wwPDB EM Validation Summary Report (i)

Nov 2, 2022 – 10:03 PM EDT

PDB ID	:	5UBQ
EMDB ID	:	EMD-8528
Title	:	Cryo-EM structure of ciliary microtubule doublet
Authors	:	Ichikawa, M.; Liu, D.; Kastritis, P.L.; Basu, K.; Bui, K.H.
Deposited on	:	2016-12-21
Resolution	:	5.70 Å(reported)

This is a wwPDB EM Validation Summary Report for a publicly released PDB entry.

We welcome your comments at *validation@mail.wwpdb.org*
A user guide is available at
https://www.wwpdb.org/validation/2017/EMValidationReportHelp
with specific help available everywhere you see the (i) 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 (1)) were used in the production of this report:

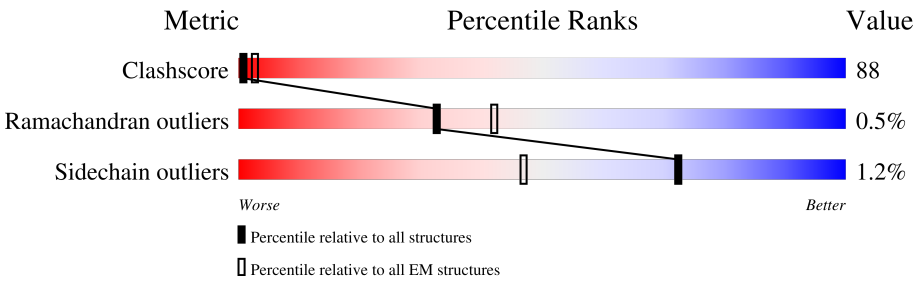
EMDB validation analysis	:	0.0.1.dev43
Mogul	:	1.8.5 (274361), CSD as541be (2020)
MolProbity	:	4.02b-467
buster-report	:	1.1.7 (2018)
Percentile statistics	:	20191225.v01 (using entries in the PDB archive December 25th 2019)
MapQ	:	1.9.9
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.31.2

1 Overall quality at a glance (i)

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

The reported resolution of this entry is 5.70 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)
Clashscore	158937	4297
Ramachandran outliers	154571	4023
Sidechain outliers	154315	3826

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	441	22% 23% 75% •
1	C	441	22% 21% 77% •
1	E	441	17% 22% 76% •
2	B	429	20% 19% 79% •
2	D	429	16% 19% 79% •
2	F	429	12% 21% 77% •

The following table lists non-polymeric compounds, carbohydrate monomers and non-standard residues in protein, DNA, RNA chains that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Chirality	Geometry	Clashes	Electron density
3	GTP	A	501	-	-	X	-
3	GTP	C	501	-	-	X	-
3	GTP	E	501	-	-	X	-
5	GDP	B	501	-	-	X	-
5	GDP	D	501	-	-	X	-
5	GDP	F	501	-	-	X	-

2 Entry composition (i)

There are 5 unique types of molecules in this entry. The entry contains 25014 atoms, of which 4476 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 Tubulin alpha chain.

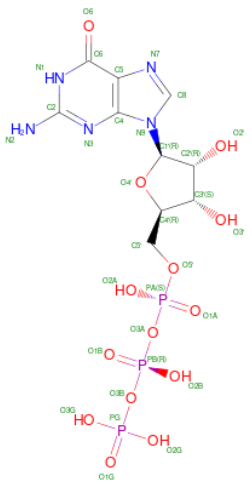
Mol	Chain	Residues	Atoms						AltConf	Trace
			Total	C	H	N	O	S		
1	C	441	4165	2163	742	581	657	22	0	0
1	E	441	4165	2163	742	581	657	22	0	0
1	A	441	4165	2163	742	581	657	22	0	0

- Molecule 2 is a protein called Tubulin beta chain.

Mol	Chain	Residues	Atoms						AltConf	Trace
			Total	C	H	N	O	S		
2	D	429	4104	2112	742	576	646	28	0	0
2	F	429	4104	2112	742	576	646	28	0	0
2	B	429	4104	2112	742	576	646	28	0	0

- Molecule 3 is GUANOSINE-5'-TRIPHOSPHATE (three-letter code: GTP) (formula: $C_{10}H_{16}N_5O_{14}P_3$).

GTP



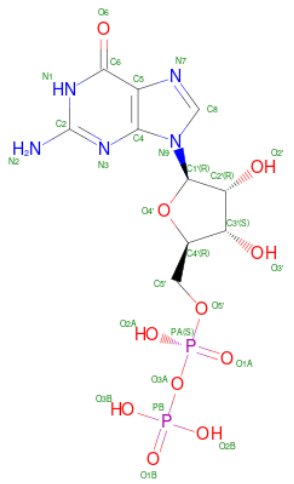
Mol	Chain	Residues	Atoms						AltConf
			Total	C	H	N	O	P	
3	C	1	35	10	3	5	14	3	0
3	E	1	35	10	3	5	14	3	0
3	A	1	35	10	3	5	14	3	0

- Molecule 4 is MAGNESIUM ION (three-letter code: MG) (formula: Mg).

Mol	Chain	Residues	Atoms		AltConf
			Total	Mg	
4	C	1	1	1	0
4	E	1	1	1	0
4	A	1	1	1	0

- Molecule 5 is GUANOSINE-5'-DIPHOSPHATE (three-letter code: GDP) (formula: $C_{10}H_{15}N_5O_{11}P_2$).

GDP



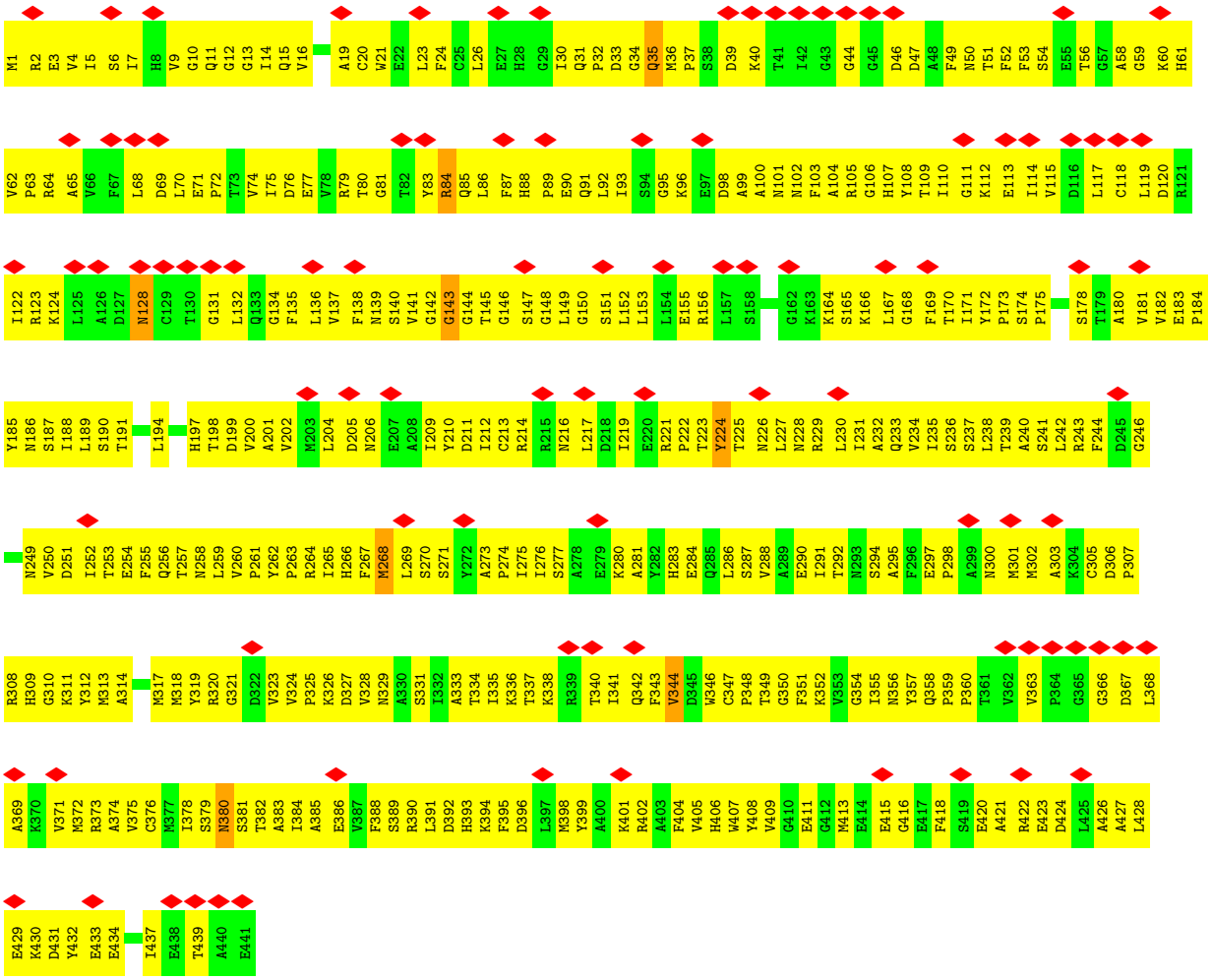
Mol	Chain	Residues	Atoms						AltConf
			Total	C	H	N	O	P	
5	D	1	33	10	5	5	11	2	0
			Total	C	H	N	O	P	
5	F	1	33	10	5	5	11	2	0
			Total	C	H	N	O	P	
5	B	1	33	10	5	5	11	2	0

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.

