

Belle II – The Beauty and the Flavour

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HELMHOLTZ



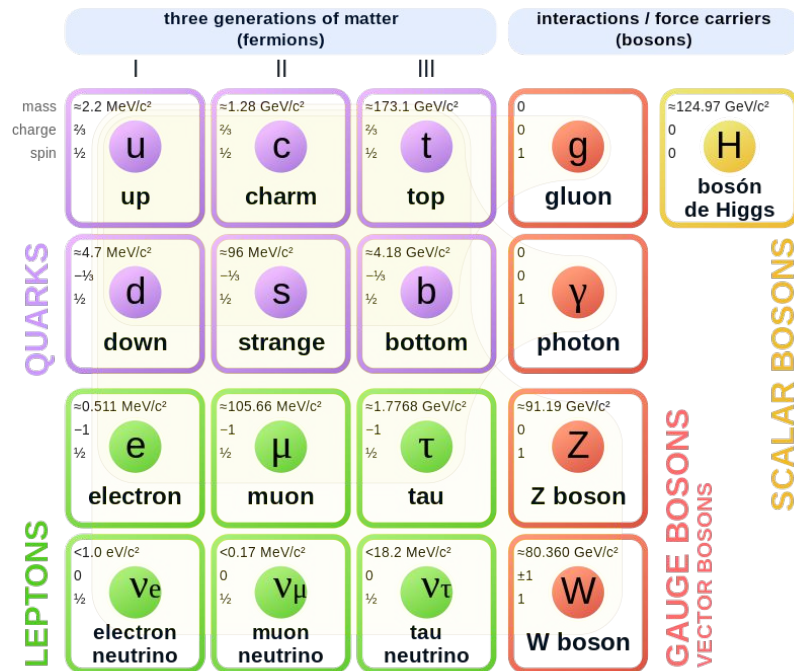
Introduction

- Standard Model
- SuperKEKB / Belle II
- Why is Belle II an important experiment ?
- Particle physics at Belle II: examples
- Conclusions

Standard Model

- **Electromagnetic force**
 - Charged particles: charged leptons, quarks
 - Force carrier: photon
- **Strong force**
 - Coloured particles: quarks
 - Force carrier: gluon(s)
- **Weak force**
 - Fermions: leptons, quarks, neutrinos
 - Force carrier: W^+ , W^- , Z^0
- **Higgs boson**
 - Gives a mass to particles

Standard Model of Elementary Particles



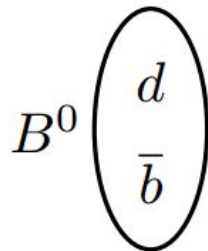
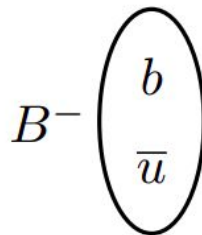
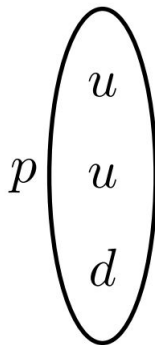
Standard Model

- Theory has been **successful** for decades
- Last missing piece: **Higgs boson**
- **BUT**
- Not enough
 - **Neutrino masses ?**
 - **Matter - antimatter asymmetry ?**
 - **Dark matter / dark energy ?**
 - **Gravity**
 - Massive particles
 - Force carrier: graviton (?)

