

Integrative Structure Validation Report ?

October 09, 2025 - 04:48 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	9A73 pdb_00009a73
PDB-Dev ID	PDBDEV_00000332
Structure Title	Integrative model of GCSPA-GCSPB 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 ?

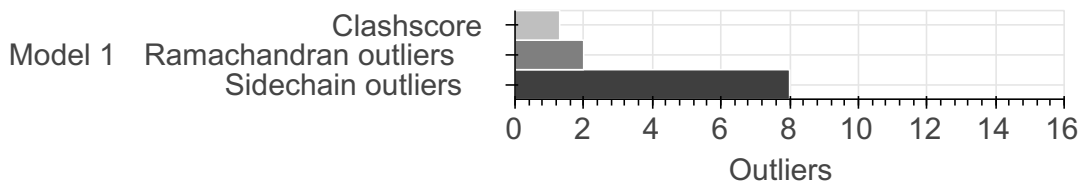
This entry consists of 1 model(s). A total of 1 dataset(s) were used to build this entry.

Name	Type	Count
Crosslinking-MS data	Experimental data	1

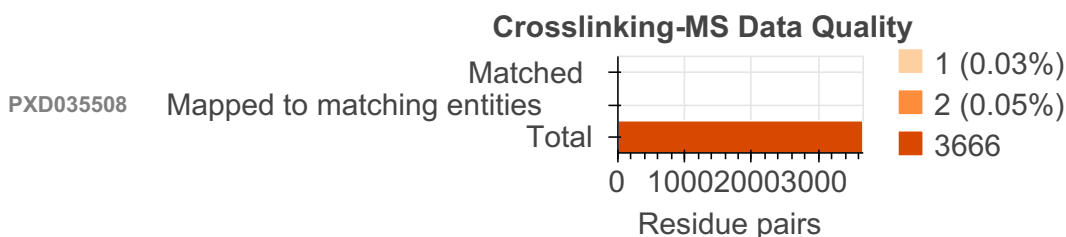
1.2. Overall quality ?

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.

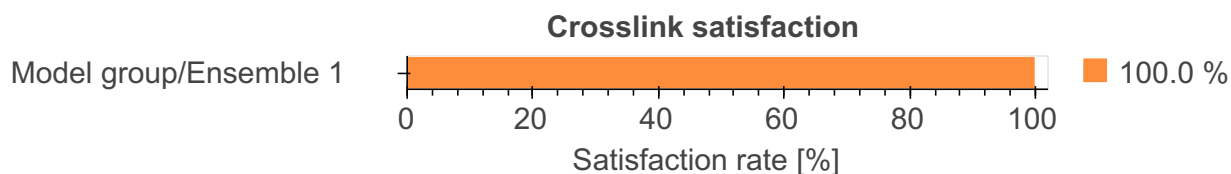
Model Quality: MolProbity Analysis ?



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	GCSPA_BACSU	A	448	-	1-448	100.00 / 0.00	Atomic
		2	GCSPE_BACSU	B	488	-	1-488	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	GCSPA_BACSU	dbseq_P54376_target	0.00	True
2	GCSPB_BACSU	dbseq_P54377_target	0.00	True

Residue pairs stats:

Source	Total	In matched entities	Total matched
9A73	5	5 (100.00%)	1 (20.00%)
PXD035508	3666	2 (0.05%)	1 (0.03%)

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 35 bond angle outliers in this entry (0.35% of 10079 assessed bonds). A summary is provided below.

Chain	Res	Type	Atoms	Z	Observed (Å)	Ideal (Å)	Model ID (Worst)	Models (Total)
B	459	GLN	OE1-CD-NE2	5.36	117.24	122.60	1	1
B	43	ASP	CA-CB-CG	5.16	117.76	112.60	1	1
B	71	ASP	CA-CB-CG	5.11	117.71	112.60	1	1
B	355	ASN	OD1-CG-ND2	5.09	117.51	122.60	1	1
A	332	GLN	OE1-CD-NE2	5.05	117.55	122.60	1	1
B	136	GLN	OE1-CD-NE2	4.97	117.63	122.60	1	1
B	105	GLN	OE1-CD-NE2	4.94	117.66	122.60	1	1
B	102	HIS	CB-CG-CD2	4.82	124.93	131.20	1	1
A	317	GLN	OE1-CD-NE2	4.79	117.81	122.60	1	1
A	431	ARG	NH1-CZ-NH2	4.67	113.23	119.30	1	1
A	69	GLN	OE1-CD-NE2	4.55	118.05	122.60	1	1
A	119	GLN	OE1-CD-NE2	4.50	118.10	122.60	1	1
A	318	HIS	CB-CG-CD2	4.49	125.37	131.20	1	1
A	14	GLN	OE1-CD-NE2	4.47	118.13	122.60	1	1
B	293	GLN	OE1-CD-NE2	4.47	118.13	122.60	1	1
A	42	HIS	CB-CG-CD2	4.45	125.41	131.20	1	1
B	381	HIS	CB-CG-CD2	4.42	125.45	131.20	1	1
A	256	GLN	OE1-CD-NE2	4.38	118.22	122.60	1	1
A	232	GLN	OE1-CD-NE2	4.36	118.24	122.60	1	1
A	301	ASP	CA-CB-CG	4.35	116.95	112.60	1	1
A	64	ASN	OD1-CG-ND2	4.33	118.27	122.60	1	1
A	133	SER	C-N-CA	4.31	129.45	121.70	1	1
B	238	GLN	OE1-CD-NE2	4.31	118.29	122.60	1	1
B	59	HIS	CB-CG-CD2	4.30	125.61	131.20	1	1
B	268	HIS	CB-CG-CD2	4.30	125.62	131.20	1	1

