



Full wwPDB NMR Structure Validation Report ⓘ

Feb 12, 2017 – 10:34 pm GMT

PDB ID : 2GIW
Title : SOLUTION STRUCTURE OF REDUCED HORSE HEART CY-
TOCHROME C, NMR, 40 STRUCTURES
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Deposited on : 1998-06-25

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

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

A user guide is available at

<http://wwpdb.org/validation/2016/NMRValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

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

Cyrange : Kirchner and Güntert (2011)
NmrClust : Kelley et al. (1996)
MolProbity : 4.02b-467
Mogul : 1.7.2 (RC1), CSD as538be (2017)
Percentile statistics : 20161228.v01 (using entries in the PDB archive December 28th 2016)
RCI : v_1n_11_5_13_A (Berjanski et al., 2005)
PANAV : Wang et al. (2010)
ShiftChecker : trunk28760
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : recalc28949

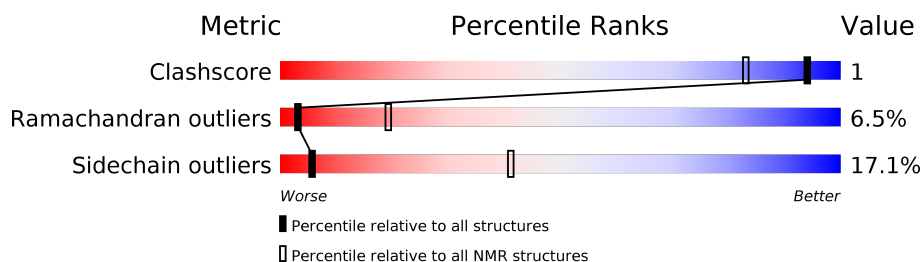
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

SOLUTION NMR

The overall completeness of chemical shifts assignment was not calculated.

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	125131	11601
Ramachandran outliers	121729	10391
Sidechain outliers	121581	10367

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	104	 76% 16% • 7%

2 Ensemble composition and analysis

This entry contains 40 models. Model 1 is the overall representative, medoid model (most similar to other models).

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:1-A:20, A:28-A:104 (97)	0.41	1

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, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 34, 35, 37, 39, 40
2	33, 38
Single-model clusters	36

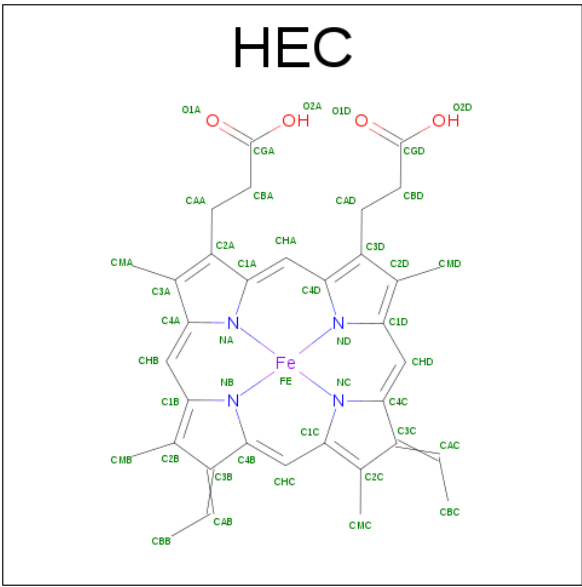
3 Entry composition i

There are 2 unique types of molecules in this entry. The entry contains 1745 atoms, of which 876 are hydrogens and 3 are deuteriums.

- Molecule 1 is a protein called CYTOCHROME C.

Mol	Chain	Residues	Atoms							Trace
1	A	104	Total	C	D	H	N	O	S	0
			1670	524	3	844	144	151	4	

- Molecule 2 is HEME C (three-letter code: HEC) (formula: C₃₄H₃₄FeN₄O₄).



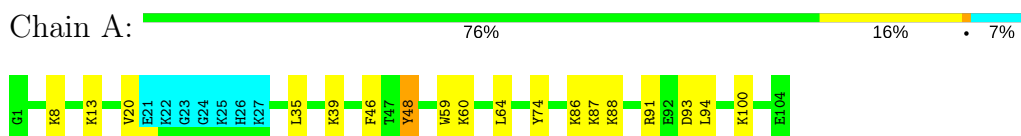
Mol	Chain	Residues	Atoms					
2	A	1	Total	C	Fe	H	N	O
			75	34	1	32	4	4

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: CYTOCHROME C

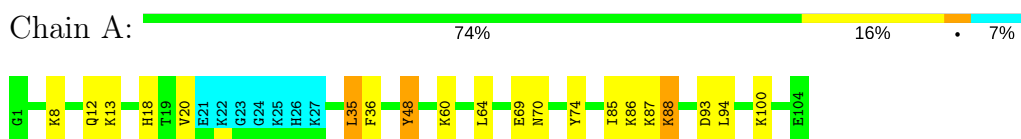


4.2 Scores per residue for each member of the ensemble

Colouring as in section [4.1](#) above.

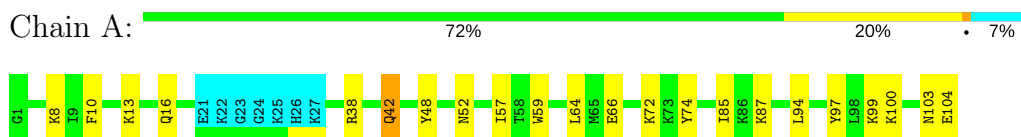
4.2.1 Score per residue for model 1 (medoid)

- Molecule 1: CYTOCHROME C



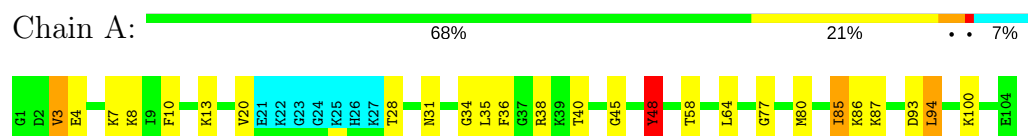
4.2.2 Score per residue for model 2

- Molecule 1: CYTOCHROME C



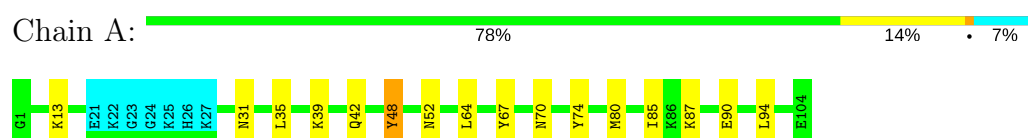
4.2.3 Score per residue for model 3

- Molecule 1: CYTOCHROME C



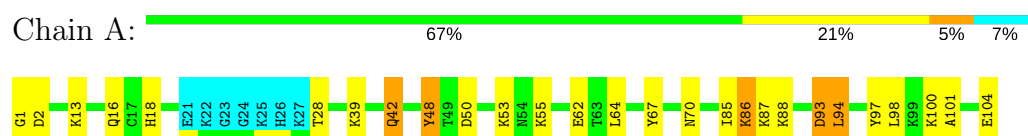
4.2.4 Score per residue for model 4

- Molecule 1: CYTOCHROME C



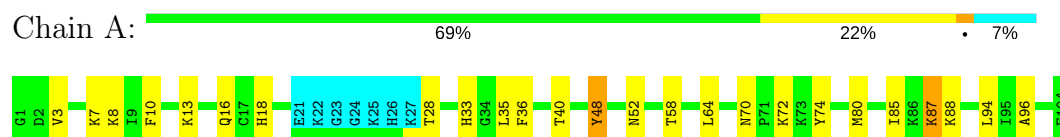
4.2.5 Score per residue for model 5

- Molecule 1: CYTOCHROME C



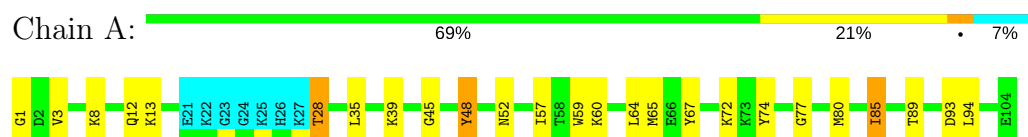
4.2.6 Score per residue for model 6

- Molecule 1: CYTOCHROME C




4.2.7 Score per residue for model 7

- Molecule 1: CYTOCHROME C



4.2.8 Score per residue for model 8

- Molecule 1: CYTOCHROME C

Chain A:  72% 18% 7%



4.2.9 Score per residue for model 9

- Molecule 1: CYTOCHROME C

Chain A:  74% 17% 7%



4.2.10 Score per residue for model 10


- Molecule 1: CYTOCHROME C

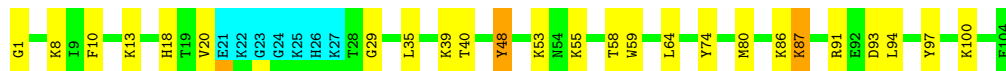
Chain A:  76% 16% 7%



4.2.11 Score per residue for model 11

- Molecule 1: CYTOCHROME C

Chain A:  69% 22% 7%



4.2.12 Score per residue for model 12

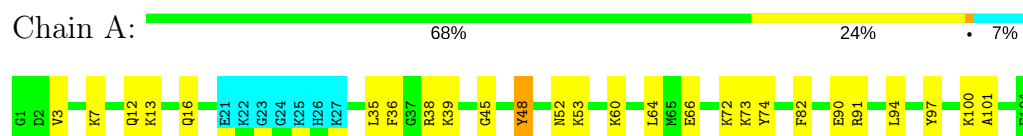
- Molecule 1: CYTOCHROME C

Chain A:  67% 26% 7%



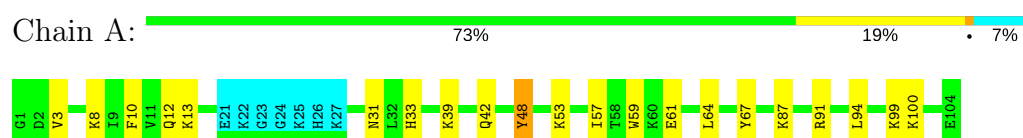
4.2.13 Score per residue for model 13

- Molecule 1: CYTOCHROME C



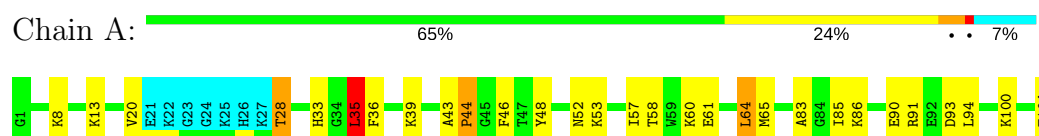
4.2.14 Score per residue for model 14

- Molecule 1: CYTOCHROME C



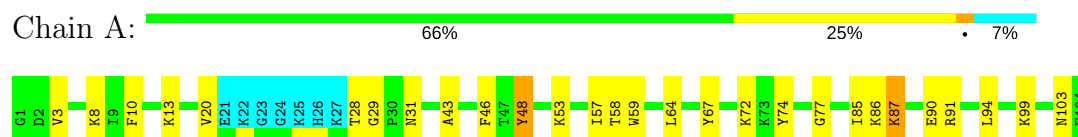
4.2.15 Score per residue for model 15

- Molecule 1: CYTOCHROME C



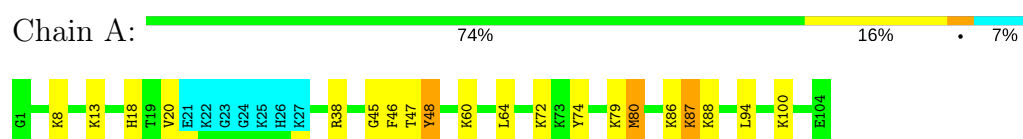
4.2.16 Score per residue for model 16

- Molecule 1: CYTOCHROME C



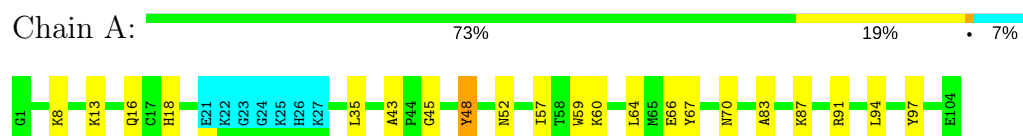
4.2.17 Score per residue for model 17

- Molecule 1: CYTOCHROME C



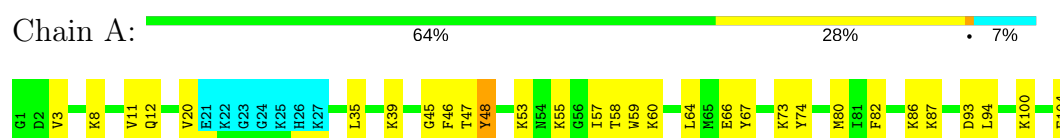
4.2.18 Score per residue for model 18

- Molecule 1: CYTOCHROME C



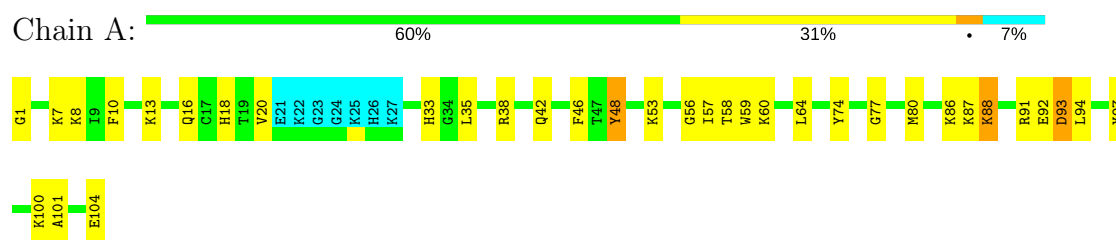
4.2.19 Score per residue for model 19

- Molecule 1: CYTOCHROME C



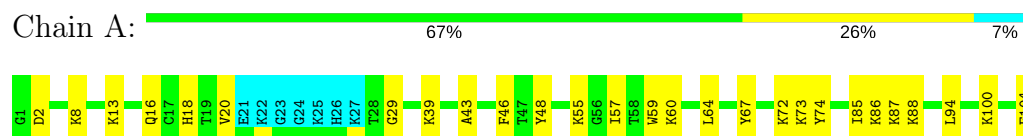
4.2.20 Score per residue for model 20

- Molecule 1: CYTOCHROME C



4.2.21 Score per residue for model 21

- Molecule 1: CYTOCHROME C



4.2.22 Score per residue for model 22

- Molecule 1: CYTOCHROME C

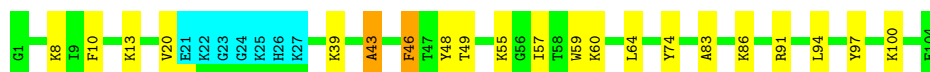




4.2.23 Score per residue for model 23

- Molecule 1: CYTOCHROME C

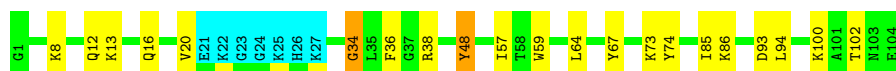
Chain A: 73% 18% 7%



4.2.24 Score per residue for model 24

- Molecule 1: CYTOCHROME C

Chain A: 73% 18% 7%



4.2.25 Score per residue for model 25

- Molecule 1: CYTOCHROME C

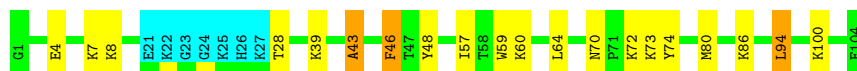
Chain A: 73% 19% 7%



4.2.26 Score per residue for model 26

- Molecule 1: CYTOCHROME C

Chain A: 74% 16% 7%



4.2.27 Score per residue for model 27

- Molecule 1: CYTOCHROME C

Chain A: 72% 20% 7%



4.2.28 Score per residue for model 28

- Molecule 1: CYTOCHROME C

Chain A: 76% 17% 7%



4.2.29 Score per residue for model 29

- Molecule 1: CYTOCHROME C

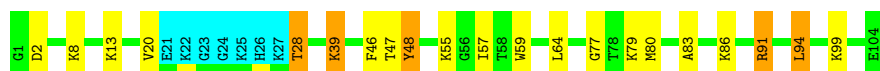
Chain A: 66% 25% 7%



4.2.30 Score per residue for model 30

- Molecule 1: CYTOCHROME C

Chain A: 73% 15% 5% 7%



4.2.31 Score per residue for model 31

- Molecule 1: CYTOCHROME C

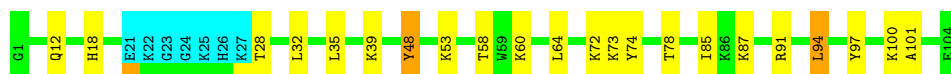
Chain A: 72% 18% 7%



4.2.32 Score per residue for model 32

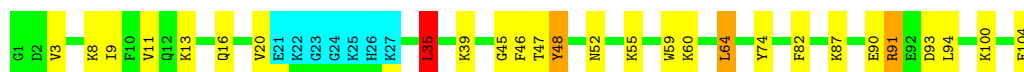
- Molecule 1: CYTOCHROME C

Chain A: 72% 19% 7%



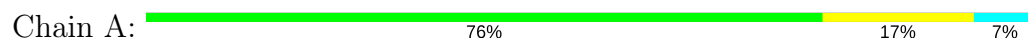
4.2.33 Score per residue for model 33

- Molecule 1: CYTOCHROME C



4.2.34 Score per residue for model 34

- Molecule 1: CYTOCHROME C



4.2.35 Score per residue for model 35

- Molecule 1: CYTOCHROME C



4.2.36 Score per residue for model 36

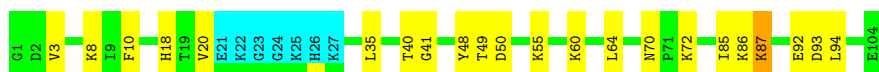
- Molecule 1: CYTOCHROME C



4.2.37 Score per residue for model 37

- Molecule 1: CYTOCHROME C

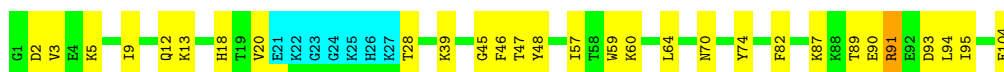




4.2.38 Score per residue for model 38

- Molecule 1: CYTOCHROME C

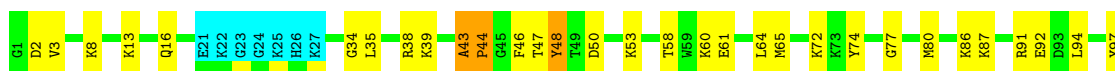
Chain A: 65% 27% 7%



4.2.39 Score per residue for model 39

- Molecule 1: CYTOCHROME C

Chain A: 63% 27% 7%



4.2.40 Score per residue for model 40

- Molecule 1: CYTOCHROME C

Chain A: 71% 19% 7%



5 Refinement protocol and experimental data overview

The models were refined using the following method: *SIMULATED ANNEALING TORSION ANGLE DYNAMICS*, *RESTRAINED ENERGY MINIMIZATION*.

Of the 40 calculated structures, 40 were deposited, based on the following criterion: *LEAST RESTRAINT VIOLATION*.

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

Software name	Classification	Version
AMBER	refinement	
DYANA	structure solution	
AMBER	structure solution	

No chemical shift data was provided. No validations of the models with respect to experimental NMR restraints is performed at this time.

6 Model quality

6.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: HEC

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	0.58±0.01	0±0/784 (0.0±0.0%)	0.92±0.02	0±0/1048 (0.0±0.0%)
All	All	0.58	0/31360 (0.0%)	0.92	3/41920 (0.0%)

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	2.9±1.1
All	All	0	117

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(°)	Ideal(°)	Models	
								Worst	Total
1	A	91	ARG	NE-CZ-NH2	-5.85	117.38	120.30	8	2
1	A	74	TYR	CB-CG-CD1	-5.18	117.89	121.00	22	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	74	TYR	Sidechain	27
1	A	48	TYR	Sidechain	23
1	A	10	PHE	Sidechain	16
1	A	18	HIS	Sidechain	14

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Mol	Chain	Res	Type	Group	Models (Total)
1	A	67	TYR	Sidechain	14
1	A	91	ARG	Sidechain	9
1	A	36	PHE	Sidechain	5
1	A	97	TYR	Sidechain	4
1	A	82	PHE	Sidechain	3
1	A	38	ARG	Sidechain	2

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	771	787	789	2±2
2	A	43	32	30	1±1
All	All	32560	32760	32760	92

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 1.

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

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:1:GLY:HA2	1:A:93:ASP:HA	0.75	1.59	20	6
1:A:1:GLY:HA2	1:A:93:ASP:CA	0.70	2.16	20	6
1:A:1:GLY:HA2	1:A:93:ASP:N	0.67	2.05	11	4
1:A:43:ALA:HB1	1:A:44:PRO:CD	0.60	2.27	39	1
1:A:94:LEU:HD12	2:A:105:HEC:HMB1	0.58	1.76	5	15
1:A:43:ALA:HB1	1:A:44:PRO:HD2	0.56	1.76	39	2
1:A:35:LEU:HD11	2:A:105:HEC:HBA1	0.53	1.80	40	1
1:A:3:VAL:HG22	1:A:96:ALA:HB1	0.52	1.81	6	1
1:A:43:ALA:HB3	1:A:47:THR:HB	0.50	1.83	39	1
2:A:105:HEC:HHA	2:A:105:HEC:CGD	0.50	2.37	14	3
1:A:3:VAL:HG23	1:A:97:TYR:HA	0.49	1.85	39	1
1:A:97:TYR:CE1	1:A:101:ALA:HB2	0.49	2.43	20	4
1:A:28:THR:O	2:A:105:HEC:HMD3	0.48	2.08	29	6
1:A:35:LEU:HD21	2:A:105:HEC:HMA3	0.47	1.86	4	2
1:A:20:VAL:HG13	1:A:20:VAL:O	0.47	2.09	36	5
2:A:105:HEC:CGD	2:A:105:HEC:HHA	0.47	2.39	12	1

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Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:28:THR:C	2:A:105:HEC:HMD3	0.47	2.30	6	1
1:A:4:GLU:OE2	1:A:7:LYS:NZ	0.46	2.48	26	1
1:A:35:LEU:HD22	1:A:35:LEU:N	0.46	2.25	8	1
1:A:91:ARG:O	1:A:95:ILE:HD13	0.46	2.10	38	1
2:A:105:HEC:CHA	2:A:105:HEC:CGD	0.45	2.94	40	1
1:A:43:ALA:HB1	1:A:46:PHE:O	0.45	2.11	26	2
1:A:32:LEU:HB3	1:A:35:LEU:HD21	0.45	1.89	32	1
1:A:20:VAL:O	1:A:20:VAL:HG13	0.45	2.11	37	5
1:A:35:LEU:HD12	1:A:59:TRP:CB	0.44	2.43	40	1
1:A:34:GLY:O	1:A:102:THR:HG22	0.44	2.13	24	1
1:A:94:LEU:CD1	2:A:105:HEC:HMB1	0.43	2.42	39	1
1:A:35:LEU:HD22	1:A:64:LEU:HD11	0.43	1.91	33	2
1:A:35:LEU:HD11	2:A:105:HEC:CBA	0.42	2.44	40	1
1:A:3:VAL:HG21	1:A:100:LYS:HD2	0.42	1.90	39	1
1:A:95:ILE:HD12	1:A:95:ILE:H	0.42	1.74	27	1
1:A:4:GLU:OE1	1:A:7:LYS:NZ	0.42	2.51	3	1
1:A:79:LYS:HB3	2:A:105:HEC:HMD2	0.41	1.93	35	1
1:A:80:MET:HA	2:A:105:HEC:CHD	0.41	2.46	17	1
1:A:40:THR:HG23	1:A:41:GLY:N	0.41	2.30	37	1
1:A:98:LEU:HD11	2:A:105:HEC:HMB3	0.41	1.92	5	1
1:A:3:VAL:HG21	1:A:100:LYS:HD3	0.40	1.93	13	1
1:A:2:ASP:OD1	1:A:3:VAL:N	0.40	2.54	39	1
1:A:43:ALA:CB	1:A:44:PRO:CD	0.40	2.97	39	1
1:A:69:GLU:OE2	1:A:88:LYS:NZ	0.40	2.53	12	1
1:A:35:LEU:HD11	2:A:105:HEC:HMA3	0.40	1.94	7	1
1:A:47:THR:C	1:A:48:TYR:CG	0.40	2.94	30	1
1:A:7:LYS:HA	1:A:97:TYR:CD2	0.40	2.51	8	1

6.3 Torsion angles ⓘ

6.3.1 Protein backbone ⓘ

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	95/104 (91%)	67±3 (71±3%)	21±3 (22±3%)	6±2 (6±2%)	3	19
All	All	3800/4160 (91%)	2698 (71%)	855 (22%)	247 (6%)	3	19

All 31 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	87	LYS	31
1	A	59	TRP	24
1	A	86	LYS	18
1	A	57	ILE	17
1	A	3	VAL	14
1	A	88	LYS	13
1	A	35	LEU	13
1	A	20	VAL	11
1	A	45	GLY	10
1	A	85	ILE	10
1	A	39	LYS	10
1	A	47	THR	9
1	A	43	ALA	8
1	A	42	GLN	8
1	A	36	PHE	6
1	A	77	GLY	6
1	A	83	ALA	5
1	A	61	GLU	5
1	A	34	GLY	4
1	A	46	PHE	4
1	A	33	HIS	3
1	A	44	PRO	3
1	A	29	GLY	3
1	A	28	THR	2
1	A	31	ASN	2
1	A	48	TYR	2
1	A	89	THR	2
1	A	32	LEU	1
1	A	91	ARG	1
1	A	56	GLY	1
1	A	50	ASP	1

6.3.2 Protein sidechains [i](#)

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all PDB entries followed by that with respect to all NMR entries. The Analysed column shows the number of residues for which the sidechain conformation was analysed and the total number of residues.

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	A	81/86 (94%)	67±3 (83±3%)	14±3 (17±3%)	6	41
All	All	3240/3440 (94%)	2685 (83%)	555 (17%)	6	41

All 55 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	64	LEU	40
1	A	48	TYR	40
1	A	13	LYS	34
1	A	8	LYS	31
1	A	94	LEU	30
1	A	60	LYS	24
1	A	100	LYS	24
1	A	80	MET	17
1	A	46	PHE	17
1	A	93	ASP	16
1	A	70	ASN	16
1	A	72	LYS	15
1	A	39	LYS	14
1	A	52	ASN	13
1	A	55	LYS	13
1	A	12	GLN	12
1	A	16	GLN	12
1	A	91	ARG	11
1	A	58	THR	11
1	A	53	LYS	11
1	A	73	LYS	9
1	A	38	ARG	9
1	A	104	GLU	8
1	A	90	GLU	8
1	A	85	ILE	8
1	A	88	LYS	8
1	A	2	ASP	7
1	A	28	THR	7
1	A	99	LYS	7
1	A	66	GLU	6
1	A	7	LYS	6
1	A	87	LYS	6
1	A	86	LYS	5
1	A	92	GLU	5
1	A	31	ASN	5
1	A	42	GLN	5

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Mol	Chain	Res	Type	Models (Total)
1	A	35	LEU	5
1	A	78	THR	4
1	A	69	GLU	4
1	A	103	ASN	3
1	A	11	VAL	3
1	A	40	THR	3
1	A	65	MET	3
1	A	50	ASP	3
1	A	49	THR	3
1	A	57	ILE	2
1	A	82	PHE	2
1	A	79	LYS	2
1	A	9	ILE	2
1	A	33	HIS	1
1	A	5	LYS	1
1	A	62	GLU	1
1	A	3	VAL	1
1	A	61	GLU	1
1	A	89	THR	1

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 carbohydrates 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	HEC	A	105	1	28,50,50	0.82±0.04	0±0 (0±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	HEC	A	105	1	16,82,82	1.38±0.13	0±0 (0±0%)

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	HEC	A	105	1	-	0±0,6,54,54	0±0,0,8,8

There are no bond-length outliers.

There are no bond-angle outliers.

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

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

No chemical shift data were provided