B(s)→eμ: search for lepton flavour violation at LHCb

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Introduction

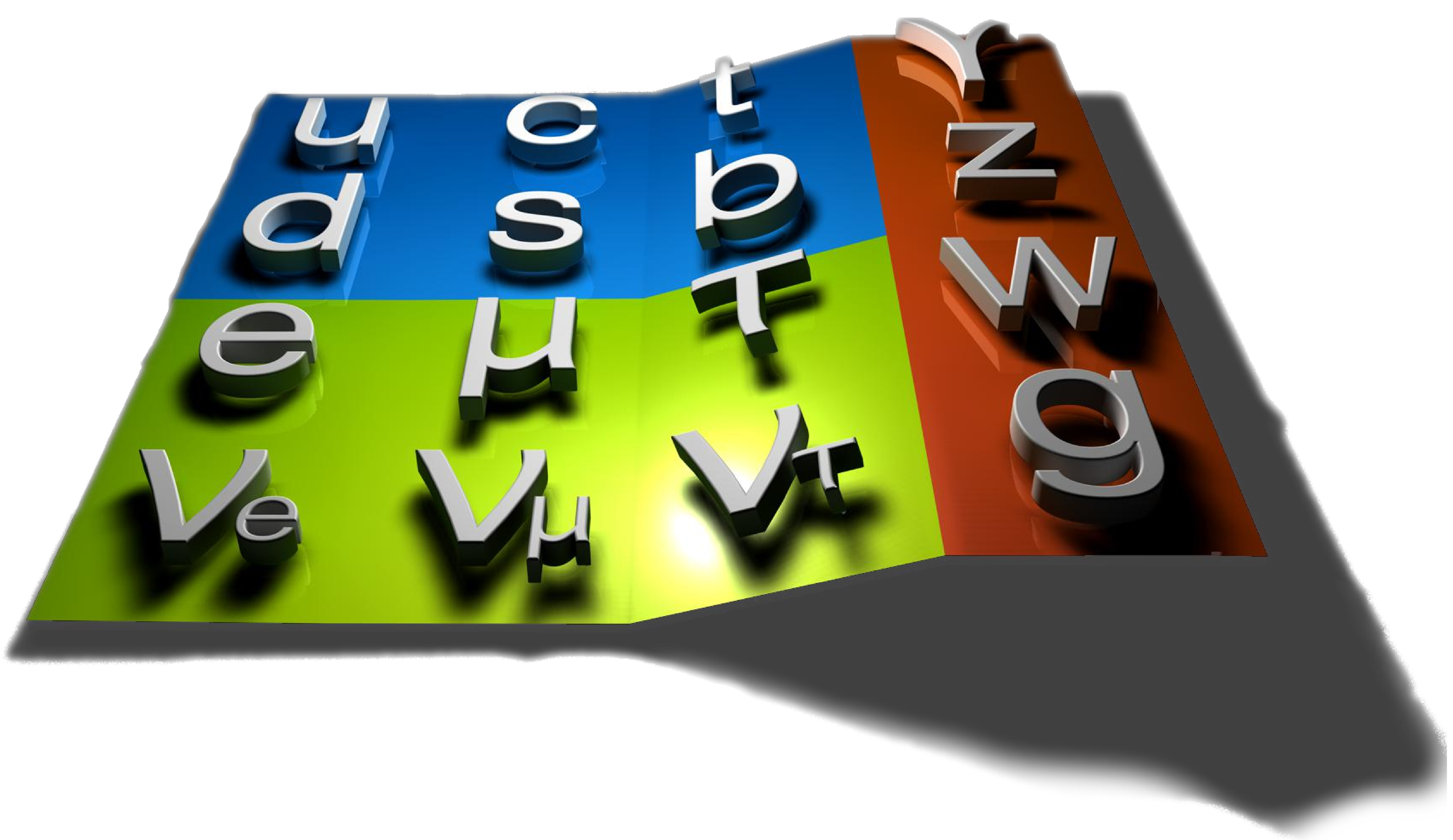
Flavour physics is the study of the interactions that distinguish between the three different copies of fundamental fermions. Within the Standard Model quarks, leptons, and neutrinos appear in three flavours, and only the interaction with the Higgs boson distinguishes these flavours, leading to flavour non-universality.

Through the years a clear understanding of the underlying mechanism of flavour mixing and flavour non-universality has emerged, and this mechanism has been successfully verified in experiments.

However, flavour physics still represents one of the most puzzling and, at the same time, interesting aspects of particle physics, summarized by two open questions:

- What determines the observed pattern of masses and mixing angles of quarks and leptons?
- Which are the sources of flavour symmetry breaking accessible at low energies?

Answering these questions is a key part of the more general program of investigating the nature of physics beyond the Standard Model.



