

# Flavour Physics at the LHC

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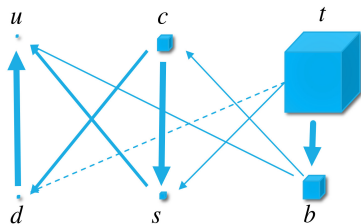
Tu Dortmund University

The 50th Anniversary of Hadron Colliders at CERN, Geneva  
October 13, 2021

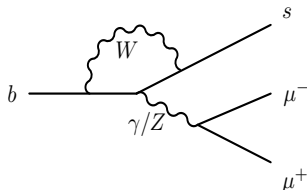
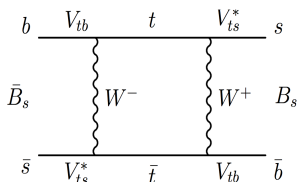


# Why Flavour Physics

- Open questions in HEP are tied to Flavour sector:
  - Mass hierarchy, matter-antimatter imbalance, 3 generations, CKM structure

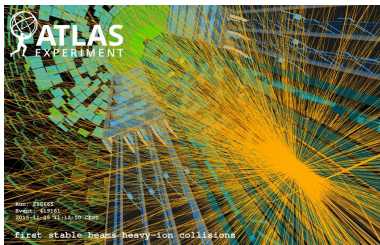


- "Heavy" Particles contribute to Flavour processes → ideal for indirect search for NP

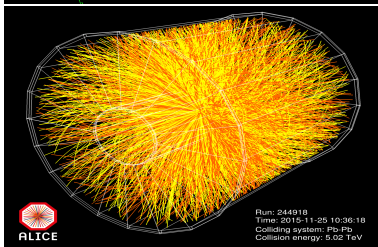
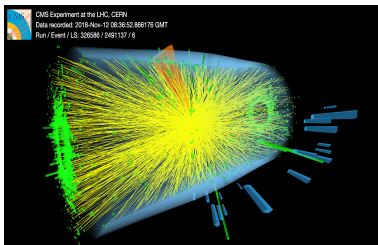
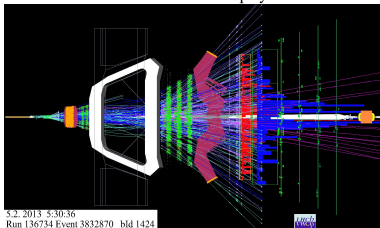


# Flavour @ Hadron collider?

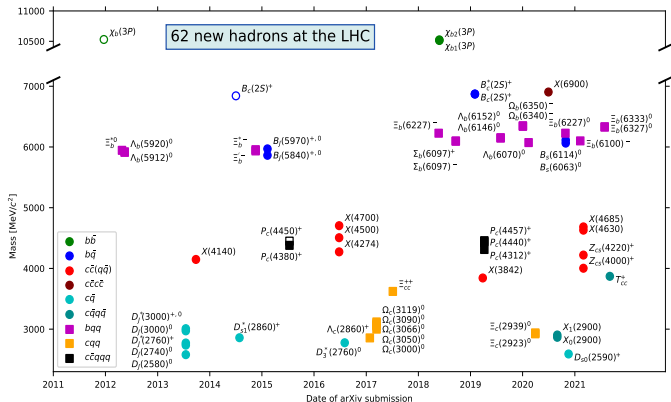
- High gain: Unprecedented statistics + access to all c- and b-hadrons
- High risk: Extremely difficult event topology



