

Searching for new physics in $B \rightarrow K^* \mu \mu$ @ LHCb

Christophe Salzmann
on behalf of the LHCb Collaboration

- LHCb
- $B \rightarrow K^* \mu \mu$
- Forward/backward asymmetry A_{FB}
- Existing measurements of A_{FB}
- A_{FB} Measurement @ LHCb
- Conclusion

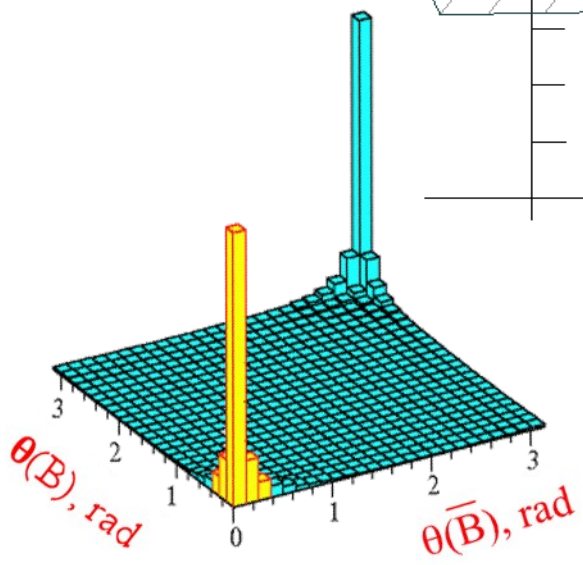
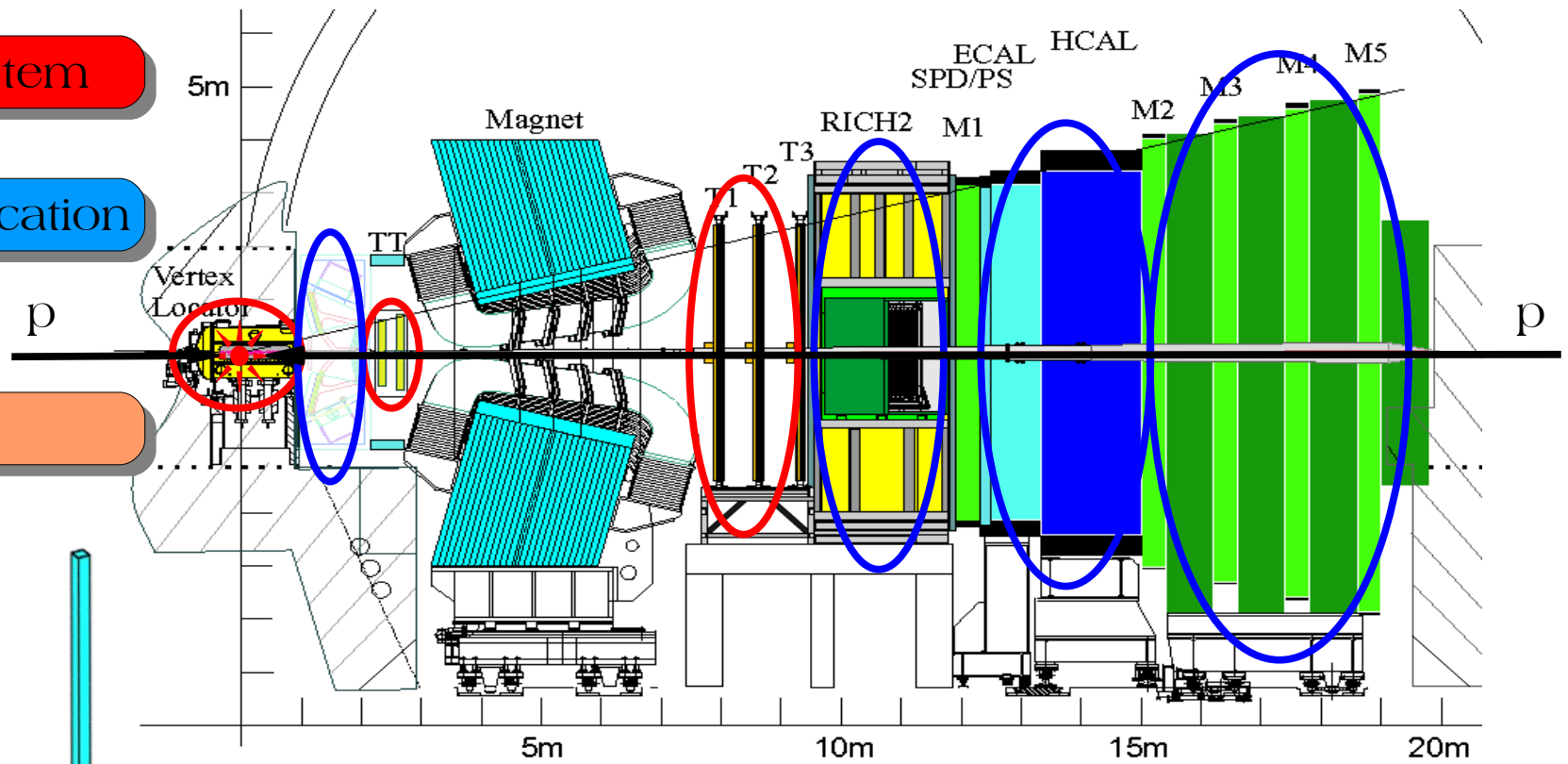
See also other LHCb talks in flavor I session:

- Flavour Tagging and mixing @ LHCb (S. Furcas)
- Charmless Hadronic Two Body B Meson Decays @ LHCb (H. V. Cliff)
- Studies of B-hadron decays to charming final states @ LHCb (M. P. Whitehead)
- b production cross sections and fragmentation fractions @ LHCb (L. Carson)

Tracking System

Particle Identification

Trigger



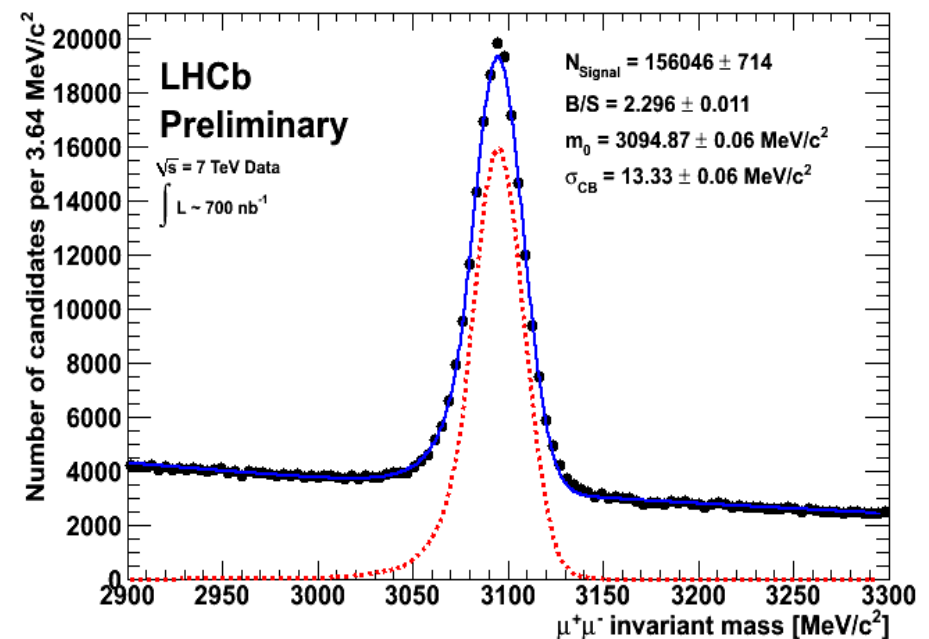
- $b \bar{b}$ are produced in very forward region
 → single arm spectrometer
- Pseudo-rapidity range: $1.9 < \eta < 4.9$

- High precision experiment
 - Excellent vertex and momentum resolution
 - Precise particle identification
- Dedicated to CP violation and rare decays in the b-sector
 - large $b\bar{b}$ cross section: $\sim 300 \mu\text{b}$

