Full wwPDB NMR Structure Validation Report (i)

May 29, 2020 – 12:05 am BST

PDB ID	:	2MVC
Title	:	Solution structure of human insulin at pH 1.9
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Deposited on	:	2014-10-02

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
https://www.wwpdb.org/validation/2017/NMRValidationReportHelp
with specific help available everywhere you see the (i) symbol.

The following versions of software and data (see references (1)) were used in the production of this report:

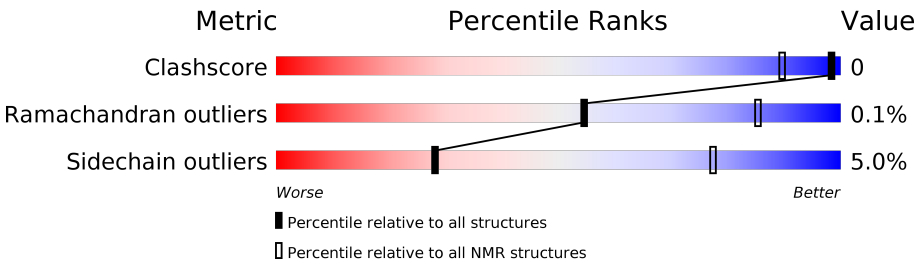
Cyrange	:	Kirchner and Güntert (2011)
NmrClust	:	Kelley et al. (1996)
MolProbity	:	4.02b-467
Percentile statistics	:	20191225.v01 (using entries in the PDB archive December 25th 2019)
RCI	:	v_1n_11_5_13_A (Berjanski et al., 2005)
PANAV	:	Wang et al. (2010)
ShiftChecker	:	2.11
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.11

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
SOLUTION NMR

The overall completeness of chemical shifts assignment is 75%.

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 >=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 <=5%

Mol	Chain	Length	Quality of chain
1	A	21	90% 10%
2	B	30	80% 7% 13%

2 Ensemble composition and analysis (i)

This entry contains 50 models. Model 28 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:3-A:21, B:1-B:26 (45)	0.37	28

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 10 clusters and 10 single-model clusters were found.

Cluster number	Models
1	6, 10, 16, 23, 25, 43, 49
2	3, 17, 24, 26, 27, 40
3	30, 32, 39, 46, 48
4	2, 4, 11, 28, 45
5	14, 20, 33, 34, 42
6	7, 12, 35
7	5, 8, 21
8	31, 38
9	15, 41
10	18, 50
Single-model clusters	1; 9; 13; 19; 22; 29; 36; 37; 44; 47

3 Entry composition (i)

There are 2 unique types of molecules in this entry. The entry contains 794 atoms, of which 389 are hydrogens and 0 are deuteriums.

- Molecule 1 is a protein called Insulin A chain.

Mol	Chain	Residues	Atoms						Trace
			Total	C	H	N	O	S	
1	A	21	315	99	152	25	35	4	0

- Molecule 2 is a protein called Insulin B chain.

Mol	Chain	Residues	Atoms						Trace
			Total	C	H	N	O	S	
2	B	30	479	158	237	40	42	2	0

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: Insulin A chain

Chain A:

• Molecule 2: Insulin B chain

Chain B:

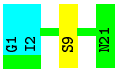
4.2 Scores per residue for each member of the ensemble

Colouring as in section 4.1 above.

4.2.1 Score per residue for model 1

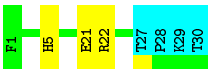
• Molecule 1: Insulin A chain

Chain A:



• Molecule 2: Insulin B chain

Chain B:



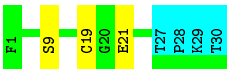
4.2.2 Score per residue for model 2

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

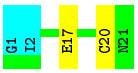
Chain B:



4.2.3 Score per residue for model 3

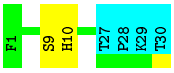
- Molecule 1: Insulin A chain

Chain A:



- Molecule 2: Insulin B chain

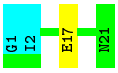
Chain B:



4.2.4 Score per residue for model 4

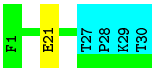
- Molecule 1: Insulin A chain

Chain A:



- Molecule 2: Insulin B chain

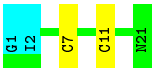
Chain B:



4.2.5 Score per residue for model 5

- Molecule 1: Insulin A chain

Chain A:



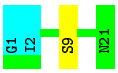
- Molecule 2: Insulin B chain

Chain B:

4.2.6 Score per residue for model 6

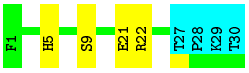
- Molecule 1: Insulin A chain

Chain A:



- Molecule 2: Insulin B chain

Chain B:



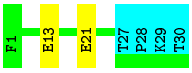
4.2.7 Score per residue for model 7

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

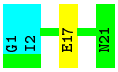
Chain B:



4.2.8 Score per residue for model 8

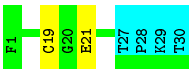
- Molecule 1: Insulin A chain

Chain A: 86% 5% 10%



- Molecule 2: Insulin B chain

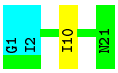
Chain B: 80% 7% 13%



4.2.9 Score per residue for model 9

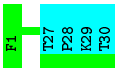
- Molecule 1: Insulin A chain

Chain A: 86% 5% 10%



- Molecule 2: Insulin B chain

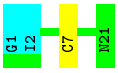
Chain B: 87% 13%



4.2.10 Score per residue for model 10

- Molecule 1: Insulin A chain

Chain A: 86% 5% 10%



- Molecule 2: Insulin B chain

Chain B: 73% 13% 13%

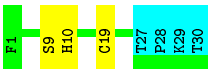
4.2.11 Score per residue for model 11

- Molecule 1: Insulin A chain

Chain A: 90% 10%

- Molecule 2: Insulin B chain

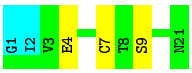
Chain B: 77% 10% 13%



4.2.12 Score per residue for model 12

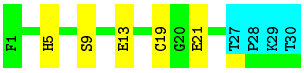
- Molecule 1: Insulin A chain

Chain A: 76% 14% 10%



- Molecule 2: Insulin B chain

Chain B: 70% 17% 13%



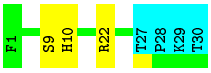
4.2.13 Score per residue for model 13

- Molecule 1: Insulin A chain

Chain A: 86% 5% 10%

- Molecule 2: Insulin B chain

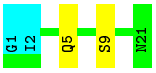
Chain B: 77% 10% 13%



4.2.14 Score per residue for model 14

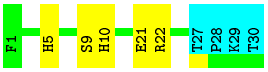
- Molecule 1: Insulin A chain

Chain A: 81% 10% 10%



- Molecule 2: Insulin B chain

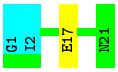
Chain B: 70% 17% 13%



4.2.15 Score per residue for model 15

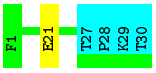
- Molecule 1: Insulin A chain

Chain A: 86% 5% 10%



- Molecule 2: Insulin B chain

Chain B: 83% • 13%



4.2.16 Score per residue for model 16

- Molecule 1: Insulin A chain

Chain A: 90% 10%

- Molecule 2: Insulin B chain

Chain B: 80% 7% 13%

4.2.17 Score per residue for model 17

- Molecule 1: Insulin A chain

Chain A: 86% 5% 10%

G1 I2 E17 N21

- Molecule 2: Insulin B chain

Chain B: 80% 7% 13%

F1 S9 C19 T27 P28 K29 T30

4.2.18 Score per residue for model 18

- Molecule 1: Insulin A chain

Chain A: 86% 5% 10%

G1 I2 N18 N21

- Molecule 2: Insulin B chain

Chain B: 77% 10% 13%

F1 E13 C19 G20 E21 T27 P28 K29 T30

4.2.19 Score per residue for model 19

- Molecule 1: Insulin A chain

Chain A: 90% 10%

G1 I2 N21

- Molecule 2: Insulin B chain

Chain B: 77% 10% 13%

F1 E13 C19 G20 E21 T27 P28 K29 T30

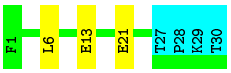
4.2.20 Score per residue for model 20

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



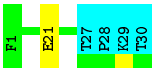
4.2.21 Score per residue for model 21

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



4.2.22 Score per residue for model 22

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:

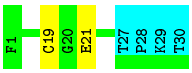
4.2.23 Score per residue for model 23

- Molecule 1: Insulin A chain

Chain A: 90% 10%

- Molecule 2: Insulin B chain

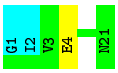
Chain B: 80% 7% 13%



4.2.24 Score per residue for model 24

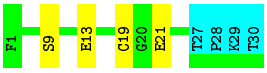
- Molecule 1: Insulin A chain

Chain A: 86% 5% 10%



- Molecule 2: Insulin B chain

Chain B: 73% 13% 13%



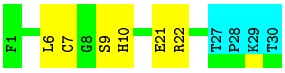
4.2.25 Score per residue for model 25

- Molecule 1: Insulin A chain

Chain A: 90% 10%

- Molecule 2: Insulin B chain

Chain B: 67% 20% 13%



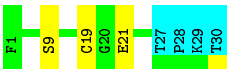
4.2.26 Score per residue for model 26

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



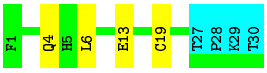
4.2.27 Score per residue for model 27

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



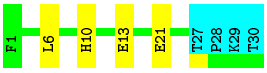
4.2.28 Score per residue for model 28 (medoid)

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



4.2.29 Score per residue for model 29

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:

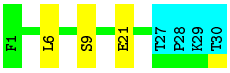
4.2.30 Score per residue for model 30

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



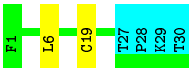
4.2.31 Score per residue for model 31

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



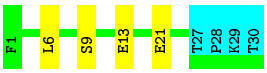
4.2.32 Score per residue for model 32

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

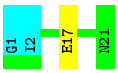
Chain B:



4.2.33 Score per residue for model 33

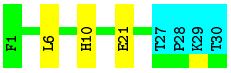
- Molecule 1: Insulin A chain

Chain A:



- Molecule 2: Insulin B chain

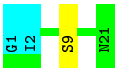
Chain B:



4.2.34 Score per residue for model 34

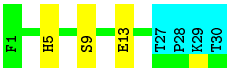
- Molecule 1: Insulin A chain

Chain A:



- Molecule 2: Insulin B chain

Chain B:



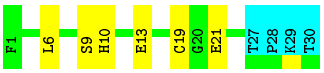
4.2.35 Score per residue for model 35

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



4.2.36 Score per residue for model 36

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:

4.2.37 Score per residue for model 37

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:

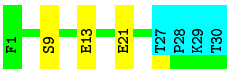
4.2.38 Score per residue for model 38

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



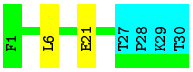
4.2.39 Score per residue for model 39

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



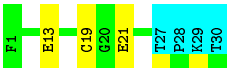
4.2.40 Score per residue for model 40

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

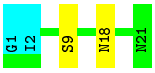
Chain B:



4.2.41 Score per residue for model 41

- Molecule 1: Insulin A chain

Chain A:



- Molecule 2: Insulin B chain

Chain B:

4.2.42 Score per residue for model 42

- Molecule 1: Insulin A chain

Chain A:

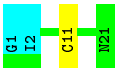
- Molecule 2: Insulin B chain

Chain B:

4.2.43 Score per residue for model 43

- Molecule 1: Insulin A chain

Chain A:



- Molecule 2: Insulin B chain

Chain B:

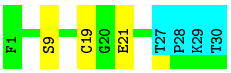
4.2.44 Score per residue for model 44

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



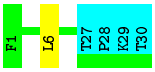
4.2.45 Score per residue for model 45

- Molecule 1: Insulin A chain

Chain A:

- Molecule 2: Insulin B chain

Chain B:



4.2.46 Score per residue for model 46

- Molecule 1: Insulin A chain

Chain A:

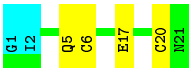
- Molecule 2: Insulin B chain

Chain B:

4.2.47 Score per residue for model 47

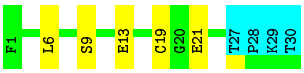
- Molecule 1: Insulin A chain

Chain A: 71% 19% 10%



- Molecule 2: Insulin B chain

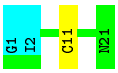
Chain B: 70% 17% 13%



4.2.48 Score per residue for model 48

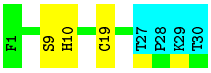
- Molecule 1: Insulin A chain

Chain A: 86% 5% 10%



- Molecule 2: Insulin B chain

Chain B: 77% 10% 13%



4.2.49 Score per residue for model 49

- Molecule 1: Insulin A chain

Chain A: 90% 10%

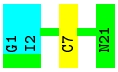
- Molecule 2: Insulin B chain

Chain B: 77% 10% 13%

4.2.50 Score per residue for model 50

- Molecule 1: Insulin A chain

Chain A:



- Molecule 2: Insulin B chain

Chain B:

5 Refinement protocol and experimental data overview (i)

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

Of the 100 calculated structures, 50 were deposited, based on the following criterion: *structures with the least restraint violations.*

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

Software name	Classification	Version
CYANA	structure solution	
Yasara	refinement	
CYANA	refinement	

The following table shows chemical shift validation statistics as aggregates over all chemical shift files. Detailed validation can be found in section 6 of this report.

Chemical shift file(s)	input_cs.cif
Number of chemical shift lists	1
Total number of shifts	526
Number of shifts mapped to atoms	526
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	75%

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

COVALENT-GEOMETRY INFOmissingINFO

5.1 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	151	136	133	0±0
2	B	211	202	198	0±0
All	All	18100	16900	16550	6

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 0.

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

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:9:SER:HA	2:B:5:HIS:CE1	0.42	2.50	34	6

5.2 Torsion angles (i)

5.2.1 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	18/21 (86%)	18±0 (99±2%)	0±0 (1±2%)	0±0 (0±1%)	44	80
2	B	25/30 (83%)	25±0 (99±1%)	0±0 (1±1%)	0±0 (0±0%)	100	100
All	All	2150/2550 (84%)	2132 (99%)	15 (1%)	3 (0%)	54	85

All 1 unique Ramachandran outliers are listed below.

Mol	Chain	Res	Type	Models (Total)
1	A	11	CYS	3

5.2.2 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	19/20 (95%)	19±1 (98±3%)	0±1 (2±3%)	54	92
2	B	22/26 (85%)	20±1 (93±5%)	2±1 (7±5%)	17	65
All	All	2050/2300 (89%)	1948 (95%)	102 (5%)	28	77

All 16 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)
2	B	9	SER	27
2	B	19	CYS	18
2	B	6	LEU	13
2	B	10	HIS	11
1	A	20	CYS	9
2	B	22	ARG	7
1	A	7	CYS	4
2	B	21	GLU	3
1	A	5	GLN	2
1	A	18	ASN	2
1	A	11	CYS	1
1	A	3	VAL	1
2	B	7	CYS	1
1	A	10	ILE	1
1	A	6	CYS	1
2	B	4	GLN	1

5.2.3 RNA (i)

There are no RNA molecules in this entry.

5.3 Non-standard residues in protein, DNA, RNA chains (i)

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

5.4 Carbohydrates (i)

There are no carbohydrates in this entry.

5.5 Ligand geometry (i)

There are no ligands in this entry.

5.6 Other polymers (i)

There are no such molecules in this entry.

5.7 Polymer linkage issues (i)

There are no chain breaks in this entry.

6 Chemical shift validation (i)

The completeness of assignment taking into account all chemical shift lists is 75% for the well-defined parts and 75% for the entire structure.

6.1 Chemical shift list 1

File name: input_cs.cif

Chemical shift list name: *assigned_chem_shift_list_1*

6.1.1 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	526
Number of shifts mapped to atoms	526
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

6.1.2 Chemical shift referencing (i)

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction ± precision, *ppm*	Suggested action
$^{13}C_{\alpha}$	46	0.04 ± 0.18	None needed (< 0.5 ppm)
$^{13}C_{\beta}$	44	0.30 ± 0.16	None needed (< 0.5 ppm)
$^{13}C'$	0	—	None (insufficient data)
^{15}N	34	-1.24 ± 0.54	Should be applied

6.1.3 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 75%, i.e. 406 atoms were assigned a chemical shift out of a possible 544. 5 out of 10 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	^{1}H	^{13}C	^{15}N
Backbone	160/225 (71%)	88/90 (98%)	41/90 (46%)	31/45 (69%)
Sidechain	212/244 (87%)	136/143 (95%)	70/92 (76%)	6/9 (67%)

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	Total	^{1}H	^{13}C	^{15}N
Aromatic	34/75 (45%)	34/39 (87%)	0/32 (0%)	0/4 (0%)
Overall	406/544 (75%)	258/272 (95%)	111/214 (52%)	37/58 (64%)

The following table shows the completeness of the chemical shift assignments for the full structure. The overall completeness is 75%, i.e. 457 atoms were assigned a chemical shift out of a possible 611. 5 out of 10 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	^{1}H	^{13}C	^{15}N
Backbone	178/253 (70%)	98/101 (97%)	46/102 (45%)	34/50 (68%)
Sidechain	245/283 (87%)	157/166 (95%)	82/107 (77%)	6/10 (60%)
Aromatic	34/75 (45%)	34/39 (87%)	0/32 (0%)	0/4 (0%)
Overall	457/611 (75%)	289/306 (94%)	128/241 (53%)	40/64 (62%)

6.1.4 Statistically unusual chemical shifts (i)

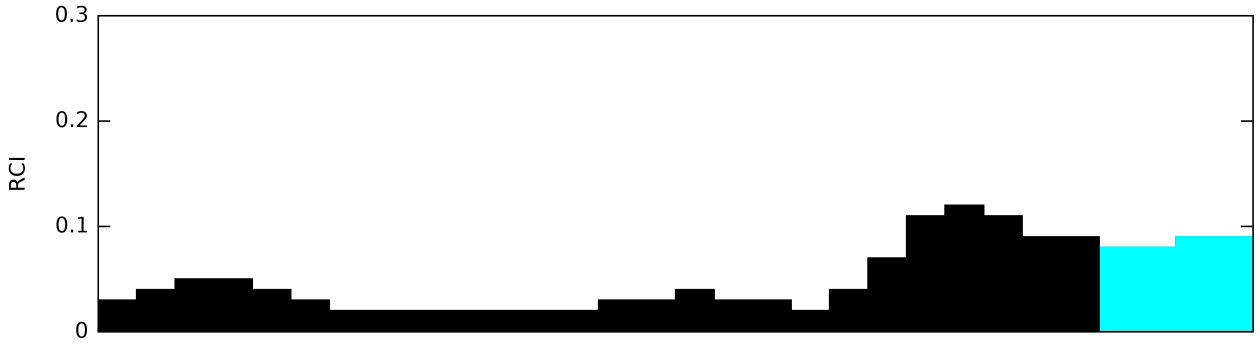
There are no statistically unusual chemical shifts.

6.1.5 Random Coil Index (RCI) plots (i)

The images below report *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:

Random coil index (RCI) for chain B:


0.3
0.2
0.1
0
RCI