$D_1(2420)$

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

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

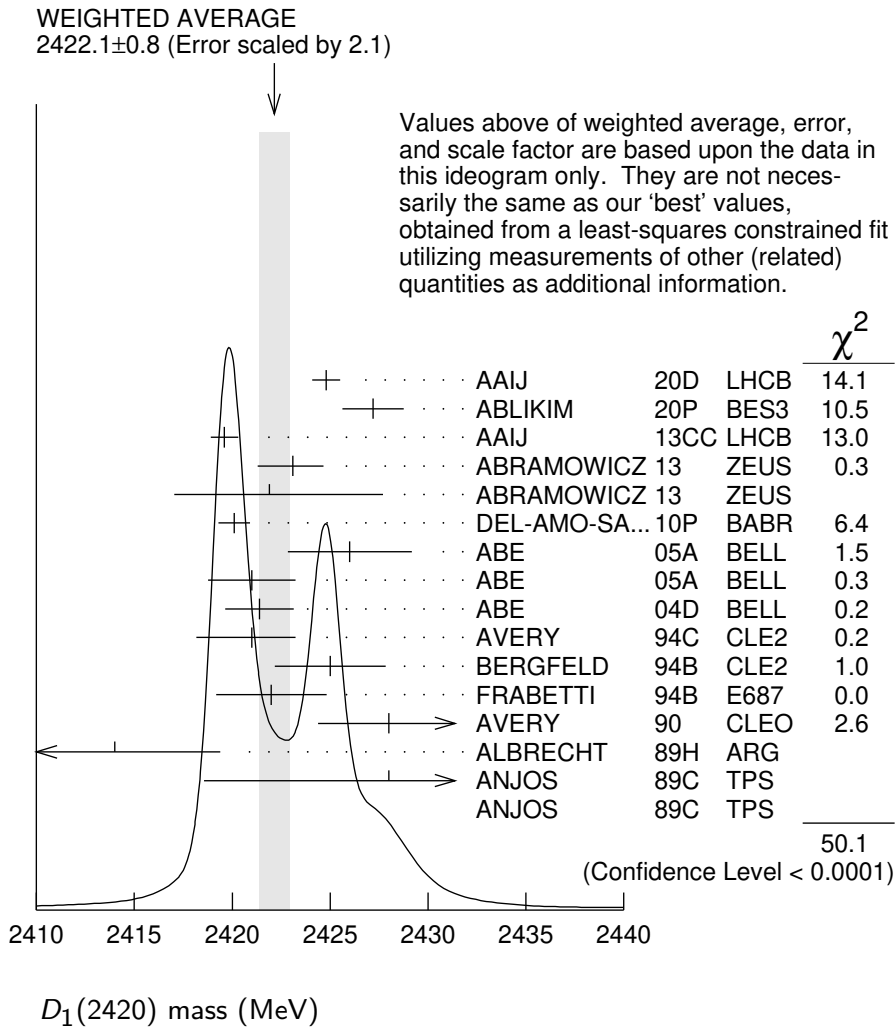[1] From a full four-body amplitude analysis of the $B^- \to D^{*+}\pi^-\pi^-$ decay.

[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.

WEIGHTED AVERAGE
2422.1±0.8 (Error scaled by 2.1)

Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our 'best' values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

			χ^2
AAIJ	20D	LHCB	14.1
ABLIKIM	20P	BES3	10.5
AAIJ	13CC	LHCB	13.0
ABRAMOWICZ	13	ZEUS	0.3
ABRAMOWICZ	13	ZEUS	
DEL-AMO-SA...	10P	BABR	6.4
ABE	05A	BELL	1.5
ABE	05A	BELL	0.3
ABE	04D	BELL	0.2
AVERY	94C	CLE2	0.2
BERGFELD	94B	CLE2	1.0
FRABETTI	94B	E687	0.0
AVERY	90	CLEO	2.6
ALBRECHT	89H	ARG	
ANJOS	89C	TPS	
ANJOS	89C	TPS	
			50.1

(Confidence Level < 0.0001)

2410   2415   2420   2425   2430   2435   2440

$D_1(2420)$ mass (MeV)

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

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	$e^{\pm}p \to D^{*+}\pi^- X$
411.7±0.7±0.4	7.5k	ABULENCIA	06A	CDF	1900 $p\overline{p} \to D^{*+}\pi^- X$

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

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
$4^{+2}_{-3}\pm3$	BERGFELD	94B	CLE2	$e^+e^- \to$ hadrons

$D_1(2420)$ WIDTH

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

[1] From a full four-body amplitude analysis of the $B^- \to D^{*+}\pi^-\pi^-$ 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] Fit includes the contribution from $D_1^*(2430)^0$.

WEIGHTED AVERAGE
31.3±1.9 (Error scaled by 2.8)

			χ^2
AAIJ	20D	LHCB	0.7
ABLIKIM	20P	BES3	6.3
AAIJ	13CC	LHCB	15.4
ABRAMOWICZ	13	ZEUS	1.0
DEL-AMO-SA...	10P	BABR	0.0
ABULENCIA	06A	CDF	28.1
ABE	05A	BELL	
ABE	05A	BELL	
ABE	04D	BELL	2.5
AVERY	94C	CLE2	2.9
BERGFELD	94B	CLE2	
FRABETTI	94B	E687	
AVERY	90	CLEO	
ALBRECHT	89H	ARG	
ANJOS	89C	TPS	

56.8
(Confidence Level < 0.0001)

$D_1(2420)$ WIDTH (MeV)
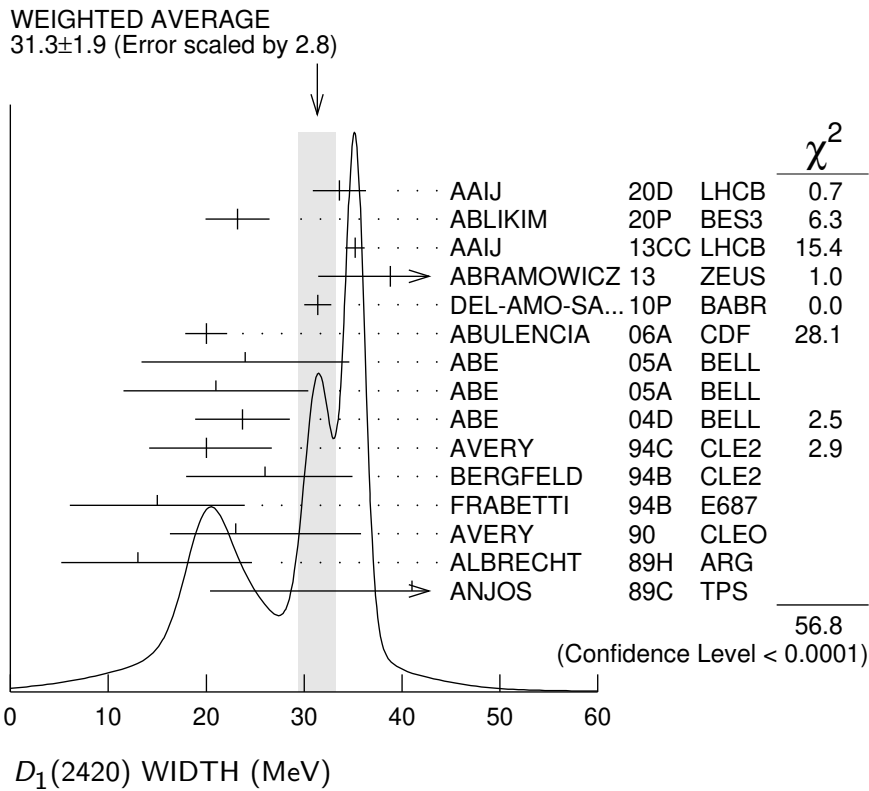
$D_1(2420)$ DECAY MODES

$\overline{D}_1(2420)$ 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	$Df_0(500)$	
Γ_5	$D_0^*(2300)^0\pi$	
Γ_6	$D^0\pi$	
Γ_7	$D^*\pi^+\pi^-$	

$D_1(2420)$ BRANCHING RATIOS

$\Gamma\left(D^*(2007)^0\pi\right)/\Gamma_{\text{total}}$ $\hfill \Gamma_1/\Gamma$

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
seen	ACKERSTAFF	97W	OPAL	0	$e^+e^- \to D^{*+}\pi^- X$
seen	AVERY	90	CLEO	0	$e^+e^- \to D^{*+}\pi^- X$
seen	ALBRECHT	89H	ARG	0	$e^+e^- \to D^*\pi^- X$
seen	ANJOS	89C	TPS	0	$\gamma N \to D^{*+}\pi^- X$
seen	ANJOS	89C	TPS	+	$\gamma N \to D^0\pi^+ X^0$

$\Gamma(D^0\pi)/\Gamma(D^*(2007)^0\pi)$ Γ_6/Γ_1

VALUE	CL%	DOCUMENT ID		TECN	CHG	COMMENT
<0.18	90	BERGFELD	94B	CLE2	+	$e^+e^- \to$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<0.24	90	AVERY	90	CLEO	0	$e^+e^- \to D^+\pi^- X$

$D_1(2420)$ 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 $D_1 \to D^*\pi$ and the $D^* \to D\pi$.

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	$e^{\pm}p \to D^{(*)+}\pi^- X$
5.72±0.25	103k	DEL-AMO-SA...10P		BABR	0	$e^+e^- \to D^{*+}\pi^- X$
5.9 $^{+3.0}_{-1.7}$ $^{+2.4}_{-1.0}$		CHEKANOV	09	ZEUS	0	$e^{\pm}p \to D^{*+}\pi^- X$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
3.30±0.48	210k	[2] AAIJ	13CC	LHCB	0	$pp \to D^{*+}\pi^- X$
3.8 ±0.6 ±0.8		[3] AUBERT	09Y	BABR	0	$B^+ \to D_1^0 \ell^+ \nu_\ell$
3.8 ±0.6 ±0.8		[3] AUBERT	09Y	BABR	+	$B^0 \to D_1^- \ell^+ \nu_\ell$
2.74 $^{+1.40}_{-0.93}$		[4] AVERY	94C	CLE2	0	$e^+e^- \to D^{*+}\pi^- X$

[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 S-wave mixing possible.

[2] Systematic uncertainty not estimated. Resonance parameters fixed.

[3] Assuming $\Gamma(\Upsilon(4S) \to B^+B^-) / \Gamma(\Upsilon(4S) \to B^0\overline{B}^0) = 1.065 \pm 0.026$ 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 *et al.*	(LHCb Collab.)
ABLIKIM	20P	PL B804 135395	M. Ablikim *et al.*	(BESIII Collab.)
AAIJ	13CC	JHEP 1309 145	R. Aaij *et al.*	(LHCb Collab.)
ABRAMOWICZ	13	NP B866 229	H. Abramowicz *et al.*	(ZEUS Collab.)
DEL-AMO-SA...	10P	PR D82 111101	P. del Amo Sanchez *et al.*	(BABAR Collab.)
AUBERT	09Y	PRL 103 051803	B. Aubert *et al.*	(BABAR Collab.)
CHEKANOV	09	EPJ C60 25	S. Chekanov *et al.*	(ZEUS Collab.)
ABULENCIA	06A	PR D73 051104	A. Abulencia *et al.*	(CDF Collab.)
ABE	05A	PRL 94 221805	K. Abe *et al.*	(BELLE Collab.)
ABE	04D	PR D69 112002	K. Abe *et al.*	(BELLE Collab.)

ABREU	98M	PL B426 231	P. Abreu *et al.*	(DELPHI Collab.)
ACKERSTAFF	97W	ZPHY C76 425	K. Ackerstaff *et al.*	(OPAL Collab.)
AVERY	94C	PL B331 236	P. Avery *et al.*	(CLEO Collab.)
BERGFELD	94B	PL B340 194	T. Bergfeld *et al.*	(CLEO Collab.)
FRABETTI	94B	PRL 72 324	P.L. Frabetti *et al.*	(FNAL E687 Collab.)
AVERY	90	PR D41 774	P. Avery, D. Besson	(CLEO Collab.)
ALBRECHT	89H	PL B232 398	H. Albrecht *et al.*	(ARGUS Collab.) JP
ANJOS	89C	PRL 62 1717	J.C. Anjos *et al.*	(FNAL E691 Collab.)