



Full wwPDB X-ray Structure Validation Report ⓘ

Sep 28, 2026 – 03:11 PM JST

PDB ID : 23TM / pdb_000023tm
Title : Structure of the 328-692 fragment of FlhA (A489E) form 2
Authors : Sakai, M.; Kinoshita, M.; Takekawa, N.; Minamino, T.; Imada, K.
Deposited on : 2026-02-16
Resolution : 3.28 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 Phenix2.2
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

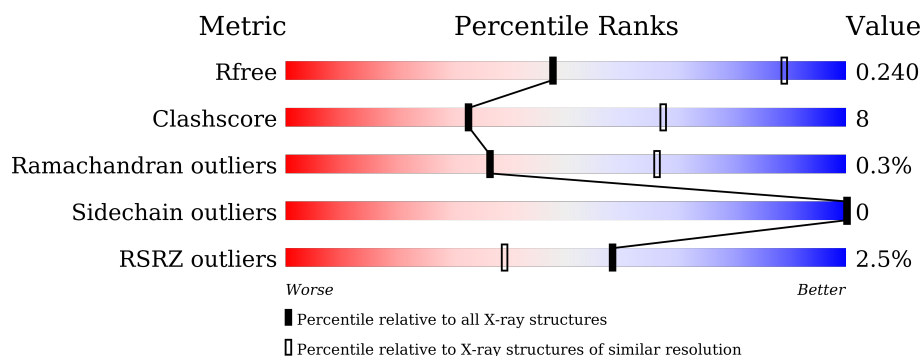
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 3.28 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	1303 (3.30-3.26)
Clashscore	190562	1354 (3.30-3.26)
Ramachandran outliers	187476	1334 (3.30-3.26)
Sidechain outliers	187428	1333 (3.30-3.26)
RSRZ outliers	180081	1303 (3.30-3.26)

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	389	 2% 70% 19% 11%
1	B	389	 3% 73% 15% 12%

2 Entry composition

There is only 1 type of molecule in this entry. The entry contains 5344 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 Flagellar biosynthesis protein FlhA.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	345	Total	C	N	O	S	0	0	0
			2677	1693	476	499	9			
1	B	344	Total	C	N	O	S	0	0	0
			2667	1687	474	497	9			

There are 50 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	304	MET	-	initiating methionine	UNP P40729
A	305	GLY	-	expression tag	UNP P40729
A	306	HIS	-	expression tag	UNP P40729
A	307	HIS	-	expression tag	UNP P40729
A	308	HIS	-	expression tag	UNP P40729
A	309	HIS	-	expression tag	UNP P40729
A	310	HIS	-	expression tag	UNP P40729
A	311	HIS	-	expression tag	UNP P40729
A	312	HIS	-	expression tag	UNP P40729
A	313	HIS	-	expression tag	UNP P40729
A	314	HIS	-	expression tag	UNP P40729
A	315	HIS	-	expression tag	UNP P40729
A	316	SER	-	expression tag	UNP P40729
A	317	SER	-	expression tag	UNP P40729
A	318	GLY	-	expression tag	UNP P40729
A	319	HIS	-	expression tag	UNP P40729
A	320	ILE	-	expression tag	UNP P40729
A	321	ASP	-	expression tag	UNP P40729
A	322	ASP	-	expression tag	UNP P40729
A	323	ASP	-	expression tag	UNP P40729
A	324	ASP	-	expression tag	UNP P40729
A	325	LYS	-	expression tag	UNP P40729
A	326	HIS	-	expression tag	UNP P40729
A	327	MET	-	expression tag	UNP P40729
A	489	GLU	ALA	engineered mutation	UNP P40729

