



wwPDB EM Map/Model Validation Report ⓘ

Apr 10, 2016 – 02:00 PM BST

PDB ID : 3JAS
EMDB ID: : EMD-6353
Title : Cryo-EM structure of dynamic GDP-microtubule (14 protofilaments) decorated with kinesin
Authors : Zhang, R.; Nogales, E.
Deposited on : 2015-06-19
Resolution : 3.50 Å(reported)

This is a wwPDB EM Map/Model Validation Report for a publicly released PDB/EMDB entry.
For rigid body fitted models, validation errors reported here could stem from errors in the original structure(s) used in the fitting.
We welcome your comments at validation@mail.wwpdb.org
A user guide is available at
<http://wwpdb.org/validation/2016/EMValidationReportHelp>

MolProbity : 4.02b-467
Mogul : 1.7.1 (RC1), CSD as537be (2016)
Percentile statistics : 20151230.v01 (using entries in the PDB archive December 30th 2015)
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et. al. (1996)
Validation Pipeline (wwPDB-VP) : trunk27241

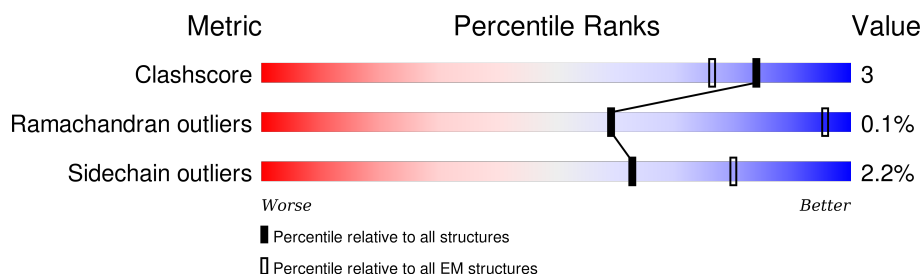
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

ELECTRON MICROSCOPY

The reported resolution of this entry is 3.50 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	114402	924
Ramachandran outliers	111179	726
Sidechain outliers	111093	686

The table below summarises the geometric issues observed across the polymeric chains. The red, orange, yellow and green segments on the bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria. 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 $\leq 5\%$.

Mol	Chain	Length	Quality of chain
1	A	451	86% 8% 5%
1	C	451	86% 8% 5%
1	E	451	88% 7% 5%
1	J	451	88% 7% 5%
1	K	451	87% 8% 5%
1	L	451	87% 7% 5%
2	B	445	85% 10% .
2	D	445	85% 11% .
2	F	445	86% 10% .

Continued on next page...

Continued from previous page...

Mol	Chain	Length	Quality of chain
2	G	445	<div><div></div><div>85%</div><div>10%</div><div></div></div>
2	H	445	<div><div></div><div>85%</div><div>10%</div><div></div></div>
2	I	445	<div><div></div><div>85%</div><div>10%</div><div></div></div>

2 Entry composition [i](#)

There are 5 unique types of molecules in this entry. The entry contains 40506 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.

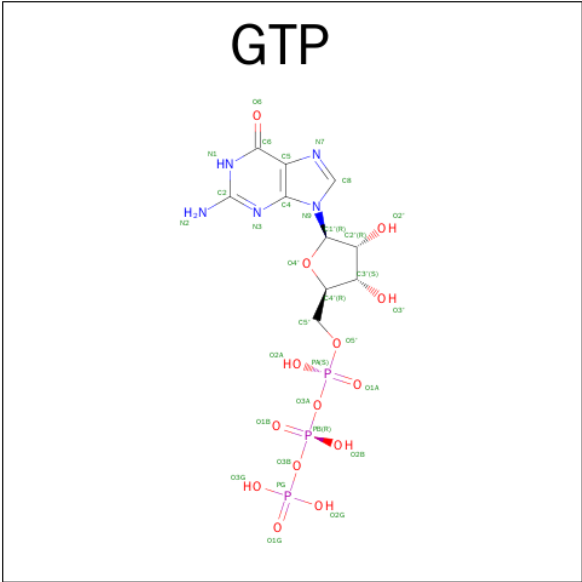
- Molecule 1 is a protein called Tubulin alpha-1B chain.

Mol	Chain	Residues	Atoms					AltConf	Trace
1	E	428	Total	C	N	O	S	0	0
			3350	2126	571	632	21		
1	J	428	Total	C	N	O	S	0	0
			3350	2126	571	632	21		
1	C	428	Total	C	N	O	S	0	0
			3350	2126	571	632	21		
1	L	428	Total	C	N	O	S	0	0
			3350	2126	571	632	21		
1	A	428	Total	C	N	O	S	0	0
			3350	2126	571	632	21		
1	K	428	Total	C	N	O	S	0	0
			3350	2126	571	632	21		

- Molecule 2 is a protein called Tubulin beta chain.

Mol	Chain	Residues	Atoms					AltConf	Trace
2	F	426	Total	C	N	O	S	0	0
			3340	2098	573	644	25		
2	G	426	Total	C	N	O	S	0	0
			3340	2098	573	644	25		
2	D	426	Total	C	N	O	S	0	0
			3340	2098	573	644	25		
2	I	426	Total	C	N	O	S	0	0
			3340	2098	573	644	25		
2	B	426	Total	C	N	O	S	0	0
			3340	2098	573	644	25		
2	H	426	Total	C	N	O	S	0	0
			3340	2098	573	644	25		

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

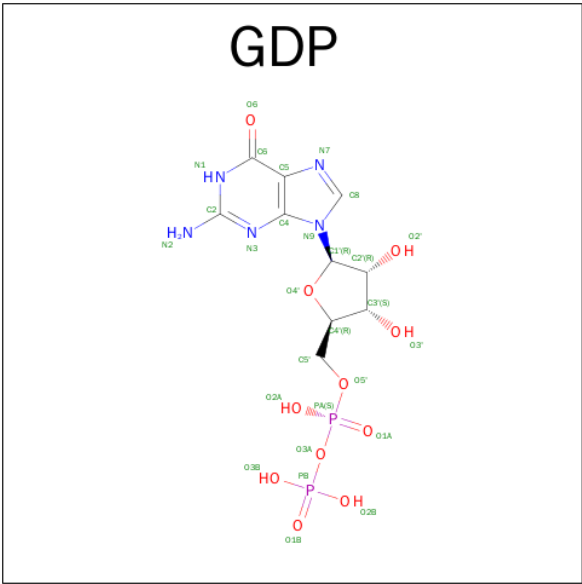


Mol	Chain	Residues	Atoms					AltConf
3	E	1	Total	C	N	O	P	0
			32	10	5	14	3	
3	J	1	Total	C	N	O	P	0
			32	10	5	14	3	
3	C	1	Total	C	N	O	P	0
			32	10	5	14	3	
3	L	1	Total	C	N	O	P	0
			32	10	5	14	3	
3	A	1	Total	C	N	O	P	0
			32	10	5	14	3	
3	K	1	Total	C	N	O	P	0
			32	10	5	14	3	

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

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

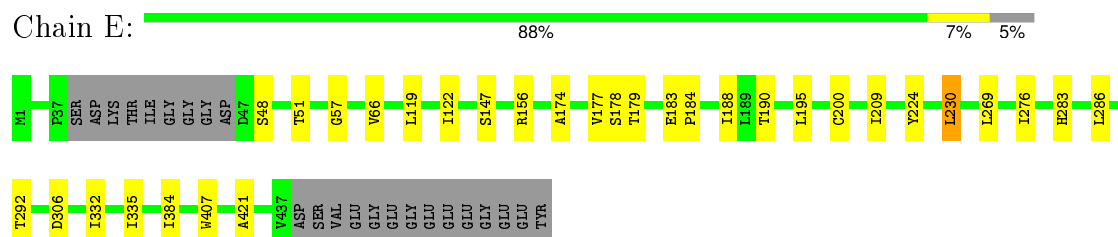
- Molecule 5 is GUANOSINE-5'-DIPHOSPHATE (three-letter code: GDP) (formula: C₁₀H₁₅N₅O₁₁P₂).



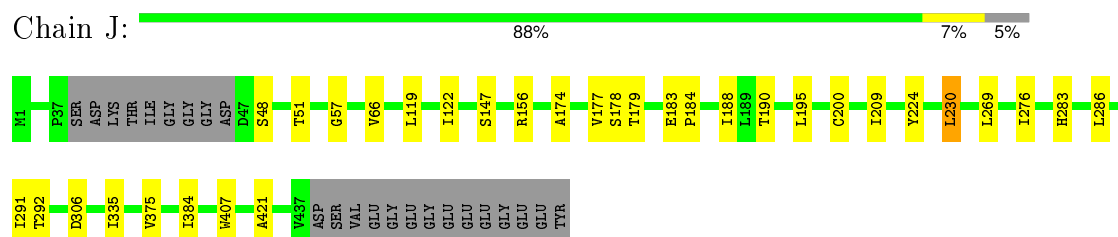
3 Residue-property plots

These plots are drawn for all protein, RNA and DNA chains in the entry. The first graphic for a chain summarises the proportions of errors displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry. 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. 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.

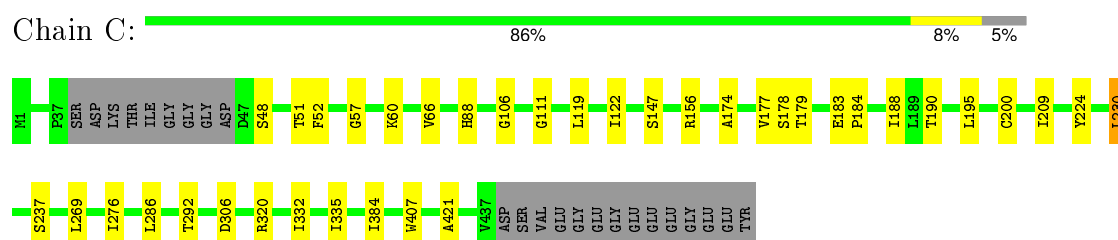
- Molecule 1: Tubulin alpha-1B chain



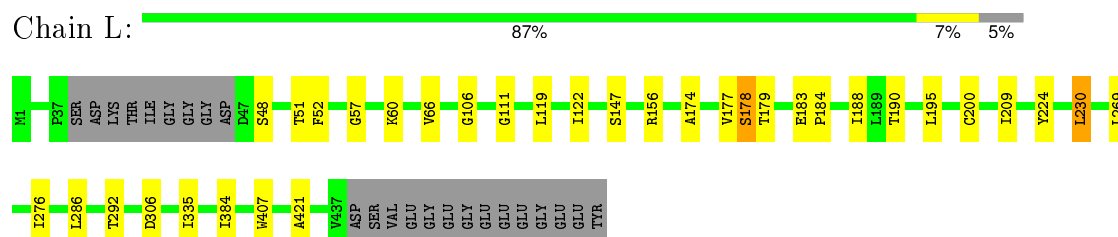
- Molecule 1: Tubulin alpha-1B chain




- Molecule 1: Tubulin alpha-1B chain

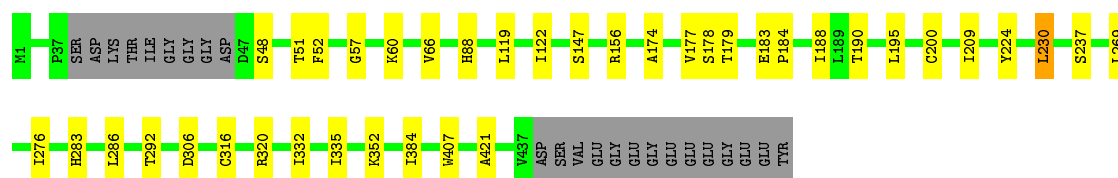


- Molecule 1: Tubulin alpha-1B chain



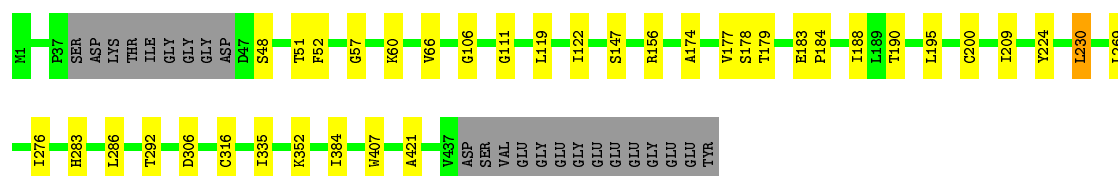
- Molecule 1: Tubulin alpha-1B chain

Chain A: 




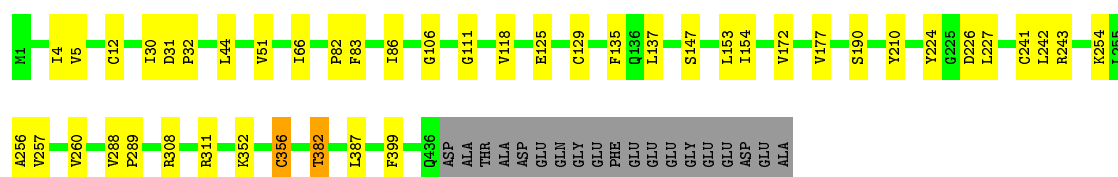
- Molecule 1: Tubulin alpha-1B chain

Chain K: 




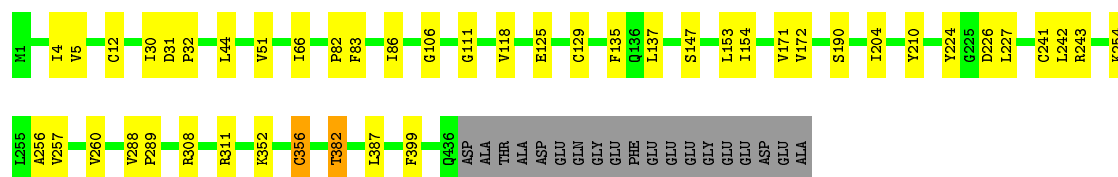
- Molecule 2: Tubulin beta chain

Chain F: 



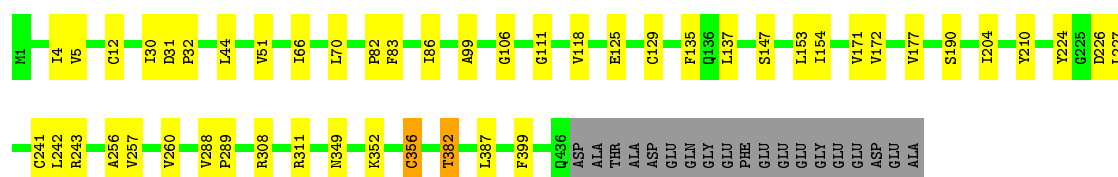
- Molecule 2: Tubulin beta chain

Chain G: 




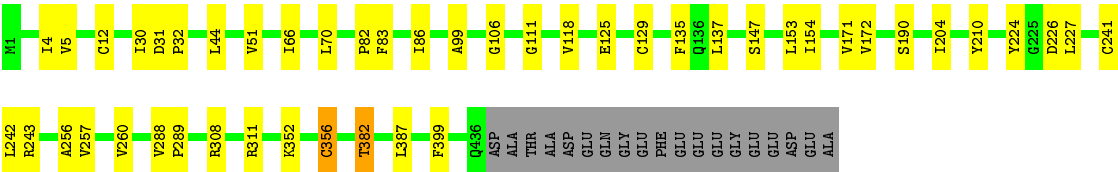
- Molecule 2: Tubulin beta chain

Chain D: 

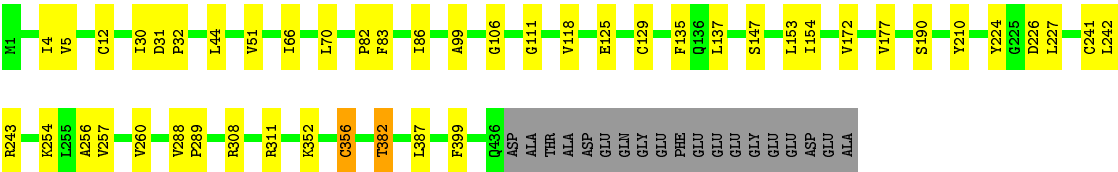
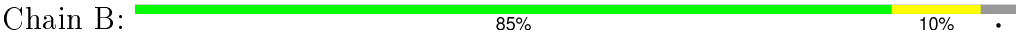


- Molecule 2: Tubulin beta chain

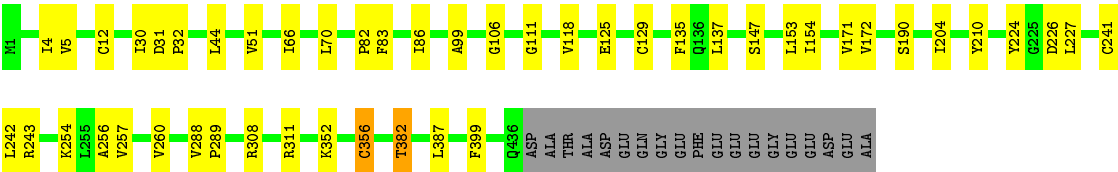
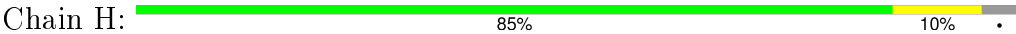
Chain I: 



• Molecule 2: Tubulin beta chain



• Molecule 2: Tubulin beta chain



4 Experimental information

Property	Value	Source
Reconstruction method	HELICAL	Depositor
Imposed symmetry	POINT, Not provided	Depositor
Number of images	Not provided	Depositor
Resolution determination method	FSC 0.143	Depositor
CTF correction method	CTFFIND4, each particle	Depositor
Microscope	FEI TITAN	Depositor
Voltage (kV)	300	Depositor
Electron dose ($e^-/\text{\AA}^2$)	27.6	Depositor
Minimum defocus (nm)	1000	Depositor
Maximum defocus (nm)	3000	Depositor
Magnification	27500	Depositor
Image detector	GATAN K2 (4k x 4k)	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, GTP, 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 >2	RMSZ	# Z >2
1	A	0.43	0/3427	0.70	0/4653
1	C	0.43	0/3427	0.70	0/4653
1	E	0.43	0/3427	0.70	0/4653
1	J	0.44	0/3427	0.70	0/4653
1	K	0.43	0/3427	0.70	0/4653
1	L	0.43	0/3427	0.70	0/4653
2	B	0.43	0/3415	0.70	0/4630
2	D	0.43	0/3415	0.70	0/4630
2	F	0.43	0/3415	0.70	0/4630
2	G	0.43	0/3415	0.70	0/4630
2	H	0.43	0/3415	0.70	0/4630
2	I	0.43	0/3415	0.70	0/4630
All	All	0.43	0/41052	0.70	0/55698

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	3350	0	3263	24	0

Continued on next page...

Continued from previous page...

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	C	3350	0	3263	20	0
1	E	3350	0	3263	17	0
1	J	3350	0	3263	16	0
1	K	3350	0	3263	21	0
1	L	3350	0	3263	18	0
2	B	3340	0	3208	24	0
2	D	3340	0	3208	25	0
2	F	3340	0	3208	23	0
2	G	3340	0	3208	23	0
2	H	3340	0	3208	24	0
2	I	3340	0	3208	23	0
3	A	32	0	12	1	0
3	C	32	0	12	0	0
3	E	32	0	12	1	0
3	J	32	0	12	1	0
3	K	32	0	12	1	0
3	L	32	0	12	0	0
4	A	1	0	0	0	0
4	C	1	0	0	0	0
4	E	1	0	0	0	0
4	J	1	0	0	0	0
4	K	1	0	0	0	0
4	L	1	0	0	0	0
5	B	28	0	12	0	0
5	D	28	0	12	0	0
5	F	28	0	12	0	0
5	G	28	0	12	0	0
5	H	28	0	12	0	0
5	I	28	0	12	0	0
All	All	40506	0	38970	232	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 3.

All (232) 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)
2:I:147:SER:OG	2:I:190:SER:OG	2.17	0.63
2:D:147:SER:OG	2:D:190:SER:OG	2.17	0.63
2:F:147:SER:OG	2:F:190:SER:OG	2.17	0.63
2:G:147:SER:OG	2:G:190:SER:OG	2.17	0.63

Continued on next page...

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
2:H:147:SER:OG	2:H:190:SER:OG	2.17	0.62
2:B:147:SER:OG	2:B:190:SER:OG	2.17	0.62
2:H:256:ALA:O	2:H:260:VAL:HG12	2.01	0.61
2:B:256:ALA:O	2:B:260:VAL:HG12	2.01	0.61
2:G:256:ALA:O	2:G:260:VAL:HG12	2.01	0.61
2:F:256:ALA:O	2:F:260:VAL:HG12	2.01	0.61
2:D:256:ALA:O	2:D:260:VAL:HG12	2.01	0.61
2:I:256:ALA:O	2:I:260:VAL:HG12	2.01	0.61
1:L:60:LYS:HZ1	1:K:283:HIS:CD2	2.22	0.58
1:L:269:LEU:HD23	1:L:384:ILE:HD11	1.86	0.57
1:J:269:LEU:HD23	1:J:384:ILE:HD11	1.85	0.57
1:K:269:LEU:HD23	1:K:384:ILE:HD11	1.86	0.57
1:C:269:LEU:HD23	1:C:384:ILE:HD11	1.86	0.57
1:A:269:LEU:HD23	1:A:384:ILE:HD11	1.86	0.57
1:E:269:LEU:HD23	1:E:384:ILE:HD11	1.86	0.57
1:L:60:LYS:NZ	1:K:283:HIS:CD2	2.72	0.56
1:J:283:HIS:CD2	1:K:60:LYS:NZ	2.73	0.56
1:E:283:HIS:CD2	1:A:60:LYS:NZ	2.74	0.56
1:J:283:HIS:CD2	1:K:60:LYS:HZ1	2.25	0.55
1:E:332:ILE:HG21	2:F:177:VAL:HG13	1.90	0.54
1:A:332:ILE:HG21	2:B:177:VAL:HG13	1.89	0.54
1:E:283:HIS:CD2	1:A:60:LYS:HZ1	2.26	0.53
1:A:174:ALA:HB3	1:A:177:VAL:O	2.09	0.53
1:K:174:ALA:HB3	1:K:177:VAL:O	2.09	0.53
1:C:332:ILE:HG21	2:D:177:VAL:HG13	1.90	0.53
1:C:60:LYS:NZ	1:A:283:HIS:CD2	2.76	0.53
2:H:288:VAL:N	2:H:289:PRO:HD2	2.24	0.52
2:F:288:VAL:N	2:F:289:PRO:HD2	2.24	0.52
2:B:288:VAL:N	2:B:289:PRO:HD2	2.24	0.52
2:G:288:VAL:N	2:G:289:PRO:HD2	2.25	0.52
1:A:276:ILE:HD11	1:A:286:LEU:HD11	1.92	0.52
2:D:288:VAL:N	2:D:289:PRO:HD2	2.24	0.52
1:C:276:ILE:HD11	1:C:286:LEU:HD11	1.92	0.52
1:L:276:ILE:HD11	1:L:286:LEU:HD11	1.92	0.52
1:C:174:ALA:HB3	1:C:177:VAL:O	2.09	0.52
1:K:276:ILE:HD11	1:K:286:LEU:HD11	1.92	0.52
1:L:174:ALA:HB3	1:L:177:VAL:O	2.09	0.52
2:I:288:VAL:N	2:I:289:PRO:HD2	2.24	0.52
1:E:276:ILE:HD11	1:E:286:LEU:HD11	1.92	0.52
1:J:174:ALA:HB3	1:J:177:VAL:O	2.09	0.51
1:E:174:ALA:HB3	1:E:177:VAL:O	2.09	0.51

Continued on next page...

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:J:276:ILE:HD11	1:J:286:LEU:HD11	1.92	0.51
1:K:147:SER:OG	1:K:190:THR:HB	2.10	0.51
1:A:147:SER:OG	1:A:190:THR:HB	2.10	0.51
1:E:147:SER:OG	1:E:190:THR:HB	2.10	0.51
1:J:147:SER:OG	1:J:190:THR:HB	2.10	0.51
1:C:147:SER:OG	1:C:190:THR:HB	2.10	0.51
1:L:147:SER:OG	1:L:190:THR:HB	2.10	0.51
1:C:60:LYS:HZ1	1:A:283:HIS:CD2	2.29	0.50
2:B:257:VAL:HG23	1:K:407:TRP:CG	2.47	0.50
2:D:257:VAL:HG23	1:L:407:TRP:CG	2.47	0.49
1:A:407:TRP:CG	2:H:257:VAL:HG23	2.47	0.49
1:C:407:TRP:CG	2:I:257:VAL:HG23	2.48	0.49
2:F:257:VAL:HG23	1:J:407:TRP:CG	2.48	0.48
2:D:82:PRO:O	2:D:83:PHE:HB2	2.14	0.48
2:H:82:PRO:O	2:H:83:PHE:HB2	2.14	0.48
2:B:82:PRO:O	2:B:83:PHE:HB2	2.14	0.48
2:I:82:PRO:O	2:I:83:PHE:HB2	2.14	0.48
1:E:407:TRP:CG	2:G:257:VAL:HG23	2.48	0.48
2:F:82:PRO:O	2:F:83:PHE:HB2	2.14	0.48
2:G:82:PRO:O	2:G:83:PHE:HB2	2.14	0.48
1:J:48:SER:O	1:J:51:THR:HG22	2.13	0.48
1:E:48:SER:O	1:E:51:THR:HG22	2.13	0.48
1:K:48:SER:O	1:K:51:THR:HG22	2.13	0.48
1:A:48:SER:O	1:A:51:THR:HG22	2.13	0.47
1:L:48:SER:O	1:L:51:THR:HG22	2.13	0.47
1:C:48:SER:O	1:C:51:THR:HG22	2.13	0.47
2:I:106:GLY:O	2:I:111:GLY:HA3	2.14	0.47
2:D:106:GLY:O	2:D:111:GLY:HA3	2.14	0.47
1:A:183:GLU:N	1:A:184:PRO:CD	2.78	0.47
1:C:183:GLU:N	1:C:184:PRO:CD	2.78	0.47
1:L:183:GLU:N	1:L:184:PRO:CD	2.78	0.47
2:G:106:GLY:O	2:G:111:GLY:HA3	2.14	0.47
2:F:106:GLY:O	2:F:111:GLY:HA3	2.14	0.47
1:K:183:GLU:N	1:K:184:PRO:CD	2.78	0.47
2:H:118:VAL:HG23	2:H:153:LEU:HD21	1.97	0.47
2:B:118:VAL:HG23	2:B:153:LEU:HD21	1.97	0.47
2:F:254:LYS:NZ	3:J:501:GTP:O3G	2.37	0.47
1:J:183:GLU:N	1:J:184:PRO:CD	2.78	0.47
2:B:106:GLY:O	2:B:111:GLY:HA3	2.14	0.47
2:H:106:GLY:O	2:H:111:GLY:HA3	2.14	0.47
3:E:501:GTP:O1G	2:G:254:LYS:NZ	2.40	0.46

Continued on next page...

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:E:183:GLU:N	1:E:184:PRO:CD	2.78	0.46
2:F:352:LYS:HA	1:J:179:THR:O	2.15	0.46
2:D:352:LYS:HA	1:L:179:THR:O	2.15	0.46
2:G:311:ARG:H	2:G:382:THR:HG22	1.80	0.46
2:F:311:ARG:H	2:F:382:THR:HG22	1.80	0.46
2:I:311:ARG:H	2:I:382:THR:HG22	1.80	0.46
2:B:311:ARG:H	2:B:382:THR:HG22	1.80	0.46
2:D:311:ARG:H	2:D:382:THR:HG22	1.80	0.46
2:H:311:ARG:H	2:H:382:THR:HG22	1.80	0.46
2:D:118:VAL:HG23	2:D:153:LEU:HD21	1.97	0.46
2:I:118:VAL:HG23	2:I:153:LEU:HD21	1.97	0.46
2:H:4:ILE:HD11	2:H:242:LEU:HD13	1.98	0.46
2:G:118:VAL:HG23	2:G:153:LEU:HD21	1.97	0.45
2:B:4:ILE:HD11	2:B:242:LEU:HD13	1.98	0.45
2:G:172:VAL:HG21	2:G:387:LEU:HD11	1.99	0.45
2:G:4:ILE:HD11	2:G:242:LEU:HD13	1.98	0.45
2:F:172:VAL:HG21	2:F:387:LEU:HD11	1.99	0.45
2:I:172:VAL:HG21	2:I:387:LEU:HD11	1.99	0.45
2:F:4:ILE:HD11	2:F:242:LEU:HD13	1.98	0.45
2:F:118:VAL:HG23	2:F:153:LEU:HD21	1.97	0.45
2:I:4:ILE:HD11	2:I:242:LEU:HD13	1.98	0.45
2:H:172:VAL:HG21	2:H:387:LEU:HD11	1.99	0.45
1:J:119:LEU:HD21	1:J:156:ARG:HB3	1.99	0.45
2:B:172:VAL:HG21	2:B:387:LEU:HD11	1.99	0.45
1:E:119:LEU:HD21	1:E:156:ARG:HB3	1.99	0.45
1:A:119:LEU:HD21	1:A:156:ARG:HB3	1.99	0.45
2:D:4:ILE:HD11	2:D:242:LEU:HD13	1.98	0.45
1:K:119:LEU:HD21	1:K:156:ARG:HB3	1.99	0.45
2:D:172:VAL:HG21	2:D:387:LEU:HD11	1.99	0.45
2:D:66:ILE:HD11	2:D:125:GLU:HG3	1.99	0.45
1:C:119:LEU:HD21	1:C:156:ARG:HB3	1.99	0.45
2:B:352:LYS:HA	1:K:179:THR:O	2.16	0.45
2:H:66:ILE:HD11	2:H:125:GLU:HG3	1.99	0.45
2:I:66:ILE:HD11	2:I:125:GLU:HG3	1.99	0.45
2:H:51:VAL:HG11	2:H:243:ARG:HG2	1.99	0.45
2:G:51:VAL:HG11	2:G:243:ARG:HG2	1.99	0.45
2:I:51:VAL:HG11	2:I:243:ARG:HG2	1.99	0.44
1:L:119:LEU:HD21	1:L:156:ARG:HB3	1.99	0.44
2:B:66:ILE:HD11	2:B:125:GLU:HG3	1.99	0.44
1:C:179:THR:O	2:I:352:LYS:HA	2.17	0.44
2:G:66:ILE:HD11	2:G:125:GLU:HG3	1.99	0.44

Continued on next page...

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
2:B:51:VAL:HG11	2:B:243:ARG:HG2	1.99	0.44
2:D:51:VAL:HG11	2:D:243:ARG:HG2	2.00	0.44
1:E:179:THR:O	2:G:352:LYS:HA	2.17	0.44
2:F:51:VAL:HG11	2:F:243:ARG:HG2	1.99	0.44
2:H:5:VAL:HG13	2:H:135:PHE:CD2	2.53	0.44
2:I:5:VAL:HG13	2:I:135:PHE:CD2	2.53	0.44
1:E:292:THR:HG22	1:E:335:ILE:HD11	2.00	0.44
1:L:292:THR:HG22	1:L:335:ILE:HD11	1.99	0.44
2:F:66:ILE:HD11	2:F:125:GLU:HG3	1.99	0.44
2:G:5:VAL:HG13	2:G:135:PHE:CD2	2.53	0.44
1:K:292:THR:HG22	1:K:335:ILE:HD11	2.00	0.44
1:J:292:THR:HG22	1:J:335:ILE:HD11	1.99	0.44
2:I:210:TYR:CE1	2:I:227:LEU:HD11	2.53	0.44
1:A:292:THR:HG22	1:A:335:ILE:HD11	2.00	0.44
2:D:210:TYR:CE1	2:D:227:LEU:HD11	2.53	0.44
2:B:5:VAL:HG13	2:B:135:PHE:CD2	2.53	0.44
1:C:292:THR:HG22	1:C:335:ILE:HD11	2.00	0.44
2:D:5:VAL:HG13	2:D:135:PHE:CD2	2.53	0.44
2:F:5:VAL:HG13	2:F:135:PHE:CD2	2.53	0.43
2:B:210:TYR:CE1	2:B:227:LEU:HD11	2.53	0.43
2:H:210:TYR:CE1	2:H:227:LEU:HD11	2.53	0.43
2:I:31:ASP:HB2	2:I:32:PRO:HD2	2.00	0.43
2:D:31:ASP:HB2	2:D:32:PRO:HD2	2.00	0.43
2:F:31:ASP:HB2	2:F:32:PRO:HD2	2.00	0.43
2:F:137:LEU:HD23	2:F:154:ILE:HD11	2.01	0.43
2:G:137:LEU:HD23	2:G:154:ILE:HD11	2.01	0.43
2:I:137:LEU:HD23	2:I:154:ILE:HD11	2.01	0.43
2:F:210:TYR:CE1	2:F:227:LEU:HD11	2.53	0.43
2:G:210:TYR:CE1	2:G:227:LEU:HD11	2.53	0.43
2:B:137:LEU:HD23	2:B:154:ILE:HD11	2.01	0.43
2:H:137:LEU:HD23	2:H:154:ILE:HD11	2.01	0.43
2:D:137:LEU:HD23	2:D:154:ILE:HD11	2.01	0.43
3:A:501:GTP:O1G	2:H:254:LYS:NZ	2.42	0.43
2:F:83:PHE:O	2:F:86:ILE:HG12	2.19	0.43
2:G:83:PHE:O	2:G:86:ILE:HG12	2.19	0.43
1:A:179:THR:O	2:H:352:LYS:HA	2.18	0.43
2:G:31:ASP:HB2	2:G:32:PRO:HD2	2.00	0.43
2:D:83:PHE:O	2:D:86:ILE:HG12	2.19	0.43
2:I:83:PHE:O	2:I:86:ILE:HG12	2.19	0.43
2:H:31:ASP:HB2	2:H:32:PRO:HD2	2.00	0.43
2:B:31:ASP:HB2	2:B:32:PRO:HD2	2.00	0.43

Continued on next page...

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
2:F:288:VAL:N	2:F:289:PRO:CD	2.82	0.42
2:G:288:VAL:N	2:G:289:PRO:CD	2.82	0.42
1:C:88:HIS:HD2	1:A:283:HIS:HB2	1.84	0.42
2:D:288:VAL:N	2:D:289:PRO:CD	2.82	0.42
1:K:66:VAL:HG21	1:K:122:ILE:HD13	2.02	0.42
1:K:209:ILE:HG23	1:K:230:LEU:HD13	2.02	0.42
2:I:288:VAL:N	2:I:289:PRO:CD	2.82	0.42
1:A:209:ILE:HG23	1:A:230:LEU:HD13	2.02	0.42
2:G:241:CYS:HA	2:G:356:CYS:SG	2.60	0.42
2:F:241:CYS:HA	2:F:356:CYS:SG	2.60	0.42
2:F:260:VAL:HG13	2:F:260:VAL:O	2.20	0.42
2:B:241:CYS:HA	2:B:356:CYS:SG	2.60	0.42
1:L:66:VAL:HG21	1:L:122:ILE:HD13	2.02	0.42
2:B:254:LYS:NZ	3:K:501:GTP:O3G	2.44	0.42
1:A:66:VAL:HG21	1:A:122:ILE:HD13	2.02	0.42
1:C:209:ILE:HG23	1:C:230:LEU:HD13	2.02	0.42
2:H:241:CYS:HA	2:H:356:CYS:SG	2.60	0.42
2:H:288:VAL:N	2:H:289:PRO:CD	2.82	0.42
2:B:83:PHE:O	2:B:86:ILE:HG12	2.19	0.42
1:L:209:ILE:HG23	1:L:230:LEU:HD13	2.02	0.42
1:E:209:ILE:HG23	1:E:230:LEU:HD13	2.02	0.42
2:G:260:VAL:HG13	2:G:260:VAL:O	2.20	0.42
1:J:209:ILE:HG23	1:J:230:LEU:HD13	2.02	0.42
2:D:241:CYS:HA	2:D:356:CYS:SG	2.60	0.42
2:B:288:VAL:N	2:B:289:PRO:CD	2.82	0.41
2:H:83:PHE:O	2:H:86:ILE:HG12	2.19	0.41
1:E:66:VAL:HG21	1:E:122:ILE:HD13	2.02	0.41
2:I:241:CYS:HA	2:I:356:CYS:SG	2.60	0.41
1:C:66:VAL:HG21	1:C:122:ILE:HD13	2.02	0.41
1:J:66:VAL:HG21	1:J:122:ILE:HD13	2.02	0.41
2:D:260:VAL:O	2:D:260:VAL:HG13	2.20	0.41
2:I:260:VAL:O	2:I:260:VAL:HG13	2.20	0.41
2:B:260:VAL:HG13	2:B:260:VAL:O	2.20	0.41
2:H:70:LEU:HD12	2:H:99:ALA:HB2	2.03	0.41
2:H:260:VAL:HG13	2:H:260:VAL:O	2.20	0.41
1:J:188:ILE:HG22	1:J:421:ALA:HB1	2.03	0.41
2:D:349:ASN:ND2	1:L:178:SER:OG	2.54	0.41
1:E:188:ILE:HG22	1:E:421:ALA:HB1	2.03	0.41
2:I:171:VAL:HA	2:I:204:ILE:O	2.21	0.41
1:E:283:HIS:HB2	1:A:88:HIS:HD2	1.85	0.41
1:L:51:THR:HG23	1:L:52:PHE:HD1	1.85	0.41

Continued on next page...

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:C:51:THR:HG23	1:C:52:PHE:HD1	1.85	0.41
2:B:70:LEU:HD12	2:B:99:ALA:HB2	2.03	0.41
2:D:171:VAL:HA	2:D:204:ILE:O	2.21	0.41
2:D:70:LEU:HD12	2:D:99:ALA:HB2	2.03	0.41
2:I:70:LEU:HD12	2:I:99:ALA:HB2	2.03	0.41
1:A:188:ILE:HG22	1:A:421:ALA:HB1	2.03	0.41
1:A:51:THR:HG23	1:A:52:PHE:HD1	1.85	0.41
1:L:106:GLY:O	1:L:111:GLY:HA3	2.21	0.41
1:K:188:ILE:HG22	1:K:421:ALA:HB1	2.03	0.41
1:C:106:GLY:O	1:C:111:GLY:HA3	2.21	0.41
1:K:283:HIS:CD2	1:K:283:HIS:N	2.88	0.40
1:K:51:THR:HG23	1:K:52:PHE:HD1	1.85	0.40
2:G:171:VAL:HA	2:G:204:ILE:O	2.21	0.40
1:K:316:CYS:HA	1:K:352:LYS:O	2.21	0.40
1:C:188:ILE:HG22	1:C:421:ALA:HB1	2.03	0.40
2:H:171:VAL:HA	2:H:204:ILE:O	2.21	0.40
1:L:188:ILE:HG22	1:L:421:ALA:HB1	2.03	0.40
1:A:283:HIS:CD2	1:A:283:HIS:N	2.89	0.40
1:A:316:CYS:HA	1:A:352:LYS:O	2.22	0.40
1:C:237:SER:HA	1:C:320:ARG:HD2	2.04	0.40
1:K:106:GLY:O	1:K:111:GLY:HA3	2.21	0.40
1:A:237:SER:HA	1:A:320:ARG:HD2	2.04	0.40
1:J:291:ILE:HD12	1:J:375:VAL:HG23	2.03	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	424/451 (94%)	411 (97%)	12 (3%)	1 (0%)	52 88
1	C	424/451 (94%)	411 (97%)	12 (3%)	1 (0%)	52 88

Continued on next page...

Continued from previous page...

Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	E	424/451 (94%)	411 (97%)	12 (3%)	1 (0%)	52	88
1	J	424/451 (94%)	411 (97%)	12 (3%)	1 (0%)	52	88
1	K	424/451 (94%)	411 (97%)	12 (3%)	1 (0%)	52	88
1	L	424/451 (94%)	411 (97%)	12 (3%)	1 (0%)	52	88
2	B	424/445 (95%)	410 (97%)	14 (3%)	0	100	100
2	D	424/445 (95%)	410 (97%)	14 (3%)	0	100	100
2	F	424/445 (95%)	410 (97%)	14 (3%)	0	100	100
2	G	424/445 (95%)	410 (97%)	14 (3%)	0	100	100
2	H	424/445 (95%)	410 (97%)	14 (3%)	0	100	100
2	I	424/445 (95%)	410 (97%)	14 (3%)	0	100	100
All	All	5088/5376 (95%)	4926 (97%)	156 (3%)	6 (0%)	59	90

All (6) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	J	57	GLY
1	E	57	GLY
1	C	57	GLY
1	L	57	GLY
1	A	57	GLY
1	K	57	GLY

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	359/379 (95%)	353 (98%)	6 (2%)	68	89
1	C	359/379 (95%)	353 (98%)	6 (2%)	68	89
1	E	359/379 (95%)	353 (98%)	6 (2%)	68	89
1	J	359/379 (95%)	353 (98%)	6 (2%)	68	89
1	K	359/379 (95%)	353 (98%)	6 (2%)	68	89

Continued on next page...

Continued from previous page...

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	L	359/379 (95%)	353 (98%)	6 (2%)	68	89
2	B	364/381 (96%)	354 (97%)	10 (3%)	52	83
2	D	364/381 (96%)	354 (97%)	10 (3%)	52	83
2	F	364/381 (96%)	354 (97%)	10 (3%)	52	83
2	G	364/381 (96%)	354 (97%)	10 (3%)	52	83
2	H	364/381 (96%)	354 (97%)	10 (3%)	52	83
2	I	364/381 (96%)	354 (97%)	10 (3%)	52	83
All	All	4338/4560 (95%)	4242 (98%)	96 (2%)	63	85

All (96) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	E	178	SER
1	E	195	LEU
1	E	200	CYS
1	E	224	TYR
1	E	230	LEU
1	E	306	ASP
2	F	12	CYS
2	F	30	ILE
2	F	44	LEU
2	F	129	CYS
2	F	224	TYR
2	F	226	ASP
2	F	308	ARG
2	F	356	CYS
2	F	382	THR
2	F	399	PHE
1	J	178	SER
1	J	195	LEU
1	J	200	CYS
1	J	224	TYR
1	J	230	LEU
1	J	306	ASP
2	G	12	CYS
2	G	30	ILE
2	G	44	LEU
2	G	129	CYS
2	G	224	TYR
2	G	226	ASP

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type
2	G	308	ARG
2	G	356	CYS
2	G	382	THR
2	G	399	PHE
1	C	178	SER
1	C	195	LEU
1	C	200	CYS
1	C	224	TYR
1	C	230	LEU
1	C	306	ASP
2	D	12	CYS
2	D	30	ILE
2	D	44	LEU
2	D	129	CYS
2	D	224	TYR
2	D	226	ASP
2	D	308	ARG
2	D	356	CYS
2	D	382	THR
2	D	399	PHE
1	L	178	SER
1	L	195	LEU
1	L	200	CYS
1	L	224	TYR
1	L	230	LEU
1	L	306	ASP
2	I	12	CYS
2	I	30	ILE
2	I	44	LEU
2	I	129	CYS
2	I	224	TYR
2	I	226	ASP
2	I	308	ARG
2	I	356	CYS
2	I	382	THR
2	I	399	PHE
1	A	178	SER
1	A	195	LEU
1	A	200	CYS
1	A	224	TYR
1	A	230	LEU
1	A	306	ASP

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type
2	B	12	CYS
2	B	30	ILE
2	B	44	LEU
2	B	129	CYS
2	B	224	TYR
2	B	226	ASP
2	B	308	ARG
2	B	356	CYS
2	B	382	THR
2	B	399	PHE
1	K	178	SER
1	K	195	LEU
1	K	200	CYS
1	K	224	TYR
1	K	230	LEU
1	K	306	ASP
2	H	12	CYS
2	H	30	ILE
2	H	44	LEU
2	H	129	CYS
2	H	224	TYR
2	H	226	ASP
2	H	308	ARG
2	H	356	CYS
2	H	382	THR
2	H	399	PHE

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (28) such sidechains are listed below:

Mol	Chain	Res	Type
1	E	88	HIS
1	E	101	ASN
1	E	283	HIS
2	F	349	ASN
1	J	101	ASN
1	J	283	HIS
2	G	349	ASN
1	C	15	GLN
1	C	88	HIS
1	C	101	ASN
1	C	283	HIS
2	D	14	ASN

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type
2	D	349	ASN
1	L	15	GLN
1	L	88	HIS
1	L	101	ASN
1	L	283	HIS
2	I	14	ASN
2	I	349	ASN
1	A	88	HIS
1	A	101	ASN
1	A	283	HIS
2	B	349	ASN
1	K	15	GLN
1	K	88	HIS
1	K	101	ASN
1	K	283	HIS
2	H	349	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 carbohydrates in this entry.

5.6 Ligand geometry [i](#)

Of 18 ligands modelled in this entry, 6 are monoatomic - leaving 12 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	A	501	4	26,34,34	1.06	2 (7%)	29,54,54	1.71	5 (17%)
5	GDP	B	501	-	24,30,30	1.12	2 (8%)	26,47,47	1.84	6 (23%)
3	GTP	C	501	4	26,34,34	1.06	2 (7%)	29,54,54	1.71	5 (17%)
5	GDP	D	501	-	24,30,30	1.10	2 (8%)	26,47,47	1.87	6 (23%)
3	GTP	E	501	4	26,34,34	1.09	2 (7%)	29,54,54	1.73	5 (17%)
5	GDP	F	501	-	24,30,30	1.11	2 (8%)	26,47,47	1.76	5 (19%)
5	GDP	G	501	-	24,30,30	1.16	2 (8%)	26,47,47	1.88	6 (23%)
5	GDP	H	501	-	24,30,30	1.15	2 (8%)	26,47,47	1.92	6 (23%)
5	GDP	I	501	-	24,30,30	1.11	2 (8%)	26,47,47	1.95	6 (23%)
3	GTP	J	501	4	26,34,34	1.07	2 (7%)	29,54,54	1.80	5 (17%)
3	GTP	K	501	4	26,34,34	1.04	2 (7%)	29,54,54	1.72	5 (17%)
3	GTP	L	501	4	26,34,34	1.04	2 (7%)	29,54,54	1.70	5 (17%)

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	A	501	4	-	0/18/38/38	0/3/3/3
5	GDP	B	501	-	-	0/12/32/32	0/3/3/3
3	GTP	C	501	4	-	0/18/38/38	0/3/3/3
5	GDP	D	501	-	-	0/12/32/32	0/3/3/3
3	GTP	E	501	4	-	0/18/38/38	0/3/3/3
5	GDP	F	501	-	-	0/12/32/32	0/3/3/3
5	GDP	G	501	-	-	0/12/32/32	0/3/3/3
5	GDP	H	501	-	-	0/12/32/32	0/3/3/3
5	GDP	I	501	-	-	0/12/32/32	0/3/3/3
3	GTP	J	501	4	-	0/18/38/38	0/3/3/3
3	GTP	K	501	4	-	0/18/38/38	0/3/3/3
3	GTP	L	501	4	-	0/18/38/38	0/3/3/3

All (24) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
5	F	501	GDP	C5-C4	2.75	1.46	1.40
5	D	501	GDP	C5-C4	2.79	1.46	1.40
3	K	501	GTP	C5-C4	2.81	1.46	1.40
3	L	501	GTP	C5-C4	2.83	1.46	1.40

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
5	B	501	GDP	C5-C4	2.86	1.46	1.40
3	A	501	GTP	C5-C4	2.88	1.47	1.40
3	J	501	GTP	C5-C4	2.90	1.47	1.40
3	C	501	GTP	C5-C4	2.92	1.47	1.40
5	G	501	GDP	C5-C4	2.92	1.47	1.40
5	I	501	GDP	C5-C4	2.93	1.47	1.40
3	E	501	GTP	C5-C4	2.93	1.47	1.40
5	H	501	GDP	C5-C4	2.95	1.47	1.40
3	K	501	GTP	C6-C5	3.10	1.47	1.41
3	L	501	GTP	C6-C5	3.15	1.47	1.41
3	C	501	GTP	C6-C5	3.19	1.47	1.41
3	A	501	GTP	C6-C5	3.23	1.47	1.41
5	I	501	GDP	C6-C5	3.31	1.48	1.41
3	J	501	GTP	C6-C5	3.32	1.48	1.41
3	E	501	GTP	C6-C5	3.38	1.48	1.41
5	D	501	GDP	C6-C5	3.40	1.48	1.41
5	F	501	GDP	C6-C5	3.41	1.48	1.41
5	G	501	GDP	C6-C5	3.49	1.48	1.41
5	H	501	GDP	C6-C5	3.51	1.48	1.41
5	B	501	GDP	C6-C5	3.53	1.48	1.41

All (65) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
5	I	501	GDP	C5-C6-N1	-4.05	118.23	123.52
5	G	501	GDP	C5-C6-N1	-4.03	118.26	123.52
5	H	501	GDP	C5-C6-N1	-3.97	118.33	123.52
3	A	501	GTP	C5-C6-N1	-3.90	118.42	123.52
3	C	501	GTP	C5-C6-N1	-3.84	118.51	123.52
3	J	501	GTP	C5-C6-N1	-3.83	118.52	123.52
3	K	501	GTP	C5-C6-N1	-3.82	118.52	123.52
5	I	501	GDP	N3-C2-N1	-3.81	122.37	127.56
5	G	501	GDP	N3-C2-N1	-3.80	122.39	127.56
5	H	501	GDP	N3-C2-N1	-3.79	122.40	127.56
3	L	501	GTP	C5-C6-N1	-3.79	118.57	123.52
5	D	501	GDP	C5-C6-N1	-3.75	118.62	123.52
5	B	501	GDP	C5-C6-N1	-3.75	118.62	123.52
3	E	501	GTP	C5-C6-N1	-3.72	118.65	123.52
5	F	501	GDP	C5-C6-N1	-3.67	118.73	123.52
5	D	501	GDP	N3-C2-N1	-3.65	122.59	127.56
5	B	501	GDP	N3-C2-N1	-3.63	122.62	127.56
5	I	501	GDP	C6-C5-C4	-3.61	116.74	120.86

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
5	H	501	GDP	C6-C5-C4	-3.60	116.74	120.86
3	J	501	GTP	C6-C5-C4	-3.57	116.78	120.86
3	E	501	GTP	C6-C5-C4	-3.51	116.85	120.86
5	F	501	GDP	N3-C2-N1	-3.50	122.79	127.56
3	K	501	GTP	C6-C5-C4	-3.47	116.89	120.86
3	C	501	GTP	N3-C2-N1	-3.46	122.86	127.56
5	D	501	GDP	C6-C5-C4	-3.44	116.92	120.86
3	L	501	GTP	N3-C2-N1	-3.44	122.88	127.56
3	L	501	GTP	C6-C5-C4	-3.41	116.96	120.86
3	J	501	GTP	C1'-N9-C4	-3.40	123.01	126.81
3	A	501	GTP	N3-C2-N1	-3.39	122.94	127.56
3	E	501	GTP	N3-C2-N1	-3.39	122.94	127.56
5	G	501	GDP	C6-C5-C4	-3.38	116.99	120.86
5	B	501	GDP	C6-C5-C4	-3.36	117.02	120.86
3	C	501	GTP	C6-C5-C4	-3.36	117.02	120.86
3	A	501	GTP	C6-C5-C4	-3.34	117.04	120.86
3	J	501	GTP	N3-C2-N1	-3.30	123.07	127.56
3	K	501	GTP	N3-C2-N1	-3.30	123.07	127.56
5	F	501	GDP	C6-C5-C4	-3.25	117.14	120.86
3	E	501	GTP	C1'-N9-C4	-2.96	123.50	126.81
3	K	501	GTP	C1'-N9-C4	-2.90	123.57	126.81
5	D	501	GDP	C1'-N9-C4	-2.59	123.92	126.81
5	I	501	GDP	C1'-N9-C4	-2.58	123.92	126.81
5	H	501	GDP	C1'-N9-C4	-2.48	124.03	126.81
3	A	501	GTP	C1'-N9-C4	-2.44	124.08	126.81
5	B	501	GDP	C1'-N9-C4	-2.34	124.19	126.81
3	L	501	GTP	C1'-N9-C4	-2.34	124.19	126.81
3	C	501	GTP	C1'-N9-C4	-2.31	124.22	126.81
5	G	501	GDP	C1'-N9-C4	-2.01	124.56	126.81
5	F	501	GDP	O3B-PB-O2B	2.26	115.75	107.44
5	B	501	GDP	O3B-PB-O2B	2.28	115.82	107.44
5	D	501	GDP	O3B-PB-O2B	2.30	115.89	107.44
5	I	501	GDP	O3B-PB-O2B	2.31	115.91	107.44
5	G	501	GDP	O3B-PB-O2B	2.31	115.93	107.44
5	H	501	GDP	O3B-PB-O2B	2.32	115.94	107.44
5	F	501	GDP	C6-N1-C2	4.97	121.70	115.88
3	K	501	GTP	C6-N1-C2	5.09	121.85	115.88
3	L	501	GTP	C6-N1-C2	5.11	121.87	115.88
3	E	501	GTP	C6-N1-C2	5.11	121.87	115.88
5	D	501	GDP	C6-N1-C2	5.12	121.88	115.88
5	B	501	GDP	C6-N1-C2	5.13	121.89	115.88
3	J	501	GTP	C6-N1-C2	5.15	121.91	115.88

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	C	501	GTP	C6-N1-C2	5.16	121.93	115.88
3	A	501	GTP	C6-N1-C2	5.18	121.95	115.88
5	G	501	GDP	C6-N1-C2	5.51	122.33	115.88
5	H	501	GDP	C6-N1-C2	5.54	122.37	115.88
5	I	501	GDP	C6-N1-C2	5.64	122.49	115.88

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

4 monomers are involved in 4 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	501	GTP	1	0
3	E	501	GTP	1	0
3	J	501	GTP	1	0
3	K	501	GTP	1	0

5.7 Other polymers [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.