



# Full wwPDB X-ray Structure Validation Report ⓘ

Nov 6, 2017 – 10:55 AM EST

PDB ID : 4KLD  
Title : DNA polymerase beta matched substrate complex with Ca<sup>2+</sup>, 0 s  
Authors : Freudenthal, B.D.; Beard, W.A.; Shock, D.D.; Wilson, S.H.  
Deposited on : unknown  
Resolution : 1.92 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](mailto:validation@mail.wwpdb.org)

A user guide is available at

<http://wwpdb.org/validation/2016/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

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The following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

MolProbity : 4.02b-467  
Mogul : 1.7.2 (RC1), CSD as538be (2017)  
Xtriage (Phenix) : 1.9-1692  
EDS : rb-20030345  
Percentile statistics : 20161228.v01 (using entries in the PDB archive December 28th 2016)  
Refmac : 5.8.0135  
CCP4 : 6.5.0  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)  
Validation Pipeline (wwPDB-VP) : rb-20030345

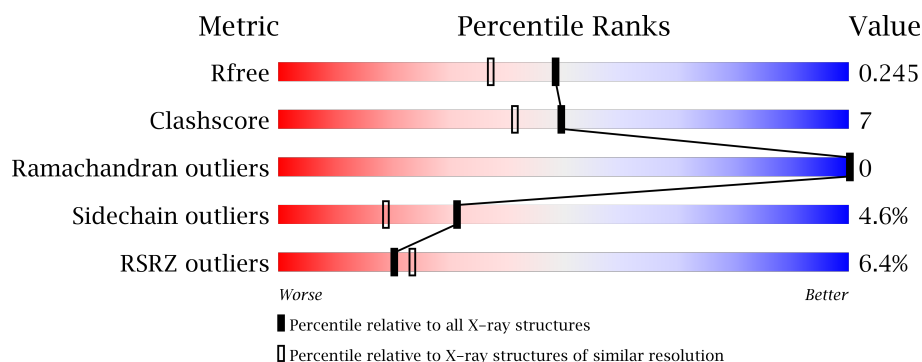
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

## *X-RAY DIFFRACTION*

The reported resolution of this entry is 1.92 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))
$R_{free}$	100719	6276 (1.94-1.90)
Clashscore	112137	7025 (1.94-1.90)
Ramachandran outliers	110173	6947 (1.94-1.90)
Sidechain outliers	110143	6948 (1.94-1.90)
RSRZ outliers	101464	6332 (1.94-1.90)

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 on the lower bar indicate the fraction of residues that contain outliers for  $\geq 3$ , 2, 1 and 0 types of geometric quality criteria. 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	T	16	<div> <div style="width: 56%;"></div> <div style="width: 44%;"></div> </div>
2	P	10	<div> <div style="width: 40%;"></div> <div style="width: 60%;"></div> </div>
3	D	5	<div> <div style="width: 60%;"></div> <div style="width: 40%;"></div> </div>
4	A	335	<div> <div style="width: 7%;"></div> <div style="width: 85%;"></div> <div style="width: 10%;"></div> <div style="width: 5%;"></div> </div>

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 crite-

ria:

Mol	Type	Chain	Res	Chirality	Geometry	Clashes	Electron density
7	NA	A	404	-	-	-	X

## 2 Entry composition

There are 9 unique types of molecules in this entry. The entry contains 3523 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 DNA chain called 5'-D(\*CP\*CP\*GP\*AP\*CP\*GP\*GP\*CP\*GP\*CP\*AP\*TP\*CP\*AP\*GP\*C)-3'.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	T	16	Total	C	N	O	P	0	0	0
			323	153	63	92	15			

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

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	P	10	Total	C	N	O	P	0	0	0
			203	97	38	59	9			

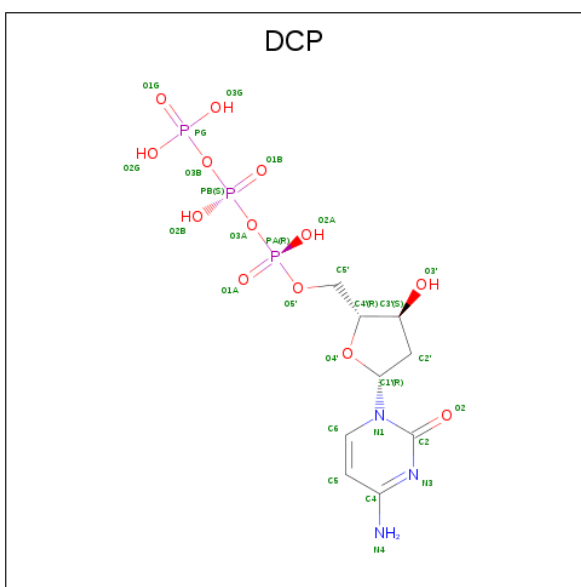
- Molecule 3 is a DNA chain called 5'-D(P\*GP\*TP\*CP\*GP\*G)-3'.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	D	5	Total	C	N	O	P	0	0	0
			106	49	20	32	5			

