



Full wwPDB EM Validation Report ⓘ

May 6, 2026 – 12:19 PM JST

PDB ID : 9MAE / pdb_00009mae
EMDB ID : EMD-63750
Title : Cryo-EM structure of heteromeric Kir4.1/5.1 potassium channel in apo state
Authors : Ning, Y.; Ge, J.; Yu, J.
Deposited on : 2025-03-14
Resolution : 3.13 Å(reported)

This is a Full wwPDB EM 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/EMValidationReportHelp>

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:

EMDB validation analysis : **FAILED**
MolProbity : 4-5-2 with Phenix2.0
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
EM percentile statistics : **NOT EXECUTED**
MapQ : **FAILED**
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.49

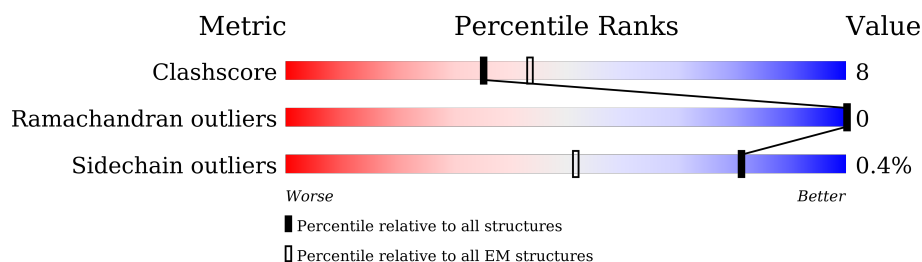
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

ELECTRON MICROSCOPY

The reported resolution of this entry is 3.13 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)	EM structures (#Entries)
Clashscore	229148	23984
Ramachandran outliers	224038	23583
Sidechain outliers	223484	23102

The table below summarises the geometric issues observed across the polymeric chains and their fit to the map. The red, orange, yellow and green segments of the 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 $\leq 5\%$

Mol	Chain	Length	Quality of chain
1	A	337	77% 17% 5%
1	C	337	79% 16% 5%
2	B	345	69% 21% 9%
2	D	345	72% 19% 9%

2 Entry composition

There are 3 unique types of molecules in this entry. The entry contains 10163 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, 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 Inward rectifier potassium channel 16.

Mol	Chain	Residues	Atoms					AltConf	Trace
1	A	320	Total	C	N	O	S	0	0
			2596	1681	440	460	15		
1	C	320	Total	C	N	O	S	0	0
			2596	1681	440	460	15		

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	19	MET	-	initiating methionine	UNP Q9NPI9
C	19	MET	-	initiating methionine	UNP Q9NPI9

- Molecule 2 is a protein called ATP-sensitive inward rectifier potassium channel 10.

Mol	Chain	Residues	Atoms					AltConf	Trace
2	B	313	Total	C	N	O	S	0	0
			2484	1613	415	447	9		
2	D	313	Total	C	N	O	S	0	0
			2484	1613	415	447	9		

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
B	24	MET	-	initiating methionine	UNP P78508
D	24	MET	-	initiating methionine	UNP P78508

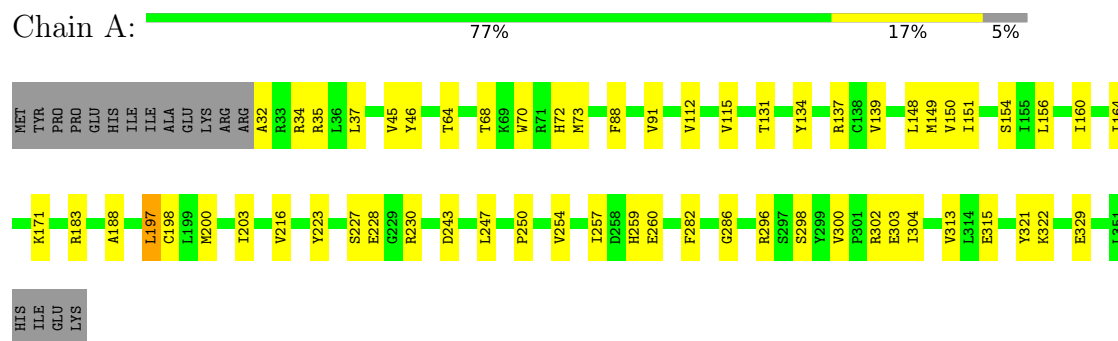
- Molecule 3 is POTASSIUM ION (CCD ID: K) (formula: K) (labeled as "Ligand of Interest" by depositor).

