Joint CASP15-CAPRI54 assembly prediction round of 2022

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Thanks to: Andriy Krystafovych, Burcu Őzden Yűcel, Ezgi Karaca

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European Bioinformatics Institute (EMBL-EBI), Hinxton, UK
Structural Biology Group, VUB-VIB, Brussels, Belgium

CAPRI

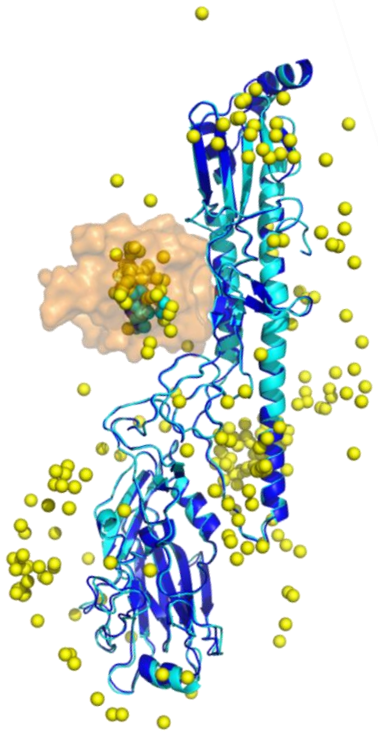
CAPRI

Since 2001

Critical **A**ssessment of
PRedicted **I**nteractions

Community-wide double blind experiment modelled after CASP, launched in 2001, aimed at assessing the performance of protein docking and scoring algorithms.

Prediction of the structure of an unpublished protein-protein, protein-DNA/RNA, protein-peptide, protein-sugar complex; extended to the prediction of binding affinity and interface water position.



Proteins, Nucleic acids, Polysaccharides, Water, Peptides, Interfaces, Assemblies, SAXS, Binding affinities, Multi-domain organization

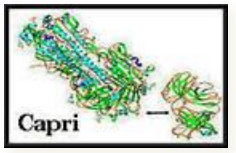
Marc

Shoshana

Guillaume

Sameer

Nurul



assessment, organization, website, operations, infrastructure

CAPRI

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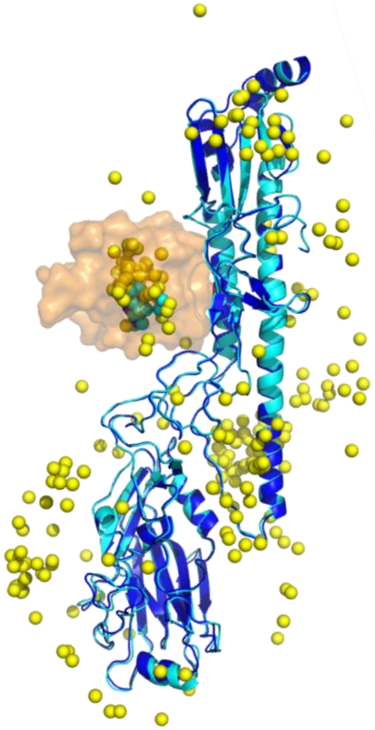
Since 2001

Critical **A**ssessment of
PRedicted **I**nteractions

Dynamic experiment

Docking experiment

Scoring experiment



Proteins, Nucleic acids, Polysaccharides, Water, Peptides, Interfaces, Assemblies, SAXS, Binding affinities, Multi-domain organization

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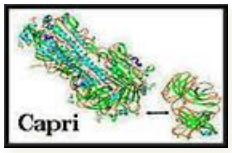

assessment, organization, website, operations, infrastructure

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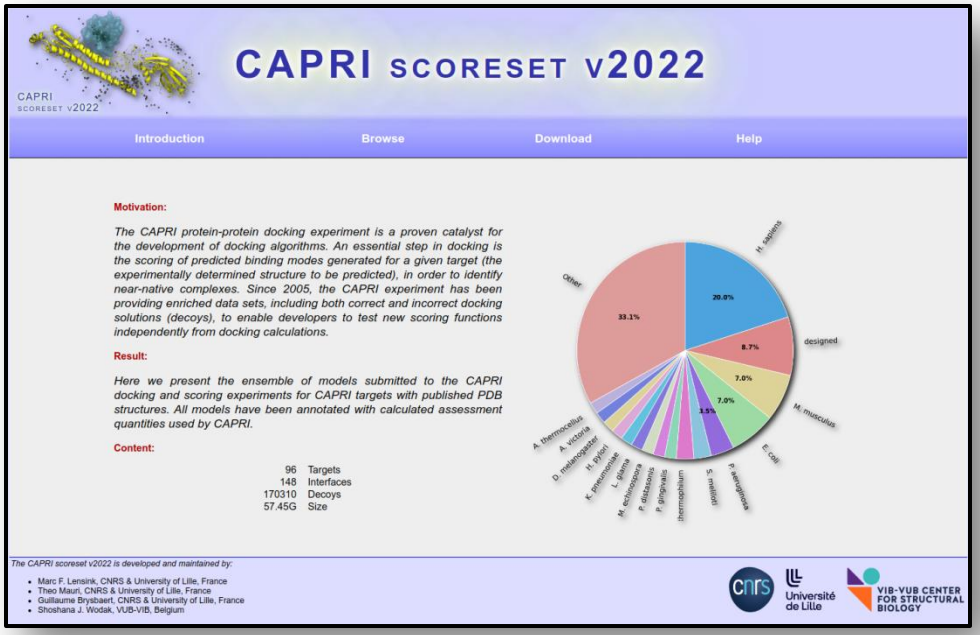
Critical **A**ssessment of
PRedicted **I**nteractions

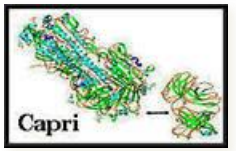
Dynamic experiment

Docking experiment

Scoring experiment

scoreset.org





Website

CAPRI

Since 2001

Critical **A**ssessment of
PRedicted **I**nteractions

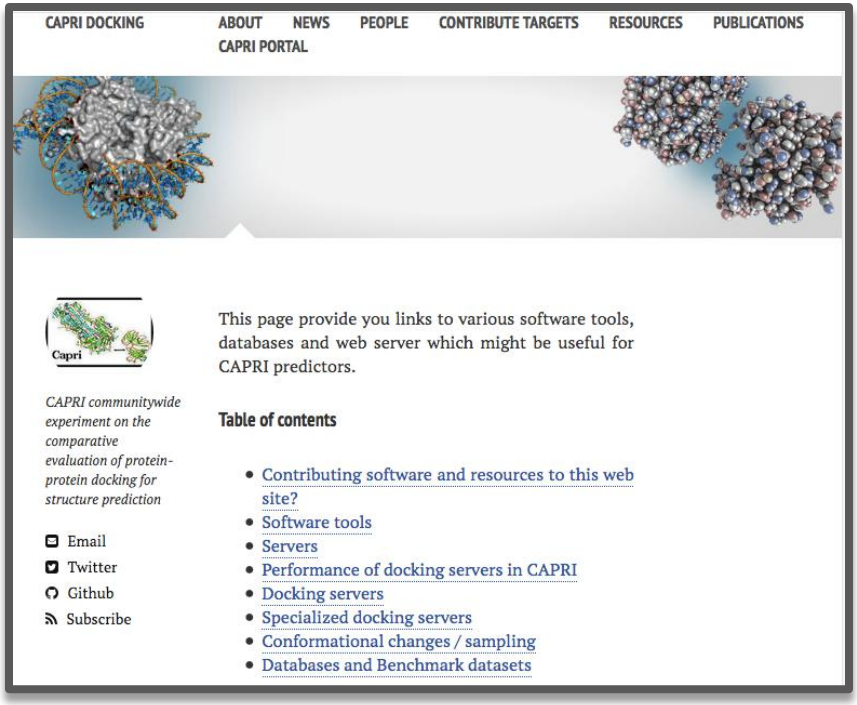
https://www.pdbe.org/capri

(for prediction submission)

https://www.capri-docking.org/

(community exchange portal)

@CAPRIdock



Meetings

CAPRI

Since 2001

Critical **A**ssessment of
PRedicted **I**nteractions

Dynamic experiment

Docking experiment

Scoring experiment

Assessment meetings

Management committee

La Londe-des-Maures	France	2002
Gaeta	Italy	2004
Toronto	Canada	2007
Barcelona	Spain	2009
Utrecht	The Netherlands	2013
Tel Aviv	Israel	2016
EBI Hinxton	UK	2019

Alexandre Bonvin	The Netherlands
Marc Lensink	France
Michael Sternberg	UK
Sandor Vajda	USA
Ilya Vakser	USA
Sameer Velankar	UK
Shoshana Wodak	Belgium
Joel Janin	France

CAPRI evaluation meetings

To date: 54 rounds, 230 targets. 7 Evaluation meetings + CASP11/12/13/14/15

7 Special Issues of Proteins dedicated to CAPRI, 2003 – 2020

CAPRI / CASP

CAPRI

Since 2001

Critical **A**ssessment of
PRedicted **I**nteractions

Joint prediction rounds since 2014:

25 Targets	Round 30
10 Targets	Round 37
21 Targets	Round 46
12 Targets	Round 50
37 Targets	Round 54

Prediction rounds on a "rolling" basis

Fits with publication schedule

3 to 4 weeks per prediction round

CASP

Since 1994

Structure **P**redictions

CASP11	2014
CASP12	2016
CASP13	2018
CASP14	2020
CASP15	2022

Prediction season

Intense 2 to 3 months

Difference in targets

Mostly hetero-dimers or –trimers
Peptides, sugars, water positions

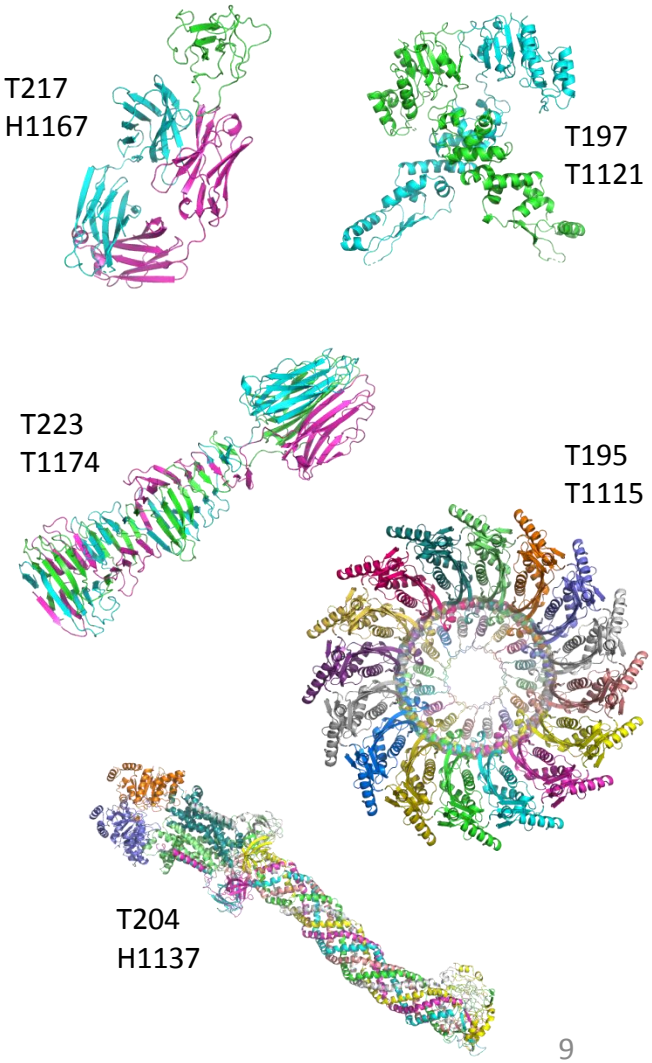
Incites method development

Mostly obligate, many homo-oligomers
Very large assemblies

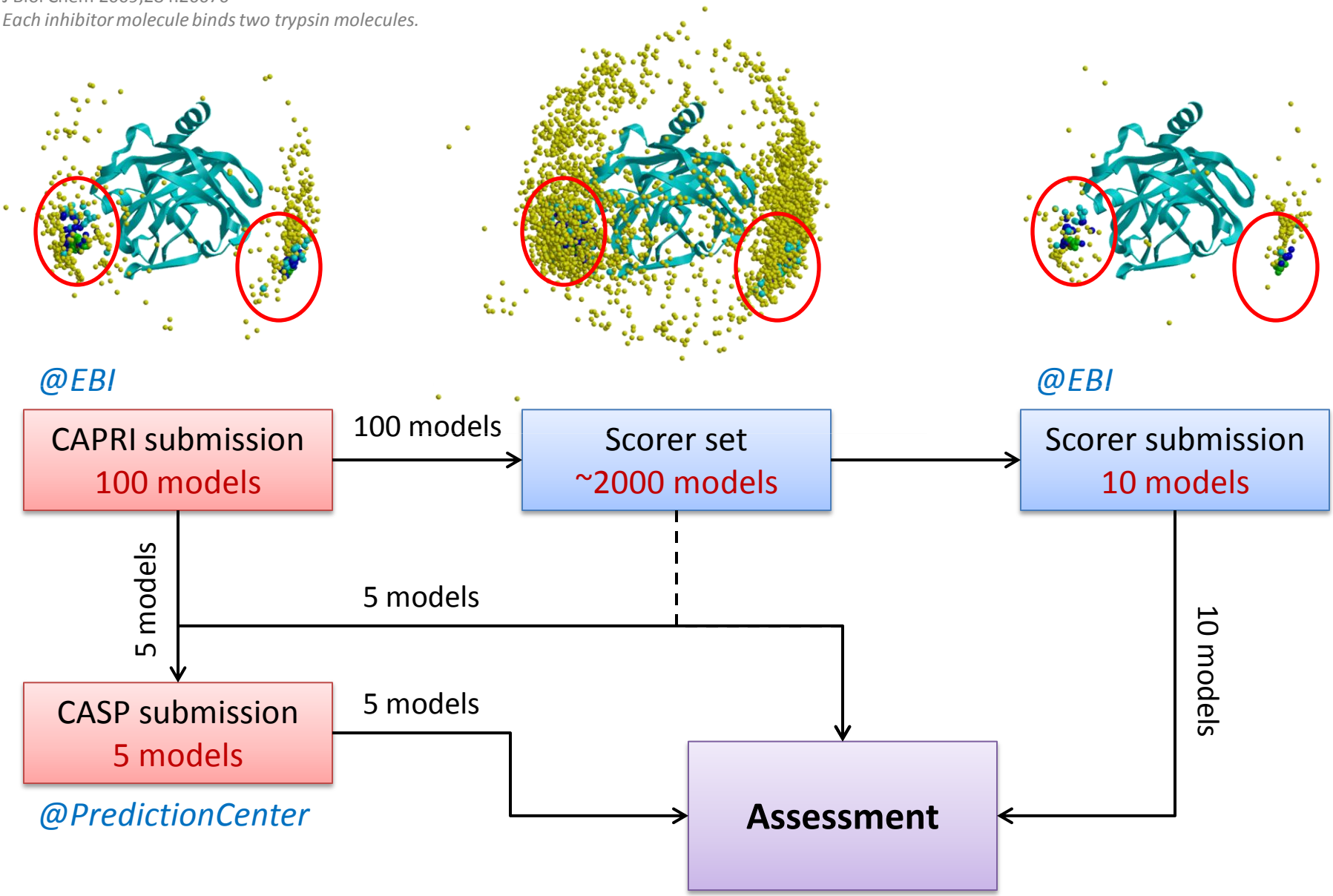
Large-scale testing of methodologies

CASP15/CAPRI statistics

CAPRI	T191 – T230		
CASP	H1106 – T1192		
Homodimers	11		
Homotrimers	3		
Hetero targets	16		
Large assemblies	7		
Multi-interface targets	5		
Number of targets	37 (4 fewer than CASP)		
Easy / Difficult targets	18 / 19		
Number of models (total)	**67 851**		
Number of models (top-5)	21 941		
Registered groups	**23**	**85**	**15**
Submitting groups	19 – 21	40 – 69	14 – 15
	CAPRI	CASP	Scorers

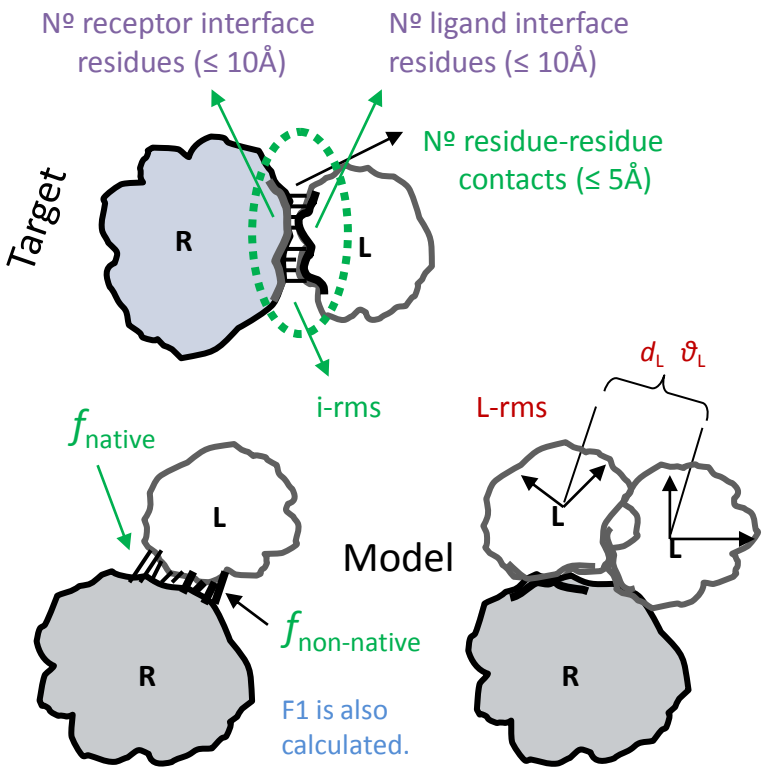


T40; Bovine trypsin/protease inhibitor
Yuxing Chen, Rui Bao; University of Science and Technology, China
J Biol Chem 2009;284:26676
Each inhibitor molecule binds two trypsin molecules.



