



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 7, 2026 – 12:23 AM UTC

PDB ID : 6U1C / pdb_00006u1c
Title : Apo form of Thermus thermophilus D-alanine-D-alanine ligase
Authors : Pederick, J.L.; Bruning, J.B.
Deposited on : 2019-08-15
Resolution : 2.20 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

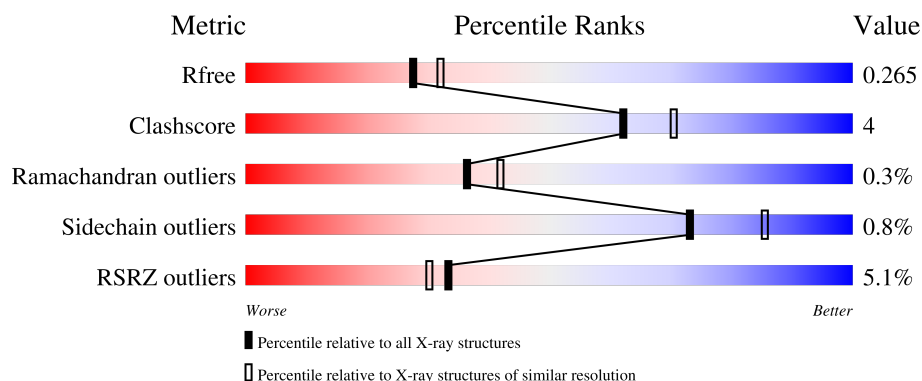
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.20 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	6164 (2.20-2.20)
Clashscore	190562	6851 (2.20-2.20)
Ramachandran outliers	187476	6768 (2.20-2.20)
Sidechain outliers	187428	6769 (2.20-2.20)
RSRZ outliers	180081	6166 (2.20-2.20)

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	327	4% 83% 12% 5%
1	B	327	7% 83% 9% 8%
1	C	327	3% 84% 8% 8%
1	D	327	5% 79% 13% 8%

2 Entry composition

There are 2 unique types of molecules in this entry. The entry contains 9078 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 D-alanine–D-alanine ligase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	310	Total	C	N	O	S	0	0	0
			2257	1468	387	398	4			
1	B	302	Total	C	N	O	S	0	0	0
			2229	1450	372	403	4			
1	C	301	Total	C	N	O	S	0	1	0
			2231	1453	376	397	5			
1	D	300	Total	C	N	O	S	0	0	0
			2197	1436	358	399	4			

There are 32 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-1	MET	-	initiating methionine	UNP Q5SHZ3
A	0	GLU	-	expression tag	UNP Q5SHZ3
A	320	HIS	-	expression tag	UNP Q5SHZ3
A	321	HIS	-	expression tag	UNP Q5SHZ3
A	322	HIS	-	expression tag	UNP Q5SHZ3
A	323	HIS	-	expression tag	UNP Q5SHZ3
A	324	HIS	-	expression tag	UNP Q5SHZ3
A	325	HIS	-	expression tag	UNP Q5SHZ3
B	-1	MET	-	initiating methionine	UNP Q5SHZ3
B	0	GLU	-	expression tag	UNP Q5SHZ3
B	320	HIS	-	expression tag	UNP Q5SHZ3
B	321	HIS	-	expression tag	UNP Q5SHZ3
B	322	HIS	-	expression tag	UNP Q5SHZ3
B	323	HIS	-	expression tag	UNP Q5SHZ3
B	324	HIS	-	expression tag	UNP Q5SHZ3
B	325	HIS	-	expression tag	UNP Q5SHZ3
C	-1	MET	-	initiating methionine	UNP Q5SHZ3
C	0	GLU	-	expression tag	UNP Q5SHZ3
C	320	HIS	-	expression tag	UNP Q5SHZ3
C	321	HIS	-	expression tag	UNP Q5SHZ3
C	322	HIS	-	expression tag	UNP Q5SHZ3

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Chain	Residue	Modelled	Actual	Comment	Reference
C	323	HIS	-	expression tag	UNP Q5SHZ3
C	324	HIS	-	expression tag	UNP Q5SHZ3
C	325	HIS	-	expression tag	UNP Q5SHZ3
D	-1	MET	-	initiating methionine	UNP Q5SHZ3
D	0	GLU	-	expression tag	UNP Q5SHZ3
D	320	HIS	-	expression tag	UNP Q5SHZ3
D	321	HIS	-	expression tag	UNP Q5SHZ3
D	322	HIS	-	expression tag	UNP Q5SHZ3
D	323	HIS	-	expression tag	UNP Q5SHZ3
D	324	HIS	-	expression tag	UNP Q5SHZ3
D	325	HIS	-	expression tag	UNP Q5SHZ3

- Molecule 2 is water.

