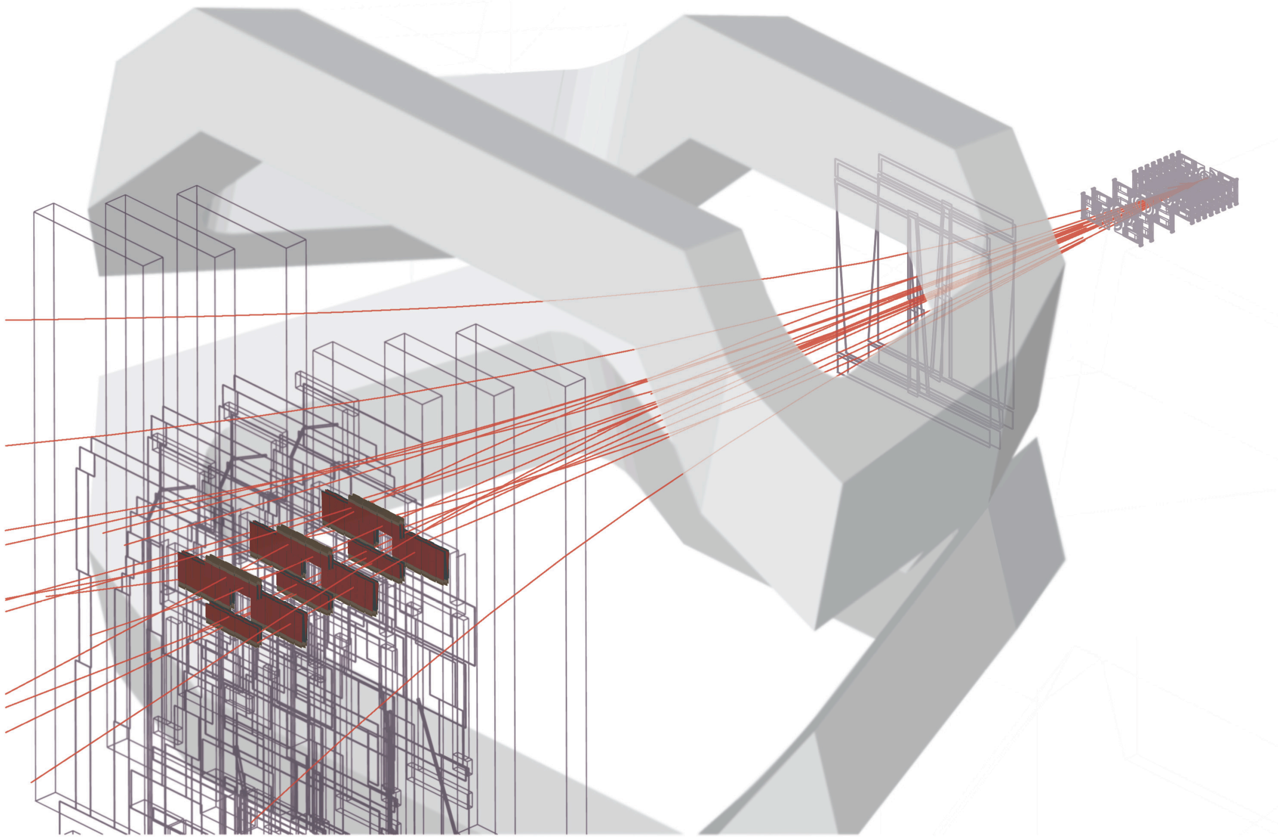
Recent LHCb Results

Presentation on behalf of LHCb Collaboration

at CERN Workshop on

Implications of LHC results for TeV-scale physics



- This talk presents several new LHCb results from the summer conferences that are particularly new and relevant to NP searches:
  - ϕ_s : the B_s mixing phase in both $B_s \rightarrow J/\psi\Phi$ and $B_s \rightarrow J/\psi f_0$
  - Limits on the rare decay $B_s \rightarrow \mu^+\mu^-$
  - Forward backward asymmetry in $B \rightarrow K^*\mu^+\mu^-$
- In 2010+2011 we have recorded approximately 700 pb^{-1} and are heading for 1 fb^{-1}. These results are based upon first ~ 340 pb^{-1}
- See parallel talks by
  - Conor Fitzpatrick : CP Violation at LHCb
  - Diego Martinez Santos : Rare Decays at LHCb

	AC	RVV2	AKM	δLL	FBMSSM	LHT	RS
$D^0 - \bar{D}^0$	★★★	★	★	★	★	★★★	?
ε_K	★	★★★	★★★	★	★	★★	★★★
$S_{\psi\phi}$	★★★	★★★	★★★	★	★	★★★	★★★
$S_{\phi K_S}$	★★★	★★	★	★★★	★★★	★	?
$A_{\rm CP}(B \to X_s\gamma)$	★	★	★	★★★	★★★	★	?
$A_{7,8}(B \to K^*\mu^+\mu^-)$	★	★	★	★★★	★★★	★★	?
$A_9(B \to K^*\mu^+\mu^-)$	★	★	★	★	★	★	?
$B \to K^{(*)}\nu\bar{\nu}$	★	★	★	★	★	★	★
$B_s \to \mu^+\mu^-$	★★★	★★★	★★★	★★★	★★★	★	★
$K^+ \to \pi^+\nu\bar{\nu}$	★	★	★	★	★	★★★	★★★
$K_L \to \pi^0\nu\bar{\nu}$	★	★	★	★	★	★★★	★★★
$\mu \to e\gamma$	★★★	★★★	★★★	★★★	★★★	★★★	★★★
d_n	★★★	★★★	★★★	★★	★★★	★	★★★
d_e	★★★	★★★	★★	★	★★★	★	★★★
$(g-2)_\mu$	★★★	★★★	★★	★★★	★★★	★	★★

Table 2: "DNA" of flavour physics effects [55] for the most interesting observables in a selection of SUSY and non-SUSY models. ★★★ signals large effects, ★★ visible but small effects and ★ implies that the given model does not predict sizable effects in that observable.

Buras, arXiv:0910.1032v1

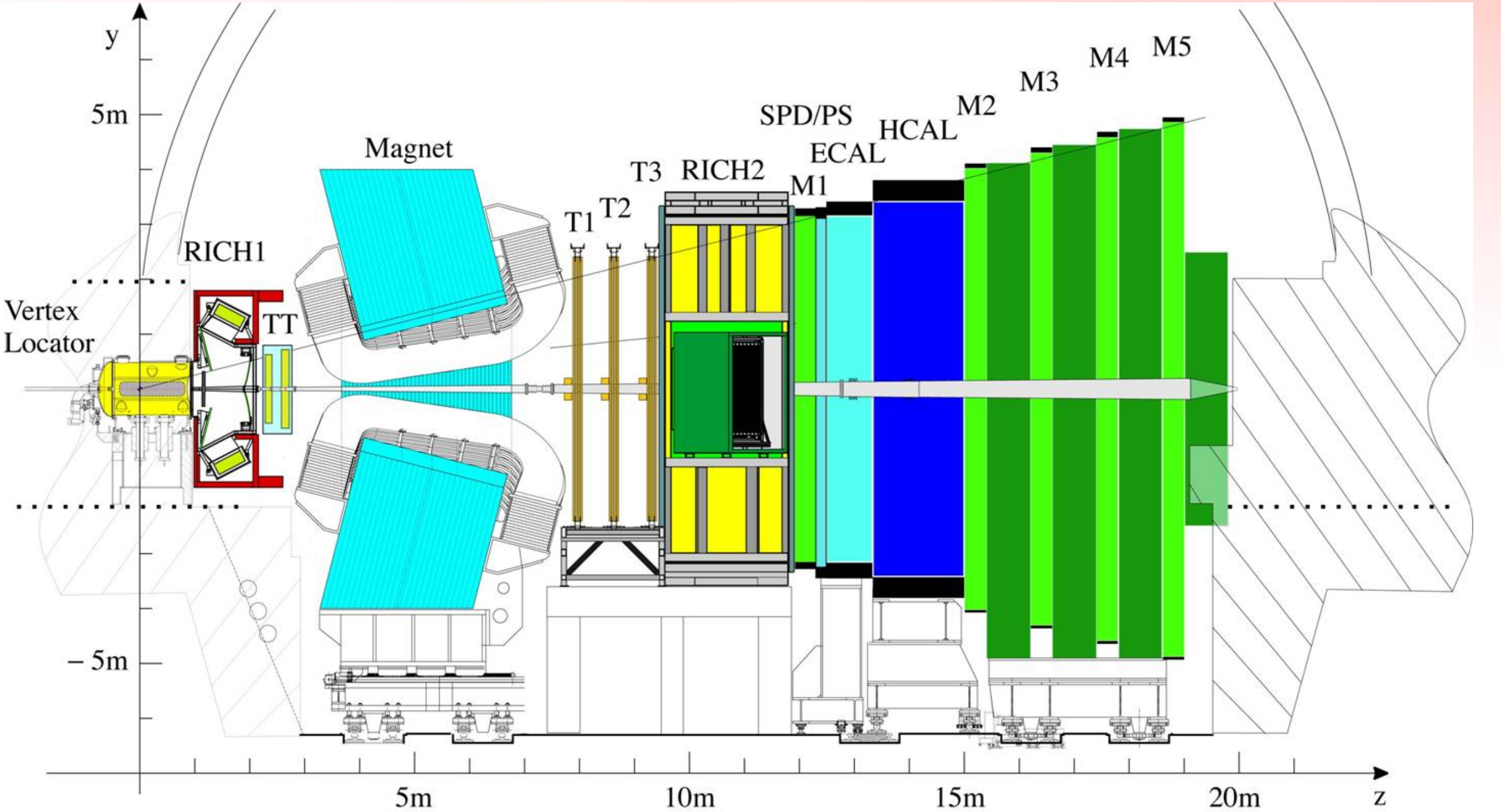
LHCb

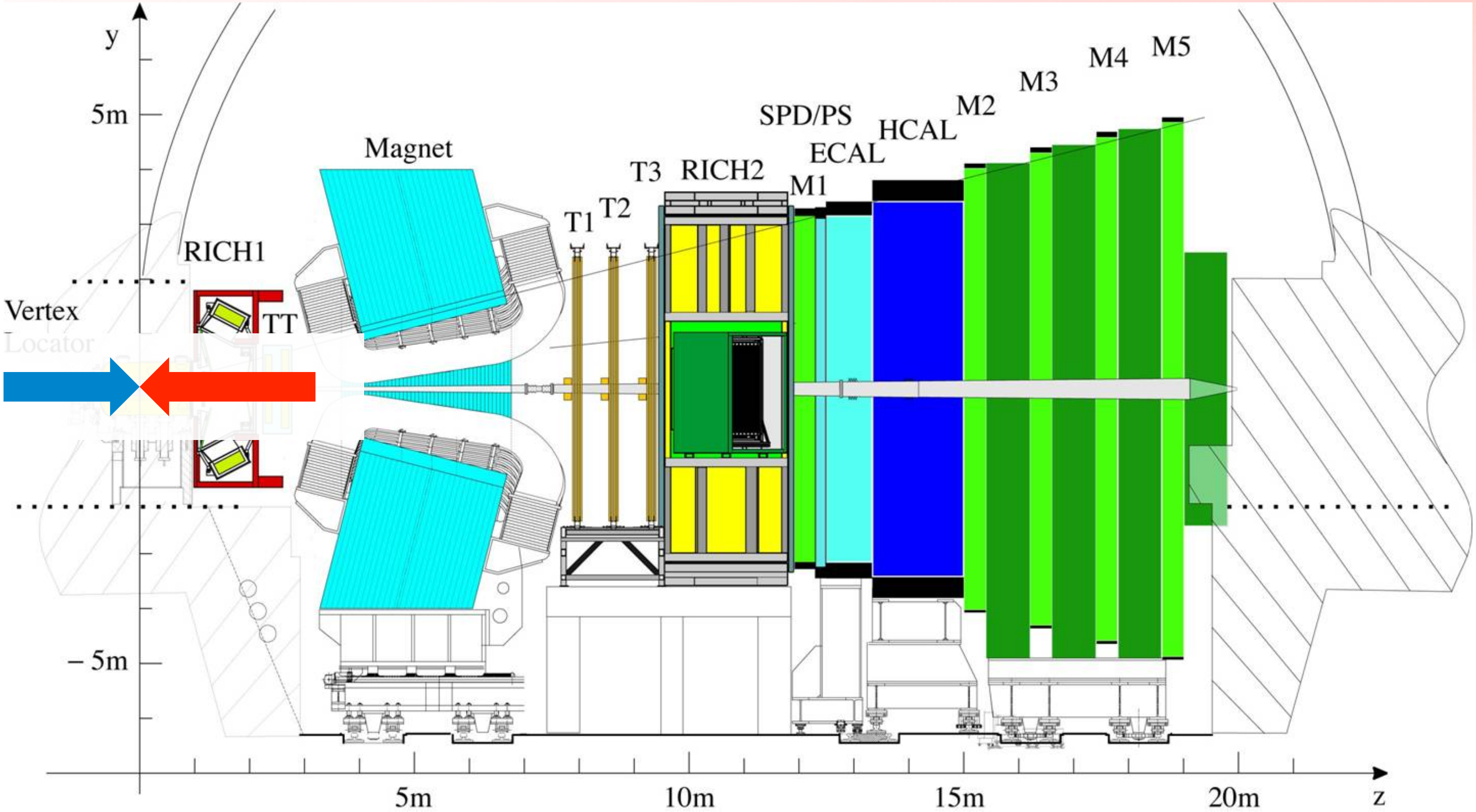
	AC	RVV2	AKM	δLL	FBMSSM	LHT	RS
$D^0 - \bar{D}^0$	★★★	★	★	★	★	★★★	?
ε_K	★	★★★	★★★	★	★	★★	★★★
$S_{\psi\phi}$	★★★	★★★	★★★	★	★	★★★	★★★
$S_{\phi K_S}$	★★★	★★	★	★★★	★★★	★	?
$A_{CP}(B \to X_s\gamma)$	★	★	★	★★★	★★★	★	?
$A_{7,8}(B \to K^*\mu^+\mu^-)$	★	★	★	★★★	★★★	★★	?
$A_9(B \to K^*\mu^+\mu^-)$	★	★	★	★	★	★	?
$B \to K^{(*)}\nu\bar{\nu}$	★	★	★	★	★	★	★
$B_s \to \mu^+\mu^-$	★★★	★★★	★★★	★★★	★★★	★	★
$K^+ \to \pi^+\nu\bar{\nu}$	★	★	★	★	★	★★★	★★★
$K_L \to \pi^0\nu\bar{\nu}$	★	★	★	★	★	★★★	★★★
$\mu \to e\gamma$	★★★	★★★	★★★	★★★	★★★	★★★	★★★
d_n	★★★	★★★	★★★	★★	★★★	★	★★★
d_e	★★★	★★★	★★	★	★★★	★	★★★
$(g-2)_\mu$	★★★	★★★	★★	★★★	★★★	★	★★

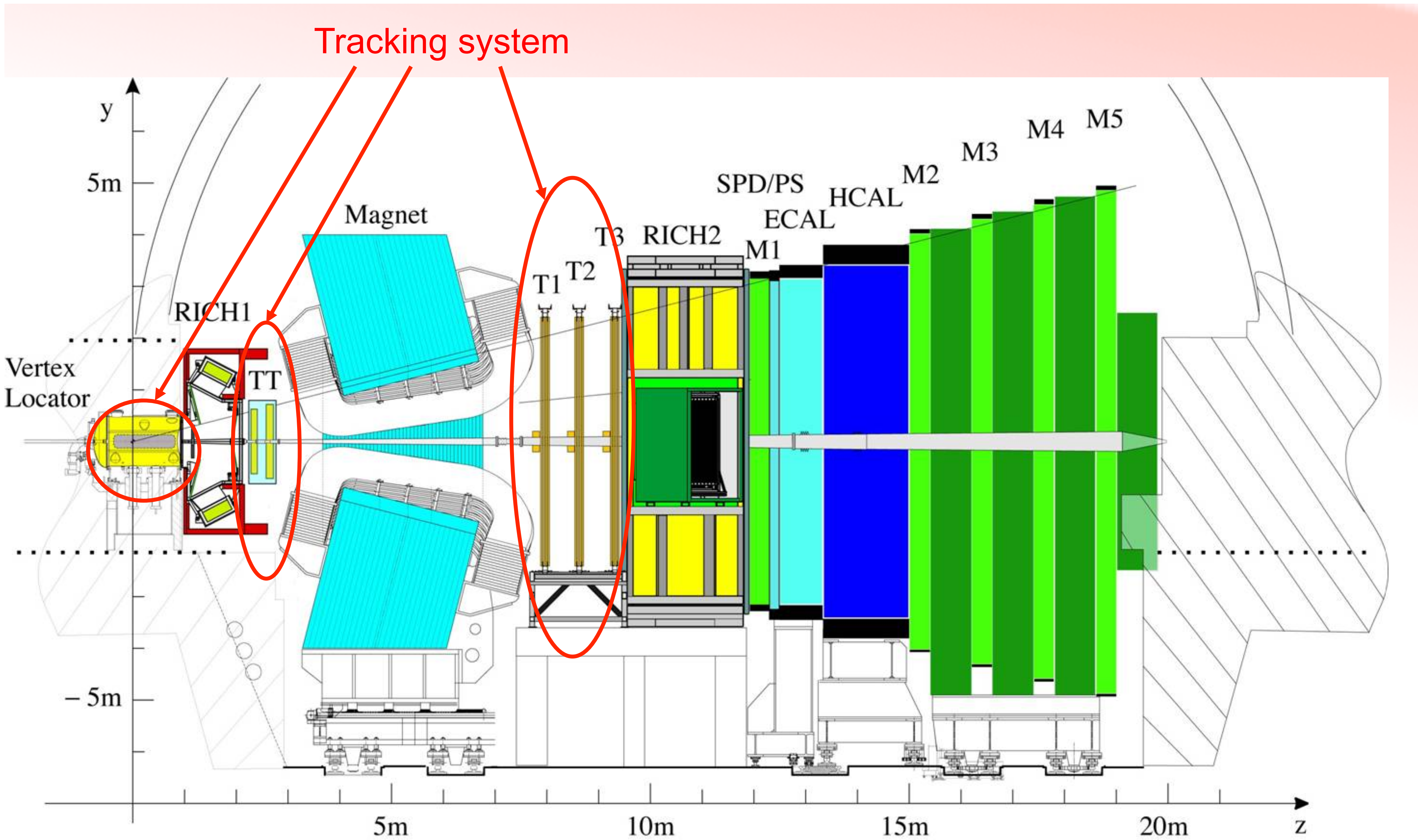
Table 2: "DNA" of flavour physics effects [55] for the most interesting observables in a selection of SUSY and non-SUSY models. ★★★ signals large effects, ★★ visible but small effects and ★ implies that the given model does not predict sizable effects in that observable.

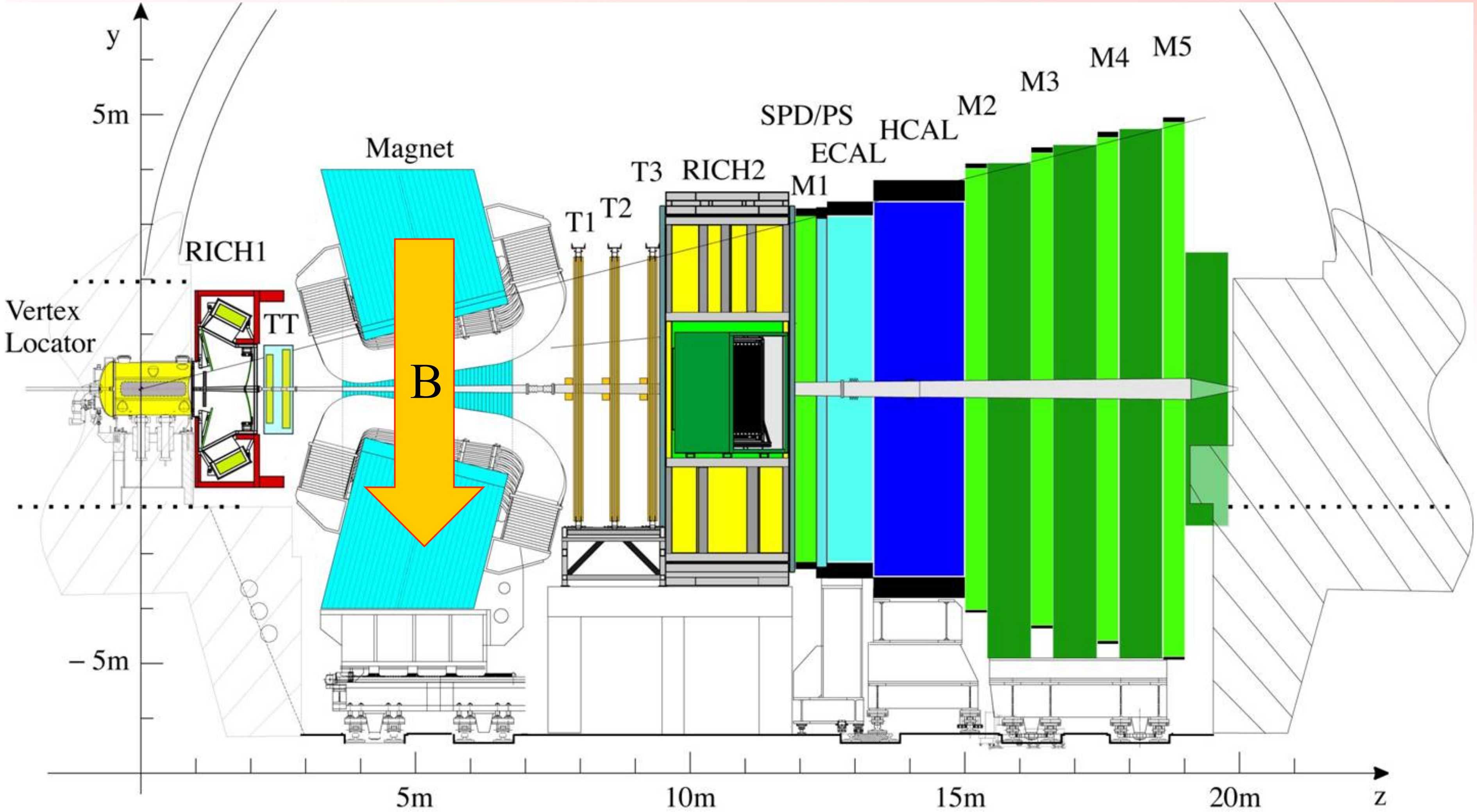
Buras, arXiv:0910.1032v1

LHCb Essentials

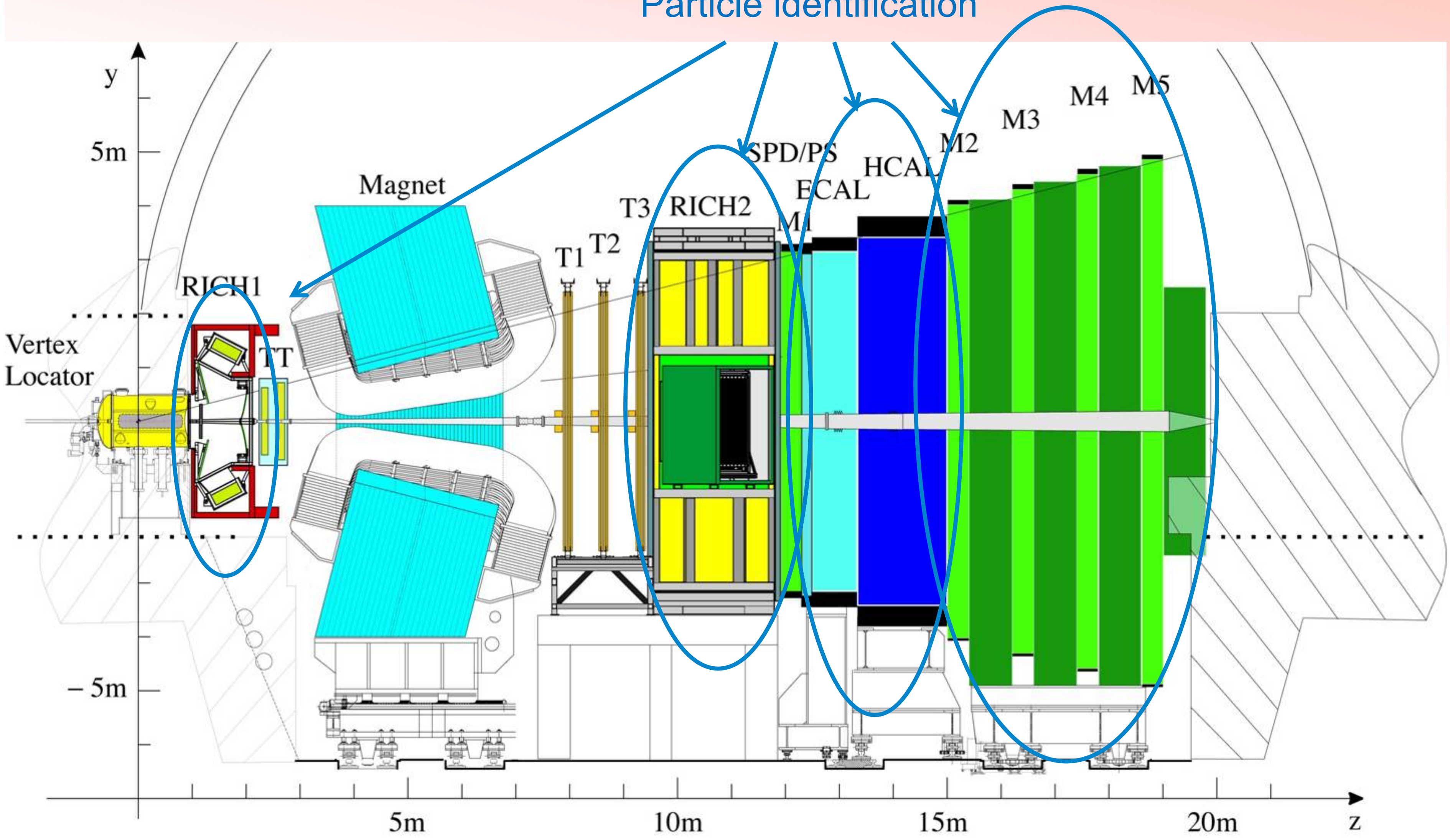

y
5m
− 5m
Vertex
Locator
RICH1
TT
Magnet
T1
T2
T3
RICH2
M1
SPD/PS
ECAL
HCAL
M2
M3
M4
M5
5m
10m
15m
20m
z

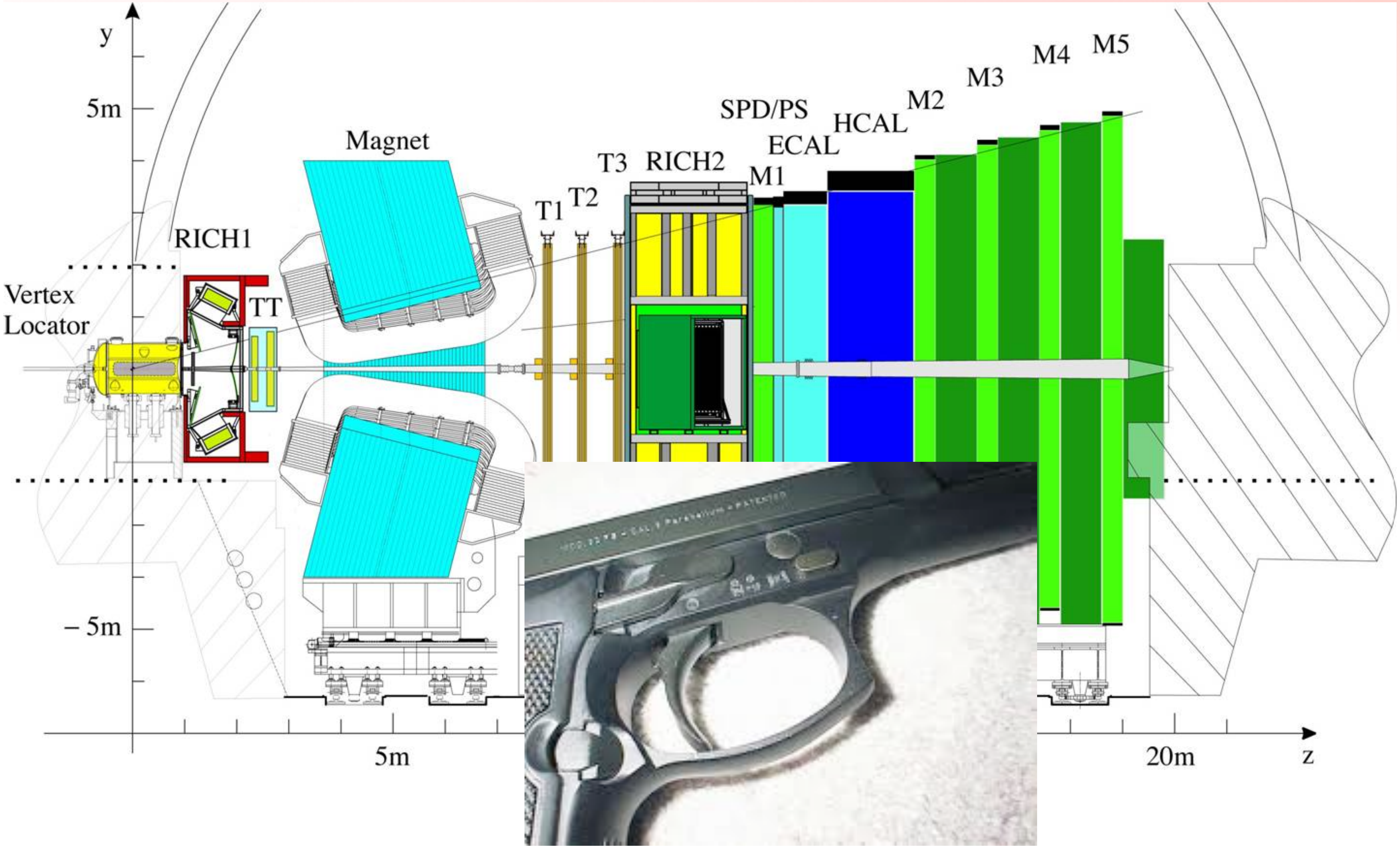

y
5m
− 5m
Magnet
RICH1
Vertex
Locator
TT
T1
T2
T3
RICH2
M1
SPD/PS
ECAL
HCAL
M2
M3
M4
M5
5m
10m
15m
20m
z


Tracking system
y
5m
– 5m
Vertex
Locator
RICH1
TT
Magnet
T1
T2
T3
RICH2
M1
SPD/PS
ECAL
HCAL
M2
M3
M4
M5
5m
10m
15m
20m
z

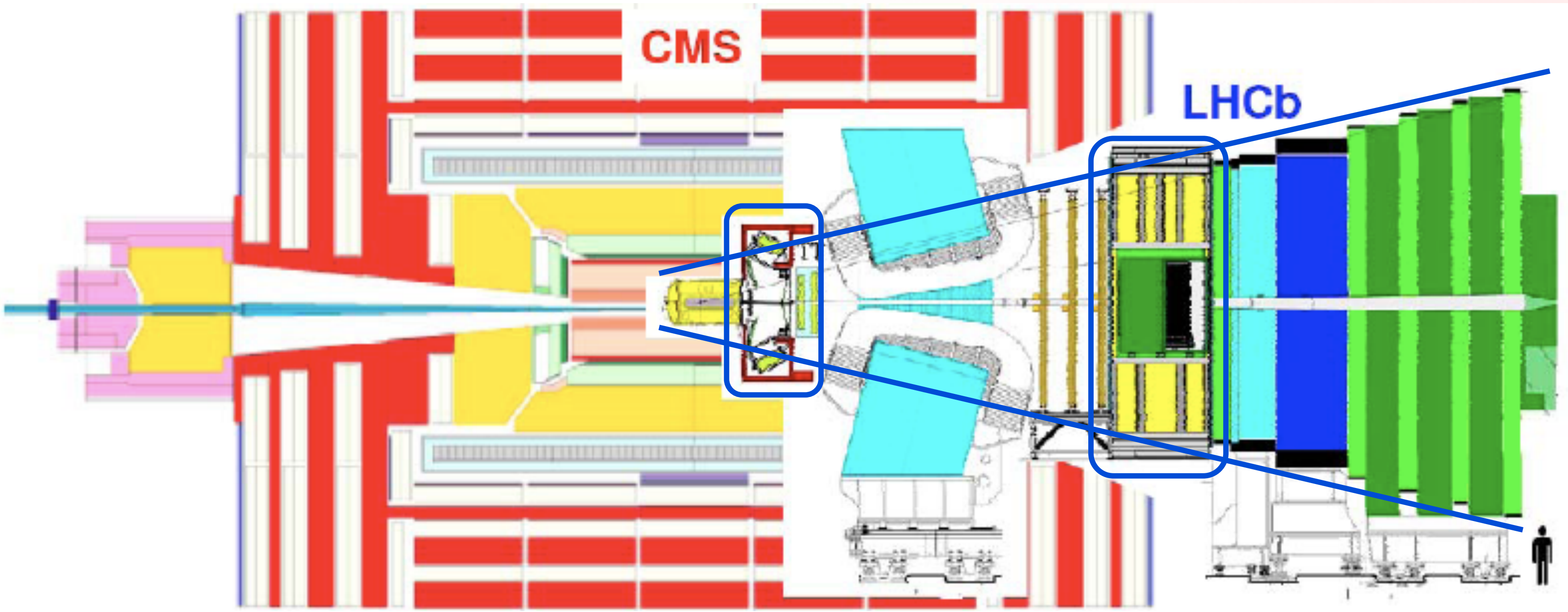

y
5m
– 5m
Magnet
B
RICH1
Vertex
Locator
TT
T1
T2
T3
RICH2
M1
SPD/PS
ECAL
HCAL
M2
M3
M4
M5
5m
10m
15m
20m
z

Particle identification

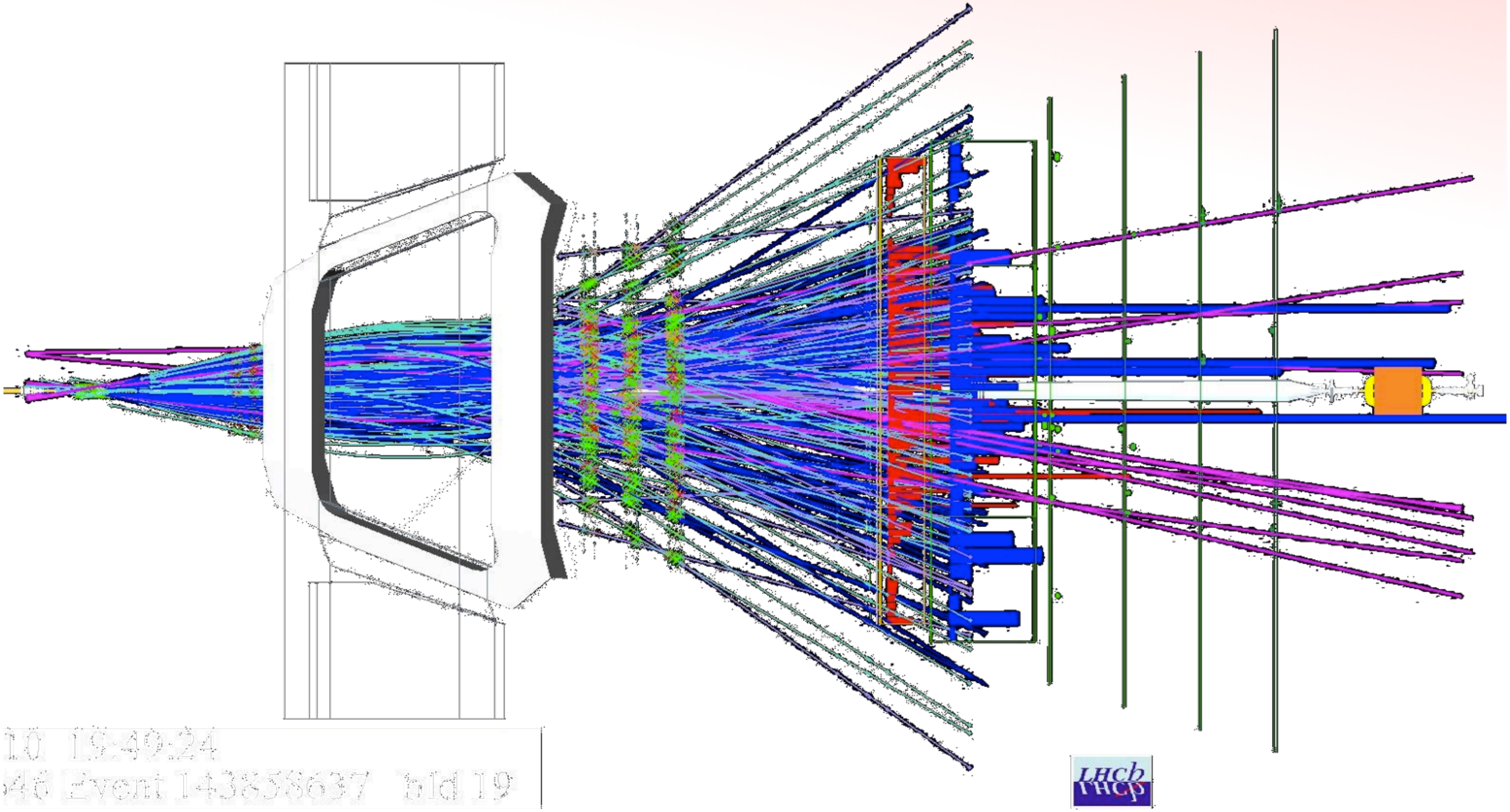



y
5m
− 5m
5m
20m
z
Vertex
Locator
RICH1
TT
Magnet
T1
T2
T3
RICH2
M1
SPD/PS
ECAL
HCAL
M2
M3
M4
M5

LHCb Essentials



A typical event...



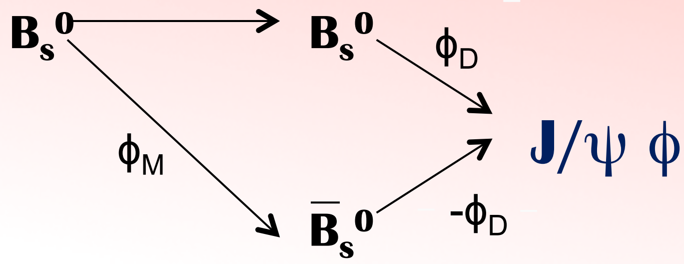
Measurements of ϕ_s (= $-2\beta_s$) using $B_s \rightarrow J/\psi\Phi$ and $B_s \rightarrow J/\psi f_0$

~ 337 pb^{-1}

All described in
LHCb-CONF-2011-049, LHCb-CONF-2011-051, LHCb-CONF-2011-0xx
(public conference notes)

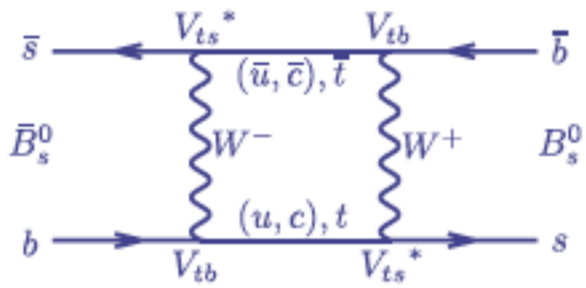
Reminder of $B_s \rightarrow J/\psi\Phi$ phenomenology

- Measure relative phase difference $\phi_s = \phi_M - 2\phi_D$ between two "legs"



- In SM $\phi_s = \phi_M = -2\beta_s$ is determined by V_{ts} in the mixing terms

- It is predicted to be small in SM ~ -0.04



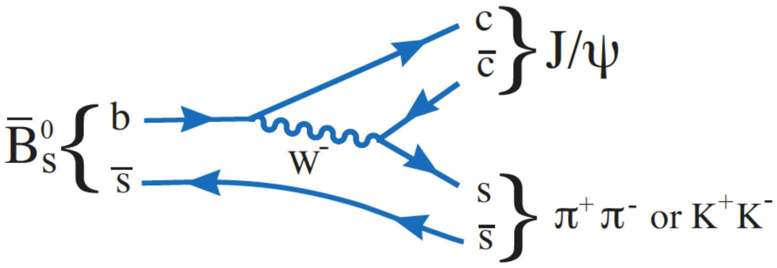
- New Physics (NP) can add large phases

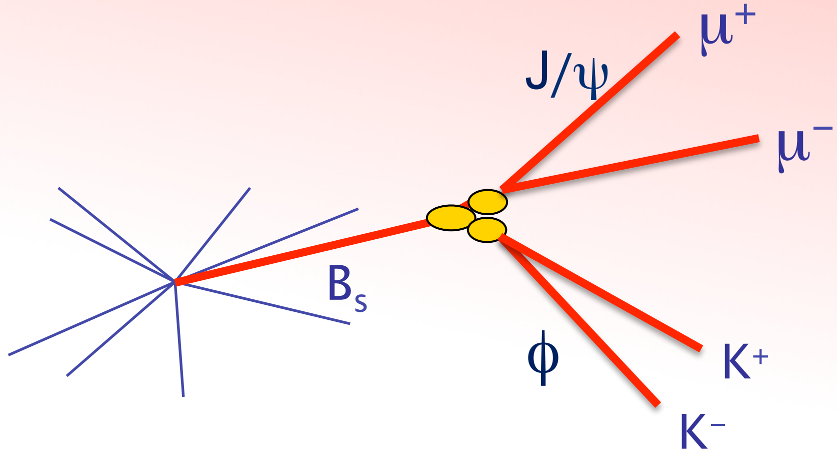
$$\phi_s = \phi_s^{SM} + \phi_s^{NP}$$

Health warning : The term ϕ_s is overloaded. It is also used for Arg-(M_{12}/Γ_{12})

The signals

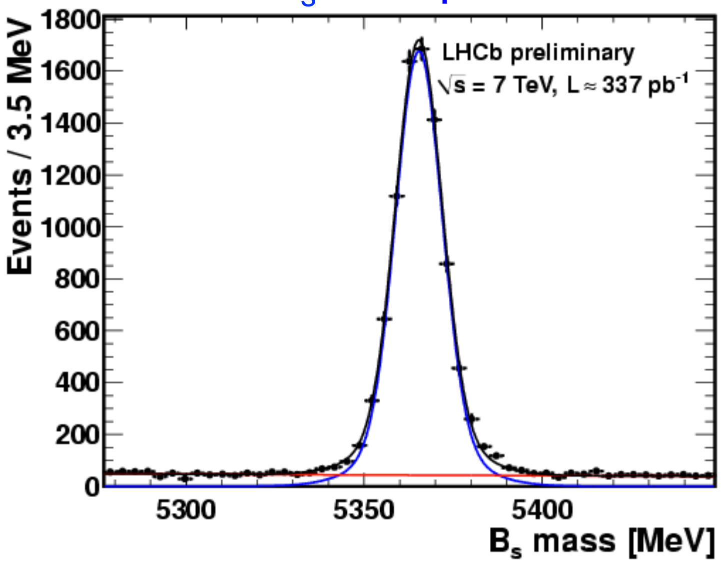
- $B_s \rightarrow J/\psi\Phi$ and $B_s \rightarrow J/\psi f_0$ are very clean decays



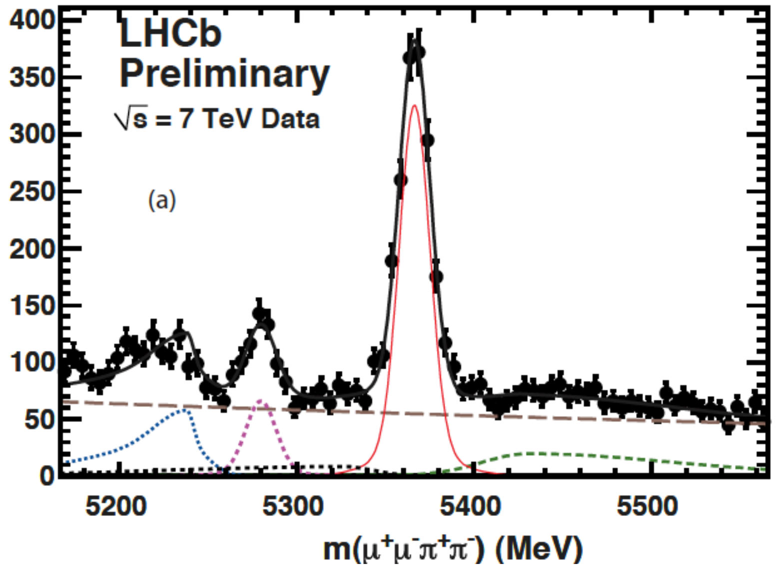


- Invariant mass distributions for selected signal samples
  - Approx 8276 $B_s \rightarrow J/\psi\Phi$ signal events
  - Approx 1428 $B_s \rightarrow J/\psi f_0$ signal events

$B_s \rightarrow J/\psi\Phi$



$B_s \rightarrow J/\psi f_0$



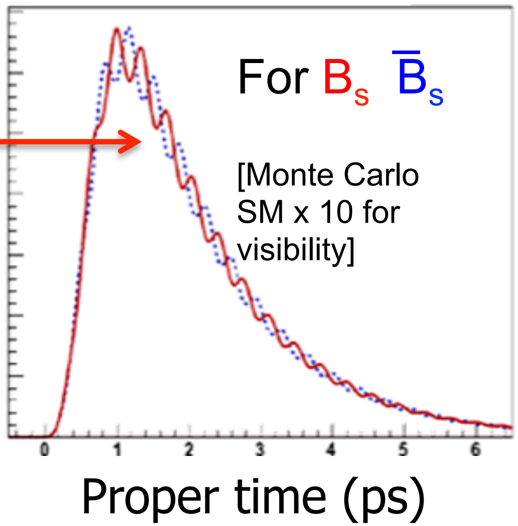
$B_s \rightarrow J/\psi f_0$ time dependence

- Straightforward differential cross section:

$$\Gamma\left(B_s^0 \to J/\psi f_0\right) = \mathcal{N}_f e^{-\Gamma_s t}\left\{e^{\Delta\Gamma_s t/2}(1+\cos\phi_s) + e^{-\Delta\Gamma_s t/2}(1-\cos\phi_s) - \sin(\phi_s)\sin\left(\Delta m_s t\right)\right\},$$

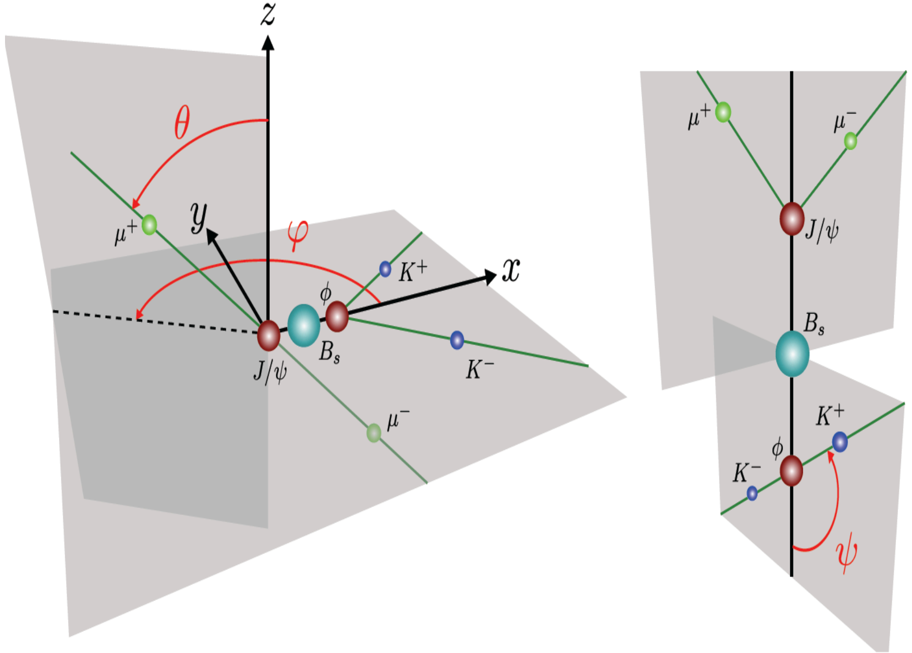
$$\Gamma\left(\overline{B}_s^0 \to J/\psi f_0\right) = \mathcal{N}_f e^{-\Gamma_s t}\left\{e^{\Delta\Gamma_s t/2}(1+\cos\phi_s) + e^{-\Delta\Gamma_s t/2}(1-\cos\phi_s) + \sin(\phi_s)\sin\left(\Delta m_s t\right)\right\}.$$

- We look for sinusoid is time distribution
  - Amplitude proportional to ϕ_s
  - Opposite sign for B/Bbar



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

- Decay to CP odd and CP even final states, so need complex analysis of decay angle distribution



- Differential cross section is "very rich"

(you are not intended to read these equations)

$$A_1 = |A_0|^2 e^{-\Gamma_s t}[\cosh\left(\frac{\Delta\Gamma}{2}t\right) - \cos\phi_s \sinh\left(\frac{\Delta\Gamma}{2}t\right) + \sin\phi_s \sin(\Delta m t)]$$

$$A_2 = |A_\parallel|^2 e^{-\Gamma_s t}[\cosh\left(\frac{\Delta\Gamma}{2}t\right) - \cos\phi_s \sinh\left(\frac{\Delta\Gamma}{2}t\right) + \sin\phi_s \sin(\Delta m t)]$$

$$A_3 = |A_\perp|^2 e^{-\Gamma_s t}[\cosh\left(\frac{\Delta\Gamma}{2}t\right) + \cos\phi_s \sinh\left(\frac{\Delta\Gamma}{2}t\right) - \sin\phi_s \sin(\Delta m t)]$$

$$A_4 = |A_\parallel||A_\perp|e^{-\Gamma_s t}[-\cos(\delta_\perp - \delta_\parallel)\sin\phi_s \sinh\left(\frac{\Delta\Gamma}{2}t\right) - \cos(\delta_\perp - \delta_\parallel)\cos\phi_s \sin(\Delta m t) + \sin(\delta_\perp - \delta_\parallel)\cos(\Delta m t)]$$

$$A_5 = |A_0||A_\parallel|e^{-\Gamma_s t}\cos(\delta_\parallel - \delta_0)[\cosh\left(\frac{\Delta\Gamma}{2}t\right) - \cos\phi_s \sinh\left(\frac{\Delta\Gamma}{2}t\right) + \sin\phi_s \sin(\Delta m t)]$$

$$A_6 = |A_0||A_\perp|e^{-\Gamma_s t}[-\cos(\delta_\perp - \delta_0)\sin\phi_s \sinh\left(\frac{\Delta\Gamma}{2}t\right) - \cos(\delta_\perp - \delta_0)\cos\phi_s \sin(\Delta m t) + \sin(\delta_\perp - \delta_0)\cos(\Delta m t)]$$

$$A_7 = |A_s|^2 e^{-\Gamma_s t}[\cosh\left(\frac{\Delta\Gamma}{2}t\right) + \cos\phi_s \sinh\left(\frac{\Delta\Gamma}{2}t\right) - \sin\phi_s \sin(\Delta m t]$$

$$A_8 = |A_s||A_\parallel|e^{-\Gamma_s t}[-\sin(\delta_\parallel - \delta_S)\sin\phi_s \sinh\left(\frac{\Delta\Gamma}{2}t\right) - \sin(\delta_\parallel - \delta_S)\cos\phi_s \sin(\Delta m t) + \cos(\delta_\parallel - \delta_S)\cos(\Delta m t)]$$

$$A_9 = |A_s||A_\perp|e^{-\Gamma_s t}\sin(\delta_\perp - \delta_S)[\cosh\left(\frac{\Delta\Gamma}{2}t\right) + \cos\phi_s \sinh\left(\frac{\Delta\Gamma}{2}t\right) - \sin\phi_s \sin(\Delta m t)]$$

$$A_{10} = |A_s||A_0|e^{-\Gamma_s t}[-\sin(\delta_0 - \delta_S)\sin\phi_s \sinh\left(\frac{\Delta\Gamma}{2}t\right) - \sin(\delta_0 - \delta_S)\cos\phi_s \sin(\Delta m t) + \cos(\delta_0 - \delta_S)\cos(\Delta m t)]$$

- At the heart of it what we actually measure is:

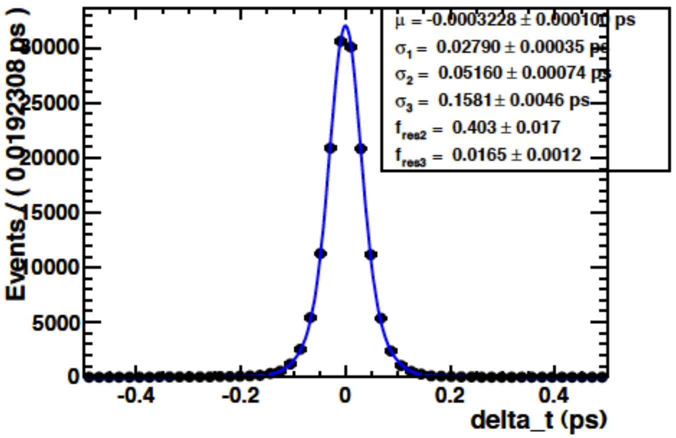
$$\sin(\phi_s) \times (1 - 2\omega_{tag}) \times \sin(\Delta m_s t)$$

Propertime resolution

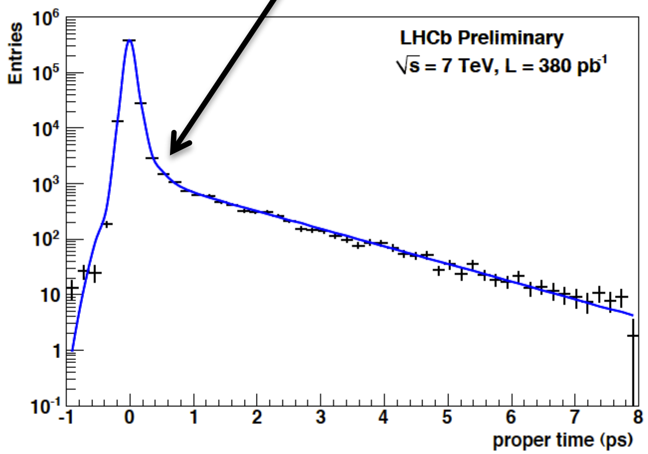
$\sin(\phi_s) \times (1 - 2\omega_{tag}) \times \sin(\Delta m_s t)$

Need good proper time resolution w.r.t. sinusoid period ~ 300fs

MC propertime resolution



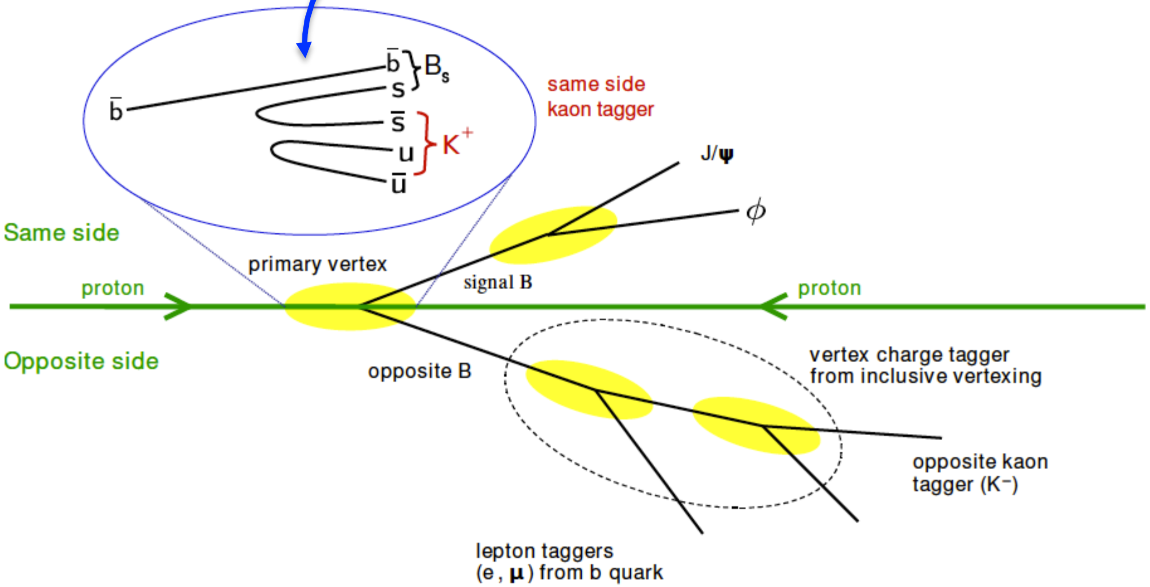
We measure from data using prompt background ~ 50fs

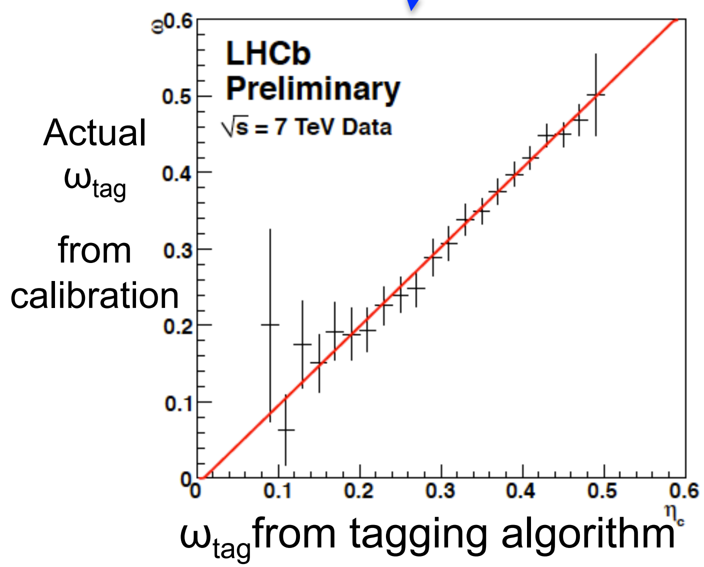


Tagging

$\sin(\phi_s) \times (1 - 2\omega_{tag}) \times \sin(\Delta m_s t)$

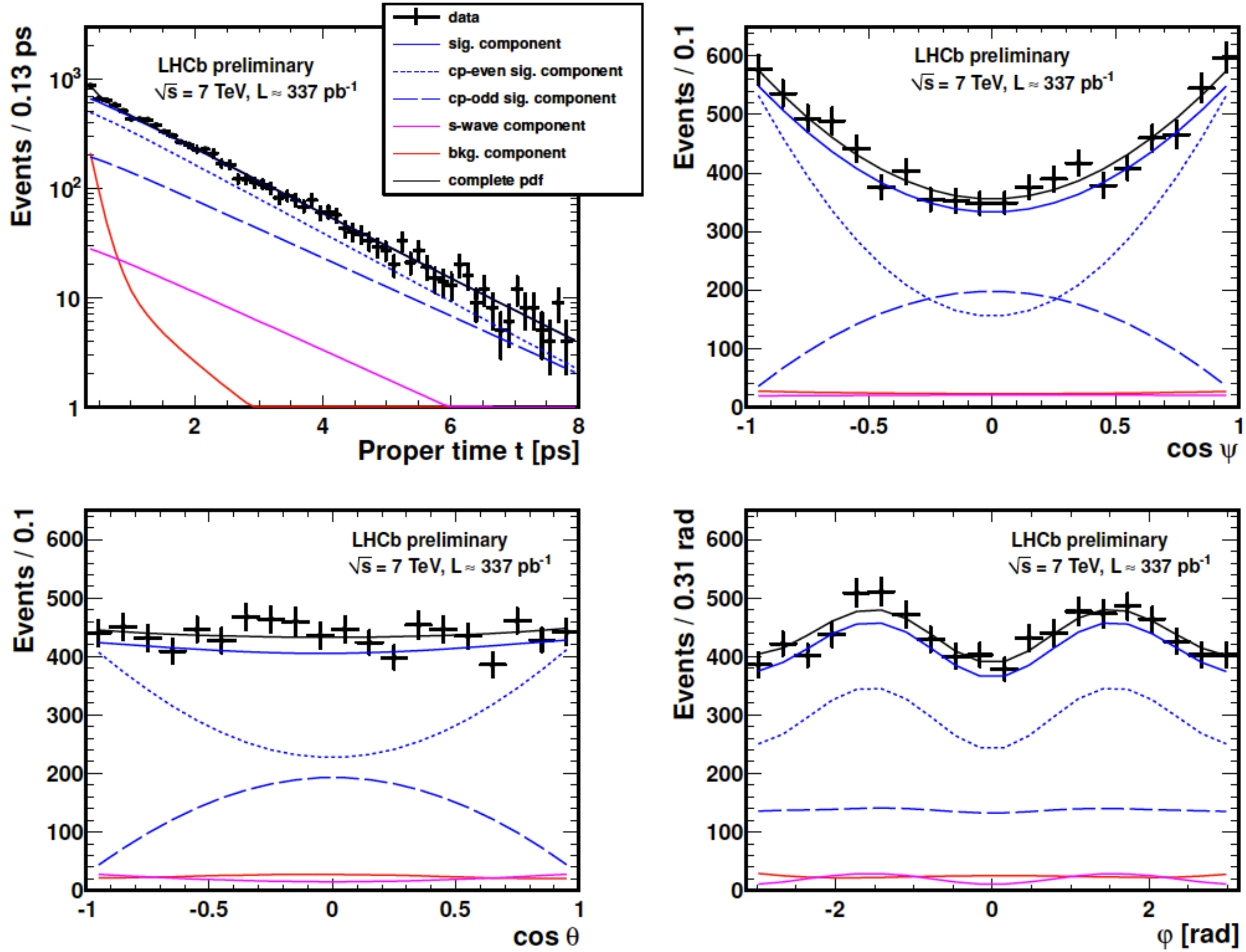
- Tagging of $B/\overline{B}$
- Verified with calibration





tagging efficiency $\varepsilon_{tag} = 27\%$
average mistag $\omega_{tag} \sim 36\%$
effective tagging power $\varepsilon_{tag}(1 - 2\omega_{tag})^2 \sim 2.1\%$

$B_s \rightarrow J/\psi\Phi$ time & angular distributions in data



$B_s \rightarrow J/\psi\Phi$: New Preliminary Results

- Maximum likelihood fit to signal + background time, angle and mass distributions.
- Use LHCb Δm_s value 17.63±0.11
- Almost all parameters have parabolic likelihood profiles
- Strong phase δ_{para} not parabolic – quote c.l. range

Parameter	Value	Stat.	Syst.
$\Gamma_s\ [ps^{-1}]$	0.656	0.008	0.008
$\Delta\Gamma_s\ [ps^{-1}]$	0.123	0.029	0.008
$\lvert A_\perp(0)\rvert^2$	0.238	0.015	0.011
$\lvert A_0(0)\rvert^2$	0.497	0.013	0.031
$\lvert A_s(0)\rvert^2$	0.041	0.016	0.019
$\delta_\perp\ [rad]$	2.94	0.37	0.12
$\delta_s\ [rad]$	3.00	0.36	0.12
$\phi_s\ [rad]$	0.13	0.18	0.07

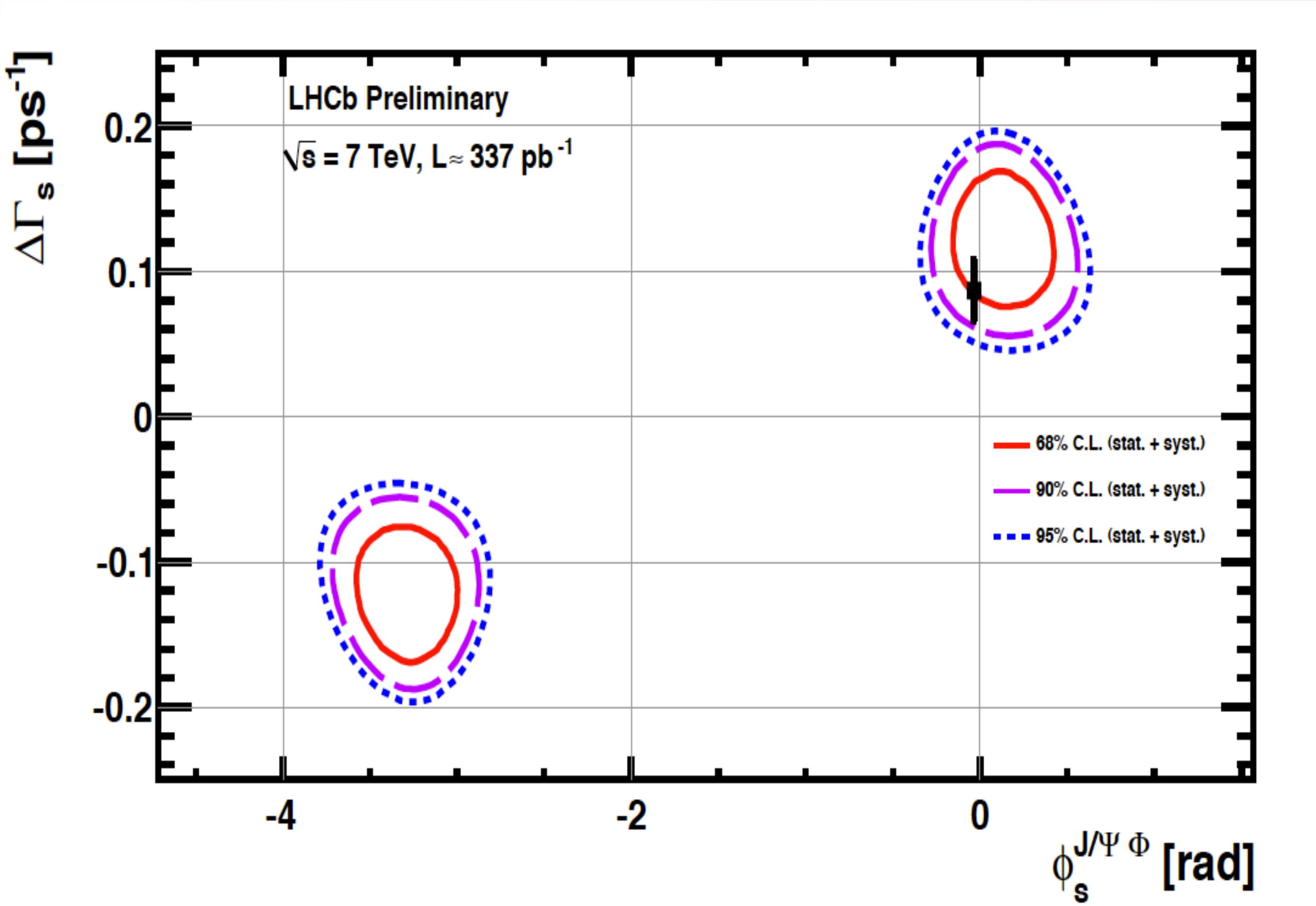
$\delta_\parallel \in [\ 3.01, 3.36\ ]$ @ 68% C.L.

- For preliminary results systematic errors are conservative

[tagging and resolution floated in fit]

Source	$\phi_s^{J/\psi\phi}$[rad]	$\Delta\Gamma_s$ [ps^{-1}]
Description of background	0.06	0.004
Angular acceptances	0.003-0.0043	0.003-0.008
z and momentum scale	–	0.002
Production asymmetry (± 10%)	< 0.01	< 0.001
CPV in mixing & decay (± 5%)	< 0.03	< 0.006
Quadratic sum	0.07 – 0.08	0.008 – 0.011

$B_s \rightarrow J/\psi\Phi$: customary 2D contour for ϕ_s -$\Delta\Gamma$



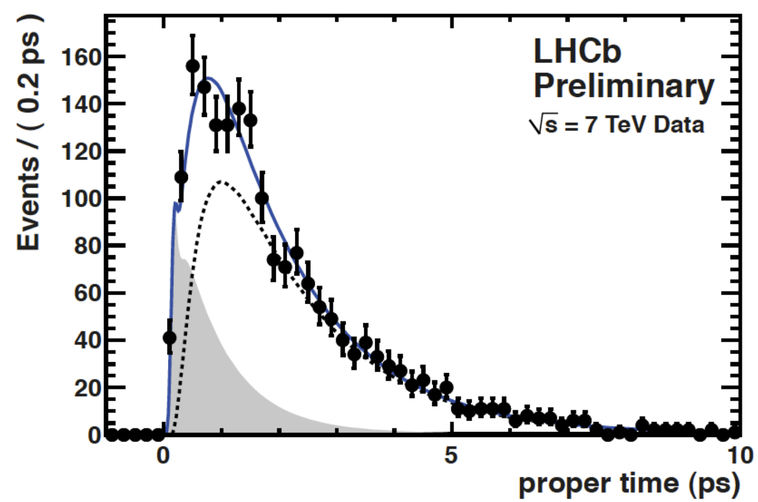
ϕ_s = 0.13 ± 0.18(stat.) ± 0.07(syst.)

$\Delta\Gamma$ = 0.123 ± 0.029(stat.) ± 0.008(syst.)

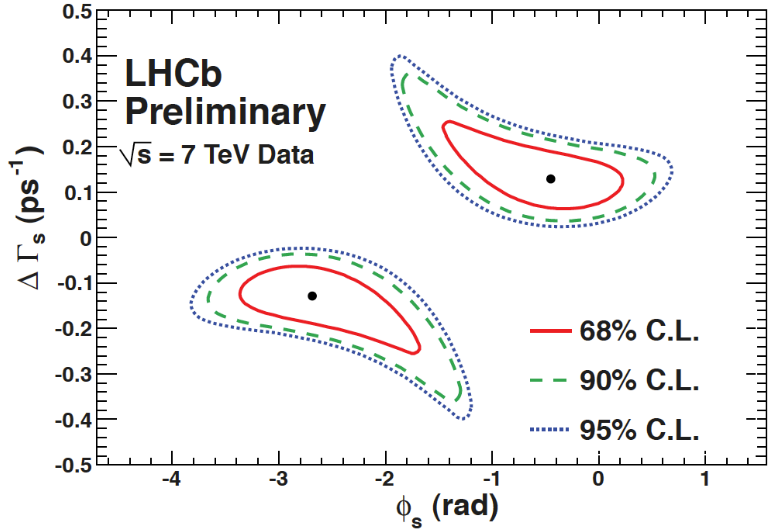
$B_s \rightarrow J/\psi f_0$ maximum likelihood fit to data

- Maximum likelihood fit to signal + background time + mass distributions

- Uses Γ and $\Delta\Gamma$ from the $B_s \rightarrow J/\psi\Phi$ analysis (+correlation)



$\phi_s = -0.44 \pm 0.44(\text{stat.}) \pm 0.02(\text{syst.})$

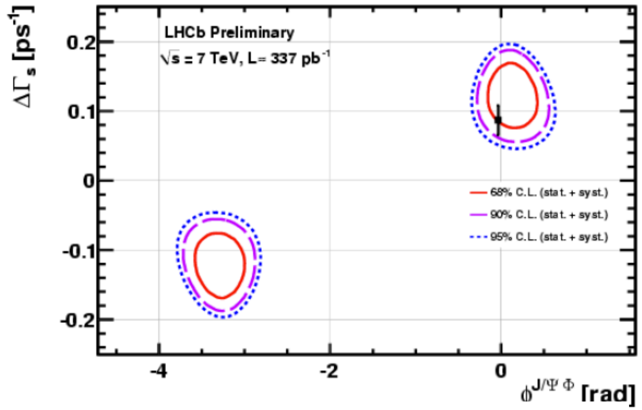


$B_s \rightarrow J/\psi\Phi$ and $B_s \rightarrow J/\psi f_0$ combined prelim.result

- Used a simultaneous fit to both datasets, taking all common parameters + correlations into account.
- Used largest syst. error.

$$\phi_s = 0.03 \pm 0.16(\text{stat.}) \pm 0.07(\text{syst.})$$

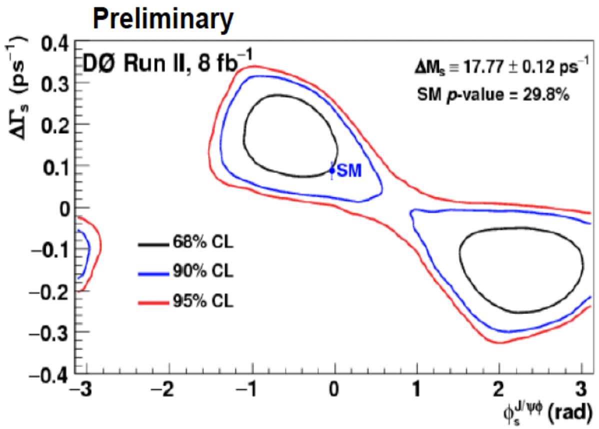
Tevatron + LHC results



LHCb – new result (not including f0)

$\phi_s = \ 0.13 \ \pm 0.18 \pm 0.07$

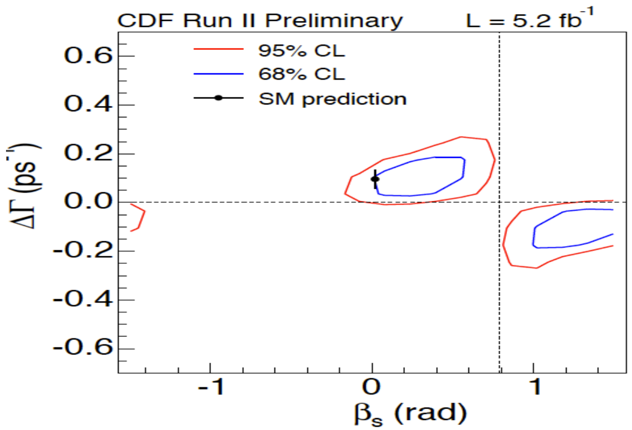
$\Delta\Gamma \ = 0.123 \ \pm 0.029 \pm 0.008$



D0 / EPS 2011 Conference / S.Burdin

$\phi_s = \ -0.55 \ +0.38 \pm 0.36$

$\Delta\Gamma \ = 0.163 \ +0.064 + 0.065$

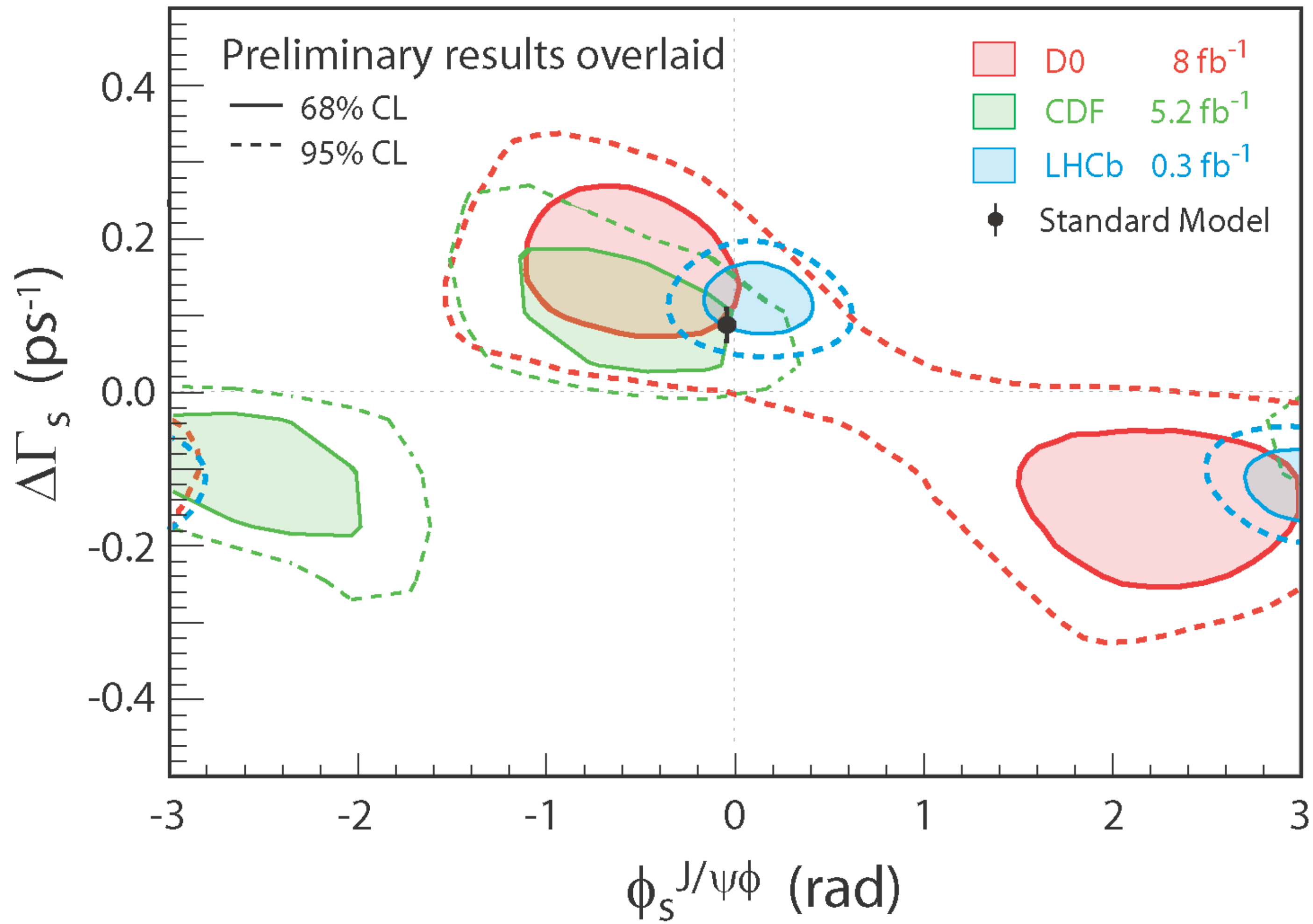


CDF Public Note 10206

$\beta_s = \ [\, 0.02 - 0.52 \,]$ 68% c.l.

$\Delta\Gamma \ = 0.075 \pm 0.035 \pm 0.01$

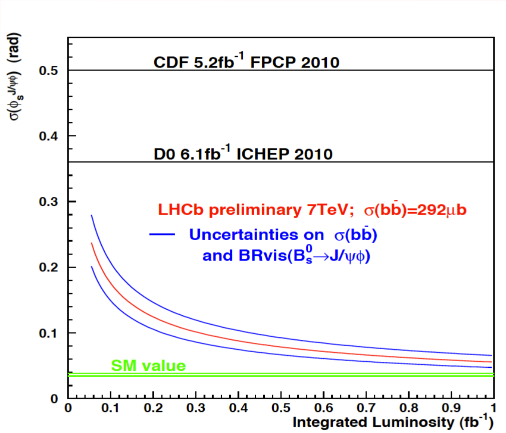
“Artists impression of overlay”



This is NOT an official accurate overlay – the experiments have not done this yet !

This is just flipping and scaling the PDFs taken from talks to give impression

Prospects



Private prediction: probably halve the error by end of 2011 data analysis

0.2 → 0.1

Prospects

Half empty glass:

NP is trouble

Prospects

Half empty glass:

NP is trouble

Half full glass

Precision will very soon be ~ SM prediction

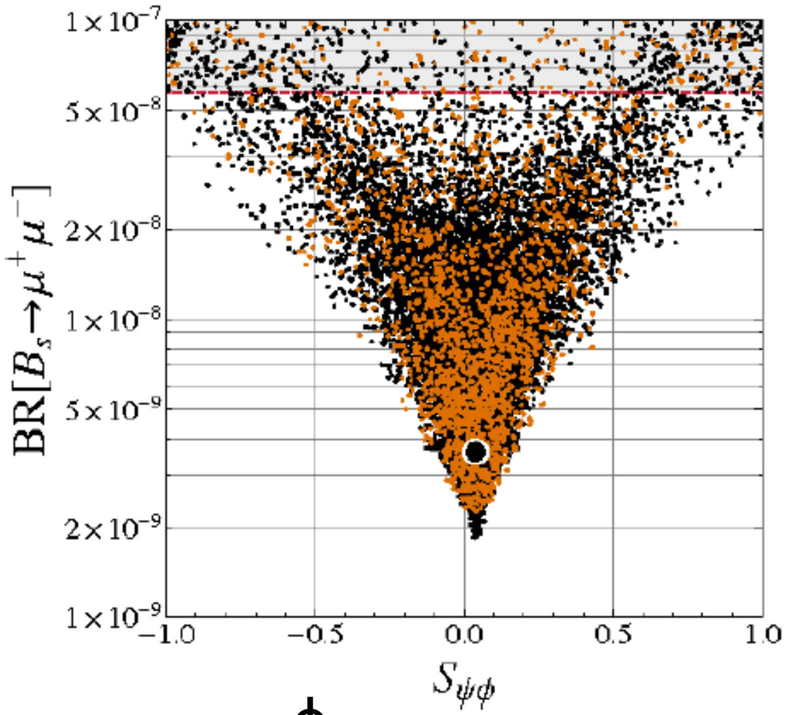
Many NP scenarios with $\phi_s \sim 0.1$

By end 2012 we will be into discovery territory

Some NP scenarios

Showing ϕ_s -vs- $B_s \to \mu^+\mu^-$

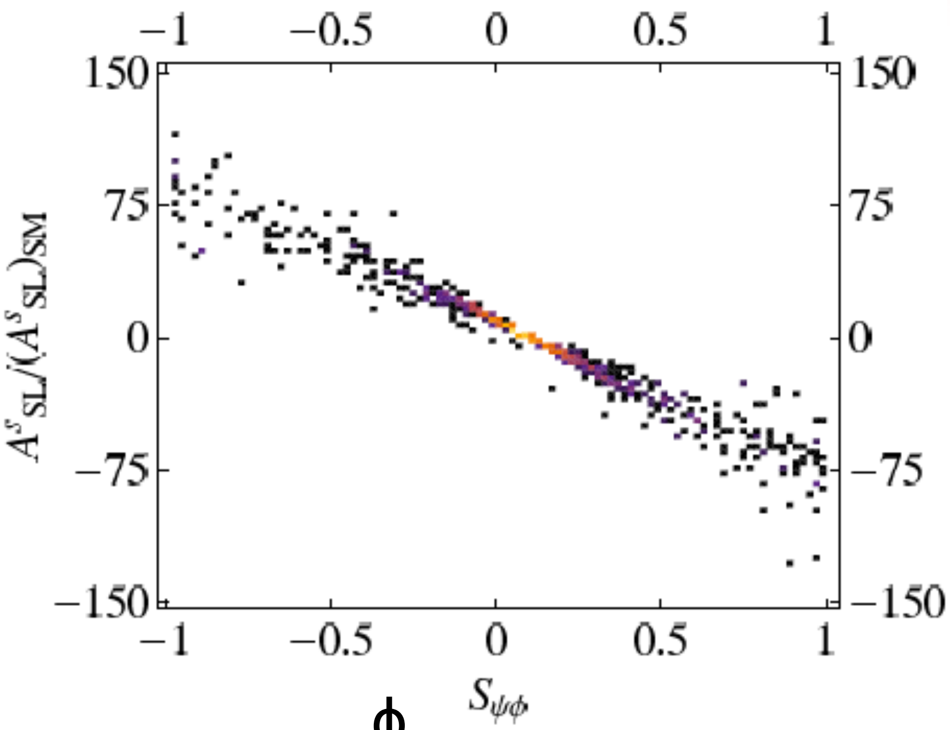
Points are different model scenarios
for SUSY "AC" model
SM point is black circle



ϕ_s

Showing ϕ_s –vs- A^s_{SL}

Points are different model scenarios
for "RSc" model



ϕ_s

Buras, arXiv:0910.1032v1

$B_s \rightarrow \mu^+\mu^-$

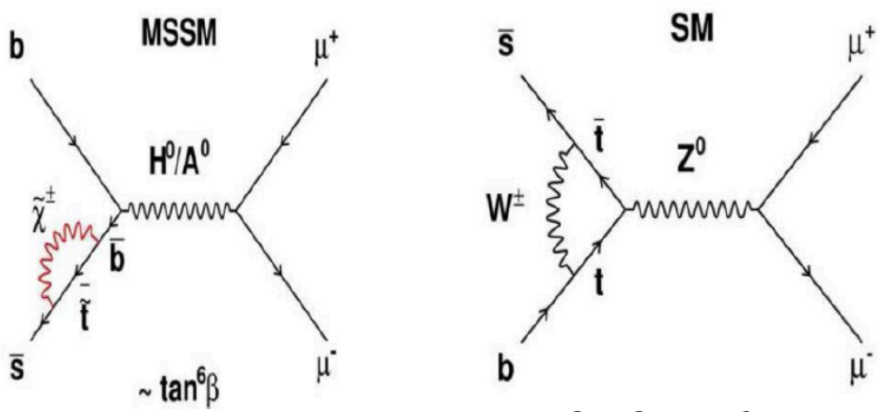
~ 340 pb^{-1}

All described in
LHCb-CONF-2011-037, LHCb-CONF-2011-047
(public conference notes)

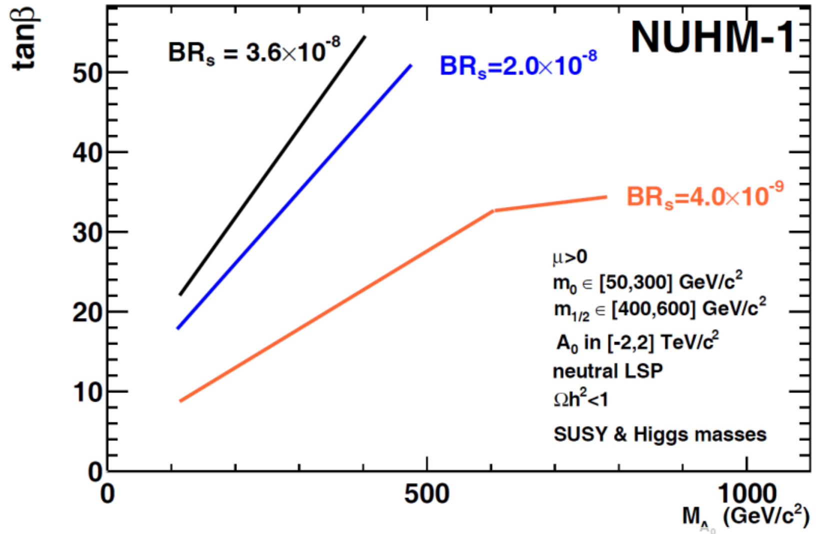
$B_s \rightarrow \mu^+\mu^-$

- Important rare decay channel
- SM Branching Ratio has precise prediction
  [A.J.Buras, arXiv:1012.1447]
  - $Br_{SM}(B_s \rightarrow \mu\mu) = (3.2 \pm 0.2)10^{-9}$

- Very high sensitivity to NP



$$Br^{MSSM}(Bq \rightarrow l^+l^-) \sim \frac{m_b^2 m_l^2 \tan^6\beta}{M_{A0}^4}$$



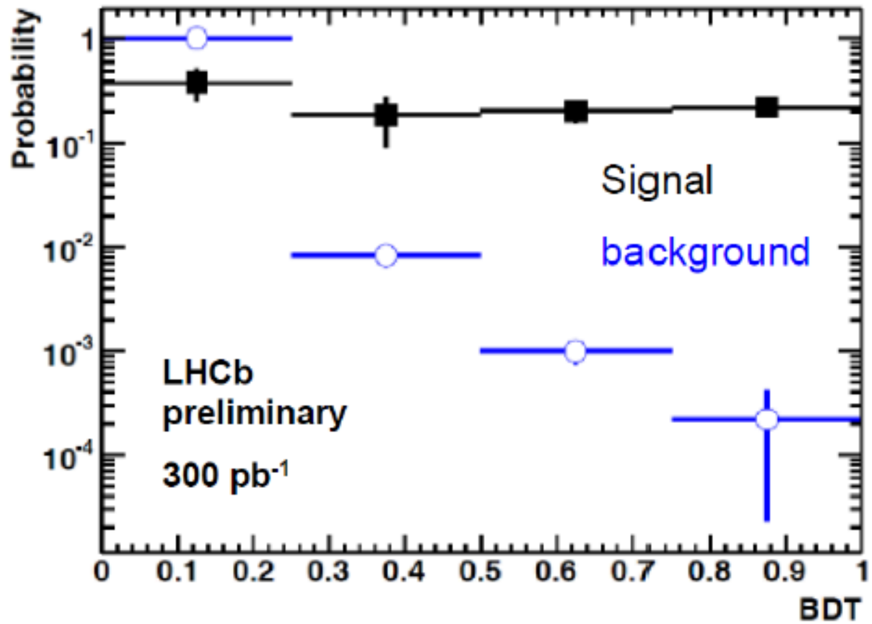
private calculation using SuperIso.
Collider Cross Talk Apr. 14 2011

Strategy very similar to 2010 analysis [PLB 699 (2011) 330] After di-μ preselection:

- Build Boosted Decision Tree out of 9 kinematical and topological variables

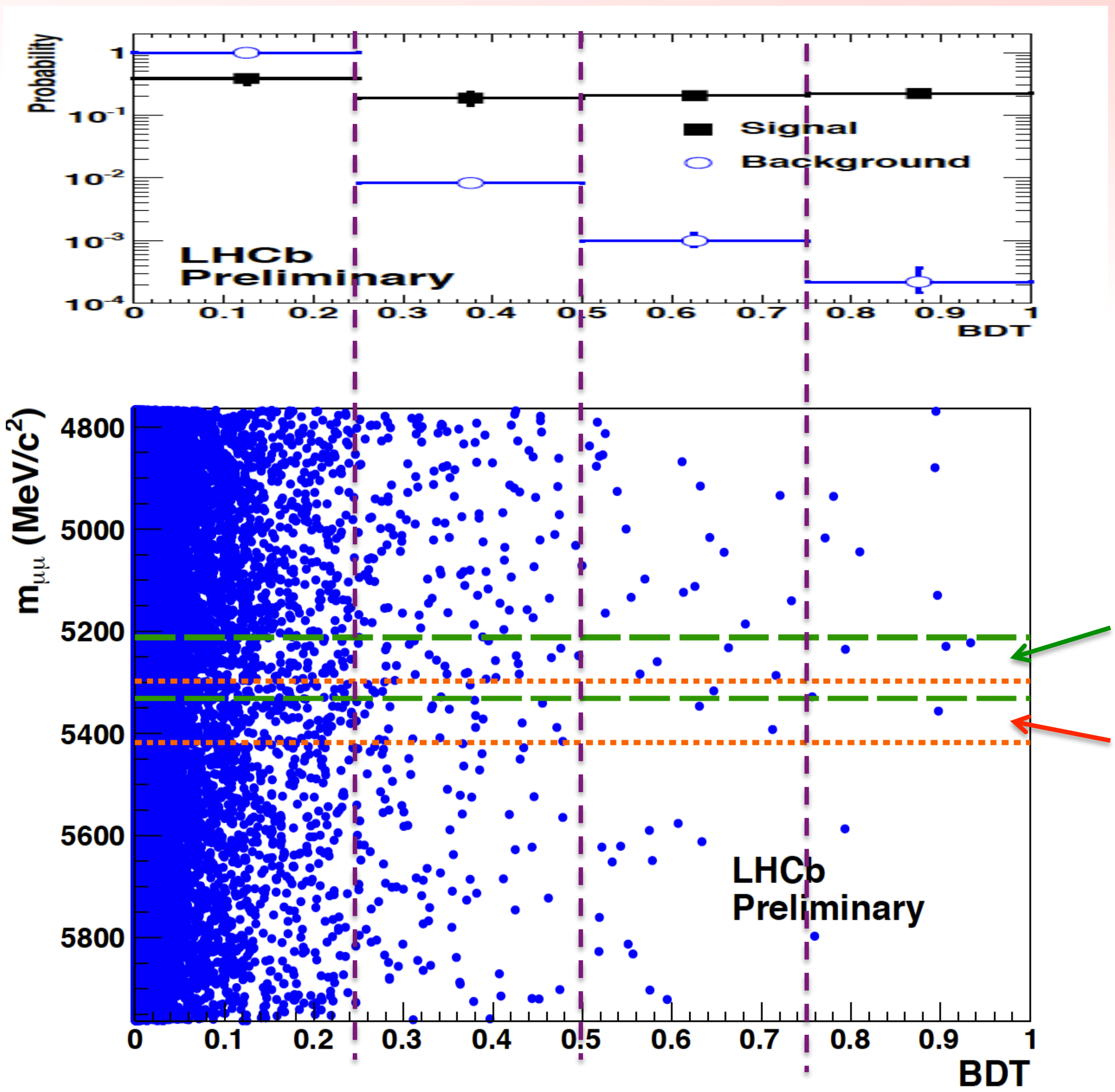
  Train BDT on MC, but calibrate on data:

  - signal response: use $B \to hh$ decays triggered on 'other B' (avoid biases!)
  - background response: use sidebands



- Invariant mass of expected signal parameterised as crystal ball, with scale & resolution (~25 MeV) calibrated from data (dimuon resonances & $B \to hh$)
- Now look in a 6 x 4 grid of $\mu^+\mu^-$ invariant mass vs BDT output
- To obtain relative BR for signal use three normalisation channels: $B^+ \to J/\Psi K^+$, $B_s \to J/\Psi \varphi$ and $B^0 \to K\pi$ – all give consistent results

4 bins of “BDT”output

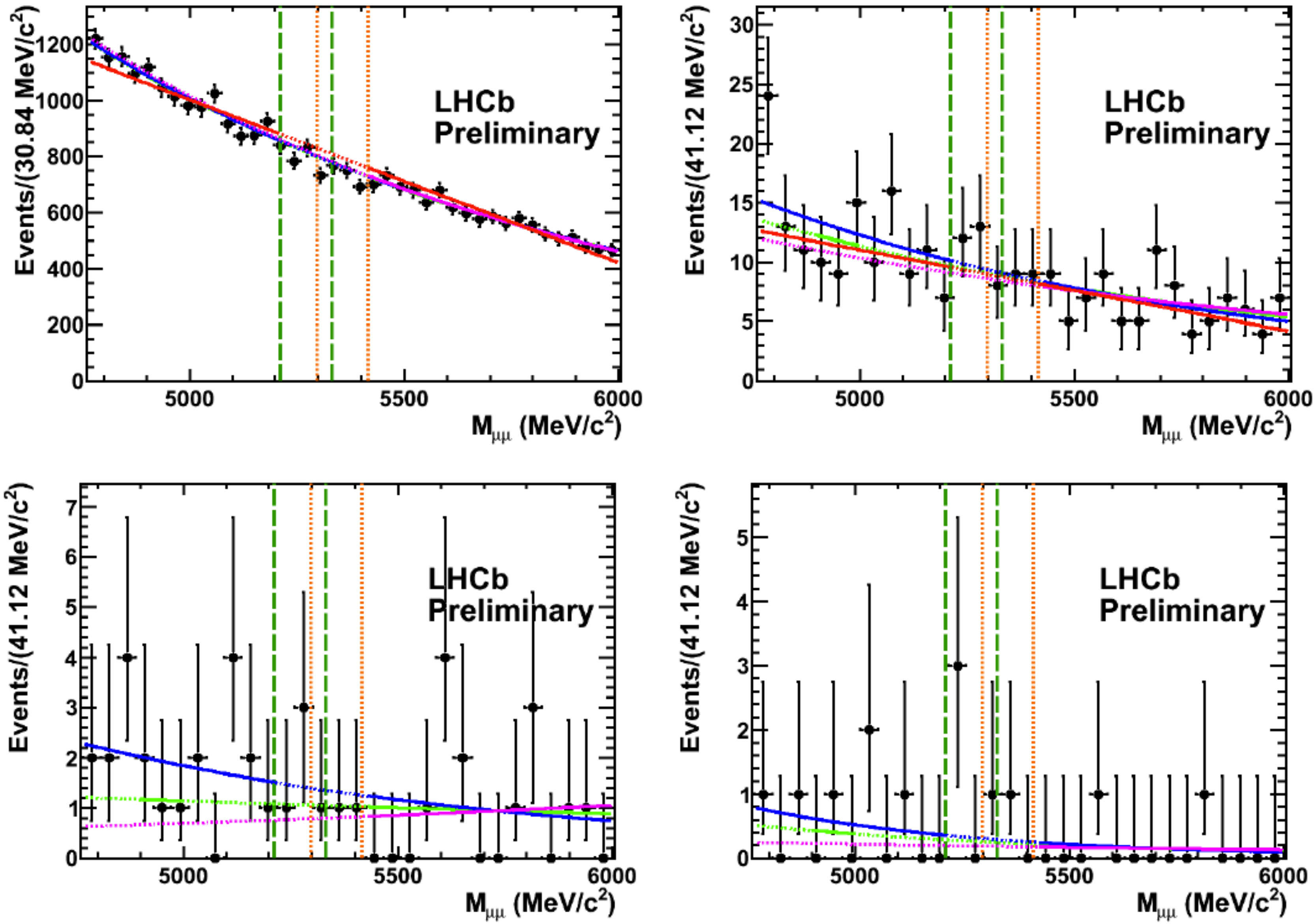


B_d search region

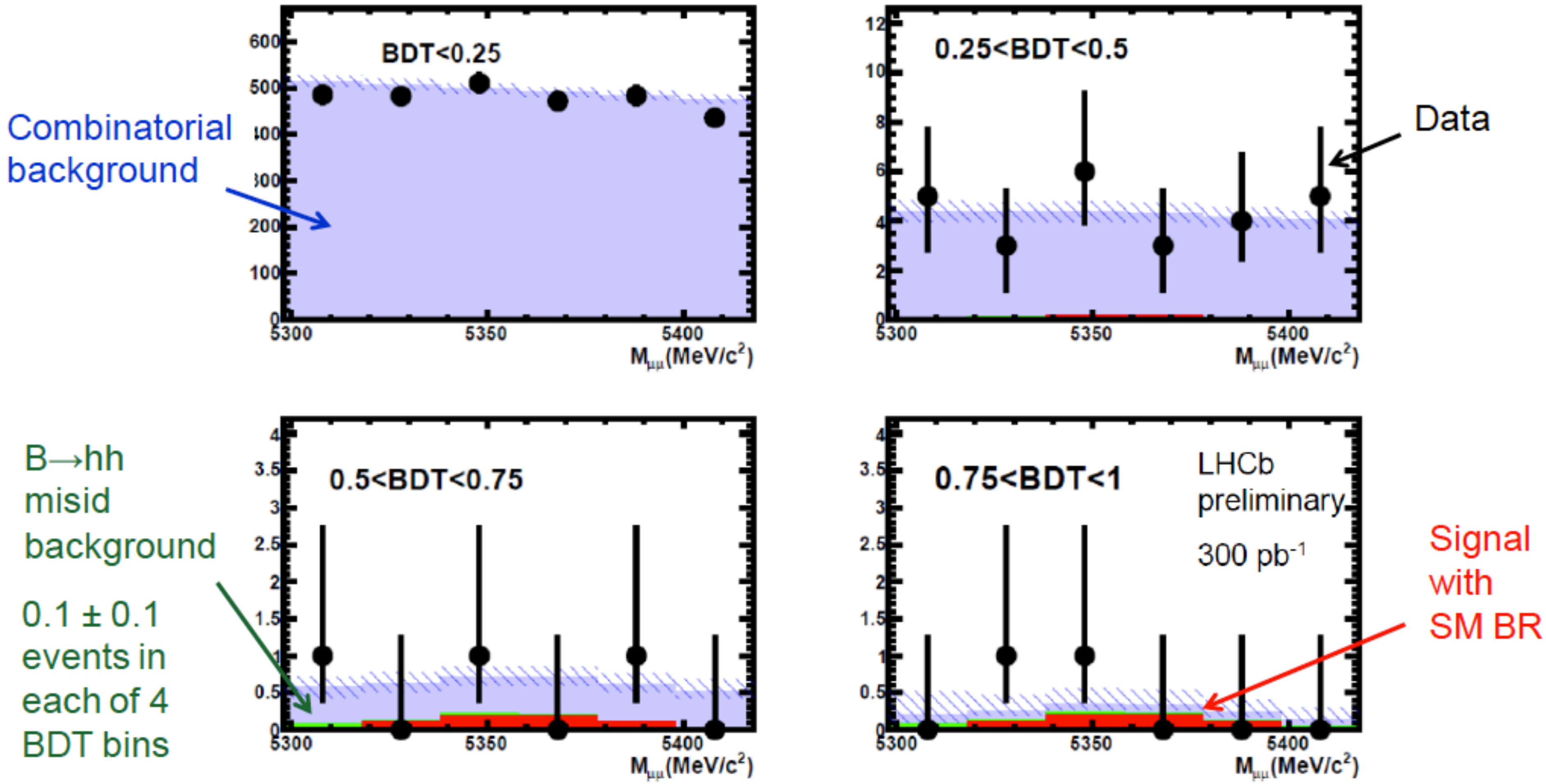
B_s search region

Search regions are ± 60 MeV of B mass

Background projections into search regions



For-each BDT slice : 6 mass bins within search region

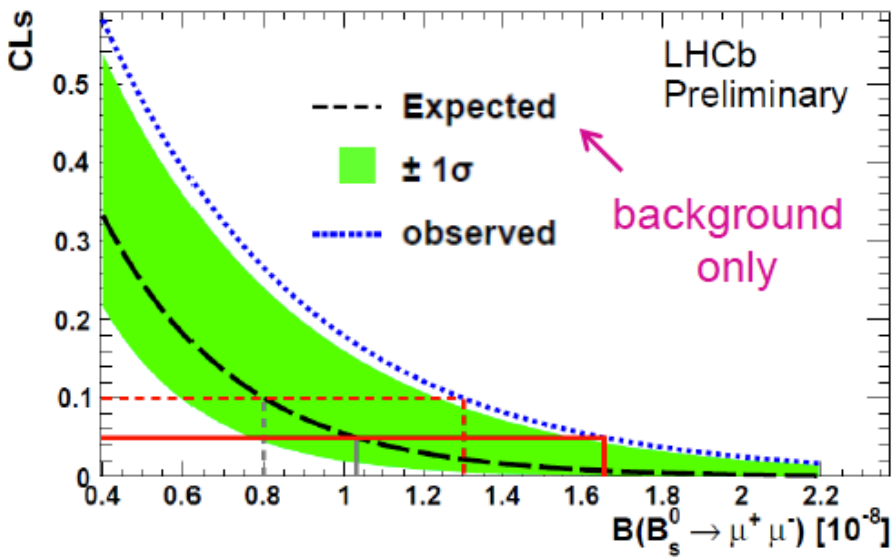


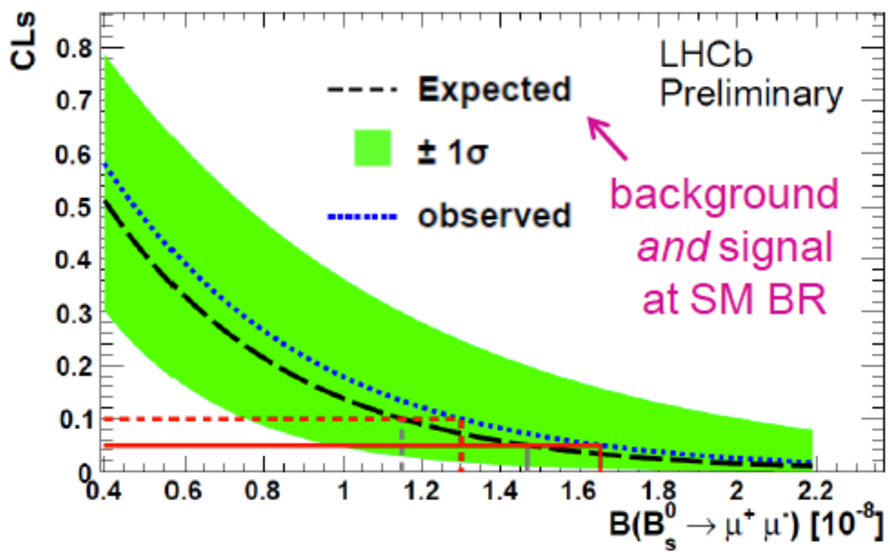
	BDT<0.25	0.25<BDT<0.5	0.5<BDT<0.75	0.75<BDT
Exp.combinatorial	2968 ± 69	25 ± 2.5	2.99 ± 0.89	0.66 ± 0.40
Exp. SM signal	1.26 ± 0.13	0.61 ± 0.06	0.67 ± 0.07	0.72 ± 0.07
Observed	2872	26	3	2

$B_s \to \mu^+\mu^-$: Observed and expected limits

- Determine limits using CLs method
  - Observed limit = blue dotted
  - Expected limit = black dashed

uses LHCb f_s/f_d =0.267± 0.021





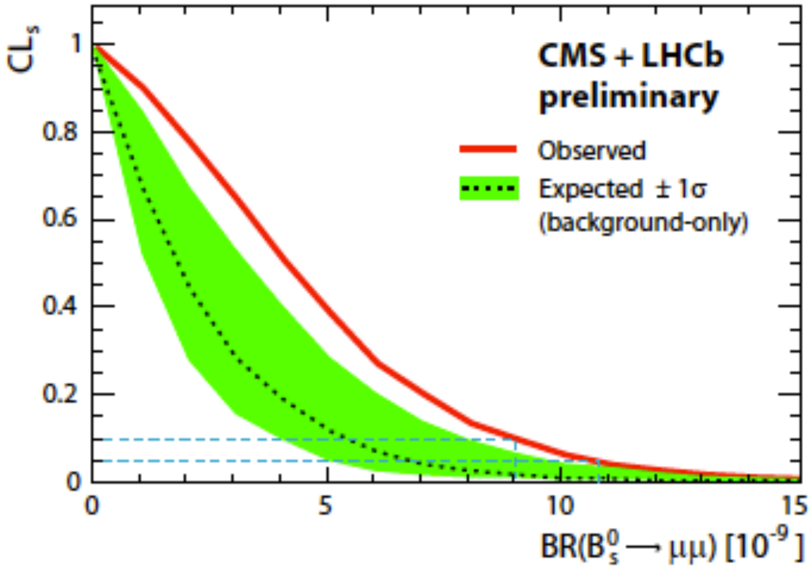
LHCb-CONF-2011-037

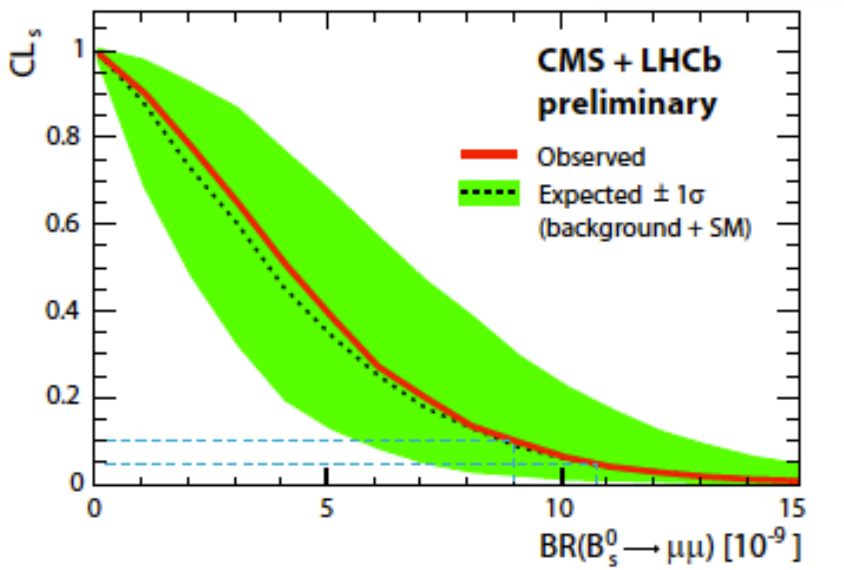
2011 data observed limit: $BR(B_s \to \mu^+\mu^-) < 1.6\ (1.3) \times 10^{-8}$ at 95%(90%) c.l.

Adding 2010 data: $BR(B_s \to \mu^+\mu^-) < 1.5\ (1.2) \times 10^{-8}$ at 95%(90%) c.l.

- LHCb and CMS have performed a preliminary combined limit [LHCb-CONF-2011-043, CMS PAS BPH-11-019]

  - LHCb $BR(B_s \rightarrow \mu^+\mu^-) < 1.5\ (1.2) \times 10^{-8}$ at 95%(90%) c.l.
  - CMS: $BR(B_s \rightarrow \mu^+\mu^-) < 1.9\ (1.6) \times 10^{-8}$ at 95%(90%) c.l

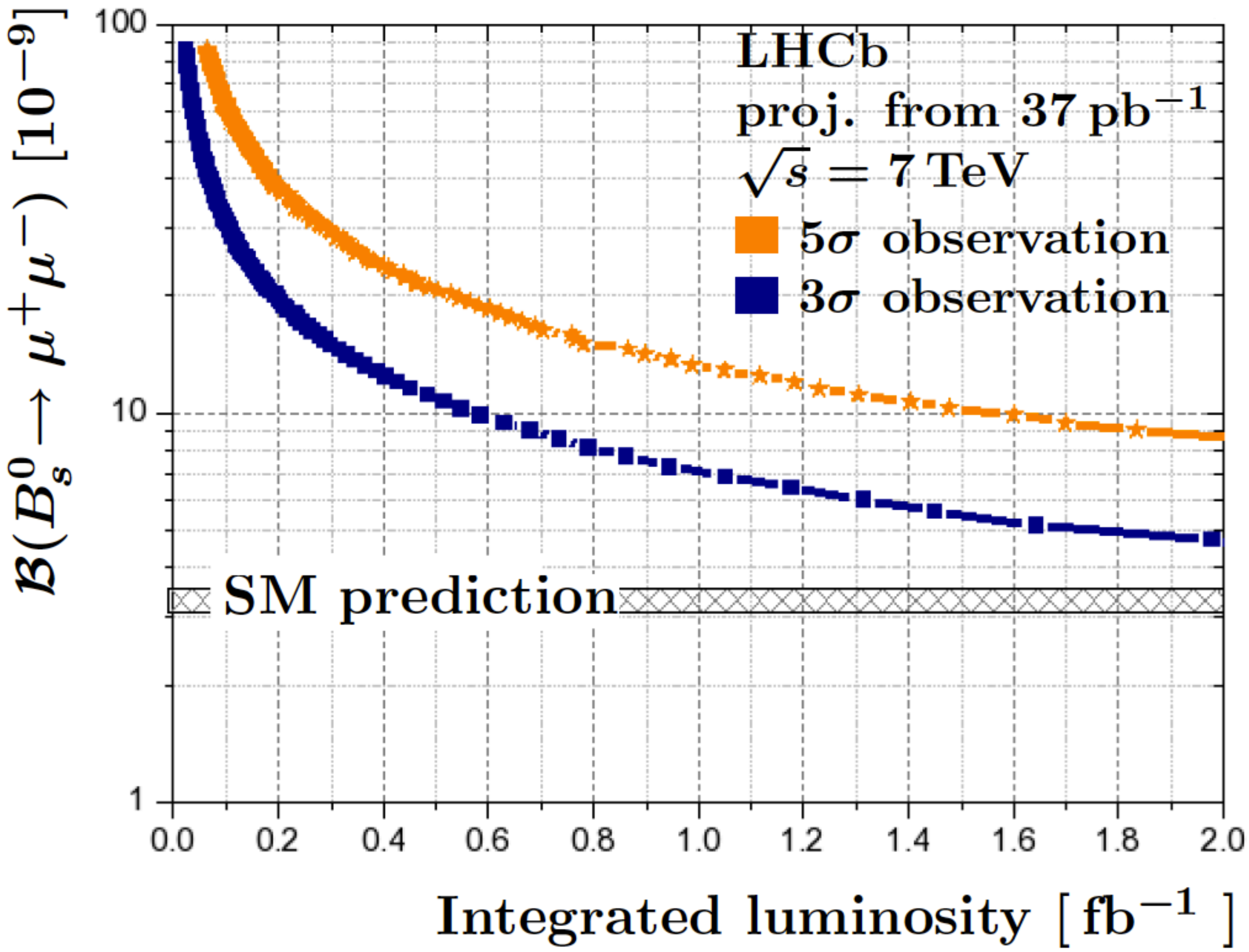




LHCb+CMS limit: $BR(B_s \rightarrow \mu^+\mu^-) < 1.1\ (0.9) \times 10^{-8}$ at 95%(90%) c.l.

This is ~ 3 times the SM BR

Projection for 2011-2012



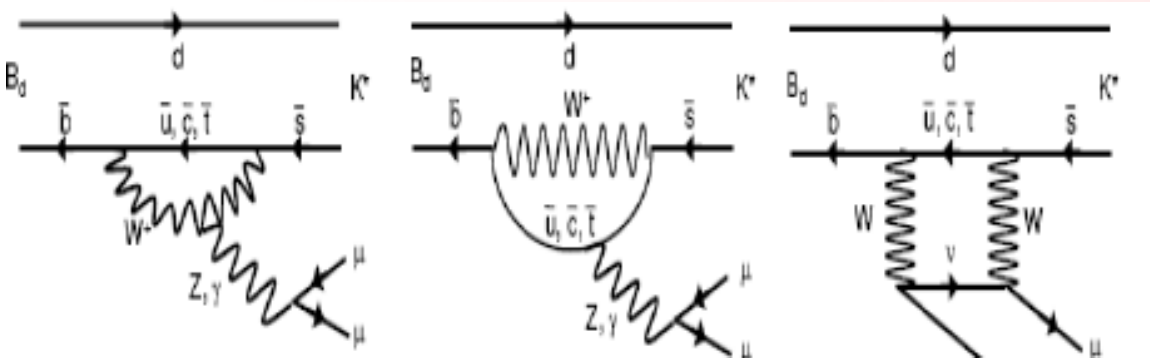
➔ See Diego Martinez Santos talk

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

~ 309 pb^{-1}

All described in LHCb-CONF-2011-038
(public conference note)

❑ This is another rare decay channel which is very sensitive to NP in loops

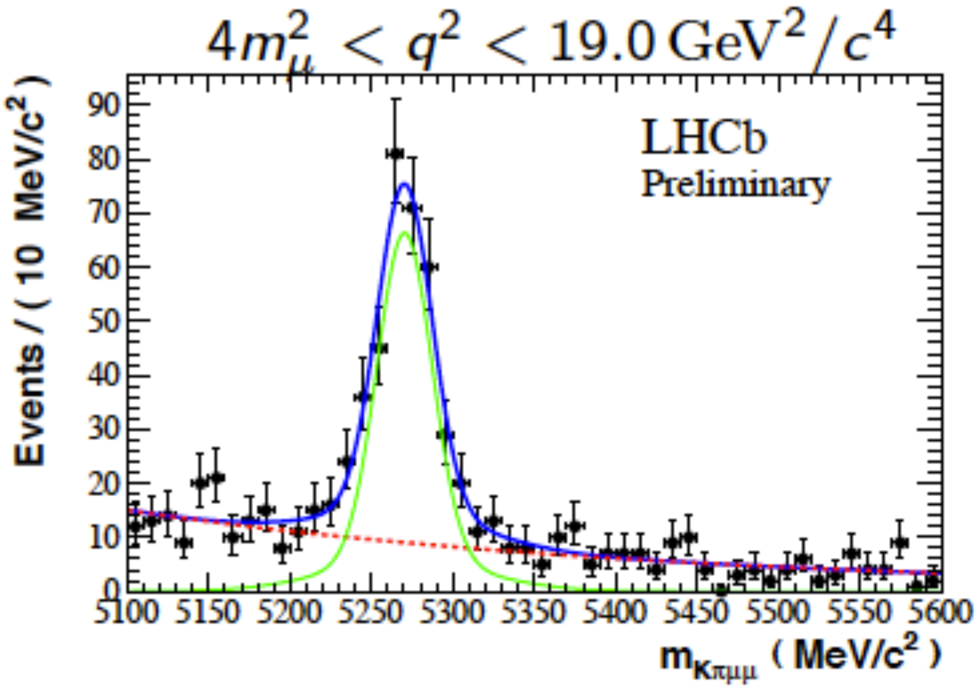


❑ 309 pb^{-1} in 2011

❑ Selected by BDT

❑ 323 signal candidates

❑ Background/Signal ~ 0.3



Analyse angular distribution and as function of q^2

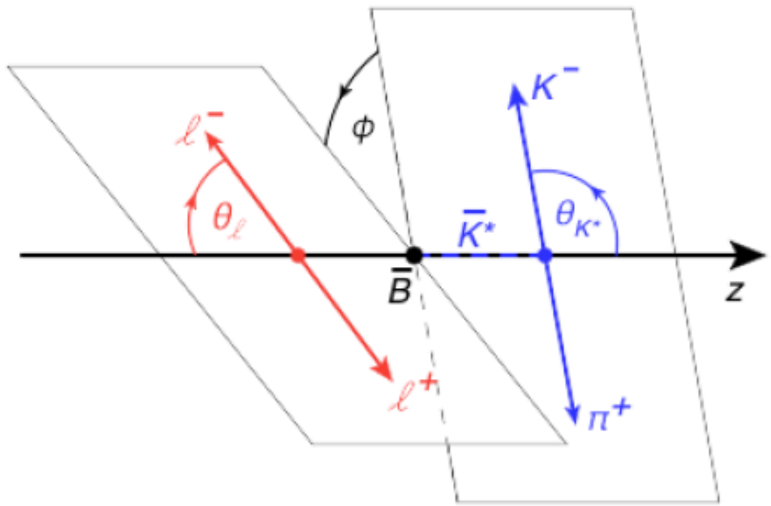
q^2 Invariant mass squared of the dimuon system $q^2 = m^2_{\mu^+\mu^-}$.

θ_ℓ Angle between the direction of the μ^- in the $\mu^+\mu^-$ rest frame and the direction of the $\mu^+\mu^-$ in the $\overline{B}_d$ rest frame.

θ_K Angle between the kaon in the $\overline{K}^{*0}$ rest frame and the $\overline{K}^{*0}$ in the $\overline{B}_d$ rest frame.

ϕ Angle between planes defined by μ^- μ^+ and the $K\pi$ in the $\overline{B}_d$ frame.

$\overline{B}_d \to \overline{K}^{*0}\ell^+\ell^-$ angular definition



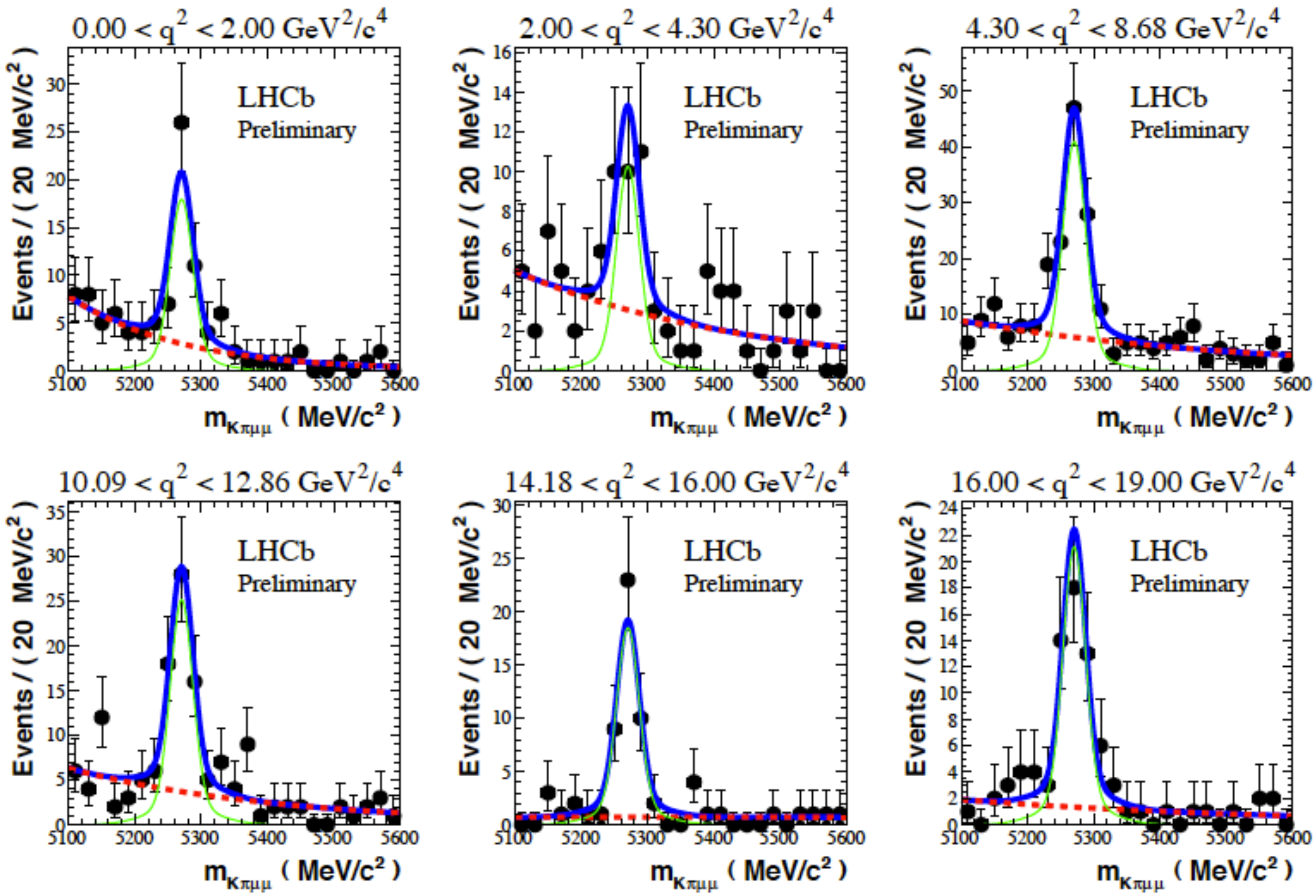
Differential cross section is complex

- 3 x P-Wave Amplitudes (+ S-Wave?) x (L,R) ➔ lots of terms with lots of coefficients
- With data today we cannot fit for all of these
- Today we fit for two combinations: A_{FB} and F_L in bins of q^2
- Ignore possible S-Wave
- Simplify to two independent 1D expressions, and do simultaneous fit.
- Use the mass distribution to distinguish S+B

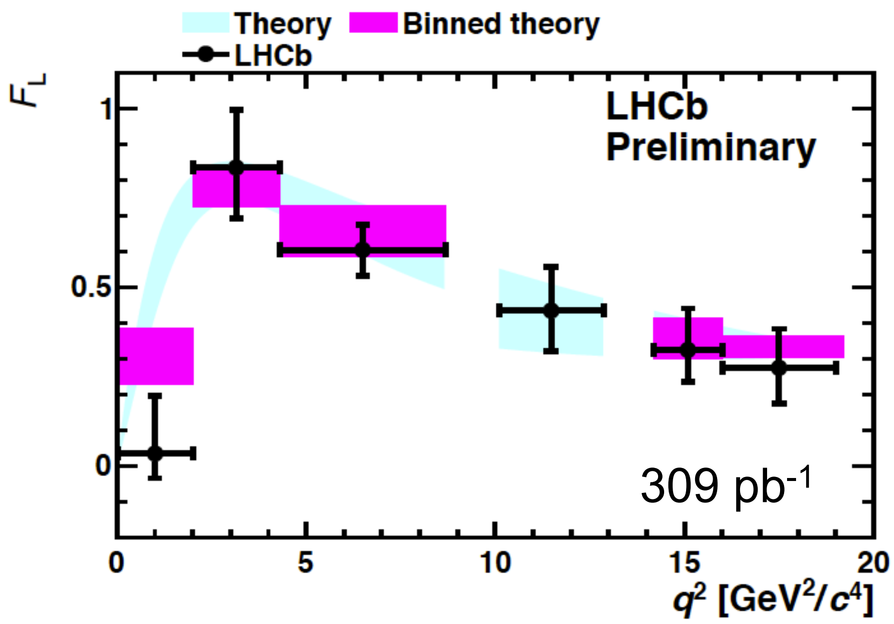
$$\frac{1}{\Gamma}\frac{\mathrm{d}^2\Gamma}{\mathrm{d}\cos\theta_\ell\,\mathrm{d}q^2} = \frac{3}{4}F_L(1-\cos^2\theta_\ell) + \frac{3}{8}(1-F_L)(1+\cos^2\theta_\ell) + A_{FB}\cos\theta_\ell$$

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

$B_d \rightarrow K^{0*}\mu^+\mu^-$ event yields in bins of q^2

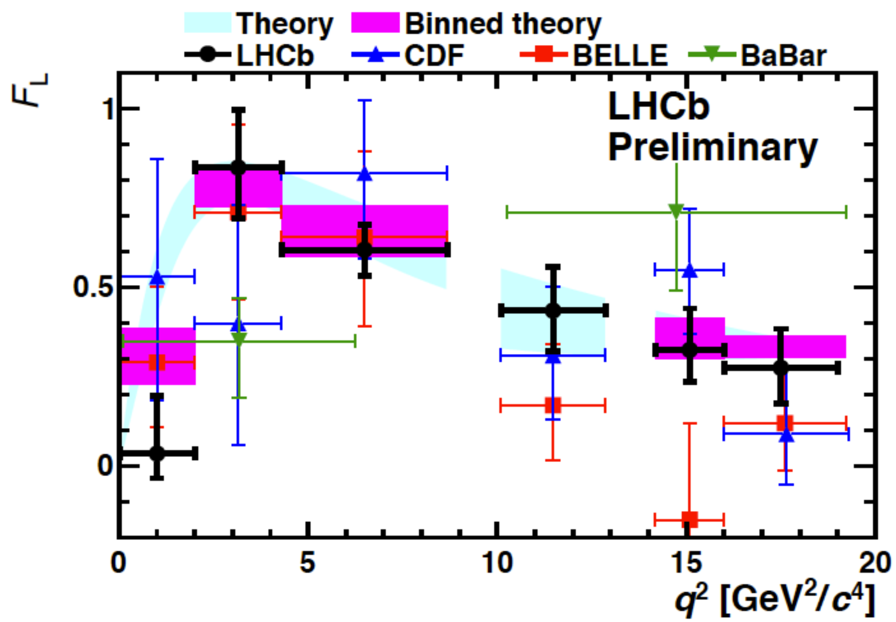


Results for F_L



Theory prediction from C. Bobeth et al. [arXiv:1105.0376v2]

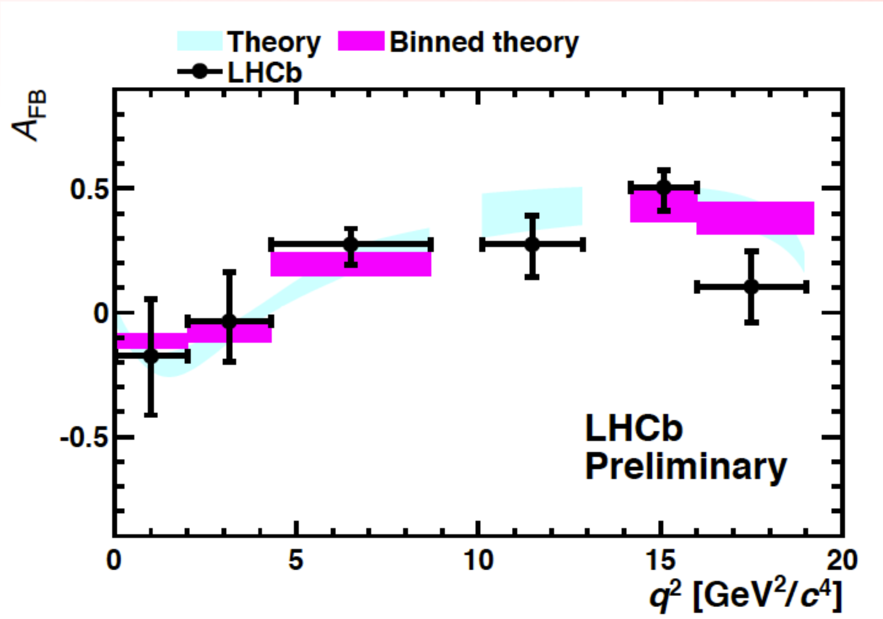
LHCb only



BaBar [PRD **79** (2009)], Belle [PRL **103** (2009)], CDF [PRL **106** (2011)]

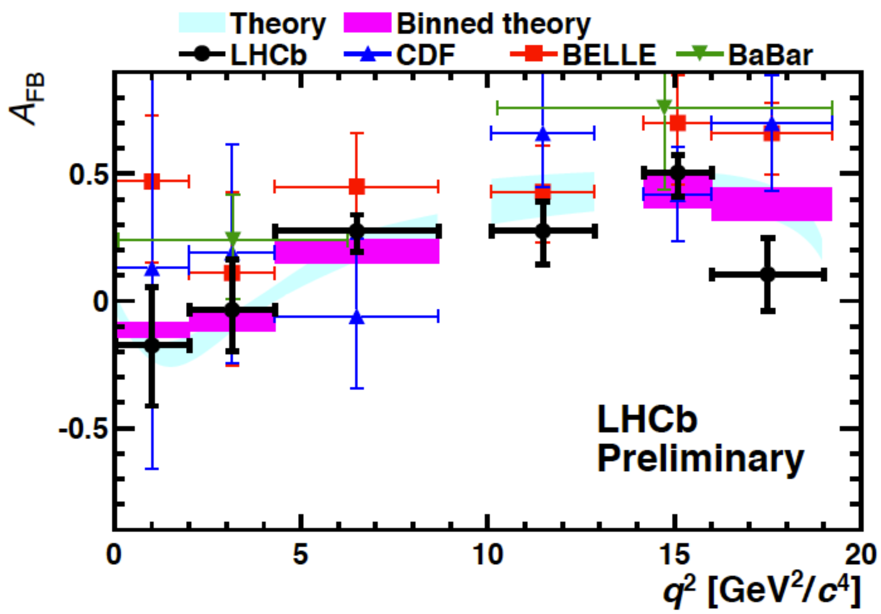
Same but with other measurements

Results for A_{FB}



Theory prediction from C. Bobeth et al. [arXiv:1105.0376v2]

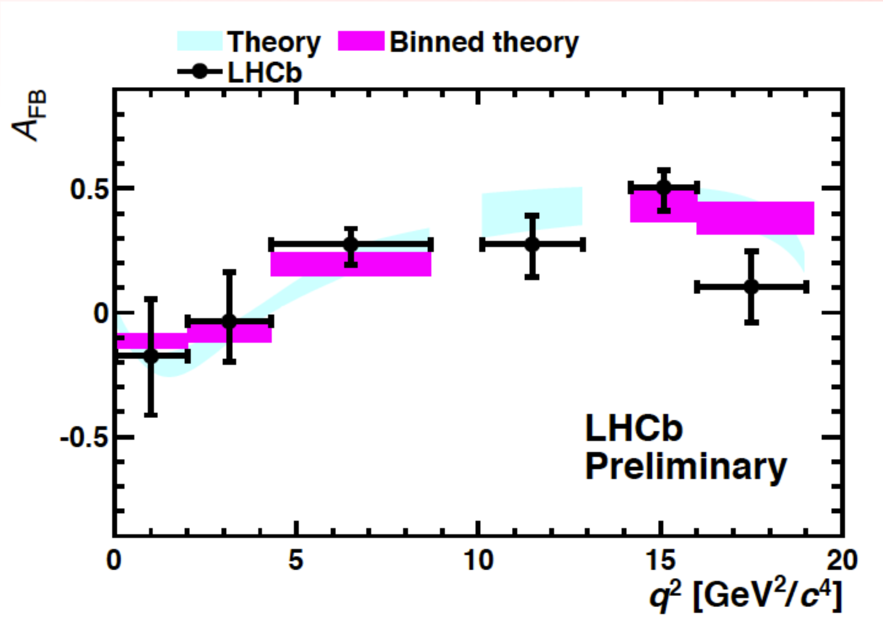
LHCb only



BaBar [PRD **79** (2009)], Belle [PRL **103** (2009)], CDF [PRL **106** (2011)]

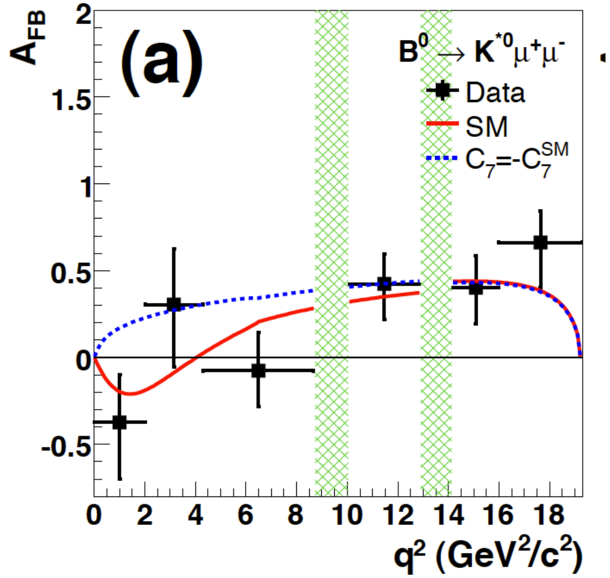
Same but with other measurements

Results for A_{FB}



Theory prediction from C. Bobeth et al. [arXiv:1105.0376v2]

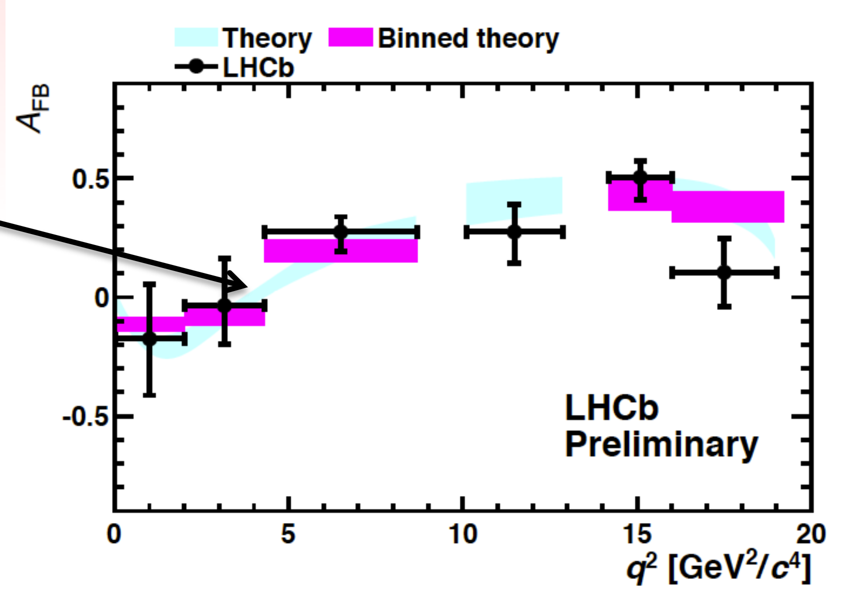
LHCb only



New CDF result arXiv:1108.0695

Next Steps

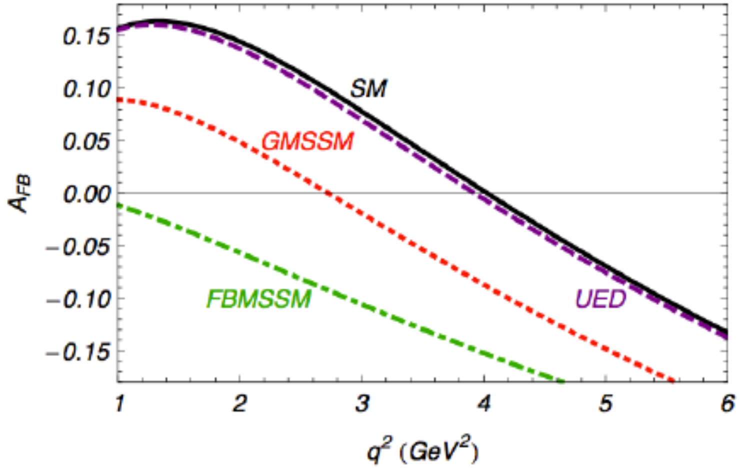
- ❑ Next step is to determine 0 crossing point accurately



Theory prediction from C. Bobeth et al. [arXiv:1105.0376v2]

- ❑ Theoretically well predicted

This plot is derived from reference using the "S6" predictions – Also its "flipped"



W.Altmannshofer et al. [JHEP 0901:019 (2009)]

- ❑ Add phi angle and add A_T^2
- ❑ With > 2 fb^{-1} try to do full angular analysis

Conclusion

- LHC is running extremely well
- LHCb is working well – and taking higher than design luminosity
- LHCb has recently contributed some important results which impact TeV scale physics
  - Measurement of the B_s mixing phase ϕ_s
  - Limits on the rare decay $B_s \rightarrow \mu^+\mu^-$
  - Forward backward asymmetry in $B \rightarrow K^*\mu^+\mu^-$
- These results are based upon first ~ 340 pb^{-1} . In 2010+2011 we have recorded approximately 700 pb^{-1} and are heading for 1 fb^{-1}