VirginiaTech
Invent the Future®

ICTAS at NCR

VT-Serge Meeting
05/04/2011

- ICTAS overview
- ICTAS at NCR
  - Motivation
  - Research Program
  - Looking ahead
- Q & A

Roop L. Mahajan

Tucker Chair Professor
Director, ICTAS
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ICTAS

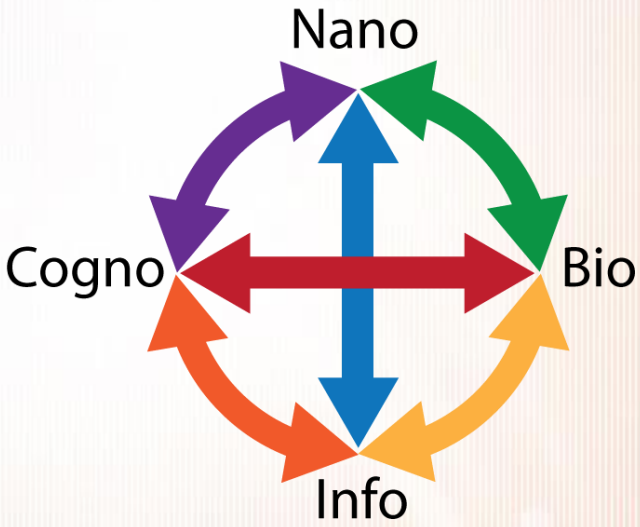
1. ICTAS acts a catalyst for Interdisciplinary Research

- *At the intersection of Engineering & the Sciences—Physical, life and social*

"Buds of creativity bloom at intersections." mahajan

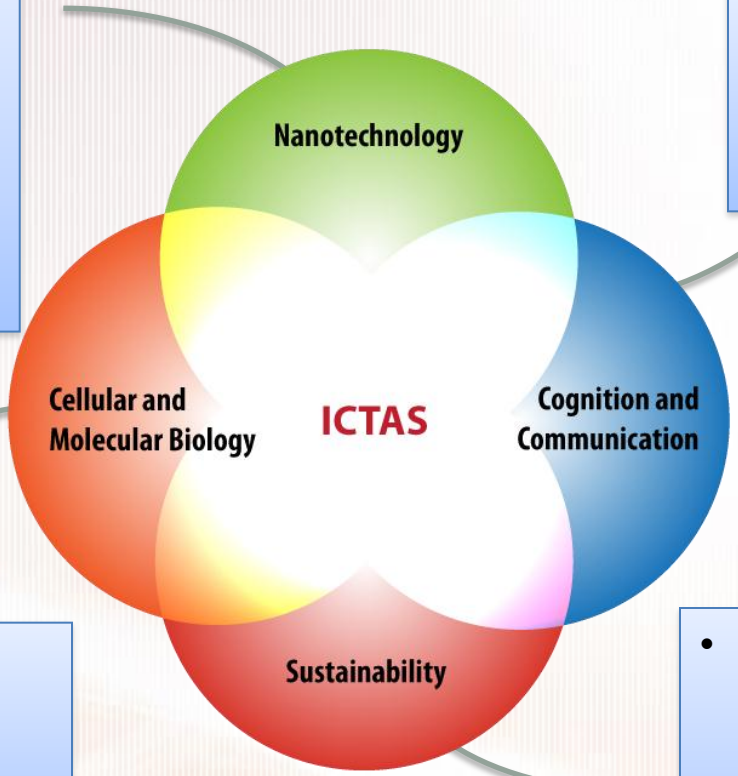
2. ICTAS is dedicated to cutting edge research at the confluence of transformative technologies

Each of these technologies has tremendous potential for impacting our lives



ICTAS Research

- Next industrial revolution
- $3.3 Trillion global market
- New phenomena, materials
- Environmental issues



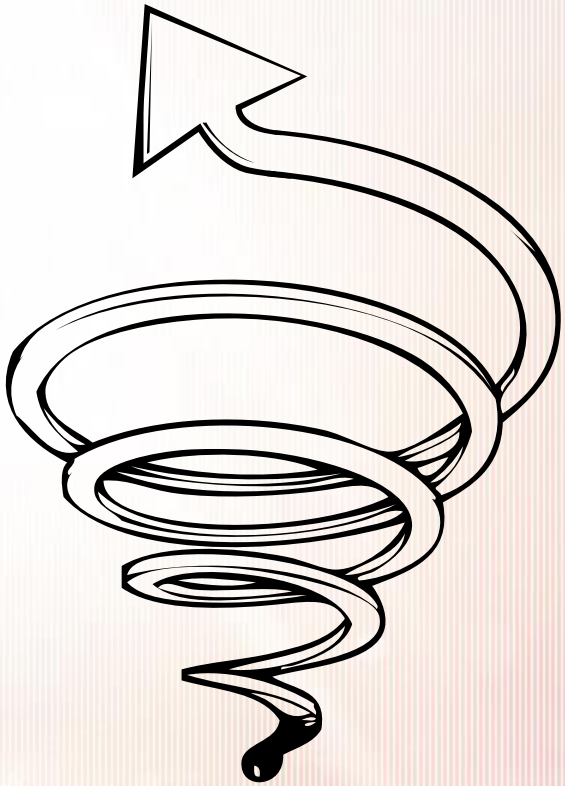
- Brain: the next frontier
- Reverse engineering the brain
- IT

- DNA, RNA
- Cell growth
- Cell differentiation
- Cellular behavior

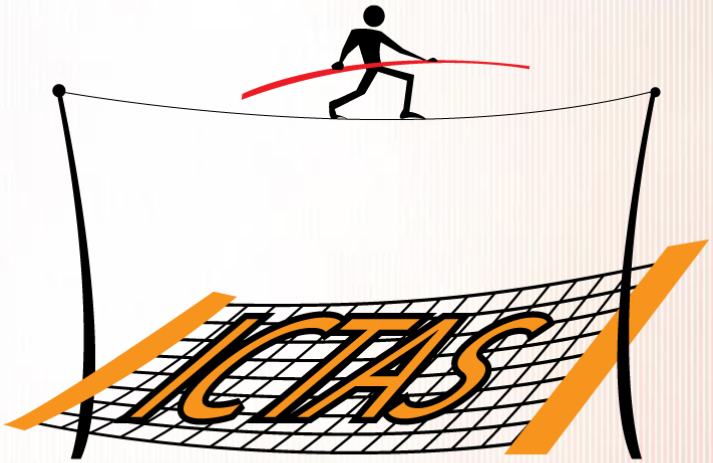
- Meeting needs of the present without compromising the ability of future generations to meet their needs

3. **ICTAS research is designed for non-linear growth and a dominant position in the field.**

   - **Among the top three**
   - **16-20 faculty; 32-40 Ph. D. students**



4. **ICTAS research is innovative with a healthy dose of blue-skies component, and is faculty-centric**



- **IT IS ALSO ABOUT THE NEXT BLACK SWAN**

Game-Changer Technologies & Black Swans

- **A Black Swan** is an event that has three characteristics;
  - ➢ it is an outlier
  - ➢ it carries an extreme impact
  - ➢ it has retrospective predictability.

"The Black Swan", by Nassim Nicholas Taleb

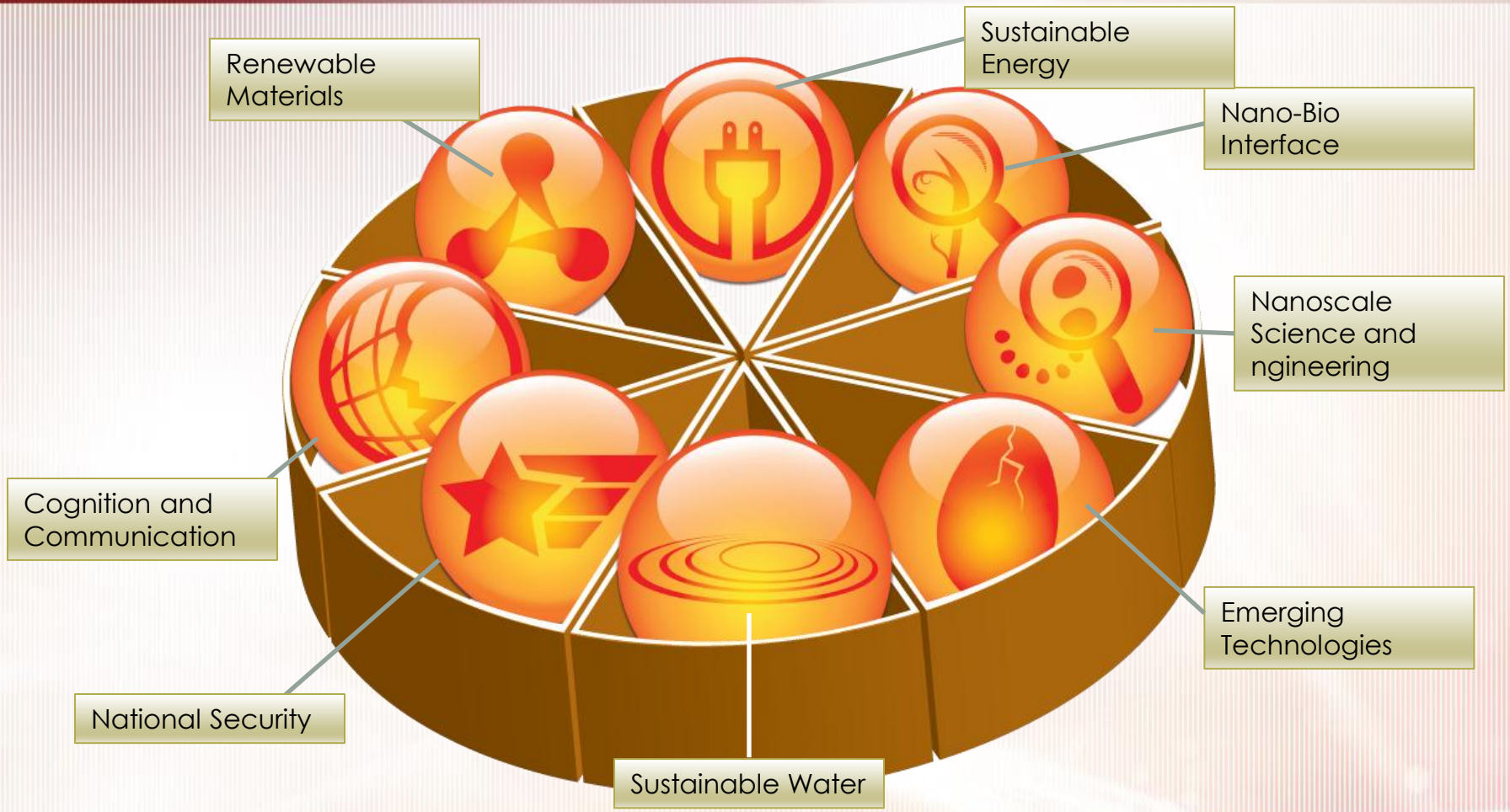
Internet **Computer** **Laser**

- ***The Black Swan Seminars– Café X***

  An informal discussion of the future

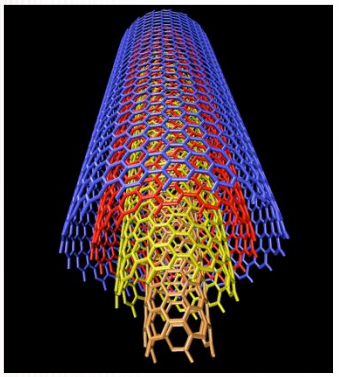
WHAT WILL MAKE YOU IRRELEVANT IN 7 years?

