

Ricerca di Nuova Fisica in decadimenti Rari

Nicola Serra



Sommario

In questo talk :

- $B_{s,d} \rightarrow \mu \mu$
- $B_d \rightarrow K^* \mu \mu$
- $B^+ \rightarrow \pi^+ \mu \mu$
- Decadimenti LNV $B^+ \rightarrow h^+ \mu \mu$
- Decadimenti Rari Radiativi

$B_{s,d} \rightarrow \mu \mu$ (vedi posters):

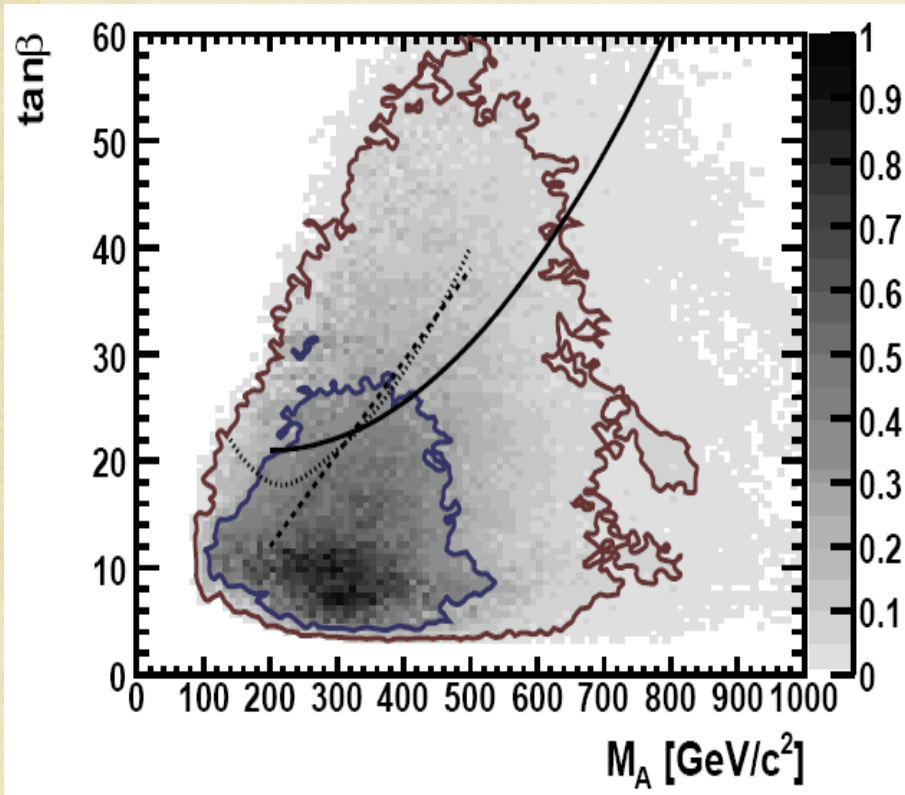
MARTINI Luca per CMS

MUSTO Elisa per ATLAS

Decadimenti Rari (vedi talk):

DE NARDO, G. "Decadimenti rari alle B-factories"

$B_{s,d} \rightarrow \mu \mu$



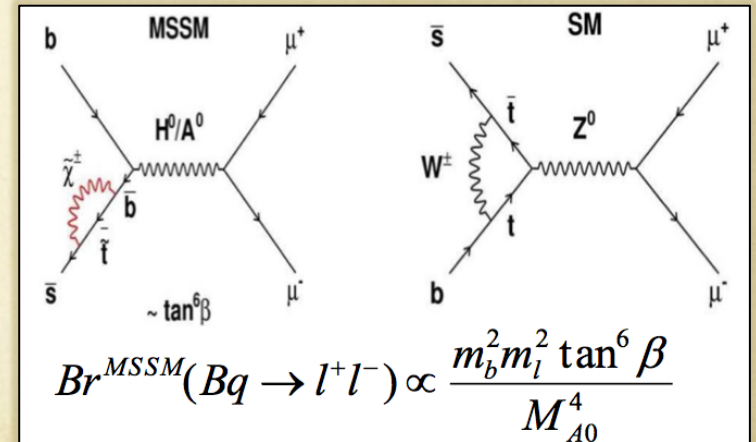
SM prediction:

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

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

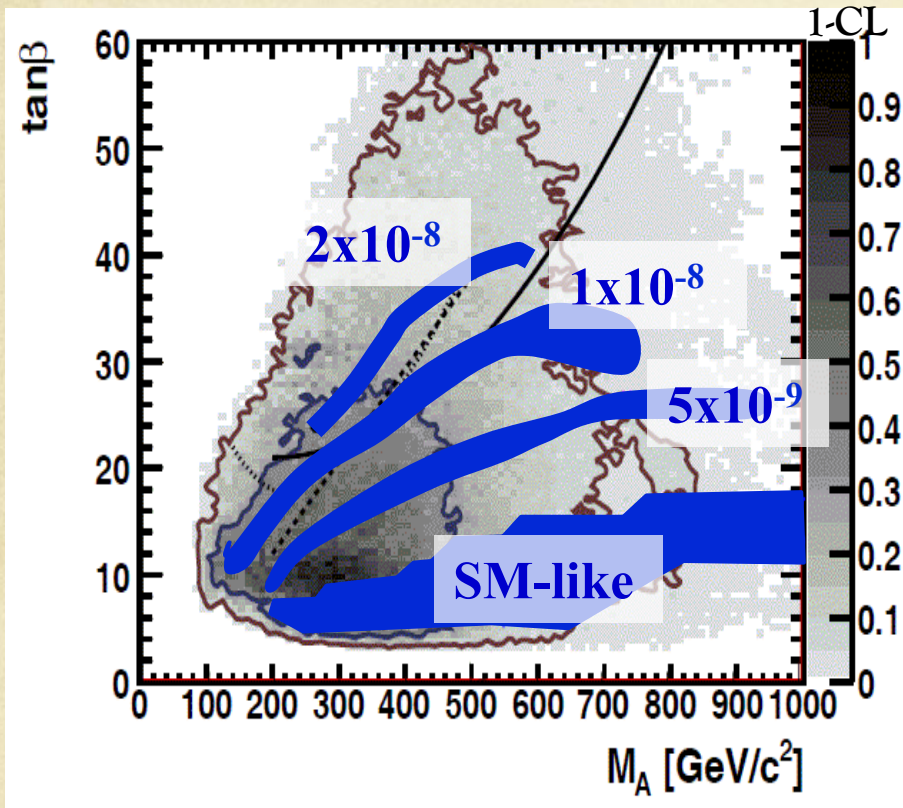
A.J. Buras arxiv:1012.1447

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



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

$$B_{s,d} \rightarrow \mu \mu$$



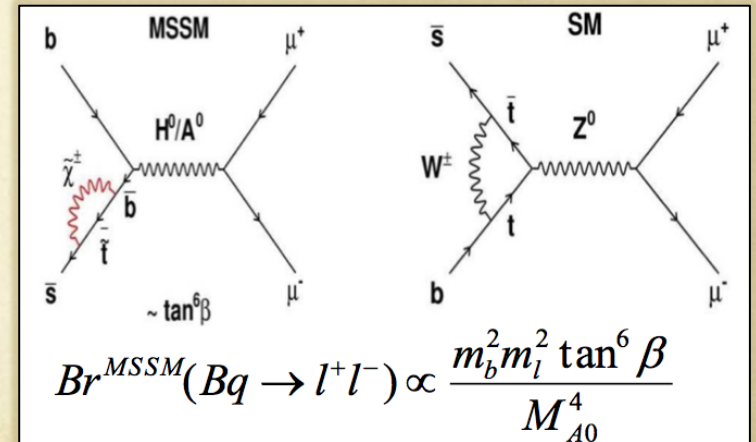
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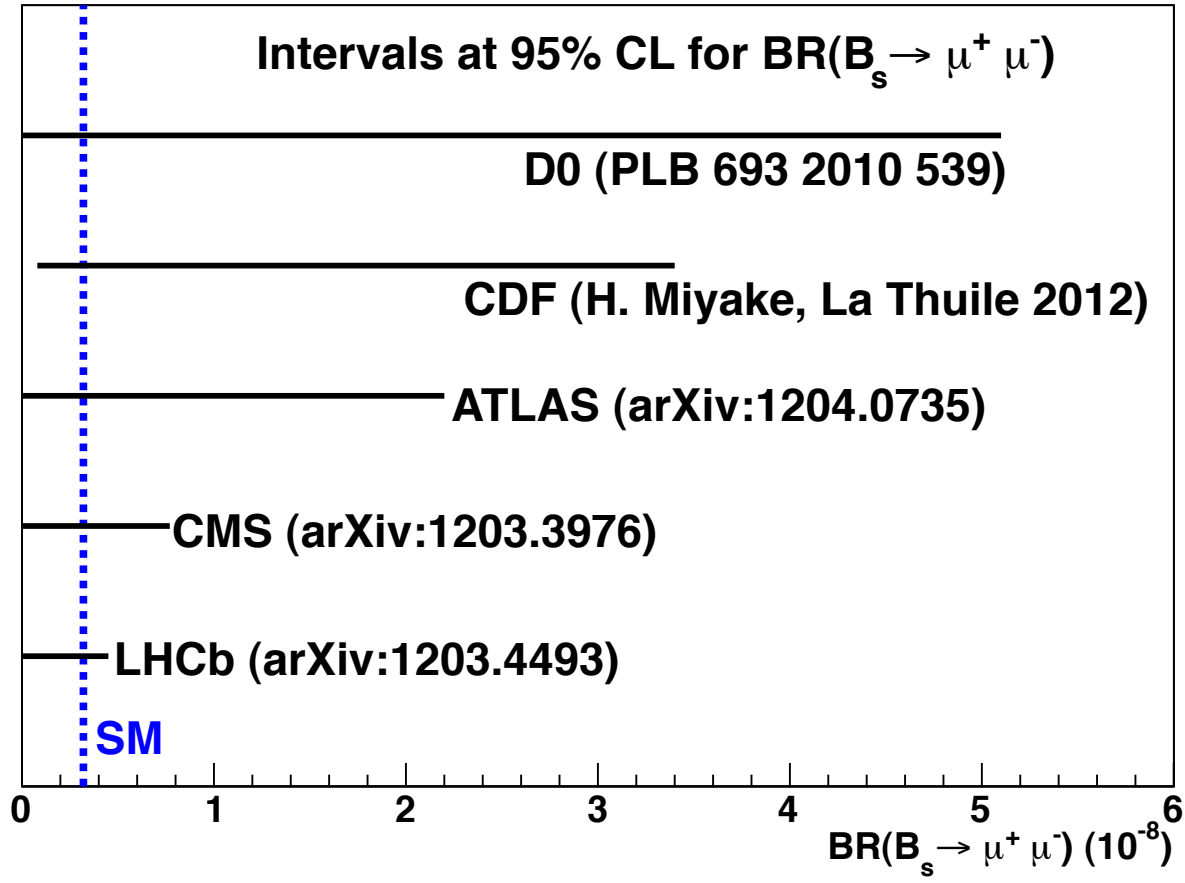
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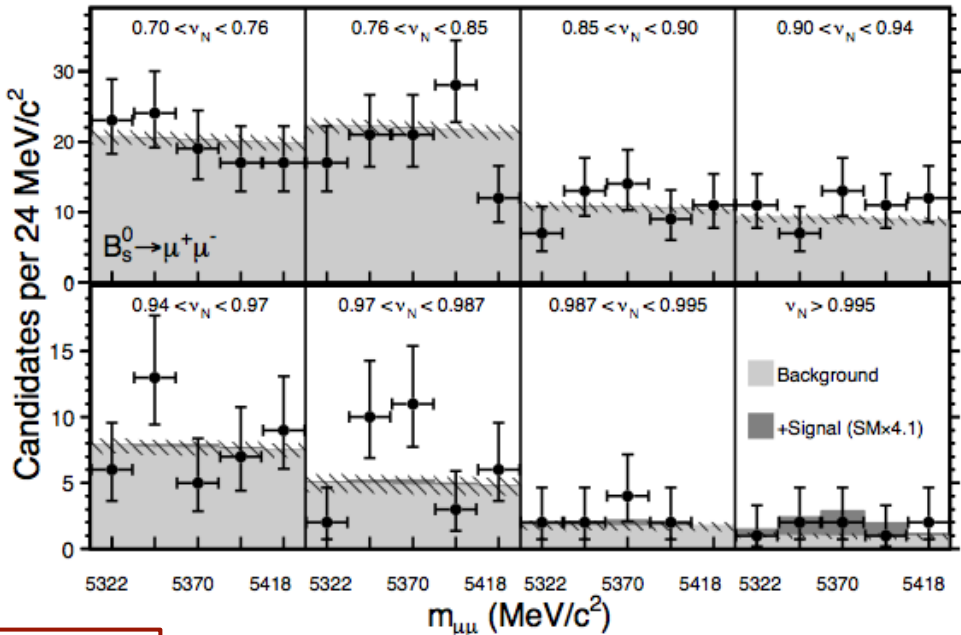
O.Buchmueller et al. Eur.Phys.J.C64:391-415,2009

Limiti Recenti



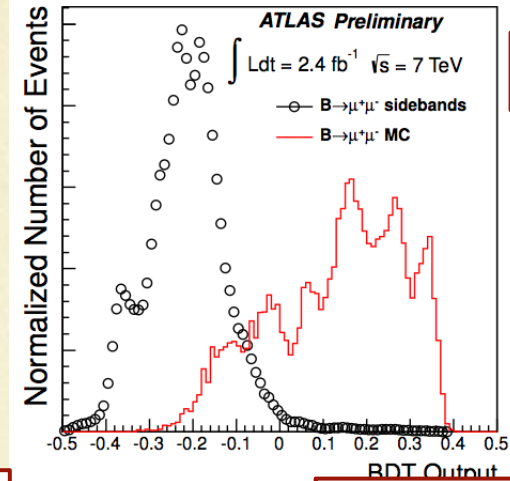
Selezione

CDF

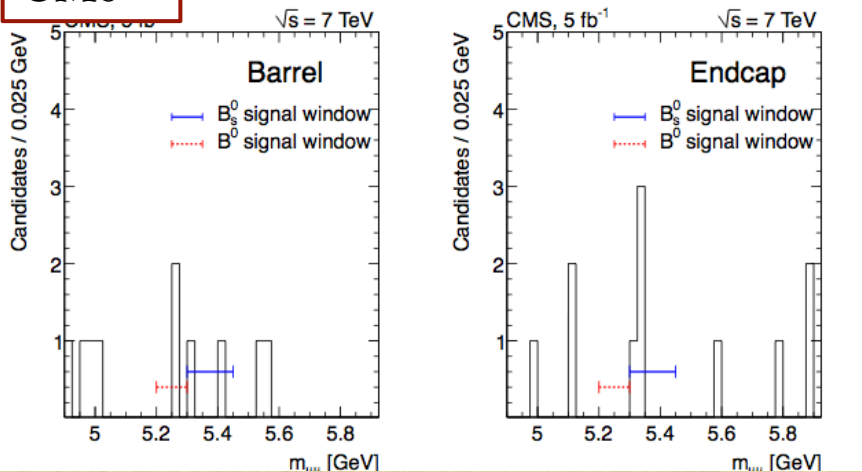


- “Neural Network” usata da CDF
- “BDT” usato da LHCb e ATLAS
- “Cut based” usata da CMS

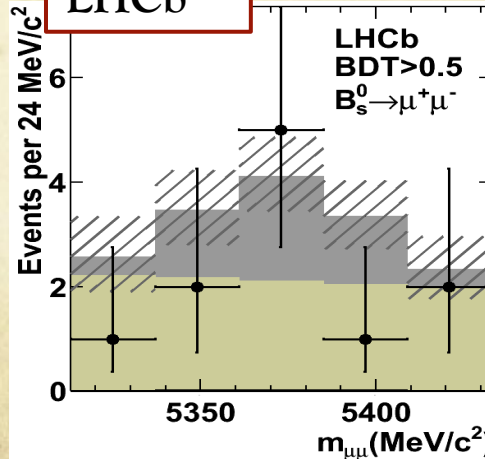
ATLAS



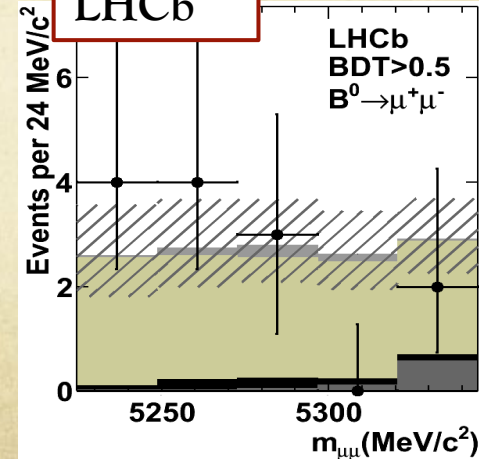
CMS



LHCb



LHCb



Normalizzazione

Canali di controllo usati per la normalizzazione:

- $B^+ \rightarrow J/\psi K^+$

Usato per normalizzazione da tutti gli esperimenti

- $B_d \rightarrow K^+ \pi$

Altri canali usati ad LHCb

- $B_s \rightarrow J/\psi \Phi$

Usato da CMS come canale di controllo

$$BR(B_{(s)} \rightarrow \mu\mu) = BR_{Norm} \times \frac{\epsilon_{Norm}}{\epsilon_{sig}} \times \frac{f_{Norm}}{f_{d(s)}} \times \frac{N_{B_{(s)} \rightarrow \mu\mu}}{N_{Norm}} = \alpha_{B_{(s)} \rightarrow \mu\mu} \times N_{B_{(s)} \rightarrow \mu\mu}$$

$$\alpha_{B_d \rightarrow \mu\mu} = (8.38 \pm 0.39) \cdot 10^{-11}$$

$$\alpha_{B_s \rightarrow \mu\mu} = (3.19 \pm 0.28) \cdot 10^{-10}$$

LHCb normalization factor!

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

LHCb Coll., Phys. Rev. D 85, 032008 (2012)
Tutti gli esperimenti ad LHC usano questo valore

Risultati

ATLAS

	Expected Limit	Observed Limit
$B_s \rightarrow \mu \mu$	2.8×10^{-8}	2.2×10^{-8}

ATLAS limit with 2.4 fb⁻¹

CMS

upper limit (95%CL)	observed	expected
$\mathcal{B}(B_s^0 \rightarrow \mu^+ \mu^-)$	7.7×10^{-9}	8.4×10^{-9}
$\mathcal{B}(B^0 \rightarrow \mu^+ \mu^-)$	1.8×10^{-9}	1.6×10^{-9}

CMS limit with 4.9 fb⁻¹

CDF

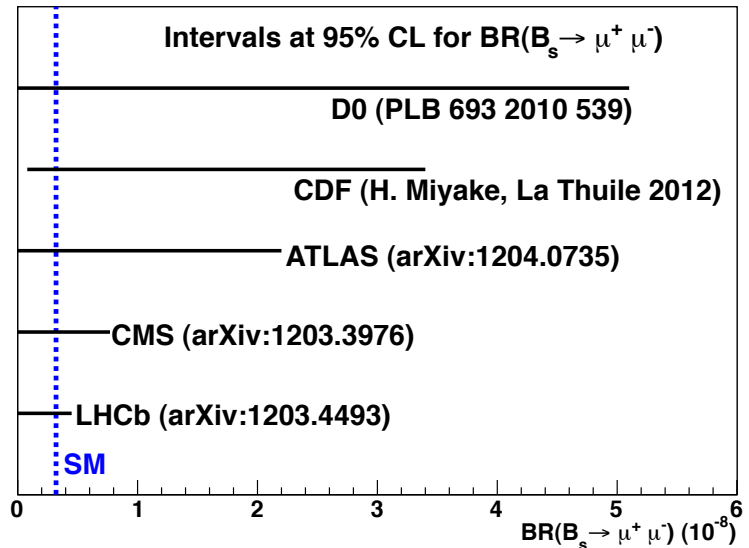
	95% CL
$B_d \rightarrow \mu \mu$	4.6×10^{-9}
$B_s \rightarrow \mu \mu$	$[0.8 \times 10^{-9}, 3.4 \times 10^{-8}]$

CDF limit with 10 fb⁻¹

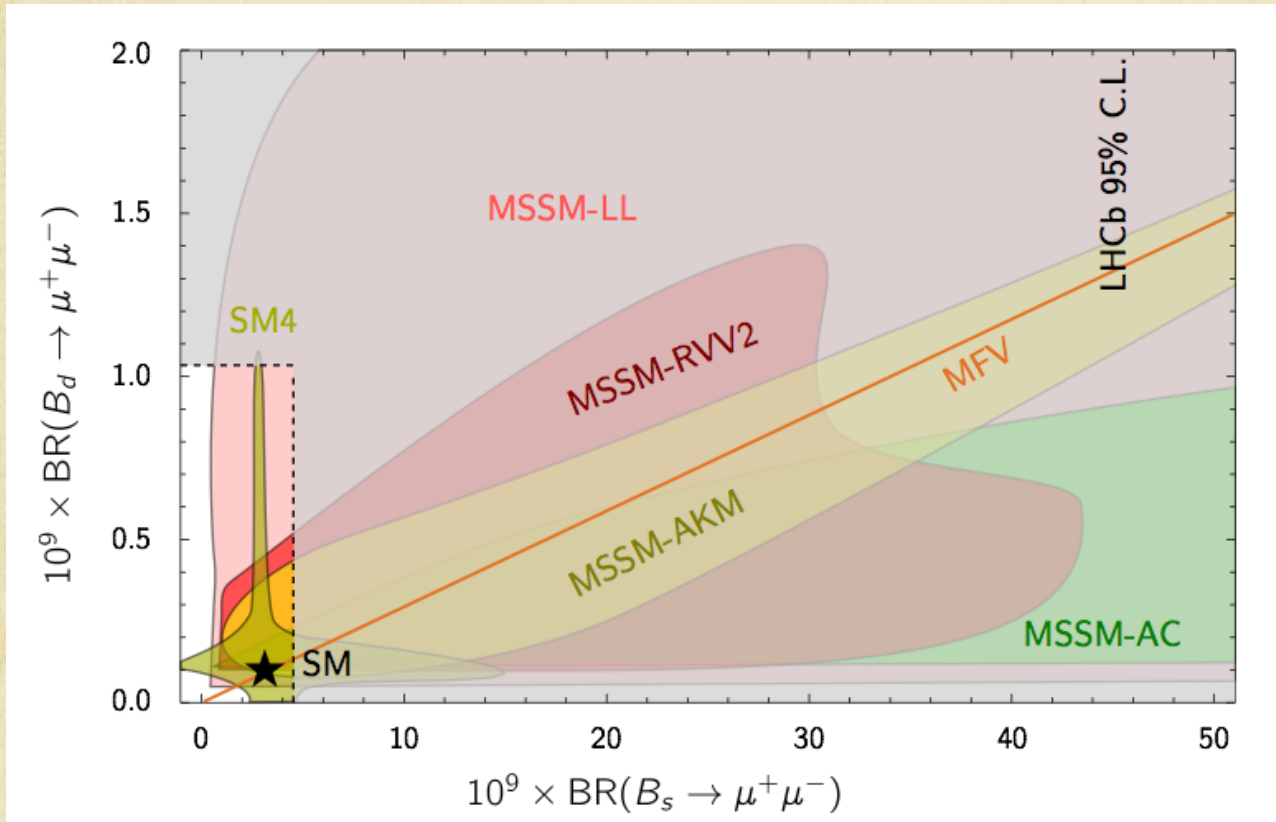
LHCb

Mode	Limit	at 90% CL	at 95% CL
$B_s^0 \rightarrow \mu^+ \mu^-$	Exp. bkg+SM	6.3×10^{-9}	7.2×10^{-9}
	Exp. bkg	2.8×10^{-9}	3.4×10^{-9}
	Observed	3.8×10^{-9}	4.5×10^{-9}
$B^0 \rightarrow \mu^+ \mu^-$	Exp. bkg	0.91×10^{-9}	1.13×10^{-9}
	Observed	0.81×10^{-9}	1.03×10^{-9}

LHCb limit with 1 fb⁻¹



Implicazioni

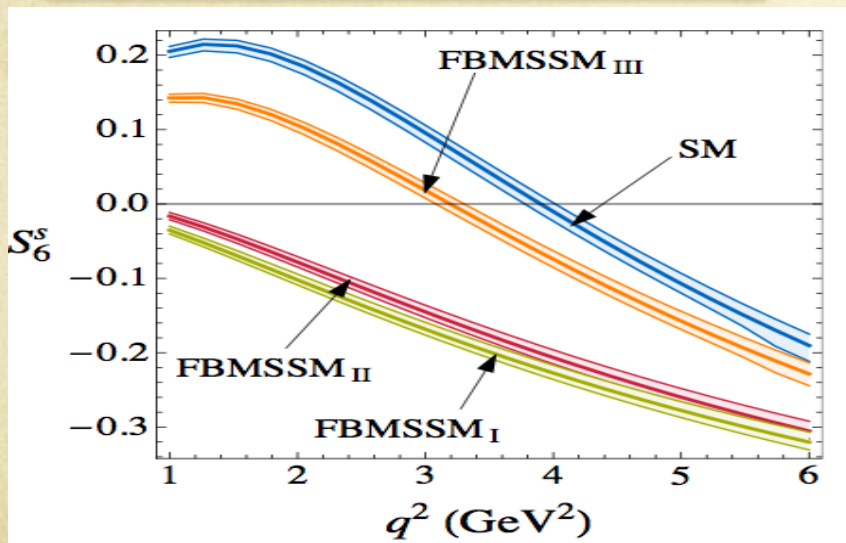
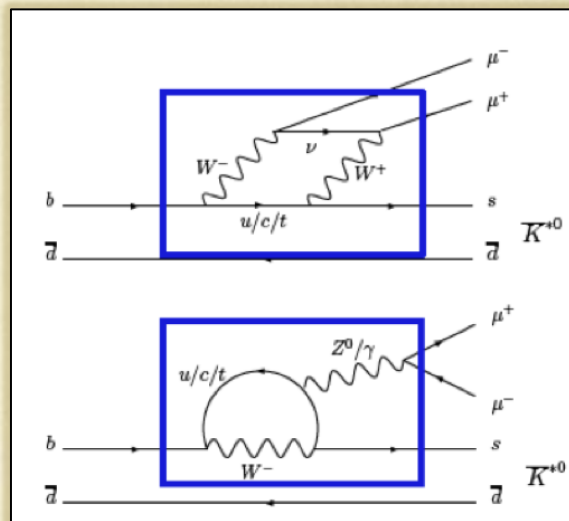
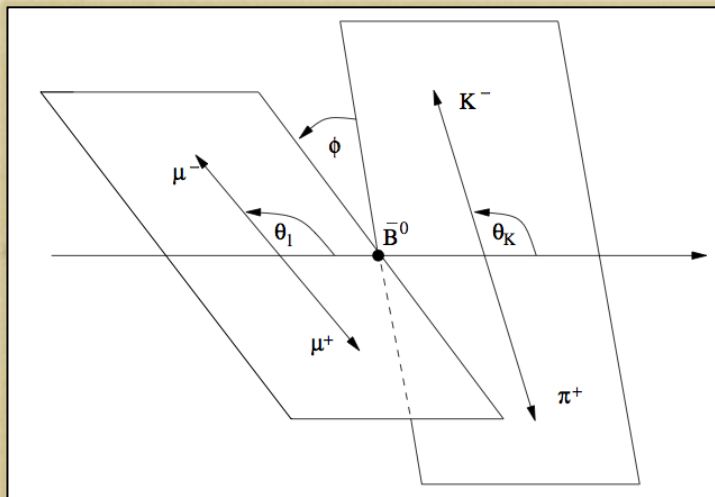


David Straub, Rencontres de Moriond EW, La Thuile (2012)

- Spazio di nuova fisica notevolmente ridotto
- Cmq ci sono modelli che predicono un BR persino soppresso (oppure SM-like)
- Possibilita' di avere un'incertezza comparabile/inferiore a quella teorica ad LHCb upgrade (50fb^{-1})

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

Questo decadimento e' descritto da tre angoli e la (massa invariante dei dimuoni)² (q^2)



Si possono costruire varie osservabili sensibili a Nuova Fisica, per cui le incertezze adroniche sono sotto controllo.

Una delle piu' note e' l'asimmetria forward-backward rispetto a ϑ_1 .

$B_d \rightarrow K^* \mu \mu$: B-factories/CDF

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$$\frac{d^4\Gamma}{d \cos \theta_\ell d \cos \theta_K d\phi dq^2} \propto [I_1^s \sin^2 \theta_K + I_1^c \cos^2 \theta_K + (I_2^s \sin^2 \theta_K + I_2^c \cos^2 \theta_K) \cos 2\theta_\ell + I_3 \sin^2 \theta_K \sin^2 \theta_\ell \cos 2\phi + I_4 \sin 2\theta_K \sin 2\theta_\ell \cos \phi + I_5 \sin 2\theta_K \sin \theta_\ell \cos \phi + (I_6^s \sin^2 \theta_K + I_6^c \cos^2 \theta_K) \cos \theta_\ell + I_7 \sin 2\theta_K \sin \theta_\ell \sin \phi + I_8 \sin 2\theta_K \sin 2\theta_\ell \sin \phi + I_9 \sin^2 \theta_K \sin^2 \theta_\ell \sin 2\phi],$$

Fit rispetto alle proiezioni rispetto agli angoli

$$\left(\frac{1}{\Gamma} \frac{d\Gamma}{d\vartheta_K} \right) = \frac{3}{2} F_L \cos^2 \vartheta_K + \frac{3}{4} (1 - F_L) \sin^2 \vartheta_K$$

$$\left(\frac{1}{\Gamma} \frac{d\Gamma}{d\vartheta_l} \right) = \frac{3}{4} F_L \sin^2 \vartheta_l + \frac{3}{8} (1 - F_L) (1 + \cos^2 \vartheta_l) + A_{FB} \cos \vartheta_l$$

$$\left(\frac{1}{\Gamma} \frac{d\Gamma}{d\phi} \right) = \frac{1}{2\pi} \left\{ 1 + \frac{1}{2} (1 - F_L) A_T^{(2)} \cos 2\phi + A_{Im} \sin 2\phi \right\}$$

BaBar: S.Akar Lake Louise (2012)

Belle: Phys.Rev.Lett. 103, 171801 (2009)

CDF :Phys. Rev. Lett. 108, 081807 (2012)

CDF :Phys. Rev. Lett. 108, 081807 (2012)

$B_d \rightarrow K^* \mu \mu$: B-factories/CDF

$$\frac{d^4\Gamma}{d \cos \theta_\ell d \cos \theta_K d\phi dq^2} \propto [I_1^s \sin^2 \theta_K + I_1^c \cos^2 \theta_K + (I_2^s \sin^2 \theta_K + I_2^c \cos^2 \theta_K) \cos 2\theta_\ell + I_3 \sin^2 \theta_K \sin^2 \theta_\ell \cos 2\phi + I_4 \sin 2\theta_K \sin 2\theta_\ell \cos \phi + I_5 \sin 2\theta_K \sin \theta_\ell \cos \phi + (I_6^s \sin^2 \theta_K + I_6^c \cos^2 \theta_K) \cos \theta_\ell + I_7 \sin 2\theta_K \sin \theta_\ell \sin \phi + I_8 \sin 2\theta_K \sin 2\theta_\ell \sin \phi + I_9 \sin^2 \theta_K \sin^2 \theta_\ell \sin 2\phi],$$

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Parametri Fisici:

A_{FB} BaBar, Belle, CDF

F_L BaBar, Belle, CDF

A_T^2 CDF

A_{Im} CDF

$B_d \rightarrow K^* \mu \mu : \text{LHCb}$

$$\frac{d^4\Gamma}{d \cos \theta_\ell d \cos \theta_K d\phi dq^2} \propto [I_1^s \sin^2 \theta_K + I_1^c \cos^2 \theta_K + (I_2^s \sin^2 \theta_K + I_2^c \cos^2 \theta_K) \cos 2\theta_\ell + I_3 \sin^2 \theta_K \sin^2 \theta_\ell \cos 2\phi + I_4 \sin 2\theta_K \sin 2\theta_\ell \cos \phi + I_5 \sin 2\theta_K \sin \theta_\ell \cos \phi + (I_6^s \sin^2 \theta_K + I_6^c \cos^2 \theta_K) \cos \theta_\ell + I_7 \sin 2\theta_K \sin \theta_\ell \sin \phi + I_8 \sin 2\theta_K \sin 2\theta_\ell \sin \phi + I_9 \sin^2 \theta_K \sin^2 \theta_\ell \sin 2\phi],$$

Con la seguente trasformazione $\phi \rightarrow \phi + \pi$ if $\phi < 0$

i termini in $\cos \phi$ e $\sin \phi$ si annullano, mentre i termini in $\cos 2\phi$ e $\sin 2\phi$ sopravvivono

$$\frac{1}{\Gamma} \frac{d^4\Gamma}{d \cos \theta_\ell d \cos \theta_K d\hat{\phi} dq^2} = \frac{9}{16\pi} \left[F_L \cos^2 \theta_K + \frac{3}{4}(1 - F_L)(1 - \cos^2 \theta_K) + F_L \cos^2 \theta_K (2 \cos^2 \theta_\ell - 1) + \frac{1}{4}(1 - F_L)(1 - \cos^2 \theta_K)(2 \cos^2 \theta_\ell - 1) + S_3(1 - \cos^2 \theta_K)(1 - \cos^2 \theta_\ell) \cos 2\hat{\phi} + \frac{4}{3}A_{FB}(1 - \cos^2 \theta_K) \cos \theta_\ell + A_{Im}(1 - \cos^2 \theta_K)(1 - \cos^2 \theta_\ell) \sin 2\hat{\phi} \right]$$

LHCb : LHCb-CONF-2012-008

$B_d \rightarrow K^* \mu \mu : \text{LHCb}$

$$\frac{d^4\Gamma}{d \cos \theta_\ell d \cos \theta_K d\phi dq^2} \propto [I_1^s \sin^2 \theta_K + I_1^c \cos^2 \theta_K + (I_2^s \sin^2 \theta_K + I_2^c \cos^2 \theta_K) \cos 2\theta_\ell + I_3 \sin^2 \theta_K \sin^2 \theta_\ell \cos 2\phi + I_4 \sin 2\theta_K \sin 2\theta_\ell \cos \phi + I_5 \sin 2\theta_K \sin \theta_\ell \cos \phi + (I_6^s \sin^2 \theta_K + I_6^c \cos^2 \theta_K) \cos \theta_\ell + I_7 \sin 2\theta_K \sin \theta_\ell \sin \phi + I_8 \sin 2\theta_K \sin 2\theta_\ell \sin \phi + I_9 \sin^2 \theta_K \sin^2 \theta_\ell \sin 2\phi],$$

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Parametri Fisici:

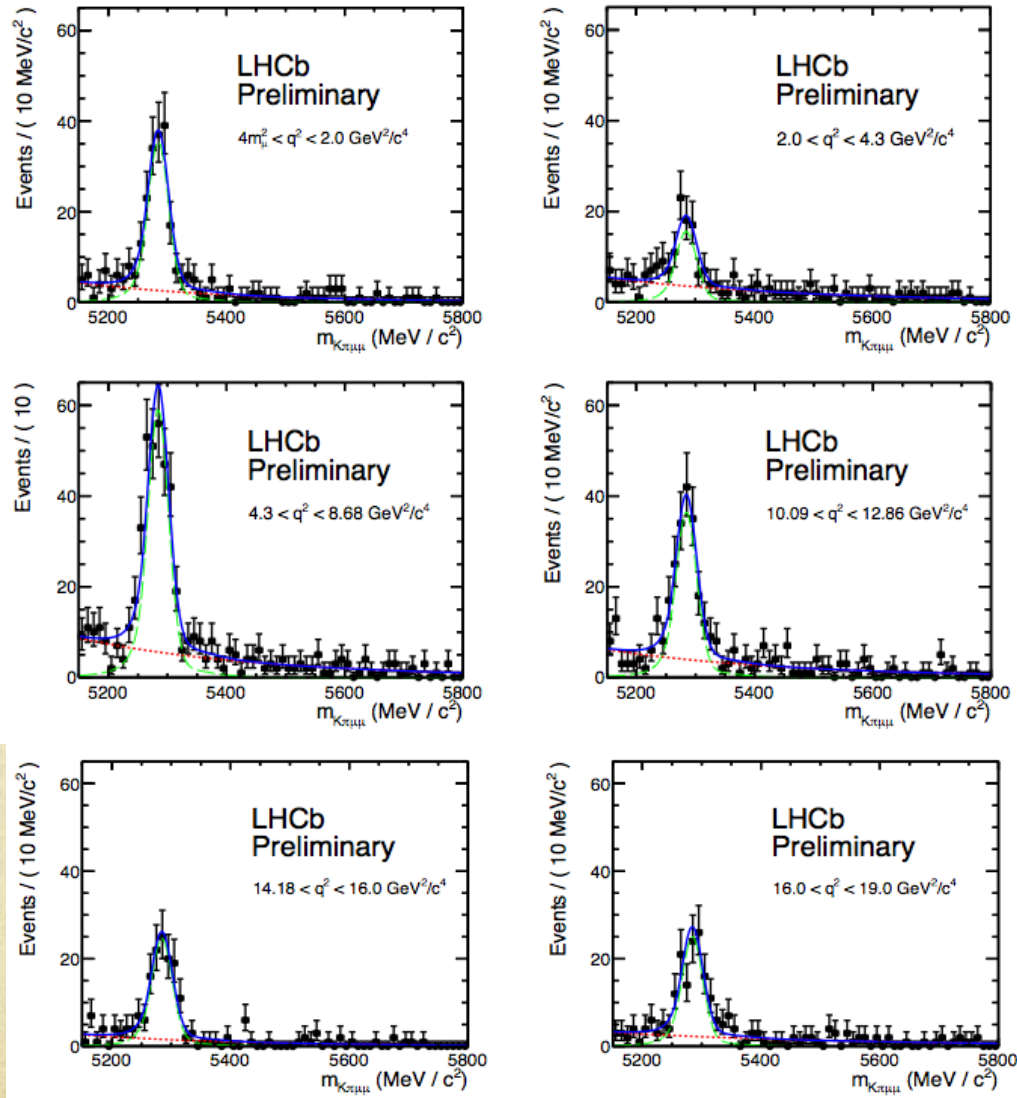
A_{FB}

F_L

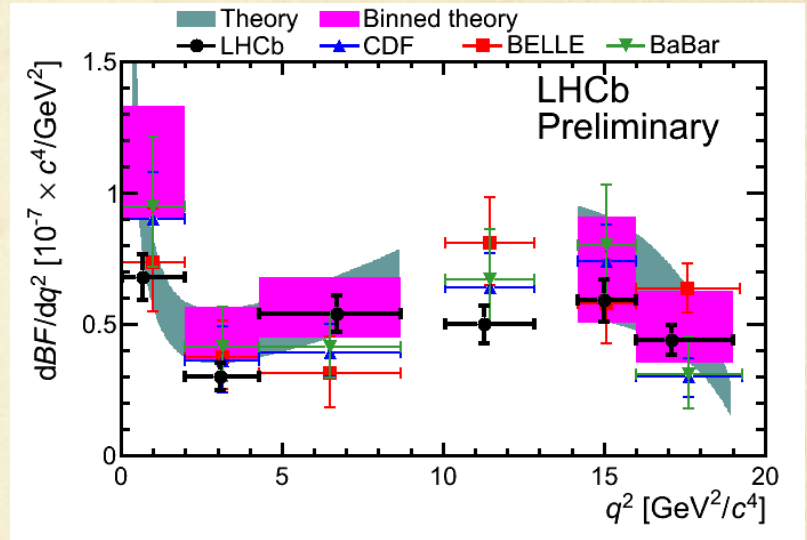
S_3 (spesso $(1 - F_L)A_T^2$ in letteratura)

A_{Im}

$B_d \rightarrow K^* \mu \mu$: LHCb



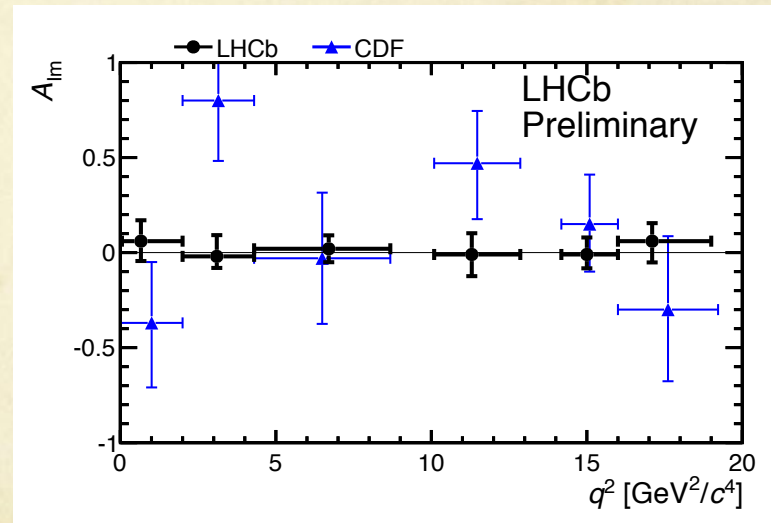
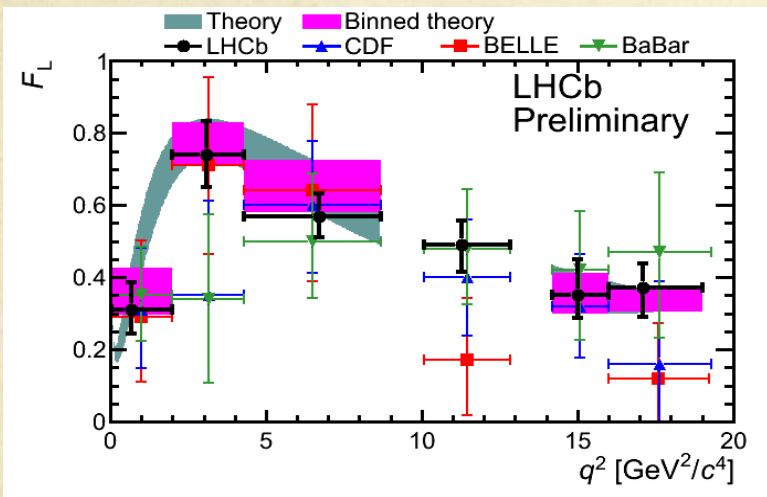
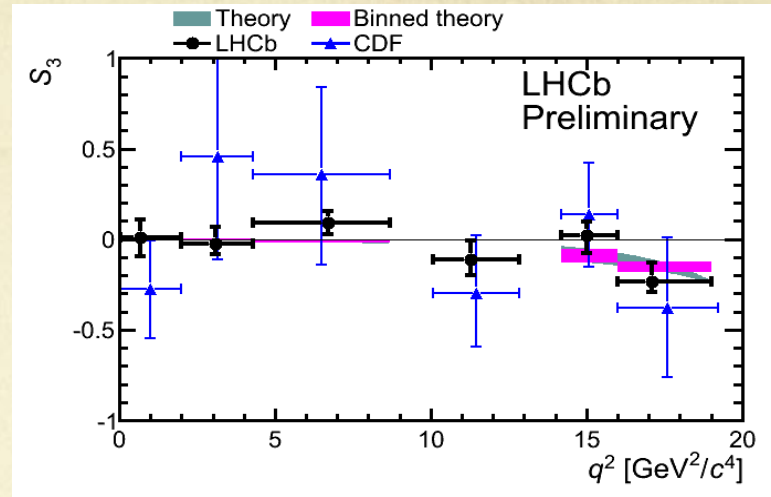
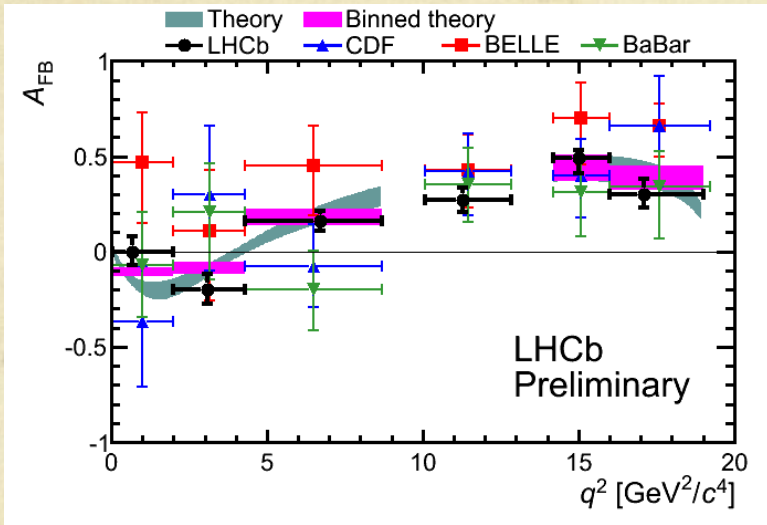
Theory prediction from
C. Bobeth, G. Hiller, D. van Dyk, JHEP 07, 067 (2011)



