



INTERDISCIPLINARY RESEARCH AT THE UNIVERSITY OF HELSINKI'S FACULTY OF SCIENCE: LESSONS LEARNED AND CASE STUDIES

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Faculty of Science



FACULTY OF SCIENCE

Mission: The faculty builds a sustainable future and fulfills scientific curiosity with research and education utilizing theory, experiments, data and computation.

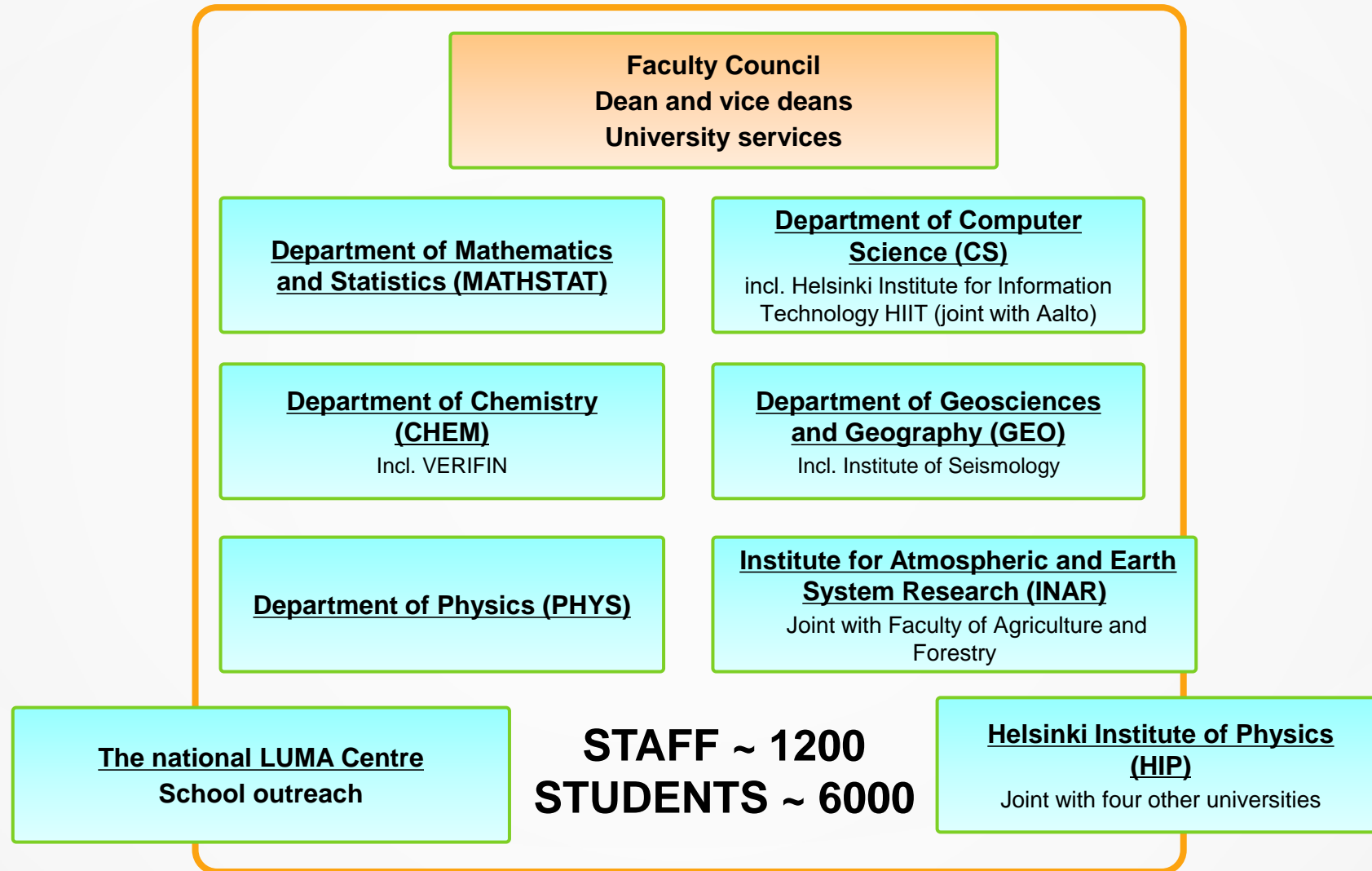
5,555
STUDENTS

1,207
EMPLOYEES

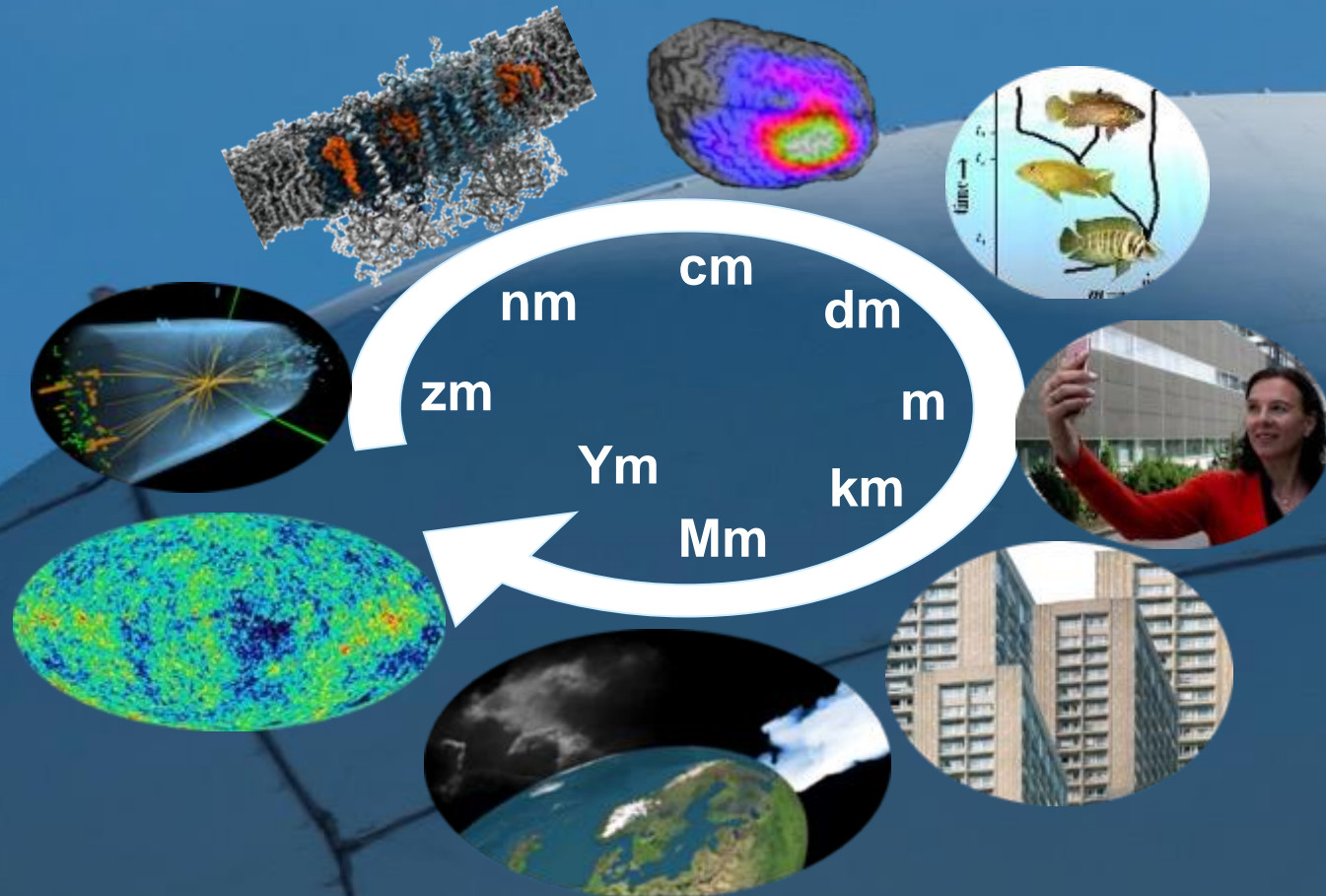
100
BUDGET
(MEUR)



OVERVIEW



RESEARCH ON ALL SCALES



Research at the Faculty of Science encompasses **all length and time scales** known to man – and we are working on discovering even more.

Fostering collaboration
Research
Education
Infrastructure
Innovation



TOWARDS GLOBAL IMPACT

Instruments:

Booster funding

Research Council of Finland

University profile building area (profi)

Flagships and Centers of Excellence

Infrastructure (FIRI)

EU

Horizon Europe, Digital Europe

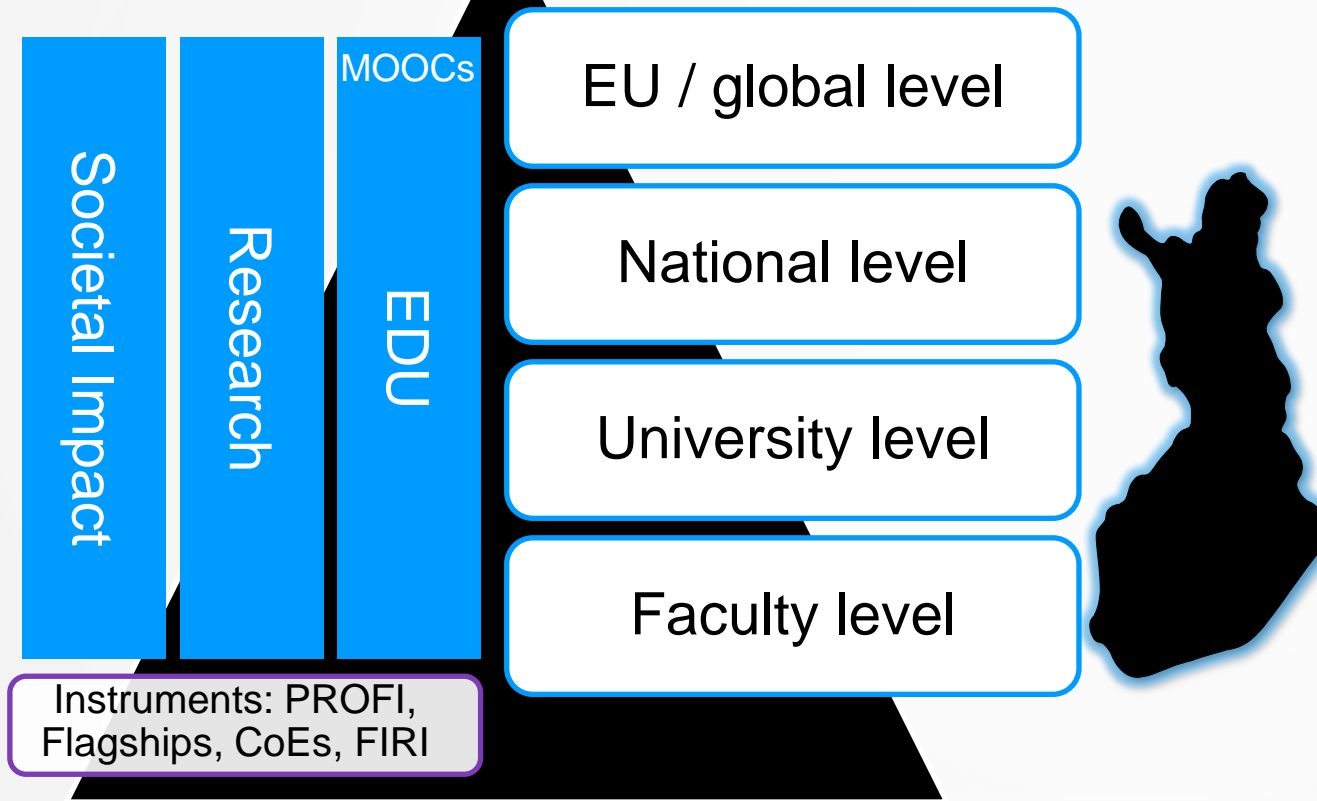
EuroHPC, ESFRIs, ...

ERCs

Profiling building area calls are key instruments for strategic development of research

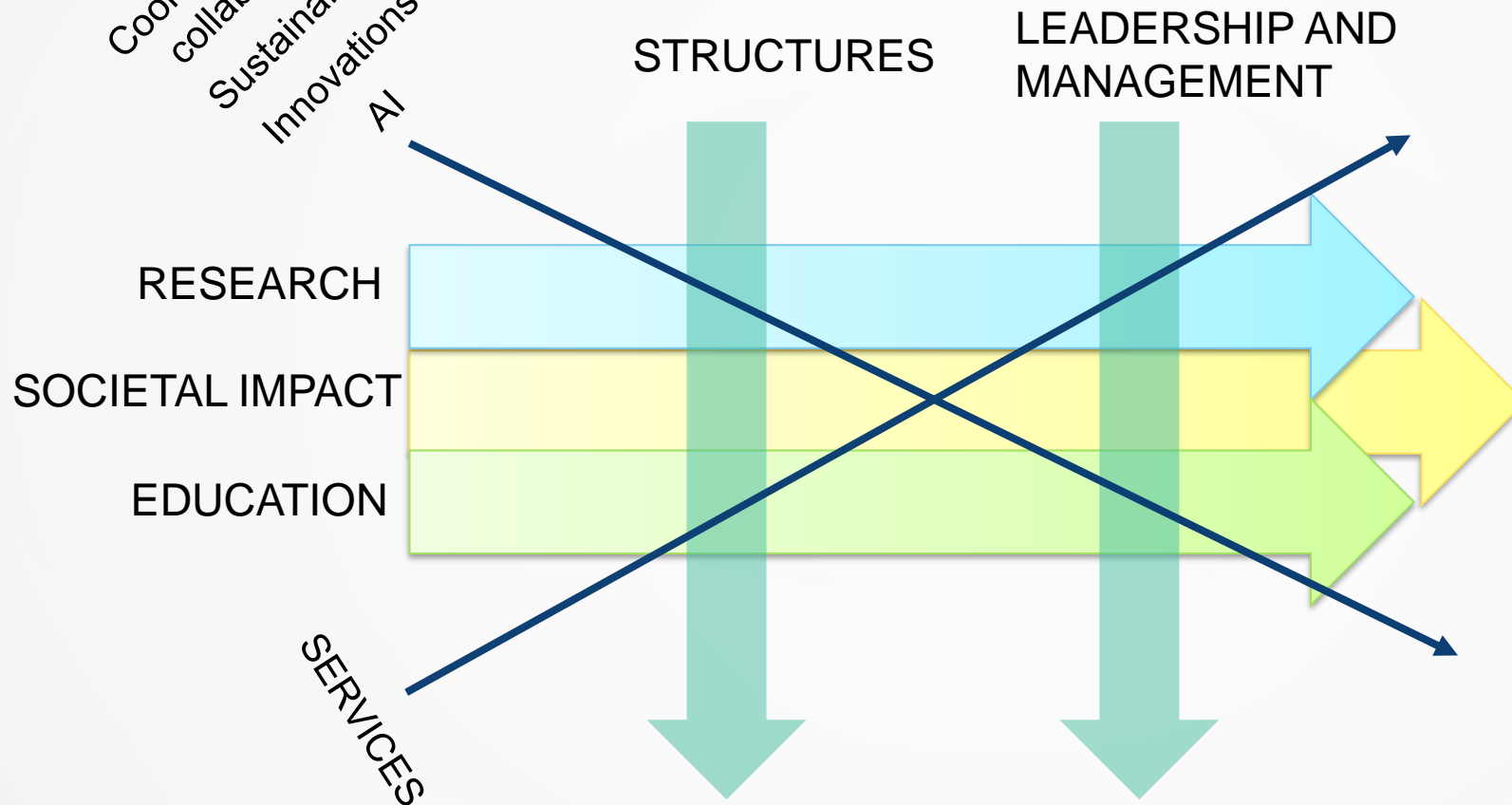
Faculty leadership view: **meeting-in-the-middle** (bottom-up, top-down strategic goals)

BREAKTHROUGH RESULTS





Coordination and
collaboration
Sustainability
Innovations
AI



Multidisciplinarity:
Multiple disciplines
address a common
problem, but their
contributions remain
separate. For example,
urban studies

Interdisciplinarity:
Disciplines merge in
methods or theory, leading
to new insights or
frameworks, often forming
new fields of study, for
example **data science**
and **atmospheric
sciences**



RESEARCH HIGHLIGHTS

- QUANTUM TECHNOLOGY
- ARTIFICIAL INTELLIGENCE (AI)
- ATMOSPHERE, CLIMATE CHANGE, AND ENVIRONMENT
- MATHEMATICS, INVERSION PROBLEMS
- PARTICLE AND SPACE PHYSICS
- ENERGY AND MATERIALS RESEARCH

FLAGSHIPS

- Atmosphere and Climate Change Competence Center ACCC
- Mathematics for Sensing, Imaging, and Modelling FAME
- Quantum Technology FQF
- Finnish Center for AI FCAI

ACCC Flagship

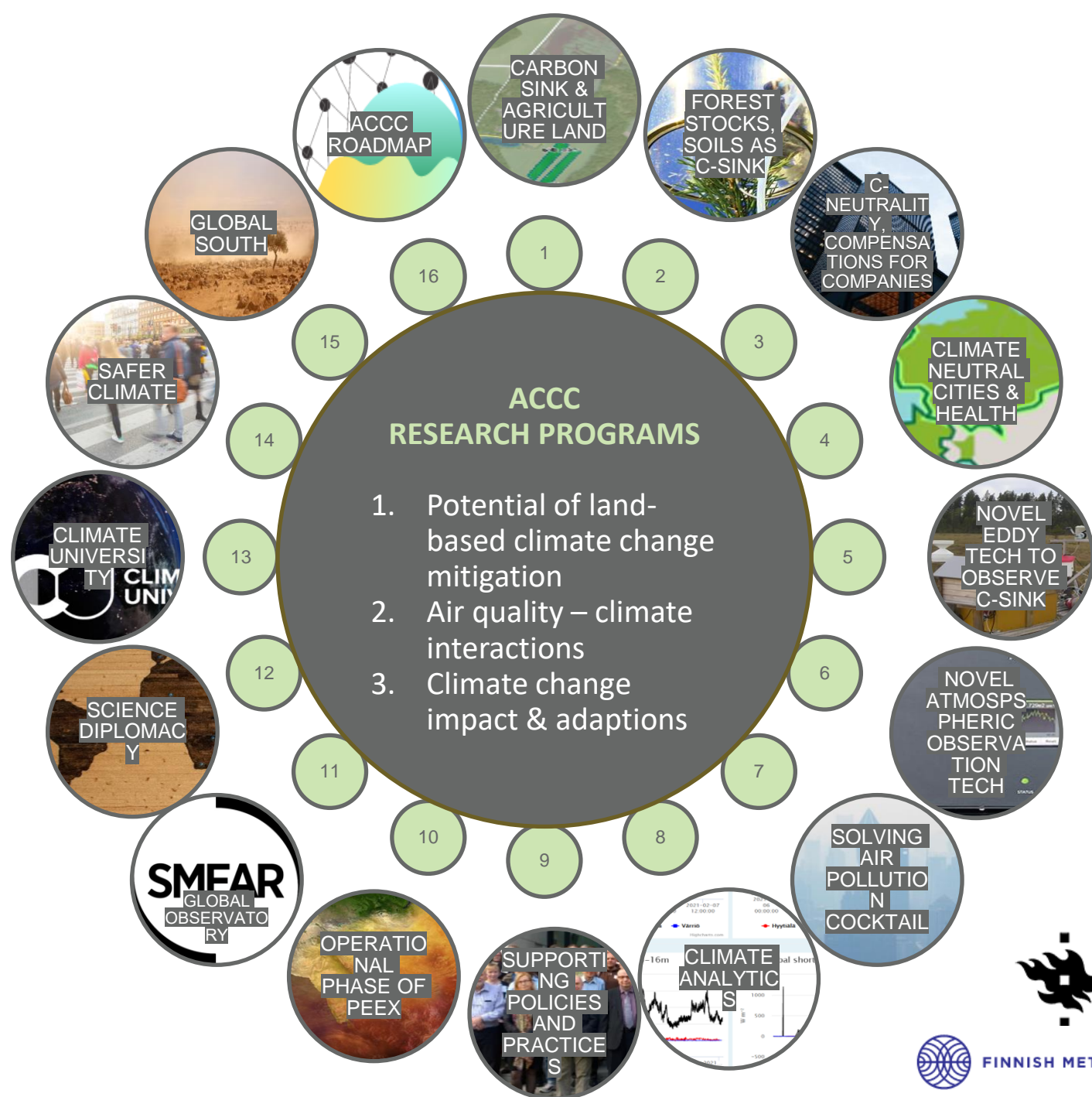
Atmosphere and Climate
Competence Center

Vision: **Safe Climate and Clear Air**

International top science on
Atmosphere – Earth surface
interactions

Leading role in developing
European environmental ESFRIs:
ICOS, ACTRIS, eLTER

Increasing business collaboration
and impact in society



FROM DEEP UNDERSTANDING TO PRACTICAL SOLUTIONS

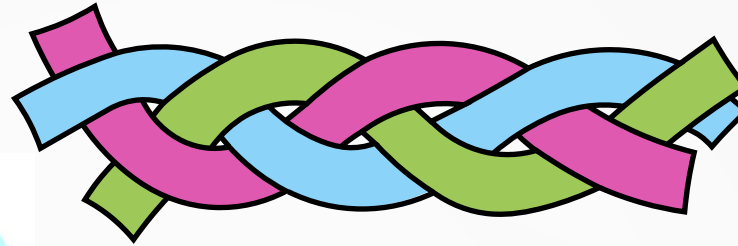
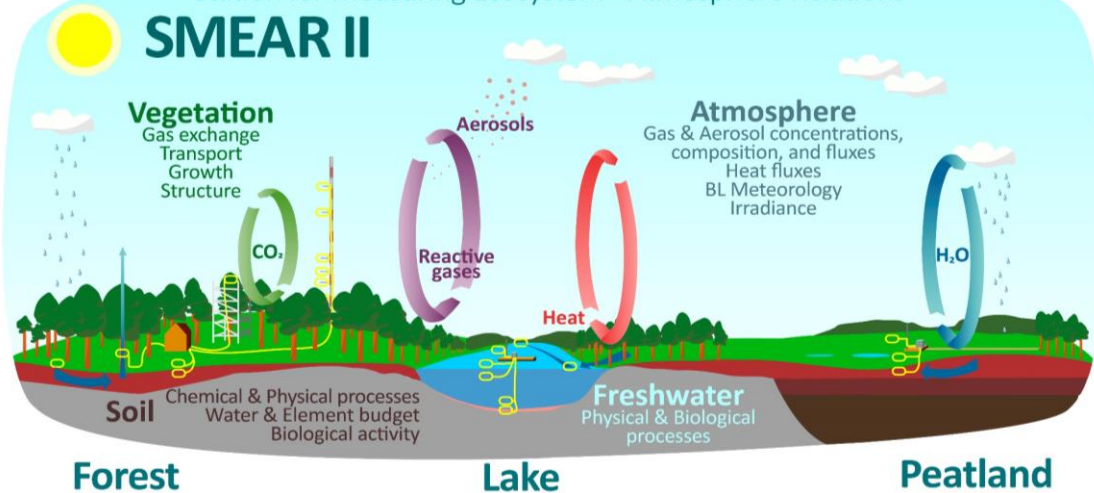


Data from our stations contribute to European Research Infrastructures

Continuous comprehensive observations

Station for Measuring Ecosystem - Atmosphere Relations

SMEAR II



Theory & Modelling



Experiments



Artificial intelligence

Academy of Finland Center of Excellence VILMA:
Virtual laboratory for molecular level atmospheric Transformations

- Next generation models for tackling the enormous chemical complexity of atmospheric air
- Novel instruments with robust error estimates
- Artificial intelligence designed for and adopted by atmospheric scientists

Academy of Finland flagship ACCC: The Atmosphere and Climate Competence Center

- Potential of land-based climate change mitigation
- Air quality- climate interactions
- Climate change impacts & adaptation



ACCC

CLEAN AIR. SAFE CLIMATE.





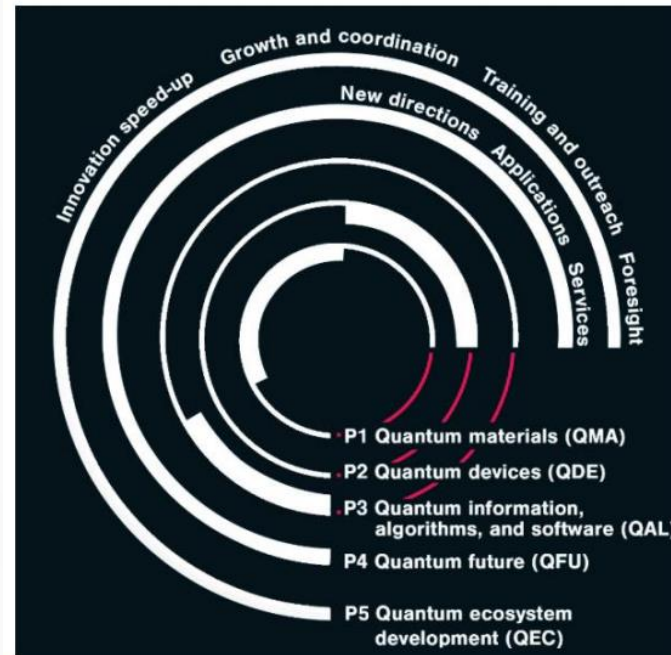
FINNISH QUANTUM FLAGSHIP (FQF)



- Brings together Finland's leading quantum experts in physics, computational science, mathematics, nanoscience & nanotechnology, and economics.

- Goals

- Initiate new business and research ventures across universities, industry, and research institutions.
- Attract, train and retain top local and international talent.
- Raise awareness in Finnish society via open-access courses and training
- Activate new relationships with other organizations in the Nordics, Europe and beyond.



- 8-year project (2024-31)
- 13M € budget (first 4 years)
- Housed within InstituteQ
- Host organizations
 - Aalto (coordinator)
 - VTT
 - University of Helsinki
 - University of Jyväskylä
 - Tampere University
 - University of Oulu
 - CSC – IT Centre for Science





QUANTUM IN FINLAND: INSTITUTEQ

- 550 university & research institute experts. (2022)
- 307 publications (2021-22)
- 19 PhD, 30 MSc (2021-22)
- 42 invention disclosures (2021-22)
- 26 patents (2021-22)
- 3 spinouts (2021-22)
- 50 companies (2022)
- 460 private sector experts (2022) 2x Den, 5x Ger
- 8 QT start-ups (2022)
- 250M € cumulative private investment since 2012

Quantum technology expertise in Finland

InstituteQ members

Tampere University

Novel quantum materials and metamaterials | Quantum emitters and lasers | Quantum photonics | Theory of quantum many-body systems

CSC

Hybrid high-performance computing and quantum computing infrastructure (HPC+QC) | Deployment of QKD in Finland

University of Turku

Quantum foundations | Optical methods

Aalto University

Superconducting technologies | Quantum materials | Integrated quantum photonics | Sensing applications | Quantum computers | Algorithms and software | Quantum communications engineering | Quantum foundations | Market emergence

University of Oulu

Quantum simulations | Cybersecurity Quantum error correction | Molecular qubits | NV-centers

University of Jyväskylä

Superconducting circuits | Quantum materials | Radiation sensors | Quantum algorithms and software | Precision measurements | Atomic clocks | Quantum photonics

University of Eastern Finland

Micro- and nanodiamond synthesis | Quantum-enhanced electromagnetic measurements | Quantum photonics

University of Helsinki

Quantum algorithms and software | Quantum simulations and NISQ | Quantum information and foundations | Quantum education research | Quantum philosophy

