



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 6, 2026 – 02:47 PM UTC

PDB ID : 5Y0C / pdb_00005y0c
Title : Crystal Structure of the human nucleosome at 2.09 angstrom resolution
Authors : Kurumizaka, H.; Arimura, Y.; Fujita, R.; Noda, M.
Deposited on : 2017-07-16
Resolution : 2.09 Å(reported)

This is a wwPDB X-ray Structure Validation Summary 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
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

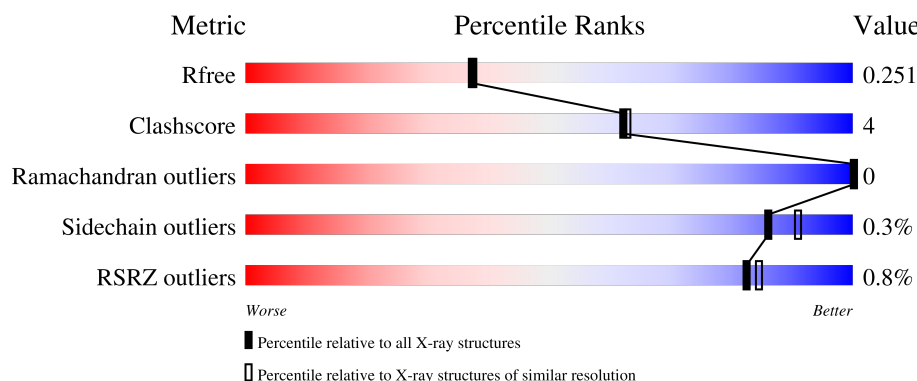
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.09 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	8172 (2.10-2.06)
Clashscore	190562	8714 (2.10-2.06)
Ramachandran outliers	187476	8641 (2.10-2.06)
Sidechain outliers	187428	8642 (2.10-2.06)
RSRZ outliers	180081	8177 (2.10-2.06)

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	I	146	
1	J	146	
2	A	139	
2	E	139	
3	B	106	

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Mol	Chain	Length	Quality of chain
3	F	106	 % 75% 7% 18%
4	C	133	 % 77% 5% 19%
4	G	133	 71% 8% 22%
5	D	129	 69% • 29%
5	H	129	 % 67% • 29%

2 Entry composition [i](#)

There are 8 unique types of molecules in this entry. The entry contains 12368 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 DNA chain called DNA (146-MER).

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	I	145	Total	C	N	O	P	0	0	0
			2972	1421	535	871	145			
1	J	146	Total	C	N	O	P	0	0	0
			2990	1431	540	874	145			

- Molecule 2 is a protein called Histone H3.1.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	A	96	Total	C	N	O	S	0	0	0
			790	499	151	136	4			
2	E	99	Total	C	N	O	S	0	0	0
			819	517	159	139	4			

There are 6 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-3	GLY	-	expression tag	UNP P68431
A	-2	SER	-	expression tag	UNP P68431
A	-1	HIS	-	expression tag	UNP P68431
E	-3	GLY	-	expression tag	UNP P68431
E	-2	SER	-	expression tag	UNP P68431
E	-1	HIS	-	expression tag	UNP P68431

- Molecule 3 is a protein called Histone H4.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	B	77	Total	C	N	O	S	0	0	0
			614	389	119	105	1			
3	F	87	Total	C	N	O	S	0	0	0
			703	442	142	118	1			

There are 6 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
B	-3	GLY	-	expression tag	UNP P62805
B	-2	SER	-	expression tag	UNP P62805
B	-1	HIS	-	expression tag	UNP P62805
F	-3	GLY	-	expression tag	UNP P62805
F	-2	SER	-	expression tag	UNP P62805
F	-1	HIS	-	expression tag	UNP P62805

- Molecule 4 is a protein called Histone H2A type 1-B/E.

Mol	Chain	Residues	Atoms				ZeroOcc	AltConf	Trace
4	C	108	Total	C	N	O	0	0	0
			835	526	165	144			
4	G	104	Total	C	N	O	0	0	0
			805	508	157	140			

There are 6 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
C	-3	GLY	-	expression tag	UNP P04908
C	-2	SER	-	expression tag	UNP P04908
C	-1	HIS	-	expression tag	UNP P04908
G	-3	GLY	-	expression tag	UNP P04908
G	-2	SER	-	expression tag	UNP P04908
G	-1	HIS	-	expression tag	UNP P04908

- Molecule 5 is a protein called Histone H2B type 1-J.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
5	D	92	Total	C	N	O	S	0	0	0
			720	453	129	136	2			
5	H	91	Total	C	N	O	S	0	0	0
			714	450	128	134	2			

