



# wwPDB EM Validation Summary Report ⓘ

Feb 23, 2026 – 12:21 PM EST

PDB ID : 9NN1 / pdb\_00009nn1  
EMDB ID : EMD-49559  
Title : Yeast V1-ATPase bound to Rtc5p  
Authors : Khan, M.M.; Wilkens, S.  
Deposited on : 2025-03-04  
Resolution : 3.70 Å(reported)  
Based on initial models : 7tmm, 9moy

This is a wwPDB EM Validation Summary Report for a publicly released PDB entry.

We welcome your comments at [validation@mail.wwpdb.org](mailto: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>.

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The following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

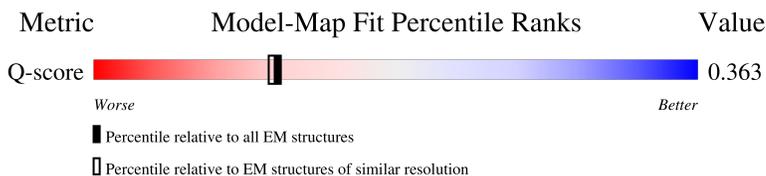
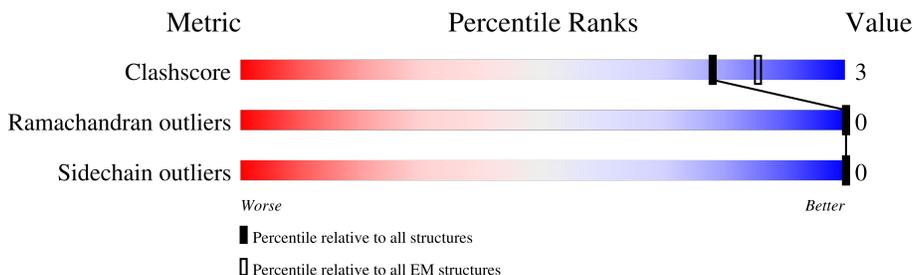
EMDB validation analysis : 0.0.1.dev132  
Mogul : 2022.3.0, CSD as543be (2022)  
MolProbity : 4-5-2 with Phenix2.0  
buster-report : 1.1.7 (2018)  
Percentile statistics : 20231227.v01 (using entries in the PDB archive December 27th 2023)  
EM percentile statistics : 202505.v01 (Using data in the EMDB 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) : 2.48.1

# 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 3.70 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	210492	15764	-
Ramachandran outliers	207382	16835	-
Sidechain outliers	206894	16415	-
Q-score	-	25397	11569 ( 3.20 - 4.20 )

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  $\geq 3$ , 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	617	91% 5% .
1	C	617	90% 6% .
1	E	617	90% 6% .
2	G	233	67% . 30%

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Mol	Chain	Length	Quality of chain
2	I	233	
2	K	233	
3	H	122	
3	J	122	
3	L	122	
4	M	256	
5	N	118	
6	R	567	
7	B	517	
7	D	517	
7	F	517	

## 2 Entry composition [i](#)

There are 8 unique types of molecules in this entry. The entry contains 77843 atoms, of which 39011 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 H(+)-transporting two-sector ATPase.

Mol	Chain	Residues	Atoms					AltConf	Trace	
			Total	C	H	N	O			S
1	A	594	9113	2909	4526	761	897	20	0	0
1	C	594	9114	2909	4527	761	897	20	0	0
1	E	594	9114	2909	4527	761	897	20	0	0

- Molecule 2 is a protein called V-type proton ATPase subunit E.

Mol	Chain	Residues	Atoms					AltConf	Trace	
			Total	C	H	N	O			S
2	G	163	2652	817	1358	219	254	4	0	0
2	I	220	3595	1103	1834	303	350	5	0	0
2	K	212	3469	1068	1771	291	335	4	0	0

- Molecule 3 is a protein called Yeast V-ATPase subunit G.

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	H	N	O		
3	H	50	781	238	406	63	74	0	0
3	J	108	1743	532	896	148	167	0	0
3	L	99	1614	493	829	137	155	0	0

- Molecule 4 is a protein called V-type proton ATPase subunit D.

Mol	Chain	Residues	Atoms					AltConf	Trace	
			Total	C	H	N	O			S
4	M	221	3604	1112	1825	322	340	5	0	0

- Molecule 5 is a protein called V-type proton ATPase subunit F.

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	H	N	O		
5	N	115	1857	589	929	157	182	0	0

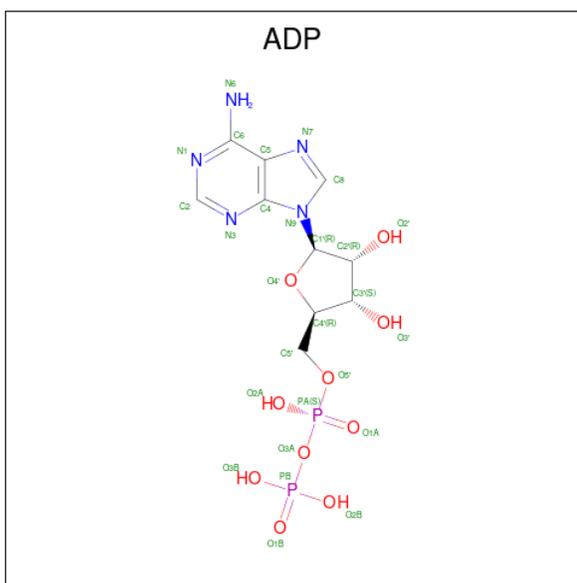
- Molecule 6 is a protein called Restriction of telomere capping protein 5.

Mol	Chain	Residues	Atoms					AltConf	Trace	
			Total	C	H	N	O			S
6	R	556	8888	2825	4446	748	846	23	0	0

- Molecule 7 is a protein called V-type proton ATPase subunit B.

Mol	Chain	Residues	Atoms						AltConf	Trace
			Total	C	H	N	O	S		
7	B	471	7410	2347	3704	634	713	12	0	0
7	D	471	7409	2347	3703	634	713	12	0	0
7	F	473	7441	2355	3718	639	717	12	0	0

- Molecule 8 is ADENOSINE-5'-DIPHOSPHATE (CCD ID: ADP) (formula:  $C_{10}H_{15}N_5O_{10}P_2$ ).

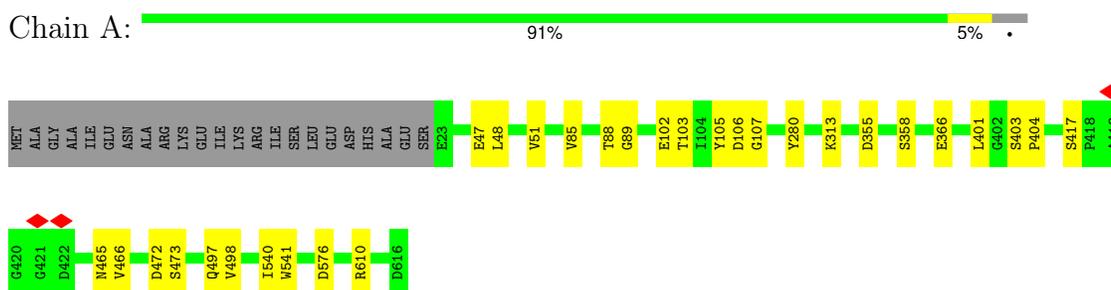


Mol	Chain	Residues	Atoms						AltConf
			Total	C	H	N	O	P	
8	E	1	39	10	12	5	10	2	0

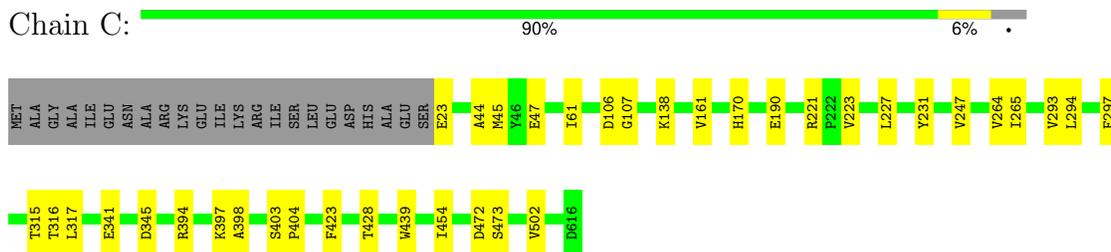
### 3 Residue-property plots

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 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.

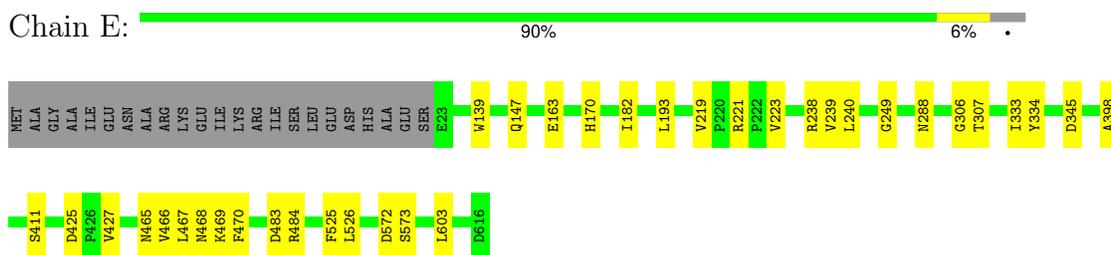
- Molecule 1: H(+)-transporting two-sector ATPase



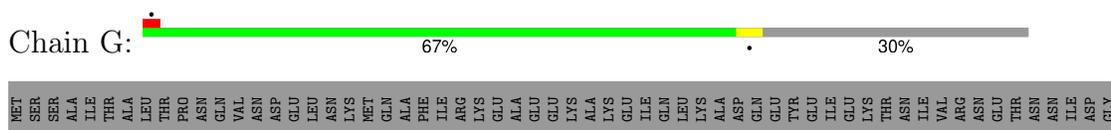
- Molecule 1: H(+)-transporting two-sector ATPase



- Molecule 1: H(+)-transporting two-sector ATPase

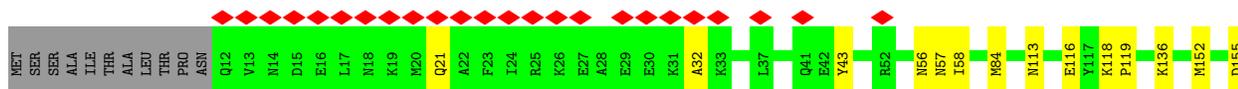
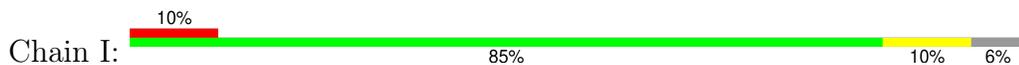


- Molecule 2: V-type proton ATPase subunit E

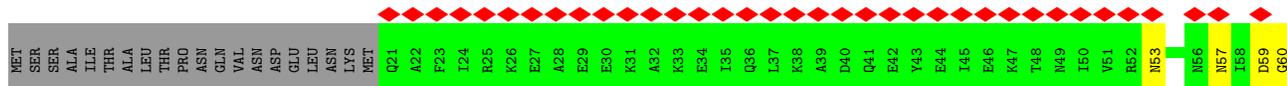
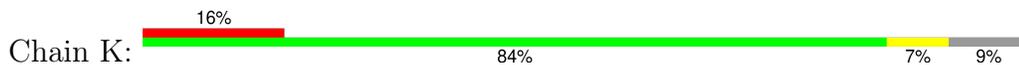




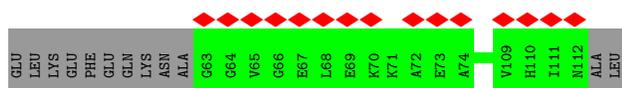
• Molecule 2: V-type proton ATPase subunit E



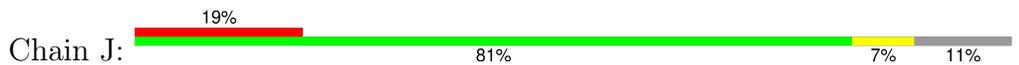
• Molecule 2: V-type proton ATPase subunit E



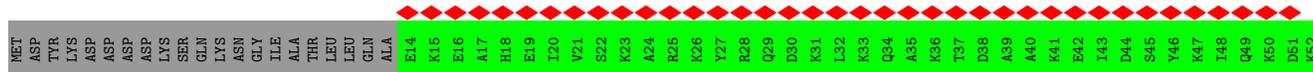
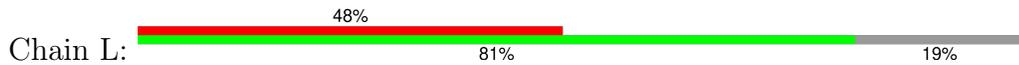
• Molecule 3: Yeast V-ATPase subunit G



• Molecule 3: Yeast V-ATPase subunit G

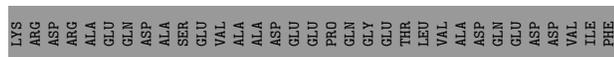
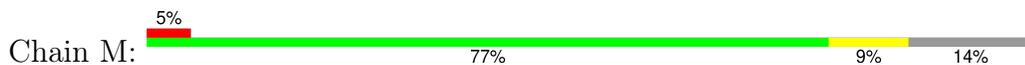


• Molecule 3: Yeast V-ATPase subunit G

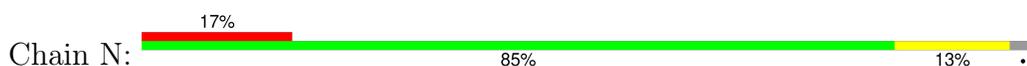




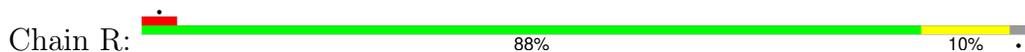
- Molecule 4: V-type proton ATPase subunit D



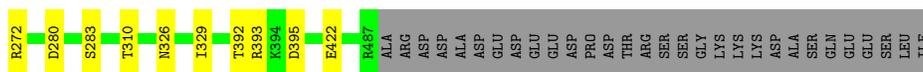
- Molecule 5: V-type proton ATPase subunit F



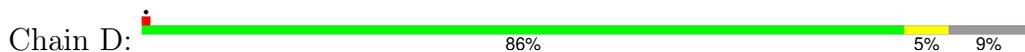
- Molecule 6: Restriction of telomere capping protein 5

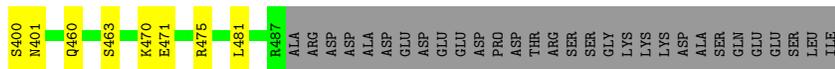


- Molecule 7: V-type proton ATPase subunit B

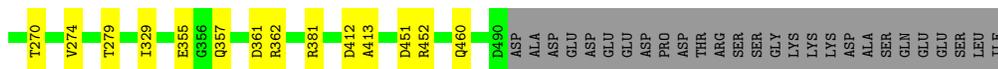
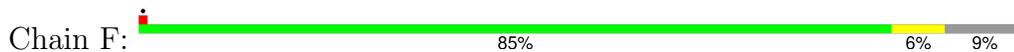


- Molecule 7: V-type proton ATPase subunit B





• Molecule 7: V-type proton ATPase subunit B



## 4 Experimental information

Property	Value	Source
EM reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, Not provided	
Number of particles used	67351	Depositor
Resolution determination method	FSC 0.143 CUT-OFF	Depositor
CTF correction method	PHASE FLIPPING AND AMPLITUDE CORRECTION	Depositor
Microscope	TFS GLACIOS	Depositor
Voltage (kV)	200	Depositor
Electron dose ( $e^-/\text{\AA}^2$ )	49.25	Depositor
Minimum defocus (nm)	400	Depositor
Maximum defocus (nm)	2000	Depositor
Magnification	Not provided	
Image detector	TFS FALCON 4i (4k x 4k)	Depositor
Maximum map value	0.059	Depositor
Minimum map value	-0.013	Depositor
Average map value	0.000	Depositor
Map value standard deviation	0.001	Depositor
Recommended contour level	0.006	Depositor
Map size (Å)	426.24, 426.24, 426.24	wwPDB
Map dimensions	256, 256, 256	wwPDB
Map angles (°)	90.0, 90.0, 90.0	wwPDB
Pixel spacing (Å)	1.665, 1.665, 1.665	Depositor

## 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: ADP

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	0.13	0/4686	0.25	0/6351
1	C	0.14	0/4686	0.27	0/6351
1	E	0.13	0/4686	0.26	0/6351
2	G	0.09	0/1305	0.24	0/1752
2	I	0.11	0/1774	0.26	0/2376
2	K	0.11	0/1712	0.25	0/2293
3	H	0.15	0/376	0.22	0/501
3	J	0.11	0/852	0.23	0/1133
3	L	0.10	0/790	0.22	0/1048
4	M	0.14	0/1798	0.26	0/2411
5	N	0.13	0/944	0.27	0/1277
6	R	0.13	0/4531	0.28	0/6116
7	B	0.14	0/3776	0.27	0/5114
7	D	0.13	0/3776	0.27	0/5114
7	F	0.15	0/3792	0.29	0/5134
All	All	0.13	0/39484	0.26	0/53322

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	4587	4526	4525	16	0
1	C	4587	4527	4525	22	0
1	E	4587	4527	4525	22	0
2	G	1294	1358	1357	5	0
2	I	1761	1834	1833	19	0
2	K	1698	1771	1770	10	0
3	H	375	406	405	0	0
3	J	847	896	895	11	0
3	L	785	829	828	0	0
4	M	1779	1825	1824	18	0
5	N	928	929	926	14	0
6	R	4442	4446	4440	36	0
7	B	3706	3704	3700	19	0
7	D	3706	3703	3700	16	0
7	F	3723	3718	3715	20	0
8	E	27	12	12	1	0
All	All	38832	39011	38980	208	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 3.

The worst 5 of 208 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)
6:R:40:THR:OG1	6:R:43:GLU:OE1	1.91	0.88
2:K:202:THR:OG1	2:K:205:GLU:OE1	1.94	0.85
7:F:266:LEU:O	7:F:270:THR:OG1	1.96	0.82
1:A:280:TYR:OH	1:A:355:ASP:OD2	1.98	0.81
4:M:44:ARG:NH1	5:N:116:PHE:O	2.15	0.79

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	592/617 (96%)	575 (97%)	17 (3%)	0	100	100
1	C	592/617 (96%)	576 (97%)	16 (3%)	0	100	100
1	E	592/617 (96%)	569 (96%)	23 (4%)	0	100	100
2	G	161/233 (69%)	160 (99%)	1 (1%)	0	100	100
2	I	218/233 (94%)	216 (99%)	2 (1%)	0	100	100
2	K	210/233 (90%)	206 (98%)	4 (2%)	0	100	100
3	H	48/122 (39%)	47 (98%)	1 (2%)	0	100	100
3	J	106/122 (87%)	105 (99%)	1 (1%)	0	100	100
3	L	97/122 (80%)	97 (100%)	0	0	100	100
4	M	219/256 (86%)	212 (97%)	7 (3%)	0	100	100
5	N	113/118 (96%)	107 (95%)	6 (5%)	0	100	100
6	R	554/567 (98%)	539 (97%)	15 (3%)	0	100	100
7	B	467/517 (90%)	458 (98%)	9 (2%)	0	100	100
7	D	467/517 (90%)	456 (98%)	11 (2%)	0	100	100
7	F	469/517 (91%)	458 (98%)	11 (2%)	0	100	100
All	All	4905/5408 (91%)	4781 (98%)	124 (2%)	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 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	498/516 (96%)	498 (100%)	0	100	100
1	C	498/516 (96%)	498 (100%)	0	100	100
1	E	498/516 (96%)	498 (100%)	0	100	100
2	G	146/208 (70%)	146 (100%)	0	100	100
2	I	197/208 (95%)	197 (100%)	0	100	100
2	K	189/208 (91%)	189 (100%)	0	100	100

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
3	H	40/102 (39%)	40 (100%)	0	100	100
3	J	89/102 (87%)	89 (100%)	0	100	100
3	L	83/102 (81%)	83 (100%)	0	100	100
4	M	192/221 (87%)	192 (100%)	0	100	100
5	N	102/104 (98%)	102 (100%)	0	100	100
6	R	499/510 (98%)	499 (100%)	0	100	100
7	B	403/444 (91%)	403 (100%)	0	100	100
7	D	403/444 (91%)	403 (100%)	0	100	100
7	F	404/444 (91%)	404 (100%)	0	100	100
All	All	4241/4645 (91%)	4241 (100%)	0	100	100

There are no protein residues with a non-rotameric sidechain to report.

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 32 such sidechains are listed below:

Mol	Chain	Res	Type
7	F	54	ASN
7	F	64	GLN
6	R	38	GLN
5	N	72	HIS
7	F	162	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

1 ligand is 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
8	ADP	E	701	-	24,29,29	0.85	0	29,45,45	1.29	2 (6%)

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
8	ADP	E	701	-	-	1/12/32/32	0/3/3/3

There are no bond length outliers.

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
8	E	701	ADP	N3-C2-N1	-4.05	123.17	128.67
8	E	701	ADP	C4-C5-N7	-2.40	106.80	109.34

There are no chirality outliers.

All (1) torsion outliers are listed below:

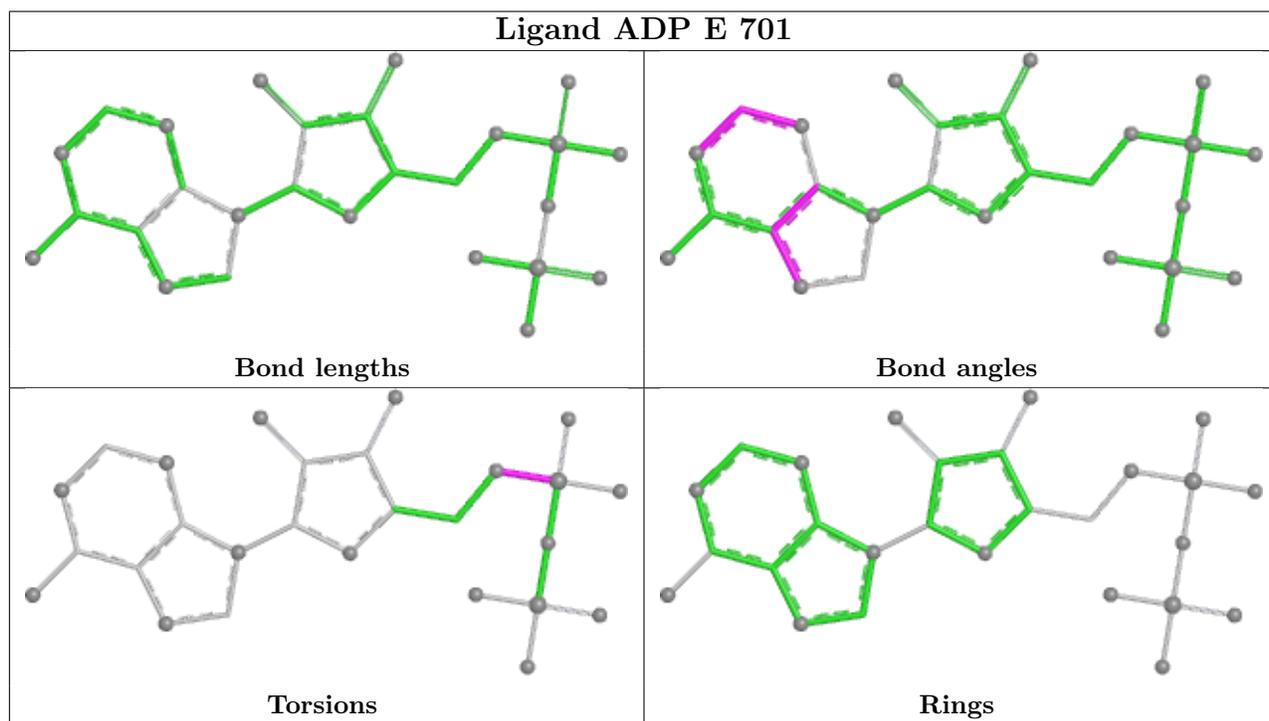
Mol	Chain	Res	Type	Atoms
8	E	701	ADP	C5'-O5'-PA-O1A

There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
8	E	701	ADP	1	0

The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less than 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier. Any bond that is central to one or more torsion angles identified as an outlier by Mogul will be highlighted in the graph. For rings, the root-mean-square deviation (RMSD) between the ring in question and similar rings identified by Mogul is calculated over all ring torsion angles. If the average RMSD is greater than 60 degrees and the minimal RMSD between the ring in question and any Mogul-identified rings is also greater than 60 degrees, then that ring is considered an outlier. The outliers are highlighted in purple. The color gray indicates Mogul did not find sufficient equivalents in the CSD to analyse the geometry.



## 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.

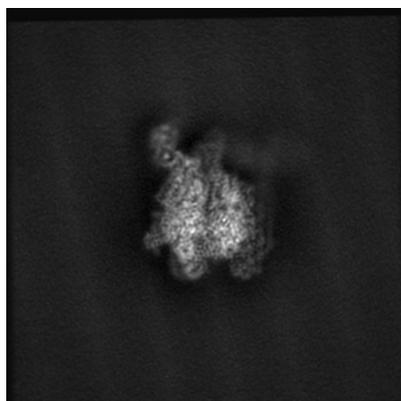
## 6 Map visualisation [i](#)

This section contains visualisations of the EMDB entry EMD-49559. These allow visual inspection of the internal detail of the map and identification of artifacts.

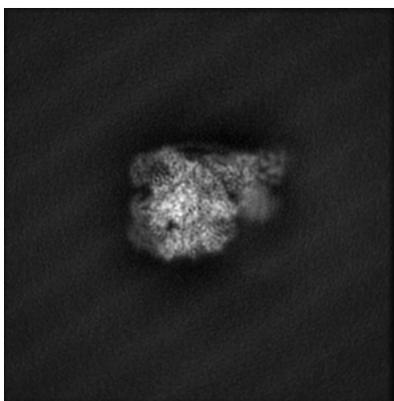
No raw map or half-maps were deposited for this entry and therefore no images, graphs, etc. pertaining to the raw map can be shown.

### 6.1 Orthogonal projections [i](#)

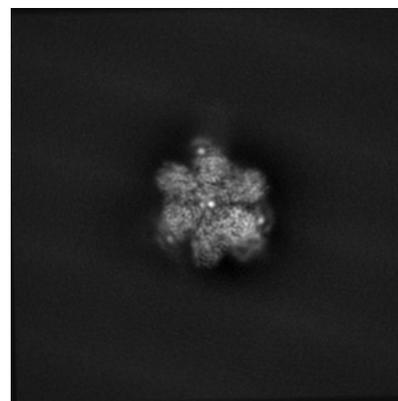
#### 6.1.1 Primary map



X



Y

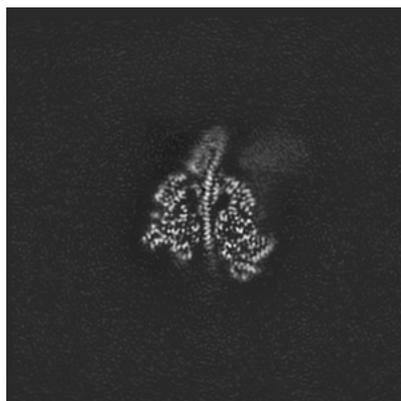


Z

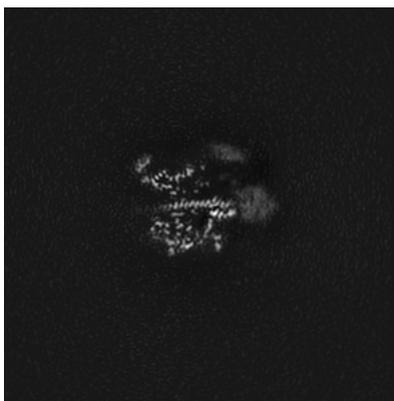
The images above show the map projected in three orthogonal directions.

### 6.2 Central slices [i](#)

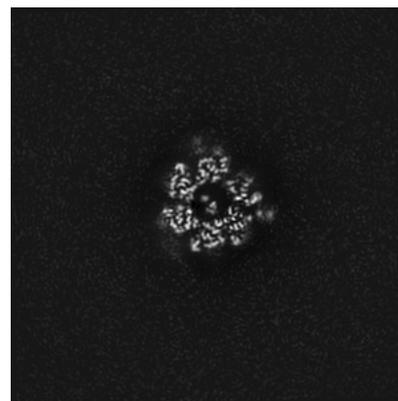
#### 6.2.1 Primary map



X Index: 128



Y Index: 128

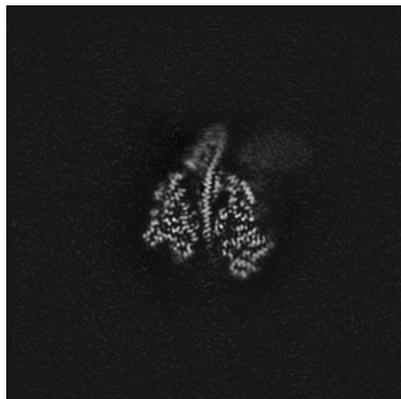


Z Index: 128

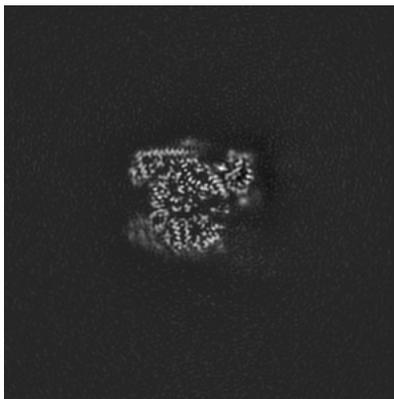
The images above show central slices of the map in three orthogonal directions.

## 6.3 Largest variance slices [i](#)

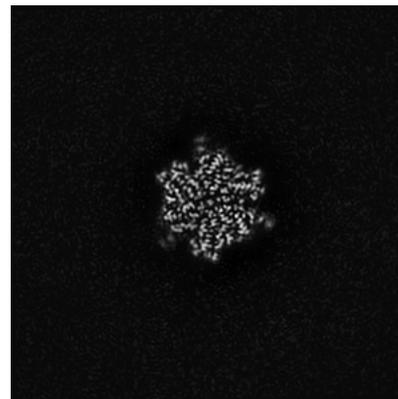
### 6.3.1 Primary map



X Index: 129



Y Index: 118

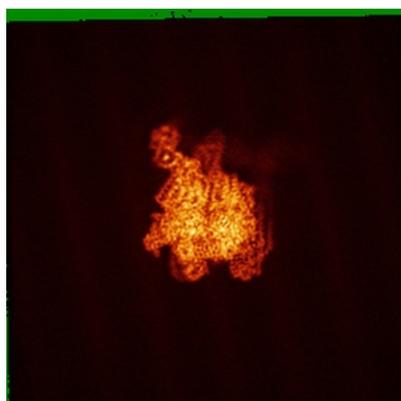


Z Index: 113

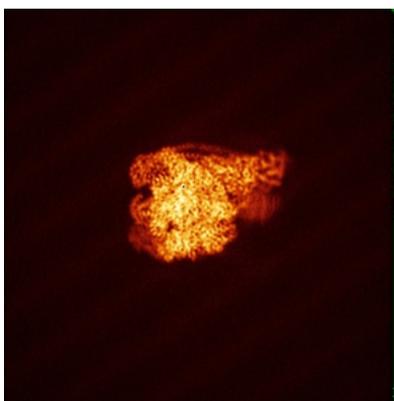
The images above show the largest variance slices of the map in three orthogonal directions.

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

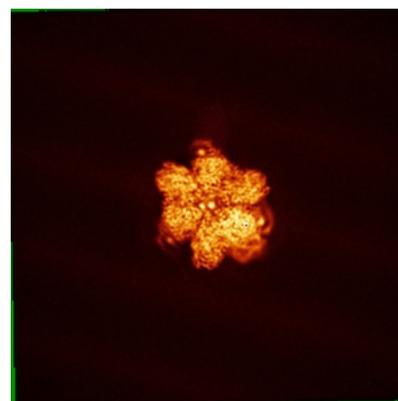
### 6.4.1 Primary map



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 [i](#)

### 6.5.1 Primary map



X



Y



Z

The images above show the 3D surface view of the map at the recommended contour level 0.006. These images, in conjunction with the slice images, may facilitate assessment of whether an appropriate contour level has been provided.

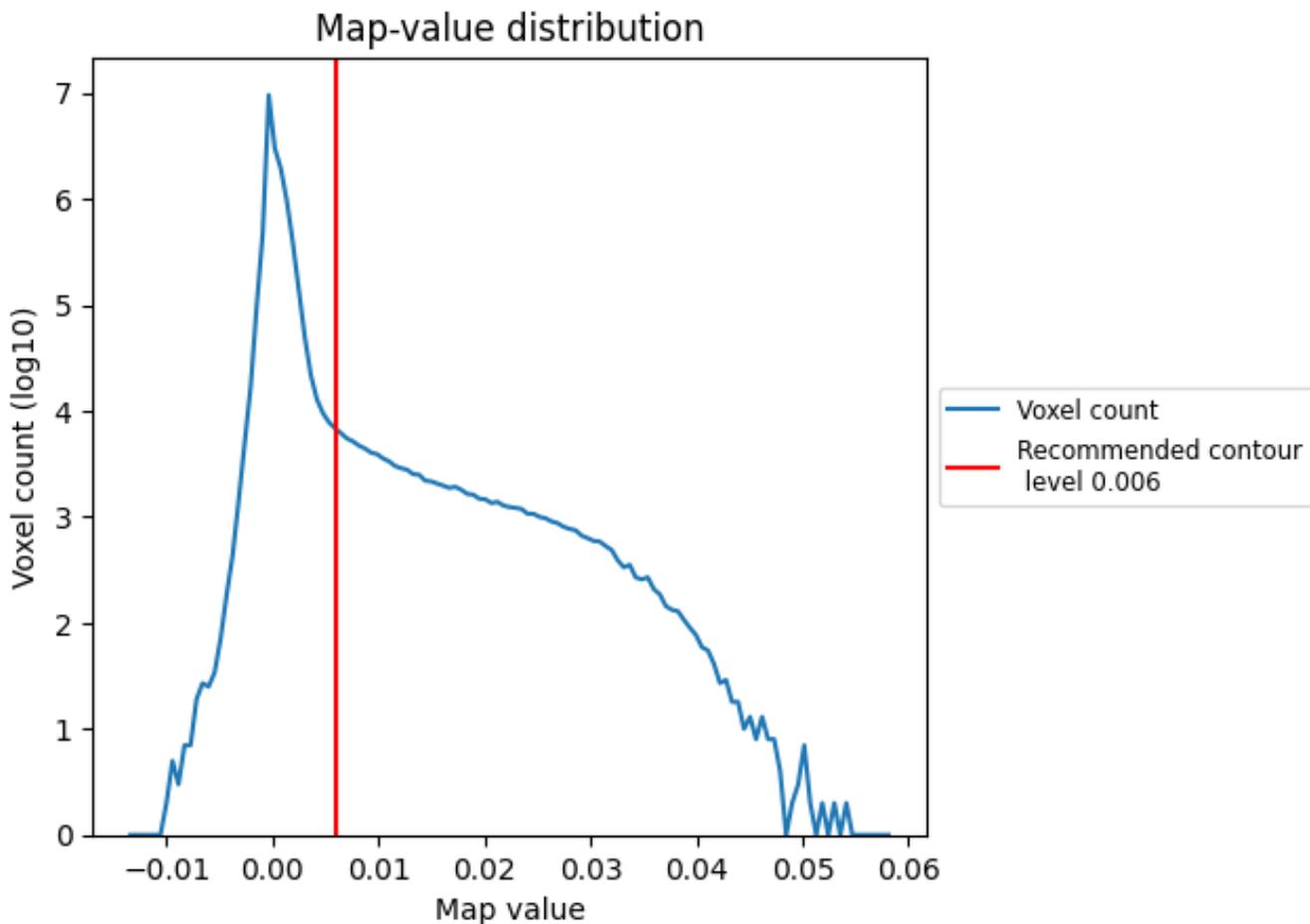
## 6.6 Mask visualisation [i](#)

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

## 7 Map analysis [i](#)

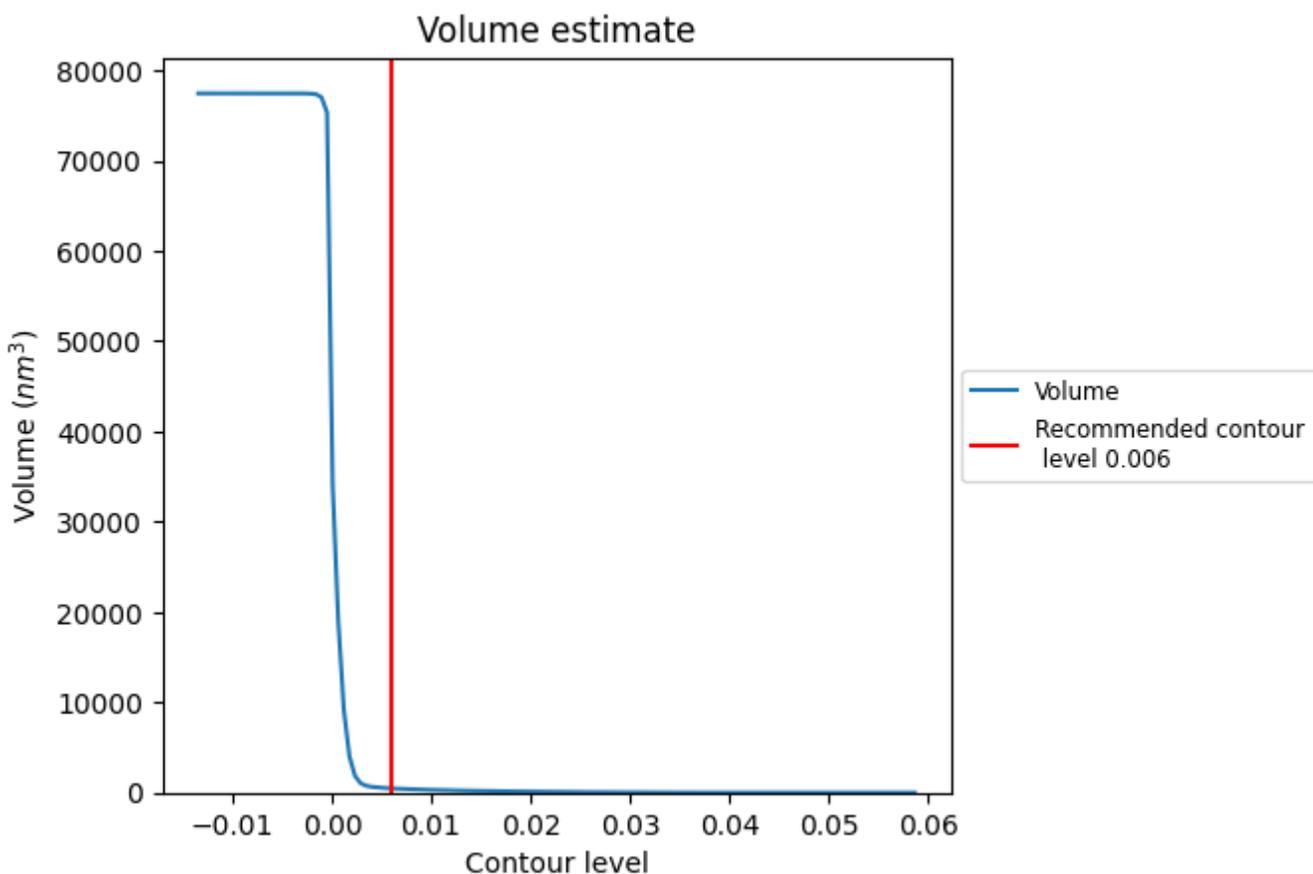
This section contains the results of statistical analysis of the map.

### 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.

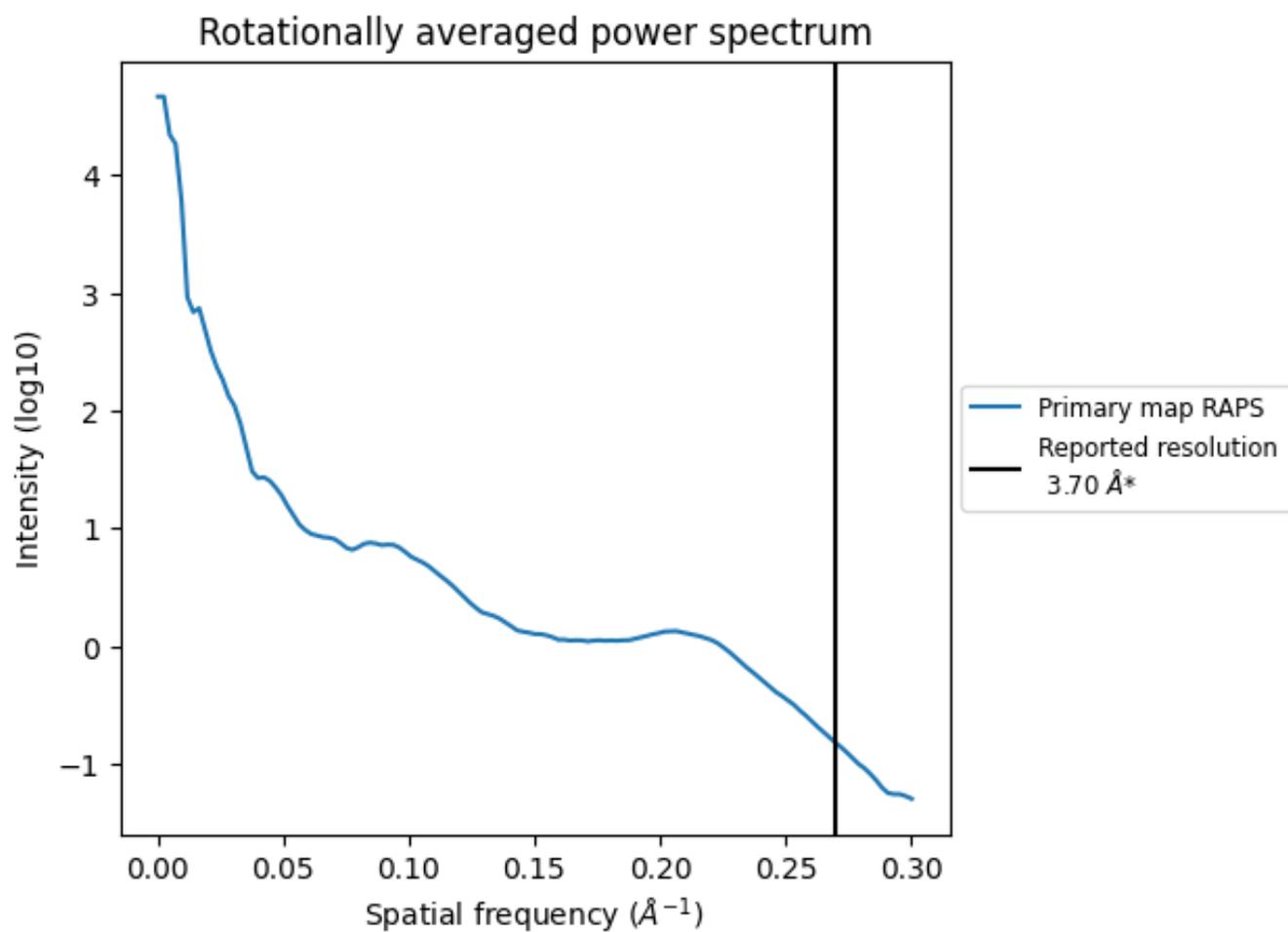
## 7.2 Volume estimate [\(i\)](#)



The volume at the recommended contour level is 474 nm<sup>3</sup>; this corresponds to an approximate mass of 428 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 0.270 Å<sup>-1</sup>

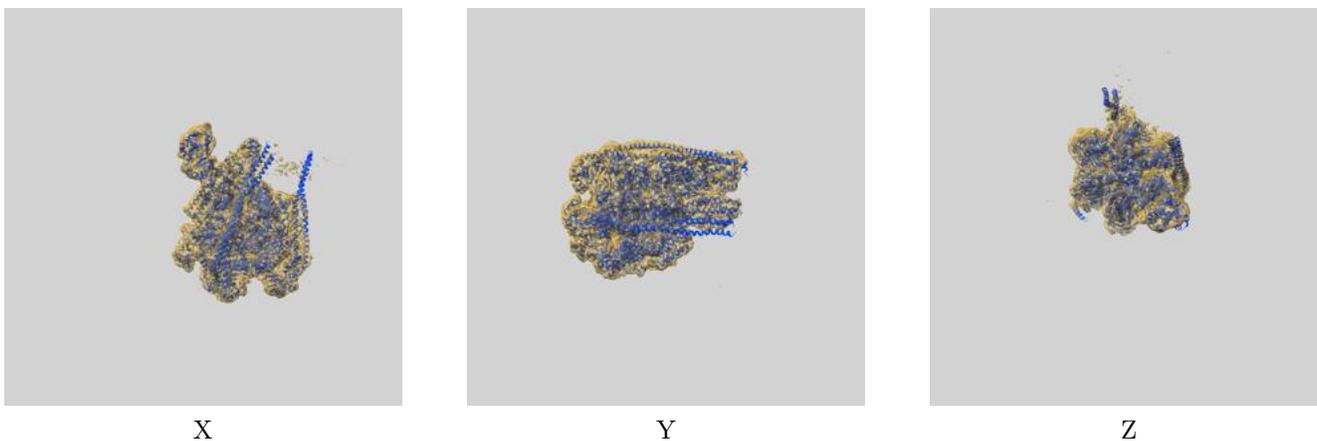
## 8 Fourier-Shell correlation

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

## 9 Map-model fit [i](#)

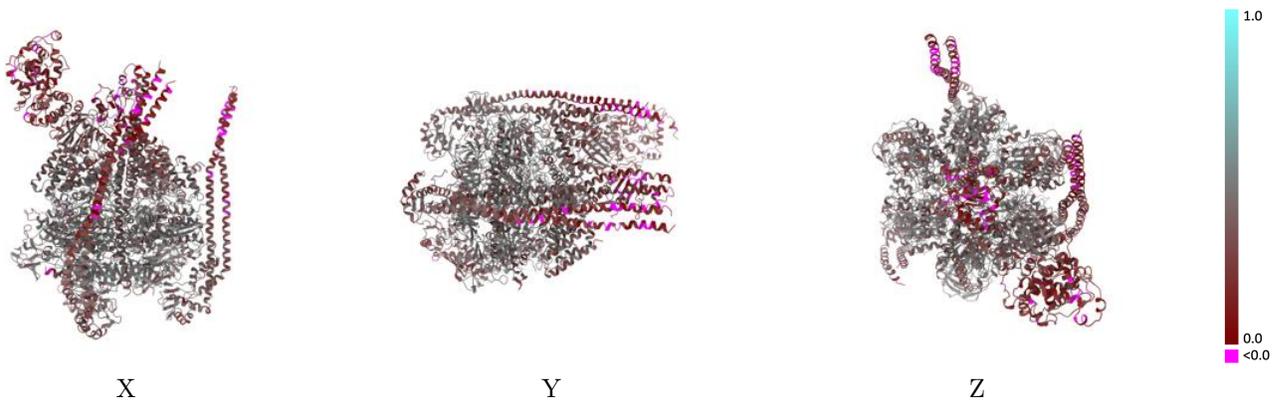
This section contains information regarding the fit between EMDB map EMD-49559 and PDB model 9NN1. Per-residue inclusion information can be found in section 3 on page 6.

### 9.1 Map-model overlay [i](#)



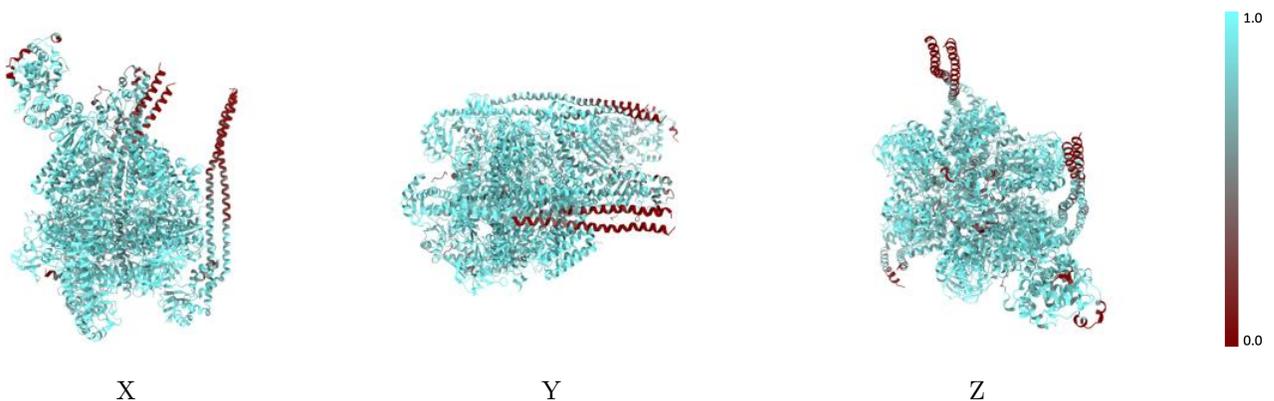
The images above show the 3D surface view of the map at the recommended contour level 0.006 at 50% transparency in yellow overlaid with a ribbon representation of the model coloured in blue. These images allow for the visual assessment of the quality of fit between the atomic model and the map.

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



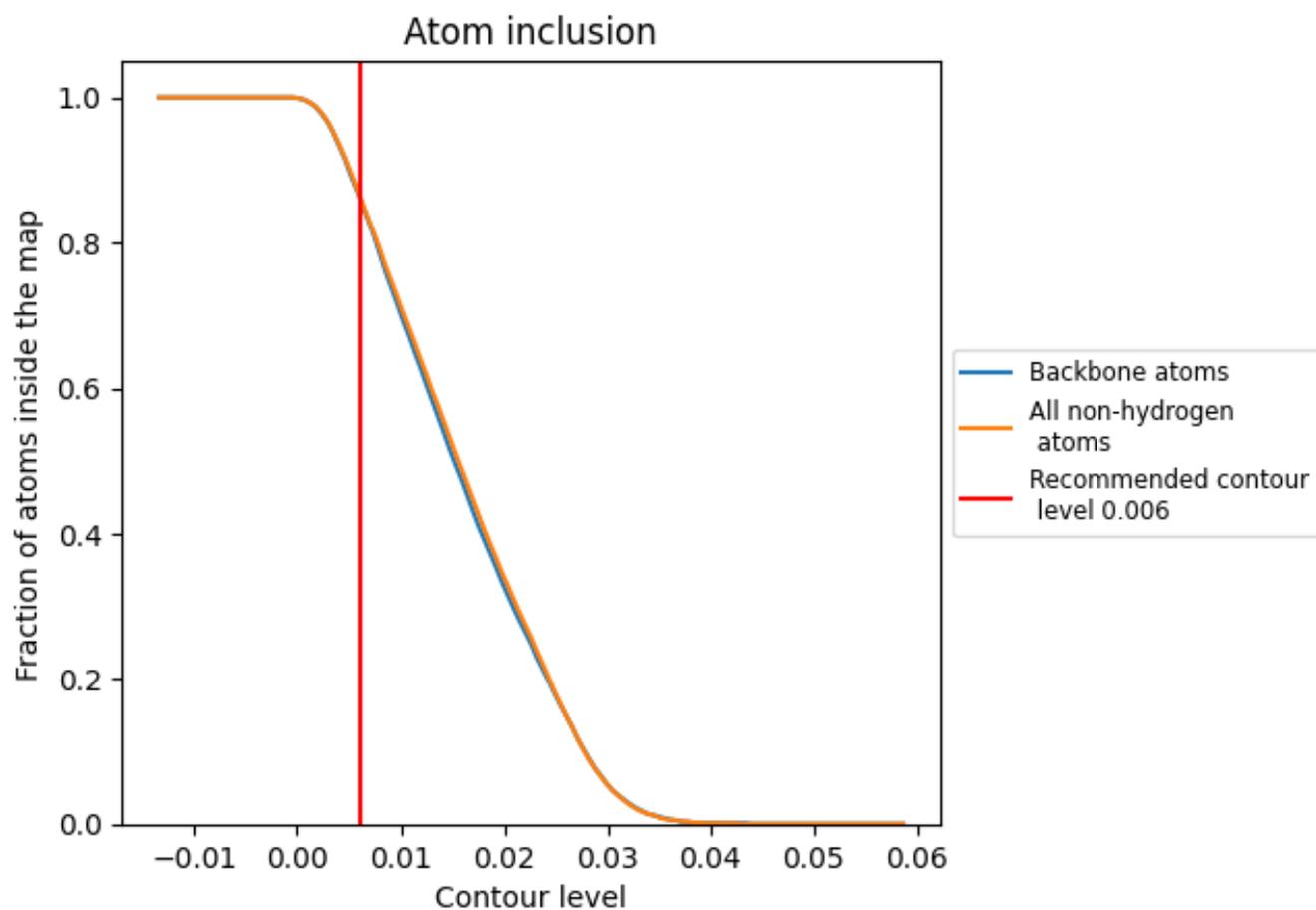
The images above show the model with each residue coloured according to its Q-score. This shows their resolvability in the map with higher Q-score values reflecting better resolvability. Please note: Q-score is calculating the resolvability of atoms, and thus high values are only expected at resolutions 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 (0.006).

## 9.4 Atom inclusion [i](#)



At the recommended contour level, 86% of all backbone atoms, 87% 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 (0.006) and Q-score for the entire model and for each chain.

Chain	Atom inclusion	Q-score
All	 0.8670	 0.3630
A	 0.9410	 0.4100
B	 0.9320	 0.4270
C	 0.9510	 0.4150
D	 0.9220	 0.4120
E	 0.9550	 0.4290
F	 0.9320	 0.4390
G	 0.7630	 0.2940
H	 0.5310	 0.2440
I	 0.8040	 0.3170
J	 0.6550	 0.2060
K	 0.7140	 0.3010
L	 0.3720	 0.1930
M	 0.7830	 0.2860
N	 0.7230	 0.1220
R	 0.8400	 0.2500

