



Full wwPDB X-ray Structure Validation Report ⓘ

Feb 16, 2026 – 12:05 PM EST

PDB ID : 9ZUM / pdb_00009zum
Title : Structure of the *Caulobacter crescentus* RNAP alpha-CTD bound to AT rich DNA
Authors : Schumacher, M.A.
Deposited on : 2025-12-24
Resolution : 2.43 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
Xtrriage (Phenix) : 2.0
EDS : 3.0
Percentile statistics : 20231227.v01 (using entries in the PDB archive December 27th 2023)
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) : 2.48

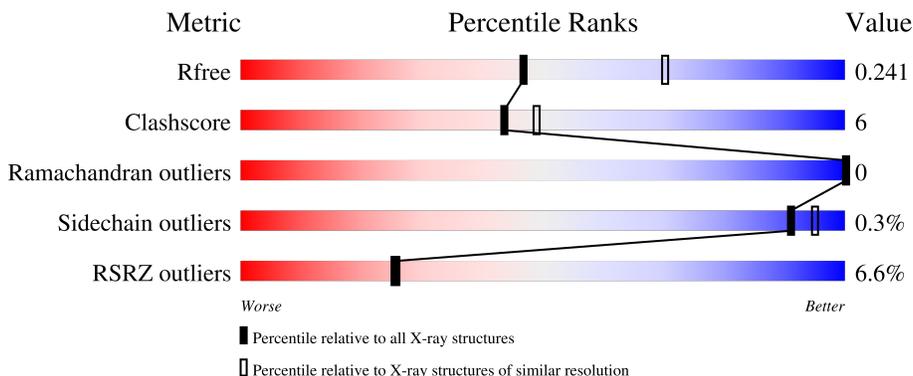
1 Overall quality at a glance i

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.43 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.



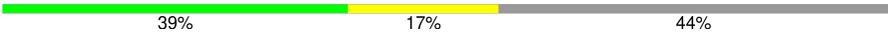
Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	164625	2124 (2.46-2.42)
Clashscore	180529	2259 (2.46-2.42)
Ramachandran outliers	177936	2244 (2.46-2.42)
Sidechain outliers	177891	2244 (2.46-2.42)
RSRZ outliers	164620	2124 (2.46-2.42)

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	83	 1% 84% 11% 5%
1	B	83	 11% 72% 22% 6%
1	C	83	 6% 81% 13% 6%
1	D	83	 7% 82% 14% 6%
1	E	83	 7% 80% 13% 7%

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Mol	Chain	Length	Quality of chain	
2	Y	18	 56%	44%
3	T	18	 39%	17% 44%

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 3597 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 DNA-directed RNA polymerase subunit alpha.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	79	611	384	106	116	5	0	0	0
1	B	78	601	380	103	113	5	0	0	0
1	C	78	594	376	101	112	5	0	0	0
1	D	80	618	390	107	116	5	0	0	0
1	E	77	592	375	102	110	5	0	0	0

There are 20 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	247	GLY	-	expression tag	UNP Q9A8S9
A	248	SER	-	expression tag	UNP Q9A8S9
A	249	HIS	-	expression tag	UNP Q9A8S9
A	250	MET	-	expression tag	UNP Q9A8S9
B	247	GLY	-	expression tag	UNP Q9A8S9
B	248	SER	-	expression tag	UNP Q9A8S9
B	249	HIS	-	expression tag	UNP Q9A8S9
B	250	MET	-	expression tag	UNP Q9A8S9
C	247	GLY	-	expression tag	UNP Q9A8S9
C	248	SER	-	expression tag	UNP Q9A8S9
C	249	HIS	-	expression tag	UNP Q9A8S9
C	250	MET	-	expression tag	UNP Q9A8S9
D	247	GLY	-	expression tag	UNP Q9A8S9
D	248	SER	-	expression tag	UNP Q9A8S9
D	249	HIS	-	expression tag	UNP Q9A8S9
D	250	MET	-	expression tag	UNP Q9A8S9
E	247	GLY	-	expression tag	UNP Q9A8S9
E	248	SER	-	expression tag	UNP Q9A8S9
E	249	HIS	-	expression tag	UNP Q9A8S9

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Chain	Residue	Modelled	Actual	Comment	Reference
E	250	MET	-	expression tag	UNP Q9A8S9

- Molecule 2 is a DNA chain called DNA (5'-D(*AP*AP*TP*TP*AP*AP*TP*TP*AP*AP*TP*TP*TP*TP*AP*AP*TP*T)-3').