LHCb Event Display



# LHC the discovery machine

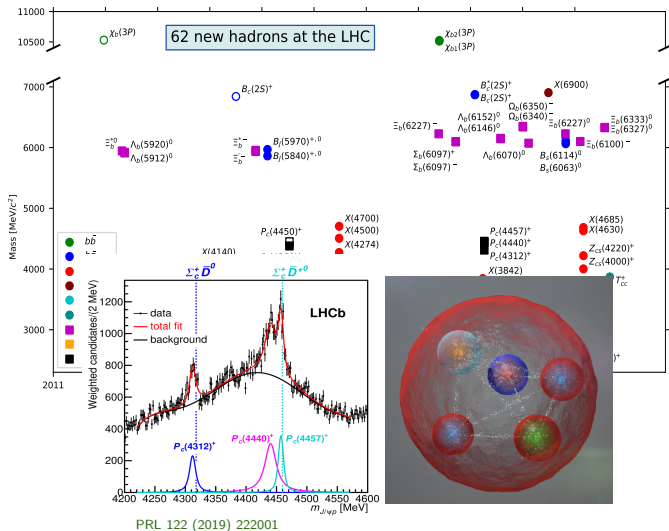


> 50 hadrons discovered at LHC for 50 years of hadron colliders

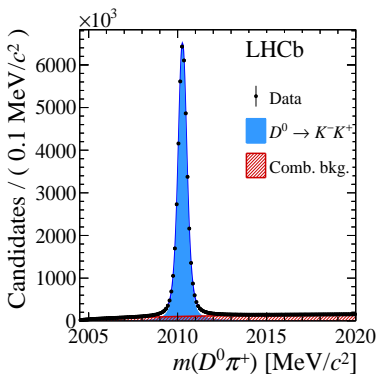
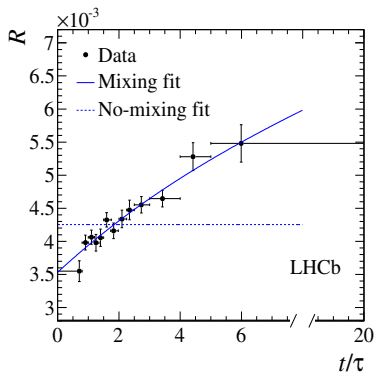




# New form of matter @ LHC: Pentaquark

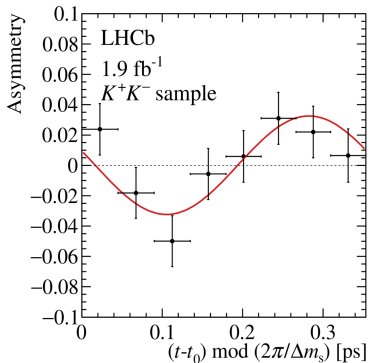
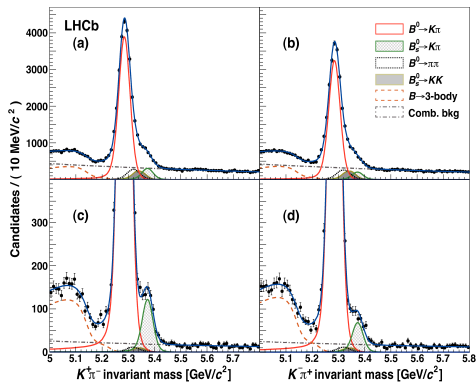


# LHC the discovery machine



First single experiment observation of **mixing**, **mass difference** and **CP violation** in Charm

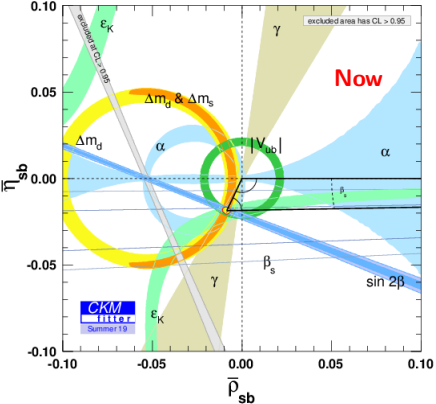
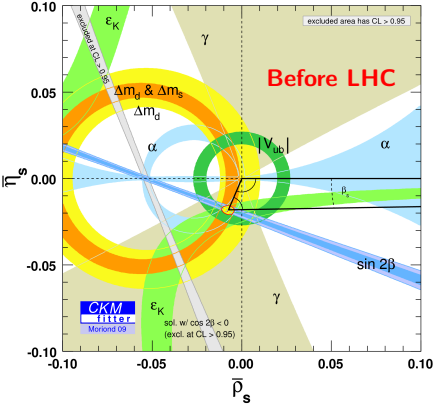
# LHC the discovery machine



First observation of **time-integrated** & **time-dependent** CP violation in  $B_s^0$  decays

