



Full wwPDB NMR Structure Validation Report ⓘ

Apr 26, 2016 – 08:21 PM BST

PDB ID : 2FWS
Title : First Ca²⁺ binding domain of the Na,Ca-exchanger (NCX1)
Authors : Hilge, M.; Aelen, J.; Vuister, G.W.
Deposited on : 2006-02-03

This is a Full wwPDB NMR Structure Validation Report for a publicly released PDB entry.
We welcome your comments at 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

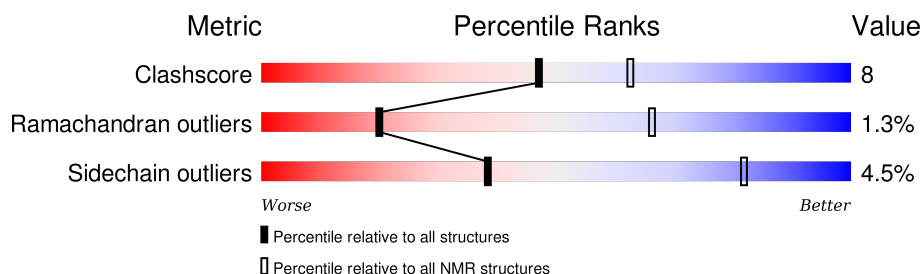
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

SOLUTION NMR

The overall completeness of chemical shifts assignment is 79%.

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 ≥ 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	139	

2 Ensemble composition and analysis

This entry contains 20 models. Model 4 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 energy*.

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:373-A:397, A:404-A:464, A:491-A:499 (95)	0.26	4

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 5 clusters and 1 single-model cluster was found.

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

3 Entry composition

There are 2 unique types of molecules in this entry. The entry contains 2067 atoms, of which 999 are hydrogens and 0 are deuteriums.

- Molecule 1 is a protein called Sodium/calcium exchanger 1.

Mol	Chain	Residues	Atoms						Trace
1	A	139	Total	C	H	N	O	S	0
			2065	666	999	170	227	3	

- Molecule 2 is CALCIUM ION (three-letter code: CA) (formula: Ca).

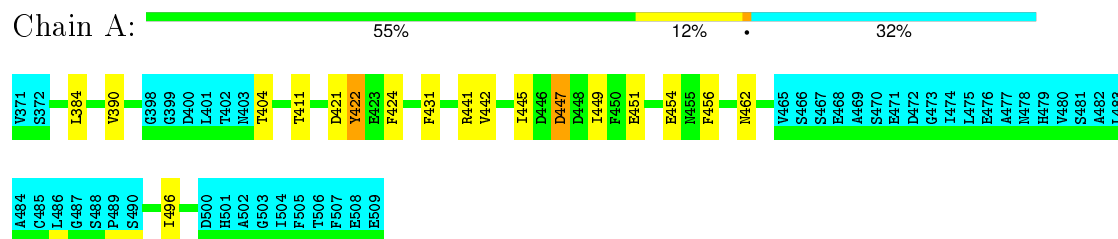
Mol	Chain	Residues	Atoms	
2	A	2	Total	Ca
			2	2

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: Sodium/calcium exchanger 1

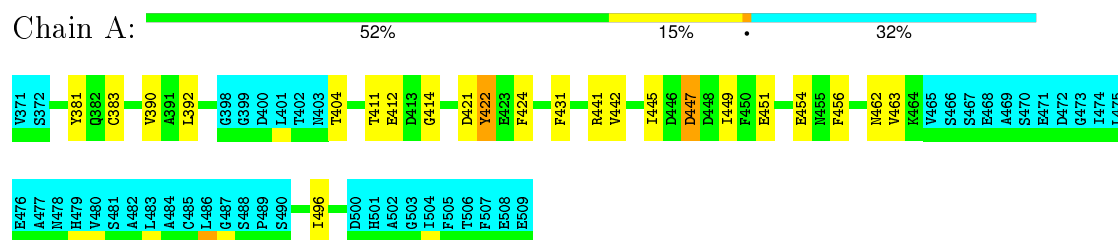


4.2 Scores per residue for each member of the ensemble

Colouring as in section 4.1 above.