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	P			
2	Y	10	204	100	32	62	10	0	0	0

- Molecule 3 is a DNA chain called DNA (5'-D(*AP*AP*TP*TP*AP*AP*AP*AP*TP*TP*AP*AP*TP*TP*AP*AP*TP*T)-3').

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	P			
3	T	10	206	100	38	58	10	0	0	0

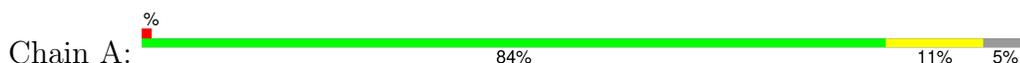
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	25	Total	O	0	0
			25	25		
4	B	23	Total	O	0	0
			23	23		
4	C	17	Total	O	0	0
			17	17		
4	D	17	Total	O	0	0
			17	17		
4	E	19	Total	O	0	0
			19	19		
4	Y	38	Total	O	0	0
			38	38		
4	T	32	Total	O	0	0
			32	32		

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.

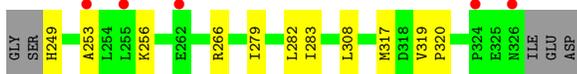
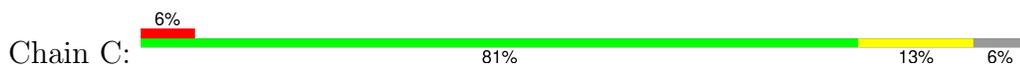
- Molecule 1: DNA-directed RNA polymerase subunit alpha



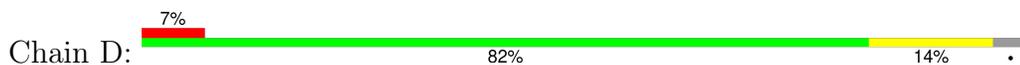
- Molecule 1: DNA-directed RNA polymerase subunit alpha



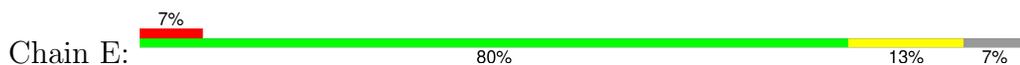
- Molecule 1: DNA-directed RNA polymerase subunit alpha



- Molecule 1: DNA-directed RNA polymerase subunit alpha



- Molecule 1: DNA-directed RNA polymerase subunit alpha



- Molecule 2: DNA (5'-D(*AP*AP*TP*TP*AP*AP*TP*TP*AP*AP*TP*TP*TP*TP*AP*AP*TP*T)-3')

Chain Y:  56% 44%



- Molecule 3: DNA (5'-D(*AP*AP*TP*TP*AP*AP*AP*AP*TP*TP*AP*AP*TP*TP*AP*AP*TP*T)-3')

Chain T:  39% 17% 44%



4 Data and refinement statistics

Property	Value	Source
Space group	P 41	Depositor
Cell constants a, b, c, α , β , γ	153.28Å 153.28Å 32.08Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	42.51 – 2.43 42.51 – 2.43	Depositor EDS
% Data completeness (in resolution range)	93.3 (42.51-2.43) 93.3 (42.51-2.43)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.06	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.10 (at 2.42Å)	Xtrriage
Refinement program	PHENIX (1.20.1_4487: ???)	Depositor
R, R_{free}	0.211 , 0.242 0.211 , 0.241	Depositor DCC
R_{free} test set	2002 reflections (6.91%)	wwPDB-VP
Wilson B-factor (Å ²)	52.0	Xtrriage
Anisotropy	0.082	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.33 , 59.3	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.33$	Xtrriage
Estimated twinning fraction	0.046 for h,-k,-l	Xtrriage
F_o, F_c correlation	0.93	EDS
Total number of atoms	3597	wwPDB-VP
Average B, all atoms (Å ²)	68.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.22% of the height of the origin peak. No significant pseudotranslation is detected.*