BaBar: S.Akar Lake Louise (2012)
Belle: Phys.Rev.Lett. 103, 171801 (2009)
CDF :Phys. Rev. Lett. 108, 081807 (2012)
LHCb: LHCb-CONF-2012-008

Massa invariante $K^* \mu \mu$

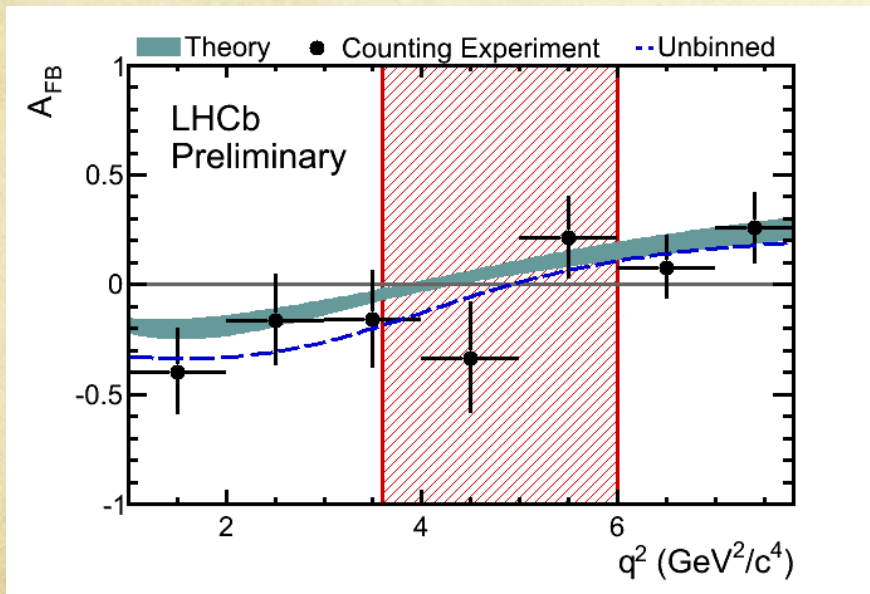
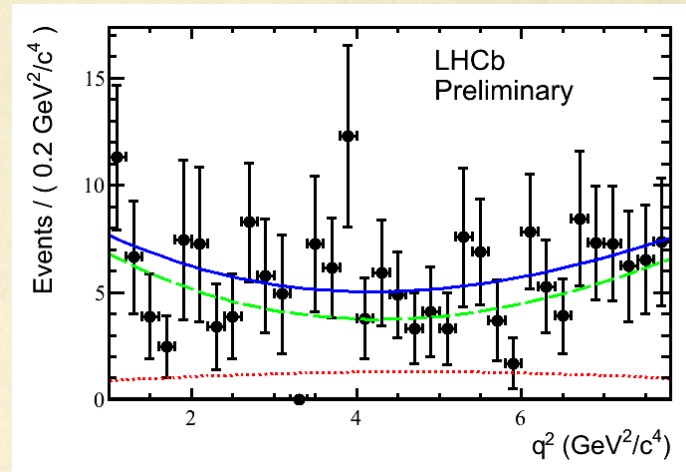
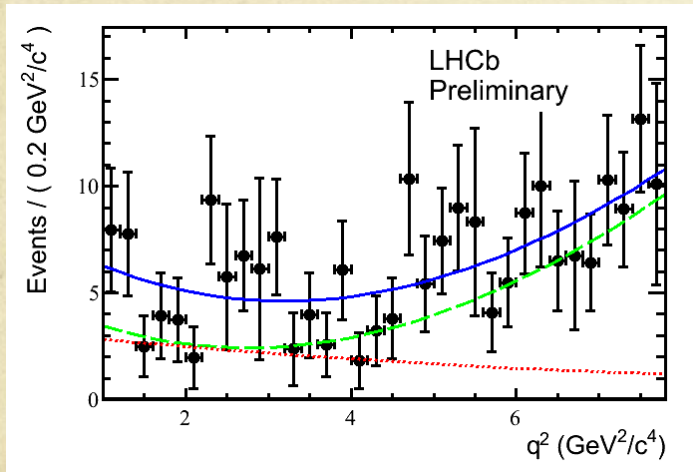
$$B_d \rightarrow K^* \mu \mu$$



BaBar: S.Akar Lake Louise (2012)
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Zero Crossing Point: LHCb



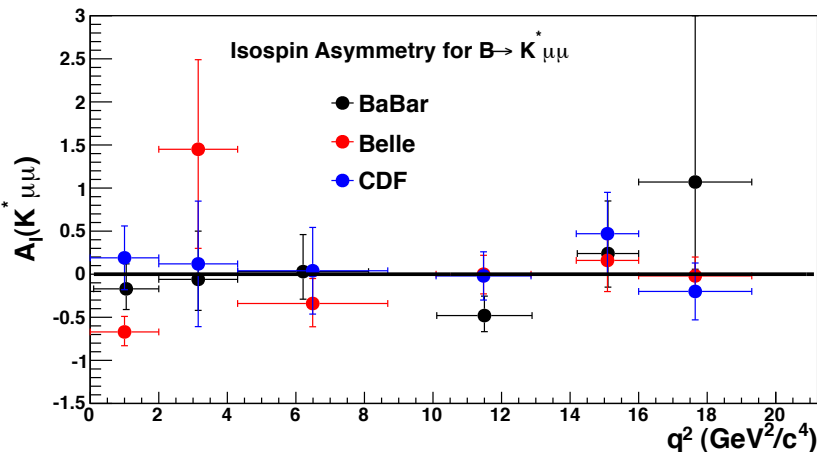
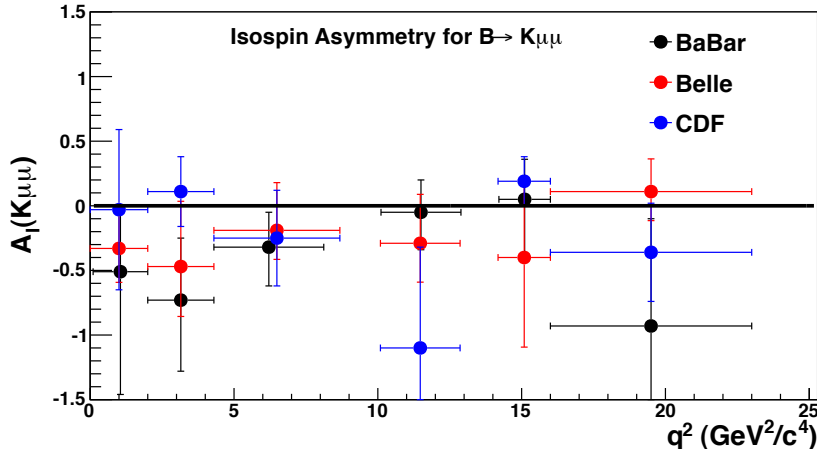
- Fit simultaneo della massa invariante ($K\pi\mu\mu$) e di q^2
- La dipendenza da q^2 e' parameterizzata con polinomi
- Stabilita' rispetto all'ordine dei polinomi controllata col MC
- "Bootstrapping" dei dati usato per calcolare il 68% CL

LHCb prospettive nel futuro immediato

- La presenza di un'onda S nel sistema $K\pi$ puo' essere inserita (al momento e' una sistematica) nell'analisi angolare \rightarrow Comporta 2 termini in piu' nelle distribuzioni angolari
- Con circa 2fb^{-1} sarebbe possibile fare un fit angolare completo

Asimmetria di Isospin

L'asimmetria di isospin e' attesa essere piccola nello SM



Esistono misure delle B-factories e di CDF

$$A_I = \frac{\mathcal{B}(B^0 \rightarrow K^{(*)0} \mu^+ \mu^-) - \frac{\tau_0}{\tau_+} \mathcal{B}(B^\pm \rightarrow K^{(*)\pm} \mu^+ \mu^-)}{\mathcal{B}(B^0 \rightarrow K^{(*)0} \mu^+ \mu^-) + \frac{\tau_0}{\tau_+} \mathcal{B}(B^\pm \rightarrow K^{(*)\pm} \mu^+ \mu^-)}$$

BaBar: S.Akar Lake Louise (2012)

Belle: Phys.Rev.Lett. 103, 171801 (2009)

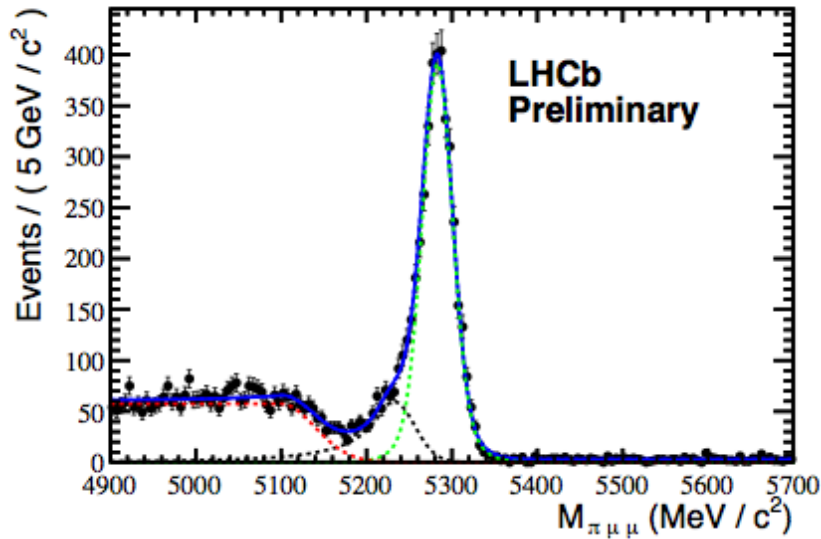
CDF :Phys. Rev. Lett. 108, 081807 (2012)

Misura di LHCb attesa presto!

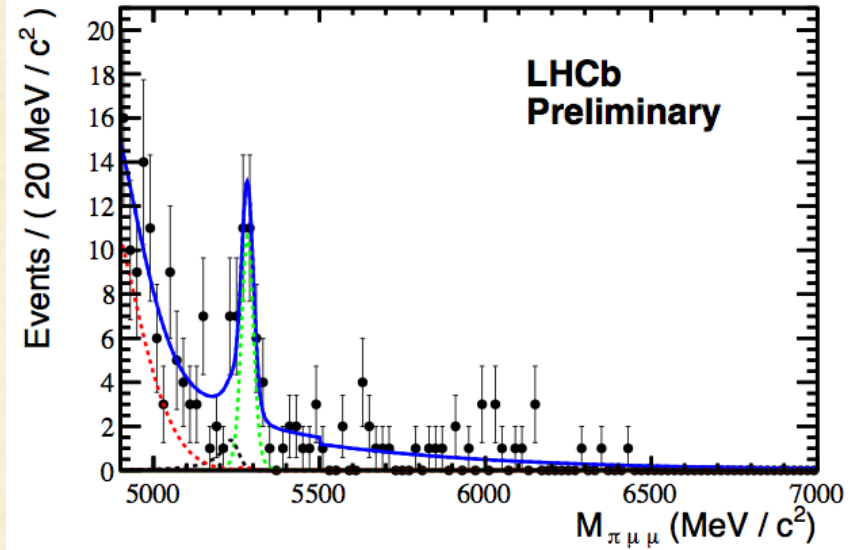
$$B^+ \rightarrow \pi^+ \mu \mu$$

E' una transizione $b \rightarrow d l l$, quindi soppressa di un fattore $|V_{td}|/|V_{ts}|$ rispetto alle transizioni $b \rightarrow s l l$.

$$B^+ \rightarrow J/\psi \pi^+$$



$$B^+ \rightarrow \pi^+ \mu \mu$$



$$BR(B^+ \rightarrow \pi^+ \mu^+ \mu^-)_{LHCb} = (2.4 \pm 0.6 \pm 0.2) \cdot 10^{-8}$$

Piu' raro decadimento del B mai osservato!

$$BR(B^+ \rightarrow \pi^+ \mu^+ \mu^-)_{SM} = (1.96 \pm 0.21) \cdot 10^{-8}$$

Buon accordo con lo SM.

LHCb: LHCb-CONF-2012-006

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LNV decays

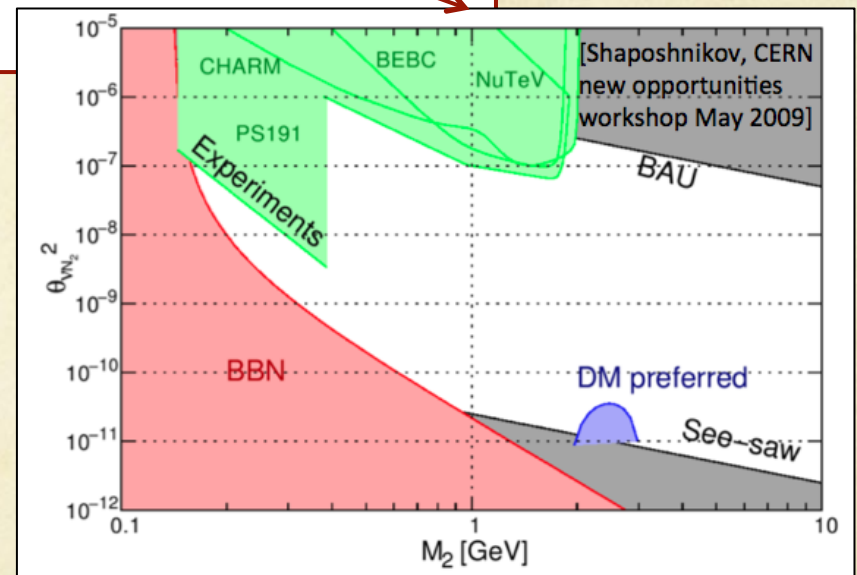
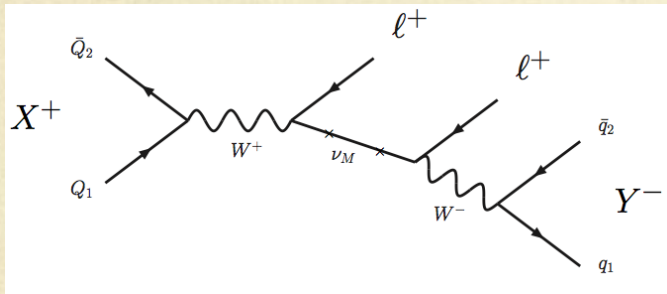
- Simili a decadimenti “neutrinoless double β ” \rightarrow assenti nello SM, $\Delta L=2$
- La produzione di neutrini puo' essere o meno risonante, a seconda della massa
- Il “rate” dipende dall'accoppiamento V_{l4} tra leptoni e neutrino di Majorana

Si veda ad es.:

Shaposhnikov *et al.*, Phys.Lett.B631:151-156,2005 (ν MSM)

Pascoli *et al.*, arXiv:0901.3589v2

G. Cvetič *et al.*, PRD82,053010(2010)



Ricerche effettuate da vari esperimenti, recentemente da LHCb e BaBar

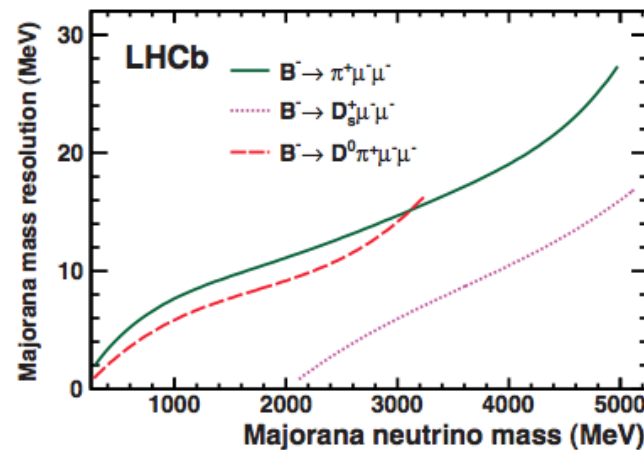
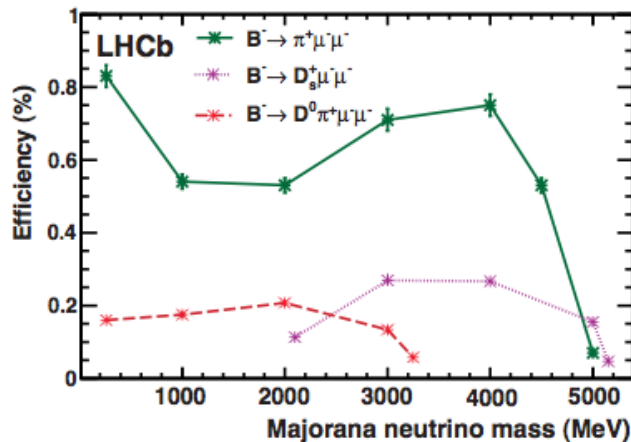
Limiti Recenti

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Channel	Upper Limit (CL)	Reference
$\mathcal{B}(B^+ \rightarrow K^- \mu^+ \mu^+)$	5.4×10^{-8} (95%)	LHCb [213]
$\mathcal{B}(B^+ \rightarrow \pi^- \mu^+ \mu^+)$	1.3×10^{-8} (95%)	LHCb [212]
$\mathcal{B}(B^+ \rightarrow \pi^- e^+ e^+)$	2.3×10^{-8} (90%)	BaBar [214]
$\mathcal{B}(B^+ \rightarrow K^- e^+ e^+)$	3.0×10^{-8} (90%)	BaBar [214]
$\mathcal{B}(B^+ \rightarrow D^- \mu^+ \mu^+)$	6.9×10^{-7} (95%)	LHCb [212]
$\mathcal{B}(B^+ \rightarrow D^{*-} \mu^+ \mu^+)$	2.8×10^{-6} (95%)	LHCb [212]
$\mathcal{B}(B^+ \rightarrow D^- e^+ e^+)$	2.6×10^{-6} (90%)	Belle [215]
$\mathcal{B}(B^+ \rightarrow D^- \mu^+ e^+)$	1.8×10^{-6} (90%)	Belle [215]
$\mathcal{B}(B^+ \rightarrow D_s^- \mu^+ \mu^+)$	5.8×10^{-7} (95%)	LHCb [212]
$\mathcal{B}(B^+ \rightarrow D^0 \pi^- \mu^+ \mu^+)$	1.5×10^{-6} (95%)	LHCb [212]

[211] LHCb, Phys. Rev. Lett. 108, 101601 (2012)
 [212] LHCb, arXiv:1201.5600 [hep-ex]
 [213] BaBar, arXiv:1202.3650 [hep-ex]
 [215] Belle, Phys. Rev. D84, 071106 (2011)

LHCb ha anche fatto studi di sensitivita' in funzione della massa e della vita media dei neutrini di Majorana (arXiv:1201.5600 [hep-ex])



- Attesi risultati interessanti per i decadimenti LNV del charm
- Limitati statisticamente, LHCb upgrade entrera' nella regione piu' interessante per il ν MSM

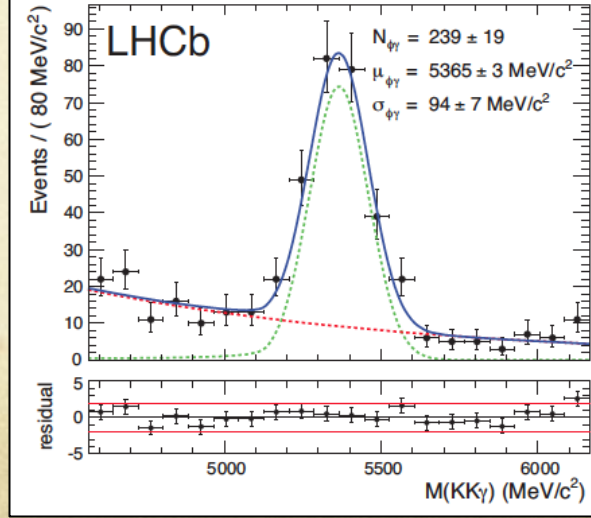
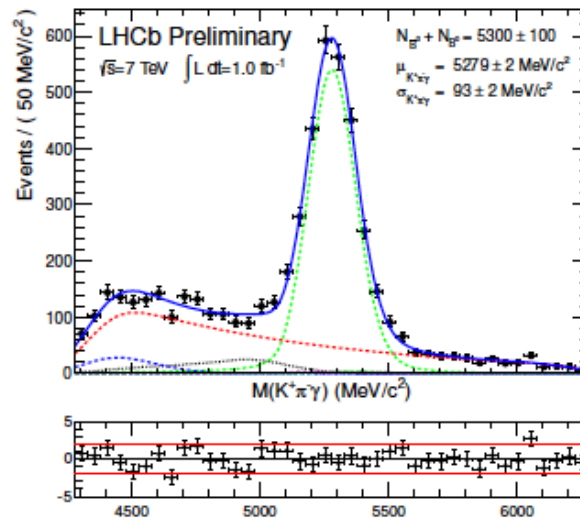
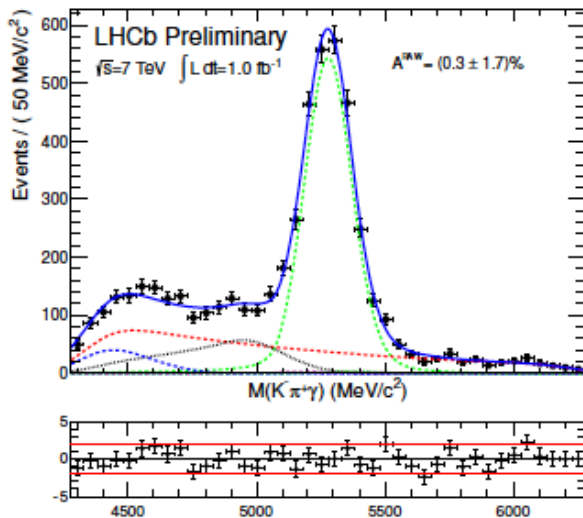
Decadimenti radiativi

