



wwPDB NMR Structure Validation Summary Report ⓘ

Mar 8, 2026 – 03:58 PM UTC

PDB ID : 2L94 / pdb_00002l94
BMRB ID : 17436
Title : Structure of the HIV-1 frameshift site RNA bound to a small molecule inhibitor of viral replication
Authors : Marcheschi, R.J.; Tonelli, M.; Kumar, A.; Butcher, S.E.
Deposited on : 2011-01-29

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
Mogul : 2022.3.0, CSD as543be (2022)
Buster-report : wwPDB partial adaption of 1.1.7 (2018)
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

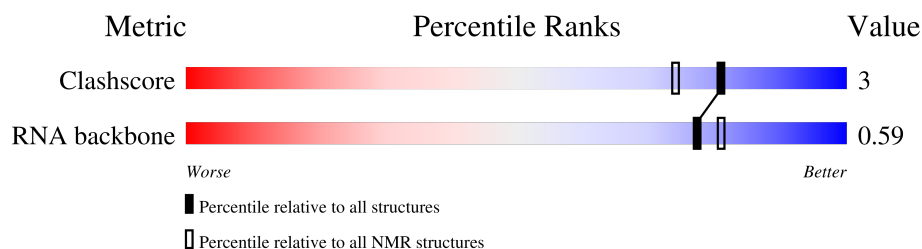
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

SOLUTION NMR

The overall completeness of chemical shifts assignment is 45%.

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
RNA backbone	8273	777

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	45	 78% 13% 7% •

2 Ensemble composition and analysis ⓘ

This entry contains 10 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.

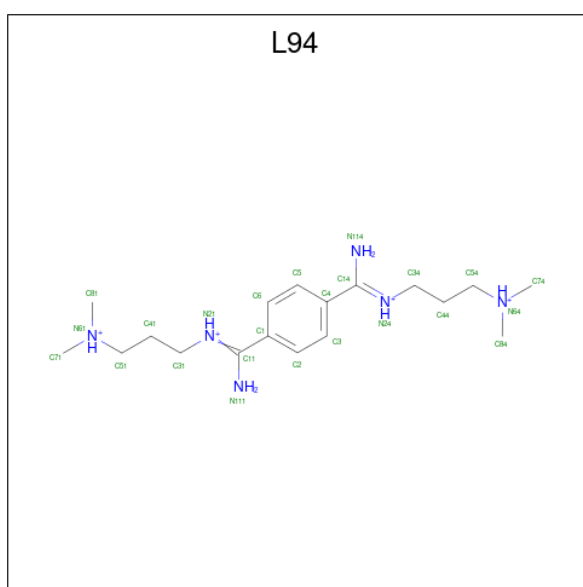
3 Entry composition [i](#)

There are 2 unique types of molecules in this entry. The entry contains 1515 atoms, of which 526 are hydrogens and 0 are deuteriums.

- Molecule 1 is a RNA chain called RNA_(45-MER).

Mol	Chain	Residues	Atoms						Trace
1	A	45	Total	C	H	N	O	P	0
			1455	430	490	178	312	45	

- Molecule 2 is N'-{(Z)-amino[4-(amino{[3-(dimethylammonio)propyl]iminio}methyl)phenyl]methylidene}-N,N-dimethylpropane-1,3-diaminium (CCD ID: L94) (formula: C₁₈H₃₆N₆).



Mol	Chain	Residues	Atoms			
2	A	1	Total	C	H	N
			60	18	36	6

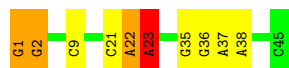
4 Residue-property plots [i](#)

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: RNA_(45-MER)

Chain A:  78% 13% 7% .

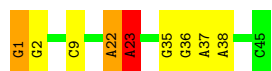


4.2 Residue scores for the representative (author defined) model from the NMR ensemble

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

- Molecule 1: RNA_(45-MER)

Chain A:  80% 13% . .



5 Refinement protocol and experimental data overview

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

Of the 50 calculated structures, 10 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
HADDOCK	refinement	2.0
HADDOCK	structure solution	2.0
Amber	refinement	9.0
Amber	structure solution	9.0
SYBYL	geometry optimization	8.0

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	439
Number of shifts mapped to atoms	439
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	45%

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: L94

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	0.70±0.00	1±0/1079 (0.1± 0.0%)	1.01±0.01	1±1/1679 (0.1± 0.0%)
All	All	0.70	10/10790 (0.1%)	1.01	13/16790 (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	1.3±0.9
All	All	0	13

All unique bond outliers are listed below.

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)	Models	
								Worst	Total
1	A	1	G	OP3-P	5.96	1.60	1.48	2	10

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	9	C	C5'-C4'-C3'	-6.20	106.70	116.00	6	1
1	A	1	G	C5'-C4'-C3'	-5.72	106.61	115.20	2	2
1	A	2	G	C4'-C3'-C2'	-5.34	97.26	102.60	5	8
1	A	36	G	C5'-C4'-C3'	-5.25	108.12	116.00	3	1
1	A	1	G	O4'-C1'-N9	5.01	115.72	108.20	4	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	23	A	Sidechain	8
1	A	21	C	Sidechain	4
1	A	9	C	Sidechain	1

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
1	A	965	490	489	3±1
2	A	24	36	36	2±1
All	All	9890	5260	5250	39

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 3.

5 of 16 unique clashes are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:22:A:O2'	1:A:23:A:C8	0.56	2.59	1	10
2:A:46:L94:H48B	2:A:46:L94:H43A	0.50	1.82	4	5
1:A:9:C:C5	2:A:46:L94:H454	0.48	2.44	7	2
1:A:9:C:N4	2:A:46:L94:H47A	0.48	2.24	8	5
1:A:27:A:H62	2:A:46:L94:H18A	0.48	1.68	3	1

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 ⓘ

Mol	Chain	Analysed	Backbone Outliers	Pucker Outliers	Suiteness
1	A	44/45 (98%)	7±0 (16±0%)	2±1 (4±1%)	0.62±0.00
All	All	448/450 (100%)	70 (16%)	19 (4%)	0.62

The overall RNA backbone suiteness is 0.59.

5 of 7 unique RNA backbone outliers are listed below:

Mol	Chain	Res	Type	Models (Total)
1	A	2	G	10
1	A	22	A	10
1	A	23	A	10
1	A	35	G	10
1	A	36	G	10

All unique RNA pucker outliers are listed below:

Mol	Chain	Res	Type	Models (Total)
1	A	1	G	8
1	A	36	G	8
1	A	20	A	1
1	A	21	C	1
1	A	35	G	1

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 ⓘ

1 ligand is modelled in this entry.

