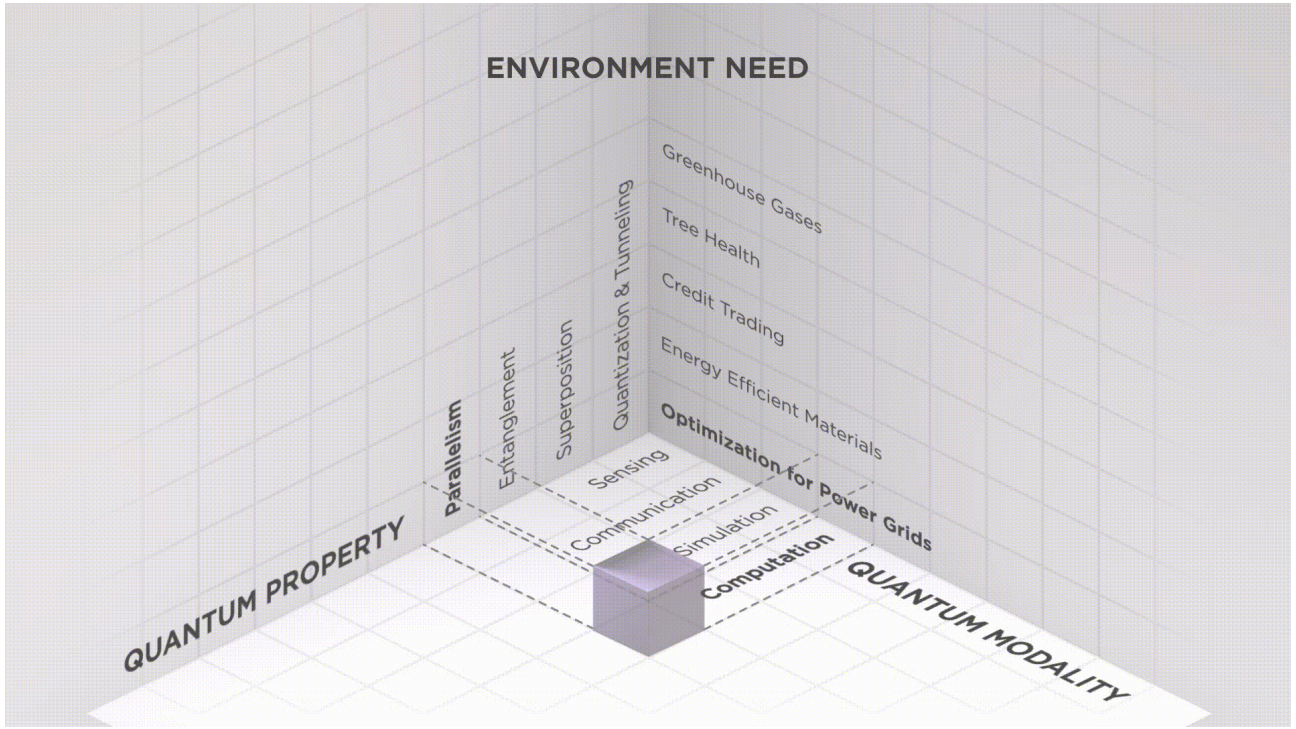
# Quantum for Environment

## Launch Event




**University of Waterloo Territorial Acknowledgement**

*The University of Waterloo acknowledges that much of our work takes place on the traditional territory of the Neutral, Anishinaabeg and Haudenosaunee peoples. Our main campus is situated on the Haldimand Tract, the land granted to the Six Nations that includes six miles on each side of the Grand River. Our active work toward reconciliation takes place across our campuses through research, learning, teaching, and community building, and is co-ordinated within the Office of Indigenous Relations.*

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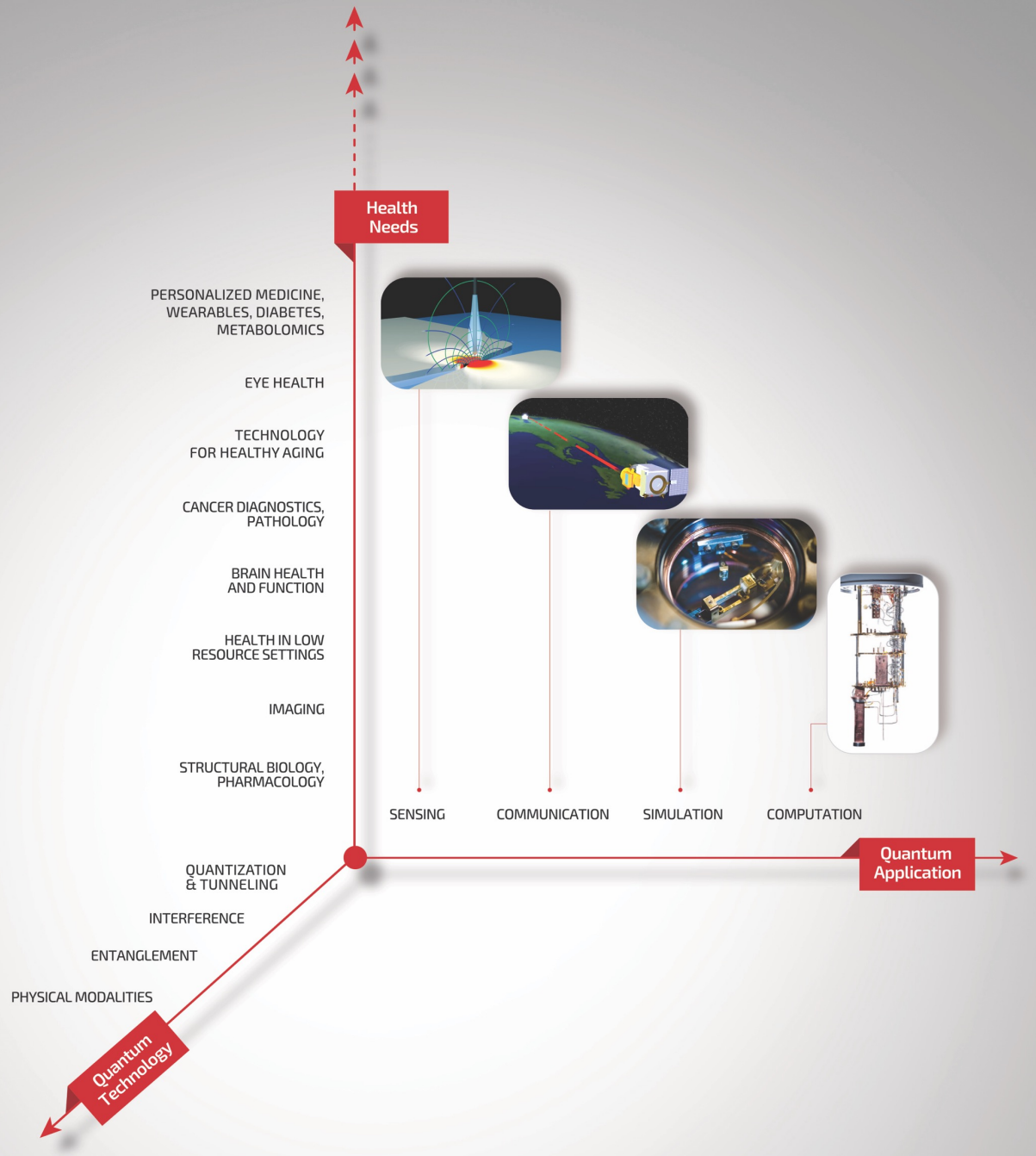
Quantum Valley Ideas Lab

AMBATURE




## Program

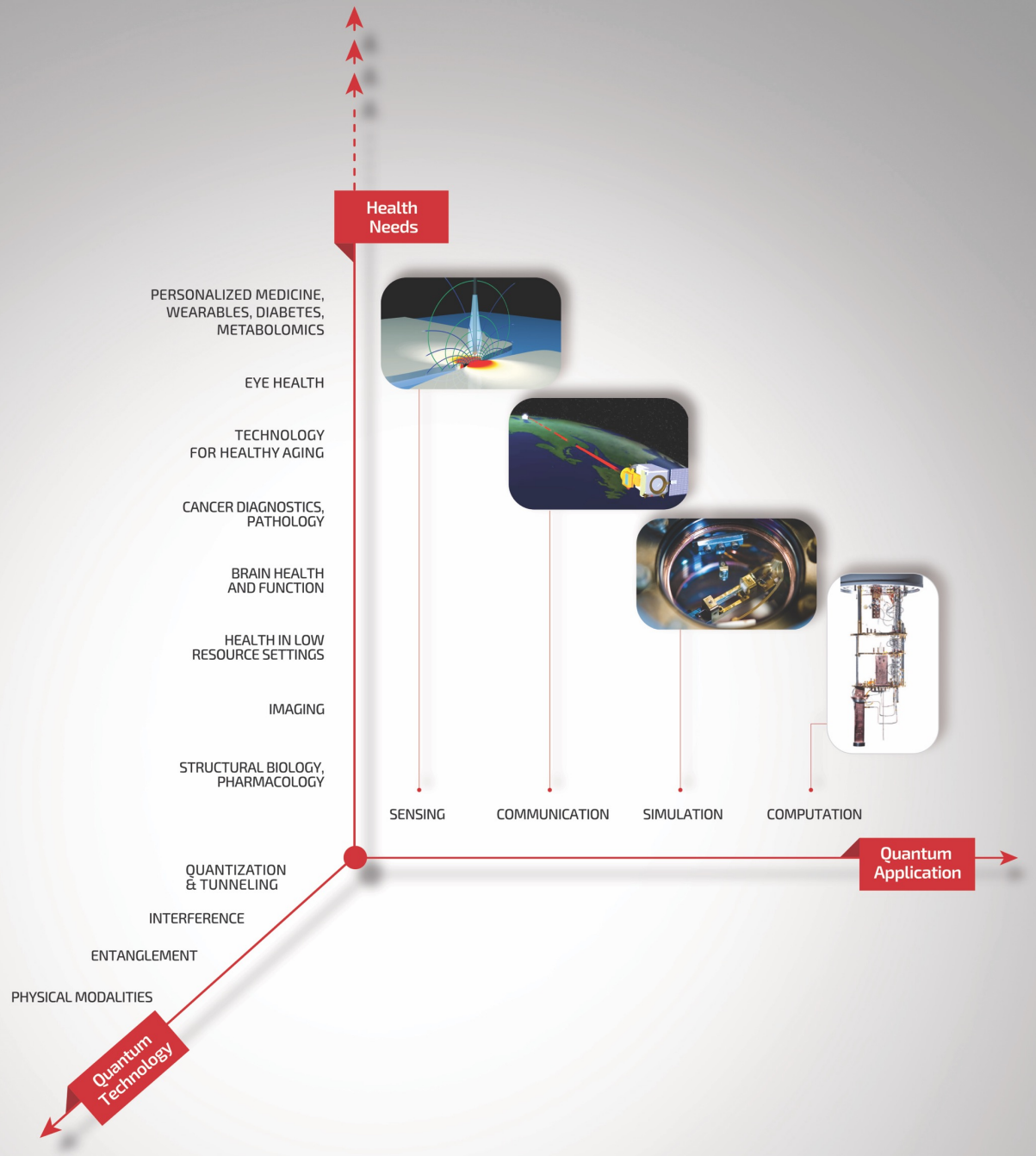
2:00 Welcome to the TQT Design Challenge

- Quantum for Health Award Presentation
- Quantum for Environment Challenge
- Needs/Opportunities, Examples
- How we will Team Build and Brainstorm

2:25 Team building and refreshments

- Review of Outcomes, David & Tracey
- Next Steps

3:45 Close




## Introduction to TQT's Design Challenge

Quantum for ?

- Annual event
- TQT, IQC and Sponsors
  - Quantum Valley Ideas Lab, Award Sponsor
  - Angstrom Engineering, Honourable Mention
  - Ambature, Honourable Mention
- Last Year Q4Health
- This Year Q4Environment
- Next Year ?
  - Energy, Ocean, Connected Societies, Space (please offer suggestions)

The design challenges are to recognize that
(1) quantum technologies will impact our world broadly,

(2) to mine for the most innovative and impactful opportunities we need to look to applications,

(3) UW as the most innovative university in Canada can provide a unique and powerful perspective on where to look for new applications of quantum.

# Honourable Mention Award

## Quantum tools for pathology, Honourable Mention

Jelena Mirkovic

Dmitry Pushin

Dusan Sarenac

# Honourable Mention Award

At-home quantum measurement of urine QuLoo, Honourable Mention

Saba Sadeghi

Peter Sprenger

Dmitry Akhmetzyanov

Jiahui Chen

# Honourable Mention Award

Detecting male infertility by merging electron spin resonance with computer assisted sperm analysis

Veronika Magdanz

Fatemeh Fani Sani

Peter Sprenger

Aaron Lewis

# Honourable Mention Award

## Design and development of a real-time monitoring microfluidic platform for multiplexed diabetes biomarker detection

Mahla Poudineh

Sanjana Srikant

Hesam Abouali

# Silver Award

## Optical metamaterial single photon detectors to improve Raman spectroscopy for use in clinical pathology

Michael Reimer

Sasan V. Grayli

Sarah Odinotski

Lucas Roy

Jack deGooyer

Sathursan Kokilathasan

# Gold Award

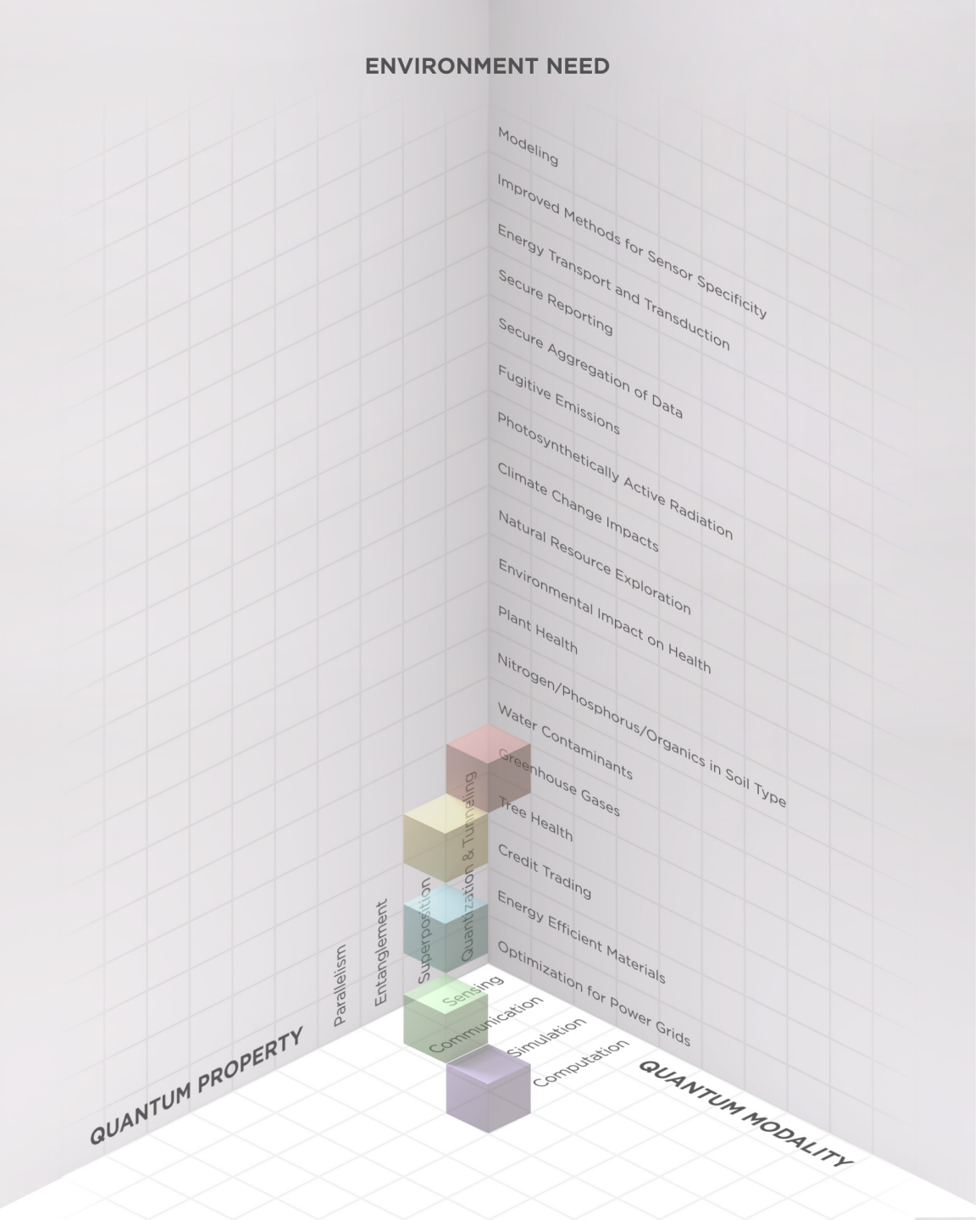
## Entangled Vision: Quantum Probes for Retinal Diagnostics

