W O R L D W I D E
wwPDB
P R O T E I N   D A T A   B A N K

wwPDB EM Validation Summary Report ⓘ

Jan 19, 2026 – 12:56 pm GMT

PDB ID	:	9QON / pdb_00009qon
EMDB ID	:	EMD-53264
Title	:	Ternary complex of the human 20S proteasome in complex with Importin-9 and two homodimers of Akirin-2 - focussed refinement on the alpha subunits, Ipo-9 and Ak2
Authors	:	Brunner, H.L.; Grundmann, L.; David, H.
Deposited on	:	2025-03-26
Resolution	:	3.20 Å(reported)

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

EMDB validation analysis	:	0.0.1.dev129
MolProbity	:	4-5-2 with Phenix2.0
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)	:	2.47

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	Percentile Ranks	Value
Clashscore		4
Ramachandran outliers		0
Sidechain outliers		1.8%

Worse   *Better*

■ Percentile relative to all structures
▯ Percentile relative to all EM structures

Metric	Model-Map Fit Percentile Ranks	Value
Q-score		0.313

Worse   *Better*

■ Percentile relative to all EM structures
▯ Percentile relative to EM structures of similar resolution
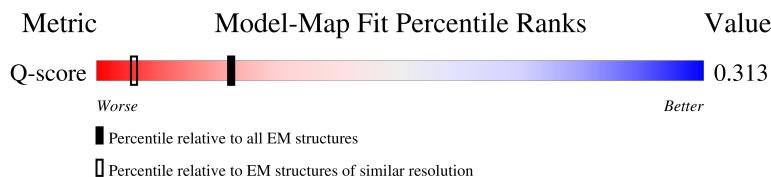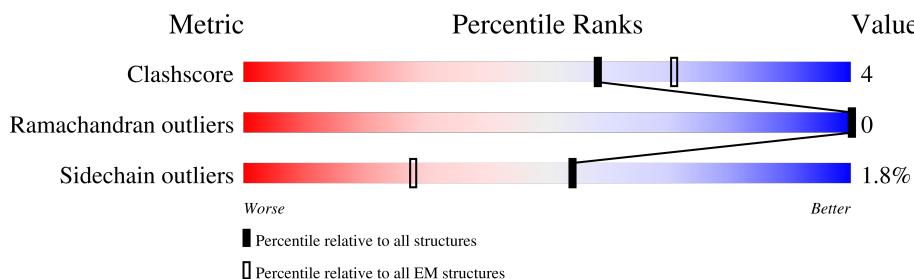
Metric	Whole archive (#Entries)	EM structures (#Entries)	Similar EM resolution (#Entries, resolution range(Å))
Clashscore	210492	15764	-
Ramachandran outliers	207382	16835	-
Sidechain outliers	206894	16415	-
Q-score	-	25397	15020 (2.70 - 3.70)

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 <=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	1041	22% · 75%
2	B	203	26% · 70%
2	C	203	38% 6% 56%
2	D	203	13% 86%
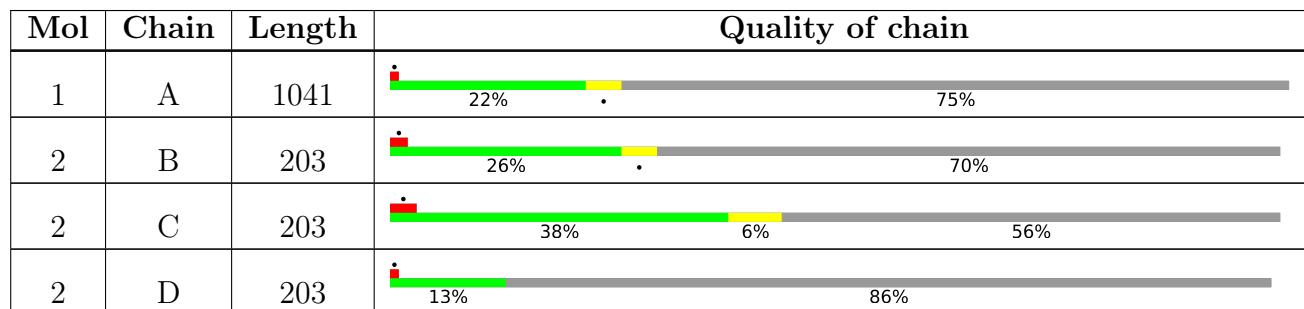
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Mol	Chain	Length	Quality of chain
3	F	255	85% 10% 5%
4	G	246	91% 8%
5	O	234	89% 9%
6	P	261	85% 9% 5%
7	Q	248	81% 14%
8	R	241	90% 10%
9	S	263	79% 11% 10%
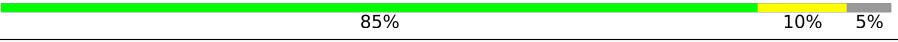
2   Entry composition ⓘ

There are 9 unique types of molecules in this entry. The entry contains 32930 atoms, of which 16396 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 Importin-9.

Mol	Chain	Residues	Atoms						AltConf	Trace
1	A	264	Total	C	H	N	O	S	0	0
			3742	1212	1818	339	362	11		

- Molecule 2 is a protein called Akirin-2.

Mol	Chain	Residues	Atoms						AltConf	Trace
2	B	61	Total	C	H	N	O	S	0	0
			1033	328	512	90	100	3		
2	C	90	Total	C	H	N	O	S	0	0
			1476	470	725	137	140	4		
2	D	28	Total	C	H	N	O	S	0	0
			426	136	206	44	39	1		

- Molecule 3 is a protein called Proteasome subunit alpha type-3.

Mol	Chain	Residues	Atoms						AltConf	Trace
3	F	242	Total	C	H	N	O	S	0	0
			3776	1201	1883	323	358	11		

- Molecule 4 is a protein called Proteasome subunit alpha type-6.

Mol	Chain	Residues	Atoms						AltConf	Trace
4	G	242	Total	C	H	N	O	S	0	0
			3781	1197	1895	315	361	13		

- Molecule 5 is a protein called Proteasome subunit alpha type-2.

Mol	Chain	Residues	Atoms						AltConf	Trace
5	O	231	Total	C	H	N	O	S	0	0
			3609	1155	1802	306	340	6		

- Molecule 6 is a protein called Proteasome subunit alpha type-4.

Mol	Chain	Residues	Atoms						AltConf	Trace
			Total	C	H	N	O	S		
6	P	248	3928	1234	1975	336	373	10	0	0

- Molecule 7 is a protein called Proteasome subunit alpha type-7.

Mol	Chain	Residues	Atoms						AltConf	Trace
			Total	C	H	N	O	S		
7	Q	237	3765	1174	1895	331	360	5	0	0

- Molecule 8 is a protein called Proteasome subunit alpha type-5.

Mol	Chain	Residues	Atoms						AltConf	Trace
			Total	C	H	N	O	S		
8	R	241	3686	1163	1836	305	370	12	0	0

- Molecule 9 is a protein called Proteasome subunit alpha type-1.

Mol	Chain	Residues	Atoms						AltConf	Trace
			Total	C	H	N	O	S		
9	S	236	3708	1166	1849	334	348	11	0	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: Importin-9

ASN PRO GLU ARG TRP THR N910 I911 P912 L913 L914 V915 L920 N923 S926 N927 A933 ALA ARG GLN ALA THR PRO ALA GLU TRP SER GLN ASP SER ASN MET TRP GLU ASP GLN GLU GLU GLU GLU GLU GLU GLU ASP GLY LEU ALA GLY GLN LEU SER ASP

ILE LEU ALA THR SER LYS TYR GLU GLU ASP TYR TYR GLU ASP GLU GLU ASP P992 L1008 Q1014 F1015 I1041

● Molecule 2: Akirin-2

Chain B:

26%   .   70%

MET ALA CYS GLY ALA THR LEU LYS ARG LEU ASP THR LEU ASP PHE ASP PRO LEU LEU SER PRO ALA SER PRO LYS ARG ARG ARG CYS ALA PRO LEU SER ALA PRO THR SER ALA ALA ALA SER PRO LEU SER ALA ALA ALA THR ALA SER PHE SER ALA ALA ALA SER PRO GLN LYS

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

SER GLY PRO ALA SER PRO GLY THR SER ALA ALA SER PRO LEU LYS LYS GLU GLN PRO LEU F142 R145 Q146 M149 R153 L154 L155 R158 V162 K173 Y178 V182 T185 Y200 V201 S202

● Molecule 2: Akirin-2

Chain C:

38%   6%   56%

MET ALA CYS GLY ALA THR LEU LYS ARG LEU ASP PHE ASP PRO LEU LEU SER PRO ALA SER PRO LYS ARG ARG ARG CYS ALA PRO LEU SER ALA PRO THR SER ALA ALA ALA SER PRO LEU SER ALA ALA ALA THR ALA SER PHE SER ALA ALA ALA SER PRO GLN LYS

TYR LEU ARG GLU PRO SER PRO F69 S74 E79 Q80 I81 L82 Y83 N84 I85 K86 Q87 E88 Y89 K90 R91 R96 H97 LEU GLU THR SER PHE GLN GLN THR ASP PRO CYS THR CYS THR SER ASP ALA GLN LEU PRO HIS ALA PHE LEU LEU SER GLY PRO ALA SER PRO GLY THR SER

SER ALA ALA SER PRO LEU LYS LYS GLU GLN PRO LEU F142 T143 L144 R158 Q188 R192 E195 S202

● Molecule 2: Akirin-2

Chain D:

13%   86%

MET ALA CYS GLY ALA THR LEU LYS ARG LEU ASP PHE ASP PRO LEU LEU SER PRO ALA SER PRO LYS ARG ARG ARG CYS ALA PRO LEU SER ALA PRO THR SER ALA ALA ALA SER PRO LEU SER ALA ALA ALA THR ALA SER PHE SER ALA ALA ALA SER PRO GLN LYS

TYR LEU ARG GLU PRO SER PRO F69 V72 E79 K94 R95 R96 HIS LEU GLU THR SER PHE GLN GLN THR ASP PRO CYS THR SER ASP ALA GLN LEU PRO HIS ALA PHE LEU LEU SER GLY PRO ALA SER PRO GLY THR SER SER ALA ALA SER PRO LEU LYS LYS GLU

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

SER TYR VAL SER

● Molecule 3: Proteasome subunit alpha type-3

Chain F:

• Molecule 4: Proteasome subunit alpha type-6

Chain G:

• Molecule 5: Proteasome subunit alpha type-2

Chain O:

• Molecule 6: Proteasome subunit alpha type-4

Chain P:

• Molecule 7: Proteasome subunit alpha type-7

Chain Q:

• Molecule 8: Proteasome subunit alpha type-5

Chain R:

• Molecule 9: Proteasome subunit alpha type-1

Chain S:

79%   11%   10%

MET F2 R3 N4 D7 Q21 E27 K30 L38 L49 K50 R51 A52 Q53 L64 H65 V66 I72 S73 I74 A79 M88 E91 I112 I134 I144 L184 G191 R196 L199 D204 I212 G213 I214 D226 V229 E237

GLU ARG PRO GLN ARG LYS ALA GLN PRO ALA GLN PRO ALA ASP GLU PRO ALA GLU LYS ALA ASP GLU PRO MET GLU HIS

4 Experimental information (i)

Property	Value	Source
EM reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, Not provided	
Number of particles used	61740	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 $(e^-/\text{Å}^2)$	44.4	Depositor
Minimum defocus (nm)	1000	Depositor
Maximum defocus (nm)	1900	Depositor
Magnification	Not provided	
Image detector	GATAN K3 BIOQUANTUM (6k x 4k)	Depositor
Maximum map value	1.880	Depositor
Minimum map value	-0.014	Depositor
Average map value	0.001	Depositor
Map value standard deviation	0.022	Depositor
Recommended contour level	0.0313	Depositor
Map size (Å)	428.99997, 428.99997, 428.99997	wwPDB
Map dimensions	300, 300, 300	wwPDB
Map angles (°)	90.0, 90.0, 90.0	wwPDB
Pixel spacing (Å)	1.43, 1.43, 1.43	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	A	0.12	0/1953	0.32	0/2654
2	B	0.16	0/529	0.32	0/706
2	C	0.12	0/761	0.31	0/1014
2	D	0.08	0/221	0.23	0/293
3	F	0.16	0/1928	0.34	0/2596
4	G	0.16	0/1920	0.32	0/2595
5	O	0.16	0/1846	0.34	0/2500
6	P	0.15	0/1983	0.33	0/2671
7	Q	0.16	0/1896	0.32	0/2558
8	R	0.14	0/1879	0.32	0/2536
9	S	0.15	0/1894	0.32	0/2559
All	All	0.15	0/16810	0.32	0/22682

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 ⓘ

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	1924	1818	1816	28	0
2	B	521	512	511	6	0
2	C	751	725	723	9	0
2	D	220	206	205	0	0
3	F	1893	1883	1882	14	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
4	G	1886	1895	1893	14	0
5	O	1807	1802	1801	13	0
6	P	1953	1975	1973	21	0
7	Q	1870	1895	1893	19	0
8	R	1850	1836	1836	13	0
9	S	1859	1849	1848	20	0
All	All	16534	16396	16381	148	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 4.

The worst 5 of 148 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)
7:Q:99:GLU:N	7:Q:99:GLU:OE2	2.11	0.82
3:F:230:ASP:OD2	3:F:231:ILE:N	2.13	0.81
7:Q:179:GLU:N	7:Q:179:GLU:OE1	2.18	0.76
1:A:733:ASP:OD1	1:A:734:GLU:N	2.19	0.75
5:O:14:PRO:O	5:O:15:SER:OG	2.07	0.72

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	258/1041 (25%)	251 (97%)	7 (3%)	0	100	100
2	B	59/203 (29%)	58 (98%)	1 (2%)	0	100	100
2	C	86/203 (42%)	81 (94%)	5 (6%)	0	100	100
2	D	26/203 (13%)	26 (100%)	0	0	100	100
3	F	240/255 (94%)	235 (98%)	5 (2%)	0	100	100

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
4	G	240/246 (98%)	234 (98%)	6 (2%)	0	100	100
5	O	229/234 (98%)	223 (97%)	6 (3%)	0	100	100
6	P	246/261 (94%)	239 (97%)	7 (3%)	0	100	100
7	Q	235/248 (95%)	231 (98%)	4 (2%)	0	100	100
8	R	239/241 (99%)	238 (100%)	1 (0%)	0	100	100
9	S	234/263 (89%)	228 (97%)	6 (3%)	0	100	100
All	All	2092/3398 (62%)	2044 (98%)	48 (2%)	0	100	100

There are no Ramachandran outliers to report.

5.3.2   Protein sidechains ⓘ

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	187/894 (21%)	184 (98%)	3 (2%)	58	79
2	B	56/171 (33%)	55 (98%)	1 (2%)	54	77
2	C	76/171 (44%)	76 (100%)	0	100	100
2	D	19/171 (11%)	18 (95%)	1 (5%)	19	52
3	F	199/212 (94%)	194 (98%)	5 (2%)	42	71
4	G	206/210 (98%)	205 (100%)	1 (0%)	86	93
5	O	190/191 (100%)	188 (99%)	2 (1%)	70	86
6	P	208/221 (94%)	205 (99%)	3 (1%)	62	82
7	Q	201/211 (95%)	193 (96%)	8 (4%)	27	59
8	R	203/203 (100%)	198 (98%)	5 (2%)	42	71
9	S	202/224 (90%)	200 (99%)	2 (1%)	73	87
All	All	1747/2879 (61%)	1716 (98%)	31 (2%)	54	77

5 of 31 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
6	P	92	LEU
8	R	224	GLN
7	Q	129	ILE
9	S	53	GLN
8	R	41	GLN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 13 such sidechains are listed below:

Mol	Chain	Res	Type
5	O	147	GLN
6	P	142	HIS
9	S	65	HIS
8	R	227	HIS
9	S	8	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 ⓘ

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-53264. 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
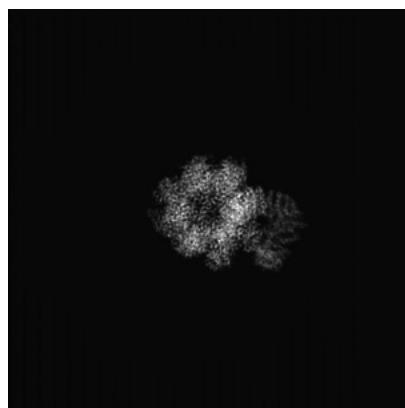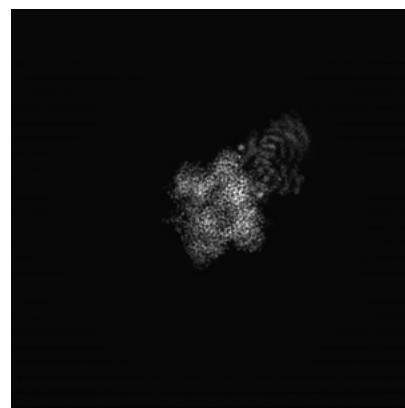
X   Y   Z

6.1.2   Raw map

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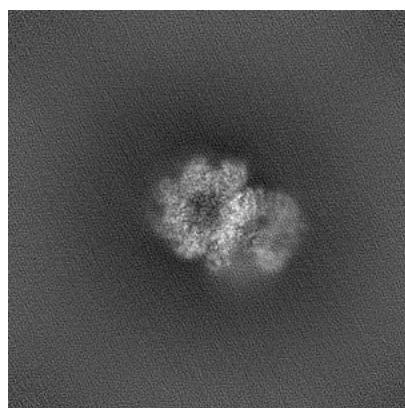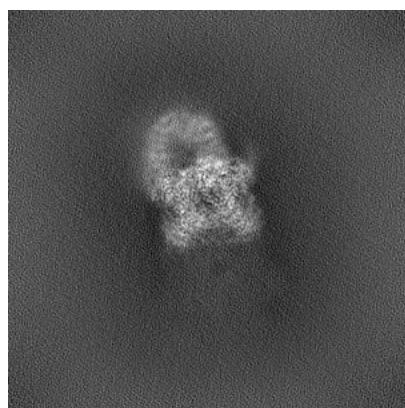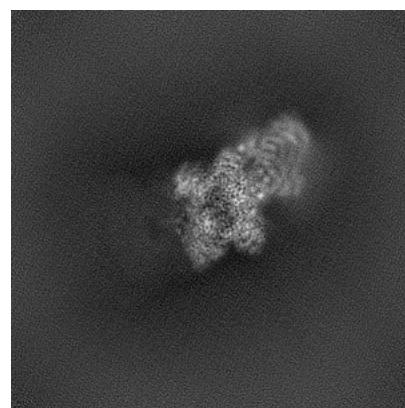
The images above show the map projected in three orthogonal directions.

6.2   Central slices ⓘ

6.2.1   Primary map
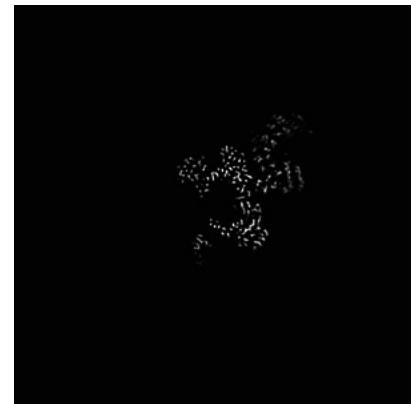
X Index: 150   Y Index: 150   Z Index: 150

6.2.2   Raw map
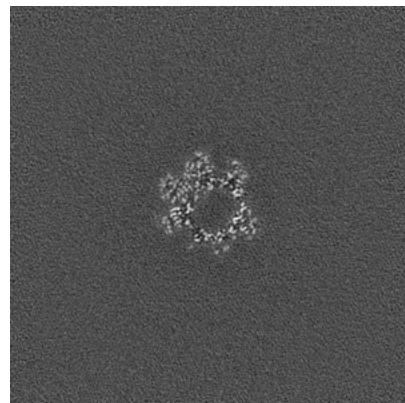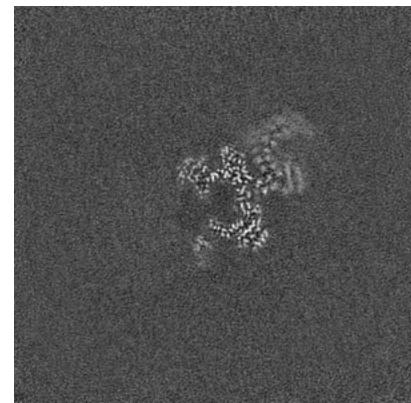
X Index: 150   Y Index: 150   Z Index: 150

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

6.3 Largest variance slices ⓘ

6.3.1 Primary map

X Index: 172	Y Index: 164	Z Index: 131

6.3.2 Raw map
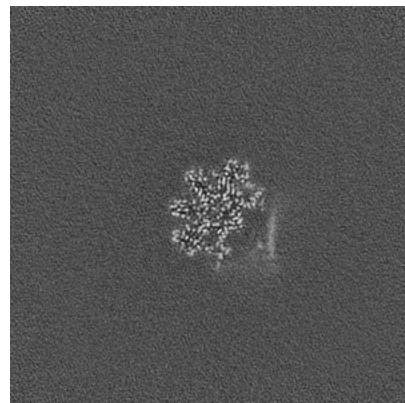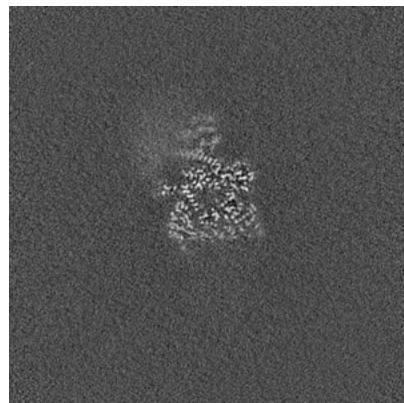
X Index: 172	Y Index: 167	Z Index: 299
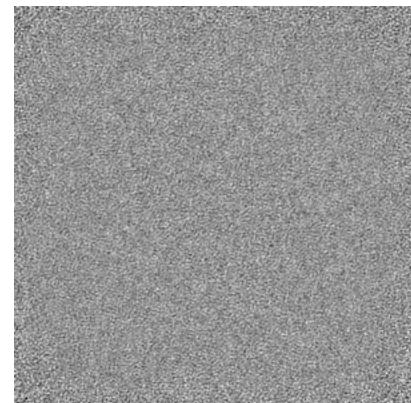
The images above show the largest variance slices of the map in three orthogonal directions.

6.4 Orthogonal standard-deviation projections (False-color) ⓘ

6.4.1 Primary map
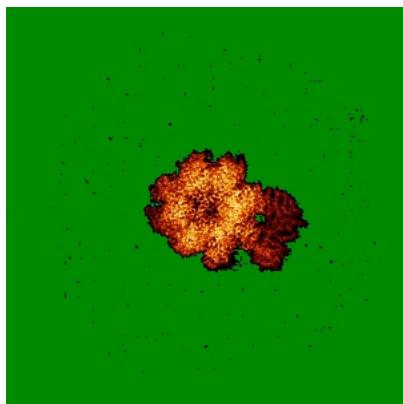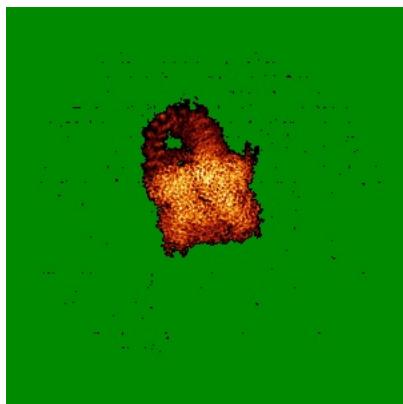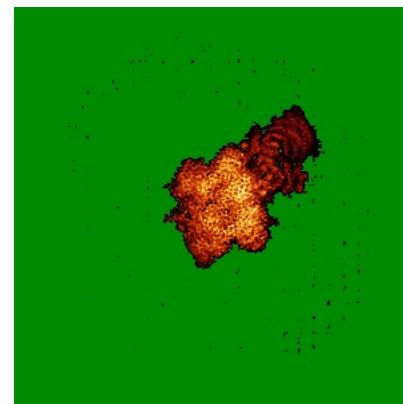
X   Y   Z

6.4.2 Raw map

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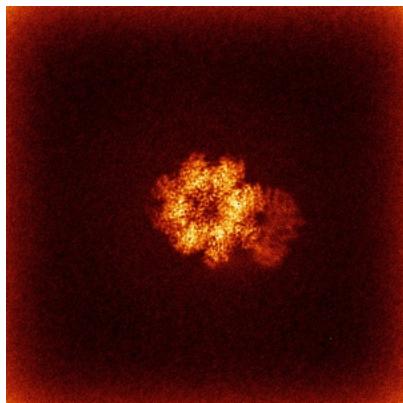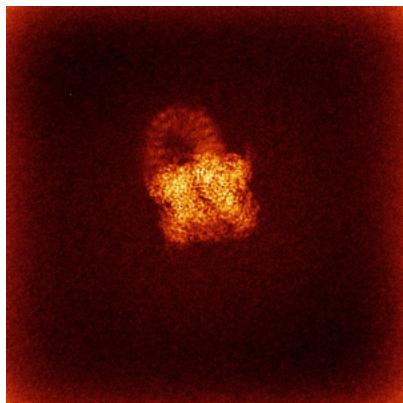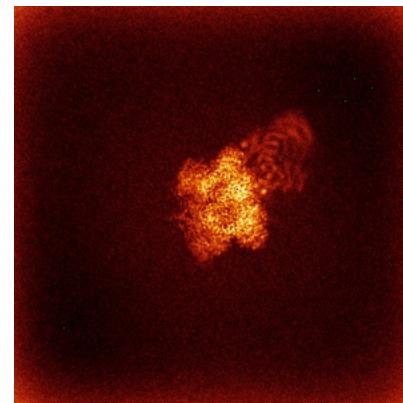
The images above show the map standard deviation projections with false color in three orthogonal directions. Minimum values are shown in green, max in blue, and dark to light orange shades represent small to large values respectively.

6.5 Orthogonal surface views (i)

6.5.1 Primary map

| X | Y | Z |
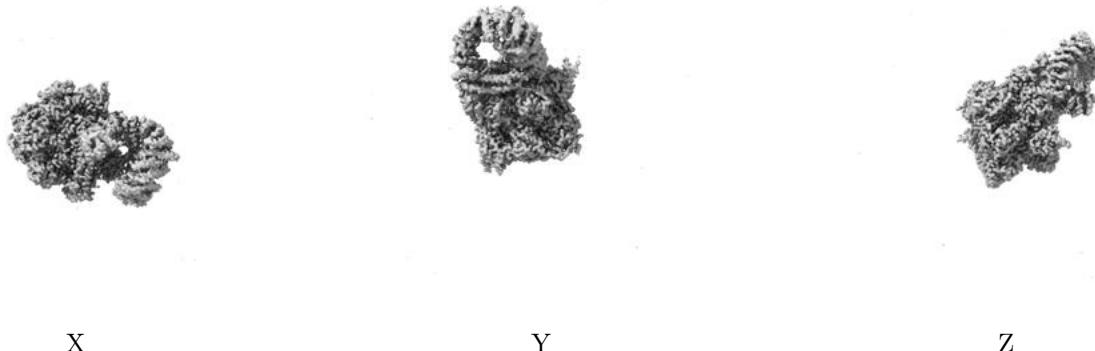
The images above show the 3D surface view of the map at the recommended contour level 0.0313. These images, in conjunction with the slice images, may facilitate assessment of whether an appropriate contour level has been provided.

6.5.2 Raw map

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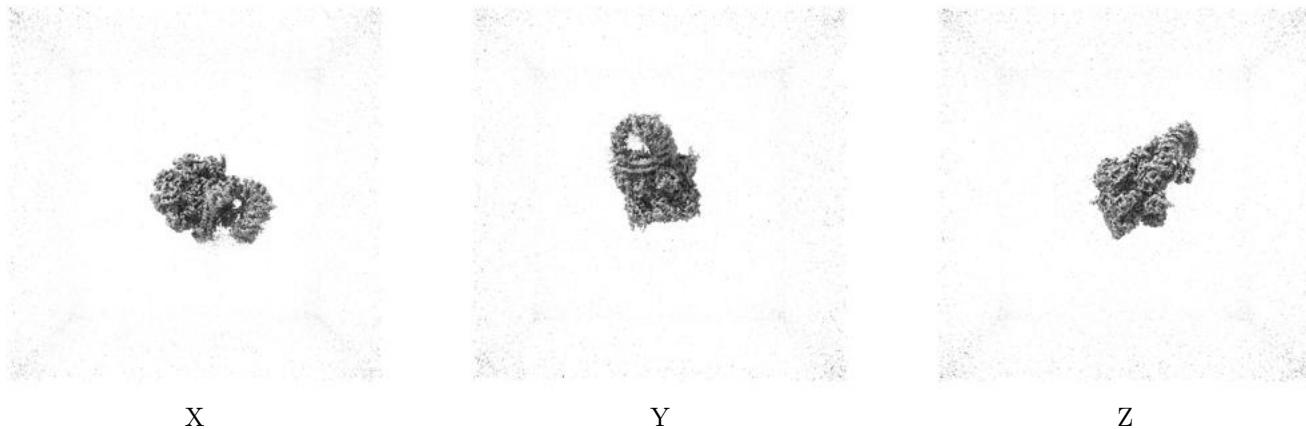
These images show the 3D surface of the raw map. The raw map's contour level was selected so that its surface encloses the same volume as the primary map does at its recommended contour level.

6.6   Mask visualisation ⓘ

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_53264_msk_1.map ⓘ

X   Y   Z
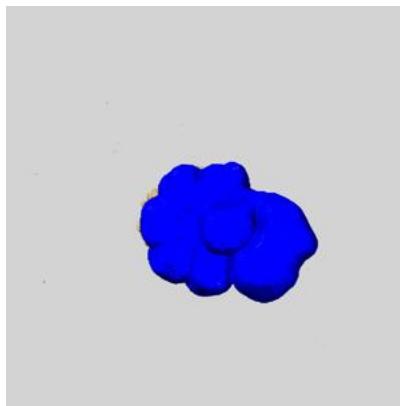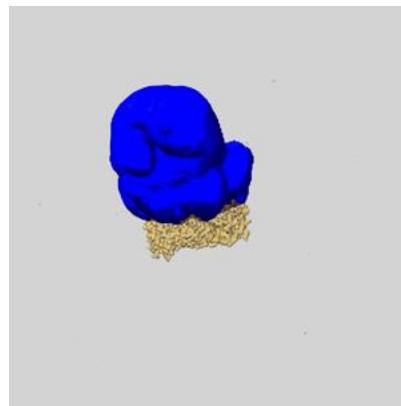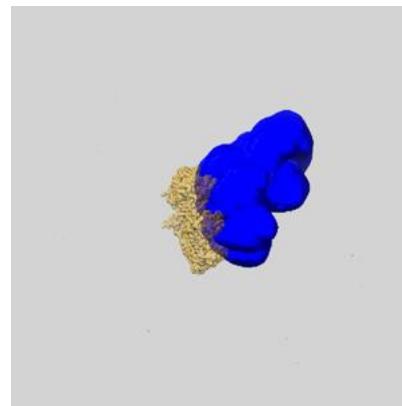
7   Map analysis ⓘ

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

7.1   Map-value distribution ⓘ

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 ⓘ
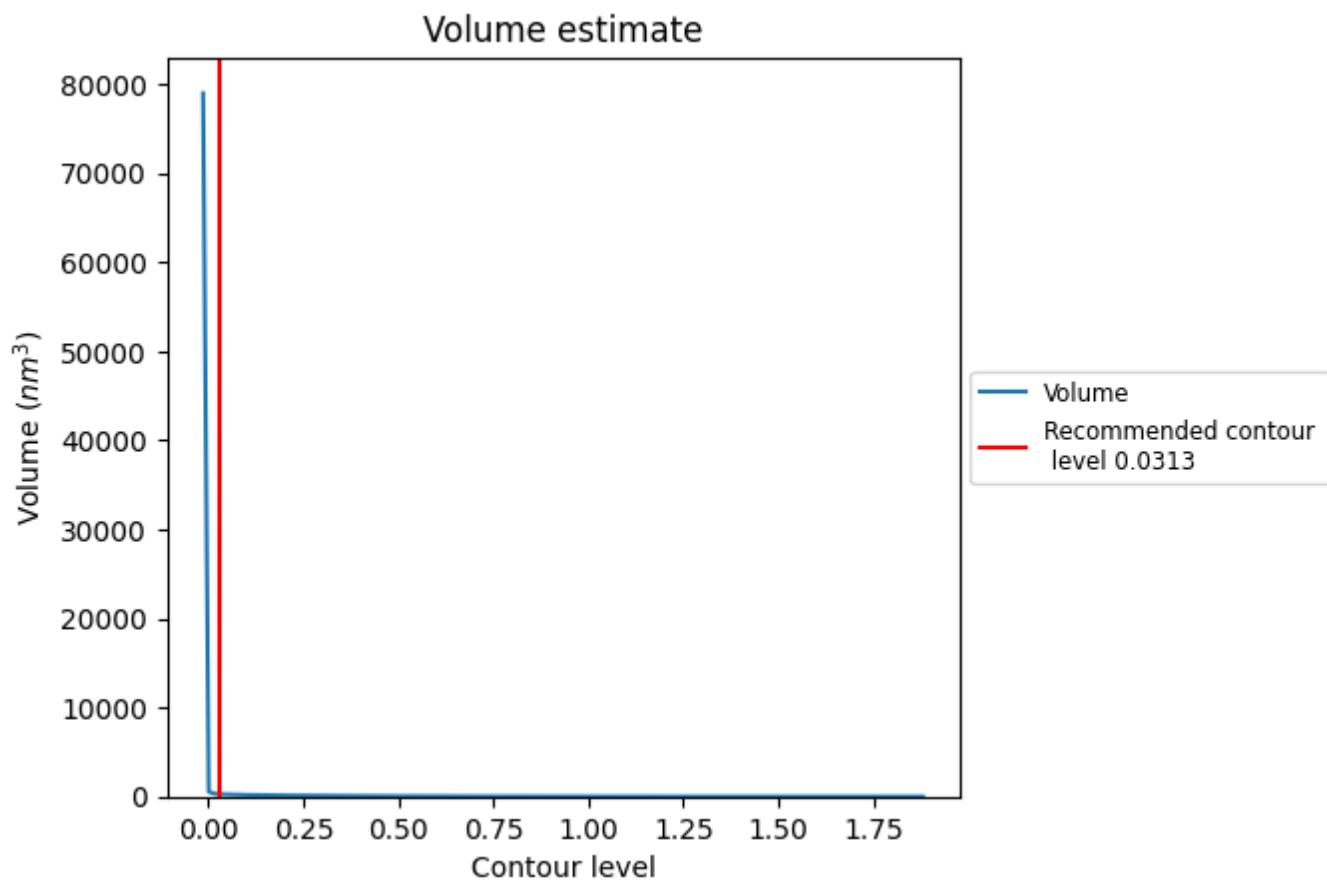
The volume at the recommended contour level is 276 nm^3; this corresponds to an approximate mass of 249 kDa.

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 ⓘ
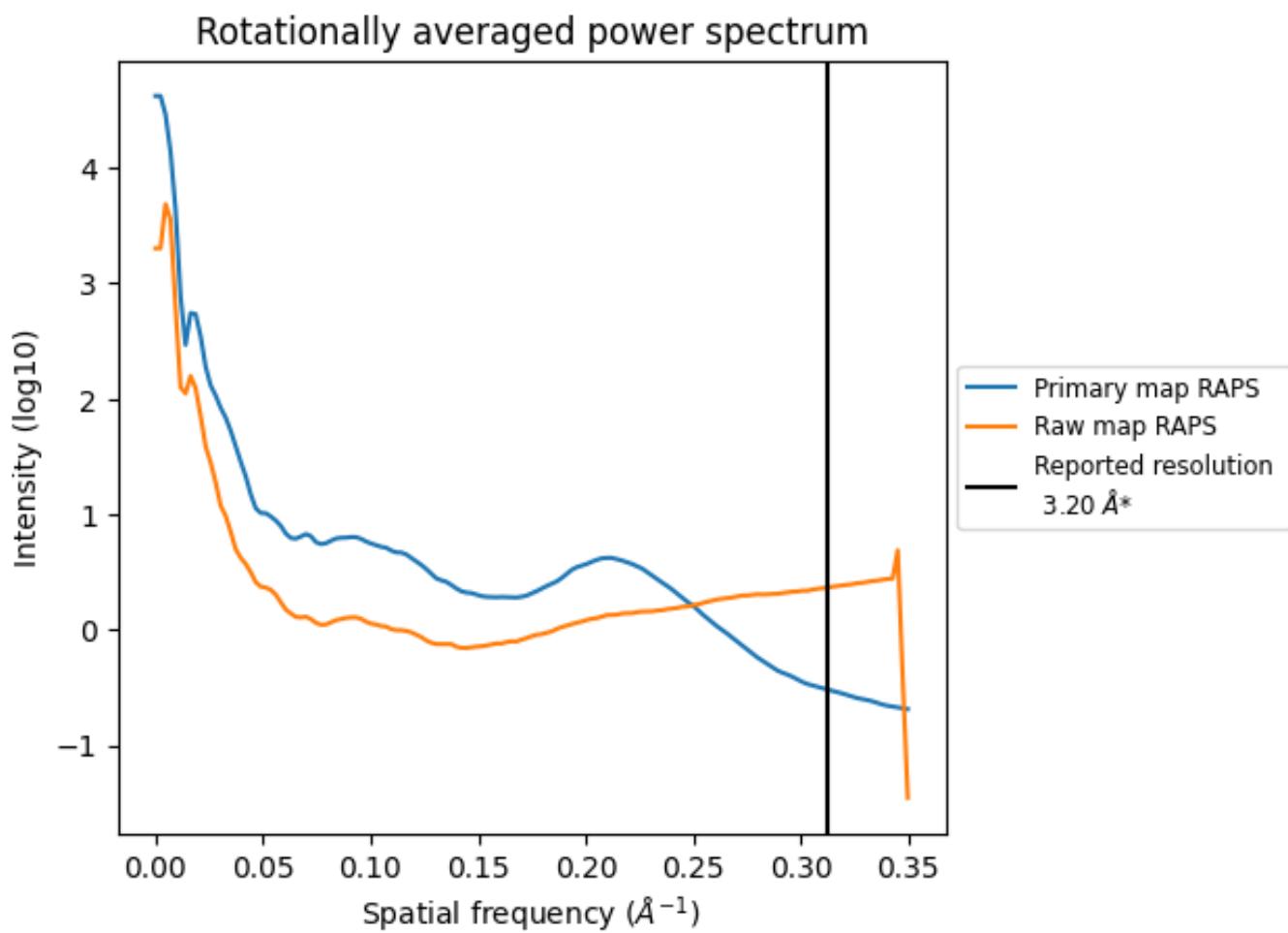
*Reported resolution corresponds to spatial frequency of 0.312 Å^{-1}

8   Fourier-Shell correlation ⓘ

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 ⓘ
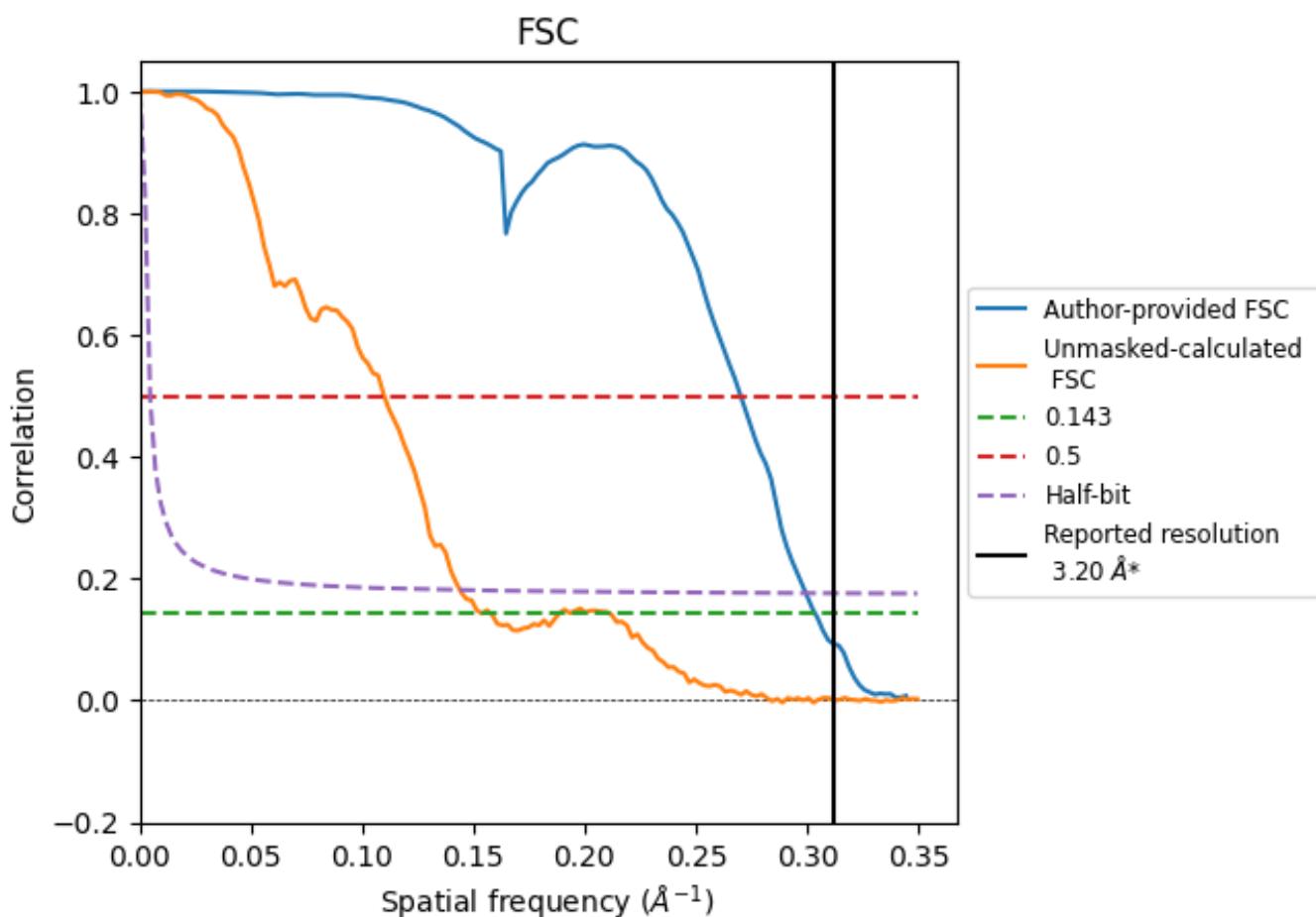
*Reported resolution corresponds to spatial frequency of 0.312 Å^{-1}

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	3.29	3.70	3.34
Unmasked-calculated*	6.51	9.10	6.94

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

9 Map-model fit ⓘ

This section contains information regarding the fit between EMDB map EMD-53264 and PDB model 9QON. Per-residue inclusion information can be found in section 3 on page 6.

## 9.1 Map-model overlay ⓘ
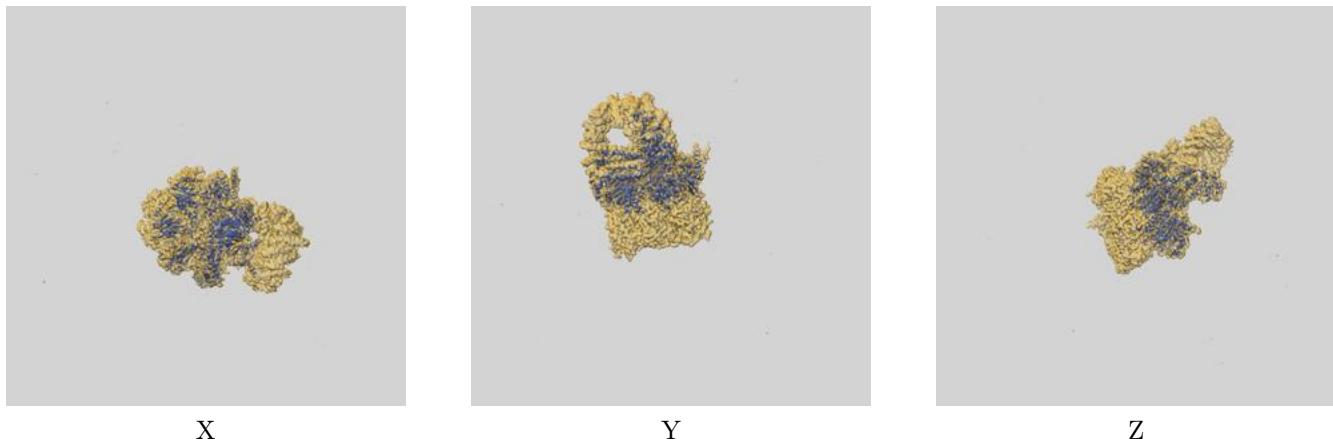
| X | Y | Z |

The images above show the 3D surface view of the map at the recommended contour level 0.0313 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 ⓘ
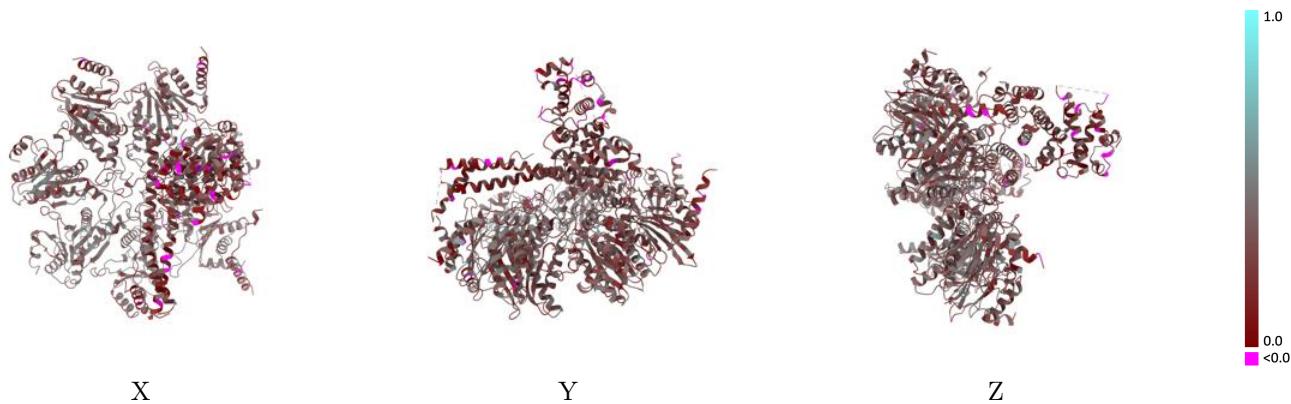
The images above show the model with each residue coloured according its Q-score. This shows their resolvability in the map with higher Q-score values reflecting better resolvability. Please note: Q-score is calculating the resolvability of atoms, and thus high values are only expected at resolutions 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 ⓘ
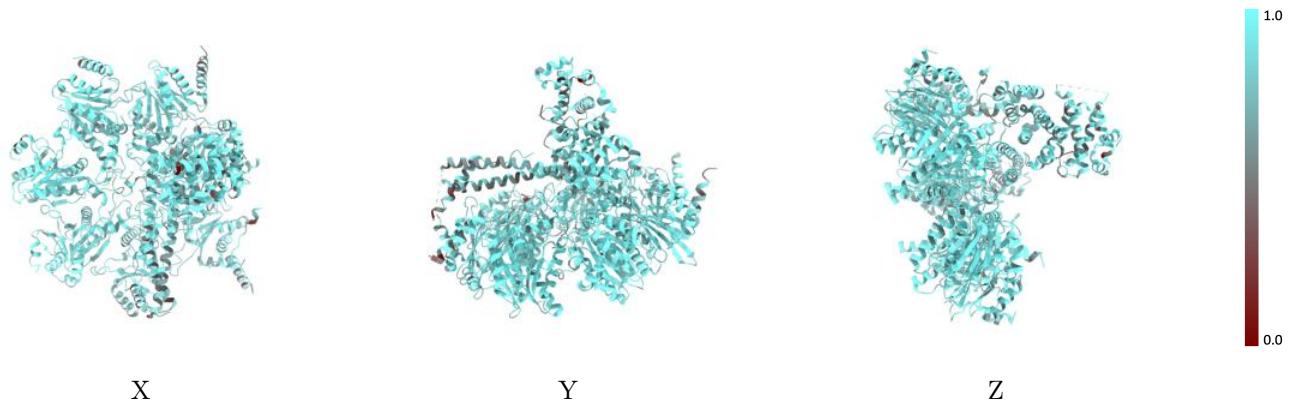
The images above show the model with each residue coloured according to its atom inclusion. This shows to what extent they are inside the map at the recommended contour level (0.0313).

9.4 Atom inclusion ⓘ
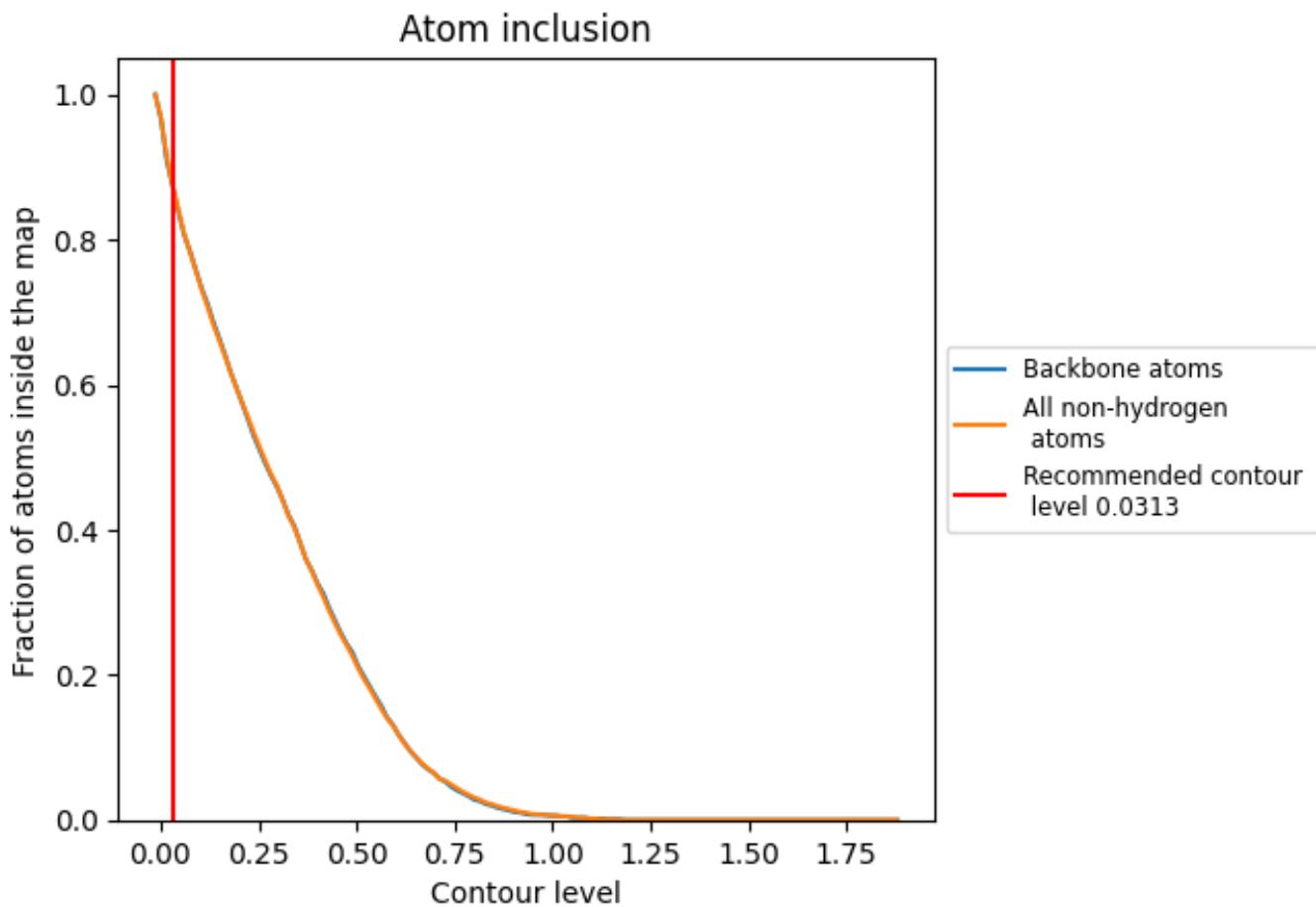
At the recommended contour level, 87% of all backbone atoms, 87% of all non-hydrogen atoms, are inside the map.

9.5 Map-model fit summary (i)

The table lists the average atom inclusion at the recommended contour level (0.0313) and Q-score for the entire model and for each chain.

Chain	Atom inclusion	Q-score
All	0.8730	0.3130
A	0.8090	0.2380
B	0.7470	0.2220
C	0.7560	0.2360
D	0.7080	0.2330
F	0.8960	0.3540
G	0.8960	0.3250
O	0.9030	0.3130
P	0.8870	0.3070
Q	0.8850	0.3190
R	0.8850	0.3430
S	0.9240	0.3700

1.0

0.0
<0.0