



Full wwPDB X-ray Structure Validation Report ⓘ

Jul 20, 2026 – 04:16 pm BST

PDB ID : 9T20 / pdb_00009t20
Title : JAK2-ruxolitinib complex with Y1007F and Y1008F mutations in the activation loop
Authors : Miao, Y.; Haikarainen, T.
Deposited on : 2025-10-22
Resolution : 2.20 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	:	1.8.4, CSD as541be (2020)
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	:	9.0.015 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.50

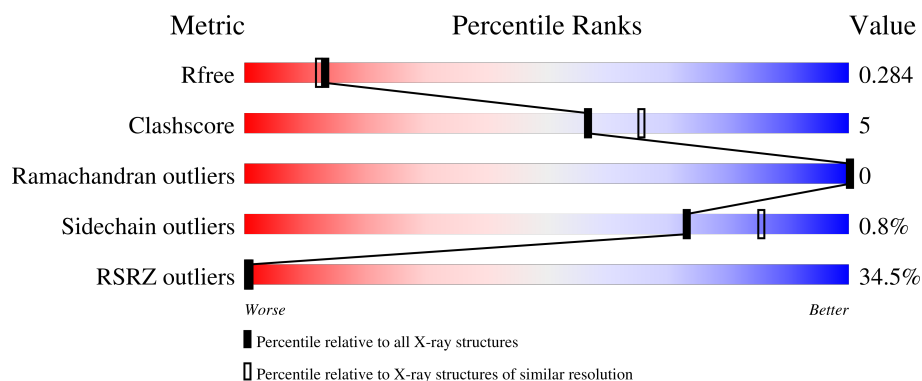
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.20 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	6164 (2.20-2.20)
Clashscore	190562	6851 (2.20-2.20)
Ramachandran outliers	187476	6768 (2.20-2.20)
Sidechain outliers	187428	6769 (2.20-2.20)
RSRZ outliers	180081	6166 (2.20-2.20)

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	316	32% 79% 12% 8%

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 4833 atoms, of which 2364 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 Tyrosine-protein kinase JAK2.

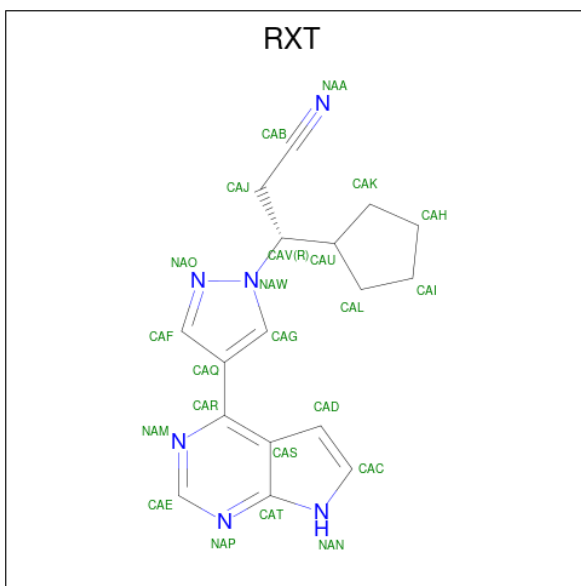
Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
1	A	290	Total	C	H	N	O	S	0	0	0
			4722	1512	2346	413	437	14			

There are 25 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	817	MET	-	initiating methionine	UNP O60674
A	818	HIS	-	expression tag	UNP O60674
A	819	HIS	-	expression tag	UNP O60674
A	820	HIS	-	expression tag	UNP O60674
A	821	HIS	-	expression tag	UNP O60674
A	822	HIS	-	expression tag	UNP O60674
A	823	HIS	-	expression tag	UNP O60674
A	824	SER	-	expression tag	UNP O60674
A	825	SER	-	expression tag	UNP O60674
A	826	GLY	-	expression tag	UNP O60674
A	827	VAL	-	expression tag	UNP O60674
A	828	ASP	-	expression tag	UNP O60674
A	829	LEU	-	expression tag	UNP O60674
A	830	GLY	-	expression tag	UNP O60674
A	831	THR	-	expression tag	UNP O60674
A	832	GLU	-	expression tag	UNP O60674
A	833	ASN	-	expression tag	UNP O60674
A	834	LEU	-	expression tag	UNP O60674
A	835	TYR	-	expression tag	UNP O60674
A	836	PHE	-	expression tag	UNP O60674
A	837	GLN	-	expression tag	UNP O60674
A	838	SER	-	expression tag	UNP O60674
A	839	MET	-	expression tag	UNP O60674
A	1007	PHE	TYR	engineered mutation	UNP O60674
A	1008	PHE	TYR	engineered mutation	UNP O60674

