# $D_{s1}(2536)^{\pm}$

$I(J^P) = 0(1^+)$
$J$, $P$ need confirmation.

Seen in $D^*(2010)^+ K^0$, $D^*(2007)^0 K^+$, and $D_s^+ \pi^+ \pi^-$. Not seen in $D^+ K^0$ or $D^0 K^+$. $J^P = 1^+$ assignment strongly favored.

## $D_{s1}(2536)^{\pm}$ MASS

The fit includes $D^{\pm}$, $D^0$, $D_s^{\pm}$, $D^{*\pm}$, $D^{*0}$, $D_s^{*\pm}$, $D_1(2420)^0$, $D_2^*(2460)^0$, and $D_{s1}(2536)^{\pm}$ mass and mass difference measurements.

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **2535.11±0.06 OUR FIT** | | | | | |
| **2535.21±0.28 OUR AVERAGE** | | | | | |
| 2537.7 ±0.5 ±3.1 | 24 | [1] ABLIKIM | 19P | BES3 | 4.6 $e^+e^- \to D_s^+ \overline{D}^0 K^-$ |
| 2535.7 ±0.6 ±0.5 | 46 | [2] ABAZOV | 09G | D0 | $B_s^0 \to D_{s1}^- \mu^+ \nu_\mu X$ |
| 2534.78±0.31±0.40 | 182 | AUBERT | 08B | BABR | $B \to \overline{D}^{(*)} D^* K$ |
| 2534.6 ±0.3 ±0.7 | 193 | AUBERT | 06P | BABR | 10.6 $e^+e^- \to D_s^+ \pi^+ \pi^- X$ |
| 2535.3 ±0.7 | 92 | [3] HEISTER | 02B | ALEP | $e^+e^- \to D^{*+} K^0 X$, $D^{*0} K^+ X$ |
| 2534.2 ±1.2 | 9 | ASRATYAN | 94 | BEBC | $\nu N \to D^* K^0 X, D^{*0} K^{\pm} X$ |
| 2535 ±0.6 ±1 | 75 | FRABETTI | 94B | E687 | $\gamma$ Be $\to D^{*+} K^0 X$, $D^{*0} K^+ X$ |
| 2535.2 ±0.5 ±1.5 | 28 | ALBRECHT | 92R | ARG | 10.4 $e^+e^- \to D^{*0} K^+ X$ |
| 2536.6 ±0.7 ±0.4 | | AVERY | 90 | CLEO | $e^+e^- \to D^{*+} K^0 X$ |
| 2535.9 ±0.6 ±2.0 | | ALBRECHT | 89E | ARG | $D_{s1}^* \to D^*(2010) K^0$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 2534.1 ±0.6 | 116 | [4] AUSHEV | 11 | BELL | $B \to D_{s1}(2536)^+ D^{(*)}$ |
| 2535.08±0.01±0.15 | 8038 | [5] LEES | 11B | BABR | 10.6 $e^+e^- \to D^{*+} K_S^0 X$ |
| $2535.57^{+0.44}_{-0.41}$±0.10 | 236 | [6] CHEKANOV | 09 | ZEUS | $e^{\pm} p \to D^{*+} K_S^0 X$, $D^{*0} K^+ X$ |
| 2535.3 ±0.2 ±0.5 | 134 | [7] ALEXANDER | 93 | CLE2 | $e^+e^- \to D^{*0} K^+ X$ |
| 2534.8 ±0.6 ±0.6 | 44 | [8] ALEXANDER | 93 | CLE2 | $e^+e^- \to D^{*+} K^0 X$ |
| 2535 ± 28 | | [9] ASRATYAN | 88 | HLBC | $\nu N \to D_s \gamma\gamma X$ |

[1] From a fit of the $D_s^+$ recoil mass distribution with an incoherent sum of the $S$-wave and $D$-wave Breit-Wigner line shapes.
[2] Using the $D^*(2010)^{\pm}$ mass of 2010.0 ± 0.4 MeV from PDG 06.
[3] Calculated using $m(D^*(2010)^{\pm}) = 2010.0 \pm 0.5$ MeV, $m(D^*(2007)^0) = 2006.7 \pm 0.5$ MeV, and the mass difference below.
[4] Systematic uncertainties not evaluated.
[5] Calculated using the mass difference $m(D_{s1}^+) - m(D^{*+})_{PDG}$ below and $m(D^{*+})_{PDG} = 2010.25 \pm 0.14$ MeV. Assuming $S$-wave decay of the $D_{s1}(2536)$ to $D^{*+} K_S^0$, using a Breit-Wigner line shape corresponding to L=0.

[6] Calculated using the mass difference $m(D_{s1}^{+}) - m(D^{*+})_{PDG}$ reported below and $m(D^{*+})_{PDG} = 2010.27 \pm 0.17$ MeV.
[7] Calculated using $m(D^{*}(2007)^{0})$=2006.6 ± 0.5 MeV and the mass difference below.
[8] Calculated using $m(D^{*}(2010)^{\pm})$=2010.1 ± 0.6 MeV and the mass difference below.
[9] Not seen in $D^{*}K$.

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## $m_{D_{s1}(2536)^{\pm}} - m_{D_s^{*}(2111)}$

The fit includes $D^{\pm}$, $D^{0}$, $D_s^{\pm}$, $D^{*\pm}$, $D^{*0}$, $D_s^{*\pm}$, $D_1(2420)^{0}$, $D_2^{*}(2460)^{0}$, and $D_{s1}(2536)^{\pm}$ mass and mass difference measurements.

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **422.9± 0.4 OUR FIT** | | | | |
| **424 ±28** | ASRATYAN | 88 | HLBC | $D_s^{*\pm}\gamma$ |

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## $m_{D_{s1}(2536)^{\pm}} - m_{D^{*}(2010)^{\pm}}$

The fit includes $D^{\pm}$, $D^{0}$, $D_s^{\pm}$, $D^{*\pm}$, $D^{*0}$, $D_s^{*\pm}$, $D_1(2420)^{0}$, $D_2^{*}(2460)^{0}$, and $D_{s1}(2536)^{\pm}$ mass and mass difference measurements.

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **524.85±0.04 OUR FIT** | | | | | |
| **524.84±0.04 OUR AVERAGE** | | | | | |
| 524.83±0.01±0.04 | 8038 | [10] LEES | 11B | BABR | 10.6 $e^{+}e^{-} \to D^{*+}K_S^{0}X$ |
| $525.30^{+0.44}_{-0.41}\pm0.10$ | 236 ± 30 | CHEKANOV | 09 | ZEUS | $e^{\pm}p \to D^{*+}K_S^{0}X$, $D^{*0}K^{+}X$ |
| 525.3 ±0.6 ±0.1 | 41 | HEISTER | 02B | ALEP | $e^{+}e^{-} \to D^{*+}K^{0}X$ |
| 524.7 ±0.6 ±0.2 | 44 | ALEXANDER | 93 | CLE2 | $e^{+}e^{-} \to D^{*+}K_S^{0}X$ |

[10] Assuming $S$-wave decay of the $D_{s1}(2536)$ to $D^{*+}K_S^{0}$, using a Breit-Wigner line shape corresponding to L=0.

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## $m_{D_{s1}(2536)^{\pm}} - m_{D^{*}(2007)^{0}}$

The fit includes $D^{\pm}$, $D^{0}$, $D_s^{\pm}$, $D^{*\pm}$, $D^{*0}$, $D_s^{*\pm}$, $D_1(2420)^{0}$, $D_2^{*}(2460)^{0}$, and $D_{s1}(2536)^{\pm}$ mass and mass difference measurements.

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **528.26±0.05 OUR FIT** Error includes scale factor of 1.2. | | | | | |
| **528.68±0.28 OUR AVERAGE** | | | | | |
| 528.7 ±1.9 ±0.5 | 51 | HEISTER | 02B | ALEP | $e^{+}e^{-} \to D^{*0}K^{+}X$ |
| 527.3 ±2.2 | 29 | ACKERSTAFF | 97W | OPAL | $e^{+}e^{-} \to D^{*0}K^{+}X$ |
| 528.7 ±0.2 ±0.2 | 134 | ALEXANDER | 93 | CLE2 | $e^{+}e^{-} \to D^{*0}K^{+}X$ |

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## $D_{s1}(2536)^{\pm}$ WIDTH

| *VALUE* (MeV) | *CL%* | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|---|
| **0.92±0.05 OUR AVERAGE** | | | | | | |
| 1.7 ±1.2 ±0.6 | | 24 | [11] ABLIKIM | 19P | BES3 | 4.6 $e^{+}e^{-} \to D_s^{+}\overline{D}^{0}K^{-}$ |
| 0.92±0.03±0.04 | | 8038 | [12] LEES | 11B | BABR | 10.6 $e^{+}e^{-} \to D^{*+}K_S^{0}X$ |

• • • We do not use the following data for averages, fits, limits, etc. • • •

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $0.75 \pm 0.23$ | | 116 | [13] AUSHEV | 11 | BELL | $B \to D_{s1}(2536)^+ D^{(*)}$ | |
| $< 2.5$ | 95 | 193 | AUBERT | 06P | BABR | 10.6 $e^+e^- \to D_s^+ \pi^+ \pi^- X$ | |
| $< 3.2$ | 90 | 75 | FRABETTI | 94B | E687 | $\gamma$Be $\to D^{*+} K^0$X, $D^{*0} K^+$X | |
| $< 2.3$ | 90 | | ALEXANDER | 93 | CLEO | $e^+e^- \to D^{*0} K^+$X | |
| $< 3.9$ | 90 | | ALBRECHT | 92R | ARG | 10.4 $e^+e^- \to D^{*0} K^+$X | |
| $< 5.44$ | 90 | | AVERY | 90 | CLEO | $e^+e^- \to D^{*+} K^0$X | |
| $< 4.6$ | 90 | | ALBRECHT | 89E | ARG | $D_{s1}^* \to D^*(2010) K^0$ | |

[11] From a fit of the $D_s^+$ recoil mass distribution with an incoherent sum of the $S$-wave and $S$-wave Breit-Wigner line shapes.

[12] Assuming $S$-wave decay of the $D_{s1}(2536)$ to $D^{*+} K_S^0$, using a Breit-Wigner line shape corresponding to L=0.

[13] Systematic uncertainties not evaluated.

## $D_{s1}(2536)^+$ DECAY MODES

Branching fractions are given relative to the one **DEFINED AS 1**. $D_{s1}(2536)^-$ modes are charge conjugates of the modes below.

| | Mode | Fraction ($\Gamma_i/\Gamma$) | Confidence level |
|---|---|---|---|
| $\Gamma_1$ | $D^*(2010)^+ K^0$ | $0.85 \pm 0.12$ | |
| $\Gamma_2$ | $(D^*(2010)^+ K^0)_{S-wave}$ | $0.61 \pm 0.09$ | |
| $\Gamma_3$ | $(D^*(2010)^+ K^0)_{D-wave}$ | | |
| $\Gamma_4$ | $D^+ \pi^- K^+$ | $0.028 \pm 0.005$ | |
| $\Gamma_5$ | $D^*(2007)^0 K^+$ | **DEFINED AS 1** | |
| $\Gamma_6$ | $D^+ K^0$ | $<0.34$ | 90% |
| $\Gamma_7$ | $D^0 K^+$ | $<0.12$ | 90% |
| $\Gamma_8$ | $D_s^{*+} \gamma$ | possibly seen | |
| $\Gamma_9$ | $D_s^+ \pi^+ \pi^-$ | seen | |

## $D_{s1}(2536)^+$ BRANCHING RATIOS

### $\Gamma(D^*(2007)^0 K^+)/\Gamma(D^*(2010)^+ K^0)$ $\Gamma_5/\Gamma_1$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$1.18 \pm 0.16$ OUR AVERAGE** | | | | | |
| $0.88 \pm 0.24 \pm 0.08$ | 116 | AUSHEV | 11 | BELL | $B \to D_{s1}(2536)^+ D^{(*)}$ |
| $2.3 \pm 0.6 \pm 0.3$ | $236 \pm 30$ | CHEKANOV | 09 | ZEUS | $e^\pm p \to D^{*+} K_S^0 X$, $D^{*0} K^+ X$ |
| $1.32 \pm 0.47 \pm 0.23$ | 92 | [14] HEISTER | 02B | ALEP | $e^+e^- \to D^{*+} K^0 X$, $D^{*0} K^+ X$ |
| $1.9\ ^{+1.1}_{-0.9} \pm 0.4$ | 35 | [14] ACKERSTAFF | 97W | OPAL | $e^+e^- \to D^{*0} K^+$X, $D^{*+} K^0$X |

| | | | | | |
|---|---|---|---|---|---|
| 1.1 ±0.3 | | ALEXANDER | 93 | CLEO | $e^+e^- \to D^{*0}K^+X, D^{*+}K^0X$ |
| 1.4 ±0.3 ±0.2 | [15] | ALBRECHT | 92R | ARG | 10.4 $e^+e^- \to D^{*0}K^+X, D^{*+}K^0X$ |

[14] Ratio of the production rates measured in $Z^0$ decays.
[15] Evaluated by us from published inclusive cross-sections.

## $\Gamma((D^*(2010)^+K^0)_{S-wave})/\Gamma(D^*(2010)^+K^0)$ $\Gamma_2/\Gamma_1$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.72±0.05±0.01** | 5485 | BALAGURA | 08 | BELL | 10.6 $e^+e^- \to D^{*+}K^0X$ |

## $\Gamma(D^+\pi^-K^+)/\Gamma(D^*(2010)^+K^0)$ $\Gamma_4/\Gamma_1$

| VALUE (units $10^{-2}$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **3.27±0.18±0.37** | 1264 | BALAGURA | 08 | BELL | 10.6 $e^+e^- \to D^+\pi^-K^+X$ |

## $\Gamma(D^+K^0)/\Gamma(D^*(2010)^+K^0)$ $\Gamma_6/\Gamma_1$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.40** | 90 | ALEXANDER | 93 | CLEO | $e^+e^- \to D^{*+}K^0X$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.43 | 90 | ALBRECHT | 89E | ARG | $D^*_{s1} \to D^*(2010)K^0$ |

## $\Gamma(D^0K^+)/\Gamma(D^*(2007)^0K^+)$ $\Gamma_7/\Gamma_5$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.12** | 90 | ALEXANDER | 93 | CLEO | $e^+e^- \to D^{*0}K^+X$ |

## $\Gamma(D_s^{*+}\gamma)/\Gamma_{total}$ $\Gamma_8/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **possibly seen** | ASRATYAN | 88 | HLBC | $\nu N \to D_s\gamma\gamma X$ |

## $\Gamma(D_s^{*+}\gamma)/\Gamma(D^*(2007)^0K^+)$ $\Gamma_8/\Gamma_5$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.42** | 90 | ALEXANDER | 93 | CLEO | $e^+e^- \to D^{*0}K^+X$ |

## $\Gamma(D_s^+\pi^+\pi^-)/\Gamma_{total}$ $\Gamma_9/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **seen** | AUBERT | 06P | BABR | 10.6 $e^+e^- \to D_s^+\pi^+\pi^-X$ |

# $D_{s1}(2536)^\pm$ REFERENCES


| | | | | |
|---|---|---|---|---|
| ABLIKIM | 19P | CP C43 031001 | M. Ablikim *et al.* | (BESIII Collab.) |
| AUSHEV | 11 | PR D83 051102 | T. Aushev *et al.* | (BELLE Collab.) |
| LEES | 11B | PR D83 072003 | J.P. Lees *et al.* | (BABAR Collab.) |
| ABAZOV | 09G | PRL 102 051801 | V.M. Abazov *et al.* | (D0 Collab.) |
| CHEKANOV | 09 | EPJ C60 25 | S. Chekanov *et al.* | (ZEUS Collab.) |
| AUBERT | 08B | PR D77 011102 | B. Aubert *et al.* | (BABAR Collab.) |
| BALAGURA | 08 | PR D77 032001 | V. Balagura *et al.* | (BELLE Collab.) |
| AUBERT | 06P | PR D74 032007 | B. Aubert *et al.* | (BABAR Collab.) |
| PDG | 06 | JP G33 1 | W.-M. Yao *et al.* | (PDG Collab.) |

| | | | | |
|---|---|---|---|---|
| HEISTER | 02B | PL B526 34 | A. Heister *et al.* | (ALEPH Collab.) |
| ACKERSTAFF | 97W | ZPHY C76 425 | K. Ackerstaff *et al.* | (OPAL Collab.) |
| ASRATYAN | 94 | ZPHY C61 563 | A.E. Asratyan *et al.* | (BIRM, BELG, CERN+) |
| FRABETTI | 94B | PRL 72 324 | P.L. Frabetti *et al.* | (FNAL E687 Collab.) |
| ALEXANDER | 93 | PL B303 377 | J. Alexander *et al.* | (CLEO Collab.) |
| ALBRECHT | 92R | PL B297 425 | H. Albrecht *et al.* | (ARGUS Collab.) |
| AVERY | 90 | PR D41 774 | P. Avery, D. Besson | (CLEO Collab.) |
| ALBRECHT | 89E | PL B230 162 | H. Albrecht *et al.* | (ARGUS Collab.) |
| ASRATYAN | 88 | ZPHY C40 483 | A.E. Asratyan *et al.* | (ITEP, SERP) |