



wwPDB EM Validation Summary Report ⓘ

Mar 5, 2026 – 10:17 AM UTC

PDB ID : 6MUP / pdb_00006mup
EMDB ID : EMD-9251
Title : CENP-A nucleosome bound by two copies of CENP-C(CD) and two copies
CENP-N(NT)
Authors : Allu, P.K.; Black, B.E.
Deposited on : 2018-10-23
Resolution : 3.50 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:

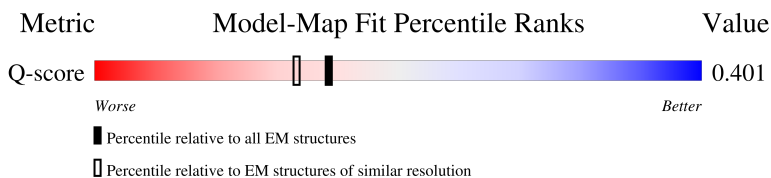
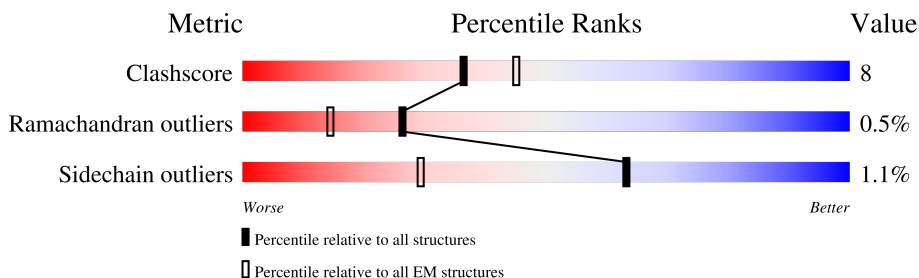
EMDB validation analysis : 0.0.1.dev132
MolProbity : 4-5-2 with Phenix2.0
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
EM percentile statistics : 202505.v01 (Using data in the EMDB archive up until May 2025)
MapQ : 1.9.13
Ideal geometry (proteins) : Engh & 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:
ELECTRON MICROSCOPY

The reported resolution of this entry is 3.50 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.









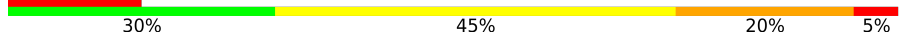



Metric	Whole archive (#Entries)	EM structures (#Entries)	Similar EM resolution (#Entries, resolution range(Å))
Clashscore	229148	23984	-
Ramachandran outliers	224038	23583	-
Sidechain outliers	223484	23102	-
Q-score	-	25397	13950 (3.00 - 4.00)

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 $\leq 5\%$. The upper red bar (where present) indicates the fraction of residues that have poor fit to the EM map (all-atom inclusion $< 40\%$). The numeric value is given above the bar.

Mol	Chain	Length	Quality of chain
1	A	102	
1	E	102	
2	B	94	
2	F	94	

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Mol	Chain	Length	Quality of chain
3	C	105	 84% 14%
3	G	105	 84% 15%
4	D	92	 89% 11%
4	H	92	 90% 10%
5	I	147	 76% 24%
6	J	147	 74% 26%
7	K	20	 15% 30% 45% 20% 5%
7	L	20	 15% 65% 30% 5%
8	M	212	 36% 81% 15%
8	N	212	 14% 74% 23%

2 Entry composition [i](#)

There are 8 unique types of molecules in this entry. The entry contains 15803 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 Histone H3-like centromeric protein A.

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	N	O	S		
1	A	102	Total	C	N	O	S	0	0
			814	527	150	136	1		
1	E	101	Total	C	N	O	S	0	0
			809	524	149	135	1		

- Molecule 2 is a protein called Histone H4.

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	N	O	S		
2	B	90	Total	C	N	O	S	0	0
			687	430	135	121	1		
2	F	90	Total	C	N	O	S	0	0
			687	430	135	121	1		

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

Mol	Chain	Residues	Atoms				AltConf	Trace
			Total	C	N	O		
3	C	103	Total	C	N	O	0	0
			785	491	155	139		
3	G	105	Total	C	N	O	0	0
			795	497	157	141		

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
C	113	SER	ALA	conflict	UNP Q93077
G	113	SER	ALA	conflict	UNP Q93077

- Molecule 4 is a protein called Histone H2B type 2-F.

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	N	O	S		
4	D	92	Total	C	N	O	S	0	0
			719	452	129	136	2		

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Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	N	O	S		
4	H	92	719	452	129	136	2	0	0

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

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	N	O	P		
5	I	147	2994	1436	532	880	146	0	0

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

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	N	O	P		
6	J	147	3027	1447	554	880	146	0	0

- Molecule 7 is a protein called Centromere protein C.

Mol	Chain	Residues	Atoms				AltConf	Trace
			Total	C	N	O		
7	K	20	174	108	36	30	0	0
7	L	19	169	105	35	29	0	0

- Molecule 8 is a protein called Centromere protein N.

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	N	O	S		
8	M	205	1712	1101	298	305	8	0	0
8	N	205	1712	1101	298	305	8	0	0

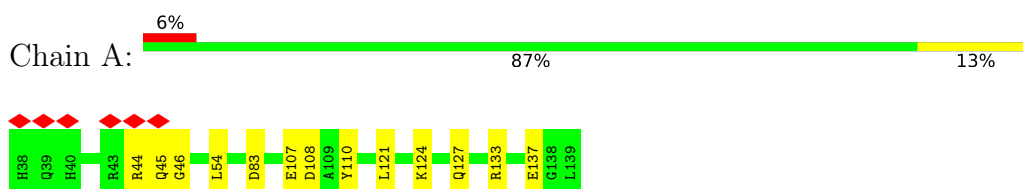
There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
M	84	ASP	GLU	conflict	UNP Q96H22
N	84	ASP	GLU	conflict	UNP Q96H22

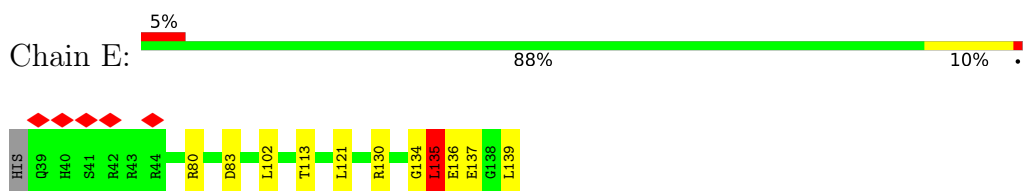
3 Residue-property plots [i](#)

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 atom inclusion in map 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 diamond above a residue indicates a poor fit to the EM map for this residue (all-atom inclusion < 40%). 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.

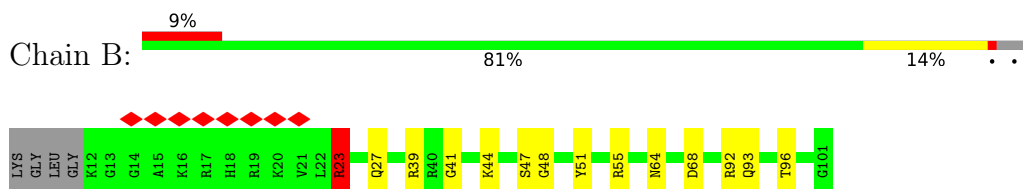
- Molecule 1: Histone H3-like centromeric protein A



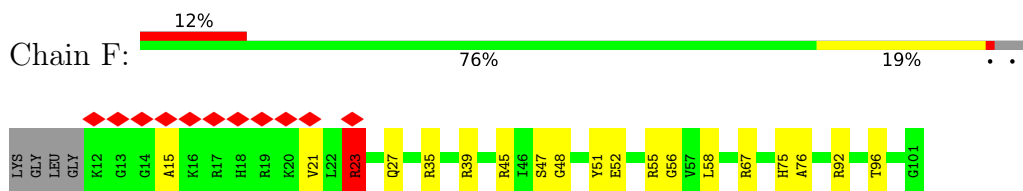
- Molecule 1: Histone H3-like centromeric protein A



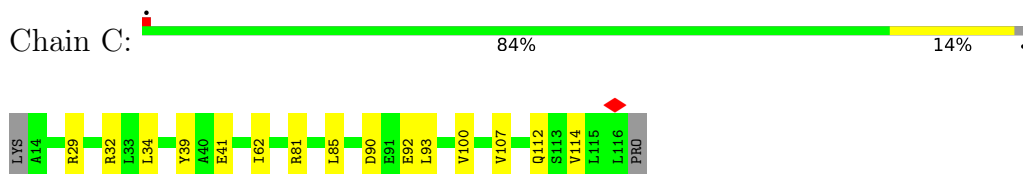
- Molecule 2: Histone H4



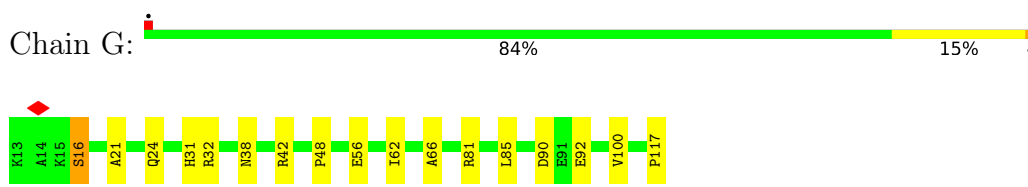
- Molecule 2: Histone H4



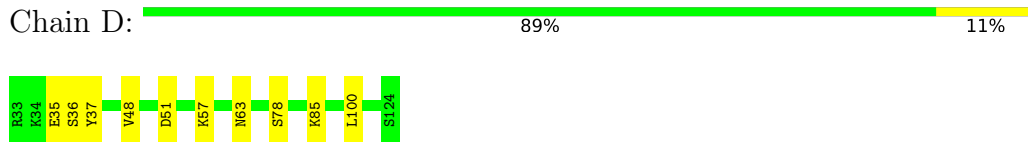
- Molecule 3: Histone H2A type 1-C



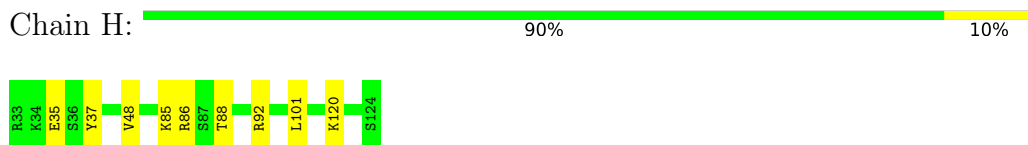
- Molecule 3: Histone H2A type 1-C



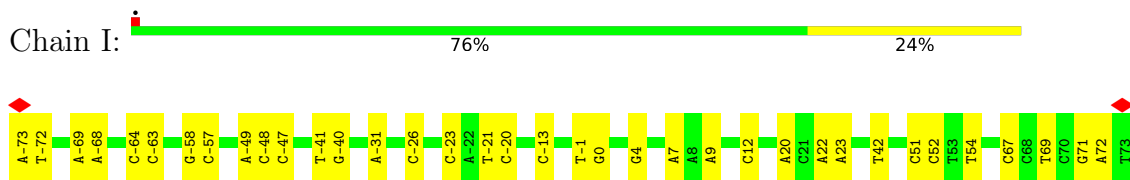
- Molecule 4: Histone H2B type 2-F



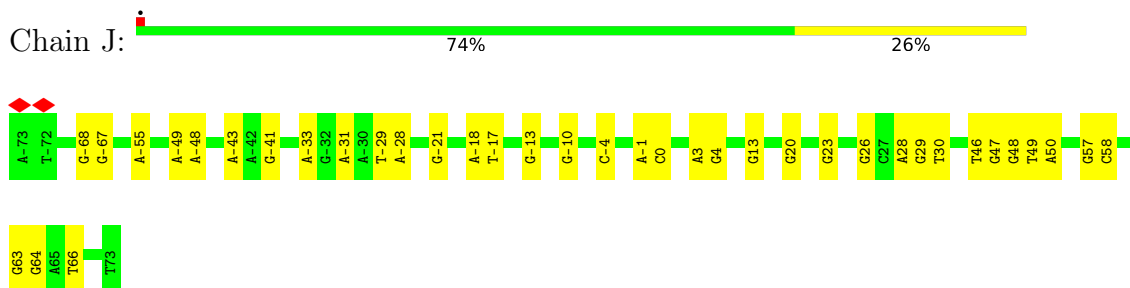
- Molecule 4: Histone H2B type 2-F



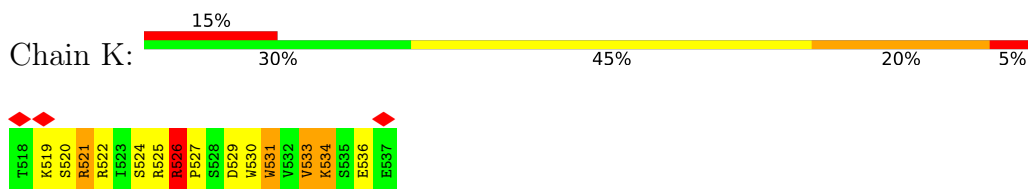
- Molecule 5: DNA (147-MER)



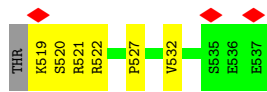
- Molecule 6: DNA (147-MER)



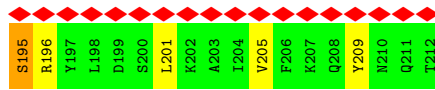
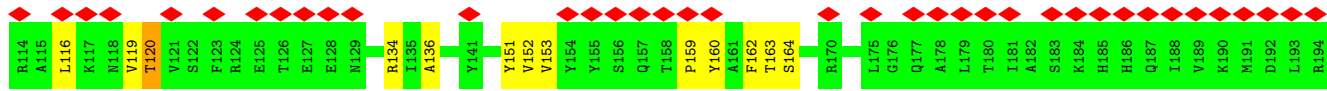
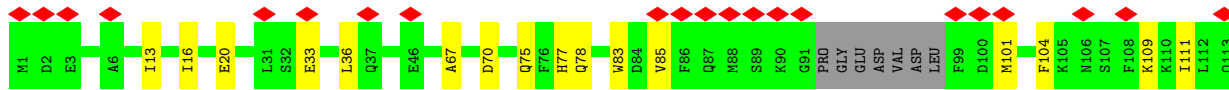
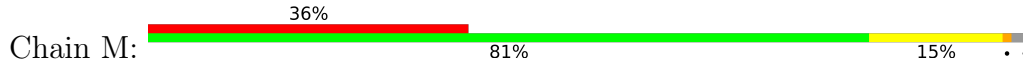
- Molecule 7: Centromere protein C



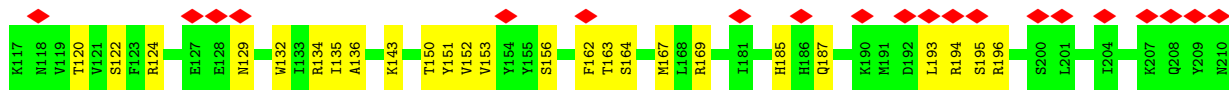
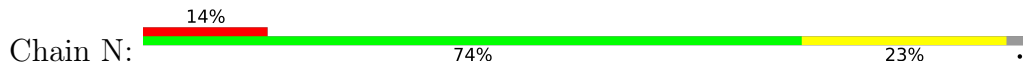
- Molecule 7: Centromere protein C



• Molecule 8: Centromere protein N



• Molecule 8: Centromere protein N



4 Experimental information

Property	Value	Source
EM reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, C1	Depositor
Number of particles used	188995	Depositor
Resolution determination method	FSC 0.143 CUT-OFF	Depositor
CTF correction method	PHASE FLIPPING AND AMPLITUDE CORRECTION	Depositor
Microscope	FEI TITAN KRIOS	Depositor
Voltage (kV)	300	Depositor
Electron dose ($e^-/\text{\AA}^2$)	40	Depositor
Minimum defocus (nm)	500	Depositor
Maximum defocus (nm)	3000	Depositor
Magnification	130000	Depositor
Image detector	GATAN K2 QUANTUM (4k x 4k)	Depositor
Maximum map value	0.259	Depositor
Minimum map value	-0.148	Depositor
Average map value	0.001	Depositor
Map value standard deviation	0.008	Depositor
Recommended contour level	0.02	Depositor
Map size (Å)	211.99998, 211.99998, 211.99998	wwPDB
Map dimensions	200, 200, 200	wwPDB
Map angles (°)	90.0, 90.0, 90.0	wwPDB
Pixel spacing (Å)	1.06, 1.06, 1.06	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	0.76	0/829	0.91	0/1118
1	E	0.79	0/824	0.91	0/1111
2	B	0.78	0/694	0.92	0/930
2	F	0.78	0/694	0.90	0/930
3	C	0.75	1/794 (0.1%)	0.82	0/1071
3	G	0.71	0/804	0.85	3/1085 (0.3%)
4	D	0.71	0/730	0.79	0/982
4	H	0.74	0/730	0.85	0/982
5	I	0.50	0/3355	0.56	0/5172
6	J	0.49	0/3399	0.55	0/5249
7	K	0.79	0/178	1.31	2/238 (0.8%)
7	L	0.32	0/173	0.92	0/231
8	M	0.39	1/1749 (0.1%)	0.68	3/2358 (0.1%)
8	N	0.30	0/1749	0.63	0/2358
All	All	0.58	2/16702 (0.0%)	0.71	8/23815 (0.0%)

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
1	E	0	2
2	B	0	1
2	F	0	2
7	K	0	1
7	L	0	1
8	M	0	1
All	All	0	9

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
8	M	195	SER	C-N	12.02	1.50	1.33
3	C	107	VAL	C-N	-6.29	1.24	1.33

The worst 5 of 8 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
8	M	195	SER	O-C-N	-13.15	104.83	122.59
8	M	195	SER	CA-C-N	9.82	140.27	122.79
8	M	195	SER	C-N-CA	9.82	140.27	122.79
3	G	117	PRO	N-CA-CB	6.79	110.47	103.00
7	K	521	ARG	CA-C-N	6.68	132.61	122.93

There are no chirality outliers.

5 of 9 planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	44	ARG	Peptide
2	B	23	ARG	Peptide
1	E	134	GLY	Peptide
1	E	135	LEU	Peptide
2	F	23	ARG	Peptide

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	814	0	829	7	0
1	E	809	0	827	7	0
2	B	687	0	700	10	0
2	F	687	0	700	13	0
3	C	785	0	819	16	0
3	G	795	0	822	18	0
4	D	719	0	738	8	0
4	H	719	0	738	8	0
5	I	2994	0	1664	32	0
6	J	3027	0	1664	34	0
7	K	174	0	171	44	0
7	L	169	0	168	9	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
8	M	1712	0	1738	29	0
8	N	1712	0	1738	28	0
All	All	15803	0	13316	198	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 8.

The worst 5 of 198 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:G:90:ASP:CG	7:K:522:ARG:NH2	1.80	1.36
7:K:526:ARG:HG3	7:K:527:PRO:CD	1.58	1.33
7:K:530:TRP:O	7:K:531:TRP:CE3	1.79	1.33
7:K:526:ARG:HG3	7:K:527:PRO:HD2	1.22	1.21
3:G:90:ASP:OD2	7:K:522:ARG:NH2	1.69	1.20

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 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	100/102 (98%)	90 (90%)	10 (10%)	0	100	100
1	E	99/102 (97%)	81 (82%)	17 (17%)	1 (1%)	12	44
2	B	88/94 (94%)	75 (85%)	12 (14%)	1 (1%)	11	43
2	F	88/94 (94%)	76 (86%)	10 (11%)	2 (2%)	5	30
3	C	101/105 (96%)	94 (93%)	7 (7%)	0	100	100
3	G	103/105 (98%)	97 (94%)	6 (6%)	0	100	100
4	D	90/92 (98%)	83 (92%)	7 (8%)	0	100	100
4	H	90/92 (98%)	83 (92%)	7 (8%)	0	100	100

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
7	K	18/20 (90%)	14 (78%)	2 (11%)	2 (11%)	0	5
7	L	17/20 (85%)	9 (53%)	8 (47%)	0	100	100
8	M	201/212 (95%)	178 (89%)	23 (11%)	0	100	100
8	N	201/212 (95%)	187 (93%)	14 (7%)	0	100	100
All	All	1196/1250 (96%)	1067 (89%)	123 (10%)	6 (0%)	26	57

5 of 6 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
7	K	531	TRP
2	F	21	VAL
1	E	135	LEU
2	F	23	ARG
2	B	23	ARG

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 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	80/87 (92%)	78 (98%)	2 (2%)	42	63
1	E	80/87 (92%)	80 (100%)	0	100	100
2	B	65/75 (87%)	65 (100%)	0	100	100
2	F	65/75 (87%)	65 (100%)	0	100	100
3	C	78/83 (94%)	77 (99%)	1 (1%)	61	72
3	G	78/83 (94%)	78 (100%)	0	100	100
4	D	79/79 (100%)	77 (98%)	2 (2%)	42	63
4	H	79/79 (100%)	77 (98%)	2 (2%)	42	63
7	K	19/20 (95%)	15 (79%)	4 (21%)	1	6
7	L	19/20 (95%)	19 (100%)	0	100	100
8	M	190/196 (97%)	190 (100%)	0	100	100
8	N	190/196 (97%)	190 (100%)	0	100	100

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles
All	All	1022/1080 (95%)	1011 (99%)	11 (1%)	63 74

5 of 11 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
7	K	526	ARG
7	K	533	VAL
7	K	536	GLU
7	K	534	LYS
4	D	85	LYS

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 23 such sidechains are listed below:

Mol	Chain	Res	Type
8	M	145	ASN
8	N	19	ASN
8	M	210	ASN
8	N	40	ASN
3	G	73	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.

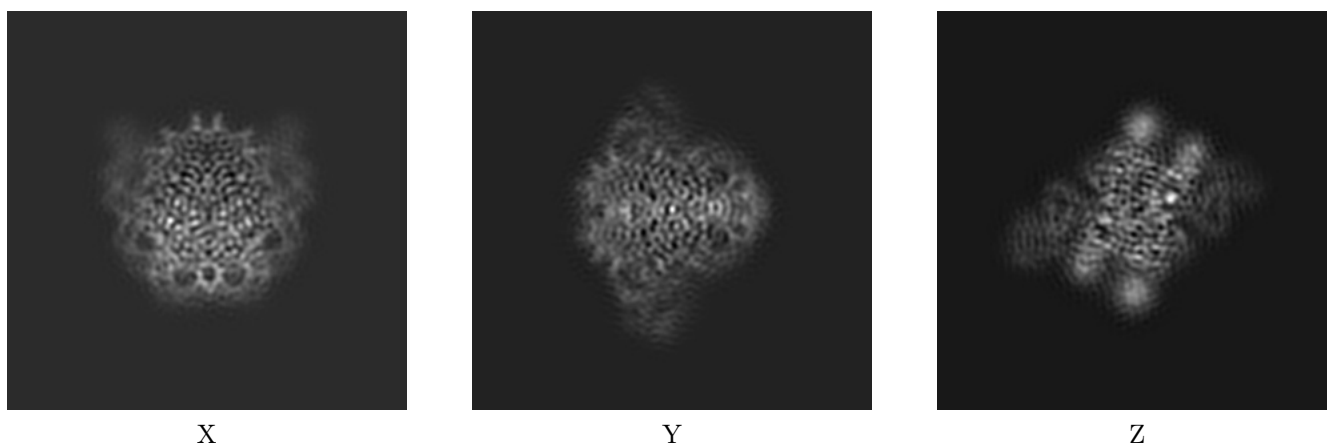
6 Map visualisation [i](#)

This section contains visualisations of the EMDB entry EMD-9251. These allow visual inspection of the internal detail of the map and identification of artifacts.

No raw map or half-maps were deposited for this entry and therefore no images, graphs, etc. pertaining to the raw map can be shown.

6.1 Orthogonal projections [i](#)

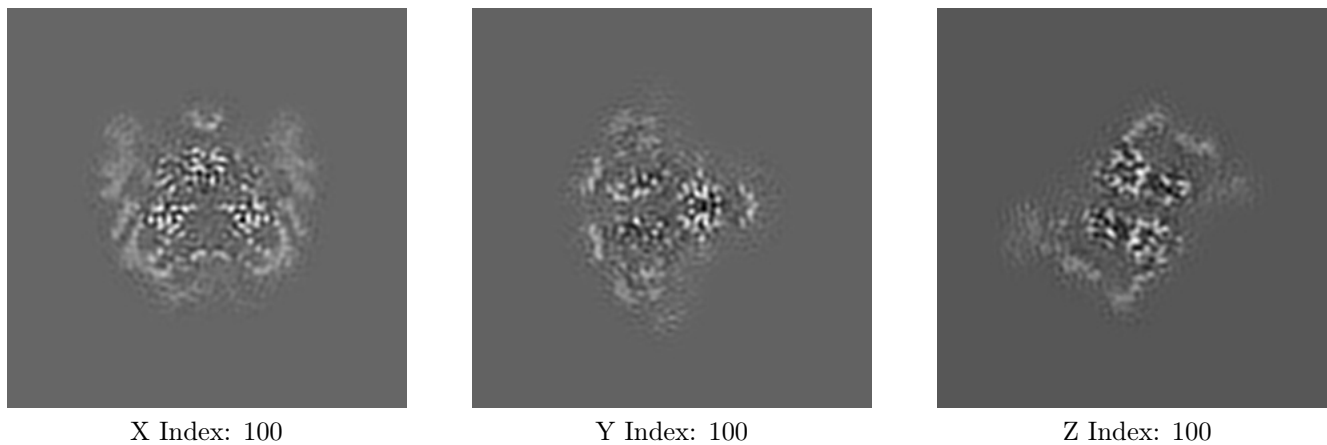
6.1.1 Primary map



The images above show the map projected in three orthogonal directions.

6.2 Central slices [i](#)

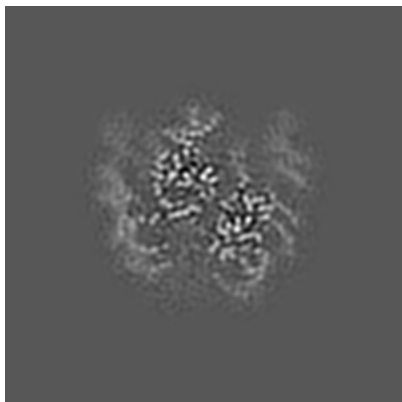
6.2.1 Primary map



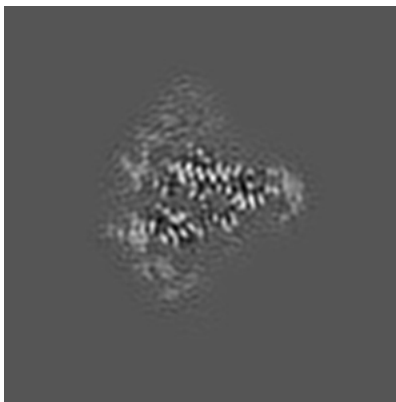
The images above show central slices of the map in three orthogonal directions.

6.3 Largest variance slices [i](#)

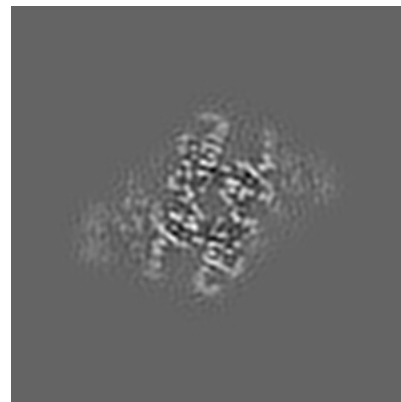
6.3.1 Primary map



X Index: 96



Y Index: 106

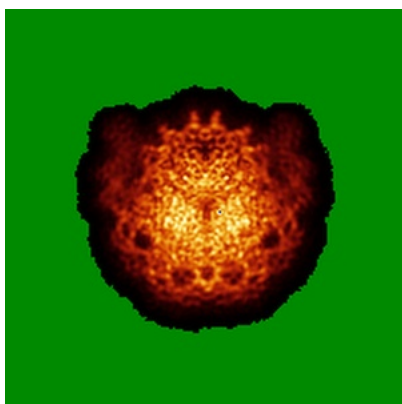


Z Index: 93

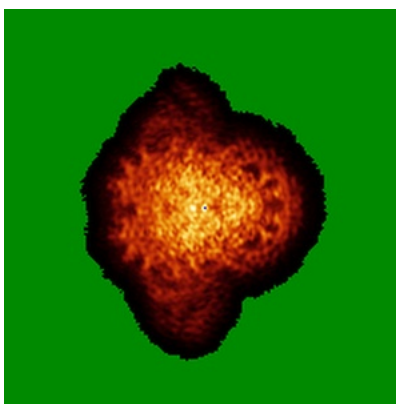
The images above show the largest variance slices of the map in three orthogonal directions.

