



wwPDB X-ray Structure Validation Summary Report ⓘ

Apr 18, 2026 – 05:43 PM UTC

PDB ID : 4P9S / pdb_00004p9s
Title : Crystal structure of the mature form of rat DMGDH
Authors : Luka, Z.; Pakhomova, S.; Loukachevitch, L.V.; Newcomer, M.E.; Wagner, C.
Deposited on : 2014-04-04
Resolution : 2.32 Å(reported)

This is a wwPDB X-ray Structure Validation Summary 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
Buster-report	:	wwPDB partial adaption of 1.1.7 (2018)
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

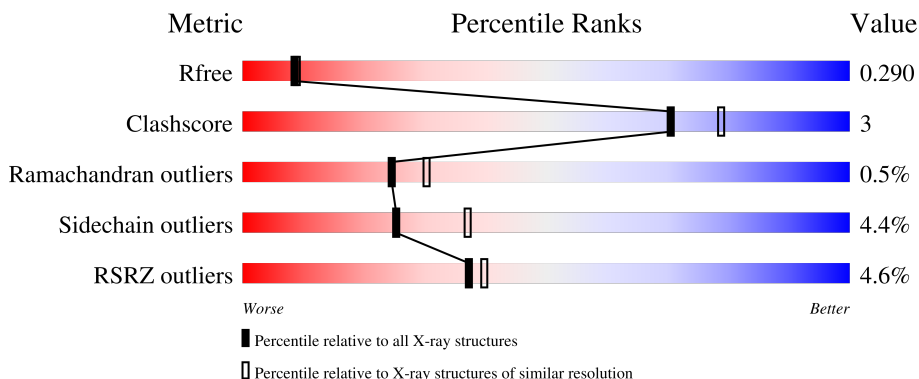
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.32 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}	180053	7754 (2.34-2.30)
Clashscore	190562	8383 (2.34-2.30)
Ramachandran outliers	187476	8303 (2.34-2.30)
Sidechain outliers	187428	8303 (2.34-2.30)
RSRZ outliers	180081	7760 (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 $\leq 5\%$. 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	848	4% 86% 10% ••
1	B	848	5% 85% 11% •

2 Entry composition

There are 3 unique types of molecules in this entry. The entry contains 13162 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 Dimethylglycine dehydrogenase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	816	Total	C	N	O	S	0	0	0
			6476	4143	1111	1203	19			
1	B	816	Total	C	N	O	S	0	0	0
			6476	4143	1111	1203	19			

There are 24 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	20	MET	-	expression tag	UNP Q5RKL4
A	21	ALA	-	expression tag	UNP Q5RKL4
A	858	ALA	-	expression tag	UNP Q5RKL4
A	859	ALA	-	expression tag	UNP Q5RKL4
A	860	LEU	-	expression tag	UNP Q5RKL4
A	861	GLU	-	expression tag	UNP Q5RKL4
A	862	HIS	-	expression tag	UNP Q5RKL4
A	863	HIS	-	expression tag	UNP Q5RKL4
A	864	HIS	-	expression tag	UNP Q5RKL4
A	865	HIS	-	expression tag	UNP Q5RKL4
A	866	HIS	-	expression tag	UNP Q5RKL4
A	867	HIS	-	expression tag	UNP Q5RKL4
B	20	MET	-	expression tag	UNP Q5RKL4
B	21	ALA	-	expression tag	UNP Q5RKL4
B	858	ALA	-	expression tag	UNP Q5RKL4
B	859	ALA	-	expression tag	UNP Q5RKL4
B	860	LEU	-	expression tag	UNP Q5RKL4
B	861	GLU	-	expression tag	UNP Q5RKL4
B	862	HIS	-	expression tag	UNP Q5RKL4
B	863	HIS	-	expression tag	UNP Q5RKL4
B	864	HIS	-	expression tag	UNP Q5RKL4
B	865	HIS	-	expression tag	UNP Q5RKL4
B	866	HIS	-	expression tag	UNP Q5RKL4
B	867	HIS	-	expression tag	UNP Q5RKL4

- # FAD
-
- The image displays the chemical structure of Flavin Adenine Dinucleotide (FAD), a crucial coenzyme. The molecule is composed of three main parts: a riboflavin (isoalloxazine) ring system, a ribitol chain, and an adenosine moiety.
- Riboflavin Ring System:** The top part of the structure features a fused ring system consisting of a benzene ring and two nitrogen-containing heterocycles (pyrimidine and imidazole). Nitrogen atoms are labeled N1A, N3A, N7A, and N9A. Carbon atoms are labeled C2A, C4A, C5A, C6A, C7A, and C8A. A carbonyl group (C=O) is attached to C2A, and another carbonyl group is attached to C4A.
 - Ribitol Chain:** A ribitol chain connects the riboflavin ring to the adenosine moiety. The ribitol chain is a five-carbon chain with hydroxyl groups at C2, C3, and C4. The carbons are labeled C1B, C2B, C3B, C4B, and C5B. The ribitol chain is shown in a zig-zag conformation.
 - Adenosine Moiety:** The bottom part of the structure is an adenosine moiety, which consists of an adenine ring system attached to a ribose sugar. The adenine ring system is a fused ring system consisting of a benzene ring and two nitrogen-containing heterocycles (pyrimidine and imidazole). Nitrogen atoms are labeled N1, N3, N7, and N9. Carbon atoms are labeled C2, C4, C5, C6, C7, and C8. A carbonyl group (C=O) is attached to C2, and another carbonyl group is attached to C4. The ribose sugar is a five-membered ring with hydroxyl groups at C2' and C3'. The carbons are labeled C1', C2', C3', C4', and C5'.
- The overall structure is shown in a 3D representation, with atoms colored by element: carbon (grey), nitrogen (blue), oxygen (red), and hydrogen (white). The structure is labeled with atom names and numbers, and the overall molecule is labeled FAD.

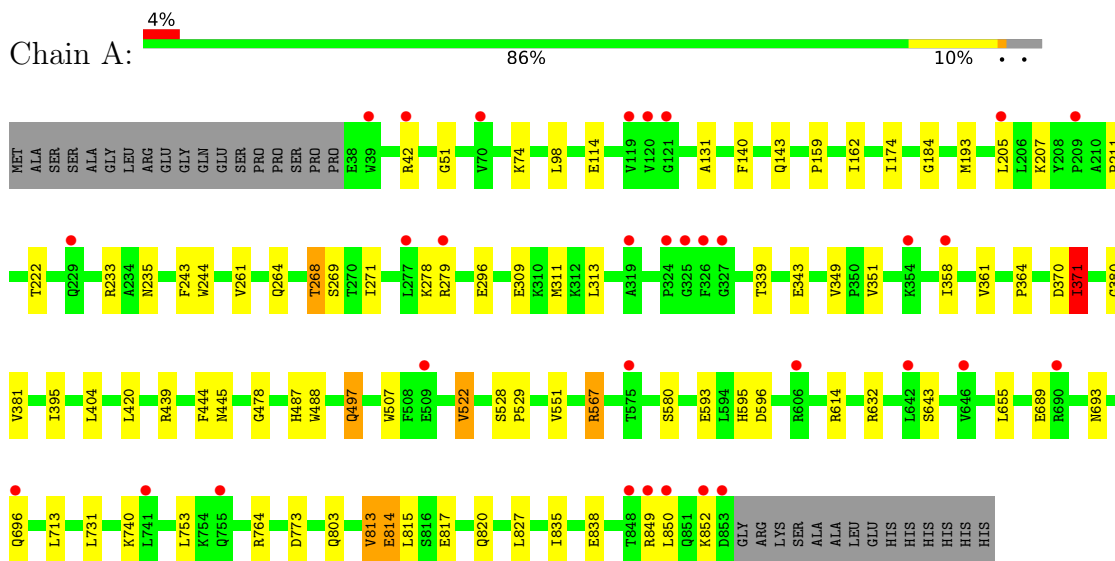
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	A	1	Total 53	C 27	N 9	O 15	P 2	0	0
2	B	1	Total 53	C 27	N 9	O 15	P 2	0	0

