Government Jobs for Physicists: Believe It or Not – Challenging and Satisfying!

by
David G. Seiler
Chief, Semiconductor Electronics Division, NIST

Presented at the March American Physical Society Meeting
March 15, 2006

Agenda

- Who Am I?
- Where Do I Work?
- What Do I Do?
- What Is a Physicist?
- Physicists in the Federal Government
- Career Advancement
- How Did I Get Here?
- Reflections from a Government Physicist

Why Should You Listen to Me?

- Worked for the same Federal Agency for the past 18 years and spent 1 year at the National Science Foundation
- Currently holds leadership role (Division Chief) at National Institute of Standards and Technology
- Made a mid-career transition from University work to Government work – unique perspective on both career paths

National Institute of Standards and Technology

"…NIST is the only Federal research agency with the express mission of working with industry to keep US technology at the leading edge…"

- Science for the 21st Century, July 2004

NIST Laboratories are located in Gaithersburg, MD, and Boulder, CO

Assets Include:

- 3,000 employees (**344 physicists!**)
- 1,600 associates
- $930 million FY 2006 operating budget
- NIST Laboratories – National measurement standards
- Manufacturing Extension Partnership
- Baldrige National Quality Award

U.S. Economy Depends on NIST Measurements

Basic Units
Maintained by NIST

- Time • Length • Mass • Temperature
- Electric Current • Light intensity
- Angle • Amount of Substance (mole)

Derived Units
Maintained by NIST

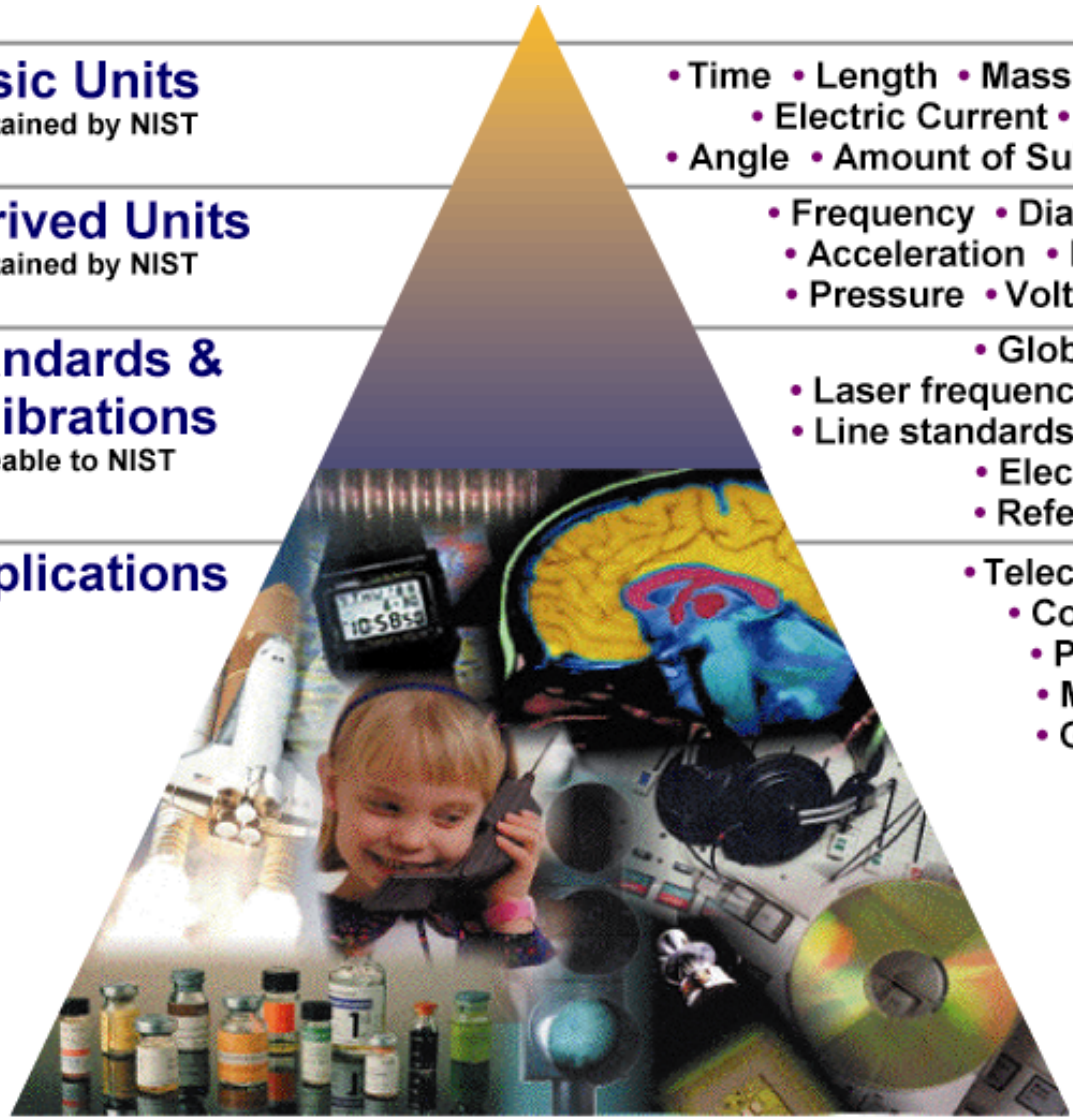
- Frequency • Diameter • Volume
- Acceleration • Density • Force
- Pressure • Voltage • Radiation

Standards & Calibrations
Traceable to NIST

- Global Time Service
- Laser frequency • Gage blocks
- Line standards • Radioactivity
- Electrical quantities
- Reference materials

Applications

- Telecommunications
- Computer "chips"
- Pharmaceuticals
- Medical imagers
- Gasoline pumps
- Digital clocks
- TV Signals
- CD-Roms
- Aircraft...

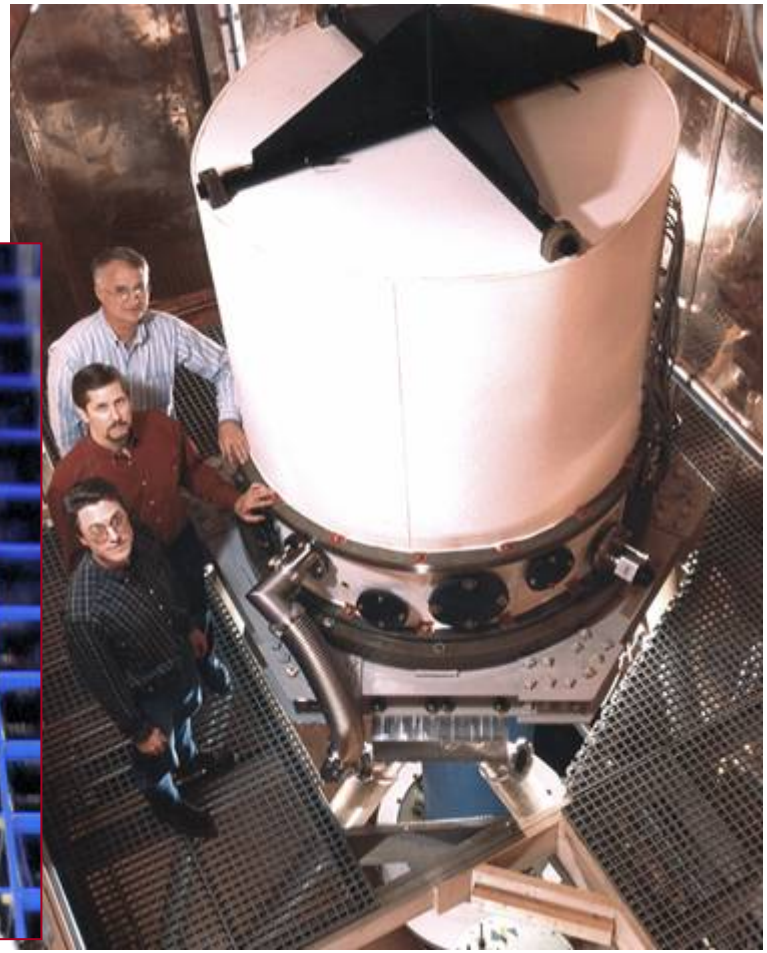


NIST Atomic Clock

The NIST F1 atomic clock, the world's best clock (as of Sept. 2005).

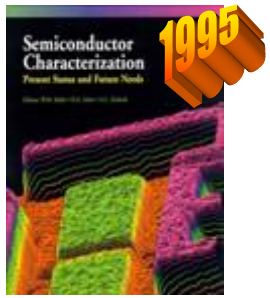
- NIST's atomic clock in Boulder, Colorado, serves as the ultimate standard for setting every wristwatch, every wall clock, every computer clock.
- The NIST F1 atomic clock (see left), which was developed, maintained, and improved by NIST, is one of the world's most accurate clocks – it will neither gain nor lose one second in 60 million years. It provides a time standard crucial for the leading edges of military and civilian technology and of science.
- www.time.gov receives billions of hits daily

Advanced Standards: The Electronic Kilogram

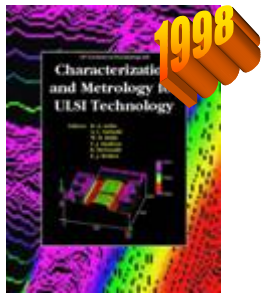


Semiconductor Metrology Conference Series Provides Focal Point for Metrology

continuing the tradition of excellence in bringing together scientists, engineers, and students for the sharing and strengthening of knowledge, research, and applications in semiconductor characterization and metrology that impact the dramatic progress in semiconductor technology and manufacturing…

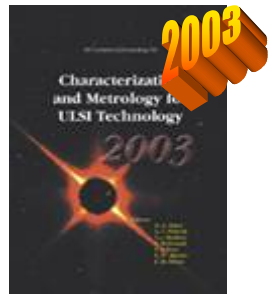


over 280 attendees



over 295 attendees

over 235 attendees



over 200 attendees

over 250 attendees

Some Keynote Speakers

Craig Barrett, President, Intel

Mark Melliar-Smith, formerly President and CEO of SEMATECH

Dennis Buss, VP, Silicon Tech. Development, Texas Instruments

Bob Helms, formerly President and CEO of SEMATECH

Michael Polcari, President and CEO of SEMATECH

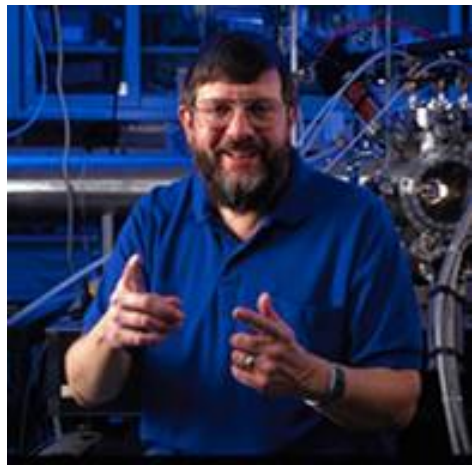
NIST Nobel Prizes for Physics

John L. (Jan) Hall, 2005

… for contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique

Eric A. Cornell, 2001

… for research leading to the landmark 1995 creation of the Bose-Einstein condensate and early studies of its properties



William D. Phillips, 1997

… for development of methods to cool and trap atoms with laser light

EEEL Organization

EEEL Laboratory Headquarters
William Anderson, Director
Alan Cookson, Deputy Director

Office of Law Enforcement Standards
Kathleen Higgins

Office of Microelectronics Programs
Stephen Knight

Optoelectronics Division

Kent Rochford

Semiconductor Electronics Division
David Seiler

Quantum Electrical Metrology Division
James Olthoff

Electromagnetics Division

Dennis Friday

Division Research Areas

- Silicon CMOS (ITRS)
  - Scanning-Probe Microscope Metrology
  - Thin-Film Ellipsometry Metrology
  - Electrical Test Structure Metrology
  - Advanced MOS Device Reliability and Characterization
  - MicroElectroMechanical Systems
  - Thermal Metrology
- MicroElectroMechanical Systems (MEMS)
  - Bionanotechnology
  - Microfluidics
  - Gas Sensors
  - Standards
- Power Electronics
  - Power Device Metrology and Characterization
- Nanoelectronics: Beyond CMOS (Long Term ITRS and Beyond)
  - Nanoelectronic Device Metrology
  - Molecular Electronics
  - Nanowires
  - Organic Electronics
- Information Technology & Software Development

I Work With Great People

Physics – What Is It?

- Physics is the basis of science and technology. It deals with how and why matter and energy act as they do.
- Physics is a passport into a broad range of science, engineering, and education careers
- People then tend to specialize
  - Astrophysics, solid state, quantum, space, applied, medical, bio, nuclear, geo, health, laser, elementary particle, theory, nano, etc
- Physics is often driven by a strong curiosity combined with a process of ongoing learning – delve down into the underlying reasons why and how things work
- Many physicists are attracted by the fact that they have a chance to break new ground, a lot of what happens and a lot of what they work on has not been done before by anyone. It's often all new, frontier work.

What is a Physicist?

- **The physicist deals with all aspects of matter and energy.**
- **Categories for the study of physics :**
  - **Motion and properties of physical objects both large and small (classical and quantum mechanics, astrophysics),**
  - **Properties of waves (optics, acoustics, electromagnetics),**
  - **Properties of states of matter (solid state, plasma physics),**
  - **Fundamental properties of matter and energy (atomic, nuclear, and particle physics),**
  - **Specialization in theoretical and/or experimental work.**
- **Physics studies range from basic research of the fundamental laws of nature to the practical development of semiconductor devices & instruments, as well as the development of standards that enable commerce.**

Some Physics Nobel Prize Winners

- **1956-For their research on semiconductors and their discovery of the transistor effect.**
  - John Bardeen — Mathematical Physics — Princeton University — 1936
  - Walter Brattain — Physics — U. of Minnesota — 1929
  - William Shockley — Solid State Physics — MIT — 1932

- **1973-For their experimental discoveries in semiconductors & superconductivity respectively.**
  - Leo Esaki — Physics — U. of Tokyo — 1959
  - Ivar Gaiever — Physics — RPI — 1964
  - Brian Josephson — Physics — Trinity College, Cambridge — 1964

- **2000-For developing semiconductor heterostructures used in high-speed & opto- electronics and IC respectively.**
  - Herbert Kroemer — Theoretical Physics — U. of Gottingen — 1952
  - Zhores Alferov — Physics&Math — Ioffe Inst. USSR — 1970
  - Jack S. Kilby — EE (BS & MS) — U. of Illinois/Wisconsin — 1947

John Bardeen also won the Nobel Prize in 1972 for Theory of Superconductivity with Cooper and Scriefffer-called the BCS Theory

Undergraduate Training

Broad Exposure in Physics

- Mechanics
- Electrostatics
- Electricity and Magnetism
- Heat and Thermodynamics
- Optics
- Solid State Physics
- Nuclear Physics
- Principles of Quantum Mechanics
- Good background in Mathematics
- Life sciences and Engineering Basic Courses

Graduate Training

Specialize

Develop discipline to formulate and carry out independent research

Study advanced courses, choose a thesis topic, develop a research plan

<u>Experiment</u>

- **Set up the equipment (Experiment)**
- **Run the experiment**
- **Collect data**
- **Analyze the data**
- **Make empirical deductions**
- **Develop theory & model**

<u>Theoretical</u>

- **Develop formalism**
- **Write computer program**
- **Production runs**
- **Visualize and analyze the data**
- **Make theoretical predictions**
- **Verify by comparing with experiment**

Physicists Are Diversified

Because of their broad scientific background, physicists in government branch out into engineering fields and other scientific fields, working with engineers and other scientists in overlapping areas. Physicists are known for their ability to work in many areas and have helped create many non-traditional fields. Some physicists move to non-technical fields such as policy and program development.

Physicist Qualities or Abilities Deemed Valuable

- Planning, organizing, and conducting research
- Problem solving
- Intellectual and personal creativity/imagination/inventiveness
- Working with a complex body of knowledge
- Working with computers
- Using advanced mathematical formulas and concepts
- Communication of one's ideas in speech and in writing essential
- Teamwork spirit and ability to work cooperatively with others
- Versatility
- Applying abstract theories to practical problems
- Understanding and applying the scientific method
- Doing detailed work accurately and consistently
- Developing new technologies
- Honesty in dealing with data, theory, and colleagues

Physicists tend to be curious, creative, and dedicated.

Most Important Aspects of Physics Education in Shaping Careers of Government Employees

- **Analytical skills** – ability to identify the problem and provide solutions, disciplined way of thinking, logical thinking, taught me to question everything and to look at facts in making decisions
- **Physics knowledge** – a broad based understanding of the physical world, established me as a technical generalist, prepared me to look at systems and processes outside the field of physics, breadth of subjects covered
- **Technical knowledge** – learned very marketable and useful skills, e.g., laboratory experience, computing experience
- **Personal traits** – mental discipline and perseverance skills from applying myself, dedication in working with others, gained confidence to take on things I don't completely understand
- **Role model and personal contacts** – advice, counseling, and perspective from advisor, professors that knew their subjects thoroughly, loved their work, and made it interesting and challenging, contacts and acquaintances made in college

Government Positions for US Physicists

- Employ about 25 % to 30 % of US Physicists
- National Aeronautics and Space Administration (NASA)
- National Science Foundation
- Nuclear Regulatory Commission
- Department of Commerce
  - NOAA, NIST
- Department of Health and Human Services
  - NIH, FDA
- Department of Energy
  - Office of Basic Energy Sciences, National Labs (Sandia, Brookhaven, Oak Ridge, National Renewable Energy Lab, Lawrence Berkeley, Los Alamos, Livermore, Argonne, etc)
- Department of Defense
  - Naval Research Lab, Army Research Lab, Wright-Patterson Air Force Base, etc.
  - OSTP
  - CIA, NSA

Entry-level Government Positions for Physicists

- Ph.D. Level: Qualify for independent basic research and development
- Master's Level: Qualify for many jobs in applied research and development
- Bachelor's Level: Often qualify as technicians, research assistants, or other types of technical jobs

Finding a Job in Government

Track Science & Technology Advances

- Subscribe to Technical and Professional Journals
- Read science & technology sections of NY Times & Wash. Post
- Websites of Professional Societies (AIP, APS, IEEE etc.)

Align Your Expectations With Reality

- Check government job websites to find out who is hiring
- Read budget reports to see who has money to hire (align your expectations with reality)

Network, Network, Network

- Attend meetings
- Place calls to known contacts (professors, peers, colleagues)
- Investigate Summer Undergraduate Research Fellowship (SURF), National Research Council and the NIST Postdoctoral Research Associateships Program
  - SURF - www.surf.nist.gov/surf2.htm
  - Postdoctoral Program - www.nist.gov/oiaa/postdoc.htm

Resume

- Emphasize coursework & Lab skills
- Emphasize breadth of knowledge
- Emphasize your skills

Career Advancement at NIST

- National Research Council Post Doc
- Scientific Staff
- Project Leader (2 – 6 staff)
- Group Leader (8 – 20 staff)
- Division Chief (20 -70 staff)
- Laboratory Director (80 – 300 staff)
- NIST Director (appointed by president)

Scientific Staff

- Technical excellence (analytical ability, expertise, publications, impact, etc)
- Communication skills
- Adaptability
- Teamwork
- Customer focused
- Creativity & imagination

Project Leader

- Leadership and vision for project
- Effective use of resources including staff and funds
- Promote visibility
- Mentor staff
- Manage conflict productively
- Ensure project safety

Group Leader

- Technical & financial leadership
- Achieve high impact for projects
- Strategic planning for multiple Groups
- Serve on Division management team
- Supervisory responsibilities
  - Develop performance plans and conduct employee appraisals
  - Promote learning and professional/career development of staff
  - Ensure timely submission of reports

Division Chief

- Provide overall leadership to Division
- Develop and implement strategic plans
- Set and drive vision & goals
- Oversee evaluation & promotion of staff
- Develop future leaders
- Ensure smooth administrative operations
- Monitor and control Division financial performance

Evolution of a Career

(LIFELONG LEARNING – STAGE ONE)

Started in K – 12

Interest in science (rock collecting) and math (doing extra homework)

Undergraduate Studies - Case Western Reserve University

- Tuition Scholarship Awarded
- 1st year excellent physics professor in a recitation section
- 2nd year – chose physics major
- Loved experimental lab work throughout
- 4th year – developed interest in solid state physics
- 1st paper published on Thin Films

Graduate Studies – Department of Physics, Purdue University

- Teaching & Research Assistant
- Loved problem solving in coursework
- Thesis Research – allowed me the freedom to develop discipline and character traits to do fundamental research. Identify thesis topic and necessary ingredients to complete thesis and publish papers

Evolution of a Career

(LIFELONG LEARNING – STAGE TWO)

- Assistant Professor, Department of Physics, University of North Texas (UNT), Denton, TX
  - Teach solid state physics and an advanced senior undergraduate laboratory course
  - Do research and supervise students in semiconductor physics
- National Bureau of Standards, Boulder, Colorado
  - InSb spin flip Raman laser
  - Learned to build and operate CO and CO2 infrared lasers
- Associate Professor, Department of Physics, University of North Texas (UNT), Denton, TX
  - Build IR lasers and use to study semiconductors
  - Start quantum electronics programs, teach laser courses, hire new professors
  - Laser induced hot electrons
  - Begin two photon absorption studies
- Research Scientist, Massachusetts Institute of Technology National Magnet Lab, Cambridge, MA
  - Dye and YAG lasers used to study two photon effects in semiconductors
- Professor, Department of Physics, University of North Texas (UNT), Denton, TX
  - Two photon spectroscopy, impurity and deep level spectroscopy
- Program Director
  Solid State Physics Program, Materials Research Division, The National Science Foundation (NSF), Washington, D.C.

Evolution of a Career

(LIFELONG LEARNING – STAGE THREE)

Started a new career in government

National Institute of Standards and Technology (Since 1988)

- Materials Technology Group Leader
  Semiconductor Electronics Division, National Institute of Standards and Technology (NIST)
- Program Analyst
  Program Office for the Director of NIST, National Institute of Standards and Technology (NIST)
- Division Chief, Semiconductor Electronics Division
  National Institute of Standards and Technology (NIST)

Reflections on My Management Philosophy

- Set realistic goals for yourself to achieve
- Never stop learning about yourself, your job, and the people you work with
- Motivating and empowering people are the most important facets of managing
- Expect excellence and quality from your staff
- Be a role model for what you “preach”
- Provide the proper environment that nourishes and stimulates creativity
- Listen well and communicate effectively

Reflections from a Government Physicist

- Challenges exist ‘tis true – bureaucracy, people management, ...

BUT STILL MANY OPPORTUNITIES EXIST:

- To do excellent research
- To be creative and innovate
- To demonstrate leadership
- Great opportunity to achieve high impact on problems of national importance
- Unique opportunities to collaborate both with industry and academia
- Enhances the technical expertise and reputation of the government and, in turn, the country
- Wide variety of mentorship opportunities
- Wide flexibility in career options

In summary, I have found my work in the government to be both challenging and satisfying