



# wwPDB X-ray Structure Validation Summary Report

Mar 1, 2014 – 02:33 AM GMT

PDB ID : 2AJF  
Title : Structure of SARS coronavirus spike receptor-binding domain complexed with its receptor  
Authors : Li, F.; Li, W.; Farzan, M.; Harrison, S.C.  
Deposited on : 2005-08-01  
Resolution : 2.90 Å(reported)

This is a wwPDB 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 <http://wwpdb.org/ValidationPDFNotes.html>

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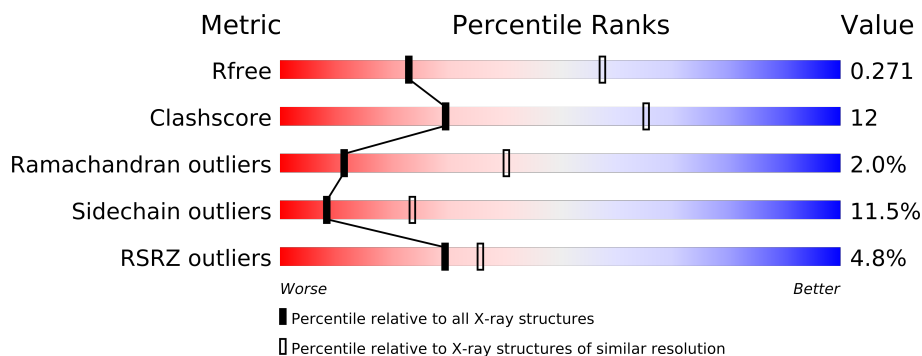
The following versions of software and data (see [references](#)) were used in the production of this report:

MolProbity : 4.02b-467  
Mogul : 1.15 2013  
Xtriage (Phenix) : dev-1323  
EDS : stable22639  
Percentile statistics : 21963  
Refmac : 5.8.0049  
CCP4 : 6.3.0 (Settle)  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et. al. (1996)  
Validation Pipeline (wwPDB-VP) : stable22683

# 1 Overall quality at a glance

The reported resolution of this entry is 2.90 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))
$R_{free}$	66092	1053 (2.90-2.90)
Clashscore	79885	1326 (2.90-2.90)
Ramachandran outliers	78287	1290 (2.90-2.90)
Sidechain outliers	78261	1292 (2.90-2.90)
RSRZ outliers	66119	1054 (2.90-2.90)

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 on the lower bar indicate the fraction of residues that contain outliers for  $\geq 3$ , 2, 1 and 0 types of geometric quality criteria. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density.

Mol	Chain	Length	Quality of chain
1	A	597	
1	B	597	
2	E	180	
2	F	180	

The following table lists non-polymeric compounds that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Geometry	Electron density
4	NAG	A	1053	-	X
4	NAG	A	1322	-	X

## 2 Entry composition

There are 7 unique types of molecules in this entry. The entry contains 12777 atoms, of which 0 are hydrogen and 0 are deuterium.

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 Angiotensin-convertingenzyme-Related Carboxypeptidase (Ace2).

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	597	Total	C	N	O	S	0	0	0
			4870	3115	806	920	29			
1	B	597	Total	C	N	O	S	0	0	0
			4870	3115	806	920	29			

- Molecule 2 is a protein called SARS-coronavirus spike protein.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	E	174	Total	C	N	O	S	0	0	0
			1403	909	228	259	7			
2	F	174	Total	C	N	O	S	0	0	0
			1403	909	228	259	7			

- Molecule 3 is a polymer of unknown type called SUGAR (3-MER).

Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
3	A	3	Total	C	N	O	0	0
			39	22	2	15		
3	B	3	Total	C	N	O	0	0
			39	22	2	15		

- Molecule 4 is SUGAR (N-ACETYL-D-GLUCOSAMINE) (three-letter code: NAG) (formula: C<sub>8</sub>H<sub>15</sub>NO<sub>6</sub>).



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

- Molecule 5 is ZINC ION (three-letter code: ZN) (formula: Zn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	B	1	Total	Zn	0	0
			1	1		
5	A	1	Total	Zn	0	0
			1	1		

- Molecule 6 is CHLORIDE ION (three-letter code: CL) (formula: Cl).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	B	1	Total	Cl	0	0
			1	1		

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Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	1	Total	Cl	0	0
			1	1		

- Molecule 7 is water.