23

- La polarizzazione del fotone nelle transizioni $b \rightarrow s \gamma$ e' sensibile a nuova fisica con "right-handed currents"
- Si puo' accedere alla polarizzazione di γ con misure di asimmetria CP
- Grazie al valore di $\Delta \Gamma_s$ non nullo il decadimento $B_s \rightarrow \Phi \gamma$ e' molto promettente
- Misure Propedeutiche: $A_{CP}(B_d \rightarrow K^{*0} \gamma) = 0.008 \pm 0.017 \pm 0.009$ (world's best)

LHCb-CONF-2012-004
LHCb Coll, arxiv:1202.6267

$$\frac{BR(B_d \rightarrow K^{*0} \gamma)}{BR(B_s \rightarrow \phi \gamma)} = 1.12 \pm 0.08^{+0.06+0.09}_{-0.04-0.08}$$



Conclusioni

- I nuovi limiti dei $B_{s,d} \rightarrow \mu \mu$ costringono molti modelli di nuova fisica
- Nuove misure delle asimmetrie nel $B_d \rightarrow K^* \mu \mu$ e la prima misura dello ZCP costringono nuova fisica
- La prima transizione $b \rightarrow d l l$ e' stata osservata da LHCb e misurato il $BR(B^+ \rightarrow \pi^+ \mu \mu)$
- Nuovi limiti nei decadimenti LNV costringono modelli con Neutrini di Majorana \rightarrow LHCb upgrade sara' in grado di "entrare" nella regione interessante del ν MSM
- La Misura dell'asimmetria di CP nel $B_d \rightarrow K^* \gamma$ e del branching ratio di $B_s \rightarrow \Phi \gamma$, preludono a misure di CP in $B_s \rightarrow \Phi \gamma$
- L'alta statistica di mesoni B e D all'upgrade di LHCb, miglioreranno sostanzialmente la nostra conoscenza di decadimenti FCNC e LFV

Backup Slides

Selection

Background:

- Combinatorio:

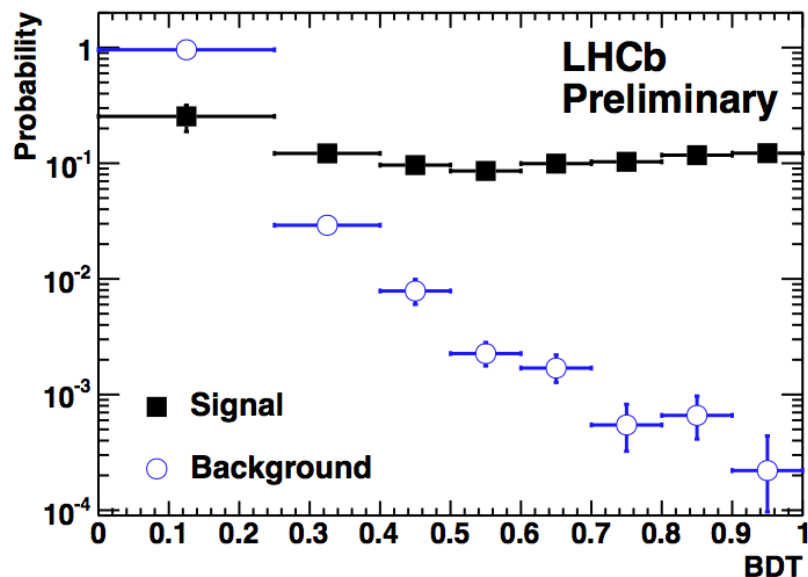
Selezione basata su un BDT con variabili geometriche e cinematiche

- $B \rightarrow hh$ con h misidentificato in μ :

Eccellenti performance di misID

$$\varepsilon_{hh \rightarrow \mu\mu} = (1.52 \pm 0.07_{stat} \pm 0.07_{syst}) \cdot 10^{-5}$$

Training del BDT fatto sul MonteCarlo e calibrato sui dati



Segnale: $B \rightarrow hh$ (trigger unbiased)

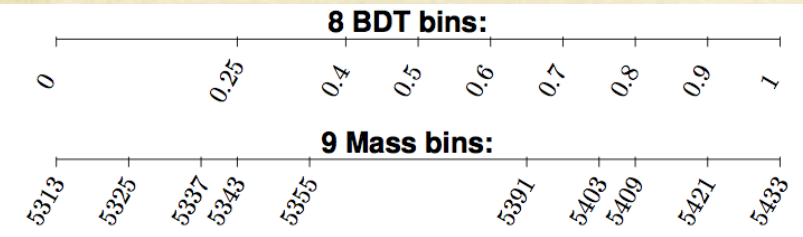
Background: Dimuon sidebands

Altri background irrilevanti:

- $B_s \rightarrow \mu\mu \gamma$, $B^+ \rightarrow \pi\mu\mu$,
 $B_c \rightarrow J\psi\mu\mu$
- $\mu\mu$ da scattering elastico
rimosso da $(Pt(B) > 500 \text{ MeV})$

Strategia LHCb

La strategia dell'analisi consiste nell'usare il metodo CLs in diversi bin di BDT e Massa



Binning ottimizzato in MC!

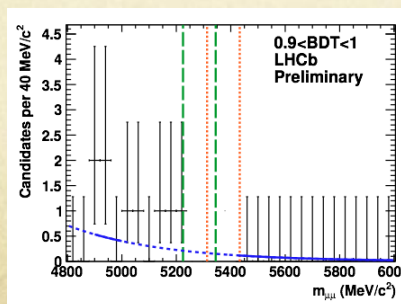
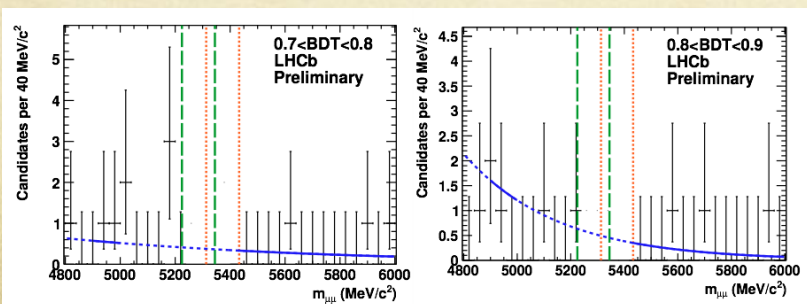
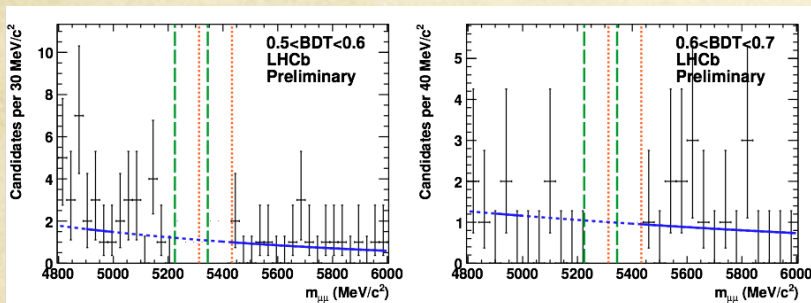
Fit della Massa Invariante:

- Segnale:
 - Crystall Ball shape
 - Risoluzione estratta interpolando le risonanze J/ψ , $\psi(2S)$, $Y(1S,2S,3S)$

$$\sigma(B_s) = (24.8 \pm 0.3_{stat} \pm 0.7_{syst}) MeV$$

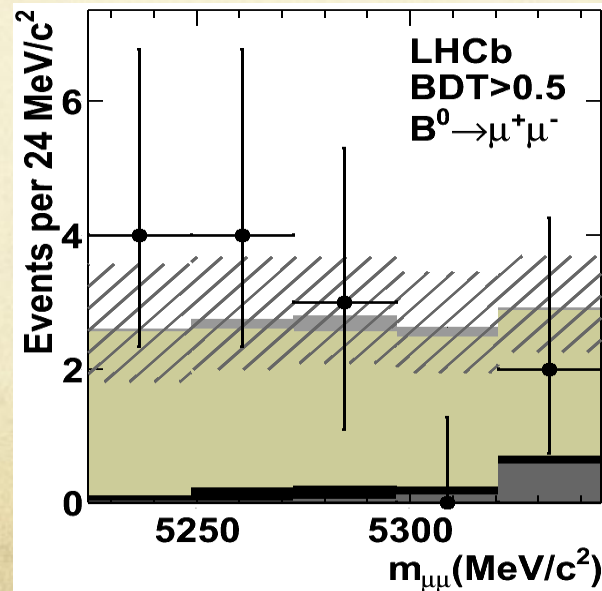
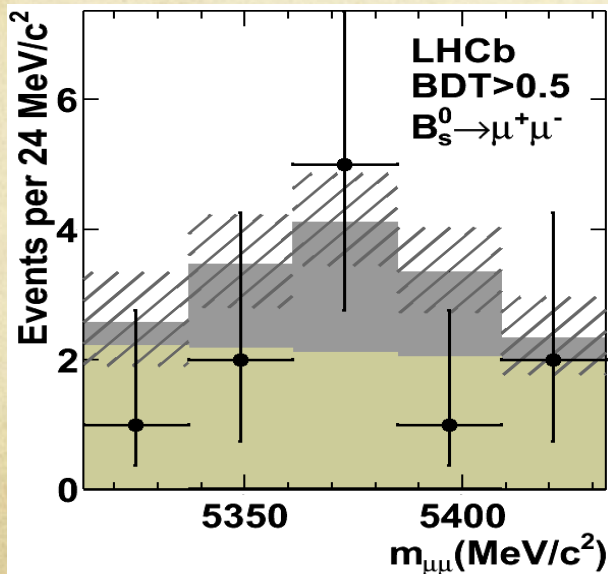
$$\sigma(B_d) = (24.3 \pm 0.3_{stat} \pm 0.6_{syst}) MeV$$