In the following table, the Counts columns list the number of bonds for which Mogul statistics could be retrieved, the number of bonds that are observed in the model and the number of bonds that are defined in the chemical component dictionary. The Link column lists molecule types, if any, to which the group is linked. The Z score for a bond length is the number of standard deviations the observed value is removed from the expected value. A bond length with $|Z| > 2$ is

considered an outlier worth inspection. RMSZ is the average root-mean-square of all Z scores of the bond lengths.

Mol	Type	Chain	Res	Link	Bond lengths		
					Counts	RMSZ	#Z>2
2	L94	A	46	-	24,24,24	3.96±0.01	8±0 (33±0%)

In the following table, the Counts columns list the number of angles for which Mogul statistics could be retrieved, the number of angles that are observed in the model and the number of angles that are defined in the chemical component dictionary. The Link column lists molecule types, if any, to which the group is linked. The Z score for a bond angle is the number of standard deviations the observed value is removed from the expected value. A bond angle with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the average root-mean-square of all Z scores of the bond angles.

Mol	Type	Chain	Res	Link	Bond angles		
					Counts	RMSZ	#Z>2
2	L94	A	46	-	26,30,30	2.05±0.06	4±0 (15±1%)

In the following table, the Chirals column lists the number of chiral outliers, the number of chiral centers analysed, the number of these observed in the model and the number defined in the chemical component dictionary. Similar counts are reported in the Torsion and Rings columns. '-' means no outliers of that kind were identified.

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
2	L94	A	46	-	-	0±0,20,22,22	0±0,1,1,1

5 of 8 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
2	A	46	L94	C4-C14	12.69	1.36	1.49	10	10
2	A	46	L94	C1-C11	12.66	1.36	1.49	9	10
2	A	46	L94	C2-C1	3.05	1.44	1.39	8	10
2	A	46	L94	C6-C1	3.00	1.44	1.39	5	10
2	A	46	L94	C3-C4	2.96	1.43	1.39	5	10

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
2	A	46	L94	N111-C11-N21	6.01	113.55	125.65	3	10

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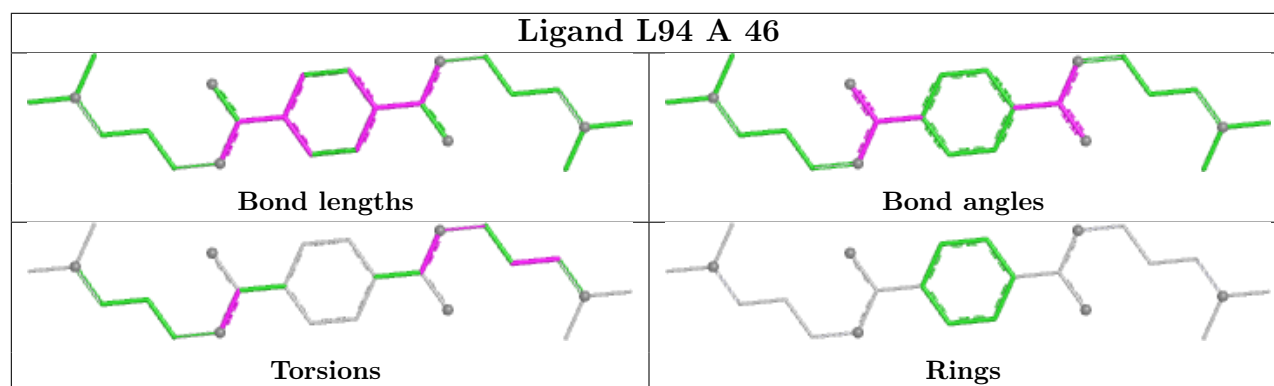
Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)	Models	
								Worst	Total
2	A	46	L94	N114-C14-N24	5.97	113.63	125.65	3	10
2	A	46	L94	C1-C11-N111	4.12	124.31	118.04	9	10
2	A	46	L94	C4-C14-N114	3.96	124.06	118.04	7	10
2	A	46	L94	C2-C1-C11	2.01	123.10	120.67	9	1

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less than 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier. Any bond that is central to one or more torsion angles identified as an outlier by Mogul will be highlighted in the graph. For rings, the root-mean-square deviation (RMSD) between the ring in question and similar rings identified by Mogul is calculated over all ring torsion angles. If the average RMSD is greater than 60 degrees and the minimal RMSD between the ring in question and any Mogul-identified rings is also greater than 60 degrees, then that ring is considered an outlier. The outliers are highlighted in purple. The color gray indicates Mogul did not find sufficient equivalents in the CSD to analyse the geometry.



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 45% for the well-defined parts and 45% for the entire structure.

7.1 Chemical shift list 1

File name: working_cs.cif

Chemical shift list name: *assigned_chemical_shifts_1*

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	439
Number of shifts mapped to atoms	439
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 45%, i.e. 387 atoms were assigned a chemical shift out of a possible 855. 0 out of 0 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	¹ H	¹³ C	¹⁵ N
Sugar	212/495 (43%)	188/270 (70%)	24/225 (11%)	0/0 (—%)
Base	175/360 (49%)	140/225 (62%)	35/76 (46%)	0/59 (0%)
Overall	387/855 (45%)	328/495 (66%)	59/301 (20%)	0/59 (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	1035
Intra-residue ($ i-j =0$)	348
Sequential ($ i-j =1$)	430
Medium range ($ i-j >1$ and $ i-j <5$)	13
Long range ($ i-j \geq 5$)	106
Inter-chain	42
Hydrogen bond restraints	96
Disulfide bond restraints	0
Total dihedral-angle restraints	329
Number of unmapped restraints	0
Number of restraints per residue	29.7
Number of long range restraints per residue ¹	4.4

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)	45.5	0.2
0.2-0.5 (Medium)	27.6	0.5
>0.5 (Large)	31.1	7.6

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)	6.0	9.97
10.0-20.0 (Medium)	1.6	19.91
>20.0 (Large)	4.7	135.23

9 Distance violation analysis ⓘ

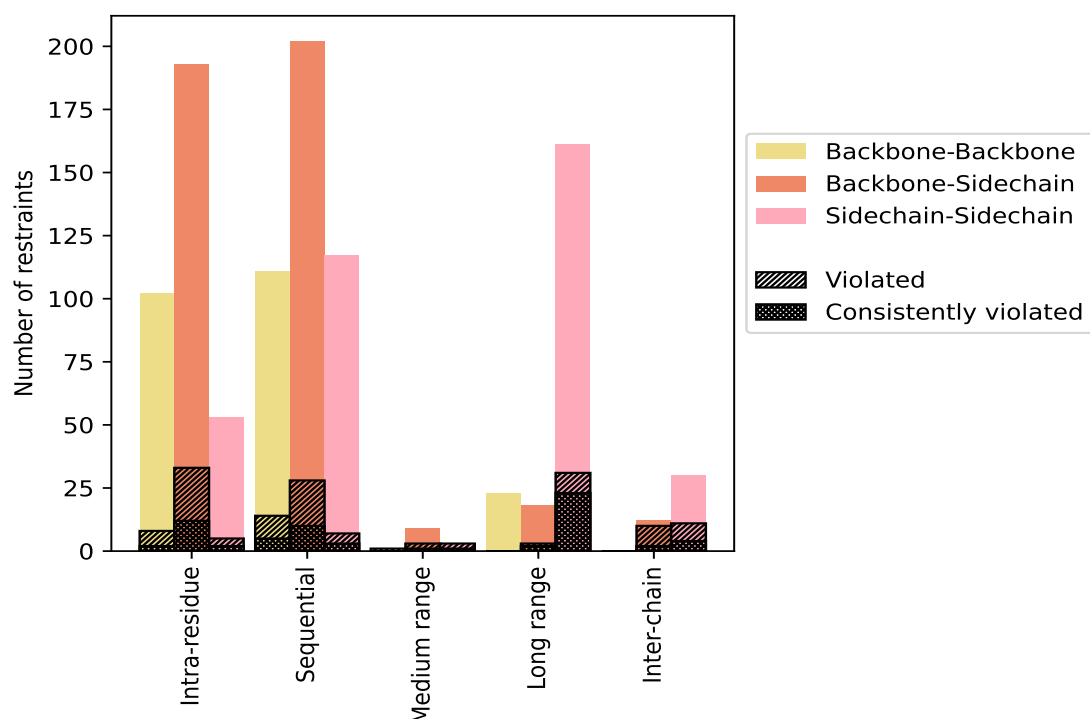
9.1 Summary of distance violations ⓘ

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)	348	33.6	46	13.2	4.4	16	4.6	1.5
Backbone-Backbone	102	9.9	8	7.8	0.8	2	2.0	0.2
Backbone-Sidechain	193	18.6	33	17.1	3.2	12	6.2	1.2
Sidechain-Sidechain	53	5.1	5	9.4	0.5	2	3.8	0.2
Sequential (i-j =1)	430	41.5	49	11.4	4.7	18	4.2	1.7
Backbone-Backbone	111	10.7	14	12.6	1.4	5	4.5	0.5
Backbone-Sidechain	202	19.5	28	13.9	2.7	10	5.0	1.0
Sidechain-Sidechain	117	11.3	7	6.0	0.7	3	2.6	0.3
Medium range (i-j >1 & i-j <5)	13	1.3	7	53.8	0.7	2	15.4	0.2
Backbone-Backbone	1	0.1	1	100.0	0.1	0	0.0	0.0
Backbone-Sidechain	9	0.9	3	33.3	0.3	1	11.1	0.1
Sidechain-Sidechain	3	0.3	3	100.0	0.3	1	33.3	0.1
Long range (i-j ≥5)	106	10.2	12	11.3	1.2	6	5.7	0.6
Backbone-Backbone	23	2.2	0	0.0	0.0	0	0.0	0.0
Backbone-Sidechain	18	1.7	3	16.7	0.3	2	11.1	0.2
Sidechain-Sidechain	65	6.3	9	13.8	0.9	4	6.2	0.4
Inter-chain	42	4.1	21	50.0	2.0	6	14.3	0.6
Backbone-Backbone	0	0.0	0	0.0	0.0	0	0.0	0.0
Backbone-Sidechain	12	1.2	10	83.3	1.0	2	16.7	0.2
Sidechain-Sidechain	30	2.9	11	36.7	1.1	4	13.3	0.4
Hydrogen bond	96	9.3	22	22.9	2.1	19	19.8	1.8
Disulfide bond	0	0.0	0	0.0	0.0	0	0.0	0.0
Total	1035	100.0	157	15.2	15.2	67	6.5	6.5
Backbone-Backbone	237	22.9	23	9.7	2.2	7	3.0	0.7
Backbone-Sidechain	434	41.9	77	17.7	7.4	27	6.2	2.6
Sidechain-Sidechain	364	35.2	57	15.7	5.5	33	9.1	3.2

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 disulfied bonds are counted in their appropriate category on the x-axis

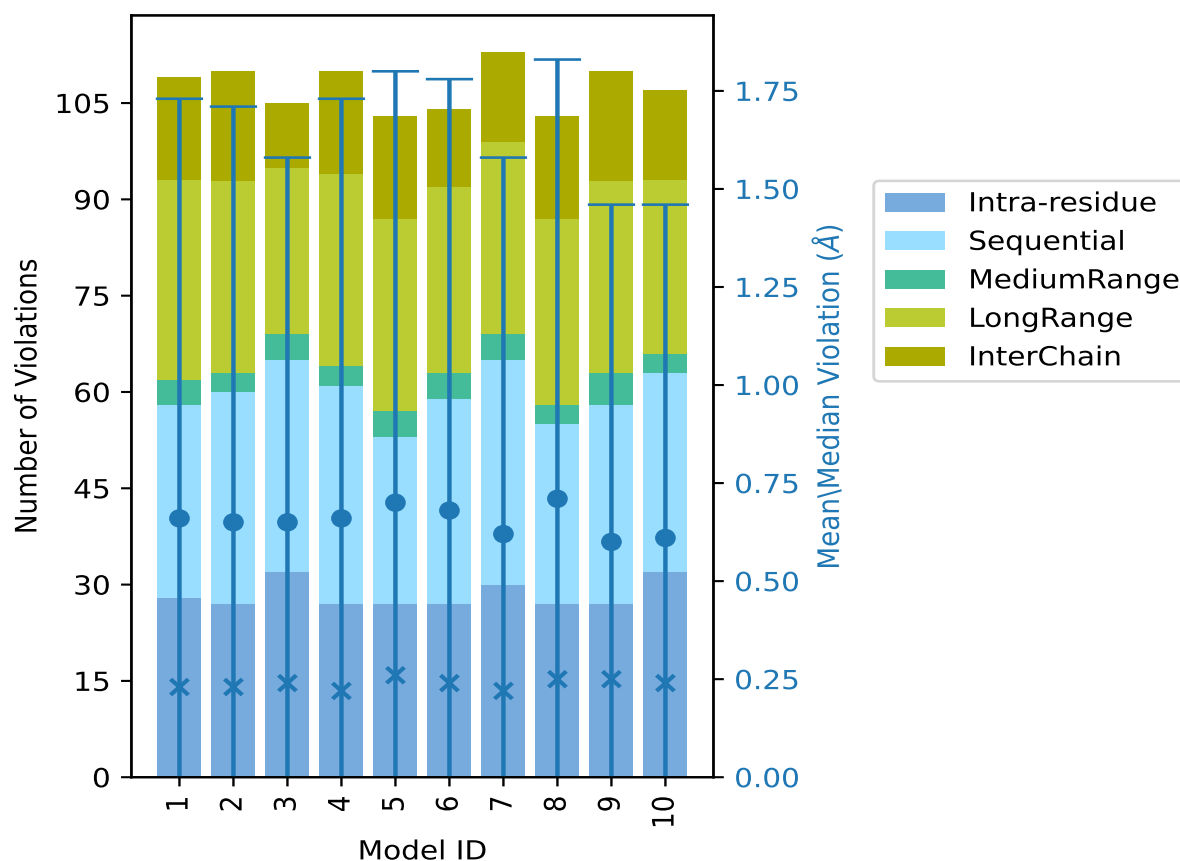
9.2 Distance violation statistics for each model [i](#)

