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

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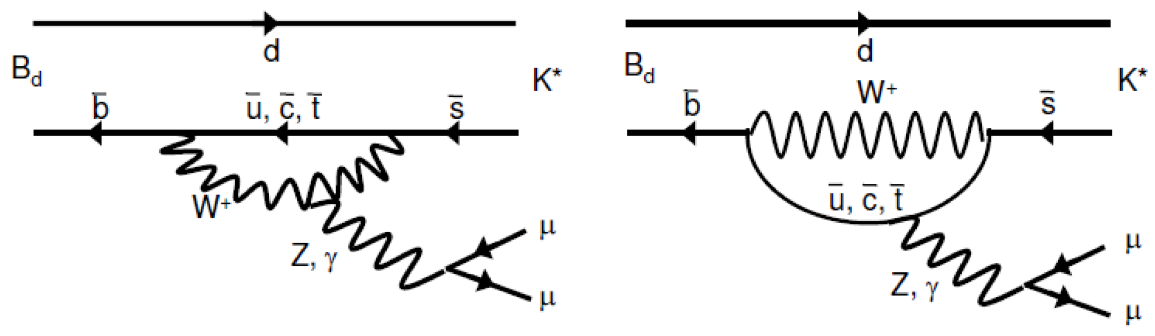
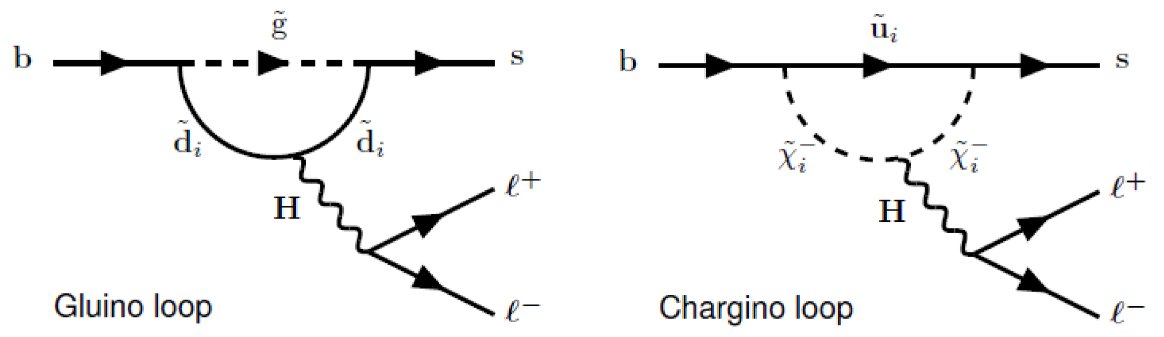
Abstract (LHCb-PAPER-2012-021, PRL 110 031801)

A measurement of the CP asymmetry in $B^0 \to K^{*0}\mu^+\mu^-$ decays 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/ψ 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 ± 0.040 (stat.) ± 0.005 (syst.), consistent with the Standard Model.