There are 6 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
D	-3	GLY	-	expression tag	UNP P06899
D	-2	SER	-	expression tag	UNP P06899
D	-1	HIS	-	expression tag	UNP P06899
H	-3	GLY	-	expression tag	UNP P06899
H	-2	SER	-	expression tag	UNP P06899
H	-1	HIS	-	expression tag	UNP P06899

- Molecule 6 is MANGANESE (II) ION (CCD ID: MN) (formula: Mn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	I	5	Total 5	Mn 5	0	0
6	J	4	Total 4	Mn 4	0	0
6	E	1	Total 1	Mn 1	0	0

- Molecule 7 is CHLORIDE ION (CCD ID: CL) (formula: Cl).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
7	A	1	Total 1	Cl 1	0	0
7	C	1	Total 1	Cl 1	0	0
7	E	1	Total 1	Cl 1	0	0
7	G	1	Total 1	Cl 1	0	0

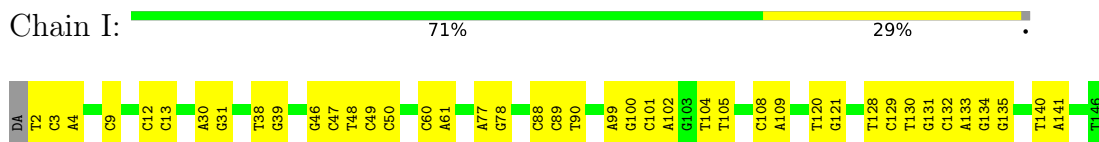
- Molecule 8 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
8	I	73	Total 73	O 73	0	0
8	J	77	Total 77	O 77	0	0
8	A	24	Total 24	O 24	0	0
8	C	41	Total 41	O 41	0	0
8	D	25	Total 25	O 25	0	0
8	E	58	Total 58	O 58	0	0
8	F	38	Total 38	O 38	0	0
8	G	32	Total 32	O 32	0	0
8	H	24	Total 24	O 24	0	0

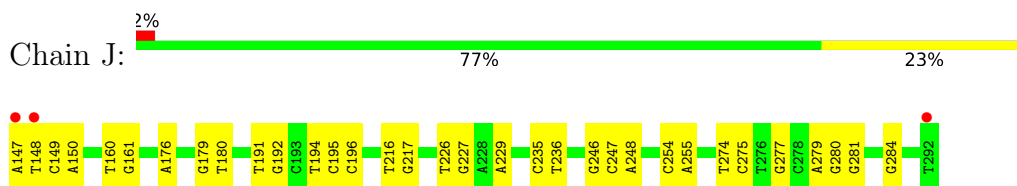
3 Residue-property plots [i](#)

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.

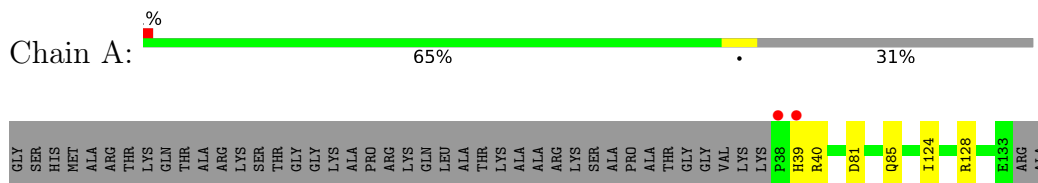
- Molecule 1: DNA (146-MER)



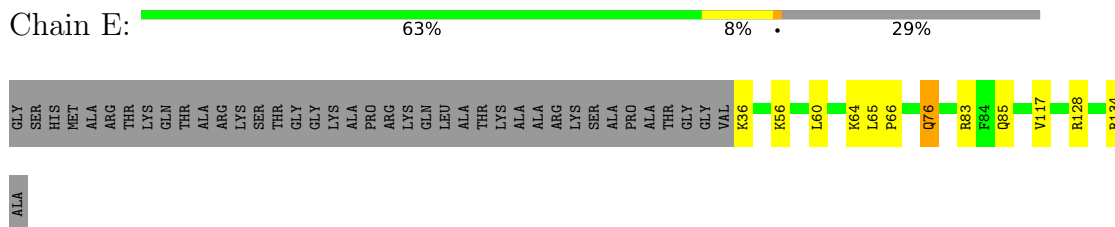
- Molecule 1: DNA (146-MER)



