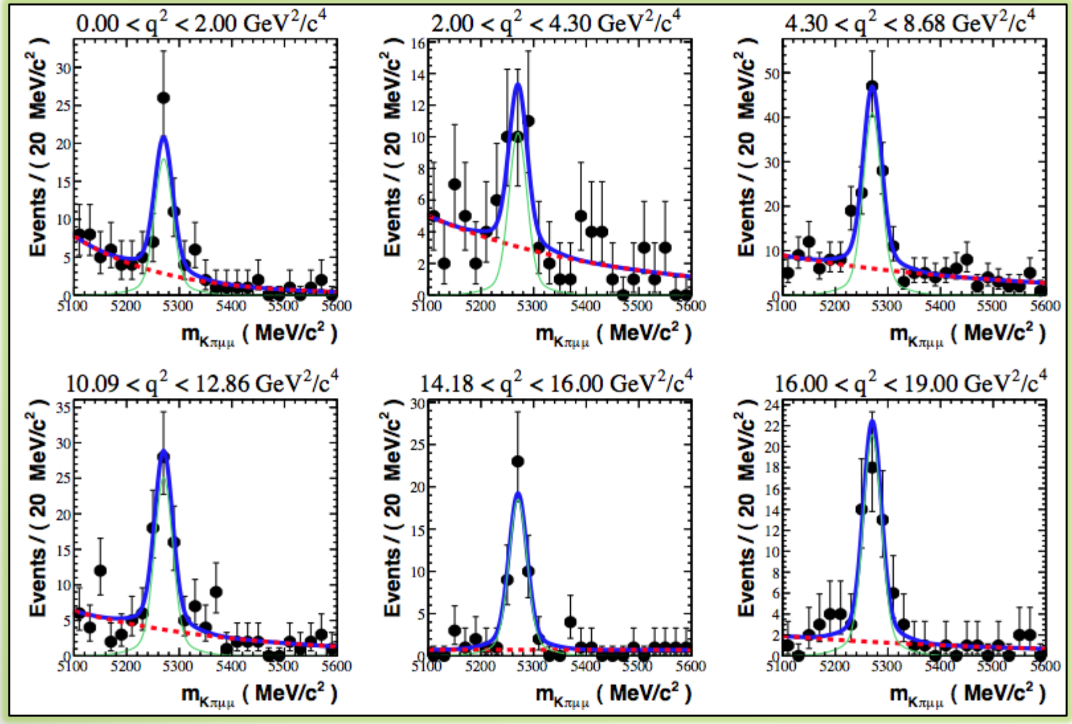


- Acceptance correction are due to reconstruction and selection;
- The low q^2 region is more sensitive to acceptance corrections;
- Important to correct event-by-event;

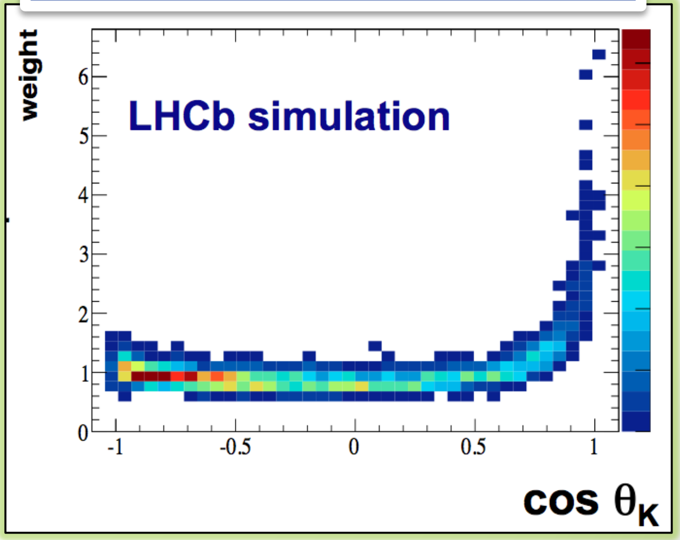
Analysis strategy

- Selection made using a BDT (designed to keep the angular acceptance flat)
- Correct for the effects of reconstruction and selection (in model independent way)
- Check simulation with control channels
- Validate using $B_d \rightarrow J/\psi\ K^*$
- Fit the Angular Observables

$B_d \rightarrow K^*\ \mu\mu$ invariant mass in bin of q^2



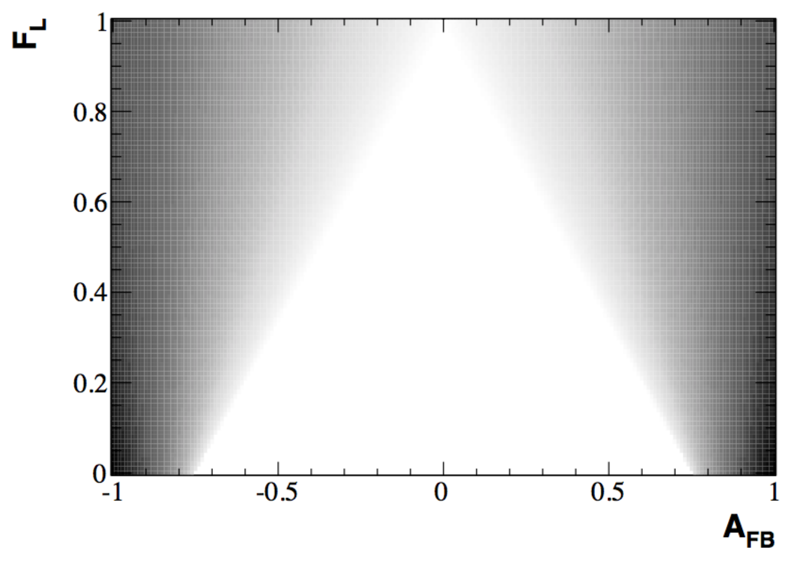
Event by event weight



What do we fit

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

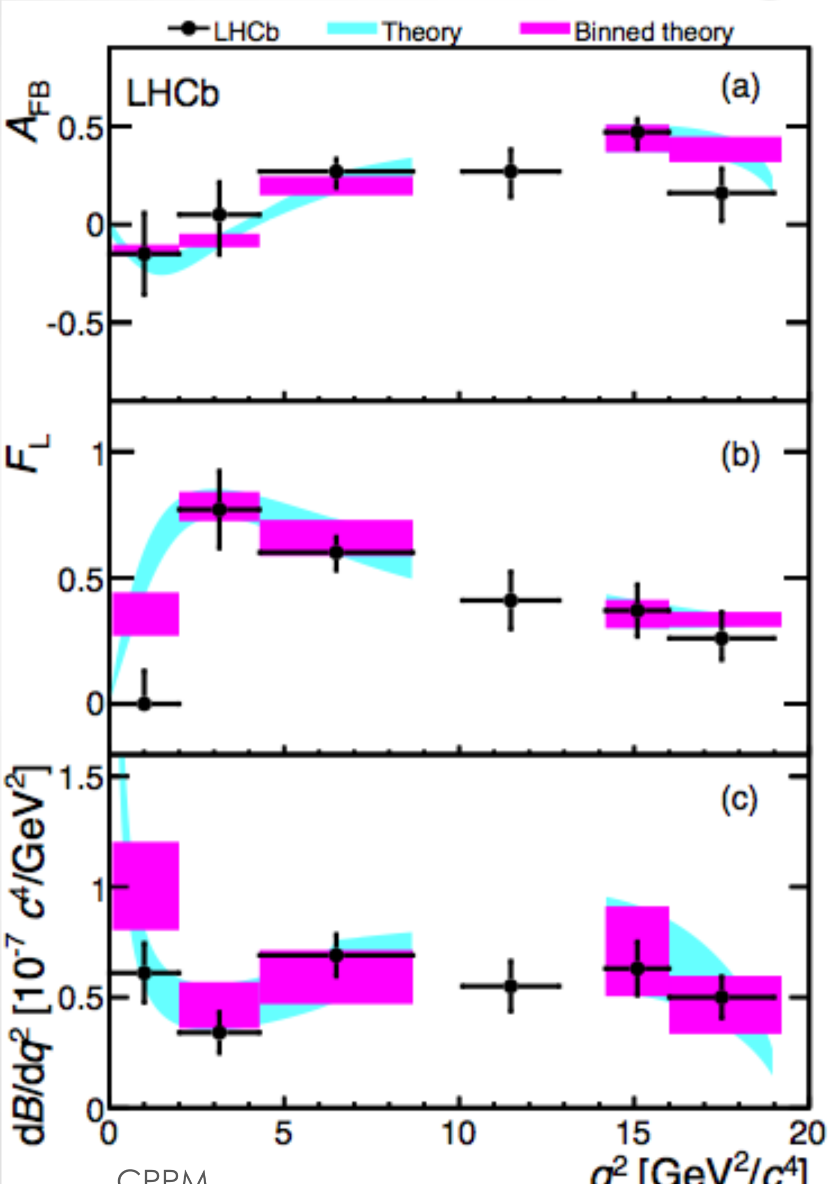
$$\frac{1}{\Gamma}\frac{\mathrm{d}^2\Gamma}{\mathrm{d}\cos\theta_\ell\,\mathrm{d}q^2} = \frac{3}{4}F_L(1-\cos^2\theta_\ell) + \frac{3}{8}(1-F_L)(1+\cos^2\theta_\ell) + A_{FB}\cos\theta_\ell$$