CAPRI Assessment

- Assessment criteria established as community consensus
- Chosen in accordance with the experiment community
- Intuitively understand model quality



f_{native}
residue-residue
5 Å

i-rms
Interface
backbone
10 Å

S-rms
Interface
side-chain
10 Å

L-rms
ligand backbone

$n_{clashes}$
atom-atom
3 Å

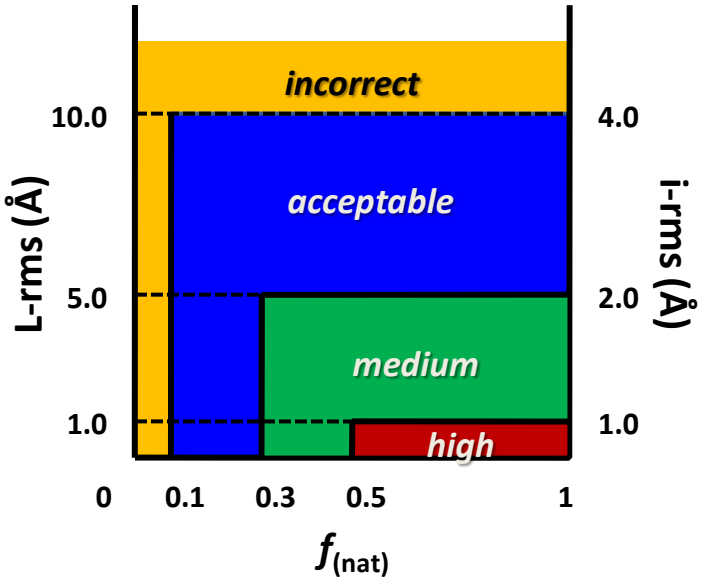
d_L

ϑ_L

*Only **L-rms**, **i-rms** and f_{nat} are used to classify protein-protein interaction models in CAPRI.*

Additional quantities are being calculated, such as S-rms, which are useful quality measures for protein-peptide interaction models.

An additional condition may be placed on f_{nonnat} values in the future.



-Focusing on individual interfaces of interaction

CAPRI Assessment

1. CAPRI assessment is
   a) receptor/ligand and
   b) interface based
   - L-rms
   - *f*(nat); i-rms

2. Four assessment categories
   - incorrect, acceptable, medium, high

3. For multimeric targets, each interface is assessed separately; depending on complexity, targets may then be split up into several assessment units (AU), with an AU representing a combination of individual interface scores
   - Either an AverageOf or BestOf

4. Final predictor score is the sum of these scores

$$\text{Score} = \omega_1 \cdot N_{ACC} + \omega_2 \cdot N_{MED} + \omega_3 \cdot N_{HIGH}$$

$$\omega_1 = 1;\ \omega_2 = 2;\ \omega_3 = 3$$

*Only **L-rms**, **i-rms** and f_{nat} are used to classify protein-protein interaction models in CAPRI.*

Additional quantities are being calculated, such as S-rms, which are useful quality measures for protein-peptide interaction models.

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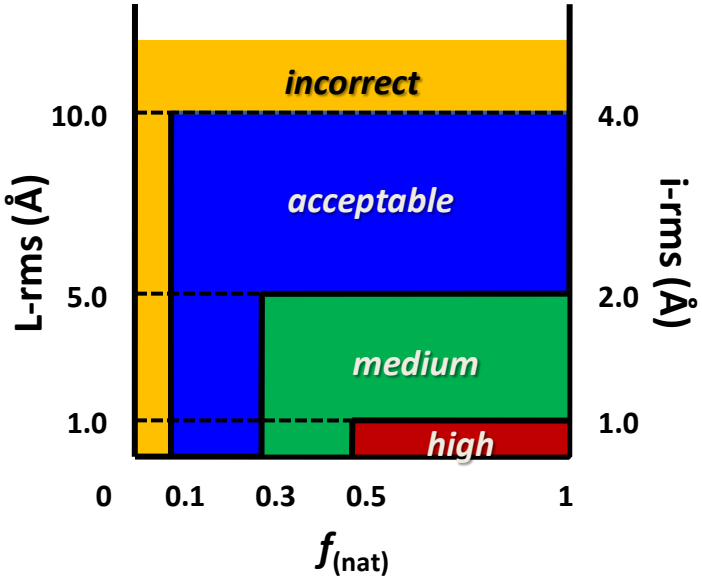


Targets with one interface (A2) and no intertwining

T198/T1123 Easy

T201/T1132 Easy

T211/T1153 Difficult

T225/T1178 Easy

T226/T1179 Easy

T229/T1187 Easy

Large assemblies

T195/T1115 Difficult

T230/T1192 Easy

Targets with one interface (A2/A3) and intertwining

T194/T1113 Difficult

T197/T1121 Difficult

T199/T1123 Easy

T213/T1160 Easy

T214/T1161 Easy

T224/T1176 Difficult

T219/T1170 Easy

T220/H1171 Easy

T221/H1172 Easy

T222/T1173 Difficult

T223/T1174 Difficult

T227/T1181 Difficult

(T192/T1109 *) Easy

T193/T1110 * Easy

* A point mutation (D180A) removes the intertwining of T193

T203/H1135 Easy

T204/H1137 Difficult

Hetero-targets with one interface (A1B1)

T191/H1106 Easy

T200/H1129 Easy

T202/H1134 Difficult

T210/H1151 Easy

T212/H1157 Difficult

T205/H1140 Difficult

T206/H1141 Difficult

T207/H1142 Difficult

T208/H1143 Difficult

T209/H1144 Difficult

Targets with one interface (A1B1 or A:HL): nanobodies and antibodies

T216/H1166 Difficult

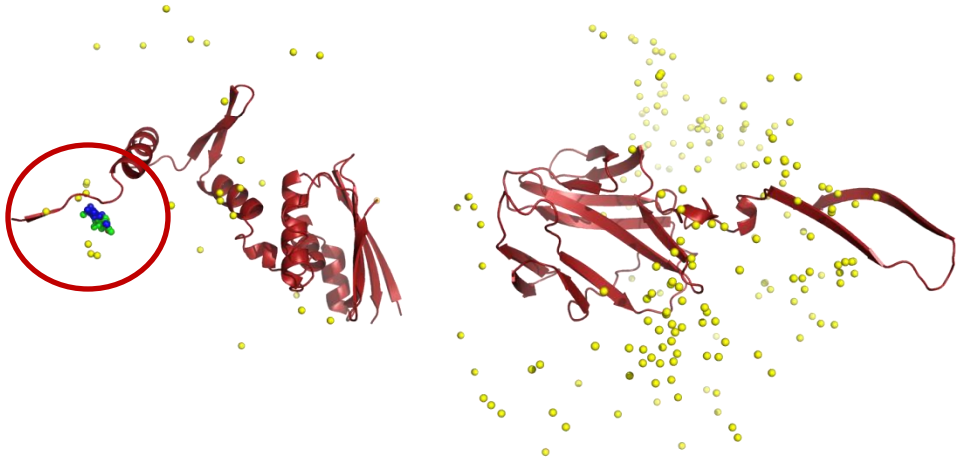
T217/H1167 Difficult

T218/H1168 Difficult

- Most target assessments are single-interface:
  - A2
  - A1B1
  - A3
  - A10
  - A16
- But some are more complicated *(and may lead to multiple assessment units)*:
  - A9B3
  - A1B1C1D1E1F1G2H1I1
  - A6/A6B1/A6B2

- Target difficulty:
  - Traditionally by template availability
    - TBM, FM
  - Now, assessed manually on basis of
    - Extent of conformational change (at interface)
    - Domain entanglement or swapping
    - Template availability
    - AlphaFold model and confidence level (p-lDDT)

  - **EASY or DIFFICULT**

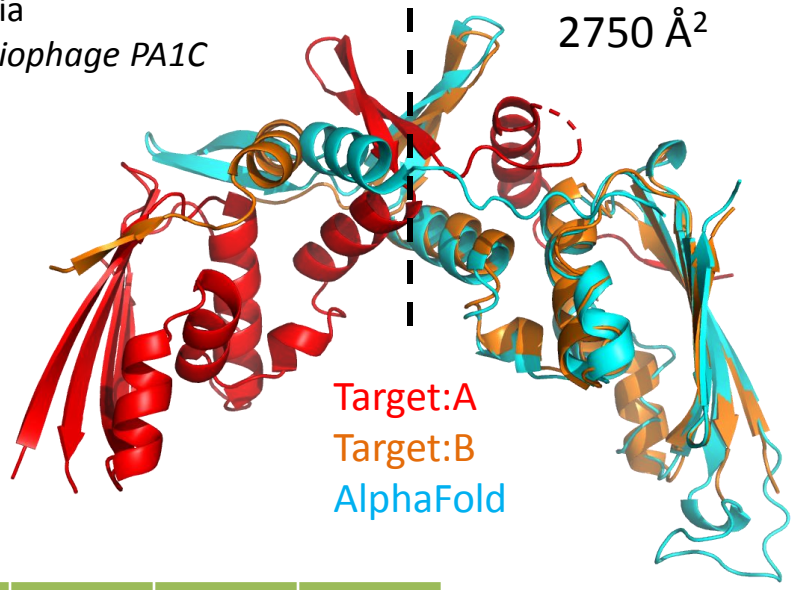


T1113/T194 T1176/T224

Examples of target difficulty

T194	T1113	no pdb	Xray	2.63	A2

Bacteria
Bacteriophage PA1C



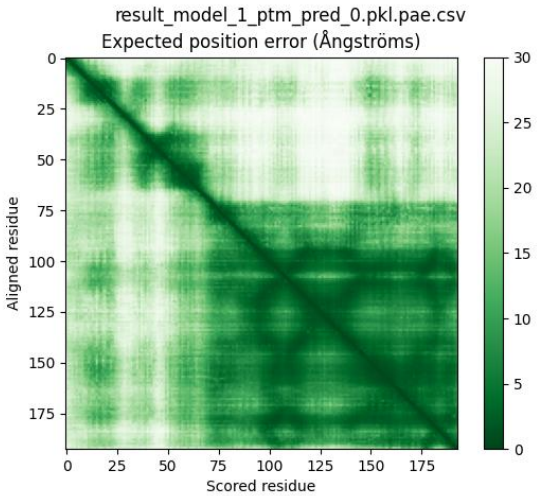
Chain	Protein	Uniprot	Length
A	gp2		193

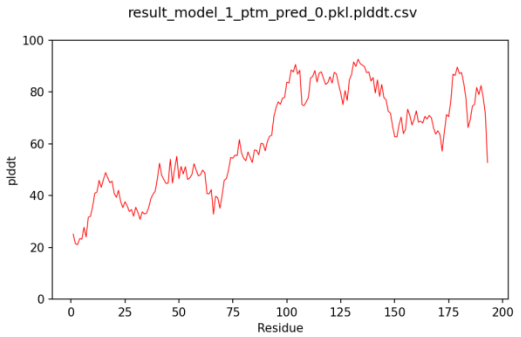
Template	RMS
No templates	
AlphaFold	8.90 (0.98)

full length

core only

DIFFICULT

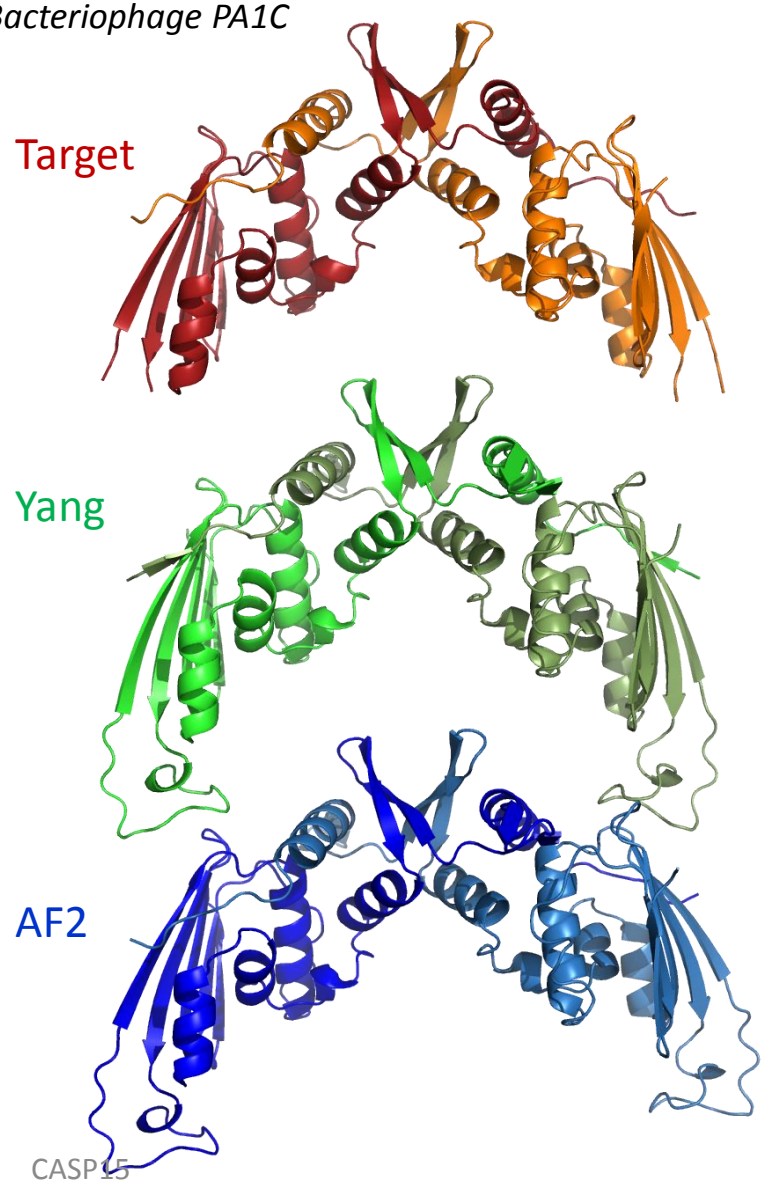




Group	Performance
Jianyi_Yang (group 439)	5/1***/4**
Negi, MULTICOM, LZERD, Kozakov, Kihara, J_Cheng, Gray, CLUSPRO, YANG-MULTIMER, BeijingAIProtein, ULTRAFOLD, PEZYFoldings, Takeda-Shitaka, RAPTORX-multi, UltraFold, ColabFold, MULTIFOLD, MULTICOM*, AF2-Multimer, …	5**

T194	T1113	no pdb	Xray	2.63	A2

Bacteria
Bacteriophage PA1C



Origin	CASP
Group	**J Yang**
Model	**3**
F(nat)	0.928
F(non)	0.094
L-rms	1.266 Å
i-rms	0.812 Å
S-rms	1.388 Å

Origin	CASP
Group	**AF2-MM**
Model	**1**
F(nat)	0.784
F(non)	0.264
L-rms	3.946 Å
i-rms	1.874 Å
S-rms	2.369 Å

Group	Performance
Jianyi_Yang	**5/1***/4****
Basically everybody including Elofsson-AF2-Multimer Also most Scorers	**1 – 5****

- AF2 makes excellent suggestion
- Interface can be improved significantly

cpTM = 0.2 pTM + 0.8 ipTM

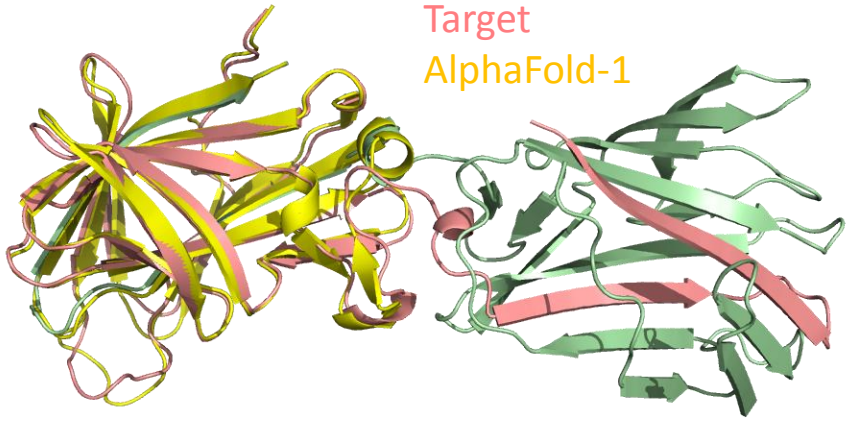
cpTM = 0.844

T224	T1176	no pdb	X-ray	2.00	A2

Interface	Chains	Area
1	A:B	5700

Bacteria
Clostridioides difficile
Uncharacterized

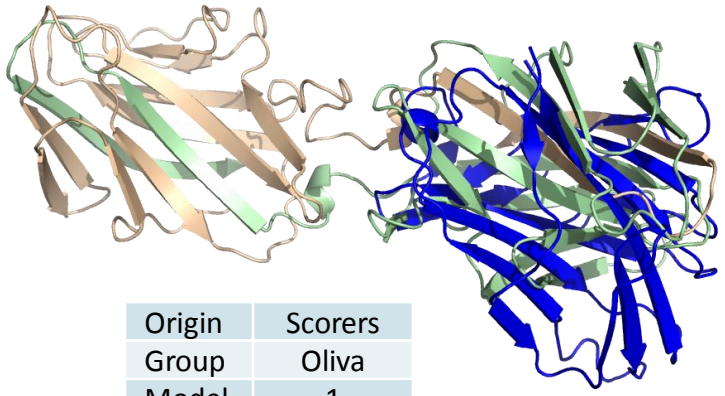
Target
Target
AlphaFold-1



Domain swap

No acceptable solutions

Best model:



Chain	Protein	Uniprot	Length
A	Idp97509	Q182N1?	170

Template	RMS	Seq ID
4bq2A	2.97	19%
5z6pA	5.77	16%
6xj9A	8.48	19%
AlphaFold	0.81	100%

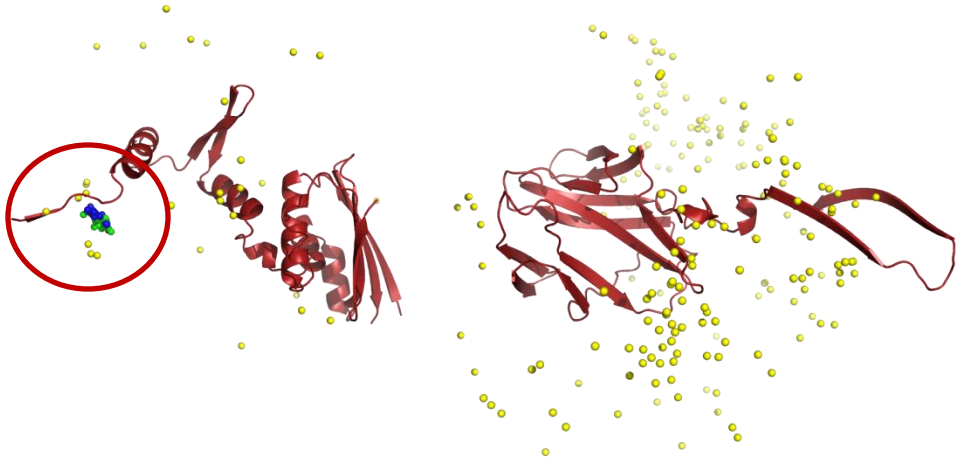
Good structures, apart from C-ter segment

Origin	Scorers
Group	Oliva
Model	1
F(nat)	0.007
L-rms	15.51 Å
i-rms	8.36 Å
θL	155 °

Target
Target
Model

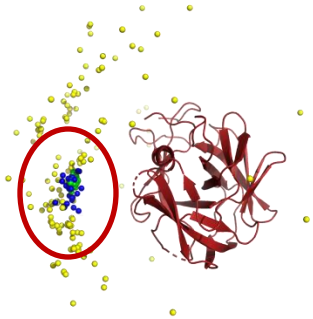
DIFFICULT

Examples of target difficulty

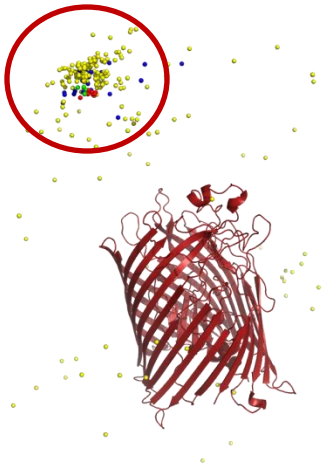


T1113/T194 T1176/T224

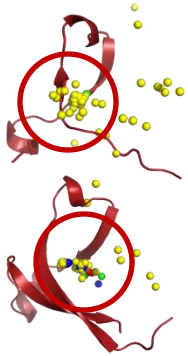
	62 Groups		63 Groups	
	Top-1	Top-5	Top-1	Top-5
High	0	1	0	0
Medium	46	54	0	0
Acceptable	9	2	0	0



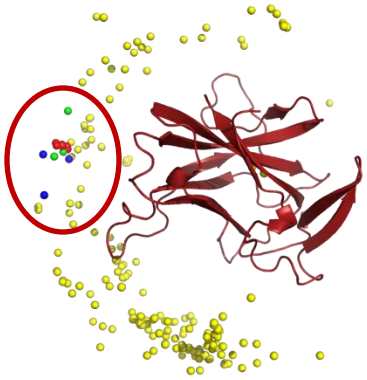
T1123/T198



H1129/T200



T1160/T213
T1161/T214

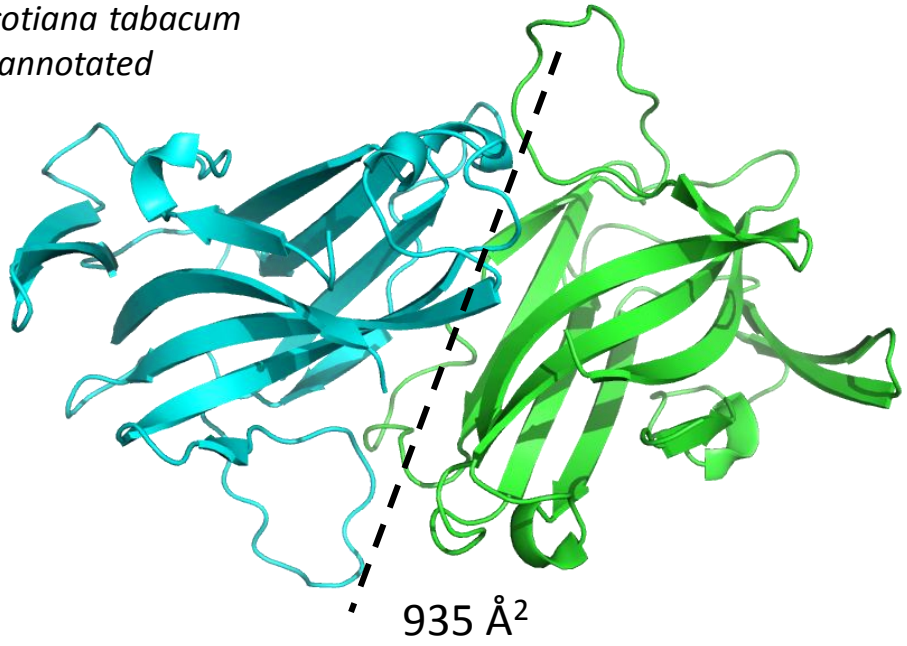


T1187/T229

Easy targets that were surprisingly difficult

T229	T1187	no pdb	X-ray	2.0	A2

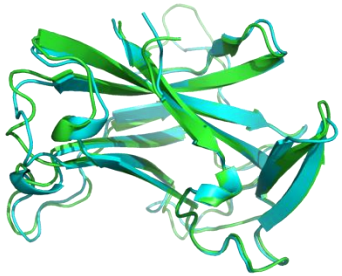
Eukaryotes
Nicotiana tabacum
Unannotated



Chain	Protein	Uniprot	Length
A	Lectin	Q94EW1	166

Template	RMS	Seq ID
None		
AF-Q207S9	0.57	100%

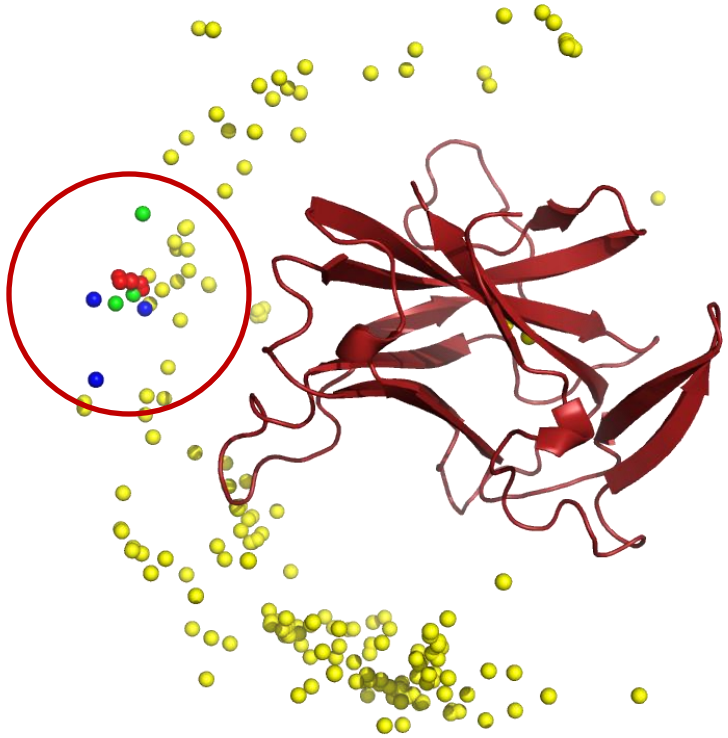
EASY



Overlap of AlphaFold model to target

T229	T1187	no pdb	X-ray	2.0	A2

Eukaryotes
Nicotiana tabacum
Unannotated



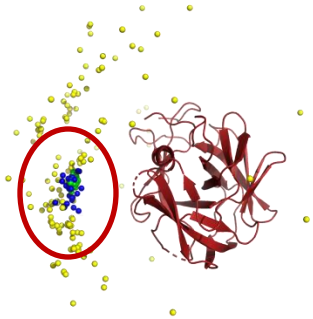
EASY

High-quality models by:

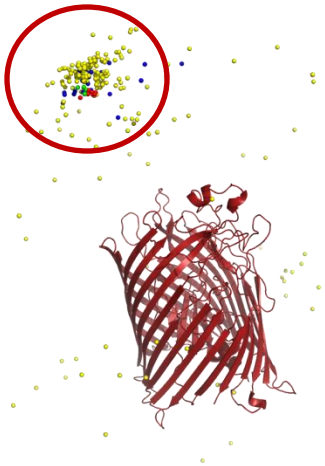
Group	Performance
BeijingAIProtein UltraFold ULTRAFOLD	**3/1***/2****
Venclovas S_Chang MULTICOM J_Cheng Bates Wallner CODOCK MULTIFOLD MULTICOM_QA MULTICOM_DEEP MULTICOM McGuffin	**1*****

The only Scorer to select an acceptable model:

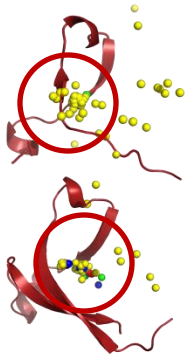
Group	Performance
Bonvin	**1**



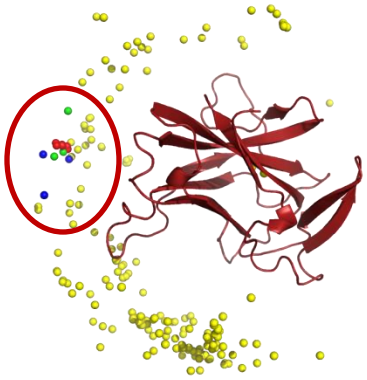
T1123/T198



H1129/T200



T1160/T213
T1161/T214



T1187/T229

Easy targets that were surprisingly difficult

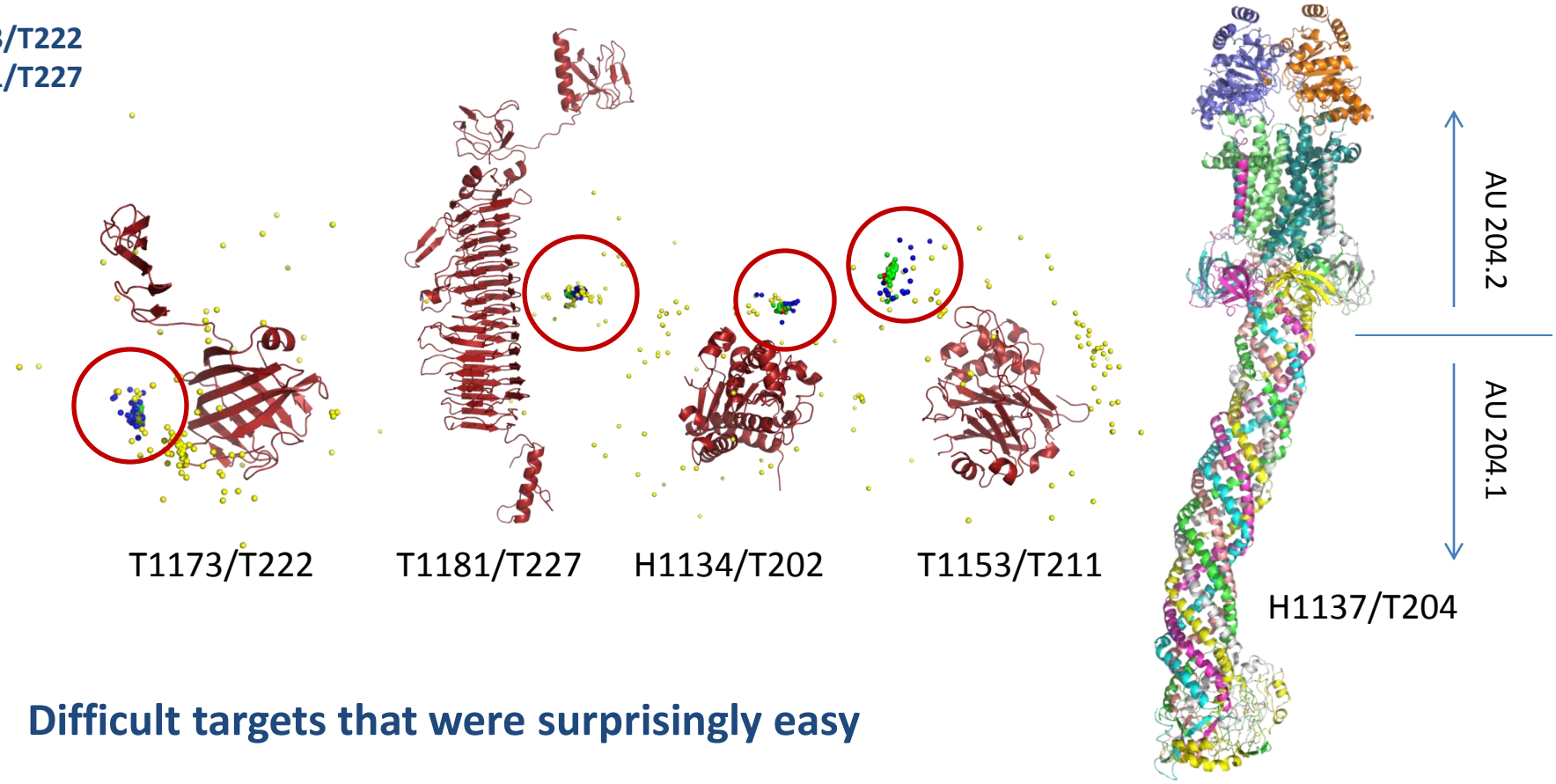
	61 Groups	
	Top-1	Top-5
High	0	0
Medium	14	19
Acceptable	7	11

71 Groups	
Top-1	Top-5
4	5
0	0
6	15

64 Groups	
Top-1	Top-5
0/0	0/4
0/1	3/3
0/1	0/3

72 Groups	
Top-1	Top-5
3	14
4	1
0	1

Also:
T1173/T222
T1181/T227

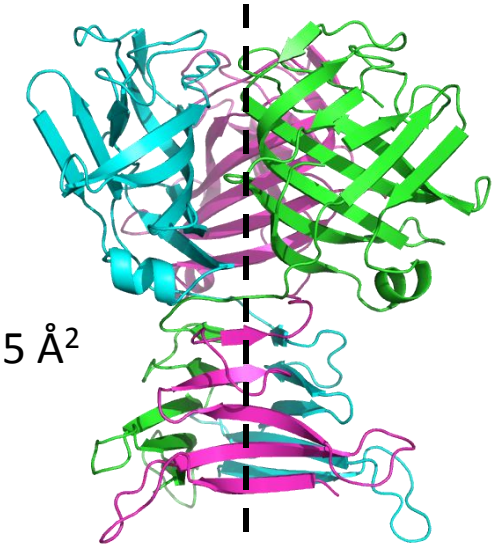


Difficult targets that were surprisingly easy

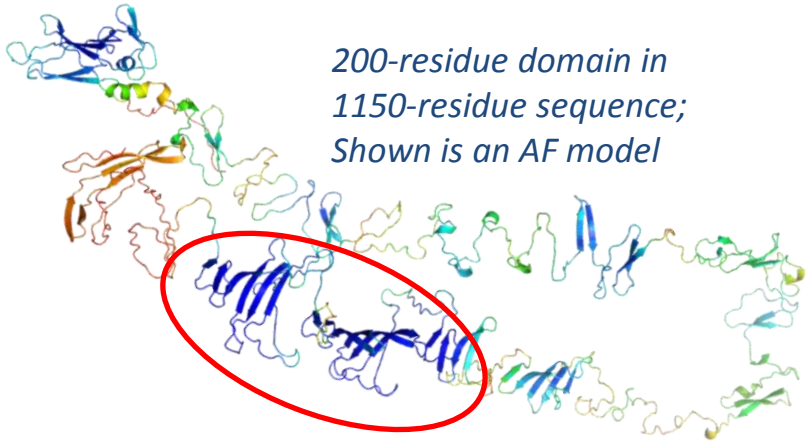
T222	T1173	no pdb	X-ray	2.40	A3

Bacteria
Bdellovibrio bacteriovorus
Cell wall surface anchor

Domain intertwining; individual domains well predicted by AF; assembly difficult



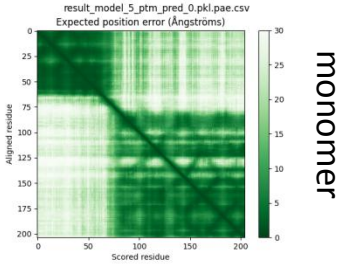
2015 Å^2



200-residue domain in 1150-residue sequence; Shown is an AF model

Chain	Protein	Uniprot	Length
A	Bd1334	Q6MNC5	204

Template	RMS
None	
AlphaFold-1	3.49
AlphaFold-5	7.87



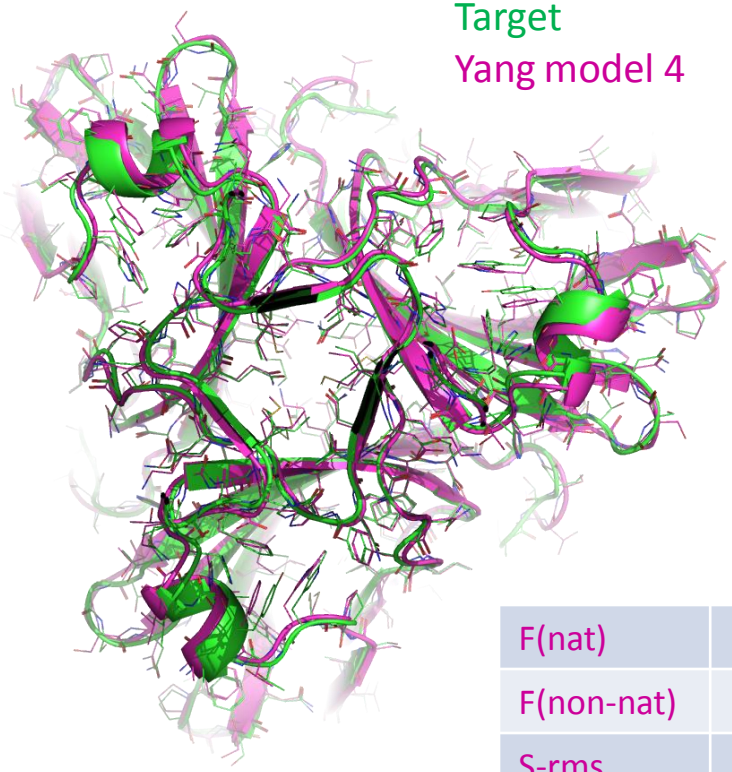
monomer

Target
AlphaFold-1
AlphaFold-5

DIFFICULT

T222	T1173	no pdb	X-ray	2.40	A3

Bacteria
Bdellovibrio bacteriovorus
Cell wall surface anchor



F(nat)	0.857
F(non-nat)	0.153
S-rms	1.85 Å

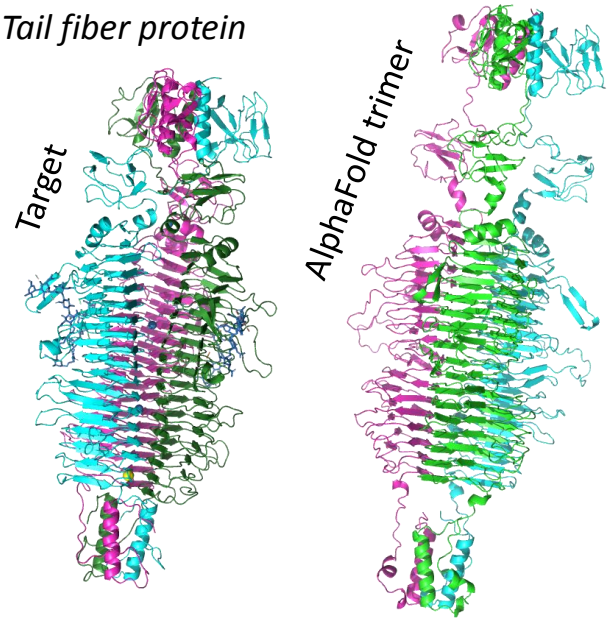
Very good side-chain placement

Group	Performance
Jianyi_Yang	5***
YANG-SERVER, YANG-MULTIMER	5/4***/1**
Wei_Zheng, J_Cheng	4/3***/1**
MULTICOM	4/2***/1**
Many others…	
AF2-Multimer	2/1**

Scorer	Performance
Takeda-Shitaka	10/9***/1**
MULTICOM	10/6***/3**
LZERD, Kihara	9/2***/6**
S_Chang	10/1***/7**
S_Huang, HDOCK	4/1***/2**
Venclovas	10/8**
Zou, MDOCKP	6/5**