Dmitry Pushin

Dusan Sarenac

Connor Kapahi

Andrew Silva




# Quantum for Environment

Climate Change
- Modeling
- Methane release (tundra, clathrates, industrial)
- Greenhouse gases
- Aerosols

Earth Imaging/Explorations
- Satellite/drone

Water
- Health of aquatic species

Oceans
- $O_2$, T, pH
- Currents
- Phytoplankton
- Coastal erosion

Human Health Impacted by a Changing Environment
- Vulnerable Communities

Energy
- Energy transport and transduction
- Energy-efficient materials
- Optimization for power grids

Natural Resources
- Tree/plant health
- Natural resource exploration

Agriculture
- Photosynthetically active radiation

Pollutants
- Micro plastics
- Forever chemicals

Data Security
- Secure reporting
- Secure aggregation of data

Finance
- Credit trading

**WHAT IS THE CHALLENGE**

Transformative Quantum Technologies (TQT) presents a design challenge to search for opportunities where quantum technology can advance environment (monitoring, stewardship). This challenge is open to University of Waterloo undergraduate and graduate students, and postdocs.

**WHY QUANTUM FOR ENVIRONMENT**

Quantum technologies allow us to perform tasks with more efficiency and greater precision than is possible in the classical world. Quantum solutions can achieve what would otherwise be impossible. It is compelling to mate these exciting new technologies with the pressing need to advance environmental monitoring and stewardship. Through this challenge, TQT aims to uncover new ways that quantum technologies might have impact in both the near and long term.

Quantum computing – select computational tasks may be exponentially faster.
Quantum simulation – obtain new insights into nature.
Quantum communications – absolute information security.
Quantum sensing – more efficient, more sensitive, more versatile, more tailorable.

The focus is to bring forth ideas that expand the potential reach of quantum technologies, there is no need to reduce ideas to practise to participate in this challenge.

Quantum technology is rapidly emerging (as we will see with the case studies in a moment). The challenge asks that you assume that the quantum technology you need exists, including fault tolerant quantum computers, versatile quantum simulators, secure quantum communication systems, and quantum sensors capable of preparing and using entanglement.

## WHO SHOULD PARTICIPATE IN QUANTUM FOR ENVIRONMENT

The Q4Environment challenge is looking for well-motivated, quantum-based ideas that can lead to innovation.

The focus is on the impacts that new technologies can have.

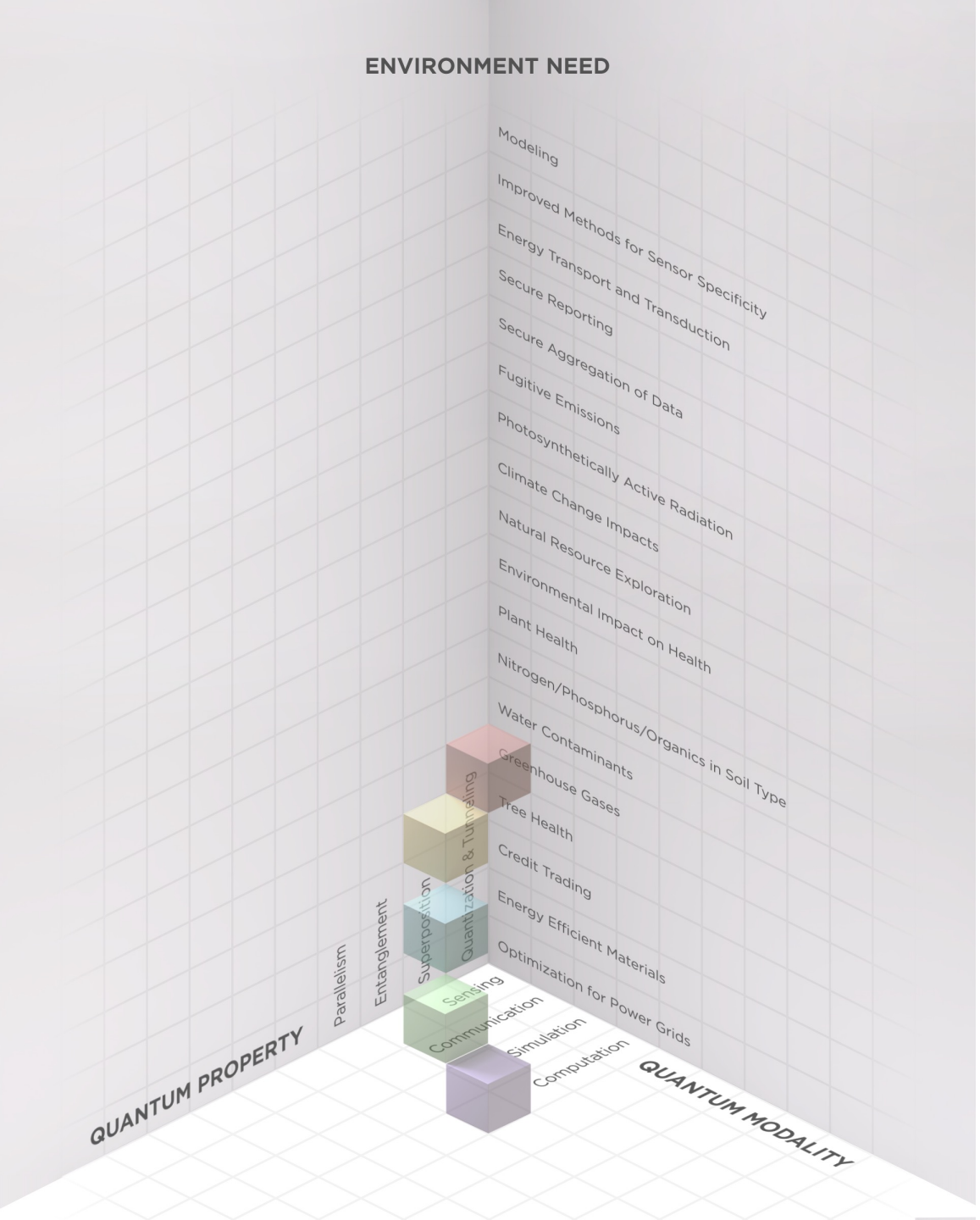
In the design proposal, the technology side should be well founded, but the expectation is that it will not have been reduced to practise. No prototype is required, but the design document should be convincing that the proposed future is possible.

We take a broad view of the environment to include climate change, energy as well as oceans, and the north, for example.

Teams need not have deep knowledge in either the quantum or environment fields, but should have explored what is in general possible. TQT will run a series of short courses to provide introductions to both quantum concepts and environment needs.

**All design submissions must be team based, with a minimum of two people (up to any number).**

The proposal must demonstrate basic knowledge and creativity in environment and in quantum.

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# Quantum For Environment Launch Event

Case Study Presenters

Tracey Forrest

Rebecca Saari

Andrew Todd

Noah Peter Rogozynski

Aiping Yu

Vassili Karanassios

Marie-Chantal Ross

# Quantum Solutions to Improve Aerosol Observation


Rebecca Saari

Professor, Civil & Environmental Engineering

rsaari@uwaterloo.ca


## Impact of having a solution

Aerosols – indoor and outdoor – are the largest environmental risk factor for early death worldwide, responsible for over 5 million deaths each year. Better data can help us to track, study, and solve this issue.

## Problem with current solution

We especially lack data in the most polluted regions, and for the most harmful aerosols. We need cheap, continuous, accurate, global monitoring resolved by size and composition.

# Ocean sensing


**Andrew Todd and Andrea Peruzzi**

Research Officers, Thermometry and Radiometry, National Research Council

**andrew.todd@nrc.gc.ca**
**andrea.peruzzi@nrc.gc.ca**


## Impact of having a solution

A more accurate suite of ocean sensors could help us better understand, model and mitigate change in the ocean affecting climate.

Suggest a new sensing solution to one (or more of): Temperature, Pressure, Salinity or pH that is deployable, long-lasting, and accurate

## Problem with current solution

Better accuracy would allow faster mitigations and improved input to models which would allow better predictions

# Optimizing eDNA technology for use in aquaculture systems


Noah Rogozynski

MSc Student, Comparative Immunology

nprogozy@uwaterloo.ca


## Impact of having a solution

- Faster, more efficient detection of disease outbreaks ultimately reduces the transmission of pathogens from aquaculture stocks to wild fish populations

## Problems with current solution

- Immune genes are polymorphic, especially in newly domesticated species
- RNA degrades rapidly under environmental conditions and must be purified/separated from other filtrates
- Cross-reactive RNAs from closely related fish species can confound readouts and are not easily removed

# Non-destructive solution to sensing salinity in fish


Marie-Chantal Ross

Program Director, NRC

Marie-Chantal.Ross@nrc-cnrc.gc.ca


## Impact of having a solution

If the industry had a non-destructive way of assessing the depth and concentration of the salt absorbed by fish when they are caught, filleted and put on ice, then fish could be better categorized and priced accordingly

## Problem with current solution

Fish quality is assessed through colour and texture on the surface, which is not always a good indicator of taste and nutrition.