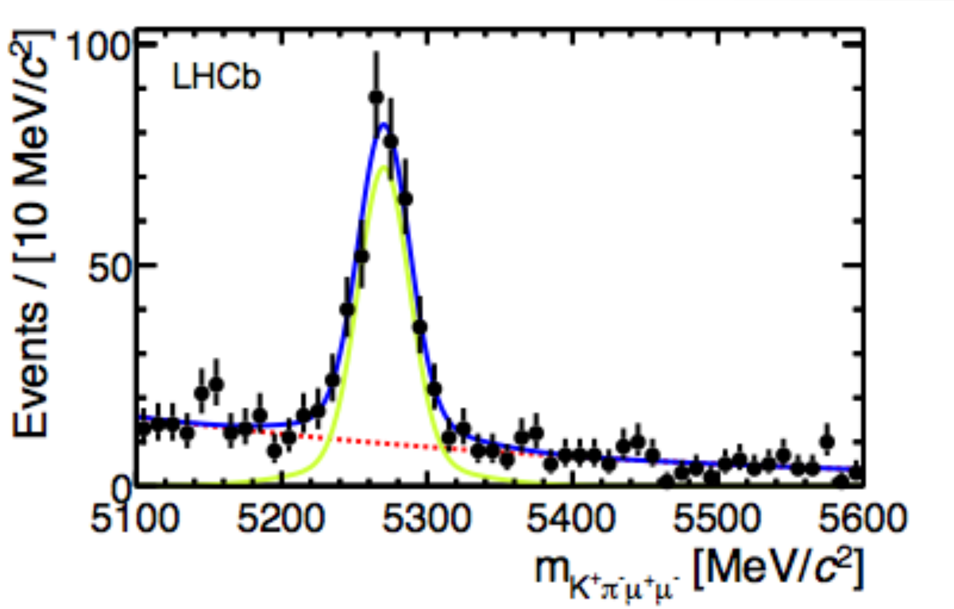
In the grey area the Pdf becomes negative.

Mathematical and physical boundary.

Bd→K*μμ results

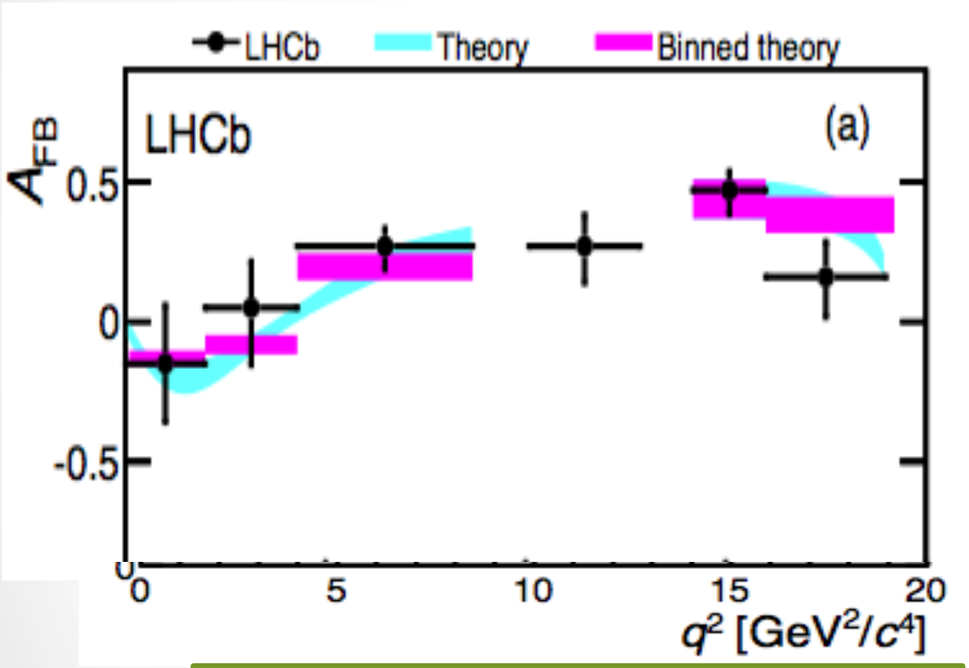


The results are all world best and in agreement with the SM

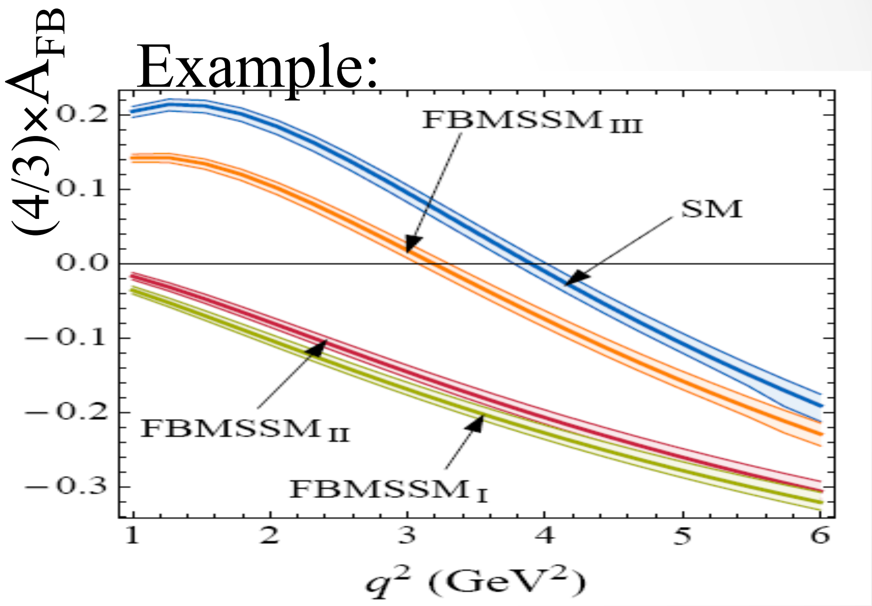


LHCb Coll., arXiv:1112.3515v2 [hep-ex]

