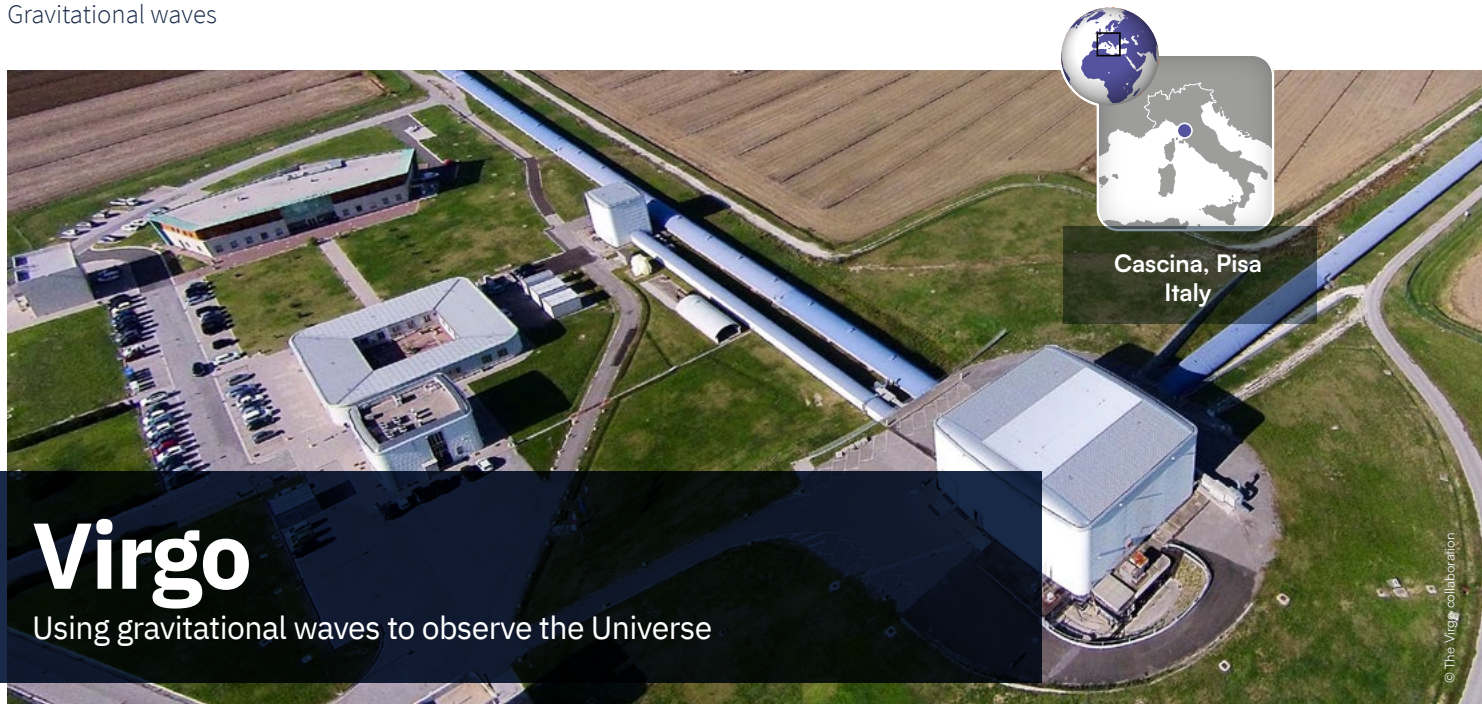
NUCLEAR & PARTICLES

National institute of nuclear and particles physics

Gravitational waves



Virgo

Using gravitational waves to observe the Universe

Scientific leader: Loïc Rolland (LAPP) *

Laboratories involved: APC (Paris), CC-IN2P3 (Lyon), IJCLab (Orsay), IPHC (Strasbourg), IP2I et LMA (Lyon), LAPP (Annecy),

Nature: research infrastructure

Status: European project in operation, mainly funded by the CNRS (France), INFN (Italy) and Nikhef (Netherlands)

Website: https://www.virgo-gw.eu/

Scientific objectives

Virgo is a gravitational wave detector. Together with the American LIGO detectors, it observes cataclysmic cosmic events such as black hole or neutron star mergers. This new field of observation opens the way to new tests of general relativity, new measurements of the expansion of the Universe and of the equation of state of dense matter, which makes up neutron stars, but also to studies of populations of black holes in the Universe. Virgo also participates in concerted campaigns to capture cosmic phenomena via various modes of observation: gravitational waves, electromagnetic waves, neutrinos, cosmic rays. Virgo is hosted and operated by the European Gravitational Observatory (EGO).

Resources deployed

- A Michelson interferometer with two 3 kilometres arms, which is sensitive to variations in length of one billionth of a billionth of a metre.
- Vacuum tubes with a diameter of 120 cm and a residual pressure of one billionth of an atmosphere. The total volume under vacuum is 7 000 m^3.
- 40 kilogrammes mirrors made of ultra-pure glass, with a flatness of more than a nanometre, which is totally isolated from sysmic noise.
- A worldwide collaboration network, including data exchange and joint publications, with Virgo, LIGO (two detectors in the USA), the Japanese detector KAGRA, and in the coming years LIGO-India.

3km
length of each arm

27
research groups

€ 12 M
per year budget

8
participating countries

3
main contributors: France, Italy, Netherlands

99,9999%
of light is reflected by the mirrors

IN2P3 CONTRIBUTIONS

- Development of optical coatings for mirrors and optical metrology systems.
- Design and implementation of the data acquisition and control system of the interferometer
- Development of the Virgo vacuum control system and vacuum chambers.
- Design and implementation of interferometer calibration systems.
- Development of algorithms for the characterisation of the detector and the analysis of gravitational wave signals.

Other french laboratories involved

Artemis (Nice), g-MAG [ILM (Lyon), INL (Lyon), INSP (Paris), Laboratoire Navier (Paris)], LKB (Paris)

1993 — Project approval by the CNRS and INFN

2007-2011 — First LIGO-Virgo data collection

2016 — Start of Advanced Virgo

2017 — First Advanced Virgo observations: detection of GW170817 (merger of two neutron stars)

2019 — LIGO-Virgo O3 data capture, one detection per week

2024-2025 — O4 data capture with LIGO, KAGRA and Virgo

2027 — O5 data collection with LIGO, KAGRA, and Virgo planned

* Since 2020

April 2024