



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 8, 2026 – 12:12 PM UTC

PDB ID : 2F78 / pdb_00002f78
Title : BenM effector binding domain with its effector benzoate
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Deposited on : 2005-11-30
Resolution : 2.05 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 : 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

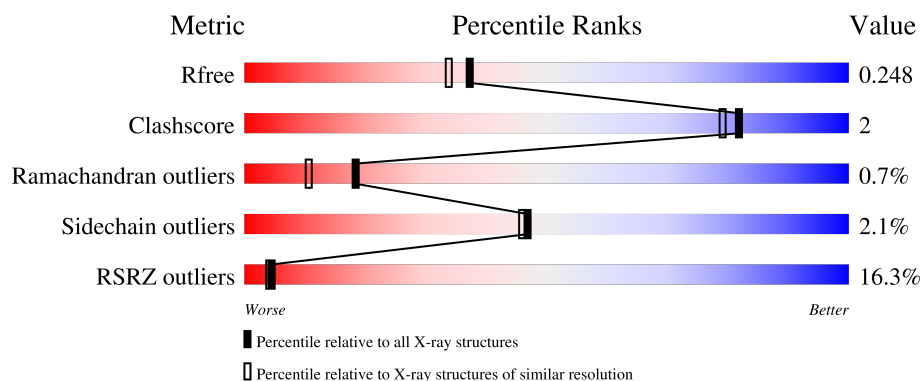
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.05 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	2260 (2.04-2.04)
Clashscore	190562	2333 (2.04-2.04)
Ramachandran outliers	187476	2318 (2.04-2.04)
Sidechain outliers	187428	2318 (2.04-2.04)
RSRZ outliers	180081	2260 (2.04-2.04)

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	232	7% 87% 8% .
1	B	232	24% 86% 6% 8%

2 Entry composition

There are 3 unique types of molecules in this entry. The entry contains 4189 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.

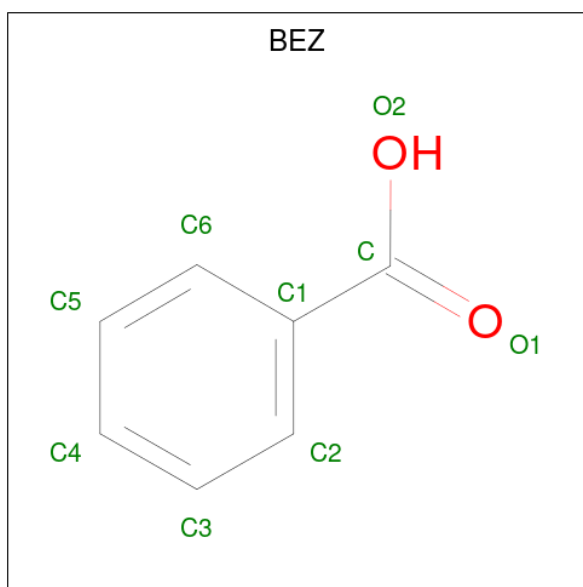
- Molecule 1 is a protein called HTH-type transcriptional regulator benM.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	222	Total	C	N	O	S	0	9	0
			1836	1183	319	329	5			
1	B	214	Total	C	N	O	S	0	3	0
			1720	1108	295	312	5			

There are 16 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	305	LEU	-	cloning artifact	UNP O68014
A	306	GLU	-	cloning artifact	UNP O68014
A	307	HIS	-	expression tag	UNP O68014
A	308	HIS	-	expression tag	UNP O68014
A	309	HIS	-	expression tag	UNP O68014
A	310	HIS	-	expression tag	UNP O68014
A	311	HIS	-	expression tag	UNP O68014
A	312	HIS	-	expression tag	UNP O68014
B	305	LEU	-	cloning artifact	UNP O68014
B	306	GLU	-	cloning artifact	UNP O68014
B	307	HIS	-	expression tag	UNP O68014
B	308	HIS	-	expression tag	UNP O68014
B	309	HIS	-	expression tag	UNP O68014
B	310	HIS	-	expression tag	UNP O68014
B	311	HIS	-	expression tag	UNP O68014
B	312	HIS	-	expression tag	UNP O68014

- Molecule 2 is BENZOIC ACID (CCD ID: BEZ) (formula: C₇H₆O₂).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	C	O	0	0
			9	7	2		
2	A	1	Total	C	O	0	0
			9	7	2		
2	B	1	Total	C	O	0	0
			9	7	2		
2	B	1	Total	C	O	0	0
			9	7	2		
2	B	1	Total	C	O	0	0
			9	7	2		

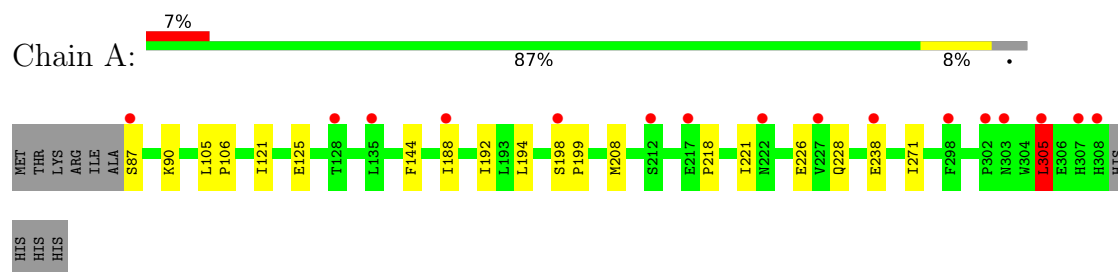
- Molecule 3 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	317	Total	O	0	0
			317	317		
3	B	271	Total	O	0	0
			271	271		

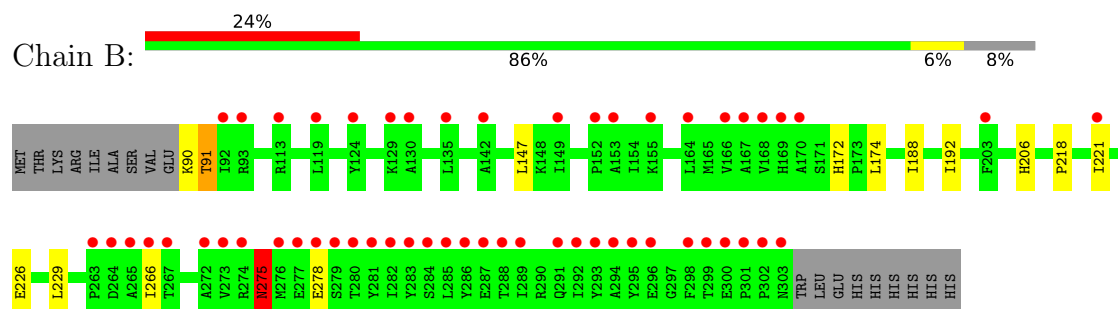
3 Residue-property plots

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: HTH-type transcriptional regulator benM



- Molecule 1: HTH-type transcriptional regulator benM



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	64.39Å 69.51Å 116.86Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	59.76 – 2.05 59.74 – 2.05	Depositor EDS
% Data completeness (in resolution range)	95.7 (59.76-2.05) 95.7 (59.74-2.05)	Depositor EDS
R_{merge}	0.07	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	3.35 (at 2.05Å)	Xtriage
Refinement program	REFMAC refmac_5.2.0005	Depositor
R, R_{free}	0.180 , 0.242 0.191 , 0.248	Depositor DCC
R_{free} test set	1635 reflections (5.08%)	wwPDB-VP
Wilson B-factor (Å ²)	26.1	Xtriage
Anisotropy	0.086	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.32 , 45.1	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	0.91	EDS
Total number of atoms	4189	wwPDB-VP
Average B, all atoms (Å ²)	36.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.60% 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: BEZ

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	0.50	0/1898	0.73	1/2574 (0.0%)
1	B	0.51	0/1763	0.75	1/2392 (0.0%)
All	All	0.50	0/3661	0.74	2/4966 (0.0%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	A	1	0
1	B	1	0
All	All	2	0

There are no bond length outliers.

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	305	LEU	N-CA-C	6.60	124.85	110.80
1	B	275	ASN	N-CA-C	5.52	122.56	110.80

All (2) chirality outliers are listed below:

Mol	Chain	Res	Type	Atom
1	A	305	LEU	CA
1	B	275	ASN	CA

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	1836	0	1891	11	0
1	B	1720	0	1769	8	0
2	A	18	0	10	0	0
2	B	27	0	15	0	0
3	A	317	0	0	1	0
3	B	271	0	0	2	0
All	All	4189	0	3685	18	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 2.

All (18) 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:194:LEU:HD21	1:A:208:MET:HE3	1.63	0.80
1:A:188[B]:ILE:HD11	3:A:1060:HOH:O	1.97	0.64
1:B:226:GLU:HG2	1:B:229[B]:LEU:HD12	1.83	0.59
1:A:218:PRO:HB2	1:A:221:ILE:HD11	1.88	0.55
1:A:125:GLU:OE1	1:B:229[B]:LEU:HD11	2.09	0.53
1:B:192:ILE:HB	1:B:221[A]:ILE:HD13	1.92	0.50
1:A:105:LEU:HB3	1:A:106:PRO:HD3	1.94	0.48
1:A:144:PHE:CE1	1:A:271:ILE:HD12	2.49	0.48
1:B:206:HIS:HE1	1:B:266:ILE:O	1.98	0.47
1:B:192:ILE:HD12	1:B:218:PRO:HB3	1.98	0.46
1:A:226:GLU:CD	1:A:228:GLN:HE22	2.25	0.45
1:B:91:THR:HG23	3:B:1138:HOH:O	2.16	0.44
1:B:147:LEU:HD21	3:B:1045:HOH:O	2.17	0.44
1:B:172:HIS:HD2	1:B:174:LEU:H	1.66	0.44
1:A:192:ILE:HB	1:A:221:ILE:HD13	2.00	0.44
1:A:198:SER:HB2	1:A:199:PRO:HD2	2.00	0.44

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	229/232 (99%)	226 (99%)	2 (1%)	1 (0%)	30	22
1	B	215/232 (93%)	212 (99%)	1 (0%)	2 (1%)	14	7
All	All	444/464 (96%)	438 (99%)	3 (1%)	3 (1%)	18	10

All (3) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	275	ASN
1	B	278	GLU
1	A	305	LEU

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	204/204 (100%)	200 (98%)	4 (2%)	48	48
1	B	190/204 (93%)	186 (98%)	4 (2%)	47	46
All	All	394/408 (97%)	386 (98%)	8 (2%)	47	48

All (8) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	87	SER
1	A	90	LYS
1	A	238	GLU

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Mol	Chain	Res	Type
1	A	305	LEU
1	B	90	LYS
1	B	91	THR
1	B	188	ILE
1	B	275	ASN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (6) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	114	GLN
1	A	307	HIS
1	B	172	HIS
1	B	185	ASN
1	B	206	HIS
1	B	248	GLN

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](#)

5 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	BEZ	B	1005	-	9,9,9	2.29	1 (11%)	11,11,11	0.97	2 (18%)
2	BEZ	B	1002	-	9,9,9	2.07	1 (11%)	11,11,11	1.12	1 (9%)
2	BEZ	A	1001	-	9,9,9	1.96	1 (11%)	11,11,11	1.29	1 (9%)
2	BEZ	B	1004	-	9,9,9	2.28	1 (11%)	11,11,11	1.12	2 (18%)
2	BEZ	A	1003	-	9,9,9	2.26	1 (11%)	11,11,11	1.04	2 (18%)

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	BEZ	B	1005	-	-	0/4/4/4	0/1/1/1
2	BEZ	B	1002	-	-	4/4/4/4	0/1/1/1
2	BEZ	A	1001	-	-	0/4/4/4	0/1/1/1
2	BEZ	B	1004	-	-	0/4/4/4	0/1/1/1
2	BEZ	A	1003	-	-	0/4/4/4	0/1/1/1

All (5) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	B	1005	BEZ	O1-C	6.67	1.41	1.22
2	B	1004	BEZ	O1-C	6.55	1.41	1.22
2	A	1003	BEZ	O1-C	6.49	1.41	1.22
2	B	1002	BEZ	O1-C	6.11	1.40	1.22
2	A	1001	BEZ	O1-C	5.84	1.39	1.22

All (8) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	1004	BEZ	O2-C-O1	-2.83	117.26	123.35
2	A	1001	BEZ	O2-C-C1	2.62	121.57	114.84
2	B	1002	BEZ	O2-C-C1	2.50	121.27	114.84
2	A	1003	BEZ	O2-C-C1	2.45	121.13	114.84
2	B	1005	BEZ	O2-C-O1	-2.30	118.41	123.35
2	A	1003	BEZ	O2-C-O1	-2.29	118.43	123.35
2	B	1004	BEZ	O2-C-C1	2.15	120.34	114.84
2	B	1005	BEZ	O2-C-C1	2.05	120.11	114.84

There are no chirality outliers.

