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REsearch INfrastructures FOR Citizens in Europe

Virgo and the international network

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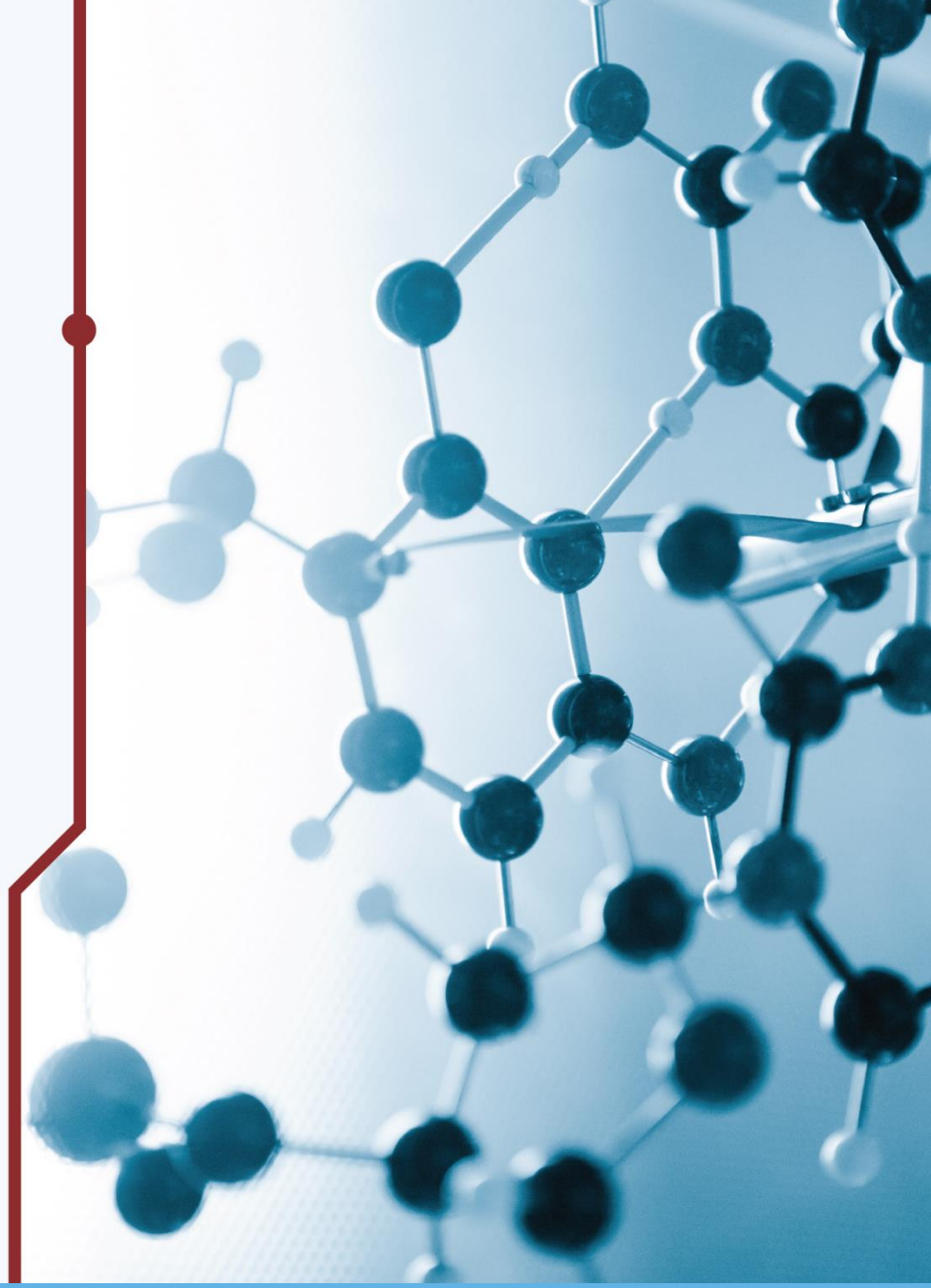
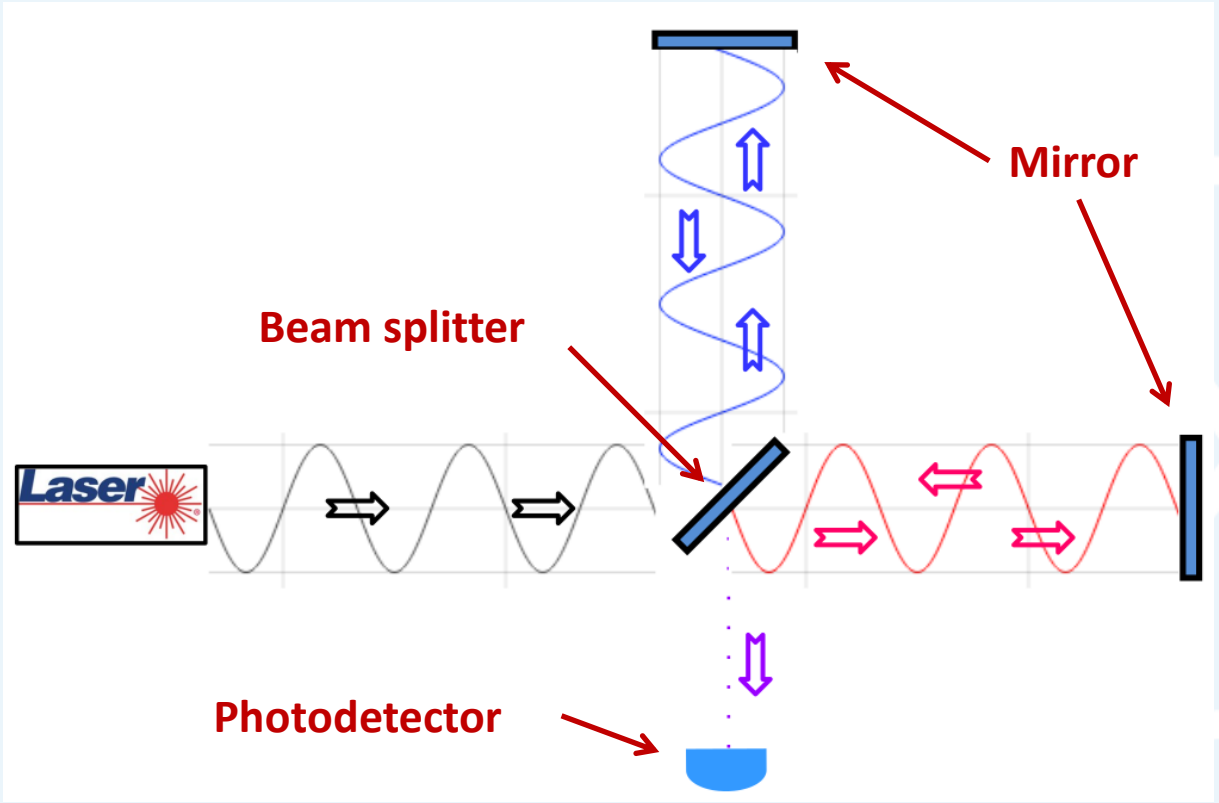


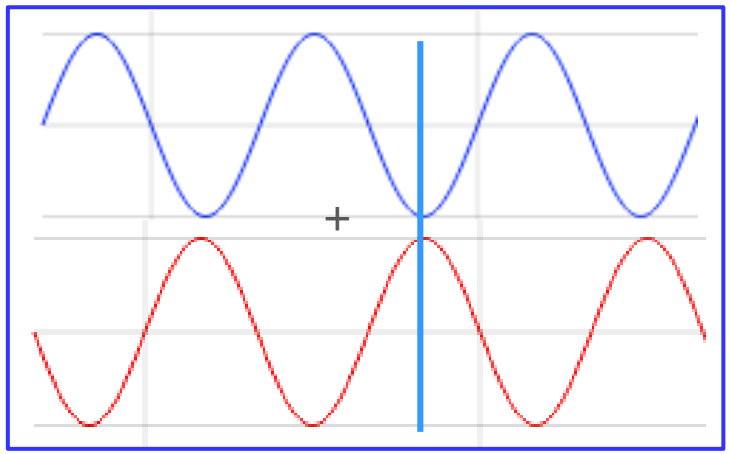
Gravitational Waves detection principle

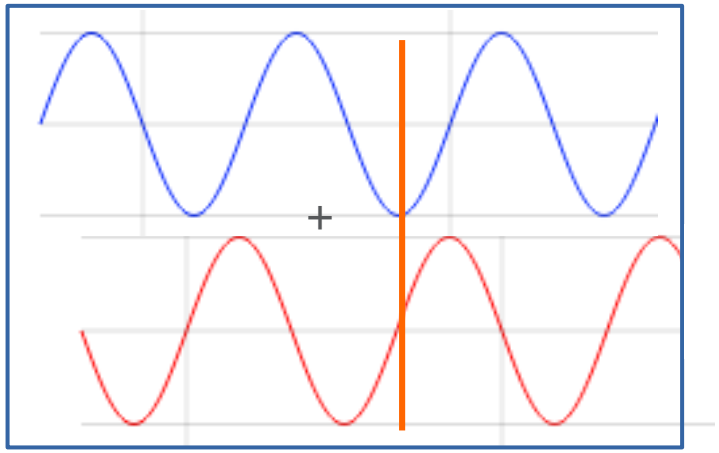
- Effect of GWs: they distort the space-time fabric around us
  - Target is to *measure a change on the distance* between two objects
  - This effect is *differential*
- Ideal instrument is a **Michelson interferometer**
  - *Interference* depends on the length difference between the Michelson arms



Interferences: Dark Fringe

- If both “arms” of the interferometer have **the same length**
  - *Both beams have opposed phase and so they cancel in a perfect way → there is no light reaching the detector*



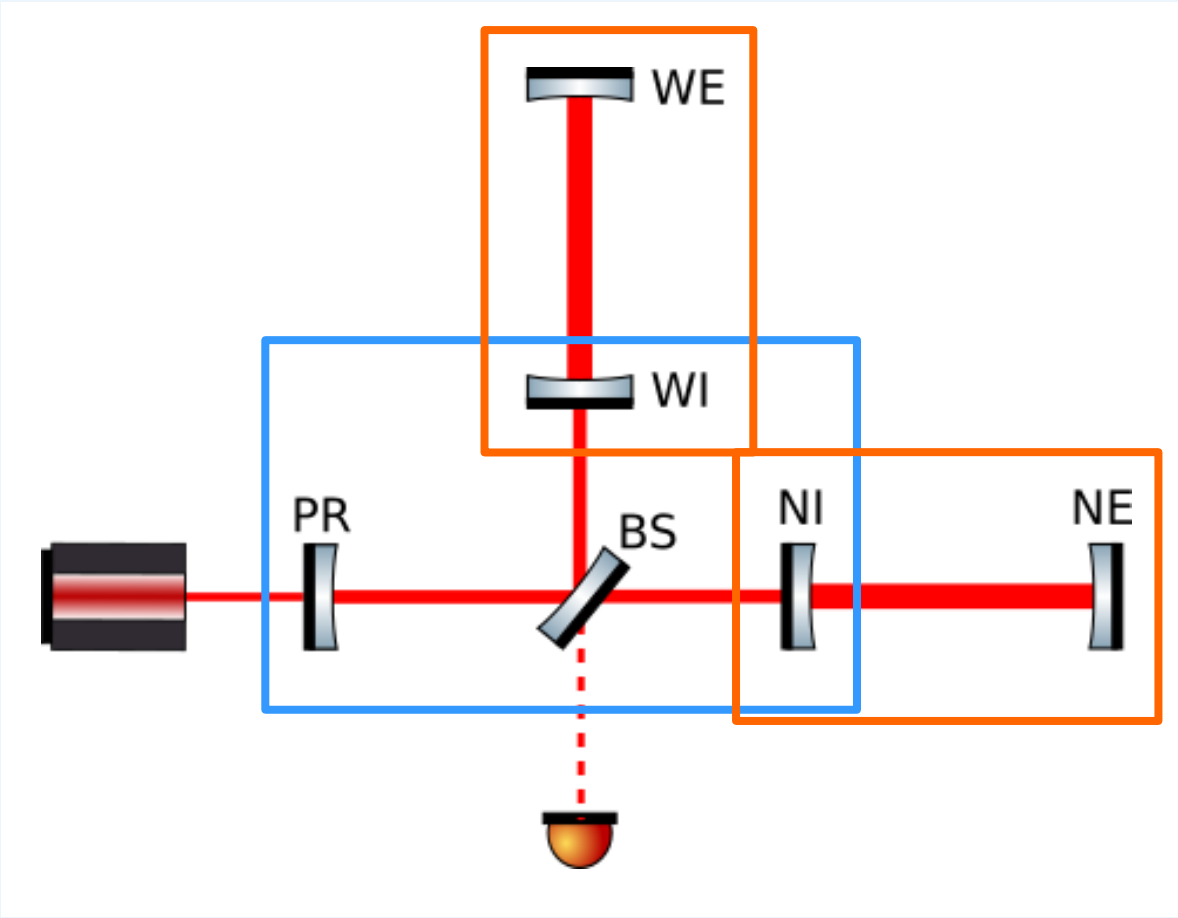


- If there is **one arm longer than the other**
  - *The sum of both beams is different from zero → some light reaches the detector*

Increasing the sensitivity

- The changes in the length that we need to measure are extremely small! → **10^{-18} m**

- **Optical cavities are used to "trap light"**
  - Optical cavities in the arms (3km) to increase the length travelled by the light
  - Optical cavity to recycle the laser power



Decreasing the noise

- The target is to *measure a length difference of the order of ~10^{-18} m* → *almost any noise source becomes limiting*
- Extreme techniques have been developed to *mitigate the different noise sources:*

Seismic noise: mirrors are suspended by a 9m tall Superattenuator → attenuation of 12 orders of magnitude!

Pressure fluctuations: work under ultra-high vacuum → P = 10^{-9} mbar

Fluctuations of the laser: need an extremely stable and “clean” laser beam

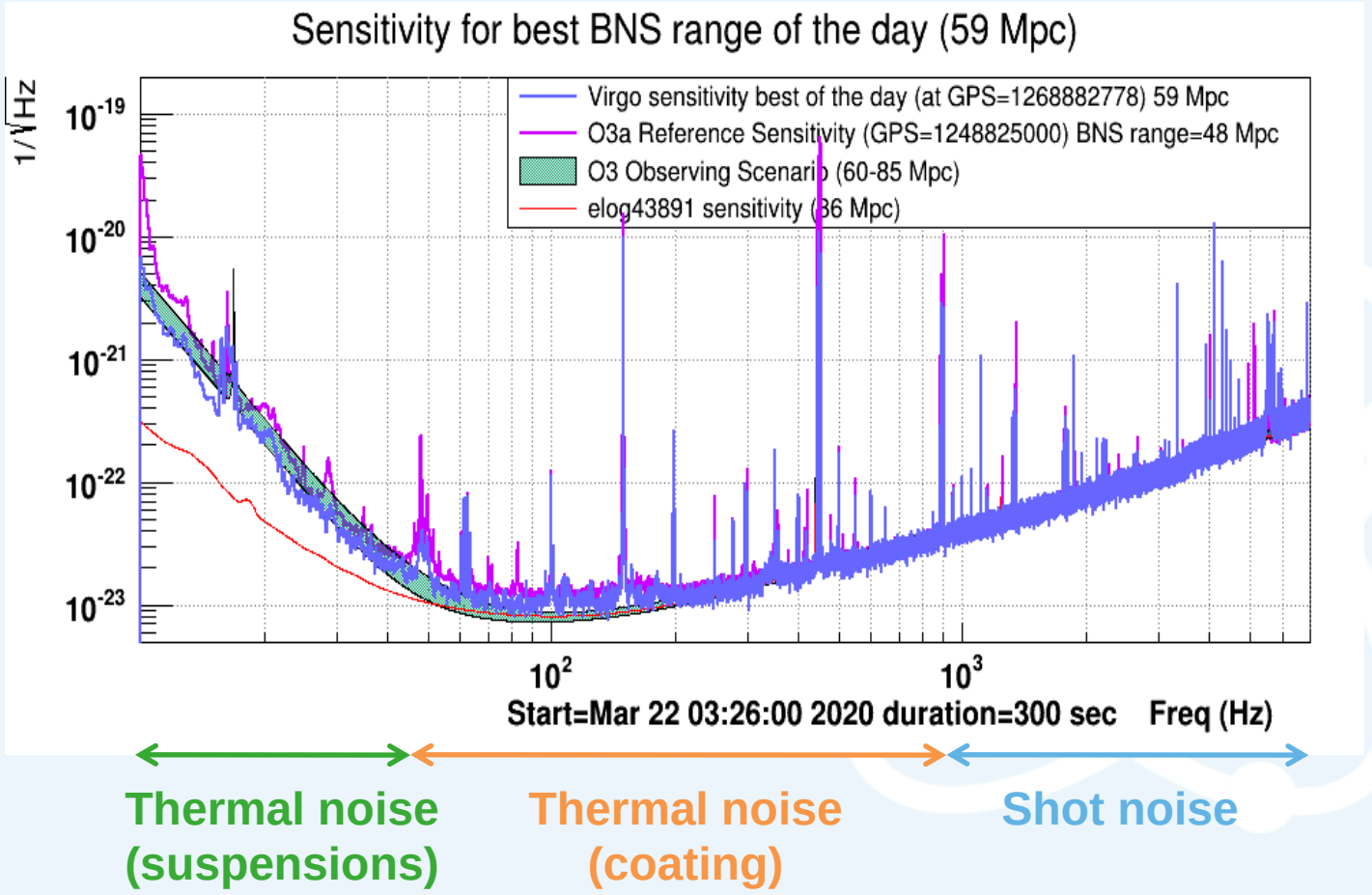
Mirrors quality: high quality surface and coatings

Fibers: very thin fibers (400 um!) to suspend mirrors of 40kg

Photodetectors: low noise photodetectors to monitor the beam all over the interferometer

Fundamental noises

- Thanks to all these technical efforts the detection of gravitational waves was possible!
- Target is to reach/decrease the so-called *fundamental noises*
  - Better coatings
  - Quantum optics
  - Newtonian noise cancellation
  - ...

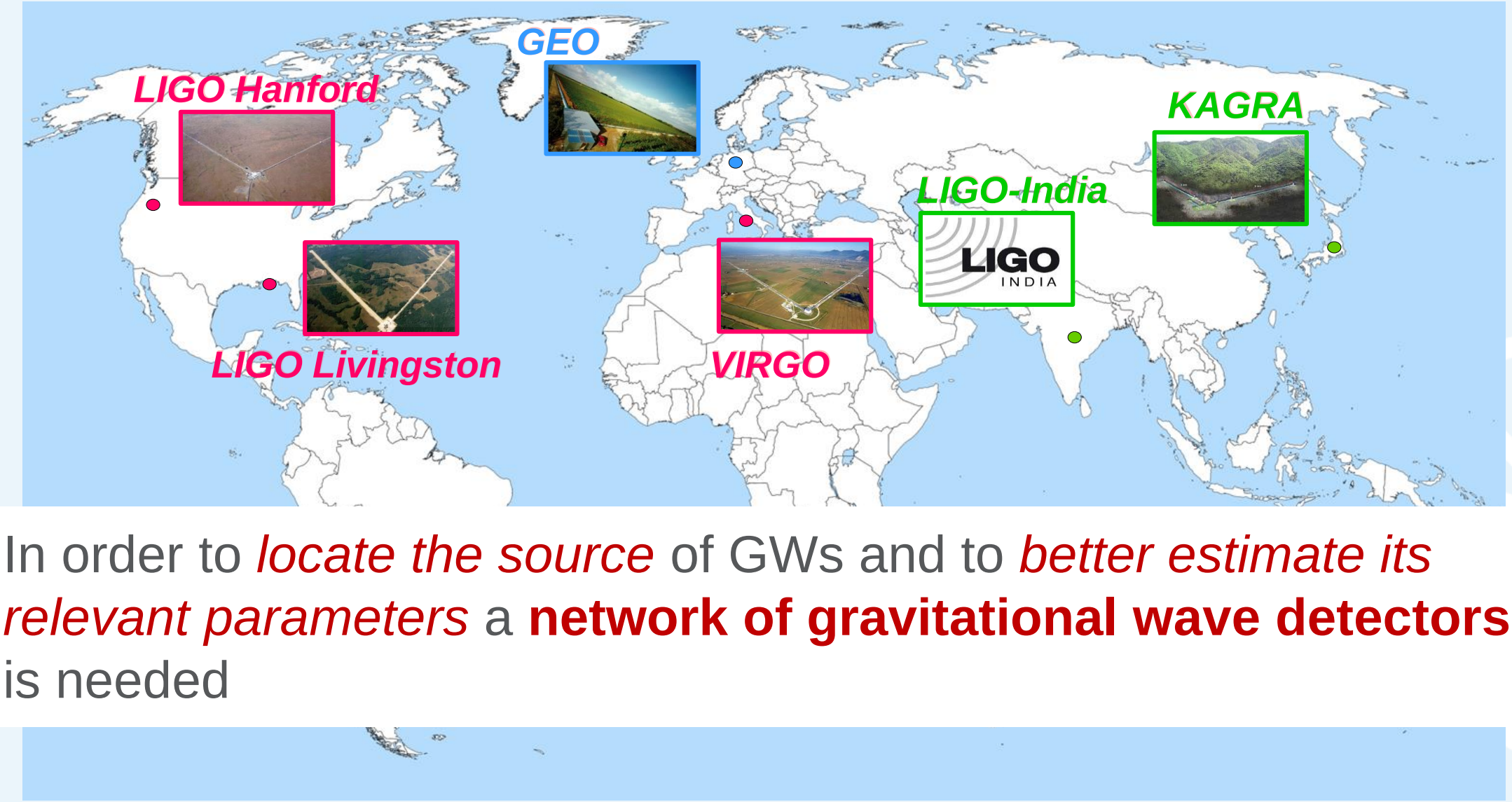


Virgo detector

- Located in the countryside of Pisa
- *Construction started in 1997* as a collaboration between Italy and France
- *First scientific data taking in 2007*
- Since then the collaboration has grown now there are scientists from *7 European countries*

- **First detection of a GW** the 14th of August 2017!

GW detectors international network



- In order to *locate the source* of GWs and to *better estimate its relevant parameters* a **network of gravitational wave detectors** is needed

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