



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 8, 2026 – 11:17 AM UTC

PDB ID : 6A97 / pdb_00006a97
Title : Crystal structure of MHC-like MILL2
Authors : Kajikawa, M.; Ose, T.; Maenaka, K.
Deposited on : 2018-07-11
Resolution : 2.15 Å(reported)

This is a Full wwPDB X-ray Structure Validation Report for a publicly released PDB entry.

We welcome your comments at validation@mail.wwpdb.org

A user guide is available at

<https://www.wwpdb.org/validation/2017/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The types of validation reports are described at

<http://www.wwpdb.org/validation/2017/FAQs#types>.

The following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

MolProbity	:	4-5-2 with Phenix2.0
Mogul	:	2022.3.0, CSD as543be (2022)
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.010 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

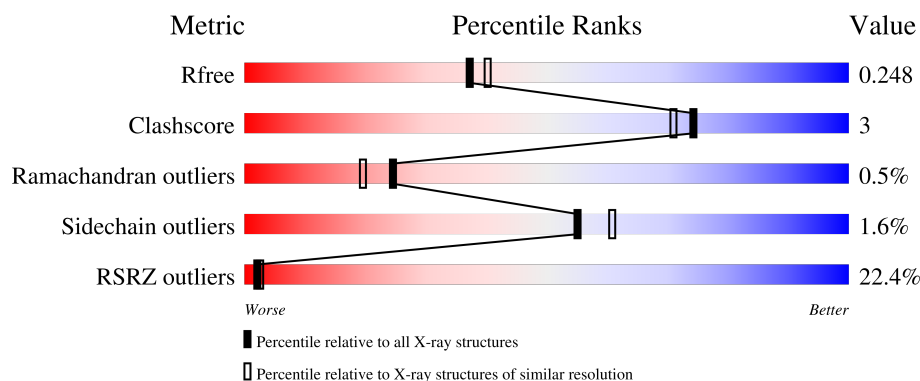
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.15 Å.

Percentile scores (ranging between 0-100) for global validation metrics of the entry are shown in the following graphic. The table shows the number of entries on which the scores are based.



Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	180053	3689 (2.16-2.12)
Clashscore	190562	3812 (2.16-2.12)
Ramachandran outliers	187476	3773 (2.16-2.12)
Sidechain outliers	187428	3772 (2.16-2.12)
RSRZ outliers	180081	3691 (2.16-2.12)

The table below summarises the geometric issues observed across the polymeric chains and their fit to the electron density. The red, orange, yellow and green segments of the lower bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria respectively. A grey segment represents the fraction of residues that are not modelled. The numeric value for each fraction is indicated below the corresponding segment, with a dot representing fractions $\leq 5\%$. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density. The numeric value is given above the bar.

Mol	Chain	Length	Quality of chain
1	A	292	
1	C	292	
2	B	100	
2	D	100	

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 5595 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, the ZeroOcc column contains the number of atoms modelled with zero occupancy, the AltConf column contains the number of residues with at least one atom in alternate conformation and the Trace column contains the number of residues modelled with at most 2 atoms.

- Molecule 1 is a protein called MHC I-like leukocyte 2 long form.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	267	Total	C	N	O	S	0	0	0
			2099	1313	378	396	12			
1	C	225	Total	C	N	O	S	0	0	0
			1719	1092	309	307	11			

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-15	MET	-	initiating methionine	UNP Q8HWE5
C	-15	MET	-	initiating methionine	UNP Q8HWE5

- Molecule 2 is a protein called Beta-2-microglobulin.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	B	97	Total	C	N	O	S	0	0	0
			775	500	130	139	6			
2	D	98	Total	C	N	O	S	0	0	0
			793	507	136	144	6			

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
B	0	MET	-	initiating methionine	UNP P01887
D	0	MET	-	initiating methionine	UNP P01887

- Molecule 3 is SULFATE ION (CCD ID: SO4) (formula: O₄S).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	C	1	Total	O	S	0	0
			5	4	1		

