



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 9, 2026 – 08:07 AM UTC

PDB ID : 1UA1 / pdb_00001ua1
Title : Structure of aminofluorene adduct paired opposite cytosine at the polymerase active site.
Authors : Hsu, G.W.; Kiefer, J.R.; Becherel, O.J.; Fuchs, R.P.P.; Beese, L.S.
Deposited on : 2004-08-11
Resolution : 2.00 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

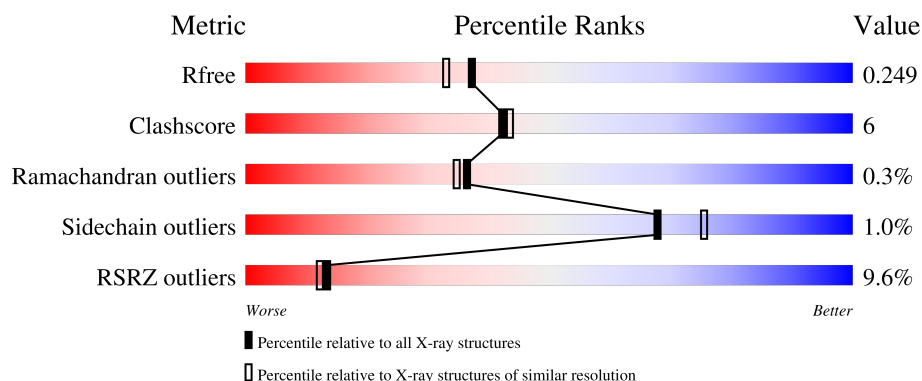
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.00 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	10052 (2.00-2.00)
Clashscore	190562	11152 (2.00-2.00)
Ramachandran outliers	187476	11031 (2.00-2.00)
Sidechain outliers	187428	11029 (2.00-2.00)
RSRZ outliers	180081	10067 (2.00-2.00)

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	B	11	18% 82% 18%
2	C	14	14% 57% 29% 14%
3	A	580	9% 82% 17% .

2 Entry composition [i](#)

There are 6 unique types of molecules in this entry. The entry contains 5607 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 primer strand.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	B	11	Total	C	N	O	P	0	0	0
			230	109	47	64	10			

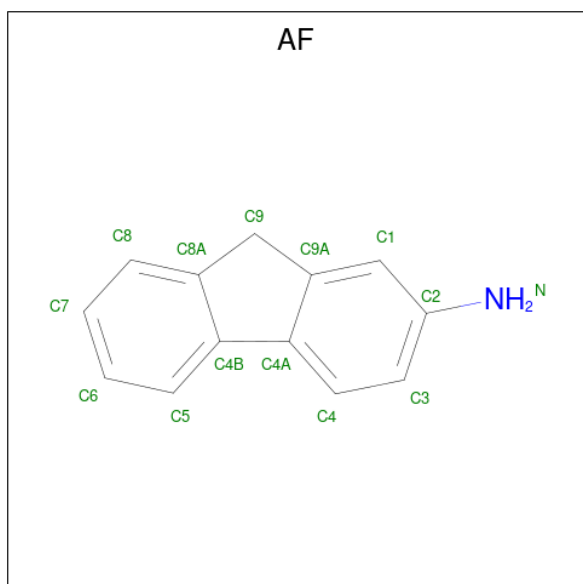
- Molecule 2 is a DNA chain called DNA template strand with aminofluorene adduct.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	C	12	Total	C	N	O	P	0	0	0
			235	114	39	71	11			

- Molecule 3 is a protein called DNA polymerase I.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	A	580	Total	C	N	O	S	0	0	0
			4650	2956	807	870	17			

- Molecule 4 is 2-AMINOFLUORENE (CCD ID: AF) (formula: C₁₃H₁₁N).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	C	1	Total	C	N	0	0
			14	13	1		

- Molecule 5 is SULFATE ION (CCD ID: SO4) (formula: O₄S).



