Search for $CP$ violation in $D^0 \rightarrow \pi^− \pi^+ \pi^0$ decays with the energy test

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Introduction

- $D^0 \rightarrow \pi^− \pi^+ \pi^0$ decay
  - $CP$ violation search in Dalitz plot
  - Singly Cabibbo-suppressed
  - Penguin-tree interference
  - Interfering resonances
- Energy test
  - Statistical method
  - Sensitive to local asymmetry of two distributions
- First application as $CP$ violation search
- Applied using GPUs
- Using full LHCb $\pi^0$ reconstruction
  - Two separate photon clusters (resolved $\pi^0$)
  - Two overlapping photon clusters (merged $\pi^0$)

LHCb detector

- Single-arm forward spectrometer, pseudorapidity range $2 < \eta < 5$, designed for the study of particles containing $b$ or $c$ quarks
- High-precision tracking system and particle identification

Dataset

- Data collected in 2012, integrated luminosity is $2 fb^{-1}$
- Flavour tag using soft pion coming from $D^0 \rightarrow D^0 \pi^0$
- Offline selection based on boosted decision trees (BDT)
- Resolved sample and merged sample are selected separately
- Yields $416 \times 10^3$ resolved candidates and $247 \times 10^3$ merged candidates

Sensitivity studies

Sensitivity studies are performed with Monte Carlo samples, with $CP$ violation introduced and acceptance efficiency applied.

Results

$p$-value for no $CP$ violation hypothesis is $(2.6 \pm 0.5) \times 10^{-2}$. 

References

[1] R. Aaij et al. (LHCb collaboration), “Search for $CP$ violation in $D^0 \rightarrow \pi^− \pi^+ \pi^0$ decays with the energy test” PLB 740(2015) 158-167.