- Molecule 4 is a protein called DNA polymerase beta.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
4	A	326	Total	C	N	O	S	0	6	0
			2658	1678	471	500	9			

- Molecule 5 is 2'-DEOXYCYTIDINE-5'-TRIPHOSPHATE (three-letter code: DCP) (formula: C<sub>9</sub>H<sub>16</sub>N<sub>3</sub>O<sub>13</sub>P<sub>3</sub>).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
5	A	1	Total	C	N	O	P	0	0
			28	9	3	13	3		

- Molecule 6 is CALCIUM ION (three-letter code: CA) (formula: Ca).

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
6	A	2	Total Ca 2 2	0	0

- Molecule 7 is SODIUM ION (three-letter code: NA) (formula: Na).

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
7	A	2	Total Na 2 2	0	0

- Molecule 8 is CHLORIDE ION (three-letter code: CL) (formula: Cl).

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
8	A	4	Total Cl 4 4	0	0

- Molecule 9 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
9	T	21	Total O 21 21	0	0

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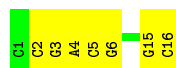
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
9	P	15	Total 15	O 15	0	0
9	D	12	Total 12	O 12	0	0
9	A	149	Total 149	O 149	0	0

### 3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA and DNA 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.

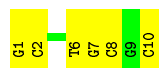
- Molecule 1: 5'-D(\*CP\*CP\*GP\*AP\*CP\*GP\*GP\*CP\*GP\*CP\*AP\*TP\*CP\*AP\*GP\*C)-3'

Chain T: 



- Molecule 2: 5'-D(\*GP\*CP\*TP\*GP\*AP\*TP\*GP\*CP\*GP\*C)-3'

Chain P: 




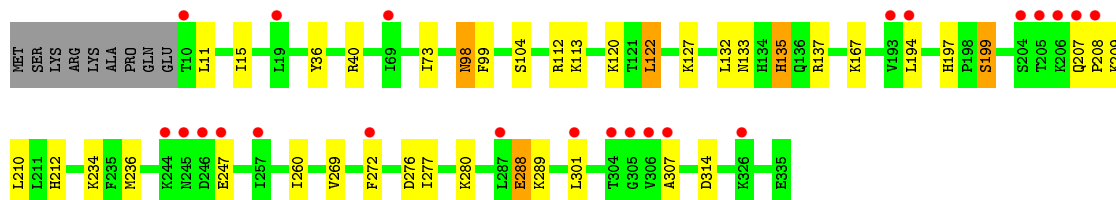
- Molecule 3: 5'-D(P\*GP\*TP\*CP\*GP\*G)-3'

Chain D: 



- Molecule 4: DNA polymerase beta

Chain A: 



## 4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	50.80Å 80.40Å 55.50Å 90.00° 107.90° 90.00°	Depositor
Resolution (Å)	23.15 – 1.92 23.15 – 1.92	Depositor EDS
% Data completeness (in resolution range)	87.2 (23.15-1.92) 86.8 (23.15-1.92)	Depositor EDS
$R_{merge}$	0.06	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	2.46 (at 1.92Å)	Xtriage
Refinement program	PHENIX 1.7 _650	Depositor
R, $R_{free}$	0.197 , 0.251 0.197 , 0.245	Depositor DCC
$R_{free}$ test set	2828 reflections (9.98%)	DCC
Wilson B-factor (Å <sup>2</sup> )	30.5	Xtriage
Anisotropy	0.246	Xtriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.36 , 51.3	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.48$ , $\langle L^2 \rangle = 0.31$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
$F_o, F_c$ correlation	0.95	EDS
Total number of atoms	3523	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	34.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.47% of the height of the origin peak. No significant pseudotranslation is detected.*

<sup>1</sup>Intensities estimated from amplitudes.

<sup>2</sup>Theoretical 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: NA, CA, DCP, 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	T	0.72	0/362	1.15	0/556
2	P	1.02	0/227	1.21	0/349
3	D	1.45	0/118	1.65	2/179 (1.1%)
4	A	0.43	0/2716	0.55	0/3649
All	All	0.59	0/3423	0.78	2/4733 (0.0%)

There are no bond length outliers.

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	D	2	DT	O4'-C1'-N1	-6.49	103.46	108.00
3	D	3	DC	O4'-C1'-N1	-5.20	104.36	108.00

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	T	323	0	179	9	0
2	P	203	0	113	4	0
3	D	106	0	57	0	0
4	A	2658	0	2684	31	0
5	A	28	0	12	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
6	A	2	0	0	0	0
7	A	2	0	0	0	0
8	A	4	0	0	0	0
9	A	149	0	0	2	0
9	D	12	0	0	0	0
9	P	15	0	0	0	0
9	T	21	0	0	0	0
All	All	3523	0	3045	43	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 7.

All (43) 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)
4:A:301:LEU:HD23	4:A:307:ALA:HA	1.14	1.05
4:A:301:LEU:HD23	4:A:307:ALA:CA	1.90	1.02
1:T:5:DC:H2''	1:T:6:DG:OP1	1.65	0.95
4:A:301:LEU:CD2	4:A:307:ALA:HA	1.98	0.92
4:A:301:LEU:HD21	4:A:307:ALA:HB2	1.56	0.86
4:A:36:TYR:CZ	4:A:40[B]:ARG:HD2	2.18	0.78
4:A:301:LEU:CD2	4:A:307:ALA:CA	2.58	0.76
4:A:301:LEU:CD2	4:A:307:ALA:HB2	2.23	0.68
4:A:98:ASN:HB3	9:A:560:HOH:O	1.94	0.68
4:A:301:LEU:CD2	4:A:307:ALA:CB	2.74	0.66
4:A:133:ASN:O	4:A:137[B]:ARG:HG2	1.97	0.65
2:P:10:DC:H5'	4:A:236:MET:HE2	1.80	0.63
1:T:2:DC:H2'	1:T:3:DG:C8	2.35	0.62
4:A:301:LEU:HD23	4:A:307:ALA:CB	2.32	0.59
4:A:99:PHE:HZ	4:A:122:LEU:HD13	1.67	0.58
4:A:209:LYS:HB3	4:A:212:HIS:HB3	1.84	0.58
4:A:288:GLU:OE1	4:A:289:LYS:HG2	2.06	0.55
4:A:276:ASP:O	4:A:280:LYS:HD3	2.08	0.53
4:A:99:PHE:CZ	4:A:122:LEU:HD13	2.44	0.52
4:A:36:TYR:CE1	4:A:40[B]:ARG:HD2	2.45	0.52
1:T:15:DG:H2''	1:T:16:DC:O5'	2.10	0.51
2:P:6:DT:H2''	2:P:7:DG:O5'	2.12	0.50
4:A:15:ILE:HD12	4:A:73:ILE:HG12	1.94	0.50
1:T:4:DA:H1'	1:T:5:DC:H5'	1.93	0.50
4:A:104:SER:OG	4:A:135:HIS:HE1	1.96	0.49
4:A:197:HIS:ND1	4:A:199:SER:HB2	2.28	0.48

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
4:A:194[B]:LEU:HA	4:A:194[B]:LEU:HD23	1.74	0.46
4:A:207:GLN:HE21	4:A:210:LEU:HD21	1.81	0.46
1:T:4:DA:H2''	1:T:5:DC:O5'	2.15	0.46
1:T:4:DA:C5	1:T:5:DC:C4	3.02	0.46
4:A:207:GLN:HA	4:A:208:PRO:HD3	1.79	0.45
1:T:2:DC:H2''	1:T:3:DG:C5'	2.47	0.44
4:A:234:LYS:NZ	4:A:236:MET:HE3	2.33	0.44
4:A:40[B]:ARG:NE	4:A:277:ILE:HD11	2.33	0.44
1:T:2:DC:H4'	1:T:3:DG:OP1	2.17	0.43
2:P:7:DG:H1'	2:P:8:DC:H5'	2.00	0.43
1:T:2:DC:H2''	1:T:3:DG:O5'	2.18	0.43
4:A:199:SER:OG	4:A:207:GLN:HG3	2.19	0.43
4:A:112[B]:ARG:HG3	4:A:113:LYS:N	2.29	0.42
4:A:98:ASN:CB	9:A:560:HOH:O	2.62	0.42
4:A:132:LEU:HB2	4:A:137[B]:ARG:HD3	2.03	0.41
4:A:194[A]:LEU:HD11	4:A:260:ILE:HG13	2.02	0.41
2:P:1:DG:H2'	2:P:2:DC:C6	2.56	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	
4	A	330/335 (98%)	324 (98%)	6 (2%)	0	100	100

There are no Ramachandran outliers to report.

### 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	
4	A	291/295 (99%)	278 (96%)	13 (4%)	32	20

All (13) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
4	A	11	LEU
4	A	98	ASN
4	A	120	LYS
4	A	122	LEU
4	A	127	LYS
4	A	135	HIS
4	A	167	LYS
4	A	199	SER
4	A	247	GLU
4	A	269	VAL
4	A	272	PHE
4	A	288	GLU
4	A	314	ASP

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

Mol	Chain	Res	Type
4	A	31	GLN
4	A	135	HIS
4	A	157	GLN
4	A	207	GLN
4	A	245	ASN
4	A	264	GLN

### 5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

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

There are no non-standard protein/DNA/RNA residues in this entry.

## 5.5 Carbohydrates

There are no carbohydrates in this entry.

## 5.6 Ligand geometry

Of 9 ligands modelled in this entry, 8 are monoatomic - leaving 1 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	$\# Z  > 2$
5	DCP	A	401	6	23,29,29	1.09	1 (4%)	25,45,45	1.09	1 (4%)

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
5	DCP	A	401	6	-	0/18/34/34	0/2/2/2

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
5	A	401	DCP	PB-O1B	2.35	1.59	1.50

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
5	A	401	DCP	O4'-C1'-N1	2.73	112.38	107.78

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

No monomer is involved in short contacts.

## 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

### 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, 95<sup>th</sup> 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 <sup>2</sup> )	Q<0.9
1	T	16/16 (100%)	-0.11	0 <span>100</span> <span>100</span>	25, 37, 47, 47	0
2	P	10/10 (100%)	-0.06	0 <span>100</span> <span>100</span>	20, 32, 42, 43	0
3	D	5/5 (100%)	-0.51	0 <span>100</span> <span>100</span>	25, 28, 34, 39	0
4	A	326/335 (97%)	0.25	23 (7%) <span>17</span> <span>19</span>	19, 30, 56, 76	0
All	All	357/366 (97%)	0.21	23 (6%) <span>20</span> <span>23</span>	19, 30, 56, 76	0

All (23) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
4	A	246	ASP	6.7
4	A	301	LEU	6.1
4	A	208	PRO	5.6
4	A	244	LYS	4.7
4	A	207	GLN	4.6
4	A	205	THR	4.3
4	A	305	GLY	3.9
4	A	306	VAL	3.1
4	A	206	LYS	3.0
4	A	245	ASN	3.0
4	A	10	THR	3.0
4	A	69	ILE	2.6
4	A	193	VAL	2.6
4	A	194[A]	LEU	2.4
4	A	307	ALA	2.3
4	A	257	ILE	2.3
4	A	19	LEU	2.1
4	A	287	LEU	2.1
4	A	304	THR	2.1
4	A	272	PHE	2.1
4	A	204	SER	2.0

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Mol	Chain	Res	Type	RSRZ
4	A	247	GLU	2.0
4	A	326	LYS	2.0

## 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 carbohydrates 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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. The B-factors column lists the minimum, median, 95<sup>th</sup> 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	LLDF	B-factors(Å <sup>2</sup> )	Q<0.9
7	NA	A	404	1/1	0.92	0.20	2.27	30,30,30,30	0
8	CL	A	406	1/1	0.98	0.16	1.65	30,30,30,30	0
7	NA	A	405	1/1	0.98	0.10	0.48	30,30,30,30	0
5	DCP	A	401	28/28	0.96	0.10	-0.44	19,24,28,28	0
6	CA	A	402	1/1	0.99	0.06	-0.89	27,27,27,27	0
6	CA	A	403	1/1	0.99	0.08	-1.36	23,23,23,23	0
8	CL	A	409	1/1	0.96	0.04	-3.96	30,30,30,30	0
8	CL	A	407	1/1	0.95	0.19	-	30,30,30,30	0
8	CL	A	408	1/1	0.96	0.20	-	30,30,30,30	0

## 6.5 Other polymers [i](#)

There are no such residues in this entry.