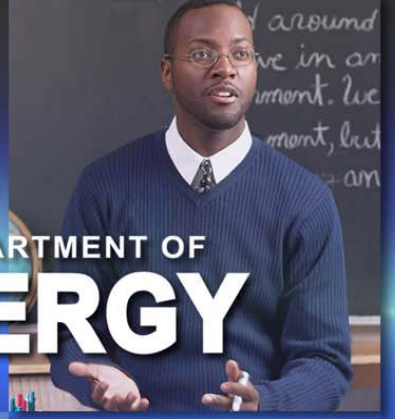


U.S. DEPARTMENT OF ENERGY

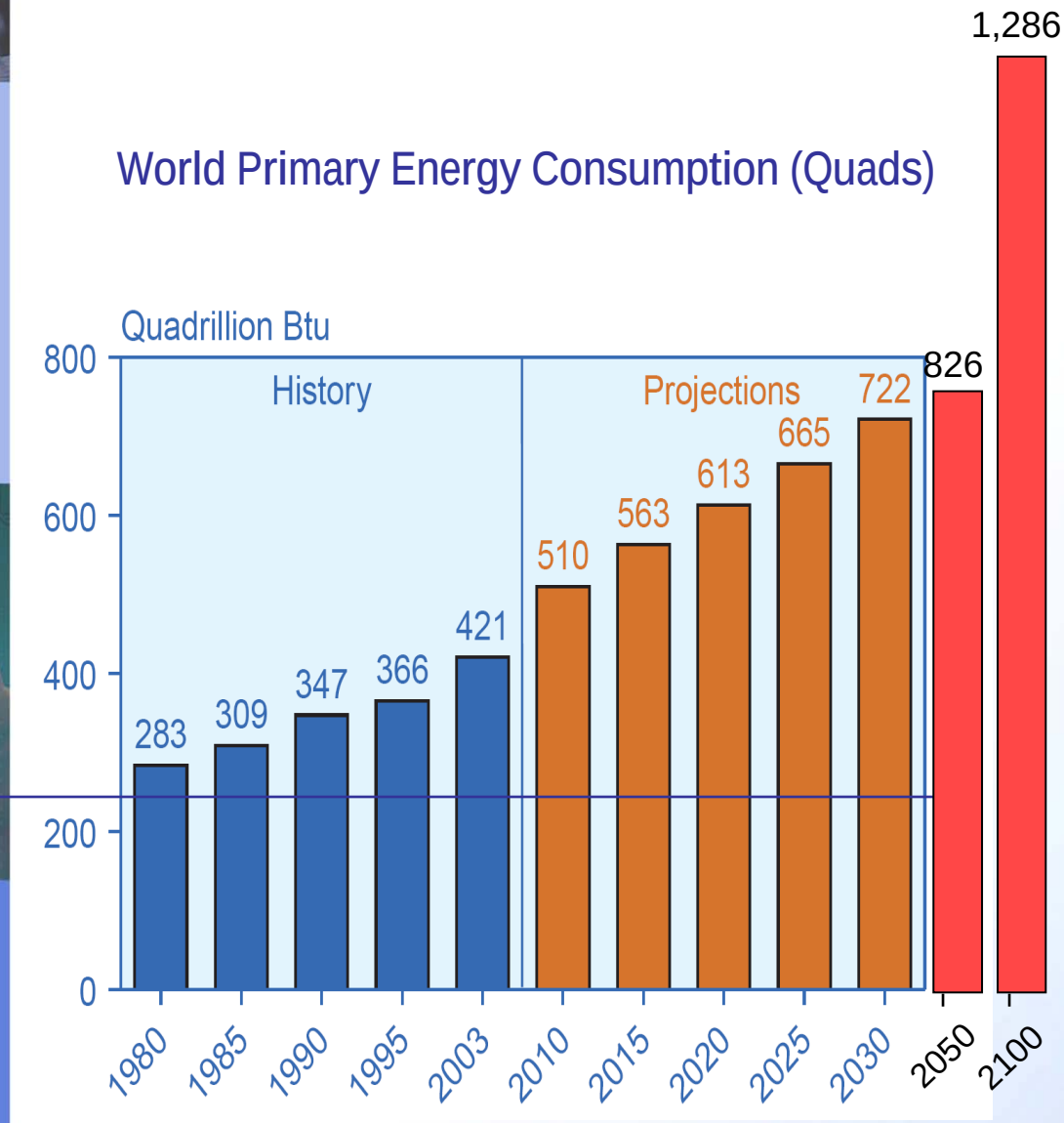
Office of Science
U.S. DEPARTMENT OF ENERGY

Workforce Development for Teachers & Scientists

Transformational Students

Bill Valdez
Director
November 10, 2008

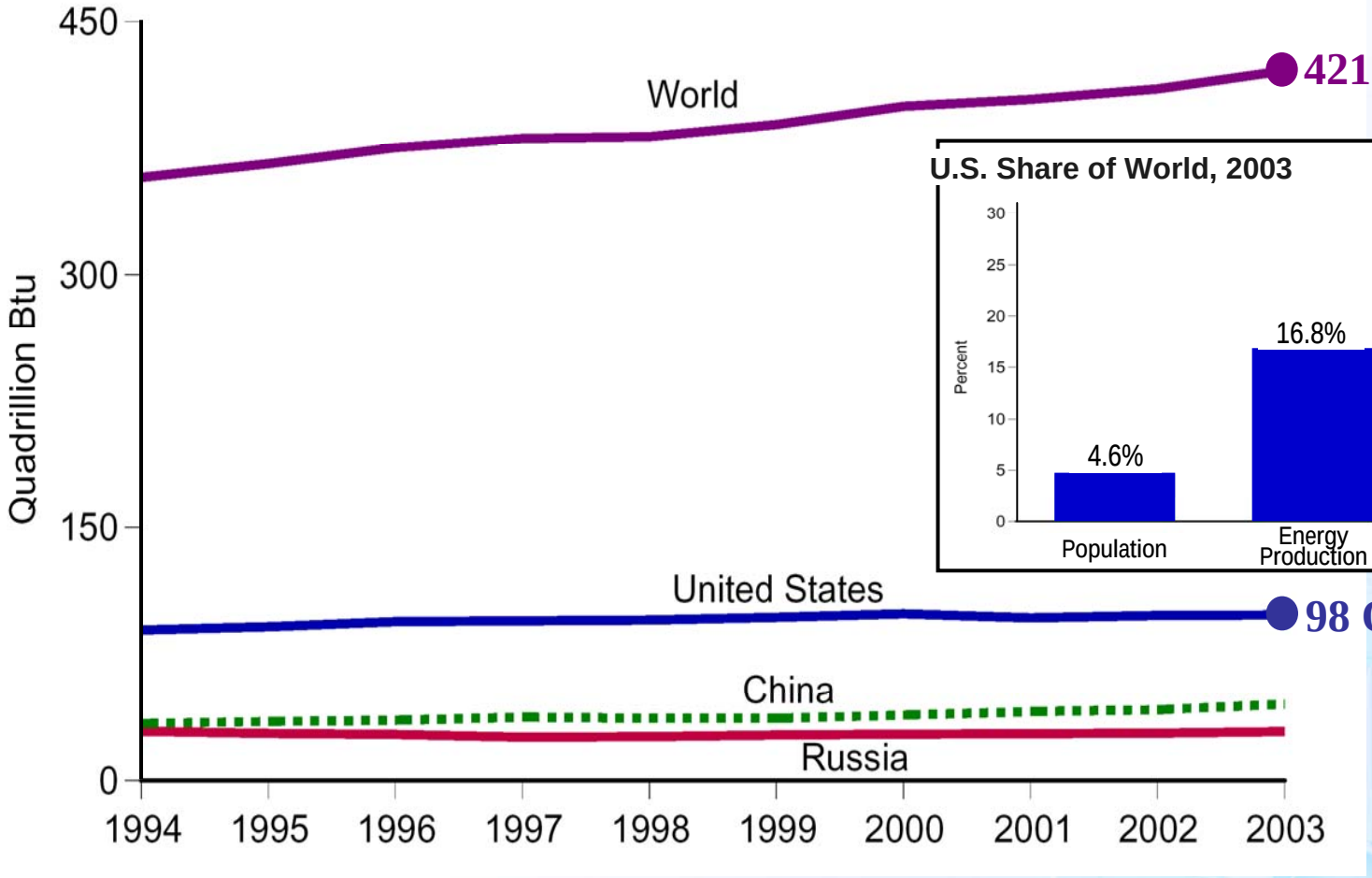
World Energy Needs will Grow Significantly in the 21st Century



Projections to 2030 are from the Energy Information Administration, International Energy Outlook, 2006.

Projections for 2050 and 2100 are based on a scenario from the Intergovernmental Panel on Climate Change (IPCC), an organization jointly established in 1988 by the World Meteorological Organization and the United Nations Environment Programme. The IPCC provides comprehensive assessments of information relevant to human-induced climate change. The scenario chosen is based on "moderate" assumptions (Scenario B2) for population and economic growth and hence is neither overly conservative nor overly aggressive.

U.S. and World Energy Consumption Today



Some equivalent ways of referring to the energy used by the U.S. in 1 year (approx. 100 Quads)

100.0 quadrillion British Thermal Units (Quads)	U.S. & British unit of energy
105.5 exa Joules (EJ)	Metric unit of energy
3.346 terawatt-years (TW-yr)	Metric unit of power (energy/sec)x(#seconds in a year)

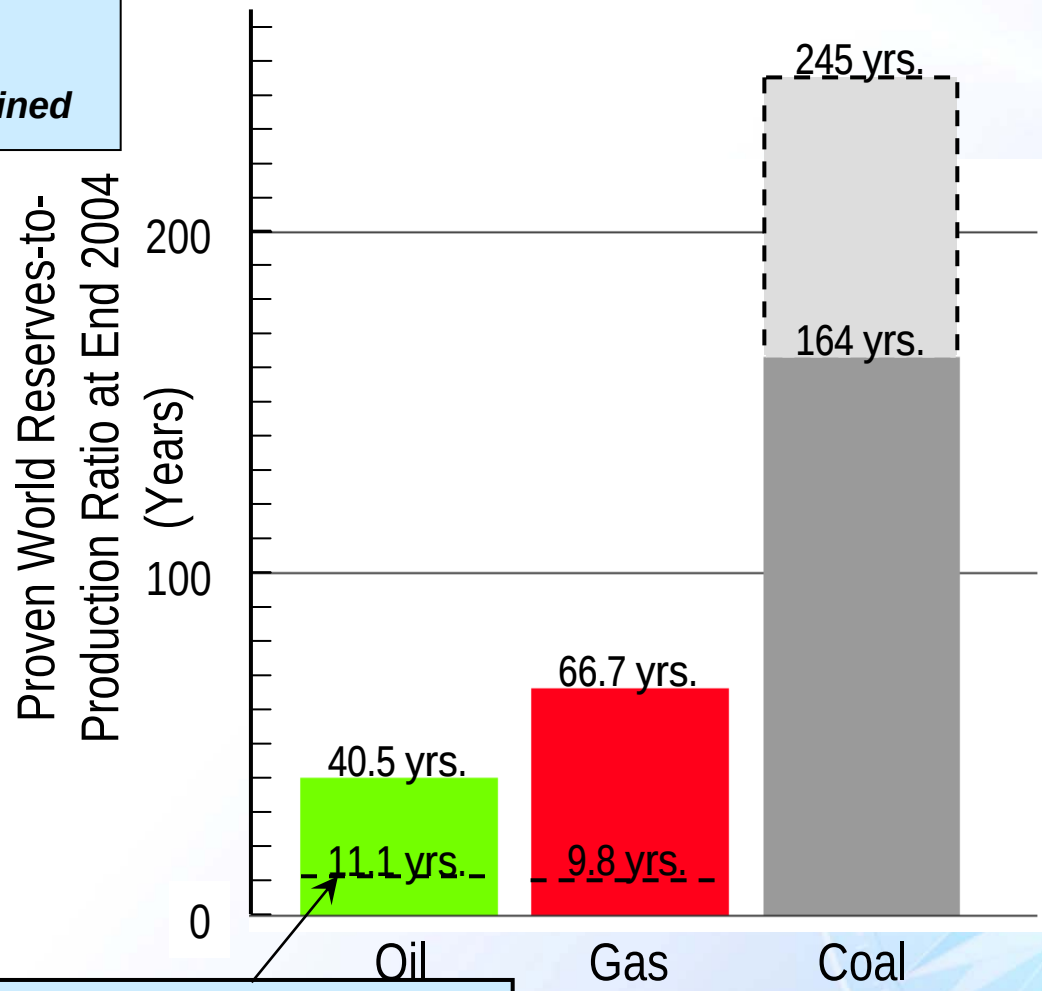
(When) Will Fossil Fuels Run Out?

This depends on:

- **SUPPLY**
- **CONSUMPTION**
- ***ECONOMICS***

These are intertwined

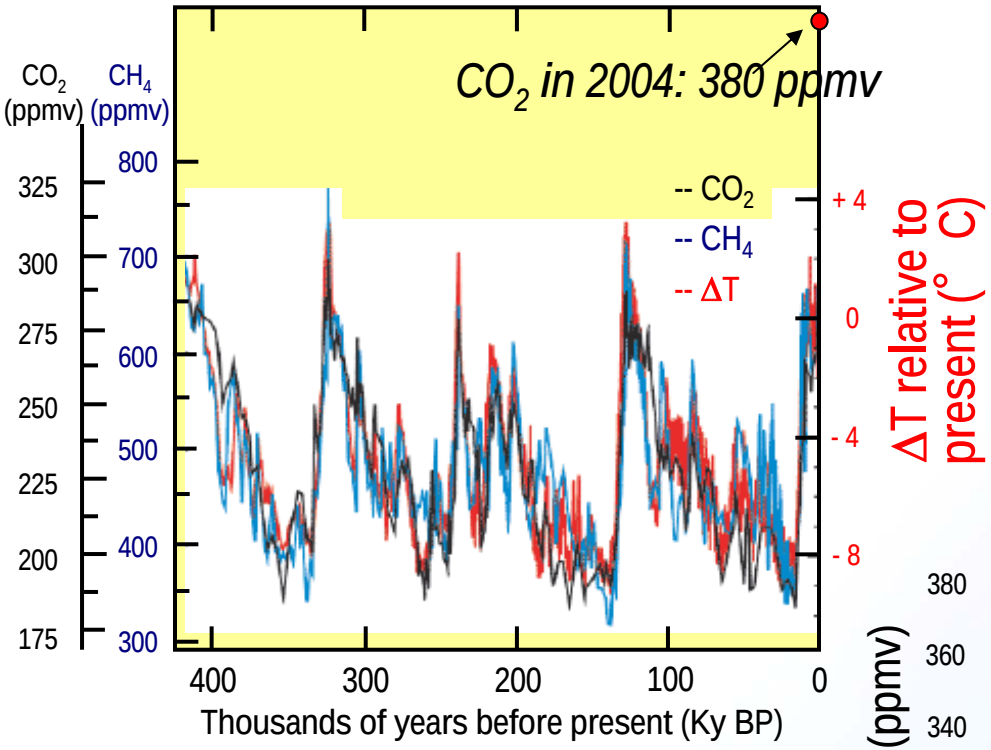
CONSUMPTION is Related to the Reserves-to-Production (R/P) Ratios



U.S. R/P ratios shown by dotted lines.

- The R/P ratio is the number of years that proved reserves would last at current production rates.
- World R/P ratios are:
  Oil = 40.5 years;
  Natural Gas = 66.7 years;
  Coal = 164 years
- U.S. R/P ratios are:
  Oil = 11.1 years;
  Natural Gas = 9.8 years;
  Coal = 245 years

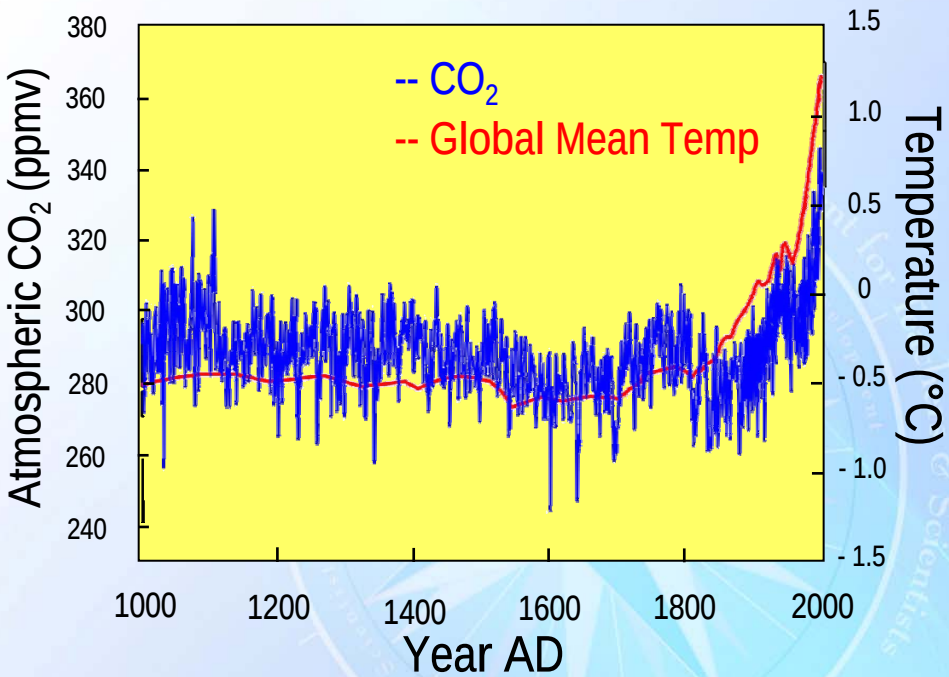
Fossil: Climate Change



Climate Change 2001: T he Scientific Basis, Fig 2.22

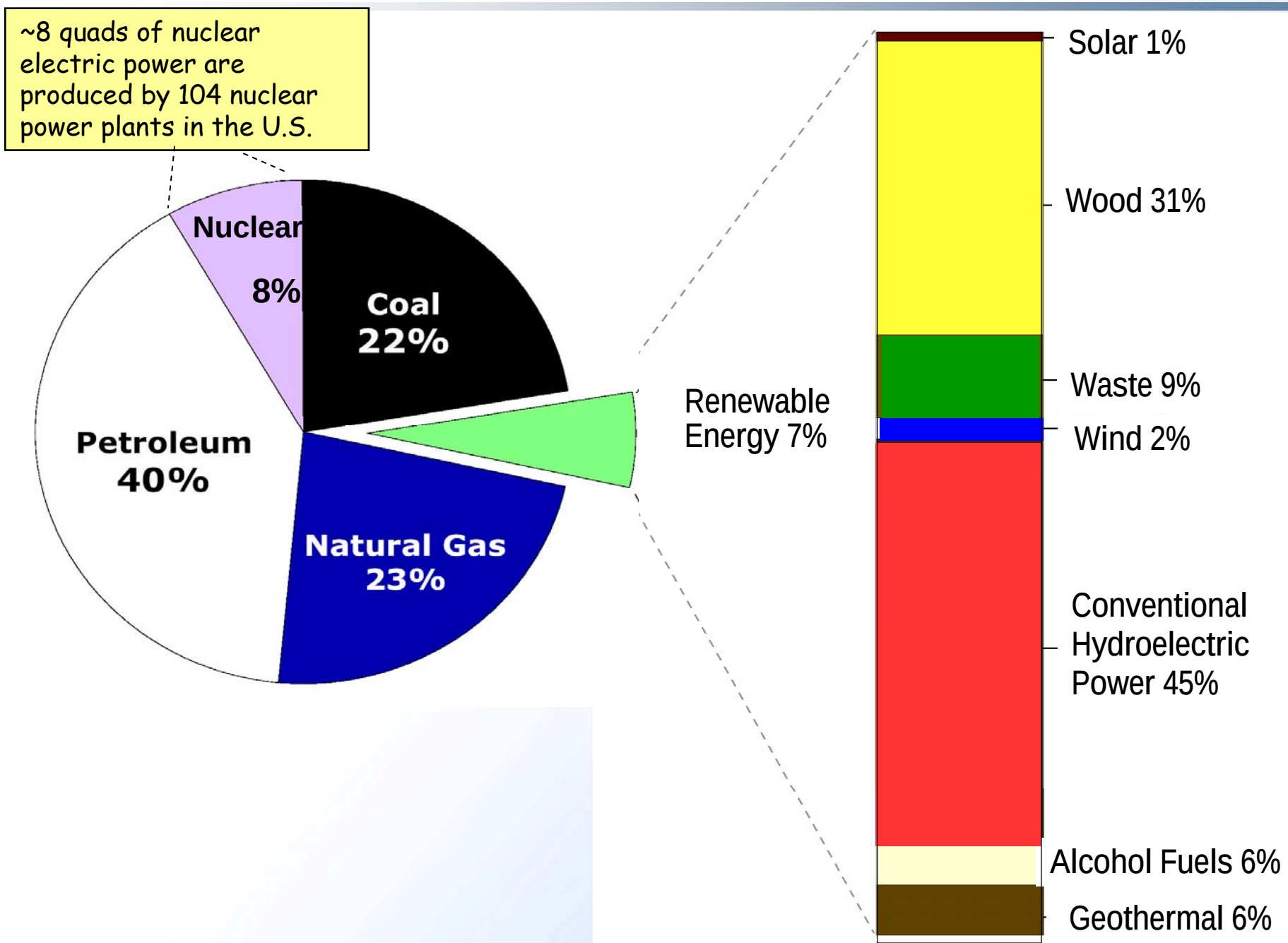
Relaxation time

transport of CO_2 or heat to deep ocean: 400 - 1000 years

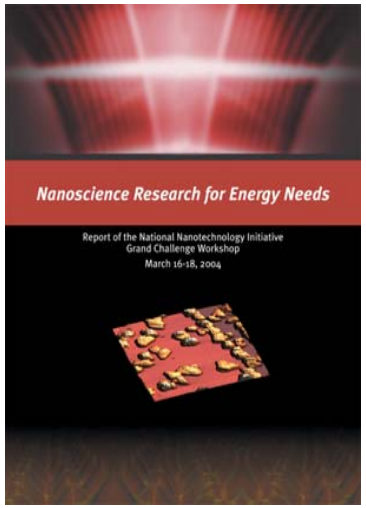


Nuclear Energy and Renewable Energy

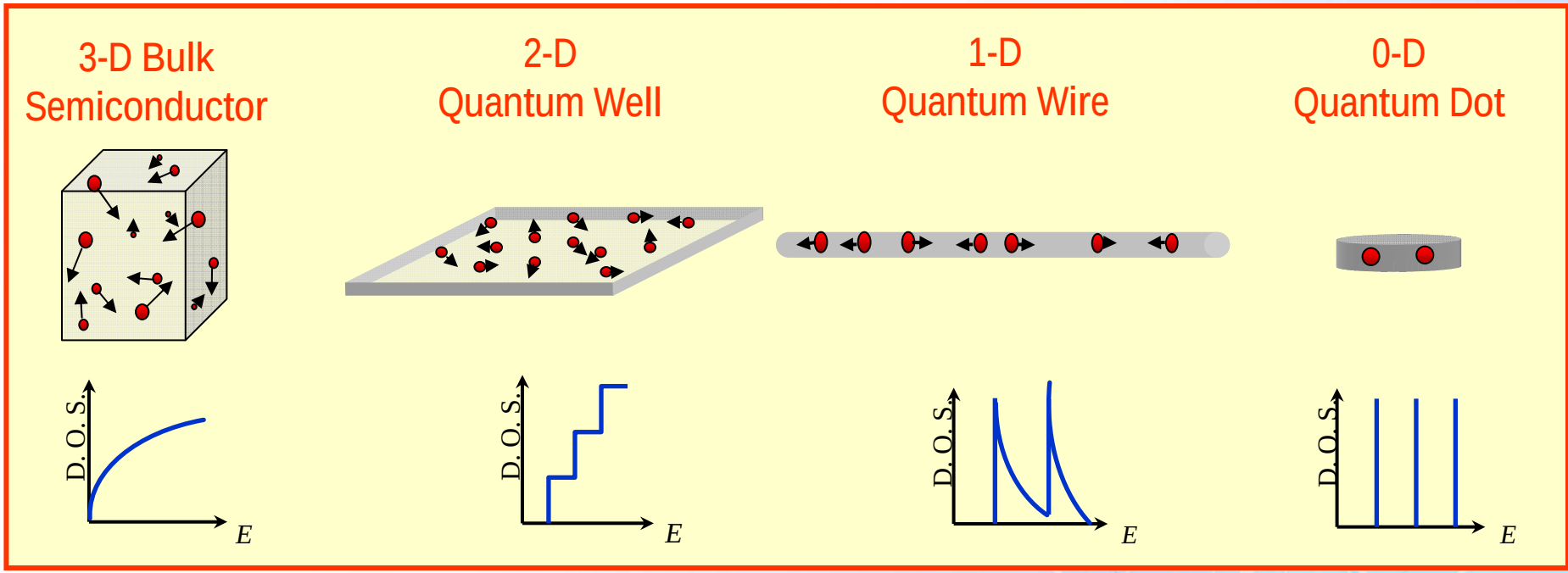
Today these are only 15% of primary energy; there is potential for significant increases. It will require effort.



Nanoscience Research for Energy Needs

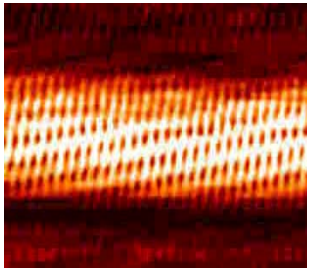


"All the elementary steps of energy conversion (charge transfer, molecular rearrangement, chemical reactions, etc.) take place on the nanoscale. Thus, the development of new nanoscale materials, as well as the methods to characterize, manipulate and assemble them, creates an entirely new paradigm for developing new and revolutionary energy technologies."

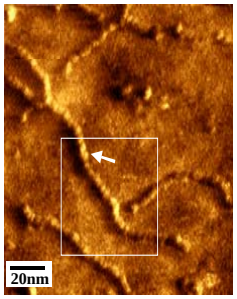


Nanoscale Characterization Tools

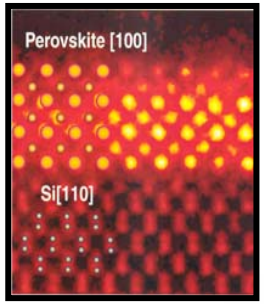
Scanning Tunneling Microscopy



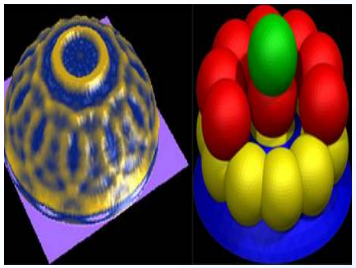
Atomic Force Microscopy



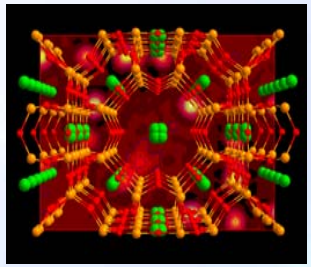
Electron Microscopy



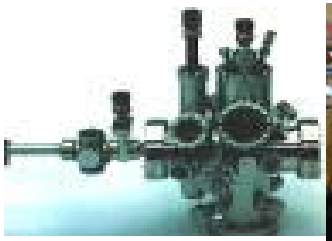
X-ray Scattering

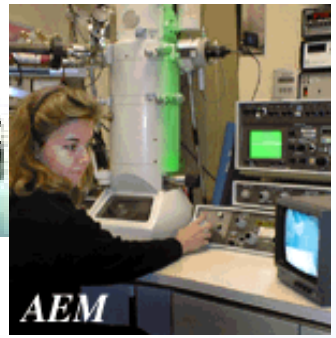


Neutron Scattering



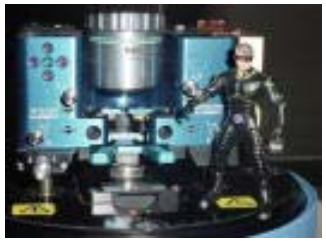
STM



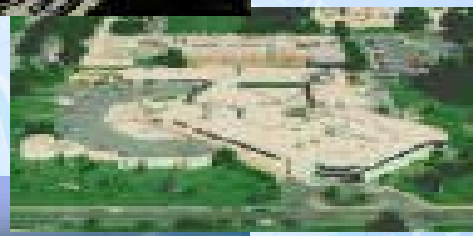


APS

AFM



NSLS



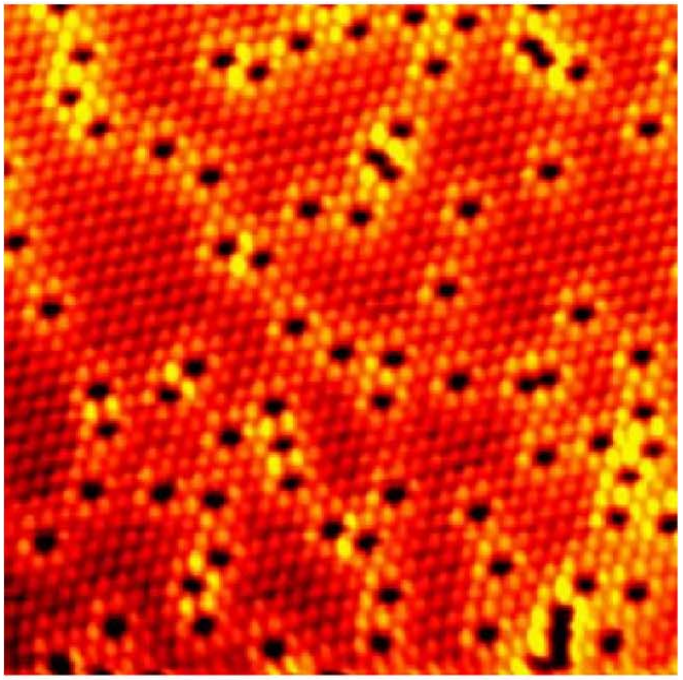
XRD

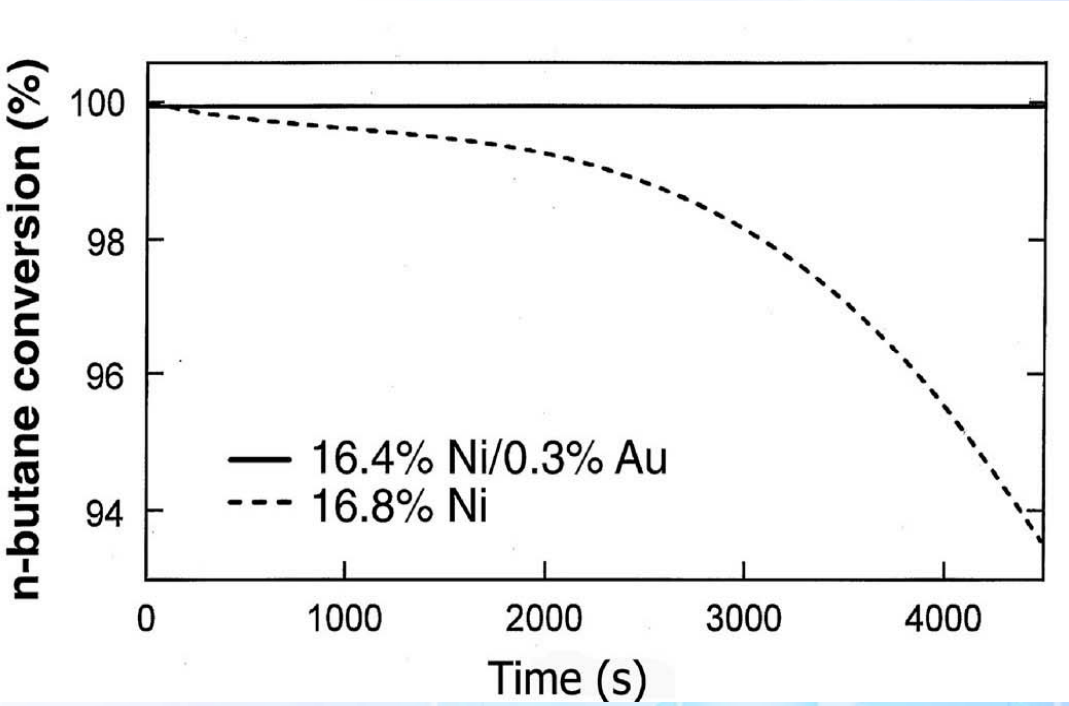
ALS

SNS

Nanoscale Catalysts for Fossil Fuel Reforming of Hydrogen

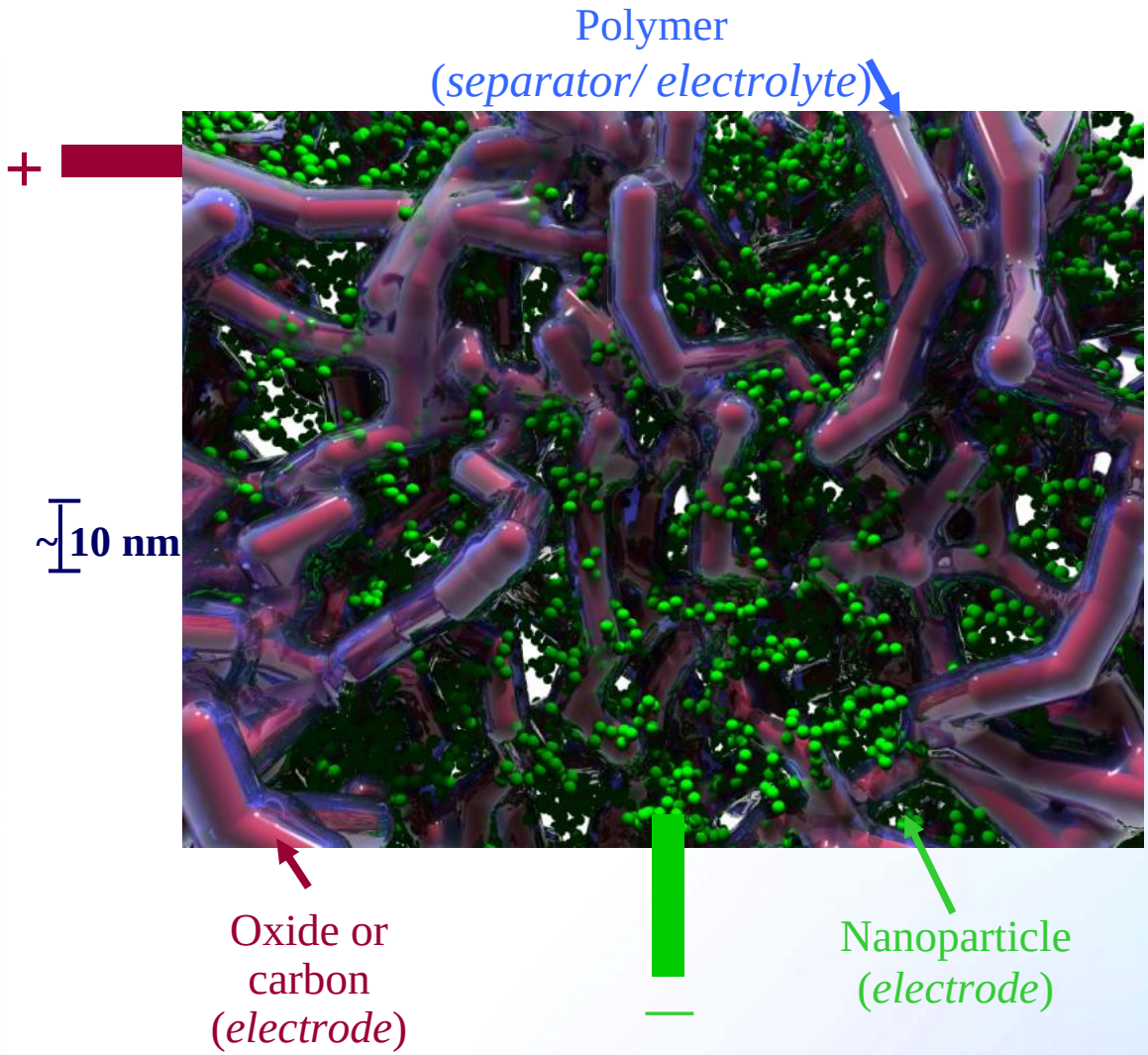
- For the next decade or more hydrogen will mainly be produced using fossil fuel feedstocks.
- Development of efficient inexpensive catalysts will be key.
- Modeling and simulation will play a significant role.





Inspired by quantum chemical calculations, Ni surface-alloyed with Au (black) on the left is used to reduce carbon poisoning of catalyst, as verified experimentally on the right.

3-D Nanoarchitectures for Power Storage



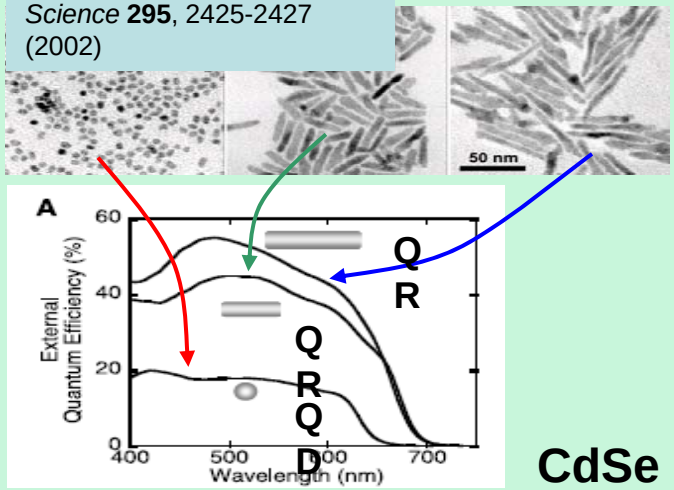
Nanostructured architectures for power storage (batteries, fuel cells, ultracapacitors, photovoltaics) provide many advantages over existing technologies to minimize power losses, improve charge/discharge rates and enhance energy densities.

Electrodes in these architectures will consist of interconnected ~10nm domains and mesopores (10-50nm). Ultrathin, conformal and a pinhole-free separator/electrolyte are electrodeposited onto the electrode nanoarchitecture. Low melting point metals (mp<200oC) or colloids fill the remaining mesoporous volume.

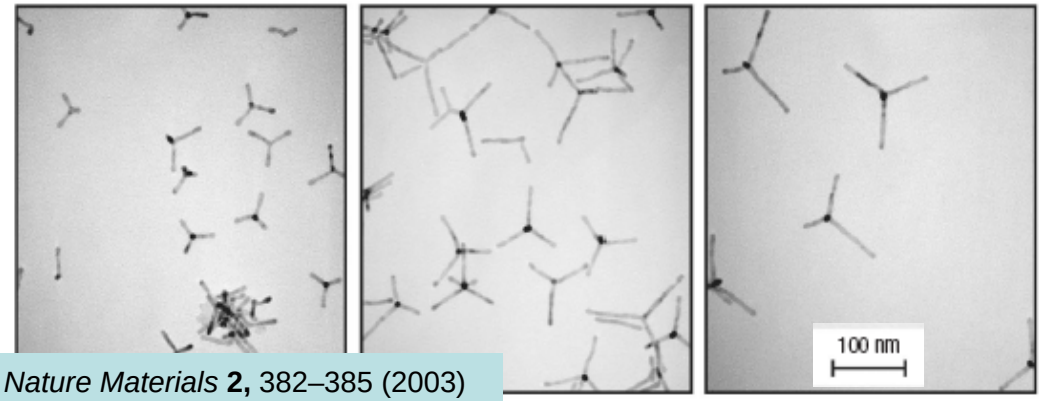
Source: Nanoscience Research for Energy Needs, NNI Grand Challenge Workshop Report

Nanocrystals for Low Cost, Higher Efficiency Solar Cells

Science **295**, 2425-2427 (2002)

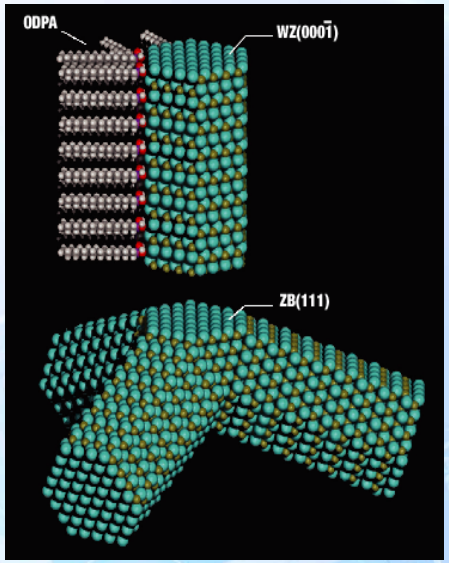


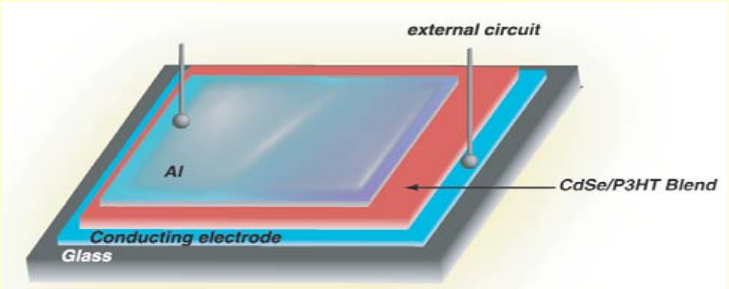
CdSe



Nature Materials **2,** 382–385 (2003)

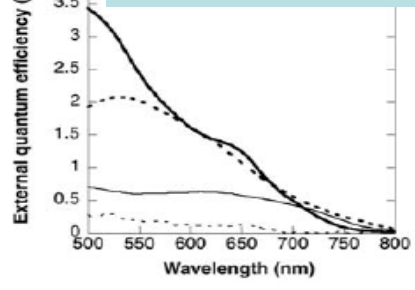
CdTe tetrapods





Organic/Inorganic Blended Cell

Science **310**, 462-465 (2005)



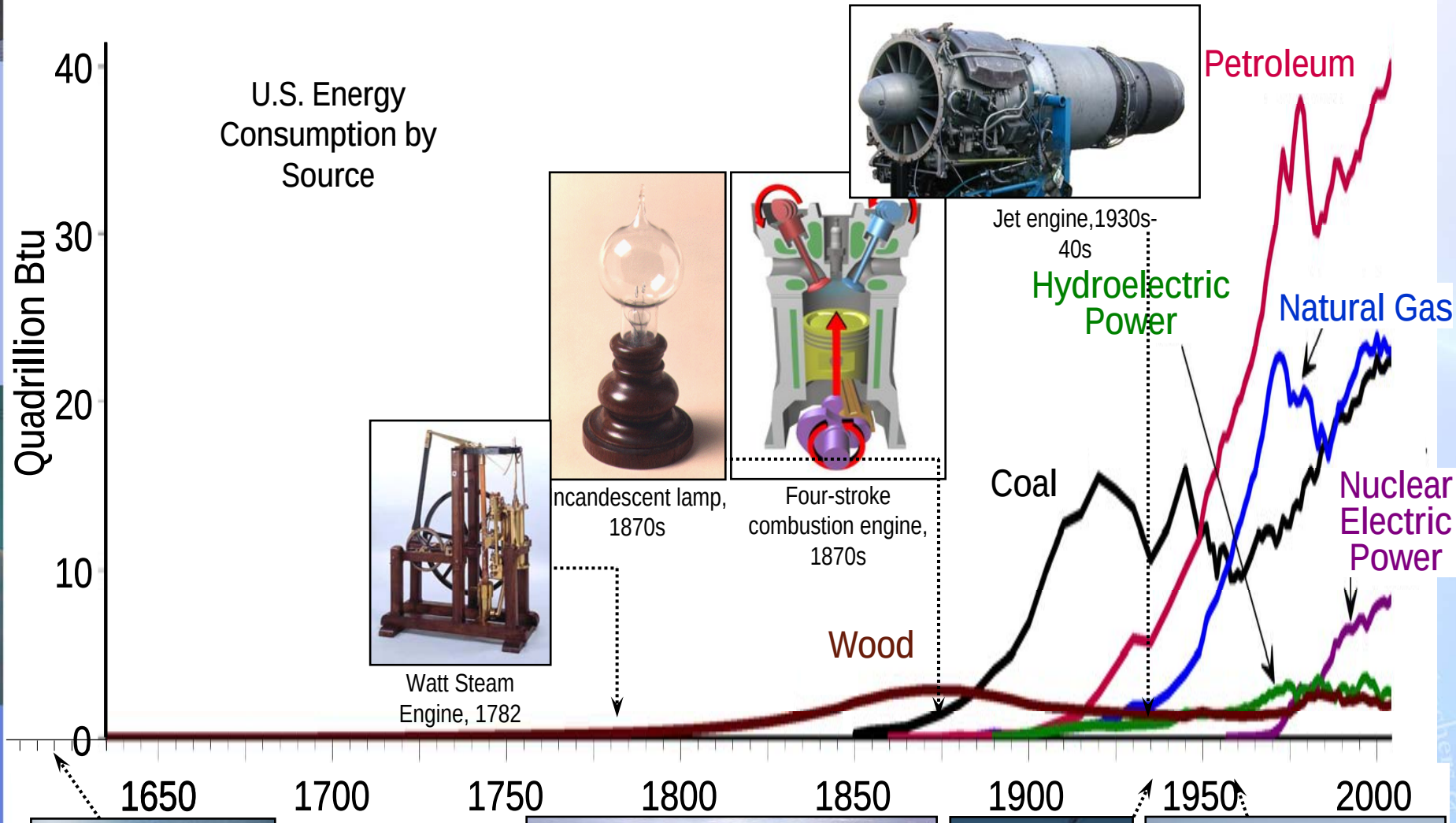
All-Inorganic Cell

Growth rates of two crystalline phases of CdTe are balanced to grow tetrapods. The zinc blend (ZB) phase nucleates initially, but the faster growing wurtzite phase continues the growth, resulting in a ***tetrapod shape****.*

A. P. Alivisatos *et al.* (LBNL)

Centuries of Fossil Fuel Usage in North America

85% of U.S. energy is from fossil fuels; 69% of petroleum is imported; nearly 60% of all primary energy is waste

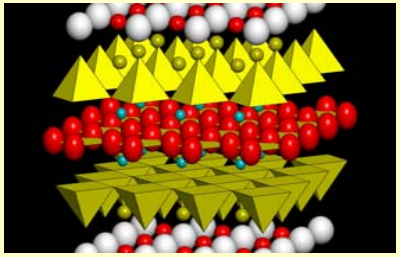


Wind, water, wood, animals, (Mayflower,1620)

