MEASURING B → μ μ K

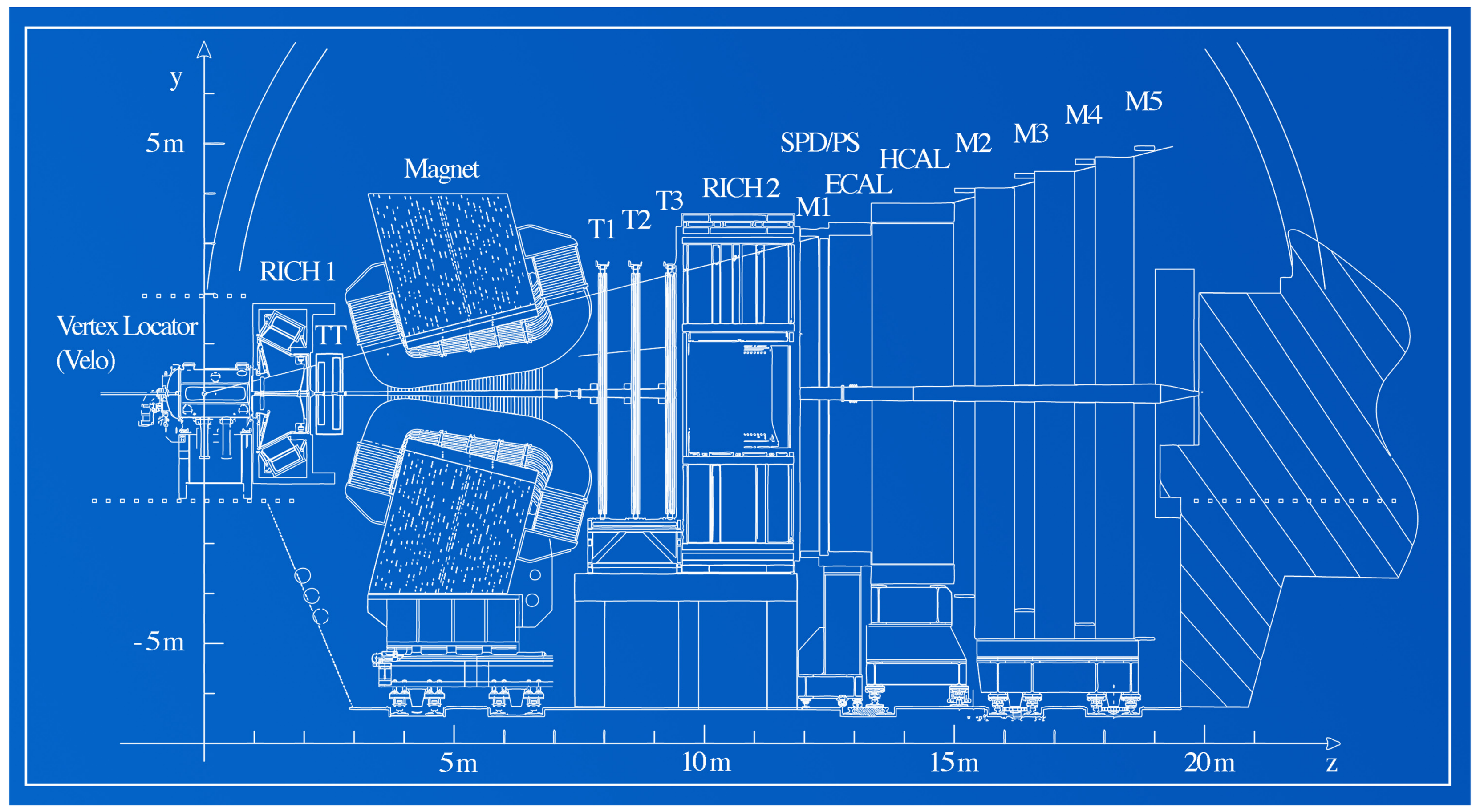
The Flavour Changing Neutral Current decay B → μ μ K, which only occurs via loop processes in the SM, is sensitive to contributions from a variety of possible new physics sources. LHCb, the dedicated b physics experiment at the LHC, will record an unprecedented number of B → μ μ K decays, allowing precision measurements of a large number of variables, which will provide evidence or place constraints for physics beyond the SM. This poster gives a short overview of the detector, introduces some of these variables and presents a selection for B → μ μ K.