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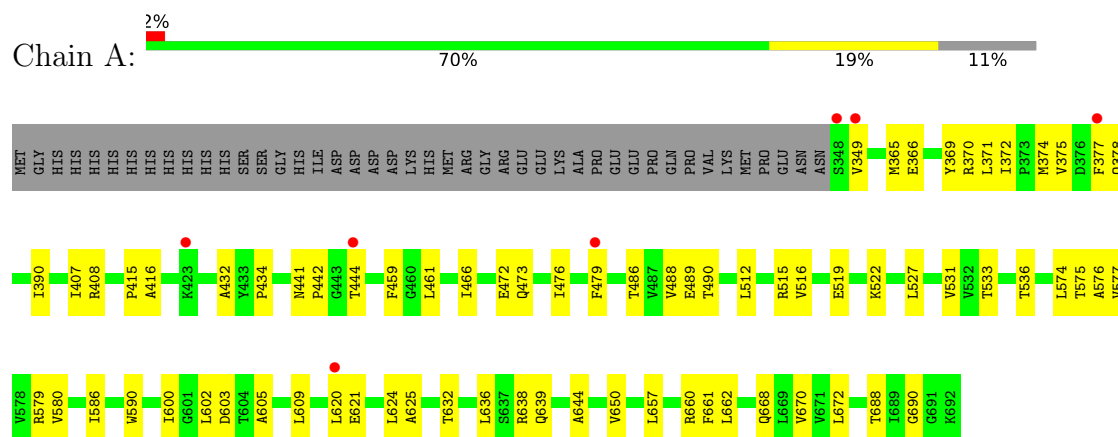
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Chain	Residue	Modelled	Actual	Comment	Reference
B	304	MET	-	initiating methionine	UNP P40729
B	305	GLY	-	expression tag	UNP P40729
B	306	HIS	-	expression tag	UNP P40729
B	307	HIS	-	expression tag	UNP P40729
B	308	HIS	-	expression tag	UNP P40729
B	309	HIS	-	expression tag	UNP P40729
B	310	HIS	-	expression tag	UNP P40729
B	311	HIS	-	expression tag	UNP P40729
B	312	HIS	-	expression tag	UNP P40729
B	313	HIS	-	expression tag	UNP P40729
B	314	HIS	-	expression tag	UNP P40729
B	315	HIS	-	expression tag	UNP P40729
B	316	SER	-	expression tag	UNP P40729
B	317	SER	-	expression tag	UNP P40729
B	318	GLY	-	expression tag	UNP P40729
B	319	HIS	-	expression tag	UNP P40729
B	320	ILE	-	expression tag	UNP P40729
B	321	ASP	-	expression tag	UNP P40729
B	322	ASP	-	expression tag	UNP P40729
B	323	ASP	-	expression tag	UNP P40729
B	324	ASP	-	expression tag	UNP P40729
B	325	LYS	-	expression tag	UNP P40729
B	326	HIS	-	expression tag	UNP P40729
B	327	MET	-	expression tag	UNP P40729
B	489	GLU	ALA	engineered mutation	UNP P40729

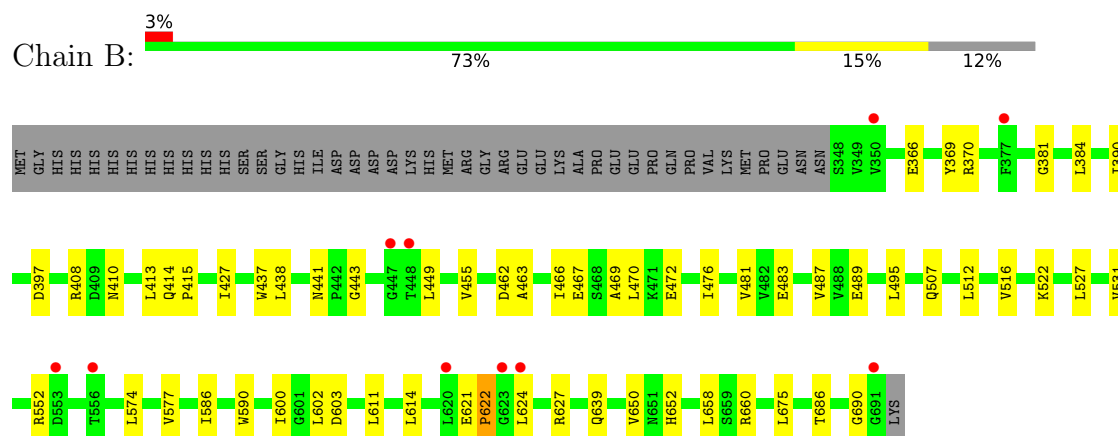
3 Residue-property plots [i](#)

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: Flagellar biosynthesis protein FlhA



• Molecule 1: Flagellar biosynthesis protein FlhA



4 Data and refinement statistics

Property	Value	Source
Space group	I 41	Depositor
Cell constants a, b, c, α , β , γ	215.97Å 215.97Å 64.46Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	53.99 – 3.28 53.99 – 3.28	Depositor EDS
% Data completeness (in resolution range)	99.8 (53.99-3.28) 99.7 (53.99-3.28)	Depositor EDS
R_{merge}	0.07	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.51 (at 3.26Å)	Xtriage
Refinement program	PHENIX 1.21.2_5419	Depositor
R, R_{free}	0.216 , 0.240 0.217 , 0.240	Depositor DCC
R_{free} test set	2011 reflections (8.68%)	wwPDB-VP
Wilson B-factor (Å ²)	98.8	Xtriage
Anisotropy	0.019	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.31 , 51.1	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	0.024 for -k,-h,-l	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	5344	wwPDB-VP
Average B, all atoms (Å ²)	93.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.25% 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	0.16	0/2723	0.35	0/3697
1	B	0.15	0/2713	0.35	0/3686
All	All	0.15	0/5436	0.35	0/7383

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	2677	0	2735	47	0
1	B	2667	0	2722	39	0
All	All	5344	0	5457	85	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 8.

