SOUTH DAKOTA MINES
An engineering, science and technology university

Quantum Partnership Workshop at SURF

SOUTH DAKOTA MINES

2023-2028 STRATEGIC PLAN

VISION

Develop world-class leaders in science and engineering to benefit society.

MISSION

EDUCATE
scientists and engineers to address global challenges.

INNOVATE
to reach our creative potential.

ENGAGE
in partnerships to transform society.

PILLARS

ACADEMIC & CO-CURRICULAR EXCELLENCE
Provide exceptional learning opportunities.

CAMPUS CULTURE
Create an inclusive & thriving campus environment.

PROMOTION & ADVANCEMENT
Build University recognition & increase engagement.

ENROLLMENT & SUCCESS
Strengthen enrollment & provide quality student support.

RESEARCH & INNOVATION
Promote innovative culture & entrepreneurial spirit.

VALUES

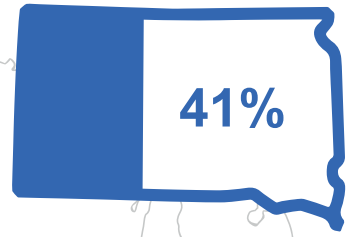
INTEGRITY **INGENUITY** **INCLUSION** **IMPACT**

Top Employers of AY23 Grads

AY23 Graduate Placement

Overall placement rate
(in discipline)

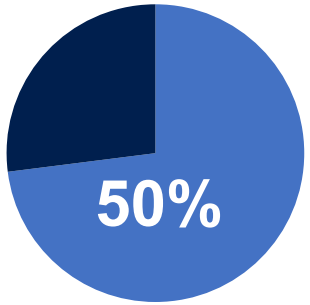
97%



working or attending grad school in SD

Graduates placed at:

- 190 companies
- 40 states
- 54 SD companies



students with internship experience

Average starting salary:

$73,547

Starting salary with an internship

~$10,000

more than without an internship

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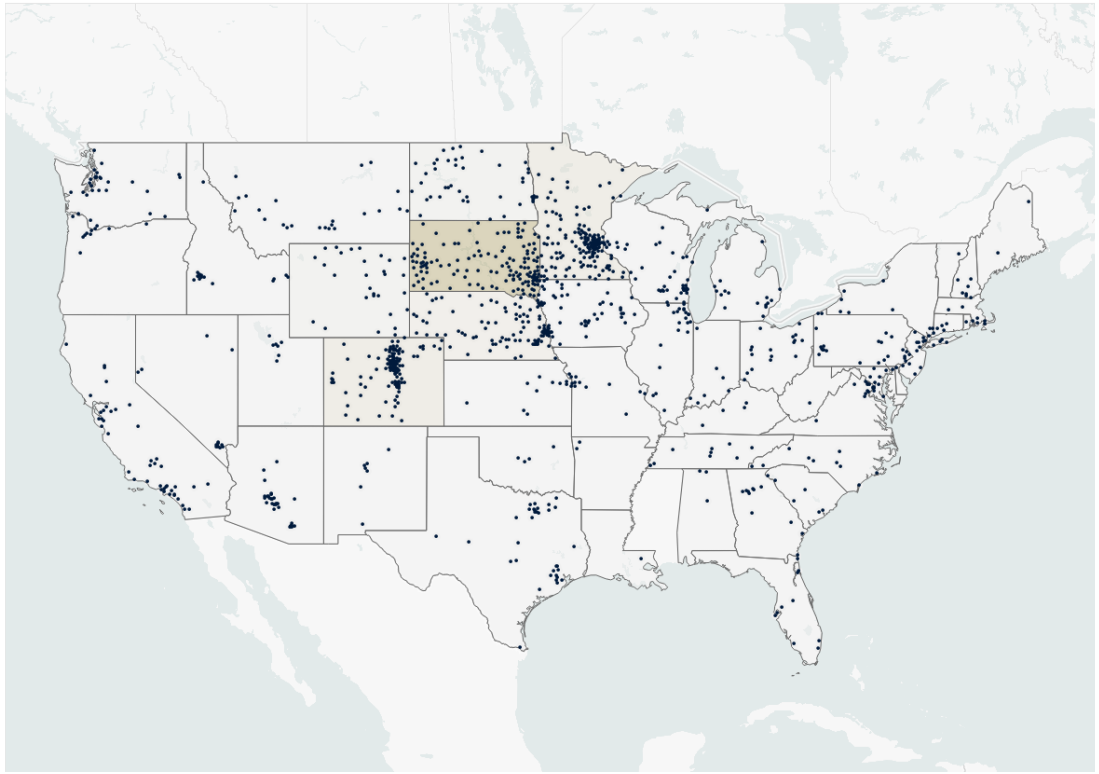
Enrollment Map

The Impact of South Dakota Advantage Program (CO, IA, MT, NE, ND, WY, IL, WI, KS, MO)

Home Residence Locations



Primary Market States	
South Dakota	1,201
Colorado	311
Minnesota	265
Nebraska	184
North Dakota	83
Iowa	57
Wisconsin	52
Montana	32
Illinois	22

Top 15 States	
South Dakota	1,201
Colorado	311
Minnesota	265
Nebraska	184
Wyoming	87
North Dakota	83
Iowa	57
Wisconsin	52
Arizona	48
California	45
Washington	37
Texas	35
Montana	32
Pennsylvania	27
Illinois	22

AY2023-24

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PROGRAM	UG	GR
Mechanical Engineering	572	22
Computer Science	196	18
Civil Engineering	187	52
Electrical Engineering	126	8
Chemical Engineering	120	23
Biomedical Engineering	108	23*
Metallurgical Engineering	104	24
Industrial Engineering	92	30
Geology	84	28**
Computer Engineering	78	***
Mining Engineering	62	33
Physics	53	24
Biology	44	-
Business Management in Technology	42	-
Health Sciences	35	-
Undeclared	32	-
Atmospheric Sciences	25	8
Mathematics	24	-
Geological Engineering	22	****
Chemistry	18	3
Science, Technology, Society	16	-

FA23 Enrollment by Program

* Includes Nanoscience/ Nanoengineering

** Includes Paleontology

*** Combined with Computer Science

**** Combined with Geology

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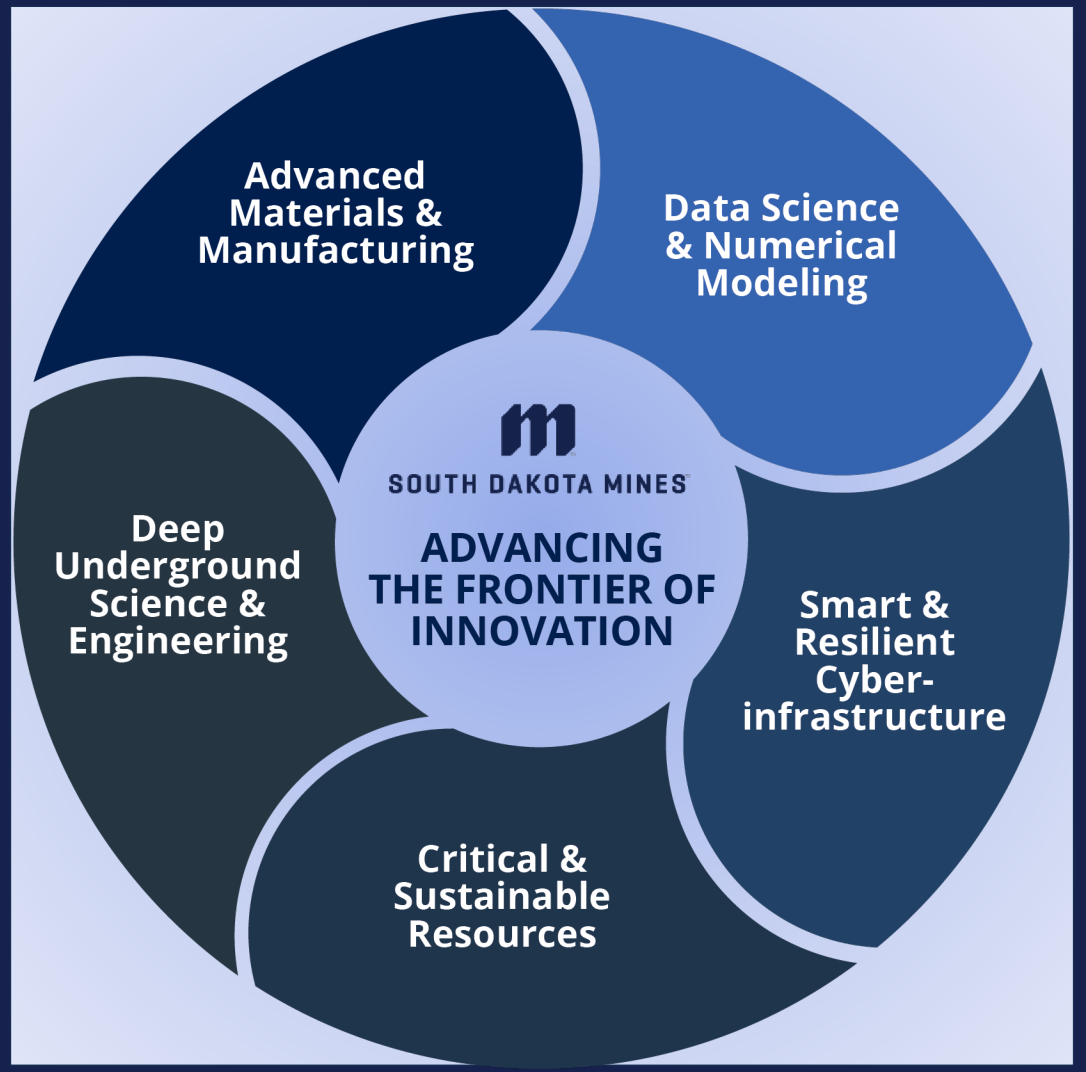
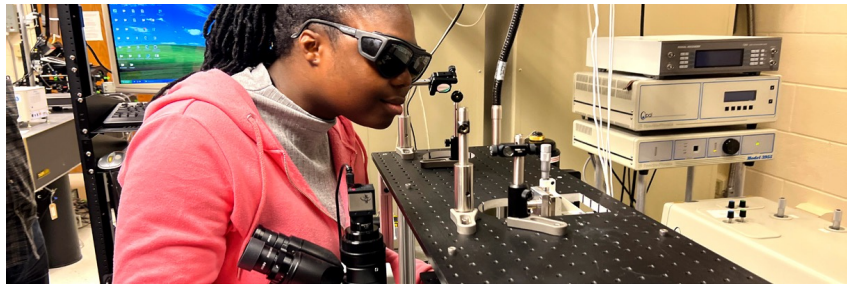
Research Affairs



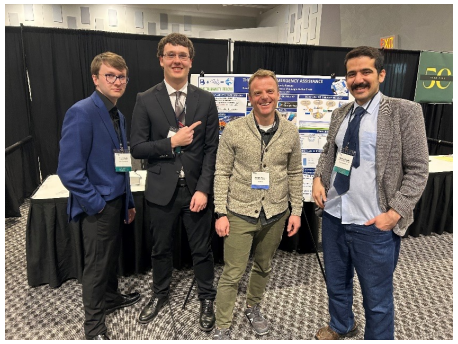
Research Affairs

Great Plains
NSF I-Corps

Quantum Information Science & Technology ~$3 M in funding for SD Mines and DSU



2024 Governor's Giant Vision



Critical Minerals UARC

- NDAA passes with call for feasibility study of Critical Materials UARC, Fall 2023
- Teaming with MT Tech

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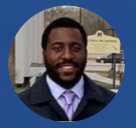
Tochukwu Emeakaroha
PhD 2022 → IBM

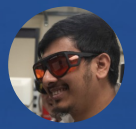
Kim Yip Chiok
MS 2022 → ASML

Tolulope Ajuwon
MS 2023 → Intel

Arik Ahmed



Yoseph Loyd



Saif Bijoy

MonArk Quantum Foundry

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Quantum Information Science and Engineering at SD Mines (QISE @ SD Mines)

Robert Anderson

Mingyuan Chen (2024)

Alexey Lipatov

Tula Paudel

Steve Smith

Shan Zhou (2022)

Qubitekk The Quantum Revolution

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QISE @ South Dakota Mines

MonArk Quantum Foundry

Departments

- Nanoscience
- Electrical Engineering Computer Science
- Physics

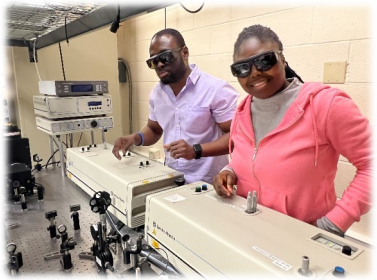
Education

Certificate in Quantum Communications approved for FA24
Supported by Nanoscience, Electrical Engineering Computer Science, Physics programs
Proposed Quantum Information Science and Engineering Minor FA25 (all majors)

Focus Areas

- Quantum Communications
- Quantum Computing
- Quantum Sensing

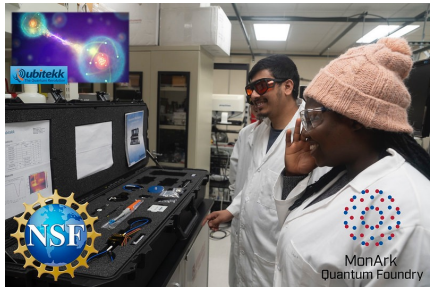
Research



Nanomaterials, Nanophotonics, Quantum materials involving 6 faculty, 6 graduate students to date.

MonArk Quantum Foundry

Workforce Development



Quantum Communication Networking leader Qubitekk donated $50K quantum networking education laboratory kit

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QISE Opportunities @ South Dakota Mines

MonArk
Quantum Foundry

- **Education Opportunities**
  - Certificate in Quantum Communication FA24
    - Primarily aimed at physics, electrical engineering and nanoscience students.
  - Proposed QISE Minor FA25
    - Designed to complement most engineering and science majors.
  - Academic Partnerships in South Dakota, Montana and Arkansas.
- **Quantum Materials Research Opportunities**
  - MonArk Quantum Foundry (3 faculty, 6 graduate students to date).
  - Federal Appropriations to establish facilities and needed infrastructure ($8M request).
  - Expand QISE: Ferroelectric 2D materials (current), nonlinear 2D materials (pending).
  - NSF, DOE ongoing funding opportunities we are better prepared for due to MonArk project.
- **Workforce Development Opportunities**
  - Faculty Recruitment, South Dakota Quantum Information Science and Technology (QUIST)
  - Industrial Collaborations
    - Qubitekk
      - Ongoing support and partnership.
      - Donation of quantum communications hardware for laboratory coursework
      - Potential for internships, co-ops
    - Discussions with IBM, Infleqtion, Google

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Quantum Communications Certificate & QIS Minor

MonArk Quantum Foundry

Certificate in Quantum Communications: In Dec 2023, the South Dakota Board of Regents approved a certificate (micro-credential) in Quantum Communications. The certificate consist of three courses, two with a 1 credit laboratory. Two are new courses and one is an existing course. These courses prepare students to work with quantum key distribution systems. The quantum photonics lab uses entangled photon networks provided by Qubitekk, Inc. The course work also prepares students to understand quantum technology at the level of practitioner. All courses are cross/listed as 500 level so the certificate can be obtained by any major, undergraduate or graduate.

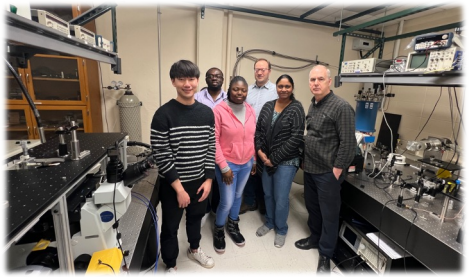
Table II Curricula for Quantum Communications Certificate

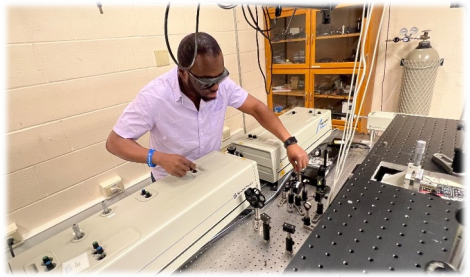
Prefix	Number	Course Title	Prerequisites for Course	Credit Hours	New (yes, no)
NANO	404/504	Nanophotonics		3	No
NANO	405/405L 505/505L	Quantum Photonics and Communications		(3-1) 4	Yes
NANO	406/406L 506/506L	Introduction to Quantum Computing and Applications		(3-1) 4	Yes
			Subtotal	11	

Minor in Quantum Information Science (QIS) is proposed. The minor will include three "core" courses in quantum materials, quantum photonics and quantum computing. The course have some commonality and work will need to be done to be sure the proper subjects are covered and not double-covered. This is part of the curricular process and department delivery. Aside from the 3 core courses, students can choose three other courses from the list in green highlight. This allows them to obtain the Minor but potentially double count some courses. Note, the certificate and the Minor would require 5 courses not double-countable.

Table III Curricula for Quantum Information Science Minor

Prefix	Number	Course Title	Prerequisites for Course	Credit Hours	New (yes, no)
NANO	402/502	Quantum Materials and Applications		3	No
NANO	405/405L 505/505L	Quantum Photonics and Communications		(3-1) 4	Yes
NANO	406/406L 506/506L	Introduction to Quantum Computing and Applications		(3-1) 4	Yes
MATH	315	Linear Algebra		3	No
NANO	404	Photonics		3	No
EE	453	Feedback Controls		3+1	No
CENG	244	Digital Signal Processing		2+1	No
CSC	448	Machine Learning		3	No
PHY	471	Quantum Mechanics		4	No
PHY	449	Computational Physics		4	No
PHY	331	Modern Physics		3	No
			Subtotal	21-23	





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Ongoing QISE Efforts and Expanding Our Team

MonArk Quantum Foundry

Robert Anderson

Area: Physics, imaging, computational Nanophotonics and simulations.

Steve Smith

Area: Physics, nonlinear optics and imaging, optical materials.

Shan Zhou (2022)

Area: Chemistry, self-assembled nanostructures, Metasurfaces.

Tochukwu Emeakaroha
PhD 2022 → IBM

Kim Yip Chiok
MS 2022 → ASML

Tolulope Ajuwon
MS 2023 → Intel

Arik Ahmed

Yoseph Loyd

Saif Bijoy

i. **MonArk Quantum Foundry** - $1M NSF funded collaboration
ii. **QUIST** - $1.2M State appropriation supporting new QIS hire
iii. **Quantum Materials Institute** – $6M Federal appropriation (on the hill)
iv. **Expand QISE** – Alexey Lipatov, Tula Paudel ($800K current, $5M pending)

Tula Paudel

Area: Materials Physics, condensed matter theory.

Mingyuan Chen (2024)

Area: Materials Science, focus on 2D materials and imaging.

Alexey Lipatov

Area: Materials Chemistry, 2D materials synthesis, characterization.

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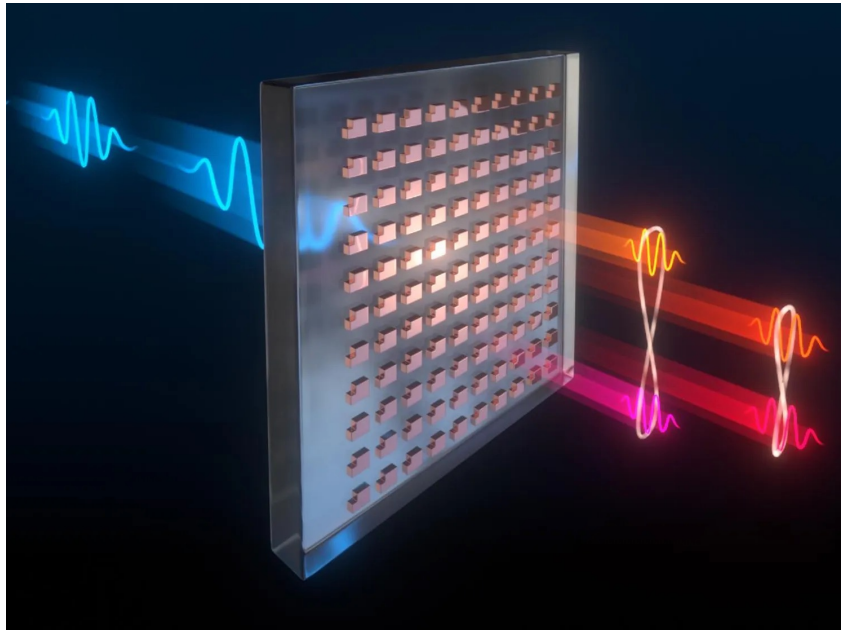
Motivation and Current Focus @ South Dakota Mines

MonArk
Quantum Foundry

Motivation: Parametric downconverters, single photon emitters, detectors and memory are key components of quantum information systems. Structure-property relations of the materials they comprise determine performance and guide their development and application.

Focus: Develop new quantum materials and spatially- and spectrally-resolved multiphoton imaging methods to characterize quantum materials on passive and enhancing substrates.



Parametric down conversion generates entangled photon pairs[1] for quantum communications.

[1]https://spectrum.ieee.org/metasurface-entangled-photons

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THANK YOU!