



Full wwPDB X-ray Structure Validation Report ⓘ

Apr 21, 2026 – 06:50 AM JST

PDB ID : 9L88 / pdb_00009l88
Title : Structure of human TREX1-DNA complex with K66R disease-associated mutation
Authors : Zhu, J.; Wang, L.; Lin, C.; Zhou, W.
Deposited on : 2024-12-27
Resolution : 2.62 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
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

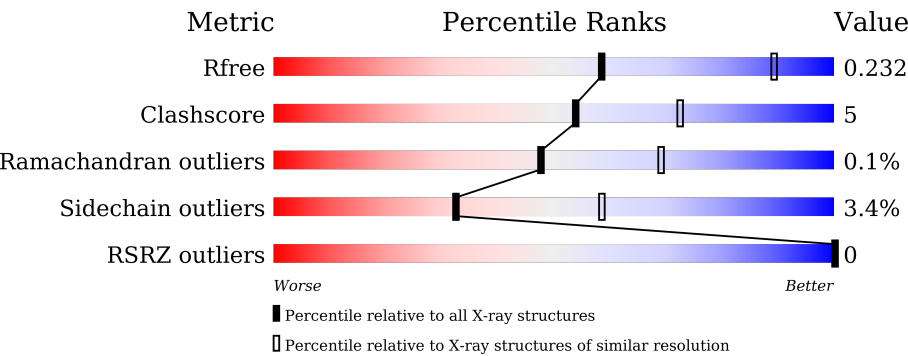
1 Overall quality at a glance i

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.62 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	4951 (2.64-2.60)
Clashscore	190562	5303 (2.64-2.60)
Ramachandran outliers	187476	5217 (2.64-2.60)
Sidechain outliers	187428	5217 (2.64-2.60)
RSRZ outliers	180081	4950 (2.64-2.60)

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	242	<div><div></div><div>78%10%12%</div></div>
1	B	242	<div><div></div><div>83%7%11%</div></div>
1	E	242	<div><div></div><div>76%11%12%</div></div>
1	F	242	<div><div></div><div>80%9%11%</div></div>
2	C	22	<div><div></div><div>41%32%27%</div></div>
2	D	22	<div><div></div><div>32%36%32%</div></div>

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Mol	Chain	Length	Quality of chain
2	G	22	 27% 36% 36%
2	H	22	 50% 18% 32%

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 7961 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 Three-prime repair exonuclease 1.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	212	Total	C	N	O	S	0	0	0
			1610	1028	279	291	12			
1	B	216	Total	C	N	O	S	0	1	0
			1644	1052	284	295	13			
1	E	213	Total	C	N	O	S	0	0	0
			1626	1038	284	292	12			
1	F	215	Total	C	N	O	S	0	0	0
			1633	1043	283	295	12			

There are 4 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	66	ARG	LYS	engineered mutation	UNP Q9NSU2
B	66	ARG	LYS	engineered mutation	UNP Q9NSU2
E	66	ARG	LYS	engineered mutation	UNP Q9NSU2
F	66	ARG	LYS	engineered mutation	UNP Q9NSU2

- Molecule 2 is a DNA chain called DNA (5'-D(P*GP*TP*TP*GP*GP*CP*CP*CP*TP*CP*TP*TP*TP*AP*GP*GP*GP*CP*CP*AP*TP*C)-3').

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	C	16	Total	C	N	O	P	0	0	0
			327	154	59	98	16			
2	D	15	Total	C	N	O	P	0	0	0
			305	144	54	92	15			
2	G	14	Total	C	N	O	P	0	0	0
			286	135	51	86	14			
2	H	15	Total	C	N	O	P	0	0	0
			305	144	54	92	15			

- Molecule 3 is LITHIUM ION (CCD ID: LI) (formula: Li).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	B	1	Total 1	Li 1	0	0
3	F	1	Total 1	Li 1	0	0

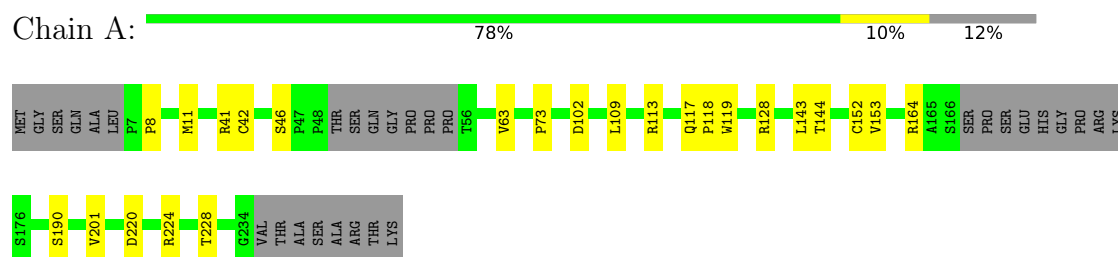
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	36	Total 36	O 36	0	0
4	B	51	Total 51	O 51	0	0
4	C	5	Total 5	O 5	0	0
4	D	12	Total 12	O 12	0	0
4	E	58	Total 58	O 58	0	0
4	F	43	Total 43	O 43	0	0
4	G	5	Total 5	O 5	0	0
4	H	13	Total 13	O 13	0	0

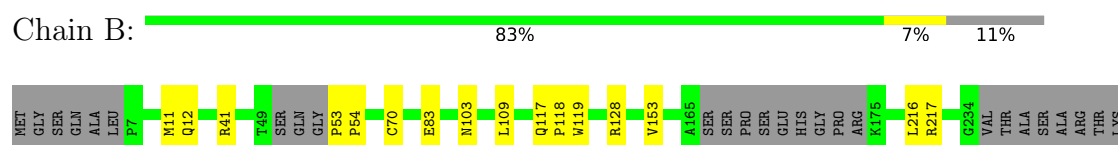
3 Residue-property plots

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.

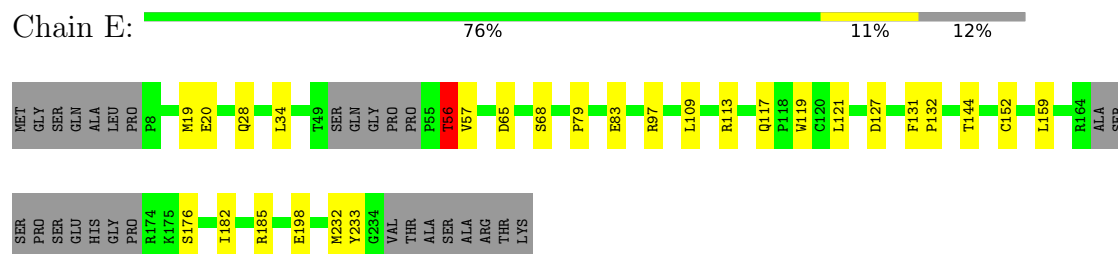
• Molecule 1: Three-prime repair exonuclease 1



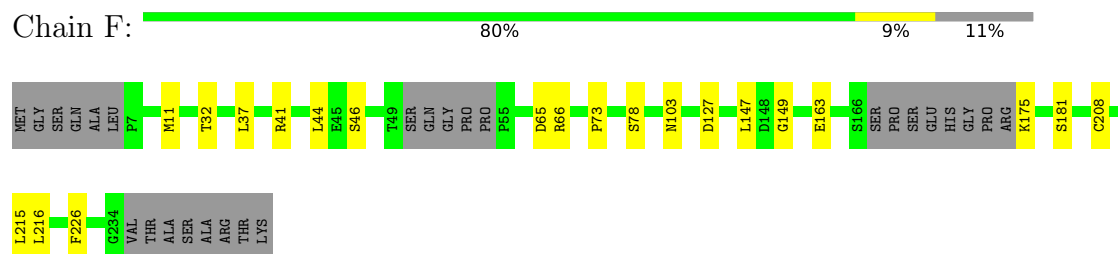
• Molecule 1: Three-prime repair exonuclease 1



• Molecule 1: Three-prime repair exonuclease 1



• Molecule 1: Three-prime repair exonuclease 1



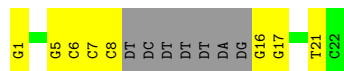
- Molecule 2: DNA (5'-D(P*GP*TP*TP*GP*GP*CP*CP*CP*TP*CP*TP*TP*TP*AP*GP*GP*GP*CP*CP*AP*TP*C)-3')

Chain C:  41% 32% 27%




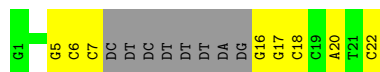
- Molecule 2: DNA (5'-D(P*GP*TP*TP*GP*GP*CP*CP*CP*TP*CP*TP*TP*TP*AP*GP*GP*GP*CP*CP*AP*TP*C)-3')

Chain D:  32% 36% 32%



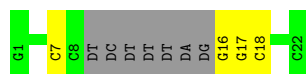
- Molecule 2: DNA (5'-D(P*GP*TP*TP*GP*GP*CP*CP*CP*TP*CP*TP*TP*TP*AP*GP*GP*GP*CP*CP*AP*TP*C)-3')

Chain G:  27% 36% 36%



- Molecule 2: DNA (5'-D(P*GP*TP*TP*GP*GP*CP*CP*CP*TP*CP*TP*TP*TP*AP*GP*GP*GP*CP*CP*AP*TP*C)-3')

Chain H:  50% 18% 32%



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	44.26Å 92.71Å 160.55Å 90.00° 90.89° 90.00°	Depositor
Resolution (Å)	32.22 – 2.62 32.22 – 2.62	Depositor EDS
% Data completeness (in resolution range)	99.3 (32.22-2.62) 95.0 (32.22-2.62)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.97 (at 2.61Å)	Xtriage
Refinement program	PHENIX 1.21.1_5127	Depositor
R, R_{free}	0.195 , 0.232 0.195 , 0.232	Depositor DCC
R_{free} test set	2001 reflections (5.12%)	wwPDB-VP
Wilson B-factor (Å ²)	33.6	Xtriage
Anisotropy	0.576	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.29 , 17.3	EDS
L-test for twinning ²	$\langle L \rangle = 0.44$, $\langle L^2 \rangle = 0.27$	Xtriage
Estimated twinning fraction	0.116 for h,-k,-l	Xtriage
F_o, F_c correlation	0.96	EDS
Total number of atoms	7961	wwPDB-VP
Average B, all atoms (Å ²)	42.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.16% 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:
LI

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	0.17	0/1652	0.35	0/2256
1	B	0.17	0/1692	0.35	0/2312
1	E	0.18	0/1668	0.36	0/2275
1	F	0.20	0/1676	0.40	0/2288
2	C	0.19	0/364	0.37	0/557
2	D	0.26	0/339	0.46	0/518
2	G	0.23	0/318	0.44	0/486
2	H	0.30	0/339	0.49	0/518
All	All	0.19	0/8048	0.38	0/11210

There are no bond length outliers.

There are no bond angle outliers.

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	A	1610	0	1609	12	0
1	B	1644	0	1651	10	0
1	E	1626	0	1633	18	0
1	F	1633	0	1637	11	0
2	C	327	0	181	7	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
2	D	305	0	170	10	0
2	G	286	0	159	5	0
2	H	305	0	170	7	0
3	B	1	0	0	0	0
3	F	1	0	0	0	0
4	A	36	0	0	4	0
4	B	51	0	0	2	0
4	C	5	0	0	0	0
4	D	12	0	0	2	0
4	E	58	0	0	4	0
4	F	43	0	0	2	0
4	G	5	0	0	1	0
4	H	13	0	0	0	0
All	All	7961	0	7210	71	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 5.

All (71) 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)
2:G:20:DA:N3	4:G:101:HOH:O	2.06	0.89
1:E:113:ARG:NH2	4:E:303:HOH:O	2.06	0.87
2:D:21:DT:OP2	4:D:101:HOH:O	1.94	0.86
1:F:149:GLY:O	4:F:401:HOH:O	1.95	0.85
1:E:65:ASP:OD2	4:E:301:HOH:O	1.97	0.83
2:D:16:DG:OP1	4:D:102:HOH:O	1.98	0.82
1:B:70:CYS:O	4:B:401:HOH:O	2.02	0.77
1:F:32:THR:HG22	1:F:73:PRO:HG3	1.65	0.77
1:A:63:VAL:O	4:A:301:HOH:O	2.02	0.77
2:D:7:DC:H2''	2:D:8:DC:H5'	1.67	0.76
2:G:7:DC:H42	2:G:16:DG:H1	1.35	0.74
1:E:127:ASP:OD2	4:E:302:HOH:O	2.06	0.72
1:A:228:THR:O	4:A:302:HOH:O	2.08	0.70
2:H:7:DC:H42	2:H:16:DG:H1	1.41	0.69
1:A:41:ARG:NH2	1:A:220:ASP:OD2	2.26	0.67
1:E:127:ASP:OD1	4:E:304:HOH:O	2.12	0.67
1:B:217:ARG:NH2	4:B:404:HOH:O	2.30	0.63
1:A:73:PRO:O	4:A:303:HOH:O	2.16	0.61
2:H:17:DG:H5''	2:H:17:DG:H8	1.64	0.60
2:C:7:DC:H2''	2:C:8:DC:H5'	1.84	0.59

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:E:159:LEU:HD13	1:E:182:ILE:HG21	1.85	0.59
2:C:1:DG:H8	2:C:1:DG:H5''	1.67	0.58
1:F:127:ASP:OD1	4:F:403:HOH:O	2.17	0.58
1:E:198:GLU:OE1	1:F:66:ARG:NH1	2.37	0.57
2:C:6:DC:H5''	2:C:6:DC:H6	1.70	0.57
2:D:6:DC:H2''	2:D:7:DC:C6	2.40	0.56
2:G:17:DG:H1'	2:G:18:DC:H5'	1.87	0.56
1:E:176:SER:O	1:E:185:ARG:NH2	2.40	0.54
2:H:17:DG:H2''	2:H:18:DC:H5'	1.89	0.53
1:E:19:MET:HG2	1:E:34:LEU:HB3	1.92	0.52
2:H:7:DC:H2'	2:H:7:DC:OP1	2.09	0.52
2:H:17:DG:H5''	2:H:17:DG:C8	2.45	0.51
1:B:11:MET:O	1:B:41:ARG:HD2	2.12	0.49
1:A:128:ARG:HH12	2:C:4:DG:H21	1.61	0.49
2:C:16:DG:H2''	2:C:17:DG:C8	2.48	0.48
1:F:208:CYS:HB3	1:F:215:LEU:HD22	1.96	0.47
1:E:28:GLN:HG2	1:E:233:TYR:CG	2.50	0.47
2:G:5:DG:H2''	2:G:6:DC:H5'	1.97	0.47
1:B:128:ARG:HH21	2:D:5:DG:H4'	1.79	0.47
1:E:56:THR:OG1	1:E:57:VAL:N	2.46	0.46
1:A:152:CYS:N	1:A:224:ARG:O	2.47	0.45
1:E:97:ARG:NH1	1:F:65:ASP:OD2	2.49	0.45
1:B:117:GLN:HG2	1:B:119:TRP:CE2	2.51	0.45
1:A:117:GLN:HG2	1:A:119:TRP:NE1	2.31	0.45
1:A:128:ARG:NH1	2:C:4:DG:H21	2.14	0.45
1:E:117:GLN:HG2	1:E:119:TRP:CE2	2.52	0.45
2:D:7:DC:H2''	2:D:8:DC:H3'	1.98	0.45
1:E:131:PHE:CZ	1:E:152:CYS:HB2	2.52	0.45
1:F:37:LEU:HG	1:F:66:ARG:HG2	1.98	0.45
1:B:53:PRO:HA	1:B:54:PRO:HD3	1.86	0.44
1:E:20:GLU:OE1	2:G:22:DC:H5'	2.17	0.43
1:E:79:PRO:O	1:E:83:GLU:HG3	2.19	0.43
1:F:11:MET:O	1:F:41:ARG:HD2	2.19	0.43
2:H:16:DG:H2''	2:H:17:DG:H5''	2.01	0.43
1:A:8:PRO:O	4:A:304:HOH:O	2.22	0.43
1:E:113:ARG:NH1	1:F:103:ASN:OD1	2.53	0.42
1:A:11:MET:SD	1:A:118:PRO:HB2	2.60	0.42
1:A:113:ARG:NH1	1:B:103:ASN:OD1	2.53	0.42
1:E:131:PHE:HB2	1:E:132:PRO:HD3	2.02	0.42
1:B:12:GLN:HG2	1:B:118:PRO:HD2	2.02	0.42
2:D:5:DG:H2''	2:D:6:DC:H5'	2.03	0.41

