

Assessing refinement models

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Selection of refinement models

- Initial suggestions from Andriy Kryshchak
 - usually best server model, < 200 residues, room for improvement
 - Online discussion of suitability, exact definition of boundaries, information to be provided to predictors
 - internal symmetry, presence of bound metal or other ligand
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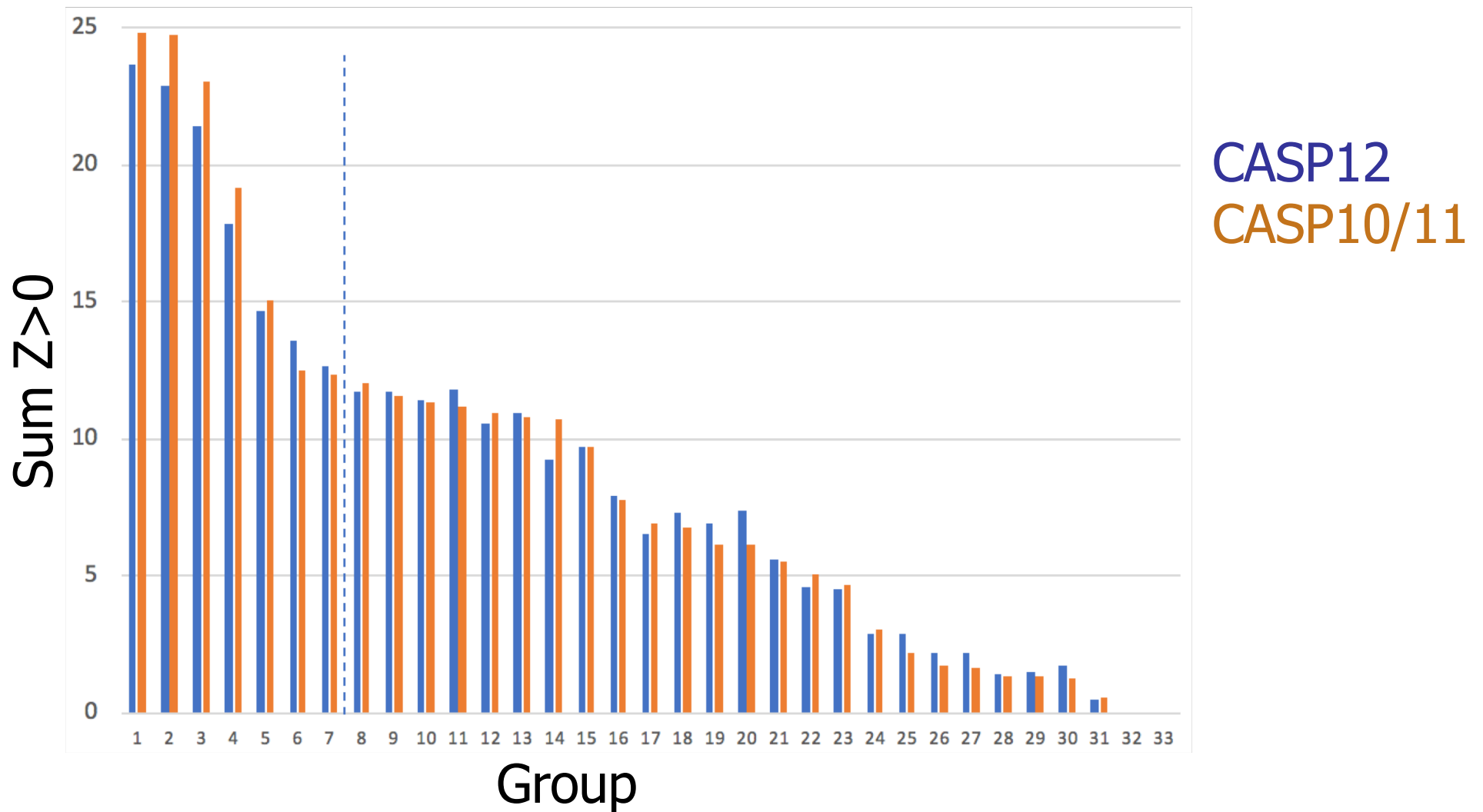
Evaluation criteria

- Refinement ranking score from CASP12
 $0.46 z. \text{RMSD} + 0.17z. GDT_{HA} + 0.2 z. SG + 0.15 z. QCS + 0.02 z. MolPrb$
 - Refinement score from CASP10/11
 $z. GDT_{HA} + z. \text{RMSD} + z. SG + 0.2z. MolPrb$
 - TBM ranking score
 $\frac{1}{3}z. GDT_{HA} + \frac{1}{9}(z. lDDT + z. CADaa + z. SG) + \frac{1}{3}z. ASE$
 - Other scores
 - molecular replacement LLG, clash score, torsion angle deviations...
-

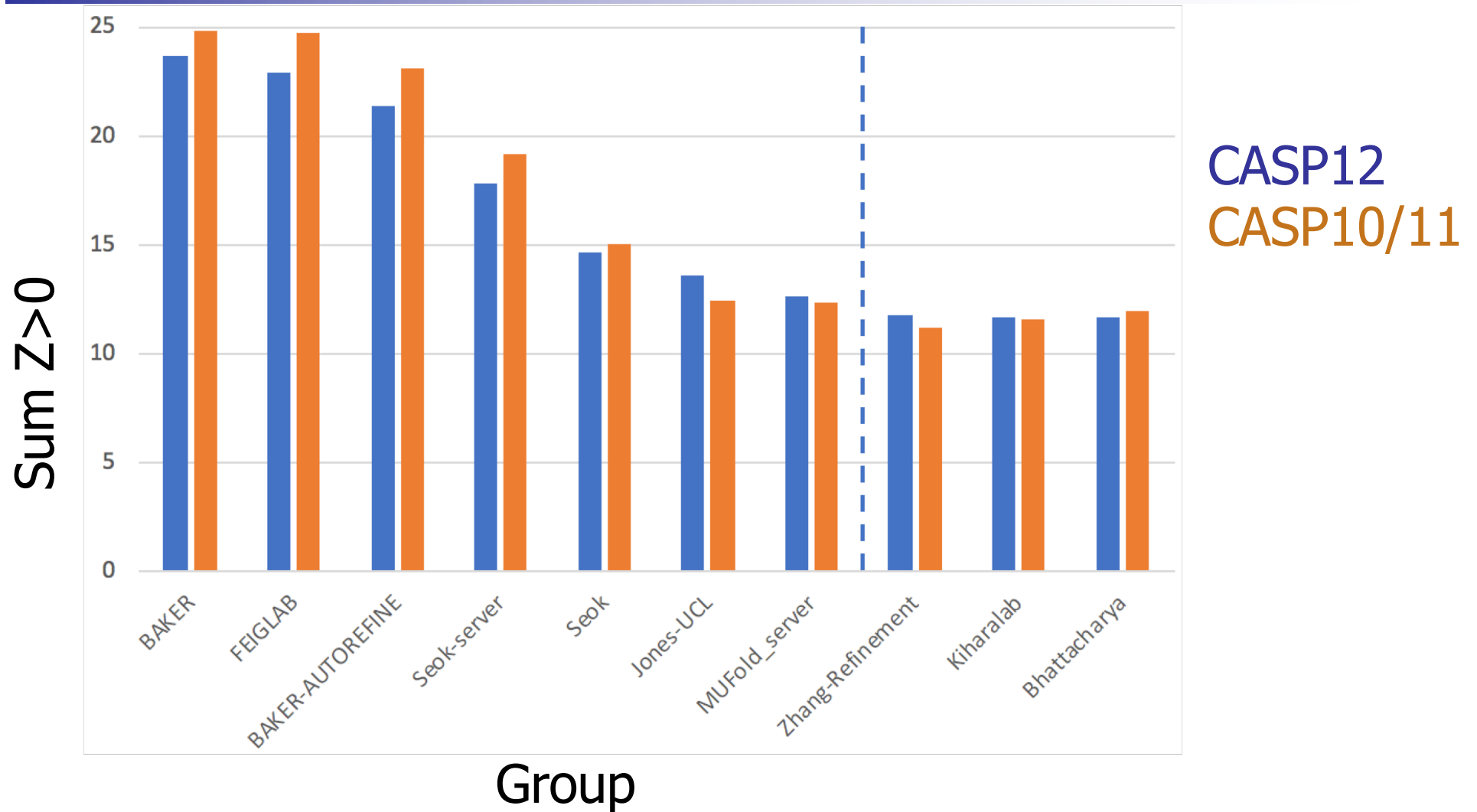
Justification of ranking scores

- Comparison with TBM
 - Refinement score in CASP12 was optimized to predict manual assessment ranking
 - check whether change from CASP10/11 affects ranking
-

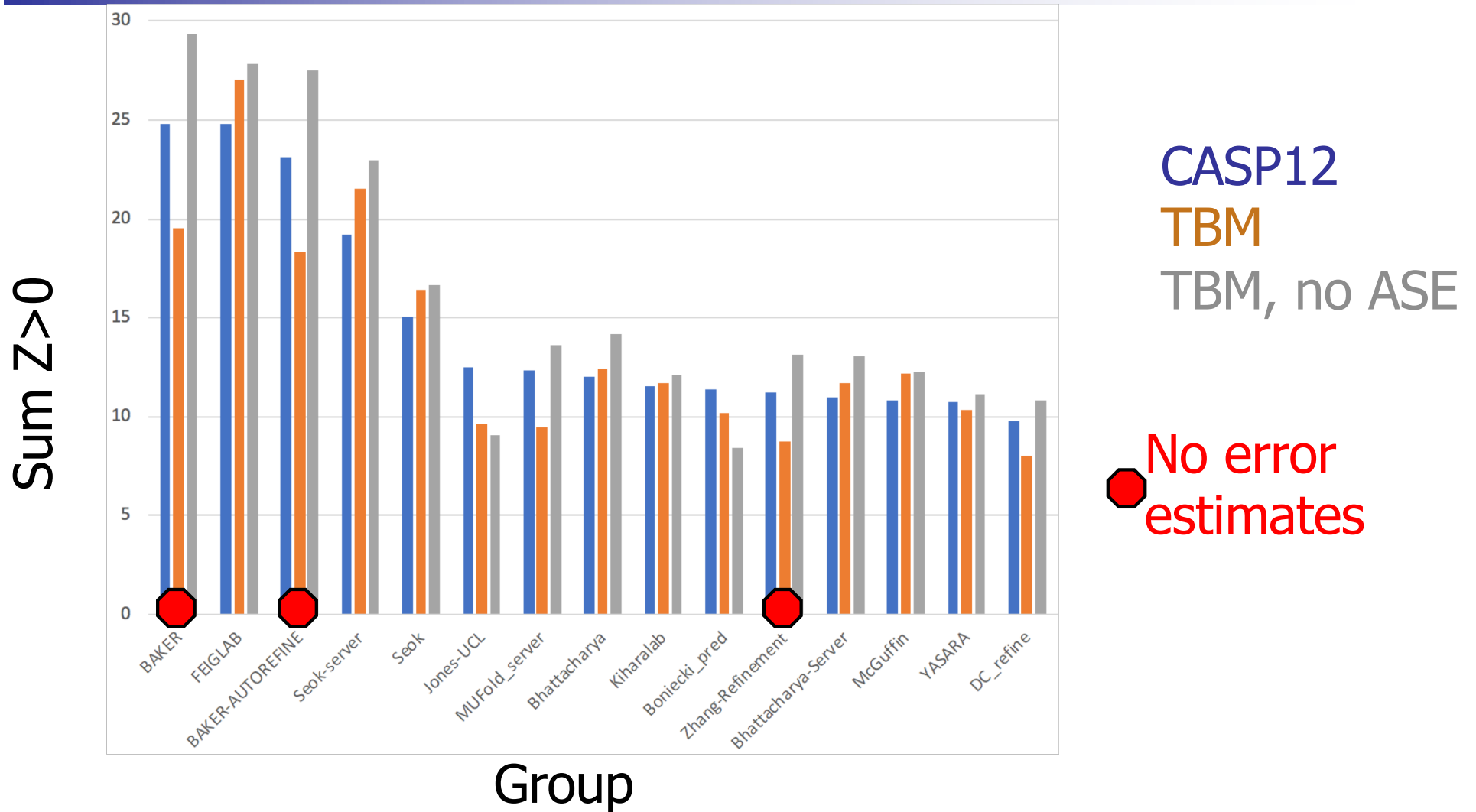
Predictors sorted by refinement ranking scores



Predictors sorted by refinement ranking scores



Compare with TBM ranking score

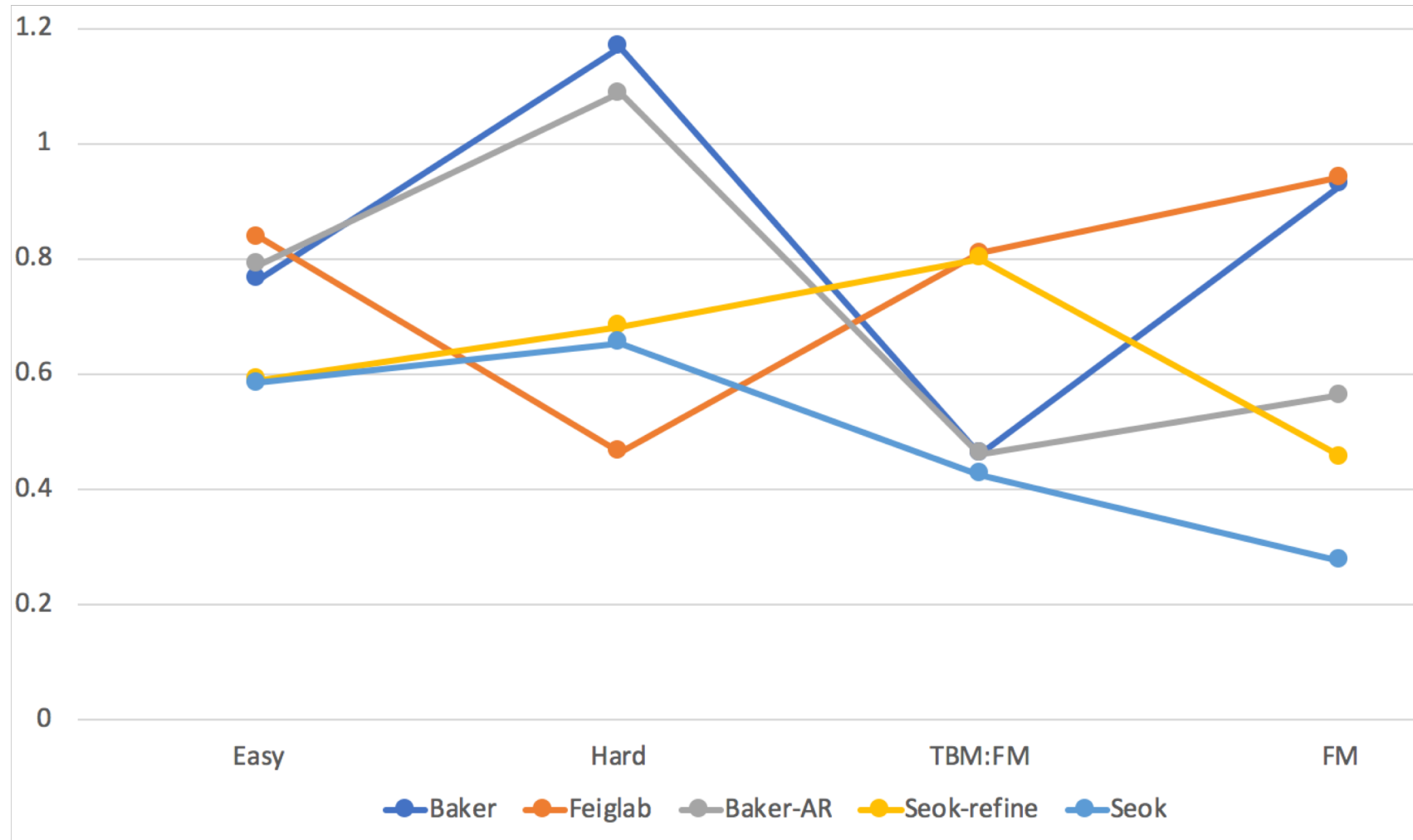


Stability of ranking

- Same top 4-7 appear in the same order with different scores and weightings
 - except for ASE, as some groups did not submit error estimates for refinement models



Predictor CASP12 scores and original target difficulty



Methods used by top groups

- Baker
 - Baker-Autorefine plus human intervention
 - Feiglab
 - iterative MD simulations with flat-bottomed restraint to start model
 - Baker-Autorefine
 - iterative model hybridization
 - restrain to start model if GDT-HA>50
 - Seok-server, Seok
 - physics-based perturbation of start model and template hybridization
-

Progress?

- Progress is difficult to evaluate
 - global statistics depend on who enters
 - as TBM gets better, less room for improvement
 - where TBM still fails, are the complications more severe?
 - refinement targets come from structures that are getting progressively bigger and more complicated

“easy” {

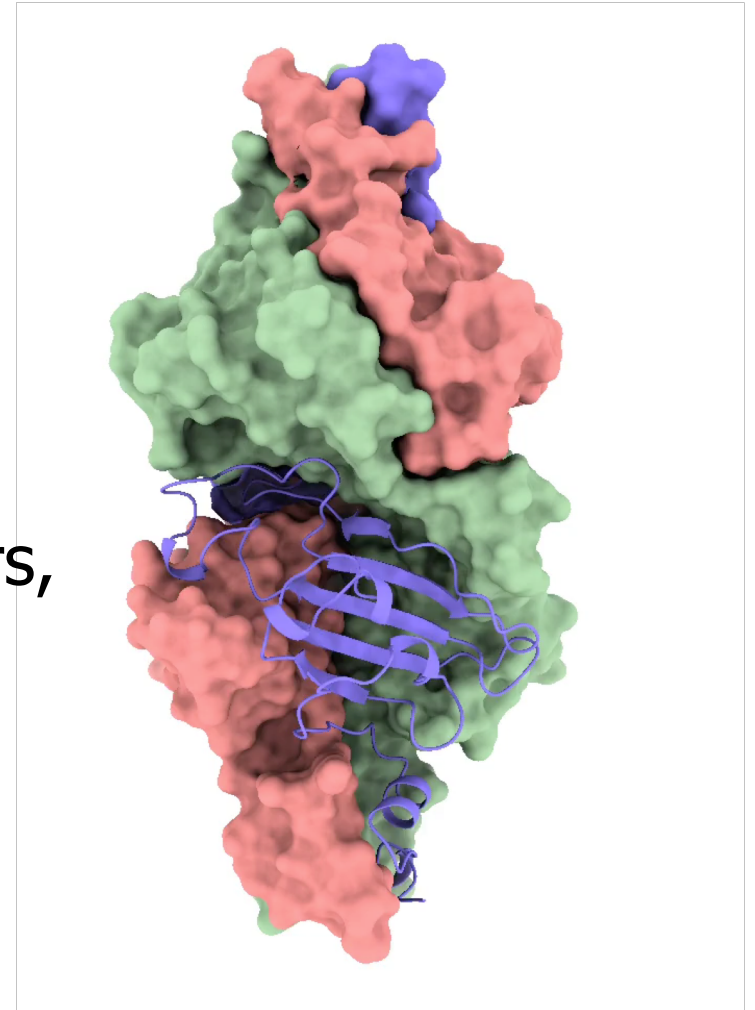
- 3 targets: single domain of monomer
- 14 targets: compact domain from larger structure, possibly multimer

“hard” {

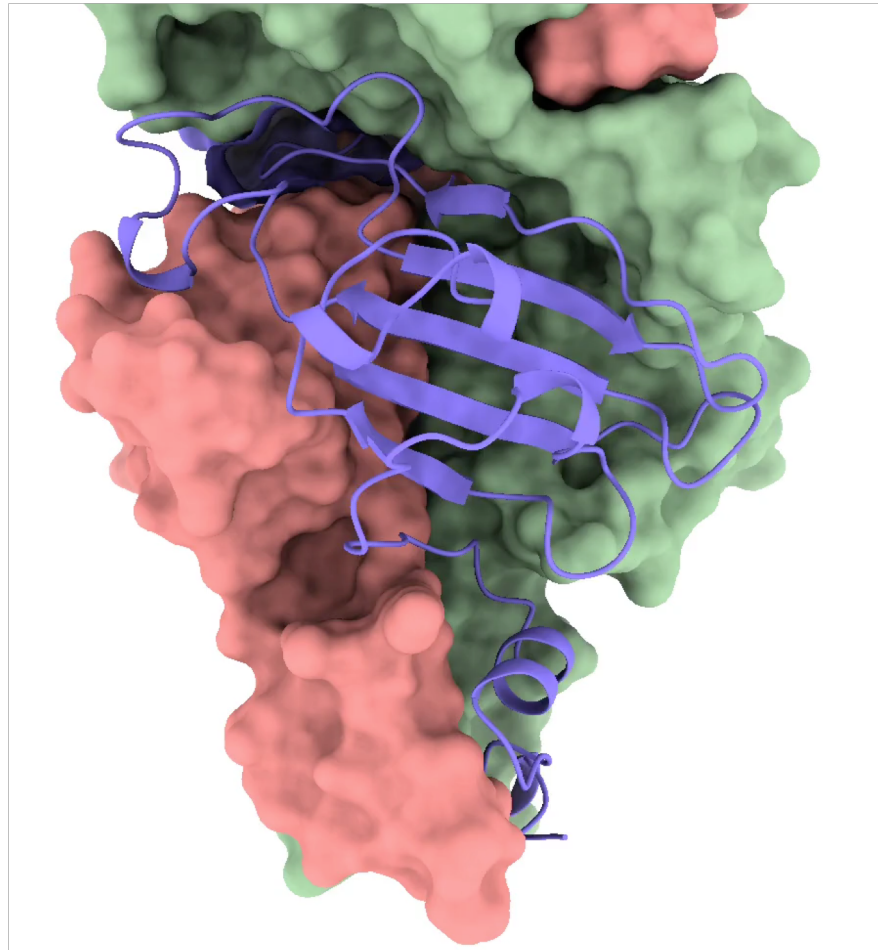
- 12 targets: domain for which conformation is likely to depend on contacts with its environment

R0989-D1: “hard” target for which structural context is important

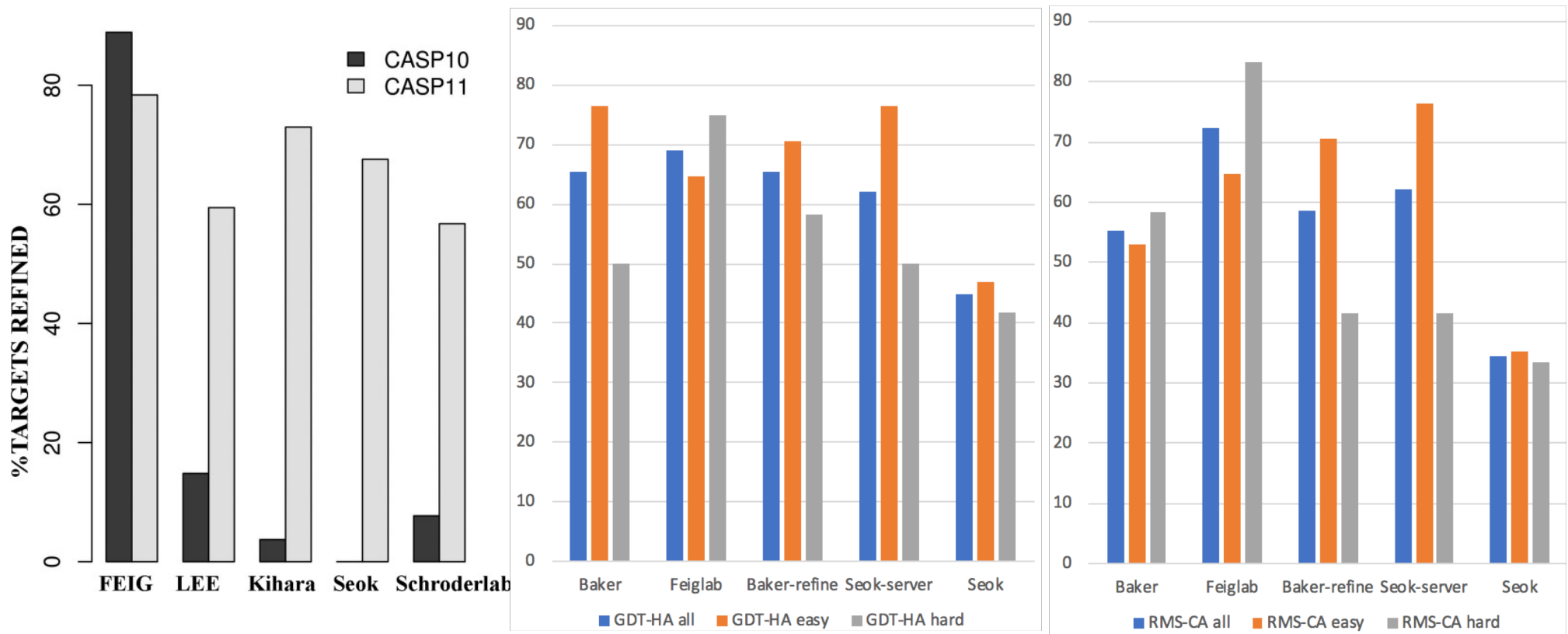
- Model is a “domain” of a monomer
- Protein is a trimer
 - N-terminal segment of D1 only makes sense as a trimer
 - identifiable templates are trimers, but differ in N-terminus



R0989-D1: close-up

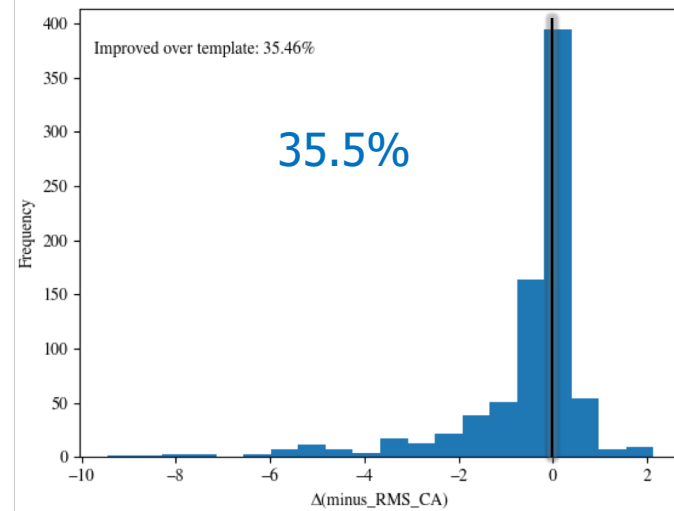
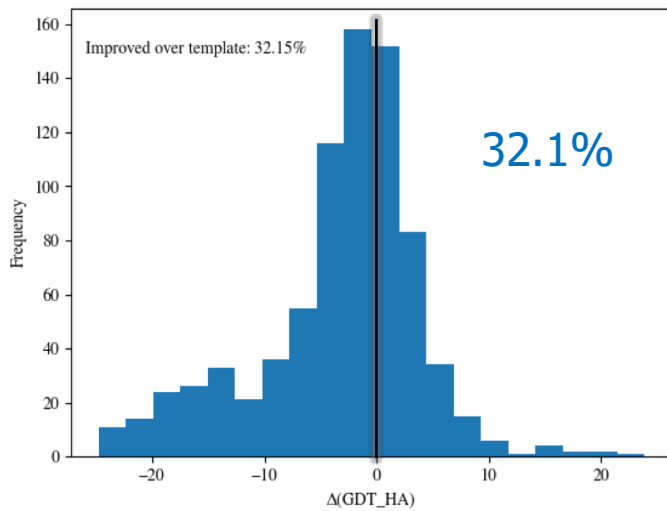
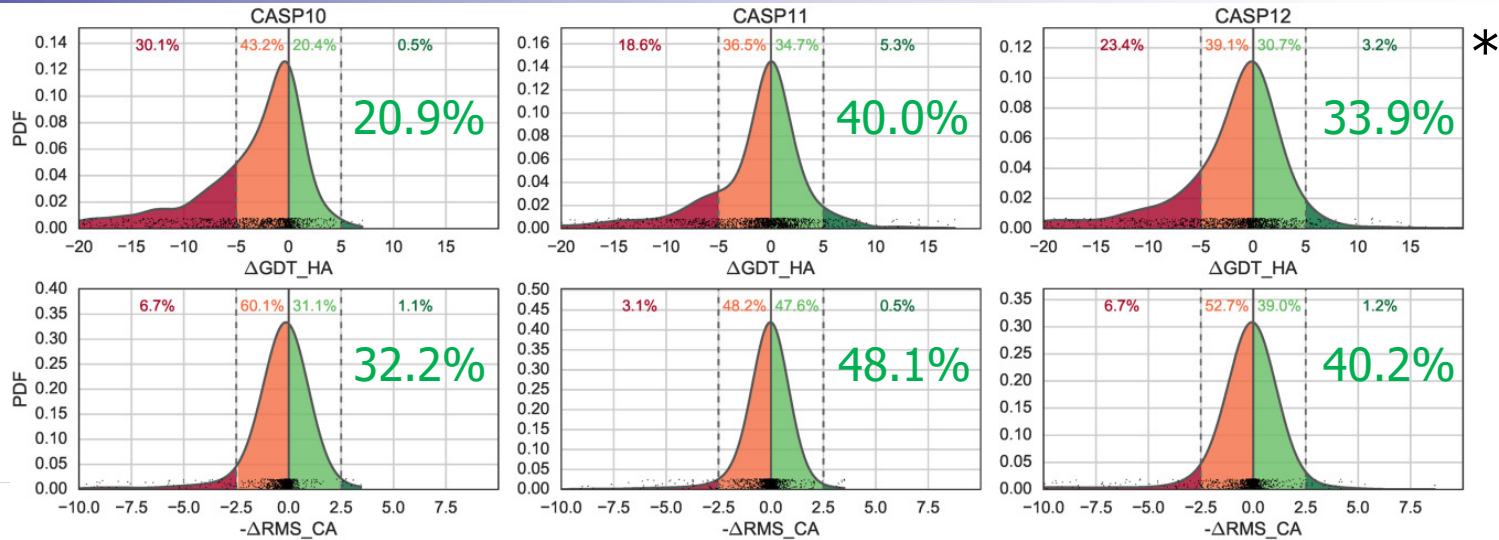


Progress? Percentage of models improved by top groups



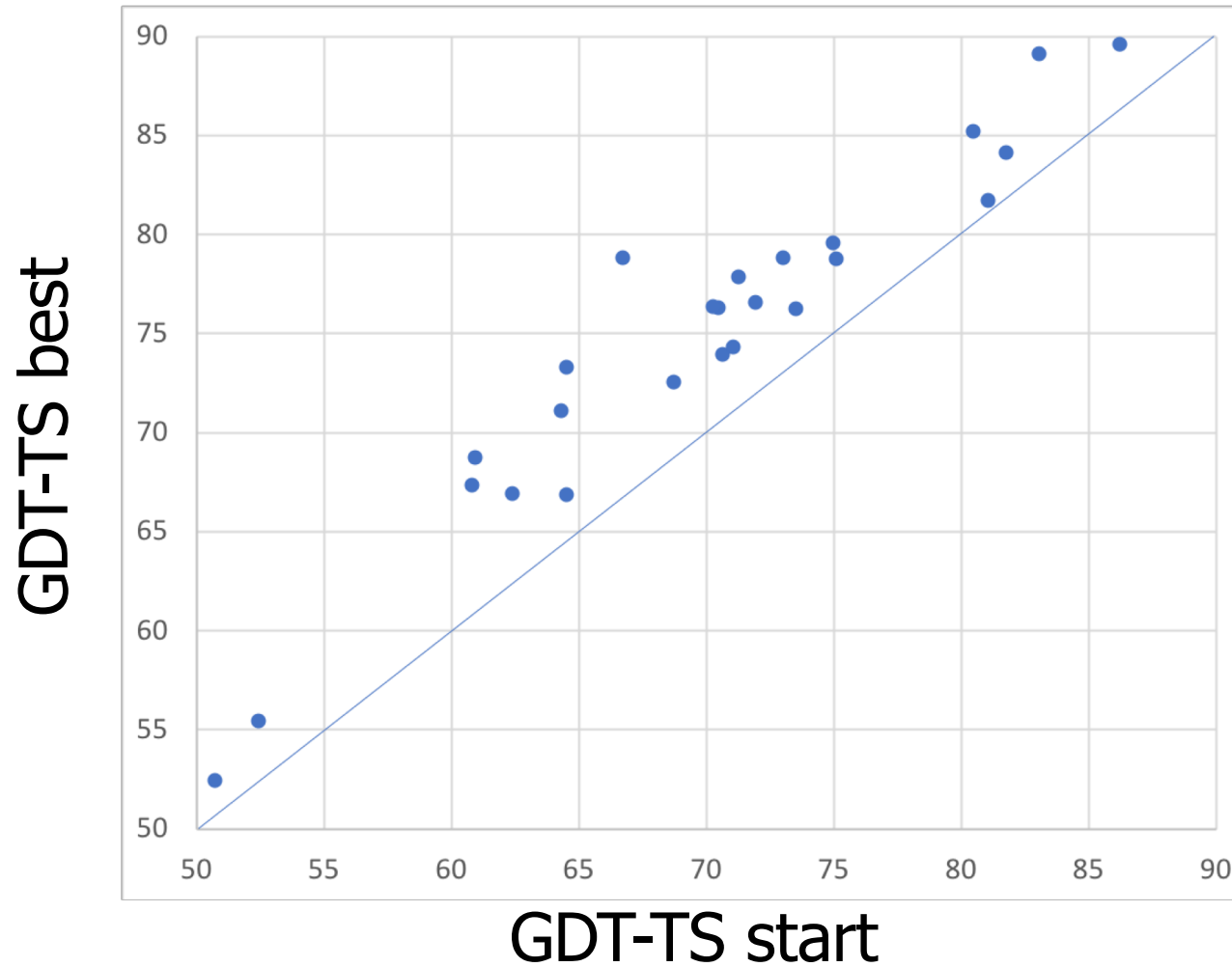
Modi & Dunbrack, 2016

Progress? Overall percentage of improved models

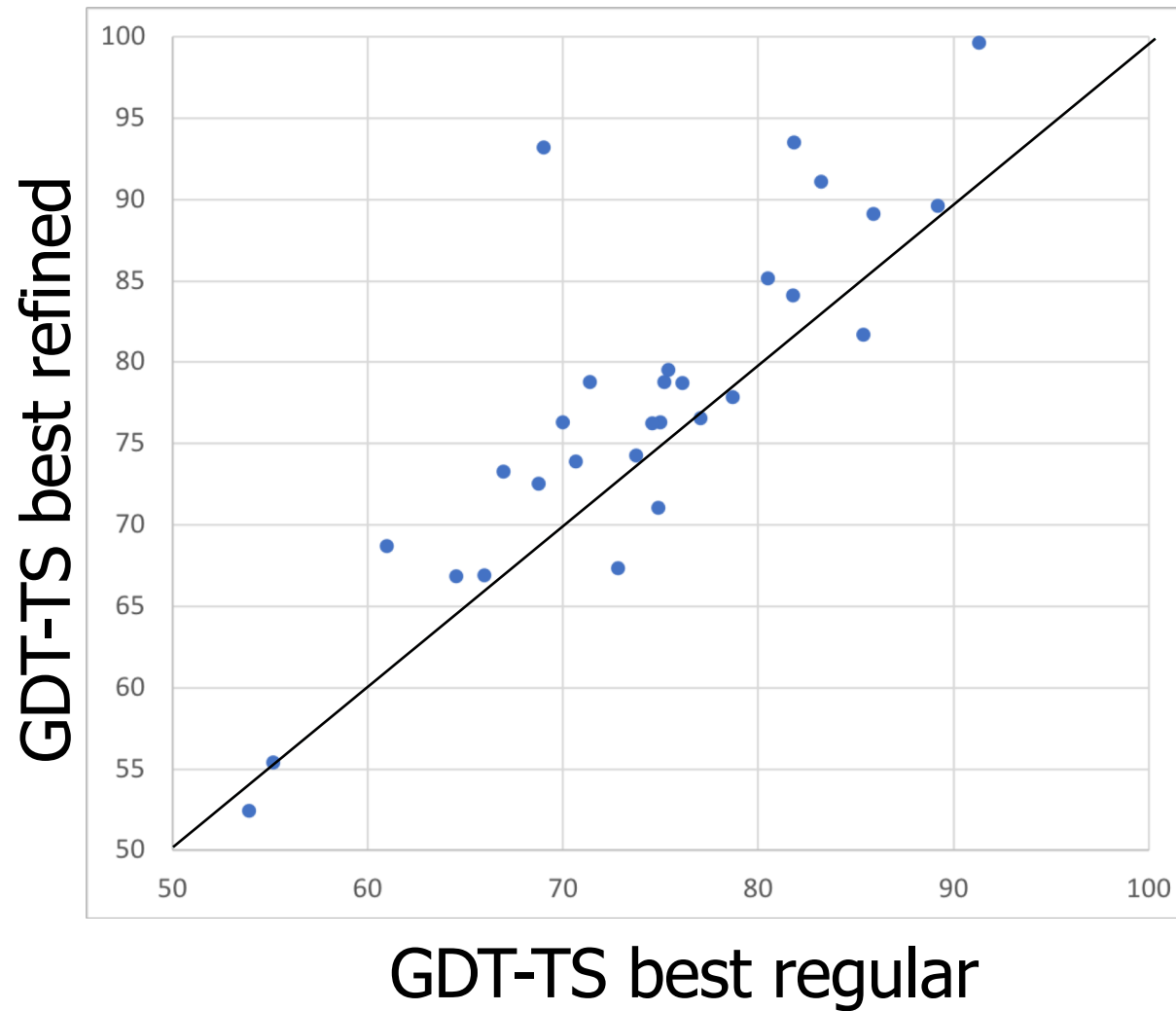


* Hovan *et al.*, 2018

Value added to starting model

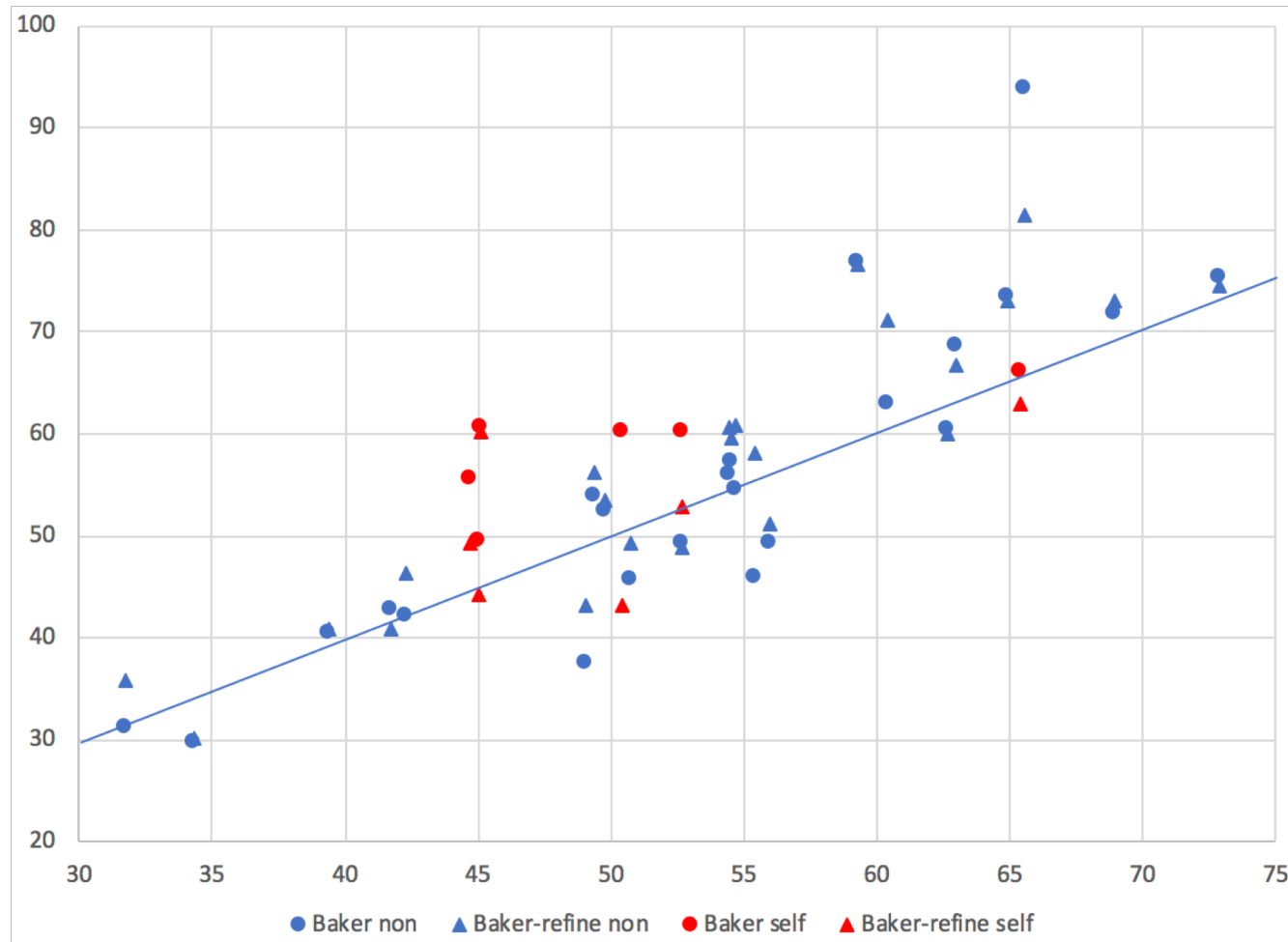


Improvement in refinement exercise



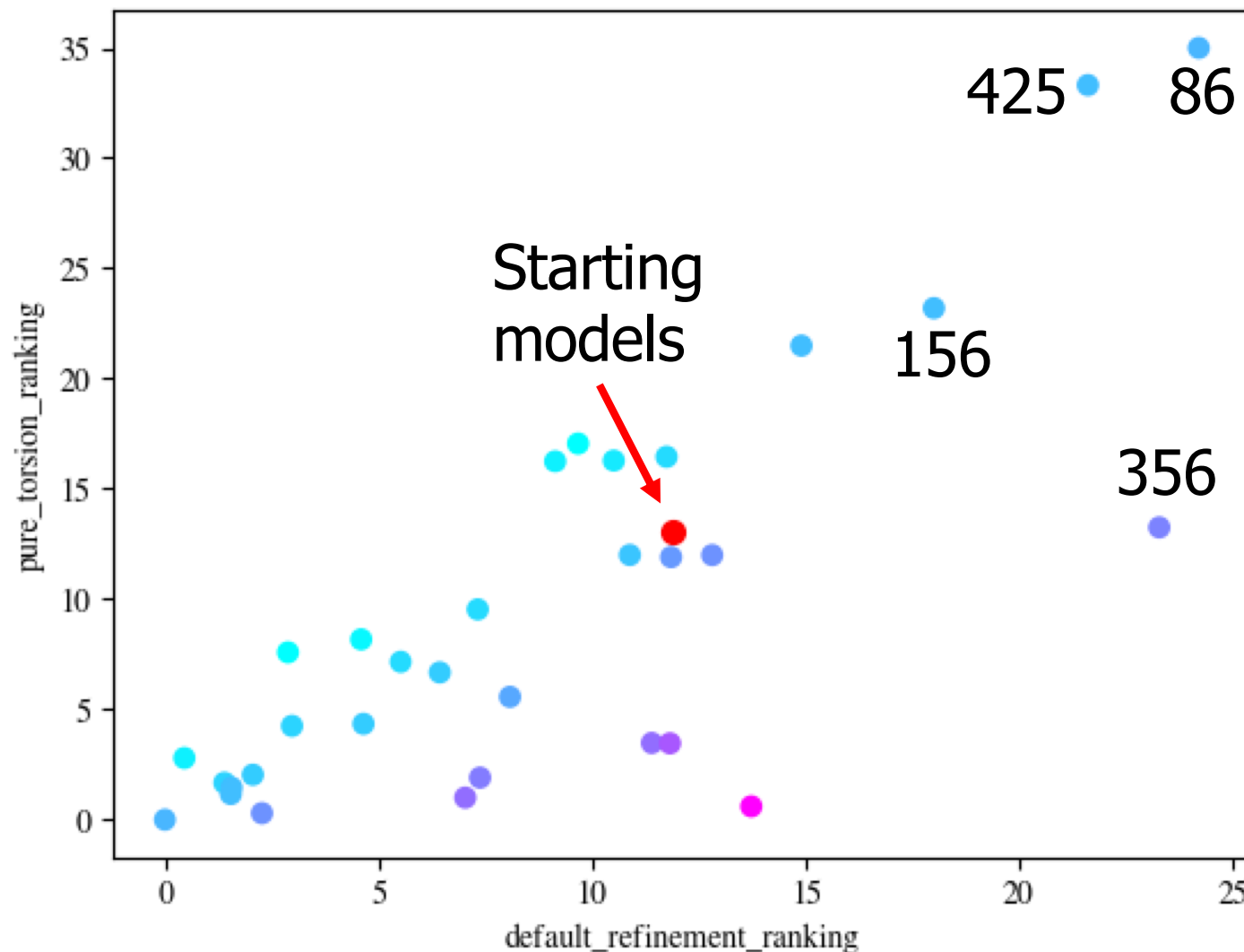
Complementarity of methods? (Baker *vs.* Baker)

GDT-HA Refined model

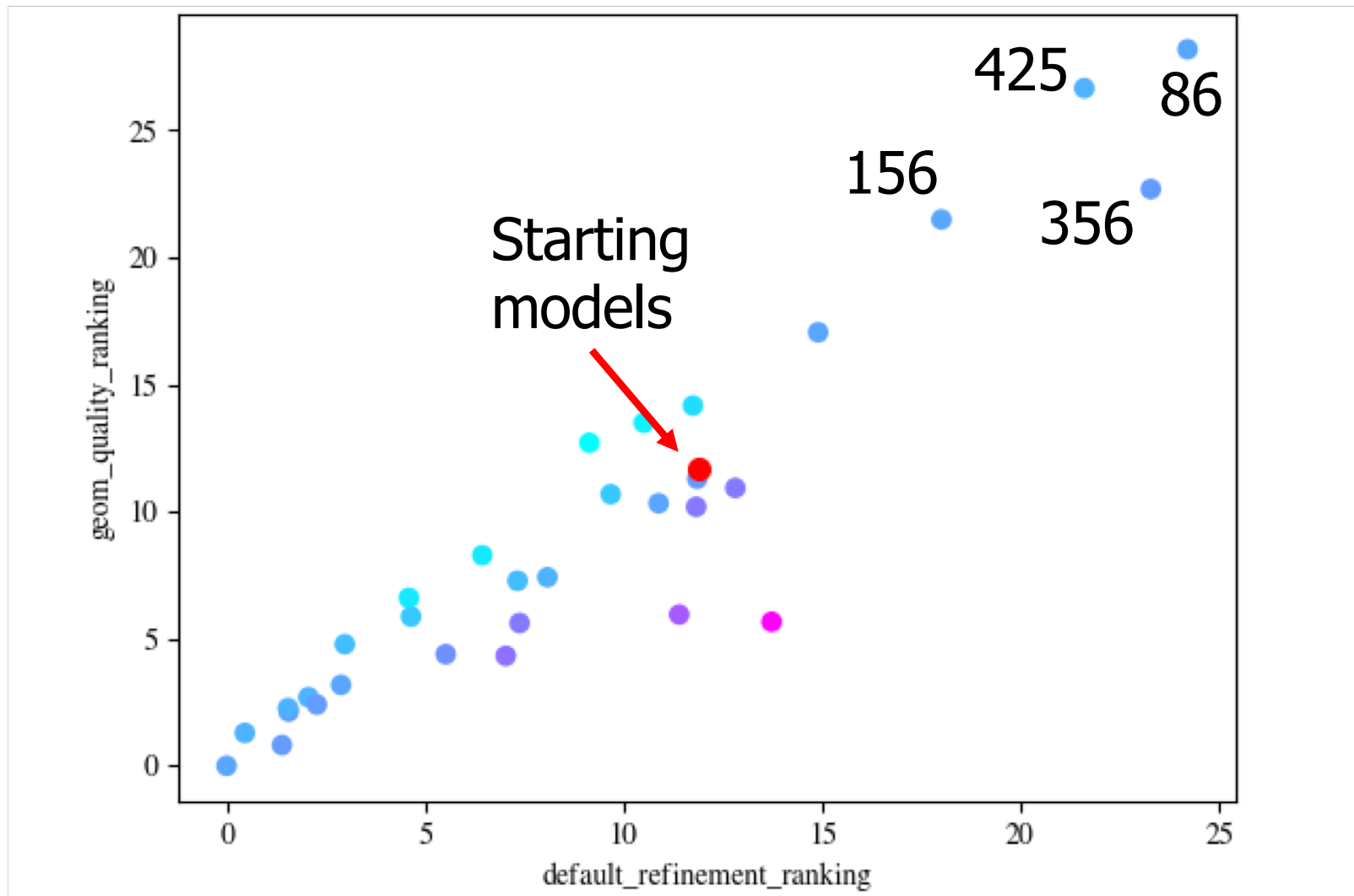


GDT-HA Starting model

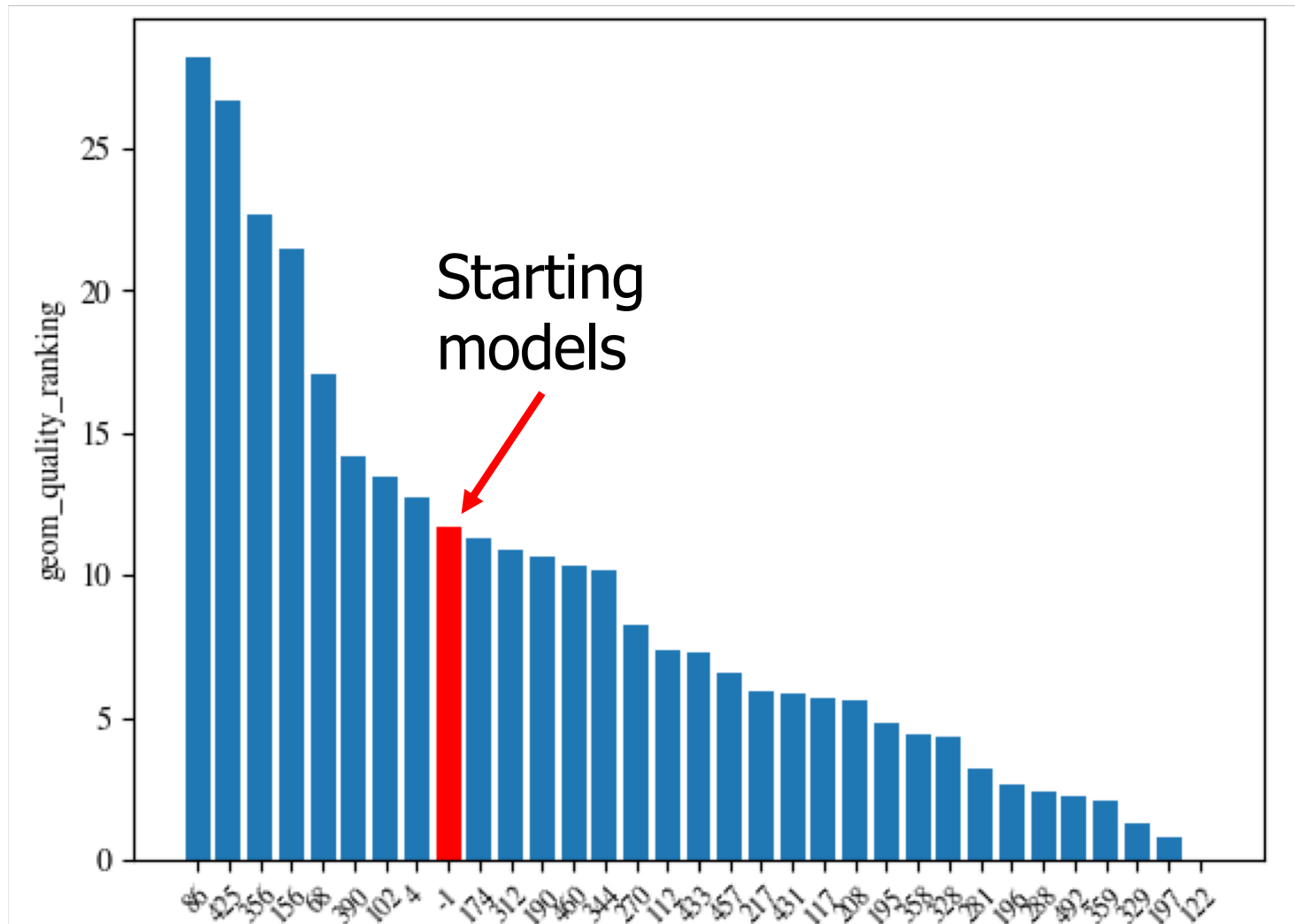
Default vs. pure-torsion ranking



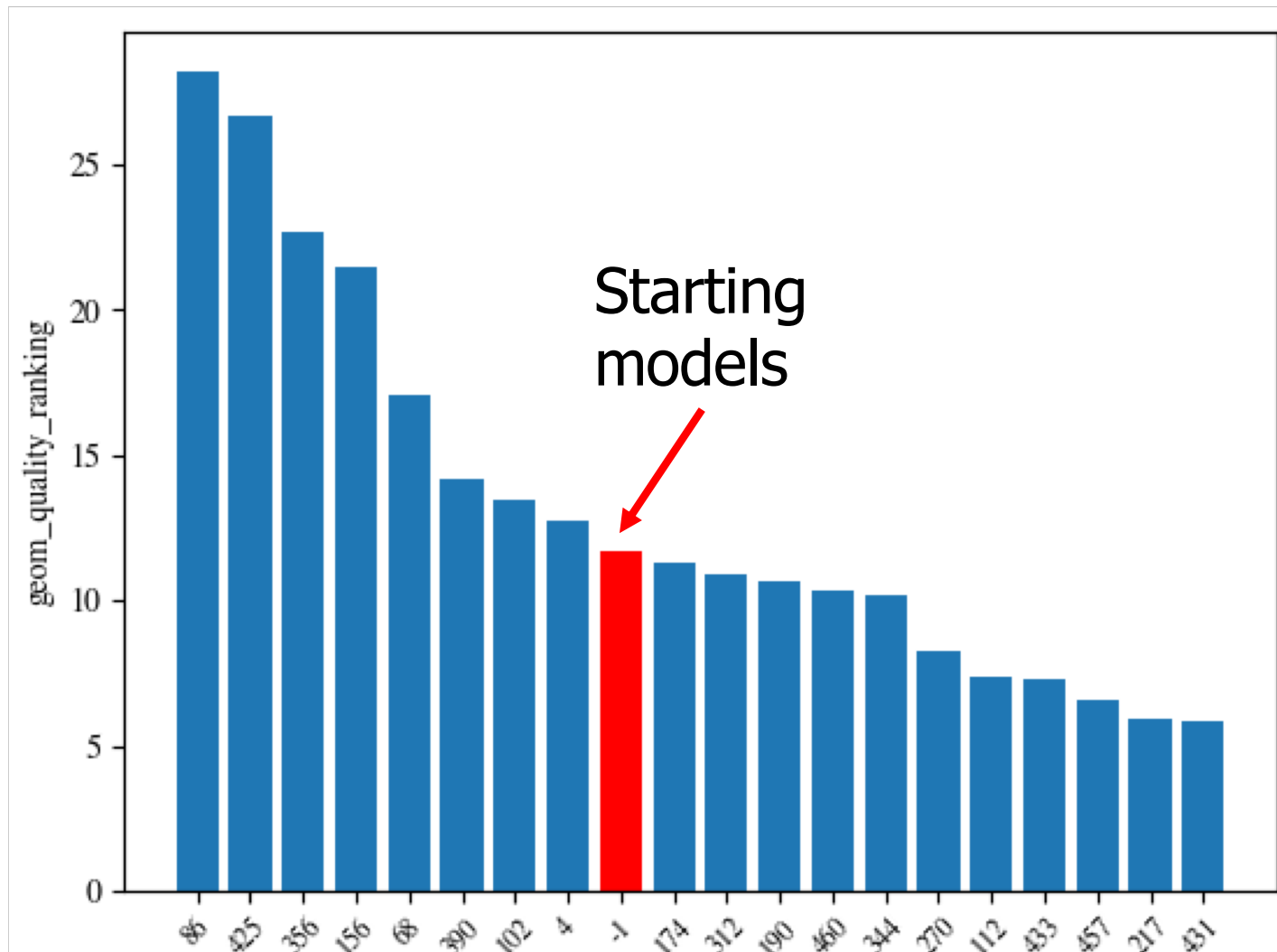
Default vs geometric quality rankings



Geometric quality-based rankings (including torsions)



