



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 12, 2026 – 10:58 AM UTC

PDB ID : 3K1P / pdb_00003k1p
Title : Crystal Structure of full-length BenM E226K mutant
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Deposited on : 2009-09-28
Resolution : 3.00 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

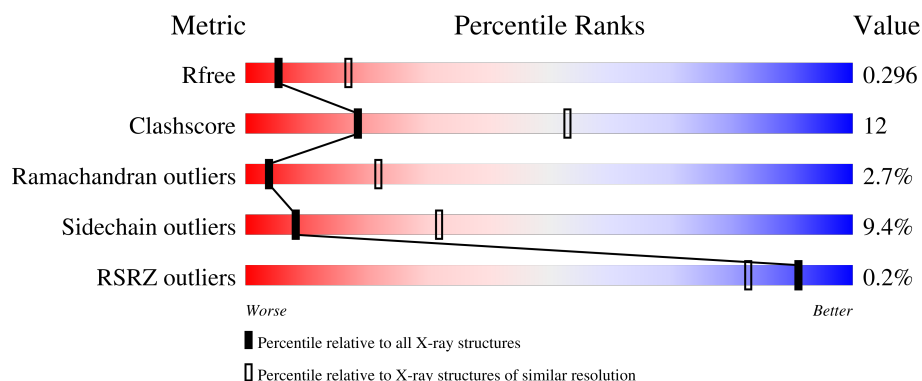
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 3.00 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	2672 (3.00-3.00)
Clashscore	190562	2977 (3.00-3.00)
Ramachandran outliers	187476	2877 (3.00-3.00)
Sidechain outliers	187428	2880 (3.00-3.00)
RSRZ outliers	180081	2671 (3.00-3.00)

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	312	 63% 30% . .
1	B	312	 69% 23% 5% .

2 Entry composition

There are 2 unique types of molecules in this entry. The entry contains 5235 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 HTH-type transcriptional regulator benM.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	303	Total	C	N	O	S	0	1	0
			2424	1554	418	443	9			
1	B	303	Total	C	N	O	S	0	3	0
			2438	1562	422	445	9			

There are 18 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	226	LYS	GLU	engineered mutation	UNP O68014
A	305	LEU	-	expression tag	UNP O68014
A	306	GLU	-	expression tag	UNP O68014
A	307	HIS	-	expression tag	UNP O68014
A	308	HIS	-	expression tag	UNP O68014
A	309	HIS	-	expression tag	UNP O68014
A	310	HIS	-	expression tag	UNP O68014
A	311	HIS	-	expression tag	UNP O68014
A	312	HIS	-	expression tag	UNP O68014
B	226	LYS	GLU	engineered mutation	UNP O68014
B	305	LEU	-	expression tag	UNP O68014
B	306	GLU	-	expression tag	UNP O68014
B	307	HIS	-	expression tag	UNP O68014
B	308	HIS	-	expression tag	UNP O68014
B	309	HIS	-	expression tag	UNP O68014
B	310	HIS	-	expression tag	UNP O68014
B	311	HIS	-	expression tag	UNP O68014
B	312	HIS	-	expression tag	UNP O68014

- Molecule 2 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	196	Total	O	0	0
			196	196		

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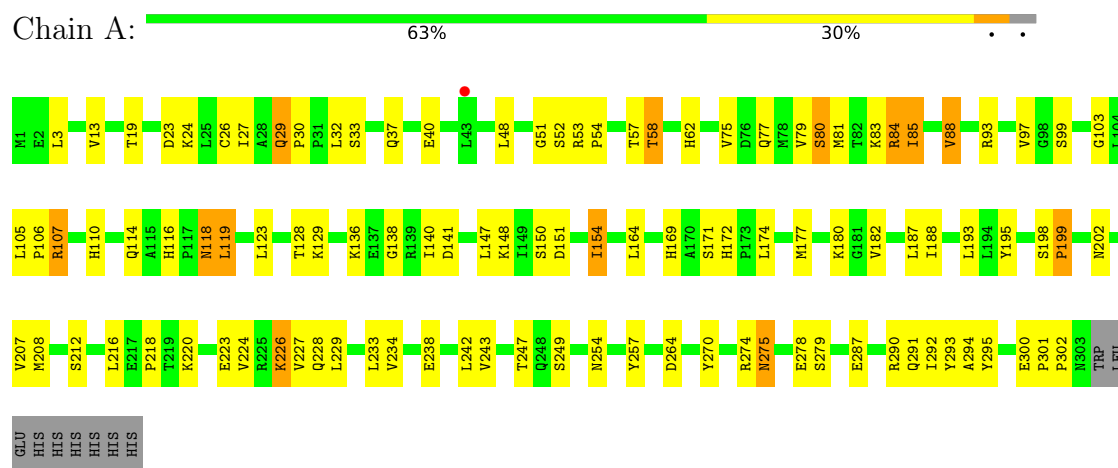
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Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	B	177	Total 177	O 177	0	0

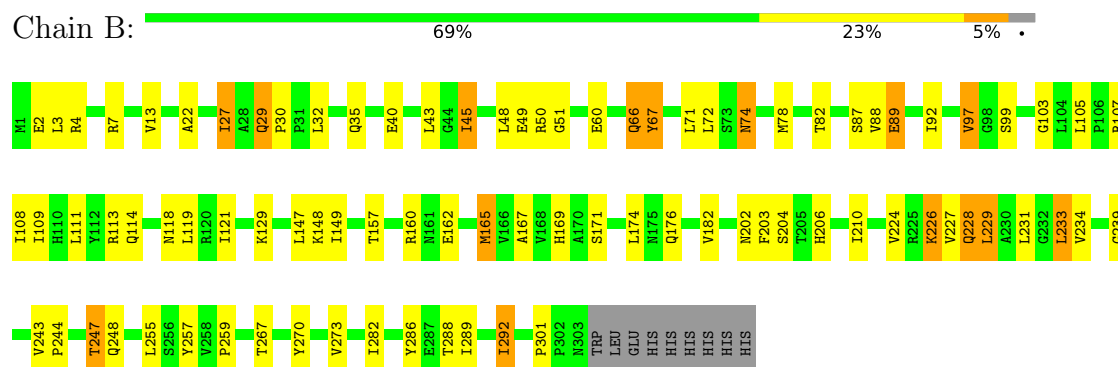
3 Residue-property plots

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: HTH-type transcriptional regulator benM



- Molecule 1: HTH-type transcriptional regulator benM



4 Data and refinement statistics

Property	Value	Source
Space group	P 2 2 21	Depositor
Cell constants a, b, c, α , β , γ	70.60Å 70.70Å 187.28Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	48.27 – 3.00 48.27 – 3.00	Depositor EDS
% Data completeness (in resolution range)	90.7 (48.27-3.00) 98.0 (48.27-3.00)	Depositor EDS
R_{merge}	0.09	Depositor
R_{sym}	0.09	Depositor
$\langle I/\sigma(I) \rangle$ ¹	3.14 (at 3.01Å)	Xtriage
Refinement program	REFMAC	Depositor
R, R_{free}	0.197 , 0.226 0.268 , 0.296	Depositor DCC
R_{free} test set	1011 reflections (5.21%)	wwPDB-VP
Wilson B-factor (Å ²)	61.4	Xtriage
Anisotropy	0.236	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.34 , 86.4	EDS
L-test for twinning ²	$\langle L \rangle = 0.52$, $\langle L^2 \rangle = 0.36$	Xtriage
Estimated twinning fraction	0.167 for k,h,-l	Xtriage
Reported twinning fraction	0.598 for H, K, L 0.402 for K, H, -L	Depositor
Outliers	1 of 19392 reflections (0.005%)	Xtriage
F_o, F_c correlation	0.92	EDS
Total number of atoms	5235	wwPDB-VP
Average B, all atoms (Å ²)	38.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.68% 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

5.1 Standard geometry

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	0.52	0/2477	0.85	0/3355
1	B	0.52	0/2494	0.86	0/3377
All	All	0.52	0/4971	0.85	0/6732

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	2424	0	2486	67	0
1	B	2438	0	2503	54	0
2	A	196	0	0	14	0
2	B	177	0	0	6	0
All	All	5235	0	4989	118	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 12.

All (118) 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:226:LYS:HD3	1:A:227:VAL:H	1.29	0.97

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:198:SER:HB2	1:A:199:PRO:HD2	1.47	0.94
1:A:118:ASN:HA	2:A:356:HOH:O	1.68	0.94
1:B:226:LYS:HD2	1:B:227:VAL:H	1.33	0.93
1:B:66:GLN:O	1:B:67:TYR:HB3	1.78	0.83
1:A:198:SER:HB2	1:A:199:PRO:CD	2.09	0.82
1:B:226:LYS:CD	1:B:227:VAL:H	1.95	0.79
1:A:3:LEU:HG	1:B:3:LEU:HG	1.64	0.78
1:B:169:HIS:HD2	1:B:171:SER:H	1.37	0.73
1:B:92:ILE:HG12	1:B:119:LEU:HD11	1.72	0.69
1:B:118:ASN:HA	2:B:409:HOH:O	1.92	0.68
1:B:169:HIS:CD2	1:B:171:SER:H	2.11	0.68
1:A:148:LYS:HE3	1:A:270:TYR:OH	1.94	0.68
1:A:169:HIS:CE1	1:A:254:ASN:HB3	2.30	0.67
1:B:229:LEU:O	1:B:233:LEU:HB2	1.93	0.67
1:A:188:ILE:HG21	1:A:216:LEU:HD22	1.78	0.66
1:B:228:GLN:OE1	2:B:394:HOH:O	2.12	0.66
1:B:40:GLU:HA	1:B:45:ILE:HG13	1.77	0.65
1:A:116:HIS:HB3	1:A:119:LEU:HD22	1.80	0.63
1:A:103:GLY:HA3	2:A:344:HOH:O	1.98	0.63
1:A:226:LYS:NZ	2:A:419:HOH:O	2.29	0.62
1:A:233:LEU:HD22	1:A:238:GLU:HG3	1.83	0.60
1:A:141:ASP:HA	1:A:274:ARG:HH22	1.65	0.60
1:A:195:TYR:CZ	1:A:227:VAL:HG23	2.37	0.60
1:A:172:HIS:CE1	1:A:174:LEU:HD12	2.37	0.59
1:B:105:LEU:O	1:B:109:ILE:HG12	2.02	0.59
1:A:195:TYR:OH	1:A:243:VAL:HG12	2.03	0.59
1:A:85:ILE:HG13	2:B:362:HOH:O	2.02	0.58
1:A:84:ARG:HD3	2:A:424:HOH:O	2.02	0.58
1:A:48:LEU:HA	1:A:58:THR:HG21	1.85	0.57
1:A:79:VAL:O	1:A:80:SER:HB2	2.05	0.56
1:A:226:LYS:HD3	1:A:227:VAL:N	2.12	0.56
1:B:165:MET:HB3	1:B:259:PRO:HA	1.86	0.56
1:A:180:LYS:HB2	2:A:505:HOH:O	2.04	0.56
1:B:226:LYS:HD2	1:B:227:VAL:HG12	1.88	0.56
1:A:290:ARG:NE	1:A:301:PRO:O	2.33	0.56
1:A:136:LYS:HG3	1:A:154:ILE:HD11	1.87	0.56
1:A:302:PRO:HD2	2:A:367:HOH:O	2.05	0.55
1:A:141:ASP:HA	1:A:274:ARG:NH2	2.22	0.55
1:A:79:VAL:HG11	1:B:43:LEU:HD13	1.88	0.54
1:A:207:VAL:HG13	1:A:242:LEU:HD22	1.89	0.54
1:A:52:SER:HB3	2:A:428:HOH:O	2.08	0.53

