

$D_1(2420)$

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

 $D_1(2420)$ 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	CHG	COMMENT
2422.1±0.6 OUR FIT	Error includes scale factor of 1.7.				
2422.1±0.8 OUR AVERAGE	Error includes scale factor of 2.1. See the ideogram below.				
2424.8±0.1±0.7	79k	¹ AAIJ	20D LHCb	0	$B^- \rightarrow D^{*+} \pi^- \pi^-$
2427.2±1.0±1.2	4207	ABLIKIM	20P BES3	+	$e^+ e^- \rightarrow D^+ D^- \pi^+ \pi^-$
2419.6±0.1±0.7	210k	AAIJ	13CC LHCb	0	$p p \rightarrow D^{*+} \pi^- X$
2423.1±1.5 ^{+0.4} _{-1.0}	2.7k	² ABRAMOWICZ13	ZEUS	0	$e^\pm p \rightarrow D^{(*)+} \pi^- X$
2421.9±4.7 ^{+3.4} _{-1.2}	759	³ ABRAMOWICZ13	ZEUS	+	$e^\pm p \rightarrow D^{(*)0} \pi^+ X$
2420.1±0.1±0.8	103k	DEL-AMO-SA..10P	BABR	0	$e^+ e^- \rightarrow D^{*+} \pi^- X$
2426 ±3 ±1	151	ABE	05A BELL	0	$B^- \rightarrow D^0 \pi^+ \pi^- \pi^-$
2421 ±2 ±1	124	ABE	05A BELL	+	$\bar{B}^0 \rightarrow D^+ \pi^+ \pi^- \pi^-$
2421.4±1.5±0.9		⁴ ABE	04D BELL	0	$B^- \rightarrow D^{*+} \pi^- \pi^-$
2421 ⁺¹ ₋₂ ±2	286	AVERY	94C CLE2	0	$e^+ e^- \rightarrow D^{*+} \pi^- X$
2425 ±2 ±2	146	BERGFELD	94B CLE2	+	$e^+ e^- \rightarrow D^{*0} \pi^+ X$
2422 ±2 ±2	51	FRABETTI	94B E687	0	$\gamma Be \rightarrow D^{*+} \pi^- X$
2428 ±3 ±2	279	AVERY	90 CLEO	0	$e^+ e^- \rightarrow D^{*+} \pi^- X$
2414 ±2 ±5	171	ALBRECHT	89H ARG	0	$e^+ e^- \rightarrow D^{*+} \pi^- X$
2428 ±8 ±5	171	ANJOS	89C TPS	0	$\gamma N \rightarrow D^{*+} \pi^- X$
2443 ±7 ±5	190	ANJOS	89C TPS	+	$\gamma N \rightarrow D^0 \pi^+ X^0$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
2420.5±2.1±0.9	3.1k	⁵ CHEKANOV	09 ZEUS	0	$e^\pm p \rightarrow D^{*+} \pi^- X$
2421.7±0.7±0.6	7.5k	ABULENCIA	06A CDF	0	$1900 p \bar{p} \rightarrow D^{*+} \pi^- X$
2425 ±3	235	⁶ ABREU	98M DLPH	0	$e^+ e^-$

¹ From a full four-body amplitude analysis of the $B^- \rightarrow D^{*+} \pi^- \pi^-$ decay.

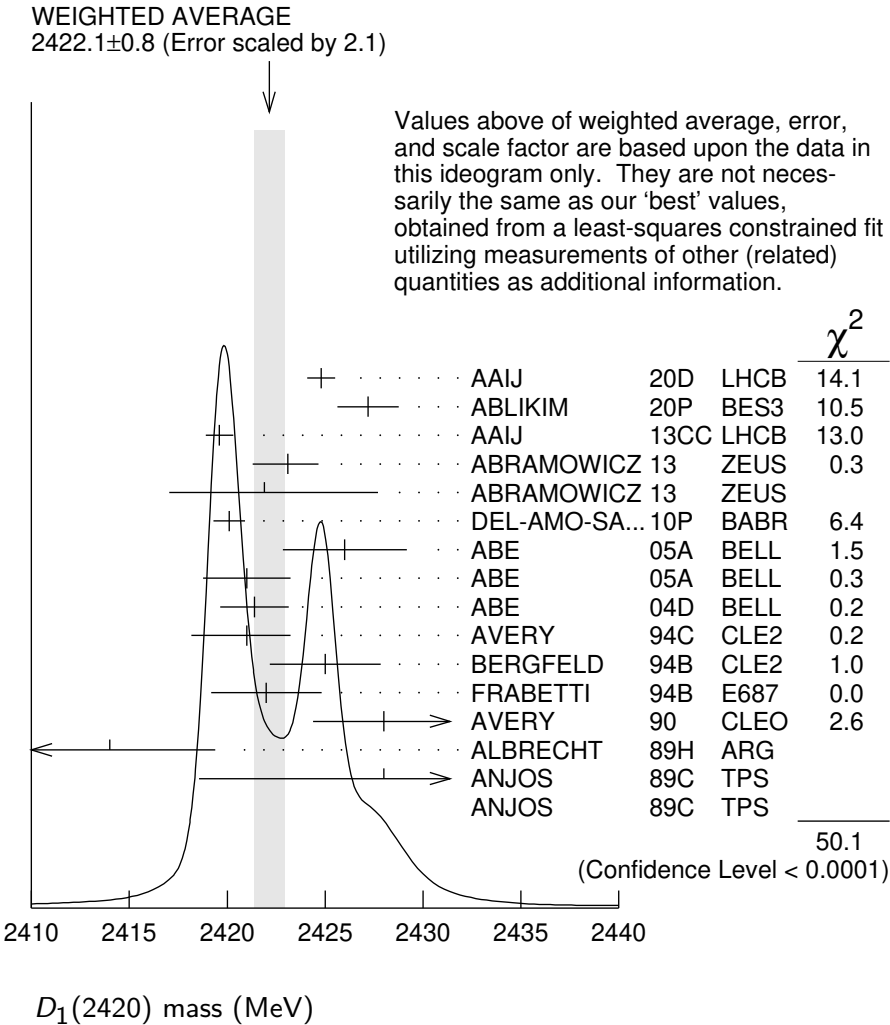
² From the combined fit of the $M(D^+ \pi^-)$ and $M(D^{*+} \pi^-)$ distributions. and A_{D_2} fixed to the theoretical prediction of -1 .

³ From the fit of the $M(D^0 \pi^+)$ distribution. The widths of the D_1^+ and D_2^{*+} are fixed to 25 MeV and 37 MeV, and A_{D_1} and A_{D_2} are fixed to the theoretical predictions of 3 and -1 , respectively.

⁴ Fit includes the contribution from $D_1^*(2430)^0$.

⁵ Calculated using the mass difference $m(D_1^0) - m(D^{*+})_{PDG}$ reported below and $m(D^{*+})_{PDG} = 2010.27 \pm 0.17$ MeV. The 0.17 MeV uncertainty of the PDG mass value should be added to the experimental uncertainty of 0.9 MeV.

⁶ No systematic error given.



$m_{D_1(2420)^0} - m_{D^{*+}}$

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
411.8±0.6 OUR FIT	Error includes scale factor of 1.7.			
411.5±0.8 OUR AVERAGE				
410.2±2.1±0.9	3.1k	CHEKANOV	09 ZEUS	$e^\pm p \rightarrow D^{*+} \pi^- X$
411.7±0.7±0.4	7.5k	ABULENCIA	06A CDF	$1900 p \bar{p} \rightarrow D^{*+} \pi^- X$

