



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 5, 2026 – 10:17 PM UTC

PDB ID : 5ZHY / pdb_00005zhy
Title : Structural characterization of the HCoV-229E fusion core
Authors : Zhang, W.; Zheng, Q.; Yan, M.; Chen, X.; Yang, H.; Zhou, W.; Rao, Z.
Deposited on : 2018-03-13
Resolution : 2.44 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	:	9.0.010 (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

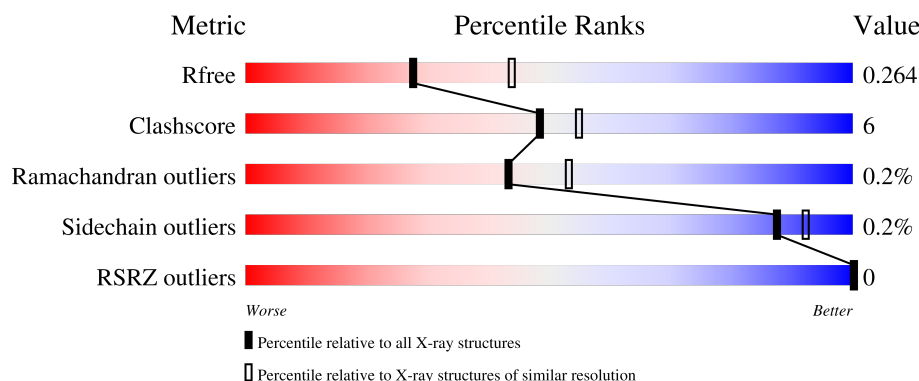
1 Overall quality at a glance ⓘ

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.44 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	2340 (2.46-2.42)
Clashscore	190562	2400 (2.46-2.42)
Ramachandran outliers	187476	2379 (2.46-2.42)
Sidechain outliers	187428	2379 (2.46-2.42)
RSRZ outliers	180081	2340 (2.46-2.42)

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	148	48% 13% 39%
1	B	148	54% 6% 40%
1	C	148	55% 5% 40%
1	D	148	47% 14% 39%
1	E	148	47% 13% 41%

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Mol	Chain	Length	Quality of chain
1	F	148	 A horizontal bar chart showing the quality of the chain. The bar is divided into three segments: a green segment representing 55%, a yellow segment representing 5%, and a grey segment representing 40%. The percentages are labeled below the corresponding segments.

2 Entry composition

There is only 1 type of molecule in this entry. The entry contains 4039 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 Spike glycoprotein, Spike glycoprotein.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	90	Total	C	N	O	S	0	0	0
			679	419	115	144	1			
1	B	89	Total	C	N	O	S	0	0	0
			671	416	113	141	1			
1	C	89	Total	C	N	O	S	0	0	0
			673	418	113	141	1			
1	D	90	Total	C	N	O	S	0	0	0
			681	421	116	143	1			
1	E	88	Total	C	N	O	S	0	0	0
			666	414	112	139	1			
1	F	89	Total	C	N	O	S	0	0	0
			669	414	112	142	1			

There are 162 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	69	LEU	-	linker	UNP P15423
A	70	VAL	-	linker	UNP P15423
A	71	PRO	-	linker	UNP P15423
A	72	ARG	-	linker	UNP P15423
A	73	GLY	-	linker	UNP P15423
A	74	SER	-	linker	UNP P15423
A	75	GLY	-	linker	UNP P15423
A	76	GLY	-	linker	UNP P15423
A	77	SER	-	linker	UNP P15423
A	78	GLY	-	linker	UNP P15423
A	79	GLY	-	linker	UNP P15423
A	80	SER	-	linker	UNP P15423
A	81	GLY	-	linker	UNP P15423
A	82	GLY	-	linker	UNP P15423
A	83	LEU	-	linker	UNP P15423
A	84	GLU	-	linker	UNP P15423
A	85	VAL	-	linker	UNP P15423

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Chain	Residue	Modelled	Actual	Comment	Reference
A	86	LEU	-	linker	UNP P15423
A	87	PHE	-	linker	UNP P15423
A	88	GLN	-	linker	UNP P15423
A	89	GLY	-	linker	UNP P15423
A	143	HIS	-	expression tag	UNP P15423
A	144	HIS	-	expression tag	UNP P15423
A	145	HIS	-	expression tag	UNP P15423
A	146	HIS	-	expression tag	UNP P15423
A	147	HIS	-	expression tag	UNP P15423
A	148	HIS	-	expression tag	UNP P15423
B	69	LEU	-	linker	UNP P15423
B	70	VAL	-	linker	UNP P15423
B	71	PRO	-	linker	UNP P15423
B	72	ARG	-	linker	UNP P15423
B	73	GLY	-	linker	UNP P15423
B	74	SER	-	linker	UNP P15423
B	75	GLY	-	linker	UNP P15423
B	76	GLY	-	linker	UNP P15423
B	77	SER	-	linker	UNP P15423
B	78	GLY	-	linker	UNP P15423
B	79	GLY	-	linker	UNP P15423
B	80	SER	-	linker	UNP P15423
B	81	GLY	-	linker	UNP P15423
B	82	GLY	-	linker	UNP P15423
B	83	LEU	-	linker	UNP P15423
B	84	GLU	-	linker	UNP P15423
B	85	VAL	-	linker	UNP P15423
B	86	LEU	-	linker	UNP P15423
B	87	PHE	-	linker	UNP P15423
B	88	GLN	-	linker	UNP P15423
B	89	GLY	-	linker	UNP P15423
B	143	HIS	-	expression tag	UNP P15423
B	144	HIS	-	expression tag	UNP P15423
B	145	HIS	-	expression tag	UNP P15423
B	146	HIS	-	expression tag	UNP P15423
B	147	HIS	-	expression tag	UNP P15423
B	148	HIS	-	expression tag	UNP P15423
C	69	LEU	-	linker	UNP P15423
C	70	VAL	-	linker	UNP P15423
C	71	PRO	-	linker	UNP P15423
C	72	ARG	-	linker	UNP P15423
C	73	GLY	-	linker	UNP P15423

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Chain	Residue	Modelled	Actual	Comment	Reference
C	74	SER	-	linker	UNP P15423
C	75	GLY	-	linker	UNP P15423
C	76	GLY	-	linker	UNP P15423
C	77	SER	-	linker	UNP P15423
C	78	GLY	-	linker	UNP P15423
C	79	GLY	-	linker	UNP P15423
C	80	SER	-	linker	UNP P15423
C	81	GLY	-	linker	UNP P15423
C	82	GLY	-	linker	UNP P15423
C	83	LEU	-	linker	UNP P15423
C	84	GLU	-	linker	UNP P15423
C	85	VAL	-	linker	UNP P15423
C	86	LEU	-	linker	UNP P15423
C	87	PHE	-	linker	UNP P15423
C	88	GLN	-	linker	UNP P15423
C	89	GLY	-	linker	UNP P15423
C	143	HIS	-	expression tag	UNP P15423
C	144	HIS	-	expression tag	UNP P15423
C	145	HIS	-	expression tag	UNP P15423
C	146	HIS	-	expression tag	UNP P15423
C	147	HIS	-	expression tag	UNP P15423
C	148	HIS	-	expression tag	UNP P15423
D	69	LEU	-	linker	UNP P15423
D	70	VAL	-	linker	UNP P15423
D	71	PRO	-	linker	UNP P15423
D	72	ARG	-	linker	UNP P15423
D	73	GLY	-	linker	UNP P15423
D	74	SER	-	linker	UNP P15423
D	75	GLY	-	linker	UNP P15423
D	76	GLY	-	linker	UNP P15423
D	77	SER	-	linker	UNP P15423
D	78	GLY	-	linker	UNP P15423
D	79	GLY	-	linker	UNP P15423
D	80	SER	-	linker	UNP P15423
D	81	GLY	-	linker	UNP P15423
D	82	GLY	-	linker	UNP P15423
D	83	LEU	-	linker	UNP P15423
D	84	GLU	-	linker	UNP P15423
D	85	VAL	-	linker	UNP P15423
D	86	LEU	-	linker	UNP P15423
D	87	PHE	-	linker	UNP P15423
D	88	GLN	-	linker	UNP P15423

