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Searches for Lepton Flavour Violation at LHCb

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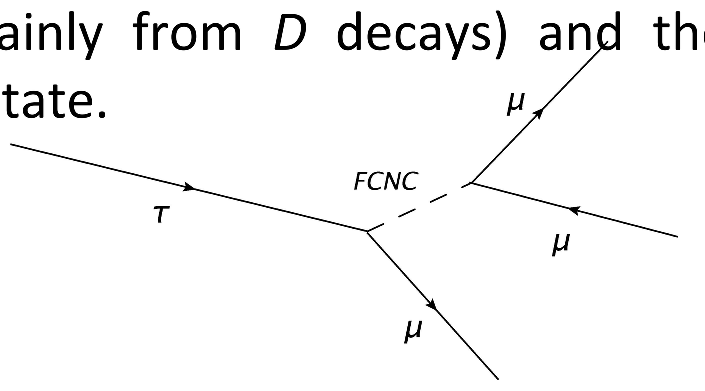
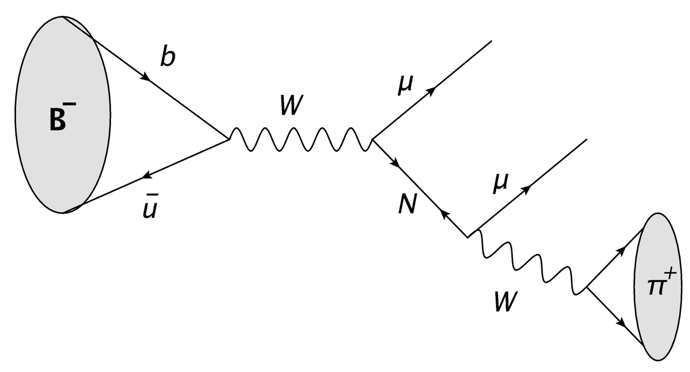
Introduction

Neutrino oscillations are in conflict with the Standard Model (SM) since it assumes neutrinos to be massless. Neutrino oscillations mean that lepton flavour is not conserved, but the small size of the neutrino mass means that lepton flavour violating decays have a branching fraction of 10^{-40} [1]. Theories beyond the SM predict larger values for the BRs, reachable by experiments at the LHC [2].

The search for LFV in $\tau \to \mu\mu\mu$ at LHCb is motivated by the large production of tau particles at the detector (mainly from *D* decays) and the clear signature of three muons in the final state.

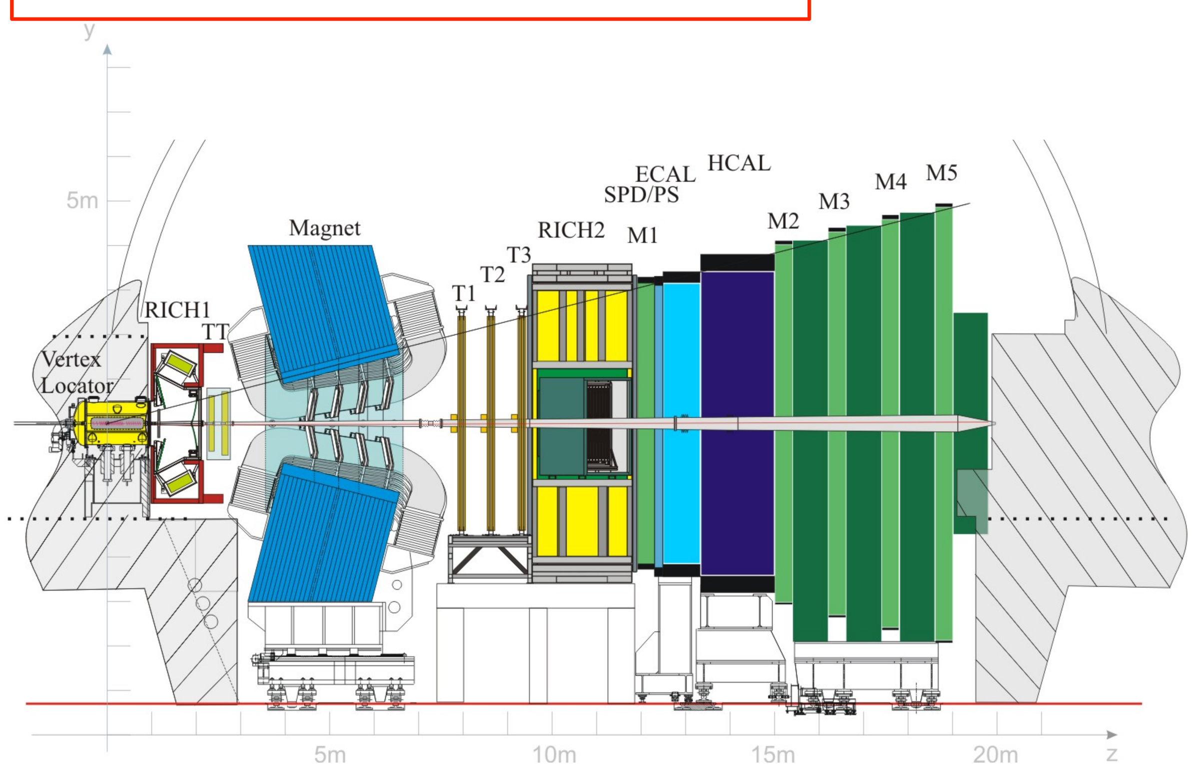


On the other hand, lepton number violation (LNV) is forbidden in the SM, but can occur through lepton mixing by non-SM particles, as Majorana neutrinos. This is studied in charged B decays, where like-sign μ are searched for in the final state. Any indication of these decays would imply the presence of new physics.



[1] Eur. Phys. J. C57 253 (2008) 13
[2] Ann. Rev. Nucl. Part. Sci 58 (2008) 315

The LHCb detector



The LHCb detector [3] is a single-arm spectrometer designed for precision studies of *b* and *c* hadrons in the forward direction.

The detector includes a high precision tracking system consisting of a silicon-strip vertex locator (VELO) , located upstream of a dipole magnet with a bending power of 4Tm and three stations of silicon-strip detectors and straw drift tubes placed downstream. The combined tracking system provides a momentum measurement with relative uncertainty between 0.4 and 0.6% and impact parameter resolution of 20μm for particle with large transverse momentum.

Different types of charged hadrons are distinguished by information from two Cherenkov detectors. A calorimeter system allows the identification of photons, electrons and hadrons. Muons are identified by a system composed of layers of iron and multiwire proportional chambers.

[3] JINST 3 315 (2008) S08005

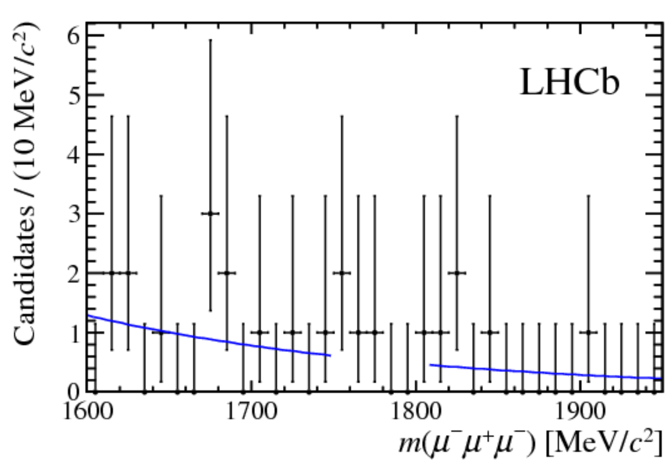
LHCb Analysis and Results

Search for LFV

[Phys. Lett. B 724 (2013)]

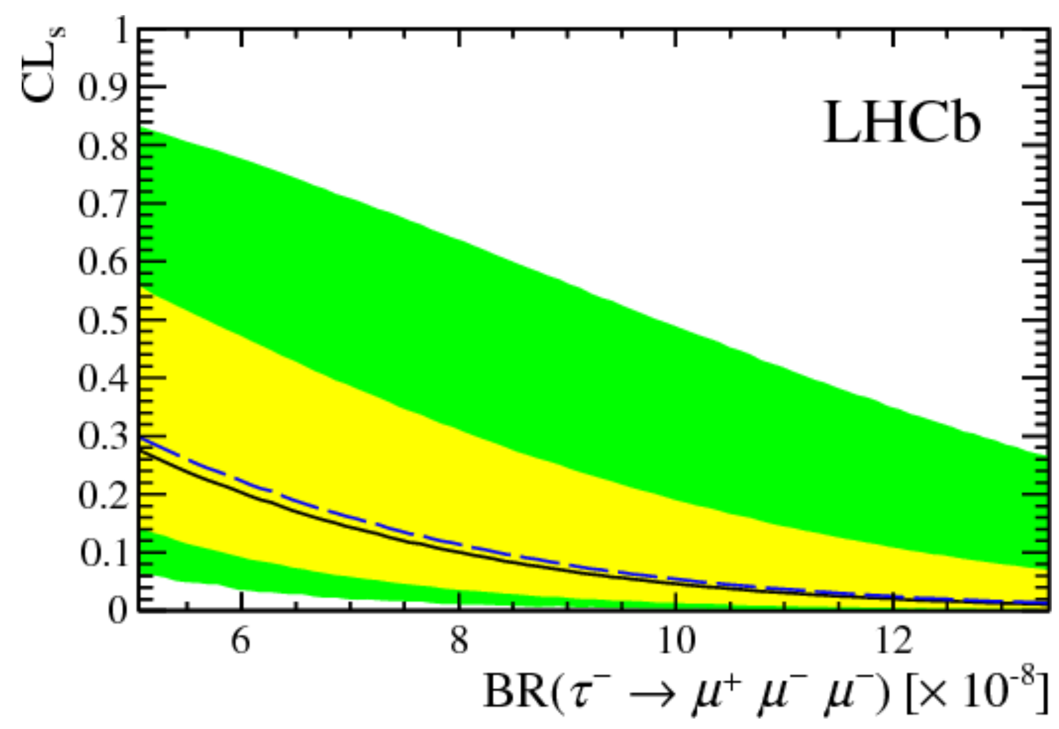
Use of 1fb^{-1} data, collected at LHCb during 2011 at √s = 7TeV.

Same topology for signal ($\tau \to \mu\mu\mu$) and normalisation channels ($D_s^- \to \phi(\mu\mu)\pi$): displaced vertex and three tracks. Veto on the ϕ mass for the signal mode. A combination of three likelihoods (mass of the three tracks, compatibility of the tracks to be muons and displaced 3-body vertices) is used to distinguish between signal and background.



No signal observed, LHCb sets the first limit at a hadron collider.

$BR_{\tau\to\mu\mu\mu} < 9.8\ 10^{-8}$ (95% CL_s)



Search for heavy Majorana ν

[LHCb, PRL 112 (2014) 131802]

Used 3fb^{-1} of data (collected in 2011 and 2012, with a centre of mass energy of 7TeV and 8TeV respectively), perform search for **short neutrino lifetime** and **long neutrino lifetime** with lifetime between 0 and 1ns and a mass between 0.25 and 5GeV where the relation

$$m_\pi + m_\mu < m_\nu < m_B - m_\mu$$

is fulfilled within the $B \to \pi\mu\mu$ decay.

Analysis based on a cut-based pre-selection followed by a multivariate algorithm.

No signal observed, sets the best world limit at **BR < $4 \cdot 10^{-9}$ at 95% CL**. Result used to set limits on $|V_{\mu 4}|$ as a function of the neutrino mass makin use of the formula from Atre *et al.* [4].

[4] J. High Energy Phys. 05 (2009) 030