



# Full wwPDB NMR Structure Validation Report ⓘ

Apr 27, 2016 – 03:42 AM BST

PDB ID : 2M5F  
Title : NMR Structure of the Complete Internal Fusion Loop mutant L529A/I544A from Ebolavirus GP2 at pH 5.5  
Authors : Gregory, S.M.; Tamm, L.K.  
Deposited on : 2013-02-22

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  
<http://wwpdb.org/validation/2016/NMRValidationReportHelp>  
with specific help available everywhere you see the ⓘ symbol.

---

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  
Mogul : unknown  
Percentile statistics : 20151230.v01 (using entries in the PDB archive December 30th 2015)  
RCI : v\_1n\_11\_5\_13\_A (Berjanski et al., 2005)  
PANAV : Wang et al. (2010)  
ShiftChecker : rb-20027457  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)  
Validation Pipeline (wwPDB-VP) : rb-20027457

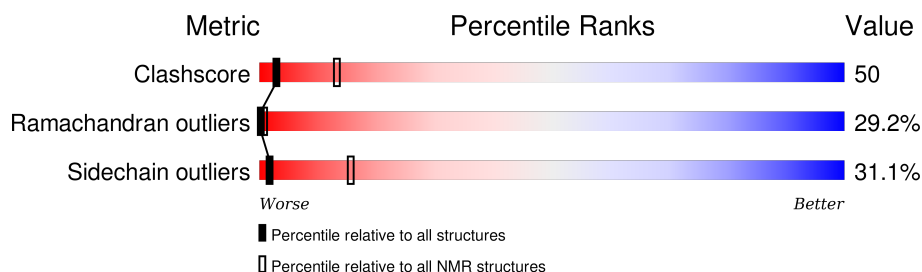
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*SOLUTION NMR*

The overall completeness of chemical shifts assignment is 89%.

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	114402	11133
Ramachandran outliers	111179	9975
Sidechain outliers	111093	9958

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	54	<div> <div>24%</div> <div>22%</div> <div>26%</div> <div>•</div> <div>26%</div> </div>

## 2 Ensemble composition and analysis

This entry contains 20 models. Model 11 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:514-A:553 (40)	0.23	11

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 and 1 single-model cluster was found.

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

### 3 Entry composition

There is only 1 type of molecule in this entry. The entry contains 797 atoms, of which 384 are hydrogens and 0 are deuteriums.

- Molecule 1 is a protein called Virion spike glycoprotein.

Mol	Chain	Residues	Atoms						Trace
1	A	54	Total	C	H	N	O	S	0
			797	262	384	71	77	3	

There are 2 discrepancies between the modelled and reference sequences:

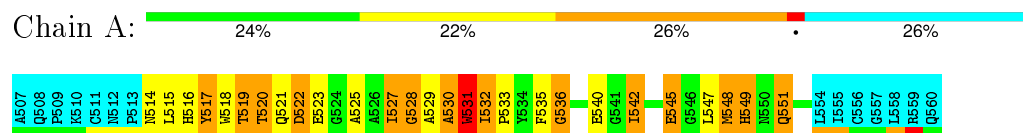
Chain	Residue	Modelled	Actual	Comment	Reference
A	529	ALA	LEU	ENGINEERED MUTATION	UNP A9QPL9
A	544	ALA	ILE	ENGINEERED MUTATION	UNP A9QPL9

## 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: Virion spike glycoprotein

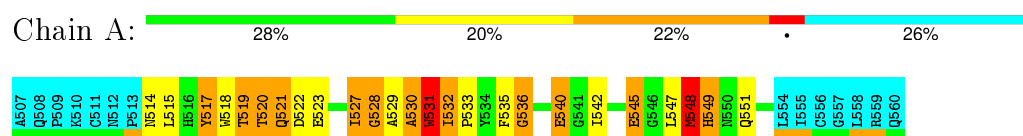


### 4.2 Scores per residue for each member of the ensemble

Colouring as in section 4.1 above.

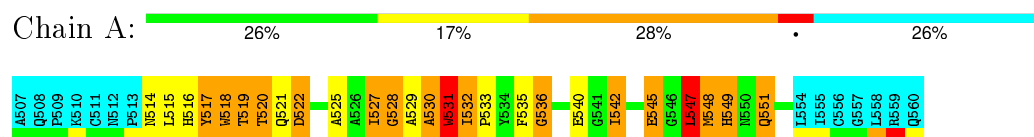
#### 4.2.1 Score per residue for model 1

- Molecule 1: Virion spike glycoprotein



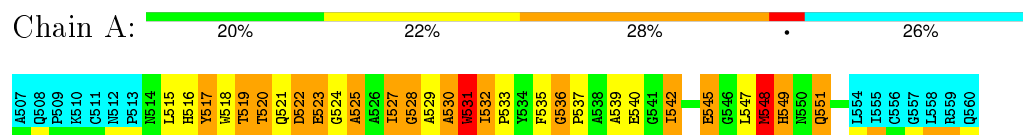
#### 4.2.2 Score per residue for model 2

- Molecule 1: Virion spike glycoprotein



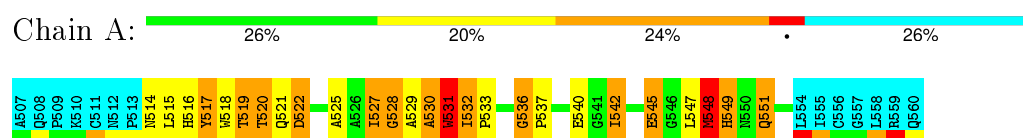
### 4.2.3 Score per residue for model 3

- Molecule 1: Virion spike glycoprotein



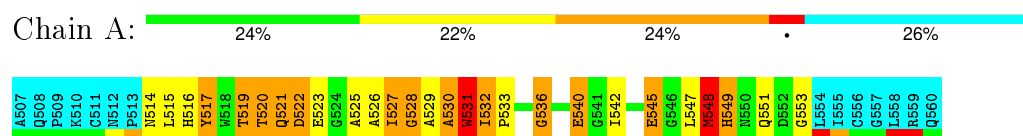
### 4.2.4 Score per residue for model 4

- Molecule 1: Virion spike glycoprotein



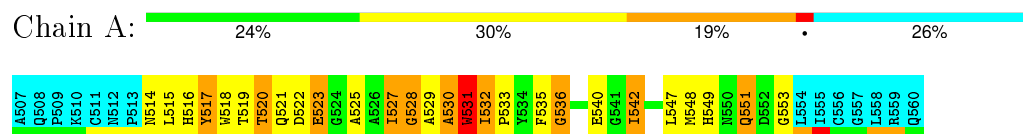
### 4.2.5 Score per residue for model 5

- Molecule 1: Virion spike glycoprotein



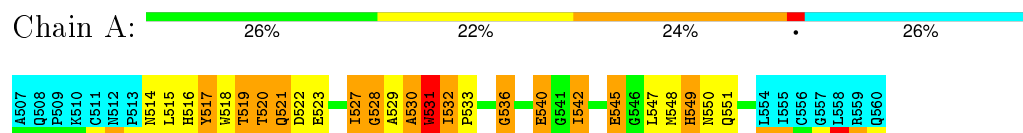
### 4.2.6 Score per residue for model 6

- Molecule 1: Virion spike glycoprotein



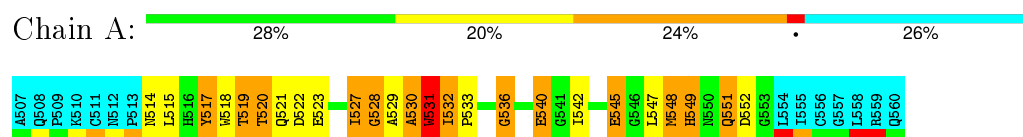
### 4.2.7 Score per residue for model 7

- Molecule 1: Virion spike glycoprotein



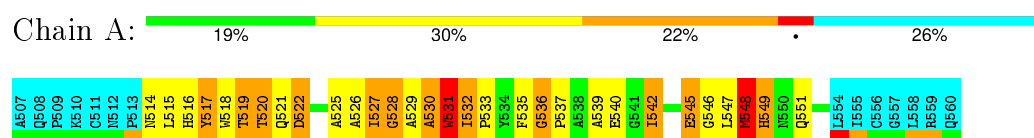
### 4.2.8 Score per residue for model 8

- Molecule 1: Virion spike glycoprotein



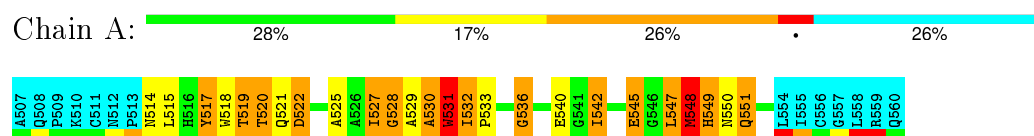
### 4.2.9 Score per residue for model 9

- Molecule 1: Virion spike glycoprotein



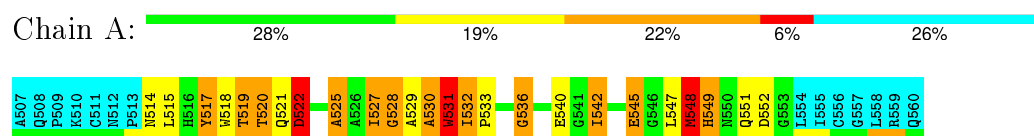
### 4.2.10 Score per residue for model 10

- Molecule 1: Virion spike glycoprotein



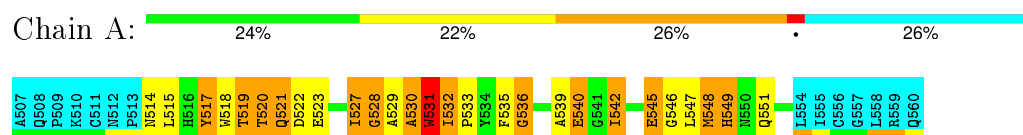
### 4.2.11 Score per residue for model 11 (medoid)

- Molecule 1: Virion spike glycoprotein



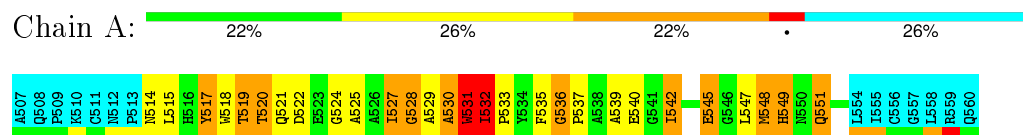
### 4.2.12 Score per residue for model 12

- Molecule 1: Virion spike glycoprotein



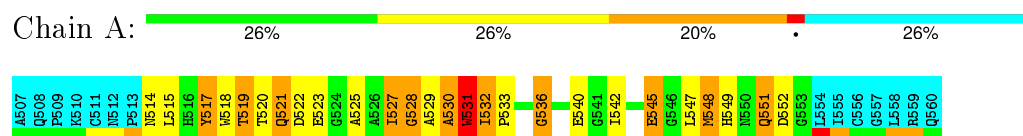
### 4.2.13 Score per residue for model 13

- Molecule 1: Virion spike glycoprotein



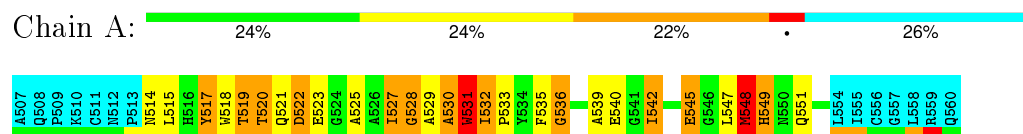
### 4.2.14 Score per residue for model 14

- Molecule 1: Virion spike glycoprotein



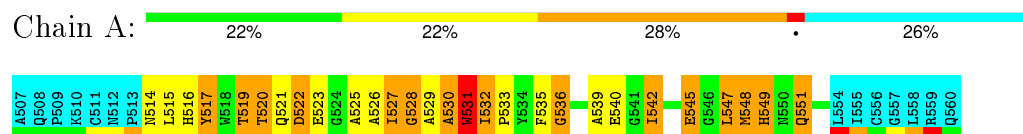
### 4.2.15 Score per residue for model 15

- Molecule 1: Virion spike glycoprotein



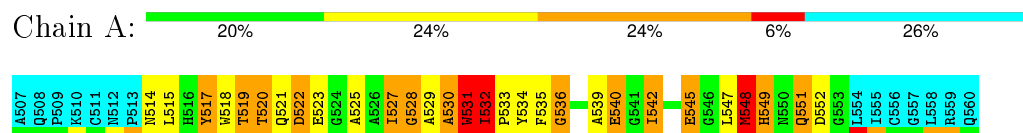
### 4.2.16 Score per residue for model 16

- Molecule 1: Virion spike glycoprotein



### 4.2.17 Score per residue for model 17

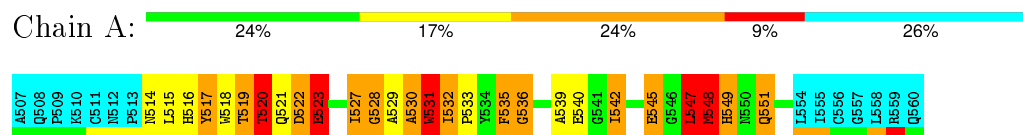
- Molecule 1: Virion spike glycoprotein





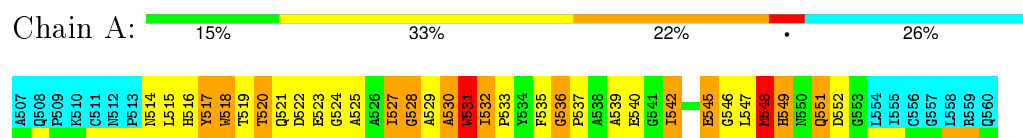
#### 4.2.18 Score per residue for model 18

- Molecule 1: Virion spike glycoprotein



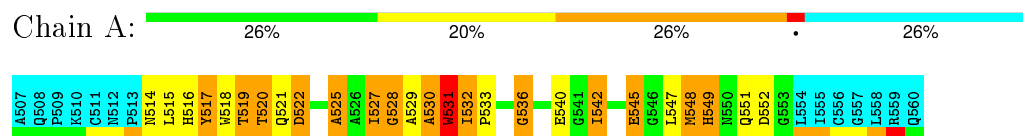
#### 4.2.19 Score per residue for model 19

- Molecule 1: Virion spike glycoprotein



#### 4.2.20 Score per residue for model 20

- Molecule 1: Virion spike glycoprotein



## 5 Refinement protocol and experimental data overview

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

Of the 200 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	refinement	

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)	2m5f_cs.str
Number of chemical shift lists	1
Total number of shifts	602
Number of shifts mapped to atoms	602
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	89%

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

## 6 Model quality ⓘ

### 6.1 Standard geometry ⓘ

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 ⓘ

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	307	271	269	29±3
All	All	6140	5420	5380	581

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 50.

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

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:532:ILE:N	1:A:533:PRO:CD	0.76	2.49	19	20
1:A:522:ASP:HB2	1:A:525:ALA:HB3	0.69	1.62	10	2
1:A:515:LEU:HD12	1:A:515:LEU:O	0.69	1.86	14	10
1:A:515:LEU:O	1:A:515:LEU:HD12	0.69	1.88	4	10
1:A:522:ASP:HB3	1:A:525:ALA:HB3	0.65	1.67	9	10
1:A:517:TYR:CZ	1:A:542:ILE:HD11	0.63	2.28	15	11
1:A:535:PHE:HB3	1:A:539:ALA:HB3	0.63	1.68	13	6
1:A:522:ASP:CB	1:A:525:ALA:HB3	0.61	2.24	19	12
1:A:532:ILE:O	1:A:536:GLY:N	0.60	2.34	6	20
1:A:547:LEU:HD12	1:A:548:MET:N	0.59	2.12	10	1
1:A:529:ALA:O	1:A:530:ALA:HB2	0.56	2.01	17	20
1:A:517:TYR:CE2	1:A:542:ILE:HD11	0.56	2.36	10	2
1:A:517:TYR:CD1	1:A:517:TYR:C	0.56	2.79	10	12
1:A:517:TYR:C	1:A:517:TYR:CD1	0.55	2.79	3	8

*Continued on next page...*

*Continued from previous page...*

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:522:ASP:CG	1:A:525:ALA:HB3	0.54	2.23	19	3
1:A:514:ASN:O	1:A:515:LEU:HG	0.53	2.02	9	19
1:A:522:ASP:OD2	1:A:525:ALA:HB3	0.53	2.03	11	1
1:A:520:THR:HG22	1:A:521:GLN:N	0.53	2.19	6	2
1:A:525:ALA:HB2	1:A:553:GLY:O	0.53	2.03	5	1
1:A:527:ILE:HG23	1:A:528:GLY:N	0.52	2.20	16	20
1:A:530:ALA:O	1:A:531:TRP:CD1	0.50	2.64	7	20
1:A:517:TYR:CZ	1:A:523:GLU:HB2	0.49	2.41	6	2
1:A:535:PHE:CB	1:A:539:ALA:HB3	0.49	2.36	18	6
1:A:545:GLU:HB2	1:A:547:LEU:HD23	0.49	1.84	5	7
1:A:518:TRP:CD1	1:A:521:GLN:CG	0.49	2.95	6	1
1:A:530:ALA:O	1:A:531:TRP:C	0.49	2.51	17	20
1:A:517:TYR:CE2	1:A:542:ILE:CD1	0.49	2.96	10	2
1:A:532:ILE:HG12	1:A:536:GLY:CA	0.48	2.39	13	18
1:A:532:ILE:N	1:A:533:PRO:HD2	0.48	2.23	1	19
1:A:536:GLY:O	1:A:540:GLU:CG	0.48	2.62	9	20
1:A:532:ILE:O	1:A:536:GLY:HA3	0.48	2.09	17	1
1:A:518:TRP:O	1:A:519:THR:C	0.48	2.52	12	16
1:A:517:TYR:OH	1:A:542:ILE:HD11	0.47	2.09	6	2
1:A:535:PHE:CD2	1:A:539:ALA:CB	0.47	2.98	17	1
1:A:536:GLY:O	1:A:540:GLU:CB	0.47	2.63	9	20
1:A:520:THR:CG2	1:A:521:GLN:N	0.47	2.77	19	18
1:A:535:PHE:CA	1:A:539:ALA:HB3	0.47	2.39	18	1
1:A:517:TYR:CZ	1:A:542:ILE:CD1	0.47	2.96	15	2
1:A:532:ILE:CG1	1:A:536:GLY:CA	0.46	2.93	17	2
1:A:536:GLY:O	1:A:540:GLU:N	0.46	2.47	17	13
1:A:523:GLU:HG2	1:A:523:GLU:O	0.46	2.10	16	3
1:A:519:THR:O	1:A:520:THR:HB	0.46	2.11	5	5
1:A:532:ILE:O	1:A:536:GLY:CA	0.46	2.64	17	1
1:A:545:GLU:OE1	1:A:548:MET:N	0.45	2.47	13	17
1:A:518:TRP:CB	1:A:523:GLU:HB3	0.45	2.41	1	8
1:A:542:ILE:O	1:A:545:GLU:HG3	0.45	2.12	2	6
1:A:518:TRP:CD1	1:A:521:GLN:CB	0.45	3.00	19	1
1:A:532:ILE:HG12	1:A:532:ILE:O	0.45	2.12	10	11
1:A:547:LEU:HD12	1:A:547:LEU:N	0.45	2.26	2	2
1:A:517:TYR:CB	1:A:549:HIS:CD2	0.45	3.00	20	4
1:A:532:ILE:N	1:A:533:PRO:HD3	0.45	2.23	17	5
1:A:545:GLU:CB	1:A:549:HIS:HB2	0.45	2.42	1	5
1:A:523:GLU:O	1:A:523:GLU:HG2	0.45	2.12	5	1
1:A:527:ILE:C	1:A:529:ALA:H	0.44	2.15	17	20
1:A:517:TYR:HB3	1:A:549:HIS:CE1	0.44	2.48	10	5

*Continued on next page...*

*Continued from previous page...*

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:530:ALA:O	1:A:532:ILE:N	0.44	2.51	10	20
1:A:532:ILE:O	1:A:532:ILE:HG12	0.44	2.12	7	6
1:A:518:TRP:CD1	1:A:522:ASP:O	0.44	2.71	18	1
1:A:529:ALA:O	1:A:530:ALA:CB	0.44	2.65	17	7
1:A:517:TYR:CD2	1:A:523:GLU:OE2	0.44	2.71	3	1
1:A:545:GLU:O	1:A:547:LEU:HG	0.43	2.13	2	2
1:A:527:ILE:O	1:A:529:ALA:N	0.43	2.51	17	4
1:A:545:GLU:OE1	1:A:549:HIS:N	0.43	2.51	13	8
1:A:517:TYR:OH	1:A:542:ILE:HD13	0.43	2.14	9	1
1:A:517:TYR:OH	1:A:537:PRO:O	0.43	2.37	9	2
1:A:535:PHE:N	1:A:535:PHE:CD1	0.43	2.87	6	1
1:A:518:TRP:O	1:A:520:THR:N	0.43	2.52	2	4
1:A:527:ILE:HG23	1:A:528:GLY:H	0.43	1.74	7	8
1:A:535:PHE:CD1	1:A:535:PHE:N	0.43	2.86	1	1
1:A:517:TYR:CB	1:A:549:HIS:CE1	0.43	3.02	8	1
1:A:515:LEU:HD23	1:A:553:GLY:HA2	0.43	1.90	6	1
1:A:517:TYR:HB3	1:A:549:HIS:CD2	0.42	2.49	11	6
1:A:517:TYR:CE2	1:A:523:GLU:OE1	0.42	2.72	19	2
1:A:542:ILE:CG2	1:A:550:ASN:HA	0.42	2.44	7	2
1:A:518:TRP:CB	1:A:523:GLU:CB	0.42	2.97	18	1
1:A:515:LEU:O	1:A:515:LEU:CD1	0.42	2.65	6	1
1:A:524:GLY:CA	1:A:537:PRO:HG2	0.42	2.45	19	2
1:A:521:GLN:O	1:A:523:GLU:N	0.42	2.53	7	3
1:A:545:GLU:OE2	1:A:546:GLY:N	0.42	2.53	9	3
1:A:535:PHE:CD2	1:A:539:ALA:HB3	0.42	2.50	17	1
1:A:532:ILE:HG13	1:A:532:ILE:O	0.42	2.15	13	1
1:A:518:TRP:CD1	1:A:521:GLN:HG2	0.41	2.49	6	1
1:A:536:GLY:O	1:A:540:GLU:HG2	0.41	2.16	13	1
1:A:545:GLU:O	1:A:547:LEU:HD22	0.41	2.16	16	1
1:A:545:GLU:OE1	1:A:549:HIS:CD2	0.41	2.74	10	2
1:A:536:GLY:O	1:A:540:GLU:HB3	0.41	2.15	9	2
1:A:517:TYR:HB3	1:A:549:HIS:CG	0.41	2.51	4	1
1:A:547:LEU:HD12	1:A:548:MET:H	0.41	1.72	10	1
1:A:524:GLY:HA2	1:A:537:PRO:HG2	0.41	1.93	3	1
1:A:550:ASN:O	1:A:551:GLN:O	0.40	2.39	10	1
1:A:532:ILE:HA	1:A:534:TYR:CE1	0.40	2.52	17	1
1:A:547:LEU:HG	1:A:548:MET:N	0.40	2.31	1	1
1:A:532:ILE:H	1:A:533:PRO:HD3	0.40	1.76	17	1
1:A:540:GLU:HG3	1:A:540:GLU:O	0.40	2.17	13	1
1:A:518:TRP:CD1	1:A:521:GLN:HG3	0.40	2.52	6	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	40/54 (74%)	14±1 (36±4%)	14±2 (35±4%)	12±1 (29±3%)	<b>0</b> <b>1</b>
All	All	800/1080 (74%)	289 (36%)	277 (35%)	234 (29%)	<b>0</b> <b>1</b>

All 16 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	530	ALA	20
1	A	551	GLN	20
1	A	531	TRP	20
1	A	528	GLY	20
1	A	527	ILE	20
1	A	548	MET	20
1	A	536	GLY	20
1	A	532	ILE	20
1	A	520	THR	19
1	A	522	ASP	18
1	A	519	THR	16
1	A	547	LEU	11
1	A	525	ALA	5
1	A	526	ALA	3
1	A	523	GLU	1
1	A	521	GLN	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	27/39 (69%)	19±2 (69±6%)	8±2 (31±6%)	<b>2</b> <b>15</b>

*Continued on next page...*

*Continued from previous page...*

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles
All	All	540/780 (69%)	372 (69%)	168 (31%)	<b>2</b> <b>15</b>

All 19 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	517	TYR	20
1	A	549	HIS	20
1	A	531	TRP	20
1	A	542	ILE	20
1	A	545	GLU	19
1	A	516	HIS	11
1	A	548	MET	11
1	A	551	GLN	11
1	A	540	GLU	6
1	A	552	ASP	6
1	A	519	THR	4
1	A	521	GLN	4
1	A	547	LEU	4
1	A	523	GLU	3
1	A	535	PHE	2
1	A	518	TRP	2
1	A	532	ILE	2
1	A	520	THR	2
1	A	522	ASP	1

### 6.3.3 RNA ⓘ

There are no RNA molecules in this entry.

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

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

## 6.5 Carbohydrates ⓘ

There are no carbohydrates in this entry.

## 6.6 Ligand geometry

There are no ligands in this entry.

## 6.7 Other polymers

There are no such molecules in this entry.

## 6.8 Polymer linkage issues

There are no chain breaks in this entry.



## 7 Chemical shift validation

The completeness of assignment taking into account all chemical shift lists is 89% for the well-defined parts and 88% for the entire structure.

### 7.1 Chemical shift list 1

File name: 2m5f\_cs.str

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

#### 7.1.1 Bookkeeping

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	602
Number of shifts mapped to atoms	602
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	0

#### 7.1.2 Chemical shift referencing

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction $\pm$ precision, ppm	Suggested action
$^{13}\text{C}_\alpha$	54	$0.12 \pm 0.32$	None needed ( $< 0.5$ ppm)
$^{13}\text{C}_\beta$	47	$-0.05 \pm 0.11$	None needed ( $< 0.5$ ppm)
$^{13}\text{C}'$	49	$2.72 \pm 0.51$	Should be applied
$^{15}\text{N}$	49	$0.60 \pm 0.27$	Should be applied

#### 7.1.3 Completeness of resonance assignments

The following table shows the completeness of the chemical shift assignments for the well-defined regions of the structure. The overall completeness is 89%, i.e. 400 atoms were assigned a chemical shift out of a possible 449. 1 out of 2 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	$^1\text{H}$	$^{13}\text{C}$	$^{15}\text{N}$
Backbone	194/196 (99%)	78/78 (100%)	78/80 (98%)	38/38 (100%)
Sidechain	158/180 (88%)	100/105 (95%)	58/71 (82%)	0/4 (0%)

*Continued on next page...*

Continued from previous page...

	Total	<sup>1</sup> H	<sup>13</sup> C	<sup>15</sup> N
Aromatic	48/73 (66%)	26/37 (70%)	22/30 (73%)	0/6 (0%)
Overall	400/449 (89%)	204/220 (93%)	158/181 (87%)	38/48 (79%)

The following table shows the completeness of the chemical shift assignments for the full structure. The overall completeness is 88%, i.e. 548 atoms were assigned a chemical shift out of a possible 626. 1 out of 4 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	<sup>1</sup> H	<sup>13</sup> C	<sup>15</sup> N
Backbone	255/262 (97%)	103/104 (99%)	103/108 (95%)	49/50 (98%)
Sidechain	245/291 (84%)	157/172 (91%)	88/108 (81%)	0/11 (0%)
Aromatic	48/73 (66%)	26/37 (70%)	22/30 (73%)	0/6 (0%)
Overall	548/626 (88%)	286/313 (91%)	213/246 (87%)	49/67 (73%)

#### 7.1.4 Statistically unusual chemical shifts [i](#)

There are no statistically unusual chemical shifts.

#### 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:

