



# wwPDB X-ray Structure Validation Summary Report ⓘ

Apr 5, 2026 – 01:21 AM UTC

PDB ID : 9NMU / pdb\_00009nmu  
Title : TCR156 bound to HLA A\*02:01-PAP  
Authors : Jude, K.M.; Chen, X.; Garcia, K.C.  
Deposited on : 2025-03-04  
Resolution : 2.10 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](mailto: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>.

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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

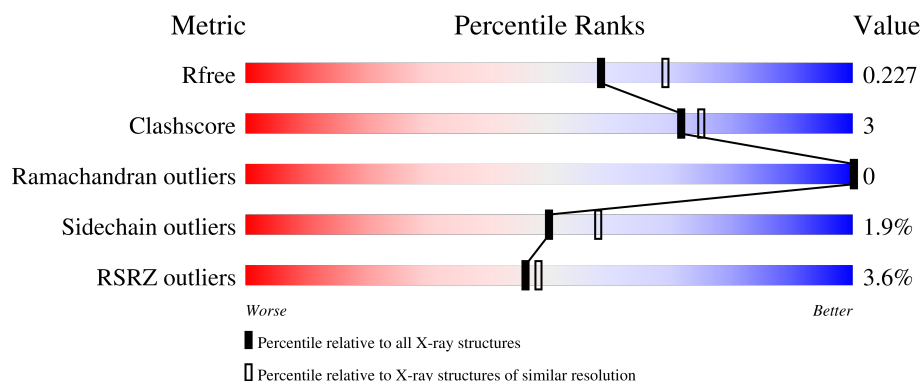
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*X-RAY DIFFRACTION*

The reported resolution of this entry is 2.10 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	6658 (2.10-2.10)
Clashscore	190562	7164 (2.10-2.10)
Ramachandran outliers	187476	7099 (2.10-2.10)
Sidechain outliers	187428	7100 (2.10-2.10)
RSRZ outliers	180081	6662 (2.10-2.10)

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  $\geq 3$ , 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	279	<div> <div>3%</div> <div>90%</div> <div>8%</div> <div>.</div> </div>
2	B	100	<div> <div>%</div> <div>93%</div> <div>7%</div> </div>
3	C	9	<div> <div>100%</div> </div>
4	D	255	<div> <div>5%</div> <div>71%</div> <div>5%</div> <div>.</div> <div>23%</div> </div>
5	E	307	<div> <div>3%</div> <div>68%</div> <div>10%</div> <div>22%</div> </div>

## 2 Entry composition

There are 8 unique types of molecules in this entry. The entry contains 6973 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 HLA class I histocompatibility antigen, A alpha chain.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	276	Total	C	N	O	S	0	1	0
			2256	1410	410	427	9			

There is a discrepancy between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	0	MET	-	initiating methionine	UNP A5I8L1

- 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			

There is a discrepancy between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
B	1	MET	-	initiating methionine	UNP P61769

- Molecule 3 is a protein called Prostatic acid phosphatase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	C	9	Total	C	N	O	S	0	0	0
			66	40	10	14	2			

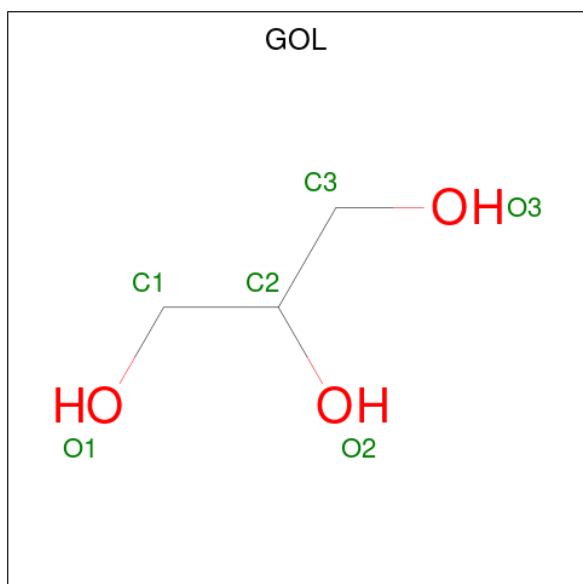
- Molecule 4 is a protein called TCR156 alpha chain.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
4	D	197	Total	C	N	O	S	0	1	0
			1542	962	256	315	9			

- Molecule 5 is a protein called TCR156 beta chain.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
5	E	240	Total	C	N	O	S	0	2	0
			1922	1212	337	368	5			

