



wwPDB EM Validation Summary Report ⓘ

Jul 6, 2026 – 02:22 PM EDT

PDB ID : 36HW / pdb_000036hw
EMDB ID : EMD-77588
Title : Salmonella Flagellar Export Apparatus FlhA transmembrane domain nonamer
in the context of the intact basal body
Authors : Johnson, S.; Johnson, M.K.; Lea, S.M.
Deposited on : 2026-06-10
Resolution : 3.55 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:

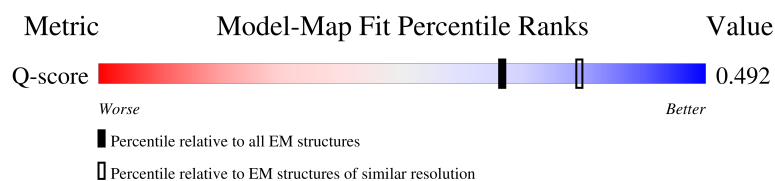
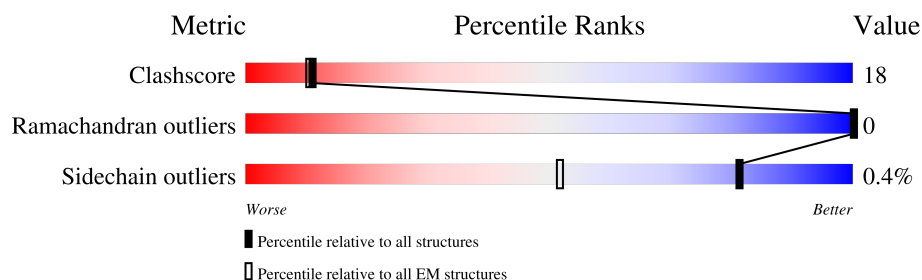
EMDB validation analysis : 0.0.1.dev133
MolProbity : 4-5-2 with Phenix2.0
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
EM percentile statistics : 202505.v01 (Using data in the EMDb archive up until May 2025)
MapQ : 1.9.13
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.50

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 3.55 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.



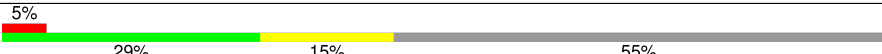
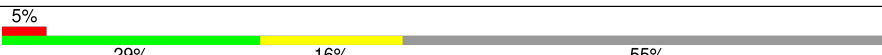
Metric	Whole archive (#Entries)	EM structures (#Entries)	Similar EM resolution (#Entries, resolution range(Å))
Clashscore	229148	23984	-
Ramachandran outliers	224038	23583	-
Sidechain outliers	223484	23102	-
Q-score	-	25397	12819 (3.05 - 4.05)

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	A2	692	 5% 29% 15% 51%
1	B2	692	 5% 28% 16% 51%
1	C2	692	 5% 29% 16% 50%
1	D2	692	 5% 29% 15% 51%

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Mol	Chain	Length	Quality of chain
1	E2	692	
1	F2	692	
1	G2	692	
1	H2	692	
1	I2	692	

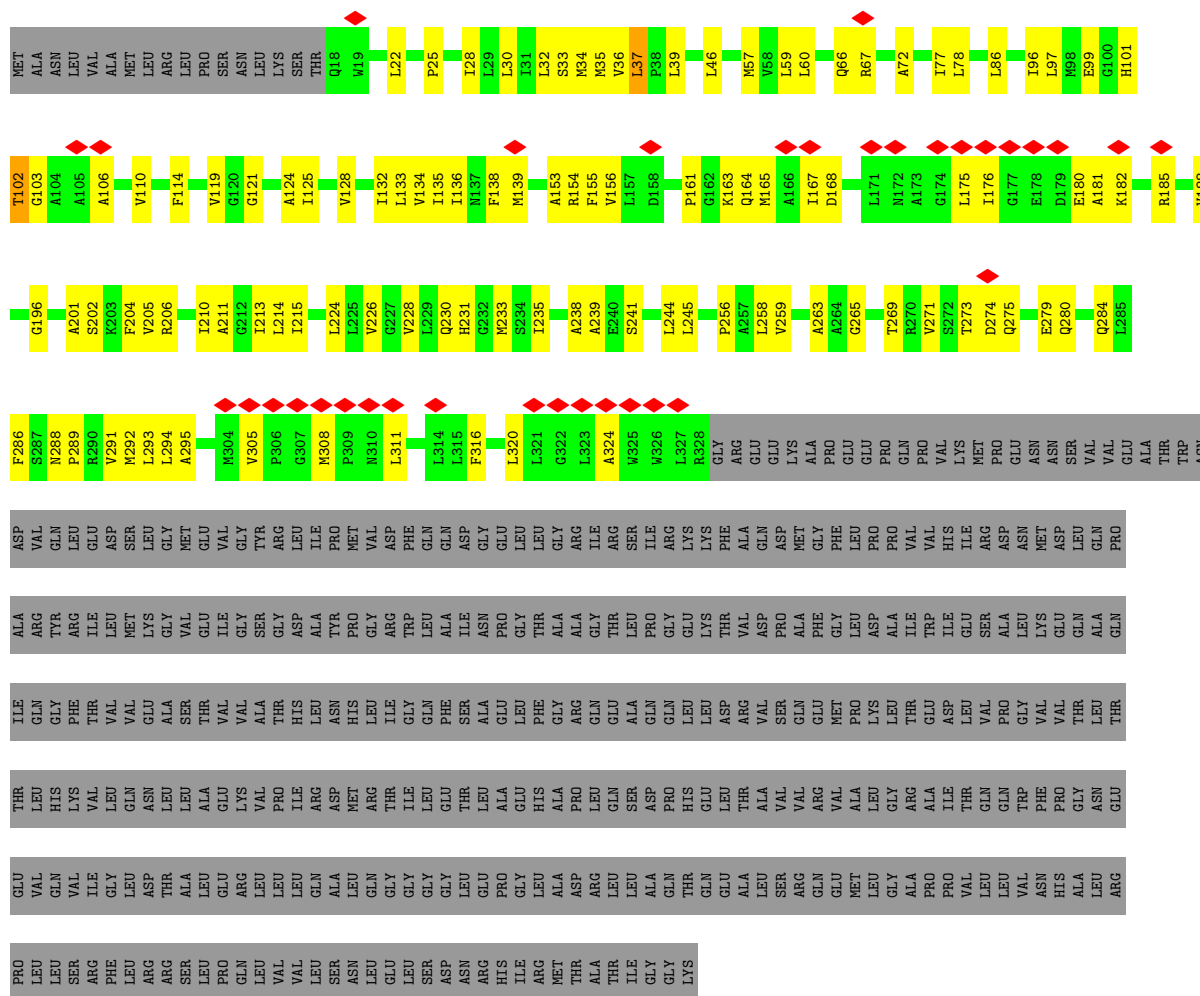
2 Entry composition

There is only 1 type of molecule in this entry. The entry contains 20781 atoms, of which 0 are hydrogens and 0 are deuteriums.

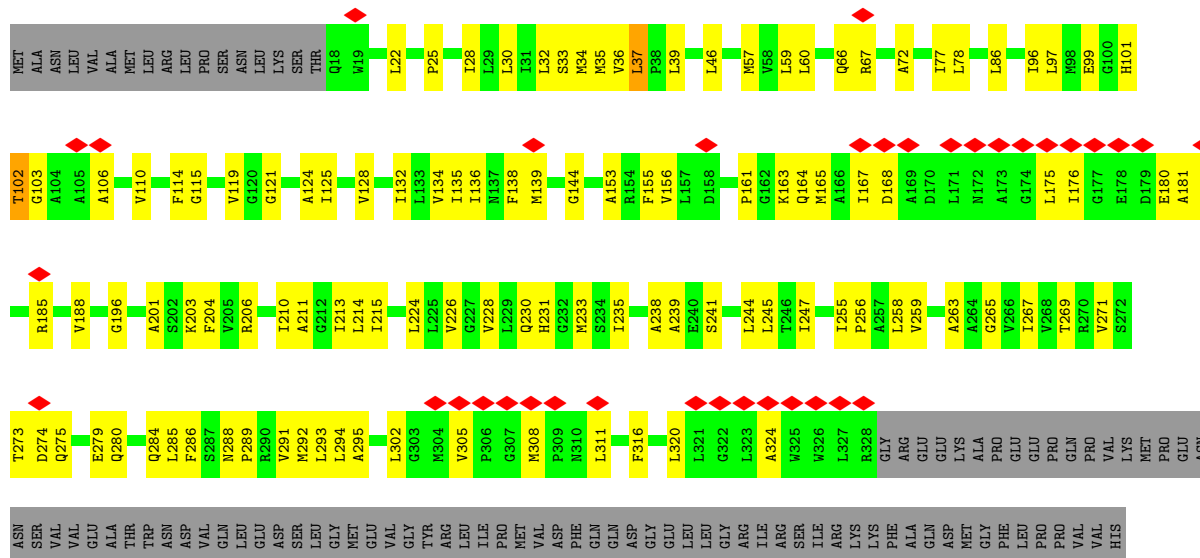
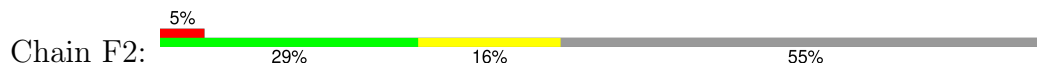
In the tables below, the AltConf column contains the number of residues with at least one atom in alternate conformation and the Trace column contains the number of residues modelled with at most 2 atoms.

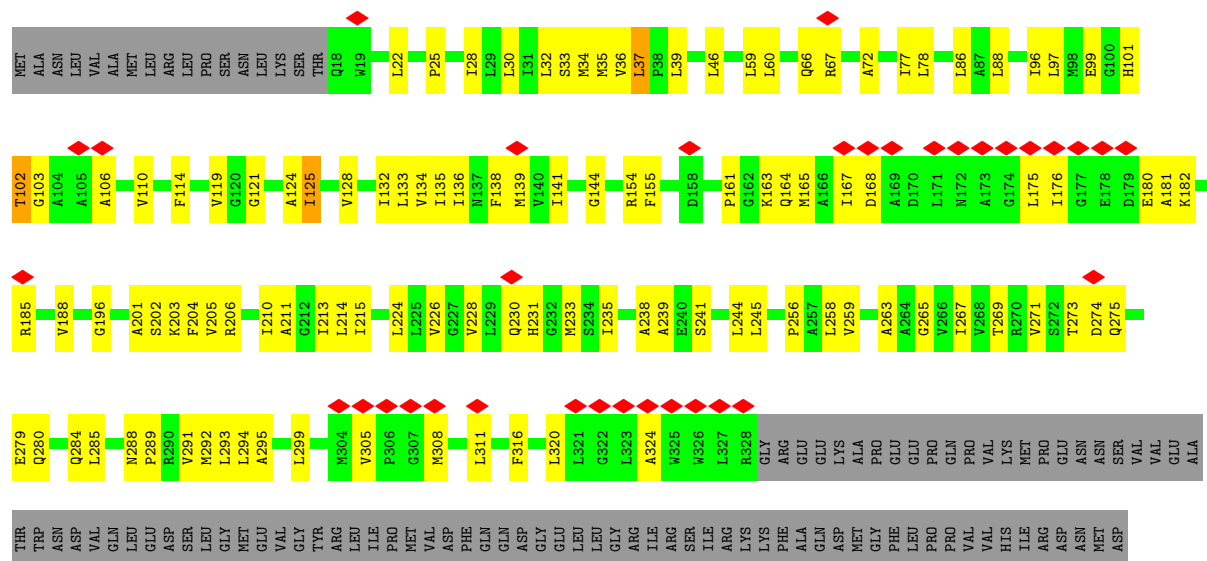
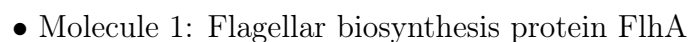
- Molecule 1 is a protein called Flagellar biosynthesis protein FlhA.

Mol	Chain	Residues	Atoms					AltConf	Trace
1	A2	311	Total	C	N	O	S	0	0
			2309	1516	377	401	15		
1	B2	311	Total	C	N	O	S	0	0
			2309	1516	377	401	15		
1	C2	311	Total	C	N	O	S	0	0
			2309	1516	377	401	15		
1	D2	311	Total	C	N	O	S	0	0
			2309	1516	377	401	15		
1	E2	311	Total	C	N	O	S	0	0
			2309	1516	377	401	15		
1	F2	311	Total	C	N	O	S	0	0
			2309	1516	377	401	15		
1	G2	311	Total	C	N	O	S	0	0
			2309	1516	377	401	15		
1	H2	311	Total	C	N	O	S	0	0
			2309	1516	377	401	15		
1	I2	311	Total	C	N	O	S	0	0
			2309	1516	377	401	15		



● Molecule 1: Flagellar biosynthesis protein FlhA





ALA	LEU	GLN	THR	GLN	LEU
ARG	GLN	ALA	LEU	ALA	GLN
PRO	PRO	ILE	THR	GLN	PRO
LEU	LEU	GLN	LEU	GLN	ALA
LEU	TYR	GLY	HIS	GLY	TYR
SER	ARG	PHE	LYS	PHE	ARG
ARG	ILE	THR	VAL	THR	ILE
PHE	LEU	GLY	LEU	VAL	LEU
LEU	LEU	VAL	GLN	VAL	MET
ARG	ASP	ASN	ASN	GLU	LYS
ARG	THR	LEU	LEU	ALA	GLY
SER	ALA	LEU	LEU	SER	VAL
PRO	LEU	THR	GLU	THR	GLU
PRO	GLU	VAL	ALA	VAL	ILE
LEU	ARG	VAL	VAL	VAL	GLY
LEU	VAL	ALA	VAL	ALA	SER
VAL	LEU	THR	PRO	THR	GLY
VAL	LEU	THR	ILE	THR	GLY
VAL	LEU	ILE	PRO	PRO	ASP
VAL	LEU	HIS	ILE	LEU	ASP
VAL	GLN	ALA	GLN	GLN	ASP
LEU	GLN	ASP	LEU	GLY	ASP
LEU	GLN	LEU	THR	LEU	TYR
LEU	GLY	LEU	ARG	LEU	PRO
GLU	GLY	THR	THR	LEU	GLY
LEU	GLY	ILE	ILE	GLY	ARG
LEU	SER	GLU	LEU	PHE	TRP
ASP	ASP	GLY	GLU	ALA	LEU
ASN	ASN	LEU	THR	SER	ILE
ARG	ASN	GLU	LEU	ALA	ASN
HIS	HIS	PRO	ALA	GLU	PRO
ILE	ILE	GLY	LEU	LEU	PRO
ARG	ARG	HIS	HIS	PHE	GLY
MET	MET	ALA	ALA	GLY	ALA
THR	THR	ASP	PRO	ARG	ALA
ALA	ALA	ARG	LEU	GLN	GLY
THR	THR	LEU	GLN	GLU	THR
ILE	ILE	LEU	SER	ALA	LEU
GLY	GLY	ALA	ASP	ASP	PRO
GLY	GLY	GLN	PRO	GLN	GLY
LYS	LYS	THR	HIS	LEU	GLU
		GLN	GLU	LEU	LYS
		GLU	LEU	ASP	THR
		LEU	THR	ARG	VAL
		ALA	ALA	VAL	ASP
		SER	VAL	SER	PRO
		ARG	VAL	GLN	ALA
		GLN	ARG	GLU	PHE
		GLU	VAL	MET	GLY
		MET	ALA	PRO	LEU
		LEU	LEU	LYS	ASP
		GLY	GLY	LEU	ALA
		ALA	ARG	THR	ILE
		PRO	ILE	GLU	TRP
		VAL	THR	ASP	ILE
		VAL	LEU	GLU	LEU
		GLN	GLN	VAL	SER
		VAL	TRP	GLY	ALA
		ASN	PHE	VAL	LEU
		HIS	PRO	THR	GLN

4 Experimental information

Property	Value	Source
EM reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, C9	Depositor
Number of particles used	19350	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 ($e^-/\text{\AA}^2$)	58.5	Depositor
Minimum defocus (nm)	500	Depositor
Maximum defocus (nm)	2500	Depositor
Magnification	Not provided	
Image detector	TFS FALCON 4i (4k x 4k)	Depositor
Maximum map value	13.949	Depositor
Minimum map value	-0.107	Depositor
Average map value	-0.012	Depositor
Map value standard deviation	0.226	Depositor
Recommended contour level	5	Depositor
Map size (Å)	537.6, 537.6, 537.6	wwPDB
Map dimensions	512, 512, 512	wwPDB
Map angles (°)	90.0, 90.0, 90.0	wwPDB
Pixel spacing (Å)	1.05, 1.05, 1.05	Depositor

5 Model quality

5.1 Standard geometry

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	A2	0.45	0/2346	0.58	1/3187 (0.0%)
1	B2	0.45	0/2346	0.58	1/3187 (0.0%)
1	C2	0.45	0/2346	0.58	1/3187 (0.0%)
1	D2	0.45	0/2346	0.58	1/3187 (0.0%)
1	E2	0.45	0/2346	0.58	1/3187 (0.0%)
1	F2	0.45	0/2346	0.58	1/3187 (0.0%)
1	G2	0.45	0/2346	0.58	1/3187 (0.0%)
1	H2	0.45	0/2346	0.58	1/3187 (0.0%)
1	I2	0.45	0/2346	0.58	1/3187 (0.0%)
All	All	0.45	0/21114	0.58	9/28683 (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	A2	0	2
1	B2	0	1
1	C2	0	1
1	D2	0	2
1	E2	0	1
1	F2	0	1
1	G2	0	2
1	H2	0	2
1	I2	0	2
All	All	0	14

There are no bond length outliers.

The worst 5 of 9 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	F2	103	GLY	N-CA-C	-5.88	99.25	113.18

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	C2	103	GLY	N-CA-C	-5.87	99.26	113.18
1	E2	103	GLY	N-CA-C	-5.87	99.27	113.18
1	G2	103	GLY	N-CA-C	-5.87	99.27	113.18
1	H2	103	GLY	N-CA-C	-5.86	99.29	113.18

There are no chirality outliers.

5 of 14 planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A2	102	THR	Peptide
1	A2	125	ILE	Peptide
1	B2	102	THR	Peptide
1	C2	102	THR	Peptide
1	D2	102	THR	Peptide

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	A2	2309	0	2450	98	0
1	B2	2309	0	2450	102	0
1	C2	2309	0	2450	102	0
1	D2	2309	0	2450	103	0
1	E2	2309	0	2450	98	0
1	F2	2309	0	2450	105	0
1	G2	2309	0	2450	101	0
1	H2	2309	0	2450	95	0
1	I2	2309	0	2450	100	0
All	All	20781	0	22050	784	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 18.

The worst 5 of 784 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:A2:226:VAL:O	1:A2:230:GLN:HB3	1.72	0.90
1:I2:226:VAL:O	1:I2:230:GLN:HB3	1.72	0.90
1:H2:226:VAL:O	1:H2:230:GLN:HB3	1.72	0.90
1:B2:226:VAL:O	1:B2:230:GLN:HB3	1.72	0.89
1:C2:226:VAL:O	1:C2:230:GLN:HB3	1.72	0.89

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	A2	309/692 (45%)	277 (90%)	32 (10%)	0	100	100
1	B2	309/692 (45%)	277 (90%)	32 (10%)	0	100	100
1	C2	309/692 (45%)	277 (90%)	32 (10%)	0	100	100
1	D2	309/692 (45%)	277 (90%)	32 (10%)	0	100	100
1	E2	309/692 (45%)	277 (90%)	32 (10%)	0	100	100
1	F2	309/692 (45%)	277 (90%)	32 (10%)	0	100	100
1	G2	309/692 (45%)	277 (90%)	32 (10%)	0	100	100
1	H2	309/692 (45%)	277 (90%)	32 (10%)	0	100	100
1	I2	309/692 (45%)	277 (90%)	32 (10%)	0	100	100
All	All	2781/6228 (45%)	2493 (90%)	288 (10%)	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	A2	241/561 (43%)	240 (100%)	1 (0%)	84	80
1	B2	241/561 (43%)	240 (100%)	1 (0%)	84	80
1	C2	241/561 (43%)	240 (100%)	1 (0%)	84	80
1	D2	241/561 (43%)	240 (100%)	1 (0%)	84	80
1	E2	241/561 (43%)	240 (100%)	1 (0%)	84	80
1	F2	241/561 (43%)	240 (100%)	1 (0%)	84	80
1	G2	241/561 (43%)	240 (100%)	1 (0%)	84	80
1	H2	241/561 (43%)	240 (100%)	1 (0%)	84	80
1	I2	241/561 (43%)	240 (100%)	1 (0%)	84	80
All	All	2169/5049 (43%)	2160 (100%)	9 (0%)	81	80

5 of 9 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	H2	37	LEU
1	I2	37	LEU
1	D2	37	LEU
1	E2	37	LEU
1	F2	37	LEU

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	E2	288	ASN
1	F2	288	ASN
1	I2	172	ASN
1	F2	275	GLN
1	G2	172	ASN

5.3.3 RNA ⓘ

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.

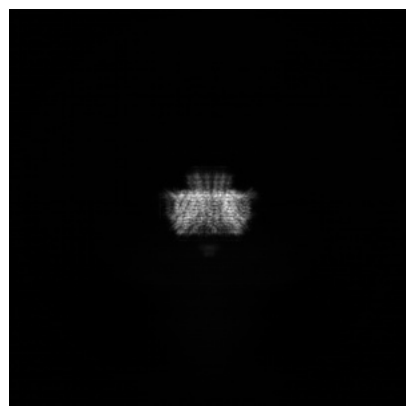
6 Map visualisation [i](#)

This section contains visualisations of the EMDB entry EMD-77588. These allow visual inspection of the internal detail of the map and identification of artifacts.

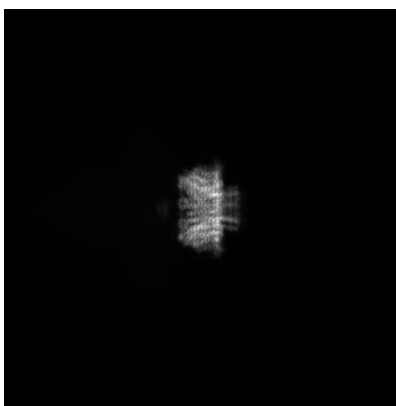
Images derived from a raw map, generated by summing the deposited half-maps, are presented below the corresponding image components of the primary map to allow further visual inspection and comparison with those of the primary map.

6.1 Orthogonal projections [i](#)

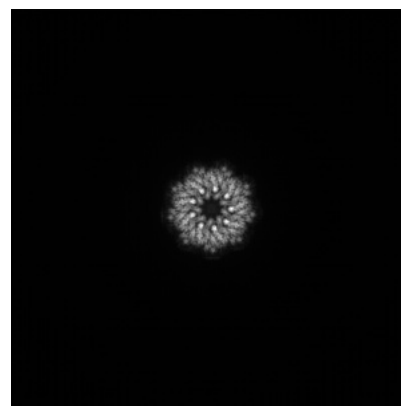
6.1.1 Primary map



X

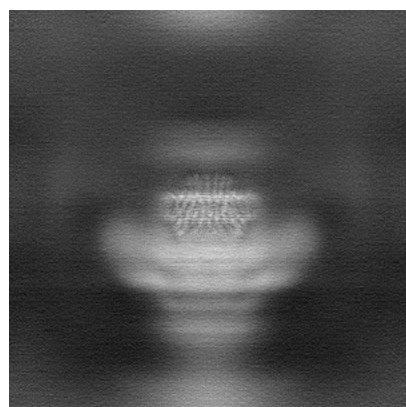


Y

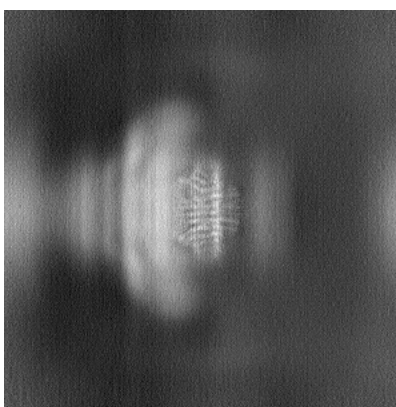


Z

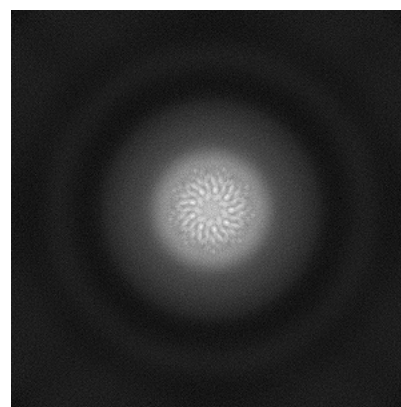
6.1.2 Raw map



X



Y

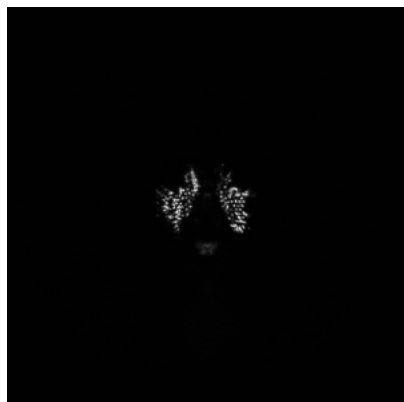


Z

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

6.2 Central slices [i](#)

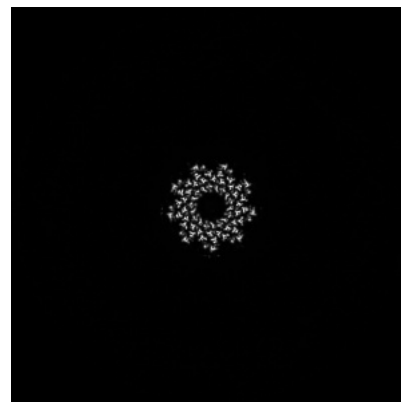
6.2.1 Primary map



X Index: 256

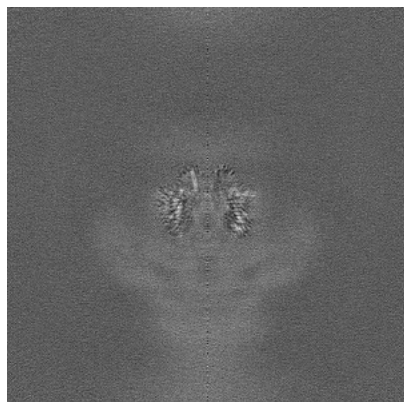


Y Index: 256

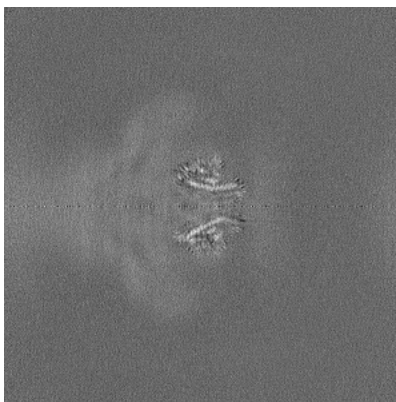


Z Index: 256

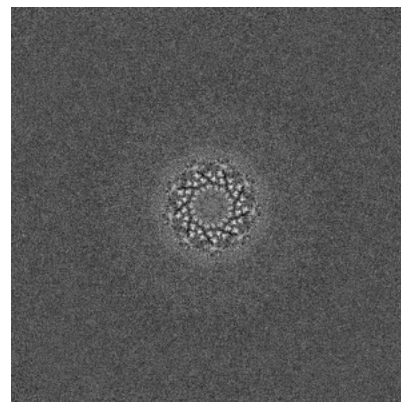
6.2.2 Raw map



X Index: 256



Y Index: 256

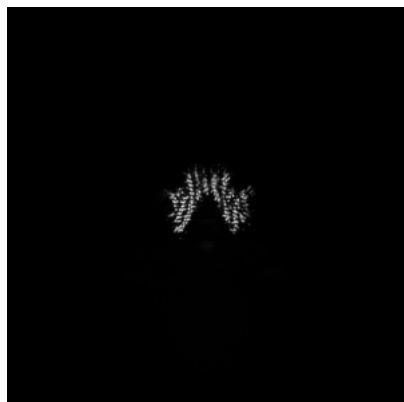


Z Index: 256

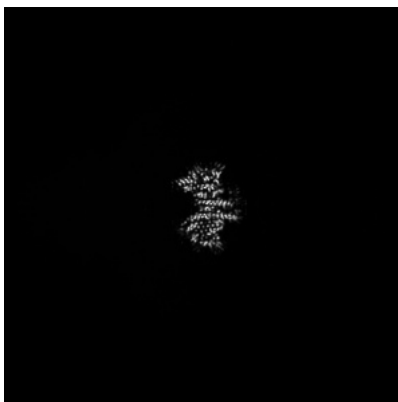
The images above show central slices of the map in three orthogonal directions.

6.3 Largest variance slices [i](#)

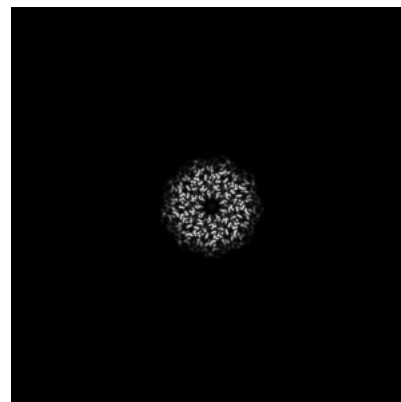
6.3.1 Primary map



X Index: 242

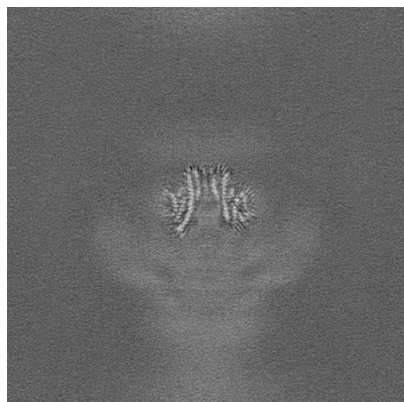


Y Index: 279



Z Index: 273

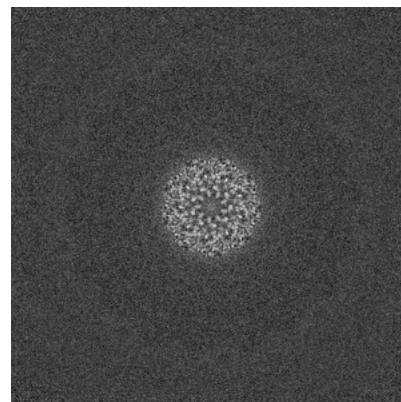
6.3.2 Raw map



X Index: 243



Y Index: 256

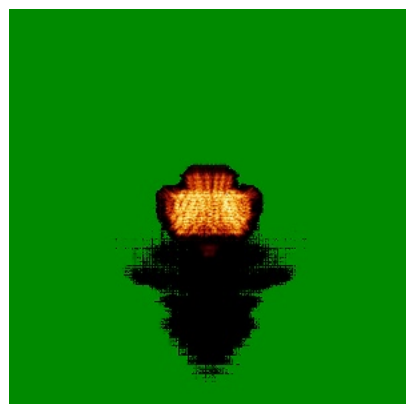


Z Index: 273

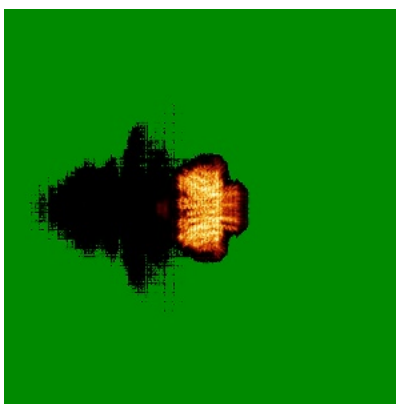
The images above show the largest variance slices of the map in three orthogonal directions.

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

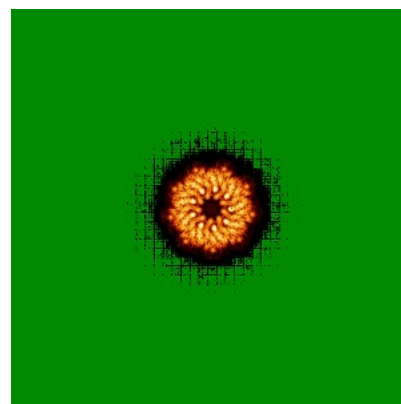
6.4.1 Primary map



X

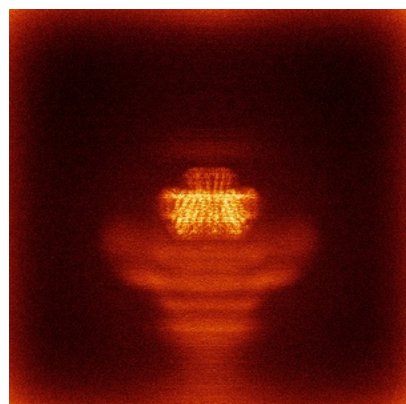


Y

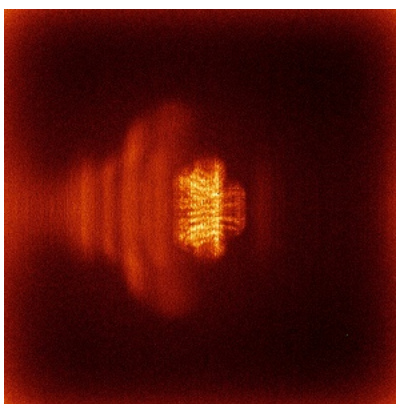


Z

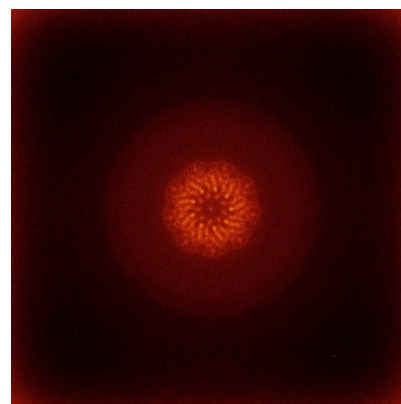
6.4.2 Raw map



X



Y

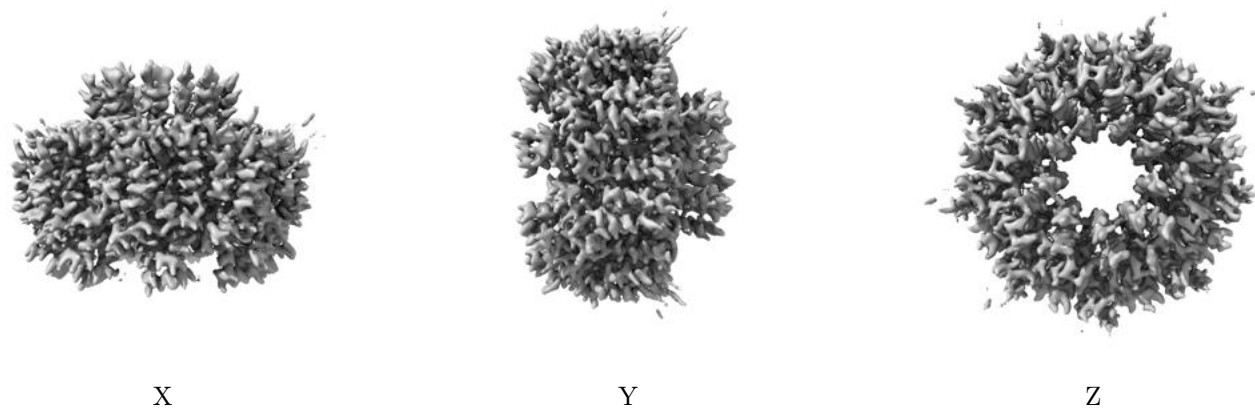


Z

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.

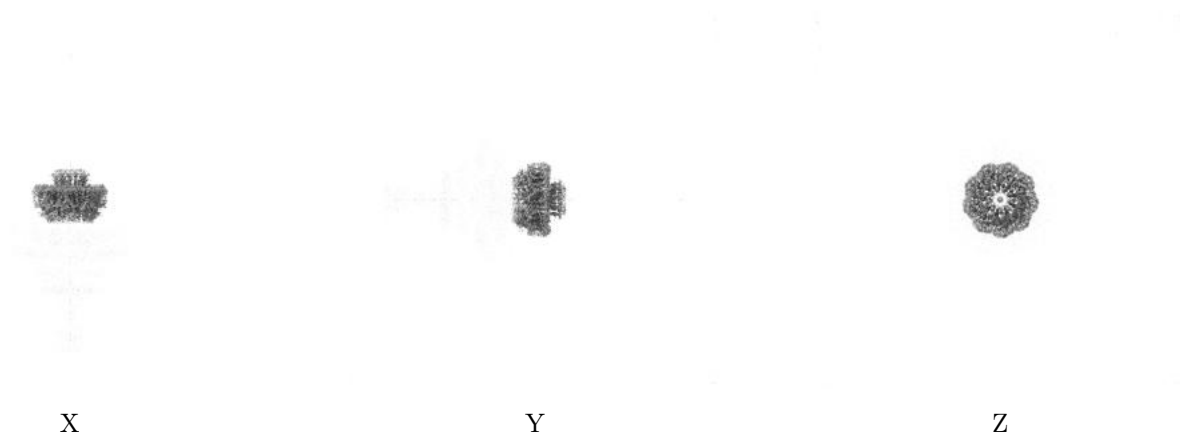
6.5 Orthogonal surface views [i](#)

6.5.1 Primary map



The images above show the 3D surface view of the map at the recommended contour level 5.0. These images, in conjunction with the slice images, may facilitate assessment of whether an appropriate contour level has been provided.

6.5.2 Raw map



These images show the 3D surface of the raw map. The raw map's contour level was selected so that its surface encloses the same volume as the primary map does at its recommended contour level.

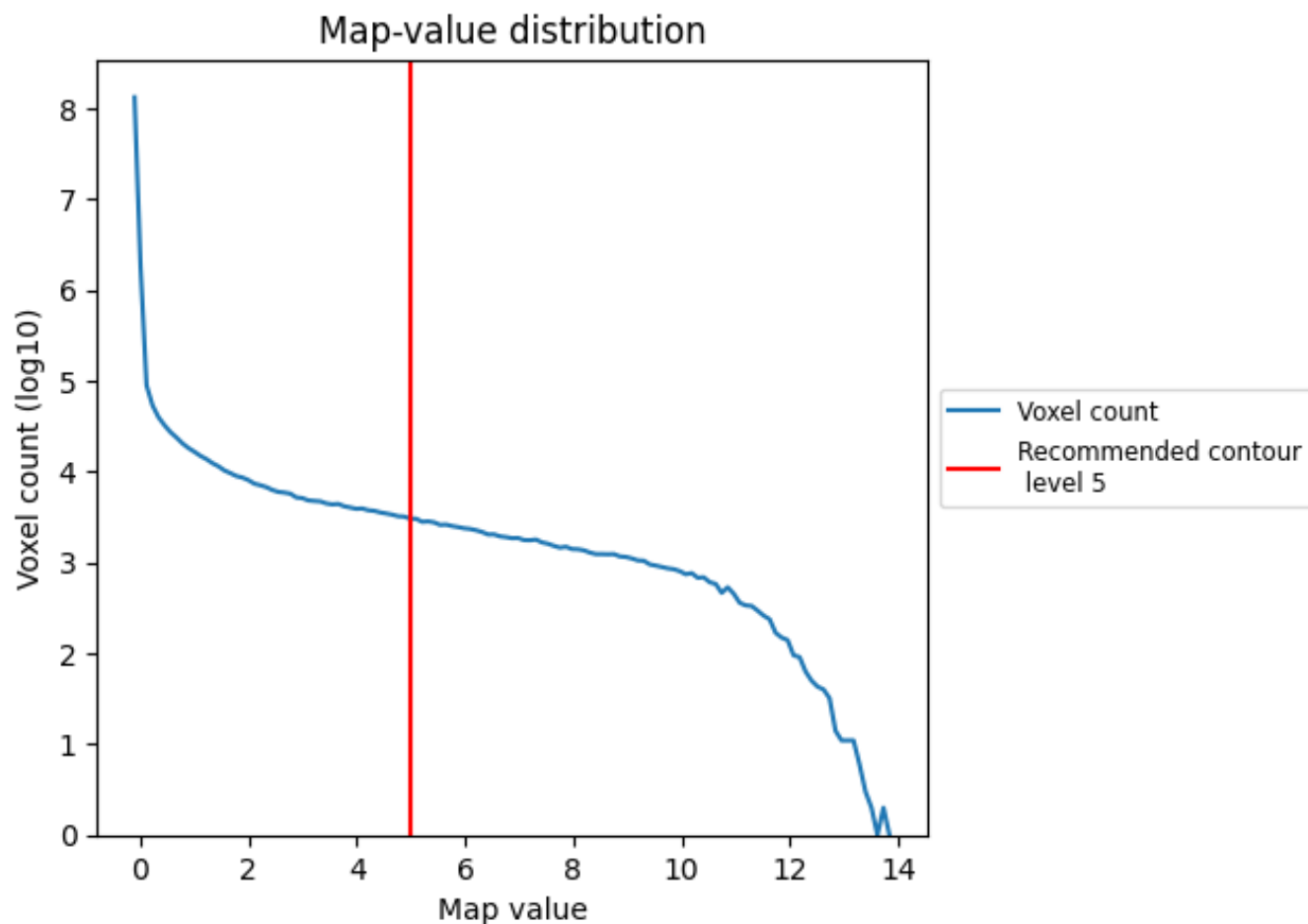
6.6 Mask visualisation [i](#)

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

7 Map analysis [i](#)

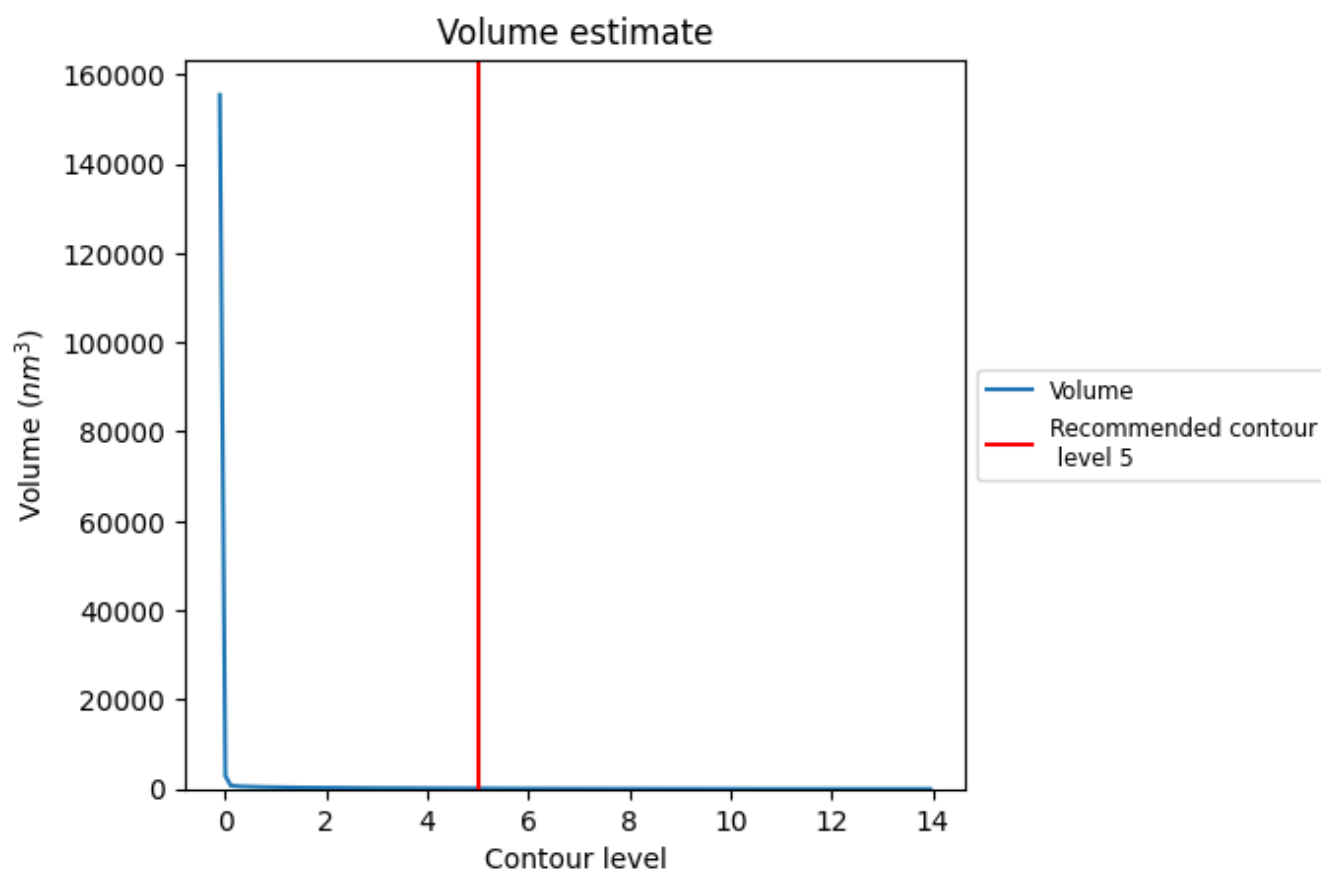
This section contains the results of statistical analysis of the map.

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.

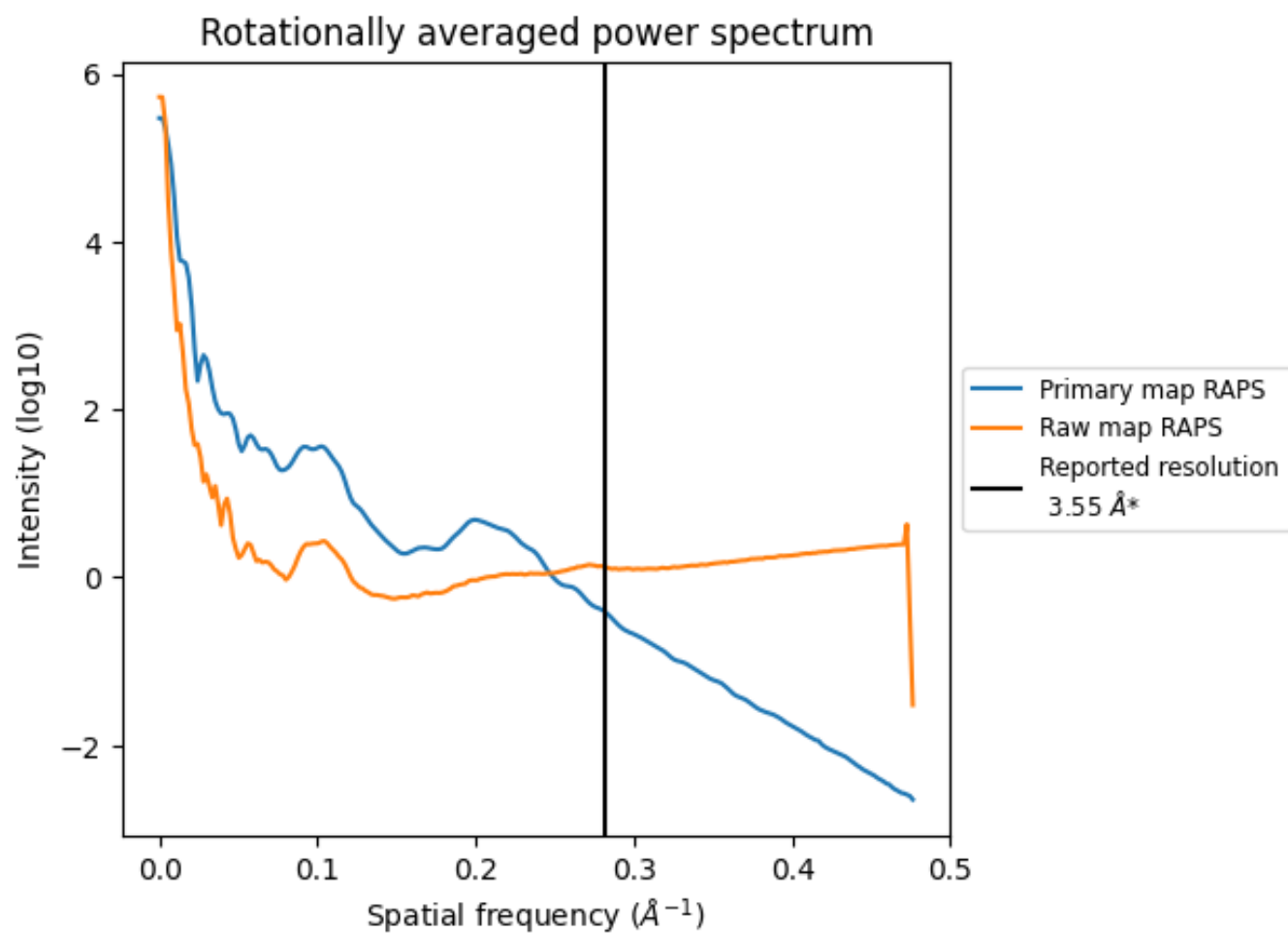
7.2 Volume estimate [i](#)



The volume at the recommended contour level is 101 nm^3 ; this corresponds to an approximate mass of 91 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 ⓘ

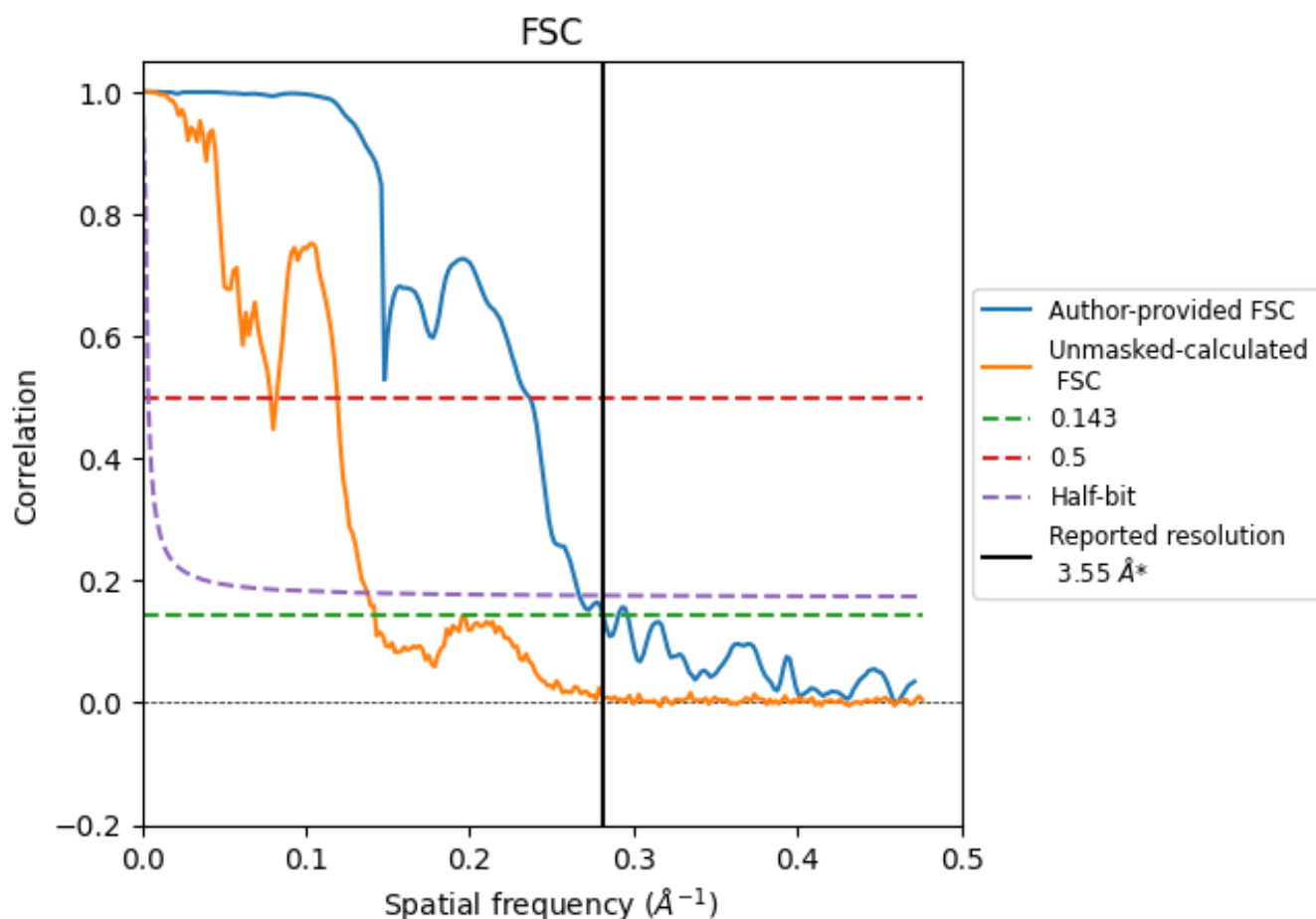


*Reported resolution corresponds to spatial frequency of 0.282 $\text{\AA}^{-1}$

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 $0.282 \text{ \AA}^{-1}$

8.2 Resolution estimates [i](#)

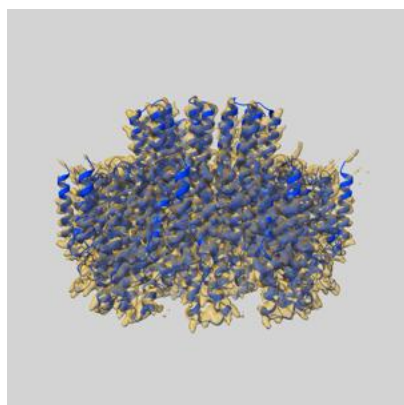
Resolution estimate (Å)	Estimation criterion (FSC cut-off)		
	0.143	0.5	Half-bit
Reported by author	3.55	-	-
Author-provided FSC curve	3.55	4.23	3.75
Unmasked-calculated*	7.04	12.76	7.27

*Resolution estimate based on FSC curve calculated by comparison of deposited half-maps. The value from deposited half-maps intersecting FSC 0.143 CUT-OFF 7.04 differs from the reported value 3.55 by more than 10 %

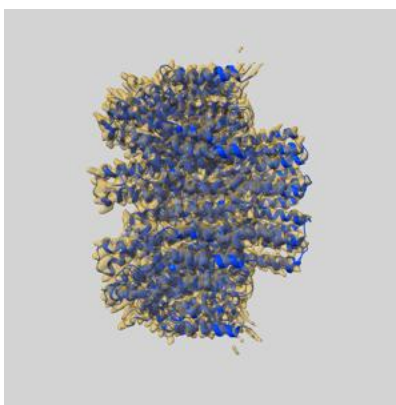
9 Map-model fit [i](#)

This section contains information regarding the fit between EMDB map EMD-77588 and PDB model 36HW. Per-residue inclusion information can be found in [section 3](#) on [page 5](#).

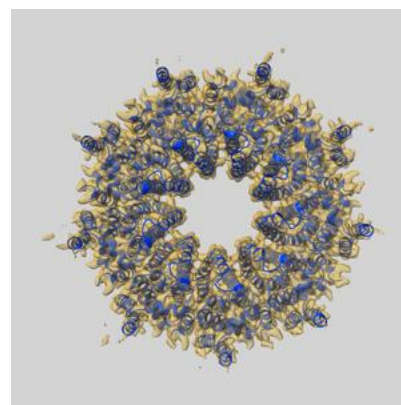
9.1 Map-model overlay [i](#)



X



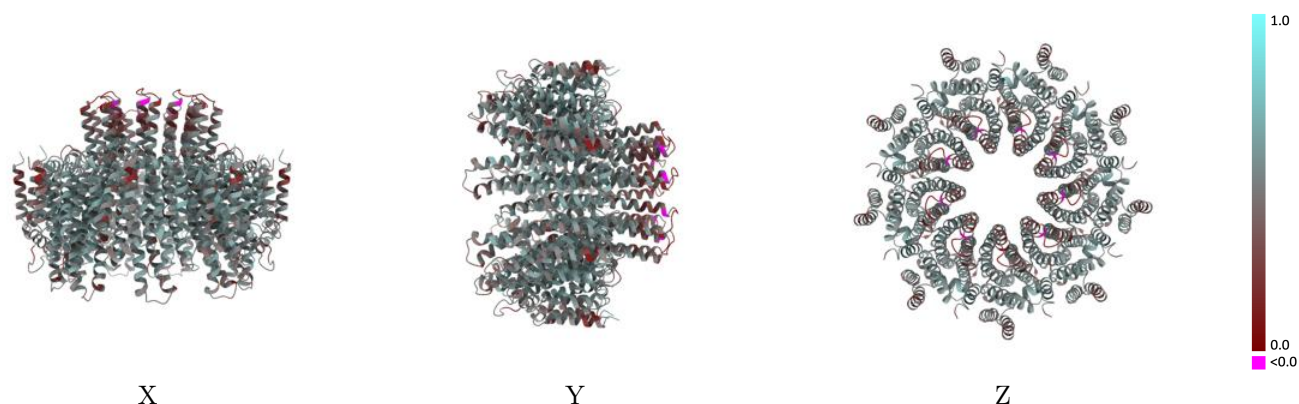
Y



Z

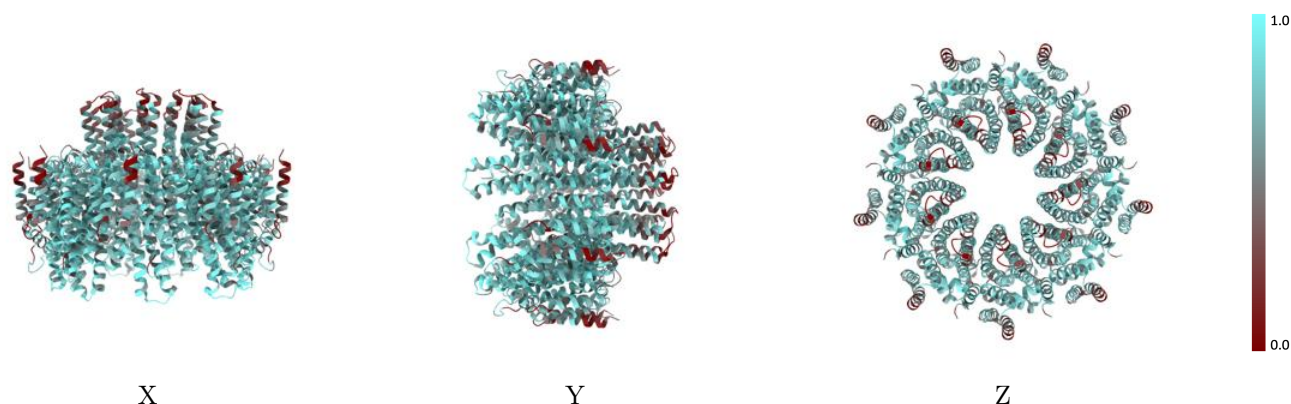
The images above show the 3D surface view of the map at the recommended contour level 5.0 at 50% transparency in yellow overlaid with a ribbon representation of the model coloured in blue. These images allow for the visual assessment of the quality of fit between the atomic model and the map.

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



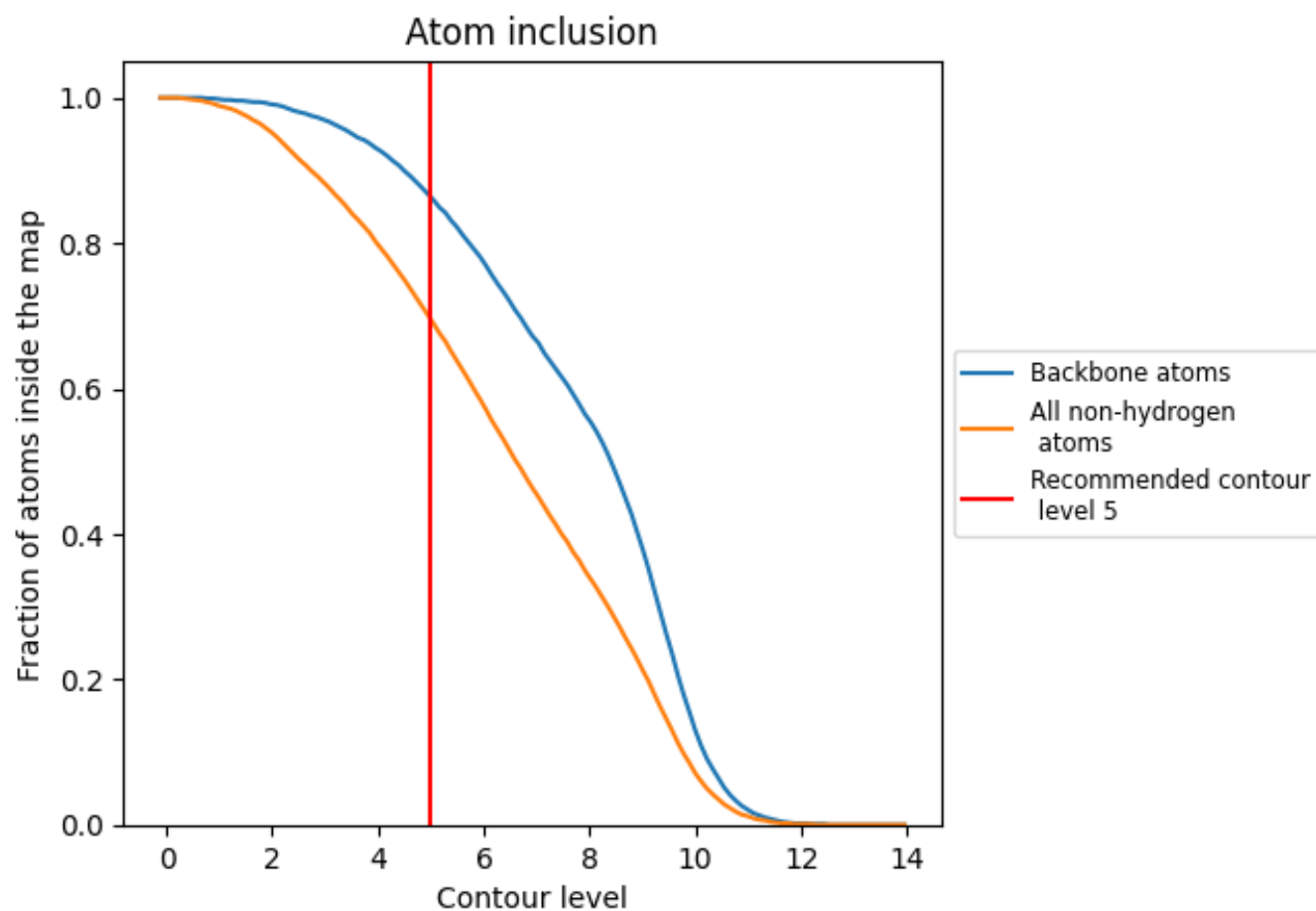
The images above show the model with each residue coloured according to its Q-score. This shows their resolvability in the map with higher Q-score values reflecting better resolvability. Please note: Q-score is calculating the resolvability of atoms, and thus high values are only expected at resolutions 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 (5).

9.4 Atom inclusion ⓘ



At the recommended contour level, 86% of all backbone atoms, 70% 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 (5) and Q-score for the entire model and for each chain.

Chain	Atom inclusion	Q-score
All	0.6950	0.4920
A2	0.6970	0.4890
B2	0.6880	0.4900
C2	0.6940	0.4910
D2	0.6960	0.4930
E2	0.6930	0.4890
F2	0.6990	0.4950
G2	0.6920	0.4900
H2	0.6930	0.4930
I2	0.6990	0.4940

1.0

0.0

<0.0