electronics and electrical engineering laboratory

Presentation to the NRC Panel

February 23-25, 2005

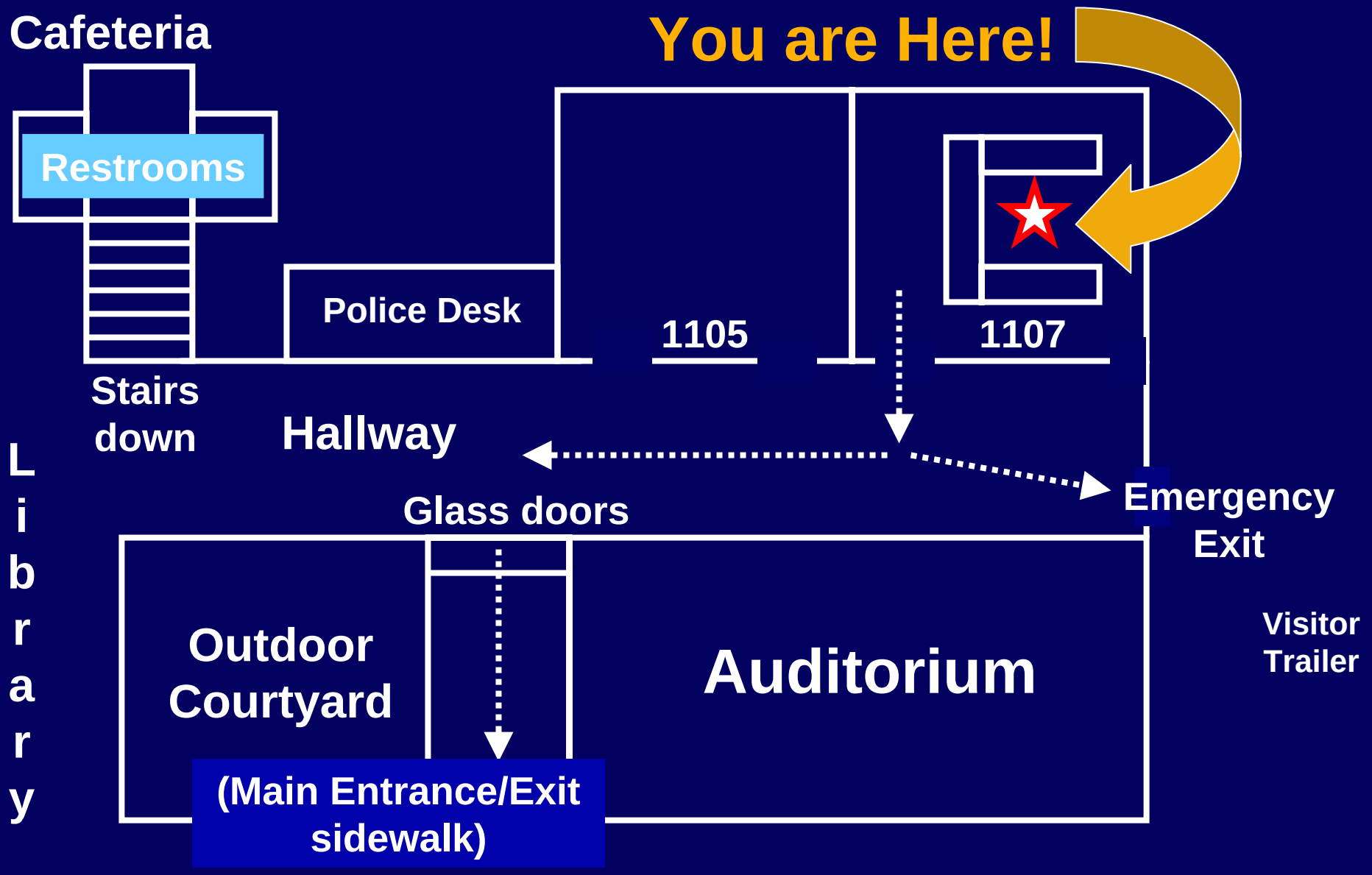
Bill Anderson
Director, EEEL

Agenda

- Safety First
- Charge to the Board
- FY04 in a Nutshell
- FY03 Panel Recommendations & Responses
- Our Organization
- Our Staff
- Highlights from Our Technical Program
- Resource Trends and Planning

Safety First

Safety First General Information



Charge to the Board on Assessment

For the FY20004/2005 assessment cycle, I ask that the Board on Assessment focus its assessment of the NIST Laboratories on three factors:

- the **technical quality and merit** of the laboratory programs relative to the state-of-the-art worldwide;
- the **effectiveness** with which the laboratory programs are carried out and the results disseminated to customers; and
- the **relevance** of the laboratory programs to the current and future needs of customers.

As part of its assessment of these three factors, I ask the Board and its Panels to consider the adequacy of the Laboratories' facilities, equipment, and human resources to enable the Laboratories to fulfill their mission and meet their customers' needs.

…Arden L. Bement, Jr., December 2003

FY04 In a Nutshell

EEEL has delivered world-leading research and has maintained and improved measurement services throughout a year of transitions:

- Gaithersburg divisions moved to AML
- EEEL implemented new Quality system
- Staff adjusted to FY03 reorganization
- Lab adjusted to an FY04 budget which was worse than previous worst-case predictions

FY05: Challenges Going Forward

Increasingly difficult to maintain core metrology focus

- Hard to obtain OA sponsorship of work so inherent to NIST mission
- Drive towards SFAs comes at some cost to core program

FY05 downsizing taking toll on staff morale

- FY03 downsizing was expected to keep us solvent, position us for growth
- Continued cuts in metrology staff

FY03 Panel Recommendations & Responses

Increase publicity of accomplishments

- EEEL has had some highly visible news coverage in FY04
- Marketing facilitator hired for upcoming management off-site
- Revised Technical Accomplishment books
- Detailed web site

Impact of tight budgets on strategic and succession planning

- Succession plans in place for all key positions
- Budget limitations continue to force downsizing

FY03 Panel Recommendations & Responses

AML move underfunded, potentially disruptive

- Nearly all projects have moved to AML without disruption of services
  - Additional moves: nanofab projects, electronic kilogram

Increase communication

- Semiannual town meetings, small group meetings with Director, regular division-level meetings

Need to share fund-raising expertise across Lab

- Mentors sharing lessons learned with others

Our Organization

EEEL Mission and Assets

Mission

To strengthen the U.S. economy and improve the quality of life by providing measurement science and technology, and by advancing standards, primarily for the electronics and electrical industries.

Assets

- Full-time permanent staff of 215, organized into 4 Divisions and 2 Offices
- Non-permanent complement of 140
- FY05 appropriated budget: $42M
- FY05 external funding: $17M
- FY05 pass-through (estimated): $15M

EEEL Organization

EEEL Management Team

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

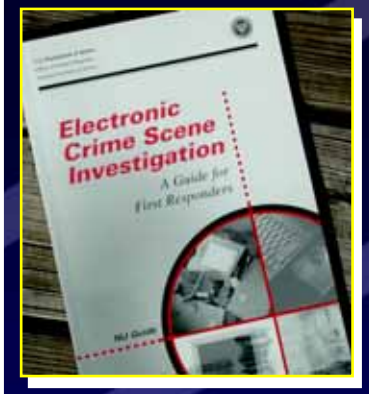
Quantum Electrical Metrology Division
James Olthoff

Electromagnetics Division

Dennis Friday

Office of Law Enforcement Standards

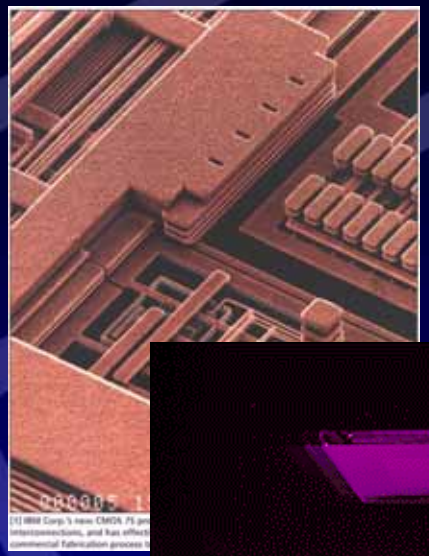
- Chemical Systems & Materials
- Critical Incident Technologies
- Weapons & Protective Systems
- Detection, Inspection and Enforcement Technologies
- Forensic Sciences
- Public Safety Communications Standards

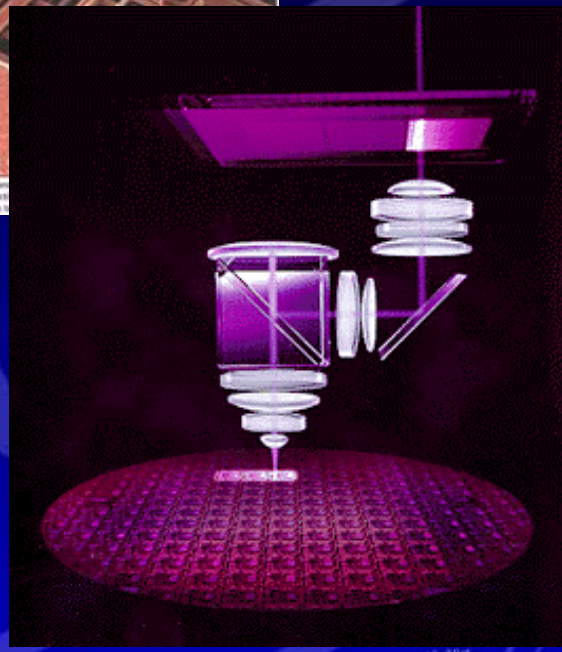


http://www.eeel.nist.gov/oles/

Office of Microelectronics Programs

- Lithography Metrology
- Critical Dimension and Overlay Metrology
- Front End Processing Metrology
- Interconnect and Packaging Metrology
- Process Metrology
- Analysis Tools and Techniques
- Device Design and Characterization
- System Design and Test Metrology
- Manufacturing Support

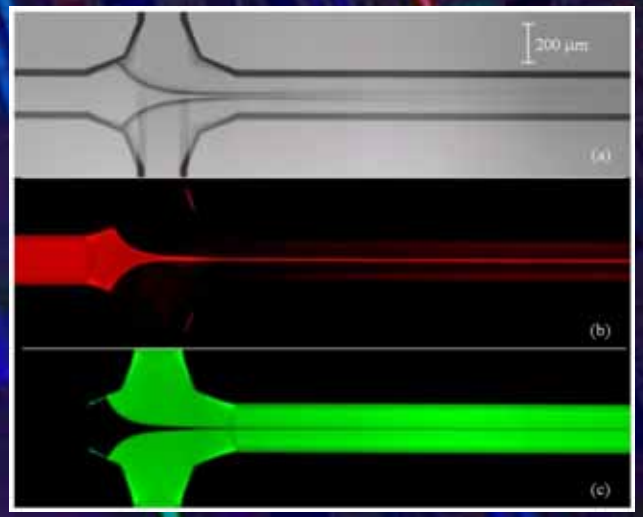




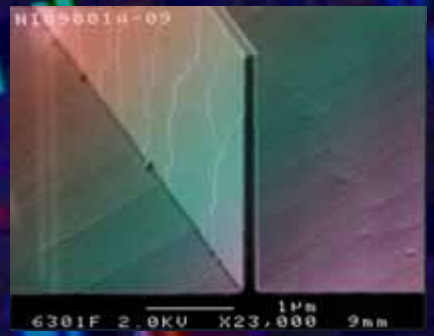
http://www.eeel.nist.gov/omp/

Semiconductor Electronics Division

Provides measurement infrastructure for:



- **Silicon CMOS**
- **Beyond CMOS**
- **MEMS/NEMS**
- **Power Electronics**
- **Compound Semiconductors**
- **Supply Chain Interoperability**



Optoelectronics Division

Provides calibrations and measurements for detectors, displays, and optical components

Provides measurement infrastructure for emerging optoelectronic materials and devices

Provides research, development, and measurements for optoelectronic nanostructures and quantum optical devices

Quantum Electrical Metrology Division

Provides the basis for ALL electrical measurements made in U.S.

Develops next-generation quantum-based standards and electrically-based measurements

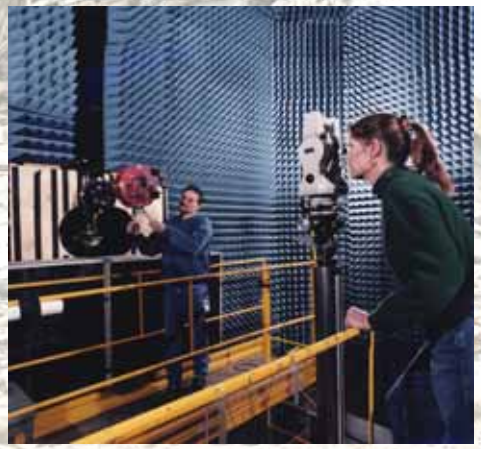
Provides calibration and measurement services for electrical standards, including: voltage, resistance, capacitance and power

Photo © Robert Rathe

Electromagnetics Division

Measurement infrastructure for:

- Basic microwave quantities: power, noise, impedance etc.
- Electromagnetic fields, probes and antennas
- Magnetic sensors and information storage technology
- Properties of high-power superconductors
- EM fields and compatibility of devices and systems
- Wireless communication systems and devices, and radio propagation



EEEL Organization: Planning & Operations

- Ongoing strategic planning
  - Division-level yearly offsites
  - Lab-level yearly offsites
- Semiannual personnel reviews
- Quarterly management reporting
  - Evolving into web-based project tracking system
- Updated Operational Plan

Payouts & Bonuses: EEEL 1st to Implement New System

Score	Comments
90	Exemplary work resulting in maximum impact. Outstanding performance that far exceeds normal expectations. Achieved very challenging stretch goals or far exceeded challenging goals.
85	Very good to excellent; highly productive while significantly exceeding normal expectations. Very good progress on stretch goals, consistently met more challenging goals, or exceeded typical goals.
80	Good, high-quality, effective work; met & often exceeded normal expectations. Consistently completed milestones.
75	A good solid contributor; meets normal expectations with appropriate work outputs.
70	OK; met most nominal expectations; missed one or more milestones.
60	Marginal Contributor
40	Minimally Acceptable

EEEL FY03 Reorganization - *Motivation*

- EEEL was anticipating a $4M shortfall in FY04
- Organization had shrunk “unevenly” through attrition
  - Several technical areas were 1-person deep
  - EEEL had Institute’s highest percentage of overhead to technical staff
- Organizational structure wasn’t optimized for teamwork
- Investment priorities needed re-evaluation

EEEL FY03 Reorganization - *Implementation*

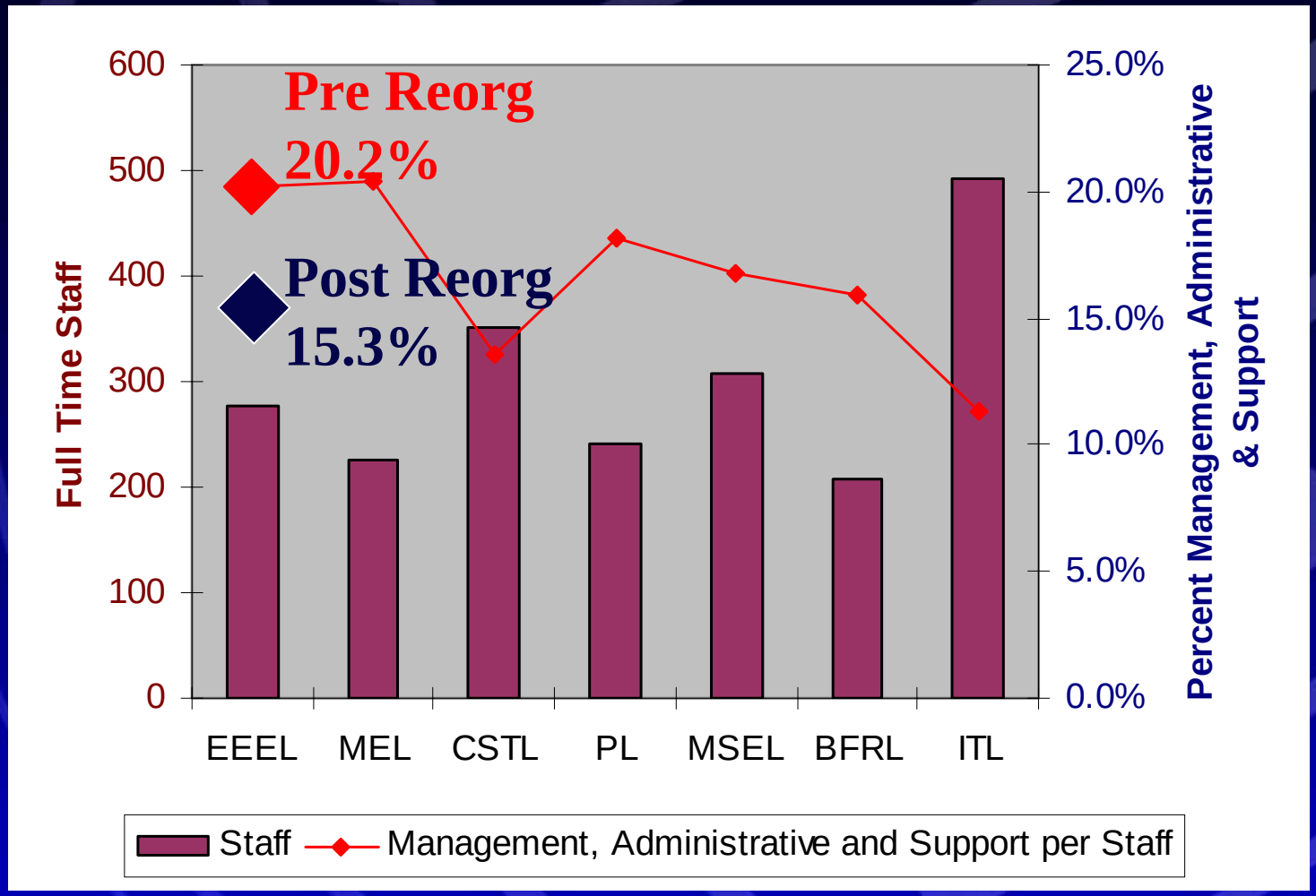
- Divisions reduced from 6 to 4
- Group Leader positions reduced by about a third to 12
- Elimination of 2 Deputy Division Chief positions
- 30 positions were eliminated from EEEL:
  - 15 technical positions (ZP + ZT)
  - 4 management positions (ZP)
  - 9 support positions (ZS)
  - 2 administrative positions (ZA)

For a savings of $6M.

EEEL FY03 Reorganization - *Results*

- EEEL balanced budget in FY04
  - In spite of fact that actual FY04 budget was even worse than our most severe projections
- EEEL created multi-disciplinary, cross-campus divisions, better positioned to compete for sponsor funds
- More “bucks to the bench”
- Weak FY04 budget kept reorg from leaving us healthy

EEEL FY03 Reorganization - *Results*



FY05 – Continued Downsizing

- 15 positions proposed to be abolished
  - 4 in the Quantum Electrical Metrology Division
  - 11 in the Electromagnetics Division
- Programmatic areas being reduced:
  - ac-Quantum Hall Resistance
  - Electric power metrology
  - Calibration services for RF power, impedance, voltage, noise and complex scattering parameters
  - Non-linear characterization of devices

Our Staff

External Recognition

One of "Brilliant 10"
Sae Woo Nam

Karel Urbanek Award
Jack Martinez

Certificate of Appreciation
John Schlager

Fellow
Sarah Gilbert

Best Paper
Kate Remley
Dylan Williams

Distinguished Service Award
Michael Francis

External Recognition

Special Recognition Award
Art Griesser, John Messina
Nick Paulter

Fellow
Herb Bennett
Robert Schwall

Allen V. Astin Best Overall Paper
Hector Laiz

Best Original Paper
Akira Fujiwara

Distinguished Medal
Ranbir Singh

External Recognition

Fellow	Ron Goldfarb Pavel Kabos Perry Wilson
Life Fellow	Herb Bennett Alan Cookson
Best Paper	David Hill Chris Holloway Perry Wilson
Graduate Student Fellowship	Javier Salcedo

Congratulations Sae Woo Nam
PECASE Awardee

DoC/NIST Recognition

Gold

Roger Marks (03)

Silver

Roger Marks (04)
David Newell (04)
Paul Hale, Tracy Clement, Dylan Williams, Juanita Morgan (04)
Susan Ballou (03)
Kate Remley, Don DeGroot, Jeffrey Jargon (03)

Allen V. Astin

John Lehman (03)

Bronze

Jim Beall, Maggie Crews, Jonathan Koch (04)
Tom Silva, Anthony Kos, Pavel Kabos (04)
John Schlager (03)
Nick Paulter (03)
Galen Koepke & John Ladbury (03)

Judson C. French

Paul Williams (04)
Dean Jarrett & Rand Elmquist (03)

Staff Diversity

- American Physical Society Assessment
  - Goal: help improve the climate for minorities and women
  - Site visits, both campuses, summer 05
- Announced EEEL Ombudsman
- Diversity Team
  - Enabled travel to Minority Serving Institutions (MSIs) and other minority organizations
  - Training
  - Talks
  - Surveys

2004 NIST Employee Survey: The Good News

Staff are generally:

- Committed to NIST
- Satisfied with jobs
- Believe their jobs are important to success of NIST
- Favorable opinion of direct management, colleagues
- Believe NIST is a safe place to work

EEEL had highest response rate of NIST labs

2004 NIST Employee Survey: The "Opportunities"

Staff expressed:

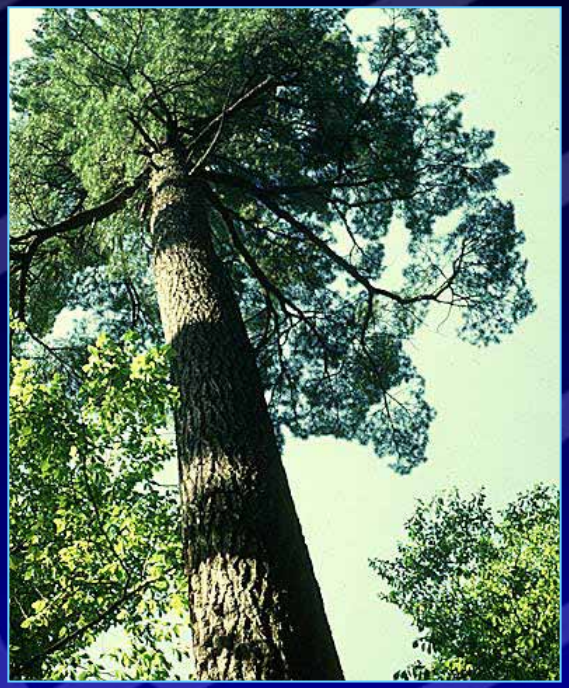
- Desire to be more engaged in the decision making process
- Less commitment to NIST
- Lack of confidence in their future at NIST
- Lack of confidence in senior management
- Less likely to recommend NIST as a place to work

EEEL Safety

- EEEL reportable injuries
  FY02: 1 (slip/fall)
  FY03: 3 (2 exertion/motion, 1 struck by)
  FY04: 0
  FY05: 1* (exertion/motion) *to date
- DuPont assessment of EEEL (FY03) and DuPont safety audit training (FY04)
- Ergonomics evaluations/training (Boulder, FY04)
- EEEL laser safety program
- EEEL facilities improvements
  - Open Air Test Site refurbished, added ventilation to provide fresh air through long tunnel, sealed walls to prevent leaks, installed telephone
- Active EEEL staff participation/leadership in NIST Safety Council, Safety Operational Committee

Highlights from Our Technical Program

NIST Strategic Focus Areas (*SFAs*)



Programmatic SFAs:

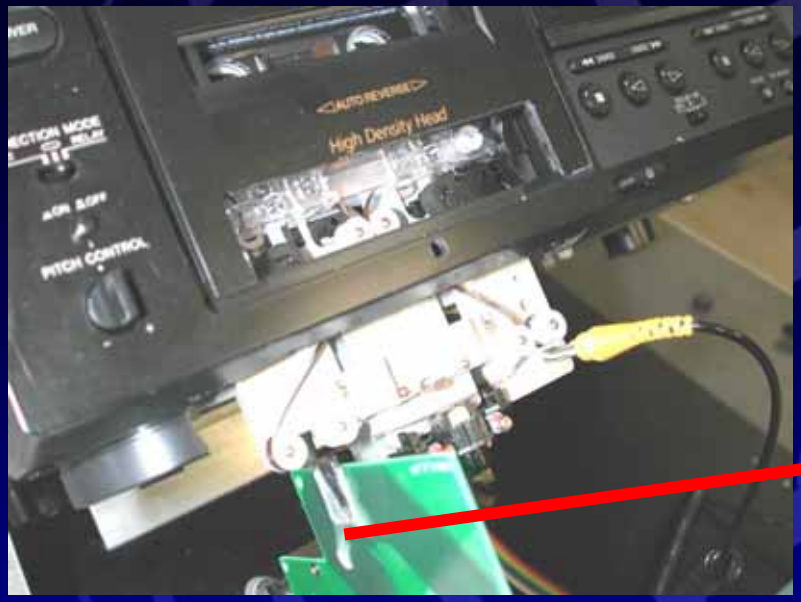
- Core Metrology & Standards
- Nanotechnology
- Biosystems & Healthcare
- Information / Knowledge Management
- Homeland Security

Core Metrology & Standards

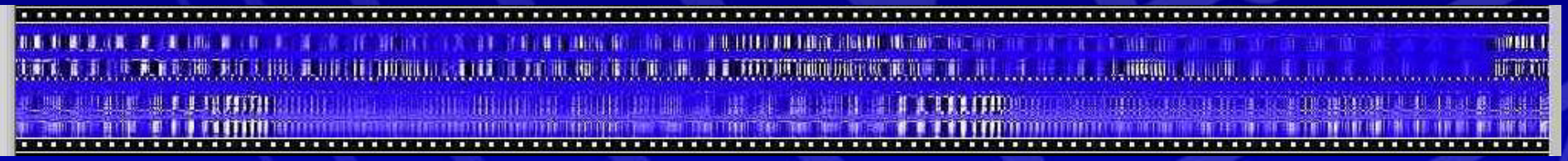
Electromagnetic Shielding: Contributing to Shuttle Safety

- NASA to use high-power radar on launch/ascent of shuttle to detect debris damage
- EEEL to measure electromagnetic shielding of both orbiter and the main liquid hydrogen fuel tank
- EEEL evaluation seen as critical step in the Shuttle's return to flight

Real Time Magnetic Tape Viewer

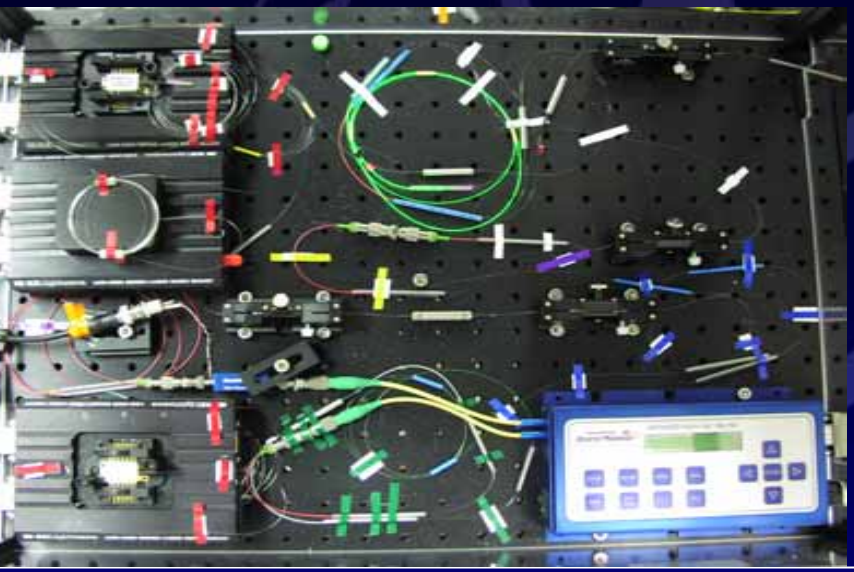


64 element head for 4 mm audio cassette tapes
Proto-type system delivered in September 2004
256 element design in progress



- One second worth of data from music audio tape
- Can tell by the beat that it's Michael Jackson

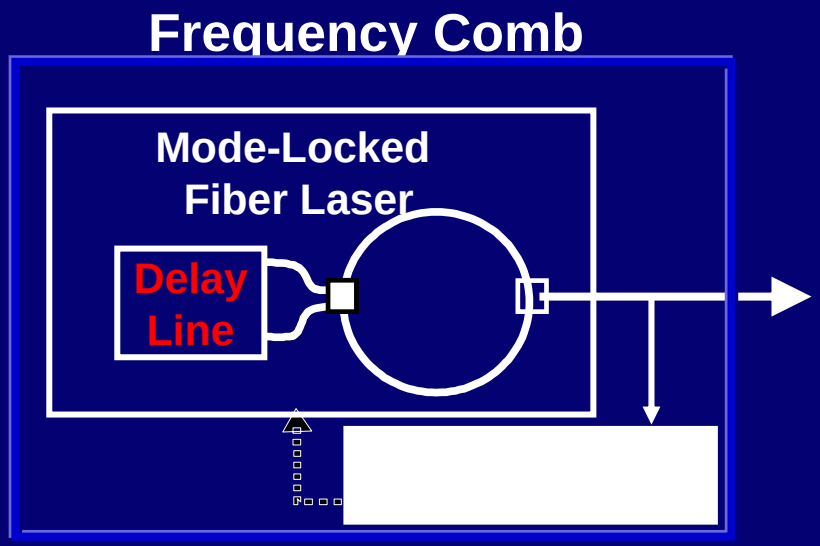
Widely Tunable Optical Frequency Comb

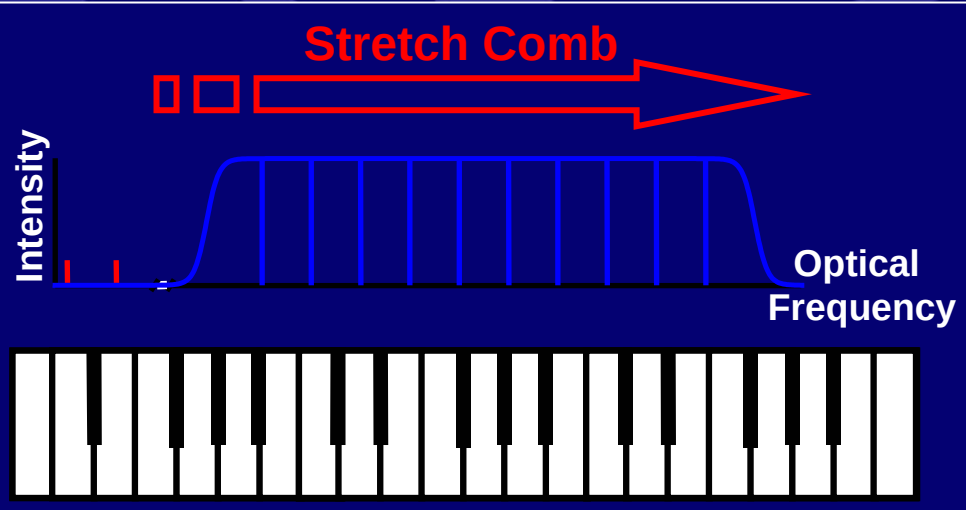


Stretch frequency comb while holding one tooth fixed

Potential applications:

- High-accuracy optical frequency metrology
- Precisely tunable IR laser (laser locked to one tooth of comb)
- Remote sensing & laser communication





Each comb line a single optical "note"
Stretching comb "re-tunes" notes

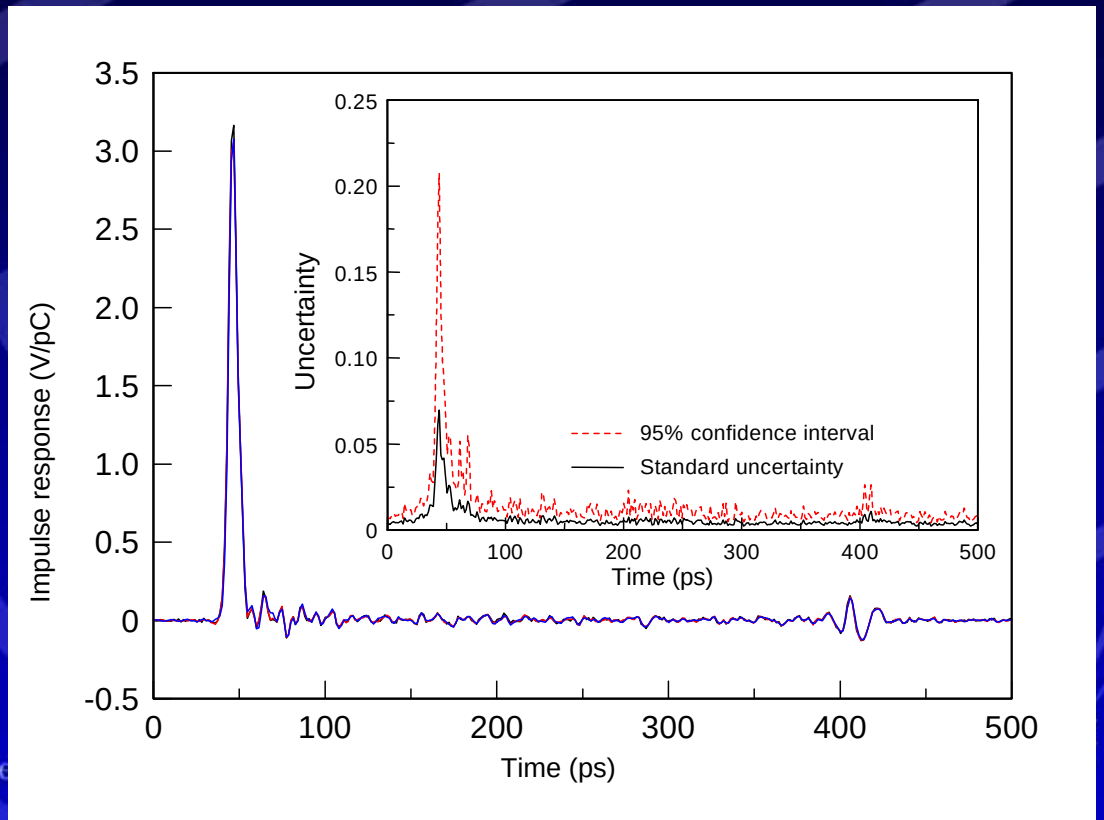
Electro-optic Sampling System: A New Paradigm in Waveform Measurement

A new concept in waveform metrology:

- **Waveform traceability to electro-optic effect**
- **New NIST temporal mismatch-corrections**
- **Joint time/frequency domain uncertainty analysis**

Represents collaboration between Optoelectronics and Electromagnetics Divisions.

Calibration services below 50GHz currently available from Quantum Electrical Metrology Division (Gaithersburg).



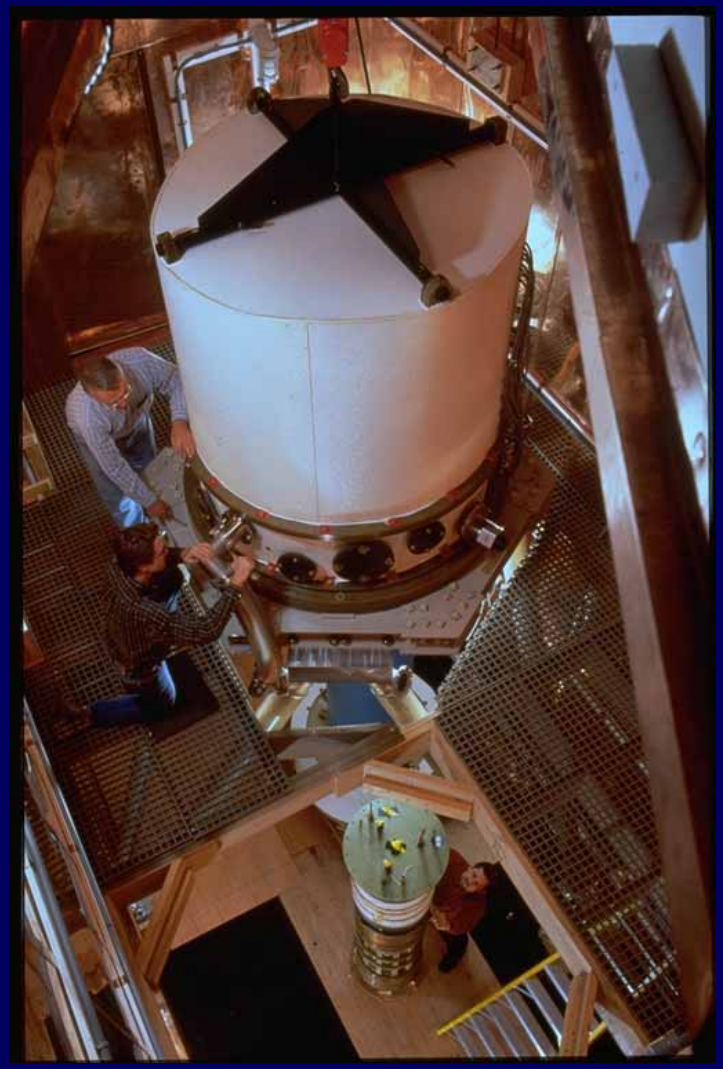
Time Synchronization Standards

Why Synchronize Time?

- Process Control
  - Correlating process data
- Manufacturing Automation
  - Coordination among tools
  - Time interval for completion

- Fault Diagnostics
  - Event sequence leading to error
    - Northeastern Blackout, August 2003
- Network Operations
  - Security
  - QoS measurement

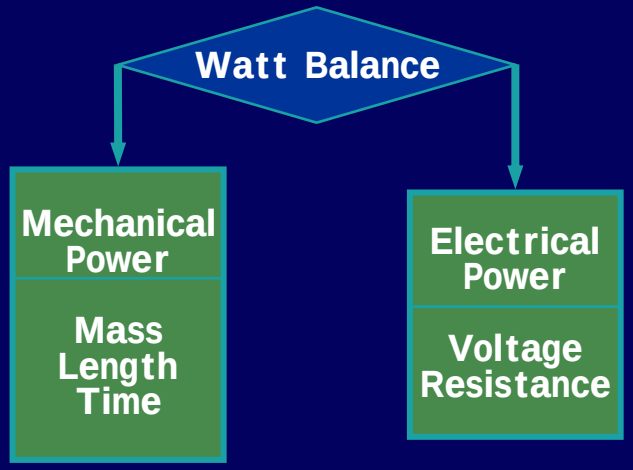
Setting Tomorrow's Standards: The Electronic Kilogram



Redefining the kilogram based on fundamental constants of nature.

Delivering:

- SI unit of voltage
- New values of fundamental constants (e.g., Planck Constant, Electron Charge)
- Nano-scale force metrology

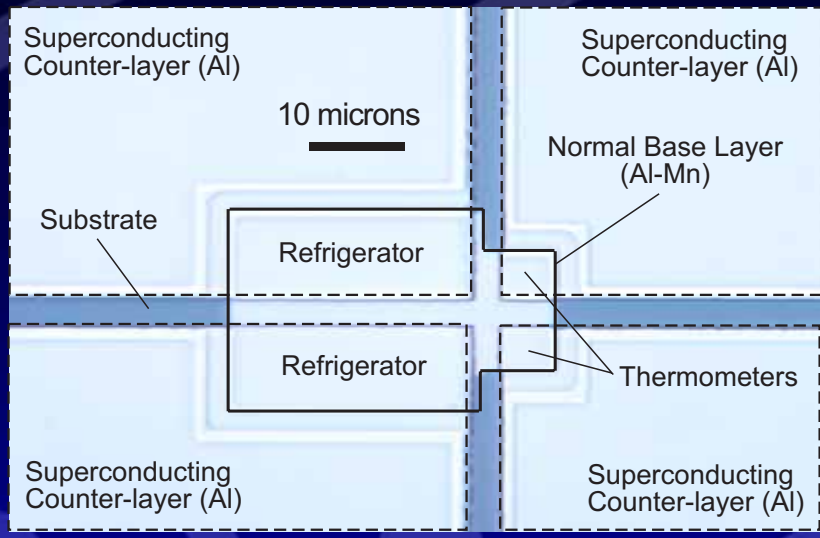


Improving the determination of fundamental constants: Redefining the kilogram by fixing the value of the Planck constant or Avogadro's constant

Nanotechnology

Quantum Sensors

- Develop sensors based on quantum phenomena for spectroscopy, imaging, and precision measurements
- Developed x-ray detector of extremely high resolution
- Fabricated an on-chip, solid-state microrefrigerator
- Demonstrated first multiplexed readout of x-ray microcalorimeter array
- Developed a full 1280-pixel multiplexed submillimeter bolometer array for SCUBA-II
- Transferred x-ray microanalysis application technology to industry



New Cryogenic Refrigerator

- Solid-state refrigerator for cooling sensors to temperatures near 0.1 K
- Based on quantum tunneling of hot electrons

cover of *Applied Physics Letters* (January 26, 2004)

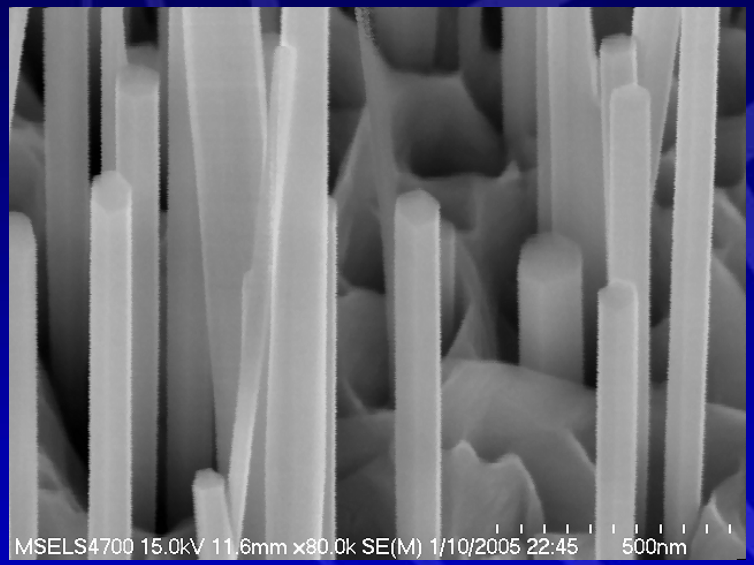
cover of *Physics Today* (May, 2004)

tunnel junctions (in corners) cool separate thin-film electronics such as a x-ray calorimeter (middle)

Compound Semiconductor Nanowires

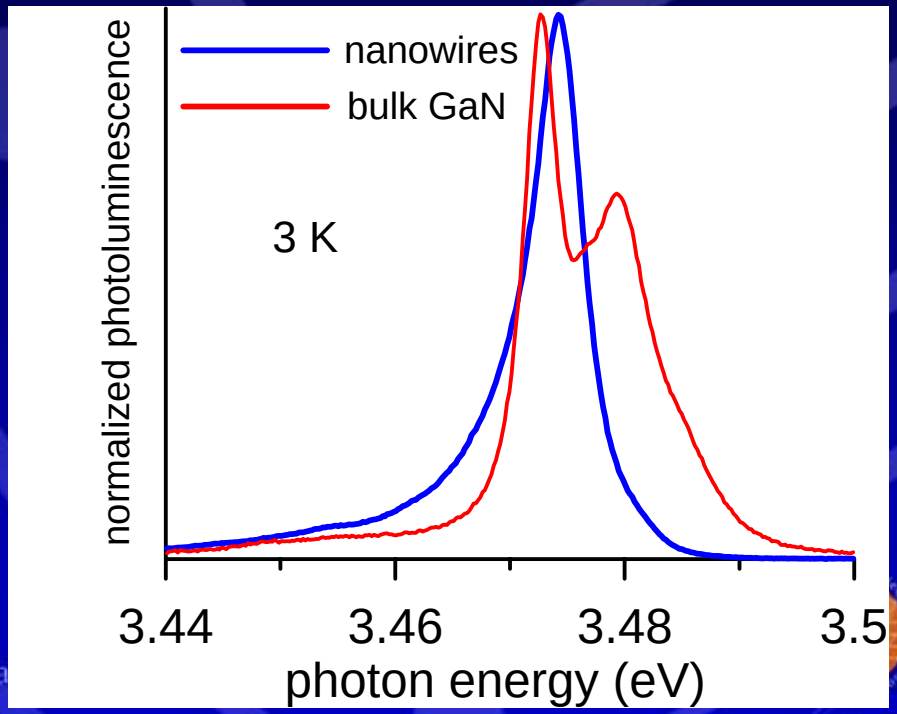
- World-class GaN nanowire growth
- High-efficiency photoluminescence
- Applications: Blue/UV nanowire lasers for biological/chemical agent sensors, in-vivo cancer diagnosis, high resolution near-field microscopy
- Fundamental material properties don't scale from macro to nano regime
- Developing nano-metrology techniques, test structures and data

Nanowires: 50-150 nm diam., 3-5 μm long

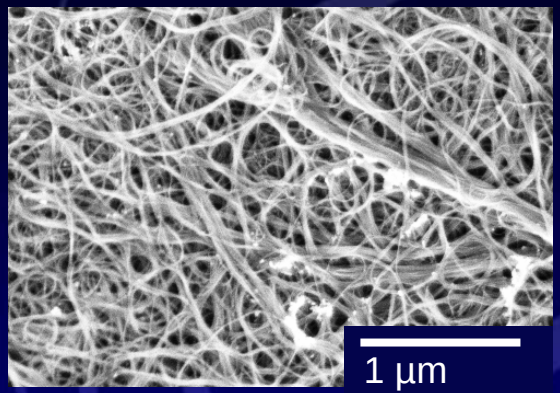


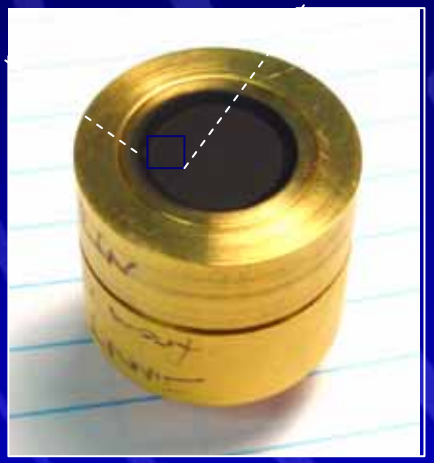
SEM image: 40° tilt

500 nm



Detector R&D: Next Generation Standards





Carbon nanotubes for the *next generation* of black thermal coatings for optical power and energy measurement standards

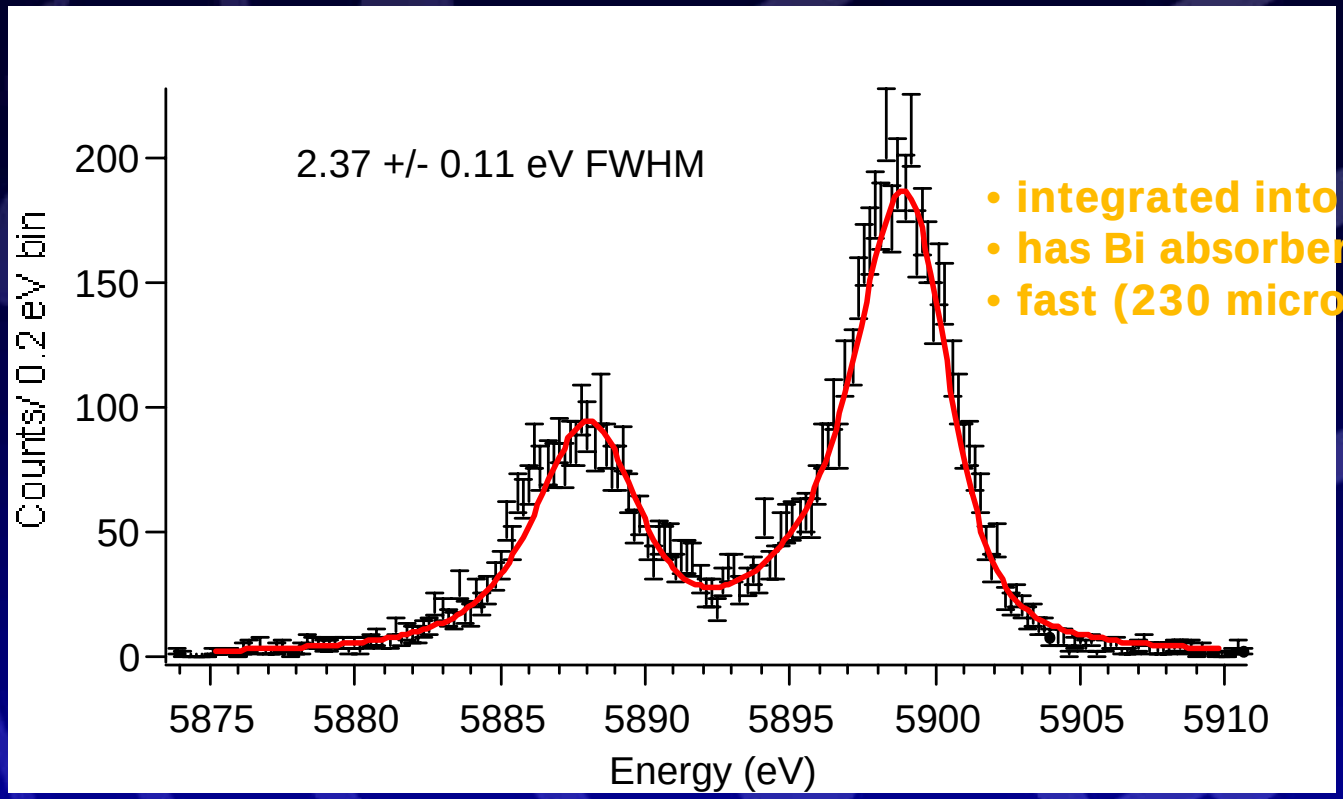
SWNTs, MWNTs on a detector as the substrate

- **High thermal conductivity**
- **High damage threshold**
- **Spectrally flat**

This pyroelectric detector coated with carbon nanotubes is the first of its kind and allows us to directly measure the optical and thermal properties of various tube compositions and topologies.

Collaboration with NREL, MSEL

World-Record Detector Performance: 2.4 eV FWHM at 5.9 keV

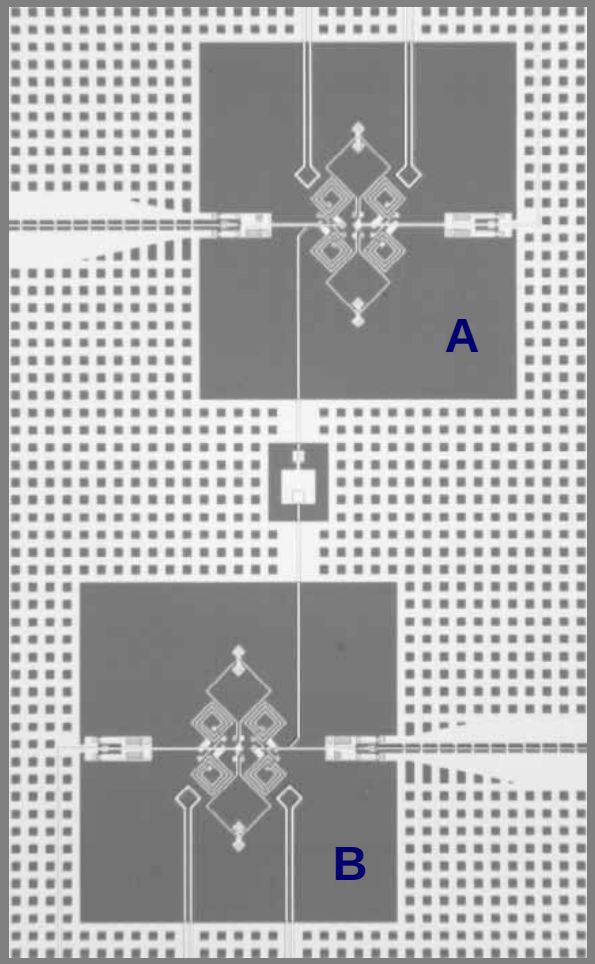


- integrated into array
- has Bi absorber for high QE
- fast (230 microsec) recovery

Best energy dispersive detector of any type!

NIST calorimeter:	**E/DE = 2490**
• magnetic calorimeter	= 1760
• calorimeter (previous)	= 1500
• SIS junction	= 540
• SiLi	= 50

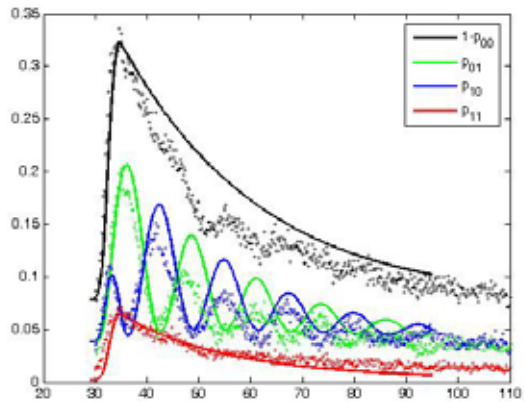
Solid State Quantum Computing

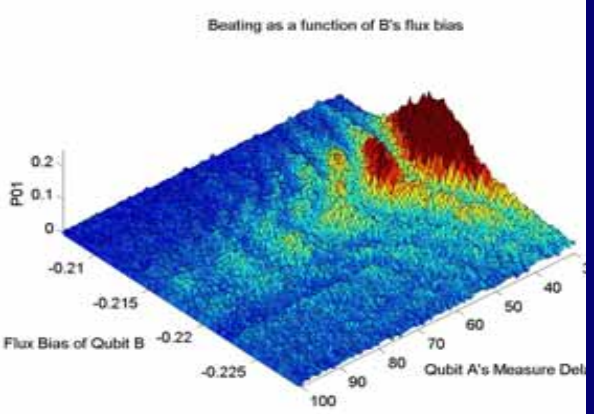


Goal: Develop a superconducting quantum computer

Approach utilizes:

- Superconducting materials with low dissipation
- Macroscopic quantum physics of Josephson junctions
- Integrated circuit fabrication using optical lithography
- Low temperature microwave engineering
- Materials research for improved junction fabrication

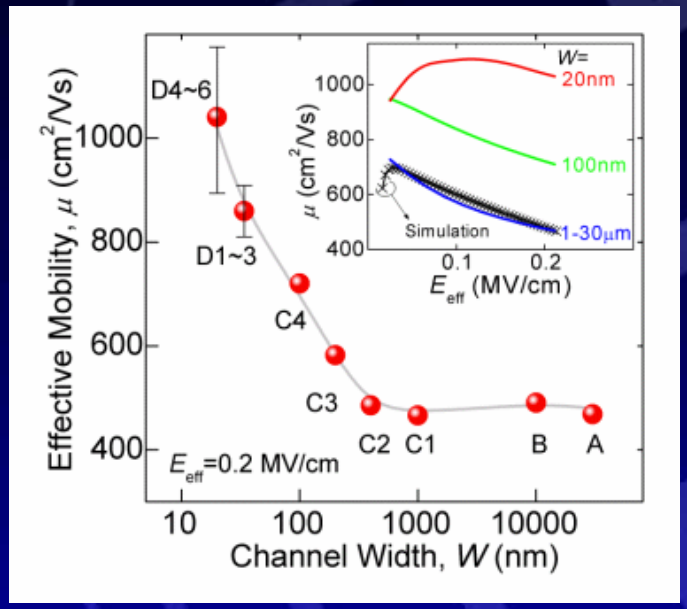




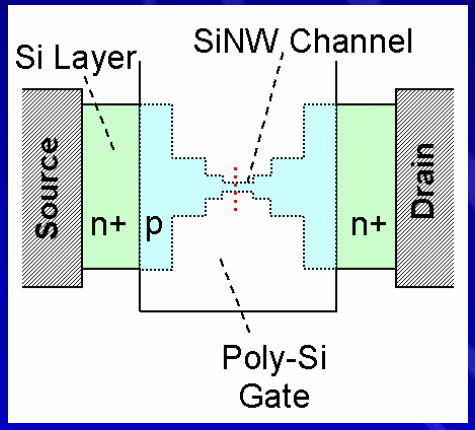
Achievements:

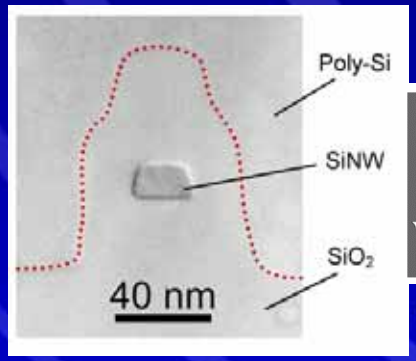
- Created "electrical atom"– qubits made from superconducting Josephson junctions
- Measured simultaneous coupled interaction between two Josephson junction qubits
- Developed materials research tools for improving Josephson junction qubits

Enhanced Inversion Mobility in Silicon Nanowire Field Effect Transistors



- Mobility extraction protocol in "top-down" Si nanowire (SiNW)
- Systematic study on SiNW FETs with different channel geometries
- SiNW shows 1.3-2.2 times higher inversion channel mobilities
- SiNW FETs by EBL may provide performance benefits that are compatible with Si ULSI technology
- Collaboration with MSEL





NANO LETTERS
Nov. 10 2004
Vol. 4, No. 11
2197−2201

Sang-Mo Koo,*,† Akira Fujiwara,‡ Jin-Ping Han,† Eric M. Vogel,† Curt A. Richter,† and John E. Bonevich§

High Inversion Current in Silicon Nanowire Field Effect Transistors

Quantum Dot Mode-Locked Lasers

Applications: Optical atomic clocks, THz generation, spectroscopy, optical coherence tomography, machining

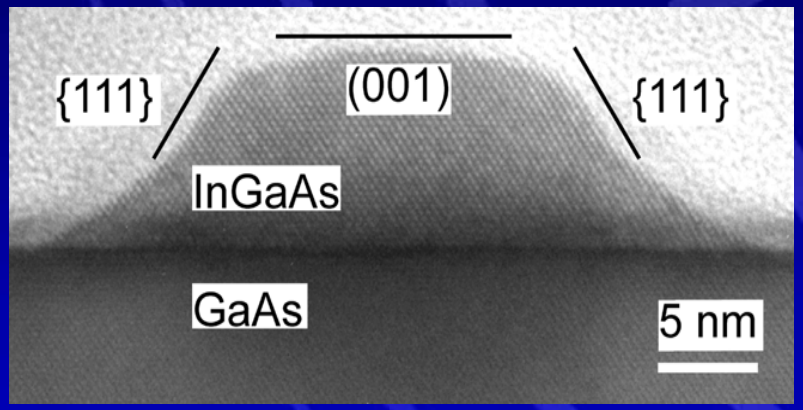
Goal: Break current performance barriers of mode-locked lasers by 10x in: pulse width, laser efficiency, device volume, cost

NIST Expertise: Growth, fabrication and physics of quantum dot (QD) lasers
Measurement of fundamental properties of QDs

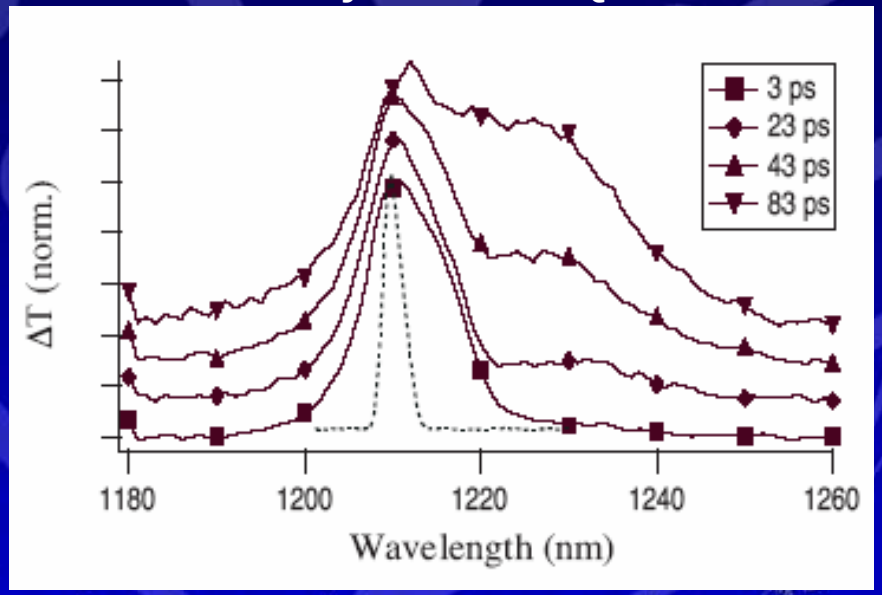
Collaboration: JILA

Funding: EEEL Director's Reserve, DARPA

TEM Image of Quantum Dot



Carrier dynamics of QDs



Office of Microelectronics Programs

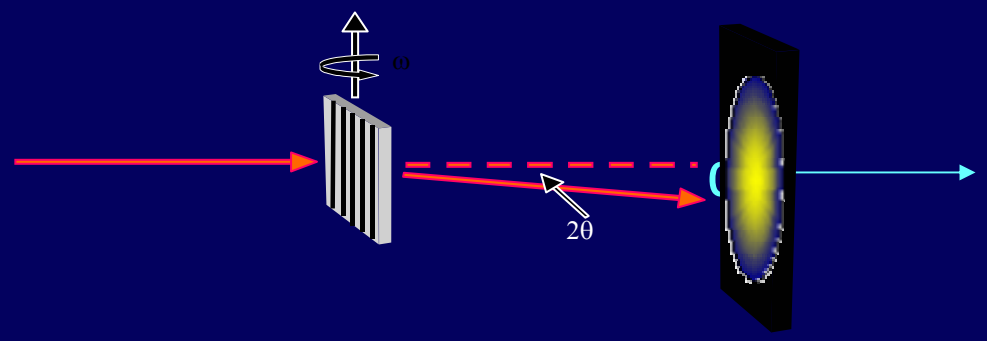
- ~$12M National Semiconductor Metrology Program (NSMP) initiative funding/year
  - All NIST Laboratories participate
- ~$12M matching funds from NIST Laboratories and other sources
- OMP manages NSMP, assists NIST management for maximum impact of projects, brokers NIST capabilities to industry

Recent OMP Project Accomplishments

- Provided key measurements for EUV and DUV lithography development
- Demonstrated capabilities of Critical Dimension Small Angel X-ray Scatterometry
- Completed guideline for porosimetry of low k materials
- Developed metric criteria for line edge roughness

OMP Funded Work

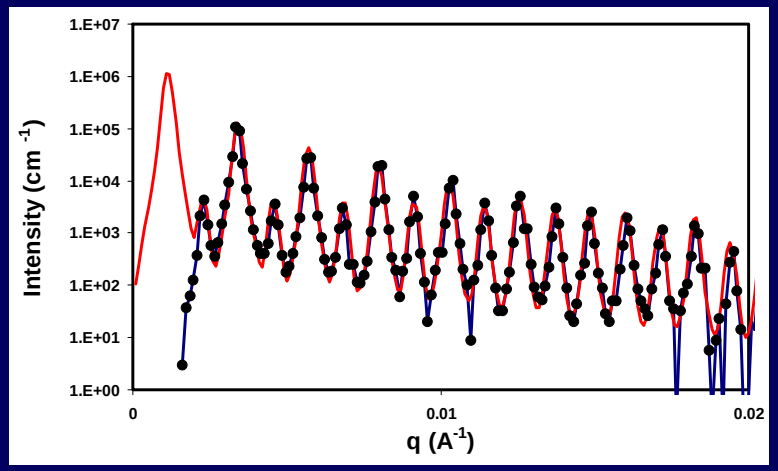
CD-SAXS: Measuring CD and Pitch



Novel technique allows accurate measurements of nanoscale features:

- **Density & thickness of sidewall damaged layer**
- **Integrity of barrier layer**
- **Line edge roughness**

First technique to provide unambiguous overlay measurements of hidden features



CD-SAXS diffraction data (black) fit to provide pitch and line width

Collaborations

Center for Neutron Research
Precision Engineering Division

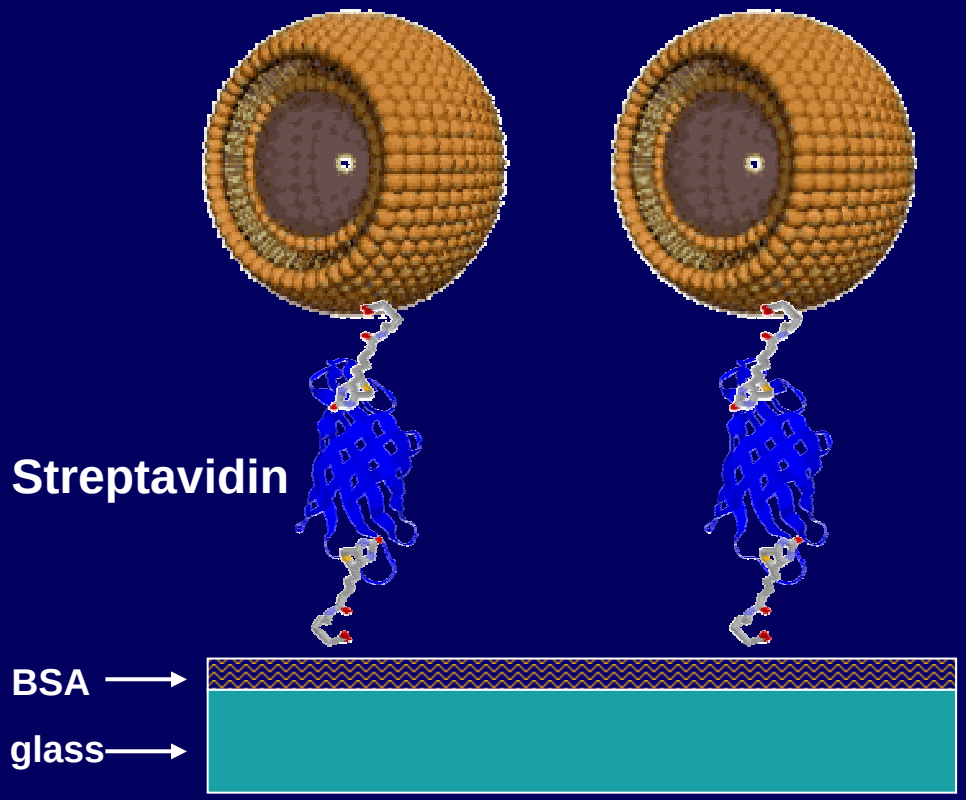
Recent OMP Project Accomplishments (Cont.)

- Developed artifact for AFM calibration down to 40 nm
- Provided second NIST assignee to ISMT
- Acceptance by SEM companies of model-based linewidth metrology for incorporation on their instruments

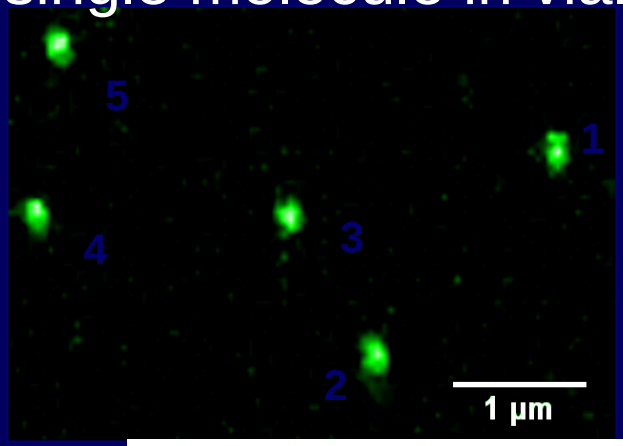
Biosystems & Healthcare

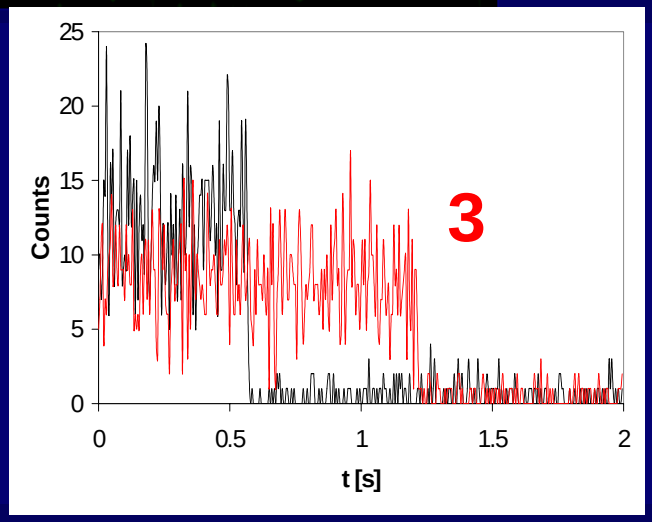
Self-Assembly of Nanovials for Single Molecule Measurements

