



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 9, 2026 – 05:59 AM UTC

PDB ID : 5F99 / pdb_00005f99
Title : X-ray Structure of the MMTV-A Nucleosome Core Particle
Authors : Frouws, T.D.; Richmond, T.J.
Deposited on : 2015-12-09
Resolution : 2.63 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

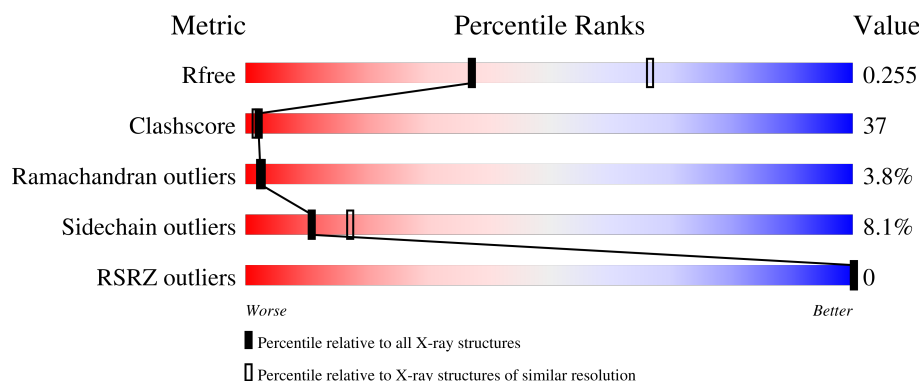
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.63 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	2053 (2.66-2.62)
Clashscore	190562	2097 (2.66-2.62)
Ramachandran outliers	187476	2066 (2.66-2.62)
Sidechain outliers	187428	2066 (2.66-2.62)
RSRZ outliers	180081	2052 (2.66-2.62)

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	135	
1	E	135	
2	B	103	
2	F	103	
3	C	129	

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Mol	Chain	Length	Quality of chain
3	G	129	
4	D	122	
4	H	122	
5	I	147	
6	J	147	

The following table lists non-polymeric compounds, carbohydrate monomers and non-standard residues in protein, DNA, RNA chains that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Chirality	Geometry	Clashes	Electron density
7	CL	A	201	-	-	X	-

2 Entry composition

There are 9 unique types of molecules in this entry. The entry contains 13349 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 Histone H3.2.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	100	Total	C	N	O	S	0	0	0
			825	521	160	142	2			
1	E	99	Total	C	N	O	S	0	0	0
			816	515	158	141	2			

There are 4 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	102	ALA	GLY	conflict	UNP P84233
A	110	ALA	CYS	conflict	UNP P84233
E	102	ALA	GLY	conflict	UNP P84233
E	110	ALA	CYS	conflict	UNP P84233

- Molecule 2 is a protein called Histone H4.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	B	83	Total	C	N	O	S	0	0	0
			662	418	129	114	1			
2	F	92	Total	C	N	O	S	0	0	0
			730	457	149	123	1			

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
B	18	ARG	HIS	engineered mutation	UNP P62799
F	18	ARG	HIS	engineered mutation	UNP P62799

- Molecule 3 is a protein called Histone H2A type 1.

Mol	Chain	Residues	Atoms				ZeroOcc	AltConf	Trace
3	C	111	Total	C	N	O	0	0	0
			859	540	169	150			

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Mol	Chain	Residues	Atoms				ZeroOcc	AltConf	Trace
3	G	121	Total	C	N	O	0	0	0
			931	583	183	165			

There are 4 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
C	99	ARG	GLY	conflict	UNP P06897
C	123	SER	ALA	conflict	UNP P06897
G	99	ARG	GLY	conflict	UNP P06897
G	123	SER	ALA	conflict	UNP P06897

- Molecule 4 is a protein called Histone H2B 1.1.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
4	D	100	Total	C	N	O	S	0	0	0
			789	495	147	145	2			
4	H	97	Total	C	N	O	S	0	0	0
			767	481	142	142	2			

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
D	32	THR	SER	conflict	UNP P02281
H	32	THR	SER	conflict	UNP P02281

- Molecule 5 is a DNA chain called DNA (147-MER).

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
5	I	147	Total	C	N	O	P	0	0	0
			2972	1417	506	902	147			

- Molecule 6 is a DNA chain called DNA (147-MER).

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
6	J	147	Total	C	N	O	P	0	0	0
			3057	1439	607	864	147			

- 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 MAGNESIUM ION (CCD ID: MG) (formula: Mg).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
8	E	1	Total 1	Mg 1	0	0

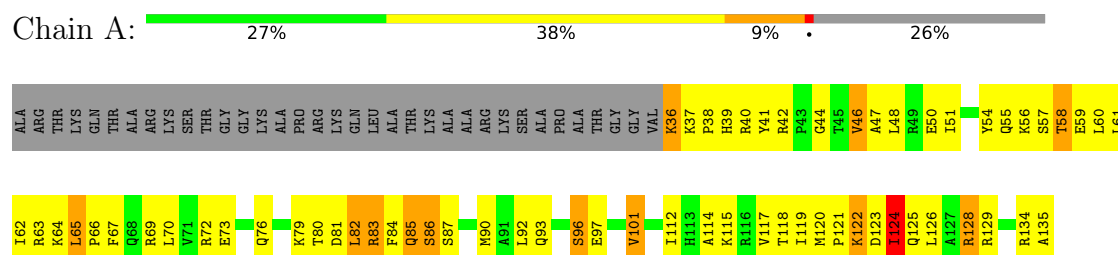
- Molecule 9 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
9	A	42	Total 42	O 42	0	0
9	B	40	Total 40	O 40	0	0
9	C	85	Total 85	O 85	0	0
9	D	90	Total 90	O 90	0	0
9	E	95	Total 95	O 95	0	0
9	F	102	Total 102	O 102	0	0
9	G	60	Total 60	O 60	0	0
9	H	56	Total 56	O 56	0	0
9	I	176	Total 176	O 176	0	0
9	J	190	Total 190	O 190	0	0

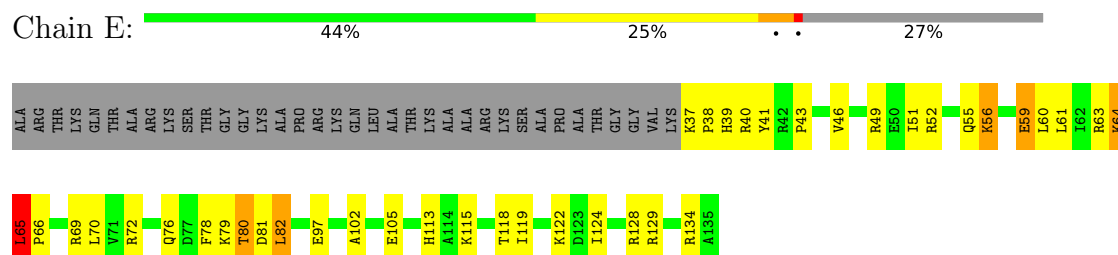
3 Residue-property plots [i](#)

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.

