



wwPDB X-ray Structure Validation Summary Report ⓘ

Dec 15, 2024 – 02:00 AM EST

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 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 : 4.02b-467
Mogul : 2022.3.0, CSD as543be (2022)
Xtriage (Phenix) : 1.21
EDS : 3.0
Percentile statistics : 20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4 : 9.0.004 (Gargrove)
Density-Fitness : 1.0.11
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.40

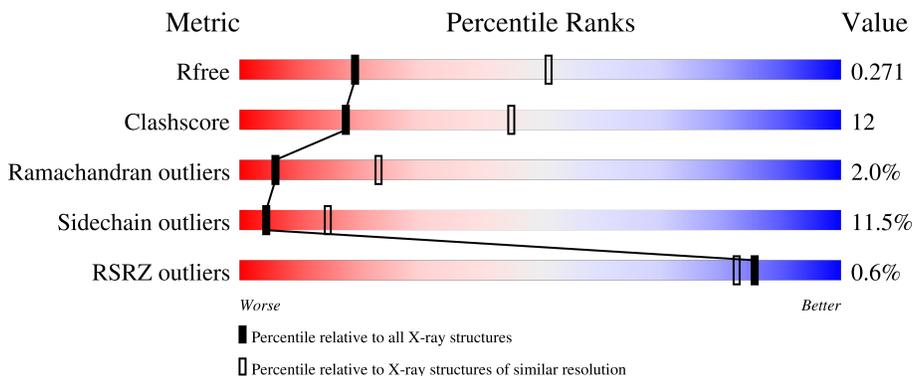
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.90 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.



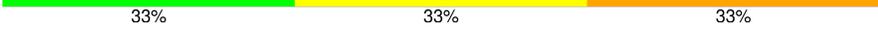
Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	164625	2335 (2.90-2.90)
Clashscore	180529	2564 (2.90-2.90)
Ramachandran outliers	177936	2514 (2.90-2.90)
Sidechain outliers	177891	2516 (2.90-2.90)
RSRZ outliers	164620	2337 (2.90-2.90)

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 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	597	
1	B	597	
2	E	180	
2	F	180	
3	C	3	

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Mol	Chain	Length	Quality of chain
3	D	3	 33% 33% 33%

2 Entry composition [i](#)

There are 7 unique types of molecules in this entry. The entry contains 12777 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.

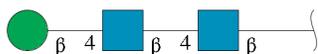
- Molecule 1 is a protein called Angiotensin-converting enzyme-Related Carboxypeptidase (Ace2).

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

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

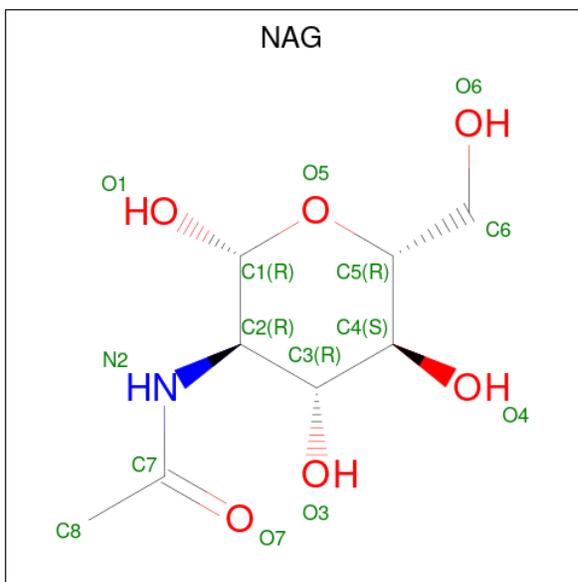
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
2	E	174	1403	909	228	259	7	0	0	0
2	F	174	1403	909	228	259	7	0	0	0

- Molecule 3 is an oligosaccharide called beta-D-mannopyranose-(1-4)-2-acetamido-2-deoxy-beta-D-glucopyranose-(1-4)-2-acetamido-2-deoxy-beta-D-glucopyranose.



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

- Molecule 4 is 2-acetamido-2-deoxy-beta-D-glucopyranose (three-letter code: NAG) (formula: C₈H₁₅NO₆).



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

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

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

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

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

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

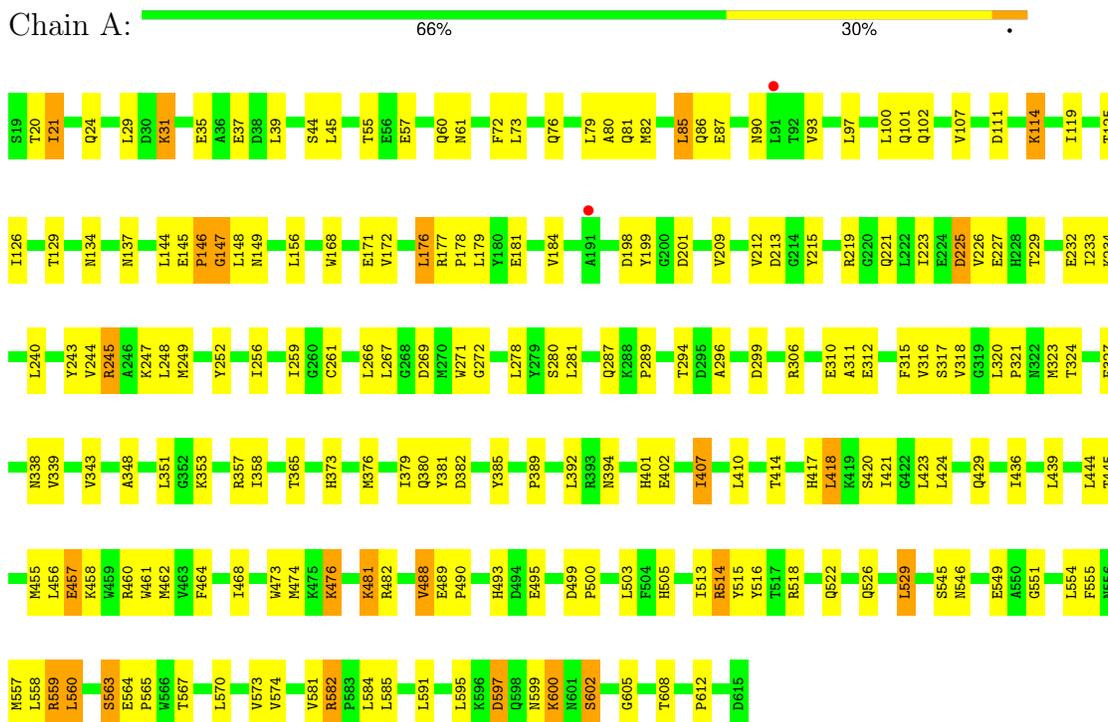
- Molecule 7 is water.

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		

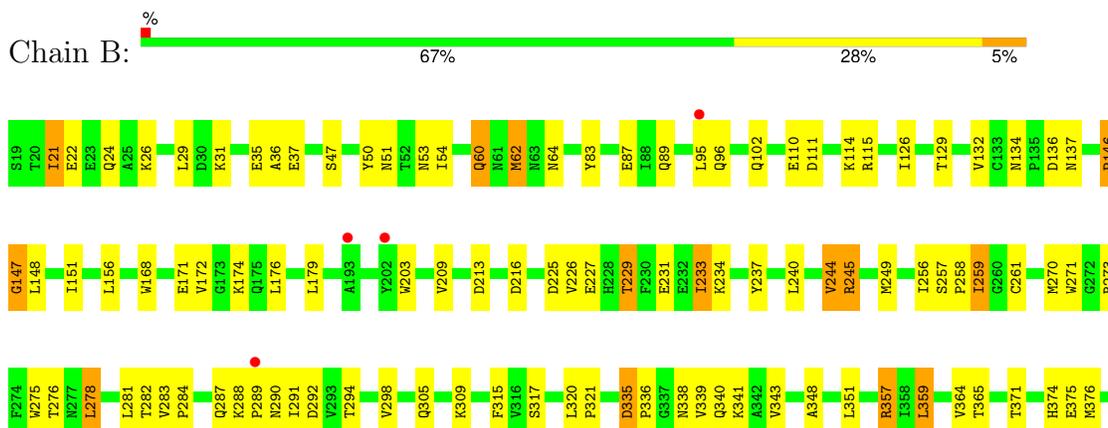
3 Residue-property plots i

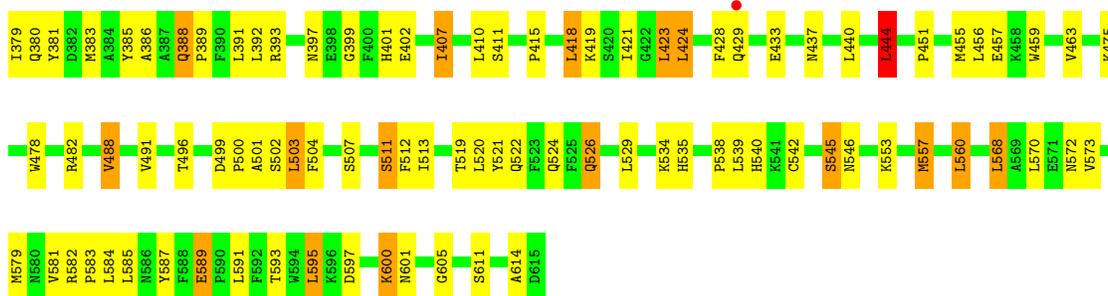
These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. 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: Angiotensin-converting enzyme-Related Carboxypeptidase (Ace2)

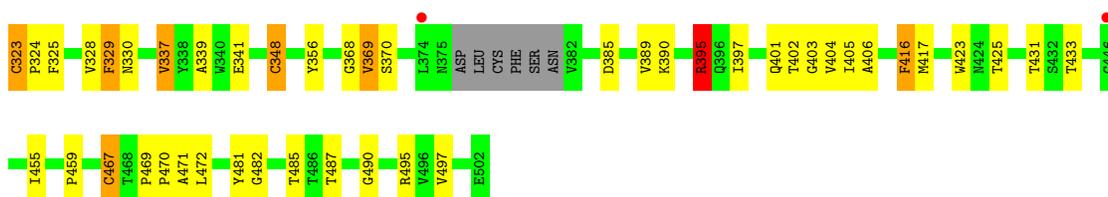


- Molecule 1: Angiotensin-converting enzyme-Related Carboxypeptidase (Ace2)

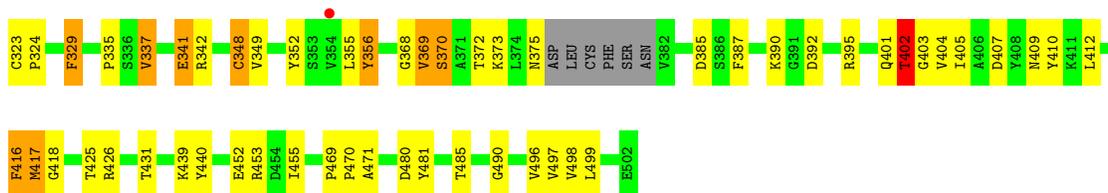




- Molecule 2: SARS-coronavirus spike protein



- Molecule 2: SARS-coronavirus spike protein



- Molecule 3: beta-D-mannopyranose-(1-4)-2-acetamido-2-deoxy-beta-D-glucopyranose-(1-4)-2-acetamido-2-deoxy-beta-D-glucopyranose



- Molecule 3: beta-D-mannopyranose-(1-4)-2-acetamido-2-deoxy-beta-D-glucopyranose-(1-4)-2-acetamido-2-deoxy-beta-D-glucopyranose



4 Data and refinement statistics i

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	82.30Å 119.43Å 113.24Å 90.00° 91.97° 90.00°	Depositor
Resolution (Å)	47.40 – 2.90 47.40 – 2.90	Depositor EDS
% Data completeness (in resolution range)	92.4 (47.40-2.90) 90.5 (47.40-2.90)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.09	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.95 (at 2.81Å)	Xtrriage
Refinement program	REFMAC 5.2.0005	Depositor
R, R_{free}	0.218 , 0.275 0.215 , 0.271	Depositor DCC
R_{free} test set	2311 reflections (4.92%)	wwPDB-VP
Wilson B-factor (Å ²)	73.2	Xtrriage
Anisotropy	0.075	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.30 , 84.1	EDS
L-test for twinning ²	$\langle L \rangle = 0.47$, $\langle L^2 \rangle = 0.30$	Xtrriage
Estimated twinning fraction	0.038 for h,-k,-l	Xtrriage
F_o, F_c correlation	0.93	EDS
Total number of atoms	12777	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 3.38% 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: ZN, NAG, BMA, 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 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	4870	0	4639	124	0
1	B	4870	0	4641	124	0
2	E	1403	0	1326	24	0
2	F	1403	0	1325	31	0
3	C	39	0	34	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
3	D	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

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 12.

The worst 5 of 302 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: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:HG2	1:B:245:ARG:HH21	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 [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	595/597 (100%)	536 (90%)	55 (9%)	4 (1%)	19	49
1	B	595/597 (100%)	529 (89%)	56 (9%)	10 (2%)	7	27
2	E	170/180 (94%)	137 (81%)	24 (14%)	9 (5%)	1	5
2	F	170/180 (94%)	143 (84%)	19 (11%)	8 (5%)	2	7
All	All	1530/1554 (98%)	1345 (88%)	154 (10%)	31 (2%)	6	23

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 [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	527/527 (100%)	458 (87%)	69 (13%)	3	10
1	B	527/527 (100%)	473 (90%)	54 (10%)	6	19
2	E	152/158 (96%)	134 (88%)	18 (12%)	4	13
2	F	152/158 (96%)	137 (90%)	15 (10%)	6	21
All	All	1358/1370 (99%)	1202 (88%)	156 (12%)	4	15

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

Mol	Chain	Res	Type
1	B	568	LEU
2	F	341	GLU
1	B	589	GLU
2	E	395	ARG
2	F	417	MET

Sometimes 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	556	ASN
1	B	586	ASN
2	E	473	ASN
1	A	580	ASN
1	A	526	GLN

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](#)

6 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	$\# Z > 2$
3	NAG	C	1	3,1	14,14,15	0.48	0	17,19,21	2.06	5 (29%)
3	NAG	C	2	3	14,14,15	0.33	0	17,19,21	2.65	3 (17%)
3	BMA	C	3	3	11,11,12	0.61	0	15,15,17	1.09	1 (6%)
3	NAG	D	1	3,1	14,14,15	0.54	0	17,19,21	0.77	0
3	NAG	D	2	3	14,14,15	0.49	0	17,19,21	1.08	2 (11%)
3	BMA	D	3	3	11,11,12	0.61	0	15,15,17	1.23	2 (13%)

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	C	1	3,1	-	4/6/23/26	0/1/1/1
3	NAG	C	2	3	-	4/6/23/26	0/1/1/1
3	BMA	C	3	3	-	1/2/19/22	0/1/1/1
3	NAG	D	1	3,1	-	4/6/23/26	0/1/1/1
3	NAG	D	2	3	-	2/6/23/26	0/1/1/1
3	BMA	D	3	3	-	2/2/19/22	0/1/1/1

There are no bond length outliers.

The worst 5 of 13 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	C	2	NAG	C1-O5-C5	9.05	124.32	112.19
3	C	1	NAG	C1-O5-C5	5.97	120.18	112.19
3	C	2	NAG	O5-C1-C2	4.37	118.06	111.29
3	C	3	BMA	C1-O5-C5	3.14	116.39	112.19
3	D	3	BMA	C1-O5-C5	2.67	115.77	112.19

There are no chirality outliers.

5 of 17 torsion outliers are listed below:

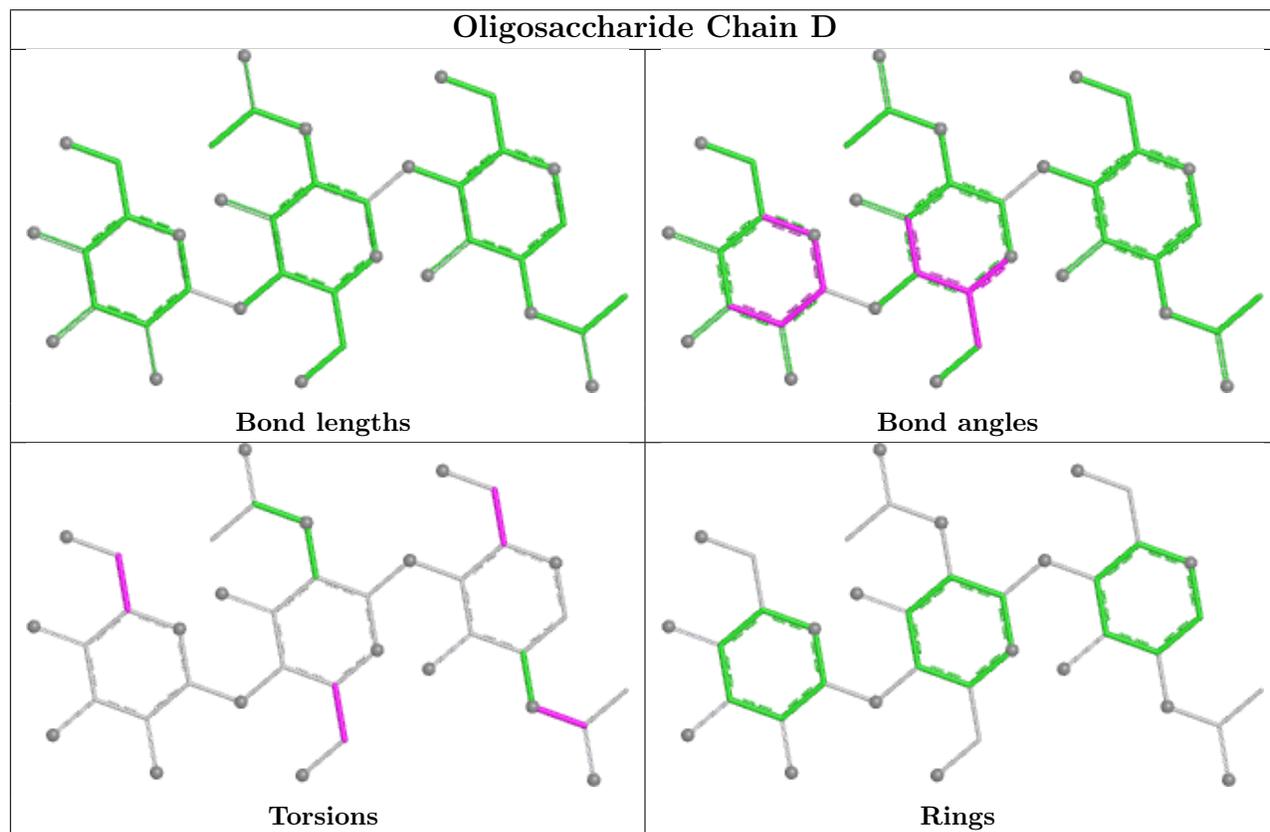
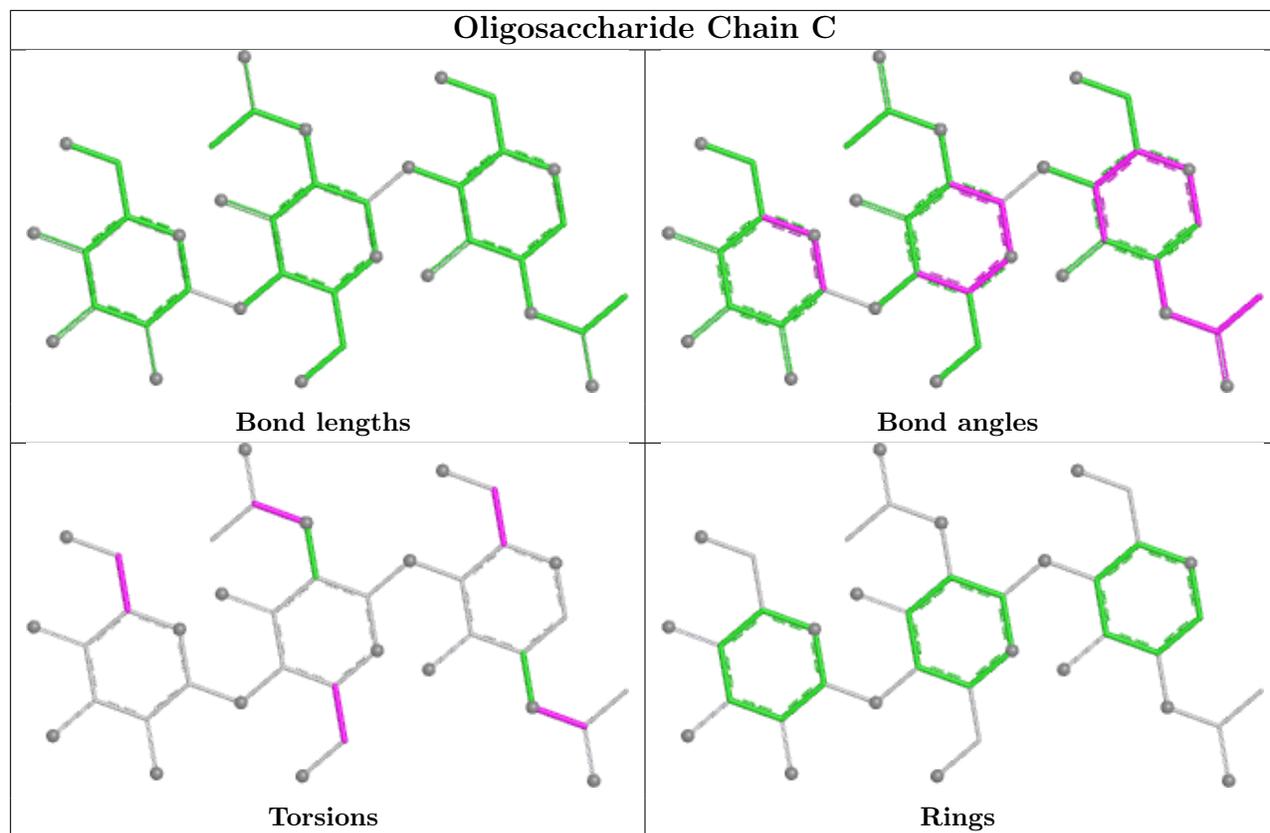
Mol	Chain	Res	Type	Atoms
3	C	1	NAG	C8-C7-N2-C2
3	C	1	NAG	O7-C7-N2-C2
3	D	1	NAG	C8-C7-N2-C2
3	D	1	NAG	O7-C7-N2-C2
3	C	2	NAG	O5-C5-C6-O6

There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	D	3	BMA	1	0

The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for oligosaccharide.



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	F	601	2	14,14,15	0.51	0	17,19,21	2.24	4 (23%)
4	NAG	A	703	1	14,14,15	0.74	0	17,19,21	1.81	4 (23%)
4	NAG	A	702	1	14,14,15	0.58	0	17,19,21	1.83	1 (5%)
4	NAG	E	601	2	14,14,15	0.51	0	17,19,21	1.40	2 (11%)
4	NAG	B	701	1	14,14,15	0.54	0	17,19,21	1.14	1 (5%)
4	NAG	A	701	1	14,14,15	0.49	0	17,19,21	1.39	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
4	NAG	F	601	2	-	0/6/23/26	0/1/1/1
4	NAG	A	703	1	-	2/6/23/26	0/1/1/1
4	NAG	A	702	1	-	3/6/23/26	0/1/1/1
4	NAG	E	601	2	-	2/6/23/26	0/1/1/1
4	NAG	B	701	1	-	2/6/23/26	0/1/1/1
4	NAG	A	701	1	-	4/6/23/26	0/1/1/1

There are no bond length outliers.

The worst 5 of 14 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
4	A	702	NAG	C1-O5-C5	6.29	120.62	112.19
4	F	601	NAG	C1-O5-C5	5.89	120.08	112.19
4	A	701	NAG	C1-O5-C5	4.39	118.07	112.19
4	F	601	NAG	C4-C3-C2	-4.33	104.67	111.02

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
4	F	601	NAG	C2-N2-C7	-4.19	117.29	122.90

There are no chirality outliers.

5 of 13 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
4	A	701	NAG	O7-C7-N2-C2
4	A	702	NAG	C8-C7-N2-C2
4	A	702	NAG	O7-C7-N2-C2
4	A	701	NAG	C8-C7-N2-C2
4	A	703	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
4	A	703	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 [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	597/597 (100%)	-0.16	2 (0%) 90 88	56, 82, 123, 147	0
1	B	597/597 (100%)	-0.01	5 (0%) 82 78	56, 82, 123, 148	0
2	E	174/180 (96%)	0.09	2 (1%) 77 72	75, 96, 142, 153	0
2	F	174/180 (96%)	0.24	1 (0%) 85 82	76, 96, 142, 152	0
All	All	1542/1554 (99%)	-0.03	10 (0%) 85 82	56, 88, 131, 153	0

The worst 5 of 10 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	289	PRO	2.7
1	B	193	ALA	2.6
2	E	374	LEU	2.6
2	F	354	VAL	2.5
1	B	202	TYR	2.4

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](#)

SUGAR-RSR INFOmissingINFO

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(\AA^2)	Q<0.9
4	NAG	A	701	14/15	0.29	0.18	88,89,90,90	0
4	NAG	E	601	14/15	0.34	0.18	108,109,112,113	0
4	NAG	F	601	14/15	0.41	0.20	106,107,108,108	0
4	NAG	A	703	14/15	0.56	0.16	72,74,77,78	0
4	NAG	B	701	14/15	0.59	0.16	72,74,76,77	0
4	NAG	A	702	14/15	0.65	0.14	75,77,78,78	0
6	CL	B	703	1/1	0.80	0.18	115,115,115,115	0
6	CL	A	705	1/1	0.93	0.18	74,74,74,74	0
5	ZN	B	702	1/1	0.99	0.09	84,84,84,84	0
5	ZN	A	704	1/1	1.00	0.10	74,74,74,74	0

6.5 Other polymers [\(i\)](#)

There are no such residues in this entry.