



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 31, 2021 – 09:04 pm BST

PDB ID : 7NXC
Title : Crystal structure of the receptor binding domain of SARS-CoV-2 P.1 variant Spike glycoprotein in complex with ACE2
Authors : Zhou, D.; Ren, J.; Stuart, D.
Deposited on : 2021-03-17
Resolution : 3.14 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 following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

MolProbity : 4.02b-467
Mogul : 1.8.5 (274361), CSD as541be (2020)
Xtriage (Phenix) : 1.13
EDS : 2.18
Percentile statistics : 20191225.v01 (using entries in the PDB archive December 25th 2019)
Refmac : 5.8.0158
CCP4 : 7.0.044 (Gargrove)
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.18

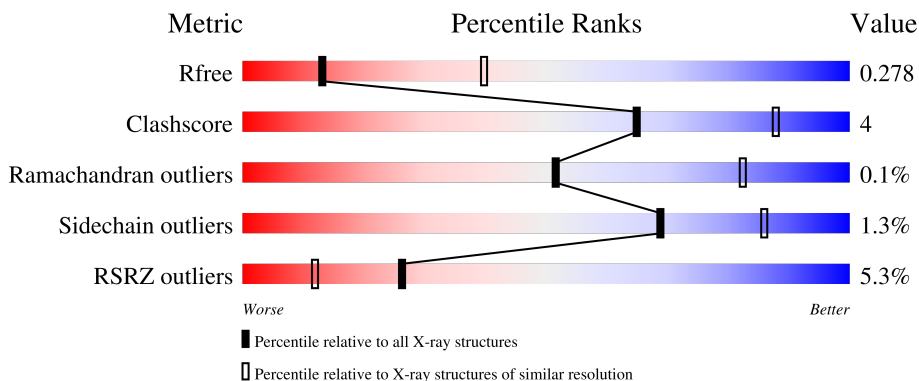
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 3.14 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}	130704	1626 (3.18-3.10)
Clashscore	141614	1735 (3.18-3.10)
Ramachandran outliers	138981	1677 (3.18-3.10)
Sidechain outliers	138945	1677 (3.18-3.10)
RSRZ outliers	127900	1588 (3.18-3.10)

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	604	
2	B	205	

2 Entry composition [i](#)

There are 3 unique types of molecules in this entry. The entry contains 6475 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 Processed angiotensin-converting enzyme 2.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	596	4862	3111	805	917	29	0	0	0

There are 7 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	616	ARG	-	expression tag	UNP Q9BYF1
A	617	HIS	-	expression tag	UNP Q9BYF1
A	618	HIS	-	expression tag	UNP Q9BYF1
A	619	HIS	-	expression tag	UNP Q9BYF1
A	620	HIS	-	expression tag	UNP Q9BYF1
A	621	HIS	-	expression tag	UNP Q9BYF1
A	622	HIS	-	expression tag	UNP Q9BYF1

- Molecule 2 is a protein called Spike protein S1.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
2	B	195	1543	991	256	288	8	0	0	0

There are 13 discrepancies between the modelled and reference sequences:

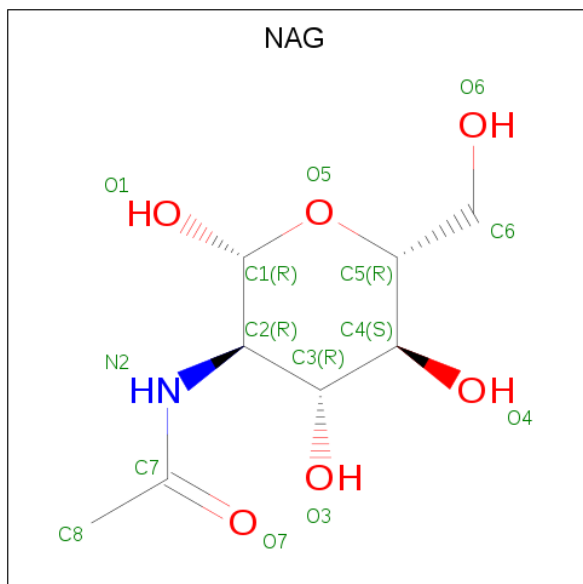
Chain	Residue	Modelled	Actual	Comment	Reference
B	324	GLU	-	expression tag	UNP P0DTC2
B	325	THR	-	expression tag	UNP P0DTC2
B	326	GLY	-	expression tag	UNP P0DTC2
B	327	HIS	-	expression tag	UNP P0DTC2
B	328	HIS	-	expression tag	UNP P0DTC2
B	329	HIS	-	expression tag	UNP P0DTC2
B	330	HIS	-	expression tag	UNP P0DTC2
B	331	HIS	-	expression tag	UNP P0DTC2
B	332	HIS	-	expression tag	UNP P0DTC2