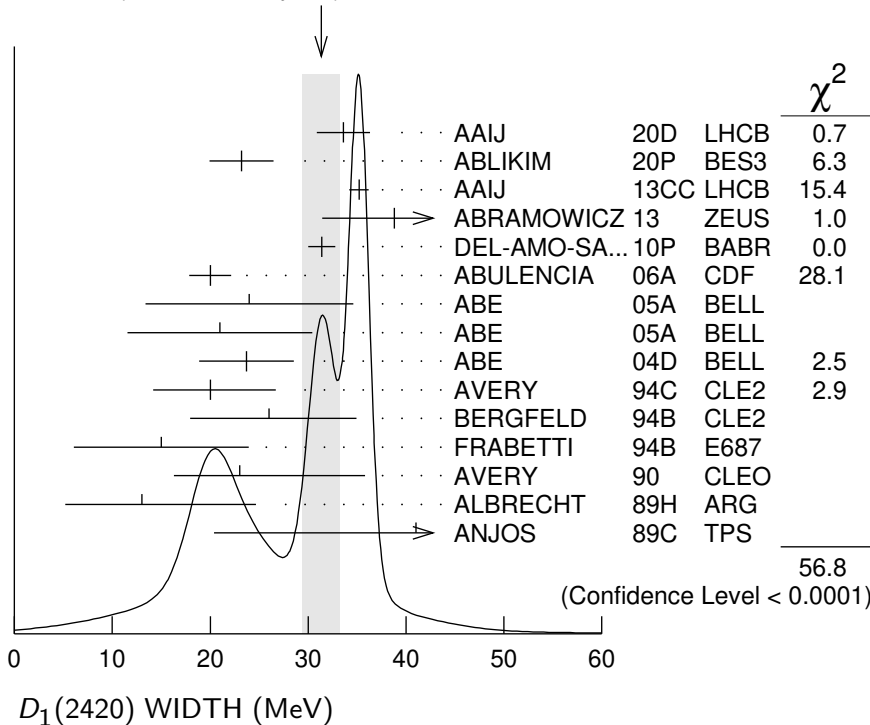
$m_{D_1(2420)^\pm} - m_{D_1(2420)^0}$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
$4^{+2}_{-3} \pm 3$	BERGFELD	94B CLE2	$e^+ e^- \rightarrow \text{hadrons}$

$D_1(2420)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
31.3$\pm$ 1.9 OUR AVERAGE		Error includes scale factor of 2.8. See the ideogram below.			
33.6 $\pm$ 0.3 $\pm$ 2.7	79k	¹ AAIJ	20D LHCb	0	$B^- \rightarrow D^{*+} \pi^- \pi^-$
23.2 $\pm$ 2.3 $\pm$ 2.3	4207	ABLIKIM	20P BES3	+	$e^+ e^- \rightarrow D^+ D^- \pi^+ \pi^-$
35.2 $\pm$ 0.4 $\pm$ 0.9	210k	AAIJ	13CC LHCb	0	$p p \rightarrow D^{*+} \pi^- X$
38.8 $\pm$ 5.0 $^{+1.9}_{-5.4}$	2.7k	² ABRAMOWICZ13	ZEUS	0	$e^\pm p \rightarrow D^{(*)+} \pi^- X$
31.4 $\pm$ 0.5 $\pm$ 1.3	103k	DEL-AMO-SA..10P	BABR	0	$e^+ e^- \rightarrow D^{*+} \pi^- X$
20.0 $\pm$ 1.7 $\pm$ 1.3	7.5k	ABULENCIA	06A CDF	0	$1900 p \bar{p} \rightarrow D^{*+} \pi^- X$
24 $\pm$ 7 $\pm$ 8	151	ABE	05A BELL	0	$B^- \rightarrow D^0 \pi^+ \pi^- \pi^-$
21 $\pm$ 5 $\pm$ 8	124	ABE	05A BELL	+	$\bar{B}^0 \rightarrow D^+ \pi^+ \pi^- \pi^-$
23.7 $\pm$ 2.7 $\pm$ 4.0		³ ABE	04D BELL	0	$B^- \rightarrow D^{*+} \pi^- \pi^-$
20 $^{+6}_{-5}$ $\pm$ 3	286	AVERY	94C CLE2	0	$e^+ e^- \rightarrow D^{*+} \pi^- X$
26 $^{+8}_{-7}$ $\pm$ 4	146	BERGFELD	94B CLE2	+	$e^+ e^- \rightarrow D^{*0} \pi^+ X$
15 $\pm$ 8 $\pm$ 4	51	FRABETTI	94B E687	0	$\gamma Be \rightarrow D^{*+} \pi^- X$
23 $^{+8}_{-6}$ $^{+10}_{-3}$	279	AVERY	90 CLEO	0	$e^+ e^- \rightarrow D^{*+} \pi^- X$
13 $\pm$ 6 $^{+10}_{-5}$	171	ALBRECHT	89H ARG	0	$e^+ e^- \rightarrow D^{*+} \pi^- X$
41 $\pm$ 19 $\pm$ 8	190	ANJOS	89C TPS	+	$\gamma N \rightarrow D^0 \pi^+ X^0$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
53.2 $\pm$ 7.2 $^{+3.3}_{-4.9}$	3.1k	CHEKANOV	09 ZEUS	0	$e^\pm p \rightarrow D^{*+} \pi^- X$
58 $\pm$ 14 $\pm$ 10	171	ANJOS	89C TPS	0	$\gamma N \rightarrow D^{*+} \pi^- X$

