



# Full wwPDB NMR Structure Validation Report ⓘ

Feb 13, 2017 – 12:20 am GMT

PDB ID : 2LR4  
Title : NMR structure of the protein NP\_390037.1 from *Bacillus subtilis*  
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Deposited on : 2012-03-22

This is a Full wwPDB NMR Structure Validation Report for a publicly released PDB entry.

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A user guide is available at

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

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:

Cyrange : Kirchner and Güntert (2011)  
NmrClust : Kelley et al. (1996)  
MolProbity : 4.02b-467  
Percentile statistics : 20161228.v01 (using entries in the PDB archive December 28th 2016)  
RCI : v\_1n\_11\_5\_13\_A (Berjanski et al., 2005)  
PANAV : Wang et al. (2010)  
ShiftChecker : trunk28760  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)  
Validation Pipeline (wwPDB-VP) : recalc28949

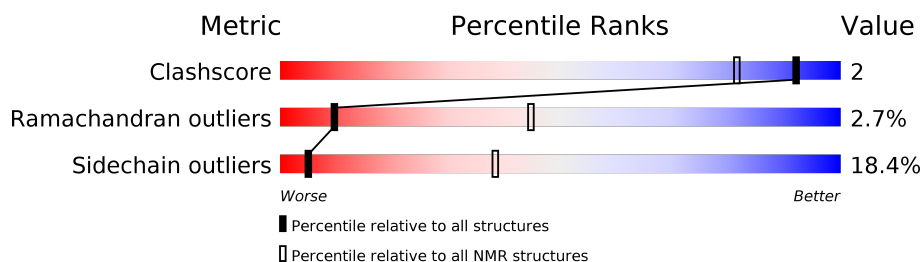
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*SOLUTION NMR*

The overall completeness of chemical shifts assignment is 87%.

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)	NMR archive (#Entries)
Clashscore	125131	11601
Ramachandran outliers	121729	10391
Sidechain outliers	121581	10367

The table below summarises the geometric issues observed across the polymeric chains and their fit to the experimental data. The red, orange, yellow and green segments indicate the fraction of residues that contain outliers for  $\geq 3$ , 2, 1 and 0 types of geometric quality criteria. A cyan segment indicates the fraction of residues that are not part of the well-defined cores, and 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  $\leq 5\%$

Mol	Chain	Length	Quality of chain
1	A	128	 84% 14% •

## 2 Ensemble composition and analysis

This entry contains 20 models. Model 1 is the overall representative, medoid model (most similar to other models).

The following residues are included in the computation of the global validation metrics.

Well-defined (core) protein residues			
Well-defined core	Residue range (total)	Backbone RMSD (Å)	Medoid model
1	A:4-A:128 (125)	0.36	1

Ill-defined regions of proteins are excluded from the global statistics.

Ligands and non-protein polymers are included in the analysis.

The models can be grouped into 2 clusters. No single-model clusters were found.

Cluster number	Models
1	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 19, 20
2	10, 18

### 3 Entry composition

There is only 1 type of molecule in this entry. The entry contains 2014 atoms, of which 1009 are hydrogens and 0 are deuteriums.

- Molecule 1 is a protein called SPBc2 prophage-derived uncharacterized protein yolA.

Mol	Chain	Residues	Atoms						Trace
1	A	128	Total	C	H	N	O	S	0
			2014	646	1009	163	193	3	

There is a discrepancy between the modelled and reference sequences:

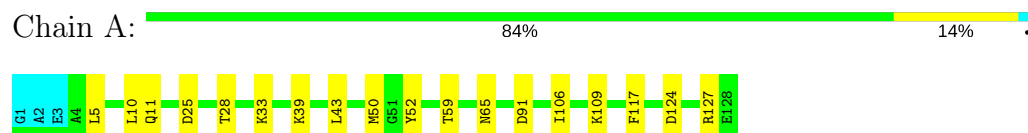
Chain	Residue	Modelled	Actual	Comment	Reference
A	1	GLY	-	leader sequence	UNP O31994

## 4 Residue-property plots

### 4.1 Average score per residue in the NMR ensemble

These plots are provided for all protein, RNA and DNA chains in the entry. The first graphic is the same as shown in the summary in section 1 of this report. The second graphic shows the sequence where residues are colour-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. Stretches of 2 or more consecutive residues without any outliers are shown as green connectors. Residues which are classified as ill-defined in the NMR ensemble, are shown in cyan with an underline colour-coded according to the previous scheme. Residues which were present in the experimental sample, but not modelled in the final structure are shown in grey.

- Molecule 1: SPBc2 prophage-derived uncharacterized protein yola

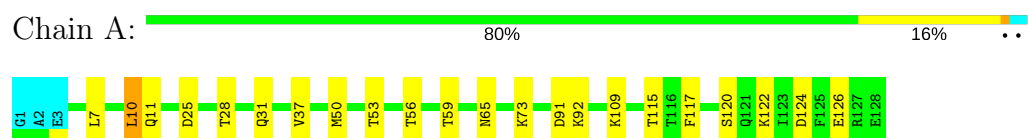


### 4.2 Scores per residue for each member of the ensemble

Colouring as in section 4.1 above.

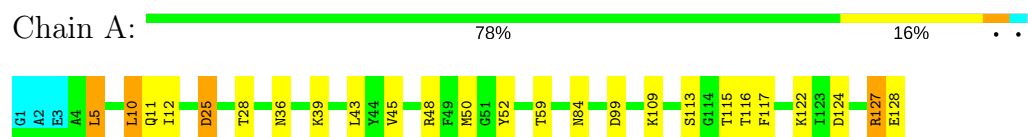
#### 4.2.1 Score per residue for model 1 (medoid)

- Molecule 1: SPBc2 prophage-derived uncharacterized protein yola



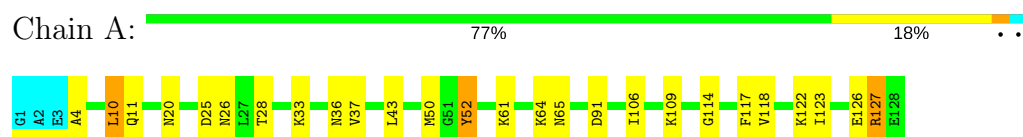
#### 4.2.2 Score per residue for model 2

- Molecule 1: SPBc2 prophage-derived uncharacterized protein yola



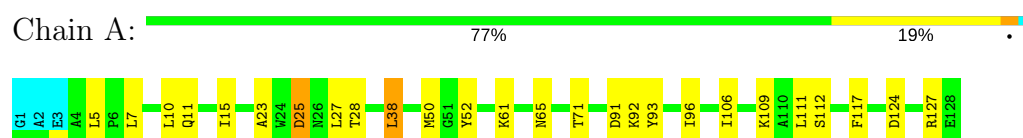
### 4.2.3 Score per residue for model 3

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA



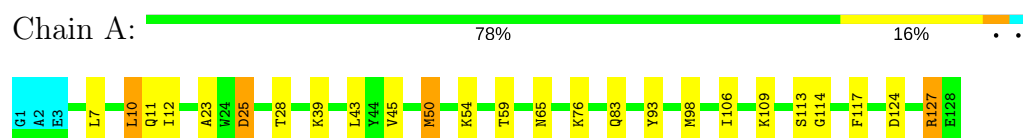
### 4.2.4 Score per residue for model 4

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA



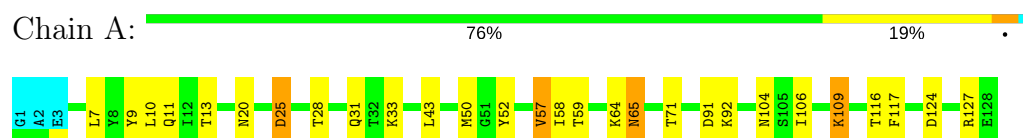
### 4.2.5 Score per residue for model 5

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA



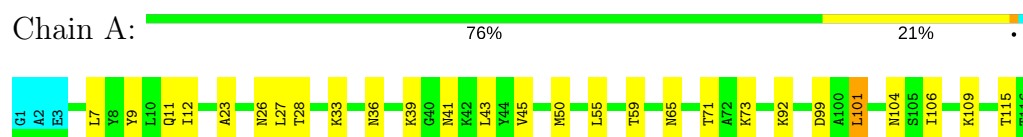
### 4.2.6 Score per residue for model 6

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA



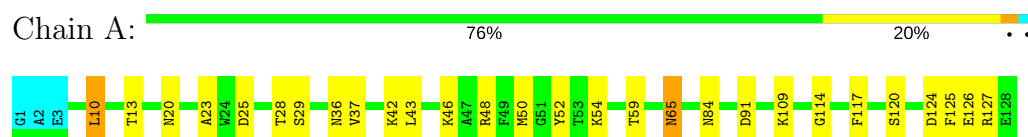
### 4.2.7 Score per residue for model 7

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA



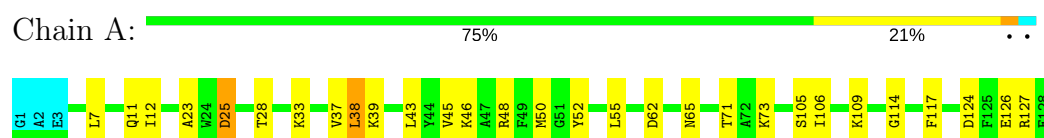
### 4.2.8 Score per residue for model 8

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA



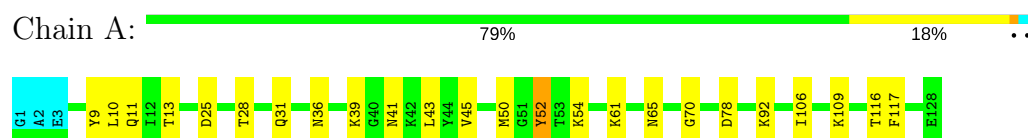
### 4.2.9 Score per residue for model 9

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA



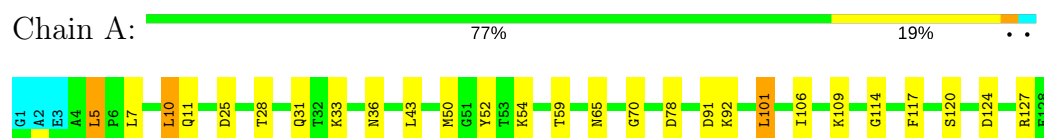
### 4.2.10 Score per residue for model 10

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA



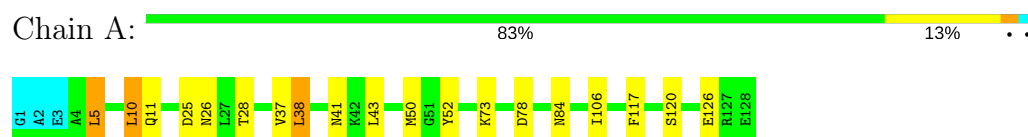
### 4.2.11 Score per residue for model 11

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA



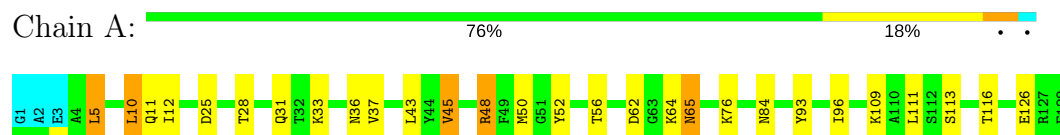
### 4.2.12 Score per residue for model 12

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA



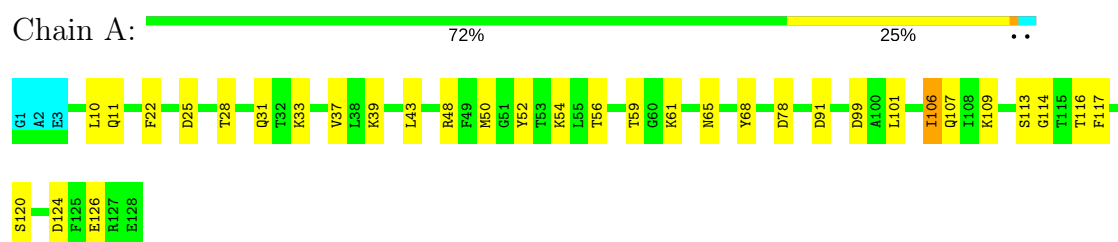
### 4.2.13 Score per residue for model 13

- Molecule 1: SPBc2 prophage-derived uncharacterized protein yola



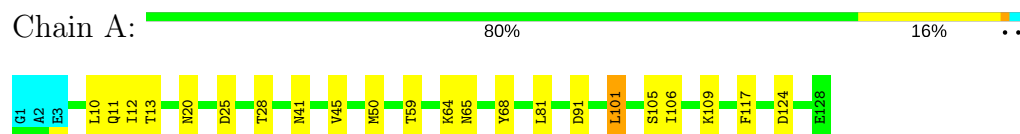
### 4.2.14 Score per residue for model 14

- Molecule 1: SPBc2 prophage-derived uncharacterized protein yola



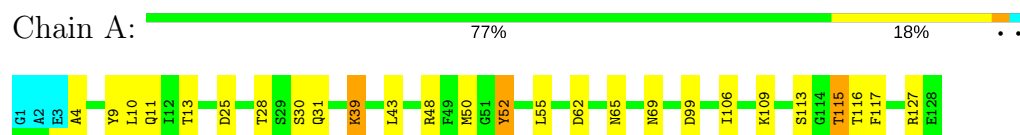
### 4.2.15 Score per residue for model 15

- Molecule 1: SPBc2 prophage-derived uncharacterized protein yola



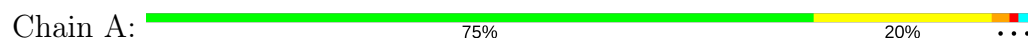
### 4.2.16 Score per residue for model 16

- Molecule 1: SPBc2 prophage-derived uncharacterized protein yola



### 4.2.17 Score per residue for model 17

- Molecule 1: SPBc2 prophage-derived uncharacterized protein yola



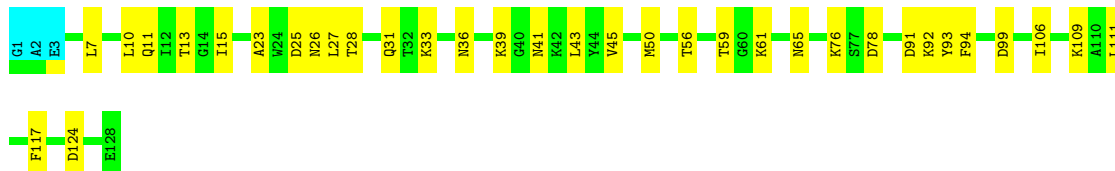




#### 4.2.18 Score per residue for model 18

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA

Chain A: 71% 27% .



#### 4.2.19 Score per residue for model 19

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA

Chain A: 77% 19% . .



#### 4.2.20 Score per residue for model 20

- Molecule 1: SPBc2 prophage-derived uncharacterized protein volA

Chain A: 77% 19% . .



## 5 Refinement protocol and experimental data overview

The models were refined using the following method: *molecular dynamics*.

Of the 80 calculated structures, 20 were deposited, based on the following criterion: *target function*.

The following table shows the software used for structure solution, optimisation and refinement.

Software name	Classification	Version
CYANA	structure solution	
OPAL	geometry optimization	
OPAL	refinement	
UNIO	structure solution	

The following table shows chemical shift validation statistics as aggregates over all chemical shift files. Detailed validation can be found in section 7 of this report.

Chemical shift file(s)	2lr4_cs.str
Number of chemical shift lists	1
Total number of shifts	1499
Number of shifts mapped to atoms	1499
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	87%

No validations of the models with respect to experimental NMR restraints is performed at this time.

## 6 Model quality i

### 6.1 Standard geometry i

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 (average) 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	0.65±0.01	0±0/1006 (0.0±0.0%)	1.05±0.03	0±1/1358 (0.0±0.1%)
All	All	0.65	0/20120 (0.0%)	1.05	7/27160 (0.0%)

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	Planarity
1	A	0.0±0.0	0.9±0.7
All	All	0	19

There are no bond-length outliers.

All unique angle outliers are listed below. They are sorted according to the Z-score of the worst occurrence in the ensemble.

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)	Models	
								Worst	Total
1	A	5	LEU	CB-CA-C	5.82	121.25	110.20	2	1
1	A	10	LEU	CB-CG-CD1	5.80	120.86	111.00	17	4
1	A	5	LEU	CB-CG-CD2	5.39	120.16	111.00	17	1
1	A	127	ARG	NE-CZ-NH2	-5.28	117.66	120.30	2	1

There are no chirality outliers.

All unique planar outliers are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type	Group	Models (Total)
1	A	9	TYR	Sidechain	5
1	A	48	ARG	Sidechain	4
1	A	127	ARG	Sidechain	4
1	A	52	TYR	Sidechain,Peptide	2

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Mol	Chain	Res	Type	Group	Models (Total)
1	A	94	PHE	Sidechain	1
1	A	68	TYR	Sidechain	1
1	A	93	TYR	Sidechain	1
1	A	30	SER	Peptide	1

## 6.2 Too-close contacts ⓘ

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in each 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 averaged over the ensemble.

Mol	Chain	Non-H	H(model)	H(added)	Clashes
1	A	987	995	995	3±2
All	All	19740	19900	19900	69

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 2.

All unique clashes are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:5:LEU:H	1:A:5:LEU:HD22	0.79	1.38	20	3
1:A:10:LEU:HD12	1:A:120:SER:HB3	0.67	1.66	14	1
1:A:38:LEU:H	1:A:38:LEU:HD22	0.67	1.50	9	2
1:A:5:LEU:CD2	1:A:5:LEU:H	0.61	2.08	20	2
1:A:7:LEU:HD12	1:A:53:THR:HG21	0.61	1.71	19	1
1:A:5:LEU:H	1:A:5:LEU:CD2	0.59	2.07	19	1
1:A:10:LEU:HD23	1:A:118:VAL:HG13	0.58	1.75	3	1
1:A:38:LEU:HD22	1:A:38:LEU:H	0.57	1.59	4	2
1:A:12:ILE:HG23	1:A:45:VAL:CG1	0.54	2.32	7	3
1:A:76:LYS:HE3	1:A:93:TYR:CZ	0.54	2.38	20	3
1:A:5:LEU:HD22	1:A:5:LEU:H	0.52	1.65	17	3
1:A:101:LEU:H	1:A:101:LEU:HD22	0.51	1.66	15	2
1:A:37:VAL:HB	1:A:126:GLU:HB2	0.50	1.81	9	7
1:A:10:LEU:HD12	1:A:120:SER:CB	0.50	2.36	12	4
1:A:106:ILE:HD13	1:A:107:GLN:N	0.49	2.22	14	1
1:A:15:ILE:HG22	1:A:27:LEU:HD21	0.49	1.85	18	2
1:A:12:ILE:HG23	1:A:45:VAL:HG13	0.49	1.83	9	4
1:A:101:LEU:N	1:A:101:LEU:HD22	0.48	2.23	11	3
1:A:57:VAL:HG12	1:A:109:LYS:HG2	0.48	1.84	6	1

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Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:58:ILE:H	1:A:65:ASN:ND2	0.48	2.07	6	1
1:A:101:LEU:HD22	1:A:101:LEU:H	0.45	1.72	14	1
1:A:113:SER:H	1:A:116:THR:HG22	0.45	1.72	14	1
1:A:76:LYS:HE2	1:A:93:TYR:CE1	0.45	2.47	5	1
1:A:37:VAL:HB	1:A:126:GLU:CB	0.45	2.42	13	2
1:A:38:LEU:H	1:A:38:LEU:CD2	0.44	2.24	19	2
1:A:27:LEU:HD22	1:A:31:GLN:OE1	0.44	2.11	18	1
1:A:4:ALA:HB1	1:A:52:TYR:CD2	0.44	2.48	16	2
1:A:12:ILE:HG22	1:A:27:LEU:CD1	0.44	2.43	7	1
1:A:39:LYS:H	1:A:39:LYS:HE3	0.44	1.71	16	1
1:A:12:ILE:HG23	1:A:45:VAL:CG2	0.43	2.42	13	1
1:A:98:MET:SD	1:A:127:ARG:HB3	0.43	2.53	5	1
1:A:5:LEU:HD22	1:A:5:LEU:N	0.42	2.28	17	1
1:A:101:LEU:HD22	1:A:101:LEU:N	0.42	2.30	14	1
1:A:122:LYS:O	1:A:123:ILE:HD13	0.41	2.14	3	1
1:A:7:LEU:HD12	1:A:50:MET:O	0.41	2.15	5	1
1:A:48:ARG:HH11	1:A:80:ILE:HD13	0.41	1.75	20	1
1:A:37:VAL:HG23	1:A:126:GLU:O	0.41	2.16	14	2
1:A:15:ILE:HD11	1:A:43:LEU:HD21	0.40	1.92	20	1

## 6.3 Torsion angles ⓘ

### 6.3.1 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 PDB entries followed by that with respect to all NMR entries. 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	124/128 (97%)	101±3 (82±2%)	20±3 (16±2%)	3±1 (3±1%)	10	45
All	All	2480/2560 (97%)	2022 (82%)	392 (16%)	66 (3%)	10	45

All 15 unique Ramachandran outliers are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type	Models (Total)
1	A	25	ASP	19
1	A	7	LEU	7
1	A	114	GLY	7

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Mol	Chain	Res	Type	Models (Total)
1	A	23	ALA	7
1	A	65	ASN	5
1	A	84	ASN	4
1	A	70	GLY	3
1	A	13	THR	3
1	A	104	ASN	2
1	A	83	GLN	2
1	A	113	SER	2
1	A	115	THR	2
1	A	26	ASN	1
1	A	53	THR	1
1	A	59	THR	1

### 6.3.2 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 PDB entries followed by that with respect to all NMR entries. 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	107/108 (99%)	87±3 (82±2%)	20±3 (18±2%)	5	38
All	All	2140/2160 (99%)	1746 (82%)	394 (18%)	5	38

All 62 unique residues with a non-rotameric sidechain are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type	Models (Total)
1	A	28	THR	20
1	A	50	MET	20
1	A	117	PHE	19
1	A	11	GLN	18
1	A	109	LYS	17
1	A	10	LEU	17
1	A	43	LEU	16
1	A	106	ILE	15
1	A	65	ASN	15
1	A	52	TYR	14
1	A	124	ASP	13
1	A	33	LYS	11
1	A	91	ASP	11

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Mol	Chain	Res	Type	Models (Total)
1	A	59	THR	10
1	A	39	LYS	9
1	A	31	GLN	9
1	A	127	ARG	8
1	A	36	ASN	8
1	A	5	LEU	8
1	A	92	LYS	7
1	A	99	ASP	6
1	A	78	ASP	6
1	A	71	THR	6
1	A	25	ASP	6
1	A	41	ASN	5
1	A	61	LYS	5
1	A	116	THR	5
1	A	20	ASN	5
1	A	73	LYS	5
1	A	54	LYS	5
1	A	55	LEU	4
1	A	64	LYS	4
1	A	62	ASP	4
1	A	38	LEU	4
1	A	26	ASN	4
1	A	56	THR	4
1	A	13	THR	3
1	A	111	LEU	3
1	A	96	ILE	3
1	A	45	VAL	3
1	A	113	SER	3
1	A	105	SER	3
1	A	101	LEU	3
1	A	115	THR	3
1	A	48	ARG	3
1	A	30	SER	3
1	A	46	LYS	3
1	A	81	LEU	2
1	A	29	SER	2
1	A	122	LYS	2
1	A	7	LEU	1
1	A	125	PHE	1
1	A	42	LYS	1
1	A	69	ASN	1
1	A	128	GLU	1

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Mol	Chain	Res	Type	Models (Total)
1	A	22	PHE	1
1	A	112	SER	1
1	A	68	TYR	1
1	A	108	ILE	1
1	A	57	VAL	1
1	A	53	THR	1
1	A	67	LEU	1

### 6.3.3 RNA [i](#)

There are no RNA molecules in this entry.

### 6.4 Non-standard residues in protein, DNA, RNA chains [i](#)

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

### 6.5 Carbohydrates [i](#)

There are no carbohydrates in this entry.

### 6.6 Ligand geometry [i](#)

There are no ligands in this entry.

### 6.7 Other polymers [i](#)

There are no such molecules in this entry.

### 6.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.



## 7 Chemical shift validation [i](#)

The completeness of assignment taking into account all chemical shift lists is 87% for the well-defined parts and 86% for the entire structure.

### 7.1 Chemical shift list 1

File name: 2lr4\_cs.str

Chemical shift list name: *assigned\_chem\_shift\_list\_1*

#### 7.1.1 Bookkeeping [i](#)

The following table shows the results of parsing the chemical shift list and reports the number of nuclei with statistically unusual chemical shifts.

Total number of shifts	1499
Number of shifts mapped to atoms	1499
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	4

#### 7.1.2 Chemical shift referencing [i](#)

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction $\pm$ precision, ppm	Suggested action
$^{13}\text{C}_\alpha$	127	$-0.27 \pm 0.15$	None needed ( $< 0.5$ ppm)
$^{13}\text{C}_\beta$	117	$-0.34 \pm 0.14$	None needed ( $< 0.5$ ppm)
$^{13}\text{C}'$	0	—	None (insufficient data)
$^{15}\text{N}$	123	$1.11 \pm 0.31$	Should be applied

#### 7.1.3 Completeness of resonance assignments [i](#)

The following table shows the completeness of the chemical shift assignments for the well-defined regions of the structure. The overall completeness is 87%, i.e. 1331 atoms were assigned a chemical shift out of a possible 1532. 0 out of 18 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	$^1\text{H}$	$^{13}\text{C}$	$^{15}\text{N}$
Backbone	494/619 (80%)	247/247 (100%)	125/250 (50%)	122/122 (100%)
Sidechain	705/779 (91%)	435/454 (96%)	254/292 (87%)	16/33 (48%)

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	Total	<sup>1</sup> H	<sup>13</sup> C	<sup>15</sup> N
Aromatic	132/134 (99%)	68/70 (97%)	62/62 (100%)	2/2 (100%)
Overall	1331/1532 (87%)	750/771 (97%)	441/604 (73%)	140/157 (89%)

The following table shows the completeness of the chemical shift assignments for the full structure. The overall completeness is 86%, i.e. 1345 atoms were assigned a chemical shift out of a possible 1556. 0 out of 18 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	<sup>1</sup> H	<sup>13</sup> C	<sup>15</sup> N
Backbone	500/634 (79%)	250/253 (99%)	127/256 (50%)	123/125 (98%)
Sidechain	713/788 (90%)	440/459 (96%)	257/296 (87%)	16/33 (48%)
Aromatic	132/134 (99%)	68/70 (97%)	62/62 (100%)	2/2 (100%)
Overall	1345/1556 (86%)	758/782 (97%)	446/614 (73%)	141/160 (88%)

#### 7.1.4 Statistically unusual chemical shifts ⓘ

The following table lists the statistically unusual chemical shifts. These are statistical measures, and large deviations from the mean do not necessarily imply incorrect assignments. Molecules containing paramagnetic centres or hemes are expected to give rise to anomalous chemical shifts.

Mol	Chain	Res	Type	Atom	Shift, ppm	Expected range, ppm	Z-score
1	A	16	THR	HG21	-0.68	2.29 – -0.01	-7.9
1	A	16	THR	HG22	-0.68	2.29 – -0.01	-7.9
1	A	16	THR	HG23	-0.68	2.29 – -0.01	-7.9
1	A	46	LYS	HG3	-0.14	2.76 – -0.04	-5.4

#### 7.1.5 Random Coil Index (RCI) plots ⓘ

The image below reports *random coil index* values for the protein chains in the structure. The height of each bar gives a probability of a given residue to be disordered, as predicted from the available chemical shifts and the amino acid sequence. A value above 0.2 is an indication of significant predicted disorder. The colour of the bar shows whether the residue is in the well-defined core (black) or in the ill-defined residue ranges (cyan), as described in section 2 on ensemble composition.

Random coil index (RCI) for chain A:

