



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 8, 2026 – 01:54 AM UTC

PDB ID : 7EHA / pdb_00007eha
Title : Crystal structure of the flagellar hook cap from Salmonella enterica serovar Typhimurium
Authors : Matsunami, H.; Yoon, Y.-H.; Imada, K.; Namba, K.; Samatey, F.A.
Deposited on : 2021-03-29
Resolution : 3.30 Å(reported)

This is a Full wwPDB X-ray Structure Validation Report for a publicly released PDB entry.

We welcome your comments at validation@mail.wwpdb.org

A user guide is available at

<https://www.wwpdb.org/validation/2017/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The types of validation reports are described at

<http://www.wwpdb.org/validation/2017/FAQs#types>.

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

MolProbity	:	4-5-2 with Phenix2.0
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.010 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

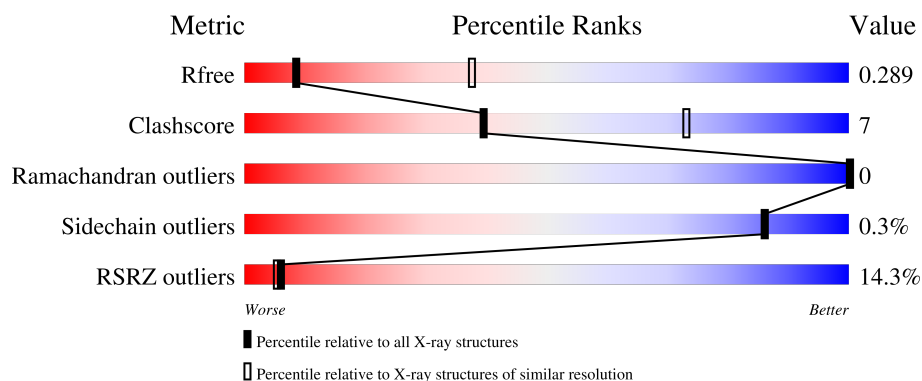
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 3.30 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)	Similar resolution (#Entries, resolution range(Å))
R_{free}	180053	1169 (3.32-3.28)
Clashscore	190562	1209 (3.32-3.28)
Ramachandran outliers	187476	1188 (3.32-3.28)
Sidechain outliers	187428	1187 (3.32-3.28)
RSRZ outliers	180081	1169 (3.32-3.28)

The table below summarises the geometric issues observed across the polymeric chains and their fit to the electron density. The red, orange, yellow and green segments of the lower bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria respectively. A grey segment represents the fraction of residues that are not modelled. The numeric value for each fraction is indicated below the corresponding segment, with a dot representing fractions $\leq 5\%$. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density. The numeric value is given above the bar.

Mol	Chain	Length	Quality of chain
1	A	232	8% 68% 8% 24%
1	B	232	9% 58% 13% 29%
1	C	232	10% 54% 16% 30%
1	D	232	20% 55% 11% 34%
1	E	232	3% 61% 10% 28%

2 Entry composition

There is only 1 type of molecule in this entry. The entry contains 5988 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, the ZeroOcc column contains the number of atoms modelled with zero occupancy, 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.

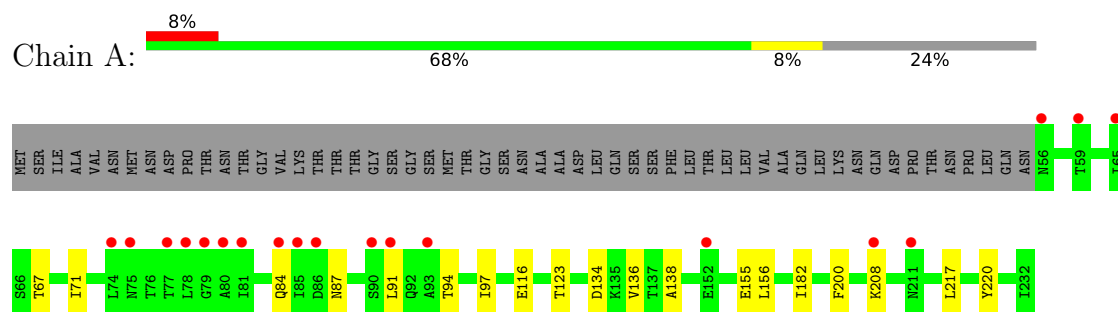
- Molecule 1 is a protein called Basal-body rod modification protein FlgD.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	177	Total	C	N	O	S	0	0	0
			1287	795	221	270	1			
1	B	165	Total	C	N	O	S	0	0	0
			1203	747	207	248	1			
1	C	162	Total	C	N	O	S	0	0	0
			1177	730	201	245	1			
1	D	154	Total	C	N	O	S	0	0	0
			1118	693	193	231	1			
1	E	166	Total	C	N	O	S	0	0	0
			1203	744	207	251	1			

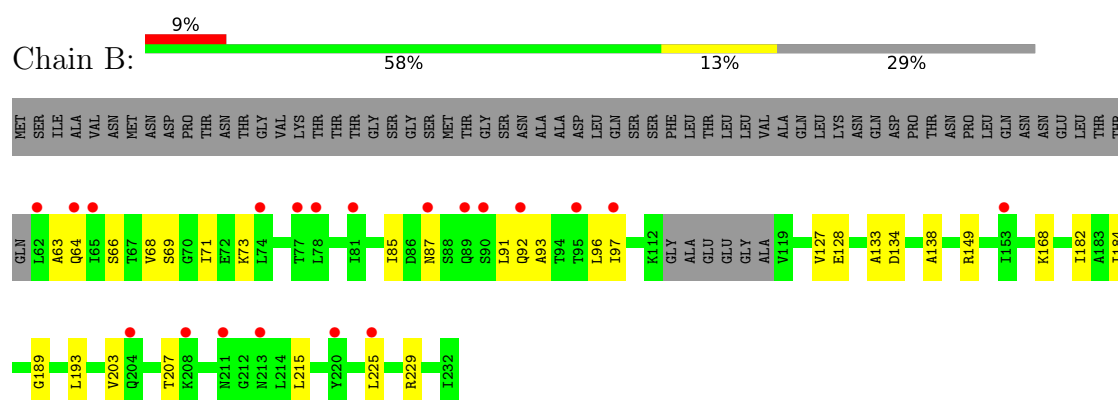
3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron 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 dot above a residue indicates a poor fit to the electron density ($RSRZ > 2$). 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.

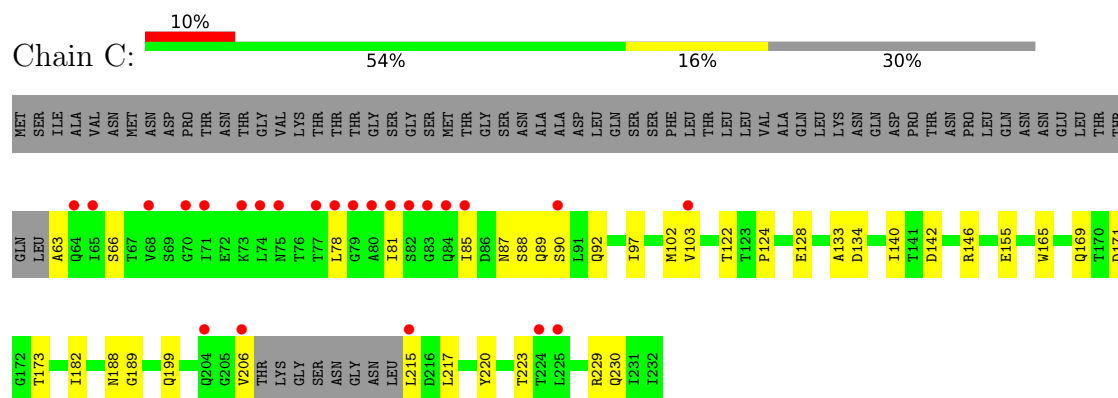
- Molecule 1: Basal-body rod modification protein FlgD



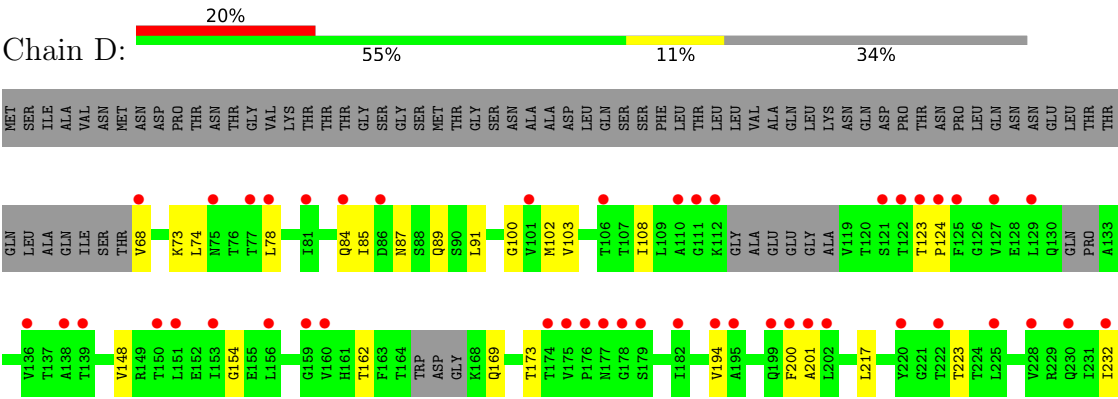
- Molecule 1: Basal-body rod modification protein FlgD



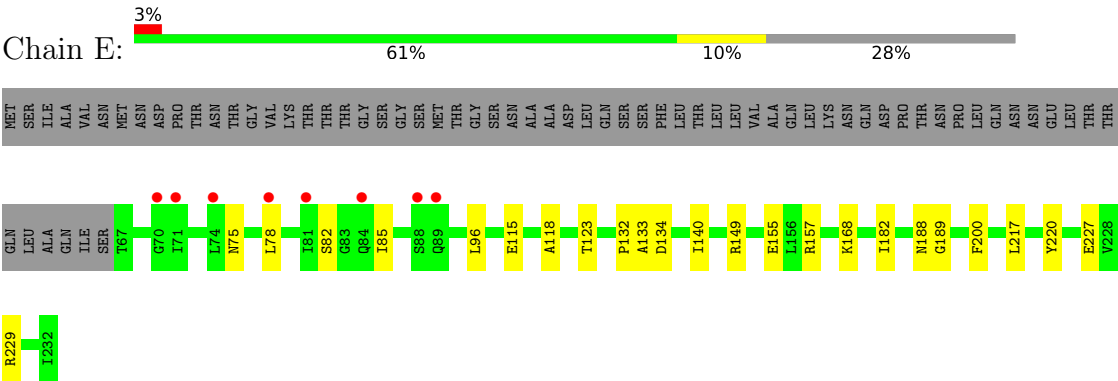
- Molecule 1: Basal-body rod modification protein FlgD



- Molecule 1: Basal-body rod modification protein FlgD



● Molecule 1: Basal-body rod modification protein FlgD



4 Data and refinement statistics

Property	Value	Source
Space group	P 32 2 1	Depositor
Cell constants a, b, c, α , β , γ	141.28Å 141.28Å 153.49Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	47.20 – 3.30 47.20 – 3.30	Depositor EDS
% Data completeness (in resolution range)	100.0 (47.20-3.30) 99.1 (47.20-3.30)	Depositor EDS
R_{merge}	0.11	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	4.73 (at 3.33Å)	Xtriage
Refinement program	PHENIX 1.9_1692	Depositor
R, R_{free}	0.244 , 0.284 0.259 , 0.289	Depositor DCC
R_{free} test set	1366 reflections (4.19%)	wwPDB-VP
Wilson B-factor (Å ²)	99.7	Xtriage
Anisotropy	0.113	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.31 , 111.6	EDS
L-test for twinning ²	$\langle L \rangle = 0.48$, $\langle L^2 \rangle = 0.31$	Xtriage
Estimated twinning fraction	0.029 for -h,-k,l	Xtriage
F_o, F_c correlation	0.89	EDS
Total number of atoms	5988	wwPDB-VP
Average B, all atoms (Å ²)	137.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.89% of the height of the origin peak. No significant pseudotranslation is detected.*

¹Intensities estimated from amplitudes.

²Theoretical values of $\langle |L| \rangle$, $\langle L^2 \rangle$ for acentric reflections are 0.5, 0.333 respectively for untwinned datasets, and 0.375, 0.2 for perfectly twinned datasets.

5 Model quality [i](#)

5.1 Standard geometry [i](#)

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	0.30	0/1300	0.71	0/1771
1	B	0.34	0/1215	0.78	0/1654
1	C	0.34	0/1189	0.82	0/1619
1	D	0.36	0/1125	0.80	1/1526 (0.1%)
1	E	0.32	0/1216	0.78	0/1656
All	All	0.33	0/6045	0.78	1/8226 (0.0%)

There are no bond length outliers.

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	D	154	GLY	N-CA-C	5.46	117.37	110.38

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	1287	0	1294	14	0
1	B	1203	0	1220	23	0
1	C	1177	0	1183	23	0
1	D	1118	0	1139	21	0
1	E	1203	0	1209	15	0
All	All	5988	0	6045	80	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 7.

All (80) 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:D:91:LEU:HD22	1:E:96:LEU:HD11	1.67	0.76
1:A:138:ALA:HB1	1:A:182:ILE:HD11	1.73	0.70
1:B:128:GLU:OE2	1:B:229:ARG:NH1	2.26	0.69
1:D:148:VAL:HG23	1:D:169:GLN:HG3	1.77	0.65
1:B:134:ASP:OD2	1:B:189:GLY:N	2.32	0.63
1:A:134:ASP:HA	1:A:155:GLU:HG2	1.81	0.63
1:C:134:ASP:HA	1:C:155:GLU:HG2	1.81	0.62
1:B:138:ALA:HB1	1:B:182:ILE:HD11	1.80	0.62
1:E:132:PRO:HB3	1:E:157:ARG:HA	1.83	0.61
1:C:78:LEU:HD13	1:D:78:LEU:HD11	1.83	0.60
1:D:74:LEU:HD21	1:E:75:ASN:HA	1.83	0.59
1:E:133:ALA:HA	1:E:188:ASN:HB3	1.85	0.59
1:C:140:ILE:HG12	1:C:182:ILE:HG22	1.85	0.58
1:C:215:LEU:N	1:C:223:THR:O	2.39	0.55
1:D:201:ALA:HB1	1:D:217:LEU:HB3	1.89	0.55
1:C:122:THR:HG21	1:C:165:TRP:HB3	1.89	0.55
1:B:97:ILE:HA	1:B:203:VAL:HB	1.89	0.54
1:C:102:MET:HE1	1:C:124:PRO:HG2	1.88	0.53
1:A:91:LEU:HB3	1:B:92:GLN:HB3	1.89	0.53
1:C:81:ILE:HD12	1:D:85:ILE:HD12	1.90	0.53
1:C:133:ALA:HA	1:C:188:ASN:HB2	1.90	0.53
1:B:149:ARG:NH1	1:B:168:LYS:O	2.40	0.53
1:D:74:LEU:HD22	1:E:78:LEU:HD22	1.91	0.52
1:D:102:MET:HG3	1:D:162:THR:HG21	1.90	0.52
1:E:149:ARG:NH1	1:E:168:LYS:O	2.41	0.51
1:E:217:LEU:HD12	1:E:220:TYR:CD1	2.45	0.51
1:D:102:MET:HE1	1:D:124:PRO:HG2	1.92	0.51
1:B:207:THR:HA	1:C:230:GLN:HG2	1.93	0.50
1:A:94:THR:HG23	1:A:97:ILE:HD12	1.94	0.50
1:A:84:GLN:HB3	1:B:85:ILE:HG21	1.93	0.49
1:C:88:SER:HB3	1:D:89:GLN:NE2	2.28	0.49
1:D:73:LYS:HD3	1:E:75:ASN:OD1	2.13	0.48
1:D:103:VAL:HG11	1:D:223:THR:HG21	1.95	0.48
1:E:140:ILE:HG12	1:E:182:ILE:HG22	1.95	0.47
1:D:84:GLN:HA	1:D:87:ASN:ND2	2.29	0.47
1:D:108:ILE:HG23	1:D:123:THR:HG22	1.96	0.47
1:E:123:THR:HB	1:E:200:PHE:HB3	1.97	0.47

Continued on next page...

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:215:LEU:HD11	1:B:225:LEU:HD23	1.98	0.46
1:B:134:ASP:CG	1:B:189:GLY:H	2.22	0.46
1:C:169:GLN:HG3	1:C:171:ASP:OD1	2.16	0.46
1:B:64:GLN:O	1:B:68:VAL:HG23	2.16	0.46
1:D:84:GLN:HA	1:D:87:ASN:HD21	1.81	0.45
1:C:142:ASP:HB3	1:C:146:ARG:HG3	1.98	0.45
1:E:227:GLU:O	1:E:229:ARG:NH1	2.49	0.45
1:C:85:ILE:O	1:C:89:GLN:HG3	2.16	0.45
1:B:87:ASN:O	1:B:91:LEU:HG	2.17	0.45
1:C:63:ALA:O	1:C:66:SER:OG	2.32	0.45
1:B:69:SER:O	1:B:73:LYS:N	2.44	0.45
1:E:82:SER:HA	1:E:85:ILE:HD12	1.99	0.44
1:A:87:ASN:O	1:A:91:LEU:HG	2.18	0.44
1:E:133:ALA:O	1:E:155:GLU:HG3	2.17	0.44
1:C:128:GLU:OE2	1:C:229:ARG:NE	2.44	0.44
1:A:208:LYS:NZ	1:B:225:LEU:O	2.50	0.44
1:E:115:GLU:HG2	1:E:118:ALA:HB2	1.98	0.43
1:B:63:ALA:O	1:B:66:SER:OG	2.31	0.43
1:B:69:SER:O	1:B:73:LYS:HG2	2.18	0.43
1:C:103:VAL:O	1:C:199:GLN:N	2.30	0.43
1:D:85:ILE:O	1:D:89:GLN:HG3	2.18	0.43
1:C:87:ASN:O	1:C:90:SER:HB2	2.19	0.43
1:D:100:GLY:HA3	1:D:200:PHE:CE1	2.53	0.43
1:B:91:LEU:HD13	1:C:92:GLN:C	2.43	0.43
1:C:169:GLN:NE2	1:C:173:THR:OG1	2.41	0.42
1:A:67:THR:HG23	1:B:68:VAL:HG22	2.02	0.42
1:A:136:VAL:HG21	1:A:156:LEU:HD12	2.02	0.42
1:C:88:SER:HB3	1:D:89:GLN:HE21	1.84	0.42
1:C:134:ASP:OD2	1:C:189:GLY:N	2.53	0.42
1:A:116:GLU:N	1:A:116:GLU:OE1	2.53	0.42
1:B:133:ALA:HB2	1:B:193:LEU:HD12	2.02	0.42
1:A:217:LEU:HD12	1:A:220:TYR:CD1	2.54	0.41
1:B:127:VAL:HB	1:B:184:ILE:HD13	2.01	0.41
1:C:217:LEU:HD12	1:C:220:TYR:CD2	2.55	0.41
1:A:123:THR:HB	1:A:200:PHE:HB3	2.01	0.41
1:C:97:ILE:HD11	1:C:206:VAL:HG23	2.02	0.41
1:D:148:VAL:HG22	1:D:169:GLN:HA	2.03	0.41
1:A:94:THR:HG21	1:B:96:LEU:HD23	2.03	0.41
1:A:71:ILE:HG13	1:B:71:ILE:HD13	2.02	0.41
1:D:102:MET:HE3	1:D:232:ILE:HG13	2.02	0.41
1:D:169:GLN:N	1:D:173:THR:O	2.34	0.41

Continued on next page...

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:93:ALA:O	1:B:96:LEU:HB2	2.21	0.40
1:E:134:ASP:OD2	1:E:189:GLY:N	2.50	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 X-ray entries followed by that with respect to entries of similar resolution.

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	175/232 (75%)	175 (100%)	0	0	100	100
1	B	161/232 (69%)	160 (99%)	1 (1%)	0	100	100
1	C	158/232 (68%)	157 (99%)	1 (1%)	0	100	100
1	D	146/232 (63%)	144 (99%)	2 (1%)	0	100	100
1	E	164/232 (71%)	164 (100%)	0	0	100	100
All	All	804/1160 (69%)	800 (100%)	4 (0%)	0	100	100

There are no Ramachandran outliers to report.

5.3.2 Protein sidechains [i](#)

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

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	141/188 (75%)	141 (100%)	0	100	100
1	B	133/188 (71%)	133 (100%)	0	100	100

Continued on next page...

Continued from previous page...

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	C	128/188 (68%)	128 (100%)	0	100	100
1	D	124/188 (66%)	122 (98%)	2 (2%)	55	72
1	E	131/188 (70%)	131 (100%)	0	100	100
All	All	657/940 (70%)	655 (100%)	2 (0%)	86	86

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

Mol	Chain	Res	Type
1	D	68	VAL
1	D	194	VAL

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (10) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	64	GLN
1	A	84	GLN
1	A	169	GLN
1	B	75	ASN
1	B	188	ASN
1	B	230	GLN
1	C	188	ASN
1	C	192	GLN
1	D	188	ASN
1	E	213	ASN

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

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

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

5.5 Carbohydrates ⓘ

There are no oligosaccharides in this entry.

5.6 Ligand geometry

There are no ligands in this entry.

5.7 Other polymers

There are no such residues in this entry.

5.8 Polymer linkage issues

There are no chain breaks in this entry.

6 Fit of model and data

6.1 Protein, DNA and RNA chains

In the following table, the column labelled ‘#RSRZ> 2’ contains the number (and percentage) of RSRZ outliers, followed by percent RSRZ outliers for the chain as percentile scores relative to all X-ray entries and entries of similar resolution. The OWAB column contains the minimum, median, 95th percentile and maximum values of the occupancy-weighted average B-factor per residue. The column labelled ‘Q< 0.9’ lists the number of (and percentage) of residues with an average occupancy less than 0.9.

Mol	Chain	Analysed	<RSRZ>	#RSRZ>2		OWAB(Å ²)	Q<0.9
1	A	177/232 (76%)	0.36	19 (10%)	11 9	52, 94, 236, 297	0
1	B	165/232 (71%)	0.62	20 (12%)	8 7	86, 127, 202, 253	0
1	C	162/232 (69%)	0.93	24 (14%)	5 5	99, 136, 224, 250	0
1	D	154/232 (66%)	1.52	47 (30%)	1 1	83, 166, 231, 268	0
1	E	166/232 (71%)	0.20	8 (4%)	35 24	59, 113, 215, 244	0
All	All	824/1160 (71%)	0.71	118 (14%)	6 5	52, 131, 225, 297	0

All (118) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	78	LEU	7.3
1	B	77	THR	6.2
1	C	81	ILE	6.2
1	D	78	LEU	6.1
1	C	71	ILE	5.6
1	C	78	LEU	5.5
1	B	78	LEU	5.1
1	D	201	ALA	5.0
1	D	160	VAL	4.9
1	A	208	LYS	4.8
1	D	225	LEU	4.6
1	D	122	THR	4.6
1	C	206	VAL	4.3
1	D	125	PHE	4.3
1	D	176	PRO	4.2
1	D	123	THR	4.1
1	D	127	VAL	4.0
1	C	77	THR	4.0
1	C	225	LEU	4.0
1	E	81	ILE	4.0

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type	RSRZ
1	A	75	ASN	4.0
1	B	74	LEU	3.9
1	C	224	THR	3.9
1	D	153	ILE	3.9
1	A	77	THR	3.8
1	B	81	ILE	3.8
1	A	81	ILE	3.7
1	C	79	GLY	3.5
1	D	202	LEU	3.5
1	A	152	GLU	3.5
1	E	70	GLY	3.5
1	D	111	GLY	3.5
1	D	77	THR	3.3
1	E	78	LEU	3.3
1	A	80	ALA	3.3
1	D	174	THR	3.3
1	C	68	VAL	3.3
1	D	136	VAL	3.2
1	A	74	LEU	3.2
1	E	74	LEU	3.1
1	D	138	ALA	3.0
1	E	89	GLN	3.0
1	C	80	ALA	3.0
1	D	177	ASN	3.0
1	B	87	ASN	3.0
1	B	153	ILE	3.0
1	D	124	PRO	2.9
1	D	68	VAL	2.9
1	A	84	GLN	2.9
1	D	156	LEU	2.9
1	C	204	GLN	2.9
1	C	82	SER	2.9
1	B	92	GLN	2.9
1	B	213	ASN	2.9
1	D	175	VAL	2.9
1	D	75	ASN	2.9
1	B	64	GLN	2.8
1	C	85	ILE	2.8
1	D	228	VAL	2.8
1	C	70	GLY	2.8
1	E	71	ILE	2.8
1	D	121	SER	2.8

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type	RSRZ
1	B	211	ASN	2.8
1	A	79	GLY	2.7
1	D	159	GLY	2.7
1	D	112	LYS	2.7
1	C	74	LEU	2.7
1	D	151	LEU	2.7
1	A	85	ILE	2.6
1	D	101	VAL	2.6
1	C	83	GLY	2.6
1	D	194	VAL	2.6
1	B	208	LYS	2.6
1	B	220	TYR	2.6
1	C	65	ILE	2.6
1	D	84	GLN	2.6
1	D	81	ILE	2.5
1	D	182	ILE	2.5
1	A	91	LEU	2.5
1	D	199	GLN	2.5
1	D	178	GLY	2.5
1	E	88	SER	2.4
1	B	62	LEU	2.4
1	D	220	TYR	2.4
1	B	204	GLN	2.4
1	C	90	SER	2.4
1	D	230	GLN	2.4
1	D	200	PHE	2.4
1	C	215	LEU	2.4
1	D	106	THR	2.3
1	B	65	ILE	2.3
1	A	59	THR	2.3
1	B	95	THR	2.3
1	D	129	LEU	2.3
1	A	211	ASN	2.3
1	C	84	GLN	2.3
1	A	86	ASP	2.2
1	C	103	VAL	2.2
1	D	110	ALA	2.2
1	E	84	GLN	2.1
1	B	90	SER	2.1
1	C	75	ASN	2.1
1	A	93	ALA	2.1
1	A	56	ASN	2.1

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type	RSRZ
1	D	139	THR	2.1
1	B	89	GLN	2.1
1	C	64	GLN	2.1
1	D	195	ALA	2.1
1	B	97	ILE	2.1
1	D	86	ASP	2.1
1	C	73	LYS	2.0
1	D	179	SER	2.0
1	A	65	ILE	2.0
1	D	150	THR	2.0
1	D	222	THR	2.0
1	B	225	LEU	2.0
1	A	90	SER	2.0
1	D	232	ILE	2.0

6.2 Non-standard residues in protein, DNA, RNA chains ⓘ

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

6.3 Carbohydrates ⓘ

There are no oligosaccharides in this entry.

6.4 Ligands ⓘ

There are no ligands in this entry.

6.5 Other polymers ⓘ

There are no such residues in this entry.