Full wwPDB X-ray Structure Validation Report (i)

Nov 3, 2026 – 12:17 PM EST

PDB ID	:	9PMI / pdb_00009pmi
Title	:	Structure of a bifunctional ulvan active enzymes
Authors	:	Mihalynuk, L.; Boraston, A.B.
Deposited on	:	2025-07-17
Resolution	:	2.45 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 (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 (i)) were used in the production of this report:

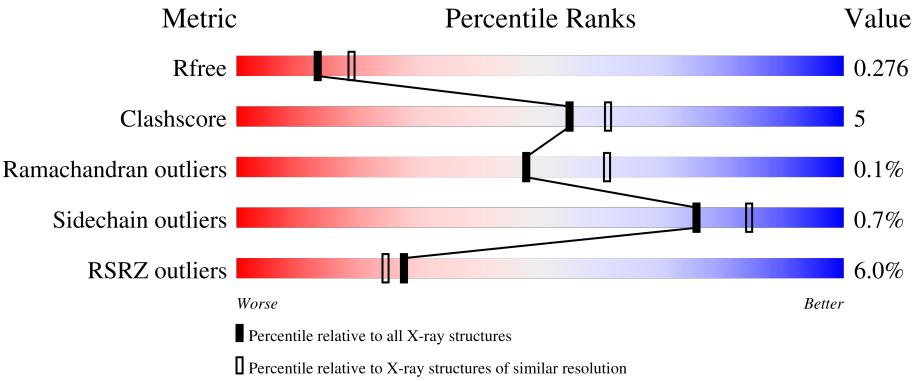
MolProbity	:	4-5-2 with Phenix2.2
Xtriage (Phenix)	:	2.2
EDS	:	3.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.015 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.51

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 2.45 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	1190 (2.46-2.46)
Clashscore	190562	1229 (2.46-2.46)
Ramachandran outliers	187476	1218 (2.46-2.46)
Sidechain outliers	187428	1218 (2.46-2.46)
RSRZ outliers	180081	1190 (2.46-2.46)

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 <=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	709	6% 86% 12% .
1	B	709	5% 84% 12% .

2 Entry composition (i)

There are 3 unique types of molecules in this entry. The entry contains 11221 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 PLunk.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	691	Total	C	N	O	S	0	0	0
			5512	3529	900	1049	34			
1	B	678	Total	C	N	O	S	0	0	0
			5412	3475	882	1023	32			

- Molecule 2 is CALCIUM ION (CCD ID: CA) (formula: Ca).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	2	Total	Ca	0	0
			2	2		
2	B	2	Total	Ca	0	0
			2	2		

- Molecule 3 is water.

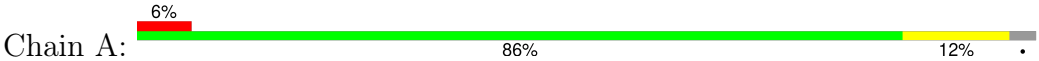
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	155	Total	O	0	0
			155	155		
3	B	138	Total	O	0	0
			138	138		

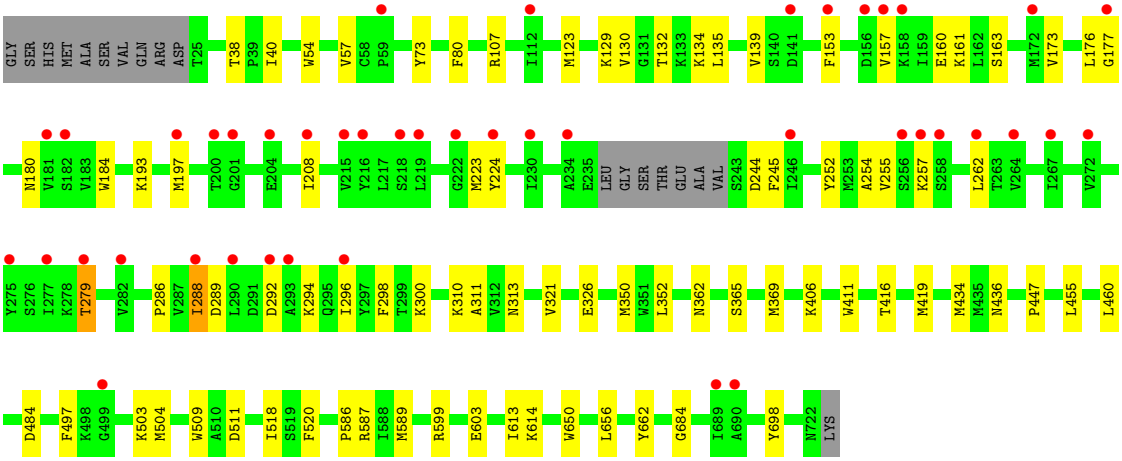
3 Residue-property plots (i)

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: PLunk

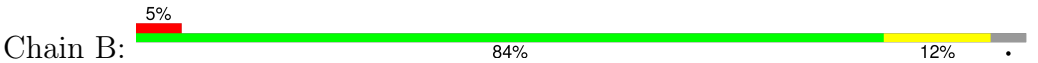
Chain A:

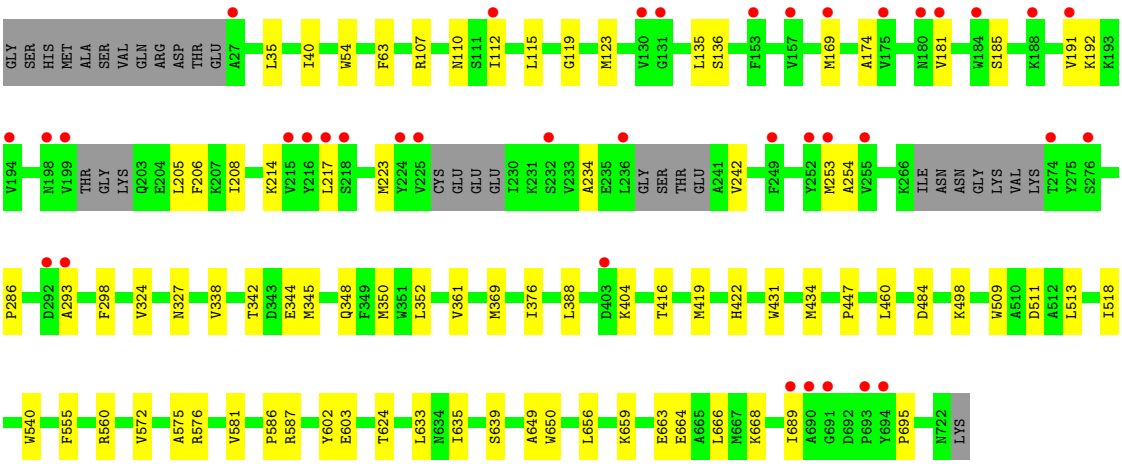




• Molecule 1: PLunk

Chain B:





4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α, β, γ	50.90Å 142.19Å 198.30Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	38.80 – 2.45 38.80 – 2.45	Depositor EDS
% Data completeness (in resolution range)	96.1 (38.80-2.45) 96.1 (38.80-2.45)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	2.36 (at 2.45Å)	Xtriage
Refinement program	PHENIX 1.21.2_5419	Depositor
R, R_{free}	0.221 , 0.277 0.221 , 0.276	Depositor DCC
R_{free} test set	2675 reflections (4.95%)	wwPDB-VP
Wilson B-factor (Å^2)	45.1	Xtriage
Anisotropy	0.080	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.33 , 43.0	EDS
L-test for twinning[2]	$< \|L\| > = 0.50$, $< L^2 > = 0.33$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o,F_c correlation	0.94	EDS
Total number of atoms	11221	wwPDB-VP
Average B, all atoms (Å^2)	53.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The analyses of the Patterson function reveals a significant off-origin peak that is 38.26 % of the origin peak, indicating pseudo-translational symmetry. The chance of finding a peak of this or larger height randomly in a structure without pseudo-translational symmetry is equal to 3.7879e-04. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

[1] Intensities estimated from amplitudes.

[2] Theoretical values of $< |L| >$, $< L^2 >$ for acentric reflections are 0.5, 0.333 respectively for untwinned datasets, and 0.375, 0.2 for perfectly twinned datasets.

5 Model quality

5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: CA

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	0.11	0/5656	0.30	0/7664
1	B	0.10	0/5552	0.28	0/7520
All	All	0.11	0/11208	0.29	0/15184

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no planarity outliers.

5.2 Too-close contacts

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in the chain respectively. The H(added) column lists the number of hydrogen atoms added and optimized by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, whereas Symm-Clashes lists symmetry-related clashes.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	5512	0	5232	58	0
1	B	5412	0	5163	46	0
2	A	2	0	0	0	0
2	B	2	0	0	0	0
3	A	155	0	0	1	0
3	B	138	0	0	1	0
All	All	11221	0	10395	102	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 5.

All (102) 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:A:288:ILE:CD1	1:A:296:ILE:HD13	2.15	0.76
1:B:112:ILE:HD11	1:B:135:LEU:HD11	1.75	0.69
1:A:447:PRO:HB3	1:B:484:ASP:HB3	1.75	0.69
1:B:223:MET:HB2	1:B:234:ALA:HB3	1.78	0.65
1:A:160:GLU:HG3	1:A:177:GLY:HA2	1.81	0.62
1:A:288:ILE:HD11	1:A:296:ILE:CD1	2.29	0.62
1:B:416:THR:HA	1:B:419:MET:HE3	1.82	0.62
1:A:294:LYS:HB3	1:A:313:ASN:HB3	1.82	0.61
1:A:484:ASP:HB3	1:B:447:PRO:HB3	1.81	0.61
1:A:288:ILE:HD13	1:A:296:ILE:HD13	1.84	0.60
1:A:288:ILE:HD11	1:A:296:ILE:HD13	1.84	0.60
1:A:193:LYS:HD2	1:A:193:LYS:H	1.66	0.59
1:A:434:MET:HB3	1:A:460:LEU:HD11	1.85	0.59
1:A:416:THR:HA	1:A:419:MET:HE3	1.86	0.57
1:A:296:ILE:HB	1:A:311:ALA:HB3	1.87	0.56
1:A:279:THR:HG21	1:A:321:VAL:HG21	1.89	0.55
1:A:245:PHE:CD2	1:A:254:ALA:HB2	2.42	0.55
1:A:589:MET:HE1	1:A:656:LEU:HD21	1.88	0.54
1:A:350:MET:HG2	1:A:369:MET:HG2	1.89	0.53
1:A:132:THR:HG23	1:A:134:LYS:H	1.72	0.53
1:A:38:THR:HG21	1:A:326:GLU:HB3	1.91	0.52
1:B:181:VAL:HG11	1:B:217:LEU:HD21	1.92	0.52
1:A:54:TRP:H	1:A:352:LEU:HD11	1.76	0.51
1:A:173:VAL:HG13	1:A:184:TRP:HB2	1.93	0.51
1:B:376:ILE:HG13	1:B:388:LEU:HD13	1.92	0.51
1:A:157:VAL:HG11	1:A:180:ASN:HB3	1.94	0.50
1:A:135:LEU:HD12	1:A:153:PHE:CE2	2.46	0.50
1:B:350:MET:HG2	1:B:369:MET:HG2	1.95	0.49
1:A:161:LYS:HB2	1:A:176:LEU:HD23	1.94	0.49
1:B:509:TRP:CD1	1:B:511:ASP:HB2	2.48	0.49
1:B:119:GLY:HA3	1:B:169:MET:HA	1.95	0.48
1:A:57:VAL:HG21	1:A:130:VAL:HG21	1.95	0.48
1:B:286:PRO:HB3	1:B:298:PHE:HB3	1.96	0.48
1:B:107:ARG:HD3	1:B:110:ASN:HD21	1.79	0.48
1:A:153:PHE:HE1	1:A:184:TRP:CZ3	2.32	0.47
1:B:242:VAL:HG21	1:B:254:ALA:HB1	1.96	0.47
1:A:223:MET:HG2	1:A:245:PHE:CZ	2.49	0.47
1:B:649:ALA:HB2	1:B:666:LEU:HD11	1.97	0.46
1:A:135:LEU:HD12	1:A:153:PHE:HE2	1.79	0.46
1:B:54:TRP:H	1:B:352:LEU:HD11	1.79	0.46
1:A:223:MET:HG3	1:A:252:TYR:CD1	2.51	0.46

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:35:LEU:HD23	1:B:327:ASN:HB3	1.98	0.46
1:A:586:PRO:HB3	1:A:650:TRP:CD2	2.51	0.46
1:B:422:HIS:NE2	1:B:431:TRP:HB2	2.31	0.46
1:B:181:VAL:HG13	1:B:206:PHE:HE1	1.80	0.46
1:B:344:GLU:HG3	1:B:345:MET:SD	2.56	0.45
1:A:107:ARG:HG3	1:A:362:ASN:OD1	2.16	0.45
1:A:288:ILE:HD11	1:A:296:ILE:HD11	1.97	0.45
1:A:289:ASP:HB3	1:A:292:ASP:O	2.17	0.45
1:B:253:MET:SD	1:B:293:ALA:HB1	2.56	0.45
1:B:342:THR:OG1	1:B:344:GLU:HG2	2.17	0.45
1:B:555:PHE:CE1	1:B:581:VAL:HG11	2.51	0.45
1:B:633:LEU:HG	1:B:635:ILE:HG22	1.98	0.45
1:B:214:LYS:HE3	1:B:214:LYS:HB2	1.78	0.45
1:B:63:PHE:HZ	1:B:123:MET:HG2	1.81	0.45
1:B:659:LYS:O	1:B:663:GLU:HB2	2.17	0.45
1:A:257:LYS:HA	1:A:262:LEU:HD23	1.99	0.45
1:B:603:GLU:HG2	1:B:656:LEU:HD21	1.98	0.45
1:A:73:TYR:CG	1:A:123:MET:HE1	2.53	0.44
1:A:80:PHE:CG	1:A:436:ASN:HB3	2.52	0.44
1:A:123:MET:O	1:A:139:VAL:HA	2.18	0.44
1:A:296:ILE:O	1:A:310:LYS:HA	2.18	0.44
1:B:586:PRO:HB3	1:B:650:TRP:CG	2.52	0.44
1:A:129:LYS:O	1:A:132:THR:HG22	2.17	0.44
1:B:633:LEU:HD11	1:B:695:PRO:HB3	2.00	0.44
1:A:197:MET:HE1	1:A:224:TYR:CZ	2.52	0.43
1:B:115:LEU:HD11	1:B:123:MET:HB3	1.99	0.43
1:A:614:LYS:HD3	1:A:662:TYR:CE2	2.53	0.43
1:A:589:MET:HE2	1:A:650:TRP:HH2	1.84	0.43
1:B:576:ARG:HD3	1:B:639:SER:OG	2.19	0.43
1:B:185:SER:O	1:B:191:VAL:HA	2.19	0.43
1:B:40:ILE:HB	1:B:324:VAL:O	2.19	0.43
1:B:345:MET:HB3	3:B:933:HOH:O	2.18	0.43
1:A:163:SER:HB3	1:A:208:ILE:HG22	2.00	0.42
1:A:262:LEU:HD21	1:A:286:PRO:HG3	2.01	0.42
1:B:434:MET:HB3	1:B:460:LEU:HD11	2.01	0.42
1:A:244:ASP:HB3	1:A:255:VAL:HG12	2.01	0.42
1:A:684:GLY:HA3	1:A:698:TYR:O	2.19	0.42
1:B:518:ILE:HG12	1:B:587:ARG:NH1	2.35	0.42
1:A:518:ILE:HG12	1:A:587:ARG:NH1	2.34	0.42
1:B:185:SER:HB3	1:B:192:LYS:HG3	2.02	0.42
1:A:197:MET:HE1	1:A:224:TYR:CE2	2.55	0.42

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:498:LYS:HD3	1:B:560:ARG:HG2	2.01	0.42
1:B:575:ALA:HB2	1:B:624:THR:O	2.19	0.42
1:B:513:LEU:HB3	1:B:540:TRP:CZ3	2.54	0.42
1:A:286:PRO:HB3	1:A:298:PHE:HB3	2.01	0.42
1:A:509:TRP:CD1	1:A:511:ASP:HB2	2.56	0.41
1:B:174:ALA:HB2	1:B:208:ILE:HD12	2.01	0.41
1:A:586:PRO:HB3	1:A:650:TRP:CG	2.54	0.41
1:A:599:ARG:O	1:A:603:GLU:HG3	2.20	0.41
1:B:540:TRP:CE2	1:B:602:TYR:HE1	2.39	0.41
1:A:497:PHE:O	1:A:503:LYS:HE3	2.20	0.41
1:A:504:MET:HG3	3:A:1050:HOH:O	2.20	0.41
1:B:434:MET:HE3	1:B:434:MET:HB2	1.93	0.41
1:A:298:PHE:HE2	1:A:300:LYS:HG3	1.85	0.41
1:B:338:VAL:HG12	1:B:348:GLN:C	2.46	0.41
1:A:38:THR:HG22	1:A:40:ILE:H	1.85	0.41
1:A:406:LYS:HA	1:A:411:TRP:CD1	2.56	0.41
1:A:184:TRP:CZ3	1:A:193:LYS:HG3	2.57	0.40
1:B:404:LYS:HD3	1:B:404:LYS:HA	1.89	0.40
1:A:455:LEU:HD13	1:A:520:PHE:HE1	1.85	0.40
1:B:664:GLU:HG2	1:B:668:LYS:HE2	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 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	687/709 (97%)	664 (97%)	23 (3%)	0	100	100
1	B	668/709 (94%)	644 (96%)	23 (3%)	1 (0%)	48	61
All	All	1355/1418 (96%)	1308 (96%)	46 (3%)	1 (0%)	48	61

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	689	ILE

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	583/617 (94%)	579 (99%)	4 (1%)	76	84
1	B	573/617 (93%)	569 (99%)	4 (1%)	76	84
All	All	1156/1234 (94%)	1148 (99%)	8 (1%)	76	84

All (8) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	279	THR
1	A	288	ILE
1	A	365	SER
1	A	613	ILE
1	B	136	SER
1	B	205	LEU
1	B	361	VAL
1	B	572	VAL

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (7) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	146	ASN
1	A	198	ASN
1	A	327	ASN
1	A	396	GLN
1	A	568	HIS
1	B	198	ASN
1	B	339	GLN

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 4 ligands modelled in this entry, 4 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 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, 95^{th} 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	691/709 (97%)	0.34	44 (6%)	25	23	27, 45, 87, 105	0
1	B	678/709 (95%)	0.41	38 (5%)	30	27	30, 53, 93, 106	0
All	All	1369/1418 (96%)	0.37	82 (5%)	27	24	27, 50, 91, 106	0

All (82) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	27	ALA	5.2
1	B	690	ALA	5.0
1	A	112	ILE	4.0
1	A	292	ASP	4.0
1	A	157	VAL	3.5
1	A	293	ALA	3.3
1	A	499	GLY	3.3
1	A	224	TYR	3.2
1	A	267	ILE	3.2
1	B	194	VAL	3.1
1	A	181	VAL	3.0
1	B	130	VAL	3.0
1	A	689	ILE	2.9
1	A	277	ILE	2.9
1	A	215	VAL	2.9
1	A	177	GLY	2.9
1	A	222	GLY	2.9
1	B	293	ALA	2.9
1	A	272	VAL	2.8
1	B	181	VAL	2.8
1	B	693	PRO	2.8
1	A	59	PRO	2.8
1	B	689	ILE	2.7
1	A	282	VAL	2.7

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Mol	Chain	Res	Type	RSRZ
1	B	274	THR	2.7
1	A	288	ILE	2.7
1	A	264	VAL	2.7
1	B	199	VAL	2.7
1	B	232	SER	2.7
1	B	403	ASP	2.6
1	A	234	ALA	2.6
1	B	691	GLY	2.6
1	A	153	PHE	2.6
1	B	169	MET	2.6
1	B	184	TRP	2.6
1	A	230	ILE	2.5
1	B	198	ASN	2.5
1	A	201	GLY	2.5
1	A	216	TYR	2.5
1	B	292	ASP	2.5
1	B	191	VAL	2.5
1	B	252	TYR	2.4
1	B	218	SER	2.4
1	A	208	ILE	2.4
1	A	182	SER	2.4
1	B	131	GLY	2.4
1	A	172	MET	2.4
1	B	157	VAL	2.4
1	A	158	LYS	2.4
1	A	279	THR	2.3
1	B	255	VAL	2.3
1	B	180	ASN	2.3
1	A	200	THR	2.3
1	A	258	SER	2.3
1	A	290	LEU	2.3
1	A	156	ASP	2.3
1	B	188	LYS	2.3
1	B	249	PHE	2.3
1	A	296	ILE	2.3
1	B	217	LEU	2.3
1	B	236	LEU	2.3
1	A	204	GLU	2.2
1	B	215	VAL	2.2
1	A	218	SER	2.2
1	A	246	ILE	2.2
1	A	275	TYR	2.2

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Mol	Chain	Res	Type	RSRZ
1	B	694	TYR	2.2
1	B	153	PHE	2.2
1	B	224	TYR	2.1
1	A	257	LYS	2.1
1	B	225	VAL	2.1
1	B	175	VAL	2.1
1	A	690	ALA	2.1
1	A	219	LEU	2.1
1	B	253	MET	2.1
1	A	262	LEU	2.0
1	B	112	ILE	2.0
1	A	141	ASP	2.0
1	A	197	MET	2.0
1	A	256	SER	2.0
1	B	276	SER	2.0
1	B	216	TYR	2.0

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

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

6.3 Carbohydrates (i)

There are no oligosaccharides in this entry.

6.4 Ligands (i)

In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95^{th} percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å^2)	Q<0.9
2	CA	B	802	1/1	0.95	0.06	63,63,63,63	0
2	CA	A	802	1/1	0.97	0.07	51,51,51,51	0
2	CA	B	801	1/1	0.99	0.02	41,41,41,41	0
2	CA	A	801	1/1	0.99	0.03	39,39,39,39	0

6.5 Other polymers (i)

There are no such residues in this entry.