



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 10, 2026 – 12:46 AM UTC

PDB ID : 2I56 / pdb_00002i56
Title : Crystal structure of L-Rhamnose Isomerase from *Pseudomonas stutzeri* with L-Rhamnose
Authors : Yoshida, H.; Yamada, M.; Takada, G.; Izumori, K.; Kamitori, S.
Deposited on : 2006-08-24
Resolution : 1.97 Å(reported)

This is a wwPDB X-ray Structure Validation Summary Report for a publicly released PDB entry.

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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

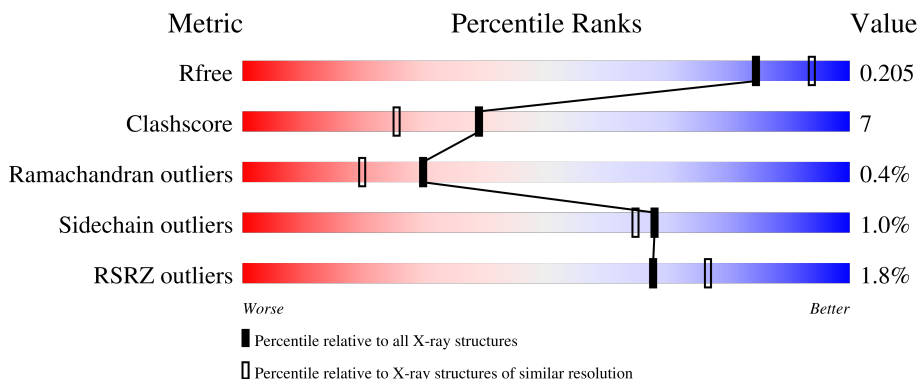
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.97 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	1506 (1.98-1.98)
Clashscore	190562	1534 (1.98-1.98)
Ramachandran outliers	187476	1518 (1.98-1.98)
Sidechain outliers	187428	1518 (1.98-1.98)
RSRZ outliers	180081	1506 (1.98-1.98)

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	438	% 81% 16% .
1	B	438	2% 80% 16% .
1	C	438	3% 79% 18% .
1	D	438	% 82% 14% .

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 14488 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 L-rhamnose isomerase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	421	Total	C	N	O	S	0	0	0
			3260	2048	584	619	9			
1	B	421	Total	C	N	O	S	0	0	0
			3260	2048	584	619	9			
1	C	428	Total	C	N	O	S	0	0	0
			3301	2073	591	628	9			
1	D	419	Total	C	N	O	S	0	0	0
			3251	2042	582	618	9			

There are 36 discrepancies between the modelled and reference sequences:

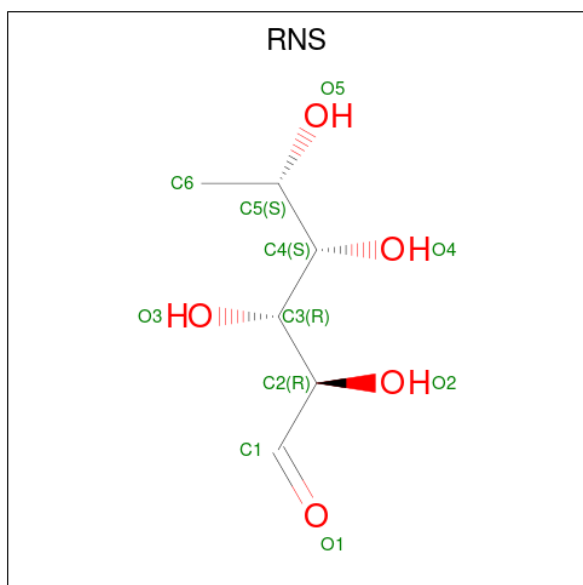
Chain	Residue	Modelled	Actual	Comment	Reference
A	150	ASN	ASP	engineered mutation	UNP Q75WH8
A	431	GLY	-	cloning artifact	UNP Q75WH8
A	432	SER	-	cloning artifact	UNP Q75WH8
A	433	HIS	-	expression tag	UNP Q75WH8
A	434	HIS	-	expression tag	UNP Q75WH8
A	435	HIS	-	expression tag	UNP Q75WH8
A	436	HIS	-	expression tag	UNP Q75WH8
A	437	HIS	-	expression tag	UNP Q75WH8
A	438	HIS	-	expression tag	UNP Q75WH8
B	150	ASN	ASP	engineered mutation	UNP Q75WH8
B	431	GLY	-	cloning artifact	UNP Q75WH8
B	432	SER	-	cloning artifact	UNP Q75WH8
B	433	HIS	-	expression tag	UNP Q75WH8
B	434	HIS	-	expression tag	UNP Q75WH8
B	435	HIS	-	expression tag	UNP Q75WH8
B	436	HIS	-	expression tag	UNP Q75WH8
B	437	HIS	-	expression tag	UNP Q75WH8
B	438	HIS	-	expression tag	UNP Q75WH8
C	150	ASN	ASP	engineered mutation	UNP Q75WH8
C	431	GLY	-	cloning artifact	UNP Q75WH8
C	432	SER	-	cloning artifact	UNP Q75WH8

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Chain	Residue	Modelled	Actual	Comment	Reference
C	433	HIS	-	expression tag	UNP Q75WH8
C	434	HIS	-	expression tag	UNP Q75WH8
C	435	HIS	-	expression tag	UNP Q75WH8
C	436	HIS	-	expression tag	UNP Q75WH8
C	437	HIS	-	expression tag	UNP Q75WH8
C	438	HIS	-	expression tag	UNP Q75WH8
D	150	ASN	ASP	engineered mutation	UNP Q75WH8
D	431	GLY	-	cloning artifact	UNP Q75WH8
D	432	SER	-	cloning artifact	UNP Q75WH8
D	433	HIS	-	expression tag	UNP Q75WH8
D	434	HIS	-	expression tag	UNP Q75WH8
D	435	HIS	-	expression tag	UNP Q75WH8
D	436	HIS	-	expression tag	UNP Q75WH8
D	437	HIS	-	expression tag	UNP Q75WH8
D	438	HIS	-	expression tag	UNP Q75WH8

- Molecule 2 is L-RHAMNOSE (CCD ID: RNS) (formula: $C_6H_{12}O_5$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	C	O	0	0
			11	6	5		
2	B	1	Total	C	O	0	0
			11	6	5		
2	C	1	Total	C	O	0	0
			11	6	5		
2	D	1	Total	C	O	0	0
			11	6	5		

- Molecule 3 is ZINC ION (CCD ID: ZN) (formula: Zn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	2	Total 2	Zn 2	0	0
3	B	2	Total 2	Zn 2	0	0
3	C	2	Total 2	Zn 2	0	0
3	D	2	Total 2	Zn 2	0	0

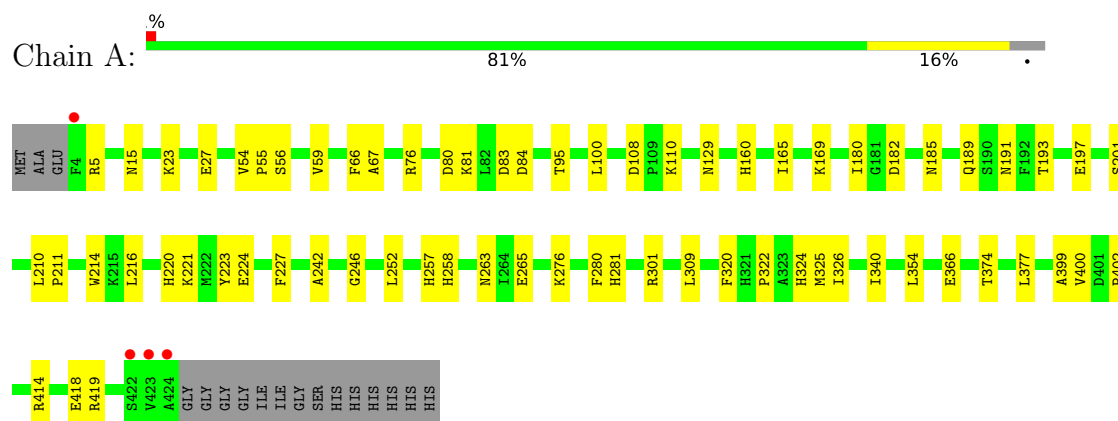
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	370	Total 370	O 370	0	0
4	B	341	Total 341	O 341	0	0
4	C	299	Total 299	O 299	0	0
4	D	354	Total 354	O 354	0	0

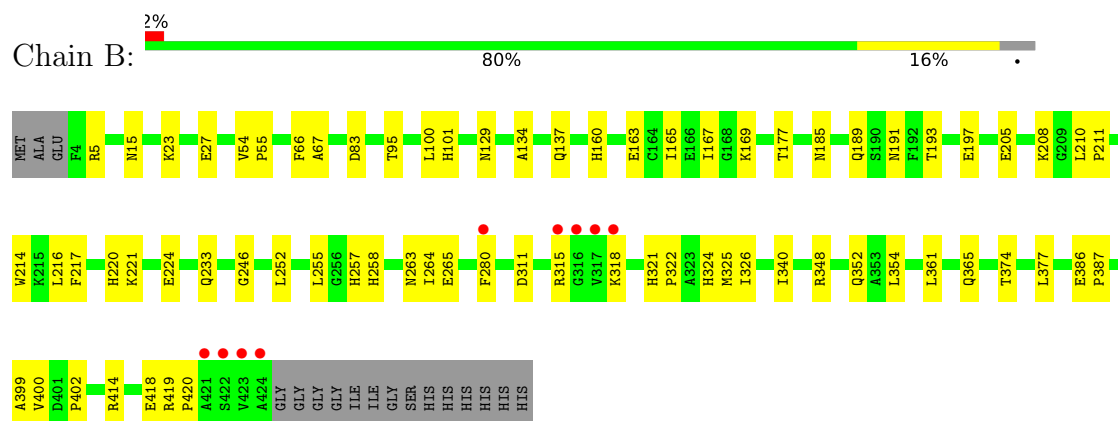
3 Residue-property plots [i](#)

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.

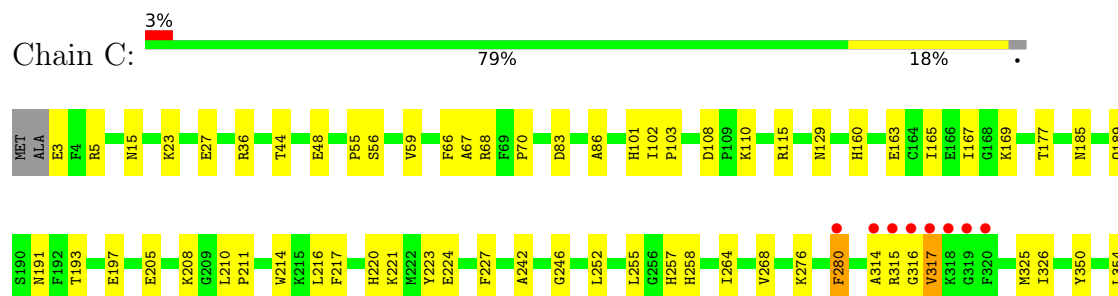
• Molecule 1: L-rhamnose isomerase



• Molecule 1: L-rhamnose isomerase

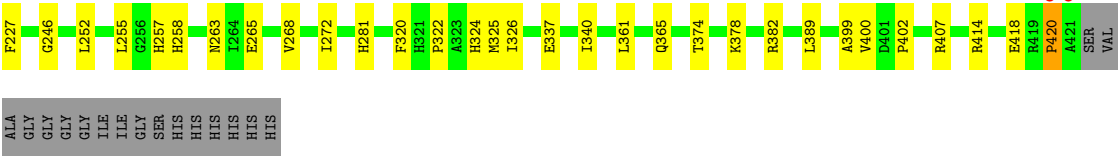
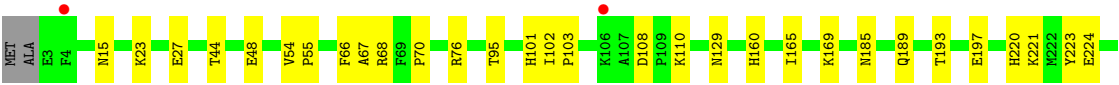
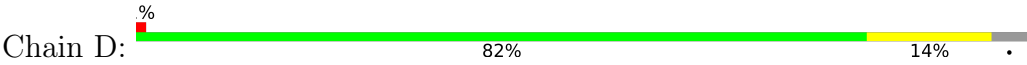


• Molecule 1: L-rhamnose isomerase





● Molecule 1: L-rhamnose isomerase



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	74.62Å 104.76Å 114.29Å 90.00° 107.96° 90.00°	Depositor
Resolution (Å)	33.25 – 1.97 33.25 – 1.97	Depositor EDS
% Data completeness (in resolution range)	97.6 (33.25-1.97) 97.7 (33.25-1.97)	Depositor EDS
R_{merge}	0.10	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	4.49 (at 1.97Å)	Xtriage
Refinement program	CNS 1.1	Depositor
R, R_{free}	0.170 , 0.205 0.169 , 0.205	Depositor DCC
R_{free} test set	11497 reflections (9.80%)	wwPDB-VP
Wilson B-factor (Å ²)	20.7	Xtriage
Anisotropy	0.156	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.35 , 41.3	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	0.016 for h,-k,-h-l	Xtriage
F_o, F_c correlation	0.96	EDS
Total number of atoms	14488	wwPDB-VP
Average B, all atoms (Å ²)	22.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.86% 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: RNS, ZN

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	0.36	0/3332	0.83	4/4518 (0.1%)
1	B	0.35	0/3332	0.83	4/4518 (0.1%)
1	C	0.34	0/3373	0.82	4/4572 (0.1%)
1	D	0.36	0/3323	0.82	4/4505 (0.1%)
All	All	0.35	0/13360	0.82	16/18113 (0.1%)

There are no bond length outliers.

The worst 5 of 16 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	246	GLY	CA-C-N	6.63	126.88	119.32
1	A	246	GLY	C-N-CA	6.63	126.88	119.32
1	C	246	GLY	CA-C-N	6.56	127.08	119.47
1	C	246	GLY	C-N-CA	6.56	127.08	119.47
1	B	246	GLY	CA-C-N	5.80	126.20	119.47

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	3260	0	3165	41	0
1	B	3260	0	3165	43	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	C	3301	0	3205	54	0
1	D	3251	0	3152	38	0
2	A	11	0	11	0	0
2	B	11	0	12	3	0
2	C	11	0	12	1	0
2	D	11	0	11	0	0
3	A	2	0	0	0	0
3	B	2	0	0	0	0
3	C	2	0	0	0	0
3	D	2	0	0	0	0
4	A	370	0	0	3	0
4	B	341	0	0	0	0
4	C	299	0	0	2	0
4	D	354	0	0	2	0
All	All	14488	0	12733	176	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 7.

The worst 5 of 176 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:129:ASN:H	1:A:160:HIS:HE1	1.12	0.93
1:A:129:ASN:H	1:A:160:HIS:CE1	1.97	0.82
1:B:129:ASN:H	1:B:160:HIS:HE1	1.29	0.81
1:C:129:ASN:H	1:C:160:HIS:HE1	1.29	0.80
1:B:205:GLU:HA	1:B:208:LYS:HE2	1.67	0.77

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	419/438 (96%)	410 (98%)	8 (2%)	1 (0%)	43	35
1	B	419/438 (96%)	406 (97%)	12 (3%)	1 (0%)	43	35
1	C	426/438 (97%)	414 (97%)	9 (2%)	3 (1%)	18	9
1	D	417/438 (95%)	406 (97%)	9 (2%)	2 (0%)	24	14
All	All	1681/1752 (96%)	1636 (97%)	38 (2%)	7 (0%)	30	20

5 of 7 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	C	317	VAL
1	A	224	GLU
1	B	224	GLU
1	C	224	GLU
1	D	224	GLU

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	330/341 (97%)	326 (99%)	4 (1%)	63	58
1	B	330/341 (97%)	326 (99%)	4 (1%)	63	58
1	C	333/341 (98%)	330 (99%)	3 (1%)	70	67
1	D	329/341 (96%)	327 (99%)	2 (1%)	78	76
All	All	1322/1364 (97%)	1309 (99%)	13 (1%)	68	65

5 of 13 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	B	377	LEU
1	C	280	PHE
1	D	389	LEU
1	C	377	LEU
1	D	374	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 29 such sidechains are listed below:

Mol	Chain	Res	Type
1	B	344	ASN
1	D	344	ASN
1	C	160	HIS
1	D	160	HIS
1	C	150	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 [i](#)

Of 12 ligands modelled in this entry, 8 are monoatomic - leaving 4 for Mogul analysis.

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	RNS	A	2001	3	9,10,10	0.45	0	12,13,13	0.94	2 (16%)
2	RNS	B	2002	-	9,10,10	0.51	0	12,13,13	0.75	1 (8%)
2	RNS	C	2003	3	9,10,10	0.43	0	12,13,13	0.91	1 (8%)
2	RNS	D	2004	3	9,10,10	0.46	0	12,13,13	0.82	1 (8%)

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	RNS	A	2001	3	-	1/13/14/14	-
2	RNS	B	2002	-	-	4/13/14/14	-
2	RNS	C	2003	3	-	1/13/14/14	-
2	RNS	D	2004	3	-	1/13/14/14	-

There are no bond length outliers.

All (5) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	A	2001	RNS	C6-C5-C4	-2.33	109.26	112.11
2	C	2003	RNS	C6-C5-C4	-2.23	109.38	112.11
2	D	2004	RNS	C6-C5-C4	-2.15	109.48	112.11
2	B	2002	RNS	C6-C5-C4	-2.05	109.60	112.11
2	A	2001	RNS	C3-C4-C5	-2.00	110.47	113.21

There are no chirality outliers.

5 of 7 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	A	2001	RNS	O1-C1-C2-C3
2	B	2002	RNS	O1-C1-C2-C3
2	C	2003	RNS	O1-C1-C2-C3
2	D	2004	RNS	O1-C1-C2-C3
2	B	2002	RNS	O3-C3-C4-O4

There are no ring outliers.

2 monomers are involved in 4 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	B	2002	RNS	3	0
2	C	2003	RNS	1	0

5.7 Other polymers ⓘ

There are no such residues in this entry.

5.8 Polymer linkage issues ⓘ

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	421/438 (96%)	-0.32	4 (0%) 79 86	12, 18, 30, 43	0
1	B	421/438 (96%)	-0.09	9 (2%) 63 72	12, 20, 34, 56	0
1	C	428/438 (97%)	0.13	13 (3%) 52 62	14, 24, 42, 62	0
1	D	419/438 (95%)	-0.21	4 (0%) 79 86	13, 20, 33, 54	0
All	All	1689/1752 (96%)	-0.12	30 (1%) 67 76	12, 20, 36, 62	0

The worst 5 of 30 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	424	ALA	7.6
1	D	421	ALA	6.4
1	A	424	ALA	4.5
1	C	319	GLY	4.4
1	C	427	GLY	4.3

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	RNS	B	2002	11/11	0.78	0.15	32,40,41,42	0
3	ZN	B	504	1/1	0.83	0.13	51,51,51,51	1
2	RNS	C	2003	11/11	0.86	0.13	40,41,42,44	0
2	RNS	D	2004	11/11	0.90	0.10	26,30,33,36	0
2	RNS	A	2001	11/11	0.93	0.08	17,24,28,29	0
3	ZN	C	506	1/1	0.94	0.06	49,49,49,49	1
3	ZN	D	508	1/1	0.96	0.08	27,27,27,27	1
3	ZN	A	502	1/1	0.97	0.08	39,39,39,39	1
3	ZN	B	503	1/1	0.98	0.04	37,37,37,37	0
3	ZN	C	505	1/1	0.99	0.03	36,36,36,36	0
3	ZN	D	507	1/1	1.00	0.03	26,26,26,26	0
3	ZN	A	501	1/1	1.00	0.04	27,27,27,27	0

6.5 Other polymers [i](#)

There are no such residues in this entry.