



wwPDB X-ray Structure Validation Summary Report ⓘ

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PDB ID : 8EYO / pdb_00008eyo
Title : Crystal Structure of Human Mitochondrial NADP⁺ Malic Enzyme 3 with NADP bound
Authors : Shaffer, P.L.; Grell, T.A.J.; Mason, M.; Thompson, A.A.; Riley, D.; Wagner, M.V.; Steele, R.; Ortiz-Meoz, R.; Wadia, J.; Sharma, S.; Yu, X.
Deposited on : 2022-10-28
Resolution : 2.49 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

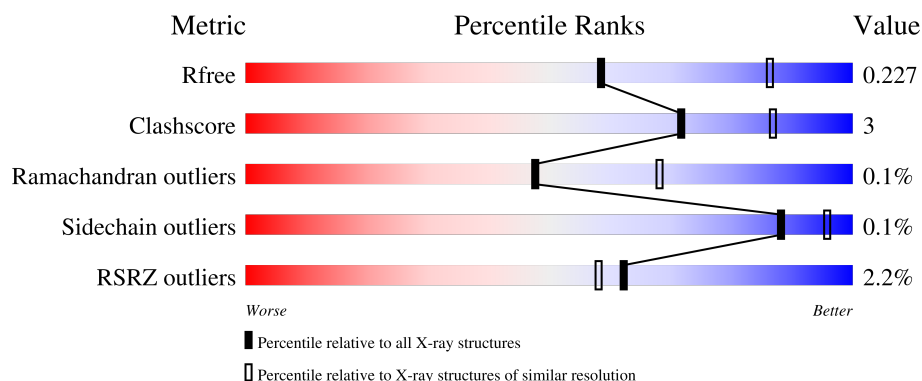
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

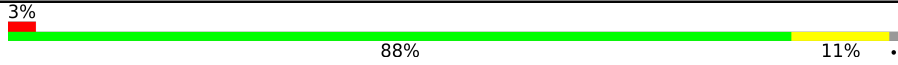
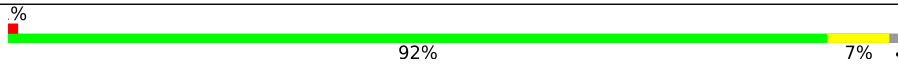
The reported resolution of this entry is 2.49 Å.

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	5829 (2.50-2.50)
Clashscore	190562	6492 (2.50-2.50)
Ramachandran outliers	187476	6378 (2.50-2.50)
Sidechain outliers	187428	6380 (2.50-2.50)
RSRZ outliers	180081	5833 (2.50-2.50)

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	568	
1	B	568	

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 9057 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 NADP-dependent malic enzyme, mitochondrial.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	562	Total	C	N	O	S	0	4	0
			4352	2792	743	793	24			
1	B	559	Total	C	N	O	S	0	7	0
			4361	2797	743	797	24			

There are 18 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	45	MET	-	initiating methionine	UNP Q16798
A	605	THR	-	expression tag	UNP Q16798
A	606	ARG	-	expression tag	UNP Q16798
A	607	GLU	-	expression tag	UNP Q16798
A	608	ASN	-	expression tag	UNP Q16798
A	609	LEU	-	expression tag	UNP Q16798
A	610	TYR	-	expression tag	UNP Q16798
A	611	PHE	-	expression tag	UNP Q16798
A	612	GLN	-	expression tag	UNP Q16798
B	45	MET	-	initiating methionine	UNP Q16798
B	605	THR	-	expression tag	UNP Q16798
B	606	ARG	-	expression tag	UNP Q16798
B	607	GLU	-	expression tag	UNP Q16798
B	608	ASN	-	expression tag	UNP Q16798
B	609	LEU	-	expression tag	UNP Q16798
B	610	TYR	-	expression tag	UNP Q16798
B	611	PHE	-	expression tag	UNP Q16798
B	612	GLN	-	expression tag	UNP Q16798

- Molecule 2 is NADP NICOTINAMIDE-ADENINE-DINUCLEOTIDE PHOSPHATE (CCD ID: NAP) (formula: C₂₁H₂₈N₇O₁₇P₃) (labeled as "Ligand of Interest" by depositor).



