



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 6, 2026 – 03:59 AM UTC

PDB ID : 2PL9 / pdb_00002pl9
Title : Crystal Structure of CheY-Mg(2+)-BeF(3)(-) in Complex with CheZ(C19)
Peptide solved from a P2(1)2(1)2 Crystal
Authors : Guhaniyogi, J.; Stock, A.M.
Deposited on : 2007-04-19
Resolution : 2.60 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
Mogul : 2022.3.0, CSD as543be (2022)
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

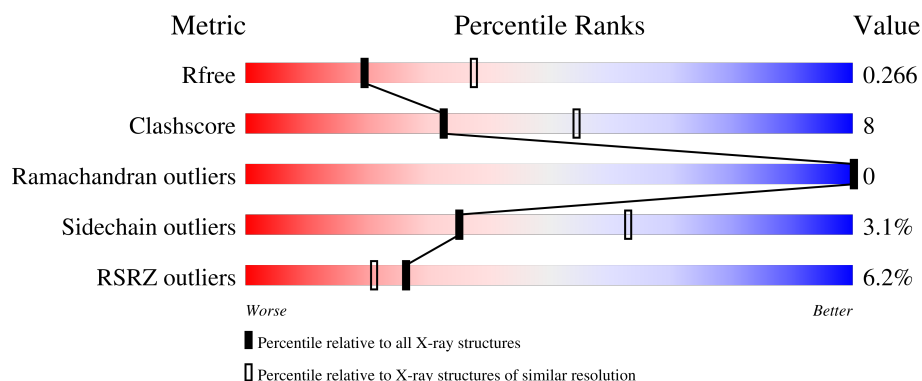
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.60 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	4008 (2.60-2.60)
Clashscore	190562	4347 (2.60-2.60)
Ramachandran outliers	187476	4277 (2.60-2.60)
Sidechain outliers	187428	4277 (2.60-2.60)
RSRZ outliers	180081	4008 (2.60-2.60)

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	128	3% 81% 16% .
1	B	128	5% 88% 9% .
1	C	128	3% 80% 19% .
2	D	19	32% 74% 26%
2	E	19	11% 63% 16% 21%

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Mol	Chain	Length	Quality of chain
2	F	19	21% 58% 21% 21%

2 Entry composition

There are 6 unique types of molecules in this entry. The entry contains 3389 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 Chemotaxis protein cheY.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	128	Total	C	N	O	S	0	0	0
			981	625	162	188	6			
1	B	128	Total	C	N	O	S	0	0	0
			981	625	162	188	6			
1	C	128	Total	C	N	O	S	0	0	0
			981	625	162	188	6			

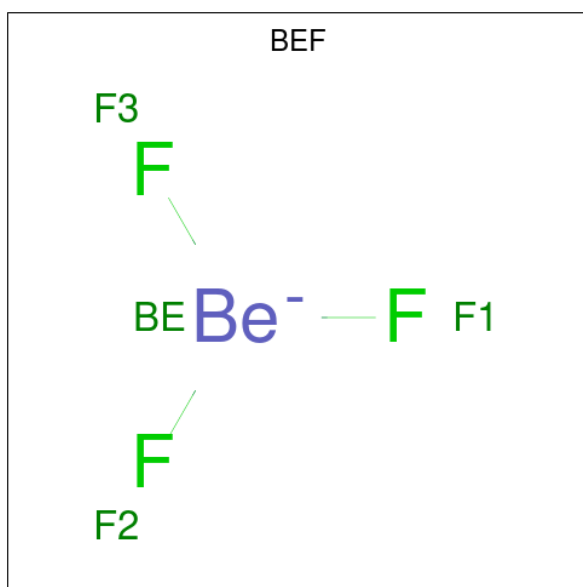
- Molecule 2 is a protein called Chemotaxis protein cheZ.

Mol	Chain	Residues	Atoms				ZeroOcc	AltConf	Trace
2	D	19	Total	C	N	O	0	0	0
			137	84	21	32			
2	E	15	Total	C	N	O	0	0	0
			114	69	17	28			
2	F	15	Total	C	N	O	0	0	0
			114	69	17	28			

- Molecule 3 is MAGNESIUM ION (CCD ID: MG) (formula: Mg).

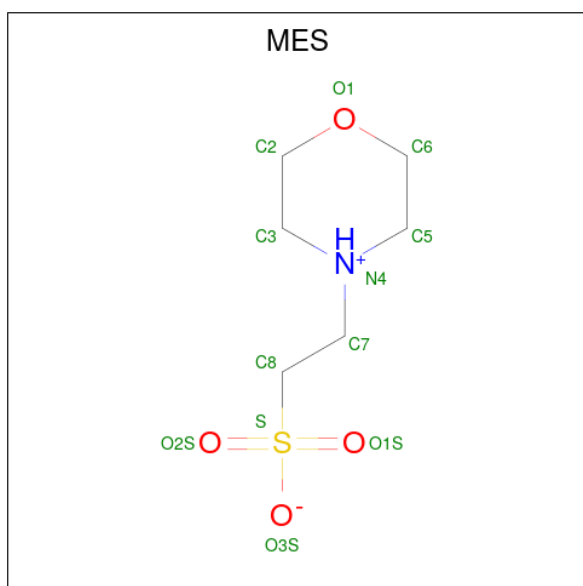
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	1	Total	Mg	0	0
			1	1		
3	B	1	Total	Mg	0	0
			1	1		
3	C	1	Total	Mg	0	0
			1	1		

- Molecule 4 is BERYLLIUM TRIFLUORIDE ION (CCD ID: BEF) (formula: BeF₃).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	A	1	Total	Be	F	0	0
			4	1	3		
4	B	1	Total	Be	F	0	0
			4	1	3		
4	C	1	Total	Be	F	0	0
			4	1	3		

- Molecule 5 is 2-(N-MORPHOLINO)-ETHANESULFONIC ACID (CCD ID: MES) (formula: $C_6H_{13}NO_4S$).

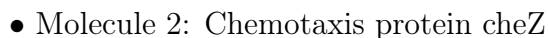
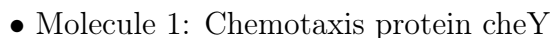


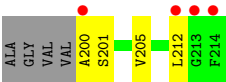
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
5	B	1	Total	C	N	O	S	0	0
			12	6	1	4	1		

- Molecule 6 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	17	Total	O	0	0
			17	17		
6	B	12	Total	O	0	0
			12	12		
6	C	20	Total	O	0	0
			20	20		
6	D	2	Total	O	0	0
			2	2		
6	F	3	Total	O	0	0
			3	3		

- Molecule 1: Chemotaxis protein cheY





4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 2	Depositor
Cell constants a, b, c, α , β , γ	68.06Å 162.97Å 37.34Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	29.40 – 2.60 29.40 – 2.60	Depositor EDS
% Data completeness (in resolution range)	99.4 (29.40-2.60) 99.3 (29.40-2.60)	Depositor EDS
R_{merge}	0.14	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	7.60 (at 2.61Å)	Xtriage
Refinement program	REFMAC 5.2.0005	Depositor
R, R_{free}	0.213 , 0.274 0.213 , 0.266	Depositor DCC
R_{free} test set	1371 reflections (10.19%)	wwPDB-VP
Wilson B-factor (Å ²)	15.2	Xtriage
Anisotropy	0.328	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.35 , 37.6	EDS
L-test for twinning ²	$\langle L \rangle = 0.45$, $\langle L^2 \rangle = 0.28$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.88	EDS
Total number of atoms	3389	wwPDB-VP
Average B, all atoms (Å ²)	22.0	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 24.36 % 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 3.8950e-03. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

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

Bond lengths and bond angles in the following residue types are not validated in this section: BEF, MES, MG

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	0.82	1/993 (0.1%)	0.90	2/1334 (0.1%)
1	B	0.76	0/993	0.92	1/1334 (0.1%)
1	C	0.77	0/993	0.86	0/1334
2	D	0.71	0/137	0.77	1/184 (0.5%)
2	E	0.75	0/114	0.75	0/152
2	F	0.73	0/114	0.73	0/152
All	All	0.78	1/3344 (0.0%)	0.88	4/4490 (0.1%)

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	119	LYS	CD-CE	5.42	1.68	1.52

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	56	SER	N-CA-C	6.61	120.27	109.24
1	A	79	SER	N-CA-C	5.28	118.82	112.38
1	B	33	VAL	N-CA-C	5.20	115.53	107.78
2	D	197	GLY	N-CA-C	-5.02	108.44	114.66

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	981	0	1003	17	0
1	B	981	0	1003	11	0
1	C	981	0	1003	18	0
2	D	137	0	126	11	0
2	E	114	0	100	2	0
2	F	114	0	100	4	0
3	A	1	0	0	0	0
3	B	1	0	0	0	0
3	C	1	0	0	0	0
4	A	4	0	0	0	0
4	B	4	0	0	0	0
4	C	4	0	0	0	0
5	B	12	0	12	0	0
6	A	17	0	0	0	0
6	B	12	0	0	0	0
6	C	20	0	0	0	0
6	D	2	0	0	0	0
6	F	3	0	0	0	0
All	All	3389	0	3347	53	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 (53) 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:106:TYR:H	1:C:119:LYS:NZ	1.57	1.03
1:C:24:LEU:HD11	1:C:113:ALA:HA	1.41	1.01
2:D:199:VAL:HG13	2:D:204:GLN:HB3	1.57	0.86
2:D:199:VAL:HG13	2:D:204:GLN:CB	2.13	0.77
1:A:96:ILE:CD1	2:D:212:LEU:CD1	2.63	0.75
1:C:106:TYR:H	1:C:119:LYS:HZ1	1.35	0.71
1:A:96:ILE:HD12	2:D:212:LEU:HD13	1.74	0.69
1:A:43:LEU:O	1:A:47:GLN:HG2	1.96	0.66
1:A:96:ILE:HD12	2:D:212:LEU:CD1	2.26	0.66
1:C:24:LEU:HD13	1:C:116:LEU:HD23	1.79	0.65
1:B:115:THR:O	1:B:119:LYS:HG2	1.98	0.63
1:B:8:PHE:HB2	1:B:33:VAL:HG22	1.81	0.62
1:B:84:LEU:HD11	1:B:107:VAL:HG23	1.81	0.61
1:A:86:VAL:HG22	1:A:107:VAL:HB	1.84	0.60

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:92:LYS:O	1:A:96:ILE:HG12	2.03	0.58
1:A:119:LYS:O	1:A:123:ILE:HG12	2.04	0.57
2:D:199:VAL:CG1	2:D:204:GLN:CB	2.83	0.57
1:C:89:GLU:OE1	1:C:94:ASN:ND2	2.37	0.56
1:C:122:LYS:HG2	1:C:126:LYS:HE3	1.87	0.56
1:B:41:ASP:O	1:B:45:LYS:HD2	2.06	0.56
2:D:199:VAL:CG1	2:D:204:GLN:HB2	2.38	0.54
1:A:11:VAL:HG12	1:A:60:MET:SD	2.48	0.53
1:A:18:ARG:HD2	1:A:35:GLU:HB3	1.90	0.52
1:C:90:ALA:HB1	2:F:200:ALA:HB3	1.91	0.52
1:B:107:VAL:HG22	1:B:119:LYS:HG3	1.92	0.52
1:A:122:LYS:O	1:A:125:GLU:HG3	2.09	0.51
2:D:199:VAL:HG13	2:D:204:GLN:HB2	1.92	0.50
1:B:95:ILE:CG2	2:E:208:LEU:HD23	2.42	0.49
1:B:119:LYS:O	1:B:123:ILE:HD13	2.12	0.48
1:B:95:ILE:HG21	2:E:208:LEU:HD23	1.95	0.48
1:C:106:TYR:N	1:C:119:LYS:NZ	2.42	0.47
1:A:96:ILE:CD1	2:D:212:LEU:HD13	2.39	0.46
2:D:199:VAL:CG1	2:D:204:GLN:HB3	2.39	0.46
1:C:58:TRP:C	1:C:58:TRP:CD1	2.92	0.46
1:A:7:LYS:HB3	1:A:51:PHE:HA	1.98	0.46
1:C:12:ASP:OD2	1:C:57:ASP:HB2	2.16	0.46
1:C:122:LYS:O	1:C:125:GLU:HG3	2.16	0.45
1:B:54:ILE:HD13	1:B:72:ILE:HD13	1.98	0.45
1:C:121:ASN:HA	1:C:124:PHE:HB2	1.99	0.44
1:B:123:ILE:N	1:B:123:ILE:CD1	2.81	0.44
1:A:64:ASP:OD1	1:A:64:ASP:C	2.61	0.43
1:C:93:GLU:HA	1:C:93:GLU:OE1	2.18	0.43
2:F:201:SER:O	2:F:205:VAL:HG23	2.18	0.43
1:A:4:LYS:HD3	1:A:4:LYS:H	1.83	0.42
1:C:96:ILE:HG12	2:F:212:LEU:HD11	2.01	0.42
1:C:108:VAL:HG13	2:F:205:VAL:HG21	2.00	0.41
1:A:41:ASP:OD1	1:A:45:LYS:NZ	2.53	0.41
1:C:8:PHE:HB2	1:C:33:VAL:HG22	2.02	0.41
1:C:54:ILE:HD13	1:C:72:ILE:HD13	2.02	0.41
1:A:96:ILE:HD11	2:D:212:LEU:CD1	2.46	0.41
1:A:54:ILE:HD13	1:A:72:ILE:HD13	2.02	0.40
1:B:87:THR:HA	1:B:109:LYS:HE3	2.03	0.40
1:C:91:LYS:HB2	1:C:94:ASN:HD22	1.85	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	126/128 (98%)	118 (94%)	8 (6%)	0	100	100
1	B	126/128 (98%)	123 (98%)	3 (2%)	0	100	100
1	C	126/128 (98%)	122 (97%)	4 (3%)	0	100	100
2	D	17/19 (90%)	16 (94%)	1 (6%)	0	100	100
2	E	13/19 (68%)	13 (100%)	0	0	100	100
2	F	13/19 (68%)	13 (100%)	0	0	100	100
All	All	421/441 (96%)	405 (96%)	16 (4%)	0	100	100

There are no Ramachandran outliers to report.

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	103/103 (100%)	100 (97%)	3 (3%)	37	65
1	B	103/103 (100%)	100 (97%)	3 (3%)	37	65
1	C	103/103 (100%)	101 (98%)	2 (2%)	50	75
2	D	15/15 (100%)	14 (93%)	1 (7%)	15	33
2	E	13/15 (87%)	11 (85%)	2 (15%)	2	5
2	F	13/15 (87%)	13 (100%)	0	100	100
All	All	350/354 (99%)	339 (97%)	11 (3%)	35	63

All (11) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	4	LYS
1	A	7	LYS
1	A	92	LYS
1	B	34	GLU
1	B	45	LYS
1	B	123	ILE
1	C	24	LEU
1	C	115	THR
2	D	208	LEU
2	E	203	ASP
2	E	211	SER

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	44	ASN
1	B	31	ASN
1	B	32	ASN
1	B	100	GLN
1	C	31	ASN
1	C	44	ASN
1	C	121	ASN
2	F	204	GLN

5.3.3 RNA [i](#)

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

Of 7 ligands modelled in this entry, 3 are monoatomic - leaving 4 for Mogul analysis.

In the following table, the Counts columns list the number of bonds (or angles) for which Mogul statistics could be retrieved, the number of bonds (or angles) that are observed in the model and the number of bonds (or angles) that are defined in the Chemical Component Dictionary. The Link column lists molecule types, if any, to which the group is linked. 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 $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	# Z > 2	Counts	RMSZ	# Z > 2
4	BEF	A	131	-	0,3,3	-	-	-		
5	MES	B	132	-	12,12,12	2.07	1 (8%)	15,16,16	4.51	8 (53%)
4	BEF	B	131	-	0,3,3	-	-	-		
4	BEF	C	131	-	0,3,3	-	-	-		

In the following table, the Chirals column lists the number of chiral outliers, the number of chiral centers analysed, the number of these observed in the model and the number defined in the Chemical Component Dictionary. Similar counts are reported in the Torsion and Rings columns. '-' means no outliers of that kind were identified.

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
5	MES	B	132	-	-	1/6/14/14	0/1/1/1

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
5	B	132	MES	C8-S	-6.55	1.68	1.77

All (8) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
5	B	132	MES	O1S-S-C8	-10.20	91.31	106.73
5	B	132	MES	O2S-S-C8	-8.63	93.69	106.73
5	B	132	MES	C5-N4-C3	7.81	125.66	108.84
5	B	132	MES	O3S-S-C8	-4.84	96.53	106.00
5	B	132	MES	O3S-S-O1S	3.69	120.63	111.40
5	B	132	MES	C7-N4-C3	2.82	118.76	111.24
5	B	132	MES	O3S-S-O2S	2.56	117.81	111.40
5	B	132	MES	O1-C2-C3	-2.05	107.36	111.77

There are no chirality outliers.

All (1) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
5	B	132	MES	C8-C7-N4-C5

There are no ring outliers.

No monomer is involved in short contacts.

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

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	128/128 (100%)	0.38	4 (3%)	51	45	19, 22, 25, 28	0
1	B	128/128 (100%)	0.64	7 (5%)	30	25	18, 22, 25, 29	0
1	C	128/128 (100%)	0.41	4 (3%)	51	45	19, 22, 26, 30	0
2	D	19/19 (100%)	1.45	6 (31%)	1	1	19, 21, 23, 24	0
2	E	15/19 (78%)	1.00	2 (13%)	7	5	21, 22, 23, 23	0
2	F	15/19 (78%)	1.36	4 (26%)	1	1	19, 21, 24, 25	0
All	All	433/441 (98%)	0.57	27 (6%)	26	21	18, 22, 25, 30	0

All (27) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	32	ASN	4.2
2	D	202	GLN	4.2
2	F	200	ALA	4.0
2	D	196	ALA	3.7
2	D	200	ALA	3.3
2	D	201	SER	3.1
2	D	198	VAL	3.1
1	B	94	ASN	3.0
1	C	127	LEU	2.9
2	E	200	ALA	2.9
2	F	212	LEU	2.9
1	B	92	LYS	2.8
1	B	43	LEU	2.7
2	F	213	GLY	2.6
1	B	42	ALA	2.6
1	B	44	ASN	2.6
1	A	125	GLU	2.5
2	D	199	VAL	2.4
1	C	20	ILE	2.4

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Mol	Chain	Res	Type	RSRZ
1	B	93	GLU	2.3
1	A	32	ASN	2.3
1	A	5	GLU	2.3
1	C	93	GLU	2.2
2	E	203	ASP	2.2
2	F	214	PHE	2.2
1	C	125	GLU	2.2
1	A	20	ILE	2.1

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, 95th 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($\text{\AA}^2$)	Q<0.9
4	BEF	C	131	4/4	0.85	0.18	24,25,25,26	0
4	BEF	A	131	4/4	0.91	0.11	18,18,19,20	0
4	BEF	B	131	4/4	0.93	0.08	21,21,21,22	0
5	MES	B	132	12/12	0.93	0.16	29,30,32,32	0
3	MG	B	130	1/1	0.94	0.06	21,21,21,21	0
3	MG	A	130	1/1	0.96	0.06	21,21,21,21	0
3	MG	C	130	1/1	0.98	0.05	18,18,18,18	0

6.5 Other polymers [i](#)

There are no such residues in this entry.