

# The National Research Council's Quantum Sensors Challenge Program

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A/Director – Quantum Sensor Challenge Program

**March 2024**



# NRC Challenge Programs

## Pandemic Response

To address challenges requiring further R&D for solutions to meet COVID-19-related needs.



[Learn more](#)

## Materials for Clean Fuels

To develop new materials for clean and sustainable sources of energy.



[Learn more](#)

## High-throughput and Secure Networks

To develop high-performance, rapid and secure communication for rural and remote communities.



[Learn more](#)

## Artificial Intelligence for Design

A foundation of AI tools, technologies and capabilities to support the above mission areas.



[Learn more](#)

## Disruptive Technology Solutions for Cell and Gene Therapy

To develop disruptive technology solutions for cell and gene therapies to significantly improve health outcomes.



[Learn more](#)

## Aging in Place

To improve the quality of life of older adults and their personal caregivers through innovation that will support safe and healthy aging.



[Learn more](#)

## Arctic and Northern

To address pressing issues impacting the quality of life of northern peoples.



[Learn more](#)

## Applied Quantum Computing

To support commercial and government innovations in quantum algorithms and applied quantum computing.



[Learn more](#)

## Internet of Things: Quantum Sensors

To develop revolutionary sensors that could be engineered and commercialized for applications in the environment, natural resources, health care, and defence.



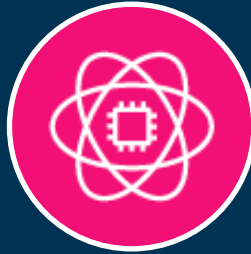
[Learn more](#)

Catalyze transformative, high-risk, high-reward research with potential for game-changing scientific discoveries and technological breakthroughs

# NRC Quantum Research Programs and Activities



**High-throughput and Secure Networks**



**Internet of Things: Quantum Sensors**



**Applied Quantum Computing**

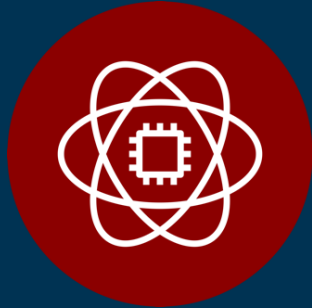


**Research Centre Activities**

# QUANTUM SENSORS PROGRAM



## QSP 7-YEAR PROGRAM (2021-2028)



**OBJECTIVE  
ADVANCE  
COMMERCIALIZATION OF  
QUANTUM SENSORS**

## 3 RESEARCH THEMES



QUANTUM  
PHOTONICS



CHIP-BASED  
QUANTUM SYSTEMS



QUANTUM  
METROLOGY



NATIONAL QUANTUM  
STRATEGY  
COMMERCIALIZATION

## Regular Program \$40M + \$6M NSERC GRANTS & CONTRIBUTIONS

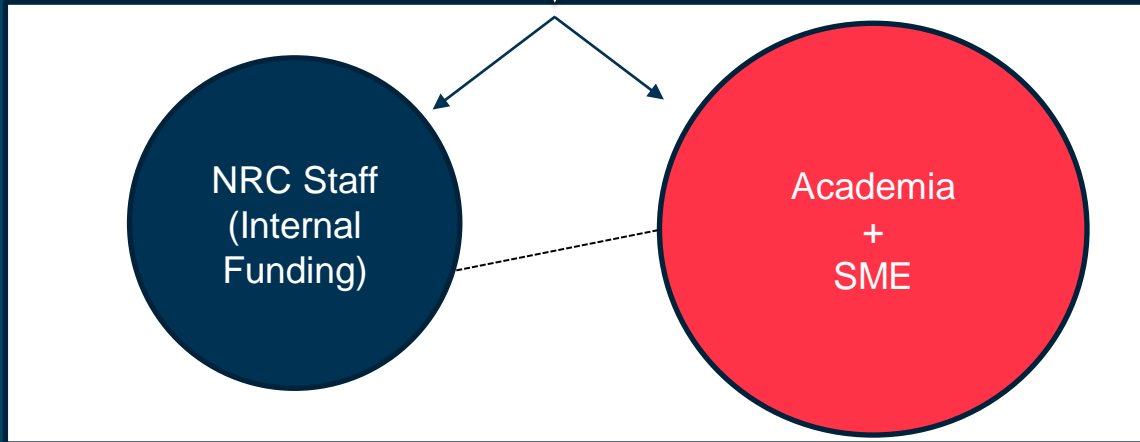


**AVAILABLE TO FUND  
COLLABORATIONS**

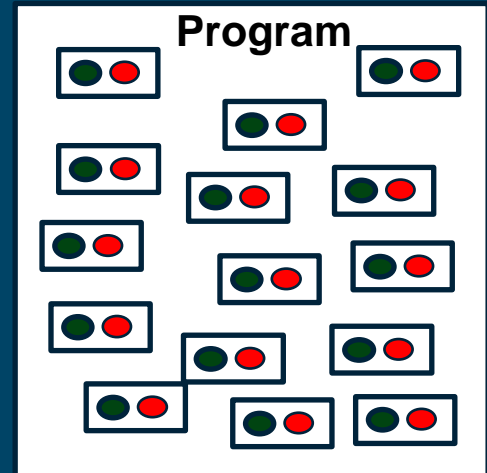
**Challenge Statement:** To develop a disruptive generation of quantum sensors that are orders of magnitude better than sensors that exist today.

# Projects in the Challenge Program Model

Collaborative Project 



Challenge Programs, enabled by the **Collaborative Science Technology and Innovation Program (CSTIP)** consist of a portfolio of collaborative projects that address an over-arching challenge



## CHALLENGE STATEMENT:

To develop a disruptive generation of quantum sensors that are orders of magnitude better than sensors that exist today

# Quantum Photonics

Total G&C projects

16

Total G&Cs Up to date

\$10.4M

G&C recipients

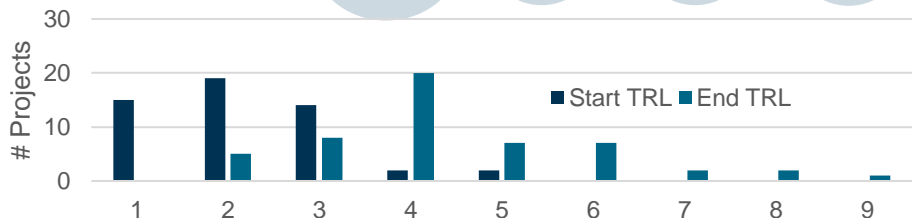
14

Int'l recipients

3

Peer-reviewed publications

25



# Semiconductor-based Quantum Sensing

Total G&C projects

13

Total G&Cs Up to Date

\$5.5M

G&C recipients

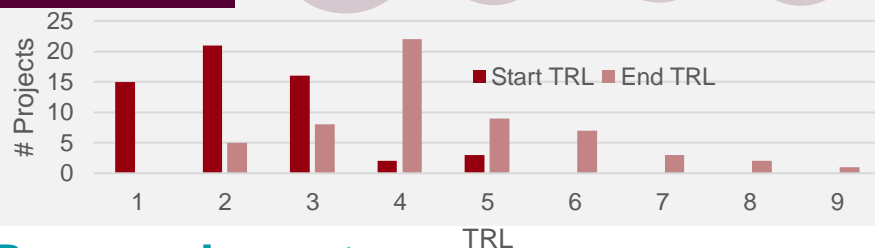
10

Int'l recipients

3

Peer-reviewed publications

10



# Quantum sensing for next-generation Metrology

Total G&C projects

11

Total G&Cs Up to Date

\$7.8M

G&C recipients

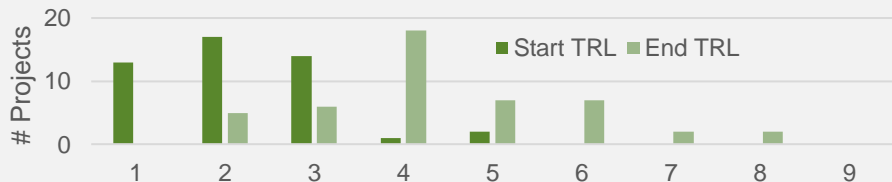
9

Int'l recipients

2

Peer-reviewed publications

5



# Program Impact

Commercialization Highlights

- 3 spin-out companies in development
- 2 related to quantum imaging
- 1 enabling technology

Success Stories

- 10x level of improvement in magnetic field sensitivity for SB Quantum prototype quantum sensor
- 100x improvement for brain neuromonitoring with quantum-sensitive cameras
- 10x decrease in measurement time from new protocol for transduction between qubit types

Quantum HQP Trained

256 HQP

- 56 Undergrads
- 30 Masters students
- 59 PhD students
- 40 Postdocs
- 19 Technicians
- 37 Others

6 SMEs  
1 not-for-profit  
Supported

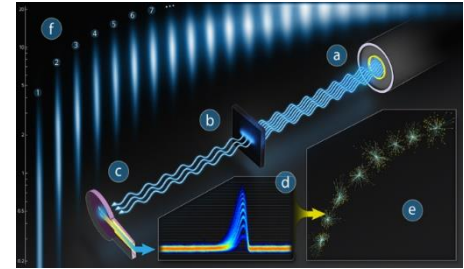
# Quantum sensing for particle physics

## Areas of potential interest from QSP

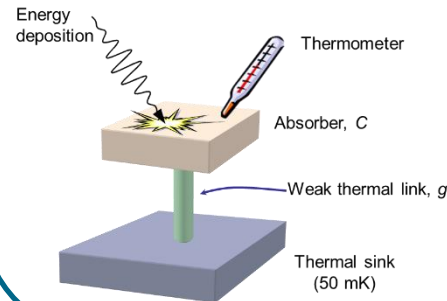
- Squeezed light based interferometry
- Optomechanical sensors
- Spin-based sensors
- Atomic clocks
- Quantum materials

[2305.11518] Quantum sensing for particle physics (arxiv.org)

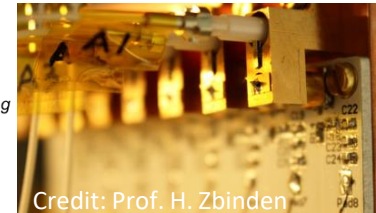
## Photon-number resolving superconducting nanowire single-photon detectors



Credit: Sean Kelly/NIST PML



QSP043  
NRC, Université de  
Genève



Credit: Prof. H. Zbinden

QSP062  
NRC, Xanadu, Imperial  
College London

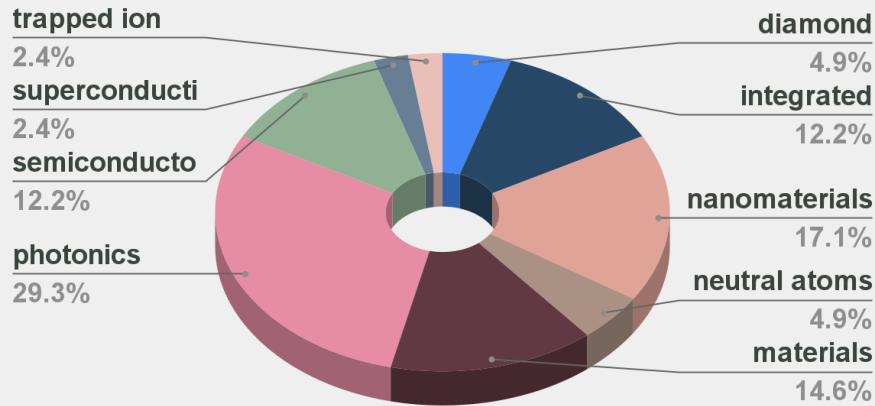


# QSP quantum sensing technologies

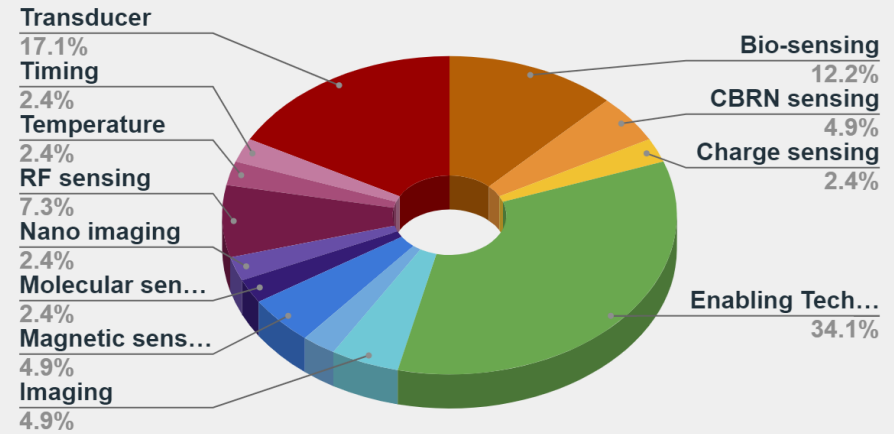
QSP supports a broad range of sensing-related quantum technologies

- Breadth of available research expertise across Canada and the NRC are limiting factors

### Physical Platform



### Sensors

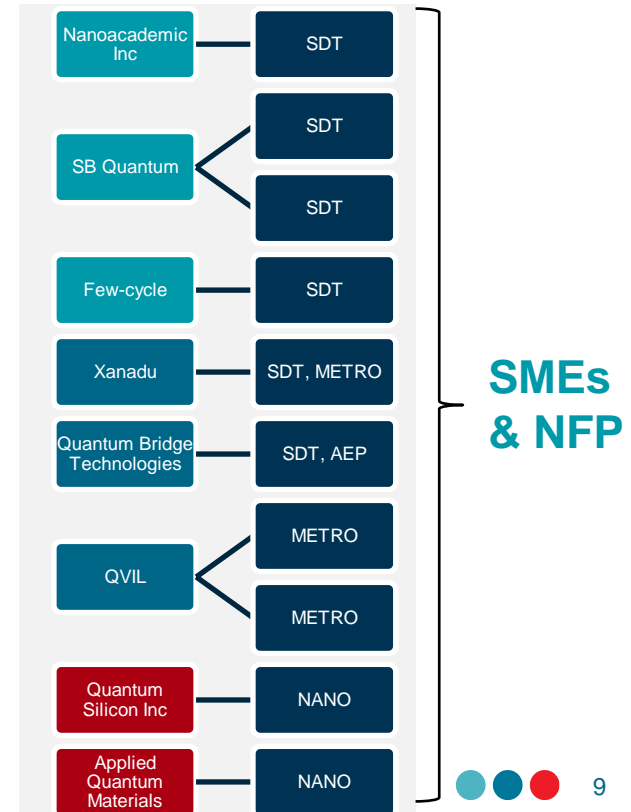
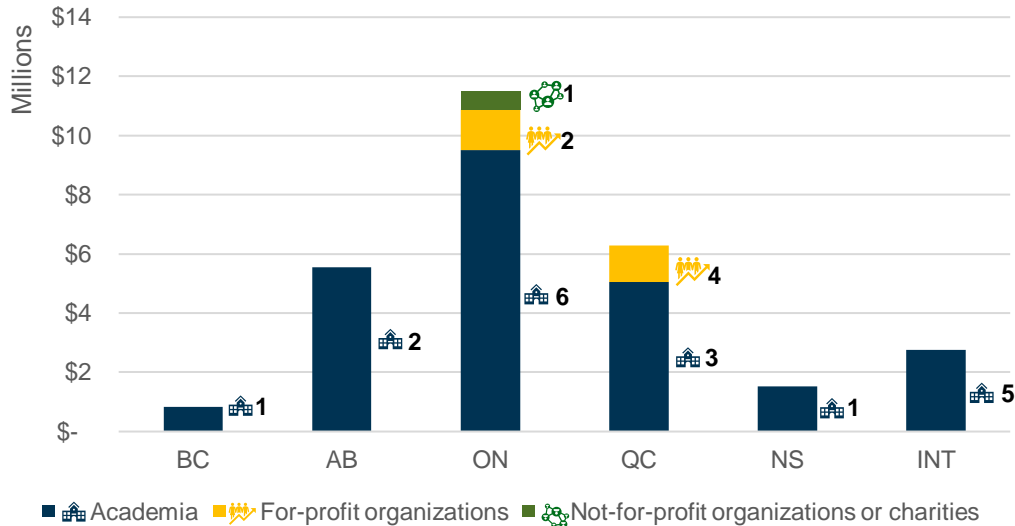




# QSP supports collaboration across the country

QSP has a strong presence across the country

Provincial Distribution of QSP funding

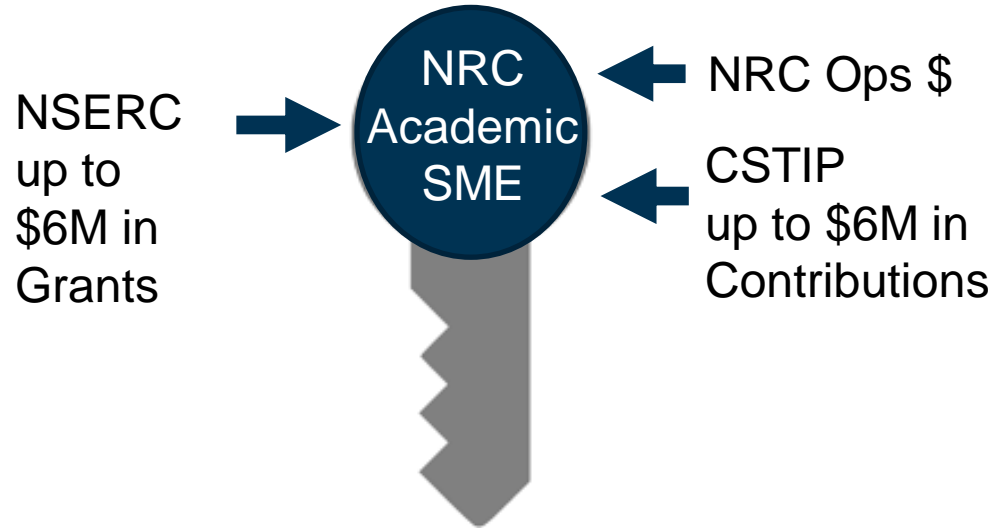


- This call directly supports the National Quantum Strategy Commercialization Pillar.
- NSERC will fund academics up to \$350k/year for 1-3 years.
- QSP will fund SMEs up to \$350k/year for 1-3 years

## NRC-NSERC Joint Alliance Quantum CFP

Call title: “Advancing the industrial readiness of quantum sensing technologies”

Each project must have



- NRC is a **partner** on the application but providing, rather than receiving funding, if approved
- OGDs may participate as (unfunded) partners

# Aligning Federal Programs: NSERC & NRC

## One portal to rule them all (NSERC's)

### NSERC

[Funding opportunities](#) that advance domestic multisectoral partnerships, the development of talent, and international collaborations

- ↳ Alliance Quantum grants
- ↳ Alliance Consortia Quantum grants
- ↳ Alliance International Quantum grants
- ↳ Collaborative Research and Training Experience (CREATE) grants

### NRC

Internal programs, interdepartmental projects, and collaborative research [Challenge Programs](#)

Support to NQS commercialization pillar:

- ↳ [Internet of Things: Quantum Sensors Challenge program](#) (QSP)
- ↳ Collaborative Science and Technology Innovation Program (CSTIP)

### TOGETHER

Alliance Quantum grants  
call for proposals

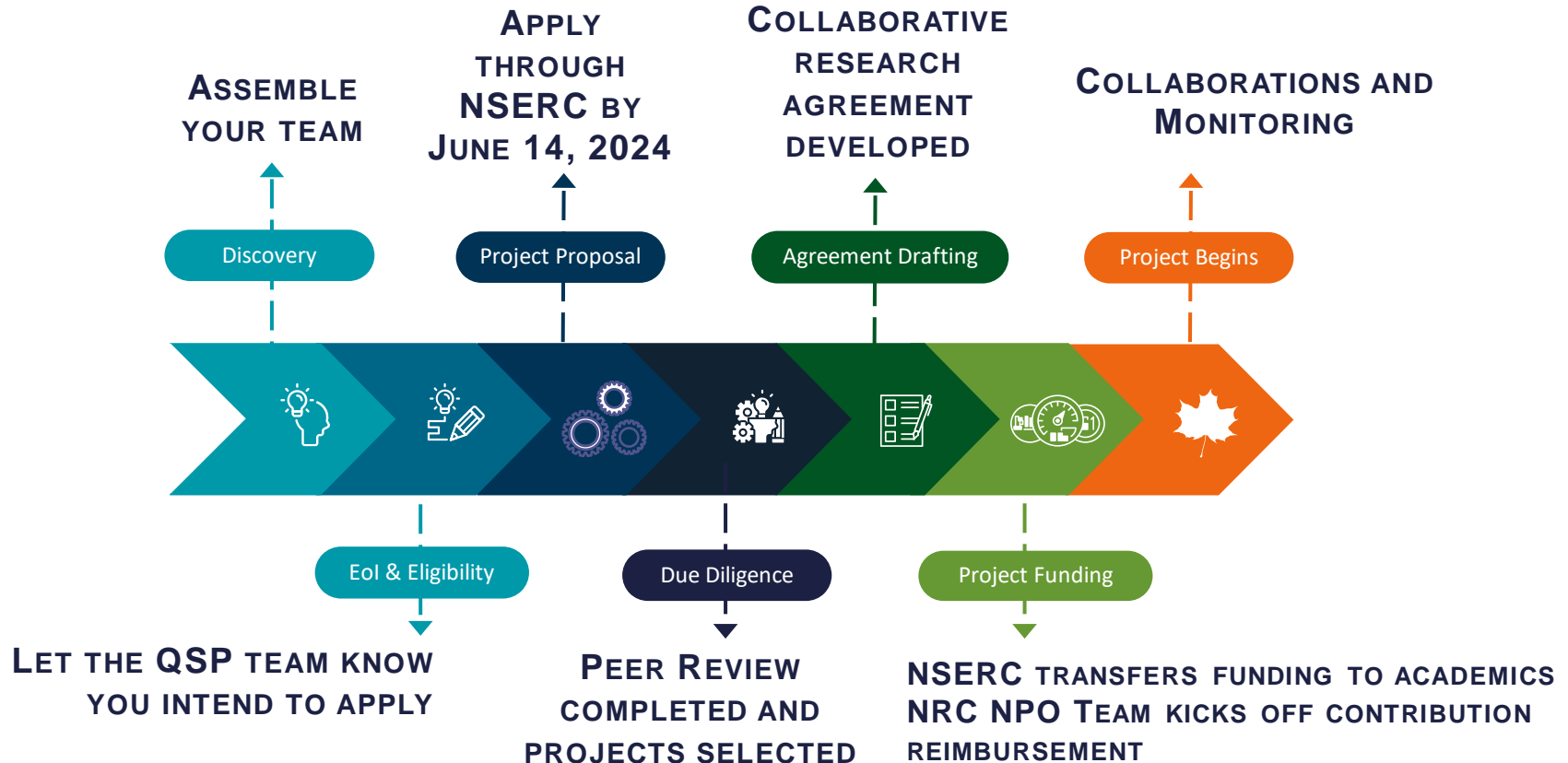
Advancing the industrial readiness  
of quantum sensing technologies

ALBERTA  
INNOVATES

INNOVATION  
Canada Foundation  
for Innovation / Fondation canadienne  
pour l'Innovation



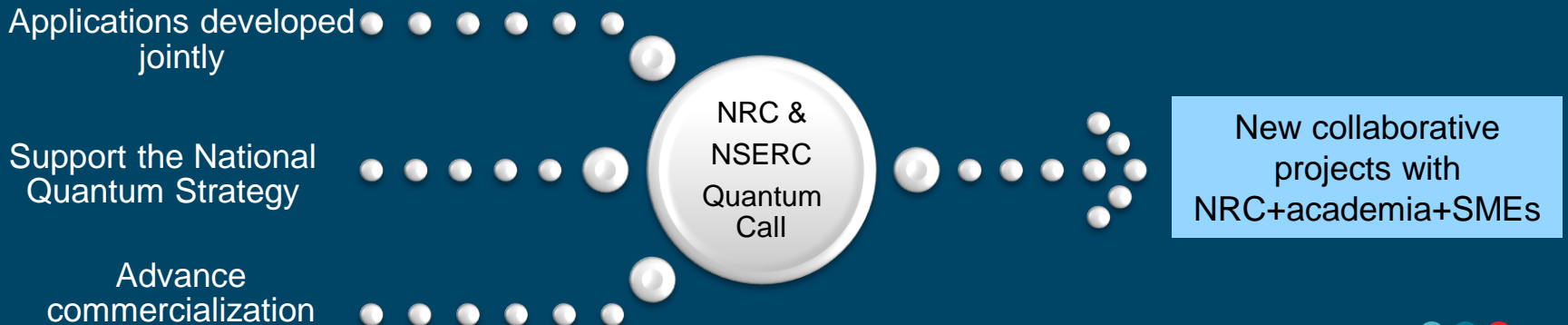
# NSERC/NRC Application process



# Timeline



## Applications submitted via NSERC Application Portal



# FIN

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# BACKUP SLIDES



# Quantum Sensing: Why it's hard to talk about

Application space

Environment

Comms

Novel materials

Biomedical

Navigation

Enabling Technologies

Remote Sensing

Sensor type

Microwave fields

Temperature

Magnetic fields

Precise Timing

Optical fields (imaging)

Charge/current

Inertial

Gravity

Physical system

Photonics

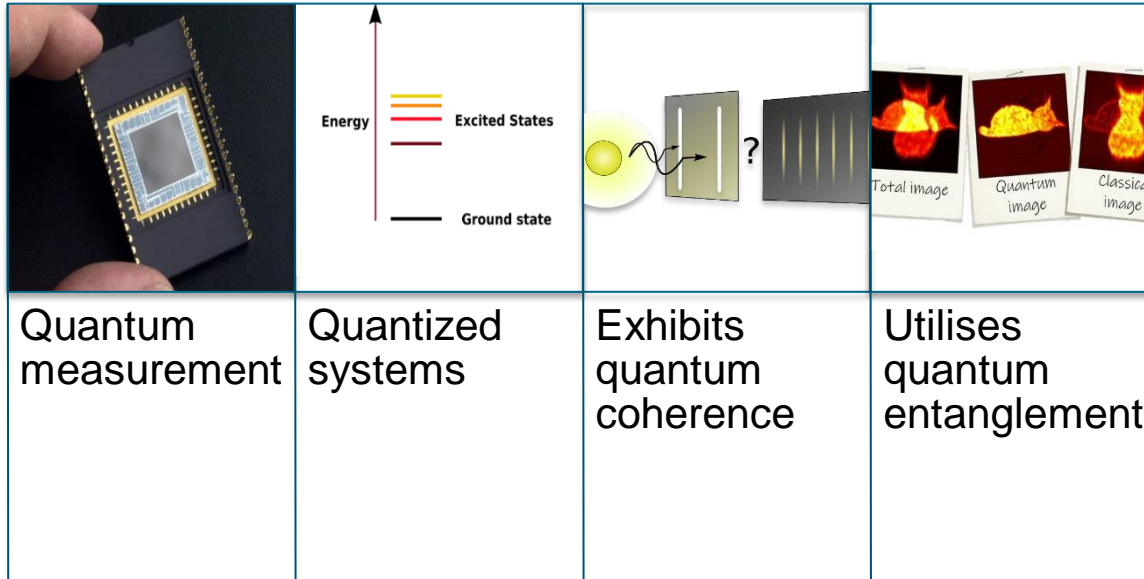
Trapped ion/atom

Super-conducting

Solid-state systems



# Quantum sensing: theme and variations



Mostly  
classical

Full quantum

# Applications of quantum sensing



## Telecom

- Clocks for synchronization and standards



## Medicine

- Improved brain scanning and imaging



## Oil & Gas

- Through-ground imaging



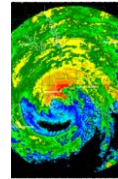
## Finance

- Clocks for time-stamping



## Transportation

- GPS-aided navigation
- Smart city: traffic monitoring



## Environment

- Monitoring climate change
- Detection of weather systems



## Defence, Safety, & Security

- Remote sensing and communication
- Mine detection