Annual Report 2024-25

NSF Award DMS-1929348
Covering activity between June 1, 2024 and May 31, 2025

Contents

1. Overview

This is the 2024-25 annual report for the Institute for Mathematical and Statistical Innovation, funded by NSF grant DMS-1929348. It covers activities of the Institute which took place between June 1, 2024 and May 31, 2025.

The Institute for Mathematical and Statistical Innovation (IMSI) is a mathematical sciences research institute hosted by the University of Chicago, and operated in partnership with Northwestern University, the University of Illinois at Chicago, and the University of Illinois at Urbana-Champaign.

1.1 Mission

The mission of IMSI is to bring rigorous mathematics and statistics to bear on complex urgent problems of significant scientific and social importance, and to spur transformational change in the mathematical sciences and the mathematical sciences community. There are three primary pillars to this mission: scientific activity, a focus on broadening participation in the mathematical sciences, and a focus on effective communication about mathematical science research to a variety of audiences.

IMSI is committed to first-rate interdisciplinary research in areas of great societal interest and impact where the mathematical sciences have the potential to contribute. It aims to make a difference in ways that are scientifically and socially important. The institute has a particular focus on problems related to areas such as data science and machine learning, health care and medicine, materials science, and quantum computing. Areas like these embody significant challenges for society at large, and meaningful progress in these will in many cases require engagement from researchers and decision makers across a variety of sectors, including academia, national labs, government, and the private sector, and will highlight the important and expanding role played by the mathematical sciences across these sectors. The challenges with which we engage require perspectives and insights from a number of directions in order to make progress, and these must emerge from interactions among researchers from multiple disciplines and employment sectors. At the same time, there is often a need for research to usefully inform policy and decision making, which requires expanding conversation and engagement beyond the realm of basic research. Moreover, the broad social impacts of these challenges implies that effective engagement with them will often require the participation of a community of researchers who can collectively bring an understanding of how these challenges are experienced across human society as a whole. This points to a need for broad participation in the mathematical sciences.

The third pillar in IMSI's mission is an emphasis on effective communication and, beyond that, effective collaboration and engagement. An important aspect of scientific progress is that the insights it generates must propagate and land with those who can make effective use of them. This often requires communicating and collaborating across differences arising from boundaries between intellectual disciplines, research cultures, employment sectors and roles, career and education stages, positions in society, and more. Scientific research often defaults to a mode of experts speaking to experts who emerge from similar research cultures. IMSI aims to encourage scientific research that

does not remain confined to this mode, and to provide ways for researchers in the mathematical sciences to build skills in communicating across boundaries.

1.2 Overview of the Year

IMSI hosted three long programs this year: The Architecture of Green Energy Systems (June 17-August 23, 2024), Statistical Methods and Mathematical Analysis for Quantum Information Science (September 16-December 13, 2024), and Uncertainty Quantification and AI for Complex Systems (March 3-May 23, 2025), with a total of eleven embedded workshops. In addition, IMSI hosted or co-sponsored nine topical research workshops, one summer school, and one winter school outside the framework of the three long programs. IMSI also sponsored a number of events during this period aimed at broadening participation and workforce development in the mathematical sciences, including the BRING MATH conference in collaboration with Argonne National Laboratory, the Infinite Possibilities Conference (part of the MSIDI initiative), two iterations of the Career Paths in the Mathematical Sciences workshop organized in collaboration with the Math Alliance and the Institute for Mathematics and its Applications, the Summer Undergraduate Mathematics and Statistics Accelerator (SUMSA), and a summer internship program for Ph.D. students.

2. Participant Demographics

2.1 List of Activities

IMSI Activities 2024-2025

Title	Type of Activity	Dates
Career Paths in the Mathematical Sciences 2024	Special Event	June 6-7, 2024
IMSI Summer Internship Program	Internship	June 10-August 16, 2024
Summer Undergraduate Mathematics and Statistics Accelerator (SUMSA)	SUMSA	June 10-August 2, 2024
The Architecture of Green Energy Systems	Long Program	June 17-August 23, 2024
The Architecture of Green Energy Systems: The Underlying Problem and Its Challenges	Short Research Event	June 17-21, 2024
Mathematical and Statistical Foundations of Digital Twins	Short Research Event	June 26-28, 2024
Two-Dimensional Random Geometry	Short Research Event	July 8-12, 2024

AI+Science Summer School	Short Research Event	July 15-19, 2024
Exploring shifts in biogeochemical cycles and mass extinction events through slow-fast dynamical systems (Interdisciplinary Research Cluster)	Short Research Event	August 5-14, 2024
Computational Imaging	Short Research Event	August 5-9, 2024
The Architecture of Green Energy Systems: Next Steps	Short Research Event	August 19-21, 2024
Challenges in Neuroimaging Data Analysis	Short Research Event	August 26-30, 2024
Statistical Methods and Mathematical Analysis for Quantum Information Science	Long Program	September 16-December 13, 2024
The Power of Near-Term Quantum Experiments: Algorithms, Noise, and Quantum Advantage beyond NISQ	Short Research Event	September 16-20, 2024
Quantum Networks	Short Research Event	September 30-October 4, 2024
BRING MATH: Bridges for the Next Generation: Mathematical Science Research and Our Future	Special Event	October 3-4, 2024
Quantum Sensing	Short Research Event	October 14-18, 2024
Quantum Hardware	Short Research Event	October 28-31, 2024
Quantum Error Correction	Short Research Event	November 11-14, 2024
Mathematical Modeling of Biological Interfacial Phenomena	Short Research Event	December 9-13, 2024
Reduced-Order Modeling for Complex Engineering Problems: From Analysis to Practical Implementation – Winter School	Short Research Event	January 29-31, 2025
Reduced-Order Modeling for Complex Engineering Problems: From Analysis to Practical Implementation – Research Workshop	Short Research Event	February 3-7, 2025
Uncertainty Quantification Strategies for Multi-Physics Systems and Digital Twins	Short Research Event	February 24-26, 2025
Uncertainty Quantification and AI for	Long Program	March 3-May 23, 2025

Complex Systems		
UQ and Trustworthy AI Algorithms for Complex Systems and Social Good	Short Research Event	March 3-7, 2025
Emergent Behavior in Complex Systems of Interacting Agents	Short Research Event	March 17-21, 2025
Kernel Methods in Uncertainty Quantification and Experimental Design	Short Research Event	March 31-April 4, 2025
Uncertainty Quantification for Material Science and Engineering	Short Research Event	April 21-25, 2025
Statistics Meets Tensors: Methodology, Theory, and Applications	Short Research Event	May 5-9, 2025
Advances in Mathematical Modeling of Mass Extinction Events (Interdisciplinary Research Cluster)	Short Research Event	May 13-23, 2025
Uncertainty Quantification and Machine Learning for Complex Physical Systems	Short Research Event	May 19-23, 2025
Career Paths in the Mathematical Sciences 2025	Special Event	May 29-30, 2025

2.2 Demographics by Type of Activity

Demographics by Activity

Activity		Long Programs '24-'25	Short Research Events '24-'25	Special Events '24-'25
Total Number of Participants (Includes all participants, speakers, and organizers)		93	1633	144
Employment/Educational Status	Faculty Member or Academic Administrator	54	659	32
	Graduate Student	29	609	17
	Non-academic Employment	4	93	16
	Postdoctoral Associate	5	231	1
	Retired / Not Employed / Self-employed	1	9	1
	Undergraduate Student	0	31	77

	High School Student	0	1	0
	Unknown	0	0	0

Activity		Long Programs '24-'25	Short Research Events '24-'25	Special Events '24-'25
Total Number of Participants (Includes all participants, speakers, and organizers)		134	2393	150
Field(s) of Expertise*	Mathematics	40	624	118
	Statistics	30	470	17
	Physics / Astronomy	17	361	1
	Chemistry	0	18	0
	Materials Science	1	49	0
	Computer Science / Information Science	10	342	6
	Engineering	20	320	2
	Life Sciences	2	36	0
	Medicine	0	22	0
	Geosciences	0	37	1
	Economics	6	47	0
	Social Sciences	2	11	1
	Education or Learning Research	0	3	2
	Other	8	53	2

*Participants were able to indicate more than one field of expertise. Those that selected multiple fields of expertise are represented in the totals more than once.

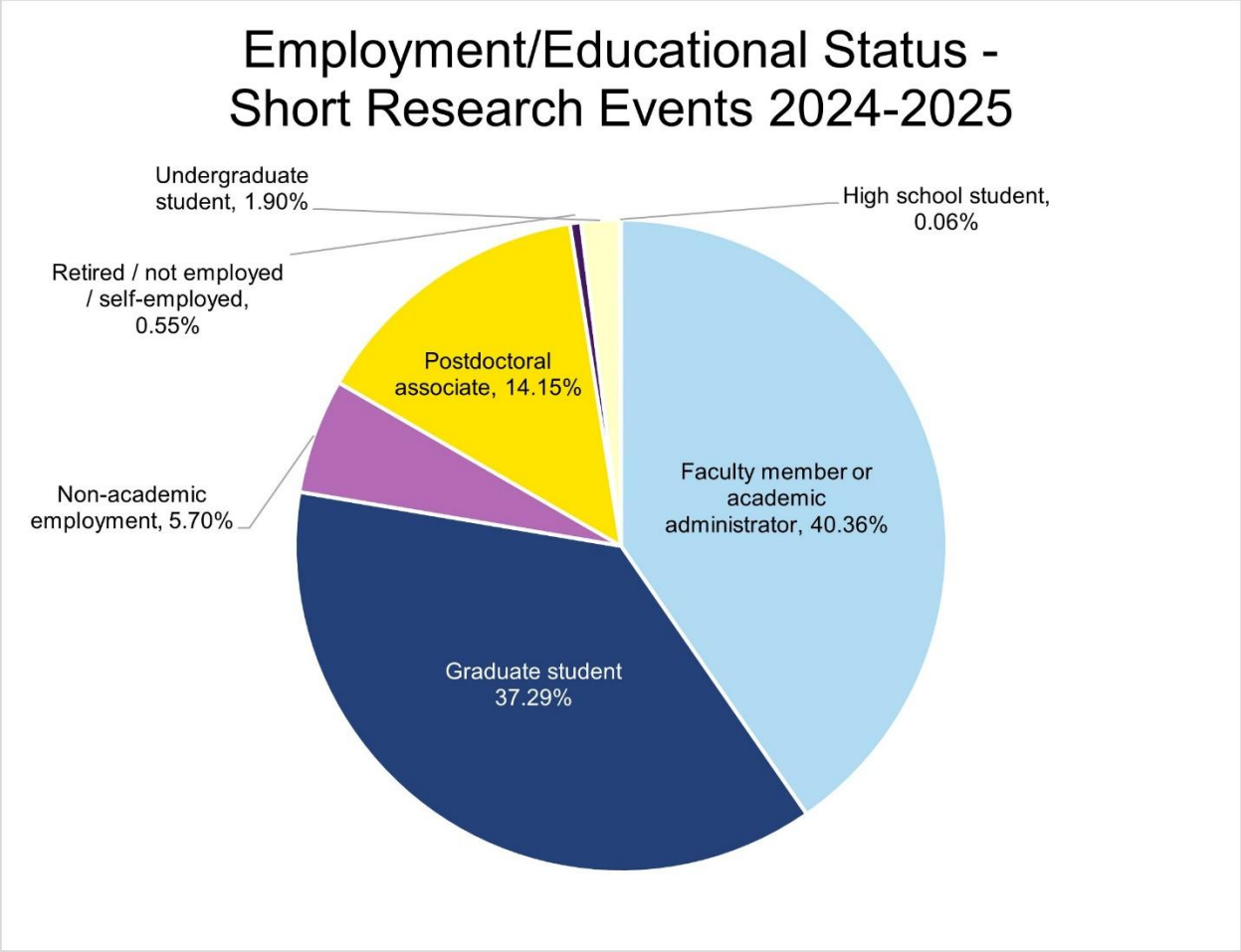
2.3 Demographics for Short Research Workshops

The following demographic information includes participants, organizers, speakers, facilitators, and panelists. Some individuals may be reflected more than one time if they participated in more than one workshop. This category of activity includes the following events:

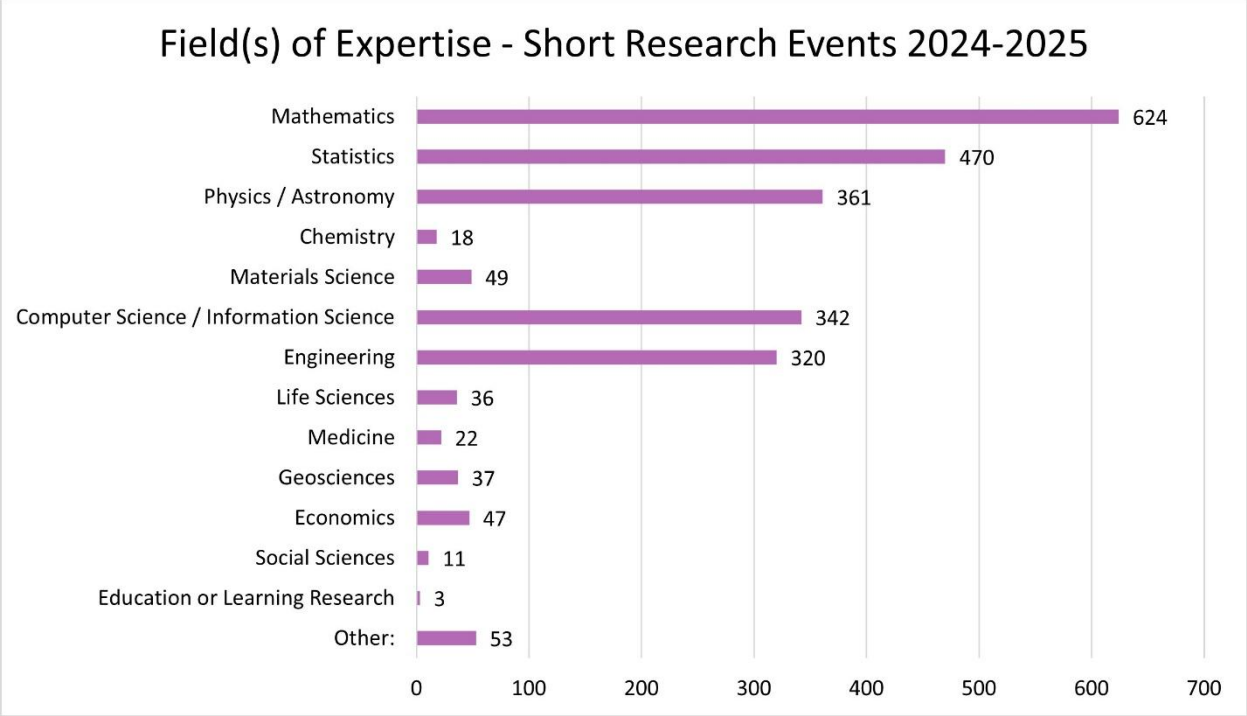
- The Architecture of Green Energy Systems: The Underlying Problem and Its Challenges
- Mathematical and Statistical Foundations of Digital Twins
- Two-Dimensional Random Geometry

- AI+Science Summer School
- Exploring shifts in biogeochemical cycles and mass extinction events through slow-fast dynamical systems (Interdisciplinary Research Cluster)
- Computational Imaging
- The Architecture of Green Energy Systems: Next Steps
- Challenges in Neuroimaging Data Analysis
- The Power of Near-Term Quantum Experiments: Algorithms, Noise, and Quantum Advantage beyond NISQ
- Quantum Networks
- Quantum Sensing
- Quantum Hardware
- Quantum Error Correction
- Mathematical Modeling of Biological Interfacial Phenomena
- Reduced-Order Modeling for Complex Engineering Problems: From Analysis to Practical Implementation – Winter School
- Reduced-Order Modeling for Complex Engineering Problems: From Analysis to Practical Implementation – Research Workshop
- Uncertainty Quantification Strategies for Multi-Physics Systems and Digital Twins
- UQ and Trustworthy AI Algorithms for Complex Systems and Social Good
- Emergent Behavior in Complex Systems of Interacting Agents
- Kernel Methods in Uncertainty Quantification and Experimental Design
- Uncertainty Quantification for Material Science and Engineering
- Statistics Meets Tensors: Methodology, Theory, and Applications
- Advances in Mathematical Modeling of Mass Extinction Events (Interdisciplinary Research Cluster)
- Uncertainty Quantification and Machine Learning for Complex Physical Systems

Short Research Events 2024-2025 - Participants by Employment/Educational Status



Short Research Events 2024-2025 - Participants by Field(s) of Expertise



Note: Participants were able to indicate more than one field of expertise. Those that selected multiple fields of expertise are represented in the totals more than once.

Short Research Events 2024-2025 - Participants by Employer/School Location (United States)

Short Research Workshops 2024-2025 - Participants by Employer/School Location (United States)			
State	Number of Participants	State	Number of Participants
Alabama	7	Montana	0
Alaska	1	Nebraska	0
Arizona	16	Nevada	1
Arkansas	1	New Hampshire	4
California	117	New Jersey	21
Colorado	17	New Mexico	14
Connecticut	9	New York	79
Delaware	2	North Carolina	42

District of Columbia	2	North Dakota	0
Florida	8	Ohio	8
Georgia	31	Oklahoma	2
Hawaii	1	Oregon	1
Idaho	3	Pennsylvania	49
Illinois	334	Puerto Rico	0
Indiana	52	Rhode Island	2
Iowa	13	South Carolina	22
Kansas	0	South Dakota	0
Kentucky	0	Tennessee	4
Louisiana	3	Texas	50
Maine	1	Utah	2
Maryland	54	Vermont	4
Massachusetts	85	Virginia	44
Michigan	53	Washington	11
Minnesota	9	West Virginia	0
Mississippi	0	Wisconsin	55
Missouri	17	Wyoming	0

Short Research Events 2024-2025 - Participants by Employer/School Location (Country)

Short Research Workshops 2024-2025 - Participants by Employer/School Location			
Country	Number of Participants	Country	Number of Participants
Australia	6	Korea, South	14
Austria	4	Morocco	1
Brazil	2	Netherlands	7
Canada	46	New Zealand	2
Chile	5	Nigeria	1

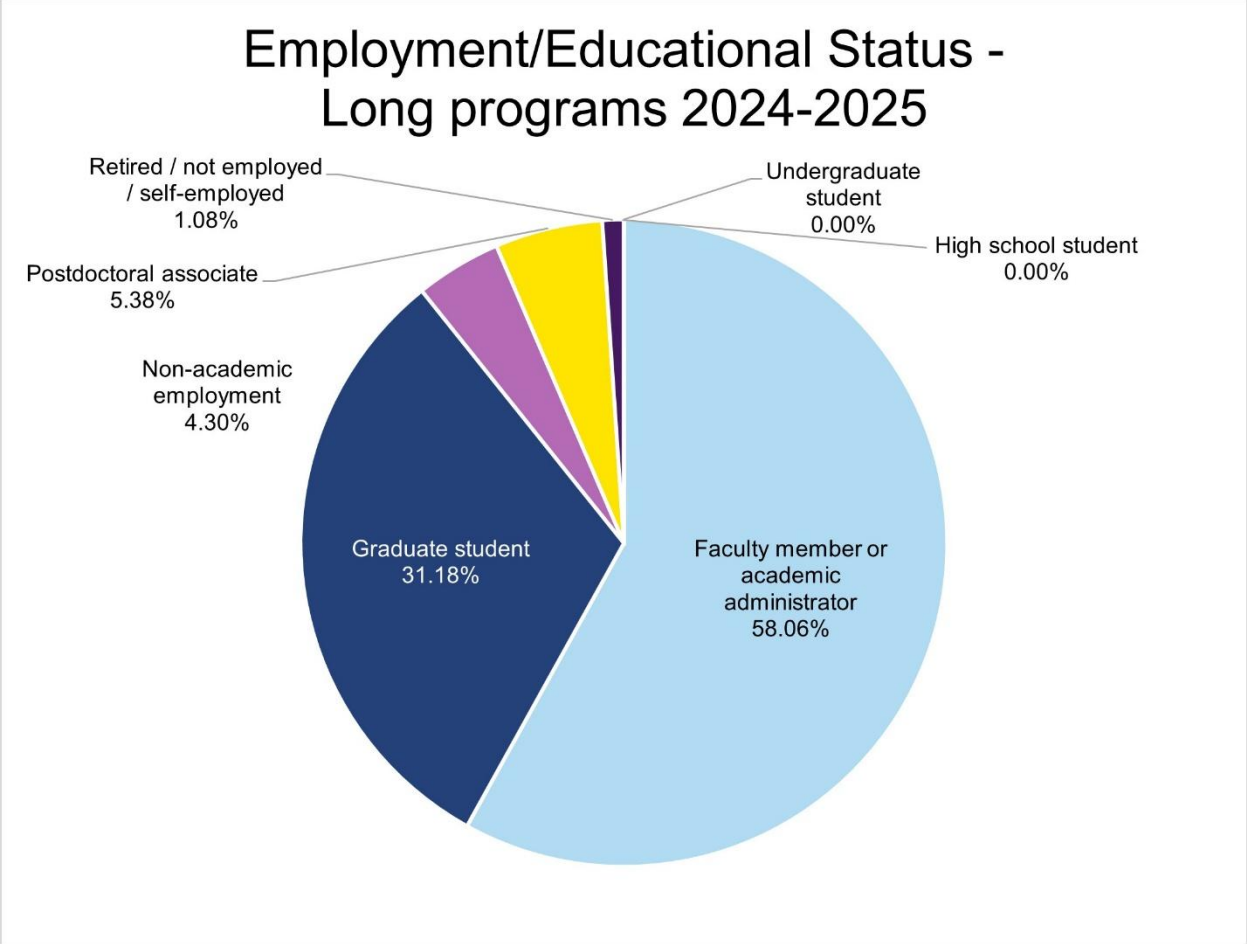
China	33	Norway	1
Colombia	11	Pakistan	2
Croatia	1	Poland	3
Denmark	3	Portugal	1
Ecuador	1	Saudi Arabia	2
Egypt	1	South Africa	2
Finland	7	Spain	4
France	1	Sri Lanka	1
France	75	Sweden	4
Germany	34	Switzerland	10
Greece	3	Taiwan	2
Hong Kong	5	Tunisia	1
Iceland	2	Turkey	1
India	14	United Kingdom	58
Italy	3	United States	1251
Japan	8	Zimbabwe	1

2.4 Demographics for Long Programs

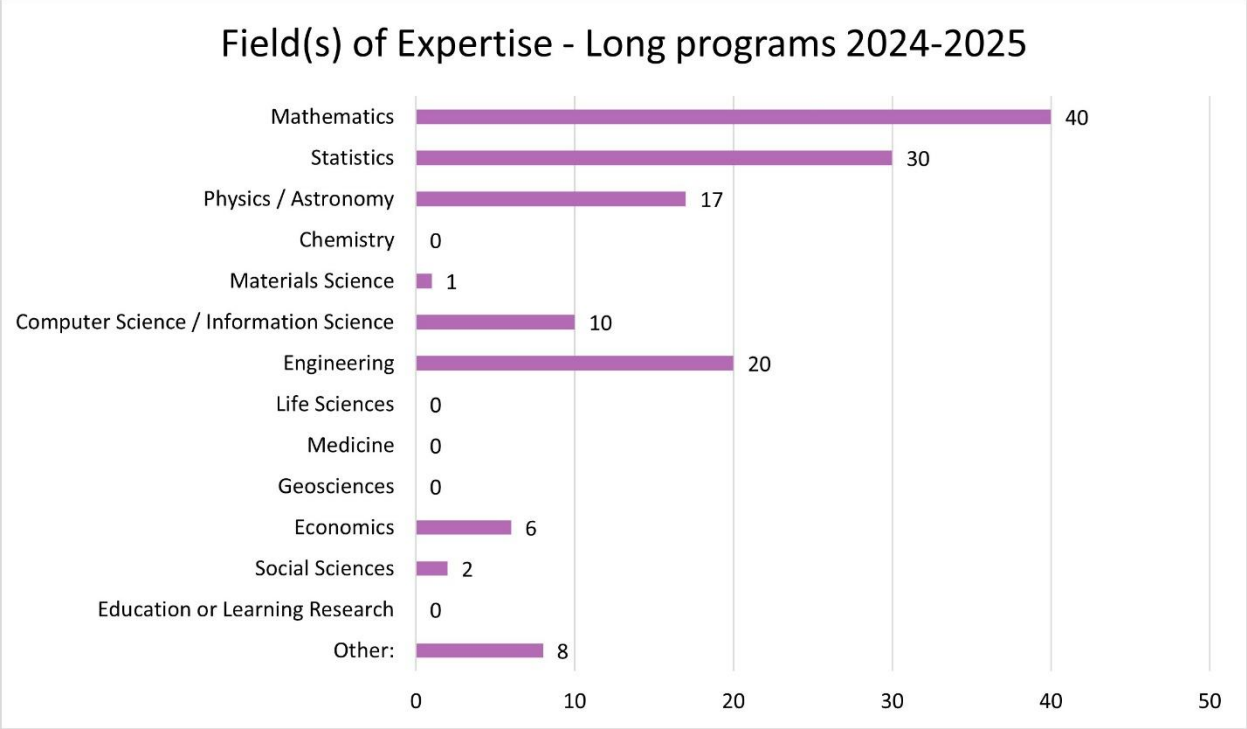
The following demographic information includes research members who were in residence during a long program.

- The Architecture of Green Energy Systems
- Statistical Methods and Mathematical Analysis for Quantum Information Science
- Uncertainty Quantification and AI for Complex Systems

Long Programs 2024-2025 - Participants by Employment/Educational Status



Long Programs 2024-2025 - Participants by Field(s) of Expertise



Note: Participants were able to indicate more than one field of expertise. Those that selected multiple fields of expertise are represented in the totals more than once.

Long Programs 2024-2025 - Participants by Employer/School Location (United States)

Long Programs 2024-2025 - Participants by Employer/School Location (United States)			
State	Number of Participants	State	Number of Participants
Alabama	0	Montana	0
Alaska	0	Nebraska	0
Arizona	0	Nevada	0
Arkansas	0	New Hampshire	1
California	4	New Jersey	0
Colorado	0	New Mexico	1
Connecticut	0	New York	5
Delaware	0	North Carolina	0
District of Columbia	0	North Dakota	0

Florida	0	Ohio	0
Georgia	2	Oklahoma	0
Hawaii	0	Oregon	0
Idaho	0	Pennsylvania	1
Illinois	12	Puerto Rico	0
Indiana	4	Rhode Island	0
Iowa	0	South Carolina	2
Kansas	0	South Dakota	0
Kentucky	0	Tennessee	0
Louisiana	0	Texas	3
Maine	0	Utah	0
Maryland	3	Vermont	0
Massachusetts	4	Virginia	4
Michigan		Washington	3
Minnesota	0	West Virginia	0
Mississippi	0	Wisconsin	8
Missouri	1	Wyoming	0

Long Programs 2024-2025 - Participants by Employer/School Location (Country)

Long Programs 2024-2025 - Participants by Employer/School Location			
Country	Number of Participants	Country	Number of Participants
Canada	4	New Zealand	1
Chile	1	Sweden	1
China	3	Switzerland	2
France	14	United Kingdom	10
Germany	1	United States	58

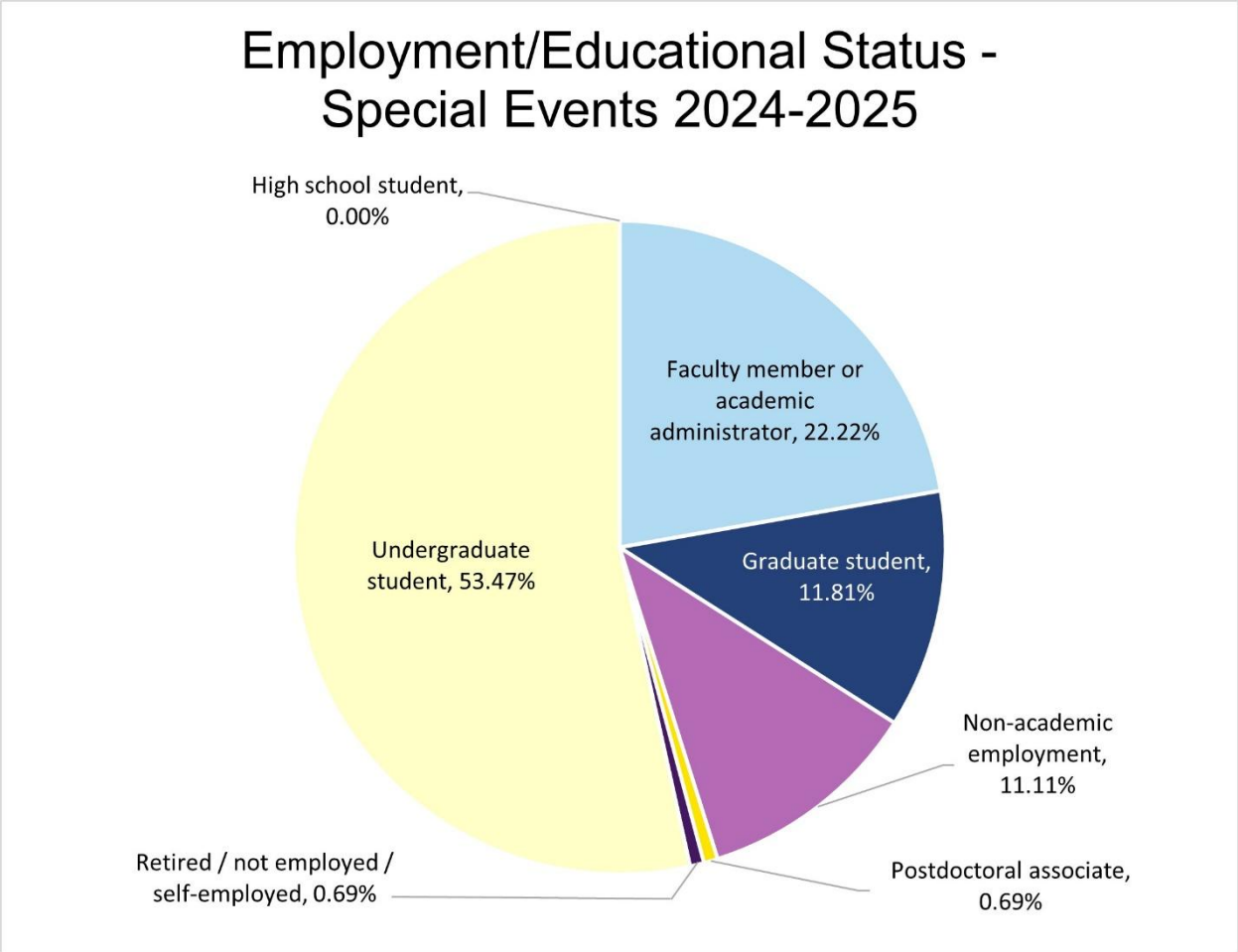
2.5 Demographics for Special Events

The following demographic information includes participants, organizers, speakers,

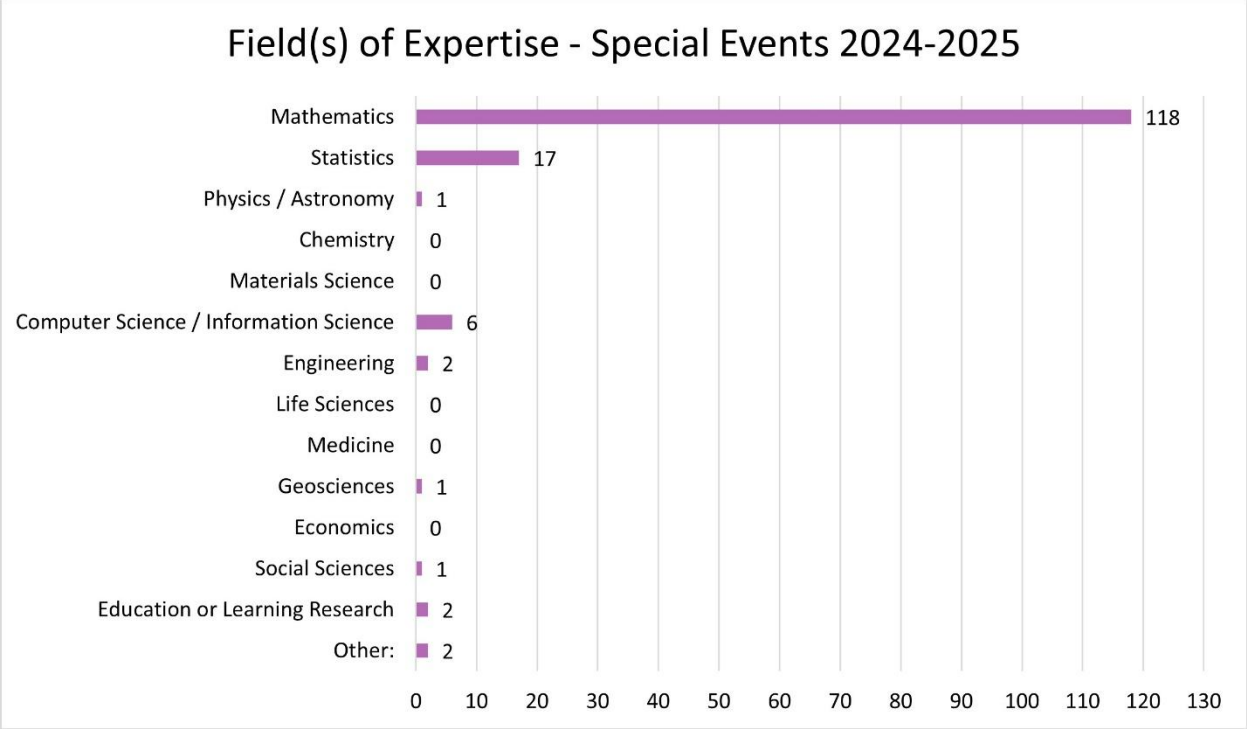
facilitators, and panelists.

- Career Paths in the Mathematical Sciences 2024
- BRING MATH: Bridges for the Next Generation: Mathematical Science Research and Our Future
- Career Paths in the Mathematical Sciences 2025

Special Events 2024-2025 - Participants by Employment/Educational Status



Special Events 2024-2025 - Participants by Field(s) of Expertise



Note: Participants were able to indicate more than one field of expertise. Those that selected multiple fields of expertise are represented in the totals more than once.

Special Events 2024-2025 - Participants by Employer/School Location (United States)

Special Events 2024-2025 - Participants by Employer/School Location (United States)			
State	Number of Participants	State	Number of Participants
Alabama	2	Montana	0
Alaska	0	Nebraska	0
Arizona	6	Nevada	0
Arkansas	3	New Hampshire	0
California	31	New Jersey	1
Colorado	2	New Mexico	5
Connecticut	0	New York	11
Delaware	0	North Carolina	9
District of Columbia	0	North Dakota	0

Florida	5	Ohio	0
Georgia	3	Oklahoma	0
Hawaii	0	Oregon	1
Idaho	1	Pennsylvania	2
Illinois	7	Puerto Rico	1
Indiana	10	Rhode Island	0
Iowa	2	South Carolina	1
Kansas	1	South Dakota	0
Kentucky	0	Tennessee	0
Louisiana	1	Texas	14
Maine	0	Utah	1
Maryland	3	Vermont	0
Massachusetts	1	Virginia	6
Michigan	0	Washington	1
Minnesota	8	West Virginia	0
Mississippi	1	Wisconsin	2
Missouri	1	Wyoming	0

3. Description of Activities

For each activity, organizers, speakers, panelists, and other presenters are listed. Full participant lists are included in an appendix.

3.1 Summer 2024 Long Program: The Architecture of Green Energy Systems

IMSI hosted a long program on *The Architecture of Green Energy Systems* from June 17 to August 23, 2024. The Long Program workshops are described in greater detail below.

This program focused on how mathematical modeling can help answer questions regarding the impact of green (low carbon) energy on society, and the ways in which financial incentives and regulations, and infrastructure changes can enhance outcomes and accelerate the transition to a green electricity system. It identified the ways in which mathematical tools can inform and shape appropriate public and private investments

and decisions, and navigate the trade-offs encountered in moving to a more sustainable economy.

The overall program consisted of an opening workshop in June that outlined the problems of interest and provided an overview of problems that require the attention of researchers. The closing workshop provided a forum to report on what has been learned, what are open questions, and what is next. Sandwiched between the opening and closing workshop was an eight-week research program. The purpose of this program was to produce ideas and research in the green energy space that address issues raised in the opening workshop and relevant topics for the architecture of green energy systems in general.

IMSI hosted 35 participants for this long program, four of whom were organizers.

Organizers	Affiliation & Department
Laura Diaz Anadon	University of Cambridge, Land Economy
Michael Ferris	University of Wisconsin, Computer Science
Dennice F. Gayme	Johns Hopkins University, Mechanical Engineering
Andy Philpott	University of Auckland, Engineering Science

Here are some quotes from the final reports of research members:

- *The program provided an exceptional platform to deepen my understanding of critical issues in green energy systems, ranging from theoretical frameworks to practical applications.*
- *I really enjoyed the 3 weeks that I spent at IMSI, one of which was the kickoff workshop week. The "long program" concept that IMSI has implemented is a great one, and a way for scholars from around the world to get together for long enough to build meaningful relationships and make progress on new research ideas.*
- *I established new collaborations that would not have occurred otherwise. It was very productive.*
- *I was extremely pleased with my ability to do meaningful work, and my exposure to new ideas and collaborations. Also, the IMSI staff are amazing!*
- *The IMSI facilities were well suited to this kind of interdisciplinary event. I enjoyed the mix of theoretical and applied talks and discussion. Listening to other's approach to problems from differing perspectives gave me insight into a number potential avenues of investigation in my own research program.*
- *I really appreciate the diversity of participants' background and the instructions on communication skills among us. This lets me actively think and improve the way I convey my research ideas to general audience.*

- *The mathematics communications workshops. And the little research group and all the inspiring and interesting discussions.*
- *A real highlight for me was the setting at the University of Chicago. It gave me a few weeks with a change of scenery to disconnect a bit from all the administrative and supervising responsibilities that I have at my home university, and spend time actually doing research and pursuing new intellectual directions. I enjoyed that quite a lot.*

The embedded workshops for the long program were as follows.

Workshop 1: The Architecture of Green Energy Systems: The Underlying Problems and Its Challenges, June 17-21, 2024

This trans-disciplinary workshop was aimed at understanding the technological, social and economic challenges of transitioning to systems that generate, deliver and consume 100% renewable energy, with a view to creating an effective physical and institutional "architecture" for this transition. Participants in the program are drawn from engineering, social sciences, economics and the mathematical sciences. The purpose of this kickoff workshop was to canvas the opinions of prominent thought leaders and researchers in renewable energy, to motivate and help shape the contents of the ensuing program. The participants shared ideas on how such systems should be designed and interact more broadly with societal needs.

The workshop was attended by 71 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Laura Diaz Anadon	University of Cambridge, Land Economy
Michael Ferris	University of Wisconsin, Computer Science
Dennice F. Gayme	Johns Hopkins University, Mechanical Engineering
Andy Philpott	University of Auckland, Engineering Science
Speakers	Affiliation & Department
Mads Almassalkhi	University of Vermont, Electrical and Biomedical Engineering
Valentina Bosetti	Università Bocconi, Economics
Michel de Lara	École des Ponts ParisTech
Shane Henderson	Cornell University, Operations Research and Information Engineering

Patrick McDaniel	University of Wisconsin, Computer Sciences
Li Na	Harvard University, Harvard John A. Paulson School of Engineering and Applied Sciences
Wei Peng	Princeton University, School of Public and International Affairs
Keywan Riahi	The International Institute for Applied Systems Analysis (IIASA)
Andy Sun	Massachusetts Institute of Technology (MIT), The Sloan School of Management
Pascal Van Hentenryck	Georgia Institute of Technology, H. Milton Stewart School of Industrial and Systems Engineering
Kommy Weldemariam	Amazon
Frank Wolak	Stanford University, Economics
Poster Presenters	Affiliation & Department
Josh Arnold	University of Wisconsin, Madison, Office of Sustainability
Beyzanur Aydin	University of Vermont, Electrical Engineering
Anaïs Berkes	University of Cambridge, Computer Science and Technology
Xin Chen	Texas A&M University, College Station, Electrical & Computer Engineering
Mazen Elsaadany	University of Vermont, Electrical Engineering
Dakota Hamilton	University of Vermont, Electrical Engineering
Jun He	Purdue University, School of Industrial Engineering
Olga Kuznetsova	Aalto University, Computer Science
Meiyi Li	University of Texas, Austin, Civil, Architectural and Environmental Engineering
Mark Noll	Northwestern University, Industrial Engineering and Management Sciences
Samuel Roa Lauby	Soil Net LLC
Hugo Santarém de Araújo	Cornell University, Civil and Environmental Engineering

Matthew Viens	University of Wisconsin, Madison, Computer Science
Shixiang Zhu	Carnegie Mellon University, Heinz College of Information Systems and Public Policy

Workshop 2: The Architecture of Green Energy Systems: Next Steps, August 19-21, 2024

This workshop brought together ideas from the long program, allowed participants to summarize results so far, prepared a summary document of progress, and built a blueprint for future collaborations and follow up mechanisms. The workshop included a panel with new invited speakers to provide independent reflections, opportunities for future funding, talks from participants, demonstrations of program tools and models, and opportunities for soapbox presentations for topics not covered in the 10-week program. A summary document detailed how green energy systems should be designed and interact more broadly with societal needs. Since the program focused on providing opportunities for researchers to collaborate on site in small groups on a number of related topics associated with green energy, participants were encouraged to prepare detailed articles on small group outcomes, and solutions generated.

The workshop was attended by 61 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Laura Diaz Anadon	University of Cambridge, Land Economy
Michael Ferris	University of Wisconsin, Computer Science
Dennice F. Gayme	Johns Hopkins University, Mechanical Engineering
Andy Philpott	University of Auckland, Engineering Science
Speakers	Affiliation & Department
Peter Cramton	University of Maryland, Economics
Richard Green	Imperial College London, Economics and Public Policy
Ben Hobbs	Johns Hopkins University, Environmental Health and Engineering
Dan Kammen	University of California, Berkeley, Energy and Resources Group
Dick O'Neill	Independent Consultant
Shmuel Oren	University of California, Berkeley, Industrial Engineering and

	Operations Research
Ramteen Sioshansi	Carnegie Mellon University, Engineering and Public Policy
Adam Wierman	California Institute of Technology, Computing and Mathematical Sciences

3.2 Fall 2024 Long Program: Statistical Methods and Mathematical Analysis for Quantum Information Science

IMSI hosted a long program on *Statistical Methods and Mathematical Analysis for Quantum Information Science* from September 16 through December 13, 2024. The Long Program workshops are described in greater detail below.

Quantum information science is a rapidly developing and broad field of research. It has made significant progress over the last decade, including the development of many promising applications such as efficient quantum computational algorithms, secure quantum communication protocols, and ultra-sensitive quantum sensors (to name just a few). Besides practical applications, quantum information science also sheds light on fundamental physics questions, including efficient descriptions of many-body systems, entanglement characterization of topological quantum systems, and quantum information scrambling of many-body systems. Novel mathematical tools and statistical models play a crucial role in investigating quantum systems. However, there are still many important open questions in quantum information science, which urgently need novel mathematical tools and statistical models. This program brought together experts with different backgrounds of mathematics, control, statistics, physics, material, and computer science, to spur transformational change in quantum information science.

IMSI hosted 24 participants for this long program, four of whom were organizers.

Organizers	Affiliation & Department
Mazyar Mirrahimi	Institut National de Recherche en Informatique et Automatique (INRIA)
Pierre Rouchon	Institut National de Recherche en Informatique et Automatique (INRIA)
Aashish Clerk	University of Chicago, The Pritzker School of Molecular Engineering
Liang Jiang	University of Chicago, The Pritzker School of Molecular Engineering

Here are some quotes from the final reports of research members:

- *I got a better understanding of the current edge of research this field focuses on, so that I can more precisely evaluate if my future research ideas can make great contributions.*

- *Some panel discussions have brought new insights to interdisciplinary research, the challenges and solutions.*
- *Got to know new people, who I have never met but heard about.*
- *Fantastic facility and staff.*

The embedded workshops for the long program were as follows.

Workshop 1: The Power of Near-Term Quantum Experiments: Algorithms, Noise, and Quantum Advantage beyond NISQ, September 16-20, 2024

We are currently in a critical period for the field of quantum computation known as the Noisy Intermediate Scale Quantum (NISQ) era, which has been marked by the first claims of experimentally implemented quantum advantage. Despite this, we do not fully understand the computational power of near-term quantum systems which are limited by uncorrected noise and relatively modest quantum resources such as number of qubits and circuit depth.

Many important questions remain: can we prove that current quantum experiments can outperform efficient classical algorithms at solving certain specific tasks? Can classical algorithms take advantage of uncorrected noise to quickly simulate near-term quantum experiments? And perhaps most pressingly, how can we mitigate the noise in quantum experiments to achieve a robust quantum computational advantage without incurring the formidable overhead of quantum error-correction? This workshop brought together researchers from a variety of perspectives — including computer scientists, physicists, and mathematicians, with the goal of answering these questions to rigorously characterize the power of near-term quantum computation.

The workshop was attended by 57 unique participants, including speakers and an organizer.

Organizer	Affiliation & Department
Bill Fefferman	University of Chicago, Computer Science
Speakers	Affiliation & Department
Shaun Datta	Stanford University, Computational & Mathematical Engineering
Abhinav Deshpande	IBM
Michael Foss-Feig	Quantinuum
Sasha Geim	Harvard University, Physics
Soumik Ghosh	University of Chicago, Computer Science
Alexey Gorshkov	University of Maryland and National Institute of Standards and

	Technology (NIST), Physics
David Gosset	University of Waterloo, Combinatorics and Optimization
Daniel Grier	University of California, San Diego (UCSD), Computer Science and Engineering and Mathematics
Jonas Helsen	Centrum Wiskunde & Informatica (CWI) Amsterdam
Marcin Kalinowski	Harvard University, Physics
Yunchao Liu	University of California, Berkeley, Electrical Engineering and Computer Sciences
Javier Martínez	École Polytechnique de Montréal, Engineering Physics
Kunal Marwaha	University of Chicago, Computer Science
Changhun Oh	Korea Advanced Institute of Science and Technology (KAIST), Physics
Yihui Quek	Massachusetts Institute of Technology (MIT), Mathematics
Adam Shaw	Stanford University, Physics
Benjamin Villalonga	Google
James Watson	University of Maryland, College Park, Computer Science

Workshop 2: Quantum Networks, September 30-October 4, 2024

Quantum cryptography has already been commercialized for urban size quantum networks. With the rapid development of quantum satellites and quantum repeaters, we expect that global-scale quantum networks will be available in the near future. Since quantum states cannot be perfectly cloned, quantum networks are fundamentally different from classical networks – for example, to overcome loss errors, we need quantum repeaters that are fundamentally different from classical repeaters. How to build an efficient, large-scale quantum network? How to characterize, optimize, and use our future quantum networks? The workshop covered robust protocols for large-scale quantum networks, conceived performance metrics, optimized quantum network architecture, and explored novel applications of quantum networks.

The workshop was attended by 55 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Sophia Economou	Virginia Polytechnic Institute & State University (Virginia Tech), Physics

Liang Jiang	University of Chicago, Pritzker School of Molecular Engineering
Filip Rozpedek	University of Massachusetts Amherst, Computer Science
Speakers	Affiliation & Department
Antonio Acin	The Institute of Photonic Sciences (ICFO)
Koji Azuma	NTT Basic Research Laboratories
Edwin Barnes	Virginia Polytechnic Institute & State University (Virginia Tech), Physics
Johannes Borregaard	Harvard University and AWS Center of Quantum Networking, Boston, Physics
Eric Chitambar	University of Illinois, Urbana-Champaign (UIUC), Electrical & Computer Engineering
Sumeet Khatri	Virginia Polytechnic Institute & State University (Virginia Tech), Computer Science
Stefan Krastanov	University of Massachusetts, Amherst, Manning College of Information & Computer Sciences
Paul Kwiat	University of Illinois, Urbana-Champaign (UIUC), Physics
Felix Leditzky	University of Illinois, Urbana-Champaign (UIUC), Mathematics
Bikun Li	University of Chicago, Pritzker School of Molecular Engineering
Narayanan Rengaswamy	University of Arizona, Electrical and Computer Engineering
Krister Shalm	National Institute of Standards and Technology (NIST)
Aziza Suleymanzade	Harvard University, Physics
Don Towsley	University of Massachusetts, Amherst, Manning College of Information & Computer Sciences
Gayane Vardoyan	University of Massachusetts, Amherst, Manning College of Information & Computer Sciences
Poster Presenters	Affiliation & Department
Nathan Arnold	University of Illinois at Urbana-Champaign, Physics
Debayan Bandyopadhyay	University of Chicago, Pritzker School of Molecular Engineering
Aparimit Chandra	University of Massachusetts Amherst, Computer Science

Xinan Chen	University of Illinois at Urbana-Champaign, Electrical & Computer Engineering
Aditya Gandotra	University of Chicago, Pritzker School of Molecular Engineering
Stav Haldar	Louisiana State University, physics and astronomy
Yuexun Huang	University of Chicago, Pritzker School of Molecular Engineering
Prateek Mantri	University of Massachusetts Amherst, Center for Quantum Networks
Xiangyi Meng	Rensselaer Polytechnic Institute, Physics, Applied Physics, and Astronomy
Maciej Ogrodnik	University of Warsaw, Quantum Photonics Laboratory
Ryosuke Shiina	University of Massachusetts Amherst, Physics
Allen Zang	University of Chicago, Pritzker School of Molecular Engineering
Guo Zheng	University of Chicago, Pritzker School of Molecular Engineering

Workshop 3: Quantum Sensing, October 14-18, 2024

Quantum sensors have already significantly revolutionized our lives, with applications including atomic clocks and global positioning systems. Distinct from classical sensors, quantum devices can achieve the more favorable Heisenberg scaling limit. In practice, however, there are imperfections, such as noise and decoherence that might potentially prevent reaching this optimal quantum behavior. What are the fundamental limits of various quantum sensors? How can we overcome practical imperfections (e.g. noise, imperfect measurement) and build robust quantum sensors? What are the novel applications of quantum sensors? This workshop brought the math and physics communities together to investigate quantum metrology and explore novel quantum sensing protocols.

The workshop was attended by 89 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Aashish Clerk	University of Chicago, Pritzker School of Molecular Engineering
Sisi Zhou	Perimeter Institute for Theoretical Physics
Speakers	**Affiliation & Department**
Ulrik Lund Andersen	Technical University of Denmark, Physics
Ania Bleszynski-	University of California, Santa Barbara (UCSB), Physics

Jayich	
Paola Cappellaro	Massachusetts Institute of Technology (MIT), Physics
Yanbei Chen	California Institute of Technology, Physics
Rafal Demkowicz-Dobrzanski	University of Warsaw, Physics
Alicja Dutkiewicz	Leiden University, Physics
Philippe Faist	Freie Universität Berlin, Physics
Andrew Jordan	Chapman University, Physics
Adam Kaufman	University of Colorado, Boulder, Physics
Mikhail Mamaev	University of Chicago, Pritzker School of Molecular Engineering
Klaus Molmer	University of Copenhagen, Niels Bohr Institute
Kater Murch	Washington University, St. Louis, Physics
Monika Schleier-Smith	Stanford University, Physics
Lorenza Viola	Dartmouth College, Physics and Astronomy
Vladan Vuletić	Massachusetts Institute of Technology (MIT), Physics
Yuxiang Yang	University of Hong Kong, Computer Science
Sisi Zhou	Perimeter Institute for Theoretical Physics
Quntao Zhuang	University of Southern California, Electrical and Computer Engineering
Poster Presenters	Affiliation & Department
Wojciech Górecki	INFN Sez. Pavia
Stanisław Kurdziałek	University of Warsaw, Quantum Imaging Lab
Lautaro Labarca	Universite de Sherbrooke, Physics
Qiushi Liu	University of Hong Kong, Computer Science

Francisco Riberi	Dartmouth College, Physics and Astronomy
Angela Riva	Institut National de Recherche en Informatique et Automatique (INRIA)
Marco Rodríguez-García	University of New Mexico, Physics and Astronomy
Yuxin Wang	University of Maryland, Joint Center for Quantum Information and Computer Science
Allen Zang	University of Chicago, Pritzker School of Molecular Engineering

Workshop 4: Quantum Hardware, October 28-31, 2024

The performance of quantum hardware still remains a major bottleneck that prevents us from benefiting from the full power of quantum computation. As we gain better control over the quantum hardware, it is crucial to use appropriate mathematical models, to systematically calibrate higher order perturbative effects, to develop robust quantum control and reservoir engineering schemes, and to improve numerical methods to reliably simulate complicated quantum systems. A major goal of this workshop was to identify the underlying challenges and develop novel mathematical tools to solve these open questions.

The workshop was attended by 86 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Jens Koch	Northwestern University, Physics and Astronomy
Ian Mondragon-Shem	Northwestern University, Physics and Astronomy
Speakers	**Affiliation & Department**
David Awschalom	University of Chicago, Physics
Hannes Bernien	University of Chicago, Pritzker School of Molecular Engineering
Ivan Deutsch	University of New Mexico, Physics
Ivana Dimitrova	Harvard University, Physics
Michael Goerz	U.S. Army Research Laboratory
Peter Groszkowski	Oak Ridge National Laboratory

Archana Kamal	Northwestern University, Physics
Angela Kou	University of Illinois at Urbana-Champaign, Physics
Daniel Lidar	University of Southern California (USC), Electrical and Computer Engineering, Chemistry, and Physics and Astronomy
Cristóbal Lledó	Université de Sherbrooke, Institut Quantique
Anja Metelmann	Karlsruhe Institute for Technology, Institute for Theoretical Condensed Matter Physics
Mazyar Mirrahimi	Institut National de Recherche en Informatique et Automatique (INRIA)
Oluwadara Ogunkoya	Fermi National Accelerator Laboratory (Fermilab), Superconducting Quantum Materials and System (SQMS) Center
Adrian Parra-Rodriguez	Consejo Superior de Investigaciones Cientificas (CSIC), Quantum Physics
Mark Saffman	University of Wisconsin, Madison, Physics
Alireza Seif	IBM Research
Aziza Suleymanzade	Harvard University, Physics
Sara Sussman	Fermi National Accelerator Laboratory (Fermilab)
Lorenza Viola	Dartmouth College, Physics and Astronomy
Poster Presenters	Affiliation & Department
Nikola Dimitrov	University of Wisconsin, Madison, Physics
Marie Frederique Dumas	Sherbrooke University, TheSQuaD
Spencer Lee	Michigan State University, Computational Mathematics, Science and Engineering
Louis Paletta	Institut National de Recherche en Informatique et Automatique (INRIA)
Angela Riva	Institut National de Recherche en Informatique et Automatique (INRIA)
Emilio Rui	Institut National de Recherche en Informatique et Automatique (INRIA)
Diego Ruiz	INRIA - Alice&Bob
Jiakai Wang	University of Wisconsin, Madison, Physics

Workshop 5: Quantum Error Correction, November 11-14, 2024

The route towards fault-tolerant quantum computation passes by quantum error correction, through which we encode the information in a redundant manner in a large Hilbert space and correct for occurring errors by continuously monitoring certain physical observables. Many experimental platforms have moved in recent years towards preparing the ground for efficient error correction. Error correction remains, however, an extremely challenging task, mainly because of large hardware overhead requirements but also because of challenging classical electronics requirements for real-time probing of error syndromes, online data processing, and error correction by feedback. This is the point where quantum error correction joins quantum control, and particularly feedback control and online parameter estimation for open quantum systems. In this regard, the workshop considered the so-called measurement-based feedback methods and autonomous feedback methods based on reservoir/dissipation engineering.

The workshop was attended by 121 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Liang Jiang	University of Chicago, Pritzker School of Molecular Engineering
Mazyar Mirrahimi	Institut National de Recherche en Informatique et Automatique (INRIA)
Pierre Rouchon	Institut National de Recherche en Informatique et Automatique (INRIA)
Speakers	**Affiliation & Department**
Benjamin Brown	IBM Quantum
Natalie Brown	Quantinuum
Margarita Davydova	California Institute of Technology, Physics
Jérémie Guillaud	Alice&Bob
Michael Gullans	University of Maryland and National Institute of Standards and Technology (NIST), Physics and Computer Science
Aleksander Kubica	Yale University, Applied Physics

Anthony Leverrier	Institut National de Recherche en Informatique et Automatique (INRIA)
Harry Putterman	AWS Center for Quantum Computing
Pedram Roushan	Google
Robert Schoelkopf	Yale University, Applied Physics
Jeff Thompson	Princeton University, Electrical and Computer Engineering
Christophe Vuillot	Institut National de Recherche en Informatique et Automatique (INRIA)
Andreas Wallraff	ETH Zurich, Physics
Chen Wang	University of Massachusetts, Amherst, Physics
Qian Xu	California Institute of Technology, Walter Burke Institute for Theoretical Physics
Ted Yoder	IBM
Beni Yoshida	Perimeter Institute for Theoretical Physics
Harry Zhou	QuEra Computing

3.3 Spring 2025 Long Program: Uncertainty Quantification and AI for Complex Systems

The field of Uncertainty Quantification (UQ) has broad applications in science and engineering, and provides a computational framework for quantifying input and response uncertainties, and making model-based predictions and their inferences. As science and technology advance, UQ problems become more complex and diverse, requiring many concepts and tools from mathematics, statistics, machine learning, optimization, and advanced computing techniques. The fast development of Artificial Intelligence (AI) has benefited many fields, including UQ. Specifically, new AI and machine learning algorithms are applied to solve larger-scale and more complicated UQ problems. UQ, together with the advancements in AI and machine learning, has the potential to drive new scientific discoveries and enable engineers to design more robust and reliable systems.

This long program focused on the newest developments in UQ methodologies and how they can improve AI systems and provide solutions to modeling complex systems. It also gave an outlook on future UQ directions and challenges. The program brought together interested parties, researchers, practitioners, and students, from different areas

of UQ, promoted communication, and further broke down barriers between disciplines. The program had a significant mentoring component, which connected researchers and students at different career stages.

IMSI hosted 34 participants for this long program, nine of whom were organizers.

Organizers	Affiliation & Department
Derek Bingham	Simon Fraser University, Statistics
Xinwei Deng	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Donald Estep	Simon Fraser University, Statistics and Actuarial Science
Robert Gramacy	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Fred Hickernell	Illinois Institute of Technology, Applied Mathematics
Roshan Joseph	Georgia Institute of Technology, Industrial and Systems Engineering
Lulu Kang	University of Massachusetts Amherst, Mathematics and Statistics
Devon Lin	Queen's University, Mathematics and Statistics
Guang Lin	Purdue University, Mathematics

Here are some quotes from the final reports of research members:

- *Some panel discussions have brought new insights to interdisciplinary research, the challenges and solutions.*
- *Got to know new people, who I have never met but heard about.*

Workshop 1: UQ and Trustworthy AI Algorithms for Complex Systems and Social Good, March 3-7, 2025

This workshop offered an overview, tutorials, and perspectives on Uncertainty Quantification (UQ) and Trustworthy AI Algorithms that are specifically designed for complex systems and social good. In particular, the workshop: 1) critically reviewed a number of important AI algorithms including deep neural networks, causal learning, generative learning frameworks, and variational algorithms, 2) explored state-of-the-art UQ methods that have incorporated the latest AI/ML algorithms in predictive modeling and analysis of complex systems such as the climate, social networks, natural disasters, advanced habitation systems, or manufacturing for space exploration, 3) discussed the ethical and explainability of AI algorithms that aim to increase their trustworthiness through transparency, fairness, and reliability, and 4) showcased real-

world case studies where UQ and trustworthy AI have been successfully implemented, e.g., climate modeling, communications and navigation, disaster and pandemic response coordination, wildlife protection, traffic management, or disease diagnosis and treatment.

The workshop was attended by 78 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Ramin Bostanabad	University of California, Irvine (UCI), Mechanical and Aerospace Engineering
Guang Lin	Purdue University, Mathematics
Natalie Elizabeth Klein	Los Alamos National Laboratory
Chih-Li Sung	Michigan State University, Statistics
Speakers	**Affiliation & Department**
Gemma Anderson	Lawrence Livermore National Laboratory
Lorena Barba	George Washington University, Mechanical and Aerospace Engineering
Alex Cannon	Environment and Climate Change Canada, Climate Research Division
Wei Chen	Northwestern University, Mechanical Engineering
Andrew Wilson	New York University, Computer Science, Mathematics
Johann Guilleminot	Duke University, Mechanical Engineering and Materials Science
Trevor Harris	University of Connecticut, Statistics
Pramod Khargonekar	University of California, Irvine (UCI), Electrical Engineering and Computer Science
Ann B Lee	Carnegie-Mellon University, Statistics and Data Science
Assad Oberai	University of Southern California (USC), Aerospace and Mechanical Engineering
Alexandros Taflanidis	University of Notre Dame, Civil and Environmental Engineering

Nathan Urban	Brookhaven National Laboratory
Danny Williamson	University of Exeter, Economics
Xianjin Yang	California Institute of Technology, Computing and Mathematical Sciences
Poster Presenters	Affiliation & Department
Teodoro Amaya	University of Notre Dame
Atlanta Chakraborty	National Renewable Energy Laboratory
Elizabeth Cucuzzella	Carnegie-Mellon University, Statistics & Data Science
Xiangrui Kong	Purdue University, Applied Mathematics
Parisa Toofani Movaghar	University of Notre Dame, Notre Dame Global Adaptation Initiative
Sang-ri Yi	University of California, Berkeley (UC Berkeley), Civil and Environmental Engineering
Zahra Zanjani Foumani	University of California, Irvine (UCI), Engineering

Workshop 2: Kernel Methods in Uncertainty Quantification and Experimental Design, March 31-April 4, 2025

This workshop focused on mathematical foundations and methodological developments in kernel methods for efficiently learning and predicting complex systems. Topics of interest encompassed probabilistic approaches to prediction, integration, optimization, approximate inference, and how these can be leveraged in the design of real and computer experiments.

The workshop was attended by 103 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Mihai Anitescu	Argonne National Laboratory
David Ginsbourger	University of Bern, Mathematics and Statistics
Fred Hickernell	Illinois Institute of Technology, Applied Mathematics
Daniel Sanz-Alonso	University of Chicago, Statistics

Dave Woods	University of Southampton, Statistics
Speakers	Affiliation & Department
Alen Alexanderian	North Carolina State University, Mathematics
Wei Chen	Northwestern University, Mechanical Engineering
Sébastien Da Veiga	ENSAI - CREST, Statistics
Matthieu Darcy	California Institute of Technology (Caltech), Computing and Mathematical Sciences
Andrew Duncan	Imperial College London, Mathematics
Roger Ghanem	University of Southern California (USC), Civil and Environmental Engineering and Aerospace and Mechanical Engineering
Robert Gramacy	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Mengyang Gu	University of California, Santa Barbara (UCSB), Statistics and Applied Probability
Roshan Joseph	Georgia Institute of Technology, H. Milton Stewart School of Industrial and Systems Engineering
Lulu Kang	University of Massachusetts Amherst, Mathematics and Statistics
Nathan Kirk	Illinois Institute of Technology, Applied Mathematics
Karina Koval	Heidelberg University, Scientific Computing and Optimization
Michael Lindsey	University of California, Berkeley (UC Berkeley), Mathematics
Simon Mak	Duke University, Statistical Science
Youssef Marzouk	Massachusetts Institute of Technology (MIT), Aeronautics and Astronautics
Natalie Maus	University of Pennsylvania, Computer and Information Science
Henry Moss	University of Cambridge and Lancaster University, Mathematical AI and Applied Mathematics and Theoretical Physics
Houman Owhadi	California Institute of Technology (Caltech), Computing and Mathematical Sciences

Mirjeta Pasha	Virginia Polytechnic Institute & State University (Virginia Tech), Mathematics
Victor Picheny	Secondmind
Clémentine Prieur	Université Grenoble Alpes, Jean Kuntzmann Laboratory
Timothy Sullivan	University of Warwick, Mathematics Institute and School of Engineering
Chih-Li Sung	Michigan State University, Statistics
Poster Presenters	Affiliation & Department
Louis Allain	Safran
Steven Barnett	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Romain Boutelet	Michigan State University, Statistics & Probability
Juan Cardenas	University of Colorado, Boulder, Aerospace Engineering Sciences
Chun-Yi Chang	Michigan State University, Statistics & Probability
Jiaheng Chen	University of Chicago, Computational and Applied Mathematics
Paula Cordero Encinar	Imperial College, Statistical Machine Learning
Thomas Cowperthwaite	University of Cambridge, Applied Mathematics
Oliver Dunbar	California Institute of Technology, Environmental Sciences and Engineering
Xinyi Fang	University of California, Santa Barbara (UCSB), Statistics and Applied Probability
Anna Flowers	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Yi-Ting Hung	Georgia State University
Ruhui Jin	University of Wisconsin, Madison, Mathematics
Aryeh Keating	Virginia Polytechnic Institute & State University (Virginia Tech), Mathematics
Hwanwoo Kim	Duke University, Statistical Science
Katherine Kreuser	Clemson University, Mathematical and Statistical Sciences
Jonghyeon Lee	California Institute of Technology, Applied Mathematics
Spencer Lee	Michigan State University, Computational Mathematics, Science and Engineering

Yizi Lin	University of California, Santa Barbara (UCSB), Statistics and Applied Probability
Chunghee Nam	Hannam University, Physics
Juan Felipe Osorio Ramirez	University of Washington, Applied Mathematics
Adrian Padilla Segarra	Onera
Parul Vijay PATIL	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Justin Reverdi	Liebherr Aerospace and IRIT laboratory
Andrew Roberts	Boston University, Computing and Data Sciences
Thomas Scott	University of Texas, Austin, Aerospace Engineering
Rudi Smith	Virginia Polytechnic Institute & State University (Virginia Tech), Mathematics
Difan Song	Georgia Institute of Technology, Industrial Engineering
Alexandra Stadler	Johannes Kepler University Linz, Applied Statistics
Tim Steinert	University of Bern, Institute of Mathematical Statistics and Actuarial Science
Shangkun Wang	Georgia Institute of Technology, Industrial and Systems Engineering
Minshen Xu	University of Massachusetts Amherst, Mathematics and Statistics
Ruiyi Yang	Princeton University, Applied & Computational Mathematics
Amin Yousefpour	University of California, Irvine (UCI), Mechanical and Aerospace Engineering

Workshop 3: Uncertainty Quantification for Material Science and Engineering, April 21-25, 2025

This workshop explored the crucial role of uncertainty quantification (UQ) in advancing materials research and development. Participants explored the unique challenges of uncertainty quantification (UQ) and machine learning in materials science, such as multi-scale modeling, energy prediction, complex material property modeling, and additive manufacturing. The workshop covered surrogate modeling techniques tailored for materials science simulations, such as Gaussian processes and neural networks and their application in optimization strategies for accelerated materials discovery. Additionally, attendees explored cutting-edge machine learning tools for materials informatics, including feature selection, dimensionality reduction, and interpretable models for scientific insights. Through interactive lectures and group discussions, participants gained practical skills in implementing UQ techniques and leveraging machine learning for material property prediction. This workshop benefited statisticians, data scientists, and applied mathematicians working on UQ for materials applications,

as well as material scientists and engineers who are interested in applying UQ methods to the materials domain. By the end, attendees were equipped with the knowledge and tools to enhance their research and stay at the forefront of materials science and engineering.

The workshop was attended by 57 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Wei Chen	SUNY Buffalo, Materials Design and Innovation
Peter Chien	University of Wisconsin, Madison, Statistics
Ying Hung	Rutgers, the State University of New Jersey, Statistics
Roshan Joseph	Georgia Institute of Technology, School of Industrial and Systems Engineering
Lulu Kang	University of Massachusetts Amherst, Mathematics and Statistics
Taylor Sparks	University of Utah, Materials Science & Engineering
Speakers	Affiliation & Department
Sterling Baird	University of Toronto, Acceleration Consortium
Wei Chen	Northwestern University, Mechanical Engineering
Aleksandr Chernatynskiy	Missouri University of Science and Technology, Physics
Kamal Choudhary	National Institute of Standards and Technology (NIST)
Ying Hung	Rutgers, the State University of New Jersey, Statistics
Surya Kalidindi	Georgia Institute of Technology, School of Mechanical Engineering
Yifan Liu	Oak Ridge National Laboratory
Noah Paulson	Argonne National Laboratory
Bruce Pitman	University at Buffalo, Materials Design and Innovation
Ralph Smith	North Carolina State University, Mathematics

Taylor Sparks	University of Utah, Materials Science & Engineering
Anh Tran	Sandia National Laboratories
Liwei Wang	Carnegie-Mellon University, Mechanical Engineering
Yan Wang	Georgia Institute of Technology, School of Mechanical Engineering
Houlong Zhuang	Arizona State University, School for Engineering of Matter, Transport and Energy
Poster Presenters	Affiliation & Department
Burak Aksoylu	Texas A&M University-San Antonio, Computational, Engineering and Mathematical Science
Yagnik Bandyopadhyay	Arizona State University, Mechanical Engineering
Luke Bodmer	SUNY Buffalo, Computational and Data Enabled Sciences
Tyler Johnson	University of California, Irvine (UCI), Mechanical Engineering
Katherine Kreuser	Clemson University, Mathematical and Statistical Sciences
Jose Morales Escalante	University of Texas, San Antonio, Applied Mathematics
Nima Negarandeh	University of California, Irvine (UCI), Probabilistic Modeling and Analysis of Complex Systems Laboratory
Kexin Xie	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Minshen Xu	University of Massachusetts Amherst, Mathematics and Statistics
Lightning Talk Presenters	Affiliation & Department
Whitney Huang	Clemson University, Mathematical and Statistical Sciences
Hwanwoo Kim	Duke University, Statistical Science
John Fritz	University of Tennessee Knoxville, Civil and Environmental Engineering
Xiao Nie	The Vanguard Group

Workshop 4: Uncertainty Quantification and Machine Learning for Complex Physical Systems, May 19-23, 2025

This workshop explored the intersection of uncertainty quantification (UQ) and machine learning (ML) in modeling and analyzing intricate physical phenomena. Participants examined the challenges of quantifying uncertainties in complex systems across various

scientific and engineering domains. The workshop covered advanced UQ techniques, including Bayesian inference, sensitivity analysis, and probabilistic modeling, tailored for complex physical systems. Attendees delved into cutting-edge machine learning approaches, such as physics-informed neural networks, deep learning for differential equations, and transfer learning, applied to physical system modeling. The workshop emphasized the synergy between UQ and ML, while exploring how these fields can complement each other to enhance prediction accuracy and reliability in complex systems. Through interactive lectures and group discussions, participants gained insights into implementing these methods in their research or industrial applications. This workshop was designed for researchers, engineers, and data scientists working with complex physical systems in fields such as fluid dynamics, climate modeling, aerospace engineering, and beyond. Attendees left equipped with state-of-the-art knowledge to tackle uncertainty and complexity in their respective domains.

The workshop was attended by 92 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Robert Gramacy	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Xiao Liu	Georgia Institute of Technology, School of Industrial and Systems Engineering
Simon Mak	Duke University, Statistics
Matthew Pratola	Indiana University Bloomington, Statistics
Qiong Zhang	Clemson University, Mathematical and Statistical Sciences
Speakers	Affiliation & Department
Annie Booth	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Amy Braverman	Jet Propulsion Laboratory
Andrew Brown	Clemson University, Mathematical and Statistical Sciences
Po-Wen Chang	Lawrence Berkeley National Laboratory
Peter Chien	University of Wisconsin, Madison, Statistics
Tiangang Cui	University of Sydney, School of Mathematics and Statistics

Gwendolyn Eadie	University of Toronto, Astronomy & Astrophysics and Statistical Sciences
Leanna House	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Ying Hung	Rutgers, the State University of New Jersey, Statistics
Youngdeok Hwang	CUNY Bernard M. Baruch College, Information Systems and Statistics
Irene Ji	JMP Statistical Discovery LLC
Emily Kang	University of Cincinnati, Mathematics
Matthias Katzfuss	University of Wisconsin, Madison, Statistics
Yiping Lu	Northwestern University, Industrial Engineering and Management Sciences
Wei Xie	Northeastern University, Mechanical and Industrial Engineering
Poster Presenters	Affiliation & Department
Nazanin Ahmadi Daryakenari	Brown University, Biomedical Engineering
Sandra Babyale	Boise State University, Computing
Rileigh Bandy	Sandia National Laboratories
Alejandro Calle-Saldarriaga	University of Wisconsin, Madison, Statistics
James Carzon	Carnegie Mellon University, Statistics
Kangan Chen	University of Wisconsin, Madison, Industrial Engineering
Shuyi Chen	Carnegie Mellon University, Information Systems and Public Policy
Changqing Cheng	Binghamton University, Systems Science and Industrial Engineering
Shirin Hosseinmardi	University of California, Irvine (UCI), Probabilistic Modeling and Analysis of Complex Systems Laboratory
Anastasia Istratuca	University of Edinburgh, Computational and Applied Mathematics
Hwanwoo Kim	Duke University, Statistical Science
Katherine Kreuser	Clemson University, Mathematical and Statistical Sciences
Yen-Chun Liu	Duke University, Statistical Science

Reetam Majumder	University of Arkansas, Fayetteville, Mathematical Sciences
Amirhossein Mollaali	Purdue University, Mechanical Engineering
Haiyi Shi	Simon Fraser University, Statistics
Colby Stakun-Pickering	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Sifan Tao	University of Wisconsin, Madison
Nathan Waniorek	University of Chicago, Statistics
Ruihan Xu	University of Chicago, Computational and Applied Mathematics
Hao Yan	Arizona State University, Biodesign Center for Molecular Design and Biomimetics

3.4 Short Research Events

IMSI held 12 short research events during the reporting period which were outside the framework of long programs. These are described in this section.

Mathematical and Statistical Foundations of Digital Twins, June 26-28, 2024

IMSI hosted the workshop *Mathematical and Statistical Foundations of Digital Twins*, June 26-28, 2024.

A digital twin (DT) is a computational model that evolves over time to persistently represent the structure, behavior, and context of a unique physical system or process. DTs are characterized by a dynamic and continuous two-way flow of information between the computational model and the physical system. Data streams from the physical system are assimilated into the computational model to reduce uncertainties and improve predictions of the model, which in turn is used as a basis for controlling the physical system, optimizing data acquisition, and providing decision support. The DT must execute rapidly enough to support decisions and controls in time scales relevant to the physical system, and must manage and quantify uncertainties across its lifecycle. Interest in the DT paradigm is growing rapidly across a range of application areas as a way to construct, manage, and capitalize on state-of-the-art computational models, data-driven learning, and decision making under uncertainty for many complex engineered and natural systems. Indeed, the global market for DTs in industry alone is projected to grow to $156 billion by 2030.

This workshop focused on mathematical, statistical, and computational foundations underlying DTs, in particular addressing challenges in (1) data assimilation and statistical inverse problems, (2) optimal control and decision making, (3) optimal experimental design, and (4) model reduction and surrogates, all in the context of DTs of complex systems. While these fields are “classical,” fundamental challenges arise in the DT setting due to the tight, dynamic interplay between assimilation and

control/decisions, the rapid time scales needed for response, the need for predictivity of reduced models/surrogates over control and parameter spaces, and the need for robustness to data and model uncertainties to support high-consequence decisions.

These present frontier mathematical, statistical, and computational challenges. The workshop featured talks and discussion on the four foundational areas identified above, and on the integration of these to address complex applications of DTs to scientific, engineering, medical, and societal problems.

This workshop had 80 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Omar Ghattas	The University of Texas, Austin, Oden Institute and Mechanical Engineering
Youssef Marzouk	Massachusetts Institute of Technology (MIT), Aeronautics and Astronautics
Claudia Schillings	Freie Universität Berlin, Mathematics & Computer Science
Irina Tezaur	Sandia National Laboratories
Speakers	**Affiliation & Department**
Marc Bocquet	École des Ponts ParisTech
Matthias Heinkenschloss	Rice University, Computational Applied Mathematics & Operations Research
Xun Huan	University of Michigan, Mechanical Engineering
Benjamin Peherstorfer	New York University, Courant Institute of Mathematical Sciences
Sebastian Reich	Universität Potsdam, Institute of Mathematics
Johannes Royset	University of Southern California, Industrial and Systems Engineering
Daniel Sanz-Alonso	University of Chicago, Statistics
Karen Veroy-Grepl	Eindhoven University of Technology, Mathematics and Computer Science
Yunan Yang	Cornell University, Mathematics

Participant comments on the workshop included the following:

- *While I work in an adjacent area (Operations Research, Sequential Decision Making), I belong to a different community. Therefore it was nice to see similar topics as I study approached from a slightly different perspective. I learned some-*

thing new from each talk, and therefore I particularly enjoyed fewer and longer talks so the speakers could go through the basics and not directly rush into their results.

- *Vibrant community and good connections.*
- *Digital twins are an important emerging field.*
- *We need more such workshops that bring people from different fields together!*
- *As an outsider I got a lot of value from the overview nature of this workshop. I assume the next workshops will be more focused, but it would be good to get some talks from industry/practitioners about the open problems they see where new theory could contribute*.

Two-Dimensional Random Geometry, July 8-12, 2024

IMSI hosted the workshop, *Two-Dimensional Random Geometry*, July 8-12, 2024.

This workshop focused on random geometric objects whose definitions are motivated by theoretical physics. In many cases, these objects are known or expected to describe the large-scale behavior of natural discrete random objects. Some of the most important examples are the following.

Schramm-Loewner evolution (SLE): random fractal curves which describe the large-scale behavior of discrete random curves which arise in statistical mechanics. For example, if one considers the critical Ising model on the square grid, then re-scales so that the size of the squares goes to zero, the interfaces between regions of positive and negative spin will converge to SLE_3 curves.

Liouville quantum gravity (LQG): random fractal surfaces which are connected to string theory and conformal field theory. These surfaces describe the large-scale behavior of random planar maps. For example, uniform random triangulations of the sphere converge, in a certain sense, to $\sqrt{8/3}$-LQG as the number of triangles tends to infinity.

There have been a huge number of exciting mathematical developments in this subject in recent years. Such developments include rigorous proofs of results which were originally justified heuristically in the physics literature, proofs of new results which were not predicted by physicists, and applications to new and unexpected topics. These developments have opened up an abundance of interesting research directions.

This workshop had 69 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Ewain Gwynne	University of Chicago, Mathematics
Nina Holden	New York University, Courant Institute of Mathematical Sciences

Xin Sun	University of Pennsylvania, Mathematics
Speakers	Affiliation & Department
Tom Alberts	University of Utah, Mathematics
Morris Ang	University of California San Diego, Mathematics
Jacopo Borga	Stanford University, Mathematics
Ahmed Bou-Rabee	New York University, Courant Institute of Mathematical Sciences
Timothy Budd	Radboud University, Physics
Thomas Budzinski	École normale supérieure de Lyon, Centre National de la Recherche Scientifique (CNRS), Mathematics
Dmitry Chelkak	University of Michigan, Mathematics
Nicolas Curien	Université Paris-Saclay, Mathematics
William Da Silva	University of Vienna, Mathematics
Bertrand Duplantier	Commissariat à L'Energie Atomique et aux energies alternatives (CEA) - Saclay
Janne Junnila	University of Helsinki, Mathematics and Statistics
Konstantinos Kavvadias	Massachusetts Institute of Technology (MIT), Mathematics
Greg Lawler	University of Chicago, Mathematics
Xinyi Li	Peking University, Beijing International Center for Mathematical Research
Jiaqi Liu	University of Pennsylvania, Mathematics
Gregory Miermont	École normale supérieure de Lyon
Minjae Park	University of Chicago, Mathematics
Eero Saksman	University of Helsinki, Mathematics and Statistics
Lukas Schoug	University of Helsinki, Mathematics and Statistics
Scott Sheffield	Massachusetts Institute of Technology (MIT), Mathematics
Karl-Theodor Sturm	University of Bonn, Institute of Applied Mathematics

Jinwoo Sung	University of Chicago, Mathematics
Zijie Zhuang	University of Pennsylvania, Statistics and Data Science
Poster Presenters	Affiliation & Department
Daniel Amankwah	University of Iceland, Mathematics
Gefei Cai	Peking University, Beijing International Center for Mathematical Research
Alicia Castro	University of Bordeaux, Combinatorics and Algorithms
Pranav Chinmay	CUNY Graduate Center, Mathematics
Matteo D'Achille	Université Paris-Sud (Orsay), The Orsay Institute of Mathematics
Xingjian Di	New York University Shanghai, Mathematics
Shuo Fan	Tsinghua University, Mathematical Sciences
Tomislav Kralj	University of Zagreb, Mathematics
Andrew Lin	Stanford University, Mathematics
Haoyu Liu	Peking University, Mathematics
Bart Zonneveld	Radboud University, Physics

Participant comments on the workshop included the following:

- *Feeling a strong, supportive community that takes all presentations seriously and engages vibrantly in discussions.*
- *The informal discussions between the presentations.*
- *The social events, including the poster session and the meals, were particularly great.*
- *I had lots of questions that I wanted to ask various people who attended the workshop, and I was able to get answers to almost all of them. I also had a chance to popularize some open problems that I came across in my own research.*
- *Being the first conference that I've attended, it was great to see how many problems and ongoing ideas many of the top researchers in the field always had on their mind (and how well everyone could communicate and share them).*

AI+Science Summer School, July 15-19, 2024

The AI + Science summer school was jointly sponsored by IMSI and the Data Science Institute (DSI) at the University of Chicago. It was hosted in IMSI space and applications were managed through IMSI's website. It focused on four core themes at the heart of this emerging paradigm of scientific discovery: 1) AI uncovering new laws of nature, 2) AI guiding scientific measurement, 3) physics-informed machine learning, and 4) scientific discovery advancing AI frontiers.

Organizers	Affiliation & Department
Simona Ahmed	University of Chicago, Data Science Institute
Anthony Badea	University of Chicago, Physics
Ritesh Kumar	University of Chicago, Data Science Institute
Peter Lu	University of Chicago, Data Science Institute
Mark Schulze	University of Chicago, Data Science Institute
Yihang Wang	University of Chicago, Chicago Center for Theoretical Chemistry
Rebecca Willett	University of Chicago, Computer Science and Statistics
Speakers	**Affiliation & Department**
Muratahan Aykol	Google DeepMind
Chihway Chang	University of Chicago, Astronomy and Astrophysics
Pedram Hassanzadeh	University of Chicago, Geophysical Sciences
Daniel Schwalbe-Koda	University of California, Los Angeles (UCLA), Materials Science and Engineering
Srijit Seal	Massachusetts Institute of Technology (MIT) and Harvard University, Broad Institute
Sunganya Sivagurunathan	Massachusetts Institute of Technology (MIT) and Harvard University, Broad Institute
Tess Smidt	Massachusetts Institute of Technology (MIT), Electrical Engineering and Computer Science
Nhan Tran	Fermilab
Zachary Ulissi	Carnegie Mellon University, Chemical Engineering

Interdisciplinary Research Cluster: Exploring shifts in biogeochemical cycles and mass extinction events through slow-fast dynamical systems, August 5-14, 2024

IMSI hosted the Interdisciplinary Research Cluster (IRC), *Exploring shifts in biogeochemical cycles and mass extinction events through slow-fast dynamical systems*, August 5-14, 2024.

Through data analysis and modeling, this IRC established a connection between substantial shifts in biogeochemical cycles and mass extinction events. The challenge is in reconciling the "fast" ecological timescales, typically ranging from 1 to 100 years, with the "slow" timescale of global biogeochemical cycles, which operate on the order of 10,000 years or more. The temporal discord between ecological dynamics and climate systems, influenced by feedback loops, necessitates the development of a mathematical framework for studying (paleo)climate tipping points related to mass extinction events. This framework specifically addresses the dynamics of "slow-fast" systems. This project was a continuation of the research conducted in the previous IRC Climate Tipping Phenomena in Non-autonomous Paleoecosystems and involves collaboration across the Mathematics of Mass Extinctions Network.

This IRC had 8 unique participants.

Participant comments on the IRC included the following:

- *The most valuable aspects of my visit to IMSI were the opportunity to reconnect and collaborate with the same group we worked with last year, which allowed us to build on our previous progress, and the access to robust computational resources that significantly enhanced our ability to analyze complex data sets.*
- *Working within a cross-disciplinary team of paleontologists, geologists, earth scientists, physicists, statisticians and mathematicians has been a wonderful learning experience. While each of us had particular sub-objectives that we were focused on, it was nice to get input from this diverse group and to contribute our expertise and perspectives to the overall goals of the working group.*

Computational Imaging, August 5-9, 2024

IMSI hosted the workshop, *Computational Imaging*, on August 5-9, 2024.

This workshop served as a venue for presenting and discussing recent advances and trends in the growing field of computational imaging, which involves imaging systems within which computation is a major component. The scope included research on all aspects of the computational imaging pipeline from data acquisition (including non-traditional sensing methods) to system modeling and optimization to image reconstruction, processing, and analytics, with talks addressing theory, algorithms and mathematical techniques, and computational hardware approaches. The range of applications was broad, including biomedical, industrial, and scientific imaging, and novel and extreme imaging systems. Given the rapidly growing interest in data-driven, machine learning, and large-scale learning and optimization-based methods in

computational imaging, the workshop had major focus on some of the key recent and new theoretical, algorithmic, and hardware (for efficient/optimized computation) developments and challenges in these areas.

This workshop had 119 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Ulugbek Kamilov	Washington University in St. Louis, Electrical and Systems Engineering
Qing Qu	University of Michigan, Electrical Engineering and Computer Science
Saiprasad Ravishankar	Michigan State University, Computational Mathematics, Science and Engineering
Rebecca Willett	University of Chicago, Statistics and Computer Science
Brendt Wohlberg	Los Alamos National Laboratory
Jong Chul Ye	Korea Advanced Institute of Science and Technology (KAIST), Kim Jaechul Graduate School of Artificial Intelligence
Speakers	Affiliation & Department
Fauzia Ahmad	Temple University, Electrical and Computer Engineering
Henry Arguello	Universidad Industrial de Santander, Computer Science
Charles Bouman	Purdue University, Electrical and Computer Engineering and Biomedical Engineering
Greg Buzzard	Purdue University, Electrical and Computer Engineering
Müjdat Çetin	University of Rochester, Electrical and Computer Engineering and Computer Science
Stanley Chan	Purdue University, Electrical and Computer Engineering and Statistics
Dongdong Chen	Heriot-Watt University, Mathematical and Computer Sciences
Se Young Chun	Seoul National University, Electrical and Computer Engineering
Jeffrey Fessler	University of Michigan, Electrical Engineering and Computer Science
Alessandro Foi	Tampere University, Information Technology and Communication Sciences
Sara Fridovich-Keil	Stanford University, Electrical Engineering
Sergio Goma	Qualcomm Technologies Inc

Vivek Goyal	Boston University, Electrical and Computer Engineering
Reinhard Heckel	Technical University of Munich (TUM), Computer Engineering
Kyong Hwan Jin	Korea University, Electrical Engineering
David Lindell	University of Toronto, Computer Science
Miki Lustig	University of California, Berkeley, Electrical Engineering and Computer Sciences
Daniel McKenzie	Colorado School of Mines, Applied Mathematics and Statistics
Saiprasad Ravishankar	Michigan State University, Computational Mathematics, Science and Engineering
Yu Sun	California Institute of Technology, Computing and Mathematical Sciences
Sabine Süsstrunk	École Polytechnique Fédérale de Lausanne (EPFL), Computer Science
Ashok Veeraraghavan	Rice University, Electrical and Computer Engineering
Laura Waller	University of California, Berkeley, Electrical Engineering and Computer Sciences
Brendt Wohlberg	Los Alamos National Laboratory
Zhizhen Zhao	University of Illinois, Urbana-Champaign, Electrical and Computer Engineering
Poster Presenters	Affiliation & Department
Akshay Agarwal	Boston University, Electrical Engineering and Computer Science
Weimin Bai	Peking University, Academy for Advanced Studies
Vasileios Charisopoulos	University of Chicago, Data Science Institute
Nicholas Chimitt	Purdue University, Intelligent Imaging Lab
Pierre-Antoine Comby	Université Paris-Sud (Orsay), Neurospin
Timofey Efimov	Carnegie-Mellon University, Computer Science
Zhenghan Fang	Johns Hopkins University, Biomedical Engineering

Lanlan Feng	University of Electronic Science and Technology of China
Nick Feng	New York University, Electrical and Computer Engineering
Berthy Feng	California Institute of Technology, Computing & Mathematical Sciences
Weijie Gan	Washington University in St. Louis, Computer Science and Engineering
Siddhant Gautam	Michigan State University, Computational Mathematics Science and Engineering
Tao Hong	University of Michigan, Functional MRI Lab
Jason Hu	University of Michigan, Electrical and Computer Engineering
Yixuan Jia	University of Michigan, Electrical and Computer Engineering
Brandon Knutson	Colorado School of Mines, Applied Mathematics
Aline Kotoski	Georgia State University, Neuroscience
Xiang Li	University of Michigan, Electrical and Computer Engineering
Rodrigo Lobos	University of Michigan, Biomedical Engineering
Owen Melia	University of Chicago, Computer Science
Shambel Mengistu	Cafoscari University of Venice, Environmental Sciences, Informatics and Statistics
Chicago Park	Washington University in St. Louis, Computer Science
Saiprasad Ravishankar	Michigan State University, Computational Mathematics
Kaustubh Sadekar	Portland State University, Computer Science
Masoud Seraji	Georgia State University, Computer Science
Liyue Shen	University of Michigan, Electrical Engineering and Computer Science
Joseph Shenouda	University of Wisconsin, Madison, Electrical and Computer Engineering
Shirin Shoushtari	Washington University in St. Louis, Electrical and Systems Engineering

Kenneth Sun	University of Michigan, Mathematics
Sergio Urrea	Universidad Industrial de Santander, Electrical and Electronic Engineering
Yuanhao Wang	Washington University in St. Louis, Engineering
Hashan Weerasooriya	Purdue University, Electrical and Computer Engineering
Zhijun Zeng	Tsinghua University, Mathematical Sciences
Weijian Zhang	Purdue University, Electrical and Computer Engineering

Participant comments on the workshop included the following:

- *I enjoyed getting to know my peers and all the professors working in the same field as me. Similarly, I was able to discuss the research my peers have been doing and make professional connections with the professors.*
- *There was enough breathing room in the schedule that I was able to have substantive conversations with colleagues, not only about science but also about key questions about career development.*
- *I am impressed with the plethora of field experts invited to this conference, and how diverse are the topics discussed. I especially loved the panel discussion, which distinguishes itself from other more formulaic ones, but still established wide consensus among the participants and brought out key takeaways.*
- *The environment created for social interactions was a high point of the workshop. Besides this, the technical content was diverse enough to capture the powerful impact computational imaging can have in different applications.*
- *As a newcomer to this ever-changing field, I was not familiar with a lot of the technical details, or the different directions people are heading towards. However, through this workshop, I realized how there are more similarities than differences between topics and modalities, so the key skills and insights are transferable.*

Challenges in Neuroimaging Data Analysis, August 26-30, 2024

IMSI hosted the workshop, *Challenges in Neuroimaging Data Analysis*, August 26-30, 2024.

Neuroimaging involves generating images of the central nervous system to understand its structure, function, or pharmacology. The field is rapidly evolving, with new techniques emerging for data acquisition and advanced statistical learning methods being developed for data analysis. Recently, there's been a surge in collecting neuroimaging data across healthcare, research, and clinical trials. Such imaging aids in

diagnosing and prognosing brain diseases, like multiple sclerosis, dementia, and schizophrenia. It helps identify issues such as strokes, tumors, and brain swelling.

Current applications, like MRI for multiple sclerosis monitoring, still present opportunities for enhanced statistical modeling. Large biomedical studies gather extensive neuroimaging data, including sMRI, DWI, and fMRI. These studies target the human brain's connectivity, understanding brain disorders, monitoring neuropsychiatric progression, and diagnosing brain cancer. The influx of data can significantly enhance our comprehension of the brain and help in creating effective treatments for neurological and psychiatric conditions. However, analyzing this data necessitates the progression of statistical learning techniques, encompassing image processing and population-based statistical evaluations. While topics like image enhancement and predictive models are of interest, the growth in statistical analysis lags behind neuroimaging advancements, challenging the application of research in clinical settings.

This workshop provided a comprehensive discussion of mathematical and statistical challenges in neuroimaging data analysis from neuroimaging techniques to large-scale neuroimaging studies to statistical learning methods. This research topic remains important and timely to ensure that researchers are equipped with the tools and methods needed to handle the large and complex datasets and to produce reliable and reproducible research findings.

This workshop had 108 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Jian Kang	University of Michigan, Biostatistics
John Kornak	University of California, San Francisco, Epidemiology and Biostatistics
Thomas Nichols	University of Oxford, Nuffield Department of Population Health
Hernando Ombao	King Abdullah University of Science and Technology (KAUST), Statistics
Sean Simpson	Wake Forest University School of Medicine, Biostatistics and Data Science
Anuj Srivastava	Florida State University, Statistics
Tingting Zhang	University of Pittsburgh, Statistics
Hongtu Zhu	University of North Carolina Chapel Hill, Biostatistics
Speakers	Affiliation & Department
Markus Axer	Forschungszentrum Jülich (FZJ), Institute of Neurosciences and Medicine

Sumanta Basu	Cornell University, Statistics and Data Science
Maxime Descoteaux	Université de Sherbrooke, Computer Science
Ani Eloyan	Brown University, Biostatistics
Jianfeng Feng	University of Warwick, Computer Science
Mark Fiecas	University of Minnesota, Twin Cities, Biostatistics
Tanya Garcia	University of North Carolina Chapel Hill, Biostatistics
Sharmistha Guha	Texas A&M University, College Station, Statistics
Jaroslaw Harezlak	Indiana University Bloomington, Epidemiology and Biostatistics
Fei Jiang	University of California, San Francisco, Epidemiology and Biostatistics
Timothy Johnson	University of Michigan, Biostatistics
Jian Kang	University of Michigan, Biostatistics
Robert Kass	Carnegie Mellon University, Statistics and Data Science
Linglong Kong	University of Alberta, Mathematical and Statistical Sciences
John Kornak	University of California, San Francisco, Epidemiology and Biostatistics
Liza Levina	University of Michigan, Statistics
Lexin Li	University of California, Berkeley, Biostatistics and Epidemiology
Tengfei Li	University of North Carolina Chapel Hill, Radiology
Martin Lindquist	Johns Hopkins University, Biostatistics
Xi (Rossi) Luo	University of Texas Health Science Center and Texas Heart Institute, Biostatistics and Data Science
Tianwen Ma	Emory University Rollins School of Public Health, Biostatistics and Bioinformatics
L. Mahadevan	Harvard University, Physics
Amanda Mejia	Indiana University Bloomington, Statistics
Thomas Nichols	University of Oxford, Nuffield Department of Population Health
Lauren O’Donnell	Harvard Medical School and Brigham and Women’s Hospital,

	Radiology
Hernando Ombao	King Abdullah University of Science and Technology (KAUST), Statistics
Hanchuan Peng	Institute for Brain and Intelligence
Xavier Pennec	Institut National de Recherche en Informatique et Automatique (INRIA)
Daniel Rowe	Marquette University, Mathematical and Statistical Sciences
Heather Shappell	Wake Forest University, Biostatistics and Data Science
Li Shen	University of Pennsylvania, Biostatistics, Epidemiology and Informatics
Ali Shojaie	University of Washington, Biostatistics
Hai Shu	New York University, Biostatistics
Sean Simpson	Wake Forest University School of Medicine, Biostatistics and Data Science
Anuj Srivastava	Florida State University, Statistics
Wesley Thompson	Laureate Institute for Brain Research
Duygu Tosun-Turgut	University of California, San Francisco, Biostatistics, Epidemiology and Informatics
Dana Tudorascu	University of Pittsburgh, Psychiatry
Marina Vannucci	Rice University, Statistics
Yu-Ping Wang	Tulane University, Biomedical Engineering
Carl Yang	Emory University, Computer Science
Laurent Younes	Johns Hopkins University, Applied Mathematics and Statistics
Tingting Zhang	University of Pittsburgh, Statistics
Zhengwu Zhang	University of North Carolina Chapel Hill, Statistics and Operations Research
Bingxin Zhao	University of Pennsylvania, Statistics and Data Science
Yi Zhao	Indiana University, Biostatistics and Health Data Science
Yize Zhao	Yale University, Biostatistics

Hongtu Zhu	University of North Carolina Chapel Hill, Biostatistics
Poster Presenters	Affiliation & Department
Konstantinos Bakas	King Abdullah University of Science and Technology (KAUST), Statistics
Benjamin Beaudett	Florida State University, Statistics
Zhiling Gu	Iowa State University, Statistics
Huaqing Jin	University of California, San Francisco (UCSF), Epidemiology & Biostatistics
Athanasia Kalogirou	Athens University of Economics and Business, Statistics
Angelina Kancheva	University of Glasgow, Medicine
Younghoon Kim	Cornell University, Statistics and Data Science
Xinyi Li	Clemson University, Mathematical and Statistical Sciences
Ha Nguyen	Cornell University, Statistics
Ruyi Pan	University of Toronto, Statistical Science
Joshua Rutsohn	University of North Carolina Chapel Hill, Biostatistics
Roddy Taing	University of Wisconsin, Madison, Statistics
Bernd Taschler	University of Oxford, Clinical Neurosciences

Participant comments on the workshop included the following:

- *My favorite experience of the workshop was the opportunity to engage with and learn from highly knowledgeable speakers and panelists. Their insights were incredibly enriching and provided valuable perspectives that deepened my understanding of the field.*
- *I loved the networking opportunities. As a junior faculty member, it was great to discuss research with some of the more renowned scientists that I look up to.*
- *Small workshop size; opportunity to meet and chat with world experts in the field; food provided on the side to save time for more discussions; helpful staff, and convenient location next to the hotel.*
- *Multidisciplinary collaborations between mathematicians/statisticians and neuroscientists can lead to impactful research in the neuroimaging community.*

- *IMSI is an outstanding venue for hosting workshops, offering both convenience and an ideal setting for productive gatherings. The workshop facilities are well-equipped and thoughtfully designed to accommodate a variety of needs, ensuring that all sessions run smoothly. Attendees greatly appreciated the opportunity to connect and engage in meaningful discussions with experts in the field, fostering a collaborative and intellectually stimulating environment. The atmosphere at IMSI not only supports but enhances the overall experience, making it a top choice for workshops that prioritize both content and participant interaction.*

Mathematical Modeling of Biological Interfacial Phenomena, December 9-13, 2024

IMSI hosted the workshop, *Mathematical Modeling of Biological Interfacial Phenomena*, December 9-13, 2024.

Interfacial phenomena can be observed in many fields and across vastly different scales, such invading population of species in a shifting climate, the geographical spread of epidemic infections, the growth of cancer tumors at the cellular level, and the propagation of electric signals in neuroscience. This workshop focused on interfacial phenomena and emphasized the role of analysis of partial differential equations in understanding them. Students and researchers were exposed to challenging problems in the fields of biology and life sciences and the development of new mathematical frameworks to advance current understanding.

This workshop had 64 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Bei Hu	University of Notre Dame, Applied and Computational Mathematics and Statistics
Adrian Lam	The Ohio State University, Mathematics
Benoît Perthame	Sorbonne Université, Laboratoire Jacques-Louis Lions (LJLL)
Speakers	Affiliation & Department
Jing An	Duke University, Mathematics
Montie Avery	Boston University, Mathematics and Statistics
Vincent Calvez	Centre National de la Recherche Scientifique (CNRS)
Noemi David	Université de Rouen, Mathematics
Anna Ghazaryan	Miami University, Mathematics

Chris Henderson	University of Arizona, Mathematics
Matt Holzer	George Mason University, Mathematical Sciences
Pierre-Emmanuel Jabin	Pennsylvania State University, Mathematics
Inwon Kim	University of California, Los Angeles (UCLA), Mathematics
Jian-Guo Liu	Duke University, Mathematics
Idriss Mazari-Fouquer	Université Paris Dauphine
Antoine Mellet	University of Maryland, Mathematics
Yoichiro Mori	University of Pennsylvania, Mathematics
Mariya Ptashnyk	Heriot-Watt University, Mathematics
Lenya Ryzhik	Stanford University, Mathematics
Rachidi Salako	University of Nevada, Las Vegas, Mathematical Sciences
Delphine Salort	Sorbonne Université, Biologie computationnelle et quantitative (LCQB)
Luis Silvestre	University of Chicago, Mathematics
Min Tang	Shanghai Jiaotong University, Institute of Natural Sciences and School of Mathematics
Olga Turanova	Michigan State University, Mathematics
Ning Wei	Purdue University, Mathematics
Chang-Hong Wu	National Yang Ming Chiao Tung University, Applied Mathematics
Shugo Yasuda	University of Hyogo, Data and Computational Science
Xinyue Zhao	University of Tennessee, Knoxville, Mathematics
Poster Presenters	Affiliation & Department
Lucca Borges Prado	Stanford University, Mathematics
Raymond Chu	University of California, Los Angeles (UCLA), Mathematics

Qingyou He	Sorbonne University, Institute of Biology Paris-Seine
Fanze Kong	University of Washington, Applied Mathematics
Jingyi Liu	University of Notre Dame, Applied Mathematics
Kayode Oluwasegun	Drexel University, Mathematics
Michael Rozowski	University of Maryland, Mathematics
Alexandra Stavrianidi	Stanford University, Mathematics
Son Tu	Michigan State University, Mathematics
Jonathan Waldmann	Miami University, Mathematics

Participant comments on the workshop included the following:

- *The opportunity to present my research progress as a graduate student in the form of a poster presentation.*
- *Two speakers presented projects similar to my own. I (a third-year domestic graduate student) recently transitioned from a student-focused role to active research. Much of the past few months has been spent exploring possible approaches to my new research project. This workshop introduced me to two more, and I intend to explore the works of Drs Jabin and Rhyzik once I return to my home institution.*
- *I have more flexibility in choosing hypotheses than I originally realized. In general, I have very little experience defining problems. The attention speakers gave to constructing their problems before conducting any analysis was an aspect of mathematics novel to me. It's a degree of freedom I did not recognize.*

Reduced-Order Modeling for Complex Engineering Problems: From Analysis to Practical Implementation – Winter School, January 29-31, 2025

IMSI hosted a Winter School on *Reduced-Order Modeling for Complex Engineering Problems: From Analysis to Practical Implementation*, January 29 – 31, 2025.

The Winter School focused on the numerical simulation of engineering problems in complex, possibly heterogeneous media, using computational approaches arising from homogenization theory, multiscale science, reduced order modeling, or a combination thereof. All aspects of mathematical modeling and numerical resolution and all aspects related to the practical implementation issues arising from the scientific questions addressed and numerical techniques employed, were presented. The synergy between these aspects was highlighted. A special emphasis was also placed on the importance of this combination of ingredients for the successful solution of engineering problems in an industrial R&D context.

The overall purpose was to introduce, describe and study approaches that allow satisfactory approximation of solutions to these complex problems in a window of time acceptable in an industrial or, more generally, practical context. The focus was on methods that do not necessarily require elaborate and intrusive modifications of existing software that often capitalizes on a significant amount of year.person work (legacy problem). Modern approaches were presented that are not dedicated to endlessly obtaining more accurate results at any computational cost, but that achieve a suitable compromise between accuracy, computational cost, and implementation workload. The industrial context and the practical feasibility were the driving motivation for the problems considered and the solutions proposed. The first part of this event (January 29-31, 2025) was a Winter School on these topics, aimed primarily at early career researchers and graduate and advanced undergraduate students. Students might come from various backgrounds (applied mathematics, computational mechanics, aerospace engineering, etc). The school included three block courses:

- Sonia Fliss (CNRS-Inria-ENSTA, France) spoke about problems of diffraction by thin layers of periodic and random materials;
- Ulrich Hetmaniuk (founder of Shift-Invert Ltd, USA) spoke about concrete software issues for multiscale computational science;
- Anthony T. Patera (MIT, USA) spoke about perspectives on engineering estimation via the heat transfer dunking problem.

This Workshop had 38 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Frederic Legoll	Ecole Nationale des Ponts et Chaussées, Mathematical and Computer Engineering
Alexei Lozinski	Université de Franche-Comté, Laboratoire de Mathématiques de Besançon
Speakers	**Affiliation & Department**
Sonia Fliss	ENSTA Paris, Applied Mathematics
Ulrich Hetmaniuk	Shift Invert Ltd
Anthony Patera	Massachusetts Institute of Technology (MIT), Mechanical Engineering

Participant comments on the Winter School included the following:

- *I really enjoyed the lectures of all three lecturers. It was very useful to get some references to read in regards to parallelism since this is something becoming increasingly important in my own work. The detailed description of the problem of*

heat transfer as it is experienced by engineers was useful to better understand what level of understanding is required to make something of increased utility.

- *Tostitos pizza rolls!*
- *The lecturers were excellent, knowledgeable, engaging, and well-prepared. I appreciated the clarity of their presentations and the way they connected different topics, making the learning experience really valuable.*

Reduced-Order Modeling for Complex Engineering Problems: From Analysis to Practical Implementation – Research Workshop, February 3-7, 2025

The second part of the event (February 3-7, 2025) was a Research Workshop devoted to this area.

This Workshop had 59 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Frederic Legoll	Ecole Nationale des Ponts et Chaussées, Mathematical and Computer Engineering
Alexei Lozinski	Université de Franche-Comté, Laboratoire de Mathématiques de Besançon
Speakers	Affiliation & Department
Christian Alber	University of Heidelberg, Applied Mathematics
Liliana Borcea	Columbia University, Applied Mathematics
Ludovic Chamoin	ENS Paris-Saclay, Mechanical Engineering
Eric Chung	The Chinese University of Hong Kong, Mathematics
Christian Doeding	University of Bonn, Institute for Numerical Simulation
Yalchin Efendiev	Texas A&M University, College Station, Mathematics
Paul Fischer	University of Illinois at Urbana-Champaign, Computer Science
Martin Gander	The University of Geneva, Mathematics
Moritz Hauck	University of Heidelberg, Interdisciplinary Center for Scientific Computing
Patrick Henning	Ruhr-Universität Bochum, Mathematics

David Knezevic	Akselos
Guanglian Li	University of Hong Kong, Mathematics
Roland Maier	Karlsruhe Institute of Technology, Mathematics
Diego Paredes	Universidad de Concepción, Applied Mathematics
Daniel Peterseim	University of Augsburg, Centre for Advanced Analytics and Predictive Sciences
Lukas Renelt	University of Muenster, Applied Mathematics
Marcus Sarkis	Worcester Polytechnic Institute, Mathematical Sciences
Kathrin Smetana	Stevens Institute of Technology, Mathematical Sciences
Timo Sprekeler	Texas A&M University, College Station, Mathematics
Poster Presenters	Affiliation & Department
Pierre Amenoagbadji	Columbia University, Applied Mathematics
Rathish Kumar	Indian Institute of Technology, Mathematics and Statistics
Loïc Balazi	University of Augsburg, Applied Mathematics
Charles Beall	Stevens Institute of Technology, Applied Mathematics
Toufik Boubehziz	University of Grenoble Alpes
Daniel Eckhardt	Karlsruhe Institute for Technology, Mathematics
Jose Garay	University of Augsburg, Computational Mathematics
Martin Hermann	University of Augsburg, Computational Mathematics
Michael Hott	University of Minnesota, Twin Cities, Mathematics
Nicklas Jävergård	Karlstads Universitet, Mathematics and Computer Science
Maher Khrais	University of Bonn, Institut für Numerische Simulation
Dilini Kolombage	University of Bonn, Institut für Numerische Simulation
Felix Krumbiegel	Karlsruhe Institute of Technology (KIT), Mathematics
Larissa Martins	Laboratório Nacional de Computação Científica - LNCC
Filip Marttala	Uppsala University, Information Technology and Computational Science

Anjali Nair	University of Chicago, Statistics
Jean Ruel	Ecole Nationale Des Ponts et Chaussees
Simon Ruget	Ecole des Ponts ParisTech
Buzheng Shan	Texas A&M University, College Station, Mathematics
Yueqi Wang	University of Hong Kong
Marissa Whitby	Stevens Institute of Technology, Mathematics
Mahima Yadav	Ruhr-Universitaet Bochum, Mathematics

Participant comments on the workshop included the following:

- *My favorite part of the workshop was the combination of networking, attending the various talks, and presenting my work. It was great to connect with researchers from different backgrounds, gain insights from the diverse presentations, and receive feedback on my own work. The environment was really engaging and inspiring.*
- *My favorite experience was the diversity and quality of the talks, it was possible to learn a lot of new stuff. The time between the talks was large and it was possible to network a lot.*
- *The atmosphere was very lively, with a good share between senior people and younger ones. The talks were well balanced between various topics. IMSI provided great support (I am very thankful for the financial support, as well as the local support: food, handling of the zoom and computer system, etc). The gathering of a school followed by a workshop was also an excellent idea. It was a great experience!*
- *Very warm collegial atmosphere. A pleasure to have coffee and meals together--where the "real work" gets done.*
- *There seems to be great interest in industrial applications. A few days after the workshop I was invited to Milan (DD23) to speak about HPC+industry. I'm certain that invite was born out of the IMSI workshop.*

Uncertainty Quantification Strategies for Multi-Physics Systems and Digital Twins, February 24-26, 2025

IMSI hosted the workshop, *Uncertainty Quantification Strategies for Multi-Physics Systems and Digital Twins*, February 24-26, 2025.

This workshop explored innovations and challenges in understanding computational methods for solving multi-physics models. Digital twins that mimic real-world dynamics can provide support in decision-making. To this end, fast surrogate models must be combined with large, time-consuming simulations to achieve a desired outcome. Particular interest is in twins that link more than one process-based model and in investigating how to build linked emulators of such systems. This workshop brought

together experts with applications in a number of different areas, working on emulation, linked emulators, and using these surrogates to assist in the construction and use of digital twins.

This workshop had 34 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Mansoor Haider	North Carolina State University, Mathematics
Susan Minkoff	Brookhaven National Laboratory
Bruce Pitman	University at Buffalo, Materials Design and Innovation
Ralph Smith	North Carolina State University, Mathematics
Elaine Spiller	Marquette University, Mathematical and Statistical Sciences
Danny Williamson	University of Exeter, Economics
Speakers	Affiliation & Department
Annie Booth	Virginia Polytechnic Institute & State University (Virginia Tech), Statistics
Emil Constantinescu	Argonne National Laboratory
Danial Faghihi	SUNY Buffalo, Mechanical and Aerospace Engineering
Serge Guillas	University College London, Statistical Science
Reinhard Laubenbacher	University of Florida, Medicine
Joseph Lyon	Marquette University, Mathematics
Susan Minkoff	Brookhaven National Laboratory
Bruce Pitman	University at Buffalo, Materials Design and Innovation
Elaine Spiller	Marquette University, Mathematical and Statistical Sciences
Karen Veroy-Grepl	Eindhoven University of Technology, Mathematics and Computer Science

Danny Williamson	University of Exeter, Economics

Participant comments on the workshop included the following:

- *The magnificent speakers. I was also invited to have dinner with some of the people whose work I admire the most in the profession and it was great to learn more from them in that setting!*
- *Macroeconomists and mathematicians have a lot to learn from each other.*
- *The importance of enhancing communication between these two "communities" if you will. There are many exciting and important topics on which we can work together.*

Emergent Behavior in Complex Systems of Interacting Agents, March 17-21, 2025

IMSI hosted the workshop, *Emergent Behavior in Complex Systems of Interacting Agents*, March 17-21, 2025.

This workshop brought together researchers interested in the phenomenon of emergence in complex systems of interacting agents. Such systems are ubiquitous in science and engineering and include the flocking of birds and schooling of fish, celestial dynamics, phototaxis in bacterial populations, consensus formation, and the coordination of unmanned aerial vehicles. As complex dynamical systems, their study is highly nontrivial, and relies on a wide range of techniques, including tools from mathematical analysis, data science, and control theory. This workshop assembled researchers from these disciplines to present recent work, and fostered interdisciplinary collaborations between mathematicians, data scientists, and control theorists. Researchers gained perspectives and insights on the phenomenon of emergence, as well as new tools to tackle the challenging problem of modeling and predicting complex behavior.

This workshop had 72 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
James Greene	Clarkson University, Mathematics
Trevor Leslie	Illinois Institute of Technology, Applied Mathematics
Ming Zhong	University of Houston, Mathematics
Speakers	**Affiliation & Department**
Nicole Abaid	Virginia Polytechnic Institute & State University (Virginia Tech), Mathematics

Zahra Aminzare	University of Iowa, Mathematics
Benoit Bonnet-Weill	Centre National de la Recherche Scientifique (CNRS), Laboratoire des Signaux et Systèmes
David Bortz	University of Colorado, Boulder, Applied Mathematics
Francesco Bullo	University of California, Santa Barbara (UCSB), Mechanical Engineering
Andreas Buttenschoen	University of Massachusetts Amherst, Mathematics
Maria D'Orsogna	California State University, Northridge (CSU Northridge), Mathematics
Xiaoqian Gong	Amherst College, Mathematics and Statistics
Siming He	University of South Carolina, Mathematics
Qin Li	University of Wisconsin, Madison, Mathematics
Fei Lu	Johns Hopkins University, Mathematics
Mauro Maggioni	Johns Hopkins University, Applied Mathematics and Statistics
Niall Mangan	Northwestern University, Applied Mathematics
Naoki Masuda	SUNY Buffalo, Mathematics
Benedetto Piccoli	Rutgers, the State University of New Jersey, Mathematics
Nancy Rodriguez	University of Colorado, Boulder, Applied Mathematics
Ruiwen Shu	University of Georgia, Mathematics
Roman Shvydkoy	University of Illinois at Chicago, Mathematics, Statistics, and Computer Science
Eitan Tadmor	University of Maryland, Mathematics
Changhui Tan	University of South Carolina, Mathematics
Konstantina Trivisa	University of Maryland, Mathematics
Ewelina Zatorska	University of Warwick, Mathematics

Poster Presenters	Affiliation & Department
Abdullah Ahmed	University of Maryland, Mathematics
Chirantha Piyamal Bandara	SUNY Buffalo, Mathematics
Sachit Butail	Northern Illinois University, Mechanical Engineering
Chi-An Chen	Illinois Institute of Technology, Applied Mathematics
Weiqi Chu	University of Massachusetts Amherst, Mathematics and Statistics
Nipuni de Silva	Clarkson University, Mathematics
Uresha Dias	Clarkson University, Mathematics
Bisna Mary Eldo	State University of New York at Buffalo, Applied Mathematics
Martin Guerra	University of Wisconsin, Madison, Mathematics
Ziheng Guo	University of Houston, Mathematics
Baoli Hao	Illinois Institute of Technology, Applied Mathematics
Quanjun Lang	Duke University, Mathematics
Yubin Lu	Illinois Institute of Technology, Applied Mathematics
Jiajie Luo	University of Chicago, Biological Sciences Division
Mengfan Xu	University of Massachusetts Amherst, Mechanical and Industrial Engineering
Zach Xu	University of Chicago, Computer Science
Sichen Yang	Johns Hopkins University, Applied Mathematics
Nicole Zalewski	Temple University, Mathematics
Zhiwei Zhang	Illinois Institute of Technology, Applied Mathematics
Quanyan Zhu	New York University, Electrical and Computer Engineering

Participant comments on the workshop included the following:

- *I really enjoyed the variety of the types of talks. Plenty of them were directly relevant to my current research. On the other hand, most of them were refreshingly new, and still (indirectly) relevant enough to inspire me to think about ways I might expand my research program in the future. This conference really struck the right balance between a focused subject matter and a diversity of methodologies.*
- *New collaborators with whom I will work in the near future.*

- *My academic network greatly benefitted. I am the only graduate student at my institution who works in my field, but I met multiple from other institutions at this workshop. They gave me valuable advice for furthering my learning and research. I returned home with so many new ideas, and new friends to call on if I need help.*
- *I think IMSI is doing a fantastic job as is. I attended another of their workshops last year that was adjacent to my research area and still very fruitful.*

Statistics Meets Tensors: Methodology, Theory, and Applications, May 5-9, 2025

IMSI hosted the workshop, *Statistics Meets Tensors*, May 5-9, 2025.

High-dimensional high-order/tensor data refers to data organized in the form of large-scale arrays spanning three or more dimensions, which becomes increasingly prevalent across various fields, including biology, medicine, psychology, education, and machine learning. Compared to low-dimensional or low-order data, the distinct characteristics of high-dimensional high-order data poses unprecedented challenges to the statistics community. For the most part, classical methods and theory tailored to matrix data may no longer apply to high-order data. While previous studies have attempted to address this issue by transforming high-order data into matrices or vectors through vectorization or matricization, this paradigm often leads to loss of intrinsic tensor structures, and as a result, suboptimal outcomes in subsequent analyses. Another major challenge stems from the computational side, as the high-dimensional high-order structure introduces severe computational difficulties previously unseen in the matrix counterpart. Many fundamental concepts and methods developed for matrix data cannot be extended to high-order data in a tractable manner; for instance, naive extensions of concepts such as operator norm, singular values, and eigenvalues all become NP-hard to compute. With these challenges in mind, there is an urgent need to develop new statistical methods and theories specifically tailored to handle high-dimensional high-order data. This workshop provided an interdisciplinary platform for collaboration, facilitating the exchange of advanced research developments and topics in statistical and computational methods for analyzing tensor data. By bringing together statisticians, mathematicians, computer scientists, psychometricians, and machine learning researchers, the program fostered development of new interdisciplinary areas at the intersection of statistics, mathematics, psychometrics, and engineering. The workshop contributed to educational and research endeavors in these emerging fields.

This workshop had 92 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Yuxin Chen	University of Pennsylvania, Statistics and Data Science
Yuqi Gu	Columbia University, Statistics

Cong Ma	University of Chicago, Statistics
Anru Zhang	Duke University, Biostatistics & Bioinformatics
Speakers	Affiliation & Department
Joshua Agterberg	University of Illinois at Urbana-Champaign, Statistics
Genevera Allen	Columbia University, Statistics
Rong Chen	Rutgers, The State University of New Jersey, Statistics
Yuejie Chi	Carnegie-Mellon University, Electrical and Computer Engineering
Elena Erosheva	University of Washington, Statistics
Jianqing Fan	Princeton University, Operations Research and Financial Engineering
Rajarshi Guhaniyogi	Texas A&M University, College Station, Statistics
Tracy Ke	Harvard University, Statistics
Sunduz Keles	University of Wisconsin, Madison, Center for Genomic Science Innovation
Tamara Kolda	MathSci.ai
Soumendra Lahiri	Washington University in St. Louis, Statistics and Data Science
Lexin Li	University of California, Berkeley (UC Berkeley), Biostatistics and Epidemiology
Himel Mallick	Cornell University, Population Health Sciences
Song Mei	University of California, Berkeley (UC Berkeley), Statistics
Andrea Montanari	Stanford University, Statistics
Marianna Pensky	University of Central Florida, Mathematics
Carey Priebe	Johns Hopkins University, Applied Mathematics and Statistics
Annie Qu	University of California, Irvine, Statistics

Galen Reeves	Duke University, Electrical and Computer Engineering, and Statistical Science
Aaron Schein	University of Chicago, Statistics
Pixu Shi	Duke University, Biostatistics and Bioinformatics
Will Wei Sun	Purdue University, School of Business
Cun-Hui Zhang	Rutgers, The State University of New Jersey, Statistics
Emma Jingfei Zhang	Emory University, Business School
Ji Zhu	University of Michigan, Statistics
Poster Presenters	Affiliation & Department
Han Chen	Duke University, Statistical Science
Jiaheng Chen	University of Chicago, Computational and Applied Mathematics
Shabarish Chenakkod	University of Michigan, Mathematics
Yuefeng Han	University of Notre Dame, Applied and Computational Mathematics and Statistics
John Hood	University of Chicago, Astronomy and Astrophysics
Amirhamzeh Khoshnam	University of Massachusetts Boston, Computational Science
Jingyang Li	University of Michigan, Mathematics
Carlos Llosa	Sandia National Laboratories
Yuetian Luo	University of Chicago, Data Science Institute
Zhongyuan Lyu	Columbia University, Data Science Institute
Kwangmoon Park	University of Wisconsin-Madison, Statistics
Riccardo Rossetti	Duke University, Statistical Science
Bobby Shi	University of Texas, Austin, Mathematics

Bongjung Sung	Duke University, Statistical Science
Runshi Tang	University of Wisconsin, Madison, Statistics
Yuchen Wu	University of Pennsylvania, Statistics and Data Science
Yuepeng Yang	University of Chicago, Statistics
Lili Zheng	University of Illinois at Urbana-Champaign, Statistics
Kangjie Zhou	Columbia University, Statistics
Yuchen Zhou	University of Illinois at Urbana-Champaign, Statistics

Participant comments on the workshop included the following:

- *Getting expert advice about a problem I'd been working on.*
- *I have exchanged ideas with many peers/senior professors.*
- *For me, it was how much depth you can get from just a handful of people when the setting is right.*

Interdisciplinary Research Cluster: Advances in Mathematical Modeling of Mass Extinction Events, May 13-23, 2025

IMSI hosted the Interdisciplinary Research Cluster (IRC), *Advances in Mathematical Modeling of Mass Extinction Events*, May 13-23, 2025.

To consolidate and synthesize findings into manuscripts aimed at high-impact journals, the organizers put together an IRC focused on finalizing research from prior IRC's. This IRC's objective was to finalize the collaborative papers, integrate interdisciplinary feedback, refine the mathematical frameworks, and clearly articulate their significance for advancing paleontological research. This concentrated effort enhanced the clarity, rigor, and impact of the participants' research, enabling them to effectively communicate groundbreaking insights into mass extinction dynamics and ecological resilience to a broad scientific audience. This project represented a continuation of the research conducted in previous IRCs "Exploring shifts in biogeochemical cycles and mass extinction events through slow-fast dynamical systems" (2024) and Climate Tipping Phenomena in Non-autonomous Paleoecosystems (2023), and involves collaboration across the Mathematics of Mass Extinctions Network.

This IRC had 10 unique participants.

Participant comments on the IRC included the following:

- *This exchange of ideas deepened my understanding of extinction dynamics and allowed me to see beyond the confines of a single discipline. It also helped me place my own research into a broader scientific narrative, bridging mathematical modeling with evolutionary and environmental history. This experience has sharpened my ability to ask more holistic, integrative questions about Earth system processes.*
- *IMSI provided a fantastic and fruitful collaborative working environment, and a convenient location for our international team of collaborators (US, UK, EU, and Indian-based) to meet in-person (with some remote participants joining for individual meetings) for the IRC. All the facilities were available for us to maximise the time in Chicago to achieve some concrete outcomes, and I really appreciated the logistical support by the staff at IMSI. As someone not from a Mathematical or Statistical background, I found the institute to be an incredibly useful resource allowing me the intellectual and physical space to work on focused research.*
- *The dedicated time and academic setting allowed for uninterrupted focus, enabling deep integration of mathematical methods with paleontological insights. Group discussions facilitated conceptual clarity and enhanced the interdisciplinary scope of the papers. The structure of the retreat—spanning analysis, writing, and internal peer review—was instrumental in accelerating manuscript development.*
- *The relationships and synergies developed during the IRC have laid the foundation for continued collaboration. We have already begun discussing future projects and joint publications, and we anticipate that this IRC will lead to long-term academic partnerships.*

3.5 Summer Undergraduate Mathematics and Statistics Accelerator (SUMSA)

The Summer Undergraduate Mathematics and Statistics Accelerator (SUMSA) was an eight-week mathematics and statistics summer bootcamp for undergraduates at U.S. colleges and universities which was hosted by IMSI on the campus of the University of Chicago from June 10 – August 2, 2024. The program helped prepare students for the rigors of graduate school in a mathematical science with lecture series and problem sessions. The primary focus of this bootcamp was basic coursework. The bootcamp offered an avenue for “standardizing” the backgrounds of undergraduates to help them develop competitive candidacies for graduate school. The topics included:

Linear algebra: real and complex vector spaces (including infinite-dimensional ones) linear transformations, bases and dimension, algebra of linear transformations, invertibility of linear transformations and isomorphism of vector spaces, determinants, positive-definite inner products, symmetric and orthogonal linear transformations and projections, singular value decompositions.

Topology of metric spaces: continuous functions, open, closed, compact, and connected sets, convergence of sequences, completeness, Heine-Borel, Bolzano Weierstrass, Banach Fixed Point Theorem.

Advanced calculus: differentiability of functions in R^n, critical points and constrained extrema, vector fields and flows, Inverse and Implicit Function Theorems. Integration in several variables, Fubini's Theorem, Change of Variables Formula, Stokes' Theorem with special cases in low dimensions.

Probability: Overview of probability models for random phenomena, independence and dependence, distribution theory, probability inequalities and limit theorems, probabilistic foundations of statistical inference, Bayes rule and diagnostic testing.

Statistical modeling: Linear and non-linear models, regression analysis, categorical data analysis, basics of inference.

Data science: Data structures, missing and irregular data, regression analysis and supervised learning, training, testing and cross validation for performance evaluation, optimization.

Accepted applicants were offered travel support and housing on the University of Chicago campus, as well as a stipend. The bootcamp was only available to participants who were able to attend in person. Participants were expected to spend the full eight weeks in residence during the program.

SUMSA 2024 had 28 participants.

Participant comments on SUMSA included the following:

- *Seeing more advanced content and learning without the pressure of grades and exams. This allowed me to solely focus on the material without the usual stress.*
- *To know that there is a lot more to Math than I was actually aware of. I loved every aspect of SUMSA, especially being able to collaborate with Professors and other peers.*
- *The program was entirely what I had hoped for: I was exposed to methods in linear algebra, probability, regression, and analysis that I would've never otherwise learned at my college. I got the opportunity to sample unfamiliar topics before taking classes for credit next fall. I felt challenged by math homework and it forced me to go out of my comfort zone, but I also learned a lot of study skills and habits. It also has improved my transition to a new college next year in multiple ways: I feel more confident in my ability to integrate myself into a new mathematics community, I feel more confident in my skills, and the coursework is helping me meet course prerequisites at my new college.*
- *My favorite part of SUMSA was meeting a diverse group of people who all shared my love of math.*
- *Late night talks and jokes with my friends. One evening while doing homework we made a lot of math jokes and laughed so hard we couldn't breathe.*
- *My favorite moment from SUMSA was when my walls were broken down. For most of the time before the program, I thought to myself "I am covering a lot of*

math and I am keeping up with those around me", and I thought I was just happy with that. Coming to this program I have learned I have had my back turned to all the math that is out there, and that I have not given myself the chance to grow and become the best mathematician I can be, I believe. It was like finding out that the world is much, much larger than what one initially thinks that it is.

- *I loved meeting so many people who were interested in math but were completely different from each other. At my school, there's less than five math majors and most of the math department retired last year so coming here and meeting dozens of people who like math and want to talk about math was lovely.*
- *My biggest takeaway from SUMSA is that I enjoy collaborating with others to solve problems we are given and come up with solutions as a team.*
- *My biggest takeaway is Math is just like other skills, in order to be good at it, you have to train it everyday.*
- *How difficult it is to collaborate and socialize with peers, but how valuable it is once you put in the effort to make it a priority.*
- *I am very thankful to the instructors for staying past their office hours to answer our questions about homework, math in general and grad school! In addition to that, I would like to express my gratitude for creating a safe and judgement-free environment for students to express their ideas and ask questions.*
- *I liked that the assignments were ungraded, it allowed me to focus on my comprehension of the subject over completion.*
- *This program greatly increased my mathematical maturity in a short period of time, I am very happy I got this opportunity and absolutely would do it again if given the chance.*
- *I really enjoyed the program, and I enjoyed the opportunity it offered. I am unsure if I will return to Uchicago in the future, as I come from a rather small school and I feel incredibly lucky to have got into the program. However, I know now that the world of mathematics is much larger than I thought, and there are far more people doing mathematics than what I could imagine. So I would like to thank IMSI for this opportunity, and I hope that they are able to continue opening the eyes of math students.*

3.6 Summer Internship Program

The IMSI Internship program is a workforce development effort to accelerate the preparation of PhD students in the mathematical sciences for careers in interdisciplinary and translational research, in industry, and in government laboratories by providing them with broadening professional experiences. Six interns were selected from a national pool of close to 100 applicants from PhD programs in mathematics, statistics, and related mathematical sciences.

The interns began with two weeks of intensive training participating in the IMSI Data Science Bootcamp, offered online via Zoom during the period May 24 – June 7, 2024. The bootcamp was led by an expert in data science and engineering. The training was full-time, interactive experience with lecture material available in advance, hands-on daily group work, and group instruction with the opportunity to interact with other interns.

The aim was to provide highly capable PhD student interns with a jump start into data science, machine learning, modeling, and analysis to enhance success in their interdisciplinary internship appointments.

The internship placements were for 8 weeks duration following the bootcamp. Interns were placed individually or in teams depending on the scope of host projects and their mentorship capacity. Interns completed necessary onboarding for the host and were embedded in labs or groups at the host institution with a lead investigator as their direct supervisor and project mentor. Upon completion of the internship, participants authored brief technical reports in the format of a scientific paper to describe their project. Hosts expressed enthusiasm for the work the interns were able to do for them. In some cases, the laboratories had not previously engaged graduate students from the mathematical sciences and were pleased with what they were able to accomplish for them.

In anonymous surveys following the program, interns indicated a high degree of satisfaction with the relevance, range of topics, and their overall experience that they received both during the bootcamp and also during the subsequent internship. They felt they received a level of material that was not available in their academic training, and they enjoyed the experience of coming together to work with different members of the group. In particular, all those surveyed chose “Strongly Agree” to the items: “The internship provided me with an opportunity to apply knowledge from my mathematical sciences education”, “The internship provided me with new knowledge and skills that will be beneficial in my career or career decision making”, “The internship provided me with a worthwhile experience“, “I would recommend the IMSI internship program to future interns“, and “The data science bootcamp that I attended prepared me for my internship”.

Participants’ home institutions and graduate degree programs:

Participant Home Institution	Participant PhD Degree Program Name
Arizona State University	Applied Mathematics
Auburn University	Mathematics
Montana State University	Statistics
Northern Illinois University	Statistics
University of Kentucky	Statistics
University of South Florida	Mathematics and Statistics

Internship host organizations:

Internship Host Organization	Area
University of Illinois Urbana-Champaign, Microbiology (x4, joint project)	1) Developing 3D chronological plots to present epidemiological shifts in pathogens; and 2) developing k-mer approaches to classify metagenomic sequencing data
University of Illinois Urbana-Champaign, Plant Biology	Use statistical approaches to determine predictive relationships between soil nitrous oxide emissions and soil properties, which may exhibit lags, interactions between spatial and temporal variation, and seasonally different relationships
University of Nebraska-Lincoln, Center for Brain, Biology & Behavior	Multivariate brain imaging studies to uncover the network organization of general intelligence

Participant comments on the internship included the following:

- *This internship has been an invaluable experience and a significant learning opportunity, particularly in the field of neuroscience research.*
- *The internship experience has significantly shaped my future career path by enhancing my technical expertise in bioinformatics and computational biology.*
- *I'm very grateful for this opportunity. The internship allowed me to apply my skills to real-world tasks and showed me how much more I have to learn. It was an invaluable experience that has broadened my understanding and deepened my commitment to my professional development.*
- *The internship provided valuable hands-on experience with cutting-edge genomic analysis tools and enhanced my skills in data visualization and bioinformatics. Collaborating with experts in the field was a significant learning opportunity.*

3.7 Special Events

Career Paths in the Mathematical Sciences 2024, June 6-7, 2024

The 2024 Career Paths in the Mathematical Sciences was jointly organized by IMSI, the Math Alliance, and the Institute for Mathematics and its Applications. This workshop gave undergraduates who are planning to enter graduate programs in a quantitative science (e.g. math, applied math, statistics, biostatistics, data science, financial mathematics, etc.) an understanding of a variety of application areas and career paths in the mathematical sciences. Student participants were nominated to attend by their faculty mentors who agreed to guide them through the process of applying to graduate programs. Students and mentors were invited to attend. The workshop included

plenary lectures, panel discussions, active learning modules, networking opportunities, and social events.

Career Paths 2024 had a total of 61 participants, including organizers, speakers, and panelists.

Organizers	Affiliation & Department
David Goldberg	Math Alliance, Purdue University, Mathematics
Phillip Kutzko	Math Alliance, University of Iowa, Mathematics
Roberto Soto	Math Alliance, California State University, Fullerton, Mathematics
Daniel Spirn	Institute for Mathematics and its Applications (IMA), University of Minnesota, Twin Cities, Mathematics
Speakers & Panelists	Affiliation & Department
Luis Bettencourt	University of Chicago, Ecology & Evolution
Rafael Ceja Ayala	Purdue University, Applied Mathematics
Ranthony Clark	Duke University, Computational and Mathematical Science
Carla Cotwright	United States Department of Defense
Erica Dawson	Centers for Disease Control and Prevention
Sara Del Valle	Los Alamos National Laboratory
Kelsey Di Pietro	GE HealthCare
Javier Flores	Pacific Northwest National Laboratory (PNNL)
Isaac Harris	Purdue University, Mathematics
Jordan Kemp	University of Chicago, Physics and Pritzker School of Molecular Engineering
Taylor Martin	Sam Houston State University, Mathematics
Bashir Mohammed	Society for Industrial and Applied Mathematics (SIAM)
Jennifer Pearl	National Science Foundation
Lauren Quesada	Colorado State University, Fort Collins, Statistics

Jacob Rezac	National Institute of Standards and Technology
Fatma Terzioglu	North Carolina State University, Mathematics
Kaelyn Willingham	University of Minnesota, Twin Cities, Mathematics
Michael Young	Carnegie Mellon University, Mathematical Sciences

Participant comments on the event included the following:

- *Meeting so many people in industry. I have not had many opportunities to talk to people with degrees in math that are working in industry.*
- *I liked being able to network and talk with different people who were attending. As well as the improv activity was beyond helpful. I really liked it.*
- *I enjoyed how everyone at the conference was welcoming and was comfortable enough to talk to each other, especially during the breaks. I enjoyed the guest speakers and hearing about their different backgrounds. I also really appreciated the diversity of the group who was in the conference.*
- *My highlight of the conference was sitting down and talking to other mentors and getting advice while sharing my own experiences. I made several connections.*
- *To learn more from people who have done it before and are helping me by informing me of opportunities.*

BRING MATH: Bridges for the Next Generation: Mathematical Science Research and Our Future, October 3 – 4, 2024

BRING MATH (BRIdges for the Next Generation: MATHematical Science Research and Our Future) was a two-day conference for undergraduates interested in the mathematical sciences. It was a collaboration between IMSI and the Mathematics and Computer Science Division at Argonne National Laboratory, and was hosted at Argonne, which is located in Lemont, Illinois.

BRING MATH had multiple purposes: 1) expose students and faculty to research in the mathematical sciences at Argonne, and to help them understand its real world applications, 2) increase students' interest in the mathematical sciences and broaden their access to opportunities to pursue that interest, 3) diversify the mathematical science community, 4) educate students about summer opportunities available to them, and 5) help students learn about career opportunities in the mathematical sciences and how to pursue them.

BRING MATH included the following activities: 1) dedicated sessions on topics such as climate change, data & information, and quantum computing & information, 2) tours of Argonne facilities such as the Advanced Photon Source, the Center for Nanoscale Materials, Argonne's supercomputing center, and the Rapid Prototyping Lab, 3) networking opportunities with researchers at Argonne, and 4) a panel on career paths in the mathematical sciences.

IMSI supported 41 participants.

Participant comments on the event included the following:

- *It would be helpful to contrast these opportunities with opportunities and careers in academia.*
- *The organization of the conference is great! Thank you all for putting together this conference and giving us the opportunity to come over.*
- *I really enjoyed this conference!*
- *It was very fun and it was great being able to meet others in my field and chat with them on everything.*

Career Paths in the Mathematical Sciences 2025, May 29-30, 2025

The 2025 Career Paths in the Mathematical Sciences was jointly organized by IMSI, the Math Alliance, and the Institute for Mathematics and its Applications. This workshop gave undergraduates who are planning to enter graduate programs in a quantitative science (e.g. math, applied math, statistics, biostatistics, data science, financial mathematics, etc.) an understanding of a variety of application areas and career paths in the mathematical sciences. Student participants were nominated to attend by their faculty mentors who agreed to guide them through the process of applying to graduate programs. Students and mentors were invited to attend. The workshop included plenary lectures, panel discussions, active learning modules, networking opportunities, and social events.

Career Paths 2025 had a total of 43 participants, including organizers, speakers, and panelists.

Organizers	Affiliation & Department
David Goldberg	Math Alliance, Purdue University, Mathematics
Phillip Kutzko	Math Alliance, University of Iowa, Mathematics
Roberto Soto	Math Alliance, California State University, Fullerton, Mathematics
Daniel Spirn	Institute for Mathematics and its Applications (IMA), University of Minnesota, Twin Cities, Mathematics
Speakers & Panelists	Affiliation & Department
Jesse Berwald	Qamia Quantum Technologies
Brian Boonstra	Jump Trading

William Cottrell	Jump Trading
Raegan Higgins	Texas Tech University, Mathematics and Statistics
Laurent Lanteigne	Hull Tactical Asset Allocation
Oluwadara Ogunkoya	Fermi National Laboratory
Daniel O'Malley	Los Alamos National Laboratory (LANL)
Danny Perez	Los Alamos National Laboratory (LANL)
Alex Popovici	Chicago Trading Company
Cathy Potts	D-Wave
Danielle Robbins	Capital Group
Michael Robert	Virginia Polytechnic Institute & State University (Virginia Tech), Mathematics
Daniela Valdez-Jasso	University of California, San Diego (UCSD), Bioengineering

Participant comments on the event included the following:

- *A group of 12 of us went out and about around town tonight and I just got settled in. When I've gone to conferences in the past, I sort of kept to myself and didn't explore much in the area. This time was different. I think with the setting - enough people to have a breadth of interests and experiences, and not so much that it's easy to let yourself get lost in the crowd. We got to be goofy together and open up with each other in the improv sessions, and that really helped build a sense of comrade. I also am starting to get inspiration about pursuing a PhD program after I finish my masters. I don't know exactly what, but my vision is certainly more clear. I haven't been to many college campuses or seen many big cities (though, I am from the Los Angeles area, so I've been around it before). I've never seen any Great Lakes before, or a river that is supporting large boats. The hosts, professors, and featured guests and panelists were so amazing, and very supportive. You all put so much into us. There are people I definitely am going to contact (both guests and speakers). So many of you pour so much into this community, show us what would be, while meeting us where we are and supporting our pathways to any current, or yet-to-be, dreams. OH! I was SUPER excited to meet Raegan. So excited I had a hard time talking, at first! She is such a rock star - she took a picture with me and I immediately showed it off to my AWM people. Thank you for giving me a chance and believing in me. I definitely believe in my-*

self more because of my experiences here and the support you all have provided.

- *The best parts were being able to talk to others and form connections. I met many people and had meaningful conversations that made me realize that a graduate program is an opportunity for me- a first-generation, female, Mexican American, college student. There's a lot of support out there that I wouldn't have known of if it weren't for this workshop so I am forever thankful to IMSI for once again receiving me with open arms and supporting me. Without their funding covering my traveling and lodging expenses, I would not have been able to participate on this workshop, so I am deeply thankful for that as well!*
- *The highlights of the conference were the networking opportunities, detailed presentations of possible career paths, and the improv session. Everything was so well planned, making practically everything the highlight!*

3.8 Education Outreach

Education Outreach Programs at UChicago

IMSI supports and provides partial funding for three education outreach programs run out of the UChicago Math Department: the Young Scholars Program (focused on pre-college students), and the Polk Bros & SESAME programs (targeted at math teachers, mainly grades 3-8).

Polk Bros.

The Polk Bros. program has as its mission the improvement of the teaching of mathematics in the Chicago Public Schools. This is accomplished by giving classes to teachers in the CPS during the summer and academic year. This past summer, starting in the last week of June 2024, Professor John Boller gave a course featuring a modern method of teaching mathematics known as the Open Approach. This method involves posing problems that seem simple but are actually representing important, central topics in mathematics and asking students (in this case CPS teachers) to solve them in as many different ways as they can. This shows the particpants that mathematics is a creative enterprise rather than a memory game where exactly one way is the right way and must be memorized. The class ran for five weeks, Monday through Thursday from 9am to noon. Due to a large class size this was given remotely.

A second course was given by Bob Fefferman, and it was a content course whose subject was Pre Calculus/Calculus.The teaching method of this course emphasized participation by the teachers, and it also had as a fundamental part of its mission showing the teachers the beauty of mathematics, and getting them away from memorizing rules, instead allowing them to gain a deep understanding and appreciation of the material and its many applications. This class ran for four weeks, Mondays through Thursdays, from 1:30 to 4:30pm. The course was also given remotely. Professor Fefferman then began, in the fifth week, a second course that dealt with

geometry. It was continued in the following academic year by holding ten three-hour sessions on Mondays evenings.

The Number of Participating teachers in the three courses were as follows:
Methods of Teaching: 63
Pre Calculus/Calculus: 71
Geometry: 68
There were 119 teachers who participated in the program, taking at least one of the classes

Below are some quotes from what teachers wrote in their evaluations of the classes:

- *This course will really change how I teach. It's not just about numbers and formulas anymore; it's about helping my students truly understand math concepts. Pre-calculus introduces more advanced thinking and problem-solving skills that will make my teaching more engaging and meaningful. This course provided me with new ideas and ways to support all my students, especially those who might find math challenging at first. I am excited to bring this knowledge back to my classroom and inspire a love for math in my students.*
- *This is my fourth course with Polk Bros and I gotta say each course is phenomenal! The professors provide a lot of knowledge in each course I've taken*
- *The Professor was very knowledgeable, enthusiastic and engaging making the class fun and easy going. Highly recommended class! Even a non-mathematician would enjoy and understand the concepts taught.*
- *Prof Boller and TA Jacob Stump were fantastic instructors who were also incredibly kind and extended so much grace as I was going through a very tough situation toward the last weeks of the class.*
- *This course has given great ideas on how to approach teaching Math in the classroom. It really focusses on the importance of how a student arrives to their answer and their way of thinking. It also has taught me some tools in tackling differentiation in Math teaching and honing in on the thought process and how students arrive to their answers is important and use that to better their understanding of Mathematics. I hope to bring what I have learned in this class to the classroom and to continue to make Math fun again.*
- *This course was very rich. We covered much ground in the last month. Professor Boller was very knowledgeable and engaging. His excitement about the content was contagious. He frequently encouraged critical thinking, created a space where mistakes were welcomed and where students felt comfortable asking clarifying questions. I would highly recommend this course to any of my colleagues in the future.*

SESAME

In 2024-25, the SESAME program continued to operate by offering classes that made up part of the Algebra Initiative project in collaboration with the Chicago Public Schools

(CPS), DePaul University, and the University of Illinois at Chicago (UIC). The Algebra Initiative is a program through which teachers take courses from the University partners so as to be able to offer a 9th grade algebra course to qualified students in the 8th grade. It includes teacher training as well as a qualifying exam. Students who then take a year-long course from a qualified teacher take an exit exam, and if they pass, they are not required to take an Algebra I course in 9th grade.

In the Autumn, Winter, and Spring Quarters at the University of Chicago, respectively, the Algebra I, II, and III courses were offered in a hybrid remote/in-person format (alternating weeks between each type), with total enrollments of 20, 19, and 18, by quarter. In all three quarters, the full roster consisted of full-time CPS teachers.

Young Scholars Program

In the Summer of 2024, the Young Scholars Program (YSP) was held in an in-person format. YSP is a four-week summer program for mathematically talented 7th through 12th graders, divided into three grade-level cohorts: 7-8, 9-10, and 11-12. Each cohort had two associated faculty instructors who taught classes and a number of undergraduate counselors who ran break-out sessions. In 2024, we had a grand total of 68 students who participated, the vast majority of whom attended the Chicago Public Schools. They divided into cohorts of 37, 25, and 22, respectively. We had 6 faculty instructors and 15 undergraduate counselors. The theme for 2024 through all of the cohorts was number theory.

Education Outreach Programs at the University of Illinois at Chicago

In 2024, the YSP ran four one-week sessions:

Number Theory and Cryptography (July 8 – July 12, 2024)
Graphs and Networks (July 15 – July 19, 2024)
Algorithms and Data (July 22 – July 26, 2024)
Probability and Statistics (July 29 – August 2, 2024)

The daily schedule included a morning lecture, guided exercise sessions based on the day's lecture, a lunch break, work on group projects, and either a guest lecture or panel or a special large group activity. Students could attend as many weekly sessions as desired, and we had 45 to 50 participants each week (with more than 70 total participants). In each week approximately two-thirds of the students were rising 9th and 10th graders; the youngest students were rising 8th graders and the oldest had just graduated from 12th grade.

Students came from high schools all around the city, both public and private, but the vast majority were from CPS schools. The program was completely free to participate in, lunches were provided, and UIC is easily accessible by public transport which made the program accessible for many students around the city. Additionally, there were no mathematical prerequisites to participate; the lectures, exercises, and group projects were designed to be approachable and interesting to students with a wide variety of

mathematical backgrounds. Students could choose which exercises to pursue and the direction of their group projects, and the graduate student instructors did a great job of making the program exciting and enriching for all the students. Seventy-three participants filled out the summary survey on their final day.

In 2024, the YSP program again partnered with Math Circles of Chicago (MC^2) to reach a wider audience of students across the city. Math Circles publicized our program to their students and teachers in the spring. The YSP summer program complemented Math Circles summer programs which focused on middle school students, and together the two summer programs offered opportunities to all Chicago students from rising 6th grade through graduating seniors.

3.9 Communication and Engagement

IMSI Communications Bootcamps

Concept

As part of IMSI's mission to improve communication within the mathematical and statistical fields, IMSI offers a series of bootcamps to help early career researchers develop their communication skills. The bootcamps, offered online and in person, build skill sets applicable to academic careers and individuals' broader communication goals. When participants complete all four sessions, they qualify for recognition of their work through a LinkedIn badge.

Bootcamp Descriptions

The Why & The Who

It is natural to wonder why it is important for mathematicians and statisticians to study communications skills and who their audiences would be for their communications. In this session, participants will dig into the importance of understanding the points and goals for their communications, discuss different types of audiences, and analyze which communications methods best match audience types.

The What

This session dives deep into ways to communicate actual mathematical and statistical content. Participants will take part in activities around the proper use of jargon, examine the important role definitions play in the mathematical sciences, and develop metaphors and analogies for their research. They will also delve into the important role the human aspect can play in connecting mathematics and statistics with lay audiences and why it is important to be careful with numbers.

The How

Humans have been telling stories to each other for as long as we have been able to communicate. In this session, participants will learn how to apply storytelling techniques to their mathematical and statistical communication practices. In order to accomplish this, they will delve into the research around using storytelling to communicate, examine

narrative structures and how they are already embedded in the mathematical sciences, and tell their own stories to each other.

The Where
Knowing why, how, what, and to whom is not enough for a mathematical or statistical communicator, they also need to know where their communication needs to be placed. In the final session, participants will consider the differences between working with the press and publishing on their own, examine a wide range of different methods of communications, and even draft the start of their own press release.

Current Impact

After an overhaul at the start of 2024 the Mathematical Communication Bootcamps have had 48 unique attendees across four long programs, with 14 participating in all four bootcamps.

MathStatBites

Concept

MathStatBites is a mathematical and statistical research blog, written by early career researchers and students in those fields to translate peer-reviewed journal articles for a non-specialist audience. There is significant interest from early career researchers who want to learn how to write accessible summaries of research for their peers and colleagues who are not experts in a particular area of research, as well as for broader audiences outside the fields of mathematics and statistics. This educational blog, MathStatBites, provides translations of research into digestible “bites,” and gives early career researchers (ie, graduate students, postdocs, and junior faculty) an opportunity to hone their writing skills.

Current Impact
From June 2024-May 2025, we had four writers publish a total of 7 posts on MathStatBites. In addition to our writers, we worked with graduate and undergraduate students to serve as editors and provide feedback as to whether we were communicating the research clearly for a student audience. Five students participated as editors across the year. We have seen a decrease in numbers for both writers and editors this year and are working with student chapters of the AMS and ASA to form a collaboration for a more sustainable and productive MathStatsBites moving forward.

Carry the Two Podcast

Concept

As part of IMSI’s goal to broaden participation and interest in mathematics and statistics, we host and produce the podcast Carry the Two. The podcast features two types of seasons: in-depth and mini. The premise for the in-depth seasons is that each episode is a conversation between two hosts, with one leading the other through a

discussion of math research that shows how the field is interesting and applicable to our everyday lives. Each episode integrates excerpts from separate conversations with expert mathematicians and/or statisticians on that episode's topic. The mini-seasons range more broadly in premise and often feature only one host and a single guest. Through this podcast, we show that math is everywhere, relevant, and useful for navigating the complexities of everyday life.

Current Impact
After our new Director of Communications and Engagement began their role at the beginning of the past year, they were able to successfully reboot Carry the Two with a new in-depth season that ran September to November 2024 and a mini-season that ran January to May. Those episodes averaged around 1,200 downloads and Carry the Two received over 19,000 total downloads in the last year.

The in-depth season consisted of 6 episodes on the topics of the intersection of mathematics and statistics with politics and democracy. It featured episodes about voting, representation, political geography, coalitions, political numbers, and polling. The mini-season was also six episodes long, and featured longer interviews with researchers who had presented on their work at IMSI including: Frank Wolak (Stanford University, Economics), Rose Yu (University of California San Diego, Computer Science and Engineering), and Lars Peter Hansen (University of Chicago, Economics, Statistics, and the Booth School of Business).

4. Preparation for Future Activity

The institute will host two long programs in 2025-26: Digital Twins: Mathematical and Statistical Foundations and Complex Applications (September15-December 12, 2025) and Theoretical Advances in Reinforcement Learning and Control (March 9-May 29, 2026). The Scientific Committee recommended moving forward with these programs during its October 2023 meeting, at which point work with the organizing committees for both programs began. Applications for both programs opened in the fall, and were announced through a number of channels, including advertisements in *SIAM News* and *Amstat News*.

The Scientific Committee met in October 2024 and April 2025. The committee recommended two proposals for long programs: Connectomics: Non-Euclidean Data Analysis for Brain Structure and Function in the fall of 2026, and Modeling and Control of Vehicular Traffic and Transportation Systems in the spring of 2027. The committee also recommended the following proposals for workshops:

- Mathematical Aspects of 2D Quantum Materials and Meta-materials
- Advancing Scientific Inverse Problems with Machine Learning
- Data Science at the Intersection of Public Health and the Environment: An Ideas Lab
- Discrete Exterior Calculus: Differential Geometry and Applications

- Distinct and Common Challenges in Numerical Methods for Deterministic and Stochastic PDEs
- Random Explorations: From Random Walks to Random Geometry
- Recent Advances in Random Networks
- Unpacking AI Weather Emulators

5. Governance

IMSI has two principal governing boards.

The IMSI **Board of Advisors** provides guidance to the Director on Institute activities, operations, and strategic planning. In addition, it plays a role in the search for and appointment of the Director. The Board has dedicated seats for one institutional member from each of the partner institutions (Northwestern University, the University of Chicago, the University of Illinois at Chicago, and the University of Illinois at Urbana-Champaign), with the remaining seats allocated to general and *ex officio* members. Members serve four-year terms, except in the case of *ex officio* members. The current institutional and general members of the Board of Advisors are as follows.

Board of Advisors	Affiliation
Chid Apte	IBM Thomas J. Watson Research Center
Dimitris Bertsimas	Massachusetts Institute of Technology (MIT)
Noah Brenowitz	NVIDIA
C. Allen Butler	Daniel H. Wagner Associates, Inc.
T. Tony Cai	University of Pennsylvania
Adrian Coles	Bristol Myers Squibb
Juan de Pablo	University of Chicago and Argonne National Laboratory
Lee DeVille	University of Illinois at Urbana-Champaign (UIUC)
Darrell Duffie	Stanford University
Madhumita (Bonnie) Ghosh-Dastidar	RAND
Tamara G. Kolda	MathSci.ai
Pierre-Louis Lions	Collège de France
Steve Sain	Jupiter Intelligence

Brooke Shipley	University of Illinois at Chicago
Ji-Ping Wang	Northwestern University
Suzanne L. Weekes	Society for Industrial and Applied Mathematics (SIAM) and Worcester Polytechnic Institute
Patrick Wolfe (Chair)	Purdue University

The **Scientific Committee** provides guidance on the overall direction for scientific activity at the Institute and evaluates proposals for specific activities. Terms for members are typically three years in length. The current members of the Scientific Committee are as follows.

Scientific Committee	Affiliation
Alicia Carriquiry	Iowa State University
René Carmona	Princeton University
Andrew Childs	University of Maryland Institute for Advanced Computer Studies
Emil Constantinescu	Argonne National Laboratory and the University of Chicago
Peter Craigmile	The City University of New York (CUNY)
Amir Dembo	Stanford University
Sandrine Dudoit	University of California, Berkeley (UC Berkeley)
Bjorn Engquist (Chair)	University of Texas at Austin
Thomas Grandine	The Boeing Company (retired)
Claude Le Bris	École des Ponts and INRIA
Danny Perez	Los Alamos National Laboratory
Leslie Smith	University of Wisconsin, Madison
Joseph Tribbia	National Center for Atmospheric Research (NCAR)
Vlad Vicol	New York University
Rebecca Willett	University of Chicago

6. Evaluation

IMSI works with East Main Evaluation and Consulting (EMEC) to evaluate its programs and activities. EMEC offers consulting and evaluation services with expertise in science and mathematics education and technology. The effort is managed by Barbara P. Heath, Ph.D. Dr. Heath founded EMEC in 2004 and has evaluated over 30 STEM-focused programs including CyVerse (formerly iPlant), multiple Math and Science Partnerships, and various informal education efforts.

This year, post-activity surveys were deployed for the following programs and events:

Career Paths in the Mathematical Sciences 2024
Data Sciences Bootcamp
IMSI Summer Internship Program
Summer Undergraduate Mathematics and Statistics Accelerator (SUMSA)
The Architecture of Green Energy Systems
The Architecture of Green Energy Systems: The Underlying Problem and Its Challenges
Mathematical and Statistical Foundations of Digital Twins
Two-Dimensional Random Geometry
AI+Science Summer School
Exploring shifts in biogeochemical cycles and mass extinction events through slow-fast dynamical systems (Interdisciplinary Research Cluster)
Computational Imaging
The Architecture of Green Energy Systems: Next Steps
Challenges in Neuroimaging Data Analysis
Young Scholars Program UC
Young Scholars Program UIC
Statistical Methods and Mathematical Analysis for Quantum Information Science
The Power of Near-Term Quantum Experiments: Algorithms, Noise, and Quantum Advantage beyond NISQ
Quantum Networks
BRING MATH: Bridges for the Next Generation: Mathematical Science Research and Our Future
Quantum Sensing

Quantum Hardware
Quantum Error Correction
Mathematical Modeling of Biological Interfacial Phenomena
Reduced-Order Modeling for Complex Engineering Problems: From Analysis to Practical Implementation – Winter School
Reduced-Order Modeling for Complex Engineering Problems: From Analysis to Practical Implementation – Research Workshop
Uncertainty Quantification Strategies for Multi-Physics Systems and Digital Twins
Uncertainty Quantification and AI for Complex Systems
UQ and Trustworthy AI Algorithms for Complex Systems and Social Good
Emergent Behavior in Complex Systems of Interacting Agents
Kernel Methods in Uncertainty Quantification and Experimental Design
Uncertainty Quantification for Material Science and Engineering
Statistics Meets Tensors: Methodology, Theory, and Applications
Advances in Mathematical Modeling of Mass Extinction Events (Interdisciplinary Research Cluster)
Uncertainty Quantification and Machine Learning for Complex Physical Systems
Career Paths in the Mathematical Sciences 2025

The surveys were designed to gauge the nature of participant experience during each activity, to measure the degree to which participants thought the specific goals for each activity were achieved, and to gather feedback about possible future directions. Surveys were typically deployed a few days after the end of the activity, and participants were given two weeks to respond. A reminder was typically sent a week after the initial deployment of each survey.

7. External Funding

IMSI receives substantial in-kind support from the University of Chicago. This support includes a full teaching release and administrative supplement for the Director, an administrative supplement for the Scientific Adviser, and the full salary of the Executive Director. In addition, the University covered the cost of the renovation of the space IMSI occupies and its ongoing maintenance.

Other Funding Support

University of Chicago	$186,088

American Mathematical Society	$5,000
Total	$191,088

8. PI and Director Biographies

Kevin Corlette, Director

Kevin Corlette was appointed as the Director of IMSI on August 1, 2020. He has been a faculty member of the Department of Mathematics at the University of Chicago since 1987. He served as chair of the department from 2001-2007, and again from 2017-2020. In addition, he served as director of the Master's Program in Financial Mathematics from 2012-2015. His research lies in differential and algebraic geometry, and has touched on areas such as non-Abelian Hodge theory, rigidity of lattices in Lie groups, and representations of fundamental groups of Kähler manifolds. He was a recipient of an NSF Postdoctoral Fellowship, a Sloan Research Fellowship, and a Presidential Young Investigator Award. He was an invited speaker at the 1994 International Congress of Mathematicians.

Hongmei Jiang, Associate Director (August 1, 2024, to Present)

Hongmei Jiang was appointed as the Associate Director of IMSI on August 1, 2024. She is a Professor of Statistics and Data Science at Northwestern University, where she has been a faculty member since 2005. Since 2021, she has served as the Director of the MS in Statistics and Data Science Program at Northwestern, overseeing its launch and growth. She served as the Local Committee Chair for the 2017 International Chinese Statistical Association (ICSA) Applied Symposium, and as the General Chair for the 12th (virtual in 2021) and 13th (in-person in 2022) ACM Conference on Bioinformatics, Computational Biology, and Health Informatics (ACM-BCB). Her research focuses on developing statistical methodologies and computational algorithms to analyze and interpret high-dimensional -omics data, including genomics, epigenomics, and metagenomics.

Takis Souganidis, Scientific Adviser

Takis Souganidis is Professor of Mathematics and Member of the Committee in Computational and Applied Mathematics at the University of Chicago. He works in deterministic and stochastic partial differential equations, and is interested in applied mathematics. He was a recipient of a Sloan Research Fellowship, and a Presidential Young Investigator Award. He was an invited speaker at the 1994 International Congress of Mathematicians and the 2019 International Congress on Industrial and Applied Mathematics. He is a Fellow of the AAAS, AMS, and SIAM.

Philip W. Hammer, Executive Director

Philip (Bo) W. Hammer was appointed Executive Director of IMSI on January 1, 2021. Hammer comes to IMSI after 10 years at the American Institute of Physics, where he

was the founding and interim Executive Director of the AIP Foundation. He also led AIP's major antiracism initiative that addressed underrepresentation of African Americans in physics and astronomy. Hammer received his BS in Physics from Humboldt State University and his PhD in Physics from the University of Oregon. From 1991-93, Hammer was an ONR Postdoctoral Fellow at the Naval Surface Warfare Center in Silver Spring, MD. Hammer spent the '93-'94 year as an APS Congressional Science Fellow working on the staff of the Subcommittee on Science in the US House of Representatives. He worked at AIP from 1994-2000, and was Director of the Society of Physics Students and Sigma Pi Sigma. From 2000-2008, Hammer was a vice president of The Franklin Institute Science Museum in Philadelphia. Hammer is a Fellow of the American Physical Society.