



# Full wwPDB X-ray Structure Validation Report ⓘ

Mar 7, 2026 – 05:08 AM UTC

PDB ID : 6VDH / pdb\_00006vdh  
Title : Crystal structure of ancestral apicomplexan lactate dehydrogenase in alternate dimer configuration with sulfate.  
Authors : Theobald, D.L.; Wirth, J.D.; Classen, S.; Perlmutter, N.  
Deposited on : 2019-12-27  
Resolution : 1.85 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](mailto: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>.

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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)  
Xtrriage (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

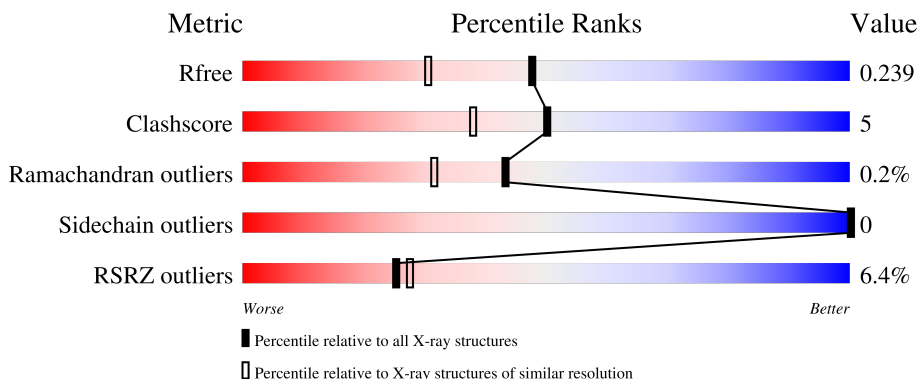
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*X-RAY DIFFRACTION*

The reported resolution of this entry is 1.85 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	3428 (1.86-1.86)
Clashscore	190562	3579 (1.86-1.86)
Ramachandran outliers	187476	3553 (1.86-1.86)
Sidechain outliers	187428	3553 (1.86-1.86)
RSRZ outliers	180081	3429 (1.86-1.86)

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  $\geq 3$ , 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	330	 6% 84% 9% 7%
1	B	330	 6% 86% 9% 5%

## 2 Entry composition [i](#)

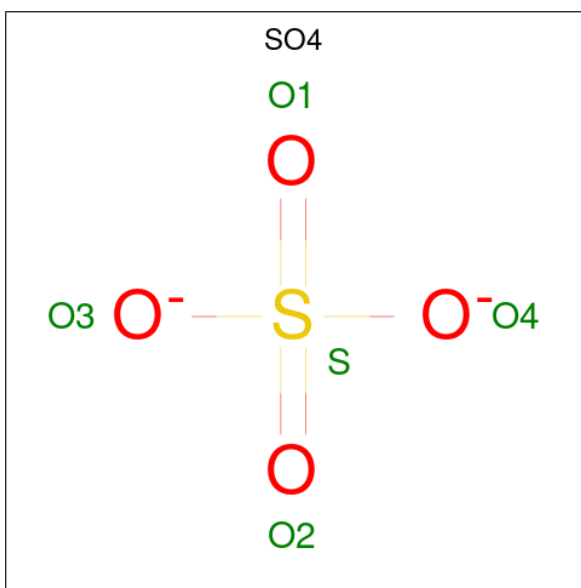
There are 3 unique types of molecules in this entry. The entry contains 9084 atoms, of which 4019 are hydrogens and 0 are deuteriums.

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 lactate dehydrogenase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace	
			Total	C	H	N	O				S
1	A	308	4360	1488	2017	390	449	16	0	1	0
1	B	313	4391	1519	2002	397	457	16	0	1	0

- Molecule 2 is SULFATE ION (CCD ID: SO4) (formula: O<sub>4</sub>S) (labeled as "Ligand of Interest" by depositor).