- Molecule 6 is GLYCEROL (CCD ID: GOL) (formula:  $C_3H_8O_3$ ).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
6	A	1	Total	C	O	0	0
			6	3	3		
6	A	1	Total	C	O	0	0
			6	3	3		
6	A	1	Total	C	O	0	0
			6	3	3		
6	B	1	Total	C	O	0	0
			6	3	3		
6	B	1	Total	C	O	0	0
			6	3	3		
6	E	1	Total	C	O	0	0
			6	3	3		
6	E	1	Total	C	O	0	0
			6	3	3		

- Molecule 7 is 2-acetamido-2-deoxy-beta-D-glucopyranose (CCD ID: NAG) (formula:  $C_8H_{15}NO_6$ ).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
7	D	1	Total	C	N	O	0	0
			14	8	1	5		
7	D	1	Total	C	N	O	0	0
			14	8	1	5		
7	E	1	Total	C	N	O	0	0
			14	8	1	5		

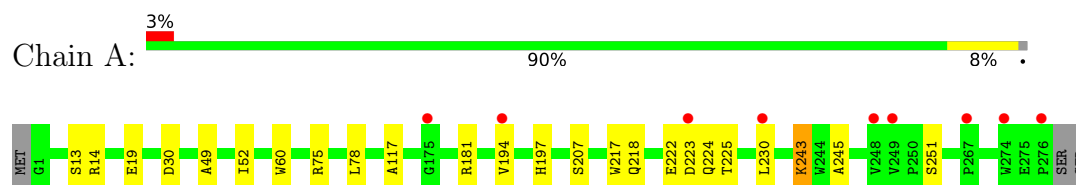
- Molecule 8 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
8	A	85	Total	O	0	0
			85	85		
8	B	43	Total	O	0	0
			43	43		
8	C	5	Total	O	0	0
			5	5		
8	D	75	Total	O	0	0
			75	75		
8	E	58	Total	O	0	0
			58	58		

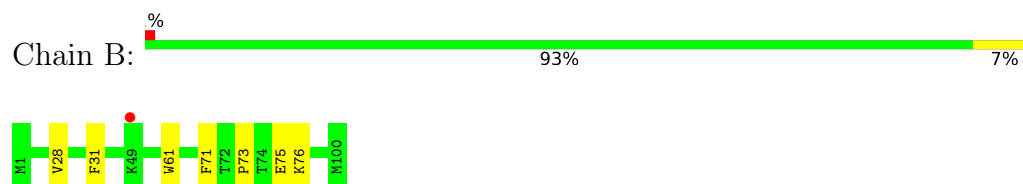
### 3 Residue-property plots

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: HLA class I histocompatibility antigen, A alpha chain



- Molecule 2: Beta-2-microglobulin

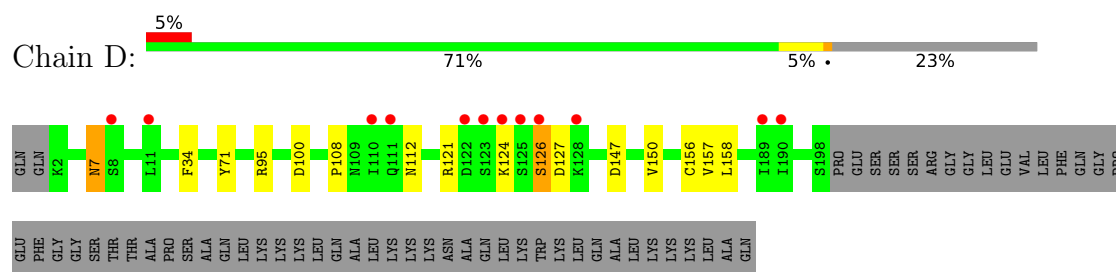


- Molecule 3: Prostatic acid phosphatase

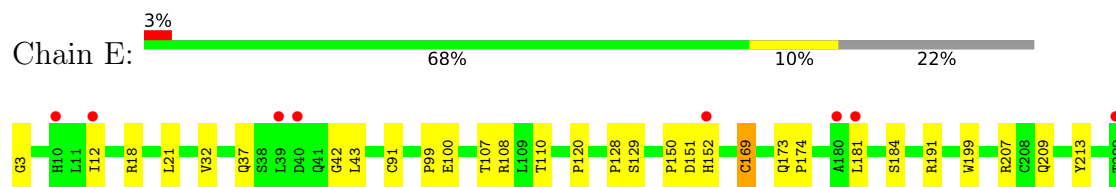


There are no outlier residues recorded for this chain.

