Welcome to the 8th Annual NNCI Conference at Stanford University

National Nanotechnology Coordinated Infrastructure

NSF

Welcome and Thank You

Welcome

- External Advisory Board Members
- NSF Program Directors
- NNCO Leadership
- Invited Speakers
- NNCI Site Leadership and Staff
- Guests

Thank You

- nano@stanford and NNCI Coordinating Office Staff
- NSF

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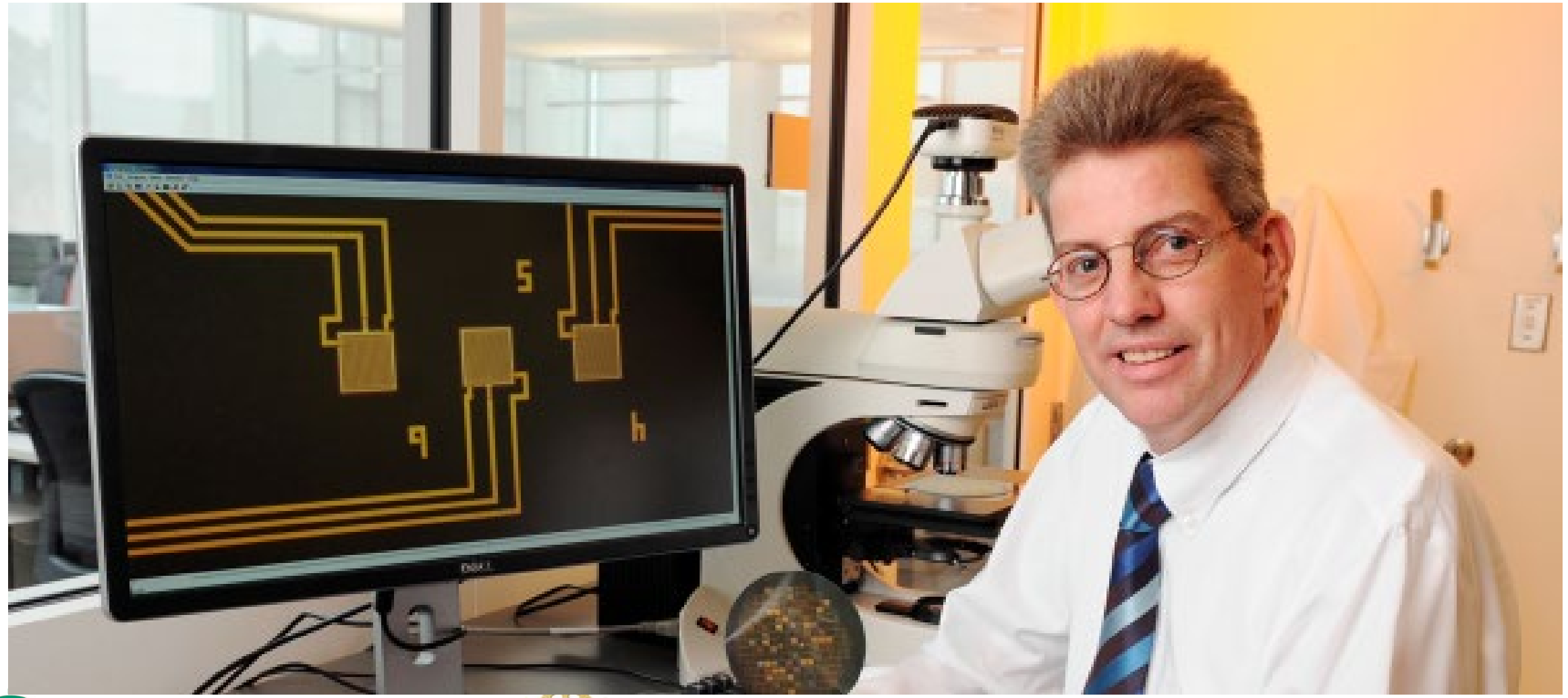
Oliver Brand (1964-2023)



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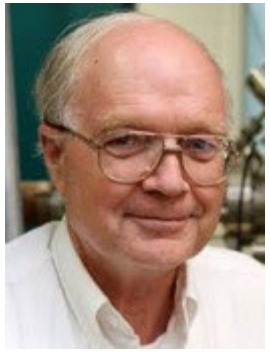
NNCI Advisory Board

Andrew Greenberg
U Wisconsin

Elaine Cohen Hubal
EPA

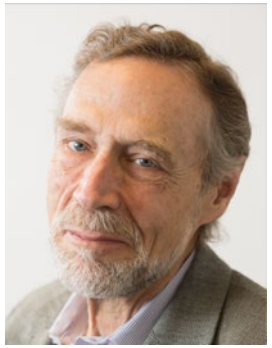
Angelique Johnson
Entrepreneur

Joe Magno
NIIT



Richard Osgood
Columbia U

Kurt Petersen
Entrepreneur



Tom Theis
Utopus Insights

Ken Wise
U Michigan

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NNCI Coordinating Office Team

Amy Duke
Program Manager
Georgia Tech

Matt Hull
AD Innovation & Entrepreneurship
Virginia Tech

Azad Naeemi
AD Computation
Georgia Tech

Mikkel Thomas
AD Education & Outreach
Georgia Tech

Jamey Wetmore
AD Societal & Ethical Implications
ASU

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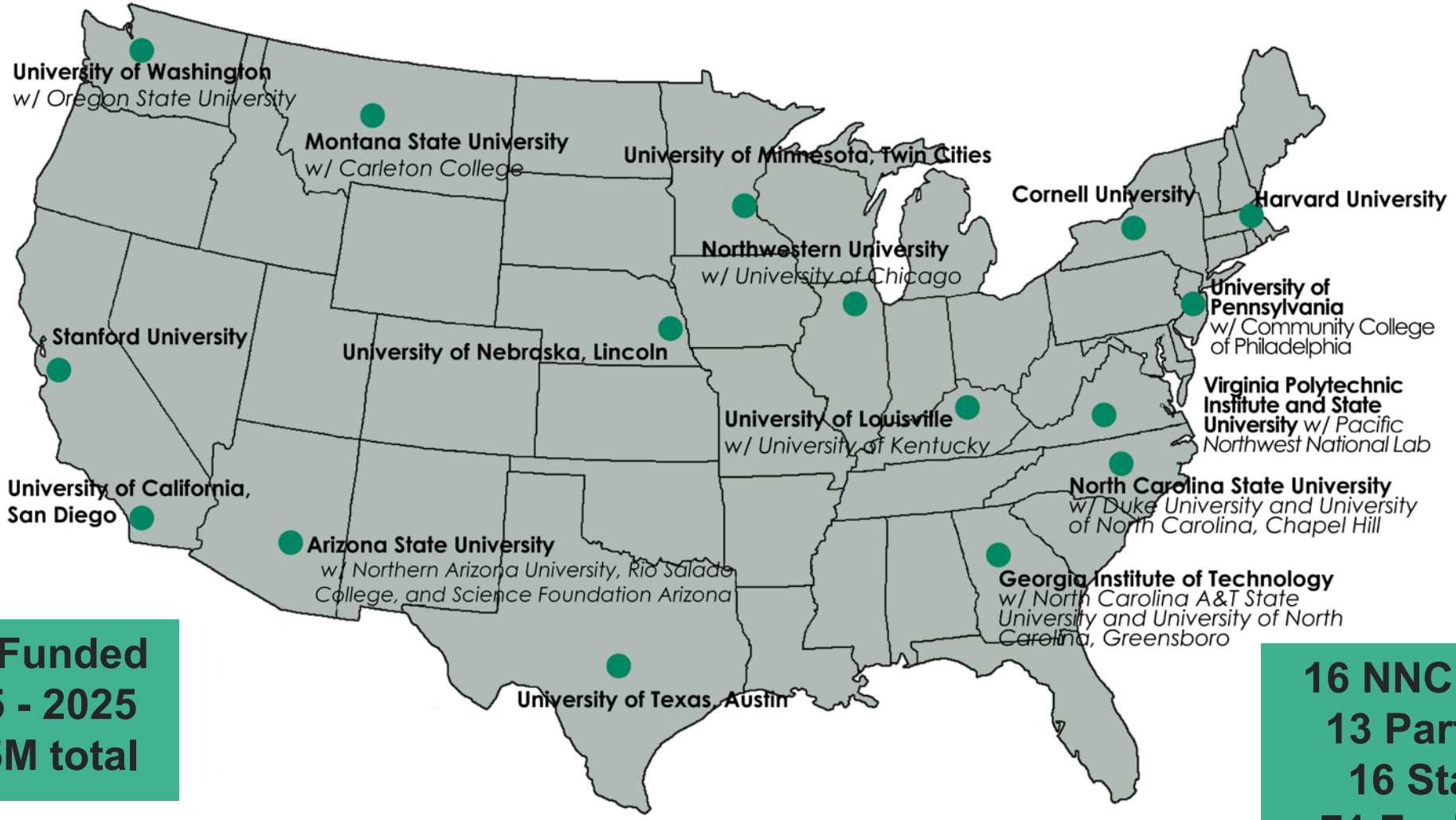
AD Reports: 10:45-11:45AM TODAY

NNCI Network



NSF Funded
2015 - 2025
$165M total

16 NNCI Sites
13 Partners
16 States
71 Facilities
>2,200 Tools

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NNCI Goals

- Provide open access to **state-of-the-art nano-fabrication & characterization facilities** and their tools across the US and **staff expertise**
- Use these resources to support **education & outreach (E&O), societal & ethical implications (SEI),** and **innovation and entrepreneurship** in/of nanotechnology.
- **Network approach to make whole more than the sum of its parts**

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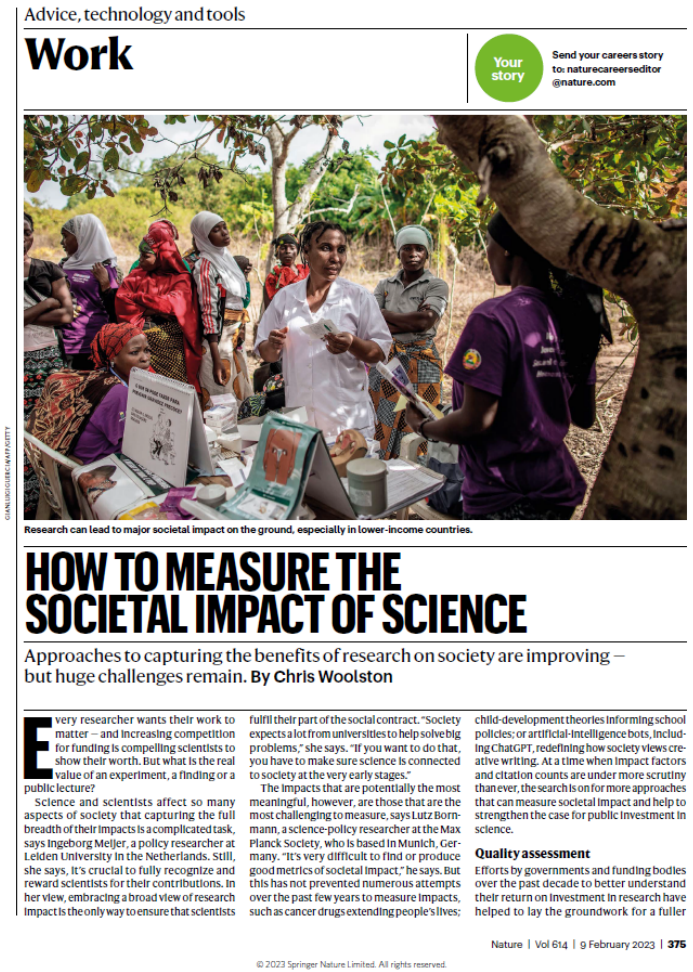
Why do we collect data and metrics?

1. Funding agencies want to see how the money is spent.
2. Universities use the data to allocate resources.
3. Facility managers use data to refine capabilities and understand userbase trends.
4. Researchers want to see the impact of their work.

NNCI metrics:

- ability to serve the greatest number and most diverse set of researchers from academia, industry, and government
- impact on the research enterprise and its economic importance
- societal impact based on improved public awareness, diversity, and workforce development
- success of the network/consortium model



Advice, technology and tools

Work

Your story

Send your careers story to: naturecareerseditor @nature.com

Research can lead to major societal impact on the ground, especially in lower-income countries.

HOW TO MEASURE THE SOCIETAL IMPACT OF SCIENCE

Approaches to capturing the benefits of research on society are improving – but huge challenges remain. **By Chris Woolston**

Every researcher wants their work to matter – and increasing competition for funding is compelling scientists to show their worth. But what is the real value of an experiment, a finding or a public lecture?

Science and scientists affect so many aspects of society that capturing the full breadth of their impacts is a complicated task, says Ingeborg Meijer, a policy researcher at Leiden University in the Netherlands. Still, she says, it's crucial to fully recognize and reward scientists for their contributions. In her view, embracing a broad view of research impact is the only way to ensure that scientists fulfil their part of the social contract. "Society expects a lot from universities to help solve big problems," she says. "If you want to do that, you have to make sure science is connected to society at the very early stages."

The impacts that are potentially the most meaningful, however, are those that are the most challenging to measure, says Lutz Bornmann, a science-policy researcher at the Max Planck Society, who is based in Munich, Germany. "It's very difficult to find or produce good metrics of societal impact," he says. But this has not prevented numerous attempts over the past few years to measure impacts, such as cancer drugs extending people's lives; child-development theories informing school policies; or artificial-intelligence bots, including ChatGPT, redefining how society views creative writing. At a time when impact factors and citation counts are under more scrutiny than ever, the search is on for more approaches that can measure societal impact and help to strengthen the case for public investment in science.

Quality assessment

Efforts by governments and funding bodies over the past decade to better understand their return on investment in research have helped to lay the groundwork for a fuller

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NNCI User Statistics Year 7 (Oct. 2021 – Sept. 2022)

	Year 7 Total	**Mean** (Min – *Median* – Max)
Unique Facility Users	**13,348**	**834** (233 – *741* – 1,677)
Unique Ext. Users	**3,381** **25.3%**	**211** (71 – *190* – 456) **26.0%** (15.1% – *24.7%* – 46.9%)
Industry Users	**1,882**	**118** (27 – *99* – 301)
Acad., Gov., For. Users	**1,499**	**94** (20 – *91* – 283)
Avg Monthly Users	**5,112**	**319** (75 – *297* – 759)
New Users Trained	**5,151**	**322** (54 – *279* – 649)
Facility Hours	**1,072,332**	**67,021** (9,142 – *61,724* – 179,802)
Ext. Facilities Hours	**253,667** **23.7%**	**15,854** (1,630 – *11,406* – 66,378) **22.2%** (6.7% – *18.0%* – 51.1%)
Hours/User	**80**	**77** (27 – *76* – 148)
Total User Fees	**$44.5M**	**$2.78M** ($303k – *$2.55M* – $6.50M)
$/Hour	**$42**	**$44** ($16 – *$46* – $77)

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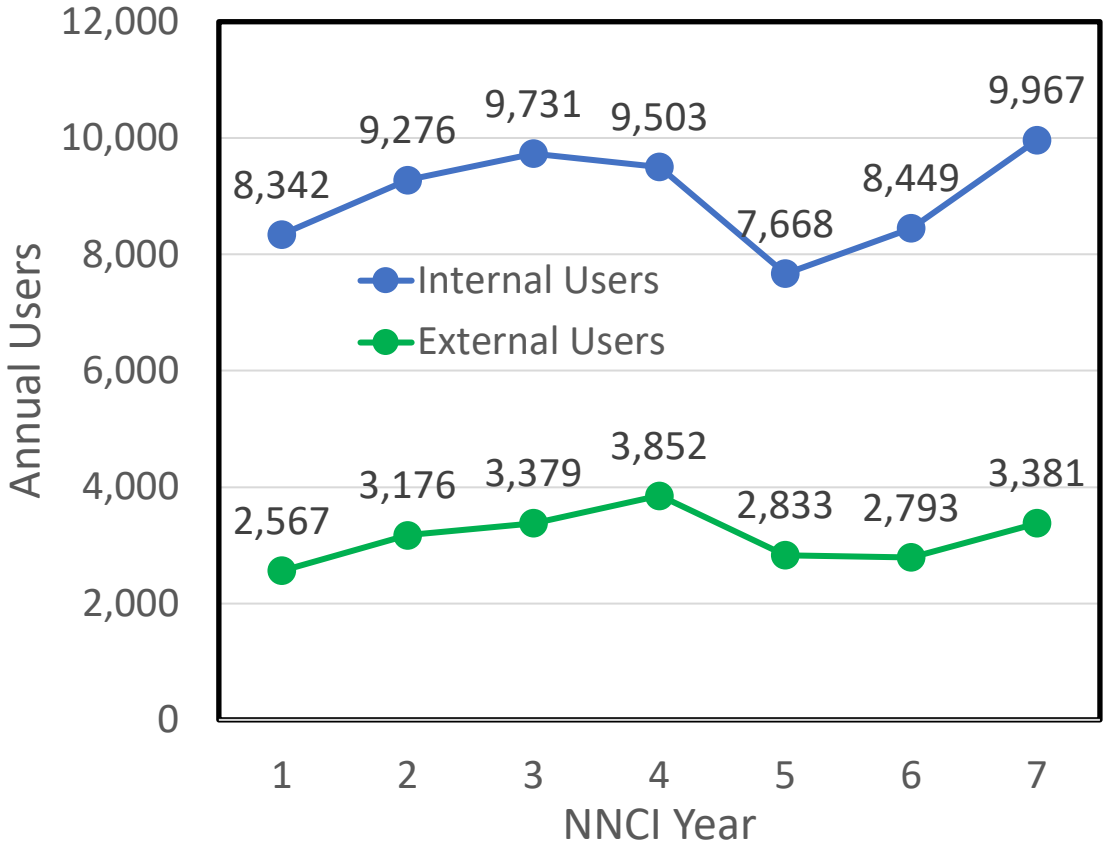
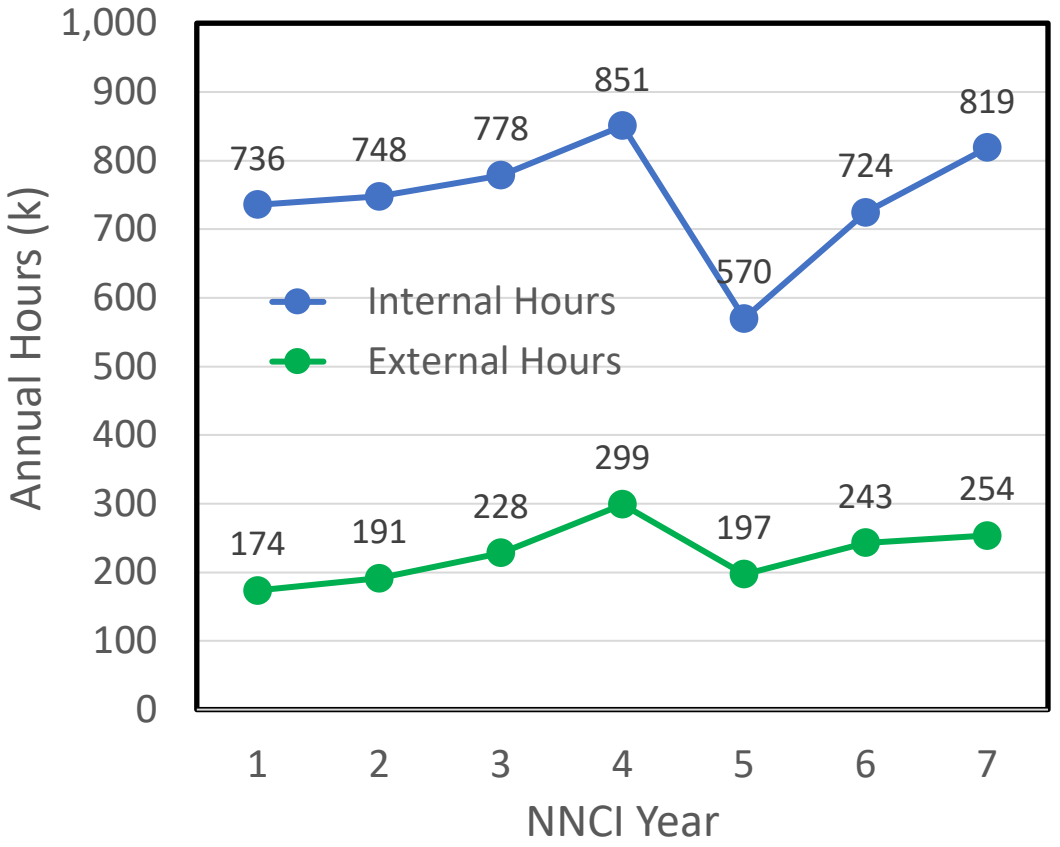
NNCI User Statistics Year 1 – Year 7

	Year 1 10/15-9/16	Year 2 10/16-9/17	Year 3 10/17-9/18	Year 4 10/18-9/19	Year 5 10/19-9/20	Year 6 10/20-9/21	Year 7 10/21-9/22
Unique Facility Users	10,909	12,452	13,110	13,355	10,501	11,242	13,348
Unique Ext. Users	2,567 23.5%	3,176 25.5%	3,379 25.8%	3,852 28.8%	2,833 27.0%	2,793 24.8%	3,381 25.3%
Industry Users	1,413	1,669	1,870	1,961	1,529	1,619	1,882
Ext. Academic Users	1,060	1,295	1,365	1,531	1,064	964	1,238
Avg Monthly Users	4,429	4,911	5,001	5,292	3,654	4,381	5,112
New Users Trained	4,116	4,563	4,981	5,194	2,813	4,414	5,151
Facility Hours	909,151	939,230	1,006,764	1,149,788	767,255	967,297	1,072,332
Ext. Facilities Hours	173,511 19.1%	191,494 20.4%	228,441 22.7%	298,986 26.0%	197,368 25.7%	242,926 25.1%	253,667 23.7%
Hours/User	83	75	77	86	73	86	80
Total User Fees	$34.3M	$37.5M	$40.5M	$43.7M	$29.4M	$39.7M	$44.5M
$/Hour	$38	$40	$40	$38	$38	$41	$42

Coordinated Infrastructure

NNCI Users & Hours: Years 1-7





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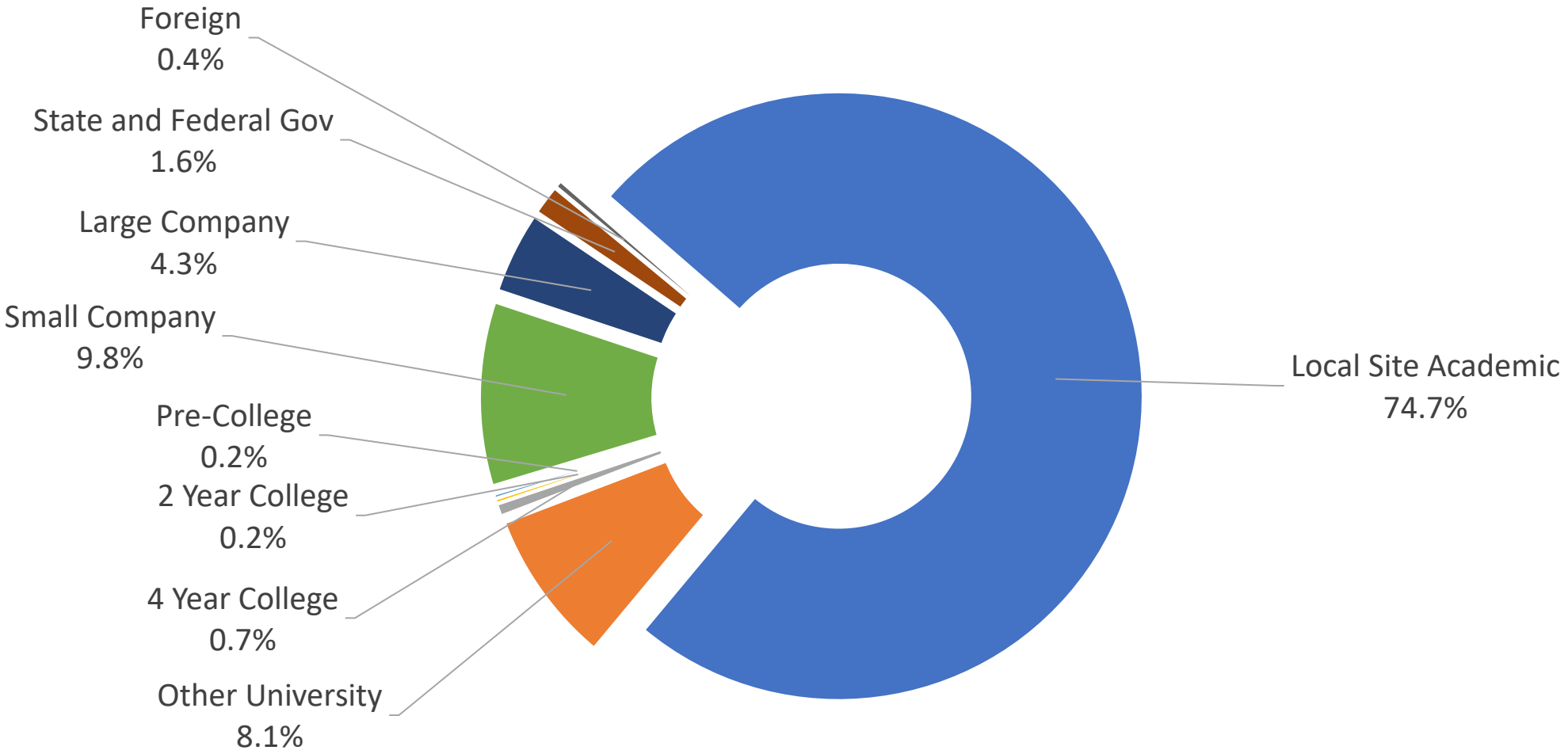
Year 4: October 2018 – September 2019
Year 5: October 2019 – September 2020
Year 6: October 2020 – September 2021
Year 7: October 2021 – September 2022

NNCI Users by Affiliation – Year 7



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NNCI Year 7 US Academic Institutions (233)

233 US academic institutions, including:

- **26 HSI, 33 EHSI**
- **5 HBCU, 2 PBI**
- **7 AANAPI**
- **1 TCU**
- **1 ANNH**

In addition:

- **562 small companies**
- **189 large companies**
- **17 government**
- **37 international**
- **23 other**

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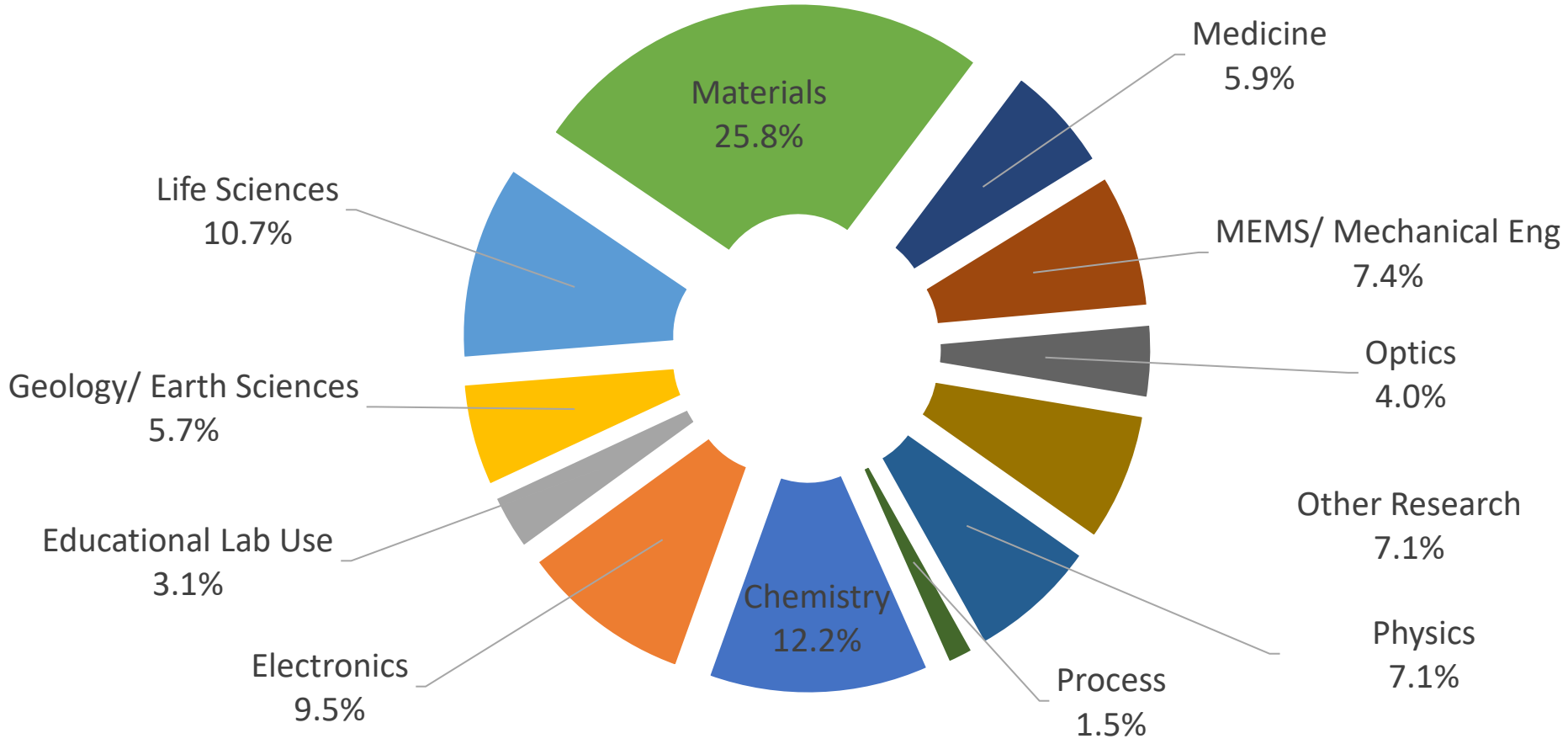
NNCI Users by Discipline – Year 7



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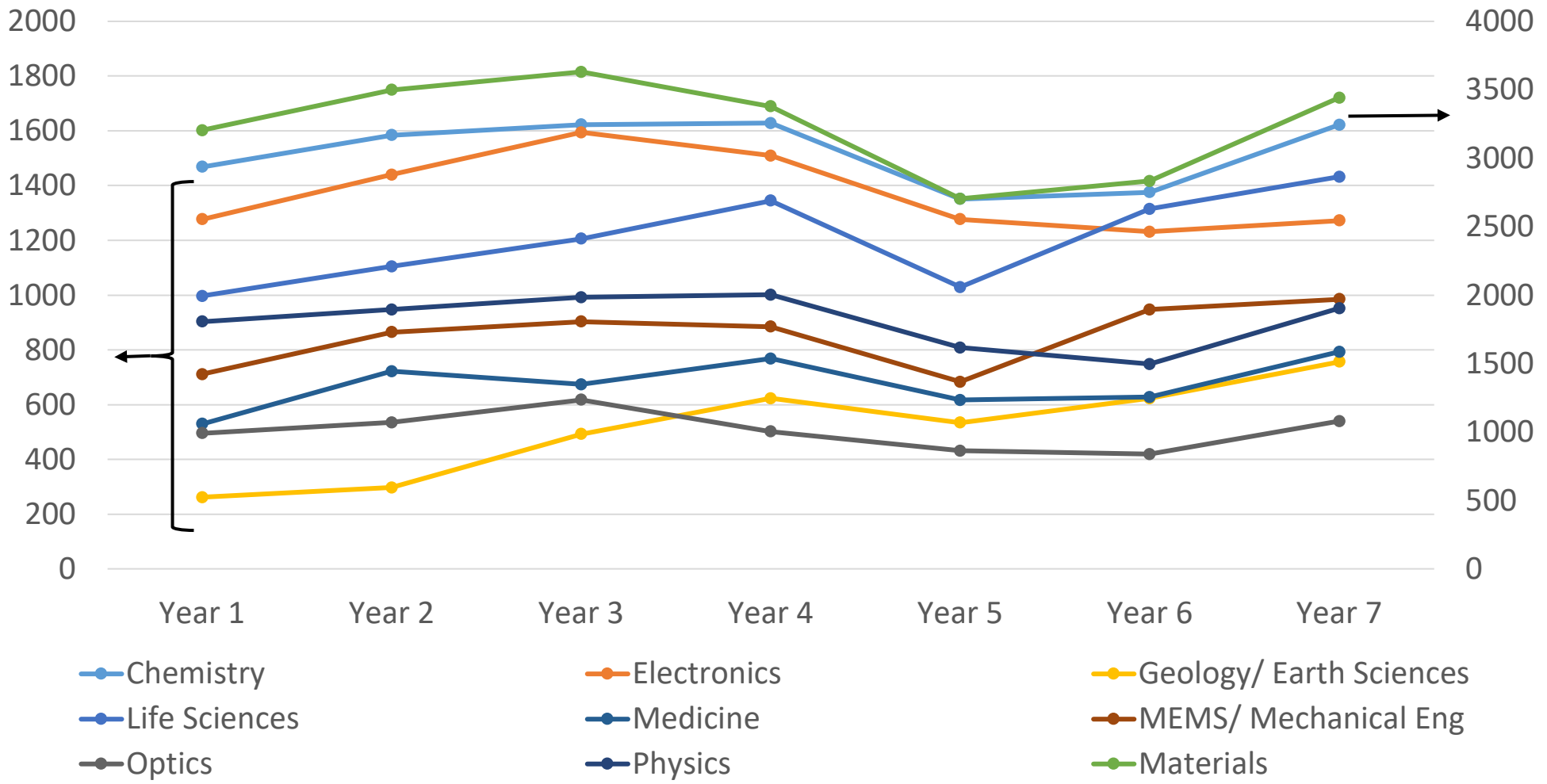
NNCI Users by Discipline – Years 1-7



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NNCI Years 5-8: 6 Months Data Comparison

	Year 5 6 months 10/2019-03/2020 "Pre-Closure"	Year 6 6 months 10/2020-03/2021 "Post-Closure"	Year 7 6 months 10/2021-03/2022 "Recovery"	Year 8 6 months 10/2022-03/2023 "Normal?"
Unique Facility Users	9,328	7,535	9,208	10,279
Unique External Users	2,451 / 26.3%	1,764 / 23.4%	2,157 / 23.4%	2,401 / 23.4%
Industry Users	1,297	1,073	1,244	1,472
Ext. Academic Users	937	533	730	755
Other External Users	217	158	183	174
Average Monthly Users	4,999	4,037	4,766	5,264
New Users Trained	2,130	1,762	2,435	2,392
Facility Hours	505,830	440,011	517,130	526,181
Ext. Facilities Hours	128,856 / 25.5%	110,978 / 25.2%	122,076 / 23.6%	118,431 / 22.5%
Hours/User	54	58	56	51
Total User Fees	$19.0M	$18.1M	$21.5M	$22.1M

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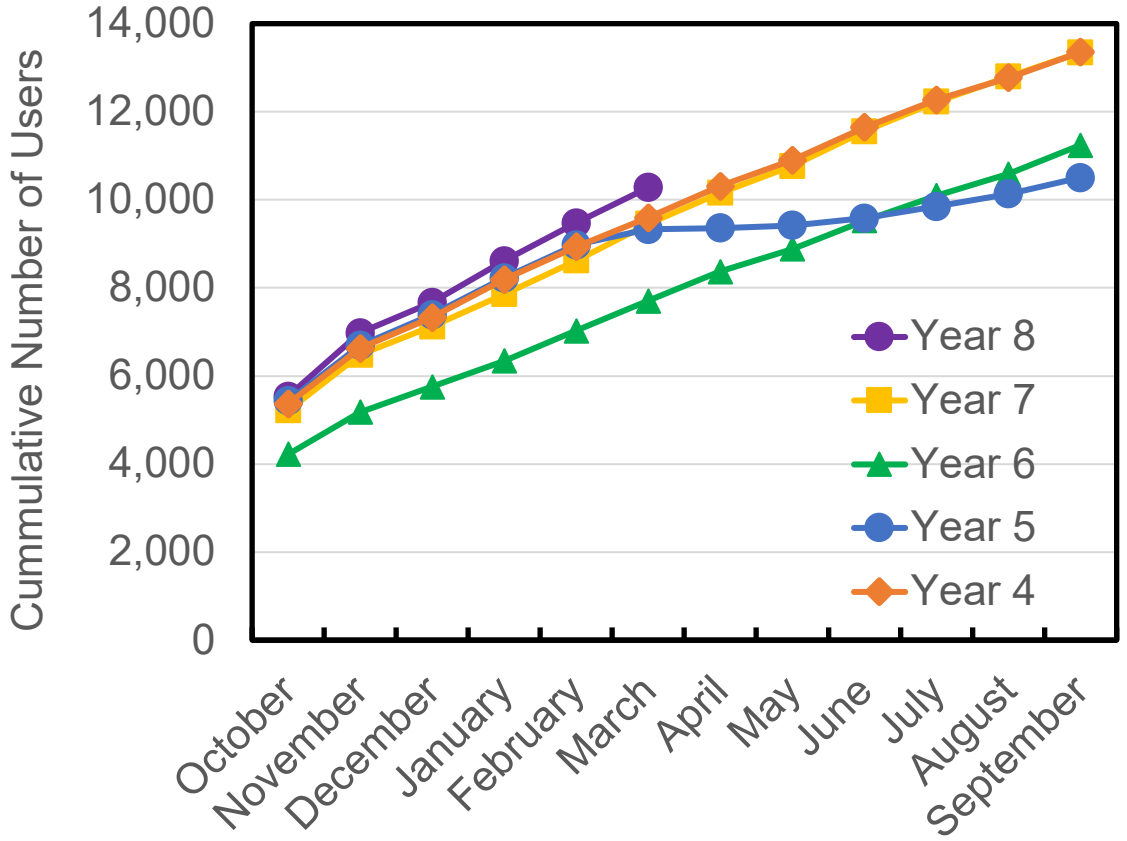
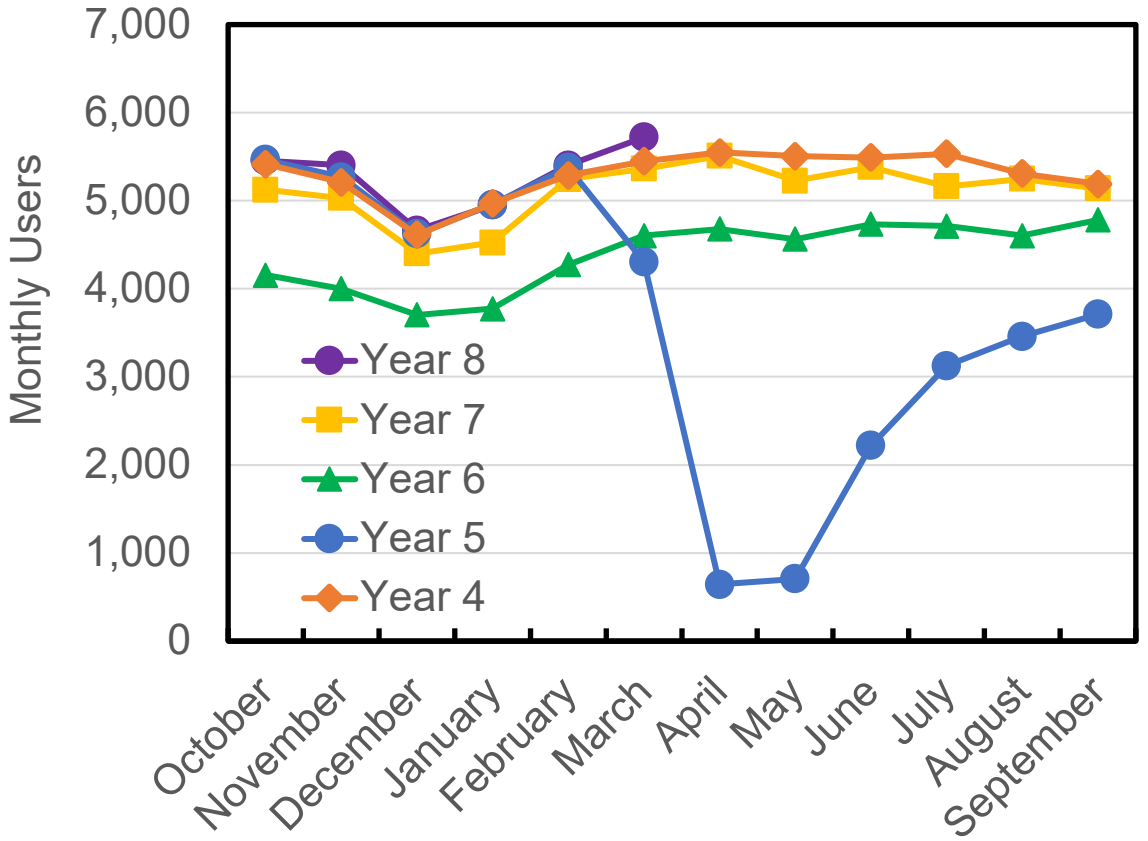
NNCI Users: Years 4-8





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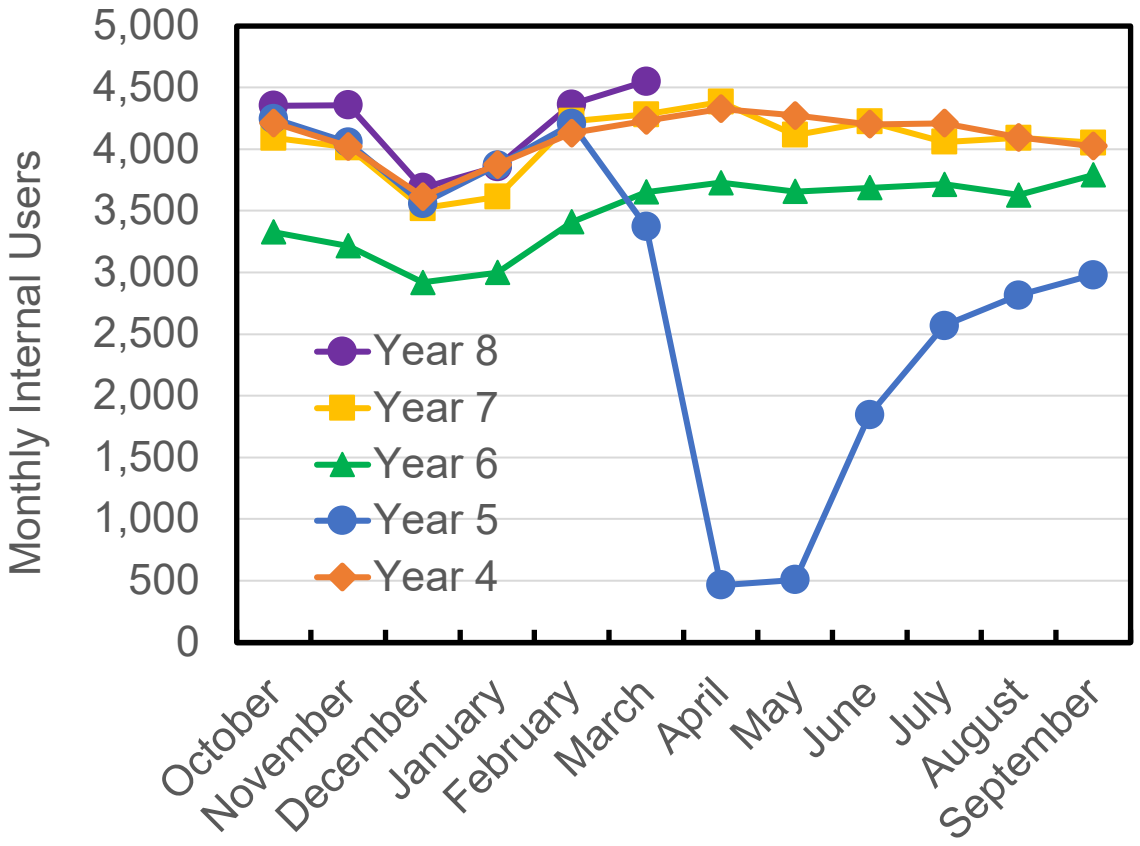
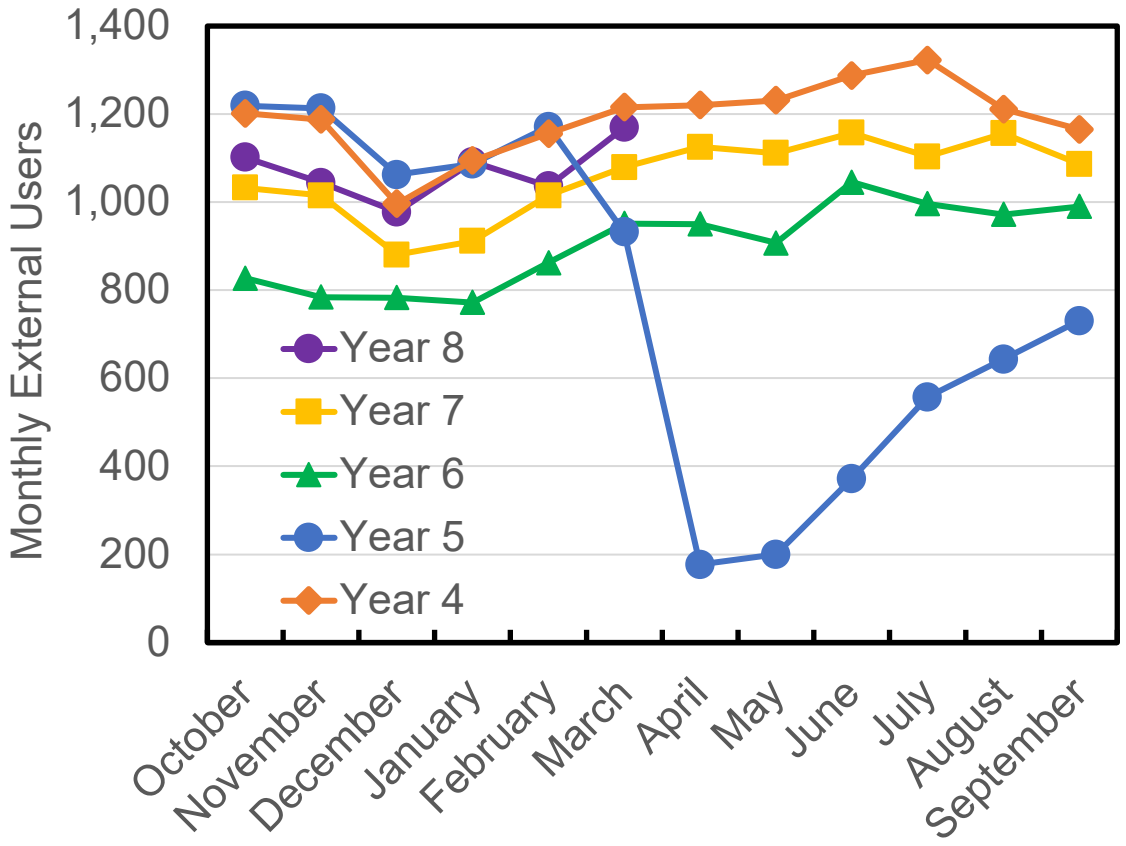
Year 4: October 2018 – September 2019
Year 5: October 2019 – September 2020
Year 6: October 2020 – September 2021
Year 7: October 2021 – September 2022
Year 8: October 2022 – September 2023

NNCI Internal vs. External Users: Years 4-8





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Year 4: October 2018 – September 2019
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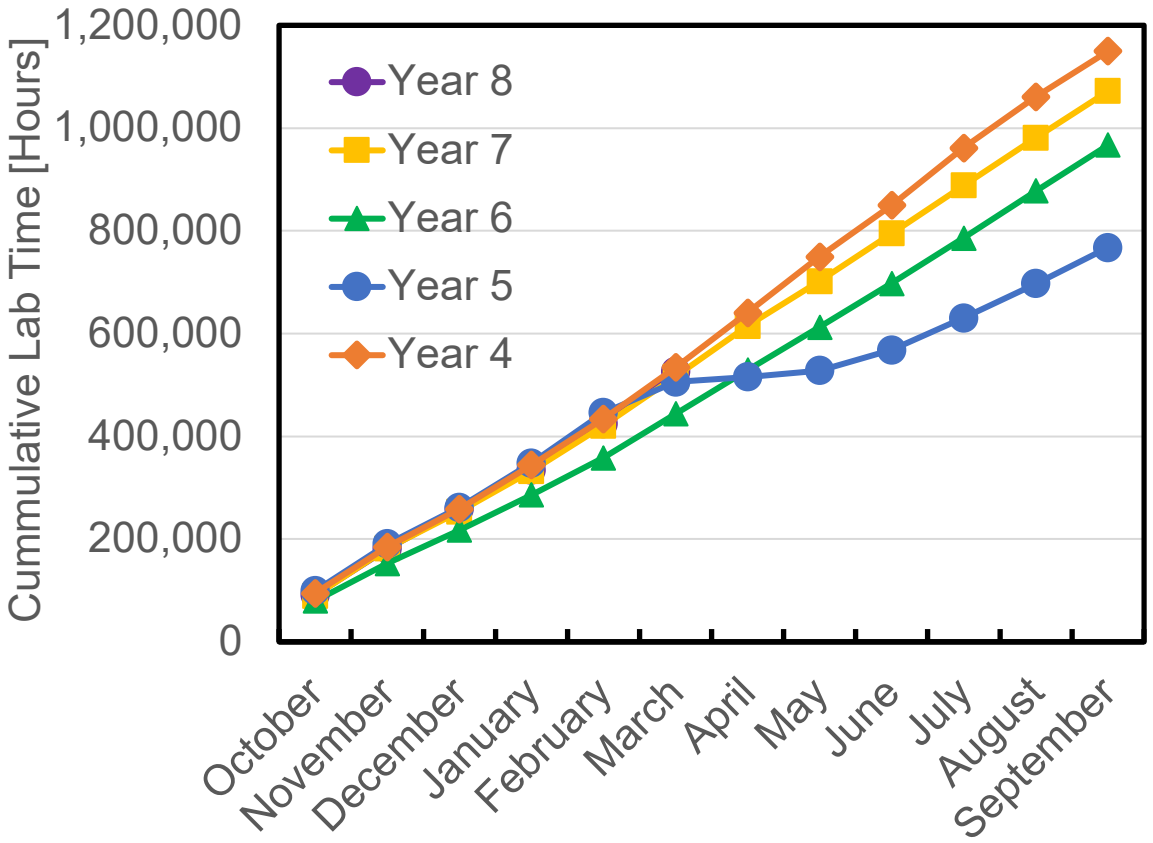
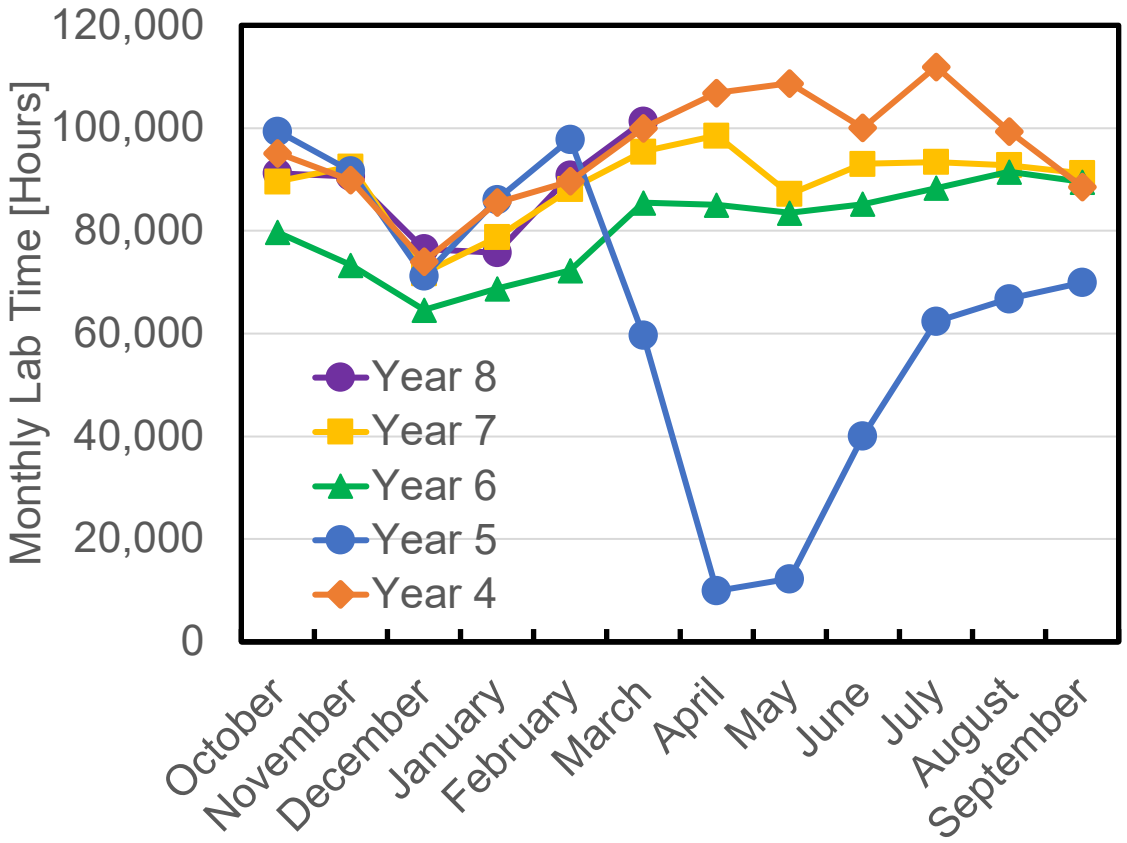
Year 6: October 2020 – September 2021
Year 7: October 2021 – September 2022
Year 8: October 2022 – September 2023

NNCI Lab Time: Years 4-8





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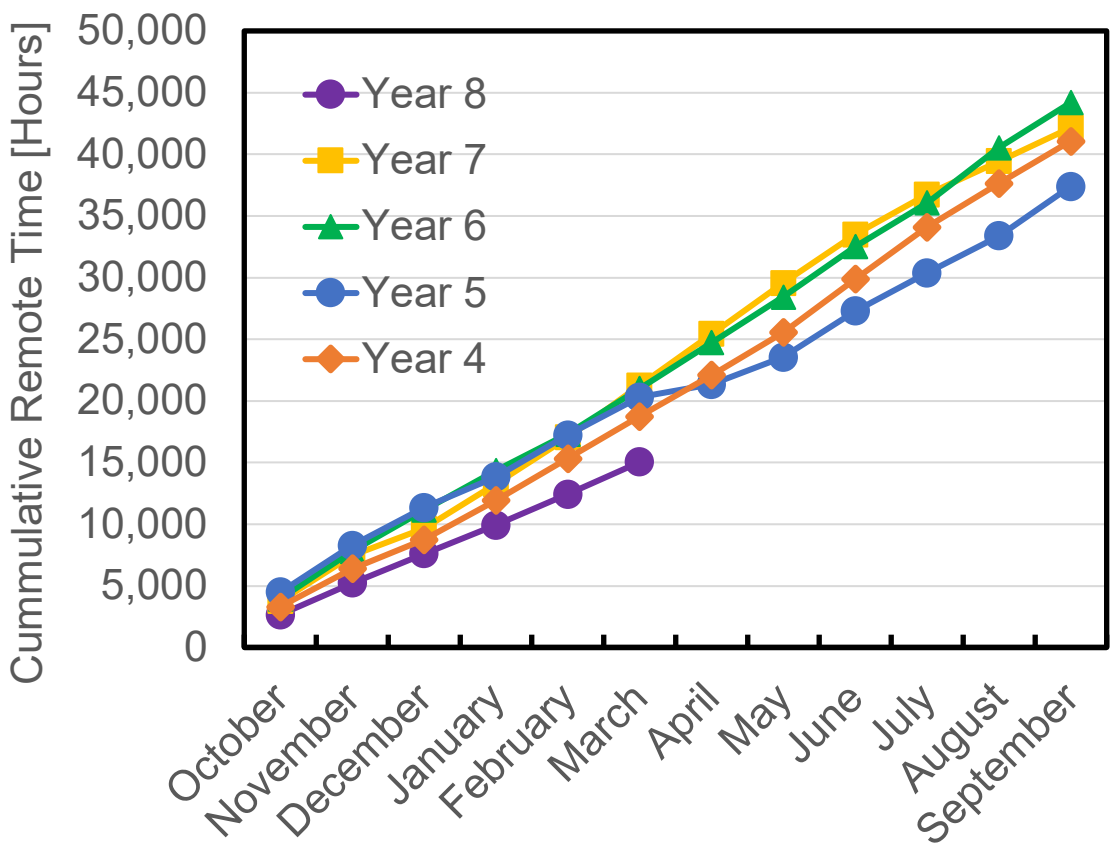
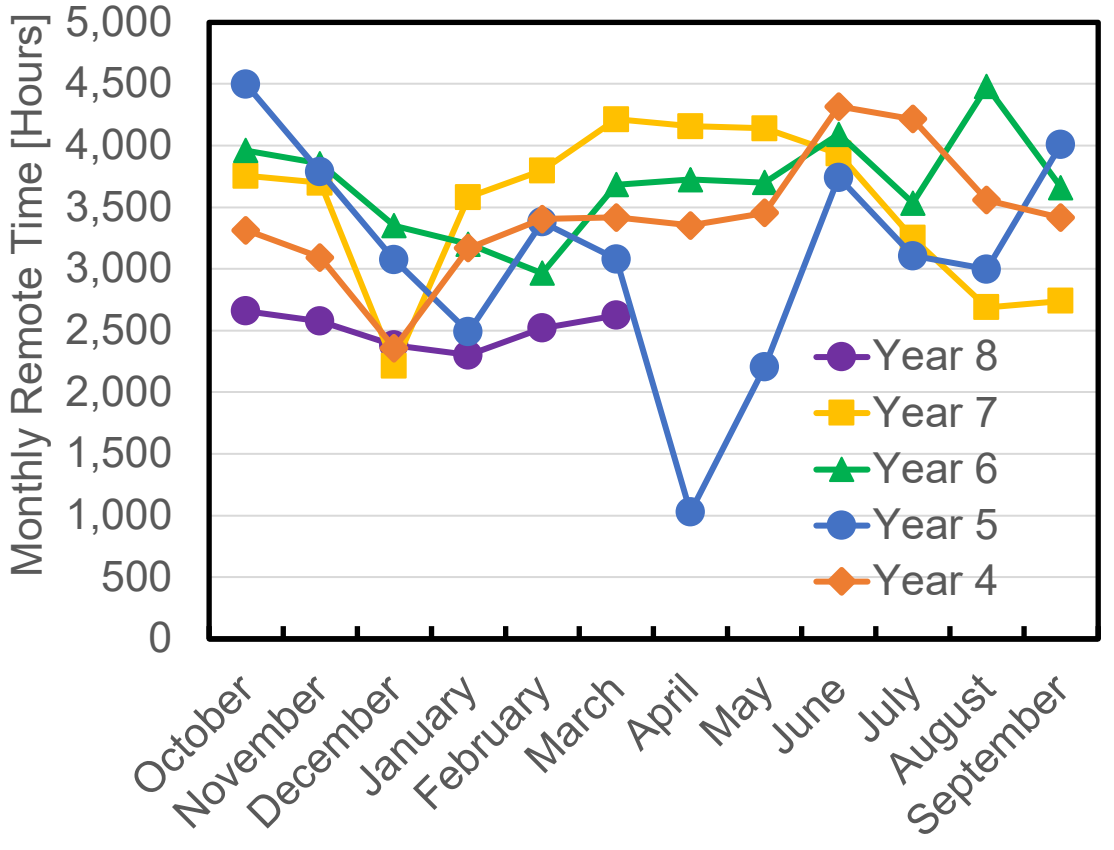
Year 4: October 2018 – September 2019
Year 5: October 2019 – September 2020
Year 6: October 2020 – September 2021
Year 7: October 2021 – September 2022
Year 8: October 2022 – September 2023

NNCI Remote Work: Years 4-8





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Year 4: October 2018 – September 2019
Year 5: October 2019 – September 2020
Year 6: October 2020 – September 2021
Year 7: October 2021 – September 2022
Year 8: October 2022 – September 2023

NNCI Impact

- Scholarly Impact - Publications
  - NSF award citations
- Degrees Granted to NNCI Users
- Courses Supported
- Supported Major Centers
- Research Funding Supported by NNCI

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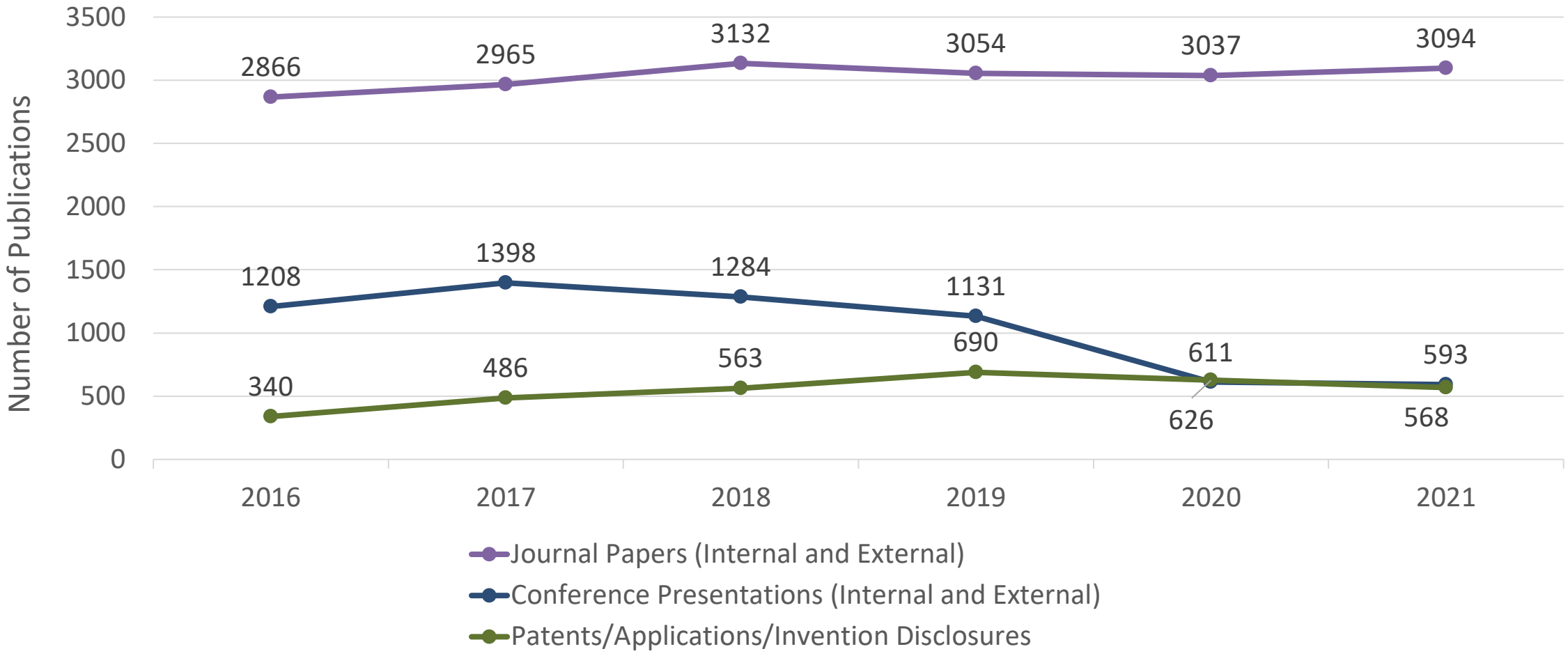
NNCI Impact – Publications CY 2016-2021



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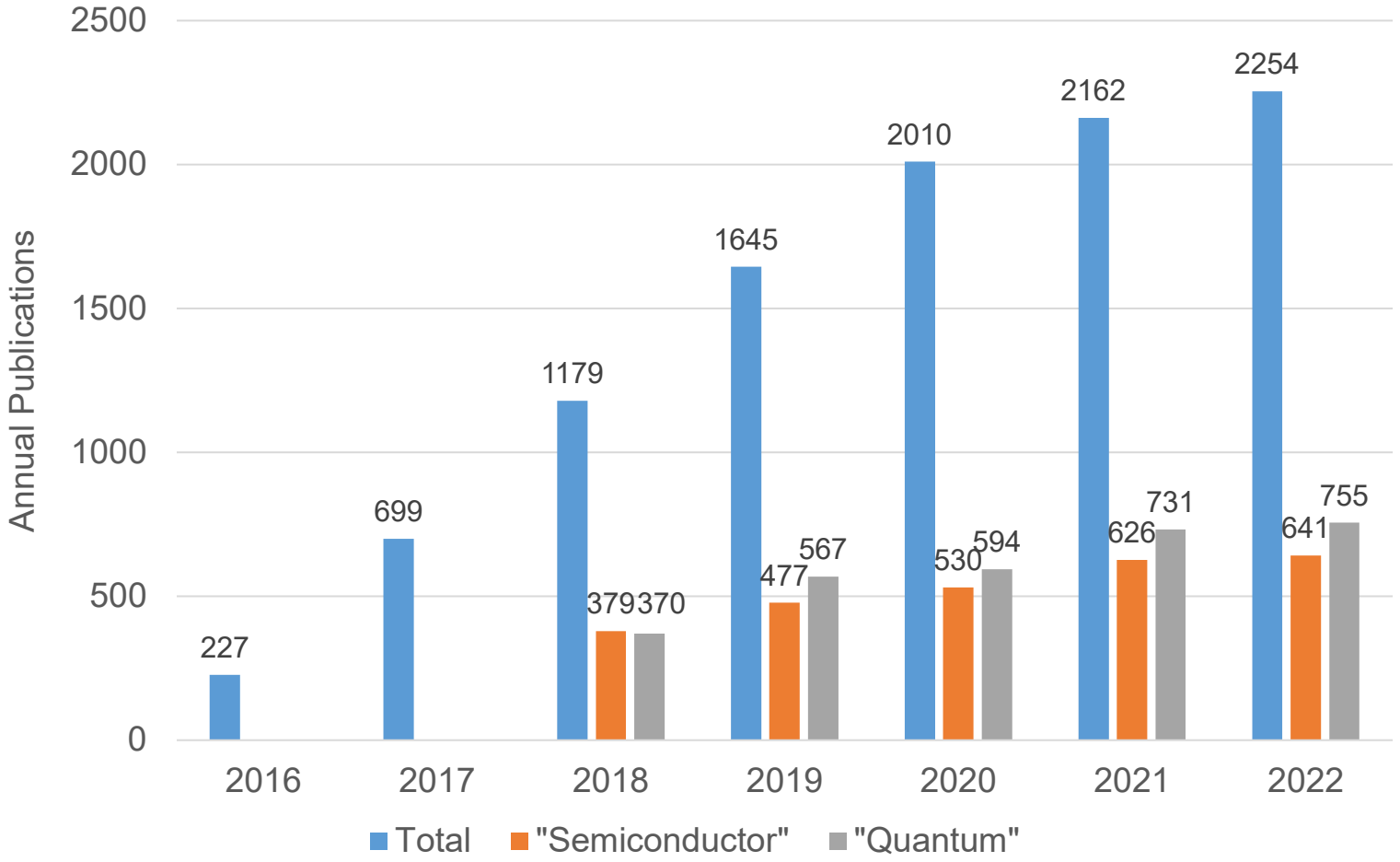
NNCI Impact – Journal Publications with Acknowledgement



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Google Scholar search for NNCI NSF award numbers (through 01/19/2023)

NNCI Impact – Degrees Granted to Users
Fall 2021 – Summer 2022 (14/16 Sites)

Academic Department	BS	MS	PhD	Other	Total
Aerospace Engineering	3	5	2	0	**10**
Biomedical Engineering	17	32	47	0	**96**
Chemical Engineering (5)	18	40	67	3	**128**
Civil and Environmental Engineering	1	15	28	0	**44**
Electrical and Computer Engineering (2)	55	123	97	0	**275**
Industrial Engineering	3	1	0	0	**4**
Materials Science and Engineering (1)	60	100	123	0	**283**
Mechanical Engineering (4)	25	60	62	1	**148**
Nanoengineering	9	27	26	0	**62**
Nuclear Engineering	0	1	1	0	**2**
Biology	10	5	10	0	**25**
Chemistry and Biochemistry (3)	31	36	103	2	**172**
Earth and Atmospheric Sciences	1	2	8	0	**11**
Physics	28	20	57	0	**105**
Nanoscience	11	3	10	0	**24**
Computer Science	7	17	2	0	**26**
Medical School	0	1	3	6	**10**
Other	17	30	33	11	**91**
Total	**296**	**518**	**679**	**23**	**1,516**

By Site: Mean=108, Range=23-333

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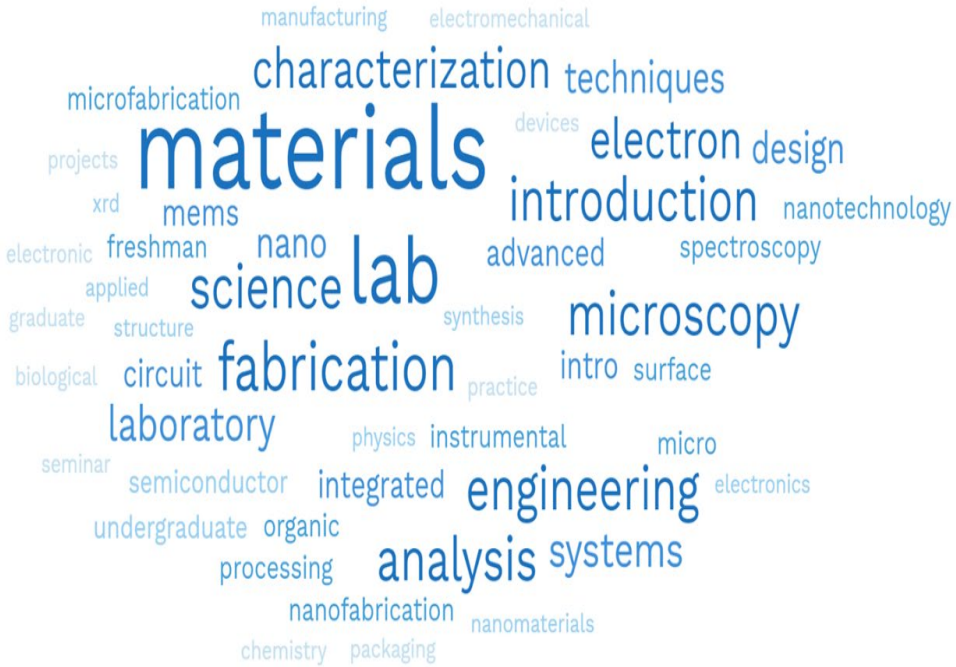
Numbers are lower bound!

NNCI Impact – Courses Supported

- More than **110 individual courses** were supported from **27 different academic departments**.
- Total course enrollment of **3,428 students** (site range: 20-1,428).

Applied Physics and Archeology
Arts & Sciences (Fine Arts)
Bioengineering
Biology
Biomedical Engineering
Biotechnology Program
Chemical and Biomolecular Engineering
Chemical Engineering
Chemistry
Earth System Science
Electrical and Computer Engineering
Electrical and Systems Engineering
Electrical Engineering
Electronics
Engineering and Applied Sciences
Engineering Summer Academy at Penn
Evolutionary Anthropology
Geosciences
Industrial Engineering
Materials Science
Materials Science and Engineering
Mechanical Engineering
Molecular Engineering
Nanoengineering
Nanoscience
Otolaryngology
Physics



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NNCI Impact – New Research Centers

59 Reported in Years 5-6:

- NSF: 13 ERC, 6 STC, 7 MRSEC, MIP, IUCRC, NRT
- DOE: 3 EFRC, Industrial Assessment Center, Energy Innovation Hub
- 5 NIH, 1 SRC, 1 NIST

11 New in Year 7:

- NSF: ERC, NRT, MIP
- DOE: 4 EFRC (3 new, 1 renewal)
- DoD: US Army DEVCOM, ONR MURI

Center for Programmable Energy Catalysis

MITIGATE FLU

PreMiEr Precision Microbiome Engineering NSF Engineering Research Center

Q-MEEN-C

ICONS Joint School of Nanoscience and Nanoengineering

GlycoMIP NSF Materials Innovation Platform

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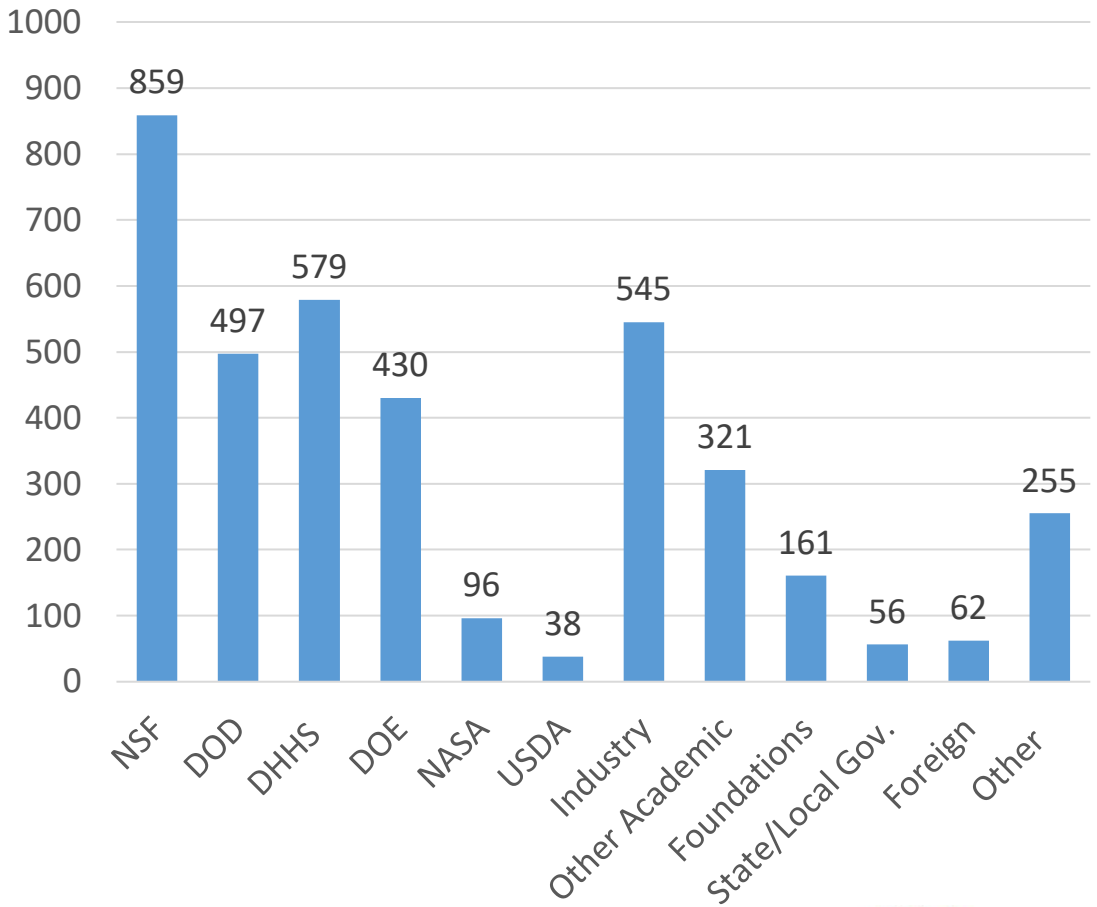
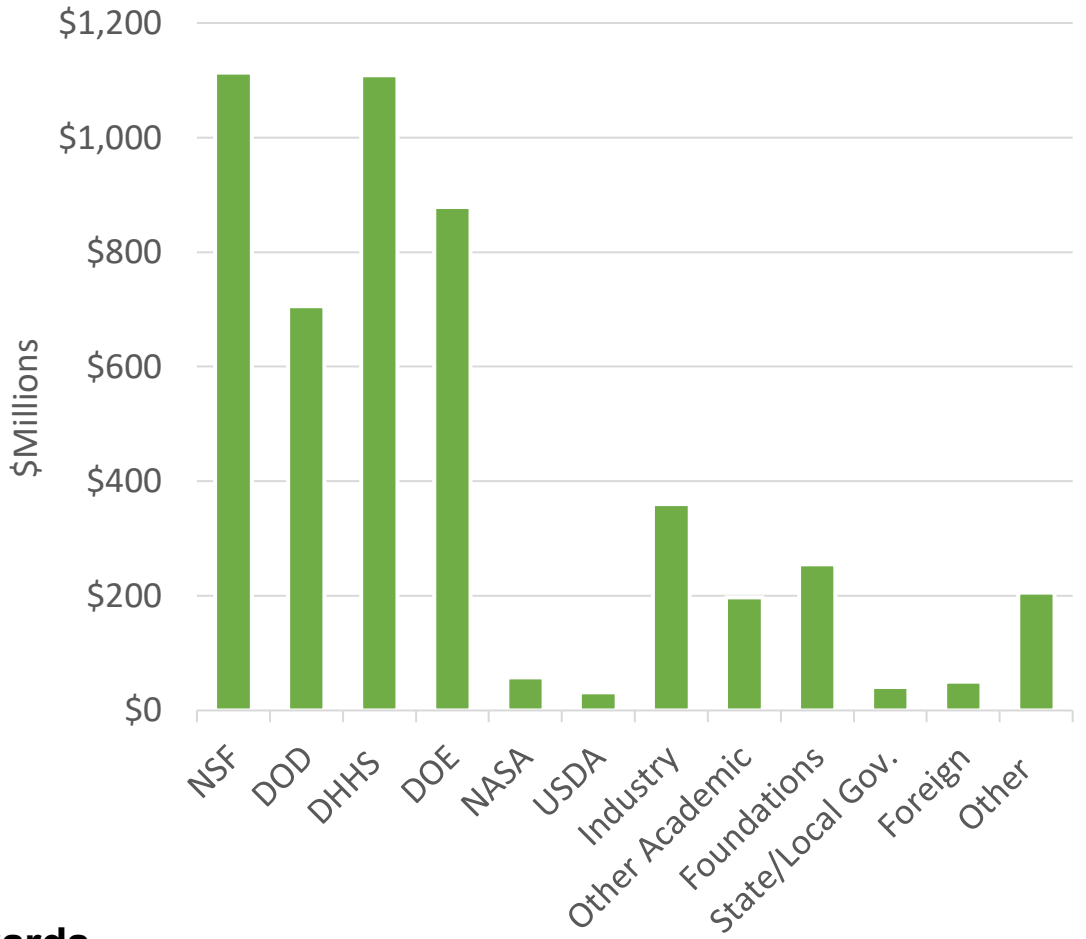
NNCI Impact – Funding Supported





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3,899 Total Awards
$5.0 Billion
2,609 Principal Investigators (29% with NSF funding)

NNCI Programs

- Subcommittees & Working Groups
- Research Communities
- Regional Networks
- NNCI Webinar Series/YouTube Channel
- NNCI User Survey
- NNCI Image Contest
- NNCI Workshop

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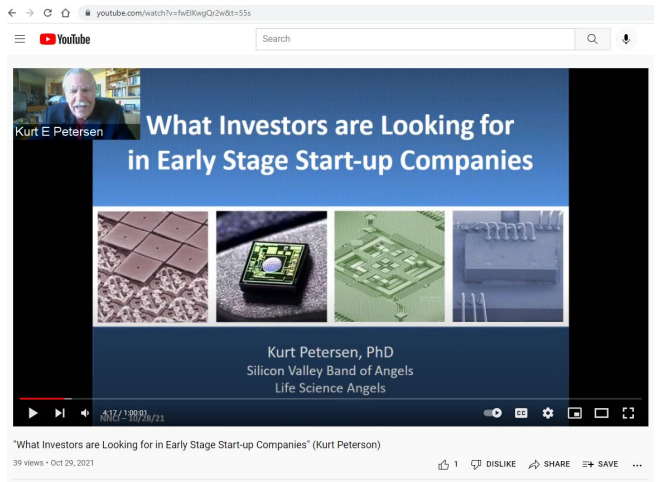
NNCI Initiatives

- Subcommittees and Technical Working Groups
- Regional Networks
  - 8 networks, ~100 partners
  - New Working Group
- Research Communities
  - Nanotechnology Convergence
  - Nano Earth Systems
  - Nano-Enabled Internet-of-Things
  - Transform Quantum
  - Understanding the Rules of Life
  - Semiconductors and Microelectronics
- Webinar Series (NNCI YouTube channel)



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2022 NNCI User Survey

- Responses: 970
  Affiliations: 67% NNCI university, 11% non-NNCI academia, 19% Industry
- How did you find out about NNCI facility?
  1. Current/former user; 2. Referral from user; 3. University website; 4. Web search; 5. Direct contact by facility
- Overall satisfaction with NNCI facility: 93.0% Somewhat or Extremely Satisfied
- NNCI facility had a positive impact on my work: 94.3% Agree or Strongly Agree
- Level of civility: <4% rated Fair/Poor
- Would you recommend the NNCI facility to a colleague? 97.9% Yes
- 150+ suggestions were received and provided to the sites

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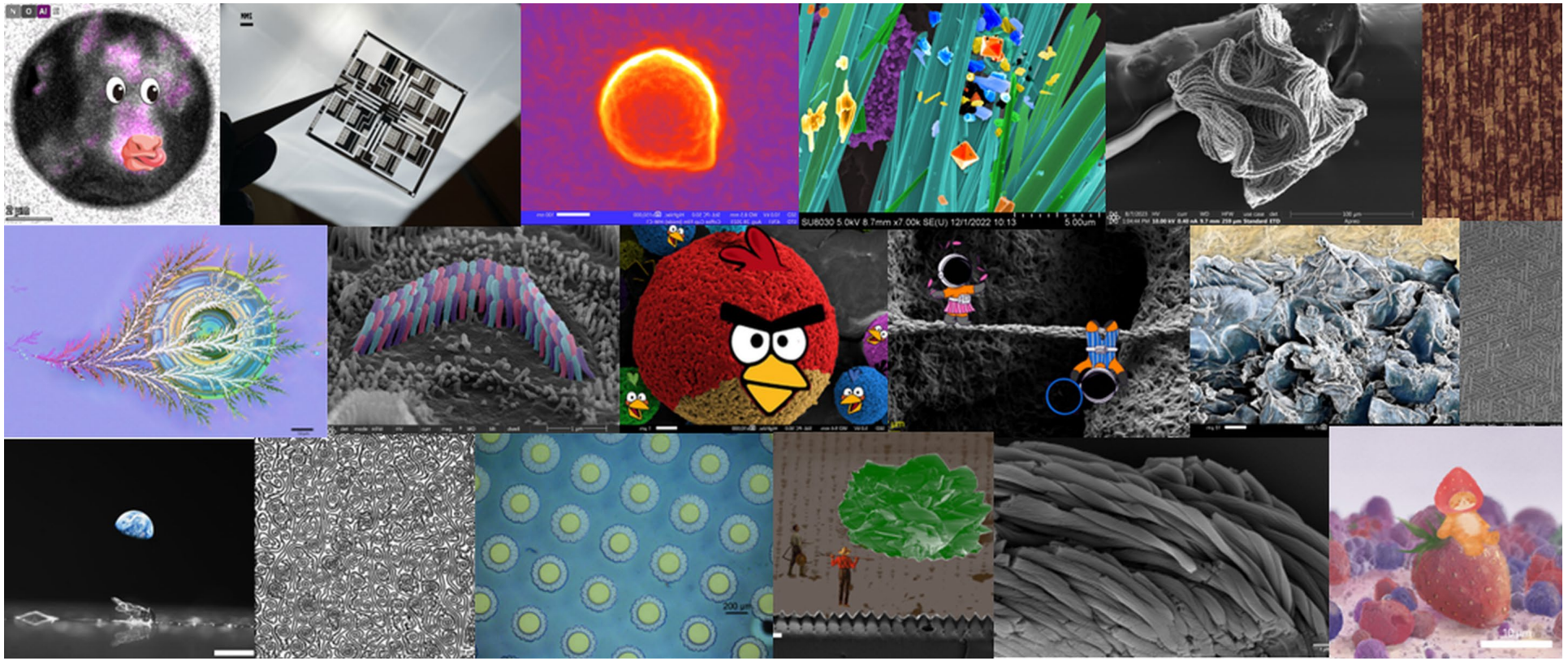
Plenty of Beauty at the Bottom Image Contest



Winners and Honorable Mentions to be announced by Associate Director for Education & Outreach!

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NNCI Workshop on Nanotechnology Infrastructure of the Future

- September 12 and 13, 2023 (Washington, DC and Online)
- 75 participants (at peak) in person and 198 virtual participants joined via Zoom.
- Keynote speakers, panels, attendee Q/A, brainstorming.
- Nexight Group guided participants in sessions on critical aspects:
  - Key research priorities
  - Education and workforce development
  - Technology translation
  - Research ecosystem and social responsibility
  - Organizational and governing principles

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Conference Site Reports & Panel Topics

What successful examples of programs, activities, and relationships in the current NNCI could be adapted or expanded for multiple sites in a future network?

- What can a set of future nanotechnology infrastructure sites do to **expand their impact regionally**?
- What role does the NNCI currently play in **workforce development** and how can a future infrastructure improve upon and scale these efforts?
- How can an NSF-funded nanotechnology program help lead and nucleate the broader national **nanotechnology infrastructure ecosystem**?
- How does NNCI **support national research priorities**, and how can this be enhanced in a future nanotechnology infrastructure?

National Nanotechnology Coordinated Infrastructure

SWOT Analysis - Strengths

- **Accessibility and Flexibility**
  - Low-cost, open access to nanotechnology tools and staff expertise
  - Exploration of new ideas using different materials, devices, processes
  - Supports fundamental and applied research
  - Multiple disciplines supported: microelectronics, MEMS, quantum, life sciences, earth sciences,…
- **Education/Workforce Development**
  - Training new student/professional users
  - Exciting the next generation via K-12 outreach
- **Networking Capability**
  - University-based facilities bring together academics, start-ups, small & large companies, government researchers, and translational activity
  - Enhanced by workshops, short courses, seminars, tech showcases, etc.
- **Consortium Model**
  - Cross-site initiatives (REU, RET, AccelNet)
  - Sharing best practices and assisting users
  - Regional networks, collaborations, and partnerships outside the NNCI broaden our reach

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SWOT Analysis - Weaknesses

- **Institutional Heterogeneity**
  - No uniform rate structure for users
  - Access models based on individual facilities and institutions
  - Range of legal and other issues
  - Diversity of local user communities
- **Multi-user Model**
  - Conflicting needs of academic and commercial users
  - Contamination and reproducibility issues
- **Communications**
  - How best to disseminate the impact and importance of the NNCI and its constituent sites
  - Limited ability for marketing and user recruitment
- **Education/Outreach/Workforce Development**
  - Local, rather than national, approach
  - Trying to reach too many audiences

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SWOT Analysis - Opportunities

- **Funding**
  - CHIPS and Science Act
  - NSF Regional Innovation Engines (TIP)
- **Partnering and Collaboration**
  - NNCO Infrastructure Leadership Summit
- **National Research Priorities**
  - National Nanotechnology Initiative
  - National Quantum Initiative
  - Pandemic Preparedness
- **Building on Our Strengths**
  - Improved communications
  - Flexibility and diversity
  - Education and training (scaling via regional networks, collaboration with community colleges)

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SWOT Analysis - Threats

- **Increasing User Numbers**
  - With stable facilities and staff support
- **Aging Facility (Cleanroom) Infrastructure**
  - Many tools are 10-20+ years old, not vendor supported anymore, and not industry standard
  - Most academic facilities have limited 200+ mm capabilities
  - Limited investment in upgrading toolsets
- **Staffing**
  - University salary structure makes it difficult to retain/replace staff
- **Limited Support for Translational Activities**
  - “Open” vs. “controlled” tools
  - Need for controlled process modules
  - Bridging the gap between research and manufacturing
- **Competing Research Infrastructure**
- **Future Funding Landscape**

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Thank You!

http://www.nnci.net