

Integrative Structure Validation Report ?

October 09, 2025 - 04:46 PM PDT

The following software was used in the production of this report:

IHMValidation Version 3.0

Python-IHM Version 2.5

MolProbity Version 4.5.2

pyHMMER Version 0.11.1

PDB ID	9A5E pdb_00009a5e
PDB-Dev ID	PDBDEV_00000271
Structure Title	Integrative model of DPO41-RPOZ by crosslinking MS and deep learning
Structure Authors	Stahl, K.; Brock, O.; Rappsilber, J.
Deposited on	2024-01-23

This is a PDB-IHM Structure Validation Report.

We welcome your comments at helpdesk@pdb-ihm.org

A user guide is available at https://pdb-ihm.org/validation_help.html with specific help available everywhere you see the ? symbol.

List of references used to build this report is available [here](#).

1. Overview ?

1.1. Summary ?

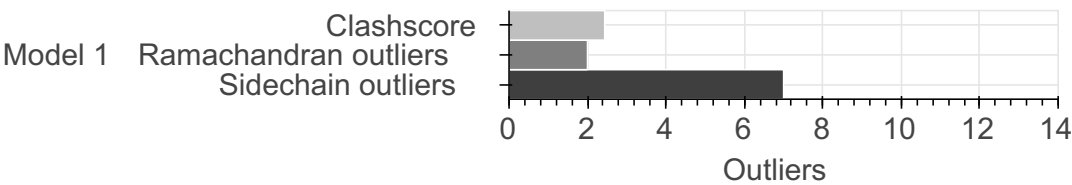
This entry consists of 1 model(s). A total of 1 dataset(s) were used to build this entry.

Name	Type	Count
Crosslinking-MS data	Experimental data	1

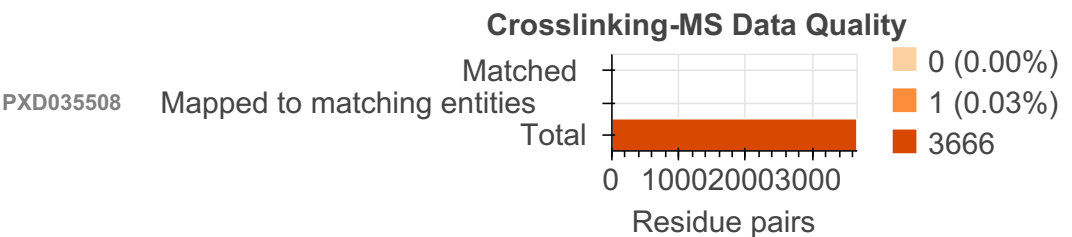
1.2. Overall quality ?

This validation report contains model quality assessments for all structures, data quality and fit to model assessments for SAS and crosslinking-MS datasets. Data quality and fit to model assessments for other datasets and model uncertainty are under development. Number of plots is limited to 256.

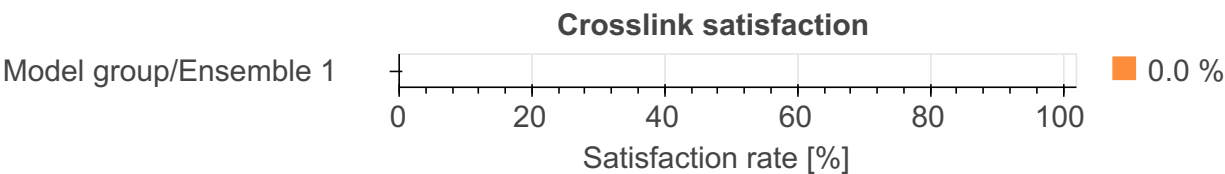
Model Quality: MolProbity Analysis ?



Data Quality ?



Fit to Data Used for Modeling ?



2. Model Details ?

2.1. Ensemble information ?

This entry consists of 0 distinct ensemble(s).

2.2. Representation ?

This entry has 1 representation(s).

ID	Model(s)	Entity ID	Molecule name	Chain(s) [auth]	Total residues	Rigid segments	Flexible segments	Model coverage/ Starting model coverage (%)	Scale
1	1	1	DPO41_BACSU	A	414	-	1-414	100.00 / 0.00	Atomic
		2	RPOZ_BACSU	B	67	-	1-67	100.00 / 0.00	Atomic

2.3. Datasets used for modeling ?

There is 1 unique dataset used to build the models in this entry.

ID	Dataset type	Database name	Data access code
1	Crosslinking-MS data	PRIDE	PXD035508

2.4. Methodology and software ?

This entry is a result of 1 distinct protocol(s).

Step number	Protocol ID	Method name	Method type	Method description	Number of computed models	Multi state modeling	Multi scale modeling
1	1	AlphaLink2	AlphaLink2	Not available	1	False	False

There is 1 software package reported in this entry.

ID	Software name	Software version	Software classification	Software location
1	AlphaLink2	1.00	model building	https://github.com/Rappsilber-Laboratory/AlphaLink2

3. Data quality ?

3.2. Crosslinking-MS

At the moment, data validation is only available for crosslinking-MS data deposited as a fully [compliant](#) dataset in the [PRIDE Crosslinking](#) database. Correspondence between crosslinking-MS and entry entities is established using [pyHMMER](#). Only residue pairs that passed the reported threshold are used for the analysis. The values in the report have to be interpreted in the context of the experiment (i.e. only a minor fraction of in-situ or in-vivo dataset can be used for modeling).

[PXD035508](#)

Number of entities in the crosslinking-MS dataset: 810

Number of entities in the entry: 2

Matching entities:

Entity ID	Molecule name	Crosslinking-MS Entity ID	E-value	Exact match
1	DPO41_BACSU	Not available	Not available	Not available
2	RPOZ_BACSU	dbseq_O35011_target	0.00	True

Residue pairs stats:

Source	Total	In matched entities	Total matched
9A5E	1	1 (100.00%)	0 (0.00%)
PXD035508	3666	1 (0.03%)	0 (0.00%)

4. Model quality ?

For models with atomic structures, MolProbity analysis is performed. For models with coarse-grained or multi-scale structures, excluded volume analysis is performed.

4.1b. MolProbity Analysis ?

Excluded volume satisfaction for the models in the entry are listed below. The Analysed column shows the number of particle-particle or particle-atom pairs for which excluded volume was analysed.

Standard geometry: bond outliers ?

There are no bond length outliers.

Standard geometry: angle outliers ?

There are 34 bond angle outliers in this entry (0.65% of 5259 assessed bonds). A summary is provided below.

Chain	Res	Type	Atoms	Z	Observed (Å)	Ideal (Å)	Model ID (Worst)	Models (Total)
A	382	THR	CA-CB-CG2	12.49	131.73	110.50	1	1
A	379	LYS	CB-CG-CD	9.12	132.28	111.30	1	1
B	2	LEU	N-CA-CB	7.95	124.01	110.50	1	1
A	374	GLU	C-N-CA	7.70	135.56	121.70	1	1
A	382	THR	OG1-CB-CG2	7.52	94.26	109.30	1	1
A	378	LYS	CA-CB-CG	6.59	127.27	114.10	1	1
A	377	ASN	OD1-CG-ND2	6.46	116.14	122.60	1	1
A	108	ASP	CA-CB-CG	6.20	118.80	112.60	1	1
A	374	GLU	CA-C-O	6.18	110.30	120.80	1	1
A	377	ASN	CA-CB-CG	5.07	117.67	112.60	1	1
A	370	GLN	OE1-CD-NE2	5.00	117.60	122.60	1	1
A	9	PHE	CA-CB-CG	4.88	118.68	113.80	1	1
B	19	LEU	C-CA-CB	4.78	119.19	110.10	1	1
A	371	GLN	C-N-CA	4.75	130.24	121.70	1	1
B	36	GLN	OE1-CD-NE2	4.65	117.95	122.60	1	1
B	31	GLN	OE1-CD-NE2	4.52	118.08	122.60	1	1
A	257	HIS	CB-CG-CD2	4.42	125.46	131.20	1	1
A	367	GLU	CA-C-N	4.38	123.47	116.90	1	1
A	186	HIS	CB-CG-CD2	4.38	125.51	131.20	1	1
B	2	LEU	C-CA-CB	4.36	118.38	110.10	1	1
A	379	LYS	CG-CD-CE	4.36	121.32	111.30	1	1
A	350	GLN	OE1-CD-NE2	4.32	118.28	122.60	1	1
A	380	TYR	C-N-CA	4.30	129.45	121.70	1	1
A	354	GLN	OE1-CD-NE2	4.30	118.30	122.60	1	1

Chain	Res	Type	Atoms	Z	Observed (Å)	Ideal (Å)	Model ID (Worst)	Models (Total)
A	381	GLY	C-N-CA	4.23	129.32	121.70	1	1
B	20	VAL	N-CA-CB	4.15	118.55	111.50	1	1
A	382	THR	N-CA-C	4.12	122.54	111.00	1	1
A	356	ASP	CA-CB-CG	4.12	116.72	112.60	1	1
B	20	VAL	CA-CB-CG1	4.09	117.34	110.40	1	1
A	310	ASN	OD1-CG-ND2	4.07	118.53	122.60	1	1
A	378	LYS	CA-C-O	4.06	113.89	120.80	1	1
A	382	THR	O-C-N	4.04	116.54	123.00	1	1
A	10	HIS	CB-CG-CD2	4.02	125.97	131.20	1	1
B	19	LEU	CA-C-N	4.00	124.20	116.20	1	1

Too-close contacts ?

The following all-atom clashscore is based on a MolProbity analysis. All-atom clashscore is defined as the number of clashes found per 1000 atoms (including hydrogen atoms). The table below contains clashscores for all atomic models in this entry.

Model ID	Clash score	Number of clashes
1	2.44	19

There are 19 clashes. The table below contains the detailed list of all clashes based on a MolProbity analysis. Bad clashes are >= 0.4 Angstrom.

Atom 1	Atom 2	Clash(Å)	Model ID (Worst)	Models (Total)
A:380:TYR:CG	B:51:LEU:HD13	0.63	1	1
A:379:LYS:HG2	B:6:ILE:HG12	0.61	1	1
A:380:TYR:CD1	B:51:LEU:HD22	0.60	1	1
A:376:LEU:HD22	A:380:TYR:CD2	0.59	1	1
A:372:MET:HA	A:375:LYS:H	0.59	1	1
A:377:ASN:HD22	A:382:THR:HG22	0.55	1	1
A:374:GLU:O	A:378:LYS:HB3	0.52	1	1
A:380:TYR:CD1	B:51:LEU:HD13	0.52	1	1
A:375:LYS:HA	A:378:LYS:HB3	0.49	1	1
A:371:GLN:C	A:374:GLU:H	0.49	1	1
A:371:GLN:HA	A:374:GLU:HB2	0.49	1	1
A:372:MET:HE3	A:376:LEU:HG	0.48	1	1
A:379:LYS:HD2	B:2:LEU:HB2	0.48	1	1
A:379:LYS:CG	B:6:ILE:HG12	0.48	1	1
A:384:LEU:HB2	B:21:THR:HA	0.46	1	1
A:369:ILE:O	A:373:MET:HB2	0.45	1	1

Atom 1	Atom 2	Clash(Å)	Model ID (Worst)	Models (Total)
A:383:LYS:HB2	B:17:TYR:CD1	0.44	1	1
B:30:MET:HE2	B:53:GLU:CD	0.44	1	1
A:377:ASN:HB3	A:382:THR:CG2	0.41	1	1

Torsion angles: Protein backbone ?

In the following table, Ramachandran outliers are listed. The Analysed column shows the number of residues for which the backbone conformation was analysed.

Model ID	Analysed	Favored	Allowed	Outliers
1	477	455	20	2

There are 2 unique backbone outliers. Detailed list of outliers are tabulated below.

Chain	Res	Type	Models (Total)
A	43	LYS	1
A	44	GLY	1

Torsion angles : Protein sidechains ?

In the following table, sidechain rotameric outliers are listed. The Analysed column shows the number of residues for which the sidechain conformation was analysed.

Model ID	Analysed	Favored	Allowed	Outliers
1	423	397	19	7

There are 7 unique sidechain outliers. Detailed list of outliers are tabulated below.

Chain	Res	Type	Models (Total)
A	357	LEU	1
A	370	GLN	1
A	371	GLN	1
A	373	MET	1
A	378	LYS	1
A	384	LEU	1
B	20	VAL	1

5. Fit to Data Used for Modeling Assessment ?

5.2. Crosslinking-MS ?

5.2.1. Restraint types ?

This table summarizes information about crosslinker(s) used for data generation, and how crosslinking information was translated into actual modeling restraints. Restraints assigned "by-residue" are interpreted as between CA atoms. Restraints between coarse-grained

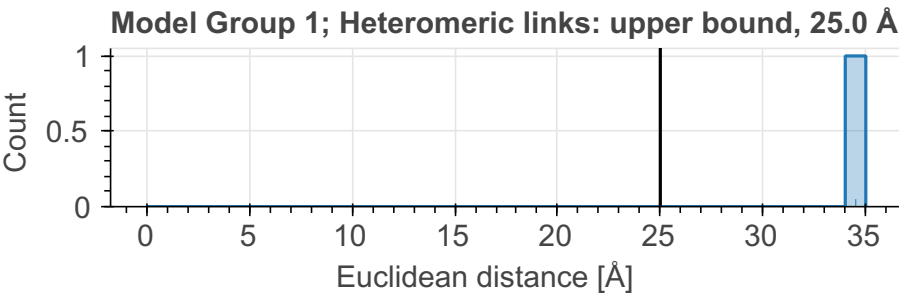
beads are indicated as "coarse-grained". *Restraint group* represents a set of crosslinking restraints applied collectively in the modeling.