- Molecule 4: TCR156 alpha chain



- Molecule 5: TCR156 beta chain



TLE	P228
PHE	D42
GLU	SER
ALA	ARG
GLN	GLY
LYS	LEU
TLE	GLU
TRP	VAL
HIS	LEU
GLU	PHE
	GLN
	GLY
	PRO
	GLU
	PHE
	GLY
	SER
	THR
	THR
	ALA
	PRO
	SER
	ALA
	GLN
	LEU
	GLU
	LYS
	GLU
	LEU
	GLN
	ALA
	LEU
	GLU
	LYS
	GLU
	ASN
	ALA
	GLN
	LEU
	GLU
	TRP
	GLU
	LEU
	GLN
	ALA
	LEU
	GLU
	LYS
	GLU
	LEU
	ALA
	GLN
	GLY
	LEU
	ASN

## 4 Data and refinement statistics

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	225.11Å 47.35Å 90.73Å 90.00° 95.83° 90.00°	Depositor
Resolution (Å)	46.32 – 2.10 46.32 – 2.10	Depositor EDS
% Data completeness (in resolution range)	98.4 (46.32-2.10) 88.2 (46.32-2.10)	Depositor EDS
$R_{merge}$	0.10	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	1.07 (at 2.10Å)	Xtriage
Refinement program	PHENIX 1.21.2_5419	Depositor
R, $R_{free}$	0.193 , 0.227 0.193 , 0.227	Depositor DCC
$R_{free}$ test set	1703 reflections (3.07%)	wwPDB-VP
Wilson B-factor (Å <sup>2</sup> )	36.6	Xtriage
Anisotropy	0.480	Xtriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.34 , 43.0	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.50$ , $\langle L^2 \rangle = 0.34$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
$F_o, F_c$ correlation	0.95	EDS
Total number of atoms	6973	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	60.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.31% of the height of the origin peak. No significant pseudotranslation is detected.*

<sup>1</sup>Intensities estimated from amplitudes.

<sup>2</sup>Theoretical 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](#)

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

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	0.15	0/2325	0.34	0/3157
2	B	0.18	0/860	0.36	0/1162
3	C	0.21	0/65	0.30	0/85
4	D	0.18	0/1577	0.36	0/2136
5	E	0.16	0/1976	0.35	0/2690
All	All	0.17	0/6803	0.35	0/9230

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	2256	0	2108	12	0
2	B	837	0	803	4	0
3	C	66	0	72	0	0
4	D	1542	0	1459	12	0
5	E	1922	0	1827	20	0
6	A	18	0	24	2	0
6	B	12	0	16	0	0
6	E	12	0	16	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
7	D	28	0	26	1	0
7	E	14	0	13	1	0
8	A	85	0	0	1	0
8	B	43	0	0	0	0
8	C	5	0	0	0	0
8	D	75	0	0	0	0
8	E	58	0	0	1	0
All	All	6973	0	6364	43	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 3.

The worst 5 of 43 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)
4:D:108:PRO:HG3	4:D:157:VAL:HG11	1.72	0.69
1:A:19:GLU:OE1	1:A:75:ARG:NH1	2.21	0.69
5:E:152:HIS:HB3	5:E:213:TYR:HB2	1.78	0.66
5:E:110:THR:HG1	5:E:152:HIS:HE2	1.38	0.63
1:A:30:ASP:HA	6:A:301:GOL:H11	1.82	0.61

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	275/279 (99%)	267 (97%)	8 (3%)	0	100	100
2	B	98/100 (98%)	97 (99%)	1 (1%)	0	100	100
3	C	7/9 (78%)	7 (100%)	0	0	100	100
4	D	196/255 (77%)	193 (98%)	3 (2%)	0	100	100

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
5	E	240/307 (78%)	236 (98%)	4 (2%)	0	100	100
All	All	816/950 (86%)	800 (98%)	16 (2%)	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	233/235 (99%)	226 (97%)	7 (3%)	36	41
2	B	95/95 (100%)	95 (100%)	0	100	100
3	C	8/8 (100%)	8 (100%)	0	100	100
4	D	177/223 (79%)	173 (98%)	4 (2%)	44	51
5	E	209/261 (80%)	206 (99%)	3 (1%)	59	67
All	All	722/822 (88%)	708 (98%)	14 (2%)	50	58

5 of 14 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
4	D	7	ASN
4	D	95	ARG
5	E	173	GLN
5	E	129	SER
5	E	169	CYS

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 11 such sidechains are listed below:

Mol	Chain	Res	Type
4	D	92	ASN
4	D	183	ASN
5	E	117	ASN
4	D	187	ASN
2	B	18	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 ⓘ

There are no oligosaccharides in this entry.

## 5.6 Ligand geometry ⓘ

10 ligands are modelled in this entry.

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	$\# Z  > 2$
6	GOL	E	402	-	5,5,5	0.33	0	5,5,5	0.41	0
7	NAG	E	401	5	14,14,15	0.72	0	17,19,21	0.92	0
6	GOL	A	303	-	5,5,5	0.36	0	5,5,5	0.34	0
6	GOL	B	201	-	5,5,5	0.37	0	5,5,5	0.33	0
6	GOL	A	302	-	5,5,5	0.28	0	5,5,5	0.43	0
6	GOL	E	403	-	5,5,5	0.31	0	5,5,5	0.36	0
7	NAG	D	302	4	14,14,15	0.68	0	17,19,21	0.82	0
6	GOL	B	202	-	5,5,5	0.33	0	5,5,5	0.40	0
6	GOL	A	301	-	5,5,5	0.31	0	5,5,5	0.41	0
7	NAG	D	301	4	14,14,15	0.73	0	17,19,21	1.46	2 (11%)

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
6	GOL	E	402	-	-	0/4/4/4	-
7	NAG	E	401	5	-	2/6/23/26	0/1/1/1
6	GOL	A	303	-	-	2/4/4/4	-
6	GOL	B	201	-	-	2/4/4/4	-
6	GOL	A	302	-	-	1/4/4/4	-
6	GOL	E	403	-	-	0/4/4/4	-
7	NAG	D	302	4	-	0/6/23/26	0/1/1/1
6	GOL	B	202	-	-	2/4/4/4	-
6	GOL	A	301	-	-	2/4/4/4	-
7	NAG	D	301	4	-	2/6/23/26	0/1/1/1

There are no bond length outliers.

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
7	D	301	NAG	C2-N2-C7	3.85	128.06	122.90
7	D	301	NAG	C4-C3-C2	2.86	115.20	111.02

There are no chirality outliers.

5 of 13 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
6	A	301	GOL	C1-C2-C3-O3
6	B	202	GOL	O1-C1-C2-C3
7	E	401	NAG	C4-C5-C6-O6
7	E	401	NAG	O5-C5-C6-O6
7	D	301	NAG	C8-C7-N2-C2

There are no ring outliers.

4 monomers are involved in 4 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
7	E	401	NAG	1	0
6	A	302	GOL	1	0
6	A	301	GOL	1	0
7	D	301	NAG	1	0

## 5.7 Other polymers [i](#)

There are no such residues in this entry.

## 5.8 Polymer linkage issues ⓘ

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, 95<sup>th</sup> 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 <sup>2</sup> )	Q < 0.9
1	A	276/279 (98%)	0.45	9 (3%)	49	51	23, 52, 132, 172	1 (0%)
2	B	100/100 (100%)	0.31	1 (1%)	79	81	34, 49, 79, 93	0
3	C	9/9 (100%)	-0.25	0	100	100	34, 37, 39, 40	0
4	D	197/255 (77%)	0.62	12 (6%)	27	29	24, 55, 110, 151	1 (0%)
5	E	240/307 (78%)	0.43	8 (3%)	49	51	27, 55, 92, 122	2 (0%)
All	All	822/950 (86%)	0.46	30 (3%)	46	48	23, 54, 110, 172	4 (0%)

The worst 5 of 30 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
4	D	126	SER	3.9
4	D	125	SER	3.9
4	D	8	SER	3.6
5	E	10	HIS	3.4
4	D	124	LYS	3.3

### 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, 95<sup>th</sup> 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(Å <sup>2</sup> )	Q<0.9
6	GOL	B	202	6/6	0.64	0.18	75,84,89,94	0
7	NAG	D	302	14/15	0.66	0.14	92,99,101,103	0
6	GOL	E	403	6/6	0.75	0.16	72,78,81,83	0
6	GOL	A	302	6/6	0.78	0.16	64,65,69,70	0
6	GOL	A	303	6/6	0.80	0.15	54,64,66,73	0
6	GOL	E	402	6/6	0.82	0.13	51,64,67,71	0
6	GOL	B	201	6/6	0.83	0.16	49,56,60,66	0
7	NAG	D	301	14/15	0.85	0.12	42,52,59,73	0
6	GOL	A	301	6/6	0.88	0.12	59,60,62,65	0
7	NAG	E	401	14/15	0.90	0.10	57,66,78,84	0

## 6.5 Other polymers ⓘ

There are no such residues in this entry.