Mol	Chain	Residues	Atoms		AltConf
3	A	2	Total	K	0
			2	2	
3	B	1	Total	K	0
			1	1	

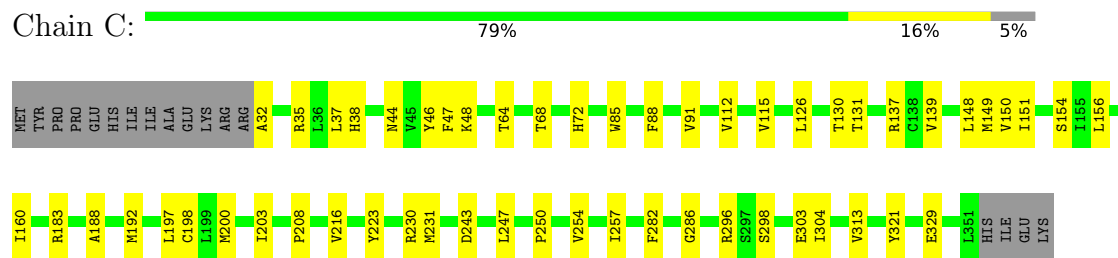
3 Residue-property plots [i](#)

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. 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. 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.

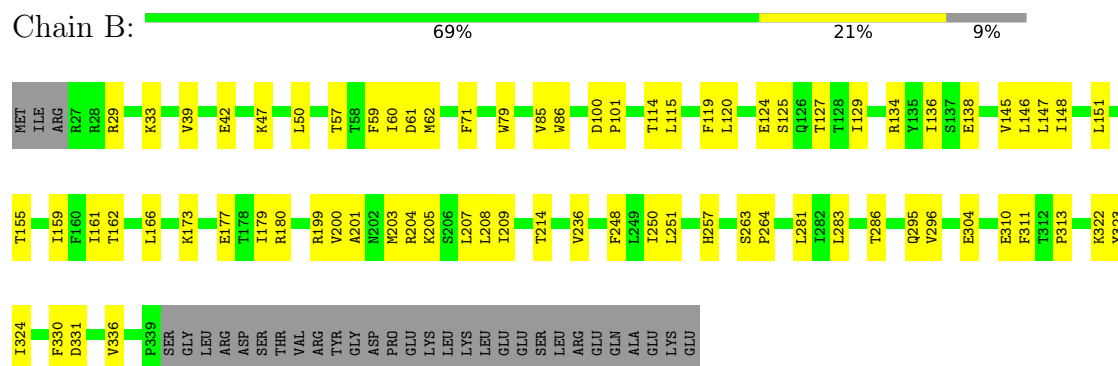
- Molecule 1: Inward rectifier potassium channel 16



- Molecule 1: Inward rectifier potassium channel 16

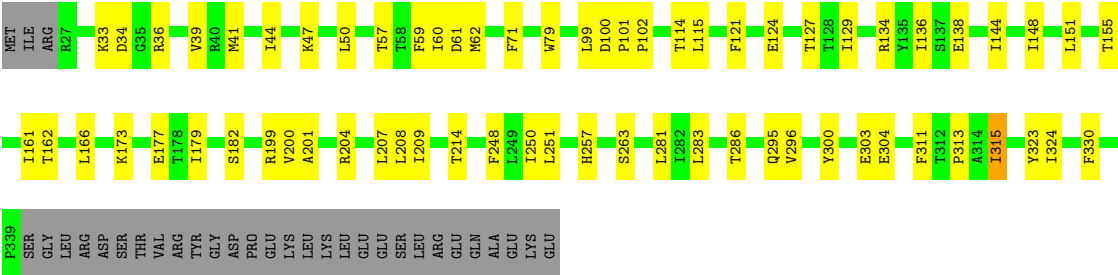


- Molecule 2: ATP-sensitive inward rectifier potassium channel 10



- Molecule 2: ATP-sensitive inward rectifier potassium channel 10





4 Experimental information

Property	Value	Source
EM reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, Not provided	
Number of particles used	336364	Depositor
Resolution determination method	FSC 0.143 CUT-OFF	Depositor
CTF correction method	PHASE FLIPPING AND AMPLITUDE CORRECTION	Depositor
Microscope	TFS KRIOS	Depositor
Voltage (kV)	300	Depositor
Electron dose ($e^-/\text{\AA}^2$)	50	Depositor
Minimum defocus (nm)	1000	Depositor
Maximum defocus (nm)	2000	Depositor
Magnification	Not provided	
Image detector	GATAN K3 (6k x 4k)	Depositor

5 Model quality [i](#)

5.1 Standard geometry [i](#)

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

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	0/2661	0.26	0/3607
1	C	0.11	0/2661	0.25	0/3607
2	B	0.12	0/2542	0.26	0/3458
2	D	0.12	0/2542	0.26	0/3458
All	All	0.11	0/10406	0.26	0/14130

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	2596	0	2582	44	0
1	C	2596	0	2582	43	0
2	B	2484	0	2527	53	0
2	D	2484	0	2527	48	0
3	A	2	0	0	0	0
3	B	1	0	0	0	0
All	All	10163	0	10218	161	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 (161) 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:322:LYS:HZ2	2:B:42:GLU:HG3	1.50	0.77
2:B:179:ILE:HD11	2:B:208:LEU:HD11	1.66	0.76
2:B:313:PRO:HB2	1:C:230:ARG:HB3	1.71	0.72
1:A:88:PHE:HD1	1:A:149:MET:HE1	1.53	0.72
1:C:321:TYR:HB2	2:D:39:VAL:HG12	1.72	0.71
1:C:35:ARG:NH2	1:C:303:GLU:OE2	2.25	0.70
1:A:35:ARG:NH2	1:A:303:GLU:OE2	2.25	0.70
1:A:37:LEU:HD21	1:A:296:ARG:HB3	1.73	0.69
1:A:321:TYR:HB2	2:B:39:VAL:HG12	1.74	0.69
2:D:177:GLU:O	2:D:204:ARG:NH1	2.28	0.67
1:C:37:LEU:HD21	1:C:296:ARG:HB3	1.77	0.66
1:A:156:LEU:O	1:A:160:ILE:HG13	1.96	0.65
1:C:156:LEU:O	1:C:160:ILE:HG13	1.97	0.65
1:C:88:PHE:HD1	1:C:149:MET:HE1	1.61	0.63
1:A:230:ARG:HB3	2:D:313:PRO:HB2	1.80	0.63
1:C:35:ARG:NH1	1:C:298:SER:OG	2.33	0.61
2:D:179:ILE:HB	2:D:296:VAL:HG21	1.82	0.61
2:D:179:ILE:HD11	2:D:208:LEU:HD11	1.82	0.61
1:A:35:ARG:NH1	1:A:298:SER:OG	2.35	0.59
1:A:68:THR:HG22	1:A:72:HIS:HB2	1.85	0.59
2:B:179:ILE:HB	2:B:296:VAL:HG21	1.86	0.58
1:C:200:MET:HB3	1:C:254:VAL:HG22	1.86	0.57
2:B:180:ARG:NH2	2:B:331:ASP:OD2	2.37	0.57
1:A:228:GLU:OE1	1:A:228:GLU:N	2.40	0.55
2:D:200:VAL:HG11	2:D:283:LEU:HD13	1.89	0.55
1:C:35:ARG:O	1:C:44:ASN:ND2	2.40	0.55
1:A:88:PHE:CD1	1:A:149:MET:HE1	2.38	0.54
2:B:114:THR:HG22	2:B:115:LEU:H	1.72	0.54
2:B:200:VAL:HG11	2:B:283:LEU:HD13	1.89	0.54
1:C:137:ARG:NH2	2:D:136:ILE:O	2.34	0.54
2:D:250:ILE:HG23	2:D:251:LEU:HG	1.89	0.54
2:B:151:LEU:O	2:B:155:THR:OG1	2.18	0.54
1:C:68:THR:HG22	1:C:72:HIS:HB2	1.89	0.54
1:A:151:ILE:HG23	2:D:79:TRP:HZ3	1.73	0.54
2:B:47:LYS:HD2	2:B:50:LEU:HD12	1.90	0.53
2:B:207:LEU:HD12	2:B:248:PHE:HB2	1.90	0.53
1:C:208:PRO:HA	2:D:41:MET:HG2	1.90	0.53
1:A:200:MET:HB3	1:A:254:VAL:HG22	1.89	0.53
2:D:47:LYS:HD2	2:D:50:LEU:HD12	1.91	0.53
1:A:154:SER:HB3	2:D:127:THR:HG21	1.90	0.53