WEIGHTED AVERAGE
31.3 $\pm$ 1.9 (Error scaled by 2.8)



¹From a full four-body amplitude analysis of the $B^- \rightarrow D^{*+} \pi^- \pi^-$ decay.

²From the combined fit of the $M(D^+ \pi^-)$ and $M(D^{*+} \pi^-)$ distributions. and A_{D_2} fixed to the theoretical prediction of -1 .

³Fit includes the contribution from $D_1^*(2430)^0$.

$D_1(2420)$ DECAY MODES

$\bar{D}_1(2420)$ modes are charge conjugates of modes below.

Mode	Fraction (Γ_i/Γ)
Γ_1 $D^*(2007)^0 \pi$	seen
Γ_2 $D \pi^+ \pi^-$	
Γ_3 $D \rho^0$	
Γ_4 $D f_0(500)$	
Γ_5 $D_0^*(2300)^0 \pi$	
Γ_6 $D^0 \pi$	
Γ_7 $D^* \pi^+ \pi^-$	

$D_1(2420)$ BRANCHING RATIOS

$\Gamma(D^*(2007)^0 \pi)/\Gamma_{\text{total}}$					Γ_1/Γ
VALUE	DOCUMENT ID	TECN	CHG	COMMENT	
seen	ACKERSTAFF 97W	OPAL	0	$e^+ e^- \rightarrow D^{*+} \pi^- X$	
seen	AVERY 90	CLEO	0	$e^+ e^- \rightarrow D^{*+} \pi^- X$	
seen	ALBRECHT 89H	ARG	0	$e^+ e^- \rightarrow D^* \pi^- X$	
seen	ANJOS 89C	TPS	0	$\gamma N \rightarrow D^{*+} \pi^- X$	
seen	ANJOS 89C	TPS	+	$\gamma N \rightarrow D^0 \pi^+ X^0$	
$\Gamma(D^0 \pi)/\Gamma(D^*(2007)^0 \pi)$					Γ_6/Γ_1
VALUE	CL%	DOCUMENT ID	TECN	CHG	COMMENT
<0.18	90	BERGFELD 94B	CLE2	+	$e^+ e^- \rightarrow \text{hadrons}$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.24	90	AVERY 90	CLEO	0	$e^+ e^- \rightarrow D^+ \pi^- X$

$D_1(2420)$ POLARIZATION AMPLITUDE A_{D_1}

A polarization amplitude A_{D_1} is a parameter that depends on the initial polarization of the D_1 and is sensitive to a possible S -wave contribution to its decay. For D_1 decays the helicity angle, θ_h , distribution varies like $1 + A_{D_1} \cos^2 \theta_h$, where θ_h is the angle in the D^* rest frame between the two pions emitted by the $D_1 \rightarrow D^* \pi$ and the $D^* \rightarrow D \pi$.

Unpolarized D_1 decaying purely via D -wave is predicted to give $A_{D_1} = 3$.

VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
5.73 ± 0.25 OUR AVERAGE					
7.8 $^{+6.7}_{-2.7}$ $^{+4.6}_{-1.8}$	2.7k	¹ ABRAMOWICZ13	ZEUS	0	$e^\pm p \rightarrow D^{(*)+} \pi^- X$

5.72 ± 0.25	103k	DEL-AMO-SA..10P	BABR	0	$e^+ e^- \rightarrow D^{*+} \pi^- X$	
$5.9 \begin{smallmatrix} +3.0 \\ -1.7 \end{smallmatrix} \begin{smallmatrix} +2.4 \\ -1.0 \end{smallmatrix}$		CHEKANOV	09	ZEUS	0	$e^\pm p \rightarrow D^{*+} \pi^- X$

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

3.30 ± 0.48	210k	² AAIJ	13CC	LHCb	0	$pp \rightarrow D^{*+}\pi^- X$
3.8 ± 0.6	± 0.8	³ AUBERT	09Y	BABR	0	$B^+ \rightarrow D_1^0 \ell^+ \nu_\ell$
3.8 ± 0.6	± 0.8	³ AUBERT	09Y	BABR	+	$B^0 \rightarrow D_1^- \ell^+ \nu_\ell$
$2.74^{+1.40}_{-0.93}$		⁴ AVERY	94C	CLE2	0	$e^+e^- \rightarrow D^{*+}\pi^- X$

¹ From the combined fit of the $M(D^+\pi^-)$ and $M(D^{*+}\pi^-)$ distributions. and A_{D_2} fixed to the theoretical prediction of -1 . A pure D -wave not excluded although some $\tilde{S}$ -wave mixing possible.

² Systematic uncertainty not estimated. Resonance parameters fixed.

³ Assuming $\Gamma(\Upsilon(4S) \rightarrow B^+B^-) / \Gamma(\Upsilon(4S) \rightarrow B^0\bar{B}^0) = 1.065 \pm 0.026$ and equal partial widths and helicity angle distributions for charged and neutral D_1 mesons.

⁴ Systematic uncertainties not estimated.

$D_1(2420)$ REFERENCES

AAIJ	20D	PR D101 032005	R. Aaij <i>et al.</i>	(LHCb Collab.)
ABLIKIM	20P	PL B804 135395	M. Ablikim <i>et al.</i>	(BESIII Collab.)
AAIJ	13CC	JHEP 1309 145	R. Aaij <i>et al.</i>	(LHCb Collab.)
ABRAMOWICZ	13	NP B866 229	H. Abramowicz <i>et al.</i>	(ZEUS Collab.)
DEL-AMO-SA...	10P	PR D82 111101	P. del Amo Sanchez <i>et al.</i>	(BABAR Collab.)
AUBERT	09Y	PRL 103 051803	B. Aubert <i>et al.</i>	(BABAR Collab.)
CHEKANOV	09	EPJ C60 25	S. Chekanov <i>et al.</i>	(ZEUS Collab.)
ABULENCIA	06A	PR D73 051104	A. Abulencia <i>et al.</i>	(CDF Collab.)
ABE	05A	PRL 94 221805	K. Abe <i>et al.</i>	(BELLE Collab.)
ABE	04D	PR D69 112002	K. Abe <i>et al.</i>	(BELLE Collab.)
ABREU	98M	PL B426 231	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACKERSTAFF	97W	ZPHY C76 425	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
AVERY	94C	PL B331 236	P. Avery <i>et al.</i>	(CLEO Collab.)
BERGFELD	94B	PL B340 194	T. Bergfeld <i>et al.</i>	(CLEO Collab.)
FRABETTI	94B	PRL 72 324	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
AVERY	90	PR D41 774	P. Avery, D. Besson	(CLEO Collab.)
ALBRECHT	89H	PL B232 398	H. Albrecht <i>et al.</i>	(ARGUS Collab.) JP
ANJOS	89C	PRL 62 1717	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)