

# Search for $CP$ Violation and Measurement of the Branching Fraction in the Decay $D^0 \rightarrow K_S^0 K_S^0$

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We report a study of the decay  $D^0 \rightarrow K_S^0 K_S^0$  using 921 fb<sup>-1</sup> of data collected at or near the  $\Upsilon(4S)$  and  $\Upsilon(5S)$  resonances with the Belle detector at the KEKB asymmetric energy  $e^+e^-$  collider. The measured time-integrated  $CP$  asymmetry is  $A_{CP}(D^0 \rightarrow K_S^0 K_S^0) = (-0.02 \pm 1.53 \pm 0.02 \pm 0.17)\%$ , and the branching fraction is  $\mathcal{B}(D^0 \rightarrow K_S^0 K_S^0) = (1.321 \pm 0.023 \pm 0.036 \pm 0.044) \times 10^{-4}$ , where the first uncertainty is statistical, the second is systematic, and the third is due to the normalization mode ( $D^0 \rightarrow K_S^0 \pi^0$ ). These results are significantly more precise than previous measurements available for this mode. The  $A_{CP}$  measurement is consistent with the standard model expectation.

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Charge-parity violation (CPV) in charm meson decays has not yet been observed and is predicted to be small [ $\mathcal{O}(10^{-3})$ ] in the standard model (SM) [1]. Hence, an observation of larger CPV in charm decays could be interpreted as a sign of new physics (NP) [1]. Singly Cabibbo-suppressed (SCS) decays [2] are of special interest as possible interference with NP amplitudes could lead to large nonzero CPV. The  $D^0 \rightarrow K_S^0 K_S^0$  decay is the most promising channel amongst the SCS decays, as the  $CP$  asymmetry may be enhanced to an observable level within the SM, thanks to the interference of the transitions  $c\bar{u} \rightarrow \bar{s}s$  and  $c\bar{u} \rightarrow \bar{d}d$ , both of which involve the tree-level exchange of a  $W$  boson [3].

Assuming the total decay width to be the same for particles and antiparticles, the time-integrated  $CP$  asymmetry is defined as

$$A_{CP} = \frac{\Gamma(D^0 \rightarrow K_S^0 K_S^0) - \Gamma(\bar{D}^0 \rightarrow K_S^0 K_S^0)}{\Gamma(D^0 \rightarrow K_S^0 K_S^0) + \Gamma(\bar{D}^0 \rightarrow K_S^0 K_S^0)}, \quad (1)$$

where  $\Gamma$  represents the partial decay width. This asymmetry has three contributions:

$$A_{CP} = A_{CP}^d + A_{CP}^m + A_{CP}^i, \quad (2)$$

where  $A_{CP}^d$  is due to direct CPV (which is decay-mode dependent),  $A_{CP}^m$  to CPV in  $D^0$ - $\bar{D}^0$  mixing, and  $A_{CP}^i$  to CPV in the interference between decays with and without mixing. The last two terms are independent of the decay final states and are related to the lifetime ( $\tau$ ) asymmetry [4],

$$A_\Gamma = \frac{\tau(D^0) - \tau(\bar{D}^0)}{\tau(D^0) + \tau(\bar{D}^0)} = -(A_{CP}^m + A_{CP}^i). \quad (3)$$

The world average for  $A_\Gamma$ ,  $(-0.032 \pm 0.026)\%$ , is consistent with zero [5]. In the SM, indirect CPV ( $A_{CP}^m + A_{CP}^i$ ) is expected to be very small, of the order of  $10^{-3}$  [1]. Direct CPV in SCS decays is further parametrically suppressed [ $\mathcal{O}(10^{-4})$ ], since it arises from the interference of the tree and penguin amplitudes [6]. However, these decays, unlike

Cabibbo favored or doubly Cabibbo suppressed ones, are sensitive to new SM contributions from strong penguin operators, especially from chromomagnetic dipole operators [1]. A recent SM-based calculation obtains a 95% confidence level upper limit of 1.1% for direct  $CP$  violation in this decay [3].

The search for time-integrated  $CP$  asymmetry in  $D^0 \rightarrow K_S^0 K_S^0$  was first performed by CLEO [7] using a data sample of 13.7 fb<sup>-1</sup> of  $e^+e^-$  collisions at the  $\Upsilon(4S)$  resonance with a measured  $CP$  asymmetry of  $(-23 \pm 19)\%$ . LHCb subsequently measured the same quantity as  $(-2.9 \pm 5.2 \pm 2.2)\%$  [8]. Both results are consistent with no CPV, in agreement with the SM expectation. Recently, BESIII reported a  $D^0 \rightarrow K_S^0 K_S^0$  branching fraction of  $(1.67 \pm 0.11 \pm 0.11) \times 10^{-4}$  [9] by analyzing data corresponding to an integrated luminosity of 2.93 fb<sup>-1</sup> taken at the  $\psi(3770)$  resonance. Belle can significantly improve these measurements using the high-statistics data samples at or near the  $\Upsilon(4S)$  and  $\Upsilon(5S)$  resonances.

In this Letter, we measure the branching fraction and the time-integrated  $CP$  asymmetry ( $A_{CP}$ ) of the neutral charmed meson decay  $D^0 \rightarrow K_S^0 K_S^0$ . The analysis is based on a data sample that corresponds to an integrated luminosity of 921 fb<sup>-1</sup> collected with the Belle detector [10] at the KEKB asymmetric-energy  $e^+e^-$  collider [11] operating at or slightly below the  $\Upsilon(4S)$  resonance and at the  $\Upsilon(5S)$  resonance with integrated luminosities of 710.5, 89.2, and 121.4 fb<sup>-1</sup>, respectively. The Belle detector is a large-solid-angle spectrometer, which includes a silicon vertex detector (SVD), a 50-layer central drift chamber (CDC), an array of aerogel threshold Cherenkov counters (ACC), time-of-flight (TOF) scintillation counters, and an electromagnetic calorimeter (ECL) comprised of CsI(Tl) crystals located inside a superconducting solenoid coil that provides a 1.5 T magnetic field. An iron flux return located outside the coil is instrumented to detect  $K_L^0$  mesons and identify muons.

For this analysis, the  $D^0$  meson is required to originate from the decay  $D^{*+} \rightarrow D^0 \pi_s^+$ , where  $\pi_s^+$  is a slow pion, in order to identify the  $D^0$  flavor and suppress the combinatorial background.

The measured raw asymmetry is

$$A_{\text{raw}} = \frac{N(D^0) - N(\bar{D}^0)}{N(D^0) + N(\bar{D}^0)} = A_{CP} + A_{FB} + A_e^\pm + A_e^K, \quad (4)$$

where all terms are small ( $< 1\%$ ):  $A_{FB}$  is the forward-backward production asymmetry of  $D^0$  mesons,  $A_e^\pm$  is the asymmetry due to different detection efficiencies for positively and negatively charged pions, and  $A_e^K$  is the asymmetry originating from the distinct strong interaction of  $K^0$  and  $\bar{K}^0$  mesons with nucleons in the detector material.  $A_{FB}$  and  $A_e^\pm$  can be eliminated through a relative measurement of  $A_{CP}$  with respect to the well-measured mode  $D^0 \rightarrow K_S^0 \pi^0$ . The value of  $A_e^K$  is estimated to be  $-0.11\%$  due to a nonvanishing asymmetry originating from the different nuclear interaction of  $K^0$  and  $\bar{K}^0$  mesons with the detector material estimated in Ref. [12]. The  $CP$  asymmetry of the signal mode is then expressed as

$$A_{CP}(D^0 \rightarrow K_S^0 K_S^0) = A_{\text{raw}}(D^0 \rightarrow K_S^0 K_S^0) - A_{\text{raw}}(D^0 \rightarrow K_S^0 \pi^0) + A_{CP}(D^0 \rightarrow K_S^0 \pi^0) + A_e^K, \quad (5)$$

where  $A_{CP}(D^0 \rightarrow K_S^0 \pi^0) = (-0.20 \pm 0.17)\%$  [13] is the world-average  $CP$  asymmetry of the normalization mode.

The  $D^{*+}$  mesons originate mostly from the  $e^+e^- \rightarrow c\bar{c}$  process via hadronization, where the inclusive yield has a large uncertainty of  $12.5\%$  [13]. To avoid this uncertainty, we measure the  $D^0 \rightarrow K_S^0 K_S^0$  branching fraction with respect to that of the  $D^0 \rightarrow K_S^0 \pi^0$  mode using the following relation:

$$\frac{\mathcal{B}(D^0 \rightarrow K_S^0 K_S^0)}{\mathcal{B}(D^0 \rightarrow K_S^0 \pi^0)} = \frac{(N/\epsilon)_{D^0 \rightarrow K_S^0 K_S^0}}{(N/\epsilon)_{D^0 \rightarrow K_S^0 \pi^0}}. \quad (6)$$

Here,  $\mathcal{B}$  is the branching fraction,  $N$  is the extracted signal yield, and  $\epsilon$  is the reconstruction efficiency. The world-average value of  $\mathcal{B}(D^0 \rightarrow K_S^0 \pi^0) = (1.20 \pm 0.04)\%$  is used [13]. In this ratio, the systematic uncertainties common to the signal and normalization channels cancel.

The analysis procedure is developed using Monte Carlo (MC) simulation based on events generated using EVTGEN [14], which includes final-state radiation effects via PHOTOS [15]; the detector response is simulated by GEANT3 [16]. The selection criteria are optimized using a figure of merit defined as  $N_{\text{sig}}/\sqrt{N_{\text{sig}} + N_{\text{bkg}}}$ , where  $N_{\text{sig}}$  ( $N_{\text{bkg}}$ ) is the number of signal (background) events in the signal region defined as  $0.144 \text{ GeV}/c^2 < \Delta M < 0.147 \text{ GeV}/c^2$  and  $1.847 \text{ GeV}/c^2 < M(D^0) < 1.882 \text{ GeV}/c^2$ , where  $\Delta M = M(D^*) - M(D^0)$ , and  $M$  is the reconstructed invariant mass of the corresponding meson candidate. We use a signal MC sample with about 400 times more events than expected in the data and estimate  $N_{\text{sig}}$  assuming  $\mathcal{B}(D^0 \rightarrow K_S^0 K_S^0) = 1.8 \times 10^{-4}$  [13]. The MC sample used

to estimate the background comprises  $B\bar{B}$  and  $q\bar{q}$  events, where  $q = u, d, s, c$  and corresponds to an integrated luminosity of 6 times that of data. The background contribution is scaled by the ratio of the number of events in the data and MC estimations in the  $\Delta M$  sideband defined as  $0.148 \text{ GeV}/c^2 < \Delta M < 0.160 \text{ GeV}/c^2$ .

We require a slow pion ( $\pi_s$ ) candidate to originate from near the interaction point (IP) by restricting its impact parameters along and perpendicular to the  $z$  axis to be less than 3 and 1 cm, respectively. The  $z$  axis is defined as the direction opposite the  $e^+$  beam. We require that the ratio of the particle identification (PID) likelihoods  $\mathcal{L}_\pi/(\mathcal{L}_\pi + \mathcal{L}_K)$  be greater than 0.4. Here,  $\mathcal{L}_\pi$  ( $\mathcal{L}_K$ ) is the likelihood of a track being a pion (kaon) and is calculated using specific ionization from the CDC, time-of-flight information from the TOF scintillation counters, and the number of photoelectrons in the ACC. With the above PID requirement, the pion identification efficiency is above 95% with a kaon misidentification probability below 5%.

The  $K_S^0$  candidates are reconstructed from pairs of oppositely charged tracks, both treated as pions, and are identified with a neural network (NN) [17]. The NN uses the following seven variables: the  $K_S^0$  momentum in the laboratory frame, the distance along the  $z$  axis between the two track helices at their closest approach, the flight length in the  $x$ - $y$  plane, the angle between the  $K_S^0$  momentum and the vector joining the IP to the  $K_S^0$  decay vertex, the angle between the pion momentum and the laboratory-frame direction in the  $K_S^0$  rest frame, the distances of closest approach in the  $x$ - $y$  plane between the IP and the two pion helices, and the total number of hits (in the CDC and SVD) for each pion track. We also require that the reconstructed invariant mass be within  $\pm 15 \text{ MeV}/c^2$  (about 4 times the resolution) of the nominal  $K_S^0$  mass [13]. The  $K_S^0$  reconstruction efficiency is 81.9%. We reconstruct neutral pion candidates from pairs of electromagnetic showers in the ECL that are not matched to any charged track. Showers in the barrel (end-cap) region of the ECL must exceed 60 (100) MeV to be considered as a  $\pi^0$  daughter candidate [18]. The invariant mass of the  $\pi^0$  candidate must lie within  $\pm 25 \text{ MeV}/c^2$  (about 4 times the resolution) of the known  $\pi^0$  mass [13]. The  $\pi^0$  momentum is required to be greater than  $640 \text{ MeV}/c$ .

To reconstruct  $D^0$  candidates, we combine two reconstructed  $K_S^0$  candidates for the signal mode (one  $K_S^0$  and one  $\pi^0$  for the normalization mode) and retain those having an invariant mass in the range  $1.847 \text{ GeV}/c^2 < M(D^0) < 1.882 \text{ GeV}/c^2$  [ $1.758 \text{ GeV}/c^2 < M(D^0) < 1.930 \text{ GeV}/c^2$ ], within  $\pm 3\sigma$  of the nominal  $D^0$  mass [13]. Finally,  $\pi_s$  candidates are combined with the  $D^0$  candidates to form  $D^*$  candidates, with the requirement that  $\Delta M$  lies in the range  $[0.140, 0.160] \text{ GeV}/c^2$ . The slow pion is constrained to originate from the IP in order to improve the  $\Delta M$  resolution. We require  $D^{*+}$  candidates to have a momentum



greater than 2.2 GeV/c in the center-of-mass frame. This requirement significantly reduces background from random  $D^0\pi_s^+$  combinations.

After all selection criteria, the fraction of signal events with multiple  $D^*$  candidates is 8.6%. If this is due to multiple  $D^0$  candidates, we retain the one having the smallest  $\sum \chi_{K_S^0}^2$ , where  $\chi_{K_S^0}^2$  is the test statistic of the  $K_S^0$  vertex-constraint fit. In case several  $D^*$  candidates remain, the one having the charged pion with the smallest transverse impact parameter is retained. This choice correctly identifies the true  $D^* \rightarrow D^0[K_S^0 K_S^0]\pi_s$  decay with an efficiency of 98%. The best-candidate selection efficiency is the same for  $D^{*+}$  and  $D^{*-}$  candidates. For the normalization mode, the fraction of signal events with multiple  $D^*$  candidates is 27.3%. If this is due to multiple  $D^0$  candidates, we retain the one having the smallest value for the sum of  $\chi_{K_S^0}^2$  and  $\chi_{\pi^0}^2$ , where  $\chi_{\pi^0}^2$  is the test statistic of the  $\pi^0$  mass-constraint fit. This procedure for  $D^0 \rightarrow K_S^0 \pi^0$  selects the correct candidate with an efficiency of 89%.

We describe the  $\Delta M$  distributions for  $D^0 \rightarrow K_S^0 K_S^0$  and  $D^0 \rightarrow K_S^0 \pi^0$  using the sum of two symmetric and one asymmetric Gaussian functions with a common most probable value. All the mode-dependent shape parameters are fixed from MC estimations, except for the mean and a common calibration factor for the symmetric Gaussians that accounts for a data-MC difference in the  $\Delta M$  resolution.

