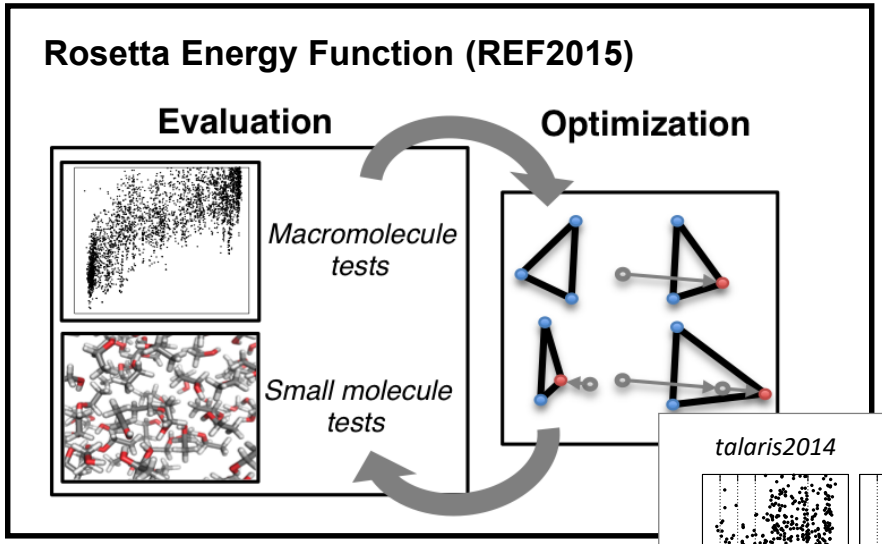
Large-scale energy guided refinement using Rosetta in CASP13

CASP13 meeting, Cancun, Dec 2018

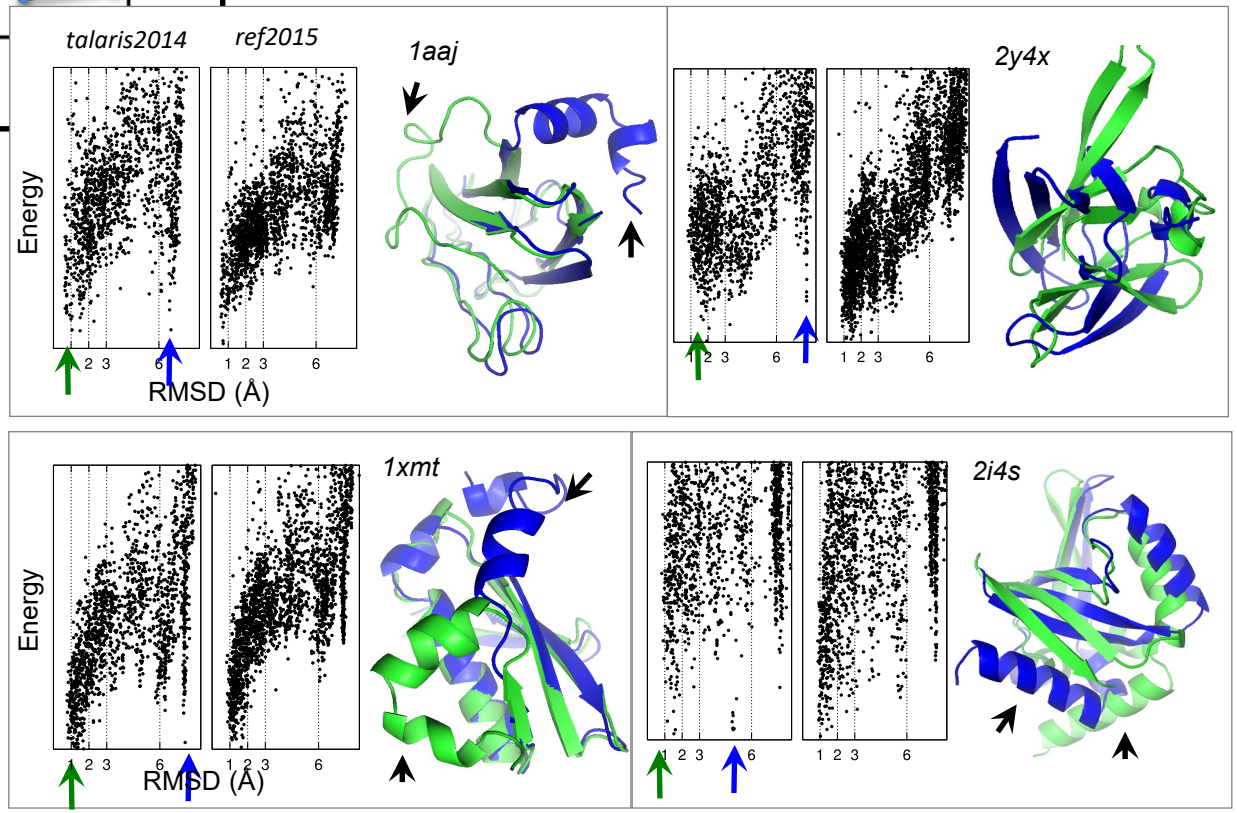
Baker lab & Institute for Protein Design, Univ of Washington