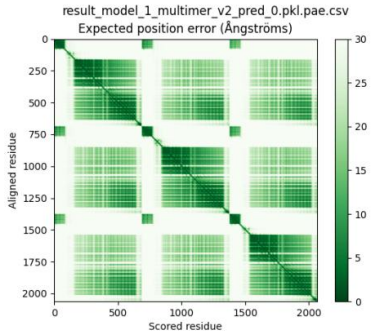
T227	T1181	no pdb	X-ray	2.30	A3

Viruses
Escherichia virus G7C
Tail fiber protein



Chain	Protein	Uniprot	Length
A	gp66	G0XNW6	2058

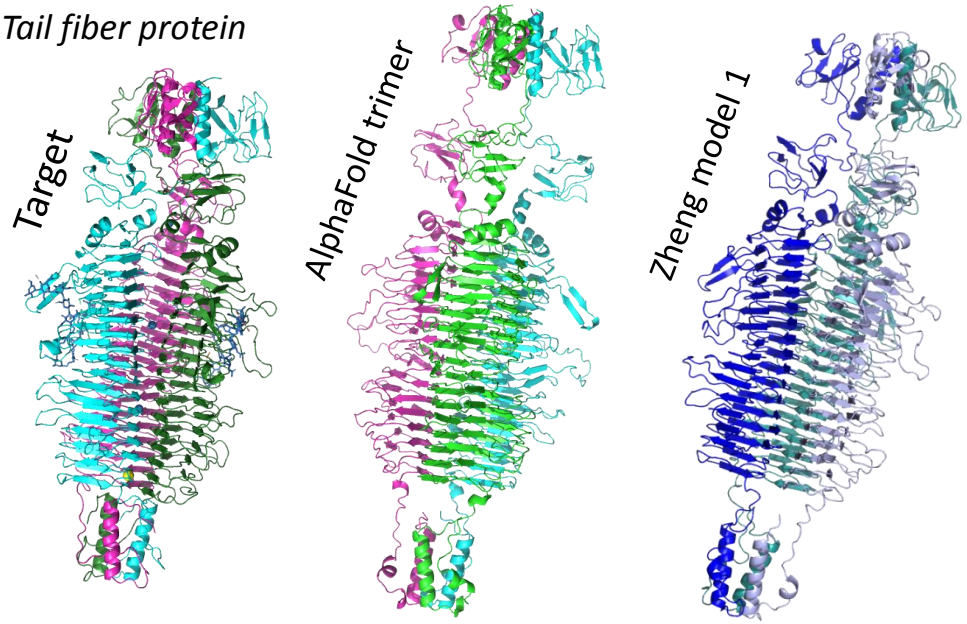
Template	RMS	Seq ID
4xot	2.53	17.2%
6nw9	4.94	15.7%
7lzj	5.34	14.7%
many others		
AlphaFold	1.14	100%



DIFFICULT

T227	T1181	no pdb	X-ray	2.30	A3

Viruses
Escherichia virus G7C
Tail fiber protein



	Kihara	PEZYFoldings	Wei Zheng
Model	5	1	1
F(nat)	0.536	0.524	0.516
F(non-nat)	0.373	0.225	0.262
L-rms	2.46 Å	2.80 Å	1.92 Å
i-rms	0.99 Å	0.85 Å	0.80 Å
S-rms	2.02 Å	1.74 Å	1.60 Å

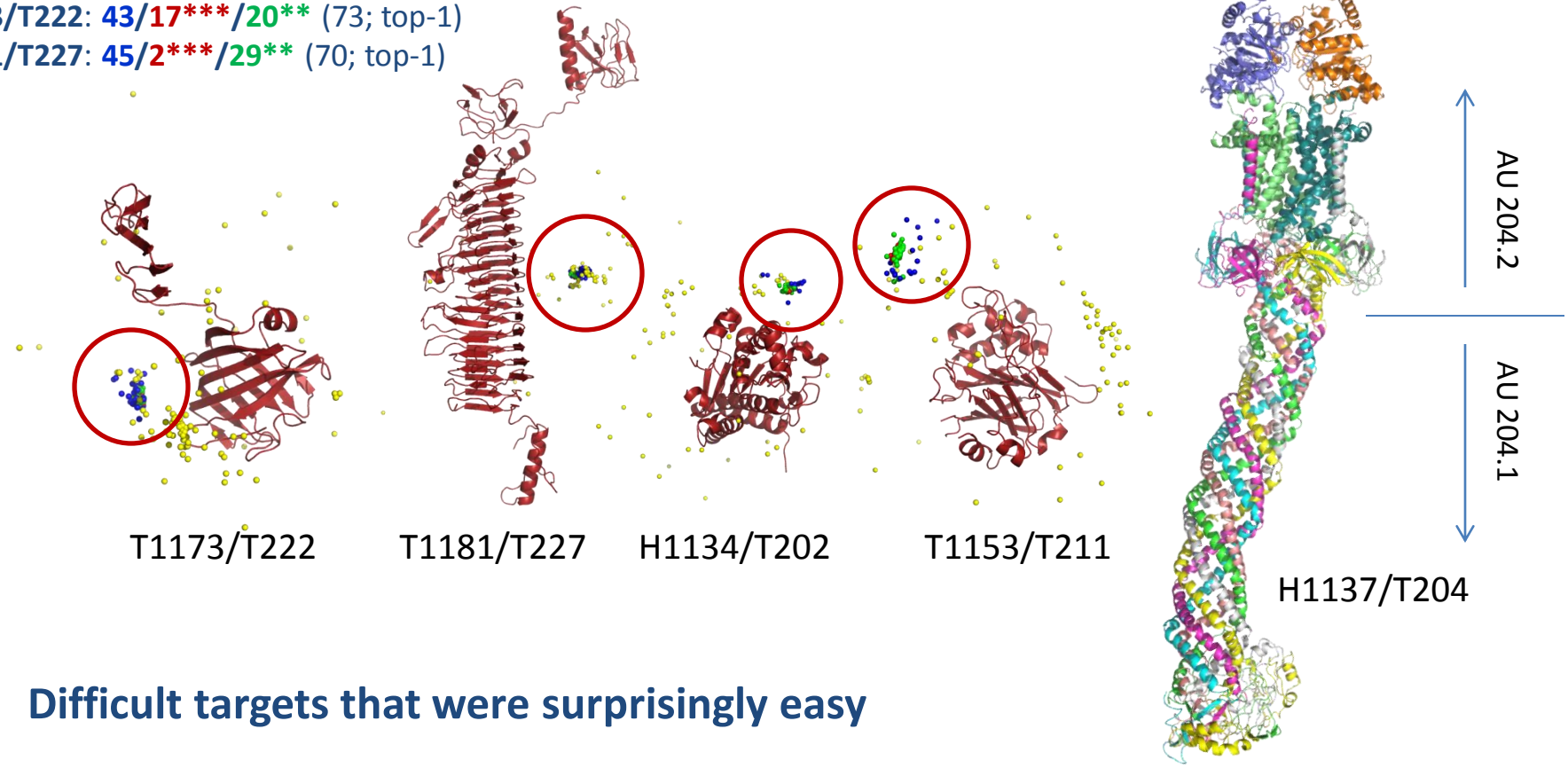
Group	Performance
Wei_Zheng, PEZYFoldings	**5/1***/4****
Kihara	**4/1***/3****
MULTICOM-*, J_Cheng, ColabFold, Ness	**5****
Yang-*, Baker	**5/4****
Some others…	
AF2-Multimer	**5/3****

Scorer	Performance
Kihara	**5/1***/4****
Takeda-Shitaka	**10****
Venclovas	**9****
Zou, MDOCKPP	**9/8****
S_Chang	**7****
Bonvin	**8/6****

Also:

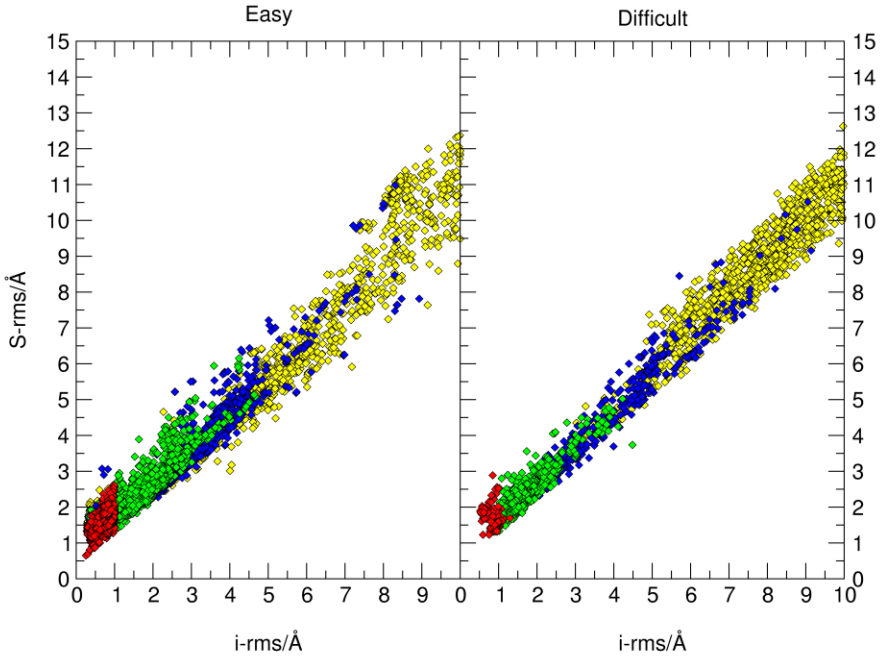
T1173/T222: **43**/**17*****/**20**** (73; top-1)

T1181/T227: **45**/**2*****/**29**** (70; top-1)

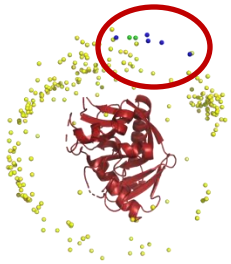


Difficult targets that were surprisingly easy

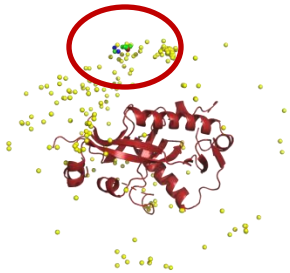
	73 Groups		70 Groups		78 Groups		59 Groups		62/64 Groups	
	Top-1	Top-5	Top-1	Top-5	Top-1	Top-5	Top-1	Top-5	Top-1	Top-5
High	17	21	2	3	11	22	12	25	0/0	0/0
Medium	20	27	29	31	48	41	28	22	3/8	5/16
Acceptable	6	10	14	19	3	2	0	2	18/27	17/25



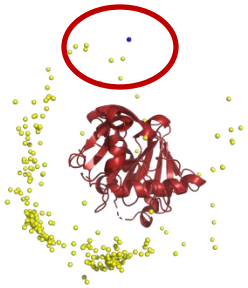
What is the relation between target difficulty and model quality?



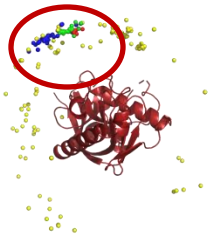
H1140/T205



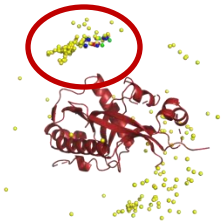
H1141/T206



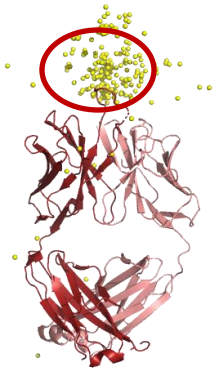
H1142/T207



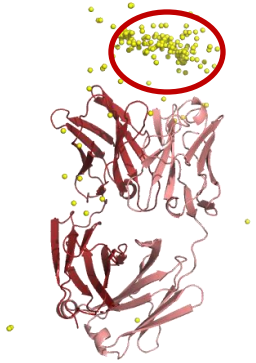
H1143/T208



H1144/T209



H1166/T216



H1167/T217

H1168/T218

Nanobody and antibody binding

T205	H1140	2.75	775 Å^2
T206	H1141	2.50	925 Å^2
T207	H1142	1.73	585 Å^2
T208	H1143	2.55	770 Å^2
T209	H1144	1.50	895 Å^2

All X-ray
Sub-Ångstrøm templates available

DIFFICULT

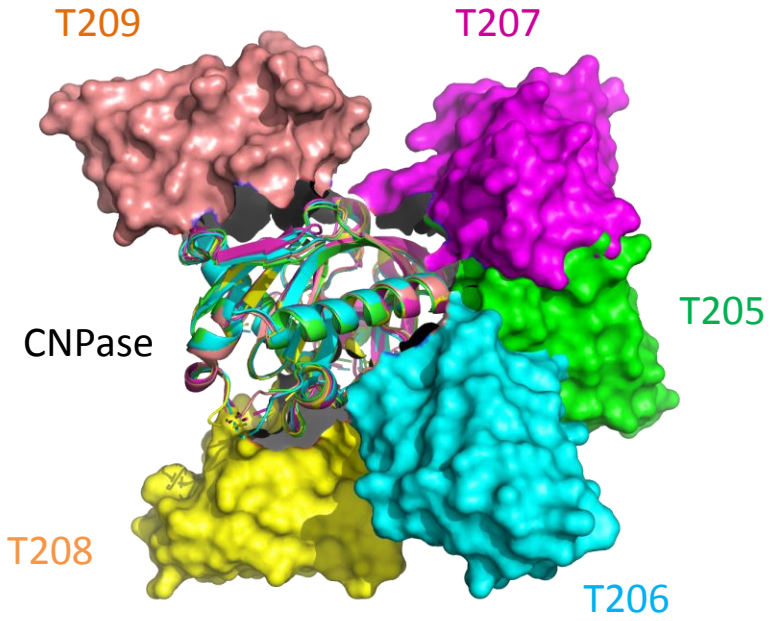
T216	H1166	7sue	2.90	1690 Å^2
T217	H1167	7sts	2.16	1600 Å^2
T218	H1168	7str	1.50	1820 Å^2

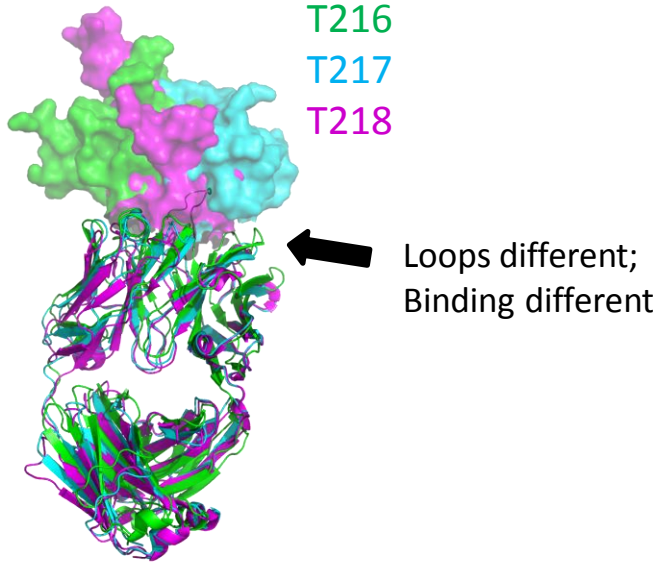
Eukaryotes
Mus musculus
Biological process: forebrain development

Chain	Protein	Uniprot	Length
A	CNPase	P16330	~ 200
B	Nanobody		~ 130

Host-pathogen
Homo sapiens / Virus
Antibody binding to SARS-CoV-2 nuclear capsid

Chain	Protein	Uniprot	Length
A	Nucleoprotein	P0DTC9	~ 115
HL	Antibody		~ 220+210



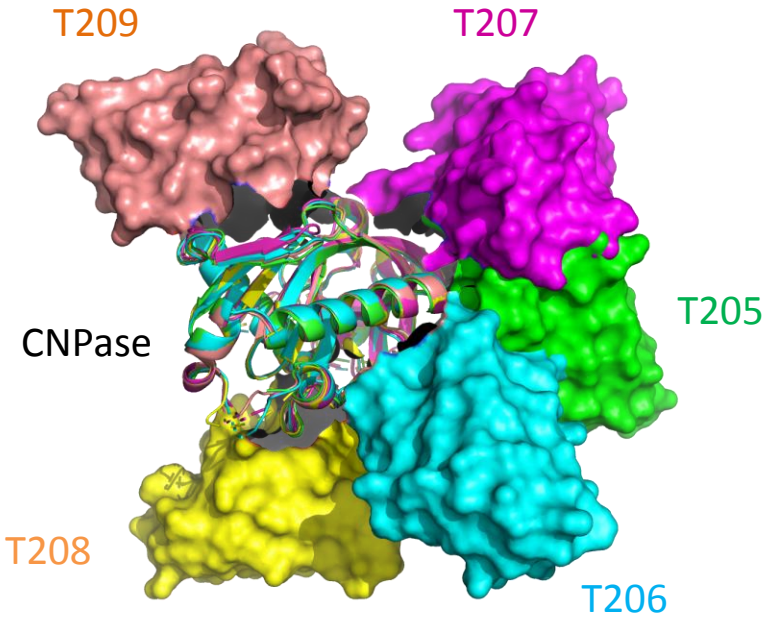


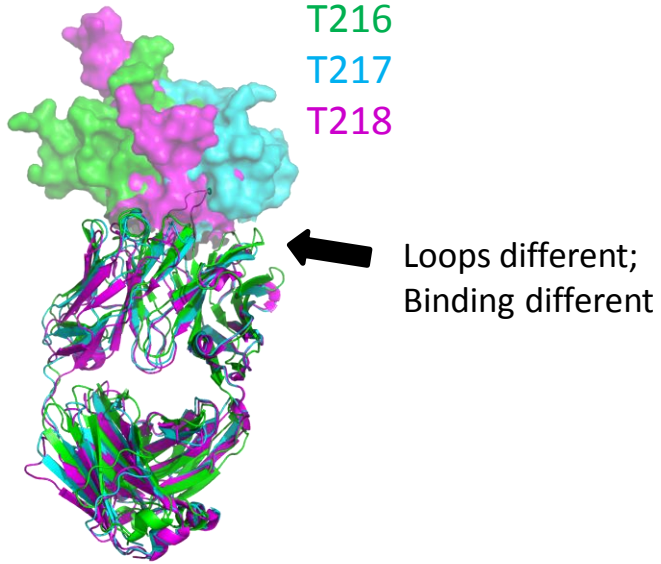
Performance over the 5 targets;
Groups predicting at least 3 of them acceptably:

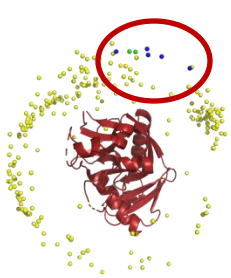
Group	Performance
Wallner	4/3***/1**
Wei_Zheng	4/2***/2**
PEZYFoldings	4/3***
Pierce	3/1***
Kihara	3/1**

Performance over the 3 targets;
Only T218 had acceptable results

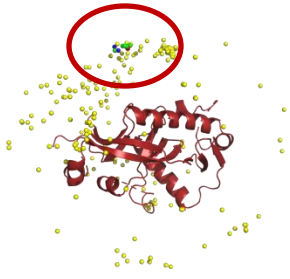
Group	Performance
MUFold_H, DFOLDING-SERVER	1***
Many others … including AF2-MM	1**



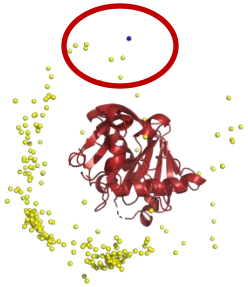




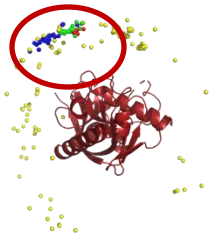
H1140/T205



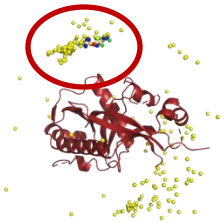
H1141/T206



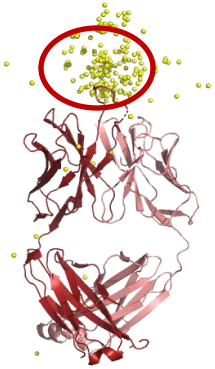
H1142/T207



H1143/T208



H1144/T209



H1166/T216

H1167/T217

H1168/T218

Nanobody and antibody binding

T205	Wei_Zheng, Wallner
T206	Wallner, Venclovas, PEZYFoldings, David_Jones-DMP
	Manifold, Wei_Zheng, S_Huang, HDOCK, DFOLDING
T207	Kihara
T208	***Basically everybody***
T209	YANG-MULTIMER, Wei_Zheng, Wallner, PEZYFoldings, Suwen_Zhao, Jianyi_Yang

T216	*Nobody*
T217	*Nobody*
T218	MUFold_H, DFOLDING-SERVER
	Basically everybody else

T208 *and* ***T218*** *had templates matching the binding site in the PDB*

Target	Best in top-1
T191	***
T192	***
T193	***
T194	**
T195	**
T197	*
T198	**
T199	***
T200	***
T201	***
T202	***
T203/1	***
T203/2	**
T204/1	**
T204/2	**
T205	**
T206	***
T207	0
T208	***
T209	***
T210	***
T211	***
T212	**
T213	0
T214	**
T216	0
T217	0
T218	***
T219/1	**
T220/2	***
T222	***
T223	**
T224	0
T225	***
T226	***
T227	***
T229	***
T230	***

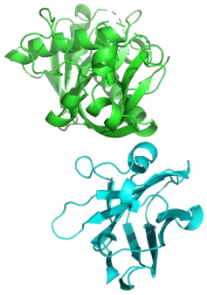
38 *Assessment Units*

21 *Have* *** *Solutions in the **top-1** submissions*

11 *Have* ** *Solutions in the **top-1** submissions*

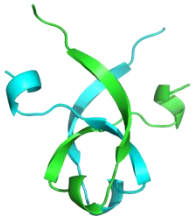
1 *Has* * *Solutions in the **top-1** submissions*

5 *Have no acceptable solutions in the **top-1** submissions*



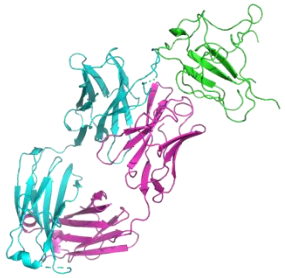
H1142/T207

Nanobody binding



T1160/T213

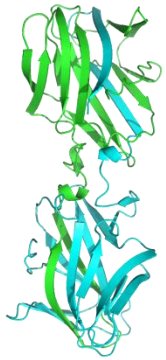
Ancient protein reconstruction



H1166/T216

H1167/T217

Antibody binding



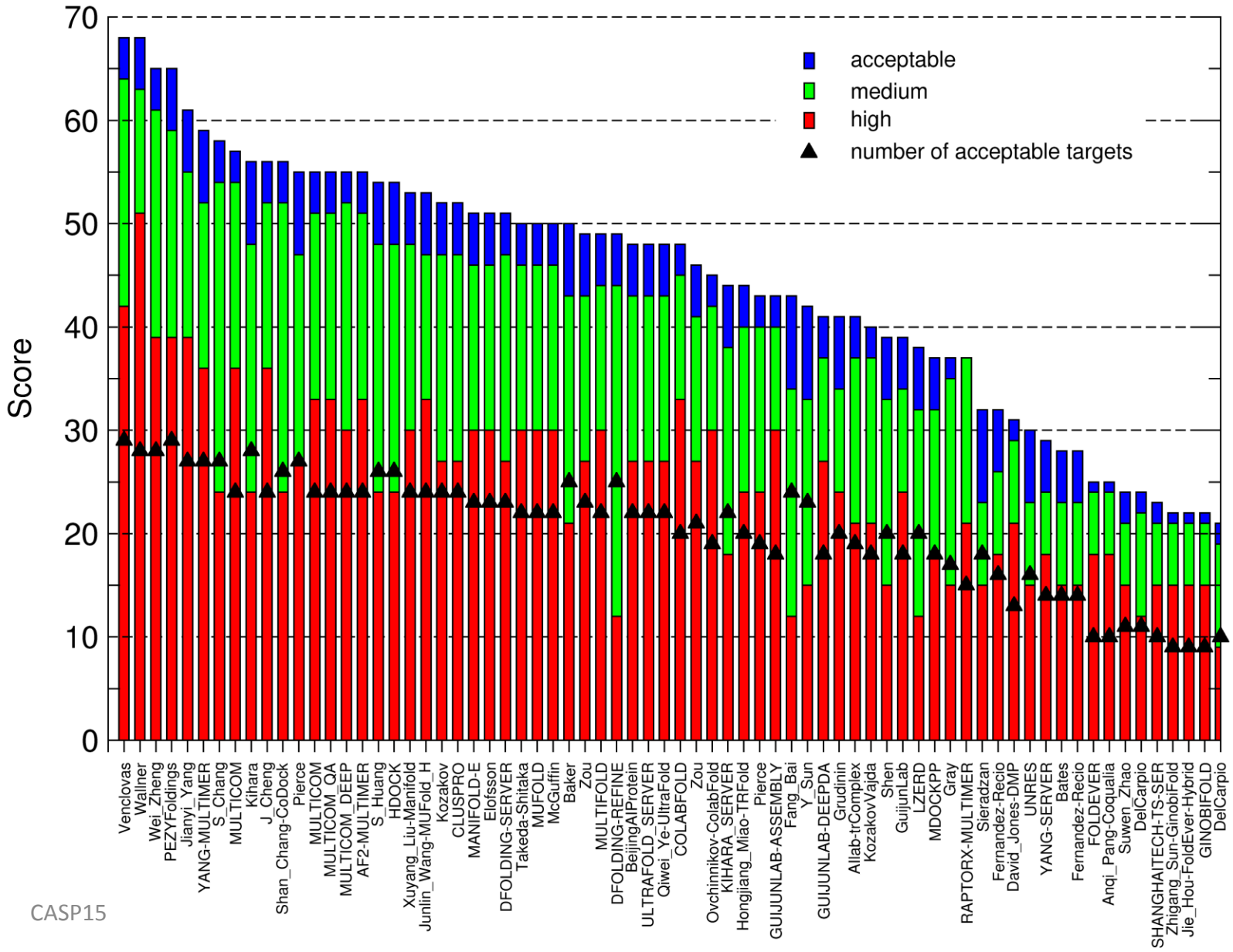
T1176/T224

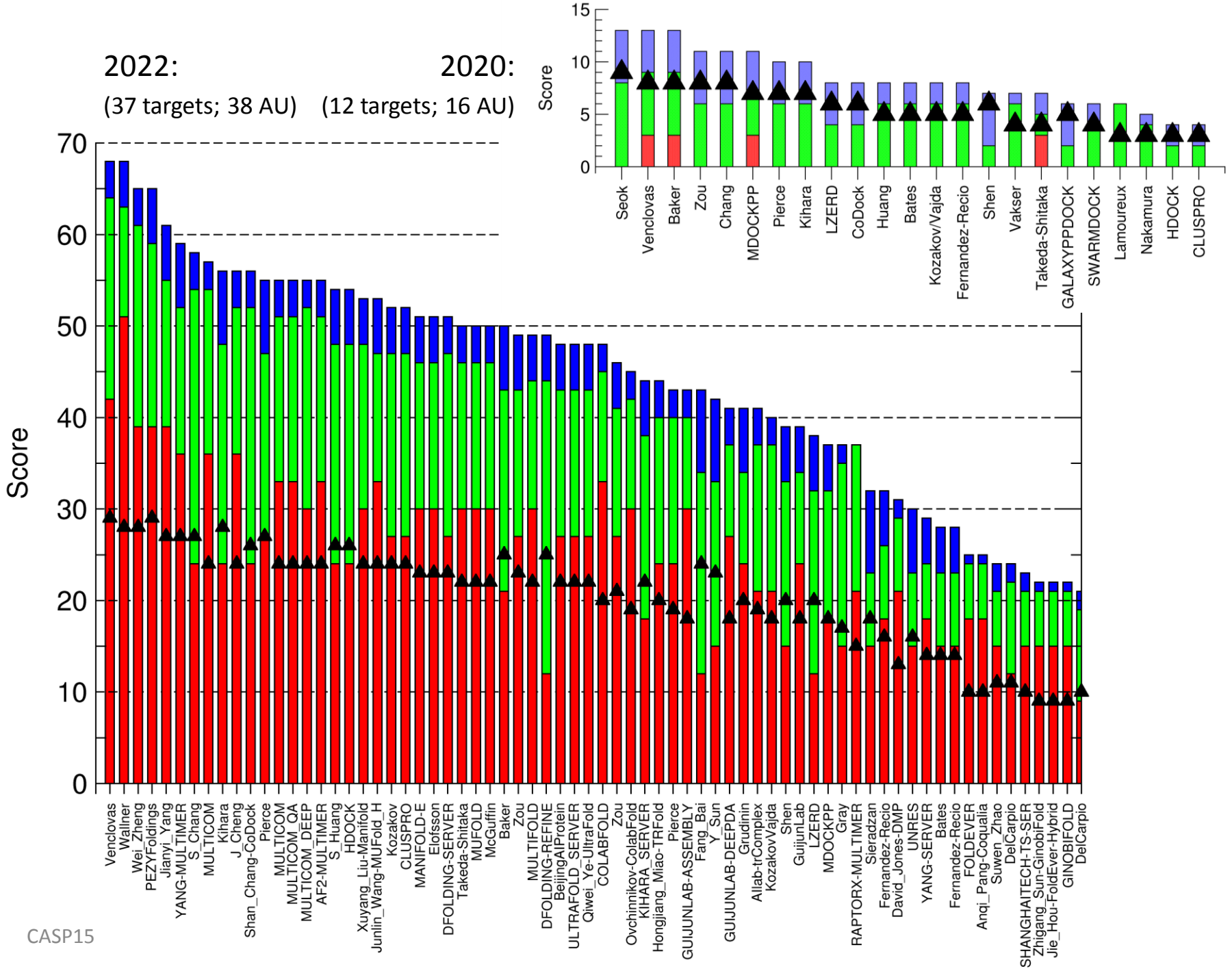
Domain swap

Ranking

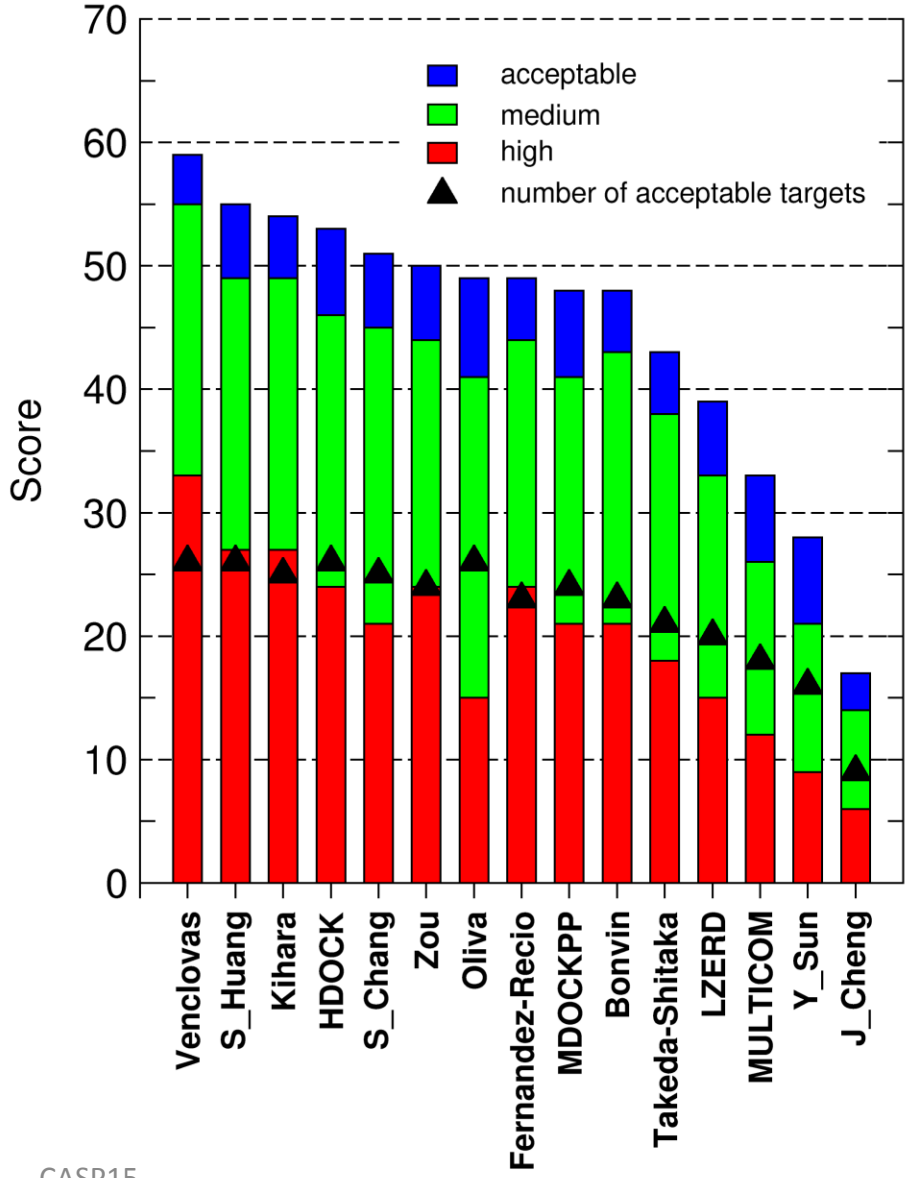
$$\text{Score} = \omega_1 \cdot N_{ACC} + \omega_2 \cdot N_{MED} + \omega_3 \cdot N_{HIGH}$$

$$\omega_1 = 1;\ \omega_2 = 2;\ \omega_3 = 3$$


Score
70
60
50
40
30
20
10
0
acceptable
medium
high
number of acceptable targets
Venclovas
Wallner
Wei_Zheng
PEZYFoldings
Jianyi_Yang
YANG-MULTIMER
S_Chang
MULTICOM
Kihara
J_Cheng
Shan_Chang-CoDock
Pierce
MULTICOM
MULTICOM_QA
MULTICOM_DEEP
AF2-MULTIMER
S_Huang
HDOCK
Xuyang_Liu-Manifold
Junlin_Wang-MUFold_H
Kozakov
CLUSPRO
MANIFOLD-E
Elofsson
DFOLDING-SERVER
Takeda-Shitaka
MUFOLD
McGuffin
Baker
Zou
MULTIFOLD
DFOLDING-REFINE
BeijingAIProtein
ULTRAFOLD_SERVER
Qiwei_Ye-UltraFold
COLABFOLD
Zou
Ovchinnikov-ColabFold
KIHARA_SERVER
Hongjiang_Miao-TRFold
Pierce
GUIJUNLAB-ASSEMBLY
Fang_Bai
Y_Sun
GUIJUNLAB-DEEPDA
Grudinin
Allab-trComplex
KozakovVajda
Shen
GuijunLab
LZERD
MDOCKPP
Gray
RAPTORX-MULTIMER
Sieradzan
Fernandez-Recio
David_Jones-DMP
UNRES
YANG-SERVER
Bates
Fernandez-Recio
FOLDEVER
Anqi_Pang-Coqualia
Suwen_Zhao
DelCarpio
SHANGHAITECH-TS-SER
Zhigang_Sun-GinobiFold
Jie_Hou-FoldEver-Hybrid
GINOBIFOLD
DelCarpio

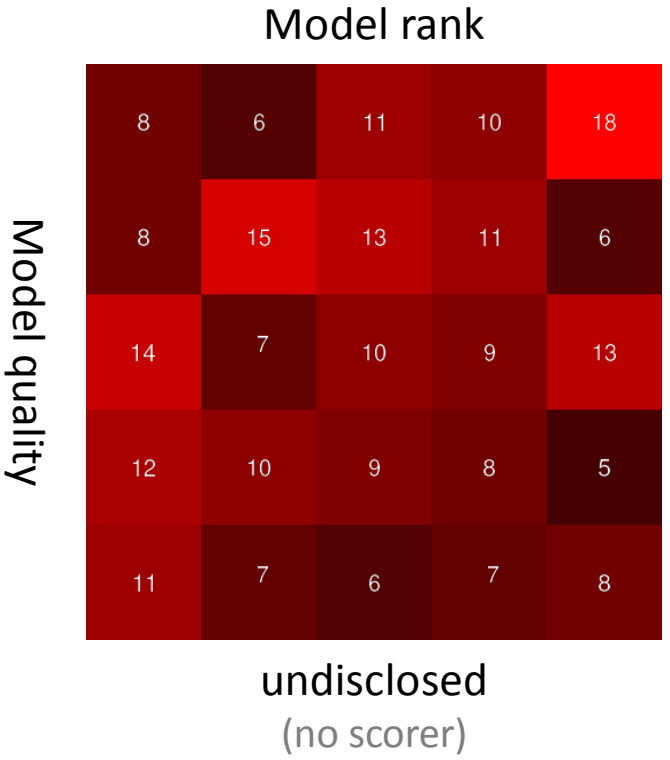

2022:
(37 targets; 38 AU)
2020:
(12 targets; 16 AU)
Score
Seok
Venclovas
Baker
Zou
Chang
MDOCKPP
Pierce
Kihara
LZERD
CoDock
Huang
Bates
Kozakov/Vajda
Fernandez-Recio
Shen
Vakser
Takeda-Shitaka
GALAXYPPDOCK
SWARMDOCK
Lamoureux
Nakamura
HDOCK
CLUSPRO
Venclovas
Wallner
Wei_Zheng
PEZYFoldings
Jianyi_Yang
YANG-MULTIMER
S_Chang
MULTICOM
Kihara
J_Cheng
Shan_Chang-CoDock
Pierce
MULTICOM
MULTICOM_QA
MULTICOM_DEEP
AF2-MULTIMER
S_Huang
HDOCK
Xuyang_Liu-Manifold
Junlin_Wang-MUFold_H
Kozakov
CLUSPRO
MANIFOLD-E
Elofsson
DFOLDING-SERVER
Takeda-Shitaka
MUFOLD
McGuffin
Baker
Zou
MULTIFOLD
DFOLDING-REFINE
BeijingAIProtein
ULTRAFOLD_SERVER
Qiwei_Ye-UltraFold
COLABFOLD
Zou
Ovchinnikov-ColabFold
KIHARA_SERVER
Hongjiang_Miao-TRFold
Pierce
GUIJUNLAB-ASSEMBLY
Fang_Bai
Y_Sun
GUIJUNLAB-DEEPDA
Grudinin
Allab-trComplex
KozakovVajda
Shen
GuijunLab
LZERD
MDOCKPP
Gray
RAPTORX-MULTIMER
Sieradzan
Fernandez-Recio
David_Jones-DMP
UNRES
YANG-SERVER
Bates
Fernandez-Recio
FOLDEVER
Anqi_Pang-Coqualia
Suwen_Zhao
DelCarpio
SHANGHAITECH-TS-SER
Zhigang_Sun-GinobiFold
Jie_Hou-FoldEver-Hybrid
GINOBIFOLD
DelCarpio
CASP15

Scorers



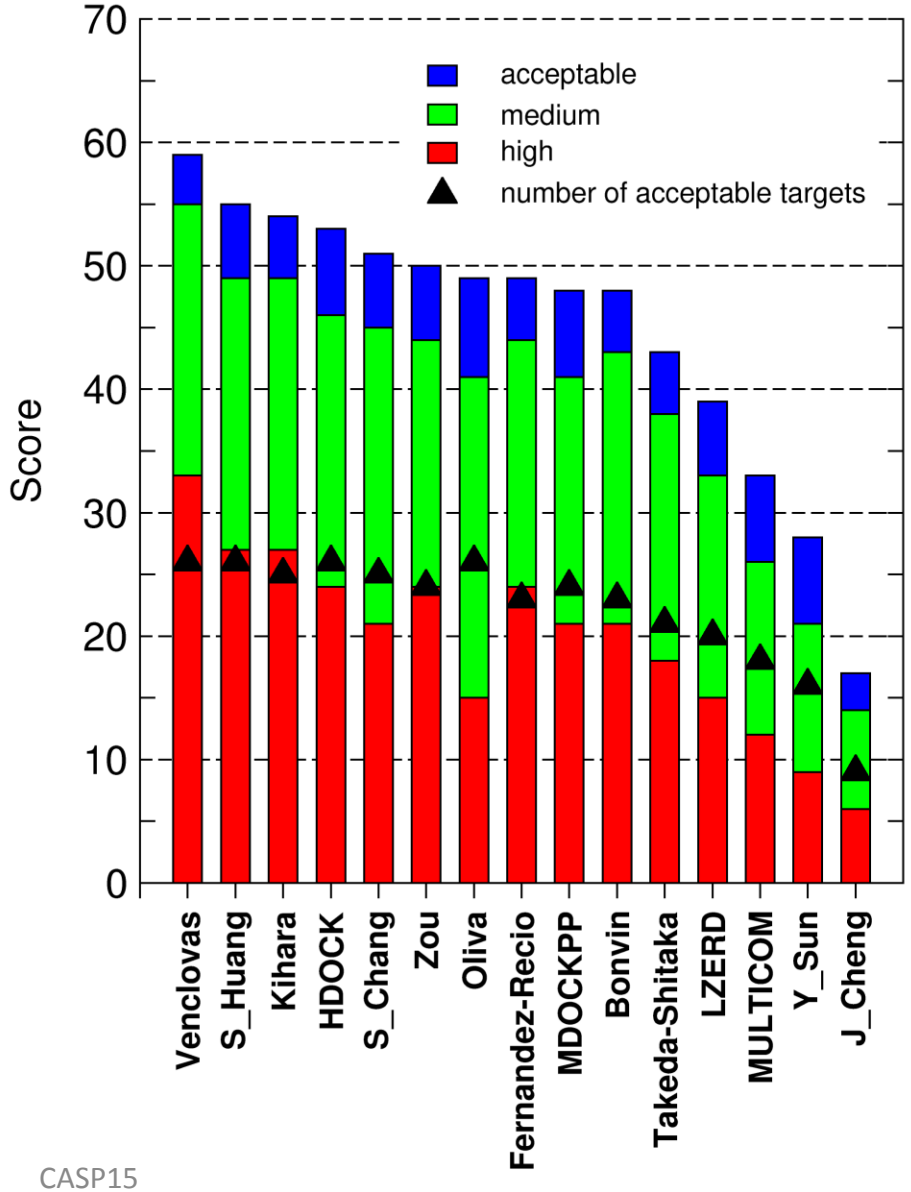
Scorers don't do much worse than Predictors.

The Scoring set was significantly poorer than on previous occasions



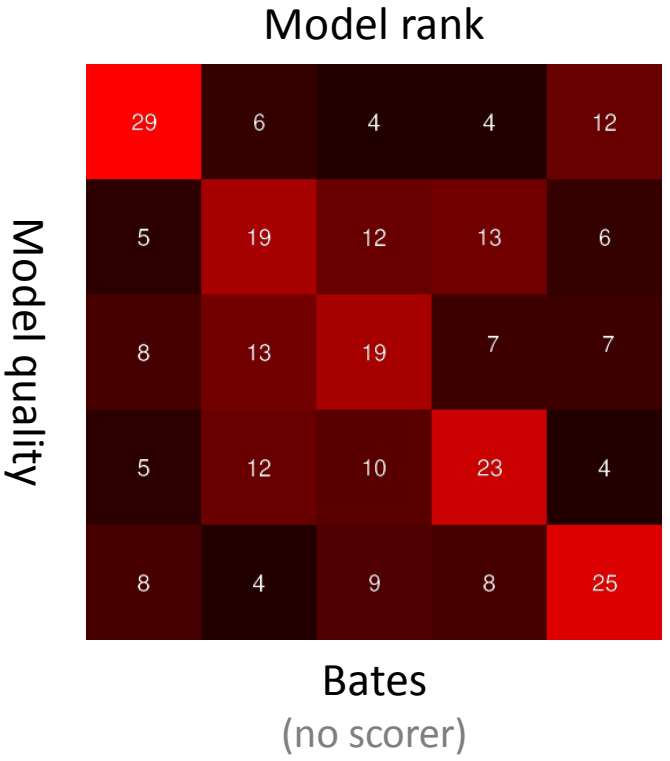
–.14

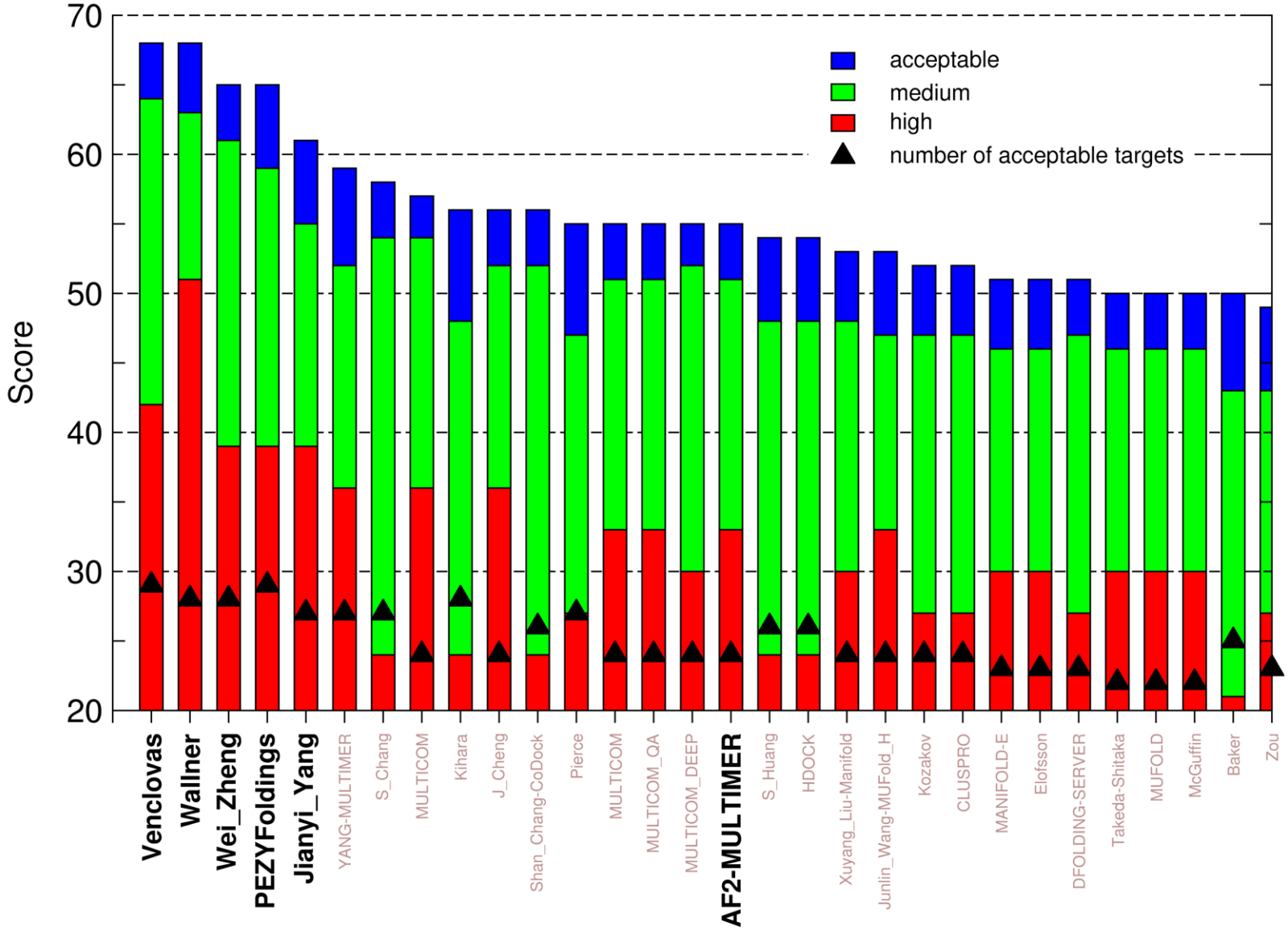
Scorers

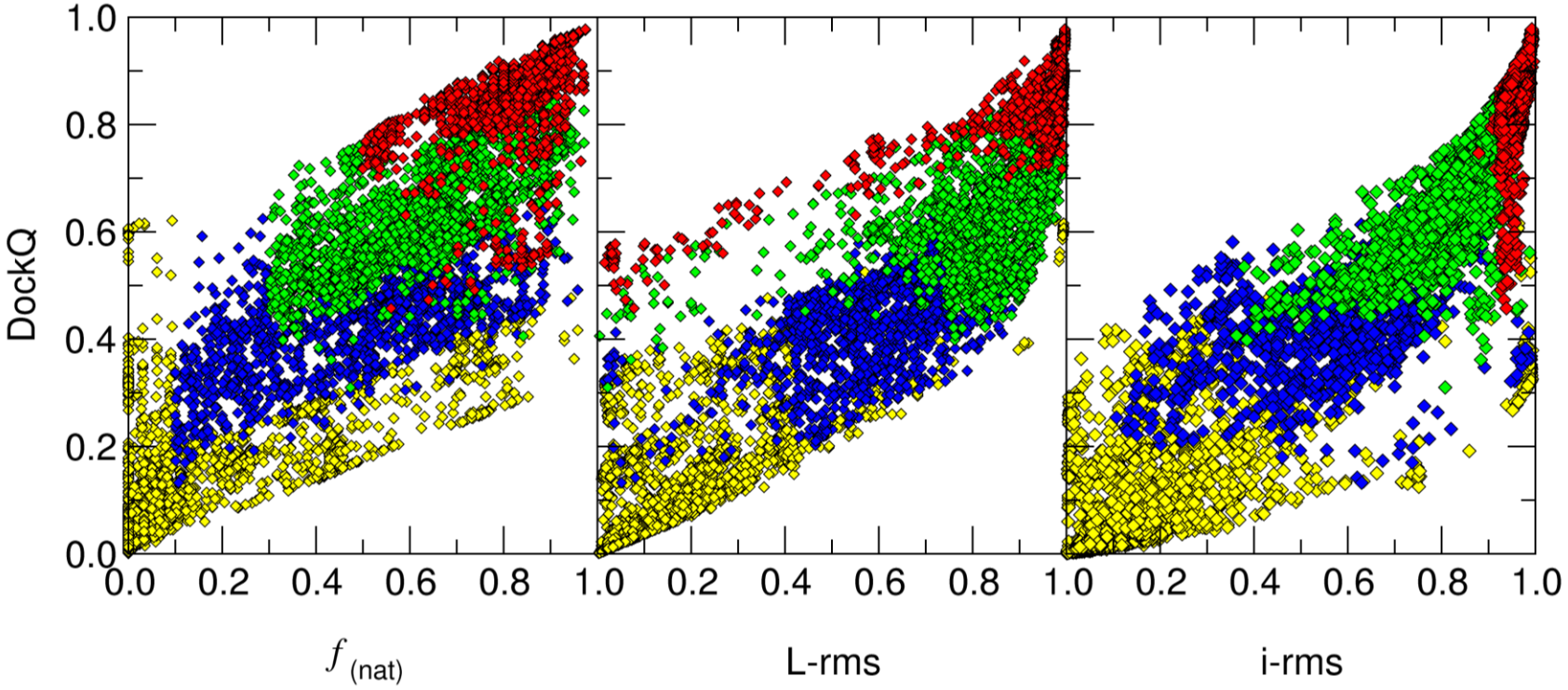


Scorers don't do much worse than Predictors.

The Scoring set was significantly poorer than on previous occasions



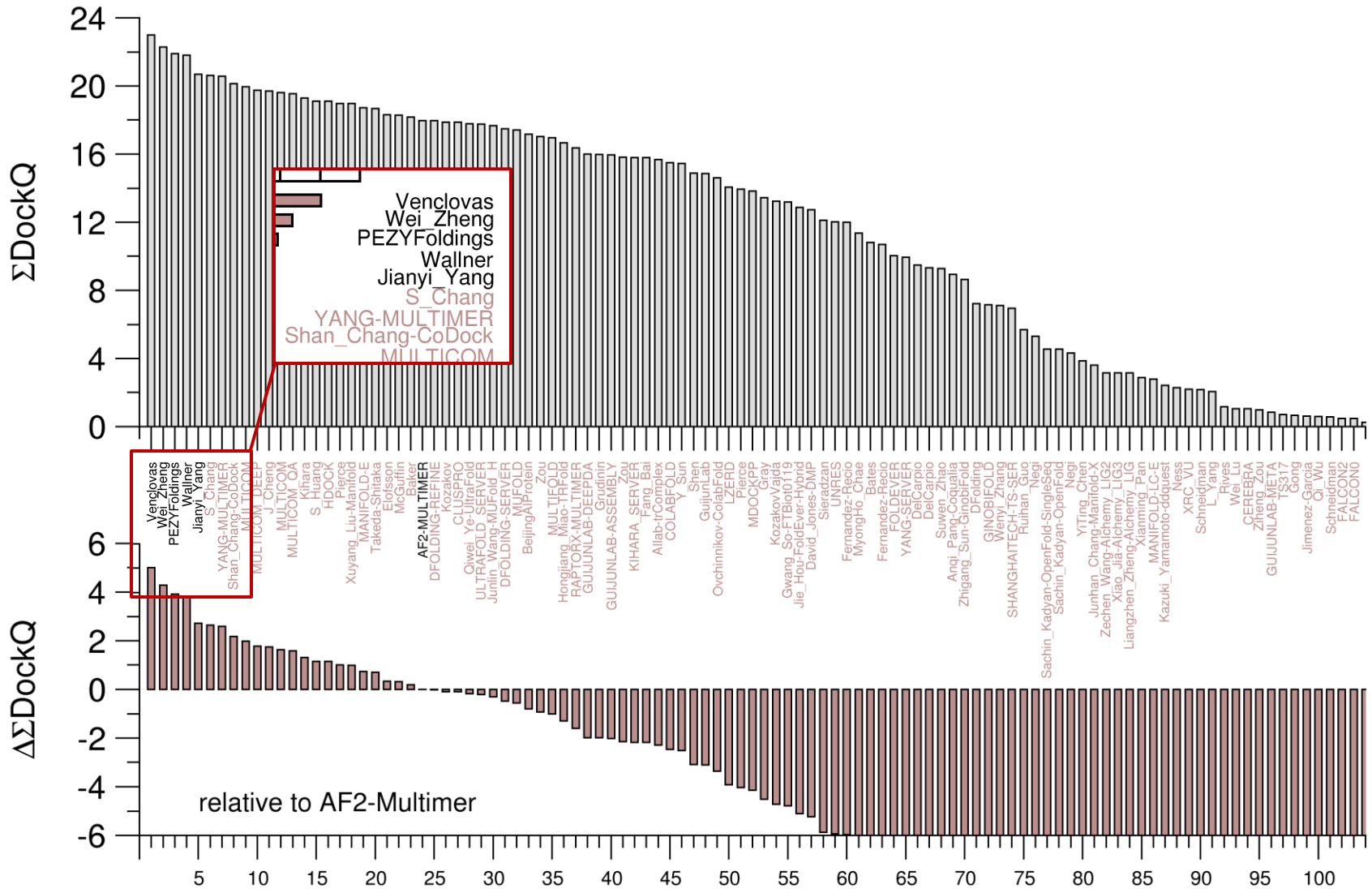

Score
70
60
50
40
30
20
acceptable
medium
high
number of acceptable targets
Venclovas
Wallner
Wei_Zheng
PEZYFoldings
Jianyi_Yang
YANG-MULTIMER
S_Chang
MULTICOM
Kihara
J_Cheng
Shan_Chang-CoDock
Pierce
MULTICOM
MULTICOM_QA
MULTICOM_DEEP
AF2-MULTIMER
S_Huang
HDOCK
Xuyang_Liu-Manifold
Junlin_Wang-MUFold_H
Kozakov
CLUSPRO
MANIFOLD-E
Elofsson
DFOLDING-SERVER
Takeda-Shitaka
MUFOLD
McGuffin
Baker
Zou



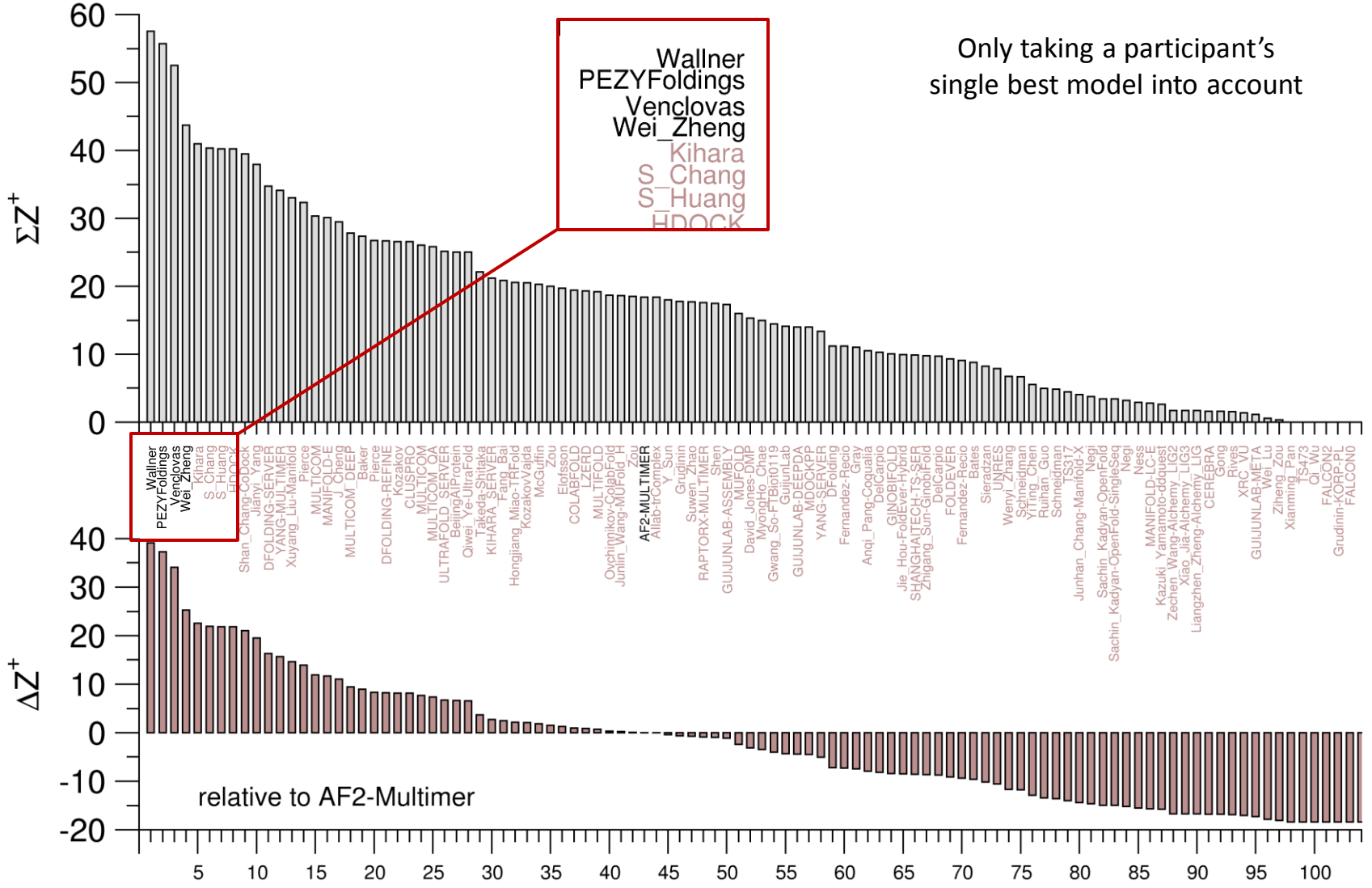
Analysis using DockQ

DockQ = ⅓ F(nat) + ⅓ L-rms + ⅓ i-rms

```
function rms_scaled(rms, d) {
  r = rms / d;
  r = 1.0 / (1.0 + r*r);
  return(r);
}
BEGIN { d1 = 8.5; d2 = 1.5; }
{ q = ($1 + rms_scaled($2, d1) + rms_scaled($3, d2)) / 3.0;
  printf "%6.4f\n", q;
}
```

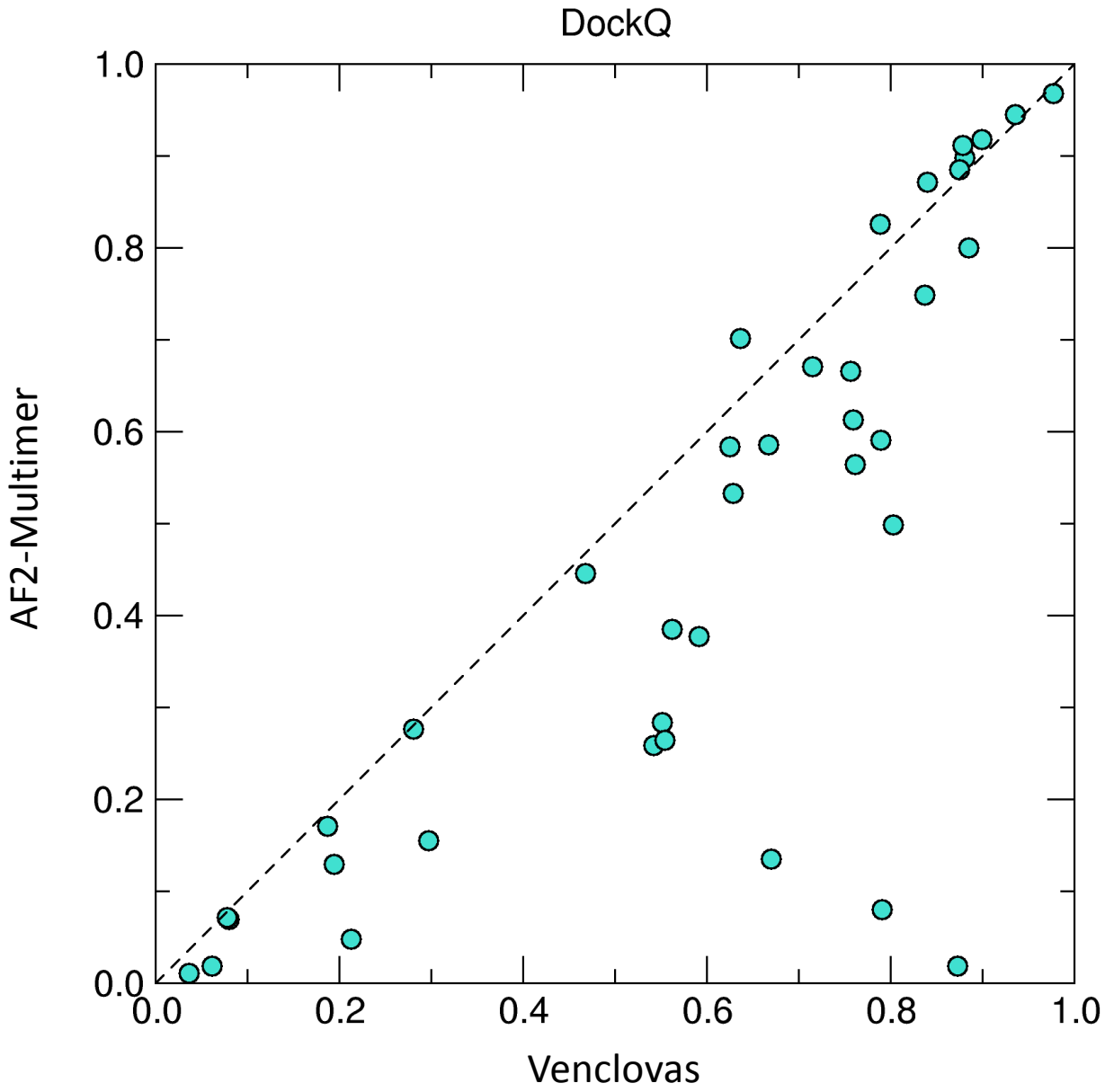

ΣDockQ
ΔΣDockQ
relative to AF2-Multimer
Venclovas
Wei_Zheng
PEZYFoldings
Wallner
Jianyi_Yang
S_Chang
YANG-MULTIMER
Shan_Chang-CoDock
MULTICOM
AF2-MULTIMER

Calculate μ and σ for top-5 models P and TS set, removing exact duplicates
Express DockQ in σ (Z-score), retain only positives
Sum

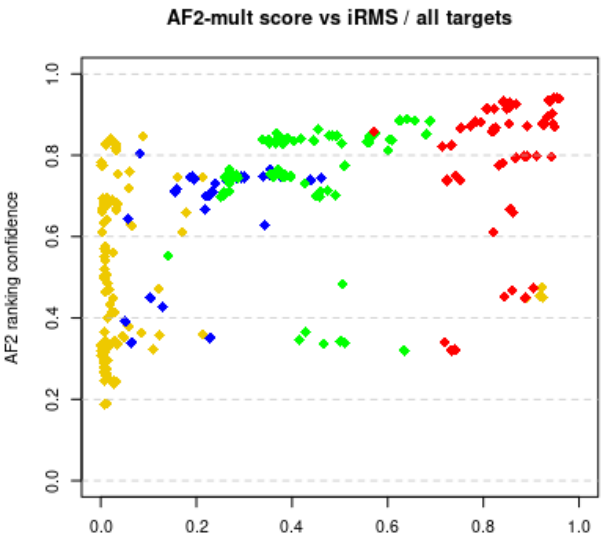


Ranking

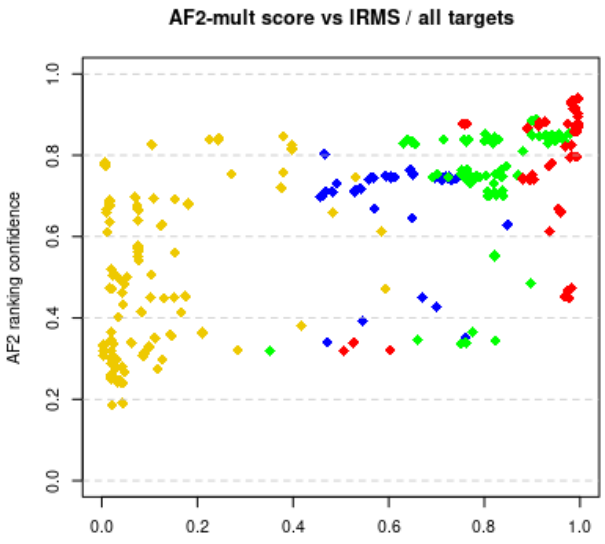
Position	CAPRI	DockQ	Z-score
1	Venclovas	Venclovas	Wallner
2	Wallner	Zheng	PEZYFoldings
3	Zheng	PEZYFoldings	Venclovas
4	PEZYFoldings	Wallner	Zheng
5	Yang	Yang	Kihara
10			Yang
16	AF2-Multimer		
24		AF2-Multimer	
43			AF2-Multimer


DockQ
AF2-Multimer
Venclovas
0.0
0.2
0.4
0.6
0.8
1.0

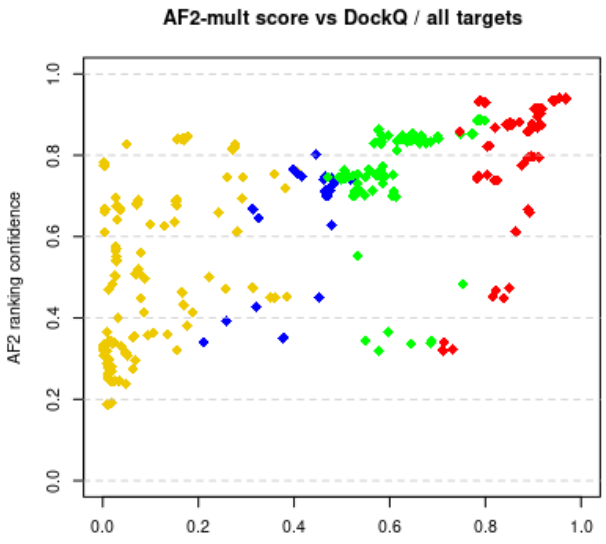
Acknowledgement: Guillaume Brysbaert, Claudio Mirabello, Arne Elofsson



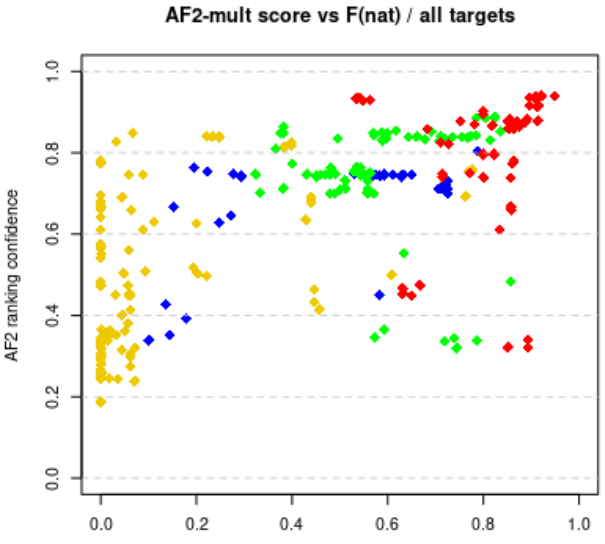
i-rms (scaled)



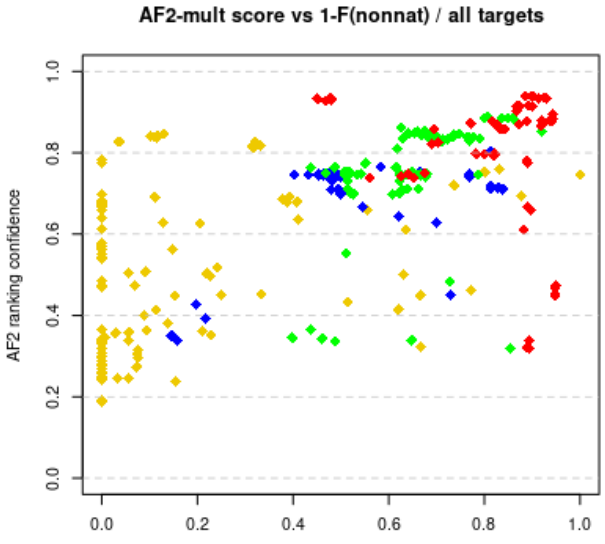
L-rms (scaled)



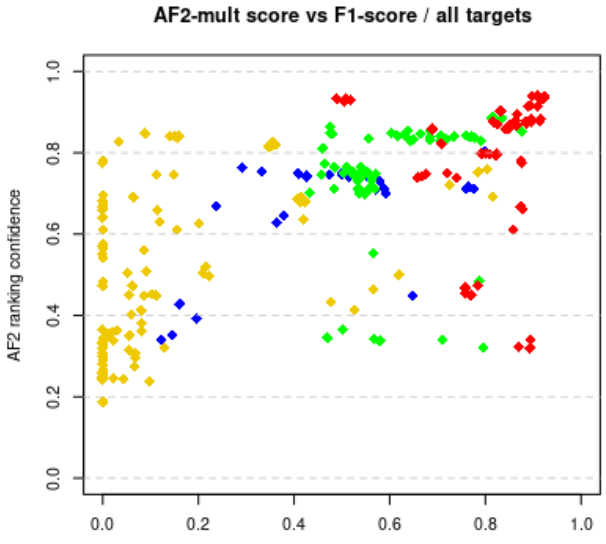
DockQ



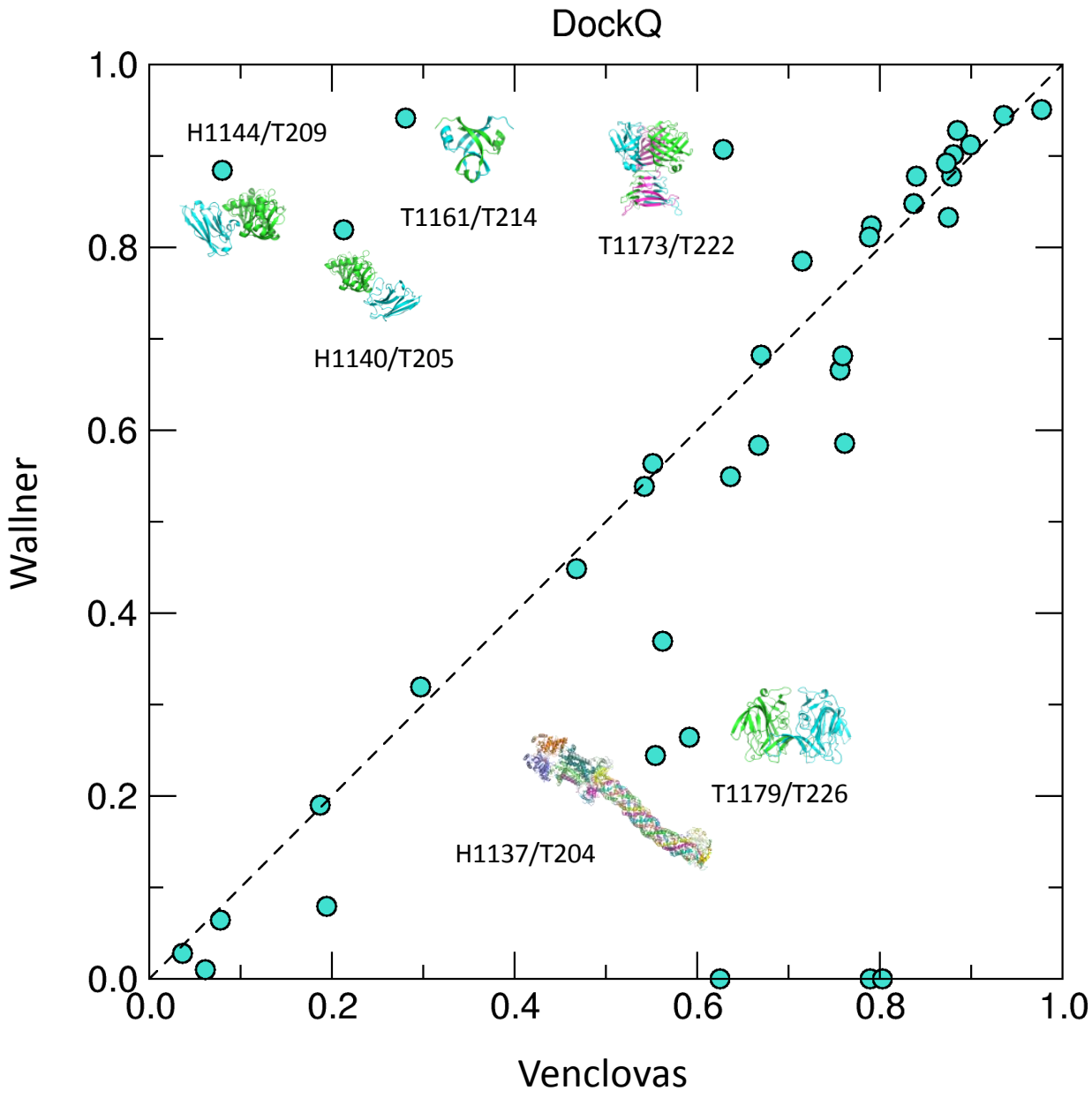
F(nat)