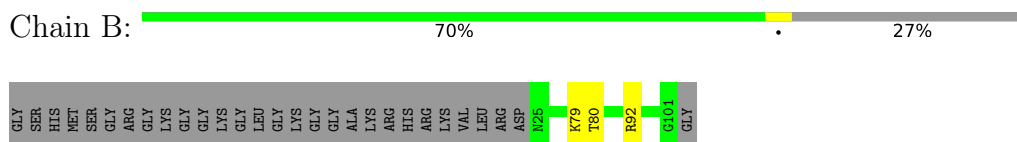
- Molecule 2: Histone H3.1



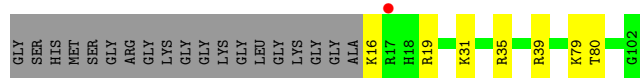
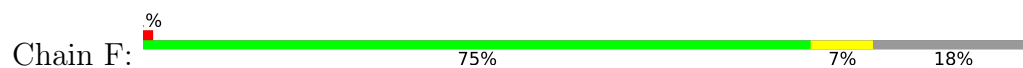
- Molecule 2: Histone H3.1



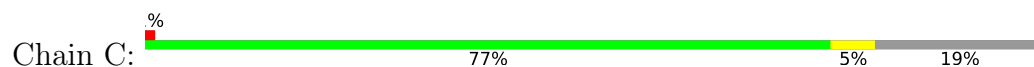
- Molecule 3: Histone H4



- Molecule 3: Histone H4



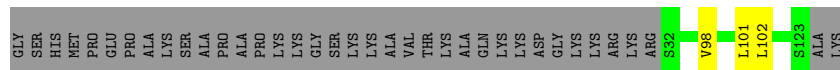
- Molecule 4: Histone H2A type 1-B/E



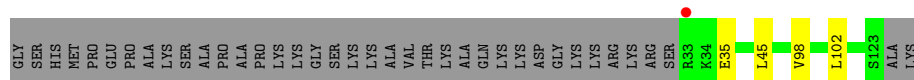
- Molecule 4: Histone H2A type 1-B/E



- Molecule 5: Histone H2B type 1-J



- Molecule 5: Histone H2B type 1-J



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	98.91Å 107.10Å 167.00Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	20.00 – 2.09 20.00 – 2.09	Depositor EDS
% Data completeness (in resolution range)	98.0 (20.00-2.09) 97.9 (20.00-2.09)	Depositor EDS
R_{merge}	0.10	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.95 (at 2.09Å)	Xtriage
Refinement program	PHENIX 1.9_1692	Depositor
R, R_{free}	0.202 , 0.249 0.212 , 0.251	Depositor DCC
R_{free} test set	1991 reflections (1.88%)	wwPDB-VP
Wilson B-factor (Å ²)	32.6	Xtriage
Anisotropy	0.482	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.33 , 37.1	EDS
L-test for twinning ²	$\langle L \rangle = 0.45$, $\langle L^2 \rangle = 0.28$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	12368	wwPDB-VP
Average B, all atoms (Å ²)	40.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.86% 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

5.1 Standard geometry

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

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	I	0.30	0/3333	0.54	0/5142
1	J	0.32	0/3354	0.57	0/5175
2	A	0.35	0/802	0.74	0/1076
2	E	0.33	0/831	0.73	1/1113 (0.1%)
3	B	0.39	0/621	0.83	0/832
3	F	0.38	0/711	0.81	0/948
4	C	0.30	0/845	0.73	0/1139
4	G	0.31	0/815	0.77	0/1100
5	D	0.31	0/731	0.75	0/983
5	H	0.30	0/725	0.73	0/975
All	All	0.32	0/12768	0.65	1/18483 (0.0%)

There are no bond length outliers.

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	E	117	VAL	N-CA-C	-6.22	107.07	113.10

There are no chirality outliers.

There are no planarity outliers.

5.2 Too-close contacts

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	I	2972	0	1640	36	0
1	J	2990	0	1652	30	0
2	A	790	0	826	6	0
2	E	819	0	864	7	0
3	B	614	0	656	5	0
3	F	703	0	755	6	0
4	C	835	0	897	4	0
4	G	805	0	861	8	0
5	D	720	0	740	3	0
5	H	714	0	735	4	0
6	E	1	0	0	0	0
6	I	5	0	0	0	0
6	J	4	0	0	0	0
7	A	1	0	0	0	0
7	C	1	0	0	0	0
7	E	1	0	0	0	0
7	G	1	0	0	0	0
8	A	24	0	0	0	0
8	C	41	0	0	0	0
8	D	25	0	0	0	0
8	E	58	0	0	0	0
8	F	38	0	0	0	0
8	G	32	0	0	0	0
8	H	24	0	0	0	0
8	I	73	0	0	1	0
8	J	77	0	0	0	0
All	All	12368	0	9626	88	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 4.

The worst 5 of 88 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:J:179:DG:H2''	1:J:180:DT:H5''	1.54	0.89
1:I:101:DC:H2''	1:I:102:DA:H5''	1.55	0.89
1:J:277:DG:H5''	1:J:277:DG:C8	2.21	0.76
2:A:39:HIS:HD2	2:A:40:ARG:N	1.84	0.75
1:J:277:DG:H5''	1:J:277:DG:H8	1.56	0.70

There are no symmetry-related clashes.

5.3 Torsion angles

5.3.1 Protein backbone

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	
2	A	94/139 (68%)	94 (100%)	0	0	100	100
2	E	97/139 (70%)	97 (100%)	0	0	100	100
3	B	75/106 (71%)	73 (97%)	2 (3%)	0	100	100
3	F	85/106 (80%)	82 (96%)	3 (4%)	0	100	100
4	C	106/133 (80%)	104 (98%)	2 (2%)	0	100	100
4	G	102/133 (77%)	100 (98%)	2 (2%)	0	100	100
5	D	90/129 (70%)	89 (99%)	1 (1%)	0	100	100
5	H	89/129 (69%)	88 (99%)	1 (1%)	0	100	100
All	All	738/1014 (73%)	727 (98%)	11 (2%)	0	100	100

There are no Ramachandran outliers to report.

5.3.2 Protein sidechains

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	
2	A	84/113 (74%)	84 (100%)	0	100	100
2	E	87/113 (77%)	85 (98%)	2 (2%)	44	49
3	B	63/81 (78%)	63 (100%)	0	100	100
3	F	72/81 (89%)	72 (100%)	0	100	100
4	C	85/102 (83%)	85 (100%)	0	100	100
4	G	83/102 (81%)	83 (100%)	0	100	100

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
5	D	79/107 (74%)	79 (100%)	0	100	100
5	H	78/107 (73%)	78 (100%)	0	100	100
All	All	631/806 (78%)	629 (100%)	2 (0%)	86	91

All (2) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
2	E	36	LYS
2	E	76	GLN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (5) such sidechains are listed below:

Mol	Chain	Res	Type
2	A	39	HIS
2	A	68	GLN
3	B	93	GLN
5	D	95	GLN
4	G	73	ASN

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

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

5.5 Carbohydrates ⓘ

There are no oligosaccharides in this entry.

5.6 Ligand geometry ⓘ

Of 14 ligands modelled in this entry, 14 are monoatomic - leaving 0 for Mogul analysis.

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.

No monomer is involved in short contacts.

5.7 Other polymers

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	I	145/146 (99%)	0.13	0 100 100	29, 47, 77, 93	0
1	J	146/146 (100%)	0.17	3 (2%) 63 66	28, 46, 78, 91	0
2	A	96/139 (69%)	0.13	2 (2%) 63 66	24, 32, 54, 69	0
2	E	99/139 (71%)	-0.18	0 100 100	18, 26, 42, 62	0
3	B	77/106 (72%)	-0.06	0 100 100	23, 32, 44, 53	0
3	F	87/106 (82%)	-0.16	1 (1%) 78 80	18, 25, 41, 62	0
4	C	108/133 (81%)	-0.10	1 (0%) 81 83	22, 29, 47, 63	0
4	G	104/133 (78%)	-0.15	0 100 100	23, 32, 51, 65	0
5	D	92/129 (71%)	-0.06	0 100 100	21, 29, 43, 51	0
5	H	91/129 (70%)	-0.08	1 (1%) 78 80	22, 30, 48, 67	0
All	All	1045/1306 (80%)	-0.02	8 (0%) 82 84	18, 33, 66, 93	0

The worst 5 of 8 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
5	H	33	ARG	2.6
2	A	38	PRO	2.5
3	F	17	ARG	2.5
1	J	148	DT	2.4
2	A	39	HIS	2.3

6.2 Non-standard residues in protein, DNA, RNA chains ⓘ

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
6	MN	I	203	1/1	0.93	0.06	54,54,54,54	0
6	MN	I	202	1/1	0.95	0.11	63,63,63,63	0
6	MN	J	3001	1/1	0.96	0.11	65,65,65,65	0
7	CL	A	2001	1/1	0.97	0.06	39,39,39,39	0
7	CL	E	202	1/1	0.97	0.09	37,37,37,37	0
7	CL	C	201	1/1	0.98	0.04	32,32,32,32	0
6	MN	J	3004	1/1	0.98	0.06	52,52,52,52	0
7	CL	G	201	1/1	0.98	0.05	27,27,27,27	0
6	MN	E	201	1/1	0.99	0.02	27,27,27,27	0
6	MN	I	201	1/1	0.99	0.03	33,33,33,33	0
6	MN	J	3002	1/1	0.99	0.02	41,41,41,41	0
6	MN	J	3003	1/1	0.99	0.04	50,50,50,50	0
6	MN	I	205	1/1	0.99	0.02	41,41,41,41	0
6	MN	I	204	1/1	1.00	0.04	42,42,42,42	0

6.5 Other polymers [i](#)

There are no such residues in this entry.