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Chain	Residue	Modelled	Actual	Comment	Reference
D	89	GLY	-	linker	UNP P15423
D	143	HIS	-	expression tag	UNP P15423
D	144	HIS	-	expression tag	UNP P15423
D	145	HIS	-	expression tag	UNP P15423
D	146	HIS	-	expression tag	UNP P15423
D	147	HIS	-	expression tag	UNP P15423
D	148	HIS	-	expression tag	UNP P15423
E	69	LEU	-	linker	UNP P15423
E	70	VAL	-	linker	UNP P15423
E	71	PRO	-	linker	UNP P15423
E	72	ARG	-	linker	UNP P15423
E	73	GLY	-	linker	UNP P15423
E	74	SER	-	linker	UNP P15423
E	75	GLY	-	linker	UNP P15423
E	76	GLY	-	linker	UNP P15423
E	77	SER	-	linker	UNP P15423
E	78	GLY	-	linker	UNP P15423
E	79	GLY	-	linker	UNP P15423
E	80	SER	-	linker	UNP P15423
E	81	GLY	-	linker	UNP P15423
E	82	GLY	-	linker	UNP P15423
E	83	LEU	-	linker	UNP P15423
E	84	GLU	-	linker	UNP P15423
E	85	VAL	-	linker	UNP P15423
E	86	LEU	-	linker	UNP P15423
E	87	PHE	-	linker	UNP P15423
E	88	GLN	-	linker	UNP P15423
E	89	GLY	-	linker	UNP P15423
E	143	HIS	-	expression tag	UNP P15423
E	144	HIS	-	expression tag	UNP P15423
E	145	HIS	-	expression tag	UNP P15423
E	146	HIS	-	expression tag	UNP P15423
E	147	HIS	-	expression tag	UNP P15423
E	148	HIS	-	expression tag	UNP P15423
F	69	LEU	-	linker	UNP P15423
F	70	VAL	-	linker	UNP P15423
F	71	PRO	-	linker	UNP P15423
F	72	ARG	-	linker	UNP P15423
F	73	GLY	-	linker	UNP P15423
F	74	SER	-	linker	UNP P15423
F	75	GLY	-	linker	UNP P15423
F	76	GLY	-	linker	UNP P15423

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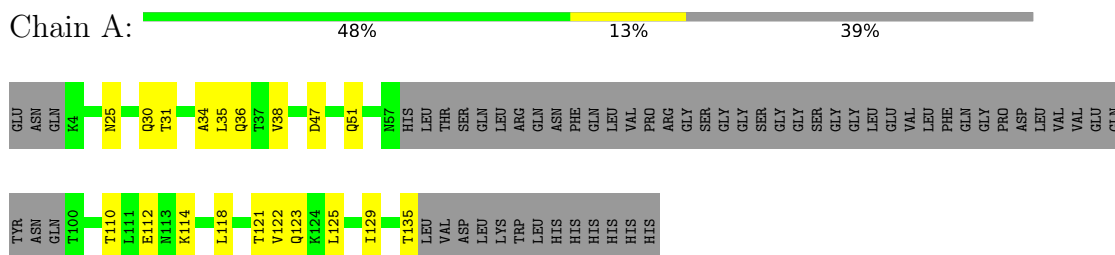
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Chain	Residue	Modelled	Actual	Comment	Reference
F	77	SER	-	linker	UNP P15423
F	78	GLY	-	linker	UNP P15423
F	79	GLY	-	linker	UNP P15423
F	80	SER	-	linker	UNP P15423
F	81	GLY	-	linker	UNP P15423
F	82	GLY	-	linker	UNP P15423
F	83	LEU	-	linker	UNP P15423
F	84	GLU	-	linker	UNP P15423
F	85	VAL	-	linker	UNP P15423
F	86	LEU	-	linker	UNP P15423
F	87	PHE	-	linker	UNP P15423
F	88	GLN	-	linker	UNP P15423
F	89	GLY	-	linker	UNP P15423
F	143	HIS	-	expression tag	UNP P15423
F	144	HIS	-	expression tag	UNP P15423
F	145	HIS	-	expression tag	UNP P15423
F	146	HIS	-	expression tag	UNP P15423
F	147	HIS	-	expression tag	UNP P15423
F	148	HIS	-	expression tag	UNP P15423

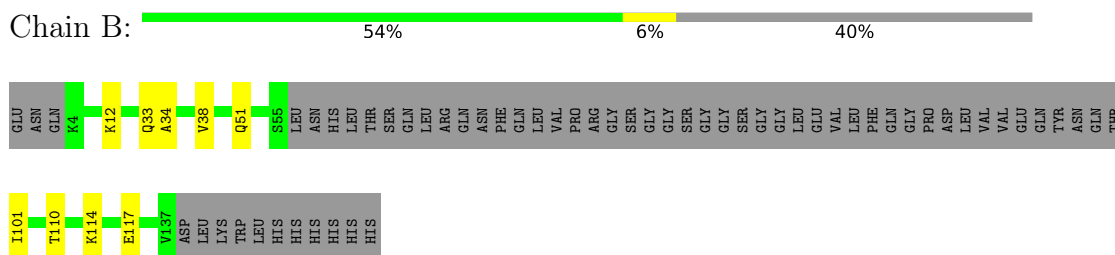
3 Residue-property plots [i](#)

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.

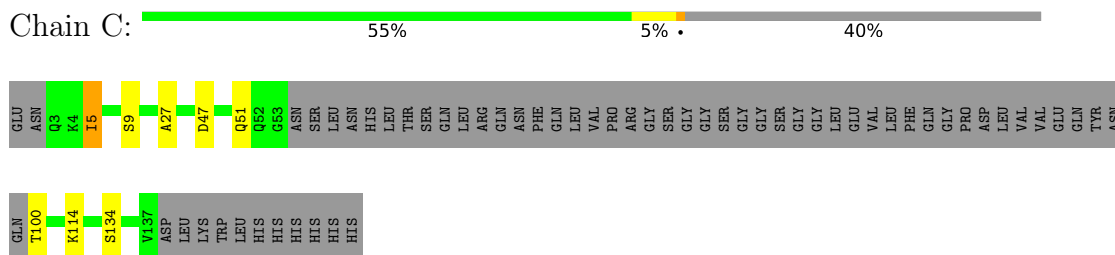
- Molecule 1: Spike glycoprotein, Spike glycoprotein



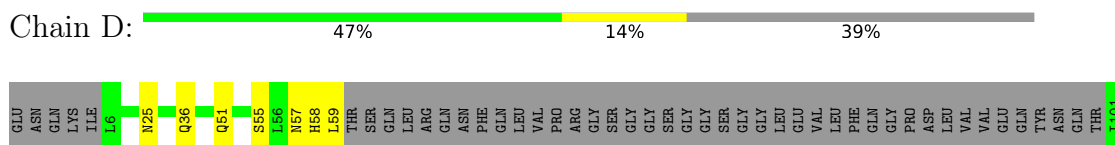
- Molecule 1: Spike glycoprotein, Spike glycoprotein



- Molecule 1: Spike glycoprotein, Spike glycoprotein

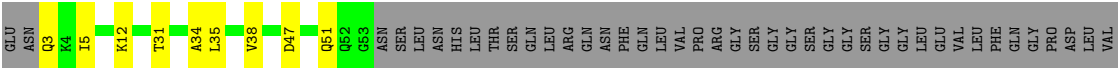


- Molecule 1: Spike glycoprotein, Spike glycoprotein





● Molecule 1: Spike glycoprotein, Spike glycoprotein



● Molecule 1: Spike glycoprotein, Spike glycoprotein



4 Data and refinement statistics

Property	Value	Source
Space group	P 1	Depositor
Cell constants a, b, c, α , β , γ	30.11Å 77.35Å 77.39Å 76.89° 89.78° 90.20°	Depositor
Resolution (Å)	31.01 – 2.44 31.01 – 2.44	Depositor EDS
% Data completeness (in resolution range)	97.0 (31.01-2.44) 97.4 (31.01-2.44)	Depositor EDS
R_{merge}	0.04	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.67 (at 2.45Å)	Xtriage
Refinement program	PHENIX 1.8.4_1496	Depositor
R, R_{free}	0.224 , 0.263 0.233 , 0.264	Depositor DCC
R_{free} test set	2020 reflections (7.99%)	wwPDB-VP
Wilson B-factor (Å ²)	48.9	Xtriage
Anisotropy	0.475	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.32 , 36.8	EDS
L-test for twinning ²	$\langle L \rangle = 0.46$, $\langle L^2 \rangle = 0.28$	Xtriage
Estimated twinning fraction	0.149 for h,-k,-l 0.147 for -h,-l,-k 0.447 for -h,l,k	Xtriage
F_o, F_c correlation	0.96	EDS
Total number of atoms	4039	wwPDB-VP
Average B, all atoms (Å ²)	60.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 9.43% 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	0.62	0/680	0.91	0/924
1	B	0.54	0/672	0.84	0/913
1	C	0.54	0/674	0.87	1/916 (0.1%)
1	D	0.63	0/683	0.96	0/929
1	E	0.56	0/667	0.84	0/906
1	F	0.55	0/670	0.86	0/912
All	All	0.57	0/4046	0.88	1/5500 (0.0%)

There are no bond length outliers.

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	C	5	ILE	N-CA-C	-5.23	105.44	110.72

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	679	0	691	13	0
1	B	671	0	687	8	0
1	C	673	0	691	7	0
1	D	681	0	689	15	0
1	E	666	0	684	10	0
1	F	669	0	681	6	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
All	All	4039	0	4123	45	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 6.

The worst 5 of 45 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:B:101:ILE:HG21	1:D:51:GLN:HG2	1.68	0.76
1:C:47:ASP:O	1:C:51:GLN:HG3	1.85	0.76
1:A:47:ASP:O	1:A:51:GLN:HG3	1.93	0.68
1:B:51:GLN:HE22	1:C:100:THR:N	1.99	0.61
1:D:103:ASN:O	1:F:44:LYS:NZ	2.34	0.60

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	86/148 (58%)	85 (99%)	1 (1%)	0	100	100
1	B	85/148 (57%)	85 (100%)	0	0	100	100
1	C	85/148 (57%)	85 (100%)	0	0	100	100
1	D	86/148 (58%)	84 (98%)	2 (2%)	0	100	100
1	E	84/148 (57%)	84 (100%)	0	0	100	100
1	F	85/148 (57%)	84 (99%)	0	1 (1%)	10	10
All	All	511/888 (58%)	507 (99%)	3 (1%)	1 (0%)	43	53

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	F	53	GLY

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	79/129 (61%)	79 (100%)	0	100	100
1	B	78/129 (60%)	78 (100%)	0	100	100
1	C	78/129 (60%)	78 (100%)	0	100	100
1	D	79/129 (61%)	78 (99%)	1 (1%)	61	72
1	E	77/129 (60%)	77 (100%)	0	100	100
1	F	78/129 (60%)	78 (100%)	0	100	100
All	All	469/774 (61%)	468 (100%)	1 (0%)	87	92

All (1) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	D	109	SER

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 15 such sidechains are listed below:

Mol	Chain	Res	Type
1	C	52	GLN
1	E	133	ASN
1	C	133	ASN
1	F	52	GLN
1	E	3	GLN

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	90/148 (60%)	-0.74	0 100 100	46, 58, 85, 102	0
1	B	89/148 (60%)	-0.73	0 100 100	43, 61, 77, 86	0
1	C	89/148 (60%)	-0.77	0 100 100	41, 59, 73, 103	0
1	D	90/148 (60%)	-0.89	0 100 100	46, 57, 83, 111	0
1	E	88/148 (59%)	-0.81	0 100 100	42, 61, 75, 81	0
1	F	89/148 (60%)	-0.89	0 100 100	41, 58, 75, 84	0
All	All	535/888 (60%)	-0.81	0 100 100	41, 59, 79, 111	0

There are no RSRZ outliers to report.

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.