The LHCb experiment at CPPM

Joan ARNAU ROMEU

CPPM, Aix-Marseille Université CNRS/IN2P3, Marseille, France

September 23, 2016

■ The LHCb experiment

→ Physics at LHCb.
→ Detector overview.
→ Some results.

■ LHCb physics at CPPM

→ Mixing induced CPV in B_s^0.
→ Very rare decays with τ in the final state.

The LHCb experiment

- The Large Hadron Collider beauty (LHCb) experiment is designed for precision studies of b (and c) quark (B and D mesons) at the LHC accelerator.
- LHCb performs Charge Parity (CP) violation measurements and it looks for indirect effects of possible physics beyond the standard model, for example in rare decay modes of flavour changing particle decays.
  - → Loop processes are sensitive to energy scales beyond the ones currently provided by the present accelerators.
  - → Deviations from the Standard Model will help in understanding Beyond the Standard Model physics.
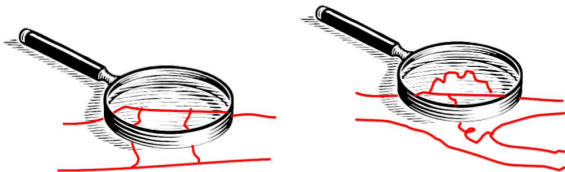
LHCb covers a wide physics program and has shown great versatility to adapt to multiple analyses.

- CP violation in beauty and charm decays.
- The quark-mixing (CKM) matrix elements measurements.
- Rare beauty and charm decays.
- Spectroscopy in pp interactions.
- QCD and EW measurements.
- Heavy quark production in the forward region.
- Exotica (pentaquarks).
- Study of Ion-Ion/proton-Ion collisions.
- Ion-fixed target experiments (proton-gas/ion-gas).
- ...

- LHCb is specialized in detecting the high amount of *B* and *D* mesons created in the proton-proton collisions.
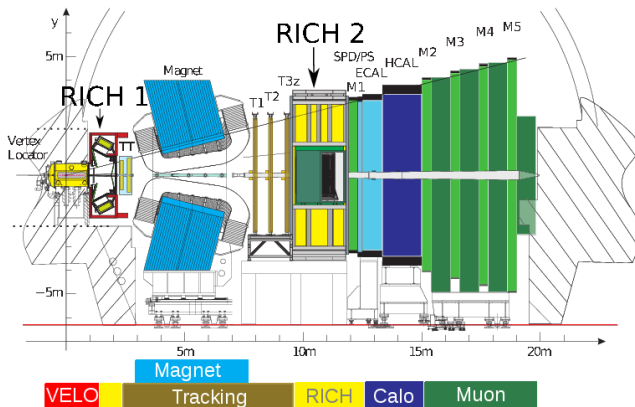
- Data recorded:

LHCb Integrated Luminosity in pp collisions 2010-2016
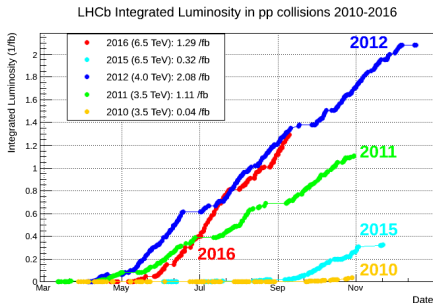
- 10^{12} *B* mesons detected per year.

- Produced all species of b-hadrons: $B^+, B^0, B^0_s, B^+_c, \Lambda_b, \Xi_b$...

- **LHCb is a single arm spectrometer in the forward region:**
 - → Unique angular coverage: 10 to 300 mrad in the horizontal and 250 mrad in the vertical plane.
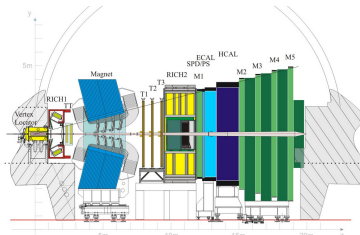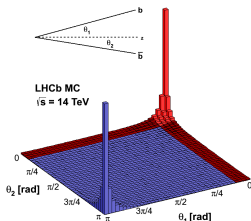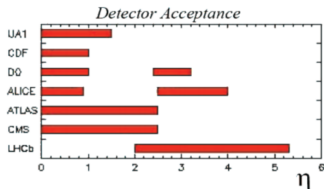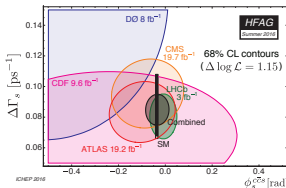
Major CPPM contributions:

→ L0muon trigger (dedicated electronics): design and realization.

→ Firmware for the distributed analysis (GRID) ⇒ Grid computing: distributed analysis firmware developments (DIRAC)

Some LHCb results

Flagship measurement with major CPPM contributions :
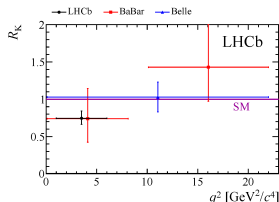
$B^0_{(s)} \to \mu\mu$ observation (CPPM!)
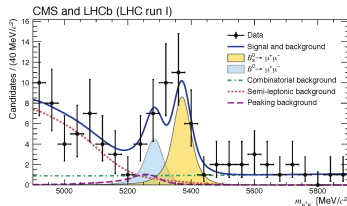
CP violation in the B_s system (CPPM!)
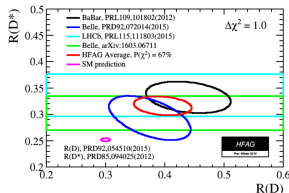

Hot topics of Lepton Flavour non-universality. tensions with Standard Model:

$$R(K) = \frac{B^+ \to K^+ \mu^+ \mu^-}{B^+ \to K^+ e^+ e^-} \quad 2.6\sigma \text{ tension}$$

$$R(D^*) = \frac{\overline{B}^0 \to D^{*+} \tau^- \overline{\nu}_\tau}{\overline{B}^0 \to D^{*+} \mu^- \overline{\nu}_\mu} \quad 4\sigma \text{ tension}$$
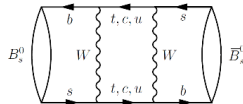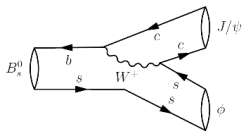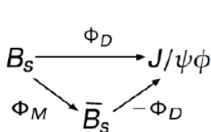
LHCb physics at CPPM

➜ Mixing induced CPV in B_s^0: First observation of $B_s^0 \to \eta_c \phi$ decay.

➜ Very rare decays with τ in the final state.

First observation of $B_s^0 \to \eta_c \phi$ decay

Simon AKAR, Olivier LEROY, Morgan MARTIN

- B_s^0 decay to $J/\psi\,\phi$ either directly, or after an oscillation to $\overline{B}_s^0$
- The interference between the two sub-processes give rise to a CP violating phase: $\phi_S^{J/\psi\,\phi} = \phi_S = \phi_M - 2\phi_D$

- Goal: reduce the statistical uncertainty on the CP violating phase ϕ_s adding a new decay mode.
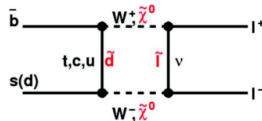
New mode: $B_s^0 \to \eta_c \phi$ (Golden mode: $B_s^0 \to J/\psi\,\phi$)

- First observation of the $B_s^0 \to \eta_c \phi$ decay mode!

Very rare decays with τ in the final state

Loop processes very suppressed and very well predicted in the SM.
⇒ Sensitive to BSM physics

- ■ $B^0_{(s)} \to \tau\tau$: Kristof DE BRUYN, Justine SERRANO, Giampiero MANCINELLI

  → Very challenging: Multiple neutrinos in the final state.
  → Upper limit set! Aiming for a paper soon.

- ■ $B^0 \to K^*\tau\tau$: Andrey TAYDUGANOV, Giampiero MANCINELLI

  → Also multiple neutrinos in the final state.
  → Work in progress...

- ■ $B^0_{(s)} \to \tau\mu$: Joan ARNAU, Julien COGAN, Giampiero MANCINELLI

  → Only one neutrino in the final state.
  → Work in progress...

Conclusions

■ Oustanding contributions from CPPM for the LHCb detector:

  → L0 muon trigger.
  → Firmware for distributed analysis.
  → Read-out boards for the whole detector in the 2019-2020 upgrade.

■ Strong CPPM involvement in key results of LHCb:

  → $B^0_{(s)} \to \mu\mu$
  → ϕ_s measurement

■ Challenging analysis in progress:

  → Mixing induced CPV in B^0_s
  → $B^0_{(s)} \to \tau\tau$, $B^0 \to K^*\tau\tau$, $B^0_{(s)} \to \tau\mu$