



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 12, 2026 – 01:31 PM UTC

PDB ID : 5OPW / pdb_00005opw
Title : Crystal structure of the GroEL mutant A109C
Authors : Yan, X.; Shi, Q.; Bracher, A.; Milicic, G.; Singh, A.K.; Hartl, F.U.; Hayer-Hartl, M.
Deposited on : 2017-08-10
Resolution : 3.19 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

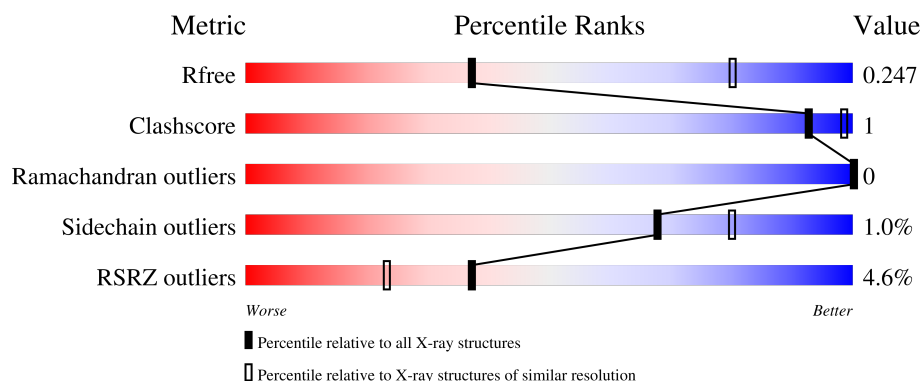
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 3.19 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	1466 (3.20-3.20)
Clashscore	190562	1573 (3.20-3.20)
Ramachandran outliers	187476	1548 (3.20-3.20)
Sidechain outliers	187428	1547 (3.20-3.20)
RSRZ outliers	180081	1466 (3.20-3.20)

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	547	2% 91% ...
1	B	547	% 91% ..
1	C	547	% 91% ..
1	D	547	6% 92% ..
1	E	547	8% 92% ..

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Mol	Chain	Length	Quality of chain
1	F	547	2% 91% 5% .
1	G	547	6% 91% . .
1	H	547	% 92% . .
1	I	547	% 92% . .
1	J	547	2% 91% . . .
1	K	547	11% 92% . .
1	L	547	3% 91% . . .
1	M	547	5% 90% 5% . .
1	N	547	12% 91% 5% .

2 Entry composition

There is only 1 type of molecule in this entry. The entry contains 53984 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 60 kDa chaperonin.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	B	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	C	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	D	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	E	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	F	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	G	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	H	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	I	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	J	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	K	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	L	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	M	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			
1	N	524	Total	C	N	O	S	0	0	0
			3856	2397	665	773	21			

There are 14 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	109	CYS	ALA	engineered mutation	UNP P0A6F5

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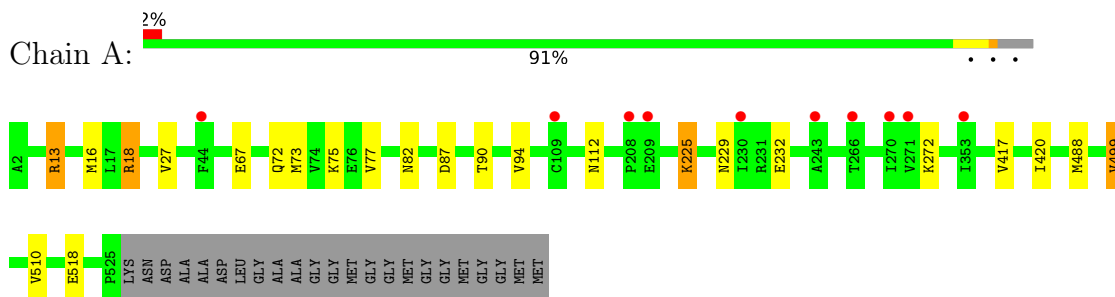
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Chain	Residue	Modelled	Actual	Comment	Reference
B	109	CYS	ALA	engineered mutation	UNP P0A6F5
C	109	CYS	ALA	engineered mutation	UNP P0A6F5
D	109	CYS	ALA	engineered mutation	UNP P0A6F5
E	109	CYS	ALA	engineered mutation	UNP P0A6F5
F	109	CYS	ALA	engineered mutation	UNP P0A6F5
G	109	CYS	ALA	engineered mutation	UNP P0A6F5
H	109	CYS	ALA	engineered mutation	UNP P0A6F5
I	109	CYS	ALA	engineered mutation	UNP P0A6F5
J	109	CYS	ALA	engineered mutation	UNP P0A6F5
K	109	CYS	ALA	engineered mutation	UNP P0A6F5
L	109	CYS	ALA	engineered mutation	UNP P0A6F5
M	109	CYS	ALA	engineered mutation	UNP P0A6F5
N	109	CYS	ALA	engineered mutation	UNP P0A6F5

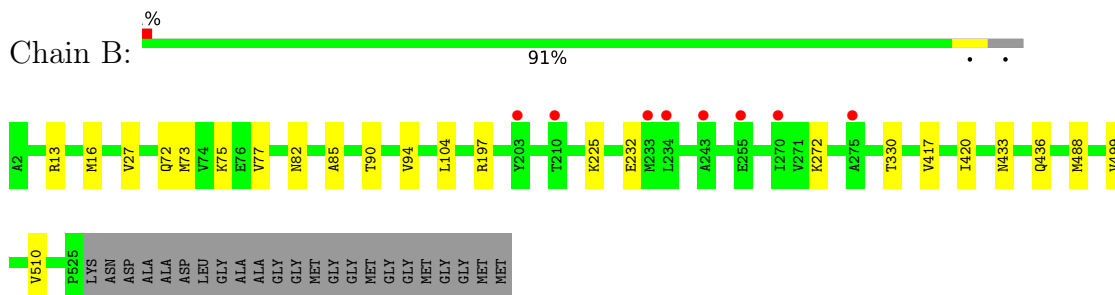
3 Residue-property plots [i](#)

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.

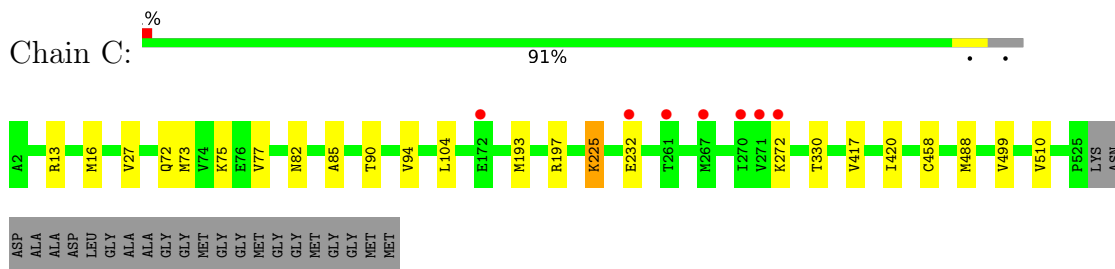
- Molecule 1: 60 kDa chaperonin



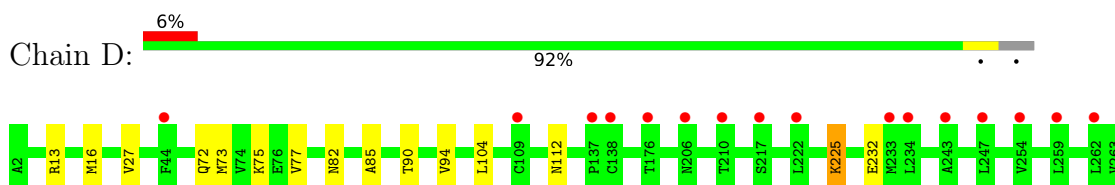
- Molecule 1: 60 kDa chaperonin

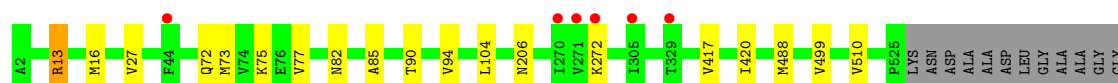


- Molecule 1: 60 kDa chaperonin



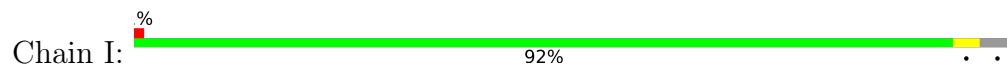
- Molecule 1: 60 kDa chaperonin





MET
GLY
GLY
MET
GLY
GLY
MET
GLY
GLY
MET

- Molecule 1: 60 kDa chaperonin



A2 M16 V27 F44 Q72 M73 V74 K75 E76 V77 N82 A85 T90 V94 M166 D167 T176 K225 E232 P246 V264 M267 K272 V417 I420 M488 V499 V510 P525 LYS ASN ASP ALA ASP LEU GLY MET

ALA
GLY
GLY
MET
GLY
GLY
MET
GLY
MET
MET

- Molecule 1: 60 kDa chaperonin



A2 M16 V27 F44 Q72 M73 V74 K75 E76 V77 N82 A85 T90 V94 M166 D167 T176 K225 E232 P246 V264 M267 K272 V417 I420 M488 V499 V510 P525 LYS ASN ASP ALA ASP LEU GLY MET

I420 M488 V499 V510 P525 LYS ASN ASP ALA ASP LEU GLY MET

- Molecule 1: 60 kDa chaperonin



A2 M16 V27 F44 Q72 M73 V74 K75 E76 V77 N82 A85 T90 V94 M166 D167 T176 K225 E232 P246 V264 M267 K272 V417 I420 M488 V499 V510 P525 LYS ASN ASP ALA ASP LEU GLY MET

E232 M233 V236 L237 V240 P246 L247 L248 I249 D253 V254 L259 L262 V263 M266 M267 I270 V271 K272 V273 A274 A275 P279 G280 F281 M288 T299 V300 I301 I305 V309 L309 T313 L314 E315 D316 L317 G318 D328 T329 T330 T331 I332 V417

I420 M488 V499 V510 P525 LYS ASN ASP ALA ASP LEU GLY MET

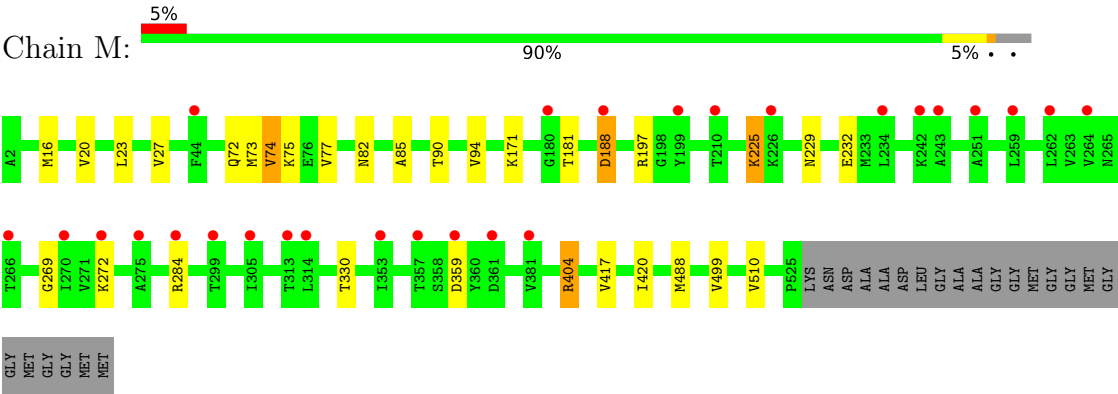
- Molecule 1: 60 kDa chaperonin



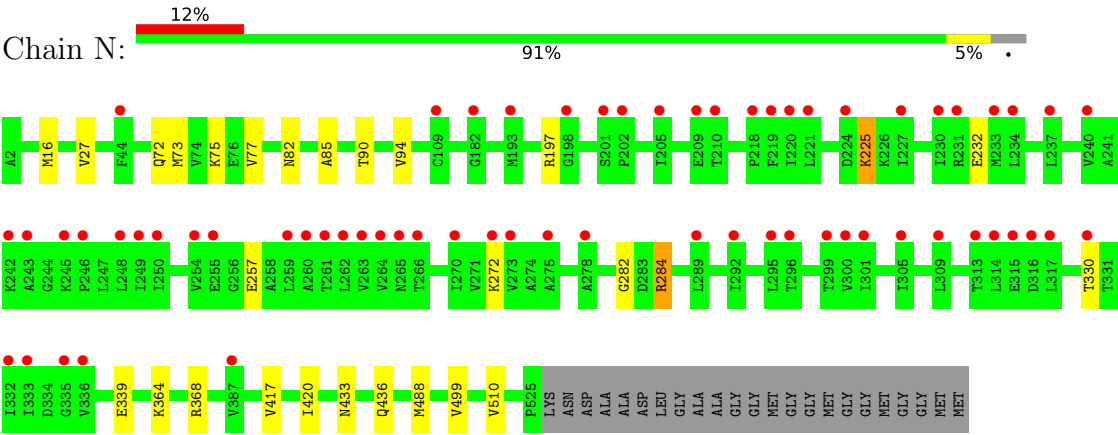
A2 M10 R13 M16 V27 F44 Q72 M73 V74 K75 E76 V77 N82 A85 T90 V94 L104 C109 G110 M111 K171 M193 P218 K225 K226 I227 V233 L234 L237 A243 G244 I250 L259 L262 T266 G269

I270 V271 K272 S302 I305 Y360 Q366 R404 V417 I420 M488 V499 V510 L524 P525 LYS ASN ASP ALA ASP LEU GLY MET

- Molecule 1: 60 kDa chaperonin



● Molecule 1: 60 kDa chaperonin



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	135.69Å 262.05Å 149.21Å 90.00° 100.81° 90.00°	Depositor
Resolution (Å)	50.00 – 3.19 50.00 – 3.19	Depositor EDS
% Data completeness (in resolution range)	99.5 (50.00-3.19) 99.5 (50.00-3.19)	Depositor EDS
R_{merge}	0.17	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.69 (at 3.19Å)	Xtriage
Refinement program	REFMAC 5.8.0071	Depositor
R, R_{free}	0.245 , 0.252 0.240 , 0.247	Depositor DCC
R_{free} test set	8289 reflections (4.90%)	wwPDB-VP
Wilson B-factor (Å ²)	63.9	Xtriage
Anisotropy	0.368	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.30 , 32.4	EDS
L-test for twinning ²	$\langle L \rangle = 0.48$, $\langle L^2 \rangle = 0.31$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.90	EDS
Total number of atoms	53984	wwPDB-VP
Average B, all atoms (Å ²)	84.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.73% 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](#)

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	0.42	0/3884	0.74	3/5244 (0.1%)
1	B	0.41	0/3884	0.71	0/5244
1	C	0.41	0/3884	0.71	1/5244 (0.0%)
1	D	0.42	0/3884	0.72	0/5244
1	E	0.41	0/3884	0.72	2/5244 (0.0%)
1	F	0.43	0/3884	0.73	2/5244 (0.0%)
1	G	0.41	0/3884	0.72	1/5244 (0.0%)
1	H	0.41	0/3884	0.72	1/5244 (0.0%)
1	I	0.40	0/3884	0.71	1/5244 (0.0%)
1	J	0.42	1/3884 (0.0%)	0.72	1/5244 (0.0%)
1	K	0.42	0/3884	0.72	1/5244 (0.0%)
1	L	0.44	0/3884	0.75	4/5244 (0.1%)
1	M	0.42	0/3884	0.74	3/5244 (0.1%)
1	N	0.46	3/3884 (0.1%)	0.82	3/5244 (0.1%)
All	All	0.42	4/54376 (0.0%)	0.73	23/73416 (0.0%)

All (4) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	N	368	ARG	CD-NE	-7.92	1.35	1.46
1	N	368	ARG	CZ-NH1	-7.04	1.22	1.32
1	J	404	ARG	CA-CB	5.36	1.61	1.53
1	N	368	ARG	CZ-NH2	5.28	1.40	1.33

The worst 5 of 23 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	N	368	ARG	NE-CZ-NH2	20.33	137.50	119.20
1	N	368	ARG	NE-CZ-NH1	-19.70	101.80	121.50
1	A	499	VAL	CB-CA-C	-9.85	99.04	112.24
1	M	404	ARG	CG-CD-NE	-7.85	94.73	112.00
1	A	499	VAL	CA-CB-CG2	6.87	122.08	110.40

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	3856	0	3975	14	0
1	B	3856	0	3975	11	0
1	C	3856	0	3975	12	0
1	D	3856	0	3975	12	0
1	E	3856	0	3975	8	0
1	F	3856	0	3975	11	0
1	G	3856	0	3975	12	0
1	H	3856	0	3975	9	0
1	I	3856	0	3975	8	1
1	J	3856	0	3975	12	0
1	K	3856	0	3975	12	0
1	L	3856	0	3975	11	0
1	M	3856	0	3975	20	1
1	N	3856	0	3975	16	0
All	All	53984	0	55650	160	1

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 1.

The worst 5 of 160 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:229:ASN:OD1	1:G:269:GLY:O	1.83	0.95
1:L:171:LYS:O	1:L:404:ARG:NH1	2.02	0.93
1:M:171:LYS:O	1:M:404:ARG:NH2	2.07	0.86
1:J:225:LYS:HG2	1:J:226:LYS:N	1.92	0.85
1:M:20:VAL:HG13	1:M:74:VAL:HG21	1.67	0.74

All (1) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:I:166:MET:O	1:M:359:ASP:OD2[1_455]	2.09	0.11

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	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	B	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	C	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	D	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	E	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	F	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	G	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	H	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	I	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	J	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	K	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	L	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	M	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
1	N	522/547 (95%)	516 (99%)	6 (1%)	0	100	100
All	All	7308/7658 (95%)	7224 (99%)	84 (1%)	0	100	100

There are no Ramachandran outliers to report.

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	405/415 (98%)	400 (99%)	5 (1%)	63	79
1	B	405/415 (98%)	402 (99%)	3 (1%)	76	83
1	C	405/415 (98%)	401 (99%)	4 (1%)	68	80
1	D	405/415 (98%)	401 (99%)	4 (1%)	68	80
1	E	405/415 (98%)	401 (99%)	4 (1%)	68	80
1	F	405/415 (98%)	399 (98%)	6 (2%)	57	76
1	G	405/415 (98%)	401 (99%)	4 (1%)	68	80
1	H	405/415 (98%)	403 (100%)	2 (0%)	81	85
1	I	405/415 (98%)	402 (99%)	3 (1%)	76	83
1	J	405/415 (98%)	401 (99%)	4 (1%)	68	80
1	K	405/415 (98%)	402 (99%)	3 (1%)	76	83
1	L	405/415 (98%)	399 (98%)	6 (2%)	57	76
1	M	405/415 (98%)	400 (99%)	5 (1%)	63	79
1	N	405/415 (98%)	400 (99%)	5 (1%)	63	79
All	All	5670/5810 (98%)	5612 (99%)	58 (1%)	68	80

5 of 58 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	G	225	LYS
1	N	225	LYS
1	J	82	ASN
1	N	94	VAL
1	M	82	ASN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 27 such sidechains are listed below:

Mol	Chain	Res	Type
1	H	37	ASN
1	J	37	ASN
1	M	453	GLN
1	I	37	ASN
1	J	453	GLN

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](#)

There are no ligands in this entry.

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

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	524/547 (95%)	0.32	10 (1%) 66 46	35, 67, 147, 180	0
1	B	524/547 (95%)	0.40	8 (1%) 72 52	40, 76, 141, 161	0
1	C	524/547 (95%)	0.25	7 (1%) 75 55	36, 62, 122, 154	0
1	D	524/547 (95%)	0.49	33 (6%) 26 17	34, 71, 146, 176	0
1	E	524/547 (95%)	0.58	43 (8%) 17 11	37, 83, 158, 189	0
1	F	524/547 (95%)	0.32	12 (2%) 61 41	37, 64, 133, 176	0
1	G	524/547 (95%)	0.50	35 (6%) 24 15	39, 80, 145, 177	0
1	H	524/547 (95%)	0.29	6 (1%) 78 61	41, 77, 125, 147	0
1	I	524/547 (95%)	0.38	6 (1%) 78 61	40, 74, 134, 162	0
1	J	524/547 (95%)	0.42	12 (2%) 61 41	45, 84, 137, 158	0
1	K	524/547 (95%)	0.75	58 (11%) 10 7	45, 98, 151, 166	0
1	L	524/547 (95%)	0.49	18 (3%) 48 30	47, 89, 170, 196	0
1	M	524/547 (95%)	0.58	27 (5%) 33 21	42, 79, 160, 199	0
1	N	524/547 (95%)	0.76	64 (12%) 8 6	45, 90, 181, 215	0
All	All	7336/7658 (95%)	0.47	339 (4%) 37 23	34, 74, 149, 215	0

The worst 5 of 339 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	E	233	MET	6.0
1	E	210	THR	5.7
1	N	233	MET	5.3
1	N	237	LEU	5.0
1	D	489	ILE	4.7

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](#)

There are no ligands in this entry.

6.5 Other polymers [i](#)

There are no such residues in this entry.