Full wwPDB X-ray Structure Validation Report (i)

PDB ID	:	6X45
Title	:	SARS-CoV2 spike glycoprotein N-terminal heptad repeat domain + SARS-CoV2(QEYKKEKE)
Authors	:	Kreitler, D.F.; Outlaw, V.K.; Gellman, S.H.
Deposited on	:	2020-05-22
Resolution	:	2.20 Å(reported)

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

|		
MolProbity	:	4.02b-467
Xtriage (Phenix)	:	1.20.1
EDS	:	3.0
Percentile statistics	:	20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4	:	9.0.003 (Gargrove)
Density-Fitness	:	1.0.11
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.39

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 2.20 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.
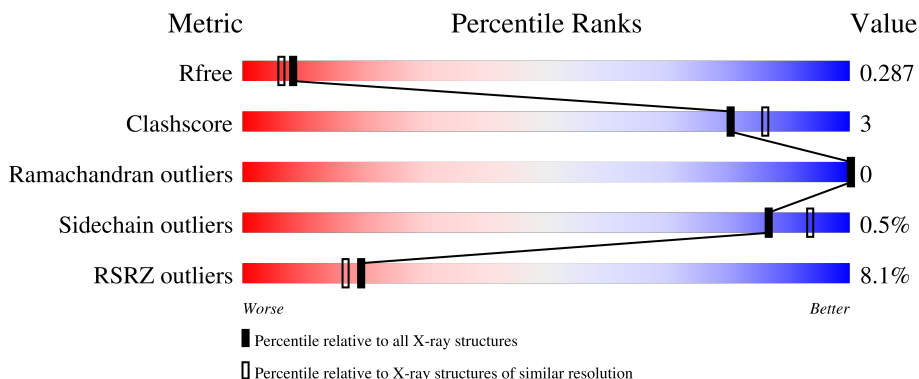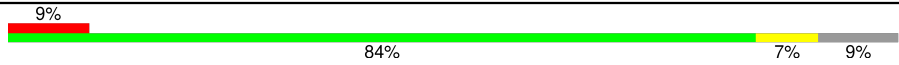

Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	164625	5791 (2.20-2.20)
Clashscore	180529	6634 (2.20-2.20)
Ramachandran outliers	177936	6560 (2.20-2.20)
Sidechain outliers	177891	6561 (2.20-2.20)
RSRZ outliers	164620	5791 (2.20-2.20)

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	D	38	8% / 87% / 11% ·
1	E	38	84% / 5% / 11%
1	F	38	5% / 84% / 5% / 11%
2	A	57	9% / 86% · / 11%
2	B	57	11% / 84% / 9% / 7%

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Mol	Chain	Length	Quality of chain
2	C	57	

2 Entry composition ⓘ

There are 3 unique types of molecules in this entry. The entry contains 3983 atoms, of which 1999 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	E	34	Total 537	C 170	H 272	N 41	O 54	0	0	0
1	D	37	Total 589	C 184	H 299	N 45	O 61	0	0	1
1	F	34	Total 525	C 167	H 263	N 41	O 54	0	0	0

There are 30 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
E	1167	ACE	-	acetylation	UNP P0DTC2
E	1171	GLN	GLY	engineered mutation	UNP P0DTC2
E	1180	GLU	GLN	engineered mutation	UNP P0DTC2
E	1181	TYR	LYS	engineered mutation	UNP P0DTC2
E	1184	LYS	ASP	engineered mutation	UNP P0DTC2
E	1185	LYS	ARG	engineered mutation	UNP P0DTC2
E	1187	GLU	ASN	engineered mutation	UNP P0DTC2
E	1192	LYS	ASN	engineered mutation	UNP P0DTC2
E	1194	GLU	ASN	engineered mutation	UNP P0DTC2
E	1204	NH2	-	amidation	UNP P0DTC2
D	1167	ACE	-	acetylation	UNP P0DTC2
D	1171	GLN	GLY	engineered mutation	UNP P0DTC2
D	1180	GLU	GLN	engineered mutation	UNP P0DTC2
D	1181	TYR	LYS	engineered mutation	UNP P0DTC2
D	1184	LYS	ASP	engineered mutation	UNP P0DTC2
D	1185	LYS	ARG	engineered mutation	UNP P0DTC2
D	1187	GLU	ASN	engineered mutation	UNP P0DTC2
D	1192	LYS	ASN	engineered mutation	UNP P0DTC2
D	1194	GLU	ASN	engineered mutation	UNP P0DTC2
D	1204	NH2	-	amidation	UNP P0DTC2
F	1167	ACE	-	acetylation	UNP P0DTC2
F	1171	GLN	GLY	engineered mutation	UNP P0DTC2
F	1180	GLU	GLN	engineered mutation	UNP P0DTC2

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Chain	Residue	Modelled	Actual	Comment	Reference
F	1181	TYR	LYS	engineered mutation	UNP P0DTC2
F	1184	LYS	ASP	engineered mutation	UNP P0DTC2
F	1185	LYS	ARG	engineered mutation	UNP P0DTC2
F	1187	GLU	ASN	engineered mutation	UNP P0DTC2
F	1192	LYS	ASN	engineered mutation	UNP P0DTC2
F	1194	GLU	ASN	engineered mutation	UNP P0DTC2
F	1204	NH2	-	amidation	UNP P0DTC2

- Molecule 2 is a protein called Spike protein S2'.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	C	52	Total 769	C 238	H 385	N 68	O 78	0	0	0
2	B	53	Total 795	C 245	H 400	N 70	O 80	0	0	0
2	A	51	Total 760	C 234	H 380	N 68	O 78	0	0	0

There are 6 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
C	911	ACE	-	acetylation	UNP P0DTC2
C	967	NH2	-	amidation	UNP P0DTC2
B	911	ACE	-	acetylation	UNP P0DTC2
B	967	NH2	-	amidation	UNP P0DTC2
A	911	ACE	-	acetylation	UNP P0DTC2
A	967	NH2	-	amidation	UNP P0DTC2

- Molecule 3 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	D	2	Total 2	O 2	0	0
3	C	2	Total 2	O 2	0	0
3	B	4	Total 4	O 4	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.
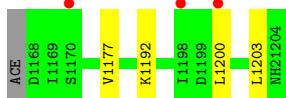
• Molecule 1: Spike protein S2'
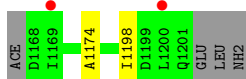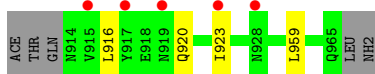
Chain E:
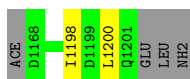
• Molecule 1: Spike protein S2'

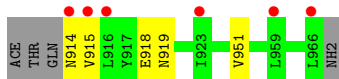Chain D:

• Molecule 1: Spike protein S2'

Chain F:

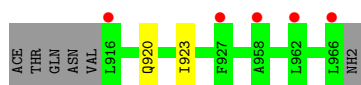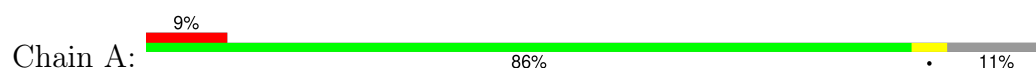• Molecule 2: Spike protein S2'

Chain C:

• Molecule 2: Spike protein S2'

Chain B:

• Molecule 2: Spike protein S2'

Chain A:

4 Data and refinement statistics ⓘ

Property	Value	Source
Space group	P 21 21 2	Depositor
Cell constants a, b, c, α, β, γ	53.54Å 54.46Å 80.12Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	45.04 – 2.20 45.04 – 2.20	Depositor EDS
% Data completeness (in resolution range)	99.1 (45.04-2.20) 91.3 (45.04-2.20)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.09	Depositor
$< I/\sigma(I) >$ [1]	1.09 (at 2.20Å)	Xtriage
Refinement program	PHENIX 1.17.1_3660	Depositor
R, R_{free}	0.243 , 0.278 0.248 , 0.287	Depositor DCC
R_{free} test set	11208 reflections (9.94%)	wwPDB-VP
Wilson B-factor (Å^2)	51.7	Xtriage
Anisotropy	0.269	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.40 , 70.6	EDS
L-test for twinning[2]	$< |L| > = 0.51, < L^2 > = 0.34$	Xtriage
Estimated twinning fraction	0.017 for k,h,-l	Xtriage
F_o,F_c correlation	0.94	EDS
Total number of atoms	3983	wwPDB-VP
Average B, all atoms (Å^2)	94.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 15.42% 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 ⓘ

5.1 Standard geometry ⓘ

Bond lengths and bond angles in the following residue types are not validated in this section: NH2

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	D	0.29	0/289	0.41	0/388
1	E	0.24	0/265	0.40	0/356
1	F	0.23	0/262	0.41	0/352
2	A	0.23	0/381	0.34	0/514
2	B	0.23	0/396	0.33	0/535
2	C	0.23	0/385	0.34	0/520
All	All	0.24	0/1978	0.37	0/2665

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 ⓘ

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	D	290	299	297	3	0
1	E	265	272	272	2	0
1	F	262	263	263	2	0
2	A	380	380	380	2	0
2	B	395	400	400	3	0
2	C	384	385	385	3	0
3	B	4	0	0	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
3	C	2	0	0	0	0
3	D	2	0	0	1	0
All	All	1984	1999	1997	10	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 3.

All (10) 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:D:1192:LYS:NZ	3:D:1301:HOH:O	2.27	0.68
2:C:916:LEU:O	2:C:920:GLN:N	2.30	0.63
2:C:959:LEU:HD23	1:F:1174:ALA:HB2	1.83	0.60
1:F:1198:ILE:HD13	2:A:923:ILE:HG12	1.85	0.59
1:E:1200:LEU:O	1:E:1200:LEU:HD12	2.03	0.58
1:E:1198:ILE:HD13	2:C:923:ILE:HG22	1.90	0.54
2:B:914:ASN:O	2:B:918:GLU:N	2.32	0.43
2:B:915:VAL:O	2:B:919:ASN:HB2	2.20	0.42
1:D:1200:LEU:HD11	2:A:920:GLN:O	2.18	0.42
1:D:1177:VAL:HB	2:B:951:VAL:HG21	2.01	0.41

There are no symmetry-related clashes.

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	D	35/38 (92%)	35 (100%)	0	0	100	100
1	E	32/38 (84%)	31 (97%)	1 (3%)	0	100	100
1	F	32/38 (84%)	32 (100%)	0	0	100	100
2	A	49/57 (86%)	49 (100%)	0	0	100	100

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
2	B	51/57 (90%)	50 (98%)	1 (2%)	0	100	100
2	C	50/57 (88%)	50 (100%)	0	0	100	100
All	All	249/285 (87%)	247 (99%)	2 (1%)	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	D	33/34 (97%)	32 (97%)	1 (3%)	36	48
1	E	29/34 (85%)	29 (100%)	0	100	100
1	F	28/34 (82%)	28 (100%)	0	100	100
2	A	41/47 (87%)	41 (100%)	0	100	100
2	B	43/47 (92%)	43 (100%)	0	100	100
2	C	41/47 (87%)	41 (100%)	0	100	100
All	All	215/243 (88%)	214 (100%)	1 (0%)	86	93

All (1) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	D	1203	LEU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. There are no such sidechains identified.

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	D	36/38 (94%)	0.43	3 (8%)	19	16	44, 75, 164, 190	0
1	E	34/38 (89%)	0.23	0	100	100	56, 82, 171, 208	0
1	F	34/38 (89%)	0.60	2 (5%)	29	26	59, 87, 162, 194	0
2	A	51/57 (89%)	0.69	5 (9%)	14	12	46, 80, 157, 188	0
2	B	53/57 (92%)	0.55	6 (11%)	11	9	37, 72, 156, 163	0
2	C	52/57 (91%)	0.69	5 (9%)	15	12	50, 82, 169, 193	0
All	All	260/285 (91%)	0.55	21 (8%)	19	17	37, 82, 164, 208	0

All (21) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
2	A	966	LEU	4.5
2	B	916	LEU	4.0
2	B	914	ASN	3.9
2	B	915	VAL	3.7
1	D	1198	ILE	3.7
2	C	919	ASN	3.7
1	D	1170	SER	3.4
2	B	966	LEU	3.4
2	C	915	VAL	2.7
2	A	958	ALA	2.6
2	A	927	PHE	2.4
2	A	962	LEU	2.4
2	C	917	TYR	2.3
2	C	923	ILE	2.2
2	A	916	LEU	2.2
2	B	923	ILE	2.2
1	D	1200	LEU	2.2
1	F	1200	LEU	2.1
2	B	959	LEU	2.1

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Mol	Chain	Res	Type	RSRZ
1	F	1169	ILE	2.0
2	C	928	ASN	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.