Lepton (Flavour) Universality

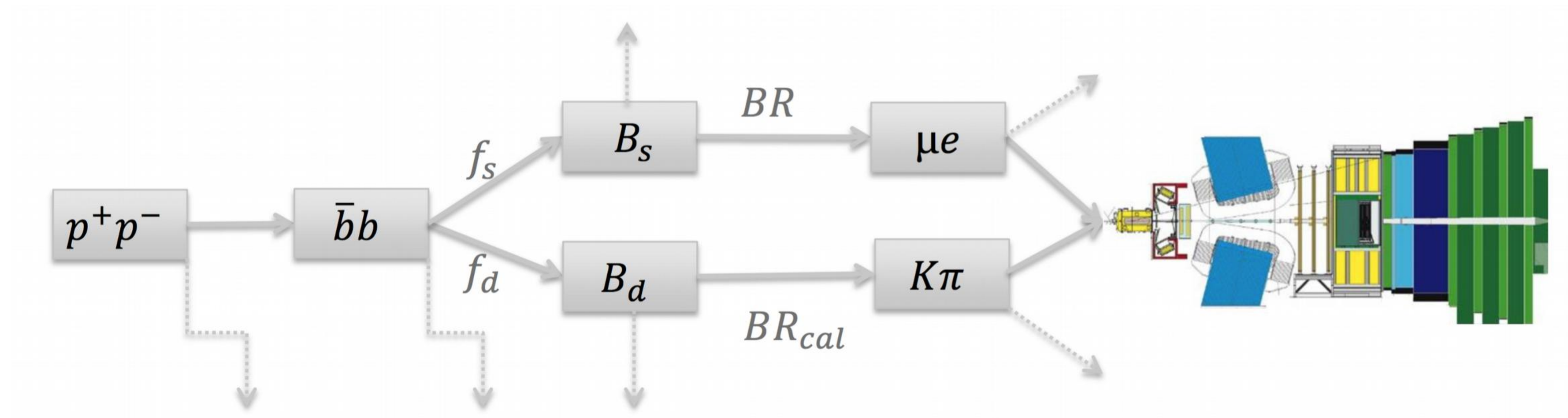
The weak interaction strength is the same for all lepton flavours. This is referred to as lepton universality. Contrary to quark flavour mixing, lepton flavour mixing seems to be exclusive for the neutrinos, notably neutrino oscillations. Flavour mixing of the charged leptons has not been observed, and is predicted to be unmeasurably small by the Standard Model. Experimental observation of charged lepton flavour mixing would thus unambiguously signal new physics.

LFV Searches at LHCb

Excellent particle identification and momentum resolution make LHCb an ideal environment to search for rare decays. We investigate LFV through decays of heavy B and D mesons into muon-electron pairs. Earlier LHCb results (90% CL) for the branching ratios were reported:

- **$Br(B^0 \to e\mu) < 2.8 \times 10^{-9}$ (1 fb^{-1})**
- **$Br(B_s^0 \to e\mu) < 1.1 \times 10^{-8}$ (1 fb^{-1})**
- **$Br(D^0 \to e\mu) < 1.3 \times 10^{-8}$ (3 fb^{-1})**

The analysis of $Br(B_{(s)} \to e\mu)$ for the 2011 & 2012 3fb^{-1} data is expected to be finalized soon.



Hints for Lepton Non-Universality

Recent experimental data in high energy physics hint toward violation of Lepton Universality in semi-leptonic decays. The statistically most significant results are for (with ℓ=e,μ):

- **$B \to D^* \ell \bar{\nu}_\ell$ 3.8σ [1,2,3]**
- **$B \to D \ell \bar{\nu}_\ell$ 2.0σ [1,2,3]**
- **$B \to K \ell^+ \ell^-$ 2.6σ [3]**
- **$h \to \mu\tau$ 2.5σ [4,5]**

[1]BaBar, [2]Belle, [3]LHCb, [4]ATLAS, [5]CMS

Violation of lepton universality necessarily leads to lepton flavour violation, as no known symmetry principle can protect the one in the absence of the other.

Implications & Prospects

Several models attempt to explain the observed non-universality, while meeting limits on decays such as $B_{(s)}^0 \to \mu\mu$ and severe constrains from e.g. $\mu \to e\gamma$ and $\mu \to eee$. Some of these models predict LFV signals within reach of LHCb†. Interesting links exist with the $pp \to \gamma\gamma$ (750GeV) excess‡, and the $(g\text{-}2)_\mu$ anomaly¶.

New measurements will help to constrain these models.

†e.g. Leptoquarks: Sahoo, Mohanta, arXiv:1512.04657; new interactions: Glashow, Guadagnoli, Lane, Phys. Rev. Lett. 114, 091801 (2015)
‡e.g. Two Higgs doublet: Bizot, Davidson, Frigerio, Kneur, arXiv:1512.08508
¶,e.g. Doubly charged scalar: Chakrabortty, Ghosh, Mondal, Srivastava, arXiv:1512.03581