- Background:
 - Esponenziale in diversi bin in BDT



Strategia

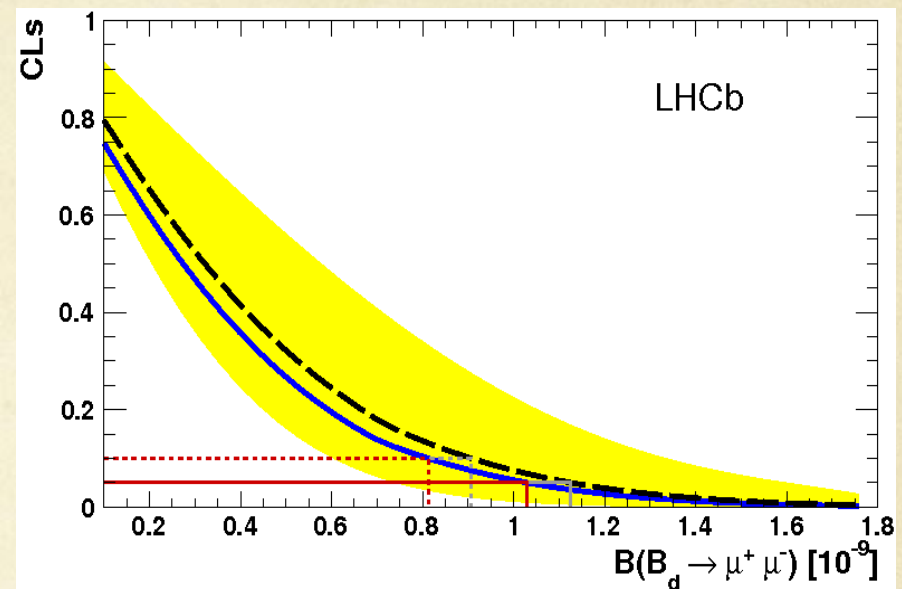
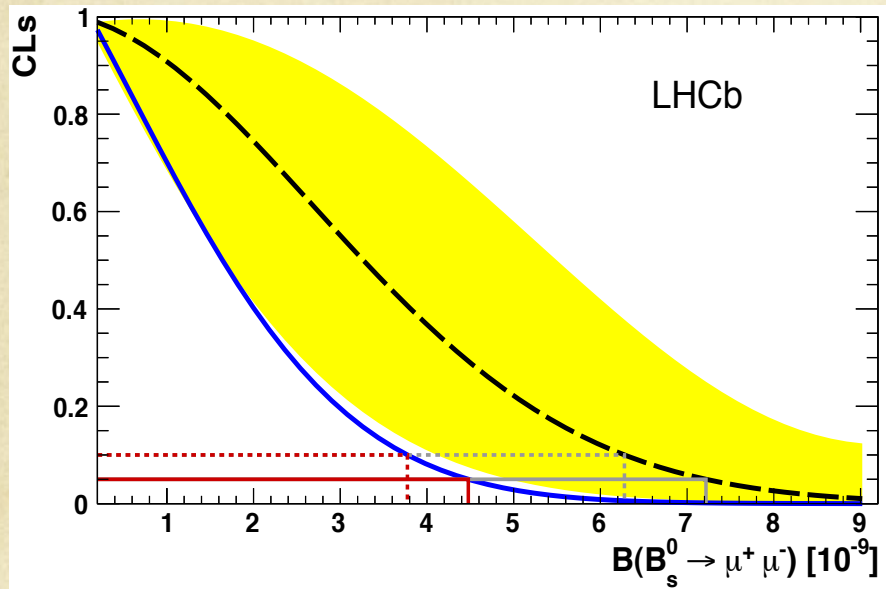
Mode	BDT bin	0.0 – 0.25	0.25 – 0.4	0.4 – 0.5	0.5 – 0.6	0.6 – 0.7	0.7 – 0.8	0.8 – 0.9	0.9 – 1.0
$B_s^0 \rightarrow \mu^+ \mu^-$	Exp. comb. bkg	1889^{+38}_{-39}	57^{+11}_{-11}	$15.3^{+3.8}_{-3.8}$	$4.3^{+1.0}_{-1.0}$	$3.30^{+0.92}_{-0.85}$	$1.06^{+0.51}_{-0.46}$	$1.27^{+0.53}_{-0.52}$	$0.44^{+0.41}_{-0.24}$
	Exp. peak. bkg	$0.124^{+0.066}_{-0.049}$	$0.063^{+0.024}_{-0.018}$	$0.049^{+0.016}_{-0.012}$	$0.045^{+0.016}_{-0.012}$	$0.050^{+0.018}_{-0.013}$	$0.047^{+0.017}_{-0.013}$	$0.049^{+0.017}_{-0.013}$	$0.047^{+0.018}_{-0.014}$
	Exp. signal	$2.55^{+0.70}_{-0.74}$	$1.22^{+0.20}_{-0.19}$	$0.97^{+0.14}_{-0.13}$	$0.861^{+0.102}_{-0.088}$	$1.00^{+0.12}_{-0.10}$	$1.034^{+0.109}_{-0.095}$	$1.18^{+0.13}_{-0.11}$	$1.23^{+0.21}_{-0.21}$
	Observed	1818	39	12	6	1	2	1	1
$B^0 \rightarrow \mu^+ \mu^-$	Exp. comb. bkg	2003^{+42}_{-43}	61^{+12}_{-11}	$16.6^{+4.3}_{-4.1}$	$4.7^{+1.3}_{-1.2}$	$3.52^{+1.13}_{-0.97}$	$1.11^{+0.71}_{-0.50}$	$1.62^{+0.76}_{-0.59}$	$0.54^{+0.53}_{-0.29}$
	Exp. peak. bkg	$0.71^{+0.36}_{-0.26}$	$0.355^{+0.146}_{-0.088}$	$0.279^{+0.110}_{-0.068}$	$0.249^{+0.099}_{-0.055}$	$0.280^{+0.109}_{-0.062}$	$0.264^{+0.103}_{-0.057}$	$0.275^{+0.108}_{-0.060}$	$0.267^{+0.106}_{-0.069}$
	Exp. cross-feed	$0.40^{+0.11}_{-0.12}$	$0.193^{+0.033}_{-0.030}$	$0.153^{+0.023}_{-0.021}$	$0.136^{+0.017}_{-0.015}$	$0.158^{+0.019}_{-0.017}$	$0.164^{+0.019}_{-0.017}$	$0.187^{+0.022}_{-0.020}$	$0.194^{+0.036}_{-0.033}$
	Exp. signal	$0.300^{+0.086}_{-0.090}$	$0.145^{+0.027}_{-0.024}$	$0.115^{+0.020}_{-0.017}$	$0.102^{+0.014}_{-0.013}$	$0.119^{+0.017}_{-0.015}$	$0.123^{+0.016}_{-0.015}$	$0.140^{+0.019}_{-0.017}$	$0.145^{+0.030}_{-0.026}$
	Observed	1904	50	20	5	2	1	4	1



Strategia

$BR(B_s \rightarrow \mu\mu) < 4.5 \cdot 10^{-9}$ at 95% CL

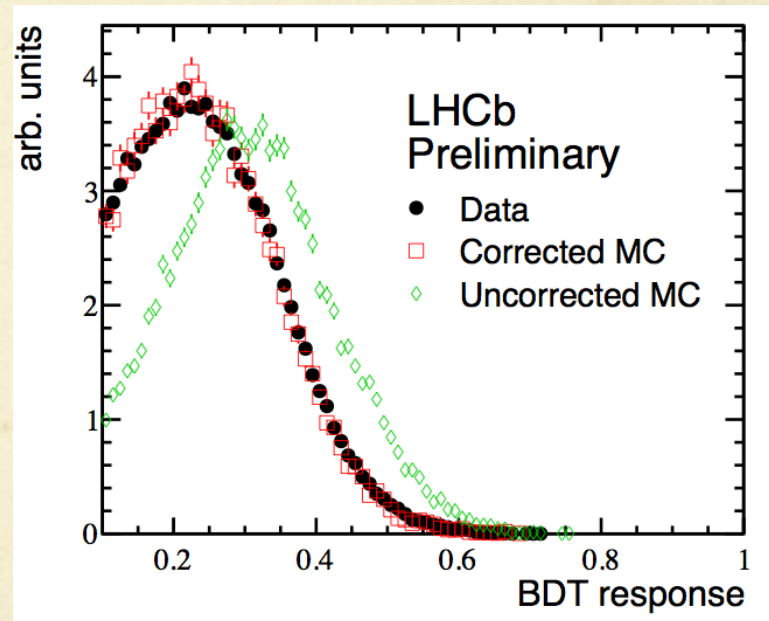
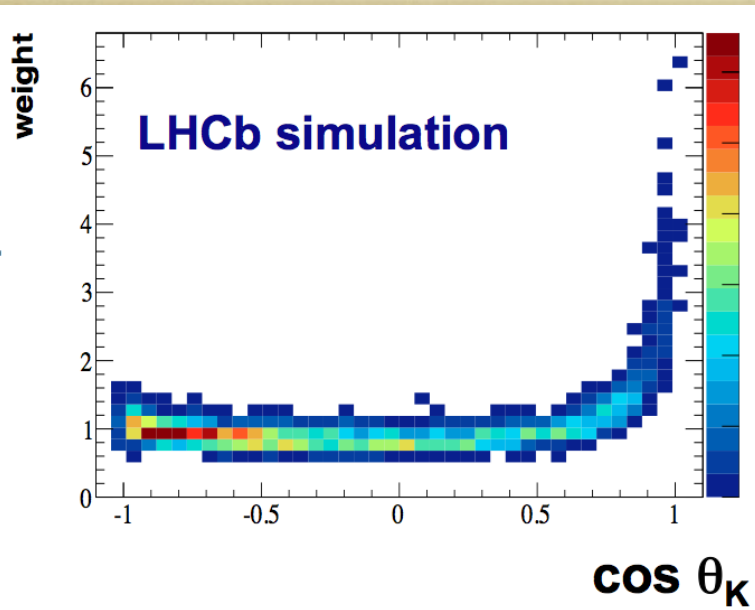
$BR(B_s \rightarrow \mu\mu) < 10.3 \cdot 10^{-10}$ at 95% CL



Mode	Limit	at 90% CL	at 95% CL
$B_s^0 \rightarrow \mu^+ \mu^-$	Exp. bkg+SM	6.3×10^{-9}	7.2×10^{-9}
	Exp. bkg	2.8×10^{-9}	3.4×10^{-9}
	Observed	3.8×10^{-9}	4.5×10^{-9}
$B^0 \rightarrow \mu^+ \mu^-$	Exp. bkg	0.91×10^{-9}	1.13×10^{-9}
	Observed	0.81×10^{-9}	1.03×10^{-9}

$B_d \rightarrow K^* \mu \mu : \text{LHCb}$

- Selection made using a BDT
- 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



We are confident that we understand data, concerning angular efficiency.

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

