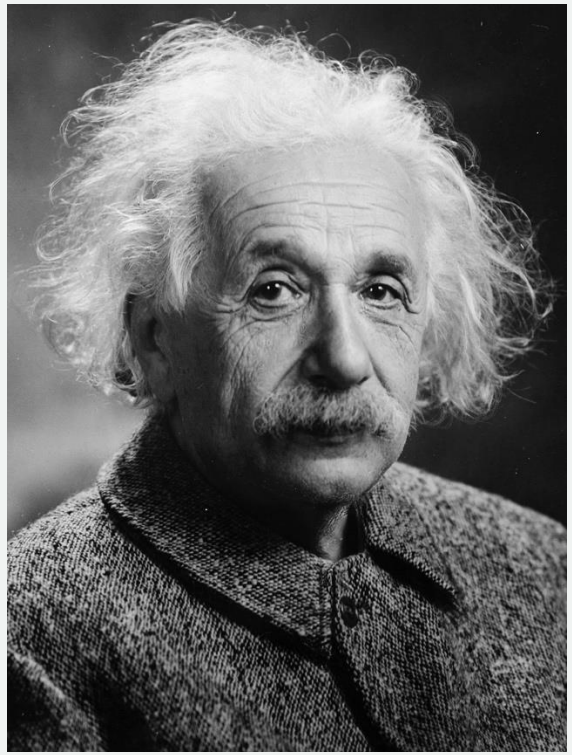
Gravitational waves data analysis

An introduction

Melissa Lopez
12th February 2025

Brief history of gravitational waves (GW)



Albert Einstein

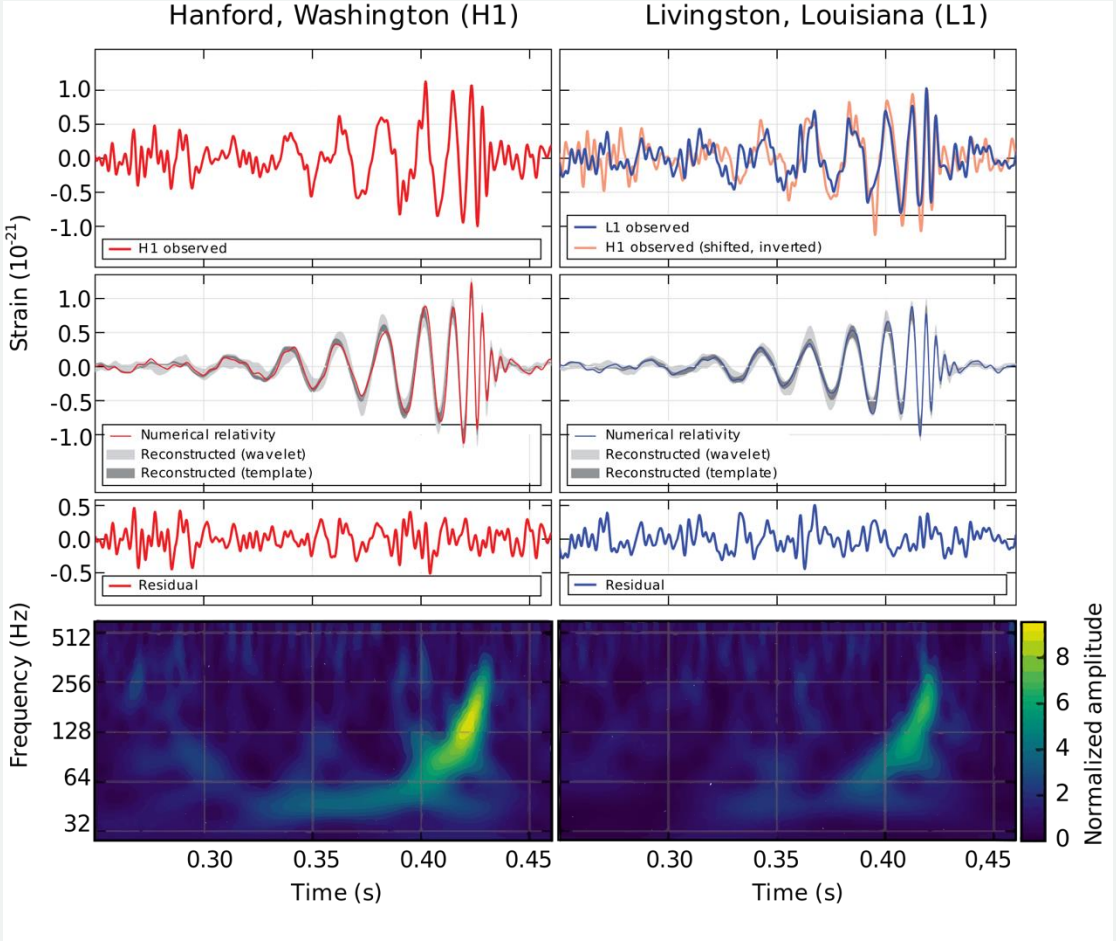
Einstein (1916)
"GW are ripples in space-time"

