

# The Research Triangle Nanotechnology Network

## *Innovative Nanotechnology Hub*



Executive Committee: Jacob Jones (NC State), Nan Jokerst (Duke), Jim Cahoon (UNC), David Berube (NC State), Mark Walters (Duke), Phil Barletta (NC State), Carrie Donley (UNC), Maude Cuchiara (NC State)

Additional Representatives: John Muth (NC State), Nicole Hedges (NC State), Phillip Strader (NC State), Bob Geil (UNC)



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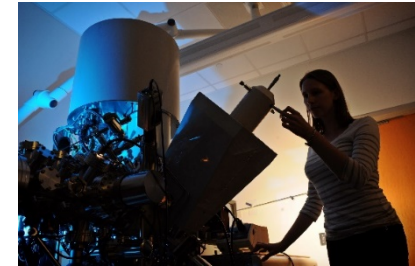
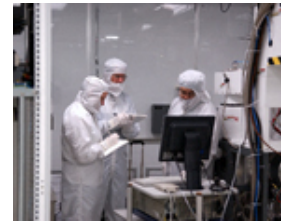
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# RTNN Site Overview

## ***Close Collaboration Among Nanotechnology Facilities at 3 Research-Intensive Universities in a 15-Mile Radius***



>200 fabrication and characterization tools

45+ technical staff to assist/create/develop

100+ principal faculty working in related nanotechnology areas

Long History of Enabling Technology Transfer and Startups

# RTNN Site Overview

## *Distinguishing Capabilities of RTNN Facilities*

**Cryo-Transmission Electron Microscopy** (resolves biomolecular structures)

**Hot Embosser** (nanoscale polymer fabrication)

**Functionalization of fibers and textile surfaces** (e.g., ALD)

**Bio-Processing Bay** (for integration of biomaterials with devices)

**Nano-Fiber Electrospinning** (needle, centrifugal, and high-throughput edge)

**Neutron Diffraction** on the nuclear reactor

**X-Ray & Neutron Imaging**

(micro-CT, neutron radiography, and 3-D tomography)

**Positron Annihilation Lifetime Spectroscopy**

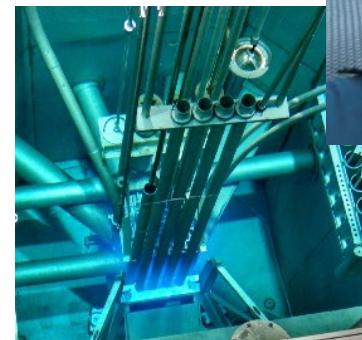
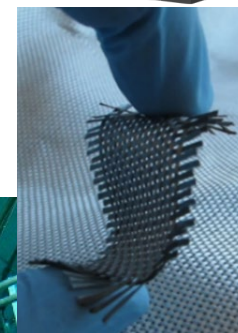
(nanoscale defect characterization)

**In Situ Microscopy and Diffraction**

(heating, cooling, liquids, gases, electrical/mechanical testing)

**Mesocosms**

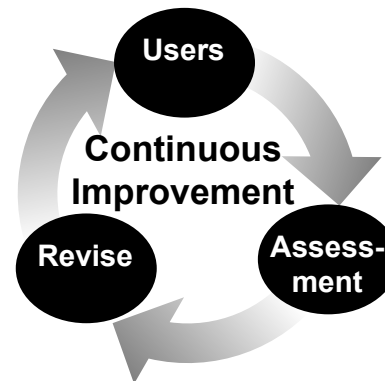
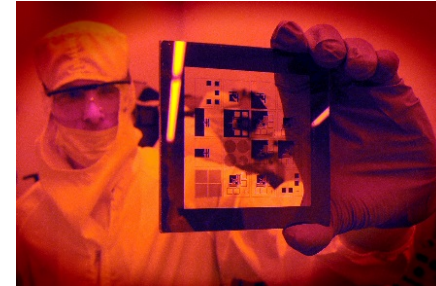
(studying interactions of nanomaterials with plants, fish, and bacteria)



# RTNN Site Overview

## *Distinguishing Goals of the RTNN Site*

- 1. Enhance access:** Dramatically enhance access to university nanotechnology facilities by lowering barriers e.g. cost, distance, and awareness
- 2. Program development:** Develop new nanotechnology tools, education, outreach, and workforce training programs
- 3. Assessment:** Evaluate the user base and user programs to institutionalize effective programs and drive change

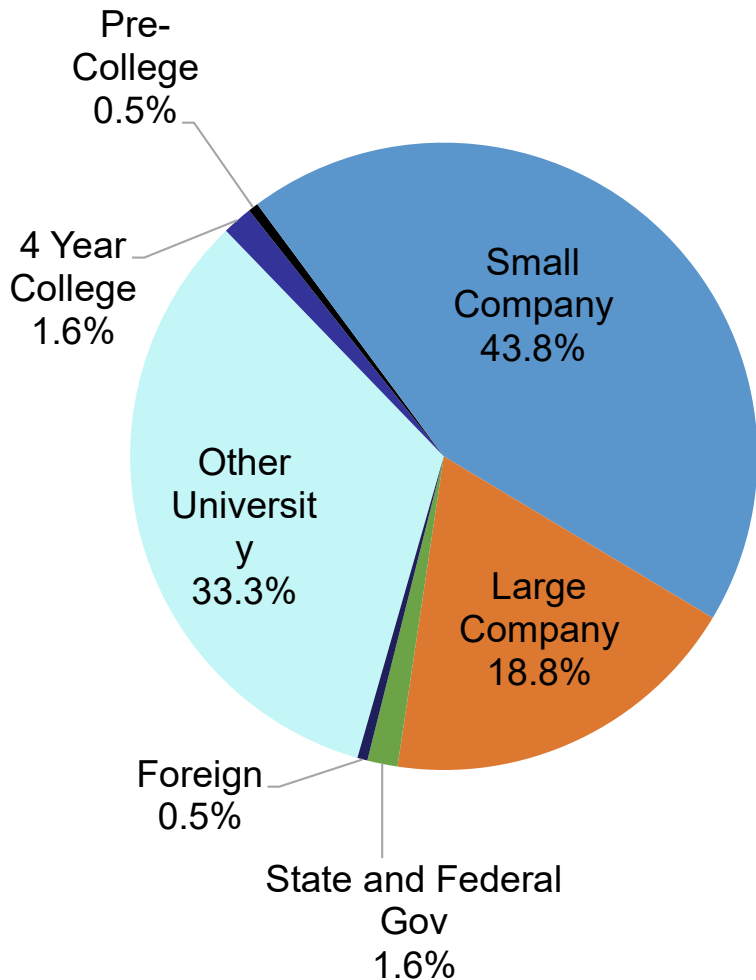


# User Statistics

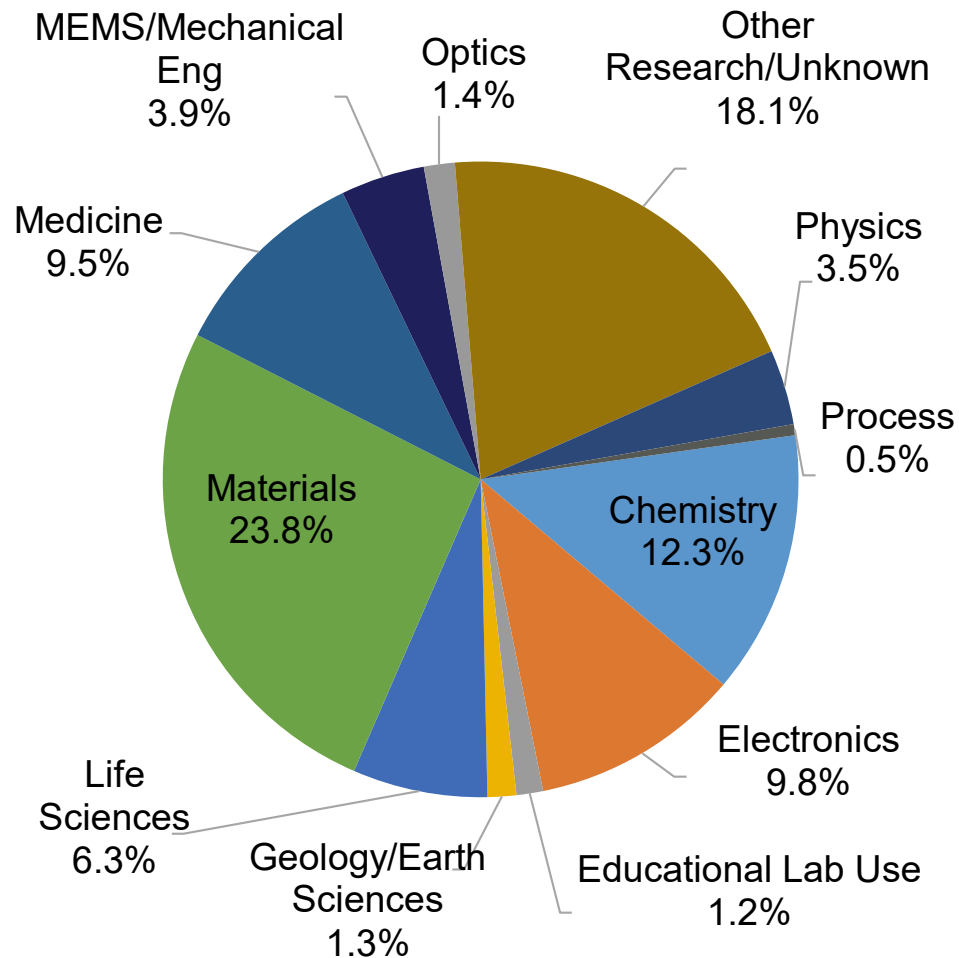
Yearly User Data Comparison			
	Year 1	Year 2	Year 3 (6 months)
<b>Total Users</b>	1,177	1,454	889
<b>Internal Users</b>	975	1,096	697
<b>External Users</b>	202 (17%)	358 (20%)	192 (22%)
<b>External Academic</b>	74	131	68
<b>External Industry</b>	128	217	120
<b>External Government</b>	0	10	3
<b>External Foreign</b>	0	0	1
<b>Total Hours</b>	53,044	51,748	24,585
<b>Internal Hours</b>	46,908	43,054	20,777
<b>External Hours</b>	6,136 (10%)	8,694 (20%)	4,703 (15%)
<b>Average Monthly Users</b>	395	422	416
<b>Average Ext. Monthly Users</b>	50 (13%)	63 (15%)	67 (16%)
<b>New Users</b>	433	527	338
<b>New External Users</b>	71 (16%)	69 (13%)	43 (13%)

# User Statistics

## External User Affiliations



## All User Disciplines



# Facility Upgrades and New Tool Capabilities

***\$10M infrastructure upgrade to NNF;***

***39 new tools since RTNN start, 18 in Year 3***

***Year 3 highlights include:***



FEI Titan  
Krios  
cryo-TEM

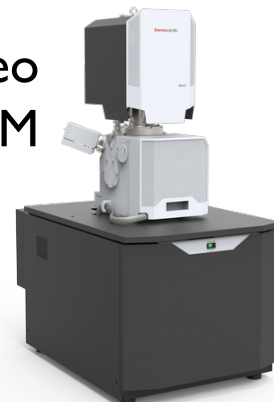
Annealsys  
AS-I Rapid  
Thermal  
Processor



Rigaku  
SmartLab  
XRD



FEI Apreo  
SEM



Hysitron TI 980  
Nanoindenter

FEI Talos  
cryo-TEM

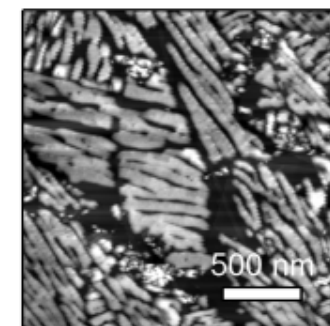
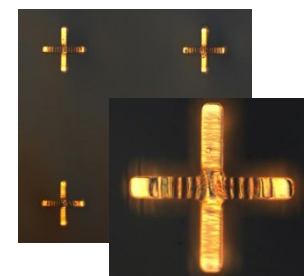
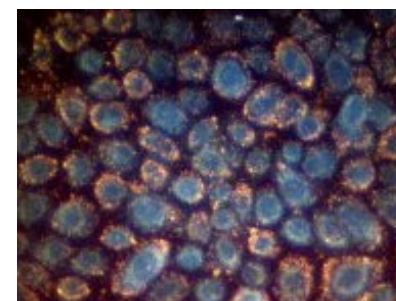
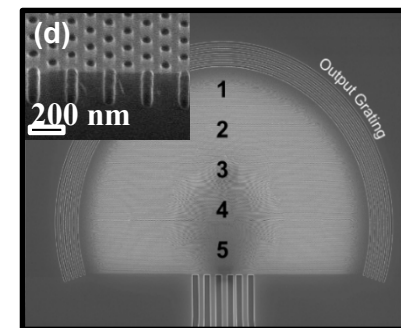


MRI awarded  
in July for  
nanoCT  
system

# Research Highlights

## **Nano-Technical Strength Areas of the RTNN:**

- 1. Interfaces, Metamaterials, Fluidics, and Heterogeneous Integration**
- 2. Nanomaterials for Biology and Environmental Assessment**
- 3. Organic and Inorganic 1- and 2-D Nanomaterials**
- 4. Textile Nanosciences and Flexible Integrated Systems**





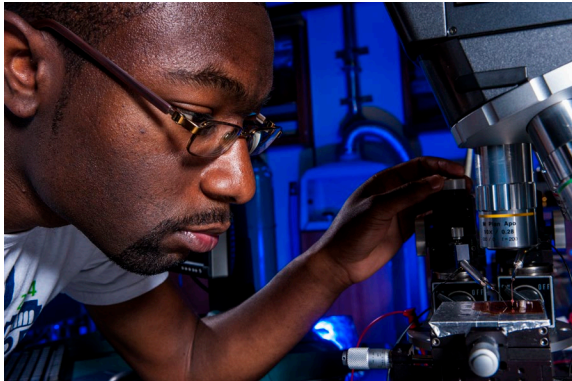
# Research Highlights

Collaboration between  
Jokerst (Duke) and  
Velev (NC State) labs

Dr. Ugonna Ohiri

Duke ECE graduate

Currently at Thor Labs



***Microparticles fabricated from silicon-on-insulator wafers are a new class of reconfigurable matter***

***Electric fields propel controllably for assembly/disassembly***



*Publication: Ohiri, U. et al. Reconfigurable engineered motile semiconductor microparticles. Nat. Commun., 9, 1791 (2018).*

# Research Highlights

## Entrepreneur/Kickstarter Highlight

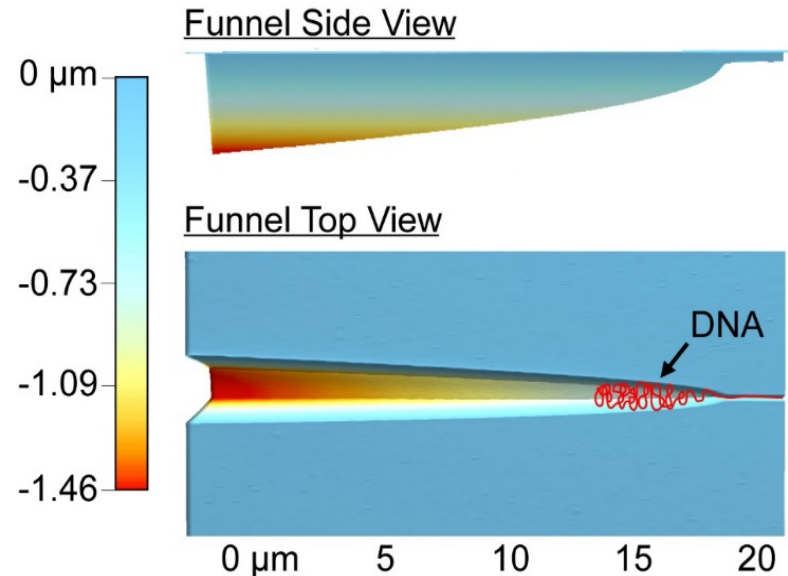


(Startup spun out of UNC)

**Fabricating and characterizing 3D nanofunnels for precise control and transport of DNA molecules for DNA sequencing**

Dr. Michael Ramsey, Scientific Founder and Director

Dr. Laurent Menard, Scientific co-founder and Director of Microfluidics Research



**AFM profiles of a FIB-synthesized three-dimensional nanochannel interfaced with a cartoon of DNA imposed on the top-view image.**

*Publication: Zhou, J. et al. Enhanced nanochannel translocation and localization of genomic DNA molecules using three-dimensional nanofunnels. Nat. Commun., 8, 807 (2017).*

# Education and Outreach: Impacting New Communities and Users

New engagement programs to address known barriers:

Cost, Distance, Awareness

*Kickstarter program: free use for new, non-traditional users*

*Nanotechnology online course (Coursera)*

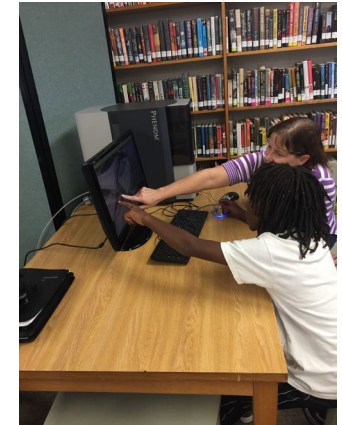
*Immersive lab experiences*

*Partnerships with youth organizations*

*Electron microscopes in K-12 Classrooms*

*Workshops for educators, e.g. community colleges and public school teachers*

*Enhanced mass communications including social media*



RTNN News, Events, and Opportunities

**Connect With Us**

- Facebook
- LinkedIn
- Twitter
- Website

**News**

**RTNN Researcher Awarded \$2M in Funds for New TEM**  
Professor Jim LeBeau has been awarded funds from NSF's Major Research Instrumentation (MRI) program to acquire a new transmission electron microscope. [Read More >>](#)

**Molecular Microscopy Consortium (MMC) brings new capabilities to the Triangle**  
The MMC brings together cryo-electron microscopy resources for structural biology applications. Director **Mario Borgia** leads the initiative. [Read More >>](#)

**RTNN Featured in R&D Magazine**  
A recent article in **R&D Magazine** discusses the RTNN's vision and highlights programs that have been developed to help achieve this mission. [Read the Article >>](#)



# Education and Outreach: Impacting New Communities and Users

2017-2018 Education & Outreach Events			
	On-Site Participants	%	Online Learners
Kickstarter Program	51	1.0%	-
Event booths (e.g., conferences, museums, libraries)	1,667	33.5%	-
K-12 booths (science nights)	640	12.9%	-
REU and REU Convocation	53	1.1%	-
Immersive lab experiences: Tours, demos, hands-on activities	1,173	23.6%	-
Classroom visits	1,111	22.3%	-
Coursera course on nanotechnology	-	-	>7,000
Workshops for educators	15	0.3%	-
Technical Events (short courses, workshops)	142	2.9%	-
Symposia/conferences	121	2.4%	-
<b>Total</b>	<b>4,973</b>	<b>100%</b>	<b>&gt;7,000</b>

*Grey boxes show activities which were evaluated.*

**60% on-site participation by women and under-represented minorities in STEM**



# Education and Outreach: Impacting New Communities and Users

## Kickstarter Program

Free time on tools for new and non-traditional users

Up to \$1,000 of use at internal rate

Rolling applications

**51 projects selected to date (>1,000 hours of use)**

>50% participation by start-up companies and non-R1 universities

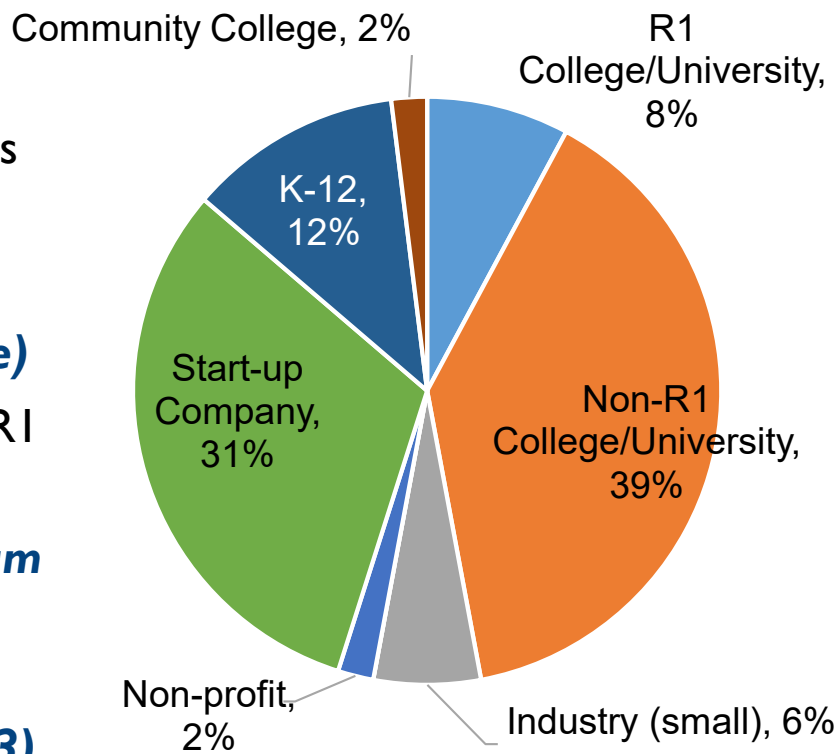
**35% of participants who have completed program have returned to facilities with own financial support**

**Evaluation with semi-structured interviews (n=13)**

Most would return to facilities if further work is needed

All would recommend the RTNN to colleagues

Many participants noted the helpfulness of staff

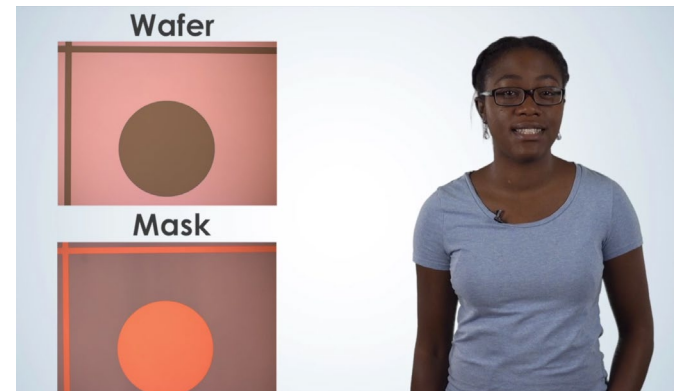


*“...there's a small group of us that are out trying to develop new ideas and kind of unconventional ways to do things. So I'm already telling them about [the Kickstarter Program].” - anonymous entrepreneur*

# Education and Outreach: Impacting New Communities and Users

## “Nanotechnology: A Maker’s Course”

- Massive Open Online Course on Coursera platform, providing education in nanofabrication and nano-characterization
- Lectures and in-lab demonstrations of equipment in RTNN labs by RTNN faculty and staff from diverse backgrounds
- Year-long project to plan, record, and deploy
- Launched **September 2017**
  - >18,000 visitors
  - >7,000 enrolled
- High satisfaction, e.g. course instruction rated 6.5 on a scale with 7 being the highest
- 93% of respondents “likely” or “very likely” to recommend course



*“I like the speaker very much, I hope I can be a scientist like her.”  
– anonymous, from evaluation*

# Education and Outreach: Impacting New Communities and Users

## *Immersive Lab Experiences for Middle and High School Students*

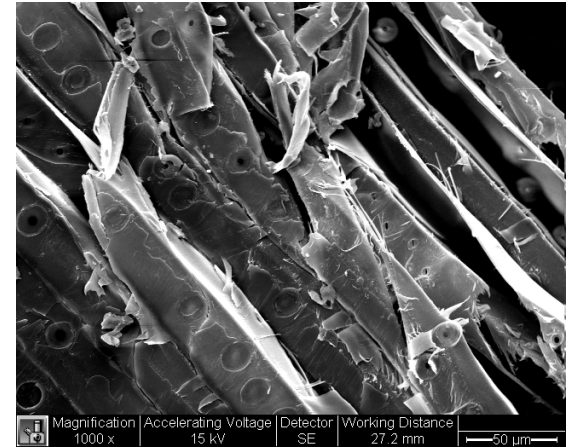
Structured, hands-on student projects using RTNN tools at all three institutions, e.g., on photolithography, electron microscopy and micro-CT

IRB-approved evaluation with parental consent

Will report results in peer-reviewed literature to disseminate best practices

Preliminary evaluation results are encouraging:

- Rated facilities on a scale 1-13 (13=best) (n=76)
  - Labs:  $11.89 \pm 1.50$
  - Staff/instructors:  $12.18 \pm 1.25$
- Content analysis is possible on evaluation questions



SEM image of pencil shavings collected by student participant

*“...I liked trying on the suits and learning how actual scientists do it”*

*“it was really fun to visit because I got to see what it would be like to be in a professional lab”*

# Education and Outreach: Impacting New Communities and Users

## *Partnerships with Youth Organizations*

### Example: **Girls STEM Day @ Duke**

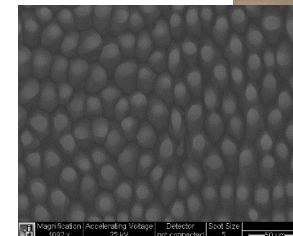
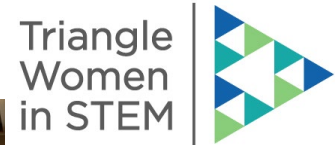
- Goals: 1. Encourage girls toward STEM careers,  
2. Earn Girl Scout badges in forensics (spectroscopy) and digital photography (SEM)

RTNN partners: IBM, Triangle Women in STEM, Credit Suisse, and Duke's Pratt School of Engineering and Trinity College of Arts and Sciences

> 100 North Carolina girls and Girl Scouts and their families

> 100 volunteers from 30+ organizations, companies, and institutions

RTNN (all 3 institutions) developed technical content, trained volunteers, and staffed event



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# NNCI Cooperative Network Activities

## Network-Wide

Lead “Building the User Base” Committee

Staff NNCI booths

Participation in 8 subcommittees and working groups

8 individuals attended the NNCI annual conference

*Small Talk* event for National Nano Day activities

Promote NNCI site events and opportunities



## Multi-Site

Sharing best practices (assessment, Kickstarter, Mendix)

Referrals to other sites (tools, online course)

## On Behalf of the Network

Hosted 2018 NNCI REU convocation

Translated “Contact Us” page on NNCI website into Spanish and respond to all inquiries



## Contáctenos

PREGÚNTANOS DE NNCI O DE NANOTECNOLOGÍA

¿Tienes una pregunta? Llena la aplicación abajo y uno de nuestros representantes te hace una repuesta.

# Societal Implications

**Goal: Leverage the RTNN team and user base to enhance the instruction and understanding of how users and society engage with nanotechnology**

**Some Activities:**

IRB approval at all three institutions

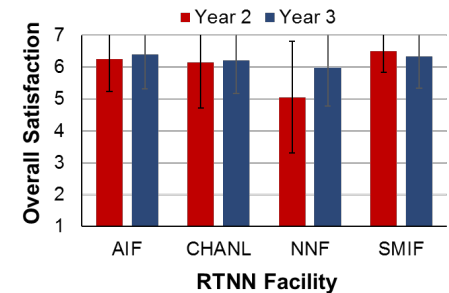
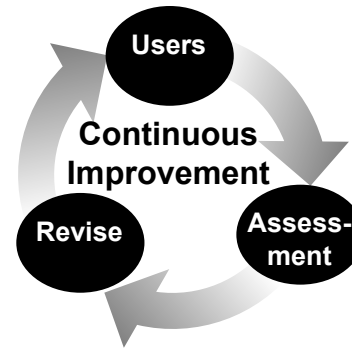
Deep assessment of users and programs

Structured interviews of users; content analysis

Regular surveys of users and many programs (several hundred responses)

Academic study of governance involving multiple stakeholder groups (Team Science)

Implemented new social media campaign across multiple platforms



# Panel Discussion – Workforce Development

## Staff – RTNN Examples and Ideas

- Sending staff to offsite technical training workshops and conferences
- Enrolling staff in university classes for free or reduced cost
- Encouraging staff to engage in teaching (e.g. co-teach or lecture in university courses)



## U/G and Grad. Students – RTNN Examples and Ideas

- Employ students in facilities to perform service work, train users, participate in outreach events
- Enable u/g students to access facilities via written proposals [Undergraduate User Program - U-UP!]

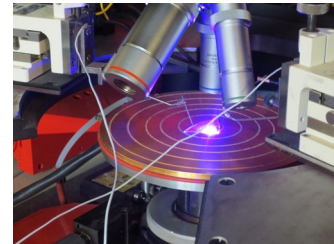


## Community Colleges – RTNN Examples and Ideas

- Teach community college educators in a 2-day, hands-on workshop

## K-12 Students and Teachers – RTNN Examples and Ideas

- Partner with youth agencies, e.g. as in the Girl's STEM Day
- Develop lesson plans that meet state and national educational standards



## Public – RTNN Examples and Ideas

- Deploy online education, e.g. “Nanotechnology, A Maker’s Course”

# RTNN Executive Committee



**Jacob Jones**  
RTNN Director  
Director of AIF  
Professor of MSE  
*NC State University*



**Nan Jokerst**  
Executive Director  
of SMIF  
Professor of ECE  
*Duke University*



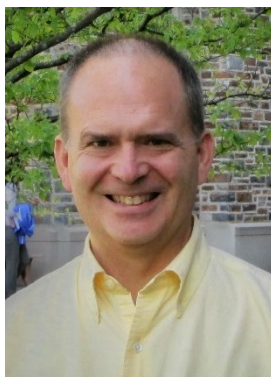
**David Berube**  
Professor of  
Communication  
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**Jim Cahoon**  
Professor of Chemistry  
Executive Director of  
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**Carrie Donley**  
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