



wwPDB X-ray Structure Validation Summary Report ⓘ

Feb 25, 2024 – 01:19 PM EST

PDB ID : 5FDN
Title : Crystal structure of phosphoenolpyruvate carboxylase from *Arabidopsis thaliana* in complex with aspartate and citrate
Authors : Connell, M.B.; Lee, M.J.Y.; Plaxton, W.C.; Jia, Z.
Deposited on : 2015-12-16
Resolution : 2.20 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 : 4.02b-467
Mogul : 1.8.5 (274361), CSD as541be (2020)
Xtriage (Phenix) : 1.13
EDS : 2.36
Percentile statistics : 20191225.v01 (using entries in the PDB archive December 25th 2019)
Refmac : 5.8.0158
CCP4 : 7.0.044 (Gargrove)
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.36

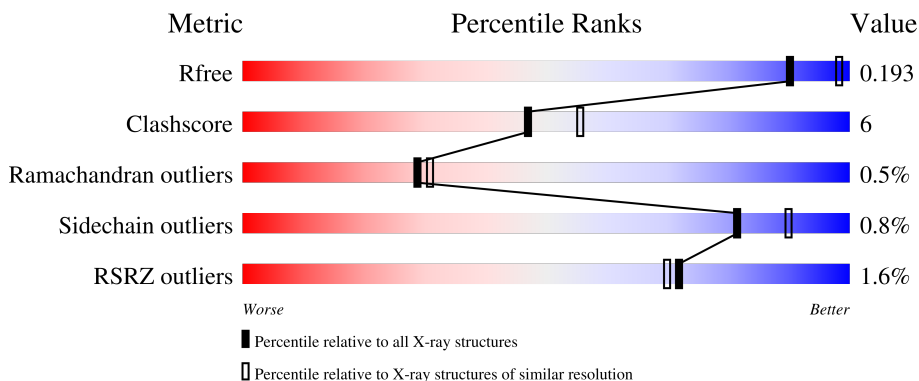
1 Overall quality at a glance

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}	130704	4898 (2.20-2.20)
Clashscore	141614	5594 (2.20-2.20)
Ramachandran outliers	138981	5503 (2.20-2.20)
Sidechain outliers	138945	5504 (2.20-2.20)
RSRZ outliers	127900	4800 (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	987	 2% 82% 10% • 7%
1	B	987	 % 80% 10% • 9%

2 Entry composition [i](#)

There are 4 unique types of molecules in this entry. The entry contains 16218 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 Phosphoenolpyruvate carboxylase 3.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	914	7346	4659	1279	1380	28	0	0	0
1	B	900	7227	4587	1251	1361	28	0	0	0

There are 38 discrepancies between the modelled and reference sequences:

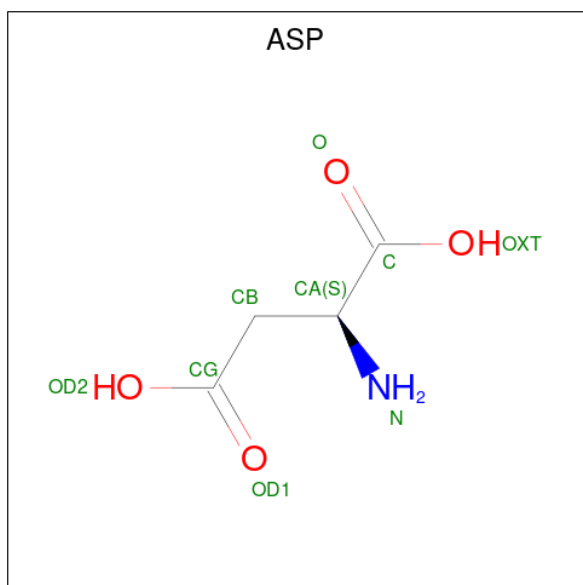
Chain	Residue	Modelled	Actual	Comment	Reference
A	-18	MET	-	initiating methionine	UNP Q84VW9
A	-17	GLY	-	expression tag	UNP Q84VW9
A	-16	SER	-	expression tag	UNP Q84VW9
A	-15	SER	-	expression tag	UNP Q84VW9
A	-14	HIS	-	expression tag	UNP Q84VW9
A	-13	HIS	-	expression tag	UNP Q84VW9
A	-12	HIS	-	expression tag	UNP Q84VW9
A	-11	HIS	-	expression tag	UNP Q84VW9
A	-10	HIS	-	expression tag	UNP Q84VW9
A	-9	HIS	-	expression tag	UNP Q84VW9
A	-8	SER	-	expression tag	UNP Q84VW9
A	-7	SER	-	expression tag	UNP Q84VW9
A	-6	GLY	-	expression tag	UNP Q84VW9
A	-5	LEU	-	expression tag	UNP Q84VW9
A	-4	VAL	-	expression tag	UNP Q84VW9
A	-3	PRO	-	expression tag	UNP Q84VW9
A	-2	ARG	-	expression tag	UNP Q84VW9
A	-1	GLY	-	expression tag	UNP Q84VW9
A	0	SER	-	expression tag	UNP Q84VW9
B	-18	MET	-	initiating methionine	UNP Q84VW9
B	-17	GLY	-	expression tag	UNP Q84VW9
B	-16	SER	-	expression tag	UNP Q84VW9
B	-15	SER	-	expression tag	UNP Q84VW9
B	-14	HIS	-	expression tag	UNP Q84VW9
B	-13	HIS	-	expression tag	UNP Q84VW9