Hahnbeom Park

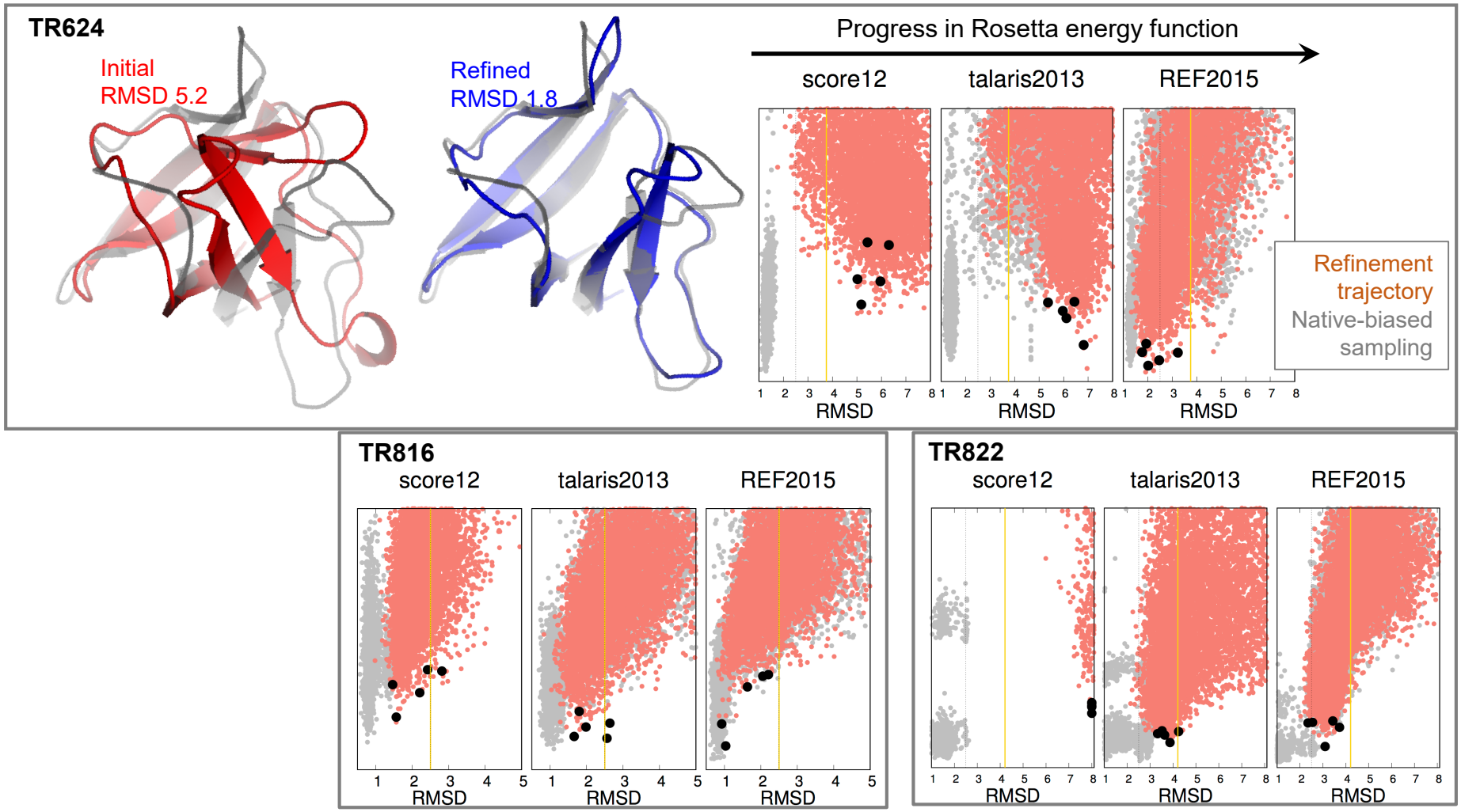
Progress in Rosetta energy function



H Park, P Bradley, P Greisen Jr., Y Liu,
VK Mulligan, DE Kim, D Baker, F DiMaio.
Simultaneous optimization of biomolecular energy function
on features from small molecules and macromolecules.
JCTC 2016.

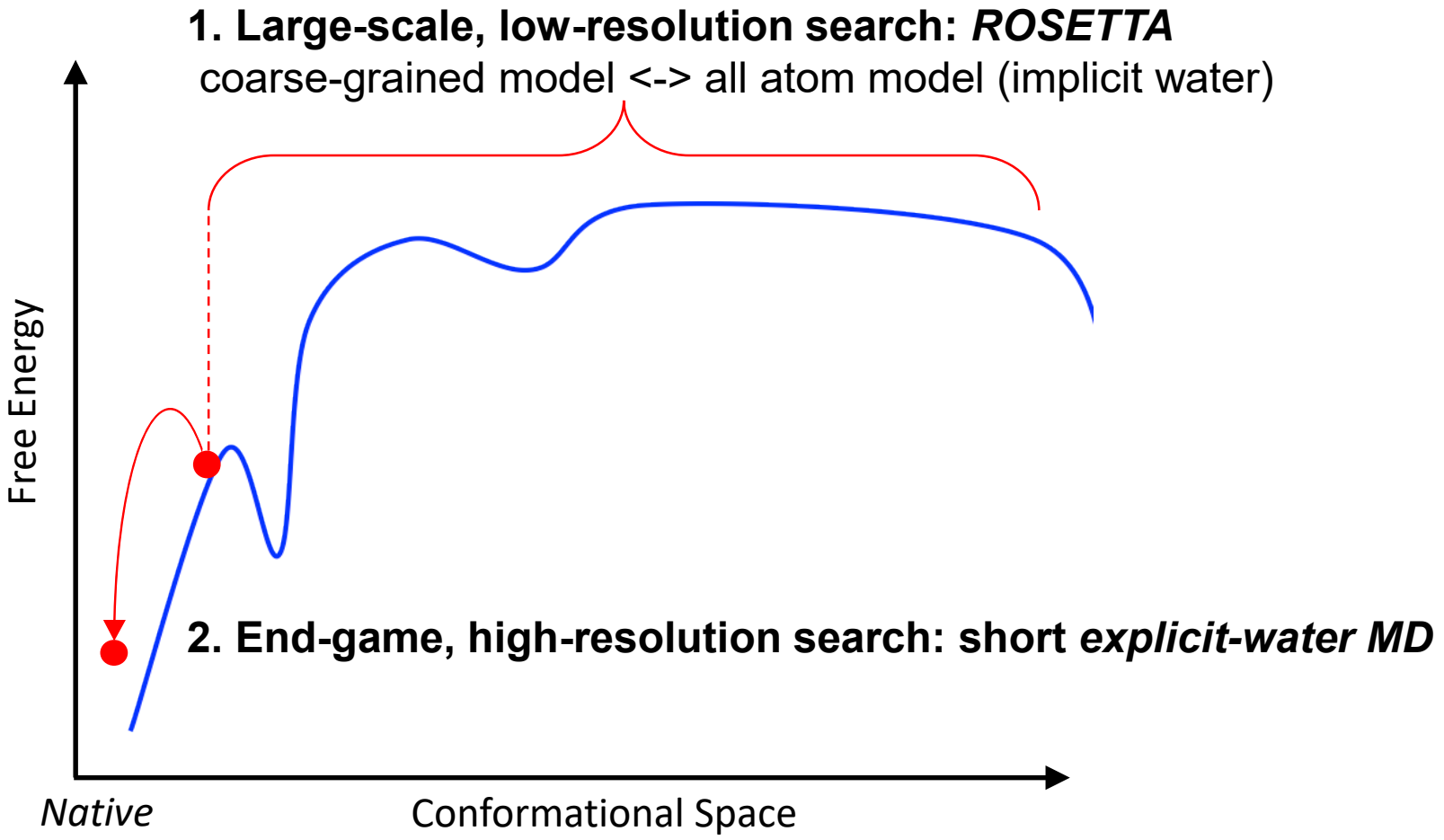


Leads to
Successful Large-scale energy guided refinement



H Park, S Ovchinnikov, DE Kim, F DiMaio, D Baker.
Refinement of homology models using large-scale energy optimization.
PNAS 2018.

General Concept:
Accomplishing refinement through two-stage approach



New Aims in CASP13

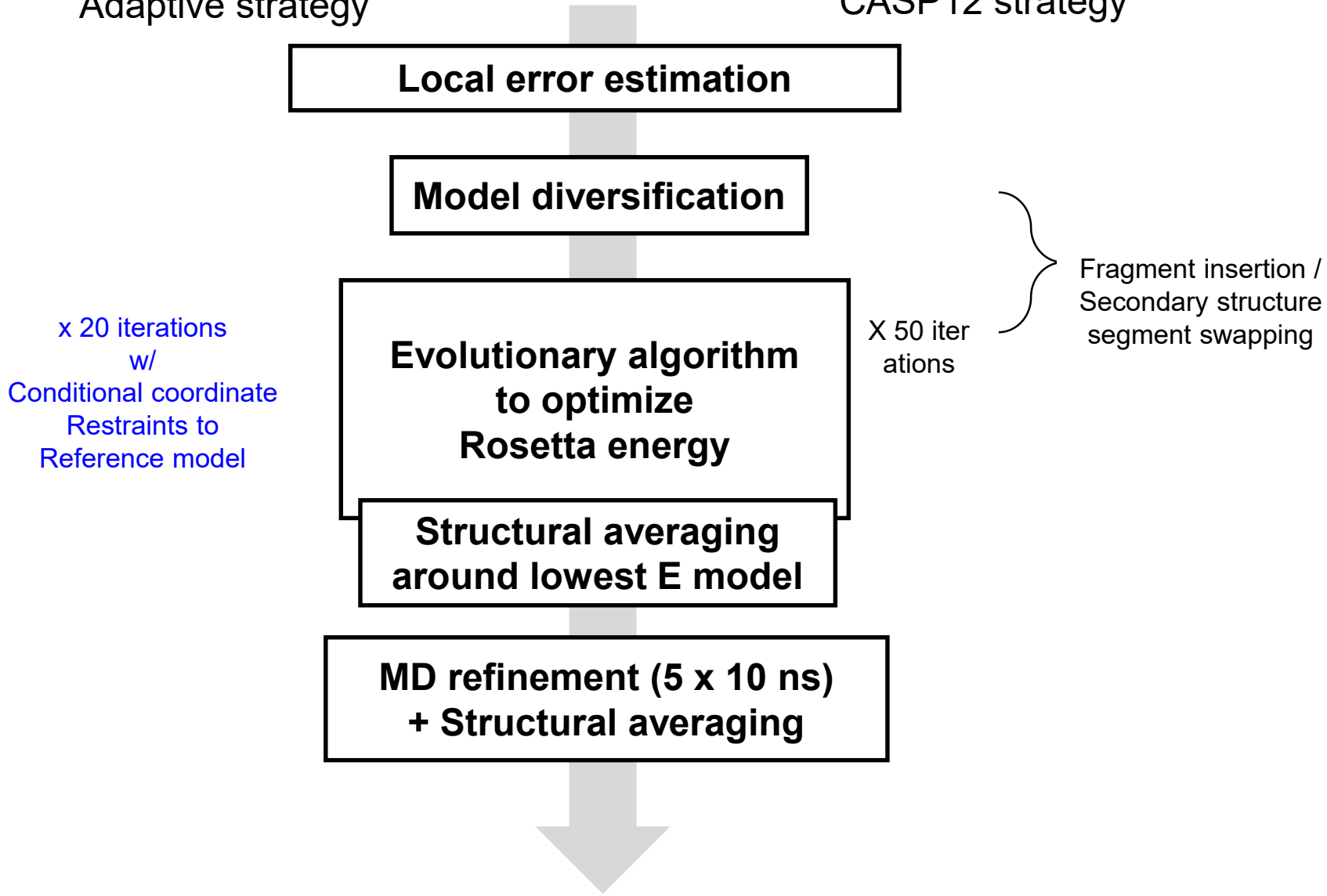
1. **Generalization:**
   Large-scale energy guided refinement to the entire class of refinement problems

2. **Consistent (still significant) refinement**

CASP13 protocol

GDT-HA > **50** (19 targets)
Adaptive strategy

GDT-HA < **50** (10 targets)
CASP12 strategy

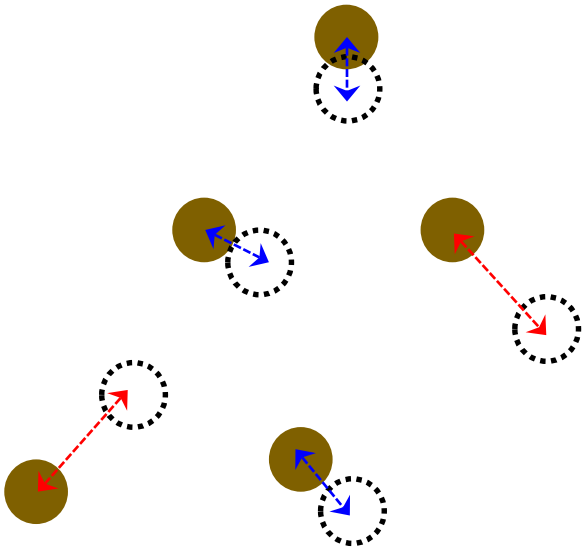


Conditional restraining on reference structure

$$E_{restraint,tot} = \sum_{i}^{k} E_i^{restraint} \quad , k \leq N$$

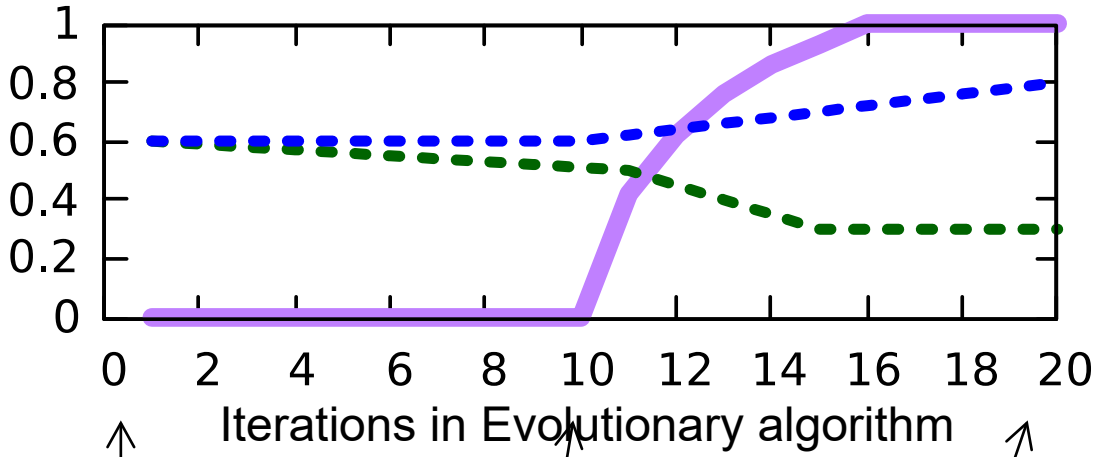
sorted by violations at given conformation

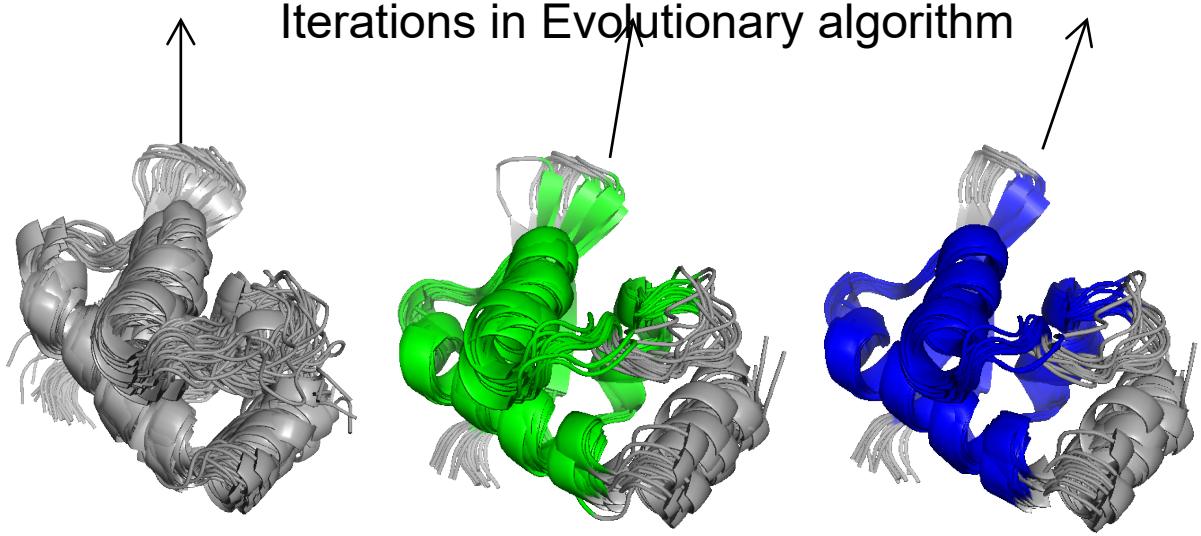
Example: N=5, K=3



Model coordinate
Reference coordinate
Restraints counted
Restraints ignored

CASP13: Adaptive strategy



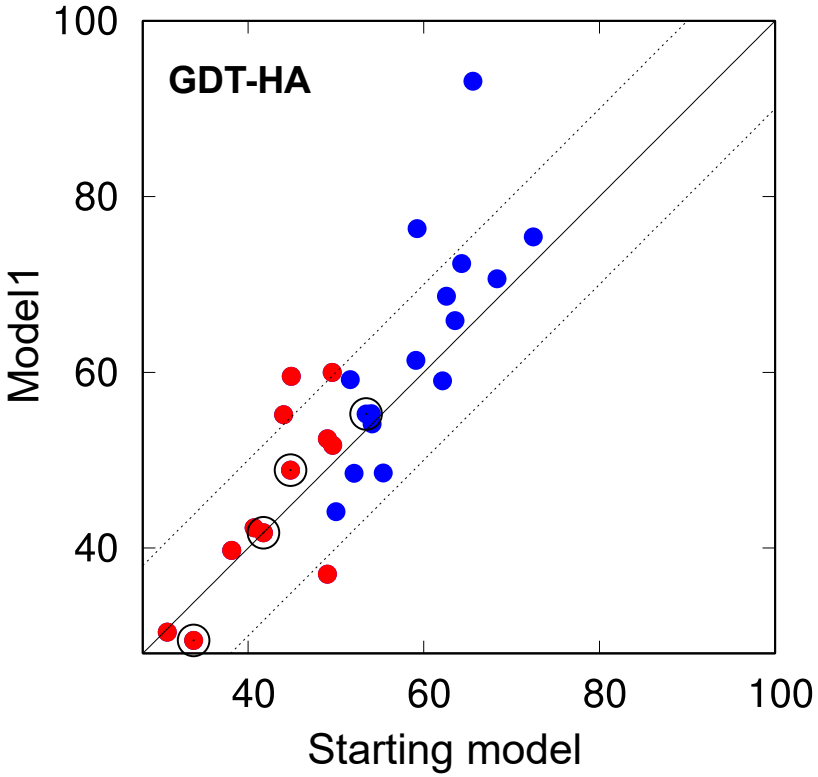


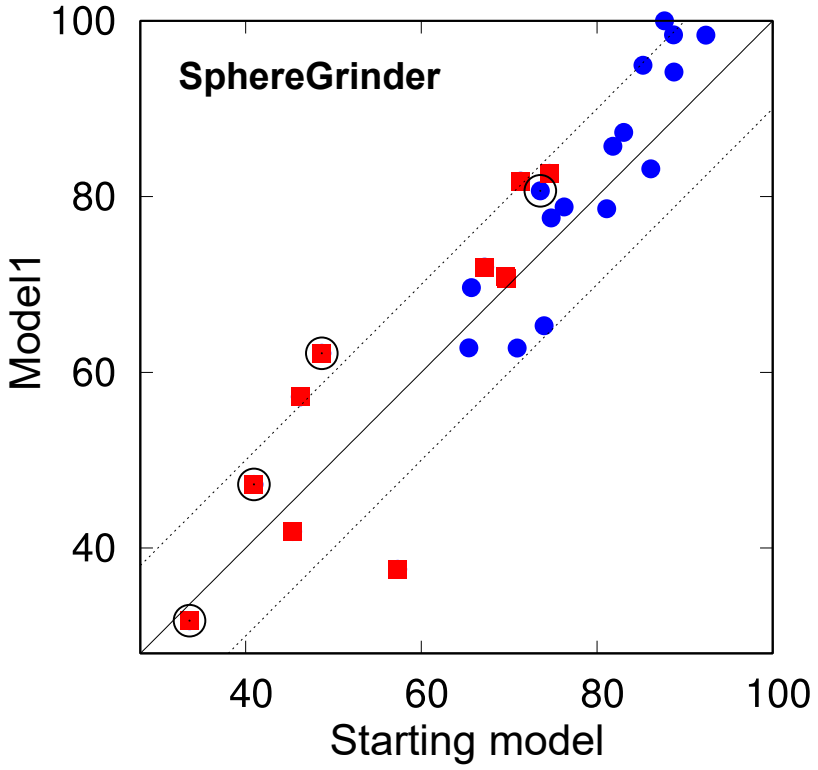