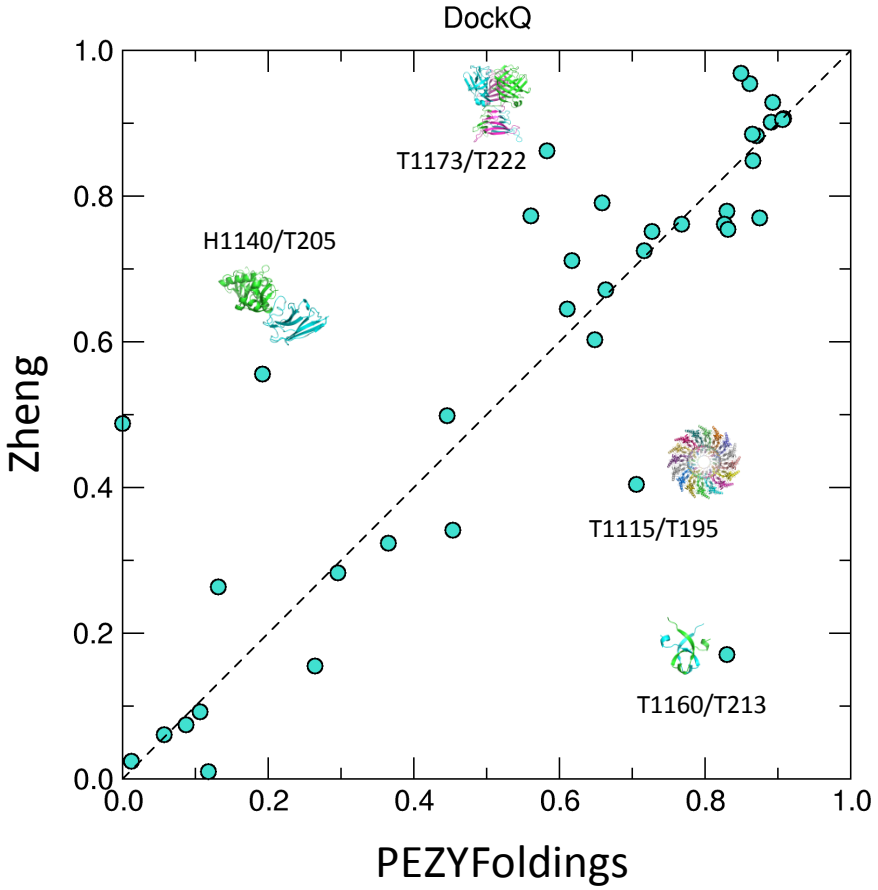


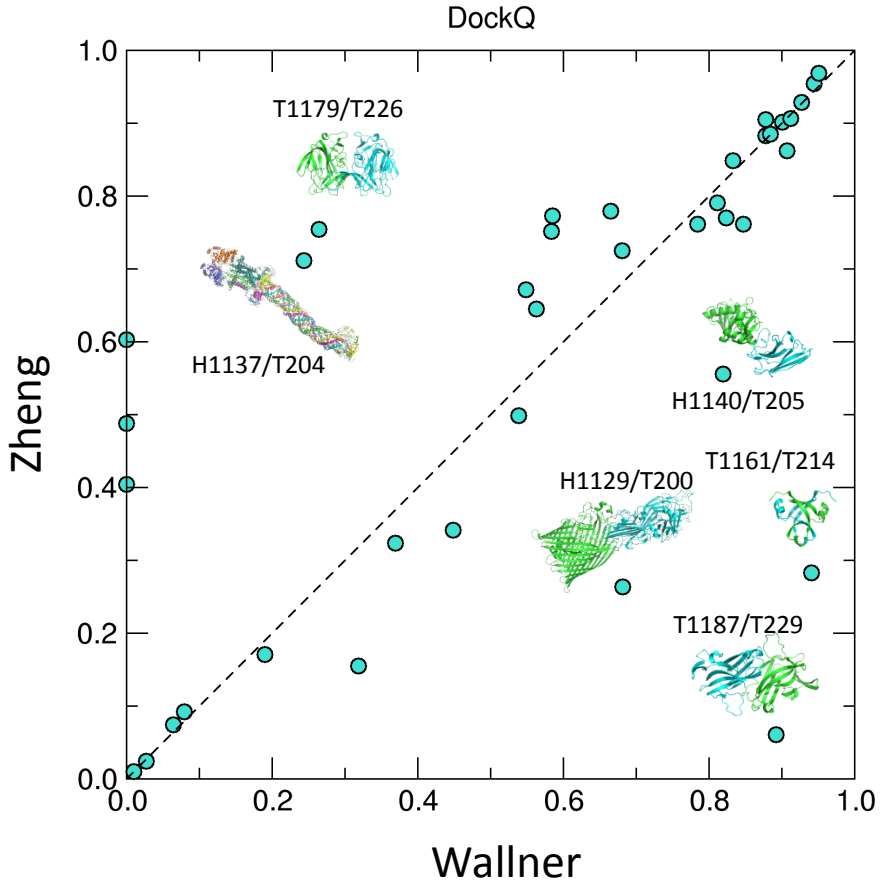
1 - F(nonnat)



F1


DockQ
Wallner
Venclovas
0.0
0.2
0.4
0.6
0.8
1.0
H1144/T209
T1161/T214
T1173/T222
H1140/T205
T1179/T226
H1137/T204


DockQ
Zheng
PEZYFoldings
0.0
0.2
0.4
0.6
0.8
1.0
T1173/T222
H1140/T205
T1115/T195
T1160/T213


DockQ
Zheng
Wallner
0.0
0.2
0.4
0.6
0.8
1.0
T1179/T226
H1137/T204
H1140/T205
T1161/T214
H1129/T200
T1187/T229

Conclusions

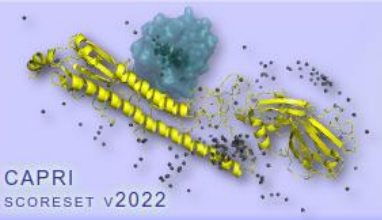
- CASP15/CAPRI54 presented the largest set of targets so far
  - Not only is the ratio of acceptably predicted targets increased, also the quality!
- Deep learning has found its way into protein docking/assembly prediction
  - AF2 produces routinely a medium-quality model for most targets
  - Many groups do better than the AlphaFold2-Multimer submission by Elofsson
  - Scoring will become increasingly more relevant (even more so than it is already)
- Target difficulty
  - Domain swap > antibody > intertwining > nanobody
- CAPRI / DockQ ranking:
  - 1. **Venclovas** – 2. **Wallner** – 3. Zheng / PEZYFoldings – 4. Yang / YANG-MULTIMER
  - **Venclovas** and **PEZYFoldings** have the most AU's with acceptable+ (**29** out of 38)
    - Followed by **Wallner**, **Zheng** and **Kihara** (**28** out of 38)
  - There is still room for improvement
    - **Venclovas** scores consistently well on everything except the nanobodies
    - **Wallner/Zheng/PEZYFoldings** do particularly well on the nanobodies
- Ranking on (DockQ) Z-score
  - Pushes **Wallner** & **PEZYFoldings** to the top
    - Pushes CAPRI participants higher and AF2 lower
  - These participants do better on the very difficult targets
- Venclovas is also the best scorer
  - Followed by Huang/HDOCK and Kihara

Acknowledgements

- CASP Team
  - For setting up the experiment and the collaboration with CAPRI
- Assembly assessors
  - Great job and nice discussion sessions
- CAPRI Management
  - Who thoroughly oversee the project
- All participants
  - Continuous support and submissions
- The experimentalists
  - Essential to CASP/CAPRI

The CAPRI Community (2019)

scoreset.org



CAPRI SCORESET v2022

Introduction | Browse | Download | Help

Motivation:

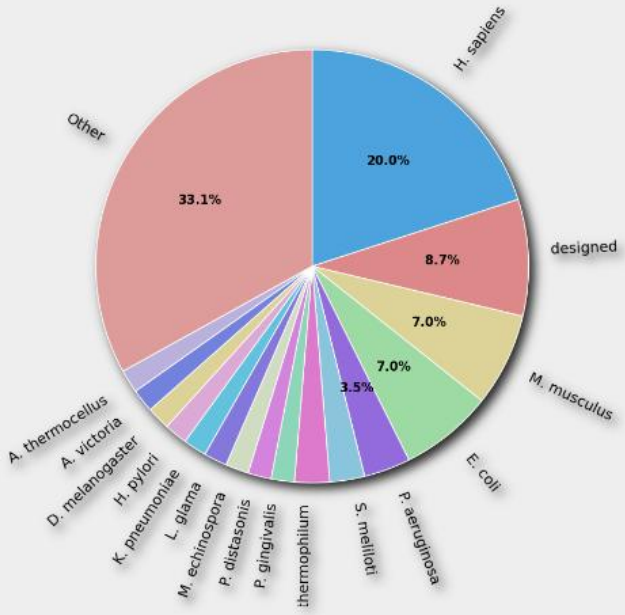
The CAPRI protein-protein docking experiment is a proven catalyst for the development of docking algorithms. An essential step in docking is the scoring of predicted binding modes generated for a given target (the experimentally determined structure to be predicted), in order to identify near-native complexes. Since 2005, the CAPRI experiment has been providing enriched data sets, including both correct and incorrect docking solutions (decoys), to enable developers to test new scoring functions independently from docking calculations.

Result:

Here we present the ensemble of models submitted to the CAPRI docking and scoring experiments for CAPRI targets with published PDB structures. All models have been annotated with calculated assessment quantities used by CAPRI.

Content:

96	Targets
148	Interfaces
170310	Decoys
57.45G	Size

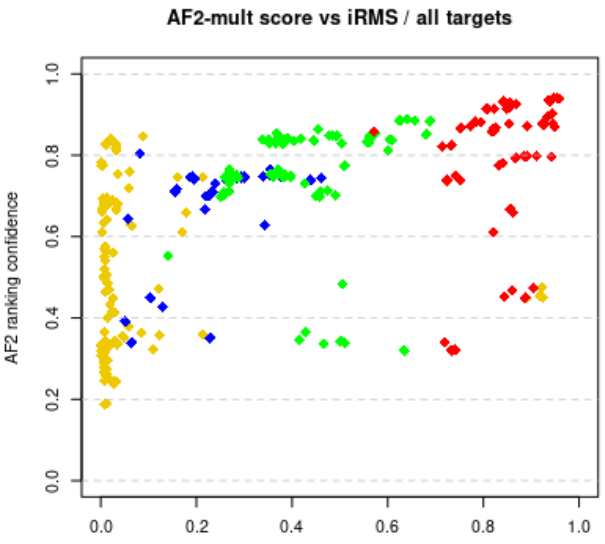


The CAPRI scoreset v2022 is developed and maintained by:

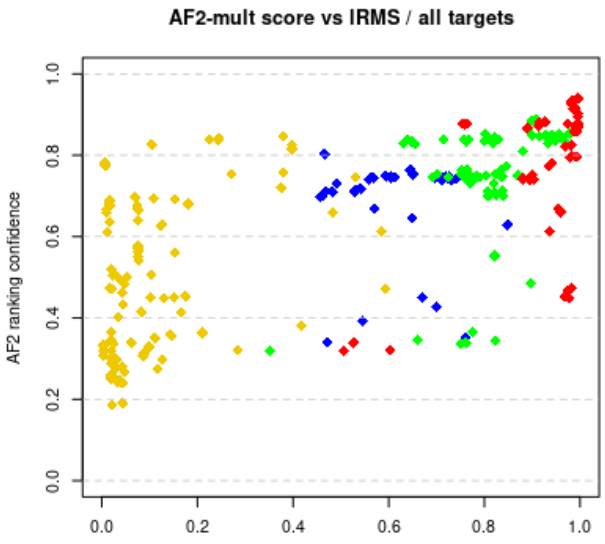
- Marc F. Lensink, CNRS & University of Lille, France
- Theo Mauri, CNRS & University of Lille, France
- Guillaume Brysbaert, CNRS & University of Lille, France
- Shoshana J. Wodak, VUB-VIB, Belgium

cnrs Université de Lille VIB-VUB CENTER FOR STRUCTURAL BIOLOGY

Acknowledgement: Guillaume Brysbaert, Claudio Mirabello, Arne Elofsson



i-rms (scaled)



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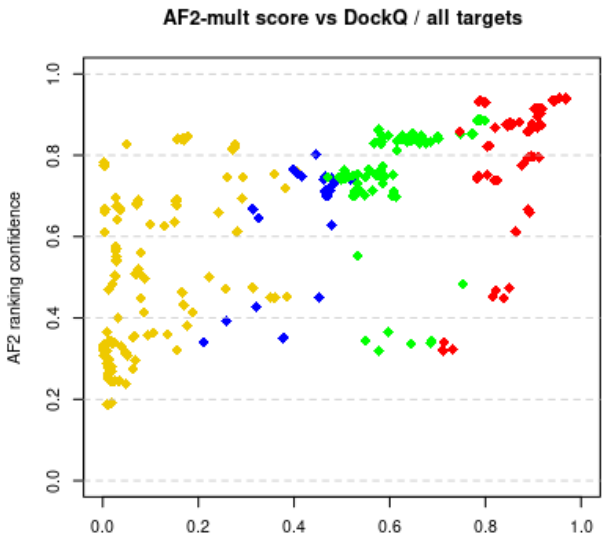
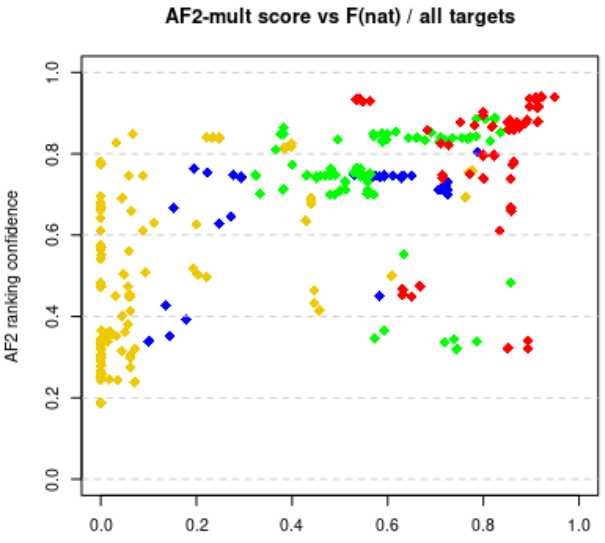
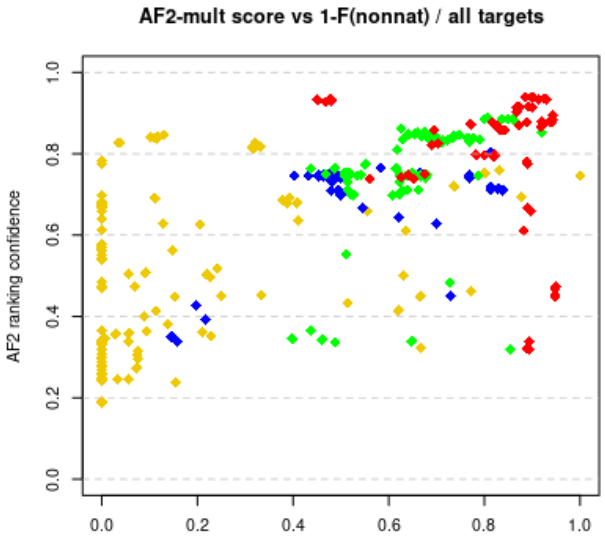


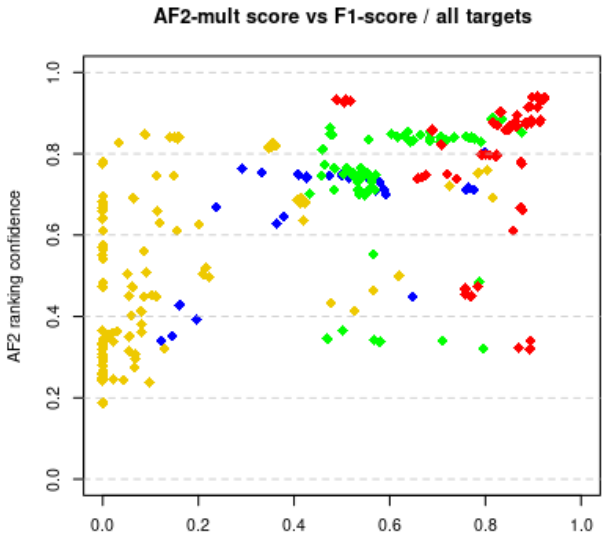
DockQ



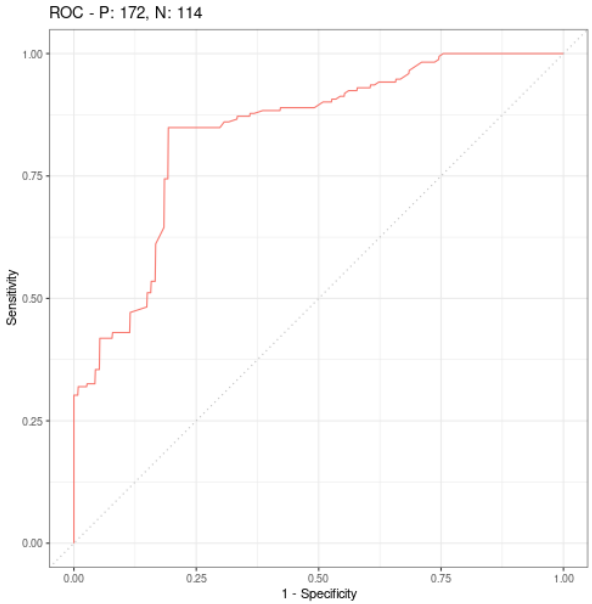
F(nat)

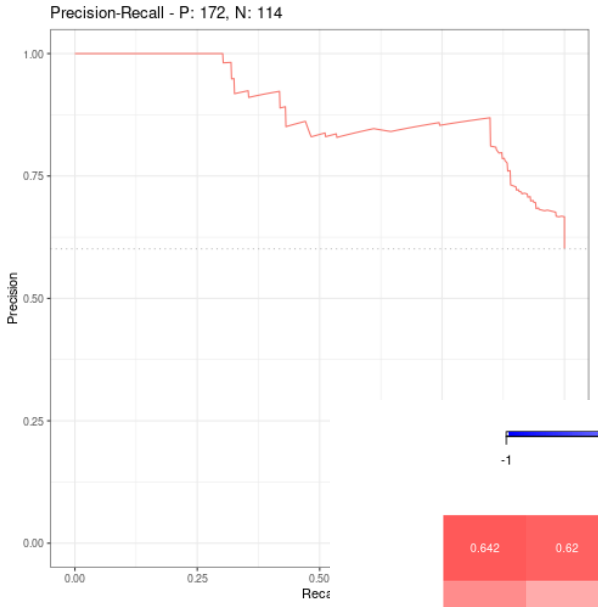


1 - F(nonnat)



F1





CASP14	
Best predictor	9/4**
AF2-MM	9/4***/1**