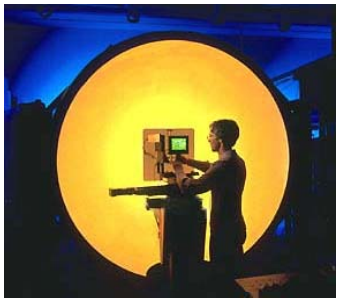
NIST Measurement Services

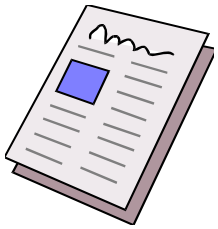
Products and services to support NIST's Measurements and Standards Mission



NIST
National Institute of Standards and Technology
U.S. Department of Commerce

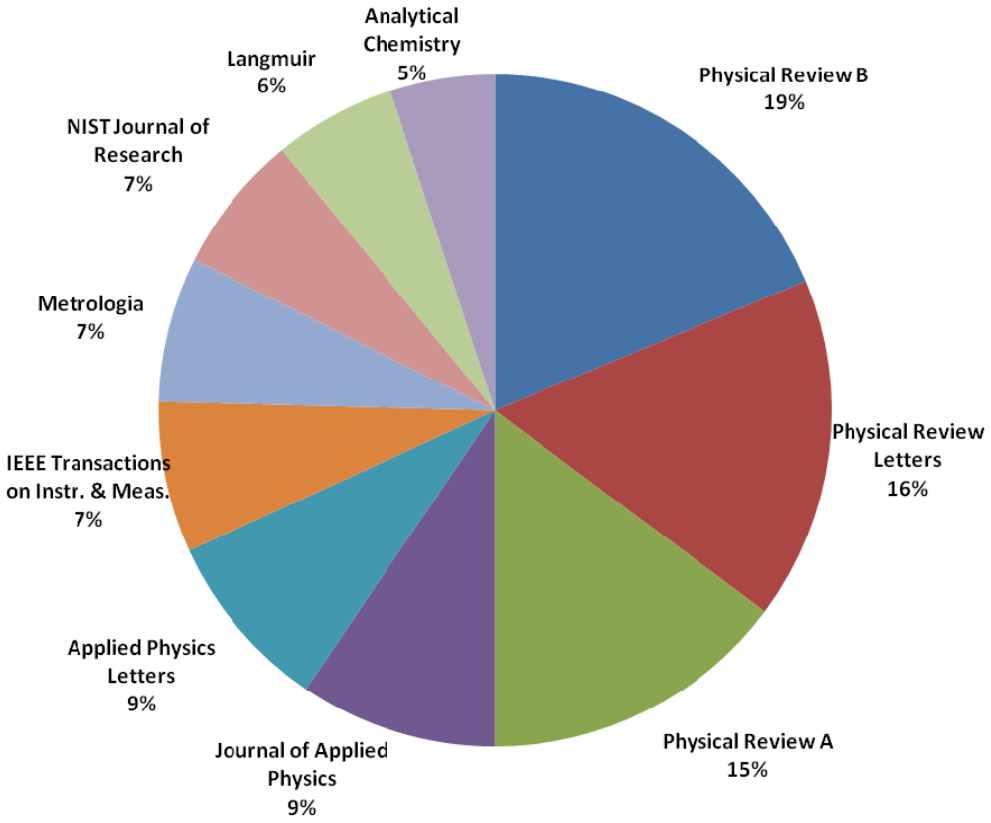
NIST Measurement Services

- NIST does it:
  - Publications on measurement science research
  - Fee-supported services
    - Standard Reference Data
    - Calibration services
    - Standard Reference Materials
    - Laboratory accreditation services (NVLAP)
- DIY – *You can do it, we can help.*
  - Services for legal metrology labs
  - Metrology training
  - Measurement practice guides
  - User facilities (CNST and NCNR)



Publication Outputs

- 2200 research publications in FY09
  - 1463 in peer-reviewed journals
- Measurement practice guides
  - SP 960 series – 20 guides from materials properties to mass spectrometry to timers and clocks
- Legal metrology guides that are adopted in Weights and Measures regulations

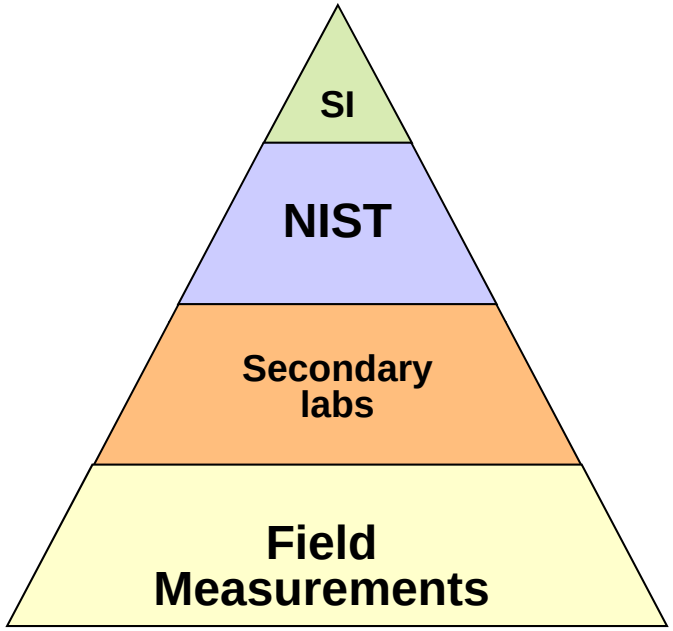


Fee-Supported Services

- Calibrations
  - Service in NIST technical lab
  - Customer sends instrument to NIST
- Standard Reference Data (SRD)
  - Evaluated numeric data on physical or chemical properties
  - Scientific algorithms on behavior of systems
- Standard Reference Materials (SRMs)
  - Physical artifacts with certified physical or chemical properties
- Laboratory Accreditation
  - Formal assessment of quality systems

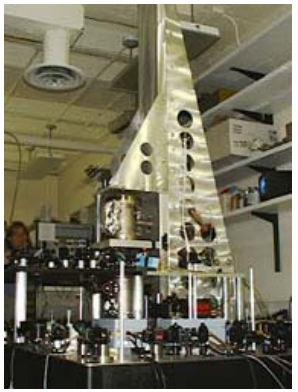
Primary Drivers

- Traceability
  - Required for accreditation
  - Required by specific vendor qualification programs
  - Implies the next driver:
- Measurement Quality



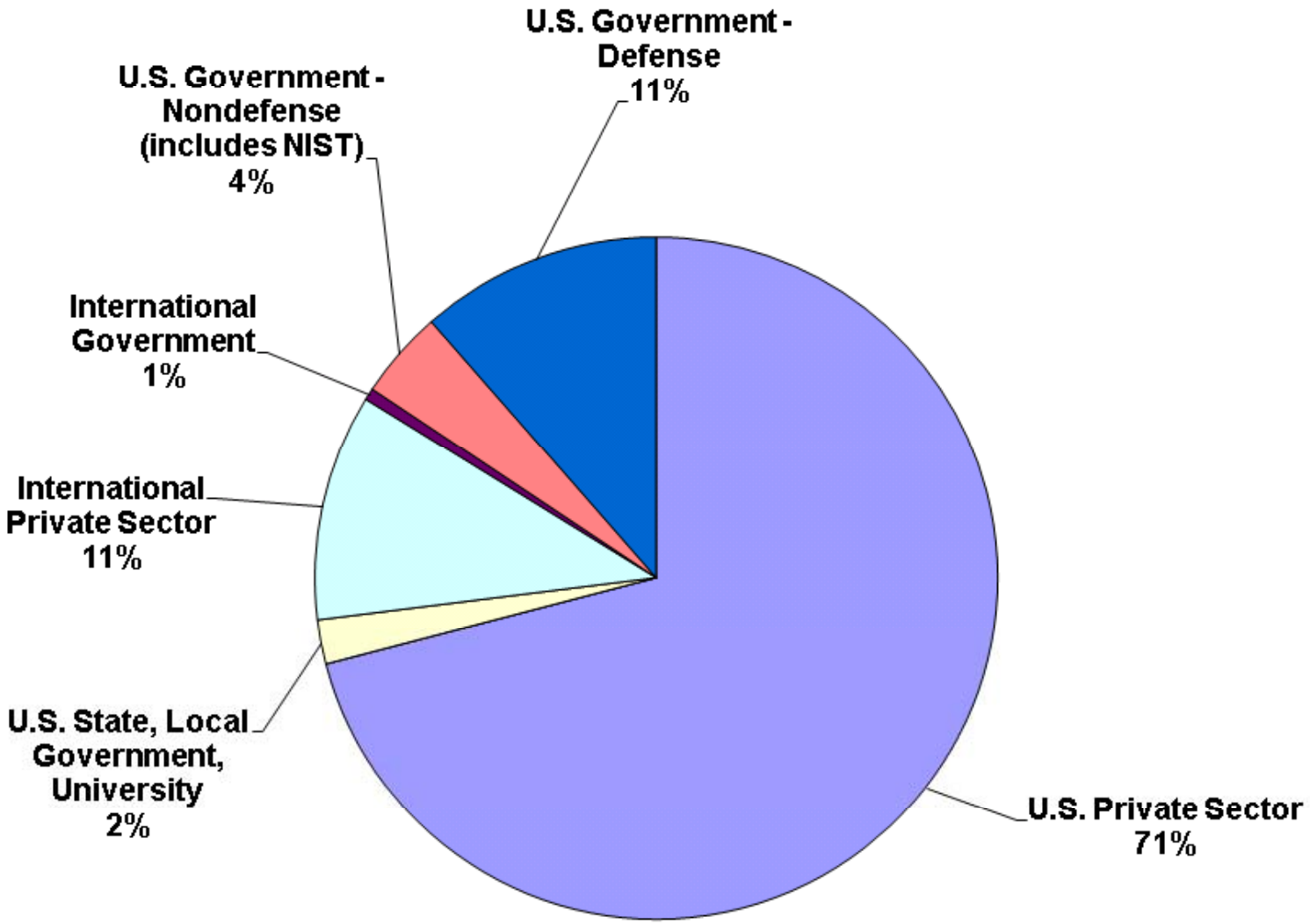
Calibration Services

Instrumentation sent to NIST Labs

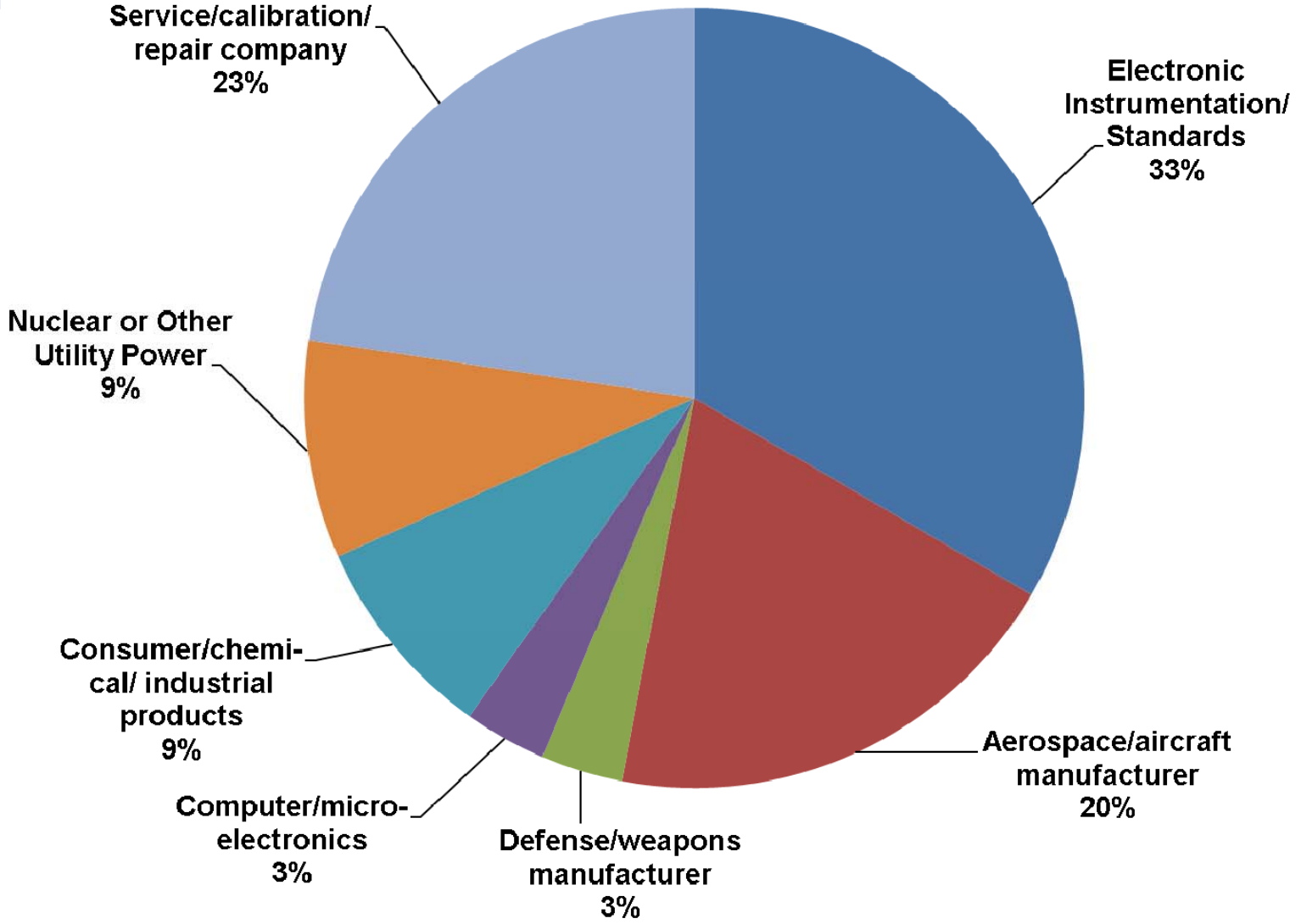


- 13 Divisions in EEEL, MEL, CSTL, PL, BFRL
- 7 major categories
  - Dimensional
  - Electromagnetic
  - Ionizing Radiation
  - Mechanical
  - Optical
  - Thermodynamic
  - Time and Frequency
- Per year:
  - 2,800 items
  - 18,000 tests
  - >600 unique customers
  - $7.6 M income
  - 1,800 customer transactions

Items Calibrated by Customer Type



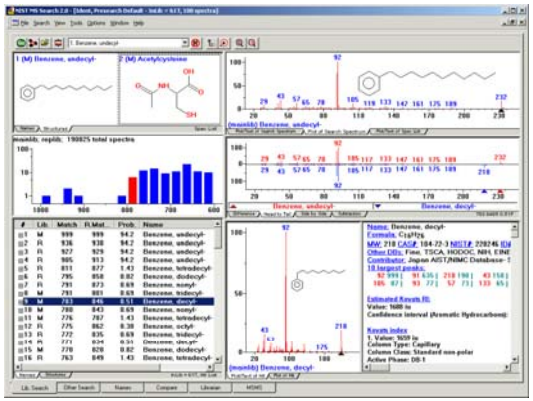
Private Sector Customer Types



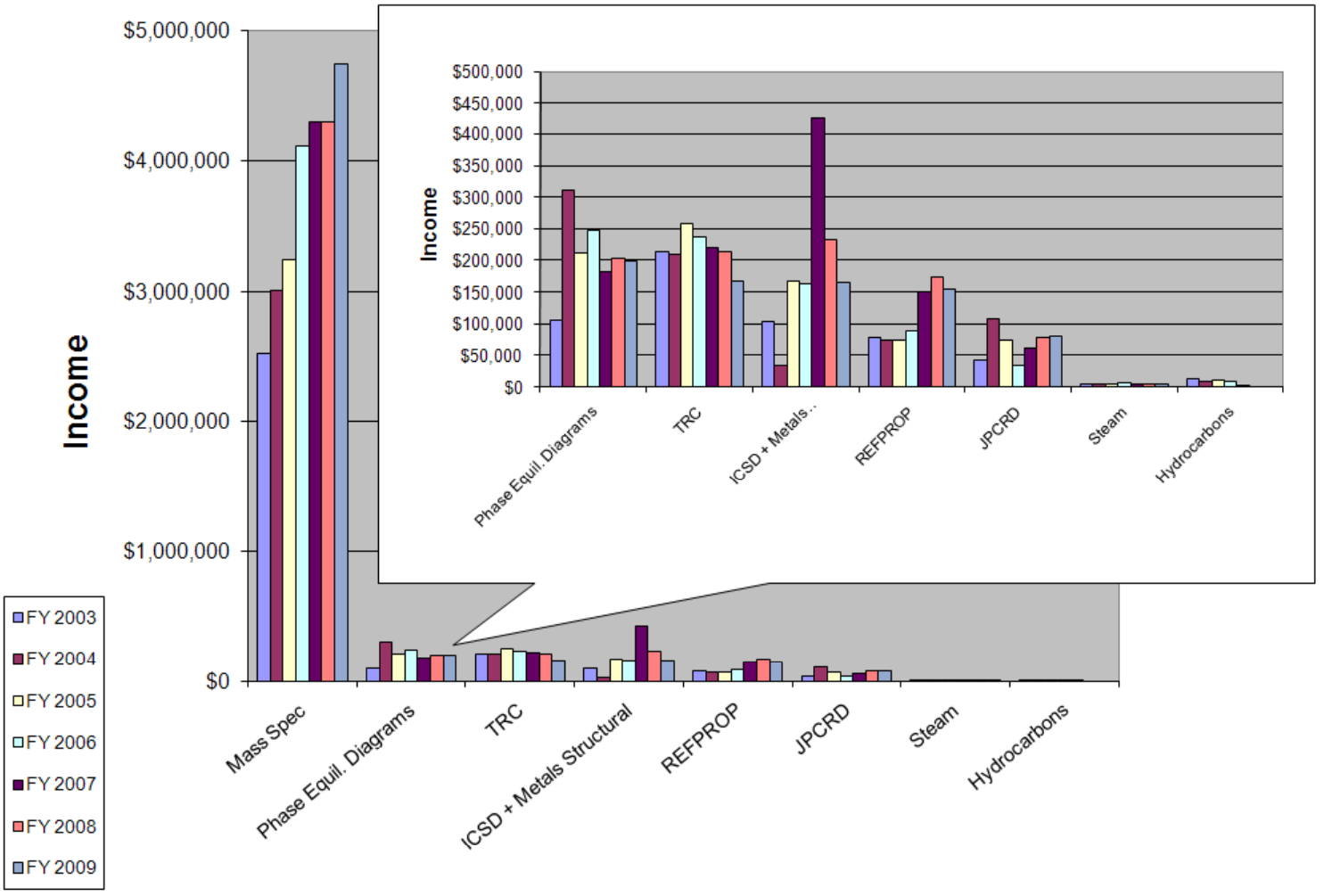
Standard Reference Data

Evaluated numeric data and scientific algorithms

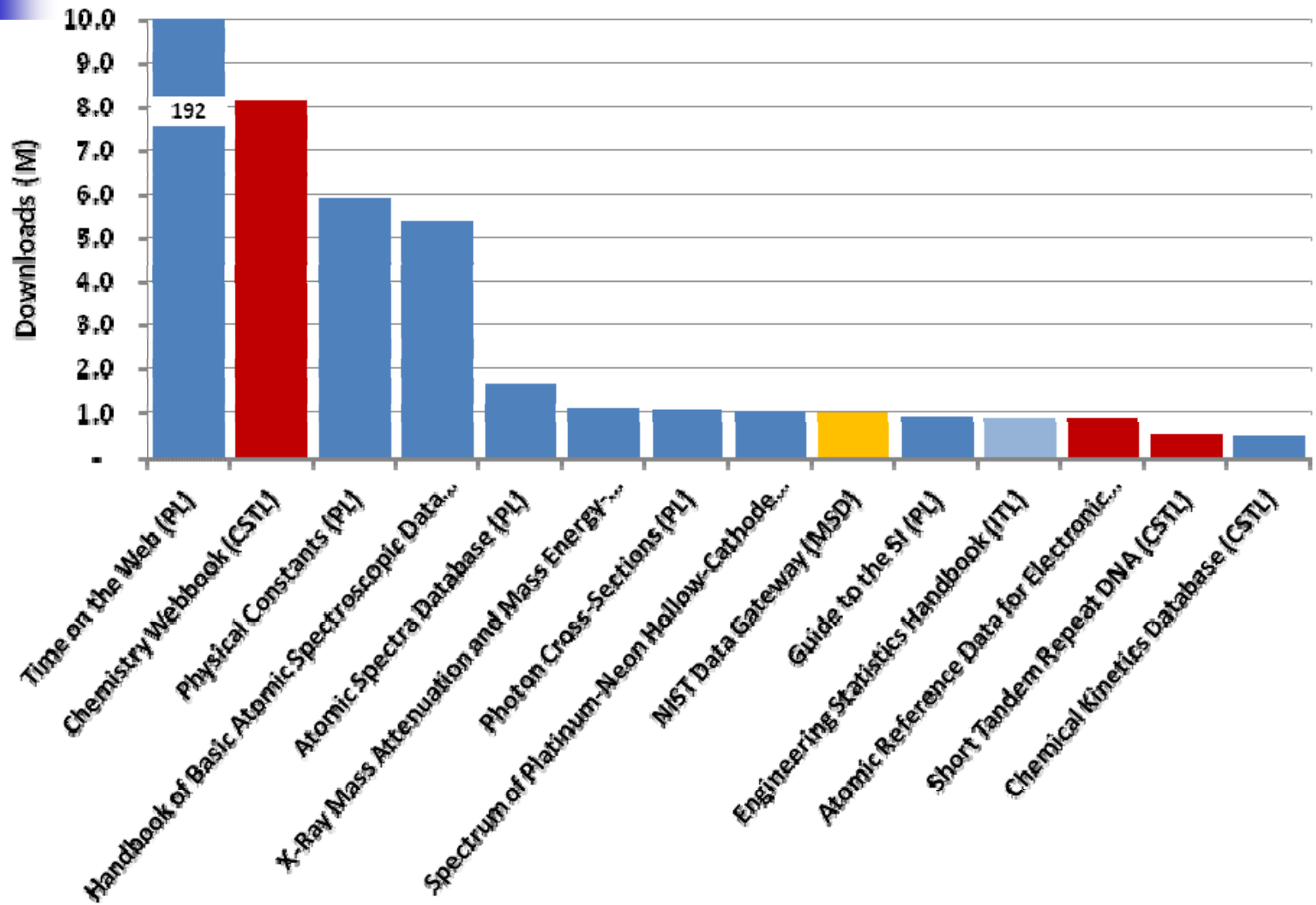
- All Labs; most divisions
- SRD Act gives NIST copyright
- Standard Reference Data
  - 55 PC products available
  - 54 Online SRD systems out of 88 total NIST systems
  - 6,000 units sold/year
  - 226 M/year data downloads
  - $5.7 M in sales
  - $7.1 M in spending



SRD Purchased Products



Free Online Systems – Top Downloads

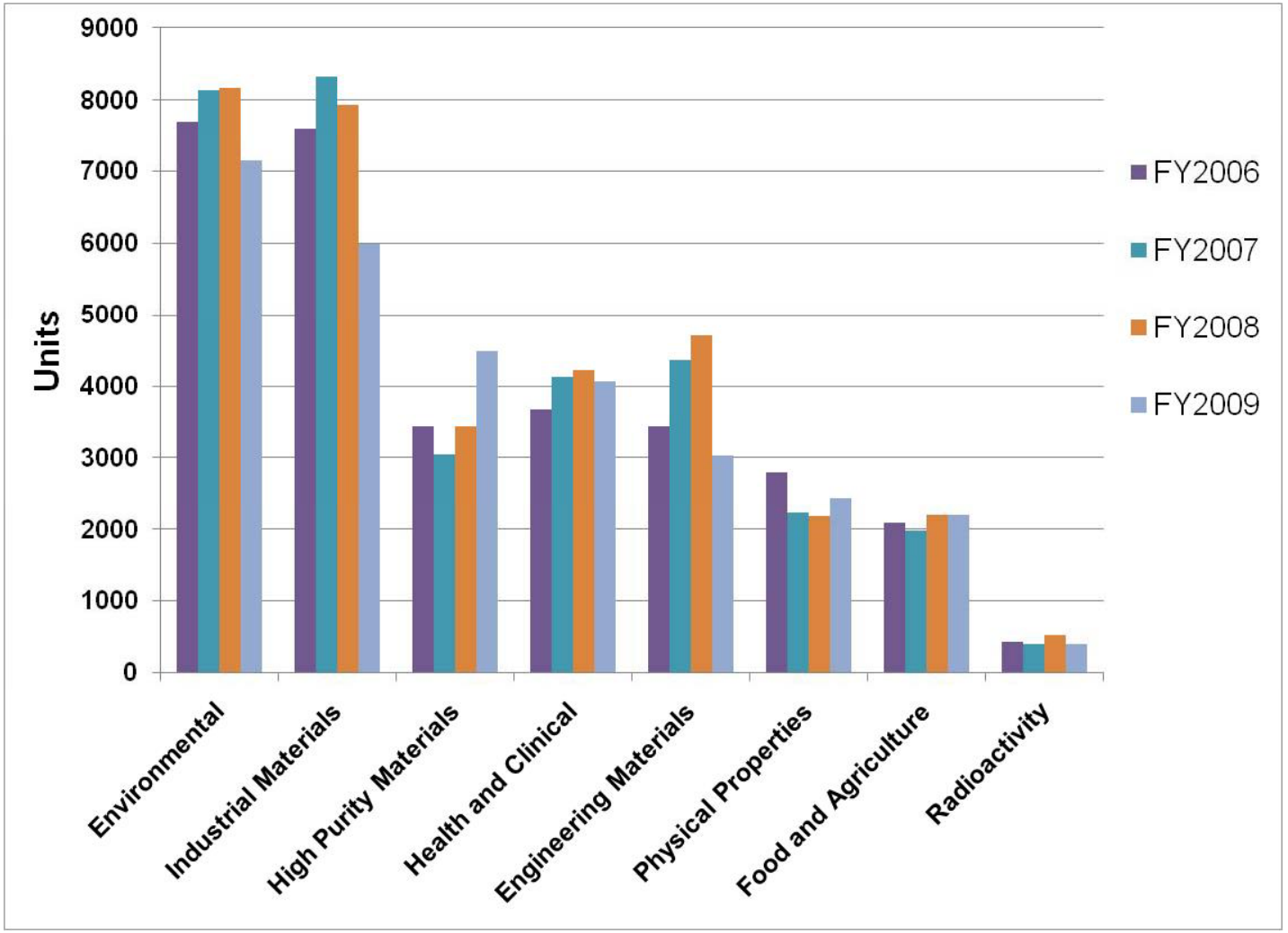


Standard Reference Materials

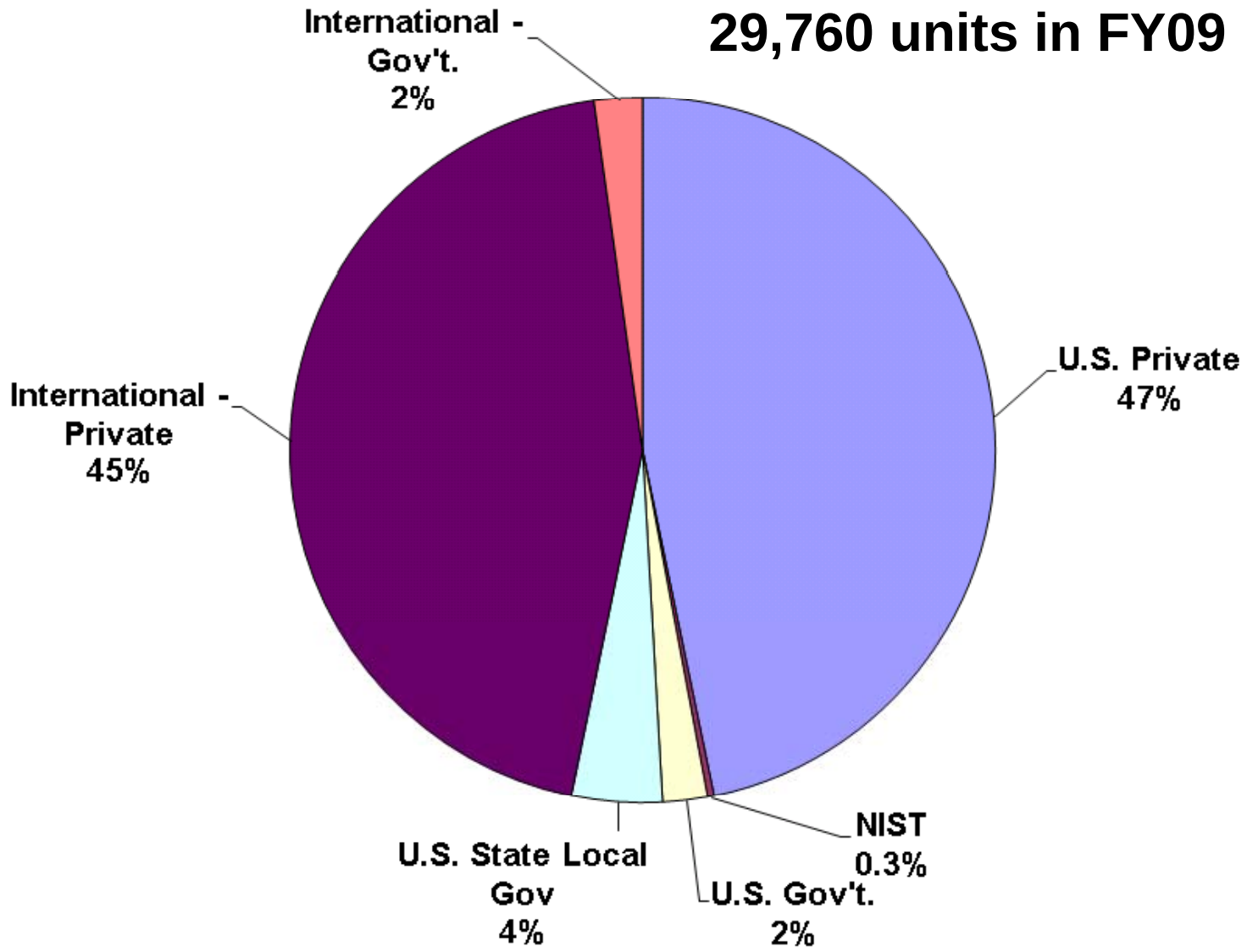
Physical artifacts with certified properties

- 20 Divisions in 6 NIST Laboratories
- 3 major categories
  - Chemical composition, physical properties and engineering properties
- ~ 1285 products
- Approx. 30,000 units sold/year, with $12M cost recovery income

Category History



SRM Units Sold by Customer Type



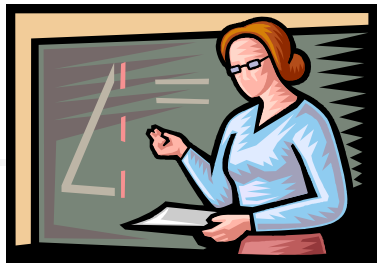
National Voluntary Laboratory Accreditation Program

- Established in 1976 (15 CFR Part 285)
  - Specific programs set by legislation and requests from other Fed. Agencies
- 18 fields of testing; 8 fields of calibration, covering > 90 parameters
- Labs are located in North America, Asia Pacific, Europe, and South America
- Nearly 800 testing and calibration laboratories
- Operates in accordance with ISO/IEC standards
  - ISO/IEC 17011 (for Accrediting Bodies)
  - ISO/IEC 17025 (for Laboratories)
- Closely linked with NIST measurement expertise

Support for Legal Metrology

- Traceability certification for State and Local Govt. Weights and Measures Labs
  - Mass
  - Volume
  - Length (tapes)
  - Temperature
  - Frequency (radar guns)
- Proficiency Testing Program
  - States
  - Calibration service providers
  - Measuring device manufactures
- Technical advice/support to National Conference of Weights and Measures
- General traceability advice (more than just legal metrology)

Metrology Training



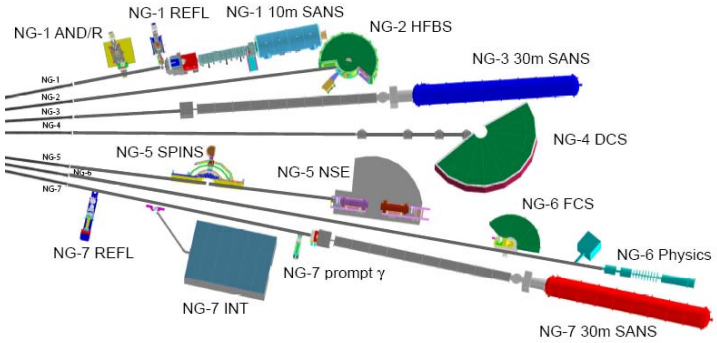
- Weights and Measures Enforcement
  - Specifications and Tolerances for Commercial Devices (Handbook 44)
  - Checking the Net Contents of Packaged Goods (Handbook 133)
  - Price Verification
- Laboratory/Metrology Seminars
  - Balance and scale metrology
  - Measurement Assurance Programs
  - Accreditation (NVLAP), Practical Measurement Assurance
- Specific metrology workshops
  - Microwave, antennas, and electrical
  - Pressure, flow, thermometry
  - Time and frequency
  - Dimensional
- Summer Programs for Students and Teachers
- User Facilities and Associated Instrumentation

60 classes

1000 students

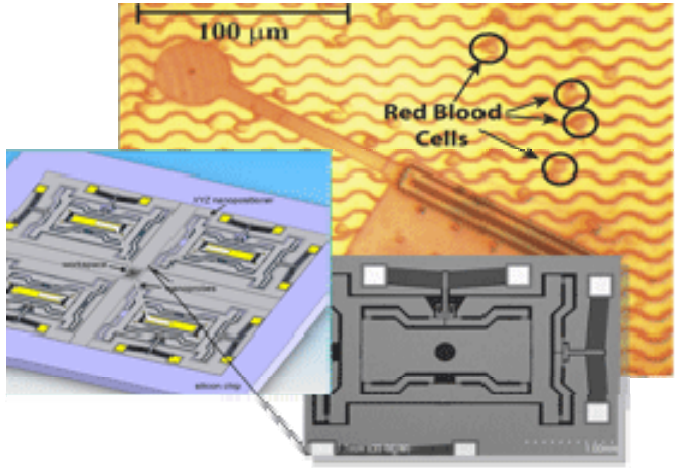
NIST Center for Neutron Research

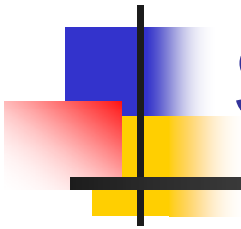
- Major national user facility for neutron-based measurements
  - Merit-based access via proposal reviews (2X /year)
- Open publication = free; proprietary = cost recovery fee
- 9 thermal neutron instruments in the confinement building
- 16 instruments in the cold beam guide hall beam stations
  - ~~Only cold source in the U.S.~~
- 2290 research participants in FY09
  - 18 NIST divisions/offices
  - 32 U.S. Government laboratories
  - 142 U.S. universities
  - 46 U.S. corporations



Center for Nanoscale Science and Technology

- NanoFab – 50 instruments for training, tool operation and process development
  - Lithography, furnaces, dry etch, metal deposition, etc.
- Access to state-of-the-art nanofabrication and nanomeasurement equipment
  - Equipment training
  - Tool operation
  - Process development
  - NIST-wide expertise
- 524 researchers in FY09
  - 8 NIST OUs
  - 12 U.S. federal laboratories
  - 56 U.S. universities
  - 23 U.S. corporations
  - 12 Foreign universities
  - 3 Foreign government laboratories
  - 1 Foreign corporation

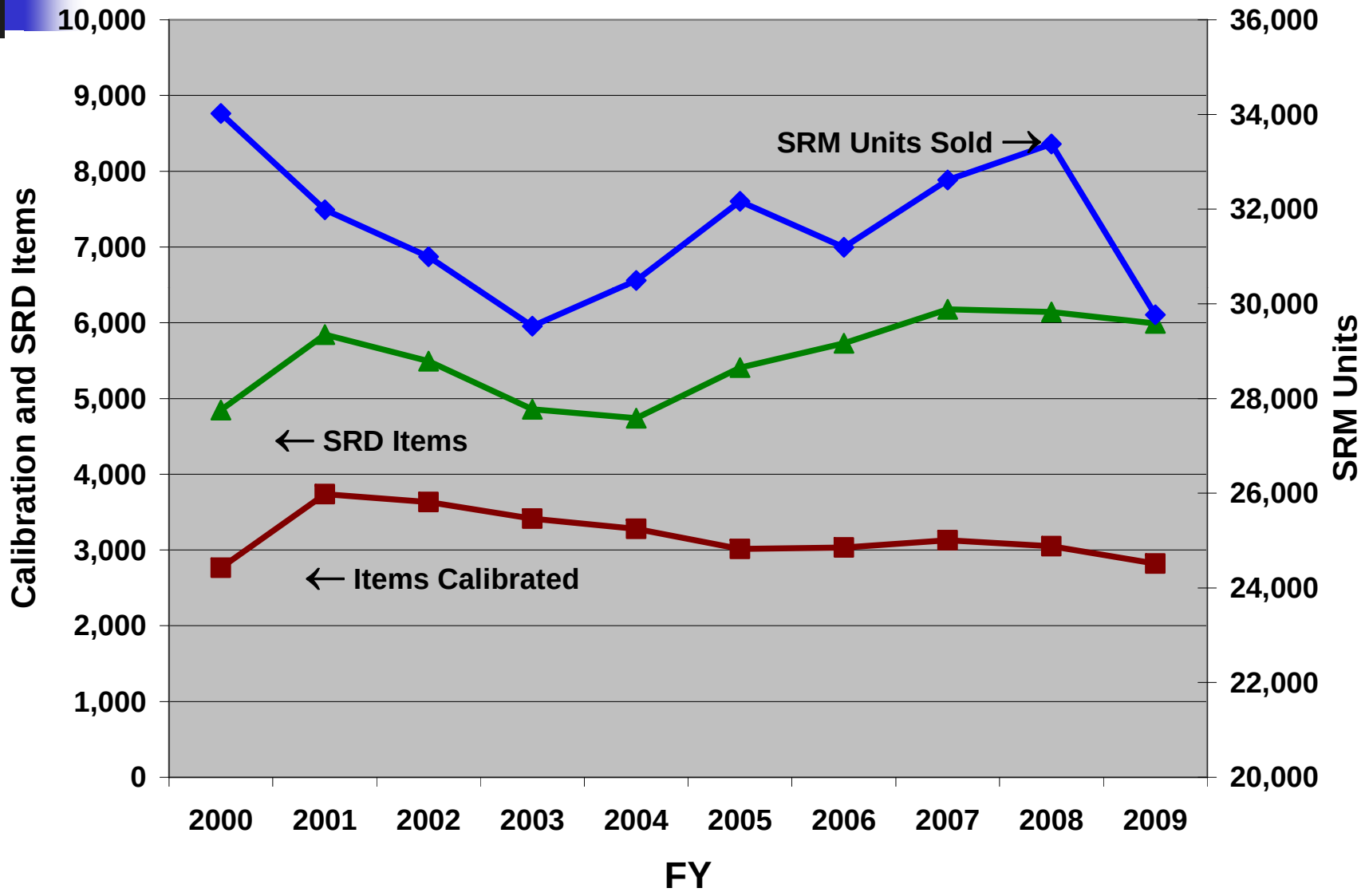




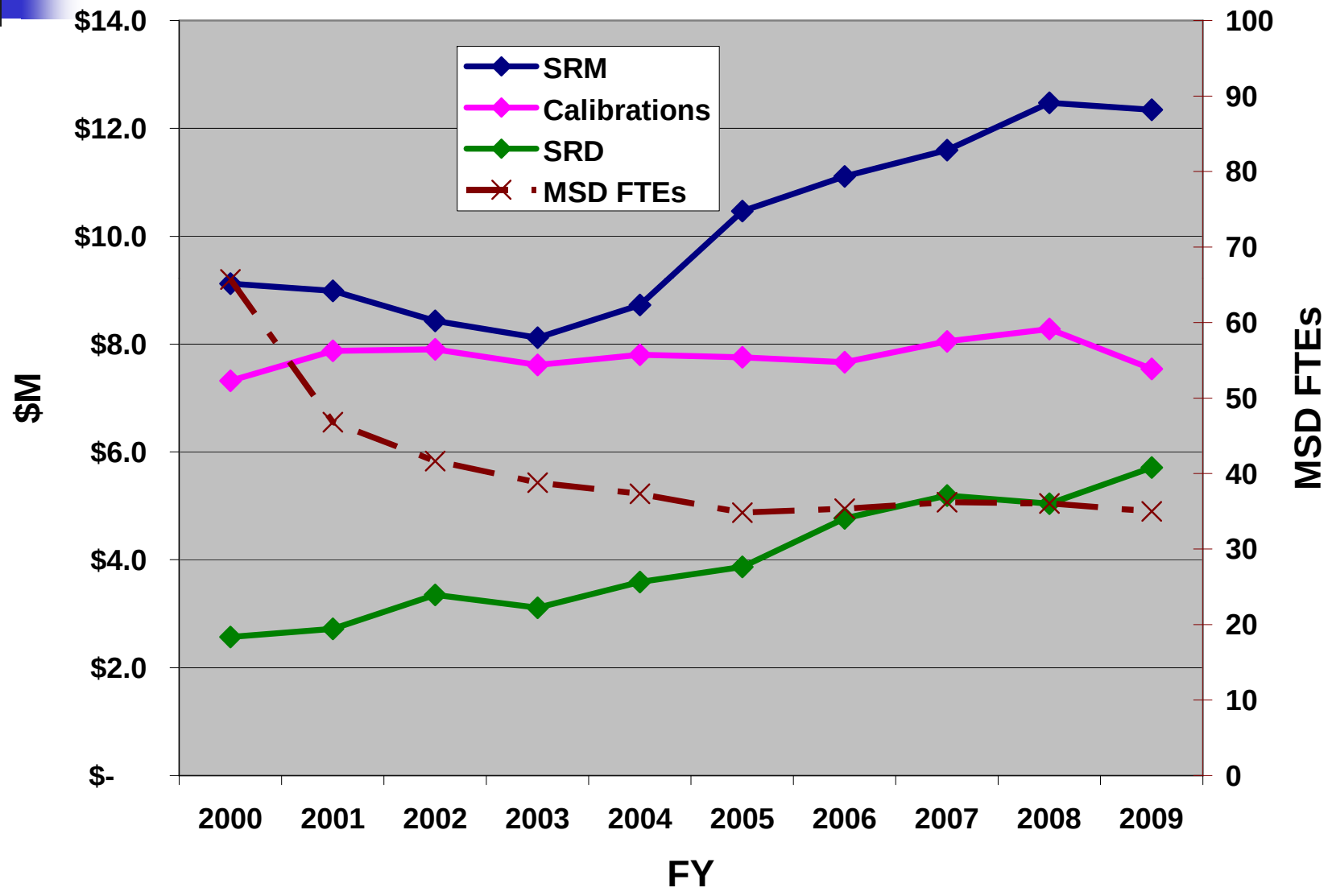
Supplementary Material

NIST
National Institute of
Standards and Technology
U.S. Department of Commerce

Fee Program Output Trends

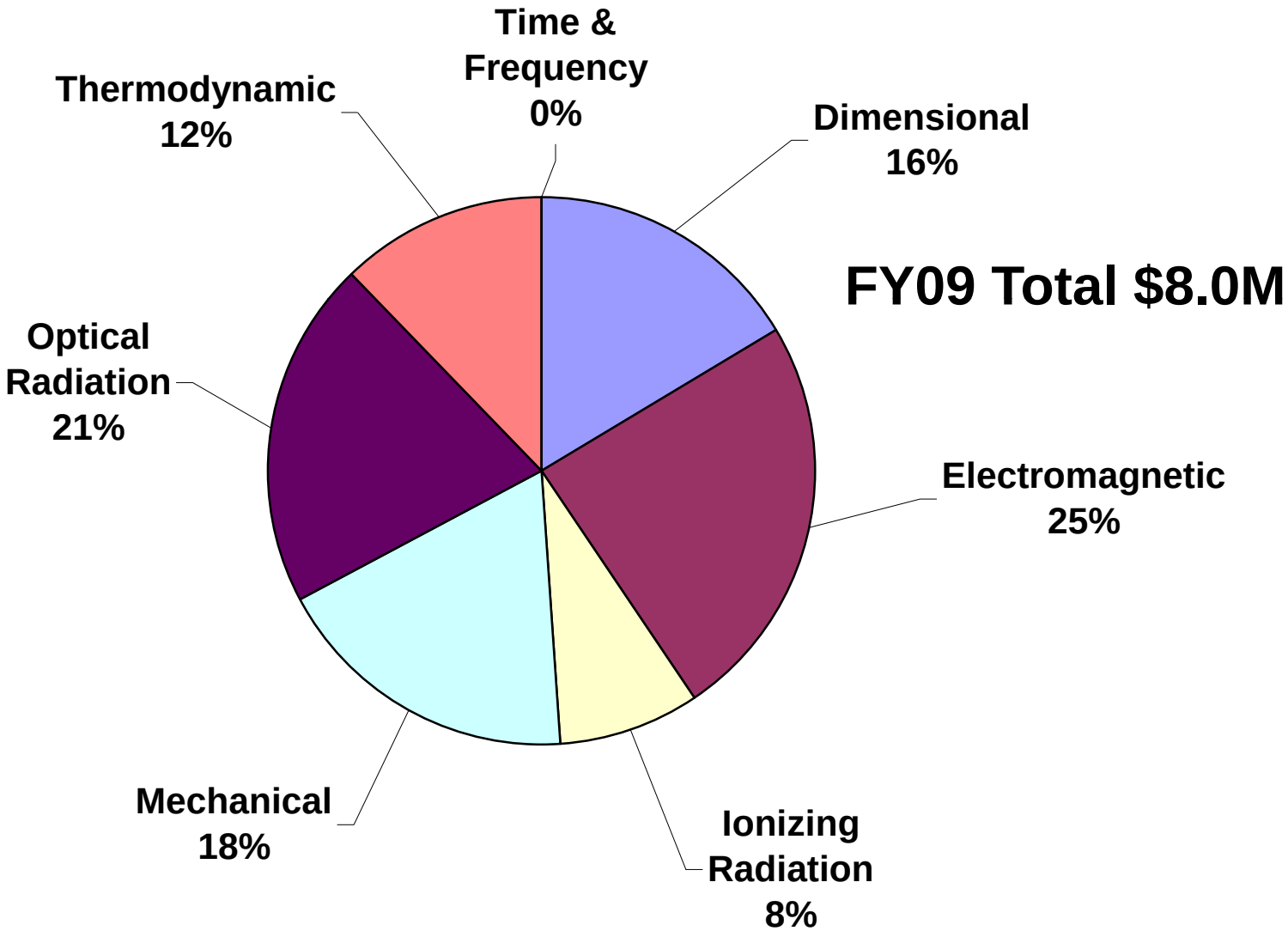


Fee Program Income Trends

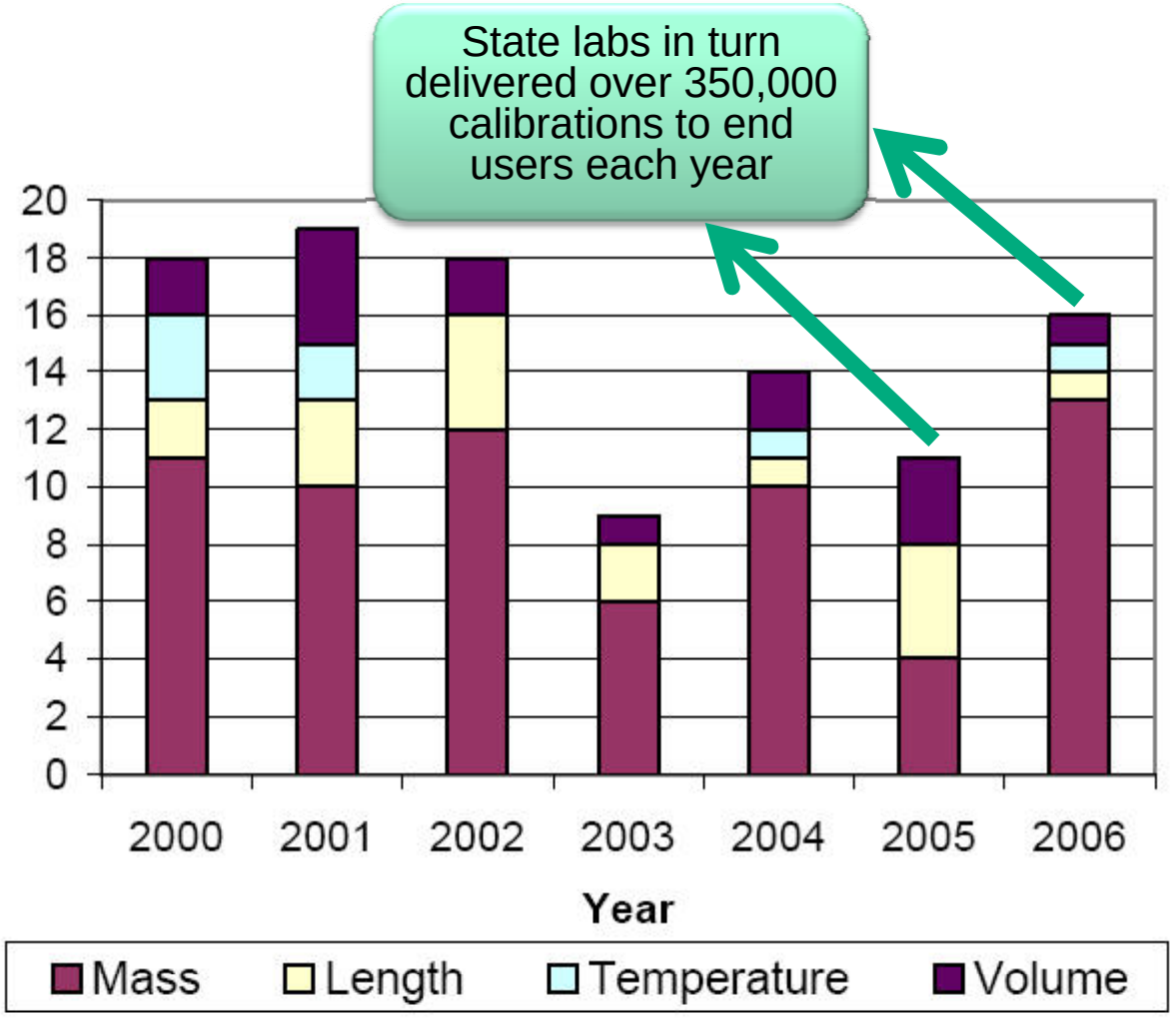


Calibration Activity

Income by Metrology Area

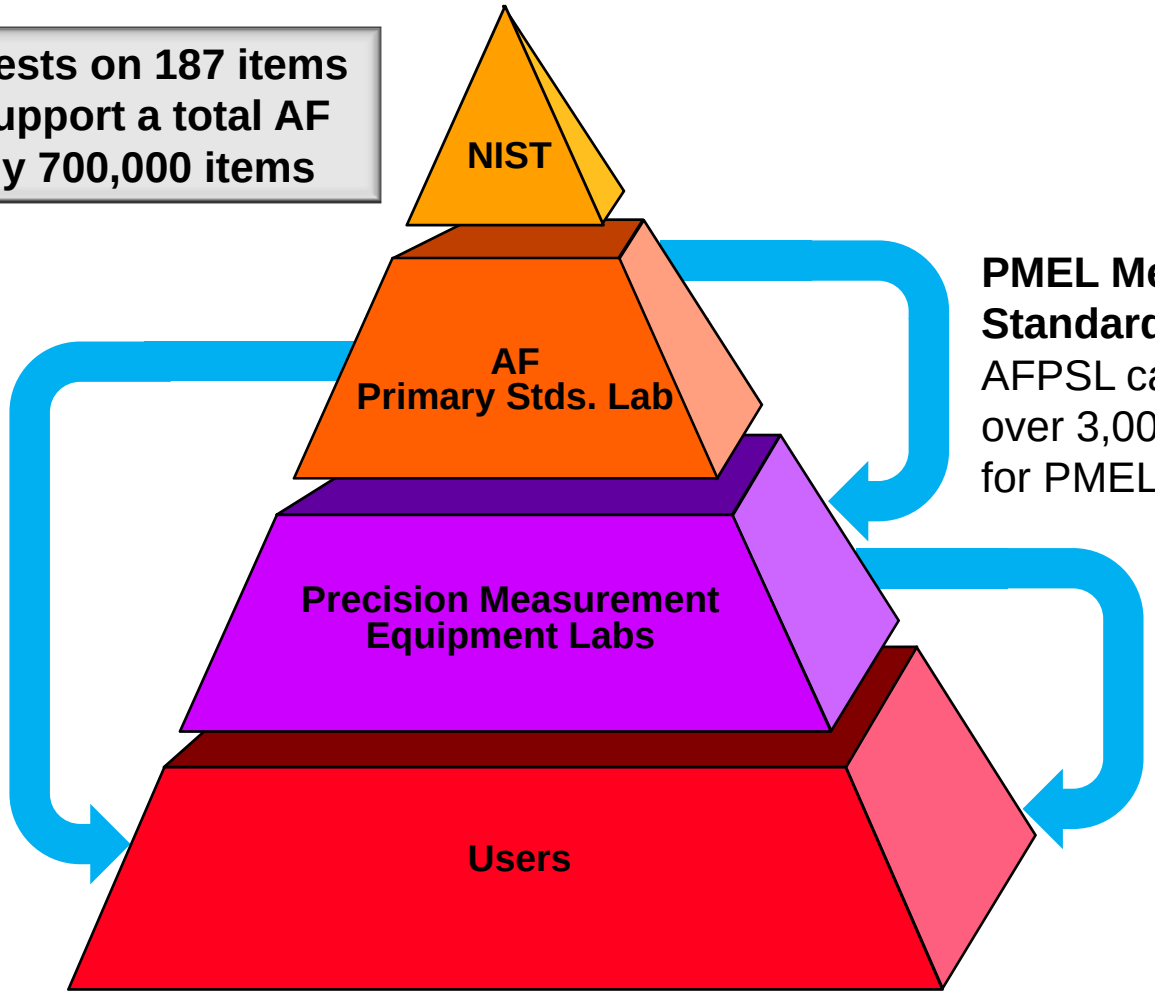


NIST Calibrations for State Labs



AFMETCAL Calibrations

1238 calibration tests on 187 items at NIST in FY09 support a total AF inventory of nearly 700,000 items



PMEL Measurement Standards: The AFPSL calibrates over 3,000 annually for PMELs

End Items: The AFPSL calibrates over 20,000 end items annually for PMELs and Major Command Customers

End Items: The PMELs in turn calibrate over 400,000 end items annually for Major Command Customers

Calibration Impact Studies

- J-Volt (1987 – 1999)
  - Benefit-to-Cost Ratio = 5
- Electric power meters
  - BCR = 12
- Laser power and energy (1999)
  - BCR = 11.3
    - 248 nm lithography lasers (1990 – 1999)
      - BCR = 3.0
    - Fiber optic detectors (1992 – 2000)
      - BCR = 9.1
- Thermocouples (1990 – 1996)
  - BCR = 2.95

SRD Legislative Authority

- Standard Reference Data Act, Public Law 90-396
  - To make evaluated scientific and technical data readily available to scientists, engineers, and the general public
  - Cost recovery and copyright authority is authorized under the same law
  - “To the extent practicable and appropriate, the prices established for such data may reflect the cost of collection, compilation, evaluation, publication, and dissemination of the data, including administrative expenses”

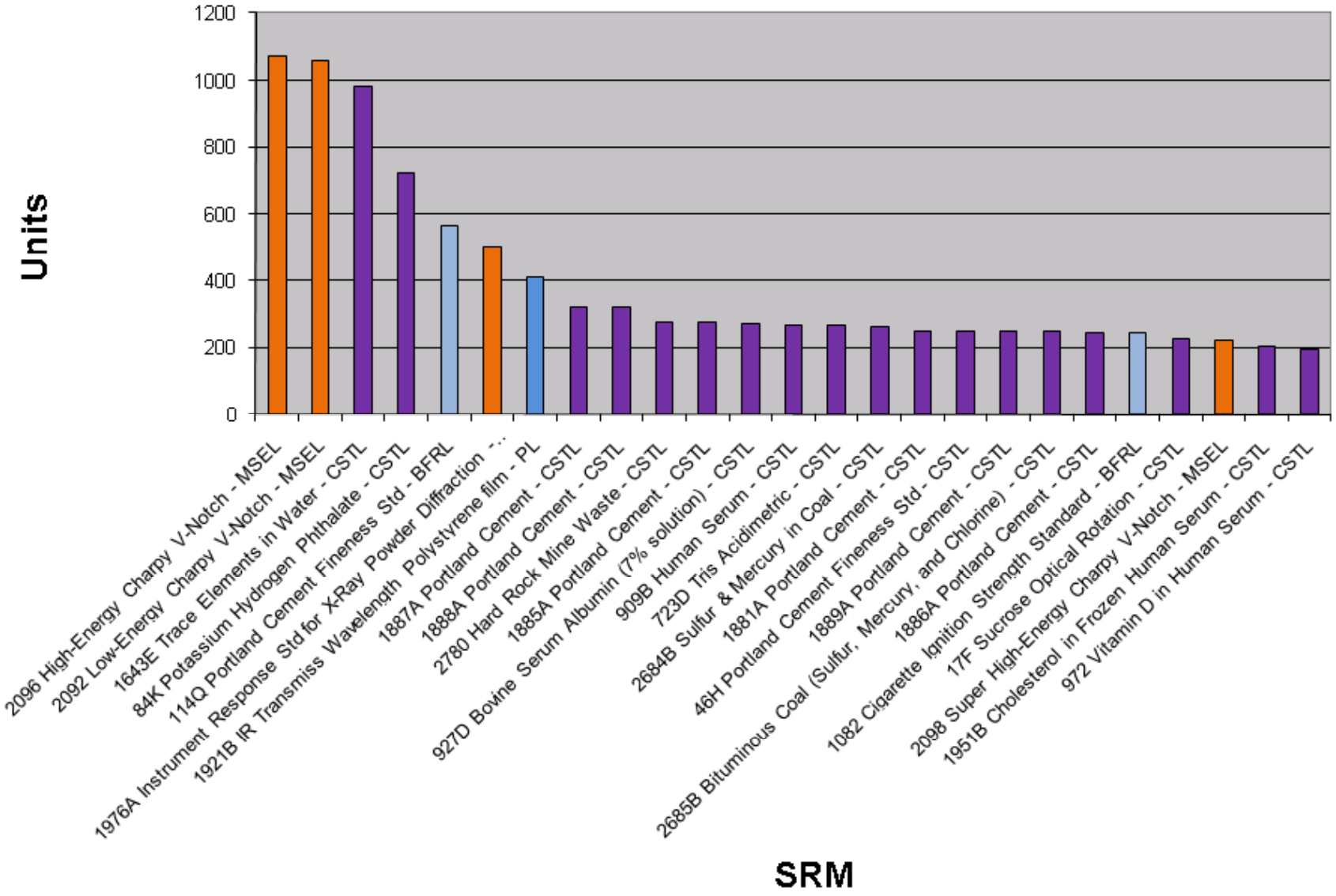
Technical Areas for NIST SRD

- **Analytical Chemistry**
- **Atomic and Molecular Physics**
- **Biotechnology**
- **Chemical and Crystal Structure**
- **Chemical Kinetics**
- **Environmental data**
- **Fire**
- **Fluids**
- **International Trade**
- **Law Enforcement**
- **Materials Properties**
- **Optical Character Recognition**
- **Surface Data**
- **Text and Video Retrieval**
- **Thermophysical & Thermochemical**

SRD Impact Studies

- REFPROP (1987 – 1996)
  - Benefit-to-Cost Ratio = 3.9
- Ceramic Phase Diagrams (1985 – 2001)
  - BCR = 10.0

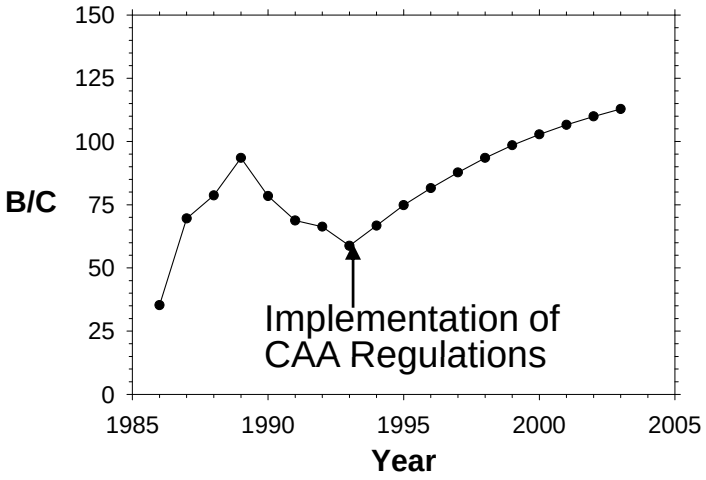
Top 30 SRMs in FY2009



Sulfur in Fossil Fuel SRMs

Industries Impacted:

- *Transportation* Diesel, Gasoline
- *Energy* Coal
- *Steel* Coke

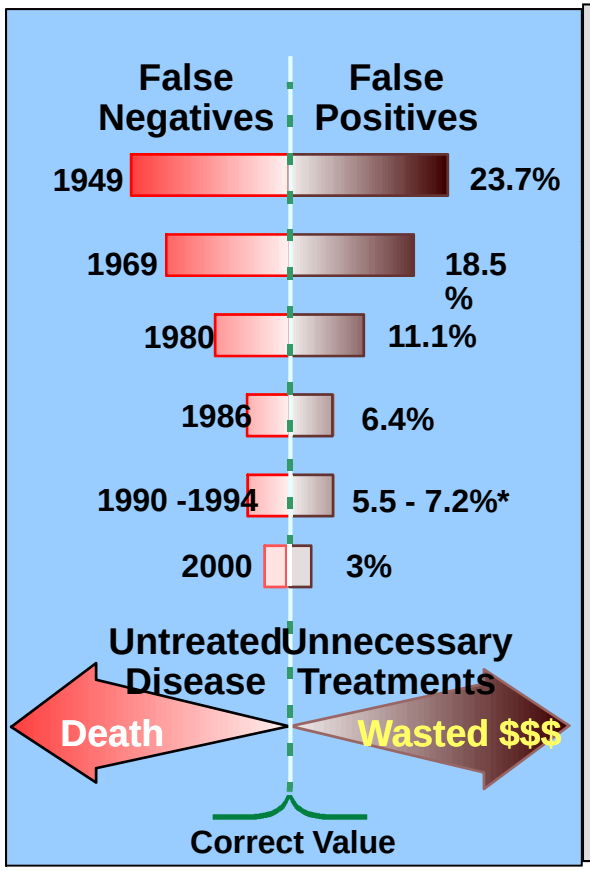


- 29 SRMs
- 45,673 units
- 2954 customers over 17 years

Benefit-Cost Ratio	113
Social Rate of Return	1,056 %

Certification of NIST SRMs for sulfur in fossil fuels uses a definitive method, developed at NIST, that virtually eliminates bias and significantly reduces the measurement uncertainty … which translates to improved production efficiency

Improved Cholesterol Measurement Accuracy Saves Health Care Dollars



NIST Contributions to National Reference System for Cholesterol

1967 – Pure Cholesterol SRM *(SRM 911)*

1980 – Cholesterol in Serum Definitive Method

1981 – First Cholesterol in Human Serum SRM *(SRM 909)*

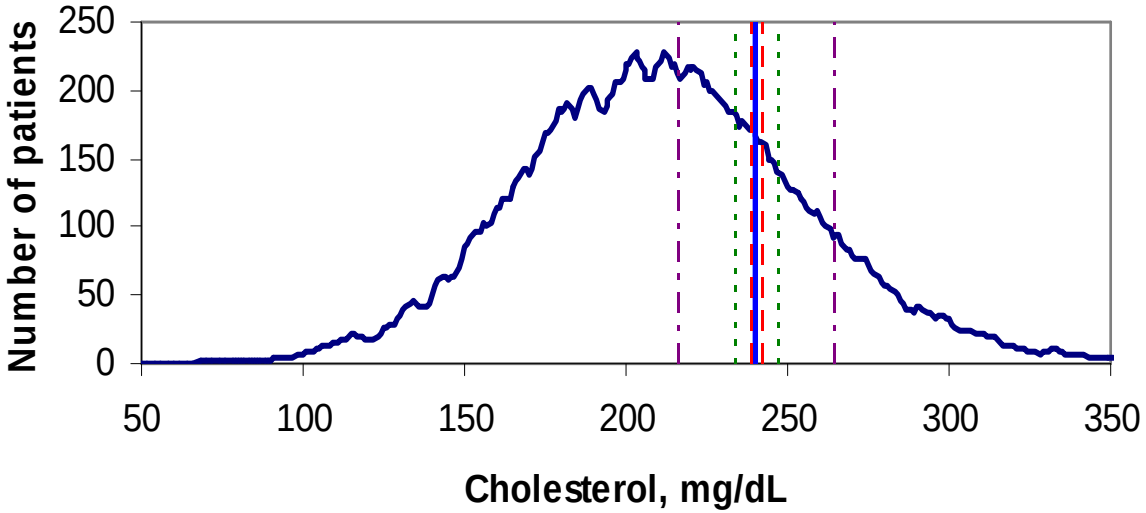
1988 – New Suite of Cholesterol in Serum SRMs at Medical Decision Points

1997 – New Suite of Fresh-Frozen Serum SRMs designed to address clinical analyzer commutability issues; Total-, HDL-, and LDL-Cholesterol and Triglyceride Values

Improvement in precision since 1968 has been estimated to **save $100M/yr in treatment costs**

*Data from GAO and CAP

Bias in Cholesterol Measurement Affects Medical Decision-Making



Cholesterol Frequency Distribution of >20,000

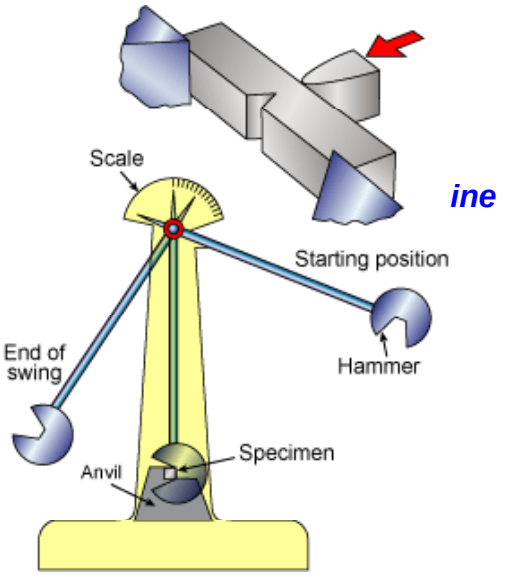
Mayo Clinic Patients

(with +1%, +3% and +10% limits around 240 mg/dL criteria point)

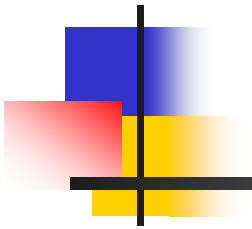
If measurement bias were:	Positives (>240 mg/dL) per 1000	Predicted Change in "Positives/1000"
-10% bias	120	-129
-3% bias	203	-46
-1% bias	234	-15
0% bias	249	
+1% bias	263	+14
+3% bias	300	+51
+10% bias	446	+197

SRM Charpy Impact Verification Program

- SRMs for the verification of Charpy V-Notch machines
  - ASTM Standard E 23 [1]
  - Accurately predict the reliability of structures, to avoid failures
  - Prioritize risk-based replacement/maintenance
- Achievements and Impact
  - >2300 units sold in FY09
  - Serves as an underpinning for quality control of the steel community and our end users ($10 B/yr)
  - Certify 10,000 specimens per year
  - Evaluate 1000 machines per year (worldwide)
  - Produces the most accurately characterized population of impact machines in the world.



The National Voluntary Laboratory Accreditation Program (NVLAP)



NIST
National Institute of Standards and Technology
U.S. Department of Commerce

NVLAP Support of U.S. Government Agencies

- Department of Energy (DOE)
- Environmental Protection Agency (EPA)
- Nuclear Regulatory Commission (NRC)
- Federal Communications Commission (FCC)
- Department of the Navy (DoN)
- Department of Housing & Urban Development (HUD)
- Department of Justice (DOJ)
- Department of Homeland Security (DHS)

NVLAP Conducts Three Programs Mandated by U.S. Congress

- Asbestos Hazard Emergency Response Act (AHERA) for testing for asbestos in public schools
- Help America Vote Act (HAVA) for the testing of voting machines
- Fastener Quality Act (FQA): Public Law 101-592- which requires that certain fasteners sold in commerce conform to the specifications to which they are represented to be manufactured.

What is Laboratory Accreditation?

- Independent, third party assessment of laboratory technical competence.
- Assessment is based on an international Standard (ISO/IEC 17025)
- Assessment of specific scope of accreditation
- Assessment by peer technical experts
- Results in formal recognition by the accreditation body

Fields of Accreditation

Calibration

Electromagnetic Compatibility & Telecommunications

Environmental

Fasteners and Metals

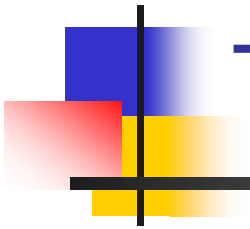
Home Security Applications

Information Technology Security Testing

Ionizing Radiation Dosimetry

Personal Body Armor

Product Testing Capabilities (e.g., carpet, plumbing, thermal insulation, lighting, motors, voting systems)



Training

Measurement Course Examples

- TS Laboratory/Metrology Seminars
  - Basic Metrology - States
  - Basic Mass - Industry
  - Intermediate Metrology
  - Advanced Mass, Advanced Mass Hands-on
  - 6 Regional Measurement Assurance Programs
  - MSC - NIST Seminars: Accreditation (NVLAP), Practical Measurement Assurance
  - NCSLI - Balance & Scale Tutorials
  - Webinars – variety of laboratory management topics
- Summer Institute for Teachers
- Display Metrology
- Laser Measurements
- ARFTG Microwave Measurements
- Microwave Measurements for Emerging Materials
- Near-Field Antenna Measurements and Microwave Holography
- Instrumentation, Metrology, and Standards for Nanomanufacturing
- Gage Blocks
- MSC - NIST Seminars: Pressure and Vacuum, Fluid Flow, Uncertainties
- Mini-Workshop on ITS-90 Fixed Points
- The Role of NIST in Improving the Accuracy of Natural Gas Flow Measurements
- Spectrophotometry
- Time and Frequency Metrology Seminar
- High-Frequency Characterization of Printer-Circuit Board materials
- Optimum CMOS Integrated LNA Design Techniques for Handsets

CNRF Training in Neutron Measurements

GRADUATE STUDENTS

- Summer School: 36 participants/year
- Tutorials: 12 participants/tutorial
- University courses

UNDERGRADUATES

SURF: 48 students since 2000

Tours

Internships

School presentations

- K-12 & TEACHERS