Measurement of the CP asymmetry in $B^0 \to K^{*0} \mu^+ \mu^-$ decays

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Abstract (LHCb-PAPER-2012-021, PRL 110 031801)
A measurement of the CP asymmetry in $B^0 \to K^{*0} \mu^+ \mu^-$ is presented, based on 1.0 fb$^{-1}$ of pp collision data recorded by the LHCb experiment during 2011. The measurement is performed in six bins of invariant mass squared of the $\mu^+\mu^-$ pair, excluding the $J/\psi$ and $\psi(2S)$ resonance regions. Production and detection asymmetries are removed using the decay $B^0 \to J/\psi K^{*0}$ as a control mode. The integrated CP asymmetry is found to be $-0.072 \pm 0.040$ (stat.) $\pm 0.005$ (syst.), consistent with the Standard Model.

The $s$-state $B \to K^{*0} \mu^+ \mu^-$ has a Standard Model (SM) branching fraction of $1.05 \times 10^{-4}$. No tree-level Feynman diagrams, proceed via loops in penguin diagrams, which are Cabibbo suppressed.

As a result, New Physics could be seen at the same level as the SM via gluino or chargino loops.[1]

**CP asymmetry in $B^0 \to K^{*0} \mu^+ \mu^-$**

- $B^0 \to K^{*0} \mu^+ \mu^-$ decays are tagged by the charge of the kaon.
- The CP asymmetry is defined as

$$A_{CP} = \frac{\Gamma(B^0 \to K^{*0} \mu^+ \mu^-) - \Gamma(B^0 \to K^{*0} \mu^- \mu^+)}{\Gamma(B^0 \to K^{*0} \mu^+ \mu^-) + \Gamma(B^0 \to K^{*0} \mu^- \mu^+)}$$

where $\Gamma$ is the rate of the $B^0$ or $B^0$ decays.

- The SM prediction is close to zero, but various New Physics models show potential deviation from the SM up to the level of $\pm 0.15$[2].

- The measured CP asymmetry can be written, to first order, as a sum of individual asymmetries,

$$A_{CP} = A_{RAW} + A_{\mu}$$

- However, the kinematics of the final states are not quite identical. Part of the difference cancels by taking an average of both magnet polarities, and the rest is considered as a systematic uncertainty. The measurement is carried out via a simultaneous mass fit in six bins of dimuon invariant mass ($q^2$), and the CP asymmetry in each is given by:

$$A_{CP} = A_{RAW} - A_{\mu}$$

**Result** $A_{CP} = -0.072 \pm 0.040$ (stat.) $\pm 0.005$ (syst.)

**Systematic Uncertainties**

- 2% of events contain duplicate candidates, remove one of each pair randomly.
- Result is average of 10 different selections.
- Kinematic differences between signal and control mode means assumption that $A_{CP} = A_{RAW} - A_{\mu}$ is not accurate:

$$A_{CP} = A_{RAW} - A_{\mu}$$

- Muon detection asymmetries, due to muon forward-backward asymmetry in $B^0 \to K^{*0} \mu^+ \mu^-$, may go cancelled.
- The control mode $B^0 \to J/\psi K^{*0}$ has no forward-backward asymmetry, and so cannot be used to account for this effect.
- Use a tag-and-probe method, and comparison of muon momentum spectra, to estimate size of effect.

- Fit systematics due to choice of signal model and resolution effects are investigated by varying the appropriate variables and repeating the fit.

**References**

[1] A. Skidmore, Rare $B^0 \to K^{*0} \mu^+ \mu^-$ decays at LHCb, IOP HEP conference, 2008.

[2] A. H. Albé et al., New Physics in $B \to \mu^+ \mu^-$: CP-Violating Observables, arXiv:1103.5344v2, 2011.