Bd→K*μμ results

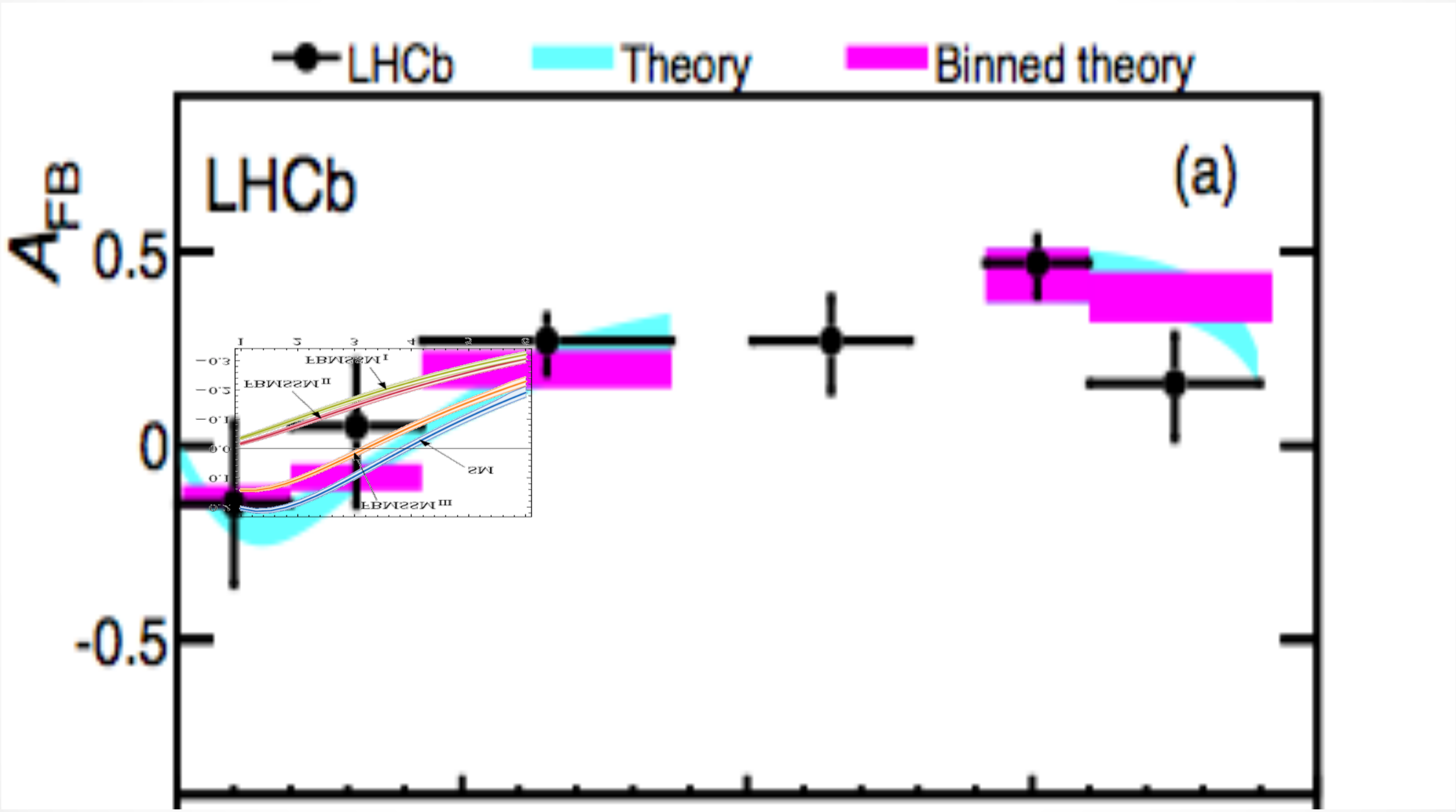


LHCb Coll., arXiv:1112.3515v2 [hep-ex]



W. Altmannshofer et al., JHEP 0901:019,200

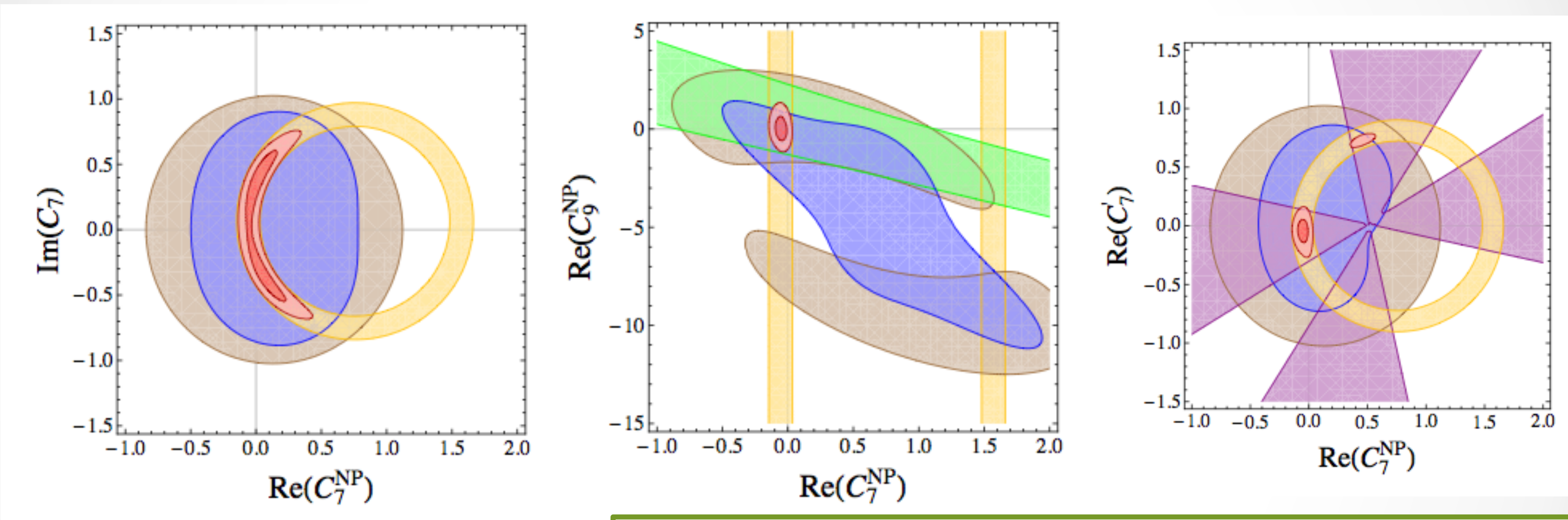
Zooming in the result



27/02/2012

Implications (Bd→K*μμ)

Example of the use of B_d →K*μμ to constrain Wilson coefficients (model independent): see W. Altmannshofer, P, Paradisi and D. M. Straubc arXiv:1111.1257v1



- B → K*μ⁺μ⁻ at low q² (blue)
- B → K*μ⁺μ⁻ at low q² (green)
- B → X_sl+l– (brown)
- BR(B → Xsγ) (yellow)
- B → K*γ (purple)
- Combined 1σ and 2σ (red)

__W. Altmannshofer, P, Paradisi and D. M. Straubc arXiv:1111.1257v1__

For similar analyses constraining Wilson Coeff see also:
C. Bobet, G. Hiller, D. van Dyk, and C. Wacker (arXiv:1111.2558v2)
S. Descotes-Genon, D. Ghosh, J. Matias, M. Ramon (arxiv:1104.3342v2)

$B_d \rightarrow K^*\mu\mu$ next steps

Differential Branching ratio of the $B_d \rightarrow K^*\mu\mu$

$$\frac{d^4\Gamma}{d\cos\theta_\ell\, d\cos\theta_K\, d\phi\, dq^2} \propto [I_1^S + I_1^C + (I_2^S + I_2^C)\cos 2\theta_\ell + I_3 \sin^2\theta_\ell \cos 2\phi + I_4 \sin 2\theta_\ell \cos\phi + I_5 \sin\theta_\ell \cos\phi + I_6 \cos\theta_\ell + I_7 \sin\theta_\ell \sin\phi + I_8 \sin 2\theta_\ell \sin\phi +$$

$$I_1^c = \left(|A_{0L}|^2 + |A_{0R}|^2\right)\cos^2\theta_K$$

$$I_1^s = \frac{3}{4}\left(|A_{\parallel L}|^2 + |A_{\parallel R}|^2 + |A_{\perp L}|^2 + |A_{\perp R}|^2\right)\sin^2\theta_K$$

$$I_2^c = -\left(|A_{0L}|^2 + |A_{0R}|^2\right)\cos^2\theta_K$$

$$I_2^s = \frac{1}{4}\left(|A_{\parallel L}|^2 + |A_{\parallel R}|^2 + |A_{\perp L}|^2 + |A_{\perp R}|^2\right)\sin^2\theta_K$$

$$I_3 = \frac{1}{2}\left(|A_{\perp L}|^2 - |A_{\parallel L}|^2 + |A_{\perp R}|^2 - |A_{\parallel R}|^2\right)\sin^2\theta_K$$

$$I_4 = \frac{1}{\sqrt{2}}\left(Re(A_{0L}A^*_{\parallel L}) + Re(A_{0R}A^*_{\parallel R})\right)\sin 2\theta_K$$

$$I_5 = \sqrt{2}\left(Re(A_{0L}A^*_{\perp L}) - Re(A_{0R}A^*_{\perp R})\right)\sin 2\theta_K$$

$$I_6 = 2\left(Re(A_{\parallel L}A^*_{\perp L}) - Re(A_{\parallel R}A^*_{\perp R})\right)\cos^2\theta_K$$

$$I_7 = \sqrt{2}\left(Im(A_{0L}A^*_{\parallel L}) - Im(A_{0R}A^*_{\parallel R})\right)\sin 2\theta_K$$

$$I_8 = \frac{1}{\sqrt{2}}\left(Im(A_{0L}A^*_{\perp L}) + Im(A_{0R}A^*_{\perp R})\right)\sin 2\theta_K$$

$$I_9 = \left(Im(A_{\parallel L}A^*_{\perp L}) + Im(A_{\parallel R}A^*_{\perp R})\right)\sin^2\theta_K$$

$A_{iL,R}$ are complex amplitudes (where $i = 0, \perp, \parallel$)

$B_d \rightarrow K^*\mu\mu$ next steps

If we apply the transformation $\varphi \rightarrow \varphi+\pi$ if $\varphi<0$.
We get rid of the terms which $\cos\varphi$ and $\sin\varphi$ (keeping $\cos(2\varphi)$ and $\sin(2\varphi)$)

$$\frac{1}{\Gamma}\frac{\mathrm{d}^4\Gamma}{\mathrm{d}\cos\theta_\ell\,\mathrm{d}\cos\theta_K\,\mathrm{d}\phi\,\mathrm{d}q^2} = \frac{9}{32\pi}\Big[F_L\cos^2\theta_K + \frac{3}{4}F_T(1-\cos^2\theta_K) + \frac{1}{4}F_T(1-\cos^2\theta_K)\cos 2\theta_\ell - F_L\cos^2\theta_K\cos 2\theta_\ell + \frac{1}{4}A_T^2F_T(1-\cos^2\theta_\ell)(1-\cos^2\theta_K)\cos 2\phi + \frac{4}{3}A_{FB}(1-\cos^2\theta_K)\cos\theta_\ell + A_{Im}(1-\cos^2\theta_K)(1-\cos^2\theta_\ell)\sin 2\phi\Big]$$

Physics Observables:

$$A_{FB} = \frac{3}{2}\frac{Re(A_{\|L}A^*_{\perp L}) - Re(A_{\|R}A^*_{\perp R})}{|A_{0L}|^2+|A_{\|L}|^2+|A_{\perp L}|^2+|A_{0R}|^2+|A_{\|R}|^2+|A_{\perp R}|^2}$$

