

Integrative Structure Validation Report ?

October 09, 2025 - 04:44 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	9A4L pdb_00009a4l
PDB-Dev ID	PDBDEV_00000242
Structure Title	Integrative model of ALF-ACNA by crosslinking MS and deep learning
Structure Authors	Stahl, K.; Brock, O.; Rappaport, J.
Deposited on	2024-01-22

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 ?

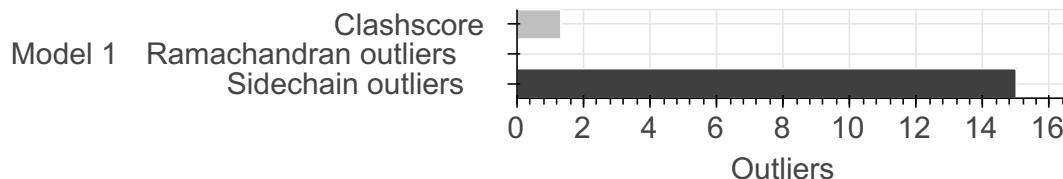
This entry consists of 1 model(s). A total of 1 dataset(s) were used to build this entry.

Name	Type	Count
Crosslinking-MS data	Experimental data	1

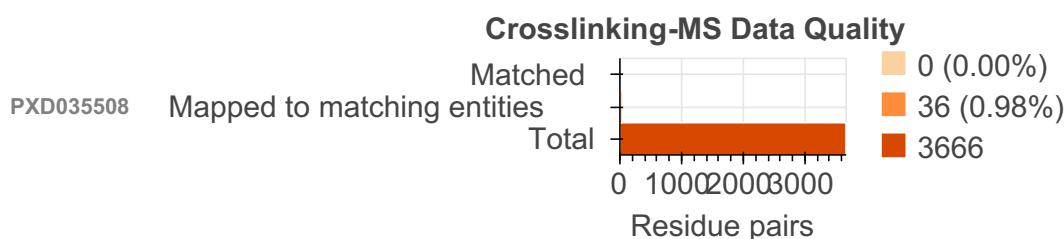
1.2. Overall quality ?

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.

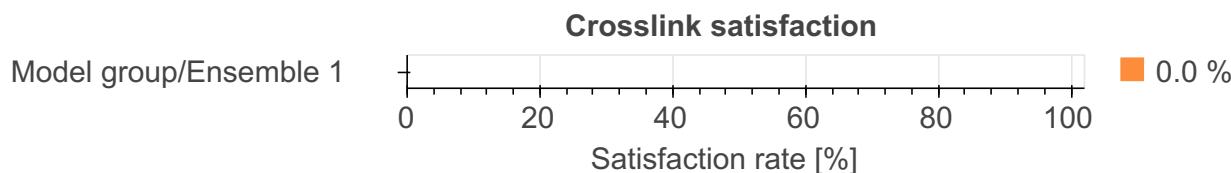
Model Quality: MolProbity Analysis [?](#)



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	ALF_BACSU	A	285	-	1-285	100.00 / 0.00	Atomic
		2	ACNA_BACSU	B	909	-	1-909	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	ALF_BACSU	dbseq_P13243_target	0.00	True
2	ACNA_BACSU	dbseq_P09339_target	0.00	True

Residue pairs stats:

Source	Total	In matched entities	Total matched
9A4L	1	1 (100.00%)	0 (0.00%)
PXD035508	3666	36 (0.98%)	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 26 bond angle outliers in this entry (0.21% of 12629 assessed bonds). A summary is provided below.

Chain	Res	Type	Atoms	Z	Observed (Å)	Ideal (Å)	Model ID (Worst)	Models (Total)
B	478	ASN	OD1-CG-ND2	5.37	117.23	122.60	1	1
B	226	ASN	CA-CB-CG	5.34	117.94	112.60	1	1
B	221	HIS	CB-CG-CD2	5.32	124.29	131.20	1	1
B	389	GLN	OE1-CD-NE2	5.07	117.53	122.60	1	1
B	595	GLN	OE1-CD-NE2	5.02	117.58	122.60	1	1
B	96	GLN	OE1-CD-NE2	5.01	117.59	122.60	1	1
B	178	GLN	OE1-CD-NE2	4.80	117.80	122.60	1	1
B	556	HIS	CB-CG-CD2	4.59	125.23	131.20	1	1
B	14	GLN	OE1-CD-NE2	4.54	118.06	122.60	1	1
A	32	GLN	OE1-CD-NE2	4.44	118.16	122.60	1	1
B	734	ARG	NE-CZ-NH2	4.40	123.16	119.20	1	1
B	189	GLN	OE1-CD-NE2	4.40	118.20	122.60	1	1
B	729	HIS	CB-CG-CD2	4.36	125.54	131.20	1	1
B	5	GLN	OE1-CD-NE2	4.31	118.29	122.60	1	1
B	643	ASP	CA-CB-CG	4.28	116.88	112.60	1	1
B	188	HIS	CB-CG-CD2	4.26	125.66	131.20	1	1
A	36	GLN	OE1-CD-NE2	4.26	118.34	122.60	1	1
A	83	HIS	CB-CG-CD2	4.25	125.67	131.20	1	1
A	181	HIS	CB-CG-CD2	4.17	125.78	131.20	1	1
B	615	GLN	OE1-CD-NE2	4.17	118.43	122.60	1	1
B	219	ASP	CA-CB-CG	4.12	108.48	112.60	1	1
B	136	HIS	CB-CG-CD2	4.10	125.87	131.20	1	1
B	720	ASN	C-CA-CB	4.10	117.89	110.10	1	1
B	837	ASN	CA-CB-CG	4.09	116.69	112.60	1	1
B	834	GLN	OE1-CD-NE2	4.05	118.55	122.60	1	1

Chain	Res	Type	Atoms	Z	Observed (Å)	Ideal (Å)	Model ID (Worst)	Models (Total)
B	125	ASN	OD1-CG-ND2	4.03	118.57	122.60	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	1.32	24

There are 24 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)
B:397:MET:HE1	B:563:TYR:CE1	0.67	1	1
B:304:LEU:HD22	B:333:TYR:CG	0.59	1	1
B:314:ALA:HA	B:317:TYR:CZ	0.59	1	1
B:491:VAL:HA	B:494:TYR:CE2	0.56	1	1
B:193:GLU:C	B:339:ARG:HH22	0.56	1	1
A:257:PRO:HA	A:260:TYR:CZ	0.53	1	1
B:679:ARG:HH21	B:758:TRP:CG	0.53	1	1
B:304:LEU:HD22	B:333:TYR:CD2	0.50	1	1
B:215:LEU:HD21	B:225:ILE:HG21	0.49	1	1
B:264:LYS:HZ3	B:301:GLU:CD	0.47	1	1
B:238:ILE:CD1	B:799:LYS:HE3	0.47	1	1
B:781:VAL:HG23	B:808:THR:HG23	0.47	1	1
A:257:PRO:HA	A:260:TYR:CE2	0.47	1	1
B:154:ASP:HA	B:635:ARG:HH12	0.45	1	1
B:117:VAL:HG21	B:906:MET:HE3	0.43	1	1
B:679:ARG:HH21	B:758:TRP:CD1	0.43	1	1
B:117:VAL:CG2	B:906:MET:HE3	0.42	1	1
B:104:VAL:HG12	B:166:PHE:CZ	0.41	1	1
B:314:ALA:HA	B:317:TYR:CE1	0.41	1	1
B:683:LYS:HE3	B:843:LEU:O	0.41	1	1
B:215:LEU:HD23	B:232:GLY:HA3	0.40	1	1
B:786:LYS:HE3	B:812:GLU:OE1	0.40	1	1
B:104:VAL:HG11	B:170:ALA:HB2	0.40	1	1
B:732:MET:HB3	B:796:TRP:CE3	0.40	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	1190	1157	33	0

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	984	952	17	15

There are 15 unique sidechain outliers. Detailed list of outliers are tabulated below.

Chain	Res	Type	Models (Total)
A	1	MET	1
A	164	LEU	1
B	7	THR	1
B	52	LEU	1
B	202	ILE	1
B	299	ILE	1
B	304	LEU	1
B	371	VAL	1
B	405	LEU	1
B	430	LEU	1
B	435	THR	1
B	612	LEU	1
B	643	ASP	1
B	790	MET	1
B	890	ASP	1

5. Fit to Data Used for Modeling Assessment ?

5.2. Crosslinking-MS ?

5.2.1. Restraint types ?

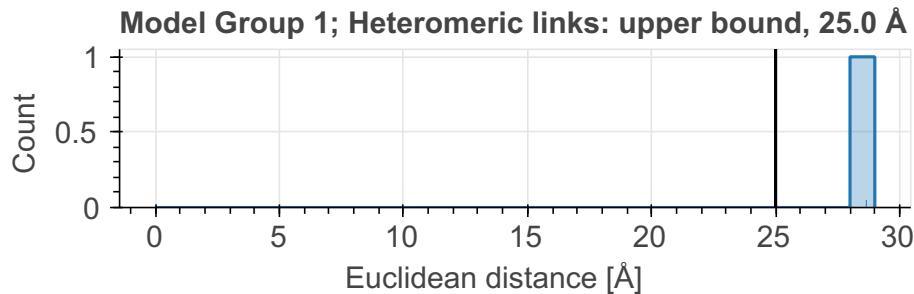
This table summarizes information about crosslinker(s) used for data generation, and how crosslinking information was translated into actual modeling restraints. Restraints assigned "by-residue" are interpreted as between CA atoms. Restraints between coarse-grained beads are indicated as "coarse-grained".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



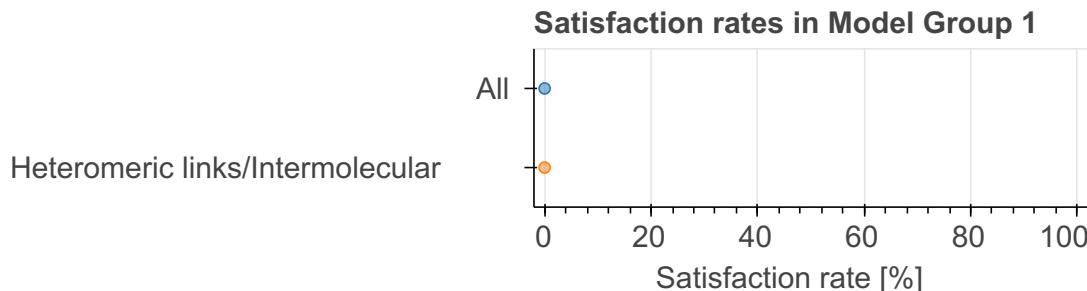
5.2.2. Satisfaction of restraints ?

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.