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Chain	Residue	Modelled	Actual	Comment	Reference
B	417	THR	LYS	variant	UNP P0DTC2
B	484	LYS	GLU	variant	UNP P0DTC2
B	501	TYR	ASN	variant	UNP P0DTC2
B	527	LYS	PRO	variant	UNP P0DTC2

- Molecule 3 is 2-acetamido-2-deoxy-beta-D-glucopyranose (three-letter code: NAG) (formula: $C_8H_{15}NO_6$).

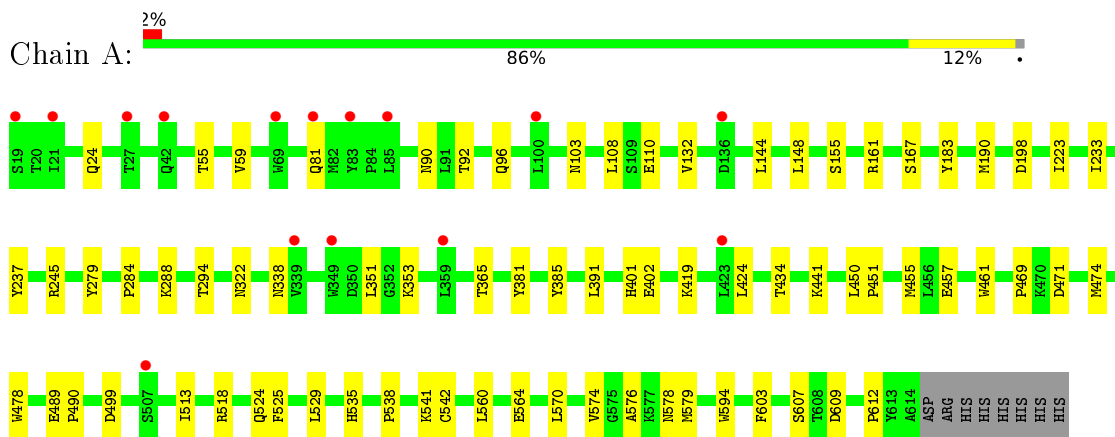


Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
			Total	C	N	O		
3	A	1	Total	C	N	O	0	0
			14	8	1	5		
3	A	1	Total	C	N	O	0	0
			14	8	1	5		
3	A	1	Total	C	N	O	0	0
			14	8	1	5		
3	B	1	Total	C	N	O	0	0
			14	8	1	5		

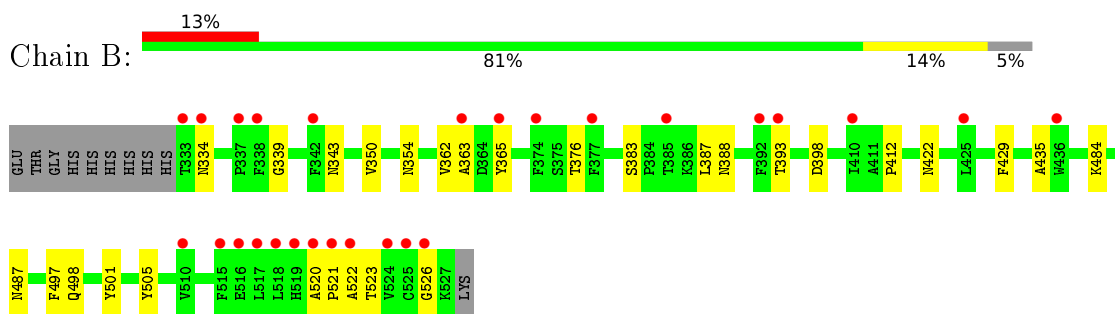
3 Residue-property plots [i](#)