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
2:B:257:HIS:HE2	2:B:263:SER:HG	1.57	0.53
1:C:32:ALA:O	1:C:223:TYR:OH	2.25	0.53
1:A:227:SER:OG	1:A:228:GLU:OE1	2.21	0.52
1:C:243:ASP:OD1	1:C:243:ASP:N	2.35	0.52
1:C:85:TRP:HZ3	2:D:148:ILE:HG23	1.75	0.51
2:D:144:ILE:O	2:D:148:ILE:HG12	2.10	0.51
1:C:88:PHE:HA	1:C:91:VAL:HG12	1.92	0.51
1:C:126:LEU:O	1:C:130:THR:OG1	2.18	0.51
1:C:216:VAL:HG22	1:C:282:PHE:HD1	1.76	0.51
1:C:88:PHE:CD1	1:C:149:MET:HE1	2.43	0.51
2:D:114:THR:HG22	2:D:115:LEU:H	1.75	0.51
2:D:257:HIS:HE2	2:D:263:SER:HG	1.56	0.51
1:A:243:ASP:OD1	1:A:243:ASP:N	2.36	0.51
2:B:250:ILE:HG23	2:B:251:LEU:HG	1.94	0.50
1:A:216:VAL:HG22	1:A:282:PHE:HD1	1.76	0.50
1:A:73:MET:HE3	1:A:171:LYS:HD2	1.92	0.50
2:B:71:PHE:HD1	2:B:161:ILE:HG21	1.76	0.50
1:A:197:LEU:HD23	1:A:257:ILE:HD12	1.93	0.50
2:B:209:ILE:N	2:B:286:THR:O	2.45	0.50
2:B:324:ILE:HD11	1:C:48:LYS:HD3	1.94	0.50
1:A:137:ARG:NH2	2:B:136:ILE:O	2.37	0.50
2:D:199:ARG:NH1	2:D:311:PHE:HB3	2.27	0.50
2:B:199:ARG:NH1	2:B:311:PHE:HB3	2.27	0.49
2:B:79:TRP:HZ3	1:C:151:ILE:HG23	1.76	0.49
2:B:100:ASP:HB3	2:B:101:PRO:HD3	1.94	0.49
2:D:71:PHE:HD1	2:D:161:ILE:HG21	1.78	0.49
1:C:64:THR:O	1:C:68:THR:OG1	2.29	0.49
1:A:88:PHE:HA	1:A:91:VAL:HG12	1.95	0.49
2:B:129:ILE:HG12	1:C:131:THR:HA	1.95	0.49
2:D:33:LYS:NZ	2:D:304:GLU:OE1	2.27	0.49
1:C:250:PRO:HG2	1:C:313:VAL:HG21	1.95	0.49
2:D:59:PHE:HA	2:D:62:MET:HG2	1.94	0.49
2:D:179:ILE:HD13	2:D:283:LEU:HD22	1.94	0.48
2:B:29:ARG:NH2	2:B:304:GLU:OE2	2.46	0.48
1:A:131:THR:HA	2:D:129:ILE:HG12	1.94	0.48
2:D:182:SER:O	2:D:300:TYR:OH	2.21	0.48
1:C:68:THR:O	1:C:72:HIS:ND1	2.46	0.48
1:A:64:THR:O	1:A:68:THR:OG1	2.29	0.48
2:B:322:LYS:HB2	1:C:46:TYR:HB2	1.96	0.48
1:A:286:GLY:O	2:B:295:GLN:NE2	2.47	0.47
2:D:207:LEU:HB3	2:D:250:ILE:HD13	1.97	0.47