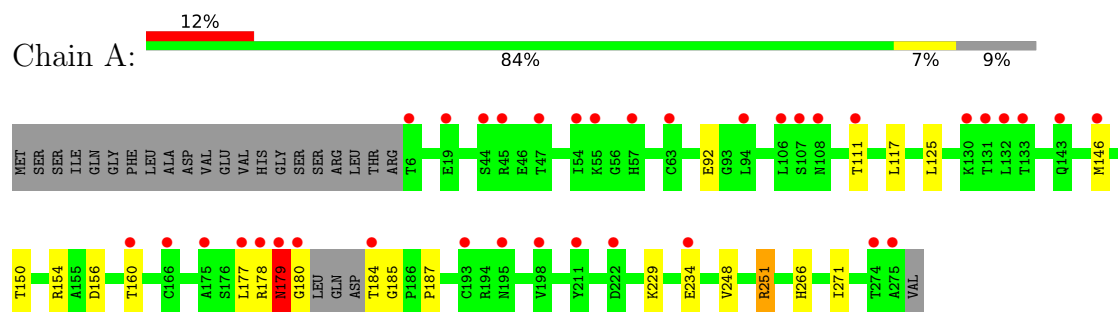
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	95	Total	O	0	0
			95	95		
4	B	33	Total	O	0	0
			33	33		
4	C	43	Total	O	0	0
			43	43		
4	D	33	Total	O	0	0
			33	33		

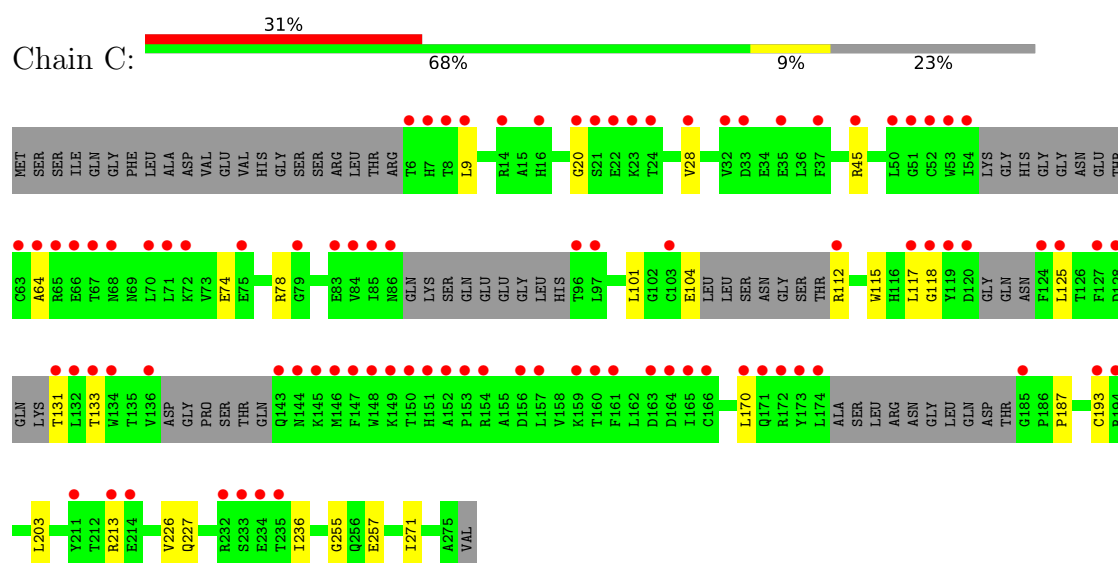
3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. Residues are color-coded according to the number of geometric quality criteria for which they contain at least one outlier: green = 0, yellow = 1, orange = 2 and red = 3 or more. A red dot above a residue indicates a poor fit to the electron density ($RSRZ > 2$). Stretches of 2 or more consecutive residues without any outlier are shown as a green connector. Residues present in the sample, but not in the model, are shown in grey.

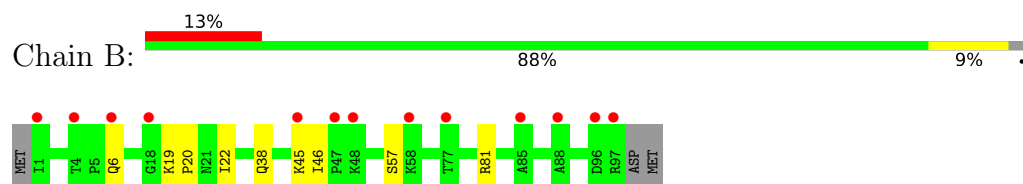
- Molecule 1: MHC I-like leukocyte 2 long form



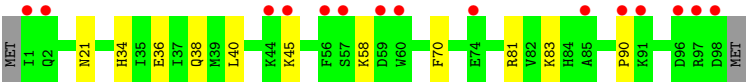
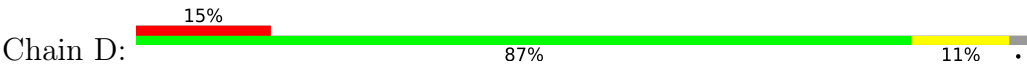
- Molecule 1: MHC I-like leukocyte 2 long form



- Molecule 2: Beta-2-microglobulin



- Molecule 2: Beta-2-microglobulin



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	89.63Å 93.50Å 138.12Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	44.82 – 2.15 44.82 – 2.15	Depositor EDS
% Data completeness (in resolution range)	99.8 (44.82-2.15) 99.8 (44.82-2.15)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.86 (at 2.14Å)	Xtriage
Refinement program	PHENIX 1.9_1692	Depositor
R, R_{free}	0.213 , 0.245 0.217 , 0.248	Depositor DCC
R_{free} test set	3199 reflections (5.00%)	wwPDB-VP
Wilson B-factor (Å ²)	45.3	Xtriage
Anisotropy	0.187	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.35 , 52.8	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	0.015 for k,h,-l	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	5595	wwPDB-VP
Average B, all atoms (Å ²)	59.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.64% of the height of the origin peak. No significant pseudotranslation is detected.*

¹Intensities estimated from amplitudes.

²Theoretical values of $\langle |L| \rangle$, $\langle L^2 \rangle$ for acentric reflections are 0.5, 0.333 respectively for untwinned datasets, and 0.375, 0.2 for perfectly twinned datasets.

5 Model quality [i](#)

5.1 Standard geometry [i](#)

Bond lengths and bond angles in the following residue types are not validated in this section: SO4

The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 5$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Chain	Bond lengths		Bond angles	
		RMSZ	$\# Z > 5$	RMSZ	$\# Z > 5$
1	A	0.31	0/2142	0.63	0/2904
1	C	0.30	0/1750	0.69	1/2376 (0.0%)
2	B	0.31	0/800	0.71	0/1090
2	D	0.29	0/817	0.71	0/1109
All	All	0.30	0/5509	0.67	1/7479 (0.0%)

There are no bond length outliers.

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	C	118	GLY	N-CA-C	5.85	118.51	110.56

There are no chirality outliers.

There are no planarity outliers.

5.2 Too-close contacts [i](#)

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in the chain respectively. The H(added) column lists the number of hydrogen atoms added and optimized by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, whereas Symm-Clashes lists symmetry-related clashes.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	2099	0	2047	13	0
1	C	1719	0	1652	12	0
2	B	775	0	747	4	0
2	D	793	0	774	7	0
3	C	5	0	0	1	0
4	A	95	0	0	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
4	B	33	0	0	0	0
4	C	43	0	0	0	0
4	D	33	0	0	0	0
All	All	5595	0	5220	33	0

The all-atom clashscore is defined as the number of clashes found per 1000 atoms (including hydrogen atoms). The all-atom clashscore for this structure is 3.

All (33) close contacts within the same asymmetric unit are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:184:THR:OG1	1:A:185:GLY:N	2.24	0.71
1:C:255:GLY:N	1:C:257:GLU:OE1	2.25	0.69
2:D:58:LYS:N	2:D:58:LYS:HD2	2.07	0.69
2:B:38:GLN:OE1	2:B:81:ARG:NH1	2.28	0.67
1:A:117:LEU:HD12	1:A:125:LEU:HD12	1.83	0.60
1:C:131:THR:HG23	1:C:133:THR:HG22	1.87	0.56
1:A:229:LYS:HD2	1:A:248:VAL:HG22	1.89	0.55
1:C:213:ARG:HB3	1:C:236:ILE:HG21	1.89	0.54
1:A:154:ARG:NH1	1:A:156:ASP:OD1	2.41	0.53
1:A:178:ARG:O	1:A:180:GLY:N	2.42	0.53
2:D:40:LEU:HD23	2:D:45:LYS:HA	1.92	0.52
1:C:9:LEU:HB2	1:C:170:LEU:HD12	1.92	0.50
1:A:251:ARG:NH1	3:C:301:SO4:S	2.84	0.50
1:C:117:LEU:HD12	1:C:125:LEU:HD23	1.93	0.50
1:C:74:GLU:OE1	1:C:78:ARG:NH1	2.44	0.50
1:A:179:ASN:N	1:A:179:ASN:OD1	2.44	0.49
2:D:81:ARG:HE	2:D:90:PRO:HB2	1.78	0.48
1:C:187:PRO:HG2	1:C:271:ILE:HD12	1.97	0.47
1:C:193:CYS:HB3	1:C:203:LEU:HD23	1.98	0.46
1:A:187:PRO:HG3	1:A:266:HIS:HD2	1.80	0.46
1:A:251:ARG:HD3	1:C:45:ARG:HH21	1.80	0.46
2:B:45:LYS:HD2	2:B:46:ILE:N	2.32	0.45
2:D:36:GLU:HB3	2:D:83:LYS:HB2	1.97	0.45
1:C:226:VAL:HG12	1:C:227:GLN:HG2	1.99	0.44
2:D:38:GLN:HE21	2:D:45:LYS:HD2	1.82	0.44
2:D:21:ASN:HB3	2:D:70:PHE:CE2	2.53	0.43
1:A:271:ILE:HG12	2:D:34:HIS:CD2	2.53	0.43
1:A:146:MET:O	1:A:150:THR:HG23	2.19	0.43
1:C:115:TRP:HE1	1:C:117:LEU:HD21	1.84	0.43
2:B:19:LYS:HA	2:B:20:PRO:HD2	1.83	0.42

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:C:104:GLU:N	1:C:112:ARG:O	2.51	0.41
1:A:156:ASP:O	1:A:160:THR:HG23	2.22	0.40
1:A:234:GLU:CD	2:B:57:SER:HB2	2.46	0.40

There are no symmetry-related clashes.

5.3 Torsion angles [i](#)

5.3.1 Protein backbone [i](#)

In the following table, the Percentiles column shows the percent Ramachandran outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the backbone conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	A	263/292 (90%)	257 (98%)	5 (2%)	1 (0%)	30	26
1	C	209/292 (72%)	199 (95%)	8 (4%)	2 (1%)	12	7
2	B	95/100 (95%)	92 (97%)	3 (3%)	0	100	100
2	D	96/100 (96%)	95 (99%)	1 (1%)	0	100	100
All	All	663/784 (85%)	643 (97%)	17 (3%)	3 (0%)	24	19

All (3) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	179	ASN
1	C	64	ALA
1	C	20	GLY

5.3.2 Protein sidechains [i](#)

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the sidechain conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	A	228/255 (89%)	223 (98%)	5 (2%)	45	49
1	C	176/255 (69%)	174 (99%)	2 (1%)	65	71
2	B	85/94 (90%)	83 (98%)	2 (2%)	43	45
2	D	89/94 (95%)	89 (100%)	0	100	100
All	All	578/698 (83%)	569 (98%)	9 (2%)	55	61

All (9) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	92	GLU
1	A	111	THR
1	A	177	LEU
1	A	179	ASN
1	A	251	ARG
2	B	6	GLN
2	B	22	ILE
1	C	28	VAL
1	C	101	LEU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (10) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	87	GLN
1	A	129	GLN
1	A	268	ASN
2	B	6	GLN
2	B	13	HIS
1	C	12	ASN
1	C	25	GLN
1	C	209	ASN
1	C	273	GLN
2	D	38	GLN

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains [i](#)

There are no non-standard protein/DNA/RNA residues in this entry.

5.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

1 ligand is modelled in this entry.

In the following table, the Counts columns list the number of bonds (or angles) for which Mogul statistics could be retrieved, the number of bonds (or angles) that are observed in the model and the number of bonds (or angles) that are defined in the Chemical Component Dictionary. The Link column lists molecule types, if any, to which the group is linked. The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	$\# Z > 2$	Counts	RMSZ	$\# Z > 2$
3	SO4	C	301	-	4,4,4	0.24	0	6,6,6	0.11	0

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	C	301	SO4	1	0

5.7 Other polymers [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues ⓘ

There are no chain breaks in this entry.

6 Fit of model and data

6.1 Protein, DNA and RNA chains

In the following table, the column labelled ‘#RSRZ> 2’ contains the number (and percentage) of RSRZ outliers, followed by percent RSRZ outliers for the chain as percentile scores relative to all X-ray entries and entries of similar resolution. The OWAB column contains the minimum, median, 95th percentile and maximum values of the occupancy-weighted average B-factor per residue. The column labelled ‘Q< 0.9’ lists the number of (and percentage) of residues with an average occupancy less than 0.9.

Mol	Chain	Analysed	<RSRZ>	#RSRZ>2	OWAB(Å ²)	Q<0.9
1	A	267/292 (91%)	0.83	36 (13%) 7 8	33, 52, 76, 91	0
1	C	225/292 (77%)	1.90	90 (40%) 1 1	39, 70, 98, 107	0
2	B	97/100 (97%)	0.94	13 (13%) 7 8	34, 56, 81, 87	0
2	D	98/100 (98%)	0.97	15 (15%) 5 6	38, 56, 77, 84	0
All	All	687/784 (87%)	1.22	154 (22%) 2 2	33, 58, 90, 107	0

All (154) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	C	63	CYS	8.2
2	B	1	ILE	7.9
2	D	60	TRP	7.8
1	C	124	PHE	7.4
1	C	64	ALA	6.6
1	C	128	ASP	6.4
1	C	233	SER	6.1
1	C	150	THR	6.1
1	C	136	VAL	6.0
2	D	1	ILE	5.8
2	B	97	ARG	5.8
2	B	96	ASP	5.8
1	C	143	GLN	5.6
1	C	174	LEU	5.6
1	C	148	TRP	5.4
1	C	147	PHE	4.8
1	C	119	TYR	4.7
1	C	144	ASN	4.6
1	C	131	THR	4.6
1	C	234	GLU	4.6
1	A	184	THR	4.5

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Mol	Chain	Res	Type	RSRZ
2	D	59	ASP	4.5
1	C	132	LEU	4.5
1	C	193	CYS	4.4
1	C	164	ASP	4.4
1	C	170	LEU	4.4
1	C	103	CYS	4.4
1	C	133	THR	4.3
1	C	151	HIS	4.3
1	C	54	ILE	4.2
2	D	57	SER	4.1
1	A	180	GLY	4.1
1	C	211	TYR	4.1
1	C	156	ASP	4.1
1	C	163	ASP	4.0
1	C	185	GLY	3.9
1	A	211	TYR	3.9
1	C	72	LYS	3.8
1	C	146	MET	3.7
1	C	6	THR	3.7
1	C	86	ASN	3.7
1	C	96	THR	3.7
1	A	19	GLU	3.6
1	C	149	LYS	3.6
1	A	108	ASN	3.5
1	A	198	VAL	3.4
1	A	275	ALA	3.4
1	C	134	TRP	3.4
1	C	37	PHE	3.4
1	A	6	THR	3.3
1	C	127	PHE	3.3
2	D	85	ALA	3.3
1	A	54	ILE	3.2
1	C	67	THR	3.2
1	C	118	GLY	3.2
2	D	45	LYS	3.2
1	C	35	GLU	3.2
1	C	160	THR	3.2
2	B	45	LYS	3.2
2	D	98	ASP	3.1
1	C	7	HIS	3.1
1	C	65	ARG	3.1
1	C	152	ALA	3.0

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Mol	Chain	Res	Type	RSRZ
1	C	112	ARG	3.0
1	C	154	ARG	3.0
2	B	77	THR	3.0
1	C	52	CYS	3.0
1	A	146	MET	3.0
1	C	22	GLU	2.9
1	C	50	LEU	2.9
1	C	157	LEU	2.9
1	C	85	ILE	2.9
1	C	20	GLY	2.9
1	C	125	LEU	2.8
1	C	75	GLU	2.8
1	C	159	LYS	2.8
1	C	120	ASP	2.8
2	D	56	PHE	2.8
2	B	85	ALA	2.8
1	A	55	LYS	2.8
1	A	57	HIS	2.8
1	C	71	LEU	2.8
1	A	166	CYS	2.8
1	C	32	VAL	2.8
1	C	194	ARG	2.7
2	D	97	ARG	2.7
1	A	274	THR	2.7
1	A	179	ASN	2.7
1	A	193	CYS	2.7
1	A	45	ARG	2.7
1	C	117	LEU	2.7
1	A	195	ASN	2.7
1	C	171	GLN	2.7
1	C	84	VAL	2.7
1	A	130	LYS	2.7
1	C	23	LYS	2.7
1	C	213	ARG	2.7
1	C	83	GLU	2.6
1	C	235	THR	2.6
1	C	21	SER	2.6
1	C	28	VAL	2.6
1	C	145	LYS	2.6
1	C	173	TYR	2.5
1	C	165	ILE	2.5
1	C	33	ASP	2.5

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Mol	Chain	Res	Type	RSRZ
1	A	160	THR	2.5
1	C	24	THR	2.5
1	C	153	PRO	2.5
2	B	58	LYS	2.5
1	A	44	SER	2.4
2	B	47	PRO	2.4
2	D	90	PRO	2.4
1	C	97	LEU	2.4
1	A	47	THR	2.4
1	A	63	CYS	2.4
1	C	53	TRP	2.4
1	A	234	GLU	2.3
2	D	74	GLU	2.3
1	A	131	THR	2.3
1	C	8	THR	2.3
1	C	68	ASN	2.3
2	B	88	ALA	2.3
2	B	48	LYS	2.3
1	C	166	CYS	2.3
1	C	172	ARG	2.3
1	C	232	ARG	2.3
1	A	175	ALA	2.3
1	C	214	GLU	2.2
2	D	91	LYS	2.2
2	B	18	GLY	2.2
1	C	66	GLU	2.2
1	A	94	LEU	2.2
1	A	177	LEU	2.2
1	A	178	ARG	2.2
2	B	4	THR	2.2
1	C	16	HIS	2.2
1	A	222	ASP	2.2
2	D	44	LYS	2.1
1	A	133	THR	2.1
1	A	143	GLN	2.1
2	D	2	GLN	2.1
1	C	45	ARG	2.1
1	A	106	LEU	2.1
1	C	9	LEU	2.1
1	C	70	LEU	2.1
2	D	96	ASP	2.1
1	A	111	THR	2.1

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Mol	Chain	Res	Type	RSRZ
1	A	107	SER	2.1
2	B	6	GLN	2.0
1	C	51	GLY	2.0
1	C	79	GLY	2.0
1	C	161	PHE	2.0
1	A	132	LEU	2.0
1	C	14	ARG	2.0

6.2 Non-standard residues in protein, DNA, RNA chains [i](#)

There are no non-standard protein/DNA/RNA residues in this entry.

6.3 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.4 Ligands [i](#)

In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
3	SO4	C	301	5/5	0.98	0.07	52,53,55,56	0

6.5 Other polymers [i](#)

There are no such residues in this entry.