



# Full wwPDB X-ray Structure Validation Report

Feb 27, 2014 – 01:00 PM GMT

PDB ID : 4MQS  
Title : Structure of active human M2 muscarinic acetylcholine receptor bound to the agonist iperoxo  
Authors : Kruse, A.C.; Ring, A.M.; Manglik, A.; Hu, J.; Hu, K.; Eitel, K.; Huebner, H.; Pardon, E.; Valant, C.; Sexton, P.M.; Christopoulos, A.; Felder, C.C.; Gmeiner, P.; Steyaert, J.; Weis, W.I.; Garcia, K.C.; Wess, J.; Kobilka, B.K.  
Deposited on : 2013-09-16  
Resolution : 3.50 Å(reported)

This is a full wwPDB 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 <http://wwpdb.org/ValidationPDFNotes.html>

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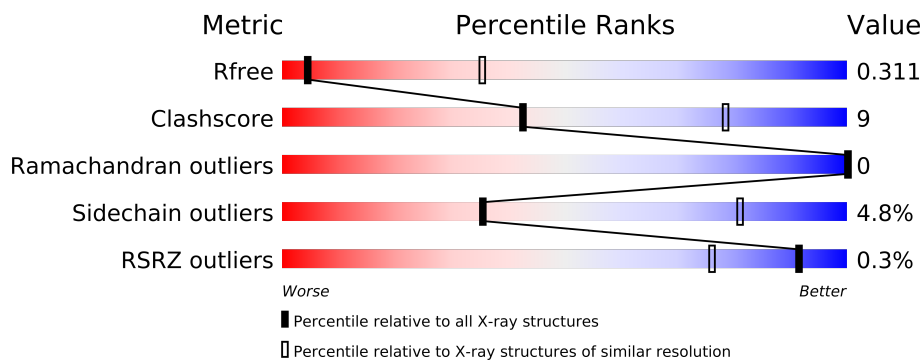
The following versions of software and data (see [references](#)) were used in the production of this report:

MolProbity : 4.02b-467  
Mogul : 1.15 2013  
Xtriage (Phenix) : dev-1323  
EDS : stable22639  
Percentile statistics : 21963  
Refmac : 5.8.0049  
CCP4 : 6.3.0 (Settle)  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et. al. (1996)  
Validation Pipeline (wwPDB-VP) : stable22683

# 1 Overall quality at a glance

The reported resolution of this entry is 3.50 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))
$R_{free}$	66092	1243 (3.70-3.30)
Clashscore	79885	1039 (3.66-3.34)
Ramachandran outliers	78287	1000 (3.66-3.34)
Sidechain outliers	78261	1000 (3.66-3.34)
RSRZ outliers	66119	1243 (3.70-3.30)

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 on the lower bar indicate the fraction of residues that contain outliers for  $\geq 3$ , 2, 1 and 0 types of geometric quality criteria. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density.

Mol	Chain	Length	Quality of chain
1	A	351	
2	B	125	

The following table lists non-polymeric compounds that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Geometry	Electron density
3	IXO	A	501	-	X

## 2 Entry composition

There are 3 unique types of molecules in this entry. The entry contains 3034 atoms, of which 0 are hydrogen and 0 are deuterium.

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 Muscarinic acetylcholine receptor M2.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	277	Total	C	N	O	S	0	0	0
			2128	1431	323	357	17			

There are 31 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-16	ASP	-	EXPRESSION TAG	UNP P08172
A	-15	TYR	-	EXPRESSION TAG	UNP P08172
A	-14	LYS	-	EXPRESSION TAG	UNP P08172
A	-13	ASP	-	EXPRESSION TAG	UNP P08172
A	-12	ASP	-	EXPRESSION TAG	UNP P08172
A	-11	ASP	-	EXPRESSION TAG	UNP P08172
A	-10	GLU	-	EXPRESSION TAG	UNP P08172
A	-9	ASN	-	EXPRESSION TAG	UNP P08172
A	-8	LEU	-	EXPRESSION TAG	UNP P08172
A	-7	TYR	-	EXPRESSION TAG	UNP P08172
A	-6	PHE	-	EXPRESSION TAG	UNP P08172
A	-5	GLN	-	EXPRESSION TAG	UNP P08172
A	-4	GLY	-	EXPRESSION TAG	UNP P08172
A	-3	LEU	-	EXPRESSION TAG	UNP P08172
A	-2	GLU	-	EXPRESSION TAG	UNP P08172
A	0	ASP	ASN	ENGINEERED MUTATION	UNP P08172
A	1	ASP	ASN	ENGINEERED MUTATION	UNP P08172
A	4	ASP	ASN	ENGINEERED MUTATION	UNP P08172
A	7	ASP	ASN	ENGINEERED MUTATION	UNP P08172
A	17	LEU	-	INSERTION	UNP P08172
A	18	GLU	-	INSERTION	UNP P08172
A	373	THR	ALA	ENGINEERED MUTATION	UNP P08172
A	374	ARG	LYS	ENGINEERED MUTATION	UNP P08172
A	467	HIS	-	EXPRESSION TAG	UNP P08172
A	468	HIS	-	EXPRESSION TAG	UNP P08172
A	469	HIS	-	EXPRESSION TAG	UNP P08172
A	470	HIS	-	EXPRESSION TAG	UNP P08172

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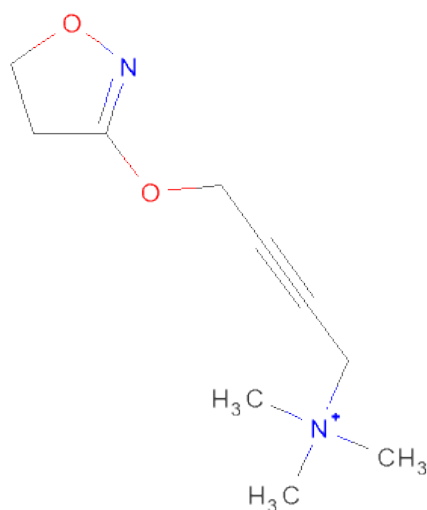
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Chain	Residue	Modelled	Actual	Comment	Reference
A	471	HIS	-	EXPRESSION TAG	UNP P08172
A	472	HIS	-	EXPRESSION TAG	UNP P08172
A	473	HIS	-	EXPRESSION TAG	UNP P08172
A	474	HIS	-	EXPRESSION TAG	UNP P08172

- Molecule 2 is a protein called Nanobody 9-8.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	B	121	Total	C	N	O	S	0	0	0
			892	550	149	189	4			

- Molecule 3 is 4-(4,5-DIHYDRO-1,2-OXAZOL-3-YLOXY)-N,N,N-TRIMETHYLBUT-2-YN-1-AMINIUM (three-letter code: IXO) (formula: C<sub>10</sub>H<sub>17</sub>N<sub>2</sub>O<sub>2</sub>).



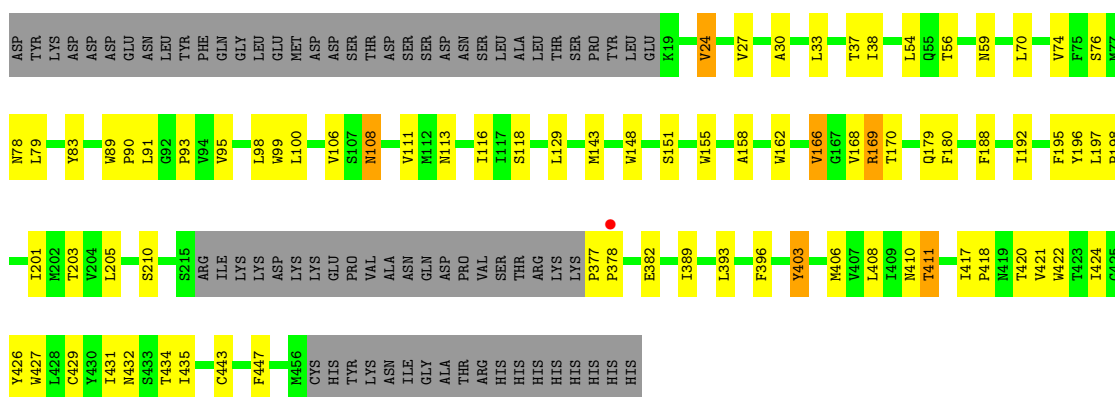
Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
3	A	1	Total	C	N	O	0	0
			14	10	2	2		

### 3 Residue-property plots

These plots are drawn for all protein, RNA and DNA chains in the entry. The first graphic for a chain summarises the proportions of errors 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: Muscarinic acetylcholine receptor M2

Chain A:



- Molecule 2: Nanobody 9-8

Chain B:



## 4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	62.90Å 78.13Å 163.48Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	32.52 – 3.50 32.52 – 3.30	Depositor EDS
% Data completeness (in resolution range)	96.1 (32.52-3.50) 88.2 (32.52-3.30)	Depositor EDS
$R_{merge}$	0.19	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	1.78 (at 3.32Å)	Xtriage
Refinement program	PHENIX (phenix.refine: dev_1241)	Depositor
R, $R_{free}$	0.249 , 0.298 0.266 , 0.311	Depositor DCC
$R_{free}$ test set	1126 reflections (10.10%)	DCC
Wilson B-factor (Å <sup>2</sup> )	81.4	Xtriage
Anisotropy	0.480	Xtriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.26 , 76.1	EDS
Estimated twinning fraction	No twinning to report.	Xtriage
L-test for twinning	$\langle  L  \rangle = 0.40$ , $\langle L^2 \rangle = 0.23$	Xtriage
Outliers	0 of 11816 reflections	Xtriage
$F_o, F_c$ correlation	0.89	EDS
Total number of atoms	3034	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	117.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.41% of the height of the origin peak. No significant pseudotranslation is detected.*

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

## 5 Model quality

### 5.1 Standard geometry

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

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	0.27	0/2191	0.46	0/3018
2	B	0.26	0/911	0.43	0/1242
All	All	0.26	0/3102	0.45	0/4260

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no planarity outliers.

### 5.2 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 hydrogens added by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, and the number in parentheses is this value normalized per 1000 atoms of the molecule in the chain. The Symm-Clashes column gives symmetry related clashes, in the same way as for the Clashes column.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	2128	0	2111	47	0
2	B	892	0	784	8	0
3	A	14	0	17	1	0
All	All	3034	0	2912	53	0

Clashscore is defined as the number of clashes calculated for the entry per 1000 atoms (including hydrogens) of the entry. The overall clashscore for this entry is 9.

All (53) close contacts within the same asymmetric unit are listed below.

Atom-1	Atom-2	Distance(Å)	Clash(Å)
1:A:162:TRP:HD1	1:A:179:GLN:HG3	1.57	0.70
2:B:53:CYS:HB2	2:B:102:TRP:HH2	1.60	0.66
1:A:166:VAL:HG12	1:A:168:VAL:H	1.67	0.59
2:B:67:ALA:HB1	2:B:71:PHE:CD2	2.37	0.59
2:B:33:ASP:O	2:B:57:SER:OG	2.18	0.59
1:A:111:VAL:HG22	1:A:396:PHE:HE2	1.70	0.57
1:A:108:ASN:OD1	1:A:155:TRP:NE1	2.39	0.56
1:A:38:ILE:HG21	1:A:74:VAL:HB	1.88	0.55
1:A:38:ILE:HG22	1:A:70:LEU:HD12	1.88	0.55
1:A:118:SER:HB3	1:A:205:LEU:HD11	1.89	0.54
1:A:129:LEU:HD21	2:B:53:CYS:HB3	1.89	0.54
1:A:33:LEU:HD21	1:A:431:ILE:HG22	1.89	0.54
1:A:418:PRO:HG2	1:A:421:VAL:HB	1.91	0.53
1:A:76:SER:HA	1:A:99:TRP:HE1	1.73	0.53
2:B:12:VAL:HG13	2:B:16:ASP:HB2	1.91	0.52
1:A:203:THR:HG22	1:A:393:LEU:HD13	1.91	0.52
1:A:403:TYR:HB3	1:A:429:CYS:SG	2.50	0.52
1:A:90:PRO:HG2	1:A:91:LEU:HD12	1.91	0.52
1:A:188:PHE:CE1	1:A:408:LEU:HG	2.45	0.51
1:A:91:LEU:HB3	1:A:95:VAL:HG11	1.92	0.51
1:A:95:VAL:HA	1:A:98:LEU:HB2	1.92	0.51
1:A:74:VAL:O	1:A:78:ASN:ND2	2.36	0.47
1:A:37:THR:HG23	1:A:434:THR:HA	1.96	0.47
1:A:406:MET:HE1	1:A:422:TRP:HA	1.97	0.47
1:A:54:LEU:O	1:A:59:ASN:ND2	2.47	0.47
1:A:410:ASN:HB2	1:A:417:ILE:HD12	1.96	0.47
1:A:93:PRO:HB3	1:A:169:ARG:CZ	2.45	0.47
1:A:91:LEU:HB3	1:A:95:VAL:CG1	2.46	0.46
1:A:197:LEU:HB3	1:A:198:PRO:HD3	1.97	0.46
1:A:192:ILE:HA	1:A:196:TYR:HD2	1.81	0.46
2:B:2:VAL:HG11	2:B:27:PHE:CE1	2.50	0.45
1:A:210:SER:HB3	1:A:389:ILE:HD12	1.99	0.45
1:A:108:ASN:HB3	1:A:151:SER:HB3	1.99	0.45
1:A:70:LEU:O	1:A:74:VAL:HG12	2.18	0.44
1:A:420:THR:O	1:A:424:ILE:HG13	2.17	0.43
1:A:30:ALA:HB1	1:A:427:TRP:CH2	2.53	0.43
1:A:195:PHE:HB2	3:A:501:IXO:H113	1.99	0.43
1:A:188:PHE:CE1	1:A:411:THR:HG21	2.54	0.43
1:A:158:ALA:O	1:A:162:TRP:HB2	2.19	0.43
1:A:106:VAL:HG12	1:A:148:TRP:HZ3	1.83	0.43
1:A:24:VAL:O	1:A:27:VAL:HG12	2.19	0.42
1:A:79:LEU:HD23	1:A:89:TRP:HH2	1.84	0.42
1:A:432:ASN:HA	1:A:435:ILE:HG12	2.01	0.42

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Atom-1	Atom-2	Distance(Å)	Clash(Å)
1:A:83:TYR:CD1	1:A:89:TRP:HB2	2.56	0.41
1:A:377:PRO:HA	1:A:378:PRO:HD3	1.97	0.41
1:A:116:ILE:HG12	1:A:143:MET:HB3	2.02	0.41
1:A:378:PRO:HB2	1:A:382:GLU:HB3	2.02	0.41
1:A:201:ILE:O	1:A:205:LEU:HG	2.21	0.41
1:A:406:MET:CE	1:A:422:TRP:HA	2.50	0.41
1:A:100:LEU:HD23	1:A:100:LEU:HA	1.85	0.40
2:B:41:ARG:O	2:B:41:ARG:HG2	2.20	0.40
1:A:111:VAL:HG22	1:A:396:PHE:CE2	2.54	0.40
1:A:56:THR:HG21	2:B:109:GLU:HB3	2.03	0.40

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	273/351 (78%)	264 (97%)	9 (3%)	0	100	100
2	B	119/125 (95%)	116 (98%)	3 (2%)	0	100	100
All	All	392/476 (82%)	380 (97%)	12 (3%)	0	100	100

There are no Ramachandran outliers to report.

### 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	224/312 (72%)	212 (95%)	12 (5%)	31	77
2	B	91/101 (90%)	88 (97%)	3 (3%)	50	88

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles
All	All	315/413 (76%)	300 (95%)	15 (5%)	35 81

All (15) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	24	VAL
1	A	108	ASN
1	A	113	ASN
1	A	166	VAL
1	A	169	ARG
1	A	170	THR
1	A	180	PHE
1	A	403	TYR
1	A	411	THR
1	A	426	TYR
1	A	443	CYS
1	A	447	PHE
2	B	12	VAL
2	B	41	ARG
2	B	108	ASP

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

Mol	Chain	Res	Type
2	B	80	ASN
2	B	113	GLN

### 5.3.3 RNA ⓘ

There are no RNA chains in this entry.

## 5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

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

## 5.5 Carbohydrates ⓘ

There are no carbohydrates in this entry.

## 5.6 Ligand geometry ⓘ

1 ligand is 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	$\# Z  > 2$
3	IXO	A	501	-	14,14,14	6.82	9 (64%)	18,18,18	1.77	4 (22%)

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
3	IXO	A	501	-	-	0/9/16/16	0/1/1/1

All (9) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	A	501	IXO	C10-N11	22.83	1.41	1.28
3	A	501	IXO	C05-N02	-5.83	1.43	1.51
3	A	501	IXO	O12-N11	-4.99	1.37	1.43
3	A	501	IXO	C14-C10	-4.97	1.40	1.49
3	A	501	IXO	C05-C06	3.20	1.49	1.46
3	A	501	IXO	C14-C13	-2.95	1.45	1.51
3	A	501	IXO	C07-C06	2.65	1.28	1.19
3	A	501	IXO	C08-C07	2.52	1.56	1.46
3	A	501	IXO	O09-C10	2.23	1.37	1.34

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	501	IXO	C08-O09-C10	4.09	120.39	115.21
3	A	501	IXO	C06-C05-N02	3.67	117.76	112.17
3	A	501	IXO	O09-C08-C07	2.95	117.09	109.39
3	A	501	IXO	O09-C10-N11	2.84	124.68	123.94

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

## 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 ⓘ

### 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	277/351 (78%)	-0.21	1 (0%) 90 71	62, 106, 148, 169	0
2	B	121/125 (96%)	0.02	0 100 100	95, 134, 179, 201	0
All	All	398/476 (83%)	-0.14	1 (0%) 91 76	62, 116, 164, 201	0

All (1) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	378	PRO	2.1

### 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 carbohydrates in this entry.

### 6.4 Ligands ⓘ

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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. 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	RSR	LLDF	B-factors(Å <sup>2</sup> )	Q<0.9
3	IXO	A	501	14/14	0.28	2.18	73,103,125,136	0

## 6.5 Other polymers ⓘ

There are no such residues in this entry.