$B_0 \rightarrow \phi \phi$ is a FCNC transition, sensitive to new physics entering the loop. LHCb has previously measured triple product asymmetries and CP-violating phase $\phi_2$ in this channel. \cite{[1],[2],[3]} It is used as normalisation for several other branching fraction measurements.

We measure the $B_0 \rightarrow \phi \phi$ branching fraction relative to $B^0 \rightarrow \phi K^*$. $B^0 \rightarrow \phi \phi$ is unobserved and highly-suppressed in the Standard Model. Predicted branching fractions range between $10^{-9}$ and $3 \times 10^{-8}$ \cite{[4],[5],[6],[7]}, but could be enhanced by new physics.

Selection & Mass Fit

![Figure: Non-factoriseable diagram from $B^0 \rightarrow \phi \phi$](image)

Figure: Non-factoriseable diagram from $B^0 \rightarrow \phi \phi$

Well-reconstructed tracks are selected with $p_T > 500$ MeV/c and significant displacement from the primary vertex. Kaons and pions are identified using information from the Ring-Imaging Cherenkov detectors.

$K^+K^-$ and $K^+\pi^-$ pairs are combined to form $\phi$ and $K^*$ candidates. Mass windows of $|m(\phi) - m(K^+K^-)| < 15 \text{ MeV/c}^2$ and $|m(K^*) - m(K^+\pi^-)| < 150 \text{ MeV/c}^2$ are applied so the S-wave fractions from previous analyses can be used. The $\phi$ and $K^*$ are required to have $p_T > 1$ GeV/c and good vertex fit quality.

$B^0$ and $B_0^\oplus$ candidates are formed by combining $\phi K^*$ and $\phi \phi$ pairs and must have significant displacement from the primary vertex.

A Boosted Decision Tree is used to suppress combinatorial background, taking into account displacement of the $B_0$ from the primary vertex, kinematic information and track isolation criteria.

$B^0 \rightarrow \phi \phi$ branching fraction

$$\frac{B(B_0^\oplus \rightarrow \phi \phi)}{B(B^0 \rightarrow \phi \phi)} = \frac{N_{\phi\phi}/N_{B^0}}{N_{\phi\phi}/N_{B_0^\oplus}} \times \frac{f_d/f_s}{\epsilon_{\phi\phi}}$$

$N$ is S-wave subtracted yield, $\epsilon$ is efficiency, $B$ is branching fraction, and $f_d/f_s$ is fragmentation fraction ratio.

- $N_{\phi\phi}/N_{B^0} = 0.440 \pm 0.018$ from fits to data.
- S-wave fractions from previous LHCb angular analyses. \cite{[3],[8]}
- $\epsilon_{\phi\phi}/\epsilon_{B^0} = 0.795 \pm 0.007$ from Monte Carlo.
- $f_d/f_s = 0.259 \pm 0.015$ taken from previous LHCb measurements \cite{[9],[10],[11]}
- $B(B^0 \rightarrow \phi \phi) = 1.00 \pm 0.06$ from averaging B-factory results. \cite{[12],[13]}

Results

The $B_0^\oplus \rightarrow \phi \phi$ branching fraction is measured to be $B(B_0^\oplus \rightarrow \phi \phi) = (1.84 \pm 0.05 (stat) \pm 0.18 (syst)) \times 10^{-5}$\cite{[14]}

Previous result from CDF: $(1.91 \pm 0.26 \pm 0.16) \times 10^{-5}$ \cite{[14]}

The dominant systematic errors come from the normalisation channel ($\pm 6.4\%$), $f_d/f_s$ ($\pm 5.8\%$) and S-wave fraction ($\pm 3.1\%$).

The upper limit on the $B^0 \rightarrow \phi \phi$ branching fraction is $B(B^0 \rightarrow \phi \phi) < 2.8 \times 10^{-8}$ (90% CL) \cite{[15]}

Previous limit from BaBar: $2.0 \pm 10^{-7}$ \cite{[15]}

References

\cite{[1],[2],[3],[4],[5],[6],[7],[8],[9],[10],[11],[12],[13],[14],[15]}