Creating a measurement environment for free-floating molecules

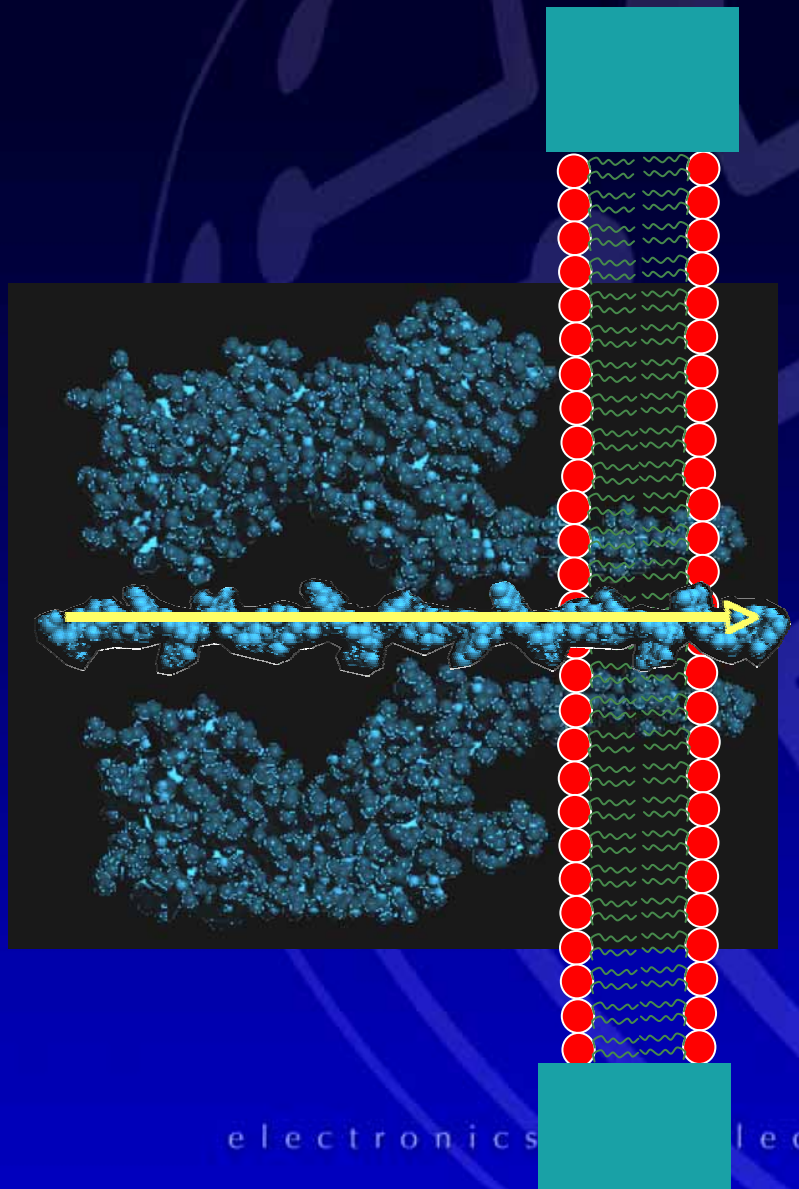


Fluorescent dye showing single molecule in vial

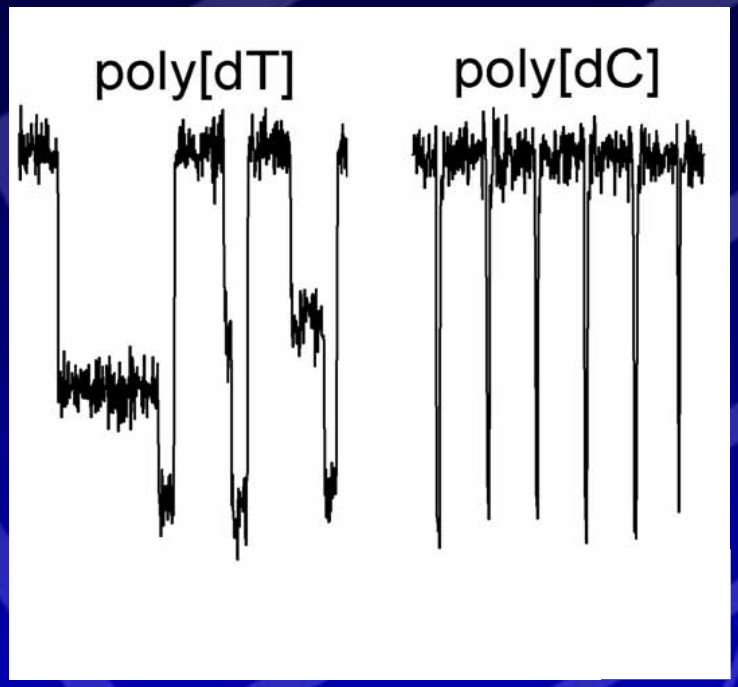




Electronic Measurements of DNA Translocation Through Nanopores

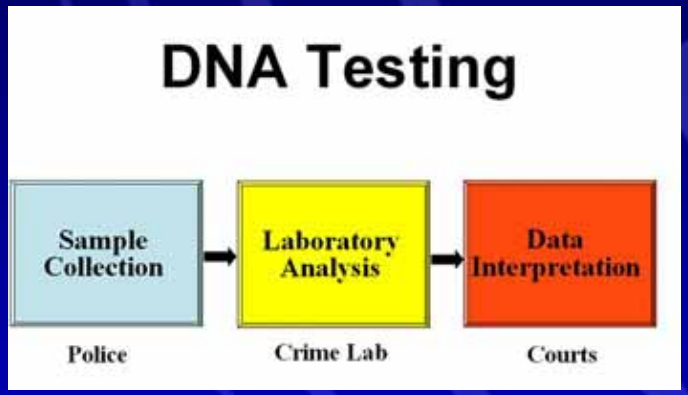


Measuring current change as DNA moves through a nanopore



New Microfluidic DNA Analysis System for Forensics Applications Demonstrated

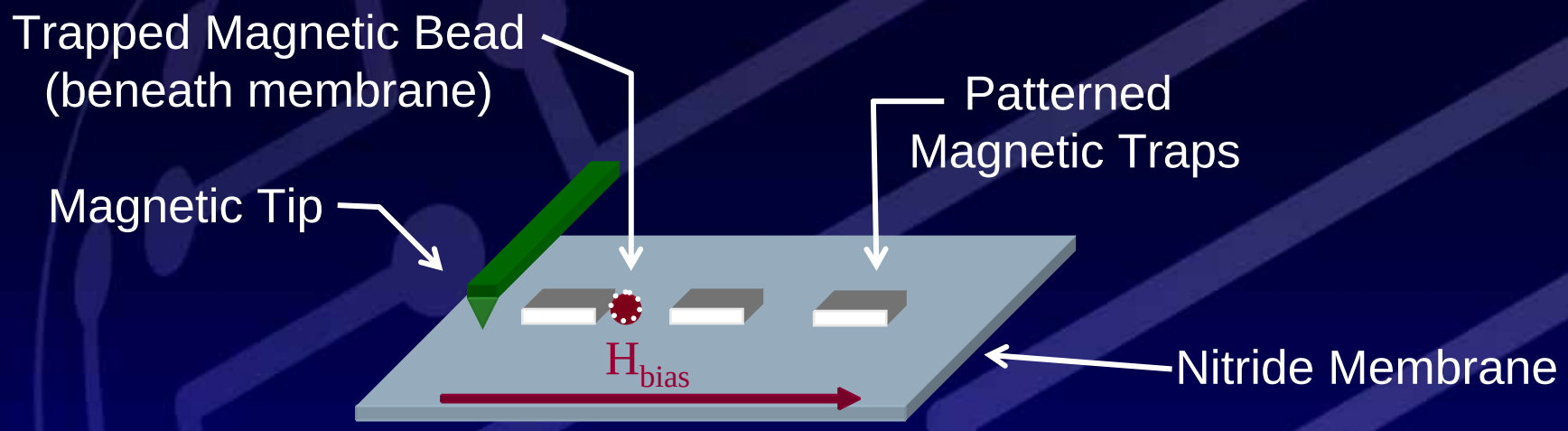
- Modern forensic DNA analysis uses a 30-minute capillary electrophoresis process to separate DNA fragments
- DoJ requested NIST's help to improve the efficiency, speed, and accuracy.
- Using a newly developed microfluidic device, NIST researchers in EEEL and CSTL have demonstrated a separation of a DNA ladder with fragments ranging from 50 to 550 base pairs in 4 minutes.

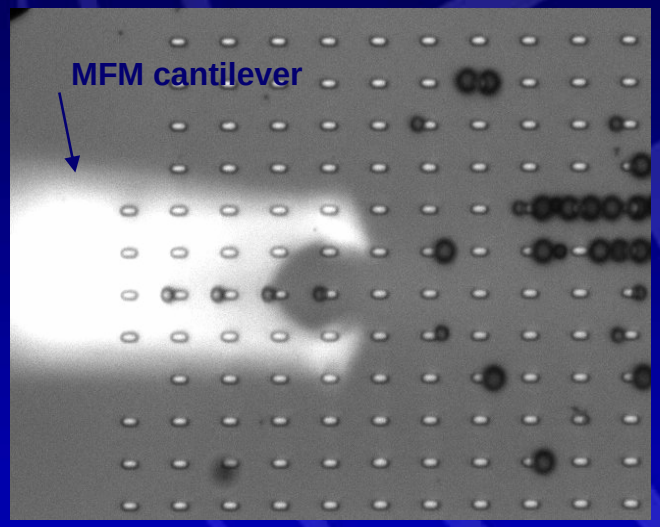


The three phases of DNA testing. NIST efforts are focused on the "Laboratory Analysis" phase.

Prototype 16 channel device for DNA fingerprinting.

Magnetic Beads: Another Tool for DNA Manipulation



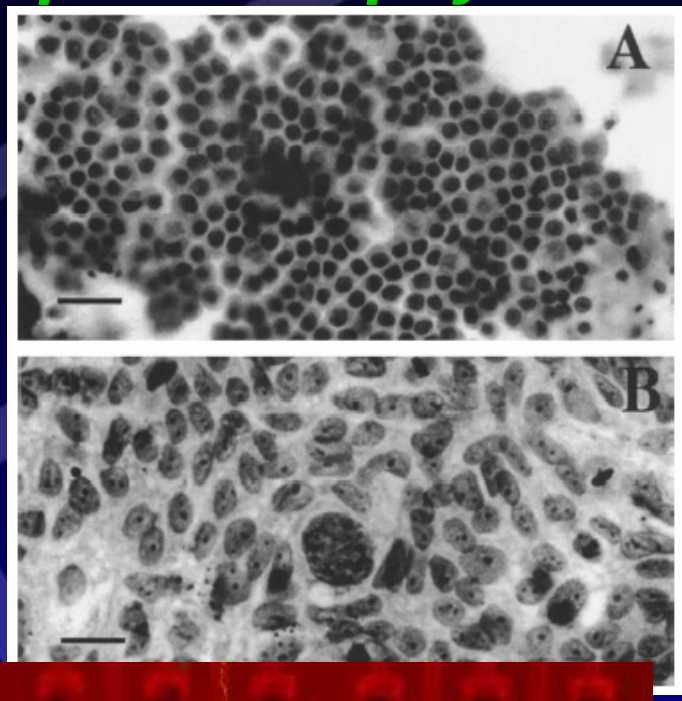


Single bead control/sorting

- Magnetic “tweezers” can stretch, twist and uncoil individual biomolecules
- Demonstrated use of MFM tip to drag particles with piconewton forces

Optical Coherence Tomography:

Early disease identification via "optical biopsy"

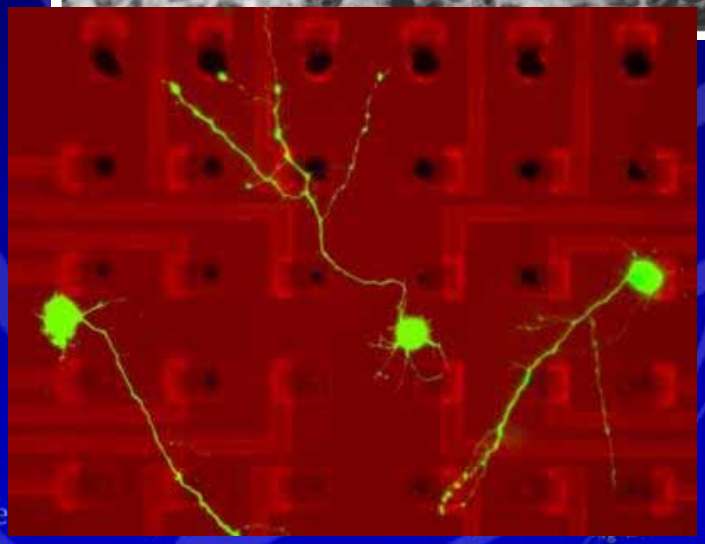


Motivation

- OCT well-suited for early identification of cancer & heart disease (the world's top two killers).
- Rapidly-growing field needs metrology to go from Qualitative to Quantitative
- OCT needs match NIST capabilities
- Window of opportunity

Strategy

- Develop new technique to measure cell nuclei (early cancer detection)
- Reduce measurement noise in glaucoma screening



Niche

- Chromatic dispersion

  early cancer detection, tissue identification…
- Polarization OCT

  early glaucoma screening, tissue characterization

electronics and electrical engine

Homeland Security

Public Safety Communications

In March of 2004, OLES completed, on behalf of DHS SAFECOM, Version 1.0 of the first ever comprehensive Public Safety Statement of Requirements for Communications and Interoperability.

- This document is the foundation piece in the effort to develop a national architecture framework for public safety communications interoperability

In June of 2003, NIST OLES, in partnership with DHS's SAFECOM and NIJ's AGILE programs, hosted a two day summit focusing on public safety communications.

- The Summit had over 104 attendees from over 50 different federal and national level agencies, programs, and/or organizations that represented federal, state, and local public safety interests
- This Summit was a significant first step in coordinating the multiple federal and national level efforts attempting to address the issue of public safety communications.

US-VISIT Passport Technology Tests

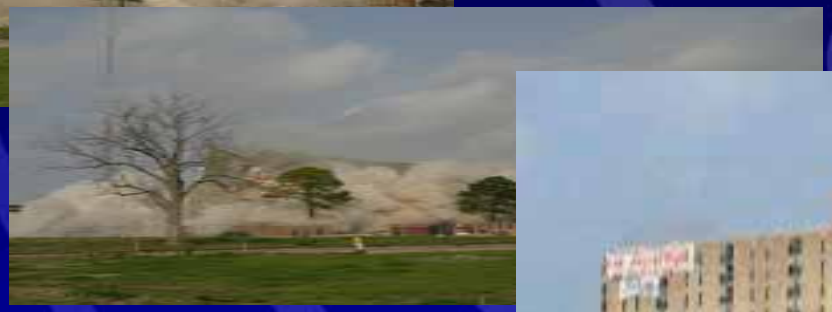
Demonstrated:

- Eavesdropping ability upon reader-passport transactions from as much as 15 m (reader dependent)
- Ability to jam from 1 m with as little as 2 w

Next Steps:

- Tests for passport durability and reliability (functionality after exposure to RF, microwave, ESD)
- Tests for ability to remotely activate and read a passport

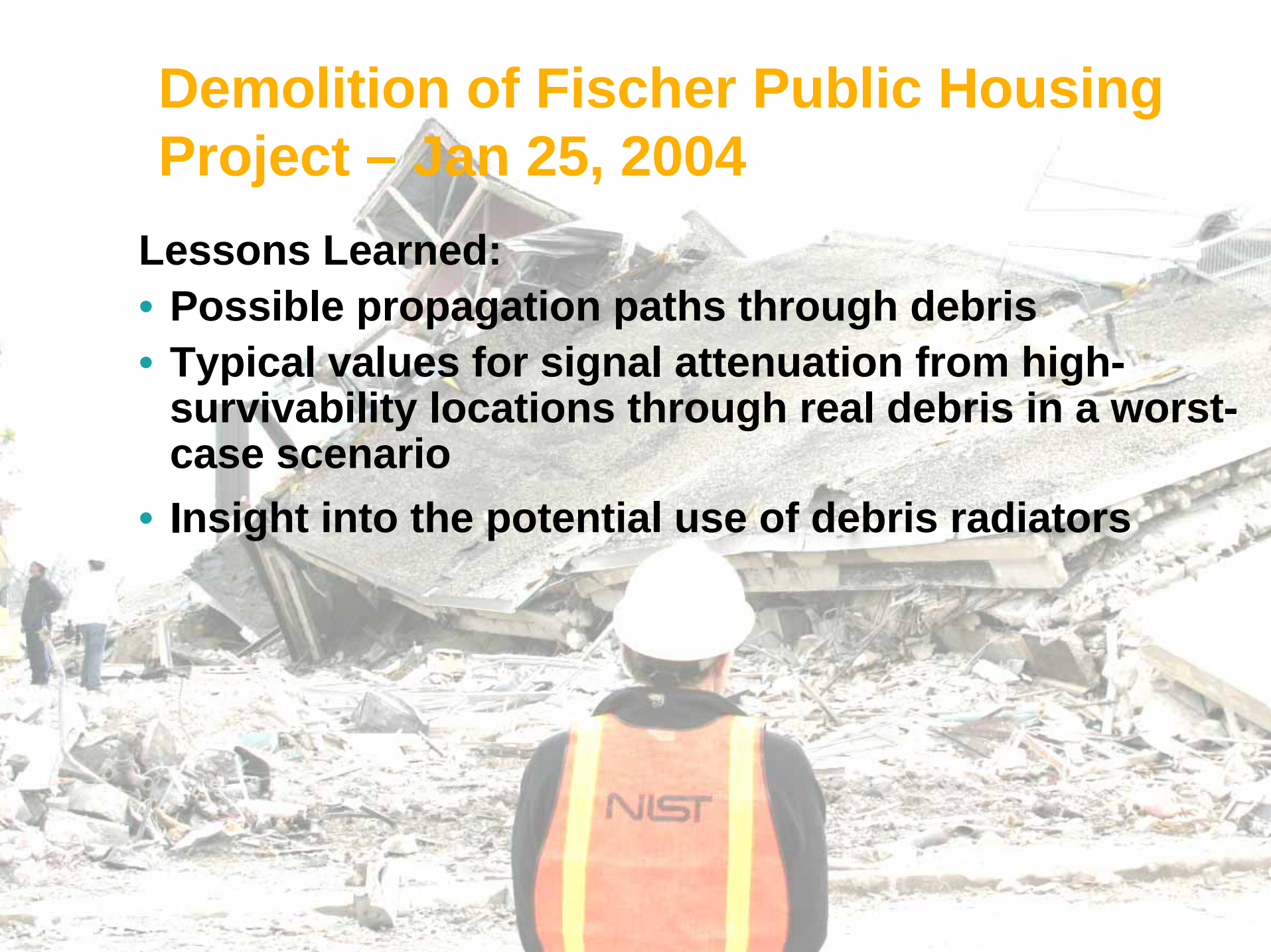
And for Some Tangible Impact…



Demolition of Fischer Public Housing Project – Jan 25, 2004

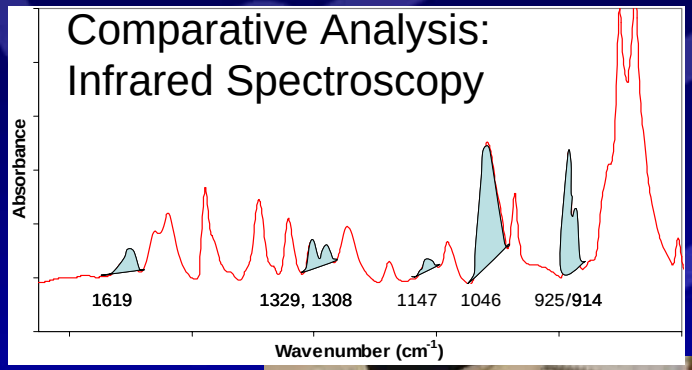
Lessons Learned:

- **Possible propagation paths through debris**
- **Typical values for signal attenuation from high-survivability locations through real debris in a worst-case scenario**
- **Insight into the potential use of debris radiators**



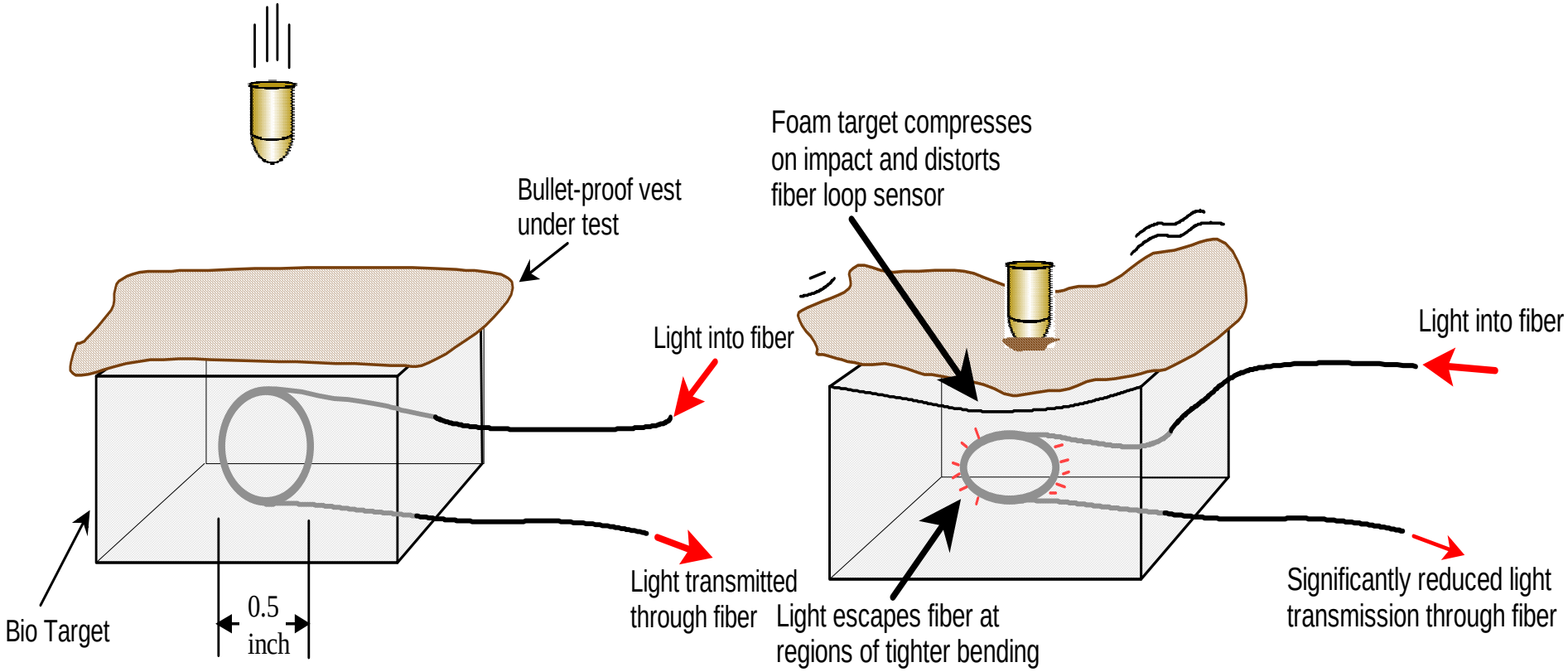
Body Armor Performance Research

- In 2003, an officer was seriously wounded when his body armor failed -- the first known instance of a vest failure.
- Attorney General Ashcroft launched a Body Armor Safety Initiative "…to address the reliability of body armor…"
- NIJ asked NIST/OLES to lead the technical effort.
- OLES established and leads a multi-laboratory team to conduct research to:
  - assess body armor in field service and evaluate armor upgrade kits,
  - measure mechanical and chemical properties of samples exposed to temperature, humidity, UV, etc.
  - identify degradation mechanisms and kinetics,
  - improve the NIJ Standard and Testing Program
- Ballistic studies show that upgrade kits may not perform satisfactorily. Ongoing experiments are indicating that moisture and UV can be detrimental.



New Method for Body Armor Testing

Using optical fiber sensors to measure force and deformation



Office of Law Enforcement Standards (OLES)

Bullets Have Fingerprints Too!

- ***Standard Bullet*** **- OLES created a standard reference material (SRM), a bullet, with the support of the National Institute of Justice (NIJ) to establish both national and international uniformity between agencies using the Integrated Ballistic Identification System (IBIS).**

- ***Ballistic Image Capture Large Data Base Study*** **– The National Academy of Sciences asked OLES to conduct an eighteen month study on the current limitations of large ballistic databases and also study the effects of images from firearms that have been fired many times.**

Metrology for Nuclear Non-Proliferation: TES Calorimeters for High-Resolution g-ray Spectroscopy

New tool for nuclear materials analysis and treaty verification

- **NIST has pioneered Transition-Edge Sensor (TES) calorimeters for soft x-ray (< 10 keV) detection. Thin-film absorbers are sufficient at these low energies.**

- **Project Goal: extend the operating range of TES calorimeters to 200 keV by developing bulk superconducting absorbers**

- **Target Performance: resolution < 70 eV at 100 keV**

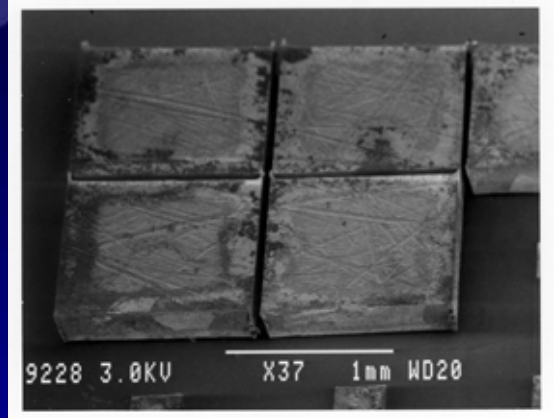
theoretical limit = 10 eV

resolution of commercial HPGe = 300-500 eV

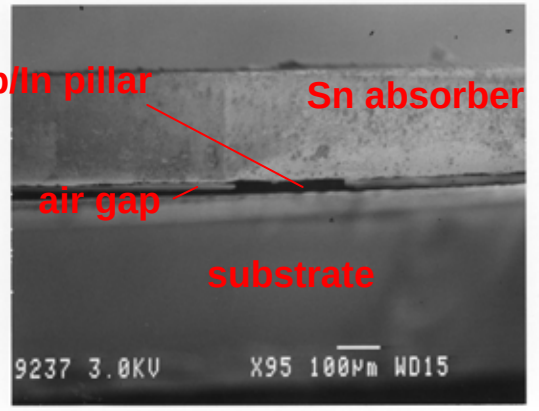
- **Applications:**
  - **-Highly accurate measurement of plutonium isotopic fractions in complex mixtures**
  - **- Non-destructive measurement of plutonium level in spent reactor fuel**
  - **- General tool for high-resolution γ-ray and hard x-ray spectroscopy**

- **Collaboration with Los Alamos Nat'l Laboratory**

NIST fabricated array of prototype absorbers



side view of a single absorber



FY04 EEEL Output Statistics

2002	2004	
215	263	Published papers
274	256	Conference talks
3134	3207	Calibration tests performed for providing the lab a total Income of **$2.1M**
173	174	participants in standards committees and professional organizations, holding **27** **leadership positions**
22	39	Hosted conferences / workshops
77	69	Standard Reference Materials sold

Key FY05 Milestones

- Establish Bioelectronics Laboratories
- Open the NIST AML Nanofabrication Facility for NIST staff
- Design and fabricate prototype electronic test structures for a variety of nanoelectronic device structures including nanowires and molecules
- Demonstrate growth of III-Nitride nanowires
- Demonstrate electrically-pumped single photon turnstile
- Demonstrate mismatch-corrected photodiode impulse response calibration with point-by-point time- and frequency-domain uncertainty analysis
- Publish a new value for Planck constant
- Simultaneously measure, in the time domain, the coupled interactions of two phase qubits coupled using a simple capacitor
- Complete design for array of zig-zag magnetoresistive sensors for high-resolution tape imaging system for FBI
- Complete development of a model for the interpretation of spectroscopic data collected with the near-field scanning microwave microscope

Quality System Implemented

SIM
SISTEMA INTERAMERICANO DE METROLOGÍA

- ***EEEL had the first and second divisions to certify quality NIST system implementations***
- ***Based on ISO/IEC 17025***
- ***Bill Anderson – Chair of SIM Quality System Task Force***

Resource Trends & Planning

Strategic Trends Affecting EEEL

Competitive Landscape

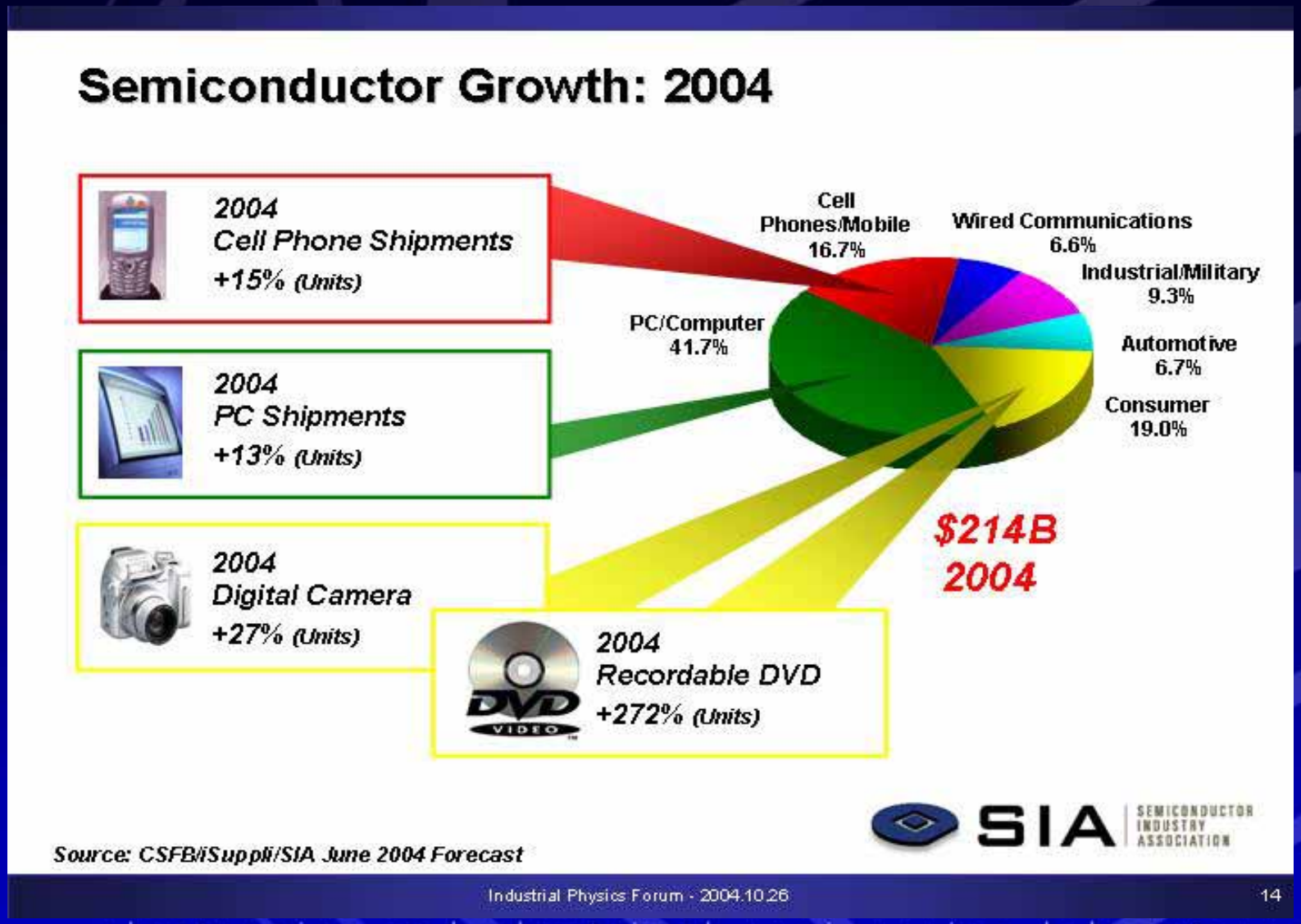
- Privatization of NPL
- Aggressive marketing by PTB in the Americas
- BIPM Mutual Recognition Agreement (MRA) opening door to competition among NMIs for calibration customers
- Competitive metrology environment pressures us to be even more efficient, more careful about what services we offer

Strategic Trends Affecting EEEL

Economic Trends

- Telecom and semiconductor industries showing mixed signs of recovery
- Power industry lagging
- Drive for value demanding customer-focused measurement services
- New priorities decreasing OA funding
- Development of emerging economies (China, etc.)

Economic Trends – Semiconductor Growth



From George Scalise, president of the Semiconductor Industry Association, "The Leadership Challenge: Maintaining a Vigorous Information Technology Ecosystem," October 26, 2004.

Strategic Trends Affecting EEEL

Technology Trends

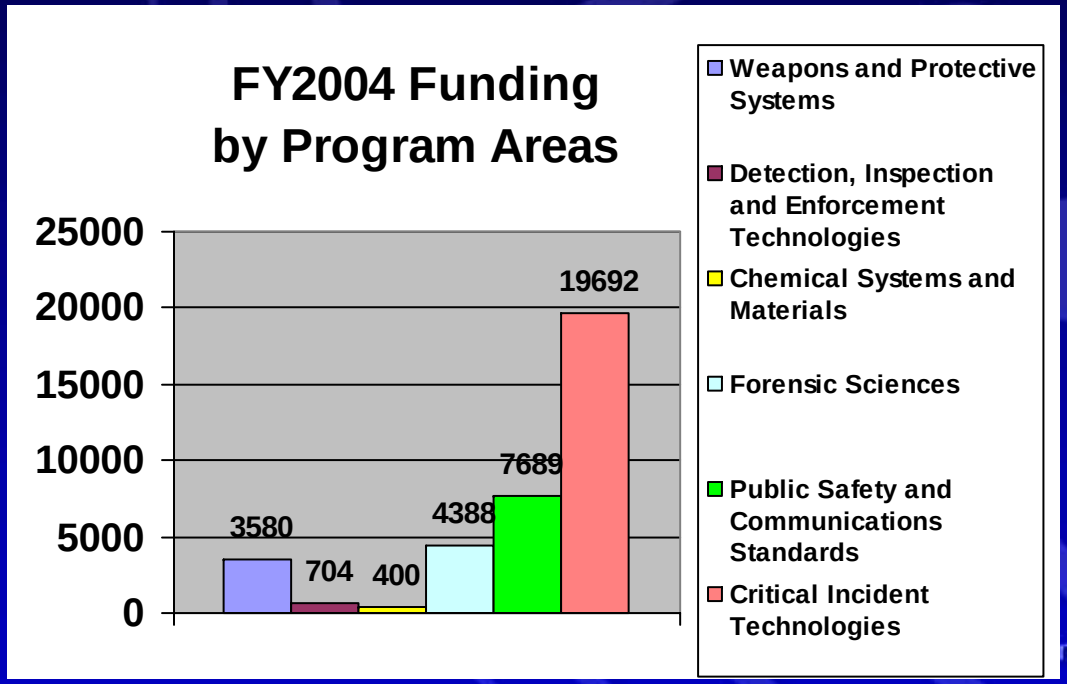
- Quantum standards & devices
- Quantum information, computing, communication
- Systems-on-a-chip
- CMOS approaching limits of growth
- Emerging nanoscale and beyond-CMOS solutions
  - Molecular electronics
  - Confined Silicon

Operational Issues

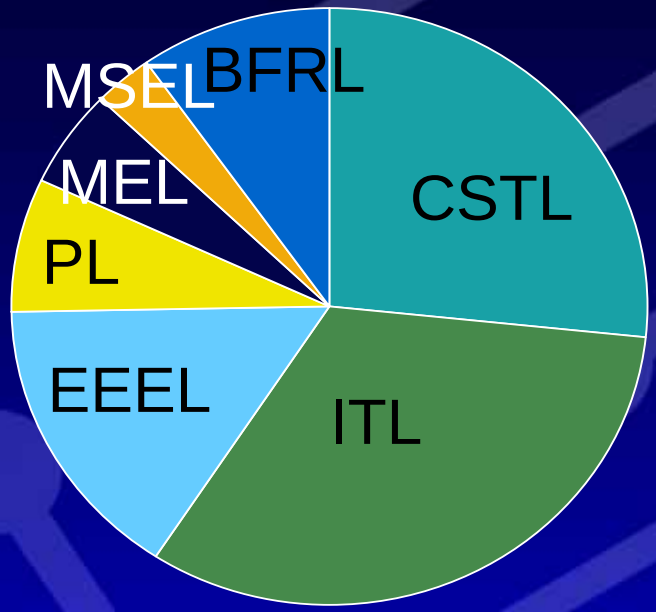
- Our complement of non-permanent staff is an increasingly critical resource
- Growth in SFAs, especially nano
- Decline in metrology investments
- Continuing budget pressures
  - Forcing redefinition of programs
  - Making it hard to attract and maintain world-class staff
- OA sponsor needs and relationships in flux
  - Changing roles of DHS, NIJ
  - Re-missioning of NASA
- Outdated RF facilities threaten future relevance of RF services, programs
  - Continued need for REML

2004 OLES Funding Distribution

- With a budget of nearly $40M, OLES now provides more funding to the Labs than does ATP
- EEEL is not OLES' primary internal client

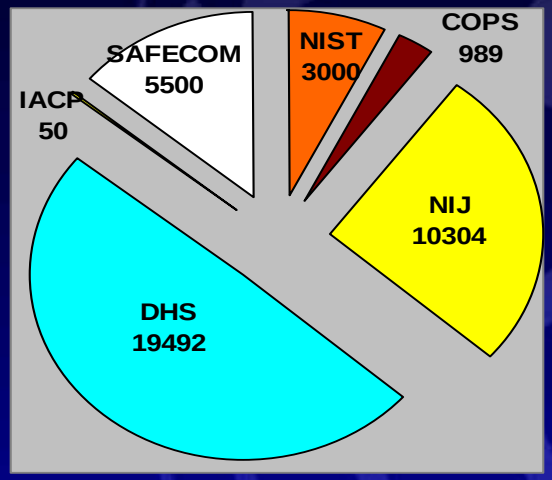


Distribution of OLES FY2004 Funding Within NIST (Total: $19.4M)

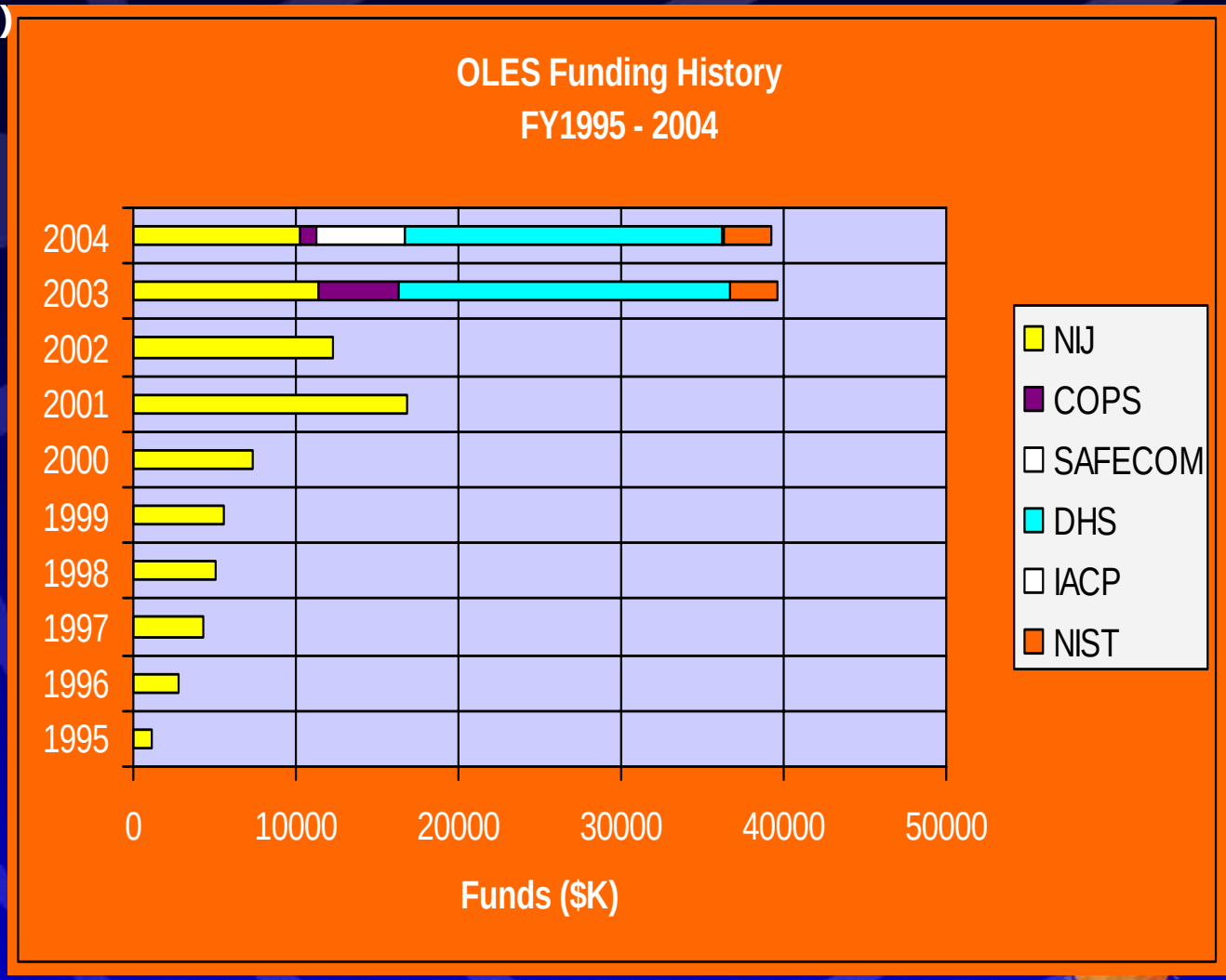


2004 OLES Funding Sources

OLES Funding Sources ($K)
FY2004



FY2004 FUNDING TOTAL
$39489K



2004 EEEL Operational Plan – SFA Investments ($M)

	FY03	FY04	FY05
Nanotechnology	$16.7	$16.7	$18.2
Homeland Security	$5.1	$5.2	$6.4
Biosystems & Health	$2.6	$2.6	$2.9
IT/Knowledge Management	$1.7	$1.8	$1.9
Core Metrology	$31.6	$28.7	$26.8

2004 Operational Plan – Top Customers in FY04 ($M)

MICROELECTRONICS	$20.6
INDUSTRIAL AND ANALYTICAL MEASUREMENTS	$7.1
HOMELAND SECURITY (LAW ENFORCEMENT, FORENSICS, ETC.)	$6.0
TELECOMMUNICATION SYSTEMS AND SERVICES	$5.9

Example EEEL Customer Interactions

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

- *Helping return the shuttle to flight through EM shielding testing*
- *Developing highly accurate sensors for precision measurements*

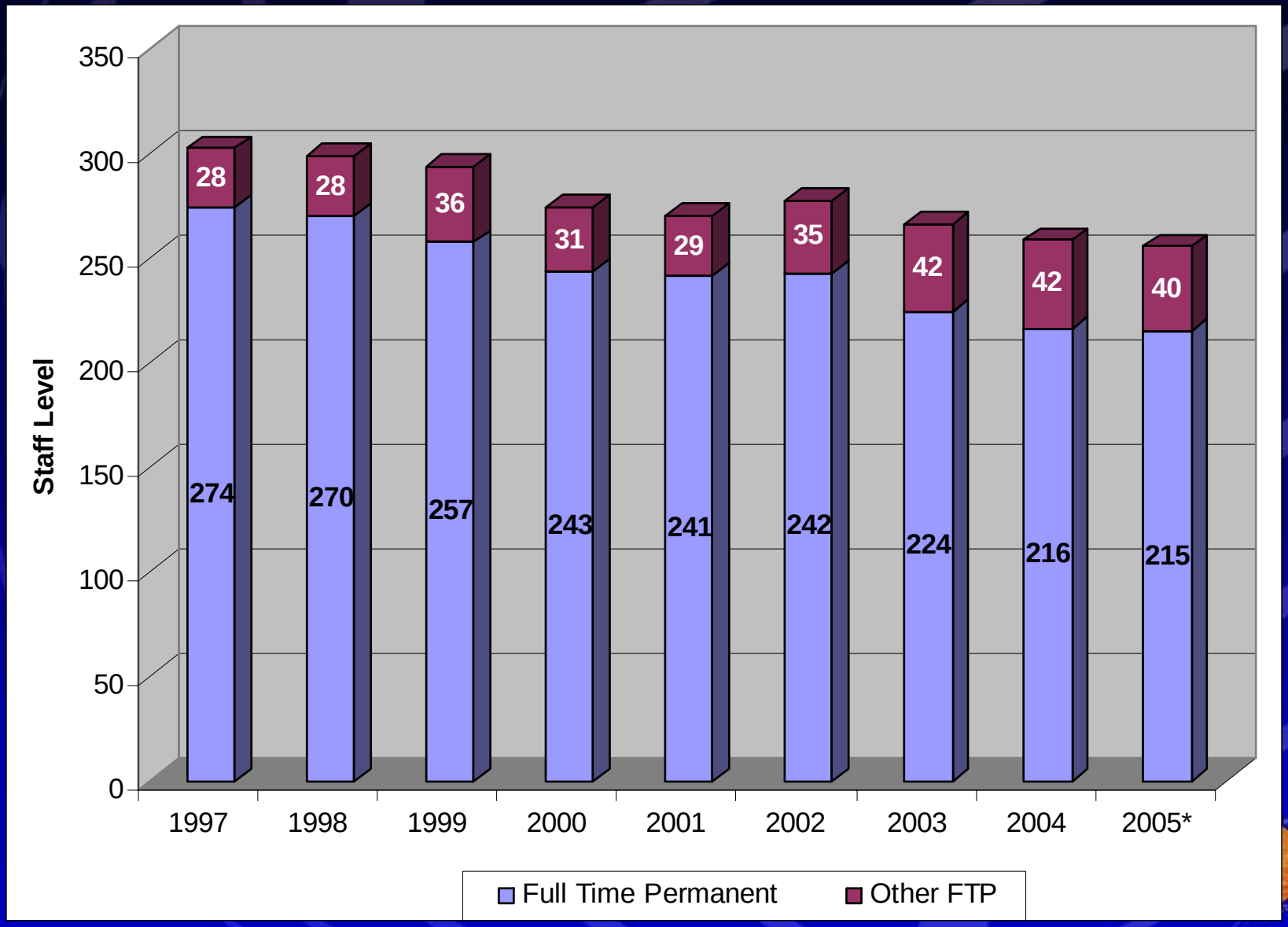
Development of Vector Network Analyzer calibration for 1 mm connectors

Agilent Technologies

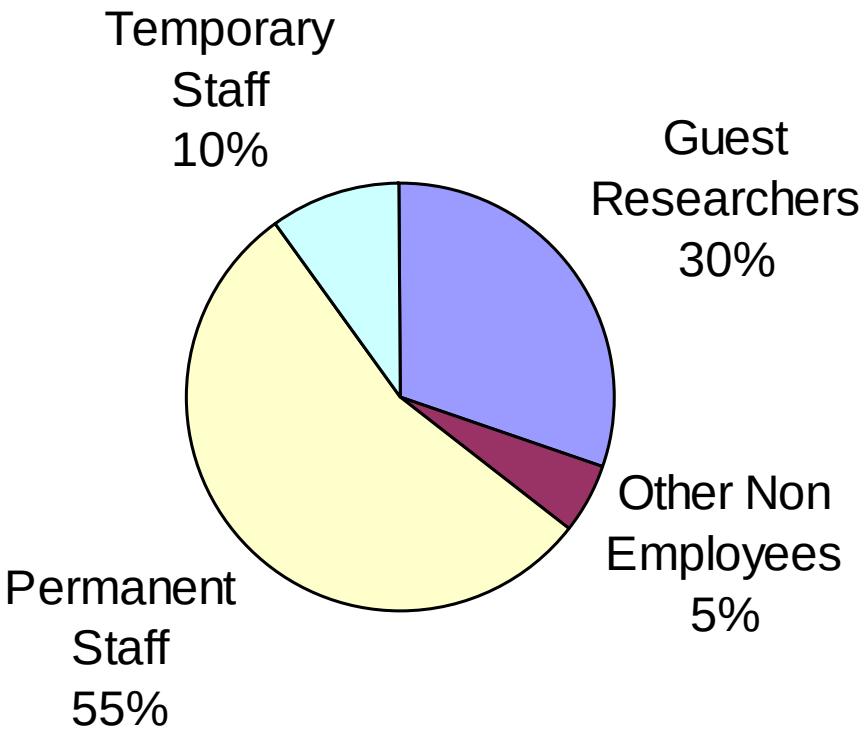
Collaborating to improve first responder communication capabilities

Phoenix Fire Department
Montgomery County Fire Department

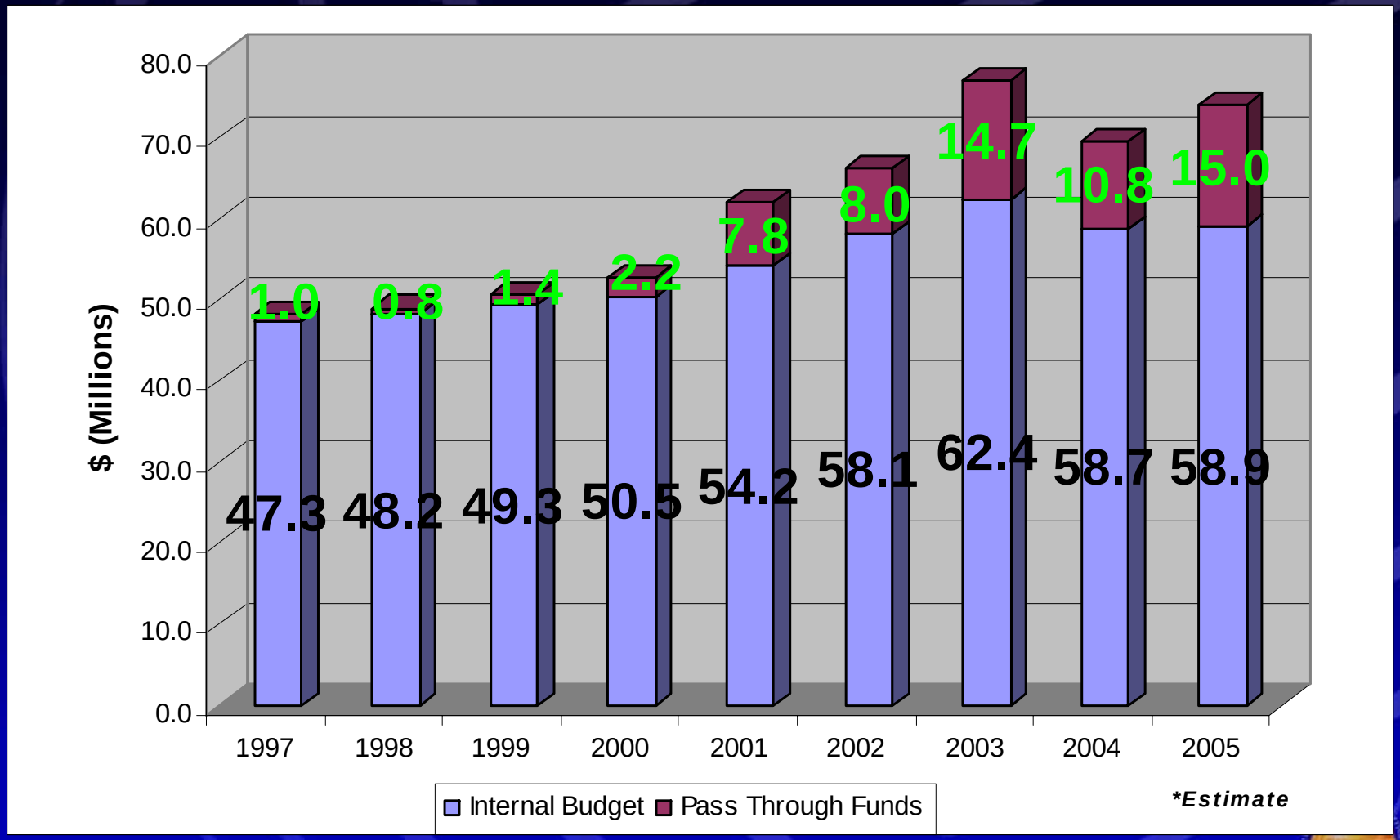
EEEL Staffing Summary



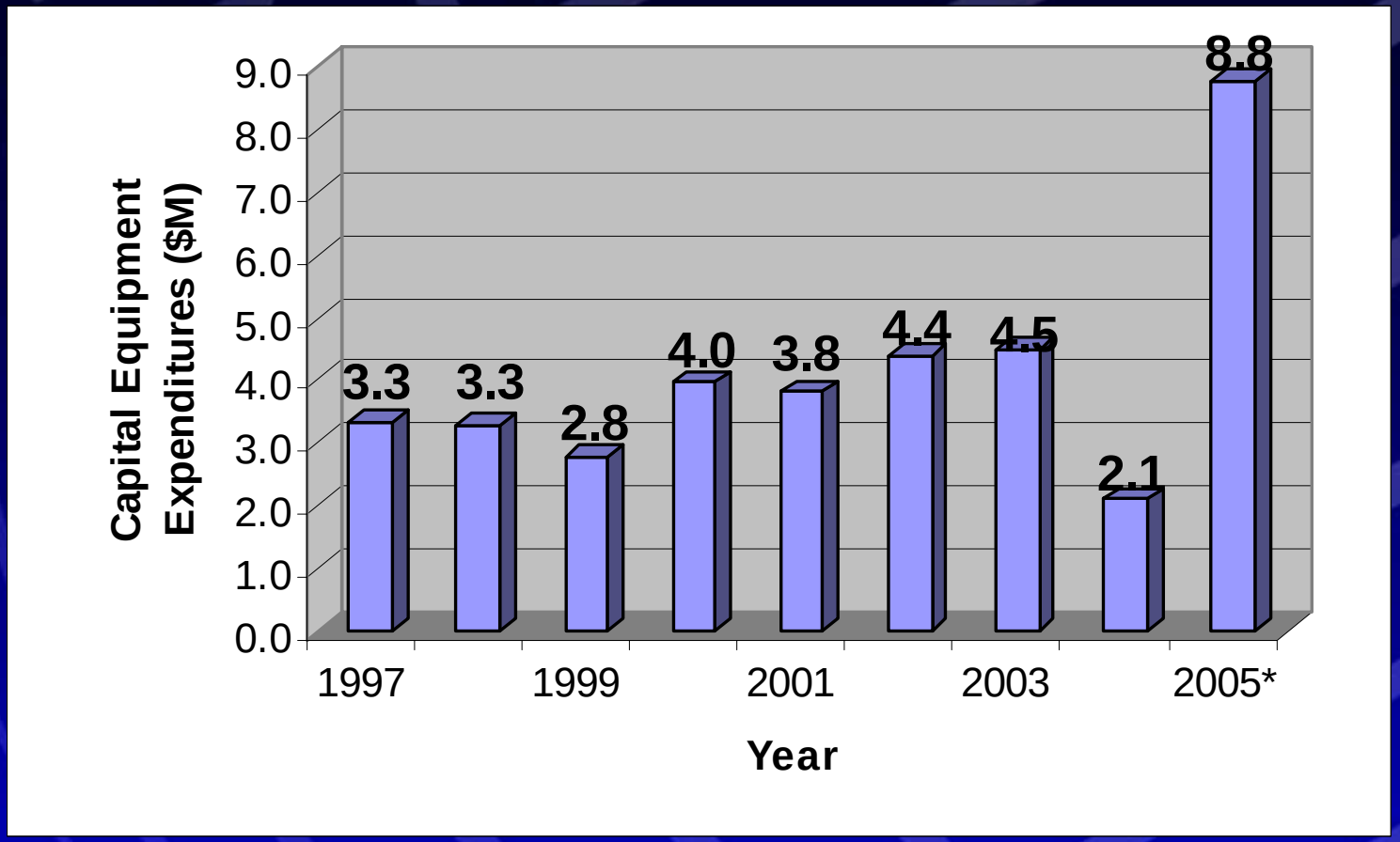
EEEL Staffing Summary



EEEL Funding: Internal and Pass Through

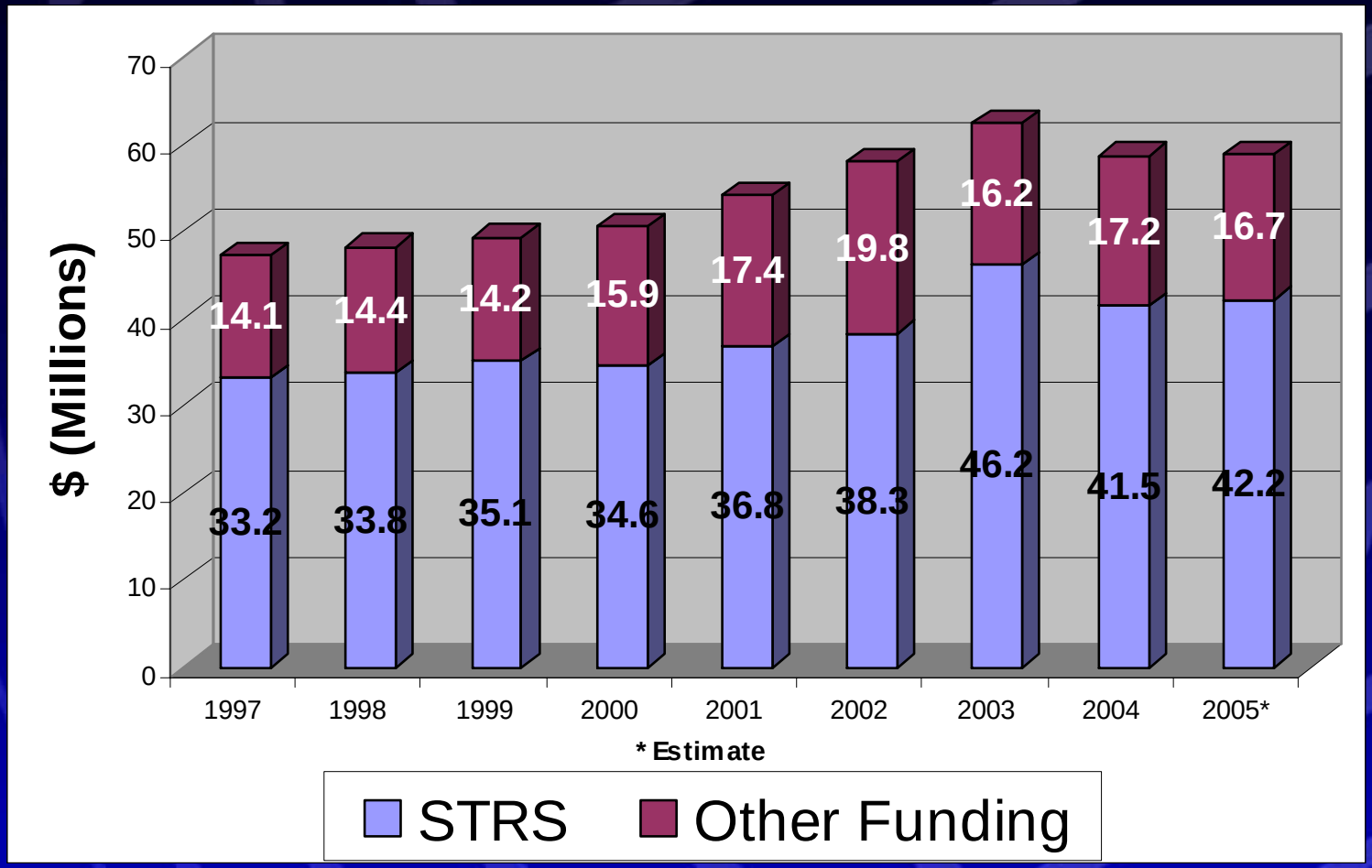


EEEL Budget:
Annual Capital Equipment Expenditures

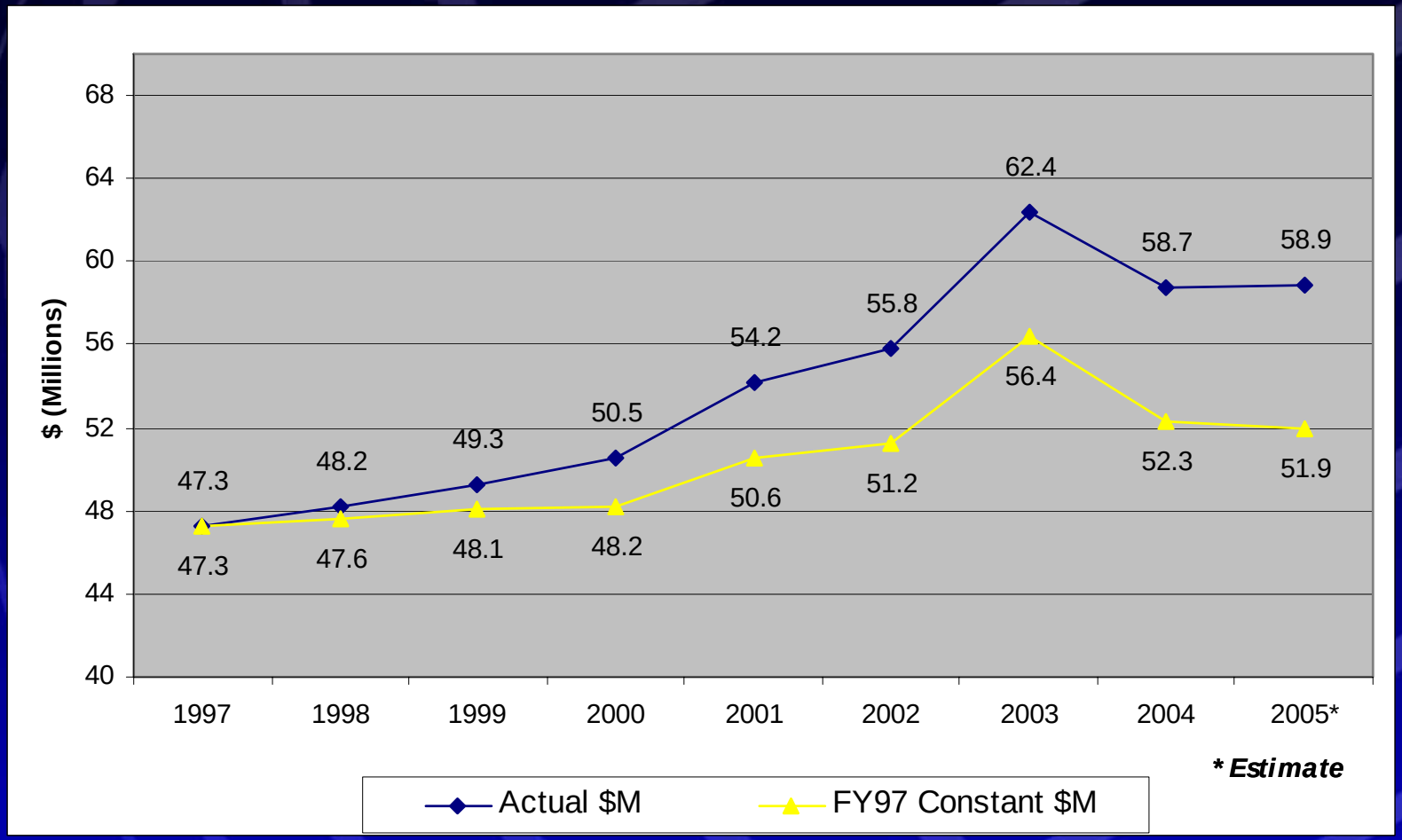


*Estimate

EEEL Internal Budget: STRS vs. Other Funding Sources

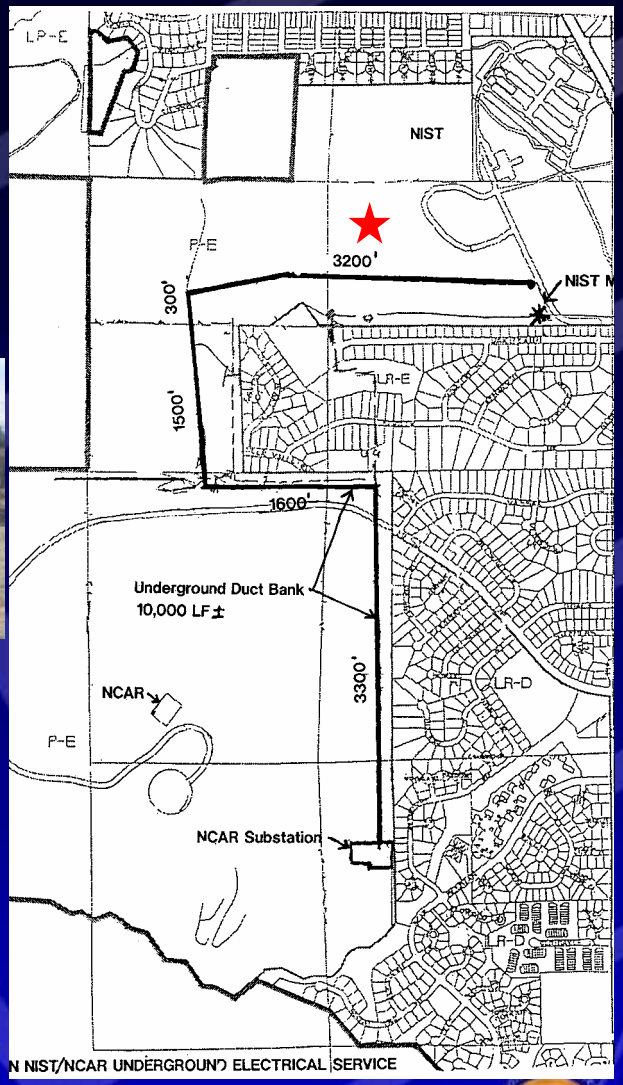


EEEL Internal Budget: Actual and Inflation-Adjusted



Facilities: Boulder Construction

- Underground Primary Electrical Service
- High Speed Switch / UPS
- Central Utility Plant



Facilities - Improvements

- Calibrations moved to AML with no interruption in service
- Moves & consolidation of space in Gaithersburg
  - Semiconductor Electronics Division
  - Office of Law Enforcement Standards
- Open Air Test Site refurbished
- Refurbishment of space for new optical fiber & component labs (Bldg 1, Wing 5) delayed due to resources
  - Intended move of Electromagnetics personnel to Building 2 delayed as a result

Facilities: Advanced Measurement Laboratory

Resistance Metrology Lab

Quantum Electrical Metrology move essentially complete

- –Resistance metrology
- –Voltage metrology
- –Impedance metrology
- –Power and energy calibrations
- –DMM calibrations
- –Fast pulse calibrations

Semiconductor Electronics move complete, aside from nanofab

Planned:

- –Calculable capacitor
- –Next generation electronic kilogram

Some environmental problems remain

electronics and electrical engineering laboratory

Facilities: Advanced Measurement Laboratory - Nanofabrication Facility

Objectives

- Drive world-leading measurement research through fabrication of prototypes of nanoscale test structures, measurement instruments, standard reference materials, electronic devices, MEMS, and bio-devices
- Provide a venue for collaboration across OUs and with external collaborators
- Facility to be a NIST-owned, shared access user facility

Facilities: Advanced Measurement Laboratory - Nanofabrication Facility

Furnaces
General Furnaces
CMOS Furnaces
LPCVD (LTO, Nitride, Poly)
Rapid Thermal Annealer1

Dry Etch
Deep RIE
Metal RIE
RIE Fluorine
Xenon Difluoride Silicon Etch

Metal Deposition
Sputterer
E-beam Evaporator
Thermal Evaporator
Various Older Evaporators

Lithography
2 Front-side Contact Mask Aligners
1 Front- & Back-side Contact Mask Aligner
Modified SEM E-Beam Lithography
Focused Ion Beam

Wafer Prep
Wafer Bonder
Wafer Saw

Infrastructure
Gas Cabinets, Furniture, Safety, Tools, Computers
DI Water System,
Environmental Gas Monitoring

Wet Chemistry
2 Photoresist Spinners
Glassware Washer
Spin rinse dryers
Heated Chemical Wet Baths

Monitoring
FE Scanning Electron Microscope
Ellipsometers
Nanospec Reflectometer
Contact Profilometer
Optical Microscope with Image Capture
4-point Probe
Optical Microscopes

Facilities: Advanced Measurement Laboratory - Nanofabrication Facility

Operations Organization

Director – Eric Vogel

Responsible for planning, coordinating, and managing all aspects of the NIST AML Nanofabrication Facility including operations, equipment, cost structure, partnerships, outreach, and space allocation.

Facility Manager/Safety Coordinator – Russ Hajdaj

Responsible for user interaction, process engineering, facility/tool protocols, and safety.

Facility Technician – Rich Roppolo, Larry Buck, Jim Owen

Responsible for ensuring the maintenance, repair, and installation of equipment, tracking and replenishing of consumables, and training of users.

Advisory Committee

At least one representative from each participating laboratory

Facilities: Advanced Measurement Laboratory - Nanofabrication Facility

Status

- Equipment fit-up nearly complete
- Equipment start-up scheduled for March
- Limited operations to begin June
- Full operation expected October 2005

Agenda – Remainder of Thursday

10:30	EEEL Outstanding Authorship, Measurement Service, Safety and Diversity Awards Ceremony; Presentation of plaques
10:45	Lab Tours (Panel Members, NRC Staff, EEEL tour guides)
11:45	Lunch (Panel Members, NRC Staff), pick up meal in Rm. 1105, eat in Rm. 1107
12:30 - 6:00	Panel Executive Session/Working Session (Panel Members, NRC Staff)
3:00	Panel Chair and Vice-Chair meet with divisional staff (“Skip-level meetings”)
3:00 - 3:30	Meeting with Senior EEEL staff (Annex C, Room 116)
3:45 - 4:15	Meeting with New EEEL staff (Annex C, Room 116)
6:00 p.m.	Adjourn
7:00 p.m.	Cocktails and Dinner – Boulder Cork Restaurant

Agenda – Friday Morning, February 25

7:30	Panel Chair and Vice-Chair meet with Kathy Higgins at breakfast to discuss OLES
8:00	Executive Session (Panel Members, NRC Staff)
11:30	Follow-up discussions with EEEL Management (Panel Members, NRC Staff, EEEL Management)
1:00	Adjourn