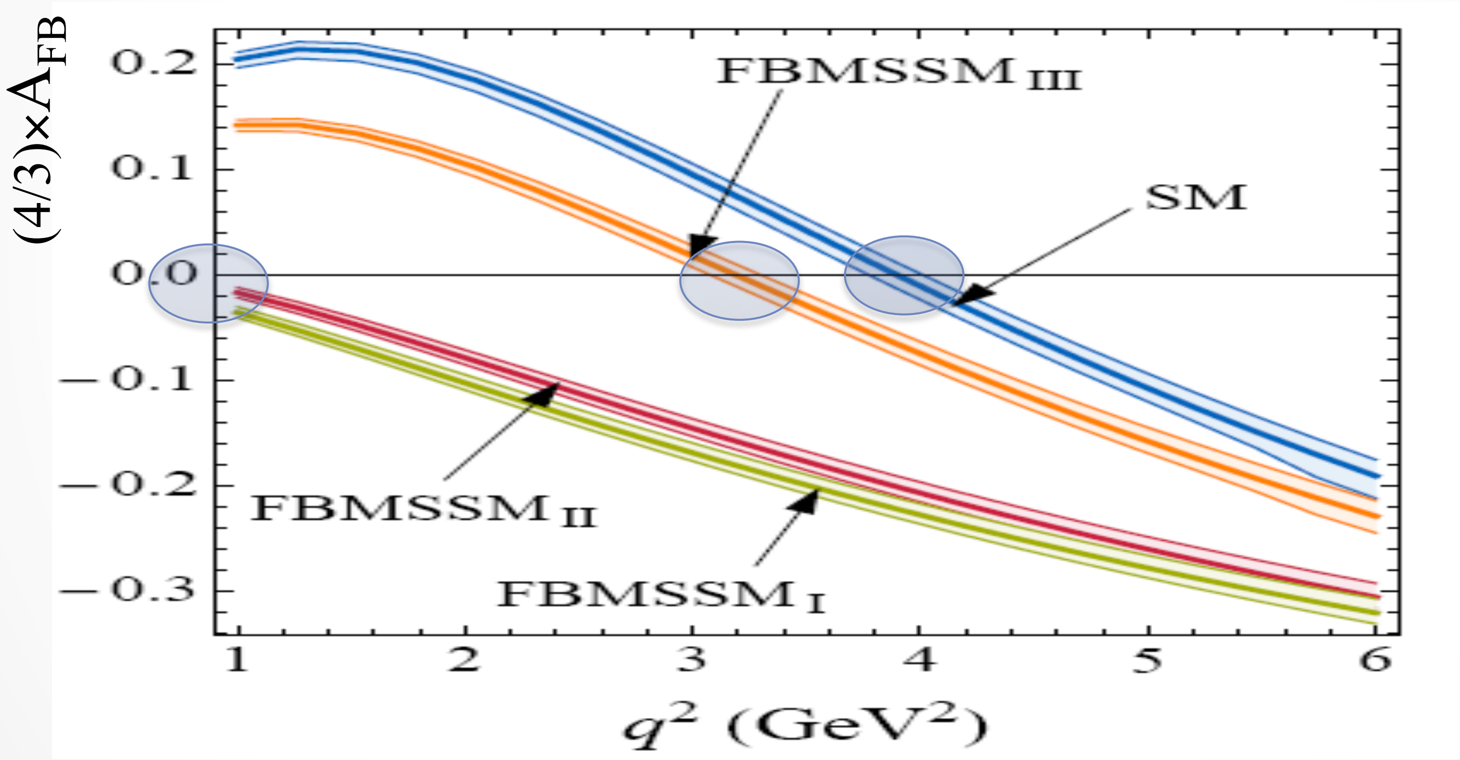
$$F_L = \frac{|A_{0L}|^2+|A_{0R}|^2}{|A_{0L}|^2+|A_{\|L}|^2+|A_{\perp L}|^2+|A_{0R}|^2+|A_{\|R}|^2+|A_{\perp R}|^2} = 1 - F_T$$

$$A_{Im} = \frac{Im(A_{\|L}A^*_{\perp L}) + Im(A_{\|R}A^*_{\perp R})}{|A_{0L}|^2+|A_{\|L}|^2+|A_{\perp L}|^2+|A_{0R}|^2+|A_{\|R}|^2+|A_{\perp R}|^2}$$

$$A_T^2 = \frac{|A_{\perp L}|^2-|A_{\|L}|^2+|A_{\perp R}|^2-|A_{\|R}|^2}{|A_{\perp L}|^2+|A_{\|L}|^2+|A_{\perp R}|^2+|A_{\|R}|^2}$$

$B_d \rightarrow K^*\mu\mu$ next steps

One important parameter distinctive of the SM and "clean" of hadronic uncertainty is the zero-crossing point



Other interesting channels

The large statistics of B mesons (and not only B mesons!) that LHCb has been accumulating will allow to enter in a unexplored interesting territory soon with LFV decays.

Examples are:

$B_{(s)} \rightarrow ll'$ where $l,l' = e,\mu,\tau$
or
$B \rightarrow hll'$ where $l,l' = e,\mu,\tau$ and $h = K, K^*, \varphi, \ldots$

But also rare decays beyond the B:

$\tau \rightarrow 3\mu$, $D \rightarrow ll'$, …

Conclusions

- Flavor physics is a powerful tool to search for NP (in particular using correlation between the different channels)
- Rare FCNC decays where the SM is suppressed are promising places to look for NP
- LHCb result for $B_s \rightarrow \mu\mu$ and $B_d \rightarrow K^*\mu\mu$ are in agreement with the SM and already constrain possible NP scenario
- Today's talk was based on ~370pb^{-1} but LHCb will have an update for spring conferences with about 3 times as much statistics (stay tuned)

Backup slides