Search for CP violation in $B^0 \to J/\psi\, K_S^0$ decays with first LHCb data

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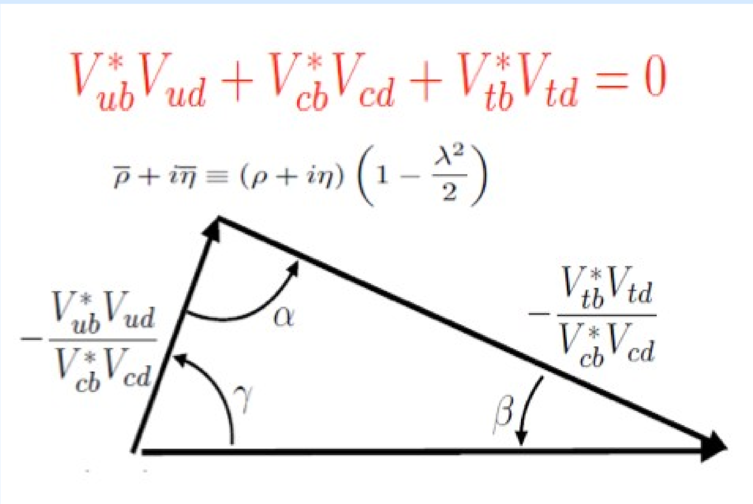
on behalf of the LHCb collaboration

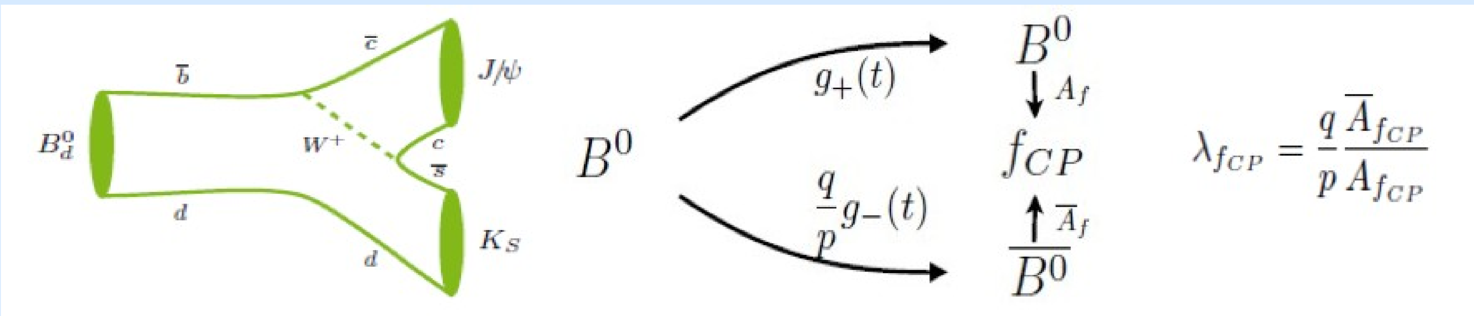
MOTIVATION

Precise measurements of standard model (SM) charge-parity (CP) violation mixing angles can reveal presence of beyond SM physics.

$$V_{\mathrm{CKM}} = \begin{pmatrix} V_{\mathrm{ud}} & V_{\mathrm{us}} & V_{\mathrm{ub}} \\ V_{\mathrm{cd}} & V_{\mathrm{cs}} & V_{\mathrm{cb}} \\ V_{\mathrm{td}} & V_{\mathrm{ts}} & V_{\mathrm{tb}} \end{pmatrix}$$



Time dependent decay rate asymmetry of $B^0 \to J/\psi K_S^0$ probes the CKM angle β.



Since $J/\psi K_S^0$ is a CP eigenstate:

$$\mathcal{A}_{J/\psi K_S^0}(t) \equiv \frac{\Gamma(\bar{B}^0(t) \to J/\psi K_S^0) - \Gamma(B^0(t) \to J/\psi K_S^0)}{\Gamma(\bar{B}^0(t) \to J/\psi K_S^0) + \Gamma(B^0(t) \to J/\psi K_S^0)} = S_{J/\psi K_S^0} \sin(\Delta m_d t) - C_{J/\psi K_S^0} \cos(\Delta m_d t)\,, \quad (1)$$

Δm_d is the mass difference between the mass eigenstates (their decay width difference is negligible).

In the SM, CP violation $b \to c\bar{c}s$ is negligible, therefore:

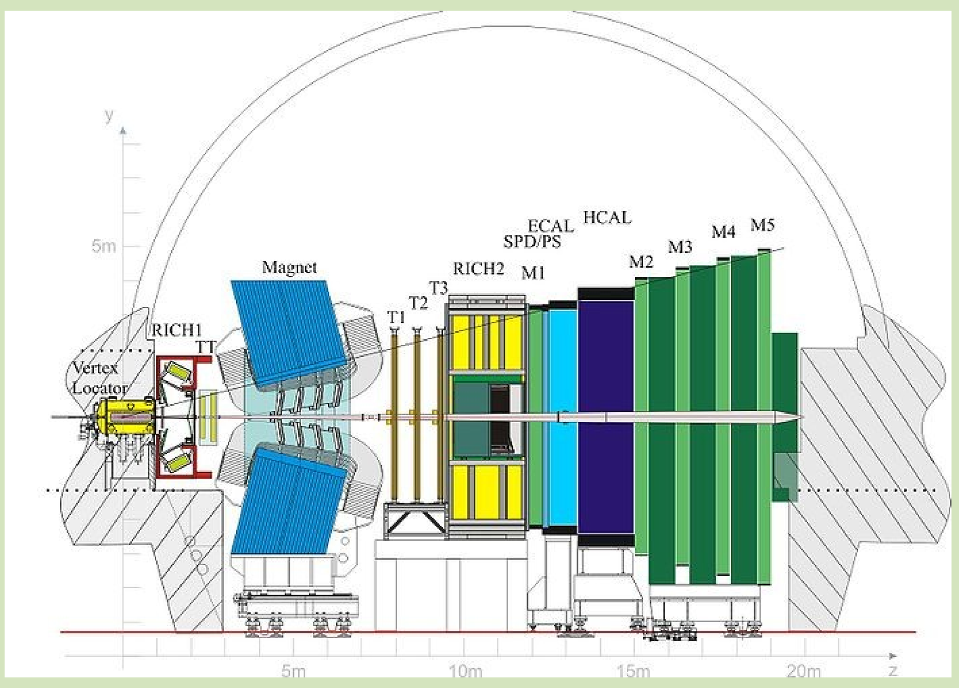
$$C_{J/\psi K_S^0} = 0$$

$$S_{J/\psi K_S^0} \simeq \sin 2\beta$$

The world average is: $\sin 2\beta = 0.673 \pm 0.023$

ANALYSIS STRATEGY

The LHCb Experiment – Forward Spectrometer

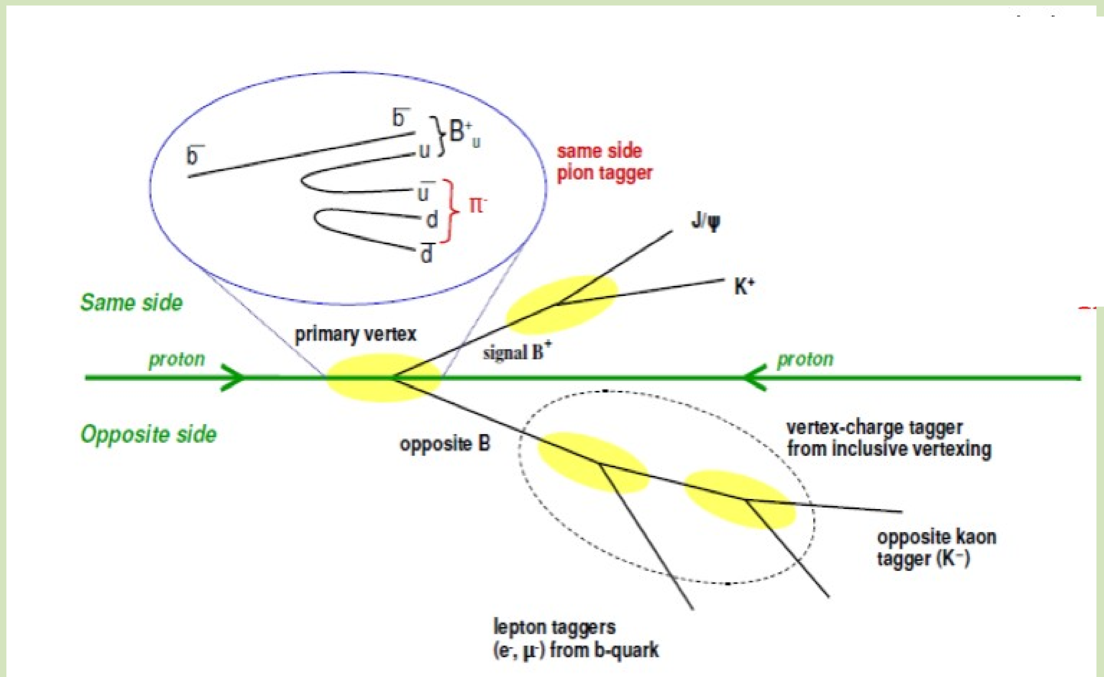


Main Components:

- Vertex Locator
- Tracking
- Magnet (3.7 Tm)
- Rich
- Calorimeter
- Muon

Event Selection

- ✘ Two type of triggers were used: unbiased and biased. The bias is with respect to the proper time distribution.
- ✘ Events were required to have a J/ψ candidate decaying in two muons and K_S^0 candidate decaying in two pions.
- ✘ Vertex quality requirements are applied to enhance signal over background ratio.
- ✘ To determine the flavor of the B^0 meson, an opposite flavor tagging was used. $B^+ \to J/\psi K^+$ and $B^0 \to J/\psi K^*$ samples are used to calibrate and certify the tagging method. Events without minimum necessary tagging information are called untagged.



RESULTS

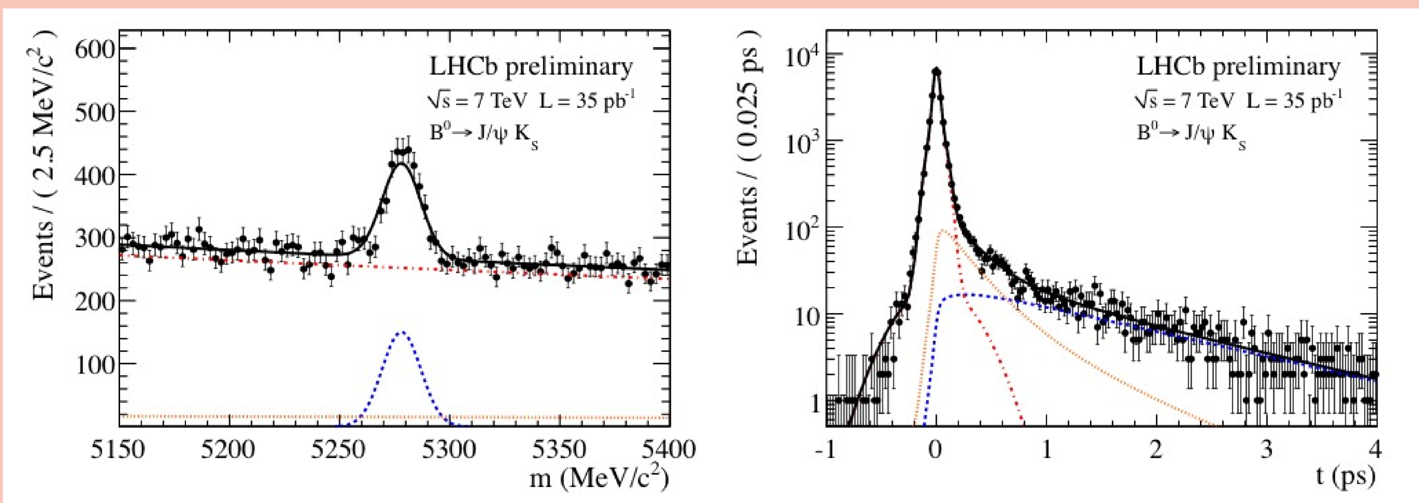
The CP violation parameter is extracted through a simultaneous multidimensional unbinned extended maximum likelihood fit.

