



wwPDB EM Validation Summary Report ⓘ

Mar 20, 2026 – 12:04 AM UTC

PDB ID : 9JC2 / pdb_00009jc2
EMDB ID : EMD-61340
Title : Engineering of ATP synthase Fo
Authors : Hamaguchi-Suzuki, N.; Ueno, H.; Yasuda, K.; Marui, R.; Adachi, N.; Senda, T.; Noji, H.; Murata, T.
Deposited on : 2024-08-28
Resolution : 3.96 Å(reported)

This is a wwPDB EM 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/EMValidationReportHelp>
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:

EMDB validation analysis : 0.0.1.dev132
MolProbity : 4-5-2 with Phenix2.0
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
EM percentile statistics : **NOT EXECUTED**
MapQ : **FAILED**
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.49

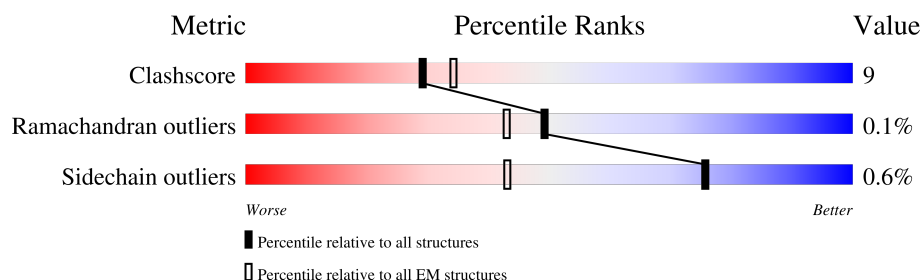
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

ELECTRON MICROSCOPY

The reported resolution of this entry is 3.96 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.



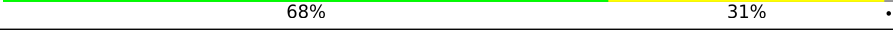
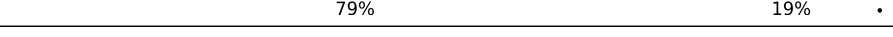
Metric	Whole archive (#Entries)	EM structures (#Entries)
Clashscore	229148	23984
Ramachandran outliers	224038	23583
Sidechain outliers	223484	23102

The table below summarises the geometric issues observed across the polymeric chains and their fit to the map. The red, orange, yellow and green segments of the 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 $\leq 5\%$.

Mol	Chain	Length	Quality of chain
1	A	237	65% 5% 30%
1	B	237	64% 6% 30%
1	C	237	65% 5% 30%
2	D	285	72% 12% 16%
3	E	87	70% 14% 16%
4	F	169	37% 63%
4	G	169	32% 68%
4	H	169	37% 62%
4	I	169	30% 69%

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Mol	Chain	Length	Quality of chain
4	J	169	
4	K	169	
5	L	72	
5	M	72	
5	N	72	
5	O	72	
5	P	72	
5	Q	72	
5	R	72	
5	S	72	
5	T	72	
5	U	72	

2 Entry composition [i](#)

There are 5 unique types of molecules in this entry. The entry contains 10815 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, 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 ATP synthase subunit a.

Mol	Chain	Residues	Atoms				AltConf	Trace
1	A	166	Total	C	N	O	0	0
			918	571	171	176		
1	B	166	Total	C	N	O	0	0
			932	583	172	177		
1	C	167	Total	C	N	O	0	0
			899	553	169	177		

- Molecule 2 is a protein called ATP synthase gamma chain.

Mol	Chain	Residues	Atoms					AltConf	Trace
2	D	239	Total	C	N	O	S	0	0
			1595	1012	269	309	5		

- Molecule 3 is a protein called ATP synthase epsilon chain.

Mol	Chain	Residues	Atoms					AltConf	Trace
3	E	73	Total	C	N	O	S	0	0
			482	311	84	86	1		

- Molecule 4 is a protein called ATP synthase subunit b.

Mol	Chain	Residues	Atoms				AltConf	Trace
4	F	62	Total	C	N	O	0	0
			317	191	62	64		
4	G	54	Total	C	N	O	0	0
			275	164	55	56		
4	H	64	Total	C	N	O	0	0
			320	192	64	64		
4	I	53	Total	C	N	O	0	0
			274	166	54	54		
4	J	64	Total	C	N	O	0	0
			325	194	65	66		

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Mol	Chain	Residues	Atoms				AltConf	Trace
4	K	57	Total	C	N	O	0	0
			286	172	57	57		

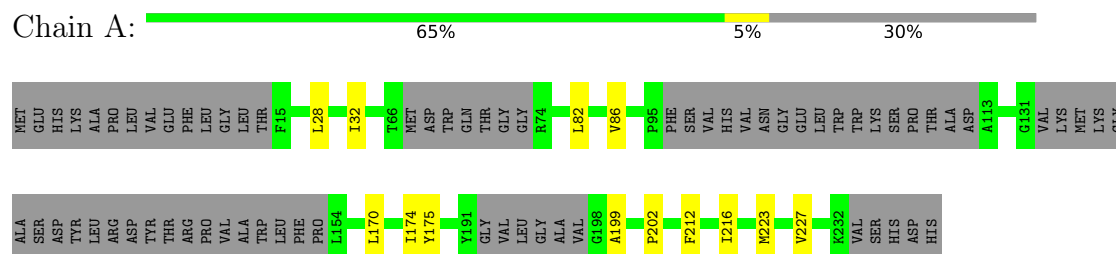
- Molecule 5 is a protein called ATP synthase subunit c.

Mol	Chain	Residues	Atoms					AltConf	Trace
5	L	71	Total	C	N	O	S	0	0
			398	242	79	76	1		
5	M	71	Total	C	N	O	S	0	0
			415	257	79	78	1		
5	N	71	Total	C	N	O	S	0	0
			428	269	80	78	1		
5	O	71	Total	C	N	O	S	0	0
			438	278	79	80	1		
5	P	71	Total	C	N	O	S	0	0
			423	263	81	78	1		
5	Q	71	Total	C	N	O	S	0	0
			437	280	78	78	1		
5	R	71	Total	C	N	O	S	0	0
			414	261	75	77	1		
5	S	71	Total	C	N	O	S	0	0
			412	255	78	78	1		
5	T	71	Total	C	N	O	S	0	0
			421	267	75	78	1		
5	U	71	Total	C	N	O	S	0	0
			406	251	75	79	1		

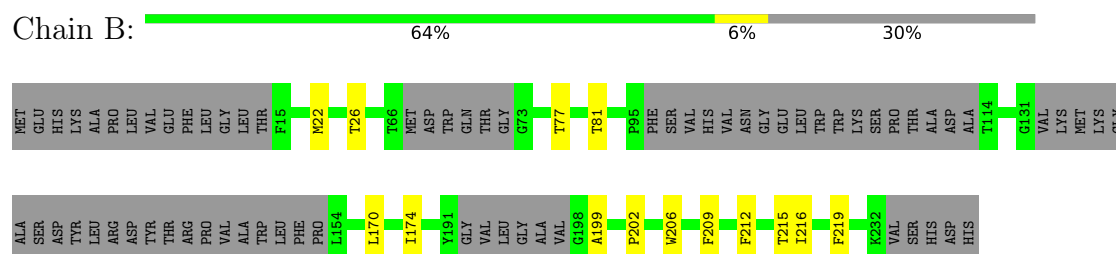
3 Residue-property plots [i](#)

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. 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. 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.

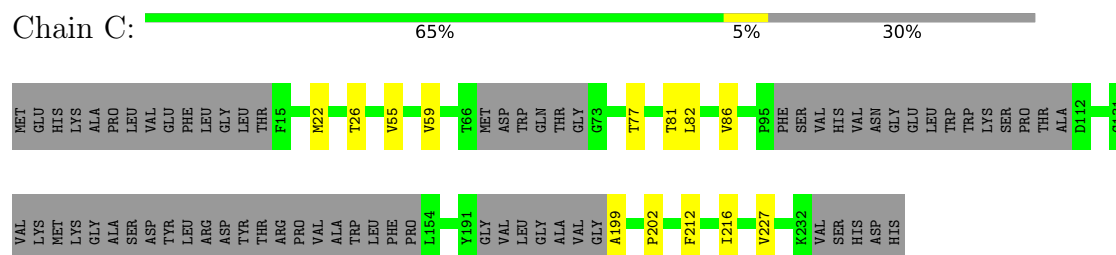
- Molecule 1: ATP synthase subunit a



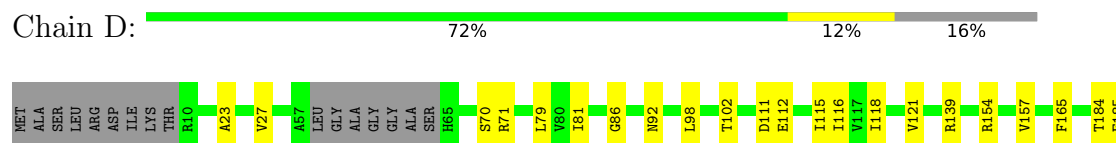
- Molecule 1: ATP synthase subunit a

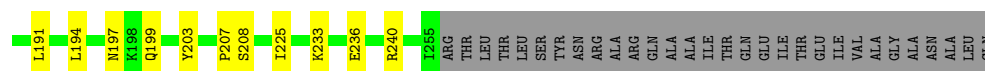


- Molecule 1: ATP synthase subunit a



- Molecule 2: ATP synthase gamma chain

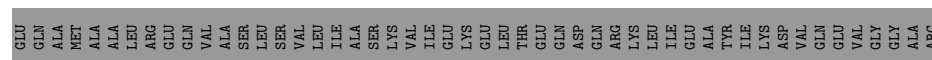
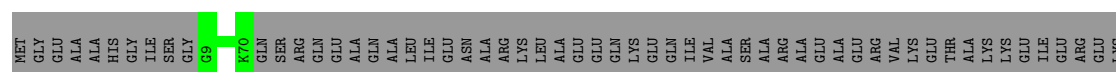




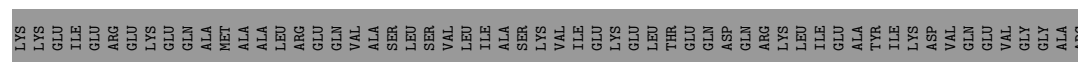
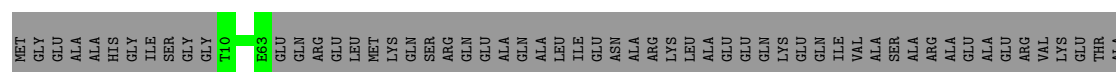
- Molecule 3: ATP synthase epsilon chain



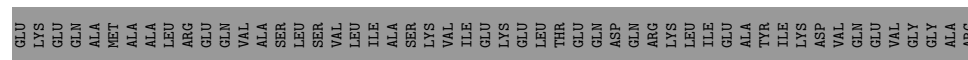
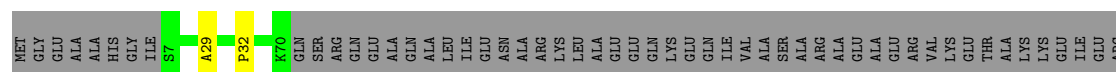
- Molecule 4: ATP synthase subunit b



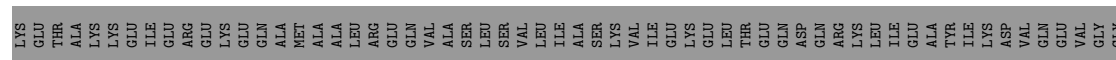
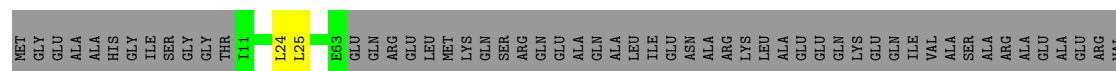
- Molecule 4: ATP synthase subunit b



- Molecule 4: ATP synthase subunit b

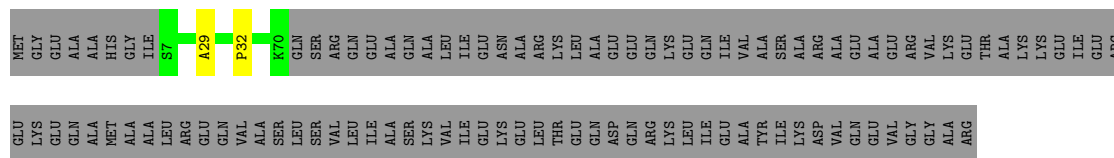


- Molecule 4: ATP synthase subunit b



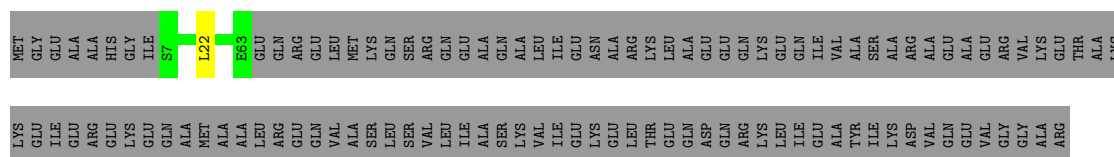
- Molecule 4: ATP synthase subunit b

Chain J:  37% 62%



- Molecule 4: ATP synthase subunit b

Chain K:  33% 66%



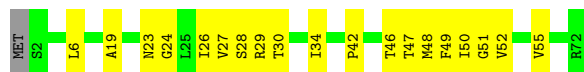
- Molecule 5: ATP synthase subunit c

Chain L:  81% 18%



- Molecule 5: ATP synthase subunit c

Chain M:  72% 26%



- Molecule 5: ATP synthase subunit c

Chain N:  78% 21%



- Molecule 5: ATP synthase subunit c

Chain O:  74% 25%

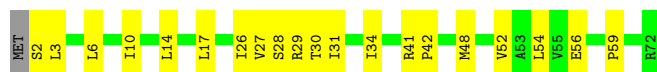


- Molecule 5: ATP synthase subunit c

Chain P:  76% 22%



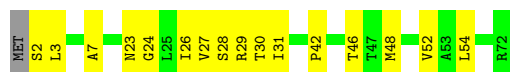
- Molecule 5: ATP synthase subunit c



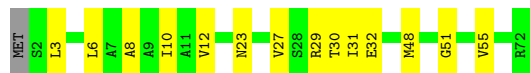
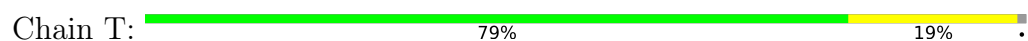
- Molecule 5: ATP synthase subunit c



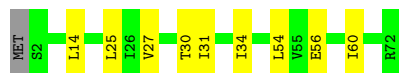
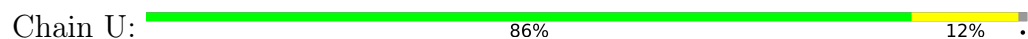
- Molecule 5: ATP synthase subunit c



- Molecule 5: ATP synthase subunit c



- Molecule 5: ATP synthase subunit c



4 Experimental information

Property	Value	Source
EM reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, C1	Depositor
Number of particles used	32633	Depositor
Resolution determination method	FSC 0.143 CUT-OFF	Depositor
CTF correction method	PHASE FLIPPING AND AMPLITUDE CORRECTION	Depositor
Microscope	TFS KRIOS	Depositor
Voltage (kV)	300	Depositor
Electron dose ($e^-/\text{\AA}^2$)	50	Depositor
Minimum defocus (nm)	800	Depositor
Maximum defocus (nm)	2000	Depositor
Magnification	Not provided	
Image detector	FEI FALCON IV (4k x 4k)	Depositor

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	0.12	0/924	0.26	0/1274
1	B	0.10	0/939	0.30	0/1293
1	C	0.11	0/901	0.27	0/1243
2	D	0.13	0/1620	0.34	0/2233
3	E	0.13	0/488	0.39	0/670
4	F	0.11	0/317	0.22	0/442
4	G	0.11	0/274	0.23	0/382
4	H	0.11	0/320	0.19	0/446
4	I	0.14	0/273	0.34	0/380
4	J	0.12	0/325	0.23	0/453
4	K	0.10	0/285	0.21	0/396
5	L	0.17	0/400	0.42	0/548
5	M	0.17	0/418	0.43	0/573
5	N	0.20	0/431	0.55	0/590
5	O	0.21	0/441	0.45	0/604
5	P	0.15	0/425	0.38	0/580
5	Q	0.17	0/440	0.39	0/603
5	R	0.16	0/417	0.36	0/573
5	S	0.15	0/414	0.33	0/567
5	T	0.15	0/424	0.41	0/582
5	U	0.11	0/408	0.25	0/561
All	All	0.14	0/10884	0.34	0/14993

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 [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	A	918	0	558	8	0
1	B	932	0	585	8	0
1	C	899	0	529	7	0
2	D	1595	0	1355	21	0
3	E	482	0	479	9	0
4	F	317	0	155	0	0
4	G	275	0	130	0	0
4	H	320	0	149	1	0
4	I	274	0	141	1	0
4	J	325	0	158	1	0
4	K	286	0	138	0	0
5	L	398	0	299	10	0
5	M	415	0	352	16	0
5	N	428	0	384	16	0
5	O	438	0	415	18	0
5	P	423	0	365	16	0
5	Q	437	0	426	20	0
5	R	414	0	362	21	0
5	S	412	0	350	15	0
5	T	421	0	383	12	0
5	U	406	0	344	7	0
All	All	10815	0	8057	176	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 9.

The worst 5 of 176 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:S:23:ASN:HD21	5:T:55:VAL:HA	1.35	0.92
5:N:27:VAL:HG23	5:O:26:ILE:HD11	1.55	0.89
5:P:27:VAL:HG22	5:P:48:MET:HE3	1.61	0.82
5:L:30:THR:HG21	5:L:48:MET:HE1	1.59	0.81
5:Q:27:VAL:HG23	5:Q:48:MET:HE1	1.69	0.74

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 PDB entries followed by that with respect to all EM entries.

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	156/237 (66%)	156 (100%)	0	0	100	100
1	B	156/237 (66%)	156 (100%)	0	0	100	100
1	C	157/237 (66%)	156 (99%)	1 (1%)	0	100	100
2	D	235/285 (82%)	223 (95%)	12 (5%)	0	100	100
3	E	69/87 (79%)	65 (94%)	4 (6%)	0	100	100
4	F	60/169 (36%)	60 (100%)	0	0	100	100
4	G	52/169 (31%)	51 (98%)	1 (2%)	0	100	100
4	H	62/169 (37%)	62 (100%)	0	0	100	100
4	I	51/169 (30%)	49 (96%)	1 (2%)	1 (2%)	6	33
4	J	62/169 (37%)	62 (100%)	0	0	100	100
4	K	55/169 (32%)	54 (98%)	1 (2%)	0	100	100
5	L	69/72 (96%)	66 (96%)	3 (4%)	0	100	100
5	M	69/72 (96%)	68 (99%)	1 (1%)	0	100	100
5	N	69/72 (96%)	68 (99%)	1 (1%)	0	100	100
5	O	69/72 (96%)	68 (99%)	1 (1%)	0	100	100
5	P	69/72 (96%)	68 (99%)	1 (1%)	0	100	100
5	Q	69/72 (96%)	69 (100%)	0	0	100	100
5	R	69/72 (96%)	69 (100%)	0	0	100	100
5	S	69/72 (96%)	68 (99%)	1 (1%)	0	100	100
5	T	69/72 (96%)	68 (99%)	1 (1%)	0	100	100
5	U	69/72 (96%)	69 (100%)	0	0	100	100
All	All	1805/2817 (64%)	1775 (98%)	29 (2%)	1 (0%)	49	81

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
4	I	24	LEU

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 PDB entries followed by that with respect to all EM entries.

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	27/198 (14%)	27 (100%)	0	100	100
1	B	31/198 (16%)	31 (100%)	0	100	100
1	C	23/198 (12%)	23 (100%)	0	100	100
2	D	128/240 (53%)	128 (100%)	0	100	100
3	E	45/70 (64%)	45 (100%)	0	100	100
4	F	3/140 (2%)	3 (100%)	0	100	100
4	G	2/140 (1%)	2 (100%)	0	100	100
4	H	1/140 (1%)	1 (100%)	0	100	100
4	I	3/140 (2%)	3 (100%)	0	100	100
4	J	3/140 (2%)	3 (100%)	0	100	100
4	K	1/140 (1%)	0	1 (100%)	0	0
5	L	17/52 (33%)	17 (100%)	0	100	100
5	M	25/52 (48%)	25 (100%)	0	100	100
5	N	28/52 (54%)	28 (100%)	0	100	100
5	O	33/52 (64%)	33 (100%)	0	100	100
5	P	25/52 (48%)	24 (96%)	1 (4%)	28	51
5	Q	34/52 (65%)	34 (100%)	0	100	100
5	R	26/52 (50%)	26 (100%)	0	100	100
5	S	25/52 (48%)	24 (96%)	1 (4%)	28	51
5	T	29/52 (56%)	29 (100%)	0	100	100
5	U	25/52 (48%)	25 (100%)	0	100	100
All	All	534/2264 (24%)	531 (99%)	3 (1%)	76	81

All (3) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
4	K	22	LEU
5	P	58	LEU
5	S	54	LEU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (4) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	207	GLN
1	B	207	GLN
2	D	180	GLN
4	I	35	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](#)

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 Map visualisation

This section contains visualisations of the EMDB entry EMD-61340. These allow visual inspection of the internal detail of the map and identification of artifacts.

Images derived from a raw map, generated by summing the deposited half-maps, are presented below the corresponding image components of the primary map to allow further visual inspection and comparison with those of the primary map.

6.1 Orthogonal projections

This section was not generated.

6.2 Central slices

This section was not generated.

6.3 Largest variance slices

This section was not generated.

6.4 Orthogonal standard-deviation projections (False-color)

This section was not generated.

6.5 Orthogonal surface views

This section was not generated.

6.6 Mask visualisation

This section was not generated. No masks/segmentation were deposited.

7 Map analysis ⓘ

This section contains the results of statistical analysis of the map.

7.1 Map-value distribution ⓘ

This section was not generated.

7.2 Volume estimate versus contour level ⓘ

This section was not generated.

7.3 Rotationally averaged power spectrum ⓘ

This section was not generated. The rotationally averaged power spectrum had issues being displayed.

8 Fourier-Shell correlation

This section was not generated. No FSC curve or half-maps provided.

9 Map-model fit

This section was not generated.