SEE DIFFERENTLY WITH NEUTRONS AT NIST

Rob Dimeo, Director

NIST Center for Neutron Research

NCNR

A National User Facility

The mission of the NIST Center for Neutron Research is to ensure the availability of neutron measurement capabilities to meet the needs of U.S. researchers from industry, university and other Government agencies.

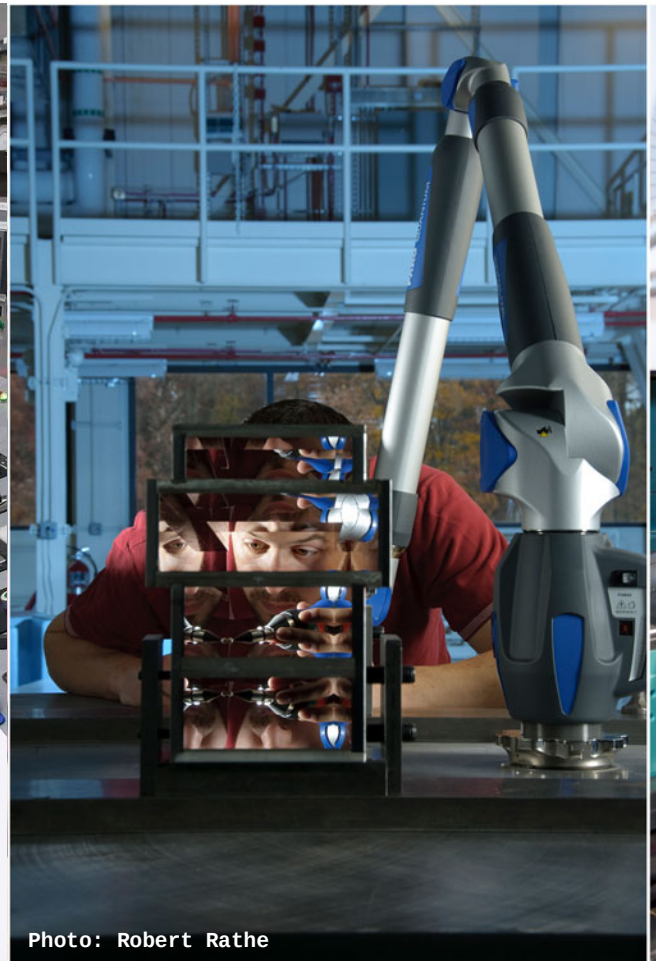


Photo: Robert Rathe

Operate the NIST Research Reactor cost effectively while ensuring the safety of the staff and general public

Develop neutron measurement techniques, develop new applications of these techniques, and **apply** them to science and engineering problems of national interest

Serve the needs of researchers from industry, university, and government by operating the research facilities of the Center as a national user facility

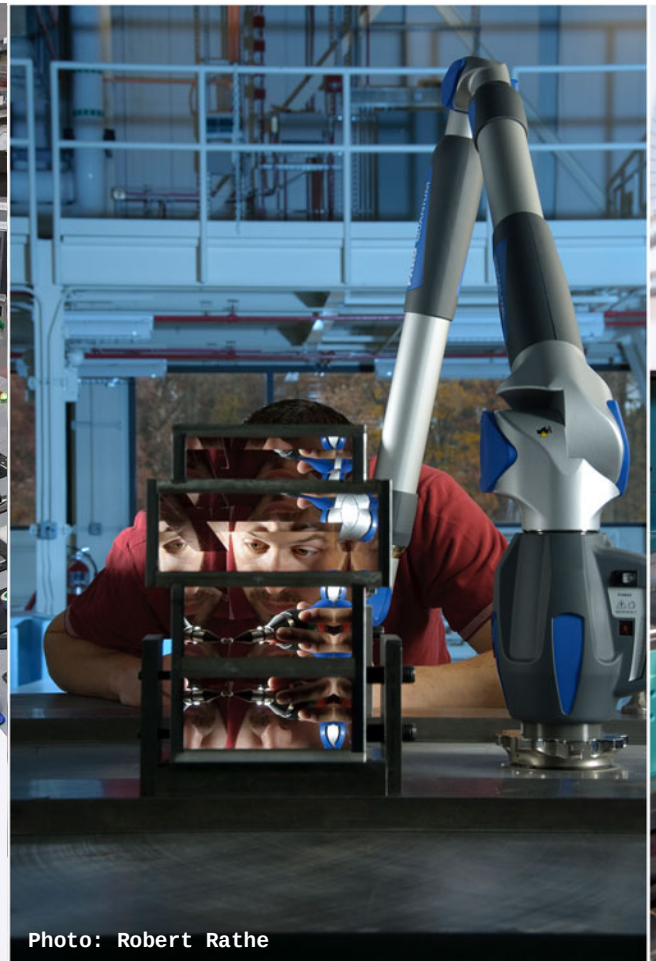


Photo: Robert Rathe

ACCESS

General User Access

TECHNICAL MERIT based – No user charges

2
proposal calls/year

2
Independent reviews
for technical merit

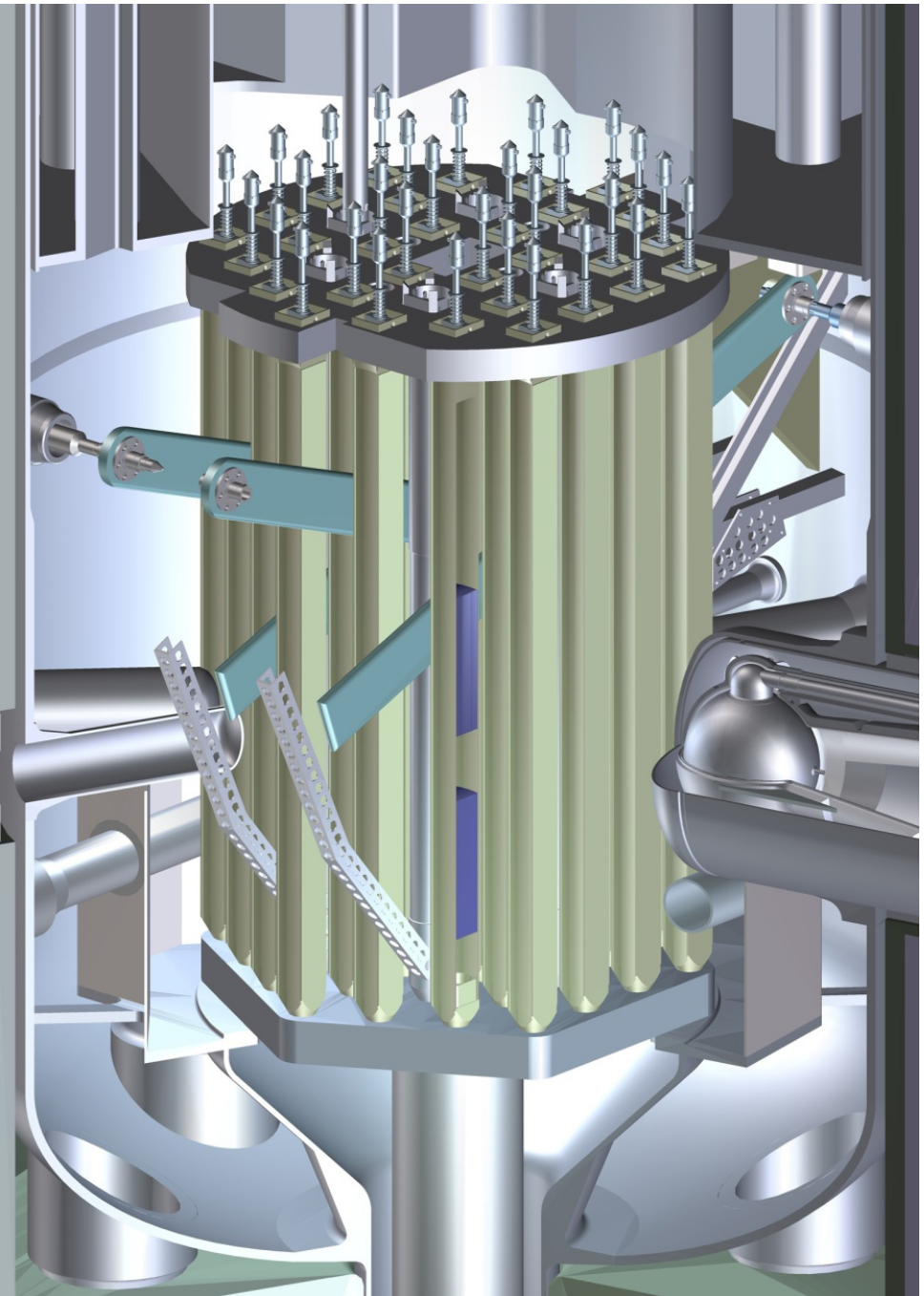
Collaborative Access

Merit based via instrument owner

Proprietary Use

Confidential results
User pays full cost recovery
per OMB A-25

MAKING NEUTRONS FOR SCIENCE



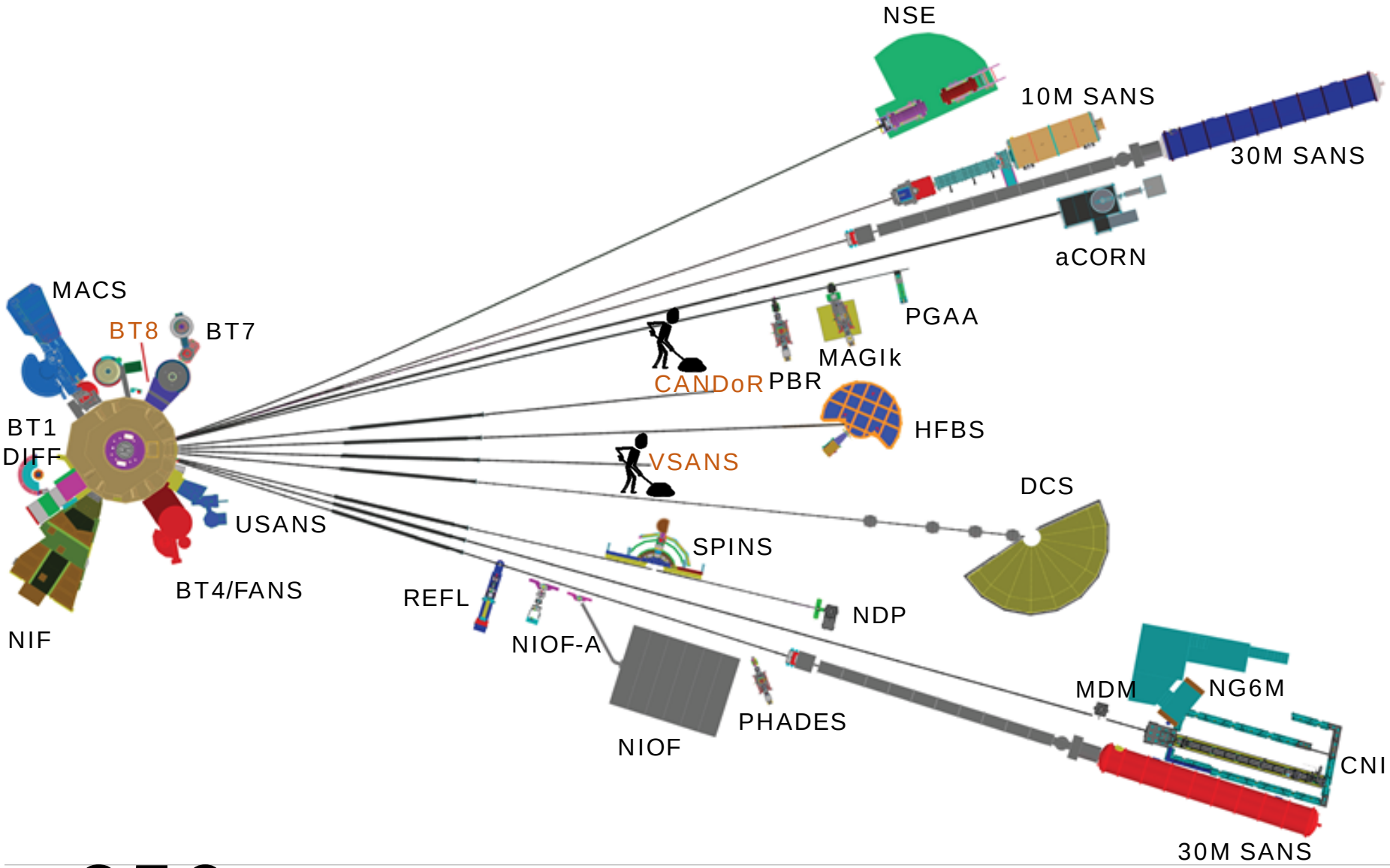
20 MW
D_2O moderated
30 fuel elements

7 cycles/year
38 day cycles
~250 days/year

Licensed through
2029

NCNR INSTRUMENT LAYOUT

March 2016

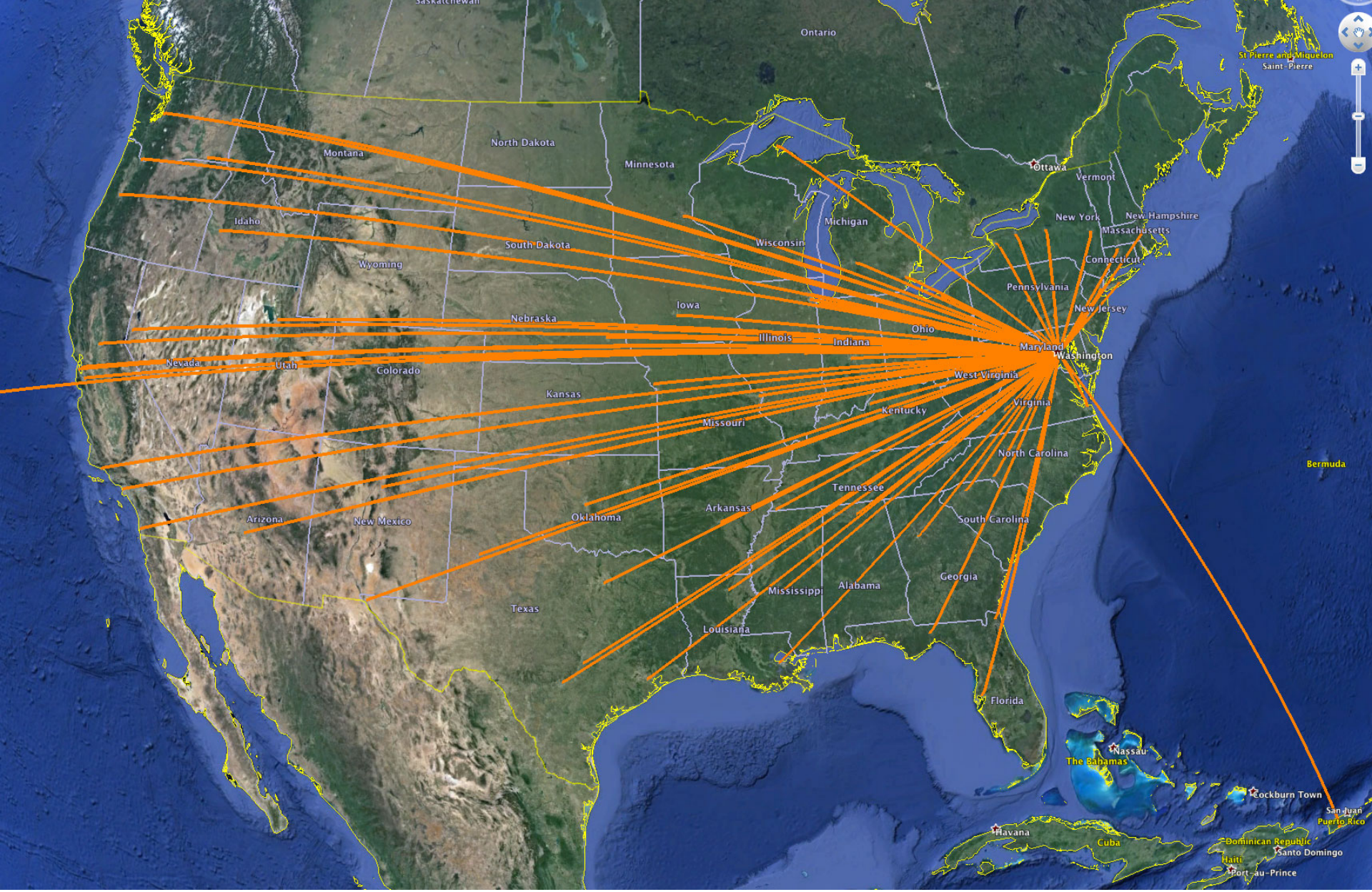


~250

operating days

THEN

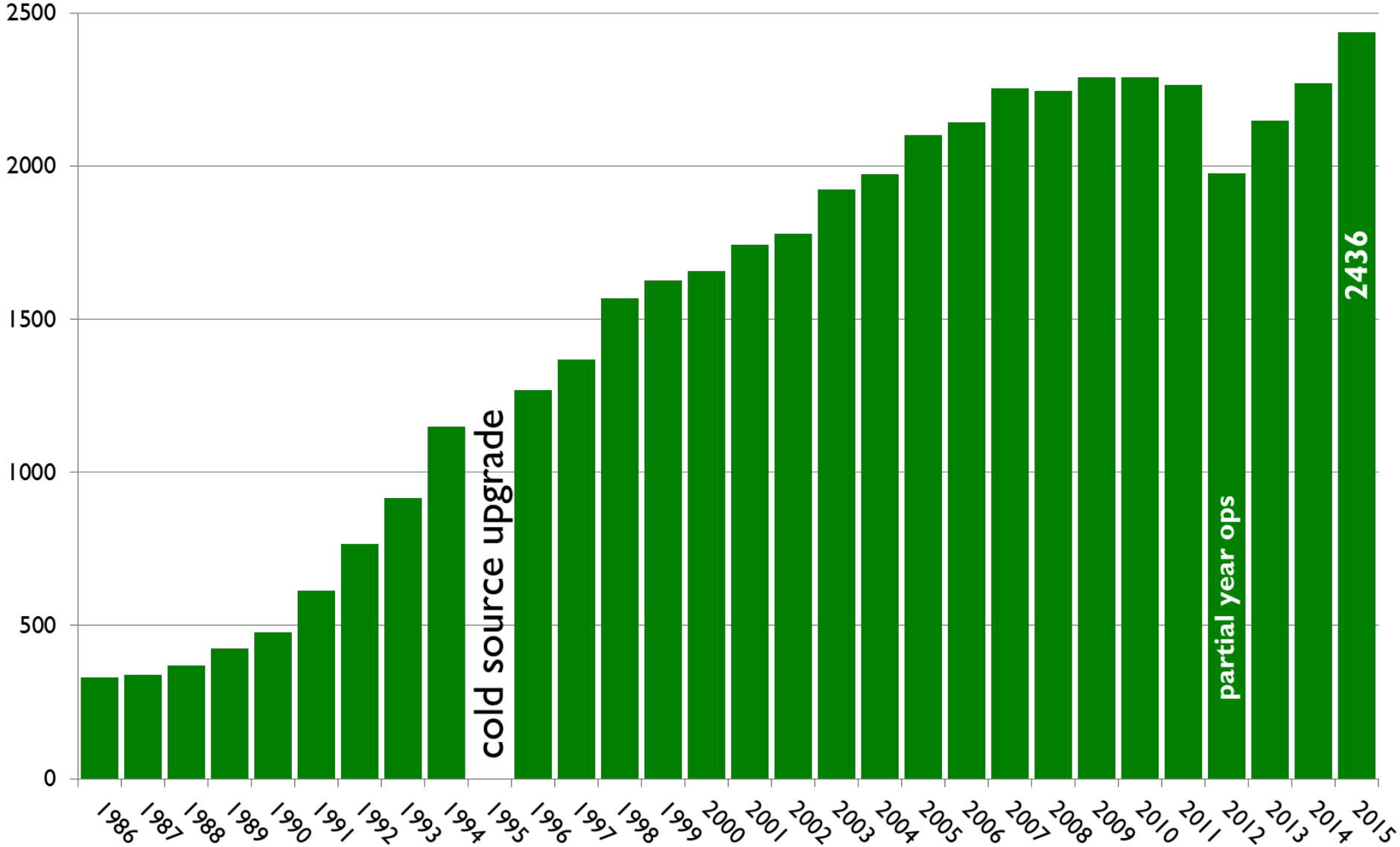
NOW



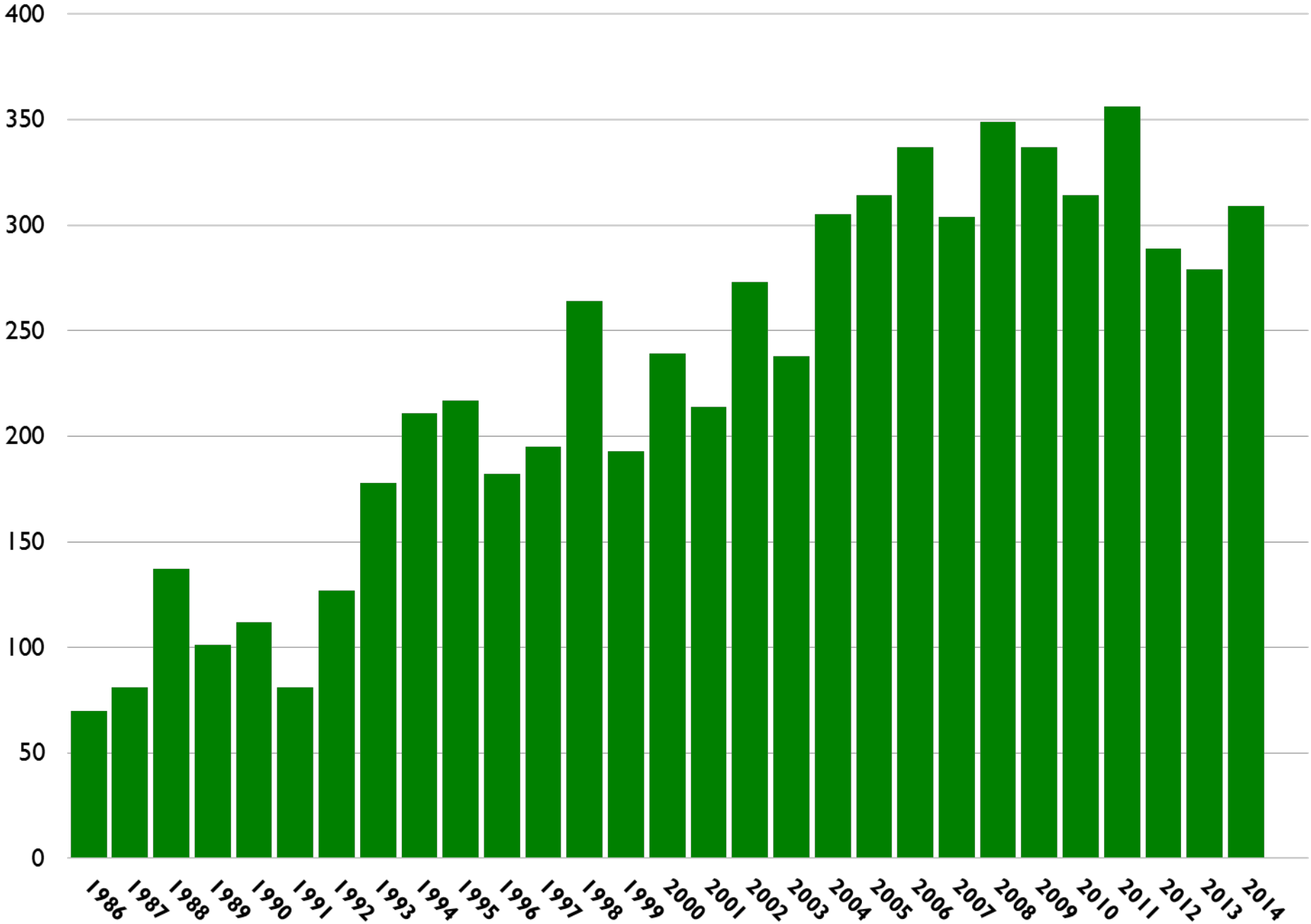
U.S. Research Participation at the NCNR

NCNR RESEARCH PARTICIPANTS

50 U.S. corporations
183 Universities
37 U.S. government labs

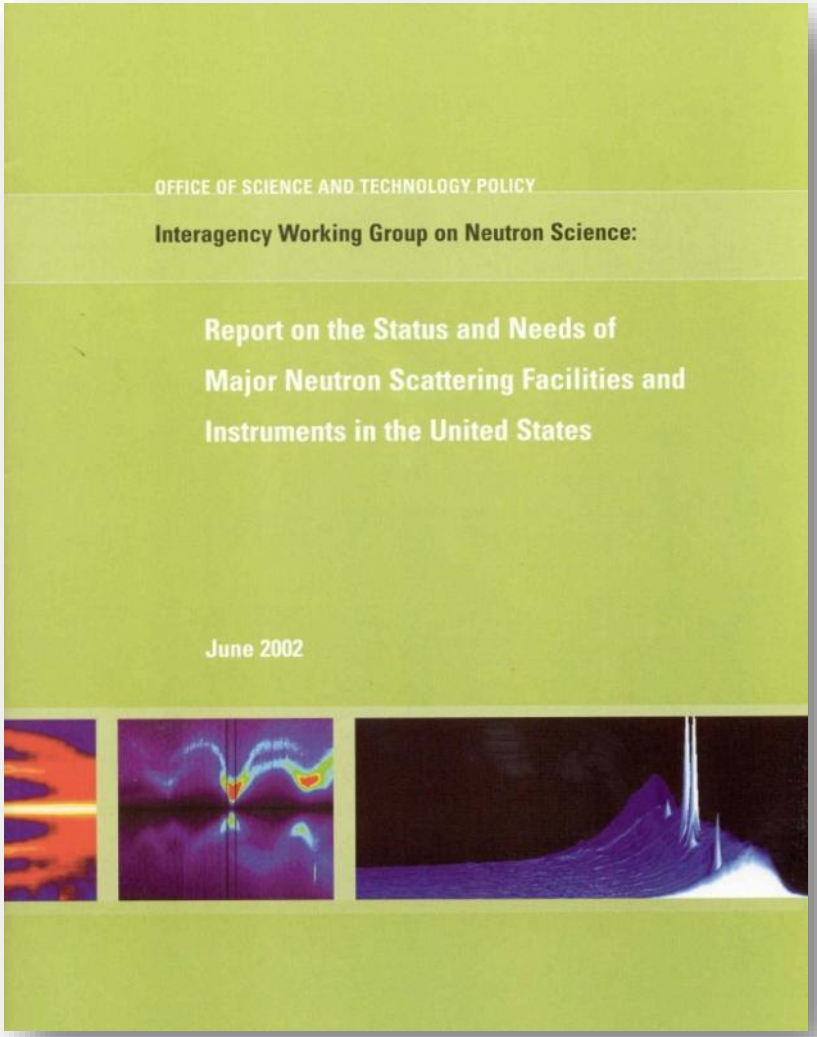


NCNR PUBLICATIONS



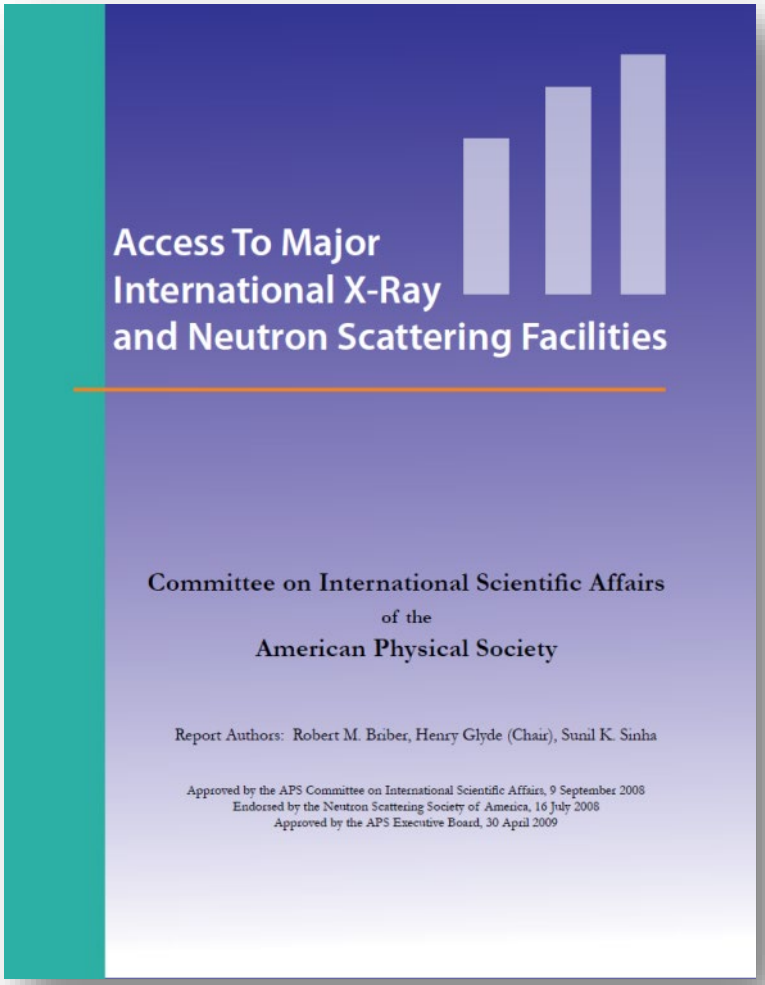
WHERE CAN YOU DO NEUTRON SCATTERING?

INSTRUMENTATION



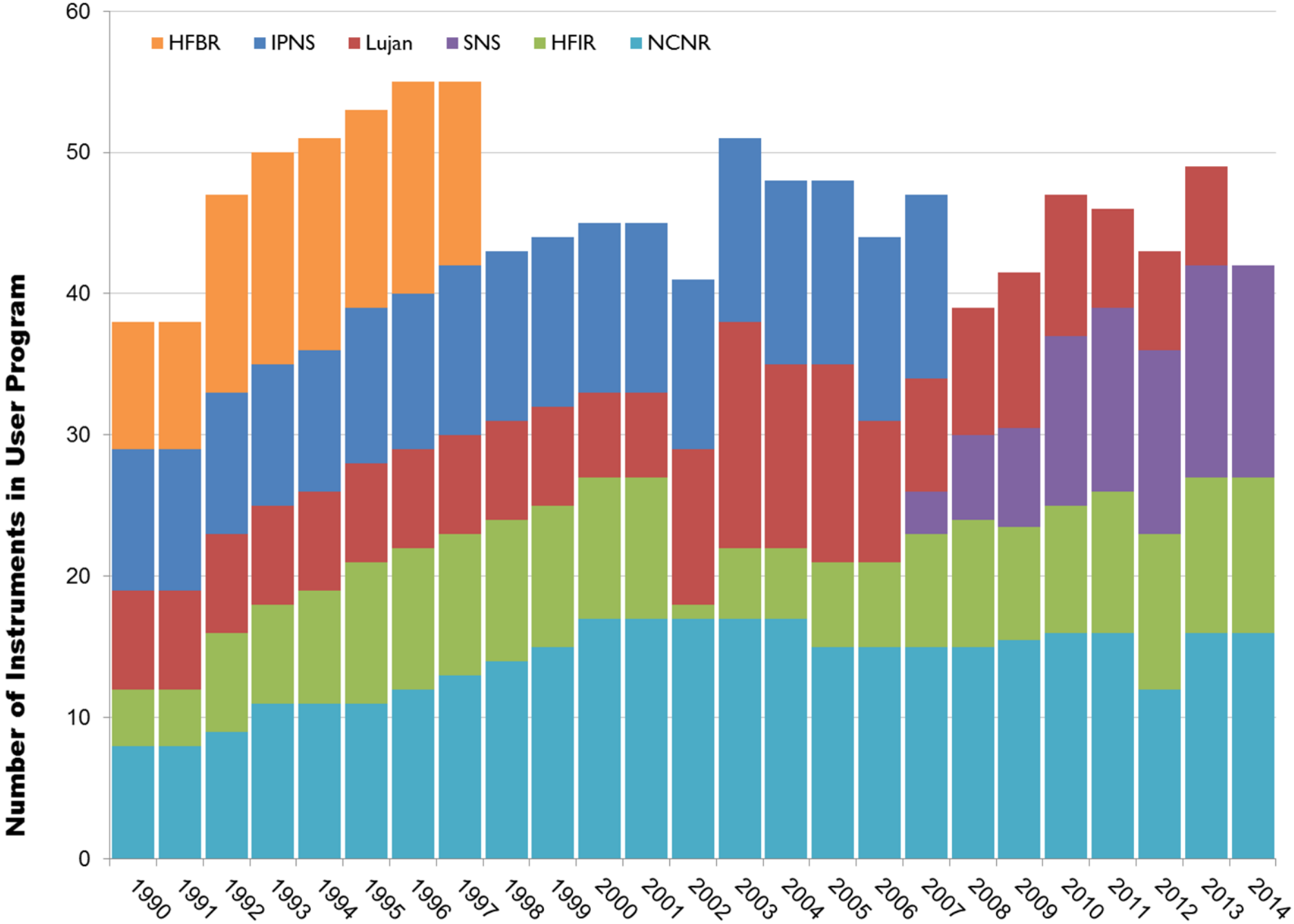
"…fully instrument and staff those sources so that they achieve the highest level of scientific productivity and serve the broadest possible user community."

INSTRUMENTATION

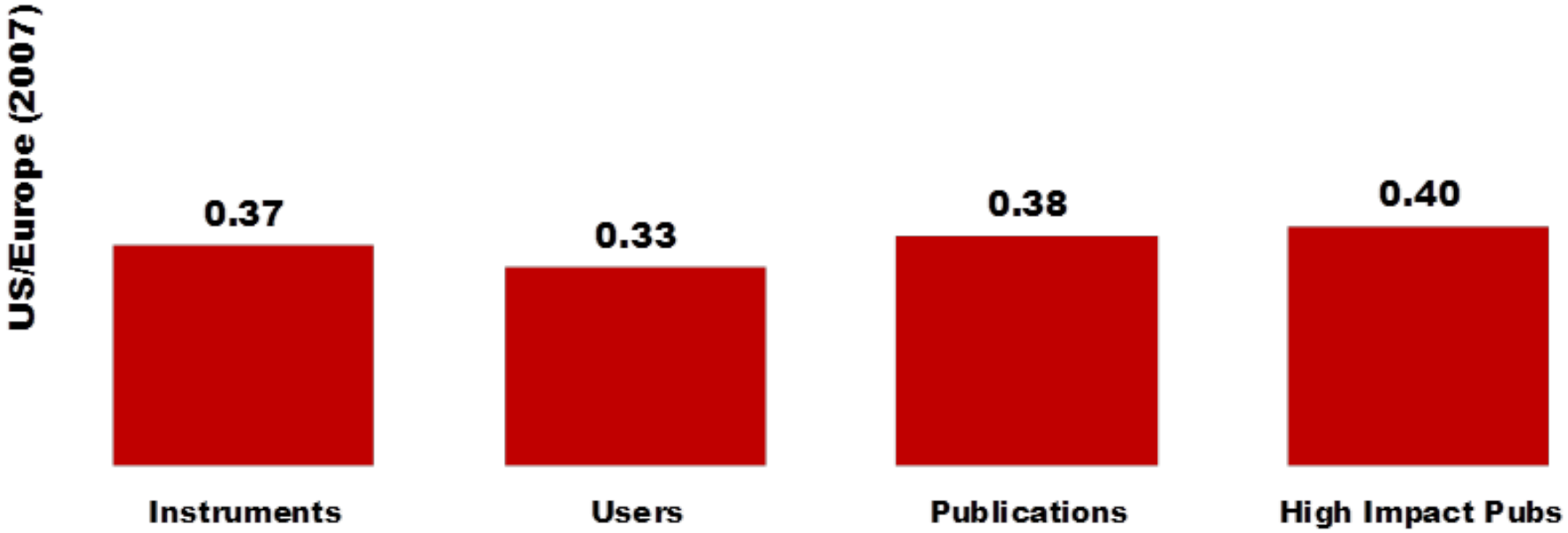


"To improve access and to enable the user community to grow *it is critically important to increase the number of instruments at major facilities in the US*. The size of the US user community is currently limited by the number of instruments.

