



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 7, 2026 – 01:03 AM UTC

PDB ID : 4MAD / pdb_00004mad
Title : Crystal structure of beta-galactosidase C (BgaC) from *Bacillus circulans* ATCC 31382
Authors : Kamerke, C.; You, D.J.; Kanaya, S.; Elling, L.
Deposited on : 2013-08-16
Resolution : 1.80 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 : 4-5-2 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

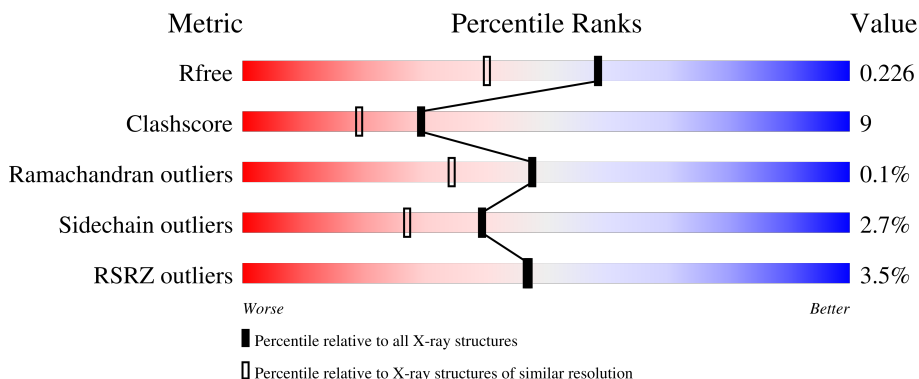
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.80 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	7662 (1.80-1.80)
Clashscore	190562	8479 (1.80-1.80)
Ramachandran outliers	187476	8391 (1.80-1.80)
Sidechain outliers	187428	8390 (1.80-1.80)
RSRZ outliers	180081	7663 (1.80-1.80)

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	600	
1	B	600	

2 Entry composition i

There are 3 unique types of molecules in this entry. The entry contains 9884 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 Beta-galactosidase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	581	4698	3040	770	874	14	0	0	0
1	B	586	4737	3066	776	881	14	0	0	0

There are 28 discrepancies between the modelled and reference sequences:

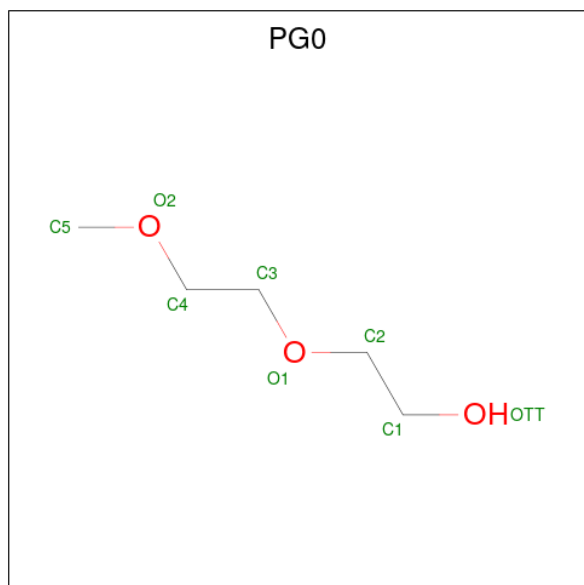
Chain	Residue	Modelled	Actual	Comment	Reference
A	-13	MET	-	expression tag	UNP O31341
A	-12	GLY	-	expression tag	UNP O31341
A	-11	SER	-	expression tag	UNP O31341
A	-10	SER	-	expression tag	UNP O31341
A	-9	HIS	-	expression tag	UNP O31341
A	-8	HIS	-	expression tag	UNP O31341
A	-7	HIS	-	expression tag	UNP O31341
A	-6	HIS	-	expression tag	UNP O31341
A	-5	HIS	-	expression tag	UNP O31341
A	-4	HIS	-	expression tag	UNP O31341
A	-3	SER	-	expression tag	UNP O31341
A	-2	GLN	-	expression tag	UNP O31341
A	-1	ASP	-	expression tag	UNP O31341
A	0	PRO	-	expression tag	UNP O31341
B	-13	MET	-	expression tag	UNP O31341
B	-12	GLY	-	expression tag	UNP O31341
B	-11	SER	-	expression tag	UNP O31341
B	-10	SER	-	expression tag	UNP O31341
B	-9	HIS	-	expression tag	UNP O31341
B	-8	HIS	-	expression tag	UNP O31341
B	-7	HIS	-	expression tag	UNP O31341
B	-6	HIS	-	expression tag	UNP O31341
B	-5	HIS	-	expression tag	UNP O31341
B	-4	HIS	-	expression tag	UNP O31341
B	-3	SER	-	expression tag	UNP O31341

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Chain	Residue	Modelled	Actual	Comment	Reference
B	-2	GLN	-	expression tag	UNP O31341
B	-1	ASP	-	expression tag	UNP O31341
B	0	PRO	-	expression tag	UNP O31341

- Molecule 2 is 2-(2-METHOXYETHOXY)ETHANOL (CCD ID: PG0) (formula: C₅H₁₂O₃).



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

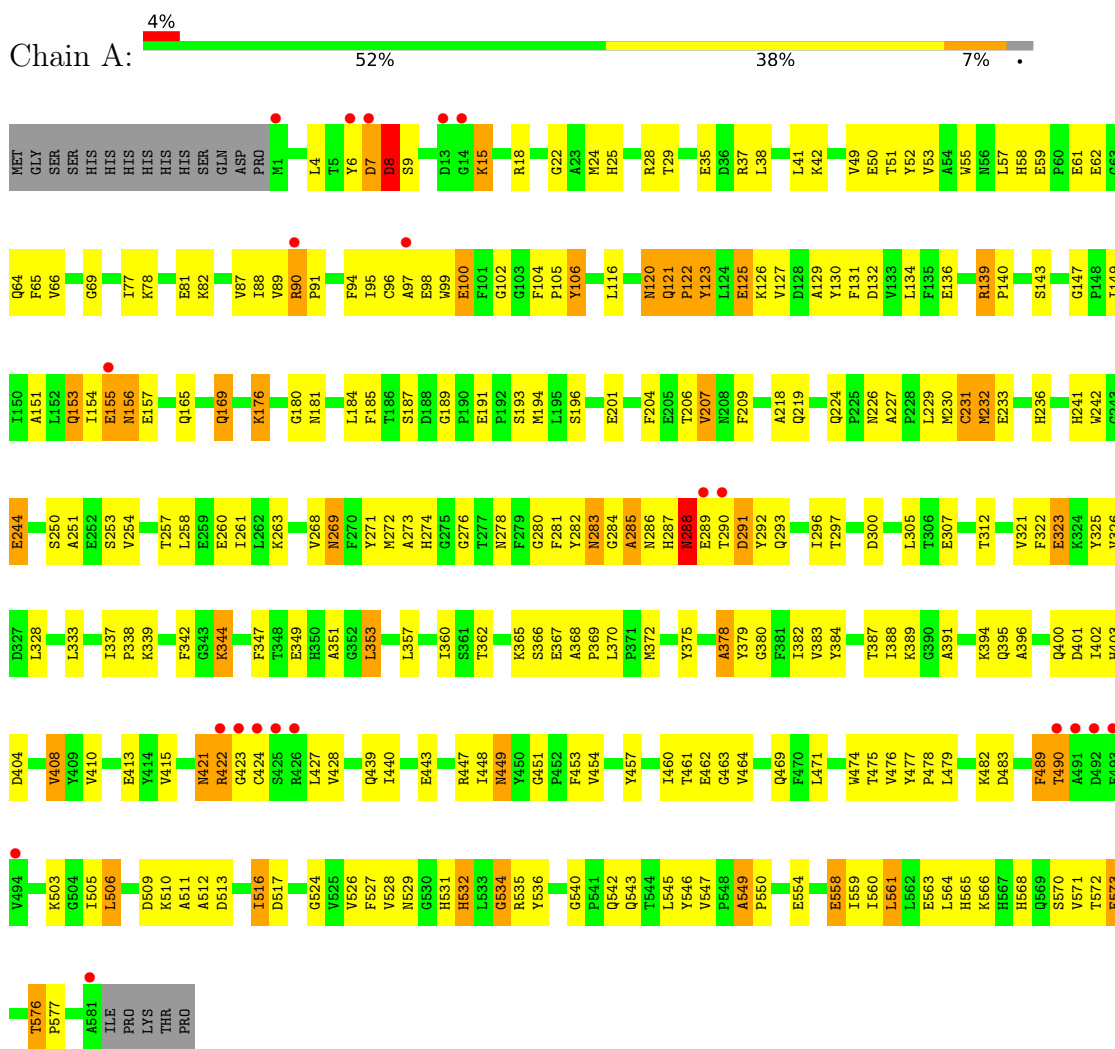
- Molecule 3 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	208	Total	O	0	0
			208	208		
3	B	217	Total	O	0	0
			217	217		

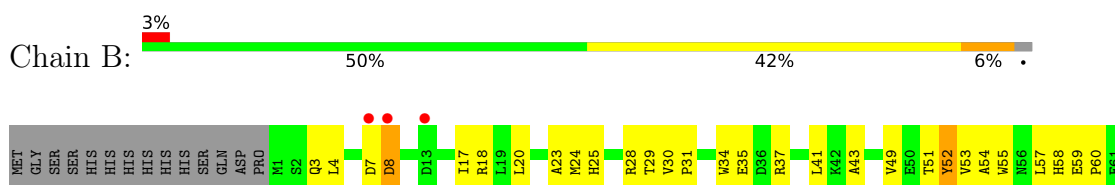
3 Residue-property plots [i](#)

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: Beta-galactosidase



• Molecule 1: Beta-galactosidase



4 Data and refinement statistics i

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, α , β , γ	143.27Å 93.12Å 119.57Å 90.00° 125.67° 90.00°	Depositor
Resolution (Å)	41.66 – 1.80 41.66 – 1.80	Depositor EDS
% Data completeness (in resolution range)	99.5 (41.66-1.80) 99.5 (41.66-1.80)	Depositor EDS
R_{merge}	0.11	Depositor
R_{sym}	0.11	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.65 (at 1.79Å)	Xtrriage
Refinement program	REFMAC refmac_5.5.0109	Depositor
R, R_{free}	0.181 , 0.216 0.193 , 0.226	Depositor DCC
R_{free} test set	5897 reflections (4.99%)	wwPDB-VP
Wilson B-factor (Å ²)	19.3	Xtrriage
Anisotropy	0.715	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.33 , 30.7	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.33$	Xtrriage
Estimated twinning fraction	0.011 for h,-k,-h-l	Xtrriage
F_o, F_c correlation	0.96	EDS
Total number of atoms	9884	wwPDB-VP
Average B, all atoms (Å ²)	22.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.06% 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: PG0

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	2.14	206/4831 (4.3%)	1.15	28/6558 (0.4%)
1	B	2.13	223/4872 (4.6%)	1.13	27/6614 (0.4%)
All	All	2.14	429/9703 (4.4%)	1.14	55/13172 (0.4%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	A	0	1
1	B	0	1
All	All	0	2

The worst 5 of 429 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	293	GLN	C-O	-9.68	1.17	1.25
1	A	288	ASN	C-N	-9.64	1.20	1.33
1	B	546	TYR	C-O	-9.26	1.12	1.24
1	B	139	ARG	C-O	-8.81	1.16	1.24
1	A	284	GLY	C-O	-8.37	1.16	1.23

The worst 5 of 55 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	474	TRP	N-CA-C	14.58	132.06	110.48
1	A	8	ASP	N-CA-C	-11.02	100.33	113.88
1	A	156	ASN	N-CA-C	9.80	124.41	108.34
1	B	474	TRP	N-CA-CB	-9.03	96.57	110.29

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	154	ILE	CA-C-N	-8.99	105.29	123.99

There are no chirality outliers.

All (2) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	421	ASN	Peptide
1	B	421	ASN	Peptide

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	4698	0	4542	74	0
1	B	4737	0	4587	86	0
2	A	16	0	24	3	0
2	B	8	0	12	0	0
3	A	208	0	0	3	0
3	B	217	0	0	2	0
All	All	9884	0	9165	160	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 9.

The worst 5 of 160 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:B:490:THR:HG22	1:B:492:ASP:H	1.08	1.15
1:A:15:LYS:HB2	1:A:15:LYS:NZ	1.48	1.14
1:B:319:ARG:HH11	1:B:319:ARG:CG	1.64	1.06
1:B:319:ARG:HH11	1:B:319:ARG:HG3	1.23	1.01
1:B:585:THR:HG22	1:B:585:THR:O	1.64	0.97

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	579/600 (96%)	565 (98%)	14 (2%)	0	100	100
1	B	584/600 (97%)	568 (97%)	15 (3%)	1 (0%)	43	31
All	All	1163/1200 (97%)	1133 (97%)	29 (2%)	1 (0%)	48	34

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	473	ASP

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	503/521 (96%)	491 (98%)	12 (2%)	43	31
1	B	508/521 (98%)	493 (97%)	15 (3%)	36	24
All	All	1011/1042 (97%)	984 (97%)	27 (3%)	39	27

5 of 27 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	B	121	GLN
1	B	319	ARG
1	B	554	GLU
1	B	263	LYS
1	B	415	VAL

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 37 such sidechains are listed below:

Mol	Chain	Res	Type
1	B	241	HIS
1	B	532	HIS
1	B	283	ASN
1	B	449	ASN
1	A	421	ASN

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](#)

3 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	PG0	B	900	-	7,7,7	0.66	0	6,6,6	0.46	0
2	PG0	A	900	-	7,7,7	0.60	0	6,6,6	0.56	0
2	PG0	A	901	-	7,7,7	0.67	0	6,6,6	0.72	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
2	PG0	B	900	-	-	3/5/5/5	-
2	PG0	A	900	-	-	2/5/5/5	-
2	PG0	A	901	-	-	1/5/5/5	-

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

5 of 6 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	B	900	PG0	C4-C3-O1-C2
2	A	900	PG0	O1-C3-C4-O2
2	A	900	PG0	C3-C4-O2-C5
2	B	900	PG0	OTT-C1-C2-O1
2	B	900	PG0	C3-C4-O2-C5

There are no ring outliers.

1 monomer is involved in 3 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	901	PG0	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	581/600 (96%)	0.27	21 (3%) 46 46	13, 20, 36, 54	0
1	B	586/600 (97%)	0.31	20 (3%) 48 48	14, 20, 37, 57	0
All	All	1167/1200 (97%)	0.29	41 (3%) 47 47	13, 20, 36, 57	0

The worst 5 of 41 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	424	CYS	6.6
1	A	289	GLU	5.8
1	A	491	ALA	4.9
1	A	423	GLY	4.6
1	A	97	ALA	4.6

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(\AA^2)	Q<0.9
2	PG0	A	900	8/8	0.72	0.20	18,29,33,39	0
2	PG0	B	900	8/8	0.84	0.21	24,29,34,42	0
2	PG0	A	901	8/8	0.92	0.14	11,28,33,34	0

6.5 Other polymers [i](#)

There are no such residues in this entry.