LIGO/Virgo (2015)
1st GW detection

Nobel prize (2017)

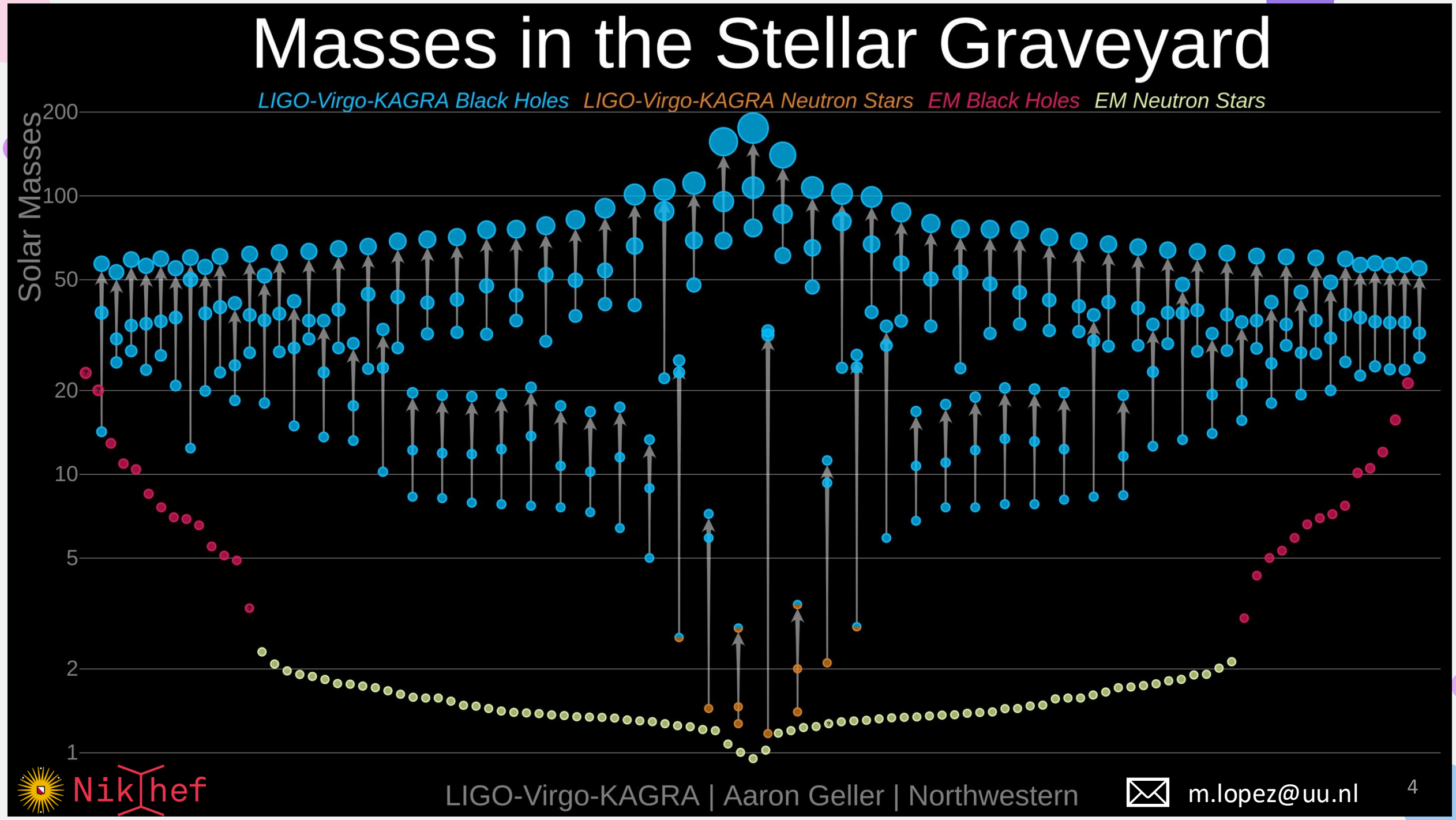
What are gravitational waves (GW)?

Einstein (1916): “GW are ripples in space-time”



Credits: Shanika Galaudage

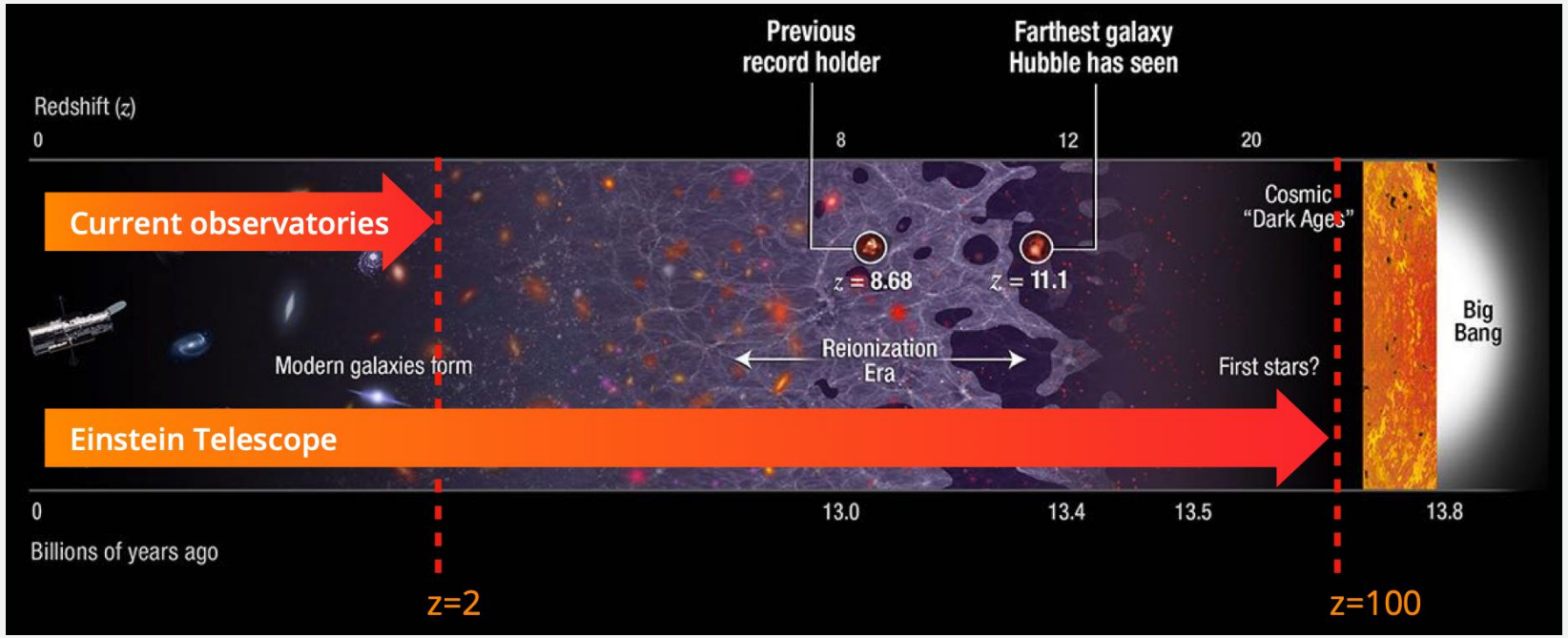
Masses in the Stellar Graveyard



m.lopez@uu.nl

Listening to the symphony of the Universe with Einstein Telescope

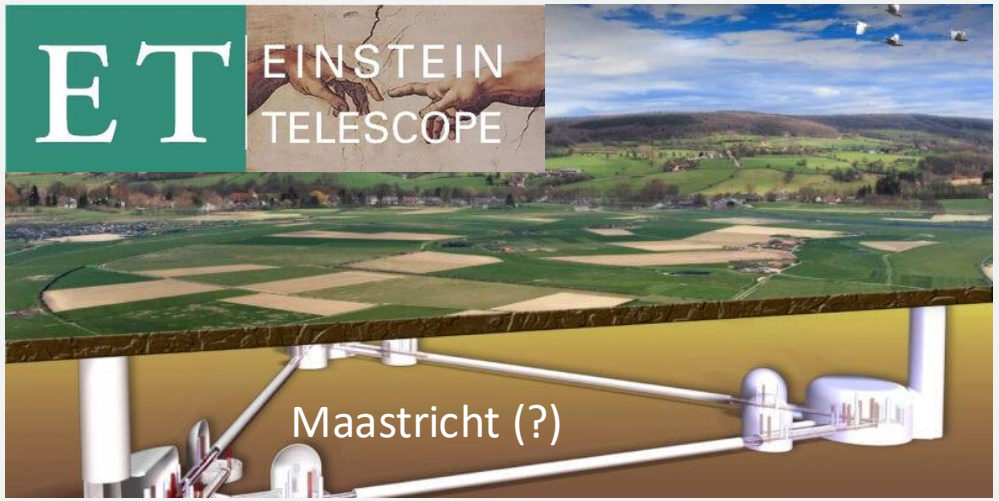
Credits: Andreas Freise



We will see *more* signals for *longer times*

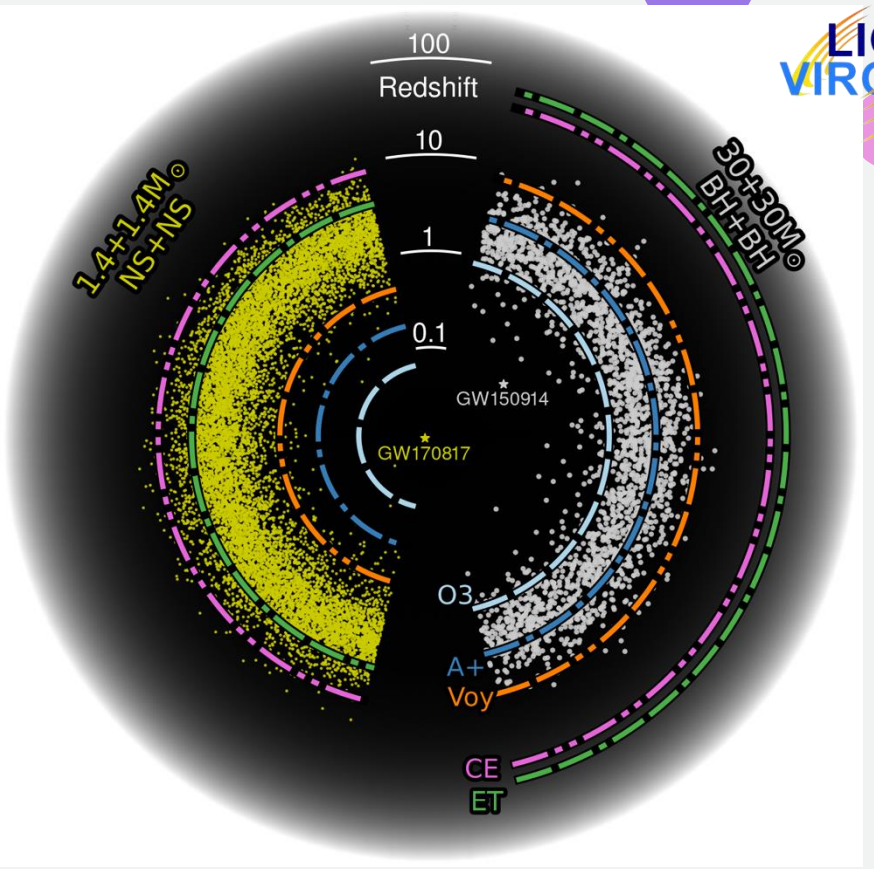
The future

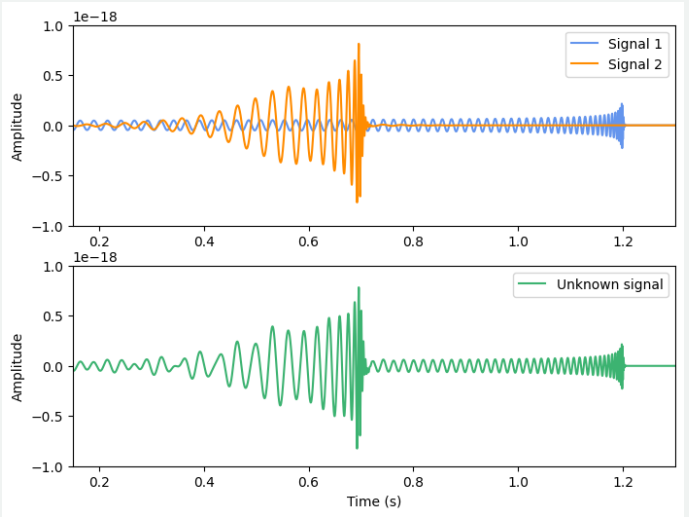
First detection in 2015 and now we have 100 GW detections so far....



Site will be decided in 2026

… and the future looks bright!





We will see more signals for longer tiems…

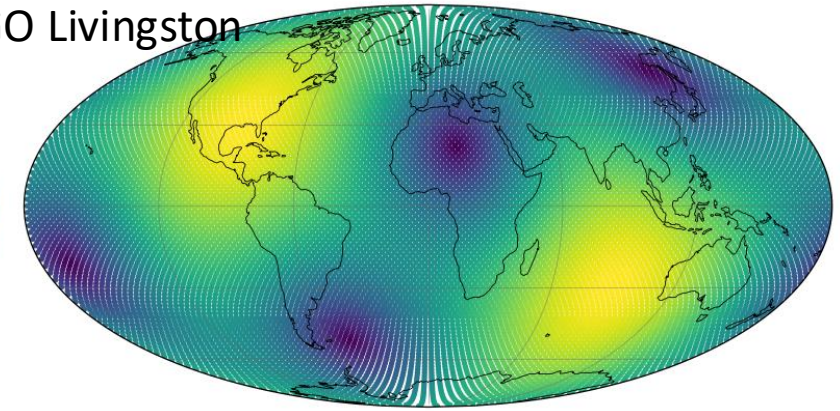
… but not only GW will overlap!

Today: a peak at GW data analysis

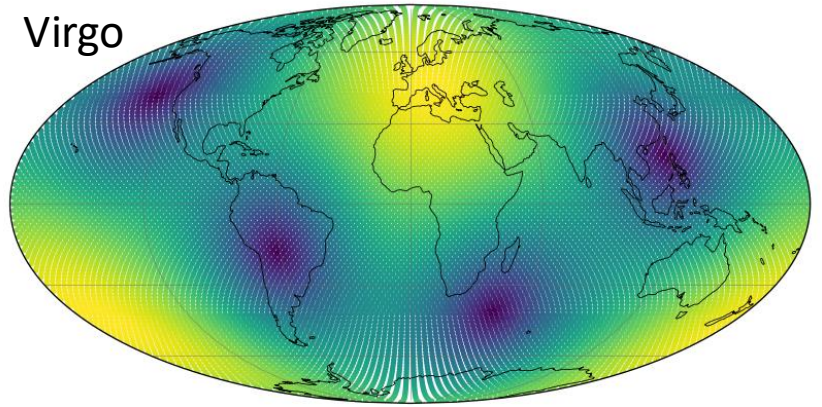
- **GW tutorial 1:** in this tutorial we talk about the antenna pattern of ground-based detectors.
- **GW tutorial 2:** we introduce the basics on how to read, pre-process and represent real detector data. It includes PSD computation.
- **GW tutorial 3:** some times it is useful to generate your own simulations. We also introduce matched filtering.
- **GW tutorial bonus track:** ET configuration - redshift as a function of the total mass.

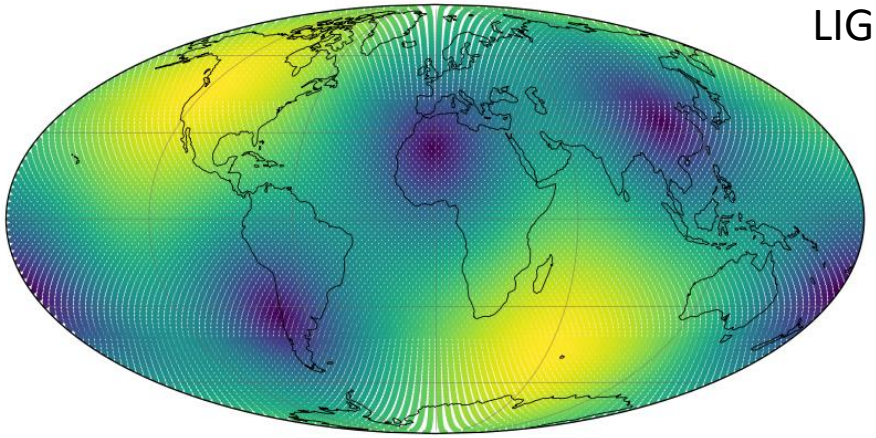
GW tutorial 1: Antenna Pattern

LIGO Livingston

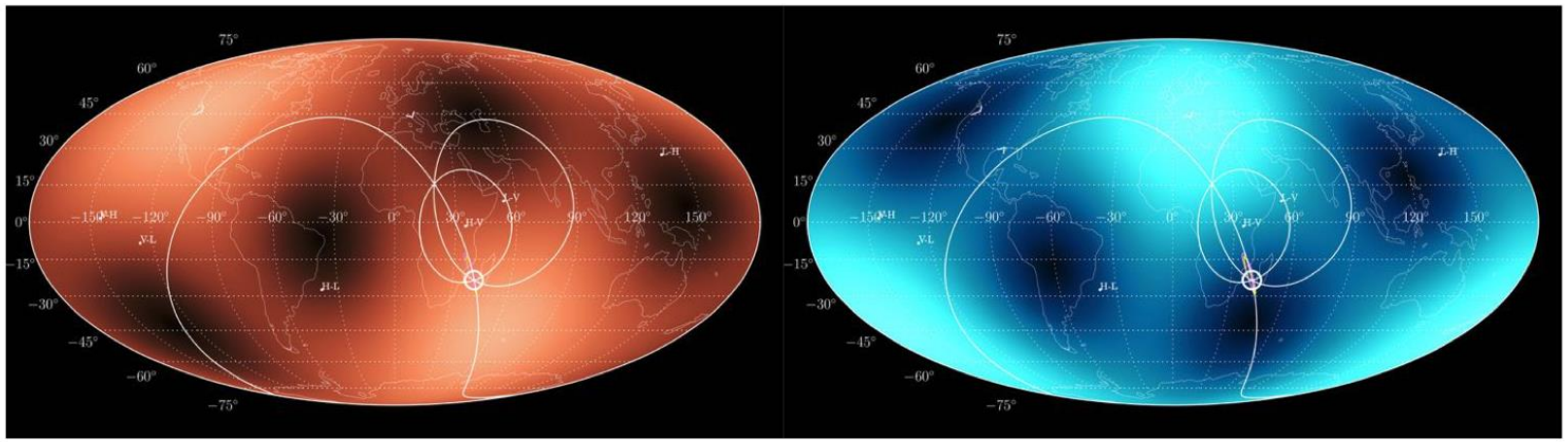


Virgo





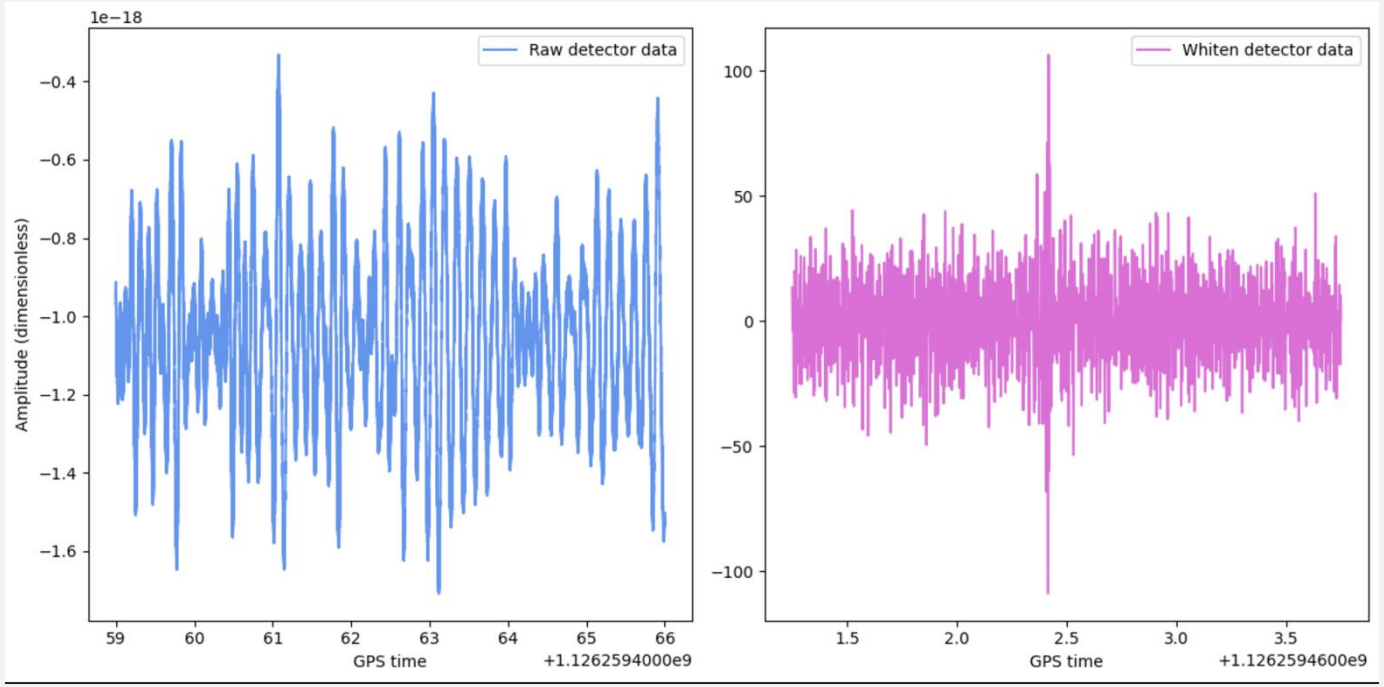
LIGO Hanford

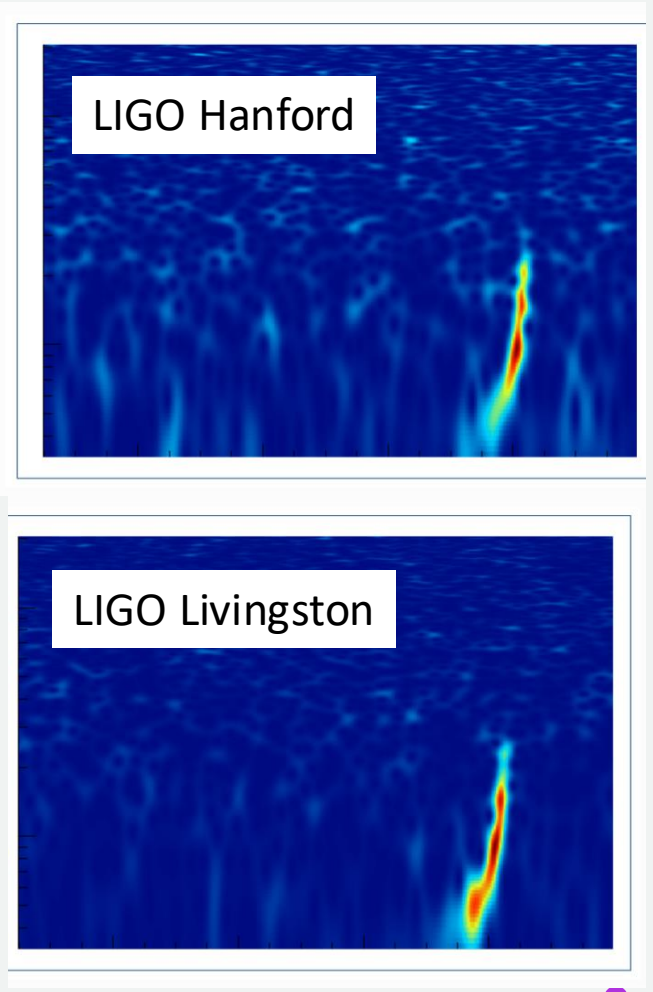


GW170817

GW tutorial 2: Detector noise

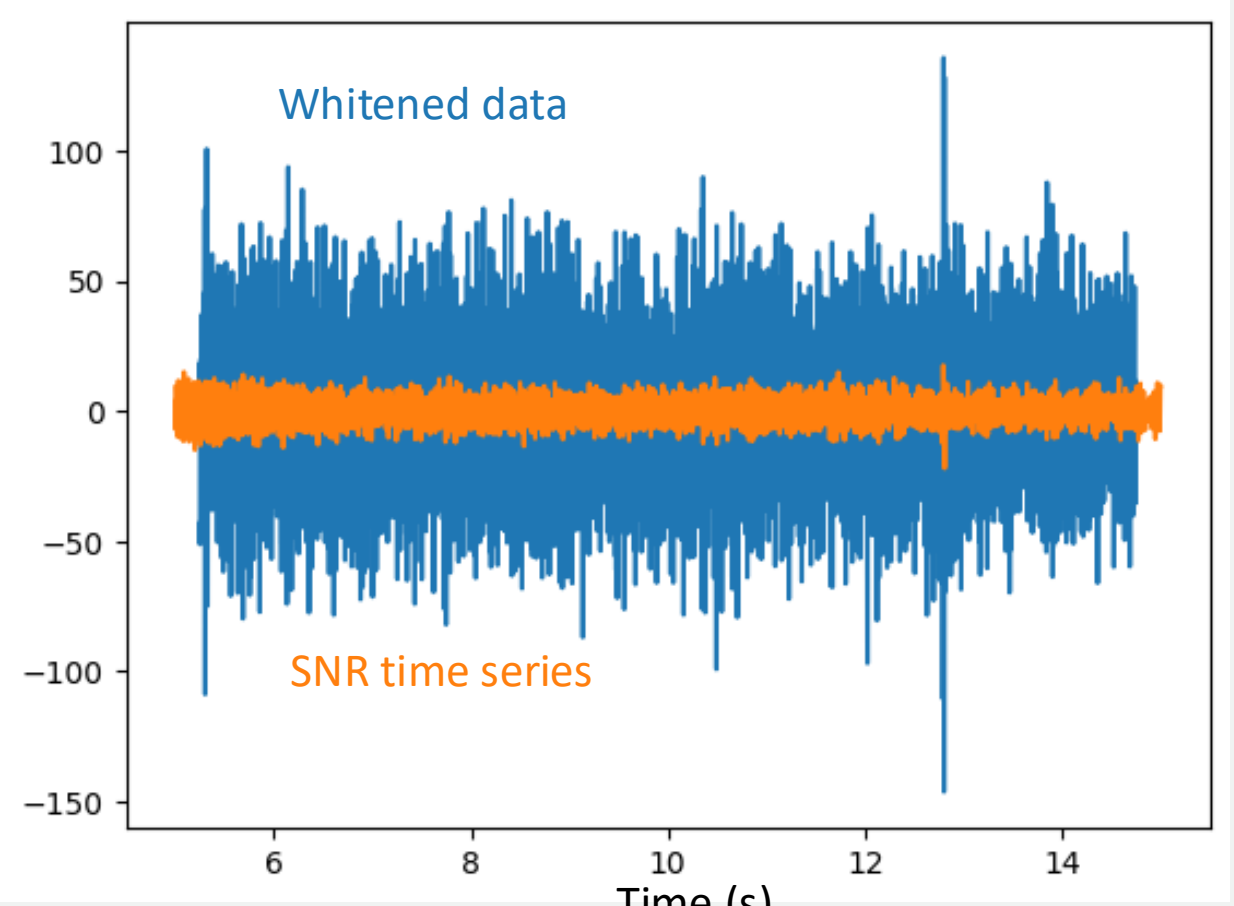
THE first detection: GW150914





First “picture” of a GW signal from a BBH

GW tutorial 3: Matched filtering



Utrecht University Nikhef

GW tutorial bonus track