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

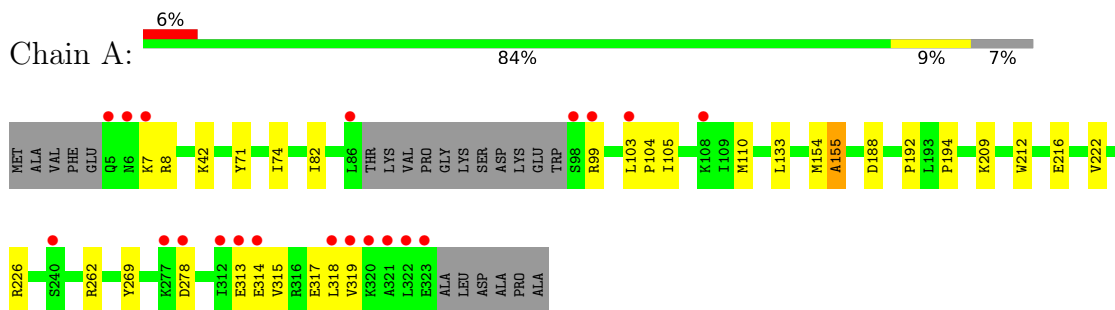
- Molecule 3 is water.

<b>Mol</b>	<b>Chain</b>	<b>Residues</b>	<b>Atoms</b>		<b>ZeroOcc</b>	<b>AltConf</b>
3	A	154	Total 154	O 154	0	0
3	B	169	Total 169	O 169	0	0

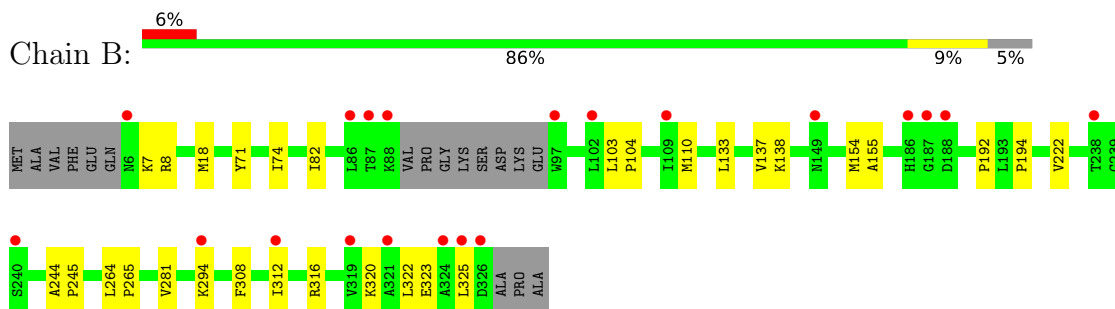
### 3 Residue-property plots [i](#)

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: lactate dehydrogenase



- Molecule 1: lactate dehydrogenase



## 4 Data and refinement statistics

Property	Value	Source
Space group	I 2 2 2	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	103.38Å 105.44Å 151.45Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	45.53 – 1.85 45.53 – 1.85	Depositor EDS
% Data completeness (in resolution range)	92.6 (45.53-1.85) 92.6 (45.53-1.85)	Depositor EDS
$R_{merge}$	(Not available)	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	1.15 (at 1.86Å)	Xtrriage
Refinement program	PHENIX 1.17_3644	Depositor
R, $R_{free}$	0.209 , 0.236 0.211 , 0.239	Depositor DCC
$R_{free}$ test set	1956 reflections (2.25%)	wwPDB-VP
Wilson B-factor (Å <sup>2</sup> )	30.3	Xtrriage
Anisotropy	0.275	Xtrriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.39 , 37.6	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.49$ , $\langle L^2 \rangle = 0.32$	Xtrriage
Estimated twinning fraction	0.009 for $-1/2^*h-1/2^*k+1/2^*l,-1/2^*h-1/2^*k-1/2^*l,h-k$ 0.005 for $-1/2^*h-1/2^*k-1/2^*l,-1/2^*h-1/2^*k+1/2^*l,-h+k$ 0.006 for $-1/2^*h+1/2^*k+1/2^*l,1/2^*h-1/2^*k+1/2^*l,h+k$ 0.022 for $-1/2^*h+1/2^*k-1/2^*l,1/2^*h-1/2^*k-1/2^*l,-h-k$ 0.045 for k,h,-l	Xtrriage
$F_o,F_c$ correlation	0.96	EDS
Total number of atoms	9084	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	42.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.50% of the height of the origin peak. No significant pseudotranslation is detected.*

<sup>1</sup>Intensities estimated from amplitudes.

