



wwPDB X-ray Structure Validation Summary Report ⓘ

Jul 8, 2026 – 01:09 pm BST

PDB ID : 28IL / pdb_000028il
Title : P1-15 T-cell Receptor bound to HLA A*2402-NF9 pMHC complex
Authors : Wall, A.; Sewell, A.K.; Motozono, C.; Rizkallah, P.J.; Fuller, A.
Deposited on : 2026-02-02
Resolution : 3.10 Å(reported)

This is a wwPDB X-ray Structure Validation Summary 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	:	9.0.015 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.50

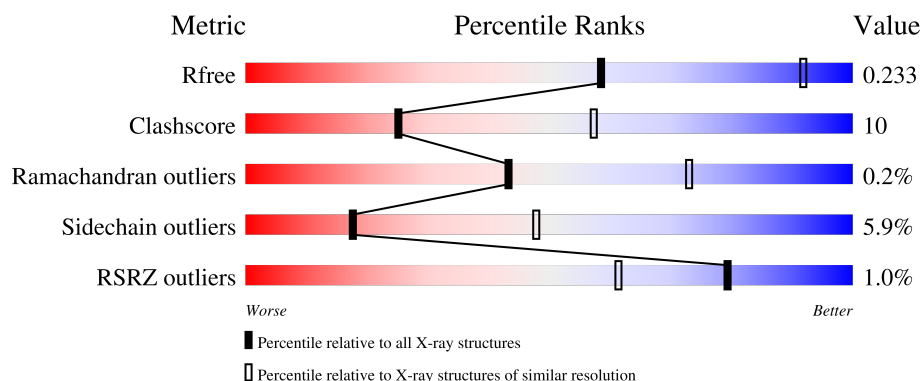
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 3.10 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	1456 (3.10-3.10)
Clashscore	190562	1539 (3.10-3.10)
Ramachandran outliers	187476	1467 (3.10-3.10)
Sidechain outliers	187428	1467 (3.10-3.10)
RSRZ outliers	180081	1456 (3.10-3.10)

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	276	
1	F	276	
2	B	100	
2	G	100	
3	C	9	

Continued on next page...

Continued from previous page...

Mol	Chain	Length	Quality of chain
3	H	9	78% 22%
4	D	204	% 59% 37% •
4	I	204	% 72% 24% •
5	E	245	71% 26% •
5	J	245	65% 34% •

2 Entry composition [i](#)

There are 5 unique types of molecules in this entry. The entry contains 13408 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 MHC class I antigen.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	276	Total	C	N	O	S	0	0	0
			2238	1392	405	431	10			
1	F	276	Total	C	N	O	S	0	0	0
			2238	1392	405	431	10			

- Molecule 2 is a protein called Beta-2-microglobulin.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	B	100	Total	C	N	O	S	0	0	0
			837	533	141	159	4			
2	G	100	Total	C	N	O	S	0	0	0
			837	533	141	159	4			

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
B	0	MET	-	initiating methionine	UNP P61769
G	0	MET	-	initiating methionine	UNP P61769

- Molecule 3 is a protein called Spike protein S1.

Mol	Chain	Residues	Atoms				ZeroOcc	AltConf	Trace
3	C	9	Total	C	N	O	0	0	0
			91	62	14	15			
3	H	9	Total	C	N	O	0	0	0
			91	62	14	15			

- Molecule 4 is a protein called P1-15 T-cell Receptor Alpha Chain.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
4	D	204	Total	C	N	O	S	0	0	0
			1600	998	270	321	11			

Continued on next page...

Continued from previous page...

