



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 6, 2026 – 04:47 AM UTC

PDB ID : 9AUN / pdb_00009aun
Title : Structure of SARS-CoV-2 Mpro mutant (T21I,T304I)
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Deposited on : 2024-02-29
Resolution : 2.29 Å(reported)

This is a Full wwPDB X-ray Structure Validation Report for a publicly released PDB entry.

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

A user guide is available at

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

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
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.010 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

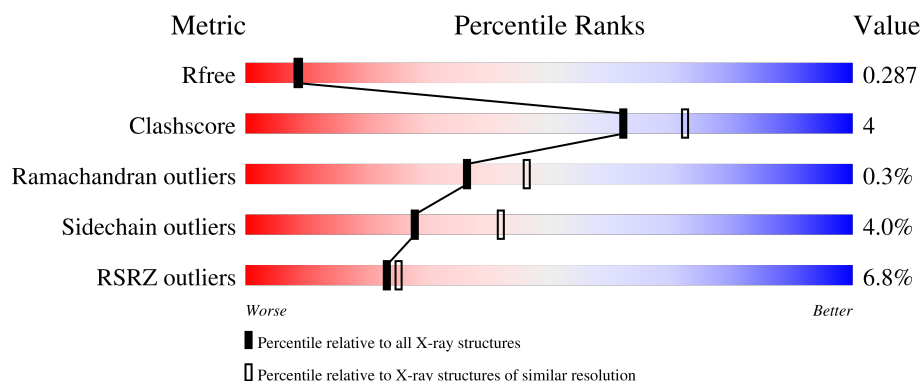
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.29 Å.

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)	Similar resolution (#Entries, resolution range(Å))
R_{free}	180053	6319 (2.30-2.30)
Clashscore	190562	6919 (2.30-2.30)
Ramachandran outliers	187476	6854 (2.30-2.30)
Sidechain outliers	187428	6854 (2.30-2.30)
RSRZ outliers	180081	6325 (2.30-2.30)

The table below summarises the geometric issues observed across the polymeric chains and their fit to the electron density. The red, orange, yellow and green segments of the lower bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria respectively. 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 $\leq 5\%$. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density. The numeric value is given above the bar.

Mol	Chain	Length	Quality of chain
1	A	306	2% 88% 12% .
1	B	306	11% 84% 14% ..

2 Entry composition

There are 2 unique types of molecules in this entry. The entry contains 4708 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, the ZeroOcc column contains the number of atoms modelled with zero occupancy, the AltConf column contains the number of residues with at least one atom in alternate conformation and the Trace column contains the number of residues modelled with at most 2 atoms.

- Molecule 1 is a protein called 3C-like proteinase nsp5.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	306	Total	C	N	O	S	0	0	0
			2369	1503	402	442	22			
1	B	301	Total	C	N	O	S	0	0	0
			2330	1476	396	436	22			

There are 4 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	21	ILE	THR	engineered mutation	UNP P0DTD1
A	304	ILE	THR	engineered mutation	UNP P0DTD1
B	21	ILE	THR	engineered mutation	UNP P0DTD1
B	304	ILE	THR	engineered mutation	UNP P0DTD1

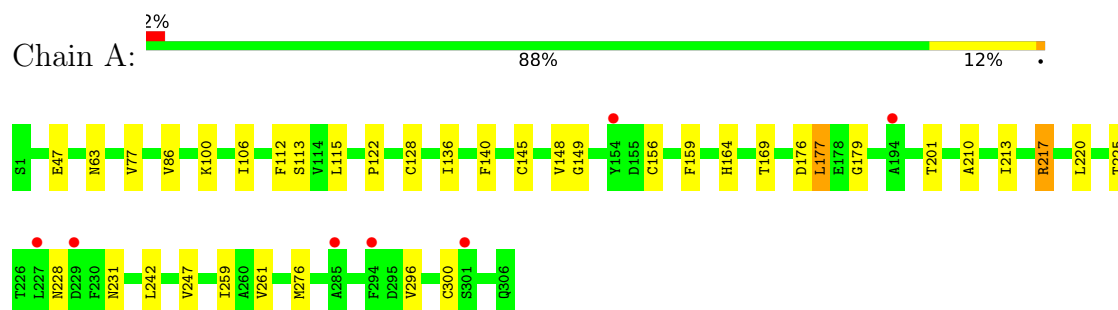
- Molecule 2 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	8	Total	O	0	0
			8	8		
2	B	1	Total	O	0	0
			1	1		

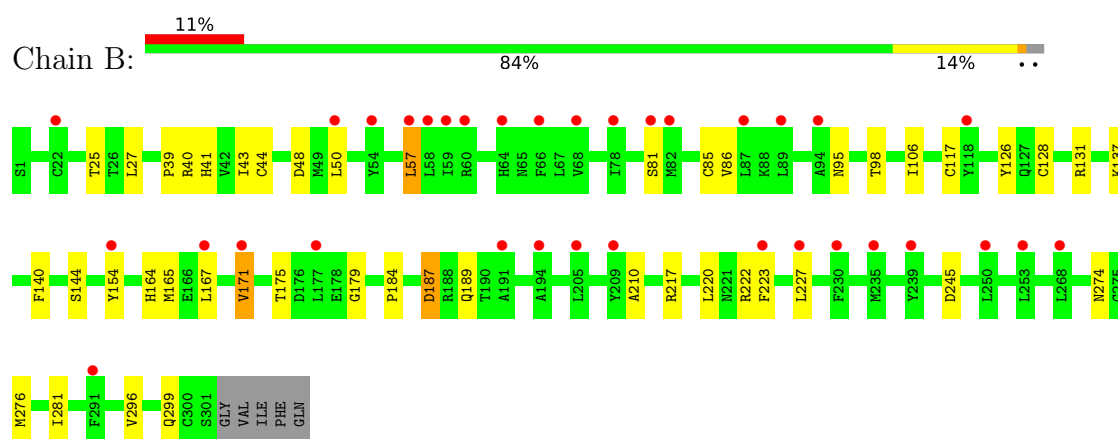
3 Residue-property plots

These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. Residues are color-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. A red dot above a residue indicates a poor fit to the electron density ($RSRZ > 2$). Stretches of 2 or more consecutive residues without any outlier are shown as a green connector. Residues present in the sample, but not in the model, are shown in grey.

• Molecule 1: 3C-like proteinase nsp5



• Molecule 1: 3C-like proteinase nsp5



4 Data and refinement statistics

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, α , β , γ	123.27 Å 82.08 Å 64.37 Å 90.00° 90.33° 90.00°	Depositor
Resolution (Å)	32.19 – 2.29 32.19 – 2.29	Depositor EDS
% Data completeness (in resolution range)	72.0 (32.19-2.29) 72.0 (32.19-2.29)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.69 (at 2.29 Å)	Xtriage
Refinement program	BUSTER 2.11.8 (8-JUN-2022)	Depositor
R, R_{free}	0.242 , 0.291 0.235 , 0.287	Depositor DCC
R_{free} test set	1052 reflections (5.04%)	wwPDB-VP
Wilson B-factor (Å ²)	64.5	Xtriage
Anisotropy	0.011	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.30 , 33.7	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.34$	Xtriage
Estimated twinning fraction	0.022 for -h,-k,l	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	4708	wwPDB-VP
Average B, all atoms (Å ²)	71.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 7.43% of the height of the origin peak. No significant pseudotranslation is detected.*

¹Intensities estimated from amplitudes.

²Theoretical values of $\langle |L| \rangle$, $\langle L^2 \rangle$ for acentric reflections are 0.5, 0.333 respectively for untwinned datasets, and 0.375, 0.2 for perfectly twinned datasets.

5 Model quality [i](#)

5.1 Standard geometry [i](#)

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 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	0.71	1/2422 (0.0%)	1.06	4/3291 (0.1%)
1	B	0.68	0/2382	1.03	1/3237 (0.0%)
All	All	0.69	1/4804 (0.0%)	1.04	5/6528 (0.1%)

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	276	MET	SD-CE	-5.71	1.65	1.79

All (5) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	187	ASP	CA-CB-CG	7.24	119.84	112.60
1	A	140	PHE	CA-CB-CG	6.00	119.80	113.80
1	A	148	VAL	CA-C-N	5.96	128.50	122.66
1	A	148	VAL	C-N-CA	5.96	128.50	122.66
1	A	176	ASP	N-CA-C	-5.39	102.90	110.35

There are no chirality outliers.

There are no planarity outliers.

5.2 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 the 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 within the asymmetric unit, whereas Symm-Clashes lists symmetry-related clashes.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	2369	0	2322	16	0
1	B	2330	0	2282	22	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
2	A	8	0	0	0	0
2	B	1	0	0	0	0
All	All	4708	0	4604	38	0

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 4.

All (38) close contacts within the same asymmetric unit are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:100:LYS:NZ	1:A:156:CYS:HB2	1.83	0.93
1:A:100:LYS:HZ2	1:A:156:CYS:HB2	1.41	0.83
1:A:86:VAL:HG13	1:A:179:GLY:HA2	1.77	0.67
1:A:100:LYS:HZ3	1:A:156:CYS:HB2	1.59	0.65
1:B:41:HIS:CE1	1:B:165:MET:HE2	2.32	0.64
1:B:43:ILE:HD12	1:B:57:LEU:HB3	1.83	0.61
1:B:41:HIS:ND1	1:B:165:MET:HE2	2.19	0.58
1:B:86:VAL:HG13	1:B:179:GLY:HA2	1.86	0.58
1:B:167:LEU:HD12	1:B:171:VAL:HG23	1.87	0.57
1:A:231:ASN:HD21	1:A:242:LEU:H	1.51	0.57
1:A:213:ILE:HG21	1:A:300:CYS:HB3	1.88	0.56
1:B:164:HIS:CE1	1:B:175:THR:HG23	2.40	0.55
1:A:115:LEU:HD11	1:A:122:PRO:HB3	1.88	0.55
1:A:231:ASN:ND2	1:A:242:LEU:H	2.05	0.55
1:A:145:CYS:SG	1:A:164:HIS:O	2.66	0.53
1:A:159:PHE:HB3	1:A:177:LEU:HD13	1.91	0.53
1:B:276:MET:HE3	1:B:281:ILE:HG13	1.93	0.51
1:B:210:ALA:HB2	1:B:296:VAL:HG13	1.94	0.50
1:B:44:CYS:HB3	1:B:48:ASP:HB2	1.94	0.50
1:A:63:ASN:HB3	1:A:77:VAL:O	2.12	0.49
1:B:40:ARG:HD3	1:B:85:CYS:HA	1.95	0.49
1:B:126:TYR:HE2	1:B:128:CYS:SG	2.37	0.48
1:B:164:HIS:CE1	1:B:175:THR:CG2	2.97	0.47
1:B:222:ARG:NH2	1:B:223:PHE:CE1	2.83	0.47
1:A:247:VAL:HG13	1:A:261:VAL:HG11	1.96	0.46
1:B:217:ARG:HB2	1:B:220:LEU:HD12	1.97	0.46
1:B:41:HIS:ND1	1:B:165:MET:CE	2.79	0.45
1:A:217:ARG:HB3	1:A:220:LEU:HD12	1.99	0.44
1:B:95:ASN:HB3	1:B:98:THR:OG1	2.18	0.44
1:B:117:CYS:O	1:B:144:SER:HA	2.18	0.43
1:B:25:THR:OG1	1:B:44:CYS:O	2.29	0.43

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:140:PHE:HB3	1:B:144:SER:OG	2.18	0.43
1:A:210:ALA:HB2	1:A:296:VAL:HG13	2.02	0.42
1:B:131:ARG:HD3	1:B:137:LYS:HE2	2.02	0.42
1:A:113:SER:O	1:A:149:GLY:HA2	2.19	0.42
1:A:112:PHE:HZ	1:A:136:ILE:HG21	1.85	0.41
1:B:126:TYR:HE2	1:B:128:CYS:HG	1.63	0.41
1:B:27:LEU:HD13	1:B:39:PRO:HD2	2.04	0.40

There are no symmetry-related clashes.

5.3 Torsion angles [i](#)

5.3.1 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 X-ray entries followed by that with respect to entries of similar resolution.

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	304/306 (99%)	294 (97%)	10 (3%)	0	100	100
1	B	299/306 (98%)	279 (93%)	18 (6%)	2 (1%)	18	23
All	All	603/612 (98%)	573 (95%)	28 (5%)	2 (0%)	36	46

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	154	TYR
1	B	184	PRO

5.3.2 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 X-ray entries followed by that with respect to entries of similar resolution.

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	263/263 (100%)	253 (96%)	10 (4%)	29	44
1	B	259/263 (98%)	248 (96%)	11 (4%)	26	40
All	All	522/526 (99%)	501 (96%)	21 (4%)	28	42

All (21) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	47	GLU
1	A	106	ILE
1	A	128	CYS
1	A	169	THR
1	A	177	LEU
1	A	201	THR
1	A	217	ARG
1	A	225	THR
1	A	228	ASN
1	A	259	ILE
1	B	50	LEU
1	B	57	LEU
1	B	81	SER
1	B	106	ILE
1	B	171	VAL
1	B	187	ASP
1	B	189	GLN
1	B	227	LEU
1	B	245	ASP
1	B	274	ASN
1	B	299	GLN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (8) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	53	ASN
1	A	163	HIS
1	A	231	ASN
1	A	238	ASN
1	B	53	ASN
1	B	95	ASN
1	B	110	GLN
1	B	164	HIS

5.3.3 RNA [i](#)

There are no RNA molecules in this entry.

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

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

5.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

There are no ligands in this entry.

5.7 Other polymers [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

6 Fit of model and data

6.1 Protein, DNA and RNA chains

In the following table, the column labelled ‘#RSRZ> 2’ contains the number (and percentage) of RSRZ outliers, followed by percent RSRZ outliers for the chain as percentile scores relative to all X-ray entries and entries of similar resolution. The OWAB column contains the minimum, median, 95th percentile and maximum values of the occupancy-weighted average B-factor per residue. The column labelled ‘Q< 0.9’ lists the number of (and percentage) of residues with an average occupancy less than 0.9.

Mol	Chain	Analysed	<RSRZ>	#RSRZ>2	OWAB(Å ²)	Q<0.9
1	A	306/306 (100%)	0.45	7 (2%) 61 63	37, 59, 81, 99	0
1	B	301/306 (98%)	1.04	34 (11%) 10 11	43, 80, 111, 120	0
All	All	607/612 (99%)	0.74	41 (6%) 23 25	37, 68, 108, 120	0

All (41) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	205	LEU	4.8
1	B	66	PHE	4.2
1	B	87	LEU	3.9
1	B	230	PHE	3.8
1	B	194	ALA	3.6
1	B	167	LEU	3.6
1	B	171	VAL	3.6
1	B	223	PHE	3.1
1	B	154	TYR	3.1
1	B	239	TYR	3.0
1	A	194	ALA	2.9
1	B	209	TYR	2.8
1	B	22	CYS	2.8
1	B	54	TYR	2.8
1	B	291	PHE	2.7
1	B	57	LEU	2.7
1	A	294	PHE	2.6
1	B	50	LEU	2.6
1	B	82	MET	2.5
1	B	235	MET	2.5
1	B	81	SER	2.5
1	B	78	ILE	2.5
1	A	154	TYR	2.5
1	B	64	HIS	2.5

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Mol	Chain	Res	Type	RSRZ
1	B	59	ILE	2.3
1	B	58	LEU	2.3
1	B	191	ALA	2.3
1	A	301	SER	2.3
1	B	250	LEU	2.3
1	B	253	LEU	2.2
1	B	68	VAL	2.2
1	B	227	LEU	2.2
1	B	94	ALA	2.2
1	A	229	ASP	2.1
1	B	89	LEU	2.1
1	B	177	LEU	2.1
1	B	268	LEU	2.1
1	B	60	ARG	2.1
1	B	118	TYR	2.0
1	A	285	ALA	2.0
1	A	227	LEU	2.0

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

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

6.3 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.4 Ligands [i](#)

There are no ligands in this entry.

6.5 Other polymers [i](#)

There are no such residues in this entry.