CERN Knowledge Transfer and Collaboration Opportunities in Cryogenics

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CERN | Knowledge Transfer
Accelerating Innovation

CIPEA CERN Innovation Programme on Environmental Applications

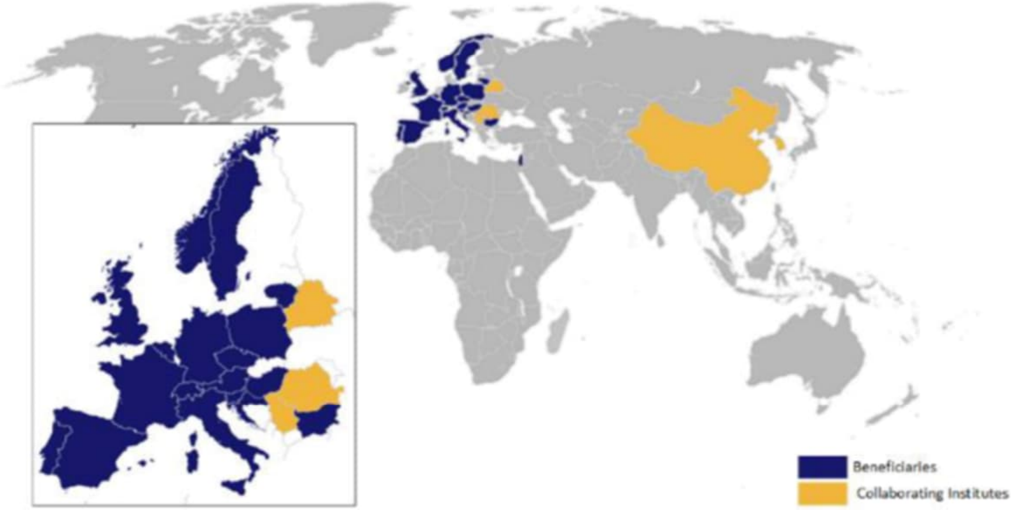
Context: AIDAinnova WP2 Communication, Outreach and Knowledge Transfer

AIDA innova

Advanced European Infrastructure for Detectors at Accelerators

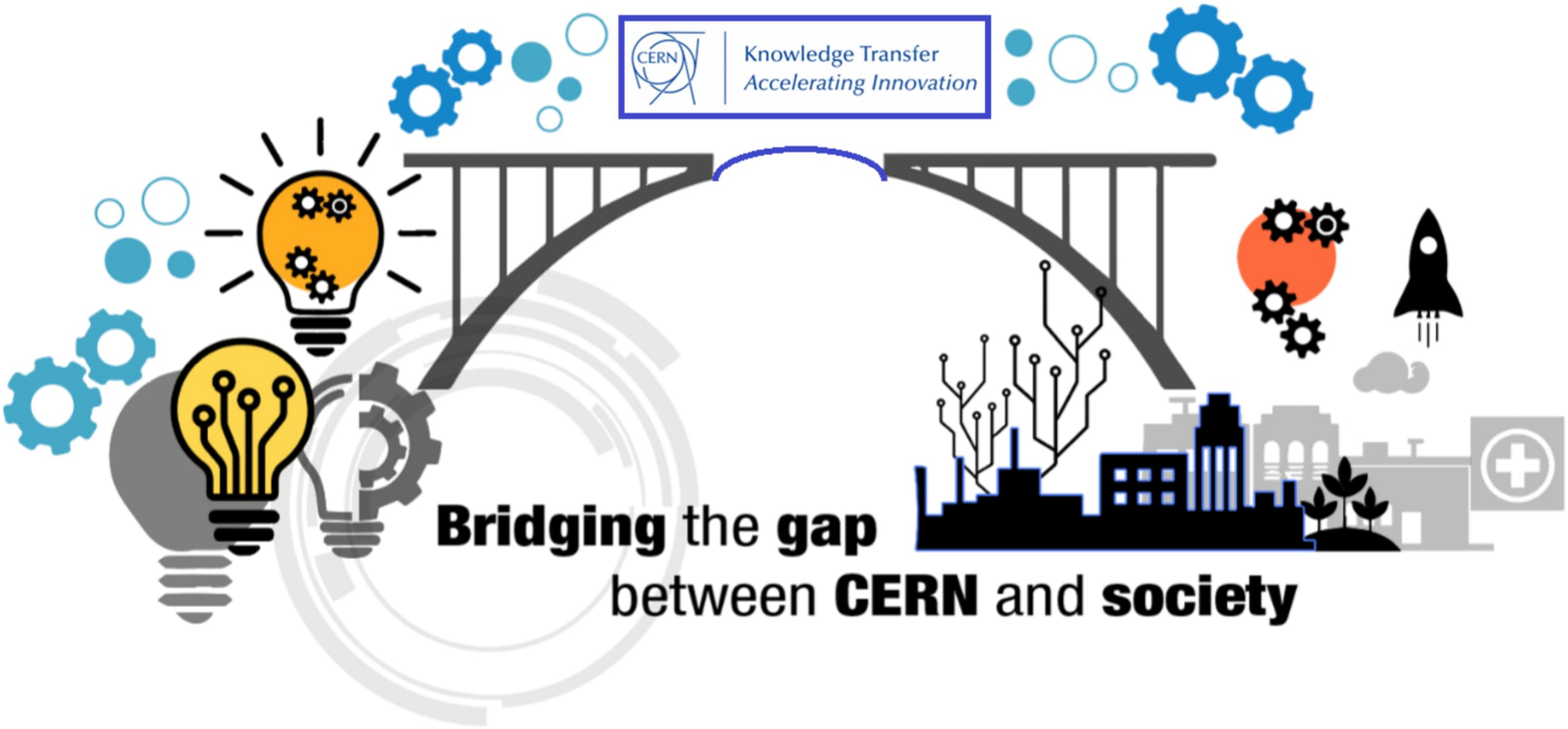
AIDAinnova is the **largest** European program on R&D for detectors for High Energy Physics (HEP)

- Collaborative framework
- Infrastructure: common interest
- 15 countries
- 46 beneficiaries
  - 35 academic + 11 industrial and RTOs
  - + 10 associated partners
- Duration: 01/04/2021 - 30/03/2025
- Coordinating institute: CERN
- Scientific coordinator: F. Sefkow (DESY) (first year), Paolo Giacomelli (INFN)
- EC contribution **10.0 M€**
- Total budget **~26 M€** (co-funding of **~16 M€)**
- Activities:
  - Joint Research & Networking activity
- Website: https://aidainnova.web.cern.ch

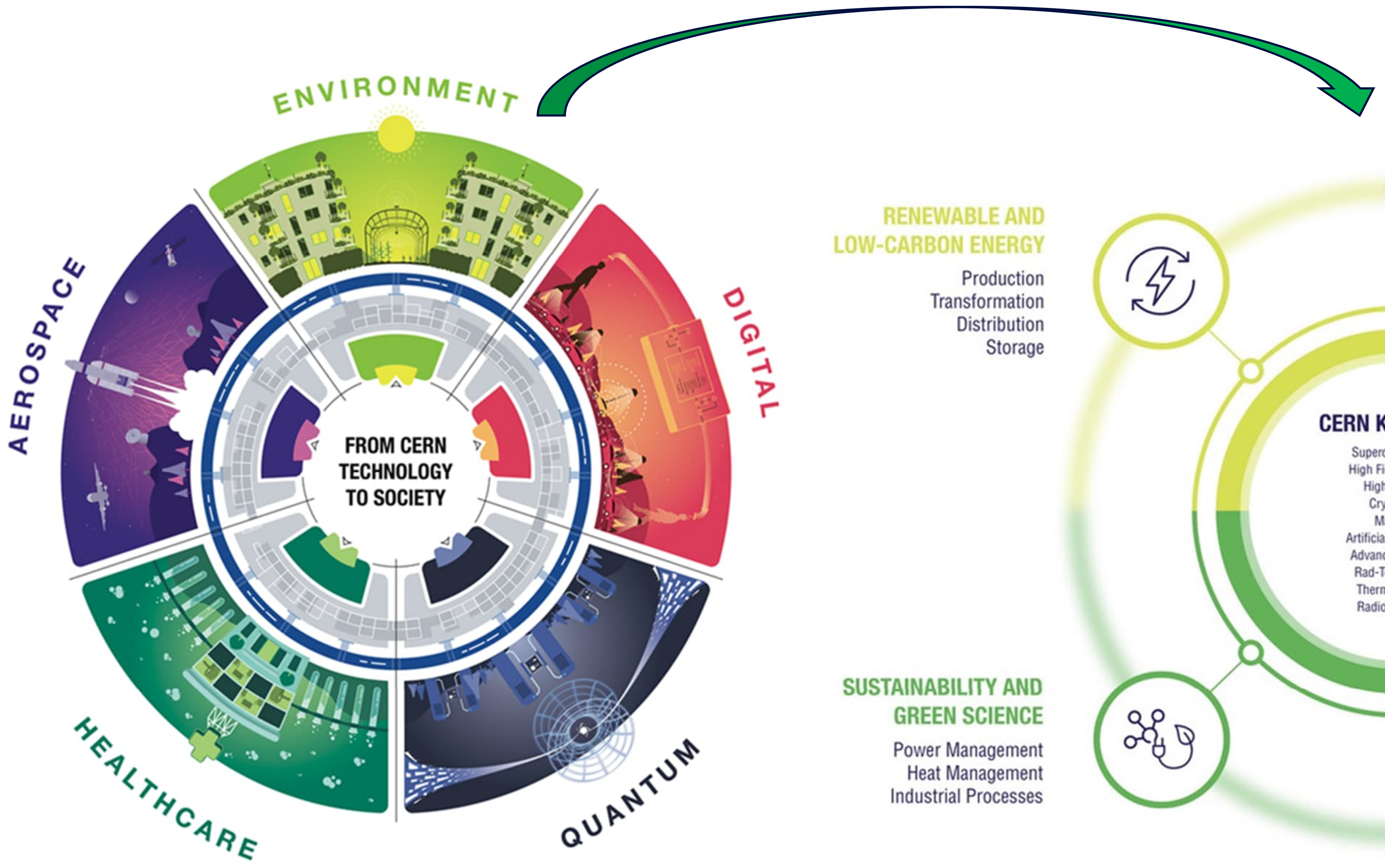


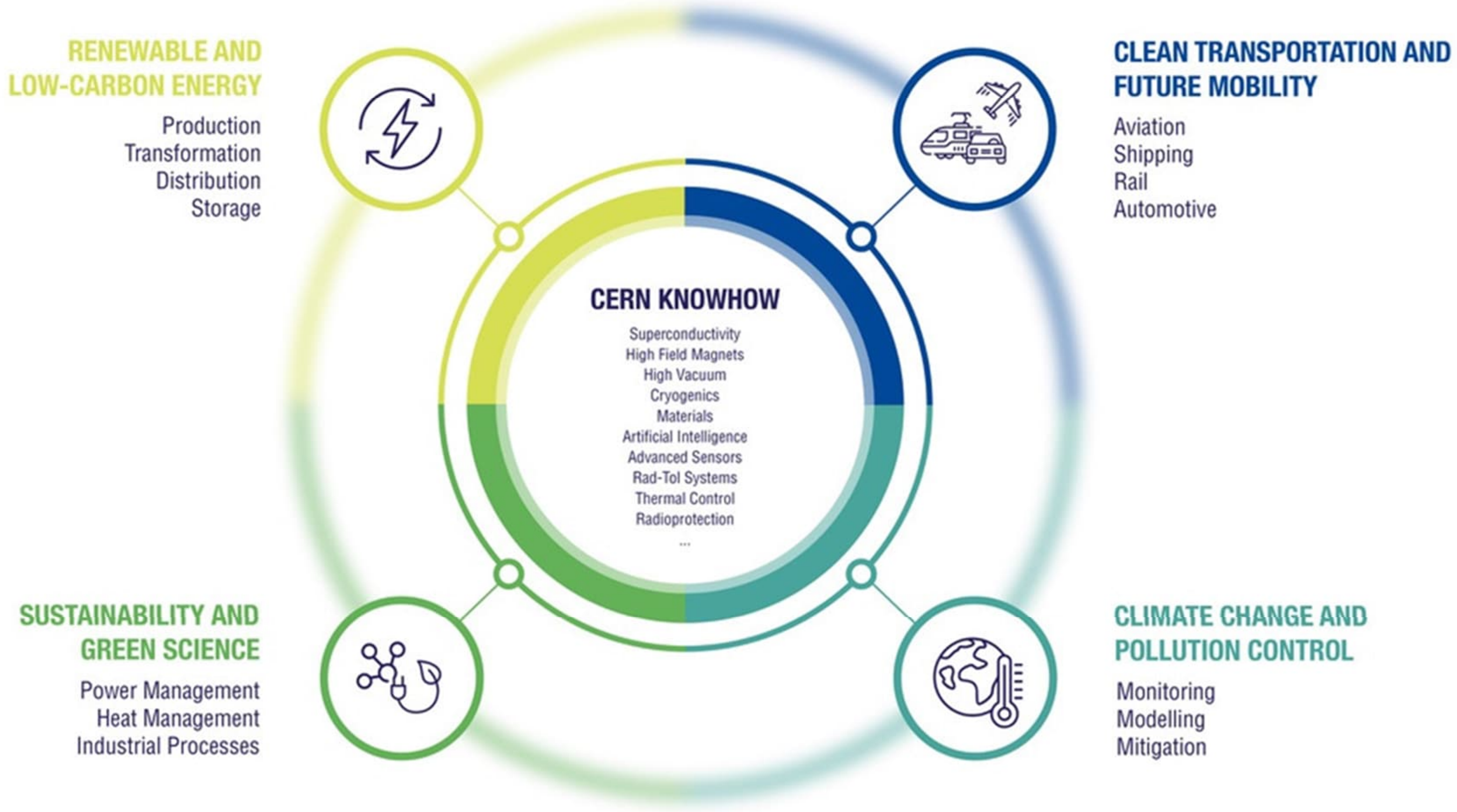
Participants bring in complementary competences and a balanced coverage of projects.

CERN Knowledge Transfer



CERN Knowledge Transfer – Main Application Areas



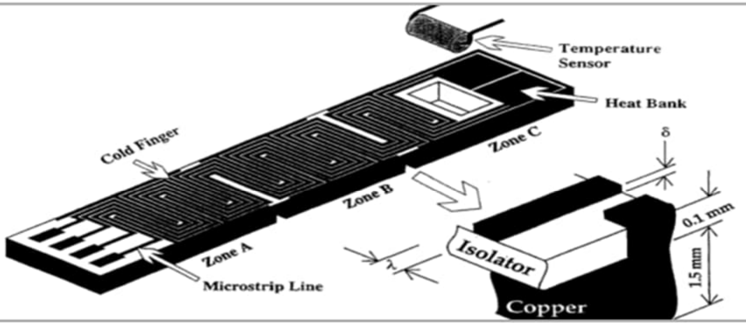


Collaboration opportunities in Cryogenics for industry

Access to CERN assets/ expertise in Cryogenics and related technical fields (superconductivity, vacuum, mechanics, materials, diagnostics…)

- Protected or open IP (hardware designs, patents, software tools)
  - Licensing
  - R&D Collaborations
- Unique testing facilities
  - Service Agreement
  - R&D Collaborations
- Experts know-how
  - Consultancy
  - Contract Research
  - R&D Collaborations

Example of hardware IP: Thermometric Measurement



what

Design, manufacture and assembly of a new type of thermometric block and support for a cryogenic thermometer measurement chain. The thermometer has been tested, produced in series and validated to function accurately under adverse environmental conditions.

tech specs

- Capable of measuring a temperature of 1.8 K +/- 5 mK
- Designed to work under extreme vacuum conditions
- Includes thermalization of sensing wires for commercial sensor
- Build using Prototype Circuit Boards (PCB)
- Easy to scale up by large series production
- Designed with industrial robustness
- Very good and easy thermal anchoring

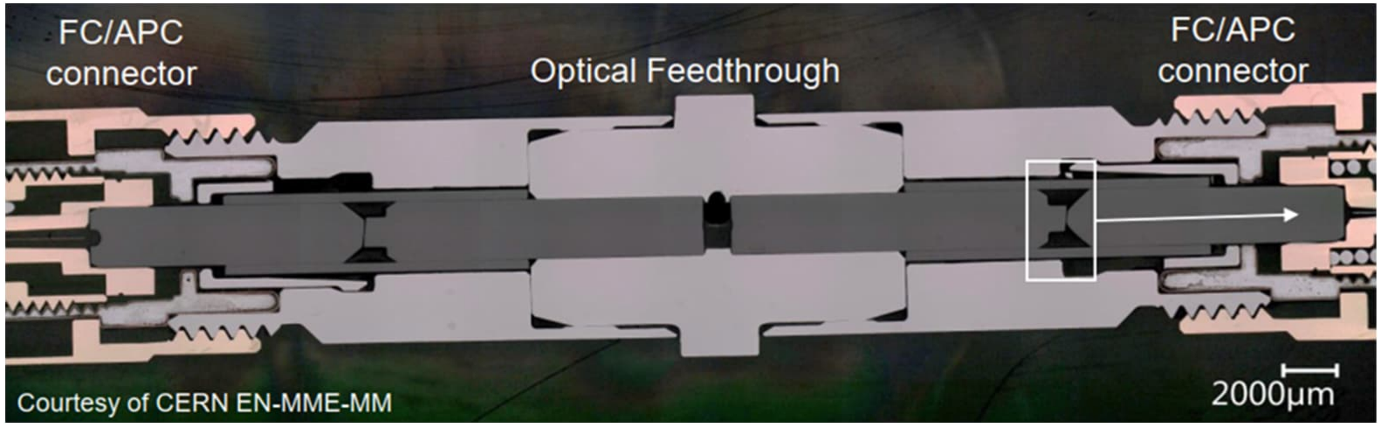
apps

- Cryogenic refrigerators
- Cryogenic installations in research institutes
- Large scale industrial cooling application

added value

- More precise and more reliable compared to commercial products
  → Less need for redundancy in design → Safe time / materials
- Easy to install
  → No cryogenic experts needed for installation → Less dependent
- Small setup
  → Compact → Easy to apply in confined spaces

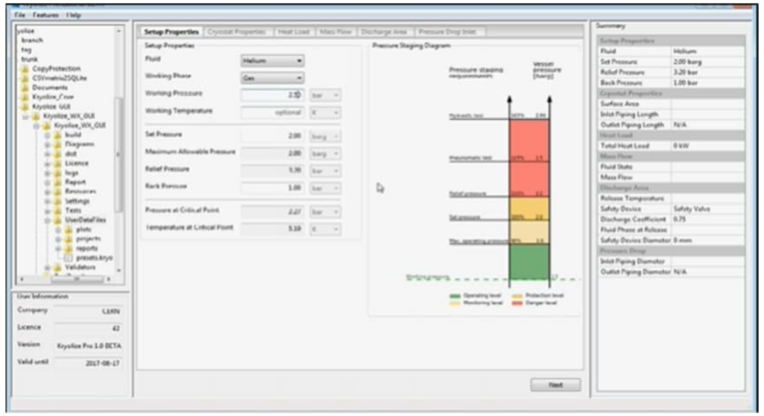
Example of hardware IP: Optical Feedthrough



Continuous optical fibre from room temperature/atmospheric pressure to cryogenics/vacuum
➔ Absence of connectors reduces significantly optical losses
➔ Ideal for applications like cryogenic structures optical strain measurement

Example of software IP: Kryolize tool

Kryolize



CERN | HSE
Occupational Health & Safety
and Environmental Protection unit

KIT
Karlsruhe Institute of Technology

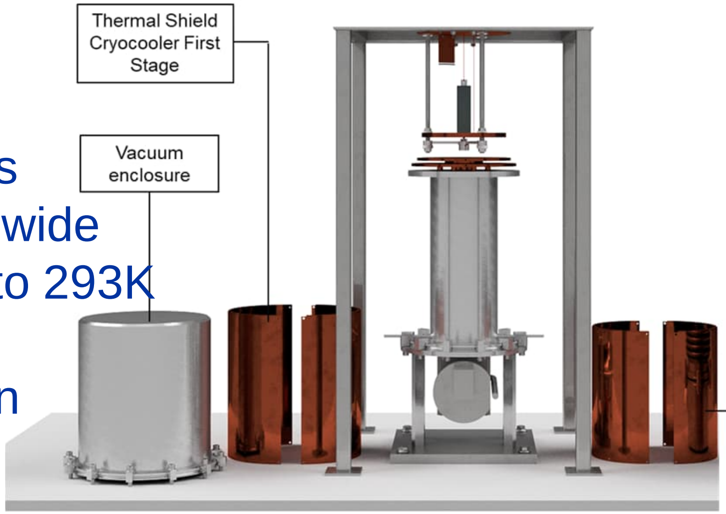
Kryolize is a software tool for sizing the minimum discharge area of a safety protection device, against overpressure. Based on international (ISO), European (EN) and American (API) standards, Kryolize allows for the calculation and sizing of safety valves for cryogenic systems.

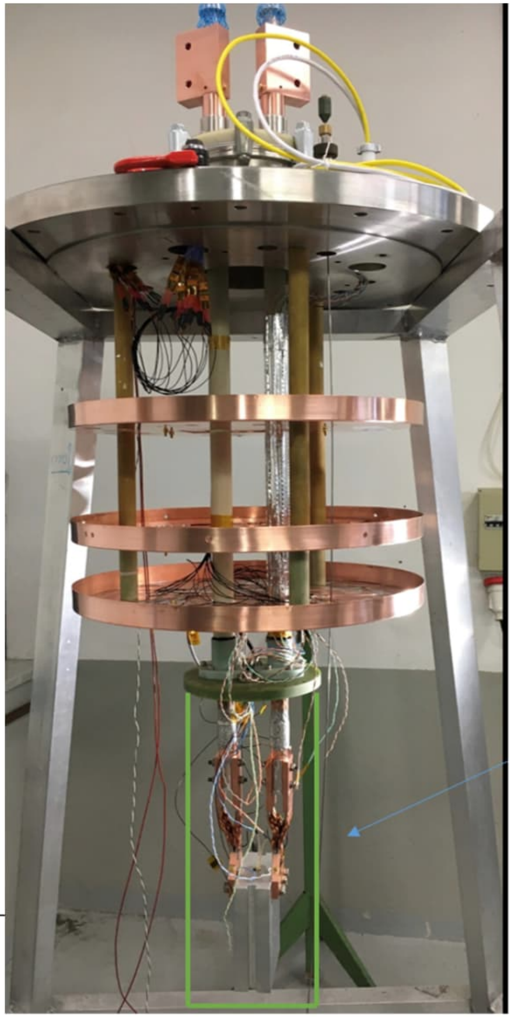
Example of key Cryogenic Testing Facility: the CryoLab

https://te-dep-crg-ci.web.cern.ch/

- Multiple LHe cryostats:
  200 mm x 1.2 m, 350 mm x 1.6 m, and 500 mm x 1.8 m
- Variable temperature cryostat insert
- Solenoidal magnetic field background cryostat up to 5 T

Measurements of standard cryogenic material properties:
- Electrical properties (RRR) of material samples and thin foils
- Tc measurement of SC thin films
- SC cable splice resistance
- Thermal conductivity and diffusivity
  of metals, insulators and compounds
- Thermal expansion of samples with wide
  range of geometries and from 4.5K to 293K
- Gas permeability of helium through
  membranes such as Mylar or Kapton





Examples of other Cryogenic Testing Infrastructures

Materials, Metrology and NDT facilities for mechanical tests at cryogenic temperatures

https://en-mme-mm.web.cern.ch/node/53

Cryostat 1: 77 K testing with a load of 200 kN in tension or compression.

Cryostat 2: 4 K testing with max load of 100 kN in tension (fracture mechanics tests also possible).

Measured mechanical properties: yield and ultimate strength, elastic modulus, ductility, fracture toughness

SC Magnets and SC links lab

Horizontal and vertical test station allowing to test at cryogenic temperature magnets and components up to 20 kA

Mechanical Measurements Lab

Strain measurement on structures at cryogenic temperatures with high spatial resolution (0.65 mm) using single optical fiber sensor and RBS (Rayleigh backscattering) technique.
Bonding technique developed for strain sensing experience in harsh environments

https://espace.cern.ch/test-en-mme-mechanical-laboratory

Vacuum facilities

Measurement of permeability and outgassing properties of cryostat materials

Examples of Cryogenic Collaborations for Environmental Applications within the CIPEA

	Compact Magnetic Confinement Fusion Energy Systems	**SC Links for On-board, Data Centers and Grid Power Distribution**	
	Accelerator Driven and Advanced Nuclear Reactors	**Liquid Hydrogen Storage and Handling Systems**	
	Engineering Systems and Tools for Low Emissions and Energy Efficiency	Technologies and Facilities for Remote and In-situ Environmental Monitoring	
	Fast, Low-power Computing Techniques based on AI	AI Platforms for Global Phenomena Modelling and Climate Simulations	

HTS for Electric Planes

SCALE: Super-Conductors for Aviation with Low Emissions

SCALE: Demonstration of superconducting power distribution systems for future LH2 electric aircraft

Feasibility assessment of SC transmission lines in the powertrain of future electric planes

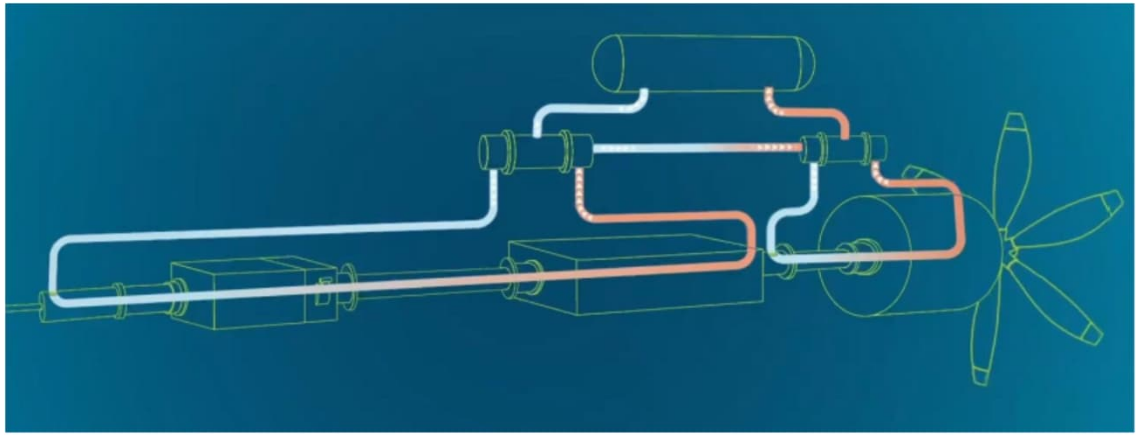
- SCALE demonstrator consists of a DC link (cable and cryostat) with two current leads
- Cooling system based on gaseous Helium

Impact: Support critical decisions on advanced technologies for clean aviation with the ambition to:

  - Halve weight and volume of components
  - Reduce voltage to below 500V
  - Increase system efficiency (+5-10%)

SCALE demonstrator successfully tested in SM18 end 2023

Airbus UpNext



https://kt.cern/news/press-release/knowledge-sharing/cern-and-airbus-partnership-future-clean-aviation

Cryostats for SC powerlines

IVAC-RED: Insulation VACuum of superconducting cables for Renewable Energy Distribution

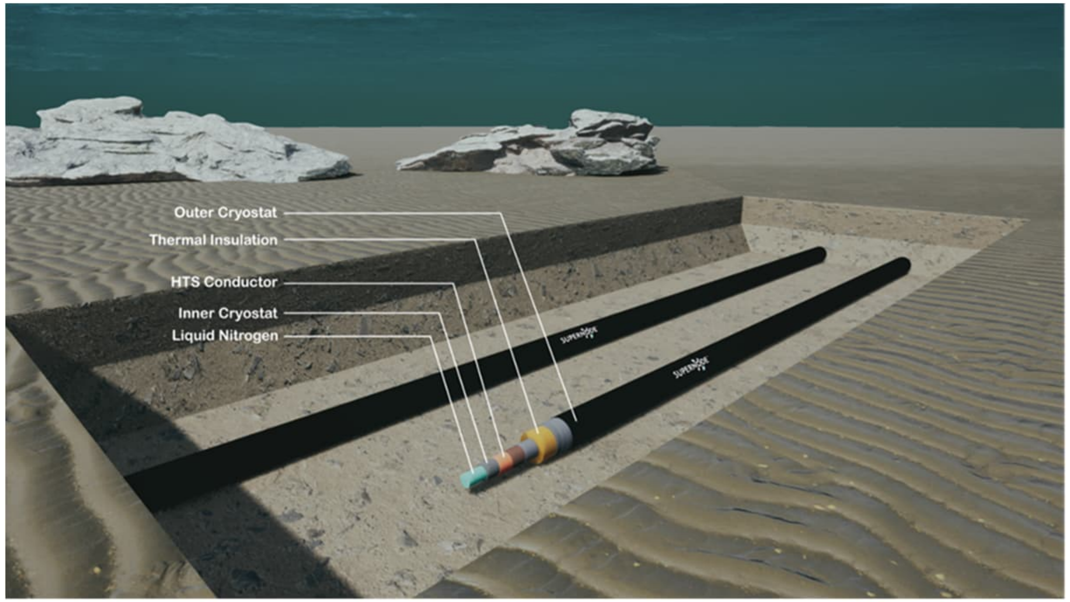
Vacuum compatibility of materials for the insulating system of long-range superconducting cables

Permeability and outgassing measurements of candidate materials for the insulating system of the LN2 cooled superconducting cables

- Test campaign in CERN facilities on SuperNode samples
- Development of dedicated test rig for real-size cylinders

Impact: Minimizing losses, cost and footprint of long-range renewable energy power transmission, for both terrestrial and submarine applications

SUPERNODE™
Connecting the Future



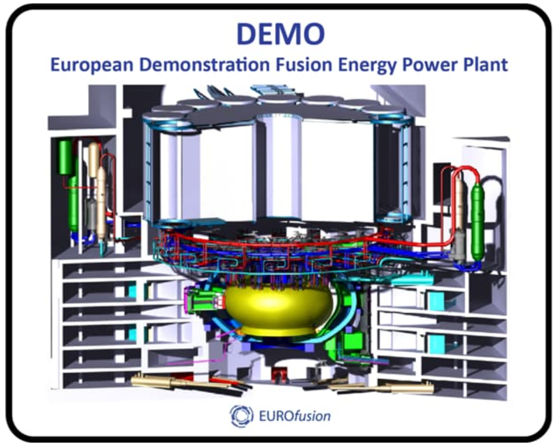
https://home.web.cern.ch/news/news/knowledge-sharing/supernode-and-cern-collaborate-new-solutions-renewable-energy

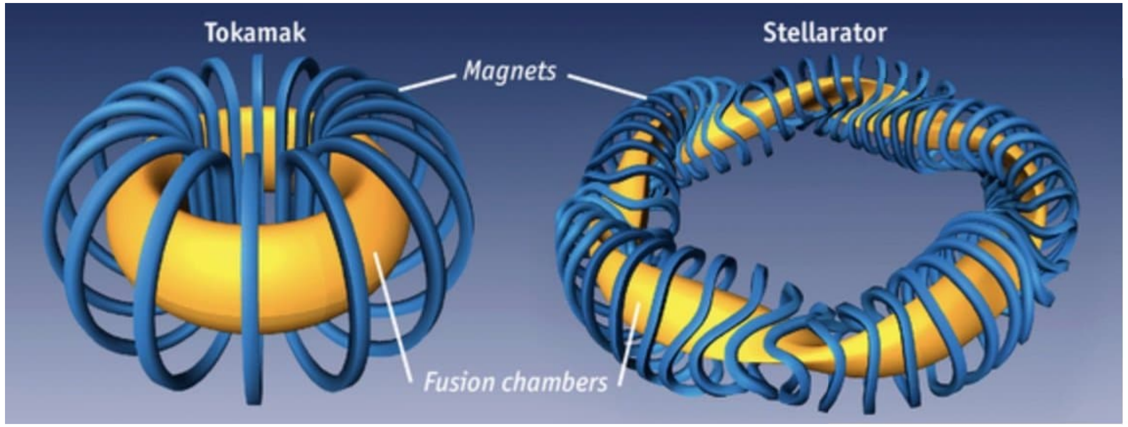
Fusion Systems

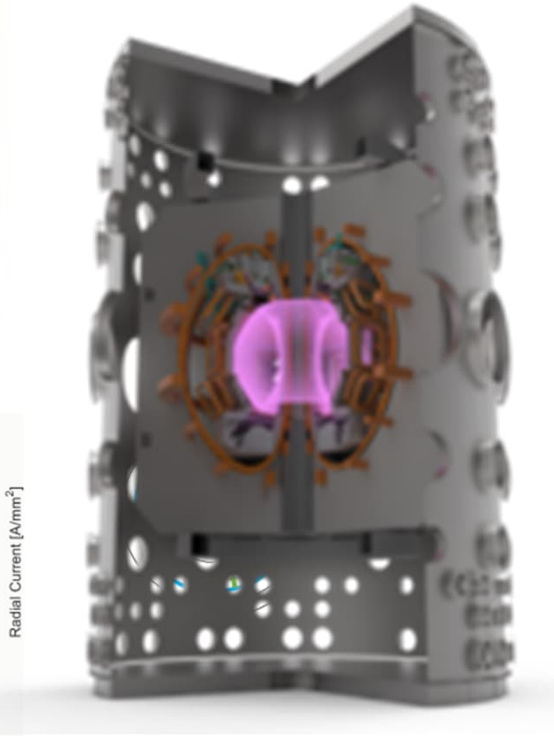
Magnetic confinement fusion – System design

Supporting system level R&D on fusion systems

FCTU – Fusion Coordination Technical Unit - supporting design and modelling activities of critical components for magnetic confinement fusion devices (tokamaks and stellerators)







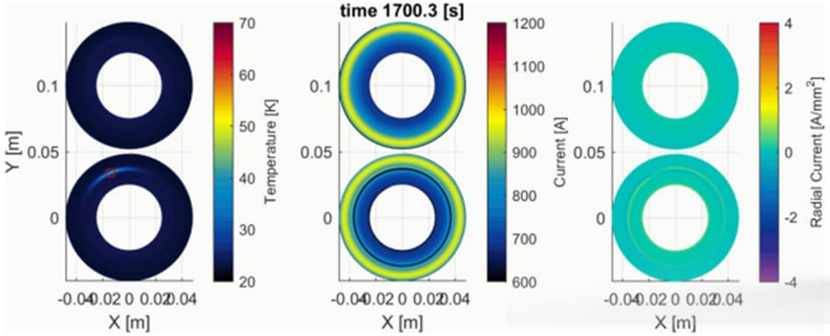
Tokamak Energy

GAUSS FUSION

EUROfusion

Impact:

Accelerating availability of unlimited affordable fusion energy



Fusion Technologies

Magnetic confinement fusion – Materials testing

Assessing the properties of steels for tokamaks

Characterization at cryogenic temperatures of high-strength austenitic stainless steel large forgings for the metallic casings for superconducting toroidal magnets of fusion machines

- Tests performed to measure mechanical properties at 4K in CERN EN-MME facilities
- Tensile tests and fracture tests + data analysis and materials characterisation

Impact:

- Optimise production of forged components
- Increase system reliability and durability

KIND

Liquid Hydrogen storage

Development of large HL2 tanks for maritime transportation

Supporting the development of large tanks for long-range maritime transport of liquid hydrogen

Collaboration with GazTransport & Technigaz (GTT) to support the development of liquid hydrogen tanks of complex shapes optimized for ships

- Consultancy to support adaptation of GNL materials selection, production and welding procedures to LH2
- Testing campaigns at CERN to determine vacuum compatibility of cryostat candidate materials
- Simulation of vacuum properties for design optimization

GTT
Technology for a sustainable world

Impact:

- Support hydrogen-based economy
- Eliminate fuel transport pollution

Liquid Hydrogen testing

Development of a testing facility for LH2 composite tanks

Development of a cryostat to test composite materials for liquid hydrogen tanks

Consultancy to support the design of a cryostat for a facility to be used for testing mechanical properties of composite materials for liquid hydrogen tanks for the transportation industry

- Starting from the design of a cryostat already developed at CERN, support was provided to the company to adapt it to their needs.

Applus+

Impact:

- Support development of LH2 equipment for transportation industry (e.g. small planes)
- Contribute to reduce aviation GHG and pollutant emissions

Thanks for your attention!

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Accelerating Innovation

CIPEA | CERN Innovation Programme on Environmental Applications

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