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Chain	Residue	Modelled	Actual	Comment	Reference
B	-12	HIS	-	expression tag	UNP Q84VW9
B	-11	HIS	-	expression tag	UNP Q84VW9
B	-10	HIS	-	expression tag	UNP Q84VW9
B	-9	HIS	-	expression tag	UNP Q84VW9
B	-8	SER	-	expression tag	UNP Q84VW9
B	-7	SER	-	expression tag	UNP Q84VW9
B	-6	GLY	-	expression tag	UNP Q84VW9
B	-5	LEU	-	expression tag	UNP Q84VW9
B	-4	VAL	-	expression tag	UNP Q84VW9
B	-3	PRO	-	expression tag	UNP Q84VW9
B	-2	ARG	-	expression tag	UNP Q84VW9
B	-1	GLY	-	expression tag	UNP Q84VW9
B	0	SER	-	expression tag	UNP Q84VW9

- Molecule 2 is ASPARTIC ACID (three-letter code: ASP) (formula: $C_4H_7NO_4$).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
			Total	C	N	O		
2	A	1	9	4	1	4	0	0
2	B	1	9	4	1	4	0	0

- Molecule 3 is CITRATE ANION (three-letter code: FLC) (formula: $C_6H_5O_7$).



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

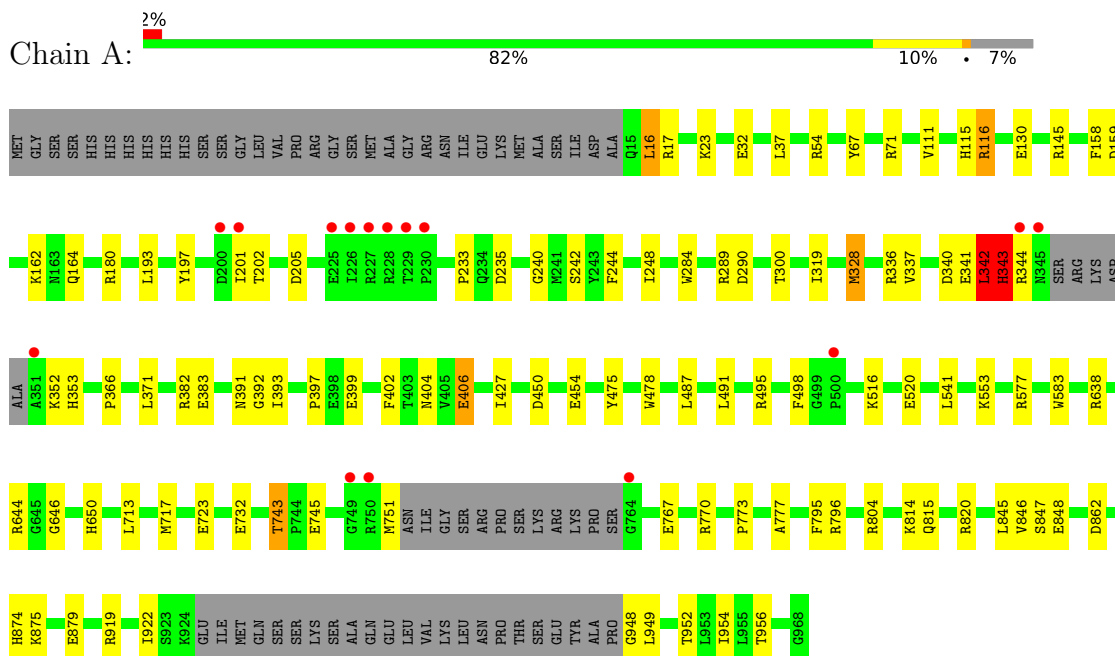
- Molecule 4 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	A	807	Total O 807 807	0	0
4	B	794	Total O 794 794	0	0

