Recent results on the CKM angle $\gamma$ measurement at LHCb and prospect for Run III and Run IV

The CKM angle $\gamma$ recent results

Above 15 completed analyses!
- 4 updated from 2017
- 3 new – Run 1 & 2 results:
  - $B^0 \rightarrow D^\mp \pi^\pm$ $D^\mp \rightarrow K^\pm \pi^\mp \pi^\mp$
  - $B^+ \rightarrow D^\mp K^\pm$ $D^\mp \rightarrow h^+ h^\mp \pi^\mp$
  - $B^+ \rightarrow DK^+$ $D^\mp \rightarrow K^\pm_h h^\mp h^\mp$
- LHCb result (at 68.3% CL) [1]:
  $$\gamma = \left(74.0^{+5.0}_{-5.8}\right) \degree$$

Motivation & Prospect for Run III and IV

- Increase the precision of measurements of the CKM matrix parameters (i.e. CP-violating phases $\gamma, \phi_s$).
- The CKM angle $\gamma$ – the least well-known angle of the CKM Unitary Triangle, probed via theoretically clean tree-level (where the interference between $b \rightarrow u, b \rightarrow c$ quark transitions).
- Long-lasting tension between direct (tree-level processes) and indirect methods – better precision is required
  - New channels are warmly welcome!
- The discrepancy between direct and indirect measurements would be a sign of Physics Beyond Standard Model.
- Prospect for Run III & IV: measurements CP-violating phases $\gamma$ and $\phi_s$ with a precision of $0.4\degree$ and 3 $\mu$rad.

LHCb Run III spectrometer

- Designed to collect $L_{int} = 50 f b^{-1}$ of data until 2030 to reduce statistic limitation of many measurements.
- Full detector readout at 30 MHz with flexible software trigger
- Full off-line quality track reconstruction and event selections performed by the trigger system in real time.
- New tracking system adjusted to work at higher luminosity: VELO (pixels). Upstream Tracker / Fibre Tracker (microstrips and fibers) [4].

New measurements

$B^0 \rightarrow DK^*$ analysis:
- Data Sample: 4.8 $fb^{-1}$
- $D$ ($D^0$ or $D^0$) meson is reconstructed in two-body ($K\pi, \pi\pi, K\pi$) or four-body final state ($K\pi\pi\pi, \pi\pi\pi\pi$).

$CP$ observables measured for the $D \rightarrow KK$ mode [5]:
- $A_{K\pi}^{K\pi} = 0.06 \pm 0.05 \pm 0.01$
- $R_{K\pi}^{K\pi} = 1.06 \pm 0.06 \pm 0.02$

$B^0 \rightarrow D_s^\pm K^*$ analysis:
- Tree-level process that will contribute to the CKM $\gamma$ measurements.
- Complex topology requires multivariate analysis (BDT/NN).

References

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The CKM angle $\gamma$ recent results

- **Above 15 completed analyses!**
  - 4 updated from 2017
  - 3 new – Run 1 & 2 results:
    - $B^0 \to D^{\mp} \pi^\pm$: $D^\mp \to K^+ \pi^- \pi^-$
    - $B^+ \to D^{\mp} K'^\pm$: $D^{\mp} \to h^+ K^- \pi^- \pi^-$
    - $B^+ \to D K^+ + D^{\mp} \to K_s^0 h^+ h^-$
  - LHCb result (at 68.3% CL) [1]:
    $$\gamma = (74.0 \pm 5.0)\,^\circ$$

Motivation & Prospect for Run III and IV

- **Increase the precision of measurements of the CKM matrix parameters (i.a. CP-violating phases $\gamma$, $\phi_c$).**
- The CKM angle $\gamma$ – the least well-known angle of the CKM Unitary Triangle, probed via theoretically clean tree-level (where the interference between $b \to u$, $b \to c$ quark transitions occurs).
- Long-lasting tension between direct (tree-level processes) and indirect methods – better precision is required
  - new channels are warmly welcome!
- The discrepancy between direct and indirect measurements would be a sign of Physics Beyond Standard Model.
- Prospect for Run III & IV: measurements CP-violating phases $\gamma$ and $\phi_c$ with a precision of 0.4° and 3 µrad.

New measurement

$B^0_s \to D_s^{\mp} K^{\mp}$ analysis:

- Run II analysis
- Data Sample: 2016-1.6 $fb^{-1}$
- Tree-level process that will contribute to the CKM $\gamma$ measurements.
- Complex topology requires multivariate analysis (BDT/NN).

References