- CIT
-
- The chemical structure of Citric acid (CIT) is shown. It consists of a central carbon atom (C3) bonded to a hydroxyl group (OH, O7) and three carboxyl groups. One carboxyl group is at the top (C6=O5, OH, O6), one is at the bottom right (C5=O3, OH, O4), and one is at the top right (C1=O1, OH, O2). The carbon atoms are labeled C1, C2, C3, C4, C5, and C6. The oxygen atoms are labeled O1, O2, O3, O4, O5, O6, and O7. The hydroxyl groups are shown in red, and the carboxyl groups are shown in green.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	1	Total C O 13 6 7	0	0
3	B	1	Total C O 13 6 7	0	0

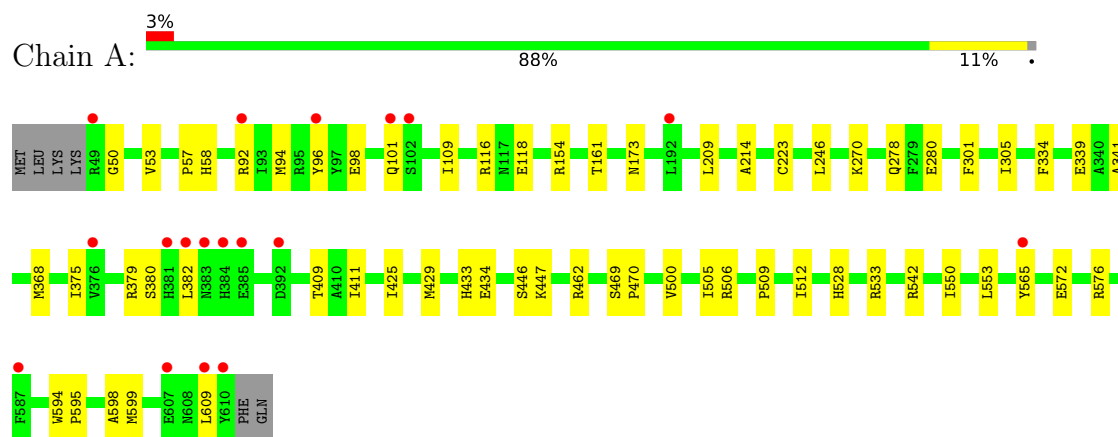
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	119	Total 119	O 119	0	0
4	B	103	Total 103	O 103	0	0

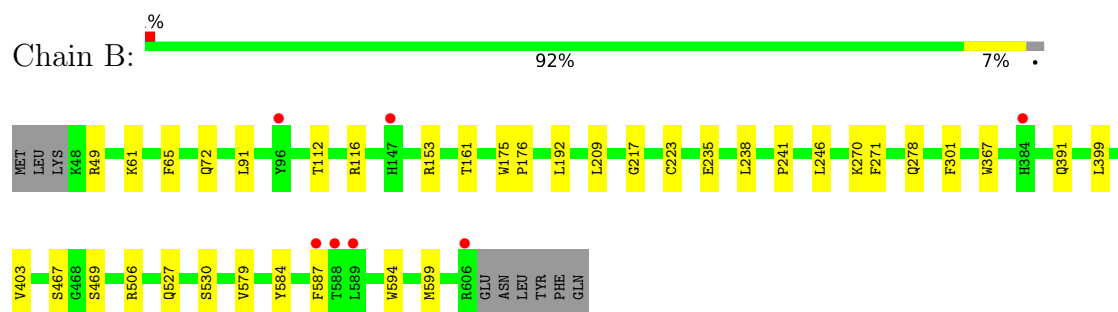
3 Residue-property plots [i](#)

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: NADP-dependent malic enzyme, mitochondrial