- | Mol | Chain | Residues | Atoms | ZeroOcc | AltConf |
|-----|-------|----------|------------------|---------|---------|
| 3 | A | 47 | Total O
47 47 | 0 | 0 |
| 3 | B | 57 | Total O
57 57 | 0 | 0 |

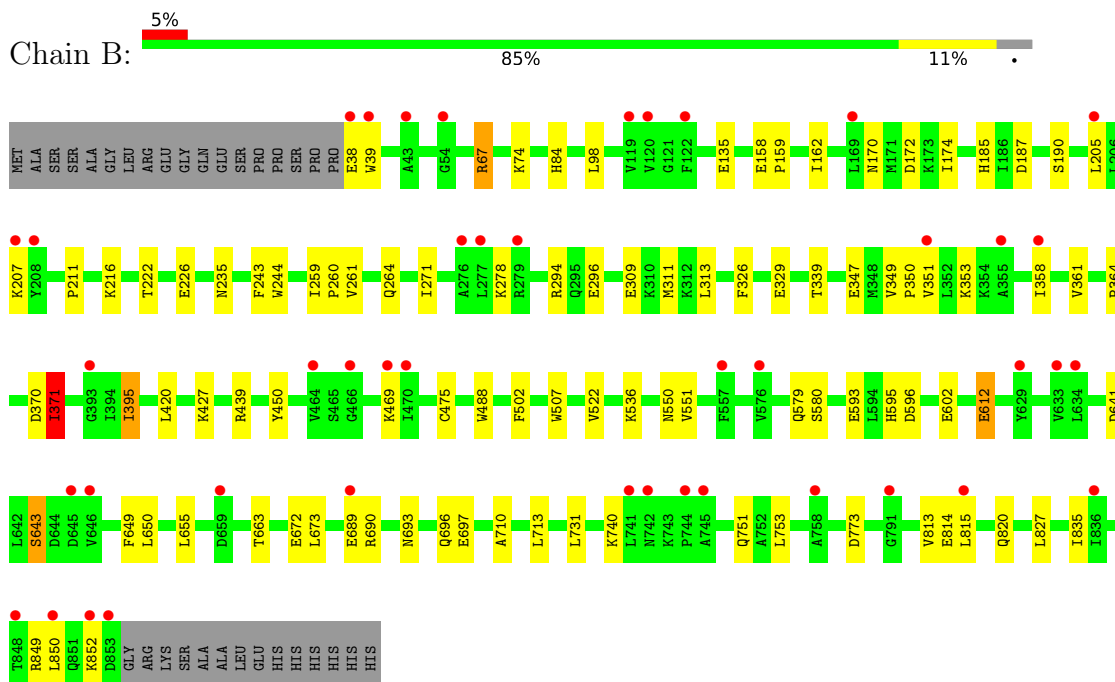
3 Residue-property plots

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: Dimethylglycine dehydrogenase



• Molecule 1: Dimethylglycine dehydrogenase



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	85.21Å 131.44Å 171.92Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	40.00 – 2.32 40.00 – 2.32	Depositor EDS
% Data completeness (in resolution range)	89.7 (40.00-2.32) 89.7 (40.00-2.32)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.08	Depositor
$\langle I/\sigma(I) \rangle$ ¹	4.71 (at 2.31Å)	Xtriage
Refinement program	REFMAC 5.8.0049	Depositor
R, R_{free}	0.253 , 0.295 0.256 , 0.290	Depositor DCC
R_{free} test set	1517 reflections (1.68%)	wwPDB-VP
Wilson B-factor (Å ²)	28.2	Xtriage
Anisotropy	0.413	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.31 , 23.4	EDS
L-test for twinning ²	$\langle L \rangle = 0.47$, $\langle L^2 \rangle = 0.29$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.89	EDS
Total number of atoms	13162	wwPDB-VP
Average B, all atoms (Å ²)	30.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.63% 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](#)

Bond lengths and bond angles in the following residue types are not validated in this section: FAD

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	0.78	0/6641	0.92	3/9015 (0.0%)
1	B	0.78	0/6641	0.91	3/9015 (0.0%)
All	All	0.78	0/13282	0.92	6/18030 (0.0%)

There are no bond length outliers.

The worst 5 of 6 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	358	ILE	CB-CA-C	-6.61	103.11	112.22
1	A	358	ILE	CB-CA-C	-6.45	103.32	112.22
1	B	349	VAL	CA-C-N	5.42	126.61	119.84
1	B	349	VAL	C-N-CA	5.42	126.61	119.84
1	A	349	VAL	CA-C-N	5.39	126.58	119.84

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	6476	0	6409	42	0
1	B	6476	0	6409	46	0
2	A	53	0	29	0	0
2	B	53	0	30	1	0

Continued on next page...

Continued from previous page...

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
3	A	47	0	0	3	0
3	B	57	0	0	1	0
All	All	13162	0	12877	87	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 3.

The worst 5 of 87 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:159:PRO:HA	1:A:162:ILE:HD12	1.62	0.80
1:B:159:PRO:HA	1:B:162:ILE:HD12	1.62	0.79
1:A:271:ILE:HG21	1:A:351:VAL:CG1	2.13	0.78
1:B:271:ILE:HG21	1:B:351:VAL:CG1	2.14	0.78
1:A:268:THR:HG21	1:A:271:ILE:HD11	1.72	0.69

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	814/848 (96%)	778 (96%)	31 (4%)	5 (1%)	21	25
1	B	814/848 (96%)	784 (96%)	27 (3%)	3 (0%)	30	37
All	All	1628/1696 (96%)	1562 (96%)	58 (4%)	8 (0%)	24	30

5 of 8 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	371	ILE
1	B	371	ILE

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type
1	A	593	GLU
1	B	593	GLU
1	A	522	VAL

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	689/714 (96%)	657 (95%)	32 (5%)	24	35
1	B	689/714 (96%)	660 (96%)	29 (4%)	26	39
All	All	1378/1428 (96%)	1317 (96%)	61 (4%)	25	37

5 of 61 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	838	GLU
1	B	751	GLN
1	B	216	LYS
1	B	731	LEU
1	B	850	LEU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 20 such sidechains are listed below:

Mol	Chain	Res	Type
1	B	550	ASN
1	B	595	HIS
1	B	821	GLN
1	B	820	GLN
1	A	579	GLN

5.3.3 RNA ⓘ

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](#)

2 ligands 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	FAD	B	901	1	58,58,58	1.64	10 (17%)	85,89,89	1.83	22 (25%)
2	FAD	A	901	1	58,58,58	1.54	12 (20%)	85,89,89	1.85	24 (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
2	FAD	B	901	1	-	6/34/50/50	0/6/6/6
2	FAD	A	901	1	-	4/34/50/50	0/6/6/6

The worst 5 of 22 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	B	901	FAD	C1'-C2'	-4.73	1.46	1.52
2	B	901	FAD	C5A-C4A	4.61	1.47	1.39
2	B	901	FAD	C9A-C5X	4.41	1.48	1.41
2	A	901	FAD	C5A-C4A	4.04	1.46	1.39
2	A	901	FAD	C9A-C5X	3.75	1.47	1.41

The worst 5 of 46 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	901	FAD	C5A-C4A-N3A	-6.80	117.36	126.72
2	A	901	FAD	C5A-C4A-N3A	-5.50	119.14	126.72
2	A	901	FAD	N3A-C4A-N9A	5.08	135.81	127.17
2	B	901	FAD	N3A-C4A-N9A	4.81	135.35	127.17
2	A	901	FAD	O4B-C1B-N9A	4.70	117.11	108.09

There are no chirality outliers.

5 of 10 torsion outliers are listed below:

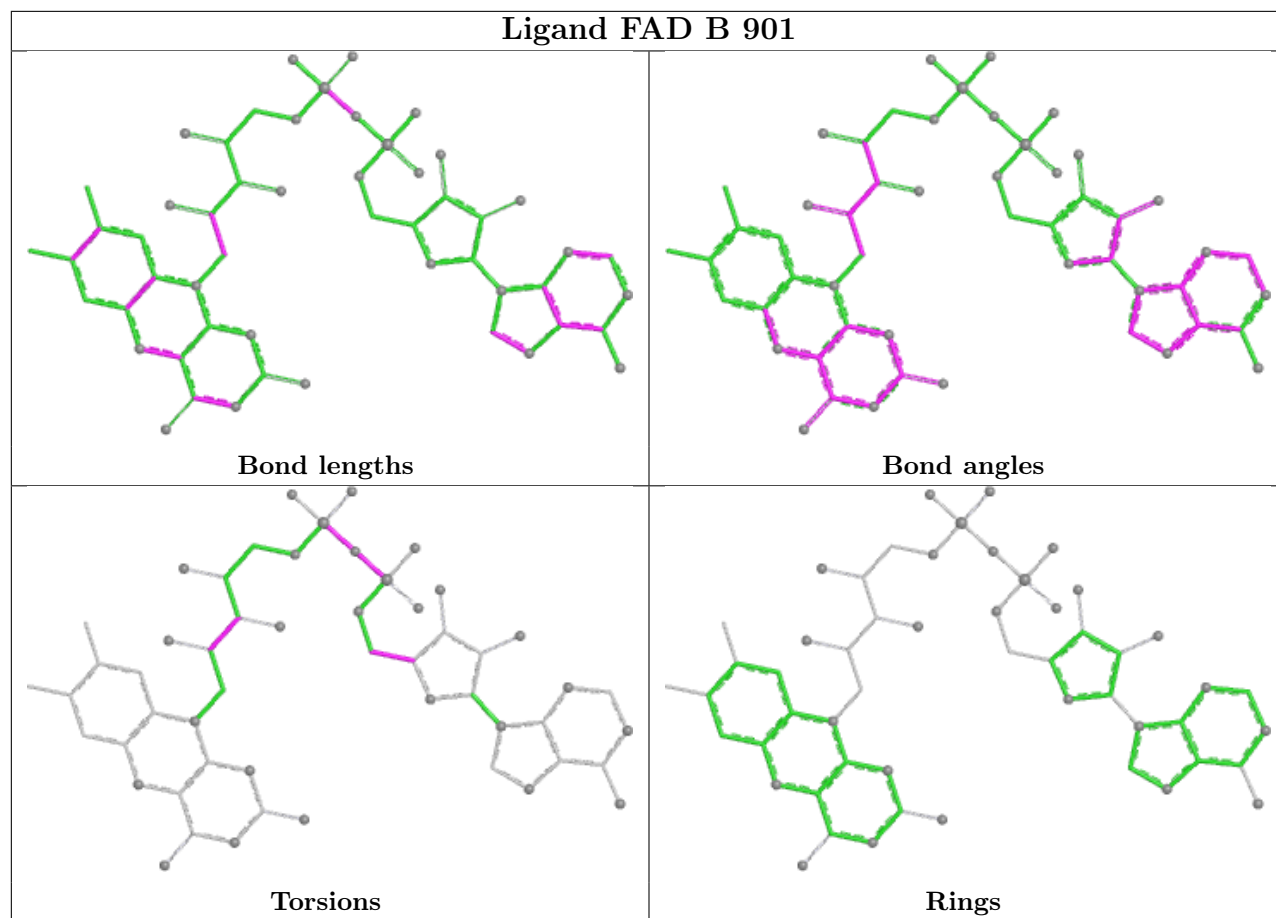
Mol	Chain	Res	Type	Atoms
2	A	901	FAD	O4B-C4B-C5B-O5B
2	A	901	FAD	PA-O3P-P-O5'
2	B	901	FAD	PA-O3P-P-O5'
2	B	901	FAD	O2'-C2'-C3'-C4'
2	B	901	FAD	O2'-C2'-C3'-O3'

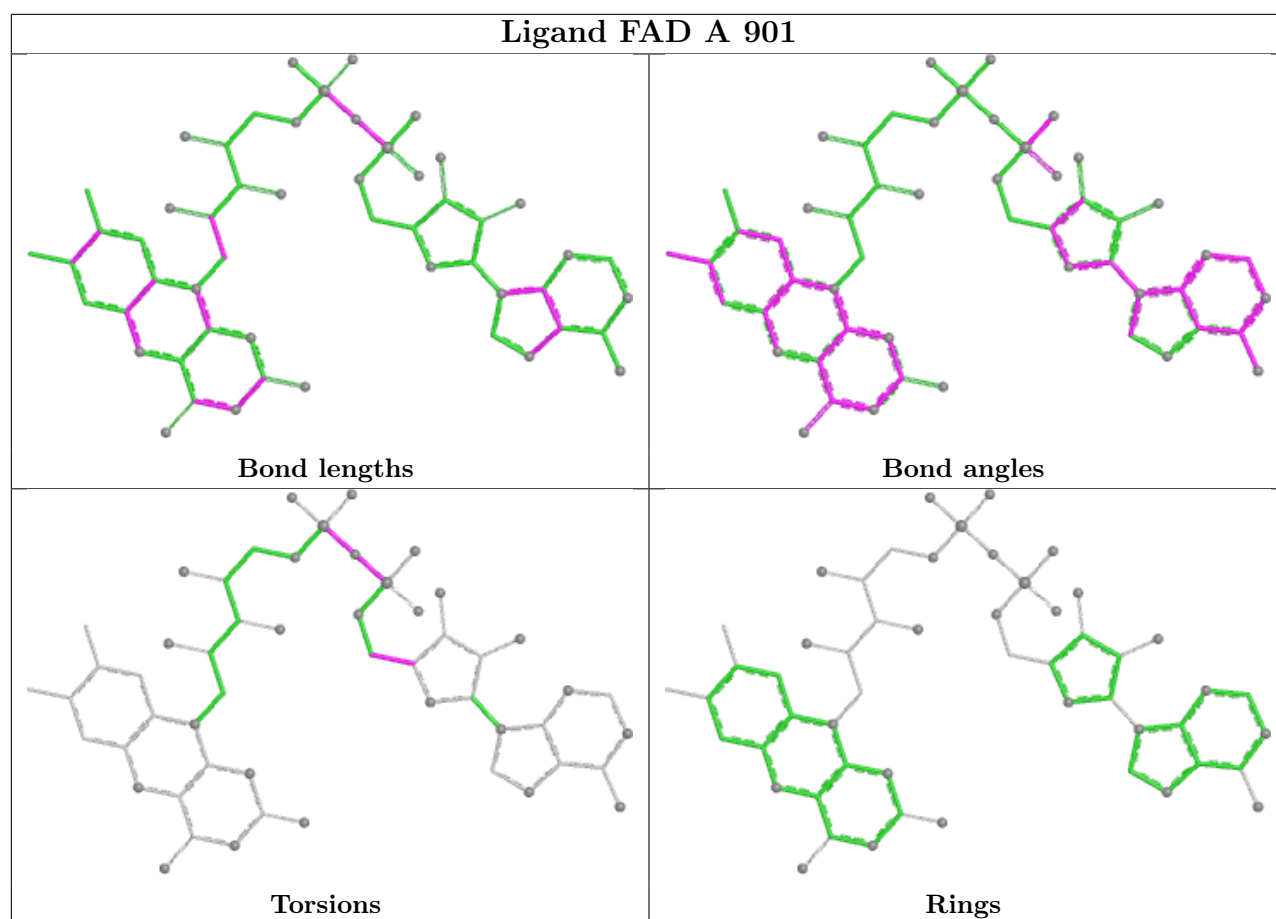
There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	B	901	FAD	1	0

The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less than 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier. Any bond that is central to one or more torsion angles identified as an outlier by Mogul will be highlighted in the graph. For rings, the root-mean-square deviation (RMSD) between the ring in question and similar rings identified by Mogul is calculated over all ring torsion angles. If the average RMSD is greater than 60 degrees and the minimal RMSD between the ring in question and any Mogul-identified rings is also greater than 60 degrees, then that ring is considered an outlier. The outliers are highlighted in purple. The color gray indicates Mogul did not find sufficient equivalents in the CSD to analyse the geometry.





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	816/848 (96%)	0.56	32 (3%) 43 46	16, 28, 45, 81	0
1	B	816/848 (96%)	0.74	43 (5%) 32 34	16, 30, 50, 83	0
All	All	1632/1696 (96%)	0.65	75 (4%) 37 40	16, 29, 48, 83	0

The worst 5 of 75 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	646	VAL	4.4
1	B	850	LEU	4.3
1	A	850	LEU	4.2
1	B	852	LYS	3.9
1	A	853	ASP	3.5

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](#)

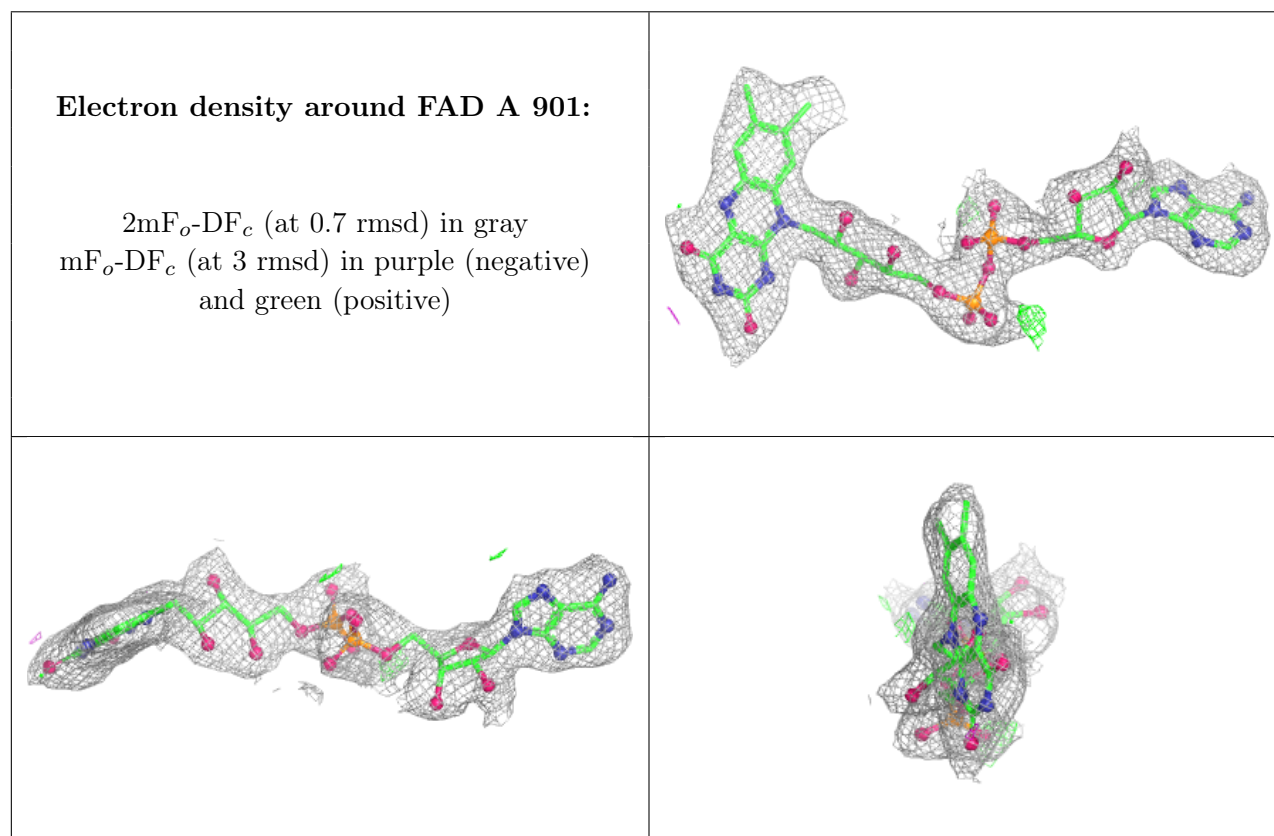
There are no oligosaccharides in this entry.

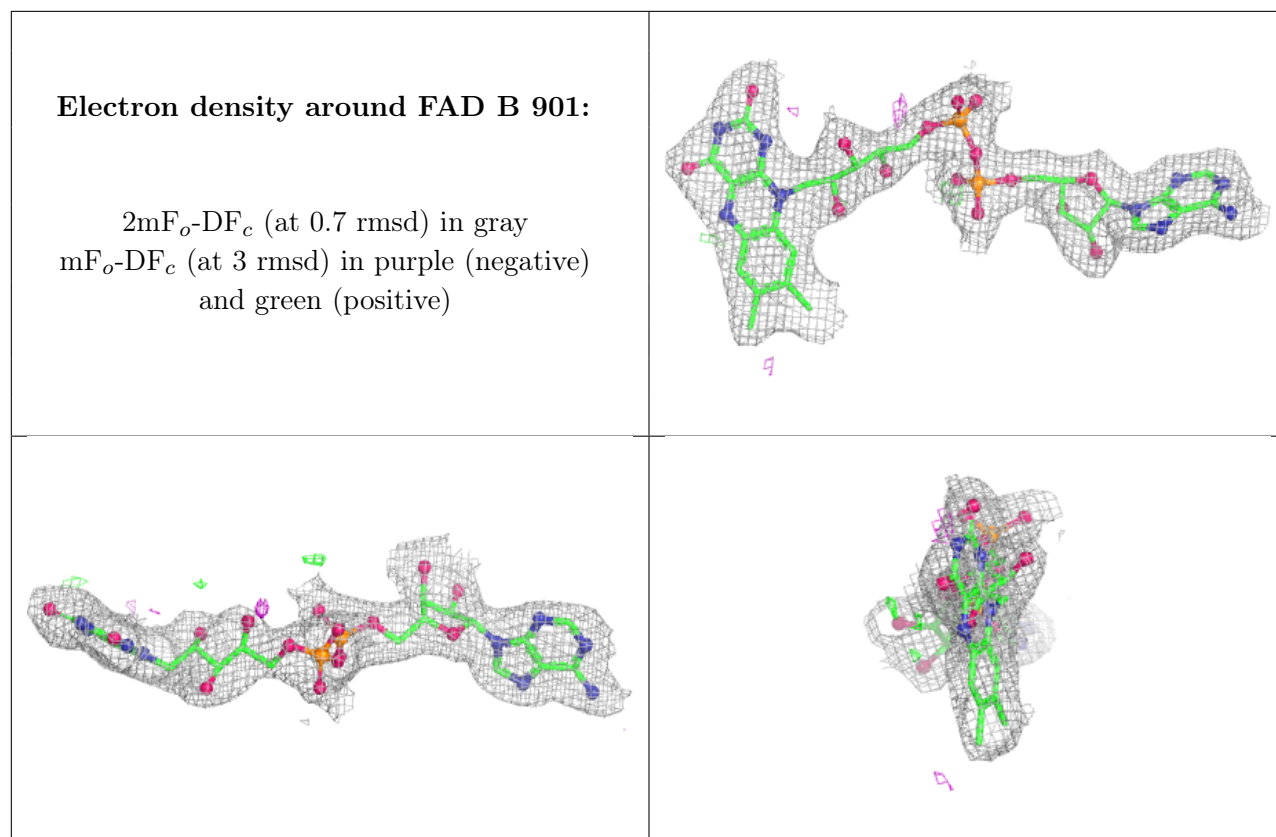
6.4 Ligands [i](#)

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
2	FAD	A	901	53/53	0.95	0.08	19,23,26,29	0
2	FAD	B	901	53/53	0.96	0.07	15,18,21,25	0

The following is a graphical depiction of the model fit to experimental electron density of all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the geometry validation Tables will also be included. Each fit is shown from different orientation to approximate a three-dimensional view.





6.5 Other polymers [i](#)

There are no such residues in this entry.