University of Zurich

MICHEL DE CIAN, michel.de.cian@cern.ch

An Experiment for Beauty

The **LHCb Detector** at the Large Hadron Collider (LHC) at CERN is a dedicated b physics experiment. Since pairs of b quarks will be predominantly produced in the forward region at the LHC, it is designed as a **single-arm forward spectrometer**. The detector consists of a **tracking system** (VELO / TT / IT / OT / dipole magnet) and subdetectors for **particle identification** (RICH1 / RICH2 / ECAL / HCAL and the Muon System). The momenta of the particles are determined by comparing their flight direction before and after the bending of their trajectories due to the **magnet.**



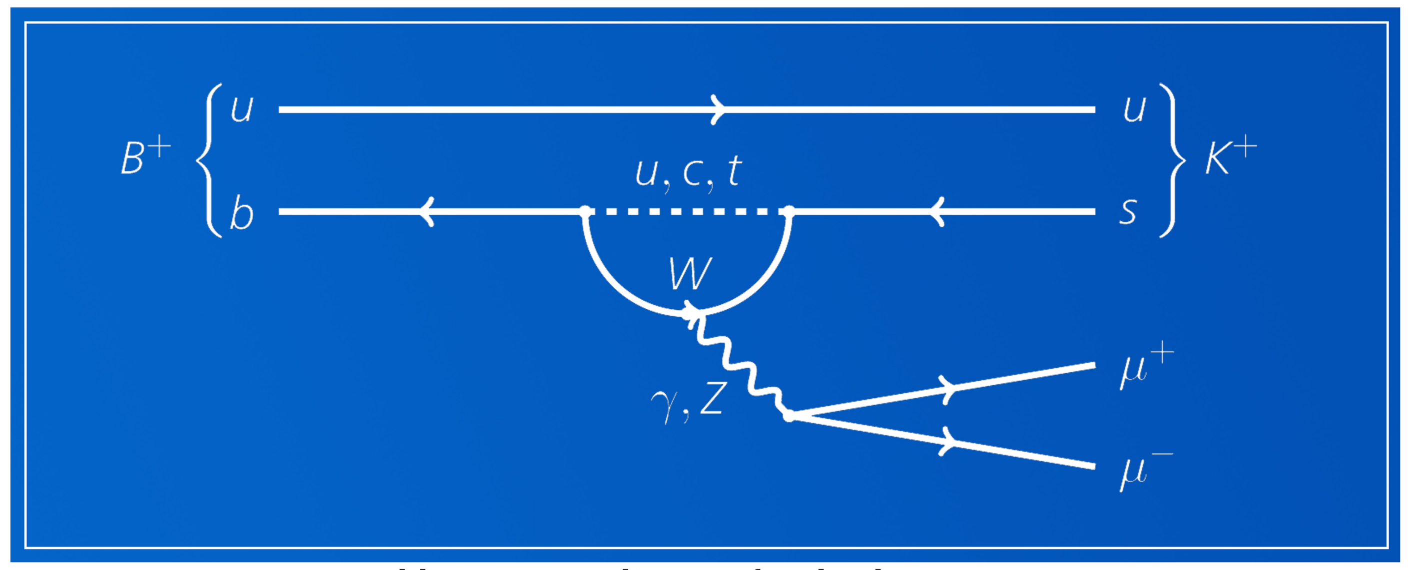
Sideview of the LHCb detector

The Decay B → μ μ K

In the Standard Model (SM), **Flavour Changing Neutral Currents (FCNC)** are forbidden at tree level. The transition b → s therefore only occurs within loop processes, which are heavily suppressed in the SM. They, however, can be enhanced in several models beyond the SM. This makes FCNCs an excellent probe for new physics, as new physics can enter at the same level as the SM processes.

The rare decay B → μ μ K has been examined (with only very limited statistics available) at the b factories Belle and BaBar, and in the Tevatron experiments. The present measured value for the branching fraction is consistent with SM predictions and is:

$$\mathcal{B}(B \to \mu\mu K) = (3.9 \pm 0.9) \cdot 10^{-7}$$



Possible Feynman diagram for the decay B → μ μ K

Measurements in B → μ μ K

At LHCb, we will be able to measure a variety of physics variables:

• **Branching fraction:** With the first 100 pb^{-1} of data on an energy of 4 TeV, the statistical error on the branching fraction can be reduced to ~ 6.5 %, corresponding to a reduction factor of ~ 3 with respect to previous measurements (assuming $\sigma_{b\bar{b}}$ ~ 500 μb).

• **Cos θ**: This angle is measured between the B$^+$ and the μ$^-$ in the di-muon rest-frame. The SM predicts:

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta} \propto (1-\cos^2\theta) + \mathcal{O}(m_l^2)$$

In models beyond the Standard Model, the distribution may get enhanced and look like:

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta} = \frac{3}{4}(1-F_H)(1-\cos^2\theta) + \frac{1}{2}F_H + A_{FB}\cos\theta$$

with F_H, giving hints to Higgs contributions, and A_{FB}, the forward-backward asymmetry of positive Muons in the di-muon rest-frame. The determination of the cos θ distribution may therefore discriminate the form of physics beyond the SM.

• **R_K:** The ratio R_K is defined as

$$R_K = \frac{\int_{q^2_{min}}^{q^2_{max}} dq^2 \frac{d\Gamma(B\to K\mu^+\mu^-)}{dq^2}}{\int_{q^2_{min}}^{q^2_{max}} dq^2 \frac{d\Gamma(B\to Ke^+e^-)}{dq^2}} \stackrel{SM}{=} 1 + \mathcal{O}\left(\frac{m_\mu^2}{m_b^2}\right)$$

Measuring this ratio is a comparable analysis as measuring cos θ, it may give hints to the form of new physics. The challenging task in R_K is to determine the branching fraction of B → e e K, the electron spectra being heavily affected by Bremsstrahlung.

The joint measurement of R_K and the branching fraction of B_s → μ μ will reveal different physics scenarios, each of them excluding or verifying assumptions made for SUSY- or Minimal Flavor Violation models.

A Selection for B → μ μ K

A selection, based on Monte Carlo data, was developed for B → μ μ K. The following criteria were applied, in order to select a sample with high purity:

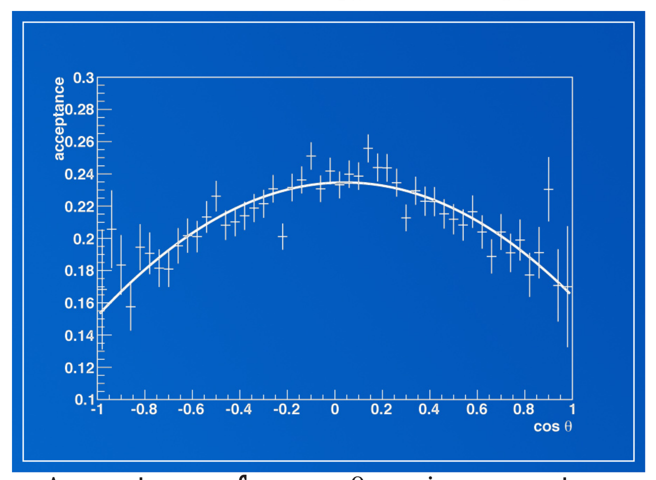
- **Momentum criteria:** Applied to the muons and the kaons to ensure a stable particle identification rate and to cut away large amounts of background. p_T cuts are avoided to prevent distortion of the cos θ acceptance.
- **Vertex quality:** The tracks of the two muons and the kaon are required to perform a good vertex fit.
- **Vertex separation:** The impact parameter of the B meson needs to be compatible, the one for the kaon incompatible with the primary vertex.
- **Track isolation criteria:** In order to veto jets, the muon and the kaon tracks need to be isolated from the rest of the event.
- **Flight direction:** The flight direction of the B meson (the line joining the primary and secondary vertex) has to be compatible with the summed momentum of the two muons and the kaon.
- **Mass cut:** The di-muon invariant mass is required to be further away than 5 σ from the J/Ψ- and the Ψ(2S) mass to reject B → J/Ψ K events.

In real data, these variables will be calibrated using the decay **B → J/Ψ K as a calibration channel for the signal**. For the background, sidebands around the B mass peak will be used. In the Monte Carlo study, the background comprised of samples with **$b\bar{b}$ → μ μ X** and **misidentified particles**. In addition, several exclusive modes like B → μ μ K* were studied, but no contribution remained in the mass window. The preliminary results for a B mass window of 60 MeV after trigger, reconstruction and selection are:

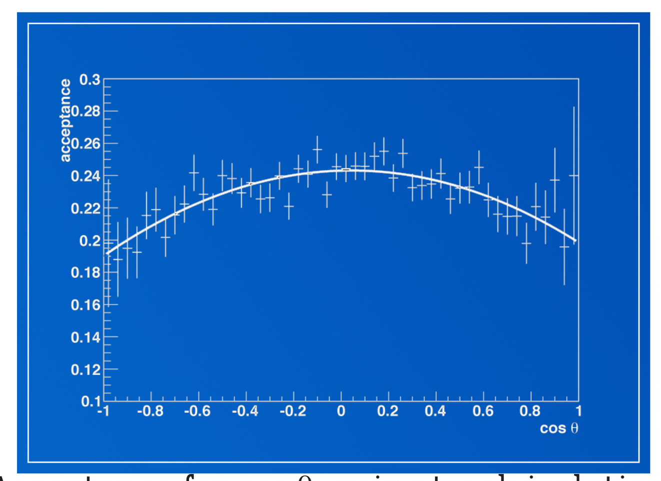
Expected Signal Yield in 100 pb^{-1} at 4 TeV per beam	230
Trigger Efficiency	80%
Expected S/B	3.8

Acceptance Effects

Acceptance effects play a major role in the analysis of cos θ. An ongoing study hints that by **avoiding p_T cuts** in the whole selection and applying track isolation criteria instead, the flatness of the acceptance can be improved (while retaining the signal yield), especially at extreme values of cos θ, where the sensitivity is highest for F_H and A_{FB}.



Acceptance for cos θ, using p_T cuts



Acceptance for cos θ, using track isolation

Typeset in Garamond and Base Twelve