ATTRACT Consortium Research Infrastructures overview

Preparation of
ATTRACT Final Conference

Research Infrastructures

Who we are?

International scientific organizations that support science in reaching its full potential

What do we do?

- Providing cutting-edge infrastructure and facilities for scientists worldwide.
- Achieving world-class excellence in fundamental and interdisciplinary research.
- Driving scientific discovery and training in fields ranging from particle physics and astronomy to molecular biology and materials science.
- Collaborating with industry to foster innovation and stimulate technology transfer.

ATTRACT

Research Infrastructures

Advancing our understanding of the universe and matter by leveraging **particle-particle interactions.**

Facility	Main Purpuse	What it Uses	What it Studies	How it Detects
CERN	Research in particle physics	Protons and heavy ions	Elementary particles that make up the universe	High-energy particle detectors
ESO	Observing the universe	(Light from space)	Cosmic objects (stars, planets, galaxies…)	Optical and infrared telescopes
ESRF The European Synchrotron	Studying matter through Synchrotron Light	X-Ray Photons	Atoms, molecules and cm-sized materials	X-ray and charged particle detectors
European XFEL	Studying matter through X-ray Lasers	X-Ray Photons	Atoms, molecules and cm-sized materials	X-ray and charged particle detectors
ILL NEUTRONS FOR SOCIETY	Studying matter through Neutrons	Neutrons	Atoms, molecules and cm-sized materials	Neutron detectors

EMBL

Europe's life sciences laboratory:
Provide access to 60+ world-class infrastructures and resources

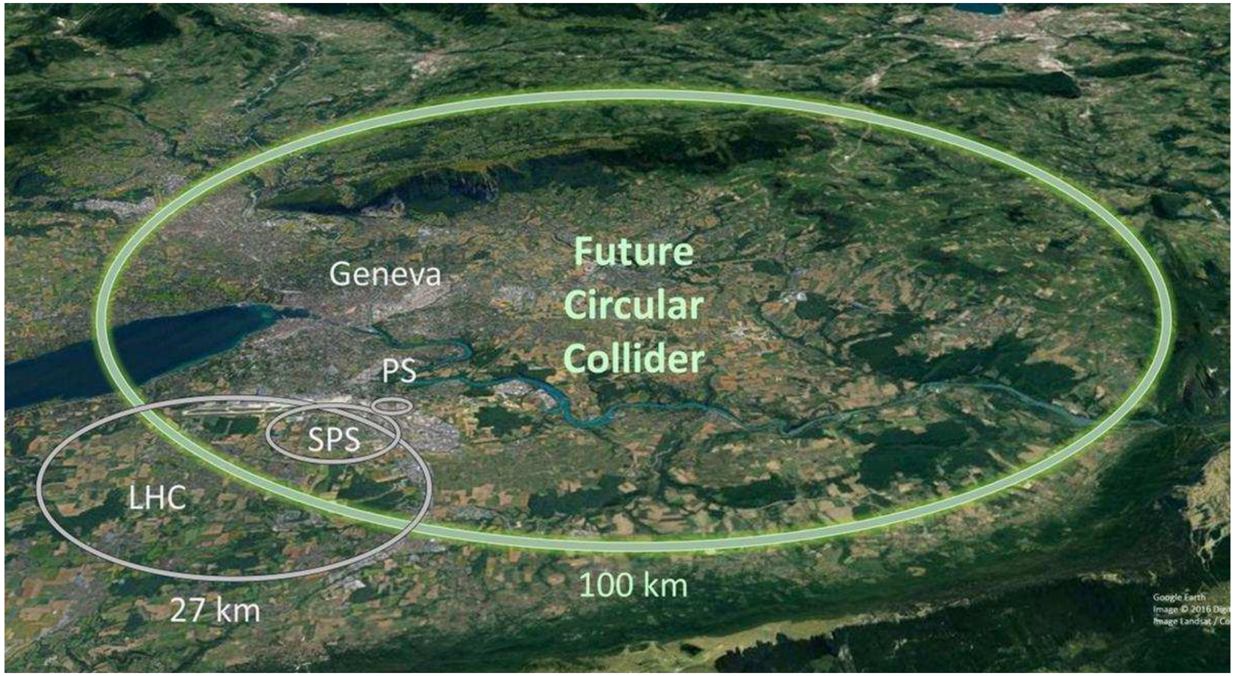
Facility card

CERN

The world's largest and powerful particle collider and much more

Who we are?