Strength of Conditional restraints (controlled parameter)

Result: Global Similarity to ref. structure

Result: Structural diversity b/w samples

RESULT: BAKER

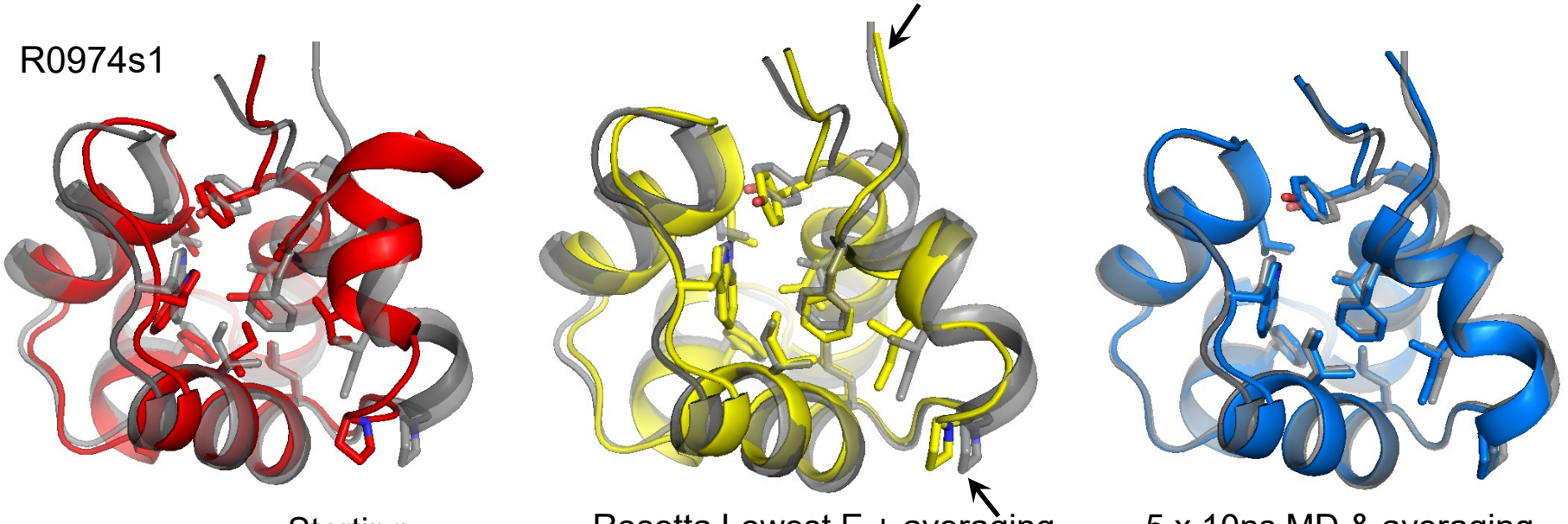




Adaptive strategy (19)
Original strategy (10)
○ Symmetric refinement attempted (5)

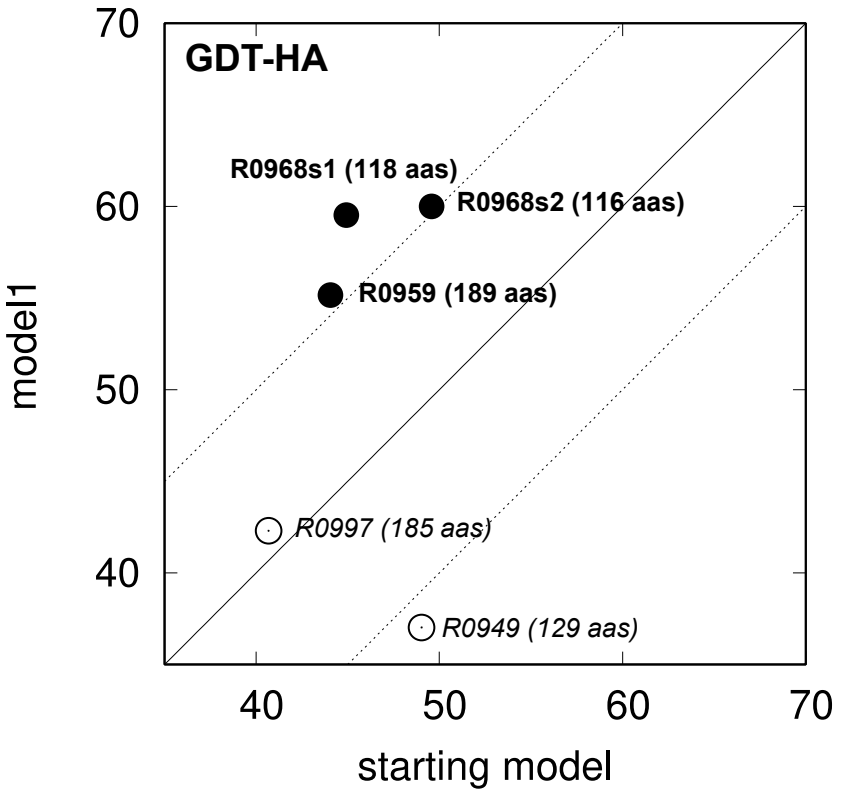
What went right:

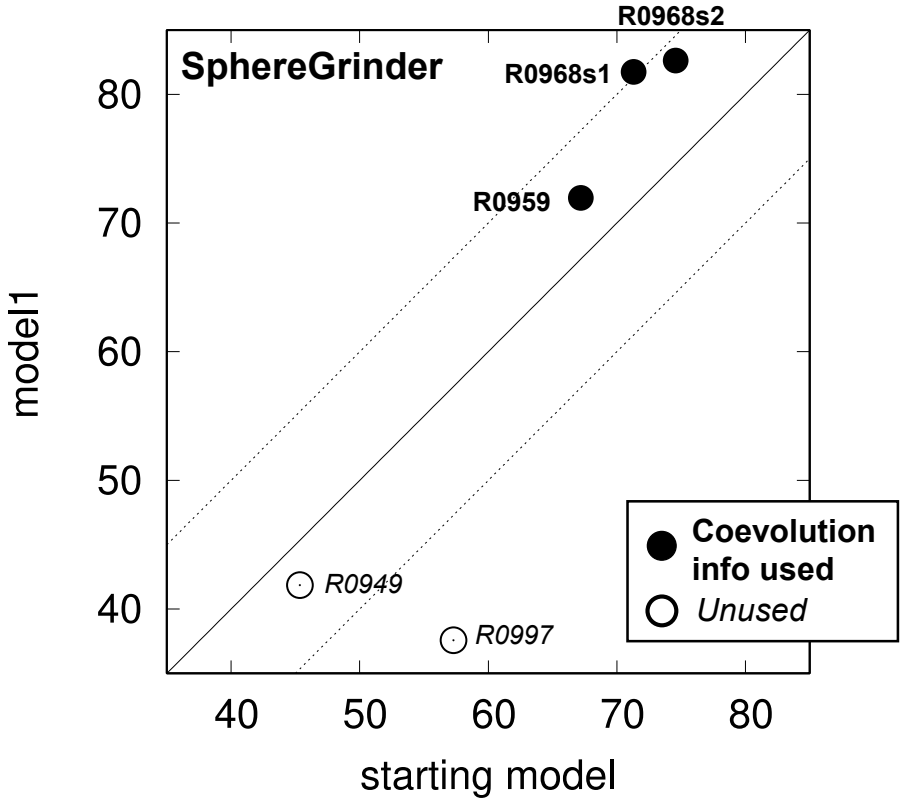
Highly accuracy prediction with Large-scale refinement