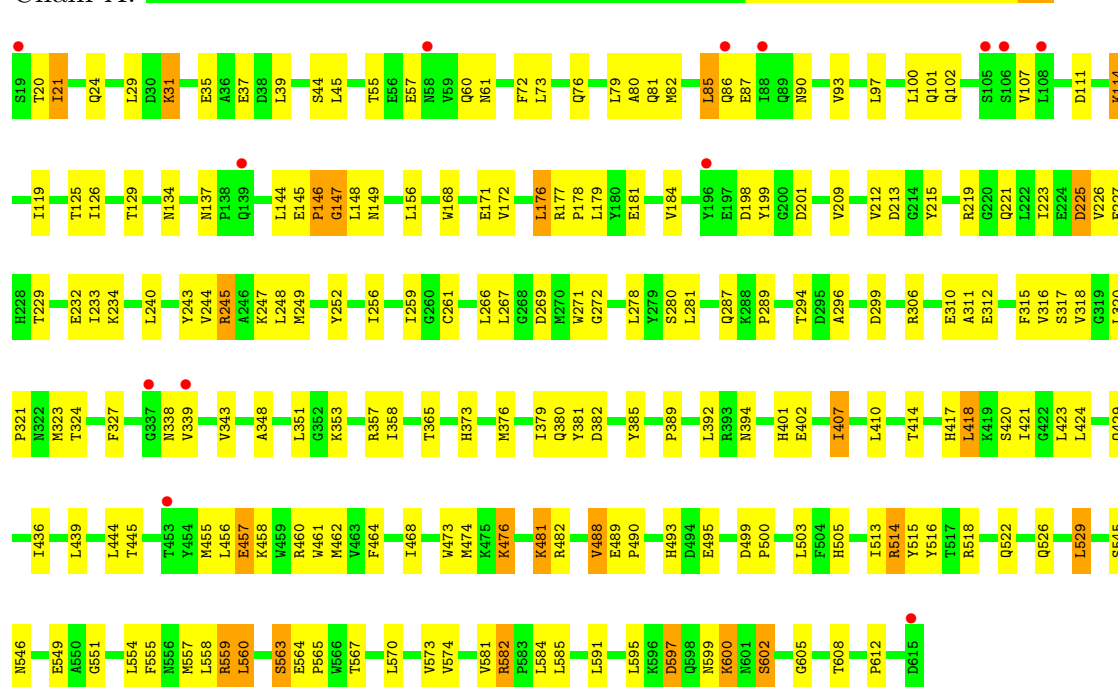
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
7	A	36	Total	O	0	0
			36	36		
7	B	24	Total	O	0	0
			24	24		
7	E	4	Total	O	0	0
			4	4		
7	F	1	Total	O	0	0
			1	1		

### 3 Residue-property plots

These plots are drawn for all protein, RNA and DNA chains in the entry. The first graphic for a chain summarises the proportions of errors 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.

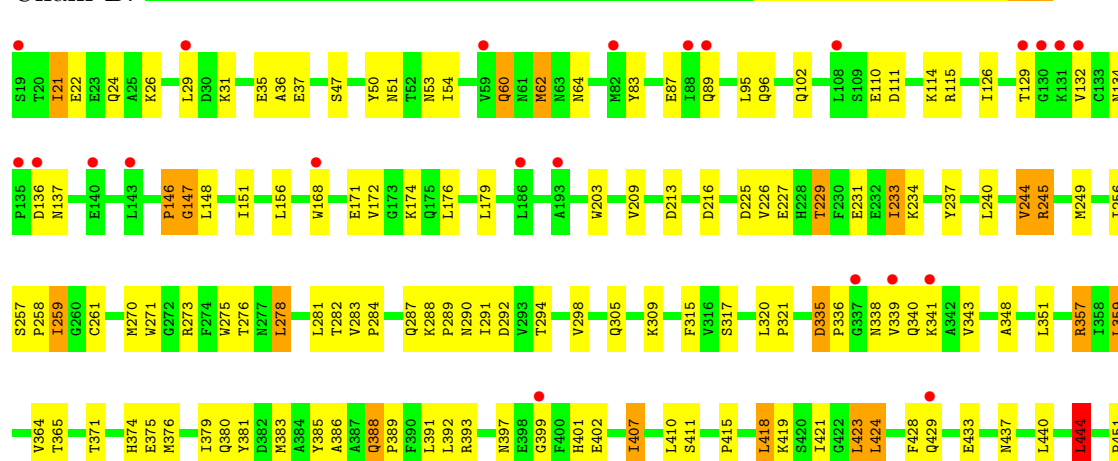
#### • Molecule 1: Angiotensin-convertingenzyme-Related Carboxypeptidase (Ace2)

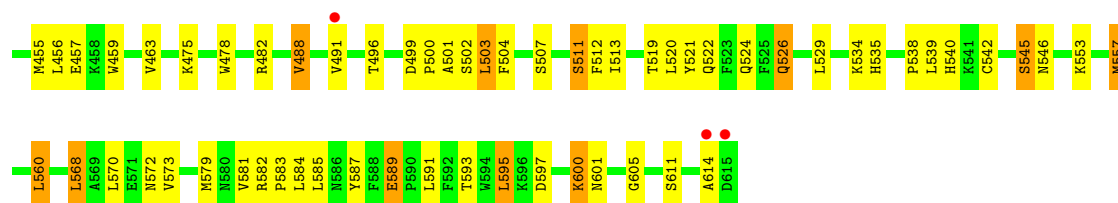
Chain A:



#### • Molecule 1: Angiotensin-convertingenzyme-Related Carboxypeptidase (Ace2)

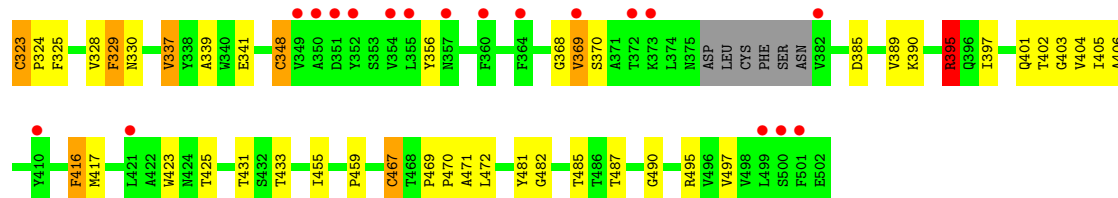
Chain B:





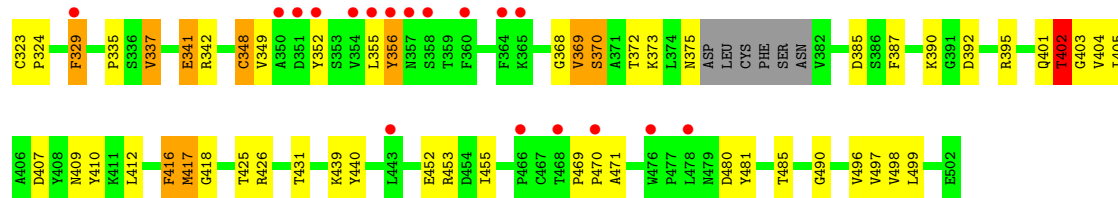
• Molecule 2: SARS-coronavirus spike protein

Chain E:



• Molecule 2: SARS-coronavirus spike protein

Chain F:



## 4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	82.30Å 119.43Å 113.24Å 90.00° 91.97° 90.00°	Depositor
Resolution (Å)	47.40 – 2.90 47.39 – 2.81	Depositor EDS
% Data completeness (in resolution range)	92.4 (47.40-2.90) 85.9 (47.39-2.81)	Depositor EDS
$R_{merge}$	(Not available)	Depositor
$R_{sym}$	0.09	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	2.95 (at 2.81Å)	Xtriage
Refinement program	REFMAC 5.2.0005	Depositor
R, $R_{free}$	0.218 , 0.275 0.216 , 0.271	Depositor DCC
$R_{free}$ test set	2254 reflections (5.14%)	DCC
Wilson B-factor (Å <sup>2</sup> )	73.2	Xtriage
Anisotropy	0.075	Xtriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.29 , 84.3	EDS
Estimated twinning fraction	0.038 for h,-k,-l	Xtriage
L-test for twinning	$\langle  L  \rangle = 0.47$ , $\langle L^2 \rangle = 0.30$	Xtriage
Outliers	0 of 50791 reflections	Xtriage
$F_o, F_c$ correlation	0.94	EDS
Total number of atoms	12777	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	90.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.38% of the height of the origin peak. No significant pseudotranslation is detected.*

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



## 5 Model quality

### 5.1 Standard geometry

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

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	0.47	0/5007	0.62	0/6803
1	B	0.45	0/5007	0.58	2/6803 (0.0%)
2	E	0.47	0/1448	0.62	0/1972
2	F	0.44	0/1448	0.60	0/1972
All	All	0.46	0/12910	0.60	2/17550 (0.0%)

There are no bond length outliers.

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	444	LEU	CA-CB-CG	5.95	128.99	115.30
1	B	423	LEU	N-CA-C	-5.10	97.22	111.00

There are no chirality outliers.

There are no planarity outliers.

### 5.2 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 hydrogens added by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, and the number in parentheses is this value normalized per 1000 atoms of the molecule in the chain. The Symm-Clashes column gives symmetry related clashes, in the same way as for the Clashes column.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	4870	0	4639	124	0
1	B	4870	0	4641	124	0
2	E	1403	0	1326	24	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
2	F	1403	0	1325	31	0
3	A	39	0	34	0	0
3	B	39	0	34	1	0
4	A	42	0	39	2	0
4	B	14	0	13	0	0
4	E	14	0	13	0	0
4	F	14	0	13	0	0
5	A	1	0	0	0	0
5	B	1	0	0	0	0
6	A	1	0	0	1	0
6	B	1	0	0	0	0
7	A	36	0	0	3	0
7	B	24	0	0	3	0
7	E	4	0	0	0	0
7	F	1	0	0	0	0
All	All	12777	0	12077	302	0

Clashscore is defined as the number of clashes calculated for the entry per 1000 atoms (including hydrogens) of the entry. The overall clashscore for this entry is 12.

The worst 5 of 302 close contacts within the same asymmetric unit are listed below.

Atom-1	Atom-2	Distance(Å)	Clash(Å)
1:A:320:LEU:HD13	1:A:380:GLN:HG2	1.36	1.05
1:A:261:CYS:HB2	1:A:488:VAL:CG2	1.93	0.97
1:B:245:ARG:HH21	1:B:245:ARG:HG2	1.32	0.94
1:A:261:CYS:HB2	1:A:488:VAL:HG22	1.48	0.94
2:F:335:PRO:HG3	2:F:341:GLU:HG2	1.49	0.93

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	595/597 (100%)	536 (90%)	55 (9%)	4 (1%)	30 72

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	B	595/597 (100%)	529 (89%)	56 (9%)	10 (2%)	14	45
2	E	170/180 (94%)	137 (81%)	24 (14%)	9 (5%)	3	9
2	F	170/180 (94%)	143 (84%)	19 (11%)	8 (5%)	4	13
All	All	1530/1554 (98%)	1345 (88%)	154 (10%)	31 (2%)	11	40

5 of 31 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	146	PRO
1	B	146	PRO
2	E	402	THR
2	E	404	VAL
2	E	416	PHE

### 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	527/527 (100%)	458 (87%)	69 (13%)	6	17
1	B	527/527 (100%)	473 (90%)	54 (10%)	11	31
2	E	152/158 (96%)	134 (88%)	18 (12%)	8	22
2	F	152/158 (96%)	137 (90%)	15 (10%)	11	34
All	All	1358/1370 (99%)	1202 (88%)	156 (12%)	8	23

5 of 156 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	B	29	LEU
1	B	276	THR
2	F	348	CYS
1	B	62	MET
1	B	156	LEU

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 34 such sidechains are listed below:

Mol	Chain	Res	Type
1	B	24	GLN
1	B	101	GLN
1	B	601	ASN
1	B	51	ASN
1	A	338	ASN

### 5.3.3 RNA ⓘ

There are no RNA chains 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 ⓘ

6 carbohydrates 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	A	1090	1,3	12,14,15	0.62	0	15,19,21	1.82	4 (26%)
3	NAG	A	1091	3	12,14,15	0.41	0	15,19,21	1.61	2 (13%)
3	BMA	A	1092	3	10,11,12	0.75	0	11,15,17	0.81	0
3	NAG	B	1090	1,3	12,14,15	0.65	0	15,19,21	0.68	0
3	NAG	B	1091	3	12,14,15	0.58	0	15,19,21	1.58	3 (20%)
3	BMA	B	1092	3	10,11,12	0.80	0	11,15,17	1.33	2 (18%)

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	A	1090	1,3	-	0/6/23/26	0/1/1/1
3	NAG	A	1091	3	-	0/6/23/26	0/1/1/1
3	BMA	A	1092	3	-	0/2/19/22	0/1/1/1
3	NAG	B	1090	1,3	-	0/6/23/26	0/1/1/1
3	NAG	B	1091	3	-	0/6/23/26	0/1/1/1
3	BMA	B	1092	3	-	0/2/19/22	0/1/1/1

There are no bond length outliers.

The worst 5 of 11 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	1091	NAG	O5-C5-C4	4.74	116.67	110.65
3	B	1091	NAG	O5-C5-C6	4.47	111.67	106.98
3	A	1090	NAG	O5-C5-C4	4.28	116.09	110.65
3	B	1092	BMA	O5-C5-C6	3.39	110.53	106.98
3	A	1090	NAG	O5-C5-C6	-2.91	103.92	106.98

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

## 5.6 Ligand geometry ⓘ

Of 10 ligands modelled in this entry, 4 are monoatomic - leaving 6 for Mogul analysis.

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$
4	NAG	A	1053	1	12,14,15	0.64	0	15,19,21	0.84	0
4	NAG	A	1322	1	12,14,15	0.47	0	15,19,21	1.43	2 (13%)
4	NAG	A	1546	1	12,14,15	0.68	0	15,19,21	1.36	2 (13%)
4	NAG	B	1322	1	12,14,15	0.61	0	15,19,21	1.06	0
4	NAG	E	1330	2	12,14,15	0.57	0	15,19,21	1.24	2 (13%)
4	NAG	F	1330	2	12,14,15	0.54	0	15,19,21	1.62	3 (20%)

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
4	NAG	A	1053	1	-	0/6/23/26	0/1/1/1
4	NAG	A	1322	1	-	0/6/23/26	0/1/1/1
4	NAG	A	1546	1	-	0/6/23/26	0/1/1/1
4	NAG	B	1322	1	-	0/6/23/26	0/1/1/1
4	NAG	E	1330	2	-	0/6/23/26	0/1/1/1
4	NAG	F	1330	2	-	0/6/23/26	0/1/1/1

There are no bond length outliers.

The worst 5 of 9 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
4	A	1322	NAG	O5-C5-C4	3.94	115.66	110.65
4	F	1330	NAG	O5-C5-C4	3.79	115.47	110.65
4	F	1330	NAG	C2-N2-C7	-3.45	117.29	123.09
4	A	1546	NAG	C3-C4-C5	-3.44	104.06	110.20
4	F	1330	NAG	C4-C3-C2	-2.72	104.67	111.32

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

## 5.7 Other polymers ⓘ

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 ⓘ

### 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, 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	597/597 (100%)	0.05	13 (2%) 59 67	56, 82, 123, 147	0
1	B	597/597 (100%)	0.27	26 (4%) 33 40	56, 82, 123, 148	0
2	E	174/180 (96%)	0.46	18 (10%) 7 9	75, 96, 142, 153	0
2	F	174/180 (96%)	0.52	18 (10%) 7 9	76, 96, 142, 152	0
All	All	1542/1554 (99%)	0.23	75 (4%) 29 34	56, 88, 131, 153	0

The worst 5 of 75 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	615	ASP	5.7
1	B	136	ASP	5.6
2	E	501	PHE	5.5
2	F	354	VAL	5.4
1	A	615	ASP	4.3

### 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 ⓘ

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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. 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	RSR	LLDF	B-factors( $\text{\AA}^2$ )	Q<0.9
3	NAG	A	1090	14/15	0.19	-0.36	79,86,89,93	0
3	NAG	B	1090	14/15	0.16	-1.21	93,99,100,102	0
3	BMA	A	1092	11/12	0.40	-	79,80,81,81	0
3	BMA	B	1092	11/12	0.20	-	83,84,84,85	0
3	NAG	A	1091	14/15	0.27	-	70,75,77,79	0
3	NAG	B	1091	14/15	0.22	-	87,90,91,91	0

## 6.4 Ligands

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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. 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	RSR	LLDF	B-factors( $\text{\AA}^2$ )	Q<0.9
4	NAG	A	1053	14/15	0.40	2.85	88,89,90,90	0
4	NAG	A	1322	14/15	0.19	2.70	75,77,78,78	0
4	NAG	A	1546	14/15	0.24	1.90	72,74,77,78	0
4	NAG	B	1322	14/15	0.24	1.55	72,74,76,77	0
5	ZN	A	901	1/1	0.22	0.49	74,74,74,74	0
4	NAG	E	1330	14/15	0.30	0.43	108,109,112,113	0
6	CL	B	1902	1/1	0.21	0.10	115,115,115,115	0
4	NAG	F	1330	14/15	0.25	-0.19	106,107,108,108	0
5	ZN	B	901	1/1	0.21	-1.07	84,84,84,84	0
6	CL	A	902	1/1	0.15	-2.78	74,74,74,74	0

## 6.5 Other polymers

There are no such residues in this entry.