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
2:D:16:DG:H2''	2:D:17:DG:OP2	2.20	0.41
1:E:132:PRO:HB2	1:E:232:MET:HB2	2.03	0.41
1:F:216:LEU:HD23	1:F:216:LEU:HA	1.94	0.41
1:B:216:LEU:HD23	1:B:216:LEU:HA	1.91	0.41
1:B:128:ARG:HH22	2:D:6:DC:H5'	1.86	0.41
2:C:6:DC:H5''	2:C:6:DC:C6	2.54	0.41
1:A:117:GLN:HG2	1:A:119:TRP:CE2	2.56	0.40
1:F:147:LEU:HB3	1:F:226:PHE:CD2	2.55	0.40
2:H:7:DC:H2'	2:H:7:DC:P	2.61	0.40
2:D:1:DG:H8	2:D:1:DG:H5''	1.86	0.40

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	
1	A	206/242 (85%)	204 (99%)	2 (1%)	0	100	100
1	B	211/242 (87%)	208 (99%)	3 (1%)	0	100	100
1	E	207/242 (86%)	203 (98%)	3 (1%)	1 (0%)	24	44
1	F	209/242 (86%)	205 (98%)	4 (2%)	0	100	100
All	All	833/968 (86%)	820 (98%)	12 (1%)	1 (0%)	48	69

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	E	56	THR

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	174/198 (88%)	164 (94%)	10 (6%)	18	38
1	B	179/198 (90%)	176 (98%)	3 (2%)	53	76
1	E	176/198 (89%)	171 (97%)	5 (3%)	38	64
1	F	177/198 (89%)	171 (97%)	6 (3%)	32	58
All	All	706/792 (89%)	682 (97%)	24 (3%)	32	58

All (24) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	42	CYS
1	A	46	SER
1	A	102	ASP
1	A	109	LEU
1	A	143	LEU
1	A	144	THR
1	A	153	VAL
1	A	164	ARG
1	A	190	SER
1	A	201	VAL
1	B	83	GLU
1	B	109	LEU
1	B	153	VAL
1	E	56	THR
1	E	68	SER
1	E	109	LEU
1	E	121	LEU
1	E	144	THR
1	F	44	LEU
1	F	46	SER
1	F	78	SER
1	F	163	GLU
1	F	175	LYS
1	F	181	SER

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

Mol	Chain	Res	Type
1	A	103	ASN
1	A	195	HIS
1	E	12	GLN
1	E	189	GLN
1	E	195	HIS

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 2 ligands modelled in this entry, 2 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 ⓘ

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	212/242 (87%)	-1.63	0 100 100	22, 40, 71, 97	0
1	B	216/242 (89%)	-1.74	0 100 100	20, 28, 50, 67	1 (0%)
1	E	213/242 (88%)	-1.71	0 100 100	21, 32, 53, 87	0
1	F	215/242 (88%)	-1.68	0 100 100	20, 31, 59, 91	0
2	C	16/22 (72%)	-1.58	0 100 100	40, 87, 115, 115	0
2	D	15/22 (68%)	-1.66	0 100 100	24, 51, 124, 140	0
2	G	14/22 (63%)	-1.55	0 100 100	34, 92, 126, 149	0
2	H	15/22 (68%)	-1.59	0 100 100	28, 50, 141, 155	0
All	All	916/1056 (86%)	-1.68	0 100 100	20, 32, 74, 155	1 (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(\AA^2)	Q<0.9
3	LI	B	301	1/1	0.96	0.31	15,15,15,15	0
3	LI	F	301	1/1	0.97	0.27	15,15,15,15	0

6.5 Other polymers [i](#)

There are no such residues in this entry.