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
4	I	204	Total	C	N	O	S	0	0	0
			1600	998	270	321	11			

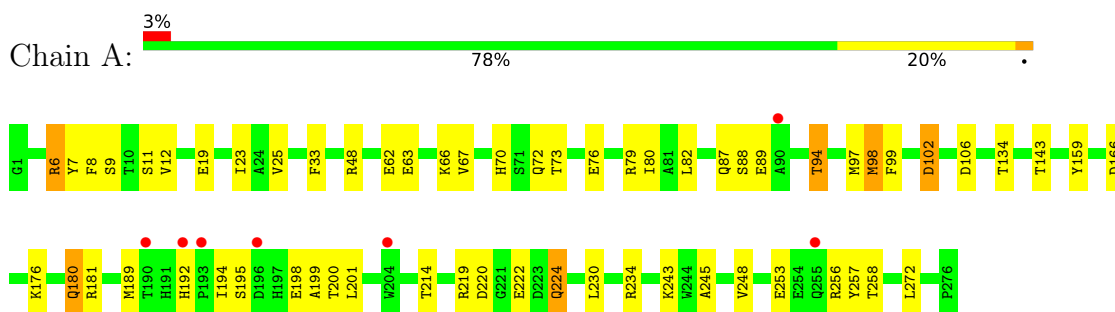
- Molecule 5 is a protein called P1-15 T-cell Receptor Beta Chain.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
5	E	245	Total	C	N	O	S	0	0	0
			1938	1212	336	380	10			
5	J	245	Total	C	N	O	S	0	0	0
			1938	1212	336	380	10			

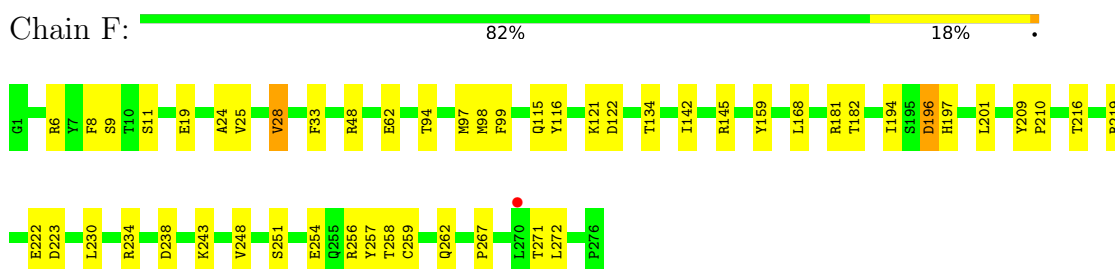
3 Residue-property plots [i](#)

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.