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	28	30	4	31	16	109	0.66	7.55	1.07	0.23
2	27	33	3	30	17	110	0.65	7.53	1.06	0.23
3	32	33	4	26	10	105	0.65	5.81	0.93	0.24
4	27	34	3	30	16	110	0.66	7.51	1.07	0.22
5	27	26	4	30	16	103	0.7	7.6	1.1	0.26
6	27	32	4	29	12	104	0.68	7.53	1.1	0.24
7	30	35	4	30	14	113	0.62	6.82	0.96	0.22
8	27	28	3	29	16	103	0.71	7.49	1.12	0.25
9	27	31	5	30	17	110	0.6	6.4	0.86	0.25
10	32	31	3	27	14	107	0.61	5.88	0.85	0.24

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 [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, 804(IR:302, SQ:381, MR:6, LR:94, IC:21) 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	%
12	9	2	1	4	28	1	10.0
4	4	1	0	0	9	2	20.0
2	3	0	1	1	7	3	30.0

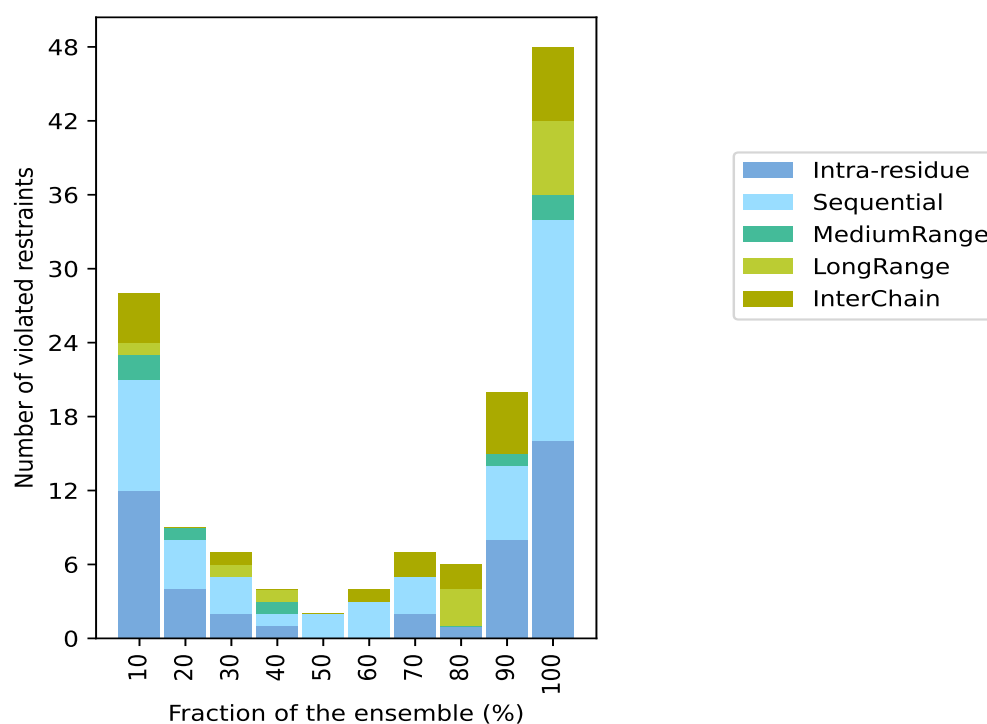
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Number of violated restraints						Fraction of the ensemble	
IR ¹	SQ ²	MR ³	LR ⁴	IC ⁵	Total	Count ⁶	%
1	1	1	1	0	4	4	40.0
0	2	0	0	0	2	5	50.0
0	3	0	0	1	4	6	60.0
2	3	0	0	2	7	7	70.0
1	0	0	3	2	6	8	80.0
8	6	1	0	5	20	9	90.0
16	18	2	6	6	48	10	100.0

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](#)

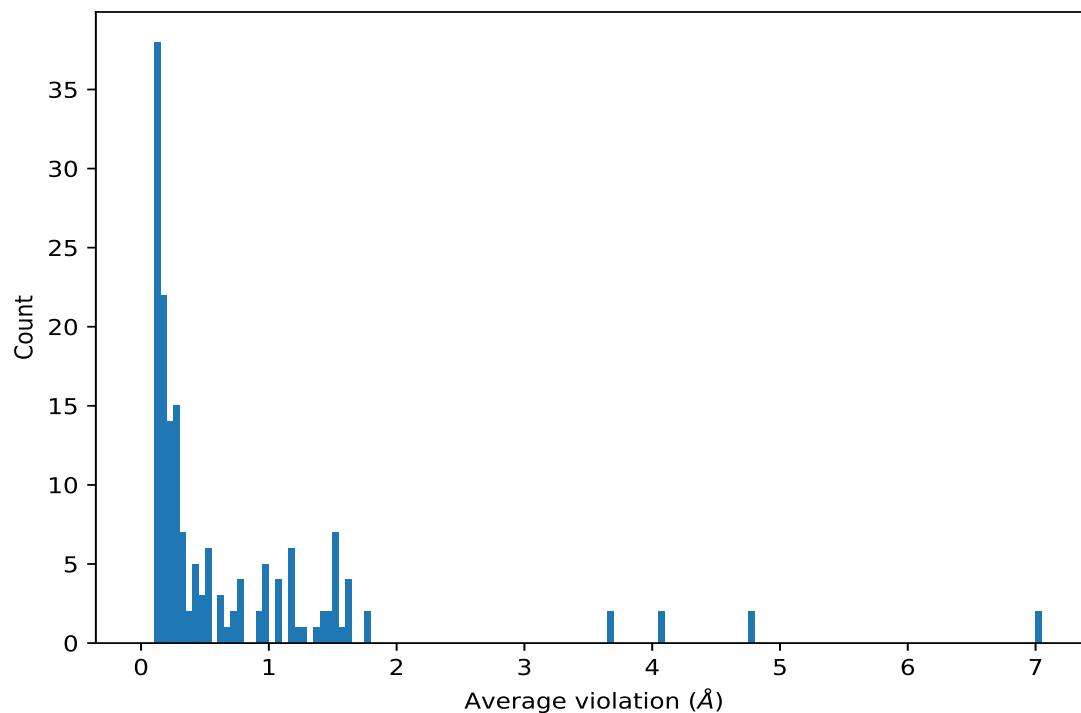


9.4 Most violated distance restraints in the ensemble [i](#)

9.4.1 Histogram : Distribution of mean distance 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



9.4.2 Table: Most violated distance restraints [i](#)

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)
(2,21)	1:16:A:U:H3	2:46:A:L94:H411	10	7.01	0.69	7.5
(2,21)	1:16:A:U:H3	2:46:A:L94:H41A	10	7.01	0.69	7.5
(2,30)	1:27:A:A:H8	2:46:A:L94:H411	10	4.78	0.5	5.08
(2,30)	1:27:A:A:H8	2:46:A:L94:H41A	10	4.78	0.5	5.08
(2,33)	1:28:A:A:H8	2:46:A:L94:H411	10	4.07	0.85	4.53
(2,33)	1:28:A:A:H8	2:46:A:L94:H41A	10	4.07	0.85	4.53
(1,3)	1:1:A:G:O6	1:45:A:C:H42	10	1.79	0.01	1.79
(1,39)	1:34:A:G:O6	1:9:A:C:H42	10	1.75	0.03	1.74
(2,62)	2:46:A:L94:H444	2:46:A:L94:H141	10	1.6	0.36	1.52
(2,62)	2:46:A:L94:H444	2:46:A:L94:H14A	10	1.6	0.36	1.52
(2,62)	2:46:A:L94:H44A	2:46:A:L94:H141	10	1.6	0.36	1.52
(2,62)	2:46:A:L94:H44A	2:46:A:L94:H14A	10	1.6	0.36	1.52
(1,35)	1:39:A:U:O4	1:7:A:A:H62	10	1.59	0.02	1.59
(1,29)	1:6:A:G:O6	1:40:A:C:H42	10	1.53	0.01	1.53
(1,87)	1:25:A:G:O6	1:18:A:C:H42	10	1.53	0.01	1.53

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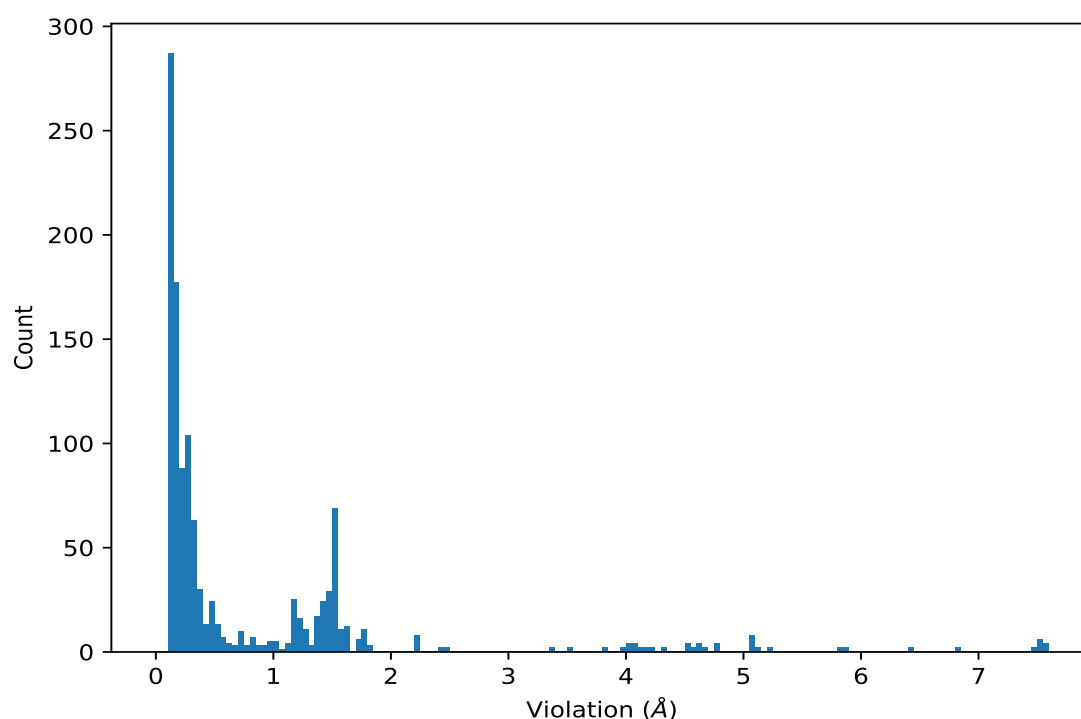
Key	Atom-1	Atom-2	Models ¹	Mean (Å)	SD ¹ (Å)	Median (Å)
(1,61)	1:30:A:G:O6	1:13:A:C:H42	10	1.52	0.01	1.52

¹Number of violated models, ²Standard 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)
(2,21)	1:16:A:U:H3	2:46:A:L94:H411	5	7.6
(2,21)	1:16:A:U:H3	2:46:A:L94:H41A	5	7.6
(2,21)	1:16:A:U:H3	2:46:A:L94:H411	1	7.55
(2,21)	1:16:A:U:H3	2:46:A:L94:H41A	1	7.55

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Key	Atom-1	Atom-2	Model ID	Violation (Å)
(2,21)	1:16:A:U:H3	2:46:A:L94:H411	2	7.53
(2,21)	1:16:A:U:H3	2:46:A:L94:H41A	2	7.53
(2,21)	1:16:A:U:H3	2:46:A:L94:H411	6	7.53
(2,21)	1:16:A:U:H3	2:46:A:L94:H41A	6	7.53
(2,21)	1:16:A:U:H3	2:46:A:L94:H411	4	7.51
(2,21)	1:16:A:U:H3	2:46:A:L94:H41A	4	7.51
(2,21)	1:16:A:U:H3	2:46:A:L94:H411	8	7.49
(2,21)	1:16:A:U:H3	2:46:A:L94:H41A	8	7.49
(2,21)	1:16:A:U:H3	2:46:A:L94:H411	7	6.82
(2,21)	1:16:A:U:H3	2:46:A:L94:H41A	7	6.82
(2,21)	1:16:A:U:H3	2:46:A:L94:H411	9	6.4
(2,21)	1:16:A:U:H3	2:46:A:L94:H41A	9	6.4
(2,21)	1:16:A:U:H3	2:46:A:L94:H411	10	5.88
(2,21)	1:16:A:U:H3	2:46:A:L94:H41A	10	5.88
(2,21)	1:16:A:U:H3	2:46:A:L94:H411	3	5.81

10 Dihedral-angle violation analysis ⓘ

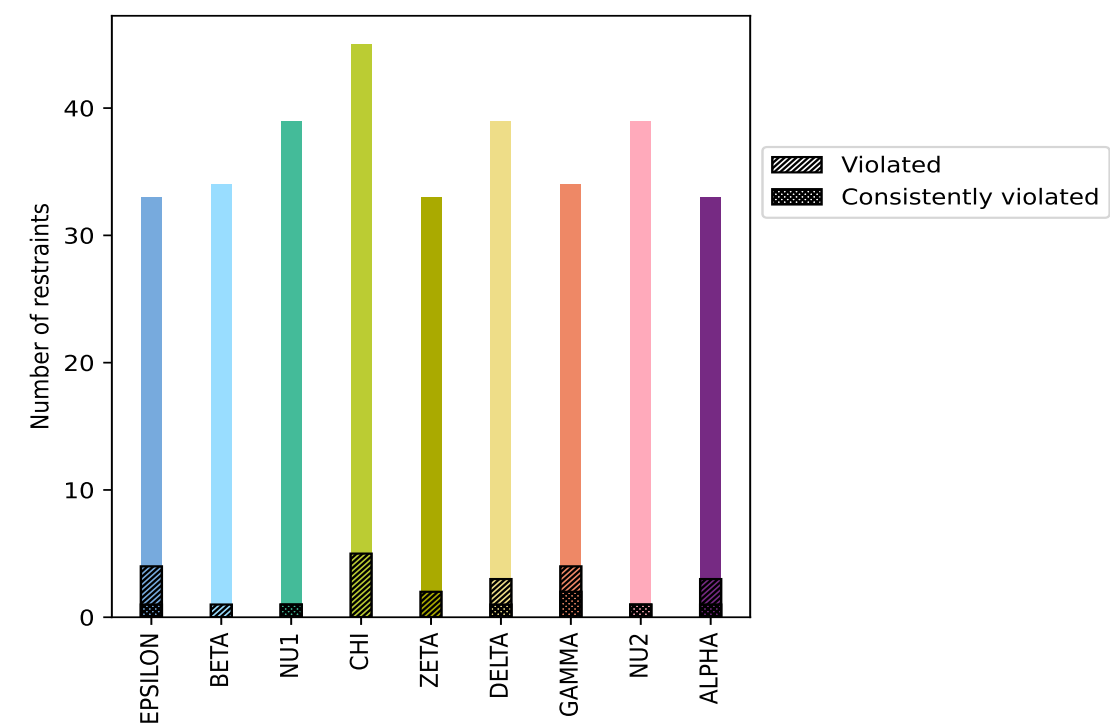
10.1 Summary of dihedral-angle violations ⓘ

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
EPSILON	33	10.0	4	12.1	1.2	1	3.0	0.3
BETA	34	10.3	1	2.9	0.3	0	0.0	0.0
NU1	39	11.9	1	2.6	0.3	1	2.6	0.3
CHI	45	13.7	5	11.1	1.5	0	0.0	0.0
ZETA	33	10.0	2	6.1	0.6	0	0.0	0.0
DELTA	39	11.9	3	7.7	0.9	1	2.6	0.3
GAMMA	34	10.3	4	11.8	1.2	2	5.9	0.6
NU2	39	11.9	1	2.6	0.3	1	2.6	0.3
ALPHA	33	10.0	3	9.1	0.9	1	3.0	0.3
Total	329	100.0	24	7.3	7.3	7	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 [i](#)



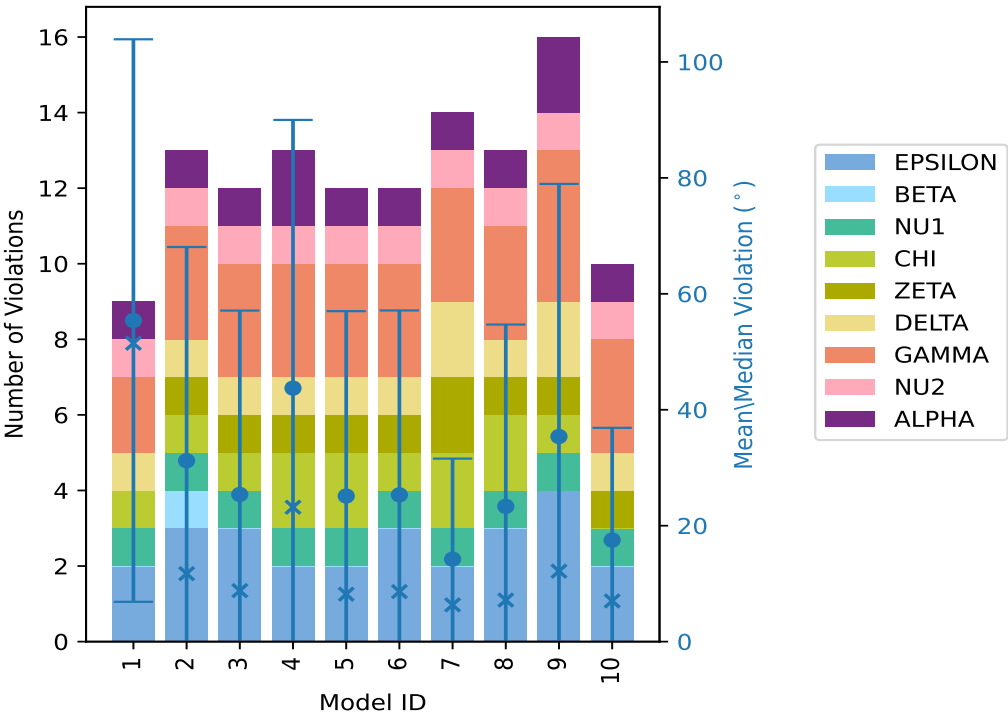
Violated and consistently violated restraints are shown using different hatch patterns in their respective categories

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 (°)
	EPSILON	BETA	NU1	CHI	ZETA	DELTA	GAMMA	NU2	ALPHA					
1	2	0	1	1	0	1	2	1	1	9	55.39	135.23	48.52	51.48
2	3	1	1	1	1	1	3	1	1	13	31.2	111.93	36.88	11.73
3	3	0	1	1	1	1	3	1	1	12	25.39	106.62	31.72	8.8
4	2	0	1	2	1	1	3	1	2	13	43.73	130.72	46.27	23.19
5	2	0	1	2	1	1	3	1	1	12	25.12	106.78	31.89	8.18
6	3	0	1	1	1	1	3	1	1	12	25.32	106.81	31.81	8.63
7	2	0	1	2	2	2	3	1	1	14	14.22	60.05	17.35	6.34
8	3	0	1	2	1	1	3	1	1	13	23.33	106.95	31.37	7.17
9	4	0	1	1	1	2	4	1	2	16	35.38	127.57	43.58	12.16
10	2	0	1	0	1	1	3	1	1	10	17.51	60.03	19.37	7.02

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

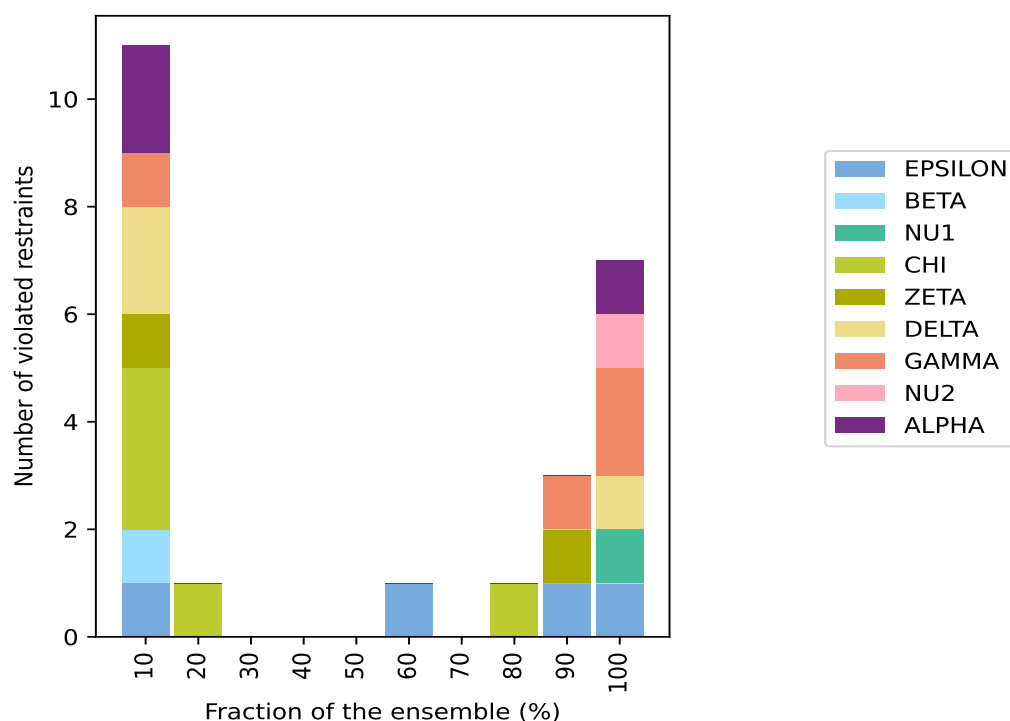
10.3 Dihedral-angle violation statistics for the ensemble [i](#)

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	
EPSILON	BETA	NU1	CHI	ZETA	DELTA	GAMMA	NU2	ALPHA	Total	Count ¹	%
1	1	0	3	1	2	1	0	2	11	1	10.0
0	0	0	1	0	0	0	0	0	1	2	20.0
0	0	0	0	0	0	0	0	0	0	3	30.0
0	0	0	0	0	0	0	0	0	0	4	40.0
0	0	0	0	0	0	0	0	0	0	5	50.0
1	0	0	0	0	0	0	0	0	1	6	60.0
0	0	0	0	0	0	0	0	0	0	7	70.0
0	0	0	1	0	0	0	0	0	1	8	80.0
1	0	0	0	1	0	1	0	0	3	9	90.0
1	0	1	0	0	1	2	1	1	7	10	100.0

¹ Number of models with violations

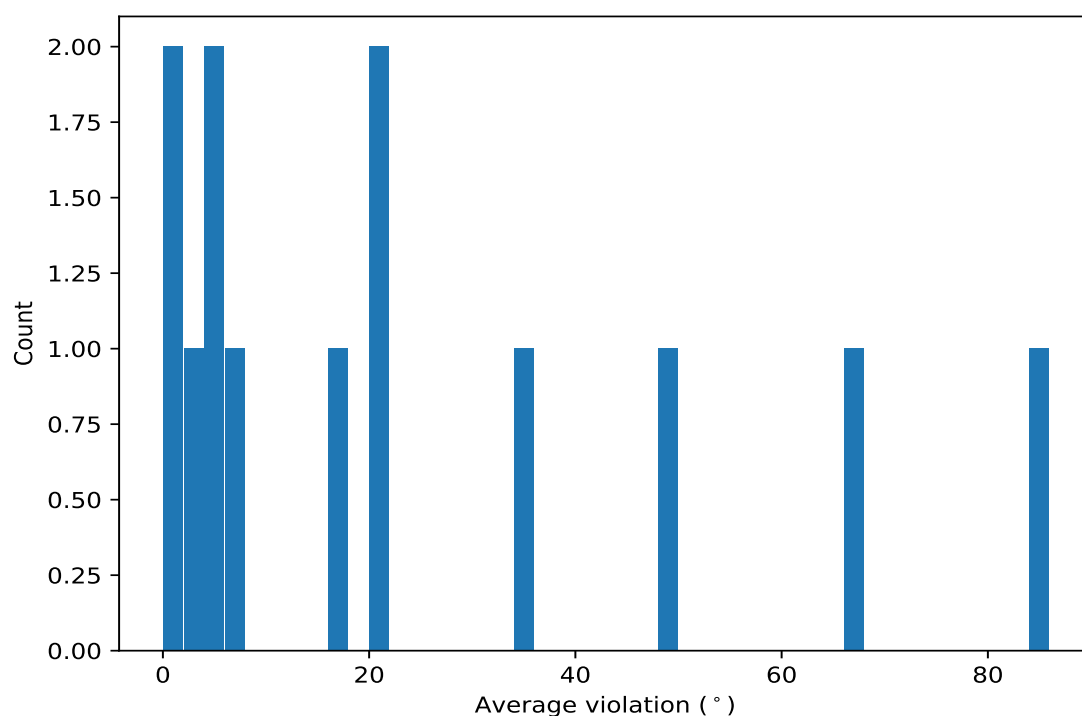
10.3.1 Bar graph : Dihedral-angle Violation statistics for the ensemble [i](#)



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 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.

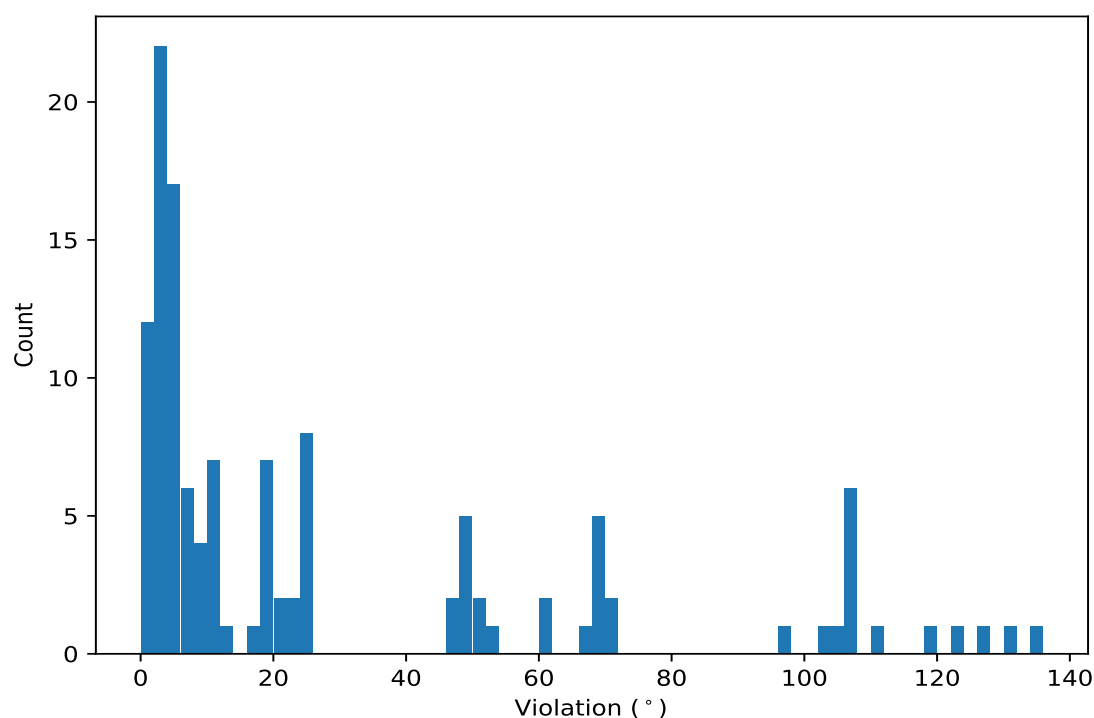
Key	Atom-1	Atom-2	Atom-3	Atom-4	Models ¹	Mean	SD ²	Median
(1,68)	1:1:A:G:O5'	1:1:A:G:C5'	1:1:A:G:C4'	1:1:A:G:C3'	10	85.94	41.74	106.44
(1,102)	1:1:A:G:C5'	1:1:A:G:C4'	1:1:A:G:C3'	1:1:A:G:O3'	10	67.08	3.6	68.48
(1,253)	1:1:A:G:C1'	1:1:A:G:C2'	1:1:A:G:C3'	1:1:A:G:C4'	10	49.53	1.78	49.82
(1,1)	1:1:A:G:O3'	1:2:A:G:P	1:2:A:G:O5'	1:2:A:G:C5'	10	35.96	33.1	25.37
(1,252)	1:1:A:G:O4'	1:1:A:G:C1'	1:1:A:G:C2'	1:1:A:G:C3'	10	20.09	1.33	19.84
(1,69)	1:2:A:G:O5'	1:2:A:G:C5'	1:2:A:G:C4'	1:2:A:G:C3'	10	20.04	29.32	10.36
(1,169)	1:40:A:C:C4'	1:40:A:C:C3'	1:40:A:C:O3'	1:41:A:U:P	10	2.34	0.33	2.37
(1,70)	1:3:A:G:O5'	1:3:A:G:C5'	1:3:A:G:C4'	1:3:A:G:C3'	9	17.14	37.73	4.11
(1,174)	1:1:A:G:C3'	1:1:A:G:O3'	1:2:A:G:P	1:2:A:G:O5'	9	6.33	0.97	6.87
(1,142)	1:2:A:G:C4'	1:2:A:G:C3'	1:2:A:G:O3'	1:3:A:G:P	9	5.54	3.94	4.22

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 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 (°)
(1,1)	1:1:A:G:O3'	1:2:A:G:P	1:2:A:G:O5'	1:2:A:G:C5'	1	135.23
(1,2)	1:2:A:G:O3'	1:3:A:G:P	1:3:A:G:O5'	1:3:A:G:C5'	4	130.72
(1,26)	1:33:A:A:O3'	1:34:A:G:P	1:34:A:G:O5'	1:34:A:G:C5'	9	127.57
(1,70)	1:3:A:G:O5'	1:3:A:G:C5'	1:3:A:G:C4'	1:3:A:G:C3'	4	123.86
(1,94)	1:34:A:G:O5'	1:34:A:G:C5'	1:34:A:G:C4'	1:34:A:G:C3'	9	119.24
(1,68)	1:1:A:G:O5'	1:1:A:G:C5'	1:1:A:G:C4'	1:1:A:G:C3'	2	111.93
(1,69)	1:2:A:G:O5'	1:2:A:G:C5'	1:2:A:G:C4'	1:2:A:G:C3'	1	107.96
(1,68)	1:1:A:G:O5'	1:1:A:G:C5'	1:1:A:G:C4'	1:1:A:G:C3'	8	106.95
(1,68)	1:1:A:G:O5'	1:1:A:G:C5'	1:1:A:G:C4'	1:1:A:G:C3'	6	106.81
(1,68)	1:1:A:G:O5'	1:1:A:G:C5'	1:1:A:G:C4'	1:1:A:G:C3'	5	106.78