

$T_{c\bar{c}}(4020)$

$$I^G(J^{PC}) = 1^+(?^-)$$

was $X(4020)$

Properties incompatible with a $q\bar{q}$ structure (exotic state). See the review on non- $q\bar{q}$ states.

Charged $T_{c\bar{c}}(4020)$ seen by ABLIKIM 13X from $e^+e^- \rightarrow \pi^+\pi^-h_c(1P)$ at c.m. energy from 3.90 to 4.42 GeV as a peak in the invariant mass distribution of the $\pi^\pm h_c(1P)$ system, and by ABLIKIM 14B from $e^+e^- \rightarrow (D^*\bar{D}^*)^\pm\pi^\mp$ events in $(D^*\bar{D}^*)^\pm$ mass. A neutral $T_{c\bar{c}}(4020)$ seen by ABLIKIM 14P at three c.m. energies in the same range in $e^+e^- \rightarrow \pi^0\pi^0h_c(1P)$ as a peak in the larger of the two masses recoiling against a π^0 . ABLIKIM 15AA observes a 5.9σ signal in $(D^*\bar{D}^*)^0$ in $e^+e^- \rightarrow (D^*\bar{D}^*)^0\pi^0$ events using collisions at two c.m. energies. Production rates and mass values support grouping neutral and charged $T_{c\bar{c}}(4020)$ together as manifestations of a single $I = 1$ particle.

 $T_{c\bar{c}}(4020)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
4024.1 ± 1.9 OUR AVERAGE					
4025.5 ^{+2.0} _{-4.7} ± 3.1	116	¹ ABLIKIM 15AA	BES3	0	$e^+e^- \rightarrow (D^*\bar{D}^*)^0\pi^0$
4026.3 ± 2.6 ± 3.7	401	¹ ABLIKIM 14B	BES3	±	$e^+e^- \rightarrow (D^*\bar{D}^*)^\pm\pi^\mp$
4023.9 ± 2.2 ± 3.8	61	^{1,2} ABLIKIM 14P	BES3	0	$e^+e^- \rightarrow \pi^0\pi^0h_c$
4022.9 ± 0.8 ± 2.7	253	¹ ABLIKIM 13X	BES3	±	$e^+e^- \rightarrow \pi^+\pi^-h_c$

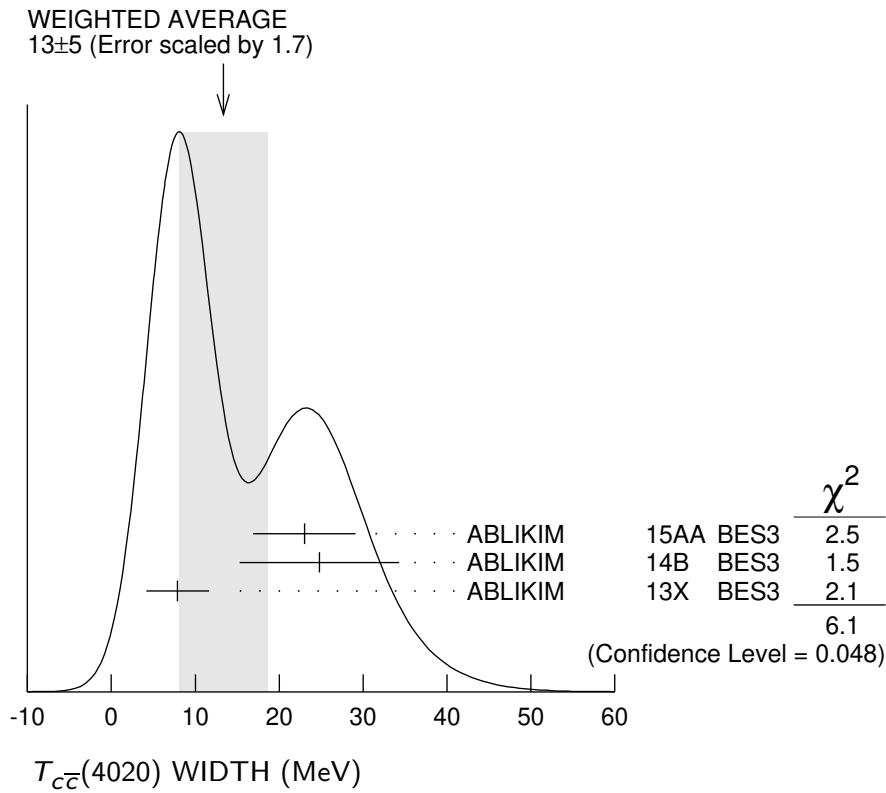
¹ Neglecting interference between the $T_{c\bar{c}}(4020)$ and non-resonant continuum.

² Assuming $J^P = 1^+$ and width of 7.9 ± 2.6 MeV.

 $T_{c\bar{c}}(4020)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
13 ± 5 OUR AVERAGE					Error includes scale factor of 1.7. See the ideogram below.
23.0 ± 6.0 ± 1.0	116	¹ ABLIKIM 15AA	BES3	0	$e^+e^- \rightarrow (D^*\bar{D}^*)^0\pi^0$
24.8 ± 5.6 ± 7.7	401	¹ ABLIKIM 14B	BES3	±	$e^+e^- \rightarrow (D^*\bar{D}^*)^\pm\pi^\mp$
7.9 ± 2.7 ± 2.6	253	¹ ABLIKIM 13X	BES3	±	$e^+e^- \rightarrow \pi^+\pi^-h_c$

¹ Neglecting interference between the $T_{c\bar{c}}(4020)$ and non-resonant continuum.



$T_{c\bar{c}}(4020)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)
Γ_1 $h_c(1P)\pi$	seen
Γ_2 $D^*\bar{D}^*$	seen
Γ_3 $D\bar{D}^* + \text{c.c.}$	not seen
Γ_4 $\eta_c \pi^+ \pi^-$	not seen
Γ_5 $\eta_c(1S)\rho(770)^\pm$	
Γ_6 $J/\psi(1S)\pi^\pm$	not seen

$T_{c\bar{c}}(4020)$ BRANCHING RATIOS

$\Gamma(h_c(1P)\pi)/\Gamma_{\text{total}}$						Γ_1/Γ
VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT	
seen	61	ABLIKIM 14P	BES3	0	$e^+e^- \rightarrow \pi^0\pi^0 h_c$	
seen	253	ABLIKIM 13X	BES3	\pm	$e^+e^- \rightarrow \pi^+\pi^- h_c$	

$\Gamma(D^*\bar{D}^*)/\Gamma_{\text{total}}$						Γ_2/Γ
VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT	
seen	116	¹ ABLIKIM 15AA	BES3	0	$e^+e^- \rightarrow (D^*\bar{D}^*)^0 \pi^0$	
seen	401	¹ ABLIKIM 14B	BES3	\pm	$e^+e^- \rightarrow (D^*\bar{D}^*)^\pm \pi^\mp$	

¹ Neglecting interference between the $T_{c\bar{c}}(4020)$ and non-resonant continuum.

$\Gamma(D\bar{D}^* + \text{c.c.})/\Gamma_{\text{total}}$ Γ_3/Γ

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
not seen	ABLIKIM	15AC	BES3	\pm $e^+ e^- \rightarrow \pi^\pm (D\bar{D}^*)^\mp$

$\Gamma(\eta_c \pi^+ \pi^-)/\Gamma_{\text{total}}$ Γ_4/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	¹ VINOKUROVA 15	BELL	$B^+ \rightarrow K^+ \eta_c \pi^+ \pi^-$

¹ VINOKUROVA 15 reports $B(B^+ \rightarrow K^+ T_{c\bar{c}}(4020)^0) \times B(T_{c\bar{c}} \rightarrow \eta_c \pi^+ \pi^-) < 1.6 \times 10^{-5}$ at 90% CL.

$\Gamma(\eta_c(1S)\rho(770)^\pm)/\Gamma(h_c(1P)\pi)$ Γ_5/Γ_1

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<1.2	90	¹ ABLIKIM	19BC	BES3 $e^+ e^- \rightarrow \pi^+ \pi^- \pi^0 \eta_c(1S)$

¹ Using $e^+ e^- \rightarrow \pi^\mp (Z_c(4020)^\pm \rightarrow h_c(1P)\pi^\pm)$ cross section at 4.23, 4.26 and 4.36 GeV from ABLIKIM 13X.

$\Gamma(J/\psi(1S)\pi^\pm)/\Gamma_{\text{total}}$ Γ_6/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	¹ ABLIKIM	17J	BES3 $e^+ e^- \rightarrow \pi^+ \pi^- J/\psi$

¹ From Partial Wave Analysis assuming $J^P = 1^+$.

$T_{c\bar{c}}(4020)$ REFERENCES

ABLIKIM	19BC	PR D100 111102	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	17J	PRL 119 072001	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	15AA	PRL 115 182002	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	15AC	PR D92 092006	M. Ablikim <i>et al.</i>	(BESIII Collab.)
VINOKUROVA	15	JHEP 1506 132	A. Vinokurova <i>et al.</i>	(BELLE Collab.)
Also		JHEP 1702 088 (errata.)	A. Vinokurava <i>et al.</i>	(BELLE Collab.)
ABLIKIM	14B	PRL 112 132001	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	14P	PRL 113 212002	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	13X	PRL 111 242001	M. Ablikim <i>et al.</i>	(BESIII Collab.)