



wwPDB NMR Structure Validation Summary Report ⓘ

Mar 6, 2026 – 08:22 PM UTC

PDB ID : 6BUT / pdb_00006but
BMRB ID : 27095
Title : Solution structure of full-length apo mammalian calmodulin bound to the IQ motif of the human voltage-gated sodium channel NaV1.2
Authors : Mahling, R.; Kilpatrick, A.M.; Shea, M.A.
Deposited on : 2017-12-11

This is a wwPDB NMR 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/NMRValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The types of validation reports are described at

<http://www.wwpdb.org/validation/2017/FAQs#types>.

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

MolProbity : 4-5-2 with Phenix2.0
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
wwPDB-RCI : v_1n_11_5_13_A (Berjanski et al., 2005)
PANAV : Wang et al. (2010)
wwPDB-ShiftChecker : v1.2
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.49

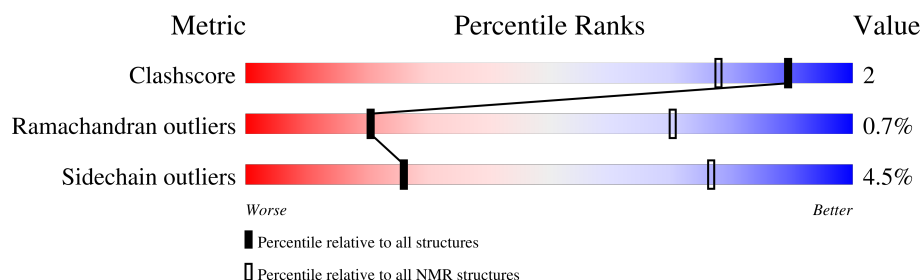
1 Overall quality at a glance

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	229148	14424
Ramachandran outliers	224038	12848
Sidechain outliers	223484	12823

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 ≥ 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	148	
2	B	31	

2 Ensemble composition and analysis

This entry contains 20 models. Model 18 is the overall representative, medoid model (most similar to other models). The authors have identified model 1 as representative, based on the following criterion: *lowest average pairwise backbone rmsd*.

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:6-A:20, A:24-A:73 (65)	0.34	5
2	A:82-A:93, A:98-A:129, A:134-A:146, B:1904- B:1920 (74)	0.24	18

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 4 clusters and 1 single-model cluster was found.

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

3 Entry composition

There are 2 unique types of molecules in this entry. The entry contains 2813 atoms, of which 1388 are hydrogens and 0 are deuteriums.

- Molecule 1 is a protein called Calmodulin-1.

Mol	Chain	Residues	Atoms						Trace
1	A	148	Total	C	H	N	O	S	0
			2262	714	1096	188	255	9	

- Molecule 2 is a protein called Sodium channel protein type 2 subunit alpha.

Mol	Chain	Residues	Atoms					Trace
2	B	31	Total	C	H	N	O	0
			551	164	292	52	43	

There are 4 discrepancies between the modelled and reference sequences:

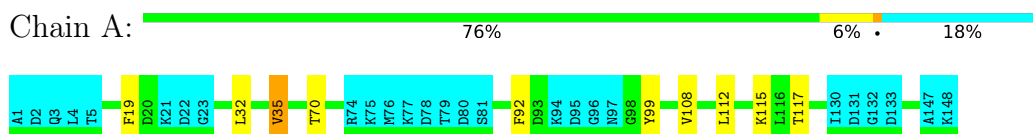
Chain	Residue	Modelled	Actual	Comment	Reference
B	-4	GLY	-	expression tag	UNP Q99250
B	-3	PRO	-	expression tag	UNP Q99250
B	-2	GLY	-	expression tag	UNP Q99250
B	-1	SER	-	expression tag	UNP Q99250

4 Residue-property plots [i](#)

4.1 Average score per residue in the NMR ensemble

These plots are provided for all protein, RNA, DNA and oligosaccharide 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: Calmodulin-1



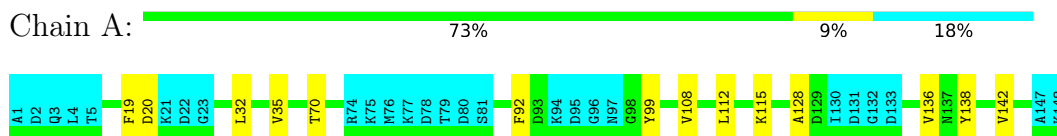
- Molecule 2: Sodium channel protein type 2 subunit alpha



4.2 Residue scores for the representative (medoid) model from the NMR ensemble

The representative model is number 18. Colouring as in section 4.1 above.

- Molecule 1: Calmodulin-1



- Molecule 2: Sodium channel protein type 2 subunit alpha



5 Refinement protocol and experimental data overview

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

Of the 40 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
CYANA	structure calculation	2.1
Amber	refinement	AMBERTOOLS 17

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)	working_cs.cif
Number of chemical shift lists	4
Total number of shifts	2115
Number of shifts mapped to atoms	2115
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%

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	0.81±0.00	0±0/983 (0.0± 0.0%)	1.35±0.02	0±1/1325 (0.0± 0.1%)
2	B	0.85±0.02	0±0/150 (0.0± 0.0%)	1.41±0.05	0±0/202 (0.0± 0.0%)
All	All	0.82	0/22660 (0.0%)	1.36	10/30540 (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	0.6±0.6
2	B	0.0±0.0	0.1±0.2
All	All	0	13

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	64	ASP	CA-CB-CG	5.61	118.21	112.60	1	4
1	A	20	ASP	CA-CB-CG	5.33	117.93	112.60	18	3
1	A	135	GLN	OE1-CD-NE2	-5.29	117.31	122.60	15	1
1	A	114	GLU	CA-C-N	5.06	131.21	121.54	14	1
1	A	114	GLU	C-N-CA	5.06	131.21	121.54	14	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	99	TYR	Sidechain	11

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Mol	Chain	Res	Type	Group	Models (Total)
2	B	1917	ARG	Sidechain	1
1	A	138	TYR	Sidechain	1

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	970	905	905	4±2
All	All	22360	21160	21160	80

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.

5 of 15 unique clashes are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:108:VAL:HG23	1:A:112:LEU:HD12	0.72	1.62	13	12
1:A:92:PHE:CZ	1:A:108:VAL:HG21	0.60	2.32	15	12
1:A:128:ALA:HB1	1:A:136:VAL:HG13	0.57	1.77	16	8
1:A:39:LEU:HD13	1:A:72:MET:HE2	0.56	1.78	2	5
1:A:19:PHE:CD1	1:A:35:VAL:HG12	0.54	2.37	12	5

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	122/148 (82%)	118±2 (96±1%)	3±2 (3±1%)	1±0 (1±0%)	18	68
2	B	17/31 (55%)	17±0 (100±0%)	0±0 (0±0%)	0±0 (0±0%)	100	100
All	All	2780/3580 (78%)	2694 (97%)	66 (2%)	20 (1%)	20	70

All 1 unique Ramachandran outliers are listed below.

Mol	Chain	Res	Type	Models (Total)
1	A	115	LYS	20

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	105/126 (83%)	100±2 (95±1%)	5±2 (5±1%)	23	74
2	B	15/27 (56%)	15±0 (99±3%)	0±0 (1±3%)	59	94
All	All	2400/3060 (78%)	2292 (96%)	108 (4%)	26	77

5 of 28 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	32	LEU	19
1	A	70	THR	19
1	A	99	TYR	13
1	A	117	THR	12
1	A	35	VAL	10

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 oligosaccharides 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 89% for the well-defined parts and 86% for the entire structure.

7.1 Chemical shift list 1

File name: working_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	1705
Number of shifts mapped to atoms	1705
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 [i](#)

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction $\pm$ precision, ppm	Suggested action
$^{13}\text{C}_\alpha$	148	-0.28 ± 0.06	None needed (< 0.5 ppm)
$^{13}\text{C}_\beta$	137	0.07 ± 0.13	None needed (< 0.5 ppm)
$^{13}\text{C}'$	144	-0.35 ± 0.10	None needed (< 0.5 ppm)
^{15}N	141	0.57 ± 0.30	None needed (imprecise)

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 77%, i.e. 1452 atoms were assigned a chemical shift out of a possible 1891. 0 out of 17 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	^1H	^{13}C	^{15}N
Backbone	609/699 (87%)	248/284 (87%)	243/278 (87%)	118/137 (86%)
Sidechain	748/1069 (70%)	493/688 (72%)	248/342 (73%)	7/39 (18%)

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	Total	^1H	^{13}C	^{15}N
Aromatic	95/123 (77%)	49/60 (82%)	46/62 (74%)	0/1 (0%)
Overall	1452/1891 (77%)	790/1032 (77%)	537/682 (79%)	125/177 (71%)

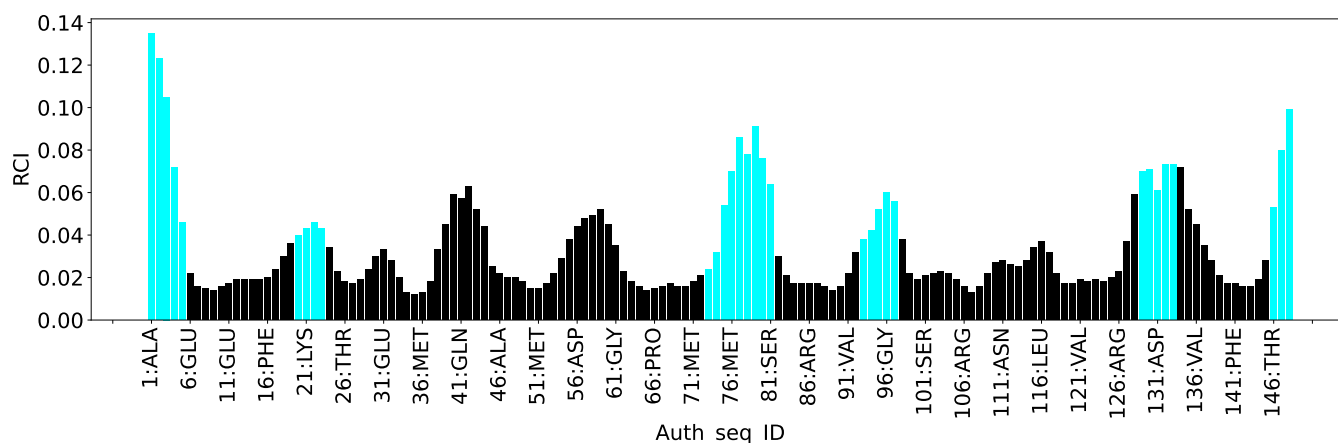
7.1.4 Statistically unusual chemical shifts [i](#)

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. If well-defined core and ill-defined regions are not identified then it is shown as gray bars.

Random coil index (RCI) for chain A:



7.2 Chemical shift list 2

File name: working_cs.cif

Chemical shift list name: *assigned_chem_shift_list_2*

7.2.1 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	368
Number of shifts mapped to atoms	368
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

7.2.2 Chemical shift referencing [i](#)

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction $\pm$ precision, ppm	Suggested action
$^{13}\text{C}_\alpha$	30	-0.79 ± 0.15	Should be checked
$^{13}\text{C}_\beta$	28	0.13 ± 0.06	None needed (< 0.5 ppm)
$^{13}\text{C}'$	29	-0.47 ± 0.15	None needed (< 0.5 ppm)
^{15}N	28	-0.05 ± 0.29	None needed (< 0.5 ppm)

7.2.3 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 12%, i.e. 223 atoms were assigned a chemical shift out of a possible 1891. 0 out of 17 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	^1H	^{13}C	^{15}N
Backbone	85/699 (12%)	34/284 (12%)	34/278 (12%)	17/137 (12%)
Sidechain	122/1069 (11%)	82/688 (12%)	40/342 (12%)	0/39 (0%)
Aromatic	16/123 (13%)	8/60 (13%)	8/62 (13%)	0/1 (0%)
Overall	223/1891 (12%)	124/1032 (12%)	82/682 (12%)	17/177 (10%)

7.2.4 Statistically unusual chemical shifts [i](#)

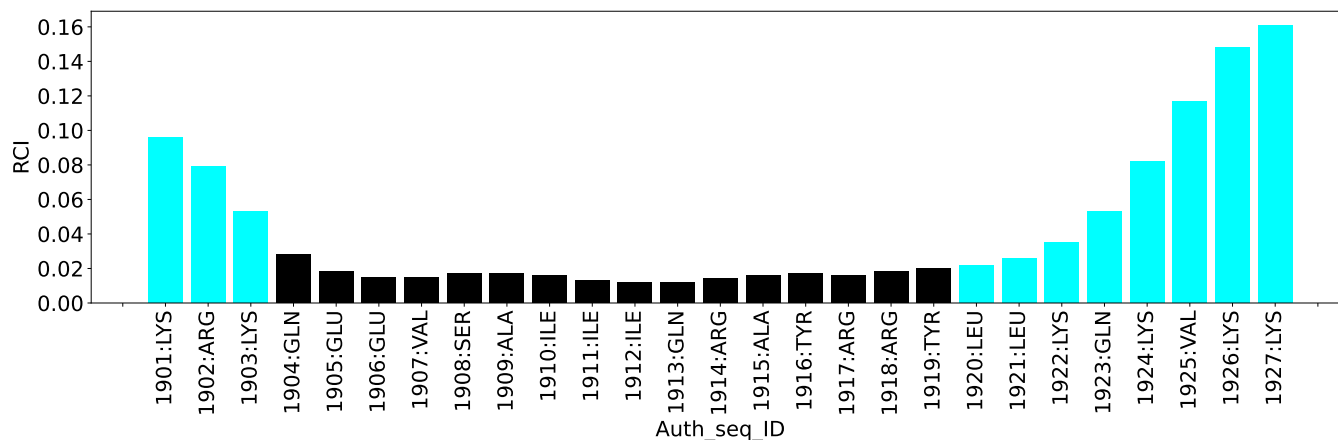
There are no statistically unusual chemical shifts.

7.2.5 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. If well-defined core and ill-defined regions are not identified then it is shown as gray bars.

Random coil index (RCI) for chain B:



7.3 Chemical shift list 3

File name: working_cs.cif

Chemical shift list name: *assigned_chem_shift_list_3*

7.3.1 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	19
Number of shifts mapped to atoms	19
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

7.3.2 Chemical shift referencing [i](#)

No chemical shift referencing corrections were calculated (not enough data).

7.3.3 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 0%, i.e. 0 atoms were assigned a chemical

shift out of a possible 1891. 0 out of 17 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	¹ H	¹³ C	¹⁵ N
Backbone	0/699 (0%)	0/284 (0%)	0/278 (0%)	0/137 (0%)
Sidechain	0/1069 (0%)	0/688 (0%)	0/342 (0%)	0/39 (0%)
Aromatic	0/123 (0%)	0/60 (0%)	0/62 (0%)	0/1 (0%)
Overall	0/1891 (0%)	0/1032 (0%)	0/682 (0%)	0/177 (0%)

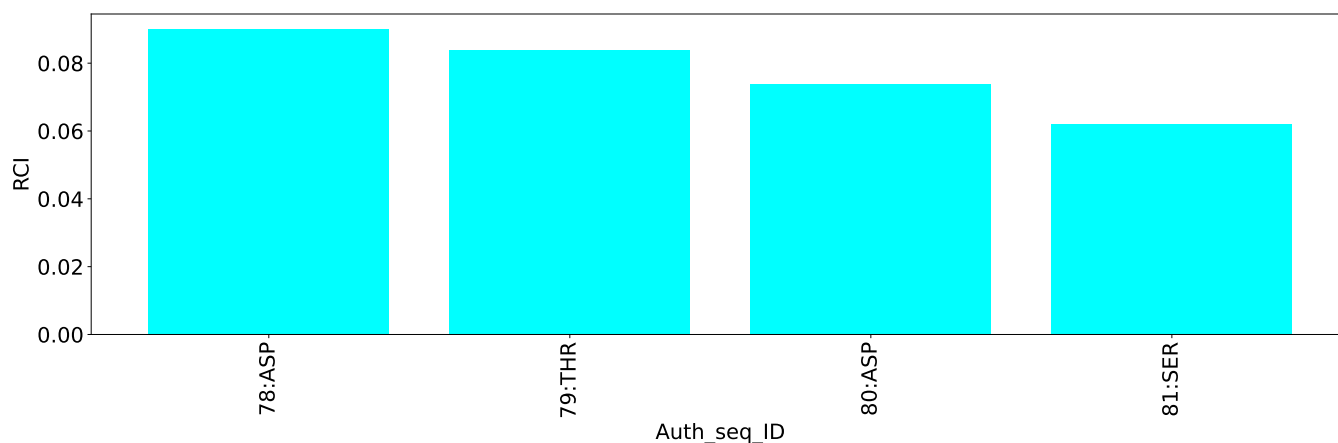
7.3.4 Statistically unusual chemical shifts [i](#)

There are no statistically unusual chemical shifts.

7.3.5 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. If well-defined core and ill-defined regions are not identified then it is shown as gray bars.

Random coil index (RCI) for chain A:



7.4 Chemical shift list 4

File name: working_cs.cif

Chemical shift list name: *assigned_chem_shift_list_4*

7.4.1 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	23
Number of shifts mapped to atoms	23
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

7.4.2 Chemical shift referencing [i](#)

No chemical shift referencing corrections were calculated (not enough data).

7.4.3 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 1%, i.e. 18 atoms were assigned a chemical shift out of a possible 1891. 0 out of 17 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	¹ H	¹³ C	¹⁵ N
Backbone	14/699 (2%)	4/284 (1%)	6/278 (2%)	4/137 (3%)
Sidechain	4/1069 (0%)	0/688 (0%)	4/342 (1%)	0/39 (0%)
Aromatic	0/123 (0%)	0/60 (0%)	0/62 (0%)	0/1 (0%)
Overall	18/1891 (1%)	4/1032 (0%)	10/682 (1%)	4/177 (2%)

7.4.4 Statistically unusual chemical shifts [i](#)

There are no statistically unusual chemical shifts.

7.4.5 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. If well-defined core and ill-defined regions are not identified then it is shown as gray bars.

Random coil index (RCI) for chain B:

