SISTEMA
INTERAMERICANO
DE METROLOGIA

SIM Metrology School

28 October – 1 November 2013

Welcome !!!

- *to the Washington DC Area*
- *to the National Institute of Standards and Technology*
- *to the 2nd SIM Metrology School*

SIM Metrology School

PROGRAM

TIMETABLE	10/28/2013	10/29/2013	10/30/2013	10/31/2013	11/01/2013
8:30AM – 9:00 AM	Intro/Welcome Willie May, NIST	Mass/Density Force/Torque Francisco Garcia CESMEC	Statistics and Uncertainty Antonio Possolo NIST	Electrical Dave Inglis NRC	Legal Metrology Carol Hockert NIST
9:00AM - 9:30AM	International Metrology Jim Olthoff NIST				
9:30AM – 9:45AM			Metrology Challenges of Climate Science James Whetstone NIST	Pressure Doug Olson NIST	Chemistry David Duewer Katrice Lippa NIST
9:45AM - 10:00AM	BREAK				
10:00AM - 10:30AM	Temperature Edgar Mendez CENAM				
10:30AM – 11:00AM		BREAK	BREAK	BREAK	BREAK
11:00AM – 11:30AM	Volume/Flow Roberto Arias CENAM	Dimensional Ted Doiron NIST	Time and Frequency Raul Solis CENAMEP	Photometry Yoshi Ohno NIST	Bio-metrology Marc Salit NIST
11:30AM – 12:00PM					
12:00PM - 1:00PM	LUNCH				
1:00PM – 1:30PM	T T V V	D D M M	Site Visit	E E Ph P	Quality Gabriela de la Guardia CENAMEP
1:30PM – 2:00PM					
2:00PM – 2:30PM				P Ph	Bio/Chem Tours MML, NIST
2:30PM – 3:00PM					
3:00PM – 3:30PM	BREAK	BREAK		BREAK	
3:30PM – 4:00PM	V V T T	M M D D		P Ph E E	Final Exam
4:00PM – 4:30PM					BREAK
4:30PM – 5:00PM				Ph P	Graduation
5:00PM - 5:30PM					

NIST is part of the Department of COMMERCE

Penny Pritzker
Secretary of Commerce

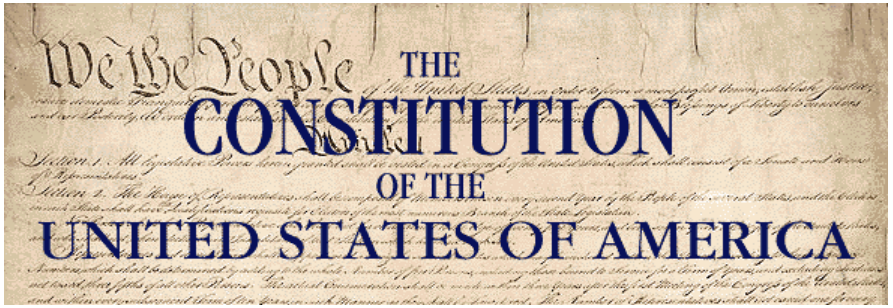
- National Oceanic and Atmospheric Administration **(National Weather Service)**
- International Trade Administration
- Patent and Trademark Office
- **National Institute of Standards & Technology**
- Economics and Statistics Administration
- Other Agencies…. **(Census Bureau)**

Pat Gallagher
NIST Director,
Under Secretary of Commerce for Standards and Technology, and
Acting Deputy Secretary of Commerce

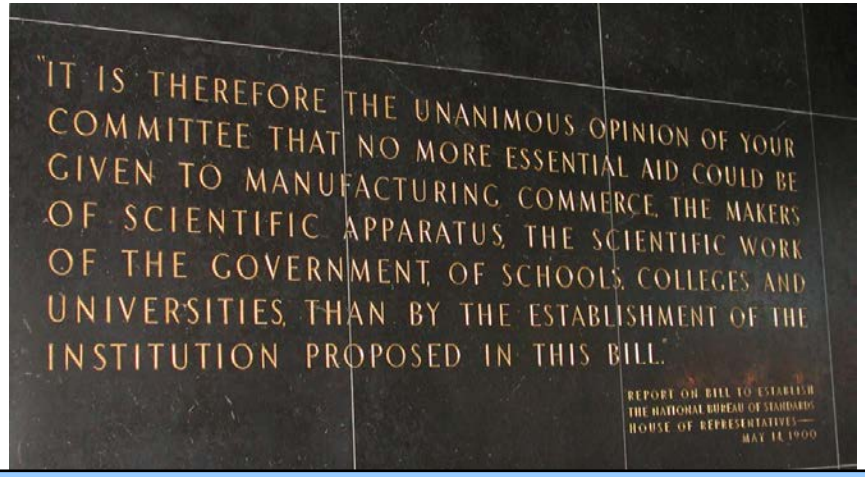
National Institute of Standards and Technology (NIST)

- Non-regulatory agency within U.S. Department of Commerce

- Founded in 1901 as National Bureau of Standards



Article I, Section 8: The Congress shall have the power to …*coin money, regulate the value thereof, and of foreign coin, and fix the standard of weights and measures*



***Unique Mission within the Federal Government* …**

to promote U.S. innovation and industrial competitiveness by advancing

measurement science, standards, and technology

in ways that enhance economic security and improve our quality of life

NIST (NBS) established in 1901

"It is therefore the unanimous opinion of your committee that no more essential aid could be given to

- manufacturing
- commerce
- the makers of scientific apparatus
- the scientific work of Government
- schools, colleges, and universities

than by the establishment of the institution proposed in this bill."

THE EVENING STAR, MONDAY, MARCH 11, 1901

CORRECT MEASURES

Function of the New Bureau of Standards.

LABORATORY TO BE ERECTED

Prof. Stratton, the Director, Details Need of Establishment.

A HANDICAP REMOVED

A new bureau of the government, authorized by the last Congress, will be established in this city in the near future and will give employment to a number of persons. It is to be known as the national bureau of standards and is to be under the control of the Treasury Department. A separate building for a laboratory, to cost not to exceed $250,000, is to be erected on a site to be purchased at a cost of $25,000.

Mr. Samuel W. Stratton of Chicago has been appointed by the President to be chief of the bureau at an annual salary of $5,000. Prof. Stratton is to have the following as-

Director Stratton.

sistants, to be appointed by the Secretary of the Treasury: One physicist, at an annual salary of $3,500; one chemist, at [illegible] two assistant physicists or chemists, at an annual salary of $2,200; one [illegible] assistant, at $1,800; one laboratory [illegible] at $1,200; one secretary, at $2,000; one [illegible] at $1,200; one messenger, at $720.

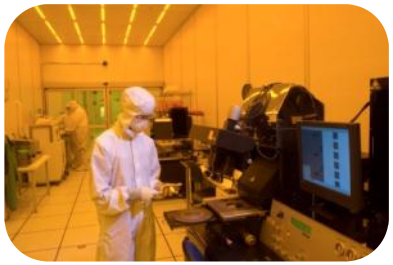
House Committee on Coinage, Weights and Measures … on the establishment of the National Bureau of Standards (now NIST)
May 3, 1900

Organic Act of 1901; Updated in 2008

Functions and activities of the Institute include:

- custody and dissemination of national standards.
- determination of physical constants and the properties of materials,
- comparison of US national standards with those of other nations
- solutions to measurement and standards problems of other government agencies
- providing (Innovation) assistance to industry

NIST Programs



© R. Rathe

NIST Laboratories

- Provide measurement and standards solutions for industry and the nation

Maksim Dubinsky/shutterstock.com

Hollings Manufacturing Extension Partnership

- Nationwide network helps smaller manufacturers compete globally

National Advanced Manufacturing Program Office

- Enhances technology transfer in U.S. manufacturing industries and helps companies overcome technical obstacles to scaling up production of new technologies

Poudre

Baldrige Performance Excellence Program

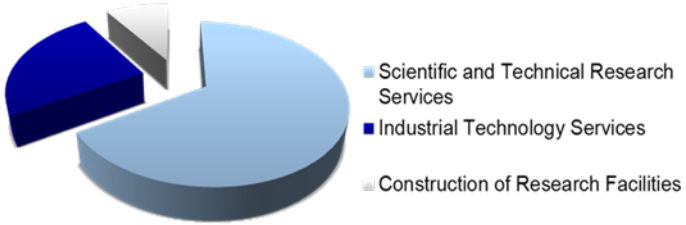
- Strengthens performance excellence in U.S. organizations

NIST-at-a-Glance

Major Assets

- **~ 3,000 Employees**; 1800 Scientists and Engineers
- **~ 2,800 Associates** and Facilities Users
- ~ 400 NIST Staff on ~1,000 national and international standards committees

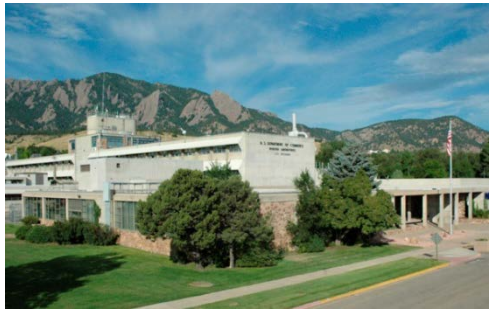
NIST FY 2013 Congressional Appropriations
$763M



Plus
~ **$120 M** from other Government Agencies
~ **$50 M** for other reimbursable services

NIST has two main campuses……

Gaithersburg, MD
62 buildings; 578 acres



Boulder, CO
26 buildings; 208 acres

+ two sites housing NIST radio stations:

- Ft. Collins; 390 acres
- Kauai; US Navy 30 acre site

and five joint institutes

- JILA – *AMO physics*
- JQI – *quantum science*
- IBBR – *biotech*
- HML – *marine science*
- NCCoE – *cybersecurity*

NIST: A Premier Scientific Institution

A world-leading measurement science and standards program

Debbie Jin
2003 MacArthur Genius Grant
2013 L'Oreal/UNESCO "For Women in Science" award

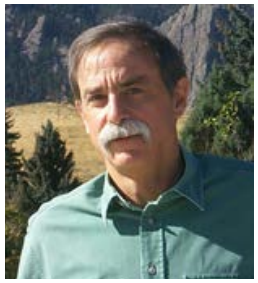
- **Work resulting in 4 + 1 Nobel Prizes since 1997**
- **Kyoto Prize winner in 2011**
- **MacArthur Fellowship winner in 2003**
- **National Medal of Science winners in 1998 and 2007**
- **~ 10 National Academy Members**
- **~120 National Society Fellows**
- **~60 National/International Awards/yr**

Dan Shechtman
2011 Nobel Prize
in Chemistry based on work while Visiting Scientist at NIST

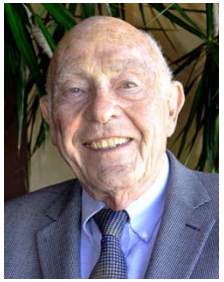
Bill Phillips
1997 Nobel Prize
in Physics

Eric Cornell
2001 Nobel Prize
in Physics

John Hall
2005 Nobel Prize
in Physics



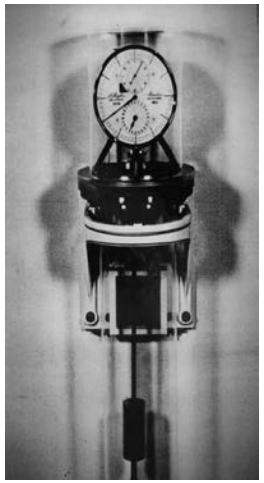
David Wineland
2007 National Medal of Science
2010 Nobel Prize



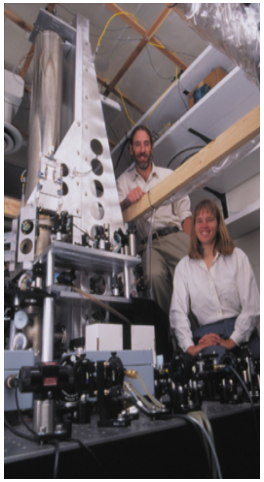
John Cahn
1997 National Medal of Science
2011 Kyoto Prize in Materials Science

NIST is still focused on the Realization of the SI

pendulum clock
1 s in 3 years
(1904)

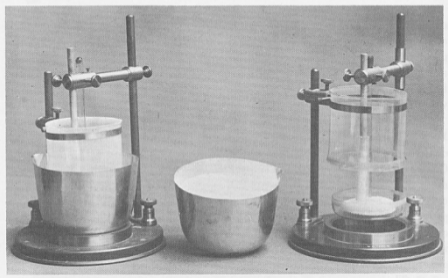


second

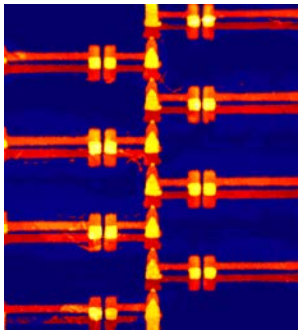


NIST F1
atomic clock
1 s in 30 million
years
(1999)

silver voltameter
current standard
(1910)

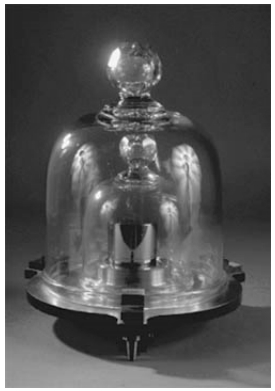


ampere



single
electron
counter
(20xx)

physical artifact
(1889)

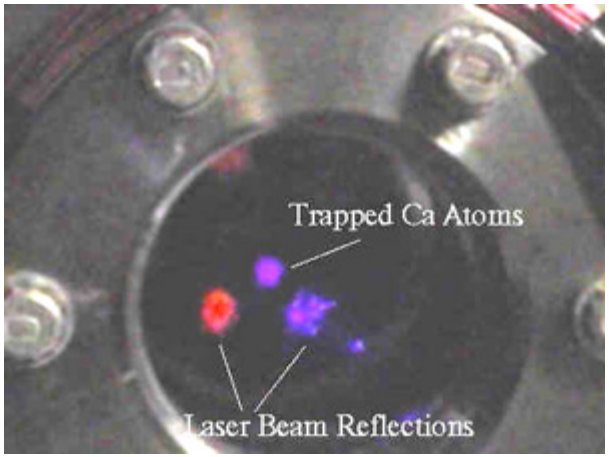


kilogram

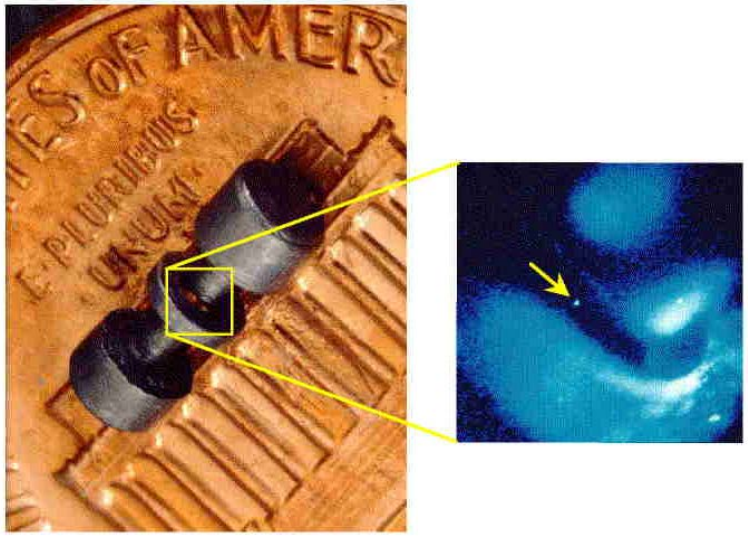
electronic
kilogram
(20xx)

Research to Develop Future Clocks

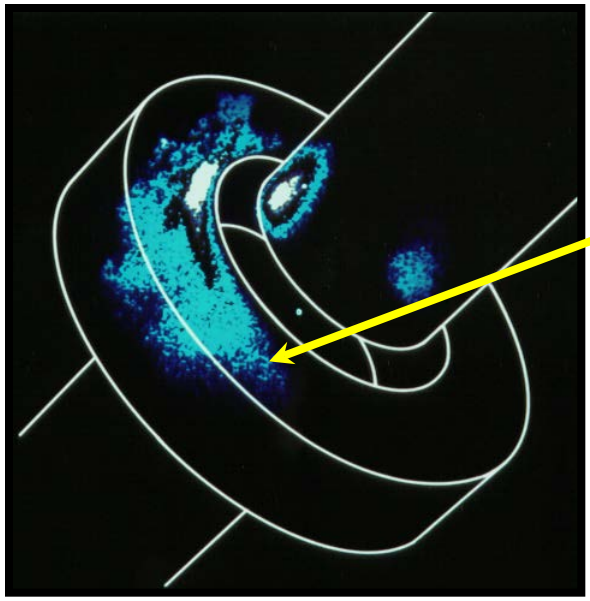
Optical clocks have the potential for accuracy about 1,000 times better than the cesium fountain (atomic) clock that currently serves as the US primary time and frequency standard (10^{-18}, 1 second in 30 billion years).



Laser-cooled calcium trap



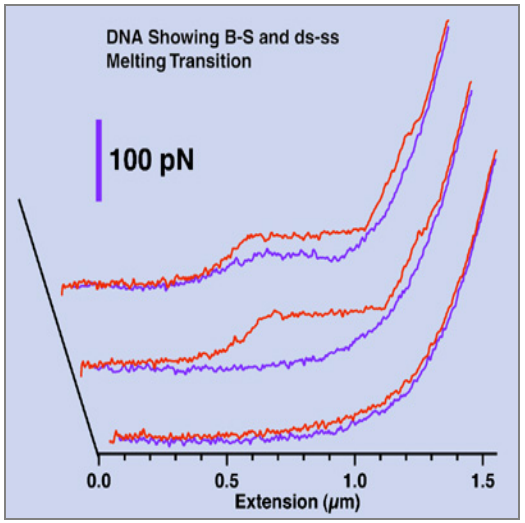
Single mercury ion trap



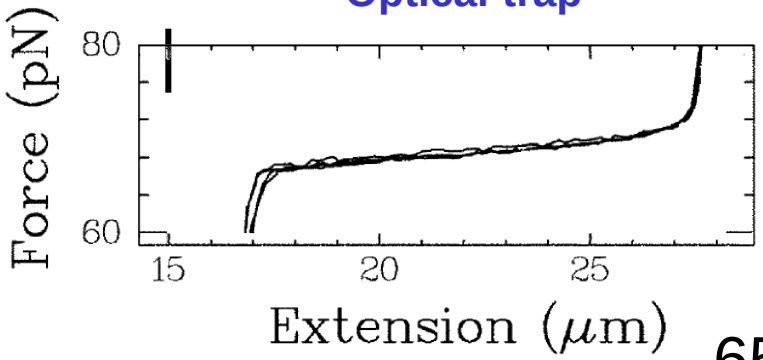
Single Ion

DNA as an Intrinsic Force Standard

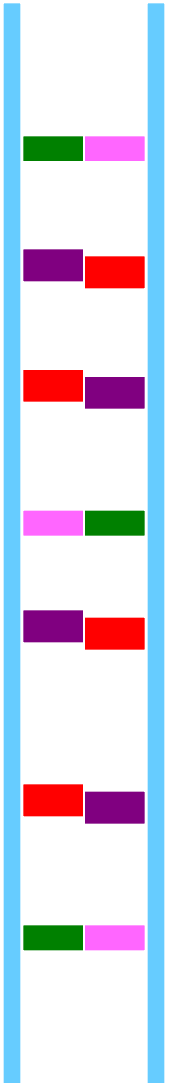
AFM



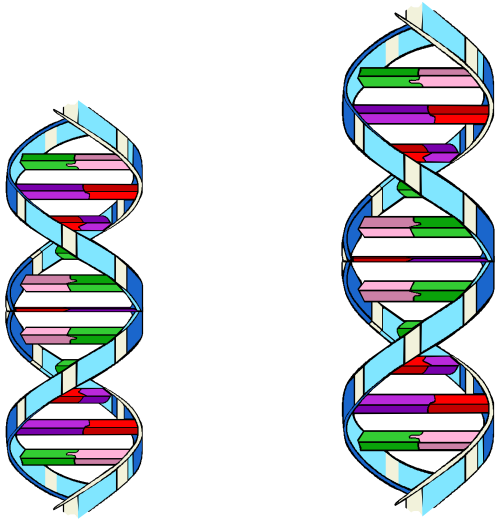
Optical trap



65 pN



- DNA can be manufactured to atomic precision anywhere in the world.
- The force required to induce DNA transition is used as a biophysics “standard” – but firm metrological basis does not exist
- NIST is working to measure the DNA transition force with traceable metrology using approaches based on both optical and AFM techniques.



Redefinition of the kilogram

Currently:

"The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram."

3rd CGPM, 1901

However:

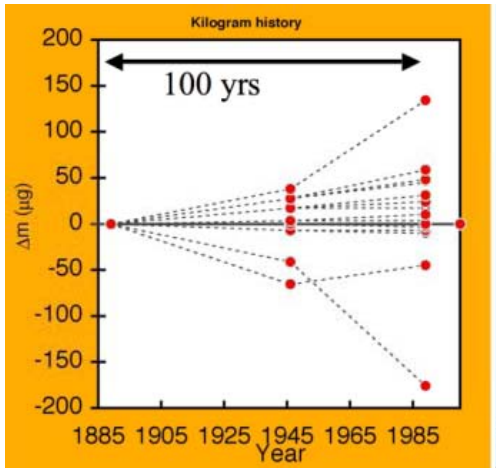
New York Times

(27 May 2003)

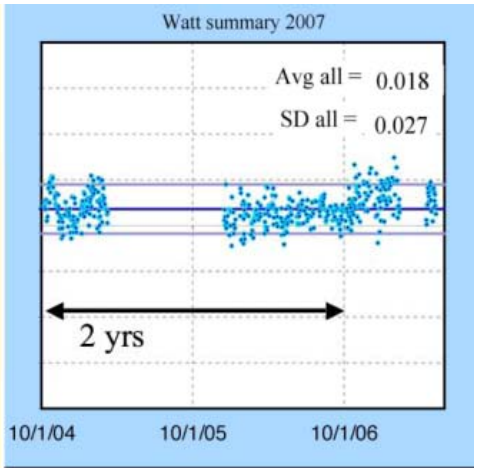
Scientists Struggling to Make the Kilogram Right Again

...The kilogram is getting lighter, scientists say, sowing potential confusion over a range of scientific endeavor...

Scatter in IPK copies

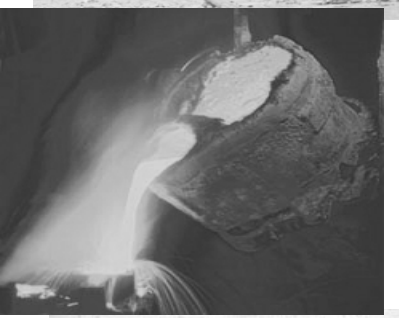


Current e-Kg scatter



Same vertical scale!

Since our inception, in addition to maintaining the more traditional National physical standards, **we have also focused a significant portion of our research and measurement services activities on addressing contemporary societal needs.**



1901 → **2013**

U.S. Innovation Agenda – NIST has an increasing role

Advanced Manufacturing

- NIST Labs
  - Precision Measurements
  - Bio and Nanomanufacturing
  - Additive Manufacturing
  - Advanced Materials
- National Advanced Manufacturing Program Office
  - AMTech
  - NNMI
- Manufacturing Extension Partnership
  - MTAC

Cybersecurity

- Executive Order – Framework for Critical Infrastructure
- National Cybersecurity Center of Excellence

Advanced Communications

Forensic Science

Healthcare

NIST Laboratory Program

providing measurement solutions for industry and the nation

Standards Coordination Office
Standards Services Division
NIST Quality Manager

Associate Director for Laboratory Programs

Special Programs Office
Law Enforcement Standards, *National Security Standards,* Climate Assessment & Advanced Communications Programs

- Material Measurement Laboratory
- Physical Measurement Laboratory
- Engineering Laboratory
- Information Technology Laboratory
- Communication Technology Laboratory
- Center for Nanoscale Science and Technology
- NIST Center for Neutron Research

Metrology Laboratories	Technology Laboratories	National User Facilities
Driving innovation through Measurement Science and Standards	Accelerating the adoption and deployment of advanced technology solutions	Providing world class, unique, cutting-edge research facilities

NIST Lab Resources for FY13

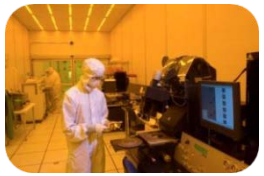
- ~ $580 million from Direct Appropriations
- ~ $120 million from Other Federal and State Agencies
- ~ $50 million for other reimbursable services

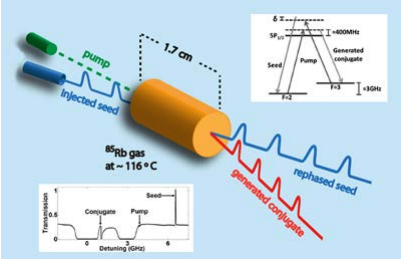
NIST Metrology Laboratories

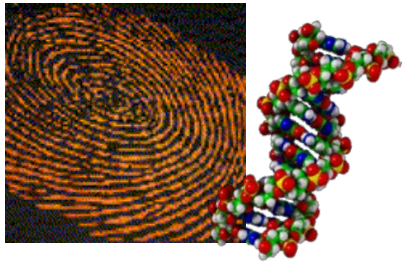
Responsible for advancing the state-of-the-art for measurement science and the dissemination of this metrology into industry, other government agencies, and academia.

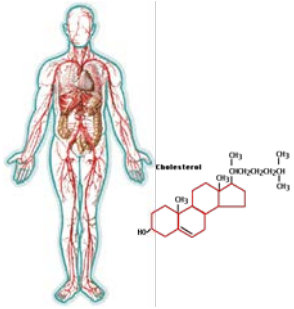
- **The Material Measurement Laboratory** (MML**) serves as the national reference laboratory for measurements in the chemical, biological, and material sciences** through activities ranging from fundamental and applied research, to the development and dissemination of certified reference materials, critically evaluated data, and other programs/tools to assure the quality of measurement results.

- **The Physical Measurement Laboratory** (PML) **develops and disseminates the national standards of length, mass, force and shock, acceleration, time and frequency, electricity, temperature, humidity, pressure and vacuum, liquid and gas flow, and electromagnetic, acoustic, ultrasonic, and ionizing radiation** through activities ranging from fundamental measurement research to provision of measurement services, including calibration services, standards, and data.





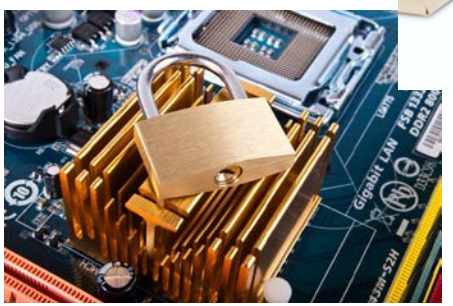




NIST Technology Laboratories

Information Technology Laboratory

- Cybersecurity
- Cloud Computing
- Identity Management
- Computer Forensics
- Wireless Communications
- Health IT

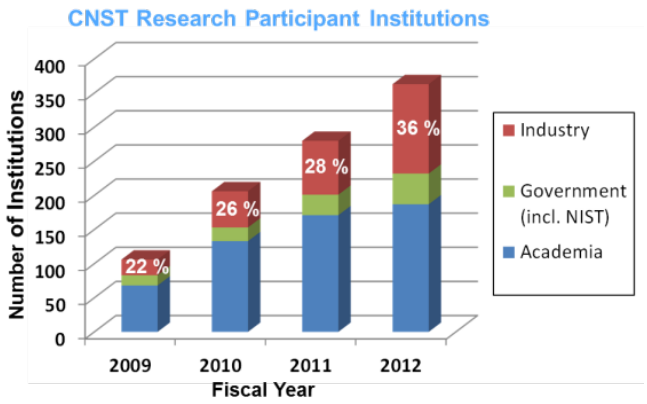


Engineering Laboratory

- Building Technologies
- Fire Research
- Smart Grid & Energy Technology
- Advanced Manufacturing Technology

User Facilities

The **Center for Nanoscale Science and Technology (CNST)** operates a national, shared-use facility for nanoscale fabrication and measurement and develops innovative nanoscale measurement and fabrication capabilities to support researchers from industry, academia, NIST, and other government agencies in nanoscale technology from discovery to production.



The **NIST Center for Neutron Research (NCNR)** operates a national user facility providing neutron-based measurement capabilities to U.S. researchers from industry, academia, NIST, and other government agencies in support of materials research, neutron imaging, chemical and biological analysis, neutron standards, dosimetry, and radiation metrology.

nSoft

A consortium focused on neutron-based measurement science
To support the manufacturing of Soft Materials

Thanks for Your Attention

and come back to visit us

Willie E. May
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National Institute of Standards and Technology
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