<sup>2</sup>Theoretical 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: SO4

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	0.16	0/2380	0.34	0/3218
1	B	0.19	0/2428	0.33	0/3284
All	All	0.17	0/4808	0.34	0/6502

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	2343	2017	2401	23	0
1	B	2389	2002	2449	29	0
2	A	5	0	0	0	0
2	B	5	0	0	0	0
3	A	154	0	0	3	0
3	B	169	0	0	2	1
All	All	5065	4019	4850	51	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 5.

All (51) 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:133:LEU:HD22	1:A:155:ALA:HB2	1.53	0.89
1:B:133:LEU:HD22	1:B:155:ALA:HB2	1.57	0.85
1:A:42:LYS:NZ	3:A:502:HOH:O	2.21	0.74
1:A:313:GLU:O	1:A:317:GLU:HG3	1.88	0.73
1:B:138:LYS:NZ	3:B:501:HOH:O	2.18	0.65
1:A:209:LYS:NZ	3:A:505:HOH:O	2.30	0.64
1:B:316:ARG:HG2	1:B:320:LYS:NZ	2.13	0.63
1:A:194:PRO:HG3	1:A:222:VAL:HG21	1.79	0.63
1:B:308:PHE:CE2	1:B:312:ILE:HD11	2.35	0.62
1:B:103:LEU:HB3	1:B:104:PRO:HD3	1.82	0.60
1:B:194:PRO:HG3	1:B:222:VAL:HG21	1.86	0.58
1:B:281:VAL:HG11	1:B:312:ILE:HD13	1.89	0.55
1:A:188:ASP:O	1:A:226:ARG:HD3	2.06	0.55
1:A:133:LEU:HD22	1:A:155:ALA:CB	2.35	0.53
1:A:315:VAL:O	1:A:319:VAL:HG23	2.10	0.52
1:B:308:PHE:CZ	1:B:312:ILE:HD11	2.44	0.51
1:B:194:PRO:HG3	1:B:222:VAL:CG2	2.41	0.50
1:A:212:TRP:CH2	1:B:294:LYS:HD2	2.47	0.50
1:B:7:LYS:HE3	1:B:8:ARG:O	2.12	0.50
1:B:133:LEU:O	1:B:137:VAL:HG23	2.12	0.50
1:A:314:GLU:O	1:A:318:LEU:HG	2.12	0.49
1:A:194:PRO:HG3	1:A:222:VAL:CG2	2.41	0.49
1:A:71:TYR:O	1:A:74:ILE:HG12	2.12	0.49
1:A:103:LEU:HB3	1:A:104:PRO:CD	2.43	0.48
1:A:7:LYS:HG3	1:A:8:ARG:O	2.13	0.48
1:A:99:ARG:N	1:A:99:ARG:HD3	2.28	0.48
1:A:192:PRO:O	1:A:194:PRO:HD3	2.13	0.48
1:A:105:ILE:HG23	3:A:565:HOH:O	2.14	0.48
1:B:325:LEU:HD23	1:B:325:LEU:HA	1.72	0.48
1:A:216:GLU:H	1:A:216:GLU:CD	2.22	0.47
1:B:316:ARG:HG2	1:B:320:LYS:HZ1	1.80	0.47
1:B:316:ARG:HG2	1:B:320:LYS:HZ3	1.78	0.46
1:A:82:ILE:HG21	1:A:110:MET:HE1	1.99	0.45
1:A:103:LEU:HB3	1:A:104:PRO:HD3	1.98	0.45
1:B:320:LYS:O	1:B:323:GLU:HB3	2.15	0.45
1:B:71:TYR:O	1:B:74:ILE:HG12	2.17	0.44
1:B:18:MET:HA	1:B:18:MET:HE2	1.99	0.44
1:B:308:PHE:O	1:B:312:ILE:HG12	2.18	0.44
1:B:192:PRO:O	1:B:194:PRO:HD3	2.17	0.44
1:B:316:ARG:O	1:B:320:LYS:NZ	2.51	0.44
1:B:316:ARG:O	1:B:320:LYS:HE2	2.18	0.43

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:110:MET:HA	1:B:110:MET:HE2	2.01	0.43
1:A:262:ARG:NH2	3:B:506:HOH:O	2.40	0.42
1:B:82:ILE:HG21	1:B:110:MET:HE1	2.02	0.42
1:B:244:ALA:HB3	1:B:245:PRO:HD3	2.02	0.42
1:A:154:MET:C	1:A:154:MET:SD	3.03	0.41
1:B:103:LEU:HD11	1:B:322:LEU:HD22	2.02	0.41
1:B:154:MET:SD	1:B:154:MET:C	3.04	0.41
1:A:269:TYR:OH	1:A:278:ASP:OD1	2.30	0.40
1:B:82:ILE:CG2	1:B:110:MET:HE1	2.51	0.40
1:B:264:LEU:HA	1:B:265:PRO:HD3	1.98	0.40

All (1) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
3:B:658:HOH:O	3:B:666:HOH:O[2_555]	2.05	0.15

## 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	305/330 (92%)	298 (98%)	6 (2%)	1 (0%)	36	25
1	B	310/330 (94%)	303 (98%)	7 (2%)	0	100	100
All	All	615/660 (93%)	601 (98%)	13 (2%)	1 (0%)	43	31

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	155	ALA

### 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	259/276 (94%)	259 (100%)	0	100	100
1	B	264/276 (96%)	264 (100%)	0	100	100
All	All	523/552 (95%)	523 (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 (8) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	123	ASN
1	A	148	HIS
1	A	290	ASN
1	B	116	ASN
1	B	131	ASN
1	B	148	HIS
1	B	186	HIS
1	B	234	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](#)

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

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	SO4	B	401	-	4,4,4	0.24	0	6,6,6	0.04	0
2	SO4	A	401	-	4,4,4	0.24	0	6,6,6	0.09	0

There are no bond length outliers.

There are no bond angle outliers.

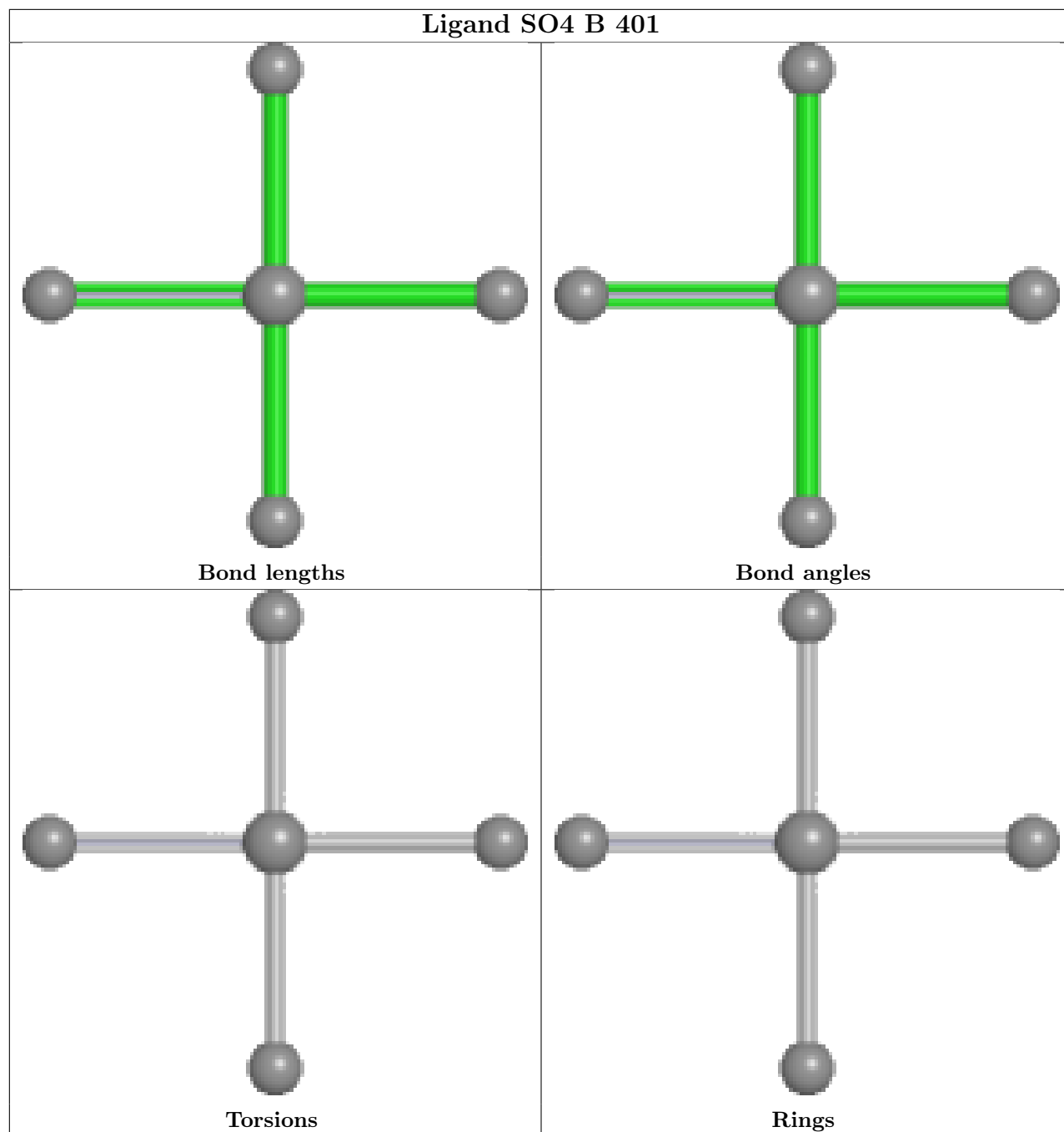
There are no chirality outliers.

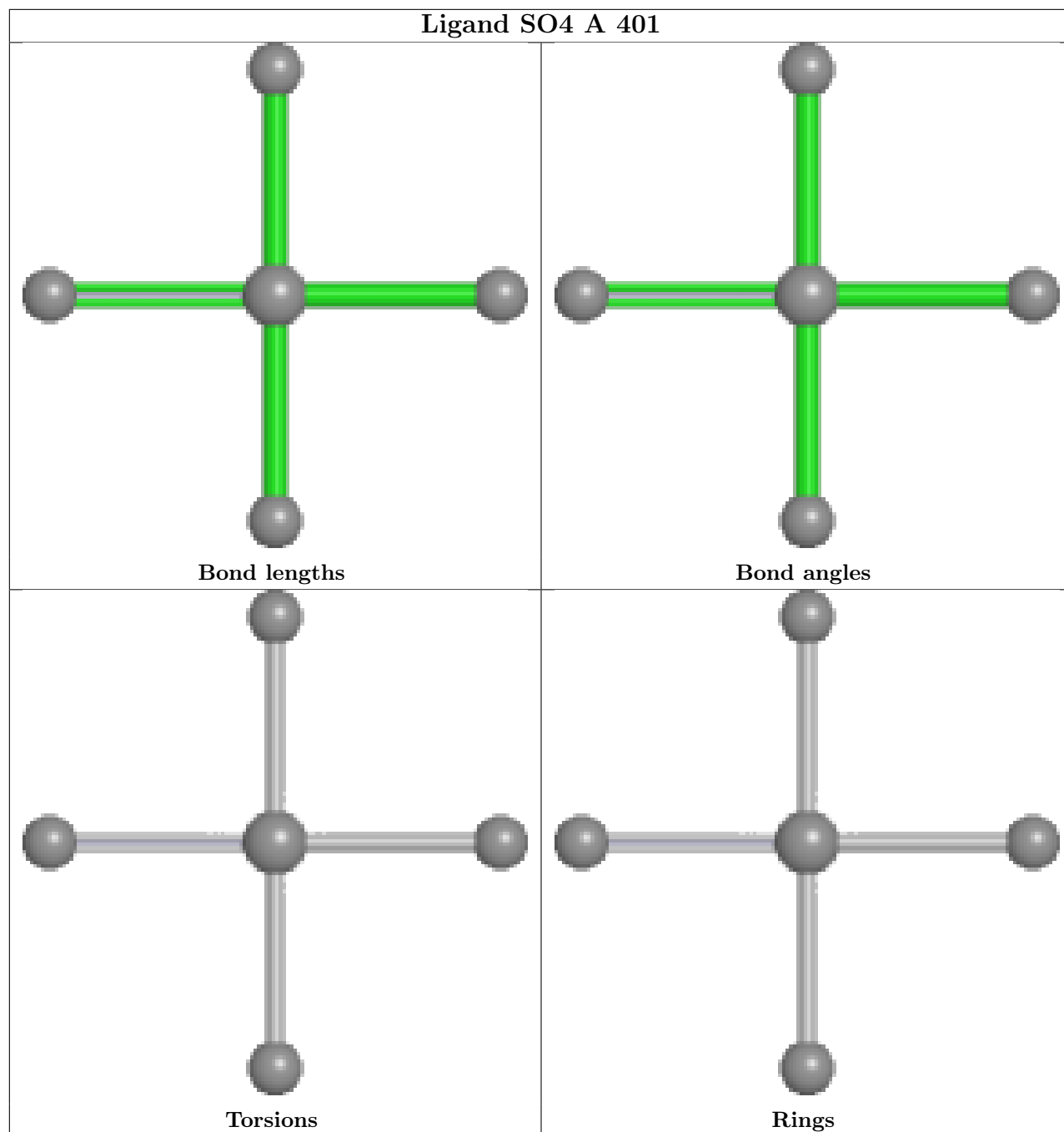
There are no torsion outliers.

There are no ring outliers.

No monomer is involved in short contacts.

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

### 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<sup>th</sup> 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 <sup>2</sup> )	Q<0.9
1	A	308/330 (93%)	0.55	20 (6%) 25 27	26, 41, 62, 84	1 (0%)
1	B	313/330 (94%)	0.51	20 (6%) 25 27	25, 40, 61, 92	1 (0%)
All	All	621/660 (94%)	0.53	40 (6%) 25 27	25, 40, 61, 92	2 (0%)

All (40) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	97	TRP	5.8
1	B	324	ALA	5.0
1	A	86	LEU	4.3
1	B	88	LYS	4.2
1	A	5	GLN	4.2
1	B	325	LEU	4.0
1	B	294	LYS	3.4
1	A	321	ALA	3.2
1	A	98	SER	3.1
1	A	312	ILE	3.1
1	B	312	ILE	3.0
1	A	319	VAL	2.9
1	A	323	GLU	2.8
1	B	186	HIS	2.7
1	A	6	ASN	2.7
1	B	240	SER	2.7
1	B	319	VAL	2.7
1	B	238	THR	2.6
1	A	313	GLU	2.6
1	A	322	LEU	2.6
1	A	7	LYS	2.6
1	B	86	LEU	2.5
1	B	188	ASP	2.5
1	A	240	SER	2.4

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Mol	Chain	Res	Type	RSRZ
1	B	326	ASP	2.4
1	B	87	THR	2.3
1	B	321	ALA	2.3
1	B	6	ASN	2.3
1	B	109	ILE	2.3
1	A	318	LEU	2.3
1	A	314	GLU	2.2
1	A	108	LYS	2.2
1	A	277	LYS	2.2
1	A	99	ARG	2.2
1	B	102	LEU	2.2
1	A	320	LYS	2.2
1	B	149	ASN	2.1
1	B	187	GLY	2.1
1	A	278	ASP	2.1
1	A	103	LEU	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](#)

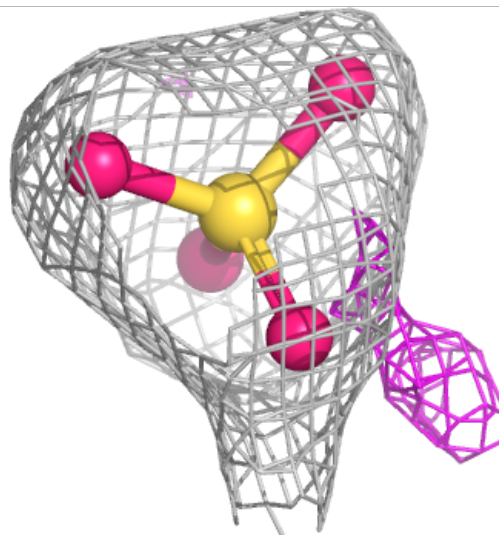
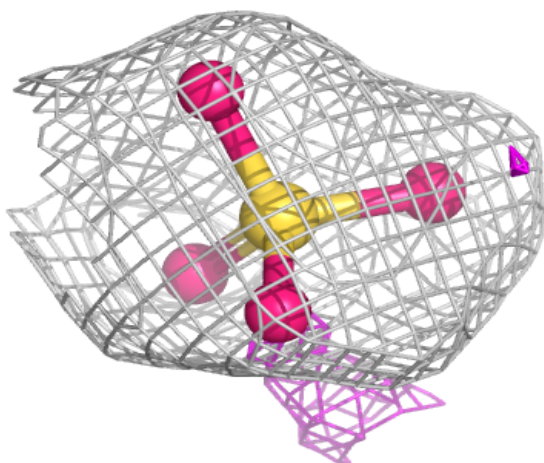
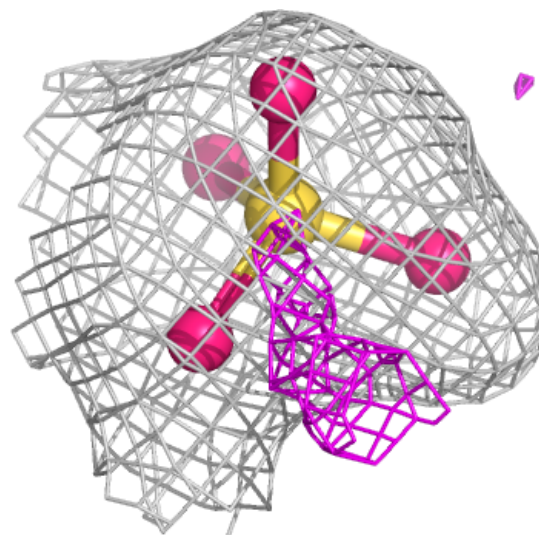
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95<sup>th</sup> percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

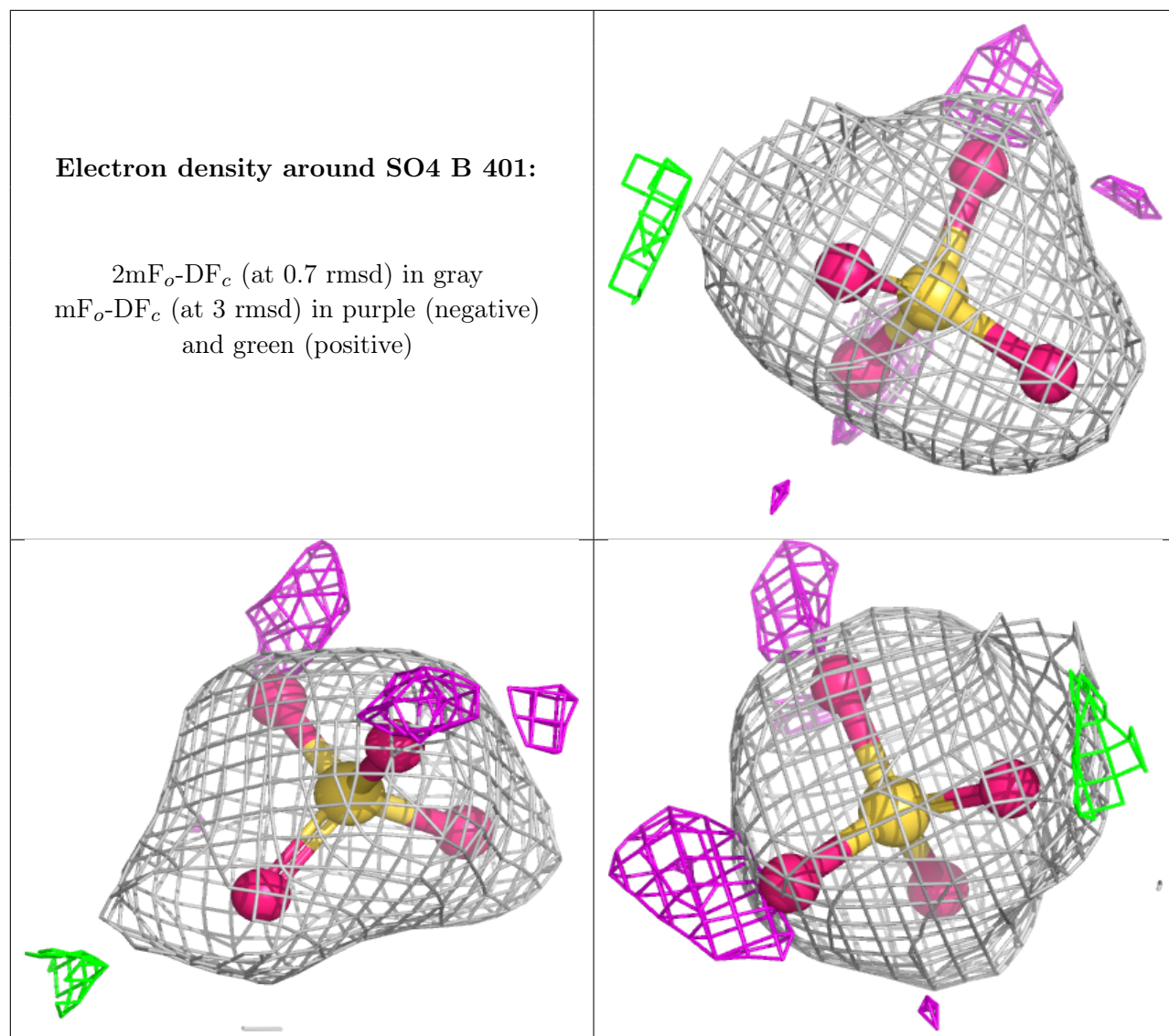
Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å <sup>2</sup> )	Q<0.9
2	SO4	A	401	5/5	0.84	0.10	50,56,66,71	0
2	SO4	B	401	5/5	0.90	0.10	46,51,55,62	0

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.

**Electron density around SO4 A 401:**

$2mF_o-DF_c$  (at 0.7 rmsd) in gray  
 $mF_o-DF_c$  (at 3 rmsd) in purple (negative)  
and green (positive)





## 6.5 Other polymers [i](#)

There are no such residues in this entry.