VTT

Microsystems design and fabrication | Quantum components and architectures | System integration | Quantum computers | Quantum standards, and atomic clocks | Deployment of QKD in Finland





TIMELINE FOR DATA SCIENCE AND AI

European Network of AI Excellence Centres (ELISE, 2020-2024)
European Lighthouse on Secure and Safe AI (ELSA, 2022-2024),
Horizon Europe, ELLIS Unit Helsinki
European Lighthouse of AI for Sustainability (ELIAS, 2023-2026),
Horizon Europe, Univ. Helsinki Affiliated Partner

Preparation
for ELLIS
Institute

ELLIS Unit Helsinki

FCAI: Finnish Center for AI

HiDATA: Helsinki Centre for Data Science

Continuation as a HIIT program

Data Science M.Sc. program

2017

2018

2019

2020

2021

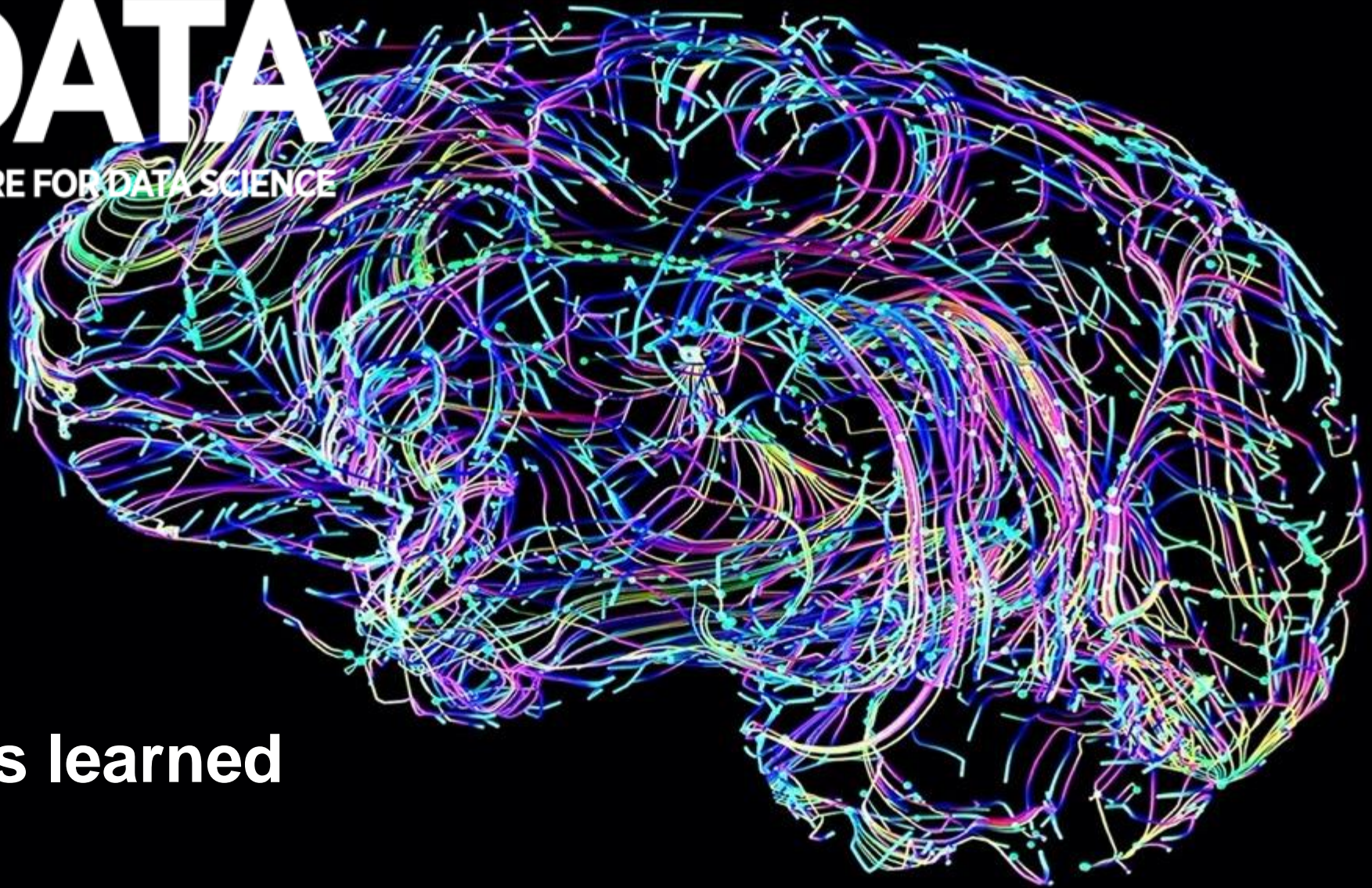
2022

2023

2024

HiDATA

HELSINKI CENTRE FOR DATA SCIENCE



Lessons learned



MISSION OF HIDATA

Helsinki Centre for Data Science (HiDATA) is a world-class hub of Data Science in Helsinki.

The large multi-disciplinary network of researchers works on both methods and applications. HiDATA is a joint hub of the University of Helsinki and Aalto University

The overarching goal of HiDATA is to leverage the synergies of the network in solving significant societal and industrial challenges related to data analysis

- **Core methodology:** Develop new data science methodology, algorithms and platform technology
- **Collaboration:** Increase collaboration between data science, application disciplines and industry
- **Infrastructures:** Ensure improved use and development of the computational infrastructures
- **Open science:** Advance open science
- **Education:** Collaborate in master and doctoral programmes



ORGANIZATION



HiDATA has a Steering Group (management team)



HiDATA has an Advisory Group with representatives from different faculties in U. Helsinki and from Aalto University



HiDATA collaborates closely with the AI Flagship (Finnish Center for AI, FCAI)



HiDATA contributes to the digitalization programme roadmaps of the universities and has close collaboration with the City of Helsinki



Events and internal meetings for principal investigators and supporting the Data Science community in Helsinki



RECRUITMENT OF EIGHT HIDATA PROFESSORS



Data-Intensive Computing in **Natural Sciences**: **Professor Jukka Nurminen**

Parallel and Distributed Data Science: **Professor Keijo Heljanko**



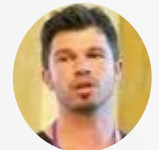
Spatiotemporal Data Analysis for Sustainability Science: **Associate professor Laura Ruotsalainen**

Computer Science and **Atmospheric Sciences**: **Associate professor Kai Puolamäki**



Machine Learning and AI: **Assistant professor Dorota Glowacka**

Machine Learning and AI: **Associate professor Antti Honkela**



Knowledge discovery in big data: **Associate professor Simon Puglisi**

Privacy-aware and secure data science: **Associate professor Nikolaj Tatti**





Lessons learned

- Community building requires many events and physical spaces
 - 25+ public events organized by HiDATA and bottom-up research meetings and events
 - The concentrated effort gives a pulse to the community
- It is important to identify and leverage synergies
 - For example, 8 new data science professors connected with the flagships and profiling areas (FCAI, ACCC, Quantum Tech, HELSUS sustainability network)
 - Infrastructure development and connecting with industries
- Alignment of community interests and aspirations with the instruments and their development, communication of the possibilities for collaboration and funding
- Crucial to find and empower champions to advance topics
- Centers and networks have a life-cycle, renewal after cycle



Finnish Center for Artificial Intelligence FCAI

- Aims to create new types of AI, which can operate with humans in the complex world, and to renew the Finnish industry and society with this Real AI
- Scientific goals: data efficiency, trust and ethics, understandability



Key facts

- Academy of Finland research and impact flagship for 2019–26, volume 250 M€
- Initiated by Aalto University, University of Helsinki, and VTT Technical Research Centre of Finland
- Built on the long track record of pioneering machine learning research in Finland, 70 professors and their groups contributing

FCAI Finnish
Center for
Artificial
Intelligence

FCAI

Top-ranked
research in our core
fields*

Research
ranked #1 in
Europe

Extensive
FCAI ecosystem

470 industry
& public
sector
members

Major leaps
towards AI literacy
for all

Elements of
AI MOOC:
950 000+
students

Key position
in the European
AI ecosystem

Host for
Finland's
ELLIS Unit

Contributions
to the strategic AI
roadmaps

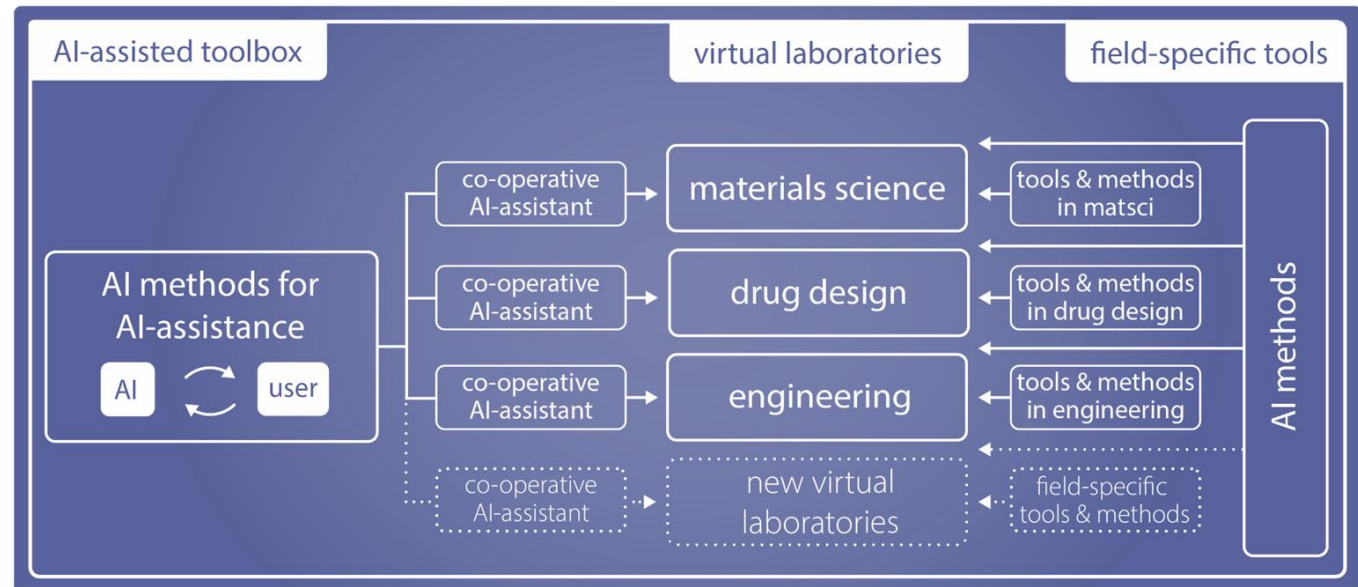
Finland's AI
program,
European AI
SRA

**) Combination of artificial
intelligence, machine learning,
human-computer-interaction,
2019–21*

Virtual labs – transforming research with AI

AI to accelerate the scientific process to meet global challenges

- Amalgamate scientific research and R&D in industry with AI assistance
- Seamless operation of physical and virtual measurements in close collaboration with AI
- Technologies generalize across sciences and laboratories



Finland's notable investments in computing infrastructure

- Spearhead: EuroHPC supercomputer LUMI – fastest in Europe and fifth globally

Klami A, Damoulas T, Engkvist O, Rinke P, Kaski S. Virtual laboratories: transforming research with AI. *Data-Centric Engineering*. 2024. doi:10.1017/dce.2024.15

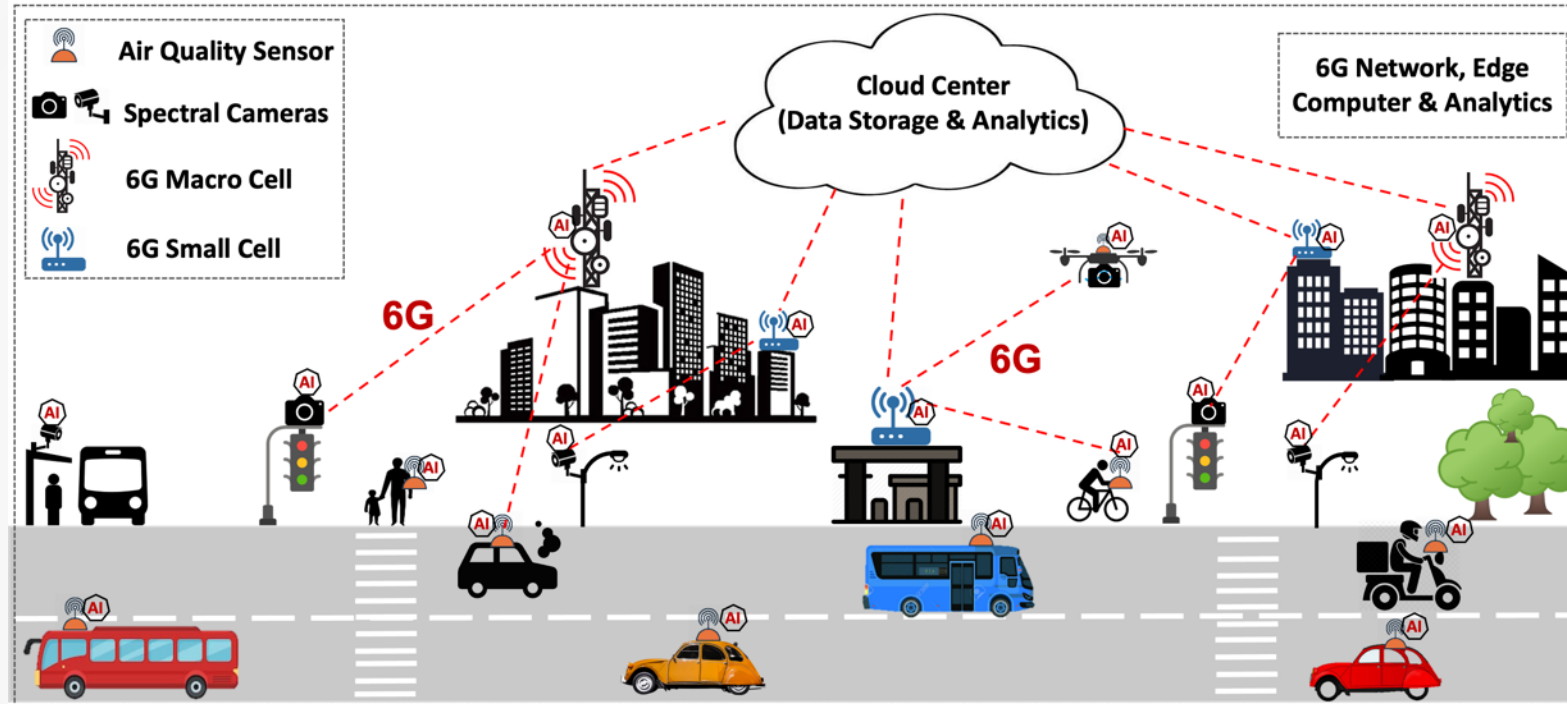


MegaSense as an interdisciplinary opening: Our starting point: station for measuring ecosystem-atmosphere relations (SMEAR)





MEGASENSE: ARCHITECTURE FOR MASSIVELY DEPLOYED ENVIRONMENTAL SENSORS



High spatio-temporal accuracy
Near real-time measurement
Self-calibrating sensor mesh



MOBILE AQ MONITORING



MEGASENSE LCS DATA VISUALISATION

PM_{2.5} monitored by 15 fixed LCS. The dark clouds show PM_{2.5} concentrations



Three months of AQ data from 20 fixed LCS in a mall



Art and science



CONCLUSIONS

Bottom-up formation of research and education excellence guided by strategy

Meeting-in-the-middle

Booster funding for new openings on faculty and university level

Synergies of research instruments (national, EU, global)

Connecting people, communities, infrastructure

Infrastructure development is key

Interdisciplinary research takes time and patience, it can take several years for building momentum and scientific impact across fields



DISCUSSION POINTS

Breaking Silos: What are the main barriers within our institution that hinder interdisciplinary collaboration? How might we break down these silos to encourage meaningful, cross-departmental work?

Reward Systems and Funding: How can we design reward and evaluation systems that recognize and incentivize interdisciplinary and multidisciplinary research, given that traditional metrics often favor single-discipline achievements? How can we encourage funding bodies and donors to value research that may not fit into traditional categories?

Curriculum Development: What would an ideal curriculum look like that genuinely prepares students for interdisciplinary collaboration? How can we equip students with both deep expertise and the adaptability to work across fields?

Role of Leadership: What role should academic leaders play in facilitating interdisciplinary research and education? How active should leaders be in guiding the strategic focus of interdisciplinary initiatives, versus allowing organic collaborations to form?

Sustainability of Interdisciplinary Programs: What steps can we take to ensure the long-term sustainability of interdisciplinary programs, especially when they do not always align with traditional departmental structures?



THANK YOU!