



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 5, 2026 – 06:31 PM UTC

PDB ID : 3TTY / pdb_00003tty
Title : Crystal structure of beta-galactosidase from *Bacillus circulans* sp. *alkalophilus* in complex with galactose
Authors : Maksimainen, M.; Hakulinen, N.; Rouvinen, J.
Deposited on : 2011-09-15
Resolution : 2.25 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

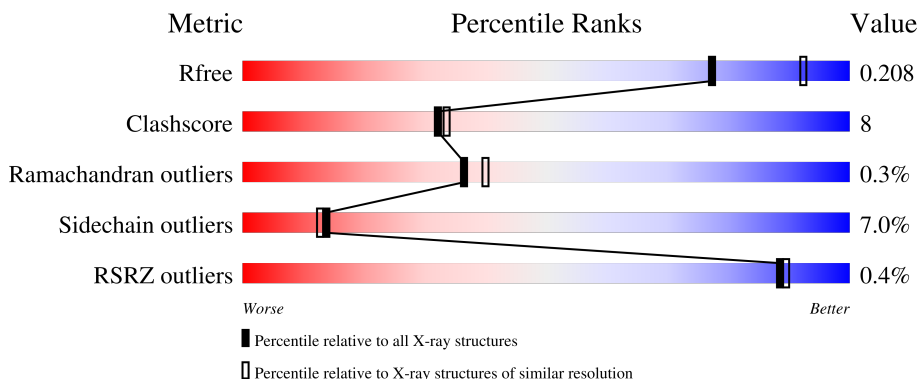
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.25 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	1898 (2.26-2.26)
Clashscore	190562	2005 (2.26-2.26)
Ramachandran outliers	187476	1965 (2.26-2.26)
Sidechain outliers	187428	1966 (2.26-2.26)
RSRZ outliers	180081	1898 (2.26-2.26)

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	675	 81% 16% .
1	B	675	 81% 16% .
1	C	675	 79% 19% .
1	D	675	 81% 17% .
1	E	675	 80% 17% .

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Mol	Chain	Length	Quality of chain
1	F	675	 <p>A horizontal bar chart representing the quality of the chain. The bar is divided into two segments: a green segment on the left labeled '79%' and a yellow segment on the right labeled '18%'. A small red square is at the beginning of the bar, and a small black dot is at the end. A '%' symbol is positioned above the start of the bar.</p>

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 35270 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.

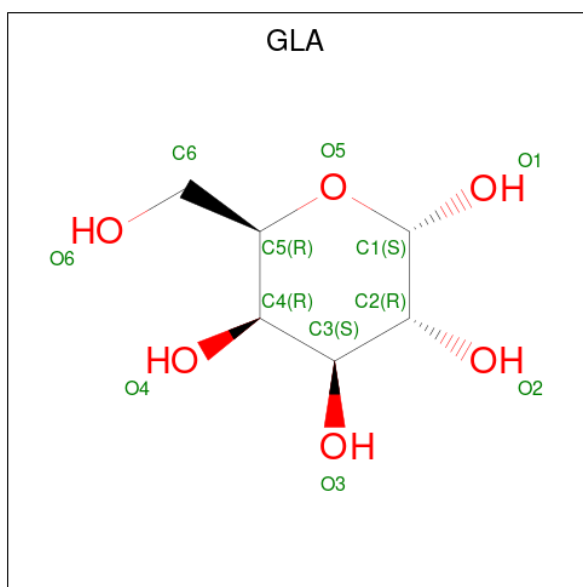
- Molecule 1 is a protein called Beta-galactosidase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	675	5446	3467	926	1018	35	0	0	0
1	B	675	5446	3467	926	1018	35	0	0	0
1	C	675	5446	3467	926	1018	35	0	0	0
1	D	675	5446	3467	926	1018	35	0	0	0
1	E	675	5446	3467	926	1018	35	0	0	0
1	F	675	5446	3467	926	1018	35	0	0	0

- Molecule 2 is ZINC ION (CCD ID: ZN) (formula: Zn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	1	Total	Zn	0	0
			1	1		
2	B	1	Total	Zn	0	0
			1	1		
2	C	1	Total	Zn	0	0
			1	1		
2	D	1	Total	Zn	0	0
			1	1		
2	E	1	Total	Zn	0	0
			1	1		
2	F	1	Total	Zn	0	0
			1	1		

- Molecule 3 is alpha-D-galactopyranose (CCD ID: GLA) (formula: C₆H₁₂O₆).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	1	Total C O 12 6 6	0	0
3	B	1	Total C O 12 6 6	0	0
3	C	1	Total C O 12 6 6	0	0
3	D	1	Total C O 12 6 6	0	0
3	E	1	Total C O 12 6 6	0	0
3	F	1	Total C O 12 6 6	0	0

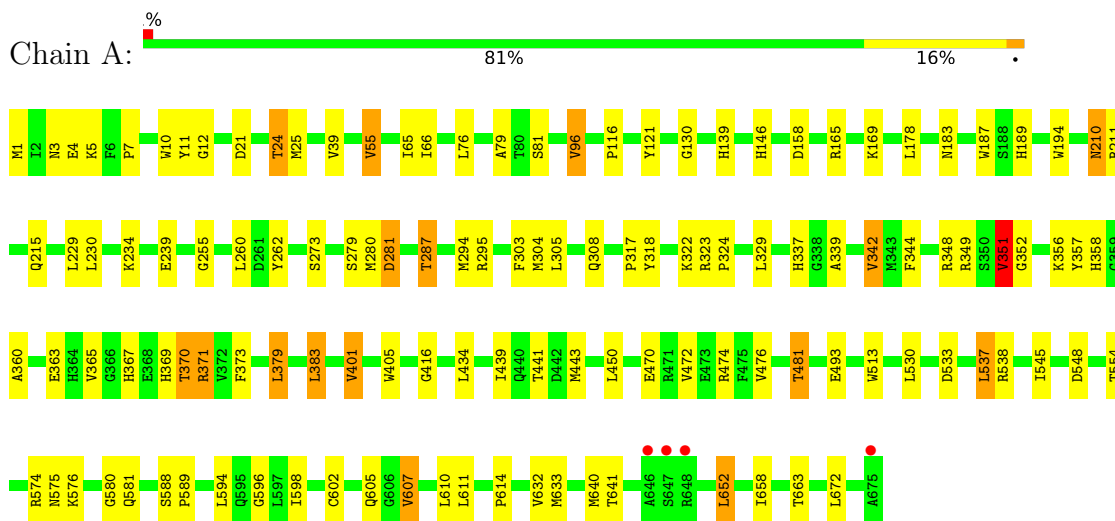
- Molecule 4 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	A	442	Total O 442 442	0	0
4	B	458	Total O 458 458	0	0
4	C	423	Total O 423 423	0	0
4	D	400	Total O 400 400	0	0
4	E	409	Total O 409 409	0	0
4	F	384	Total O 384 384	0	0

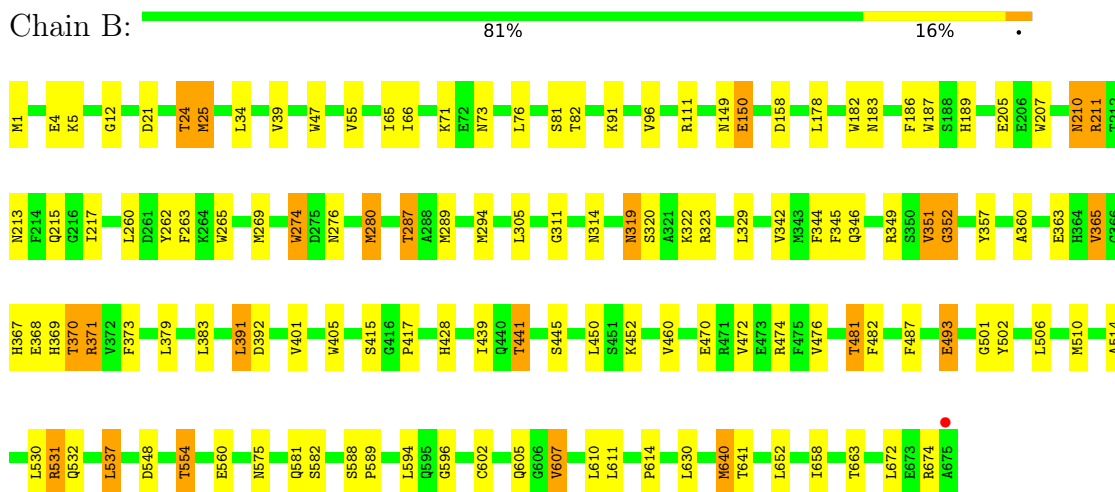
3 Residue-property plots

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.

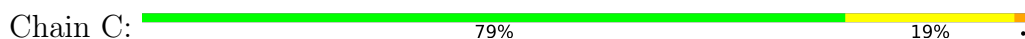
- Molecule 1: Beta-galactosidase

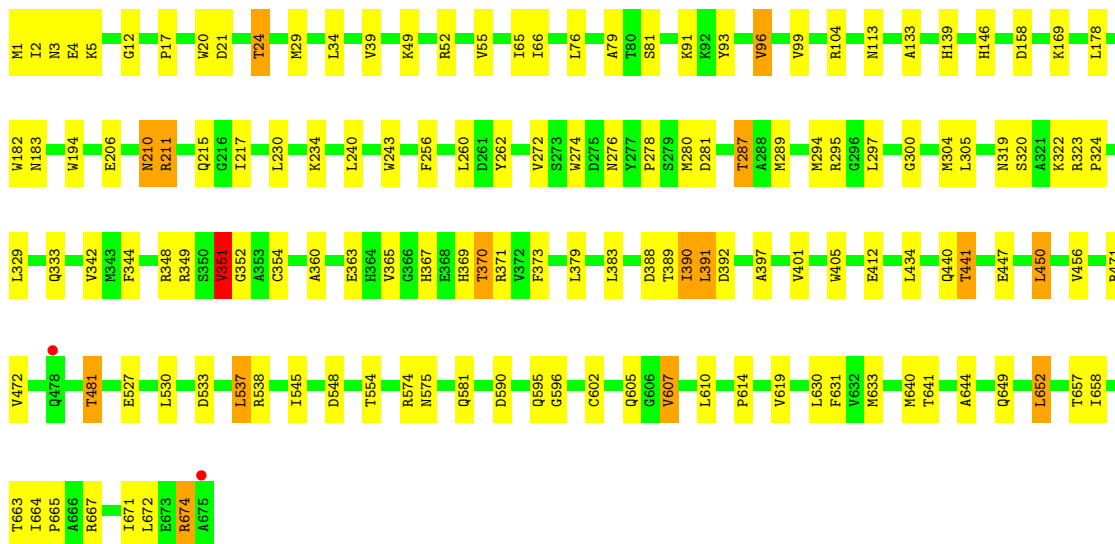


- Molecule 1: Beta-galactosidase

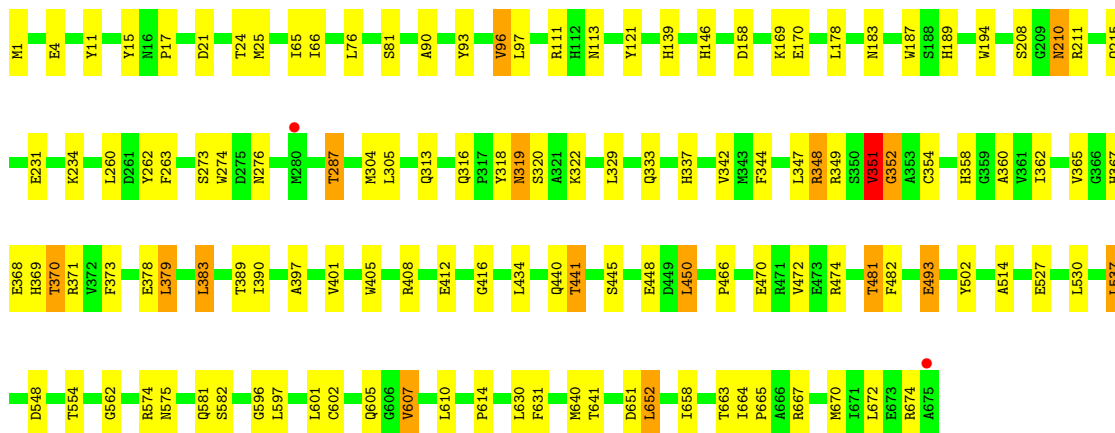
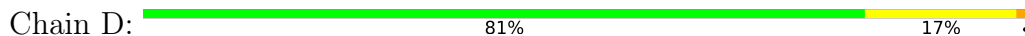


- Molecule 1: Beta-galactosidase

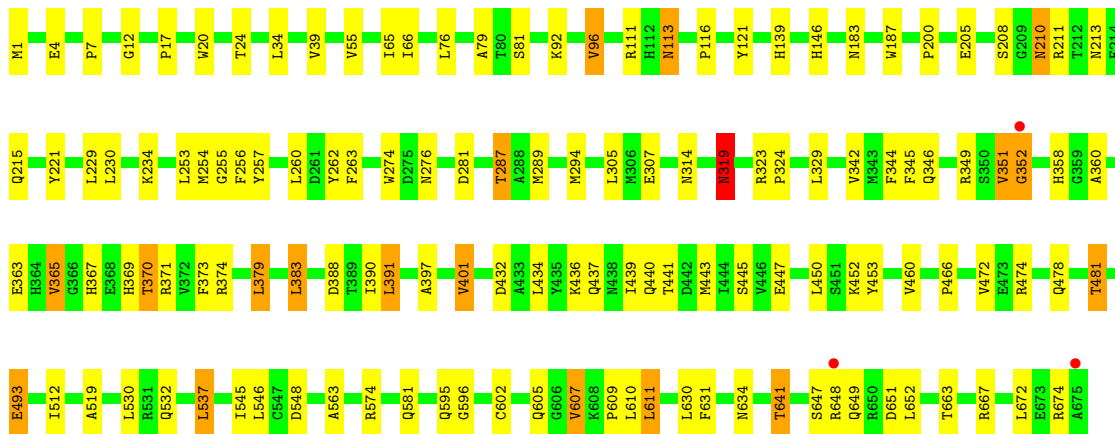
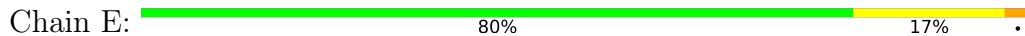




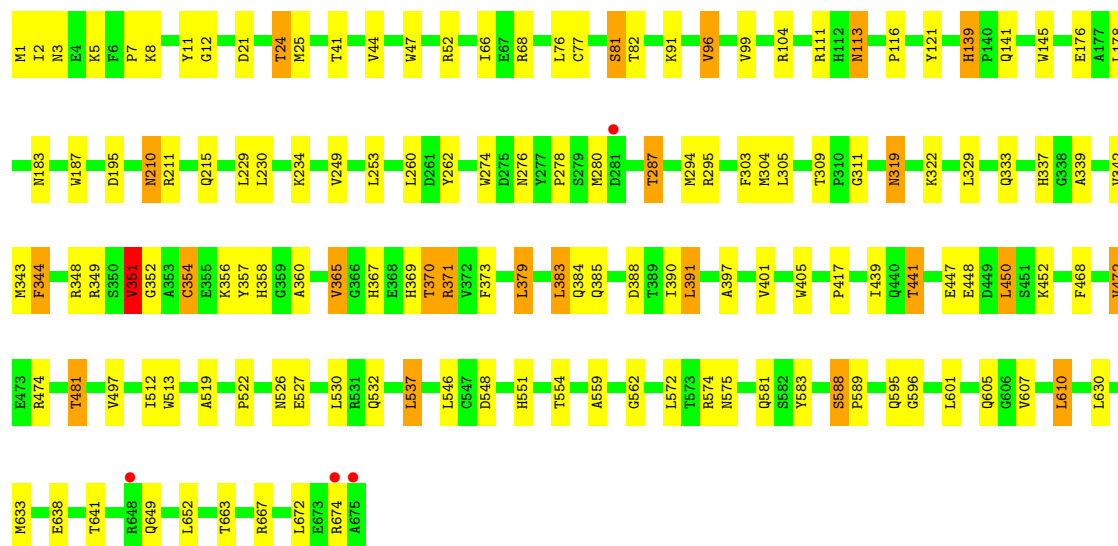
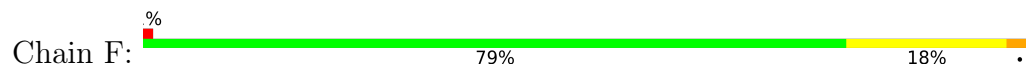
• Molecule 1: Beta-galactosidase



• Molecule 1: Beta-galactosidase



- Molecule 1: Beta-galactosidase



4 Data and refinement statistics

Property	Value	Source
Space group	H 3	Depositor
Cell constants a, b, c, α , β , γ	228.20Å 228.20Å 246.80Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	47.57 – 2.25 47.57 – 2.25	Depositor EDS
% Data completeness (in resolution range)	99.2 (47.57-2.25) 99.2 (47.57-2.25)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	3.14 (at 2.24Å)	Xtrriage
Refinement program	PHENIX (phenix.refine: 1.6.4_486)	Depositor
R, R_{free}	0.160 , 0.210 0.160 , 0.208	Depositor DCC
R_{free} test set	11278 reflections (5.00%)	wwPDB-VP
Wilson B-factor (Å ²)	22.2	Xtrriage
Anisotropy	0.245	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.32 , 30.4	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.33$	Xtrriage
Estimated twinning fraction	0.014 for h,-h-k,-l	Xtrriage
F_o, F_c correlation	0.96	EDS
Total number of atoms	35270	wwPDB-VP
Average B, all atoms (Å ²)	24.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 1.77% 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: GLA, ZN

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	0/5591	0.80	4/7581 (0.1%)
1	B	0.48	0/5591	0.80	1/7581 (0.0%)
1	C	0.49	0/5591	0.81	3/7581 (0.0%)
1	D	0.47	0/5591	0.80	4/7581 (0.1%)
1	E	0.47	0/5591	0.79	5/7581 (0.1%)
1	F	0.47	0/5591	0.80	6/7581 (0.1%)
All	All	0.47	0/33546	0.80	23/45486 (0.1%)

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
1	C	0	1
1	D	0	1
1	E	0	1
1	F	0	1
All	All	0	6

There are no bond length outliers.

The worst 5 of 23 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	F	351	VAL	N-CA-C	8.76	122.11	113.53
1	A	139	HIS	CA-C-N	8.02	127.66	119.56
1	A	139	HIS	C-N-CA	8.02	127.66	119.56
1	E	351	VAL	N-CA-C	6.46	119.86	113.53

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	351	VAL	N-CA-C	6.25	122.33	109.34

There are no chirality outliers.

5 of 6 planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	344	PHE	Peptide
1	B	344	PHE	Peptide
1	C	344	PHE	Peptide
1	D	344	PHE	Peptide
1	E	344	PHE	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	5446	0	5225	89	0
1	B	5446	0	5225	82	0
1	C	5446	0	5225	96	0
1	D	5446	0	5225	91	0
1	E	5446	0	5225	84	0
1	F	5446	0	5225	107	0
2	A	1	0	0	0	0
2	B	1	0	0	0	0
2	C	1	0	0	0	0
2	D	1	0	0	0	0
2	E	1	0	0	0	0
2	F	1	0	0	0	0
3	A	12	0	12	0	0
3	B	12	0	12	0	0
3	C	12	0	12	0	0
3	D	12	0	12	0	0
3	E	12	0	12	1	0
3	F	12	0	12	0	0
4	A	442	0	0	5	0
4	B	458	0	0	6	0
4	C	423	0	0	8	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
4	D	400	0	0	2	0
4	E	409	0	0	5	0
4	F	384	0	0	11	0
All	All	35270	0	31422	512	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 8.

The worst 5 of 512 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:F:481:THR:HG22	1:F:605:GLN:HE21	1.16	1.11
1:A:641:THR:HG22	1:A:663:THR:HG22	1.36	1.07
1:B:370:THR:HG22	1:B:373:PHE:H	1.21	1.05
1:C:370:THR:HG22	1:C:373:PHE:H	1.22	1.04
1:D:641:THR:HG22	1:D:663:THR:HG22	1.39	1.03

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	673/675 (100%)	646 (96%)	26 (4%)	1 (0%)	48 56
1	B	673/675 (100%)	646 (96%)	24 (4%)	3 (0%)	30 31
1	C	673/675 (100%)	648 (96%)	24 (4%)	1 (0%)	48 56
1	D	673/675 (100%)	650 (97%)	21 (3%)	2 (0%)	36 40
1	E	673/675 (100%)	648 (96%)	22 (3%)	3 (0%)	30 31
1	F	673/675 (100%)	647 (96%)	25 (4%)	1 (0%)	48 56
All	All	4038/4050 (100%)	3885 (96%)	142 (4%)	11 (0%)	36 40

5 of 11 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	150	GLU
1	B	319	ASN
1	D	319	ASN
1	E	319	ASN
1	F	319	ASN

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	575/575 (100%)	539 (94%)	36 (6%)	16	16
1	B	575/575 (100%)	527 (92%)	48 (8%)	10	8
1	C	575/575 (100%)	533 (93%)	42 (7%)	13	12
1	D	575/575 (100%)	539 (94%)	36 (6%)	16	16
1	E	575/575 (100%)	535 (93%)	40 (7%)	14	13
1	F	575/575 (100%)	537 (93%)	38 (7%)	15	14
All	All	3450/3450 (100%)	3210 (93%)	240 (7%)	14	13

5 of 240 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	C	481	THR
1	F	379	LEU
1	D	348	ARG
1	F	370	THR
1	F	638	GLU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 79 such sidechains are listed below:

Mol	Chain	Res	Type
1	E	210	ASN
1	F	313	GLN

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Mol	Chain	Res	Type
1	E	313	GLN
1	E	605	GLN
1	F	425	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](#)

Of 12 ligands modelled in this entry, 6 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	$\# Z > 2$
3	GLA	F	677	-	12,12,12	0.52	0	17,17,17	1.06	2 (11%)
3	GLA	A	677	-	12,12,12	0.69	0	17,17,17	1.22	2 (11%)
3	GLA	D	677	-	12,12,12	0.57	0	17,17,17	1.38	3 (17%)
3	GLA	B	677	-	12,12,12	0.57	0	17,17,17	1.17	2 (11%)
3	GLA	C	677	-	12,12,12	0.52	0	17,17,17	1.24	0
3	GLA	E	677	-	12,12,12	0.48	0	17,17,17	1.02	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	GLA	F	677	-	-	0/2/22/22	0/1/1/1
3	GLA	A	677	-	-	0/2/22/22	0/1/1/1
3	GLA	D	677	-	-	0/2/22/22	0/1/1/1
3	GLA	B	677	-	-	0/2/22/22	0/1/1/1
3	GLA	C	677	-	-	0/2/22/22	0/1/1/1
3	GLA	E	677	-	-	0/2/22/22	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(°)
3	B	677	GLA	O5-C1-C2	2.77	115.18	110.30
3	D	677	GLA	C6-C5-C4	-2.72	106.33	113.02
3	A	677	GLA	C1-O5-C5	-2.36	109.09	113.65
3	A	677	GLA	O1-C1-C2	2.27	115.58	108.98
3	F	677	GLA	O5-C1-C2	2.26	114.28	110.30

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	E	677	GLA	1	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	675/675 (100%)	-0.62	4 (0%) 85 86	14, 22, 39, 83	0
1	B	675/675 (100%)	-0.69	1 (0%) 92 92	13, 20, 37, 83	0
1	C	675/675 (100%)	-0.59	2 (0%) 90 90	13, 21, 39, 85	0
1	D	675/675 (100%)	-0.53	2 (0%) 90 90	14, 23, 42, 73	0
1	E	675/675 (100%)	-0.58	3 (0%) 88 89	14, 23, 41, 84	0
1	F	675/675 (100%)	-0.53	4 (0%) 85 86	14, 24, 43, 93	0
All	All	4050/4050 (100%)	-0.59	16 (0%) 88 89	13, 22, 41, 93	0

The worst 5 of 16 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	F	675	ALA	5.6
1	C	675	ALA	5.4
1	E	675	ALA	3.3
1	A	675	ALA	3.3
1	D	675	ALA	2.9

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
3	GLA	A	677	12/12	0.96	0.07	16,19,24,25	0
3	GLA	B	677	12/12	0.97	0.06	16,20,25,28	0
3	GLA	C	677	12/12	0.97	0.05	17,19,23,26	0
3	GLA	D	677	12/12	0.97	0.06	15,17,20,23	0
3	GLA	E	677	12/12	0.97	0.05	20,21,26,27	0
3	GLA	F	677	12/12	0.98	0.05	18,21,25,27	0
2	ZN	A	676	1/1	0.99	0.02	17,17,17,17	0
2	ZN	B	676	1/1	0.99	0.01	18,18,18,18	0
2	ZN	E	676	1/1	1.00	0.01	19,19,19,19	0
2	ZN	F	676	1/1	1.00	0.01	20,20,20,20	0
2	ZN	C	676	1/1	1.00	0.01	19,19,19,19	0
2	ZN	D	676	1/1	1.00	0.01	18,18,18,18	0

6.5 Other polymers [i](#)

There are no such residues in this entry.