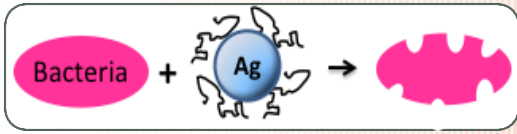
Research Thrusts

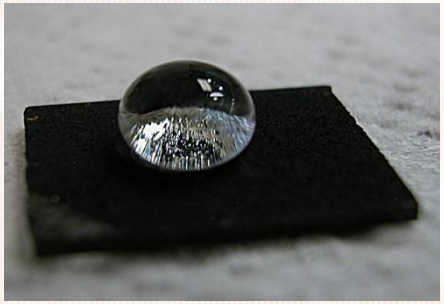


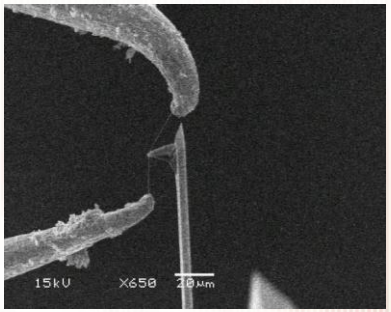
Nanotechnology

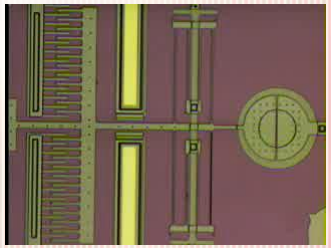
- Environmental Nano-science and Technology
- Nano-materials including carbonaceous materials
- *Nano-sensors*
- Nano-devices
- Nano-composites
- Nano-fibers
- *Nano-Computation*





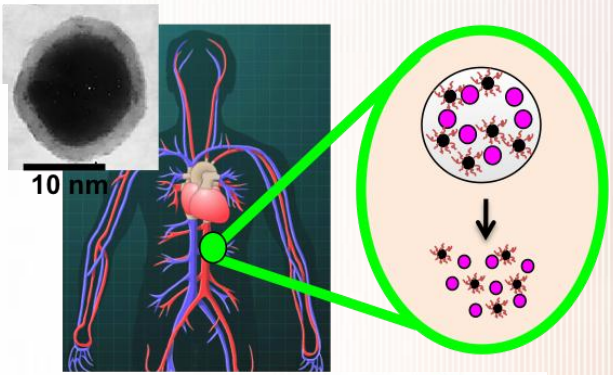


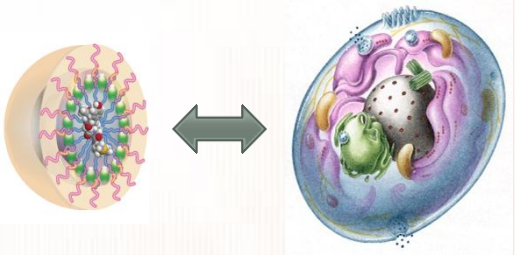


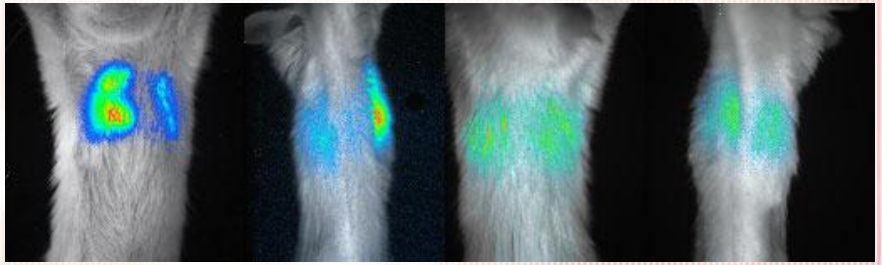


Nano-Bio Interface

- **Targeted Delivery of Nano-medicine**
- **Non-invasive Sensing and Diagnosis**
- **Inflammation**
- ***Bio-Imaging***
- **Biomedical Computing & Cellular Engineering Microsystems (CEMS)**
- **System Biology of Engineered Tissues**
- **Veterinary Regenerative Medicine**







SBES M-BEDS ISBET CFI
GU CVRM WFU

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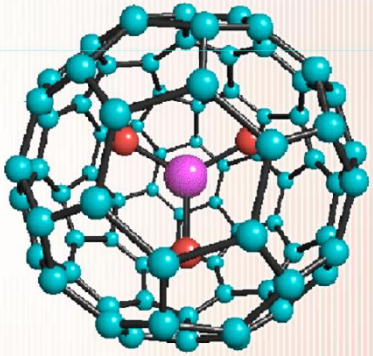
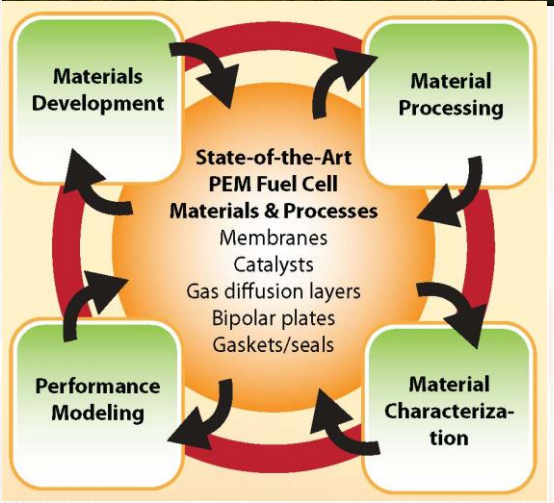
Sustainable Energy

Principle areas of research

- *Cleaner more efficient energy conversion systems*
  - *Fuel cells*
- *Renewable energy resources*
  - *Solar*
    - *Organic Photovoltaic cells*
    - *Multi-junction solar cells*
    - *Wind energy*
  - *Bio-fuels*
  - *Energy harvesting*
- *Clean Coal Energy*
- *Energy Efficient Buildings*
- *Smart Grid*





Thrust Leader: *Michael Ellis (ME)*
Associated Faculty*: More than 30 faculty members from 7 departments in the Colleges of Science and Engineering.*

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National Security

- **IDIQ with Dahlgren**
  - **Ground Unmanned Support Surrogate *(GUSS)***
    - A "flagship" project with NSWC Dahlgren for Marine Corps War-fighting Lab.
    - Four Vehicles participated in Rim of Pacific (RIMPAC) Exercise 2010
    - Operated by Marines
    - Significant Press Interest

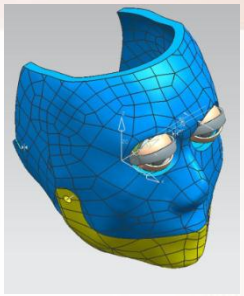
"GUSS surprised everybody with its growth and technological capability."

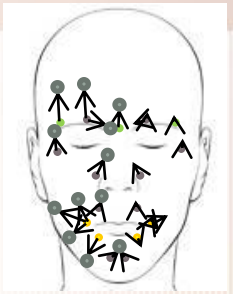
-Vince Goulding, Director
Experiments Division Marine Corps War fighting Lab

- Modes of operation
  - GPS/Waypoint Sight
  - "Follow Me"
  - Drive by Wire
  - Manual

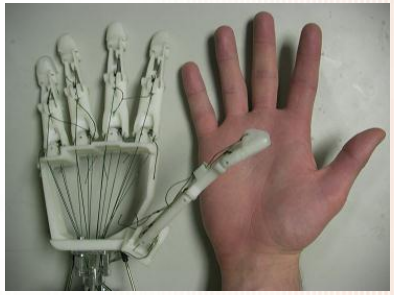
- **Autonomous Vehicles**
- **Sensor and sensor fusion**
- ***Cyber Security***

Emerging Technologies

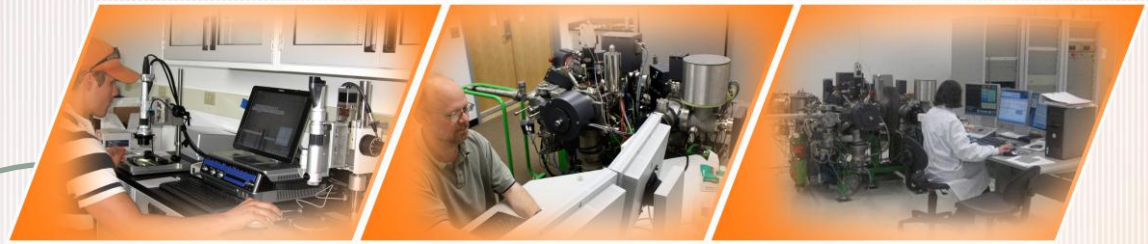




- **Humanoid Hospital**
- ***Discovery Analytics***
- **Space@VT**
  - Cubesat technology for geospace exploration.
- **Innovation- based Manufacturing**
- **Bio-Inspired Science and Technology**
  - ***Bats- digitalization & simulation; Smithsonian***



Infrastructure

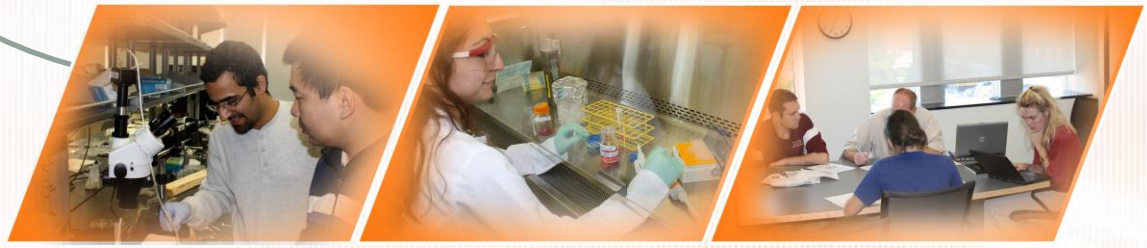


ICTAS HQ

ICTAS CRC

ICTAS LSC

ICTAS NCR



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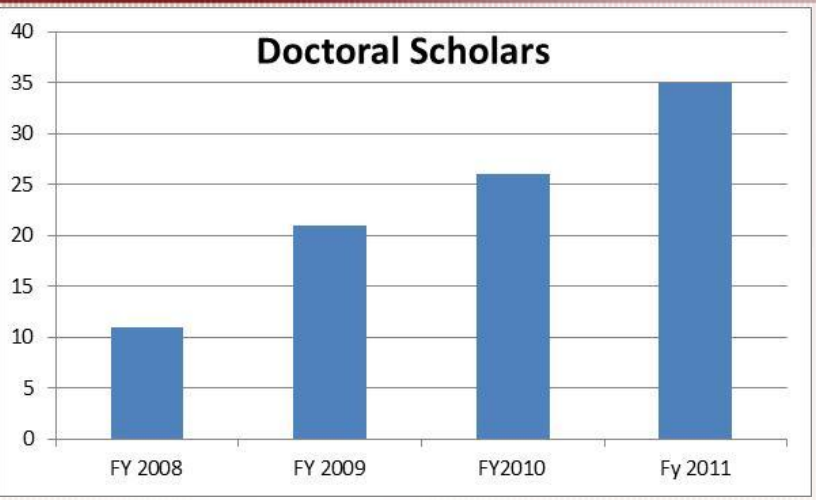
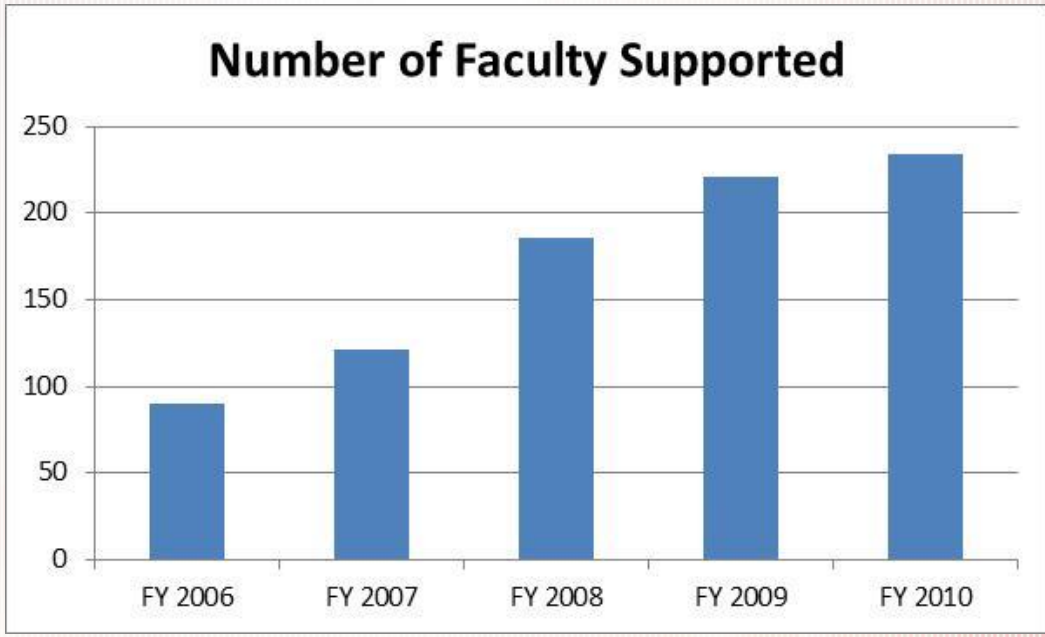
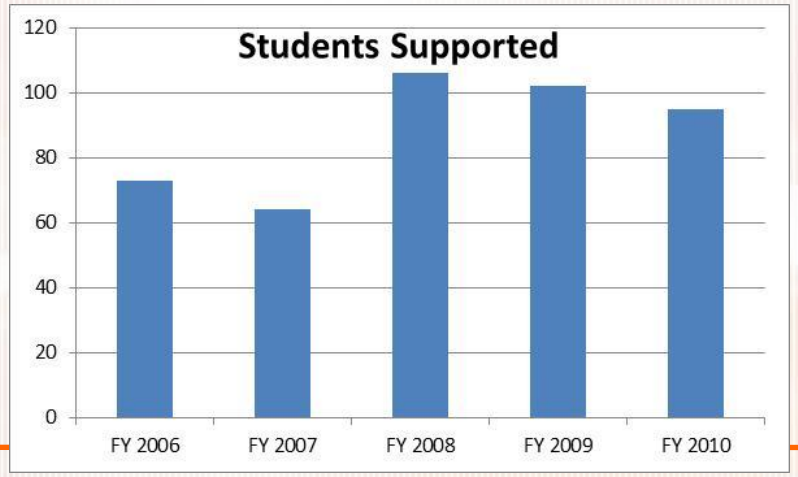
ICTAS

Motivation

ICTAS by the numbers

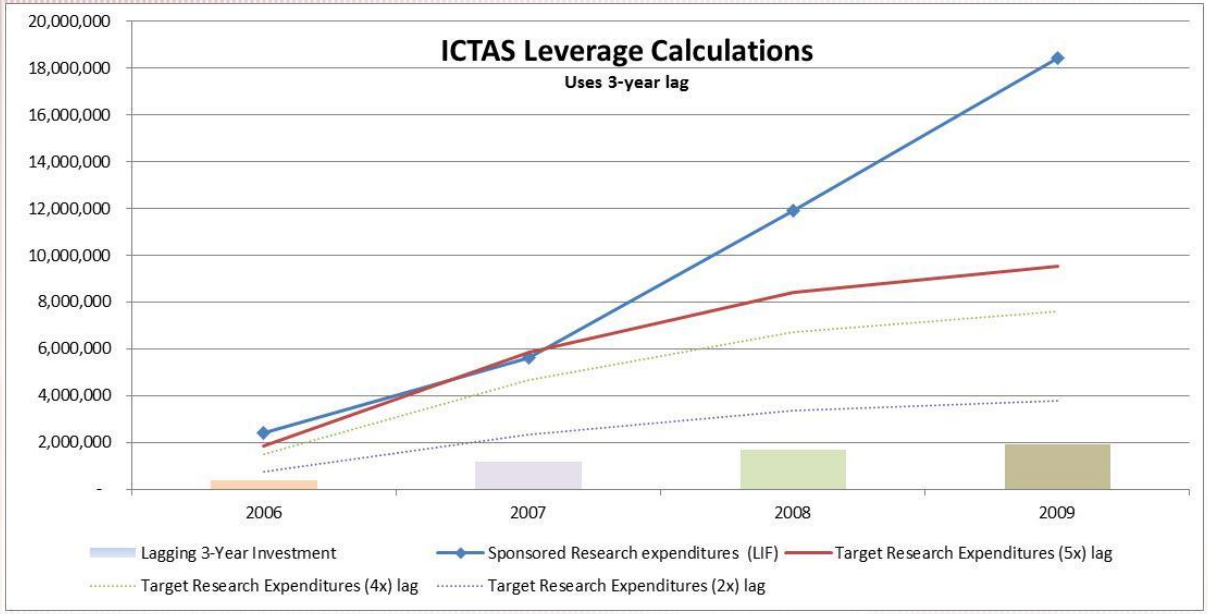


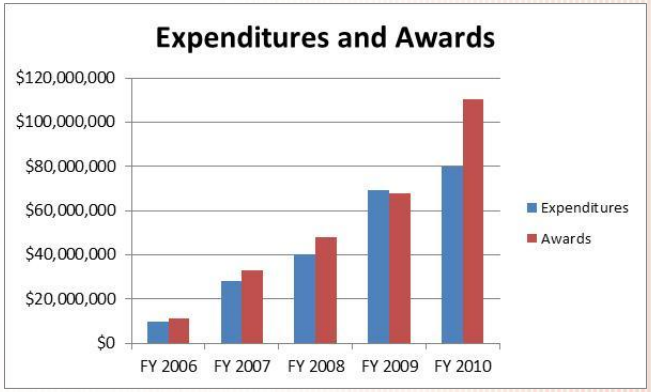




Motivation

ICTAS by the numbers





ICTAS at NCR

Motivation

- **Collaborative laboratory space essential to research growth**
- **All the ICTAS space in Blacksburg almost fully occupied**
- **NCR offers an opportunity in both space and ecology**
- **Can grow research expenditures at a faster clip > 2x in 5 years**
  - Target 3x in 6 including slow growth during the initial period of investment extended over 2-3 years

ICTAS at NCR
Research Areas

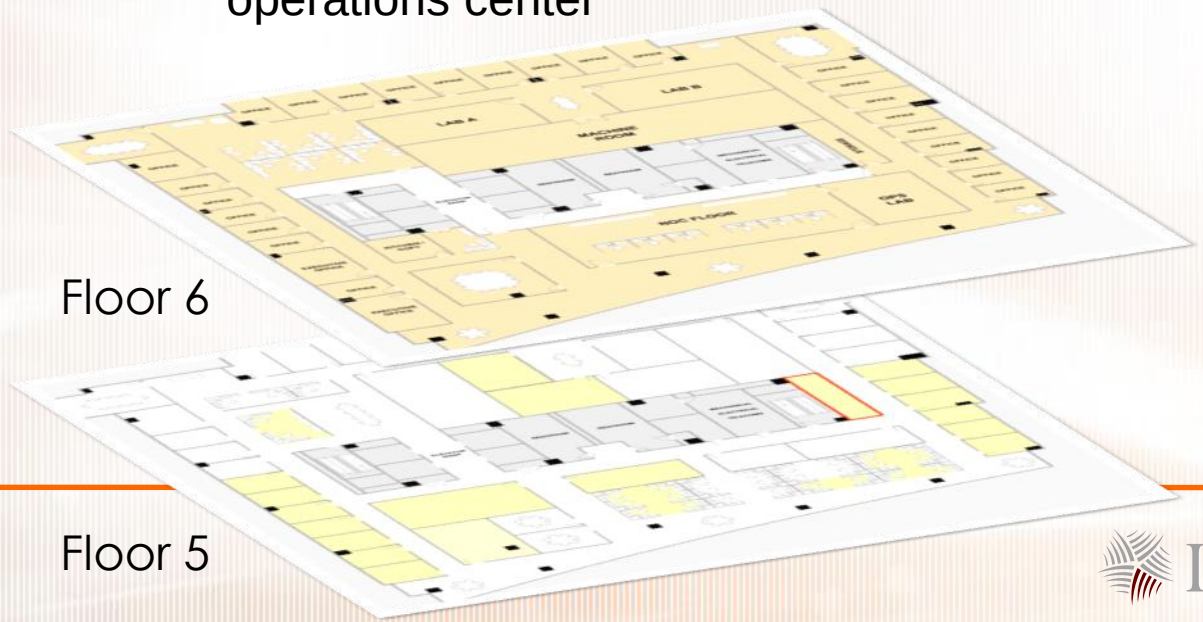
- Current space ~7,000 SF; usable: ~3,000 SF
  - Six Offices ~ 1,200 SF
  - 3 Labs ~ 1,800 SF

- Catalyst for ***three clusters***
  - **Cyber Security**
    - Anchor Faculty (AF): Prof. Charles Clancy (ECE); CS Faculty (Prof. Ramakrishnan and a new hire)
  - **Energy/Nuclear Energy**
    - AF: Prof. Alireza Haghighat (ME); Dr. Satish Kulkarni (ICTAS), Prof. Diana Farkas (MSE)
    - *Synergy with ARI (In progress): Prof. Saifur Rahman (ECE)*
  - **Discovery Analytics**
    - AF: Prof. Dr. Naren Ramakrishnan (CS)

- ***Emerging Research Area***
  - **Biomedical & Nanoscale Computation**
    - AF: Profs. Joseph Wang (ECE), Diana Farkas, Naren Ramakrishanan, Roop Mahajan (ICTAS), Georgetown U

Cyber Security
AF: Professor Charles Clancy, ECE

- Cybersecurity Innovations Laboratory
  - Partnership with TBN Industry Sponsor and NPS
  - VT & NPS occupy 13 offices, 16 cubes, 6 labs
  - TBN Industry Sponsor occupies entire floor with cyber R&D and 24/7 network security operations center



Research Themes

Secure mobile communications using COTS equipment and infrastructure

Security in the Cloud

Autonomic Network Defense

Significant Community of Interest for Cyber Security

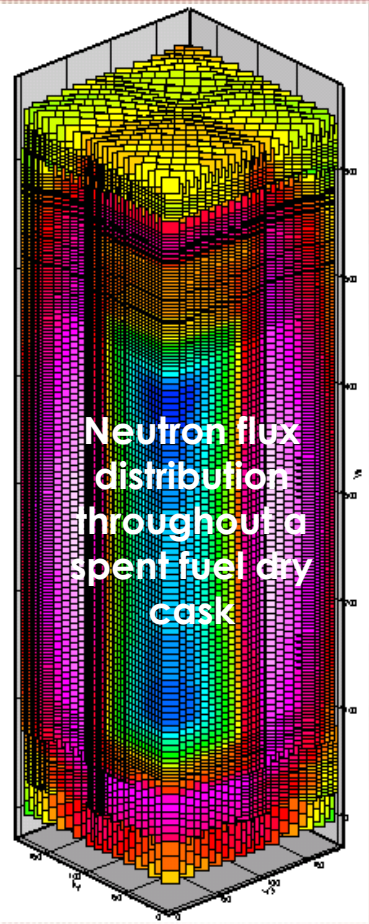
10 Academic Faculty
20 Students & Post-docs
10 Industry Researchers

Operational Facilities for Research Testing

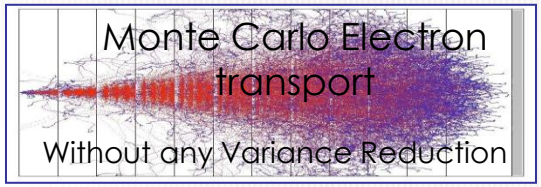
Support for Classified Research

Nuclear Energy

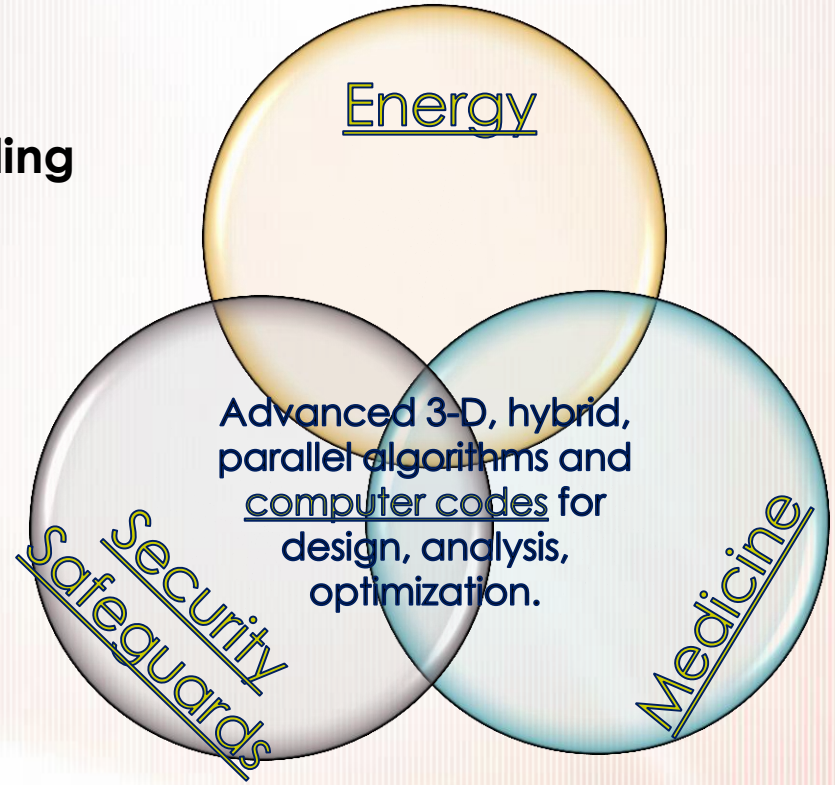
AF: Professor Haghighat, ME



Significant expertise
In n advanced modeling



With ADIES Automated Variance Reduction technique



Particle Transport Parallel Computing & Visualization (PTPCV), NCR

- A PC cluster with 120 CPUs and at least ~500 GB of memory

Nuclear Energy

Prof. Haghighat's On-going projects

- **Energy – Advanced Algorithms for Simulation of Advanced Reactors**
  funded by DOE-Nuclear Energy University Program (in collaboration with Georgia Tech) ($214k, April 2011- July 2013)

- **Nuclear Security and Safeguards**
  An Innovative Hybrid Deterministic/Monte Carlo Radiation Transport Method for Modeling Radiation Sensor Systems, funded by DOE-NNSA (in collaboration with Georgia Tech) ($207k, Jan 2011 – Sept 2012)

  Development of a Calculation Methodology for Determination of Detector Response for a Monitoring System for the Spent Fuel Pool, funded by LLNL ($120k, Sept 2007-Oct 2011; $60k contract with HSWTECH LLC)

- **Medicine**
  Deterministic methodology for image improvement of Single Photon Emission Computed Tomography (SPECT), submitted a proposal to DOE-Office of Science, ($570 k, Oct 2011 – Sept 2014)

~ $1.2 M

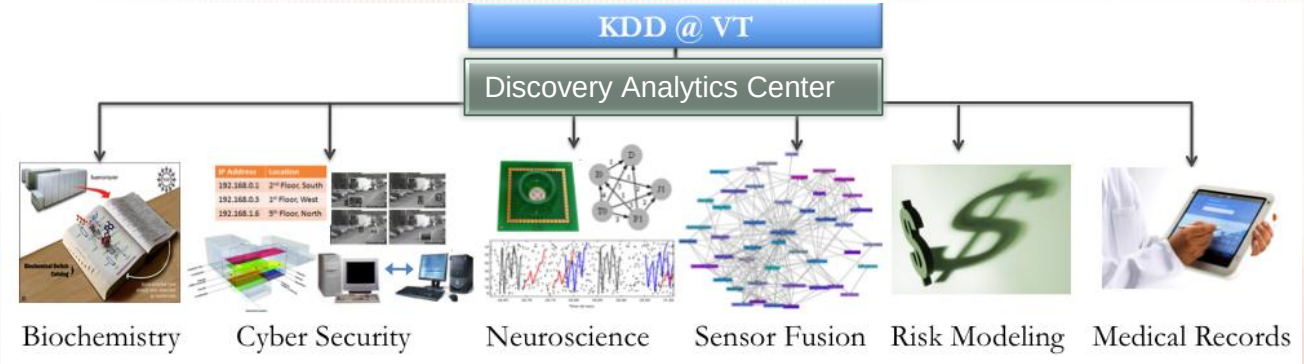
Centers of excellence in the following areas:

- Computational Modeling and Simulation (CMS) techniques and tools for nuclear systems;
- Design of detection systems for Nuclear Security and Safeguards, and
- Development of innovative imaging algorithms for radiation diagnostic devices.

Discovery Analytics

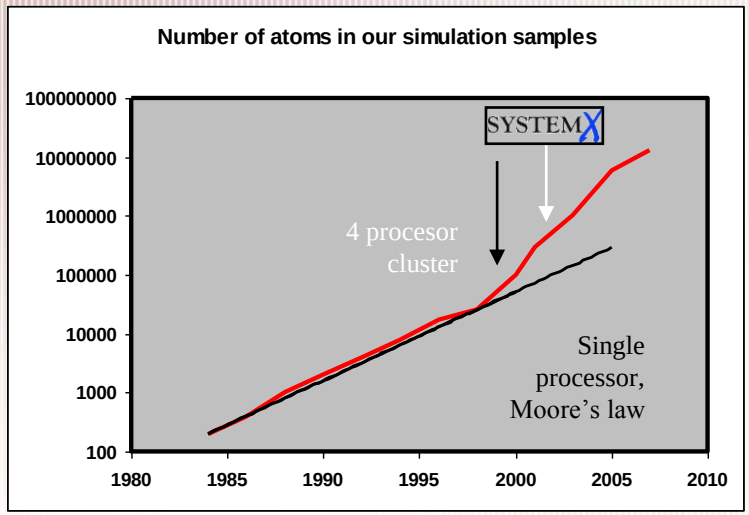
AF: Prof. Naren Ramakrishanan*, CS

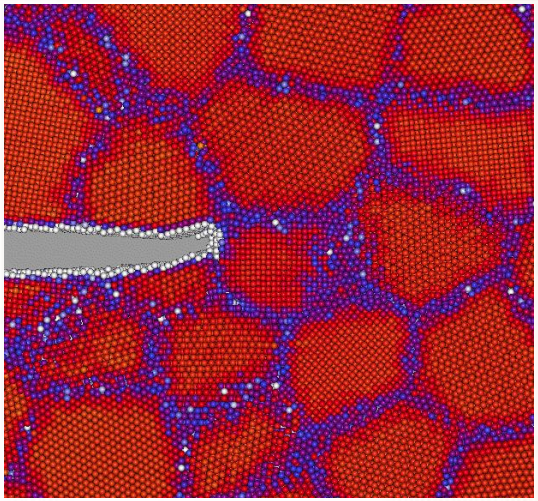
- The use of **data mining** algorithms and analytics to foster knowledge discovery in diverse domains
  - Extracting non-trivial and actionable patterns from data
    - Terabytes/petabytes/even exabytes of data

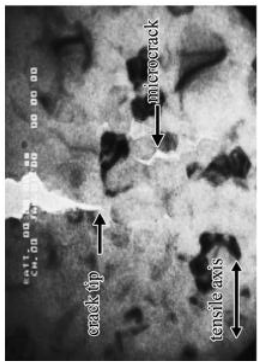


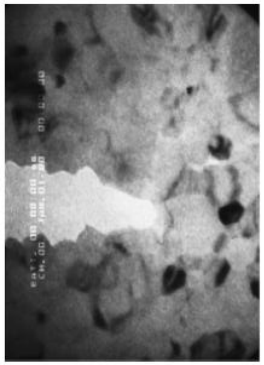
Nanoscale Computation

AF: Professor Diana Farkas, MSE









Experimental **Simulation**

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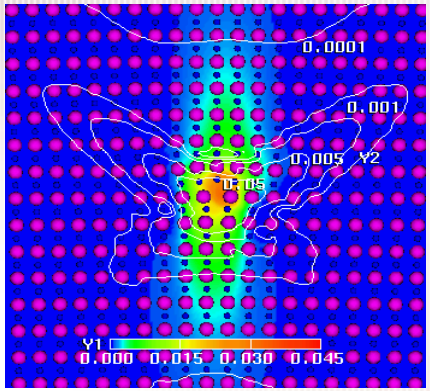
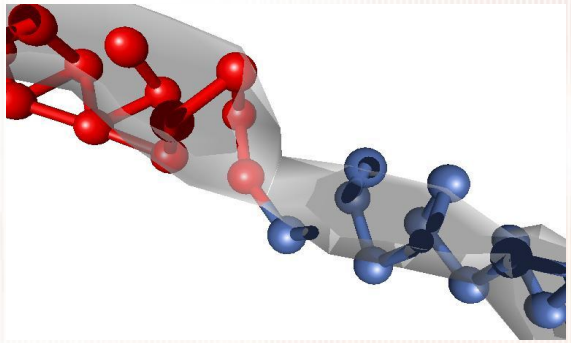
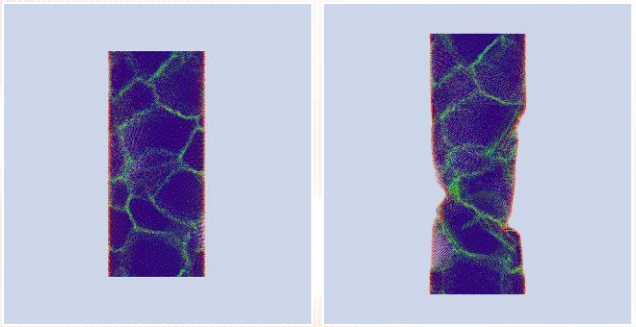
Nanoscale computation Research Examples

A **Defects in nuclear materials**

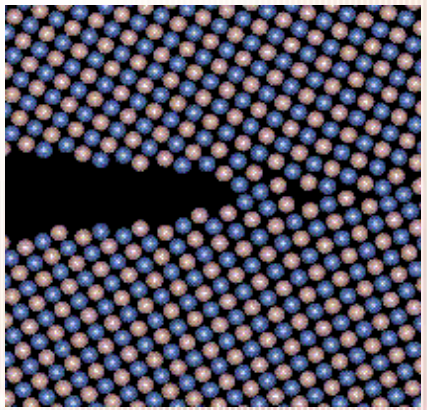




B **Nano-crystalline materials, and nanofoams for energy applications**



C **Nanowires, nanoparticles , interface structure behavior**



Biomedical Computing

AF: Prof. Joseph Wang, ECE

- **Team:** 2 FTE tenure-track faculty members, 12 FT PhD-level GRAs, 1 res scientist.
- **Partnerships**: Johns Hopkins Medical Institutions, Georgetown University Medical Center, Children's National Medical Center, Wake Forest University Hospital, National Cancer Institute, University of Maryland Medical School.
- **Expertise:** Machine learning, signal processing, pattern recognition, biomedical imaging , systems theory.
- **Areas:** Bioinformatics, computational systems biology, medical imaging, genomic signal and data analysis, learning biological networks, biomarker discovery, genome-wide association study, proteomics data analysis, etc.
- **Sponsors**: National Institutes of Health, National Science Foundation, Department of Defense, NASA. Total $14M research funds since 1996.

EXTEND TO CEMS
Strong collaboration with GW
Dr. Chris Wilcox; MD/Ph.D.
Nephrology & Hypertension

Discovery Analytics Growth Plan 3x in 6 years

- **Cyber Security**
  - **"$0.6 M in FY11 to $6.5 M in FY18" ; Conservative estimate –** Charles Clancy
- **Discovery Analytics**
  - Ph. D. graduates from 6 to 20
  - Research expenditures: $0.75M/yr to $4-6M/yr
  - Journal publications (in PNAS, Science, Nature, etc.): 1-2/yr to 4-5/yr
  - Top-tier conference publications (<10% acceptance rate): 10/yr to 40/yr
- **Nuclear Energy**
  - Ph. D. graduates from 3 to 10
  - Research Faculty: 1 to 3
  - Affiliate faculty : 7 to 12
  - Research expenditures: $0.4M/yr to $ 1.2 M/yr

Discovery Analytics
Growth Plan
3x in 6 years

- **Strategic plans in all the research areas not fully defined yet.**
- **Elements in place**
- **Very optimistic about growth**

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ICTAS at NCR

VT-Serge Meeting
05/04/2011

- ICTAS overview
- ICTAS at NCR
  - Motivation
  - Research Program
  - Looking ahead
- Q & A

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