Full wwPDB X-ray Structure Validation Report ⓘ

Mar 5, 2026 – 06:52 PM UTC

PDB ID	:	4W72 / pdb_00004w72
Title	:	Crystal Structure of Full-Length Split GFP Mutant E115C/T118H Disulfide Dimer With Copper Mediated Crystal Contacts, P 21 21 21, Form 1
Authors	:	Leibly, D.J.; Waldo, G.S.; Yeates, T.O.
Deposited on	:	2014-08-21
Resolution	:	2.00 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:

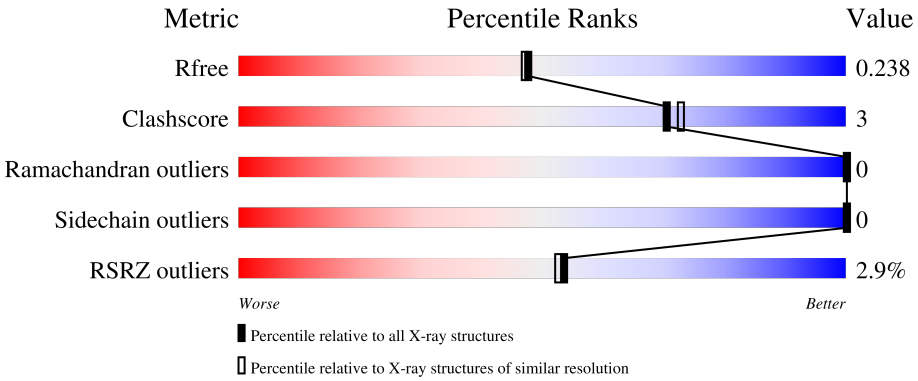
MolProbity	:	4-5-2 with Phenix2.0
Mogul	:	2022.3.0, CSD as543be (2022)
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.010 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 2.00 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	10052 (2.00-2.00)
Clashscore	190562	11152 (2.00-2.00)
Ramachandran outliers	187476	11031 (2.00-2.00)
Sidechain outliers	187428	11029 (2.00-2.00)
RSRZ outliers	180081	10067 (2.00-2.00)

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	229	2% 90% 8% .
1	B	229	3% 89% 9% .

2 Entry composition (i)

There are 3 unique types of molecules in this entry. The entry contains 3817 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 fluorescent protein E115C/T118H.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	225	Total	C	N	O	S	0	0	0
			1808	1152	308	344	4			
1	B	225	Total	C	N	O	S	0	0	0
			1806	1150	307	345	4			

- Molecule 2 is COPPER (II) ION (CCD ID: CU) (formula: Cu).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	1	Total	Cu	0	0
			1	1		

- Molecule 3 is water.

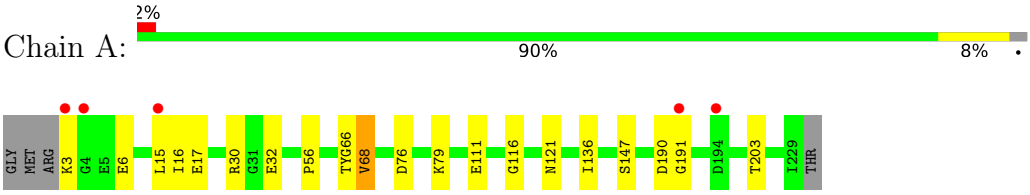
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	116	Total	O	0	0
			116	116		
3	B	86	Total	O	0	0
			86	86		

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.

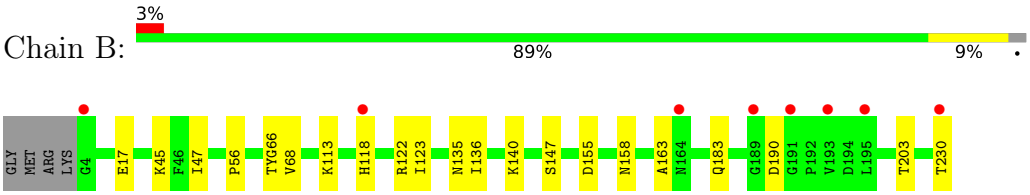
• Molecule 1: fluorescent protein E115C/T118H

Chain A:



• Molecule 1: fluorescent protein E115C/T118H

Chain B:



4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α, β, γ	72.54Å 74.40Å 89.15Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	57.12 – 2.00 57.12 – 2.00	Depositor EDS
% Data completeness (in resolution range)	99.6 (57.12-2.00) 99.9 (57.12-2.00)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.06	Depositor
$< I/\sigma(I) >$ [1]	1.73 (at 2.00Å)	Xtriage
Refinement program	PHENIX (PHENIX.REFINE: DEV_1555)	Depositor
R, R_{free}	0.190 , 0.235 0.198 , 0.238	Depositor DCC
R_{free} test set	3340 reflections (10.00%)	wwPDB-VP
Wilson B-factor (Å^2)	41.0	Xtriage
Anisotropy	0.408	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.34 , 30.0	EDS
L-test for twinning[2]	$< \|L\| > = 0.51$, $< L^2 > = 0.35$	Xtriage
Estimated twinning fraction	0.000 for k,h,-l	Xtriage
F_o,F_c correlation	0.96	EDS
Total number of atoms	3817	wwPDB-VP
Average B, all atoms (Å^2)	46.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.56% 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: CRO, CU

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	0.47	1/1826 (0.1%)	0.78	1/2468 (0.0%)
1	B	0.53	2/1824 (0.1%)	0.80	6/2467 (0.2%)
All	All	0.50	3/3650 (0.1%)	0.79	7/4935 (0.1%)

All (3) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	68	VAL	N-CA	-7.11	1.32	1.46
1	B	68	VAL	N-CA	-6.52	1.33	1.46
1	B	122	ARG	C-O	-5.91	1.16	1.24

All (7) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	B	123	ILE	CB-CA-C	-6.80	100.40	110.33
1	B	123	ILE	CA-C-N	-6.67	112.13	122.87
1	B	123	ILE	C-N-CA	-6.67	112.13	122.87
1	B	122	ARG	CA-C-N	6.45	131.95	122.99
1	B	122	ARG	C-N-CA	6.45	131.95	122.99
1	B	123	ILE	N-CA-C	5.76	116.41	108.12
1	A	68	VAL	N-CA-CB	-5.13	102.77	111.50

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	A	1808	0	1758	16	1
1	B	1806	0	1751	12	1
2	A	1	0	0	0	0
3	A	116	0	0	0	0
3	B	86	0	0	1	0
All	All	3817	0	3509	24	1

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 (24) 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:3:LYS:HG2	1:A:6:GLU:OE1	1.68	0.92
1:B:45:LYS:HE2	1:B:47:ILE:HD11	1.73	0.71
1:A:15:LEU:C	1:A:15:LEU:HD23	2.18	0.69
1:A:116:GLY:HA3	1:B:113:LYS:HE3	1.75	0.68
1:B:17:GLU:HG3	3:B:463:HOH:O	1.98	0.63
1:A:17:GLU:CD	1:B:118:HIS:HE2	2.07	0.63
1:B:155:ASP:OD2	1:B:158:ASN:ND2	2.32	0.61
1:A:68:VAL:O	1:A:68:VAL:HG23	2.02	0.60
1:A:30:ARG:NH1	1:A:32:GLU:OE1	2.33	0.60
1:A:16:ILE:HG12	1:A:121:ASN:HB3	1.86	0.58
1:B:163:ALA:HB3	1:B:183:GLN:HB3	1.88	0.56
1:A:76:ASP:HA	1:A:79:LYS:HD2	1.92	0.51
1:A:17:GLU:OE1	1:B:118:HIS:NE2	2.40	0.51
1:B:56:PRO:HD3	1:B:136:ILE:O	2.12	0.49
1:A:15:LEU:HD23	1:A:15:LEU:O	2.12	0.48
1:A:17:GLU:CD	1:B:118:HIS:NE2	2.71	0.47
1:A:15:LEU:C	1:A:15:LEU:CD2	2.88	0.44
1:A:147:SER:HB2	1:A:203:THR:O	2.18	0.43
1:A:56:PRO:HD3	1:A:136:ILE:O	2.19	0.43
1:B:190:ASP:N	1:B:190:ASP:OD1	2.53	0.42
1:A:190:ASP:N	1:A:191:GLY:HA3	2.34	0.42
1:B:135:ASN:HA	1:B:140:LYS:HE2	2.03	0.41
1:A:16:ILE:HG22	1:A:17:GLU:N	2.35	0.41
1:B:147:SER:HB2	1:B:203:THR:O	2.21	0.40

All (1) symmetry-related close contacts are listed below. The label for Atom-2 includes the sym-

metry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:111:GLU:OE1	1:B:230:THR:OG1[3_455]	2.13	0.07

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	220/229 (96%)	214 (97%)	6 (3%)	0	100	100
1	B	220/229 (96%)	219 (100%)	1 (0%)	0	100	100
All	All	440/458 (96%)	433 (98%)	7 (2%)	0	100	100

There are no Ramachandran outliers to report.

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	194/197 (98%)	194 (100%)	0	100	100
1	B	194/197 (98%)	194 (100%)	0	100	100
All	All	388/394 (98%)	388 (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 (5) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	135	ASN
1	A	159	ASN
1	A	177	GLN
1	B	135	ASN
1	B	159	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)

2 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	$\#\|Z\| > 2$
1	CRO	B	66	1	22,23,24	3.07	12 (54%)	30,32,34	1.70	11 (36%)
1	CRO	A	66	1	22,23,24	3.33	6 (27%)	30,32,34	3.50	10 (33%)

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	CRO	B	66	1	-	0/12/31/32	0/2/2/2
1	CRO	A	66	1	-	1/12/31/32	0/2/2/2

All (18) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	66	CRO	CB2-CA2	12.43	1.47	1.35
1	B	66	CRO	CA3-N3	-6.26	1.35	1.47
1	B	66	CRO	OG1-CB1	-6.02	1.27	1.43

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	B	66	CRO	CA2-C2	-5.71	1.42	1.48
1	B	66	CRO	CA1-N1	-4.84	1.34	1.47
1	A	66	CRO	CA1-N1	-4.75	1.34	1.47
1	A	66	CRO	C2-N3	-4.61	1.29	1.40
1	B	66	CRO	C2-N3	-4.05	1.30	1.40
1	A	66	CRO	CA2-C2	-3.96	1.44	1.48
1	A	66	CRO	CA2-N2	-3.31	1.31	1.38
1	B	66	CRO	O2-C2	-3.27	1.16	1.23
1	B	66	CRO	C1-N2	-3.23	1.27	1.32
1	B	66	CRO	OH-CZ	-2.53	1.31	1.37
1	B	66	CRO	CG1-CB1	-2.50	1.44	1.51
1	B	66	CRO	C1-N3	-2.41	1.33	1.37
1	B	66	CRO	CE1-CZ	2.28	1.43	1.39
1	B	66	CRO	CB2-CA2	-2.09	1.33	1.35
1	A	66	CRO	C1-N2	2.09	1.35	1.32

All (21) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	A	66	CRO	O2-C2-CA2	-10.26	124.47	131.02
1	A	66	CRO	C2-N3-C1	-9.13	103.84	108.07
1	A	66	CRO	CA2-C2-N3	8.32	110.48	103.50
1	A	66	CRO	O3-C3-CA3	-4.86	103.58	125.47
1	A	66	CRO	CB2-CA2-C2	4.82	128.20	122.36
1	A	66	CRO	C2-CA2-N2	-3.91	106.15	108.95
1	B	66	CRO	C1-CA1-N1	3.54	116.11	109.78
1	A	66	CRO	N3-C1-N2	3.44	114.20	111.48
1	B	66	CRO	OG1-CB1-CA1	3.32	116.08	109.00
1	B	66	CRO	O3-C3-CA3	-3.07	111.67	125.47
1	A	66	CRO	C3-CA3-N3	3.04	119.34	112.43
1	B	66	CRO	CG1-CB1-CA1	-2.63	106.17	112.18
1	A	66	CRO	CB2-CA2-N2	-2.29	125.65	128.76
1	B	66	CRO	CE2-CZ-CE1	2.15	123.19	119.77
1	B	66	CRO	CD1-CE1-CZ	-2.11	117.65	119.88
1	B	66	CRO	C3-CA3-N3	2.05	117.08	112.43
1	B	66	CRO	N3-C1-N2	2.04	113.09	111.48
1	B	66	CRO	O2-C2-CA2	-2.04	129.72	131.02
1	A	66	CRO	CA3-N3-C2	2.03	128.13	123.67
1	B	66	CRO	CD2-CG2-CD1	2.03	120.66	117.65
1	B	66	CRO	CB2-CA2-C2	2.00	124.78	122.36

There are no chirality outliers.

All (1) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
1	A	66	CRO	N1-CA1-CB1-CG1

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)

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

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	224/229 (97%)	0.24	5 (2%)	62	61	33, 44, 64, 104	0
1	B	224/229 (97%)	0.19	8 (3%)	46	45	35, 45, 59, 105	0
All	All	448/458 (97%)	0.21	13 (2%)	53	52	33, 44, 63, 105	0

All (13) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	15	LEU	6.2
1	A	191	GLY	4.2
1	A	3	LYS	3.3
1	B	230	THR	2.9
1	B	191	GLY	2.8
1	A	4	GLY	2.5
1	B	4	GLY	2.5
1	B	118	HIS	2.4
1	B	164	ASN	2.3
1	B	195	LEU	2.1
1	B	193	VAL	2.1
1	B	189	GLY	2.1
1	A	194	ASP	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, 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
1	CRO	A	66	22/23	0.93	0.08	37,39,42,44	0

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Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å^2)	Q<0.9
1	CRO	B	66	22/23	0.94	0.08	36,39,44,48	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(Å^2)	Q<0.9
2	CU	A	301	1/1	0.88	0.13	131,131,131,131	0

6.5 Other polymers (i)

There are no such residues in this entry.