



wwPDB NMR Structure Validation Summary Report ⓘ

Mar 5, 2026 – 11:02 AM UTC

PDB ID : 9ECQ / pdb_00009ecq
BMRB ID : 31216
Title : NMR solution structure of tRNA-Arg-UCU-4-1 anticodon stem loop with no chemical modifications
Authors : Berger, K.D.; Puthenpeedikakkal, A.M.K.; Matthews, D.H.; Fu, D.
Deposited on : 2024-11-15

This is a wwPDB NMR Structure Validation Summary Report for a publicly released PDB entry.

We welcome your comments at validation@mail.wwpdb.org

A user guide is available at

<https://www.wwpdb.org/validation/2017/NMRValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The types of validation reports are described at

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

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

MolProbity : 4-5-2 with Phenix2.0
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
wwPDB-RCI : v_1n_11_5_13_A (Berjanski et al., 2005)
PANAV : Wang et al. (2010)
wwPDB-ShiftChecker : v1.2
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

2 Ensemble composition and analysis

This entry contains 15 models. This entry does not contain polypeptide chains, therefore identification of well-defined residues and clustering analysis are not possible. All residues are included in the validation scores.

3 Entry composition [i](#)

There is only 1 type of molecule in this entry. The entry contains 538 atoms, of which 184 are hydrogens and 0 are deuteriums.

- Molecule 1 is a RNA chain called Neuronally expressed tRNA-Arg-UCU-4-1 anticodon stem-loop.

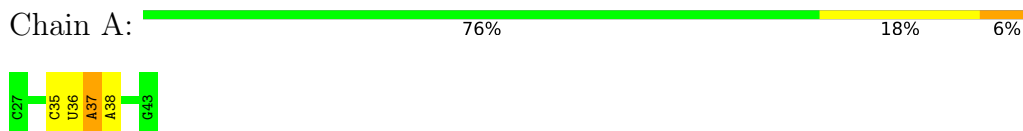
Mol	Chain	Residues	Atoms						Trace
			Total	C	H	N	O	P	
1	A	17	538	160	184	60	118	16	0

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.

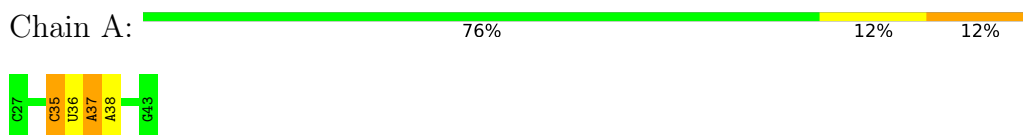
- Molecule 1: Neuronally expressed tRNA-Arg-UCU-4-1 anticodon stem-loop



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

The representative model is number 1. Colouring as in section 4.1 above.

- Molecule 1: Neuronally expressed tRNA-Arg-UCU-4-1 anticodon stem-loop



5 Refinement protocol and experimental data overview

The models were refined using the following method: *simulated annealing*.

Of the 300 calculated structures, 15 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
Amber	structure calculation	
Amber	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	127
Number of shifts mapped to atoms	127
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	39%

6 Model quality [i](#)

6.1 Standard geometry [i](#)

There are no covalent bond-length or bond-angle outliers.

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	1.7±0.8
All	All	0	26

There are no bond-length outliers.

There are no bond-angle outliers.

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	37	A	Sidechain	13
1	A	35	C	Sidechain	6
1	A	32	C	Sidechain	4
1	A	27	C	Sidechain	3

6.2 Too-close contacts [i](#)

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

Mol	Chain	Non-H	H(model)	H(added)	Clashes
All	All	5310	2760	2760	-

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 -.

There are no clashes.

6.3 Torsion angles [i](#)

6.3.1 Protein backbone [i](#)

There are no protein molecules in this entry.

6.3.2 Protein sidechains [i](#)

There are no protein molecules in this entry.

6.3.3 RNA [i](#)

Mol	Chain	Analysed	Backbone Outliers	Pucker Outliers	Suiteness
1	A	16/17 (94%)	4±0 (25±0%)	1±1 (7±5%)	0.44±0.00
All	All	240/255 (94%)	60 (25%)	16 (7%)	0.44

The overall RNA backbone suiteness is 0.42.

All unique RNA backbone outliers are listed below:

Mol	Chain	Res	Type	Models (Total)
1	A	35	C	15
1	A	36	U	15
1	A	37	A	15
1	A	38	A	15

All unique RNA pucker outliers are listed below:

Mol	Chain	Res	Type	Models (Total)
1	A	35	C	9
1	A	38	A	6
1	A	36	U	1

6.4 Non-standard residues in protein, DNA, RNA chains [i](#)

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

6.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.6 Ligand geometry [i](#)

There are no ligands in this entry.

6.7 Other polymers [i](#)

There are no such molecules in this entry.

6.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

7 Chemical shift validation [i](#)

The completeness of assignment taking into account all chemical shift lists is 39% for the well-defined parts and 39% for the entire structure.

7.1 Chemical shift list 1

File name: working_cs.cif

Chemical shift list name: *starch_output*

7.1.1 Bookkeeping [i](#)

The following table shows the results of parsing the chemical shift list and reports the number of nuclei with statistically unusual chemical shifts.

Total number of shifts	127
Number of shifts mapped to atoms	127
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	0

7.1.2 Chemical shift referencing [i](#)

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

7.1.3 Completeness of resonance assignments [i](#)

The following table shows the completeness of the chemical shift assignments for the well-defined regions of the structure. The overall completeness is 39%, i.e. 122 atoms were assigned a chemical shift out of a possible 316. 0 out of 0 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	¹ H	¹³ C	¹⁵ N
Sugar	84/187 (45%)	84/102 (82%)	0/85 (0%)	0/0 (—%)
Base	38/129 (29%)	38/78 (49%)	0/31 (0%)	0/20 (0%)
Overall	122/316 (39%)	122/180 (68%)	0/116 (0%)	0/20 (0%)

7.1.4 Statistically unusual chemical shifts [i](#)

There are no statistically unusual chemical shifts.

7.1.5 Random Coil Index (RCI) plots

No *random coil index*(RCI) plot could be generated from the current chemical shift list. RCI is only applicable to proteins

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	270
Intra-residue ($ i-j =0$)	164
Sequential ($ i-j =1$)	60
Medium range ($ i-j >1$ and $ i-j <5$)	8
Long range ($ i-j \geq 5$)	17
Inter-chain	0
Hydrogen bond restraints	21
Disulfide bond restraints	0
Total dihedral-angle restraints	74
Number of unmapped restraints	0
Number of restraints per residue	20.2
Number of long range restraints per residue ¹	2.2

¹Long 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)	None	None
0.2-0.5 (Medium)	0.1	0.22
>0.5 (Large)	None	None

8.2.2 Average number of dihedral-angle violations per model

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)	0.1	2.84
10.0-20.0 (Medium)	None	None
>20.0 (Large)	0.3	64.97

9 Distance violation analysis [i](#)

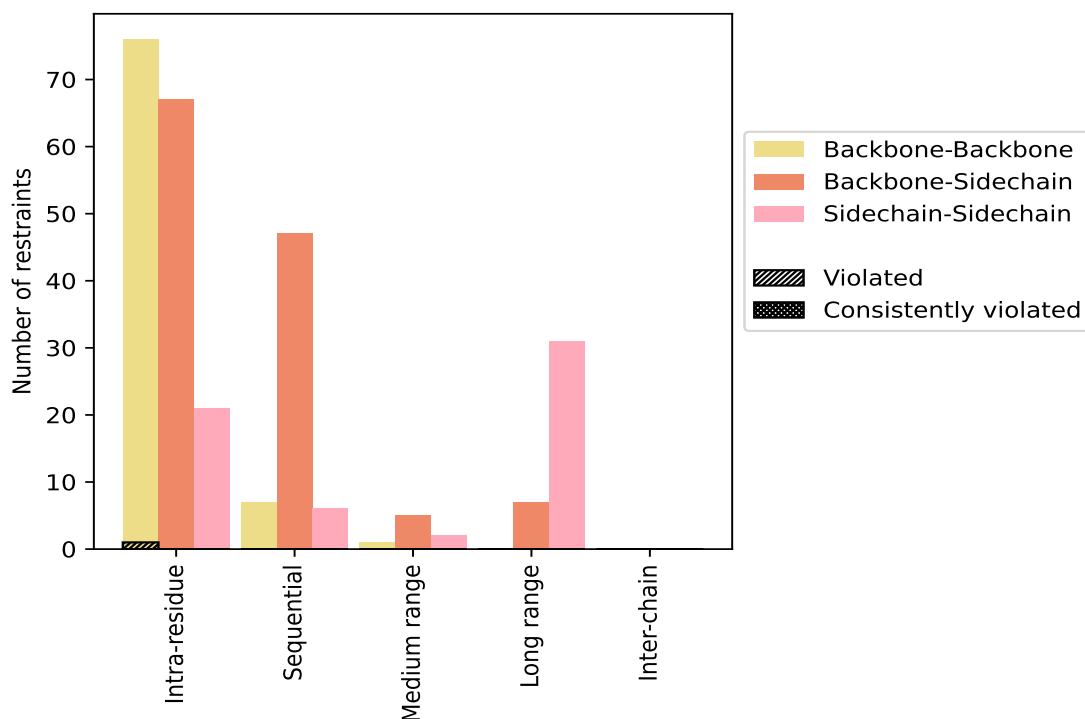
9.1 Summary of distance violations [i](#)

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.

Restrains type	Count	% ¹	Violated ³			Consistently Violated ⁴		
			Count	% ²	% ¹	Count	% ²	% ¹
Intra-residue ($i-j =0$)	164	60.7	1	0.6	0.4	0	0.0	0.0
Backbone-Backbone	76	28.1	1	1.3	0.4	0	0.0	0.0
Backbone-Sidechain	67	24.8	0	0.0	0.0	0	0.0	0.0
Sidechain-Sidechain	21	7.8	0	0.0	0.0	0	0.0	0.0
Sequential ($i-j =1$)	60	22.2	0	0.0	0.0	0	0.0	0.0
Backbone-Backbone	7	2.6	0	0.0	0.0	0	0.0	0.0
Backbone-Sidechain	47	17.4	0	0.0	0.0	0	0.0	0.0
Sidechain-Sidechain	6	2.2	0	0.0	0.0	0	0.0	0.0
Medium range ($i-j >1$ & $i-j <5$)	8	3.0	0	0.0	0.0	0	0.0	0.0
Backbone-Backbone	1	0.4	0	0.0	0.0	0	0.0	0.0
Backbone-Sidechain	5	1.9	0	0.0	0.0	0	0.0	0.0
Sidechain-Sidechain	2	0.7	0	0.0	0.0	0	0.0	0.0
Long range ($i-j \geq 5$)	17	6.3	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	7	2.6	0	0.0	0.0	0	0.0	0.0
Sidechain-Sidechain	10	3.7	0	0.0	0.0	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	21	7.8	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	270	100.0	1	0.4	0.4	0	0.0	0.0
Backbone-Backbone	84	31.1	1	1.2	0.4	0	0.0	0.0
Backbone-Sidechain	126	46.7	0	0.0	0.0	0	0.0	0.0
Sidechain-Sidechain	60	22.2	0	0.0	0.0	0	0.0	0.0

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 [i](#)



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

9.2 Distance violation statistics for each model [i](#)

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	0	0	0	0	0	0	0.0	0.0	0.0	0.0
2	0	0	0	0	0	0	0.0	0.0	0.0	0.0
3	0	0	0	0	0	0	0.0	0.0	0.0	0.0
4	0	0	0	0	0	0	0.0	0.0	0.0	0.0
5	0	0	0	0	0	0	0.0	0.0	0.0	0.0
6	0	0	0	0	0	0	0.0	0.0	0.0	0.0
7	0	0	0	0	0	0	0.0	0.0	0.0	0.0
8	0	0	0	0	0	0	0.0	0.0	0.0	0.0
9	0	0	0	0	0	0	0.0	0.0	0.0	0.0
10	0	0	0	0	0	0	0.0	0.0	0.0	0.0

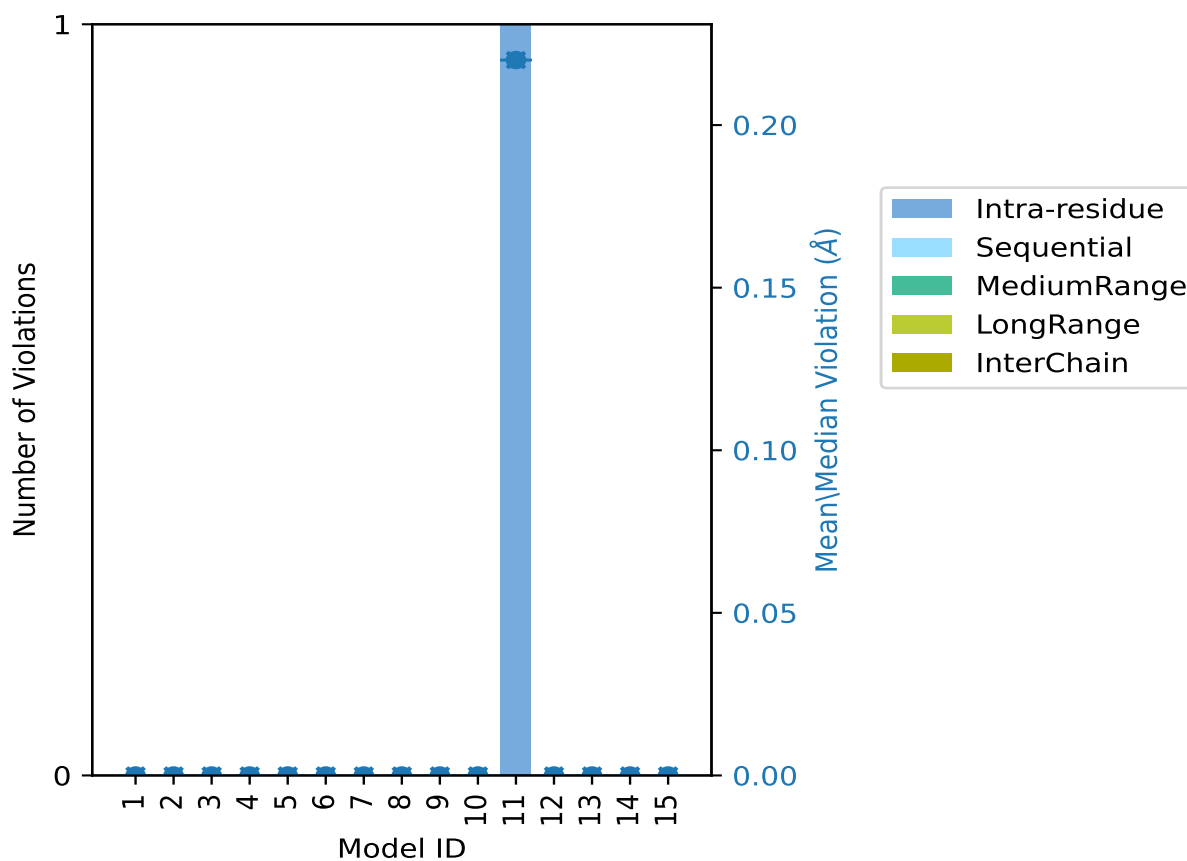
Continued on next page...

Continued from previous page...

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	1	0	0	0	0	1	0.22	0.22	0.0	0.22
12	0	0	0	0	0	0	0.0	0.0	0.0	0.0
13	0	0	0	0	0	0	0.0	0.0	0.0	0.0
14	0	0	0	0	0	0	0.0	0.0	0.0	0.0
15	0	0	0	0	0	0	0.0	0.0	0.0	0.0

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

9.2.1 Bar graph : Distance Violation statistics for each model [i](#)



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

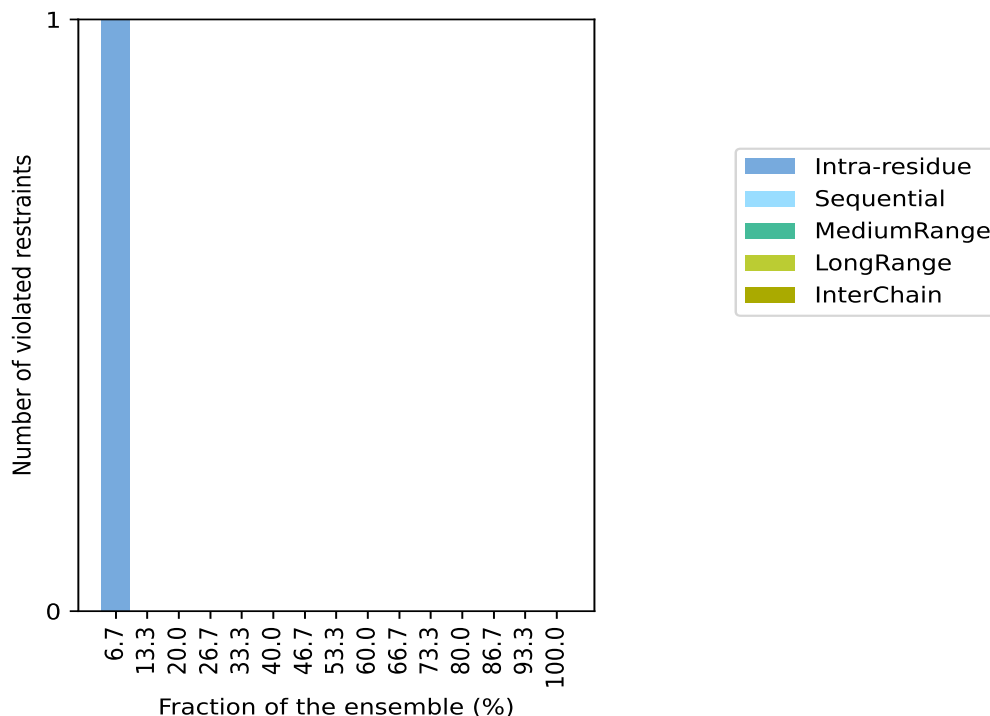
9.3 Distance violation statistics for the ensemble

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, 248(IR:163, SQ:60, MR:8, LR:17, 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	%
1	0	0	0	0	1	1	6.7
0	0	0	0	0	0	2	13.3
0	0	0	0	0	0	3	20.0
0	0	0	0	0	0	4	26.7
0	0	0	0	0	0	5	33.3
0	0	0	0	0	0	6	40.0
0	0	0	0	0	0	7	46.7
0	0	0	0	0	0	8	53.3
0	0	0	0	0	0	9	60.0
0	0	0	0	0	0	10	66.7
0	0	0	0	0	0	11	73.3
0	0	0	0	0	0	12	80.0
0	0	0	0	0	0	13	86.7
0	0	0	0	0	0	14	93.3
0	0	0	0	0	0	15	100.0

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

9.3.1 Bar graph : Distance violation statistics for the ensemble [i](#)



9.4 Most violated distance restraints in the ensemble [i](#)

No violations found

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.

Data insufficient to plot histogram

9.5.2 Table : All distance violations [i](#)

The following table lists the absolute value of the violation for each restraint in the ensemble sorted by its 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)
(1,150)	1:37:A:A:H5'	1:37:A:A:H1'	11	0.22

10 Dihedral-angle violation analysis [i](#)

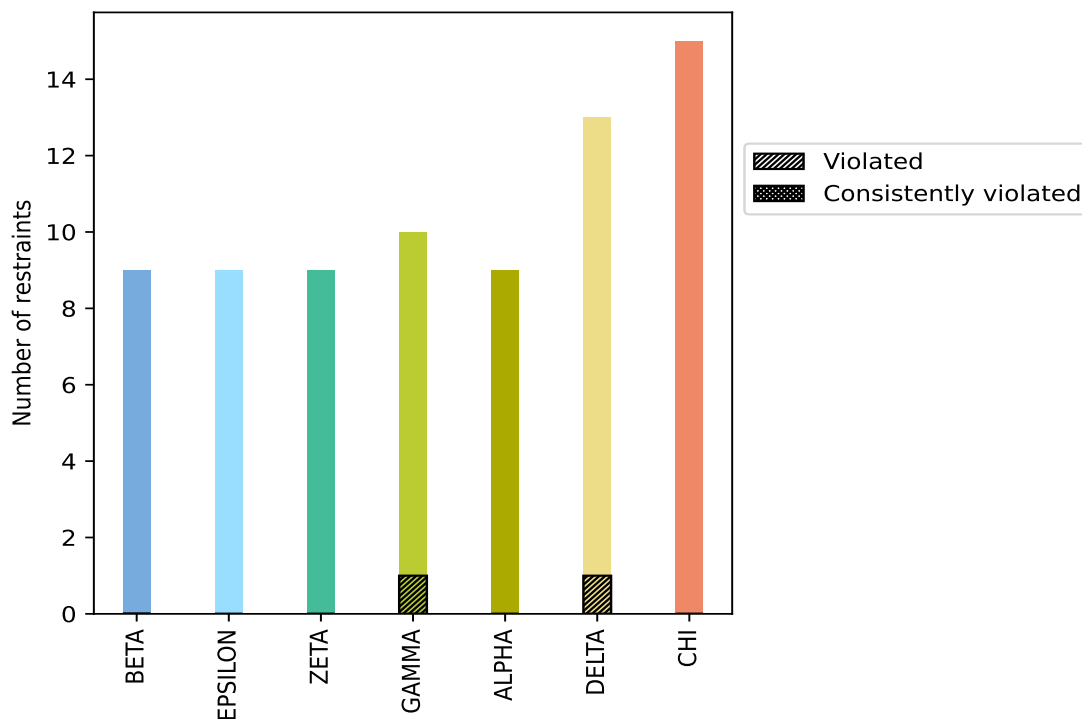
10.1 Summary of dihedral-angle violations [i](#)

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
BETA	9	12.2	0	0.0	0.0	0	0.0	0.0
EPSILON	9	12.2	0	0.0	0.0	0	0.0	0.0
ZETA	9	12.2	0	0.0	0.0	0	0.0	0.0
GAMMA	10	13.5	1	10.0	1.4	0	0.0	0.0
ALPHA	9	12.2	0	0.0	0.0	0	0.0	0.0
DELTA	13	17.6	1	7.7	1.4	0	0.0	0.0
CHI	15	20.3	0	0.0	0.0	0	0.0	0.0
Total	74	100.0	2	2.7	2.7	0	0.0	0.0

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 [i](#)



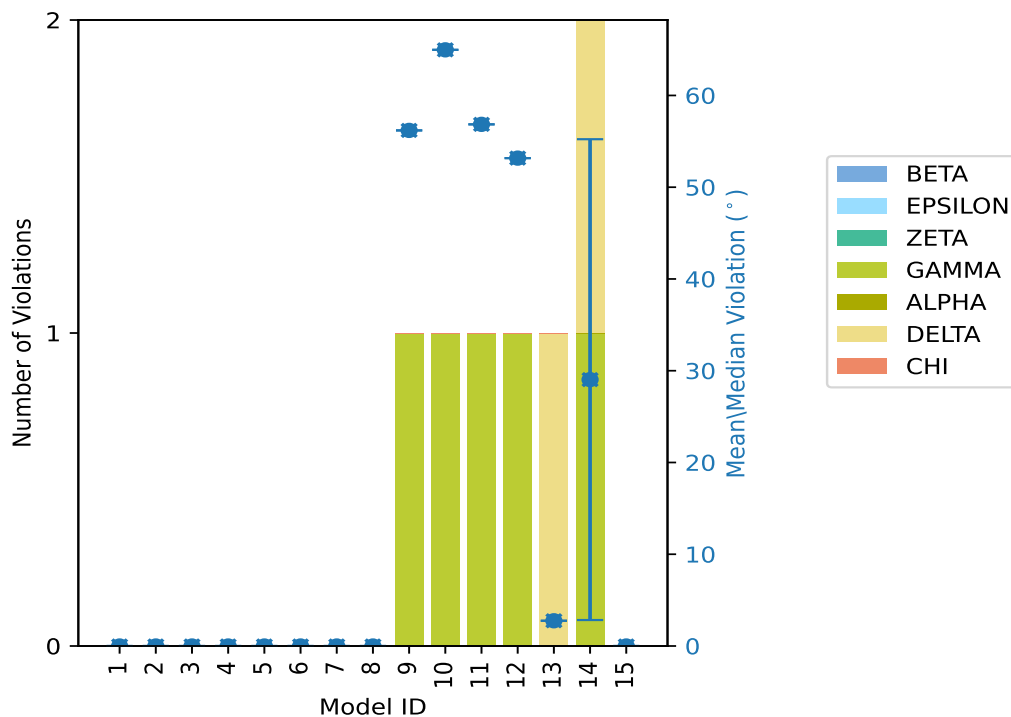
Violated and consistently violated restraints are shown using different hatch patterns in their respective categories

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								Total	Mean (°)	Max (°)	SD (°)	Median (°)
	BETA	EPSILON	ZETA	GAMMA	ALPHA	DELTA	CHI						
1	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	
2	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	
3	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	
4	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	
5	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	
6	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	
7	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	
8	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	
9	0	0	0	1	0	0	0	1	56.19	56.19	0.0	56.19	
10	0	0	0	1	0	0	0	1	64.97	64.97	0.0	64.97	
11	0	0	0	1	0	0	0	1	56.85	56.85	0.0	56.85	
12	0	0	0	1	0	0	0	1	53.17	53.17	0.0	53.17	
13	0	0	0	0	0	1	0	1	2.75	2.75	0.0	2.75	
14	0	0	0	1	0	1	0	2	29.03	55.23	26.2	29.03	
15	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	

10.2.1 Bar graph : Dihedral violation statistics for each model [i](#)



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

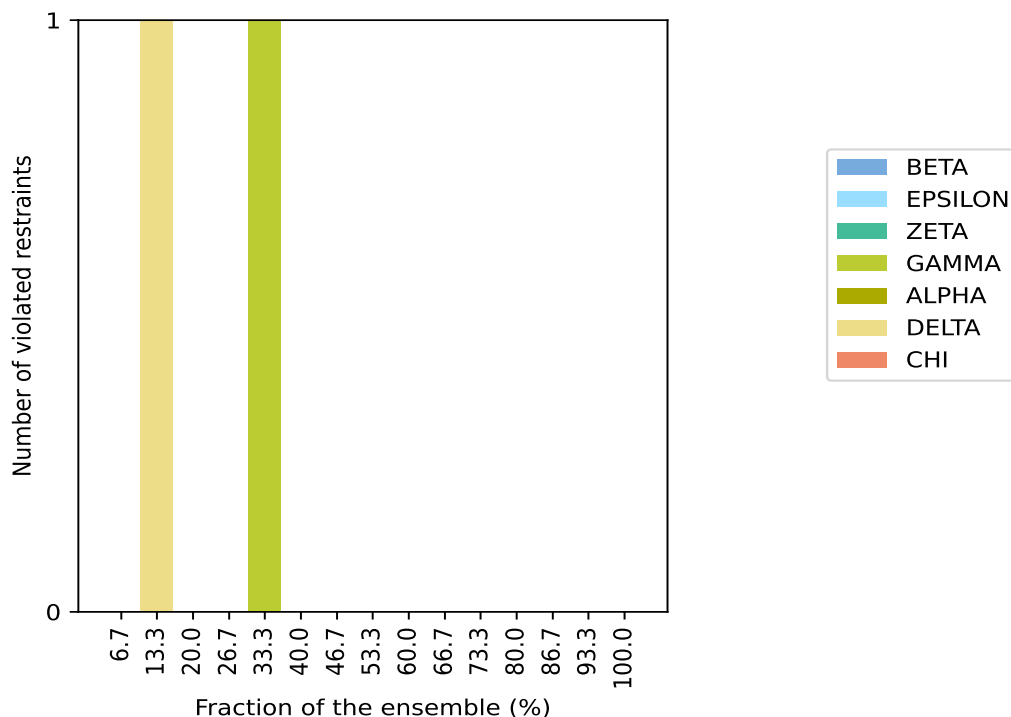
10.3 Dihedral-angle violation statistics for the ensemble [i](#)

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	
BETA	EPSILON	ZETA	GAMMA	ALPHA	DELTA	CHI	Total	Count ¹	%
0	0	0	0	0	0	0	0	1	6.7
0	0	0	0	0	1	0	1	2	13.3
0	0	0	0	0	0	0	0	3	20.0
0	0	0	0	0	0	0	0	4	26.7
0	0	0	1	0	0	0	1	5	33.3
0	0	0	0	0	0	0	0	6	40.0
0	0	0	0	0	0	0	0	7	46.7
0	0	0	0	0	0	0	0	8	53.3
0	0	0	0	0	0	0	0	9	60.0
0	0	0	0	0	0	0	0	10	66.7
0	0	0	0	0	0	0	0	11	73.3
0	0	0	0	0	0	0	0	12	80.0
0	0	0	0	0	0	0	0	13	86.7
0	0	0	0	0	0	0	0	14	93.3
0	0	0	0	0	0	0	0	15	100.0

¹ Number of models with violations

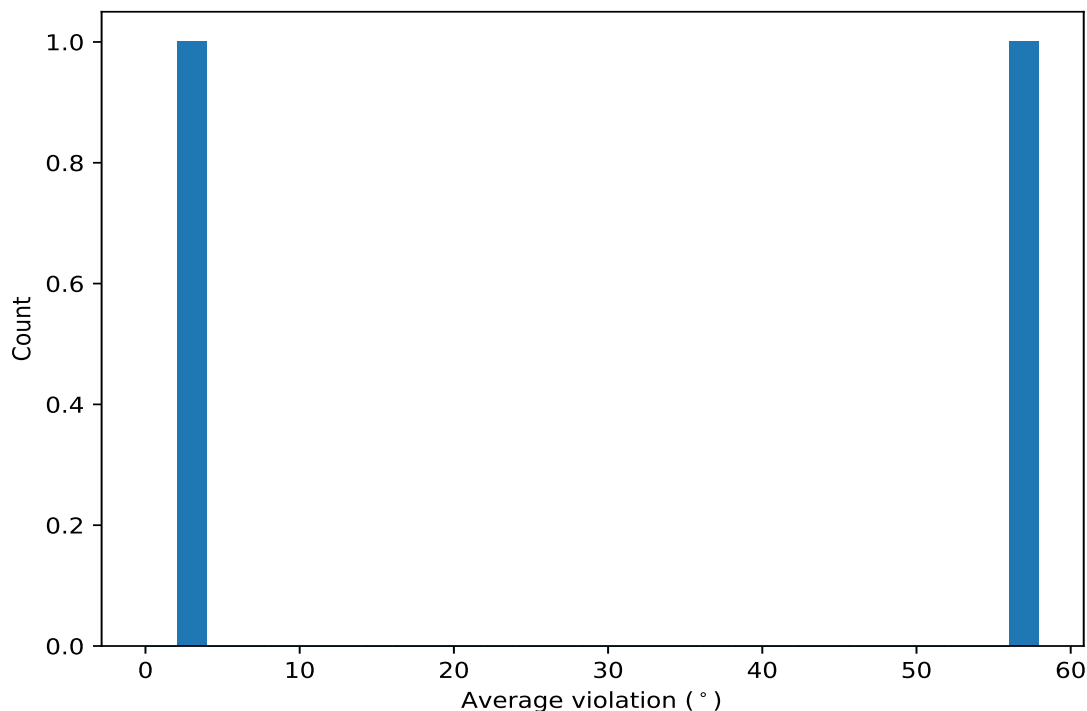
10.3.1 Bar graph : Dihedral-angle Violation statistics for the ensemble [i](#)



10.4 Most violated dihedral-angle restraints in the ensemble [i](#)

10.4.1 Histogram : Distribution of mean dihedral-angle violations [i](#)

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 [i](#)

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

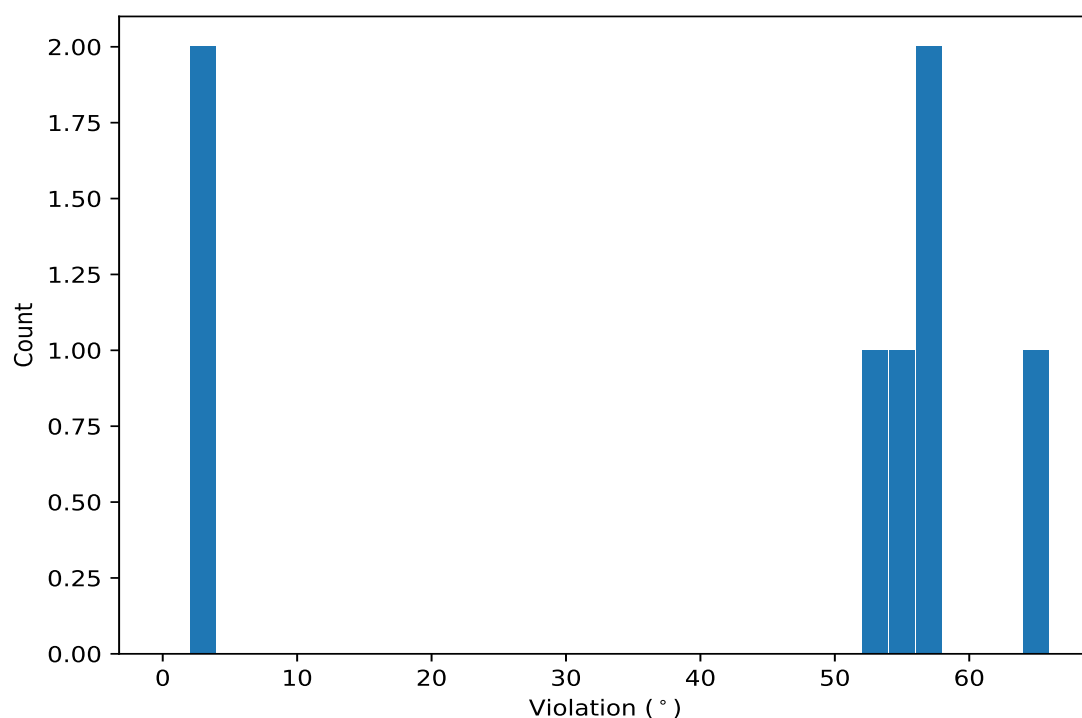
Key	Atom-1	Atom-2	Atom-3	Atom-4	Models ¹	Mean	SD ²	Median
(1,19)	1:27:A:C:O5'	1:27:A:C:C5'	1:27:A:C:C4'	1:27:A:C:C3'	5	57.28	4.04	56.19
(1,36)	1:36:A:U:C5'	1:36:A:U:C4'	1:36:A:U:C3'	1:36:A:U:O3'	2	2.8	0.04	2.8

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

10.5 All violated dihedral-angle restraints [i](#)

10.5.1 Histogram : Distribution of violations [i](#)

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 [i](#)

The following table lists the absolute value of the violation for each restraint in the ensemble sorted by its 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 (°)
(1,19)	1:27:A:C:O5'	1:27:A:C:C5'	1:27:A:C:C4'	1:27:A:C:C3'	10	64.97
(1,19)	1:27:A:C:O5'	1:27:A:C:C5'	1:27:A:C:C4'	1:27:A:C:C3'	11	56.85
(1,19)	1:27:A:C:O5'	1:27:A:C:C5'	1:27:A:C:C4'	1:27:A:C:C3'	9	56.19
(1,19)	1:27:A:C:O5'	1:27:A:C:C5'	1:27:A:C:C4'	1:27:A:C:C3'	14	55.23
(1,19)	1:27:A:C:O5'	1:27:A:C:C5'	1:27:A:C:C4'	1:27:A:C:C3'	12	53.17
(1,36)	1:36:A:U:C5'	1:36:A:U:C4'	1:36:A:U:C3'	1:36:A:U:O3'	14	2.84
(1,36)	1:36:A:U:C5'	1:36:A:U:C4'	1:36:A:U:C3'	1:36:A:U:O3'	13	2.75