



Full wwPDB EM Validation Report ⓘ

Mar 29, 2026 – 11:28 AM UTC

PDB ID : 7WSF / pdb_00007wsf
EMDB ID : EMD-32756
Title : Cryo-EM structure of SARS-CoV spike receptor-binding domain in complex with minke whale ACE2
Authors : Li, S.; Han, P.; Qi, J.
Deposited on : 2022-01-29
Resolution : 2.87 Å(reported)

This is a Full wwPDB EM Validation 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

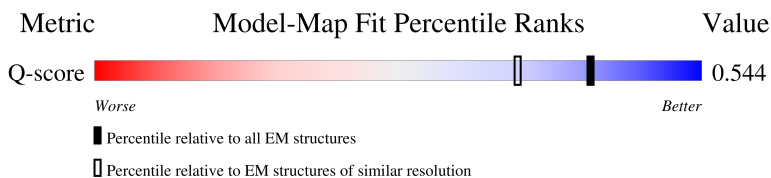
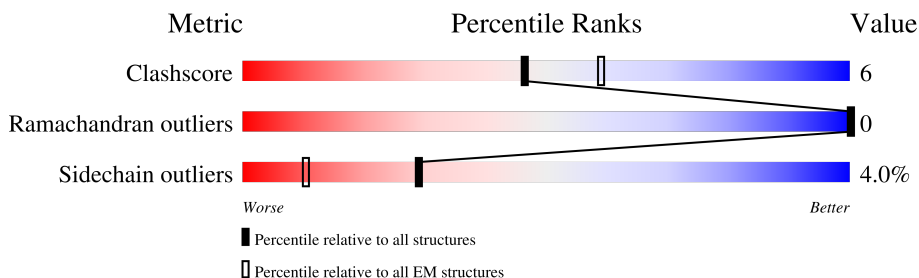
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

ELECTRON MICROSCOPY

The reported resolution of this entry is 2.87 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	12062 (2.37 - 3.37)

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	739	
2	B	190	

2 Entry composition

There are 3 unique types of molecules in this entry. The entry contains 7170 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 Angiotensin-converting enzyme.

Mol	Chain	Residues	Atoms					AltConf	Trace
1	A	693	Total	C	N	O	S	0	0
			5677	3626	950	1071	30		

- Molecule 2 is a protein called Spike protein S1.

Mol	Chain	Residues	Atoms					AltConf	Trace
2	B	186	Total	C	N	O	S	0	0
			1492	964	242	278	8		

There are 8 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
B	503	GLY	-	expression tag	UNP P59594
B	504	SER	-	expression tag	UNP P59594
B	505	LEU	-	expression tag	UNP P59594
B	506	GLU	-	expression tag	UNP P59594
B	507	VAL	-	expression tag	UNP P59594
B	508	LEU	-	expression tag	UNP P59594
B	509	PHE	-	expression tag	UNP P59594
B	510	GLN	-	expression tag	UNP P59594

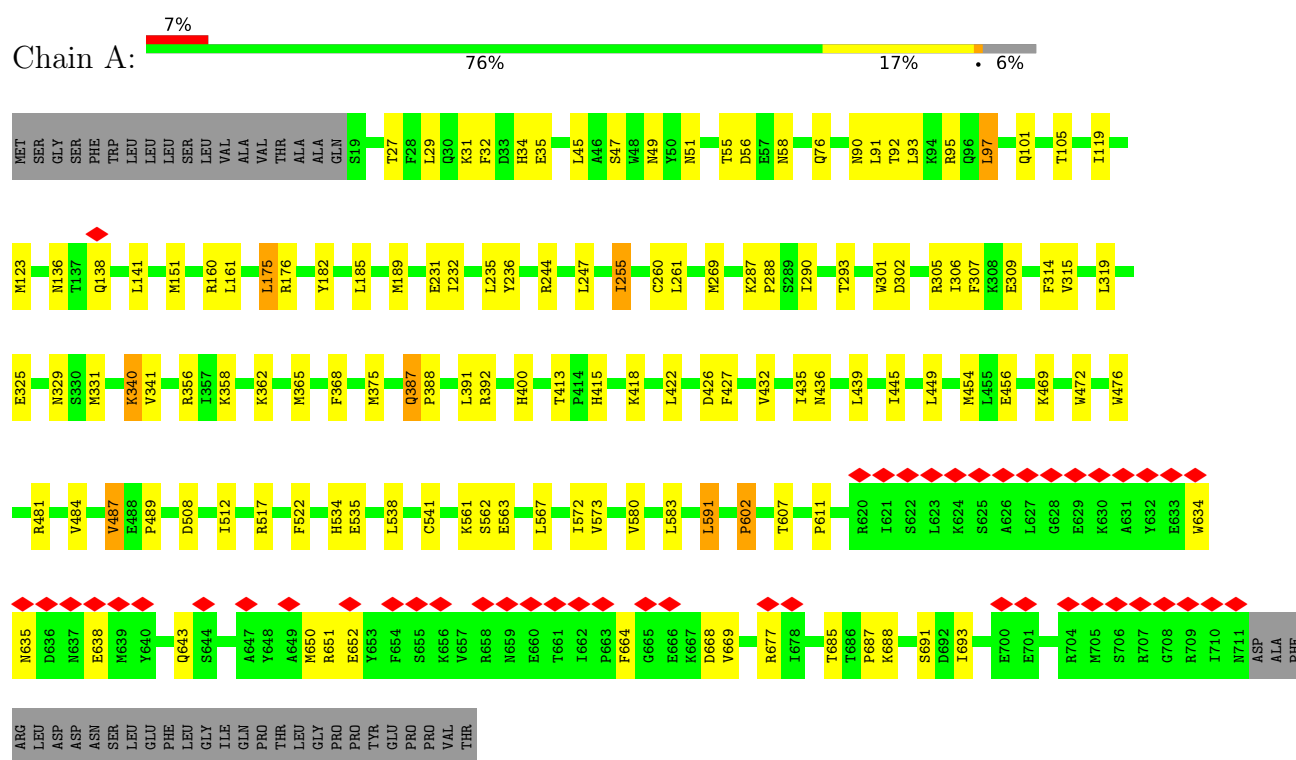
- Molecule 3 is ZINC ION (CCD ID: ZN) (formula: Zn) (labeled as "Ligand of Interest" by depositor).

