Full wwPDB EM Validation Report ⓘ

Apr 20, 2026 – 01:12 PM EDT

PDB ID	:	9NZU / pdb_00009nzu
EMDB ID	:	EMD-49960
Title	:	Atomic resolution cryoEM structure of HPV16 bound to heparin
Authors	:	Langley, C.H.; Hafenstein, S.L.
Deposited on	:	2025-04-01
Resolution	:	1.90 Å(reported)

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

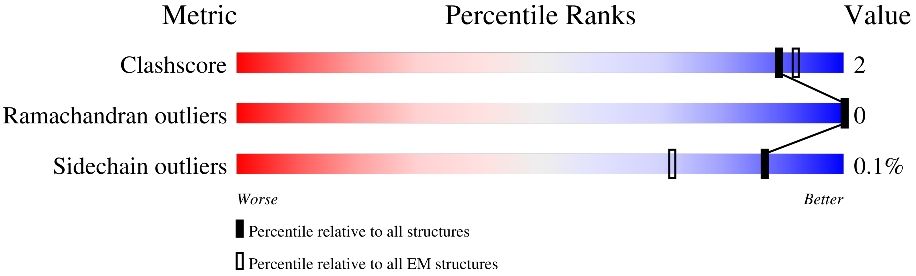
EMDB validation analysis	:	0.0.1.dev132
MolProbity	:	4-5-2 with Phenix2.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
EM percentile statistics	:	202505.v01 (Using data in the EMDB archive up until May 2025)
MapQ	:	1.9.13
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

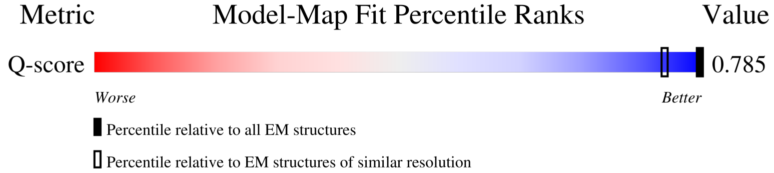
1 Overall quality at a glance ⓘ

The following experimental techniques were used to determine the structure:
ELECTRON MICROSCOPY

The reported resolution of this entry is 1.90 Å.

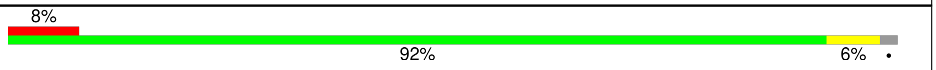
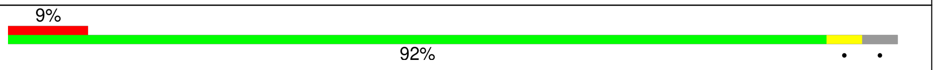
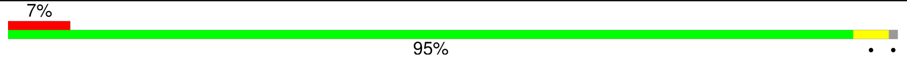
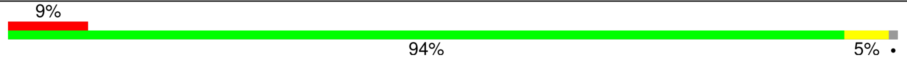
Percentile scores (ranging between 0-100) for global validation metrics of the entry are shown in the following graphic. The table shows the number of entries on which the scores are based.





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	1185 (1.40 - 2.40)

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	485	
1	B	485	
1	C	485	
1	D	485	

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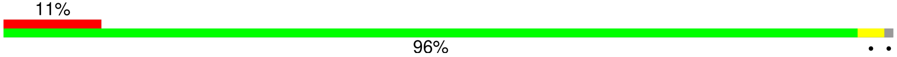
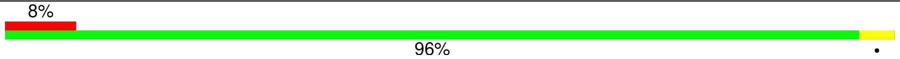
Mol	Chain	Length	Quality of chain
1	E	485	
1	F	485	

2 Entry composition

There are 3 unique types of molecules in this entry. The entry contains 46058 atoms, of which 22008 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 Major capsid protein L1.

Mol	Chain	Residues	Atoms						AltConf	Trace
			Total	C	H	N	O	S		
1	F	483	7500	2424	3710	633	711	22	0	0
1	B	466	7235	2335	3576	615	688	21	0	0
1	C	480	7461	2412	3690	630	707	22	0	0
1	D	480	7460	2412	3689	630	707	22	0	0
1	E	481	7470	2416	3694	631	708	21	0	0
1	A	474	7374	2380	3649	627	697	21	0	0

- Molecule 2 is MAGNESIUM ION (CCD ID: MG) (formula: Mg).

Mol	Chain	Residues	Atoms		AltConf
			Total	Mg	
2	F	35	35	35	0
2	B	38	38	38	0
2	C	35	35	35	0
2	D	30	30	30	0
2	E	24	24	24	0
2	A	27	27	27	0

- Molecule 3 is water.

Mol	Chain	Residues	Atoms		AltConf
			Total	O	
3	F	253	253	253	0

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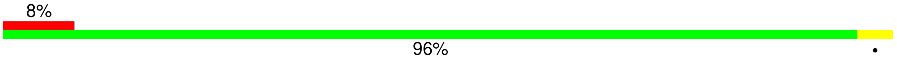
Mol	Chain	Residues	Atoms		AltConf
			Total	O	
3	B	236	236	236	0
3	C	243	243	243	0
3	D	219	219	219	0
3	E	204	204	204	0
3	A	214	214	214	0

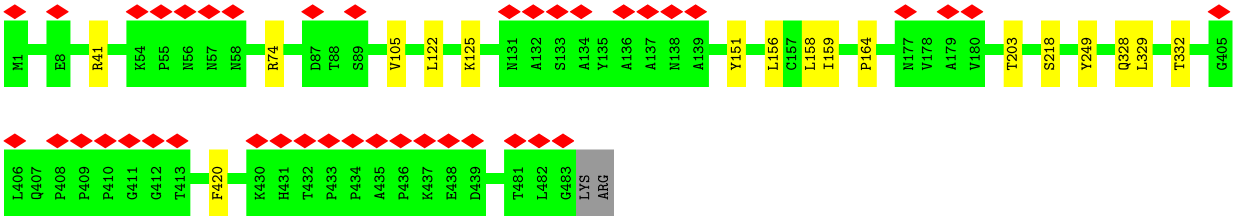
3 Residue-property plots ⓘ

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: Major capsid protein L1

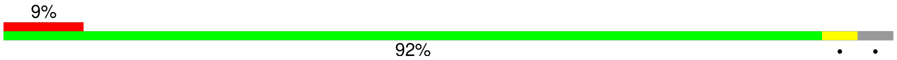
Chain F:

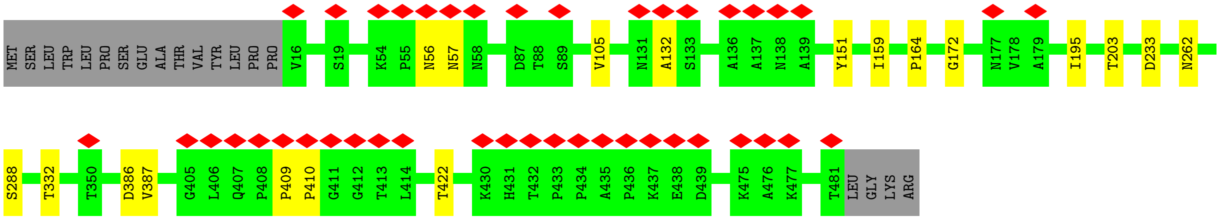




- Molecule 1: Major capsid protein L1

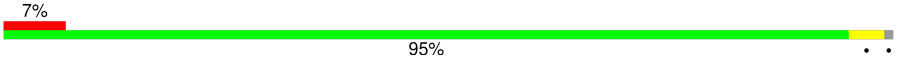
Chain B:

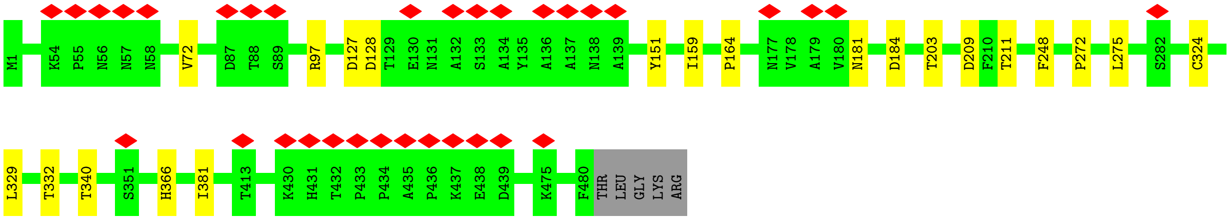




- Molecule 1: Major capsid protein L1

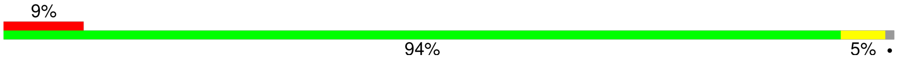
Chain C:

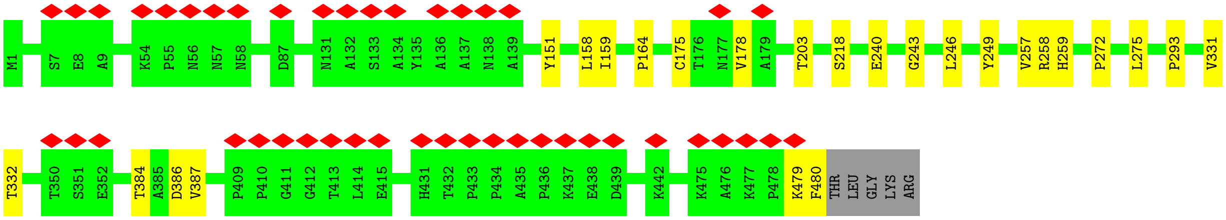




- Molecule 1: Major capsid protein L1

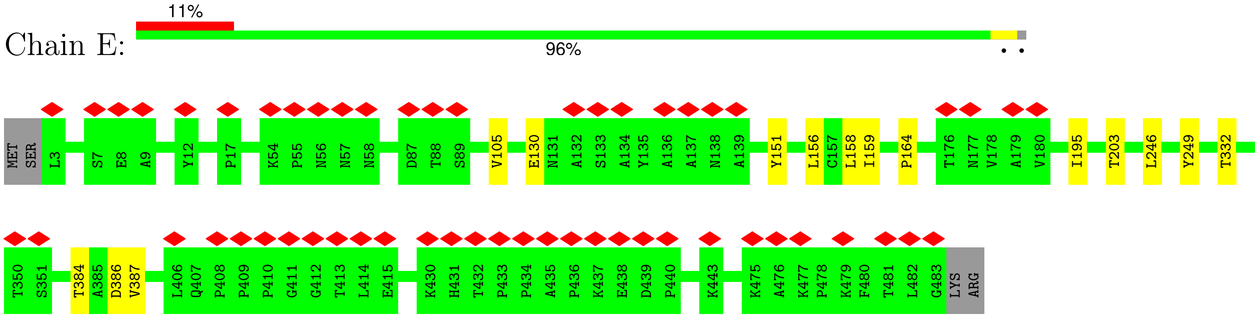
Chain D:





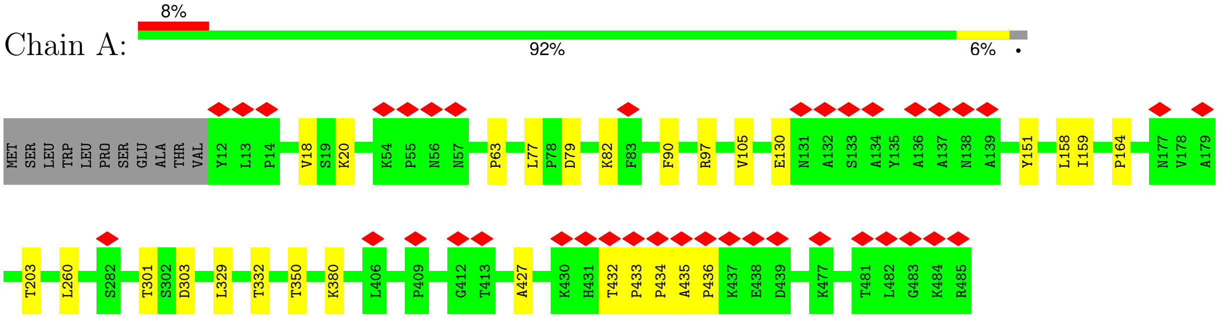
- Molecule 1: Major capsid protein L1

Chain E:



- Molecule 1: Major capsid protein L1

Chain A:



4 Experimental information ⓘ

Property	**Value**	**Source**
EM reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, Not provided	
Number of particles used	44159	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 ($e^-/\text{Å}^2$)	39.75	Depositor
Minimum defocus (nm)	500	Depositor
Maximum defocus (nm)	2000	Depositor
Magnification	Not provided	
Image detector	FEI FALCON IV (4k x 4k)	Depositor
Maximum map value	7.906	Depositor
Minimum map value	-0.274	Depositor
Average map value	0.127	Depositor
Map value standard deviation	0.211	Depositor
Recommended contour level	0.9	Depositor
Map size (Å)	392.92, 392.92, 392.92	wwPDB
Map dimensions	760, 760, 760	wwPDB
Map angles (°)	90.0, 90.0, 90.0	wwPDB
Pixel spacing (Å)	0.517, 0.517, 0.517	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: MG

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	0.20	0/3827	0.40	0/5209
1	B	0.20	0/3758	0.41	0/5115
1	C	0.19	0/3876	0.39	0/5280
1	D	0.19	0/3876	0.39	0/5280
1	E	0.19	0/3881	0.39	0/5288
1	F	0.20	0/3895	0.40	0/5306
All	All	0.20	0/23113	0.40	0/31478

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	3725	3649	3646	18	0
1	B	3659	3576	3572	14	0
1	C	3771	3690	3687	12	0
1	D	3771	3689	3686	16	0
1	E	3776	3694	3691	13	0
1	F	3790	3710	3708	13	0
2	A	27	0	0	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
2	B	38	0	0	0	0
2	C	35	0	0	0	0
2	D	30	0	0	0	0
2	E	24	0	0	0	0
2	F	35	0	0	0	0
3	A	214	0	0	1	0
3	B	236	0	0	0	0
3	C	243	0	0	3	0
3	D	219	0	0	0	0
3	E	204	0	0	0	0
3	F	253	0	0	0	0
All	All	24050	22008	21990	79	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 2.

All (79) 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:F:125:LYS:NZ	1:B:132:ALA:O	2.15	0.79
1:F:156:LEU:HD11	1:F:158:LEU:HD21	1.67	0.75
1:E:156:LEU:HD11	1:E:158:LEU:HD21	1.70	0.74
1:E:384:THR:OG1	1:E:386:ASP:OD1	2.08	0.69
1:F:156:LEU:HD11	1:F:158:LEU:CD2	2.26	0.64
1:E:156:LEU:HD11	1:E:158:LEU:CD2	2.28	0.63
1:D:258:ARG:NE	1:E:130:GLU:OE2	2.26	0.59
1:B:56:ASN:OD1	1:B:57:ASN:N	2.36	0.59
1:F:105:VAL:HG11	1:F:159:ILE:CD1	2.34	0.57
1:D:159:ILE:HD12	1:D:331:VAL:HG22	1.85	0.57
1:B:262:ASN:ND2	1:B:288:SER:O	2.37	0.55
1:F:122:LEU:O	1:F:218:SER:OG	2.21	0.54
1:A:433:PRO:N	1:A:434:PRO:CD	2.71	0.54
1:D:384:THR:OG1	1:D:386:ASP:OD1	2.26	0.53
1:A:301:THR:OG1	1:A:303:ASP:OD1	2.24	0.53
1:D:246:LEU:HD11	1:D:249:TYR:HB3	1.92	0.52
1:C:164:PRO:HG3	1:C:332:THR:OG1	2.11	0.50
1:A:432:THR:HB	1:A:433:PRO:HD3	1.93	0.50
1:D:240:GLU:OE1	1:D:243:GLY:N	2.43	0.50
1:A:90:PHE:O	1:A:380:LYS:NZ	2.38	0.49
1:D:164:PRO:HG3	1:D:332:THR:OG1	2.12	0.48
1:E:158:LEU:HD23	1:E:249:TYR:HB2	1.97	0.46

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:386:ASP:OD1	1:B:387:VAL:N	2.48	0.46
1:D:175:CYS:SG	1:D:178:VAL:HG23	2.55	0.46
1:C:159:ILE:HD12	1:C:248:PHE:CZ	2.51	0.46
1:C:272:PRO:HD2	1:C:275:LEU:HD12	1.97	0.46
1:E:246:LEU:HD11	1:E:249:TYR:HB3	1.98	0.46
1:C:324:CYS:SG	1:C:329:LEU:HD13	2.56	0.46
1:D:151:TYR:CG	1:D:203:THR:HB	2.51	0.45
1:E:105:VAL:HG11	1:E:159:ILE:CD1	2.47	0.45
1:E:151:TYR:CD1	1:E:203:THR:HB	2.52	0.45
1:A:105:VAL:HG11	1:A:159:ILE:CD1	2.47	0.45
1:A:158:LEU:HD11	1:A:164:PRO:HB3	1.98	0.45
1:F:158:LEU:HD23	1:F:249:TYR:HB2	1.99	0.44
1:D:272:PRO:HD2	1:D:275:LEU:HD12	1.99	0.44
1:E:164:PRO:HG2	1:E:195:ILE:HB	2.00	0.44
1:B:172:GLY:HA3	1:A:427:ALA:HB2	1.98	0.44
1:C:209:ASP:OD1	1:C:211:THR:HG22	2.17	0.44
1:E:386:ASP:OD1	1:E:387:VAL:N	2.48	0.44
1:A:97:ARG:HB2	3:A:790:HOH:O	2.16	0.44
1:B:151:TYR:CD1	1:B:203:THR:HB	2.52	0.44
1:A:77:LEU:HD11	1:A:329:LEU:HD11	1.98	0.44
1:A:151:TYR:CG	1:A:203:THR:HB	2.53	0.44
1:B:422:THR:O	1:B:422:THR:HG22	2.18	0.44
1:C:381:ILE:HB	3:C:808:HOH:O	2.18	0.44
1:D:479:LYS:O	1:D:480:PHE:C	2.61	0.44
1:E:164:PRO:HG3	1:E:332:THR:OG1	2.17	0.44
1:A:164:PRO:HG3	1:A:332:THR:OG1	2.18	0.44
1:F:151:TYR:CD1	1:F:203:THR:HB	2.54	0.43
1:D:259:HIS:CE1	1:E:130:GLU:HG2	2.52	0.43
1:E:151:TYR:CG	1:E:203:THR:HB	2.52	0.43
1:D:158:LEU:HG	1:D:246:LEU:CD1	2.49	0.43
1:B:105:VAL:HG11	1:B:159:ILE:CD1	2.49	0.43
1:F:164:PRO:HG3	1:F:332:THR:OG1	2.19	0.43
1:D:386:ASP:OD1	1:D:387:VAL:N	2.51	0.43
1:D:151:TYR:CD1	1:D:203:THR:HB	2.54	0.42
1:C:340:THR:O	1:C:366:HIS:HD2	2.02	0.42
1:F:420:PHE:CD2	1:A:63:PRO:HG3	2.54	0.42
1:B:409:PRO:N	1:B:410:PRO:CD	2.83	0.42
1:A:18:VAL:HG12	1:A:20:LYS:H	1.83	0.42
1:B:164:PRO:HG3	1:B:332:THR:OG1	2.20	0.42
1:C:127:ASP:OD1	1:C:128:ASP:N	2.53	0.42
1:A:151:TYR:CD1	1:A:203:THR:HB	2.54	0.42

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:130:GLU:HG2	1:A:260:LEU:HD13	2.01	0.42
1:F:74:ARG:NE	1:F:328:GLN:OE1	2.38	0.42
1:A:79:ASP:HB3	1:A:82:LYS:HD3	2.01	0.42
1:A:350:THR:HG22	1:A:350:THR:O	2.19	0.42
1:B:151:TYR:CG	1:B:203:THR:HB	2.55	0.41
1:F:151:TYR:CG	1:F:203:THR:HB	2.55	0.41
1:C:151:TYR:CD1	1:C:203:THR:HB	2.55	0.41
1:B:164:PRO:HG2	1:B:195:ILE:HB	2.03	0.41
1:C:181:ASN:N	1:C:184:ASP:OD2	2.41	0.41
1:C:72:VAL:HG13	3:C:717:HOH:O	2.21	0.41
1:C:97:ARG:HB2	3:C:808:HOH:O	2.21	0.41
1:D:159:ILE:CD1	1:D:331:VAL:HG13	2.51	0.41
1:F:41:ARG:HH12	1:B:233:ASP:CG	2.28	0.40
1:F:41:ARG:NH1	1:B:233:ASP:OD1	2.44	0.40
1:D:257:VAL:HG13	1:D:293:PRO:HB2	2.04	0.40
1:A:435:ALA:N	1:A:436:PRO:CD	2.84	0.40

There are no symmetry-related clashes.

5.3 Torsion angles ⓘ

5.3.1 Protein backbone ⓘ

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	472/485 (97%)	462 (98%)	10 (2%)	0	100	100
1	B	464/485 (96%)	453 (98%)	11 (2%)	0	100	100
1	C	478/485 (99%)	471 (98%)	7 (2%)	0	100	100
1	D	478/485 (99%)	470 (98%)	8 (2%)	0	100	100
1	E	479/485 (99%)	470 (98%)	9 (2%)	0	100	100
1	F	481/485 (99%)	476 (99%)	5 (1%)	0	100	100
All	All	2852/2910 (98%)	2802 (98%)	50 (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	412/422 (98%)	412 (100%)	0	100	100
1	B	405/422 (96%)	405 (100%)	0	100	100
1	C	418/422 (99%)	418 (100%)	0	100	100
1	D	418/422 (99%)	417 (100%)	1 (0%)	87	90
1	E	418/422 (99%)	418 (100%)	0	100	100
1	F	420/422 (100%)	419 (100%)	1 (0%)	87	90
All	All	2491/2532 (98%)	2489 (100%)	2 (0%)	87	90

All (2) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	F	329	LEU
1	D	218	SER

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (23) such sidechains are listed below:

Mol	Chain	Res	Type
1	F	56	ASN
1	F	153	GLN
1	F	168	HIS
1	F	270	ASN
1	F	373	GLN
1	F	429	GLN
1	B	153	GLN
1	B	305	GLN
1	B	327	ASN
1	B	366	HIS
1	B	429	GLN
1	C	168	HIS

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Mol	Chain	Res	Type
1	C	366	HIS
1	D	138	ASN
1	D	259	HIS
1	D	357	ASN
1	E	153	GLN
1	E	327	ASN
1	E	373	GLN
1	E	429	GLN
1	A	153	GLN
1	A	168	HIS
1	A	177	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 189 ligands modelled in this entry, 189 are 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.

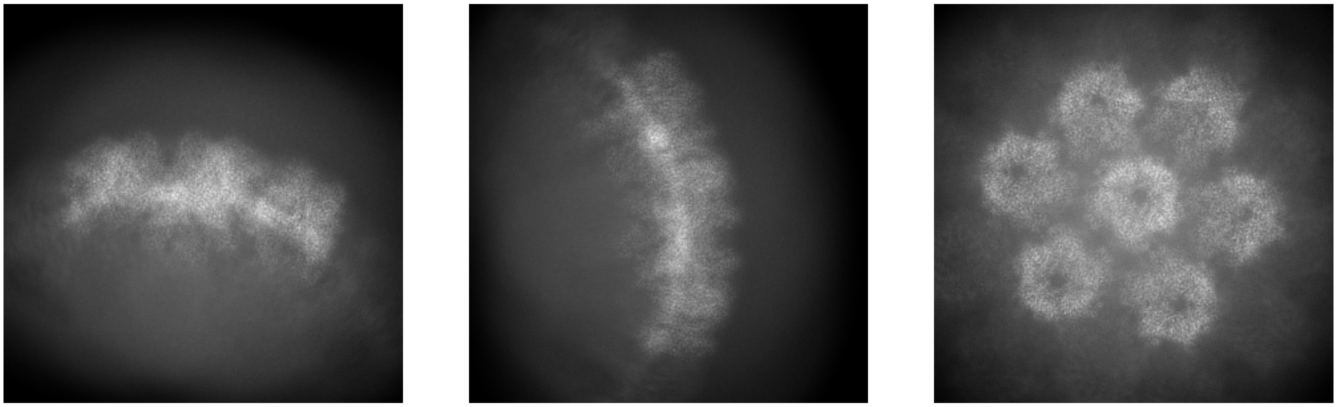
6 Map visualisation

This section contains visualisations of the EMDB entry EMD-49960. 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

6.1.1 Primary map



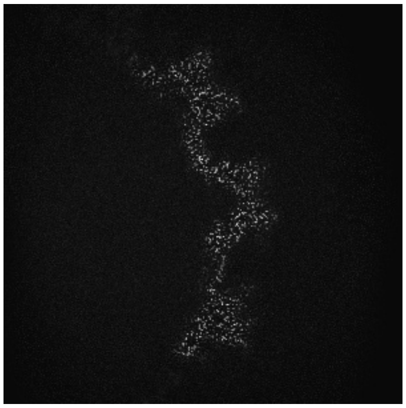
X Y Z

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

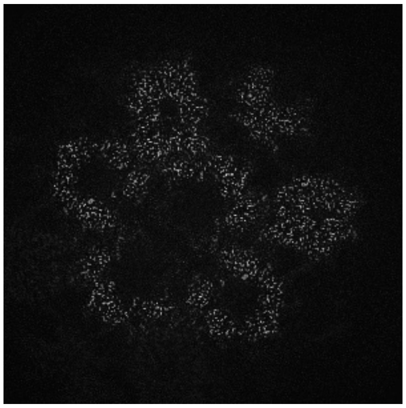
6.2 Central slices

6.2.1 Primary map

X Index: 380



Y Index: 380

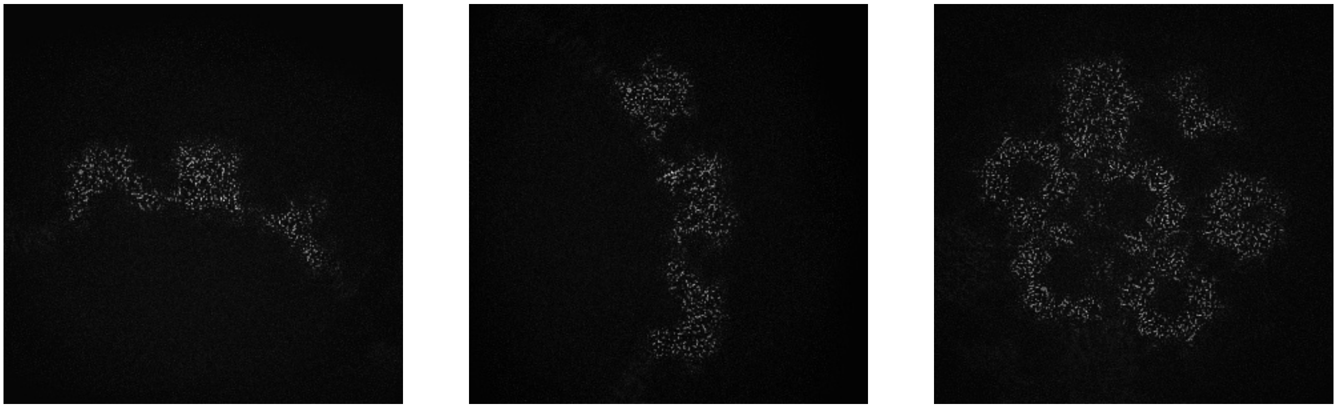


Z Index: 380

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

6.3 Largest variance slices

6.3.1 Primary map

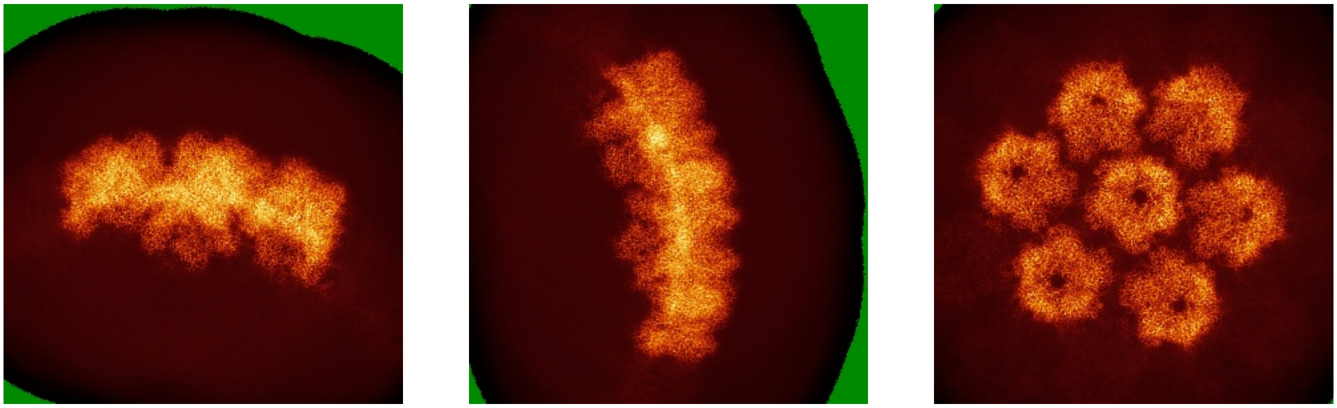


X Index: 440 Y Index: 419 Z Index: 389

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

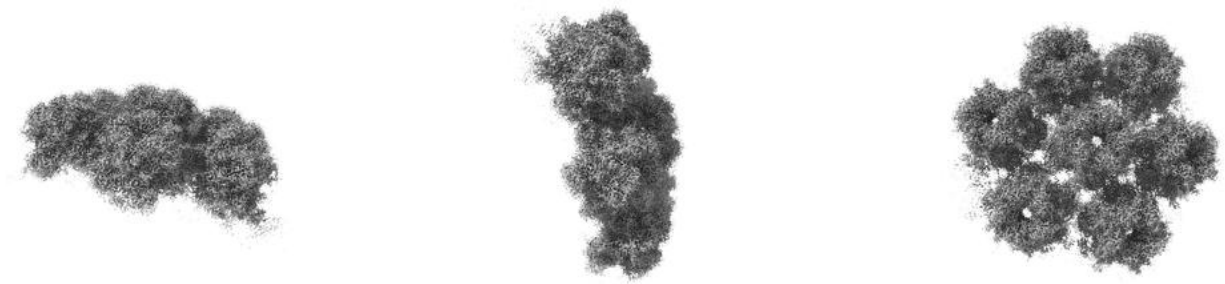


X Y Z

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

6.5.1 Primary map



X Y Z

The images above show the 3D surface view of the map at the recommended contour level 0.9. These images, in conjunction with the slice images, may facilitate assessment of whether an appropriate contour level has been provided.

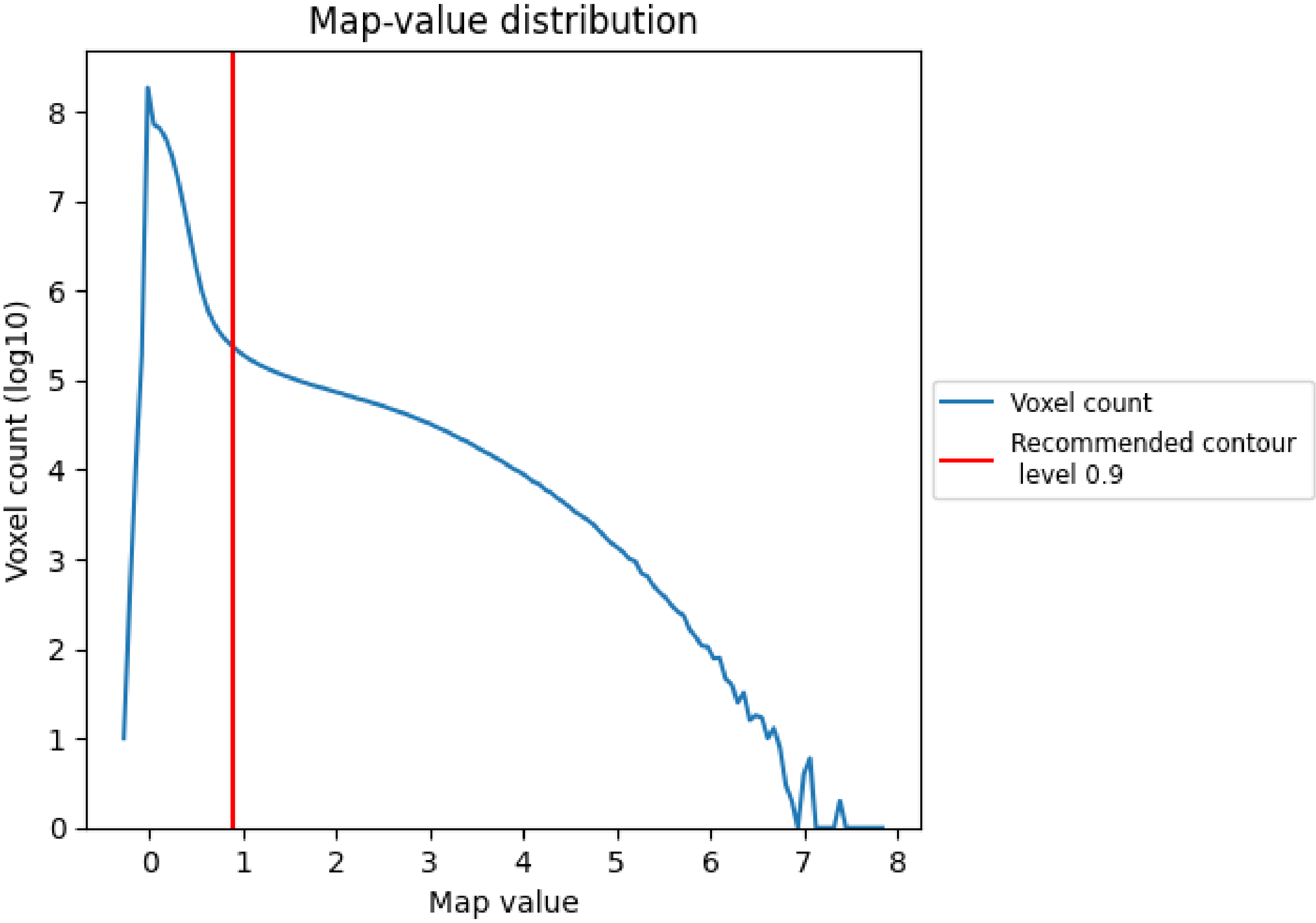
6.6 Mask visualisation

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

7 Map analysis ⓘ

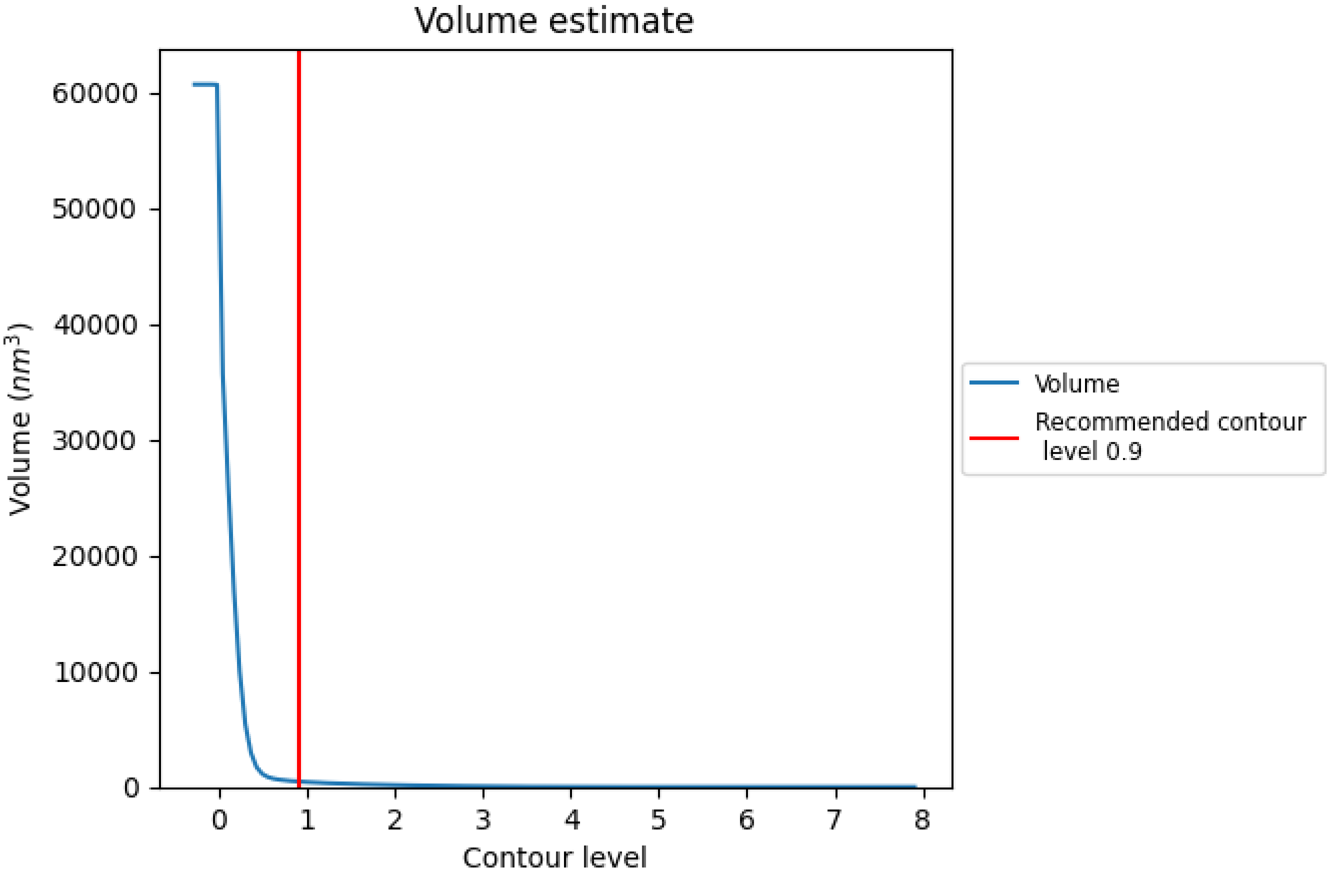
This section contains the results of statistical analysis of the map.

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.

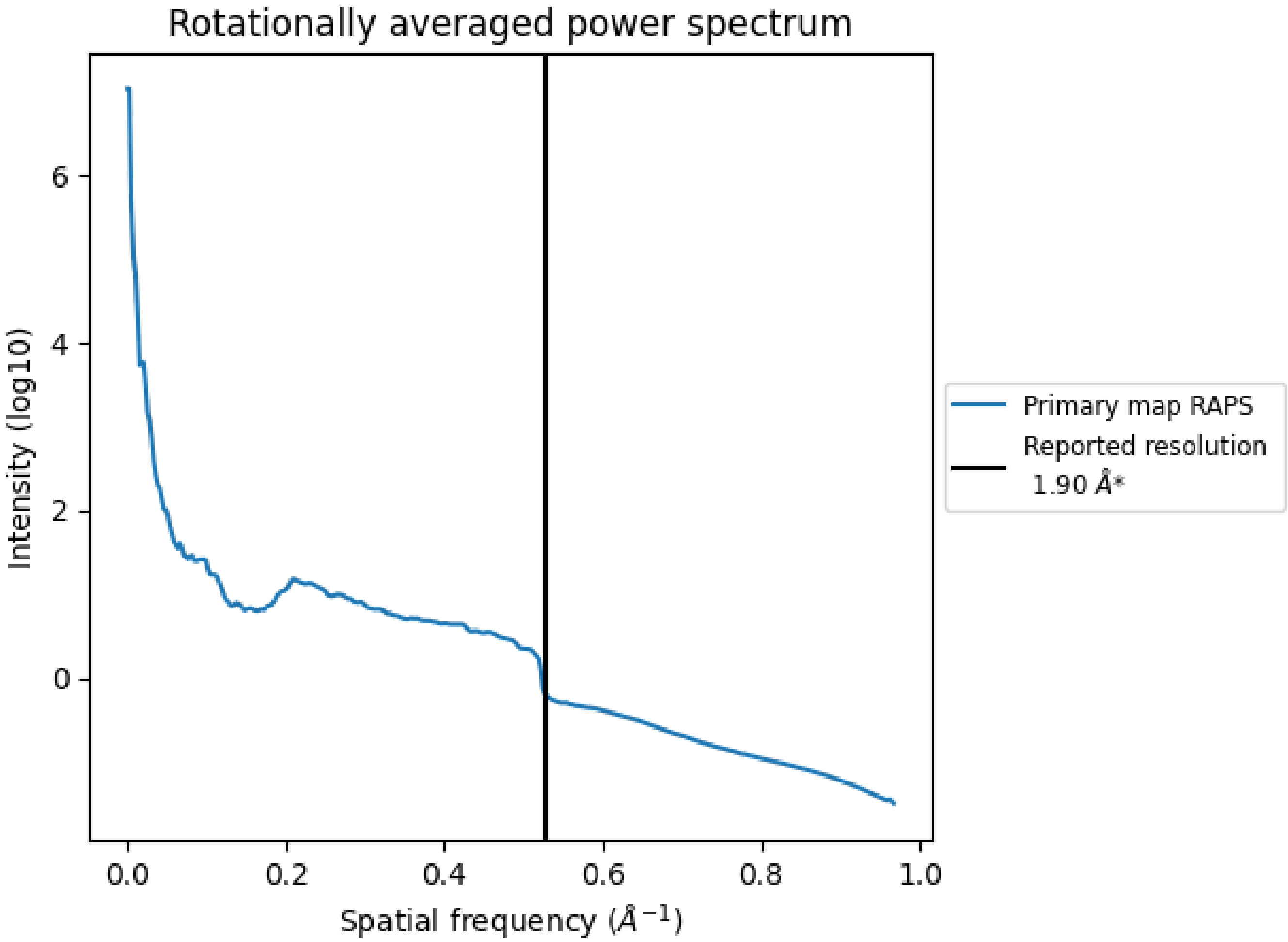
7.2 Volume estimate ⓘ



The volume at the recommended contour level is 469 nm^3; this corresponds to an approximate mass of 424 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 0.526 $Å^{-1}$

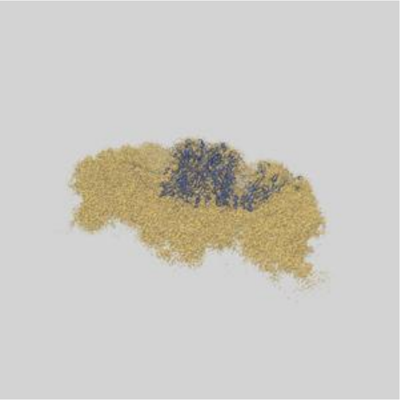
8 Fourier-Shell correlation ⓘ

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

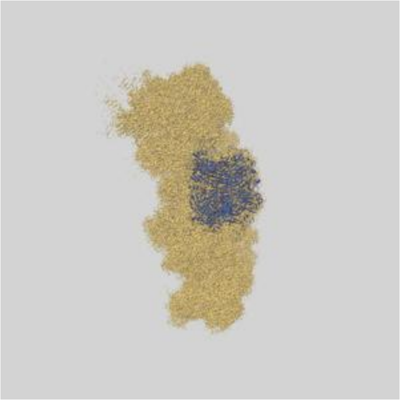
9 Map-model fit

This section contains information regarding the fit between EMDB map EMD-49960 and PDB model 9NZU. Per-residue inclusion information can be found in section 3 on page 6.

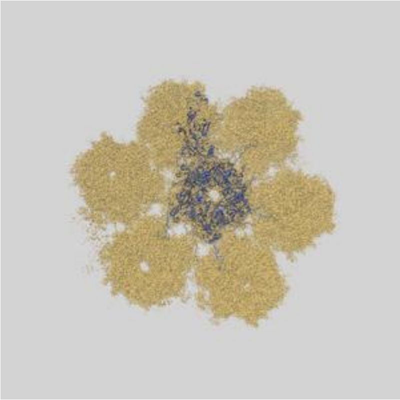
9.1 Map-model overlay



X



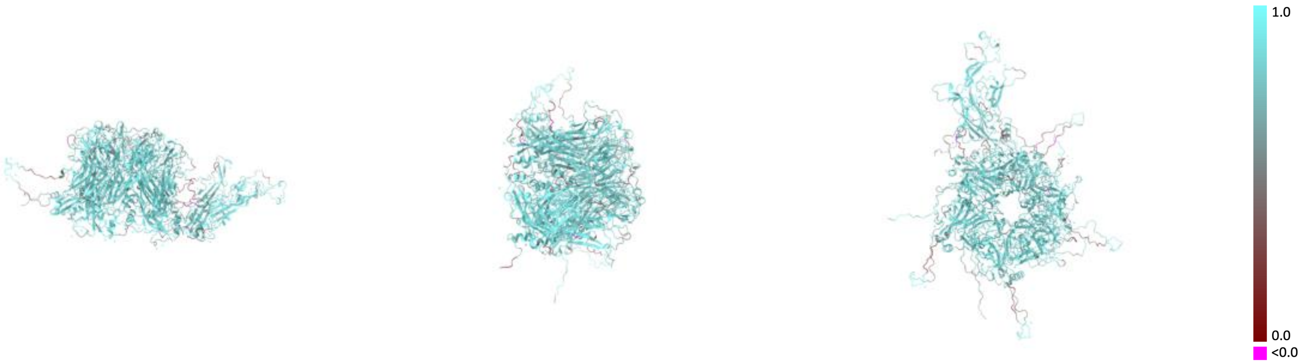
Y



Z

The images above show the 3D surface view of the map at the recommended contour level 0.9 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.

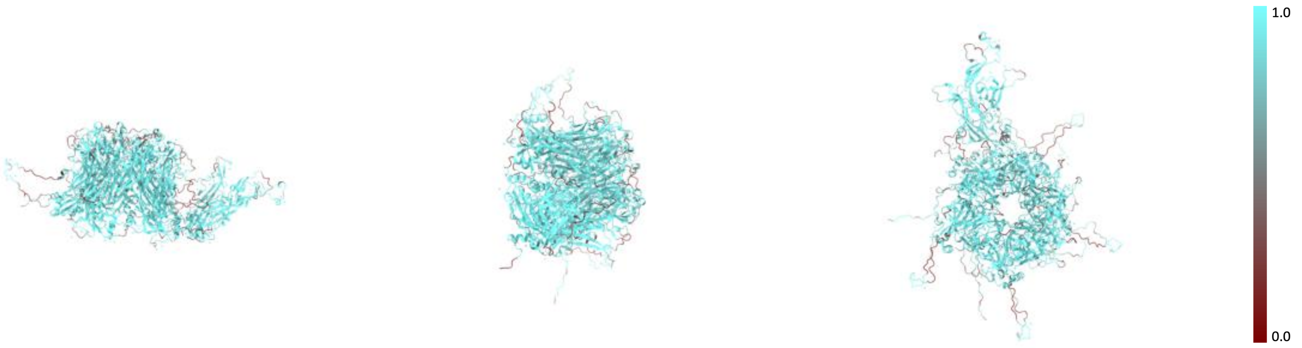
9.2 Q-score mapped to coordinate model



X Y Z

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.

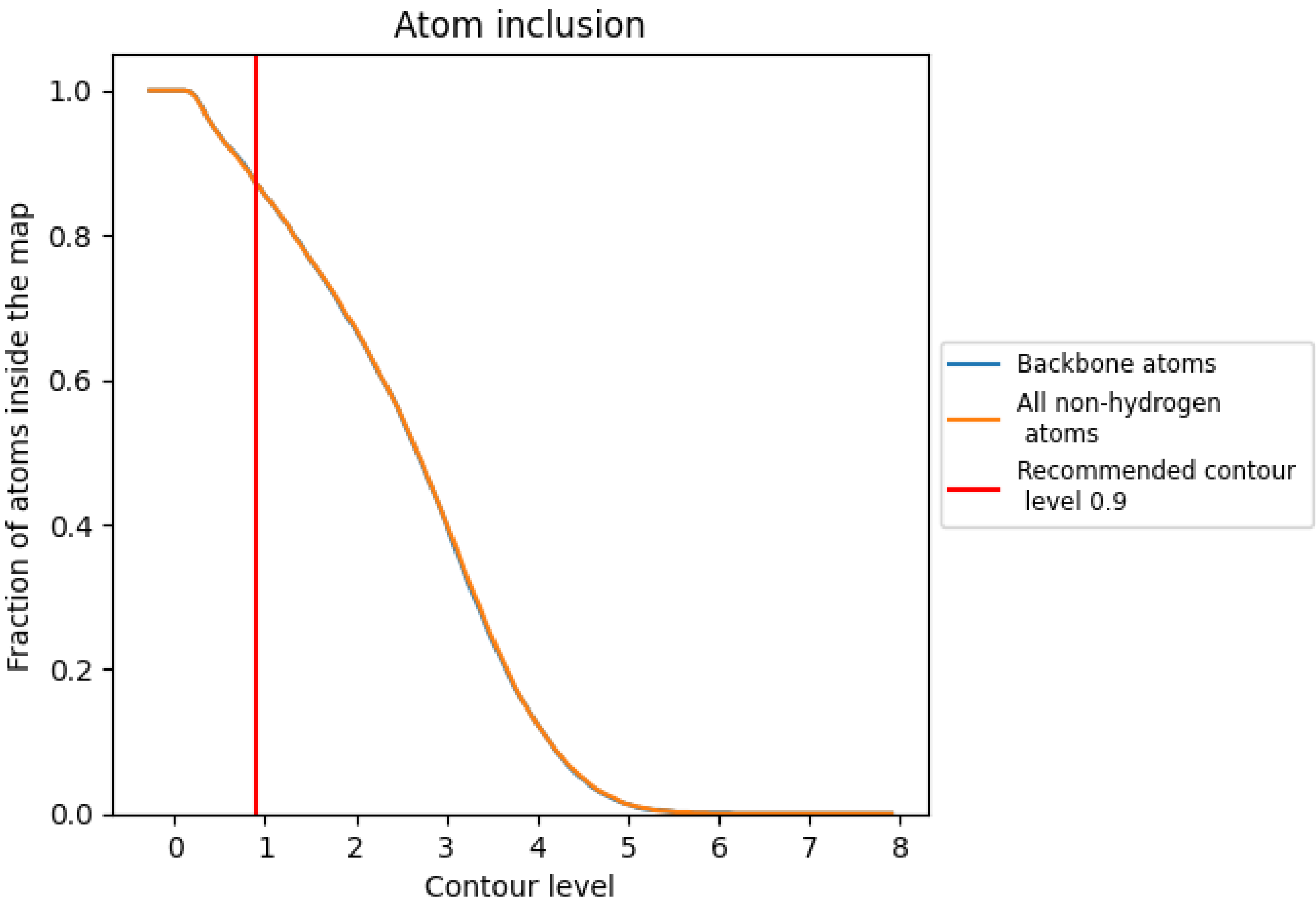
9.3 Atom inclusion mapped to coordinate model



X Y Z

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 (0.9).

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 (0.9) and Q-score for the entire model and for each chain.

Chain	Atom inclusion	Q-score
All	▬ 0.8700	▬ 0.7850
A	▬ 0.8670	▬ 0.7750
B	▬ 0.8720	▬ 0.7800
C	▬ 0.8880	▬ 0.7980
D	▬ 0.8790	▬ 0.7910
E	▬ 0.8590	▬ 0.7820
F	▬ 0.8770	▬ 0.7830