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:287:GLU:O	1:A:291:GLN:HG3	2.07	0.53
1:B:92:ILE:HB	1:B:119:LEU:HD21	1.89	0.53
1:B:165:MET:HE2	1:B:257:TYR:HB3	1.91	0.52
1:B:88:VAL:HG22	1:B:118:ASN:O	2.10	0.51
1:B:273:VAL:HG11	1:B:282:ILE:HG21	1.92	0.51
1:A:118:ASN:ND2	1:A:118:ASN:H	2.09	0.50
1:B:67:TYR:HE1	1:B:71:LEU:HD12	1.76	0.50
1:A:164:LEU:HD13	1:A:242:LEU:HD23	1.93	0.50
1:A:174:LEU:HD22	1:A:182:VAL:HG11	1.94	0.50
1:A:77:GLN:O	1:A:81:MET:HB2	2.12	0.50
1:B:4[A]:ARG:HE	1:B:35:GLN:HE22	1.59	0.49
1:B:244:PRO:HD2	1:B:247:THR:HG21	1.94	0.49
1:A:3:LEU:HB2	1:B:2:GLU:HA	1.95	0.49
1:A:80:SER:O	1:A:84:ARG:HG3	2.13	0.48
1:B:29:GLN:HB3	1:B:30:PRO:HD3	1.95	0.48
1:A:105:LEU:HB3	1:A:106:PRO:HD3	1.95	0.48
1:A:218:PRO:HA	2:A:335:HOH:O	2.13	0.47
1:B:7:ARG:HE	1:B:72:LEU:HD21	1.79	0.47
1:A:107:ARG:HB3	2:A:371:HOH:O	2.13	0.47
1:A:79:VAL:O	1:A:80:SER:CB	2.62	0.47
1:A:128:THR:HG22	2:A:464:HOH:O	2.14	0.47
1:A:182:VAL:HG21	1:A:187:LEU:HD21	1.95	0.47
1:A:193:LEU:HD12	1:A:234:VAL:HG23	1.96	0.47
1:B:234:VAL:HG22	1:B:239:GLY:O	2.15	0.47
1:B:174:LEU:HD22	1:B:182:VAL:HG11	1.97	0.46
1:A:83:LYS:C	1:A:85:ILE:H	2.23	0.46
1:B:226:LYS:CD	1:B:227:VAL:N	2.71	0.46
1:A:123:LEU:N	2:A:355:HOH:O	2.48	0.46
1:B:148:LYS:HE2	1:B:270:TYR:OH	2.15	0.46
1:B:203:PHE:CZ	1:B:244:PRO:HD3	2.50	0.46
1:A:13:VAL:HG22	1:A:48:LEU:HD11	1.98	0.46
1:B:113:ARG:HG3	1:B:121:ILE:HD12	1.97	0.46
1:B:111:LEU:HD23	1:B:288:THR:HG23	1.97	0.45
1:B:286:TYR:OH	1:B:301:PRO:HB2	2.17	0.45
1:A:83:LYS:HB2	2:B:378:HOH:O	2.16	0.45
1:B:97:VAL:HG12	1:B:99:SER:HB3	1.98	0.45
1:A:138:GLY:HA2	1:A:274:ARG:NH1	2.31	0.45
1:A:292:ILE:HA	1:A:295:TYR:HD2	1.82	0.45
1:A:290:ARG:NH1	1:A:300:GLU:OE2	2.50	0.45
1:B:74:ASN:O	1:B:78:MET:HB2	2.18	0.44
1:A:53:ARG:HA	1:A:54:PRO:HA	1.87	0.44

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:13:VAL:HG22	1:B:48:LEU:HD11	2.00	0.44
1:B:226:LYS:HA	1:B:226:LYS:HD3	1.60	0.44
1:A:220:LYS:HB2	2:A:439:HOH:O	2.18	0.44
1:B:67:TYR:CE1	1:B:71:LEU:HD12	2.53	0.44
1:B:206:HIS:O	1:B:210:ILE:HG12	2.17	0.44
1:A:83:LYS:O	1:A:85:ILE:N	2.50	0.43
1:A:257:TYR:HD2	2:A:488:HOH:O	2.01	0.43
1:A:227:VAL:HG13	1:A:228:GLN:N	2.33	0.43
1:B:248:GLN:HG2	1:B:257:TYR:CD2	2.54	0.43
1:B:160:ARG:NH2	1:B:162:GLU:HG3	2.33	0.43
1:A:97:VAL:HG12	1:A:99:SER:HB3	2.00	0.43
1:B:160:ARG:HH22	1:B:162:GLU:HG3	1.82	0.43
1:B:167:ALA:HB1	1:B:255:LEU:HD11	2.01	0.43
1:A:29:GLN:HB2	1:A:30:PRO:HD3	2.01	0.43
1:A:57:THR:HB	1:A:62:HIS:HB2	2.01	0.42
1:B:49:GLU:HB2	2:B:486:HOH:O	2.19	0.42
1:B:286:TYR:HA	1:B:289:ILE:HD12	2.01	0.42
1:A:202:ASN:HB2	2:A:351:HOH:O	2.20	0.42
1:B:22:ALA:HA	1:B:27:ILE:HD11	2.01	0.42
1:A:247:THR:C	1:A:249:SER:H	2.28	0.42
1:A:93:ARG:HB2	1:A:140:ILE:HA	2.02	0.42
1:A:150:SER:O	1:A:151:ASP:HB2	2.20	0.41
1:B:165:MET:SD	1:B:248:GLN:OE1	2.78	0.41
1:A:33:SER:O	1:A:37:GLN:HG2	2.21	0.41
1:A:174:LEU:CD2	1:A:182:VAL:HG11	2.50	0.41
1:A:169:HIS:CD2	1:A:171:SER:H	2.38	0.41
1:A:293:TYR:O	1:A:294:ALA:C	2.63	0.41
1:B:169:HIS:HD2	1:B:171:SER:N	2.13	0.41
1:B:202:ASN:OD1	1:B:204:SER:HB3	2.21	0.41
1:B:226:LYS:O	1:B:229:LEU:HB2	2.21	0.41
1:A:110:HIS:O	1:A:114:GLN:HG2	2.21	0.41
1:B:108:ILE:HG22	1:B:109:ILE:HD13	2.03	0.41
1:B:103:GLY:HA3	2:B:348:HOH:O	2.21	0.40
1:B:231:LEU:HD21	1:B:243:VAL:HG11	2.03	0.40
1:B:292:ILE:HD13	1:B:292:ILE:HA	1.89	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	302/312 (97%)	268 (89%)	23 (8%)	11 (4%)	2	16
1	B	304/312 (97%)	265 (87%)	33 (11%)	6 (2%)	6	28
All	All	606/624 (97%)	533 (88%)	56 (9%)	17 (3%)	4	21