Chain	Res	Type	Atoms	Z	Observed (Å)	Ideal (Å)	Model ID (Worst)	Models (Total)
B	4	GLN	OE1-CD-NE2	4.27	118.33	122.60	1	1
B	261	ASP	CA-CB-CG	4.22	116.82	112.60	1	1
A	4	ARG	NE-CZ-NH2	4.17	122.95	119.20	1	1
A	104	GLN	OE1-CD-NE2	4.14	118.46	122.60	1	1
B	272	HIS	CB-CG-CD2	4.13	125.83	131.20	1	1
A	331	ASN	OD1-CG-ND2	4.11	118.49	122.60	1	1
A	165	HIS	CB-CG-CD2	4.11	125.86	131.20	1	1
B	155	HIS	CB-CG-CD2	4.10	125.87	131.20	1	1
B	380	LYS	C-CA-CB	4.06	117.81	110.10	1	1
A	134	SER	C-N-CA	4.03	128.96	121.70	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	1.30	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:50:GLU:HG3	B:88:ILE:HD12	0.57	1	1
A:244:LEU:HD11	A:354:ILE:HG21	0.51	1	1
B:245:TYR:HD2	B:267:VAL:HG23	0.47	1	1
A:101:THR:HG23	A:294:ARG:NH1	0.46	1	1
B:297:PRO:HA	B:317:ARG:HH22	0.45	1	1
A:16:MET:HE2	B:358:LEU:HG	0.45	1	1
A:366:LYS:HE3	A:376:VAL:HG11	0.45	1	1
B:81:THR:CG2	B:83:LYS:HE3	0.45	1	1
B:284:PRO:HG2	B:333:ILE:HD11	0.44	1	1
B:297:PRO:HA	B:317:ARG:NH2	0.44	1	1
B:75:TYR:CE1	B:410:HIS:CG	0.43	1	1
A:94:SER:HA	A:97:TYR:CE2	0.42	1	1
B:300:PRO:HG3	B:321:ILE:HD11	0.42	1	1
A:348:LYS:HE3	B:45:ASP:HB2	0.42	1	1
A:213:TYR:CE1	A:220:ILE:HG23	0.42	1	1
A:244:LEU:HD11	A:354:ILE:CG2	0.41	1	1

Atom 1	Atom 2	Clash(Å)	Model ID (Worst)	Models (Total)
B:344:MET:HE2	B:352:VAL:HG23	0.41	1	1
B:218:ASN:HA	B:219:PRO:C	0.40	1	1
A:36:VAL:CG1	B:262:MET:HG2	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	932	904	26	2

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

Chain	Res	Type	Models (Total)
A	134	SER	1
A	378	PHE	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	781	753	20	8

There are 8 unique sidechain outliers. Detailed list of outliers are tabulated below.

Chain	Res	Type	Models (Total)
A	23	SER	1
A	235	SER	1
A	359	LEU	1
B	43	ASP	1
B	51	VAL	1
B	230	THR	1
B	325	LYS	1
B	466	ILE	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

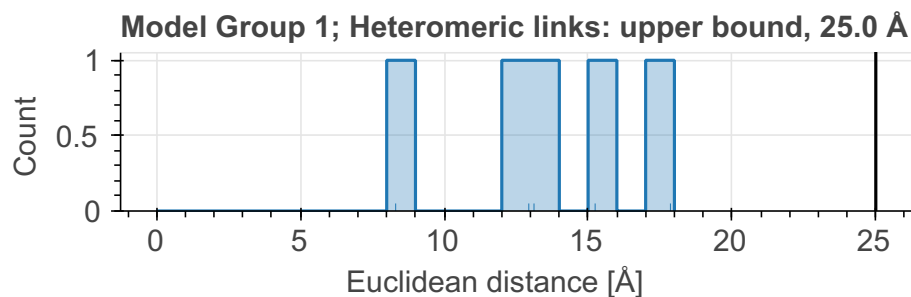
actual modeling restraints. Restraints assigned "by-residue" are interpreted as between CA atoms. Restraints between coarse-grained beads are indicated as "coarse-grained". Restraint group represents a set of crosslinking restraints applied collectively in the modeling.

There are 5 crosslinking restraints combined in 5 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	4
SDA	LYS	CA	SER	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=5)
1	1	1	1/1	All	100.00	0.00	5
				Heteromeric links/ Intermolecular	100.00	0.00	5

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.

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