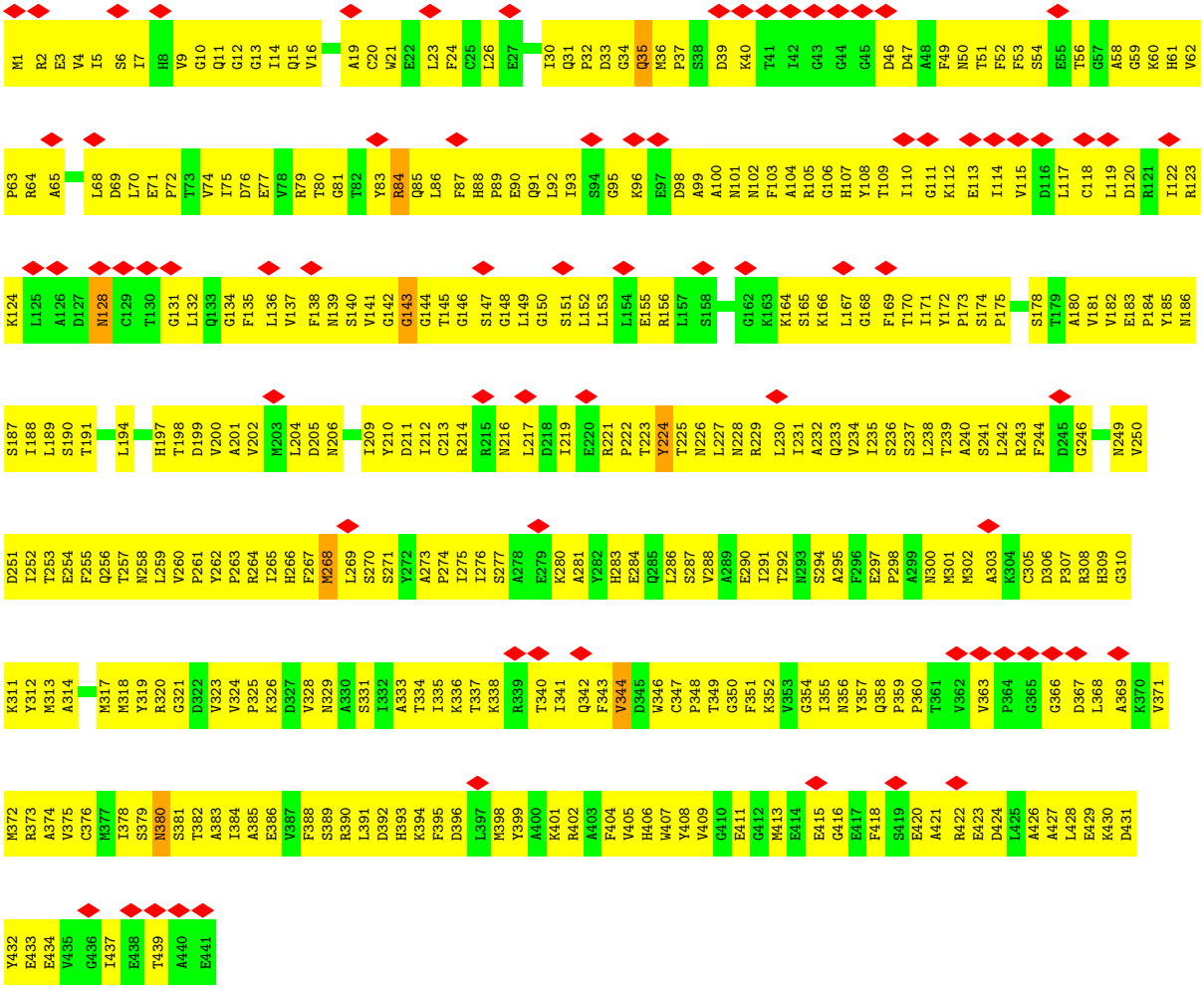
- Molecule 1: Tubulin alpha chain

Chain C:



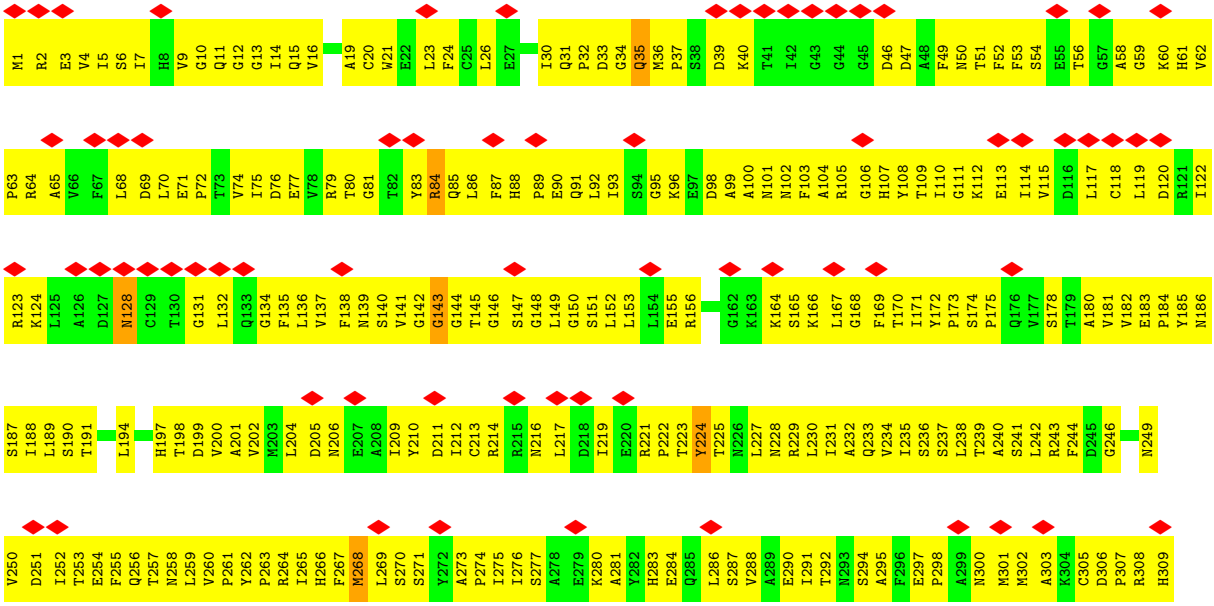
- Molecule 1: Tubulin alpha chain

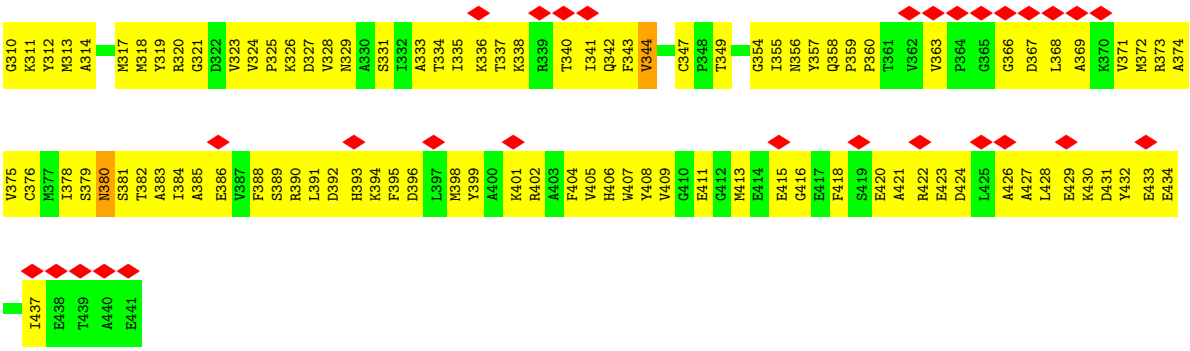
Chain E:



- Molecule 1: Tubulin alpha chain

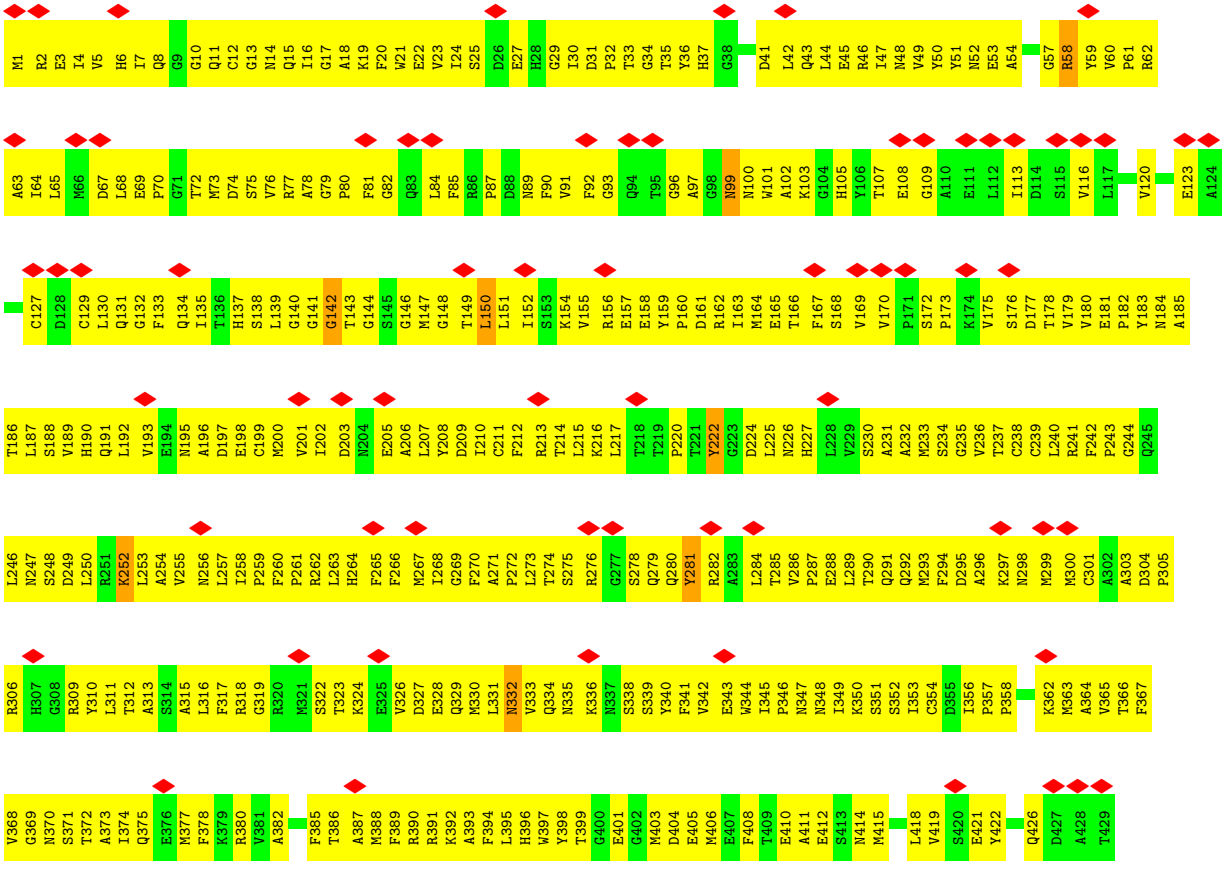
Chain A:





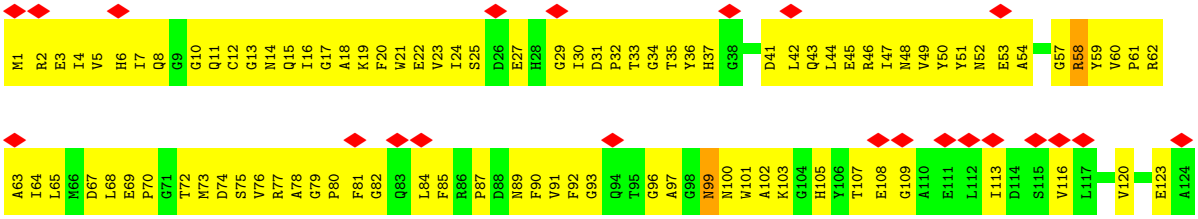
- Molecule 2: Tubulin beta chain

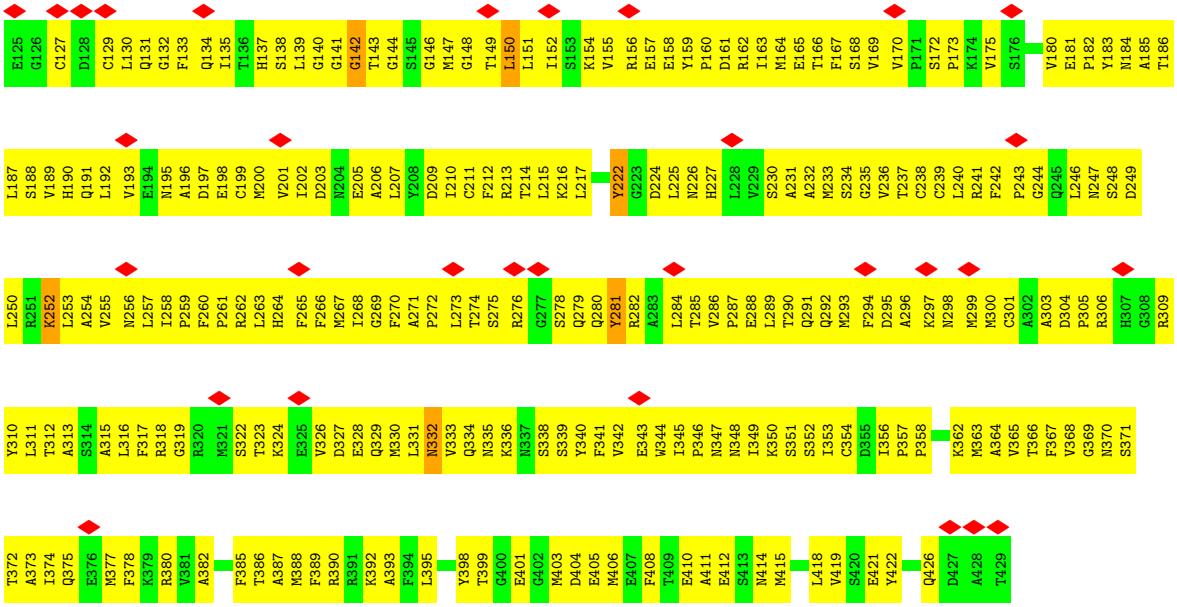
Chain D:



- Molecule 2: Tubulin beta chain

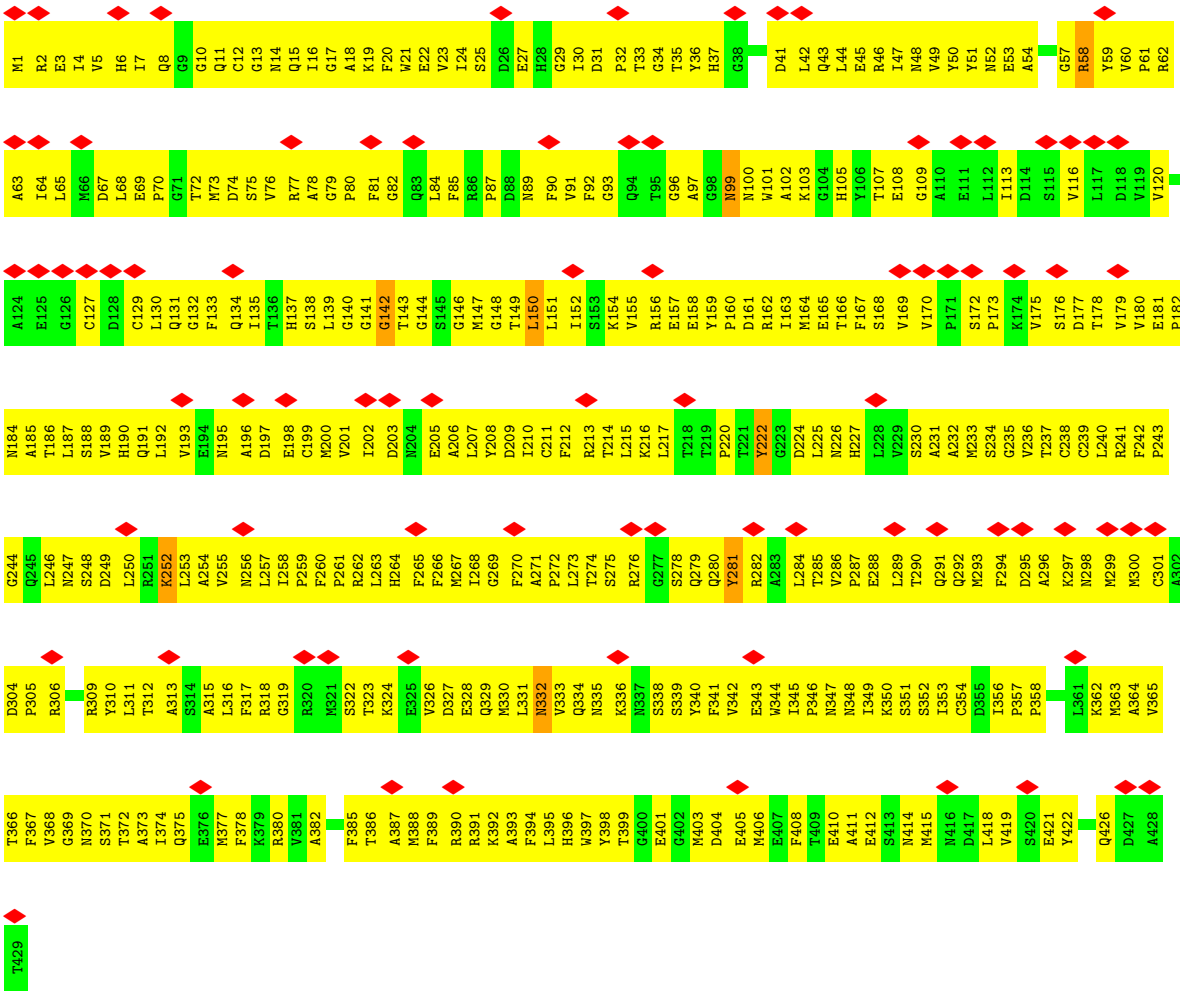
Chain F:





- Molecule 2: Tubulin beta chain

Chain B:



4 Experimental information (i)

Property	Value	Source
EM reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, C1	Depositor
Number of particles used	127429	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 ($e^-/Å^2$)	45	Depositor
Minimum defocus (nm)	1200	Depositor
Maximum defocus (nm)	3800	Depositor
Magnification	59000	Depositor
Image detector	FEI FALCON II (4k x 4k)	Depositor
Maximum map value	0.385	Depositor
Minimum map value	-0.169	Depositor
Average map value	0.004	Depositor
Map value standard deviation	0.032	Depositor
Recommended contour level	0.105	Depositor
Map size (Å)	704.0, 704.0, 704.0	wwPDB
Map dimensions	256, 256, 256	wwPDB
Map angles (°)	90.0, 90.0, 90.0	wwPDB
Pixel spacing (Å)	2.75, 2.75, 2.75	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: GDP, MG, GTP

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	0.58	1/3495 (0.0%)	0.61	0/4735
1	C	0.58	1/3495 (0.0%)	0.61	0/4735
1	E	0.58	1/3495 (0.0%)	0.61	0/4735
2	B	0.55	0/3435	0.66	3/4648 (0.1%)
2	D	0.55	0/3435	0.66	3/4648 (0.1%)
2	F	0.55	0/3435	0.66	3/4648 (0.1%)
All	All	0.57	3/20790 (0.0%)	0.64	9/28149 (0.0%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand.A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	A	0	1
1	C	0	1
1	E	0	1
2	B	0	1
2	D	0	1
2	F	0	1
All	All	0	6

All (3) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	C	35	GLN	C-N	-8.20	1.15	1.34
1	A	35	GLN	C-N	-8.16	1.15	1.34
1	E	35	GLN	C-N	-8.15	1.15	1.34

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

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	F	252	LYS	CD-CE-NZ	8.21	130.58	111.70
2	B	252	LYS	CD-CE-NZ	8.20	130.55	111.70
2	D	252	LYS	CD-CE-NZ	8.19	130.53	111.70
2	B	150	LEU	CA-CB-CG	-5.56	102.51	115.30
2	D	150	LEU	CA-CB-CG	-5.56	102.52	115.30

There are no chirality outliers.

5 of 6 planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	143	GLY	Peptide
1	C	143	GLY	Peptide
2	D	99	ASN	Peptide
1	E	143	GLY	Peptide
2	F	99	ASN	Peptide

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	3423	742	3353	550	0
1	C	3423	742	3348	694	0
1	E	3423	742	3348	692	0
2	B	3362	742	3244	701	0
2	D	3362	742	3244	700	0
2	F	3362	742	3244	558	0
3	A	32	3	9	41	0
3	C	32	3	9	41	0
3	E	32	3	9	41	0
4	A	1	0	0	1	0
4	C	1	0	0	1	0
4	E	1	0	0	1	0
5	B	28	5	11	21	0
5	D	28	5	11	21	0
5	F	28	5	11	21	0
All	All	20538	4476	19841	3536	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 88.

The worst 5 of 3536 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:C:347:CYS:CB	2:B:388:MET:HE3	1.21	1.67
2:D:388:MET:HE3	1:E:347:CYS:CB	1.18	1.64
2:D:388:MET:CE	1:E:347:CYS:HA	1.38	1.53
2:D:12:CYS:HB2	5:D:501:GDP:C8	1.45	1.52
2:F:12:CYS:HB2	5:F:501:GDP:C8	1.45	1.52

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	439/441 (100%)	377 (86%)	59 (13%)	3 (1%)	22	62
1	C	439/441 (100%)	377 (86%)	59 (13%)	3 (1%)	22	62
1	E	439/441 (100%)	377 (86%)	59 (13%)	3 (1%)	22	62
2	B	427/429 (100%)	388 (91%)	38 (9%)	1 (0%)	47	81
2	D	427/429 (100%)	388 (91%)	38 (9%)	1 (0%)	47	81
2	F	427/429 (100%)	388 (91%)	38 (9%)	1 (0%)	47	81
All	All	2598/2610 (100%)	2295 (88%)	291 (11%)	12 (0%)	32	69

5 of 12 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	C	49	PHE
1	E	49	PHE
1	A	49	PHE
1	C	344	VAL
1	E	344	VAL

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	371/371 (100%)	365 (98%)	6 (2%)	62	79
1	C	371/371 (100%)	365 (98%)	6 (2%)	62	79
1	E	371/371 (100%)	365 (98%)	6 (2%)	62	79
2	B	365/365 (100%)	362 (99%)	3 (1%)	81	89
2	D	365/365 (100%)	362 (99%)	3 (1%)	81	89
2	F	365/365 (100%)	362 (99%)	3 (1%)	81	89
All	All	2208/2208 (100%)	2181 (99%)	27 (1%)	72	83

5 of 27 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	E	380	ASN
2	F	332	ASN
2	B	222	TYR
2	F	281	TYR
1	A	84	ARG

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 58 such sidechains are listed below:

Mol	Chain	Res	Type
2	F	191	GLN
2	B	414	ASN
2	F	396	HIS
2	B	375	GLN
2	B	195	ASN

5.3.3 RNA (i)

There are no RNA molecules in this entry.

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

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

5.5 Carbohydrates (i)

There are no monosaccharides in this entry.

5.6 Ligand geometry (i)

Of 9 ligands modelled in this entry, 3 are monoatomic - leaving 6 for Mogul analysis.

In the following table, the Counts columns list the number of bonds (or angles) for which Mogul statistics could be retrieved, the number of bonds (or angles) that are observed in the model and the number of bonds (or angles) that are defined in the Chemical Component Dictionary. The Link column lists molecule types, if any, to which the group is linked. 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 $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	$\#\|Z\| > 2$	Counts	RMSZ	$\#\|Z\| > 2$
3	GTP	C	501	1	26,34,34	1.38	3 (11%)	32,54,54	1.73	7 (21%)
3	GTP	A	501	1	26,34,34	1.39	3 (11%)	32,54,54	1.73	7 (21%)
5	GDP	F	501	2	24,30,30	1.48	3 (12%)	30,47,47	1.49	7 (23%)
5	GDP	D	501	2	24,30,30	1.47	3 (12%)	30,47,47	1.49	7 (23%)
3	GTP	E	501	1	26,34,34	1.38	3 (11%)	32,54,54	1.73	7 (21%)
5	GDP	B	501	2	24,30,30	1.48	3 (12%)	30,47,47	1.48	7 (23%)

In the following table, the Chirals column lists the number of chiral outliers, the number of chiral centers analysed, the number of these observed in the model and the number defined in the Chemical Component Dictionary. Similar counts are reported in the Torsion and Rings columns. '-' means no outliers of that kind were identified.

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
3	GTP	C	501	1	-	8/18/38/38	0/3/3/3
3	GTP	A	501	1	-	8/18/38/38	0/3/3/3
5	GDP	F	501	2	-	3/12/32/32	0/3/3/3
5	GDP	D	501	2	-	3/12/32/32	0/3/3/3
3	GTP	E	501	1	-	8/18/38/38	0/3/3/3
5	GDP	B	501	2	-	3/12/32/32	0/3/3/3

The worst 5 of 18 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
5	F	501	GDP	C5-C6	-4.13	1.39	1.47
5	B	501	GDP	C5-C6	-4.12	1.39	1.47
5	D	501	GDP	C5-C6	-4.10	1.39	1.47
3	A	501	GTP	C5-C6	-3.73	1.39	1.47
3	E	501	GTP	C5-C6	-3.71	1.39	1.47

The worst 5 of 42 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
3	A	501	GTP	PB-O3B-PG	-4.42	117.64	132.83
3	E	501	GTP	PB-O3B-PG	-4.42	117.67	132.83
3	C	501	GTP	PB-O3B-PG	-4.41	117.71	132.83
3	C	501	GTP	PA-O3A-PB	-3.45	120.99	132.83
3	E	501	GTP	PA-O3A-PB	-3.44	121.02	132.83

There are no chirality outliers.

5 of 33 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	C	501	GTP	PB-O3B-PG-O2G
3	C	501	GTP	C5'-O5'-PA-O3A
3	C	501	GTP	C5'-O5'-PA-O2A
3	C	501	GTP	C4'-C5'-O5'-PA
3	E	501	GTP	PB-O3B-PG-O2G

There are no ring outliers.

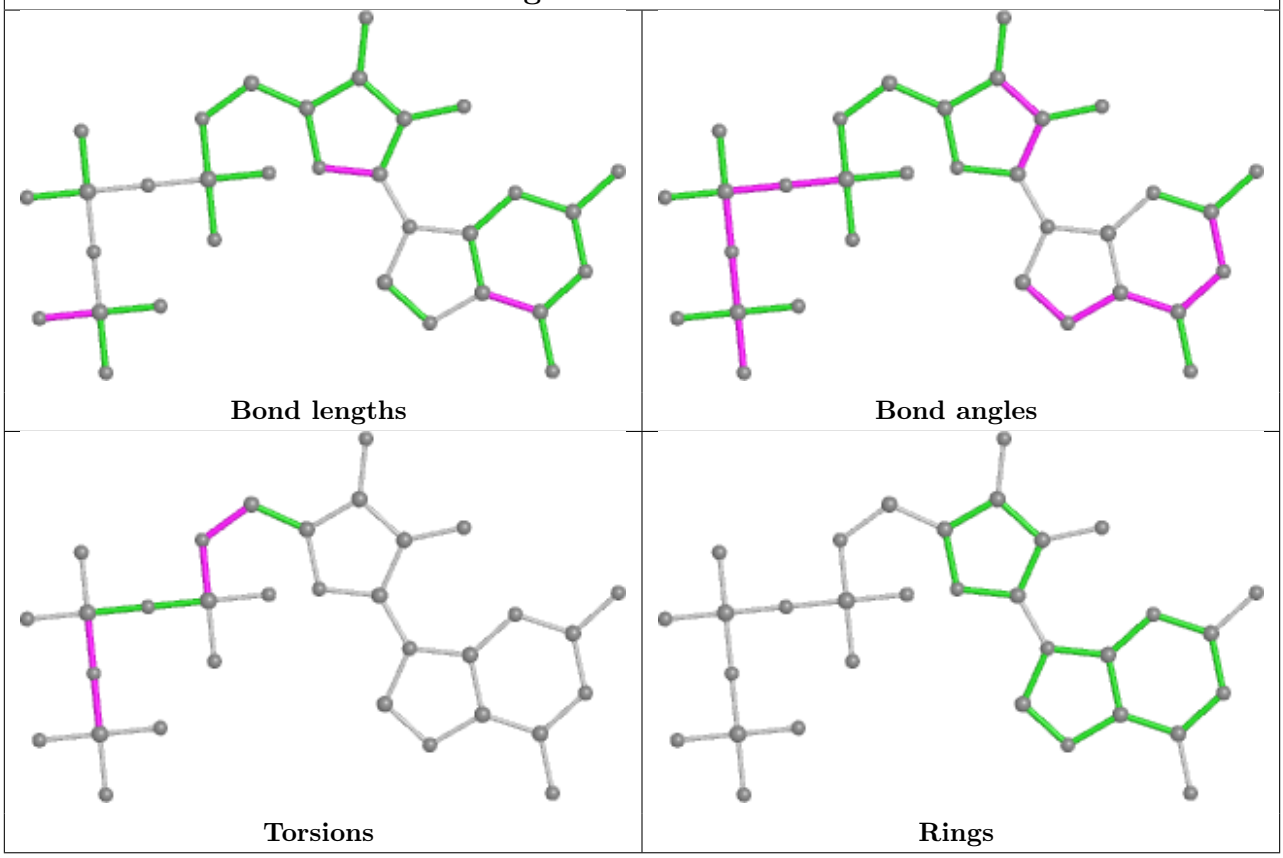
6 monomers are involved in 186 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	C	501	GTP	41	0
3	A	501	GTP	41	0
5	F	501	GDP	21	0
5	D	501	GDP	21	0
3	E	501	GTP	41	0
5	B	501	GDP	21	0

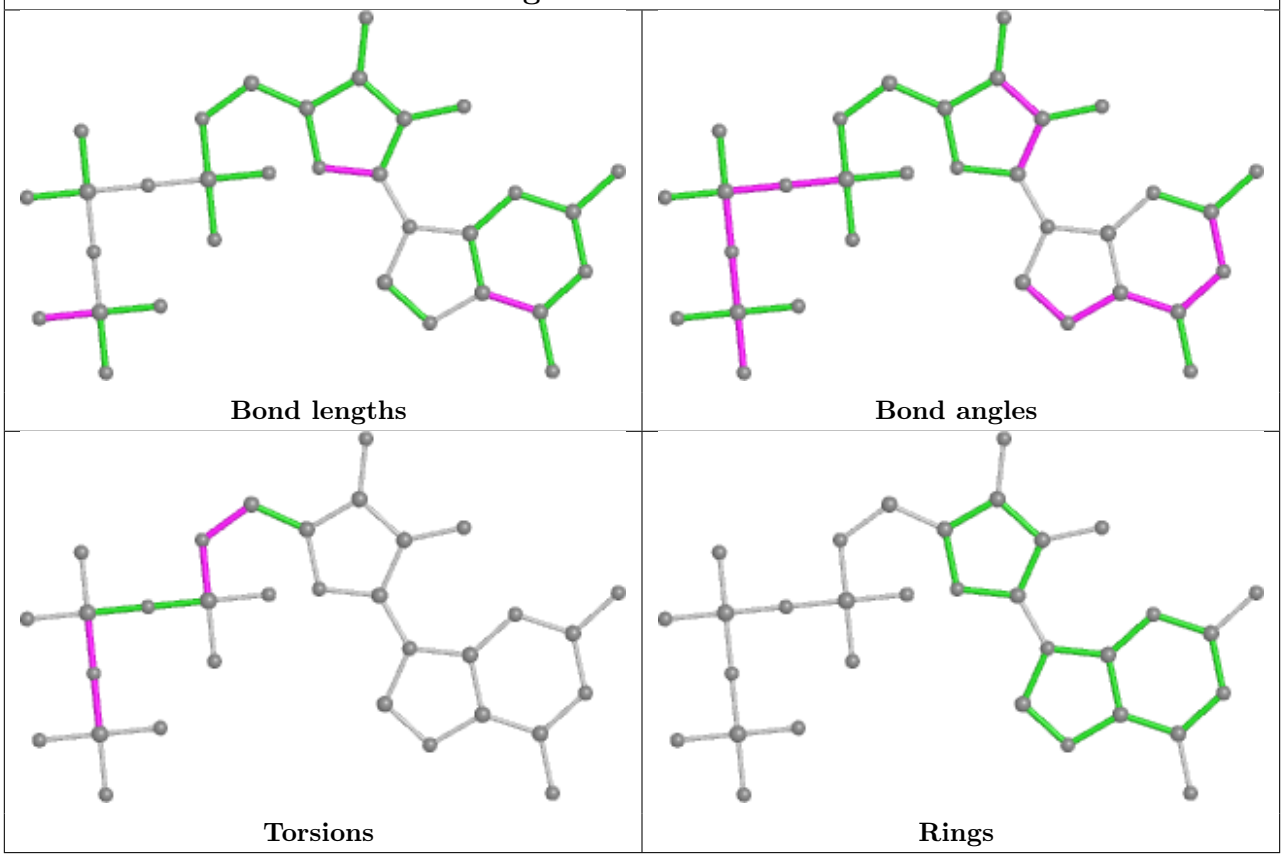
The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less then 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier.

Any bond that is central to one or more torsion angles identified as an outlier by Mogul will be highlighted in the graph. For rings, the root-mean-square deviation (RMSD) between the ring in question and similar rings identified by Mogul is calculated over all ring torsion angles. If the average RMSD is greater than 60 degrees and the minimal RMSD between the ring in question and any Mogul-identified rings is also greater than 60 degrees, then that ring is considered an outlier. The outliers are highlighted in purple. The color gray indicates Mogul did not find sufficient equivalents in the CSD to analyse the geometry.

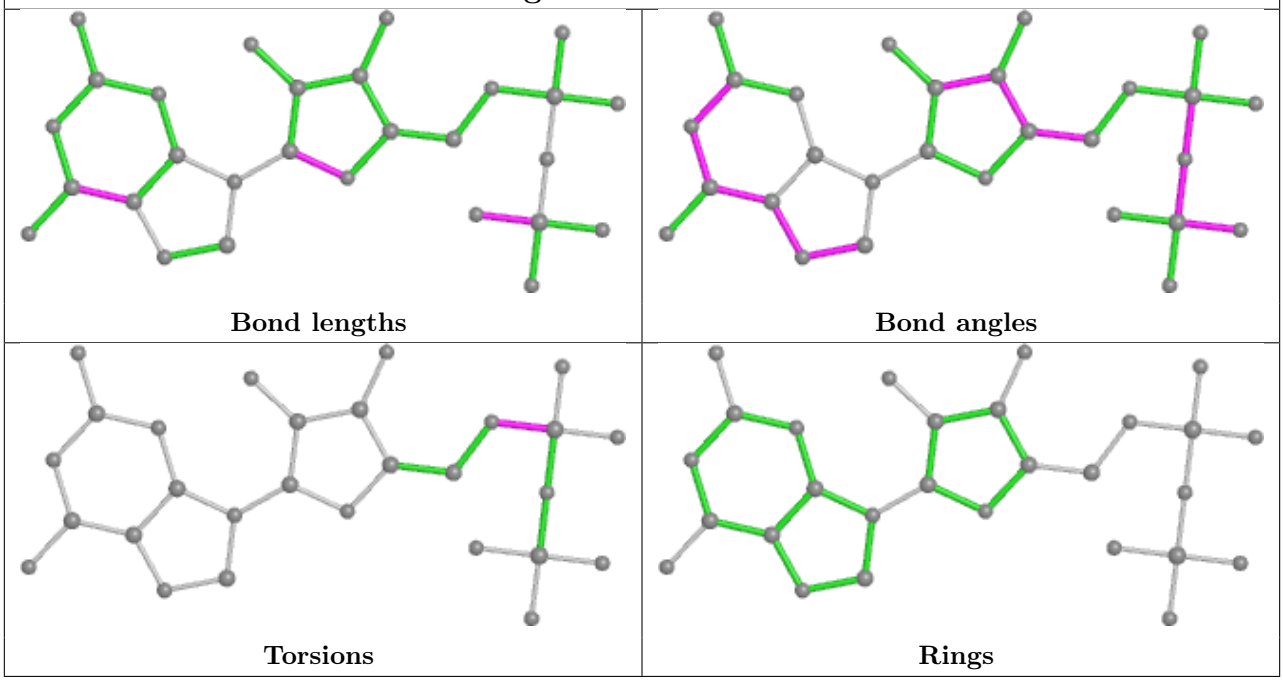
Ligand GTP C 501



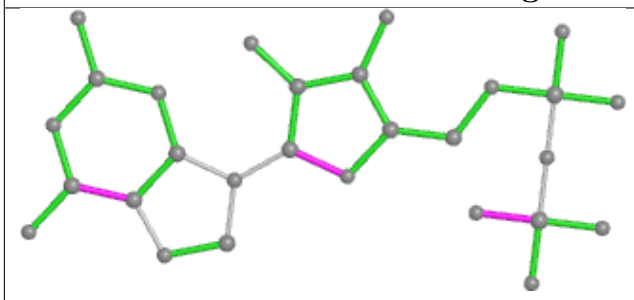
Ligand GTP A 501



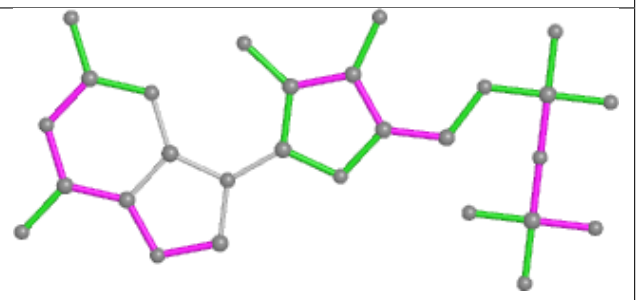
Ligand GDP F 501



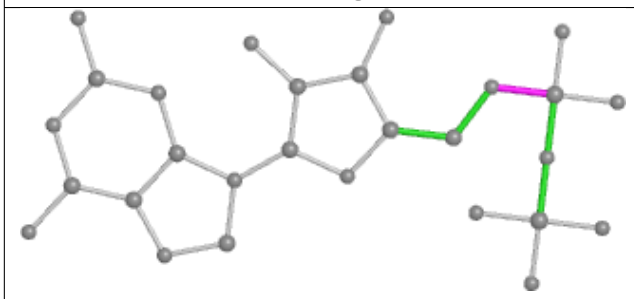
Ligand GDP D 501



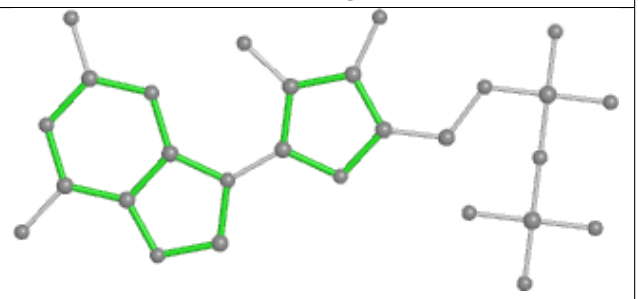
Bond lengths



Bond angles

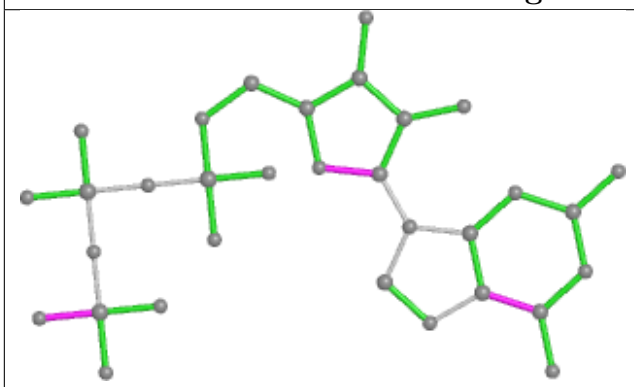


Torsions

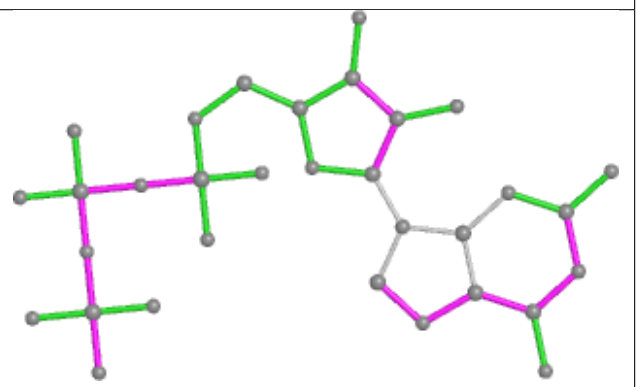


Rings

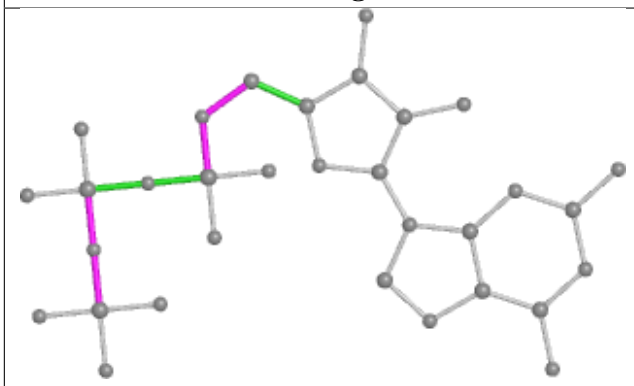
Ligand GTP E 501



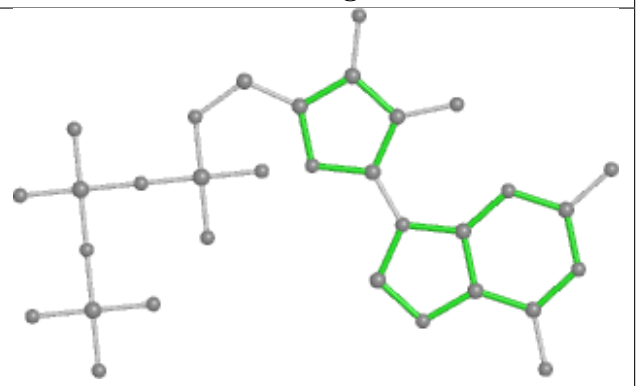
Bond lengths



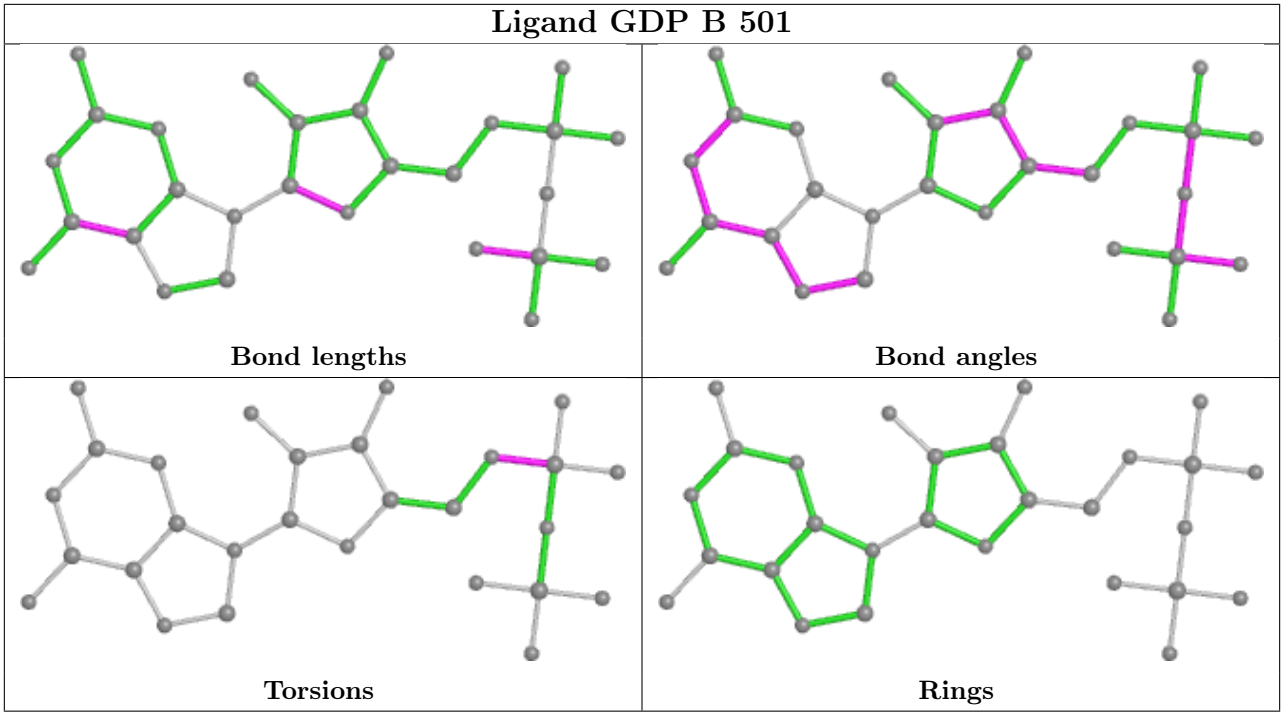
Bond angles



Torsions



Rings



5.7 Other polymers (i)

There are no such residues in this entry.

5.8 Polymer linkage issues (i)

The following chains have linkage breaks:

Mol	Chain	Number of breaks
1	C	1
1	E	1
1	A	1

All chain breaks are listed below:

Model	Chain	Residue-1	Atom-1	Residue-2	Atom-2	Distance (Å)
1	C	35:GLN	C	36:MET	N	1.15
1	E	35:GLN	C	36:MET	N	1.15
1	A	35:GLN	C	36:MET	N	1.15

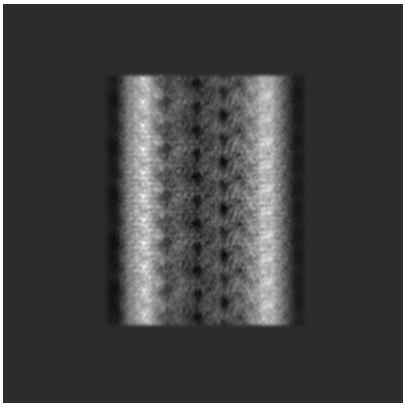
6 Map visualisation (i)

This section contains visualisations of the EMDB entry EMD-8528. These allow visual inspection of the internal detail of the map and identification of artifacts.

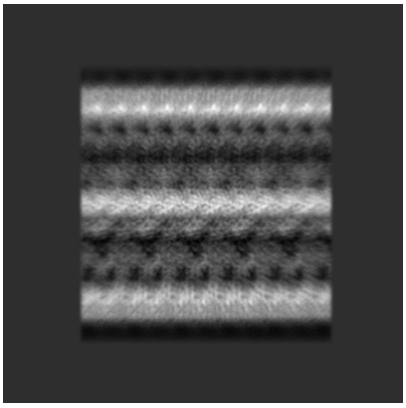
No raw map or half-maps were deposited for this entry and therefore no images, graphs, etc. pertaining to the raw map can be shown.

6.1 Orthogonal projections (i)

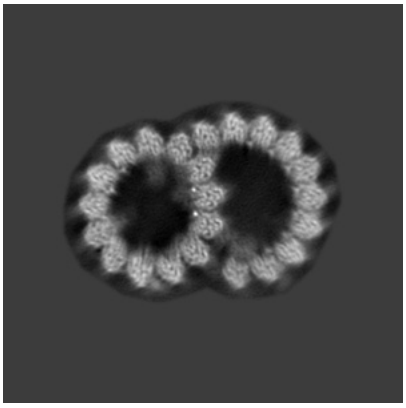
6.1.1 Primary map



X



Y

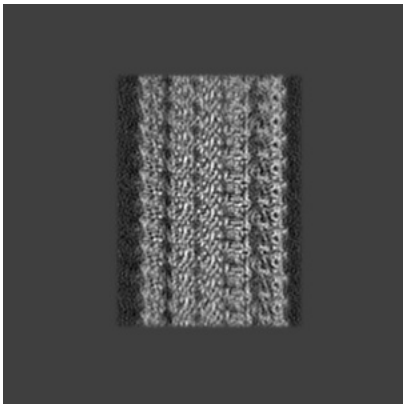


Z

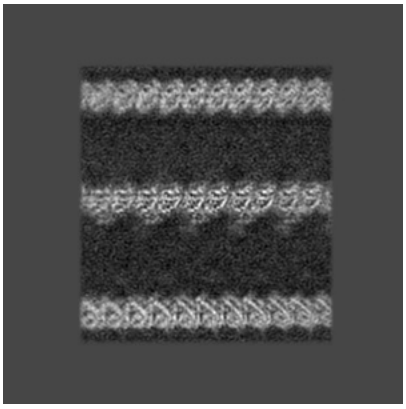
The images above show the map projected in three orthogonal directions.

6.2 Central slices (i)

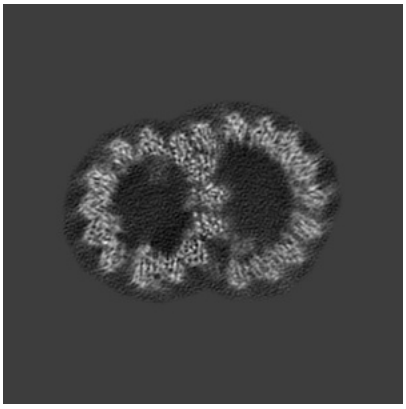
6.2.1 Primary map



X Index: 128



Y Index: 128

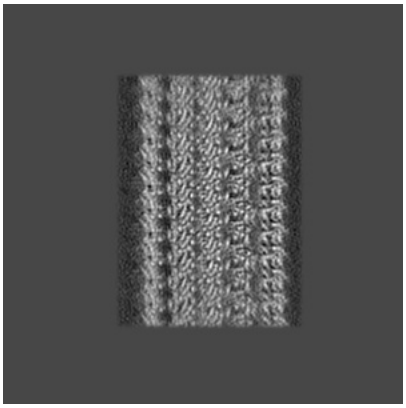


Z Index: 128

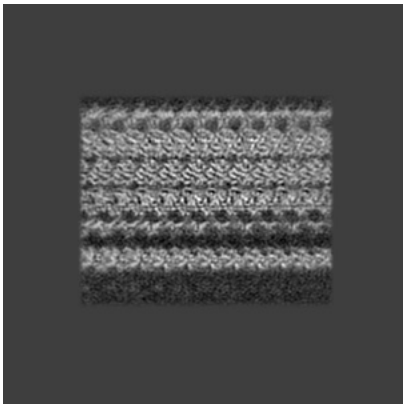
The images above show central slices of the map in three orthogonal directions.

6.3 Largest variance slices (i)

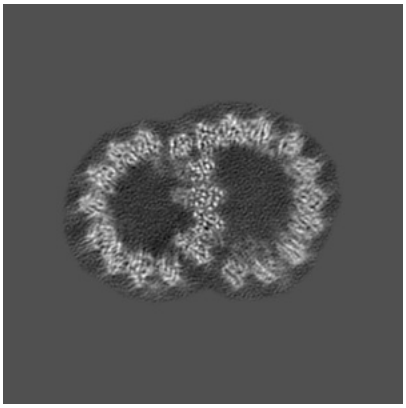
6.3.1 Primary map



X Index: 129



Y Index: 172

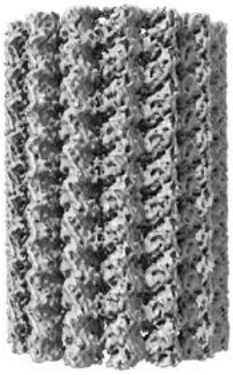


Z Index: 121

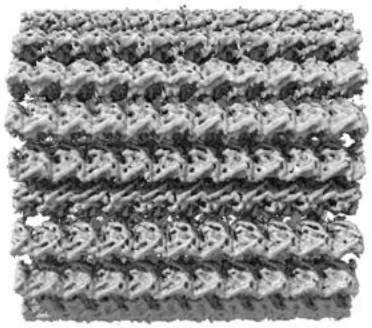
The images above show the largest variance slices of the map in three orthogonal directions.

6.4 Orthogonal surface views (i)

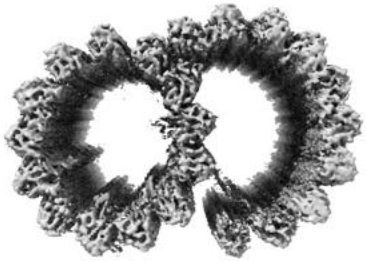
6.4.1 Primary map



X



Y



Z

The images above show the 3D surface view of the map at the recommended contour level 0.105. These images, in conjunction with the slice images, may facilitate assessment of whether an appropriate contour level has been provided.

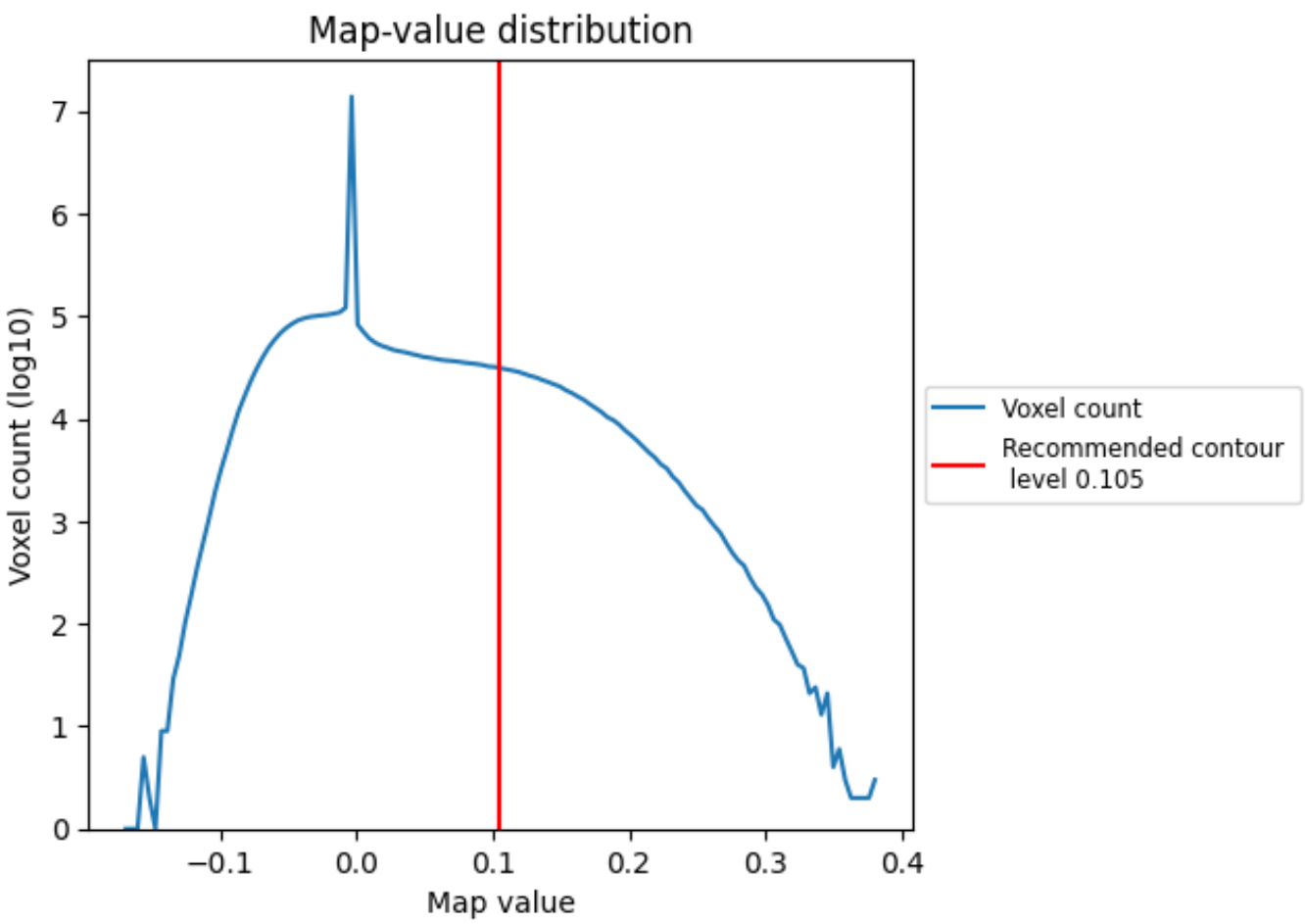
6.5 Mask visualisation (i)

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

7 Map analysis (i)

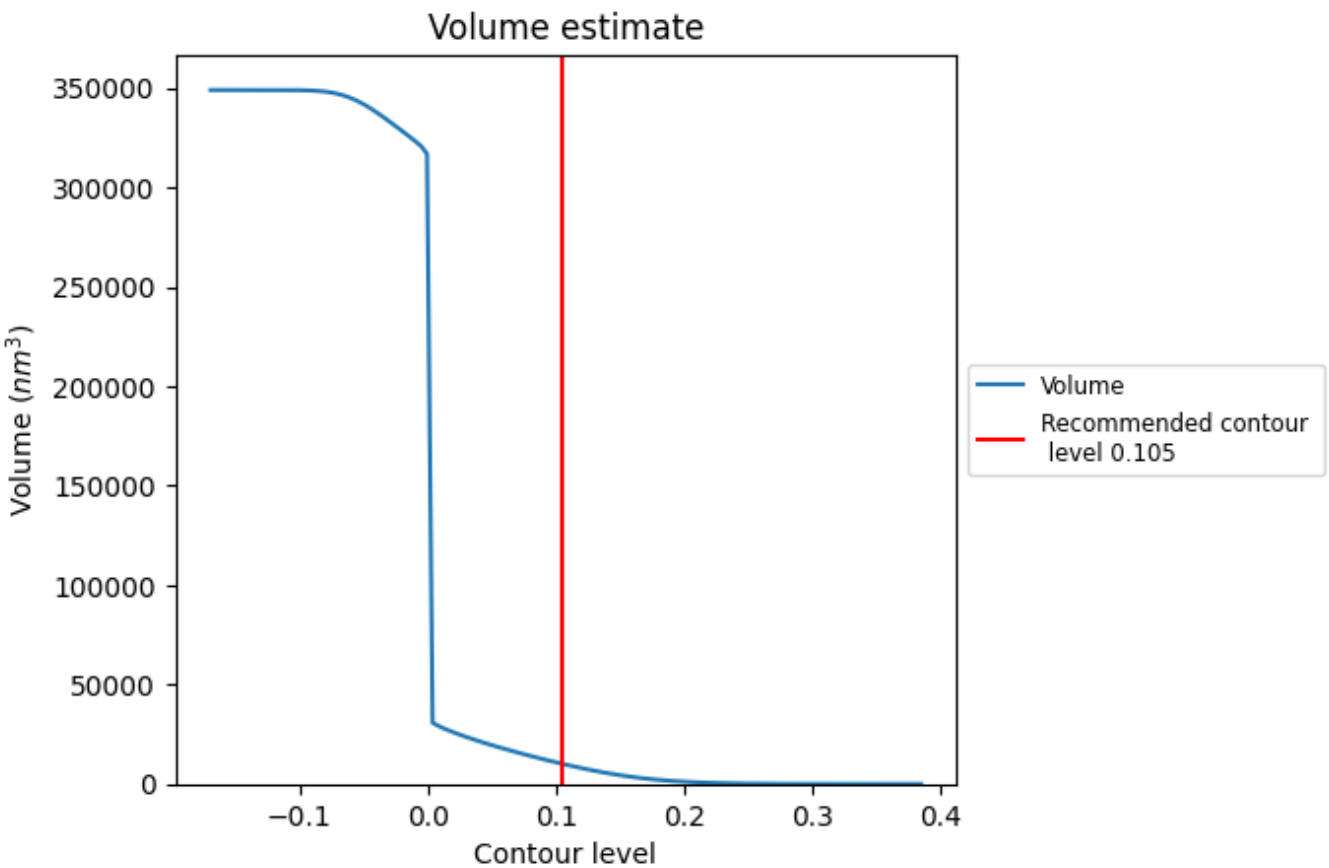
This section contains the results of statistical analysis of the map.

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.

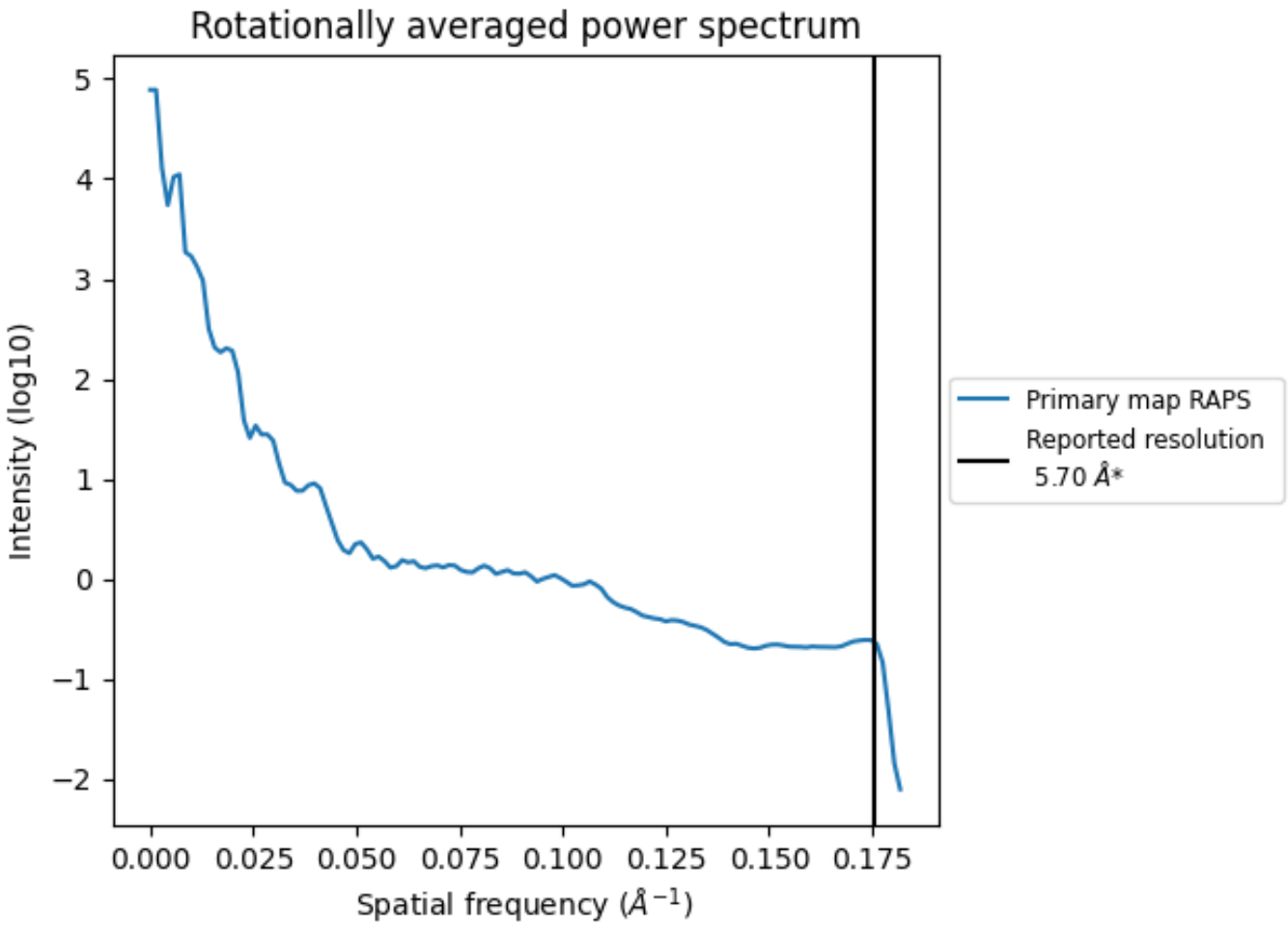
7.2 Volume estimate (i)



The volume at the recommended contour level is 10124 nm^3; this corresponds to an approximate mass of 9145 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 (i)



*Reported resolution corresponds to spatial frequency of 0.175 Å^{-1}

8 Fourier-Shell correlation (i)

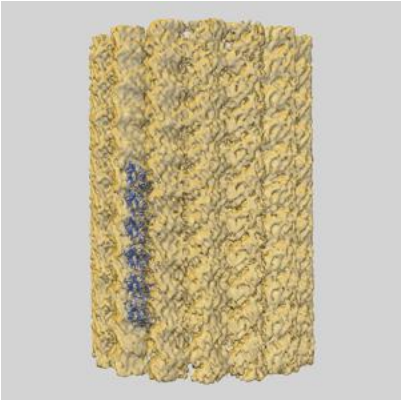
This section was not generated. No FSC curve or half-maps provided.

9 Map-model fit (i)

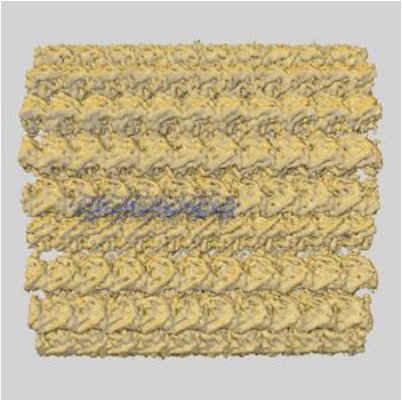
This section contains information regarding the fit between EMDB map EMD-8528 and PDB model 5UBQ. Per-residue inclusion information can be found in section 3 on page 7.

9.1 Map-model overlays

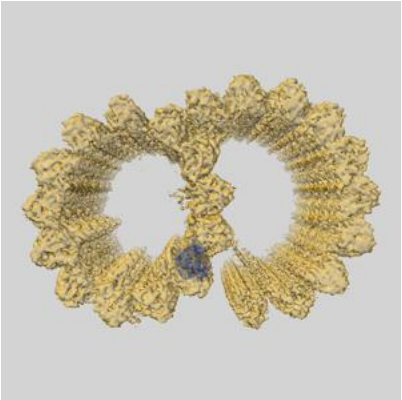
9.1.1 Map-model overlay (i)



X

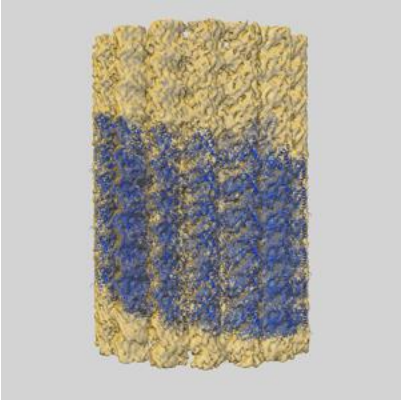


Y

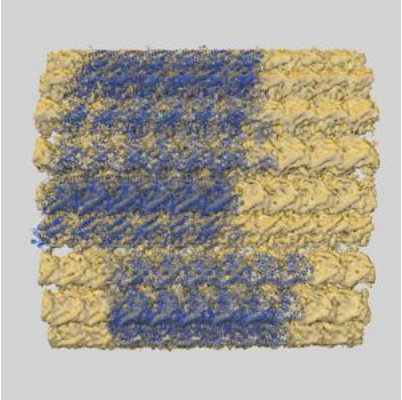


Z

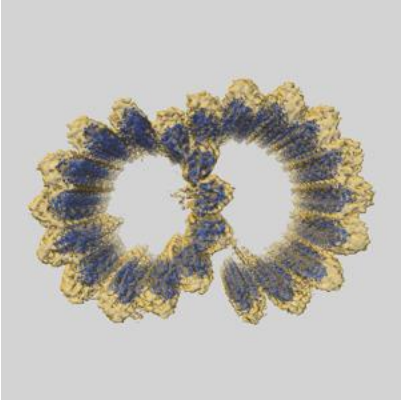
9.1.2 Map-model assembly overlay (i)



X



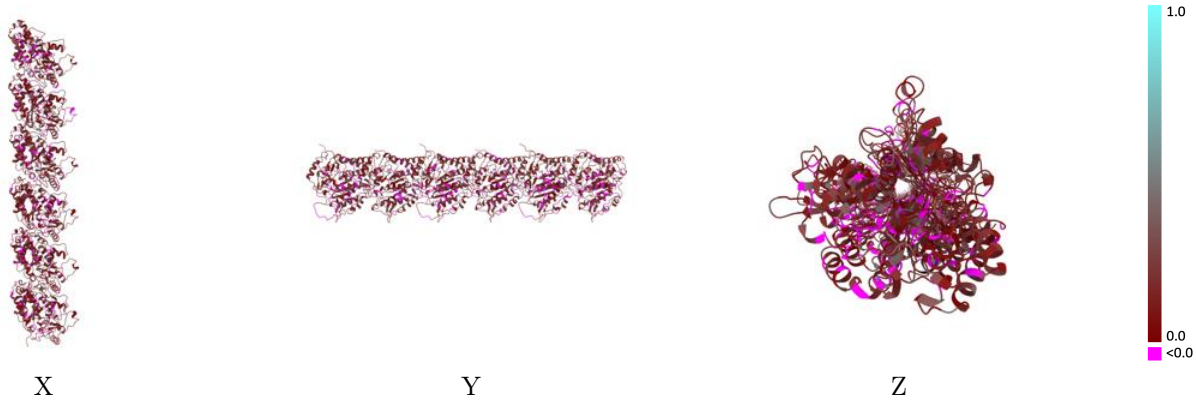
Y



Z

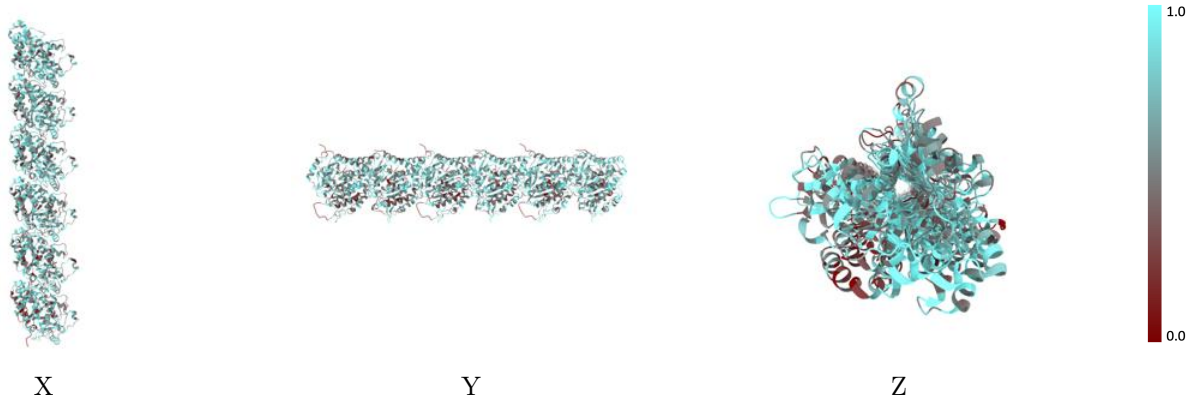
The images above show the 3D surface view of the map at the recommended contour level 0.105 at 50% transparency in yellow overlaid with a ribbon representation of the model coloured in blue. These images allow for the visual assessment of the quality of fit between the atomic model and the map.

9.2 Q-score mapped to coordinate model (i)



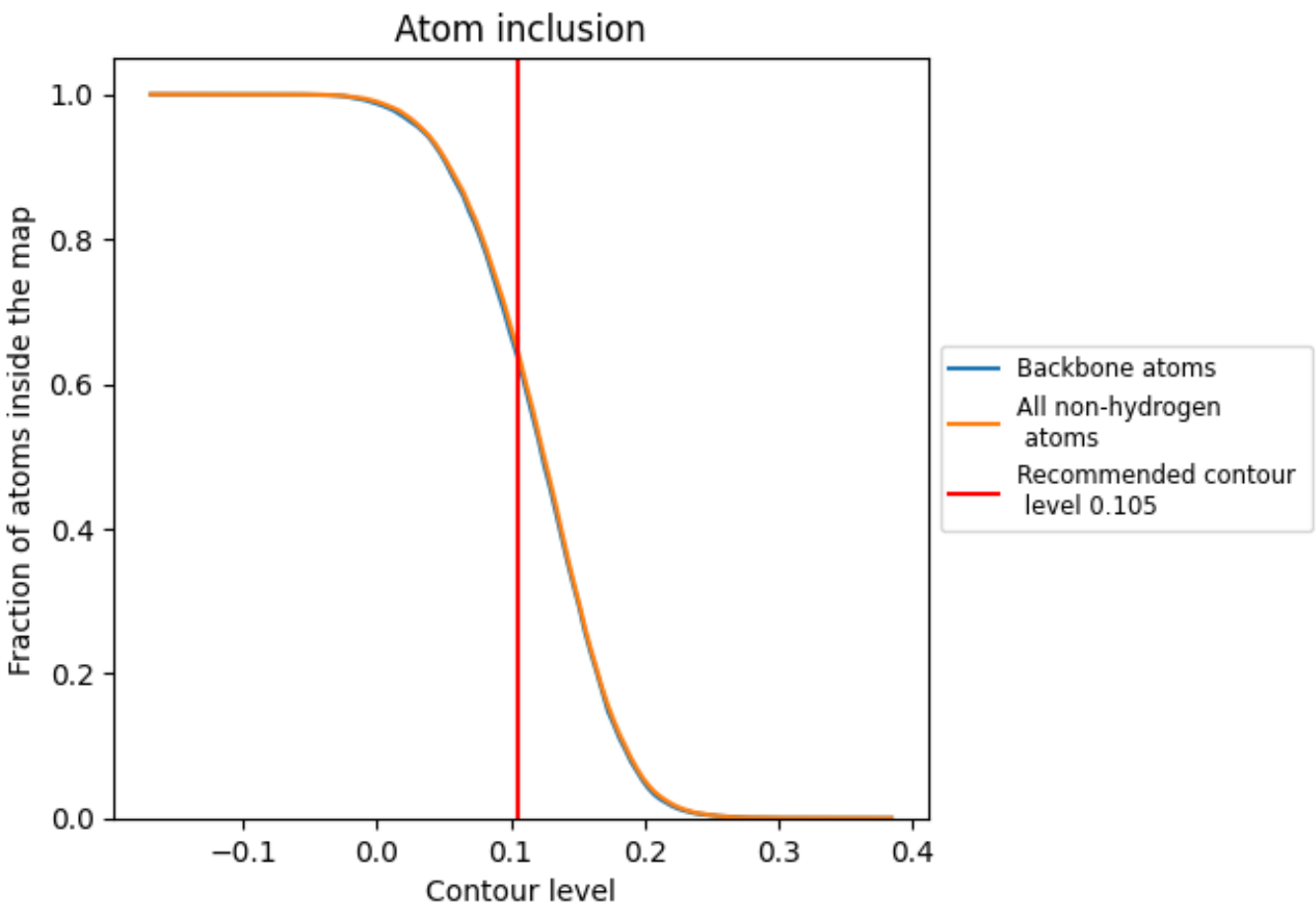
The images above show the model with each residue coloured according its Q-score. This shows their resolvability in the map with higher Q-score values reflecting better resolvability. Please note: Q-score is calculating the resolvability of atoms, and thus high values are only expected at resolutions 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 (0.105).

9.4 Atom inclusion (i)



At the recommended contour level, 64% of all backbone atoms, 65% 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 (0.105) and Q-score for the entire model and for each chain.

Chain	Atom inclusion	Q-score
All	0.6474	0.1440
A	0.6194	0.1400
B	0.6393	0.1440
C	0.6462	0.1420
D	0.6751	0.1490
E	0.6622	0.1440
F	0.6811	0.1470