CERN (European Organization for Nuclear Research) is the **world's leading particle physics laboratory**, based near Geneva.
It brings together scientists from around the world to study the fundamental building blocks of our Universe.



ATTRACT

What we do?

We explore what matter is made of and how the universe works by colliding particles together at very high speeds and analyzing the results.

Our goal is to answer big questions like:

- What is the universe made of?
- How did it begin?
- Why is there more matter than antimatter?

How we do it?

- We use powerful particle accelerators, like the Large Hadron Collider (LHC), to make protons or heavy ions collide at nearly the speed of light.
- We place giant detectors (like ATLAS, CMS) around these collision points to record what happens, and analyze particles and interactions created in the collision.
- We ensure ultra-precise time synchronization across thousands of devices, spread over kilometres, and transfer data at Gigabit speeds.

CERN

What can we find out? (result examples)

- Discovery of the Higgs boson (explains why particles have mass)
- Study of quark-gluon plasma, a state of matter from just after the Big Bang
- Search for dark matter and extra dimensions
- Understanding antimatter and why the universe is made mostly of matter

Facility card

EMBL

Europe's life sciences laboratory

ATTRACT

Who we are?

The European Molecular Biology Laboratory (EMBL) advances molecular biology research across Europe. In its six sites—Heidelberg, Barcelona, Grenoble, Hamburg, Hinxton (EMBL-EBI), and Rome—EMBL realizes the core missions of fundamental research, scientific services, training, technology development, and the integration of European life science research.

EMBL

ATTRACT

What we do?

- **Research:** From genomes to whole organisms, we explore the secrets of life.
- We provide **access to 60+ world-class infrastructures and resources**:
  - **Bioinformatics/Data Resources**
  - **Experimental Services**: Structural biology, imaging, genomics, proteomics, metabolomics, in vivo gene editing, chemical biology
- **Training and networking**: We are a hub for learning, networking, and innovation

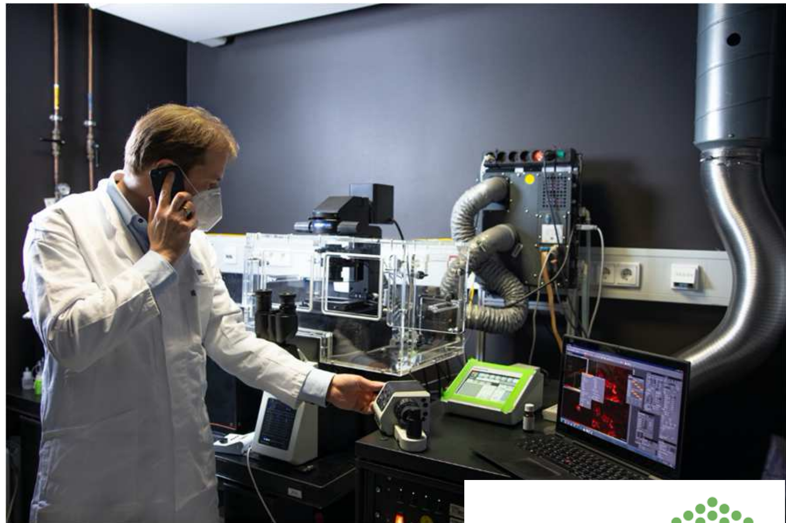
How we do it?

- Access to **high-performance computing resources**
- Expert **support in image data handling**, segmentation, and visualisation
- **X-ray Structural Biology** Facilities
- **Sample Preparation & Characterization** Facilities
- Advanced **Microscopy** Facilities

EMBL

What kind of samples?

- **Biomolecules**, like enzymes, antibiotics
- **Cells**, the fundamental unit of life
- **Wide range of organisms**, including collectives of bacteria, unicellular and multicellular eukaryotes
- **Genome** analysis, sequence and structural alignment
- Animal and human **tissues**



What can we find out? (result examples)

- Create innovative approaches to big data challenges in biology and build practical solutions to real-world problems.
- 3D structures of human and viral proteins to understand how they interact with the nucleic acids DNA and RNA.
- Understand the origin, development, and evolution of organisms and their communities
- Understand how the fundamental unit of life, the cell, functions molecularly and physically
- How millions of different cells interact with each other – chemically, physically and dynamically – to form healthy tissues and organs.
- Investigate the connections between gene expression, cell metabolism, and their role in human disease

Facility card

The world’s most advanced ground-based telescopes

ATTRACT

Who we are?

ESO (European Southern Observatory) is Europe’s leading astronomy organization, operating the world’s most advanced ground-based telescopes. It’s based in Chile, where the skies are very clear and dry—perfect for observing space.

What we do?

We observe and study the universe, from **planets and stars** to **galaxies and black holes**.

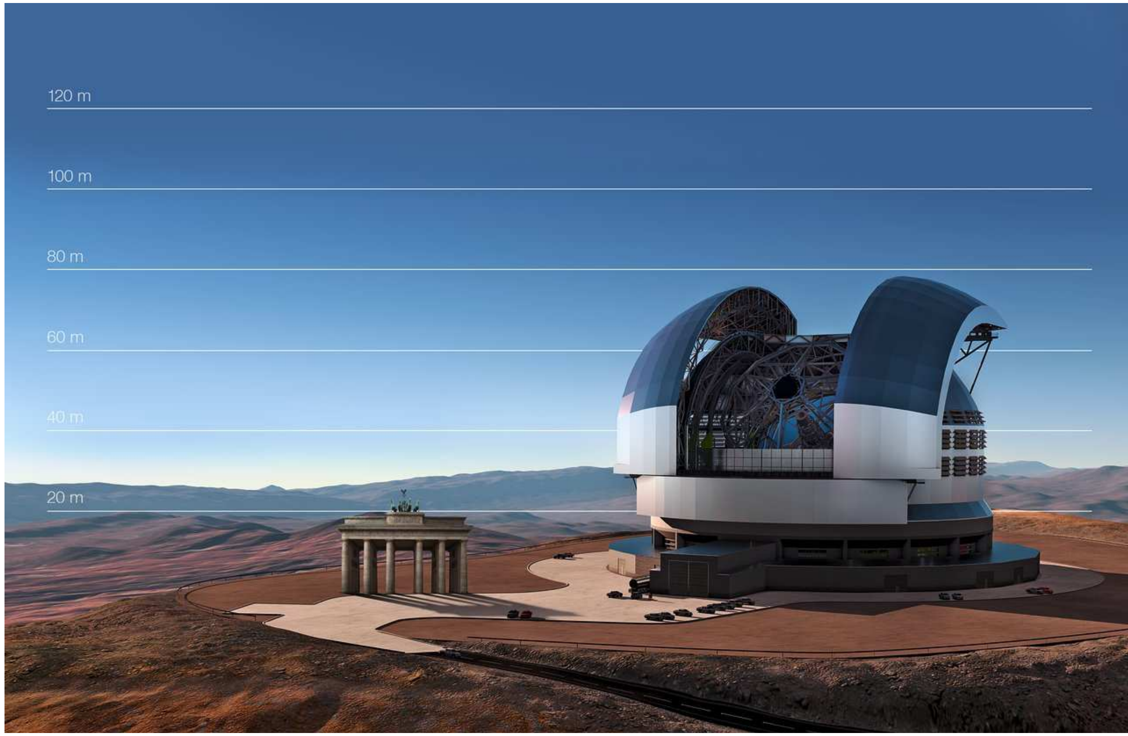
Our goal is to understand how the universe formed, how it evolves, and what it contains—including the search for **life beyond Earth**.

How we do it?

- We use huge telescopes like the **Very Large Telescope** (VLT) and soon the **Extremely Large Telescope** (ELT).
- These telescopes collect light from space in optical and infrared wavelengths.
- **Advanced cameras** and **spectrometers** attached to the telescopes analyze this light to extract information about distant cosmic objects

What can we find out? (result examples)

- Discovered and studied **exoplanets** (planets outside our solar system)
- Captured **the first image of a black hole** (Event Horizon Telescope collaboration)
- Studied **how galaxies evolve and** how stars are born and die
- Investigated the **chemical makeup of stars and planets** to look for signs of life



Facility card

ESRF
The European Synchrotron

World's brightest
Synchrotron Light Source

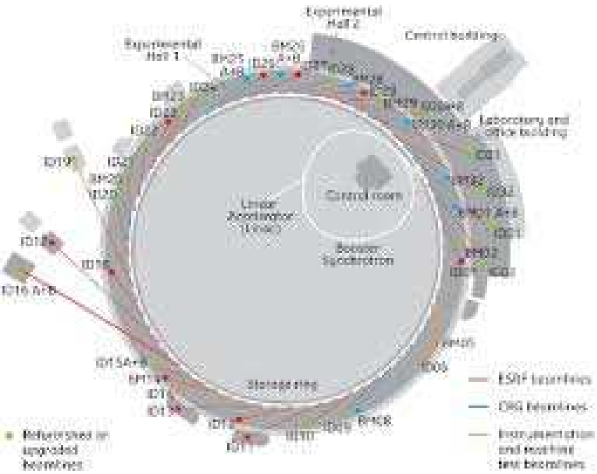
Who we are?

ESRF (European Synchrotron Radiation Facility) is a **world-leading research center** located in Grenoble, France.
We generate **powerful X-ray light** to study the internal structure of materials at the **atomic and molecular level**.

What we do?

- We help scientists from many fields “see inside” matter without destroying it.

- Our X-rays are used to analyze materials from ancient fossils and artworks to viruses, batteries, and advanced materials.



How we do it?

- We use a synchrotron, a circular particle accelerator that produces very intense X-ray beams.

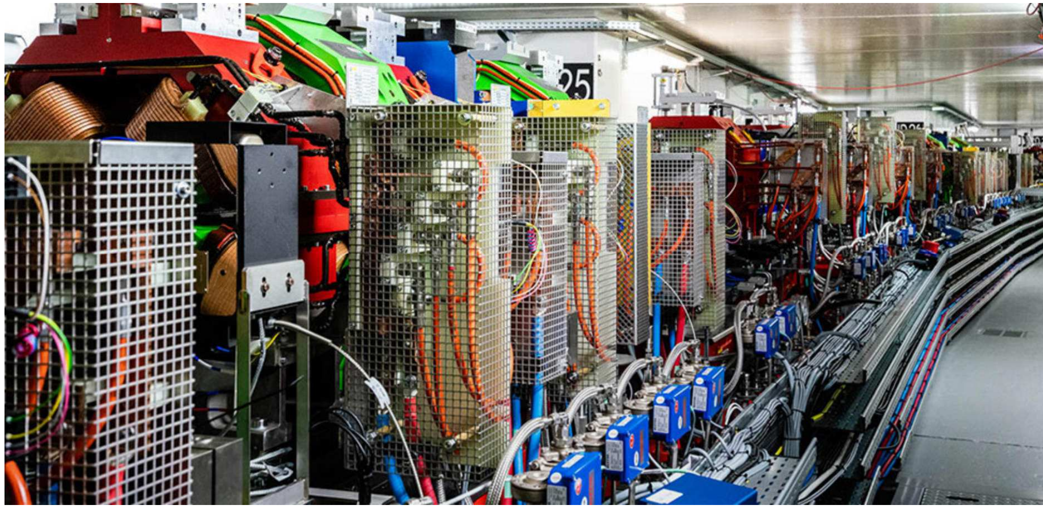
- Scientists **direct** these **beams** at their **samples** and **measure how the X-rays interact** (scatter, absorb, etc.). The **patterns tell us about the sample’s** structure **and** composition at the microscopic or even atomic scale

- Advanced instruments:
  - Detectors and Spectrometers to characterise scattered or emitted particles
  - Optics to shape the X-ray beam.
  - Microfluidics for sample delivery into X-rays.

What kind of samples?

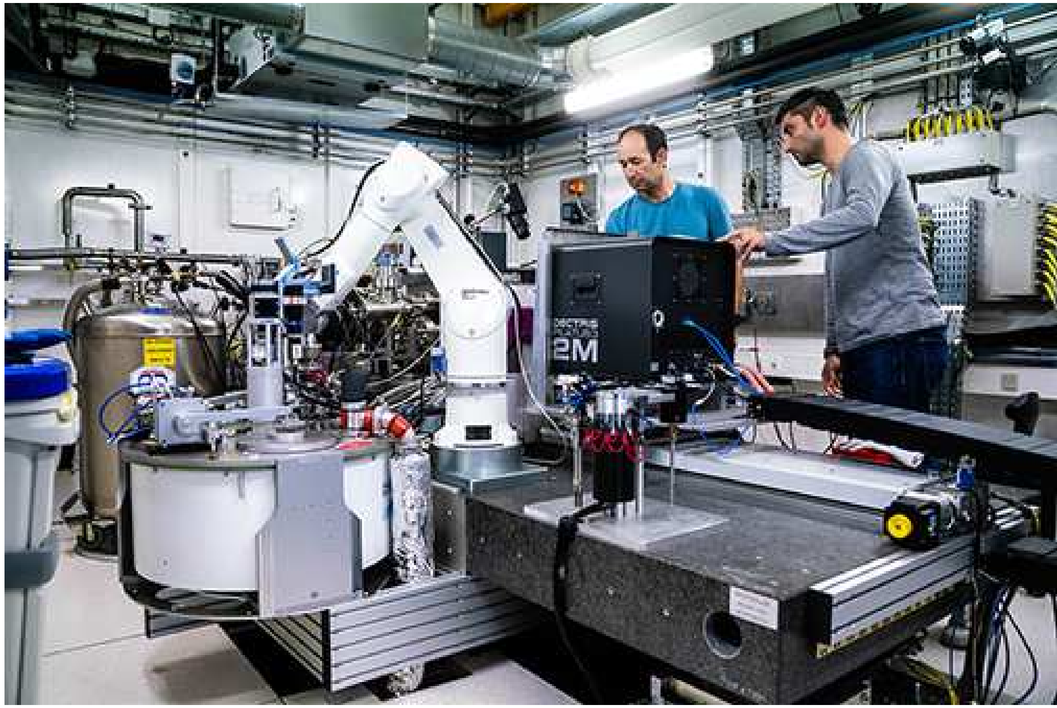
A wide variety including:

- **Biological samples:** proteins, viruses, tissues
- **Materials:** metals, ceramics, composites, semiconductors
- **Cultural heritage:** paintings, mummies, archaeological objects
- **Industrial products:** batteries, catalysts, pharmaceuticals



What can we find out? (result examples)

- Reveal the 3D structure of viruses to support vaccine development
- Study how batteries degrade to improve energy storage
- Analyze pigments and techniques in historic paintings
- Understand materials under stress for safer engineering
- Observe chemical reactions in real time to develop better catalysts



Facility card

European XFEL

The world's largest X-RAY Laser

Who we are? A big facility studying **tiny objects** (molecules and atoms)

The world's largest **X-ray laser facility** that studies the **structure and behavior of atoms and molecules** to understand the dynamics of chemical reactions and biological processes, and material behaviors.

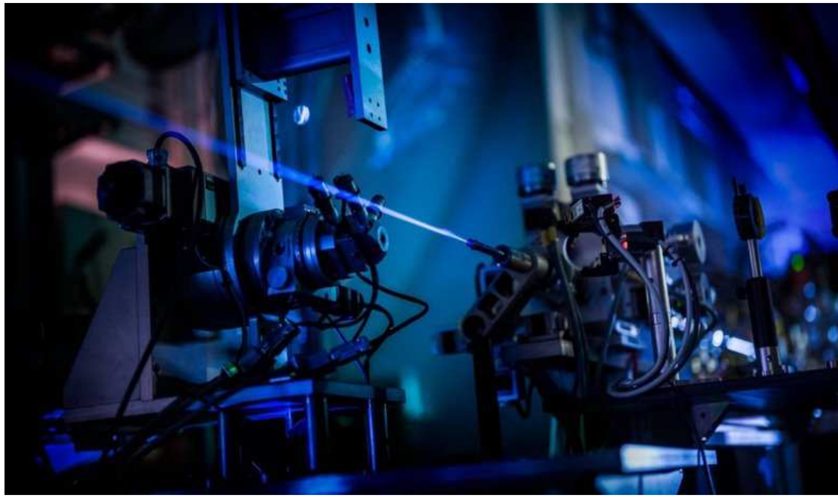
What we do?

- Create ultrafast “molecular movies” to observe (bio)chemical reactions as they happen
- See atoms and molecules at high resolution
- Understand electron behavior in materials
- Study fast, random processes in nature and materials

How we do it?

- Use **powerful X-Ray laser flashes** that are extremely short (femtoseconds), ultra-bright, and at high repetition (MHz frequency) to see atomic and molecular structures as they evolve - in real time.
- Advanced instruments:
  - Detectors and Spectrometers to characterise scattered or emitted particles
  - Optics to shape the X-ray beam.
  - Undulators and accelerators to generate the X-rays.
  - Liquid jets, aerosol generators, and fast sample scanners to deliver the samples to X-rays.

What kind of samples?



- **Biomolecules**(e.g. proteins, viruses, and enzymes)
- **Nanomaterials(**e.g. magnetic materials and catalysts)
- **Matter Under Extreme Conditions** (e.g. study materials for aerospace engineering behaviour during harsh working conditions, or simulate environments inside planets)
- **Crystals and Thin Films (**e. g. materials for solar panels)
- **Gases and Aerosols** (e.g. like those that form smog)

What can we find out? (result examples)

- How enzymes work
  (→ understanding antibiotic resistance)

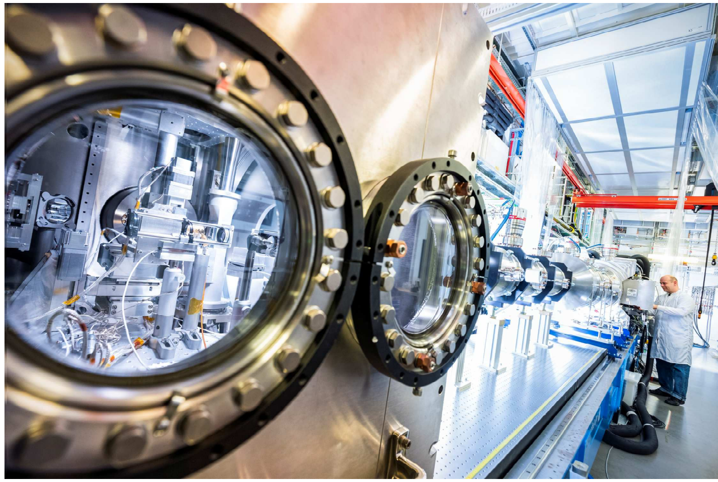
- What happens when sound waves shake material apart
  (→ helps industries make better materials with less waste)

- How materials respond under stress
  (→ design stronger, longer-lasting products—like more durable car tires)

- How magnetic materials behave
  (→ faster, greener data storage)

- Real-time view of photosynthesis
  (→ new renewable energy solutions)

- What happens during a chemical reaction
  (→ design of new materials or fuels)



Facility card

NEUTRONS FOR SOCIETY

World's leader in neutron science

ATTRACT

Who we are?

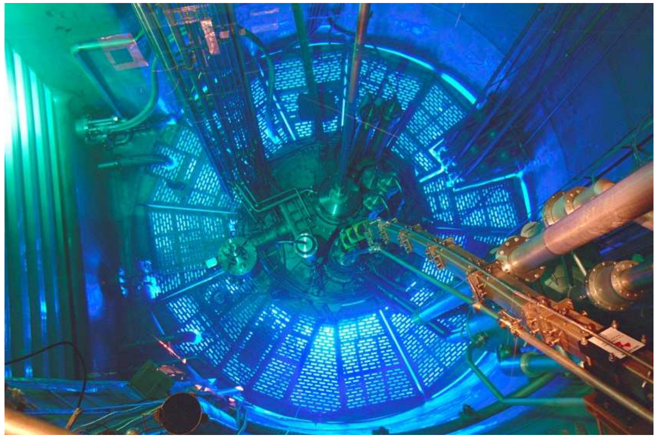
ILL (Institut Laue-Langevin) is one of the world's leading **neutron research centers**, located in **Grenoble, France**.

We use **neutrons** to explore the structure and dynamics of materials at the **atomic and molecular level**.

NEUTRONS FOR SOCIETY

What we do?

- We help **scientists understand** how materials are built and how they behave.
- Our neutron beams allow **research** in physics, chemistry, biology, materials science, and even cultural heritage.

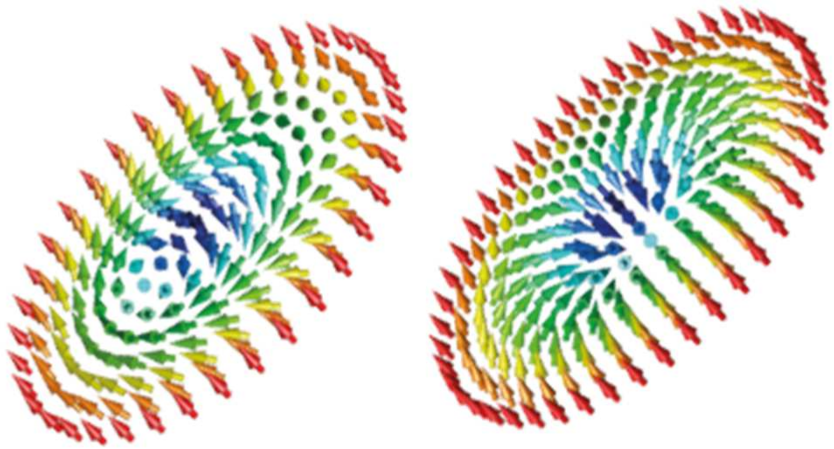


How we do it?

- We operate a **high-flux nuclear reactor** that produces a steady stream of neutrons.
- These **neutrons** are directed at samples, and their interaction (scattering or absorption) provides **detailed insights**.
- Advanced instruments:
  - Detectors and Spectrometers to characterise scattered or emitted particles
  - Optics to shape neutron beams.

What kind of samples?

- **Soft matter:** polymers, gels, biological tissues
- **Metals and alloys**: for stress analysis and materials design
- **Magnetic materials:** for electronics and data storage
- **Crystals and liquids**: to understand atomic arrangements and motion
- **Cultural heritage artifacts:** non-destructive internal analysis



I. Kezsmarki et al., Nature Materials, 2015, **14**, 1116; DOI: 10.1038/nmat4402ptions.

What can we find out? (result examples)

- Understand **how proteins move in cells** (biomedical applications)
- Improve the **durability of metal** parts under stress
- Analyze the magnetic structure of **new materials** for **energy-efficient tech**
- Study fuel cells and battery materials to **support green energy**
- Reveal the inner structure of ancient artifacts without damaging them