The backgrounds caused by processes with the same final state as the reconstructed modes, mainly,  $D^0 \rightarrow K_S^0 \pi^+ \pi^-$  for the signal mode and  $D^0 \rightarrow \pi^+ \pi^- \pi^0$  for the normalization mode, peak in the  $\Delta M$  distribution. These peaking backgrounds are estimated directly from the data using the  $K_S^0$  mass sidebands defined as  $0.470 \text{ GeV}/c^2 < M_{\pi\pi} < 0.478 \text{ GeV}/c^2$  and  $0.516 \text{ GeV}/c^2 < M_{\pi\pi} < 0.526 \text{ GeV}/c^2$ . The peaking background has the same  $\Delta M$  shape as the signal, and its yield is fixed based on the estimation described above to 267 events for  $D \rightarrow K_S^0 \pi^+ \pi^-$  and 1923 events for  $D^0 \rightarrow \pi^+ \pi^- \pi^0$ . The combinatorial background shapes are modeled with an empirical threshold function  $f(x) = (x - m_\pi)^a \exp[-b(x - m_\pi)]$ , where  $m_\pi$  is the nominal charged pion mass, and  $a$  and  $b$  are shape parameters.

An extended unbinned maximum likelihood fit to the two combined-charge  $D^*$   $\Delta M$  distributions yields  $5399 \pm 87$   $D^0 \rightarrow K_S^0 K_S^0$  events and  $537360 \pm 833$   $D^0 \rightarrow K_S^0 \pi^0$  events. A simultaneous fit of the  $\Delta M$  distributions for  $D^{*+}$  and  $D^{*-}$  (see Fig. 1) is used to calculate the raw asymmetry in  $D^0 \rightarrow K_S^0 K_S^0$ . A similar procedure is followed for the  $D^0 \rightarrow K_S^0 \pi^0$  sample. The signal and background shape parameters are common for both the particle and antiparticle. Both asymmetries in signal and background are allowed to vary in the fit. The value of  $A_{\text{raw}}$  for the peaking background in  $D^0 \rightarrow K_S^0 \pi^0$  is fixed to zero, whereas its value in  $D^0 \rightarrow K_S^0 K_S^0$  is fixed to the value

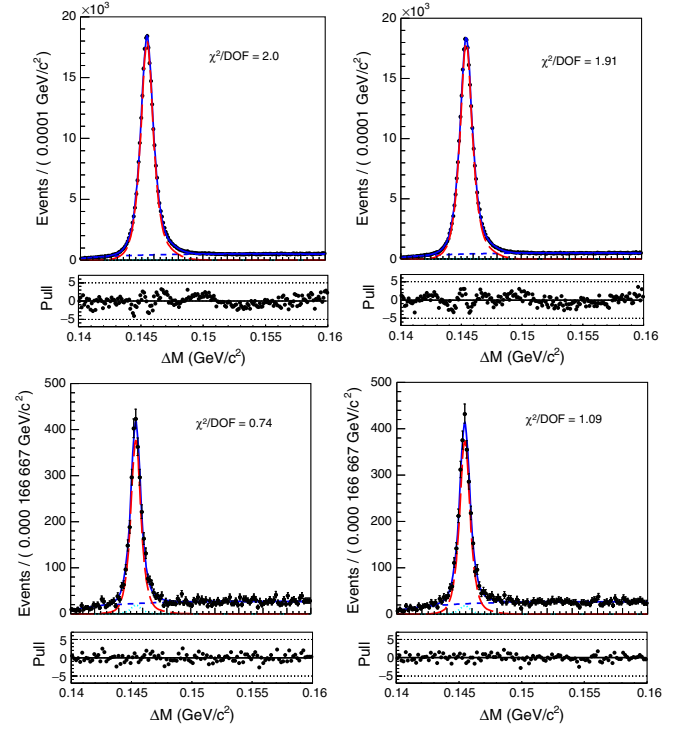


FIG. 1. Distributions of the mass difference  $\Delta M$  for selected  $D^{*+}$  (left) and  $D^{*-}$  (right) candidates reconstructed as  $D^0[K_S^0 K_S^0]\pi_s$  (top) and  $D^0[K_S^0 \pi^0]\pi_s$  (bottom) decays. The points with error bars show the data, and the curves show the result of the fits with the following components: signal (long-dashed red), peaking background (dotted cyan), combinatorial background (dashed blue), and their sum (plain blue). The normalized residuals (pulls) and  $\chi^2/\text{DOF}$ , where DOF is the number of degrees of freedom, are also shown for each plot.

obtained in the data for the  $D^0 \rightarrow K_S^0 \pi^0$  signal. Here we assume that the peaking background in  $D^0 \rightarrow K_S^0 \pi^0$  has zero net  $A_{CP}$ . The fitted values of  $A_{\text{raw}}$  for the  $D^0 \rightarrow K_S^0 K_S^0$  and  $D^0 \rightarrow K_S^0 \pi^0$  decay modes are  $(+0.45 \pm 1.53)\%$  and  $(+0.16 \pm 0.14)\%$ , respectively. The resulting time-integrated  $CP$ -violating asymmetry in the  $D^0 \rightarrow K_S^0 K_S^0$  decay is  $A_{CP} = (-0.02 \pm 1.53)\%$ .

For the branching fraction measurement, we use only the  $D^{*+}$  candidates that have a momentum greater than 2.5 GeV/c in the center-of-mass frame. This suppresses the component arising from  $b\bar{b}$  events and, hence, simplifies the efficiency estimation and controls the systematic uncertainty, which is the dominant uncertainty in this measurement. The  $\Delta M$  fit yields  $4755 \pm 79$   $D^0 \rightarrow K_S^0 K_S^0$  decays and  $475439 \pm 767$   $D^0 \rightarrow K_S^0 \pi^0$  decays. The selection efficiencies are  $(9.74 \pm 0.02)\%$  and  $(11.11 \pm 0.02)\%$ , respectively. Using Eq. (6), we then obtain  $\mathcal{B}(D^0 \rightarrow K_S^0 K_S^0) / \mathcal{B}(D^0 \rightarrow K_S^0 \pi^0) = (1.101 \pm 0.023)\%$ . All quoted uncertainties are statistical.

Table I lists various sources of systematic uncertainties in  $A_{CP}$  and  $\mathcal{B}$  of  $D^0 \rightarrow K_S^0 K_S^0$ . As the branching fraction

TABLE I. Contributions to the systematic uncertainties of the measurements of the  $CP$  asymmetry  $A_{CP}$  (absolute errors) and branching fraction  $\mathcal{B}$  (relative errors) for the  $D^0 \rightarrow K_S^0 K_S^0$  mode.

Source	$A_{CP}$ (%)	$\mathcal{B}$ (%)
$D^0 \rightarrow K_S^0 K_S^0$ PDF parametrization	$\pm 0.01$	$\pm 0.28$
$D^0 \rightarrow K_S^0 \pi^0$ PDF parametrization	$\pm 0.00$	$\pm 0.23$
$D^0 \rightarrow K_S^0 K_S^0$ peaking background	$\pm 0.01$	$\pm 0.59$
$D^0 \rightarrow K_S^0 \pi^0$ peaking background	$\pm 0.00$	$\pm 0.03$
$K^0/\bar{K}^0$ material effects	$\pm 0.01$	$\dots$
$K_S^0$ reconstruction efficiency	$\dots$	$\pm 1.57$
$\pi^0$ reconstruction efficiency	$(\dots)$	$\pm 2.16$
Quadratic sum of above	$\pm 0.02$	$\pm 2.76$
External input ( $D^0 \rightarrow K_S^0 \pi^0$ mode)	$\pm 0.17$	$\pm 3.33$

measurement is a relative measurement, most of the systematic uncertainties common between the signal and normalization channel cancel. The uncertainties on the probability distribution function (PDF) parametrization are estimated by varying each fixed shape parameter by its uncertainty and repeating the fit. We independently vary the calibration factor for each Gaussian to account for different data-MC difference in the broad and narrow parts of the signal PDF. The systematic uncertainty is taken as the quadratic sum of the changes in the fitted results.

The peaking background is estimated from the  $K_S^0$  mass sidebands, and we fix the yield in the final fit using the scale factor between the signal region and sideband in the MC estimations after removing the signal contamination. We repeat the fit procedure by varying the fixed yield by its statistical error, and we take the difference between the resulting signal yield and the nominal value as the systematic uncertainty due to the fixed peaking background. We refit by varying the fixed  $A_{\text{raw}}$  by its statistical error and take the difference of the refitted and nominal results as the systematic uncertainty. The uncertainty due to fixing  $A_{\text{raw}}$  for the peaking component in both  $D^0 \rightarrow K_S^0 K_S^0$  and  $D^0 \rightarrow K_S^0 \pi^0$  is negligible. The dominant systematic uncertainty on  $A_{CP}$  is from the uncertainty on the  $A_{CP}$  measurement of the normalization channel,  $D^0 \rightarrow K_S^0 \pi^0$ .

The systematic uncertainties on the reconstruction efficiency that do not cancel in the ratio to the normalization mode are those related to the reconstruction of the  $K_S^0$  and the  $\pi^0$ . For both the MC calculation and data, the  $K_S^0$  reconstruction efficiencies are estimated by calculating the ratio  $R$  of the  $D^0 \rightarrow K_S^0 \pi^0$  signal yield extracted with and without the nominal  $K_S^0$  requirements. Then, the double ratio  $R_{\text{data}}/R_{\text{MC}} = (98.57 \pm 0.40)\%$  quantifies the possible difference between the data and simulations. We correct for the efficiency and assign a systematic uncertainty of 1.40%. The tracking efficiency per track of 0.35% is obtained from a large sample of  $D^{*\pm} \rightarrow D^0 \pi^\pm$ , where the  $D^0$  decays to  $K_S^0 \pi^+ \pi^-$  [19]. It is added linearly for the two daughters of the  $K_S^0$  and combined with the above uncertainty, yielding

1.57% for the systematic uncertainty due to  $K_S^0$  reconstruction. There is a systematic uncertainty on the  $\pi^0$  reconstruction efficiency. We obtain the corresponding data-MC correction factor  $(95.14 \pm 2.16)\%$  from a sample of  $\tau^- \rightarrow \pi^- \pi^0 \nu_\tau$  decay [19]. We apply this correction and assign 2.16% as a systematic uncertainty. Lastly, we take the uncertainty on the world-average branching fraction of the normalization mode  $D^0 \rightarrow K_S^0 \pi^0$ . These individual contributions are added in quadrature to obtain the total systematic uncertainty.

Using a data sample that corresponds to an integrated luminosity of  $921 \text{ fb}^{-1}$ , we have measured the time-integrated  $CP$ -violating asymmetry in the  $D^0 \rightarrow K_S^0 K_S^0$  decay to be

$$A_{CP} = (-0.02 \pm 1.53 \pm 0.02 \pm 0.17)\%,$$

where the first uncertainty is statistical, the second is systematic, and the third is due to the uncertainty on  $A_{CP}$  of  $D^0 \rightarrow K_S^0 \pi^0$ . From our measurement of the branching fraction ratio,

$$\frac{\mathcal{B}(D^0 \rightarrow K_S^0 K_S^0)}{\mathcal{B}(D^0 \rightarrow K_S^0 \pi^0)} = (1.101 \pm 0.023 \pm 0.030)\%,$$

we obtain the  $D^0 \rightarrow K_S^0 K_S^0$  branching fraction as

$$\begin{aligned} \mathcal{B}(D^0 \rightarrow K_S^0 K_S^0) \\ = (1.321 \pm 0.023 \pm 0.036 \pm 0.044) \times 10^{-4}, \end{aligned}$$

where the first uncertainty is statistical, the second is systematic, and the third is due to the uncertainty on  $\mathcal{B}$  of  $D^0 \rightarrow K_S^0 \pi^0$ .

The  $A_{CP}$  result is consistent with the SM expectation and improves the uncertainty with respect to the recent measurement of this quantity by LHCb [8] by about a factor of 4. Furthermore, the precision is already comparable to the theory prediction [3]. While the  $\mathcal{B}$  result is consistent with the world average [13], it is  $2.3\sigma$  away from a recent BESIII measurement [9]. Both the  $A_{CP}$  and  $\mathcal{B}$  measurements are the most precise ones available for the  $D^0 \rightarrow K_S^0 K_S^0$  mode.

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