wwPDB NMR Structure Validation Summary Report

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PDB ID	:	9FP9 / pdb_00009fp9
BMRB ID	:	34920
Title	:	Three-dimensional structure of the Merozoite surface protein 1 C-terminal domain
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Deposited on	:	2024-06-13

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 (i) 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 (1)) were used in the production of this report:

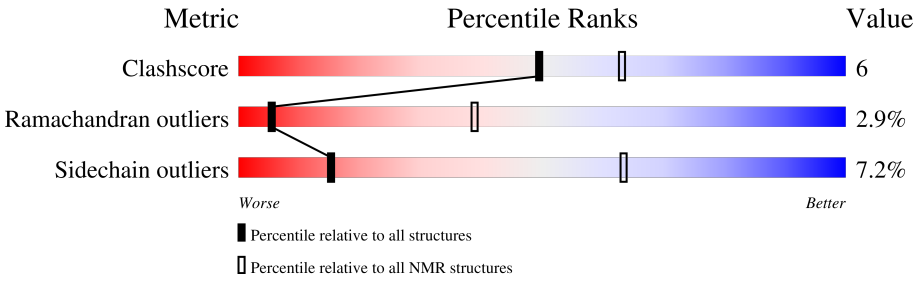
MolProbity	:	4-5-2 with Phenix2.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
wwPDB-RCI	:	v_1n_11_5_13_A (Berjanski et al., 2005)
PANAV	:	Wang et al. (2010)
wwPDB-ShiftChecker	:	v1.2
BMRB Restraints Analysis	:	v1.2
Ideal geometry (proteins)	:	Engh & Huber (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 90%.

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 <=5%

Mol	Chain	Length	Quality of chain
1	A	104	74% 11% • 14%

2 Ensemble composition and analysis

This entry contains 20 models. Model 9 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:16-A:104 (89)	0.86	9

Ill-defined regions of proteins are excluded from the global statistics.

Ligands and non-protein polymers are included in the analysis.

The models can be grouped into 2 clusters and 1 single-model cluster was found.

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

3 Entry composition (i)

There is only 1 type of molecule in this entry. The entry contains 1513 atoms, of which 722 are hydrogens and 0 are deuteriums.

- Molecule 1 is a protein called Merozoite surface protein 1.

Mol	Chain	Residues	Atoms						Trace
			Total	C	H	N	O	S	
1	A	104	1513	475	722	141	162	13	0

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	1	MET	LEU	engineered mutation	UNP A0A1C6YE36
A	104	GLY	SER	engineered mutation	UNP A0A1C6YE36

4 Residue-property plots

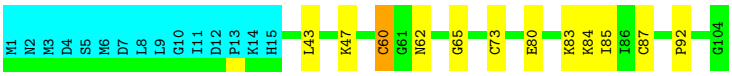
4.1 Average score per residue in the NMR ensemble

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: Merozoite surface protein 1

Chain A:





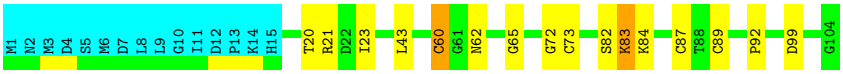
4.2 Residue scores for the representative (medoid) model from the NMR ensemble

The representative model is number 9. Colouring as in section 4.1 above.

- Molecule 1: Merozoite surface protein 1

Chain A:





5 Refinement protocol and experimental data overview

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

Of the 100 calculated structures, 20 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
ARTINA	structure calculation	
CYANA	refinement	3.98.15
X-PLOR NIH	refinement	

The following table shows chemical shift validation statistics as aggregates over all chemical shift files. Detailed validation can be found in section 7 of this report.

Chemical shift file(s)	working_cs.cif
Number of chemical shift lists	1
Total number of shifts	1142
Number of shifts mapped to atoms	1142
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	90%

6 Model quality

6.1 Standard geometry

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	0.69±0.02	0±0/687 (0.0± 0.0%)	0.78±0.02	0±0/931 (0.0± 0.0%)
All	All	0.69	0/13740 (0.0%)	0.78	2/18620 (0.0%)

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(^{o})	Ideal(^{o})	Models	
								Worst	Total
1	A	91	GLU	CA-C-N	5.38	126.57	119.84	5	1
1	A	91	GLU	C-N-CA	5.38	126.57	119.84	5	1

There are no chirality outliers.

There are no planarity outliers.

6.2 Too-close contacts

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in each chain respectively. The H(added) column lists the number of hydrogen atoms added and optimized by MolProbity. The Clashes column lists the number of clashes averaged over the ensemble.

Mol	Chain	Non-H	H(model)	H(added)	Clashes
1	A	675	610	610	7±2
All	All	13500	12200	12200	146

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 6.

5 of 52 unique clashes are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:60:CYS:O	1:A:65:GLY:HA2	0.70	1.86	19	20
1:A:83:LYS:HD3	1:A:83:LYS:O	0.65	1.92	15	2
1:A:43:LEU:HB3	1:A:65:GLY:O	0.61	1.96	8	2
1:A:82:SER:O	1:A:83:LYS:HB2	0.58	1.96	6	9
1:A:72:GLY:O	1:A:87:CYS:HA	0.57	1.99	16	6

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	88/104 (85%)	80±1 (91±2%)	6±2 (6±2%)	3±1 (3±1%)	5	39
All	All	1760/2080 (85%)	1599 (91%)	110 (6%)	51 (3%)	5	39

All 4 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	92	PRO	20
1	A	83	LYS	15
1	A	84	LYS	9
1	A	61	GLY	7

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	75/89 (84%)	70±2 (93±3%)	5±2 (7±3%)	15	63
All	All	1500/1780 (84%)	1392 (93%)	108 (7%)	15	63

5 of 21 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	73	CYS	17
1	A	60	CYS	14
1	A	47	LYS	12
1	A	18	ILE	8
1	A	89	CYS	8

6.3.3 RNA

There are no RNA molecules in this entry.

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

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

6.5 Carbohydrates

There are no oligosaccharides in this entry.

6.6 Ligand geometry

There are no ligands in this entry.

6.7 Other polymers

There are no such molecules in this entry.

6.8 Polymer linkage issues

There are no chain breaks in this entry.

7 Chemical shift validation

The completeness of assignment taking into account all chemical shift lists is 90% for the well-defined parts and 88% 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

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	1142
Number of shifts mapped to atoms	1142
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	3

7.1.2 Chemical shift referencing

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction ± precision, *ppm*	Suggested action
$^{13}C_{\alpha}$	98	0.12 ± 0.27	None needed (< 0.5 ppm)
$^{13}C_{\beta}$	91	-0.21 ± 0.30	None needed (< 0.5 ppm)
$^{13}C'$	99	0.08 ± 0.14	None needed (< 0.5 ppm)
^{15}N	94	-0.08 ± 0.18	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 90%, i.e. 980 atoms were assigned a chemical shift out of a possible 1094. 0 out of 4 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	^{1}H	^{13}C	^{15}N
Backbone	430/444 (97%)	179/182 (98%)	169/178 (95%)	82/84 (98%)
Sidechain	504/582 (87%)	332/368 (90%)	157/182 (86%)	15/32 (47%)

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	Total	^{1}H	^{13}C	^{15}N
Aromatic	46/68 (68%)	24/32 (75%)	21/35 (60%)	1/1 (100%)
Overall	980/1094 (90%)	535/582 (92%)	347/395 (88%)	98/117 (84%)

7.1.4 Statistically unusual chemical shifts (i)

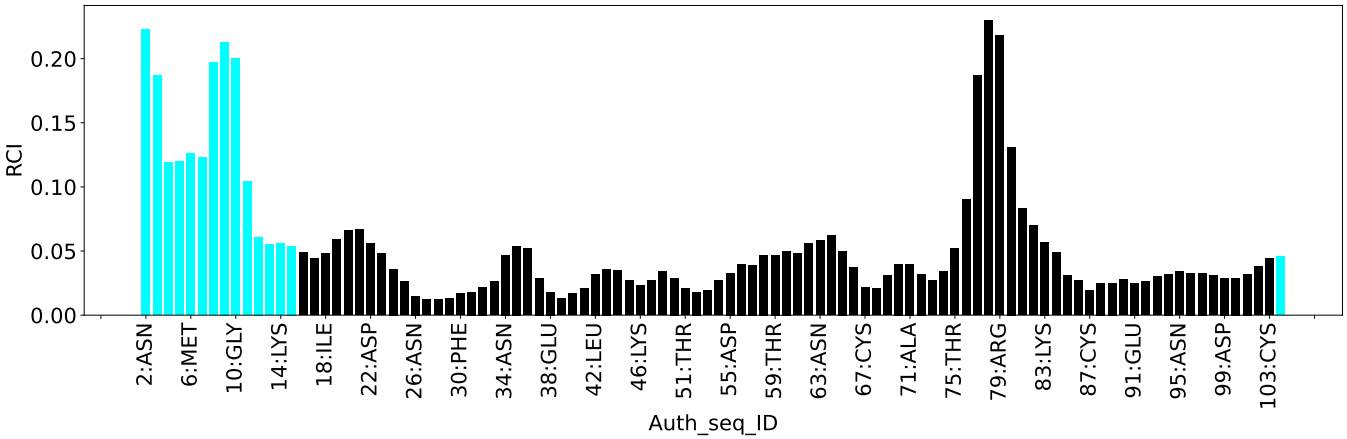
The following table lists the statistically unusual chemical shifts. These are statistical measures, and large deviations from the mean do not necessarily imply incorrect assignments. Molecules containing paramagnetic centres or hemes are expected to give rise to anomalous chemical shifts.

List Id	Chain	Res	Type	Atom	Shift, *ppm*	Expected range, *ppm*	Z-score
1	A	24	PRO	HD2	1.45	1.93 – 5.38	-6.4
1	A	30	PHE	HB2	0.82	1.20 – 4.80	-6.0
1	A	26	ASN	HB2	1.00	1.27 – 4.34	-5.9

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:



8 NMR restraints analysis

8.1 Conformationally restricting restraints

The following table provides the summary of experimentally observed NMR restraints in different categories. Restraints are classified into different categories based on the sequence separation of the atoms involved.

Description	Value
Total distance restraints	1086
Intra-residue (|i-j|=0)	328
Sequential (|i-j|=1)	310
Medium range (|i-j|>1 and |i-j|<5)	173
Long range (|i-j|≥5)	275
Inter-chain	0
Hydrogen bond restraints	0
Disulfide bond restraints	0
Total dihedral-angle restraints	142
Number of unmapped restraints	0
Number of restraints per residue	11.8
Number of long range restraints per residue[1]	2.6

[1]Long range hydrogen bonds and disulfide bonds are counted as long range restraints while calculating the number of long range restraints per residue

8.2 Residual restraint violations

This section provides the overview of the restraint violations analysis. The violations are binned as small, medium and large violations based on its absolute value. Average number of violations per model is calculated by dividing the total number of violations in each bin by the size of the ensemble.

8.2.1 Average number of distance violations per model

Distance violations less than 0.1 Å
are not included in the calculation.

Bins (Å)	Average number of violations per model	Max (Å)
0.1-0.2 (Small)	26.4	0.2
0.2-0.5 (Medium)	9.7	0.49
>0.5 (Large)	None	None

8.2.2 Average number of dihedral-angle violations per model (i)

Dihedral-angle violations less than 1° are not included in the calculation.

Bins (°)	Average number of violations per model	Max (°)
1.0-10.0 (Small)	21.9	5.23
10.0-20.0 (Medium)	None	None
>20.0 (Large)	None	None

9 Distance violation analysis (i)

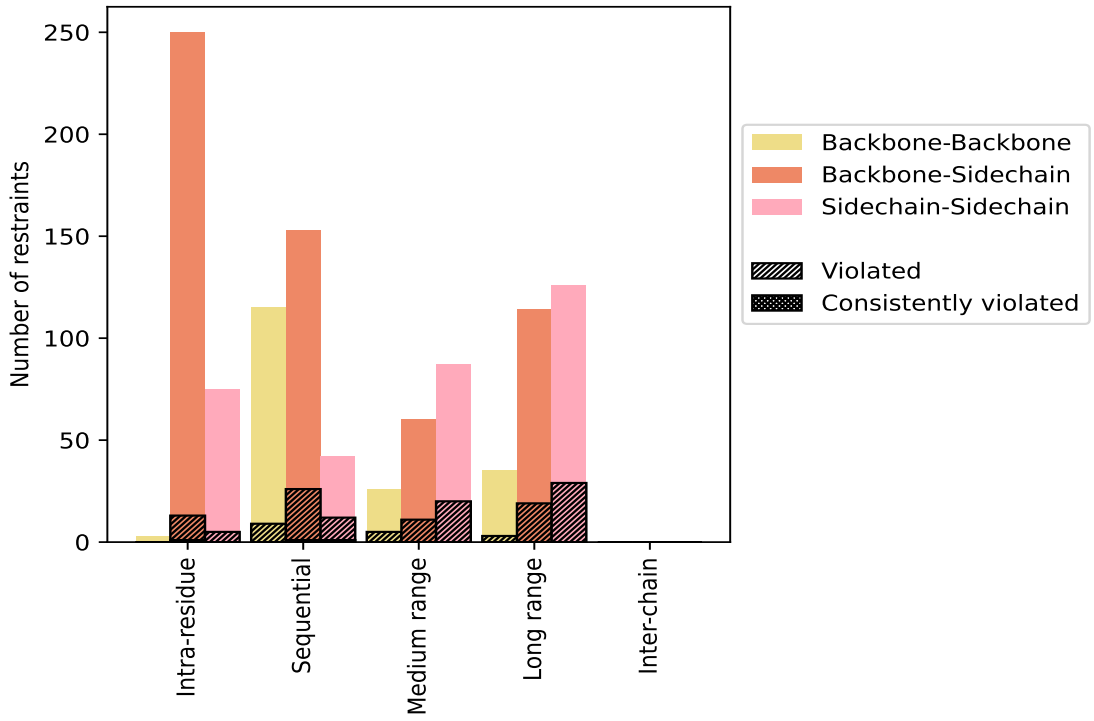
9.1 Summary of distance violations (i)

The following table shows the summary of distance violations in different restraint categories based on the sequence separation of the atoms involved. Each category is further sub-divided into three sub-categories based on the atoms involved. Violations less than 0.1 Å are not included in the statistics.

Restraints type	Count	%[1]	Violated[3]			Consistently Violated[4]		
			Count	%[2]	%[1]	Count	%[2]	%[1]
Intra-residue (|i-j|=0)	328	30.2	18	5.5	1.7	1	0.3	0.1
Backbone-Backbone	3	0.3	0	0.0	0.0	0	0.0	0.0
Backbone-Sidechain	250	23.0	13	5.2	1.2	1	0.4	0.1
Sidechain-Sidechain	75	6.9	5	6.7	0.5	0	0.0	0.0
Sequential (|i-j|=1)	310	28.5	47	15.2	4.3	2	0.6	0.2
Backbone-Backbone	115	10.6	9	7.8	0.8	0	0.0	0.0
Backbone-Sidechain	153	14.1	26	17.0	2.4	1	0.7	0.1
Sidechain-Sidechain	42	3.9	12	28.6	1.1	1	2.4	0.1
Medium range (|i-j|>1 & |i-j|<5)	173	15.9	36	20.8	3.3	0	0.0	0.0
Backbone-Backbone	26	2.4	5	19.2	0.5	0	0.0	0.0
Backbone-Sidechain	60	5.5	11	18.3	1.0	0	0.0	0.0
Sidechain-Sidechain	87	8.0	20	23.0	1.8	0	0.0	0.0
Long range (|i-j|≥5)	275	25.3	51	18.5	4.7	0	0.0	0.0
Backbone-Backbone	35	3.2	3	8.6	0.3	0	0.0	0.0
Backbone-Sidechain	114	10.5	19	16.7	1.7	0	0.0	0.0
Sidechain-Sidechain	126	11.6	29	23.0	2.7	0	0.0	0.0
Inter-chain	0	0.0	0	0.0	0.0	0	0.0	0.0
Backbone-Backbone	0	0.0	0	0.0	0.0	0	0.0	0.0
Backbone-Sidechain	0	0.0	0	0.0	0.0	0	0.0	0.0
Sidechain-Sidechain	0	0.0	0	0.0	0.0	0	0.0	0.0
Hydrogen bond	0	0.0	0	0.0	0.0	0	0.0	0.0
Disulfide bond	0	0.0	0	0.0	0.0	0	0.0	0.0
Total	1086	100.0	152	14.0	14.0	3	0.3	0.3
Backbone-Backbone	179	16.5	17	9.5	1.6	0	0.0	0.0
Backbone-Sidechain	577	53.1	69	12.0	6.4	2	0.3	0.2
Sidechain-Sidechain	330	30.4	66	20.0	6.1	1	0.3	0.1

[1] percentage calculated with respect to the total number of distance restraints, [2] percentage calculated with respect to the number of restraints in a particular restraint category, [3] violated in at least one model, [4] violated in all the models

9.1.1 Bar chart : Distribution of distance restraints and violations



Violated and consistently violated restraints are shown using different hatch patterns in their respective categories. The hydrogen bonds and disulfied bonds are counted in their appropriate category on the x-axis

9.2 Distance violation statistics for each model

The following table provides the distance violation statistics for each model in the ensemble. Violations less than 0.1 Å
are not included in the statistics.

Model ID	Number of violations						Mean (Å)	Max (Å)	SD[6] (Å)	Median (Å)
	IR[1]	SQ[2]	MR[3]	LR[4]	IC[5]	Total				
1	5	15	10	15	0	45	0.17	0.36	0.06	0.15
2	4	16	8	6	0	34	0.17	0.35	0.07	0.14
3	5	13	12	8	0	38	0.15	0.36	0.05	0.13
4	7	16	10	10	0	43	0.18	0.41	0.07	0.16
5	5	12	12	8	0	37	0.19	0.33	0.07	0.17
6	5	17	8	9	0	39	0.17	0.42	0.08	0.15
7	5	16	7	11	0	39	0.17	0.38	0.07	0.14
8	8	18	9	7	0	42	0.18	0.34	0.06	0.16
9	7	16	8	10	0	41	0.17	0.34	0.06	0.14
10	3	17	11	10	0	41	0.16	0.36	0.06	0.14

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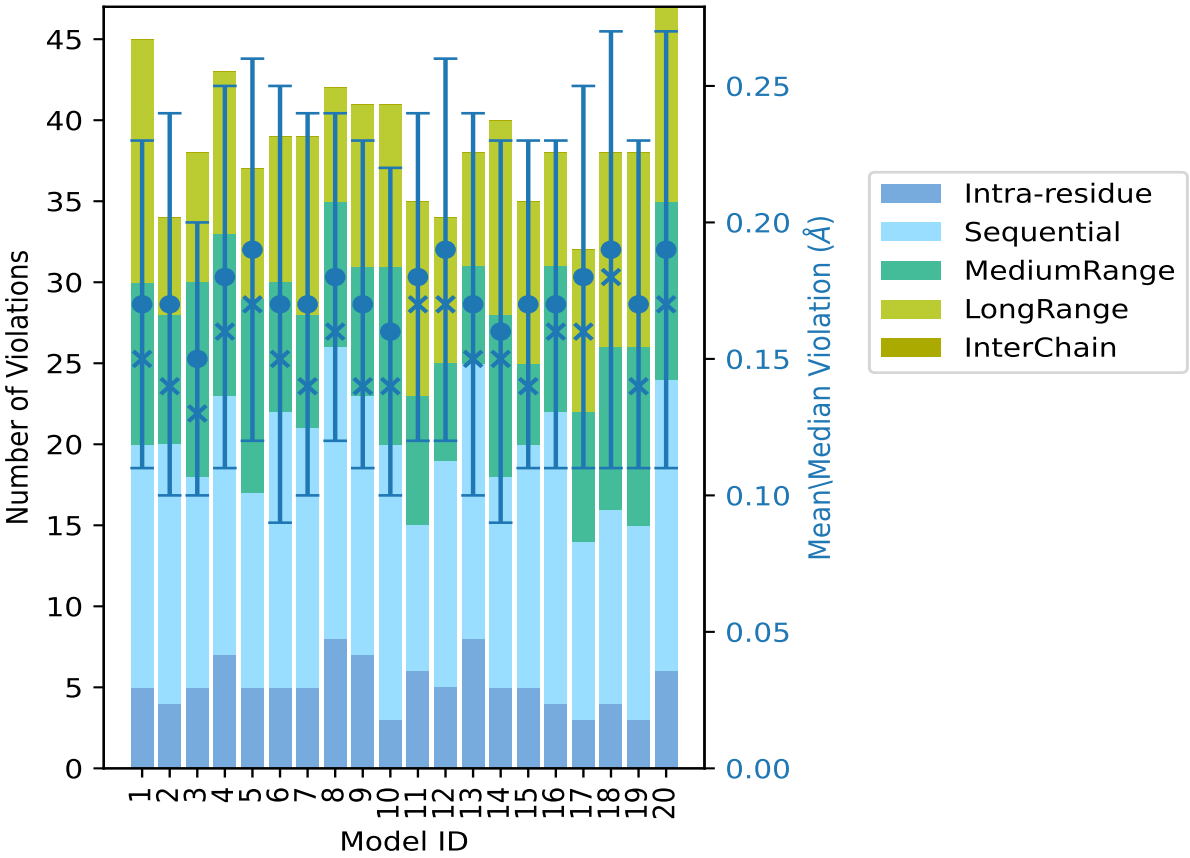
Model ID	Number of violations						Mean (Å)	Max (Å)	SD[6] (Å)	Median (Å)
	IR[1]	SQ[2]	MR[3]	LR[4]	IC[5]	Total				
11	6	9	8	12	0	35	0.18	0.35	0.06	0.17
12	5	14	6	9	0	34	0.19	0.35	0.07	0.17
13	8	17	6	7	0	38	0.17	0.37	0.07	0.15
14	5	13	10	12	0	40	0.16	0.42	0.07	0.15
15	5	15	5	10	0	35	0.17	0.33	0.06	0.14
16	4	18	9	7	0	38	0.17	0.37	0.06	0.16
17	3	11	8	10	0	32	0.18	0.43	0.07	0.16
18	4	12	10	12	0	38	0.19	0.49	0.08	0.18
19	3	12	11	12	0	38	0.17	0.34	0.06	0.14
20	6	18	11	12	0	47	0.19	0.46	0.08	0.17

[1]Intra-residue restraints, [2]Sequential restraints, [3]Medium range restraints, [4]Long range restraints, [5]Inter-chain restraints, [6]Standard deviation

9.2.1 Bar graph : Distance Violation statistics for each model



The mean(dot),median(x) and the standard deviation are shown in blue with respect to the y axis on the right

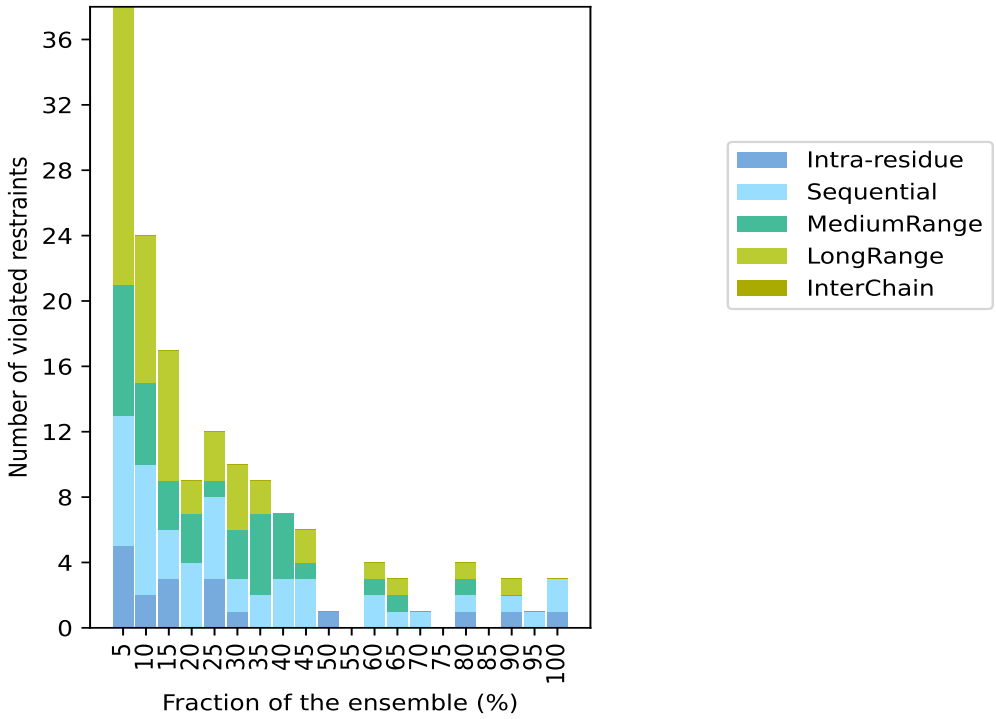
9.3 Distance violation statistics for the ensemble (i)

Violation analysis may find that some restraints are violated in few models and some are violated in most of models. The following table provides this information as number of violated restraints for a given fraction of the ensemble. In total, 934(IR:310, SQ:263, MR:137, LR:224, IC:0) restraints are not violated in the ensemble.

Number of violated restraints						Fraction of the ensemble	
IR[1]	SQ[2]	MR[3]	LR[4]	IC[5]	Total	Count[6]	%
5	8	8	17	0	38	1	5.0
2	8	5	9	0	24	2	10.0
3	3	3	8	0	17	3	15.0
0	4	3	2	0	9	4	20.0
3	5	1	3	0	12	5	25.0
1	2	3	4	0	10	6	30.0
0	2	5	2	0	9	7	35.0
0	3	4	0	0	7	8	40.0
0	3	1	2	0	6	9	45.0
1	0	0	0	0	1	10	50.0
0	0	0	0	0	0	11	55.0
0	2	1	1	0	4	12	60.0
0	1	1	1	0	3	13	65.0
0	1	0	0	0	1	14	70.0
0	0	0	0	0	0	15	75.0
1	1	1	1	0	4	16	80.0
0	0	0	0	0	0	17	85.0
1	1	0	1	0	3	18	90.0
0	1	0	0	0	1	19	95.0
1	2	0	0	0	3	20	100.0

[1]Intra-residue restraints, [2]Sequential restraints, [3]Medium range restraints, [4]Long range restraints, [5]Inter-chain restraints, [6] Number of models with violations

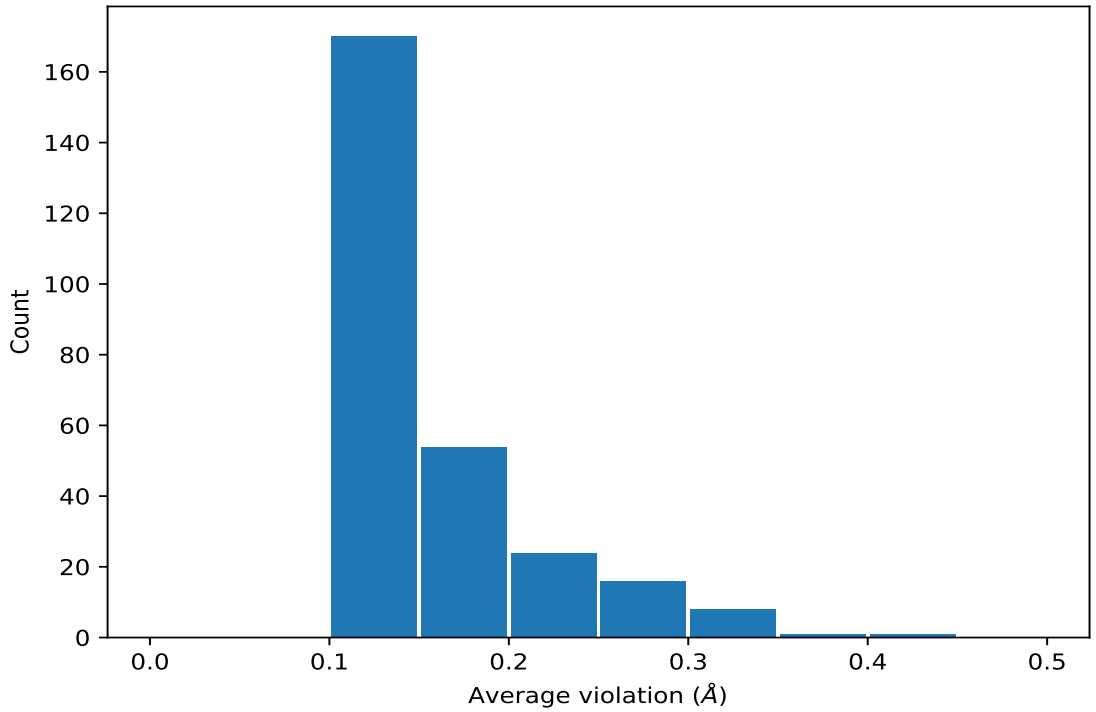
9.3.1 Bar graph : Distance violation statistics for the ensemble



9.4 Most violated distance restraints in the ensemble

9.4.1 Histogram : Distribution of mean distance violations

The following histogram shows the distribution of the average value of the violation. The average is calculated for each restraint that is violated in more than one model over all the violated models in the ensemble



9.4.2 Table: Most violated distance restraints

The following table provides the mean and the standard deviation of the violations for the 10 worst performing restraints, sorted by number of violated models and the mean violation value. The Key (restraint list ID, restraint ID) is the unique identifier for a given restraint. Rows with same key represent combinatorial or ambiguous restraints and are counted as a single restraint.

Key	Atom-1	Atom-2	Models[1]	Mean (Å)	SD[1] (Å)	Median (Å)
(1,315)	1:46:A:LYS:HD3	1:47:A:LYS:HA	20	0.25	0.05	0.24
(1,168)	1:92:A:PRO:HG2	1:93:A:THR:HG21	20	0.25	0.05	0.24
(1,168)	1:92:A:PRO:HG2	1:93:A:THR:HG22	20	0.25	0.05	0.24
(1,168)	1:92:A:PRO:HG2	1:93:A:THR:HG23	20	0.25	0.05	0.24
(1,168)	1:92:A:PRO:HG3	1:93:A:THR:HG21	20	0.25	0.05	0.24
(1,168)	1:92:A:PRO:HG3	1:93:A:THR:HG22	20	0.25	0.05	0.24
(1,168)	1:92:A:PRO:HG3	1:93:A:THR:HG23	20	0.25	0.05	0.24
(1,693)	1:30:A:PHE:H	1:30:A:PHE:HZ	20	0.2	0.04	0.2
(1,1077)	1:91:A:GLU:HB2	1:92:A:PRO:HA	19	0.15	0.03	0.15
(1,1077)	1:91:A:GLU:HB3	1:92:A:PRO:HA	19	0.15	0.03	0.15
(1,1017)	1:68:A:ASP:HB2	1:69:A:PRO:HG2	18	0.32	0.07	0.34
(1,1017)	1:68:A:ASP:HB2	1:69:A:PRO:HG3	18	0.32	0.07	0.34
(1,1017)	1:68:A:ASP:HB3	1:69:A:PRO:HG2	18	0.32	0.07	0.34
(1,1017)	1:68:A:ASP:HB3	1:69:A:PRO:HG3	18	0.32	0.07	0.34
(1,91)	1:65:A:GLY:HA3	1:85:A:ILE:HD11	18	0.17	0.05	0.18
(1,91)	1:65:A:GLY:HA3	1:85:A:ILE:HD12	18	0.17	0.05	0.18

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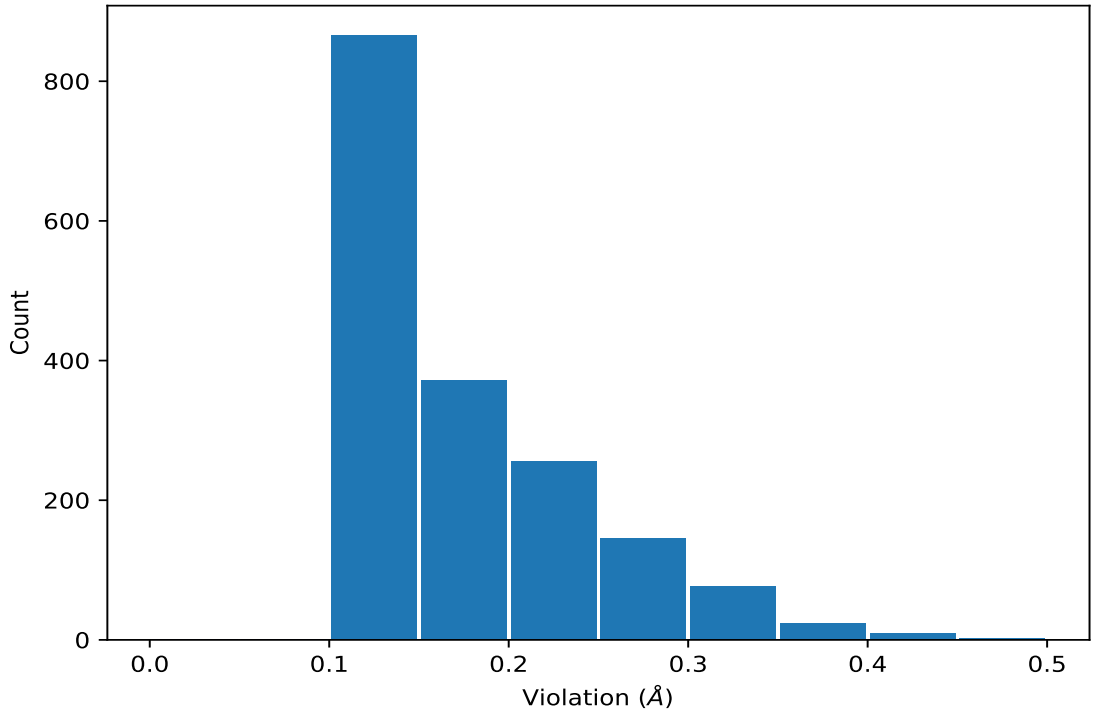
Key	Atom-1	Atom-2	Models[1]	Mean (Å)	SD[1] (Å)	Median (Å)
(1,91)	1:65:A:GLY:HA3	1:85:A:ILE:HD13	18	0.17	0.05	0.18
(1,814)	1:11:A:ILE:HA	1:11:A:ILE:HD11	18	0.16	0.03	0.16
(1,814)	1:11:A:ILE:HA	1:11:A:ILE:HD12	18	0.16	0.03	0.16
(1,814)	1:11:A:ILE:HA	1:11:A:ILE:HD13	18	0.16	0.03	0.16
(1,297)	1:46:A:LYS:HA	1:46:A:LYS:HD3	16	0.2	0.04	0.2
(1,287)	1:11:A:ILE:HG12	1:14:A:LYS:HD2	16	0.15	0.04	0.15
(1,287)	1:11:A:ILE:HG12	1:14:A:LYS:HD3	16	0.15	0.04	0.15
(1,261)	1:45:A:TYR:HE1	1:54:A:GLU:HA	16	0.15	0.03	0.15

[1]Number of violated models, [2]Standard deviation

9.5 All violated distance restraints (i)

9.5.1 Histogram : Distribution of distance violations (i)

The following histogram shows the distribution of the absolute value of the violation for all violated restraints in the ensemble.



9.5.2 Table : All distance violations (i)

The following table provides the 10 worst performing restraints, sorted by the violation value. The Key (restraint list ID, restraint ID) is the unique identifier for a given restraint. Rows with same key represent combinatorial or ambiguous restraints and are counted as a single restraint.

Key	Atom-1	Atom-2	Model ID	Violation (Å)
(1,687)	1:9:A:LEU:H	1:10:A:GLY:H	18	0.49
(1,640)	1:6:A:MET:HA	1:7:A:ASP:H	20	0.46
(1,1070)	1:90:A:LYS:HA	1:90:A:LYS:HD2	17	0.43
(1,1070)	1:90:A:LYS:HA	1:90:A:LYS:HD3	17	0.43
(1,1017)	1:68:A:ASP:HB2	1:69:A:PRO:HG2	14	0.42
(1,1017)	1:68:A:ASP:HB2	1:69:A:PRO:HG3	14	0.42
(1,1017)	1:68:A:ASP:HB3	1:69:A:PRO:HG2	14	0.42
(1,1017)	1:68:A:ASP:HB3	1:69:A:PRO:HG3	14	0.42
(1,640)	1:6:A:MET:HA	1:7:A:ASP:H	6	0.42
(1,1070)	1:90:A:LYS:HA	1:90:A:LYS:HD2	4	0.41
(1,1070)	1:90:A:LYS:HA	1:90:A:LYS:HD3	4	0.41
(1,794)	1:12:A:ASP:HA	1:13:A:PRO:HB3	18	0.4
(1,1017)	1:68:A:ASP:HB2	1:69:A:PRO:HG2	6	0.38
(1,1017)	1:68:A:ASP:HB2	1:69:A:PRO:HG3	6	0.38
(1,1017)	1:68:A:ASP:HB3	1:69:A:PRO:HG2	6	0.38
(1,1017)	1:68:A:ASP:HB3	1:69:A:PRO:HG3	6	0.38
(1,1017)	1:68:A:ASP:HB2	1:69:A:PRO:HG2	7	0.38
(1,1017)	1:68:A:ASP:HB2	1:69:A:PRO:HG3	7	0.38
(1,1017)	1:68:A:ASP:HB3	1:69:A:PRO:HG2	7	0.38
(1,1017)	1:68:A:ASP:HB3	1:69:A:PRO:HG3	7	0.38
(1,1017)	1:68:A:ASP:HB2	1:69:A:PRO:HG2	16	0.37

10 Dihedral-angle violation analysis

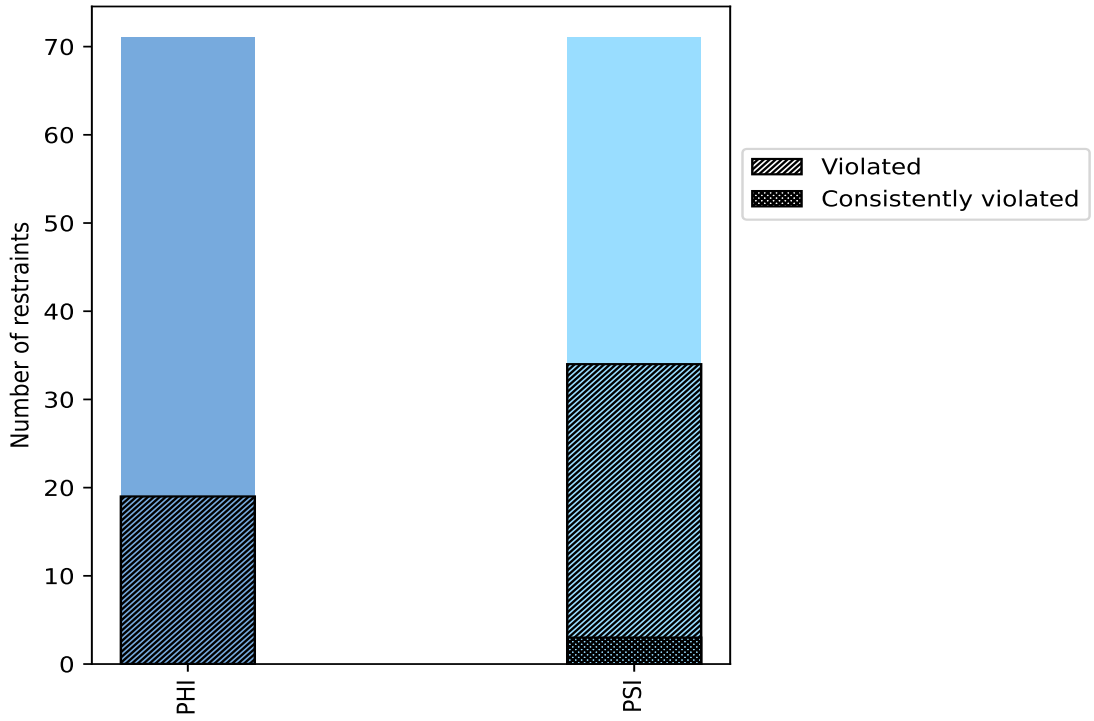
10.1 Summary of dihedral-angle violations

The following table provides the summary of dihedral-angle violations in different dihedral-angle types. Violations less than 1° are not included in the calculation.

Angle type	Count	%[1]	Violated[3]			Consistently Violated[4]		
			Count	%[2]	%[1]	Count	%[2]	%[1]
PHI	71	50.0	19	26.8	13.4	0	0.0	0.0
PSI	71	50.0	34	47.9	23.9	3	4.2	2.1
Total	142	100.0	53	37.3	37.3	3	2.1	2.1

[1] percentage calculated with respect to total number of dihedral-angle restraints, [2] percentage calculated with respect to number of restraints in a particular dihedral-angle type, [3] violated in at least one model, [4] violated in all the models

10.1.1 Bar chart : Distribution of dihedral-angles and violations



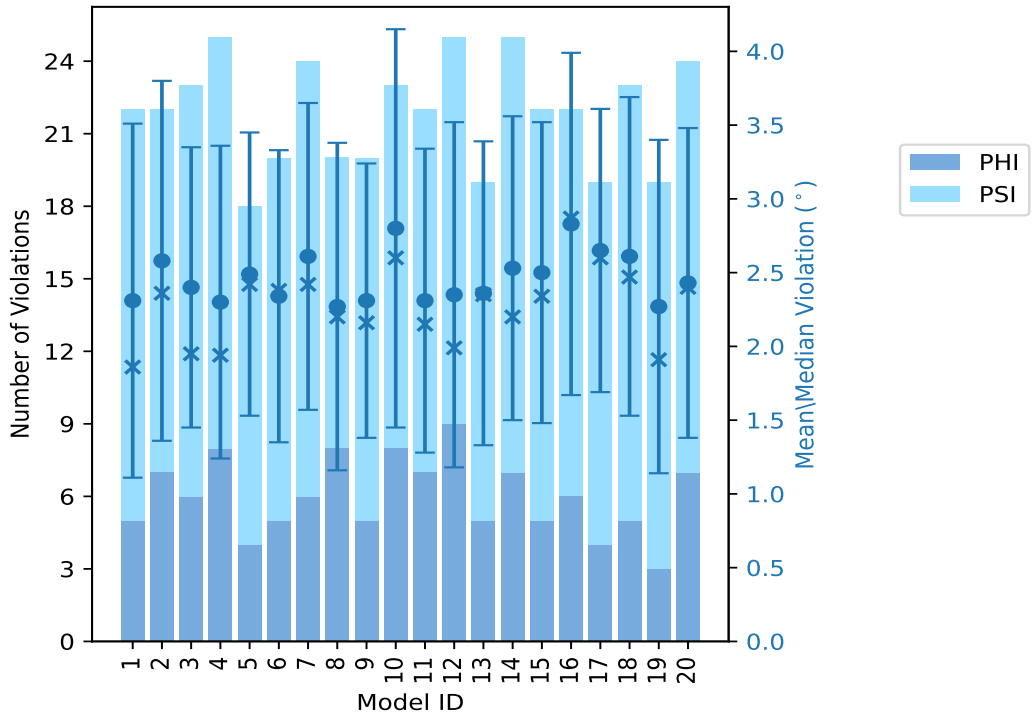
Violated and consistently violated restraints are shown using different hatch patterns in their respective categories

10.2 Dihedral-angle violation statistics for each model (i)

The following table provides the dihedral-angle violation statistics for each model in the ensemble. Violations less than 1° are not included in the statistics.

Model ID	Number of violations			Mean (°)	Max (°)	SD (°)	Median (°)
	PHI	PSI	Total				
1	5	17	22	2.31	4.97	1.2	1.86
2	7	15	22	2.58	5.17	1.22	2.36
3	6	17	23	2.4	4.79	0.95	1.95
4	8	17	25	2.3	5.12	1.06	1.94
5	4	14	18	2.49	4.33	0.96	2.42
6	5	15	20	2.34	4.98	0.99	2.38
7	6	18	24	2.61	4.8	1.04	2.42
8	8	12	20	2.27	4.54	1.11	2.2
9	5	15	20	2.31	4.62	0.93	2.16
10	8	15	23	2.8	5.23	1.35	2.6
11	7	15	22	2.31	5.17	1.03	2.15
12	9	16	25	2.35	4.58	1.17	1.99
13	5	14	19	2.36	5.05	1.03	2.35
14	7	18	25	2.53	4.77	1.03	2.2
15	5	17	22	2.5	3.98	1.02	2.34
16	6	16	22	2.83	4.91	1.16	2.87
17	4	15	19	2.65	4.54	0.96	2.6
18	5	18	23	2.61	4.63	1.08	2.47
19	3	16	19	2.27	5.04	1.13	1.91
20	7	17	24	2.43	5.02	1.05	2.4

10.2.1 Bar graph : Dihedral violation statistics for each model



The mean(dot),median(x) and the standard deviation are shown in blue with respect to the y axis on the right

10.3 Dihedral-angle violation statistics for the ensemble

Violation analysis may find that some restraints are violated in very few models and some are violated in most of models. The following table provides this information as number of violated restraints for a given fraction of ensemble.

Number of violated restraints			Fraction of the ensemble	
PHI	PSI	Total	Count[1]	%
4	5	9	1	5.0
5	3	8	2	10.0
1	2	3	3	15.0
0	3	3	4	20.0
0	1	1	5	25.0
0	3	3	6	30.0
3	1	4	7	35.0
1	1	2	8	40.0
0	1	1	9	45.0
1	1	2	10	50.0
0	0	0	11	55.0

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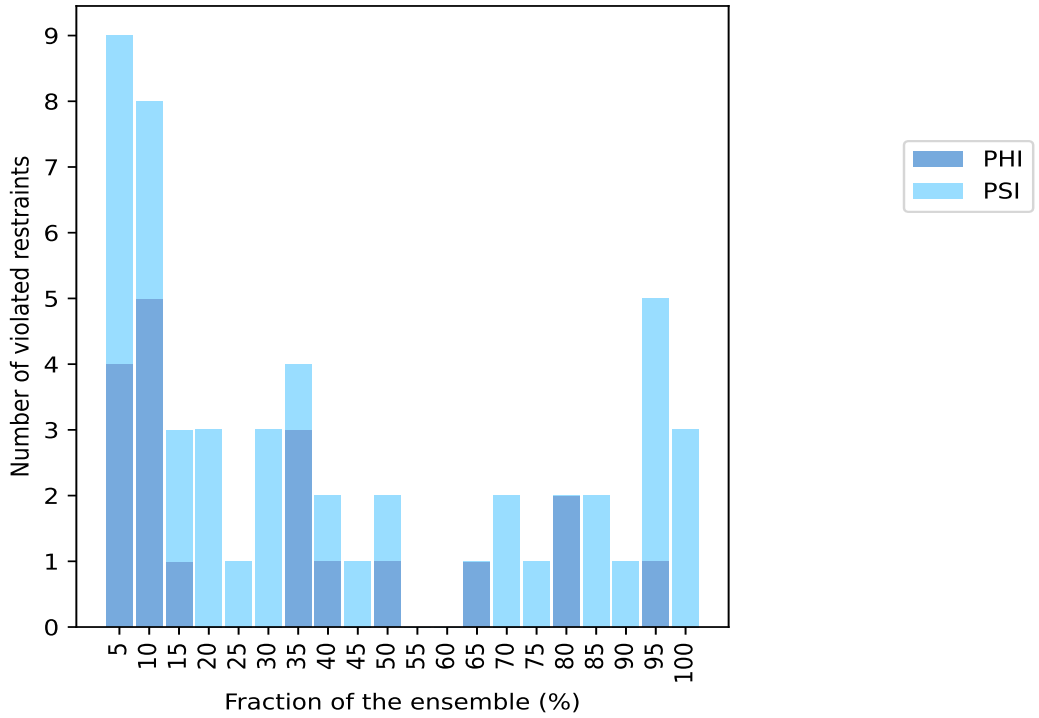
Number of violated restraints			Fraction of the ensemble	
PHI	PSI	Total	Count[1]	%
0	0	0	12	60.0
1	0	1	13	65.0
0	2	2	14	70.0
0	1	1	15	75.0
2	0	2	16	80.0
0	2	2	17	85.0
0	1	1	18	90.0
1	4	5	19	95.0
0	3	3	20	100.0

[1] Number of models with violations

10.3.1 Bar graph : Dihedral-angle Violation statistics for the ensemble

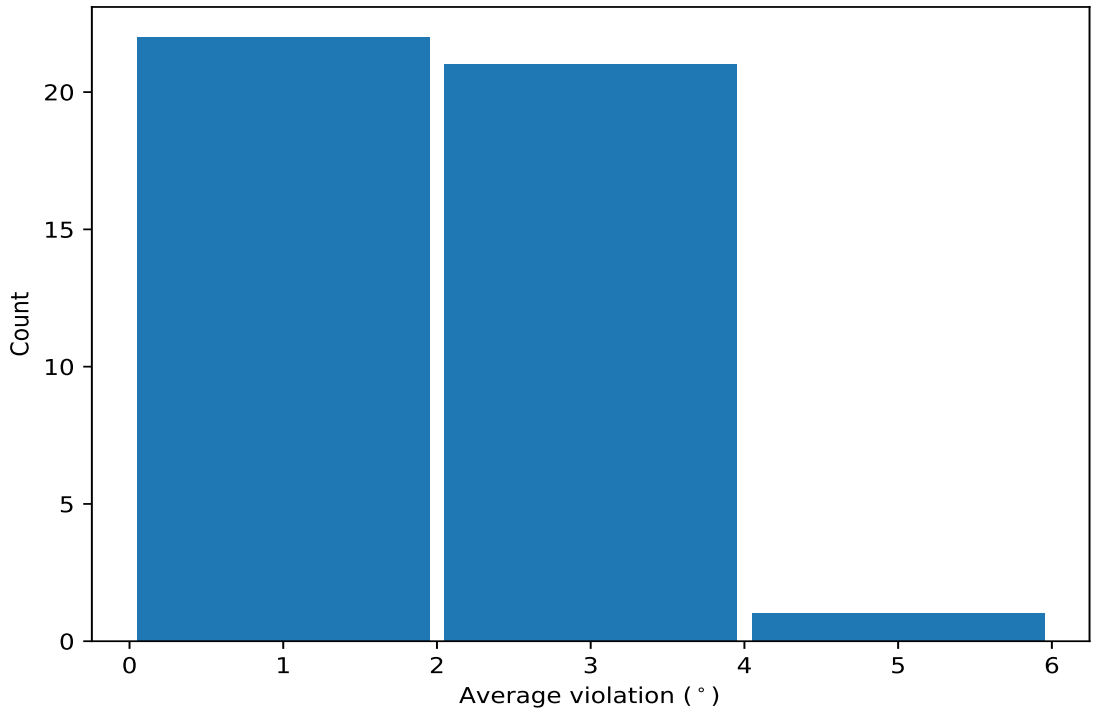


10.4 Most violated dihedral-angle restraints in the ensemble

10.4.1 Histogram : Distribution of mean dihedral-angle violations

The following histogram shows the distribution of the average value of the violation. The average is calculated for each restraint that is violated in more than one model over all the violated models

in the ensemble



10.4.2 Table: Most violated dihedral-angle restraints

The following table provides the mean and the standard deviation of the violations for the 10 worst performing restraints, sorted by number of violated models and the mean violation value. The Key (restraint list ID, restraint ID) is the unique identifier for a given restraint.

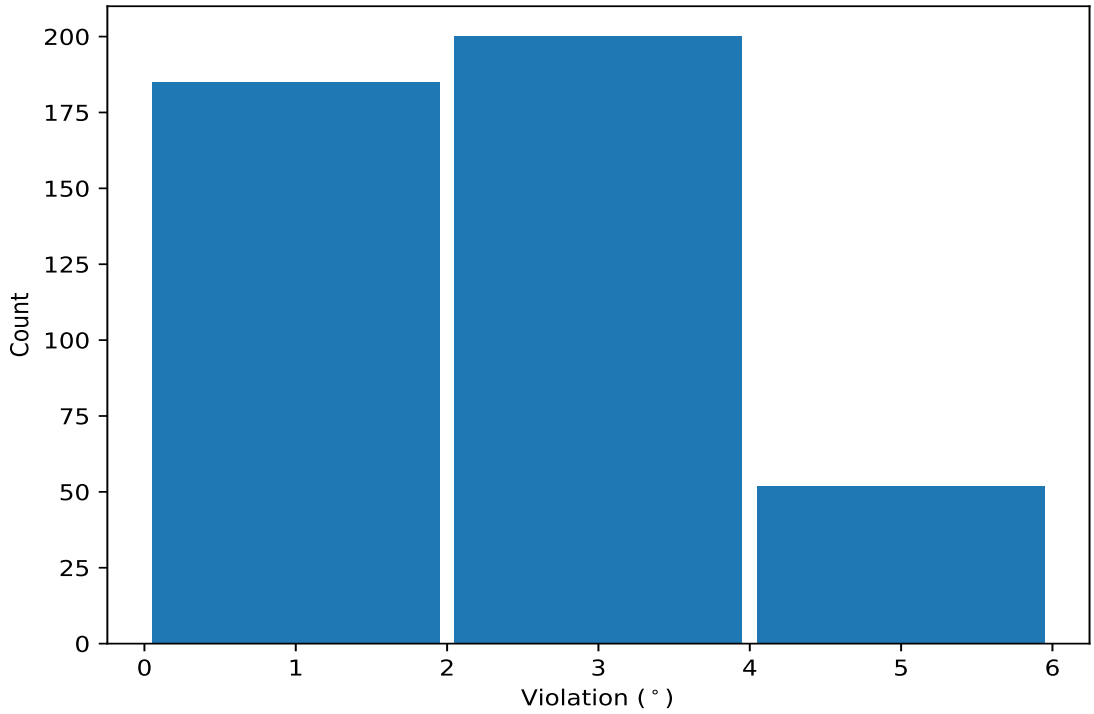
Key	Atom-1	Atom-2	Atom-3	Atom-4	Models[1]	Mean	SD[2]	Median
(1,78)	1:60:A:CYS:N	1:60:A:CYS:CA	1:60:A:CYS:C	1:61:A:GLY:N	20	4.08	0.71	4.26
(1,82)	1:62:A:ASN:N	1:62:A:ASN:CA	1:62:A:ASN:C	1:63:A:ASN:N	20	3.08	0.72	2.97
(1,80)	1:61:A:GLY:N	1:61:A:GLY:CA	1:61:A:GLY:C	1:62:A:ASN:N	20	2.54	0.74	2.5
(1,119)	1:89:A:CYS:C	1:90:A:LYS:N	1:90:A:LYS:CA	1:90:A:LYS:C	19	3.98	0.88	3.93
(1,118)	1:89:A:CYS:N	1:89:A:CYS:CA	1:89:A:CYS:C	1:90:A:LYS:N	19	3.49	0.73	3.46
(1,4)	1:12:A:ASP:N	1:12:A:ASP:CA	1:12:A:ASP:C	1:13:A:PRO:N	19	3.09	1.14	2.83
(1,14)	1:18:A:ILE:N	1:18:A:ILE:CA	1:18:A:ILE:C	1:19:A:ASN:N	19	2.54	0.94	2.37
(1,16)	1:19:A:ASN:N	1:19:A:ASN:CA	1:19:A:ASN:C	1:20:A:THR:N	19	2.53	0.93	2.25
(1,108)	1:82:A:SER:N	1:82:A:SER:CA	1:82:A:SER:C	1:83:A:LYS:N	18	2.73	0.83	2.62
(1,2)	1:11:A:ILE:N	1:11:A:ILE:CA	1:11:A:ILE:C	1:12:A:ASP:N	17	2.77	0.68	2.93

[1] Number of violated models, [2]Standard deviation, All angle values are in degree (°)

10.5 All violated dihedral-angle restraints

10.5.1 Histogram : Distribution of violations

The following histogram shows the distribution of the absolute value of the violation for all violated restraints in the ensemble.



10.5.2 Table: All violated dihedral-angle restraints

The following table provides the list of violations for the 10 worst performing restraints, sorted by the violation value. The Key (restraint list ID, restraint ID) is the unique identifier for a given restraint.

Key	Atom-1	Atom-2	Atom-3	Atom-4	Model ID	Violation (°)
(1,119)	1:89:A:CYS:C	1:90:A:LYS:N	1:90:A:LYS:CA	1:90:A:LYS:C	10	5.23
(1,118)	1:89:A:CYS:N	1:89:A:CYS:CA	1:89:A:CYS:C	1:90:A:LYS:N	11	5.17
(1,4)	1:12:A:ASP:N	1:12:A:ASP:CA	1:12:A:ASP:C	1:13:A:PRO:N	2	5.17
(1,119)	1:89:A:CYS:C	1:90:A:LYS:N	1:90:A:LYS:CA	1:90:A:LYS:C	4	5.12
(1,119)	1:89:A:CYS:C	1:90:A:LYS:N	1:90:A:LYS:CA	1:90:A:LYS:C	13	5.05
(1,78)	1:60:A:CYS:N	1:60:A:CYS:CA	1:60:A:CYS:C	1:61:A:GLY:N	19	5.04
(1,119)	1:89:A:CYS:C	1:90:A:LYS:N	1:90:A:LYS:CA	1:90:A:LYS:C	20	5.02
(1,78)	1:60:A:CYS:N	1:60:A:CYS:CA	1:60:A:CYS:C	1:61:A:GLY:N	6	4.98
(1,119)	1:89:A:CYS:C	1:90:A:LYS:N	1:90:A:LYS:CA	1:90:A:LYS:C	1	4.97
(1,119)	1:89:A:CYS:C	1:90:A:LYS:N	1:90:A:LYS:CA	1:90:A:LYS:C	11	4.95