Mol	Chain	Residues	Atoms		AltConf
3	A	1	Total	Zn	0
			1	1	

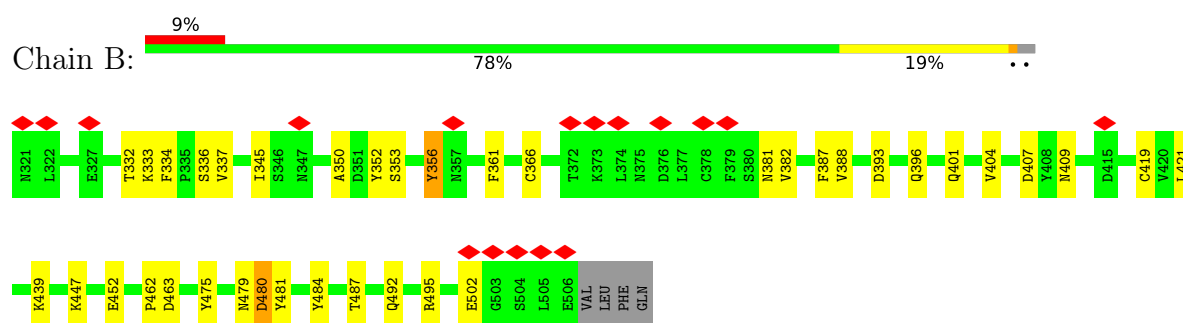
3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry 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: Angiotensin-converting enzyme



• Molecule 2: Spike protein S1



4 Experimental information

Property	Value	Source
EM reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, Not provided	
Number of particles used	146539	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 ($e^-/\text{\AA}^2$)	60	Depositor
Minimum defocus (nm)	1000	Depositor
Maximum defocus (nm)	2000	Depositor
Magnification	Not provided	
Image detector	GATAN K3 (6k x 4k)	Depositor
Maximum map value	2.223	Depositor
Minimum map value	-1.533	Depositor
Average map value	-0.001	Depositor
Map value standard deviation	0.053	Depositor
Recommended contour level	0.23	Depositor
Map size (Å)	240.84001, 240.84001, 240.84001	wwPDB
Map dimensions	360, 360, 360	wwPDB
Map angles (°)	90.0, 90.0, 90.0	wwPDB
Pixel spacing (Å)	0.669, 0.669, 0.669	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: ZN

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	0.11	0/5832	0.23	0/7904
2	B	0.11	0/1539	0.23	0/2098
All	All	0.11	0/7371	0.23	0/10002

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	5677	0	5423	67	0
2	B	1492	0	1410	24	0
3	A	1	0	0	0	0
All	All	7170	0	6833	86	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 6.

All (86) 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:432:VAL:O	1:A:436:ASN:ND2	2.23	0.71
2:B:345:ILE:HB	2:B:382:VAL:HB	1.76	0.67
1:A:651:ARG:HB2	1:A:664:PHE:HB2	1.77	0.67
1:A:244:ARG:HG3	1:A:255:ILE:HD11	1.78	0.66
1:A:232:ILE:HD13	1:A:449:LEU:HD13	1.77	0.65
2:B:336:SER:OG	2:B:439:LYS:O	2.16	0.64
1:A:47:SER:O	1:A:51:ASN:ND2	2.30	0.63
1:A:161:LEU:HD23	1:A:691:SER:HA	1.80	0.62
1:A:287:LYS:HD3	1:A:288:PRO:HD2	1.83	0.61
1:A:572:ILE:HG23	1:A:573:VAL:HG23	1.84	0.60
2:B:388:VAL:HG22	2:B:495:ARG:HG2	1.85	0.59
1:A:481:ARG:NH2	1:A:607:THR:O	2.32	0.58
2:B:404:VAL:O	2:B:409:ASN:ND2	2.34	0.58
1:A:176:ARG:NH2	1:A:469:LYS:O	2.37	0.57
1:A:45:LEU:O	1:A:49:ASN:ND2	2.39	0.56
2:B:393:ASP:OD2	2:B:481:TYR:OH	2.22	0.55
1:A:325:GLU:OE2	2:B:492:GLN:NE2	2.39	0.55
2:B:396:GLN:HA	2:B:401:GLN:HG2	1.89	0.55
1:A:418:LYS:HD3	1:A:427:PHE:HB3	1.90	0.54
1:A:27:THR:HG21	2:B:462:PRO:HG3	1.89	0.54
1:A:95:ARG:NH2	1:A:561:LYS:O	2.41	0.54
1:A:445:ILE:HD13	1:A:522:PHE:HZ	1.73	0.53
1:A:123:MET:HA	1:A:175:LEU:HD11	1.91	0.53
1:A:32:PHE:HD1	1:A:76:GLN:HG2	1.73	0.53
1:A:260:CYS:HB2	1:A:487:VAL:HG13	1.91	0.52
2:B:337:VAL:HG22	2:B:409:ASN:HB3	1.92	0.52
2:B:332:THR:HG23	2:B:333:LYS:HG3	1.93	0.51
1:A:685:THR:HG22	1:A:693:ILE:HG22	1.90	0.51
2:B:381:ASN:H	2:B:502:GLU:HB3	1.75	0.51
2:B:463:ASP:OD1	2:B:463:ASP:N	2.44	0.50
1:A:643:GLN:HG3	1:A:669:VAL:HB	1.93	0.50
1:A:34:HIS:NE2	2:B:479:ASN:HB2	2.27	0.50
1:A:387:GLN:O	1:A:392:ARG:NH1	2.45	0.49
1:A:31:LYS:HD2	2:B:475:TYR:HD1	1.77	0.49
1:A:314:PHE:HD1	1:A:319:LEU:HD12	1.76	0.49
1:A:55:THR:OG1	1:A:56:ASP:N	2.45	0.49
1:A:235:LEU:HD13	1:A:591:LEU:HG	1.94	0.49
1:A:413:THR:HG22	1:A:415:HIS:H	1.78	0.49
1:A:391:LEU:HD13	1:A:562:SER:HA	1.95	0.48
1:A:31:LYS:NZ	1:A:35:GLU:OE1	2.45	0.48
1:A:534:HIS:CD2	1:A:541:CYS:HB2	2.48	0.48
2:B:484:TYR:HB2	2:B:487:THR:HG23	1.95	0.48

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:301:TRP:CH2	1:A:309:GLU:HG3	2.50	0.47
1:A:668:ASP:OD2	1:A:687:PRO:HG3	2.15	0.47
2:B:366:CYS:HA	2:B:419:CYS:HA	1.97	0.47
1:A:119:ILE:HD12	1:A:185:LEU:HD12	1.98	0.46
1:A:635:ASN:OD1	1:A:677:ARG:NE	2.44	0.46
1:A:329:ASN:HB3	1:A:356:ARG:NE	2.31	0.46
1:A:331:MET:HE2	1:A:358:LYS:HG3	1.98	0.46
1:A:29:LEU:HD11	1:A:97:LEU:HD12	1.98	0.46
1:A:244:ARG:NH2	1:A:602:PRO:O	2.49	0.46
1:A:302:ASP:H	1:A:305:ARG:HB3	1.82	0.45
1:A:340:LYS:NZ	1:A:341:VAL:O	2.49	0.45
1:A:454:MET:HE1	1:A:476:TRP:CE3	2.51	0.45
1:A:182:TYR:OH	1:A:508:ASP:OD1	2.30	0.44
1:A:489:PRO:HA	1:A:611:PRO:HG2	1.99	0.44
2:B:407:ASP:HB3	2:B:447:LYS:HG2	1.99	0.44
1:A:29:LEU:HD12	1:A:93:LEU:HD22	2.00	0.44
1:A:31:LYS:HD2	2:B:475:TYR:CD1	2.52	0.44
2:B:350:ALA:HB1	2:B:352:TYR:CZ	2.53	0.43
2:B:480:ASP:OD1	2:B:480:ASP:N	2.52	0.43
1:A:55:THR:HG23	1:A:58:ASN:H	1.84	0.43
1:A:456:GLU:HG2	1:A:512:ILE:HB	2.00	0.43
1:A:151:MET:HA	1:A:151:MET:HE2	2.01	0.43
1:A:151:MET:SD	1:A:269:MET:HA	2.59	0.43
1:A:293:THR:HB	1:A:365:MET:H	1.83	0.43
1:A:307:PHE:HD1	1:A:375:MET:HE3	1.84	0.42
1:A:90:ASN:ND2	1:A:92:THR:OG1	2.52	0.42
1:A:302:ASP:OD1	1:A:305:ARG:N	2.51	0.42
1:A:231:GLU:HB2	1:A:580:VAL:HG11	2.01	0.42
1:A:469:LYS:HA	1:A:472:TRP:CD1	2.55	0.42
2:B:334:PHE:HB3	2:B:388:VAL:HG23	2.02	0.42
1:A:151:MET:O	1:A:160:ARG:NH1	2.49	0.42
1:A:236:TYR:OH	1:A:484:VAL:O	2.27	0.41
1:A:563:GLU:HB3	1:A:567:LEU:HD23	2.02	0.41
1:A:306:ILE:HG23	1:A:368:PHE:HD1	1.85	0.41
1:A:512:ILE:HD12	1:A:512:ILE:HA	1.94	0.41
1:A:105:THR:HA	1:A:189:MET:HG3	2.02	0.41
2:B:361:PHE:CD2	2:B:421:LEU:HD22	2.56	0.41
1:A:387:GLN:HG3	1:A:388:PRO:HD2	2.02	0.41
1:A:176:ARG:HH12	1:A:472:TRP:HB2	1.86	0.41
1:A:247:LEU:HD12	1:A:261:LEU:HD22	2.02	0.41
1:A:522:PHE:CD2	1:A:583:LEU:HD23	2.56	0.40

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
2:B:337:VAL:HA	2:B:387:PHE:HB2	2.02	0.40
1:A:97:LEU:O	1:A:101:GLN:N	2.51	0.40
2:B:353:SER:HA	2:B:356:TYR:CE1	2.56	0.40

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	691/739 (94%)	675 (98%)	16 (2%)	0	100	100
2	B	184/190 (97%)	176 (96%)	8 (4%)	0	100	100
All	All	875/929 (94%)	851 (97%)	24 (3%)	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	614/654 (94%)	586 (95%)	28 (5%)	24	55
2	B	163/167 (98%)	160 (98%)	3 (2%)	51	78
All	All	777/821 (95%)	746 (96%)	31 (4%)	29	60

All (31) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	91	LEU
1	A	97	LEU
1	A	136	ASN
1	A	138	GLN
1	A	141	LEU
1	A	175	LEU
1	A	255	ILE
1	A	290	ILE
1	A	315	VAL
1	A	340	LYS
1	A	362	LYS
1	A	387	GLN
1	A	400	HIS
1	A	422	LEU
1	A	426	ASP
1	A	435	ILE
1	A	439	LEU
1	A	487	VAL
1	A	517	ARG
1	A	535	GLU
1	A	538	LEU
1	A	591	LEU
1	A	602	PRO
1	A	634	TRP
1	A	638	GLU
1	A	650	MET
1	A	652	GLU
1	A	688	LYS
2	B	356	TYR
2	B	452	GLU
2	B	480	ASP

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (8) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	63	ASN
1	A	153	ASN
1	A	193	ASN
1	A	238	GLN
1	A	298	ASN
1	A	598	ASN
1	A	637	ASN
1	A	689	ASN

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 ⓘ

Of 1 ligands modelled in this entry, 1 is monoatomic - leaving 0 for Mogul analysis.

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

No monomer is involved in short contacts.

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.

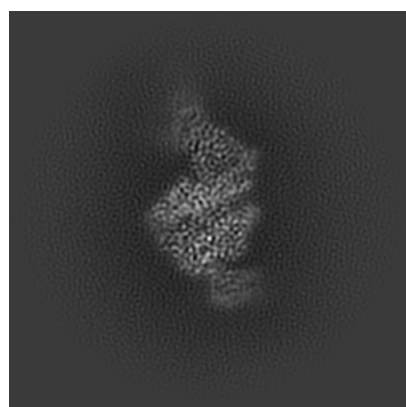
6 Map visualisation [i](#)

This section contains visualisations of the EMDB entry EMD-32756. These allow visual inspection of the internal detail of the map and identification of artifacts.

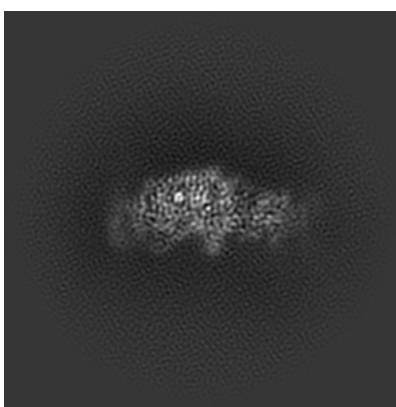
No raw map or half-maps were deposited for this entry and therefore no images, graphs, etc. pertaining to the raw map can be shown.

6.1 Orthogonal projections [i](#)

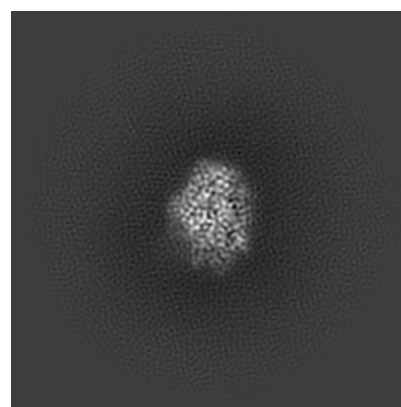
6.1.1 Primary map



X



Y

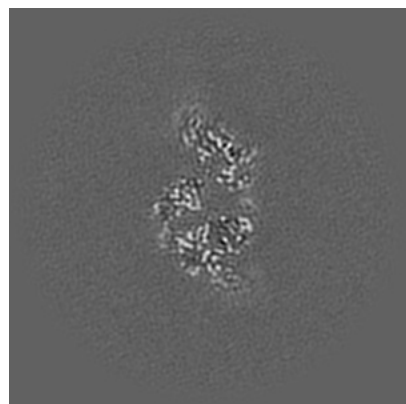


Z

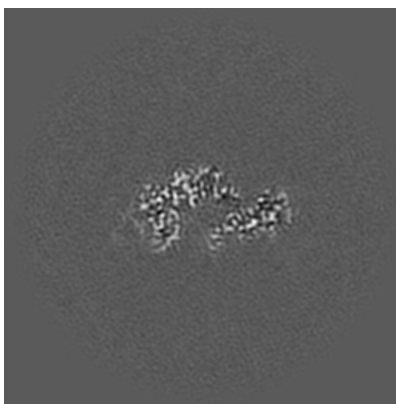
The images above show the map projected in three orthogonal directions.

6.2 Central slices [i](#)

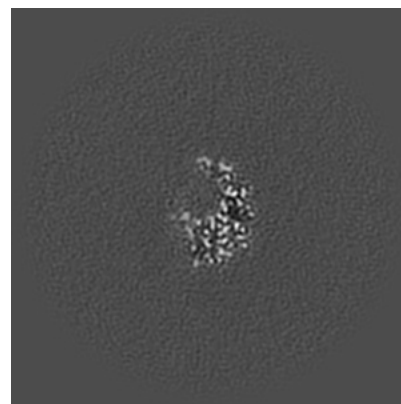
6.2.1 Primary map



X Index: 180



Y Index: 180

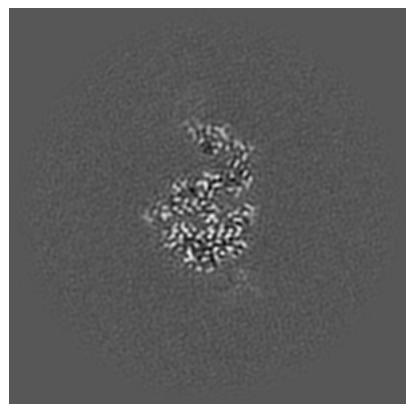


Z Index: 180

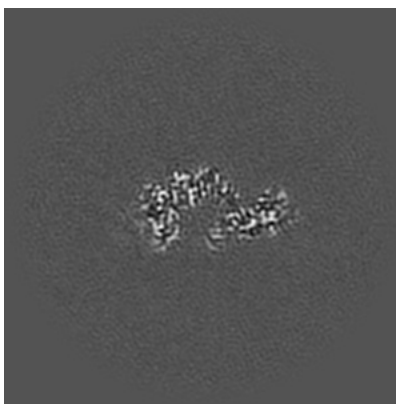
The images above show central slices of the map in three orthogonal directions.

6.3 Largest variance slices [i](#)

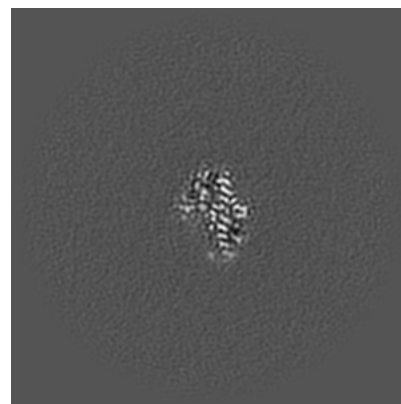
6.3.1 Primary map



X Index: 190



Y Index: 179

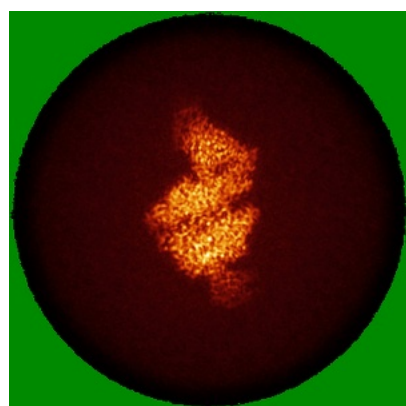


Z Index: 155

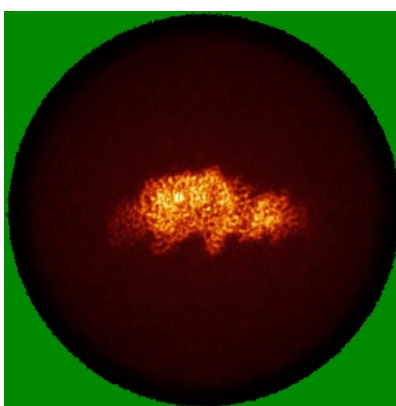
The images above show the largest variance slices of the map in three orthogonal directions.

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

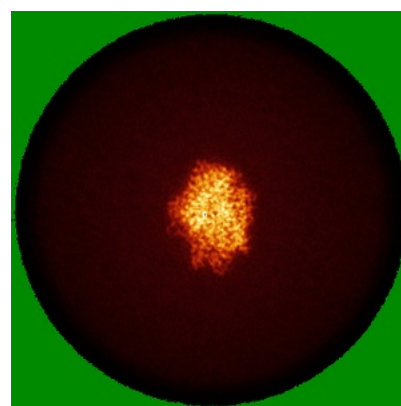
6.4.1 Primary map



X



Y

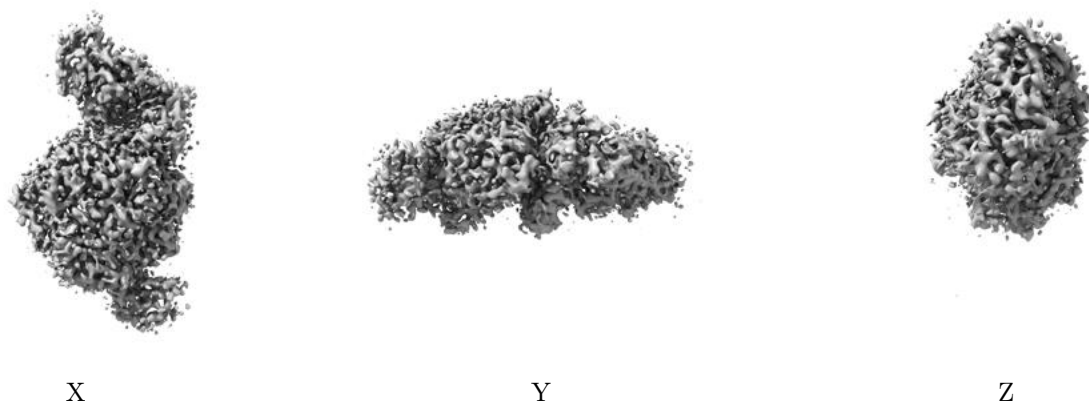


Z

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



The images above show the 3D surface view of the map at the recommended contour level 0.23. These images, in conjunction with the slice images, may facilitate assessment of whether an appropriate contour level has been provided.

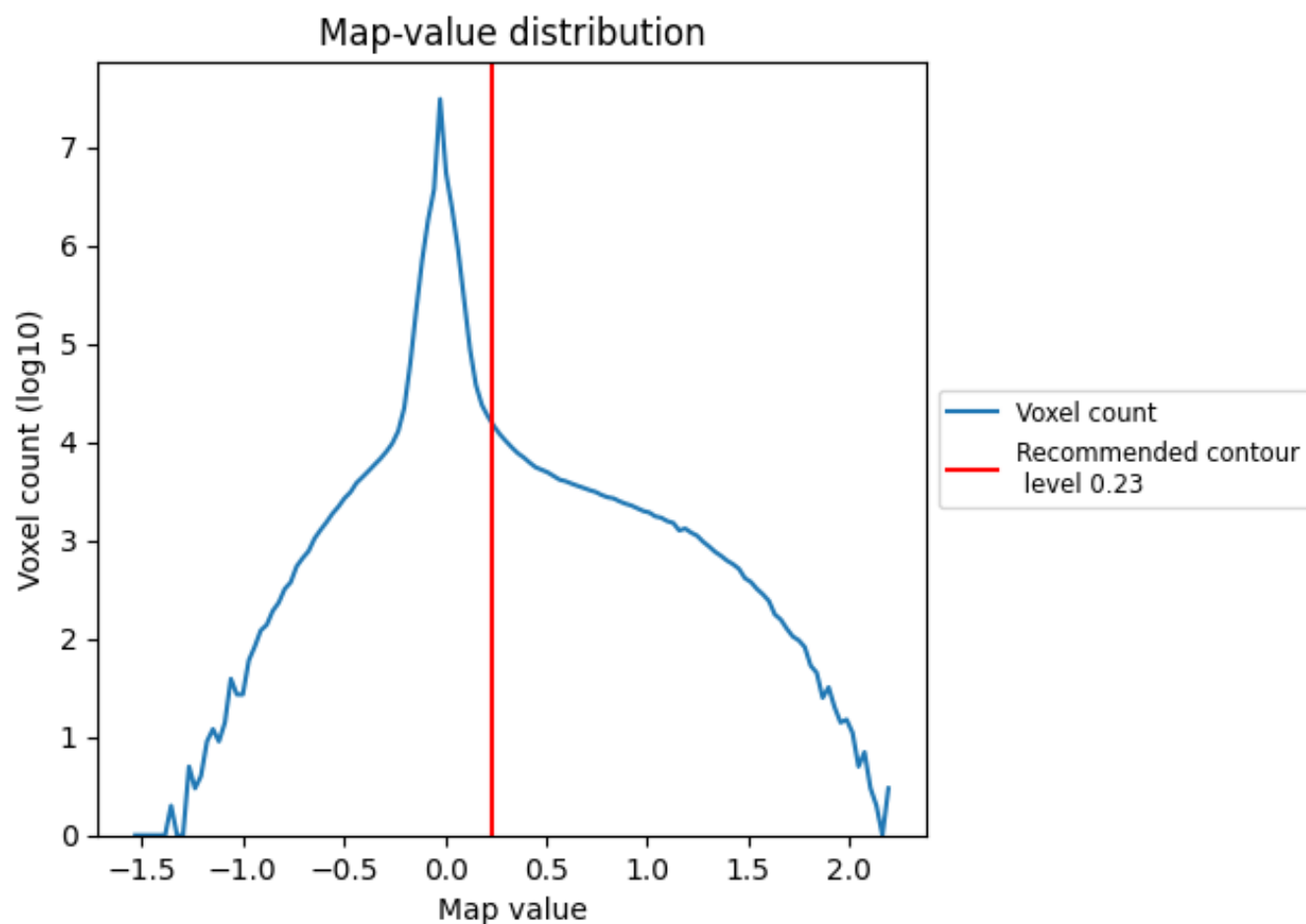
6.6 Mask visualisation [i](#)

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

7 Map analysis [i](#)

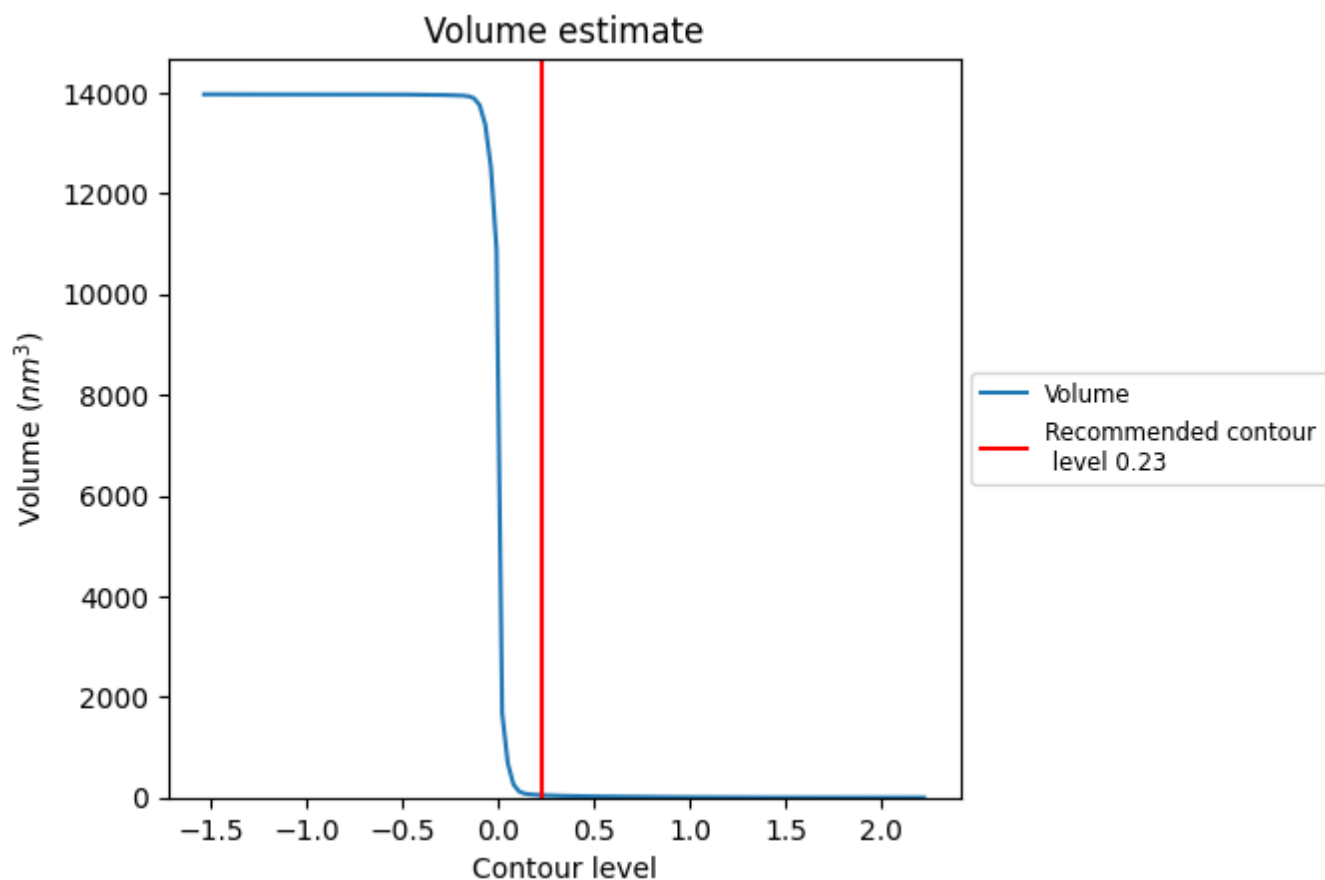
This section contains the results of statistical analysis of the map.

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.

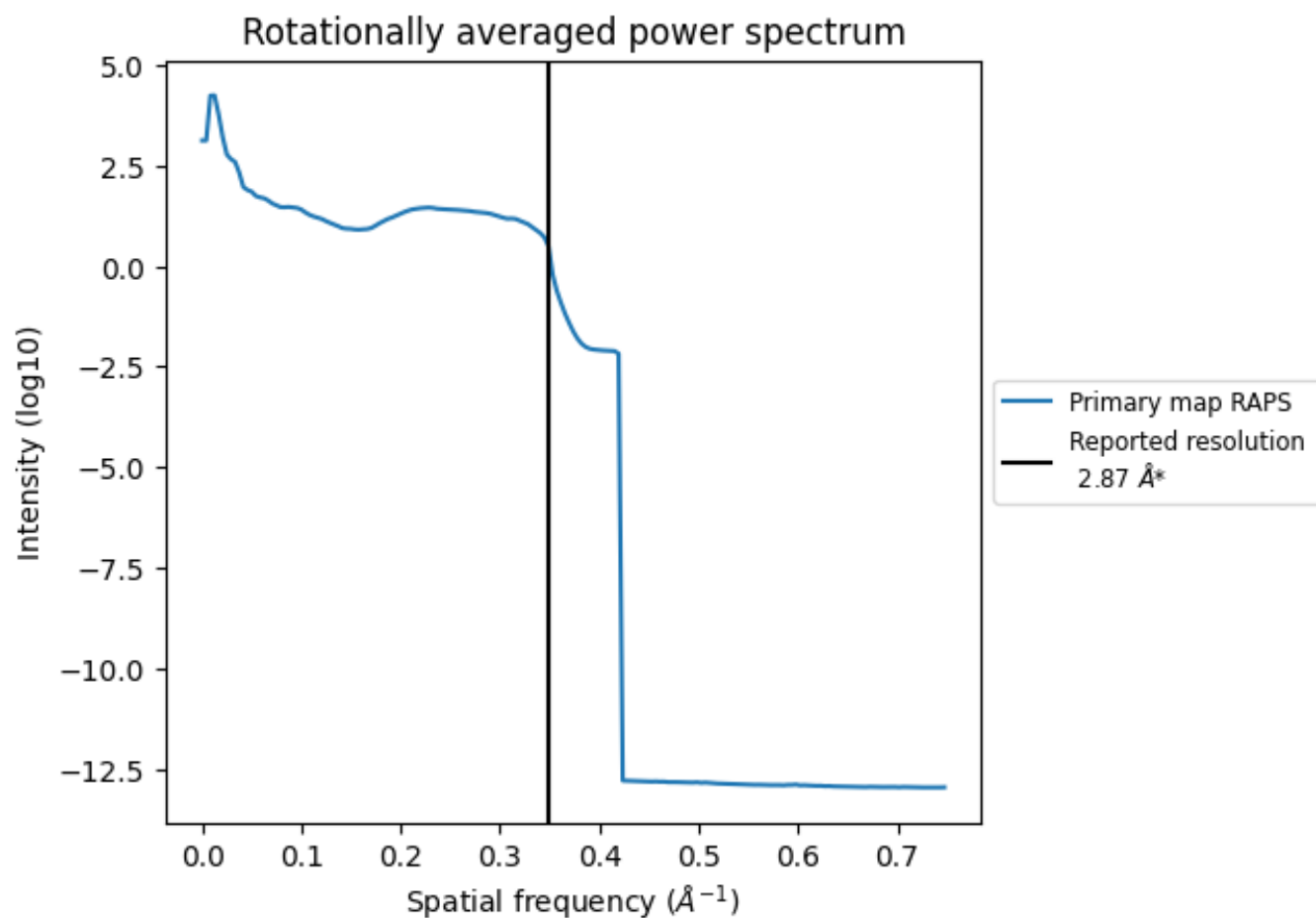
7.2 Volume estimate [i](#)



The volume at the recommended contour level is 48 nm³; this corresponds to an approximate mass of 43 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 ⓘ

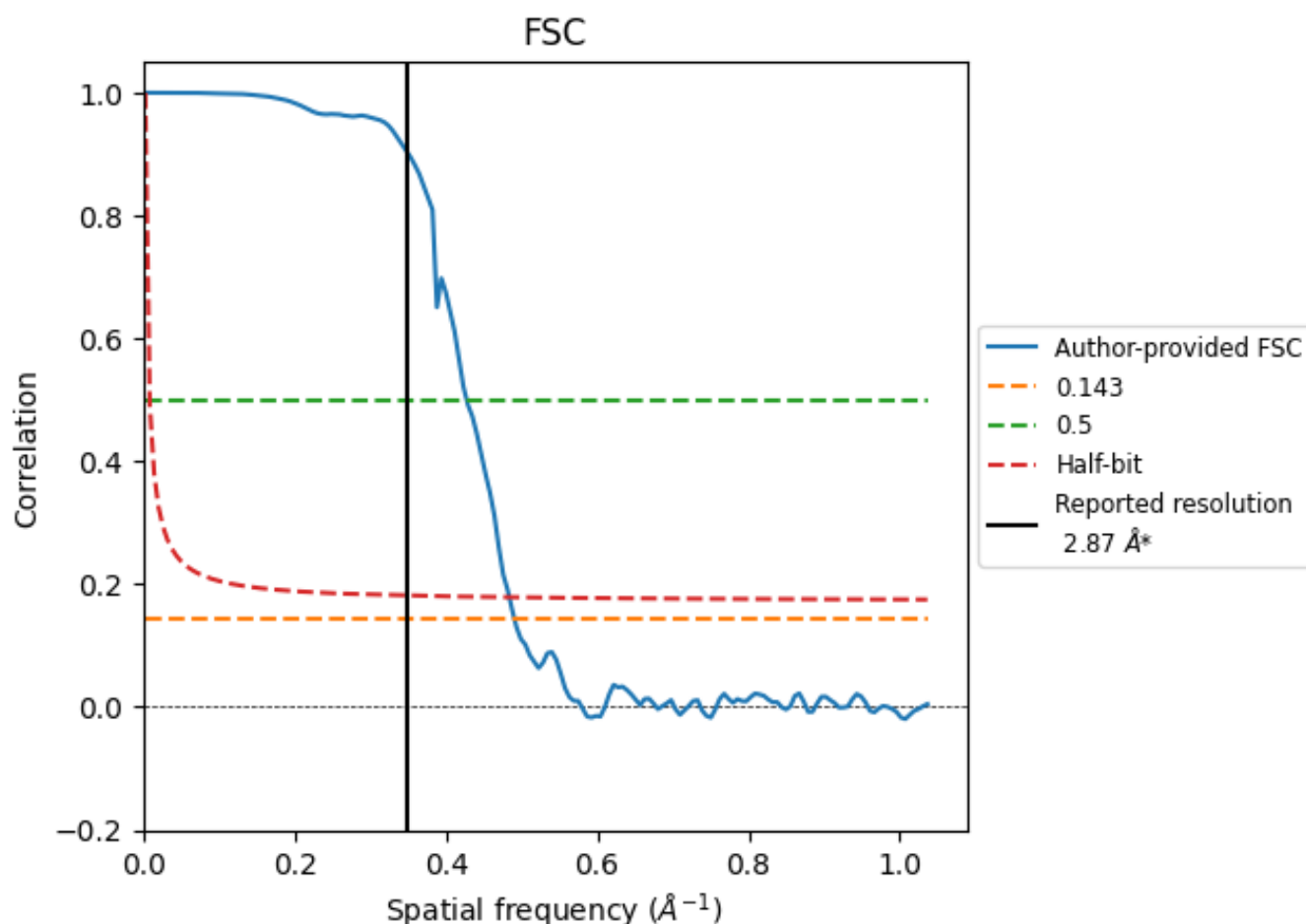


*Reported resolution corresponds to spatial frequency of 0.348 Å⁻¹

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 0.348 Å⁻¹

8.2 Resolution estimates [i](#)

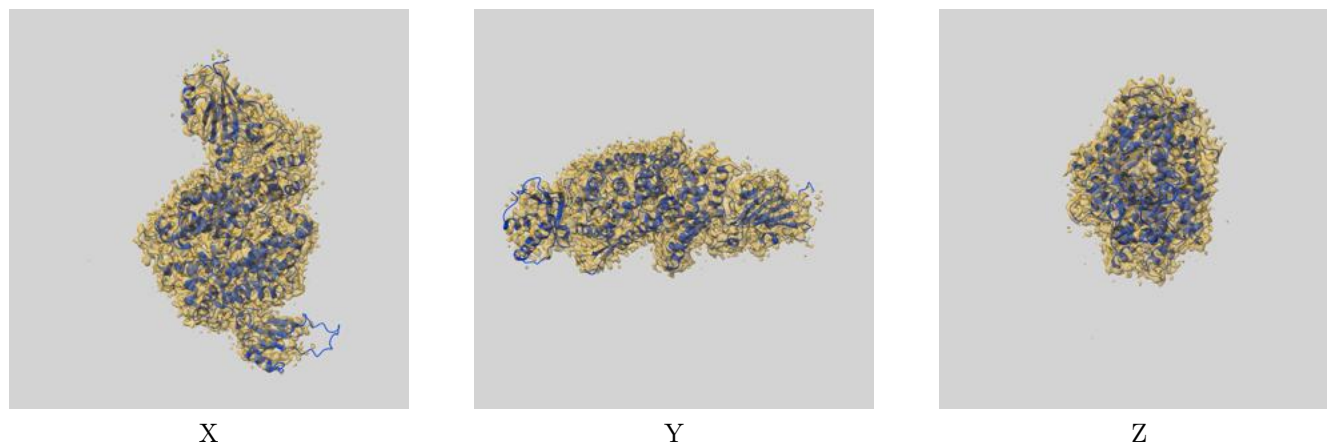
Resolution estimate (Å)	Estimation criterion (FSC cut-off)		
	0.143	0.5	Half-bit
Reported by author	2.87	-	-
Author-provided FSC curve	2.04	2.34	2.07
Unmasked-calculated*	-	-	-

*Resolution estimate based on FSC curve calculated by comparison of deposited half-maps. The value from author-provided FSC intersecting FSC 0.143 CUT-OFF 2.04 differs from the reported value 2.87 by more than 10 %

9 Map-model fit [i](#)

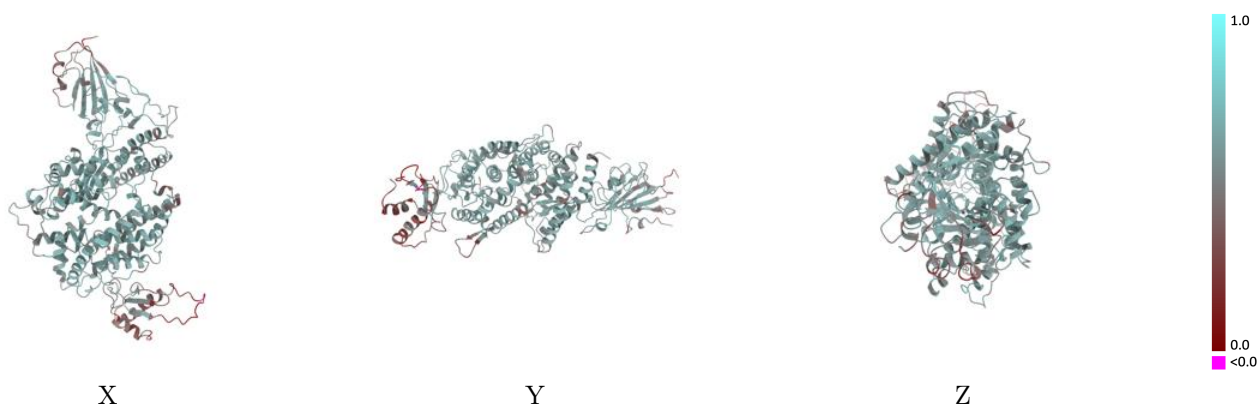
This section contains information regarding the fit between EMDB map EMD-32756 and PDB model 7WSF. Per-residue inclusion information can be found in [section 3](#) on [page 4](#).

9.1 Map-model overlay [i](#)



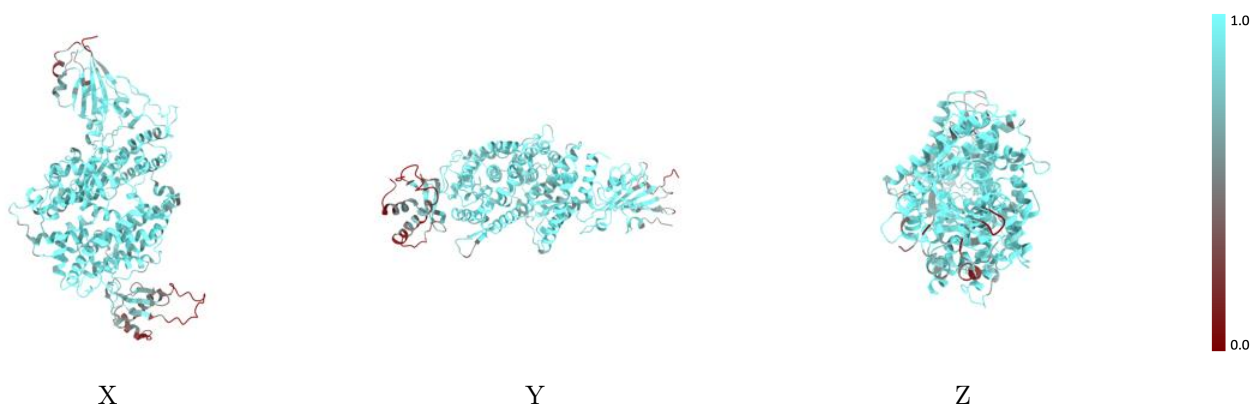
The images above show the 3D surface view of the map at the recommended contour level 0.23 at 50% transparency in yellow overlaid with a ribbon representation of the model coloured in blue. These images allow for the visual assessment of the quality of fit between the atomic model and the map.

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



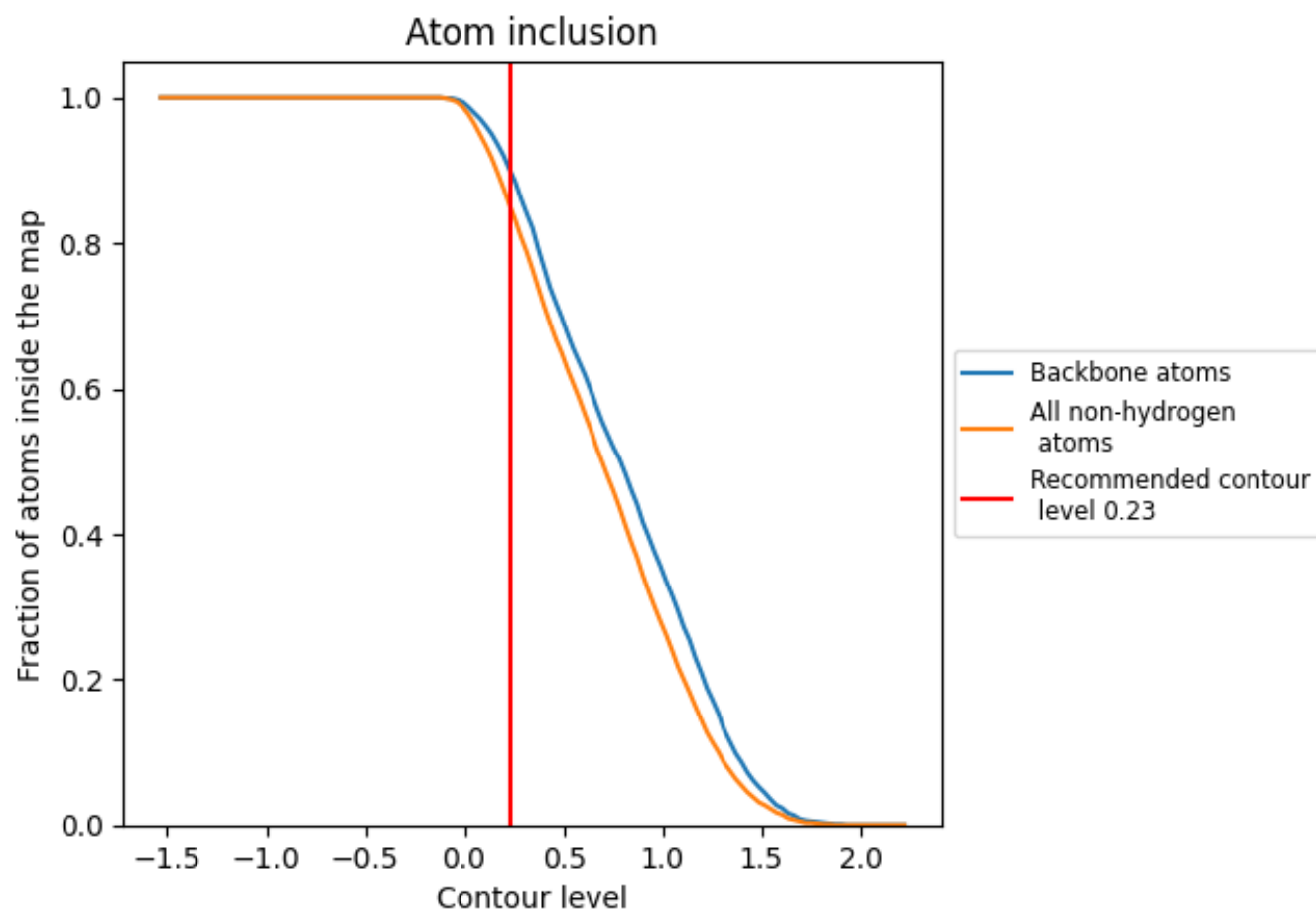
The images above show the model with each residue coloured according to its Q-score. This shows their resolvability in the map with higher Q-score values reflecting better resolvability. Please note: Q-score is calculating the resolvability of atoms, and thus high values are only expected at resolutions 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 (0.23).

9.4 Atom inclusion [i](#)



At the recommended contour level, 90% of all backbone atoms, 85% 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 (0.23) and Q-score for the entire model and for each chain.

Chain	Atom inclusion	Q-score
All	0.8520	0.5440
A	0.8580	0.5460
B	0.8320	0.5380

