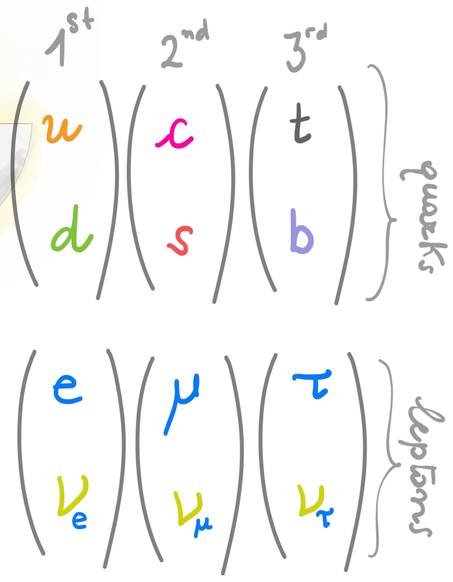
The four forces of nature

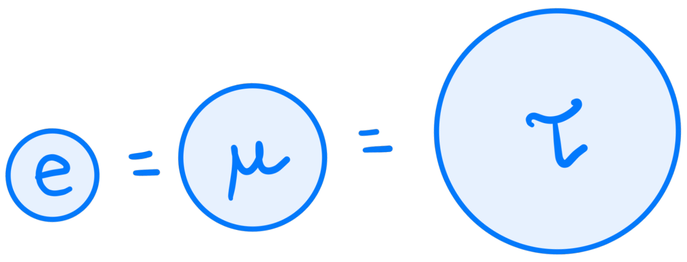
Gravitational, **electromagnetic**, **weak** and **strong** are the known fundamental forces of nature.

- They explain **phenomena** at distances ranging from **billionth of billionth of millimeters** up to **light-years**.
- The universe is composed by quarks and leptons **organised in 3 families** - stable matter is only made out of the **first one**!



- The other **two families** are artificially produced at the LHC in **high energy proton-proton collisions**.
- The **known forces** interact with the **same strength** with all leptons, **regardless of their family**

Lepton flavour universality



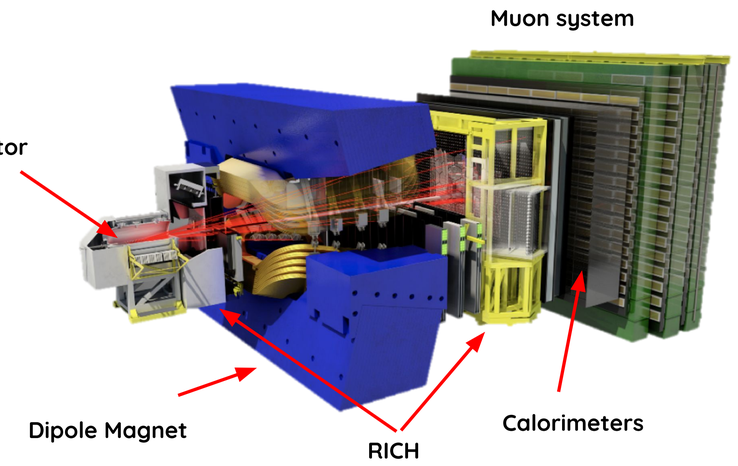
The **only known exception** being the **Higgs particle**, causing them to have **different masses**

- **Any deviation** from this behaviour would point to **new unknown phenomena!**

b is for beauty

The **LHCb detector** is a massive detector, situated at one of the four proton-proton collision points **at the Large Hadron Collider (CERN)**

- The b in LHCb stands for **beauty quark**, which is like a down quark but very **heavy and unstable**.
- We **study** 'b-quarks' by looking at **their decay products** inside the LHCb detector.
- This helps to **shed light on the mysteries of the Universe** such as matter-antimatter asymmetry, lepton flavour universality and much more!

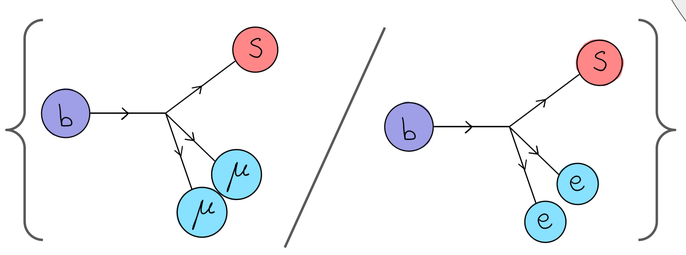


Not everyone knows that:

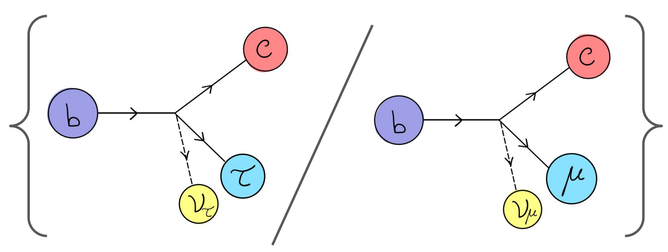
- **One trillion 'b-quarks'** are produced every year in LHCb
  - The LHCb collects data equivalent to **a 32 meter pile of DVDs** each day!
    - You can **visit LHCb** right now!

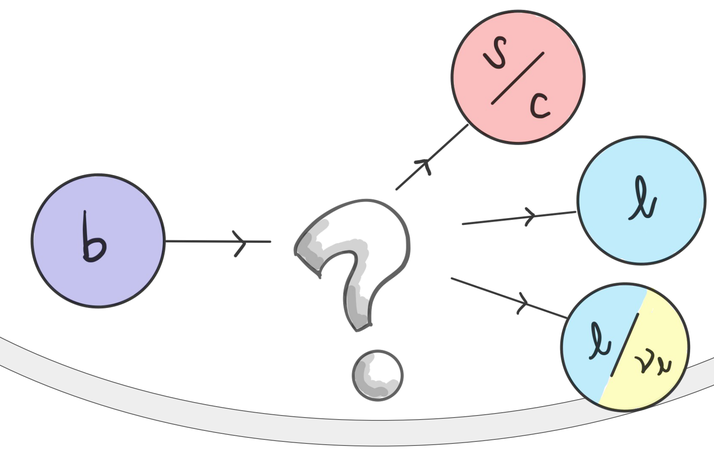
Hints of a 5th force at LHCb

R_K

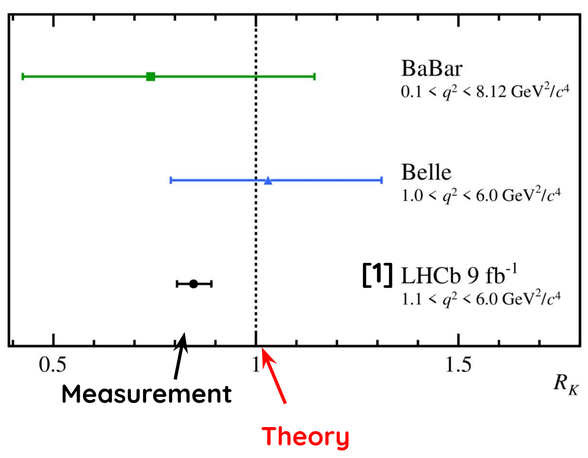


R_{D^*}



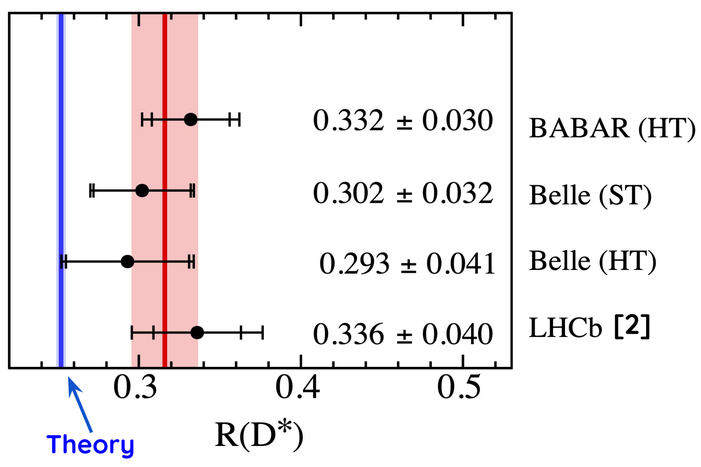


Muons/Electrons



- We **test lepton flavour universality** by **measuring the ratio** R of how many times a **b-quark decays to different lepton families**
- We **expect** these numbers to be **the same**, up to effects due to the different lepton masses.
- We observe a **consistent deviation** from the **value predicted** by theory!

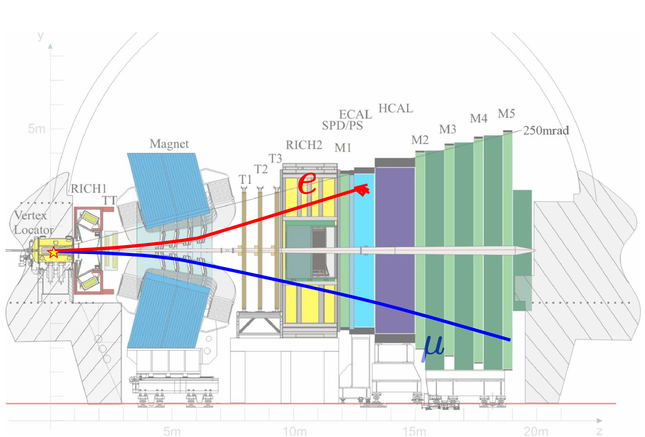
Taus/Muons

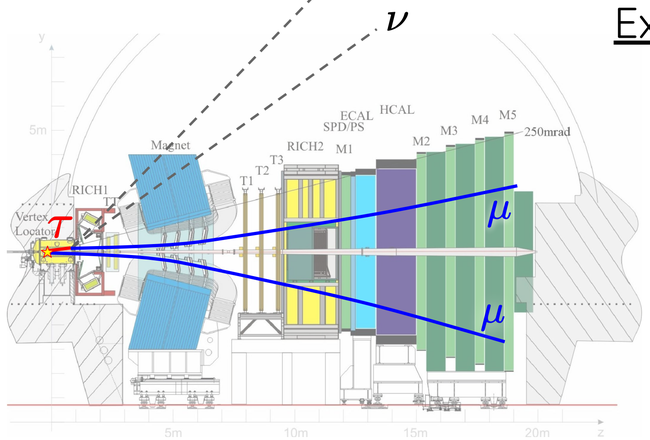


Experimental challenges:

Electrons and muons interact with the detector very **differently**:

- **Muons** go through almost **undisturbed**
- **Electrons lose** significant **energy** and are way more **difficult** to **reconstruct**





Experimental challenges:

Some of the **decay products** of the tau leptons **are neutrinos**:

- **Neutrinos interact very feebly** with matter and therefore **pass undisturbed** through the detector
- The b-quark **decay** can **not** be **fully reconstructed**

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Are we close to finding a new force of nature?

Come and join the effort!

For more info visit our webpage:

References
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[2] https://www.nature.com/articles/nature22346.pdf

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