



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 8, 2026 – 07:55 AM UTC

PDB ID : 4M56 / pdb_00004m56
Title : The Structure of Wild-type MalL from Bacillus subtilis
Authors : Hobbs, J.K.; Jiao, W.; Easter, A.D.; Parker, E.J.; Schipper, L.A.; Arcus, V.L.
Deposited on : 2013-08-08
Resolution : 2.30 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 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 : 4-5-2 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

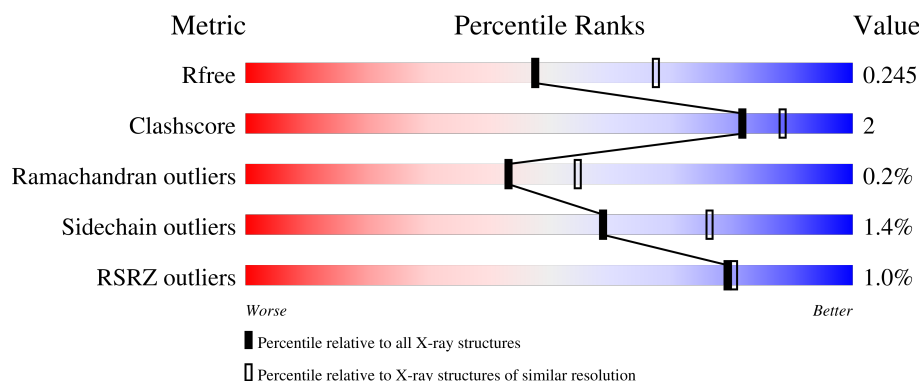
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

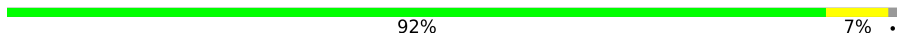
The reported resolution of this entry is 2.30 Å.

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	6319 (2.30-2.30)
Clashscore	190562	6919 (2.30-2.30)
Ramachandran outliers	187476	6854 (2.30-2.30)
Sidechain outliers	187428	6854 (2.30-2.30)
RSRZ outliers	180081	6325 (2.30-2.30)

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	561	 92% 7% .
1	B	561	 2% 92% 7% .

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
2	GLO	A	601	-	X	-	-

2 Entry composition [i](#)

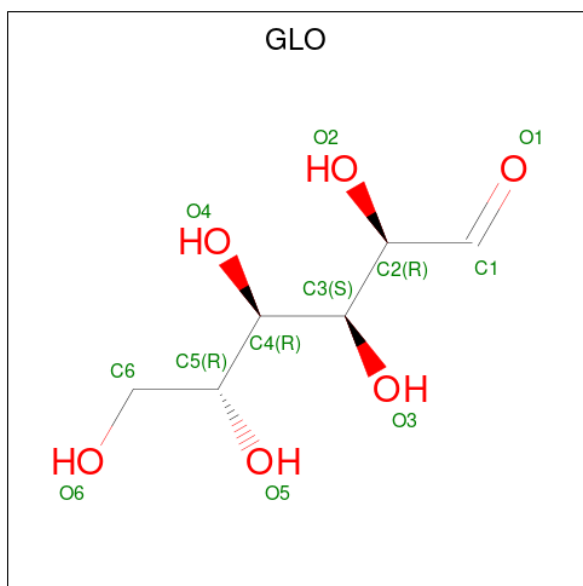
There are 5 unique types of molecules in this entry. The entry contains 10098 atoms, of which 0 are hydrogens and 0 are deuteriums.

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 Oligo-1,6-glucosidase 1.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	555	Total	C	N	O	S	5	4	0
			4573	2930	761	858	24			
1	B	556	Total	C	N	O	S	4	3	0
			4567	2923	758	862	24			

- Molecule 2 is D-glucose (CCD ID: GLO) (formula: C₆H₁₂O₆).



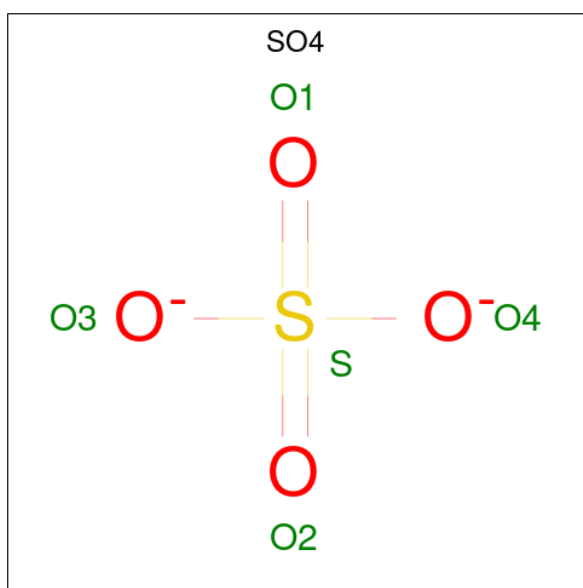
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	C	O	0	0
			12	6	6		
2	B	1	Total	C	O	0	0
			12	6	6		

- Molecule 3 is GLYCEROL (CCD ID: GOL) (formula: C₃H₈O₃).



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

- Molecule 4 is SULFATE ION (CCD ID: SO4) (formula: O₄S).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	B	1	Total	O	S	0	0
			5	4	1		

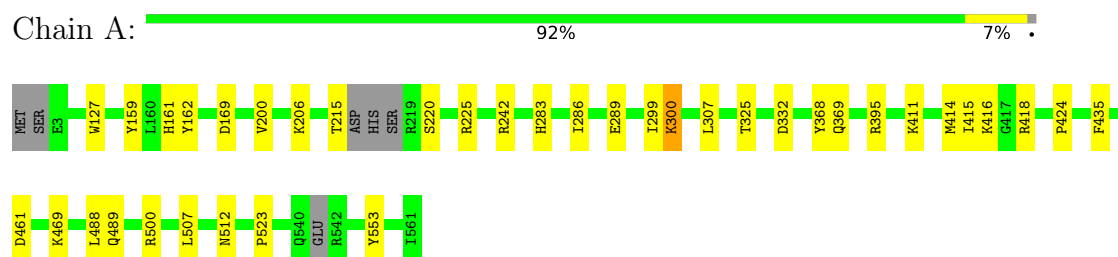
- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	466	Total 466	O 466	0	0
5	B	451	Total 451	O 451	0	0

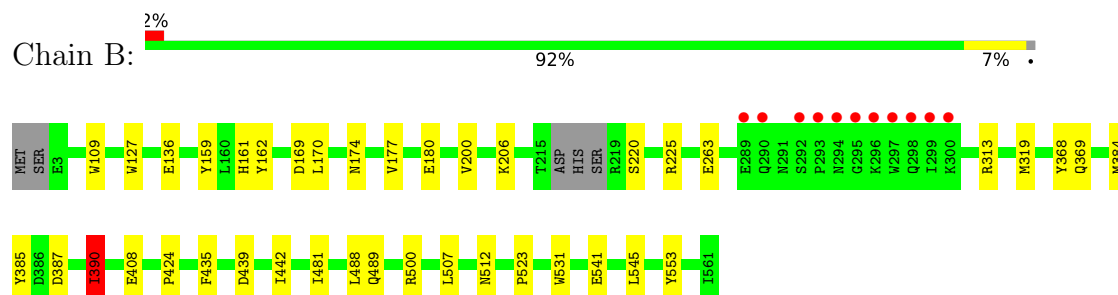
3 Residue-property plots

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: Oligo-1,6-glucosidase 1



- Molecule 1: Oligo-1,6-glucosidase 1



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	61.65Å 100.26Å 101.49Å 90.00° 103.28° 90.00°	Depositor
Resolution (Å)	32.95 – 2.30 32.95 – 2.30	Depositor EDS
% Data completeness (in resolution range)	95.5 (32.95-2.30) 95.6 (32.95-2.30)	Depositor EDS
R_{merge}	0.16	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.90 (at 2.29Å)	Xtriage
Refinement program	REFMAC 5.7.0029	Depositor
R, R_{free}	0.187 , 0.245 0.193 , 0.245	Depositor DCC
R_{free} test set	2622 reflections (4.91%)	wwPDB-VP
Wilson B-factor (Å ²)	18.6	Xtriage
Anisotropy	0.362	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.36 , 45.2	EDS
L-test for twinning ²	$\langle L \rangle = 0.48$, $\langle L^2 \rangle = 0.30$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.93	EDS
Total number of atoms	10098	wwPDB-VP
Average B, all atoms (Å ²)	23.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.10% 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

5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: GOL, GLO, SO4

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	0.81	1/4710 (0.0%)	0.89	3/6374 (0.0%)
1	B	0.78	0/4702	0.87	5/6368 (0.1%)
All	All	0.79	1/9412 (0.0%)	0.88	8/12742 (0.1%)

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	411	LYS	CG-CD	-7.70	1.29	1.52

All (8) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	442	ILE	CA-C-N	-5.56	114.24	119.85
1	B	442	ILE	C-N-CA	-5.56	114.24	119.85
1	A	523	PRO	O-C-N	5.35	123.77	121.31
1	B	541	GLU	CB-CA-C	-5.29	104.28	111.95
1	A	523	PRO	CA-C-N	5.26	126.42	119.84
1	A	523	PRO	C-N-CA	5.26	126.42	119.84
1	B	523	PRO	O-C-N	5.25	123.73	121.31
1	B	390	ILE	N-CA-CB	5.19	119.23	110.56

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	A	4573	0	4342	21	0
1	B	4567	0	4307	21	0
2	A	12	0	12	2	0
2	B	12	0	11	1	0
3	A	6	0	8	3	0
3	B	6	0	8	0	0
4	B	5	0	0	0	0
5	A	466	0	0	6	0
5	B	451	0	0	7	0
All	All	10098	0	8688	44	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 2.

All (44) 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:325:THR:O	3:A:602:GOL:H2	1.71	0.91
1:B:109:TRP:CZ2	1:B:180:GLU:HG2	2.25	0.72
1:A:286:ILE:HG22	5:A:854:HOH:O	1.91	0.68
2:A:601:GLO:H5	5:A:710:HOH:O	1.98	0.63
1:A:289:GLU:HG2	1:A:300:LYS:HD3	1.81	0.62
1:B:313:ARG:HD3	5:B:874:HOH:O	2.04	0.56
1:B:385:TYR:HB3	1:B:390:ILE:HD11	1.87	0.54
1:B:385:TYR:HB3	1:B:390:ILE:CD1	2.39	0.53
1:B:481:ILE:HA	5:B:1061:HOH:O	2.07	0.52
1:B:174:ASN:O	1:B:177:VAL:HG22	2.09	0.52
1:B:387:ASP:HB3	1:B:390:ILE:HD13	1.92	0.50
1:A:512:ASN:O	1:A:553:TYR:HA	2.13	0.49
1:A:500:ARG:HB2	1:A:507:LEU:HB3	1.95	0.49
1:B:500:ARG:HB2	1:B:507:LEU:HB3	1.94	0.48
1:A:283:HIS:CE1	3:A:602:GOL:H32	2.49	0.48
1:B:136:GLU:OE1	5:B:751:HOH:O	2.19	0.48
1:B:263:GLU:OE2	5:B:1025:HOH:O	2.20	0.47
1:B:161:HIS:HA	1:B:169:ASP:OD1	2.14	0.47
1:A:161:HIS:HA	1:A:169:ASP:OD1	2.14	0.47
1:A:461:ASP:HB2	5:A:1112:HOH:O	2.14	0.47
1:A:418:ARG:NH2	2:A:601:GLO:H2	2.31	0.45
1:B:127:TRP:CZ3	1:B:159:TYR:HB3	2.52	0.45
1:B:512:ASN:O	1:B:553:TYR:HA	2.16	0.45

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:127:TRP:CZ3	1:A:159:TYR:HB3	2.52	0.45
1:A:161:HIS:HE1	5:A:1033:HOH:O	2.00	0.44
1:B:424:PRO:HB3	1:B:435:PHE:CG	2.52	0.44
1:B:109:TRP:CZ2	1:B:180:GLU:CG	2.99	0.44
1:B:162:TYR:CZ	1:B:206:LYS:HE3	2.53	0.43
1:A:368:TYR:O	1:A:369:GLN:C	2.61	0.43
1:A:424:PRO:HB3	1:A:435:PHE:CG	2.54	0.42
1:A:162:TYR:CZ	1:A:206:LYS:HE3	2.54	0.42
1:A:283:HIS:CE1	3:A:602:GOL:C3	3.02	0.42
1:B:319:MET:HE3	5:B:1100:HOH:O	2.19	0.42
1:B:368:TYR:O	1:B:369:GLN:C	2.61	0.42
1:A:286:ILE:CD1	1:A:307:LEU:HA	2.50	0.41
1:B:531:TRP:CG	1:B:545:LEU:HD12	2.55	0.41
1:A:332:ASP:HA	1:A:418:ARG:HD2	2.03	0.41
1:A:299:ILE:HG22	1:A:416:LYS:HE3	2.03	0.41
1:A:488:LEU:O	1:A:489:GLN:C	2.63	0.41
2:B:603:GLO:H61	5:B:866:HOH:O	2.20	0.41
1:A:414:MET:HG2	5:A:810:HOH:O	2.21	0.41
1:B:408:GLU:HG3	5:B:1150:HOH:O	2.21	0.41
1:B:488:LEU:O	1:B:489:GLN:C	2.64	0.41
1:A:415:ILE:HD11	5:A:920:HOH:O	2.21	0.40

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	553/561 (99%)	533 (96%)	19 (3%)	1 (0%)	43	55
1	B	555/561 (99%)	536 (97%)	18 (3%)	1 (0%)	43	55
All	All	1108/1122 (99%)	1069 (96%)	37 (3%)	2 (0%)	43	55

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	200	VAL
1	B	200	VAL

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	486/502 (97%)	478 (98%)	8 (2%)	55	73
1	B	483/502 (96%)	477 (99%)	6 (1%)	63	79
All	All	969/1004 (96%)	955 (99%)	14 (1%)	59	76

All (14) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	215	THR
1	A	220	SER
1	A	225	ARG
1	A	242	ARG
1	A	300	LYS
1	A	395	ARG
1	A	469[A]	LYS
1	A	469[B]	LYS
1	B	170	LEU
1	B	220	SER
1	B	225	ARG
1	B	384	MET
1	B	390	ILE
1	B	439	ASP

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (5) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	449	GLN

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Mol	Chain	Res	Type
1	B	41	ASN
1	B	247	HIS
1	B	449	GLN
1	B	468	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](#)

There are no oligosaccharides 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$
2	GLO	A	601	-	10,11,11	1.88	3 (30%)	13,14,14	2.38	10 (76%)
2	GLO	B	603	-	10,11,11	2.21	2 (20%)	13,14,14	3.15	8 (61%)
3	GOL	B	602	-	5,5,5	0.26	0	5,5,5	0.87	0
3	GOL	A	602	-	5,5,5	1.07	0	5,5,5	1.24	1 (20%)
4	SO4	B	601	-	4,4,4	0.48	0	6,6,6	0.62	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
3	GOL	B	602	-	-	2/4/4/4	-
2	GLO	A	601	-	-	8/15/16/16	-
3	GOL	A	602	-	-	2/4/4/4	-
2	GLO	B	603	-	-	6/15/16/16	-

All (5) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	B	603	GLO	C3-C2	5.35	1.61	1.53
2	A	601	GLO	C3-C2	4.17	1.59	1.53
2	B	603	GLO	C4-C3	3.74	1.60	1.53
2	A	601	GLO	C4-C3	2.85	1.58	1.53
2	A	601	GLO	O3-C3	2.13	1.48	1.43

All (19) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	603	GLO	C4-C3-C2	6.05	124.08	113.49
2	B	603	GLO	C5-C4-C3	4.89	119.99	112.48
2	B	603	GLO	O3-C3-C2	4.52	117.53	109.13
2	B	603	GLO	O4-C4-C5	-3.76	100.38	108.93
2	A	601	GLO	C5-C4-C3	3.56	117.94	112.48
2	A	601	GLO	C3-C2-C1	3.04	120.30	111.03
2	A	601	GLO	O5-C5-C4	2.95	116.14	109.25
2	A	601	GLO	C6-C5-C4	2.86	118.00	112.17
2	B	603	GLO	O6-C6-C5	-2.86	105.16	111.16
2	B	603	GLO	C3-C2-C1	2.81	119.60	111.03
3	A	602	GOL	O3-C3-C2	2.67	122.41	110.38
2	A	601	GLO	O6-C6-C5	2.39	116.17	111.16
2	B	603	GLO	O4-C4-C3	2.34	114.94	109.46
2	B	603	GLO	O3-C3-C4	2.31	114.85	109.46
2	A	601	GLO	O4-C4-C5	-2.30	103.71	108.93
2	A	601	GLO	O3-C3-C2	2.26	113.33	109.13
2	A	601	GLO	O5-C5-C6	-2.25	103.90	109.03
2	A	601	GLO	O4-C4-C3	-2.25	104.21	109.46
2	A	601	GLO	C4-C3-C2	2.14	117.24	113.49

There are no chirality outliers.

All (18) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	A	601	GLO	O1-C1-C2-C3
2	A	601	GLO	O3-C3-C4-C5
2	B	603	GLO	C1-C2-C3-O3
2	B	603	GLO	O2-C2-C3-O3
2	B	603	GLO	C2-C3-C4-C5
2	B	603	GLO	C2-C3-C4-O4
3	B	602	GOL	O1-C1-C2-C3
2	A	601	GLO	C3-C4-C5-C6
3	B	602	GOL	O1-C1-C2-O2
2	A	601	GLO	C2-C3-C4-C5
2	A	601	GLO	O2-C2-C3-O3
2	B	603	GLO	C3-C4-C5-C6
2	A	601	GLO	C3-C4-C5-O5
2	A	601	GLO	O3-C3-C4-O4
2	A	601	GLO	O4-C4-C5-C6
3	A	602	GOL	C1-C2-C3-O3
2	B	603	GLO	O4-C4-C5-C6
3	A	602	GOL	O2-C2-C3-O3

There are no ring outliers.

3 monomers are involved in 6 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	601	GLO	2	0
2	B	603	GLO	1	0
3	A	602	GOL	3	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	555/561 (98%)	-0.35	0 100 100	8, 20, 35, 63	7 (1%)
1	B	556/561 (99%)	-0.22	11 (1%) 65 66	11, 23, 48, 90	6 (1%)
All	All	1111/1122 (99%)	-0.29	11 (0%) 79 80	8, 21, 43, 90	13 (1%)

All (11) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	297	TRP	5.9
1	B	299	ILE	4.5
1	B	295	GLY	4.1
1	B	300	LYS	3.6
1	B	296	LYS	3.4
1	B	293	PRO	2.7
1	B	294	ASN	2.7
1	B	289	GLU	2.5
1	B	298	GLN	2.5
1	B	290	GLN	2.2
1	B	292	SER	2.2

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, 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
2	GLO	B	603	12/12	0.83	0.12	28,32,36,36	0
2	GLO	A	601	12/12	0.84	0.14	20,24,28,35	0
3	GOL	A	602	6/6	0.85	0.14	27,29,32,35	0
3	GOL	B	602	6/6	0.91	0.10	31,33,34,36	0
4	SO4	B	601	5/5	0.95	0.10	40,41,43,44	0

6.5 Other polymers [i](#)

There are no such residues in this entry.