LHCb Collaboration
Phys.Let.B 694.209,2010

2010 data: 36 pb^{-1}
2011 data: already 82 pb^{-1}

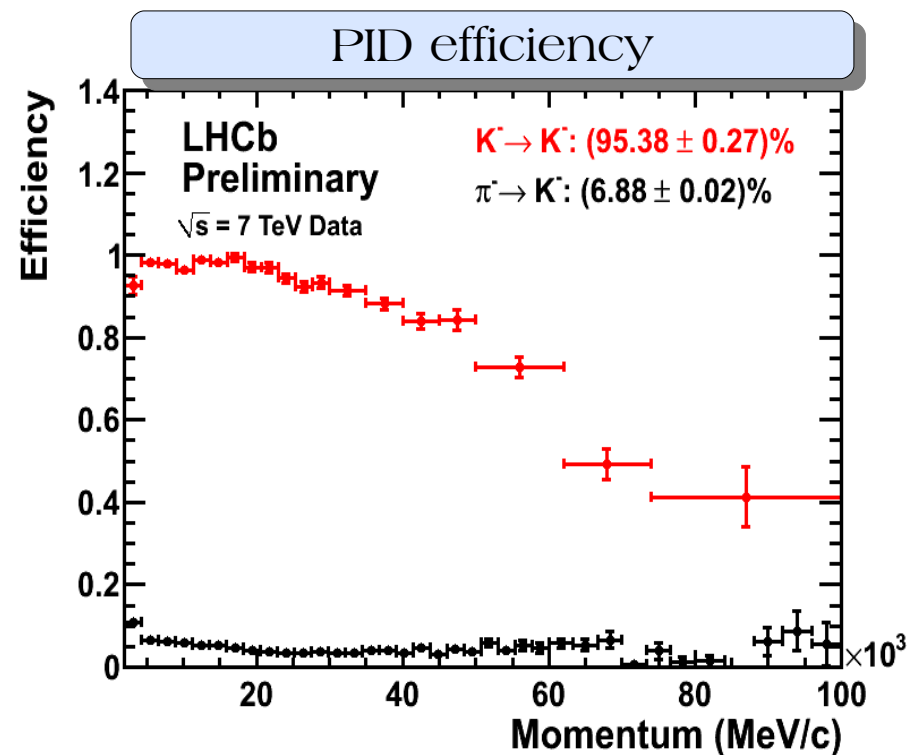
J/Ψ mass peak resolution: 13.3 MeV



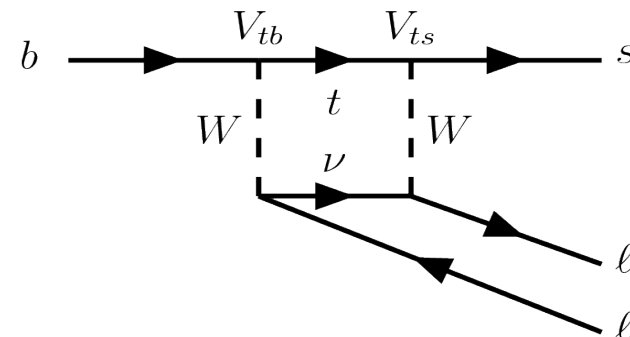
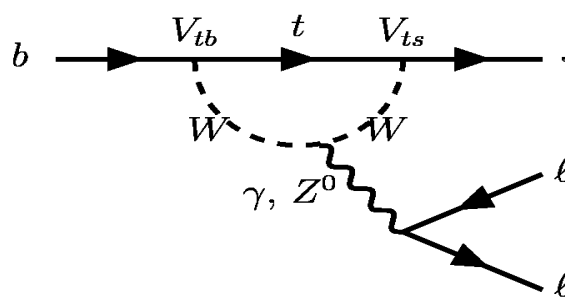
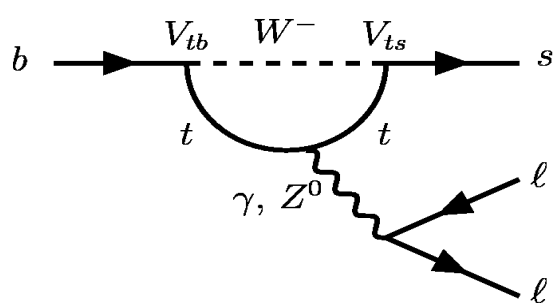
- High precision experiment
 - Excellent vertex and momentum resolution
 - **Precise particle identification**
- Dedicated to CP violation and rare decays in the b-sector
 - large $b\bar{b}$ cross section: $\sim 300 \mu\text{b}$

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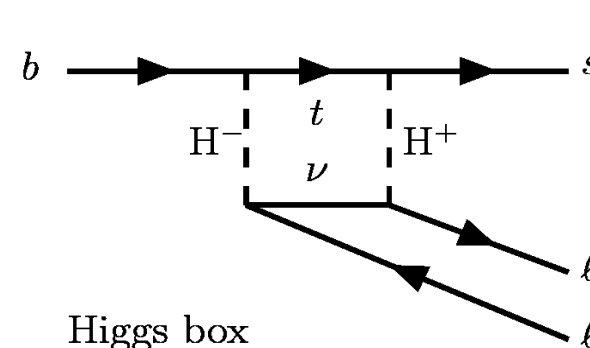
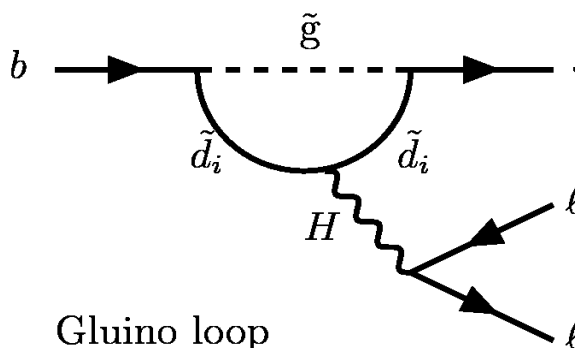
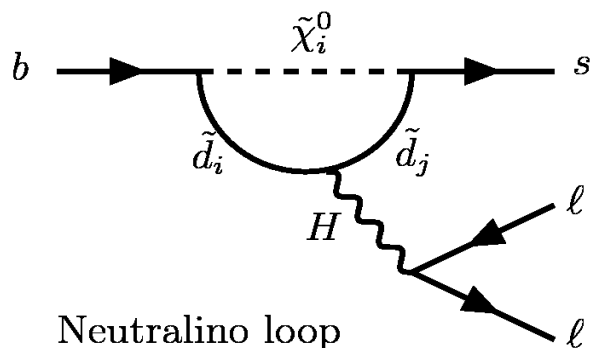
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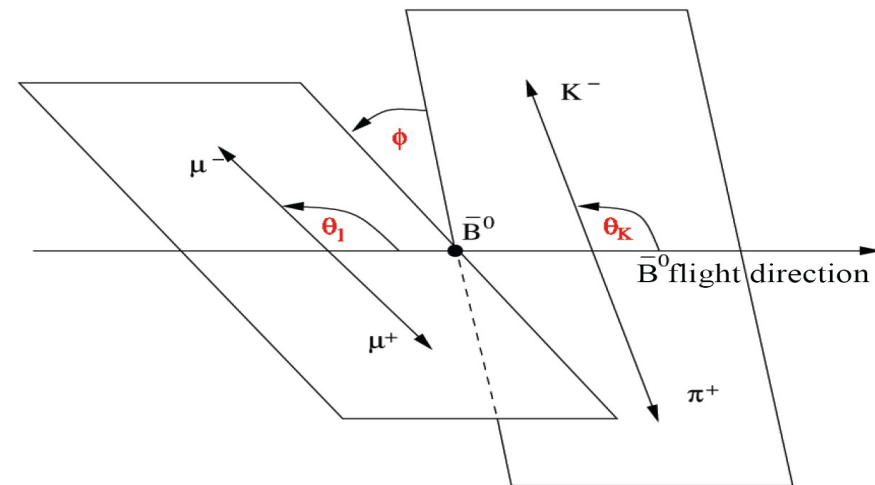
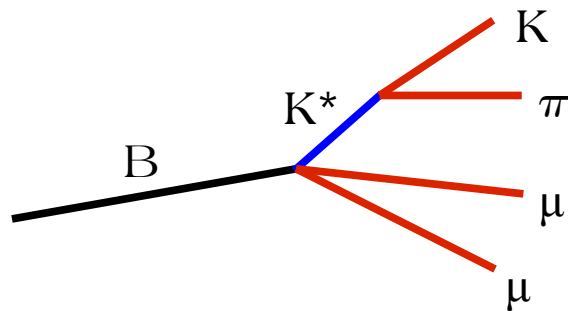
- $B \rightarrow K^* \mu \mu$ is a rare decay ($BR: 1.15 \cdot 10^{-6}$)
 - Forbidden at tree level in SM (FCNC)
 - Penguin or box diagram



- sensitive to new physics



- Topology of the decay contains a lot of information
- Fully described by Θ_l, Θ_K, Φ and q^2



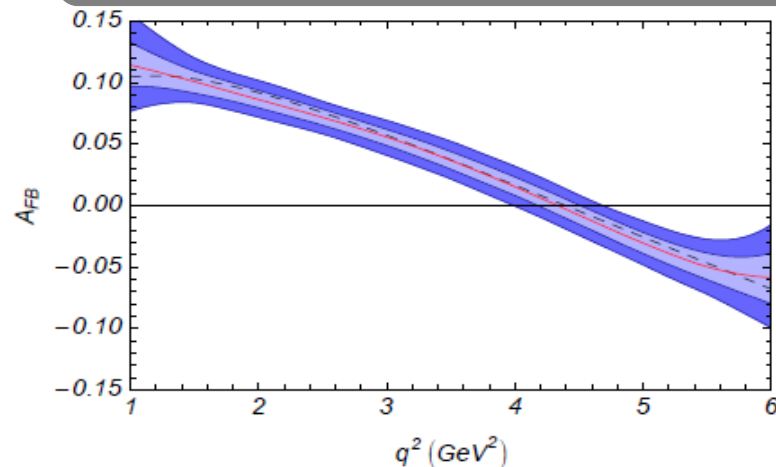
- Lots of observables, most popular is forward/backward asymmetry

$$A_{FB}(q^2) = \frac{N(\theta_l < \frac{\pi}{2}, q^2) - N(\theta_l > \frac{\pi}{2}, q^2)}{N(\theta_l < \frac{\pi}{2}, q^2) + N(\theta_l > \frac{\pi}{2}, q^2)}$$

- Precise SM prediction
- Precise measurement possible

W. Reece and U. Egede
 Public LHCb note 2008-041

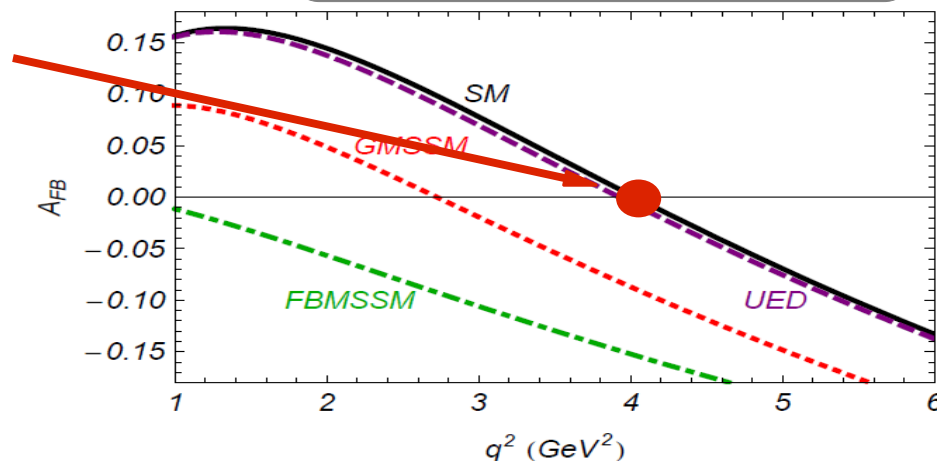
Measurement precision 10 fb⁻¹



- A_{FB} is sensitive to the Wilson Coefficients C_7, C_9 and C_{10}
- A_{FB} magnitude $\rightarrow C_{10}$
- Zero crossing point $\rightarrow C_7, C_9$

Altmannshofer, et al
 JHEP 0901.019, 2009

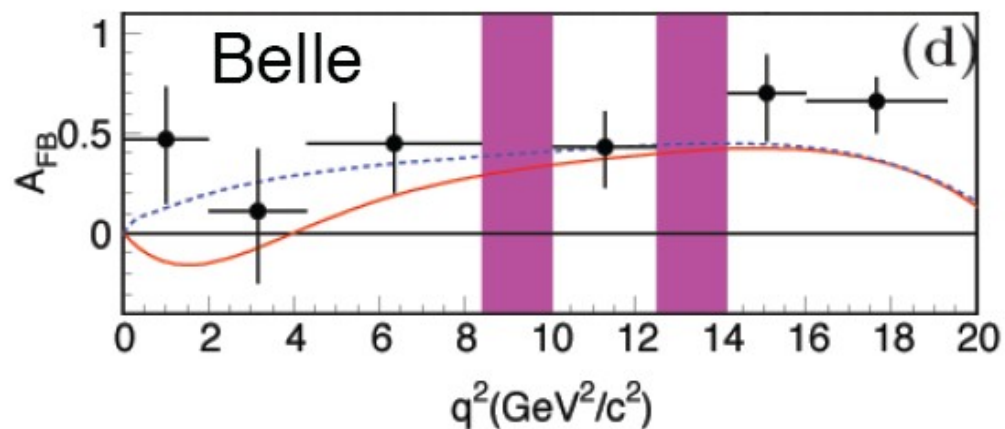
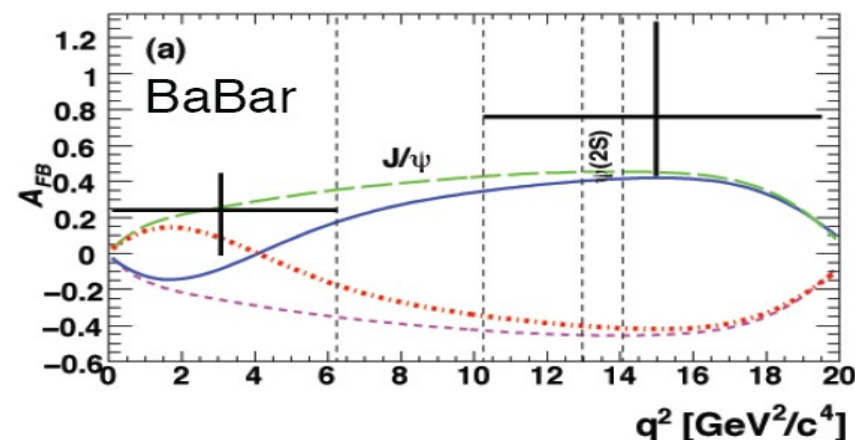
SM	Flavour blind SUSY
Universal extra dimensions	Non minimal flavor violating SUSY



- BaBar: 60 $B \rightarrow K^* l l$ events

- $384 \cdot 10^6$ $B\bar{B}$ events

BaBar Collaboration
PRD.79.031102,2009



- Belle: 230 $B \rightarrow K^* l l$ events

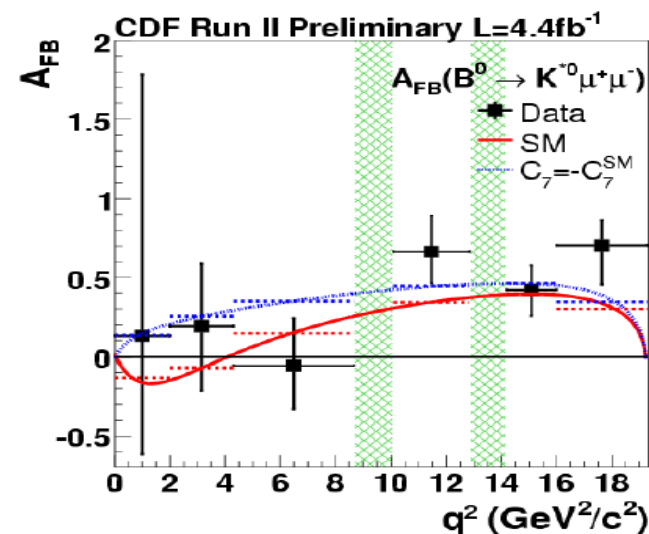
- $657 \cdot 10^6$ $B\bar{B}$ events

Belle Collaboration
PRL.103.171801,2009

- CDF: 100 $B \rightarrow K^* \mu \mu$ events

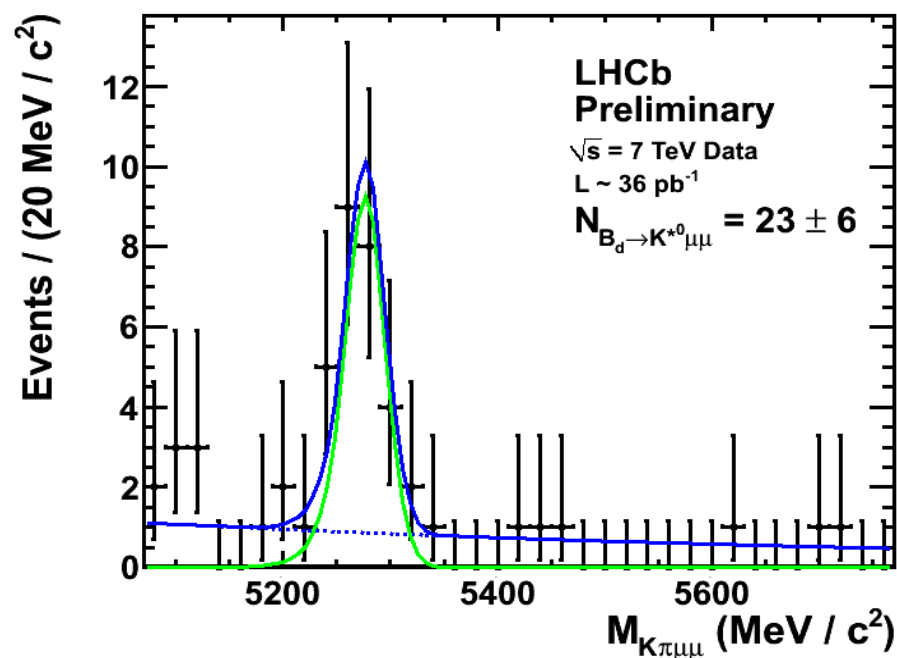
- 4.4 fb^{-1}

CDF Collaboration
CDF public note 10047



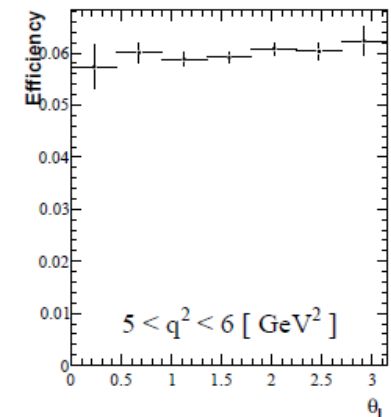
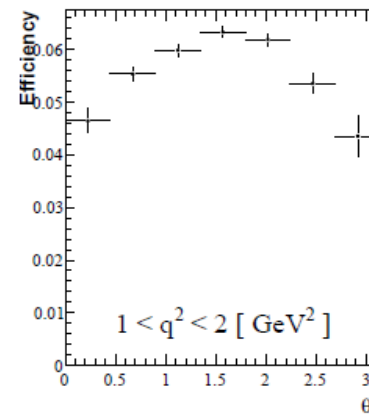
- Collected 36 pb^{-1} in 2010
 - Selection base on boosted decision tree
 - 23 ± 6 $B \rightarrow K^* \mu \mu$ events in 2010
- Collected already 82 pb^{-1} in 2011
 - We have already collected the same order of events as BaBar, Belle and CDF

$K^* \mu \mu$ mass distribution for 2010 data

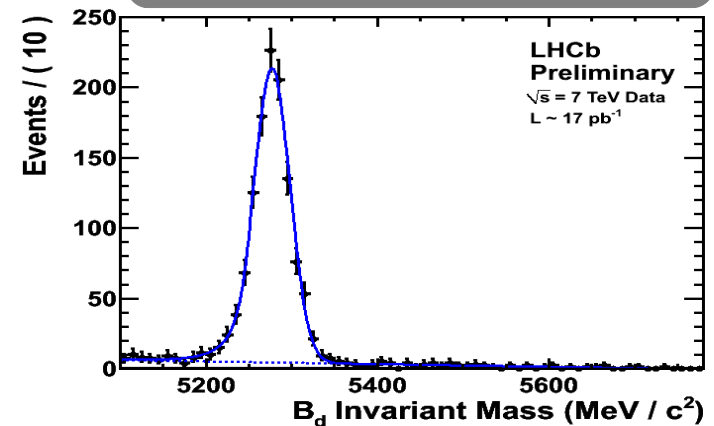


- For a clean A_{FB} measurement we need precise knowledge about efficiencies depending on Θ_1 and q^2 and correct for them
 - Acceptance effects
 - From the detector geometry
 - From reconstruction
 - From selection
- Compute event by event correction
 - Use data derived efficiencies
 - correct MC
 - Test correction on control channels
 - $B \rightarrow K^* J/\psi$

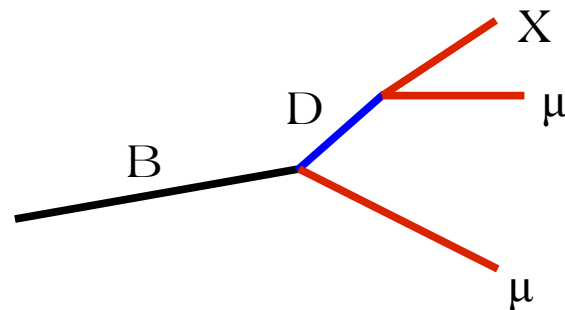
Signal efficiency derived from MC (geometry and reconstruction effects)



$B \rightarrow K^* J/\psi$ mass peak



- Background contamination has impact on the zero crossing point and its precision
 - Events with two μ 's coming from two different B decays
 - symmetric background
 - Only affects the precision of the zero crossing point measurement
 - Study backgrounds on real data obtained from B mass sidebands
 - Events with a semi-leptonic B decay and a subsequent semi-leptonic D decay in the tree
 - asymmetric background
 - Affects the zero crossing point measurement it self
 - Study background on real data obtained from electron/muon sample



- The counting method does not use all information that can be extracted from A_{FB}
 - Fitting the partial rate

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

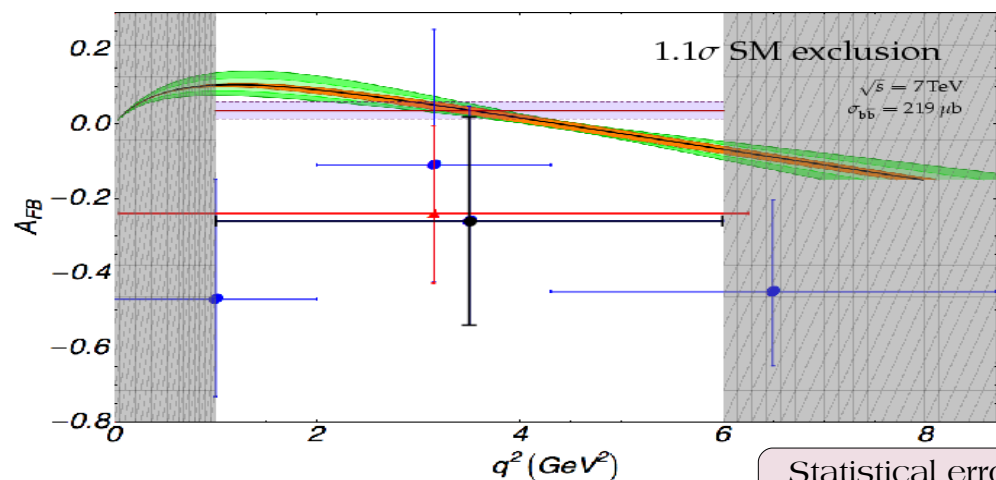
- This will allow to determine A_{FB} and F_L in one go
- Fitting partial rate on Θ_K and Φ will allow to fit additional observables and increase the measured precision

- Possible deviation from Standard Model
- Assume Belle is right, how well can we exclude the Standard Model if we measure the mean A_{FB} in the bin of 1 – 6 GeV^2

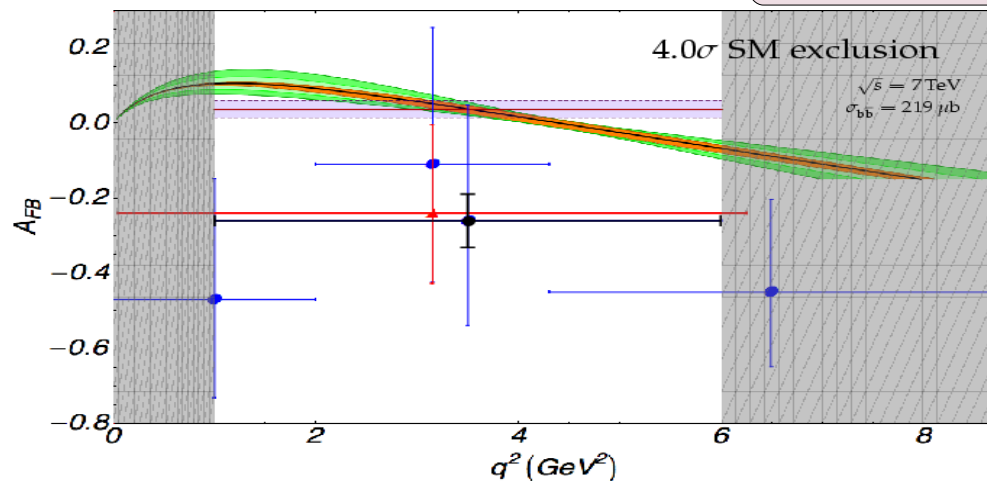
100 pb^{-1}
1.1 σ SM exclusion

1 fb^{-1}
4 σ SM exclusion

Will collect 1 fb^{-1} of data
till the end of 2011



Statistical errors only



- LHCb operated well in 2010
 - Observation 23 events of the rare decay $B \rightarrow K^* \mu \mu$ in 36 pb^{-1}
- Main issue for this analysis is to understand all possible affects on A_{FB} from acceptance effects and backgrounds
 - Work ongoing using real data to correct for this effects
- Already collected 2 times more data in 2011 than in 2010