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](#)

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	0.11	0/621	0.30	0/840
1	B	0.15	0/610	0.34	0/824
1	C	0.23	0/603	0.37	0/816
1	D	0.23	0/628	0.44	0/850
1	E	0.14	0/601	0.34	0/812
2	Y	0.23	0/227	0.50	0/348
3	T	0.29	0/231	0.52	0/354
All	All	0.19	0/3521	0.38	0/4844

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	611	0	612	6	0
1	B	601	0	609	11	0
1	C	594	0	598	7	0
1	D	618	0	620	7	0
1	E	592	0	603	8	0
2	Y	204	0	117	0	0
3	T	206	0	115	3	0
4	A	25	0	0	1	0
4	B	23	0	0	3	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
4	C	17	0	0	2	0
4	D	17	0	0	1	0
4	E	19	0	0	3	0
4	T	32	0	0	2	0
4	Y	38	0	0	0	0
All	All	3597	0	3274	40	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 6.

All (40) 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:B:279:ILE:HD13	1:B:311:MET:HE1	1.76	0.67
1:E:266:ARG:NH2	4:E:401:HOH:O	2.30	0.64
1:A:313:LEU:HD22	1:A:317:MET:HE1	1.77	0.64
3:T:6:DA:N7	4:T:103:HOH:O	2.31	0.63
1:C:249:HIS:N	4:C:401:HOH:O	2.31	0.63
3:T:14:DA:N7	4:T:102:HOH:O	2.31	0.60
1:A:283:ILE:HB	1:A:317:MET:HE2	1.85	0.59
1:E:252:PRO:HA	1:E:255:LEU:HD12	1.84	0.58
1:C:266:ARG:NH2	4:C:402:HOH:O	2.37	0.56
1:B:266:ARG:NH2	4:B:401:HOH:O	2.38	0.56
1:E:298:ARG:NH1	4:E:402:HOH:O	2.40	0.54
1:B:280:GLY:HA3	1:B:322:TRP:CH2	2.44	0.53
1:B:251:ASN:HB3	1:B:254:LEU:HD23	1.90	0.53
1:A:261:LEU:HD11	1:A:279:ILE:HD11	1.90	0.53
1:E:286:THR:HG23	1:E:289:GLU:H	1.73	0.52
1:E:276:ILE:HD11	1:E:285:LYS:HG3	1.93	0.51
1:B:285:LYS:NZ	4:B:403:HOH:O	2.43	0.50
1:D:299:LYS:NZ	3:T:5:DA:OP1	2.40	0.50
1:D:319:VAL:HG12	1:D:322:TRP:HB2	1.94	0.49
1:B:313:LEU:HD23	1:B:317:MET:HE1	1.95	0.48
1:B:276:ILE:HG23	1:B:281:ASP:HB2	1.96	0.47
1:A:266:ARG:NH2	4:A:401:HOH:O	2.47	0.47
1:C:253:ALA:O	1:C:256:LYS:HG3	2.15	0.47
1:D:286:THR:HG22	1:D:289:GLU:HG3	1.96	0.46
1:A:251:ASN:HB3	1:A:254:LEU:HG	1.98	0.46
1:E:319:VAL:HG12	1:E:322:TRP:HB2	1.97	0.46
1:B:287:GLU:HG2	1:B:301:LEU:HD11	1.97	0.45
1:C:279:ILE:O	1:C:283:ILE:HG13	2.16	0.45

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:306:GLU:OE2	1:E:292:ARG:HD2	2.17	0.45
1:B:298:ARG:NH1	4:B:402:HOH:O	2.41	0.45
1:C:319:VAL:HA	1:C:320:PRO:HD3	1.92	0.43
1:C:282:LEU:HD23	1:C:308:LEU:HD21	2.00	0.43
1:D:283:ILE:HB	1:D:317:MET:HE2	2.01	0.42
1:D:258:VAL:HG22	1:D:277:VAL:O	2.19	0.42
1:C:317:MET:HE3	1:C:317:MET:HB3	1.85	0.42
1:B:250:MET:HG2	1:B:251:ASN:N	2.34	0.42
1:D:266:ARG:NH2	4:D:402:HOH:O	2.53	0.41
1:D:291:LEU:HD21	1:D:301:LEU:HD22	2.03	0.41
1:B:280:GLY:O	1:B:284:GLN:HG3	2.21	0.41
1:E:266:ARG:HD2	4:E:410:HOH:O	2.21	0.41

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	77/83 (93%)	76 (99%)	1 (1%)	0	100	100
1	B	76/83 (92%)	76 (100%)	0	0	100	100
1	C	76/83 (92%)	75 (99%)	1 (1%)	0	100	100
1	D	78/83 (94%)	74 (95%)	4 (5%)	0	100	100
1	E	75/83 (90%)	74 (99%)	1 (1%)	0	100	100
All	All	382/415 (92%)	375 (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	68/73 (93%)	68 (100%)	0	100	100
1	B	66/73 (90%)	65 (98%)	1 (2%)	60	73
1	C	65/73 (89%)	65 (100%)	0	100	100
1	D	68/73 (93%)	68 (100%)	0	100	100
1	E	65/73 (89%)	65 (100%)	0	100	100
All	All	332/365 (91%)	331 (100%)	1 (0%)	91	95

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

Mol	Chain	Res	Type
1	B	325	GLU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (2) such sidechains are listed below:

Mol	Chain	Res	Type
1	B	314	HIS
1	C	284	GLN

5.3.3 RNA [i](#)

There are no RNA molecules in this entry.

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

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

5.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

There are no ligands in this entry.

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	79/83 (95%)	0.05	1 (1%) 74 76	41, 62, 99, 119	0
1	B	78/83 (93%)	0.61	9 (11%) 11 10	39, 71, 115, 134	0
1	C	78/83 (93%)	0.51	5 (6%) 27 26	41, 74, 117, 148	0
1	D	80/83 (96%)	0.49	6 (7%) 22 22	37, 72, 122, 140	0
1	E	77/83 (92%)	0.54	6 (7%) 20 20	41, 71, 117, 126	0
2	Y	10/18 (55%)	-0.51	0 100 100	38, 39, 41, 42	0
3	T	10/18 (55%)	-0.31	0 100 100	38, 40, 47, 52	0
All	All	412/451 (91%)	0.40	27 (6%) 26 25	37, 69, 115, 148	0

All (27) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	D	327	ILE	4.9
1	A	326	ASN	4.7
1	B	326	ASN	4.7
1	B	249	HIS	4.6
1	E	325	GLU	4.3
1	B	250	MET	4.0
1	D	248	SER	3.8
1	E	321	ASN	3.7
1	E	249	HIS	3.6
1	B	262	GLU	3.6
1	B	321	ASN	3.5
1	D	326	ASN	3.5
1	B	320	PRO	3.4
1	C	326	ASN	3.4
1	C	324	PRO	3.0
1	D	324	PRO	2.7
1	D	250	MET	2.7

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Mol	Chain	Res	Type	RSRZ
1	C	253	ALA	2.6
1	B	253	ALA	2.5
1	C	255	LEU	2.4
1	E	320	PRO	2.4
1	E	312	GLY	2.2
1	B	260	GLU	2.2
1	D	260	GLU	2.2
1	B	259	ASP	2.1
1	E	261	LEU	2.0
1	C	262	GLU	2.0

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

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

6.3 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.4 Ligands [i](#)

There are no ligands in this entry.

6.5 Other polymers [i](#)

There are no such residues in this entry.