



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 5, 2026 – 12:32 PM UTC

PDB ID : 6HHU / pdb_00006hhu
Title : Structure of the Bacillus anthracis Sap S-layer assembly domain
Authors : Remaut, H.; Fioravanti, A.
Deposited on : 2018-08-29
Resolution : 2.70 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

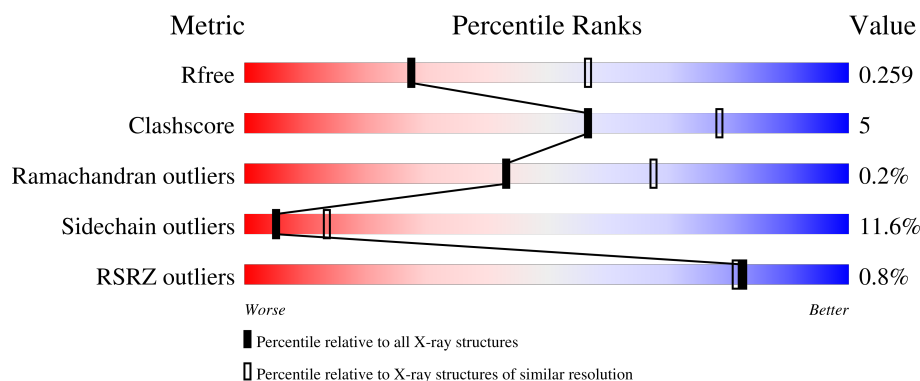
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.70 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	3538 (2.70-2.70)
Clashscore	190562	3843 (2.70-2.70)
Ramachandran outliers	187476	3778 (2.70-2.70)
Sidechain outliers	187428	3778 (2.70-2.70)
RSRZ outliers	180081	3538 (2.70-2.70)

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	606	 77% 18% . .
2	G	129	 69% 22% . 8%
3	H	134	 69% 19% . 8%

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 6373 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 S-layer protein sap.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	588	Total	C	N	O	Se	0	0	0
			4401	2772	724	902	3			

There are 8 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	215	MSE	-	initiating methionine	UNP P49051
A	662	ASN	GLN	conflict	UNP P49051
A	815	HIS	-	expression tag	UNP P49051
A	816	HIS	-	expression tag	UNP P49051
A	817	HIS	-	expression tag	UNP P49051
A	818	HIS	-	expression tag	UNP P49051
A	819	HIS	-	expression tag	UNP P49051
A	820	HIS	-	expression tag	UNP P49051

- Molecule 2 is a protein called nanobody AF684.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	G	119	Total	C	N	O	S	0	0	0
			902	559	163	176	4			

- Molecule 3 is a protein called Nanobody AF694.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	H	123	Total	C	N	O	S	0	0	0
			956	604	161	187	4			

- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	74	Total	O	0	0
			74	74		

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Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	G	17	Total	O	0	0
			17	17		
4	H	23	Total	O	0	0
			23	23		

4 Data and refinement statistics

Property	Value	Source
Space group	C 2 2 21	Depositor
Cell constants a, b, c, α , β , γ	107.55Å 115.11Å 152.77Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	32.10 – 2.70 32.10 – 2.70	Depositor EDS
% Data completeness (in resolution range)	99.8 (32.10-2.70) 99.6 (32.10-2.70)	Depositor EDS
R_{merge}	0.22	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.87 (at 2.69Å)	Xtriage
Refinement program	BUSTER 2.10.3	Depositor
R, R_{free}	0.186 , 0.250 0.194 , 0.259	Depositor DCC
R_{free} test set	1326 reflections (4.96%)	wwPDB-VP
Wilson B-factor (Å ²)	57.6	Xtriage
Anisotropy	0.361	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.35 , 80.5	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	6373	wwPDB-VP
Average B, all atoms (Å ²)	65.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.34% 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

5.1 Standard geometry

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	0.89	0/4436	1.33	30/5993 (0.5%)
2	G	0.94	1/916 (0.1%)	1.22	1/1237 (0.1%)
3	H	0.84	1/981 (0.1%)	1.31	9/1332 (0.7%)
All	All	0.89	2/6333 (0.0%)	1.31	40/8562 (0.5%)