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
2:D:41:MET:HE2	2:D:44:ILE:HG23	1.95	0.47
1:A:68:THR:O	1:A:72:HIS:ND1	2.47	0.47
2:B:162:THR:O	2:B:166:LEU:HG	2.15	0.47
2:D:100:ASP:HB3	2:D:101:PRO:HD3	1.96	0.47
2:D:207:LEU:HD12	2:D:248:PHE:HB2	1.96	0.47
2:D:61:ASP:HB3	2:D:173:LYS:HD2	1.97	0.47
1:C:198:CYS:HB3	1:C:254:VAL:HG13	1.98	0.46
2:B:136:ILE:HG13	2:B:147:LEU:HD22	1.97	0.46
2:B:124:GLU:OE2	2:B:134:ARG:NH2	2.48	0.46
1:C:286:GLY:O	2:D:295:GLN:NE2	2.47	0.46
1:A:148:LEU:HA	1:A:151:ILE:HD12	1.98	0.46
2:D:138:GLU:H	2:D:138:GLU:HG2	1.60	0.46
1:A:259:HIS:CE1	1:A:260:GLU:HG2	2.51	0.46
1:A:198:CYS:HB3	1:A:254:VAL:HG13	1.97	0.46
2:D:214:THR:O	2:D:281:LEU:HD23	2.16	0.46
1:C:192:MET:HB3	1:C:192:MET:HE3	1.81	0.46
2:D:124:GLU:OE2	2:D:134:ARG:NH2	2.49	0.45
1:A:250:PRO:HG2	1:A:313:VAL:HG21	1.98	0.45
1:C:139:VAL:HG21	1:C:150:VAL:HG21	1.98	0.45
2:D:162:THR:O	2:D:166:LEU:HG	2.15	0.45
1:C:188:ALA:HB3	1:C:304:ILE:HG12	1.98	0.45
2:D:209:ILE:N	2:D:286:THR:O	2.50	0.45
2:B:127:THR:HG21	1:C:154:SER:HB3	1.99	0.45
2:B:145:VAL:O	2:B:148:ILE:HG22	2.16	0.45
2:B:208:LEU:O	2:B:209:ILE:HD13	2.17	0.45
1:A:46:TYR:HD2	2:D:324:ILE:HG22	1.82	0.44
2:B:59:PHE:HA	2:B:62:MET:HG3	2.00	0.44
2:B:177:GLU:O	2:B:204:ARG:NH2	2.51	0.44
2:B:214:THR:O	2:B:281:LEU:HD23	2.16	0.44
2:D:50:LEU:HD23	2:D:50:LEU:HA	1.84	0.44
1:C:85:TRP:CZ3	2:D:148:ILE:HG23	2.51	0.44
1:A:315:GLU:HB3	1:A:322:LYS:HB3	1.99	0.44
2:D:99:LEU:C	2:D:102:PRO:HD2	2.43	0.44
1:C:203:ILE:HG23	1:C:247:LEU:HD11	1.99	0.44
2:B:205:LYS:HG3	1:C:47:PHE:CE2	2.53	0.44
2:D:251:LEU:HD13	2:D:315:ILE:HD12	2.00	0.44
2:B:57:THR:HA	2:B:60:ILE:HG22	2.00	0.43
1:C:183:ARG:NH2	1:C:329:GLU:OE2	2.46	0.43
2:D:57:THR:HA	2:D:60:ILE:HG22	2.00	0.43
2:D:151:LEU:O	2:D:155:THR:OG1	2.20	0.43
1:A:112:VAL:HG13	1:A:115:VAL:HB	2.01	0.43

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:C:112:VAL:HG13	1:C:115:VAL:HB	2.01	0.43
1:A:45:VAL:HG12	2:D:323:TYR:HB2	2.01	0.43
2:B:61:ASP:HB3	2:B:173:LYS:HD2	1.99	0.43
2:D:47:LYS:HA	2:D:47:LYS:HD3	1.80	0.43
1:A:188:ALA:HB3	1:A:304:ILE:HG12	2.00	0.43
2:B:323:TYR:CE1	1:C:231:MET:HE1	2.54	0.43
1:A:183:ARG:NH2	1:A:329:GLU:OE2	2.42	0.42
1:C:38:HIS:NE2	1:C:44:ASN:HB2	2.34	0.42
2:D:34:ASP:OD2	2:D:36:ARG:NE	2.43	0.42
1:A:203:ILE:HG23	1:A:247:LEU:HD11	2.00	0.42
1:C:148:LEU:HA	1:C:151:ILE:HD12	2.01	0.42
2:D:201:ALA:HB2	2:D:330:PHE:CE1	2.54	0.42
2:D:207:LEU:HD23	2:D:207:LEU:H	1.84	0.42
2:B:201:ALA:HB2	2:B:330:PHE:CE1	2.54	0.42
2:B:33:LYS:NZ	2:B:304:GLU:OE1	2.30	0.42
1:C:231:MET:HE2	1:C:231:MET:HB2	1.79	0.42
1:A:139:VAL:HG21	1:A:150:VAL:HG21	2.01	0.42
2:B:199:ARG:HD3	2:B:330:PHE:CD1	2.55	0.42
1:A:247:LEU:HD12	1:A:247:LEU:HA	1.89	0.41
2:B:119:PHE:HE2	1:C:151:ILE:HD11	1.85	0.41
2:B:120:LEU:HD23	2:B:120:LEU:HA	1.94	0.41
2:B:204:ARG:HA	2:B:204:ARG:HD3	1.80	0.41
2:B:57:THR:O	2:B:60:ILE:HG22	2.20	0.41
1:C:197:LEU:HD23	1:C:257:ILE:HD12	2.02	0.41
2:B:207:LEU:HB3	2:B:250:ILE:HD13	2.03	0.41
1:A:164:ILE:HG22	2:B:159:ILE:HG21	2.02	0.41
1:A:70:TRP:CE2	1:A:171:LYS:HD3	2.55	0.41
1:A:32:ALA:O	1:A:223:TYR:OH	2.24	0.41
2:B:310:GLU:HG3	2:B:336:VAL:HG21	2.03	0.41
2:D:121:PHE:HD2	2:D:134:ARG:HB3	1.86	0.41
1:A:34:ARG:HD3	1:A:34:ARG:HA	1.82	0.41
2:B:86:TRP:CH2	2:B:136:ILE:HD11	2.56	0.41
2:D:57:THR:O	2:D:60:ILE:HG22	2.21	0.41
2:B:250:ILE:HD12	2:B:250:ILE:HA	1.93	0.40
2:B:85:VAL:HG12	2:B:146:LEU:HD11	2.03	0.40
1:A:134:TYR:OH	2:B:125:SER:OG	2.26	0.40
2:B:180:ARG:HG2	2:B:203:MET:HE3	2.02	0.40
1:A:300:VAL:HG23	1:A:302:ARG:HG2	2.03	0.40
2:B:236:VAL:HG22	2:B:264:PRO:HG2	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 PDB entries followed by that with respect to all EM entries.

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	318/337 (94%)	308 (97%)	10 (3%)	0	100	100
1	C	318/337 (94%)	307 (96%)	11 (4%)	0	100	100
2	B	311/345 (90%)	304 (98%)	7 (2%)	0	100	100
2	D	311/345 (90%)	303 (97%)	8 (3%)	0	100	100
All	All	1258/1364 (92%)	1222 (97%)	36 (3%)	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 PDB entries followed by that with respect to all EM entries.

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	284/300 (95%)	283 (100%)	1 (0%)	84	84
1	C	284/300 (95%)	284 (100%)	0	100	100
2	B	275/304 (90%)	274 (100%)	1 (0%)	84	84
2	D	275/304 (90%)	273 (99%)	2 (1%)	76	79
All	All	1118/1208 (92%)	1114 (100%)	4 (0%)	81	84

All (4) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	197	LEU
2	B	138	GLU

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Mol	Chain	Res	Type
2	D	303	GLU
2	D	315	ILE

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (9) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	242	ASN
1	A	349	GLN
2	B	235	ASN
1	C	242	ASN
1	C	349	GLN
2	D	104	ASN
2	D	113	HIS
2	D	228	ASN
2	D	235	ASN

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 [i](#)

Of 3 ligands modelled in this entry, 3 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 [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.