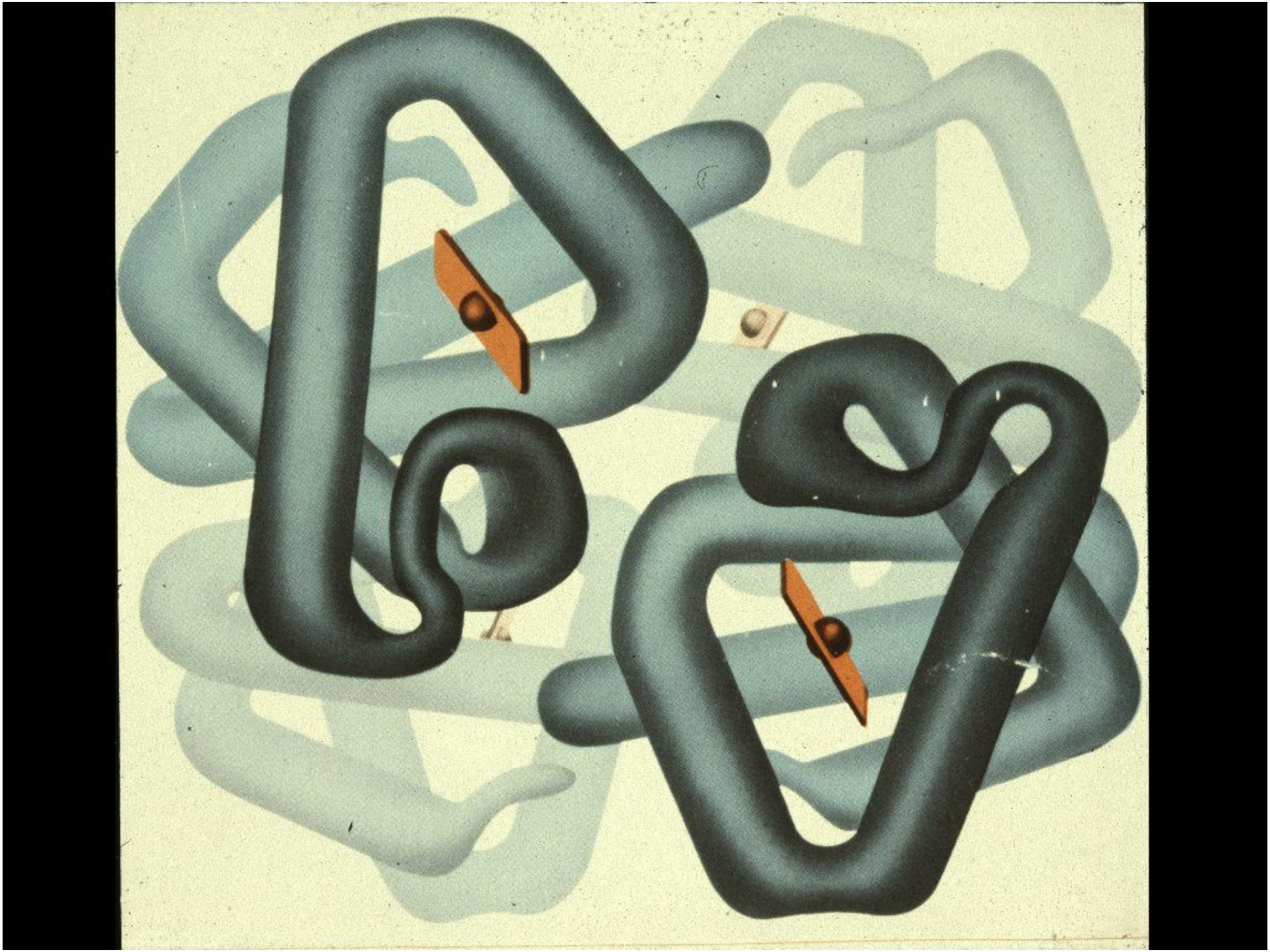
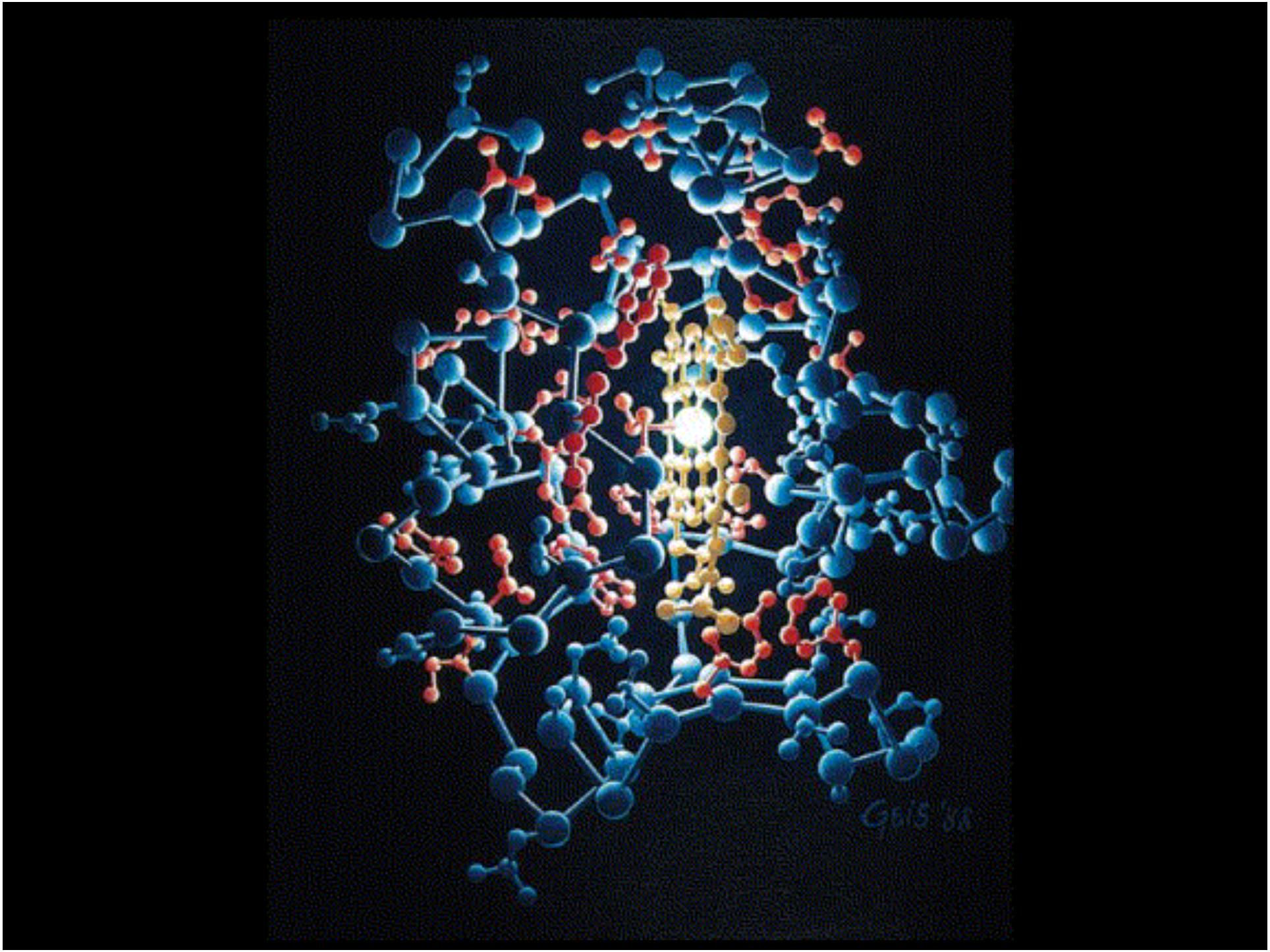
Symposium Celebrating the 40th Anniversary of the Protein Data Bank,
Cold Spring Harbor, NY, USA, October 29, 2011

Structural Biology by NMR and the Protein Data Bank

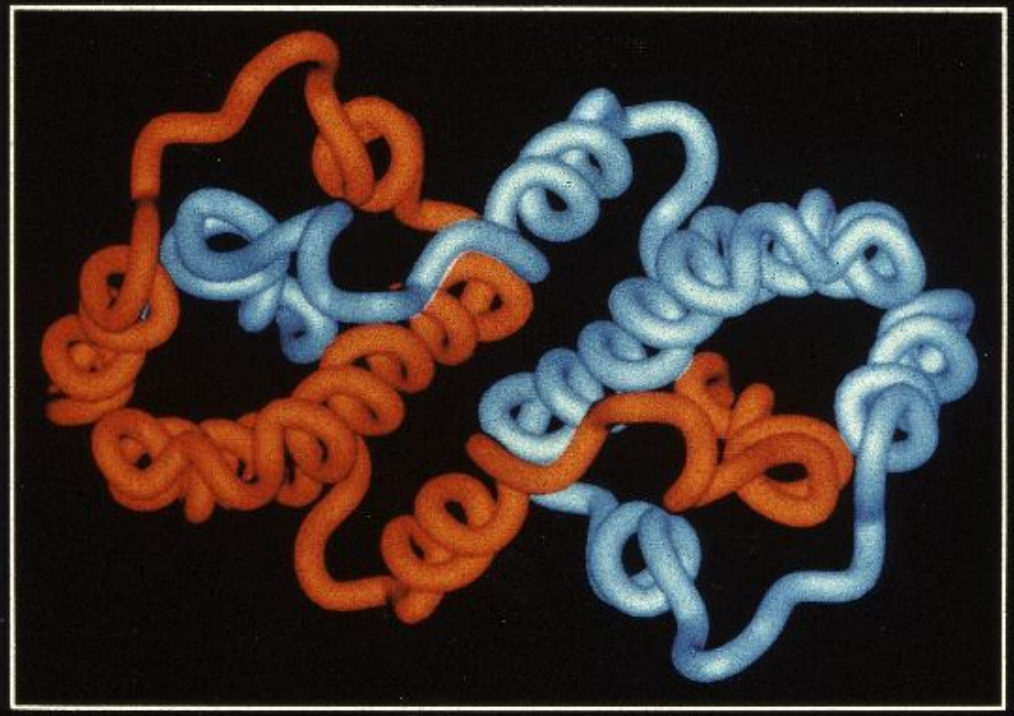
Kurt Wüthrich
The Scripps Research Institute, La Jolla, CA, USA and
ETH Zürich, Zürich, Switzerland





MACROMOLECULAR STRUCTURES 1992

Atomic structures of biological macromolecules reported during 1991

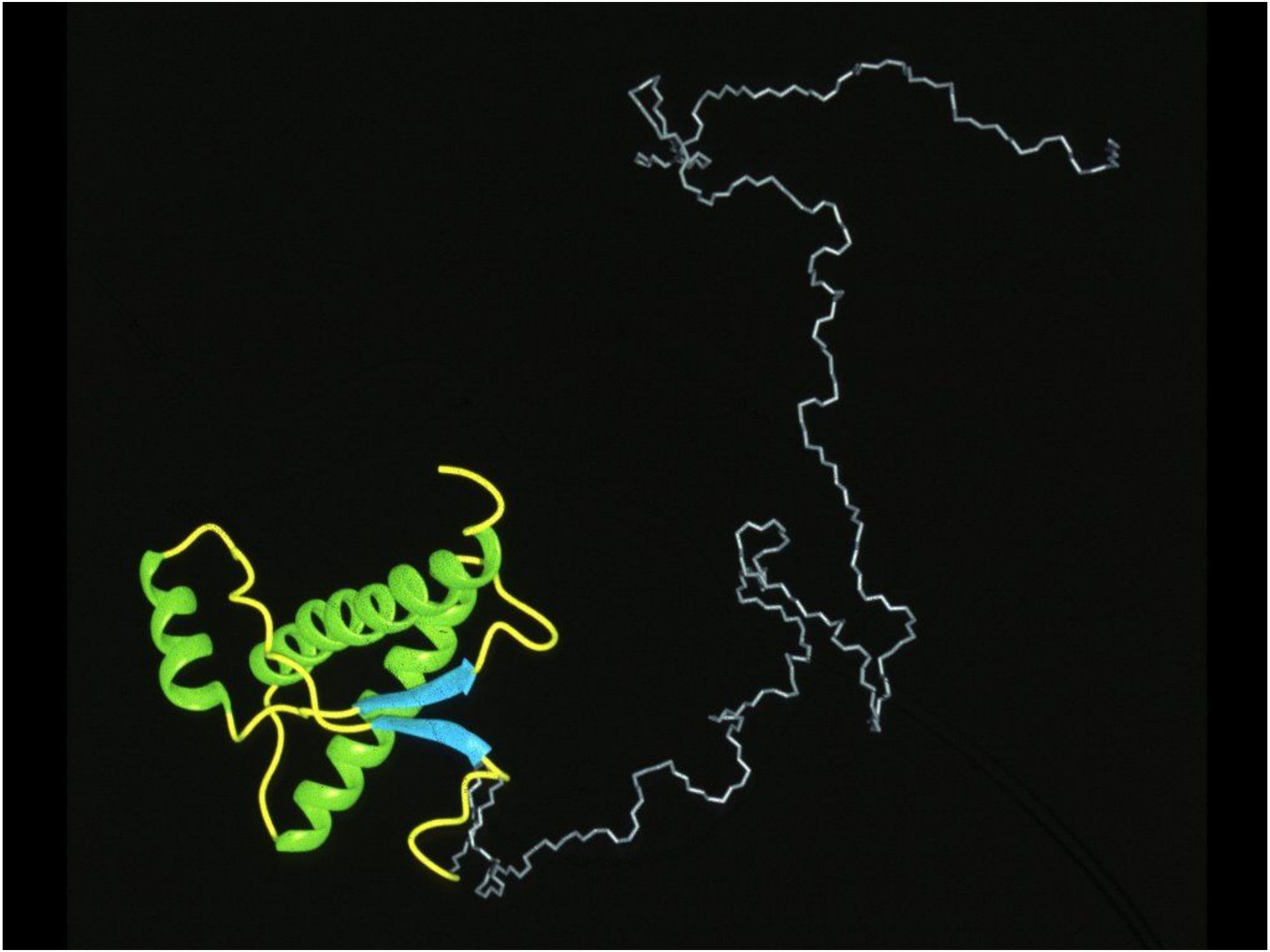


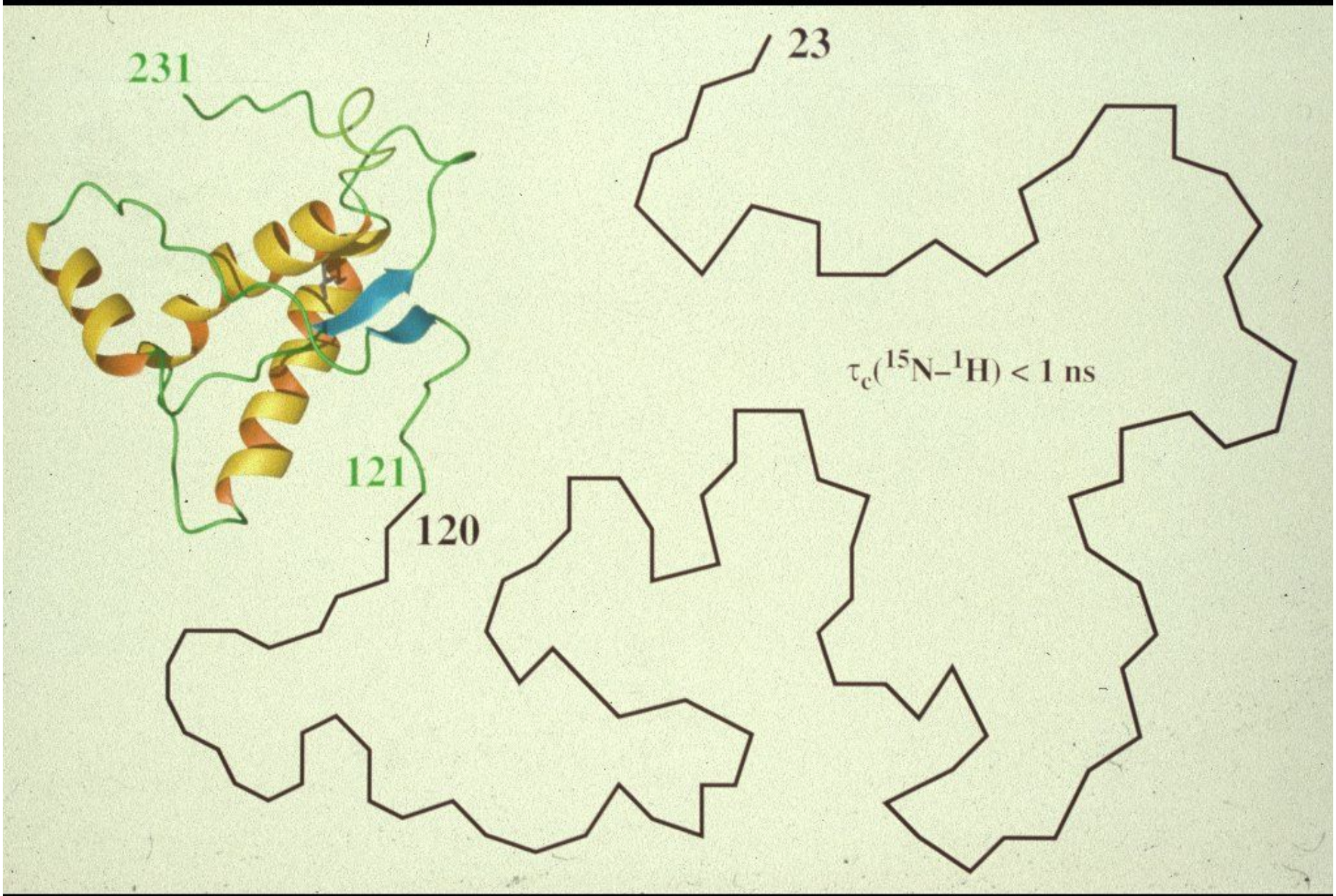
Edited by Wayne A Hendrickson and Kurt Wüthrich

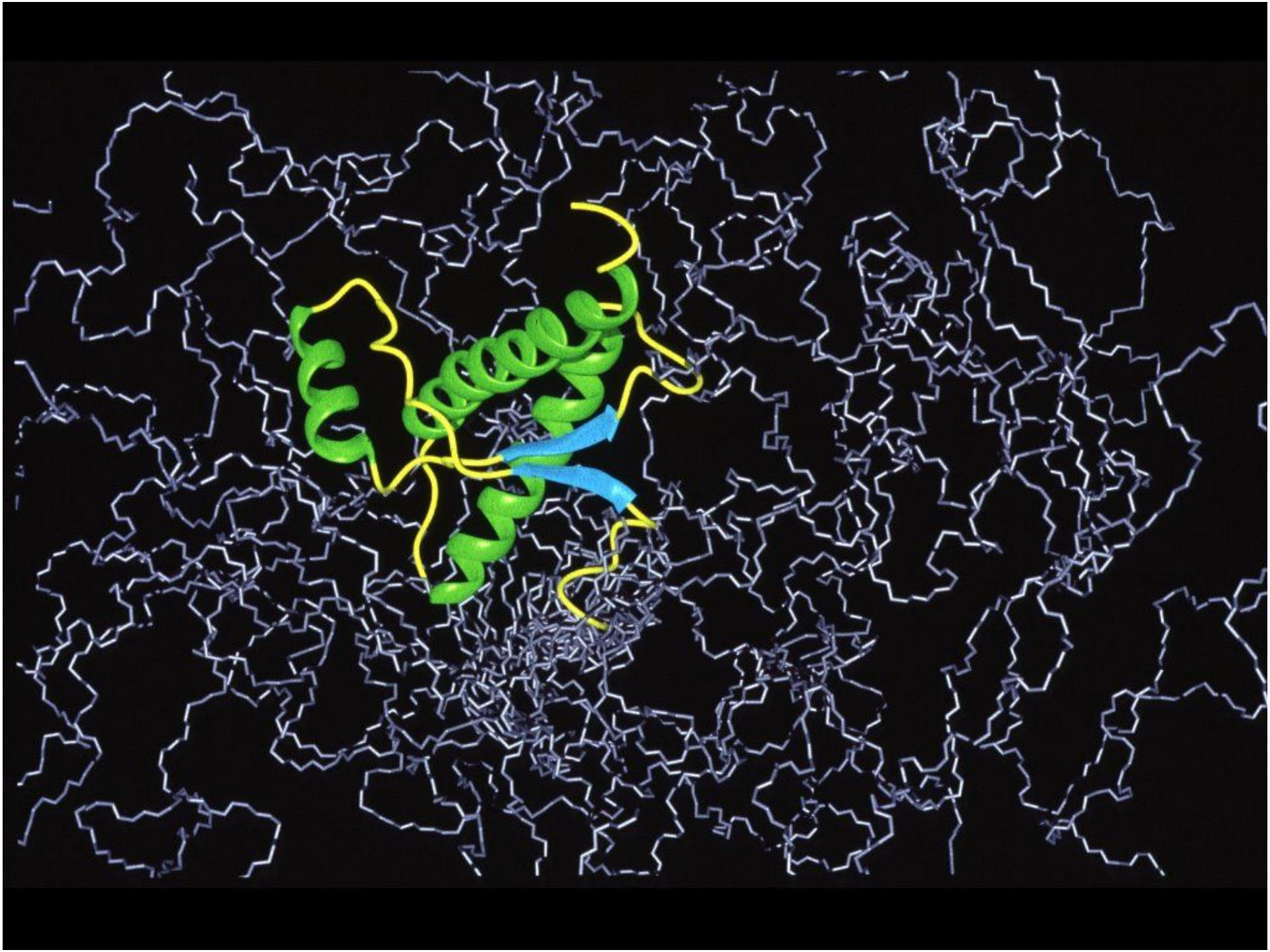
New 3D Structures of Proteins and Nucleic Acids

(Source: Macromolecular Structures 1991,..., 1999)

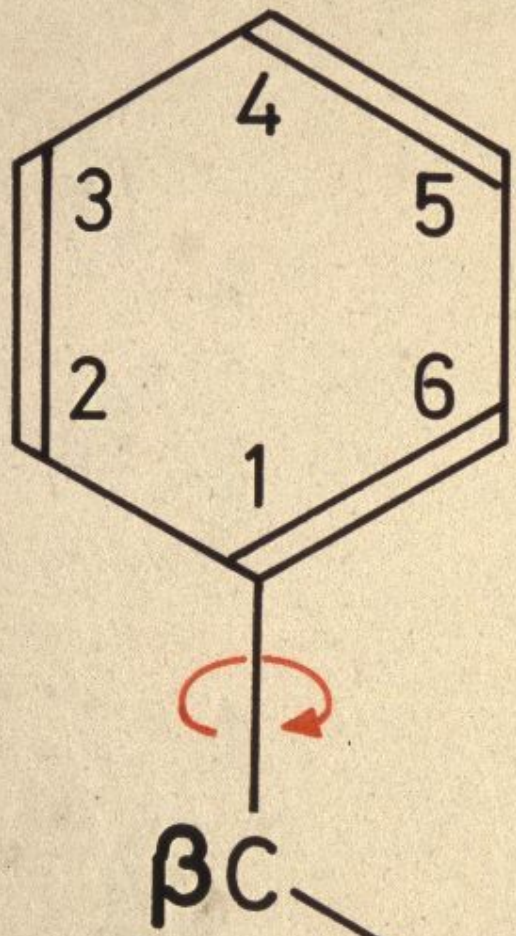
Year	X-rays (single crystals)	NMR (solution)	Other methods (crystals, fibers)
1990	109	23	2
1991	123	36	-
1992	168	61	-
1993	207	59	-
1994	377	100	2
1995	394	102	-
1996	461	112	-
1997	540	99	-
1998	747	125	2

