$\Theta(1540)^+$

$I(J^P) = 0(?^?)$ Status: ∗∗

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$\Theta(1540)^+$ MASS

As is done through the *Review*, papers are listed by year, with the latest year first, and within each year they are listed alphabetically. NAKANO 03 was the earliest paper.

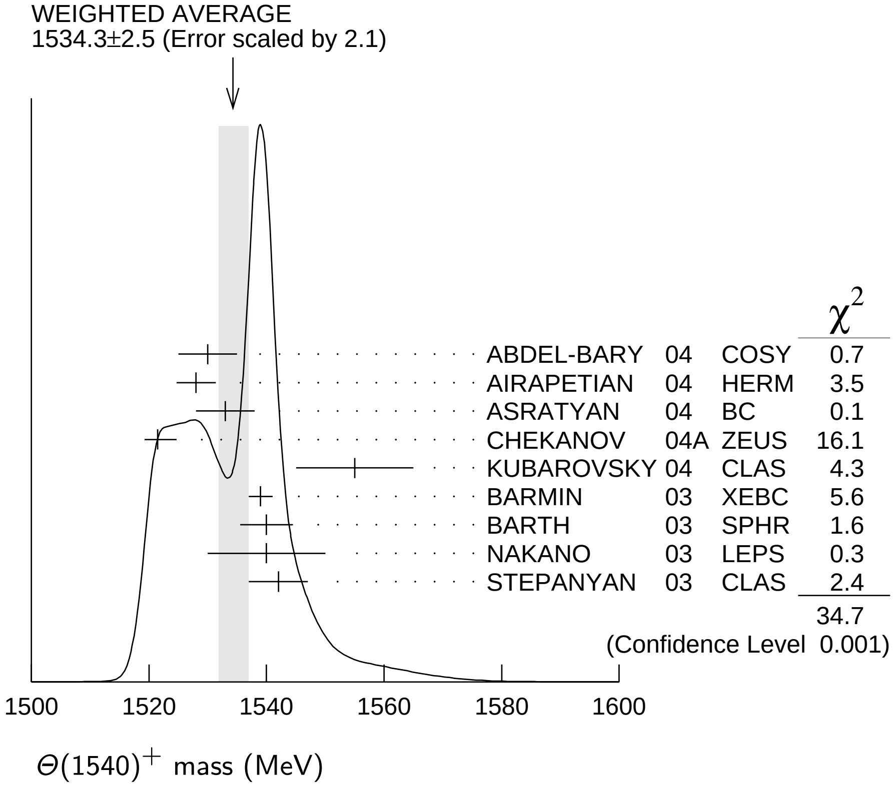
Since our 2004 edition, there have been several new claimed sightings of the $\Theta(1540)^+$ (see entries below marked with bars to the right), but there have also been several searches with negative results:

- ANTIPOV 04 (SPHINX Collab.) in $pN \to (nK^+, pK^0_S$, or $pK^0_L)\ \overline{K}^0 N$ in proton–carbon reactions at 70 GeV/c;
- BAI 04G (BES Collab.) in J/ψ and $\psi(2S)$ decays;
- SCHAEL 04 (ALEPH Collab.) in Z decays;
- ABT 04A (HERA-B Collab.) in p nucleus reactions at midrapidity and $\sqrt{s}$=41.6 GeV;
- LONGO 04 (HyperCP Collab.) in interactions of a high-energy beam of π^+, K^+, p, and charged hyperons with tungsten.

In general, these experiments with negative results have many more events than do the experiments with positive results. (Against this, however, it may be argued that the recent negative results are often from experiments with different reactions or at different energies from the experiments with positive results.)

Furthermore, the $\Theta(1540)^+$ finds almost no support from the claimed observations of other pentaquarks, the $\Phi(1860)$ and the $\Theta_c(3100)$, for which the evidence is very weak. (See the Listings following the $\Theta(1540)^+$.) Thus we have reduced the status of the $\Theta(1540)^+$ to two stars.

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*	
1534.3± 2.5 OUR AVERAGE		Error includes scale factor of 2.1. See the ideogram below.				
1530 ± 5		[1] ABDEL-BARY	04	COSY	$pp \to \Sigma^+ K^0 p$	▌
1528.0± 2.6±2.1	59	[2] AIRAPETIAN	04	HERM	$\gamma^* d \to pK^0_S X$	▌
1533 ± 5	27	[3] ASRATYAN	04	BC	ν, $\overline{\nu}$ in p,d,Ne, BEBC, 15-ft	
1521.5± $1.5^{+2.8}_{-1.7}$	221	[4] CHEKANOV	04A	ZEUS	$\gamma^* p \to p/\overline{p} K^0_S X$	▌
1555 ±10	41	[5] KUBAROVSKY	04	CLAS	$\gamma p \to \pi^+ K^- K^+ n$	
1539 ± 2	29	[6] BARMIN	03	XEBC	$K^+ \text{Xe} \to K^0 p \text{Xe}'$	
1540 ± 4 ±2	63	[7] BARTH	03	SPHR	$\gamma p \to nK^+ K^0_S$	
1540 ±10	19	[8] NAKANO	03	LEPS	$\gamma\, ^{12}\text{C} \to K^+ K^- n X$	
1542 ± 5	43	[9] STEPANYAN	03	CLAS	$\gamma d \to K^+ K^- p n$	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
1559 ± 3		[10] GIBBS	04		$K^+ d$ total cross section	▌



$\Theta(1540)^{+}$ WIDTH

Given the systematic uncertainties of the estimates of CAHN 04 and GIBBS 04, we think it more reasonable to give the common value for the width and error rather than average the two values.

VALUE (MeV)	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.9 ±0.3 OUR ESTIMATE						
0.90±0.21 OUR AVERAGE						
0.9 ±0.3			[11] CAHN	04		$K^{+} n \rightarrow K^{0} p$ in xenon
0.9 ±0.3			GIBBS	04	PWA	K^{+}d total cross section
• • • We do not use the following data for averages, fits, limits, etc. • • •						
17 ±9 ±3			AIRAPETIAN	04	HERM	$\gamma^{*} d \rightarrow p K^{0}_{S} X$
<20			ASRATYAN	04	BC	ν, $\overline{\nu}$ in p,d,Ne, BEBC and 15-ft
8 ±4		221	CHEKANOV	04A	ZEUS	$\gamma^{*} p \rightarrow p/\overline{p} K^{0}_{S} X$
<26			KUBAROVSKY	04	CLAS	$\gamma p \rightarrow \pi^{+} K^{-} K^{+} n$
< 1			[12] SIBIRTSEV	04		$K^{+} d \rightarrow K^{0} p p$ reanalysis
$\lesssim$ 1			[13] ARNDT	03	DPWA	$K^{+} N$ partial-wave reanalysis
< 9	90		BARMIN	03	XEBC	K^{+}Xe $\rightarrow K^{0} p$ Xe$'$
<25	90		BARTH	03	SPHR	$\gamma p \rightarrow n K^{+} K^{0}_{S}$
<25	90		NAKANO	03	LEPS	$\gamma\, ^{12}$C $\rightarrow K^{+} K^{-} n$ X
<21			STEPANYAN	03	CLAS	$\gamma d \rightarrow K^{+} K^{-} p n$

$\Theta(1540)^+$ DECAY MODES

NK is the only strong decay mode allowed for a strangeness S=+1 resonance of this mass.

	Mode	Fraction (Γ_i/Γ)
Γ_1	KN	100%

$\Theta(1540)^+$ FOOTNOTES

[1] ABDEL-BARY 04 finds a peak with a statistical significance of 4–to–6 standard deviations, depending on background assumptions. The width is consistent with resolution.

[2] AIRAPETIAN 04, in $e^+ d$ at 27.6 GeV, finds 59 $\pm$ 16 events (3.7 σ) in the peak.

[3] ASRATYAN 04 analyzes old BEBC and 15-ft bubble-chamber data and estimates a peak of 27 $K^0 p$ events (mostly from ν, $\overline{\nu}$ in Ne) above a background of 8 events and claims a statistical significance of 6.7 standard deviations.

[4] CHEKANOV 04A, in $e^\pm p$ at c.m. energies near 300 GeV and $Q^2 > 20$ GeV^2, finds 221 $\pm$ 48 events (4.6 σ) in the peak.

[5] KUBAROVSKY 04 estimates a peak of 41 $K^+ n$ events and claims a statistical significance of 7.8 $\pm$ 1.0 standard deviations.

[6] BARMIN 03 estimates a peak of 29 $K^0 p$ events above a background of 44 events and claims a statistical significance of 4.4 standard deviations.

[7] BARTH 03 estimates a peak of 63 $\pm$ 13 $K^+ n$ events and claims a significance of 4.8 standard deviations.

[8] NAKANO 03 estimates a peak of 19.0 $\pm$ 2.8 $K^+ n$ events above a background of 17.0 $\pm$ 2.8 events and claims a significance of $4.6^{+1.2}_{-1.0}$ standard deviations.

[9] STEPANYAN 03 estimates a peak of 43 $K^+ n$ events above a background of 54 events and claims a statistical significance of 5.2 $\pm$ 0.5 standard deviations.

[10] GIBBS 04 analyses K^+d total-cross-section data with corrections for K^+ double scattering and for the neutron Fermi momentum. Evidence is found for a state at 1559 $\pm$ 3 MeV if it is in the P_{01} wave, or at 1547 $\pm$ 2 MeV if in the S_{01} wave (errors are statistical only).

[11] CAHN 04 uses the integrated $K^+ n \rightarrow K^0 p$ cross section estimated from the DIANA experiment in xenon (BARMIN 03); some assumptions are needed. Other of their estimates, based on measured $K^+ d$ cross sections, give upper limits in the 1–4 MeV range.

[12] SIBIRTSEV 04 introduces a test resonance at 1540 MeV in the P_{01} KN partial wave in an analysis of $K^+ d \rightarrow K^0 pp$ data. The analysis uses the Julich model and takes into account Fermi motion in the deuteron.

[13] ARNDT 03 introduces a test resonance in various partial waves in a reanalysis of $K^+ N$ elastic-scattering data and finds that a width of more than an MeV or so would greatly increase the χ^2 of the fit.

$\Theta(1540)^+$ REFERENCES

ABDEL-BARY	04	PL B595 127	M. Abdel-Bary *et al.*	(COSY-TOF Collab.)
ABT	04A	PRL 93 212003	I. Abt *et al.*	(HERA B Collab.)
AIRAPETIAN	04	PL B585 213	A. Airapetian *et al.*	(HERA HERMES Collab.)
ANTIPOV	04	EPJ A21 455	Yu.M. Antipov *et al.*	(IHEP SPHINX Collab.)
ASRATYAN	04	PAN 67 682	A.E. Asratyan, A. Dolgolenko, M. Kubantsev	(ITEP)
		Translated from YAF 67 704.		

BAI	04G	PR D70 012004	J.Z. Bai *et al.*	(BEPC BES Collab.)
CAHN	04	PR D69 011501R	R.N. Cahn, G.H. Trilling	(LBNL)
CHEKANOV	04A	PL B591 7	S. Chekanov *et al.*	(HERA ZEUS Collab.)
GIBBS	04	PR C70 045208	W.R. Gibbs	(NMSU)
KUBAROVSKY	04	PRL 92 032001	V. Kubarovsky *et al.*	(Jefferson Lab CLAS Collab.)
LONGO	04	PR D70 111101R	M.J. Longo *et al.*	(FNAL HyperCP Collab.)
SCHAEL	04	PL B599 1	S. Schael *et al.*	(ALEPH Collab.)
SIBIRTSEV	04	PL B599 230	A. Sibirtsev *et al.*	(JULI, ADLD, BONN)
ARNDT	03	PR C68 042201R	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(GWU)
BARMIN	03	PAN 66 1715	V.V. Barmin *et al.*	(ITEP DIANA Collab.)
		Translated from YAF 66 1763.		
BARTH	03	PL B572 127	J. Barth *et al.*	(Bonn SAPHIR Collab.)
NAKANO	03	PRL 91 012002	T. Nakano *et al.*	(SPring-8 LEPS Collab.)
STEPANYAN	03	PRL 91 252001	S. Stepanyan *et al.*	(Jefferson Lab CLAS Collab.)