Full wwPDB X-ray Structure Validation Report (i)

May 13, 2025 – 02:07 PM JST

PDB ID	:	8X5O / pdb_00008x5o
Title	:	Crystal structure of the post-fusion core of MjHKUr-CoV spike protein.
Authors	:	Zhu, Y.; Yang, X.; Sun, F.
Deposited on	:	2023-11-17
Resolution	:	2.67 Å(reported)

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

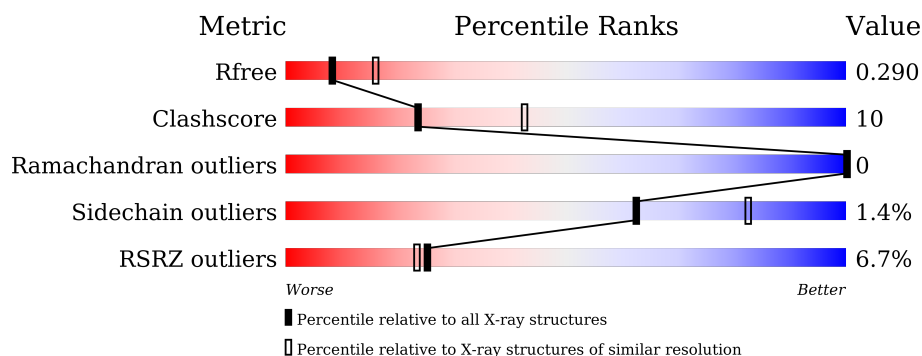|		
MolProbity	:	4-5-2 with Phenix2.0rc1
Xtriage (Phenix)	:	2.0rc1
EDS	:	3.0
Percentile statistics	:	20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4	:	9.0.006 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.43.1

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 2.67 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	Percentile Ranks	Value
Rfree		0.290
Clashscore		10
Ramachandran outliers		0
Sidechain outliers		1.4%
RSRZ outliers		6.7%

Worse .... *Better*

▮ Percentile relative to all X-ray structures

❏ Percentile relative to X-ray structures of similar resolution

Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R$_{free}$	164625	4708 (2.70-2.66)
Clashscore	180529	5138 (2.70-2.66)
Ramachandran outliers	177936	5071 (2.70-2.66)
Sidechain outliers	177891	5071 (2.70-2.66)
RSRZ outliers	164620	4708 (2.70-2.66)

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 <=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	126	6% / 74% 13% 13%
1	B	126	6% / 69% 17% 14%
1	C	126	6% / 66% 22% · 11%

2 Entry composition ⓘ

There are 2 unique types of molecules in this entry. The entry contains 2612 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 spike protein S2.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	109	Total	C	N	O	S	0	0	0
			823	513	138	170	2			
1	B	108	Total	C	N	O	S	0	0	0
			817	508	137	170	2			
1	C	112	Total	C	N	O	S	0	0	0
			847	526	141	178	2			

There are 27 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	996	ALA	SER	conflict	UNP A3EX94
A	1036	ASN	GLN	conflict	UNP A3EX94
A	1061	ASN	ALA	conflict	UNP A3EX94
A	1065	SER	-	linker	UNP A3EX94
A	1066	GLY	-	linker	UNP A3EX94
A	1067	GLY	-	linker	UNP A3EX94
A	1068	ARG	-	linker	UNP A3EX94
A	1069	GLY	-	linker	UNP A3EX94
A	1070	GLY	-	linker	UNP A3EX94
B	996	ALA	SER	conflict	UNP A3EX94
B	1036	ASN	GLN	conflict	UNP A3EX94
B	1061	ASN	ALA	conflict	UNP A3EX94
B	1065	SER	-	linker	UNP A3EX94
B	1066	GLY	-	linker	UNP A3EX94
B	1067	GLY	-	linker	UNP A3EX94
B	1068	ARG	-	linker	UNP A3EX94
B	1069	GLY	-	linker	UNP A3EX94
B	1070	GLY	-	linker	UNP A3EX94
C	996	ALA	SER	conflict	UNP A3EX94
C	1036	ASN	GLN	conflict	UNP A3EX94
C	1061	ASN	ALA	conflict	UNP A3EX94
C	1065	SER	-	linker	UNP A3EX94
C	1066	GLY	-	linker	UNP A3EX94

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Chain	Residue	Modelled	Actual	Comment	Reference
C	1067	GLY	-	linker	UNP A3EX94
C	1068	ARG	-	linker	UNP A3EX94
C	1069	GLY	-	linker	UNP A3EX94
C	1070	GLY	-	linker	UNP A3EX94
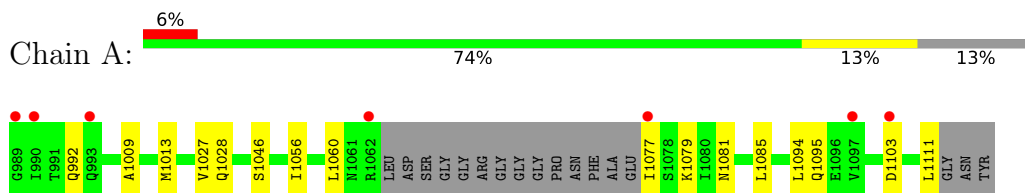
- Molecule 2 is water.

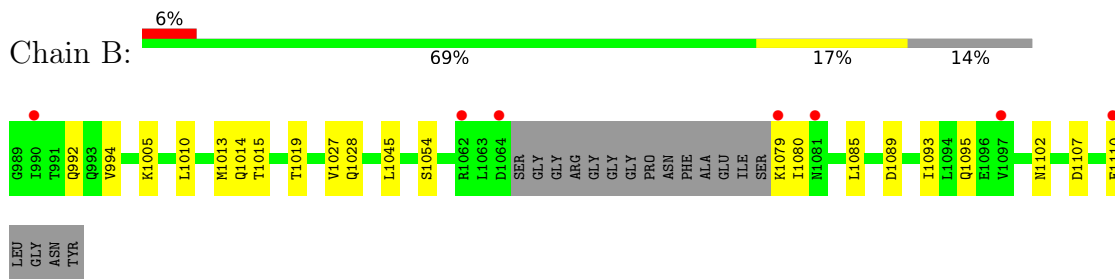| Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	39	Total 39	O 39	0	0
2	B	40	Total 40	O 40	0	0
2	C	46	Total 46	O 46	0	0

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.
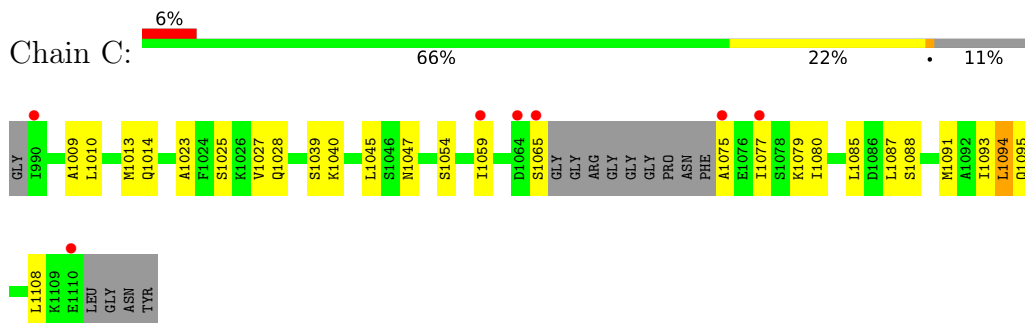
- Molecule 1: spike protein S2

- Molecule 1: spike protein S2

- Molecule 1: spike protein S2

4 Data and refinement statistics ⓘ

Property	Value	Source
Space group	P 63 2 2	Depositor
Cell constants a, b, c, α, β, γ	198.74Å 198.74Å 64.13Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	34.42 – 2.67 34.42 – 2.67	Depositor EDS
% Data completeness (in resolution range)	99.2 (34.42-2.67) 99.3 (34.42-2.67)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$<I/\sigma(I)>$ [1]	1.91 (at 2.68Å)	Xtriage
Refinement program	PHENIX (1.20.1_4487: ???)	Depositor
R, R_{free}	0.241 , 0.291 0.241 , 0.290	Depositor DCC
R_{free} test set	1100 reflections (5.07%)	wwPDB-VP
Wilson B-factor (Å^2)	33.0	Xtriage
Anisotropy	0.201	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.35 , 58.9	EDS
L-test for twinning[2]	$<|L|> = 0.48, <L^2> = 0.31$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o,F_c correlation	0.91	EDS
Total number of atoms	2612	wwPDB-VP
Average B, all atoms (Å^2)	38.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.88% of the height of the origin peak. No significant pseudotranslation is detected.*

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[1]Intensities estimated from amplitudes.
[2]Theoretical values of $<|L|>$, $<L^2>$ 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	0.15	0/826	0.30	0/1114
1	B	0.13	0/820	0.25	0/1106
1	C	0.14	0/850	0.31	0/1147
All	All	0.14	0/2496	0.29	0/3367

There are no bond length outliers.

There are no bond angle outliers.

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	823	0	839	15	1
1	B	817	0	827	17	0
1	C	847	0	856	26	1
2	A	39	0	0	5	0
2	B	40	0	0	4	1
2	C	46	0	0	5	1
All	All	2612	0	2522	50	2

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 10.

All (50) 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:C:1047:ASN:ND2	2:C:1201:HOH:O	1.89	0.81
1:A:1103:ASP:OD2	2:A:1201:HOH:O	2.02	0.77
1:C:1039:SER:OG	2:C:1202:HOH:O	2.02	0.76
1:B:1010:LEU:HA	1:B:1013:MET:HE3	1.71	0.72
1:B:1085:LEU:HD21	1:C:1027:VAL:HG12	1.73	0.69
1:B:1079:LYS:N	2:B:1202:HOH:O	2.25	0.69
1:B:1080:ILE:O	2:B:1201:HOH:O	2.12	0.67
1:C:1010:LEU:HA	1:C:1013:MET:HE3	1.78	0.66
1:A:1081:ASN:OD1	2:A:1202:HOH:O	2.12	0.66
1:A:1009:ALA:O	1:A:1013:MET:HG3	1.96	0.65
1:A:992:GLN:HE22	1:B:992:GLN:HG3	1.63	0.64
1:C:1108:LEU:O	2:C:1204:HOH:O	2.14	0.64
1:C:1065:SER:OG	2:C:1205:HOH:O	2.15	0.64
1:A:1056:ILE:O	1:A:1060:LEU:HB2	1.98	0.63
1:A:1085:LEU:HD21	1:B:1027:VAL:HG22	1.81	0.63
1:C:1075:ALA:HB1	1:C:1079:LYS:HE2	1.85	0.59
1:C:1075:ALA:O	1:C:1079:LYS:N	2.37	0.57
1:B:1089:ASP:O	1:B:1093:ILE:HG13	2.07	0.55
1:A:1013:MET:HE2	1:C:1013:MET:HE1	1.88	0.55
1:C:1023:ALA:O	1:C:1027:VAL:HG13	2.06	0.55
1:C:1077:ILE:HA	1:C:1080:ILE:HD12	1.90	0.53
1:C:1028:GLN:HA	1:C:1085:LEU:HD23	1.90	0.52
1:B:1015:THR:O	1:B:1019:THR:HG23	2.11	0.51
1:B:1110:GLU:CD	1:B:1110:GLU:H	2.19	0.51
1:C:1091:MET:O	1:C:1095:GLN:HG2	2.11	0.51
1:A:1028:GLN:HA	1:A:1085:LEU:HD23	1.92	0.50
1:C:1009:ALA:O	1:C:1013:MET:HG3	2.12	0.49
1:C:1010:LEU:HG	1:C:1014:GLN:HE21	1.77	0.49
1:A:1077:ILE:N	2:A:1205:HOH:O	2.46	0.47
1:C:1088:SER:OG	2:C:1203:HOH:O	2.12	0.47
1:B:1107:ASP:N	2:B:1203:HOH:O	2.27	0.46
1:C:1087:LEU:O	1:C:1091:MET:HG3	2.16	0.46
2:A:1211:HOH:O	1:B:1005:LYS:HE3	2.16	0.45
1:C:1025:SER:HB2	1:C:1091:MET:HE1	1.98	0.45
1:A:1095:GLN:HG2	2:A:1206:HOH:O	2.16	0.45
1:B:1014:GLN:NE2	1:B:1102:ASN:OD1	2.49	0.45
1:B:1028:GLN:HA	1:B:1085:LEU:HD23	1.99	0.45
1:B:1079:LYS:O	1:C:1040:LYS:NZ	2.49	0.45
1:B:1013:MET:SD	1:C:1013:MET:SD	3.16	0.43
1:A:1027:VAL:HG22	1:C:1085:LEU:HD21	1.99	0.43
1:A:1111:LEU:HD23	1:A:1111:LEU:HA	1.91	0.43
1:C:1093:ILE:O	1:C:1096:GLU:HG2	2.19	0.43

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:1046:SER:HB2	1:A:1077:ILE:N	2.34	0.42
1:C:1075:ALA:O	1:C:1079:LYS:HG2	2.18	0.42
1:B:1095:GLN:NE2	2:B:1210:HOH:O	2.53	0.42
1:A:1077:ILE:HA	1:A:1079:LYS:HE3	2.01	0.41
1:C:1094:LEU:O	1:C:1098:VAL:HG23	2.20	0.41
1:A:1094:LEU:HD23	1:A:1094:LEU:HA	1.89	0.41
1:C:1094:LEU:HD12	1:C:1094:LEU:HA	1.87	0.41
1:B:1045:LEU:HD13	1:C:1045:LEU:HD21	2.02	0.41

All (2) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:1079:LYS:NZ	1:C:1059:ILE:O[9_554]	2.18	0.02
2:B:1212:HOH:O	2:C:1206:HOH:O[1_556]	2.18	0.02

5.3 Torsion angles ⓘ

5.3.1 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 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	105/126 (83%)	103 (98%)	2 (2%)	0	100	100
1	B	104/126 (82%)	103 (99%)	1 (1%)	0	100	100
1	C	108/126 (86%)	106 (98%)	2 (2%)	0	100	100
All	All	317/378 (84%)	312 (98%)	5 (2%)	0	100	100

There are no Ramachandran outliers to report.

5.3.2 Protein sidechains ⓘ

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	93/103 (90%)	93 (100%)	0	100	100
1	B	92/103 (89%)	90 (98%)	2 (2%)	47	73
1	C	96/103 (93%)	94 (98%)	2 (2%)	48	74
All	All	281/309 (91%)	277 (99%)	4 (1%)	62	82

All (4) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	B	994	VAL
1	B	1054	SER
1	C	1054	SER
1	C	1094	LEU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (4) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	1061	ASN
1	B	1014	GLN
1	B	1095	GLN
1	B	1100	GLN

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

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

5.5 Carbohydrates ⓘ

There are no oligosaccharides in this entry.

5.6 Ligand geometry ⓘ

There are no ligands in this entry.

5.7 Other polymers ⓘ

There are no such residues in this entry.

5.8 Polymer linkage issues ⓘ

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	109/126 (86%)	0.22	7 (6%)	27	24	19, 35, 67, 129	0
1	B	108/126 (85%)	0.23	7 (6%)	26	24	18, 31, 58, 83	0
1	C	112/126 (88%)	0.25	8 (7%)	23	21	21, 34, 63, 76	0
All	All	329/378 (87%)	0.23	22 (6%)	25	23	18, 34, 66, 129	0

All (22) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	990	ILE	5.4
1	B	1064	ASP	4.8
1	B	1110	GLU	4.7
1	B	1079	LYS	4.4
1	A	989	GLY	4.3
1	C	1065	SER	4.3
1	C	990	ILE	3.9
1	A	1062	ARG	3.9
1	A	1097	VAL	3.6
1	B	1097	VAL	2.9
1	B	1062	ARG	2.8
1	C	1075	ALA	2.6
1	A	1103	ASP	2.6
1	C	1110	GLU	2.5
1	C	1064	ASP	2.5
1	A	1077	ILE	2.4
1	B	990	ILE	2.3
1	C	1105	TYR	2.2
1	B	1081	ASN	2.2
1	C	1059	ILE	2.1
1	A	993	GLN	2.1
1	C	1077	ILE	2.0

6.2 Non-standard residues in protein, DNA, RNA chains ⓘ

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

6.3 Carbohydrates ⓘ

There are no monosaccharides in this entry.

6.4 Ligands ⓘ

There are no ligands in this entry.

6.5 Other polymers ⓘ

There are no such residues in this entry.