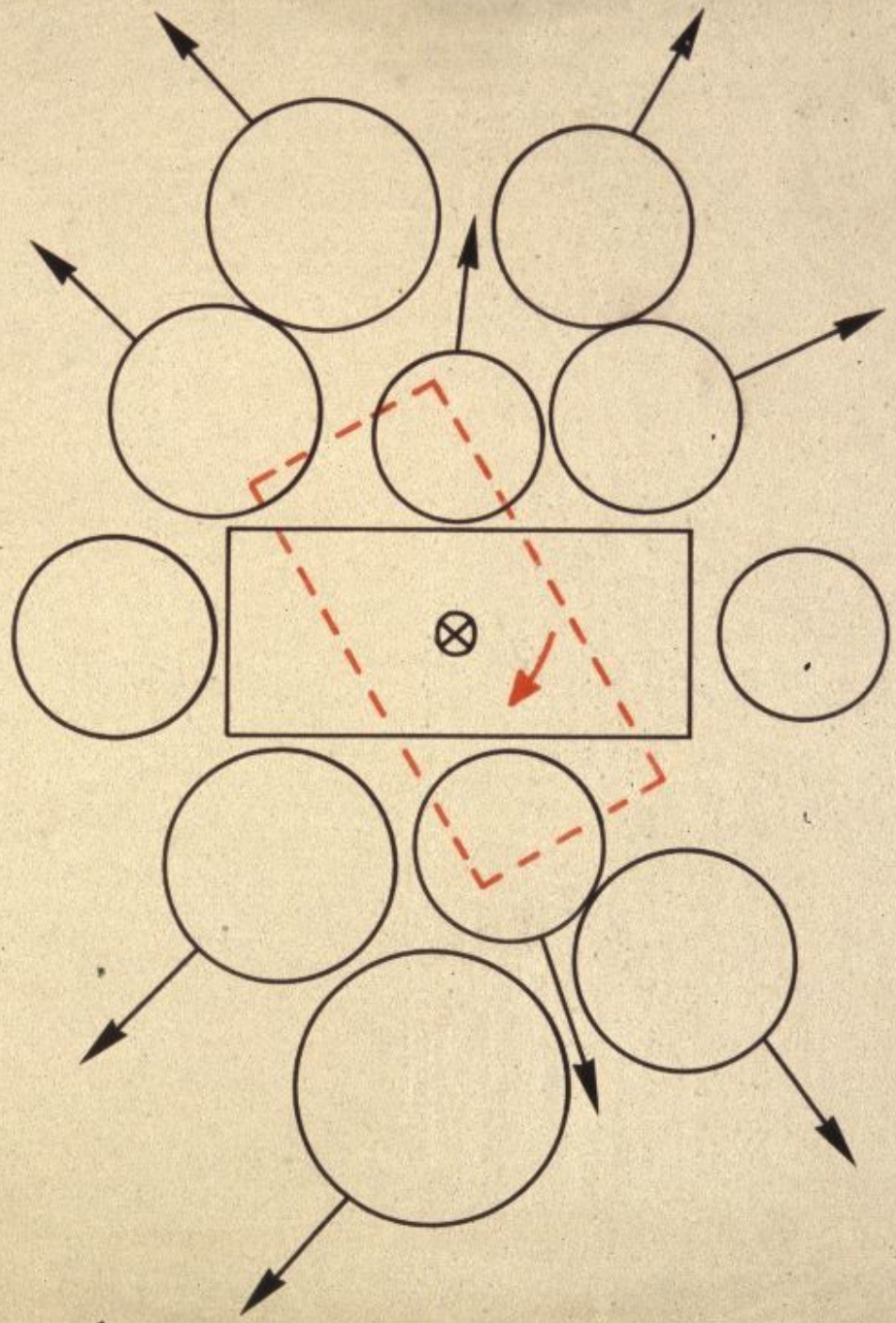


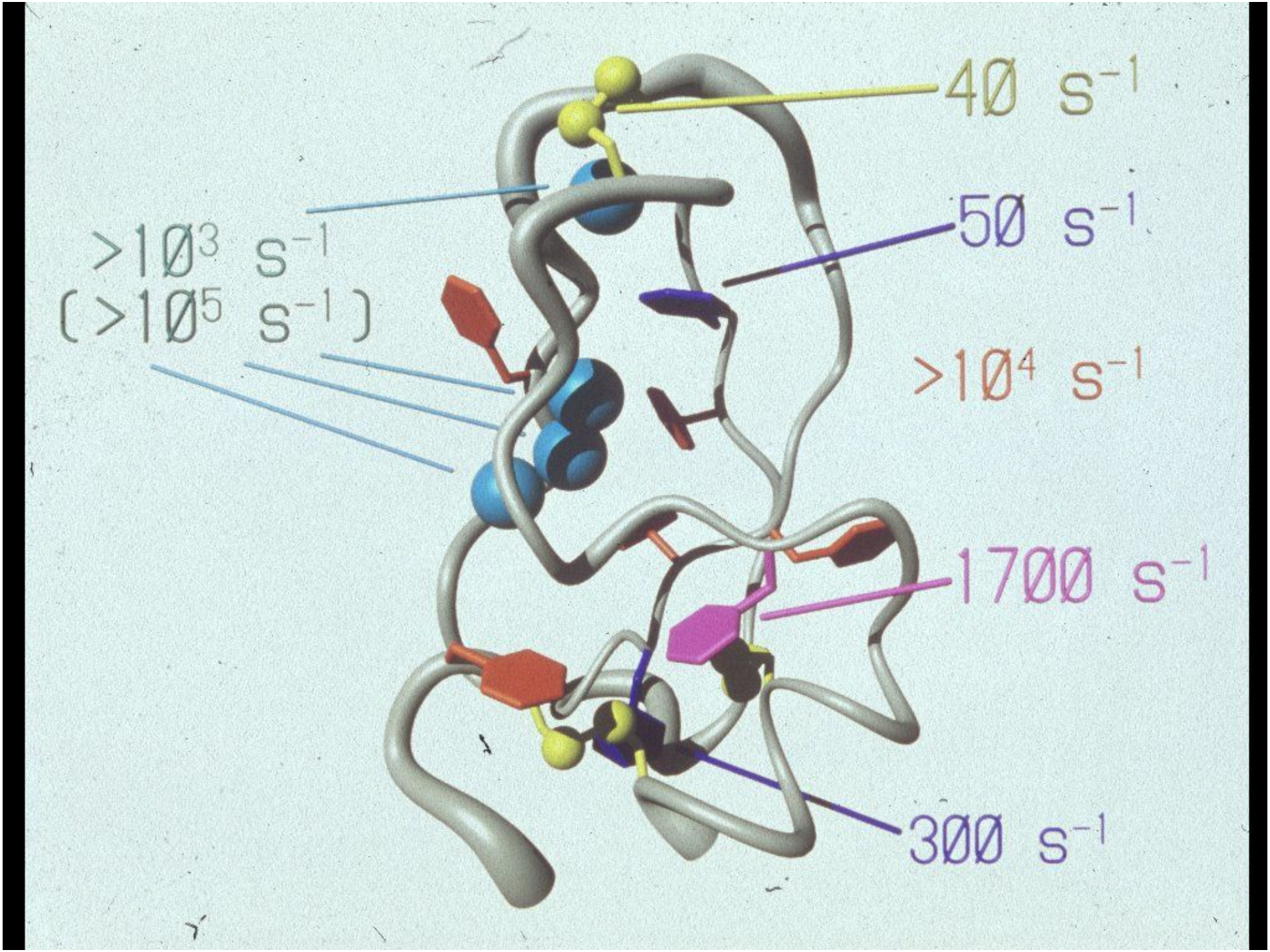

231
121
120
23
$\tau_c(^{15}N–^{1}H) < 1$ ns



Ring Flips of Phe and Tyr


4
3
5
2
6
1
βC




40 s⁻¹
50 s⁻¹
>10³ s⁻¹
(>10⁵ s⁻¹)
>10⁴ s⁻¹
1700 s⁻¹
300 s⁻¹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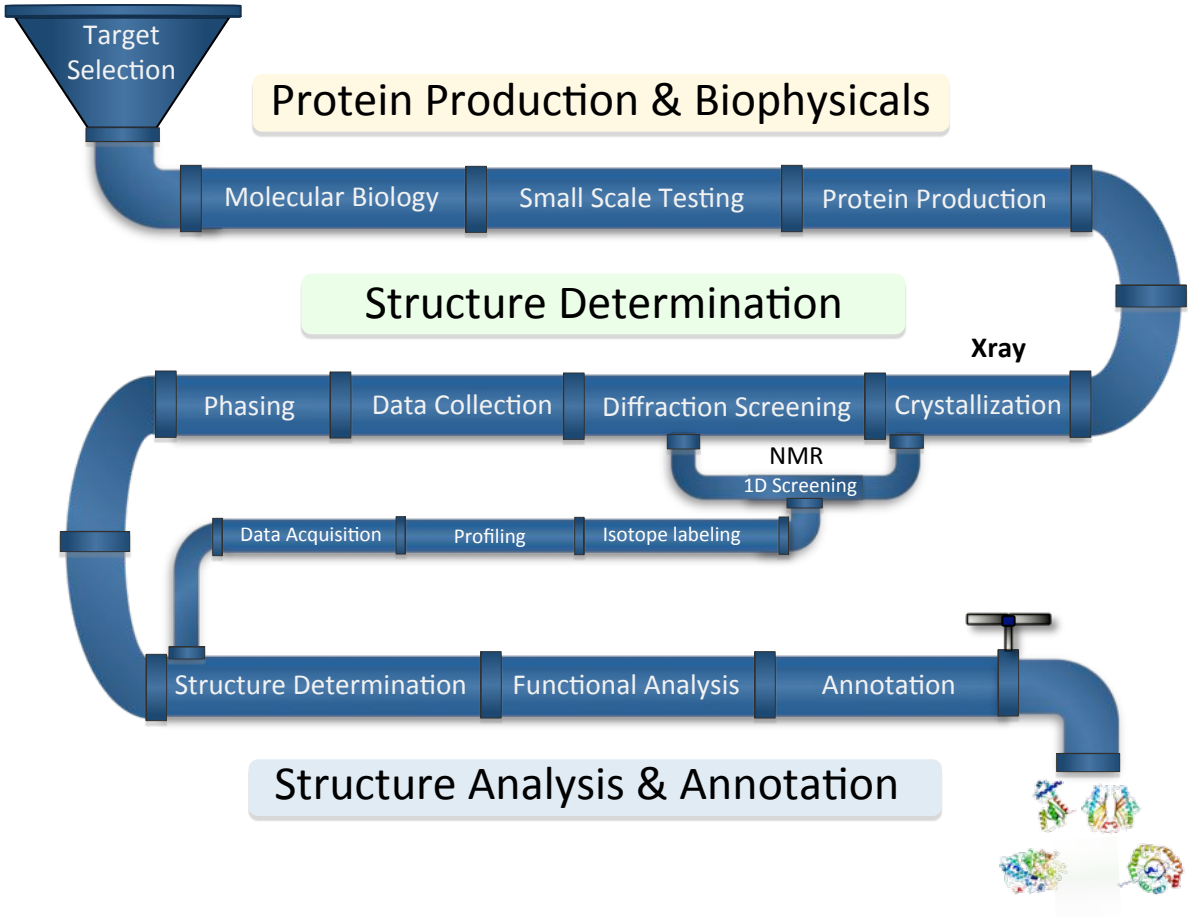
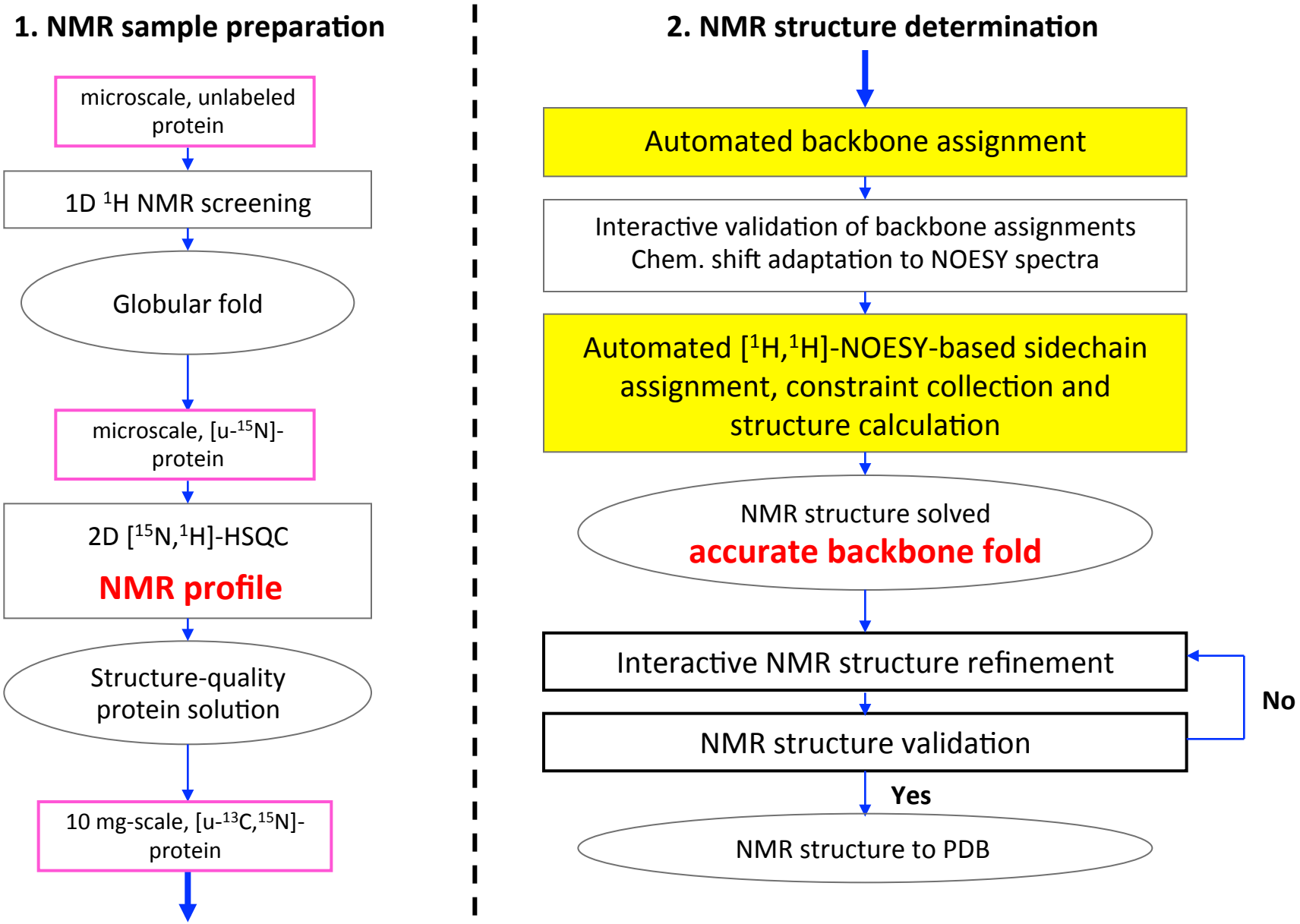
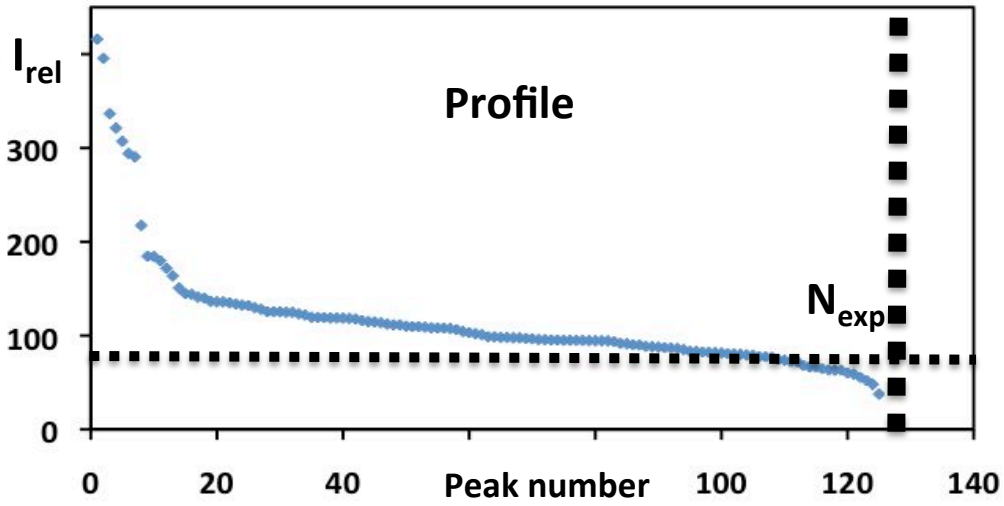
HT Structure Determination Pipeline

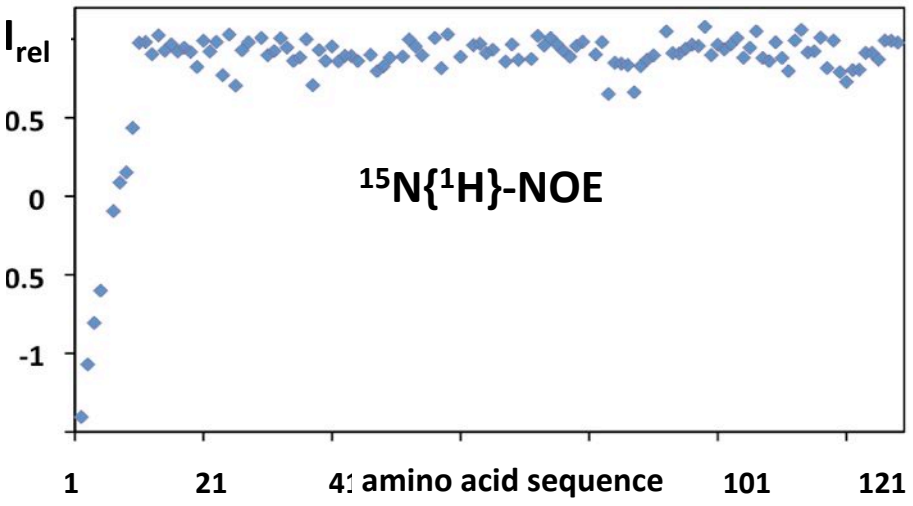


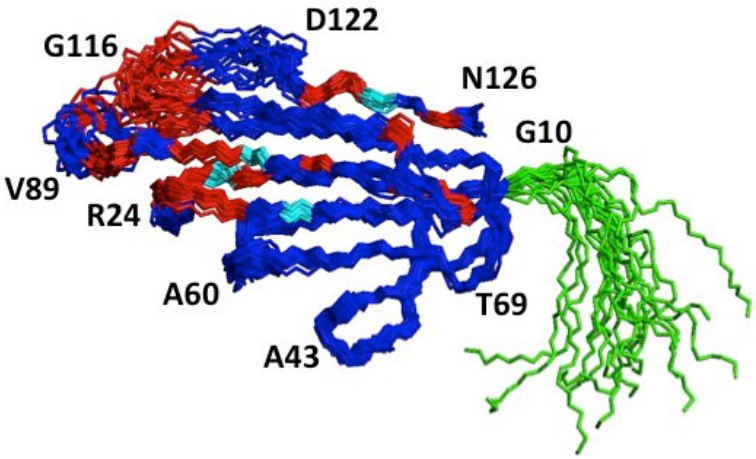
Protocol for automated NMR structure determination

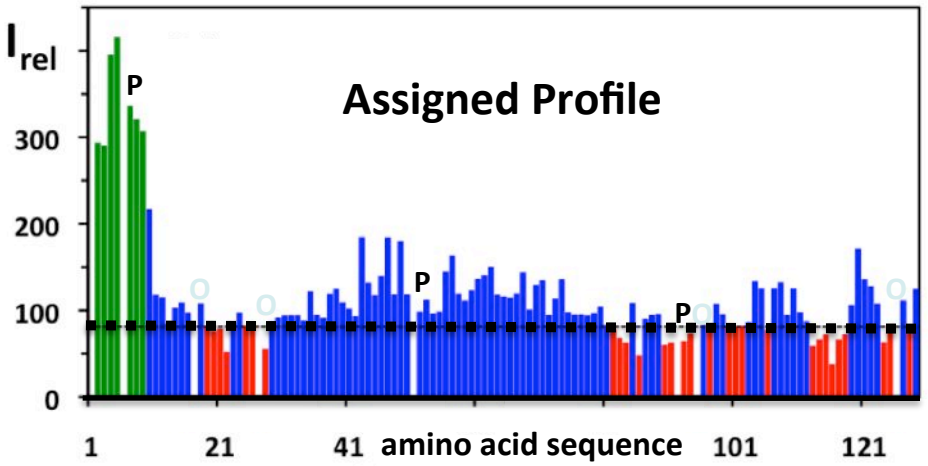


[^{15}N,^{1}H]-NMR-Profiles and Protein Structure

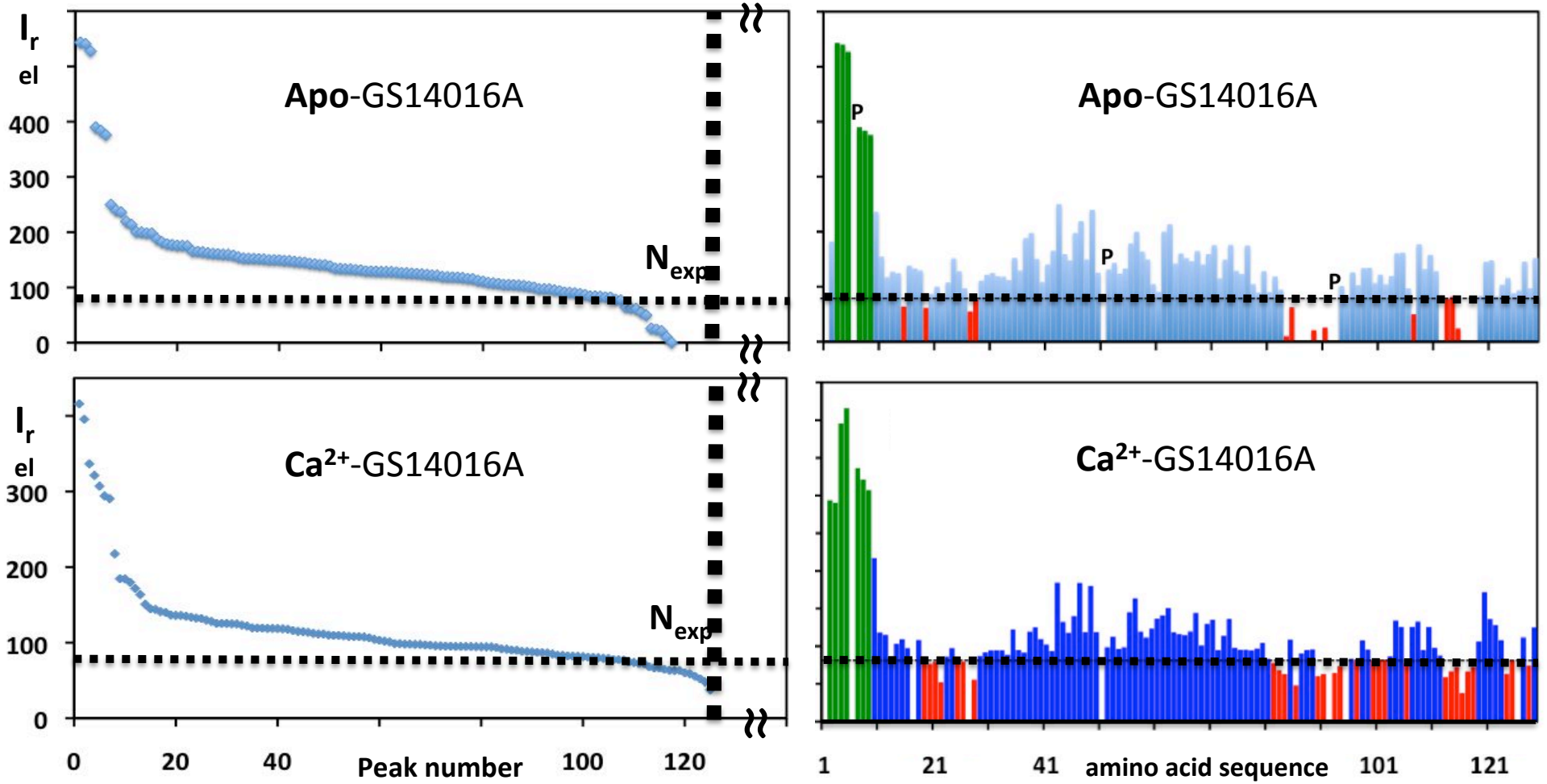




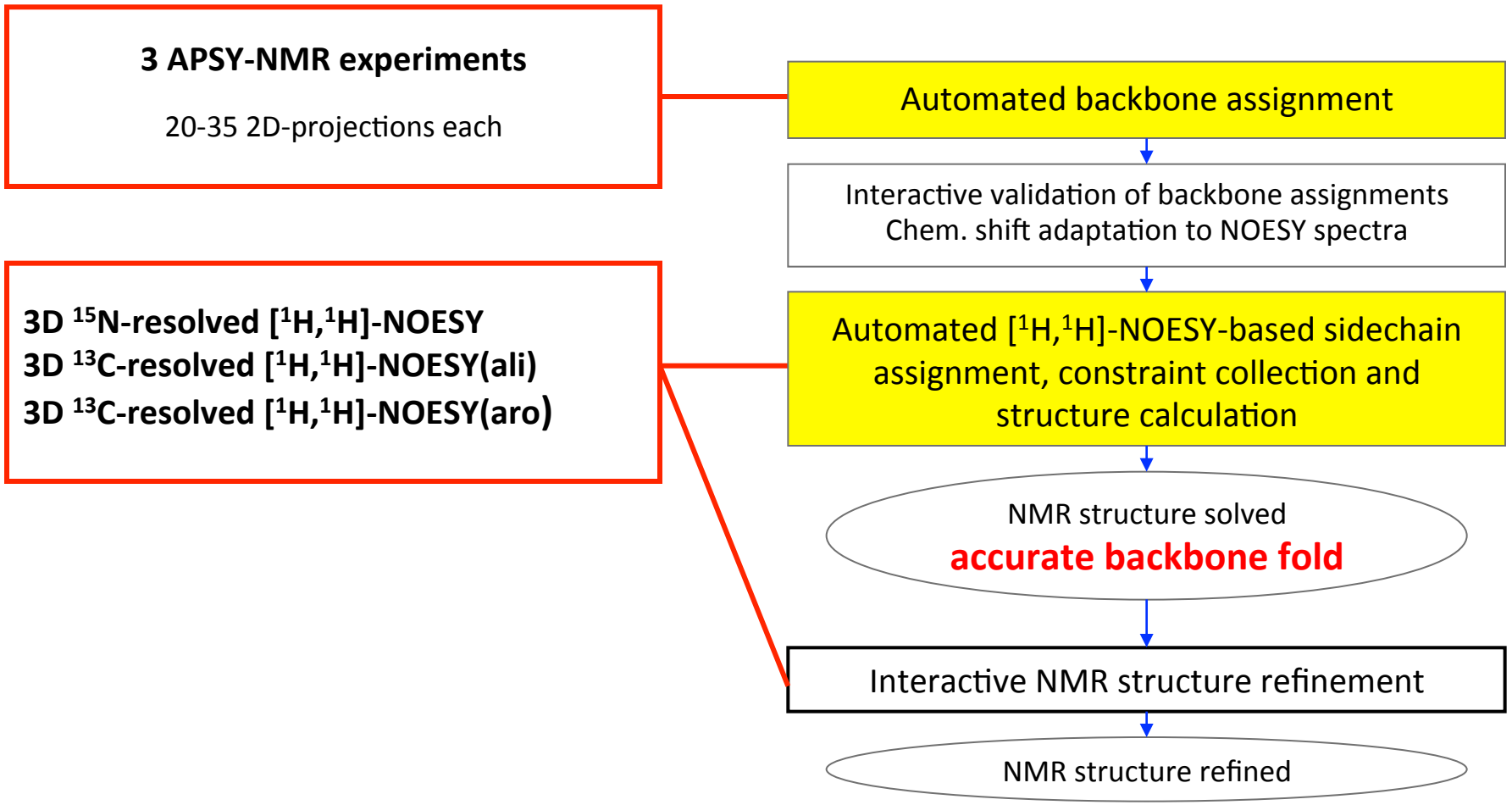




[^{15}N,^{1}H]-NMR-Profiles and Protein Complexation



NMR experiments



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Developing HT methods for Gene to Structure and Function

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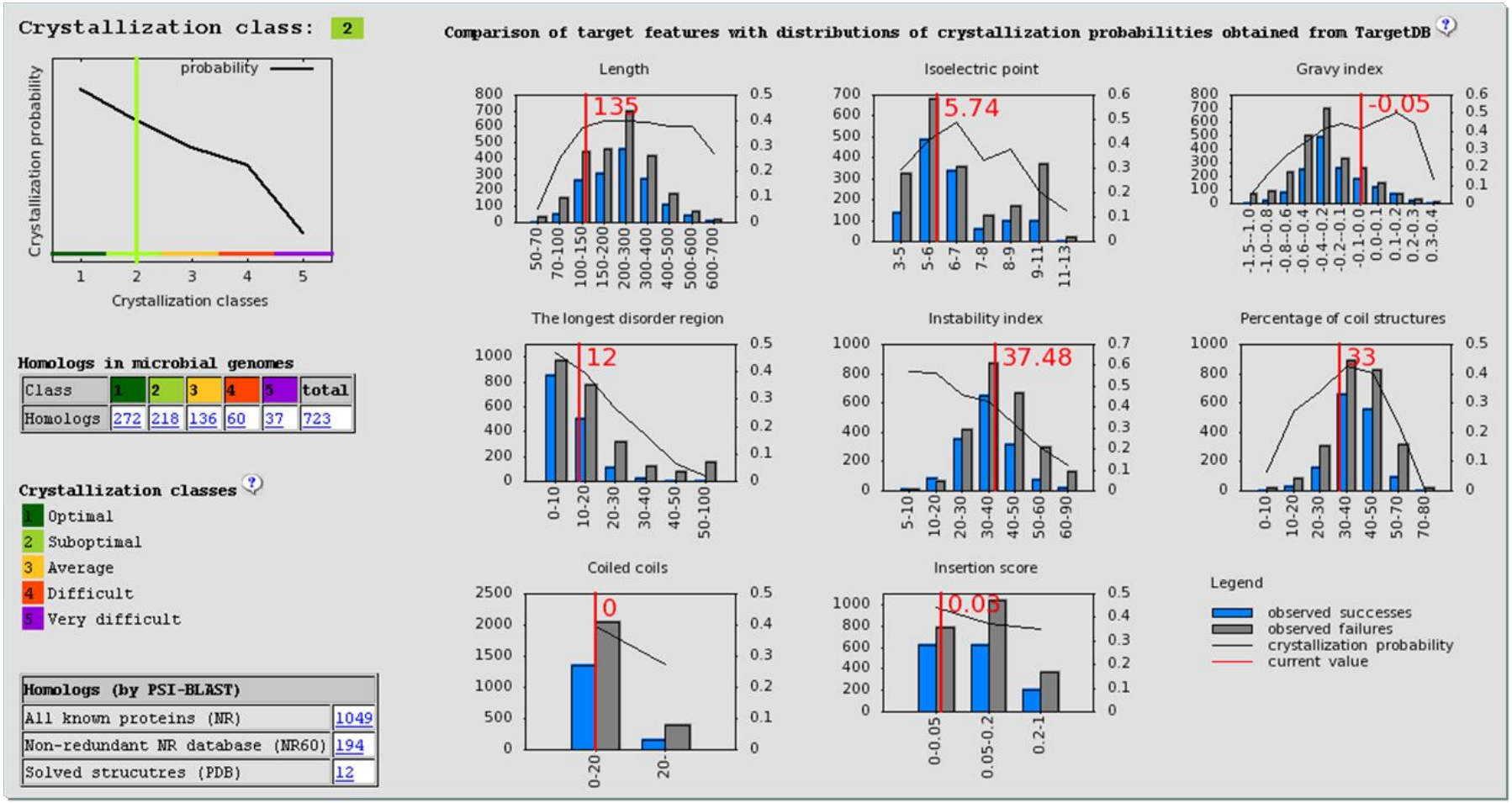
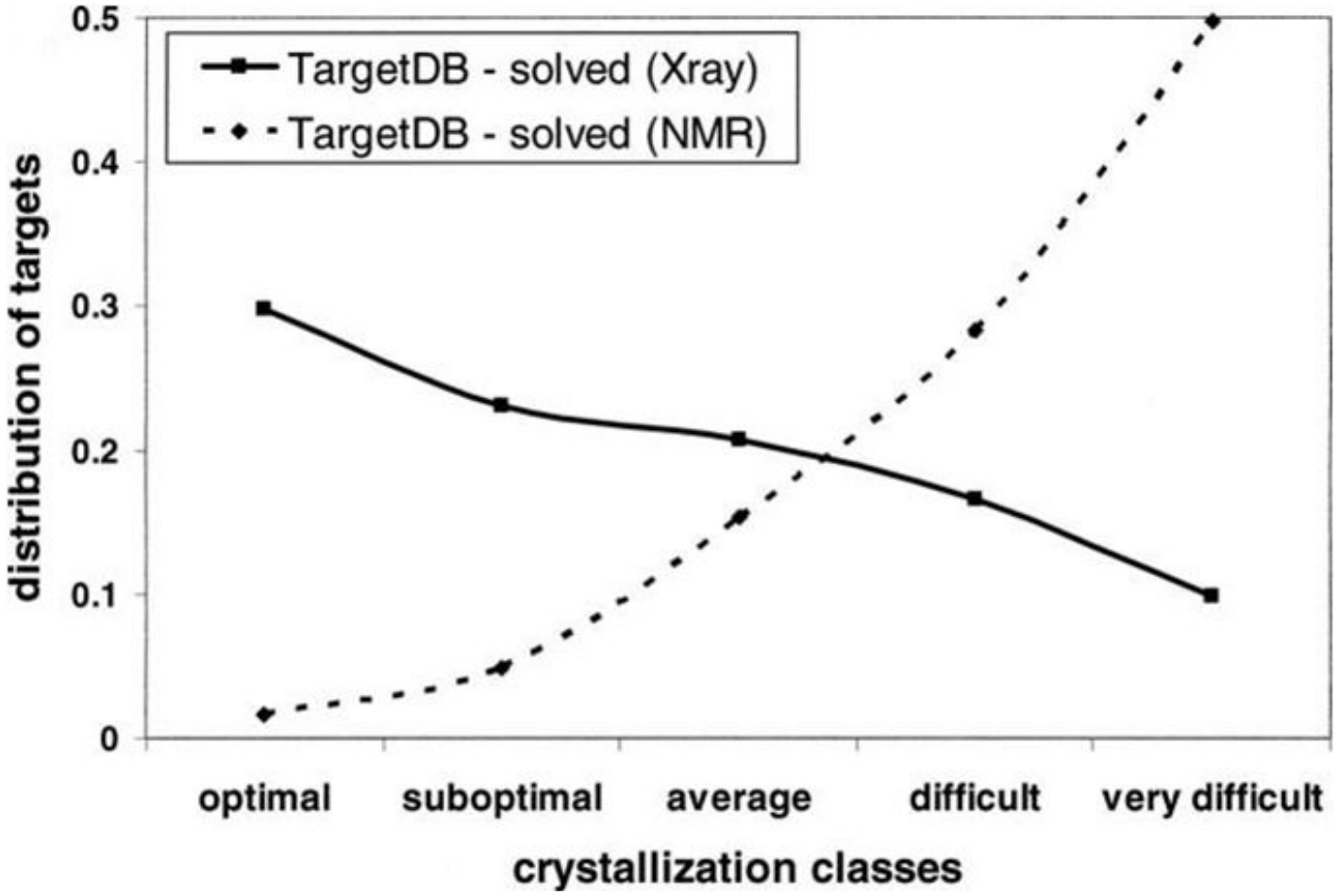
XtalPred: a web server for prediction of protein crystallizability

(http://ffas.burnham.org/XtalPred-cgi/xtal.pl)

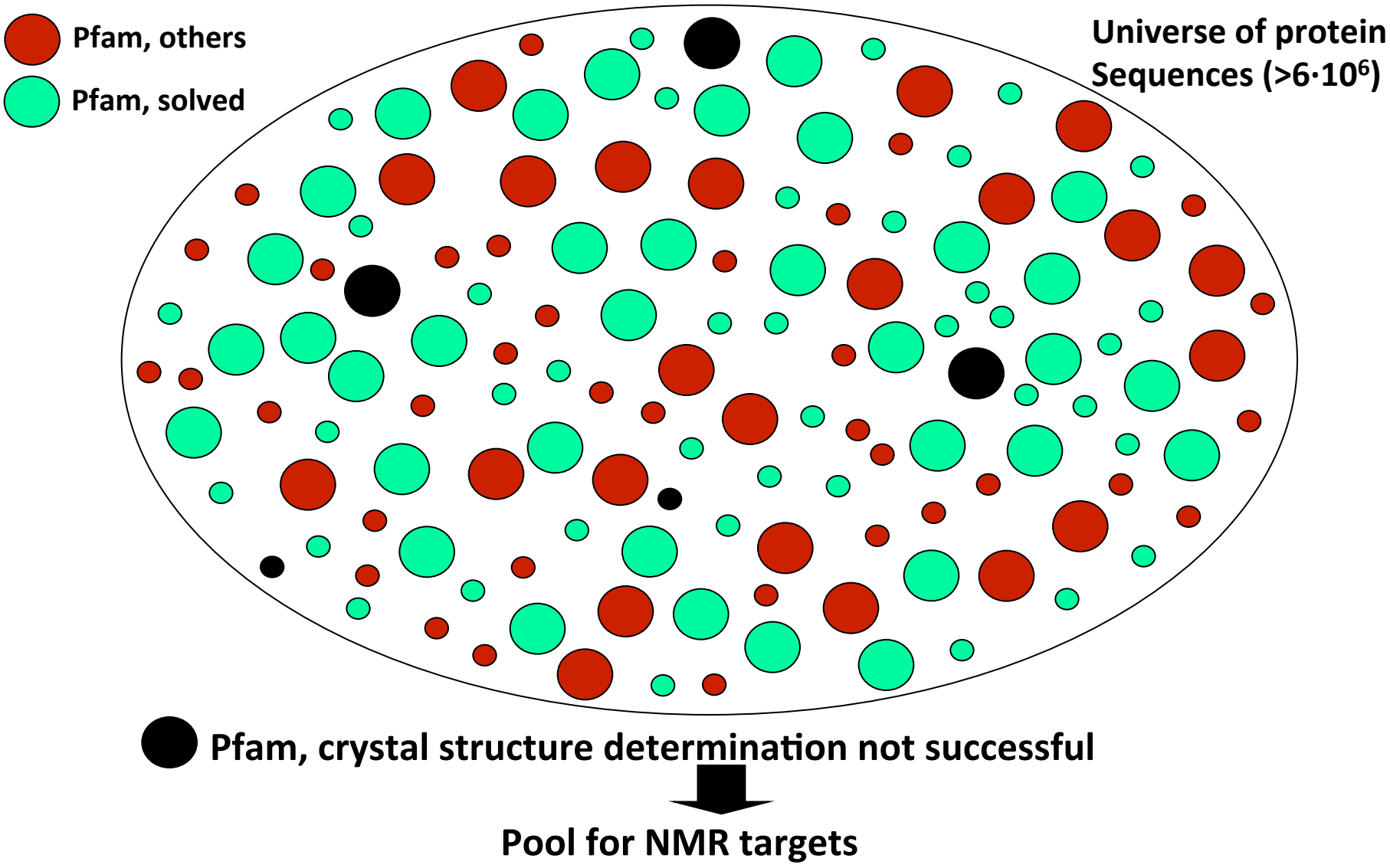


Xray and NMR highly complementary

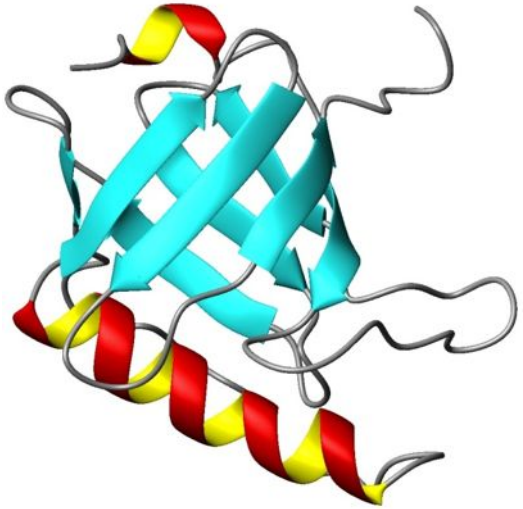


Slabinski L, Jaroszewski L, Rodrigues AP, Rychlewski L, Wilson IA, Lesley SA, Godzik A. **"The challenge of protein structure determination- lessons from structural genomics,"** *Protein Science,* 16: 2472-2482 (2007).

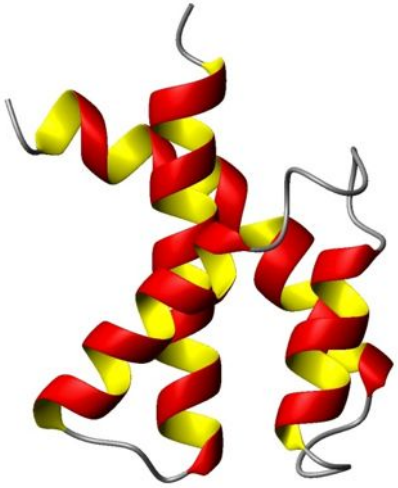
JCSG NMR Target Selection on the HT-Crystallography Background



Structural Coverage of New Pfams by NMR



2KTS / PF03724



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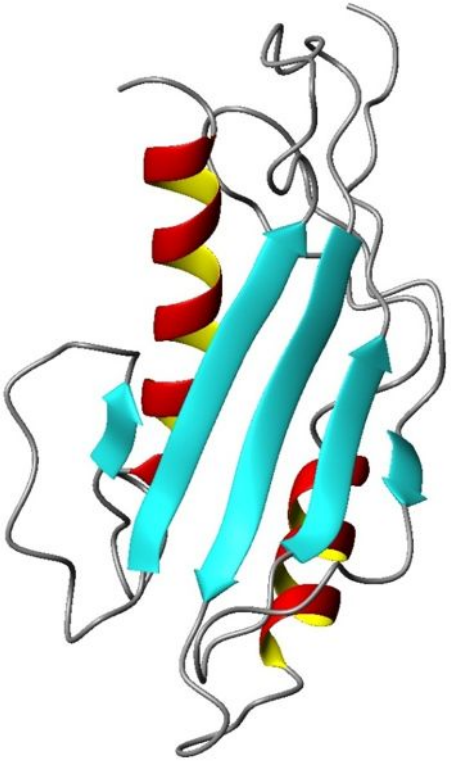
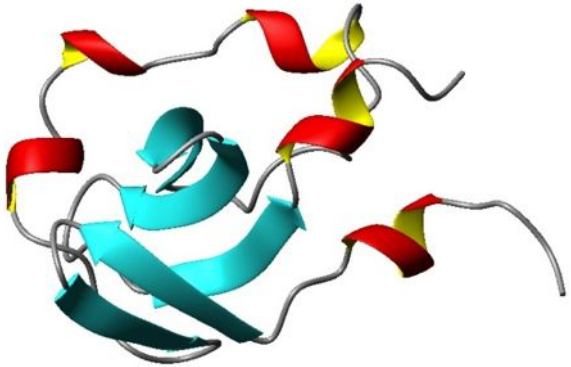
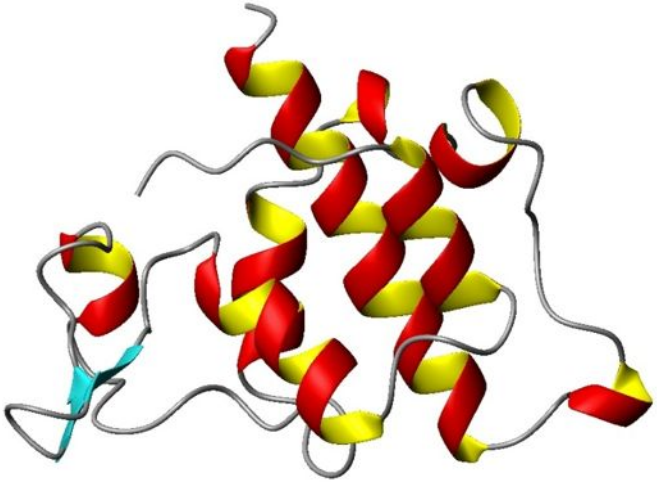


2L25 / BIG_19



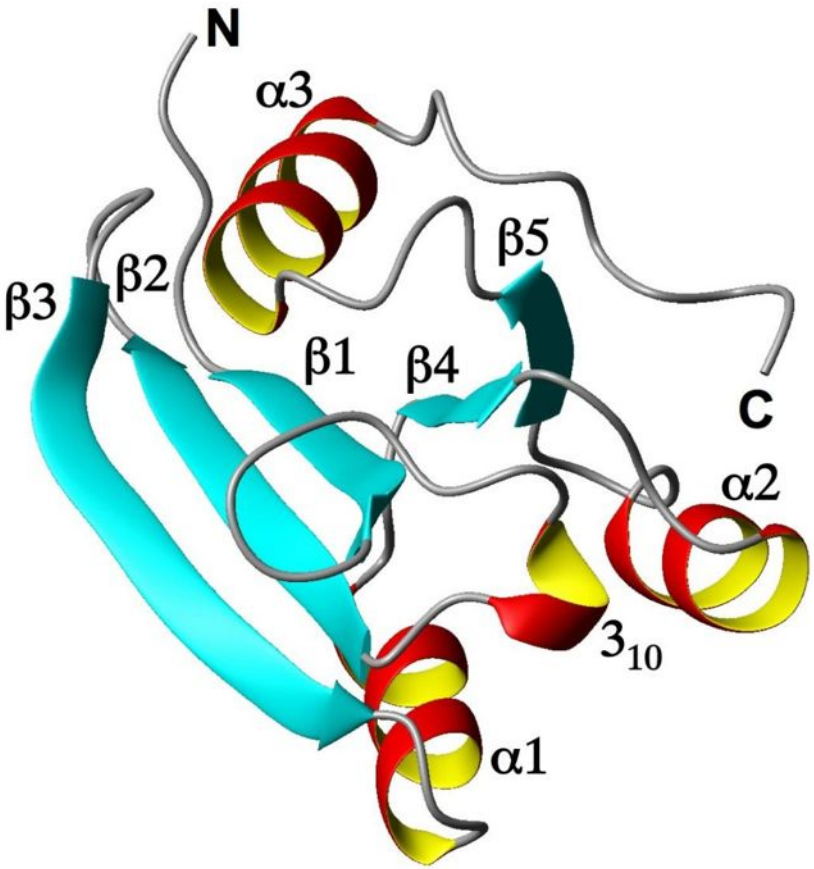
2L1S / DUF3315



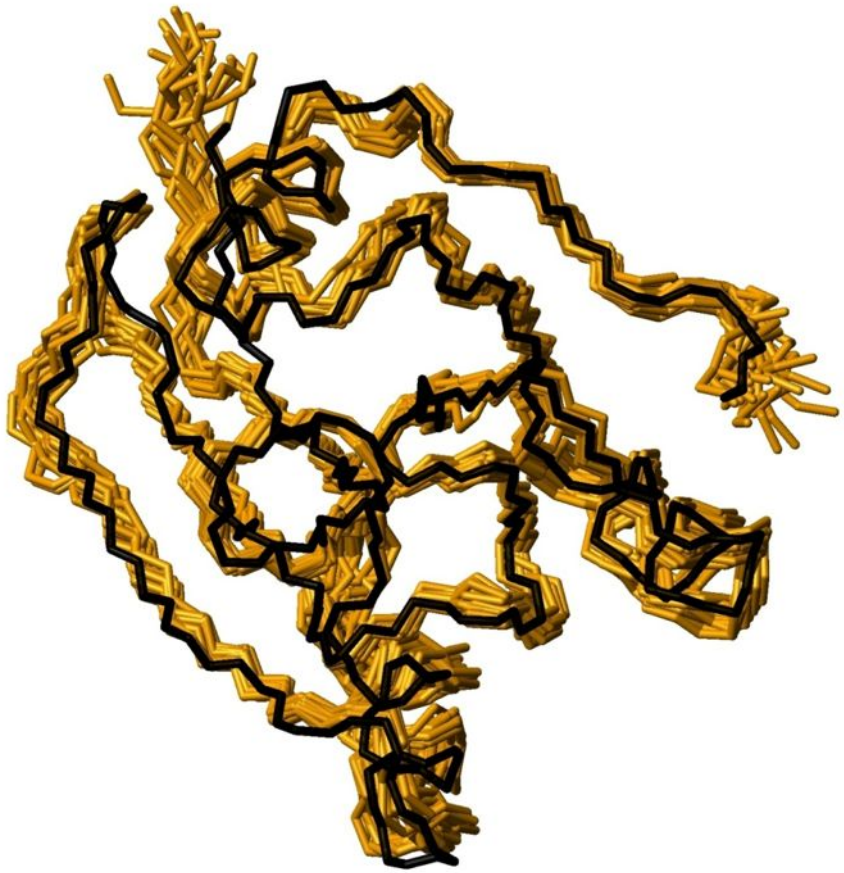
2L1N / DUF1823

NP_247299.1 (*Methanococcus jannaschii*)