There are 1 crosslinking restraints combined in 1 restraint groups.

Linker	Residue 1	Atom 1	Residue 2	Atom 2	Restraint type	Distance, Å	Count
SDA	LYS	CA	LYS	CA	upper bound	25.00	1

Distograms of individual restraints

Distograms (i.e., histogram plots of distances) provide an overview of distributions of distances between residues for which chemical crosslinks were identified. The shift of the distogram relative to the threshold value may indicate a poor model. Restraints with identical thresholds are grouped into one plot. Only the best distance per restraint per model group/ensemble is plotted. Inter- and intramolecular (including self-links) restraints are also grouped into one plot. Distance for a restraint between coarse-grained beads is calculated as a minimal distance between shells; if beads intersect, the distance will be reported as 0.0. A bead with the highest available resolution for a given residue is used for the assessment.



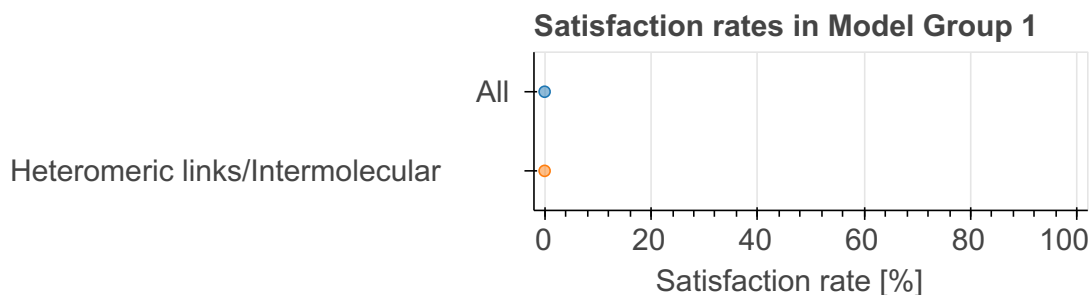
5.2.2. Satisfaction of restraints ?

*Satisfaction of restraints is calculated on a **restraint group** (a set of crosslinking restraints applied collectively in the modeling) level. Satisfaction of a restraint group depends on satisfaction of individual restraints in the group and the conditionality (all/any). A restraint group is considered satisfied, if the condition was met in at least one model of the model group/ensemble. The number of measured restraints can be smaller than the total number of restraint groups if crosslinks involve non-modeled residues. Only deposited models are used for validation right now.*

State group	State	Model group	# of Deposited models/Total	Restraint group type	Satisfied (%)	Violated (%)	Count (Total=1)
1	1	1	1/1	All	0.00	100.00	1
				Heteromeric links/ Intermolecular	0.00	100.00	1

Per-model satisfaction rates in ensembles

Every point represents one model in a model group/ensemble. Where possible, boxplots with quartile marks are also plotted.



6. Fit to Data Used for Validation Assessment

Validation for this section is under development.

Acknowledgments

The development of integrative model validation metrics, implementation of a model validation pipeline, and creation of a validation report for integrative structures are funded by NSF awards to the [PDB-IHM team](#) (DBI-1756248, DBI-2112966, DBI-2112967, DBI-2112968, and DBI-1756250) and awards from NSF, NIH, and DOE to the [RCSB PDB](#) (DBI-2321666, R01GM157729, and DE-SC0019749). The PDB-IHM team and members of the [Sali lab](#) contributed model validation metrics and software packages.

Dr. Jill Trewhella, Dr. Dina Schneidman, and members of the [SASBDB](#) repository are acknowledged for their advice and support in implementing SAS validation methods. Team members from the labs of Dr. Juri Rappsilber; Dr. Alexander Leitner; Dr. Andrea Graziadei, and members of [PRIDE](#) database are acknowledged for their advice and support in implementing crosslinking-MS validation methods. We are grateful to Dr. Shruthi Viswanath for discussions about uncertainty assessment of integrative structural models.

Members of the [wwPDB Integrative/Hybrid Methods Task Force](#) provided recommendations and community support for the project.