Geometric quality-based rankings (including torsions)



86 = Baker
425 = Baker-Autorefine
356 = Feiglab
156 = Seok-server
68 = Seok
390 = Bhattacharya
102 = Bhattacharya-server
4 = Yasara

Value-added metrics for R0981-D4 (FM target)

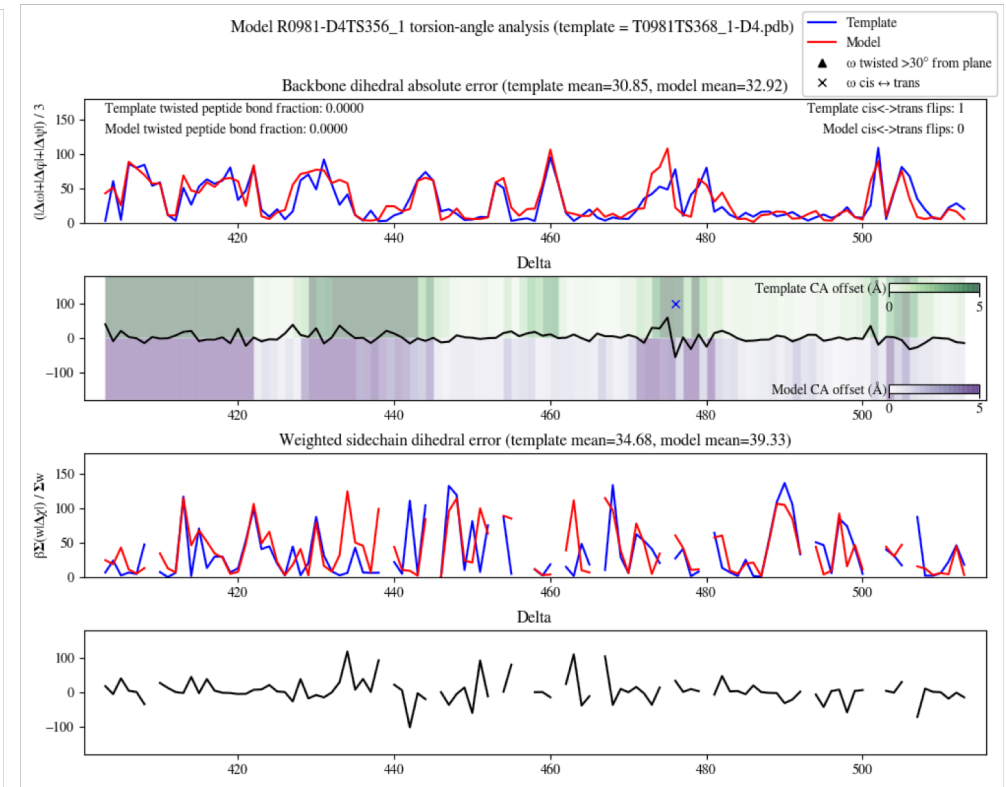
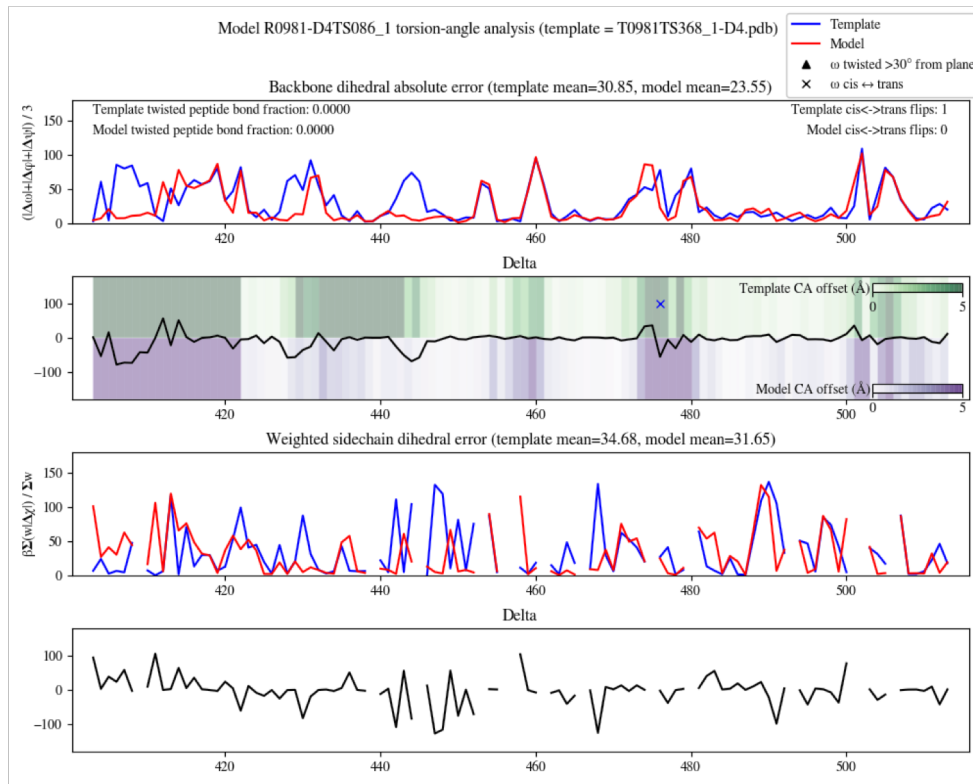
#	Model	ΔGDT_TS	ΔGDT_HA	ΔGDC_SC	ΔRMS_CA	ΔRMS_ALL	ΔMammoth	ΔDall	ΔMolPrb	ΔIDDT	ΔSG	ΔCAD(AA)	ΔRPF	ΔQCS	ΔSOV	ΔCE	ΔCoDM	ΔDFM	ΔHanded.	ΔTM	ΔFlexE
	starting (actual scores not Δ)	62.39	45.05	20.24	6.80	7.38	5.98	10.80	1.33	0.51	55.86	0.53	0.53	88.36	70.70	5.04	0.75	0.54	0.79	0.65	18.42
1.	R0981-D4TS086_1	4.505	4.505	7.928	-1.325	-0.928	0.325	1.000	-0.410	0.095	12.612	0.067	0.089	1.596	14.000	0.420	0.062	-0.056	0.015	0.037	-10.500
2.	R0981-D4TS208_1	1.352	1.353	1.930	-0.660	-0.222	-0.758	-0.500	0.548	0.025	-1.802	-0.004	0.028	-0.027	-7.200	0.150	0.052	-0.098	0.024	0.018	0.720
3.	R0981-D4TS460_1	1.802	1.125	1.012	-0.182	-0.177	0.000	0.200	1.310	0.011	0.901	0.011	0.016	0.642	0.100	0.150	0.008	-0.065	0.007	0.009	0.000
4.	R0981-D4TS102_1	0.226	0.225	1.424	-0.043	-0.061	0.000	0.000	0.243	0.010	0.901	0.004	0.014	-0.065	0.000	0.150	-0.001	0.016	0.002	-0.003	-0.260
5.	R0981-D4TS217_1	0.000	0.000	-0.000	-0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	0.000	0.000	0.000	0.000
6.	R0981-D4TS156_1	-1.351	-0.002	0.618	-0.214	-0.209	0.000	0.700	-0.091	0.013	-2.252	0.016	0.002	0.701	-4.300	-0.300	-0.011	0.099	-0.008	-0.012	-3.080
7.	R0981-D4TS433_1	0.000	-0.225	-20.244	0.017	-0.689	0.216	-0.100	-	-0.353	-10.415	-0.110	-0.405	-0.045	0.000	0.000	-0.001	-0.006	-0.001	-0.002	0.050
8.	R0981-D4TS390_1	0.000	-0.450	1.312	-0.031	-0.049	0.000	-0.100	0.176	0.008	0.901	0.004	0.012	-0.150	0.000	0.150	-0.002	-0.001	0.001	-0.005	-0.380
9.	R0981-D4TS190_1	0.000	-0.900	1.199	-0.437	-0.349	-0.433	-0.900	0.108	-0.004	-0.451	0.005	-0.004	-0.870	-1.800	0.290	0.031	-0.004	0.000	-0.001	-4.430
10.	R0981-D4TS457_1	0.000	-0.902	1.387	-0.783	-0.756	0.325	-0.700	-0.016	0.014	0.450	0.006	0.034	-0.316	4.000	0.290	0.052	-0.122	0.026	0.009	-0.340
11.	R0981-D4TS425_1	-2.477	-0.902	-0.281	-0.733	-0.533	-0.866	-0.900	0.114	0.015	2.703	0.014	0.011	0.353	6.100	0.150	0.062	-0.042	-0.021	-0.038	-4.300
12.	R0981-D4TS174_1	-2.477	-1.800	-0.825	-0.097	-0.118	0.108	-0.100	0.355	-0.000	-1.802	0.006	0.004	0.206	0.100	0.150	-0.008	-0.010	0.003	-0.015	-2.190
13.	R0981-D4TS288_1	-1.576	-2.478	-0.825	-0.132	-0.016	0.000	0.400	0.536	-0.004	-2.252	-0.009	-0.024	-0.291	-2.200	-0.300	0.002	0.011	0.016	-0.019	3.350
14.	R0981-D4TS328_1	-4.729	-2.478	-3.862	0.488	0.858	-0.433	-1.600	1.466	-0.028	-1.802	-0.017	-0.043	-1.199	-0.600	-0.150	-0.040	0.162	-0.027	-0.037	-5.010
15.	R0981-D4TS356_1	-1.801	-2.928	-3.937	-0.376	-0.375	-0.108	-0.900	-0.444	0.009	2.703	0.008	0.022	-1.233	-2.000	0.290	0.012	-0.096	0.004	-0.015	-0.400
16.	R0981-D4TS358_1	-2.252	-2.928	-1.219	-0.158	-0.107	0.108	-0.900	1.158	-0.048	-4.505	-0.023	-0.024	-1.956	0.200	-0.150	0.011	-0.048	0.026	-0.018	-1.600
17.	R0981-D4TS068_1	-2.477	-3.155	-3.562	-0.745	-0.599	-0.108	-0.800	0.176	-0.013	2.252	0.002	0.004	0.228	7.900	-0.150	0.004	-0.025	0.021	-0.016	-1.750
18.	R0981-D4TS344_1	-2.252	-3.605	-2.362	-0.199	-0.078	0.000	-0.700	0.109	-0.013	1.351	-0.015	-0.018	-0.333	-3.400	0.000	-0.048	0.014	0.005	-0.012	-1.660
19.	R0981-D4TS281_1	-6.081	-4.055	-3.374	1.546	1.771	-1.515	-1.600	1.324	-0.070	-12.613	-0.019	-0.075	-2.814	1.500	-0.300	-0.060	0.176	-0.054	-0.064	-3.130
20.	R0981-D4TS492_1	-5.180	-4.282	-2.343	1.020	1.011	-0.866	-0.800	0.606	-0.044	-5.856	-0.004	-0.058	-1.773	-1.900	-0.790	-0.066	-0.004	-0.017	-0.050	13.120
21.	R0981-D4TS329_1	-8.108	-4.952	-1.725	4.492	4.512	-2.164	-3.900	1.520	-0.076	-12.162	-0.025	-0.082	-8.339	-2.400	-0.790	-0.263	0.538	-0.197	-0.080	22.660
22.	R0981-D4TS196_1	-3.378	-5.180	-1.294	-0.481	-0.471	0.325	-0.900	0.291	-0.010	-2.252	-0.028	-0.006	-1.173	-14.600	0.150	-0.007	-0.006	0.012	-0.014	-3.450
23.	R0981-D4TS359_1	-3.378	-5.180	-1.294	-0.481	-0.471	0.325	-0.900	0.291	-0.010	-2.252	-0.028	-0.006	-1.173	-14.600	0.150	-0.007	-0.006	0.012	-0.014	-3.450
24.	R0981-D4TS117_1	-4.955	-6.755	-7.386	0.119	0.158	-1.190	-1.800	2.725	-0.030	-3.604	-0.047	-0.009	-4.064	-16.900	0.290	0.022	-0.009	-0.008	-0.032	-3.420
25.	R0981-D4TS004_1	-6.081	-7.657	-4.255	0.007	-0.020	-0.758	-1.800	-0.468	-0.029	-3.604	-0.009	-0.025	-5.872	-3.300	0.150	-0.031	0.059	-0.015	-0.056	0.970
26.	R0981-D4TS270_1	-8.558	-10.588	-6.617	-0.050	-0.033	-1.082	-2.200	0.324	-0.031	-0.901	-0.009	-0.027	-2.173	-4.300	0.000	0.006	0.078	-0.022	-0.081	0.140
27.	R0981-D4TS195_1	-11.486	-12.838	-7.179	2.008	1.935	-2.273	-5.200	0.556	-0.072	-17.568	-0.033	-0.079	-16.847	-13.000	0.000	-0.047	0.079	-0.059	-0.101	2.660
28.	R0981-D4TS112_1	-14.639	-15.315	-10.441	0.434	0.491	-2.273	-3.600	0.140	-0.067	-12.613	-0.034	-0.072	-6.034	-7.100	-0.150	-0.044	0.109	-0.039	-0.143	2.100
29.	R0981-D4TS431_1	-25.675	-22.973	-15.052	7.192	7.105	-4.329	-6.400	0.456	-0.152	-31.982	-0.092	-0.222	-28.255	-16.400	-0.790	-0.411	0.786	-0.252	-0.277	37.210

Refinement improvements in R0981-D4

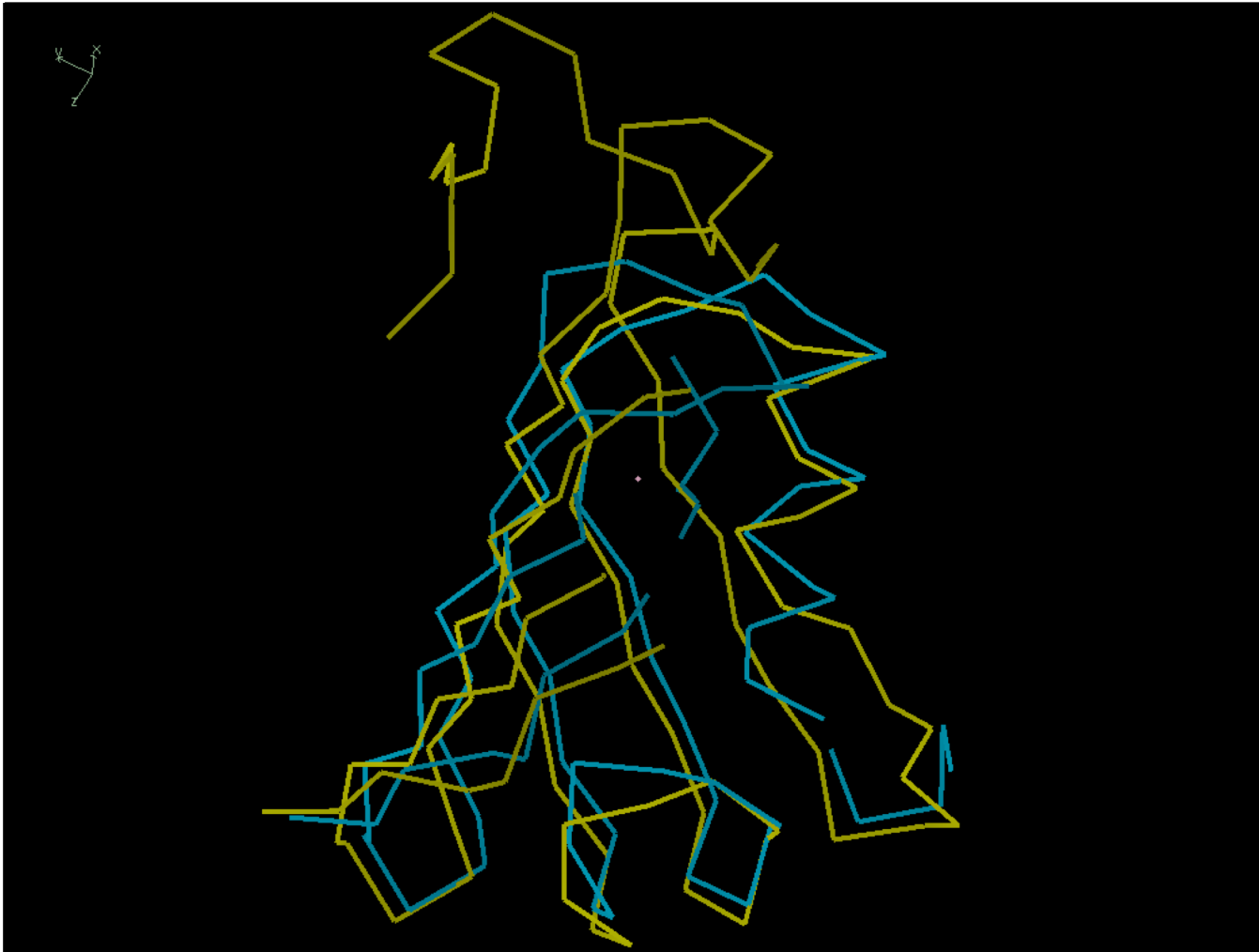
R0981-D4: starting model from Baker-RosettaServer

Baker best model

Feiglab best model



Refinement of R0981-D4



experimental

5m9f_A

start

TS086_1

Correlation with MR tests

- Much more overlap in top groups than in TBM category
 - except for effect on MR of error weighting in AWSEM
 - Refinement improved details of models detected by torsion deviations
 - Correlates with extent of value added for MR
-

Questions for future CASPs

- Should refinement groups be told the GDT-HA value of the starting model?
 - Should the starting model (almost) always be the best server model?
 - Should the evaluation focus much more explicitly on the details of the model?
 - Can deep learning improve refinement?
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Acknowledgements

- Tristan Croll: value-added calculations, movies
- Andriy Kryshatafovych & Prediction Center!

welcometrust

Phenix 
