Integrative Structure Validation Report

October 09, 2025 - 04:43 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	9A3D | pdb_00009a3d
PDB-Dev ID	PDBDEV_00000198
Structure Title	Model of E. coli BamB by in-cell photo-crosslinking MS and deep learning
Structure Authors	Stahl, K.; Graziadei, A.; Dau, T.; Brock, O.; Rappsilber, J.
Deposited on	2023-02-03

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

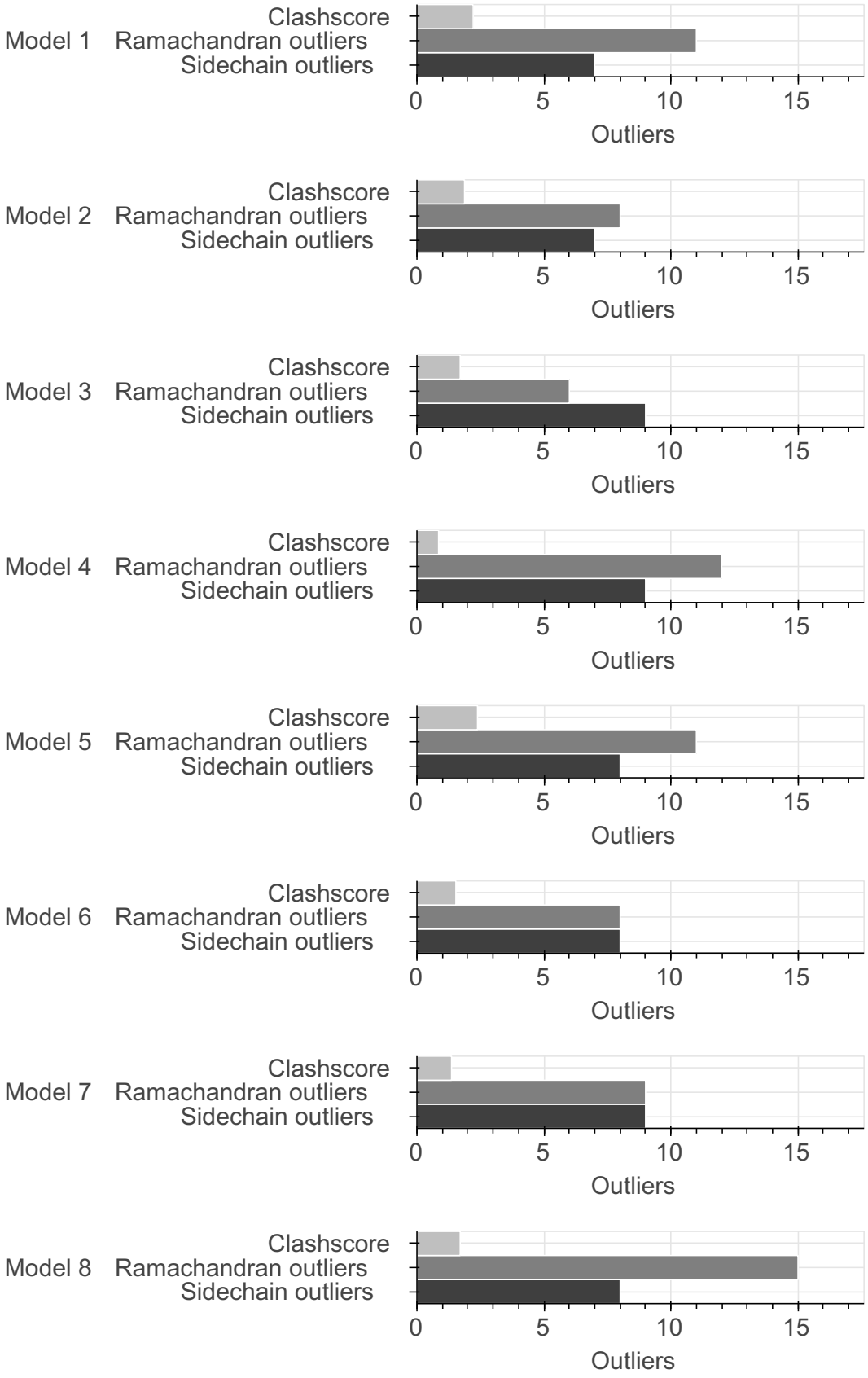
This entry consists of 10 model(s). A total of 1 dataset(s) were used to build this entry.

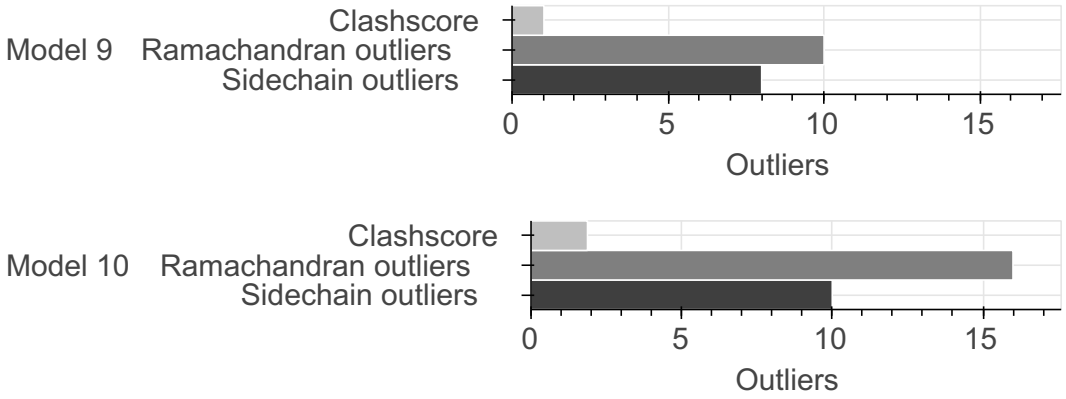
Name	Type	Count
Crosslinking-MS data	Experimental data	1

1.2. Overall quality

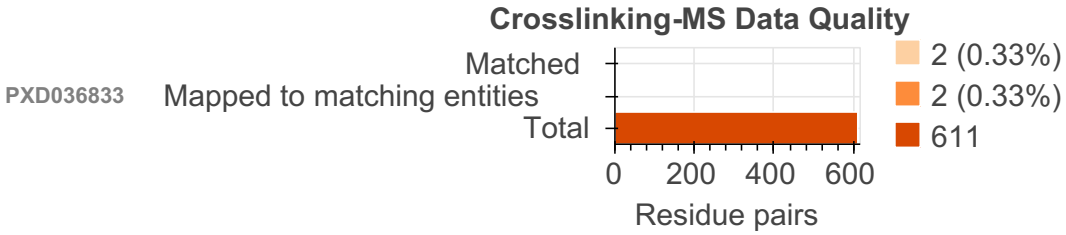
This validation report contains model quality assessments for all structures, data quality and fit to model assessments for SAS and crosslinking-MS datasets. Data quality and fit to model assessments for other datasets and model uncertainty are under development. Number of plots is limited to 256.

Model Quality: MolProbity Analysis

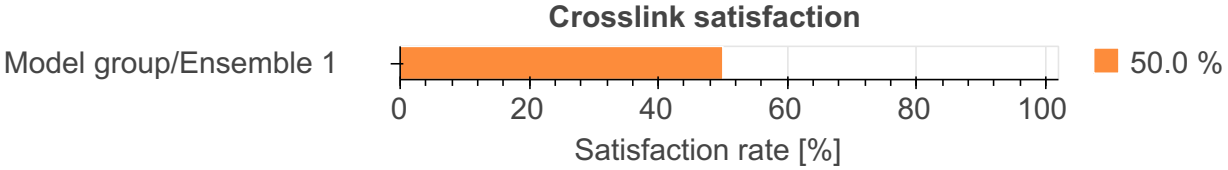




Data Quality



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	1-10	1	P77774	A	392	-	1-392	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	jPOSTrepo	JPST001851

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	AlphaLink	AlphaLink with 10 msa subsamples	Not available	10	False	False

There is 1 software package reported in this entry.

ID	Software name	Software version	Software classification	Software location
1	AlphaLink	1.00	model building	https://github.com/lhatsk/AlphaLink

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).

PXD036833

Number of entities in the crosslinking-MS dataset: 1102

Number of entities in the entry: 1

Matching entities:

Entity ID	Molecule name	Crosslinking-MS Entity ID	E-value	Exact match
1	P77774	dbseq_P77774_target	0.00	True

Residue pairs stats:

Source	Total	In matched entities	Total matched
9A3D	2	2 (100.00%)	2 (100.00%)
PXD036833	611	2 (0.33%)	2 (0.33%)

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-partice 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 214 bond angle outliers in this entry (0.52% of 40920 assessed bonds). A summary is provided below.

Chain	Res	Type	Atoms	|Z|	Observed (Å)	Ideal (Å)	Model ID (Worst)	Models (Total)
A	2	GLN	C-N-CA	8.85	137.63	121.70	7	3
A	223	GLN	OE1-CD-NE2	6.33	116.27	122.60	9	10
A	194	LEU	C-N-CA	6.17	132.81	121.70	7	1
A	6	LEU	C-N-CA	6.09	132.66	121.70	6	1
A	8	LEU	CA-C-N	5.87	125.70	116.90	3	2
A	368	GLN	OE1-CD-NE2	5.86	116.74	122.60	1	9
A	76	ASP	CA-CB-CG	5.65	118.25	112.60	9	10
A	324	HIS	CB-CG-CD2	5.62	123.90	131.20	6	1
A	242	ASP	CA-CB-CG	5.59	118.19	112.60	1	6
A	62	ASN	OD1-CG-ND2	5.56	117.04	122.60	2	1
A	341	ASP	CA-CB-CG	5.55	118.15	112.60	9	8
A	229	GLN	OE1-CD-NE2	5.52	117.08	122.60	1	3
A	360	GLN	OE1-CD-NE2	5.51	117.09	122.60	2	8
A	301	GLN	OE1-CD-NE2	5.37	117.23	122.60	4	6
A	19	GLY	C-N-CA	5.31	131.26	121.70	1	1
A	170	GLN	OE1-CD-NE2	5.29	117.31	122.60	9	7
A	9	PRO	CA-N-CD	5.27	104.63	112.00	9	2
A	319	GLN	OE1-CD-NE2	5.18	117.42	122.60	2	2
A	172	GLN	OE1-CD-NE2	5.15	117.45	122.60	3	10
A	4	ARG	C-N-CA	4.96	130.62	121.70	3	3
A	234	GLN	OE1-CD-NE2	4.94	117.66	122.60	1	10
A	168	ASN	OD1-CG-ND2	4.93	117.67	122.60	3	7
A	26	GLU	O-C-N	4.89	115.18	123.00	10	1
A	64	HIS	CB-CG-CD2	4.89	124.85	131.20	2	3
A	62	ASN	CA-CB-CG	4.85	117.45	112.60	2	1

