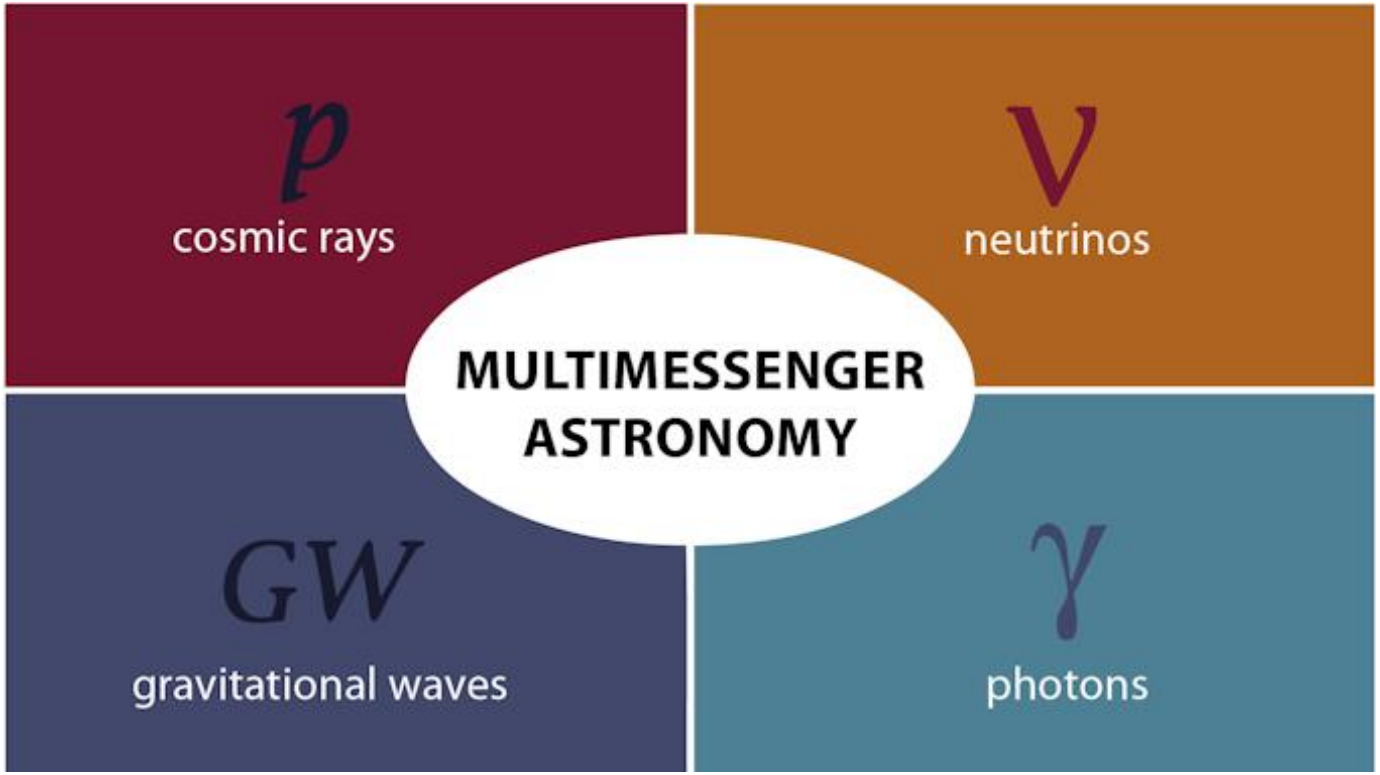
Multimessenger astronomy

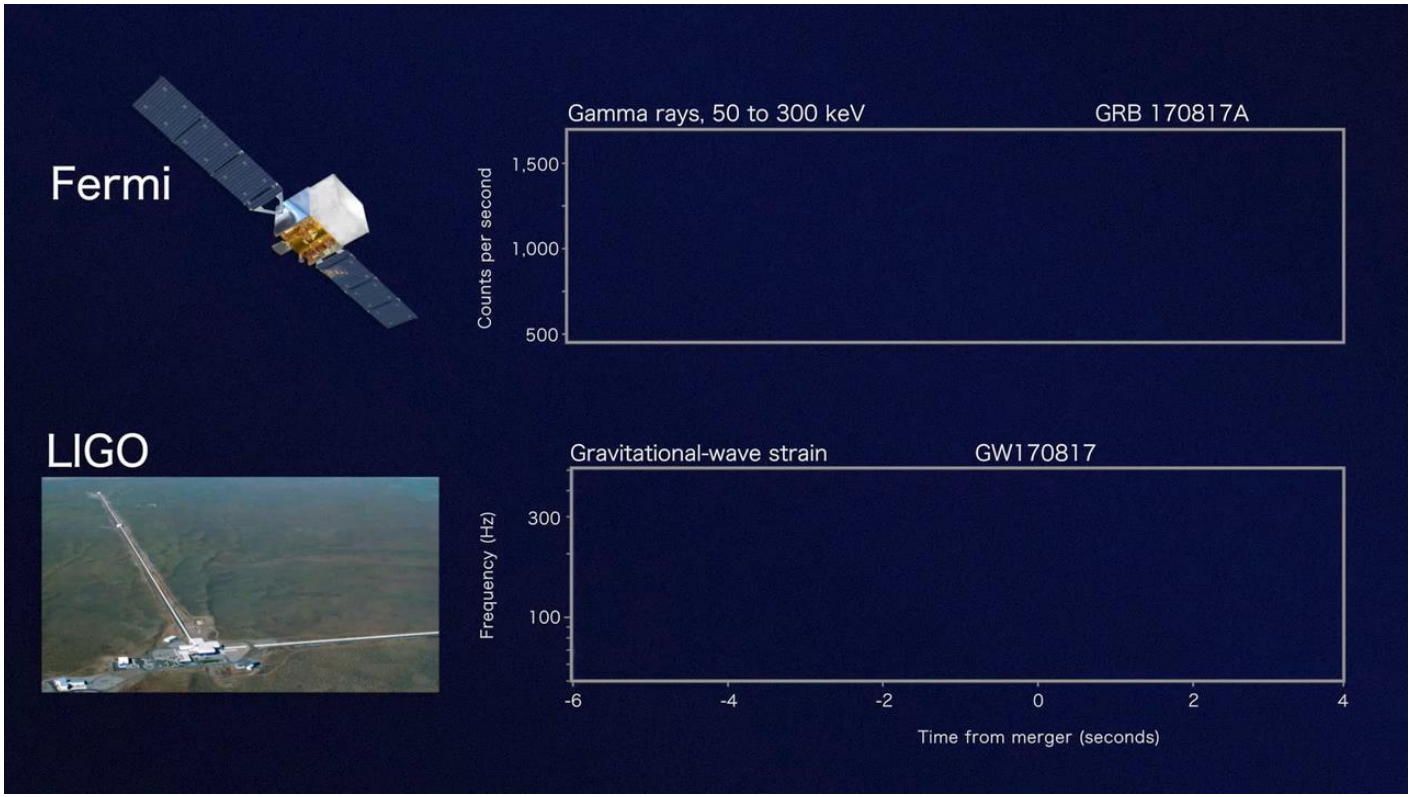
- From Wikipedia:

> **Multi-messenger astronomy is astronomy based on the coordinated observation and interpretation of signals carried by disparate "messengers": electromagnetic radiation, gravitational waves, neutrinos, and cosmic rays. They are created by different astrophysical processes, and thus reveal different information about their sources.**



A striking recent example: GW170817

- Signals recorded within 1.7 second
  - LIGO (gravitational waves) first
  - Then the GBM instrument (gamma ray burst) on board the Fermi satellite

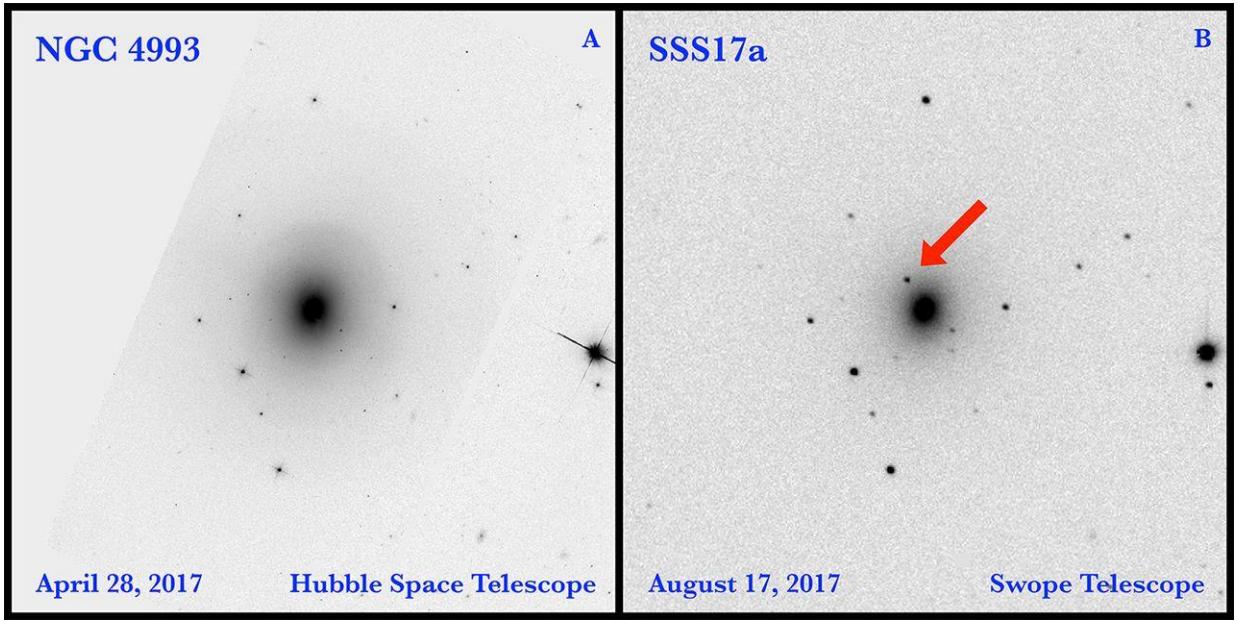


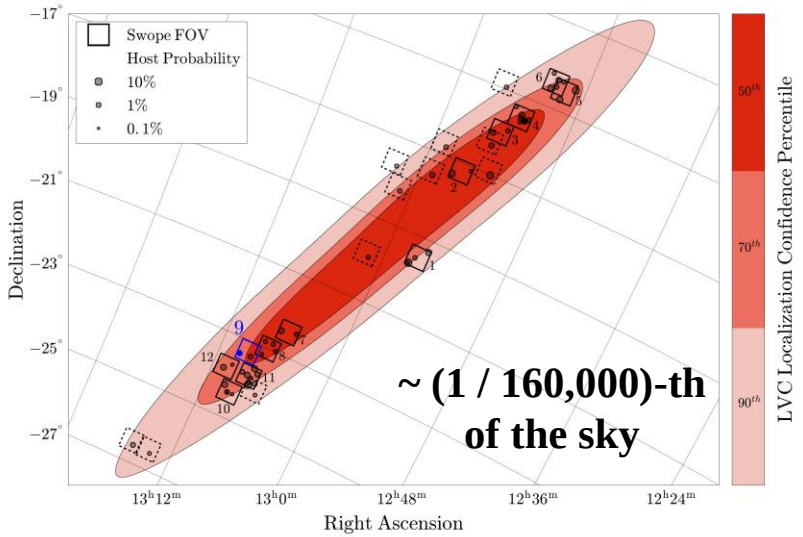
→ Thursday August 17th, 2017 at 07:41 CST: a truly new window onto the Universe

A needle in a haystack

- 2017/08/18
  01:33 CEST

→ Discovery of the optical counterpart by the SWOPE telescope in Chile





A race against time

GW170817

Binary neutron star merger

A LIGO / Virgo gravitational wave detection with associated electromagnetic events observed by over 70 observatories.

Distance
130 million light years

Discovered
17 August 2017

Type
Neutron star merger

12:41:04 UTC
A gravitational wave from a binary neutron star merger is detected.

gravitational wave signal
Two neutron stars, each the size of a city but with at least the mass of the sun, collided with each other.

gamma ray burst
A short gamma ray burst is an intense beam of gamma ray radiation which is produced just after the merger.

+ 2 seconds
A gamma ray burst is detected.

GW170817 allows us to measure the expansion rate of the universe directly using gravitational waves for the first time,.

Detecting gravitational waves from a neutron star merger allows us to find out more about the structure of these unusual objects.

This multimessenger event provides confirmation that neutron star mergers can produce short gamma ray bursts.

Au

The observation of a kilonova allowed us to show that neutron star mergers could be responsible for the production most of the heavy elements, like gold, in the universe.

Observing both electromagnetic and gravitational waves from the event provides compelling evidence that gravitational waves travel at the same speed as light.

kilonova
Decaying neutron-rich material creates a glowing kilonova, producing heavy metals like gold and platinum.

+10 hours 52 minutes
A new bright source of optical light is detected in a galaxy called NGC 4993, in the constellation of Hydra.

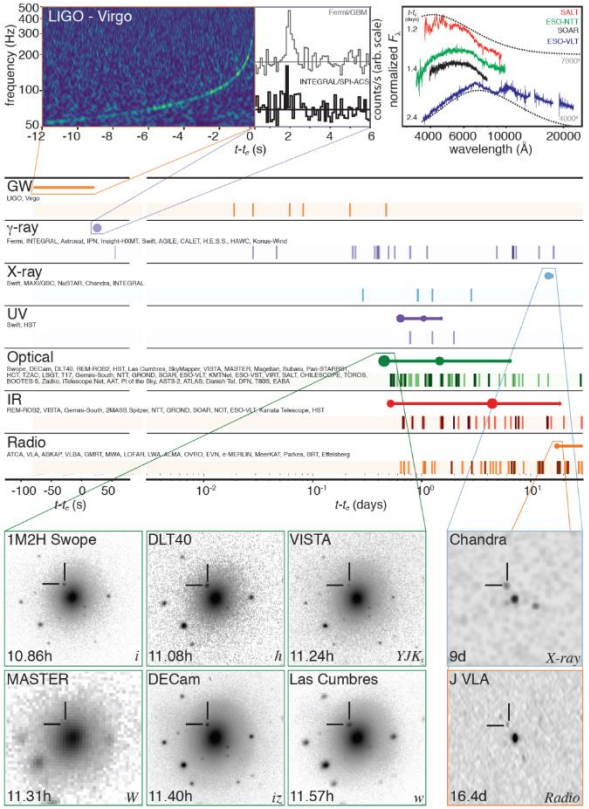
+11 hours 36 minutes
Infrared emission observed.

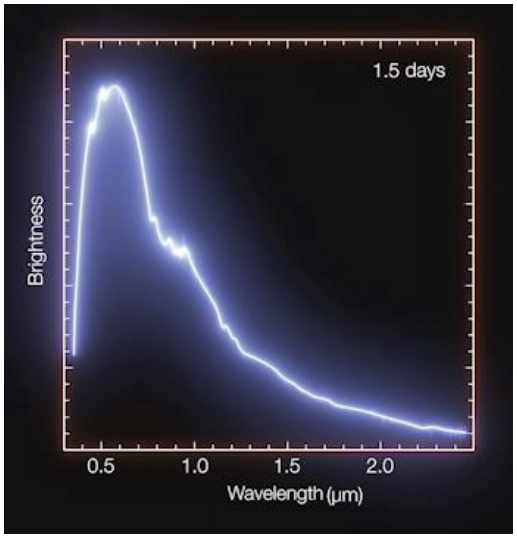
+15 hours
Bright ultraviolet emission detected.

+9 days
X-ray emission detected.

radio remnant
As material moves away from the merger it produces a shockwave in the interstellar medium - the tenuous material between stars. This produces emission which can last for years.

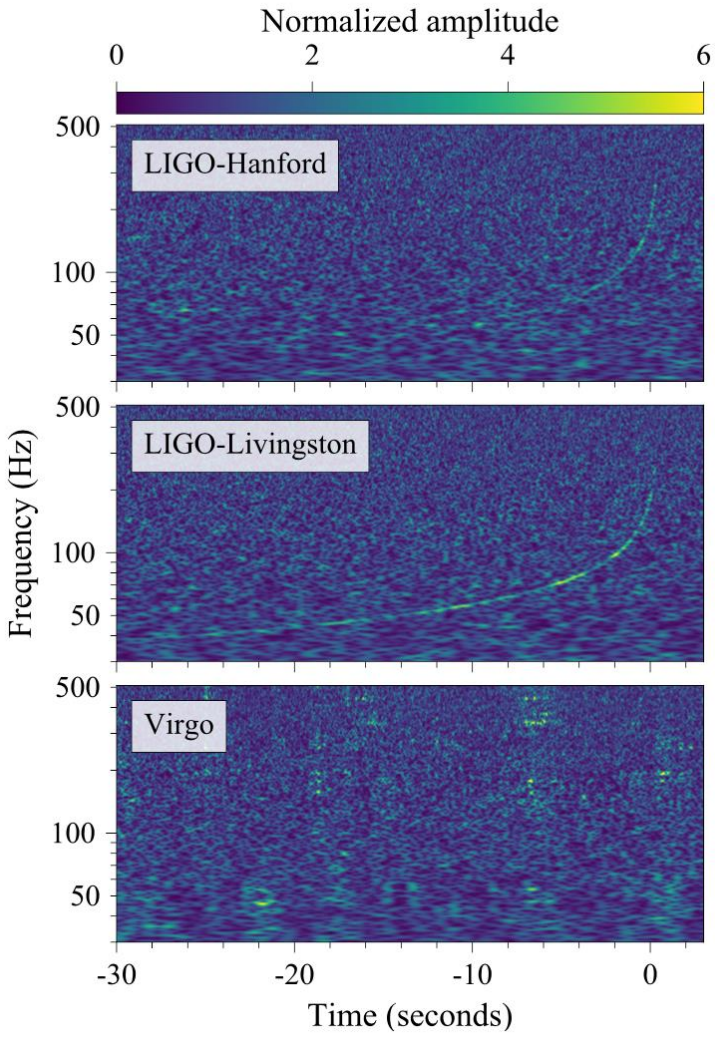
+16 days
Radio emission detected.

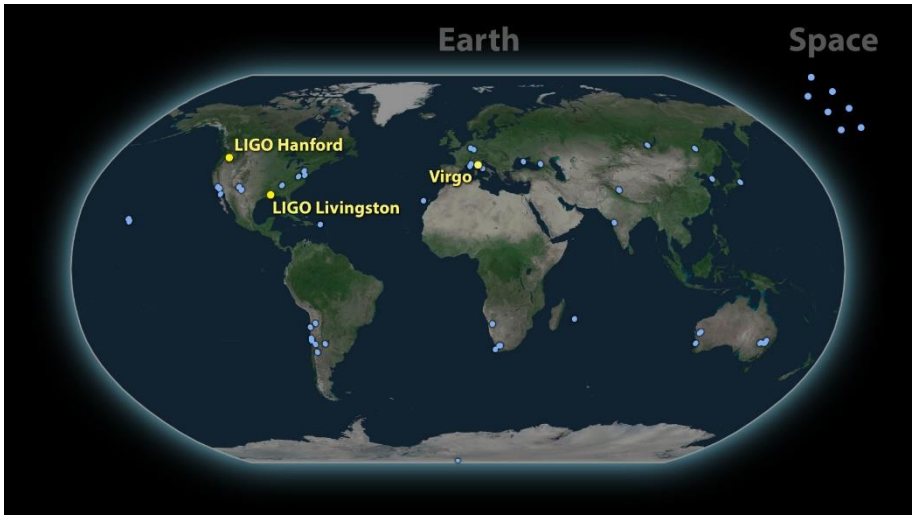




A worldwide effort

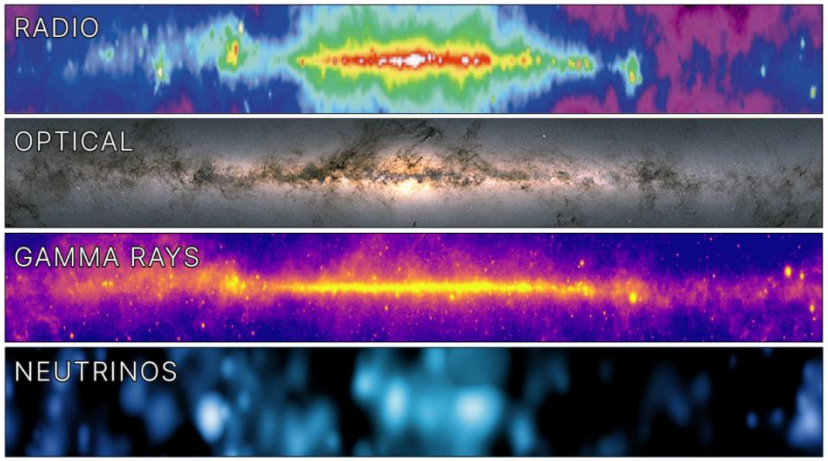
- The example of GW170817





Not limited to gravitational waves

- Milky Way map: electromagnetic spectrum + … neutrinos – IceCube, summer 2023



- SN1987A: E.M. + neutrinos