- Molecule 1: NADP-dependent malic enzyme, mitochondrial



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 2	Depositor
Cell constants a, b, c, α , β , γ	152.16Å 75.67Å 118.63Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	39.54 – 2.49 39.54 – 2.49	Depositor EDS
% Data completeness (in resolution range)	99.3 (39.54-2.49) 93.4 (39.54-2.49)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.11	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.98 (at 2.48Å)	Xtriage
Refinement program	PHENIX 1.16_3549	Depositor
R, R_{free}	0.179 , 0.226 0.182 , 0.227	Depositor DCC
R_{free} test set	1065 reflections (1.06%)	wwPDB-VP
Wilson B-factor (Å ²)	42.2	Xtriage
Anisotropy	0.370	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.33 , 45.4	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	9057	wwPDB-VP
Average B, all atoms (Å ²)	51.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.90% 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

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

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	0.14	0/4460	0.34	0/6060
1	B	0.12	0/4478	0.33	0/6081
All	All	0.13	0/8938	0.34	0/12141

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

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	4352	0	4303	38	0
1	B	4361	0	4324	22	0
2	A	48	0	23	0	0
2	B	48	0	23	0	0
3	A	13	0	5	1	0
3	B	13	0	5	0	0
4	A	119	0	0	1	0
4	B	103	0	0	1	0
All	All	9057	0	8683	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 3.

The worst 5 of 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:379:ARG:HB3	1:A:382:LEU:HD11	1.67	0.75
1:A:375:ILE:HG23	1:A:382:LEU:HD23	1.80	0.62
1:A:594:TRP:HB2	1:A:599:MET:HE2	1.81	0.62
1:B:161:THR:HB	1:B:246:LEU:HD11	1.82	0.61
1:B:61:LYS:HE2	1:B:584:TYR:HB3	1.82	0.60

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	564/568 (99%)	549 (97%)	15 (3%)	0	100	100
1	B	564/568 (99%)	553 (98%)	10 (2%)	1 (0%)	43	63
All	All	1128/1136 (99%)	1102 (98%)	25 (2%)	1 (0%)	48	68

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	192	LEU

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	456/482 (95%)	454 (100%)	2 (0%)	84	93
1	B	460/482 (95%)	460 (100%)	0	100	100
All	All	916/964 (95%)	914 (100%)	2 (0%)	88	95

All (2) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	506[A]	ARG
1	A	506[B]	ARG

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 8 such sidechains are listed below:

Mol	Chain	Res	Type
1	B	433	HIS
1	B	381	HIS
1	B	278	GLN
1	B	147	HIS
1	B	346	HIS

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](#)

4 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	NAP	B	701	-	50,52,52	3.78	18 (36%)	71,80,80	1.87	18 (25%)
2	NAP	A	701	-	50,52,52	3.83	19 (38%)	71,80,80	1.95	18 (25%)
3	CIT	B	702	-	12,12,12	1.08	0	17,17,17	1.38	1 (5%)
3	CIT	A	702	-	12,12,12	1.07	0	17,17,17	1.54	2 (11%)

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	NAP	B	701	-	-	5/35/67/67	0/5/5/5
2	NAP	A	701	-	-	5/35/67/67	0/5/5/5
3	CIT	B	702	-	-	5/16/16/16	-
3	CIT	A	702	-	-	7/16/16/16	-

The worst 5 of 37 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	701	NAP	O4D-C1D	16.19	1.62	1.40
2	B	701	NAP	O4D-C1D	16.14	1.62	1.40
2	B	701	NAP	C2B-C1B	-9.31	1.30	1.53
2	A	701	NAP	C2B-C1B	-9.11	1.30	1.53
2	A	701	NAP	O4B-C1B	8.74	1.62	1.42

The worst 5 of 39 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	A	701	NAP	N6A-C6A-N1A	-5.68	105.73	118.38
2	B	701	NAP	N6A-C6A-N1A	-5.65	105.78	118.38
2	B	701	NAP	N3A-C2A-N1A	-5.60	120.11	128.58
2	A	701	NAP	N3A-C2A-N1A	-5.58	120.14	128.58
2	A	701	NAP	C5A-C4A-N3A	-5.12	119.66	126.72

There are no chirality outliers.

5 of 22 torsion outliers are listed below:

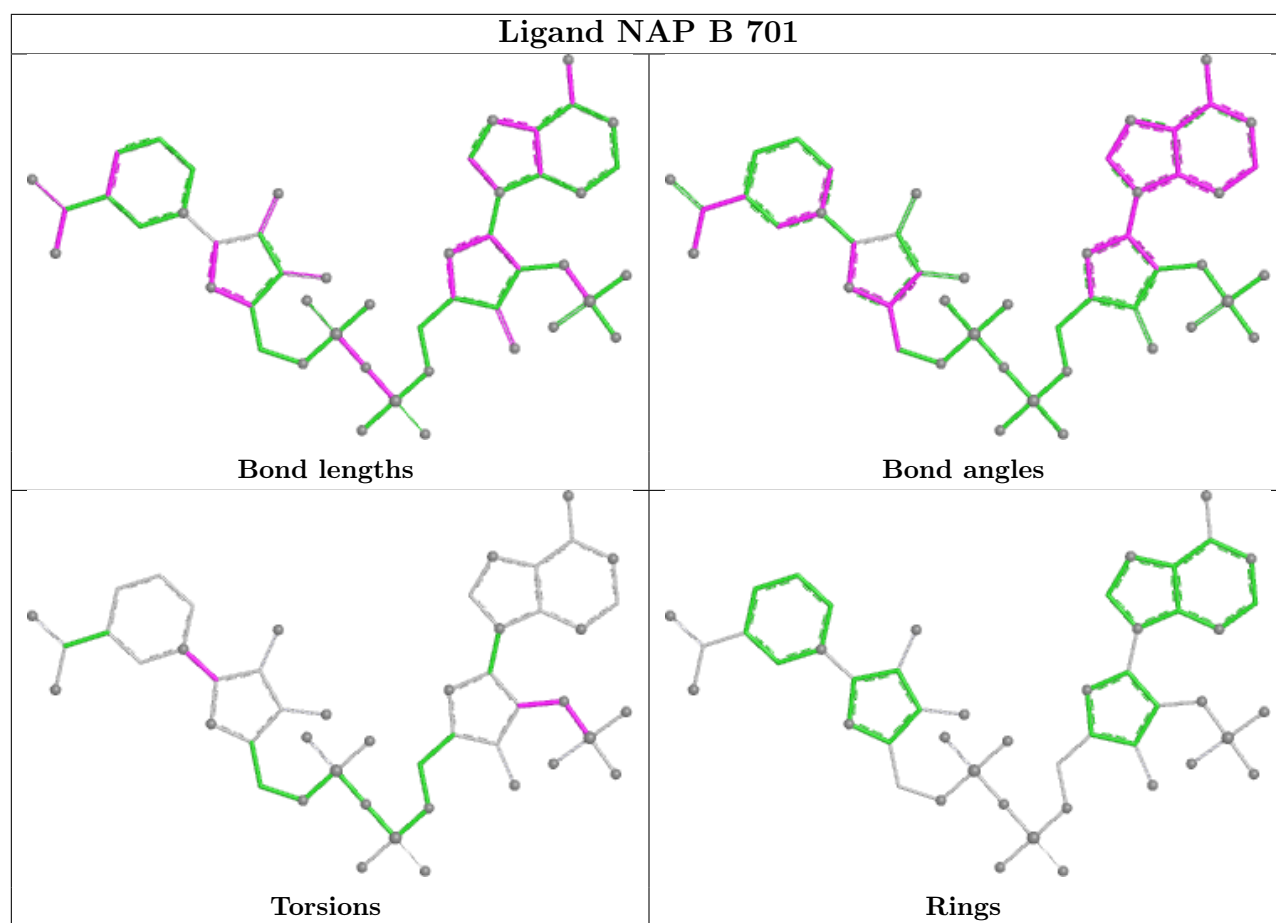
Mol	Chain	Res	Type	Atoms
2	A	701	NAP	O4D-C1D-N1N-C6N
2	B	701	NAP	O4D-C1D-N1N-C6N
3	A	702	CIT	O7-C3-C6-O5
3	A	702	CIT	O7-C3-C6-O6
3	A	702	CIT	C4-C3-C6-O5

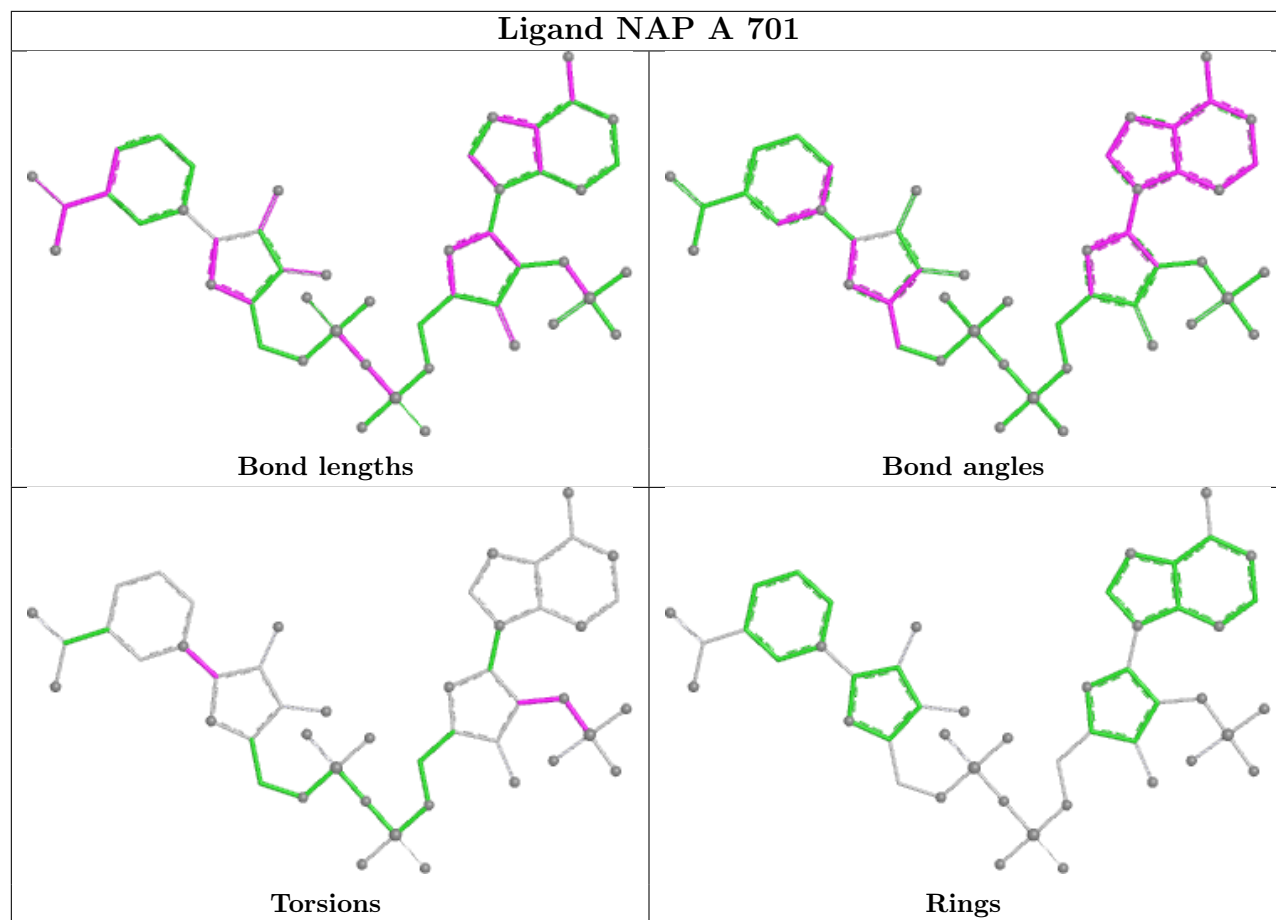
There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	702	CIT	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	562/568 (98%)	-0.13	18 (3%) 50 46	24, 48, 80, 131	4 (0%)
1	B	559/568 (98%)	-0.22	7 (1%) 75 71	20, 48, 73, 103	7 (1%)
All	All	1121/1136 (98%)	-0.18	25 (2%) 62 58	20, 48, 76, 131	11 (0%)

The worst 5 of 25 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	96[A]	TYR	4.8
1	A	565	TYR	3.7
1	A	383	ASN	3.5
1	A	192	LEU	3.2
1	A	610	TYR	3.2

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](#)

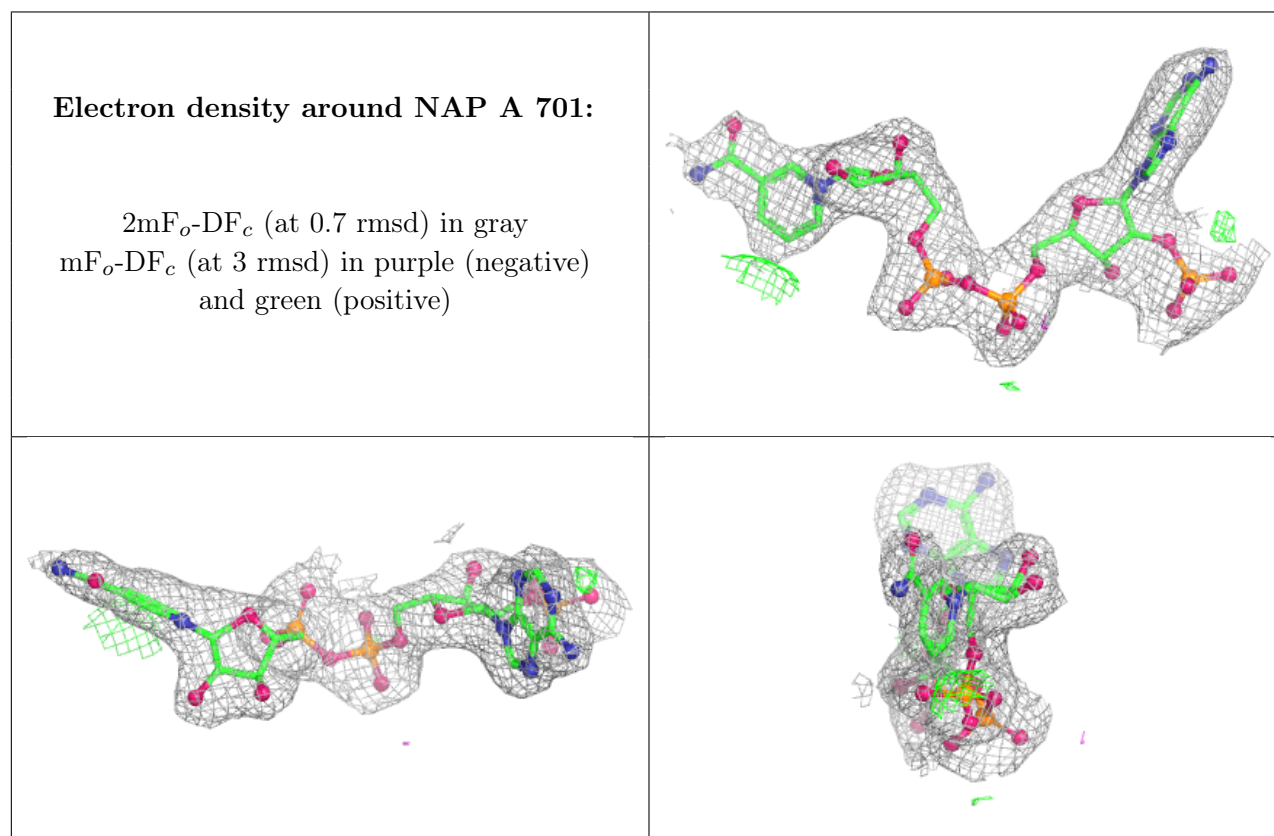
There are no oligosaccharides in this entry.

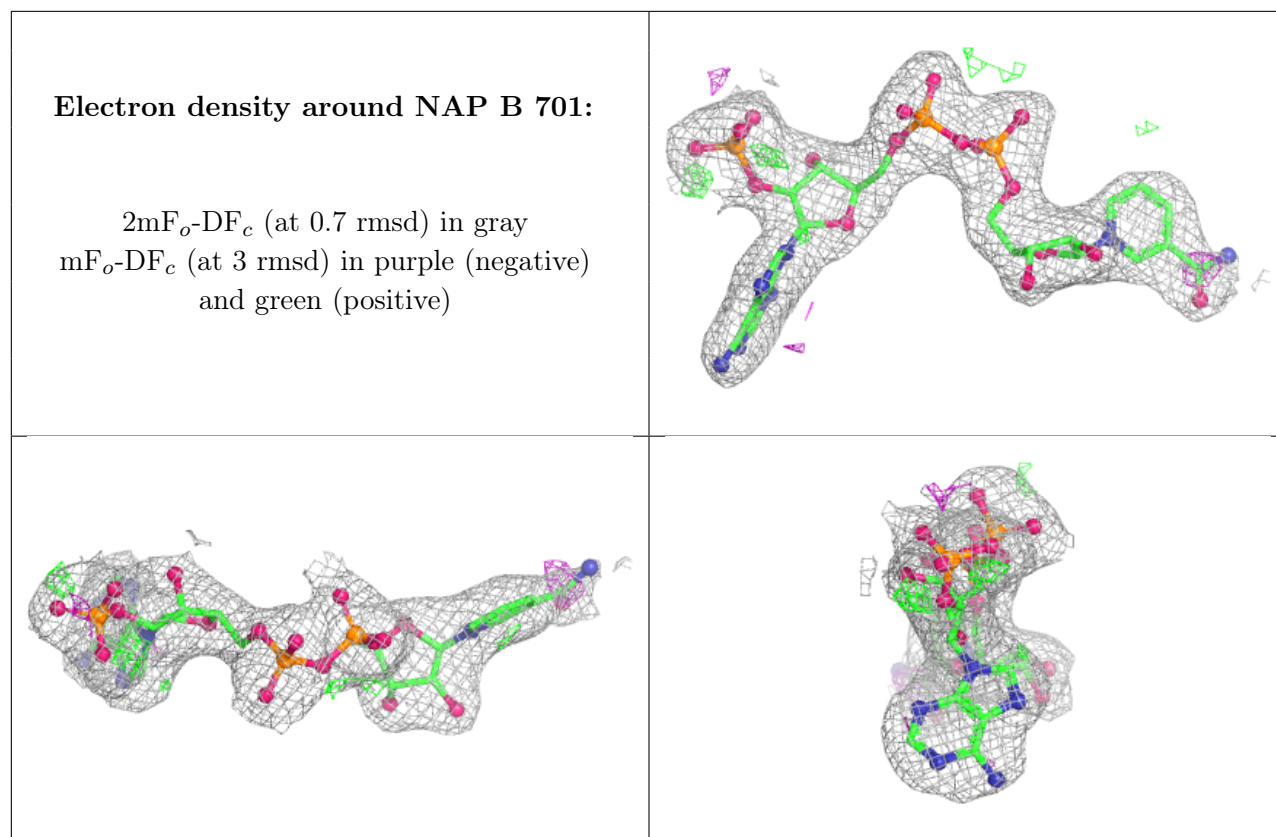
6.4 Ligands [i](#)

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
3	CIT	A	702	13/13	0.85	0.14	62,91,99,99	0
3	CIT	B	702	13/13	0.89	0.14	79,94,96,97	0
2	NAP	A	701	48/48	0.95	0.07	45,54,63,67	0
2	NAP	B	701	48/48	0.96	0.07	41,49,54,58	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.