Scientifically successful access today, especially for new users, depends on the active assistance and collaboration of facility instrument scientists at a scientific level."


HFBR
IPNS
Lujan
SNS
HFIR
NCNR
Number of Instruments in User Program
0
10
20
30
40
50
60
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

The US neutron scattering community is ~35% of that in Europe



(as defined by C. Vettier)

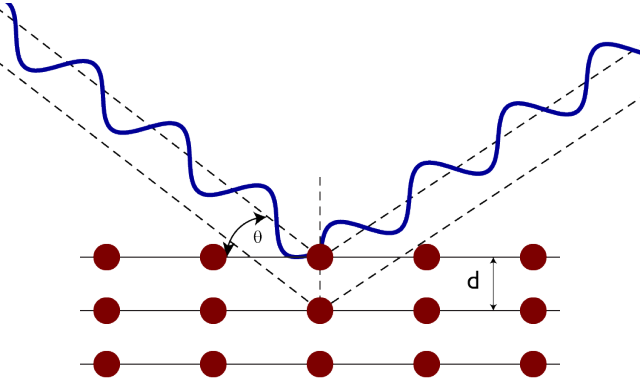
The US scientific community would produce more high quality science if it had *more good neutron scattering instruments*.

NCNR

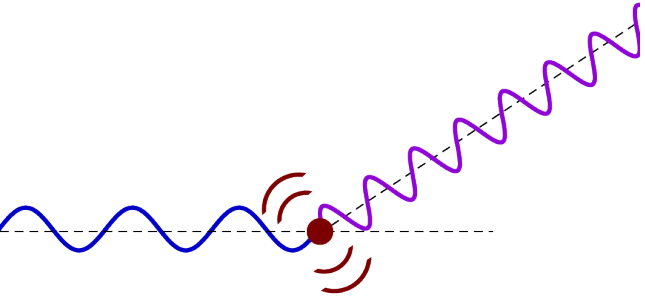
A Facility for Science

NEUTRONS – AN IDEAL PROBE PARTICLE FOR SEEING DIFFERENTLY

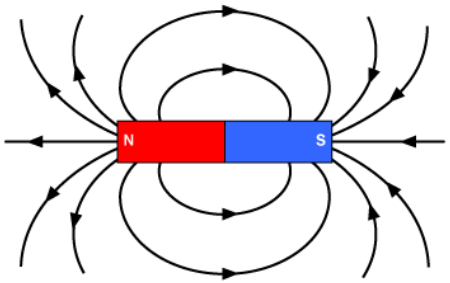
λ ~ interatomic spacing



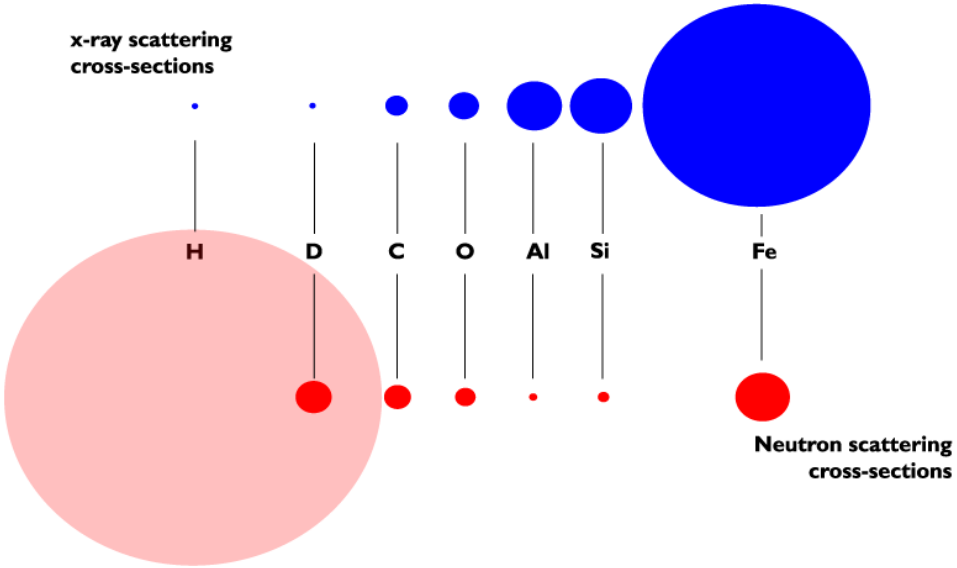
E ~ atomic motion



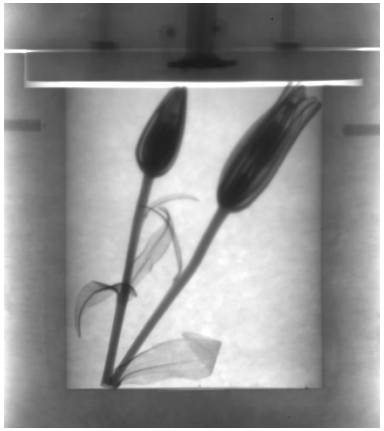
Magnetic



Scattering power varies randomly across the periodic table and from isotope to isotope

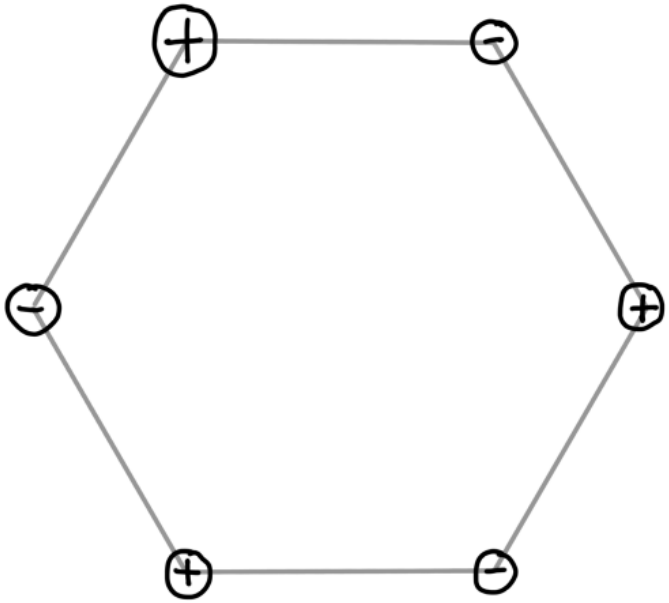


Penetrating

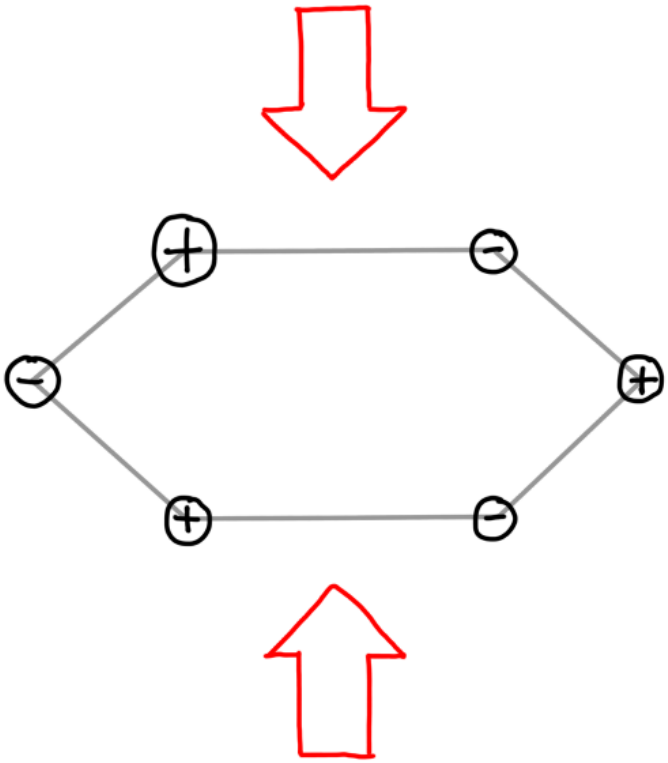


Piezoelectrics

mechanical energy ↔ electrical energy



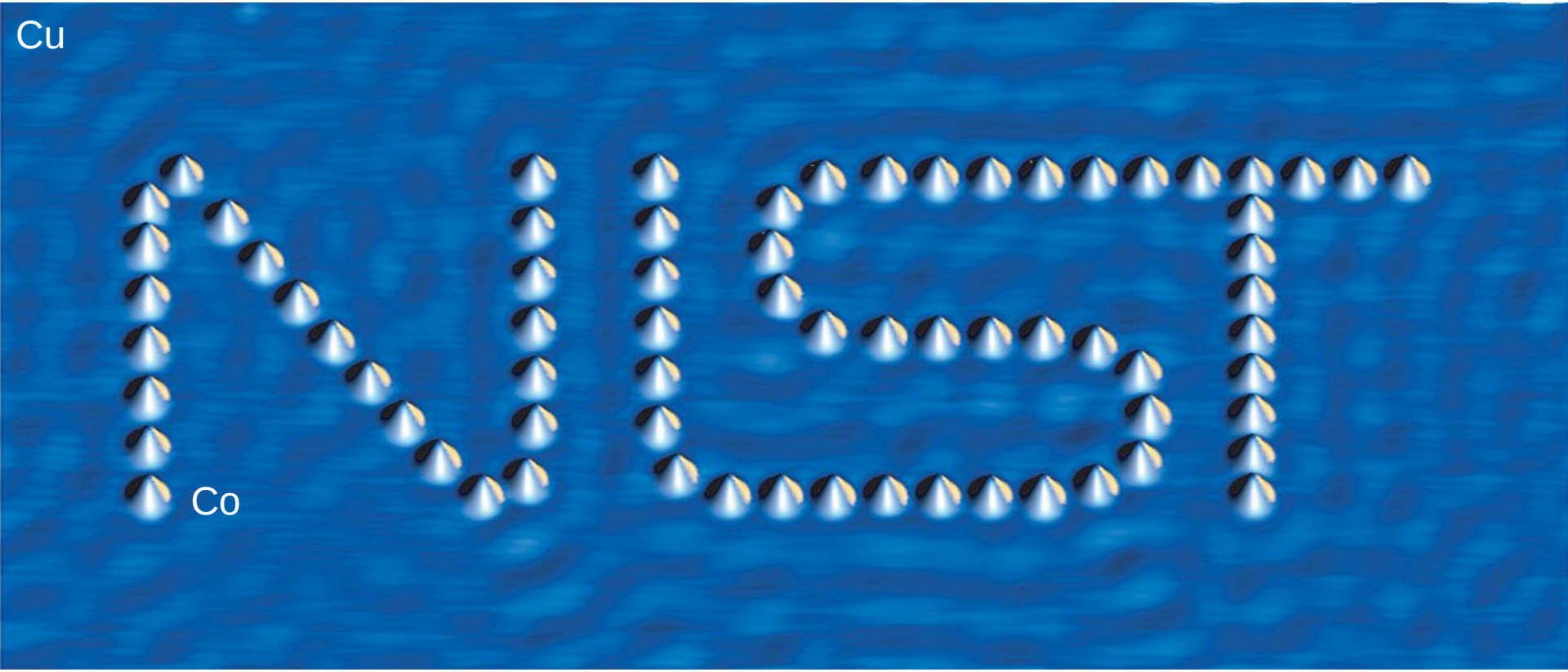
RELAXED
EQUILIBRIUM



COMPRESSED

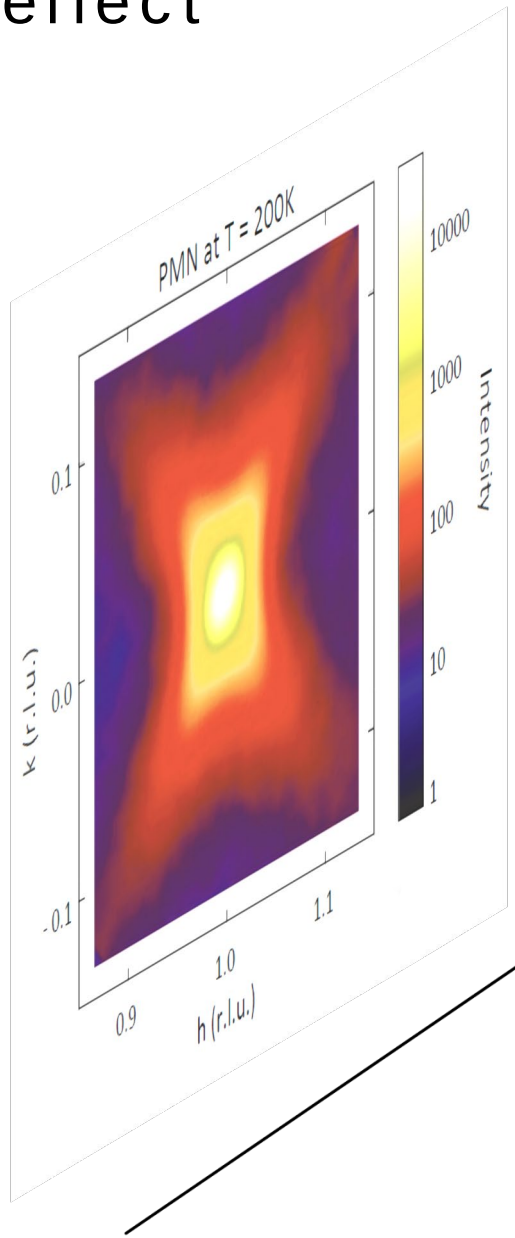
CHARGE SEPARATION

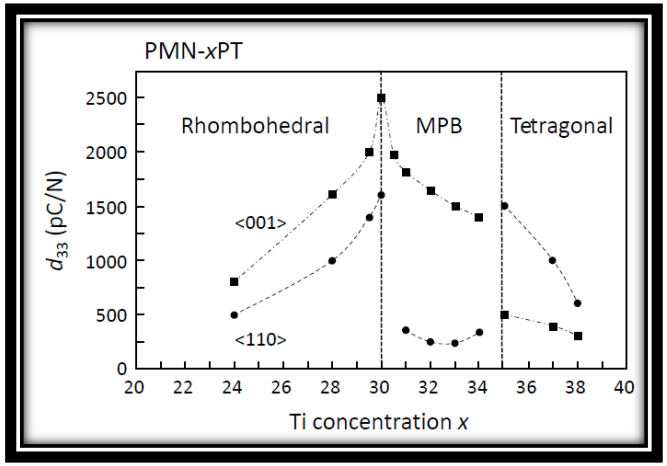
Piezoelectrics

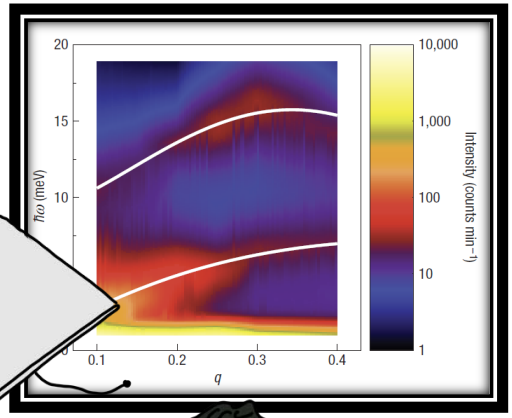


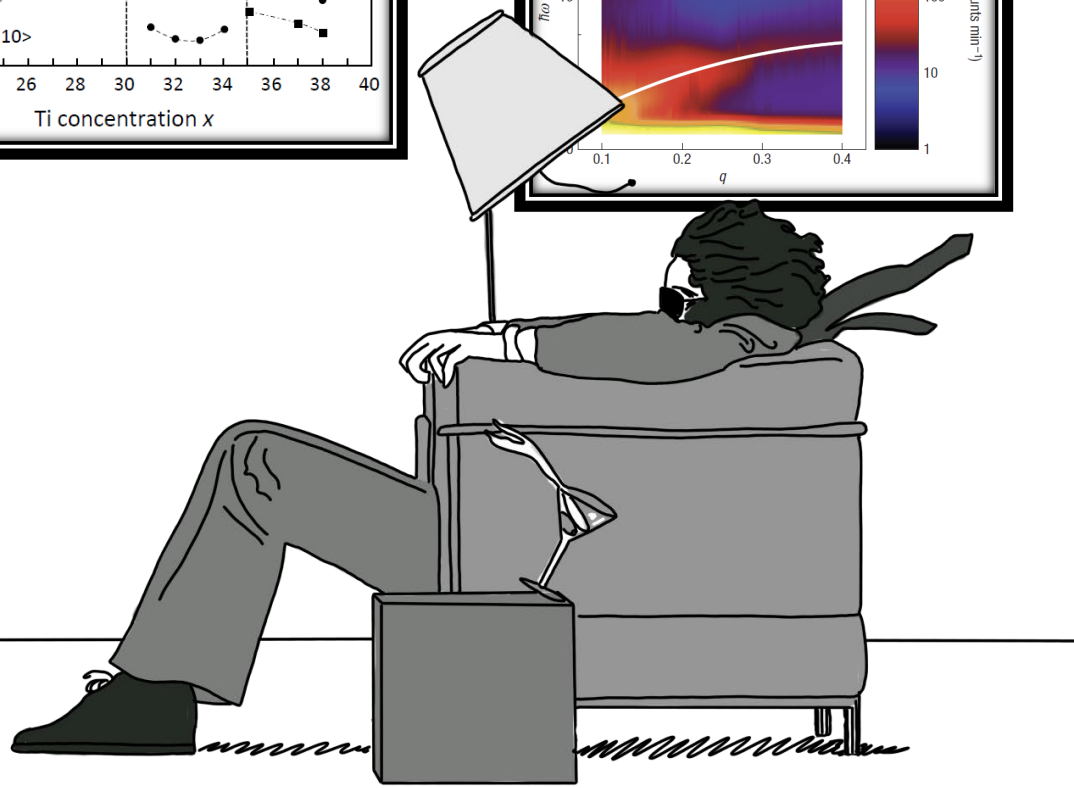
Credit: J. Stroscio, R. Celotta/NIST

Relaxor ferroelectric has *record-setting* piezoelectric effect





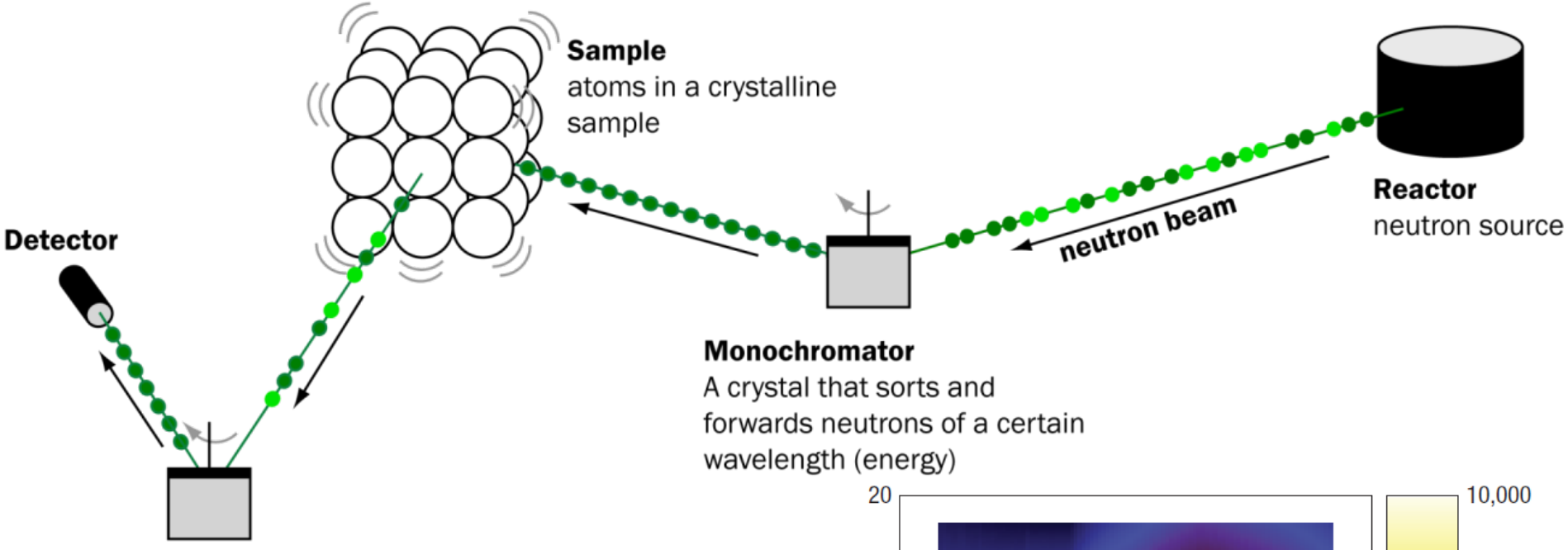


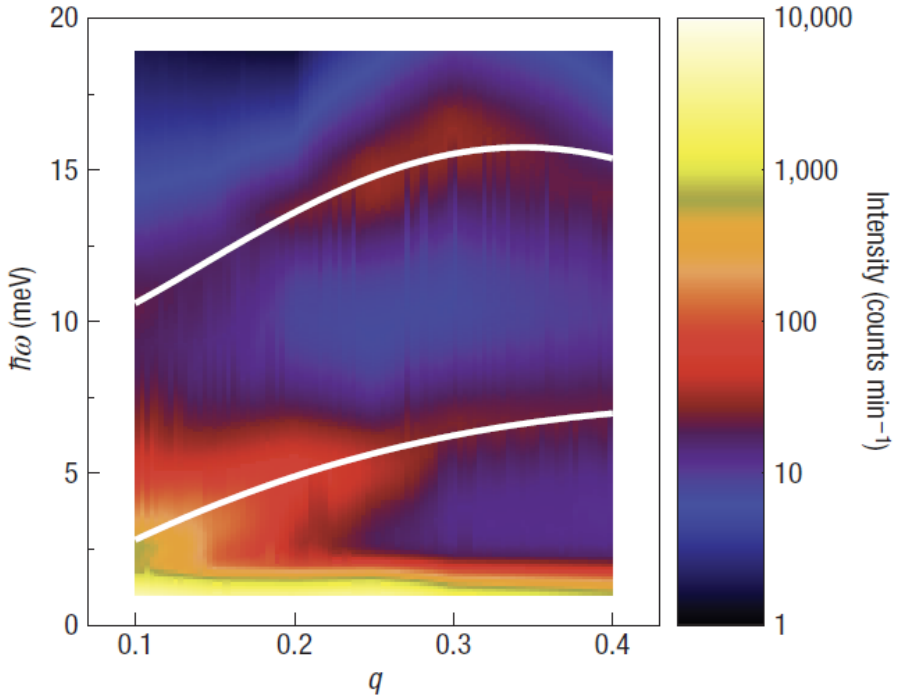


Xu *et. al.* Nature Mat. 7, 562 (2008)
P.M.Gehring, J. Adv. Dielectrics 2(2), 1241005 (2012)

Piezoelectrics

PZN-4.5%PT



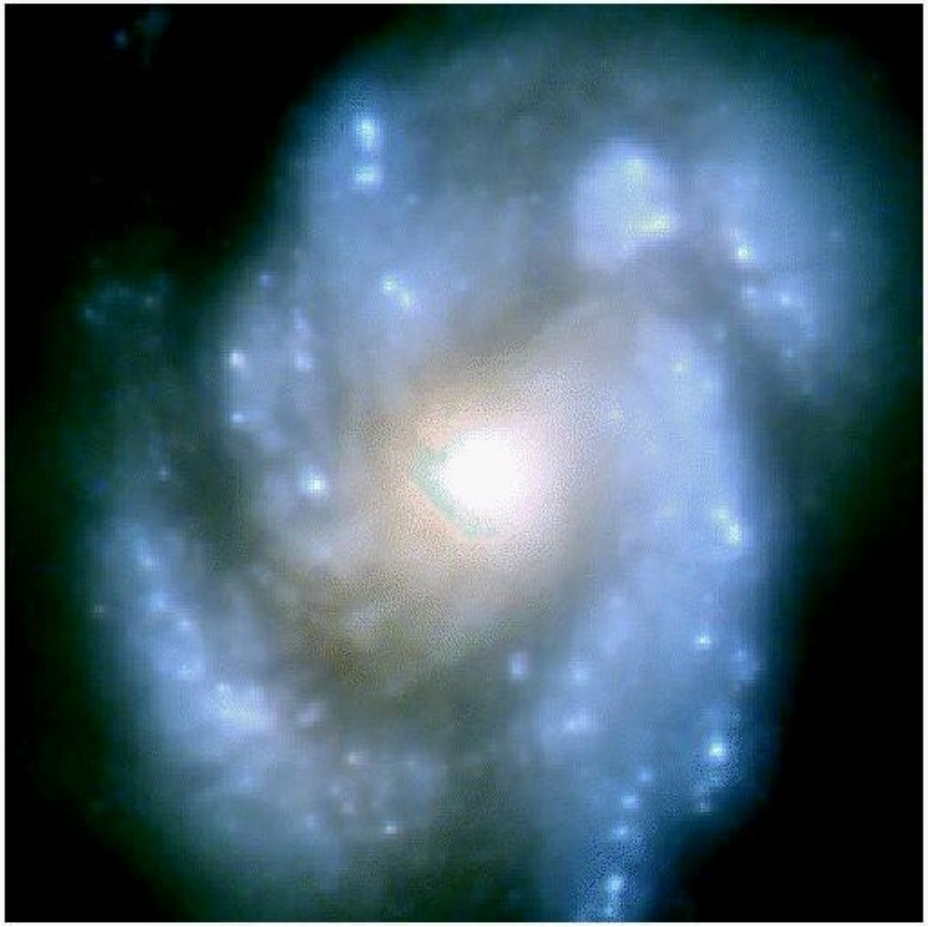


Xu *et. al.* Nature Mat. 7, 562 (2008)

M100 Galactic Nucleus

Hubble Space Telescope

before corrective optics



Wide Field Planetary Camera 1

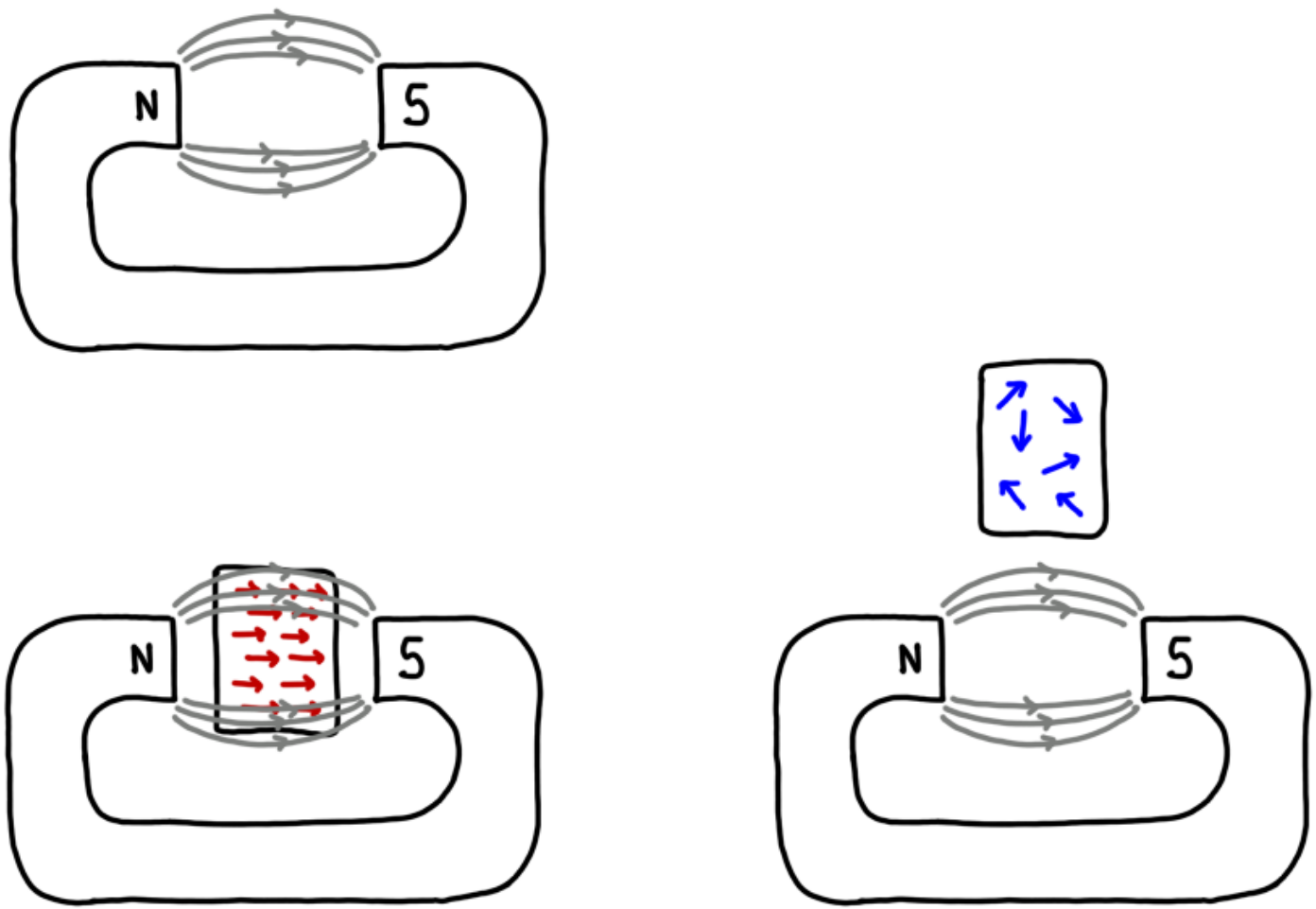
after corrective optics

Wide Field Planetary Camera 2

http://hubblesite.org/newscenter/archive/releases/1994/01/image/a/

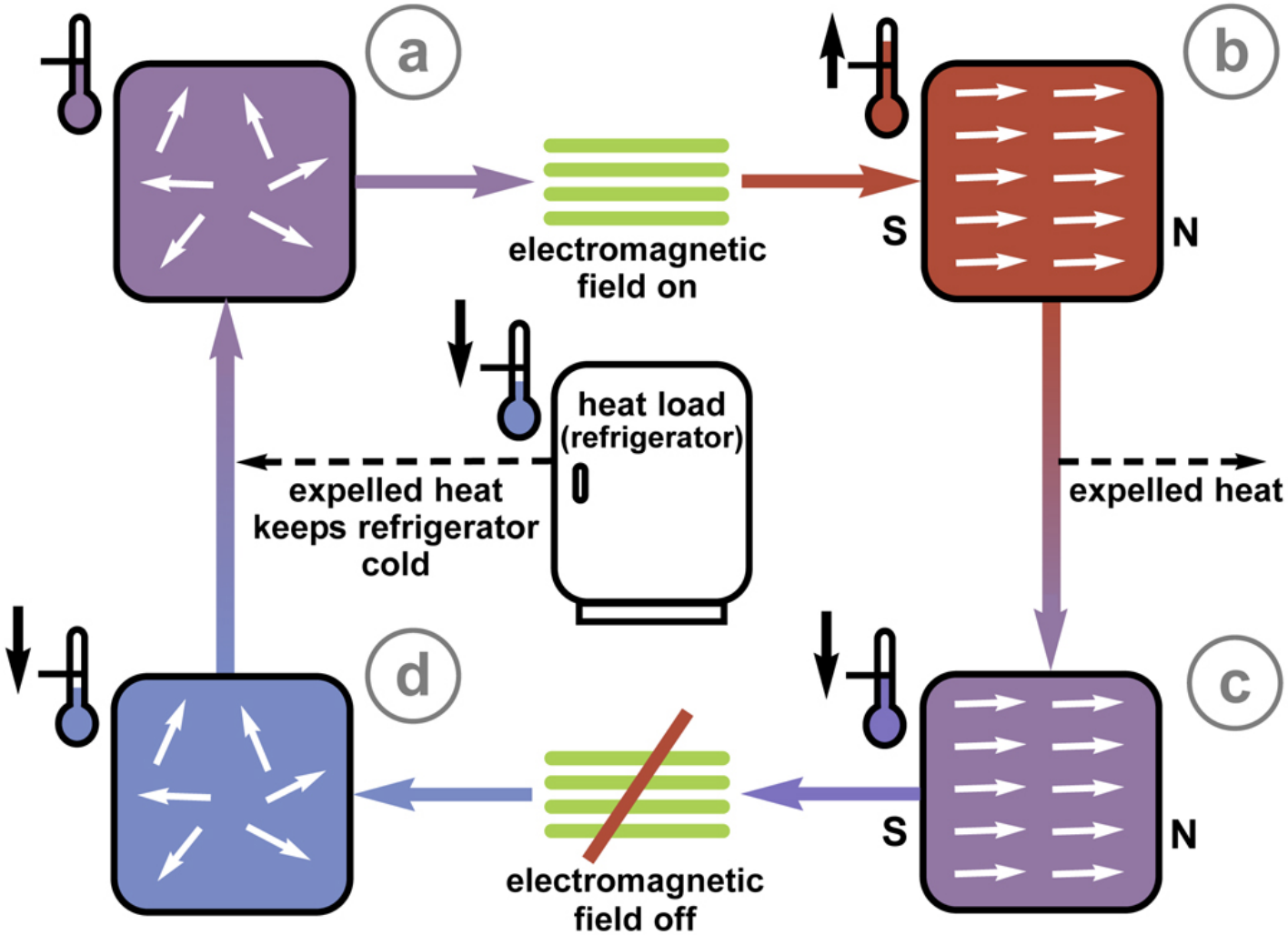
Magnetocalorics

magnetic energy ↔ thermal energy



Magnetocalorics

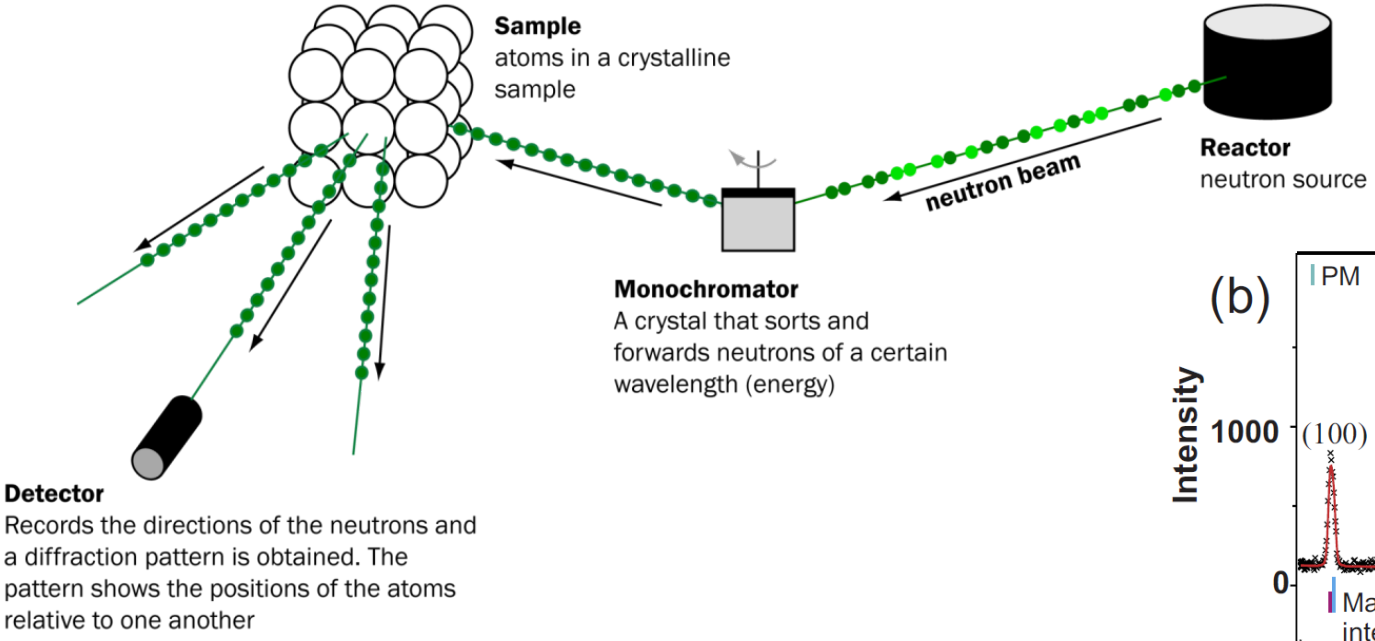
magnetic energy ↔ thermal energy

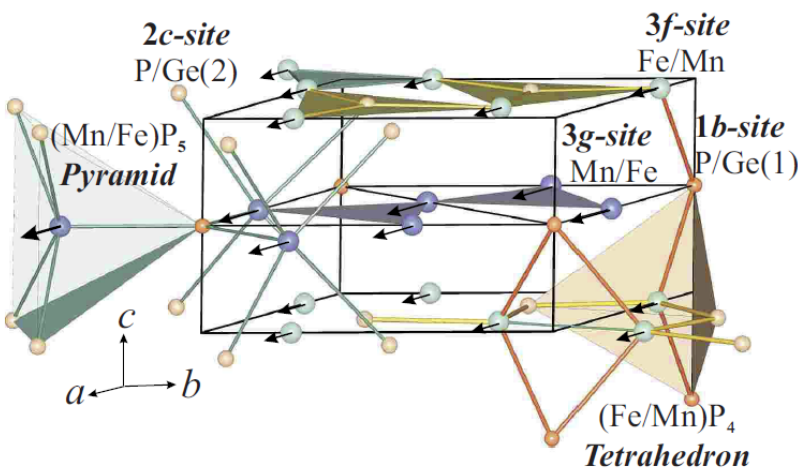


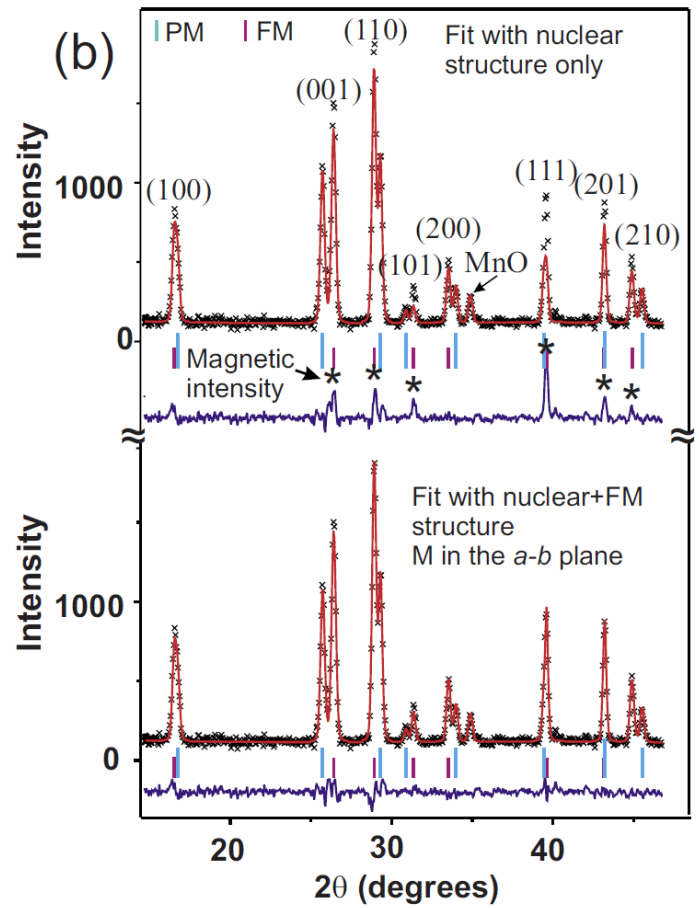
Credit: Talbott, NIST

Magnetocalorics

When the neutrons collide with the atoms they change direction - they are scattered elastically.







D.Liu et. al., Phys. Rev. B 79, 014435 (2009)

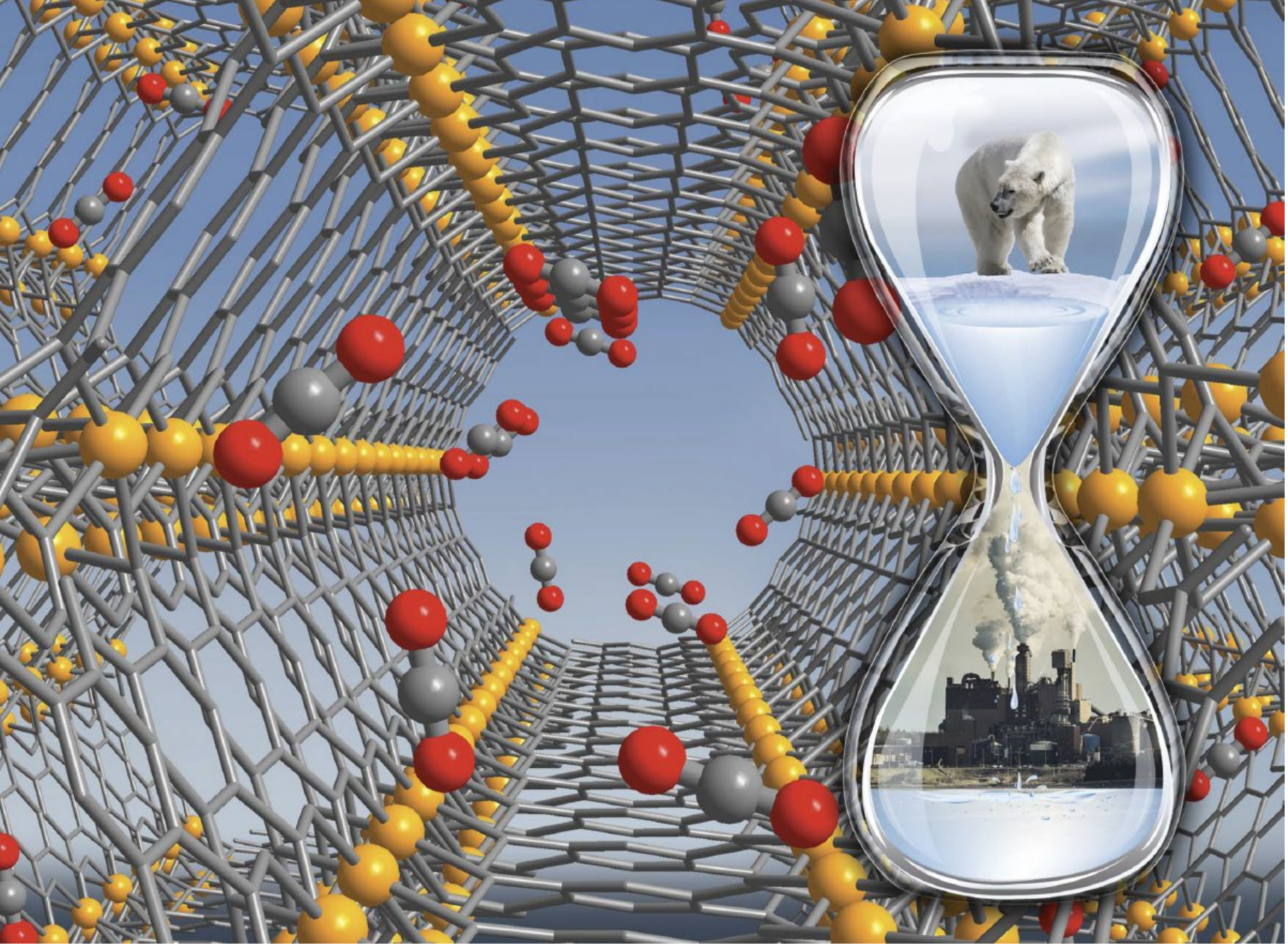
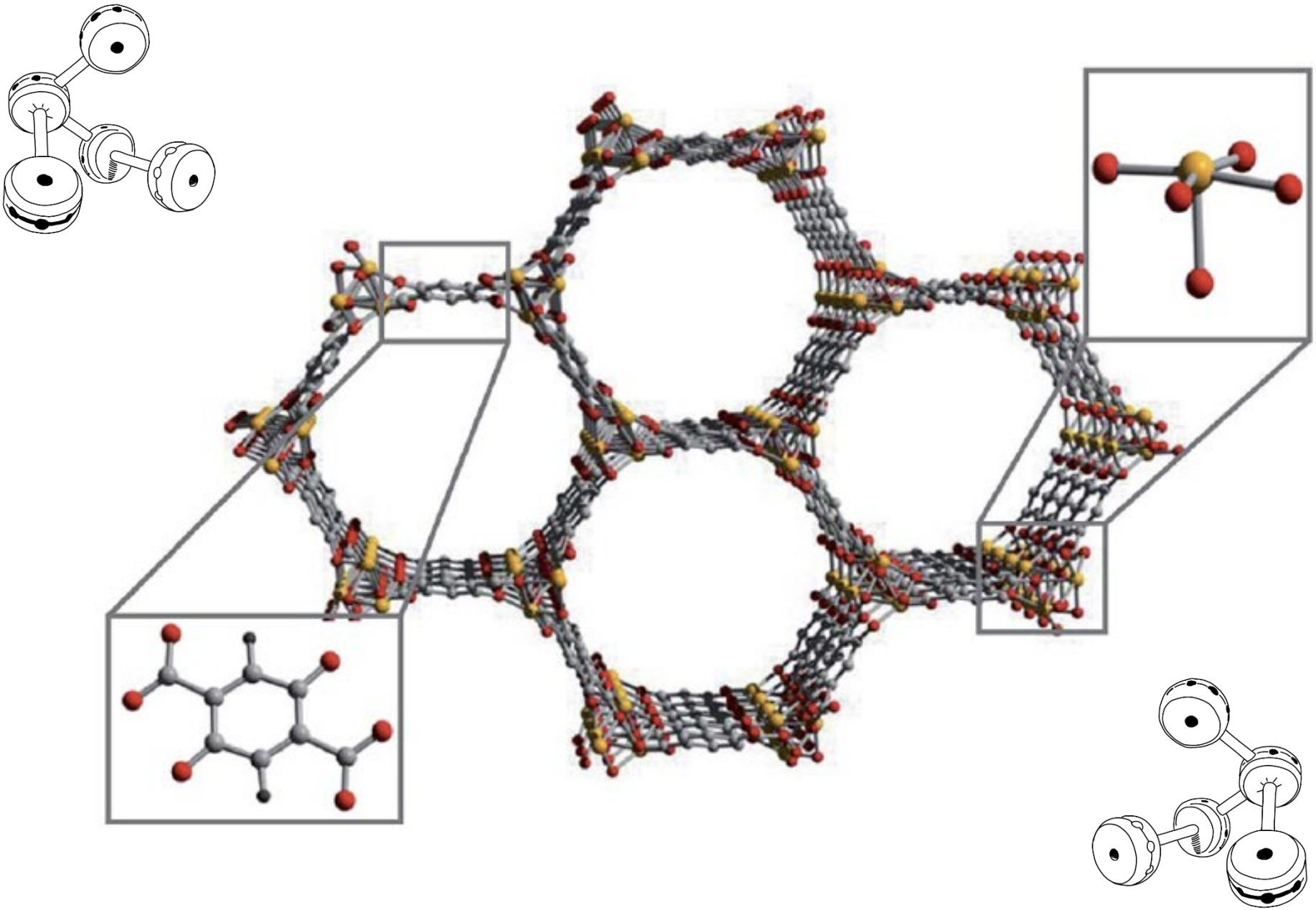


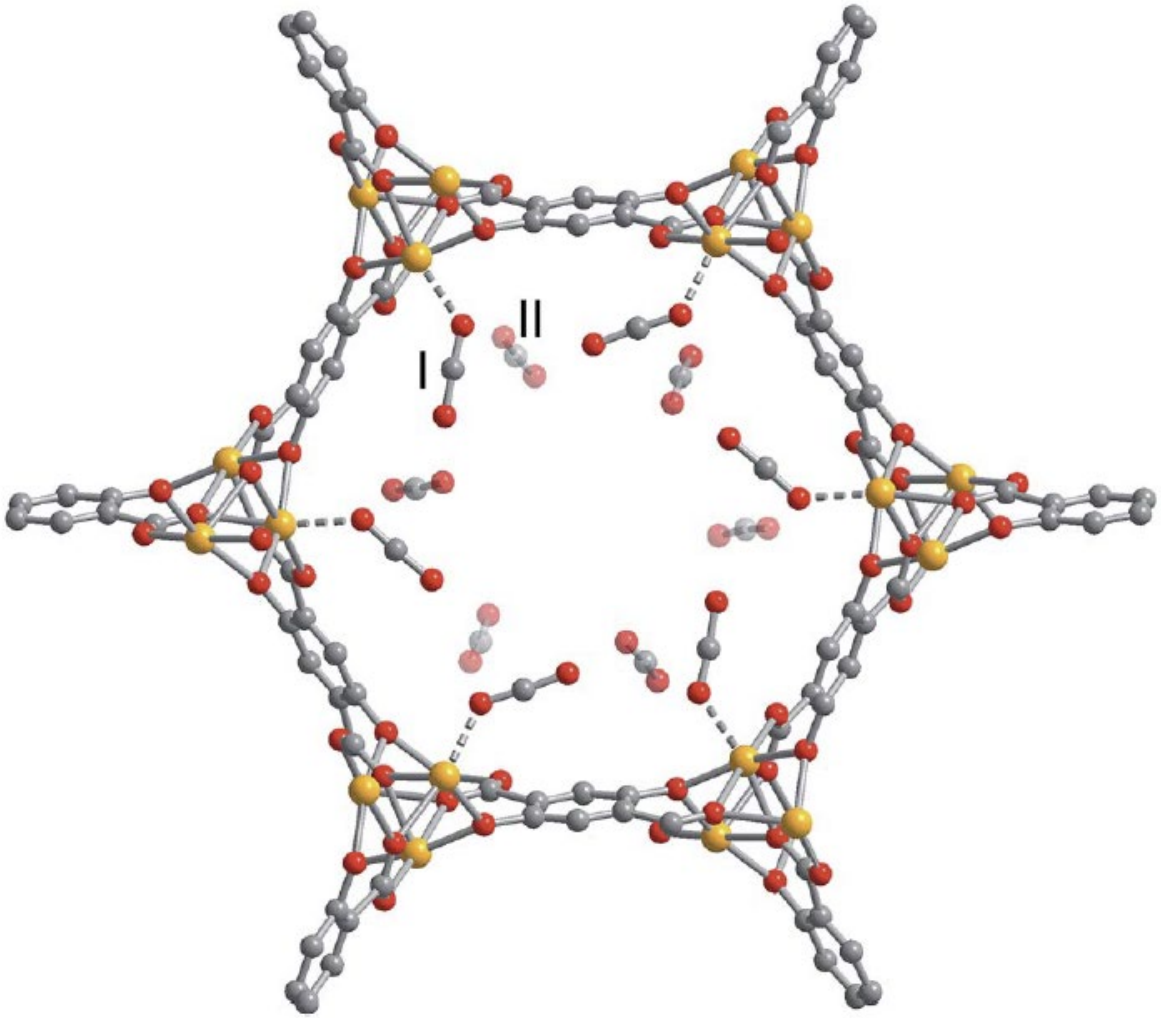
Image reproduced by permission of Craig Brown and The Royal Society of Chemistry from *Chem. Sci.*, 2014, **5**, 4569, DOI: 10.1039/C4SC02064B.

Metal-Organic Frameworks



W.L.Queen et. al., Chem. Sci. 5, 4569 (2014).

Metal-Organic Frameworks



W.L.Queen et. al., Chem. Sci. 5, 4569 (2014).

NON-NEWTONIAN FLUIDS

Credit: Mike Mozart (https://flic.kr/p/rTb4z6)

NON-NEWTONIAN FLUIDS

Credit: Aqua Mechanical (https://flic.kr/p/DKqNao)

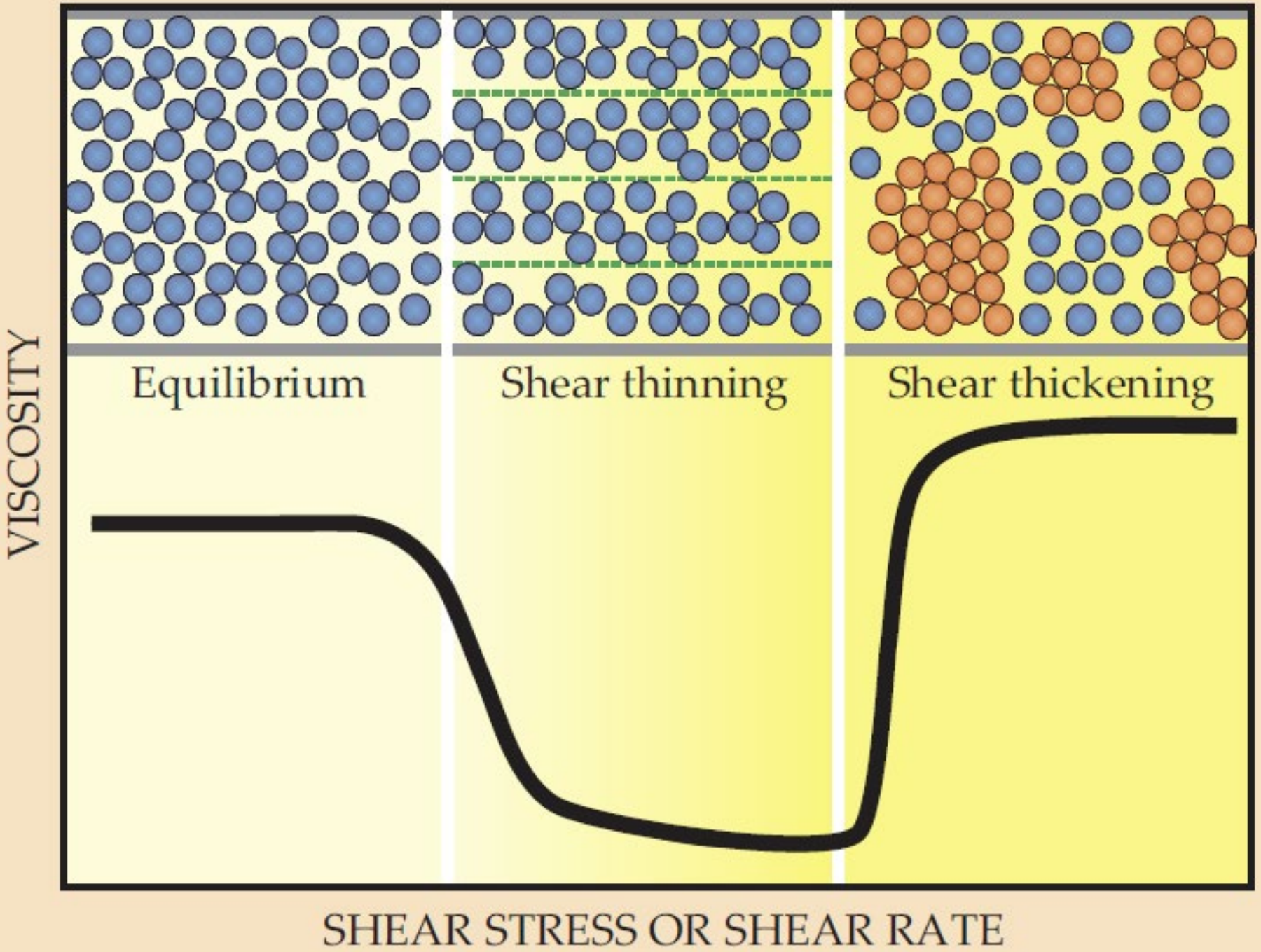
NON-NEWTONIAN FLUIDS

Credit: Benno Hansen (https://flic.kr/p/9HXeiL)

NON-NEWTONIAN FLUIDS

Credit: Sherman Geronimo-Tan (https://flic.kr/p/4WKsPg)

N.J.Wagner and J.F.Brady, Physics Today **62**(10), 27 (2009)



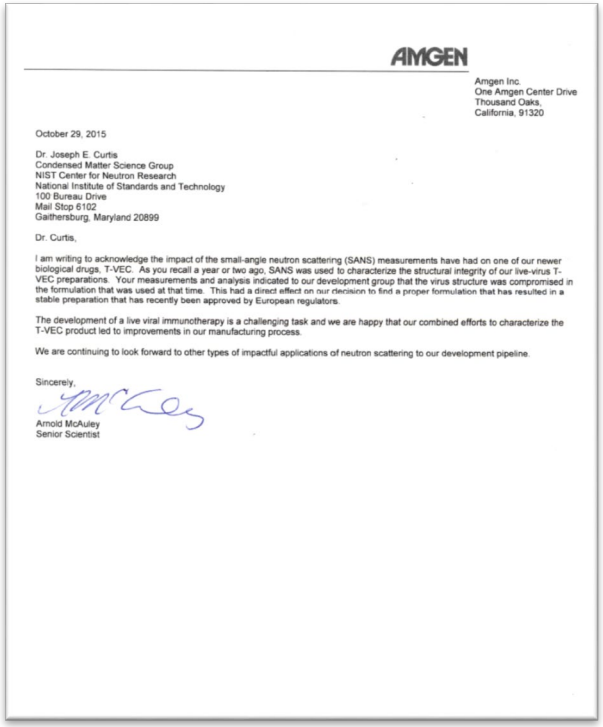
SHEAR THICKENING FLUIDS

SHEAR THICKENING FLUIDS

NEUTRONS HELP AMGEN WITH FORMULATION OF ANTI-CANCER DRUG: T-VEC

IMLYGIC

Injectable formulation of T-VEC for treatment of melanoma



AMGEN

Amgen Inc.
One Amgen Center Drive
Thousand Oaks,
California, 91320

October 29, 2015

Dr. Joseph E. Curtis
Condensed Matter Science Group
NIST Center for Neutron Research
National Institute of Standards and Technology
100 Bureau Drive
Mail Stop 6102
Gaithersburg, Maryland 20899

Dr. Curtis,

I am writing to acknowledge the impact of the small-angle neutron scattering (SANS) measurements have had on one of our newer biological drugs, T-VEC. As you recall a year or two ago, SANS was used to characterize the structural integrity of our live-virus T-VEC preparations. Your measurements and analysis indicated to our development group that the virus structure was compromised in the formulation that was used at that time. This had a direct effect on our decision to find a proper formulation that has resulted in a stable preparation that has recently been approved by European regulators.

The development of a live viral immunotherapy is a challenging task and we are happy that our combined efforts to characterize the T-VEC product led to improvements in our manufacturing process.

We are continuing to look forward to other types of impactful applications of neutron scattering to our development pipeline.

Sincerely,

Arnold McAuley
Senior Scientist

"Your (SANS) measurements and analysis indicated to our development group that the virus structure was compromised in the formulation that was used at that time. This had a direct effect on our decision to find a proper formulation that has resulted in a stable preparation that has recently been approved by European regulators."

Arnold McAuley
Amgen Senior Scientist

Approved by FDA in October 2015

All photos used for the slides describing non-Newtonian fluids and metal-organic frameworks are licensed under the Creative Commons License.

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Shear thickening schematic reproduced with permission from N.J. Wagner and J.F. Brady, Physics Today **62**(10), 27. Copyright 2009, American Institute of Physics.