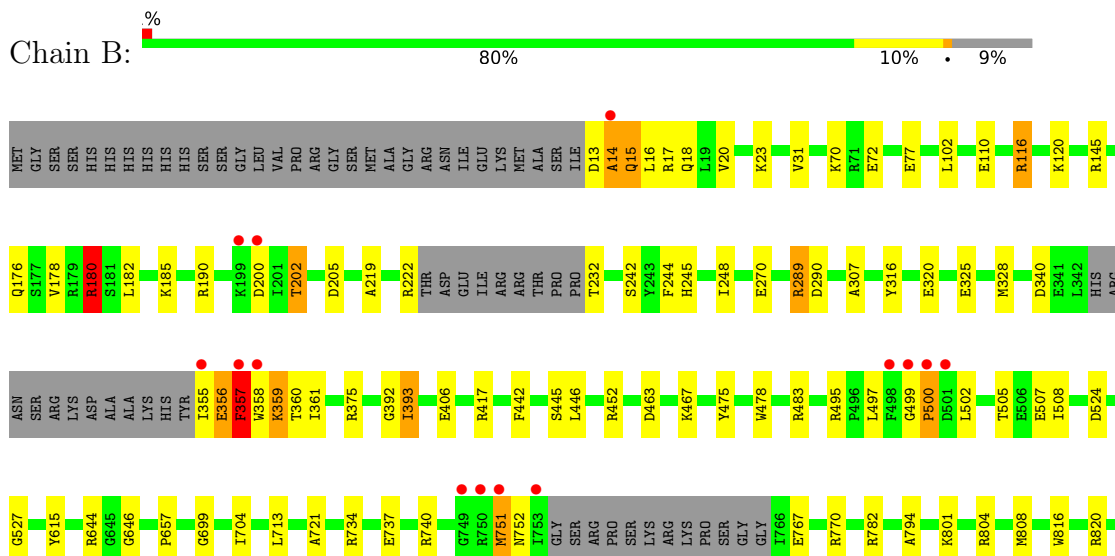
3 Residue-property plots [i](#)

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: Phosphoenolpyruvate carboxylase 3



• Molecule 1: Phosphoenolpyruvate carboxylase 3



D834	W851	E855	D862	L884	K885	Q886	Y894	Y904	R908	R919	I922	S923	K924	GLU	ILE	MET	GLN	SER	SER	LYS	SER	ALA	GLN	GLU	LEU	VAL	LYS	LEU	ASN	PRO	THR	SER	GLU	TYR	ALA	PRO	G948	G968
------	------	------	------	------	------	------	------	------	------	------	------	------	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	------

4 Data and refinement statistics i

Property	Value	Source
Space group	C 2 2 2	Depositor
Cell constants a, b, c, α , β , γ	264.26Å 268.13Å 77.93Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	48.87 – 2.20 48.87 – 2.20	Depositor EDS
% Data completeness (in resolution range)	100.0 (48.87-2.20) 99.9 (48.87-2.20)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.08	Depositor
$\langle I/\sigma(I) \rangle$ ¹	6.41 (at 2.20Å)	Xtrriage
Refinement program	PHENIX (1.10.1_2155: ???)	Depositor
R, R_{free}	0.173 , 0.193 0.173 , 0.193	Depositor DCC
R_{free} test set	2013 reflections (1.43%)	wwPDB-VP
Wilson B-factor (Å ²)	22.0	Xtrriage
Anisotropy	0.000	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.33 , 23.1	EDS
L-test for twinning ²	$\langle L \rangle = 0.48$, $\langle L^2 \rangle = 0.32$	Xtrriage
Estimated twinning fraction	0.249 for -k,-h,-l	Xtrriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	16218	wwPDB-VP
Average B, all atoms (Å ²)	27.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.45% 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: FLC

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	0.43	2/7498 (0.0%)	0.56	2/10146 (0.0%)
1	B	0.42	0/7373	0.61	4/9976 (0.0%)
All	All	0.42	2/14871 (0.0%)	0.58	6/20122 (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	0	2
1	B	0	2
All	All	0	4

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	406	GLU	CG-CD	7.02	1.62	1.51
1	A	406	GLU	CD-OE1	-5.62	1.19	1.25

The worst 5 of 6 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	180	ARG	NE-CZ-NH2	-9.16	115.72	120.30
1	B	751	MET	CA-CB-CG	6.45	124.26	113.30
1	A	116	ARG	NE-CZ-NH2	-5.96	117.32	120.30
1	B	751	MET	C-N-CA	5.80	136.20	121.70
1	B	116	ARG	NE-CZ-NH2	-5.75	117.42	120.30

There are no chirality outliers.

All (4) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	16	LEU	Peptide
1	A	343	HIS	Peptide
1	B	356	GLU	Peptide
1	B	699	GLY	Peptide

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	7346	0	7319	81	0
1	B	7227	0	7201	98	0
2	A	9	0	3	0	0
2	B	9	0	3	0	0
3	A	13	0	5	1	0
3	B	13	0	5	1	0
4	A	807	0	0	37	0
4	B	794	0	0	35	3
All	All	16218	0	14536	180	3

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 6.

The worst 5 of 180 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:B:316:TYR:HH	1:B:355:ILE:N	1.41	1.19
1:B:232:THR:N	4:B:1101:HOH:O	1.84	1.09
1:B:116:ARG:NH2	4:B:1104:HOH:O	1.97	0.96
1:B:316:TYR:OH	1:B:355:ILE:N	1.99	0.96
1:A:71:ARG:N	4:A:1102:HOH:O	1.97	0.96

All (3) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
4:B:1731:HOH:O	4:B:1735:HOH:O[4_566]	1.83	0.37
4:B:1253:HOH:O	4:B:1592:HOH:O[1_554]	2.08	0.12
4:B:1759:HOH:O	4:B:1799:HOH:O[4_566]	2.18	0.02

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	906/987 (92%)	879 (97%)	24 (3%)	3 (0%)	41	46
1	B	890/987 (90%)	858 (96%)	26 (3%)	6 (1%)	22	22
All	All	1796/1974 (91%)	1737 (97%)	50 (3%)	9 (0%)	29	31

5 of 9 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	344	ARG
1	B	14	ALA
1	B	15	GLN
1	B	360	THR
1	B	393	ILE

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	798/860 (93%)	792 (99%)	6 (1%)	81	90
1	B	786/860 (91%)	779 (99%)	7 (1%)	78	88

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles
All	All	1584/1720 (92%)	1571 (99%)	13 (1%)	81 90

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

Mol	Chain	Res	Type
1	B	202	THR
1	B	289	ARG
1	B	406	GLU
1	B	357	PHE
1	B	359	LYS

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (4) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	184	GLN
1	A	245	HIS
1	A	915	ASN
1	B	245	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 monosaccharides 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	ASP	A	1001	-	6,8,8	1.09	0	8,10,10	1.14	1 (12%)
2	ASP	B	1001	-	6,8,8	1.23	1 (16%)	8,10,10	1.12	0
3	FLC	B	1002	-	12,12,12	1.36	1 (8%)	17,17,17	2.36	5 (29%)
3	FLC	A	1002	-	12,12,12	1.30	1 (8%)	17,17,17	2.48	6 (35%)

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	ASP	A	1001	-	-	0/8/8/8	-
2	ASP	B	1001	-	-	0/8/8/8	-
3	FLC	B	1002	-	-	0/16/16/16	-
3	FLC	A	1002	-	-	1/16/16/16	-

All (3) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	B	1002	FLC	CB-CBC	2.57	1.56	1.53
3	A	1002	FLC	CB-CBC	2.52	1.56	1.53
2	B	1001	ASP	OXT-C	-2.13	1.23	1.30

The worst 5 of 12 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	B	1002	FLC	OB2-CBC-CB	6.68	124.65	113.05
3	A	1002	FLC	CB-CA-CAC	-5.75	99.89	113.81
3	A	1002	FLC	OB2-CBC-CB	5.69	122.93	113.05
3	B	1002	FLC	CB-CA-CAC	-4.50	102.91	113.81
3	B	1002	FLC	OB2-CBC-OB1	-2.53	115.78	123.82

There are no chirality outliers.

All (1) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	A	1002	FLC	CBC-CB-CG-CGC

There are no ring outliers.

2 monomers are involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	B	1002	FLC	1	0
3	A	1002	FLC	1	0

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	914/987 (92%)	-0.60	15 (1%) 72 70	11, 24, 50, 100	0
1	B	900/987 (91%)	-0.64	14 (1%) 72 70	10, 24, 48, 72	0
All	All	1814/1974 (91%)	-0.62	29 (1%) 72 70	10, 24, 49, 100	0

The worst 5 of 29 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	226	ILE	9.1
1	A	201	ILE	7.3
1	A	200	ASP	5.2
1	A	228	ARG	5.1
1	B	501	ASP	5.0

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 monosaccharides 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(\AA^2)	Q<0.9
3	FLC	A	1002	13/13	0.93	0.11	16,26,34,46	0
3	FLC	B	1002	13/13	0.94	0.14	18,23,35,46	0
2	ASP	B	1001	9/9	0.96	0.09	18,21,24,24	0
2	ASP	A	1001	9/9	0.98	0.08	16,21,22,23	0

6.5 Other polymers [i](#)

There are no such residues in this entry.