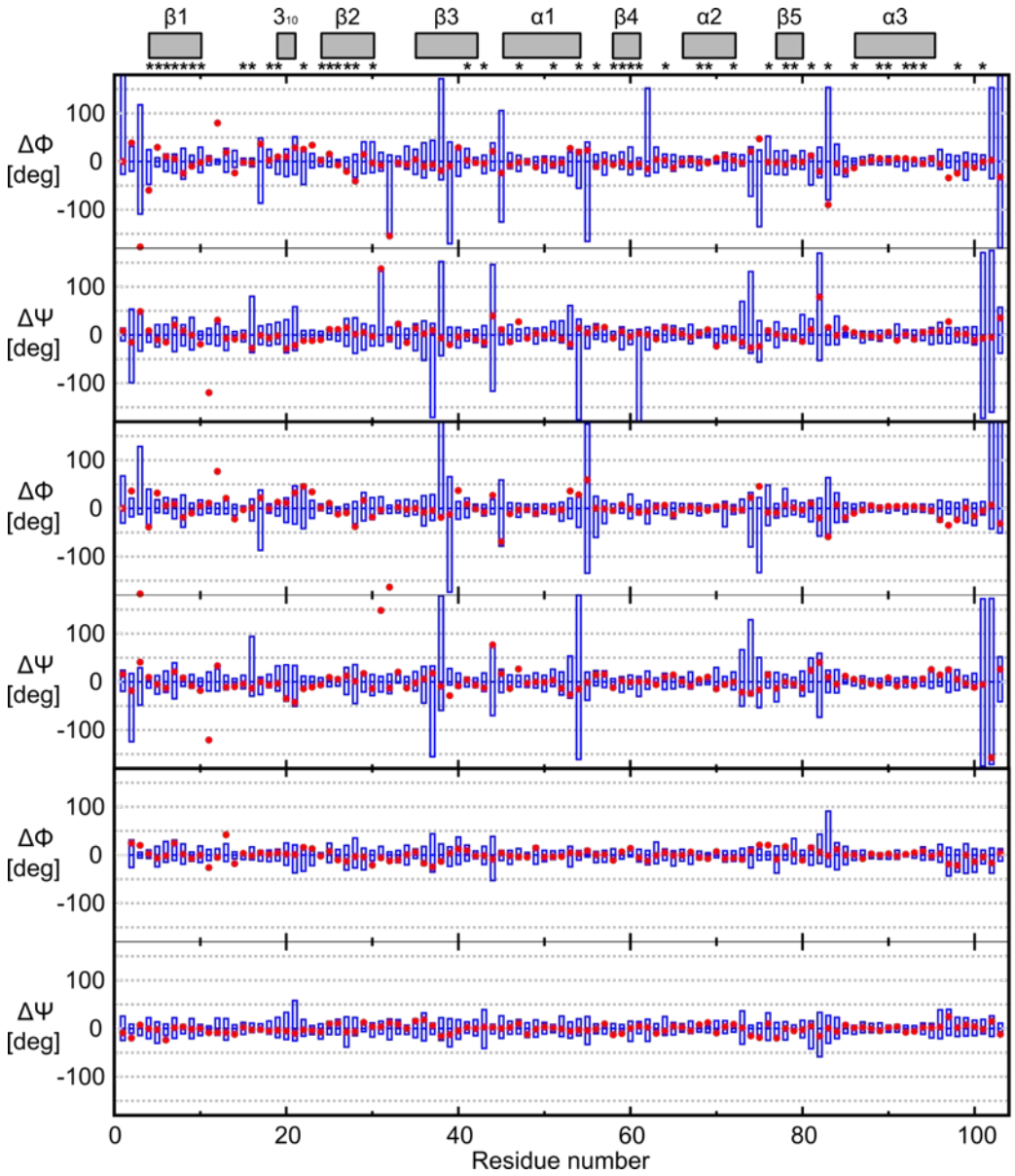
NMR



NMR/Crystal



Backbone Dihedral Angles Φ and Ψ



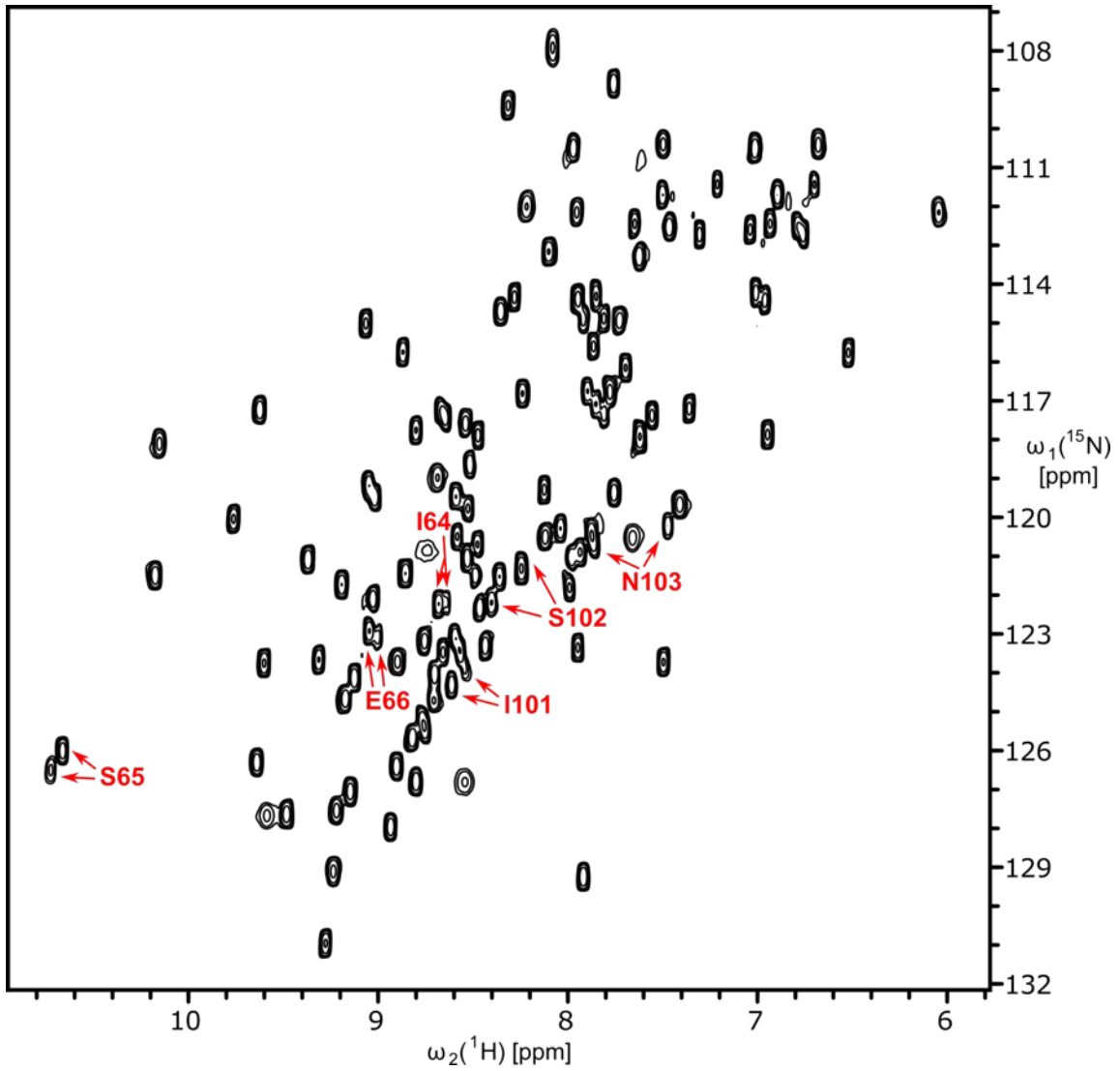
NMR structure
Crystal structure

Reference NMR
Crystal structure

Reference Crystal
Crystal structure

NP_247299.1: *cis*/*trans* isomers of N103–P104

NMR chemical shifts: two conformations for 64–66 and 101–104

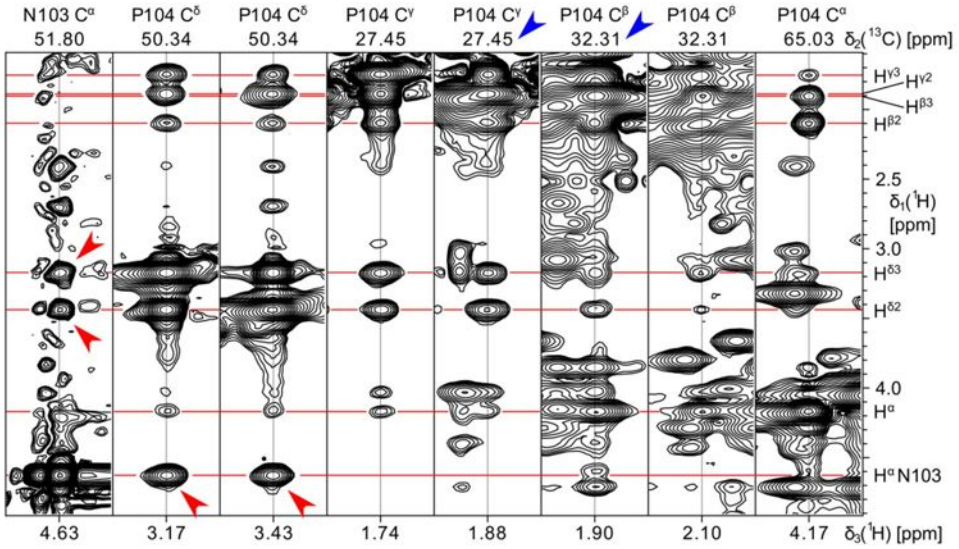


NP_247299.1: *cis*/*trans* isomers of N103–P104

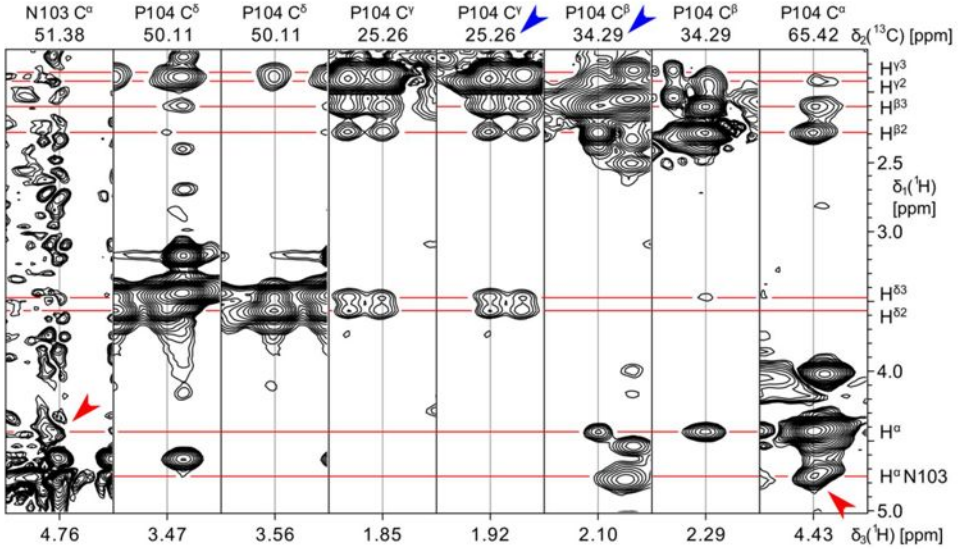
Identification from ^{13}C chemical shifts (➤) and ^{1}H–^{1}H NOEs (➤)

3D ^{13}C-resolved $[^{1}H, ^{1}H]$-NOESY

trans - Pro

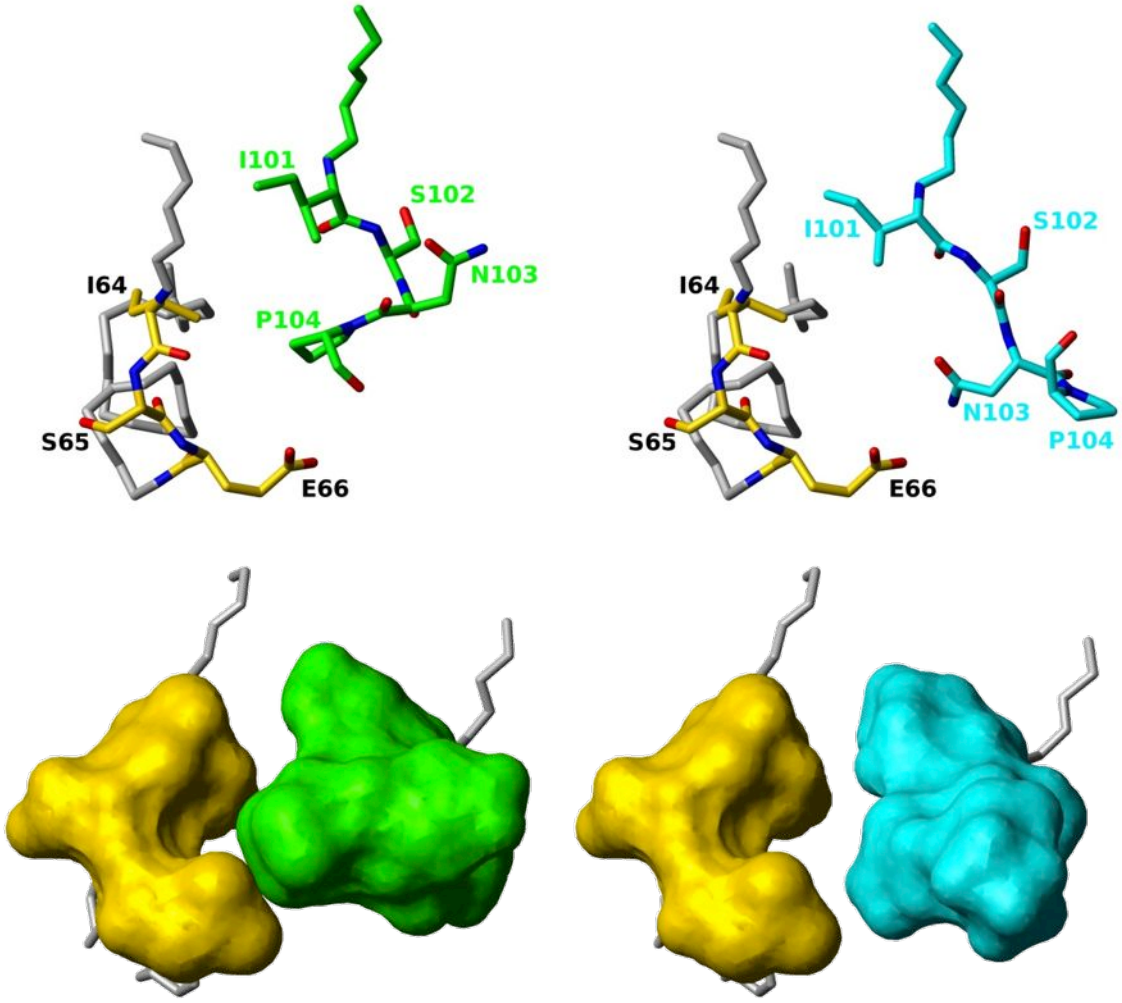


cis - Pro



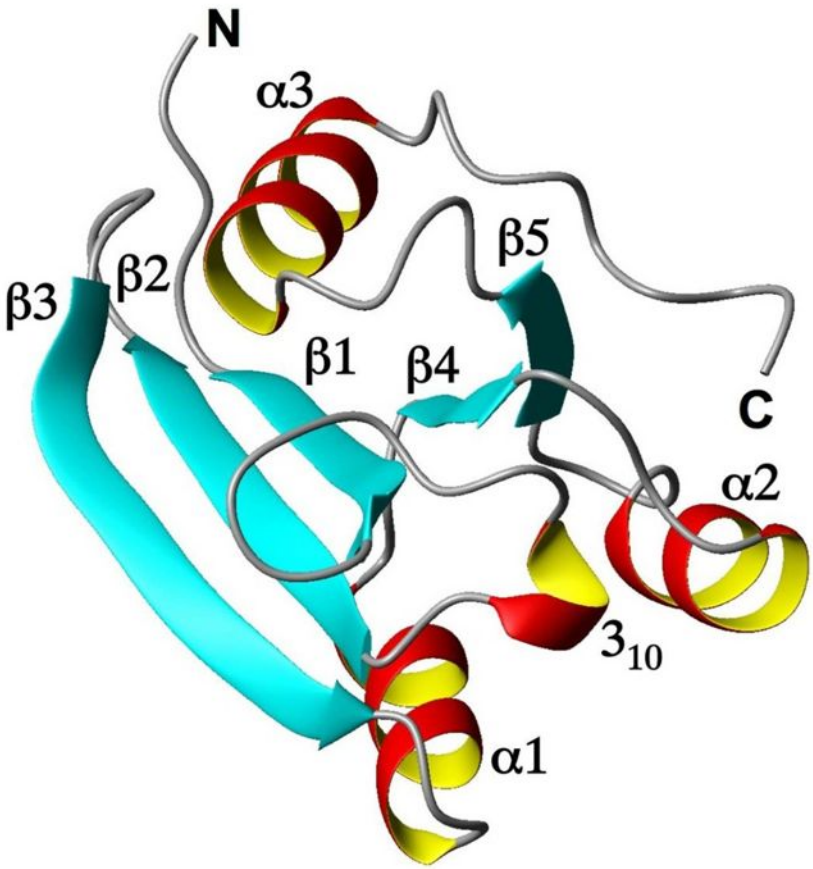
NP_247299.1: segments 64–66 and 101–104

trans-P104 *cis*-P104

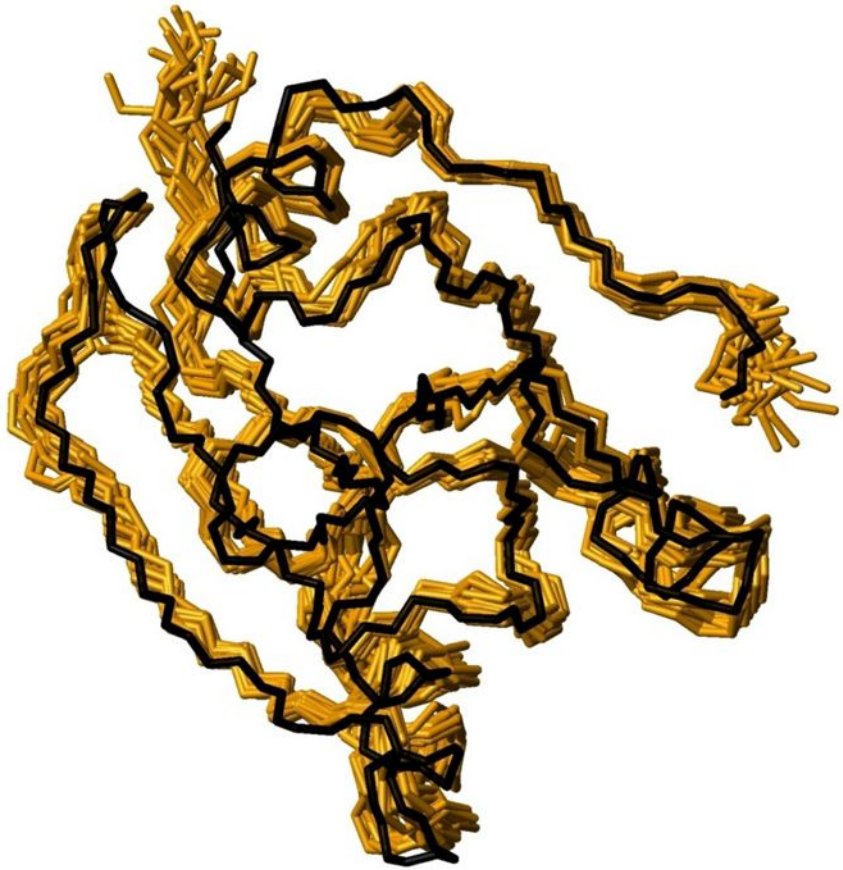


NP_247299.1 (*Methanococcus jannaschii*)

NMR



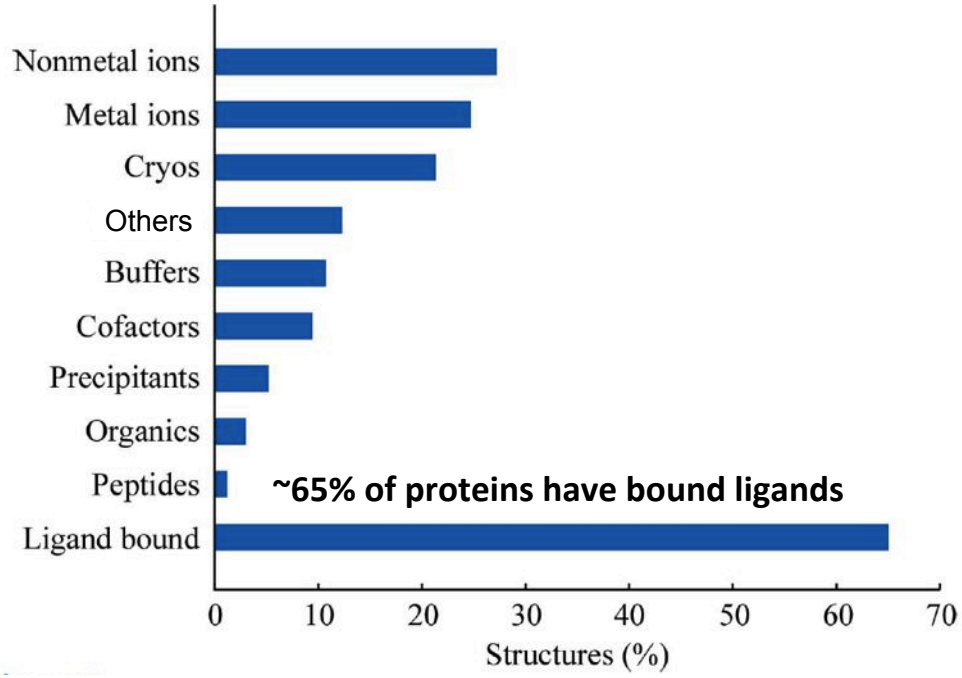
NMR/Crystal



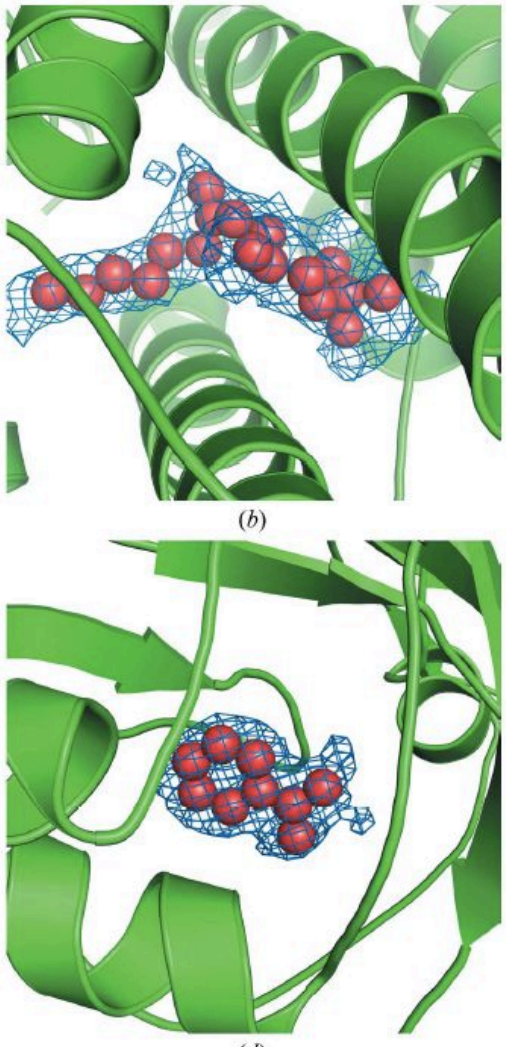
Bound Ligands Aid in Functional Annotation of Proteins

- Much diversity of ligands is found in protein crystal structures of the JCSG and other PSI centers.
- Interesting role for NMR in solution:
  - The identity of the bound ligand is often difficult to confirm by X-ray crystallography alone.
  - Scarcity of Apo-protein crystal structures.

Types of bound ligands identified in PSI structures

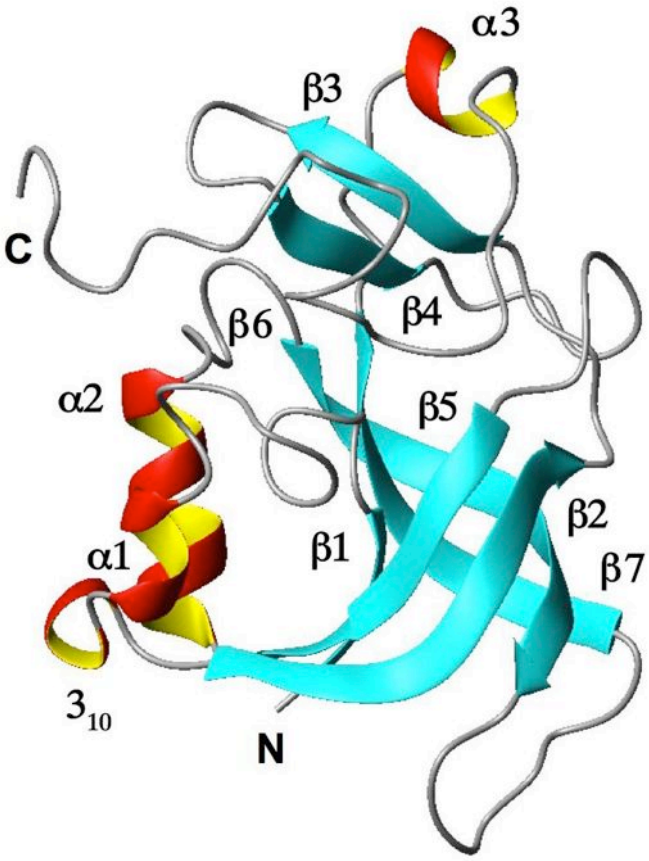


Examples of unknown ligands bound to JCSG structures

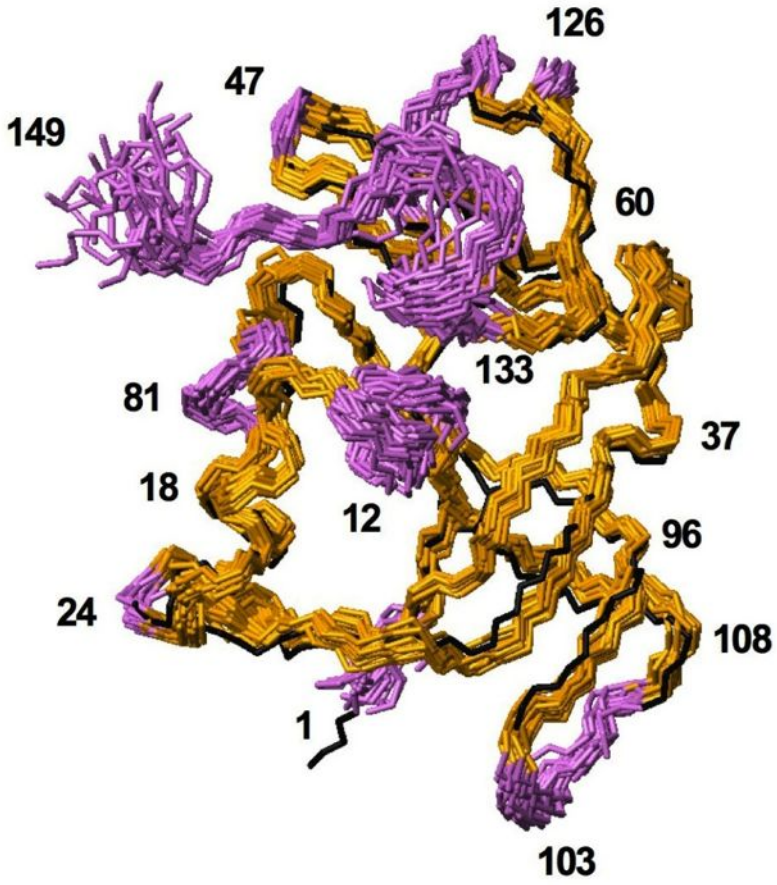


A2LD1 (*Mus musculus*)

NMR

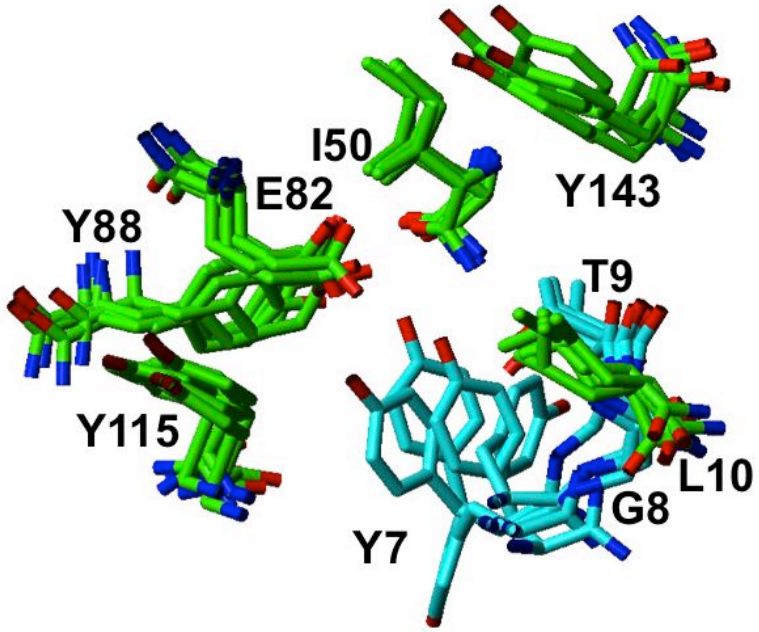


NMR/Crystal



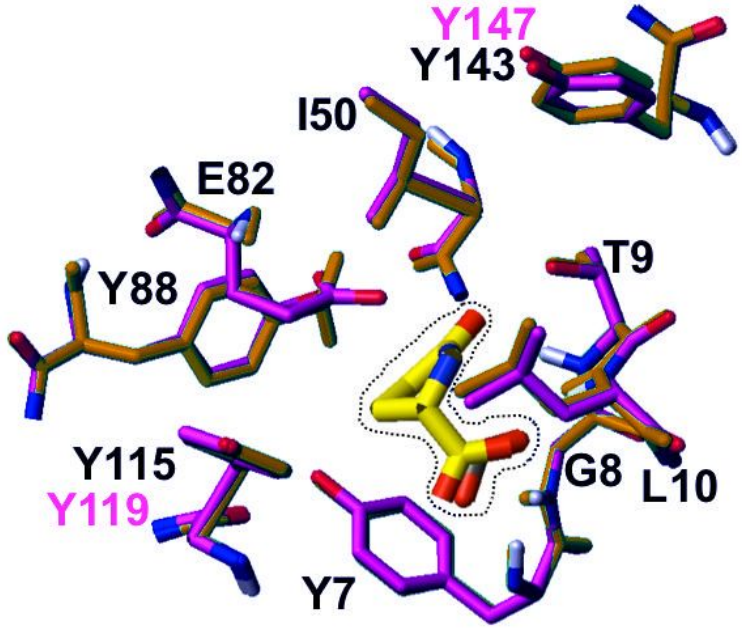
A2LD1 Active Site

NMR



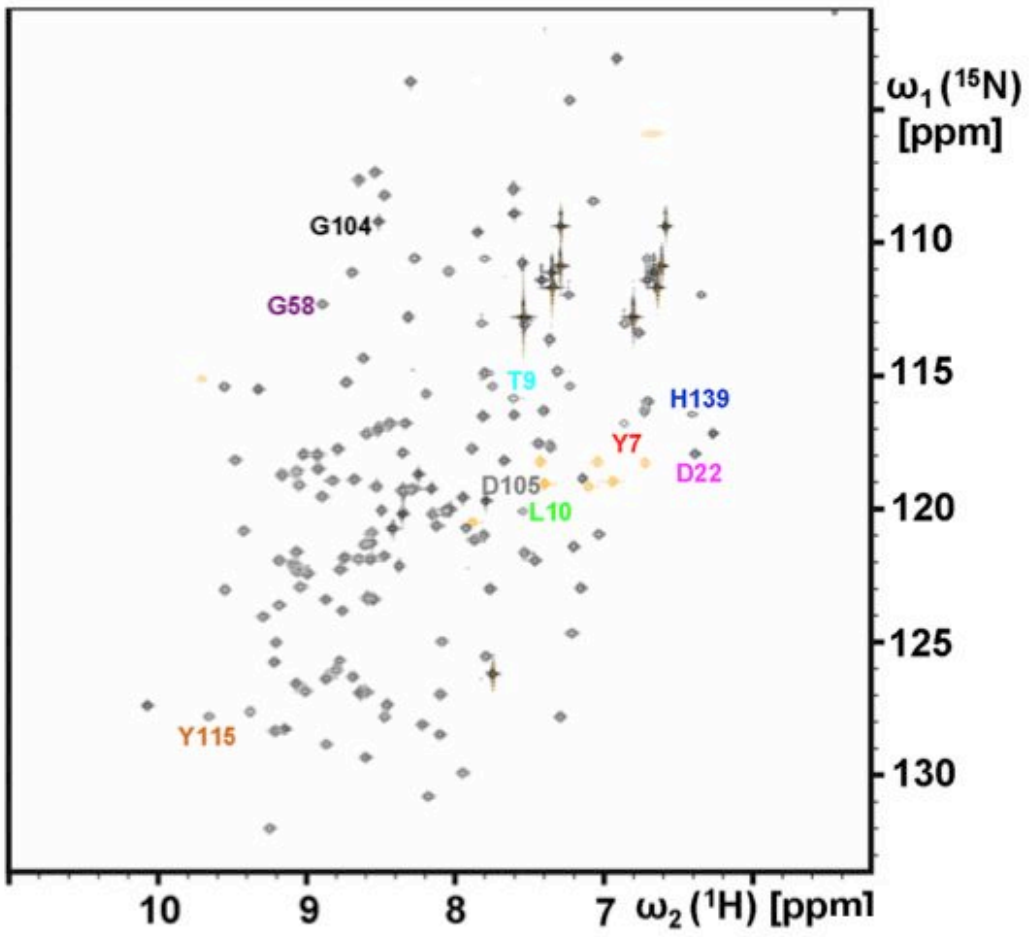
Crystal Structures

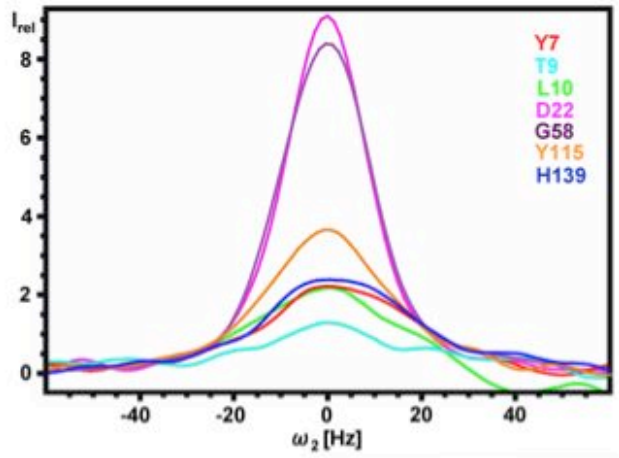
A2LD1 (formate) **GGACT (5-oxo-*L*-α-proline)**

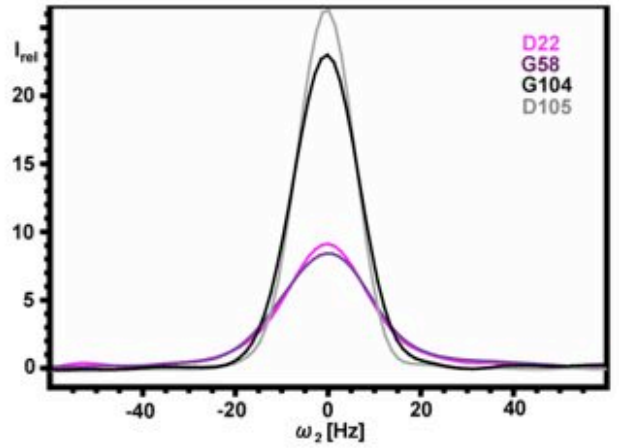


A2LD1

[^{15}N,^{1}H]-HSQC Lineshapes







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JCSG NMR Core

NMR Core Leader	**Kurt Wüthrich**
NMR Core Manager	**Pedro Serrano**
NMR Core Protein Production Manager	**Michael Geralt**
NMR Specialist	**Reto Horst**

Automation of Protein Structure Determination

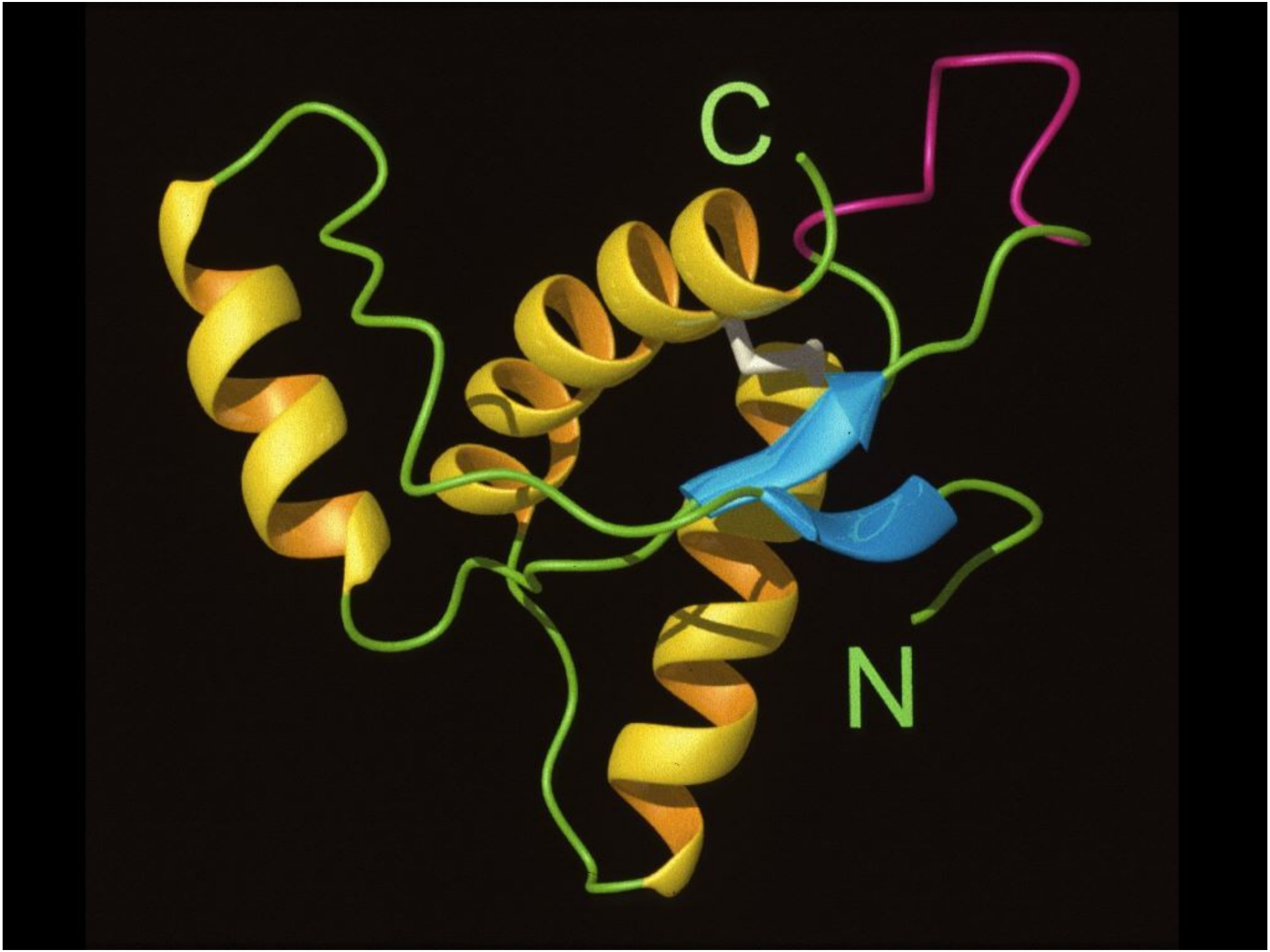
Samit Dutta
Kristaps Jaudzems
Biswaranjan Mohanty
Lukas Susac
Atia-tul-Wahab

Collaborations:

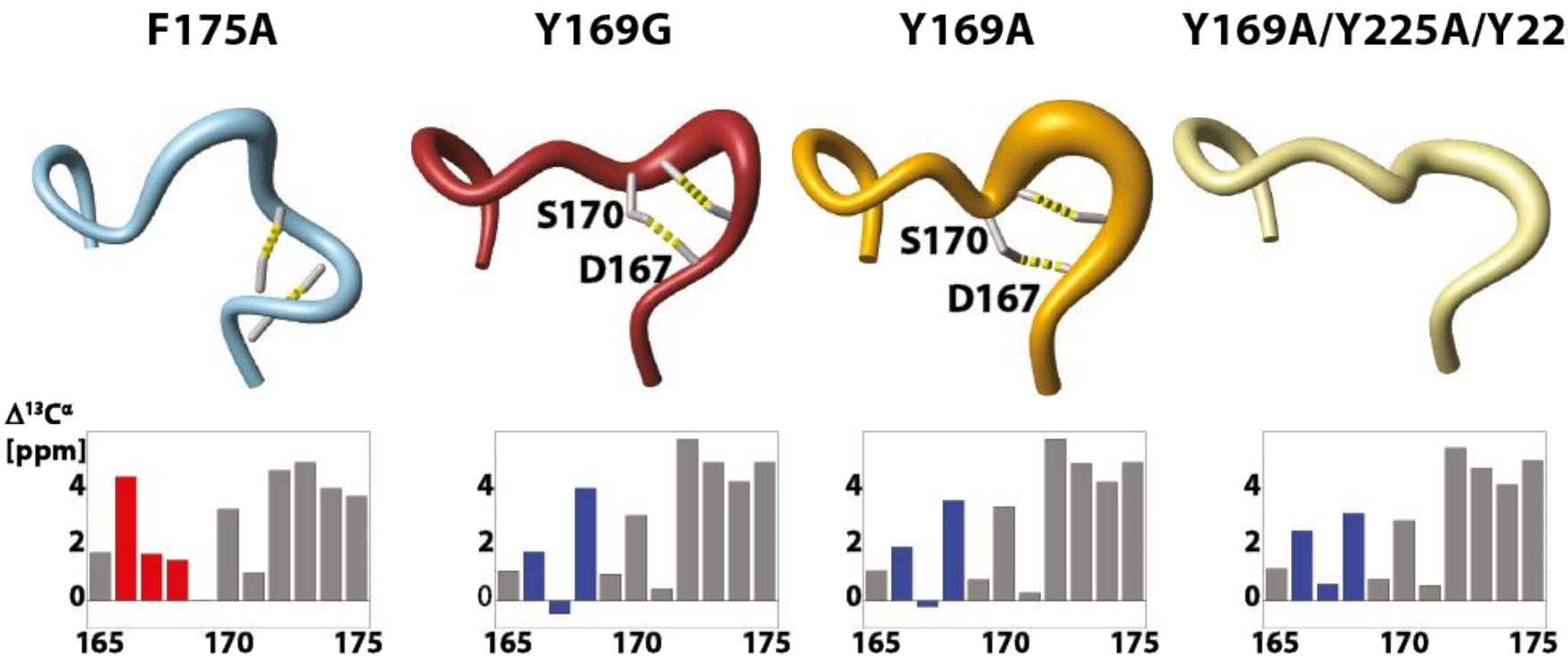
Bill Pedrini	**ETH Zürich**
Torsten Herrmann	**UCB Lyon**

Prion Proteins

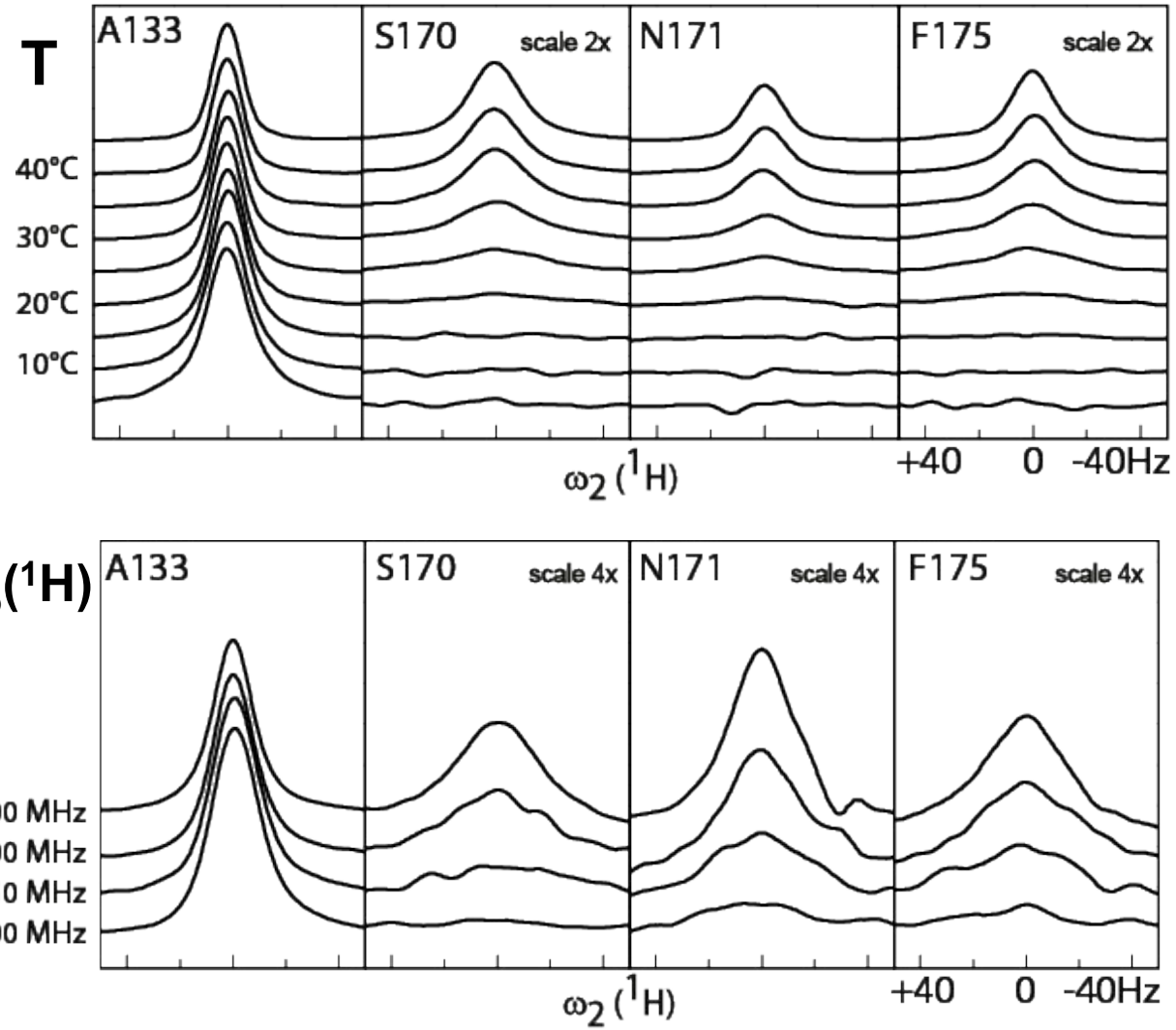
1996 –


C
N

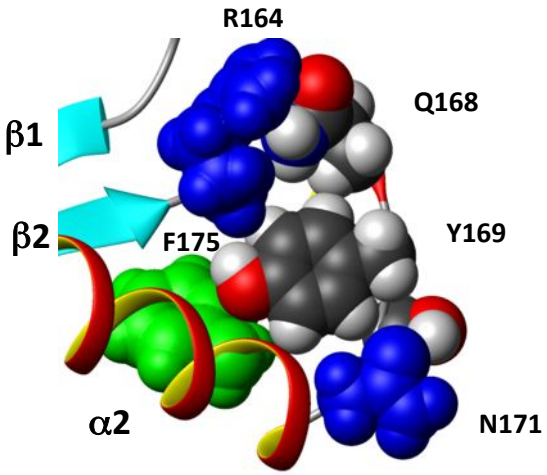
β2-α2 loop in variants of mPrP(121–231)



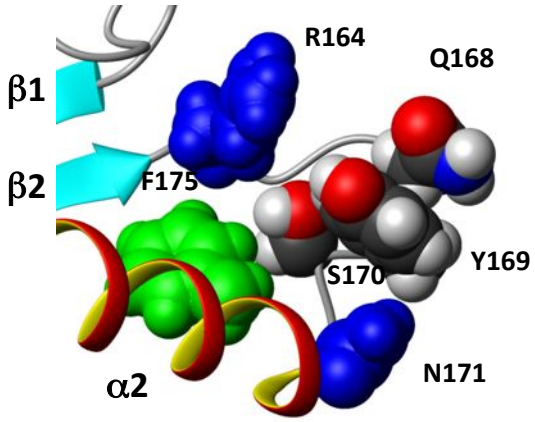
mPrP[Y225A,Y226A](121–231)



mPrP Models: mPrP[Y169A → Y]



$\chi^1 = +60$



$\chi^1 = -60$