



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 9, 2026 – 12:23 PM UTC

PDB ID : 6UR4 / pdb_00006ur4
Title : DNA polymerase I Large Fragment from *Bacillus stearothermophilus* with DNA template and 3'-amino primer
Authors : Zhang, W.; Lelyveld, V.S.; Szostak, J.W.
Deposited on : 2019-10-22
Resolution : 2.25 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

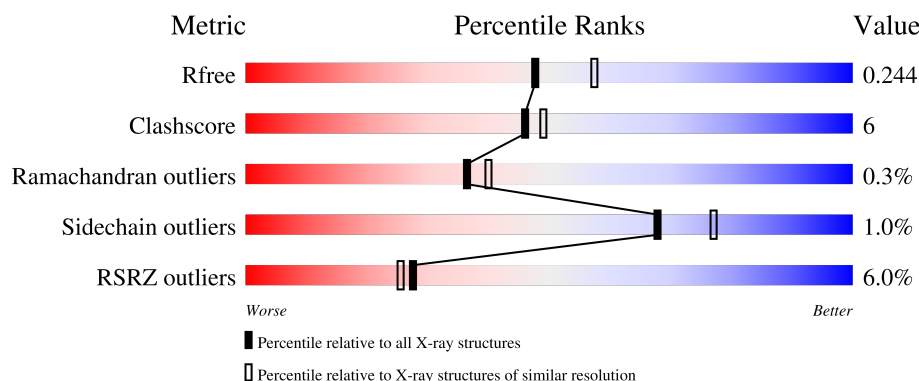
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.25 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	579	6% 87% 12%
2	B	9	11% 67% 33%
3	C	11	18% 100%

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 5219 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 DNA polymerase I.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	579	Total	C	N	O	S	0	0	0
			4649	2956	807	869	17			

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	598	ASP	ALA	variant	UNP D9N168
A	713	VAL	PRO	variant	UNP D9N168

- Molecule 2 is a DNA chain called DNA (5'-D(*GP*CP*GP*AP*TP*CP*AP*GP*(C42))-3').

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	B	9	Total	C	N	O	P	0	0	0
			182	87	37	50	8			

- Molecule 3 is a DNA chain called DNA (5'-D(P*CP*GP*CP*TP*GP*AP*TP*CP*GP*CP*A)-3').

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	C	11	Total	C	N	O	P	0	0	0
			224	106	41	66	11			

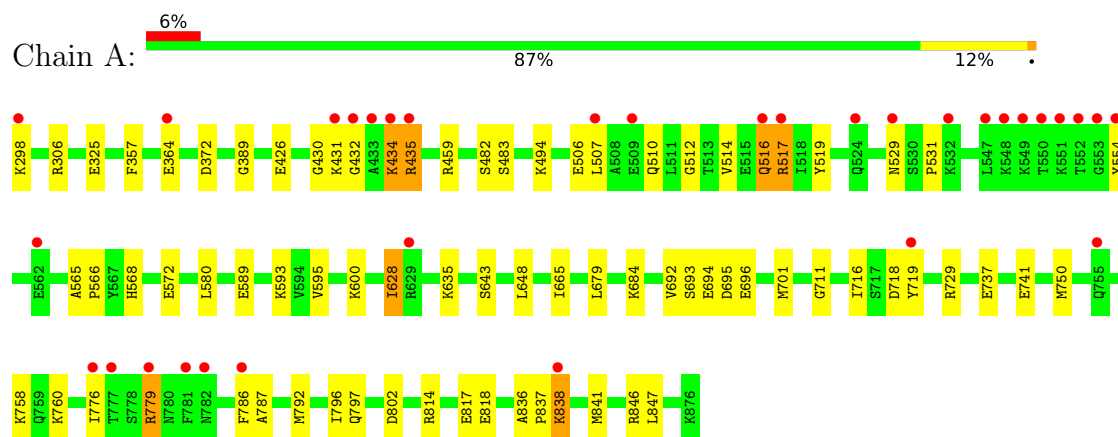
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	155	Total	O	0	0
			155	155		
4	B	2	Total	O	0	0
			2	2		
4	C	7	Total	O	0	0
			7	7		

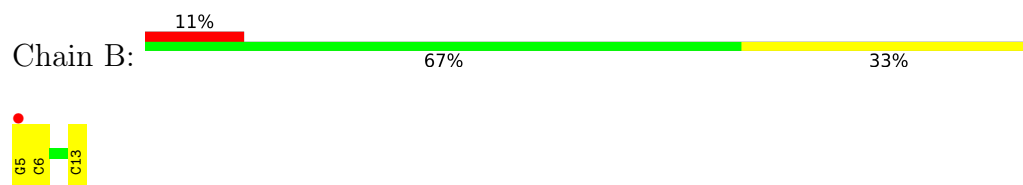
3 Residue-property plots

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.

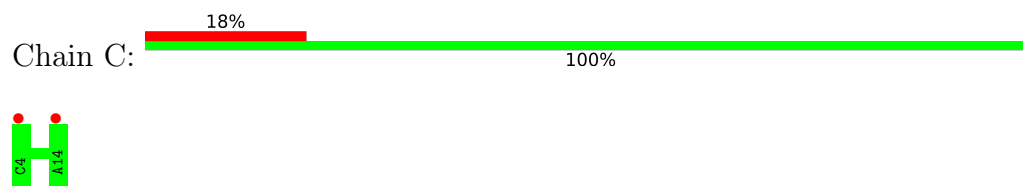
• Molecule 1: DNA polymerase I



• Molecule 2: DNA (5'-D(*GP*CP*GP*AP*TP*CP*AP*GP*(C42))-3')



• Molecule 3: DNA (5'-D(P*CP*GP*CP*TP*GP*AP*TP*CP*GP*CP*A)-3')



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	87.61Å 93.92Å 106.12Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	28.40 – 2.25 28.40 – 2.25	Depositor EDS
% Data completeness (in resolution range)	94.4 (28.40-2.25) 94.4 (28.40-2.25)	Depositor EDS
R_{merge}	0.14	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	13.83 (at 2.24Å)	Xtriage
Refinement program	PHENIX 1.17_3644	Depositor
R, R_{free}	0.205 , 0.244 0.205 , 0.244	Depositor DCC
R_{free} test set	1946 reflections (4.59%)	wwPDB-VP
Wilson B-factor (Å ²)	23.9	Xtriage
Anisotropy	0.091	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.33 , 25.1	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.93	EDS
Total number of atoms	5219	wwPDB-VP
Average B, all atoms (Å ²)	30.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.27% 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: C42

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	0.99	0/4733	1.38	32/6395 (0.5%)
2	B	0.40	0/183	0.74	0/281
3	C	0.45	0/250	0.98	0/383
All	All	0.96	0/5166	1.34	32/7059 (0.5%)

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	3

There are no bond length outliers.

All (32) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	694	GLU	CA-C-N	7.28	130.76	120.28
1	A	694	GLU	C-N-CA	7.28	130.76	120.28
1	A	837	PRO	CA-C-N	6.58	129.40	120.38
1	A	837	PRO	C-N-CA	6.58	129.40	120.38
1	A	459	ARG	O-C-N	-6.06	114.35	121.32
1	A	719	TYR	O-C-N	-6.01	115.75	122.12
1	A	516	GLN	CA-C-O	-5.92	111.96	119.31
1	A	818	GLU	CA-C-N	5.71	130.92	122.82
1	A	818	GLU	C-N-CA	5.71	130.92	122.82
1	A	838	LYS	O-C-N	5.70	128.17	122.12
1	A	482	SER	CA-C-N	5.53	127.95	120.38
1	A	482	SER	C-N-CA	5.53	127.95	120.38
1	A	357	PHE	CA-C-N	5.38	127.54	120.60

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	357	PHE	C-N-CA	5.38	127.54	120.60
1	A	512	GLY	CA-C-N	5.31	127.66	120.38
1	A	512	GLY	C-N-CA	5.31	127.66	120.38
1	A	760	LYS	CA-C-N	-5.31	113.12	122.09
1	A	760	LYS	C-N-CA	-5.31	113.12	122.09
1	A	483	SER	O-C-N	5.30	127.74	122.12
1	A	306	ARG	CA-C-N	5.29	128.18	120.98
1	A	306	ARG	C-N-CA	5.29	128.18	120.98
1	A	568	HIS	CA-C-N	5.29	127.31	120.44
1	A	568	HIS	C-N-CA	5.29	127.31	120.44
1	A	517	ARG	O-C-N	-5.26	116.15	122.15
1	A	802	ASP	CA-CB-CG	5.20	117.80	112.60
1	A	797	GLN	CA-C-N	5.14	125.66	120.00
1	A	797	GLN	C-N-CA	5.14	125.66	120.00
1	A	519	TYR	CA-C-N	5.05	127.00	120.44
1	A	519	TYR	C-N-CA	5.05	127.00	120.44
1	A	786	PHE	O-C-N	-5.04	116.78	122.12
1	A	372	ASP	CA-C-N	5.04	127.28	120.38
1	A	372	ASP	C-N-CA	5.04	127.28	120.38

There are no chirality outliers.

All (3) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	516	GLN	Mainchain
1	A	517	ARG	Mainchain
1	A	572	GLU	Mainchain

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	4649	0	4704	57	0
2	B	182	0	103	1	0
3	C	224	0	124	0	0
4	A	155	0	0	5	0
4	B	2	0	0	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
4	C	7	0	0	0	0
All	All	5219	0	4931	58	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 6.

All (58) 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:GLU:HG2	1:A:435:ARG:NH1	1.82	0.94
1:A:750:MET:HG3	4:A:1055:HOH:O	1.73	0.87
1:A:325:GLU:HG2	1:A:435:ARG:HH11	1.39	0.86
1:A:430:GLY:HA3	1:A:434:LYS:O	1.78	0.83
1:A:507:LEU:CD2	1:A:580:LEU:HD22	2.13	0.79
1:A:426:GLU:OE2	1:A:431:LYS:HD2	1.82	0.79
1:A:507:LEU:HD21	1:A:580:LEU:HD22	1.68	0.75
1:A:692:VAL:HG21	1:A:701:MET:HE1	1.70	0.74
1:A:665:ILE:HD11	1:A:796:ILE:HD11	1.73	0.71
1:A:779:ARG:NH2	1:A:779:ARG:HB2	2.06	0.70
1:A:426:GLU:CD	1:A:431:LYS:HD2	2.17	0.69
1:A:716:ILE:HD12	1:A:716:ILE:O	1.93	0.69
1:A:779:ARG:HG2	1:A:779:ARG:HH21	1.57	0.69
1:A:779:ARG:HB2	1:A:779:ARG:CZ	2.25	0.67
1:A:779:ARG:HH21	1:A:779:ARG:CG	2.08	0.66
1:A:648:LEU:HD11	1:A:838:LYS:HD3	1.77	0.65
1:A:665:ILE:HD11	1:A:796:ILE:CD1	2.27	0.64
1:A:758:LYS:HG2	1:A:776:ILE:CG2	2.29	0.63
1:A:494:LYS:HE3	1:A:643:SER:HA	1.81	0.62
2:B:5:DG:H2"	2:B:6:DC:OP2	2.00	0.62
1:A:711:GLY:C	1:A:716:ILE:HG23	2.27	0.58
1:A:847:LEU:C	1:A:847:LEU:HD23	2.30	0.56
1:A:298:LYS:HD2	4:A:940:HOH:O	2.05	0.56
1:A:750:MET:SD	1:A:792:MET:HB3	2.48	0.54
1:A:679:LEU:HD13	1:A:684:LYS:HG3	1.90	0.52
1:A:758:LYS:HG2	1:A:776:ILE:HG21	1.92	0.51
1:A:750:MET:SD	1:A:792:MET:HG2	2.51	0.51
1:A:779:ARG:NH2	1:A:779:ARG:CB	2.73	0.51
1:A:595:VAL:CG1	1:A:600:LYS:HA	2.42	0.50
1:A:779:ARG:NH2	1:A:779:ARG:CG	2.71	0.49
1:A:750:MET:CB	4:A:1055:HOH:O	2.61	0.49
1:A:750:MET:CG	4:A:1055:HOH:O	2.45	0.49

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:364:GLU:OE1	1:A:389:GLY:HA2	2.13	0.48
1:A:510:GLN:O	1:A:514:VAL:HG23	2.14	0.48
1:A:506:GLU:O	1:A:510:GLN:HG3	2.13	0.47
1:A:750:MET:SD	1:A:792:MET:CB	3.03	0.47
1:A:426:GLU:HG3	1:A:431:LYS:HB3	1.97	0.47
1:A:695:ASP:OD1	1:A:696:GLU:HG3	2.15	0.47
1:A:758:LYS:HG2	1:A:776:ILE:HG23	1.96	0.47
1:A:836:ALA:HB3	1:A:841:MET:CE	2.46	0.46
1:A:838:LYS:HA	1:A:838:LYS:HD2	1.78	0.46
1:A:846:ARG:HD2	4:A:1047:HOH:O	2.15	0.45
1:A:758:LYS:HA	1:A:776:ILE:HG21	1.99	0.45
1:A:529:ASN:O	1:A:531:PRO:HD3	2.17	0.45
1:A:565:ALA:HB3	1:A:566:PRO:HD3	1.98	0.45
1:A:589:GLU:O	1:A:593:LYS:HG3	2.17	0.44
1:A:679:LEU:CD1	1:A:684:LYS:HG3	2.46	0.44
1:A:718:ASP:HB2	1:A:729:ARG:HG2	1.98	0.44
1:A:776:ILE:HG12	1:A:787:ALA:HB1	2.00	0.44
1:A:814:ARG:NH1	1:A:817:GLU:OE2	2.50	0.44
1:A:434:LYS:HD3	1:A:434:LYS:HA	1.70	0.44
1:A:648:LEU:HD11	1:A:838:LYS:CD	2.44	0.44
1:A:426:GLU:OE2	1:A:431:LYS:CD	2.61	0.43
1:A:737:GLU:O	1:A:741:GLU:HG3	2.19	0.42
1:A:750:MET:SD	1:A:792:MET:CG	3.07	0.42
1:A:635:LYS:HB2	1:A:635:LYS:HE2	1.70	0.42
1:A:693:SER:OG	1:A:695:ASP:OD1	2.37	0.41
1:A:494:LYS:CE	1:A:643:SER:HA	2.49	0.41

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	577/579 (100%)	554 (96%)	21 (4%)	2 (0%)	36	40

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	432	GLY
1	A	628	ILE

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	496/496 (100%)	491 (99%)	5 (1%)	68	77

All (5) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	434	LYS
1	A	435	ARG
1	A	554	TYR
1	A	628	ILE
1	A	779	ARG

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (6) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	576	HIS
1	A	704	GLN
1	A	723	GLN
1	A	724	ASN
1	A	755	GLN
1	A	823	HIS

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

1 non-standard protein/DNA/RNA residue is 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	C42	B	13	2,3	17,20,21	1.51	2 (11%)	20,28,31	1.69	4 (20%)

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	C42	B	13	2,3	-	0/7/21/22	0/2/2/2

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	B	13	C42	C2'-C3'	-4.13	1.45	1.53
2	B	13	C42	C2-N1	-2.20	1.35	1.40

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	13	C42	O2-C2-N3	-4.37	115.44	122.33
2	B	13	C42	O2-C2-N1	2.73	124.24	118.90
2	B	13	C42	C2'-C1'-N1	-2.40	107.80	113.81
2	B	13	C42	O4'-C1'-N1	2.13	111.65	107.86

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

No monomer is involved in short contacts.

5.5 Carbohydrates

There are no oligosaccharides in this entry.

5.6 Ligand geometry

There are no ligands in this entry.

5.7 Other polymers

There are no such residues in this entry.

5.8 Polymer linkage issues

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, 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	579/579 (100%)	0.17	33 (5%) 29 27	14, 25, 57, 97	0
2	B	8/9 (88%)	0.14	1 (12%) 8 7	21, 33, 68, 73	0
3	C	11/11 (100%)	-0.04	2 (18%) 3 3	19, 27, 55, 74	0
All	All	598/599 (99%)	0.16	36 (6%) 27 25	14, 25, 58, 97	0

All (36) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	434	LYS	6.4
1	A	786	PHE	4.9
1	A	552	THR	4.7
1	A	550	THR	4.2
1	A	432	GLY	3.9
1	A	548	LYS	3.7
1	A	551	LYS	3.7
1	A	298	LYS	3.6
1	A	719	TYR	3.5
1	A	781	PHE	3.4
1	A	629	ARG	3.2
1	A	433	ALA	3.2
1	A	782	ASN	3.2
1	A	777	THR	3.1
1	A	779	ARG	3.1
1	A	431	LYS	3.1
1	A	549	LYS	2.7
1	A	517	ARG	2.7
1	A	364	GLU	2.7
1	A	547	LEU	2.7
2	B	5	DG	2.6
1	A	435	ARG	2.6
1	A	529	ASN	2.5

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Mol	Chain	Res	Type	RSRZ
1	A	776	ILE	2.5
1	A	516	GLN	2.5
1	A	562	GLU	2.4
1	A	532	LYS	2.4
1	A	509	GLU	2.3
3	C	14	DA	2.2
1	A	755	GLN	2.2
1	A	838	LYS	2.2
1	A	507	LEU	2.2
1	A	554	TYR	2.1
1	A	553	GLY	2.1
3	C	4	DC	2.1
1	A	524	GLN	2.0

6.2 Non-standard residues in protein, DNA, RNA chains [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	C42	B	13	19/20	0.97	0.06	19,21,25,26	0

6.3 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.4 Ligands [i](#)

There are no ligands in this entry.

6.5 Other polymers [i](#)

There are no such residues in this entry.