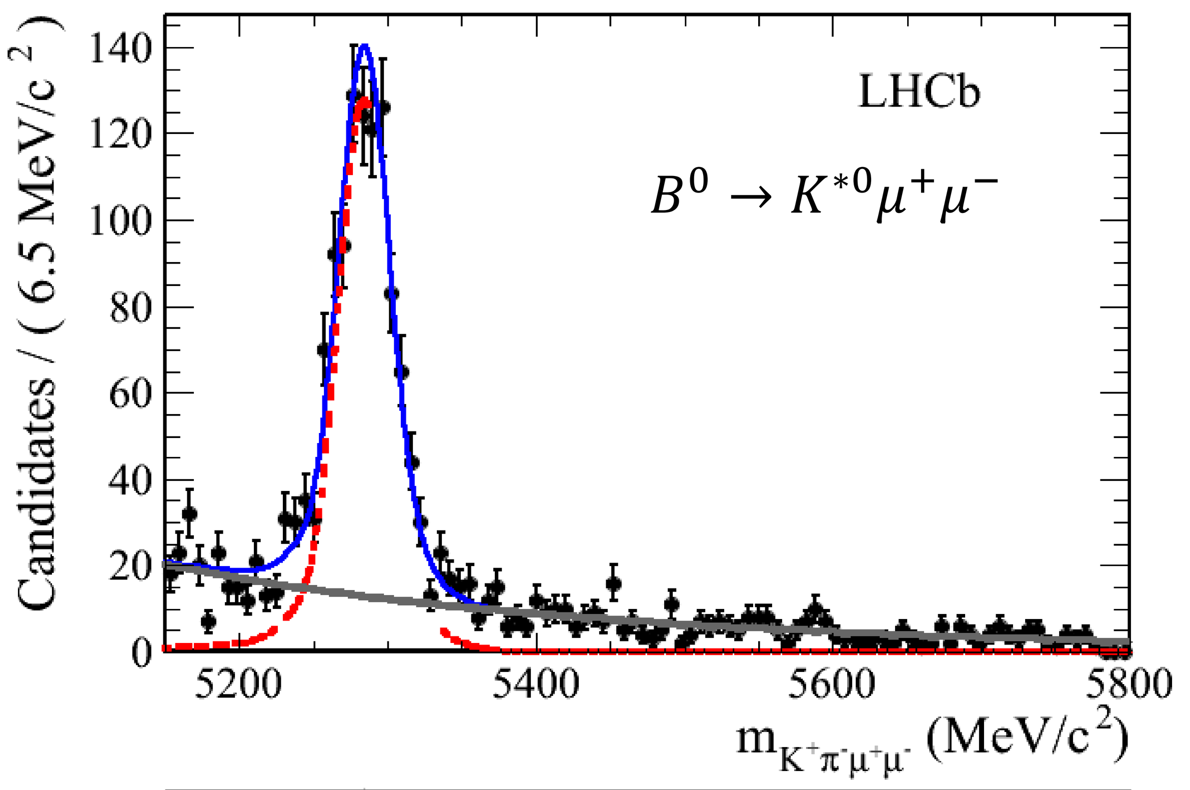
- $B^0 \to K^{*0}\mu^+\mu^-$ has a Standard Model (SM) branching fraction of 1.05 x 10^{-6}.
- No tree-level Feynman diagrams, proceed via loops in"penguin diagrams, which are Cabibbo suppressed.