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

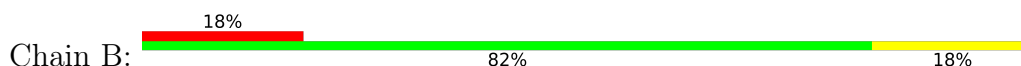
- Molecule 6 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	B	13	Total	O	0	0
			13	13		
6	C	19	Total	O	0	0
			19	19		
6	A	431	Total	O	0	0
			431	431		

3 Residue-property plots

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.

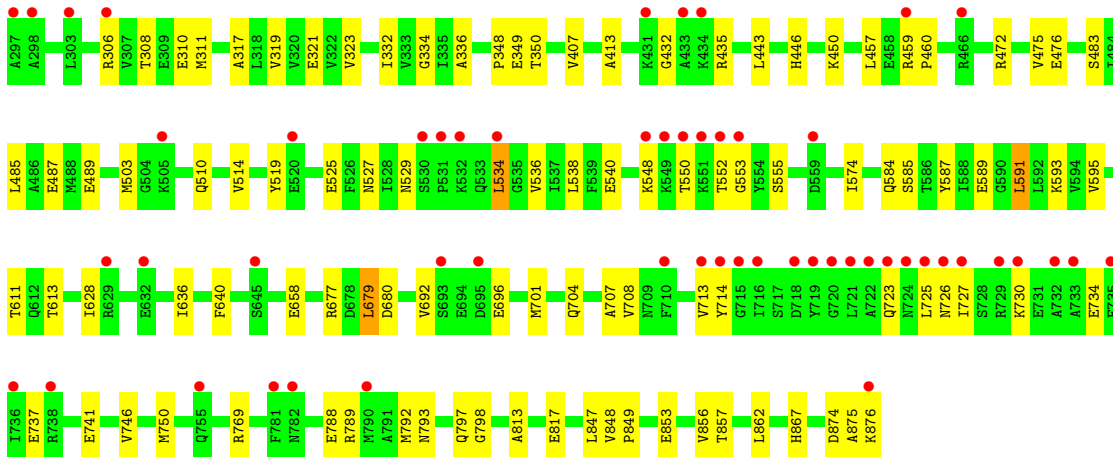
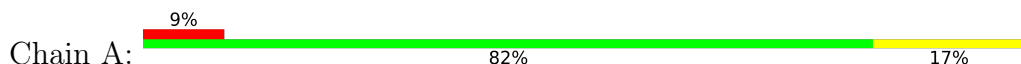
- Molecule 1: DNA primer strand



- Molecule 2: DNA template strand with aminofluorene adduct



- Molecule 3: DNA polymerase I



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	87.64Å 93.44Å 105.47Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	33.70 – 2.00 33.70 – 2.00	Depositor EDS
% Data completeness (in resolution range)	95.5 (33.70-2.00) 95.6 (33.70-2.00)	Depositor EDS
R_{merge}	0.08	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.72 (at 2.00Å)	Xtriage
Refinement program	CNS	Depositor
R, R_{free}	0.216 , 0.249 0.216 , 0.249	Depositor DCC
R_{free} test set	2849 reflections (5.04%)	wwPDB-VP
Wilson B-factor (Å ²)	27.3	Xtriage
Anisotropy	0.069	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.36 , 39.9	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	5607	wwPDB-VP
Average B, all atoms (Å ²)	31.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.99% 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, AF

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	B	0.29	0/259	0.65	0/400
2	C	0.30	0/261	0.71	0/399
3	A	0.38	0/4734	0.86	12/6398 (0.2%)
All	All	0.37	0/5254	0.84	12/7197 (0.2%)

There are no bond length outliers.