All (85) 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:522:LYS:HB2	1:B:507:GLN:HE22	1.50	0.75
1:A:621:GLU:OE1	1:A:624:LEU:HB2	1.89	0.72

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:375:VAL:HG21	1:A:407:ILE:HG21	1.72	0.71
1:A:638:ARG:HH22	1:A:688:THR:H	1.38	0.70
1:A:638:ARG:NH2	1:A:688:THR:H	1.92	0.66
1:B:466:ILE:HD12	1:B:470:LEU:HD23	1.77	0.65
1:B:381:GLY:HA3	1:B:384:LEU:HD12	1.80	0.64
1:A:657:LEU:HD13	1:A:660:ARG:HH11	1.64	0.63
1:B:603:ASP:HB2	1:B:690:GLY:HA3	1.80	0.63
1:A:390:ILE:HD11	1:A:489:GLU:HG3	1.82	0.61
1:B:390:ILE:HD11	1:B:489:GLU:HG3	1.82	0.61
1:A:442:PRO:HB2	1:A:444:THR:HG23	1.84	0.60
1:A:527:LEU:HD12	1:A:531:VAL:HB	1.84	0.60
1:B:624:LEU:HD12	1:B:627:ARG:HB3	1.82	0.59
1:A:473:GLN:O	1:A:476:ILE:HG12	2.05	0.57
1:B:650:VAL:HG11	1:B:658:LEU:HD12	1.89	0.55
1:A:459:PHE:HB2	1:A:461:LEU:HD13	1.89	0.54
1:A:369:TYR:CE2	1:A:415:PRO:HB3	2.43	0.54
1:A:600:ILE:HG12	1:A:639:GLN:HG3	1.89	0.54
1:B:600:ILE:HG12	1:B:639:GLN:HG3	1.90	0.53
1:B:427:ILE:HG13	1:B:495:LEU:HD13	1.91	0.53
1:A:365:MET:HE1	1:A:488:VAL:HG11	1.92	0.52
1:B:472:GLU:O	1:B:476:ILE:HG12	2.09	0.52
1:A:441:ASN:HB2	1:A:479:PHE:CE1	2.46	0.51
1:B:467:GLU:HG3	1:B:469:ALA:H	1.76	0.51
1:A:512:LEU:O	1:A:516:VAL:HG23	2.11	0.51
1:A:366:GLU:HA	1:A:408:ARG:O	2.11	0.51
1:B:370:ARG:HD3	1:B:415:PRO:HB2	1.93	0.51
1:B:527:LEU:HD12	1:B:531:VAL:HB	1.92	0.50
1:B:466:ILE:HG23	1:B:470:LEU:HB3	1.93	0.50
1:A:371:LEU:HD13	1:A:416:ALA:HA	1.93	0.50
1:B:366:GLU:HA	1:B:408:ARG:O	2.11	0.50
1:B:621:GLU:CD	1:B:622:PRO:HD3	2.37	0.50
1:A:670:VAL:HG12	1:A:672:LEU:HD13	1.93	0.49
1:B:602:LEU:HD22	1:B:650:VAL:HG12	1.94	0.49
1:B:660:ARG:HH11	1:B:660:ARG:HG3	1.76	0.49
1:B:455:VAL:HG12	1:B:462:ASP:HA	1.95	0.49
1:B:410:ASN:HB3	1:B:413:LEU:HD13	1.94	0.49
1:A:625:ALA:HB1	1:A:661:PHE:CZ	2.48	0.48
1:B:449:LEU:HD22	1:B:470:LEU:HD21	1.94	0.48
1:A:657:LEU:HD13	1:A:660:ARG:NH1	2.28	0.48
1:B:369:TYR:CE2	1:B:415:PRO:HB3	2.48	0.48
1:A:472:GLU:O	1:A:476:ILE:HG23	2.14	0.47