All (17) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	129	LYS
1	A	24	LYS
1	A	26	CYS
1	A	40	GLU
1	A	80	SER
1	A	84	ARG
1	B	67	TYR
1	A	29	GLN
1	B	29	GLN
1	B	87	SER
1	A	51	GLY
1	B	89	GLU
1	A	275[A]	ASN
1	A	275[B]	ASN
1	B	51	GLY
1	A	199	PRO
1	A	88	VAL

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	268/276 (97%)	242 (90%)	26 (10%)	8	30
1	B	270/276 (98%)	245 (91%)	25 (9%)	8	32
All	All	538/552 (98%)	487 (90%)	51 (10%)	8	31

All (51) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	19	THR
1	A	23	ASP
1	A	27	ILE
1	A	32	LEU
1	A	58	THR
1	A	75	VAL
1	A	85	ILE
1	A	88	VAL
1	A	107	ARG
1	A	118	ASN
1	A	119	LEU
1	A	129	LYS
1	A	147	LEU
1	A	154	ILE
1	A	177	MET
1	A	208	MET
1	A	212	SER
1	A	223	GLU
1	A	224	VAL
1	A	226	LYS
1	A	229	LEU
1	A	264	ASP
1	A	275[A]	ASN
1	A	275[B]	ASN
1	A	278	GLU
1	A	279	SER
1	B	27	ILE
1	B	32	LEU
1	B	45	ILE
1	B	50	ARG
1	B	60	GLU
1	B	66	GLN
1	B	74	ASN
1	B	82	THR

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Mol	Chain	Res	Type
1	B	89	GLU
1	B	97	VAL
1	B	107	ARG
1	B	114	GLN
1	B	147	LEU
1	B	149	ILE
1	B	157	THR
1	B	165	MET
1	B	176	GLN
1	B	224	VAL
1	B	226	LYS
1	B	228	GLN
1	B	229	LEU
1	B	233	LEU
1	B	247	THR
1	B	267	THR
1	B	292	ILE

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (12) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	29	GLN
1	A	46	GLN
1	A	77	GLN
1	A	118	ASN
1	A	169	HIS
1	A	185	ASN
1	B	29	GLN
1	B	35	GLN
1	B	62	HIS
1	B	66	GLN
1	B	74	ASN
1	B	169	HIS

5.3.3 RNA ⓘ

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 oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

There are no ligands in this entry.

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.

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	303/312 (97%)	-1.18	1 (0%) 90 79	2, 16, 109, 124	1 (0%)
1	B	303/312 (97%)	-1.13	0 100 100	2, 18, 134, 144	3 (0%)
All	All	606/624 (97%)	-1.16	1 (0%) 91 83	2, 17, 126, 144	4 (0%)

All (1) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	43	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.