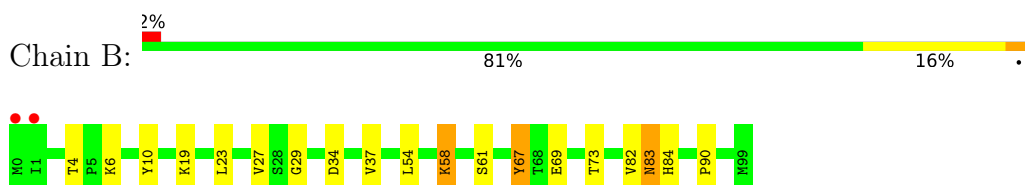
- Molecule 1: MHC class I antigen



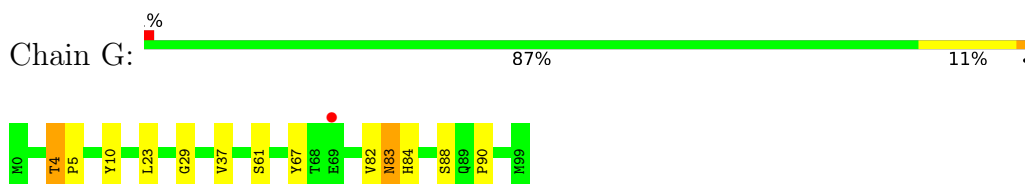
- Molecule 1: MHC class I antigen



- Molecule 2: Beta-2-microglobulin



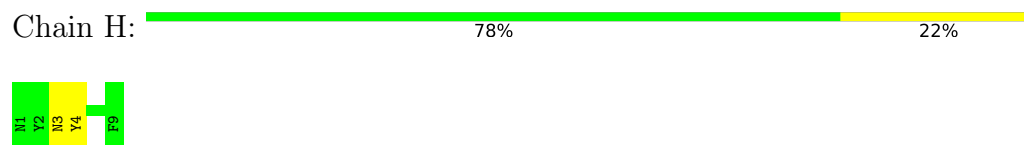
- Molecule 2: Beta-2-microglobulin



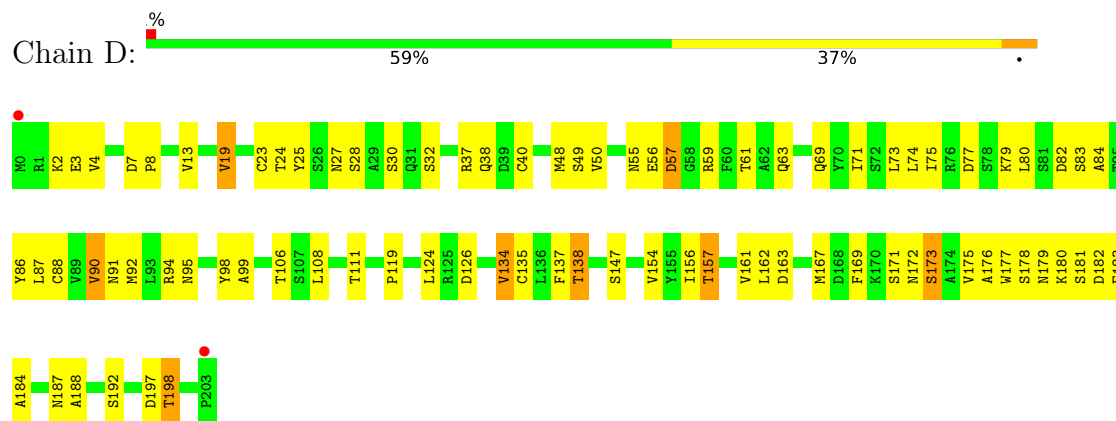
- Molecule 3: Spike protein S1



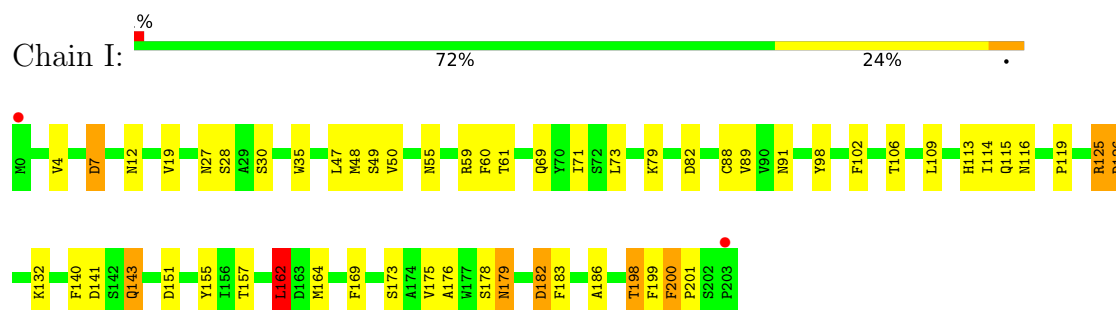
- Molecule 3: Spike protein S1



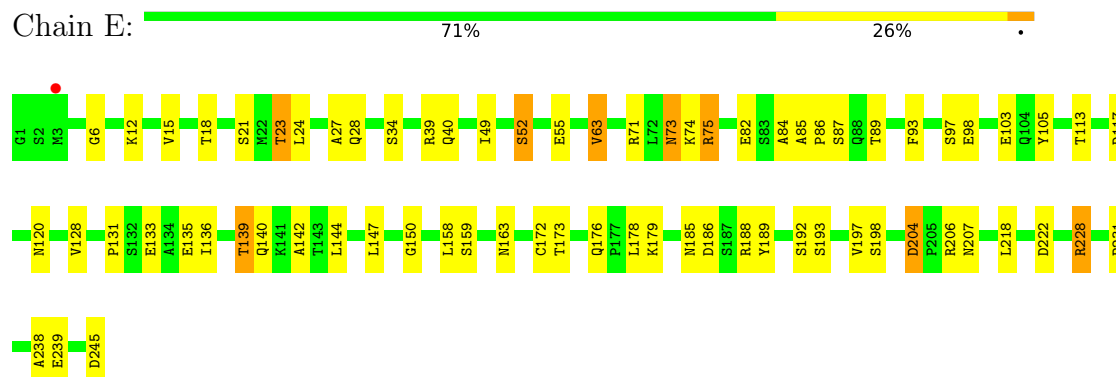
- Molecule 4: P1-15 T-cell Receptor Alpha Chain



- Molecule 4: P1-15 T-cell Receptor Alpha Chain

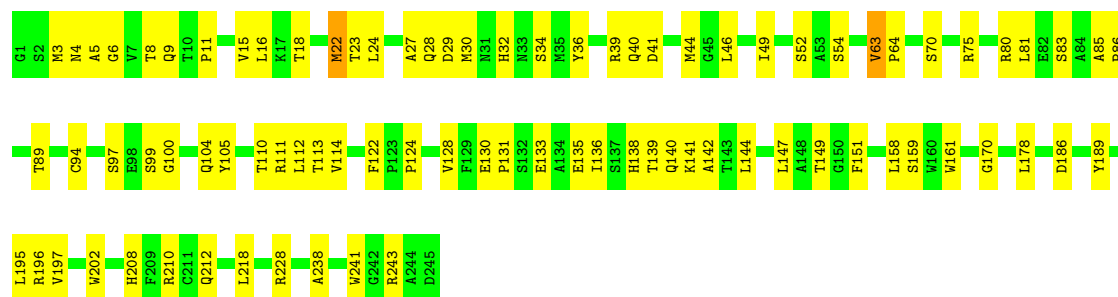


- Molecule 5: P1-15 T-cell Receptor Beta Chain



● Molecule 5: P1-15 T-cell Receptor Beta Chain

Chain J:  65% 34% .



4 Data and refinement statistics

Property	Value	Source
Space group	P 31 2 1	Depositor
Cell constants a, b, c, α , β , γ	200.41Å 200.41Å 156.34Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	60.56 – 3.10 60.56 – 3.10	Depositor EDS
% Data completeness (in resolution range)	99.9 (60.56-3.10) 99.9 (60.56-3.10)	Depositor EDS
R_{merge}	0.29	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.33 (at 3.13Å)	Xtriage
Refinement program	REFMAC 5.8.0430	Depositor
R, R_{free}	0.189 , 0.231 0.194 , 0.233	Depositor DCC
R_{free} test set	3394 reflections (5.15%)	wwPDB-VP
Wilson B-factor (Å ²)	93.9	Xtriage
Anisotropy	0.152	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.32 , 104.4	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	0.018 for -h,-k,l	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	13408	wwPDB-VP
Average B, all atoms (Å ²)	114.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.38% 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	0.61	0/2299	1.13	8/3116 (0.3%)
1	F	0.58	0/2299	1.03	3/3116 (0.1%)
2	B	0.59	0/860	1.05	0/1162
2	G	0.56	0/860	0.98	1/1162 (0.1%)
3	C	0.55	0/94	0.97	0/125
3	H	0.49	0/94	0.72	0/125
4	D	0.61	0/1635	1.13	7/2215 (0.3%)
4	I	0.59	0/1635	1.15	7/2215 (0.3%)
5	E	0.63	0/1989	1.14	8/2703 (0.3%)
5	J	0.57	0/1989	1.08	2/2703 (0.1%)
All	All	0.59	0/13754	1.09	36/18642 (0.2%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	F	0	1
5	E	0	1
All	All	0	2

There are no bond length outliers.

The worst 5 of 36 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
4	I	200	PHE	O-C-N	-8.34	117.69	121.53
4	I	126	ASP	CA-CB-CG	7.79	120.39	112.60
5	E	139	THR	CA-CB-OG1	-7.00	99.10	109.60
1	F	19	GLU	CB-CG-CD	6.90	124.33	112.60
5	E	245	ASP	CA-CB-CG	6.72	119.32	112.60

There are no chirality outliers.

All (2) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
5	E	228	ARG	Sidechain
1	F	181	ARG	Sidechain

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	2238	0	2095	35	0
1	F	2238	0	2095	23	0
2	B	837	0	803	11	0
2	G	837	0	803	7	0
3	C	91	0	85	11	0
3	H	91	0	85	4	0
4	D	1600	0	1522	55	0
4	I	1600	0	1524	33	0
5	E	1938	0	1827	40	0
5	J	1938	0	1827	56	0
All	All	13408	0	12666	250	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 10.

The worst 5 of 250 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:192:HIS:HB2	1:A:200:THR:HB	1.57	0.87
2:B:37:VAL:HG22	2:B:82:VAL:HG22	1.59	0.83
5:E:135:GLU:O	5:E:139:THR:HG22	1.80	0.81
5:J:135:GLU:O	5:J:139:THR:HG22	1.79	0.81
1:A:230:LEU:HD13	1:A:245:ALA:HB2	1.64	0.80

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	274/276 (99%)	255 (93%)	18 (7%)	1 (0%)	30	61
1	F	274/276 (99%)	252 (92%)	21 (8%)	1 (0%)	30	61
2	B	98/100 (98%)	93 (95%)	5 (5%)	0	100	100
2	G	98/100 (98%)	90 (92%)	8 (8%)	0	100	100
3	C	7/9 (78%)	6 (86%)	1 (14%)	0	100	100
3	H	7/9 (78%)	6 (86%)	1 (14%)	0	100	100
4	D	202/204 (99%)	186 (92%)	15 (7%)	1 (0%)	24	57
4	I	202/204 (99%)	190 (94%)	12 (6%)	0	100	100
5	E	243/245 (99%)	227 (93%)	16 (7%)	0	100	100
5	J	243/245 (99%)	230 (95%)	12 (5%)	1 (0%)	30	61
All	All	1648/1668 (99%)	1535 (93%)	109 (7%)	4 (0%)	43	73

All (4) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
4	D	8	PRO
1	A	195	SER
5	J	64	PRO
1	F	267	PRO

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	232/232 (100%)	217 (94%)	15 (6%)	15	44
1	F	232/232 (100%)	222 (96%)	10 (4%)	26	57
2	B	95/95 (100%)	87 (92%)	8 (8%)	10	35
2	G	95/95 (100%)	93 (98%)	2 (2%)	47	71
3	C	9/9 (100%)	8 (89%)	1 (11%)	6	24
3	H	9/9 (100%)	9 (100%)	0	100	100
4	D	184/184 (100%)	172 (94%)	12 (6%)	15	44
4	I	184/184 (100%)	172 (94%)	12 (6%)	15	44
5	E	211/211 (100%)	196 (93%)	15 (7%)	13	41
5	J	211/211 (100%)	200 (95%)	11 (5%)	21	51
All	All	1462/1462 (100%)	1376 (94%)	86 (6%)	18	48

5 of 86 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	F	94	THR
4	I	178	SER
1	F	196	ASP
4	I	50	VAL
5	J	8	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 45 such sidechains are listed below:

Mol	Chain	Res	Type
1	F	192	HIS
4	I	31	GLN
1	F	224	GLN
2	G	83	ASN
4	I	91	ASN

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 [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 ⓘ

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	276/276 (100%)	-0.17	7 (2%) 58 37	84, 114, 172, 193	0
1	F	276/276 (100%)	-0.19	1 (0%) 88 76	93, 134, 224, 242	0
2	B	100/100 (100%)	-0.17	2 (2%) 65 44	94, 123, 157, 167	0
2	G	100/100 (100%)	-0.01	1 (1%) 79 61	113, 139, 169, 177	0
3	C	9/9 (100%)	-0.66	0 100 100	87, 92, 99, 101	0
3	H	9/9 (100%)	-0.67	0 100 100	99, 103, 112, 118	0
4	D	204/204 (100%)	-0.33	2 (0%) 79 61	67, 91, 115, 130	0
4	I	204/204 (100%)	-0.38	2 (0%) 79 61	73, 101, 139, 152	0
5	E	245/245 (100%)	-0.48	1 (0%) 88 76	64, 87, 110, 123	0
5	J	245/245 (100%)	-0.50	0 100 100	75, 96, 129, 142	0
All	All	1668/1668 (100%)	-0.31	16 (0%) 79 61	64, 106, 174, 242	0

The worst 5 of 16 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
4	D	203	PRO	3.9
2	B	1	ILE	3.5
4	D	0	MET	3.1
2	B	0	MET	3.0
5	E	3	MET	3.0

6.2 Non-standard residues in protein, DNA, RNA chains ⓘ

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.