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:586:ILE:HG23	1:A:590:TRP:HZ3	1.79	0.47
1:A:605:ALA:O	1:A:609:LEU:HG	2.15	0.47
1:A:575:THR:O	1:A:579:ARG:HG3	2.15	0.46
1:A:602:LEU:HD23	1:A:650:VAL:HG12	1.97	0.46
1:A:620:LEU:HD13	1:A:625:ALA:HB2	1.97	0.46
1:B:437:TRP:HE3	1:B:481:VAL:HG12	1.80	0.46
1:A:636:LEU:HD21	1:A:668:GLN:HG2	1.98	0.46
1:A:600:ILE:CG1	1:A:639:GLN:HG3	2.46	0.46
1:B:522:LYS:HB3	1:B:522:LYS:HE3	1.68	0.46
1:A:625:ALA:HB1	1:A:661:PHE:CE1	2.51	0.45
1:A:533:THR:HG23	1:A:536:THR:H	1.82	0.44
1:A:486:THR:O	1:A:490:THR:HG23	2.17	0.44
1:B:574:LEU:O	1:B:577:VAL:HG22	2.18	0.44
1:B:512:LEU:O	1:B:516:VAL:HG23	2.17	0.44
1:A:670:VAL:HG12	1:A:672:LEU:CD1	2.47	0.44
1:B:466:ILE:HG22	1:B:467:GLU:O	2.18	0.44
1:B:603:ASP:CB	1:B:690:GLY:HA3	2.47	0.44
1:A:370:ARG:HD3	1:A:415:PRO:HB2	2.00	0.44
1:A:576:ALA:O	1:A:580:VAL:HG13	2.18	0.43
1:B:622:PRO:HB2	1:B:624:LEU:H	1.81	0.43
1:A:639:GLN:OE1	1:A:644:ALA:HB3	2.19	0.43
1:B:397:ASP:O	1:B:552:ARG:HD2	2.17	0.43
1:B:414:GLN:HB3	1:B:415:PRO:HD2	2.00	0.43
1:A:370:ARG:HH21	1:A:434:PRO:HD2	1.83	0.43
1:B:438:LEU:HD11	1:B:463:ALA:HB1	2.00	0.43
1:A:374:MET:HE2	1:A:374:MET:HB3	1.74	0.42
1:A:377:PHE:CD1	1:A:378:GLN:HG3	2.54	0.42
1:A:515:ARG:HH12	1:A:519:GLU:HB2	1.84	0.42
1:A:371:LEU:HD11	1:A:432:ALA:O	2.19	0.42
1:A:603:ASP:HB2	1:A:690:GLY:HA3	2.01	0.42
1:B:586:ILE:HG23	1:B:590:TRP:HZ3	1.84	0.42
1:A:369:TYR:HA	1:A:372:ILE:HG13	2.01	0.42
1:A:466:ILE:H	1:A:466:ILE:HG13	1.78	0.41
1:B:652:HIS:HB2	1:B:675:LEU:HD13	2.01	0.41
1:B:483:GLU:O	1:B:487:VAL:HG23	2.20	0.41
1:B:639:GLN:OE1	1:B:686:THR:HB	2.20	0.41
1:A:632:THR:HG21	1:A:662:LEU:HD22	2.03	0.41
1:B:441:ASN:C	1:B:443:GLY:H	2.27	0.41
1:B:611:LEU:O	1:B:614:LEU:HB2	2.22	0.40
1:A:472:GLU:HG2	1:A:473:GLN:N	2.35	0.40
1:B:600:ILE:CG1	1:B:639:GLN:HG3	2.50	0.40

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:574:LEU:O	1:A:577:VAL:HG22	2.22	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	343/389 (88%)	326 (95%)	16 (5%)	1 (0%)	36	66
1	B	342/389 (88%)	330 (96%)	11 (3%)	1 (0%)	36	66
All	All	685/778 (88%)	656 (96%)	27 (4%)	2 (0%)	36	66

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	622	PRO
1	A	349	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 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	289/329 (88%)	289 (100%)	0	100	100
1	B	288/329 (88%)	288 (100%)	0	100	100
All	All	577/658 (88%)	577 (100%)	0	100	100

There are no protein residues with a non-rotameric sidechain to report.

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (8) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	494	HIS
1	A	510	GLN
1	A	588	GLN
1	A	633	GLN
1	A	680	ASN
1	B	355	ASN
1	B	507	GLN
1	B	589	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 ⓘ

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 [i](#)

6.1 Protein, DNA and RNA chains [i](#)

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	345/389 (88%)	0.08	7 (2%) 65 46	56, 93, 137, 169	0
1	B	344/389 (88%)	0.15	10 (2%) 53 35	56, 89, 132, 159	0
All	All	689/778 (88%)	0.12	17 (2%) 58 39	56, 91, 135, 169	0

All (17) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	377	PHE	4.2
1	B	620	LEU	3.8
1	B	691	GLY	3.6
1	B	448	THR	3.3
1	A	620	LEU	3.3
1	A	348	SER	3.2
1	A	349	VAL	3.1
1	B	447	GLY	3.1
1	B	624	LEU	2.6
1	A	377	PHE	2.4
1	B	553	ASP	2.3
1	B	623	GLY	2.2
1	B	350	VAL	2.1
1	A	444	THR	2.1
1	A	479	PHE	2.1
1	A	423	LYS	2.1
1	B	556	THR	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.