

$T_{c\bar{c}s1}(4000)$

$$I(J^P) = \frac{1}{2}(1^+)$$

OMITTED FROM SUMMARY TABLE

was  $Z_{cs}(4000)$

Properties incompatible with a  $q\bar{q}$  structure (exotic state). See the review on "Heavy Non- $q\bar{q}$  Mesons."

Seen by AAIJ 21E in  $B^+ \rightarrow T_{c\bar{c}s1}(4000)^+ \phi$  with  $T_{c\bar{c}s1}(4000)^+ \rightarrow J/\psi K^+$  using an amplitude analysis of  $B^+ \rightarrow J/\psi \phi K^+$  with a significance (accounting for systematic uncertainties) of  $15 \sigma$ . The  $J^P = 1^+$  assignment is favored with high significance. ABLIKIM 21G also reports a  $J^P = 1^+$   $Z_{cs}$  state in this mass region using  $e^+ e^- \rightarrow K^+(D_s^- D^{*0} + D_s^{*-} D^0)$  with a significance of  $5.3 \sigma$ . The incompatible values for the widths reported by AAIJ 21E and ABLIKIM 21G could either indicate the existence of two separate states or possibly be explained in a coupled channel model (see ORTEGA 21).

NODE=M259

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### $T_{c\bar{c}s1}(4000)$ MASS

| VALUE (MeV)   | EVTS                                | DOCUMENT ID | TECN      | COMMENT   |
|---|-------------------------------------|-------------|-----------|---|
| <b>3980-4010 OUR EVALUATION</b>                                 |                                     |             |           |   |
| <b>3988 ± 5 OUR AVERAGE</b> Error includes scale factor of 2.7. |                                     |             |           |   |
| 3991 <sup>+12</sup> <sub>-10</sub>                              | <sup>+9</sup> <sub>-17</sub>        | 1 AAIJ      | 23AQ LHCB | $B^0 \rightarrow J/\psi \phi K_S^0$                       |
| 3992.2 ± 1.7  | ± 1.6                               | 2 ABLIKIM   | 22AE BES3 | $e^+ e^- \rightarrow K_S^0 (D_s^- D^{*+} + D_s^{*-} D^+)$ |
| 4003 ± 6  | <sup>+4</sup> <sub>-14</sub>        | 24k 3 AAIJ  | 21E LHCB  | $B^+ \rightarrow J/\psi \phi K^+$                         |
| 3982.5 <sup>+</sup> <sub>-</sub>                                | <sup>1.8</sup> <sub>2.6</sub> ± 2.1 | 4 ABLIKIM   | 21G BES3  | $e^+ e^- \rightarrow K^+ (D_s^- D^{*0} + D_s^{*-} D^0)$   |

NODE=M259M

NODE=M259M

→ UNCHECKED ←

<sup>1</sup> From an amplitude analysis of the decay  $B^0 \rightarrow J/\psi \phi K_S^0$  with a significance of  $4.0 \sigma$ . The mass difference with respect to the charged partner in AAIJ 21E is  $-12^{+11+6}_{-10-4}$  MeV.

<sup>2</sup> Pole mass for a mass-, width-dependent Breit-Wigner fit to the mass spectrum recoiling against  $K_S^0$  at center of mass energies between 4.628 and 4.699 GeV, with a significance of  $4.6 \sigma$ .

<sup>3</sup> From an amplitude analysis of the decay  $B^+ \rightarrow J/\psi \phi K^+$  with a significance of  $15 \sigma$ .

<sup>4</sup> Pole mass for a mass-dependent Breit-Wigner fit to the mass spectrum recoiling against  $K^+$  at center of mass energies between 4.628 and 4.698 GeV, with a significance of  $5.3 \sigma$ .

NODE=M259M;LINKAGE=E

NODE=M259M;LINKAGE=D

NODE=M259M;LINKAGE=A

NODE=M259M;LINKAGE=B

### $T_{c\bar{c}s1}(4000)$ WIDTH

| VALUE (MeV)   | EVTS                                | DOCUMENT ID | TECN      | COMMENT   |
|---|-------------------------------------|-------------|-----------|---|
| <b>5-150 OUR EVALUATION</b>   |                                     |             |           |   |
| <b>14 ± 4 OUR AVERAGE</b> Error includes scale factor of 1.1. [13 ± 4 MeV OUR 2023 AVERAGE] |                                     |             |           |   |
| 105 <sup>+29</sup> <sub>-25</sub>   | <sup>+17</sup> <sub>-23</sub>       | 1 AAIJ      | 23AQ LHCB | $B^0 \rightarrow J/\psi \phi K_S^0$                       |
| 7.7 <sup>+</sup> <sub>-</sub>   | <sup>4.1</sup> <sub>3.8</sub> ± 4.3 | 2 ABLIKIM   | 22AE BES3 | $e^+ e^- \rightarrow K_S^0 (D_s^- D^{*+} + D_s^{*-} D^+)$ |
| 131 ± 15  | ± 26                                | 24k 3 AAIJ  | 21E LHCB  | $B^+ \rightarrow J/\psi \phi K^+$                         |
| 12.8 <sup>+</sup> <sub>-</sub>  | <sup>5.3</sup> <sub>4.4</sub> ± 3.0 | 4 ABLIKIM   | 21G BES3  | $e^+ e^- \rightarrow K^+ (D_s^- D^{*0} + D_s^{*-} D^0)$   |

NODE=M259W

NODE=M259W

→ UNCHECKED ←

NEW

<sup>1</sup> From an amplitude analysis of the decay  $B^0 \rightarrow J/\psi \phi K_S^0$  with a significance of  $4.0 \sigma$ .

<sup>2</sup> Pole width for a mass-, width-dependent Breit-Wigner fit to the mass spectrum recoiling against  $K_S^0$  at center of mass energies between 4.628 and 4.699 GeV, with a significance of  $4.6 \sigma$ .

<sup>3</sup> From an amplitude analysis of the decay  $B^+ \rightarrow J/\psi \phi K^+$  with a significance of  $15 \sigma$ .

<sup>4</sup> Pole width for a mass-dependent Breit-Wigner fit to the mass spectrum recoiling against  $K^+$  at center of mass energies between 4.628 and 4.698 GeV, with a significance of  $5.3 \sigma$ .

NODE=M259W;LINKAGE=D

NODE=M259W;LINKAGE=C

NODE=M259W;LINKAGE=A

NODE=M259W;LINKAGE=B

| Mode  | Fraction ( $\Gamma_i/\Gamma$ ) |
|---|--------------------------------|
| $\Gamma_1$ $J/\psi K^+$                                 | seen                           |
| $\Gamma_2$ $J/\psi K_S^0$                               | seen                           |
| $\Gamma_3$ $D_s^+ \bar{D}^{*0}$ or $D_s^{*+} \bar{D}^0$ | seen                           |
| $\Gamma_4$ $D_s^+ D^{*-}$ or $D_s^{*+} D^-$             | seen                           |

NODE=M259215;DESIG=1  
DESIG=4  
DESIG=2  
DESIG=3

### $T_{c\bar{c}s1}(4000)$ DECAY MODES

NODE=M259225

$\Gamma(J/\psi K^+)/\Gamma_{\text{total}}$   $\Gamma_1/\Gamma$

NODE=M259R01  
NODE=M259R01

| VALUE | EVTs | DOCUMENT ID       | TECN     | COMMENT                           |
|-------|------|-------------------|----------|-----------------------------------|
| seen  | 24k  | <sup>1</sup> AAIJ | 21E LHCB | $B^+ \rightarrow J/\psi \phi K^+$ |

<sup>1</sup> From an amplitude analysis of the decay  $B^+ \rightarrow J/\psi \phi K^+$  with a significance of 15  $\sigma$ .

NODE=M259R01;LINKAGE=A

$\Gamma(J/\psi K_S^0)/\Gamma_{\text{total}}$   $\Gamma_2/\Gamma$

NODE=M259R02  
NODE=M259R02

| VALUE | DOCUMENT ID       | TECN      | COMMENT                             |
|-------|-------------------|-----------|-------------------------------------|
| seen  | <sup>1</sup> AAIJ | 23AQ LHCB | $B^0 \rightarrow J/\psi \phi K_S^0$ |

<sup>1</sup> From an amplitude analysis of the decay  $B^0 \rightarrow J/\psi \phi K_S^0$  with a significance of 4.0  $\sigma$ .

NODE=M259R02;LINKAGE=A

$\Gamma(D_s^+ \bar{D}^{*0} \text{ or } D_s^{*+} \bar{D}^0)/\Gamma_{\text{total}}$   $\Gamma_3/\Gamma$

NODE=M259R00  
NODE=M259R00

| VALUE | DOCUMENT ID          | TECN     | COMMENT  |
|-------|----------------------|----------|--|
| seen  | <sup>1</sup> ABLIKIM | 21G BES3 | $e^+ e^- \rightarrow K^+(D_s^- D^{*0} + D_s^{*-} D^0)$ |

<sup>1</sup> Seen in the spectrum recoiling against  $K^+$  in  $e^+ e^- \rightarrow K^+(D_s^- D^{*0} + D_s^{*-} D^0)$  collisions at center of mass energies between 4.628 and 4.698 GeV, with a significance of 5.3  $\sigma$ .

NODE=M259R00;LINKAGE=A

$\Gamma(J/\psi K^+)/\Gamma(D_s^+ \bar{D}^{*0} \text{ or } D_s^{*+} \bar{D}^0)$   $\Gamma_1/\Gamma_3$

NODE=M259R04  
NODE=M259R04

| VALUE | CL% | DOCUMENT ID | TECN      | COMMENT                              |
|-------|-----|-------------|-----------|--------------------------------------|
| <0.03 | 90  | ABLIKIM     | 23BI BES3 | $e^+ e^- \rightarrow K^+ K^- J/\psi$ |

$\Gamma(D_s^+ D^{*-} \text{ or } D_s^{*+} D^-)/\Gamma_{\text{total}}$   $\Gamma_4/\Gamma$

NODE=M259R03  
NODE=M259R03

| VALUE | DOCUMENT ID          | TECN      | COMMENT  |
|-------|----------------------|-----------|--|
| seen  | <sup>1</sup> ABLIKIM | 22AE BES3 | $e^+ e^- \rightarrow K_S^0(D_s^- D^{*+} + D_s^{*-} D^+)$ |

<sup>1</sup> Seen in the mass spectrum recoiling against  $K_S^0$  at center of mass energies between 4.628 and 4.699 GeV, with a significance of 4.6  $\sigma$ .

NODE=M259R03;LINKAGE=A

### $T_{c\bar{c}s1}(4000)$ REFERENCES

NODE=M259

|         |                     |                                       |                   |             |
|---------|---------------------|---------------------------------------|-------------------|-------------|
| AAIJ    | 23AQ PRL 131 131901 | R. Aaij <i>et al.</i>                 | (LHCb Collab.)    | REFID=62429 |
| ABLIKIM | 23BI PRL 131 211902 | M. Ablikim <i>et al.</i>              | (BESIII Collab.)  | REFID=62434 |
| ABLIKIM | 22AE PRL 129 112003 | M. Ablikim <i>et al.</i>              | (BESIII Collab.)  | REFID=61877 |
| AAIJ    | 21E PRL 127 082001  | R. Aaij <i>et al.</i>                 | (LHCb Collab.) JP | REFID=61150 |
| ABLIKIM | 21G PRL 126 102001  | M. Ablikim <i>et al.</i>              | (BESIII Collab.)  | REFID=61065 |
| ORTEGA  | 21 PL B818 136382   | P.G. Ortega, D.R. Entem, F. Fernandez |                   | REFID=61108 |