4.2.1 Score per residue for model 1

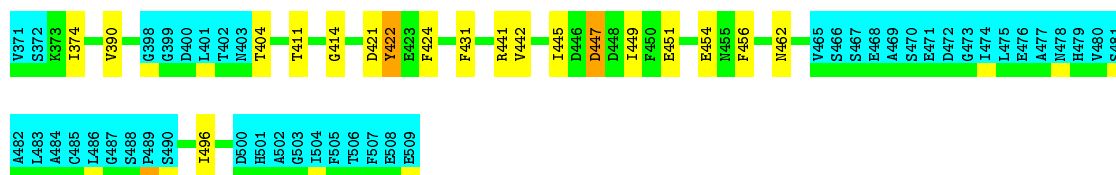
- Molecule 1: Sodium/calcium exchanger 1



4.2.2 Score per residue for model 2

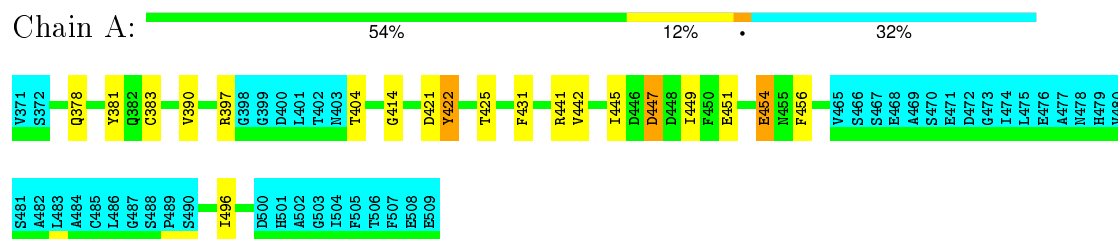
- Molecule 1: Sodium/calcium exchanger 1





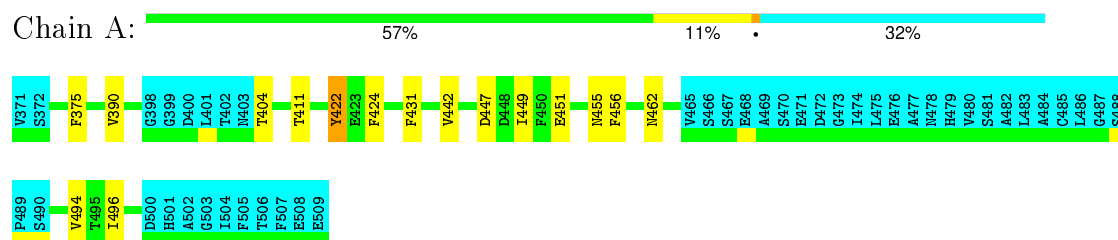
4.2.3 Score per residue for model 3

- Molecule 1: Sodium/calcium exchanger 1



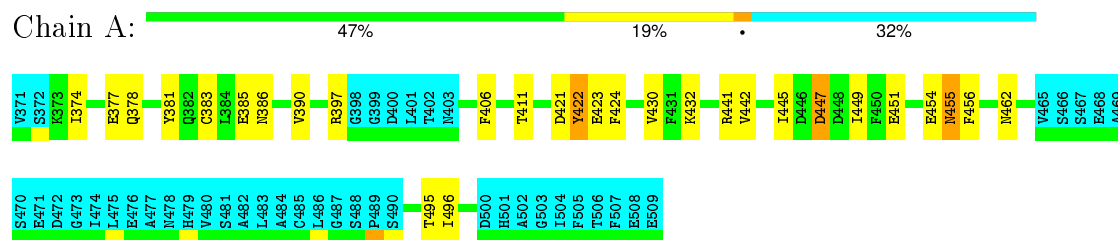
4.2.4 Score per residue for model 4 (medoid)

- Molecule 1: Sodium/calcium exchanger 1



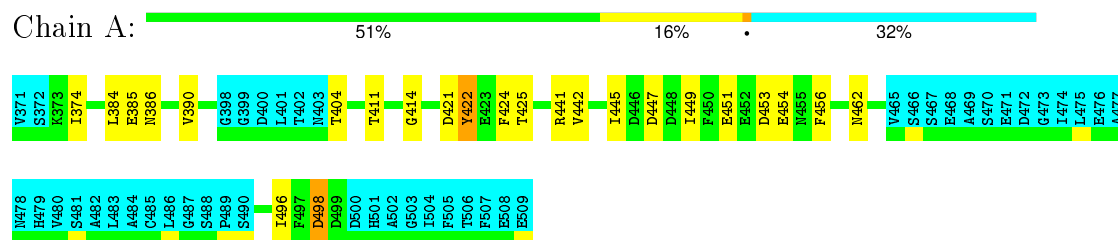
4.2.5 Score per residue for model 5

- Molecule 1: Sodium/calcium exchanger 1



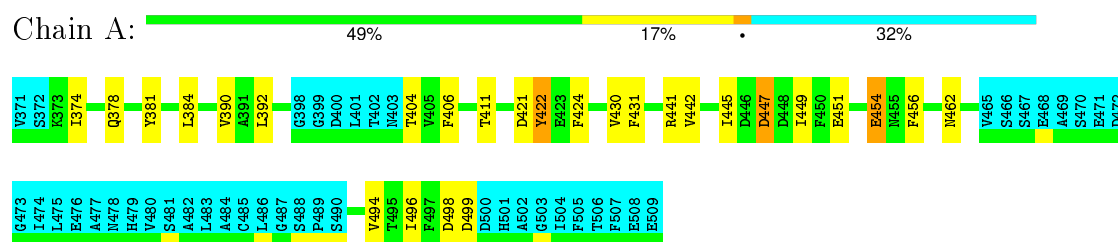
4.2.6 Score per residue for model 6

- Molecule 1: Sodium/calcium exchanger 1



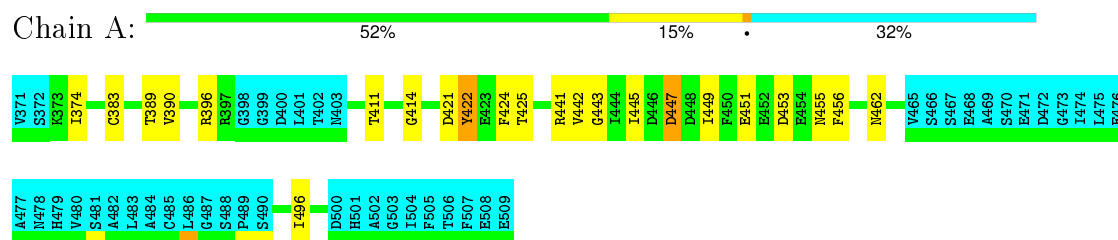
4.2.7 Score per residue for model 7

- Molecule 1: Sodium/calcium exchanger 1



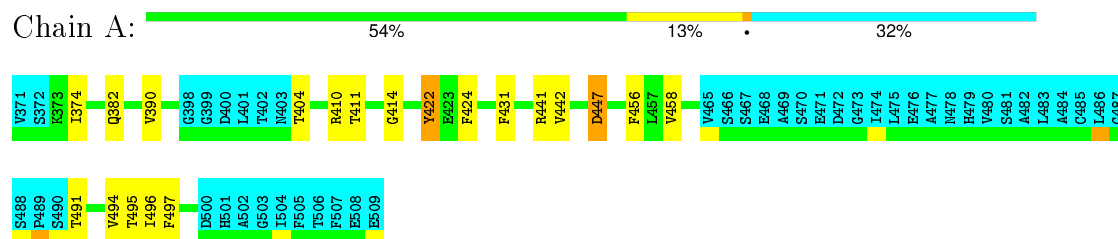
4.2.8 Score per residue for model 8

- Molecule 1: Sodium/calcium exchanger 1



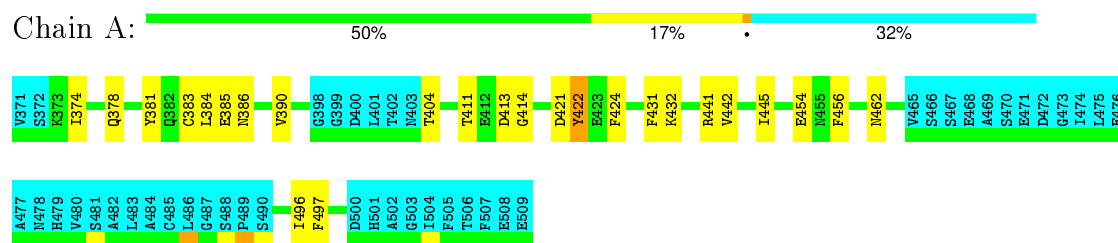
4.2.9 Score per residue for model 9

- Molecule 1: Sodium/calcium exchanger 1



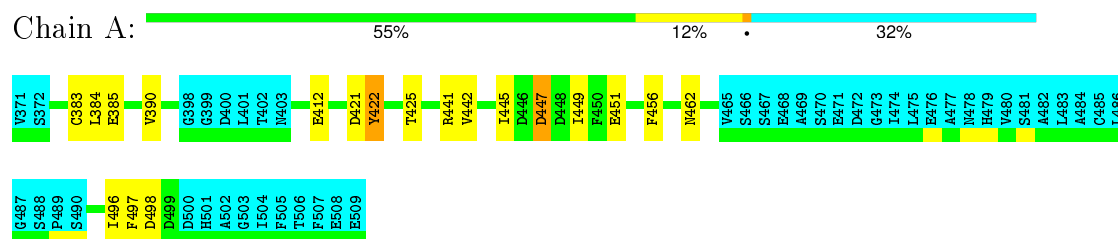
4.2.10 Score per residue for model 10

- Molecule 1: Sodium/calcium exchanger 1



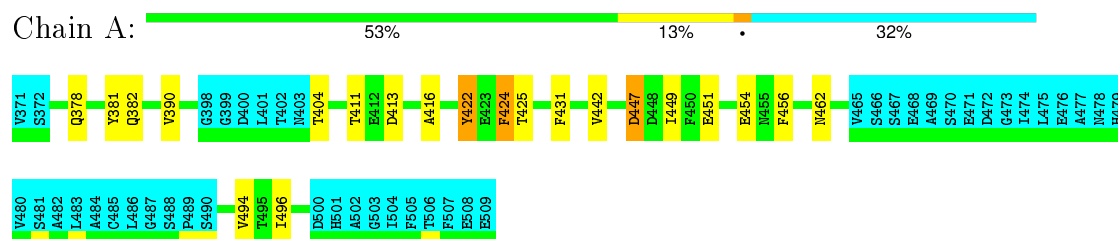
4.2.11 Score per residue for model 11

- Molecule 1: Sodium/calcium exchanger 1



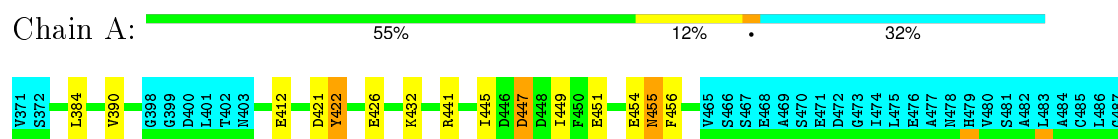
4.2.12 Score per residue for model 12

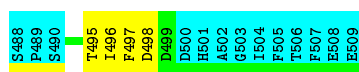
- Molecule 1: Sodium/calcium exchanger 1



4.2.13 Score per residue for model 13

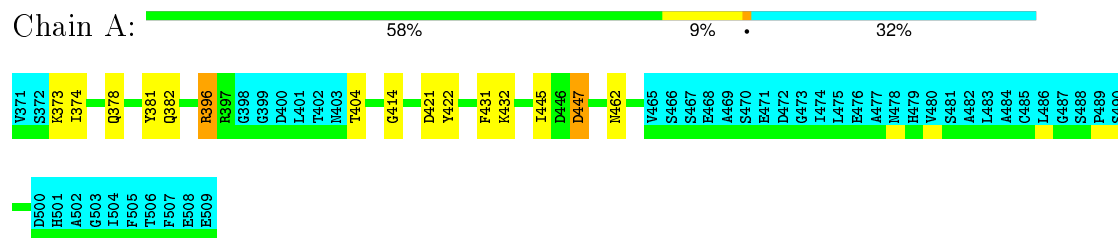
- Molecule 1: Sodium/calcium exchanger 1





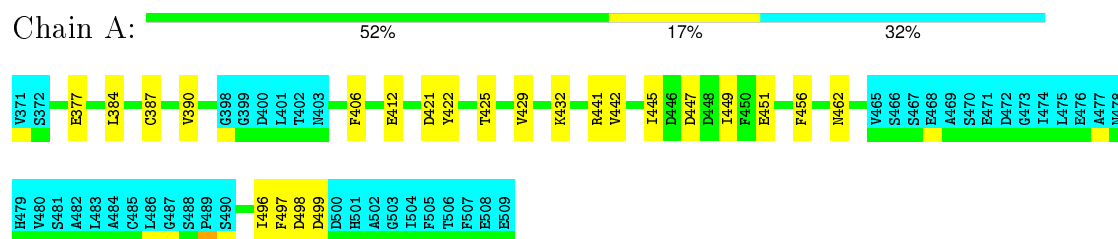
4.2.14 Score per residue for model 14

- Molecule 1: Sodium/calcium exchanger 1



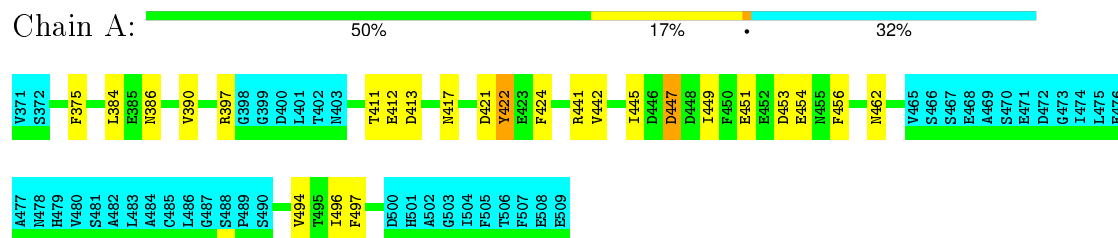
4.2.15 Score per residue for model 15

- Molecule 1: Sodium/calcium exchanger 1



4.2.16 Score per residue for model 16

- Molecule 1: Sodium/calcium exchanger 1



4.2.17 Score per residue for model 17

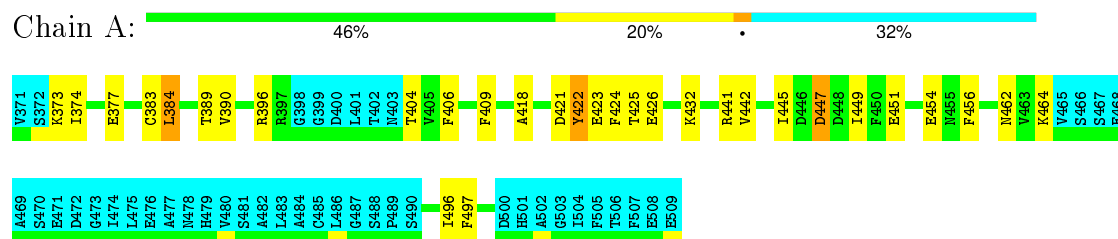
- Molecule 1: Sodium/calcium exchanger 1





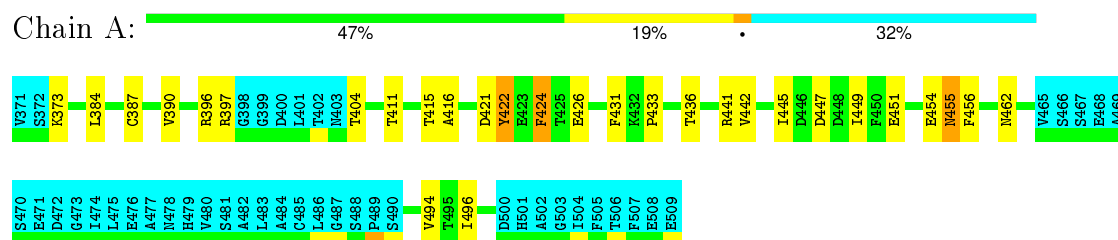
4.2.18 Score per residue for model 18

- Molecule 1: Sodium/calcium exchanger 1



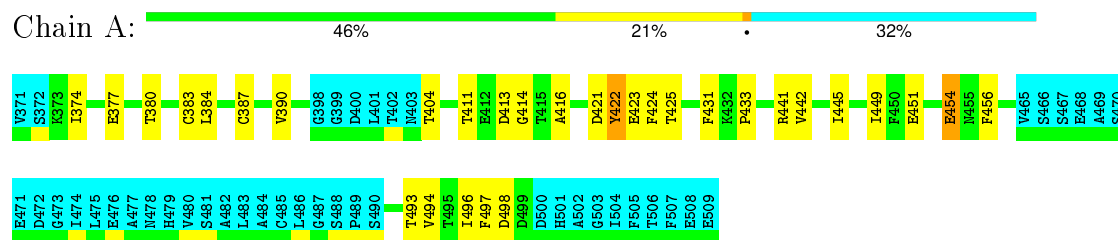
4.2.19 Score per residue for model 19

- Molecule 1: Sodium/calcium exchanger 1



4.2.20 Score per residue for model 20

- Molecule 1: Sodium/calcium exchanger 1



5 Refinement protocol and experimental data overview

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

Of the 100 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 solution	2.0
X-PLOR	refinement	NIH version 2.9.7

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)	BMRB entry 7009
Number of chemical shift lists	1
Total number of shifts	1422
Number of shifts mapped to atoms	1422
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	79%

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](#)

Bond lengths and bond angles in the following residue types are not validated in this section: CA

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	0.99±0.02	0±0/769 (0.0±0.0%)	0.79±0.02	1±1/1043 (0.1±0.1%)
All	All	0.99	2/15380 (0.0%)	0.79	29/20860 (0.1%)

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	0.1±0.3
All	All	0	2

All unique bond 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(Å)	Ideal(Å)	Models	
								Worst	Total
1	A	385	GLU	CD-OE1	-6.07	1.19	1.25	5	1
1	A	385	GLU	CD-OE2	-5.43	1.19	1.25	10	1

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	454	GLU	OE1-CD-OE2	-6.77	115.18	123.30	16	12
1	A	447	ASP	CB-CG-OD1	6.49	124.14	118.30	14	14
1	A	385	GLU	OE1-CD-OE2	-5.66	116.50	123.30	5	2
1	A	447	ASP	CB-CG-OD2	5.19	122.97	118.30	13	1

There are no chirality outliers.

All unique planar outliers are listed below.

Mol	Chain	Res	Type	Group	Models (Total)
1	A	396	ARG	Sidechain	2

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	756	719	719	12±3
2	A	2	0	0	0±1
All	All	15160	14380	14380	231

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 8.

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

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:416:ALA:HB3	1:A:422:TYR:OH	0.67	1.90	17	3
1:A:384:LEU:HA	1:A:497:PHE:O	0.65	1.91	20	4
1:A:449:ILE:O	1:A:451:GLU:HG3	0.65	1.91	6	17
1:A:422:TYR:CE2	1:A:496:ILE:HD13	0.64	2.28	20	16
1:A:385:GLU:OE2	2:A:600:CA:CA	0.64	1.75	11	1
1:A:451:GLU:OE1	2:A:650:CA:CA	0.64	1.75	12	1
1:A:451:GLU:OE2	2:A:600:CA:CA	0.64	1.75	12	1
1:A:498:ASP:OD2	2:A:600:CA:CA	0.62	1.75	20	3
1:A:411:THR:OG1	1:A:424:PHE:HA	0.61	1.95	1	14
1:A:404:THR:HA	1:A:431:PHE:O	0.59	1.98	9	11
1:A:396:ARG:HB3	1:A:436:THR:O	0.59	1.97	19	1
1:A:442:VAL:HG11	1:A:456:PHE:CZ	0.57	2.34	12	16
1:A:384:LEU:HB2	1:A:387:CYS:SG	0.56	2.40	17	4
1:A:383:CYS:SG	1:A:390:VAL:HB	0.55	2.42	3	7
1:A:385:GLU:HB2	1:A:498:ASP:HA	0.53	1.80	6	2
1:A:421:ASP:O	1:A:445:ILE:HB	0.52	2.04	20	17
1:A:373:LYS:O	1:A:396:ARG:HA	0.51	2.05	18	3
1:A:390:VAL:O	1:A:441:ARG:HA	0.50	2.05	5	17
1:A:406:PHE:CE2	1:A:430:VAL:HG22	0.50	2.42	5	1
1:A:383:CYS:SG	1:A:390:VAL:HG23	0.49	2.47	20	1

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Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:422:TYR:CE1	1:A:456:PHE:HD2	0.49	2.26	6	12
1:A:413:ASP:OD1	1:A:417:ASN:HA	0.49	2.08	16	1
1:A:406:PHE:CE1	1:A:430:VAL:HG13	0.49	2.42	7	1
1:A:456:PHE:CE2	1:A:496:ILE:HD11	0.48	2.43	12	9
1:A:384:LEU:HD13	1:A:497:PHE:O	0.48	2.09	11	7
1:A:390:VAL:HG11	1:A:494:VAL:HG11	0.48	1.86	20	7
1:A:455:ASN:HB3	1:A:495:THR:HA	0.47	1.84	5	2
1:A:409:PHE:O	1:A:426:GLU:HA	0.47	2.09	18	1
1:A:415:THR:HG22	1:A:455:ASN:O	0.47	2.09	19	1
1:A:412:GLU:O	1:A:456:PHE:HB2	0.46	2.10	1	5
1:A:422:TYR:OH	1:A:454:GLU:HG2	0.46	2.11	10	5
1:A:422:TYR:CZ	1:A:456:PHE:HD2	0.45	2.28	17	1
1:A:413:ASP:HB2	1:A:416:ALA:O	0.45	2.11	12	1
1:A:406:PHE:HB2	1:A:464:LYS:HB3	0.45	1.87	18	1
1:A:425:THR:HG21	1:A:442:VAL:HG22	0.45	1.88	18	8
1:A:378:GLN:HB2	1:A:381:TYR:CZ	0.45	2.47	3	3
1:A:378:GLN:HB2	1:A:381:TYR:CE1	0.44	2.47	7	3
1:A:384:LEU:HD12	1:A:386:ASN:OD1	0.44	2.13	16	2
1:A:384:LEU:CD1	1:A:499:ASP:HB2	0.44	2.42	17	1
1:A:422:TYR:CZ	1:A:496:ILE:HD13	0.44	2.47	8	2
1:A:406:PHE:HA	1:A:429:VAL:O	0.43	2.14	15	1
1:A:458:VAL:O	1:A:491:THR:HA	0.43	2.13	9	2
1:A:381:TYR:CE2	1:A:392:LEU:HA	0.43	2.48	7	2
1:A:377:GLU:HB3	1:A:381:TYR:OH	0.42	2.13	5	1
1:A:397:ARG:NE	1:A:397:ARG:HA	0.42	2.30	19	1
1:A:389:THR:HG22	1:A:443:GLY:HA2	0.42	1.91	8	1
1:A:418:ALA:HB1	1:A:424:PHE:HB3	0.41	1.92	18	1
1:A:385:GLU:HB2	1:A:498:ASP:CB	0.41	2.45	11	1
1:A:380:THR:HA	1:A:493:THR:O	0.41	2.15	20	1
1:A:413:ASP:HA	1:A:416:ALA:O	0.41	2.16	20	1
1:A:375:PHE:CZ	1:A:397:ARG:HG2	0.40	2.52	16	1
1:A:389:THR:HA	1:A:442:VAL:O	0.40	2.17	18	1
1:A:382:GLN:HA	1:A:495:THR:O	0.40	2.16	9	1
1:A:422:TYR:CD2	1:A:496:ILE:HD13	0.40	2.52	17	2
1:A:451:GLU:HB2	1:A:498:ASP:HB2	0.40	1.92	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	95/139 (68%)	88±1 (93±1%)	5±1 (6±1%)	1±1 (1±1%)	20	66
All	All	1900/2780 (68%)	1767 (93%)	108 (6%)	25 (1%)	20	66

All 3 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	462	ASN	14
1	A	414	GLY	10
1	A	413	ASP	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	84/118 (71%)	80±1 (96±2%)	4±1 (4±2%)	38	82
All	All	1680/2360 (71%)	1605 (96%)	75 (4%)	38	82

All 18 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	422	TYR	20
1	A	447	ASP	15
1	A	432	LYS	6
1	A	455	ASN	5
1	A	423	GLU	4
1	A	453	ASP	3
1	A	384	LEU	3

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Mol	Chain	Res	Type	Models (Total)
1	A	498	ASP	3
1	A	377	GLU	3
1	A	426	GLU	2
1	A	386	ASN	2
1	A	382	GLN	2
1	A	424	PHE	2
1	A	499	ASP	1
1	A	397	ARG	1
1	A	462	ASN	1
1	A	404	THR	1
1	A	410	ARG	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](#)

Of 2 ligands modelled in this entry, 2 are monoatomic - leaving 0 for Mogul analysis.

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

The completeness of assignment taking into account all chemical shift lists is 79% for the well-defined parts and 77% for the entire structure.

7.1 Chemical shift list 1

File name: BMRB entry 7009

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	1422
Number of shifts mapped to atoms	1422
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	2

7.1.2 Chemical shift referencing

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction \pm precision, ppm	Suggested action
$^{13}\text{C}_\alpha$	132	-0.00 ± 0.15	None needed (< 0.5 ppm)
$^{13}\text{C}_\beta$	122	-0.29 ± 0.13	None needed (< 0.5 ppm)
$^{13}\text{C}'$	0	—	—
^{15}N	128	0.14 ± 0.42	None needed (< 0.5 ppm)

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 79%, i.e. 904 atoms were assigned a chemical shift out of a possible 1140. 13 out of 13 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	^1H	^{13}C	^{15}N
Backbone	372/473 (79%)	187/189 (99%)	92/190 (48%)	93/94 (99%)
Sidechain	466/563 (83%)	285/321 (89%)	175/219 (80%)	6/23 (26%)

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	Total	¹H	¹³C	¹⁵N
Aromatic	66/104 (63%)	44/57 (77%)	22/46 (48%)	0/1 (0%)
Overall	904/1140 (79%)	516/567 (91%)	289/455 (64%)	99/118 (84%)

The following table shows the completeness of the chemical shift assignments for the full structure. The overall completeness is 77%, i.e. 1216 atoms were assigned a chemical shift out of a possible 1586. 19 out of 20 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	¹H	¹³C	¹⁵N
Backbone	523/691 (76%)	263/276 (95%)	132/278 (47%)	128/137 (93%)
Sidechain	621/759 (82%)	378/433 (87%)	237/301 (79%)	6/25 (24%)
Aromatic	72/136 (53%)	49/75 (65%)	23/58 (40%)	0/3 (0%)
Overall	1216/1586 (77%)	690/784 (88%)	392/637 (62%)	134/165 (81%)

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	396	ARG	HB2	-0.09	3.15 – 0.45	-7.0
1	A	494	VAL	HB	-0.09	3.59 – 0.39	-6.5

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:

