

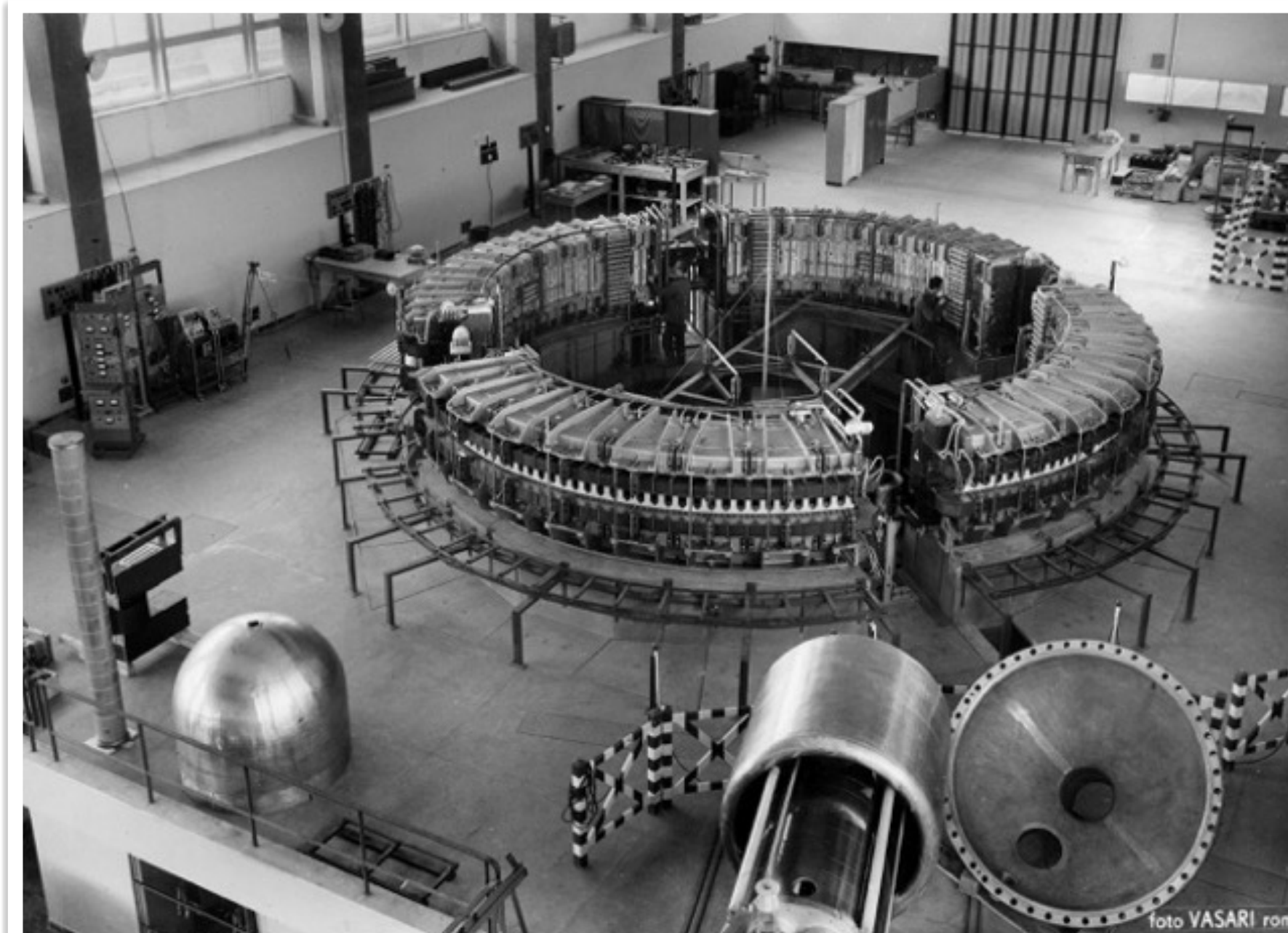
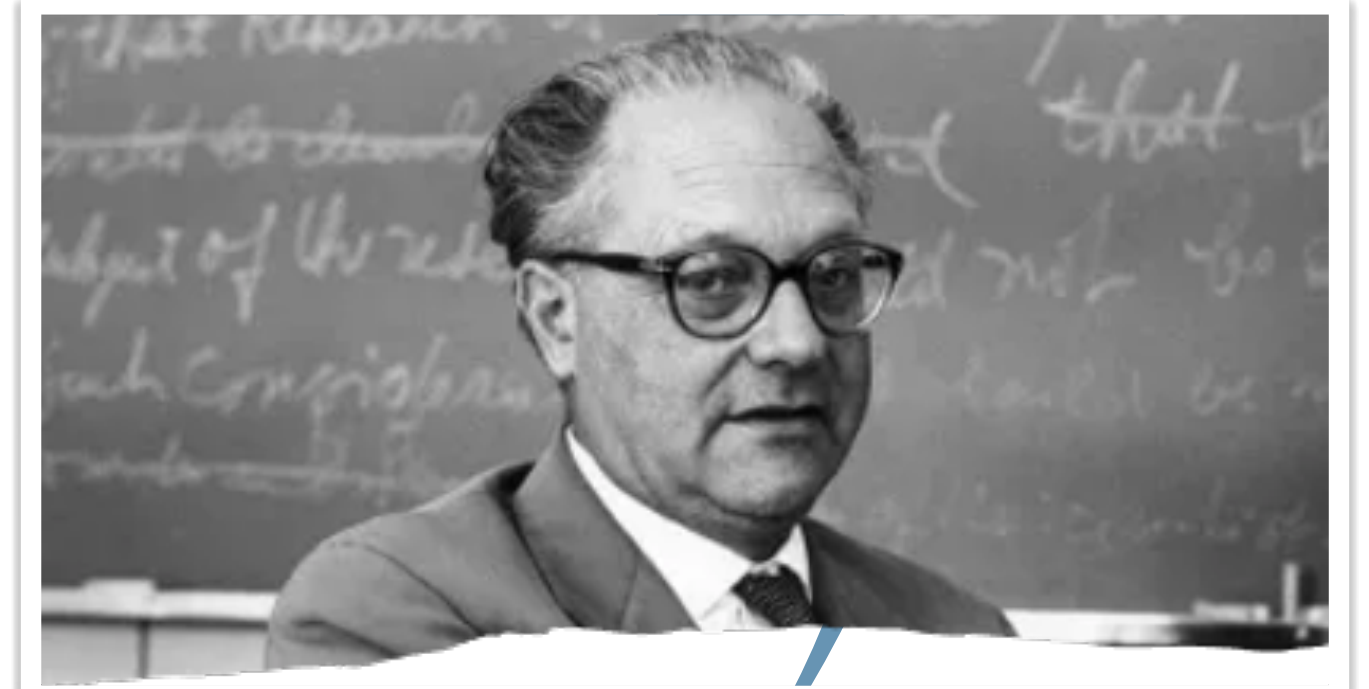
L'Istituto Nazionale di Fisica Nucleare

Open Day INFN - 9 Ottobre 2025

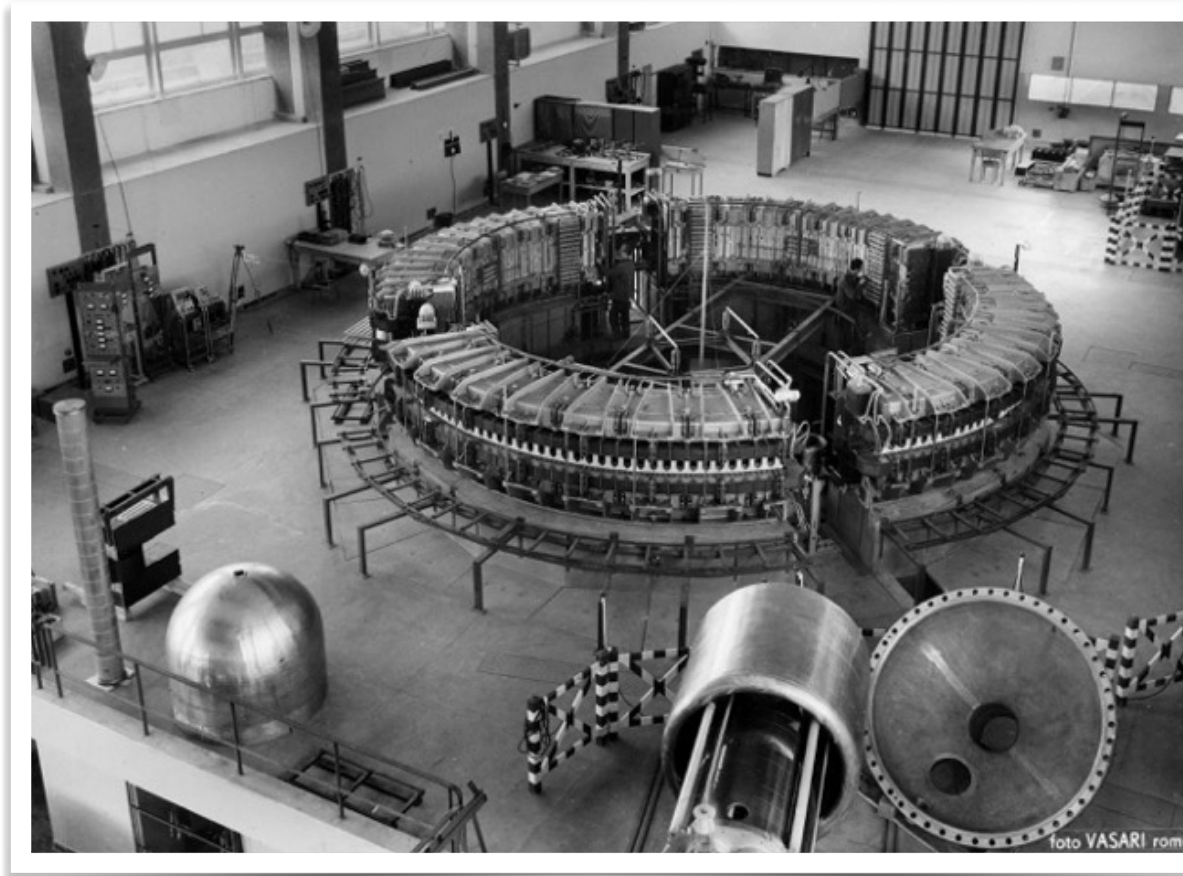
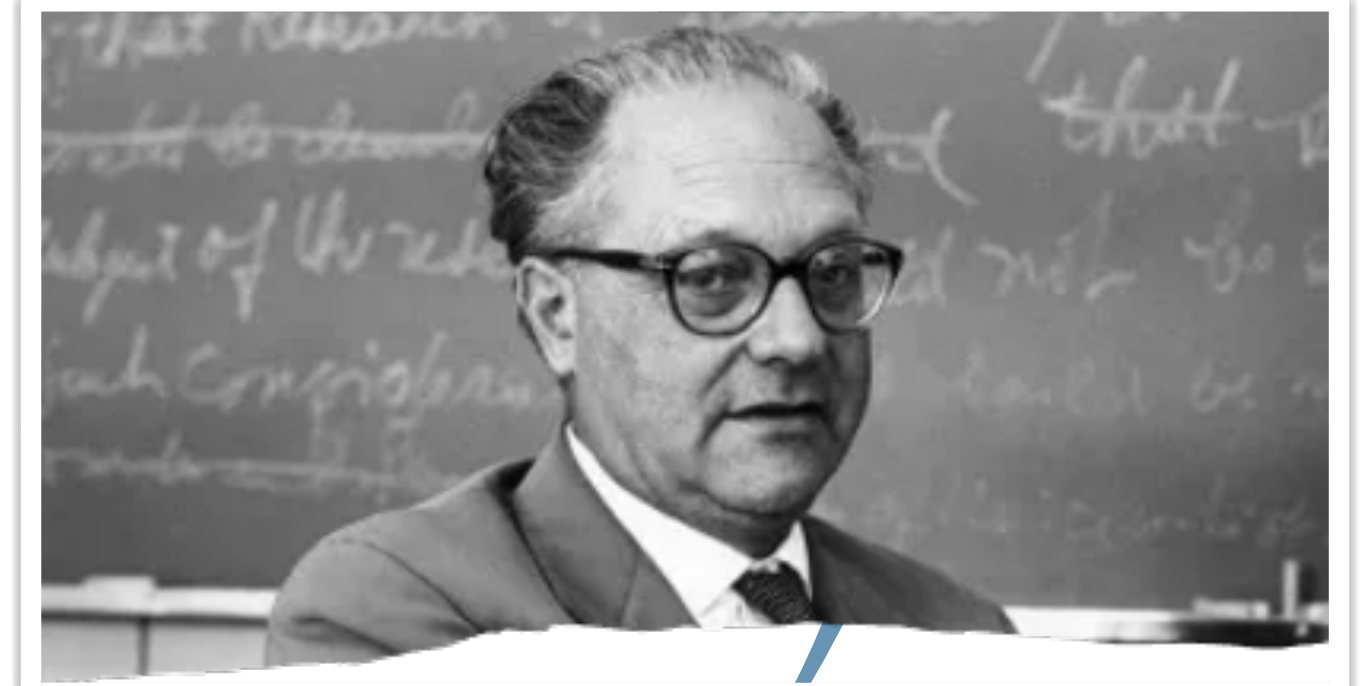
M. Bauce



Where we come from



The INFN, founded in **1951**, has a long and prestigious history tracing back to **Enrico Fermi and the Via Panisperna boys**

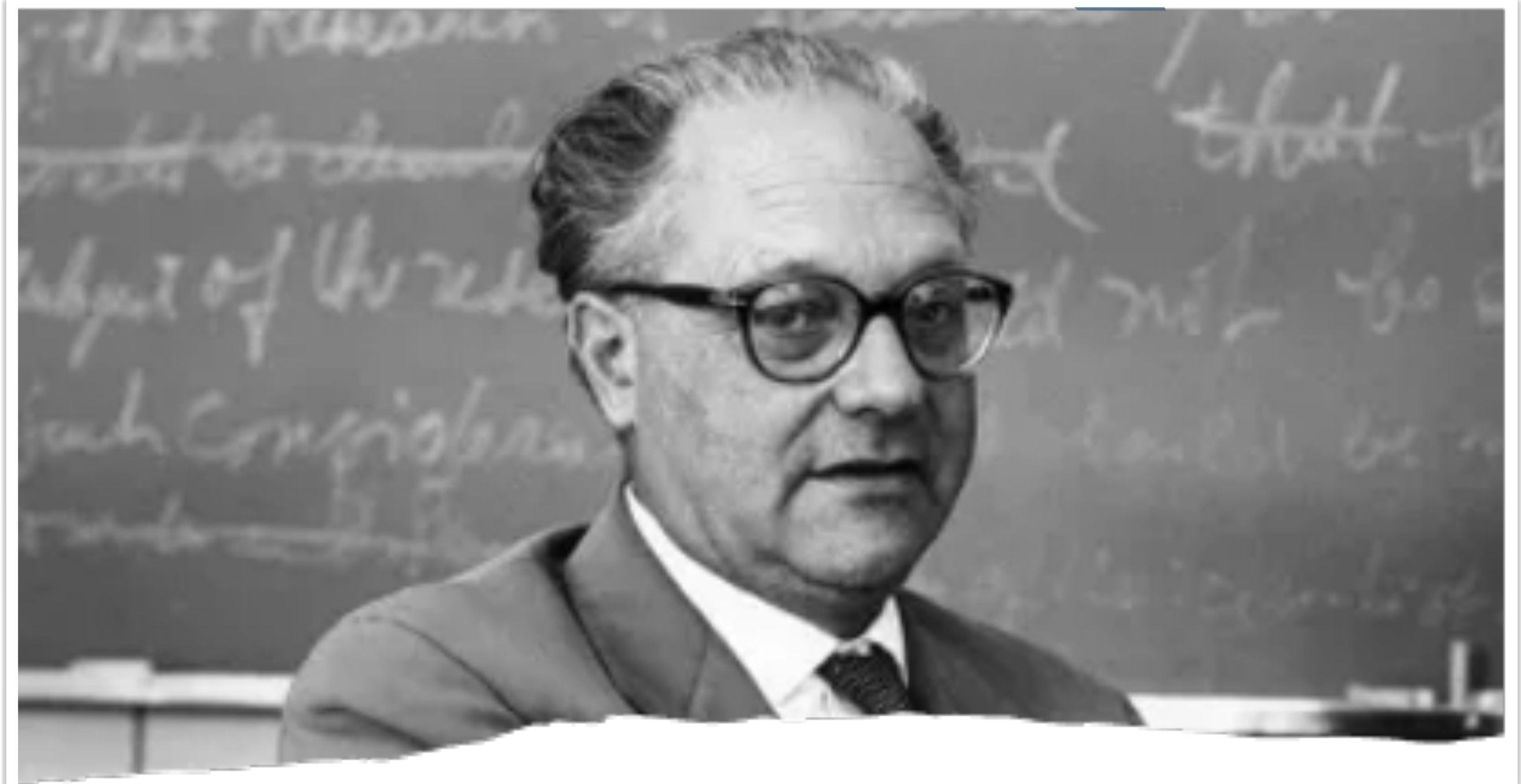




<https://storia.infn.it>

Amaldi also gave a fundamental contribution to the foundation of **CERN** (in 1952) and of **ESA**

After the emigration abroad of Fermi, Segrè, Rasetti and Pontecorvo, and the mysterious disappearance of Majorana, it was **Edoardo Amaldi** who, in **1951**, founded the INFN together with **Gilberto Bernardini**.



Our mission

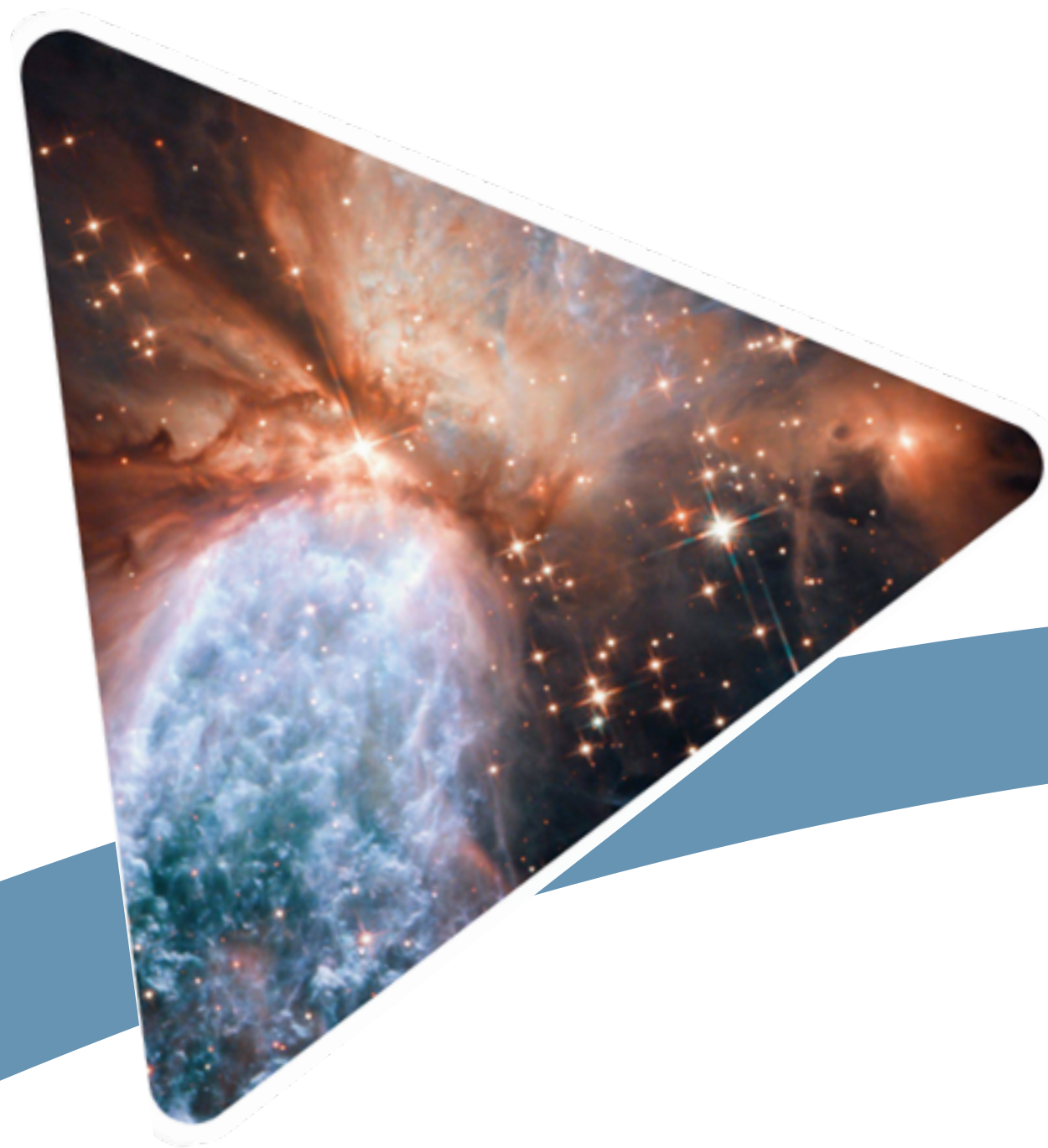


Università Ricerca AFAM



Pushing beyond the frontiers of knowledge

The secrets of matter
and the Big Bang



Our
mission

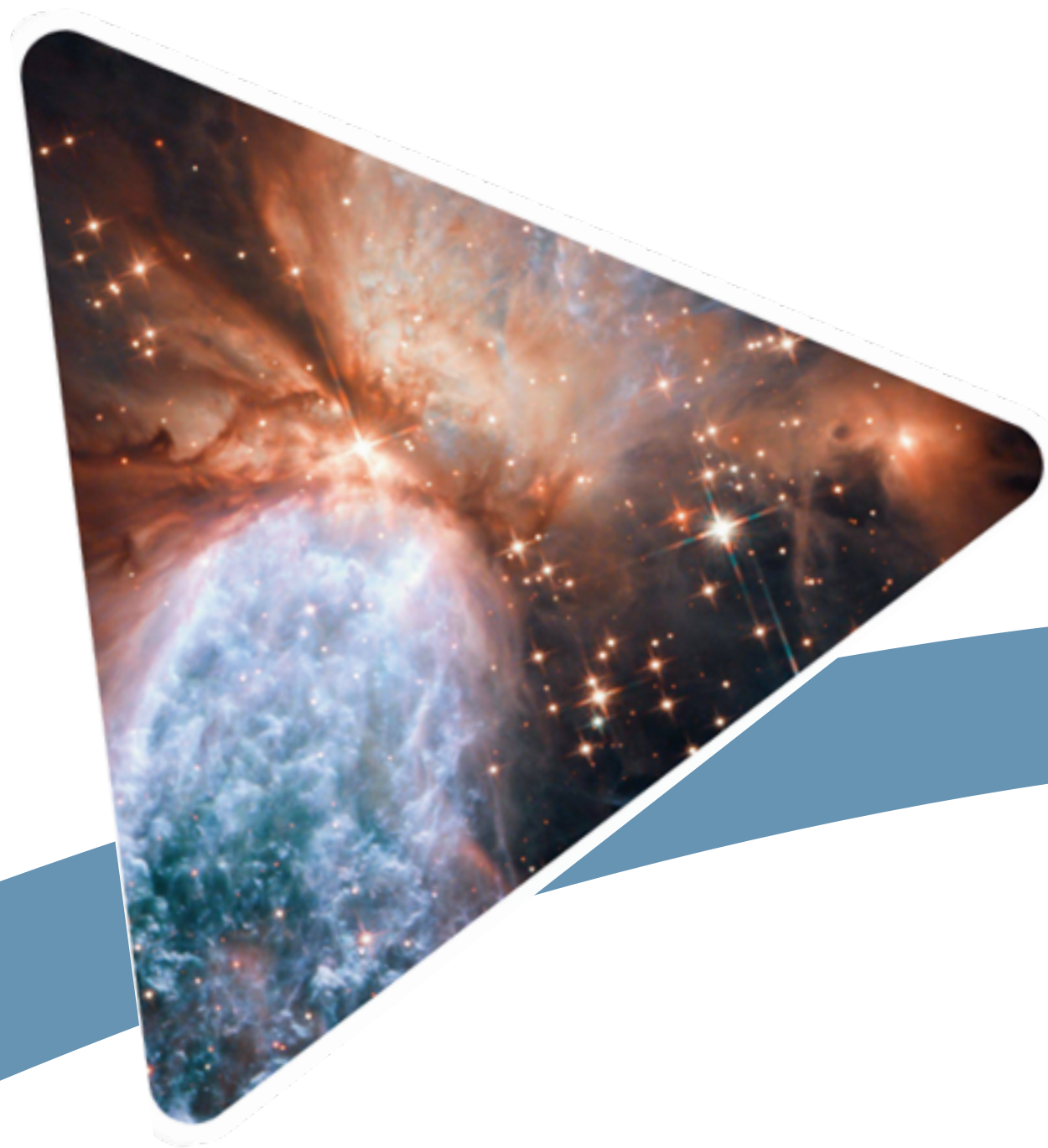


Università Ricerca AFAM



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Develop new
cutting-edge
technologies



Our
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**Pushing beyond
the frontiers of
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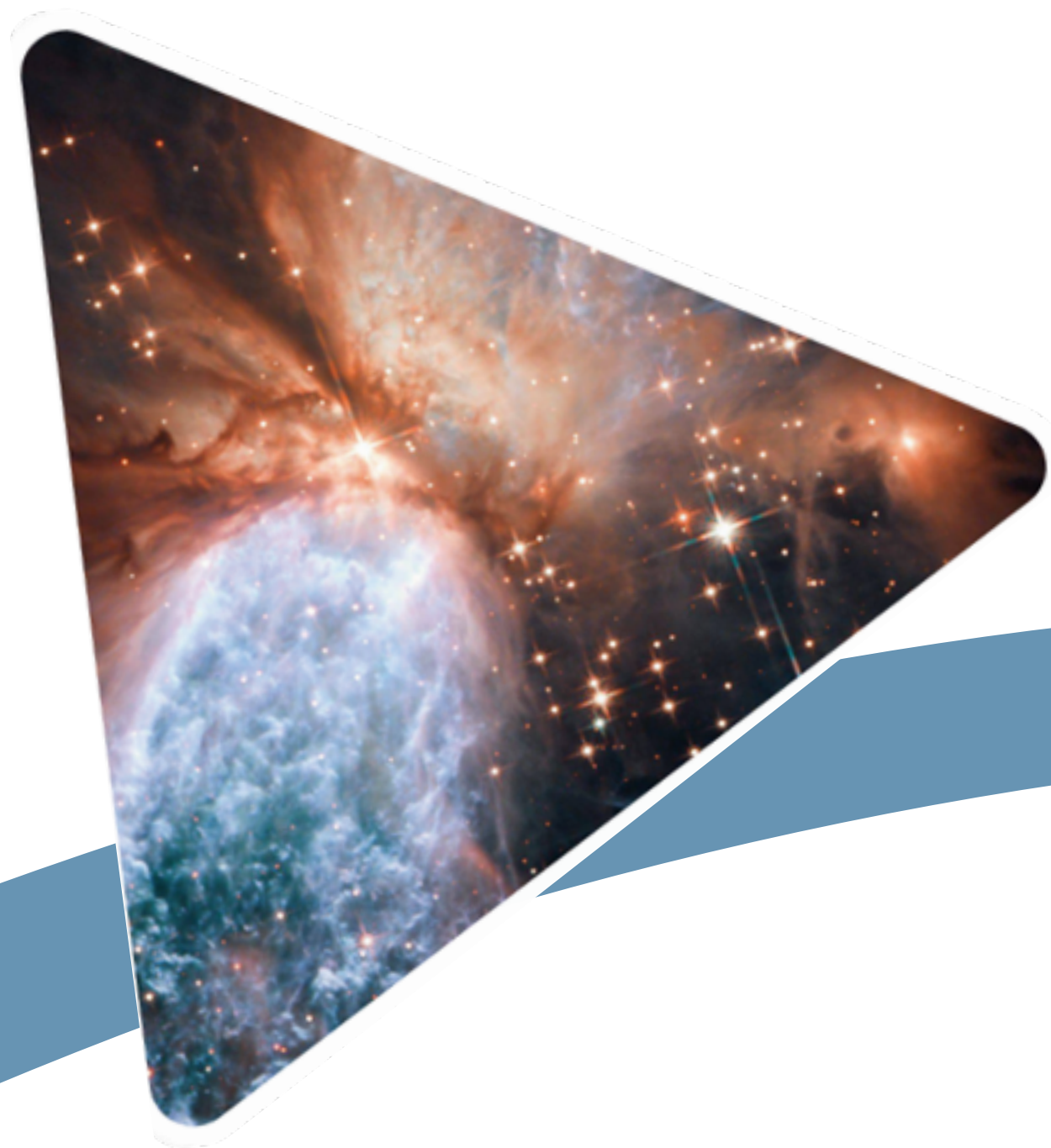
The secrets of matter
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**Develop new
cutting-edge
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Our
mission

Training

scientists and
engineers of the future



**Pushing beyond
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The secrets of matter
and the Big Bang

**Develop new
cutting-edge
technologies**

Our
mission

Training

scientists and
engineers of the future

Work together

with the best researches from all
over the world



INFN is
a community of
over **6000** people





INFN is
a community of
over **6000 people**

about **25%** are young researcher
including **postdocs**, scholarship
holders, and **PhD students**

Scholarships also available for
undergraduates
with opportunities to gain
**experience in international
institutions.**





L'INFN
across Italy

4 facilities in the Rome area



Laboratori Nazionali di Frascati (LNF)



Sezione di Roma 2 (Univ. Tor Vergata)



Sezione di Roma 3 (Univ. Roma Tre)



Sezione di Roma (Univ. La Sapienza)



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L'INFN
across Italy

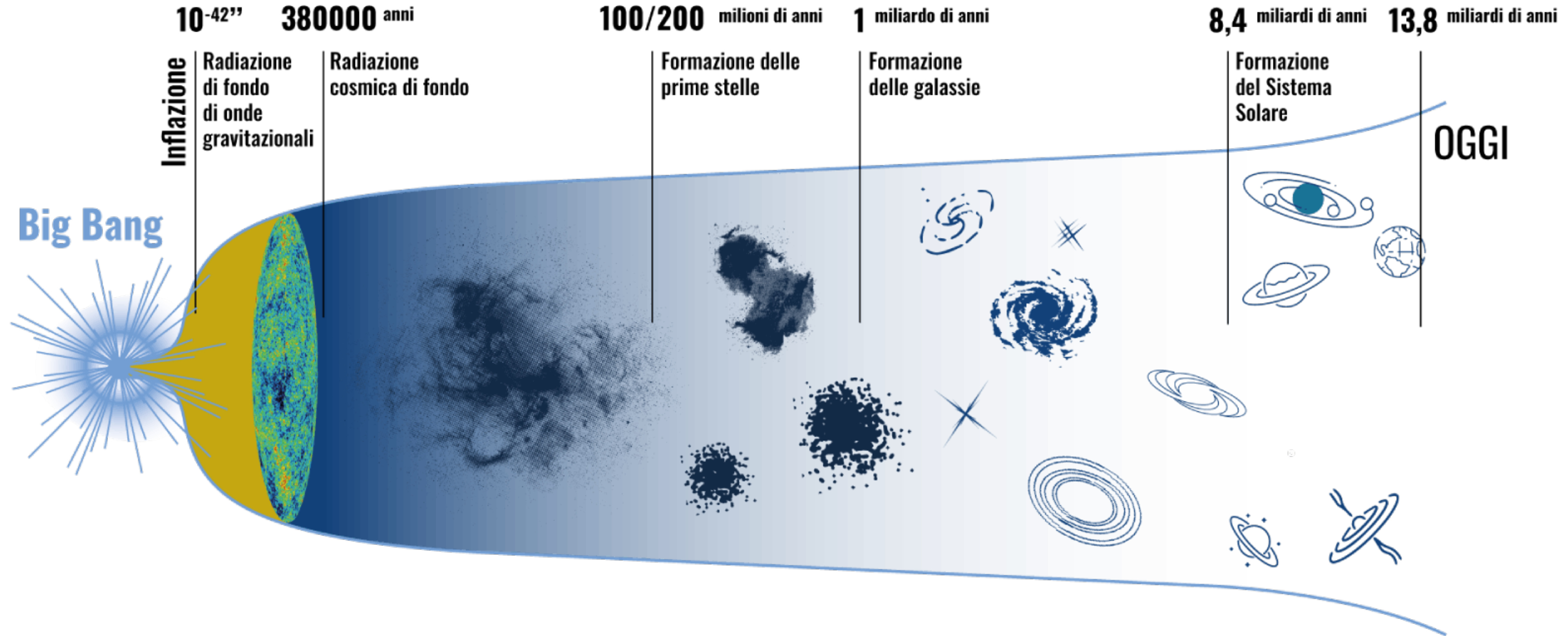
What we do



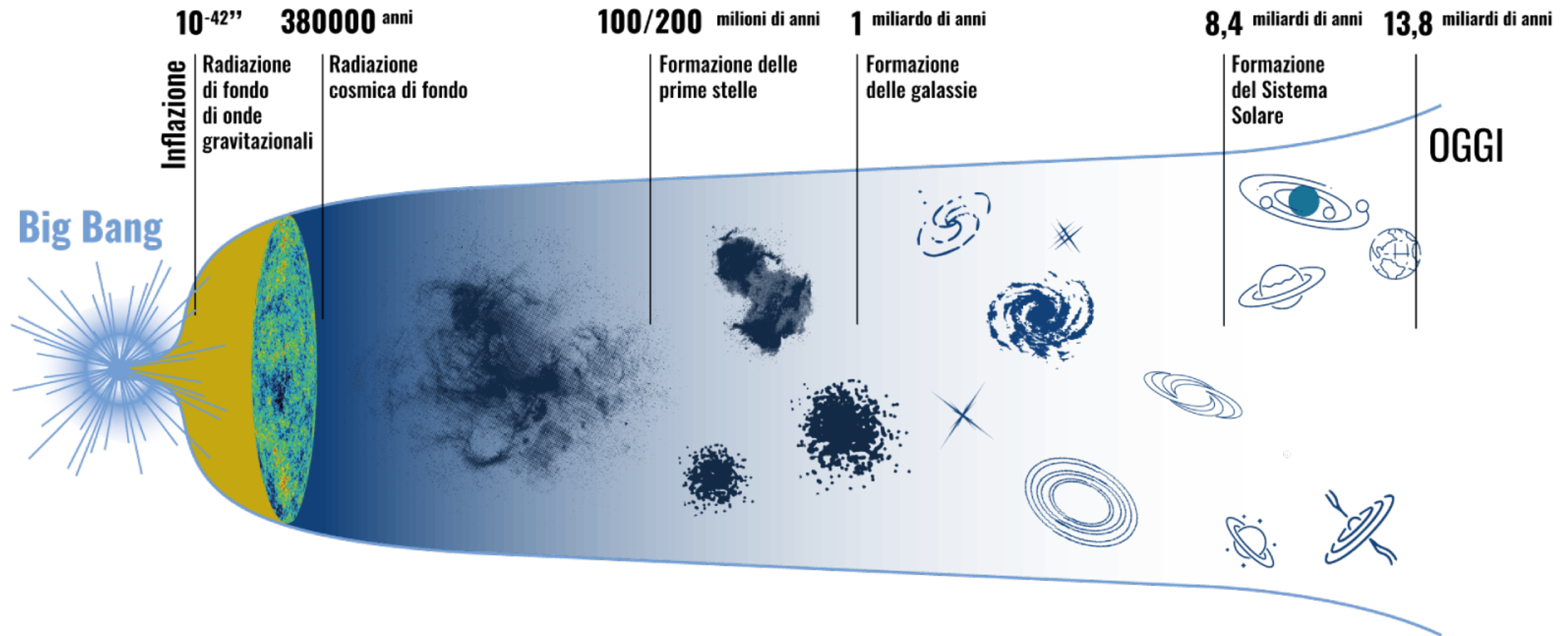


What we do

The challenge: understanding the Universe soon after the Big Bang

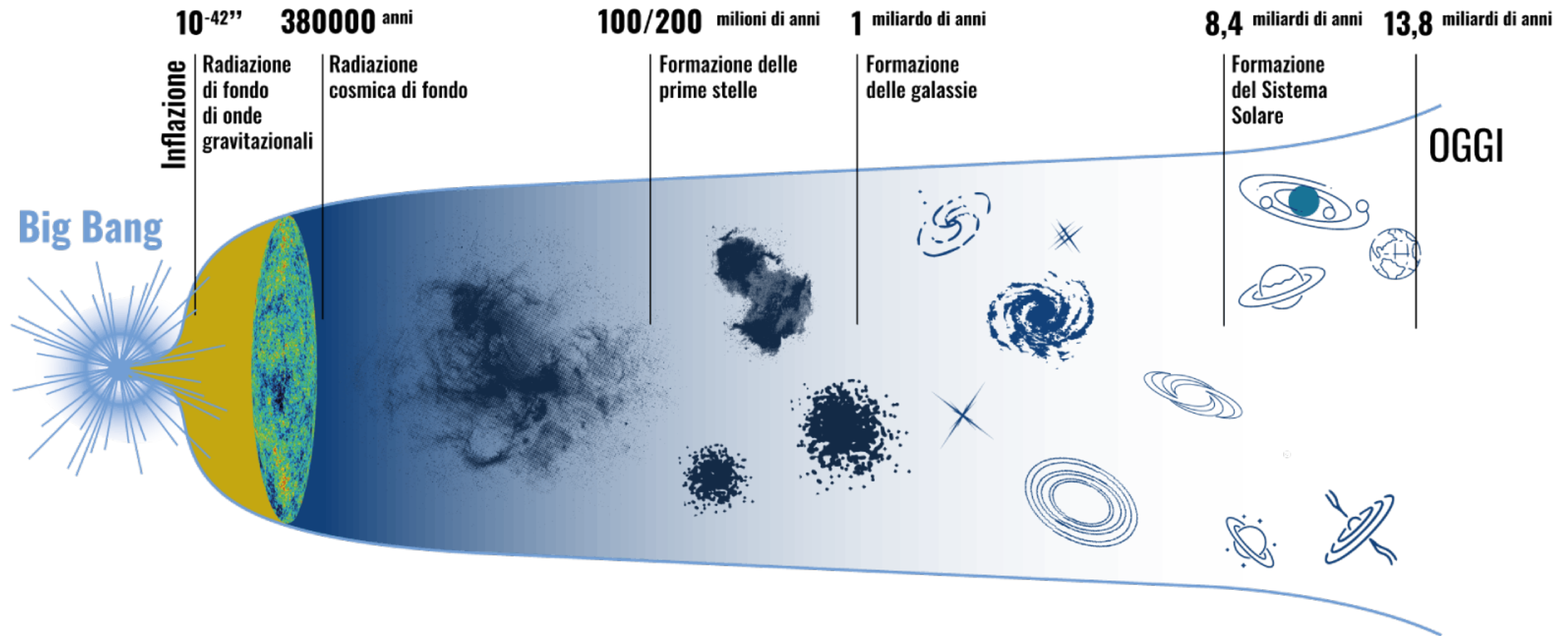


The challenge: understanding the Universe soon after the Big Bang



Studying the nature and properties of Dark Matter helps to clarify how structures formed.

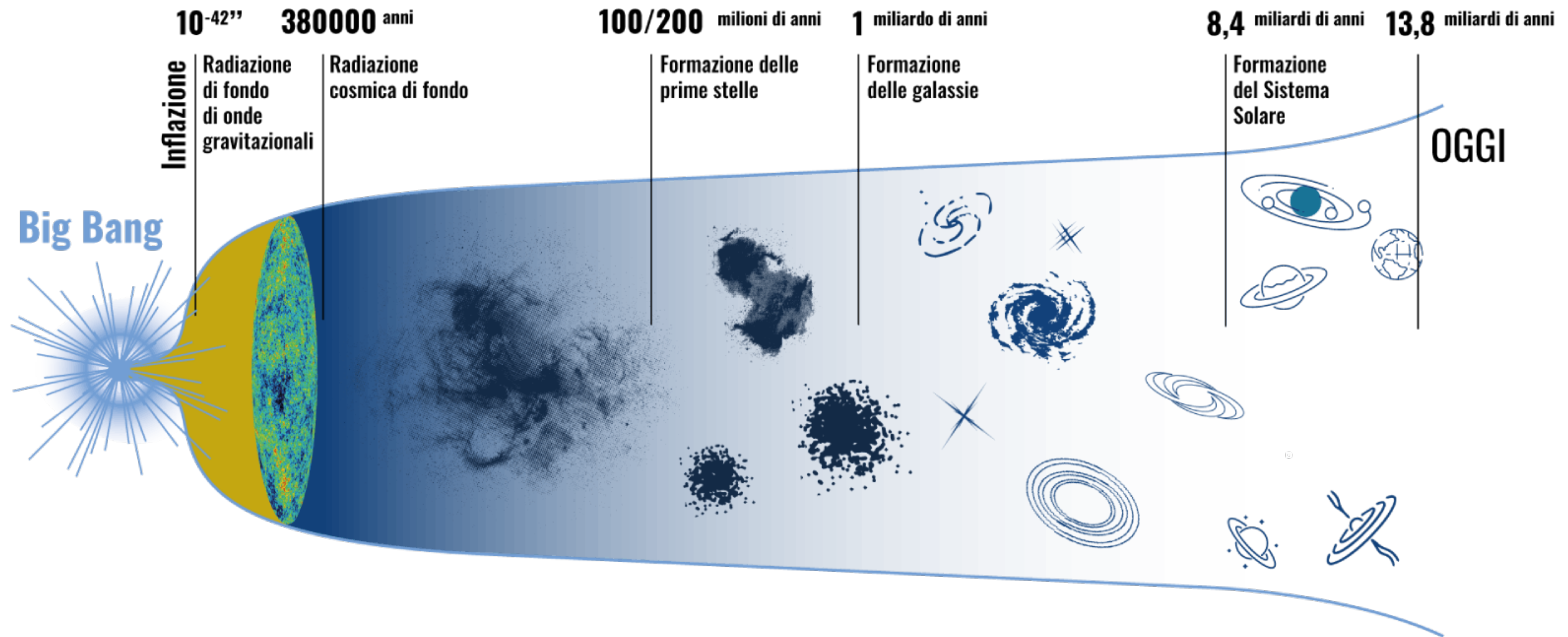
The challenge: understanding the Universe soon after the Big Bang



Studying the nature and properties of Dark Matter helps to clarify how structures formed.

Studying the constituents of matter at ever higher energies allows us to observe the history of our Universe further back in time.

The challenge: understanding the Universe soon after the Big Bang

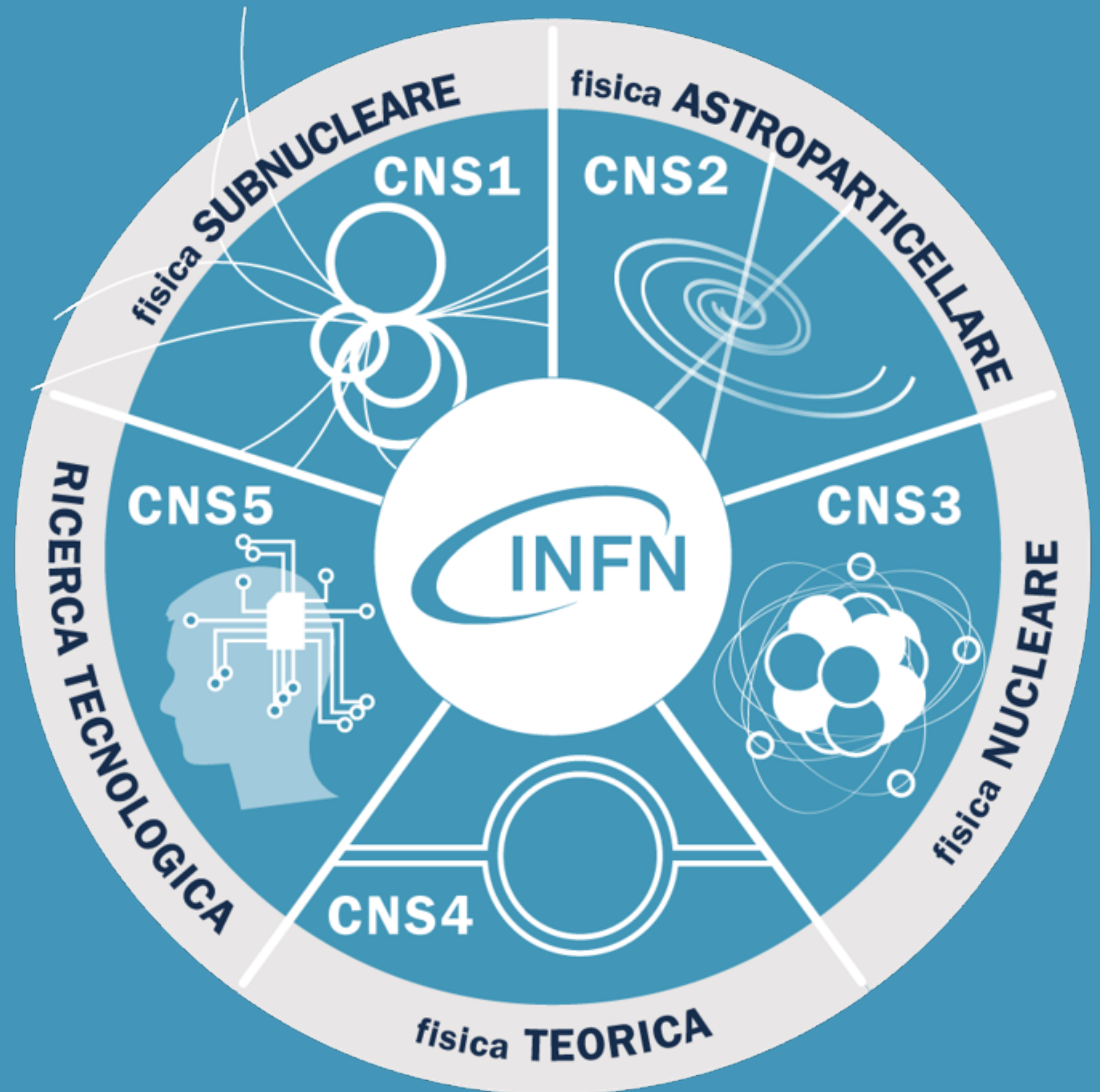


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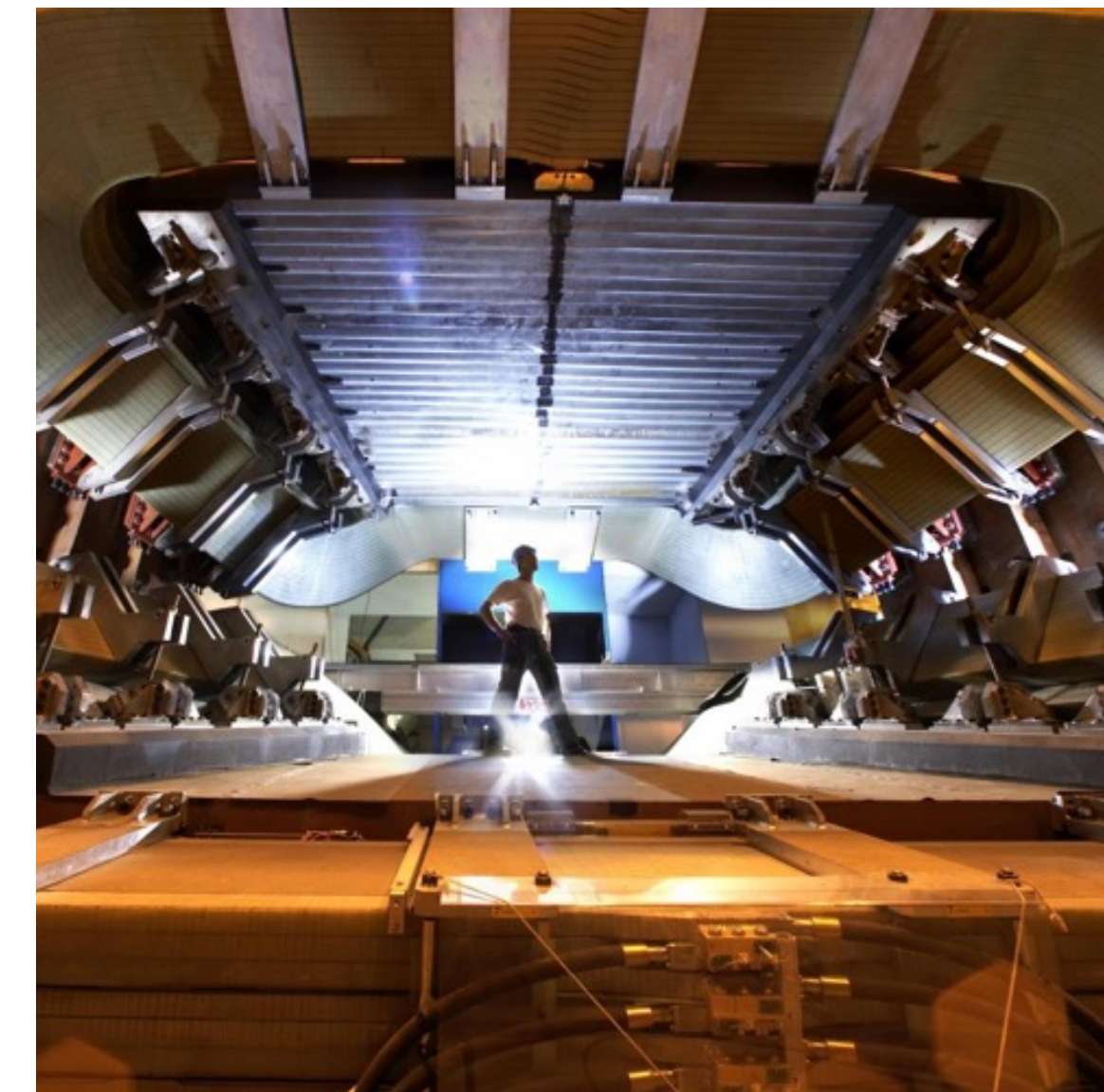
Gravitational waves and neutrinos let us look back at the primordial Universe, even before the Cosmic Microwave Background.

**The 5 research
domain**
and the national
scientific committees



Coordinates studies of the interactions of the fundamental constituents of matter through **experiments with particle accelerators**.

Using particle accelerators at ever higher energies, we can produce new particles not present under ordinary conditions, study aspects such as the **mechanism of mass generation** – starting with the Higgs boson, discovered in 2012 – and explore possible scenarios of New Physics that address unresolved problems and go beyond the Standard Model.



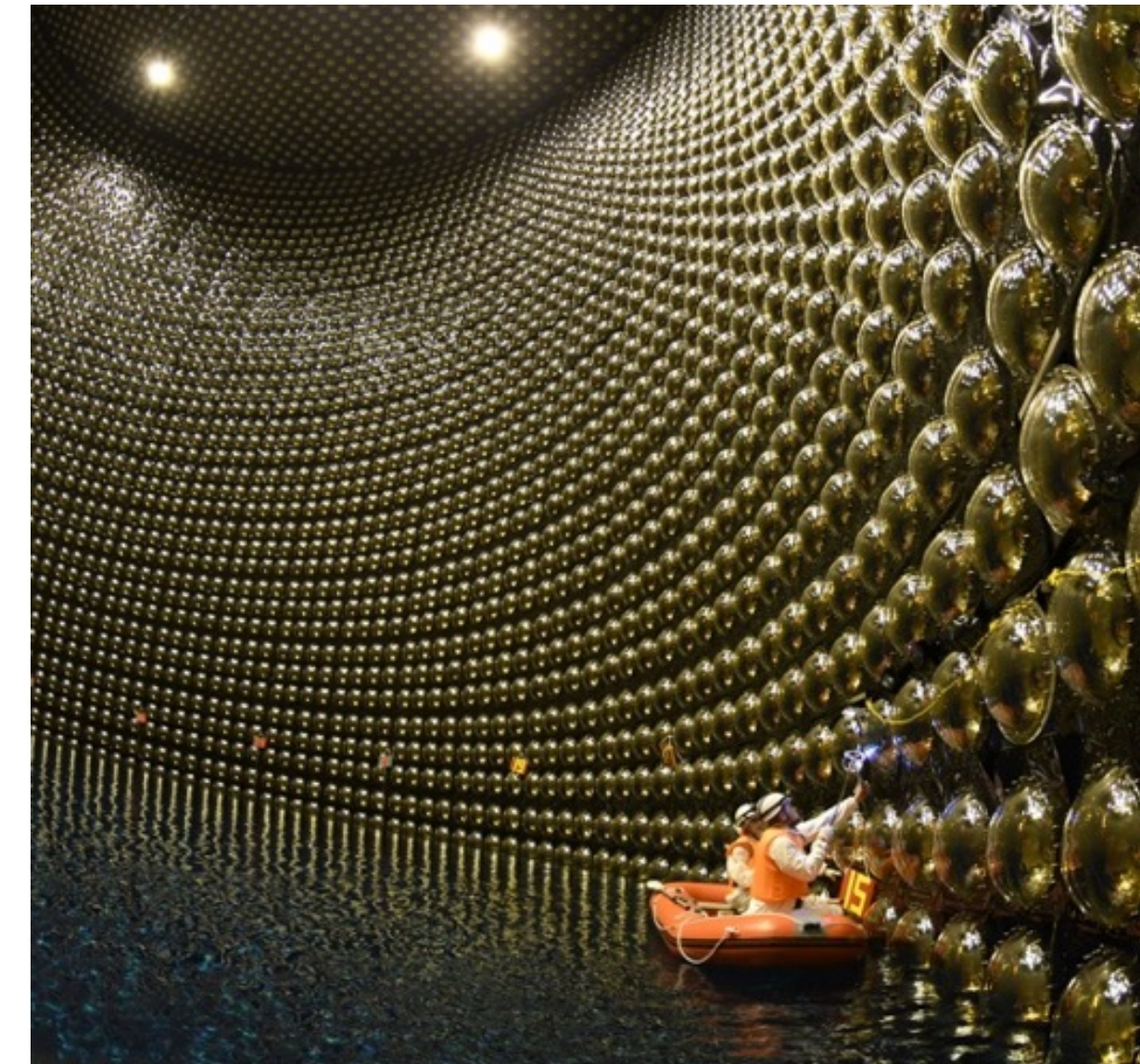
We explore **two complementary frontiers** of our experimental limits: energy and luminosity.

We use increasingly powerful particle accelerators to reach **ever higher collision energies**, allowing the formation of new particles (as in the LHC).

Alternatively (or simultaneously, in the case of the LHC), we try to enhance the occurrence of the **rarest events**, thereby pushing the **precision measurements** of these events to the extreme.

Coordinates research activities in Astroparticle domain. This research focuses on aspects of fundamental physics that cannot be probed with particle accelerators, exploring them indirectly by using the Universe as a natural accelerator for all kinds of radiation, or by investigating extremely rare processes in laboratories like the Gran Sasso Lab.

Experiments are conducted to study the cosmic microwave background, cosmic rays, neutrinos, gravitational waves, ultra-high-energy gamma rays, and other rare particles that can provide important clues about the matter–antimatter asymmetry in the Universe or could constitute dark matter.



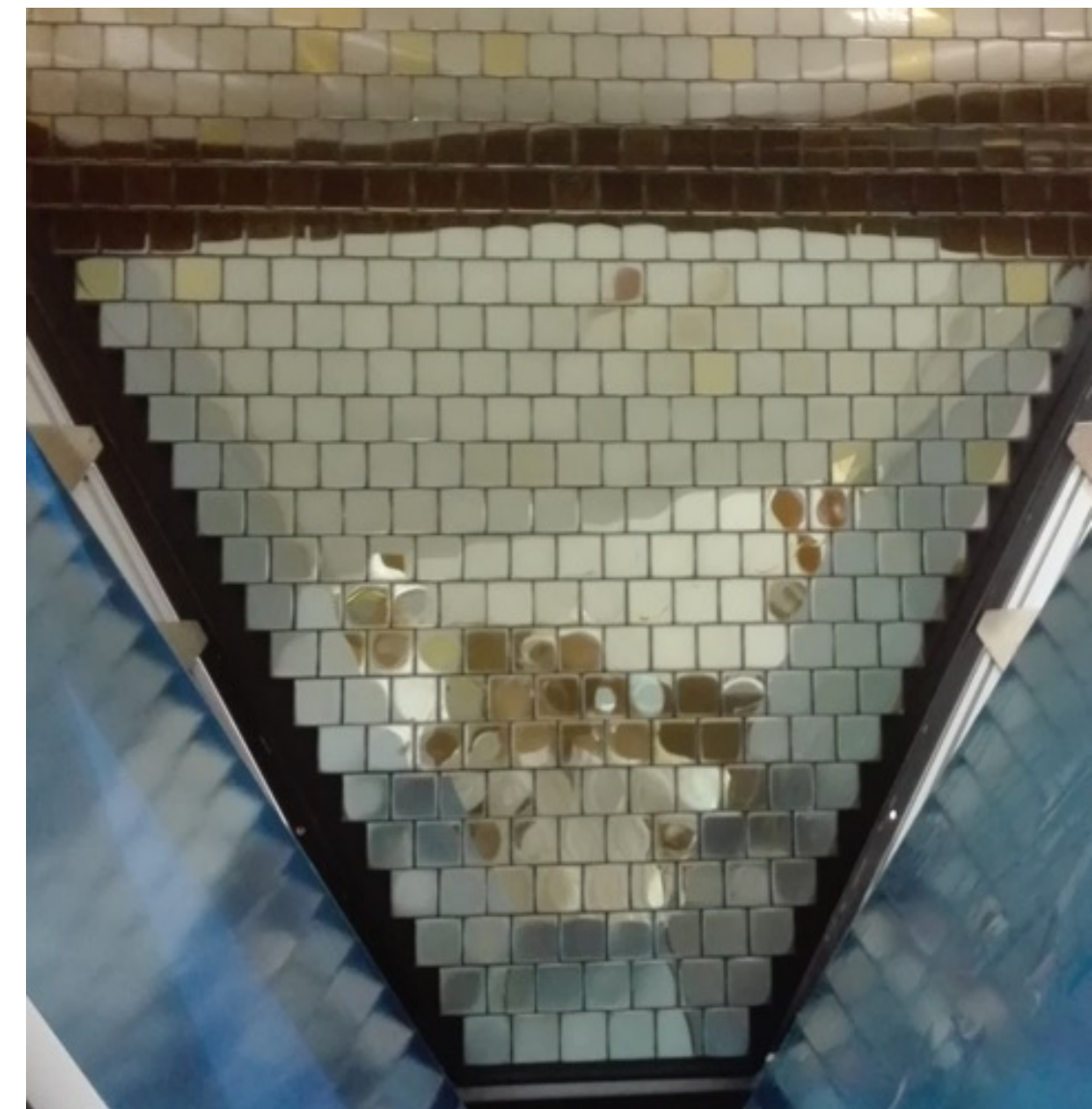
One of the most fascinating current challenges is the study of gravity and gravitational waves, predicted by Einstein and recently observed by the Virgo-LIGO collaboration, opening a new and very promising window for observing the Universe and studying black holes.

It studies how the elementary constituents of matter, the **quarks**, come together when atomic nuclei are formed, using high-energy particle collisions, for example at Jefferson Lab between an electron and a nucleus.

At CERN in Geneva, collisions between Lead nuclei can create, for a brief moment, a bubble of **quark-gluon plasma**, the state of the primordial Universe.

The mechanisms of star formation are studied at the INFN National Laboratories: at Gran Sasso, the LUNA accelerator can investigate the formation of nuclei at energies comparable to those found in stars, much lower than those achieved in standard particle accelerators. Sophisticated accelerators and detectors, among the most advanced in the world, are installed at Legnaro Laboratory and at the Laboratori Nazionali del Sud to produce and study unstable nuclei, in order to understand the formation mechanisms of heavy nuclei, with masses greater than iron, in massive stars.

At the Frascati National Laboratories, studies also focus on the nuclear force in the presence of 'strange' quarks, which is crucial, among other things, for understanding how neutron stars behave.



This division coordinates research in theoretical physics, creating **hypotheses**, **models**, and **theories** to explain current experimental results and to explore new directions for the physics of the future.

These studies rely, on one hand, on experimental results from accelerators and astroparticle physics experiments, and on the other hand, on mathematical methods and formal and numerical techniques.

Among the most significant topics are: the investigation of the **origin of the mass** of elementary particles, the nature and properties of so-called **dark matter**, the explanation of the **matter–antimatter asymmetry** in the Universe, and the **quantum-level unification of all fundamental interactions**, including gravity.

Other research focuses on the study of the nature and intrinsic structure of space-time, the physics of the nucleus and its constituent particles, including processes from the time of the Big Bang and the subsequent evolution of the Universe.

$$\begin{aligned} & \partial_\mu \phi^\dagger \partial^\mu \phi + \mu^2 \phi^\dagger \phi - \lambda (\phi^\dagger \phi)^2 \\ & - ie (\phi^\dagger \partial_\mu \phi - \partial_\mu \phi^\dagger \phi) A^\mu \\ \phi &= \frac{1}{\sqrt{2}} (\phi_1 + i \phi_2) \\ \phi_1 &= \langle \phi_1 \rangle + \varphi_1 \\ \phi_2 &= \varphi_2 \end{aligned}$$

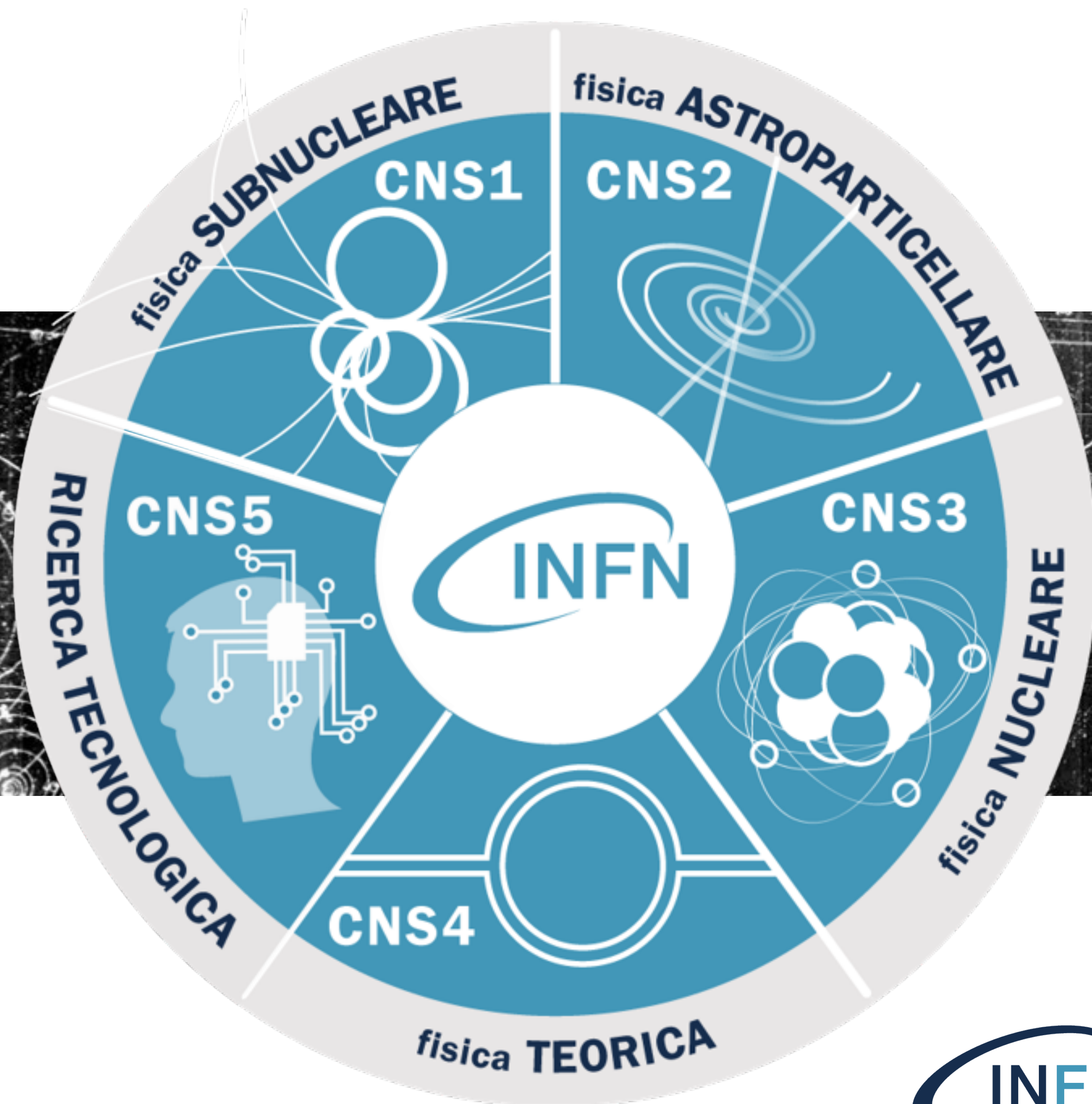
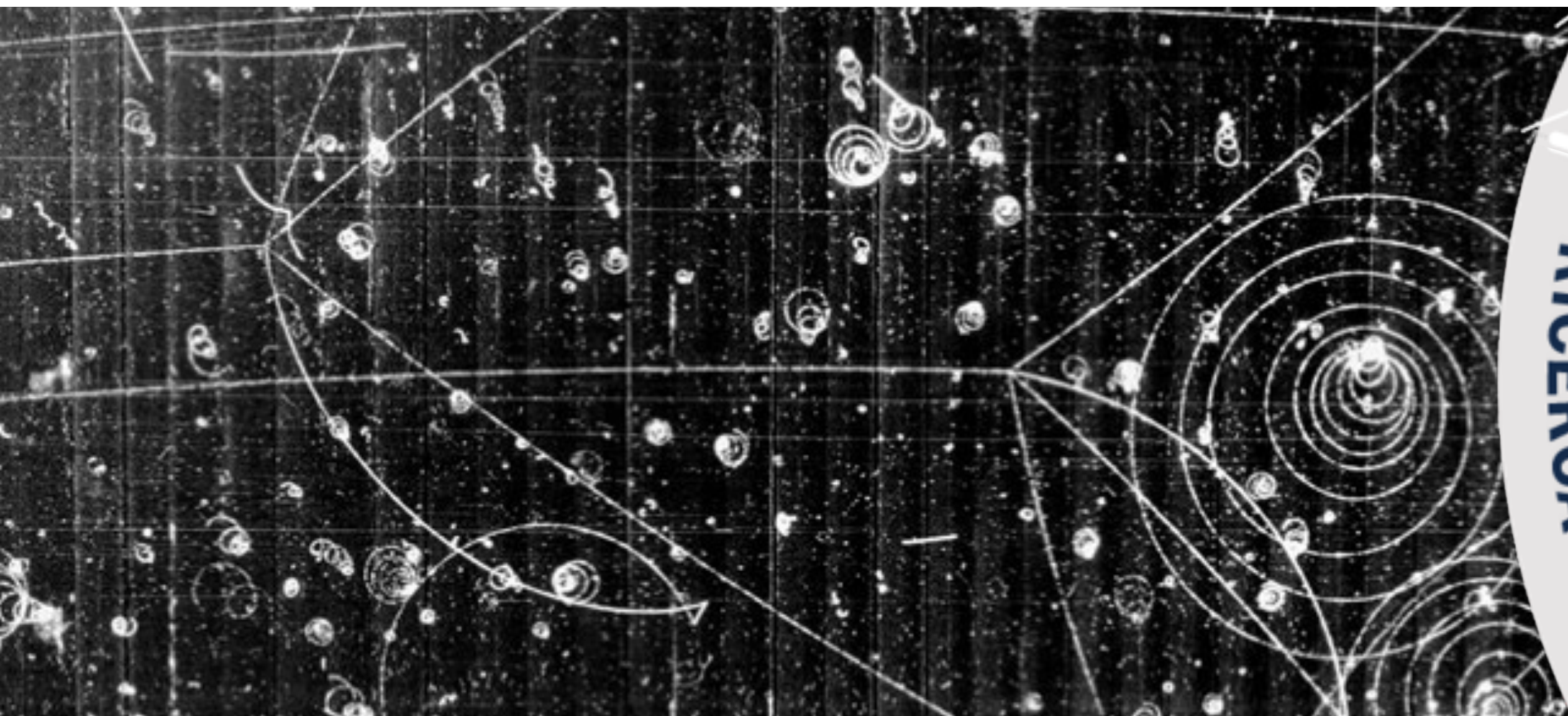


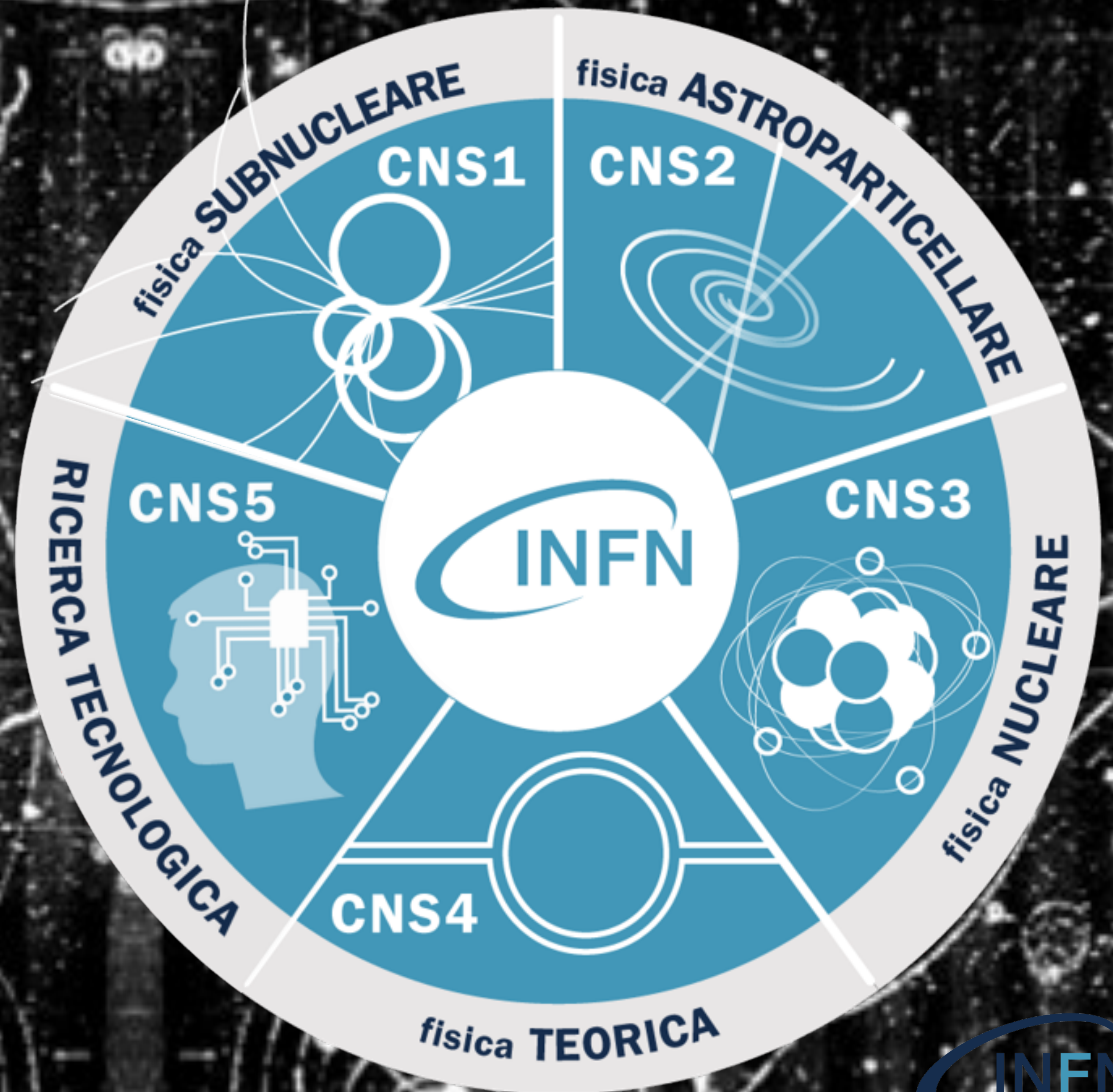
It coordinates technological research and the development of applications, promoting the use of fundamental physics tools, methods, and technologies in other fields.

INFN is a strong national and international reference for the development of future prototypes and the construction of today's particle accelerators.

These are used, in addition to fundamental physics research, in other fields of research as well as in economic and social applications.







4 LUGLIO 2012

The **ATLAS** and **CMS** Collaborations announce the observation of a new particle produced in proton–proton collisions at the **CERN Large Hadron Collider**, consistent with the **HIGGS BOSON** predicted by the Standard Model.

The Rome Section has made a key contribution to the design and construction of detectors, to data analysis, and to theoretical studies.



11 FEBBRAIO 2016

The **LIGO–Virgo** Collaboration announces the first direct observation of GRAVITATIONAL WAVES, predicted in 1916 by Albert Einstein's General Theory of Relativity.



The Rome Section made a key contribution to the design and construction of the interferometer, to data analysis, and to the theoretical studies that led to this breakthrough.



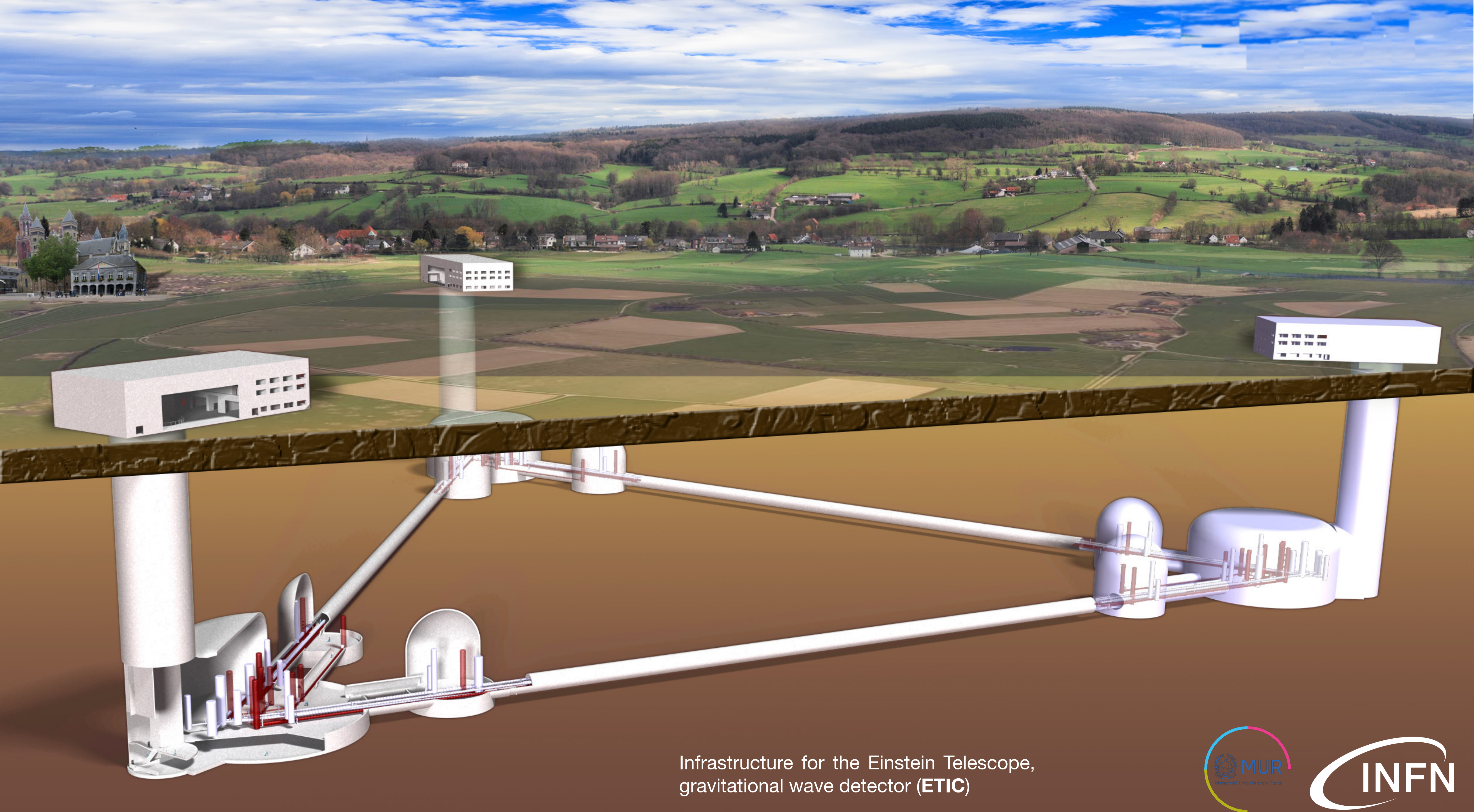
Where are we going?



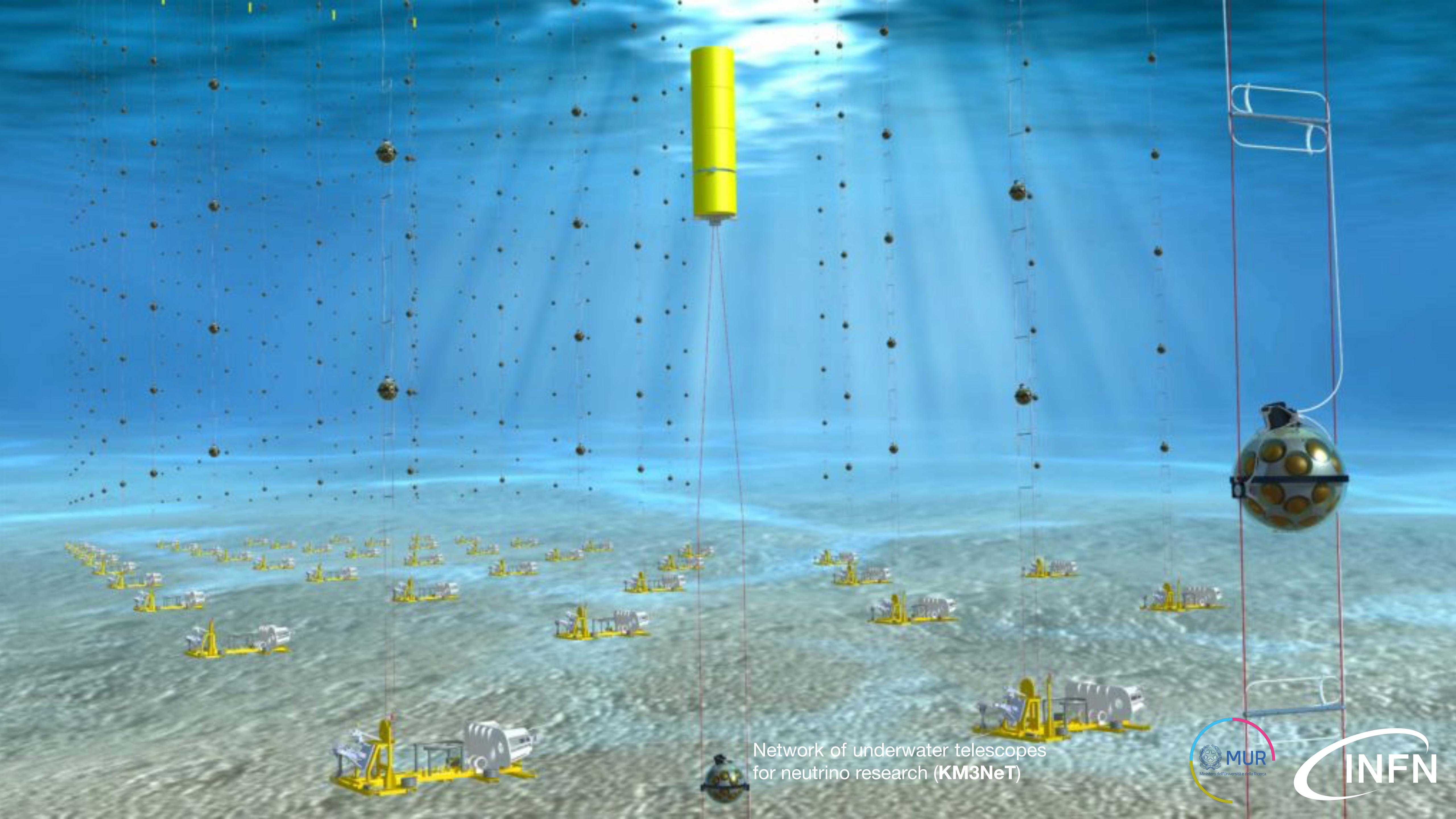


National Center for High-Performance
Computing, Big Data, and Quantum
Computing (ICSC, Terabit)

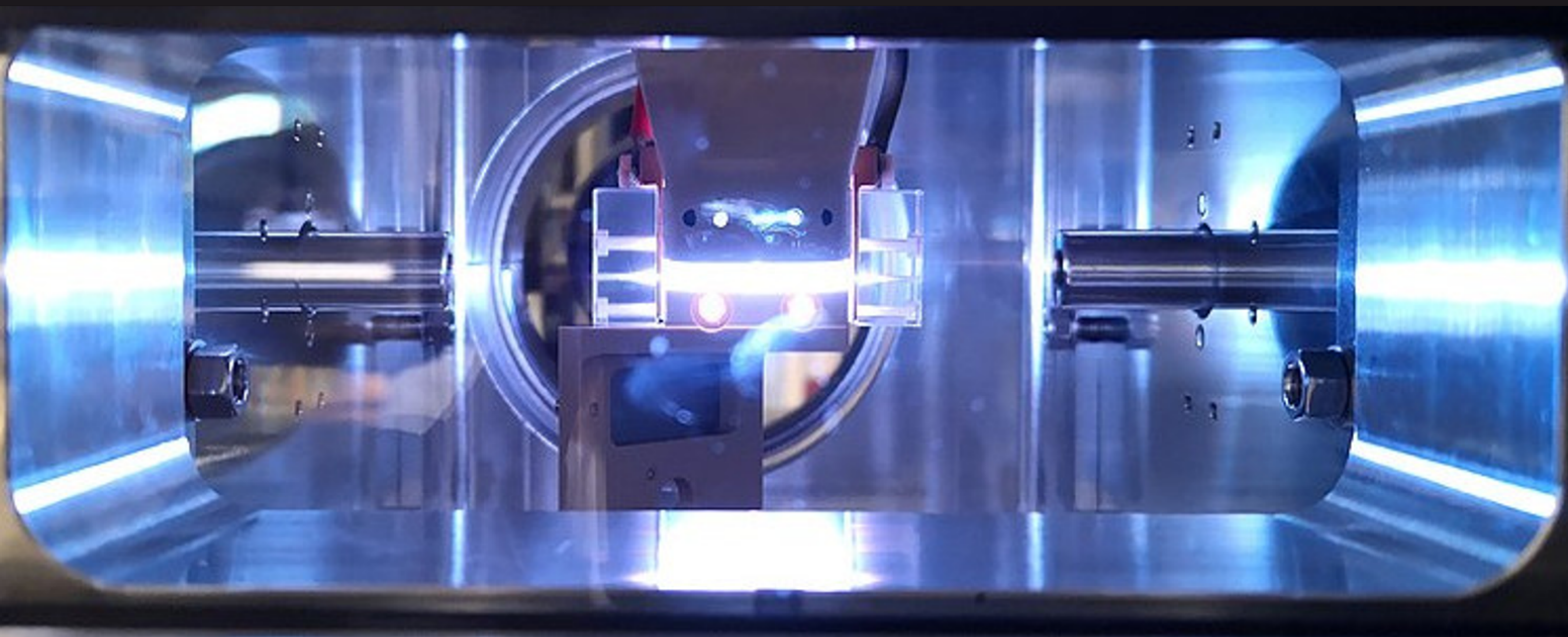




Infrastructure for the Einstein Telescope,
gravitational wave detector (**ETIC**)



Network of underwater telescopes
for neutrino research (KM3NeT)



Development of new accelerator
technologies with plasma sources (**EuAPS**)





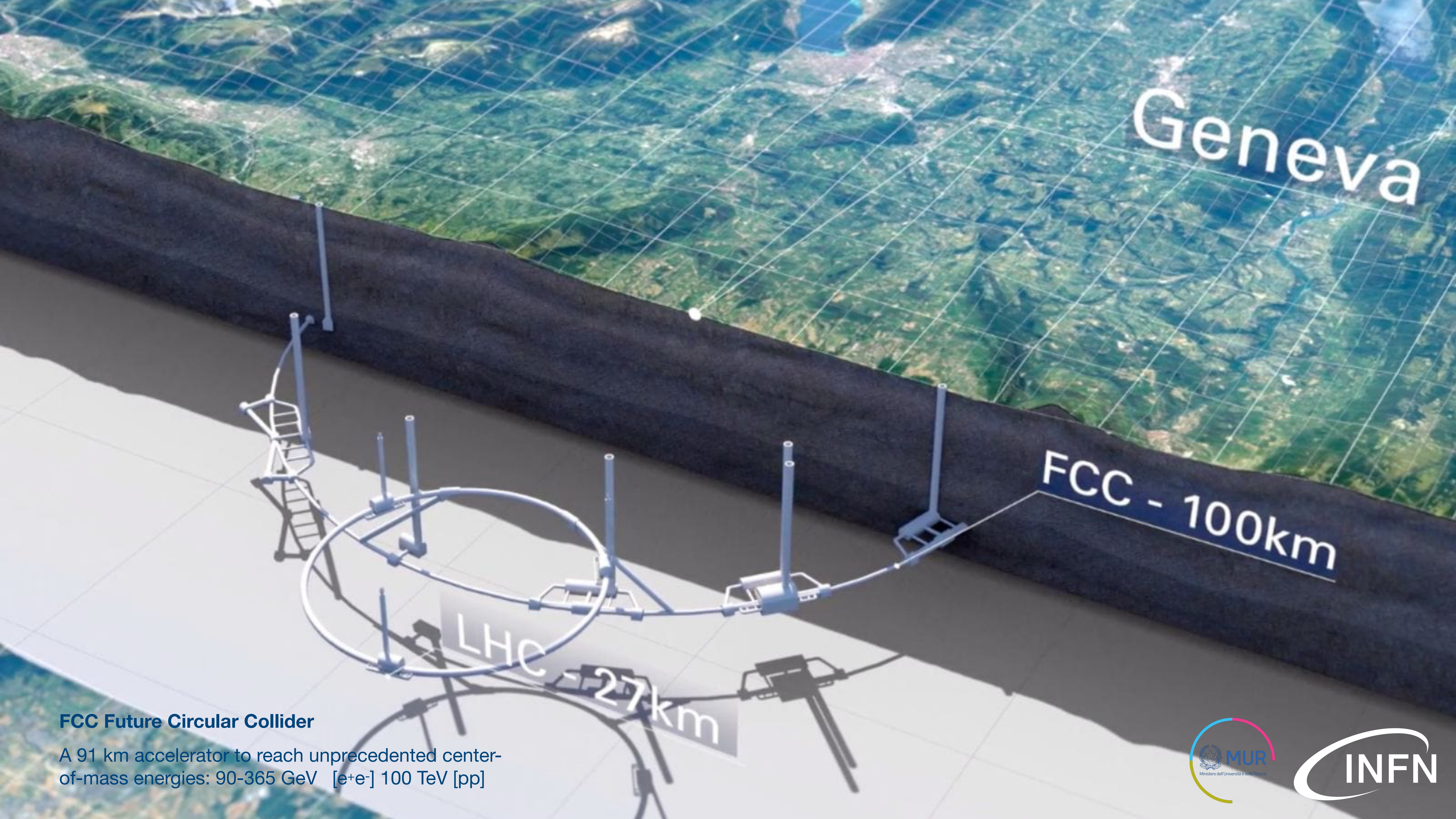
Research infrastructure on
superconductivity (IRIS)





Enhancement of the Gran Sasso
National Laboratories (LNGS)





Geneva

FCC - 100km

LHC - 27km

FCC Future Circular Collider

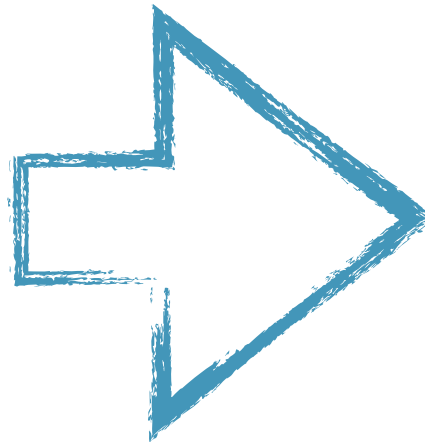
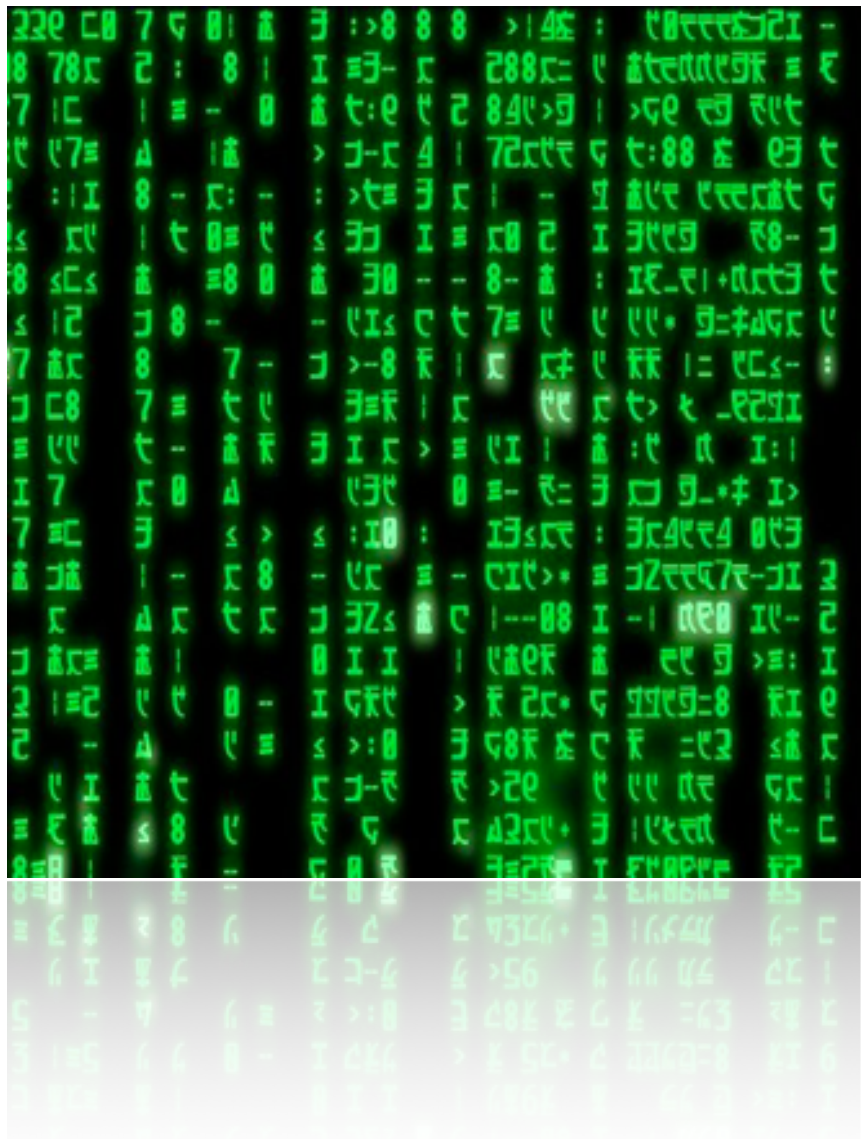
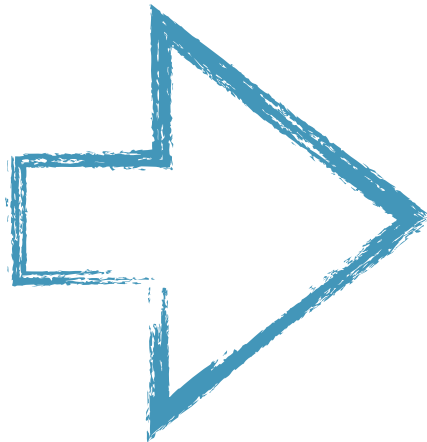
A 91 km accelerator to reach unprecedented center-of-mass energies: 90-365 GeV [e^+e^-] 100 TeV [pp]



Computing, Machine Learning e Intelligenza Artificiale



Petabyte of Data from experiments



Distributed computing:
Hundreds of computing centers
Data access for scientists

INFN Roma Computing Center



HPC: High Performance Computing



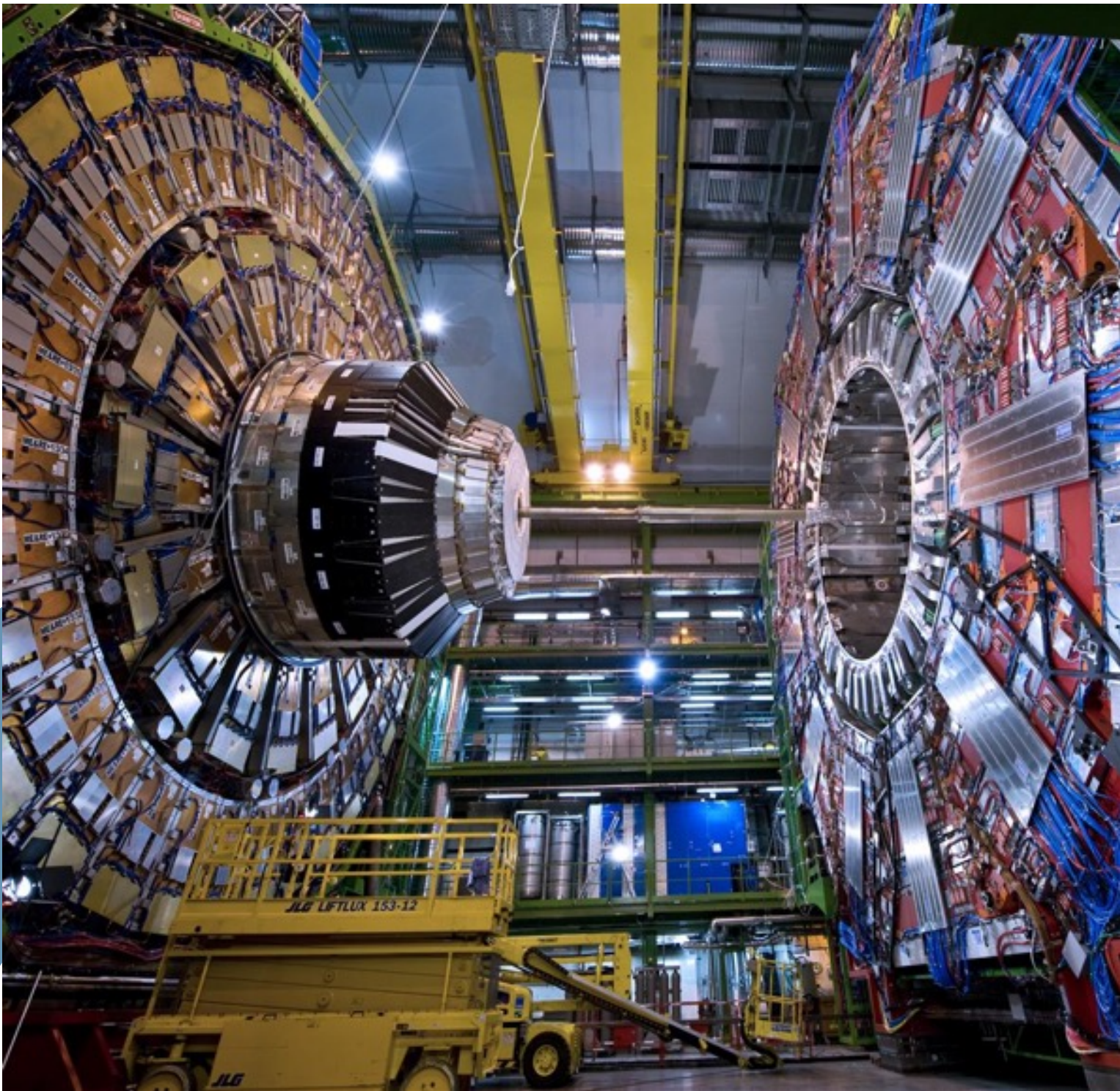
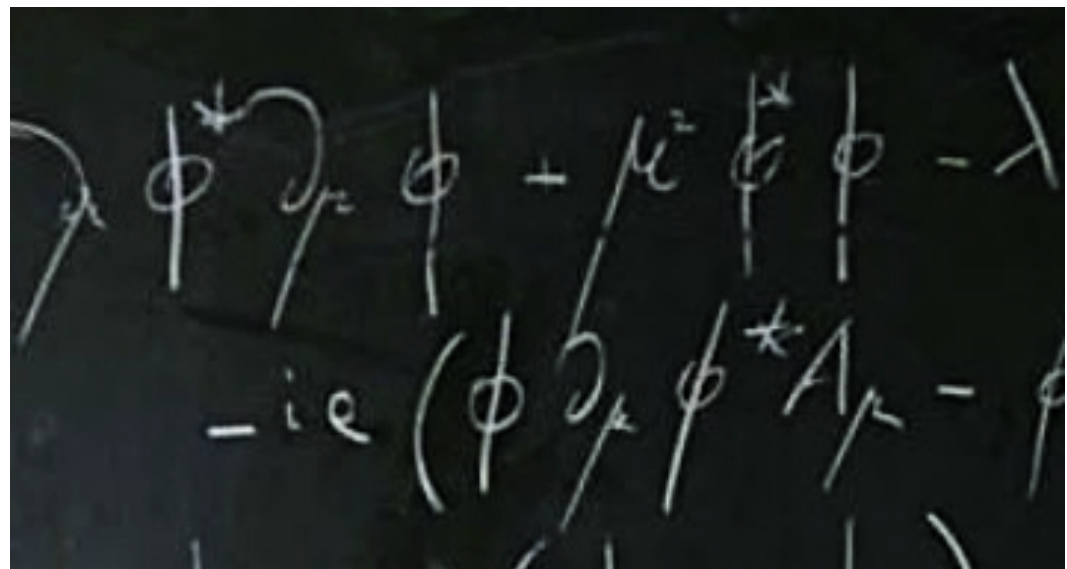
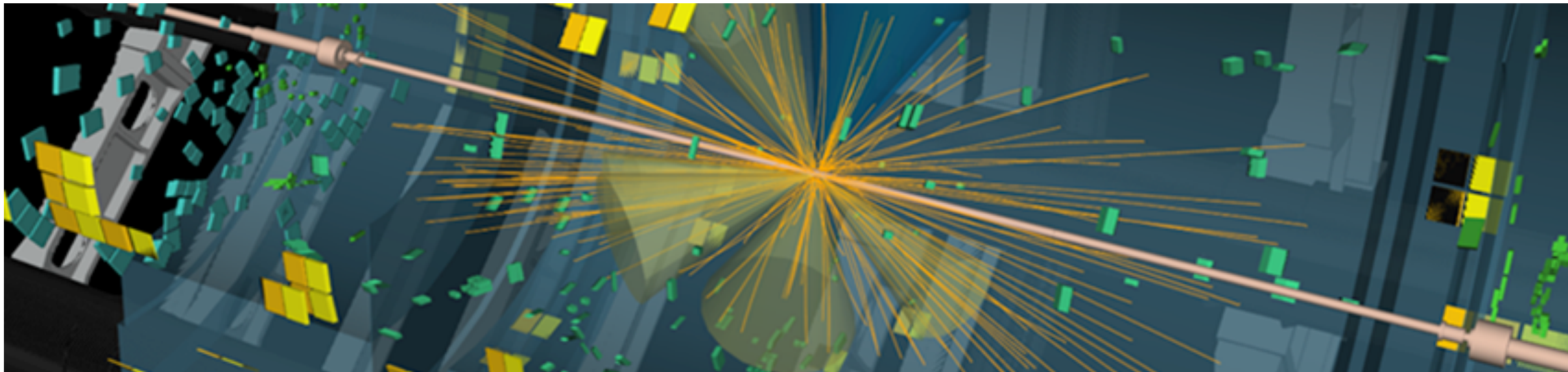
2 PB of storage, 2500 core for processing

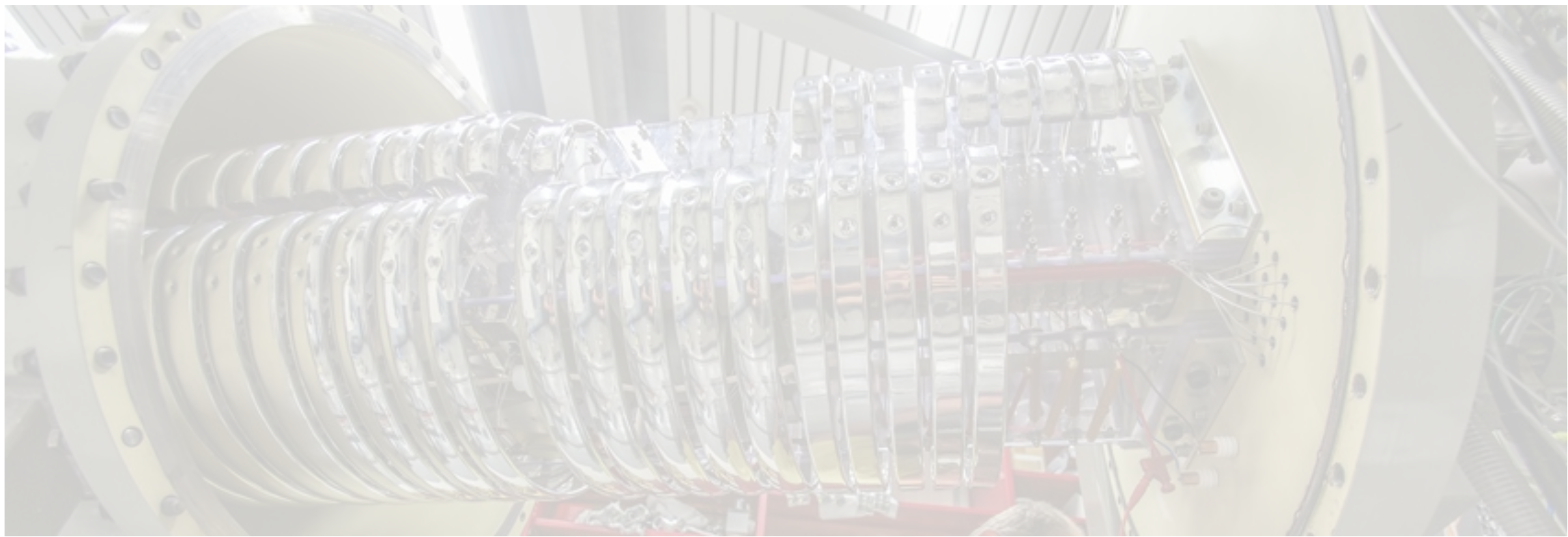
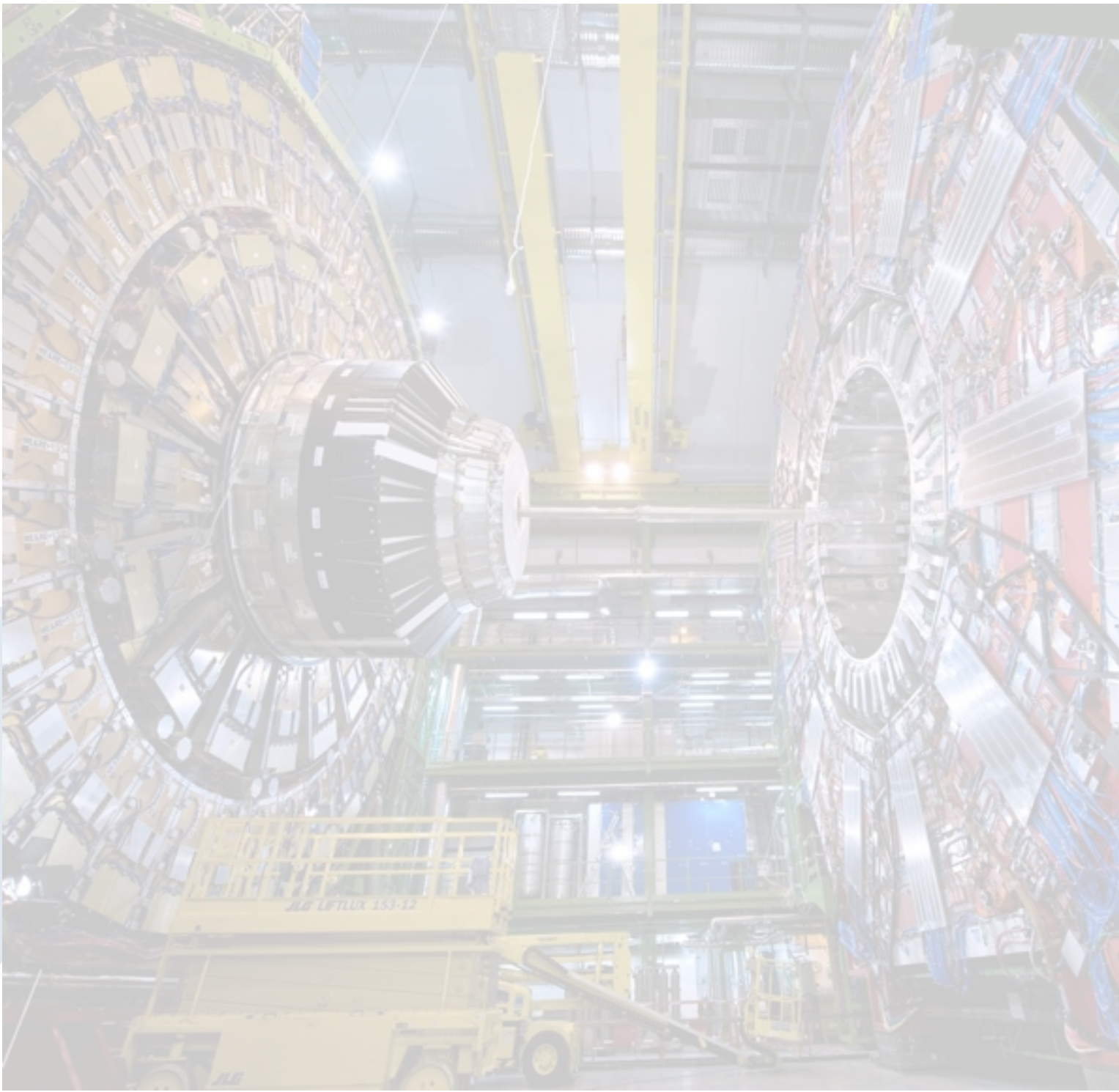
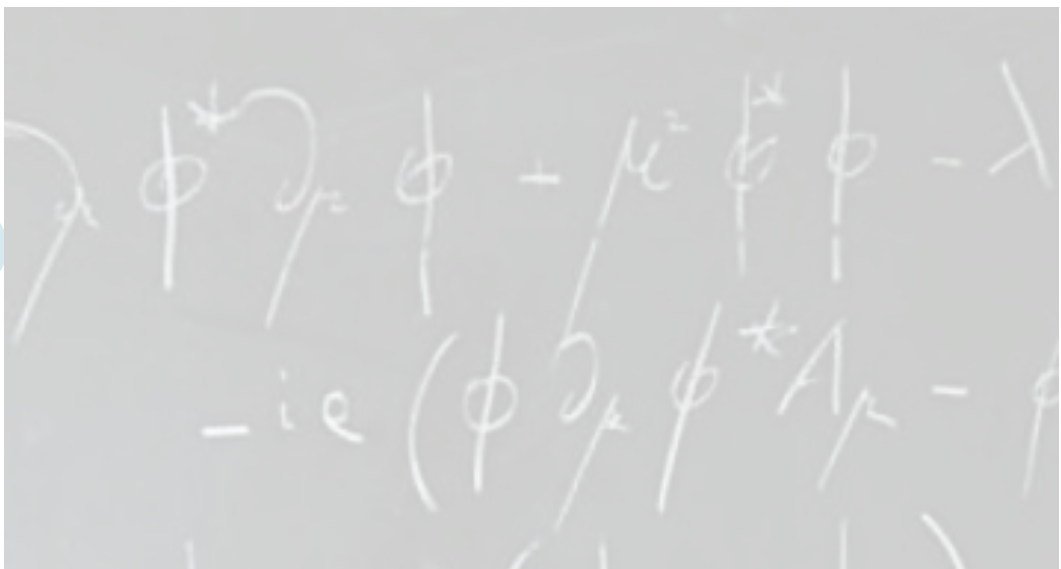
Machine Learning

- ▶ Deep neural networks per classificazione di dati sperimentali
- ▶ Quantum Computing: comprendere quali ricerche potranno beneficiare dell'uso di algoritmi quantistici. In particolare, Quantum Machine Learning
- ▶ Fisica Applicata (imaging, medicina, beni culturali)











So many ideas, so many projects, so many activities,
and yet **many more** await to be done,
and to be *invented*



Istituto Nazionale di Fisica Nucleare