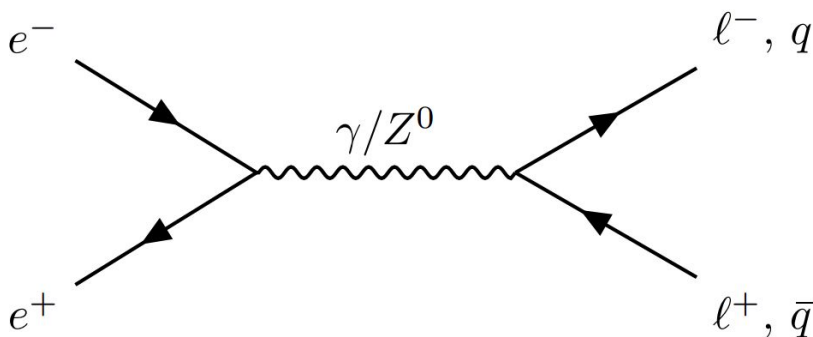
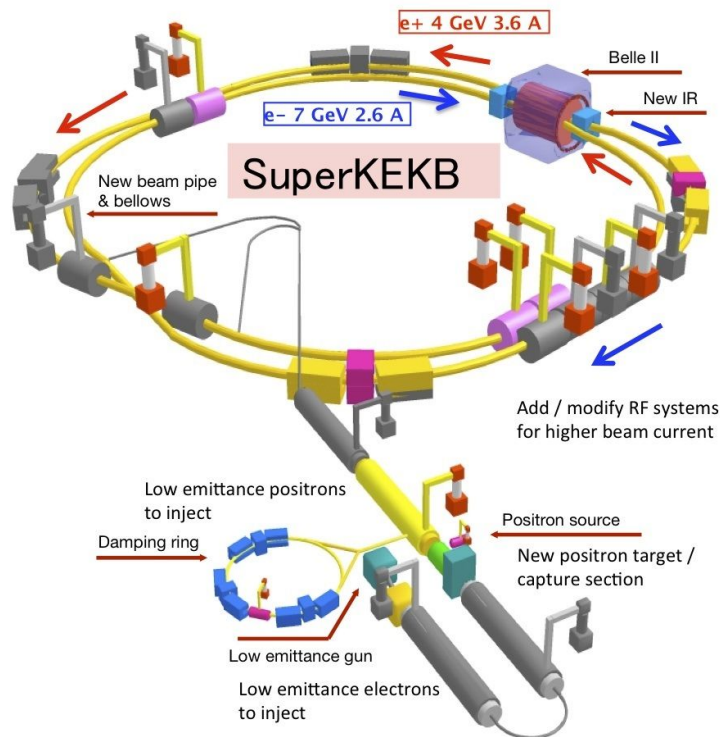
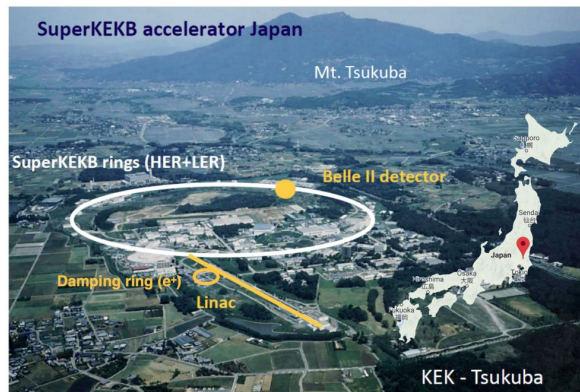
Hadrons

Mesons / Baryons

- **Composite** states of **quarks** and gluons
 - **2** quarks: **meson**
 - **3** quarks: **baryon** (proton, neutron...)
- Described by Quantum Chromodynamics (QCD)
- **B meson: 1 beauty** (bottom) quark + another quark

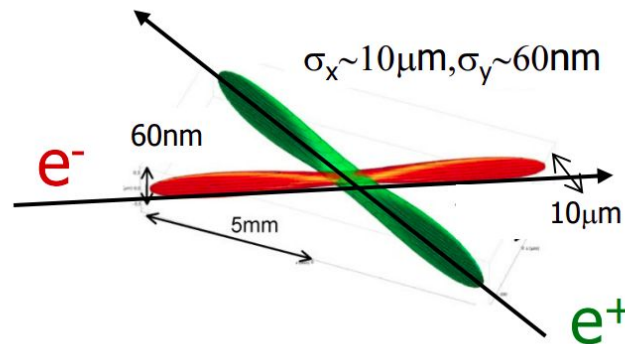
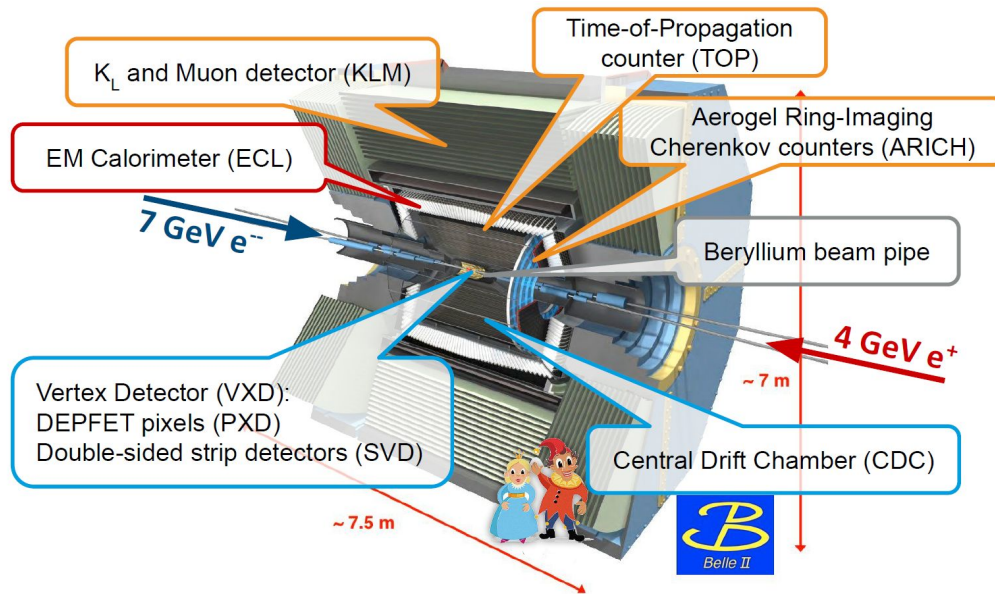


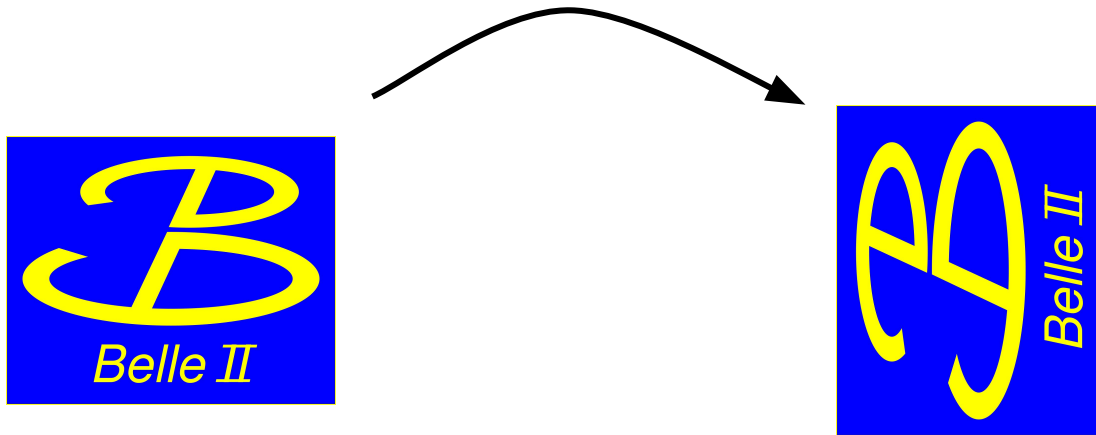
SuperKEKB



Belle II

- Improved successor of Belle
- Asymmetric **electron - positron collider**
- First collisions in **2019**
- 1300 members, 126 institutions, 27 countries



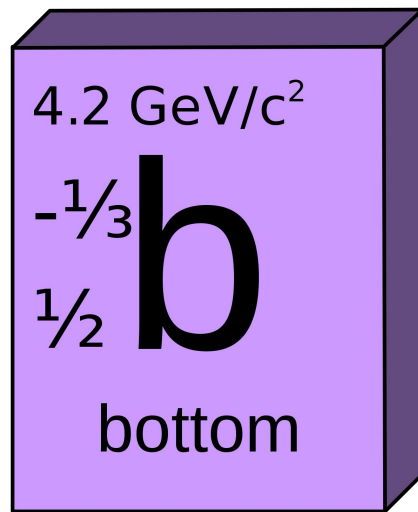
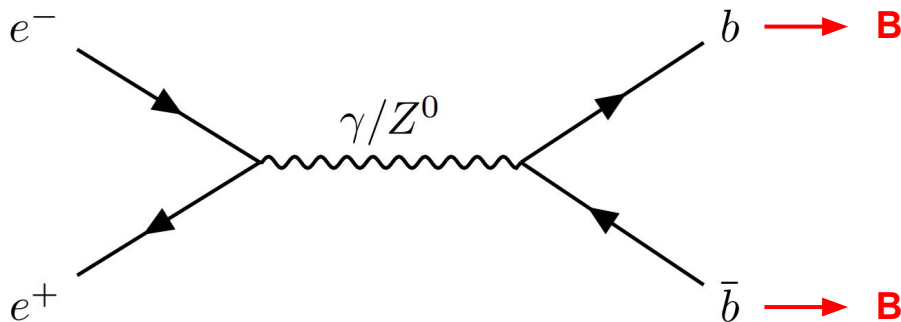


- Collisions of electrons and anti-electrons
- Beauty quarks: “belle” in French = beautiful
- BEAST experiment: **B**eam **E**xorcism for **A** **S**table Belle Experiment



Why is Belle II an important experiment ?

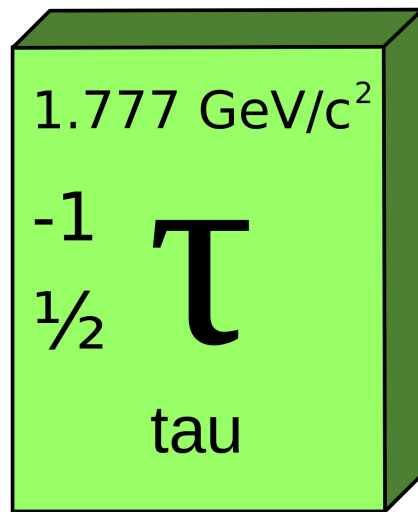
- Largest $e^+ - e^-$ collider collaboration in the world (BESIII...)
- Plenty of **physics subjects** can be covered
 - B physics (LHCb*, BaBar, Belle, CLEO...)



* Other major B physics experiment: proton-proton collisions \rightarrow complementary approaches

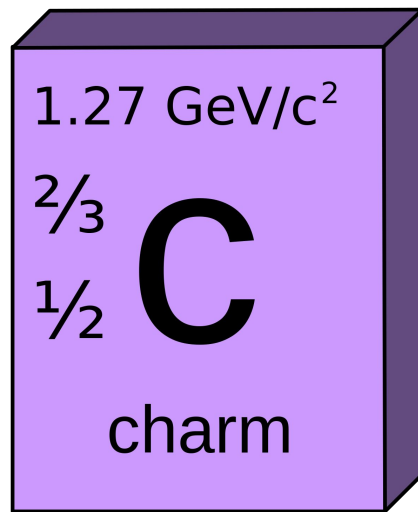
Why is Belle II an important experiment

- Largest $e^+ - e^-$ collider collaboration in the world
- Plenty of **physics subjects** can be covered
 - B physics
 - τ physics



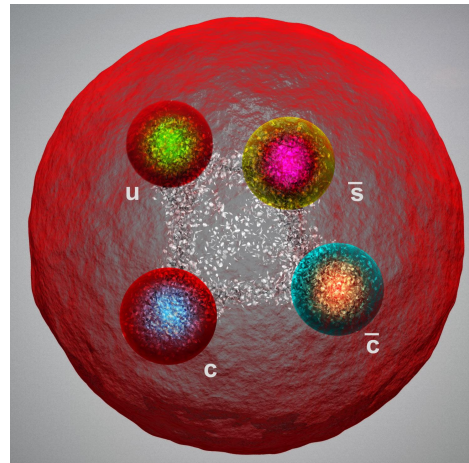
Why is Belle II an important experiment

- Largest $e^+ - e^-$ collider collaboration in the world
- Plenty of **physics subjects** can be covered
 - B physics
 - τ physics
 - Charm physics



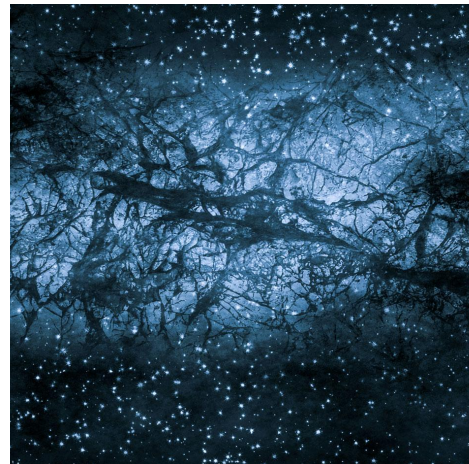
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- Plenty of **physics subjects** can be covered
 - B physics
 - τ physics
 - Charm physics
 - Exotics searches



Why is Belle II an important experiment

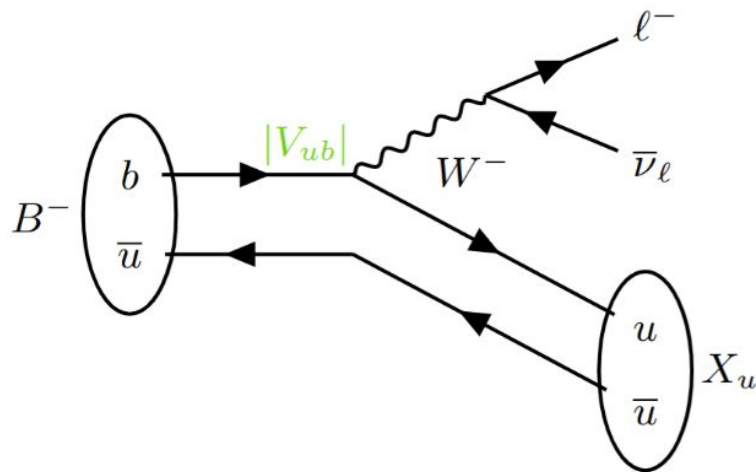
- Largest $e^+ - e^-$ collider collaboration in the world
- Plenty of **physics subjects** can be covered
 - B physics
 - τ physics
 - Charm physics
 - Exotics searches
 - Dark matter searches



Example 1

Semi-leptonic B decays

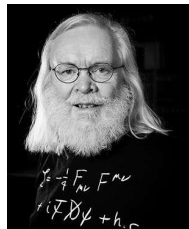
- **Count number of events** and deduce properties of decay
 - Measure **SM parameters**: V_{cb}/V_{ub}
 - Lepton flavour universality: ratio of 2 decays
- What do these events look like in a detector?
 - 1 track: lepton
 - 1 complex signature: meson
 - Missing energy: neutrino
 - Second B meson



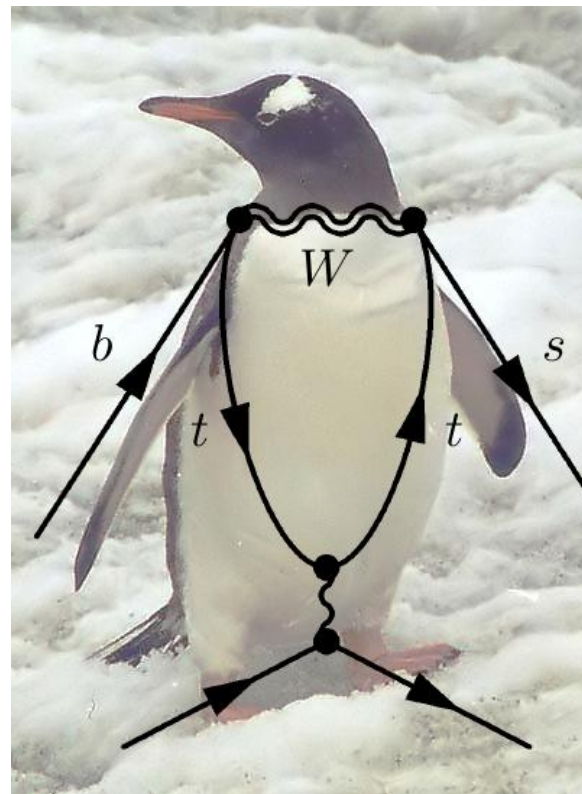
Example 2

Penguin diagrams

- John Ellis in 1977



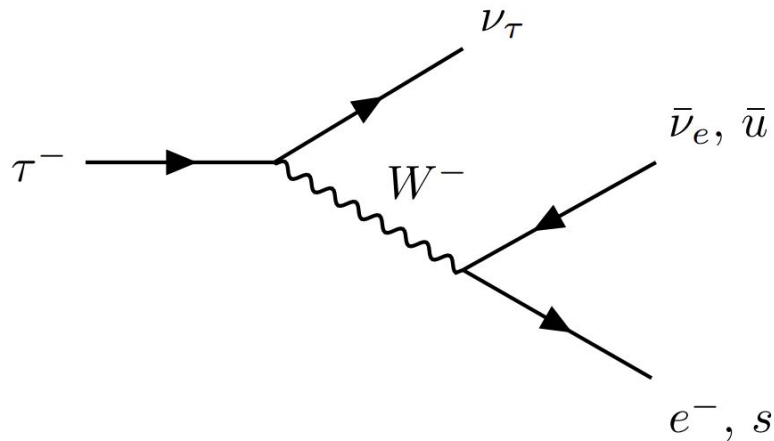
- Very **rare processes** \Rightarrow very hard to measure
 - Observation can be a challenge
 - Measure ratios
- Only **Belle II** can measure decays with **two neutrinos**



Example 3

τ physics

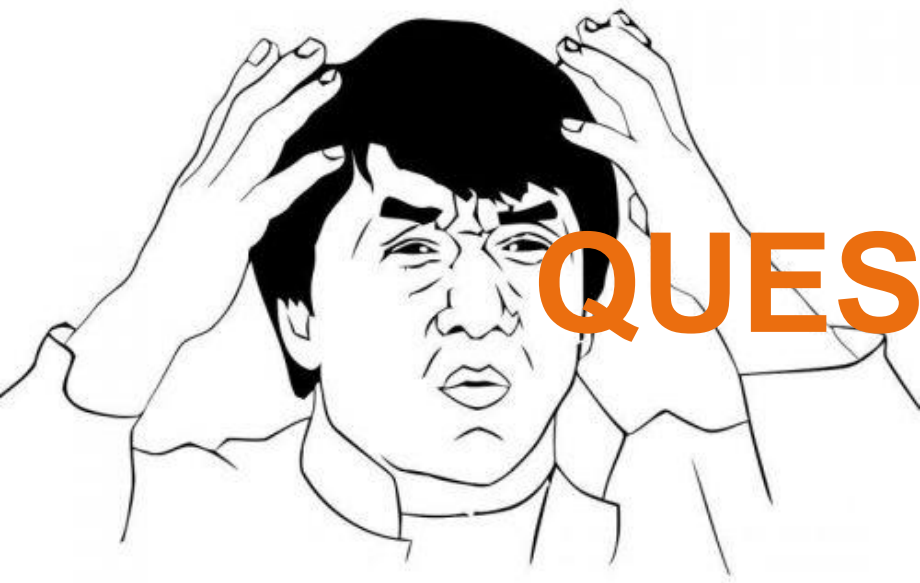
- τ decays
 - **Mass**
 - **Lifetime**
 - More complex **SM parameters**: V_{us} for example
 - **Asymmetries** between similar processes



What does the future hold ?

- 31 articles for now and many more to come
 - Semi-leptonic decays
 - Rare penguin decays
 - τ mass
 - ...
- Belle II is still a young experiment
- Promising results
- Next generation experiments: FCC, muon colliders...
 - Belle II wants to push the technology to the limit
 - FCC: e^+e^- collider \rightarrow Belle II example





QUESTIONS

