



# Full wwPDB NMR Structure Validation Report ⓘ

May 28, 2020 – 11:49 pm BST

PDB ID : 2MLB  
Title : NMR solution structure of a computational designed protein based on template of human erythrocytic ubiquitin  
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Deposited on : 2014-02-21

This is a Full wwPDB NMR 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

<https://www.wwpdb.org/validation/2017/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 : 20191225.v01 (using entries in the PDB archive December 25th 2019)  
RCI : v\_1n\_11\_5\_13\_A (Berjanski et al., 2005)  
PANAV : Wang et al. (2010)  
ShiftChecker : 2.11  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)  
Validation Pipeline (wwPDB-VP) : 2.11

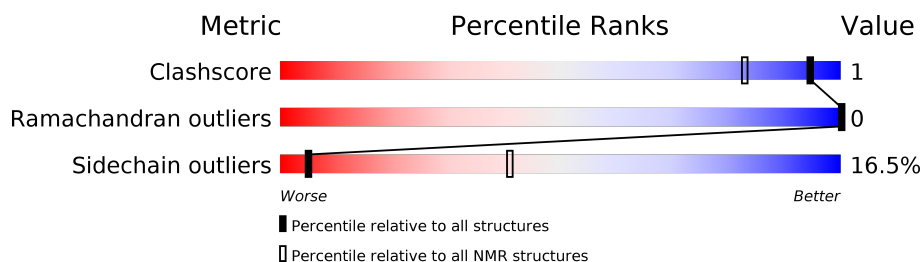
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*SOLUTION NMR*

The overall completeness of chemical shifts assignment is 81%.

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	158937	12864
Ramachandran outliers	154571	11451
Sidechain outliers	154315	11428

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	79	

## 2 Ensemble composition and analysis ⓘ

This entry contains 20 models. Model 8 is the overall representative, medoid model (most similar to other models). The authors have identified model 1 as representative, based on the following criterion: *closest to the average*.

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:2-A:72 (71)	0.27	8

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

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

NmrClust was unable to cluster the ensemble.

Error message: Inconsistent models

### 3 Entry composition [i](#)

There is only 1 type of molecule in this entry. The entry contains 1234 atoms, of which 634 are hydrogens and 0 are deuteriums.

- Molecule 1 is a protein called redesigned ubiquitin.

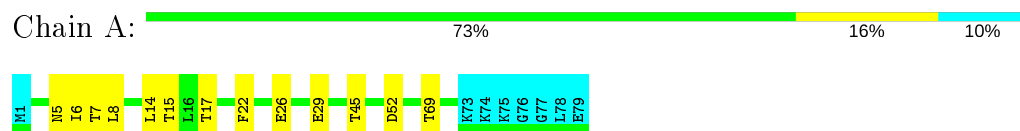
Mol	Chain	Residues	Atoms						Trace
1	A	79	Total	C	H	N	O	S	0
			1234	380	634	96	123	1	

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

### 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: redesigned ubiquitin

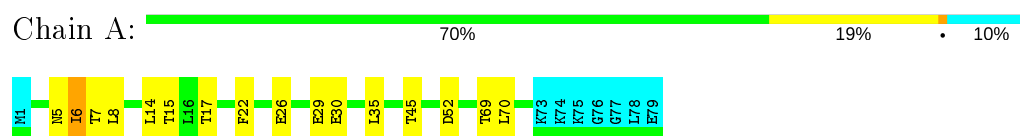


### 4.2 Scores per residue for each member of the ensemble

Colouring as in section [4.1](#) above.

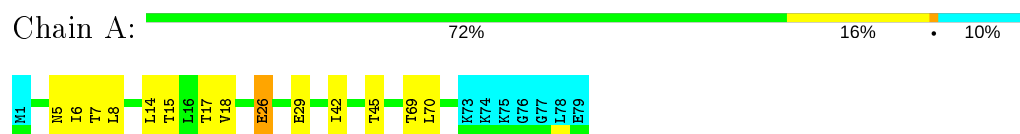
#### 4.2.1 Score per residue for model 1

- Molecule 1: redesigned ubiquitin



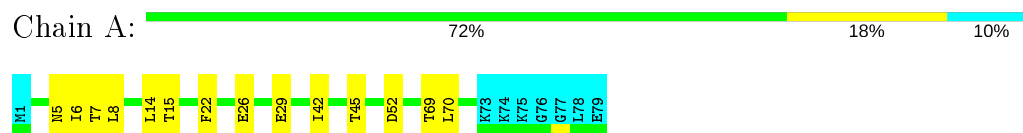
#### 4.2.2 Score per residue for model 2

- Molecule 1: redesigned ubiquitin



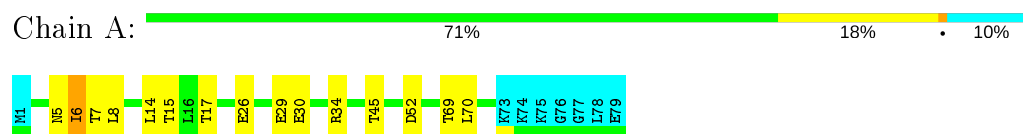
### 4.2.3 Score per residue for model 3

- Molecule 1: redesigned ubiquitin



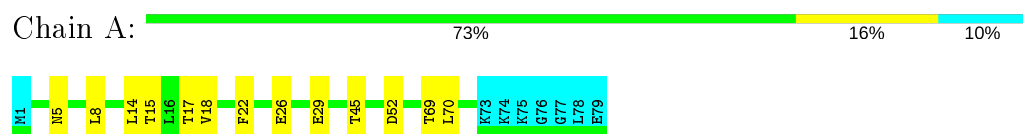
### 4.2.4 Score per residue for model 4

- Molecule 1: redesigned ubiquitin



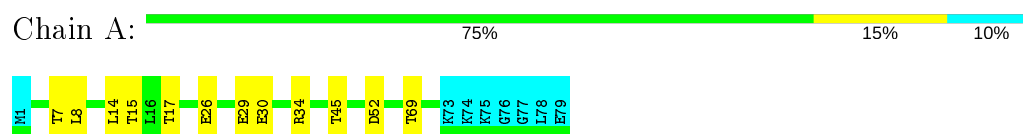
### 4.2.5 Score per residue for model 5

- Molecule 1: redesigned ubiquitin



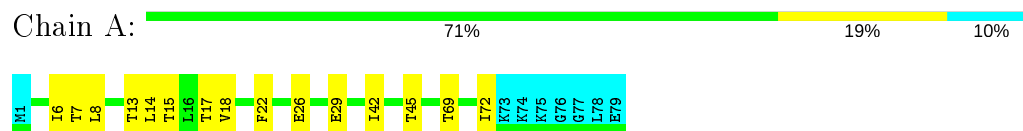
### 4.2.6 Score per residue for model 6

- Molecule 1: redesigned ubiquitin



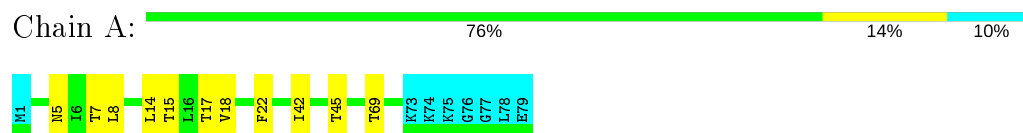
### 4.2.7 Score per residue for model 7

- Molecule 1: redesigned ubiquitin



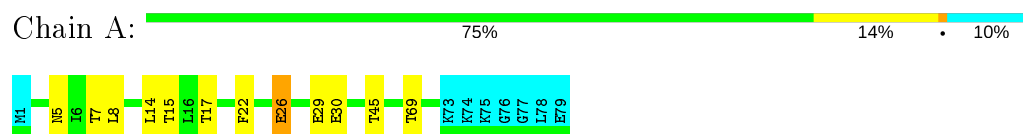
#### 4.2.8 Score per residue for model 8 (medoid)

- Molecule 1: redesigned ubiquitin



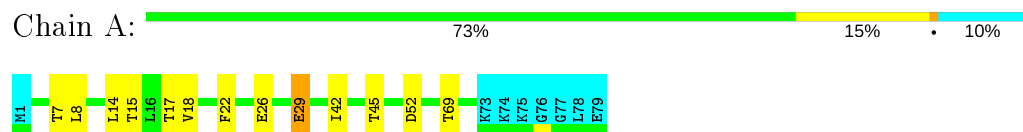
#### 4.2.9 Score per residue for model 9

- Molecule 1: redesigned ubiquitin



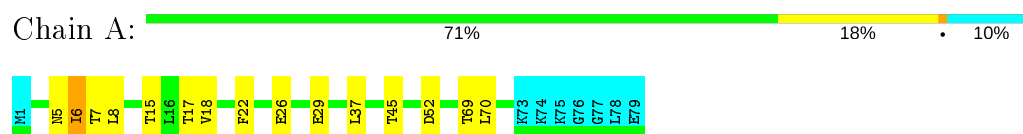
#### 4.2.10 Score per residue for model 10

- Molecule 1: redesigned ubiquitin



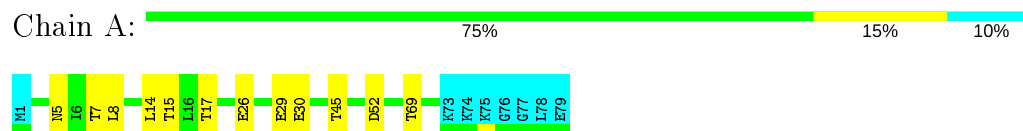
#### 4.2.11 Score per residue for model 11

- Molecule 1: redesigned ubiquitin



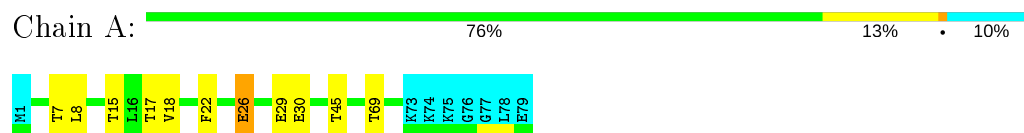
#### 4.2.12 Score per residue for model 12

- Molecule 1: redesigned ubiquitin



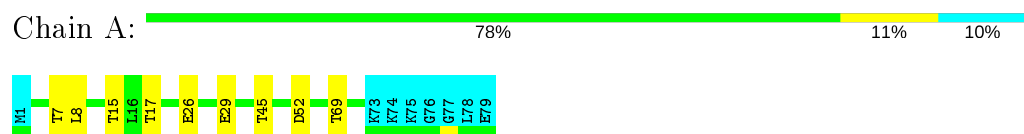
### 4.2.13 Score per residue for model 13

- Molecule 1: redesigned ubiquitin



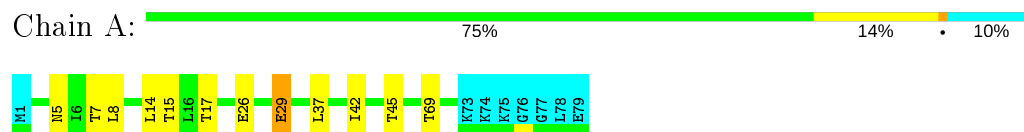
### 4.2.14 Score per residue for model 14

- Molecule 1: redesigned ubiquitin



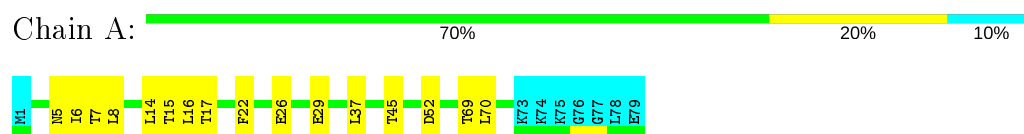
### 4.2.15 Score per residue for model 15

- Molecule 1: redesigned ubiquitin



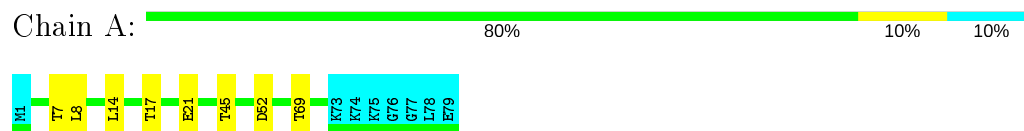
### 4.2.16 Score per residue for model 16

- Molecule 1: redesigned ubiquitin



### 4.2.17 Score per residue for model 17

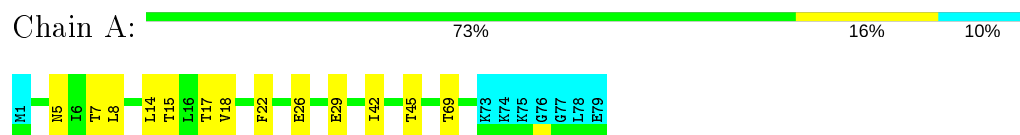
- Molecule 1: redesigned ubiquitin





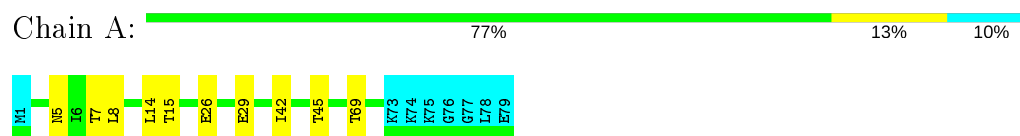
#### 4.2.18 Score per residue for model 18

- Molecule 1: redesigned ubiquitin



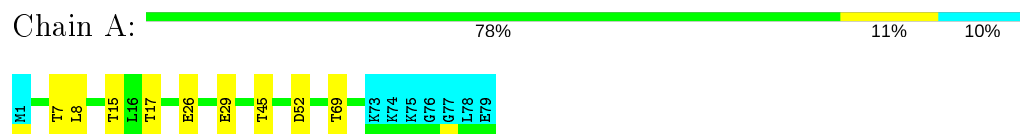
#### 4.2.19 Score per residue for model 19

- Molecule 1: redesigned ubiquitin



#### 4.2.20 Score per residue for model 20

- Molecule 1: redesigned ubiquitin



## 5 Refinement protocol and experimental data overview

The models were refined using the following method: *simulated annealing*.

Of the 1000 calculated structures, 20 were deposited, based on the following criterion: *structures with the lowest energy*.

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

Software name	Classification	Version
CNS	geometry optimization	1.3
CNS	refinement	1.3
CNS	structure solution	1.3

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)	input_cs.cif
Number of chemical shift lists	1
Total number of shifts	901
Number of shifts mapped to atoms	901
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	81%

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](#)

There are no covalent bond-length or bond-angle outliers.

There are no bond-length outliers.

There are no bond-angle outliers.

There are no chirality outliers.

There are no planarity outliers.

### 6.2 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 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	539	561	560	1±1
All	All	10780	11220	11200	25

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 1.

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

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:26:GLU:O	1:A:29:GLU:HG2	0.54	2.02	3	16
1:A:6:ILE:HG22	1:A:70:LEU:HD23	0.52	1.82	4	6
1:A:26:GLU:O	1:A:29:GLU:HG3	0.50	2.06	10	2
1:A:6:ILE:O	1:A:13:THR:HA	0.44	2.13	7	1

### 6.3 Torsion angles [i](#)

#### 6.3.1 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 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	71/79 (90%)	70±1 (99±1%)	1±1 (1±1%)	0±0 (0±0%)	100	100
All	All	1420/1580 (90%)	1400 (99%)	20 (1%)	0 (0%)	100	100

There are no Ramachandran outliers.

### 6.3.2 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 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	63/69 (91%)	53±2 (83±3%)	10±2 (17±3%)	5	41
All	All	1260/1380 (91%)	1052 (83%)	208 (17%)	5	41

All 23 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	69	THR	20
1	A	8	LEU	20
1	A	45	THR	20
1	A	15	THR	19
1	A	7	THR	19
1	A	17	THR	18
1	A	14	LEU	16
1	A	5	ASN	13
1	A	52	ASP	12
1	A	22	PHE	11
1	A	42	ILE	8
1	A	18	VAL	8
1	A	30	GLU	6
1	A	6	ILE	3
1	A	26	GLU	3
1	A	37	LEU	3
1	A	34	ARG	2
1	A	29	GLU	2
1	A	72	ILE	1
1	A	70	LEU	1
1	A	16	LEU	1

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Mol	Chain	Res	Type	Models (Total)
1	A	35	LEU	1
1	A	21	GLU	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 81% for the well-defined parts and 81% for the entire structure.

### 7.1 Chemical shift list 1

File name: input\_cs.cif

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	901
Number of shifts mapped to atoms	901
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	38

#### 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
$^{13}\text{C}_\alpha$	79	$-0.10 \pm 0.19$	None needed ( $< 0.5$ ppm)
$^{13}\text{C}_\beta$	72	$0.05 \pm 0.15$	None needed ( $< 0.5$ ppm)
$^{13}\text{C}'$	0	—	None (insufficient data)
$^{15}\text{N}$	74	$0.43 \pm 0.35$	None needed ( $< 0.5$ ppm)

#### 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 81%, i.e. 671 atoms were assigned a chemical shift out of a possible 832. 0 out of 13 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	$^1\text{H}$	$^{13}\text{C}$	$^{15}\text{N}$
Backbone	274/345 (79%)	137/137 (100%)	71/142 (50%)	66/66 (100%)
Sidechain	391/462 (85%)	235/265 (89%)	154/185 (83%)	2/12 (17%)

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	<b>Total</b>	<b><sup>1</sup>H</b>	<b><sup>13</sup>C</b>	<b><sup>15</sup>N</b>
Aromatic	6/25 (24%)	6/13 (46%)	0/10 (0%)	0/2 (0%)
Overall	671/832 (81%)	378/415 (91%)	225/337 (67%)	68/80 (85%)

The following table shows the completeness of the chemical shift assignments for the full structure. The overall completeness is 81%, i.e. 753 atoms were assigned a chemical shift out of a possible 935. 0 out of 14 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	<b>Total</b>	<b><sup>1</sup>H</b>	<b><sup>13</sup>C</b>	<b><sup>15</sup>N</b>
Backbone	305/385 (79%)	152/153 (99%)	79/158 (50%)	74/74 (100%)
Sidechain	442/525 (84%)	267/303 (88%)	173/207 (84%)	2/15 (13%)
Aromatic	6/25 (24%)	6/13 (46%)	0/10 (0%)	0/2 (0%)
Overall	753/935 (81%)	425/469 (91%)	252/375 (67%)	76/91 (84%)

#### 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	71	GLU	HB3	36.27	3.10 – 0.90	155.8
1	A	71	GLU	HB2	33.39	3.08 – 0.98	149.3
1	A	68	ILE	HB	40.78	3.24 – 0.34	134.5
1	A	70	LEU	HB2	44.77	3.32 – -0.08	126.9
1	A	71	GLU	HA	54.83	6.30 – 2.20	123.4
1	A	70	LEU	HA	54.09	6.66 – 1.96	105.9
1	A	68	ILE	HA	59.43	6.98 – 1.38	98.7
1	A	70	LEU	HD11	27.28	2.16 – -0.64	94.7
1	A	70	LEU	HG	26.82	3.16 – -0.14	76.7
1	A	70	LEU	HB3	27.74	3.34 – -0.26	72.8
1	A	68	ILE	HG21	18.83	2.13 – -0.57	66.9
1	A	68	ILE	HG13	27.63	3.26 – -0.84	64.4
1	A	68	ILE	HG12	14.46	3.27 – -0.73	33.0
1	A	71	GLU	CG	2.07	42.24 – 29.94	-27.7
1	A	71	GLU	CA	1.73	67.86 – 46.86	-26.5
1	A	70	LEU	CA	0.85	66.36 – 44.96	-25.6
1	A	70	LEU	CG	0.66	32.55 – 21.05	-22.7
1	A	68	ILE	CA	0.80	75.08 – 48.18	-22.6
1	A	70	LEU	CB	0.66	51.69 – 32.89	-22.1
1	A	68	ILE	CB	0.80	48.82 – 28.42	-18.5
1	A	71	GLU	CB	2.07	38.65 – 21.35	-16.1
1	A	68	ILE	CG1	0.60	36.54 – 18.94	-15.4

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Mol	Chain	Res	Type	Atom	Shift, ppm	Expected range, ppm	Z-score
1	A	70	LEU	HD12	4.98	2.16 – -0.64	15.1
1	A	70	LEU	CD1	0.66	32.77 – 16.57	-14.8
1	A	68	ILE	HG22	4.76	2.13 – -0.57	14.7
1	A	70	LEU	CD2	1.35	32.60 – 15.60	-13.4
1	A	68	ILE	CG2	0.60	24.63 – 10.43	-11.9
1	A	71	GLU	HG2	4.50	3.33 – 1.23	10.6
1	A	49	LYS	HE2	1.46	3.87 – 1.97	-7.7
1	A	49	LYS	HE3	1.46	3.86 – 1.96	-7.6
1	A	68	ILE	CD1	0.60	21.91 – 5.01	-7.6
1	A	49	LYS	HG2	3.09	2.67 – 0.07	6.6
1	A	20	PRO	HG2	3.87	3.48 – 0.38	6.3
1	A	49	LYS	HG3	3.09	2.76 – -0.04	6.2
1	A	34	ARG	HG2	3.24	2.92 – 0.22	6.2
1	A	20	PRO	HG3	3.87	3.56 – 0.26	6.0
1	A	34	ARG	HD2	1.85	4.27 – 1.97	-5.5
1	A	34	ARG	HD3	1.85	4.36 – 1.86	-5.1

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

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:

