



wwPDB EM Validation Summary Report ⓘ

Mar 9, 2026 – 12:27 AM UTC

PDB ID : 8QOT / pdb_00008qot
EMDB ID : EMD-18541
Title : Structure of the mu opioid receptor bound to the antagonist nanobody NbE
Authors : Yu, J.; Kumar, A.; Zhang, X.; Martin, C.; Raia, P.; Manglik, A.; Ballet, S.;
Boland, A.; Stoeber, M.
Deposited on : 2023-09-29
Resolution : 3.20 Å (reported)
Based on initial models : 7PHQ, 4DKL

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

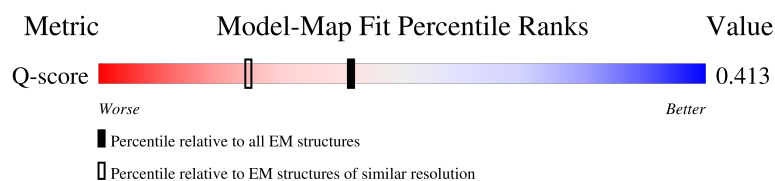
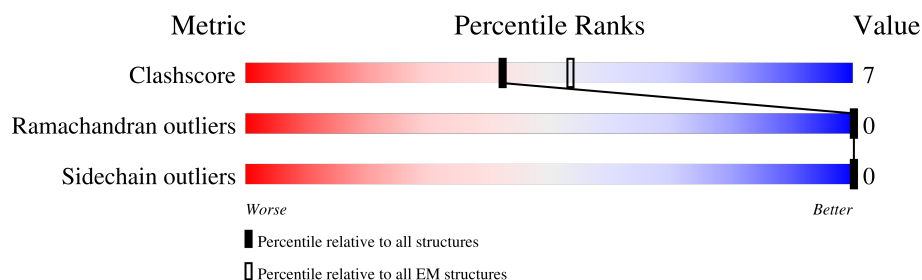
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

ELECTRON MICROSCOPY

The reported resolution of this entry is 3.20 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	15020 (2.70 - 3.70)

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	482	
2	B	171	
3	H	262	
4	L	238	

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Mol	Chain	Length	Quality of chain
5	K	159	16% 67% 9% 24%

2 Entry composition

There are 5 unique types of molecules in this entry. The entry contains 7493 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 Mu-type opioid receptor.

Mol	Chain	Residues	Atoms					AltConf	Trace
1	A	287	Total	C	N	O	S	1	0
			2320	1542	370	383	25		

There are 88 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-25	MET	-	initiating methionine	UNP P42866
A	-24	LYS	-	expression tag	UNP P42866
A	-23	THR	-	expression tag	UNP P42866
A	-22	ILE	-	expression tag	UNP P42866
A	-21	ILE	-	expression tag	UNP P42866
A	-20	ALA	-	expression tag	UNP P42866
A	-19	LEU	-	expression tag	UNP P42866
A	-18	SER	-	expression tag	UNP P42866
A	-17	TYR	-	expression tag	UNP P42866
A	-16	ILE	-	expression tag	UNP P42866
A	-15	PHE	-	expression tag	UNP P42866
A	-14	CYS	-	expression tag	UNP P42866
A	-13	LEU	-	expression tag	UNP P42866
A	-12	VAL	-	expression tag	UNP P42866
A	-11	PHE	-	expression tag	UNP P42866
A	-10	ALA	-	expression tag	UNP P42866
A	-9	ASP	-	expression tag	UNP P42866
A	-8	TYR	-	expression tag	UNP P42866
A	-7	LYS	-	expression tag	UNP P42866
A	-6	ASP	-	expression tag	UNP P42866
A	-5	ASP	-	expression tag	UNP P42866
A	-3	ASP	SER	conflict	UNP P42866
A	-2	ALA	SER	conflict	UNP P42866
A	-1	MET	ALA	conflict	UNP P42866
A	46	GLU	-	insertion	UNP P42866
A	47	ASN	-	insertion	UNP P42866
A	48	LEU	-	insertion	UNP P42866
A	49	TYR	-	insertion	UNP P42866

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Chain	Residue	Modelled	Actual	Comment	Reference
A	50	PHE	-	insertion	UNP P42866
A	51	GLN	-	insertion	UNP P42866
A	359	LEU	-	insertion	UNP P42866
A	360	GLU	-	insertion	UNP P42866
A	361	VAL	-	insertion	UNP P42866
A	362	LEU	-	insertion	UNP P42866
A	363	PHE	-	insertion	UNP P42866
A	364	GLN	-	insertion	UNP P42866
A	365	GLY	-	insertion	UNP P42866
A	366	PRO	-	insertion	UNP P42866
A	407	SER	-	expression tag	UNP P42866
A	408	SER	-	expression tag	UNP P42866
A	409	LEU	-	expression tag	UNP P42866
A	410	ALA	-	expression tag	UNP P42866
A	411	GLU	-	expression tag	UNP P42866
A	412	GLU	-	expression tag	UNP P42866
A	413	ASN	-	expression tag	UNP P42866
A	414	LEU	-	expression tag	UNP P42866
A	415	TYR	-	expression tag	UNP P42866
A	416	PHE	-	expression tag	UNP P42866
A	417	GLN	-	expression tag	UNP P42866
A	418	SER	-	expression tag	UNP P42866
A	419	TRP	-	expression tag	UNP P42866
A	420	SER	-	expression tag	UNP P42866
A	421	HIS	-	expression tag	UNP P42866
A	422	PRO	-	expression tag	UNP P42866
A	423	GLN	-	expression tag	UNP P42866
A	424	PHE	-	expression tag	UNP P42866
A	425	GLU	-	expression tag	UNP P42866
A	426	LYS	-	expression tag	UNP P42866
A	427	GLY	-	expression tag	UNP P42866
A	428	GLY	-	expression tag	UNP P42866
A	429	GLY	-	expression tag	UNP P42866
A	430	SER	-	expression tag	UNP P42866
A	431	GLY	-	expression tag	UNP P42866
A	432	GLY	-	expression tag	UNP P42866
A	433	GLY	-	expression tag	UNP P42866
A	434	SER	-	expression tag	UNP P42866
A	435	GLY	-	expression tag	UNP P42866
A	436	GLY	-	expression tag	UNP P42866
A	437	GLY	-	expression tag	UNP P42866
A	438	SER	-	expression tag	UNP P42866

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Chain	Residue	Modelled	Actual	Comment	Reference
A	439	TRP	-	expression tag	UNP P42866
A	440	SER	-	expression tag	UNP P42866
A	441	HIS	-	expression tag	UNP P42866
A	442	PRO	-	expression tag	UNP P42866
A	443	GLN	-	expression tag	UNP P42866
A	444	PHE	-	expression tag	UNP P42866
A	445	GLU	-	expression tag	UNP P42866
A	446	LYS	-	expression tag	UNP P42866
A	447	GLY	-	expression tag	UNP P42866
A	448	ALA	-	expression tag	UNP P42866
A	449	HIS	-	expression tag	UNP P42866
A	450	HIS	-	expression tag	UNP P42866
A	451	HIS	-	expression tag	UNP P42866
A	452	HIS	-	expression tag	UNP P42866
A	453	HIS	-	expression tag	UNP P42866
A	454	HIS	-	expression tag	UNP P42866
A	455	HIS	-	expression tag	UNP P42866
A	456	HIS	-	expression tag	UNP P42866

- Molecule 2 is a protein called Nanobody E (NbE).

Mol	Chain	Residues	Atoms					AltConf	Trace
2	B	125	Total	C	N	O	S	0	0
			948	595	159	190	4		

- Molecule 3 is a protein called NabFab HC.

Mol	Chain	Residues	Atoms					AltConf	Trace
3	H	226	Total	C	N	O	S	0	0
			1708	1088	282	333	5		

- Molecule 4 is a protein called NabFab LC.

Mol	Chain	Residues	Atoms					AltConf	Trace
4	L	209	Total	C	N	O	S	0	0
			1586	989	268	324	5		

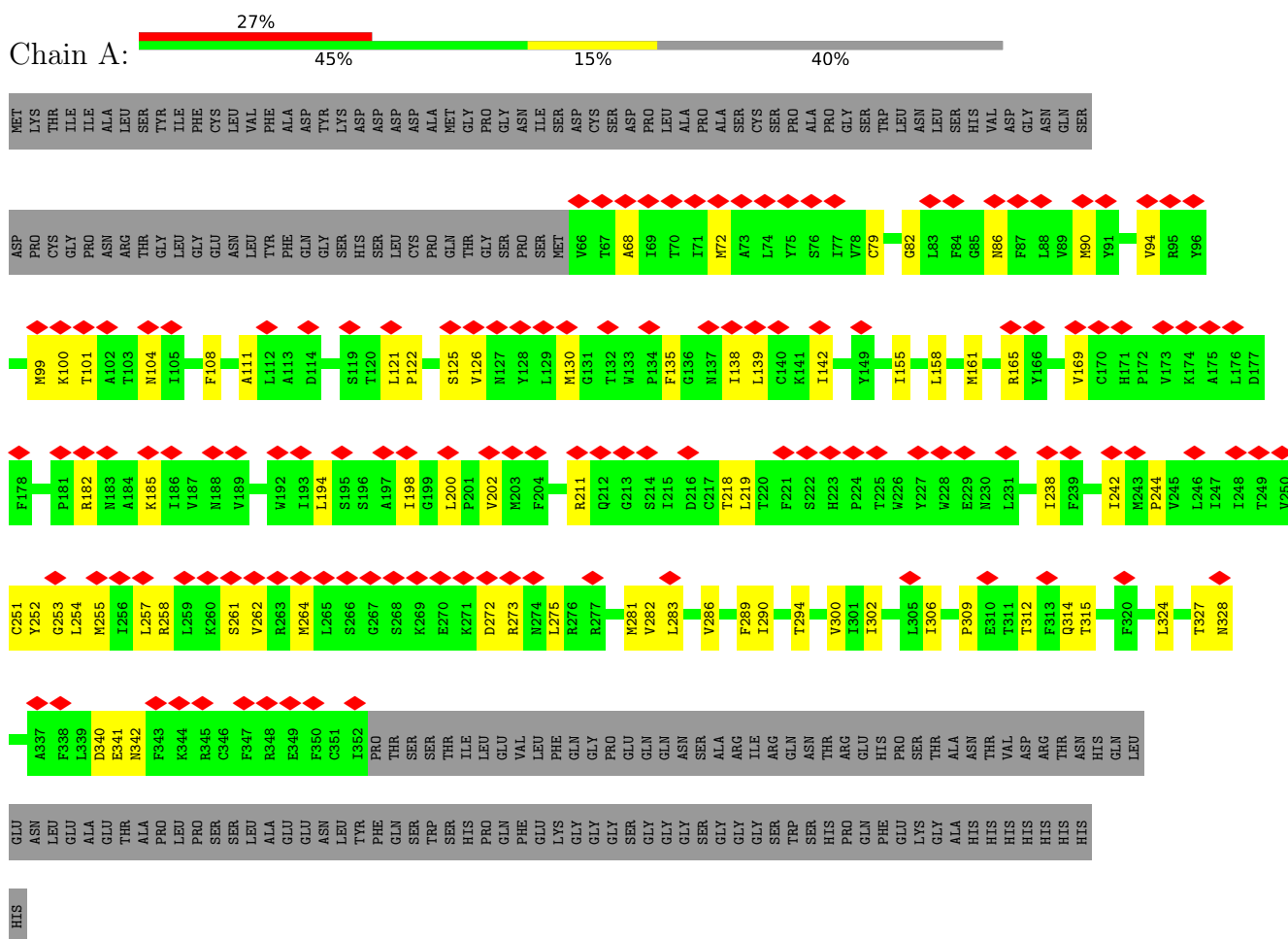
- Molecule 5 is a protein called Anti-Fab Nanobody.

Mol	Chain	Residues	Atoms					AltConf	Trace
5	K	121	Total	C	N	O	S	0	0
			931	577	164	186	4		

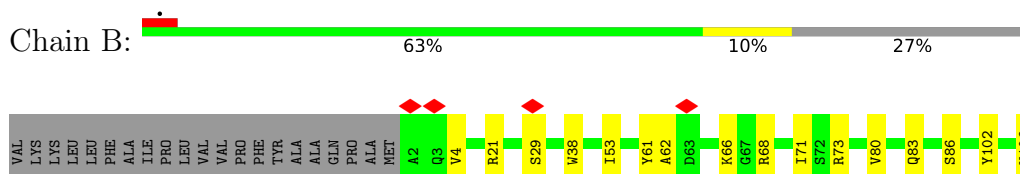
3 Residue-property plots

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: Mu-type opioid receptor



- Molecule 2: Nanobody E (NbE)



ALA
HIS
HIS
HIS
HIS
HIS
HIS
GLY
ALA
ALA
GLU
GLN
LYS
LEU
ILE
SER
GLU
ASP
LEU
ASN
GLY
ALA
ALA

- Molecule 3: NabFab HC

Chain H: 

MET LYS LYS ASN ILE PHE LEU ALA SER MET PHE VAL PHE SER ILE ALA THR ASN ALA TYR ALA GLU ILE SER E1 L20 W47 Y50 S53 Y59 A60 D61 F67 T68 I69 D72 K75 N76 M82 L82C M100H V111 L124 S128

K129 SER THR SER GLY G134 L138 L141 E148 Y176 S188 K201 N204 V211 S215 CYS ASP LYS THR THR

- Molecule 4: NabFab LC

Chain L: 

MET LYS LYS ASN ILE ALA PHE LEU ALA SER MET PHE VAL PHE SER ILE ALA THR ASN ALA TYR ALA SER ASP ILE GLN M4 S7 V19 R24 A25 S26 Q27 S28 V29 S30 S31 A32 V33 L46 Y55 S63 R66 D70 T74 I75 F83 Q89

Q90 S93 S94 V104 E105 R108 T109 V115 F118 L135 L136 Q147 L154 Q166 T172 Y173 D185 Y186 E187 K188 V196 T197 H198 Q199 G212 GLU CYS

- Molecule 5: Anti-Fab Nanobody

Chain K: 

MET LYS TYR LEU PRO THR ALA ALA GLY LEU LEU LEU ALA ALA GLN PRO ALA MET MET MET HIS HIS HIS HIS GLY GLU ASN LEU TYR PHE GLN GLY SER Q1 V2 Q3 L4 Q5 E6 G16 R19 L20 A24 R27 R31 M34 Q39

G42 F47 V50 R52A S53 G54 D55 D61 G65 R66 F67 D72 D73 A74 K75 N76 L80 Q81 M82 N82A S82B V89 I94 D95 D101 Q105 S112 S113

4 Experimental information

Property	Value	Source
EM reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, Not provided	
Number of particles used	445766	Depositor
Resolution determination method	FSC 0.143 CUT-OFF	Depositor
CTF correction method	NONE	Depositor
Microscope	FEI TALOS ARCTICA	Depositor
Voltage (kV)	200	Depositor
Electron dose ($e^-/\text{\AA}^2$)	40	Depositor
Minimum defocus (nm)	600	Depositor
Maximum defocus (nm)	2000	Depositor
Magnification	150000	Depositor
Image detector	FEI FALCON III (4k x 4k)	Depositor
Maximum map value	1.790	Depositor
Minimum map value	-0.044	Depositor
Average map value	0.000	Depositor
Map value standard deviation	0.017	Depositor
Recommended contour level	0.2	Depositor
Map size ($\text{\AA}$)	312.288, 312.288, 312.288	wwPDB
Map dimensions	320, 320, 320	wwPDB
Map angles ($^\circ$)	90.0, 90.0, 90.0	wwPDB
Pixel spacing ($\text{\AA}$)	0.9759, 0.9759, 0.9759	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	0.19	0/2380	0.39	0/3242
2	B	0.19	0/968	0.31	0/1309
3	H	0.18	0/1757	0.36	0/2401
4	L	0.19	0/1618	0.33	0/2195
5	K	0.24	0/950	0.35	0/1284
All	All	0.20	0/7673	0.36	0/10431

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	2320	0	2407	51	0
2	B	948	0	909	12	0
3	H	1708	0	1619	13	0
4	L	1586	0	1554	20	0
5	K	931	0	878	9	0
All	All	7493	0	7367	99	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 7.

The worst 5 of 99 close contacts within the same asymmetric unit are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:258:ARG:HH11	1:A:262:VAL:HG11	1.35	0.92
3:H:82:MET:HB3	3:H:82(C):LEU:HD11	1.57	0.86
1:A:135:PHE:HB3	1:A:139:LEU:HD12	1.63	0.80
3:H:138:LEU:HD13	3:H:211:VAL:HG21	1.64	0.78
1:A:254:LEU:HD23	1:A:257:LEU:HD12	1.74	0.70

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	286/482 (59%)	273 (96%)	13 (4%)	0	100	100
2	B	123/171 (72%)	119 (97%)	4 (3%)	0	100	100
3	H	222/262 (85%)	214 (96%)	8 (4%)	0	100	100
4	L	207/238 (87%)	201 (97%)	6 (3%)	0	100	100
5	K	119/159 (75%)	115 (97%)	4 (3%)	0	100	100
All	All	957/1312 (73%)	922 (96%)	35 (4%)	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	262/424 (62%)	262 (100%)	0	100	100

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
2	B	100/134 (75%)	100 (100%)	0	100	100
3	H	184/218 (84%)	184 (100%)	0	100	100
4	L	184/208 (88%)	184 (100%)	0	100	100
5	K	97/125 (78%)	97 (100%)	0	100	100
All	All	827/1109 (75%)	827 (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. All (3) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	188	ASN
4	L	147	GLN
4	L	166	GLN

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

5.5 Carbohydrates ⓘ

There are no oligosaccharides in this entry.

5.6 Ligand geometry ⓘ

There are no ligands in this entry.

5.7 Other polymers ⓘ

There are no such residues in this entry.

5.8 Polymer linkage issues ⓘ

There are no chain breaks in this entry.

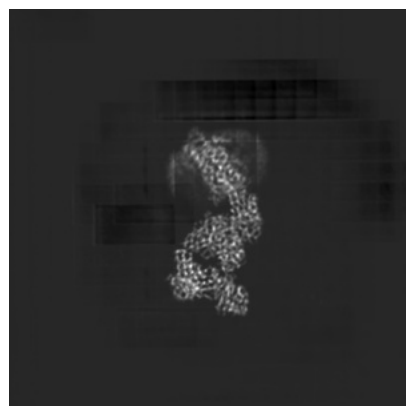
6 Map visualisation [i](#)

This section contains visualisations of the EMDB entry EMD-18541. These allow visual inspection of the internal detail of the map and identification of artifacts.

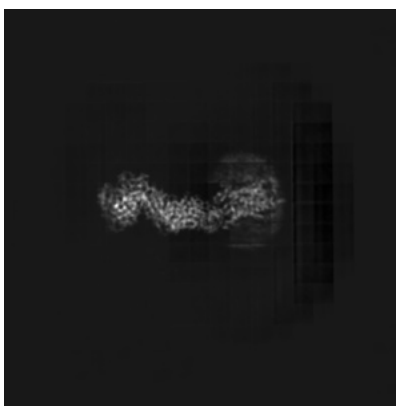
Images derived from a raw map, generated by summing the deposited half-maps, are presented below the corresponding image components of the primary map to allow further visual inspection and comparison with those of the primary map.

6.1 Orthogonal projections [i](#)

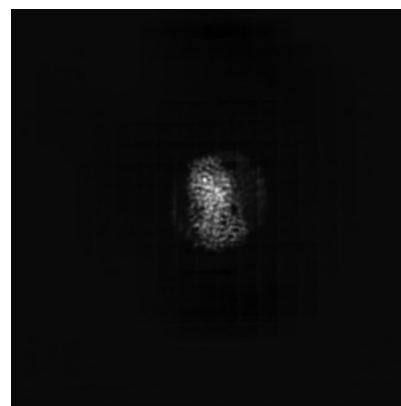
6.1.1 Primary map



X

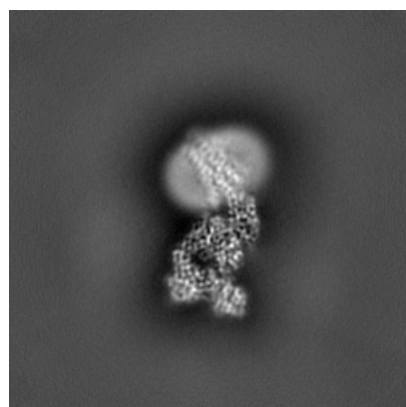


Y

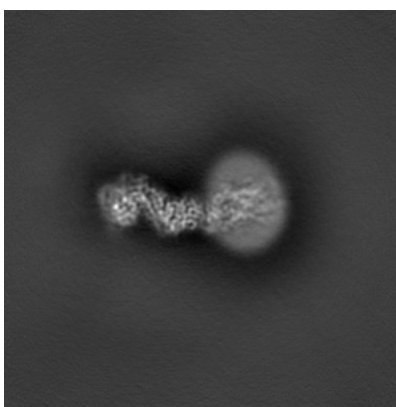


Z

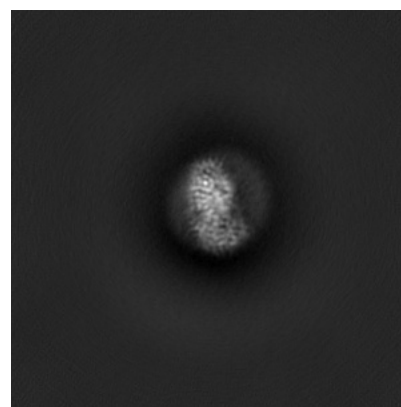
6.1.2 Raw map



X



Y



Z

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

6.2 Central slices [i](#)

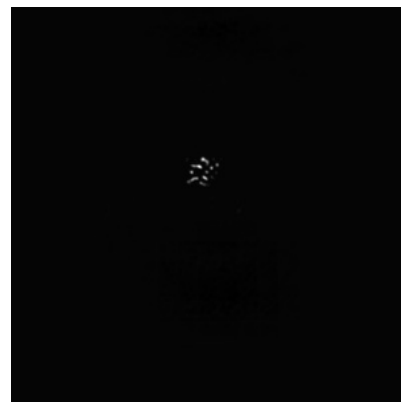
6.2.1 Primary map



X Index: 160

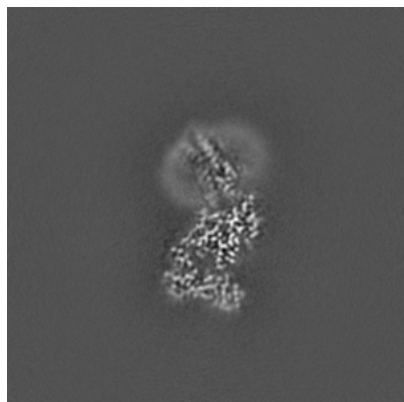


Y Index: 160

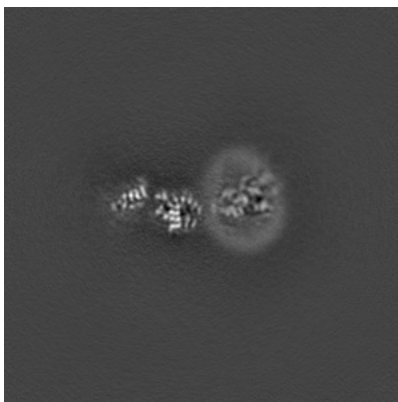


Z Index: 160

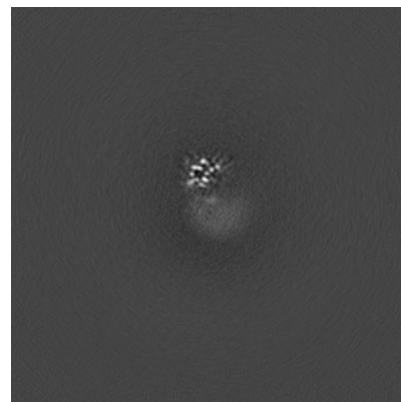
6.2.2 Raw map



X Index: 160



Y Index: 160



Z Index: 160

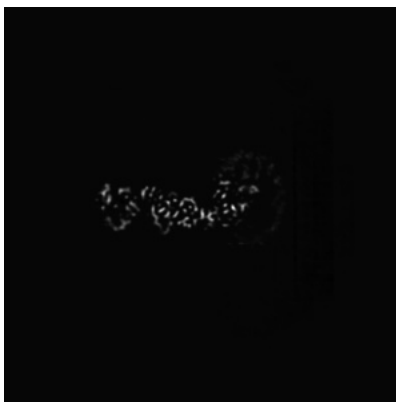
The images above show central slices of the map in three orthogonal directions.

6.3 Largest variance slices [i](#)

6.3.1 Primary map



X Index: 164

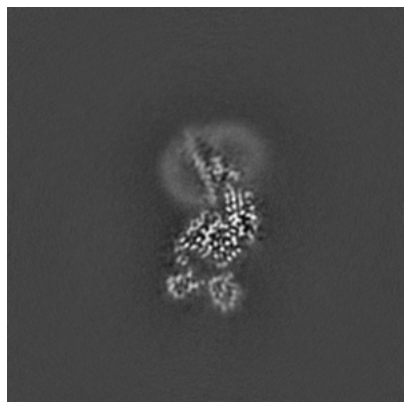


Y Index: 178

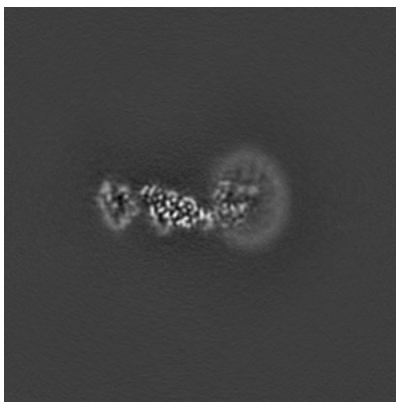


Z Index: 96

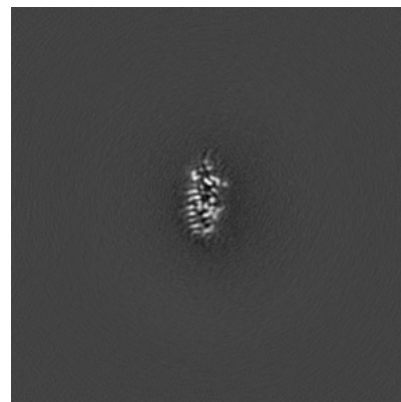
6.3.2 Raw map



X Index: 155



Y Index: 177

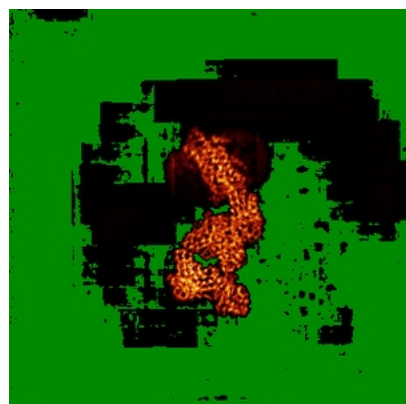


Z Index: 134

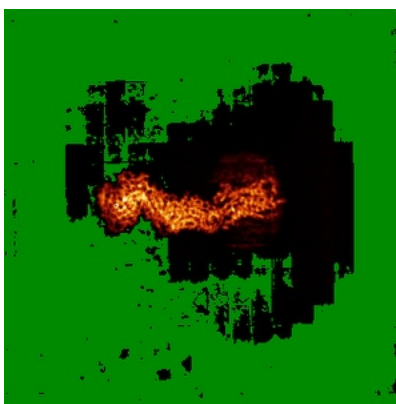
The images above show the largest variance slices of the map in three orthogonal directions.

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

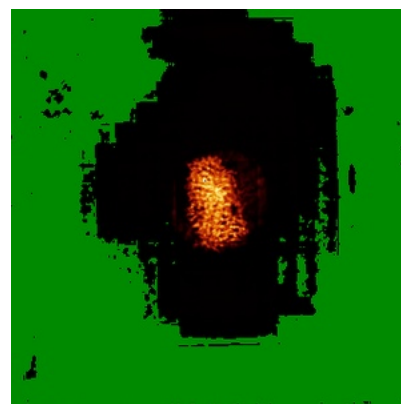
6.4.1 Primary map



X

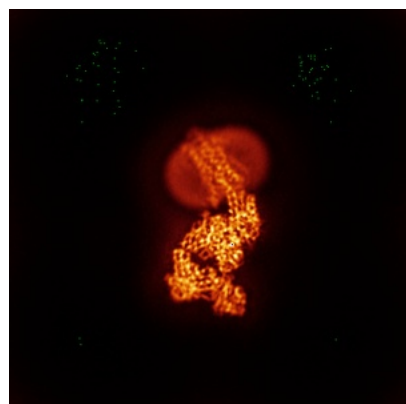


Y

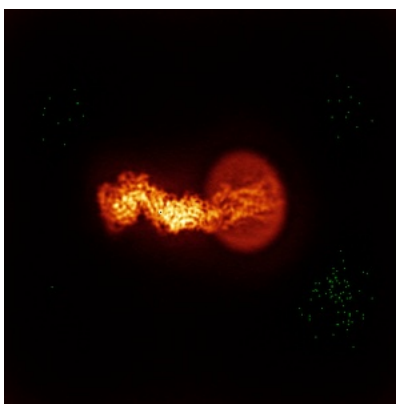


Z

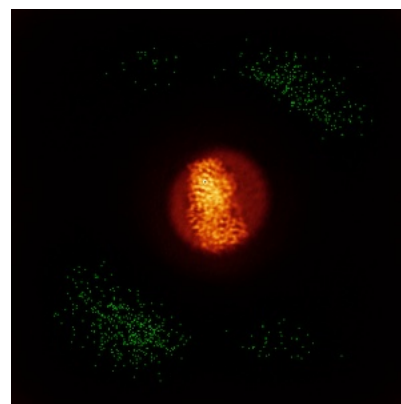
6.4.2 Raw map



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](#)

This section was not generated.

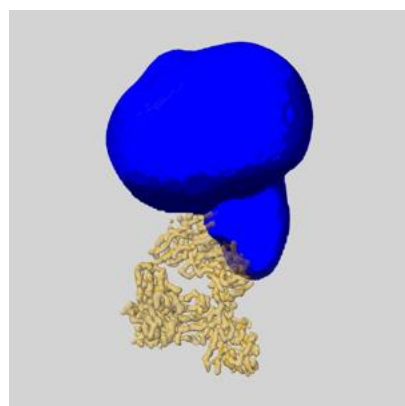
6.6 Mask visualisation [i](#)

This section shows the 3D surface view of the primary map at 50% transparency overlaid with the specified mask at 0% transparency

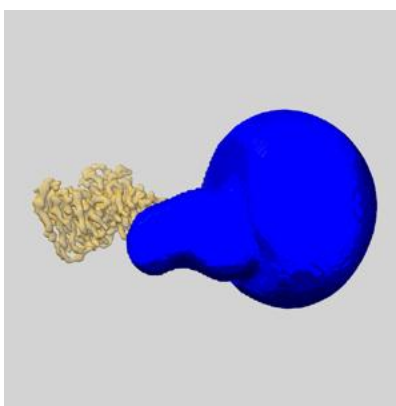
A mask typically either:

- Encompasses the whole structure
- Separates out a domain, a functional unit, a monomer or an area of interest from a larger structure

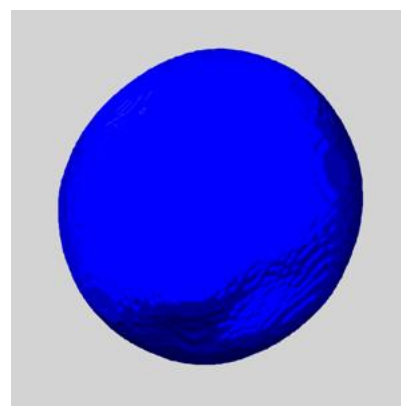
6.6.1 emd_18541_msk_1.map [i](#)



X



Y

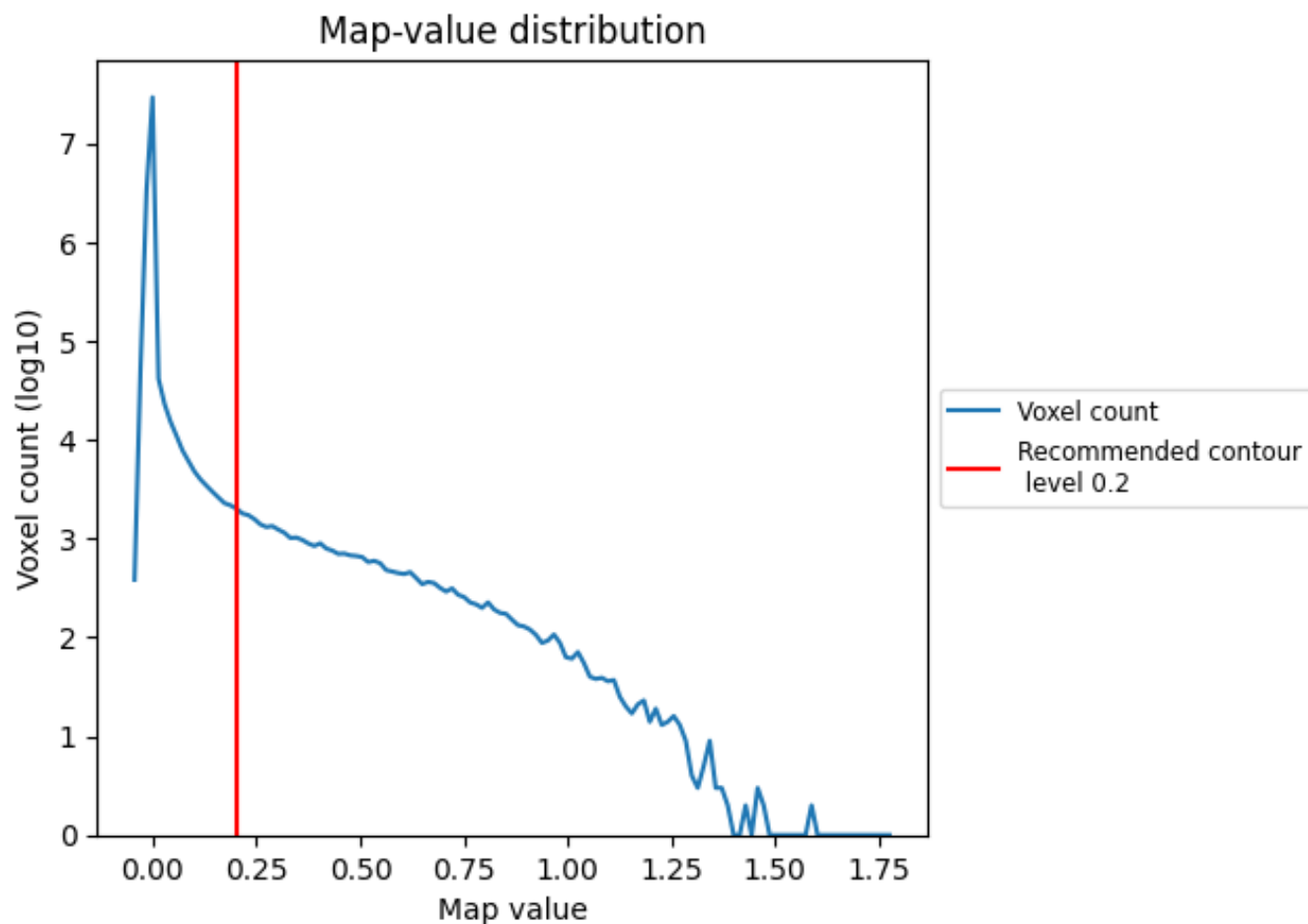


Z

7 Map analysis [i](#)

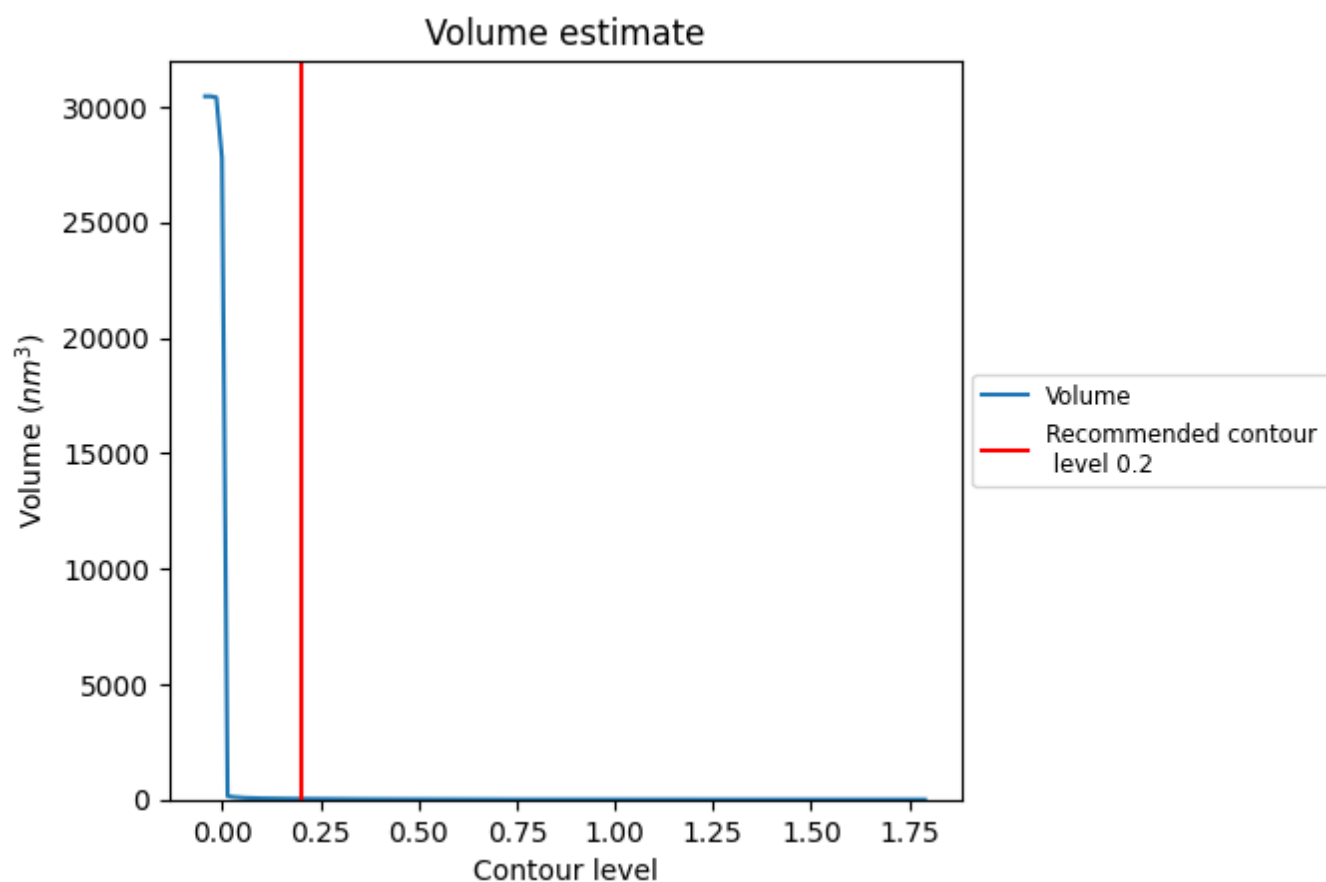
This section contains the results of statistical analysis of the map.

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.

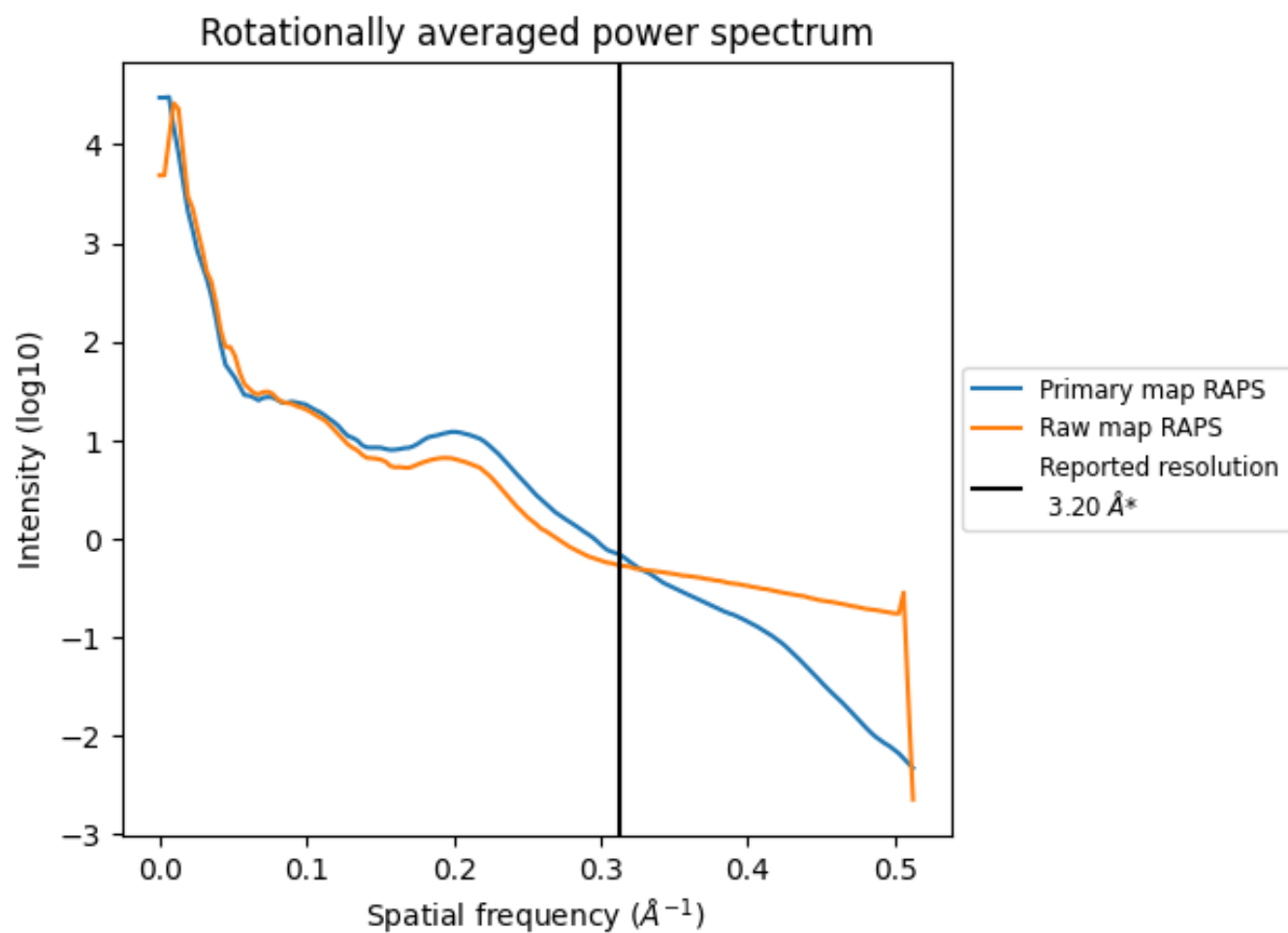
7.2 Volume estimate [i](#)



The volume at the recommended contour level is 32 nm^3 ; this corresponds to an approximate mass of 29 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 ⓘ

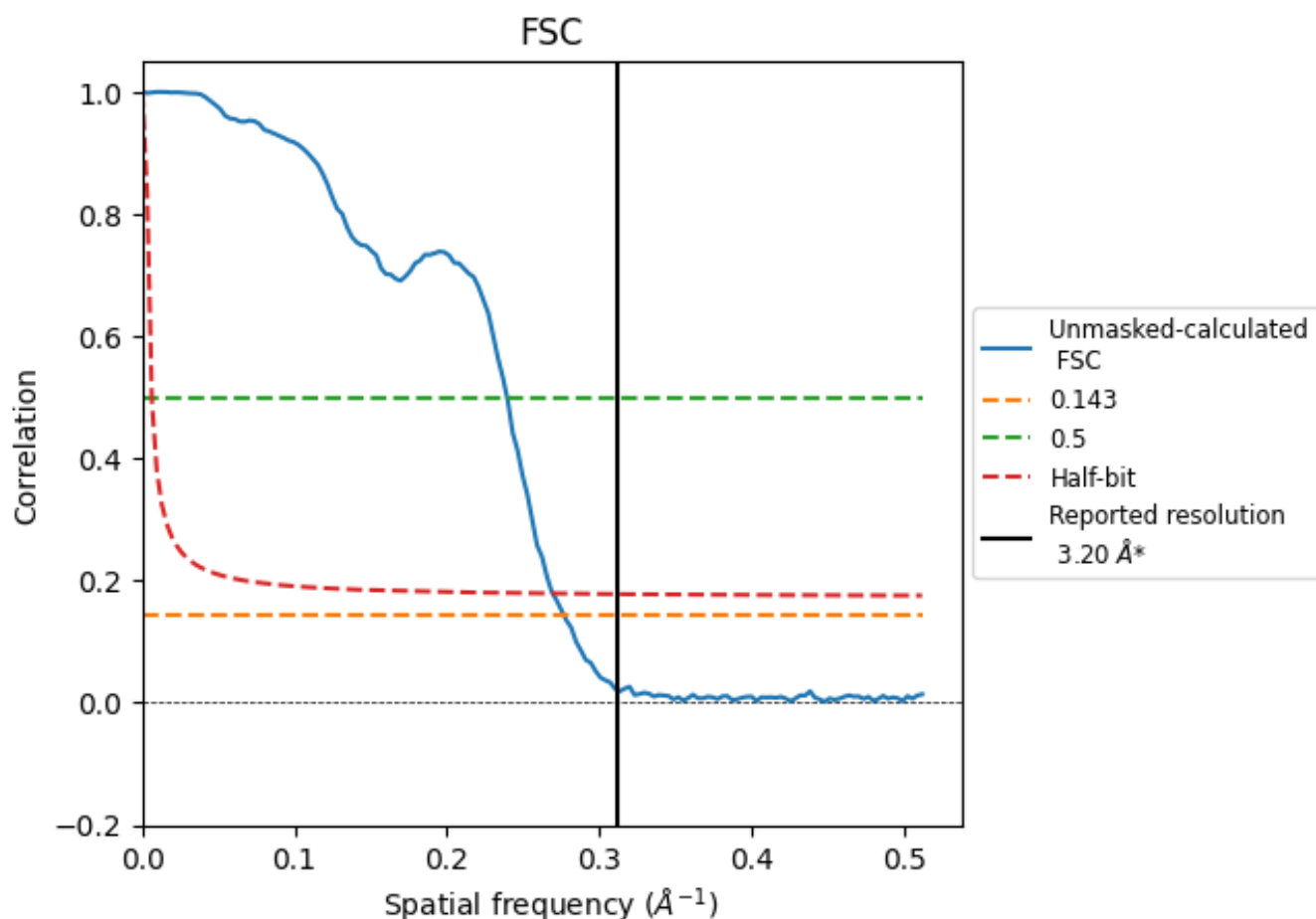


*Reported resolution corresponds to spatial frequency of $0.312 \text{ \AA}^{-1}$

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 0.312 Å⁻¹

8.2 Resolution estimates [i](#)

Resolution estimate (Å)	Estimation criterion (FSC cut-off)		
	0.143	0.5	Half-bit
Reported by author	3.20	-	-
Author-provided FSC curve	-	-	-
Unmasked-calculated*	3.61	4.17	3.71

*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 3.61 differs from the reported value 3.2 by more than 10 %

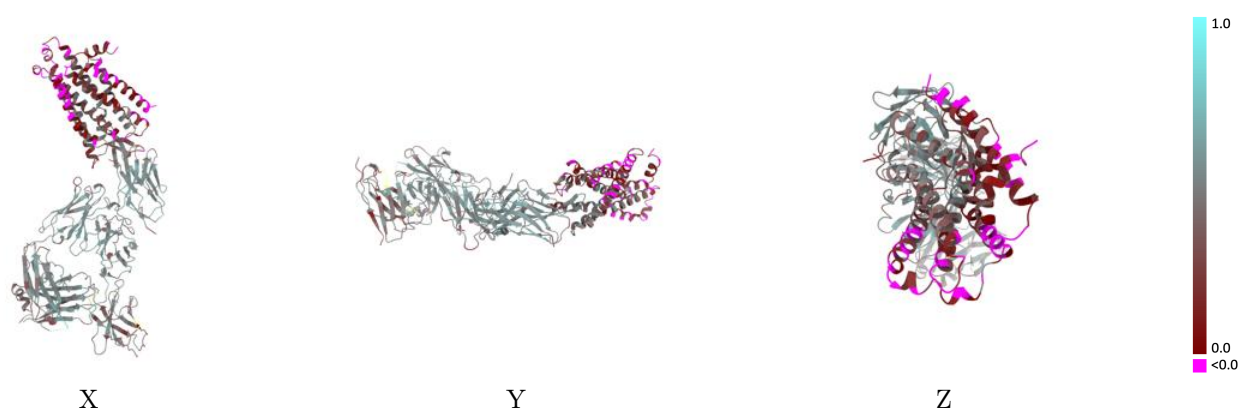
9 Map-model fit [i](#)

This section contains information regarding the fit between EMDB map EMD-18541 and PDB model 8QOT. Per-residue inclusion information can be found in section [3](#) on page [7](#).

9.1 Map-model overlay [i](#)

This section was not generated.

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

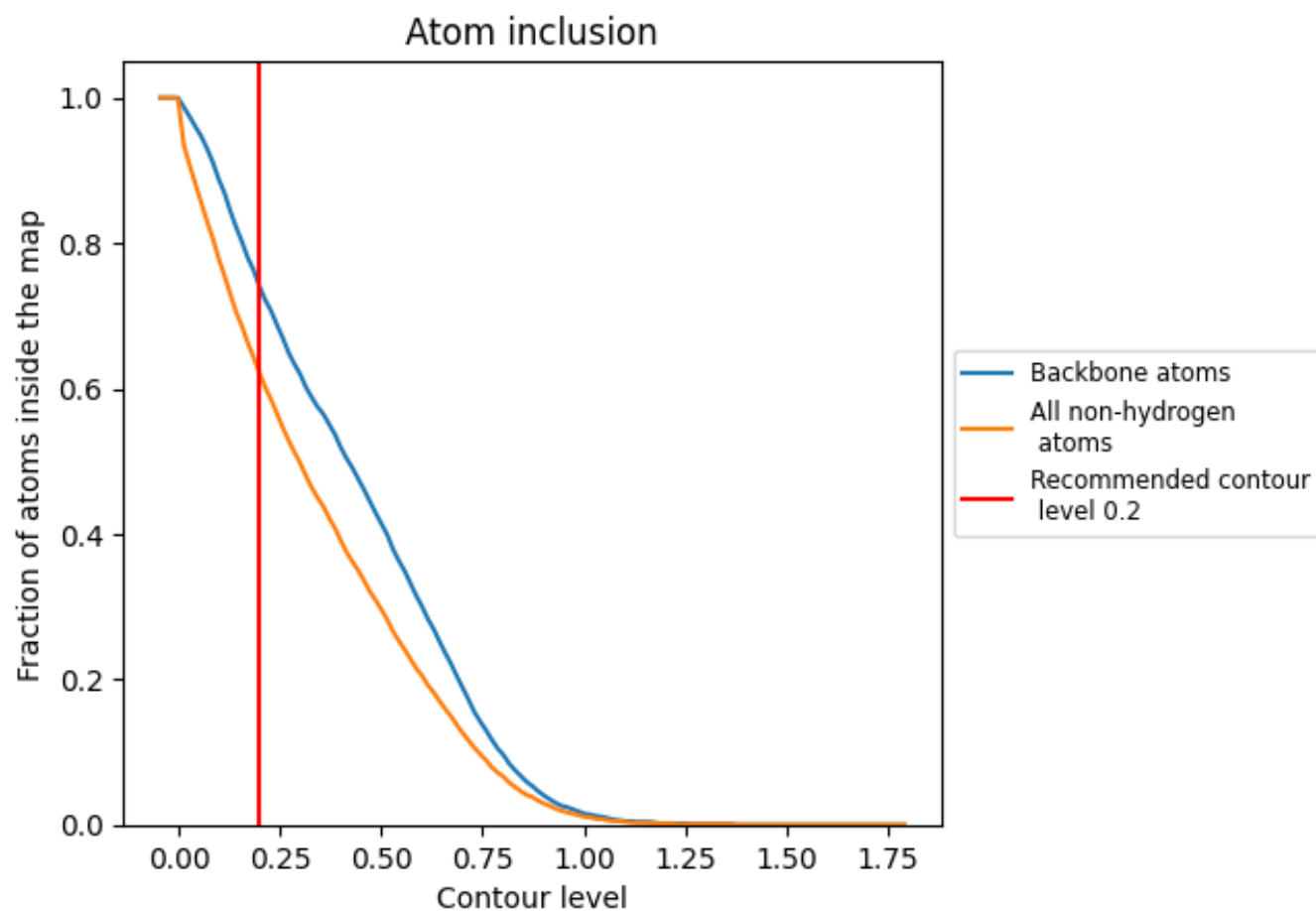


The images above show the model with each residue coloured according to its Q-score. This shows their resolvability in the map with higher Q-score values reflecting better resolvability. Please note: Q-score is calculating the resolvability of atoms, and thus high values are only expected at resolutions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

This section was not generated.

9.4 Atom inclusion [i](#)



At the recommended contour level, 74% of all backbone atoms, 62% 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 (0.2) and Q-score for the entire model and for each chain.

Chain	Atom inclusion	Q-score
All	0.6210	0.4130
A	0.4380	0.2300
B	0.7510	0.5220
H	0.7270	0.5100
K	0.5860	0.4230
L	0.7160	0.5030