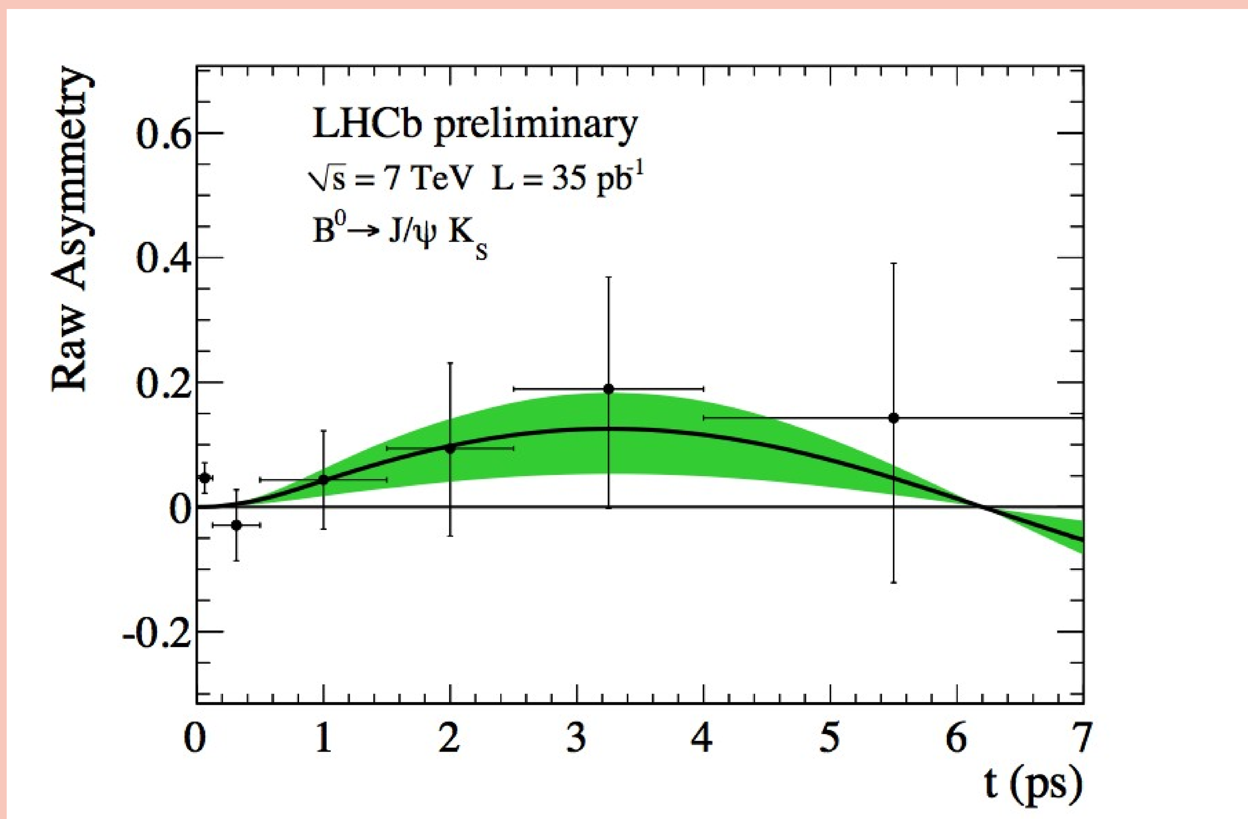
Four subsamples (biased, unbiassed, tagged and untagged) and four observables (B mass, B proper time, flavor tagging decision and wrong tag probability) are used.

Systematic Uncertainties

Source	uncertainty
tagger calibration	0.044
per-event mistags p.d.f.	0.016
Δm_d uncertainty, z scale	0.0017
proper time resolution	0.0085
high proper time acceptance	0.0018
biased events acceptance	0.0039
biased TIS events acceptance	0.0063
production asymmetry	0.024
total (sum in squares)	0.054

Proper Life Time and B mass Fits





$$S_{J/\psi K_S^0} = 0.53^{+0.28}_{-0.29}(\mathrm{stat}) \pm 0.05(\mathrm{syst})$$

CONCLUSIONS

First measurement of CP violation in the $B^0 \to J/\psi K_S^0$ at LHCb with $36\,\mathrm{pb}^{-1}$. Result is compatible with world average. Analysis strategy is validated to be used for a precise measurement with about $1\,\mathrm{fb}^{-1}$.

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