Full wwPDB X-ray Structure Validation Report (i)

May 24, 2025 – 05:07 pm BST

PDB ID	:	9FEM / pdb_00009fem
Title	:	mNeonGreen - Directionality of Optical Properties of Fluorescent Proteins
Authors	:	Myskova, J.; Brynda, J.; Lazar, J.
Deposited on	:	2024-05-21
Resolution	:	2.32 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 (i) 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 (1)) were used in the production of this report:

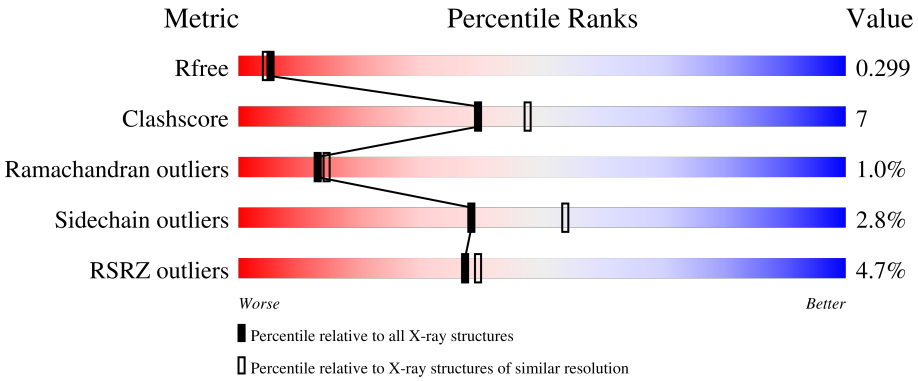
MolProbity	:	4-5-2 with Phenix2.0rc1
Mogul	:	1.8.4, CSD as541be (2020)
Xtriage (Phenix)	:	2.0rc1
EDS	:	3.0
Percentile statistics	:	20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4	:	9.0.003 (Gargrove)
Density-Fitness	:	1.0.11
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.43.1

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 2.32 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	7250 (2.34-2.30)
Clashscore	180529	8063 (2.34-2.30)
Ramachandran outliers	177936	7993 (2.34-2.30)
Sidechain outliers	177891	7993 (2.34-2.30)
RSRZ outliers	164620	7250 (2.34-2.30)

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 <=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	240	4% 65% 22% · 10%

2 Entry composition (i)

There are 3 unique types of molecules in this entry. The entry contains 1744 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.

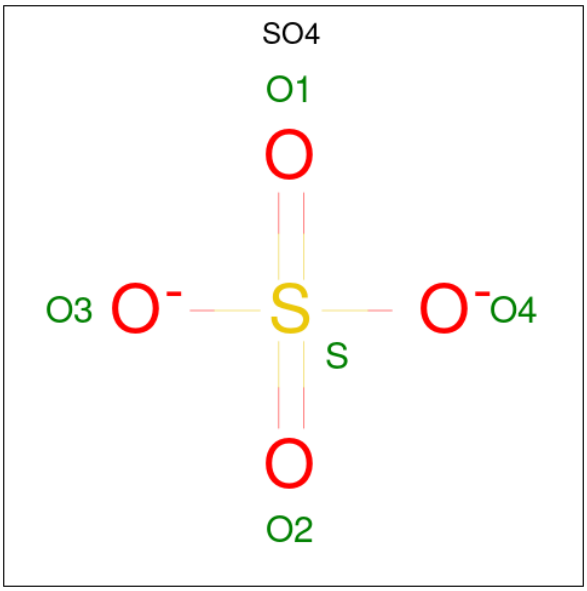
- Molecule 1 is a protein called mNeonGreen.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	215	1718	1097	290	323	8	0	0	0

There are 9 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	58	CR2	GLY	conflict	UNP A0A1S4NYF2
A	?	-	TYR	deletion	UNP A0A1S4NYF2
A	?	-	GLY	deletion	UNP A0A1S4NYF2
A	227	HIS	-	expression tag	UNP A0A1S4NYF2
A	228	HIS	-	expression tag	UNP A0A1S4NYF2
A	229	HIS	-	expression tag	UNP A0A1S4NYF2
A	230	HIS	-	expression tag	UNP A0A1S4NYF2
A	231	HIS	-	expression tag	UNP A0A1S4NYF2
A	232	HIS	-	expression tag	UNP A0A1S4NYF2

- Molecule 2 is SULFATE ION (CCD ID: SO4) (formula: O_4S).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
2	A	1	Total O S 5 4 1	0	0

- Molecule 3 is water.

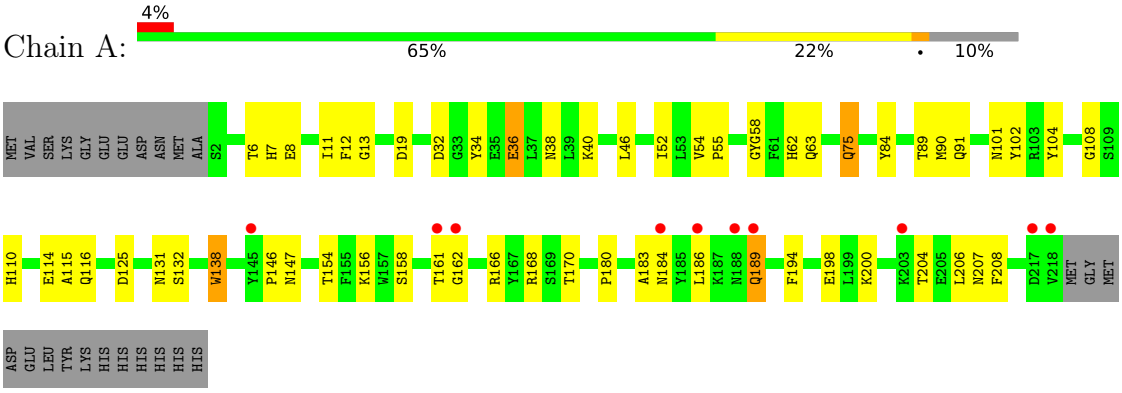
Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	21	Total O 21 21	0	0

3 Residue-property plots (i)

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: mNeonGreen

Chain A:



4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 41 21 2	Depositor
Cell constants a, b, c, α, β, γ	59.50Å 59.50Å 132.68Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	30.48 – 2.32 30.48 – 2.32	Depositor EDS
% Data completeness (in resolution range)	98.8 (30.48-2.32) 98.9 (30.48-2.32)	Depositor EDS
R_{merge}	0.08	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	1.11 (at 2.31Å)	Xtriage
Refinement program	REFMAC 5.8.0267	Depositor
R, R_{free}	0.230 , 0.294 0.233 , 0.299	Depositor DCC
R_{free} test set	544 reflections (5.01%)	wwPDB-VP
Wilson B-factor (Å^2)	41.1	Xtriage
Anisotropy	0.062	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.29 , 29.5	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	0.93	EDS
Total number of atoms	1744	wwPDB-VP
Average B, all atoms (Å^2)	54.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.91% of the height of the origin peak. No significant pseudotranslation is detected.*

[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: SO4, CR2

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	1.26	7/1749 (0.4%)	1.62	20/2371 (0.8%)

All (7) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	198	GLU	C-O	6.70	1.32	1.23
1	A	194	PHE	C-O	-6.04	1.16	1.24
1	A	7	HIS	CE1-NE2	5.94	1.38	1.32
1	A	104	TYR	C-O	5.73	1.31	1.23
1	A	146	PRO	C-O	-5.71	1.17	1.24
1	A	62	HIS	CE1-NE2	5.40	1.38	1.32
1	A	207	ASN	C-O	5.39	1.30	1.24

All (20) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	A	161	THR	CA-CB-OG1	-7.55	98.27	109.60
1	A	125	ASP	CA-CB-CG	6.90	119.50	112.60
1	A	84	TYR	O-C-N	6.62	130.58	123.56
1	A	12	PHE	CA-C-O	-6.18	114.83	121.38
1	A	184	ASN	CA-CB-CG	-5.99	106.61	112.60
1	A	161	THR	CB-CA-C	-5.96	98.96	113.15
1	A	46	LEU	CA-C-N	5.84	131.96	122.67
1	A	46	LEU	C-N-CA	5.84	131.96	122.67
1	A	131	ASN	CA-C-O	-5.79	114.51	121.40
1	A	204	THR	CA-CB-OG1	-5.78	100.93	109.60
1	A	156	LYS	CB-CA-C	5.58	118.74	109.53
1	A	101	ASN	CA-CB-CG	-5.43	107.17	112.60
1	A	208	PHE	CA-C-O	-5.30	114.98	120.70
1	A	154	THR	CA-CB-OG1	-5.25	101.72	109.60

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Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	A	84	TYR	CA-C-N	5.12	131.93	122.92
1	A	84	TYR	C-N-CA	5.12	131.93	122.92
1	A	180	PRO	CA-C-O	-5.10	115.53	121.34
1	A	198	GLU	CB-CA-C	5.05	119.28	109.33
1	A	75	GLN	CA-C-N	5.02	127.00	120.28
1	A	75	GLN	C-N-CA	5.02	127.00	120.28

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	1718	0	1619	22	0
2	A	5	0	0	1	0
3	A	21	0	0	2	0
All	All	1744	0	1619	22	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 7.

All (22) 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:206:LEU:C	1:A:206:LEU:HD12	2.29	0.57
1:A:38:ASN:HD21	1:A:40:LYS:HE2	1.71	0.56
1:A:91:GLN:HB2	3:A:410:HOH:O	2.04	0.56
1:A:206:LEU:HD12	1:A:206:LEU:O	2.05	0.55
1:A:6:THR:OG1	1:A:110:HIS:ND1	2.34	0.55
1:A:166:ARG:NH2	1:A:168:ARG:HD3	2.27	0.49
1:A:90:MET:HA	1:A:170:THR:O	2.12	0.49
1:A:34:TYR:OH	1:A:36:GLU:HG3	2.13	0.48
1:A:138:TRP:HB2	2:A:301:SO4:O2	2.13	0.48
1:A:63:GLN:O	1:A:75:GLN:HG2	2.14	0.48
1:A:32:ASP:OD1	1:A:32:ASP:C	2.55	0.47

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:8:GLU:OE1	1:A:110:HIS:NE2	2.39	0.44
1:A:13:GLY:O	1:A:19:ASP:HA	2.17	0.44
1:A:102:TYR:HA	1:A:114:GLU:O	2.19	0.43
1:A:147:ASN:OD1	1:A:147:ASN:C	2.61	0.42
1:A:11:ILE:HA	1:A:115:ALA:O	2.19	0.42
1:A:189:GLN:HE21	1:A:189:GLN:HB3	1.52	0.42
1:A:52:ILE:HD12	1:A:52:ILE:HA	1.79	0.41
1:A:54:VAL:HG13	1:A:55:PRO:HA	2.01	0.41
1:A:89:THR:HG22	3:A:410:HOH:O	2.20	0.41
1:A:132:SER:O	1:A:162:GLY:N	2.54	0.41
1:A:183:ALA:HA	1:A:186:LEU:HD12	2.03	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	210/240 (88%)	202 (96%)	6 (3%)	2 (1%)	13 14

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	138	TRP
1	A	108	GLY

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	179/205 (87%)	174 (97%)	5 (3%)	38 54

All (5) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	36	GLU
1	A	116	GLN
1	A	158	SER
1	A	189	GLN
1	A	200	LYS

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	38	ASN
1	A	189	GLN
1	A	201	HIS
1	A	207	ASN

5.3.3 RNA (i)

There are no RNA molecules in this entry.

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

1 non-standard protein/DNA/RNA residue is 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	$\#\|Z\| > 2$
1	CR2	A	58	1	20,20,21	3.50	5 (25%)	25,27,29	5.37	7 (28%)

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
1	CR2	A	58	1	-	1/6/25/26	0/2/2/2

All (5) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	58	CR2	CB2-CA2	12.80	1.45	1.35
1	A	58	CR2	CA2-C2	-5.33	1.43	1.48
1	A	58	CR2	C2-N3	-4.32	1.29	1.39
1	A	58	CR2	CE2-CD2	3.71	1.45	1.38
1	A	58	CR2	CA2-N2	-2.21	1.33	1.38

All (7) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	A	58	CR2	O2-C2-CA2	-16.53	121.68	130.96
1	A	58	CR2	CA2-C2-N3	15.25	110.58	103.37
1	A	58	CR2	C2-N3-C1	-9.24	103.47	107.99
1	A	58	CR2	C1-CA1-N1	-8.35	94.39	112.85
1	A	58	CR2	O3-C3-CA3	-5.64	109.35	126.39
1	A	58	CR2	C2-CA2-N2	-2.50	107.18	108.93
1	A	58	CR2	N3-C1-N2	2.36	114.58	111.76

There are no chirality outliers.

All (1) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
1	A	58	CR2	C3-CA3-N3-C2

There are no ring outliers.

No monomer is involved in short contacts.

5.5 Carbohydrates (i)

There are no oligosaccharides in this entry.

5.6 Ligand geometry (i)

1 ligand is 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	SO4	A	301	-	4,4,4	0.32	0	6,6,6	0.18	0

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	A	301	SO4	1	0

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, 95^{th} 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	214/240 (89%)	0.62	10 (4%) 37 39	38, 51, 76, 93	0

All (10) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	162	GLY	3.4
1	A	218	VAL	2.6
1	A	188	ASN	2.6
1	A	203	LYS	2.5
1	A	217	ASP	2.5
1	A	186	LEU	2.3
1	A	184	ASN	2.2
1	A	189	GLN	2.2
1	A	145	TYR	2.1
1	A	161	THR	2.0

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

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, 95^{th} 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
1	CR2	A	58	19/20	0.95	0.08	35,46,53,55	0

6.3 Carbohydrates

There are no monosaccharides in this entry.

6.4 Ligands

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, 95^{th} 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	SO4	A	301	5/5	0.92	0.13	46,54,68,78	0

6.5 Other polymers

There are no such residues in this entry.