



Full wwPDB NMR Structure Validation Report ⓘ

Apr 26, 2016 – 09:07 PM BST

PDB ID : 2FWU
Title : Second Ca²⁺ binding domain of the Na,Ca-exchanger (NCX1)
Authors : Hilge, M.; Vuister, G.W.; Aelen, J.
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

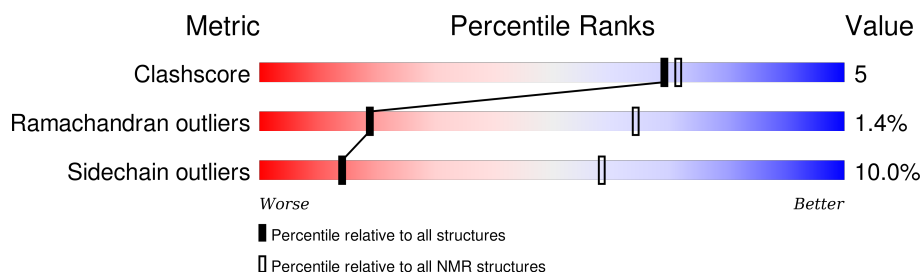
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

SOLUTION NMR

The overall completeness of chemical shifts assignment is 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	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	157	

2 Ensemble composition and analysis ⓘ

This entry contains 20 models. Model 2 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:503-A:597, A:633-A:649 (112)	0.46	2

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 3 clusters and 2 single-model clusters were found.

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

3 Entry composition

There are 2 unique types of molecules in this entry. The entry contains 2467 atoms, of which 1215 are hydrogens and 0 are deuteriums.

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

Mol	Chain	Residues	Atoms						Trace
1	A	157	Total	C	H	N	O	S	0
			2465	784	1215	201	261	4	

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

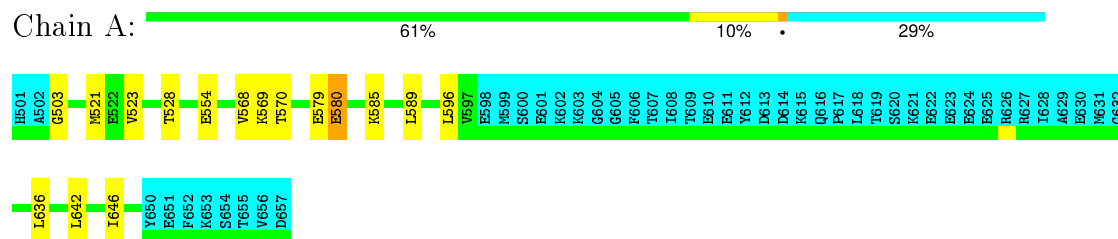
Mol	Chain	Residues	Atoms	
2	A	2	Total	Ca
			2	2

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

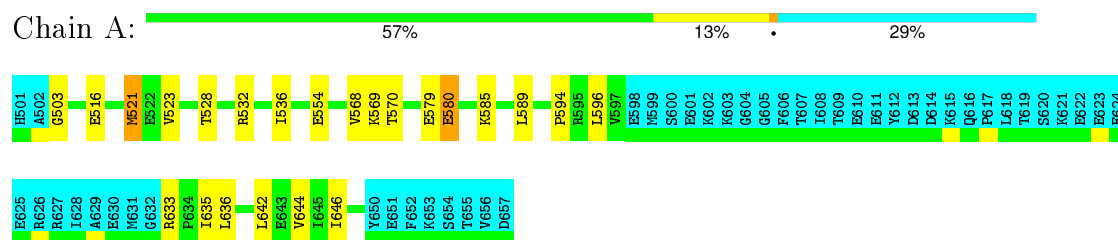


4.2 Scores per residue for each member of the ensemble

Colouring as in section 4.1 above.

4.2.1 Score per residue for model 1

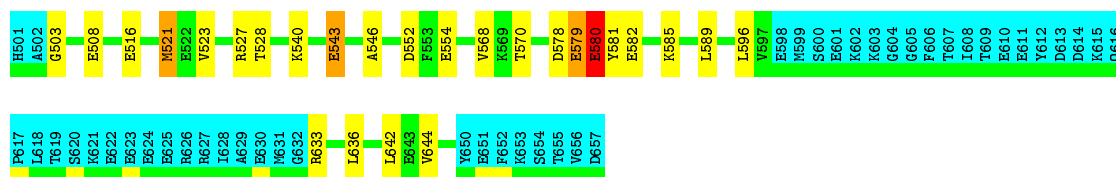
- Molecule 1: Sodium/calcium exchanger 1



4.2.2 Score per residue for model 2 (medoid)

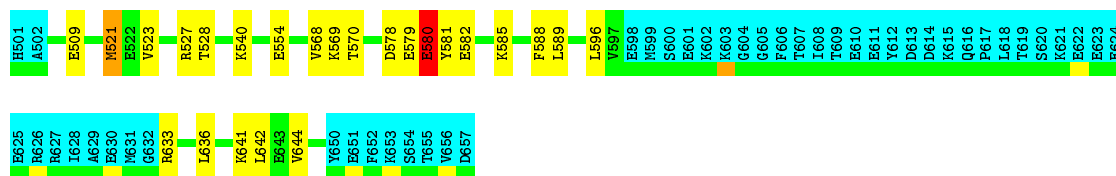
- Molecule 1: Sodium/calcium exchanger 1





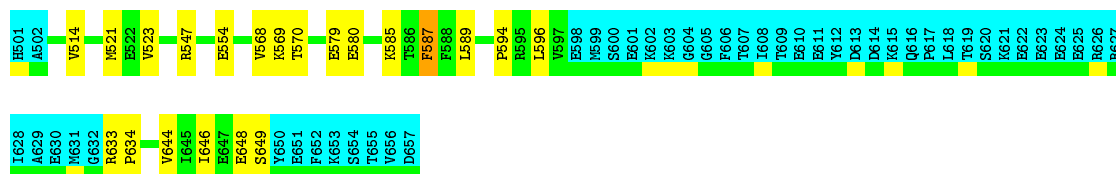
4.2.3 Score per residue for model 3

- Molecule 1: Sodium/calcium exchanger 1



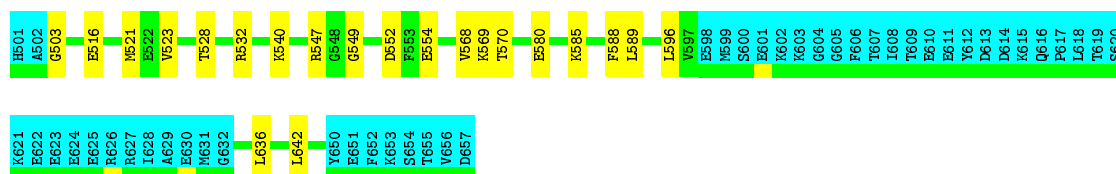
4.2.4 Score per residue for model 4

- Molecule 1: Sodium/calcium exchanger 1



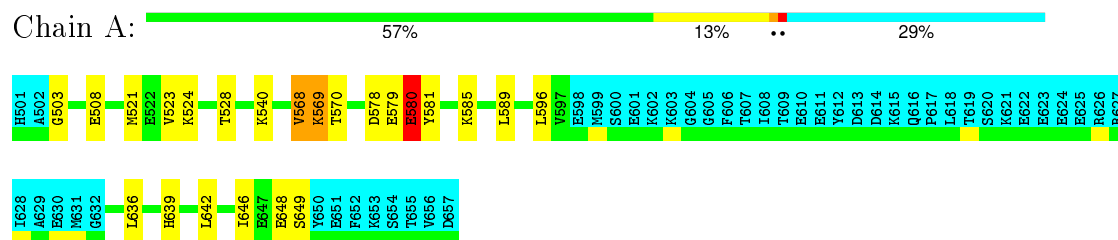
4.2.5 Score per residue for model 5

- Molecule 1: Sodium/calcium exchanger 1



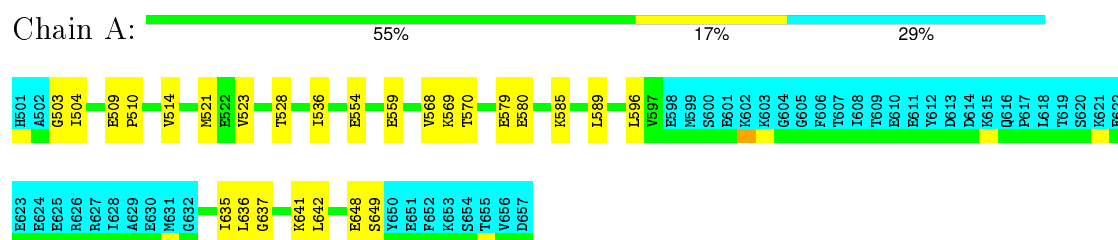
4.2.6 Score per residue for model 6

- Molecule 1: Sodium/calcium exchanger 1



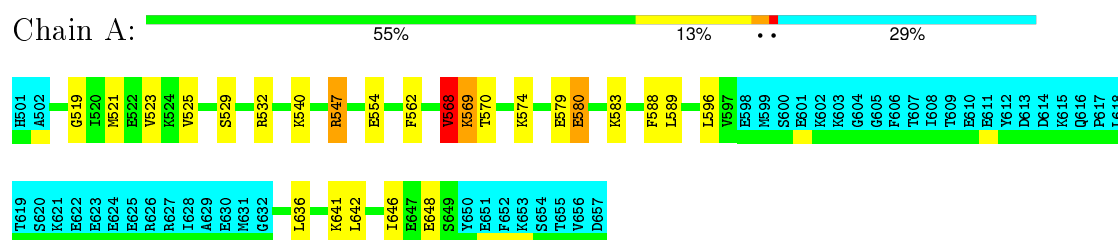
4.2.7 Score per residue for model 7

- Molecule 1: Sodium/calcium exchanger 1



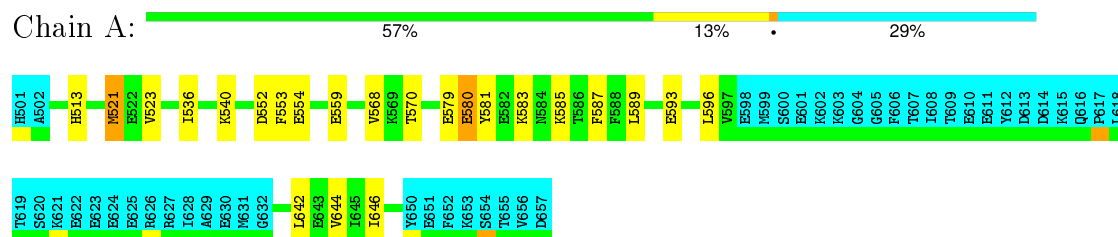
4.2.8 Score per residue for model 8

- Molecule 1: Sodium/calcium exchanger 1



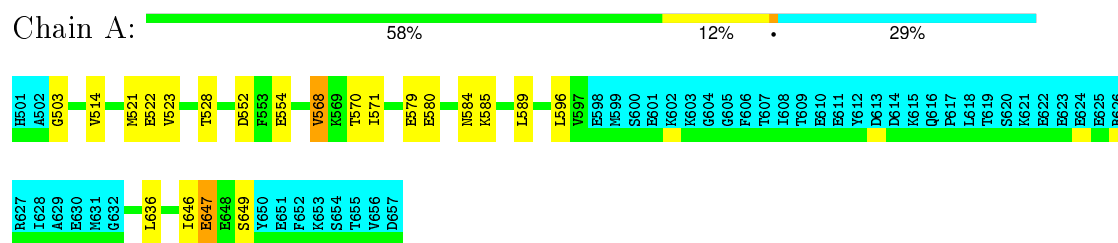
4.2.9 Score per residue for model 9

- Molecule 1: Sodium/calcium exchanger 1



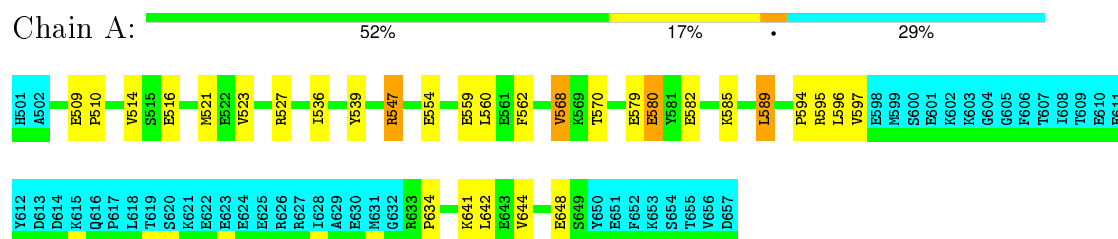
4.2.10 Score per residue for model 10

- Molecule 1: Sodium/calcium exchanger 1



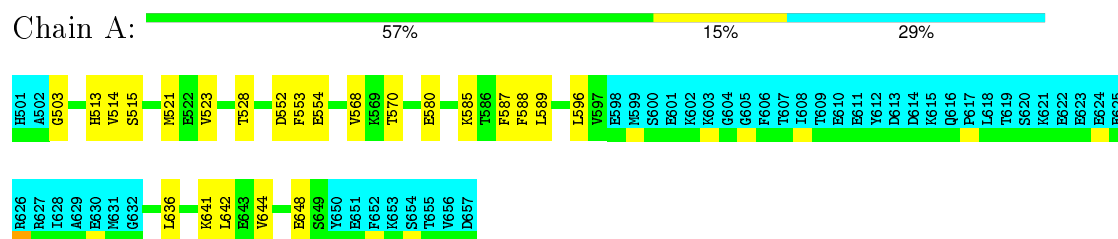
4.2.11 Score per residue for model 11

- Molecule 1: Sodium/calcium exchanger 1



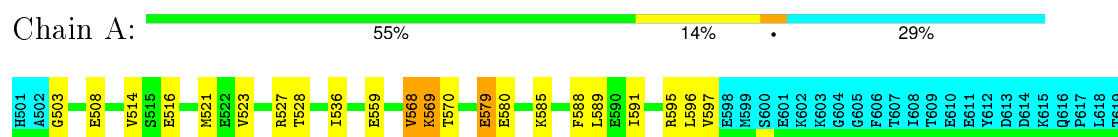
4.2.12 Score per residue for model 12

- Molecule 1: Sodium/calcium exchanger 1



4.2.13 Score per residue for model 13

- Molecule 1: Sodium/calcium exchanger 1

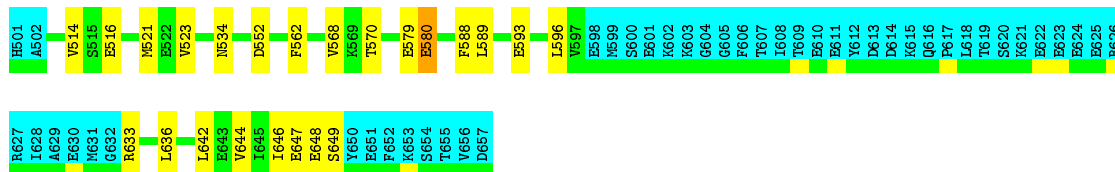




4.2.14 Score per residue for model 14

- Molecule 1: Sodium/calcium exchanger 1

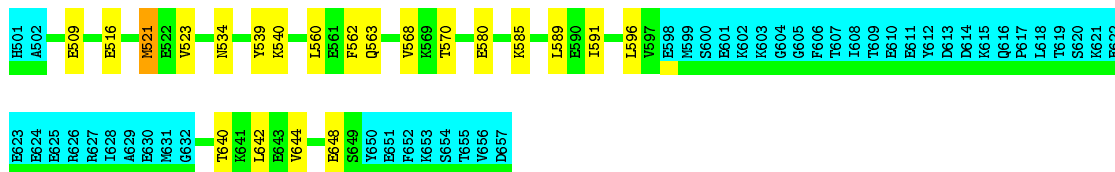
Chain A: 57% 14% 29%



4.2.15 Score per residue for model 15

- Molecule 1: Sodium/calcium exchanger 1

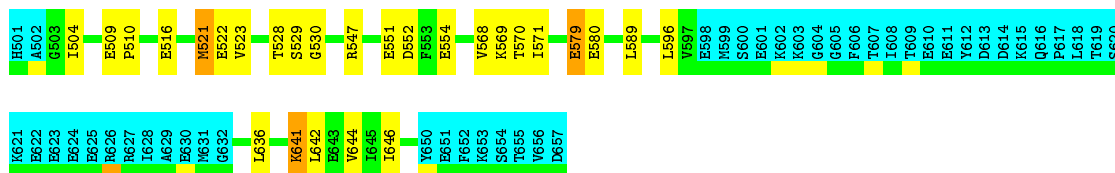
Chain A: 58% 13% 29%



4.2.16 Score per residue for model 16

- Molecule 1: Sodium/calcium exchanger 1

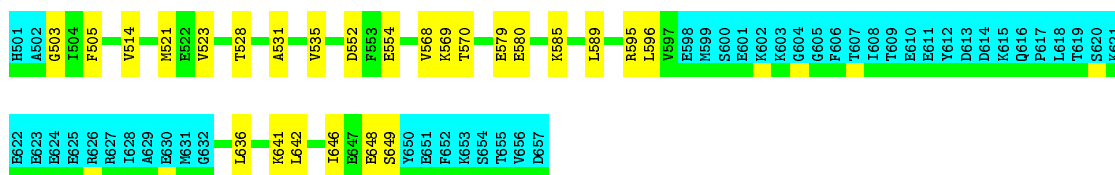
Chain A: 54% 15% 29%



4.2.17 Score per residue for model 17

- Molecule 1: Sodium/calcium exchanger 1

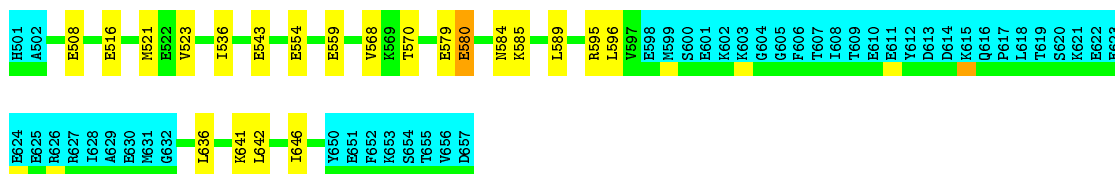
Chain A: 55% 16% 29%



4.2.18 Score per residue for model 18

- Molecule 1: Sodium/calcium exchanger 1

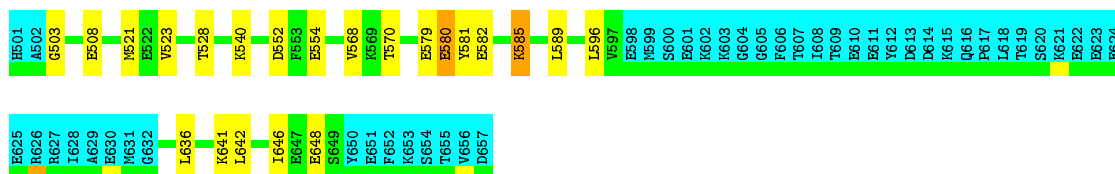
Chain A: 58% 13% 29%



4.2.19 Score per residue for model 19

- Molecule 1: Sodium/calcium exchanger 1

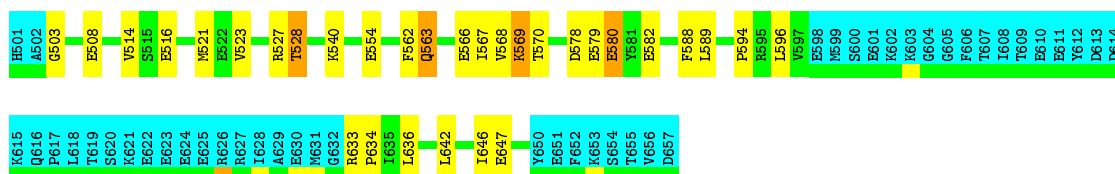
Chain A: 57% 13% 29%



4.2.20 Score per residue for model 20

- Molecule 1: Sodium/calcium exchanger 1

Chain A: 52% 17% 29%



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 7008
Number of chemical shift lists	1
Total number of shifts	1675
Number of shifts mapped to atoms	1675
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](#)

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	0.97±0.03	1±1/896 (0.1±0.1%)	0.78±0.03	1±1/1210 (0.1±0.1%)
All	All	0.97	16/17920 (0.1%)	0.78	29/24200 (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	0.2±0.5
All	All	0	5

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	579	GLU	CD-OE2	-7.77	1.17	1.25	13	2
1	A	648	GLU	CD-OE1	-7.07	1.17	1.25	7	3
1	A	580	GLU	CD-OE1	-6.64	1.18	1.25	14	7
1	A	579	GLU	CD-OE1	5.65	1.31	1.25	1	2
1	A	516	GLU	CD-OE1	-5.59	1.19	1.25	18	1
1	A	580	GLU	CD-OE2	-5.02	1.20	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	648	GLU	OE1-CD-OE2	-6.75	115.19	123.30	7	3
1	A	582	GLU	OE1-CD-OE2	-6.72	115.24	123.30	11	4

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)	Models	
								Worst	Total
1	A	579	GLU	OE1-CD-OE2	-6.64	115.33	123.30	9	1
1	A	516	GLU	OE1-CD-OE2	-6.63	115.34	123.30	11	9
1	A	580	GLU	OE1-CD-OE2	-6.47	115.54	123.30	1	11
1	A	529	SER	N-CA-CB	-6.35	100.98	110.50	16	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	547	ARG	Sidechain	2
1	A	595	ARG	Sidechain	2
1	A	527	ARG	Sidechain	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	882	872	872	8±2
2	A	2	0	0	1±1
All	All	17680	17440	17440	161

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 5.

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

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:552:ASP:OD1	2:A:850:CA:CA	0.67	1.72	2	8
1:A:648:GLU:OE2	2:A:800:CA:CA	0.66	1.72	17	7
1:A:503:GLY:HA3	1:A:528:THR:OG1	0.59	1.97	20	2
1:A:582:GLU:OE1	1:A:585:LYS:HB3	0.59	1.97	19	1
1:A:523:VAL:HG21	1:A:642:LEU:HD21	0.58	1.74	6	11
1:A:516:GLU:HB2	1:A:647:GLU:O	0.57	1.99	13	1
1:A:523:VAL:O	1:A:570:THR:HA	0.57	2.00	20	20
1:A:514:VAL:HG11	1:A:521:MET:SD	0.56	2.41	17	9

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Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:503:GLY:HA2	1:A:528:THR:OG1	0.55	2.02	2	9
1:A:521:MET:HE2	1:A:644:VAL:HG21	0.54	1.78	1	5
1:A:553:PHE:HB3	1:A:587:PHE:CE2	0.54	2.38	12	2
1:A:521:MET:HE1	1:A:644:VAL:HG21	0.53	1.79	12	5
1:A:504:ILE:O	1:A:528:THR:HB	0.53	2.03	16	1
1:A:510:PRO:HA	1:A:641:LYS:O	0.52	2.04	11	3
1:A:525:VAL:O	1:A:568:VAL:HA	0.51	2.05	8	1
1:A:547:ARG:HB3	1:A:551:GLU:OE1	0.51	2.05	16	1
1:A:580:GLU:HG2	1:A:581:TYR:O	0.51	2.05	9	4
1:A:536:ILE:CG2	1:A:559:GLU:HB3	0.51	2.36	13	4
1:A:594:PRO:HG2	1:A:634:PRO:O	0.50	2.06	20	3
1:A:646:ILE:N	1:A:646:ILE:HD12	0.49	2.22	19	7
1:A:569:LYS:HA	1:A:569:LYS:HE3	0.48	1.83	20	3
1:A:562:PHE:CZ	1:A:569:LYS:HB2	0.47	2.44	8	2
1:A:646:ILE:HD12	1:A:646:ILE:N	0.46	2.25	10	4
1:A:569:LYS:HA	1:A:569:LYS:HE2	0.46	1.85	4	1
1:A:593:GLU:OE1	1:A:633:ARG:HD3	0.46	2.10	14	1
1:A:524:LYS:HD2	1:A:568:VAL:CG2	0.46	2.41	6	1
1:A:591:ILE:HG12	1:A:640:THR:OG1	0.45	2.12	13	2
1:A:523:VAL:HG21	1:A:642:LEU:CD2	0.45	2.42	18	6
1:A:522:GLU:HA	1:A:571:ILE:O	0.45	2.12	10	2
1:A:528:THR:HG23	1:A:531:ALA:HB2	0.45	1.89	17	1
1:A:519:GLY:O	1:A:574:LYS:HA	0.44	2.12	8	1
1:A:584:ASN:ND2	1:A:647:GLU:HA	0.44	2.27	10	1
1:A:547:ARG:HB2	1:A:552:ASP:CB	0.44	2.43	16	1
1:A:527:ARG:HG2	1:A:528:THR:N	0.43	2.28	2	2
1:A:536:ILE:HB	1:A:595:ARG:CG	0.43	2.44	13	1
1:A:539:TYR:CE1	1:A:560:LEU:HG	0.43	2.49	15	2
1:A:536:ILE:HG23	1:A:559:GLU:HB3	0.43	1.90	11	1
1:A:587:PHE:CE2	1:A:646:ILE:HD11	0.43	2.49	4	1
1:A:588:PHE:HA	1:A:642:LEU:O	0.42	2.15	12	7
1:A:543:GLU:HB2	1:A:546:ALA:O	0.42	2.14	2	1
1:A:505:PHE:CZ	1:A:528:THR:HB	0.42	2.48	17	1
1:A:569:LYS:HE2	1:A:569:LYS:HA	0.42	1.90	16	1
1:A:527:ARG:CZ	1:A:567:ILE:HG22	0.42	2.45	20	1
1:A:535:VAL:HA	1:A:595:ARG:O	0.42	2.15	17	1
1:A:503:GLY:HA3	1:A:528:THR:HG1	0.41	1.75	20	1
1:A:563:GLN:HB2	1:A:566:GLU:HB2	0.41	1.91	20	1
1:A:547:ARG:N	1:A:547:ARG:HD2	0.41	2.31	8	1
1:A:547:ARG:HB2	1:A:552:ASP:HB2	0.41	1.91	16	1
1:A:536:ILE:HG12	1:A:597:VAL:CG2	0.41	2.45	11	1

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Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:568:VAL:O	1:A:569:LYS:HG2	0.41	2.15	13	1
1:A:536:ILE:O	1:A:594:PRO:HA	0.41	2.16	1	1
1:A:527:ARG:HD3	1:A:562:PHE:CZ	0.41	2.51	11	1
1:A:580:GLU:HG2	1:A:581:TYR:CD2	0.41	2.51	6	1
1:A:589:LEU:HB3	1:A:642:LEU:HB3	0.40	1.93	11	1
1:A:504:ILE:HG23	1:A:637:GLY:CA	0.40	2.47	7	1
1:A:534:ASN:ND2	1:A:563:GLN:HG2	0.40	2.32	15	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	112/157 (71%)	100±2 (90±2%)	10±2 (9±2%)	2±1 (1±1%)	19	64
All	All	2240/3140 (71%)	2007 (90%)	201 (9%)	32 (1%)	19	64

All 8 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	568	VAL	20
1	A	649	SER	6
1	A	549	GLY	1
1	A	579	GLU	1
1	A	584	ASN	1
1	A	532	ARG	1
1	A	597	VAL	1
1	A	529	SER	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	99/139 (71%)	89±2 (90±2%)	10±2 (10±2%)	14	58
All	All	1980/2780 (71%)	1782 (90%)	198 (10%)	14	58

All 29 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	596	LEU	20
1	A	589	LEU	20
1	A	580	GLU	18
1	A	636	LEU	16
1	A	585	LYS	16
1	A	554	GLU	16
1	A	579	GLU	14
1	A	521	MET	11
1	A	540	LYS	9
1	A	569	LYS	9
1	A	641	LYS	7
1	A	508	GLU	6
1	A	578	ASP	4
1	A	633	ARG	4
1	A	509	GLU	4
1	A	568	VAL	3
1	A	547	ARG	3
1	A	647	GLU	2
1	A	562	PHE	2
1	A	635	ILE	2
1	A	532	ARG	2
1	A	543	GLU	2
1	A	583	LYS	2
1	A	639	HIS	1
1	A	563	GLN	1
1	A	587	PHE	1
1	A	528	THR	1
1	A	640	THR	1
1	A	534	ASN	1

6.3.3 RNA ⓘ

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 81% for the well-defined parts and 76% for the entire structure.

7.1 Chemical shift list 1

File name: BMRB entry 7008

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	1675
Number of shifts mapped to atoms	1675
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	1

7.1.2 Chemical shift referencing

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction \pm precision, ppm	Suggested action
$^{13}\text{C}_\alpha$	146	-0.12 ± 0.13	None needed (< 0.5 ppm)
$^{13}\text{C}_\beta$	134	-0.12 ± 0.17	None needed (< 0.5 ppm)
$^{13}\text{C}'$	0	—	—
^{15}N	145	-0.10 ± 0.31	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 81%, i.e. 1101 atoms were assigned a chemical shift out of a possible 1361. 16 out of 17 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	^1H	^{13}C	^{15}N
Backbone	438/552 (79%)	219/220 (100%)	112/224 (50%)	107/108 (99%)
Sidechain	610/725 (84%)	376/419 (90%)	231/280 (82%)	3/26 (12%)

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	Total	¹ H	¹³ C	¹⁵ N
Aromatic	53/84 (63%)	35/46 (76%)	18/36 (50%)	0/2 (0%)
Overall	1101/1361 (81%)	630/685 (92%)	361/540 (67%)	110/136 (81%)

The following table shows the completeness of the chemical shift assignments for the full structure. The overall completeness is 76%, i.e. 1466 atoms were assigned a chemical shift out of a possible 1920. 18 out of 19 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	¹ H	¹³ C	¹⁵ N
Backbone	590/775 (76%)	299/309 (97%)	146/314 (46%)	145/152 (95%)
Sidechain	804/1020 (79%)	503/593 (85%)	298/389 (77%)	3/38 (8%)
Aromatic	72/125 (58%)	47/68 (69%)	25/54 (46%)	0/3 (0%)
Overall	1466/1920 (76%)	849/970 (88%)	469/757 (62%)	148/193 (77%)

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	644	VAL	HB	0.25	3.59 – 0.39	-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:

