Study of the B decay to $K^{*0}\mu^+\mu^-$ with LHCb

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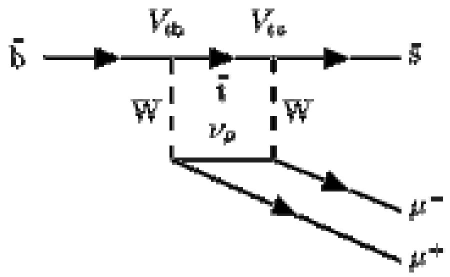
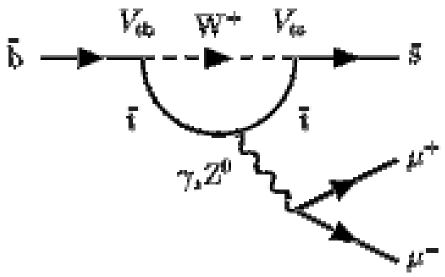
Physics Motivations

- Rare B decay, ΔF=1 FCNC,
  only recently available to experiments
- Sensible to **new physics**
- Supressed by α_{em} relative to $B \rightarrow \gamma X_S$
- But with a cleaner experimental signature

Branching Ratio $(\times 10^6)$	
SM	1.2 ± 0.4
Belle	< 3.0
BaBar	< 3.0

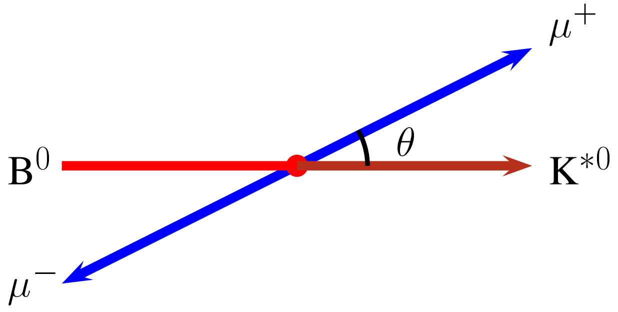


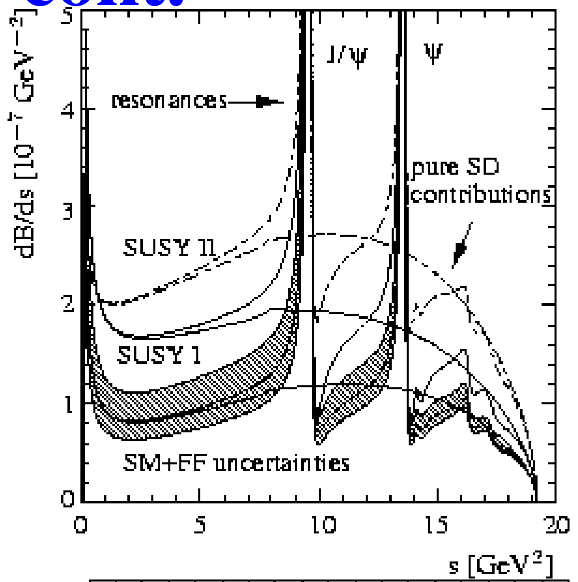


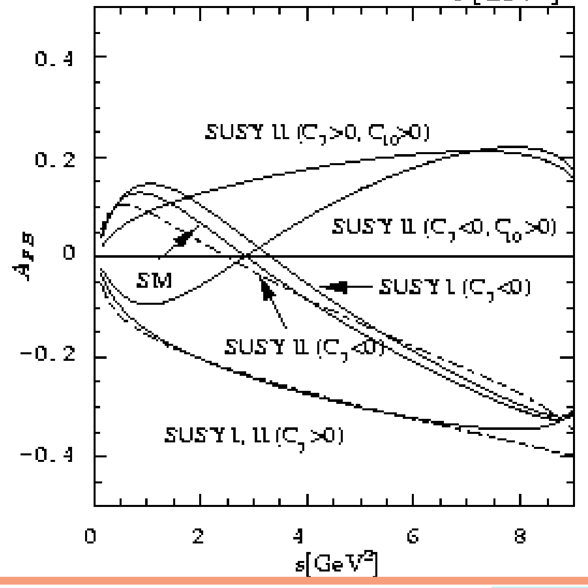
Physics Motivations - cont.

Interesting observables

- $\mu^-\mu^+$ inv. mass distributions
- $A_{CP} = \frac{BR_r^{B^0} - BR_r^{\bar{B}^0}}{BR_r^{B^0} + BR_r^{\bar{B}^0}}$
- $A_{FB}(s) = \left(\int_0^1 d\cos\theta - \int_{-1}^0 d\cos\theta \right) \frac{d^2\Gamma}{ds\,d\cos\theta}$
- $A_{CP} = \frac{A_{FB}^{B^0} - A_{FB}^{\bar{B}^0}}{A_{FB}^{B^0} + A_{FB}^{\bar{B}^0}}$







Simulation

- Generators
  - Signal: Adapted from RAREB
  - Backgrounds: Pythia+QQ
- Multiple interactions
- Interaction with the detector: Geant 3.21

$B^0 \to \mu^+\mu^- K^{*0}$	50k
bb-inclusive	10M
$b \to \mu^+ c(\mu^- s$ or $\mu^- d)$	200k
$B^0 \to \mu^+ X, \bar{B}^0 \to \mu^- X$	~1.8M
$B^0 \to J/\psi K^{*0}$	150k
$B_s^0 \to J/\psi \phi$(KK)	~ 200k

Optimized detector (LHCb light)

L=2×10^{32} cm^{-2}s^{-1}

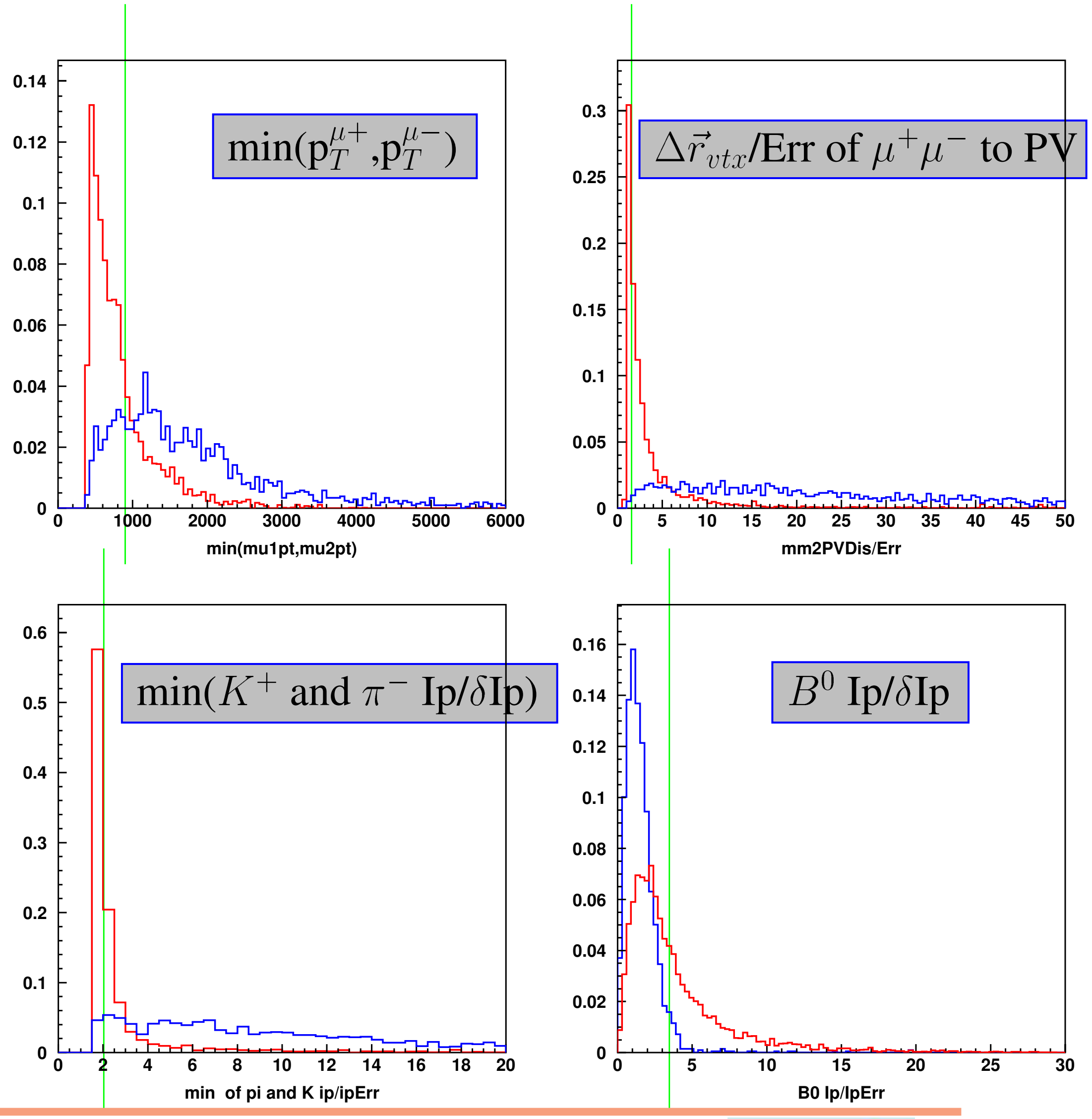
10^{12} $b\bar{b}$ a year

Realistic detector responses & reconstruction

Selection

Tracks traverse the full spectrometer
PID info from different subdetectors
L0 and L1 trigger

p_T of μ^- and μ^+	> 900 MeV/c^2
J/ψ mass rejection window	2900-3200 MeV/c^2
ψ(2s) mass rejection window	3650-3725 MeV/c^2
$\Delta\vec{r}_{vtx}$/Err of $\mu^+\mu^-$ or K^{*0} to PV	> 1.5
Ip/δIp of pions and kaons	> 2.0
p_T of K^{*0}	> 900 MeV/c
Ip/δIp of B0 to Prim. Vtx	< 3.5
N$_{ch}$ with Ip/IpErr to B0Vtx $<$3.0	11
Mass window for B^0	$\pm$ 50 MeV/c^2



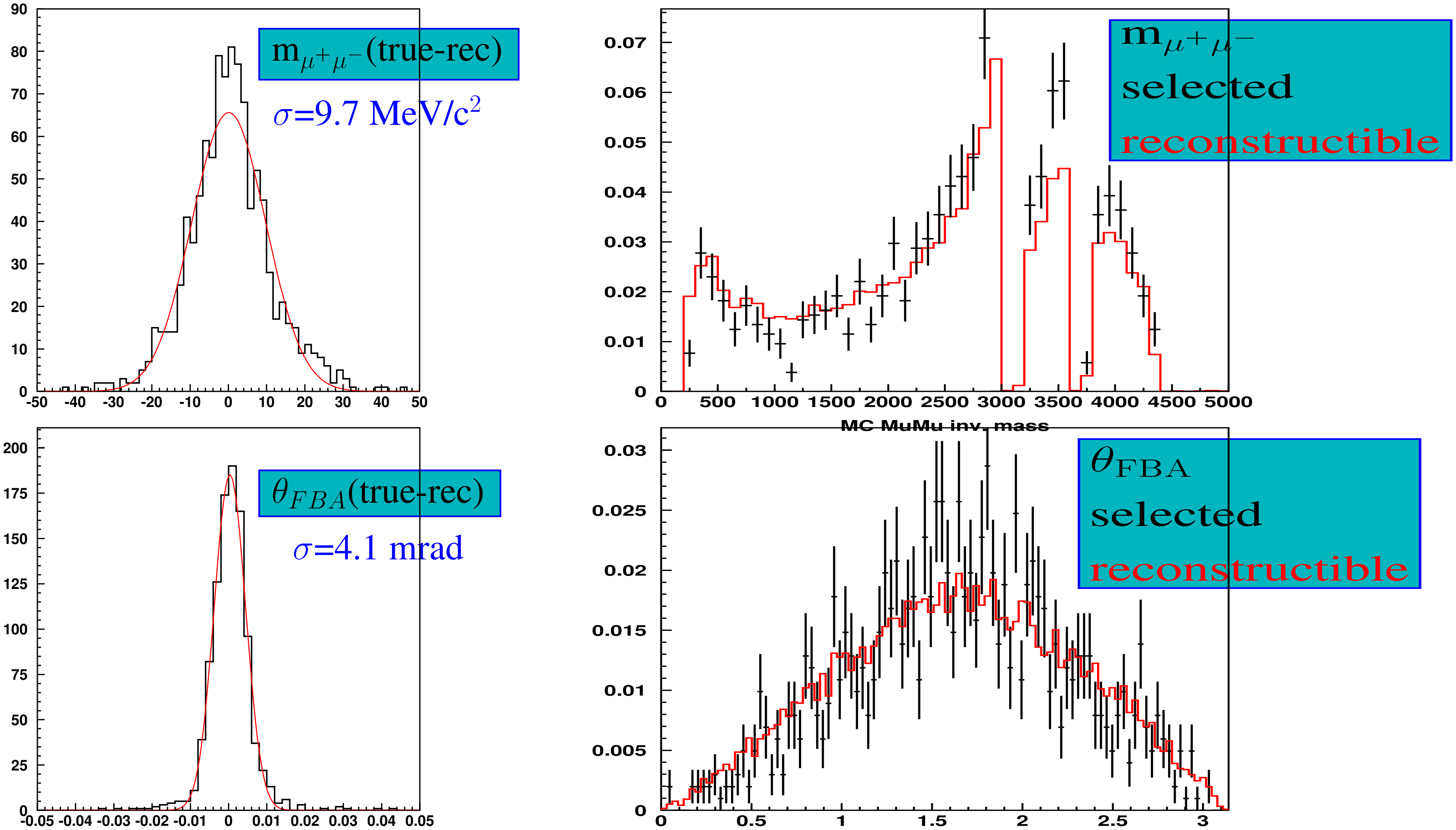
Annual yields and B/S ratios

	Simulated	Selected	N_{Year} ($\times 10^3$)	B/S
$B^0 \to \mu^+\mu^- K^{*0}$	50k	997	4.37±0.14	
bb-inc.	10M	0	[0-5.39]	[0-1.23]
$b \to \mu^+ c(\mu^- X_{s,d})$	200k	0	[0-3.76]	[0-0.86]
$B^0 \to \mu^+ X$+ h.c.	1.7M	9	[0.62-2.20]	[0.14-0.50]
Others			[0.02-0.08]	[0.02-0.11]
Total				[0.66-2.20]

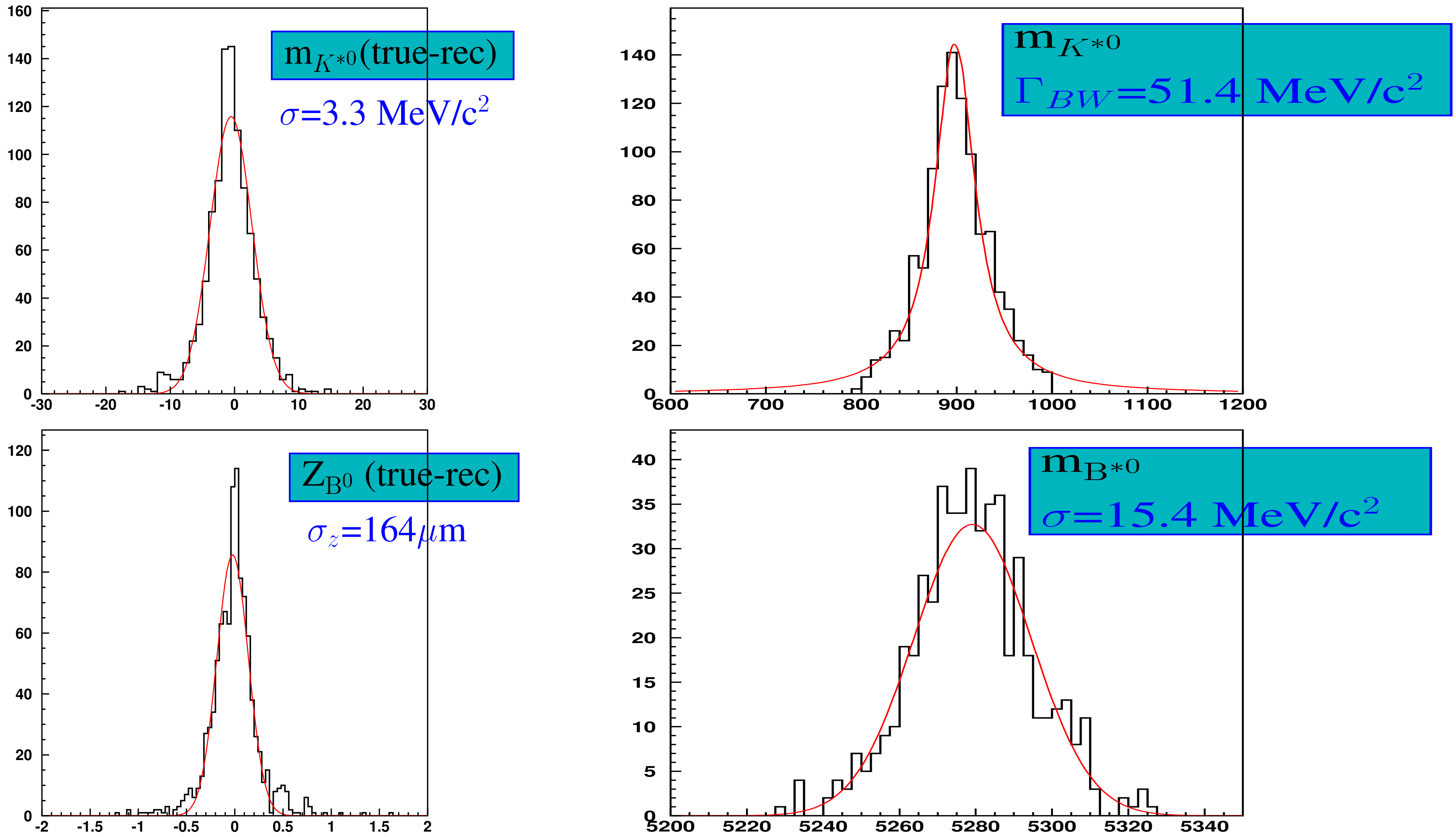
1) Inclusive backgrounds selected in a B^0 mass window of ± 1 GeV/c^2

2) [. . .] indicates 90% CL limits.(e.g.: 0 selected, 90% CL for the mean is [0,2.3])

$\mu^+\mu^-$ inv. mass and θ_{FBA}



K^{*0} and B^0



$m_{K^{*0}}$(true-rec)
σ=3.3 MeV/c^2
$m_{K^{*0}}$
Γ_{BW}=51.4 MeV/c^2
Z_{B^0} (true-rec)
σ_z=164μm
$m_{B^{*0}}$
σ=15.4 MeV/c^2

BR and A_{CP} precision estimates

- Precision of signal yield:
  $\sigma_{\mathrm{S}} = \sqrt{\mathrm{S} + (1+r)B}$
  r=B^0 mass side bins factor: r=50 MeV/(1000-100) MeV = 0.055
  B should be better known. For S=4370 and the extrema values in
  B/S = [0.66,2.20], we have $\boxed{\sigma_{\mathrm{S}} = 86.1 - 120.5}$

- Branching ratios:
  $\frac{\sigma_{\mathrm{B}R}}{\mathrm{B}R} = \frac{\sigma_{\mathrm{S}}}{\mathrm{S}}$ $\boxed{\frac{\sigma_{\mathrm{B}R}}{\mathrm{B}R} = 2.0\%\text{-}2.8\%}$

  statistical errors only

  The present theoretical uncertainty on BR is about 30%

- CP violation in decay ratios:

  After One Year

  $A_{CP} = \frac{BR^B - BR^{\bar{B}}}{BR^B + BR^{\bar{B}}}$.
  Using the input SM BR and assuming A_{CP}=0,
  $$\boxed{\sigma_{A_{CP}} = \sigma_{BR}/\sqrt{2}BR = 1.4\% - 1.9\%}$$

Conclusions and Prospects

- The rare decay $B^0 \to \mu^+\mu^- K^{*0}(K\pi)$ can be well reconstructed in LHCb with good resolutions for the interesting variables
- We expect a annual yield of 4370 signal events, with the S/B in the 90% CL [0.66,2.2]
- We can measure the branching ratio and corresponding CP assimetry within a few percent already after one year of data taking
- The knowldge of the background yields and distributions is still limited due to low statistics of the simulations
- Other important observables, as the dimuon inv. mass distribution, the forward-backward assymetry and its associated CP assimetry, need better knowledge of the background
- We intend to extend the analysis to the inclusive $B \to \mu^+\mu^- X_s$ case and to the $B^0 \to e^+e^- K^{*0}$ decay