Chain	Res	Type	Atoms	|Z|	Observed (Å)	Ideal (Å)	Model ID (Worst)	Models (Total)
A	187	LEU	C-N-CA	4.83	130.39	121.70	4	3
A	230	GLN	OE1-CD-NE2	4.75	117.85	122.60	3	10
A	130	GLN	OE1-CD-NE2	4.68	117.92	122.60	2	6
A	211	GLY	C-N-CA	4.66	130.09	121.70	1	1
A	266	ASN	OD1-CG-ND2	4.66	117.94	122.60	4	9
A	359	GLN	OE1-CD-NE2	4.64	117.96	122.60	1	2
A	39	GLU	C-N-CA	4.64	130.05	121.70	2	1
A	41	GLN	OE1-CD-NE2	4.57	118.03	122.60	1	7
A	40	ASN	OD1-CG-ND2	4.54	118.06	122.60	1	4
A	1	MET	C-N-CA	4.50	129.80	121.70	2	2
A	195	ARG	NH1-CZ-NH2	4.47	113.49	119.30	9	1
A	215	ARG	NE-CZ-NH1	4.44	125.94	121.50	4	1
A	276	GLN	OE1-CD-NE2	4.43	118.17	122.60	6	10
A	190	PRO	CA-N-CD	4.40	105.85	112.00	7	1
A	26	GLU	CA-C-N	4.39	124.98	116.20	10	1
A	347	HIS	CB-CG-CD2	4.38	125.51	131.20	7	8
A	363	ASP	CA-CB-CG	4.37	108.23	112.60	9	1
A	175	ASN	OD1-CG-ND2	4.36	118.24	122.60	9	3
A	188	ASP	CA-CB-CG	4.35	116.95	112.60	1	1
A	7	LEU	N-CA-CB	4.35	103.10	110.50	6	1
A	264	ASN	OD1-CG-ND2	4.33	118.27	122.60	1	2
A	246	ASP	C-CA-CB	4.32	118.31	110.10	1	1
A	325	ARG	NE-CZ-NH2	4.32	123.09	119.20	6	1
A	3	LEU	C-N-CA	4.25	129.34	121.70	10	1
A	295	ARG	NH1-CZ-NH2	4.23	113.80	119.30	6	1
A	24	ASN	OD1-CG-ND2	4.23	118.37	122.60	4	2
A	5	LYS	C-N-CA	4.20	129.27	121.70	8	2
A	355	ARG	NE-CZ-NH2	4.20	122.98	119.20	6	1
A	58	ASN	OD1-CG-ND2	4.16	118.44	122.60	4	2
A	10	GLY	C-N-CA	4.15	129.17	121.70	8	1
A	300	ASP	C-CA-CB	4.14	117.96	110.10	1	1
A	195	ARG	N-CA-CB	4.12	103.49	110.50	6	1
A	57	GLY	C-N-CA	4.12	129.11	121.70	2	1
A	195	ARG	N-CA-C	4.11	122.52	111.00	7	1
A	193	SER	C-N-CA	4.11	129.10	121.70	7	1

Chain	Res	Type	Atoms	|Z|	Observed (Å)	Ideal (Å)	Model ID (Worst)	Models (Total)
A	2	GLN	O-C-N	4.11	116.43	123.00	7	1
A	154	ARG	NE-CZ-NH2	4.10	122.89	119.20	2	1
A	26	GLU	C-N-CA	4.09	129.06	121.70	10	1
A	2	GLN	OE1-CD-NE2	4.09	118.51	122.60	10	1
A	28	ASP	N-CA-C	4.08	99.58	111.00	10	1
A	215	ARG	NH1-CZ-NH2	4.07	114.01	119.30	4	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	2.21	13
2	1.87	11
3	1.70	10
4	0.85	5
5	2.38	14
6	1.53	9
7	1.36	8
8	1.70	10
9	1.02	6
10	1.87	11

There are 97 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:5:LYS:HB3	A:6:LEU:HD12	0.68	6	1
A:35:LEU:HD21	A:324:HIS:CE1	0.67	6	1
A:360:GLN:HE22	A:390:ILE:HG23	0.63	2	1
A:42:PHE:CZ	A:44:PRO:HG3	0.62	2	1
A:235:ALA:HB1	A:243:ARG:HA	0.61	1	1
A:35:LEU:HD21	A:324:HIS:NE2	0.59	6	1
A:261:LEU:HD21	A:286:VAL:HB	0.55	1	4
A:62:ASN:HB3	A:369:THR:HG22	0.55	5	1
A:286:VAL:HA	A:300:ASP:HA	0.54	1	7
A:41:GLN:NE2	A:355:ARG:HH12	0.54	5	6
A:150:GLU:CD	A:195:ARG:HH21	0.53	9	1

Atom 1	Atom 2	Clash(Å)	Model ID (Worst)	Models (Total)
A:189:MET:HE1	A:212:ASP:OD2	0.53	3	1
A:261:LEU:HD21	A:286:VAL:CG1	0.52	3	6
A:64:HIS:CE1	A:154:ARG:HH11	0.51	1	1
A:190:PRO:CD	A:213:ASN:HD21	0.51	8	1
A:194:LEU:HD12	A:244:LEU:HD11	0.50	5	1
A:169:GLY:HA2	A:189:MET:HE3	0.50	1	1
A:308:LEU:HD23	A:315:THR:HA	0.50	7	2
A:48:TRP:CE2	A:389:SER:HB2	0.49	2	5
A:213:ASN:ND2	A:215:ARG:HH21	0.49	1	1
A:63:LEU:O	A:369:THR:HG21	0.49	5	1
A:212:ASP:HA	A:246:ASP:HA	0.49	1	1
A:44:PRO:HB2	A:360:GLN:HE21	0.49	2	1
A:189:MET:SD	A:211:GLY:HA3	0.48	2	1
A:64:HIS:NE2	A:154:ARG:HD3	0.48	9	2
A:152:LEU:CD1	A:195:ARG:HB3	0.48	4	1
A:265:GLY:HA3	A:284:GLY:O	0.47	10	4
A:331:VAL:HG11	A:371:PRO:O	0.47	5	2
A:295:ARG:HH12	A:352:GLU:HA	0.47	10	6
A:24:ASN:C	A:26:GLU:H	0.46	10	1
A:285:SER:HB2	A:301:GLN:CD	0.46	3	1
A:64:HIS:CE1	A:154:ARG:HD3	0.46	1	1
A:167:SER:HA	A:197:GLU:OE2	0.46	3	1
A:73:TYR:CD1	A:117:VAL:HG21	0.43	5	5
A:193:SER:HB2	A:212:ASP:CB	0.43	6	1
A:249:THR:HG21	A:261:LEU:HD23	0.43	1	1
A:152:LEU:HB3	A:196:GLY:HA2	0.42	2	1
A:297:TYR:CD1	A:337:LEU:HD11	0.42	5	1
A:165:HIS:NE2	A:189:MET:CE	0.42	1	1
A:238:SER:HA	A:242:ASP:OD2	0.42	2	1
A:303:ASP:OD1	A:325:ARG:HA	0.42	2	1
A:307:ALA:C	A:308:LEU:HD12	0.42	5	1
A:83:ALA:HB2	A:93:TRP:CE2	0.41	7	6
A:156:VAL:HG21	A:200:PRO:O	0.41	7	1
A:52:VAL:O	A:80:LEU:HD23	0.41	3	1
A:26:GLU:HB3	A:28:ASP:H	0.41	10	1

Atom 1	Atom 2	Clash(Å)	Model ID (Worst)	Models (Total)
A:285:SER:HB3	A:301:GLN:CD	0.41	10	2
A:121:HIS:HB2	A:123:TYR:CZ	0.41	2	2
A:26:GLU:HA	A:27:GLU:C	0.41	10	1
A:38:VAL:HG12	A:40:ASN:H	0.40	7	1
A:173:ALA:HB2	A:183:TRP:CZ2	0.40	6	1
A:59:PHE:HB3	A:60:TYR:CD2	0.40	8	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	390	347	32	11
2	390	349	33	8
3	390	366	18	6
4	390	351	27	12
5	390	361	18	11
6	390	357	25	8
7	390	354	27	9
8	390	351	24	15
9	390	354	26	10
10	390	355	19	16

There are 39 unique backbone outliers. Detailed list of outliers are tabulated below.