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: Processed angiotensin-converting enzyme 2



- Molecule 2: Spike protein S1



4 Data and refinement statistics

Property	Value	Source
Space group	P 41 21 2	Depositor
Cell constants a, b, c, α , β , γ	103.50Å 103.50Å 225.91Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	69.62 – 3.14 69.62 – 3.14	Depositor EDS
% Data completeness (in resolution range)	99.8 (69.62-3.14) 99.9 (69.62-3.14)	Depositor EDS
R_{merge}	0.50	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.07 (at 3.13Å)	Xtrriage
Refinement program	PHENIX 1.19_4092	Depositor
R, R_{free}	0.226 , 0.278 0.225 , 0.278	Depositor DCC
R_{free} test set	1097 reflections (4.93%)	wwPDB-VP
Wilson B-factor (Å ²)	87.2	Xtrriage
Anisotropy	0.276	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.34 , 39.9	EDS
L-test for twinning ²	$\langle L \rangle = 0.44$, $\langle L^2 \rangle = 0.26$	Xtrriage
Estimated twinning fraction	No twinning to report.	Xtrriage
F_o, F_c correlation	0.92	EDS
Total number of atoms	6475	wwPDB-VP
Average B, all atoms (Å ²)	90.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.73% 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](#)

Bond lengths and bond angles in the following residue types are not validated in this section: 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	0.26	0/4999	0.45	0/6792
2	B	0.28	0/1587	0.51	1/2161 (0.0%)
All	All	0.26	0/6586	0.46	1/8953 (0.0%)

There are no bond length outliers.

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	497	PHE	C-N-CA	5.24	134.81	121.70

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	4862	0	4635	40	0
2	B	1543	0	1458	15	0
3	A	56	0	52	2	0
3	B	14	0	13	0	0
All	All	6475	0	6158	52	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 4.

All (52) 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:402:GLU:HB3	1:A:518:ARG:HD2	1.73	0.70
2:B:520:ALA:HB1	2:B:521:PRO:HD2	1.75	0.69
1:A:245:ARG:NH2	1:A:603:PHE:O	2.26	0.68
1:A:574:VAL:HG23	1:A:576:ALA:H	1.60	0.66
1:A:490:PRO:HA	1:A:612:PRO:HG2	1.79	0.65
1:A:81:GLN:NE2	1:A:103:ASN:OD1	2.31	0.62
1:A:294:THR:HG23	1:A:365:THR:HA	1.84	0.59
1:A:607:SER:OG	1:A:609:ASP:OD1	2.22	0.58
2:B:521:PRO:HB2	2:B:523:THR:HG23	1.86	0.57
1:A:96:GLN:HB3	1:A:391:LEU:HD12	1.89	0.55
1:A:538:PRO:HD2	1:A:541:LYS:HD3	1.89	0.53
1:A:24:GLN:OE1	2:B:487:ASN:ND2	2.42	0.53
2:B:363:ALA:H	2:B:526:GLY:HA2	1.75	0.50
1:A:322:ASN:HD22	3:A:801:NAG:C7	2.25	0.49
1:A:560:LEU:HD22	1:A:564:GLU:HG3	1.94	0.49
2:B:350:VAL:HG22	2:B:422:ASN:HB3	1.95	0.49
1:A:284:PRO:HB3	1:A:594:TRP:CH2	2.48	0.49
1:A:55:THR:O	1:A:59:VAL:HG23	2.13	0.49
1:A:570:LEU:O	1:A:574:VAL:HG22	2.14	0.48
1:A:90:ASN:OD1	1:A:92:THR:HG22	2.13	0.48
2:B:393:THR:HA	2:B:522:ALA:HA	1.95	0.47
1:A:233:ILE:HD13	1:A:450:LEU:HD13	1.97	0.46
2:B:334:ASN:O	2:B:362:VAL:N	2.44	0.46
2:B:412:PRO:HG3	2:B:429:PHE:HB3	1.97	0.46
1:A:108:LEU:HD11	1:A:190:MET:HB2	1.97	0.46
1:A:223:ILE:HG12	1:A:461:TRP:CZ3	2.51	0.45
1:A:578:ASN:OD1	1:A:579:MET:N	2.49	0.45
1:A:535:HIS:CD2	1:A:542:CYS:HB2	2.51	0.45
1:A:144:LEU:HA	1:A:148:LEU:HB2	1.99	0.45
2:B:354:ASN:O	2:B:398:ASP:HA	2.17	0.45
2:B:365:TYR:HB2	2:B:388:ASN:HB3	2.00	0.44
1:A:155:SER:O	1:A:161:ARG:HD2	2.18	0.43
2:B:376:THR:HB	2:B:435:ALA:HB3	1.99	0.43
1:A:322:ASN:ND2	3:A:801:NAG:C7	2.81	0.43
2:B:339:GLY:O	2:B:343:ASN:HB2	2.18	0.43
1:A:279:TYR:CE1	1:A:441:LYS:HB2	2.54	0.43
1:A:535:HIS:CE1	1:A:542:CYS:HA	2.54	0.43
1:A:132:VAL:HG11	1:A:167:SER:HB3	2.00	0.42
1:A:353:LYS:HB3	2:B:501:TYR:CD1	2.54	0.42
1:A:474:MET:HE1	1:A:499:ASP:HB2	2.01	0.42

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:353:LYS:HD2	2:B:505:TYR:CD2	2.54	0.42
1:A:457:GLU:HG2	1:A:513:ILE:HB	2.02	0.42
1:A:351:LEU:HD12	1:A:351:LEU:H	1.85	0.41
2:B:383:SER:H	2:B:387:LEU:HD22	1.84	0.41
1:A:524:GLN:HB3	1:A:574:VAL:HG11	2.01	0.41
1:A:469:PRO:HB2	1:A:471:ASP:OD1	2.20	0.41
1:A:288:LYS:HD3	1:A:434:THR:HG23	2.03	0.41
1:A:419:LYS:HG3	1:A:424:LEU:HB3	2.03	0.41
1:A:237:TYR:CE1	1:A:451:PRO:HG2	2.56	0.41
1:A:478:TRP:CD2	1:A:489:GLU:HB3	2.57	0.40
1:A:402:GLU:HB3	1:A:518:ARG:CD	2.47	0.40
1:A:525:PHE:O	1:A:529:LEU:HG	2.22	0.40

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	594/604 (98%)	573 (96%)	20 (3%)	1 (0%)	47	78
2	B	193/205 (94%)	175 (91%)	18 (9%)	0	100	100
All	All	787/809 (97%)	748 (95%)	38 (5%)	1 (0%)	51	82

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	338	ASN

5.3.2 Protein sidechains [i](#)

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	526/534 (98%)	519 (99%)	7 (1%)	69	86
2	B	167/177 (94%)	165 (99%)	2 (1%)	71	87
All	All	693/711 (98%)	684 (99%)	9 (1%)	69	86

All (9) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	110	GLU
1	A	183	TYR
1	A	198	ASP
1	A	381	TYR
1	A	385	TYR
1	A	401	HIS
1	A	455	MET
2	B	484	LYS
2	B	498	GLN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (2) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	42	GLN
1	A	535	HIS

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 monosaccharides in this entry.

5.6 Ligand geometry [i](#)

5 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
3	NAG	B	601	2	14,14,15	0.42	0	17,19,21	0.76	1 (5%)
3	NAG	A	804	1	14,14,15	0.69	1 (7%)	17,19,21	1.04	2 (11%)
3	NAG	A	803	1	14,14,15	0.92	1 (7%)	17,19,21	0.56	0
3	NAG	A	801	1	14,14,15	0.28	0	17,19,21	0.55	0
3	NAG	A	802	1	14,14,15	0.46	0	17,19,21	0.78	1 (5%)

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
3	NAG	B	601	2	-	0/6/23/26	0/1/1/1
3	NAG	A	804	1	-	2/6/23/26	0/1/1/1
3	NAG	A	803	1	-	2/6/23/26	0/1/1/1
3	NAG	A	801	1	-	0/6/23/26	0/1/1/1
3	NAG	A	802	1	-	0/6/23/26	0/1/1/1

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	A	803	NAG	O5-C1	-3.32	1.38	1.43
3	A	804	NAG	O5-C1	-2.35	1.40	1.43

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed($^{\circ}$)	Ideal($^{\circ}$)
3	A	802	NAG	C1-O5-C5	2.40	115.44	112.19
3	B	601	NAG	C1-O5-C5	2.38	115.41	112.19
3	A	804	NAG	C3-C4-C5	2.29	114.33	110.24
3	A	804	NAG	C4-C3-C2	2.28	114.36	111.02

There are no chirality outliers.

All (4) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	A	803	NAG	C4-C5-C6-O6
3	A	803	NAG	O5-C5-C6-O6
3	A	804	NAG	C4-C5-C6-O6
3	A	804	NAG	O5-C5-C6-O6

There are no ring outliers.

1 monomer is involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	801	NAG	2	0

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	596/604 (98%)	0.41	15 (2%) 57 37	62, 81, 119, 167	0
2	B	195/205 (95%)	0.95	27 (13%) 2 1	71, 99, 158, 190	0
All	All	791/809 (97%)	0.55	42 (5%) 26 12	62, 85, 135, 190	0

All (42) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
2	B	519	HIS	7.6
2	B	521	PRO	7.3
2	B	333	THR	6.2
2	B	520	ALA	5.1
2	B	365	TYR	4.8
1	A	136	ASP	4.1
2	B	515	PHE	4.0
2	B	518	LEU	3.8
2	B	525	CYS	3.7
2	B	522	ALA	3.6
1	A	69	TRP	3.3
1	A	81	GLN	3.0
1	A	423	LEU	3.0
1	A	19	SER	2.9
2	B	524	VAL	2.9
2	B	338	PHE	2.8
2	B	342	PHE	2.8
2	B	374	PHE	2.8
1	A	349	TRP	2.7
1	A	359	LEU	2.6
1	A	21	ILE	2.6
2	B	410	ILE	2.6
2	B	337	PRO	2.5
1	A	42	GLN	2.5

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Mol	Chain	Res	Type	RSRZ
2	B	393	THR	2.5
1	A	85	LEU	2.4
2	B	377	PHE	2.4
2	B	425	LEU	2.4
2	B	517	LEU	2.4
2	B	526	GLY	2.4
1	A	339	VAL	2.3
2	B	392	PHE	2.2
2	B	436	TRP	2.2
1	A	83	TYR	2.1
2	B	516	GLU	2.1
2	B	510	VAL	2.1
2	B	363	ALA	2.1
2	B	334	ASN	2.1
1	A	27	THR	2.0
1	A	100	LEU	2.0
2	B	385	THR	2.0
1	A	507	SER	2.0

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 monosaccharides 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(Å ²)	Q<0.9
3	NAG	A	804	14/15	0.71	0.25	84,114,120,121	0
3	NAG	A	802	14/15	0.79	0.24	78,98,106,107	0
3	NAG	A	803	14/15	0.82	0.22	95,104,109,115	0
3	NAG	A	801	14/15	0.84	0.17	80,103,112,113	0
3	NAG	B	601	14/15	0.89	0.17	73,94,104,104	0

6.5 Other polymers

There are no such residues in this entry.