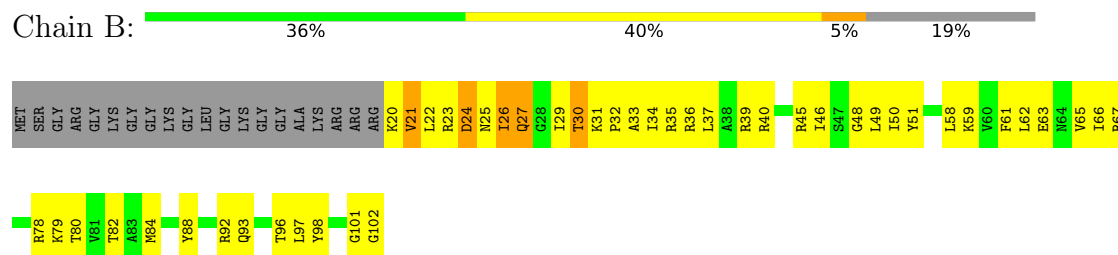
• Molecule 1: Histone H3.2



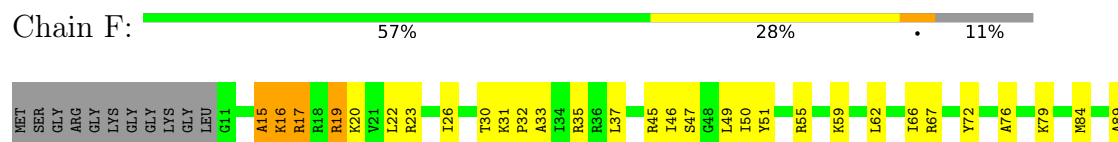
• Molecule 1: Histone H3.2



• Molecule 2: Histone H4



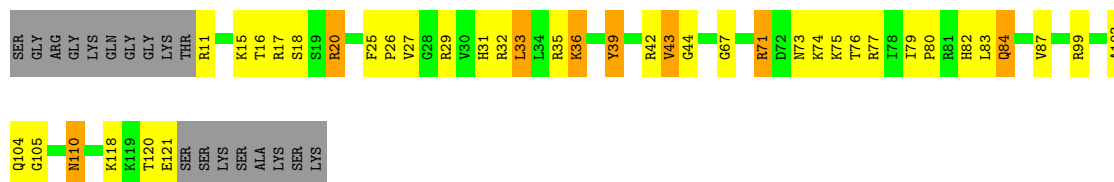
• Molecule 2: Histone H4





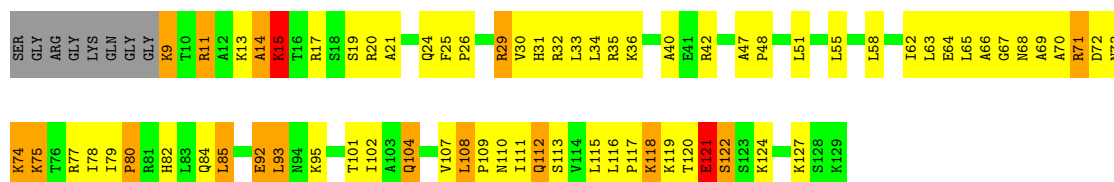
- Molecule 3: Histone H2A type 1

Chain C: 55% 25% 6% 14%



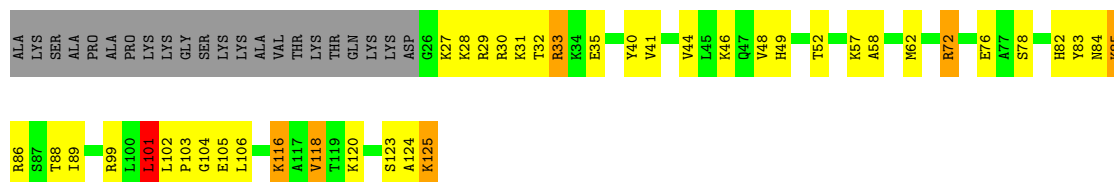
- Molecule 3: Histone H2A type 1

Chain G: 39% 41% 12% 6%



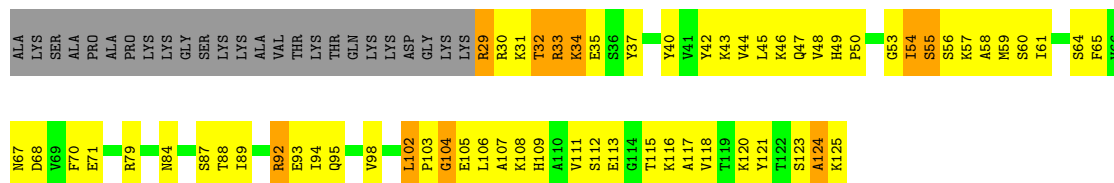
- Molecule 4: Histone H2B 1.1

Chain D: 48% 28% 5% 18%



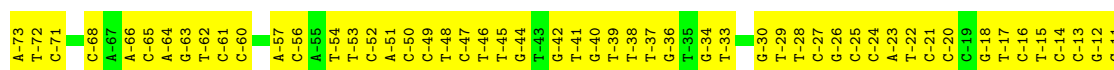
- Molecule 4: Histone H2B 1.1

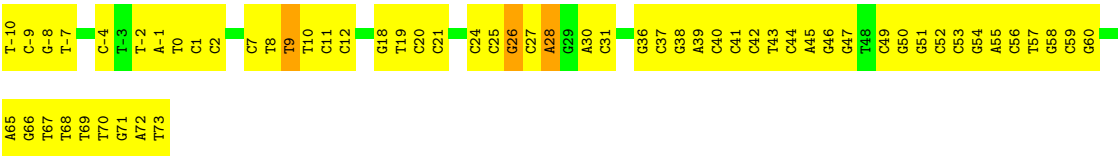
Chain H: 28% 43% 8% 20%



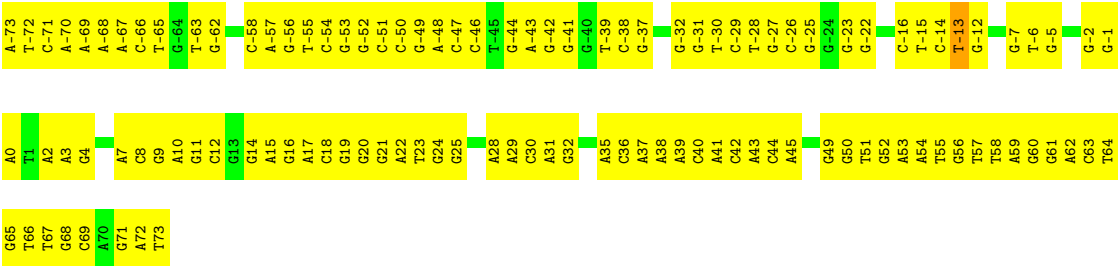
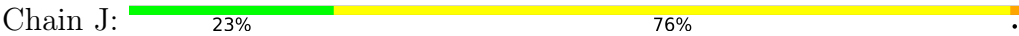
- Molecule 5: DNA (147-MER)

Chain I: 24% 74% 2%





● Molecule 6: DNA (147-MER)



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	107.87Å 178.91Å 109.06Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	29.68 – 2.63 29.68 – 2.63	Depositor EDS
% Data completeness (in resolution range)	94.2 (29.68-2.63) 94.4 (29.68-2.63)	Depositor EDS
R_{merge}	0.08	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.29 (at 2.64Å)	Xtriage
Refinement program	CNS 1.3	Depositor
R, R_{free}	0.175 , 0.252 0.178 , 0.255	Depositor DCC
R_{free} test set	3008 reflections (4.76%)	wwPDB-VP
Wilson B-factor (Å ²)	61.5	Xtriage
Anisotropy	0.628	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.29 , 82.2	EDS
L-test for twinning ²	$\langle L \rangle = 0.46$, $\langle L^2 \rangle = 0.29$	Xtriage
Estimated twinning fraction	0.027 for l,-k,h	Xtriage
F_o, F_c correlation	0.97	EDS
Total number of atoms	13349	wwPDB-VP
Average B, all atoms (Å ²)	104.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.00% 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: MG, CL

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	0.71	0/837	1.10	3/1121 (0.3%)
1	E	0.96	0/828	1.29	6/1110 (0.5%)
2	B	0.72	0/669	1.12	5/894 (0.6%)
2	F	0.99	1/737 (0.1%)	1.19	2/980 (0.2%)
3	C	0.91	0/869	1.14	4/1171 (0.3%)
3	G	0.65	0/941	1.10	4/1264 (0.3%)
4	D	0.99	2/800 (0.2%)	1.13	3/1070 (0.3%)
4	H	0.77	0/778	1.17	6/1043 (0.6%)
5	I	0.34	0/3318	0.70	1/5109 (0.0%)
6	J	0.34	0/3444	0.63	0/5320
All	All	0.64	3/13221 (0.0%)	0.92	34/19082 (0.2%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	A	0	1
5	I	0	2
6	J	0	2
All	All	0	5

All (3) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	D	58	ALA	CA-CB	-7.71	1.41	1.53
4	D	62	MET	SD-CE	6.24	1.95	1.79
2	F	33	ALA	CA-CB	-5.20	1.45	1.53

The worst 5 of 34 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
4	D	101	LEU	N-CA-C	9.97	124.11	111.24
1	A	124	ILE	N-CA-C	-9.86	98.22	111.44
4	H	102	LEU	CA-C-N	9.86	129.62	119.76
4	H	102	LEU	C-N-CA	9.86	129.62	119.76
1	E	64	LYS	N-CA-C	9.54	121.37	110.97

There are no chirality outliers.

All (5) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	41	TYR	Sidechain
5	I	26	DG	Sidechain
5	I	28	DA	Sidechain
6	J	-12	DG	Sidechain
6	J	-13	DT	Sidechain

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	A	825	0	871	108	0
1	E	816	0	858	49	0
2	B	662	0	709	72	0
2	F	730	0	788	43	0
3	C	859	0	921	53	0
3	G	931	0	1005	108	0
4	D	789	0	828	48	0
4	H	767	0	799	95	0
5	I	2972	0	1659	190	0
6	J	3057	0	1640	209	0
7	A	1	0	0	3	0
7	C	1	0	0	0	0
7	E	1	0	0	0	0
7	G	1	0	0	0	0
8	E	1	0	0	0	0
9	A	42	0	0	6	0
9	B	40	0	0	10	0
9	C	85	0	0	5	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
9	D	90	0	0	9	0
9	E	95	0	0	13	0
9	F	102	0	0	13	0
9	G	60	0	0	10	0
9	H	56	0	0	7	0
9	I	176	0	0	23	0
9	J	190	0	0	15	0
All	All	13349	0	10078	829	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 37.

The worst 5 of 829 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)
5:I:24:DC:H2''	5:I:25:DC:H5''	1.23	1.18
6:J:-51:DC:H2''	6:J:-50:DC:H5''	1.20	1.16
5:I:50:DG:H2''	5:I:51:DG:H5''	1.26	1.15
6:J:-48:DA:H2''	6:J:-47:DC:H5''	1.26	1.15
5:I:43:DT:H2''	5:I:44:DC:H5'	1.20	1.14

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	98/135 (73%)	81 (83%)	12 (12%)	5 (5%)	1	1
1	E	97/135 (72%)	91 (94%)	6 (6%)	0	100	100
2	B	81/103 (79%)	67 (83%)	13 (16%)	1 (1%)	10	15
2	F	90/103 (87%)	82 (91%)	5 (6%)	3 (3%)	3	3

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
3	C	109/129 (84%)	92 (84%)	16 (15%)	1 (1%)	14	21
3	G	119/129 (92%)	85 (71%)	22 (18%)	12 (10%)	0	0
4	D	98/122 (80%)	90 (92%)	6 (6%)	2 (2%)	6	8
4	H	95/122 (78%)	82 (86%)	7 (7%)	6 (6%)	1	1
All	All	787/978 (80%)	670 (85%)	87 (11%)	30 (4%)	2	3

5 of 30 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	85	GLN
1	A	86	SER
4	D	85	LYS
3	G	11	ARG
3	G	14	ALA

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	
1	A	86/109 (79%)	77 (90%)	9 (10%)	6	9
1	E	85/109 (78%)	80 (94%)	5 (6%)	18	29
2	B	68/79 (86%)	63 (93%)	5 (7%)	13	20
2	F	73/79 (92%)	72 (99%)	1 (1%)	59	75
3	C	88/101 (87%)	79 (90%)	9 (10%)	7	10
3	G	97/101 (96%)	86 (89%)	11 (11%)	5	7
4	D	85/102 (83%)	76 (89%)	9 (11%)	6	9
4	H	83/102 (81%)	78 (94%)	5 (6%)	17	29
All	All	665/782 (85%)	611 (92%)	54 (8%)	11	17

5 of 54 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
4	D	102	LEU
1	E	78	PHE
4	H	29	ARG
4	D	116	LYS
1	E	56	LYS

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 20 such sidechains are listed below:

Mol	Chain	Res	Type
3	G	68	ASN
4	H	47	GLN
4	H	84	ASN
4	H	67	ASN
3	C	38	ASN

5.3.3 RNA [i](#)

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](#)

Of 5 ligands modelled in this entry, 5 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 [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

6 Fit of model and data [i](#)

6.1 Protein, DNA and RNA chains [i](#)

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	100/135 (74%)	-0.51	0 100 100	49, 81, 147, 175	0
1	E	99/135 (73%)	-0.92	0 100 100	36, 53, 98, 144	0
2	B	83/103 (80%)	-0.60	0 100 100	56, 77, 121, 170	0
2	F	92/103 (89%)	-0.99	0 100 100	35, 50, 93, 153	0
3	C	111/129 (86%)	-0.88	0 100 100	35, 57, 128, 190	0
3	G	121/129 (93%)	-0.62	0 100 100	55, 82, 177, 210	0
4	D	100/122 (81%)	-0.87	0 100 100	35, 60, 142, 173	0
4	H	97/122 (79%)	-0.69	0 100 100	41, 77, 127, 151	0
5	I	147/147 (100%)	-0.80	0 100 100	65, 136, 204, 227	0
6	J	147/147 (100%)	-0.75	0 100 100	64, 139, 200, 232	0
All	All	1097/1272 (86%)	-0.76	0 100 100	35, 78, 175, 232	0

There are no RSRZ outliers to report.

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(Å ²)	Q<0.9
7	CL	G	201	1/1	0.93	0.07	62,62,62,62	1
7	CL	C	201	1/1	0.96	0.05	67,67,67,67	1
7	CL	E	201	1/1	0.97	0.06	54,54,54,54	1
7	CL	A	201	1/1	0.97	0.04	49,49,49,49	1
8	MG	E	202	1/1	0.99	0.03	33,33,33,33	0

6.5 Other polymers [i](#)

There are no such residues in this entry.