

# $\chi_{c1}(4140)$

$$I^G(J^{PC}) = 0^+(1^{++})$$

was  $X(4140)$

This state shows properties different from a conventional  $q\bar{q}$  state. A candidate for an exotic structure. See the review on non- $q\bar{q}$  states.

Seen by AALTONEN 09AH, ABAZOV 14A, CHATRCHYAN 14M, AAIJ 17C in  $B^+ \rightarrow \chi_{c1} K^+$ ,  $\chi_{c1} \rightarrow J/\psi\phi$ , and by ABAZOV 15M separately in both prompt ( $4.7\sigma$ ) and non-prompt ( $5.6\sigma$ ) production in  $p\bar{p} \rightarrow J/\psi\phi + \text{anything}$ . Not seen by SHEN 10 in  $\gamma\gamma \rightarrow J/\psi\phi$  and ABLIKIM 15 in  $e^+e^- \rightarrow \gamma J/\psi\phi$  at  $\sqrt{s} = 4.23, 4.26, 4.36$  GeV.

## $\chi_{c1}(4140)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>4146.5 ± 3.0 OUR AVERAGE</b>		Error includes scale factor of 1.3. See the ideogram below.		
4118 ± 11 <sup>+19</sup> / <sub>-36</sub>	24k	<sup>1</sup> AAIJ	21E LHCb	$B^+ \rightarrow J/\psi\phi K^+$
4143.4 <sup>+2.9</sup> / <sub>-3.0</sub> ± 0.6	19	<sup>2</sup> AALTONEN	17 CDF	$B^+ \rightarrow J/\psi\phi K^+$
4152.5 ± 1.7 <sup>+6.2</sup> / <sub>-5.4</sub>	616	<sup>3</sup> ABAZOV	15M D0	$p\bar{p} \rightarrow J/\psi\phi + \text{anything}$
4159.0 ± 4.3 ± 6.6	52	<sup>4</sup> ABAZOV	14A D0	$B^+ \rightarrow J/\psi\phi K^+$
4148.0 ± 2.4 ± 6.3	0.3k	<sup>5</sup> CHATRCHYAN 14M	CMS	$B^+ \rightarrow J/\psi\phi K^+$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
4146.5 ± 4.5 <sup>+4.6</sup> / <sub>-2.8</sub>	4289	<sup>6,7</sup> AAIJ	17C LHCb	$B^+ \rightarrow J/\psi\phi K^+$
4143.0 ± 2.9 ± 1.2	14	<sup>8,9</sup> AALTONEN	09AH CDF	$B^+ \rightarrow J/\psi\phi K^+$

<sup>1</sup> From an amplitude analysis of the decay  $B^+ \rightarrow J/\psi\phi K^+$  with a significance of  $13\sigma$ .

<sup>2</sup> Statistical significance of more than  $5\sigma$ .

<sup>3</sup> Statistical significance of more than  $6\sigma$ .

<sup>4</sup> Statistical significance of  $3.1\sigma$ .

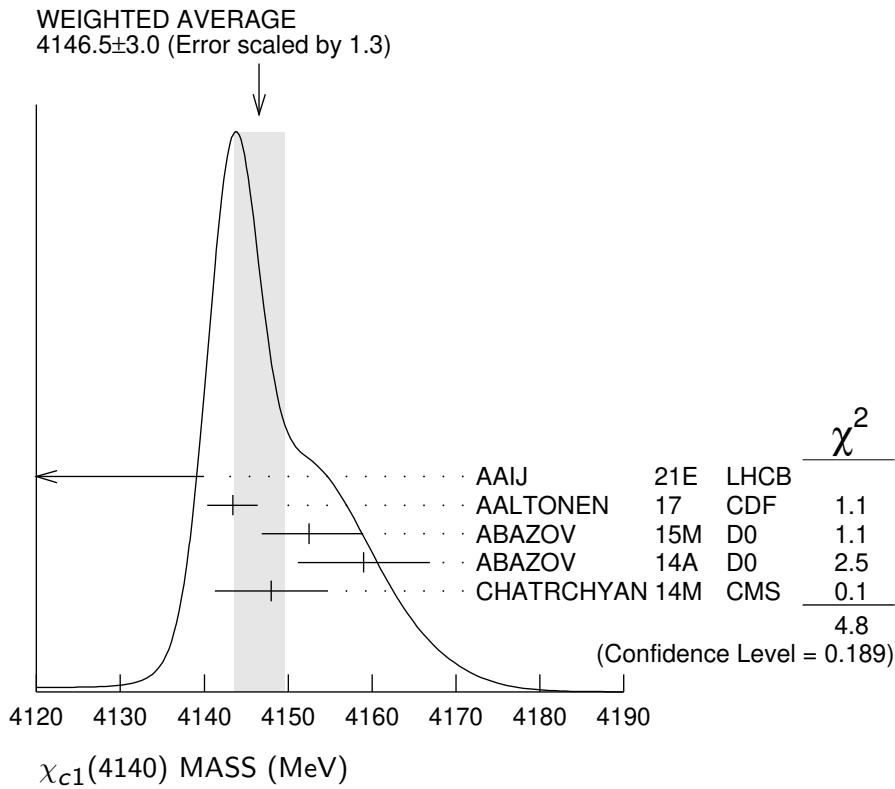
<sup>5</sup> From a fit assuming an S-wave relativistic Breit-Wigner shape above a three-body phase-space non-resonant component with statistical significance of more than  $5\sigma$ .

<sup>6</sup> From an amplitude analysis of the decay  $B^+ \rightarrow J/\psi\phi K^+$  with a significance of  $8.4\sigma$ .

<sup>7</sup> Superseded by AAIJ 21E.

<sup>8</sup> Statistical significance of  $3.8\sigma$ .

<sup>9</sup> Superseded by AALTONEN 17.



### $\chi_{c1}(4140)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>19 <math>\pm</math> <math>\frac{7}{5}</math> OUR AVERAGE</b>				
162 $\pm$ 21 $\frac{+24}{-49}$	24k	1 AAIJ	21E LHCB	$B^+ \rightarrow J/\psi \phi K^+$
15.3 $\frac{+10.4}{-6.1} \pm 2.5$	19	2 AALTONEN	17 CDF	$B^+ \rightarrow J/\psi \phi K^+$
16.3 $\pm 5.6 \pm 11.4$	616	3 ABAZOV	15M D0	$p\bar{p} \rightarrow J/\psi \phi + \text{anything}$
20 $\pm 13 \frac{+3}{-8}$	52	4 ABAZOV	14A D0	$B^+ \rightarrow J/\psi \phi K^+$
28 $\frac{+15}{-11} \pm 19$	0.3k	5 CHATRCHYAN 14M	CMS	$B^+ \rightarrow J/\psi \phi K^+$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
83 $\pm 21 \frac{+21}{-14}$	4289	6,7 AAIJ	17C LHCB	$B^+ \rightarrow J/\psi \phi K^+$
11.7 $\frac{+8.3}{-5.0} \pm 3.7$	14	8,9 AALTONEN	09AH CDF	$B^+ \rightarrow J/\psi \phi K^+$

<sup>1</sup> From an amplitude analysis of the decay  $B^+ \rightarrow J/\psi \phi K^+$  with a significance of  $13 \sigma$ .  
<sup>2</sup> Statistical significance of more than  $5 \sigma$ .  
<sup>3</sup> Statistical significance of more than  $6 \sigma$ .  
<sup>4</sup> Statistical significance of  $3.1 \sigma$ .  
<sup>5</sup> From a fit assuming an S-wave relativistic Breit-Wigner shape above a three-body phase-space non-resonant component with statistical significance of more than  $5 \sigma$ .  
<sup>6</sup> From an amplitude analysis of the decay  $B^+ \rightarrow J/\psi \phi K^+$  with a significance of  $8.4 \sigma$ .  
<sup>7</sup> Superseded by AAIJ 21E.  
<sup>8</sup> Statistical significance of  $3.8 \sigma$ .  
<sup>9</sup> Superseded by AALTONEN 17.

### $\chi_{c1}(4140)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $J/\psi\phi$	seen
$\Gamma_2$ $\gamma\gamma$	not seen

### $\chi_{c1}(4140)$ $\Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

$\Gamma(\gamma\gamma) \times \Gamma(J/\psi\phi)/\Gamma_{\text{total}}$					$\Gamma_2/\Gamma_1$
VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT	
<41	90	<sup>1</sup> SHEN	10	BELL	$10.6 e^+e^- \rightarrow e^+e^- J/\psi\phi$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
< 6	90	<sup>2</sup> SHEN	10	BELL	$10.6 e^+e^- \rightarrow e^+e^- J/\psi\phi$
<sup>1</sup> For $J^P = 0^+$ .					
<sup>2</sup> For $J^P = 2^+$ .					

### $\chi_{c1}(4140)$ BRANCHING RATIOS

$\Gamma(J/\psi\phi)/\Gamma_{\text{total}}$					$\Gamma_1/\Gamma$
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	
seen	24k	<sup>1</sup> AAIJ	21E	LHCB	$B^+ \rightarrow J/\psi\phi K^+$
seen	616	<sup>2</sup> ABAZOV	15M	D0	$p\bar{p} \rightarrow J/\psi\phi + \text{anything}$
seen	52	<sup>3</sup> ABAZOV	14A	D0	$B^+ \rightarrow J/\psi\phi K^+$
seen	0.3k	<sup>4</sup> CHATRCHYAN	14M	CMS	$B^+ \rightarrow J/\psi\phi K^+$
seen	14	<sup>5</sup> AALTONEN	09AH	CDF	$B^+ \rightarrow J/\psi\phi K^+$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
seen	4289	<sup>6,7</sup> AAIJ	17C	LHCB	$B^+ \rightarrow J/\psi\phi K^+$
not seen		<sup>8</sup> ABLIKIM	15	BES3	$e^+e^- \rightarrow \gamma\phi J/\psi$
not seen		<sup>9</sup> AAIJ	12AA	LHCB	$pp \rightarrow B^+ X$ at 7 TeV

- <sup>1</sup> From an amplitude analysis of the decay  $B^+ \rightarrow J/\psi\phi K^+$  with a significance of  $13\sigma$ .
- <sup>2</sup> Statistical significance of more than  $6\sigma$ .
- <sup>3</sup> ABAZOV 14A reports  $B(B^+ \rightarrow \chi_{c1}(4140)K^+ \rightarrow J/\psi\phi K^+)/B(B^+ \rightarrow J/\psi\phi K^+) = (19 \pm 7 \pm 4)\%$  with  $3.1\sigma$  significance.
- <sup>4</sup> From a fit assuming an S-wave relativistic Breit-Wigner shape above a three-body phase-space non-resonant component with statistical significance of more than  $5\sigma$ .
- <sup>5</sup> Statistical significance of  $3.8\sigma$ .
- <sup>6</sup> From an amplitude analysis of the decay  $B^+ \rightarrow J/\psi\phi K^+$  with a significance of  $8.4\sigma$ .
- <sup>7</sup> Superseded by AAIJ 21E.
- <sup>8</sup> Reported  $\sigma(e^+e^- \rightarrow \gamma\chi_{c1}(4140)) \cdot B(\chi_{c1}(4140) \rightarrow J/\psi\phi) < 0.35, 0.28, \text{ and } 0.33$  pb at 4.23, 4.26, and 4.36 GeV, respectively, at 90% CL.
- <sup>9</sup> Reported  $B(B^+ \rightarrow \chi_{c1}(4140)K^+) \cdot B(\chi_{c1}(4140) \rightarrow J/\psi\phi)/B(B^+ \rightarrow J/\psi\phi K^+) < 0.07$  at 90% CL.

$\Gamma(\gamma\gamma)/\Gamma_{\text{total}}$					$\Gamma_2/\Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT		
not seen	SHEN	10	BELL	$10.6 e^+e^- \rightarrow e^+e^- J/\psi\phi$	

## $\chi_{c1}(4140)$ REFERENCES

AAIJ	21E	PRL 127 082001	R. Aaij <i>et al.</i>	(LHCb Collab.)
AAIJ	17C	PRL 118 022003	R. Aaij <i>et al.</i>	(LHCb Collab.) JP
Also		PR D95 012002	R. Aaij <i>et al.</i>	(LHCb Collab.)
AALTONEN	17	MPL A32 1750139	T. Altonen <i>et al.</i>	(CDF Collab.)
ABAZOV	15M	PRL 115 232001	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABLIKIM	15	PR D91 032002	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABAZOV	14A	PR D89 012004	V.M. Abazov <i>et al.</i>	(D0 Collab.)
CHATRCHYAN	14M	PL B734 261	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
AAIJ	12AA	PR D85 091103	R. Aaij <i>et al.</i>	(LHCb Collab.)
SHEN	10	PRL 104 112004	C.P. Shen <i>et al.</i>	(BELLE Collab.)
AALTONEN	09AH	PRL 102 242002	T. Aaltonen <i>et al.</i>	(CDF Collab.)

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