- Molecule 2 is (3R)-3-cyclopentyl-3-[4-(7H-pyrrolo[2,3-d]pyrimidin-4-yl)-1H-pyrazol-1-yl]pro

panenitrile (CCD ID: RXT) (formula: C₁₇H₁₈N₆).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
2	A	1	Total	C	H	N	0	0
			41	17	18	6		

- Molecule 3 is SODIUM ION (CCD ID: NA) (formula: Na).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	3	Total	Na	0	0
			3	3		

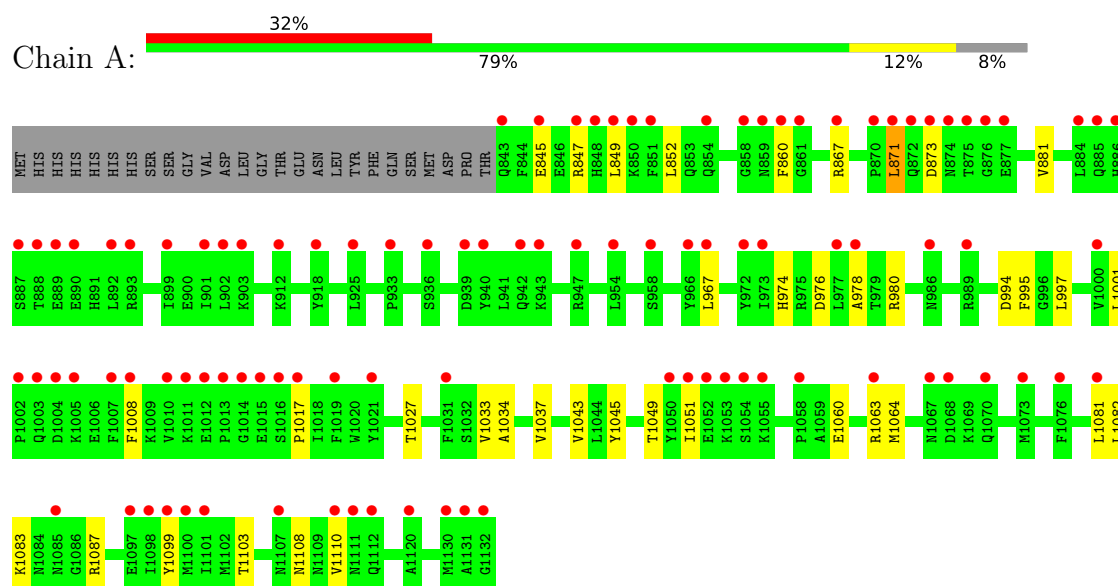
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	66	Total	O	0	1
			67	67		

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: Tyrosine-protein kinase JAK2



4 Data and refinement statistics

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, α , β , γ	107.10Å 69.31Å 49.67Å 90.00° 99.95° 90.00°	Depositor
Resolution (Å)	39.42 – 2.20 39.42 – 2.20	Depositor EDS
% Data completeness (in resolution range)	97.4 (39.42-2.20) 97.4 (39.42-2.20)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	3.49 (at 2.20Å)	Xtriage
Refinement program	PHENIX 1.21.1_5286	Depositor
R, R_{free}	0.242 , 0.284 0.242 , 0.284	Depositor DCC
R_{free} test set	844 reflections (4.62%)	wwPDB-VP
Wilson B-factor (Å ²)	15.8	Xtriage
Anisotropy	0.713	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.36 , 48.8	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	0.85	EDS
Total number of atoms	4833	wwPDB-VP
Average B, all atoms (Å ²)	28.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.79% 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: NA, RXT

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	0.32	0/2428	0.37	0/3269

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	2376	2346	2345	22	0
2	A	23	18	18	0	0
3	A	3	0	0	0	0
4	A	67	0	0	1	0
All	All	2469	2364	2363	22	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 (22) 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:1087:ARG:NH2	1:A:1108:ASN:OD1	2.28	0.66
1:A:1064:MET:HE2	1:A:1081:LEU:HD11	1.78	0.65
1:A:967:LEU:HD23	4:A:1305:HOH:O	1.98	0.62
1:A:1081:LEU:HD23	1:A:1082:LEU:N	2.18	0.58
1:A:1045:TYR:O	1:A:1049:THR:HG23	2.08	0.54
1:A:1099:TYR:O	1:A:1103:THR:HG23	2.08	0.53
1:A:967:LEU:HD21	1:A:995:PHE:HE2	1.77	0.49
1:A:871:LEU:O	1:A:873:ASP:N	2.40	0.48
1:A:976:ASP:HB2	1:A:997:LEU:HD12	1.95	0.47
1:A:978:ALA:HA	1:A:1043:VAL:HG22	1.96	0.47
1:A:1033:VAL:O	1:A:1037:VAL:HG23	2.15	0.47
1:A:1027:THR:HG21	1:A:1083:LYS:NZ	2.30	0.46
1:A:1051:ILE:HG22	1:A:1051:ILE:O	2.16	0.45
1:A:1081:LEU:HD23	1:A:1081:LEU:C	2.42	0.45
1:A:974:HIS:NE2	1:A:994:ASP:O	2.50	0.45
1:A:845:GLU:OE1	1:A:847:ARG:NH1	2.50	0.44
1:A:1034:ALA:CB	1:A:1110:VAL:HG13	2.48	0.43
1:A:980:ARG:NH2	1:A:1017:PRO:HB3	2.34	0.42
1:A:852:LEU:HD11	1:A:867:ARG:HB2	2.01	0.42
1:A:1001:LEU:HD23	1:A:1008:PHE:HD2	1.83	0.42
1:A:849:LEU:HD21	1:A:881:VAL:HG21	2.03	0.41
1:A:1060:GLU:OE2	1:A:1063:ARG:NH2	2.53	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	288/316 (91%)	278 (96%)	10 (4%)	0	100	100

There are no Ramachandran outliers to report.

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	260/288 (90%)	258 (99%)	2 (1%)	73 85

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

Mol	Chain	Res	Type
1	A	860	PHE
1	A	871	LEU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (2) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	955	GLN
1	A	988	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 4 ligands modelled in this entry, 3 are monoatomic - leaving 1 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	RXT	A	1201	-	26,26,26	0.67	0	29,36,36	1.19	3 (10%)

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	RXT	A	1201	-	-	2/14/22/22	0/4/4/4

There are no bond length outliers.

All (3) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	A	1201	RXT	CAF-NAO-NAW	3.56	105.72	104.12
2	A	1201	RXT	CAL-CAU-CAK	2.12	108.32	102.91
2	A	1201	RXT	CAL-CAU-CAV	-2.07	109.30	113.03

There are no chirality outliers.

All (2) torsion outliers are listed below:

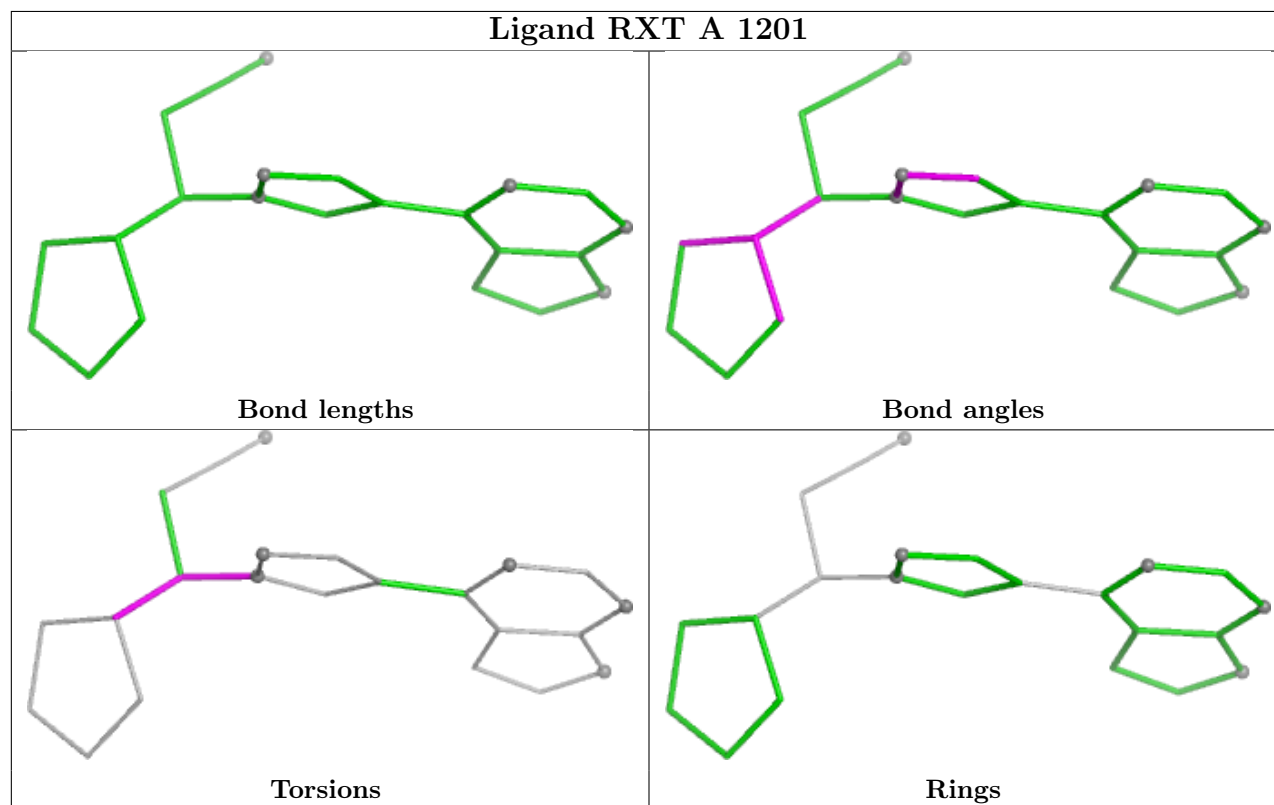
Mol	Chain	Res	Type	Atoms
2	A	1201	RXT	CAL-CAU-CAV-CAJ
2	A	1201	RXT	CAJ-CAV-NAW-NAO

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, 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	290/316 (91%)	1.74	100 (34%) 1 0	8, 21, 73, 118	0

All (100) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	1013	PRO	8.9
1	A	860	PHE	6.5
1	A	1085	ASN	6.1
1	A	1014	GLY	5.7
1	A	1012	GLU	5.7
1	A	859	ASN	5.6
1	A	874	ASN	5.5
1	A	1054	SER	5.5
1	A	871	LEU	5.3
1	A	1051	ILE	5.2
1	A	885	GLN	5.0
1	A	1063	ARG	4.9
1	A	1050	TYR	4.9
1	A	1068	ASP	4.8
1	A	1017	PRO	4.7
1	A	876	GLY	4.7
1	A	892	LEU	4.0
1	A	1131	ALA	3.9
1	A	1008	PHE	3.8
1	A	884	LEU	3.7
1	A	1132	GLY	3.6
1	A	1052	GLU	3.6
1	A	943	LYS	3.6
1	A	1112	GLN	3.5
1	A	1004	ASP	3.5
1	A	1011	LYS	3.5
1	A	1010	VAL	3.4

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Mol	Chain	Res	Type	RSRZ
1	A	875	THR	3.4
1	A	1053	LYS	3.4
1	A	872	GLN	3.4
1	A	1021	TYR	3.3
1	A	1015	GLU	3.3
1	A	1098	ILE	3.2
1	A	903	LYS	3.2
1	A	942	GLN	3.1
1	A	889	GLU	3.1
1	A	986	ASN	3.1
1	A	849	LEU	3.1
1	A	870	PRO	3.1
1	A	1100	MET	3.1
1	A	1007	PHE	3.1
1	A	1002	PRO	3.1
1	A	888	THR	3.0
1	A	1003	GLN	3.0
1	A	954	LEU	3.0
1	A	887	SER	3.0
1	A	912	LYS	2.9
1	A	1101	ILE	2.9
1	A	861	GLY	2.9
1	A	1016	SER	2.8
1	A	893	ARG	2.8
1	A	939	ASP	2.8
1	A	1130	MET	2.8
1	A	1000	VAL	2.8
1	A	989	ARG	2.7
1	A	886	HIS	2.7
1	A	972	TYR	2.7
1	A	1097	GLU	2.7
1	A	973	ILE	2.7
1	A	978	ALA	2.6
1	A	1099	TYR	2.6
1	A	936	SER	2.6
1	A	940	TYR	2.6
1	A	890	GLU	2.5
1	A	947	ARG	2.5
1	A	867	ARG	2.5
1	A	967	LEU	2.5
1	A	1120	ALA	2.5
1	A	858	GLY	2.5

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Mol	Chain	Res	Type	RSRZ
1	A	848	HIS	2.4
1	A	1111	ASN	2.4
1	A	918	TYR	2.3
1	A	1031	PHE	2.3
1	A	966	TYR	2.3
1	A	851	PHE	2.3
1	A	1019	PHE	2.3
1	A	1107	ASN	2.3
1	A	1076	PHE	2.2
1	A	873	ASP	2.2
1	A	1005	LYS	2.2
1	A	843	GLN	2.2
1	A	1058	PRO	2.2
1	A	1055	LYS	2.2
1	A	958	SER	2.2
1	A	1073	MET	2.1
1	A	877	GLU	2.1
1	A	901	ILE	2.1
1	A	1081	LEU	2.1
1	A	854	GLN	2.1
1	A	1070	GLN	2.1
1	A	845	GLU	2.1
1	A	899	ILE	2.1
1	A	925	LEU	2.1
1	A	902	LEU	2.1
1	A	1067	ASN	2.1
1	A	847	ARG	2.0
1	A	1110	VAL	2.0
1	A	850	LYS	2.0
1	A	977	LEU	2.0
1	A	933	PRO	2.0

6.2 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

6.3 Carbohydrates ⓘ

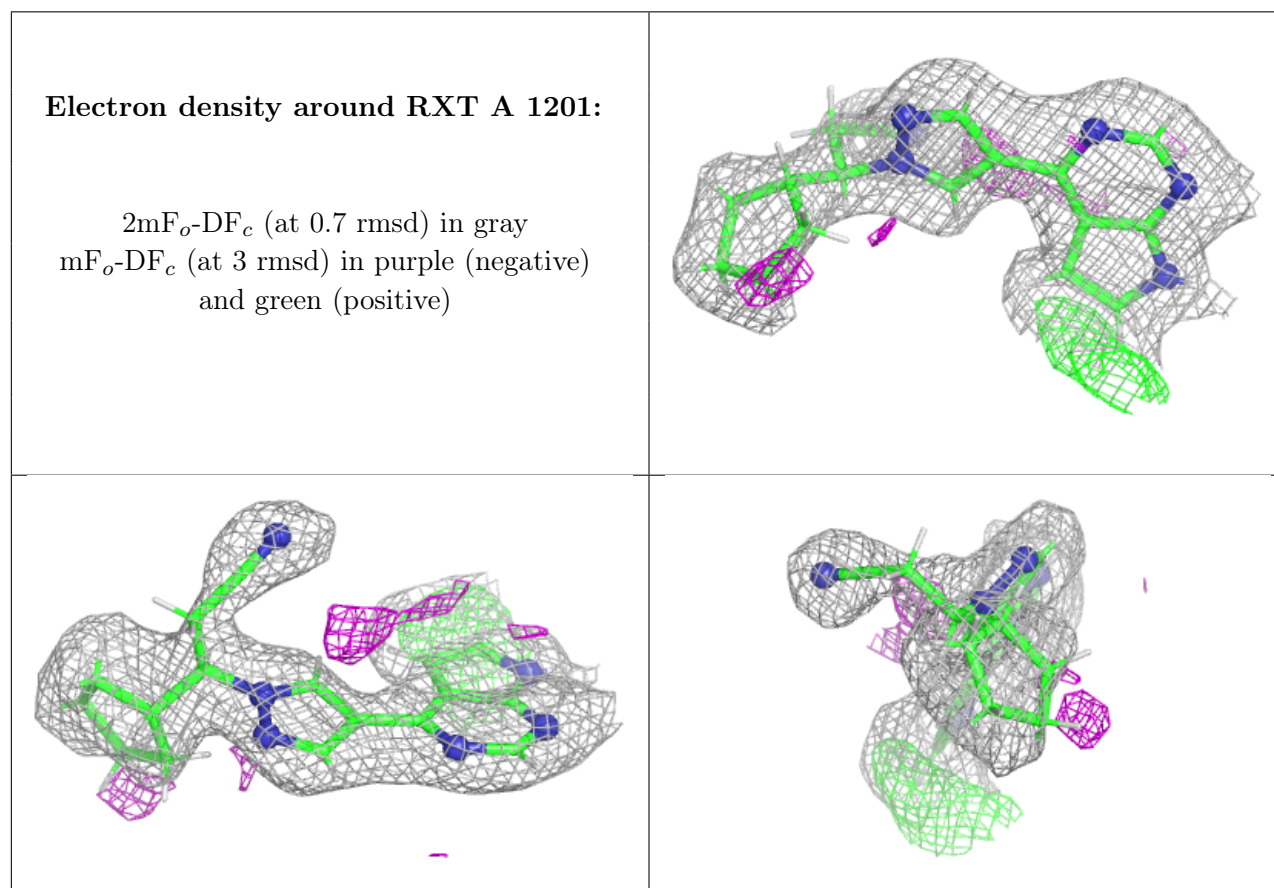
There are no oligosaccharides in this entry.

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	NA	A	1202	1/1	0.69	0.19	45,45,45,45	0
3	NA	A	1204	1/1	0.82	0.14	33,33,33,33	0
2	RXT	A	1201	23/23	0.83	0.13	7,14,30,33	0
3	NA	A	1203	1/1	0.85	0.12	20,20,20,20	1

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.