All (12) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	321	GLU	N-CA-C	6.89	119.80	109.25
3	A	680	ASP	N-CA-C	-6.52	98.56	108.67
3	A	475	VAL	N-CA-C	6.34	117.12	110.72
3	A	847	LEU	N-CA-C	6.16	117.80	111.14
3	A	769	ARG	N-CA-C	-6.12	101.87	110.50
3	A	793	ASN	N-CA-C	5.64	119.33	112.23
3	A	585	SER	N-CA-C	5.50	116.97	110.97
3	A	332	ILE	N-CA-C	-5.47	99.27	107.37
3	A	862	LEU	N-CA-C	-5.41	100.88	109.59
3	A	317	ALA	N-CA-C	-5.31	100.64	109.46
3	A	538	LEU	N-CA-C	5.28	116.84	111.14
3	A	457	LEU	N-CA-C	5.19	119.32	112.89

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	B	230	0	125	2	0
2	C	235	0	137	5	0
3	A	4650	0	4701	60	0
4	C	14	0	10	0	0
5	A	15	0	0	0	0
6	A	431	0	0	3	0
6	B	13	0	0	0	0
6	C	19	0	0	0	0
All	All	5607	0	4973	64	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 6.

All (64) 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)
3:A:692:VAL:HG21	3:A:701:MET:HE1	1.62	0.81
3:A:789:ARG:HA	3:A:792:MET:HE3	1.68	0.74
3:A:730:LYS:O	3:A:734:GLU:HG3	1.87	0.73
3:A:587:TYR:O	3:A:591:LEU:HB2	1.88	0.73
3:A:797:GLN:NE2	6:A:3103:HOH:O	2.13	0.70
3:A:677:ARG:HB2	3:A:679:LEU:HD13	1.83	0.60
3:A:874:ASP:C	3:A:876:LYS:H	2.10	0.60
3:A:323:VAL:HG12	3:A:435:ARG:HH12	1.66	0.59
3:A:677:ARG:CB	3:A:679:LEU:HD13	2.33	0.59
3:A:813:ALA:O	3:A:817:GLU:HG3	2.03	0.59
3:A:750:MET:SD	3:A:792:MET:HB3	2.44	0.58
3:A:534:LEU:HD21	3:A:574:ILE:HD13	1.87	0.57
3:A:725:LEU:O	3:A:727:ILE:HG23	2.05	0.57
3:A:519:TYR:CD1	3:A:525:GLU:HA	2.40	0.56
3:A:536:VAL:O	3:A:540:GLU:HB2	2.06	0.55
1:B:6:DA:H61	2:C:37:DT:H3	1.54	0.54
3:A:856:VAL:HG12	3:A:857:THR:N	2.22	0.53
3:A:788:GLU:O	3:A:792:MET:HG3	2.09	0.52
3:A:848:VAL:HB	3:A:849:PRO:HD3	1.90	0.52
3:A:472:ARG:HH11	3:A:472:ARG:HG2	1.74	0.52
2:C:27:DG:N3	2:C:27:DG:H2'	2.25	0.52
3:A:432:GLY:O	3:A:435:ARG:HB2	2.10	0.52
3:A:334:GLY:HA2	3:A:348:PRO:HD3	1.91	0.51

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
3:A:510:GLN:O	3:A:514:VAL:HG23	2.11	0.51
3:A:472:ARG:NH1	3:A:476:GLU:OE2	2.45	0.50
3:A:527:ASN:HD21	3:A:529:ASN:HB2	1.77	0.50
3:A:527:ASN:ND2	3:A:529:ASN:H	2.10	0.49
3:A:692:VAL:CG2	3:A:701:MET:HE1	2.39	0.49
2:C:27:DG:H1'	3:A:714:TYR:O	2.13	0.48
3:A:550:THR:CG2	3:A:553:GLY:H	2.26	0.48
3:A:308:THR:OG1	3:A:311:MET:HE3	2.13	0.48
3:A:875:ALA:O	3:A:876:LYS:C	2.57	0.48
3:A:874:ASP:C	3:A:876:LYS:N	2.72	0.47
3:A:737:GLU:O	3:A:741:GLU:HG3	2.15	0.47
3:A:713:VAL:HG12	6:A:3103:HOH:O	2.14	0.47
3:A:503:MET:HE1	3:A:636:ILE:HD13	1.97	0.47
3:A:707:ALA:HB3	3:A:725:LEU:HD21	1.96	0.47
3:A:692:VAL:HB	3:A:696:GLU:HB2	1.98	0.46
3:A:867:HIS:CG	3:A:876:LYS:OXT	2.69	0.46
3:A:704:GLN:O	3:A:708:VAL:HG23	2.15	0.46
3:A:589:GLU:O	3:A:593:LYS:HG3	2.15	0.46
3:A:319:VAL:HB	3:A:336:ALA:HB3	1.99	0.45
3:A:446:HIS:NE2	3:A:450:LYS:HD2	2.32	0.45
1:B:6:DA:H2''	1:B:7:DG:O5'	2.17	0.45
3:A:723:GLN:C	3:A:726:ASN:H	2.24	0.45
3:A:483:SER:O	3:A:487:GLU:HG3	2.16	0.45
3:A:584:GLN:O	3:A:589:GLU:HG3	2.17	0.44
3:A:591:LEU:HD21	3:A:640:PHE:CZ	2.52	0.44
3:A:306:ARG:HH21	3:A:306:ARG:HG3	1.84	0.43
3:A:485:LEU:O	3:A:489:GLU:HG3	2.18	0.43
3:A:591:LEU:O	3:A:595:VAL:HG23	2.18	0.43
2:C:29:DA:OP1	3:A:611:THR:HA	2.19	0.42
3:A:658:GLU:HG2	3:A:797:GLN:HE22	1.83	0.42
2:C:36:DC:H2'	2:C:37:DT:H72	2.01	0.41
3:A:349:GLU:HG2	3:A:350:THR:N	2.34	0.41
3:A:548:LYS:HD2	3:A:555:SER:OG	2.20	0.41
3:A:746:VAL:O	3:A:750:MET:HG2	2.21	0.41
3:A:407:VAL:HG11	3:A:413:ALA:HB2	2.02	0.41
3:A:459:ARG:HB3	3:A:460:PRO:CD	2.51	0.41
3:A:613:THR:O	3:A:798:GLY:HA2	2.21	0.41
3:A:856:VAL:CG1	3:A:857:THR:N	2.83	0.41
3:A:677:ARG:HB3	3:A:679:LEU:HD13	2.01	0.40
3:A:713:VAL:CG1	6:A:3103:HOH:O	2.68	0.40
3:A:849:PRO:O	3:A:853:GLU:HG3	2.22	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	
3	A	578/580 (100%)	558 (96%)	18 (3%)	2 (0%)	36	35

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
3	A	552	THR
3	A	628	ILE

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	
3	A	495/495 (100%)	490 (99%)	5 (1%)	68	75

All (5) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
3	A	310	GLU
3	A	443	LEU
3	A	534	LEU
3	A	591	LEU
3	A	679	LEU

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

Mol	Chain	Res	Type
3	A	356	GLN
3	A	405	GLN
3	A	418	GLN
3	A	524	GLN
3	A	527	ASN
3	A	529	ASN
3	A	533	GLN
3	A	638	GLN
3	A	724	ASN
3	A	726	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 ⓘ

4 ligands are 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	$\# Z > 2$
4	AF	C	327	2	16,16,16	2.47	12 (75%)	23,23,23	0.83	0
5	SO4	A	910	-	4,4,4	0.36	0	6,6,6	0.05	0

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	# Z > 2	Counts	RMSZ	# Z > 2
5	SO4	A	912	-	4,4,4	0.36	0	6,6,6	0.08	0
5	SO4	A	911	-	4,4,4	0.35	0	6,6,6	0.07	0

In the following table, the Chirals column lists the number of chiral outliers, the number of chiral centers analysed, the number of these observed in the model and the number defined in the Chemical Component Dictionary. Similar counts are reported in the Torsion and Rings columns. '-' means no outliers of that kind were identified.

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
4	AF	C	327	2	-	-	0/3/3/3

All (12) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	C	327	AF	C4B-C4A	-3.26	1.38	1.46
4	C	327	AF	C5-C4B	3.16	1.44	1.40
4	C	327	AF	C1-C9A	3.05	1.44	1.39
4	C	327	AF	C4-C4A	2.98	1.44	1.40
4	C	327	AF	C2-N	2.85	1.48	1.38
4	C	327	AF	C8-C8A	2.82	1.44	1.39
4	C	327	AF	C1-C2	2.69	1.44	1.39
4	C	327	AF	C4B-C8A	2.64	1.46	1.40
4	C	327	AF	C4A-C9A	2.50	1.46	1.40
4	C	327	AF	C7-C8	2.12	1.42	1.38
4	C	327	AF	C7-C6	2.11	1.42	1.38
4	C	327	AF	C6-C5	2.09	1.42	1.38

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	B	11/11 (100%)	0.93	2 (18%) 3 3	29, 38, 67, 72	0
2	C	12/14 (85%)	1.05	2 (16%) 4 4	27, 41, 67, 73	0
3	A	580/580 (100%)	0.42	54 (9%) 14 13	18, 27, 49, 63	0
All	All	603/605 (99%)	0.44	58 (9%) 13 12	18, 27, 51, 73	0

All (58) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
3	A	550	THR	6.0
3	A	876	LYS	5.5
3	A	552	THR	5.4
3	A	723	GLN	5.3
3	A	719	TYR	5.0
3	A	297	ALA	4.8
3	A	729	ARG	4.5
3	A	551	LYS	4.3
3	A	782	ASN	4.2
3	A	727	ILE	4.1
3	A	735	PHE	4.0
3	A	520	GLU	3.9
3	A	553	GLY	3.8
3	A	298	ALA	3.6
3	A	722	ALA	3.6
3	A	531	PRO	3.4
2	C	37	DT	3.3
3	A	790	MET	3.1
3	A	629	ARG	3.0
3	A	695	ASP	3.0
3	A	306	ARG	3.0
3	A	718	ASP	3.0
3	A	714	TYR	3.0

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Mol	Chain	Res	Type	RSRZ
1	B	6	DA	2.9
3	A	459	ARG	2.9
3	A	431	LYS	2.9
2	C	36	DC	2.9
3	A	738	ARG	2.8
3	A	716	ILE	2.8
3	A	725	LEU	2.8
3	A	466	ARG	2.6
3	A	733	ALA	2.6
3	A	730	LYS	2.6
3	A	713	VAL	2.6
3	A	434	LYS	2.6
3	A	559	ASP	2.6
3	A	710	PHE	2.6
3	A	530	SER	2.5
3	A	693	SER	2.5
3	A	534	LEU	2.5
3	A	720	GLY	2.5
3	A	726	ASN	2.5
3	A	548	LYS	2.5
3	A	736	ILE	2.4
3	A	303	LEU	2.4
3	A	721	LEU	2.4
3	A	645	SER	2.3
3	A	433	ALA	2.3
3	A	632	GLU	2.3
3	A	724	ASN	2.3
1	B	7	DG	2.3
3	A	505	LYS	2.2
3	A	715	GLY	2.2
3	A	532	LYS	2.1
3	A	549	LYS	2.1
3	A	781	PHE	2.1
3	A	732	ALA	2.1
3	A	755	GLN	2.1

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
4	AF	C	327	14/14	0.75	0.18	42,43,44,44	0
5	SO4	A	910	5/5	0.91	0.10	64,64,64,64	0
5	SO4	A	912	5/5	0.91	0.12	54,54,54,54	0
5	SO4	A	911	5/5	0.92	0.11	50,50,50,50	0

6.5 Other polymers [i](#)

There are no such residues in this entry.