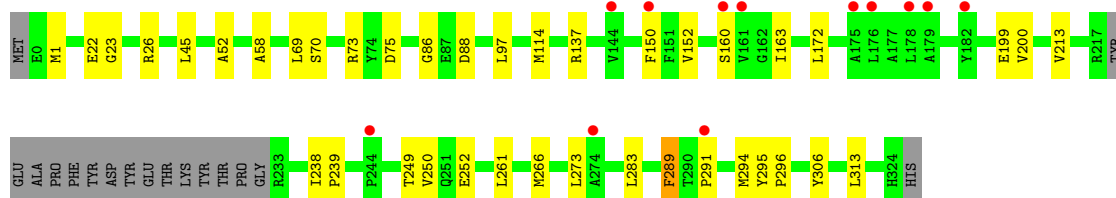
Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
2	A	37	Total O 37 37	0	0
2	B	41	Total O 41 41	0	0
2	C	46	Total O 46 46	0	0
2	D	40	Total O 40 40	0	0

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 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.

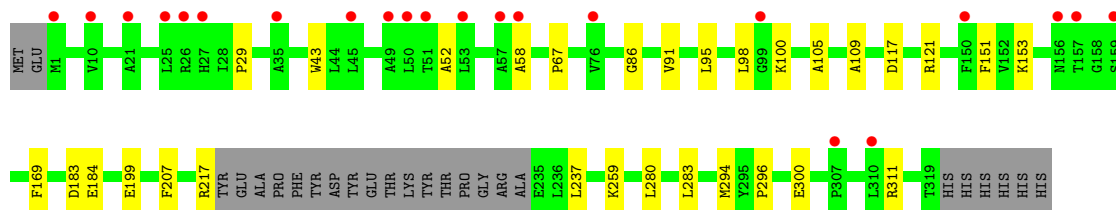
• Molecule 1: D-alanine–D-alanine ligase

Chain A: 



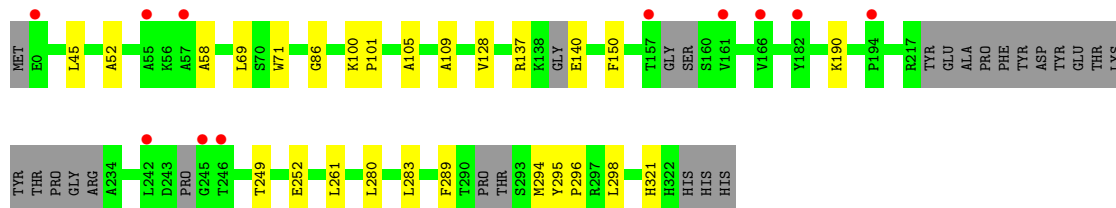
• Molecule 1: D-alanine–D-alanine ligase

Chain B: 



• Molecule 1: D-alanine–D-alanine ligase

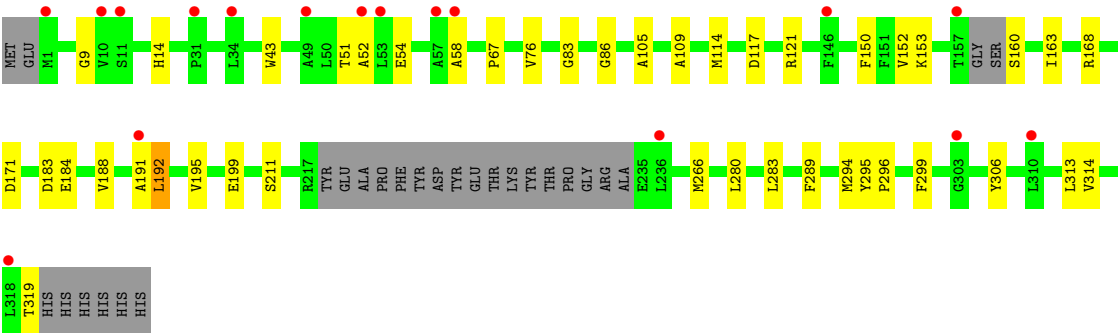
Chain C: 



• Molecule 1: D-alanine–D-alanine ligase

Chain D: 





4 Data and refinement statistics

Property	Value	Source
Space group	P 1	Depositor
Cell constants a, b, c, α , β , γ	55.87Å 68.69Å 91.79Å 68.31° 79.71° 65.99°	Depositor
Resolution (Å)	33.25 – 2.20 33.25 – 2.20	Depositor EDS
% Data completeness (in resolution range)	97.8 (33.25-2.20) 97.8 (33.25-2.20)	Depositor EDS
R_{merge}	0.08	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.51 (at 2.20Å)	Xtriage
Refinement program	PHENIX 1.16_3549	Depositor
R, R_{free}	0.238 , 0.265 0.238 , 0.265	Depositor DCC
R_{free} test set	2986 reflections (5.08%)	wwPDB-VP
Wilson B-factor (Å ²)	37.7	Xtriage
Anisotropy	0.666	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.36 , 40.1	EDS
L-test for twinning ²	$\langle L \rangle = 0.46$, $\langle L^2 \rangle = 0.29$	Xtriage
Estimated twinning fraction	0.028 for -h,-k,-k+1	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	9078	wwPDB-VP
Average B, all atoms (Å ²)	46.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 9.33% 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	0.14	0/2317	0.34	0/3175
1	B	0.15	0/2286	0.34	0/3130
1	C	0.13	0/2284	0.33	0/3118
1	D	0.13	0/2253	0.33	0/3088
All	All	0.14	0/9140	0.34	0/12511

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	2257	0	2203	21	0
1	B	2229	0	2196	17	0
1	C	2231	0	2197	13	0
1	D	2197	0	2161	23	0
2	A	37	0	0	0	0
2	B	41	0	0	1	0
2	C	46	0	0	0	0
2	D	40	0	0	0	0
All	All	9078	0	8757	72	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 4.

All (72) 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:249:THR:HA	1:C:252:GLU:HG2	1.85	0.59
1:B:52:ALA:HB1	1:B:58:ALA:HB2	1.85	0.59
1:D:52:ALA:HB1	1:D:58:ALA:HB2	1.84	0.58
1:A:160:SER:HA	1:A:163:ILE:HD12	1.86	0.58
1:D:43:TRP:CE3	1:D:67:PRO:HG3	2.40	0.57
1:D:150:PHE:HA	1:D:191:ALA:H	1.68	0.57
1:D:152:VAL:HG22	1:D:188:VAL:HG22	1.88	0.56
1:D:76:VAL:HG21	1:D:314:VAL:HG13	1.87	0.55
1:B:183:ASP:OD1	1:B:184:GLU:N	2.40	0.55
1:C:45:LEU:HD22	1:C:69:LEU:HD21	1.90	0.54
1:B:280:LEU:HD21	1:B:283:LEU:HD12	1.90	0.54
1:D:9:GLY:O	1:D:14:HIS:ND1	2.33	0.54
1:A:23:GLY:HA3	1:A:291:PRO:HD3	1.91	0.53
1:D:280:LEU:HD21	1:D:283:LEU:HD12	1.91	0.53
1:D:199:GLU:OE1	1:D:294:MET:HG2	2.11	0.51
1:C:261:LEU:HD12	1:C:283:LEU:HD22	1.92	0.51
1:D:153:LYS:HG2	1:D:163:ILE:HG23	1.93	0.51
1:B:43:TRP:CE3	1:B:67:PRO:HG3	2.46	0.50
1:B:105:ALA:HB1	1:B:109:ALA:HB3	1.94	0.50
1:A:249:THR:HA	1:A:252:GLU:HG2	1.93	0.50
1:A:199:GLU:OE1	1:A:294:MET:HG2	2.12	0.50
1:D:296:PRO:HB3	1:D:306:TYR:HD1	1.78	0.49
1:B:217:ARG:NH2	2:B:403:HOH:O	2.44	0.49
1:C:52:ALA:HB1	1:C:58:ALA:HB2	1.95	0.48
1:B:29:PRO:HG3	1:B:311:ARG:HB2	1.95	0.48
1:D:117:ASP:O	1:D:121:ARG:HG3	2.13	0.48
1:D:192:LEU:HB2	1:D:195:VAL:HG21	1.95	0.48
1:C:137[B]:ARG:O	1:C:140:GLU:HB3	2.14	0.47
1:A:200:VAL:HG21	1:A:250:VAL:HG12	1.95	0.47
1:D:266:MET:HB3	1:D:313:LEU:HD21	1.97	0.47
1:D:83:GLY:HA2	1:D:114:MET:HE1	1.97	0.46
1:A:289:PHE:O	1:A:306:TYR:OH	2.29	0.46
1:A:137:ARG:NH1	1:B:259:LYS:HE2	2.31	0.46
1:A:266:MET:HB3	1:A:313:LEU:HD21	1.98	0.46
1:D:192:LEU:HB2	1:D:195:VAL:CG2	2.45	0.46
1:B:217:ARG:HD2	1:B:237:LEU:HD11	1.98	0.45
1:C:101:PRO:HG3	1:C:321:HIS:CG	2.51	0.45
1:C:294:MET:O	1:C:298:LEU:HG	2.16	0.45
1:A:261:LEU:HD12	1:A:283:LEU:HD22	1.99	0.45
1:D:296:PRO:HB3	1:D:306:TYR:CD1	2.52	0.44

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:70:SER:O	1:A:73:ARG:HG2	2.17	0.44
1:C:105:ALA:HB1	1:C:109:ALA:HB3	1.98	0.44
1:B:98:LEU:HB3	1:B:100:LYS:HG2	1.98	0.44
1:D:183:ASP:OD1	1:D:184:GLU:N	2.51	0.44
1:A:22:GLU:O	1:A:26:ARG:HG3	2.17	0.44
1:A:88:ASP:HB3	1:A:114:MET:HE2	2.00	0.43
1:A:52:ALA:HB1	1:A:58:ALA:HB2	2.00	0.43
1:C:150:PHE:HB3	1:C:190:LYS:HA	2.01	0.43
1:A:45:LEU:HD22	1:A:69:LEU:HD21	2.00	0.43
1:A:295:TYR:HB3	1:A:296:PRO:HD3	2.01	0.43
1:B:151:PHE:HB3	1:B:153:LYS:HE3	2.00	0.43
1:B:207:PHE:CE1	1:B:259:LYS:HE3	2.54	0.43
1:A:150:PHE:CE1	1:A:172:LEU:HD13	2.54	0.42
1:D:51:THR:O	1:D:54:GLU:HG2	2.18	0.42
1:D:168:ARG:NH2	1:D:171:ASP:OD1	2.52	0.42
1:D:211:SER:HB3	1:D:299:PHE:CE2	2.54	0.42
1:A:238:ILE:HA	1:A:239:PRO:HA	1.92	0.42
1:A:200:VAL:HG22	1:A:213:VAL:HG22	2.01	0.42
1:C:295:TYR:HB3	1:C:296:PRO:HD3	2.02	0.42
1:D:105:ALA:HB1	1:D:109:ALA:HB3	2.02	0.42
1:D:295:TYR:HB3	1:D:296:PRO:HD3	2.02	0.41
1:B:199:GLU:OE1	1:B:294:MET:HG2	2.21	0.41
1:B:117:ASP:O	1:B:121:ARG:HG3	2.21	0.41
1:A:97:LEU:HD11	1:B:91:VAL:HA	2.02	0.41
1:C:137[A]:ARG:O	1:C:140:GLU:HB3	2.21	0.41
1:B:296:PRO:O	1:B:300:GLU:HG3	2.21	0.41
1:C:71:TRP:O	1:C:100:LYS:HE3	2.21	0.41
1:A:152:VAL:O	1:A:163:ILE:HA	2.21	0.41
1:A:1:MET:HA	1:A:75:ASP:OD2	2.20	0.40
1:B:95:LEU:HD23	1:B:98:LEU:HD12	2.03	0.40
1:C:128:VAL:HG11	1:C:280:LEU:HD23	2.03	0.40
1:D:160:SER:HA	1:D:163:ILE:HD12	2.02	0.40

There are no symmetry-related clashes.

5.3 Torsion angles

5.3.1 Protein backbone

In the following table, the Percentiles column shows the percent Ramachandran outliers of the chain as a percentile score with respect to all 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	306/327 (94%)	292 (95%)	13 (4%)	1 (0%)	36	42
1	B	298/327 (91%)	293 (98%)	4 (1%)	1 (0%)	36	42
1	C	290/327 (89%)	276 (95%)	13 (4%)	1 (0%)	36	42
1	D	294/327 (90%)	284 (97%)	9 (3%)	1 (0%)	36	42
All	All	1188/1308 (91%)	1145 (96%)	39 (3%)	4 (0%)	36	42

All (4) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	C	86	GLY
1	A	86	GLY
1	B	86	GLY
1	D	86	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 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	218/264 (83%)	216 (99%)	2 (1%)	70	84
1	B	222/264 (84%)	221 (100%)	1 (0%)	81	90
1	C	221/264 (84%)	220 (100%)	1 (0%)	81	90
1	D	219/264 (83%)	216 (99%)	3 (1%)	59	75
All	All	880/1056 (83%)	873 (99%)	7 (1%)	73	85

All (7) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	273	LEU
1	A	289	PHE

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Mol	Chain	Res	Type
1	B	169	PHE
1	C	289	PHE
1	D	192	LEU
1	D	289	PHE
1	D	319	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (1) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	63	HIS

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	310/327 (94%)	0.50	12 (3%) 43 40	27, 43, 71, 86	0
1	B	302/327 (92%)	0.61	22 (7%) 21 18	27, 48, 65, 71	0
1	C	301/327 (92%)	0.52	11 (3%) 45 42	24, 42, 64, 72	1 (0%)
1	D	300/327 (91%)	0.66	17 (5%) 29 26	29, 49, 68, 73	0
All	All	1213/1308 (92%)	0.57	62 (5%) 33 30	24, 46, 68, 86	1 (0%)

All (62) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	178	LEU	3.9
1	B	99	GLY	3.8
1	C	245	GLY	3.8
1	D	303	GLY	3.5
1	C	246	THR	3.2
1	B	156	ASN	3.2
1	A	291	PRO	3.0
1	B	57	ALA	3.0
1	B	51	THR	3.0
1	C	182	TYR	2.9
1	C	166	VAL	2.9
1	D	157	THR	2.9
1	D	1	MET	2.9
1	B	35	ALA	2.9
1	A	179	ALA	2.8
1	B	45	LEU	2.8
1	C	55	ALA	2.8
1	D	318	LEU	2.7
1	B	21	ALA	2.6
1	C	157	THR	2.6
1	B	53	LEU	2.6

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Mol	Chain	Res	Type	RSRZ
1	D	191	ALA	2.6
1	D	58	ALA	2.5
1	D	31	PRO	2.5
1	B	159	SER	2.5
1	A	176	LEU	2.5
1	B	50	LEU	2.4
1	D	236	LEU	2.4
1	D	49	ALA	2.4
1	A	160	SER	2.4
1	D	34	LEU	2.4
1	A	274	ALA	2.3
1	A	175	ALA	2.3
1	D	57	ALA	2.3
1	D	146	PHE	2.3
1	A	182	TYR	2.3
1	B	49	ALA	2.3
1	B	307	PRO	2.2
1	B	157	THR	2.2
1	D	11	SER	2.2
1	A	161	VAL	2.2
1	D	10	VAL	2.2
1	D	310	LEU	2.2
1	B	1	MET	2.2
1	B	310	LEU	2.2
1	B	26	ARG	2.1
1	A	144	VAL	2.1
1	B	76	VAL	2.1
1	A	150	PHE	2.1
1	C	0	GLU	2.1
1	B	27	HIS	2.1
1	C	161	VAL	2.1
1	C	57	ALA	2.1
1	A	244	PRO	2.1
1	B	10	VAL	2.1
1	B	25	LEU	2.1
1	B	58	ALA	2.0
1	D	52	ALA	2.0
1	C	194	PRO	2.0
1	B	150	PHE	2.0
1	C	242	LEU	2.0
1	D	53	LEU	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](#)

There are no ligands in this entry.

6.5 Other polymers [i](#)

There are no such residues in this entry.