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	G	82	MET	SD-CE	-8.76	1.57	1.79
3	H	34	MET	SD-CE	-5.97	1.64	1.79

All (40) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	H	47	TRP	CA-C-N	-9.94	113.02	122.66
3	H	47	TRP	C-N-CA	-9.94	113.02	122.66
1	A	630	ASP	CA-CB-CG	7.35	119.95	112.60
3	H	67	PHE	CA-CB-CG	6.71	120.51	113.80
1	A	390	ILE	CA-C-N	6.49	129.31	120.54
1	A	390	ILE	C-N-CA	6.49	129.31	120.54
1	A	330	VAL	N-CA-CB	6.37	118.15	110.31
1	A	261	GLU	N-CA-C	-6.32	104.39	111.28
1	A	422	VAL	N-CA-CB	6.13	117.62	110.82
1	A	796	PHE	CA-C-N	6.13	128.81	120.54
1	A	796	PHE	C-N-CA	6.13	128.81	120.54
1	A	323	ASP	CA-CB-CG	6.09	118.69	112.60
1	A	661	ALA	N-CA-C	-6.09	104.47	113.61
1	A	221	THR	N-CA-C	-6.04	100.41	108.74
3	H	102	GLY	N-CA-C	6.04	117.68	111.95
3	H	92	VAL	N-CA-CB	5.93	117.18	110.72
3	H	95	CYS	N-CA-C	-5.85	101.02	110.32
1	A	793	LYS	N-CA-C	-5.80	99.83	109.46
3	H	49	SER	N-CA-C	5.80	117.34	108.52

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	706	PRO	CA-C-N	5.76	127.99	120.28
1	A	706	PRO	C-N-CA	5.76	127.99	120.28
1	A	261	GLU	CA-C-N	5.74	128.54	120.28
1	A	261	GLU	C-N-CA	5.74	128.54	120.28
3	H	29	PHE	CA-C-N	5.68	128.67	120.38
3	H	29	PHE	C-N-CA	5.68	128.67	120.38
1	A	610	ASP	CA-CB-CG	5.53	118.13	112.60
1	A	503	ASN	CA-CB-CG	5.52	118.12	112.60
1	A	699	PHE	CA-CB-CG	5.52	119.32	113.80
1	A	522	ASP	CA-CB-CG	5.48	118.08	112.60
1	A	297	LEU	CA-C-N	5.44	130.82	122.93
1	A	297	LEU	C-N-CA	5.44	130.82	122.93
1	A	418	ASP	CA-CB-CG	5.36	117.95	112.60
1	A	327	THR	CB-CA-C	5.33	118.53	109.84
1	A	451	ASP	CA-CB-CG	5.24	117.84	112.60
1	A	377	GLU	CB-CG-CD	5.22	121.48	112.60
1	A	430	PHE	CA-C-N	5.19	129.92	122.40
1	A	430	PHE	C-N-CA	5.19	129.92	122.40
2	G	40	VAL	N-CA-C	-5.04	101.22	108.53
1	A	729	LEU	CA-C-N	5.02	127.26	120.38
1	A	729	LEU	C-N-CA	5.02	127.26	120.38

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	4401	0	4575	40	0
2	G	902	0	881	10	0
3	H	956	0	906	10	0
4	A	74	0	0	0	0
4	G	17	0	0	0	0
4	H	23	0	0	0	0
All	All	6373	0	6362	58	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 5.

All (58) 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:575:THR:HG23	1:A:584:LYS:HG3	1.61	0.80
1:A:219:ALA:O	1:A:327:THR:HB	1.88	0.74
1:A:255:LYS:O	1:A:256:GLU:HG3	1.88	0.73
3:H:101:TYR:H	3:H:108:GLN:HE22	1.36	0.73
1:A:221:THR:HG22	1:A:328:GLU:HB2	1.71	0.73
1:A:648:THR:HG21	1:A:683:TYR:HA	1.73	0.69
1:A:786:VAL:HG22	1:A:791:GLU:HB3	1.76	0.68
1:A:783:LEU:CD1	1:A:785:VAL:HG23	2.27	0.65
1:A:605:LEU:HA	1:A:622:MSE:HE3	1.82	0.62
1:A:783:LEU:HD13	1:A:785:VAL:HG23	1.82	0.61
2:G:28:ILE:HG21	2:G:99:LEU:HD22	1.83	0.60
3:H:37:VAL:HG12	3:H:94:TYR:HB2	1.85	0.58
1:A:499:LEU:HD23	1:A:585:ALA:HB1	1.84	0.58
3:H:47:TRP:CD2	3:H:107:GLY:HA2	2.38	0.58
1:A:686:THR:HG22	1:A:696:THR:HG22	1.87	0.56
1:A:244:THR:HG22	1:A:251:LYS:HG2	1.88	0.55
1:A:783:LEU:C	1:A:783:LEU:HD12	2.32	0.55
1:A:515:LYS:HG2	1:A:559:VAL:HG22	1.88	0.55
1:A:573:VAL:HG22	1:A:586:THR:HG22	1.90	0.54
2:G:92:VAL:HG23	2:G:94:TYR:CE2	2.43	0.53
1:A:780:VAL:HG22	1:A:800:VAL:HB	1.90	0.53
1:A:504:VAL:HB	1:A:587:LEU:HD21	1.91	0.53
1:A:245:ASN:O	1:A:249:ASN:HA	2.10	0.52
3:H:100:LYS:HD2	3:H:110:GLU:HB3	1.91	0.52
3:H:6:GLU:OE1	3:H:94:TYR:HA	2.10	0.51
1:A:241:ILE:HG13	1:A:257:VAL:HG21	1.92	0.50
1:A:242:LYS:HB2	1:A:283:ASP:HB3	1.91	0.50
1:A:318:GLN:HA	2:G:101:THR:O	2.12	0.50
1:A:648:THR:CG2	1:A:683:TYR:HA	2.41	0.49
3:H:47:TRP:CE2	3:H:107:GLY:HA2	2.47	0.49
1:A:734:LEU:HD22	1:A:744:ALA:HB1	1.95	0.48
3:H:6:GLU:HA	3:H:21:SER:O	2.13	0.48
1:A:595:GLY:O	1:A:630:ASP:HB2	2.14	0.47
1:A:506:LEU:O	1:A:591:LEU:HA	2.15	0.46
1:A:255:LYS:O	1:A:256:GLU:CG	2.62	0.46
1:A:355:LYS:HZ2	1:A:356:GLY:H	1.62	0.46
3:H:20:LEU:HD12	3:H:80:LEU:HD23	1.98	0.46

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:255:LYS:C	1:A:256:GLU:HG3	2.41	0.46
1:A:307:GLN:O	1:A:380:VAL:HA	2.15	0.46
1:A:506:LEU:HB3	1:A:591:LEU:HD23	1.98	0.46
2:G:63:VAL:HG13	2:G:67:PHE:HB2	1.97	0.46
1:A:648:THR:HG21	1:A:683:TYR:CD1	2.51	0.45
3:H:101:TYR:H	3:H:108:GLN:NE2	2.10	0.45
1:A:332:PRO:O	2:G:29:PHE:HB2	2.17	0.45
1:A:689:LEU:O	1:A:692:LYS:HG2	2.17	0.45
2:G:39:GLN:HE21	2:G:45:ARG:HE	1.64	0.45
1:A:601:GLU:HG3	1:A:629:VAL:HG21	2.00	0.44
2:G:90:THR:HG23	2:G:116:THR:HA	1.99	0.43
1:A:387:VAL:HG22	1:A:434:THR:HG23	1.99	0.43
1:A:217:ALA:HA	1:A:226:GLU:O	2.19	0.43
1:A:506:LEU:HD13	1:A:562:ALA:HB2	2.00	0.43
1:A:304:MSE:HG3	1:A:319:PHE:HB3	2.00	0.43
2:G:82:MET:HE1	2:G:115:VAL:HG21	2.01	0.43
2:G:23:ALA:HB2	2:G:77:THR:HG22	2.02	0.42
1:A:506:LEU:HD23	1:A:506:LEU:HA	1.88	0.42
1:A:506:LEU:HB3	1:A:591:LEU:CD2	2.51	0.41
3:H:53:SER:HA	3:H:71:ARG:NH2	2.35	0.41
2:G:111:GLN:CD	2:G:111:GLN:H	2.29	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	A	582/606 (96%)	543 (93%)	37 (6%)	2 (0%)	36	60
2	G	117/129 (91%)	111 (95%)	6 (5%)	0	100	100
3	H	121/134 (90%)	118 (98%)	3 (2%)	0	100	100
All	All	820/869 (94%)	772 (94%)	46 (6%)	2 (0%)	43	68

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	616	GLU
1	A	474	SER

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	485/496 (98%)	431 (89%)	54 (11%)	6	15
2	G	94/103 (91%)	81 (86%)	13 (14%)	3	9
3	H	101/111 (91%)	89 (88%)	12 (12%)	5	13
All	All	680/710 (96%)	601 (88%)	79 (12%)	5	13

All (79) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	220	VAL
1	A	226	GLU
1	A	236	LEU
1	A	249	ASN
1	A	253	LEU
1	A	254	VAL
1	A	271	TYR
1	A	272	SER
1	A	291	GLU
1	A	292	VAL
1	A	313	GLU
1	A	315	THR
1	A	327	THR
1	A	329	VAL
1	A	330	VAL
1	A	355	LYS
1	A	374	GLU
1	A	378	VAL
1	A	380	VAL

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Mol	Chain	Res	Type
1	A	381	SER
1	A	383	GLU
1	A	441	GLU
1	A	459	VAL
1	A	484	VAL
1	A	499	LEU
1	A	502	THR
1	A	506	LEU
1	A	511	VAL
1	A	533	THR
1	A	540	ASP
1	A	543	GLU
1	A	546	GLU
1	A	575	THR
1	A	601	GLU
1	A	636	LEU
1	A	660	ASP
1	A	663	VAL
1	A	670	VAL
1	A	672	THR
1	A	673	VAL
1	A	688	VAL
1	A	695	THR
1	A	700	LYS
1	A	702	VAL
1	A	711	LEU
1	A	721	LYS
1	A	748	LYS
1	A	777	SER
1	A	787	LYS
1	A	788	ASP
1	A	791	GLU
1	A	793	LYS
1	A	794	VAL
1	A	797	ASP
2	G	3	GLN
2	G	4	LEU
2	G	7	SER
2	G	25	SER
2	G	53	SER
2	G	63	VAL
2	G	66	ARG

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Mol	Chain	Res	Type
2	G	68	THR
2	G	88	GLU
2	G	105	SER
2	G	113	THR
2	G	117	VAL
2	G	118	SER
3	H	11	LEU
3	H	12	VAL
3	H	19	ARG
3	H	30	SER
3	H	37	VAL
3	H	38	ARG
3	H	48	VAL
3	H	53	SER
3	H	57	THR
3	H	71	ARG
3	H	75	LYS
3	H	116	GLN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (8) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	503	ASN
1	A	547	GLN
1	A	555	ASN
1	A	767	ASN
2	G	39	GLN
3	H	73	ASN
3	H	83	ASN
3	H	108	GLN

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 [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 [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	585/606 (96%)	-0.09	6 (1%) 79 78	36, 64, 105, 139	0
2	G	119/129 (92%)	-0.10	1 (0%) 82 81	38, 54, 81, 99	0
3	H	123/134 (91%)	-0.25	0 100 100	40, 56, 79, 94	0
All	All	827/869 (95%)	-0.12	7 (0%) 82 81	36, 60, 101, 139	0

All (7) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	651	LYS	3.6
1	A	661	ALA	2.7
2	G	40	VAL	2.5
1	A	649	THR	2.3
1	A	596	ALA	2.2
1	A	600	PHE	2.1
1	A	653	GLY	2.1

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.