6.4 Orthogonal standard-deviation projections (False-color) [i](#)

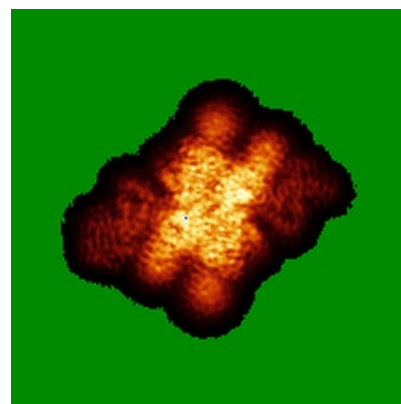
6.4.1 Primary map



X



Y



Z

The images above show the map standard deviation projections with false color in three orthogonal directions. Minimum values are shown in green, max in blue, and dark to light orange shades represent small to large values respectively.

6.5 Orthogonal surface views

This section was not generated.

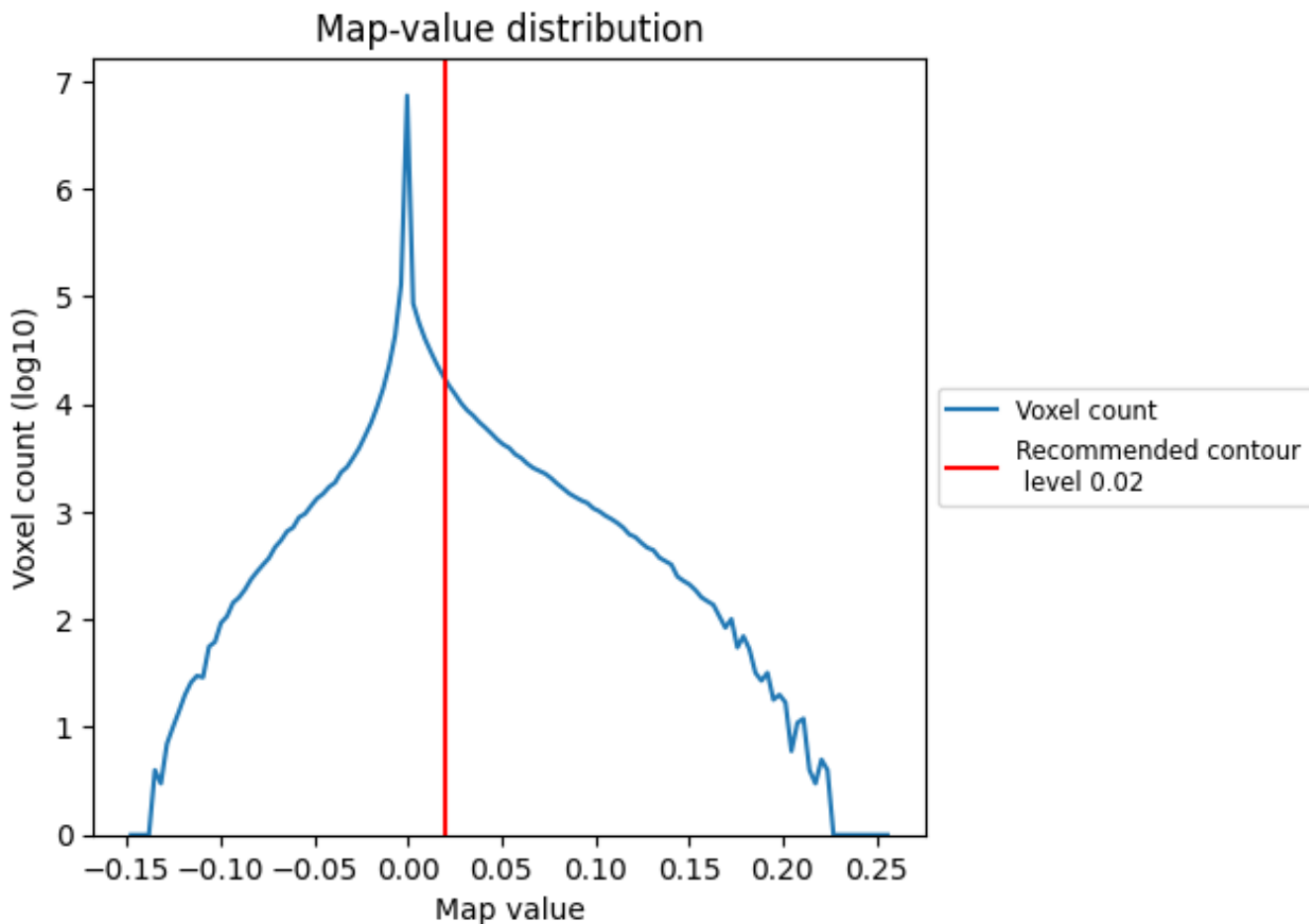
6.6 Mask visualisation

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

7 Map analysis [i](#)

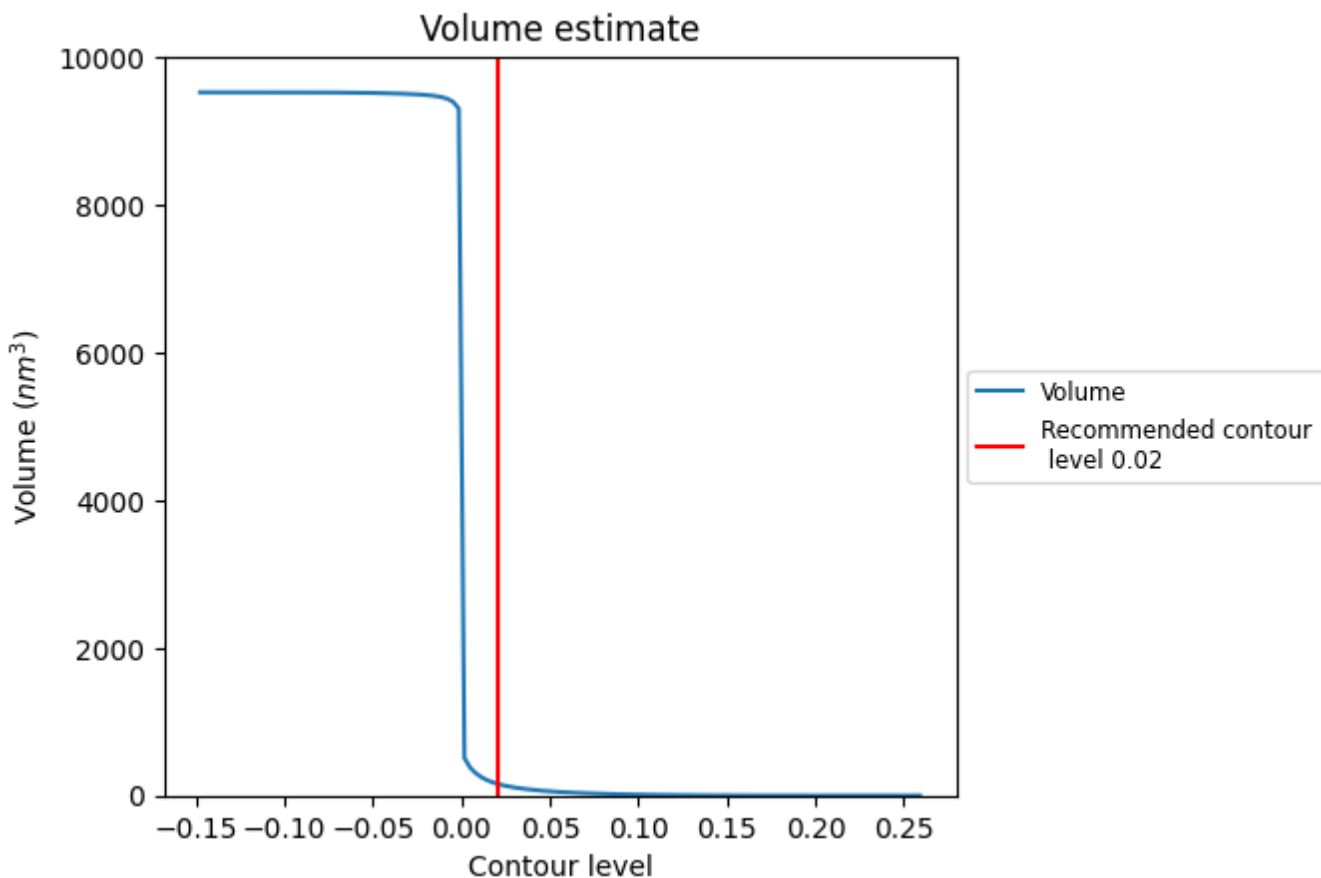
This section contains the results of statistical analysis of the map.

7.1 Map-value distribution [i](#)



The map-value distribution is plotted in 128 intervals along the x-axis. The y-axis is logarithmic. A spike in this graph at zero usually indicates that the volume has been masked.

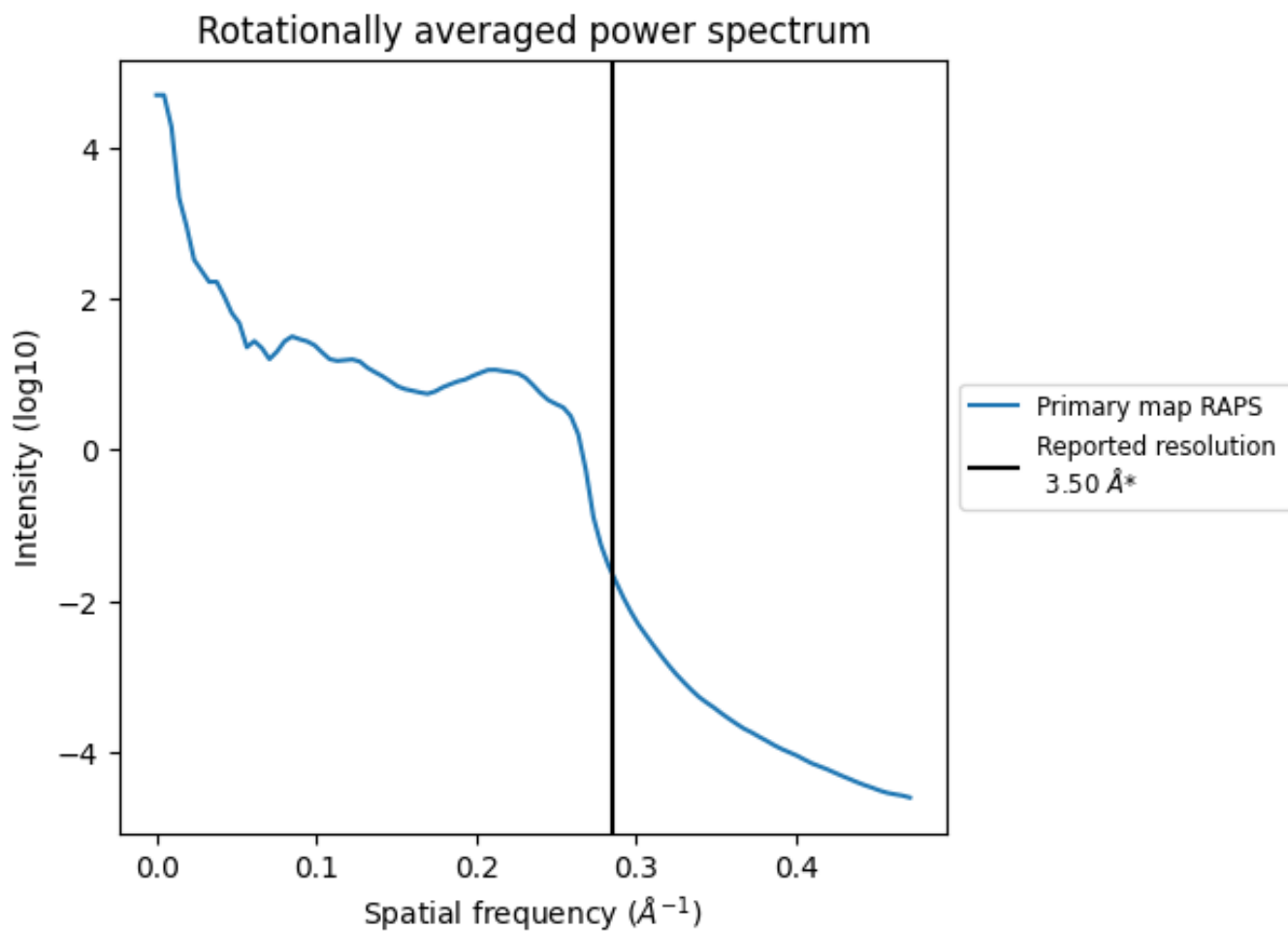
7.2 Volume estimate [\(i\)](#)



The volume at the recommended contour level is 161 nm^3 ; this corresponds to an approximate mass of 146 kDa.

The volume estimate graph shows how the enclosed volume varies with the contour level. The recommended contour level is shown as a vertical line and the intersection between the line and the curve gives the volume of the enclosed surface at the given level.

7.3 Rotationally averaged power spectrum i

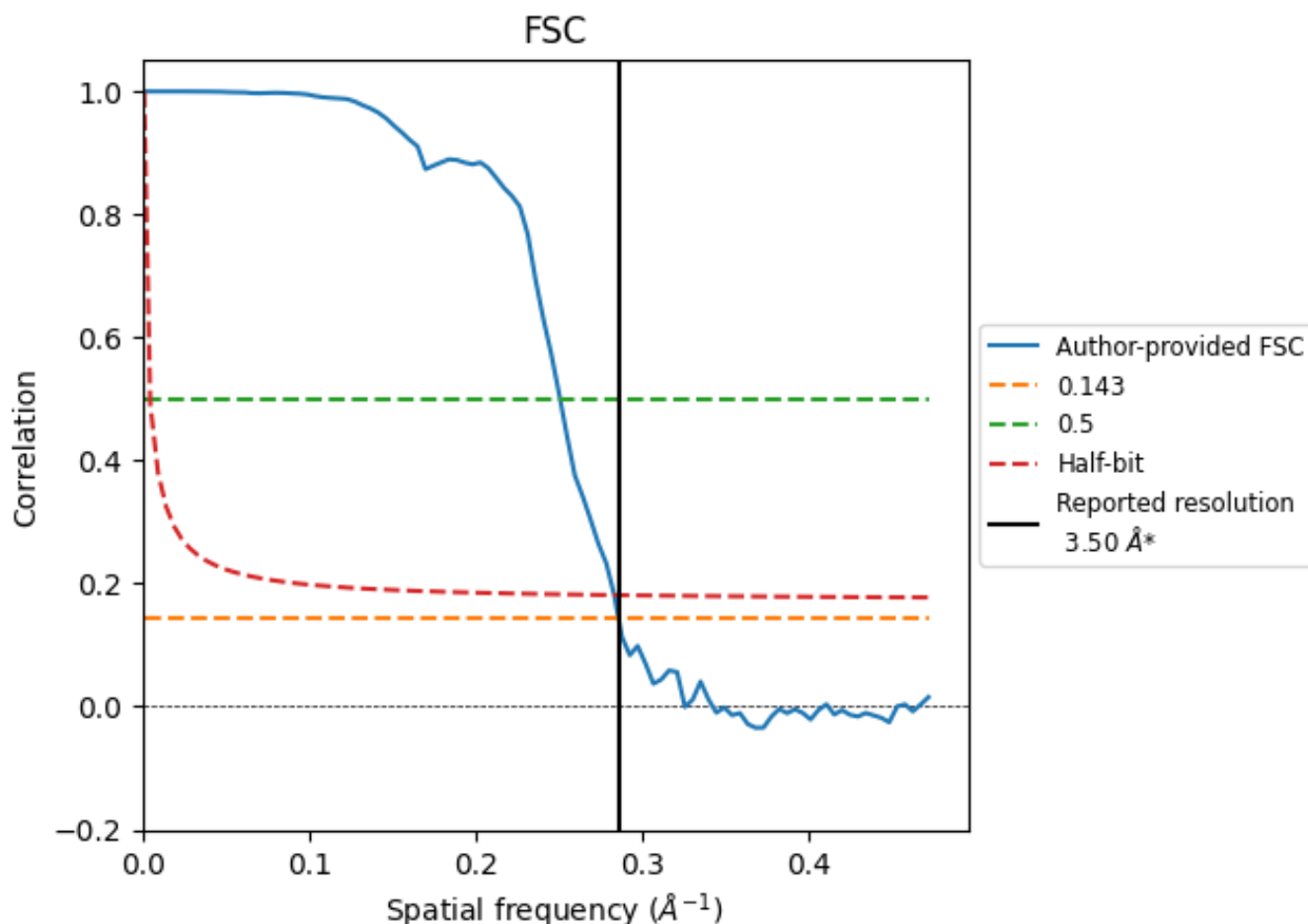


*Reported resolution corresponds to spatial frequency of 0.286 Å⁻¹

8 Fourier-Shell correlation [i](#)

Fourier-Shell Correlation (FSC) is the most commonly used method to estimate the resolution of single-particle and subtomogram-averaged maps. The shape of the curve depends on the imposed symmetry, mask and whether or not the two 3D reconstructions used were processed from a common reference. The reported resolution is shown as a black line. A curve is displayed for the half-bit criterion in addition to lines showing the 0.143 gold standard cut-off and 0.5 cut-off.

8.1 FSC [i](#)



*Reported resolution corresponds to spatial frequency of 0.286 \AA^{-1}

8.2 Resolution estimates [i](#)

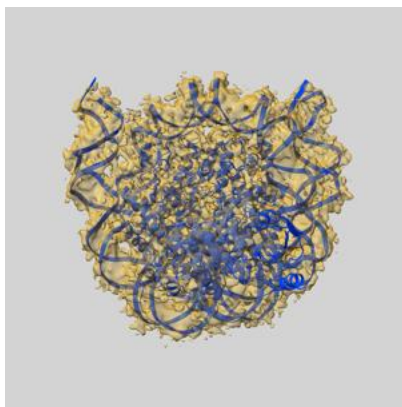
Resolution estimate (Å)	Estimation criterion (FSC cut-off)		
	0.143	0.5	Half-bit
Reported by author	3.50	-	-
Author-provided FSC curve	3.50	3.99	3.53
Unmasked-calculated*	-	-	-

*Resolution estimate based on FSC curve calculated by comparison of deposited half-maps.

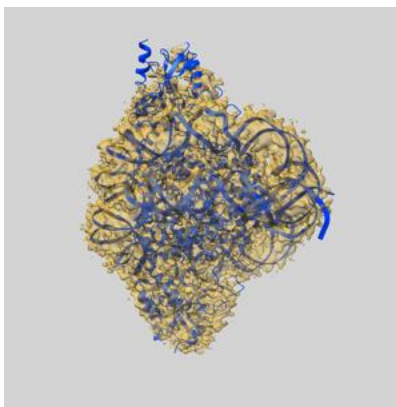
9 Map-model fit [i](#)

This section contains information regarding the fit between EMDB map EMD-9251 and PDB model 6MUP. Per-residue inclusion information can be found in section [3](#) on page [6](#).

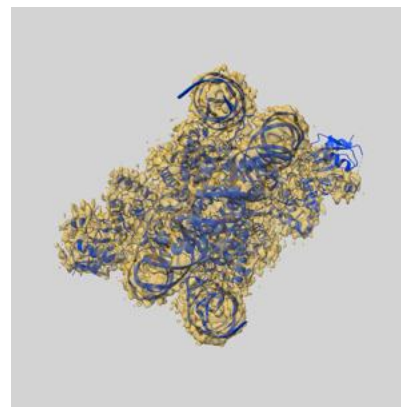
9.1 Map-model overlay [i](#)



X



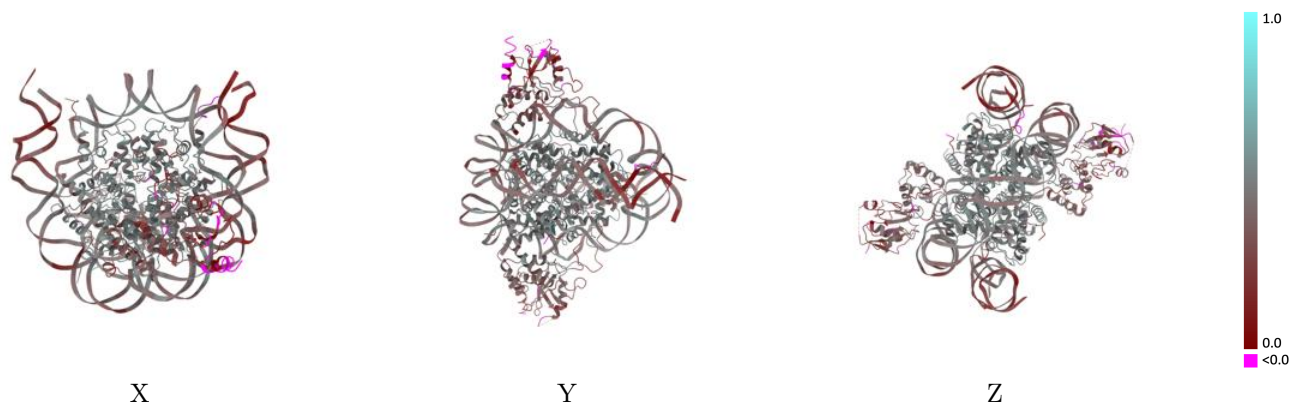
Y



Z

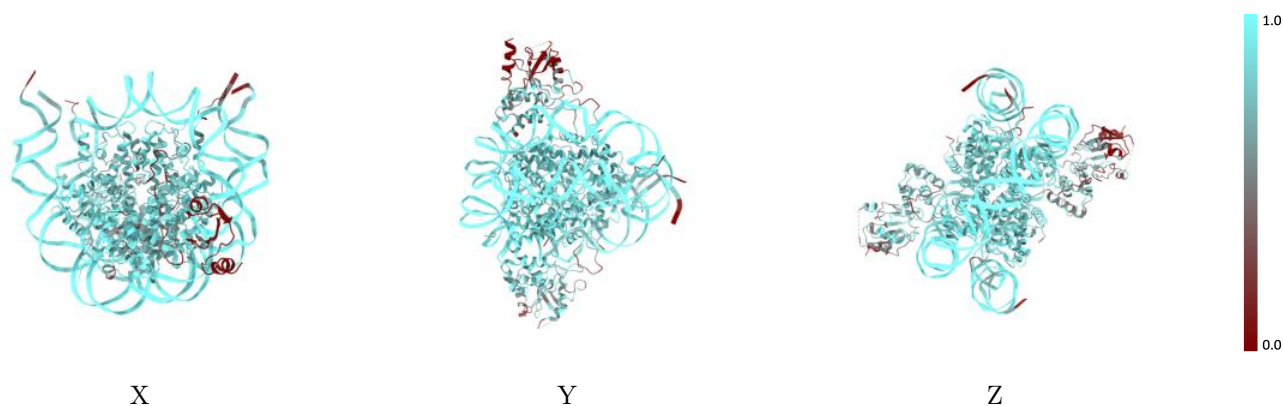
The images above show the 3D surface view of the map at the recommended contour level 0.02 at 50% transparency in yellow overlaid with a ribbon representation of the model coloured in blue. These images allow for the visual assessment of the quality of fit between the atomic model and the map.

9.2 Q-score mapped to coordinate model [\(i\)](#)



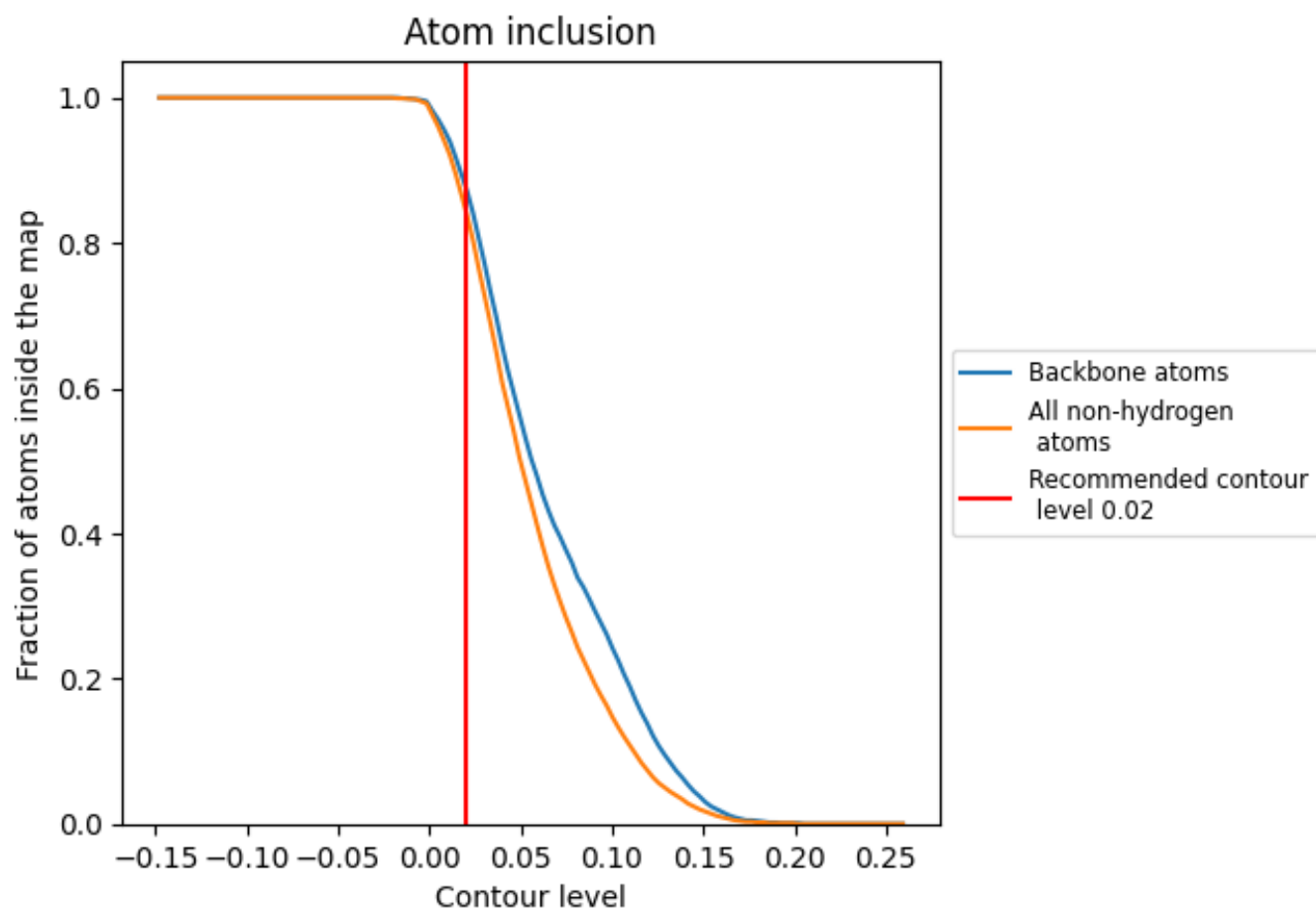
The images above show the model with each residue coloured according to its Q-score. This shows their resolvability in the map with higher Q-score values reflecting better resolvability. Please note: Q-score is calculating the resolvability of atoms, and thus high values are only expected at resolutions at which atoms can be resolved. Low Q-score values may therefore be expected for many entries.

9.3 Atom inclusion mapped to coordinate model [\(i\)](#)



The images above show the model with each residue coloured according to its atom inclusion. This shows to what extent they are inside the map at the recommended contour level (0.02).































9.4 Atom inclusion [i](#)



At the recommended contour level, 88% of all backbone atoms, 84% of all non-hydrogen atoms, are inside the map.

9.5 Map-model fit summary

The table lists the average atom inclusion at the recommended contour level (0.02) and Q-score for the entire model and for each chain.

Chain	Atom inclusion	Q-score
All	 0.8440	 0.4010
A	 0.8750	 0.4830
B	 0.8530	 0.4730
C	 0.9050	 0.4930
D	 0.9470	 0.5040
E	 0.8920	 0.4880
F	 0.8610	 0.4730
G	 0.9160	 0.4920
H	 0.9300	 0.5010
I	 0.9450	 0.3890
J	 0.9480	 0.3830
K	 0.7200	 0.3340
L	 0.6670	 0.3220
M	 0.4700	 0.2500
N	 0.6880	 0.3100

