wwPDB X-ray Structure Validation Summary Report (i)

Oct 12, 2021 – 12:28 PM EDT

PDB ID	:	2EX3
Title	:	Bacteriophage phi29 DNA polymerase bound to terminal protein
Authors	:	Kamtekar, S.; Berman, A.J.; Wang, J.; de Vega, M.; Blanco, L.; Salas, M.; Steitz, T.A.
Deposited on	:	2005-11-07
Resolution	:	3.00 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 (i) symbol.

The following versions of software and data (see references (1)) were used in the production of this report:

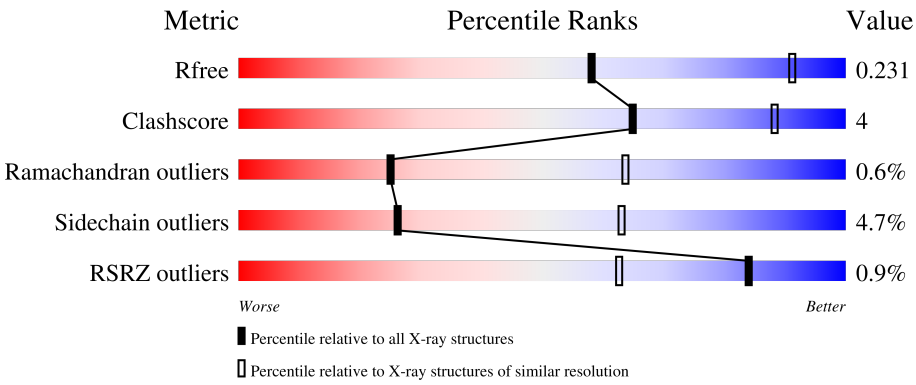
MolProbity	:	4.02b-467
Xtriage (Phenix)	:	1.13
EDS	:	2.23.2
Percentile statistics	:	20191225.v01 (using entries in the PDB archive December 25th 2019)
Refmac	:	5.8.0158
CCP4	:	7.0.044 (Gargrove)
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.23.2

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 3.00 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}	130704	2092 (3.00-3.00)
Clashscore	141614	2416 (3.00-3.00)
Ramachandran outliers	138981	2333 (3.00-3.00)
Sidechain outliers	138945	2336 (3.00-3.00)
RSRZ outliers	127900	1990 (3.00-3.00)

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 <=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	575	81% 18% ••
1	C	575	% 82% 16% ••
1	E	575	% 86% 12% ••
1	G	575	86% 11% ••
1	I	575	% 87% 11% ••

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Mol	Chain	Length	Quality of chain
1	K	575	.% 84% 14% ••
2	B	230	.% 75% 10% • 15%
2	D	230	2% 77% 7% • 15%
2	F	230	77% 7% • 15%
2	H	230	2% 73% 12% 15%
2	J	230	.% 73% 12% 15%
2	L	230	.% 76% 8% • 15%

2 Entry composition (i)

There are 3 unique types of molecules in this entry. The entry contains 37108 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.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	570	4661	3036	753	851	21	0	0	0
1	C	570	4661	3036	753	851	21	0	0	0
1	E	570	4661	3036	753	851	21	0	0	0
1	G	570	4661	3036	753	851	21	0	0	0
1	I	570	4661	3036	753	851	21	0	0	0
1	K	570	4661	3036	753	851	21	0	0	0

There are 12 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	12	ALA	ASP	engineered mutation	UNP P03680
A	66	ALA	ASP	engineered mutation	UNP P03680
C	12	ALA	ASP	engineered mutation	UNP P03680
C	66	ALA	ASP	engineered mutation	UNP P03680
E	12	ALA	ASP	engineered mutation	UNP P03680
E	66	ALA	ASP	engineered mutation	UNP P03680
G	12	ALA	ASP	engineered mutation	UNP P03680
G	66	ALA	ASP	engineered mutation	UNP P03680
I	12	ALA	ASP	engineered mutation	UNP P03680
I	66	ALA	ASP	engineered mutation	UNP P03680
K	12	ALA	ASP	engineered mutation	UNP P03680
K	66	ALA	ASP	engineered mutation	UNP P03680

- Molecule 2 is a protein called DNA terminal protein.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
2	B	196	1521	959	261	296	5	0	0	0
2	D	196	1521	959	261	296	5	0	0	0
2	F	196	1521	959	261	296	5	0	0	0
2	H	196	1521	959	261	296	5	0	0	0
2	J	196	1521	959	261	296	5	0	0	0
2	L	196	1521	959	261	296	5	0	0	0

- Molecule 3 is LEAD (II) ION (three-letter code: PB) (formula: Pb).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
			Total	Pb		
3	A	3	3	3	0	0
3	C	3	3	3	0	0
3	E	3	3	3	0	0
3	G	3	3	3	0	0
3	I	2	2	2	0	0
3	K	2	2	2	0	0

3 Residue-property plots (i)

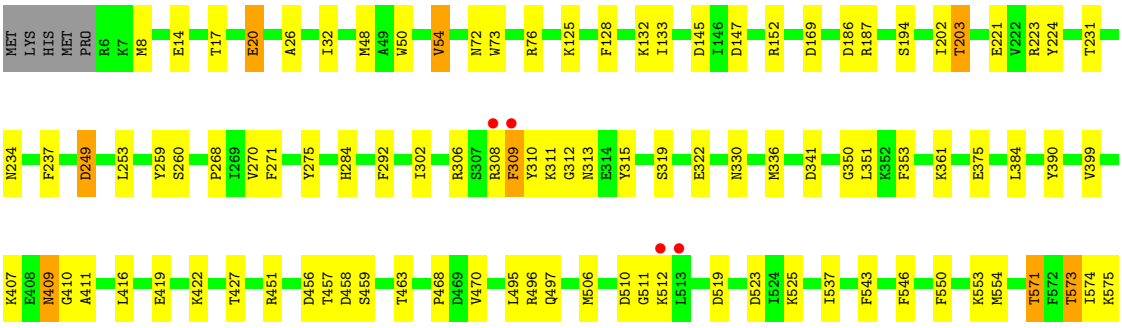
These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. 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: DNA polymerase

Chain A:

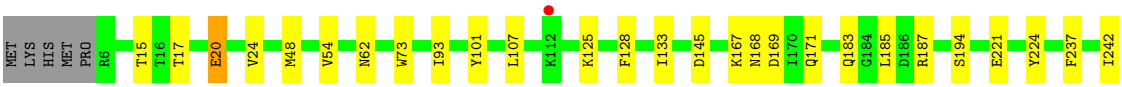
• Molecule 1: DNA polymerase

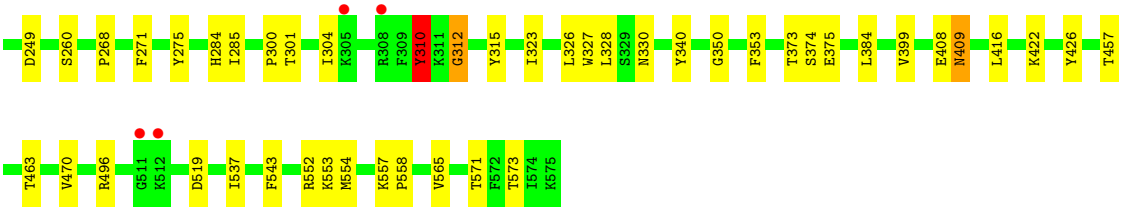
Chain C:



• Molecule 1: DNA polymerase

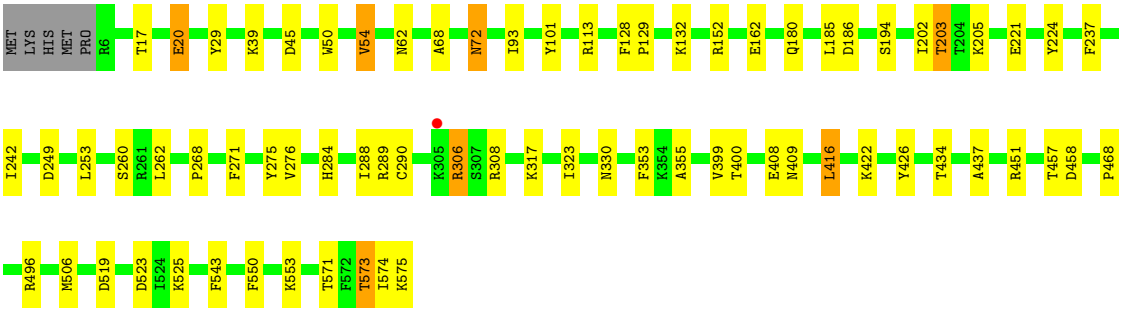
Chain E:





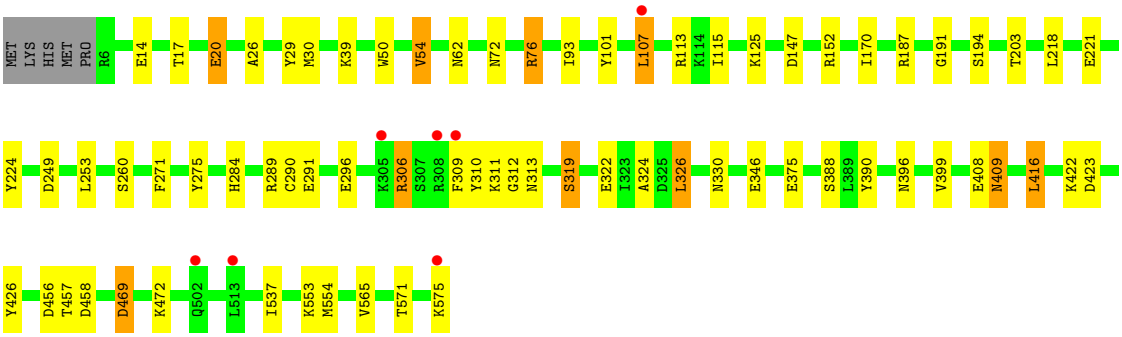
• Molecule 1: DNA polymerase

Chain G:



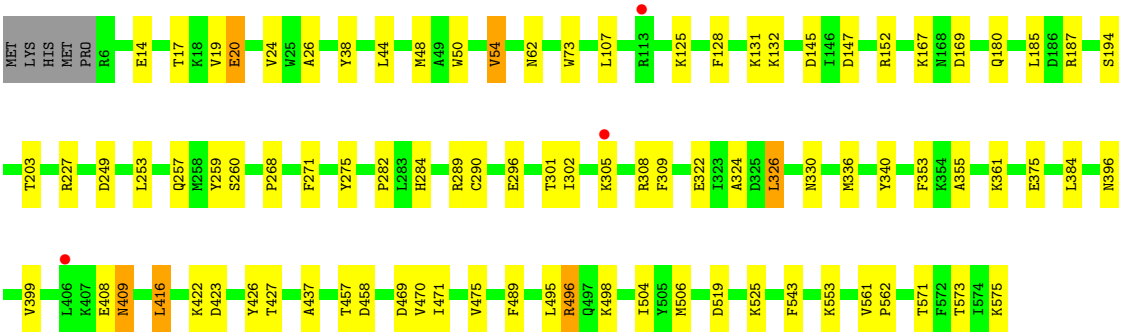
• Molecule 1: DNA polymerase

Chain I:



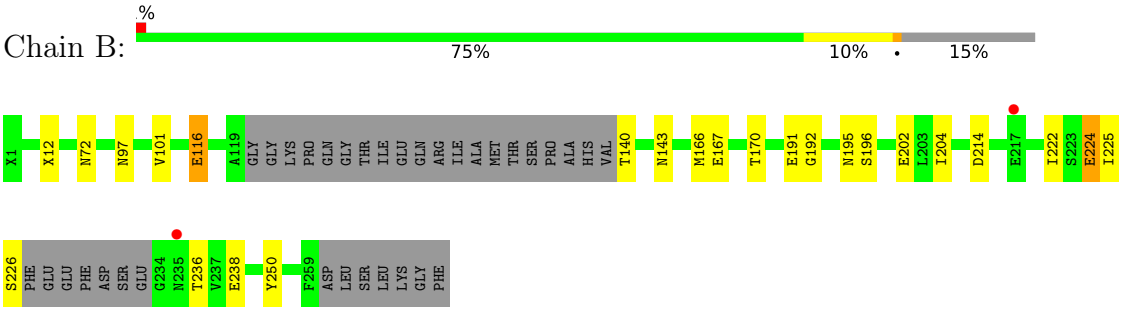
• Molecule 1: DNA polymerase

Chain K:



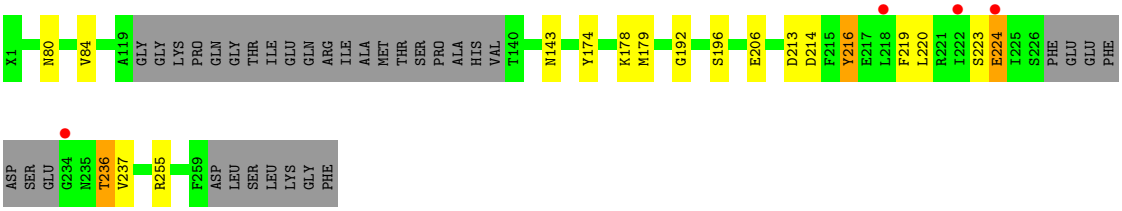
• Molecule 2: DNA terminal protein

Chain B: %



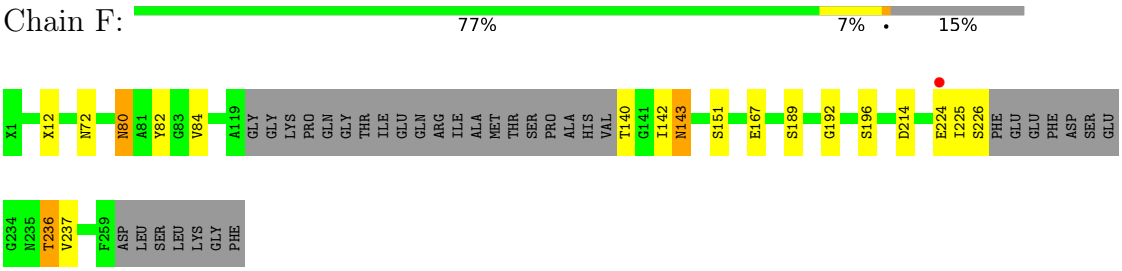
- Molecule 2: DNA terminal protein

Chain D: 2%



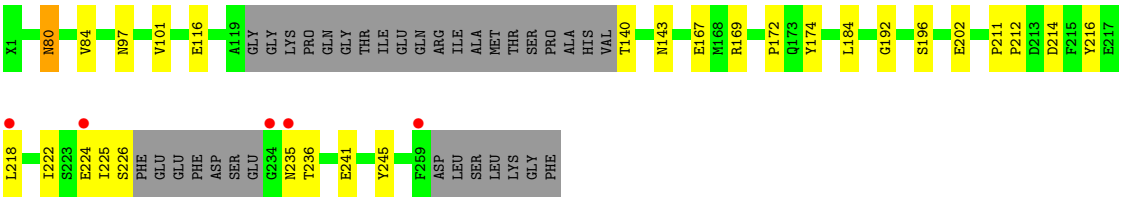
- Molecule 2: DNA terminal protein

Chain F:



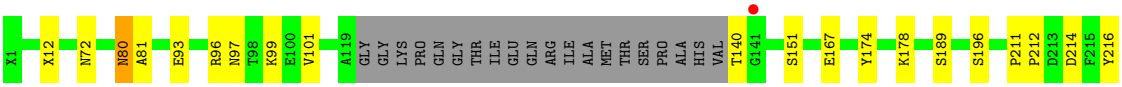
- Molecule 2: DNA terminal protein

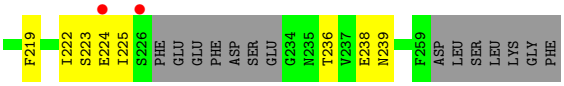
Chain H: 2%



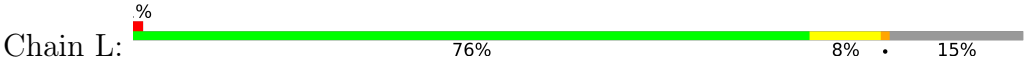
- Molecule 2: DNA terminal protein

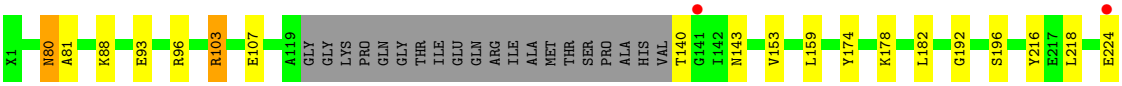
Chain J: %

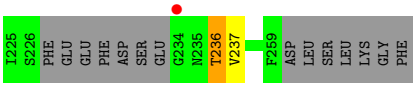




• Molecule 2: DNA terminal protein







4 Data and refinement statistics (i)

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, α, β, γ	304.93Å 220.28Å 217.16Å 90.00° 45.40° 90.00°	Depositor
Resolution (Å)	48.85 – 3.00 48.83 – 3.00	Depositor EDS
% Data completeness (in resolution range)	99.7 (48.85-3.00) 99.7 (48.83-3.00)	Depositor EDS
R_{merge}	0.09	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	1.43 (at 3.01Å)	Xtriage
Refinement program	REFMAC	Depositor
R, R_{free}	0.200 , 0.229 0.204 , 0.231	Depositor DCC
R_{free} test set	20161 reflections (9.97%)	wwPDB-VP
Wilson B-factor (Å^2)	91.1	Xtriage
Anisotropy	0.010	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.33 , 96.6	EDS
L-test for twinning[2]	$< \|L\| > = 0.49$, $< L^2 > = 0.31$	Xtriage
Estimated twinning fraction	0.006 for -h+2*l,k,-h+l 0.011 for -h-k+l,-l,-k 0.006 for -h+k+l,l,k 0.008 for -k-l,-h+l,-l 0.008 for k-l,h-l,-l 0.039 for k+l,h-l,k 0.044 for h+k-l,l,h-l 0.038 for -k+l,-h+l,-k 0.036 for h-k-l,-l,h-l 0.010 for h,-k,h-l 0.023 for h-2*l,-k,-l	Xtriage
F_o,F_c correlation	0.94	EDS
Total number of atoms	37108	wwPDB-VP
Average B, all atoms (Å^2)	99.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 1.97% of the height of the origin peak. No significant pseudotranslation is detected.*

[1]Intensities estimated from amplitudes.

[2]Theoretical values of $< |L| >$, $< L^2 >$ 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: PB

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	0.38	0/4780	0.53	0/6448
1	C	0.37	0/4780	0.52	0/6448
1	E	0.37	0/4780	0.52	0/6448
1	G	0.37	0/4780	0.53	0/6448
1	I	0.37	0/4780	0.51	0/6448
1	K	0.37	0/4780	0.51	0/6448
2	B	0.36	0/1373	0.50	0/1837
2	D	0.38	0/1373	0.50	0/1837
2	F	0.36	0/1373	0.50	0/1837
2	H	0.35	0/1373	0.50	0/1837
2	J	0.38	0/1373	0.49	0/1837
2	L	0.37	0/1373	0.48	0/1837
All	All	0.37	0/36918	0.51	0/49710

There are no bond length outliers.

There are no bond angle outliers.

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	A	4661	0	4668	53	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	C	4661	0	4668	51	0
1	E	4661	0	4668	35	0
1	G	4661	0	4668	35	0
1	I	4661	0	4668	36	0
1	K	4661	0	4668	43	0
2	B	1521	0	1366	13	0
2	D	1521	0	1365	13	0
2	F	1521	0	1366	11	0
2	H	1521	0	1365	15	0
2	J	1521	0	1366	14	0
2	L	1521	0	1366	14	0
3	A	3	0	0	0	0
3	C	3	0	0	0	0
3	E	3	0	0	0	0
3	G	3	0	0	0	0
3	I	2	0	0	0	0
3	K	2	0	0	0	0
All	All	37108	0	36202	303	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 4.

The worst 5 of 303 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)
2:L:80:ASN:HD22	2:L:81:ALA:H	1.28	0.81
1:E:310:TYR:CE1	1:E:312:GLY:HA2	2.20	0.76
1:E:399:VAL:HG21	1:E:422:LYS:HB2	1.69	0.75
1:I:309:PHE:CE1	1:I:322:GLU:HG2	2.24	0.72
1:A:370:ILE:O	1:A:374:SER:HB2	1.89	0.72

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	568/575 (99%)	547 (96%)	17 (3%)	4 (1%)	22	60
1	C	568/575 (99%)	543 (96%)	21 (4%)	4 (1%)	22	60
1	E	568/575 (99%)	540 (95%)	23 (4%)	5 (1%)	17	55
1	G	568/575 (99%)	549 (97%)	15 (3%)	4 (1%)	22	60
1	I	568/575 (99%)	543 (96%)	20 (4%)	5 (1%)	17	55
1	K	568/575 (99%)	543 (96%)	19 (3%)	6 (1%)	14	50
2	B	156/230 (68%)	149 (96%)	7 (4%)	0	100	100
2	D	156/230 (68%)	148 (95%)	8 (5%)	0	100	100
2	F	156/230 (68%)	149 (96%)	7 (4%)	0	100	100
2	H	156/230 (68%)	149 (96%)	7 (4%)	0	100	100
2	J	156/230 (68%)	148 (95%)	8 (5%)	0	100	100
2	L	156/230 (68%)	148 (95%)	8 (5%)	0	100	100
All	All	4344/4830 (90%)	4156 (96%)	160 (4%)	28 (1%)	25	64

5 of 28 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	E	310	TYR
1	A	426	TYR
1	C	312	GLY
1	C	511	GLY
1	E	312	GLY

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	501/506 (99%)	478 (95%)	23 (5%)	27	64
1	C	501/506 (99%)	476 (95%)	25 (5%)	24	60

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	E	501/506 (99%)	479 (96%)	22 (4%)	28	65
1	G	501/506 (99%)	480 (96%)	21 (4%)	30	66
1	I	501/506 (99%)	477 (95%)	24 (5%)	25	62
1	K	501/506 (99%)	477 (95%)	24 (5%)	25	62
2	B	147/175 (84%)	139 (95%)	8 (5%)	22	57
2	D	147/175 (84%)	143 (97%)	4 (3%)	44	77
2	F	147/175 (84%)	140 (95%)	7 (5%)	25	62
2	H	147/175 (84%)	138 (94%)	9 (6%)	18	53
2	J	147/175 (84%)	139 (95%)	8 (5%)	22	57
2	L	147/175 (84%)	139 (95%)	8 (5%)	22	57
All	All	3888/4086 (95%)	3705 (95%)	183 (5%)	26	63

5 of 183 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
2	H	202	GLU
2	J	80	ASN
1	I	17	THR
1	I	306	ARG
2	J	236	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 42 such sidechains are listed below:

Mol	Chain	Res	Type
1	I	284	HIS
1	K	171	GLN
1	I	330	ASN
2	J	80	ASN
1	K	330	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 monosaccharides in this entry.

5.6 Ligand geometry (i)

Of 16 ligands modelled in this entry, 16 are monoatomic - leaving 0 for Mogul analysis.

There are no bond length outliers.

There are no bond angle outliers.

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)

The following chains have linkage breaks:

Mol	Chain	Number of breaks
2	J	2
2	F	2
2	D	2
2	H	2
2	L	2
2	B	2

The worst 5 of 12 chain breaks are listed below:

Model	Chain	Residue-1	Atom-1	Residue-2	Atom-2	Distance (Å)
1	J	12:UNK	C	26:UNK	N	19.24
1	F	12:UNK	C	26:UNK	N	19.18

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Model	Chain	Residue-1	Atom-1	Residue-2	Atom-2	Distance (Å)
1	D	12:UNK	C	26:UNK	N	19.10
1	H	12:UNK	C	26:UNK	N	19.05
1	L	12:UNK	C	26:UNK	N	18.98

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	570/575 (99%)	0.21	1 (0%)	95	87	86, 99, 112, 132	0
1	C	570/575 (99%)	0.26	4 (0%)	87	69	84, 99, 112, 158	0
1	E	570/575 (99%)	0.24	5 (0%)	84	63	85, 99, 111, 143	0
1	G	570/575 (99%)	0.21	1 (0%)	95	87	85, 98, 111, 140	0
1	I	570/575 (99%)	0.20	7 (1%)	79	54	86, 99, 111, 148	0
1	K	570/575 (99%)	0.25	3 (0%)	91	75	86, 98, 112, 145	0
2	B	162/230 (70%)	0.26	2 (1%)	79	54	76, 99, 113, 124	0
2	D	162/230 (70%)	0.36	4 (2%)	57	29	83, 98, 114, 125	0
2	F	162/230 (70%)	0.34	1 (0%)	89	72	78, 99, 114, 125	0
2	H	162/230 (70%)	0.26	5 (3%)	49	21	80, 99, 114, 125	0
2	J	162/230 (70%)	0.28	3 (1%)	66	37	82, 98, 114, 125	0
2	L	162/230 (70%)	0.33	3 (1%)	66	37	82, 98, 115, 124	0
All	All	4392/4830 (90%)	0.24	39 (0%)	84	63	76, 99, 112, 158	0

The worst 5 of 39 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
2	J	224	GLU	4.2
1	E	308	ARG	3.6
2	D	234	GLY	3.6
1	E	512	LYS	3.5
1	E	305	LYS	3.5

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 monosaccharides 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	PB	C	706	1/1	0.56	0.16	191,191,191,191	1
3	PB	K	715	1/1	0.79	0.08	175,175,175,175	1
3	PB	E	707	1/1	0.81	0.09	174,174,174,174	1
3	PB	C	705	1/1	0.83	0.08	162,162,162,162	1
3	PB	E	709	1/1	0.85	0.07	182,182,182,182	1
3	PB	A	702	1/1	0.88	0.05	165,165,165,165	1
3	PB	I	714	1/1	0.89	0.09	180,180,180,180	1
3	PB	E	708	1/1	0.91	0.13	160,160,160,160	1
3	PB	G	710	1/1	0.93	0.12	158,158,158,158	1
3	PB	A	701	1/1	0.94	0.07	157,157,157,157	1
3	PB	I	713	1/1	0.94	0.13	155,155,155,155	1
3	PB	C	704	1/1	0.95	0.19	146,146,146,146	1
3	PB	K	716	1/1	0.96	0.13	160,160,160,160	1
3	PB	G	711	1/1	0.97	0.13	156,156,156,156	1
3	PB	A	703	1/1	0.98	0.19	103,103,103,103	1
3	PB	G	712	1/1	0.99	0.19	106,106,106,106	1

6.5 Other polymers (i)

There are no such residues in this entry.