What went right / wrong (human):

Restraining search space with Co-evolution information consistently helps





Challenge: Symmetric modeling

R0981-D4

CASP:
Images redacted

Challenge: Size dependency

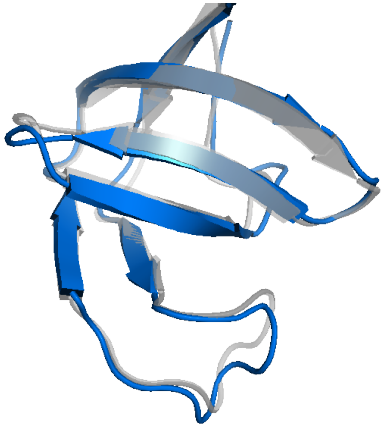
Significant improvements mostly from small proteins

R0974s1, 0.5 Å **(69 aas)**

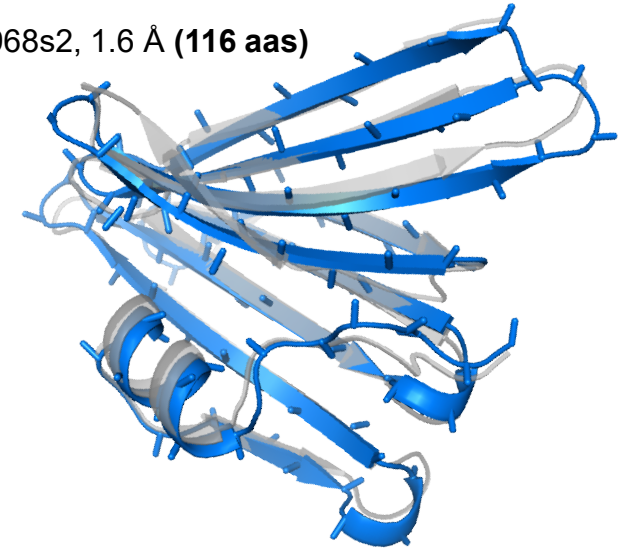
CASP:
Image redacted

R0986s1, 1.2 Å **(92 aas)**

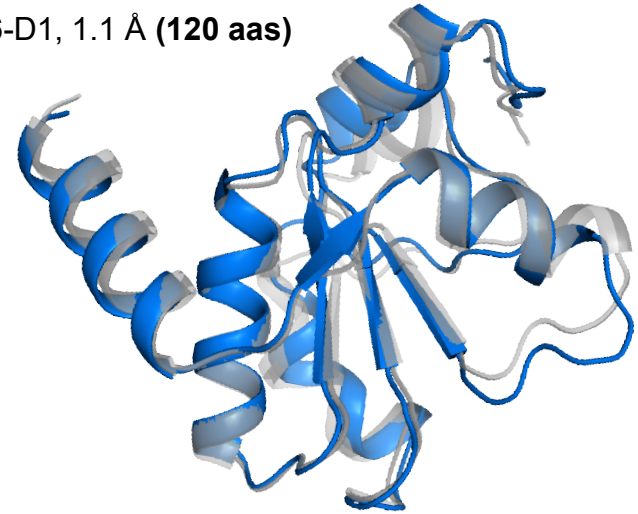
R1002-D2, 1.4 Å **(59 aas)**



R0968s2, 1.6 Å **(116 aas)**



R0976-D1, 1.1 Å **(120 aas)**



Summary

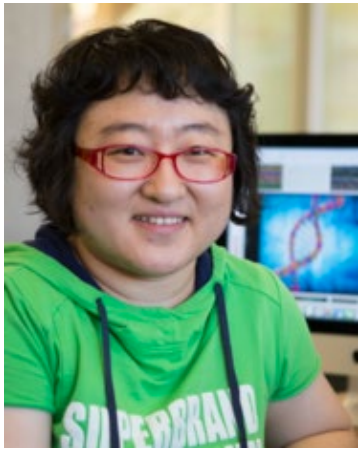
- Significant and consistent improvements through large-scale energy guided refinement
  - Progress in Rosetta energy function
  - Selective usage of reference model information
  - Integration of Rosetta modeling and explicit water MD

- Potential for using Coevolution information in Refinement challenge

- Sampling issue: > 120 aas or homo-oligomers

Acknowledgements

Gyu Rie Lee

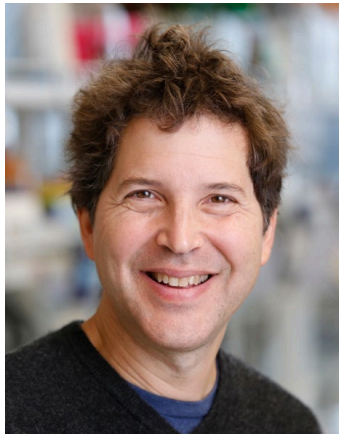


Qian Cong
(inventor of QCS)

Ivan Anishchanka

David Kim

Frank DiMaio
(REF2015)



David Baker