



Full wwPDB X-ray Structure Validation Report ⓘ

Jul 27, 2026 – 06:06 AM EDT

PDB ID : 9YAC / pdb_00009yac
Title : Measles Virus Fusion Glycoprotein Postfusion Core (T461I/N462S/N465S Variant)
Authors : Vithanage, N.; Outlaw, V.K.
Deposited on : 2025-09-15
Resolution : 1.63 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
Mogul	:	2022.3.0, CSD as543be (2022)
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.015 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.50

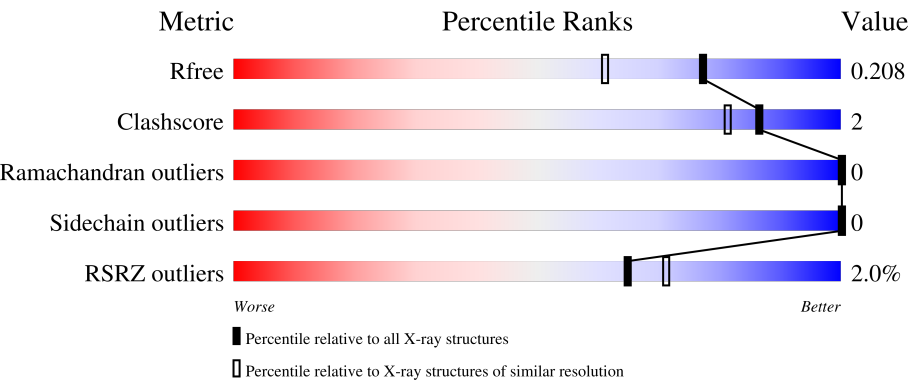
1 Overall quality at a glance i

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.63 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	1141 (1.64-1.64)
Clashscore	190562	1171 (1.64-1.64)
Ramachandran outliers	187476	1151 (1.64-1.64)
Sidechain outliers	187428	1150 (1.64-1.64)
RSRZ outliers	180081	1141 (1.64-1.64)

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	50	2% 94% 6%
1	C	50	96% .
1	E	50	2% 94% . .
2	B	38	3% 92% 5%
2	D	38	3% 95% 5%

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Mol	Chain	Length	Quality of chain
2	F	38	3% 89% 5% 5%

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 4109 atoms, of which 1961 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 Fusion glycoprotein F1 N-terminal heptad repeat (HR1).

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	C	50	Total	C	H	N	O	0	0	1
			735	225	365	66	79			
1	A	50	Total	C	H	N	O	0	2	1
			757	233	375	67	82			
1	E	48	Total	C	H	N	O	0	0	1
			705	216	349	64	76			

There are 9 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
C	141	ACE	-	acetylation	UNP P69358
C	171	THR	MET	conflict	UNP P69358
C	190	NH2	-	amidation	UNP P69358
A	141	ACE	-	acetylation	UNP P69358
A	171	THR	MET	conflict	UNP P69358
A	190	NH2	-	amidation	UNP P69358
E	141	ACE	-	acetylation	UNP P69358
E	171	THR	MET	conflict	UNP P69358
E	190	NH2	-	amidation	UNP P69358

- Molecule 2 is a protein called Fusion glycoprotein F1 C-terminal heptad repeat (HR2).

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	D	38	Total	C	H	N	O	0	2	1
			580	175	299	46	60			
2	B	36	Total	C	H	N	O	0	3	1
			569	171	291	46	61			
2	F	36	Total	C	H	N	O	0	1	1
			549	165	282	45	57			

There are 18 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
D	451	ACE	-	acetylation	UNP P69358
D	461	ILE	THR	variant	UNP P69358
D	462	SER	ASN	variant	UNP P69358
D	465	SER	ASN	variant	UNP P69358
D	487	NLE	MET	engineered mutation	UNP P69358
D	488	NH2	-	amidation	UNP P69358
B	451	ACE	-	acetylation	UNP P69358
B	461	ILE	THR	variant	UNP P69358
B	462	SER	ASN	variant	UNP P69358
B	465	SER	ASN	variant	UNP P69358
B	487	NLE	MET	engineered mutation	UNP P69358
B	488	NH2	-	amidation	UNP P69358
F	451	ACE	-	acetylation	UNP P69358
F	461	ILE	THR	variant	UNP P69358
F	462	SER	ASN	variant	UNP P69358
F	465	SER	ASN	variant	UNP P69358
F	487	NLE	MET	engineered mutation	UNP P69358
F	488	NH2	-	amidation	UNP P69358

- Molecule 3 is MAGNESIUM ION (CCD ID: MG) (formula: Mg).

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	1	Total Mg 1 1	0	0

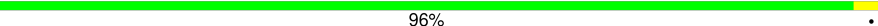
- Molecule 4 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	C	30	Total O 30 30	0	0
4	D	43	Total O 43 43	0	0
4	A	38	Total O 38 38	0	0
4	B	32	Total O 32 32	0	0
4	E	36	Total O 36 36	0	0
4	F	34	Total O 34 34	0	0

3 Residue-property plots

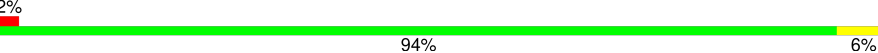
These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. 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.

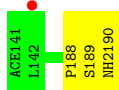
- Molecule 1: Fusion glycoprotein F1 N-terminal heptad repeat (HR1)

Chain C:  96%

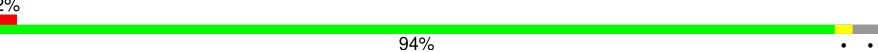


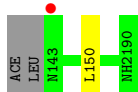
- Molecule 1: Fusion glycoprotein F1 N-terminal heptad repeat (HR1)

Chain A:  2% 94% 6%

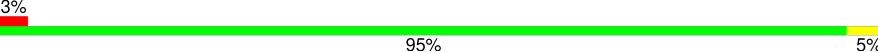


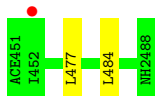
- Molecule 1: Fusion glycoprotein F1 N-terminal heptad repeat (HR1)

Chain E:  2% 94% 6% 8%

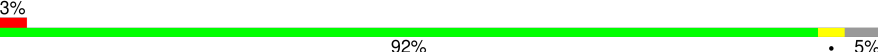


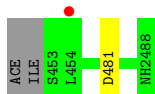
- Molecule 2: Fusion glycoprotein F1 C-terminal heptad repeat (HR2)

Chain D:  3% 95% 5%



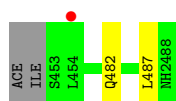
- Molecule 2: Fusion glycoprotein F1 C-terminal heptad repeat (HR2)

Chain B:  3% 92% 5% 2%



- Molecule 2: Fusion glycoprotein F1 C-terminal heptad repeat (HR2)

Chain F:  3% 89% 5% 5%



4 Data and refinement statistics

Property	Value	Source
Space group	P 3	Depositor
Cell constants a, b, c, α , β , γ	50.26Å 50.26Å 71.64Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	27.66 – 1.63 27.66 – 1.63	Depositor EDS
% Data completeness (in resolution range)	99.9 (27.66-1.63) 99.9 (27.66-1.63)	Depositor EDS
R_{merge}	0.13	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.54 (at 1.63Å)	Xtriage
Refinement program	PHENIX 1.21.2_5419	Depositor
R, R_{free}	0.177 , 0.208 0.177 , 0.208	Depositor DCC
R_{free} test set	1996 reflections (7.90%)	wwPDB-VP
Wilson B-factor (Å ²)	20.5	Xtriage
Anisotropy	0.019	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.41 , 40.9	EDS
L-test for twinning ²	$\langle L \rangle = 0.52$, $\langle L^2 \rangle = 0.35$	Xtriage
Estimated twinning fraction	0.003 for -h,-k,l 0.056 for h,-h-k,-l 0.026 for -k,-h,-l	Xtriage
F_o, F_c correlation	0.97	EDS
Total number of atoms	4109	wwPDB-VP
Average B, all atoms (Å ²)	31.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The analyses of the Patterson function reveals a significant off-origin peak that is 20.15 % of the origin peak, indicating pseudo-translational symmetry. The chance of finding a peak of this or larger height randomly in a structure without pseudo-translational symmetry is equal to 9.2557e-03. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

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](#)

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

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	0.29	0/386	0.36	0/525
1	C	0.25	0/368	0.35	0/501
1	E	0.27	0/356	0.40	0/484
2	B	0.21	0/274	0.39	0/366
2	D	0.25	0/275	0.40	0/368
2	F	0.22	0/260	0.35	0/347
All	All	0.26	0/1919	0.38	0/2591

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	382	375	380	2	0
1	C	370	365	366	3	0
1	E	356	349	347	1	0
2	B	278	291	288	1	0
2	D	281	299	300	3	0
2	F	267	282	280	2	0
3	A	1	0	0	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
4	A	38	0	0	0	0
4	B	32	0	0	1	0
4	C	30	0	0	0	0
4	D	43	0	0	0	0
4	E	36	0	0	0	0
4	F	34	0	0	1	0
All	All	2148	1961	1961	8	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 2.

All (8) 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:154:LEU:HG	2:D:484:LEU:HD11	1.66	0.75
1:C:161:ILE:HG22	2:D:477:LEU:HD11	1.82	0.60
1:A:189:SER:HG	1:A:190:NH2:N	2.02	0.57
1:A:188:PRO:O	1:A:189:SER:C	2.53	0.50
1:C:154:LEU:CG	2:D:484:LEU:HD11	2.40	0.48
1:E:150:LEU:HG	2:F:487:NLE:HE1	1.98	0.45
2:B:481[B]:ASP:OD1	4:B:501:HOH:O	2.22	0.41
2:F:482:GLN:HG2	4:F:525:HOH:O	2.21	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	50/50 (100%)	46 (92%)	4 (8%)	0	100	100
1	C	48/50 (96%)	48 (100%)	0	0	100	100

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	E	46/50 (92%)	46 (100%)	0	0	100	100
2	B	36/38 (95%)	36 (100%)	0	0	100	100
2	D	37/38 (97%)	36 (97%)	1 (3%)	0	100	100
2	F	34/38 (90%)	34 (100%)	0	0	100	100
All	All	251/264 (95%)	246 (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	42/40 (105%)	42 (100%)	0	100	100
1	C	40/40 (100%)	40 (100%)	0	100	100
1	E	38/40 (95%)	38 (100%)	0	100	100
2	B	32/30 (107%)	32 (100%)	0	100	100
2	D	32/30 (107%)	32 (100%)	0	100	100
2	F	30/30 (100%)	30 (100%)	0	100	100
All	All	214/210 (102%)	214 (100%)	0	100	100

There are no protein residues with a non-rotameric sidechain to report.

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (3) such sidechains are listed below:

Mol	Chain	Res	Type
1	C	145	GLN
1	C	169	GLN
1	A	145	GLN

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

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

3 non-standard protein/DNA/RNA residues are modelled in this entry.

In the following table, the Counts columns list the number of bonds (or angles) for which Mogul statistics could be retrieved, the number of bonds (or angles) that are observed in the model and the number of bonds (or 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 length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	$\# Z > 2$	Counts	RMSZ	$\# Z > 2$
2	NLE	D	487	2	6,7,8	0.55	0	2,7,9	0.29	0
2	NLE	B	487	2	6,7,8	0.44	0	2,7,9	0.26	0
2	NLE	F	487	2	6,7,8	0.43	0	2,7,9	0.26	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	NLE	D	487	2	-	0/5/6/8	-
2	NLE	B	487	2	-	0/5/6/8	-
2	NLE	F	487	2	-	0/5/6/8	-

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.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	F	487	NLE	1	0

5.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

Of 1 ligands modelled in this entry, 1 is monoatomic - leaving 0 for Mogul analysis.

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.

No monomer is involved in short contacts.

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 [i](#)

6.1 Protein, DNA and RNA chains [i](#)

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	48/50 (96%)	-0.12	1 (2%) 63 70	14, 24, 61, 86	2 (4%)
1	C	48/50 (96%)	-0.14	0 100 100	17, 26, 58, 79	0
1	E	47/50 (94%)	-0.24	1 (2%) 63 70	17, 24, 49, 65	0
2	B	34/38 (89%)	-0.22	1 (2%) 53 59	13, 26, 75, 82	3 (8%)
2	D	35/38 (92%)	-0.15	1 (2%) 53 59	13, 25, 45, 75	2 (5%)
2	F	34/38 (89%)	-0.28	1 (2%) 53 59	12, 25, 60, 76	1 (2%)
All	All	246/264 (93%)	-0.19	5 (2%) 65 71	12, 25, 61, 86	8 (3%)

All (5) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	E	143	ASN	3.5
2	D	452	ILE	3.0
1	A	142	LEU	2.6
2	B	454	LEU	2.4
2	F	454	LEU	2.1

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

In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled ‘Q< 0.9’ lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å ²)	Q<0.9
2	NLE	B	487	8/9	0.80	0.14	31,41,46,46	0
2	NLE	D	487	8/9	0.82	0.13	25,36,47,47	0
2	NLE	F	487	8/9	0.90	0.08	24,35,44,44	0

6.3 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.4 Ligands [i](#)

In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
3	MG	A	201	1/1	0.91	0.08	27,27,27,27	0

6.5 Other polymers [i](#)

There are no such residues in this entry.