wwPDB X-ray Structure Validation Summary Report (i)

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PDB ID	:	9VRQ / pdb_00009vrq
Title	:	Crystal structure of FOXC2/NFAT1 complex bound to ARRE2 DNA
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Deposited on	:	2025-07-07
Resolution	:	2.80 Å(reported)

This is a wwPDB X-ray Structure Validation Summary 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 (i) 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 (1)) were used in the production of this report:

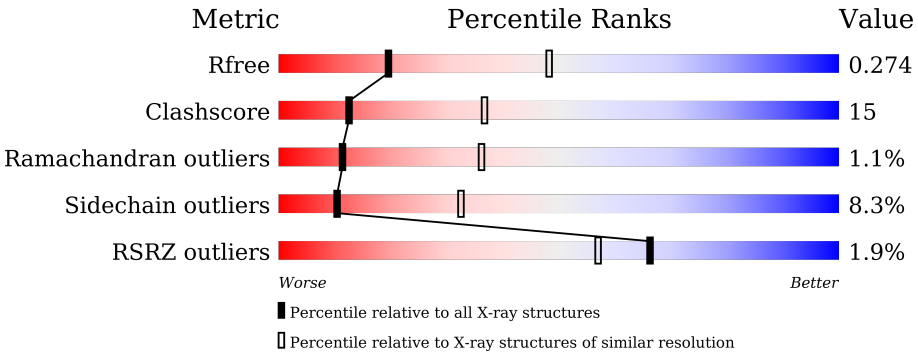
MolProbity	:	4-5-2 with Phenix2.0
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.010 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 2.80 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	3866 (2.80-2.80)
Clashscore	190562	4276 (2.80-2.80)
Ramachandran outliers	187476	4196 (2.80-2.80)
Sidechain outliers	187428	4198 (2.80-2.80)
RSRZ outliers	180081	3869 (2.80-2.80)

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 <=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	103	4% 52% 29% 7% • 11%
2	C	21	67% 33%
3	D	21	76% 24%
4	N	287	% 66% 31% •

2 Entry composition (i)

There are 5 unique types of molecules in this entry. The entry contains 3939 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 Forkhead box protein C2.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	92	Total	C	N	O	S	0	0	0
			776	502	137	133	4			

There are 2 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	70	GLY	-	expression tag	UNP Q99958
A	71	PRO	-	expression tag	UNP Q99958

- Molecule 2 is a DNA chain called ARRE2-S.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	C	21	Total	C	N	O	P	0	0	0
			431	209	76	126	20			

- Molecule 3 is a DNA chain called ARRE2-AS.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	D	21	Total	C	N	O	P	0	0	0
			424	206	76	122	20			

- Molecule 4 is a protein called Nuclear factor of activated T-cells, cytoplasmic 2.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
4	N	287	Total	C	N	O	S	0	0	0
			2275	1426	413	427	9			

There are 4 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
N	394	SER	LEU	conflict	UNP Q13469
N	395	VAL	PRO	conflict	UNP Q13469

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Chain	Residue	Modelled	Actual	Comment	Reference
N	501	VAL	ILE	conflict	UNP Q13469
N	562	ALA	THR	conflict	UNP Q13469

- Molecule 5 is water.

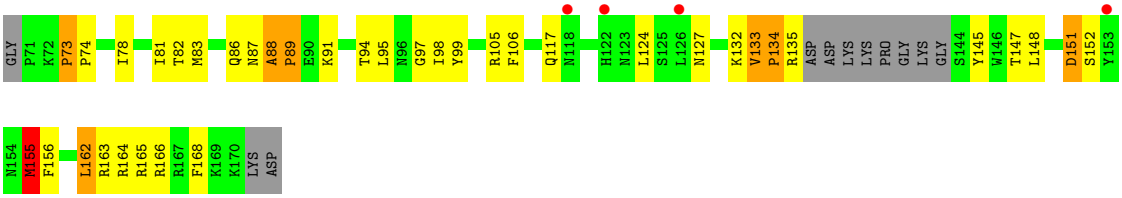
Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
5	A	2	Total O 2 2	0	0
5	C	9	Total O 9 9	0	0
5	D	2	Total O 2 2	0	0
5	N	20	Total O 20 20	0	0

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.

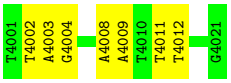
• Molecule 1: Forkhead box protein C2

Chain A:



• Molecule 2: ARRE2-S

Chain C:

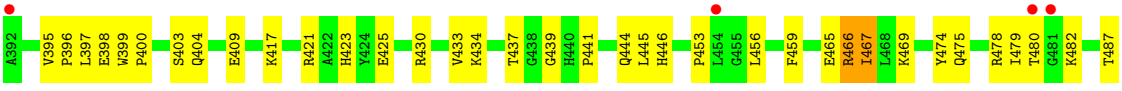


• Molecule 3: ARRE2-AS

Chain D:

• Molecule 4: Nuclear factor of activated T-cells, cytoplasmic 2

Chain N:



4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α, β, γ	65.98Å 77.34Å 117.06Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	38.67 – 2.80 38.67 – 2.80	Depositor EDS
% Data completeness (in resolution range)	99.8 (38.67-2.80) 99.7 (38.67-2.80)	Depositor EDS
R_{merge}	0.23	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	2.67 (at 2.81Å)	Xtriage
Refinement program	PHENIX (1.19.2_4158: ???)	Depositor
R, R_{free}	0.237 , 0.288 0.230 , 0.274	Depositor DCC
R_{free} test set	1056 reflections (4.94%)	wwPDB-VP
Wilson B-factor (Å^2)	58.1	Xtriage
Anisotropy	0.222	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.33 , 20.0	EDS
L-test for twinning[2]	$< \|L\| > = 0.47$, $< L^2 > = 0.29$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o,F_c correlation	0.91	EDS
Total number of atoms	3939	wwPDB-VP
Average B, all atoms (Å^2)	57.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 8.51% of the height of the origin peak. No significant pseudotranslation is detected.*

[1] Intensities estimated from amplitudes.

[2] Theoretical values of $< |L| >$, $< L^2 >$ 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

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	0.93	1/799 (0.1%)	0.96	5/1078 (0.5%)
2	C	0.20	0/483	0.46	0/745
3	D	0.22	0/475	0.46	0/730
4	N	0.76	0/2325	0.71	6/3148 (0.2%)
All	All	0.71	1/4082 (0.0%)	0.71	11/5701 (0.2%)

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	73	PRO	CA-C	-5.19	1.48	1.52

The worst 5 of 11 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	A	88	ALA	CA-C-N	11.69	134.45	119.84
1	A	88	ALA	C-N-CA	11.69	134.45	119.84
4	N	634	GLN	CA-C-N	7.70	127.87	119.87
4	N	634	GLN	C-N-CA	7.70	127.87	119.87
4	N	395	VAL	CA-C-N	7.33	127.29	120.03

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	776	0	751	39	0
2	C	431	0	242	6	0
3	D	424	0	240	5	0
4	N	2275	0	2267	69	0
5	A	2	0	0	0	0
5	C	9	0	0	0	0
5	D	2	0	0	0	0
5	N	20	0	0	1	0
All	All	3939	0	3500	112	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 15.

The worst 5 of 112 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:88:ALA:HB1	1:A:89:PRO:HD2	1.30	1.10
4:N:423:HIS:HB3	4:N:430:ARG:HG3	1.48	0.94
1:A:88:ALA:CB	1:A:89:PRO:HD2	1.93	0.90
1:A:83:MET:SD	4:N:400:PRO:HG2	2.19	0.82
1:A:74:PRO:O	1:A:162:LEU:CD1	2.27	0.82

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	88/103 (85%)	80 (91%)	6 (7%)	2 (2%)	5 18
4	N	285/287 (99%)	273 (96%)	10 (4%)	2 (1%)	18 47
All	All	373/390 (96%)	353 (95%)	16 (4%)	4 (1%)	11 36

All (4) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	134	PRO
4	N	646	ARG
1	A	89	PRO
4	N	620	GLN

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	83/94 (88%)	77 (93%)	6 (7%)	13	39
4	N	253/255 (99%)	231 (91%)	22 (9%)	9	30
All	All	336/349 (96%)	308 (92%)	28 (8%)	10	32

5 of 28 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
4	N	487	THR
4	N	664	LYS
4	N	589	LEU
4	N	648	LYS
4	N	585	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (5) such sidechains are listed below:

Mol	Chain	Res	Type
4	N	446	HIS
4	N	575	HIS
4	N	601	GLN
4	N	649	HIS
4	N	669	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)

There are no ligands in this entry.

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, 95^{th} 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	92/103 (89%)	0.55	4 (4%) 40 31	45, 68, 82, 96	0
2	C	21/21 (100%)	0.12	0 100 100	48, 57, 76, 80	0
3	D	21/21 (100%)	0.12	0 100 100	42, 59, 85, 89	0
4	N	287/287 (100%)	0.18	4 (1%) 73 64	34, 50, 78, 99	0
All	All	421/432 (97%)	0.25	8 (1%) 66 57	34, 55, 81, 99	0

The worst 5 of 8 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
4	N	392	ALA	4.3
1	A	118	ASN	3.3
1	A	153	TYR	2.8
4	N	480	THR	2.6
4	N	454	LEU	2.5

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

There are no ligands in this entry.

6.5 Other polymers (i)

There are no such residues in this entry.