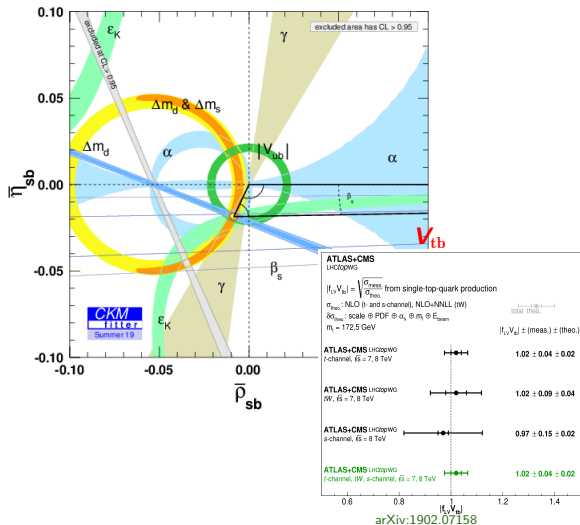
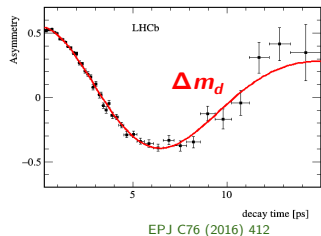
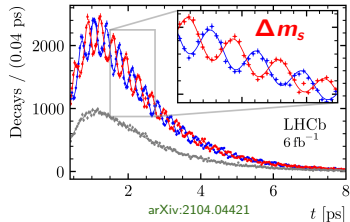
# CKM @ LHC

$$V_{\text{CKM}} \sim \begin{pmatrix} V_{ud} & V_{us} & |V_{ub}|, \gamma \\ V_{cd} & V_{cs} & |V_{cb}| \\ \Delta m_d, \beta & \Delta m_s, \beta_s & |V_{tb}| \end{pmatrix}$$

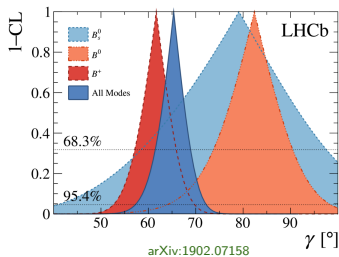
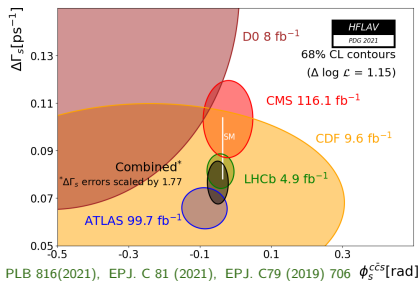
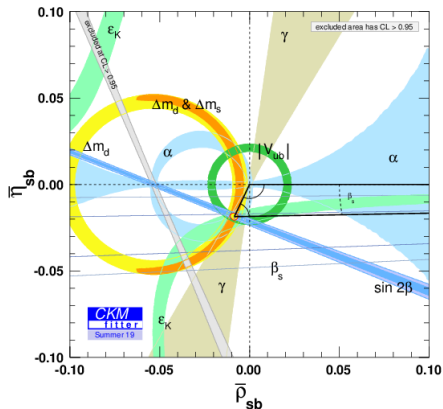


# LHC the precision machine

—  $B_s^0 \rightarrow D_s^- \pi^+$  —  $\bar{B}_s^0 \rightarrow D_s^- \pi^+$  — Untagged

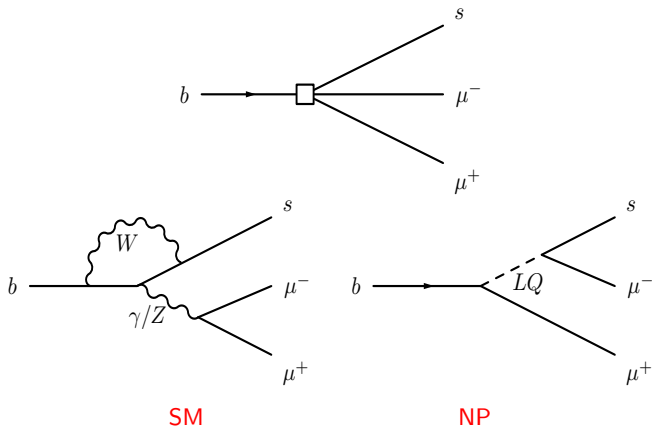


# LHC the precision machine



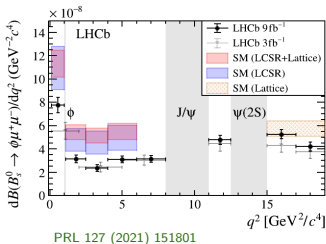
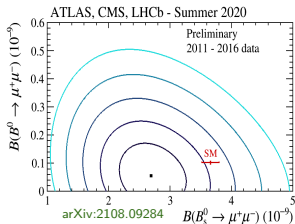
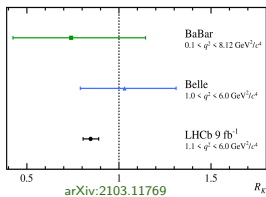
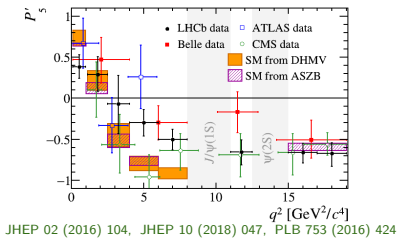
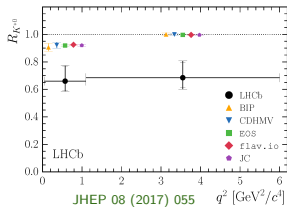
## $b \rightarrow sll$ anomalies

- $b \rightarrow sll$ : Flavour Changing processes
- Happens through a penguin diagram ... where New Physics would appear!



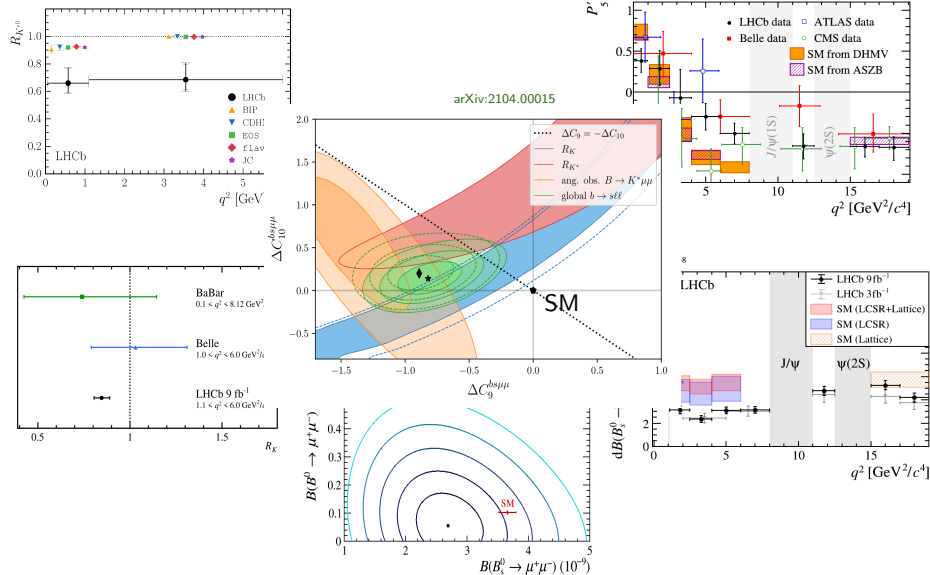


# $b \rightarrow sll$ anomalies



# $b \rightarrow sll$ anomalies:

arXiv:2104.00015



## Conclusion

- LHC is truly a Flavour machine → great harvest!
  - Discovery machine: new particles, new behavior of matter/anti-matter
  - Precision machine: stringent constrains on CKM structure
  - Tantalizing anomalies in  $b \rightarrow s\ell\ell$ : more Flavour measurements to be conclusive
- High-Luminosity LHC era → Flavour physics will excel!
  - High-risk: busy event topology
  - High-gain: boost current searches & new Flavour measurements
- We express our gratitude to our colleagues in the CERN accelerator departments for the excellent performance of the LHC