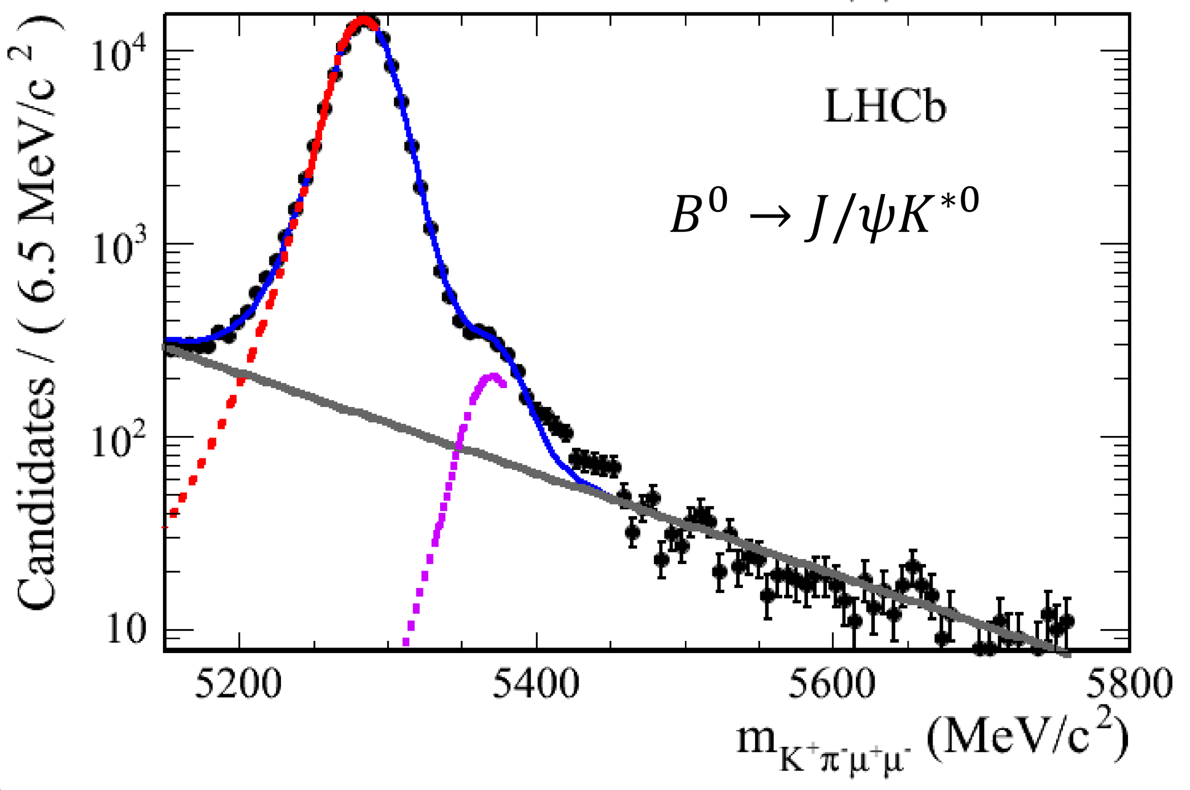


- As a result, New Physics could be seen at the same level as the SM via gluino or chargino loops[1].



Mass Fits





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

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

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

where Γ is the rate of the B^0 or $\overline{B^0}$ decays.

- The SM prediction is close to zero, but various New Physics models show potential deviation from the SM up to the level of ±0.15[2].
- The measured raw asymmetry can be written, to first order, as a sum of individual asymmetries,

$$A_{RAW} = A_{CP} + \kappa A_P + A_D$$

where A_P is the $B^0/\overline{B^0}$ production asymmetry, and A_D is the kaon-pion detection asymmetry.

- To remove the detector asymmetries, the channel $B^0 \to J/\psi(\mu^+\mu^-)K^{*0}$, which has the same final state and negligible physics asymmetry, is used,

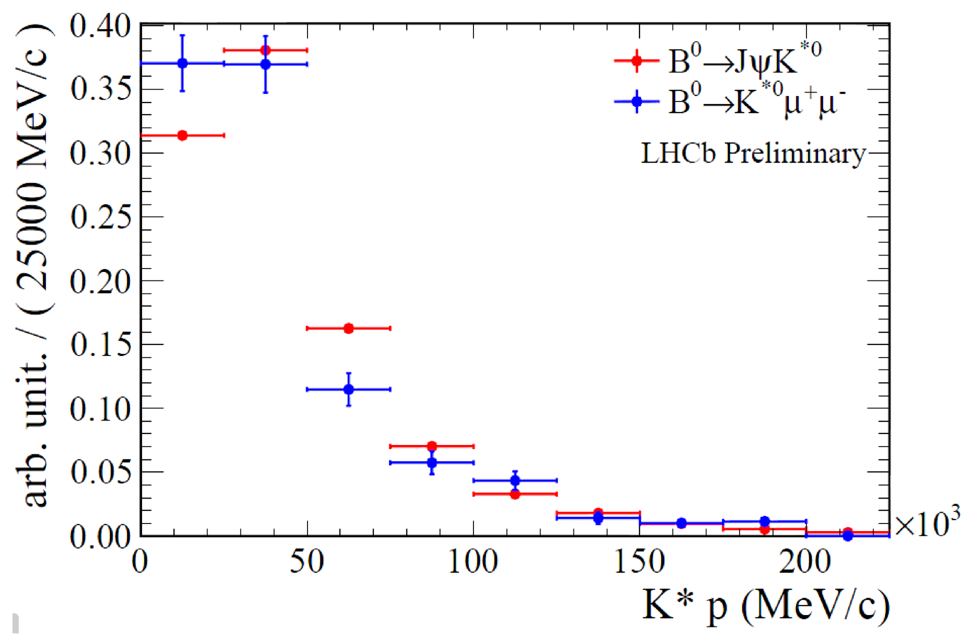
$$A_{J/\psi K^{*0}} \approx \kappa A_P + A_D.$$

- 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:

$$A_{CP} = A_{RAW} - A_{J/\psi K^{*0}}.$$

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 $A_{CP} = A_{RAW} - A_{J/\psi K^{*0}}$ is not accurate:

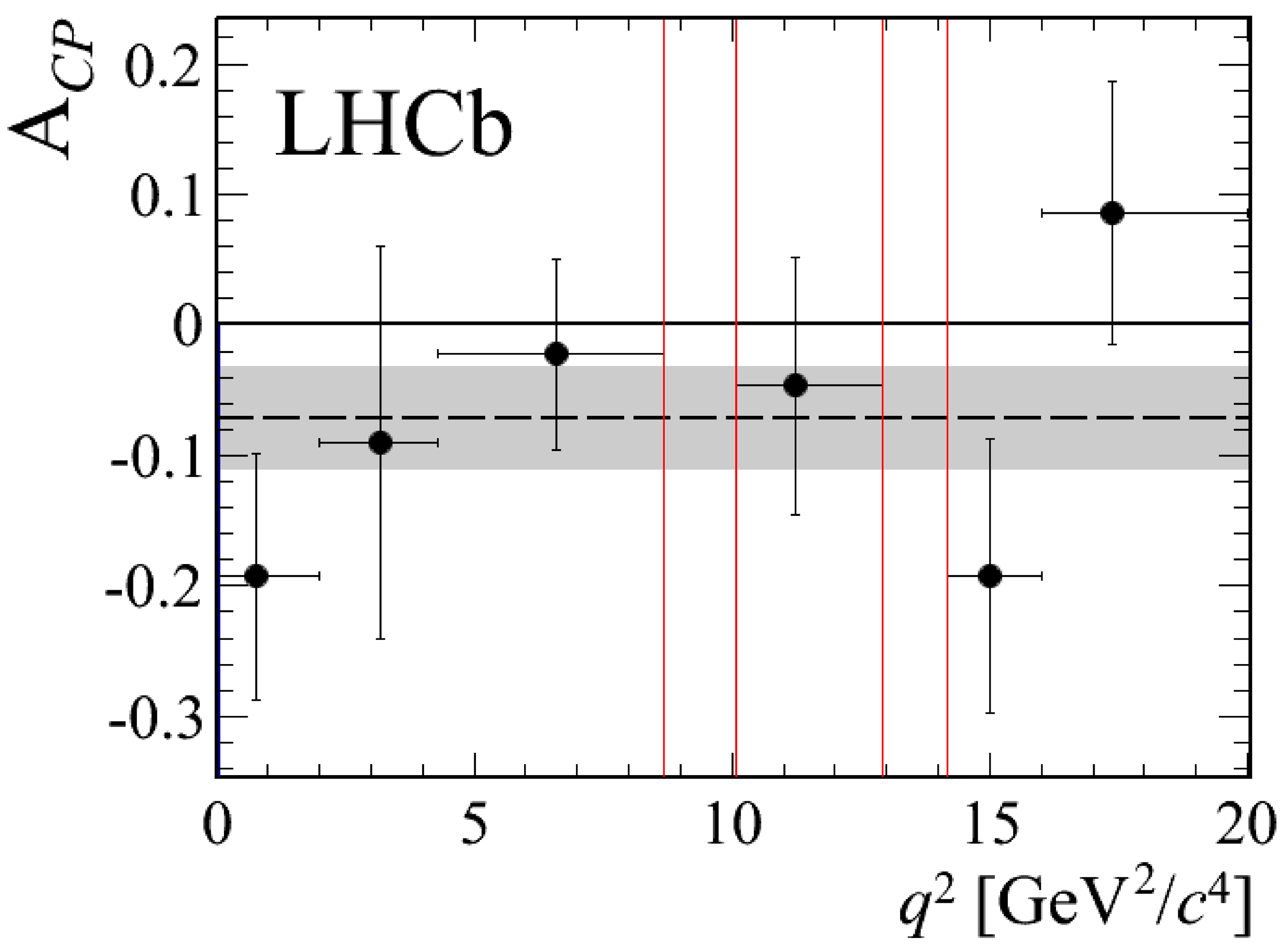


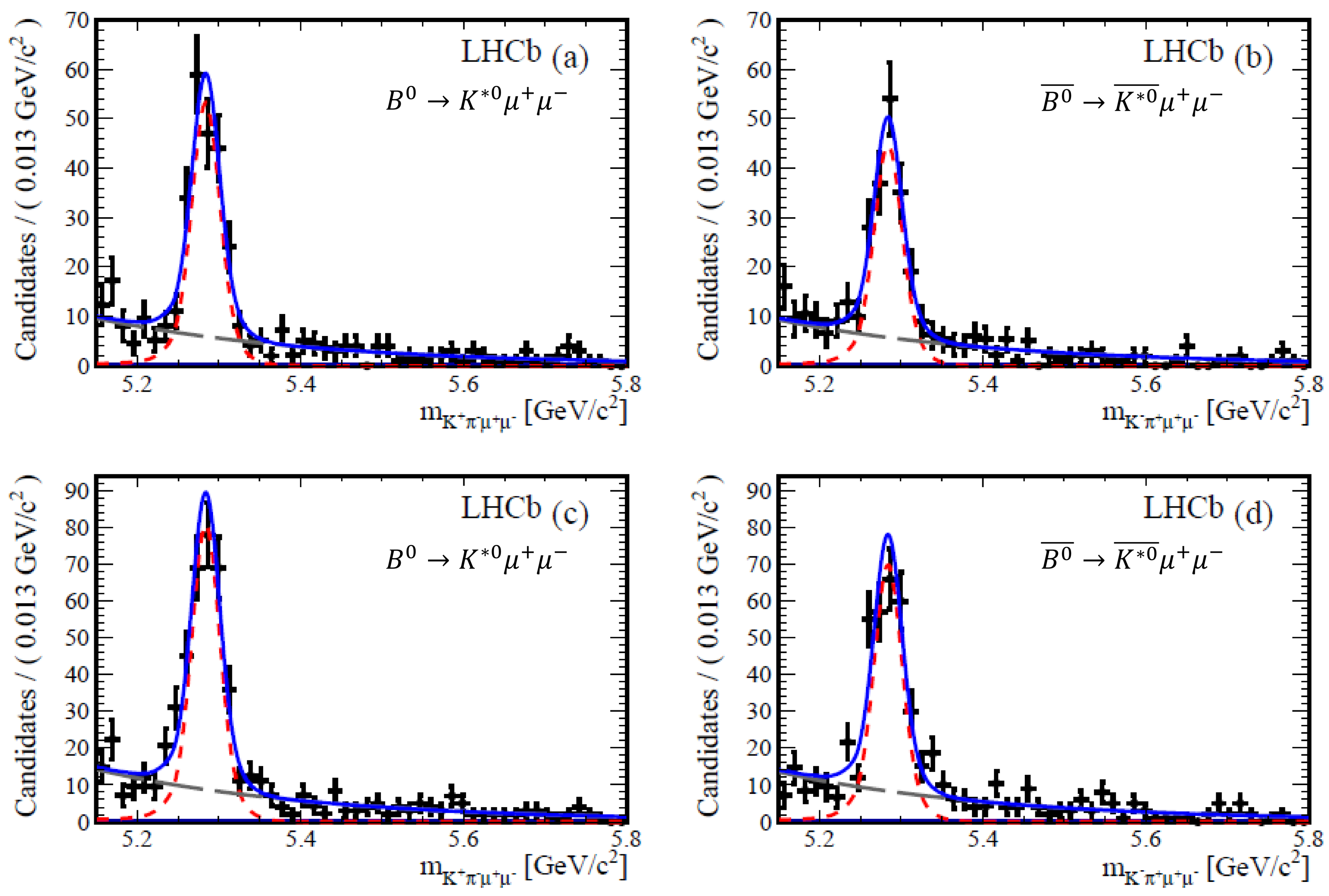
- Reweight $B^0 \to J/\psi K^{*0}$ yields to those of $B^0 \to K^{*0}\mu^+\mu^-$, calculate new $A_{J/\psi K^{*0}}$ to investigate size of the effect.
- **Muon detection asymmetries,** due to muon forward-backward asymmetry in $B^0 \to K^{*0}\mu^+\mu^-$, may go uncancelled.
- The control mode $B^0 \to J/\psi K^{*0}$ 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.

Duplicate candidates	0.002
Kinematic differences	0.002
$\mu^\pm$ asymmetry	0.005
Fit systematics	0.001
Total	0.005

Results

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





References:
[1] H. Skottowe, Rare $B^0 \to K^{*0}\mu^+\mu^-$ decays at LHCb, IoP HEP conference, 2008.
[2] A. Alok et al, New Physics in $b \to s\mu^+\mu^-$: CP-Violating Observables, arXiv:1103.5344v2, 2011.