# Photocatalytic $CO_2$ Reduction by MXene Quantum Dots Coated $TiO_2$ nanowire


Aiping Yu

Professor, Chemical Engineering

aipingyu@uwaterloo.ca


## Impact of having a solution

1. Enhance the photocatalytic efficiency.
2. Improve selectivity to turn $CO_2$ into certain chemicals.

## Problem with current solution

1. $TiO_2$ is the most cost-effective photocatalyst for $CO_2$ reduction. However, the selectivity of the catalyst is low.
2. There is a need to further improve the efficiency and selectivity to turn $CO_2$ into certain chemicals.

# Quantum technologies as they apply to environmental measurements in the field


Vassili Karanassios

Professor, Chemistry

Co-founder, Nano Technology program

vkaranassios@uwaterloo.ca


## Impact of having a solution

Portable, handheld instruments (shirt pocket size) for chemical analysis will revolutionize chemical analysis and environmental measurements in the field by allowing practitioners to bring the lab to the sample. For example, measurement of Hg in permafrost areas of Canada. In sum, development of high-performance sensors (& micro-instruments) for environmental monitoring, and technology enabling climate-change observations will be proposed.

## Problem with current solution

**Current (existing) solutions are expensive and time-consuming because** environmental samples are (typically) collected in the field and are brought to the lab for analysis.

# Quantum-enhanced soil carbon monitoring


Tracey Forrest

Director, TQT Program

tforrest@uwaterloo.ca


## Impact of having a solution

Important for carbon sequestration, the release of gases and agriculture. Soils contain ~75% of the carbon pool on land and may sequester ~10% of anthropogenic emissions in the next 25 yrs.

## Problem with current solution

Wide range of current solutions with limitations (e.g., slow & invasive). Existing ag market. Emerging carbon market. A good moment to ask, is there a potential role for quantum, and what might that look like?

# Quantum-improved tree health monitoring


Tracey Forrest

Director, TQT Program

tforrest@uwaterloo.ca


## Impact of having a solution

Accurate tree health diagnostics and monitoring would enable early intervention thereby improving tree survival rates and associated biodiversity and carbon sequestration outcomes.

## Problem with current solution

Current large-scale tree-planting efforts lack effective monitoring. Not surprising to see 50% survival rate of trees after 5 years. Is there a better solution available to us through quantum?

# Quantum-improved reliability of satellite-derived measures of methane release


Tracey Forrest

Director, TQT Program

tforrest@uwaterloo.ca


## Impact of having a solution

Early and accurate monitoring of methane release over large areas, e.g., Northern Canada, would serve as an important indicator of the climate change.

## Problem with current solution

Solutions available today are typically location- and time-specific (e.g., an oil & gas facility). Can quantum play a role in enabling dynamic measurement of methane over large geographic areas via satellite?

**Team building activity**

Add ideas (bullet points) to the 12 topic boards

For each topic added to the board suggest what quantum modality will be enabling.

Today, we are collecting ideas.
- Think broad
- Think impact

Today, we are not evaluating if something is possible.
- Be welcoming
- Be open to new possibilities
- Address, where might quantum technology help?

Encourage each other to add to the boards.
- All ideas should find a place.

Quantum Modality

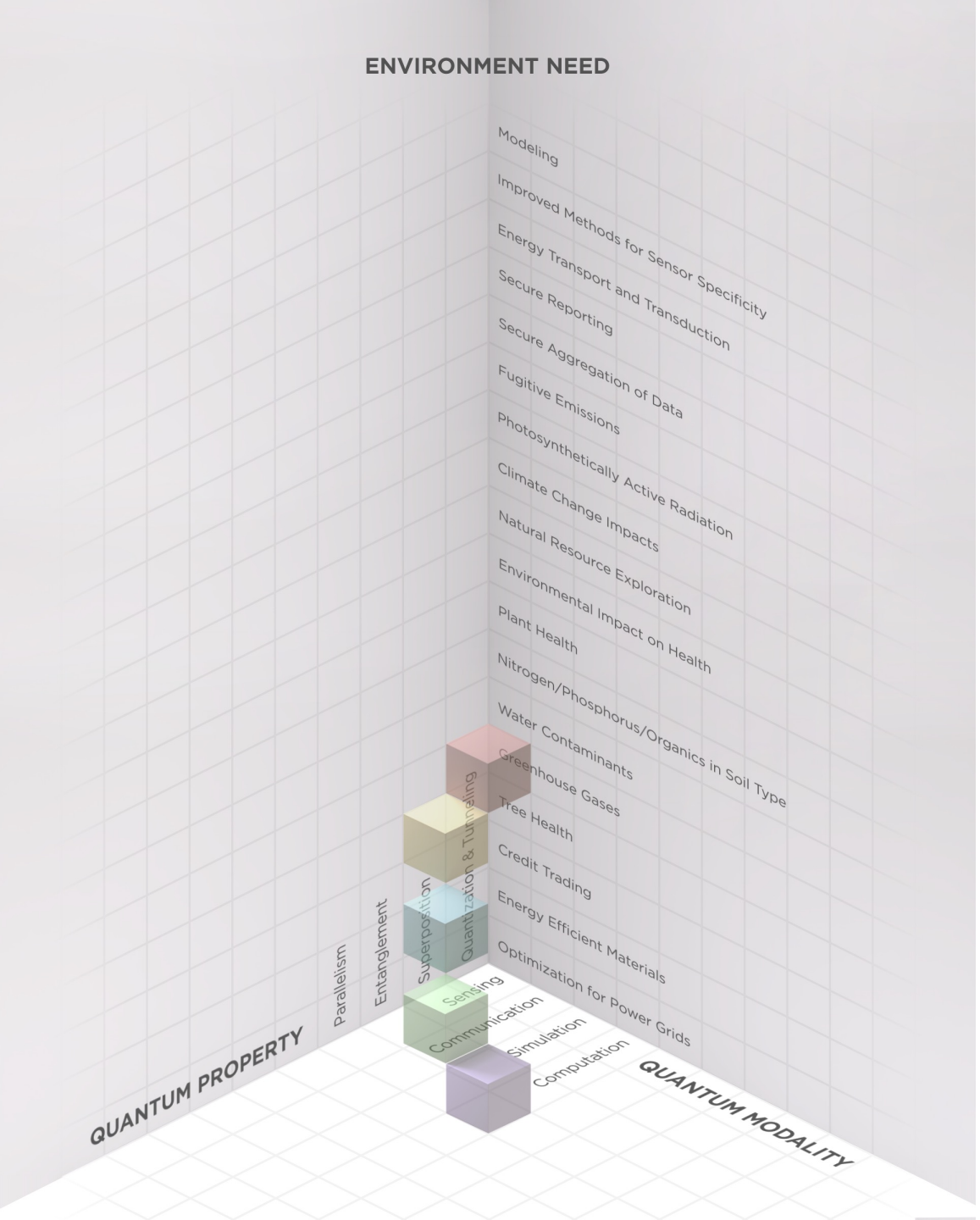
Q1 – Quantum Sensing
Q2 – Quantum Communication
Q3 – Quantum Simulation
Q4 – Quantum Computing

Topics

E1 – Climate Change
E2 – Earth Imaging/Explorations
E3 – Water
E4 – Oceans
E5 – Human Health
E6 – Energy
E7 – Natural Resources
E8 – Agriculture
E9 – Pollutants
E10 – Data Security
E11 – Finance
E12 – Other

# Review of Outcomes for Quantum for Environment

- Brainstorming Session



**NEXT STEPS and KEY DATES:**

- June 6, 2023
  Q4Environment Launch Event

- July 14, 2023
  Registration of teams/topics, assigned a mentor

- October 2023
  Q4Environment @ Quantum Opportunities & Showcase 2023

- February 2024, Designs due
  What environmental question does your solution address?
  Why an answer would be important?
  Why quantum technologies are a path to achieving this outcome?
  What is needed to make this a reality?

- March 2024, Invited presentations, final judging and Awards
  Multiple awards of up to $5,000.

Solo registration QR code

Team registration QR code

**Information Sessions on Quantum Technology and Environment:**

Coming, register your team online at Quantum for Environment.

**Informal Mixers:**

Dates to be announced.

**Velocity and Greenhouse:**

Connect with them to learn about social innovation and how to develop an idea into a business.

tqt.uwaterloo.ca/opportunities/quantum-for-environment-design-challenge/

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