All (4) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	B	1002	BEZ	O2-C-C1-C2
2	B	1002	BEZ	O2-C-C1-C6
2	B	1002	BEZ	O1-C-C1-C2
2	B	1002	BEZ	O1-C-C1-C6

There are no ring outliers.

No monomer is involved in short contacts.

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	222/232 (95%)	0.96	16 (7%) 21 21	13, 35, 46, 58	9 (4%)
1	B	214/232 (92%)	1.56	55 (25%) 1 1	16, 33, 60, 74	3 (1%)
All	All	436/464 (93%)	1.25	71 (16%) 4 4	13, 34, 49, 74	12 (2%)

All (71) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	170	ALA	6.0
1	B	168	VAL	5.5
1	B	303	ASN	5.2
1	B	263	PRO	4.9
1	B	278	GLU	4.7
1	B	298	PHE	4.6
1	B	265	ALA	4.5
1	B	286	TYR	4.5
1	A	307	HIS	4.5
1	B	299	THR	4.3
1	B	149	ILE	4.3
1	B	280	THR	4.3
1	B	267	THR	4.3
1	B	169	HIS	4.2
1	B	292	ILE	4.1
1	B	167	ALA	4.0
1	B	155	LYS	4.0
1	B	119	LEU	4.0
1	B	203	PHE	3.8
1	B	289	ILE	3.8
1	B	281	TYR	3.7
1	B	142	ALA	3.6
1	B	293	TYR	3.6
1	A	227	VAL	3.5

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Mol	Chain	Res	Type	RSRZ
1	B	266	ILE	3.4
1	B	301	PRO	3.4
1	B	302	PRO	3.4
1	B	295	TYR	3.3
1	A	302	PRO	3.3
1	B	294	ALA	3.3
1	B	135	LEU	3.3
1	B	283	TYR	3.2
1	A	303	ASN	3.2
1	B	166	VAL	3.2
1	B	130	ALA	3.1
1	A	217	GLU	3.1
1	A	87	SER	3.1
1	B	113	ARG	3.0
1	A	305	LEU	3.0
1	B	296	GLU	2.9
1	A	222	ASN	2.9
1	B	282	ILE	2.8
1	A	198	SER	2.8
1	B	276	MET	2.8
1	B	277	GLU	2.8
1	B	221[A]	ILE	2.8
1	B	285	LEU	2.7
1	B	284	SER	2.7
1	B	93	ARG	2.7
1	A	308	HIS	2.7
1	A	298	PHE	2.6
1	B	124	TYR	2.6
1	B	153	ALA	2.6
1	B	273	VAL	2.6
1	B	288	THR	2.4
1	B	129	LYS	2.4
1	B	152	PRO	2.3
1	B	274[A]	ARG	2.3
1	B	279	SER	2.2
1	A	188[A]	ILE	2.2
1	B	264	ASP	2.2
1	A	238	GLU	2.2
1	B	287	GLU	2.2
1	B	300	GLU	2.1
1	A	128	THR	2.1
1	B	92	ILE	2.1

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Mol	Chain	Res	Type	RSRZ
1	B	272	ALA	2.1
1	A	135	LEU	2.0
1	B	164	LEU	2.0
1	A	212	SER	2.0
1	B	291	GLN	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, 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	BEZ	B	1005	9/9	0.79	0.17	55,55,55,56	0
2	BEZ	B	1004	9/9	0.86	0.12	30,30,31,32	0
2	BEZ	A	1003	9/9	0.86	0.12	30,31,31,32	0
2	BEZ	B	1002	9/9	0.87	0.10	35,36,37,38	0
2	BEZ	A	1001	9/9	0.94	0.16	21,23,24,24	0

6.5 Other polymers [i](#)

There are no such residues in this entry.