Chain	Res	Type	Models (Total)
A	28	ASP	9
A	105	SER	8
A	26	GLU	7
A	11	LEU	5
A	16	LEU	5
A	312	GLY	5
A	9	PRO	4
A	21	SER	4
A	188	ASP	4
A	2	GLN	3
A	5	LYS	3
A	15	THR	3

Chain	Res	Type	Models (Total)
A	17	LEU	3
A	20	CYS	3
A	29	VAL	3
A	3	LEU	2
A	4	ARG	2
A	12	LEU	2
A	13	SER	2
A	14	VAL	2
A	18	SER	2
A	19	GLY	2
A	27	GLU	2
A	59	PHE	2
A	106	LYS	2
A	167	SER	2
A	195	ARG	2
A	196	GLY	2
A	6	LEU	1
A	7	LEU	1
A	8	LEU	1
A	25	SER	1
A	30	VAL	1
A	31	LYS	1
A	40	ASN	1
A	103	TRP	1
A	114	GLY	1
A	190	PRO	1
A	323	LEU	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	321	308	6	7
2	321	303	11	7
3	321	304	8	9
4	321	309	3	9

Model ID	Analysed	Favored	Allowed	Outliers
5	321	302	11	8
6	321	306	7	8
7	321	306	6	9
8	321	305	8	8
9	321	302	11	8
10	321	302	9	10

There are 22 unique sidechain outliers. Detailed list of outliers are tabulated below.

Chain	Res	Type	Models (Total)
A	300	ASP	10
A	8	LEU	9
A	6	LEU	8
A	12	LEU	8
A	11	LEU	7
A	76	ASP	7
A	3	LEU	6
A	15	THR	4
A	16	LEU	4
A	189	MET	3
A	285	SER	3
A	18	SER	2
A	194	LEU	2
A	212	ASP	2
A	21	SER	1
A	37	THR	1
A	99	GLU	1
A	192	LEU	1
A	270	LEU	1
A	281	ARG	1
A	329	SER	1
A	369	THR	1

5. Fit to Data Used for Modeling Assessment

5.2. Crosslinking-MS

5.2.1. Restraint types

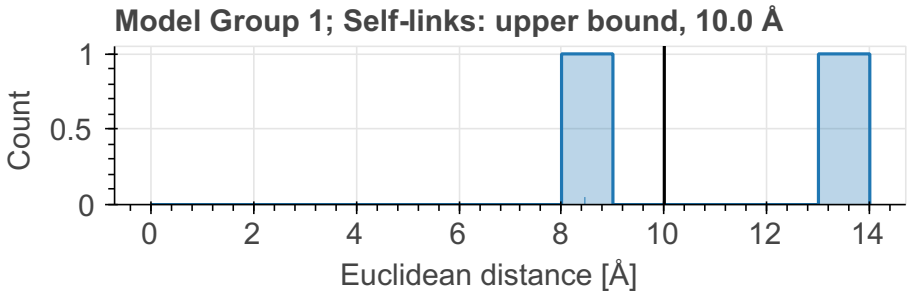
This table summarizes information about crosslinker(s) used for data generation, and how crosslinking information was translated into actual modeling restraints. Restraints assigned "by-residue" are interpreted as between CA atoms. Restraints between coarse-grained beads are indicated as "coarse-grained". Restraint group represents a set of crosslinking restraints applied collectively in the modeling.

There are 2 crosslinking restraints combined in 2 restraint groups.

Linker	Residue 1	Atom 1	Residue 2	Atom 2	Restraint type	Distance, Å	Count
L-Photo-Leucine	ALA	CA	LEU	CA	upper bound	10.00	1
L-Photo-Leucine	ASN	CA	LEU	CA	upper bound	10.00	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=2)
1	1	1	10/10	All	50.00	50.00	2
				Self-links/ Intramolecular	50.00	50.00	2

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.