Intercontinental Rail System

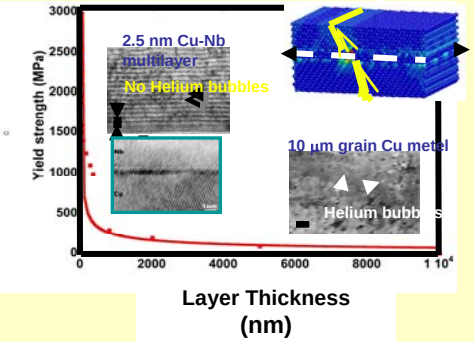
Eisenhower Highway System, 1956

Our Energy Future Depends on Atomic, Molecular, and Nanoscale Level Control of Matter and Processes

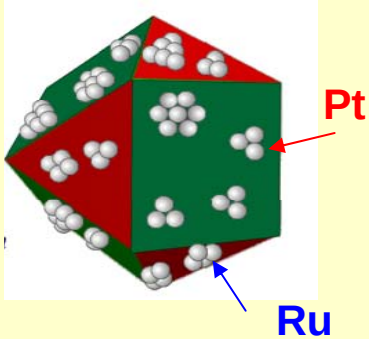


Reliable, high-capacity electric grid: High Tc superconductors

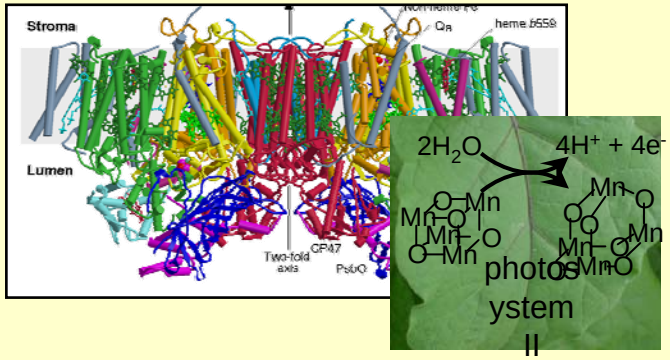
Solid-state lighting and applications of quantum confinement



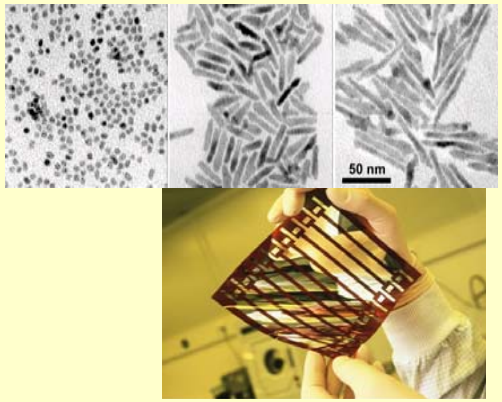
Nanocomposites for extreme environments



Atomic scale control of catalytic reactions for energy technologies



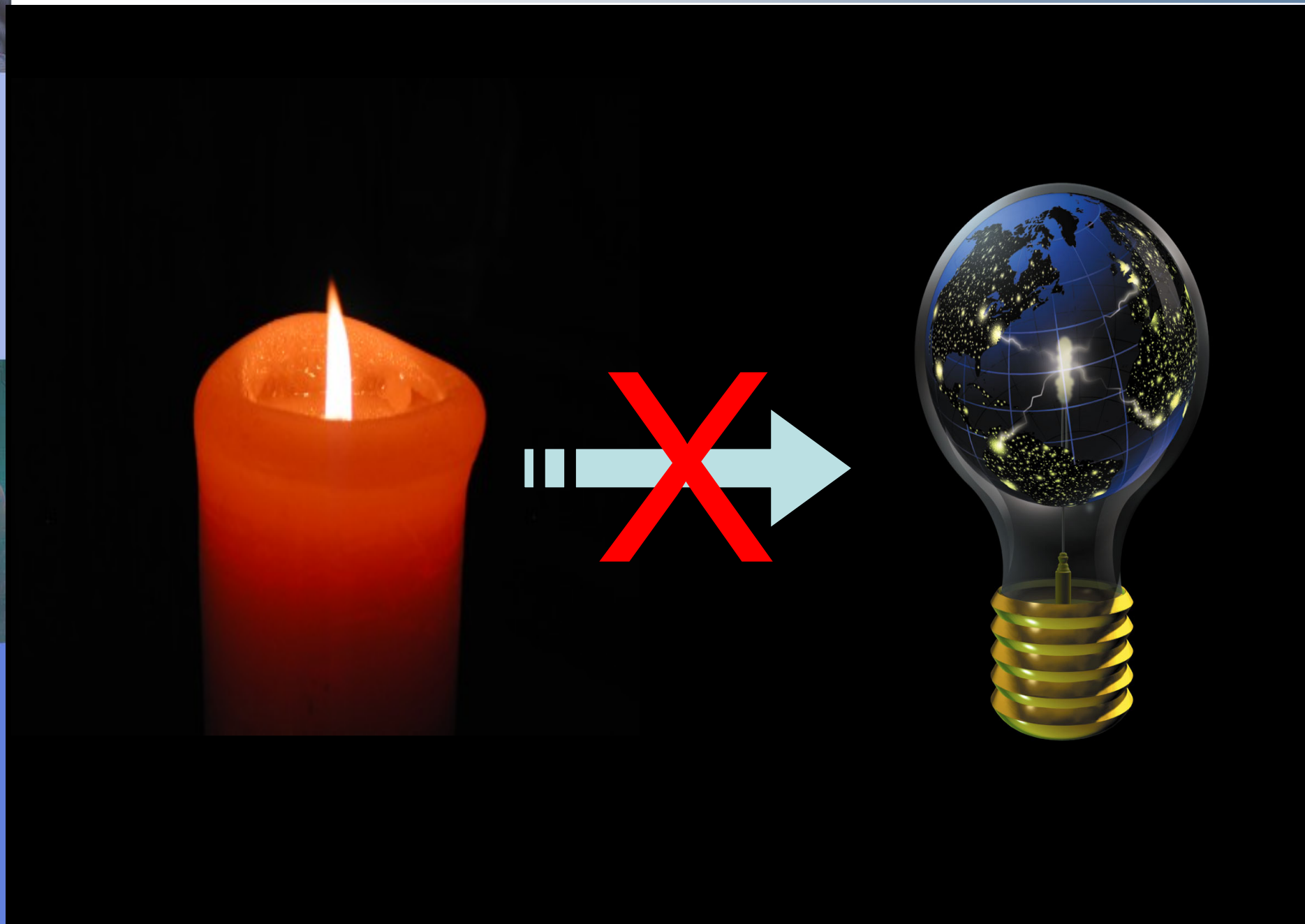
Bio-inspired nanoscale assemblies – self-repairing and defect-tolerant systems



Solar paint –based PV cells

Leading Scientific Innovations to Economic Competitiveness and Energy Security

… but electricity was not discovered via incremental improvements to the candle



The Solution Lies in Transformational Discoveries

- We must meet the increasing demand for energy without adding catastrophically to atmospheric carbon dioxide
- Current fossil energy sources, current energy production methods, and current technology cannot meet the challenge
- Incremental changes in technology will not suffice...
- We need transformational discoveries and truly disruptive technologies

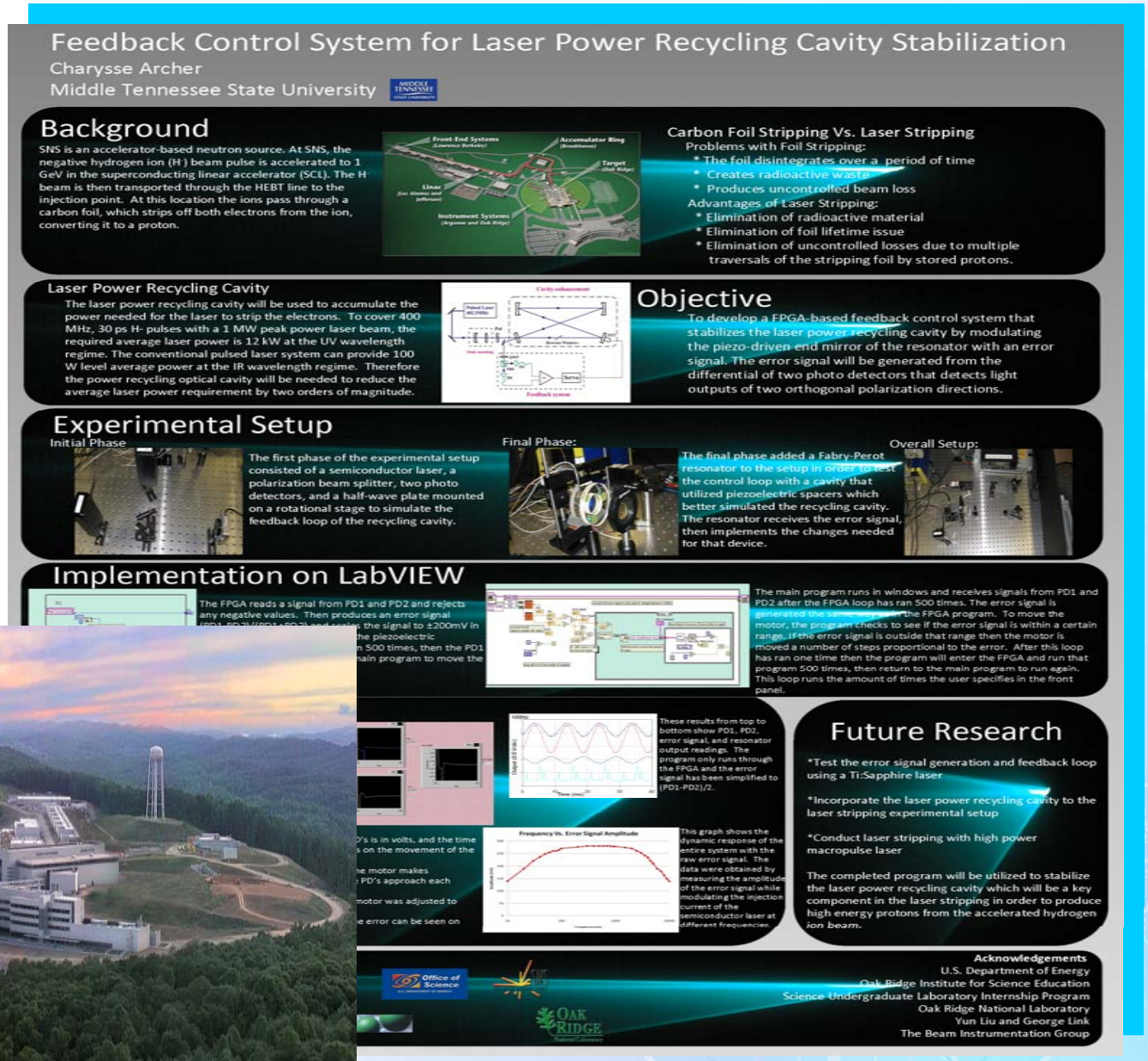
WHERE will these Transformational Discoveries Occur?

Our Presence . . .

WHO Will Make These Transformational Discoveries?

- SERCh participants represent the students who will be making these discoveries. Their posters demonstrate a bridge between current research and future breakthroughs.
- 2008 SERCh Participants:
  - Research conducted at 13 DOE laboratories
  - Applicants from 102 universities
- Today's students will make these discoveries
- We will need to proactively:
  - Recruit
  - Train

Students Research with the SNS at Oak Ridge National Laboratory (ORNL)



Feedback Control System for Laser Power Recycling Cavity Stabilization

Charysse Archer

Middle Tennessee State University

Background

SNS is an accelerator-based neutron source. At SNS, the negative hydrogen ion (H^-) beam pulse is accelerated to 1 GeV in the superconducting linear accelerator (SCL). The H^- beam is then transported through the HEBT line to the injection point. At this location the ions pass through a carbon foil, which strips off both electrons from the ion, converting it to a proton.

Carbon Foil Stripping Vs. Laser Stripping

Problems with Foil Stripping:

* The foil disintegrates over a period of time
* Creates radioactive waste
* Produces uncontrolled beam loss

Advantages of Laser Stripping:

* Elimination of radioactive material
* Elimination of foil lifetime issue
* Elimination of uncontrolled losses due to multiple traversals of the stripping foil by stored protons.

Laser Power Recycling Cavity

The laser power recycling cavity will be used to accumulate the power needed for the laser to strip the electrons. To cover 400 MHz, 30 ps H- pulses with a 1 MW peak power laser beam, the required average laser power is 12 kW at the UV wavelength regime. The conventional pulsed laser system can provide 100 W level average power at the IR wavelength regime. Therefore the power recycling optical cavity will be needed to reduce the average laser power requirement by two orders of magnitude.

Objective

To develop a FPGA-based feedback control system that stabilizes the laser power recycling cavity by modulating the piezo-driven end mirror of the resonator with an error signal. The error signal will be generated from the differential of two photo detectors that detects light outputs of two orthogonal polarization directions.

Experimental Setup

Initial Phase

The first phase of the experimental setup consisted of a semiconductor laser, a polarization beam splitter, two photo detectors, and a half-wave plate mounted on a rotational stage to simulate the feedback loop of the recycling cavity.

Final Phase:

The final phase added a Fabry-Perot resonator to the setup in order to test the control loop with a cavity that utilized piezoelectric spacers which better simulated the recycling cavity. The resonator receives the error signal, then implements the changes needed for that device.

Overall Setup:

Implementation on LabVIEW

The FPGA reads a signal from PD1 and PD2 and rejects any negative values. Then produces an error signal

The main program runs in windows and receives signals from PD1 and PD2 after the FPGA loop has ran 500 times. The error signal is generated the same way as the FPGA program. To move the motor, the program checks to see if the error signal is within a certain range. If the error signal is outside that range then the motor is moved a number of steps proportional to the error. After this loop has ran one time then the program will enter the FPGA and run that program 500 times, then return to the main program to run again. This loop runs the amount of times the user specifies in the front panel.

These results from top to bottom show PD1, PD2, error signal, and resonator output readings. The program only runs through the FPGA and the error signal has been simplified to (PD1-PD2)/2.

This graph shows the dynamic response of the entire system with the raw error signal. The data were obtained by measuring the amplitude of the error signal while modulating the injection current of the semiconductor laser at different frequencies.

Future Research

*Test the error signal generation and feedback loop using a Ti:Sapphire laser

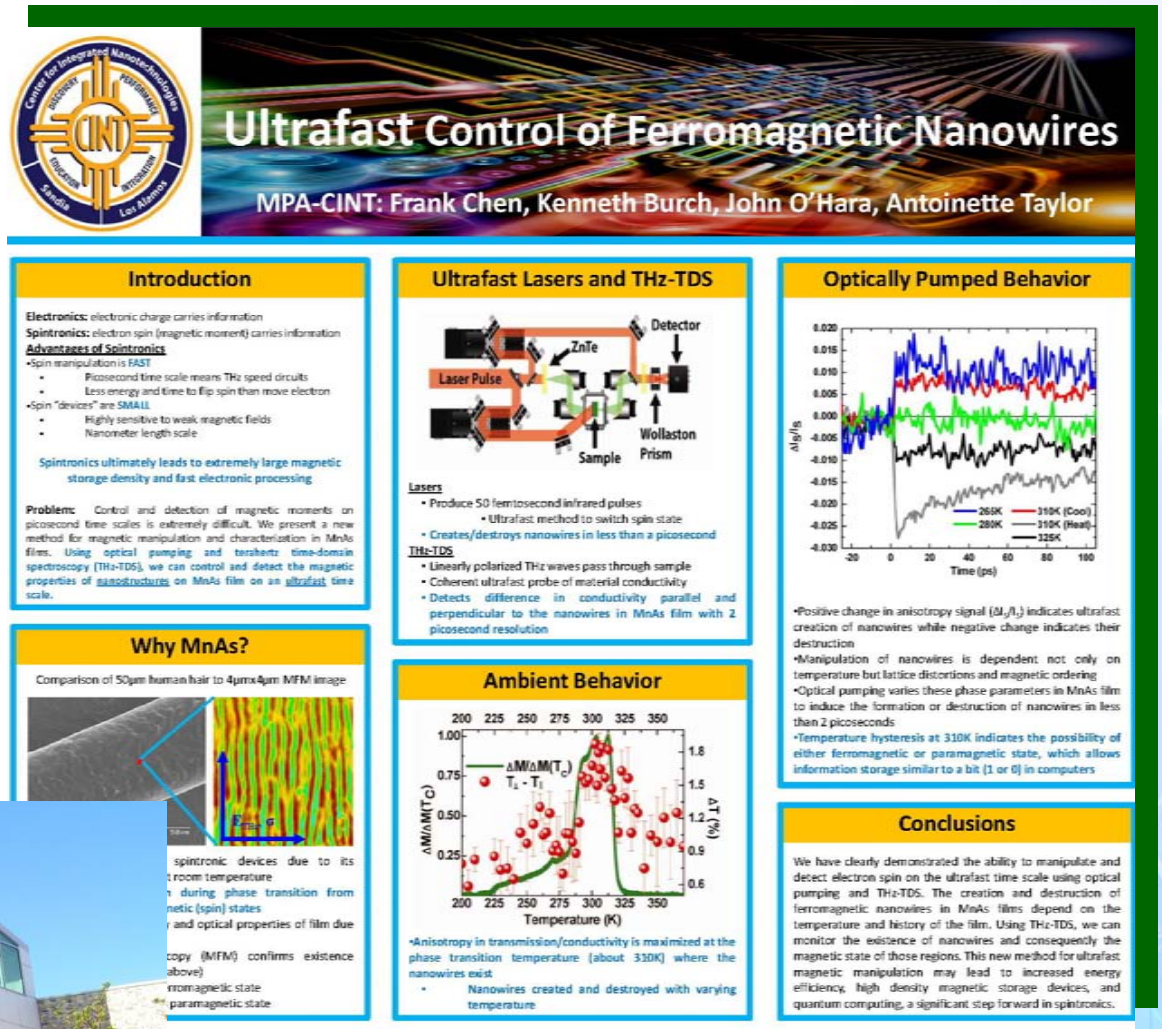
*Incorporate the laser power recycling cavity to the laser stripping experimental setup

*Conduct laser stripping with high power macropulse laser

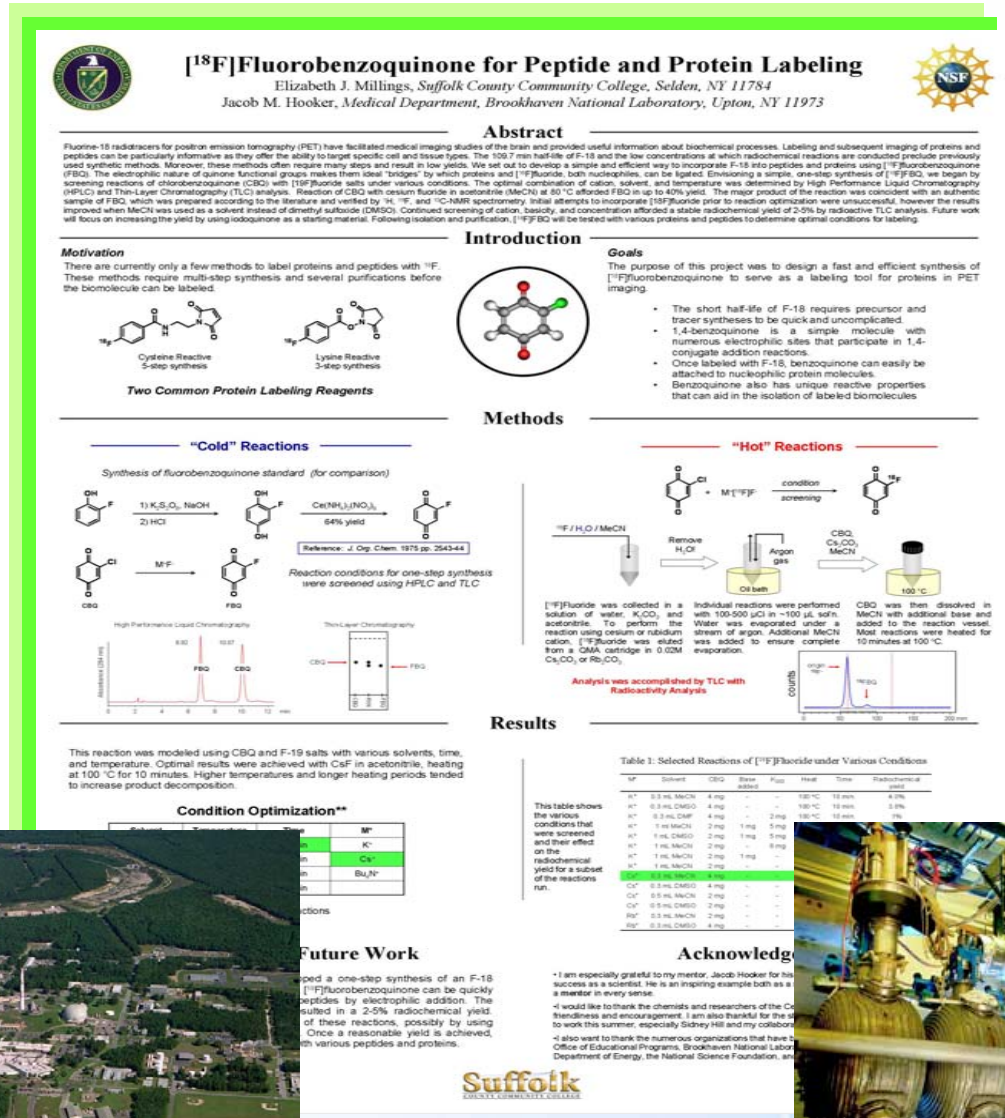
The completed program will be utilized to stabilize the laser power recycling cavity which will be a key component in the laser stripping in order to produce high energy protons from the accelerated hydrogen ion beam.

Acknowledgements
U.S. Department of Energy
Oak Ridge Institute for Science Education
Science Undergraduate Laboratory Internship Program
Oak Ridge National Laboratory
Yun Liu and George Link
The Beam Instrumentation Group

Students Research Nanotechnology at the Center for Integrated Nanotechnologies (CINT)



Students Apply Research to Medical Technology at Brookhaven National Laboratory (BNL)



[18F]Fluorobenzoquinone for Peptide and Protein Labeling

Elizabeth J. Millings, *Suffolk County Community College, Selden, NY 11784*
Jacob M. Hooker, *Medical Department, Brookhaven National Laboratory, Upton, NY 11973*

Abstract

Fluorine-18 radiotracers for positron emission tomography (PET) have facilitated medical imaging studies of the brain and provided useful information about biochemical processes. Labeling and subsequent imaging of proteins and peptides can be particularly informative as they offer the ability to target specific cell and tissue types. The 109.7 min half-life of F-18 and the low concentrations at which radiochemical reactions are conducted preclude previously used synthetic methods. Moreover, these methods often require many steps and result in low yields. We set out to develop a simple and efficient way to incorporate F-18 into peptides and proteins using [18F]fluorobenzoquinone (FBQ). The electrophilic nature of quinone functional groups makes them ideal "bridges" by which proteins and [18F]fluoride, both nucleophiles, can be ligated. Envisioning a simple, one-step synthesis of [18F]FBQ, we began by screening reactions of chlorobenzoquinone (CBQ) with [19F]fluoride salts under various conditions. The optimal combination of cation, solvent, and temperature was determined by High Performance Liquid Chromatography (HPLC) and Thin-Layer Chromatography (TLC) analysis. Reaction of CBQ with cesium fluoride in acetonitrile (MeCN) at 80 °C afforded FBQ in up to 40% yield. The major product of the reaction was coincident with an authentic sample of FBQ, which was prepared according to the literature and verified by 1H, 19F, and 13C-NMR spectrometry. Initial attempts to incorporate [18F]fluoride prior to reaction optimization were unsuccessful, however the results improved when MeCN was used as a solvent instead of dimethyl sulfoxide (DMSO). Continued screening of cation, basicity, and concentration afforded a stable radiochemical yield of 2-5% by radioactive TLC analysis. Future work will focus on increasing the yield by using iodoquinone as a starting material. Following isolation and purification, [18F]FBQ will be tested with various proteins and peptides to determine optimal conditions for labeling.

Introduction

Motivation

There are currently only a few methods to label proteins and peptides with 18F. These methods require multi-step synthesis and several purifications before the biomolecule can be labeled.

Cysteine Reactive 5-step synthesis

Lysine Reactive 3-step synthesis

Two Common Protein Labeling Reagents

Goals

The purpose of this project was to design a fast and efficient synthesis of [18F]fluorobenzoquinone to serve as a labeling tool for proteins in PET imaging.

- The short half-life of F-18 requires precursor and tracer syntheses to be quick and uncomplicated.
- 1,4-benzoquinone is a simple molecule with numerous electrophilic sites that participate in 1,4-conjugate addition reactions.
- Once labeled with F-18, benzoquinone can easily be attached to nucleophilic protein molecules.
- Benzoquinone also has unique reactive properties that can aid in the isolation of labeled biomolecules

Methods

"Cold" Reactions

Synthesis of fluorobenzoquinone standard (for comparison)

1) $K_2S_2O_8$, NaOH
2) HCl

$Ce(NH_4)_2(NO_3)_6$
64% yield

Reference: J. Org. Chem. 1975 pp. 2543-44

M+F-

CBQ → FBQ

Reaction conditions for one-step synthesis were screened using HPLC and TLC

High Performance Liquid Chromatography

Thin-Layer Chromatography

"Hot" Reactions

M+[18F]F- → condition screening

18F / H_2O / MeCN

Remove H_2O

Argon gas

Oil bath

CBQ, Cs_2CO_3, MeCN

100 °C

[18F]Fluoride was collected in a solution of water, K_2CO_3 and acetonitrile. To perform the reaction using cesium or rubidium cation, [18F]fluoride was eluted from a QMA cartridge in 0.02M Cs_2CO_3 or Rb_2CO_3.

Individual reactions were performed with 100-500 µCi in ~100 µL sol'n. Water was evaporated under a stream of argon. Additional MeCN was added to ensure complete evaporation.

CBQ was then dissolved in MeCN with additional base and added to the reaction vessel. Most reactions were heated for 10 minutes at 100 °C.

Analysis was accomplished by TLC with Radioactivity Analysis

counts

Results

This reaction was modeled using CBQ and F-19 salts with various solvents, time, and temperature. Optimal results were achieved with CsF in acetonitrile, heating at 100 °C for 10 minutes. Higher temperatures and longer heating periods tended to increase product decomposition.

Condition Optimization**

	M+
	K+
	Cs+
	Bu_4N^+

Table 1: Selected Reactions of [18F]Fluoride under Various Conditions

This table shows the various conditions that were screened and their effect on the radiochemical yield for a subset of the reactions run.

M+	Solvent	CBQ	Base added	K_{222}	Heat	Time	Radiochemical yield
K+	0.3 mL MeCN	4 mg	-	-	100 °C	10 min	4.0%
K+	0.3 mL DMSO	4 mg	-	-	100 °C	10 min	3.0%
K+	0.3 mL DMF	4 mg	-	2 mg	100 °C	10 min	1%
K+	1 mL MeCN	2 mg	1 mg	5 mg			
K+	1 mL DMSO	2 mg	1 mg	5 mg			
K+	1 mL MeCN	2 mg	-	8 mg			
K+	1 mL MeCN	2 mg	1 mg				
K+	1 mL MeCN	2 mg	-	-			
Cs+	0.3 mL MeCN	4 mg	-	-			
Cs+	0.3 mL DMSO	4 mg	-	-			
Cs+	0.5 mL MeCN	2 mg	-	-			
Cs+	0.5 mL DMSO	2 mg	-	-			
Rb+	0.3 mL MeCN	2 mg	-	-			
Rb+	0.3 mL DMSO	4 mg	-	-			

Future Work

...ped a one-step synthesis of an F-18 [18F]fluorobenzoquinone can be quickly ...peptides by electrophilic addition. The ...sulted in a 2-5% radiochemical yield. ... of these reactions, possibly by using ... Once a reasonable yield is achieved, ...th various peptides and proteins.

Acknowledg

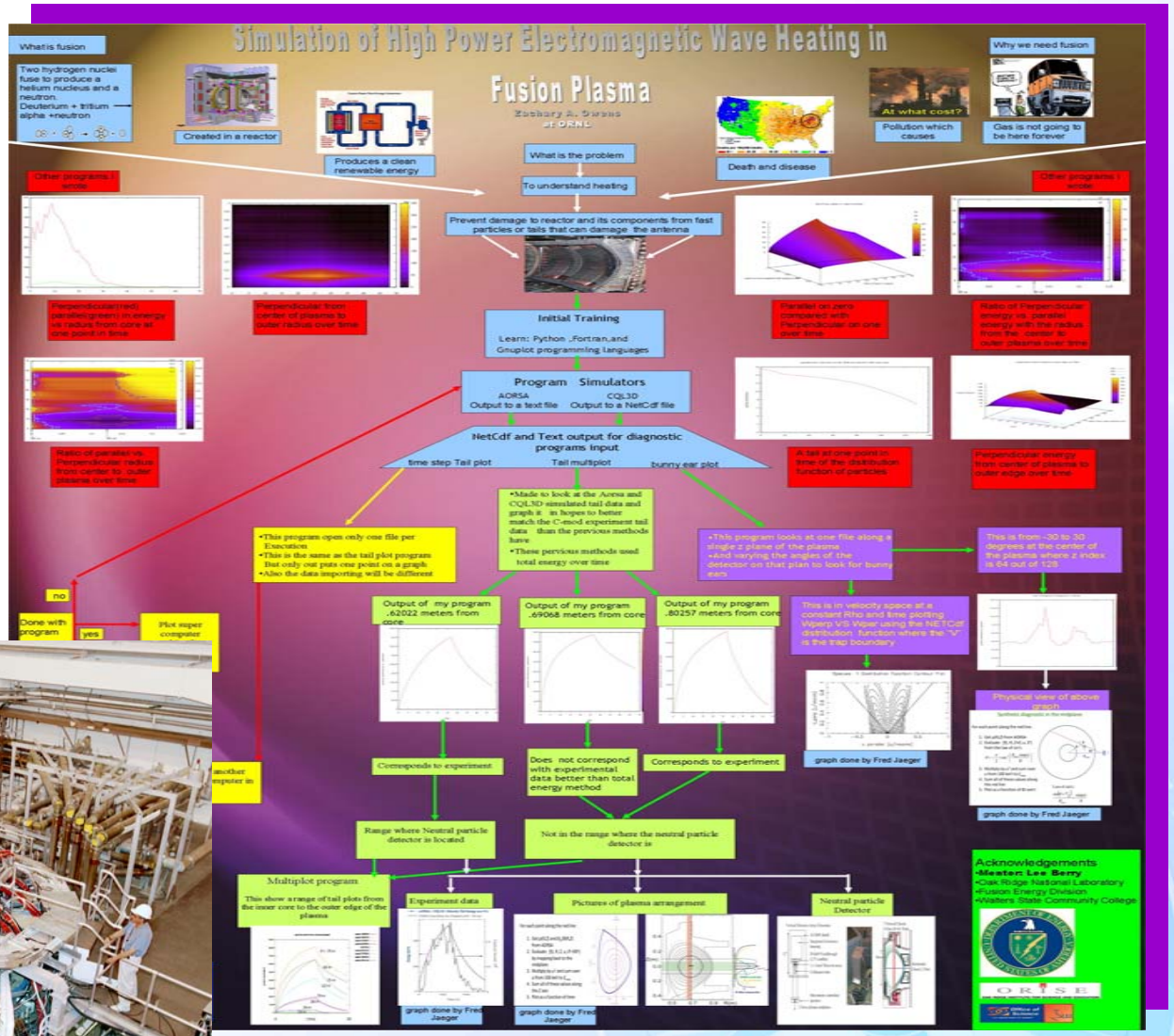
• I am especially grateful to my mentor, Jacob Hooker for his ... success as a scientist. He is an inspiring example both as a ... a mentor in every sense.

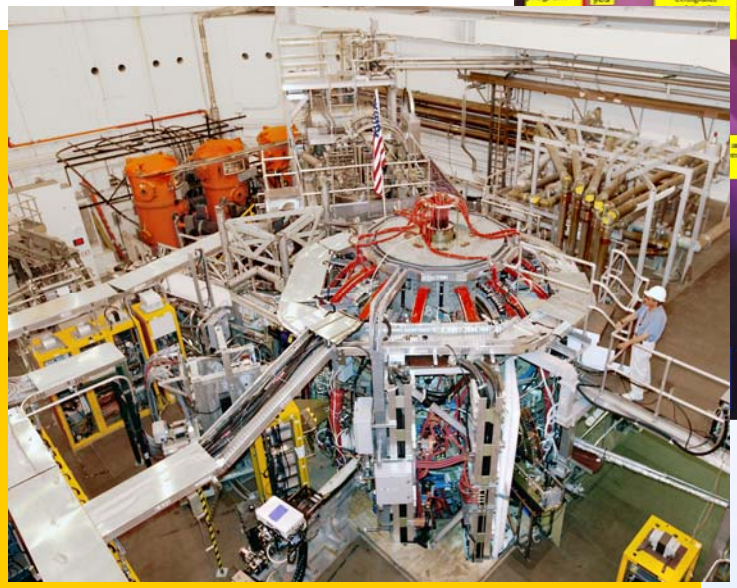
• I would like to thank the chemists and researchers of the Ce... friendliness and encouragement. I am also thankful for the s... to work this summer, especially Sidney Hill and my collabora...

• I also want to thank the numerous organizations that have ... Office of Educational Programs, Brookhaven National Labor... Department of Energy, the National Science Foundation, an...

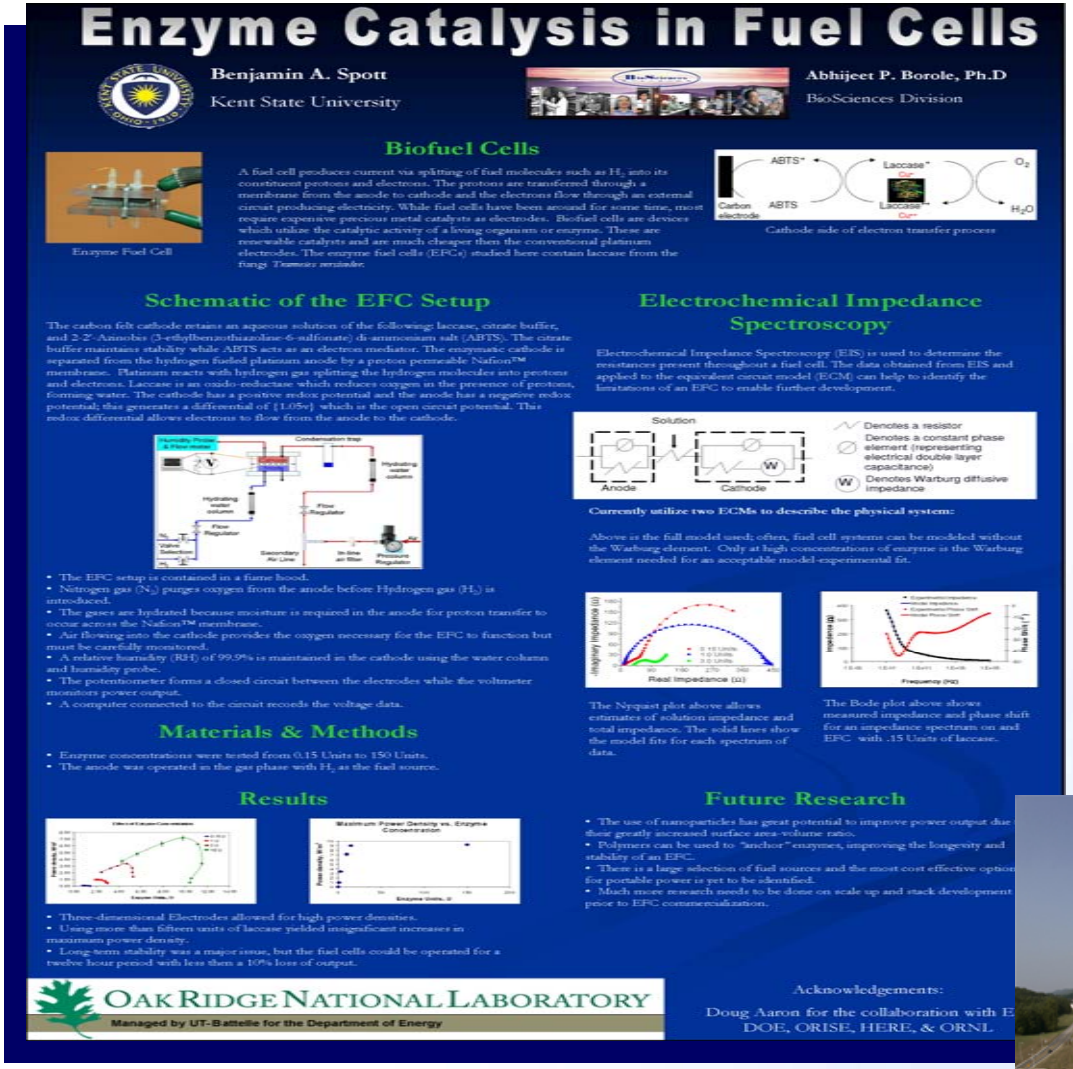
Suffolk COUNTY COMMUNITY COLLEGE

Students Research Fusion at ORNL & Princeton Plasma Physics Laboratory (PPPL)

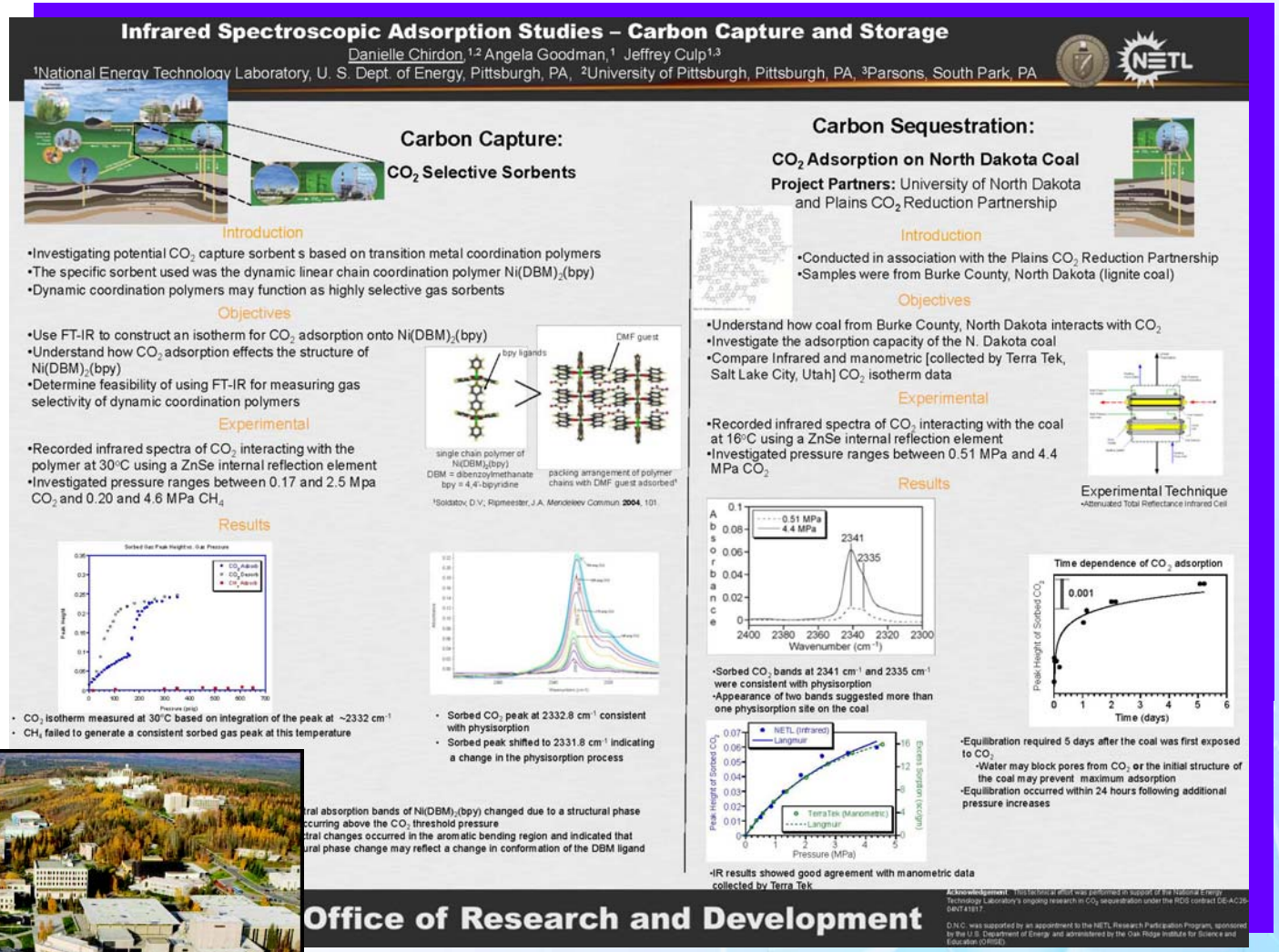




Students Research Alternative Fuels at ORNL



Students Research Climate Change at National Energy Technology Laboratory



Infrared Spectroscopic Adsorption Studies – Carbon Capture and Storage

Danielle Chirdon,[1,2] Angela Goodman,[1] Jeffrey Culp[1,3]
[1]National Energy Technology Laboratory, U. S. Dept. of Energy, Pittsburgh, PA, [2]University of Pittsburgh, Pittsburgh, PA, [3]Parsons, South Park, PA

Carbon Capture:

CO_2 Selective Sorbents

Introduction

- Investigating potential CO_2 capture sorbent s based on transition metal coordination polymers
- The specific sorbent used was the dynamic linear chain coordination polymer $Ni(DBM)_2(bpy)$
- Dynamic coordination polymers may function as highly selective gas sorbents

Objectives

- Use FT-IR to construct an isotherm for CO_2 adsorption onto $Ni(DBM)_2(bpy)$
- Understand how CO_2 adsorption effects the structure of $Ni(DBM)_2(bpy)$
- Determine feasibility of using FT-IR for measuring gas selectivity of dynamic coordination polymers

Experimental

- Recorded infrared spectra of CO_2 interacting with the polymer at 30°C using a ZnSe internal reflection element
- Investigated pressure ranges between 0.17 and 2.5 Mpa CO_2 and 0.20 and 4.6 MPa CH_4

Results

- CO_2 isotherm measured at 30°C based on integration of the peak at ~2332 cm^{-1}
- CH_4 failed to generate a consistent sorbed gas peak at this temperature

- Sorbed CO_2 peak at 2332.8 cm^{-1} consistent with physisorption
- Sorbed peak shifted to 2331.8 cm^{-1} indicating a change in the physisorption process

Carbon Sequestration:

CO_2 Adsorption on North Dakota Coal

Project Partners: University of North Dakota and Plains CO_2 Reduction Partnership

Introduction

- Conducted in association with the Plains CO_2 Reduction Partnership
- Samples were from Burke County, North Dakota (lignite coal)

Objectives

- Understand how coal from Burke County, North Dakota interacts with CO_2
- Investigate the adsorption capacity of the N. Dakota coal
- Compare Infrared and manometric [collected by Terra Tek, Salt Lake City, Utah] CO_2 isotherm data

Experimental

- Recorded infrared spectra of CO_2 interacting with the coal at 16°C using a ZnSe internal reflection element
- Investigated pressure ranges between 0.51 MPa and 4.4 MPa CO_2

Experimental Technique

Results

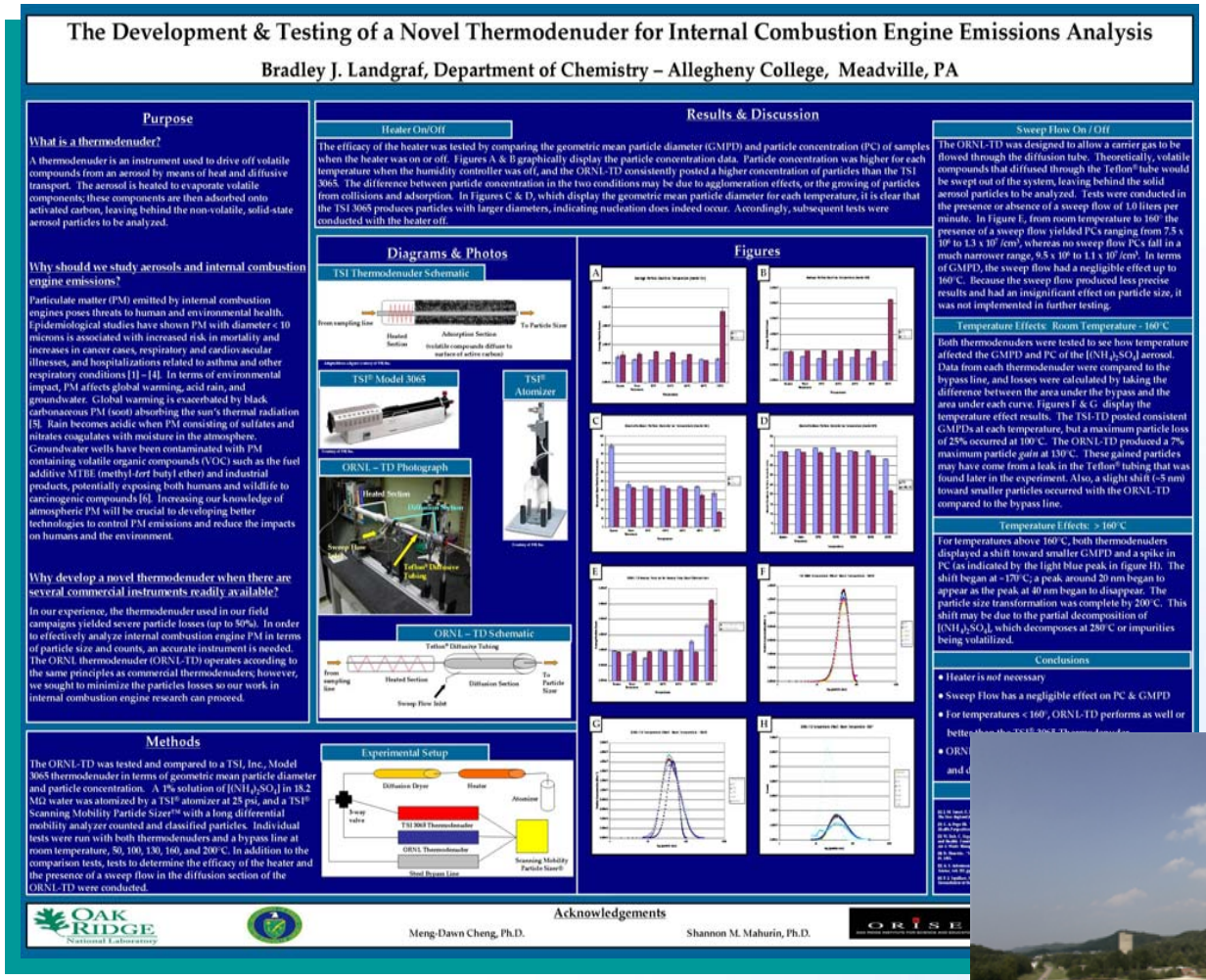
- Sorbed CO_2 bands at 2341 cm^{-1} and 2335 cm^{-1} were consistent with physisorption
- Appearance of two bands suggested more than one physisorption site on the coal

- Equilibration required 5 days after the coal was first exposed to CO_2
  - Water may block pores from CO_2 or the initial structure of the coal may prevent maximum adsorption
- Equilibration occurred within 24 hours following additional pressure increases

- IR results showed good agreement with manometric data collected by Terra Tek

Office of Research and Development

Students Research Pollution Reduction at ORNL



The Development & Testing of a Novel Thermodenuder for Internal Combustion Engine Emissions Analysis

Bradley J. Landgraf, Department of Chemistry – Allegheny College, Meadville, PA

Purpose

What is a thermodenuder?

A thermodenuder is an instrument used to drive off volatile compounds from an aerosol by means of heat and diffusive transport. The aerosol is heated to evaporate volatile components; these components are then adsorbed onto activated carbon, leaving behind the non-volatile, solid-state aerosol particles to be analyzed.

Why should we study aerosols and internal combustion engine emissions?

Particulate matter (PM) emitted by internal combustion engines poses threats to human and environmental health. Epidemiological studies have shown PM with diameter < 10 microns is associated with increased risk in mortality and increases in cancer cases, respiratory and cardiovascular illnesses, and hospitalizations related to asthma and other respiratory conditions [1] – [4]. In terms of environmental impact, PM affects global warming, acid rain, and groundwater. Global warming is exacerbated by black carbonaceous PM (soot) absorbing the sun's thermal radiation [5]. Rain becomes acidic when PM consisting of sulfates and nitrates coagulates with moisture in the atmosphere. Groundwater wells have been contaminated with PM containing volatile organic compounds (VOC) such as the fuel additive MTBE (methyl-*tert* butyl ether) and industrial products, potentially exposing both humans and wildlife to carcinogenic compounds [6]. Increasing our knowledge of atmospheric PM will be crucial to developing better technologies to control PM emissions and reduce the impacts on humans and the environment.

Why develop a novel thermodenuder when there are several commercial instruments readily available?

In our experience, the thermodenuder used in our field campaigns yielded severe particle losses (up to 50%). In order to effectively analyze internal combustion engine PM in terms of particle size and counts, an accurate instrument is needed. The ORNL thermodenuder (ORNL-TD) operates according to the same principles as commercial thermodenuders; however, we sought to minimize the particles losses so our work in internal combustion engine research can proceed.

Methods

The ORNL-TD was tested and compared to a TSI, Inc., Model 3065 thermodenuder in terms of geometric mean particle diameter and particle concentration. A 1% solution of $[(NH_4)_2SO_4]$ in 18.2 MΩ water was atomized by a TSI® atomizer at 25 psi, and a TSI® Scanning Mobility Particle Sizer™ with a long differential mobility analyzer counted and classified particles. Individual tests were run with both thermodenuders and a bypass line at room temperature, 50, 100, 130, 160, and 200°C. In addition to the comparison tests, tests to determine the efficacy of the heater and the presence of a sweep flow in the diffusion section of the ORNL-TD were conducted.

Experimental Setup

Diagrams & Photos

TSI Thermodenuder Schematic

TSI® Model 3065

TSI® Atomizer

ORNL – TD Photograph

ORNL – TD Schematic

Results & Discussion

Heater On/Off

The efficacy of the heater was tested by comparing the geometric mean particle diameter (GMPD) and particle concentration (PC) of samples when the heater was on or off. Figures A & B graphically display the particle concentration data. Particle concentration was higher for each temperature when the humidity controller was off, and the ORNL-TD consistently posted a higher concentration of particles than the TSI 3065. The difference between particle concentration in the two conditions may be due to agglomeration effects, or the growing of particles from collisions and adsorption. In Figures C & D, which display the geometric mean particle diameter for each temperature, it is clear that the TSI 3065 produces particles with larger diameters, indicating nucleation does indeed occur. Accordingly, subsequent tests were conducted with the heater off.

Figures

Sweep Flow On / Off

The ORNL-TD was designed to allow a carrier gas to be flowed through the diffusion tube. Theoretically, volatile compounds that diffused through the Teflon® tube would be swept out of the system, leaving behind the solid aerosol particles to be analyzed. Tests were conducted in the presence or absence of a sweep flow of 1.0 liters per minute. In Figure E, from room temperature to 160° the presence of a sweep flow yielded PCs ranging from 7.5 x 10^8 to 1.3 x 10^7 /cm^3, whereas no sweep flow PCs fall in a much narrower range, 9.5 x 10^8 to 1.1 x 10^7 /cm^3. In terms of GMPD, the sweep flow had a negligible effect up to 160°C. Because the sweep flow produced less precise results and had an insignificant effect on particle size, it was not implemented in further testing.

Temperature Effects: Room Temperature - 160°C

Both thermodenuders were tested to see how temperature affected the GMPD and PC of the $[(NH_4)_2SO_4]$ aerosol. Data from each thermodenuder were compared to the bypass line, and losses were calculated by taking the difference between the area under the bypass and the area under each curve. Figures F & G display the temperature effect results. The TSI-TD posted consistent GMPDs at each temperature, but a maximum particle loss of 25% occurred at 100°C. The ORNL-TD produced a 7% maximum particle *gain* at 130°C. These gained particles may have come from a leak in the Teflon® tubing that was found later in the experiment. Also, a slight shift (~5 nm) toward smaller particles occurred with the ORNL-TD compared to the bypass line.

Temperature Effects: > 160°C

For temperatures above 160°C, both thermodenuders displayed a shift toward smaller GMPD and a spike in PC (as indicated by the light blue peak in figure H). The shift began at ~170°C; a peak around 20 nm began to appear as the peak at 40 nm began to disappear. The particle size transformation was complete by 200°C. This shift may be due to the partial decomposition of $[(NH_4)_2SO_4]$, which decomposes at 280°C or impurities being volatilized.

Conclusions

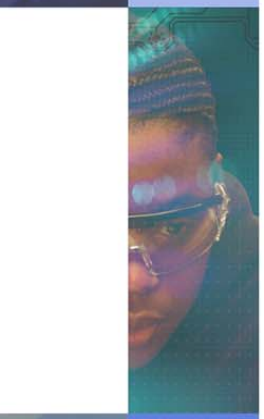
- Heater is *not* necessary
- Sweep Flow has a negligible effect on PC & GMPD
- For temperatures < 160°, ORNL-TD performs as well or better than the TSI® 3065 Thermodenuder
- ORNL-TD [illegible]

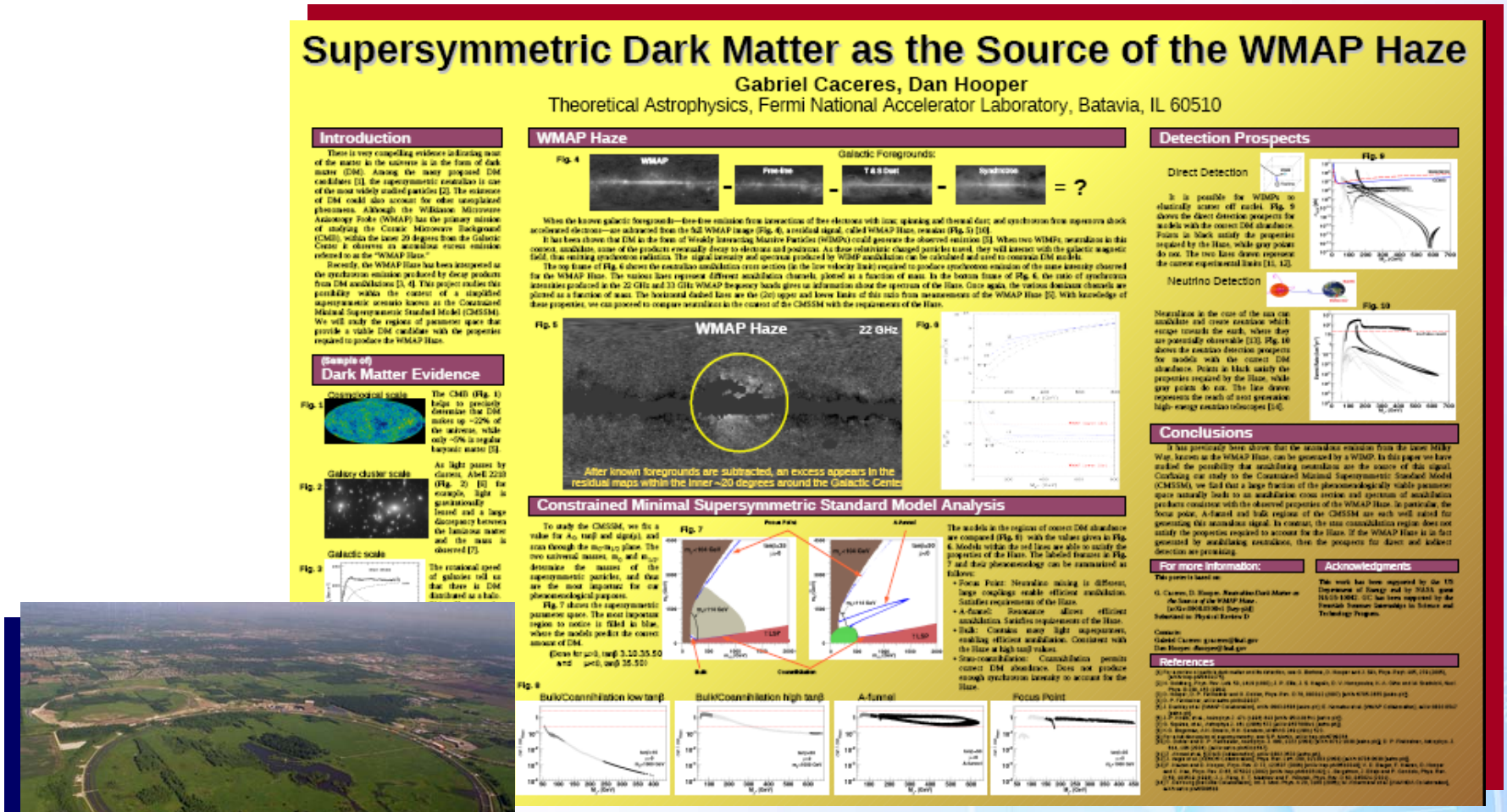
Acknowledgements

Meng-Dawn Cheng, Ph.D.

Shannon M. Mahurin, Ph.D.

Students Research the Nature of the Universe at Fermi





Supersymmetric Dark Matter as the Source of the WMAP Haze

Gabriel Caceres, Dan Hooper

Theoretical Astrophysics, Fermi National Accelerator Laboratory, Batavia, IL 60510

Introduction

(Sample of) Dark Matter Evidence

Fig. 1 Cosmological scale

Fig. 2 Galaxy cluster scale

Fig. 3 Galactic scale

WMAP Haze

Fig. 4 Galactic Foregrounds: WMAP - Free-free - T & S Dust - Synchrotron = ?

Fig. 5 WMAP Haze 22 GHz

After known foregrounds are subtracted, an excess appears in the residual maps within the inner ~20 degrees around the Galactic Center

Fig. 9

Constrained Minimal Supersymmetric Standard Model Analysis

Fig. 7

Fig. 8 Bulk/Coannihilation low tanβ; Bulk/Coannihilation high tanβ; A-funnel; Focus Point

Detection Prospects

Direct Detection

Fig. 9

Neutrino Detection

Fig. 10

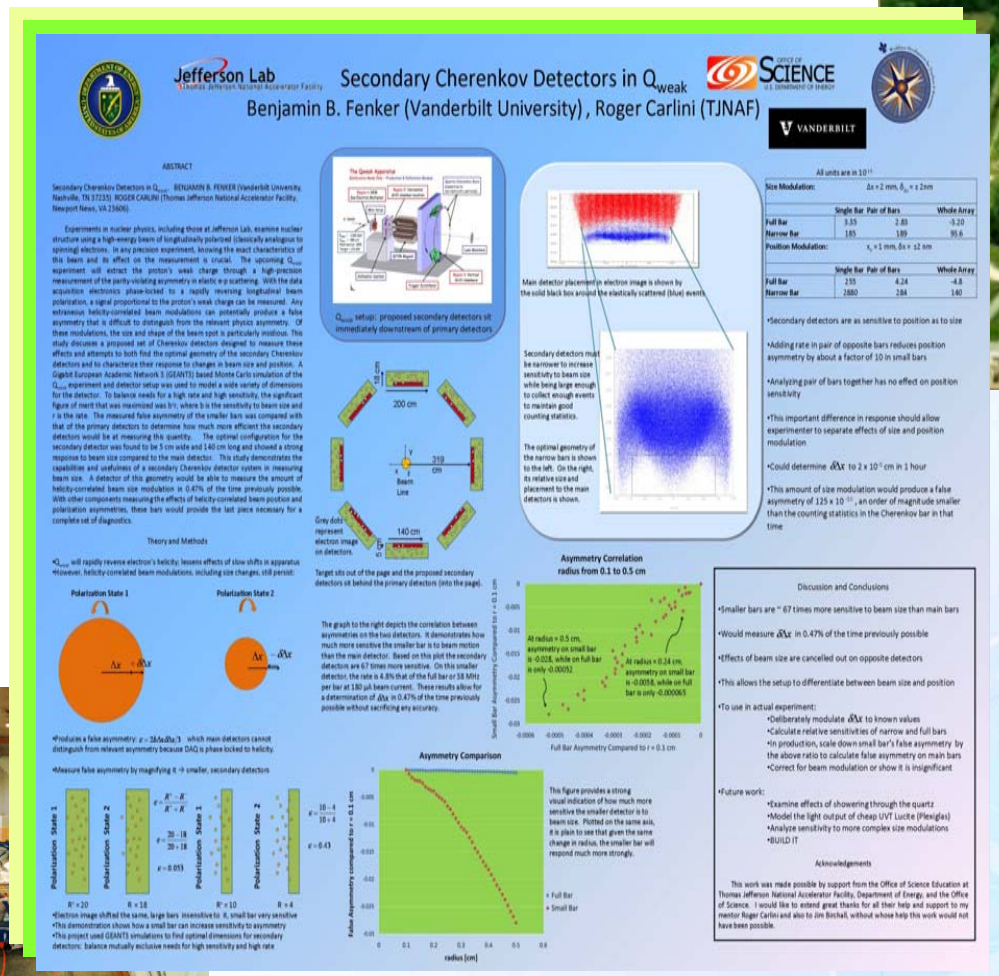
Conclusions

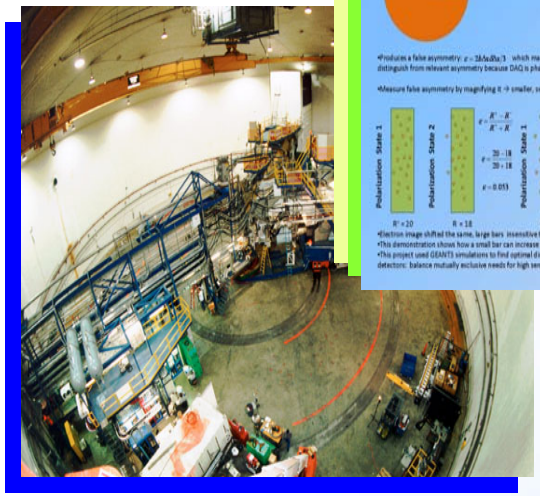
For more information:

Acknowledgments

References

Students Contribute to Accelerator Technology at Jefferson Laboratory





WDTS' Future Workforce Strategy

National Goal

The Office of Workforce Development for Teachers and Scientists will prepare a diverse workforce of scientists, engineers, and educators to keep America at the forefront of innovation. The Department of Energy will utilize its unique intellectual and physical resources to enhance the ability of educators and our Nation's educational systems to teach science and mathematics.

- Prepare a diverse workforce of scientists, engineers, and educators to keep America at the forefront of innovation.
- Utilize DOE's unique intellectual and physical resources to enhance the ability of educators and our Nation's educational systems to teach science and mathematics.
- Implement a proactive, data-driven, and results-focused model that promotes and strengthens the greater STEM education and research community.

U.S. Trains the World's Workforce

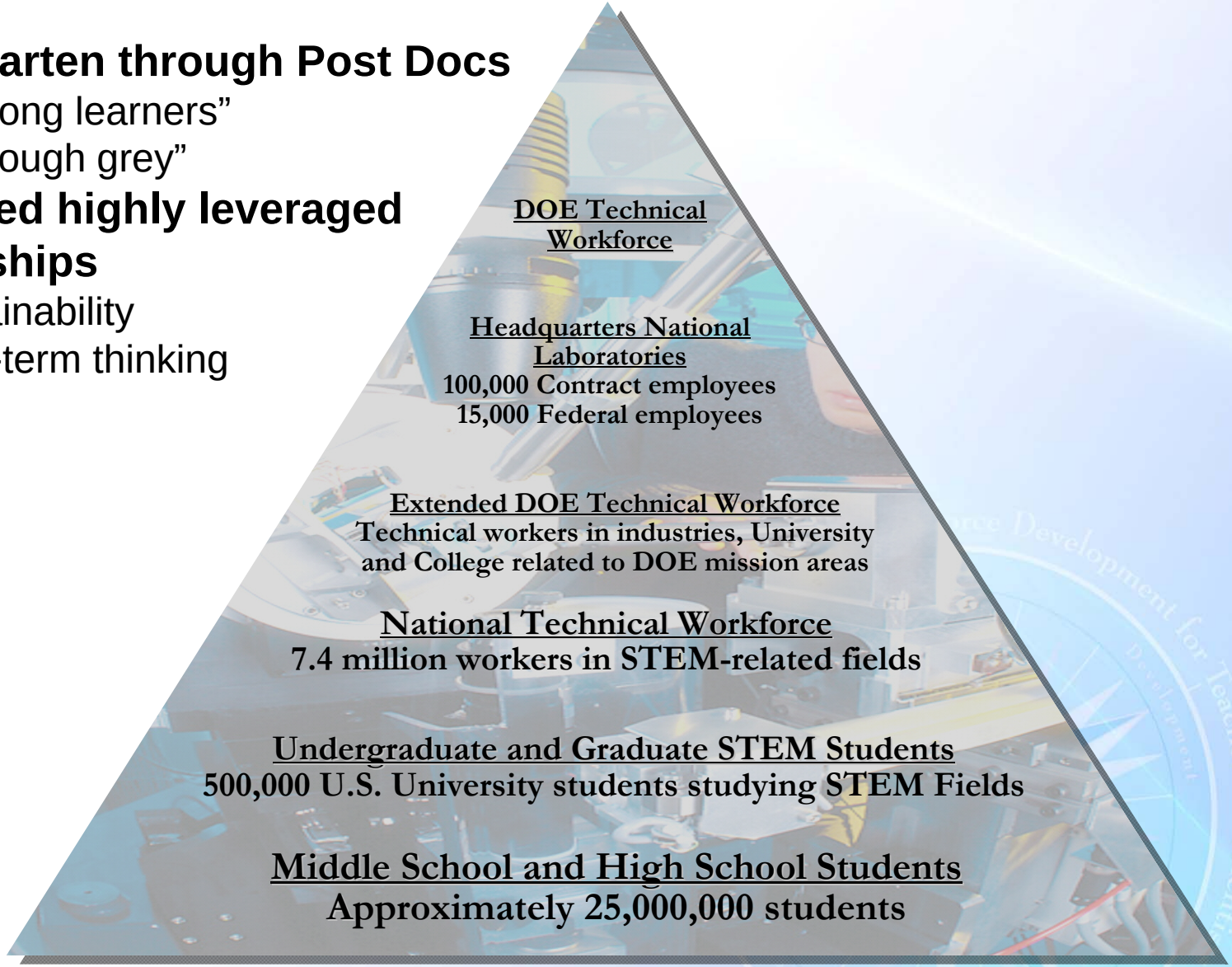
- The U.S. possesses an immense capacity for training the world's scientists
  - Large percentage of research conducted at the university level is by foreign nationals
  - Approximately one third of graduate students in the sciences are foreign nationals
  - The U.S. needs to utilize this capacity with its own citizens
- Large pool of U.S. talent to draw from
  - 3 – 4 % of the U.S. population are involved in STEM-related fields
  - 15 – 20% of the U.S. population is science literate or a science attentive audience
- Other countries have similar needs for native-born scientists
  - Trained in the U.S.
  - Take skills back home

National Needs Delivered Locally

- Define large scale goals in terms of the local delivery mechanisms
  - Implement at the local level
  - Local outcomes percolate up to national & transnational levels
    - Local goals must align with higher level goals
    - Local programs coordinate to create national platform
- Understand the local conditions
  - Industrial needs: chemical, pharmaceutical, electronic and technology
  - Rural/urban
  - Diverse workforce
- National Imperatives
  - GDP & national economy
  - National security
- Training a workforce locally to meet national imperatives

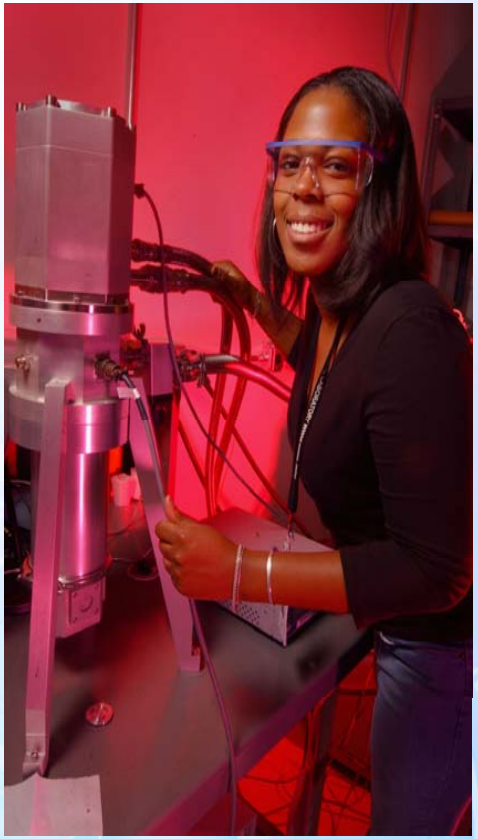
Pipeline Approach

- **Kindergarten through Post Docs**
  - "Life long learners"
  - "K through grey"
- **Integrated highly leveraged partnerships**
  - Sustainability
  - Long-term thinking



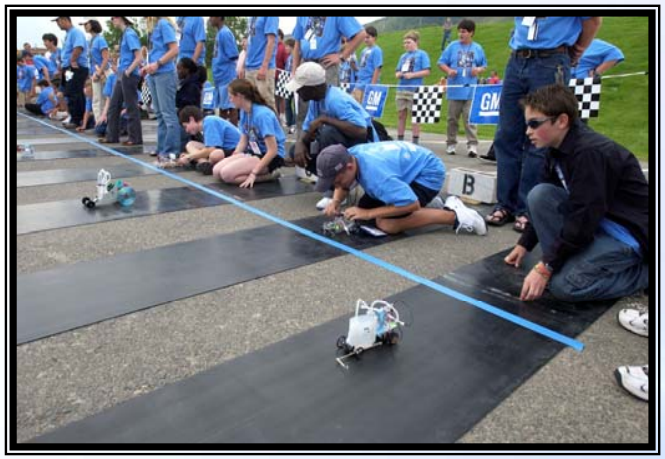
Future Workforce Strategy

- **Educators:** Highly qualified K-16 educators who engage students in authentic science and improve the nation's STEM education capabilities.
- **Students:** Greatly expanded, more knowledgeable, and more diverse population of skilled scientists, engineers, and mathematicians.
- **Workforce Development:** Sustained pipeline of workforce-ready talent available to DOE's national laboratories, Federal workforce, private industry, and academia.
- **Program Capacity:** Leverage expertise and resources through specially-configured, high-impact public/private partnerships that will maximize, expand, and sustain the nation's STEM workforce.



Pre-College Activities

- **National Science Bowl**
  - High School now in its 19th year
  - Middle School started in 2000
  - Encourage students to study math & science



- **Regional events**
  - Hosted by DOE sites, colleges & universities, utilities, other educational institutions
  - Hundreds of volunteers
  - More than 16,000 high school students
  - More than 5000 middle school students

Pre-College Activities

- **Real World Design Challenge**
  - High school students
  - Ten states in 2009
  - Government - industry partnerships
  - Build lasting mentor relationships
  - Connects students and educators to the real world
    - Applies real world tools to real world challenges
    - Bridges classroom curriculum with real world applications
  - Scalable
    - Cross-disciplinary
    - Cross agency collaboration
    - Individualized to highlight state strengths

Undergraduate Laboratory Research Internships

Science Undergraduate Laboratory Internship

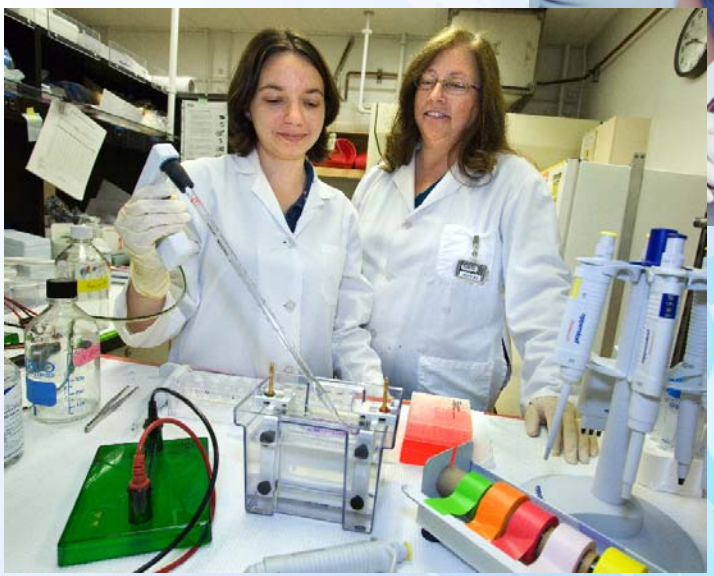
Community College Institute

Pre-Service Teacher Program

- Unique Characteristic of the Program is an intensive research experience mentored by a laboratory scientist or engineer
- Participants are required to produce a written summary of their work – creates an environment of high expectations
- These experiences connect students to the Grand Challenges facing the nation

Science Undergraduate Laboratory Internships (SULI)

- Highly competitive
- Best and brightest program
- 550 Students in 2008
- 17 National laboratories participate
- Goal is to recruit a diverse group of participants
- Partnership with NSF



Community College Institute (CCI)

- Students spend 20% of their time with enhancement activities
  - Career options
  - Writing & presentation skills
  - Seminars
- Develop technical skills that make students highly competitive in the workforce

Pre-Service Teachers Internship (PST)

- Goal is to enhance the nation's supply of proficient K-12 science, mathematics, and technology teachers
- Provide an authentic research experience to take back to the classroom

- Master Teachers
  - Organize and present enrichment activities
  - Work with the student's mentor & laboratory education staff
  - Assist students in transferring laboratory experience to classroom

Faculty and Student Teams (FaST)

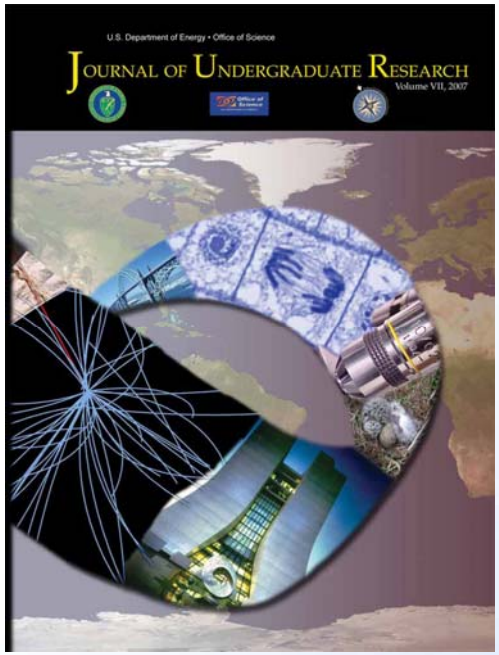
- Goal is to build research capacity at universities that currently lack the ability to do research
- Faculty from institutions that are below the 50th percentile in federal research funding
- Includes faculty from community colleges
- Teams are 1 faculty member and up to 3 students
- Partnership with NSF
- FaST has led to grants to participating colleges

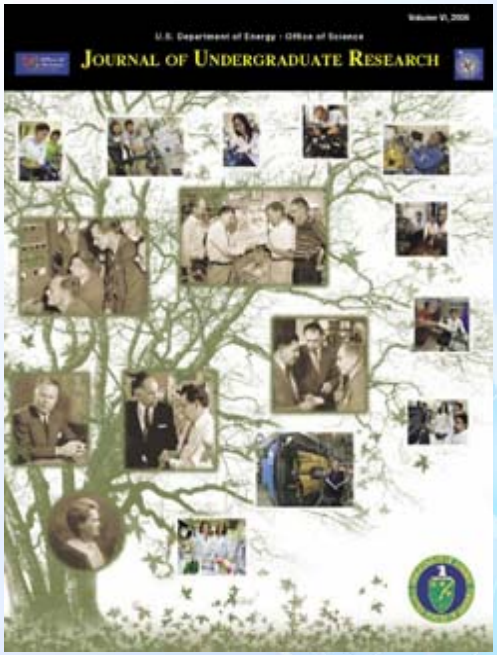
FaST Faculty Grants Submitted & Funded

- Since the program began (2000), many FaST faculty have submitted research grant proposals to federal agencies, national laboratories, and other entities (public and private)
- Many proposals have been funded (3 examples):
  - Jackson State University (MS) - Use of two-dimensional gel electrophoresis
  - Laney Community College (CA) & LBNL - Environmental Control Technology Education for Advanced Building Operation and Management
  - Southern University (LA) - X ray Detector Lab Development

Journal of Undergraduate Research

- Peer-reviewed, undergraduate journal
- Students participating in ANY program at the national laboratories can submit an abstract
- Top papers from WDTS programs are reviewed and selected for full publication





Questions and Comments

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