Full wwPDB X-ray Structure Validation Report ⓘ

Feb 22, 2021 – 11:08 AM GMT

PDB ID	:	7BEJ
Title	:	Crystal structure of the receptor binding domain of SARS-CoV-2 Spike glycoprotein in complex with COVOX-158 Fab (crystal form 1)
Authors	:	Zhou, D.; Zhao, Y.; Ren, J.; Stuart, D.
Deposited on	:	2020-12-23
Resolution	:	2.42 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 ①) were used in the production of this report:

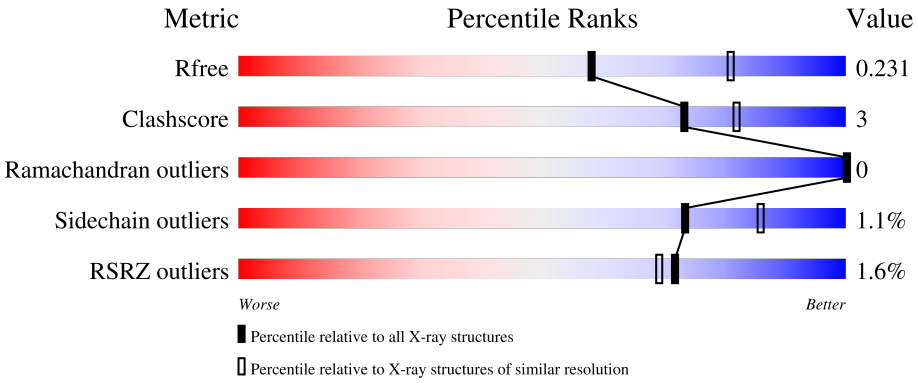
MolProbity	:	4.02b-467
Mogul	:	1.8.5 (274361), CSD as541be (2020)
Xtriage (Phenix)	:	1.13
EDS	:	2.17.1.dev1
Percentile statistics	:	20191225.v01 (using entries in the PDB archive December 25th 2019)
Refmac	:	5.8.0158
CCP4	:	7.0.044 (Gargrove)
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.17.1.dev1

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 2.42 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	4647 (2.44-2.40)
Clashscore	141614	5161 (2.44-2.40)
Ramachandran outliers	138981	5073 (2.44-2.40)
Sidechain outliers	138945	5074 (2.44-2.40)
RSRZ outliers	127900	4543 (2.44-2.40)

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 <=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	H	222	2% 89% 7% .
2	L	214	% 89% 11%
3	E	205	2% 87% 7% 5%
4	A	3	33% 67%

The following table lists non-polymeric compounds, carbohydrate monomers and non-standard

residues in protein, DNA, RNA chains that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Chirality	Geometry	Clashes	Electron density
6	FMT	E	804	-	-	-	X

2 Entry composition

There are 7 unique types of molecules in this entry. The entry contains 4899 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 COVOX-158 heavy chain.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	H	215	Total	C	N	O	S	0	1	0
			1594	1002	267	318	7			

- Molecule 2 is a protein called COVOX-158 light chain.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	L	213	Total	C	N	O	S	0	2	0
			1645	1033	275	331	6			

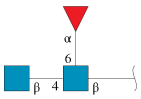
- Molecule 3 is a protein called Spike glycoprotein.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	E	195	Total	C	N	O	S	0	0	0
			1545	990	258	289	8			

There are 10 discrepancies between the modelled and reference sequences:

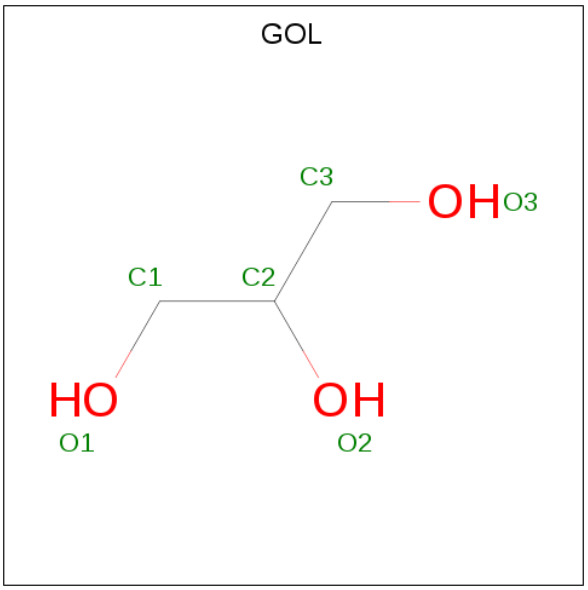
Chain	Residue	Modelled	Actual	Comment	Reference
E	324	GLU	-	expression tag	UNP P0DTC2
E	325	THR	-	expression tag	UNP P0DTC2
E	326	GLY	-	expression tag	UNP P0DTC2
E	327	HIS	-	expression tag	UNP P0DTC2
E	328	HIS	-	expression tag	UNP P0DTC2
E	329	HIS	-	expression tag	UNP P0DTC2
E	330	HIS	-	expression tag	UNP P0DTC2
E	331	HIS	-	expression tag	UNP P0DTC2
E	332	HIS	-	expression tag	UNP P0DTC2
E	527	LYS	PRO	engineered mutation	UNP P0DTC2

- Molecule 4 is an oligosaccharide called 2-acetamido-2-deoxy-beta-D-glucopyranose-(1-4)-[alpha-L-fucopyranose-(1-6)]2-acetamido-2-deoxy-beta-D-glucopyranose.



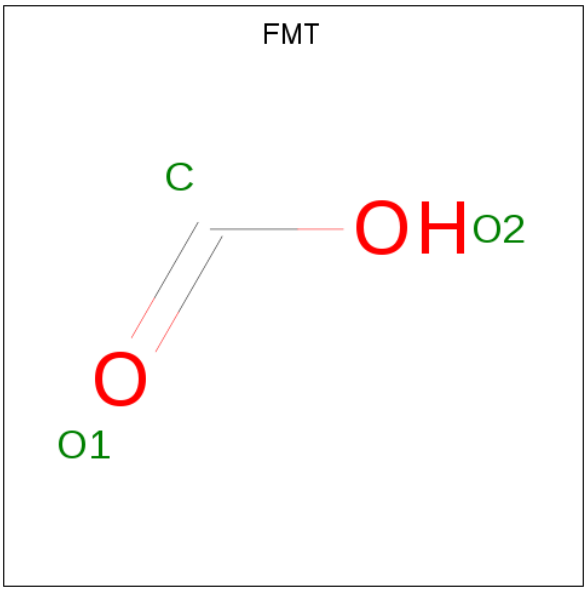
Mol	Chain	Residues	Atoms	ZeroOcc	AltConf	Trace
4	A	3	Total C N O 38 22 2 14	0	0	0

- Molecule 5 is GLYCEROL (three-letter code: GOL) (formula: $C_3H_8O_3$).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
5	L	1	Total C O 6 3 3	0	0
5	E	1	Total C O 6 3 3	0	0

- Molecule 6 is FORMIC ACID (three-letter code: FMT) (formula: CH_2O_2).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
6	L	1	Total C O 3 1 2	0	0
6	E	1	Total C O 3 1 2	0	0
6	E	1	Total C O 3 1 2	0	0
6	E	1	Total C O 3 1 2	0	0
6	E	1	Total C O 3 1 2	0	0
6	E	1	Total C O 3 1 2	0	0

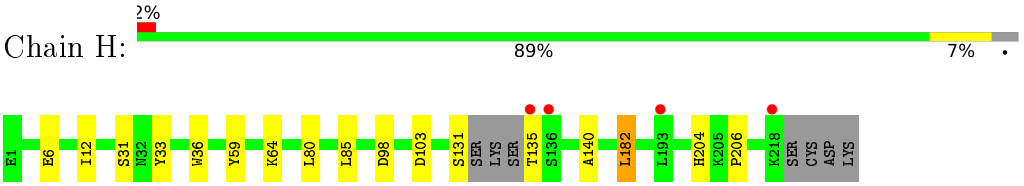
- Molecule 7 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
7	H	15	Total O 15 15	0	0
7	L	14	Total O 14 14	0	0
7	E	18	Total O 18 18	0	0

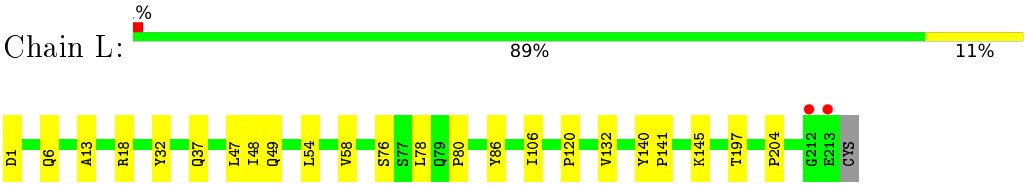
3 Residue-property plots (i)

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.

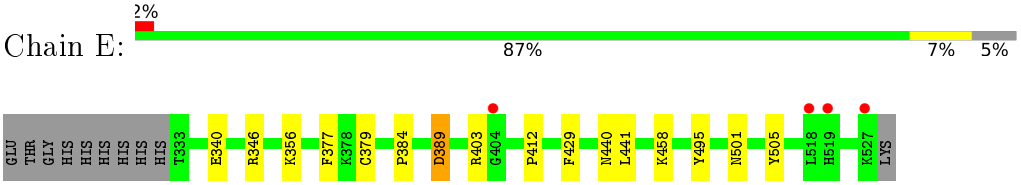
• Molecule 1: COVOX-158 heavy chain



• Molecule 2: COVOX-158 light chain



• Molecule 3: Spike glycoprotein



• Molecule 4: 2-acetamido-2-deoxy-beta-D-glucopyranose-(1-4)-[alpha-L-fucopyranose-(1-6)]2-acetamido-2-deoxy-beta-D-glucopyranose

4 Data and refinement statistics (i)

Property	Value	Source
Space group	C 2 2 21	Depositor
Cell constants a, b, c, α, β, γ	53.17Å 232.32Å 135.16Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	53.36 – 2.42 53.36 – 2.42	Depositor EDS
% Data completeness (in resolution range)	97.6 (53.36-2.42) 97.6 (53.36-2.42)	Depositor EDS
R_{merge}	0.25	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	1.02 (at 2.42Å)	Xtriage
Refinement program	PHENIX 1.18.1_3865	Depositor
R, R_{free}	0.190 , 0.231 0.190 , 0.231	Depositor DCC
R_{free} test set	1612 reflections (5.08%)	wwPDB-VP
Wilson B-factor (Å^2)	53.4	Xtriage
Anisotropy	0.286	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.38 , 41.5	EDS
L-test for twinning[2]	$< \|L\| > = 0.49$, $< L^2 > = 0.33$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o,F_c correlation	0.95	EDS
Total number of atoms	4899	wwPDB-VP
Average B, all atoms (Å^2)	57.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.08% of the height of the origin peak. No significant pseudotranslation is detected.*

[1] Intensities estimated from amplitudes.

[2] Theoretical values of $< |L| >$, $< L^2 >$ 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

Bond lengths and bond angles in the following residue types are not validated in this section: FMT, GOL, FUC, 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	H	0.26	0/1632	0.50	1/2222 (0.0%)
2	L	0.27	0/1685	0.50	0/2286
3	E	0.27	0/1588	0.45	0/2160
All	All	0.27	0/4905	0.48	1/6668 (0.0%)

There are no bond length outliers.

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	H	182	LEU	CA-CB-CG	5.64	128.28	115.30

There are no chirality outliers.

There are no planarity outliers.

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	H	1594	0	1571	12	0
2	L	1645	0	1614	13	0
3	E	1545	0	1465	9	0
4	A	38	0	34	0	0
5	E	6	0	8	0	0
5	L	6	0	8	0	0
6	E	15	0	5	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
6	L	3	0	1	0	0
7	E	18	0	0	0	0
7	H	15	0	0	0	0
7	L	14	0	0	0	0
All	All	4899	0	4706	31	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.

All (31) 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)
3:E:389:ASP:OD1	3:E:389:ASP:N	2.19	0.72
3:E:340:GLU:OE2	3:E:356:LYS:NZ	2.33	0.61
2:L:32:TYR:OH	3:E:495:TYR:O	2.21	0.58
2:L:18:ARG:HG3	2:L:76:SER:HA	1.86	0.57
2:L:47:LEU:HA	2:L:58:VAL:HG21	1.91	0.53
2:L:37:GLN:HB2	2:L:47:LEU:HD11	1.90	0.53
2:L:48:ILE:HD13	2:L:54:LEU:HA	1.91	0.52
1:H:12:ILE:HG21	1:H:85:LEU:HD13	1.93	0.51
2:L:197:THR:HG22	2:L:204:PRO:HB3	1.94	0.50
2:L:120:PRO:HD3	2:L:132:VAL:HG22	1.94	0.49
3:E:379:CYS:SG	3:E:384:PRO:HG3	2.55	0.47
1:H:135:THR:HA	1:H:140:ALA:HA	1.97	0.47
1:H:59:TYR:O	1:H:64:LYS:NZ	2.48	0.47
1:H:33:TYR:HB2	1:H:98:ASP:HB3	1.96	0.46
1:H:204:HIS:CD2	1:H:206:PRO:HD2	2.50	0.46
3:E:440:ASN:ND2	3:E:441:LEU:HG	2.32	0.45
2:L:80:PRO:HA	2:L:106:ILE:HG13	1.99	0.44
2:L:13:ALA:HB3	2:L:78:LEU:HD22	2.00	0.44
1:H:36:TRP:CE2	1:H:80:LEU:HB2	2.53	0.44
1:H:103:ASP:OD1	1:H:103:ASP:N	2.46	0.44
2:L:140:TYR:CG	2:L:141:PRO:HA	2.54	0.43
3:E:501:ASN:HB3	3:E:505:TYR:HB2	2.00	0.43
3:E:412:PRO:HG3	3:E:429:PHE:HB3	2.01	0.42
1:H:33:TYR:CB	1:H:98:ASP:HB3	2.49	0.42
3:E:403:ARG:HG3	3:E:495:TYR:CE1	2.55	0.42
2:L:6:GLN:NE2	2:L:86:TYR:O	2.43	0.41
1:H:31:SER:OG	3:E:458:LYS:HE3	2.20	0.41
1:H:131:SER:HB2	1:H:135:THR:HB	2.02	0.41
1:H:103:ASP:OD2	2:L:49:GLN:NE2	2.54	0.41

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:H:36:TRP:NE1	1:H:80:LEU:HB2	2.37	0.40
2:L:145:LYS:HB3	2:L:197:THR:OG1	2.21	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	H	212/222 (96%)	209 (99%)	3 (1%)	0	100	100
2	L	213/214 (100%)	202 (95%)	11 (5%)	0	100	100
3	E	193/205 (94%)	186 (96%)	7 (4%)	0	100	100
All	All	618/641 (96%)	597 (97%)	21 (3%)	0	100	100

There are no Ramachandran outliers to report.

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	H	181/187 (97%)	179 (99%)	2 (1%)	73	86
2	L	188/187 (100%)	187 (100%)	1 (0%)	88	95
3	E	168/177 (95%)	165 (98%)	3 (2%)	59	75
All	All	537/551 (98%)	531 (99%)	6 (1%)	73	86

All (6) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	H	6	GLU
1	H	182	LEU
2	L	1	ASP
3	E	346	ARG
3	E	377	PHE
3	E	389	ASP

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (1) such sidechains are listed below:

Mol	Chain	Res	Type
1	H	168	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)

3 monosaccharides 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	$\#\|Z\| > 2$
4	NAG	A	1	4,3	14,14,15	0.40	0	17,19,21	0.80	1 (5%)
4	NAG	A	2	4	14,14,15	0.41	0	17,19,21	0.58	0
4	FUC	A	3	4	10,10,11	1.33	1 (10%)	14,14,16	0.74	0

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	1	4,3	-	2/6/23/26	0/1/1/1
4	NAG	A	2	4	-	0/6/23/26	0/1/1/1
4	FUC	A	3	4	-	-	0/1/1/1

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	A	3	FUC	O5-C1	-3.36	1.38	1.43

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
4	A	1	NAG	C1-O5-C5	2.56	115.67	112.19

There are no chirality outliers.

All (2) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
4	A	1	NAG	O5-C5-C6-O6
4	A	1	NAG	C4-C5-C6-O6

There are no ring outliers.

No monomer is involved in short contacts.

5.6 Ligand geometry (i)

8 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	FMT	E	803	-	0,2,2	0.00	-	0,1,1	0.00	-
5	GOL	E	802	-	5,5,5	0.98	0	5,5,5	0.96	0
6	FMT	E	805	-	0,2,2	0.00	-	0,1,1	0.00	-
6	FMT	E	804	-	0,2,2	0.00	-	0,1,1	0.00	-
6	FMT	E	806	-	0,2,2	0.00	-	0,1,1	0.00	-
6	FMT	E	801	-	0,2,2	0.00	-	0,1,1	0.00	-
5	GOL	L	301	-	5,5,5	0.89	0	5,5,5	1.03	0
6	FMT	L	302	-	0,2,2	0.00	-	0,1,1	0.00	-

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
5	GOL	E	802	-	-	2/4/4/4	-
5	GOL	L	301	-	-	2/4/4/4	-

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

All (4) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
5	L	301	GOL	O1-C1-C2-C3
5	E	802	GOL	O1-C1-C2-C3
5	L	301	GOL	O1-C1-C2-O2
5	E	802	GOL	O1-C1-C2-O2

There are no ring outliers.

No monomer is involved in short contacts.

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, 95^{th} 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	H	215/222 (96%)	0.09	4 (1%)	66	64	42, 57, 82, 123	0
2	L	213/214 (99%)	0.04	2 (0%)	84	82	41, 53, 78, 110	0
3	E	195/205 (95%)	0.21	4 (2%)	63	60	39, 51, 79, 105	0
All	All	623/641 (97%)	0.11	10 (1%)	72	69	39, 54, 81, 123	0

All (10) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	H	135	THR	5.3
2	L	213	GLU	3.9
1	H	136	SER	3.5
3	E	518	LEU	3.4
3	E	519	HIS	2.7
1	H	218	LYS	2.7
3	E	527	LYS	2.6
2	L	212	GLY	2.5
1	H	193	LEU	2.3
3	E	404	GLY	2.2

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. The B-factors column lists the minimum, median, 95^{th} 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
4	NAG	A	2	14/15	0.80	0.21	95,105,109,112	0
4	FUC	A	3	10/11	0.83	0.34	102,110,114,117	0
4	NAG	A	1	14/15	0.93	0.14	60,76,95,96	0

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^{th} 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
6	FMT	E	804	3/3	0.80	0.41	72,72,73,74	0
5	GOL	E	802	6/6	0.81	0.33	57,67,70,75	0
6	FMT	E	806	3/3	0.83	0.15	66,66,67,68	0
6	FMT	L	302	3/3	0.92	0.22	45,45,61,66	0
6	FMT	E	805	3/3	0.94	0.14	65,65,69,79	0
5	GOL	L	301	6/6	0.94	0.25	59,60,62,64	0
6	FMT	E	801	3/3	0.95	0.35	60,60,67,68	0
6	FMT	E	803	3/3	0.98	0.19	57,57,61,63	0

6.5 Other polymers (i)

There are no such residues in this entry.