Measurement of branching fraction and search for CP violation in $D^0 \to K_S^0 K_S^0 \pi^+ \pi^-$ decays at Belle

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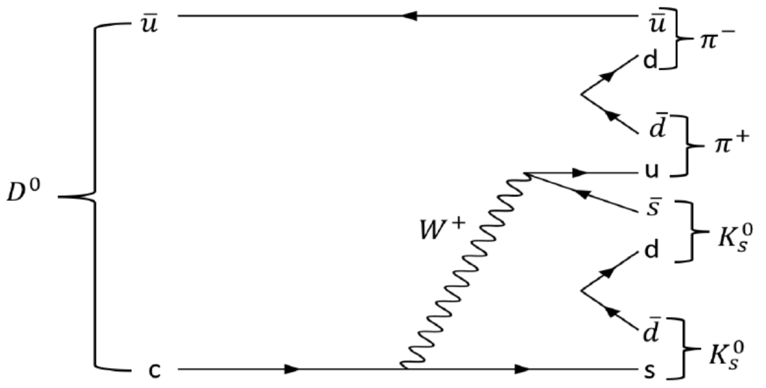
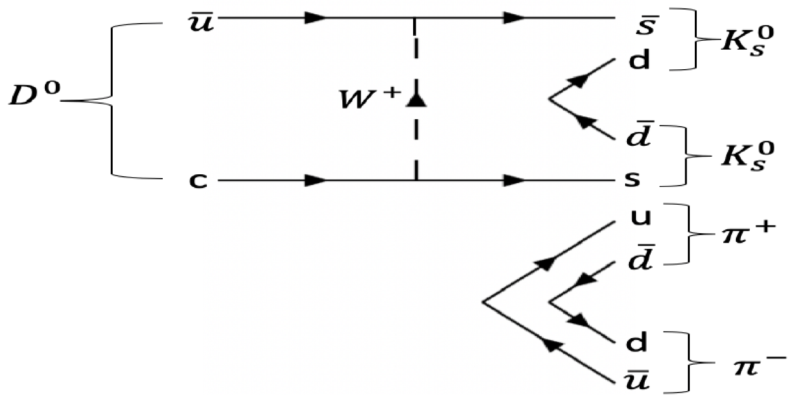
Motivation:

- In Standard Model framework, charm meson decays are expected to have very small *CP* violation, $\mathcal{O}(10^{-3})$ or smaller [1]
- *CP* violation measurement significantly deviating from SM expectation will probe new physics.
- Singly Cabibbo suppressed (SCS) charm decays are expected to be uniquely sensitive to new physics effects. [1]
- First experimental observation of *CP* violation in SCS charm mesons was made by LHCb. [2]
- In this analysis, we have searched for *CP* violation in the SCS charm meson decay $D^0 \to K_s^0 K_s^0 \pi^+ \pi^-$
- We also performed branching fraction measurement for this decay mode. *(previously measured by BESIII)*





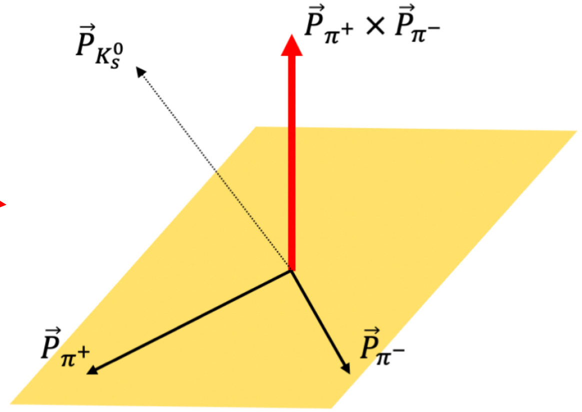
[1] (yuval grossman, et al. Phys.Rev.D 75 (2007), 036008)
[2] LHCb Collaboration Phys.Rev.Lett. 122 (2019) 21, 211803

CP violating observable a_{CP}^{T} :

- We measure the *CP* violation using T-odd triple product (TP) asymmetries.
- We define scalar triple product C_T as:
  - $C_T = \vec{p}_{K_S^0} \cdot (\vec{p}_{\pi^+} \times \vec{p}_{\pi^-})$ (K_s^0 with higher momentum is used)

- *I. I. Y. Bigi. Charm physics: Like Botticelli in the Sistine Chapel.*
- *Michael Gronau et.al PRD,495 84(9), Nov 2011.*

  - For D^0 decays, T-odd triple product asymmetry A_T is defined as :
    - $A_T = \frac{N_1\,(C_T>0) - N_2\,(C_T<0)}{N_1\,(C_T>0) + N_2\,(C_T<0)}$



  - For $\bar{D}^0$ decays, CP conjugate observables: $A_T \xrightarrow{CP} \bar{A}_T$, $C_T \xrightarrow{C} \bar{C}_T \xrightarrow{P} -\bar{C}_T$
    - $\bar{A}_T = \frac{N_3\,(-\bar{C}_T>0) - N_4(-\bar{C}_T<0)}{N_3\,(-\bar{C}_T>0) + N_4(-\bar{C}_T<0)}$

- The difference $a_{CP}^{\mathrm{T}} = \frac{1}{2}(A_T - \bar{A}_T)$ is a *CP* violating observable.
- The observable a_{CP}^{T} is independent of effects from strong phases.
- By construction, a_{CP}^{T} is mostly unaffected by production and detection related asymmetries.

- *Michael Gronau et.al PRD,495 84(9), Nov 2011.*

CP violation measurement using A_{CP} :

- We also measure the CP violating observable A_{CP} defined as:

$$A_{CP}^{\det} = \frac{N(D^0 \to f) - N(\bar{D}^0 \to \bar{f})}{N(D^0 \to f) + N(\bar{D}^0 \to \bar{f})}$$

  - It is the difference in number of D^0 and $\bar{D}^0$ decays to the CP conjugate final states f and $\bar{f}$.

- Measurement of both A_{CP} and a_{CP}^{T} are complementary to each other:
  - The observable $\boldsymbol{A_{CP}} \propto \boldsymbol{sin(\phi)\, sin(\delta)}$, where (ϕ) is weak and (δ) is strong phase difference between the contributing amplitudes.
  - The observable $\boldsymbol{a_{CP}^{T}} \propto \boldsymbol{sin(\phi)\, cos(\delta)}$
  - To observe a non zero A_{CP} strong phase difference (δ) must be non zero, whereas the a_{CP}^{T} is largest when the strong phase difference (δ) is zero.

- *A. Datta et.al, Int.J.Mod.Phys.A 19 (2004), 2505-2544*

Branching fraction (BF) measurement:

- With our data sample of 921 fb^{-1} , we can perform world's most precise measurement of $D^0 \to K_s^0\, K_s^0\, \pi^+\, \pi^-$ branching fraction.

- We will measure the branching fraction relative to normalization channel $D^0 \to K_s^0\, \pi^+\, \pi^-$.

- The Branching fraction is calculated using :

$$\mathcal{B}(D^0 \to K_S^0\, K_S^0\, \pi^+\pi^-) = \left(\frac{N_{K_S^0\, K_S^0 \pi^+\pi^-}}{N_{K_S^0 \pi^+\pi^-}}\right)\left(\frac{\varepsilon_{K_S^0 \pi^+\pi^-}}{\varepsilon_{K_S^0\, K_S^0 \pi^+\pi^-}}\right) \times \frac{\mathcal{B}(D^0 \to K_S^0\, \pi^+\pi^-)}{\mathcal{B}(K_S^0 \to \pi^+\pi^-)}$$

Reconstruction efficiency for $D^0 \to K_s^0\, \pi^+\, \pi^-$

World average value

World average value

Total $D^0 \to K_s^0\, K_s^0\, \pi^+\, \pi^-$

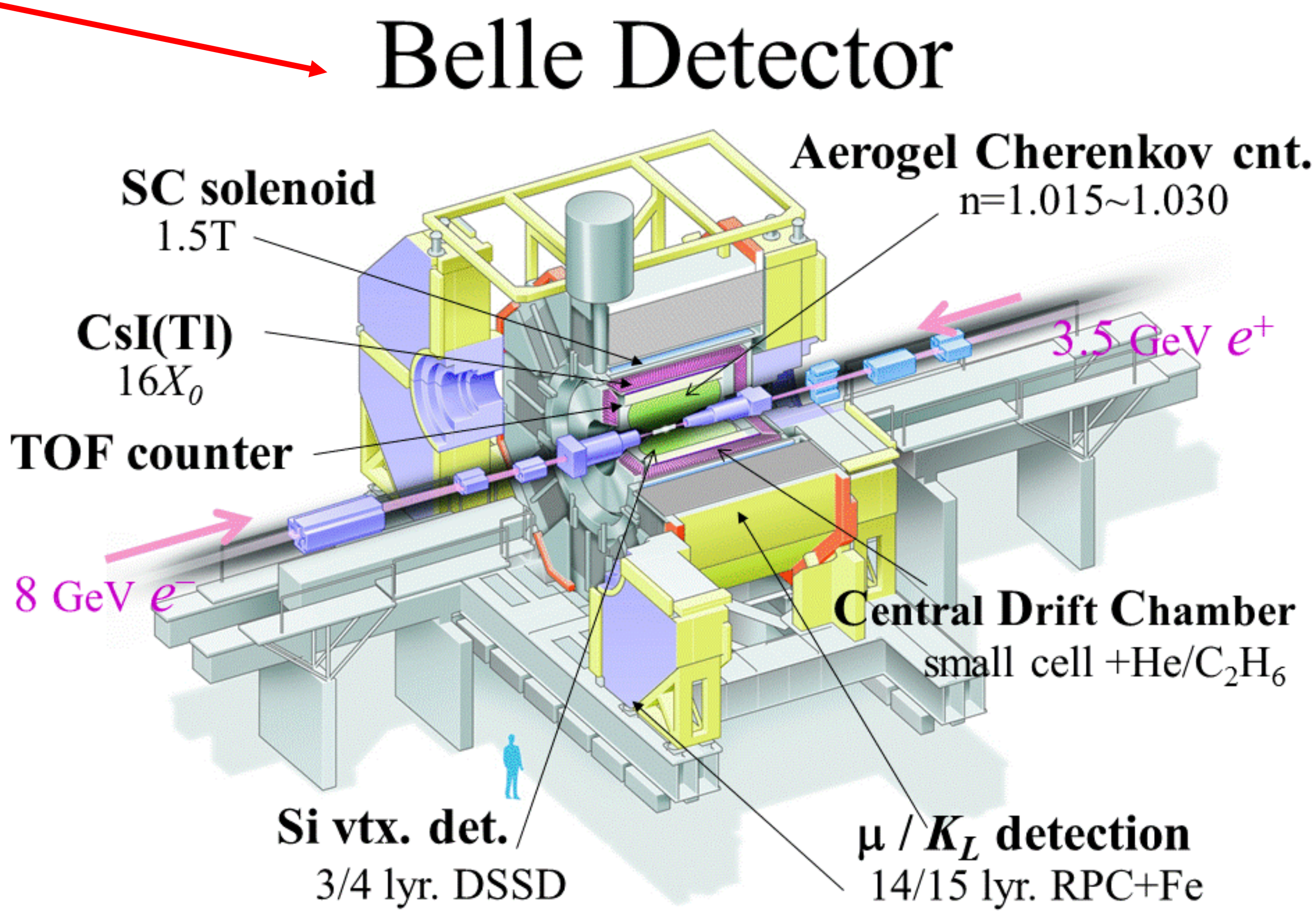
Total $D^0 \to K_s^0\, \pi^+\, \pi^-$

Reconstruction efficiency for $D^0 \to K_s^0\, K_s^0\, \pi^+\, \pi^-$

Belle detector and data sample:

- KEKB accelerator: collided 8 GeV e^- with 3.5 GeV e^+ . *(https://lib506extopc.kek.jp/preprints/PDF/1995/9524/ 9524007.pdf)*
- Belle detector is situated at collision point of KEKB accelerator. *(Nucl.Instrum.Meth.A 479 (2002), 117-232)*
- Belle detector had:
  - good PID
  - good vertexing capability

- For this analysis we have used data sample corresponding to **921 $\mathbf{fb^{-1}}$** integrated luminosity.
- Data is collected at e^+e^- COM energy equal to Υ(4S), 60 MeV below Υ(4S) and Υ(5S) resonances.



Reconstruction of decay at Belle detector

- Reconstructed decay chain and the corresponding selection criteria are summarized in the figure on right.
- In case of multiple candidate events, we choose a single candidate corresponding to the lowest value for $\sum \chi^2/\text{ndf}$ of D^*, D^0 and K_S^0 vertex fit.
- We get a reconstruction efficiency of 6.92% for $D^0 \to K_S^0 K_S^0 \pi^+\pi^-$
- We apply same set of selection criteria for normalization channel $D^0 \to K_S^0\pi^+\pi^-$ and obtain a reconstruction efficiency of 14.97 %

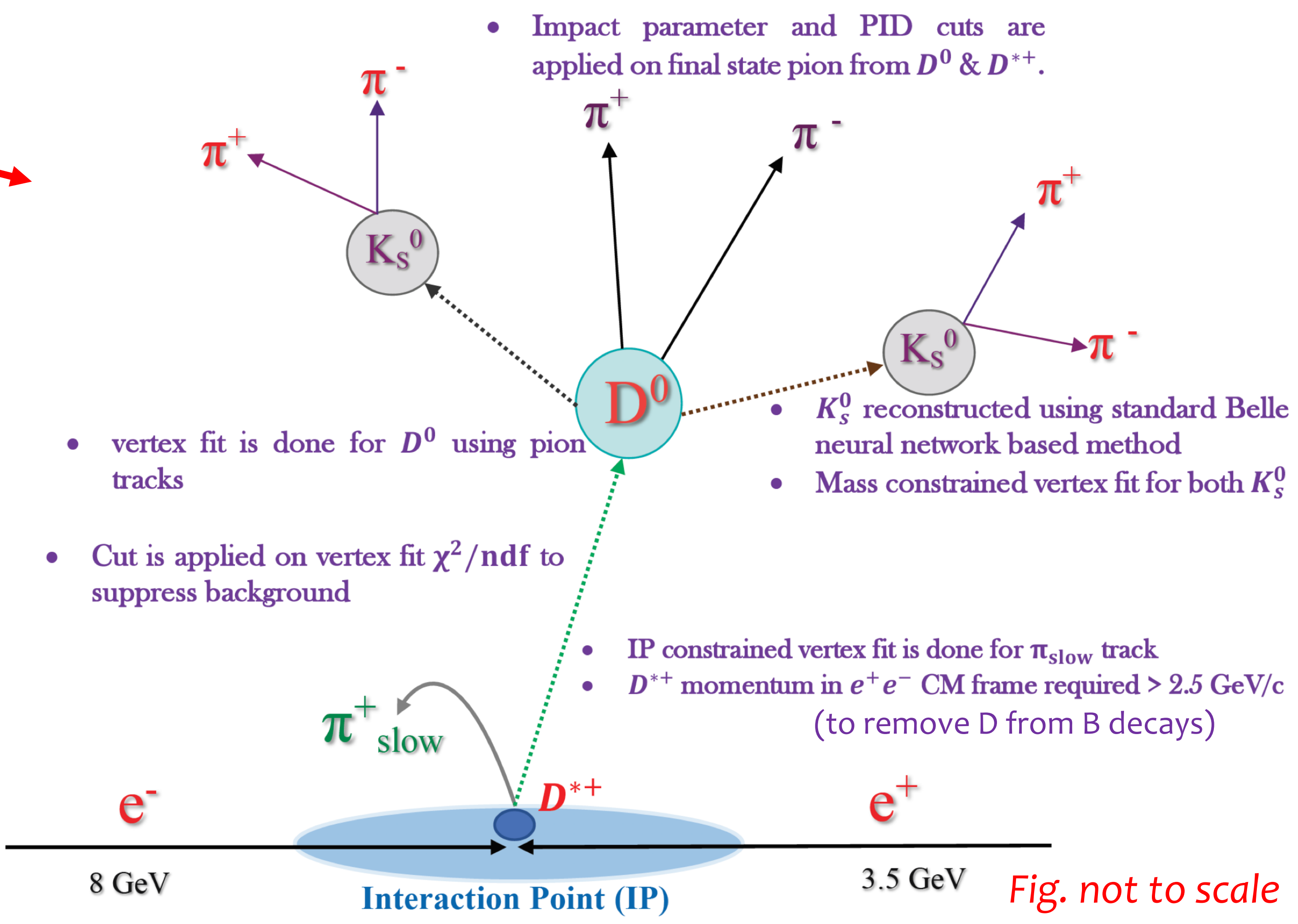


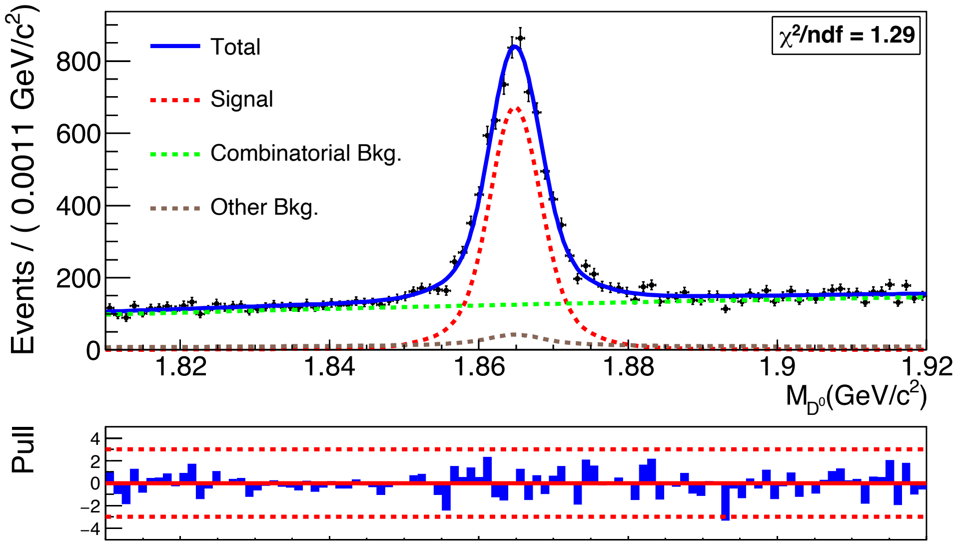
Fig. not to scale

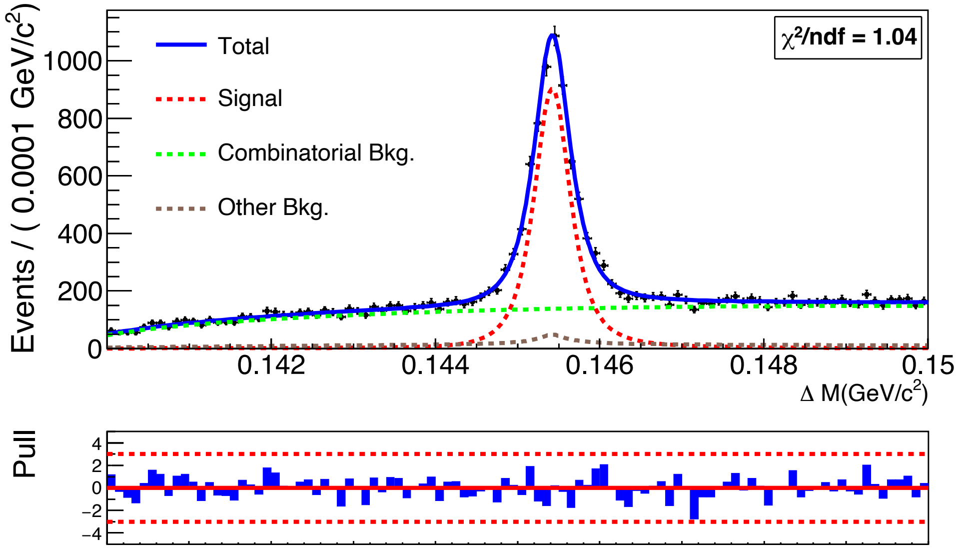
Branching fraction measurement

Signal extraction for BF measurement:

- $D^0 \rightarrow K_S^0 K_S^0 \pi^+ \pi^-$:
  - To extract the signal events from data sample we have used a 2d unbinned extended maximum likelihood fit in variables: $M_{D^0}[M(K_S^0 K_S^0 \pi^+ \pi^-)]$ and ΔM $[M(K_S^0 K_S^0 \pi^+ \pi^- \pi^+_{slow}) - M(K_S^0 K_S^0 \pi^+ \pi^-)]$
  - Fit results from 921 fb^{-1} Belle data:

Details on signal and background pdf in backup slide #22



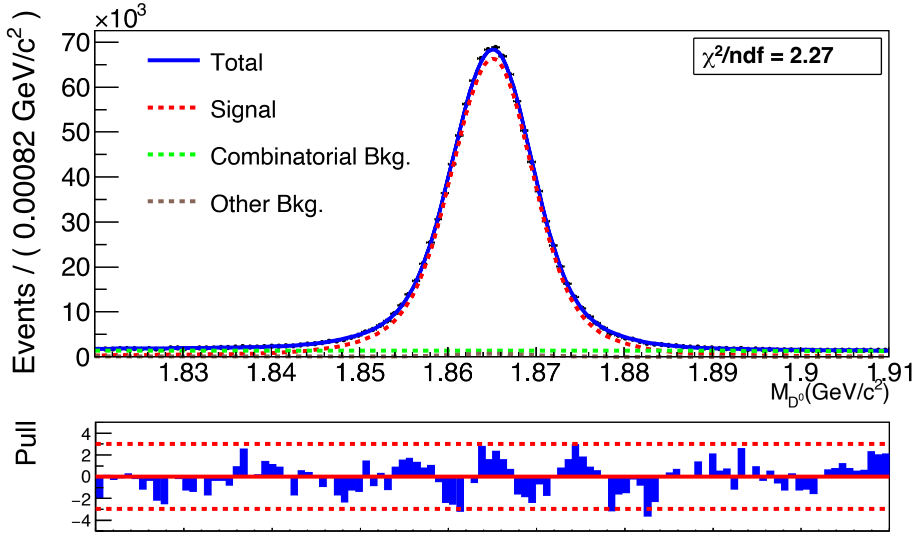


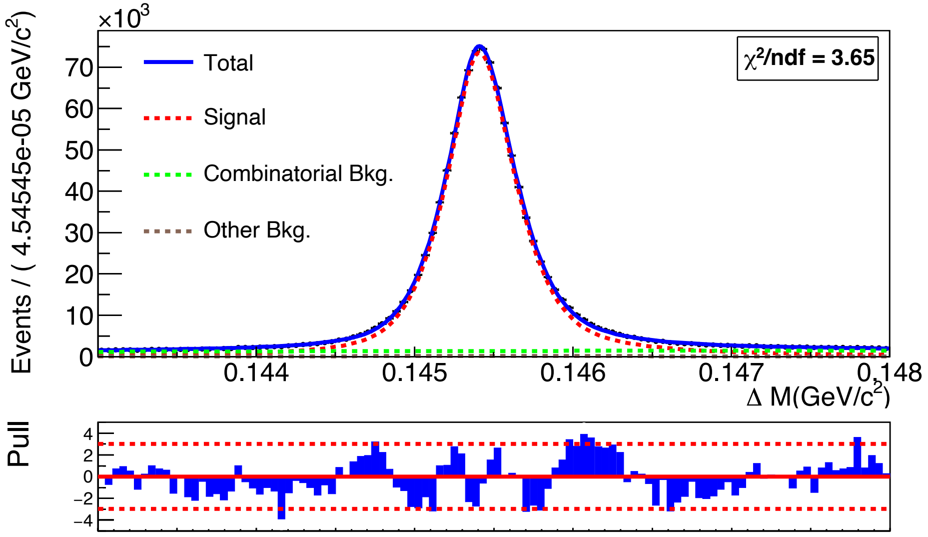
- We obtain 6095$\pm$ 98 signal events from 921 fb^{-1} of data.
- We perform the branching fraction measurement relative to normalization channel $D^0 \rightarrow K_S^0 \pi^+ \pi^-$

Signal extraction for BF measurement:

- $D^0 \to K_s^0\pi^+\pi^-$:
  - To extract the signal events from data sample we have used a 2d binned extended maximum likelihood fit in variables M_{D^0} and ΔM
  - Fit results from 921 fb^{-1} Belle data:

Details on signal and background pdf in backup slide #22





- We obtain 1069870$\pm$ 1831 $D^0 \to K_s^0\pi^+\pi^-$ events from 921 fb^{-1} of data.
- The measured values are:
  - BF($D^0\to K_s^0\, K_s^0\, \pi^+\, \pi^-$)/BF($D^0\to K_s^0\, \pi^+\, \pi^-$) = [1.72 $\pm$ 0.03 (stat.) $\pm$ 0.04 (syst.)] %
  - BF($D^0\to K_s^0\, K_s^0\, \pi^+\, \pi^-$) $= [4.82 \pm 0.08\,(\text{stat.})\,^{+0.10}_{-0.11}\,(\text{syst.}) \pm 0.31\,(\text{norm.})] \times 10^{-4}$

A_{CP} measurement

Fit for A_{CP} :

- The A_{CP} value obtained using below equation includes contribution from non CP violating production and reconstruction asymmetries:

$$A_{CP}^{\det} = \frac{N(D^0 \to f) - N(\overline{D}^0 \to \overline{f})}{N(D^0 \to f) + N(\overline{D}^0 \to \overline{f})}$$

- $A_{CP}^{\det} = A_{CP} + A_{FB} + A_{\epsilon}^{\pi_s}$

  A_{CP} → CP violating asymmetry

  A_{FB} → Forward backward asymmetry

  $A_{\epsilon}^{\pi_s}$ → Asymmetry due to difference in reconstruction efficiency between π_s^+ and π_s^-

- To account for $A_{\varepsilon}^{\pi_s}$, we weight the D^0 and $\overline{D}^0$ events as :

$$\begin{aligned} w_{D^0} &= 1 - A_{\epsilon}^{\pi_s}(p_T, \cos\theta_{\pi_s}) \\ w_{\overline{D}^0} &= 1 + A_{\epsilon}^{\pi_s}(p_T, \cos\theta_{\pi_s}) \end{aligned}$$

- Resulting A_{CP} now includes $A_{CP}^{\text{cor}} = A_{CP} + A_{FB}$.

- The forward backward asymmetry is odd function of cos(θ^*), where θ^* is D* polar angle in COM frame.

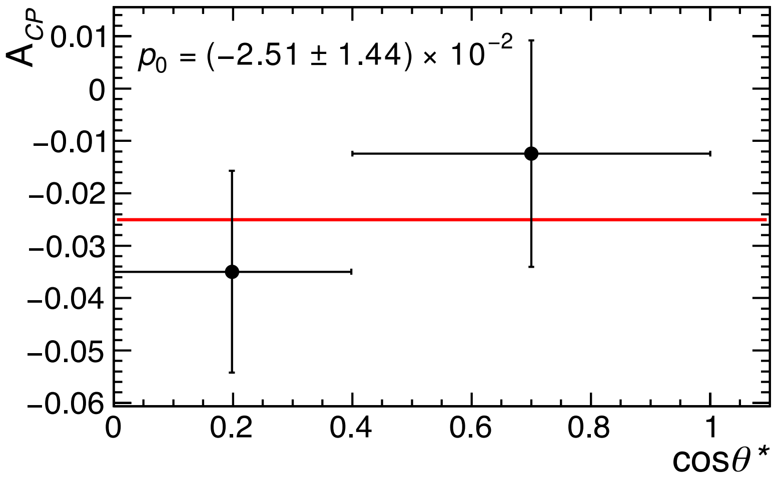
- For a given cos(θ^*) bin, we obtain true CP violating asymmetr

$$A_{CP} = \frac{A_{CP}^{\text{cor}}(\cos\theta^*) + A_{CP}^{\text{cor}}(-\cos\theta^*)}{2}$$

- The average of all positive cos(θ^*) bins will be quoted as final A_{CP} asymmetry.

A_{CP} results from 921 fb^{-1} Belle data:

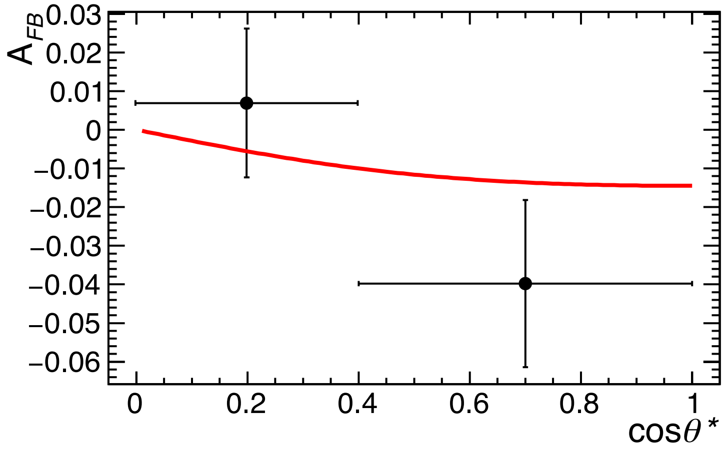
A_{CP} values as function of $\cos(\theta^*)$:



- The red line is a straight line fit to A_{CP} values

- Final A_{CP} result is :
  $A_{CP} = \left[-2.51 \pm 1.44\ (\text{stat.})\ ^{+0.35}_{-0.52}\ (\text{syst.})\right] \times 10^{-2}$

A_{FB} values as function of $\cos(\theta^*)$:



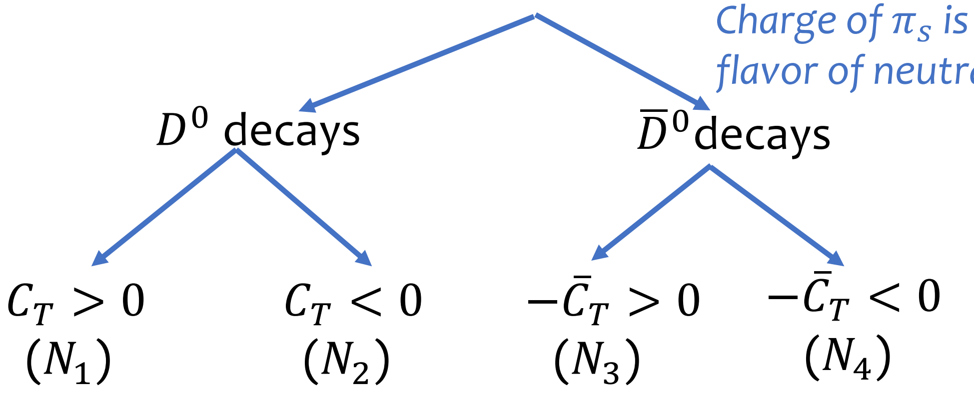
- The red lines shows the expected prediction for A_{FB}
  $A_{FB} = 0.029 \cos(\theta^*) / (1 + \cos^2(\theta^*))$

$a_{\mathrm{CP}}^{\mathrm{T}}$ measurement

Simultaneous fit for a_{CP}^{T} measurement:

- To measure a_{CP}^{T}, data sample is divided into four categories:

Charge of π_s is used to tag the flavor of neutral D meson



- To obtain a_{CP}^{T} , we perform a 2d unbinned extended maximum likelihood fit simultaneously to these four datasets.
- Instead of yields N_1, N_2, N_3 and N_4 , we float N_1 , A_T , N_3 and a_{CP}^{T}. This choice is made to get correct uncertainty in a_{CP}^{T} from fit results instead of calculating them using the uncertainty in yields.
- The expression for N_2 and N_4 in terms of N_1 , A_T , N_3 and a_{CP}^{T} are obtained as shown below:
- $A_T = \frac{N_1\,(C_T>0) - N_2\,(C_T<0)}{N_1\,(C_T>0) + N_2\,(C_T<0)}$, $\longrightarrow$ $N_2 = \frac{N_1\,(1-A_T)}{(1+A_T)}$
- $\bar{A}_T = \frac{N_3\,(-\bar{C}_T>0) - N_4(-\bar{C}_T<0)}{N_3\,(-\bar{C}_T>0) + N_4(-\bar{C}_T<0)}$ and $a_{CP}^{\mathrm{T}} = \frac{1}{2}(A_T - \bar{A}_T)$ $\longrightarrow$ $N_4 = \frac{N_3\,(1-(A_T - 2*a_{\mathrm{CP}}^{\mathrm{T}}))}{1+(A_T - 2*a_{\mathrm{CP}}^{\mathrm{T}})}$

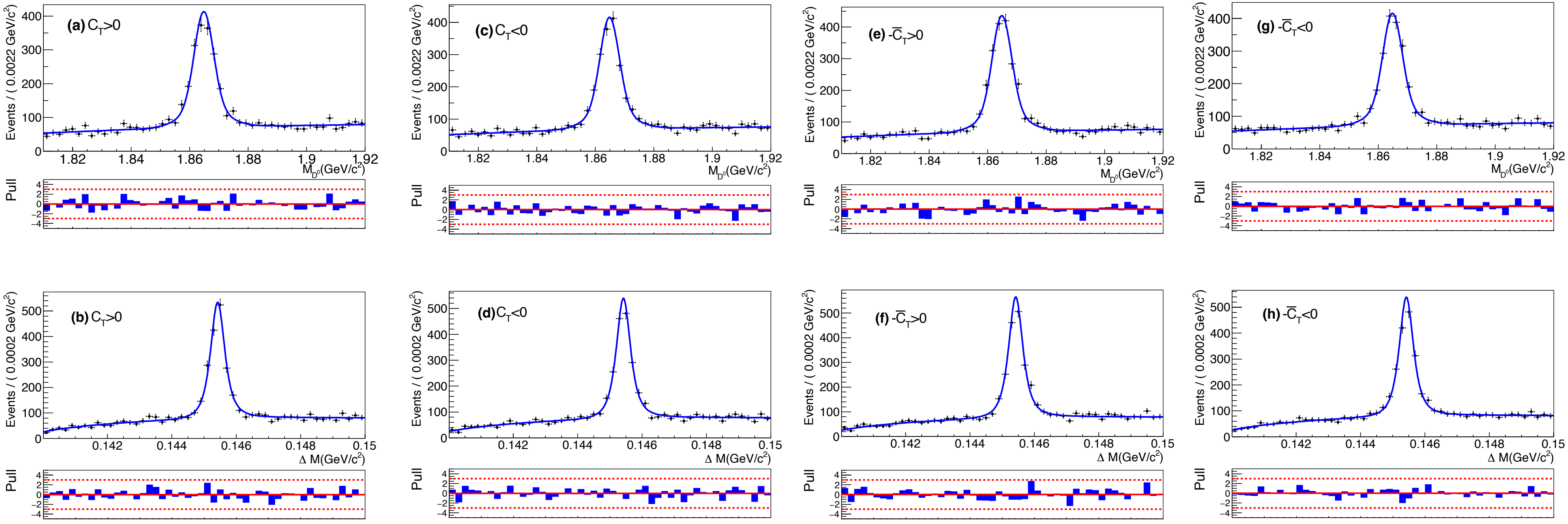
Simultaneous fit for a_{CP}^{T} measurement:

- From 921 fb^{-1} Belle data we obtain:
  - $a_{CP}^{T} = [-1.95 \pm 1.42\ (\text{stat.})\ ^{+0.14}_{-0.12}\ (\text{syst.})]\%$
  - The result is consistent with no *CP* violation within uncertainties.
- Simultaneous fit projections on M_{D^0} and ΔM for four data samples are shown below:

$C_T > 0$ | $C_T < 0$ | $-\bar{C}_T > 0$ | $-\bar{C}_T < 0$

M_{D^0} projections →

ΔM projections →



Summary:

1. We have measured the branching fraction of $D^0 \to K_S^0\, K_S^0\, \pi^+\, \pi^-$:

   $\boldsymbol{BF(D^0 \to K_S^0\, K_S^0\, \pi^+\, \pi^-) = [4.82\ \pm 0.08\ (\mathrm{stat.})\ {}^{+0.10}_{-0.11}\ (\mathrm{syst.})\ \pm 0.31\ (\mathrm{norm.})] \times 10^{-4}}$

   - *(BESIII measurement:* $= [5.30\ \pm 0.90\ (\mathrm{stat.}) \pm 0.30\ (\mathrm{syst.})] \times 10^{-4})$

   This is the world's most precise measurement for this decay mode.

2> We have measured the CP violating observable A_{CP} :

   $\boldsymbol{A_{CP} = \left[-2.51\ \pm 1.44\ (\mathrm{stat.})\ {}^{+0.35}_{-0.52}\ (\mathrm{syst.})\ \right] \times 10^{-2}}$

   The measured A_{CP} value is consistent with zero CP violation.

3> We have measured CP violating observable a_{CP}^T:

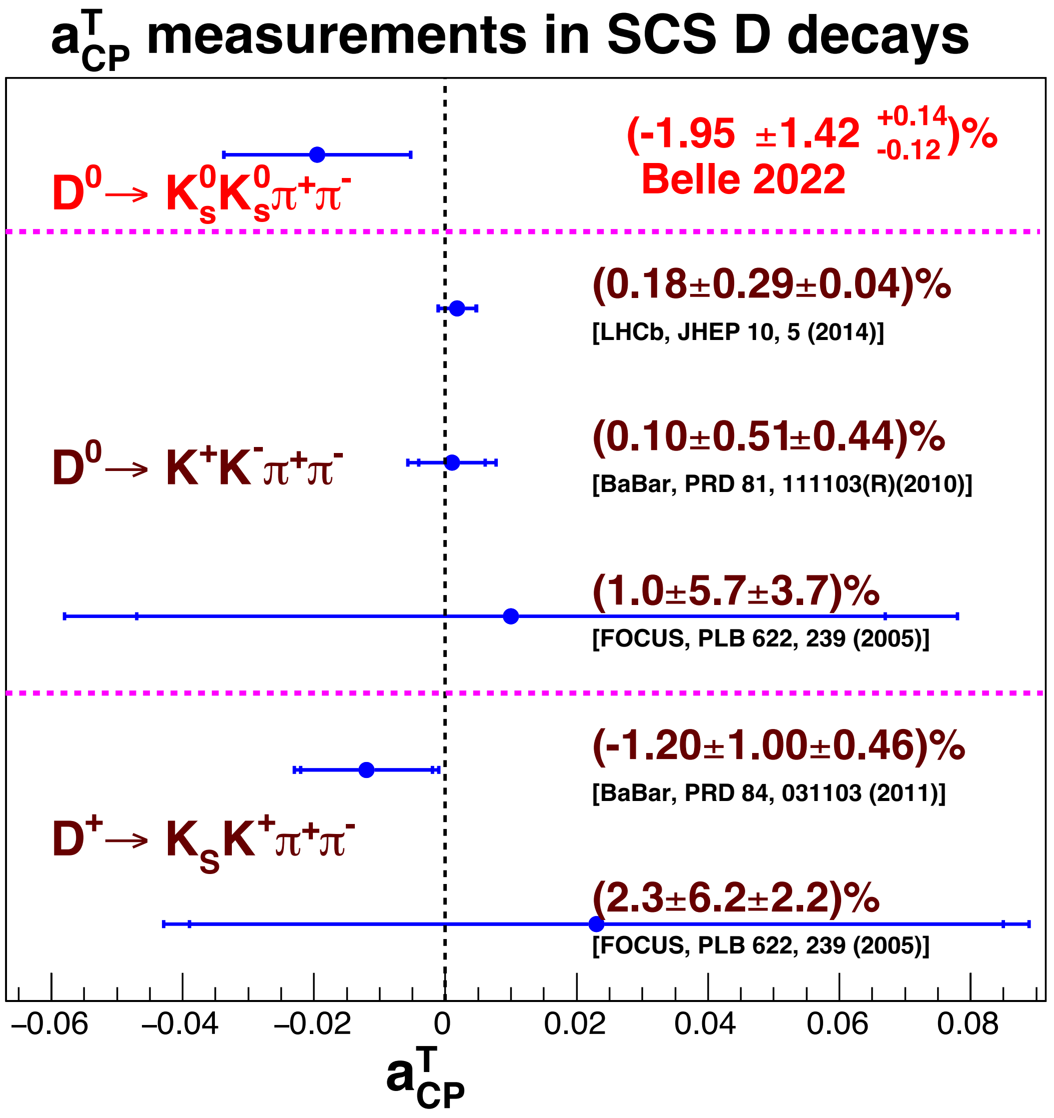
   $\boldsymbol{a_{CP}^T = \left[-1.95\ \pm 1.42\ (\mathrm{stat.})\ {}^{+0.14}_{-0.12}\ (\mathrm{syst.})\right] \times 10^{-2}}$

   This measurement is also consistent with zero CP violation.

Thank You!

Backup

Search for CP violation using a_{CP}^{T-odd} in D decays :



Variables used for K_S^0 reconstruction by Belle neural network based method

- K_S^0 momentum in lab frame.
- Distance along the z axis between two track helices at their closest approach.
- Flight length in x-y plane.
- Angle between K_S^0 momentum and the vector joining IP to K_S^0 decay vertex.
- Angle between π momentum and laboratory frame direction in K_S^0 rest frame.
- Distance of closest approach in the x-y plane between the IP and the two pion helices.
- Total number of hits in SVD (silicon vertex detector) and CDC (central drift chamber) for two pion tracks.

Signal extraction for BF measurement:

- $\boldsymbol{D^0 \to K_s^0 K_s^0 \pi^+ \pi^-}$:
  - Using simulation, events are divided into following categories:
    - **Events with correctly reconstructed signal decays.**
    - **Random $\boldsymbol{\pi_{\mathrm{slow}}}$ background.** *(correctly reconstructed D^0 combined with wrong π_{slow})*
    - **Broken charm peaking background.** *(reconstruction missed one or more final state particles from a real D^0 decay to a non signal final state)*
    - $\boldsymbol{D^0 \to 3K_s^0}$ **peaking background** *(96% vetoed by selection on $\pi^+\pi^-$ invariant mass).*
    - **Combinatorial background.** *(random combination of final state particles)*

- $\boldsymbol{D^0 \to K_s^0 \pi^+ \pi^-}$:
  - Using simulation, events are divided into following categories:
    - **Events with correctly reconstructed signal decays.**
    - **Random $\boldsymbol{\pi_{\mathrm{slow}}}$ background.**
    - **Broken charm peaking background.**
    - **Combinatorial background.**

Details of pdfs used to extract signal:

1> $D^0 \to K_S^0 K_S^0 \pi^+ \pi^-$:

Component type	M_{D^0}	ΔM
Signal decays	3 Asymmetric Gaussian (AG)	2AG + 1 student-t
Mis-reconstructed signal	2nd order chebychev polynomial	4th order chebychev polynomial
Random π_{slow} background	Same as signal	$Q^{\frac{1}{2}} + \alpha Q^{\frac{3}{2}}$ (Q = $\Delta M - M_\pi$)
Broken charm background	2 gaussian	student-t
$D^0 \to 3K_S^0$ background	gaussian	student-t
Combinatoric background	2nd order chebychev polynomial	$Q^{\frac{1}{2}} + \alpha' Q^{\frac{3}{2}}$

2> $D^0 \to K_S^0 \pi^+ \pi^-$:

Component type	M_{D^0}	ΔM
Signal decays	3 Asymmetric Gaussian (AG)	1G + 1 Asymmetric student-t
Random π_{slow} background	Same as signal	$Q^{\frac{1}{2}} + \alpha Q^{\frac{3}{2}}$ (Q = $\Delta M - M_\pi$)
Broken charm background	gaussian + 2nd order polynomial	student-t
Combinatoric background	1st order chebychev polynomial	$Q^{\frac{1}{2}} + \alpha' Q^{\frac{3}{2}}$

Rearranging asymmetry equations on slide 5

- $A_T = \frac{N_1\,(C_T>0) - N_2\,(C_T<0)}{N_1\,(C_T>0) + N_2\,(C_T<0)}$, $\Longrightarrow N_2 = \frac{N_1\,(1-A_T)}{(1+A_T)}$

- $\bar{A}_T = \frac{N_3\,(-\bar{C}_T>0) - N_4(-\bar{C}_T<0)}{N_3\,(-\bar{C}_T>0) + N_4(-\bar{C}_T<0)}$ and $a_{\text{CP}}^{\text{T-odd}} = \frac{1}{2}(A_T - \bar{A}_T) \Longrightarrow N_4 = \frac{N_3\,(1-(A_T - 2*a_{\text{CP}}^{\text{T-odd}}))}{1+(A_T - 2*a_{\text{CP}}^{\text{T-odd}})}$

Systematic uncertainty for BF:

Summary of systematic uncertainty for BF measurement:

Source	$K_S^0 K_S^0 \pi^+\pi^-$ (%)	$K_S^0 \pi^+\pi^-$ (%)
Fixed PDF parameters	0.14	0.09
$D^0 \to K_S^0 K_S^0 K_S^0$ background	0.11	–
Broken charm background	0.98	–
MC statistics	0.26	0.17
PID efficiency correction	0.80	0.74
K_S^0 reconstruction efficiency	0.83	0.36
Tracking Efficiency	0.70	
$M(\pi^+\pi^-)$ veto efficiency	$^{+0.42}_{-0.93}$	–
Fraction of mis-reconst. signal	$^{+0.02}_{-0.03}$	–
$D^0 \to K_S^0 K_S^0 \pi^+\pi^-$ decay model	0.73	
$\mathcal{B}(K_S^0 \to \pi^+\pi^-)$	0.07	–
Total for $\mathcal{B}_{K_S^0 K_S^0 \pi^+\pi^-}/\mathcal{B}_{K_S^0 \pi^+\pi^-}$	$^{+2.07}_{-2.23}$	

The final BF results are:

1> BF($D^0 \to K_S^0 K_S^0 \pi^+ \pi^-$)/BF($D^0 \to K_S^0 \pi^+ \pi^-$) =
$[1.72 \pm 0.03\,(\text{stat.}) \pm 0.04\,(\text{syst.})]\,\%$

2> BF($D^0 \to K_S^0 K_S^0 \pi^+ \pi^-$) =
$[4.82 \pm 0.08\,(\text{stat.})\,^{+0.10}_{-0.11}\,(\text{syst.}) \pm 0.31\,(\text{norm.})] \times 10^{-4}$

- This is the world's most precise measurement for $D^0 \to K_S^0 K_S^0 \pi^+ \pi^-$ branching fraction.

BESIII result:
BF($D^0 \to K_S^0 K_S^0 \pi^+ \pi^-$) =
$[5.20 \pm 0.90\,(\text{stat.}) \pm 0.30\,(\text{syst.})] \times 10^{-4}$

Systematic uncertainty for a_{CP}^{T} :

Summary of systematic uncertainties evaluated for a_{CP}^{T}:

Source	(%)
Fixed PDF parameters	0.010
$D^0 \to K_S^0 K_S^0 K_S^0$ background	${}^{+0.000}_{-0.013}$
Broken charm background	${}^{+0.014}_{-0.040}$
Efficiency variation with C_T, $\overline{C}_T$	${}^{+0.14}_{-0.11}$
Total	${}^{+0.14}_{-0.12}$

- This yield a final result $a_{CP}^{T} = [-1.95 \pm 1.42\,(\text{stat.})\,{}^{+0.14}_{-0.12}\,(\text{syst.})]\%$
- This result is consistent with no CP violation within uncertainties.

Systematic uncertainty for A_{CP} :

Summary of systematic uncertainties evaluated for A_{CP}

Sources	(%)
Fixed PDF parameters	± 0.01
$D^0 \to K_S^0 K_S^0 K_S^0$ background	$^{+0.02}_{-0.03}$
Broken charm background	$^{+0.09}_{-0.07}$
Binning in $\cos\theta^*$	$^{+0.33}_{-0.51}$
Reconstruction asymmetry $A_\epsilon^{\pi_s}$	± 0.01
Fixed background fractions	± 0.04
Total	$^{+0.35}_{-0.52}$

- Final A_{CP} result is :

$$A_{CP} = \left[-2.51 \pm 1.44\,(\text{stat.})\ ^{+0.35}_{-0.52}\,(\text{syst.})\right] \times 10^{-2}$$

$A_{\varepsilon}^{\pi_s}$ weights for A_{CP} :

$$A_{\varepsilon}^{\pi_s} = \frac{\varepsilon_f^+ - \varepsilon_f^-}{\varepsilon_f^+ + \varepsilon_f^-}$$

$\varepsilon_f^{\pm}$: reconstruction efficiency for $\pi_{slow}^{\pm}$

$$w_{D^0} = 1 + A_{\varepsilon}^{\pi_s} = \frac{2\varepsilon_f^+}{\varepsilon_f^+ + \varepsilon_f^-}$$

$$w_{\overline{D}^0} = 1 - A_{\varepsilon}^{\pi_s} = \frac{2\varepsilon_f^-}{\varepsilon_f^+ + \varepsilon_f^-}$$

Efficiency for D^0 and $\overline{D}^0$ become same after applying these weights

All measurements of CP violation in charm decays using a_{CP}^{T-odd}:

- *https://hflav-eos.web.cern.ch/hflav-eos/charm/cp_asym/charm_todd_19Sep19.html*

T-odd asymmetries in D^0 decays

Year	Experiment	T-odd asymmetry in the decay mode D0 to K+K-π+π-	$A_{T\text{-odd}} = (A_T - \bar{A}_T)/2$
2019	BELLE	J. B. Kim et al. (BELLE Collab.), Phys. Rev. D 99, 011104 (2019).	+0.0052 ± 0.0037 ± 0.0007
2014	LHCb	R. Aaij et al. (LHCb Collab.), JHEP 10, 5 (2014).	+0.0018 ± 0.0029 ± 0.0004
2010	BABAR	P. del Amo Sanchez et al. (BABAR Collab.), Phys. Rev. D81, 111103 (2010).	+0.0010 ± 0.0051 ± 0.0044
2005	FOCUS	J.M. Link et al. (FOCUS Collab.), Phys. Lett. B 622, 239 (2005).	+0.010 ± 0.057 ± 0.037
		HFLAV average	+0.0035 ± 0.0021
Year	Experiment	T-odd asymmetry in the decay mode D0 to K0sπ+π-π0	$A_{T\text{-odd}} = (A_T - \bar{A}_T)/2$
2017	BELLE	K. Prasanth et al. (BELLE Collab.), Phys. Rev. D 95, 091101 (2017).	-0.00028 ± 0.00138 (+0.00023 -0.00076)

T-odd asymmetries in D^+ decays

Year	Experiment	T-odd asymmetry in the decay mode D+ to K0sK+π+π-	$A_{T\text{-odd}} = (A_T - \bar{A}_T)/2$
2011	BABAR	J.P. Lees et al. (BABAR Collab.), Phys. Rev. D 84, 031103 (2011).	-0.0120 ± 0.0100 ± 0.0046
2005	FOCUS	J.M. Link et al. (FOCUS Collab.), Phys. Lett. B 622, 239 (2005).	+0.023 ± 0.062 ± 0.022
		HFLAV average	-0.0110 ± 0.0109

T-odd asymmetries in D_s^+ decays

Year	Experiment	T-odd asymmetry in the decay mode Ds+ to K0sK+π+π-	$A_{T\text{-odd}} = (A_T - \bar{A}_T)/2$
2011	BABAR	J.P. Lees et al. (BABAR Collab.), Phys. Rev. D 84, 031103 (2011).	-0.0136 ± 0.0077 ± 0.0034
2005	FOCUS	J.M. Link et al. (FOCUS Collab.), Phys. Lett. B 622, 239 (2005).	-0.036 ± 0.067 ± 0.023
		HFLAV average	-0.0139 ± 0.0084