

Scientific Challenges in the Einstein Telescope era

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ET Industry Computing
Workshop

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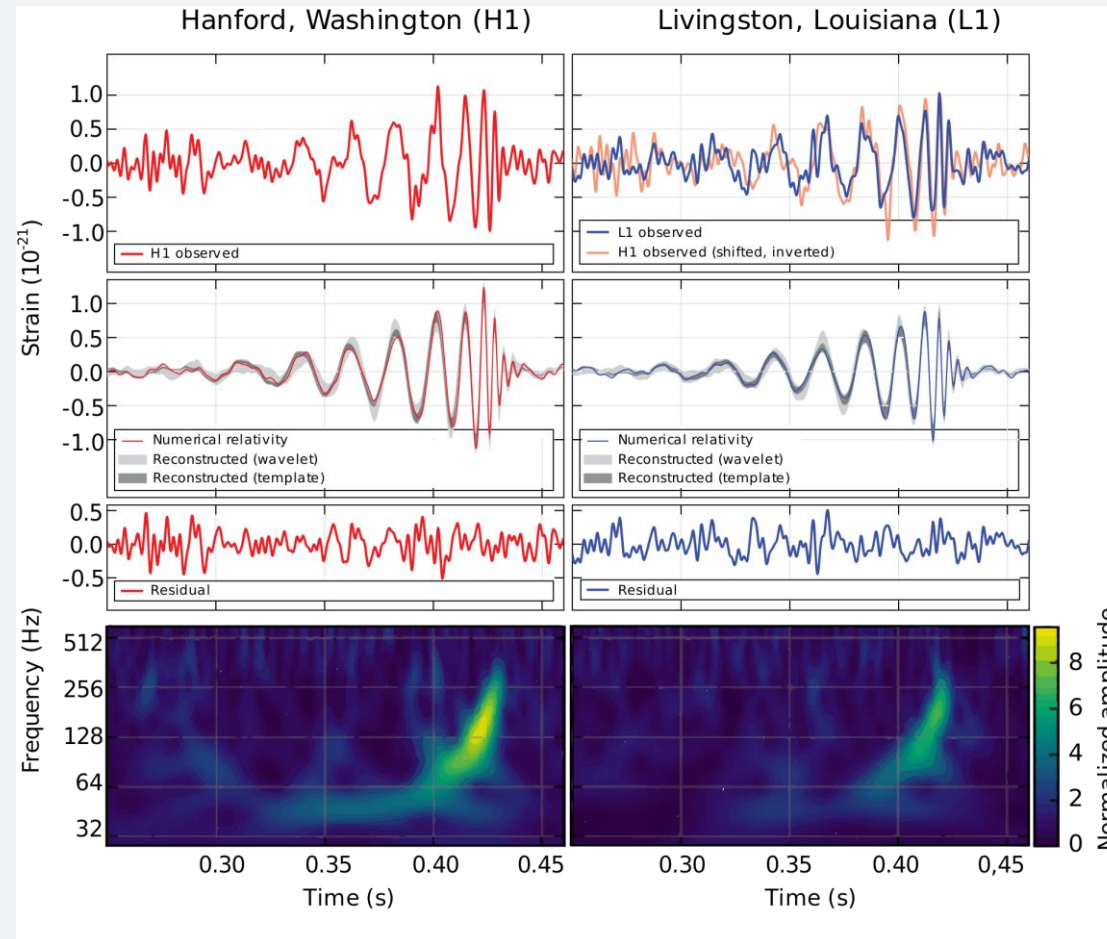


Utrecht
University

Nik|hef

What are gravitational waves (GW)?

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



Credits: Shanika Galaudage

Detector
output
(strain)

How do we analyze gravitational-wave data?

Detector
characterization

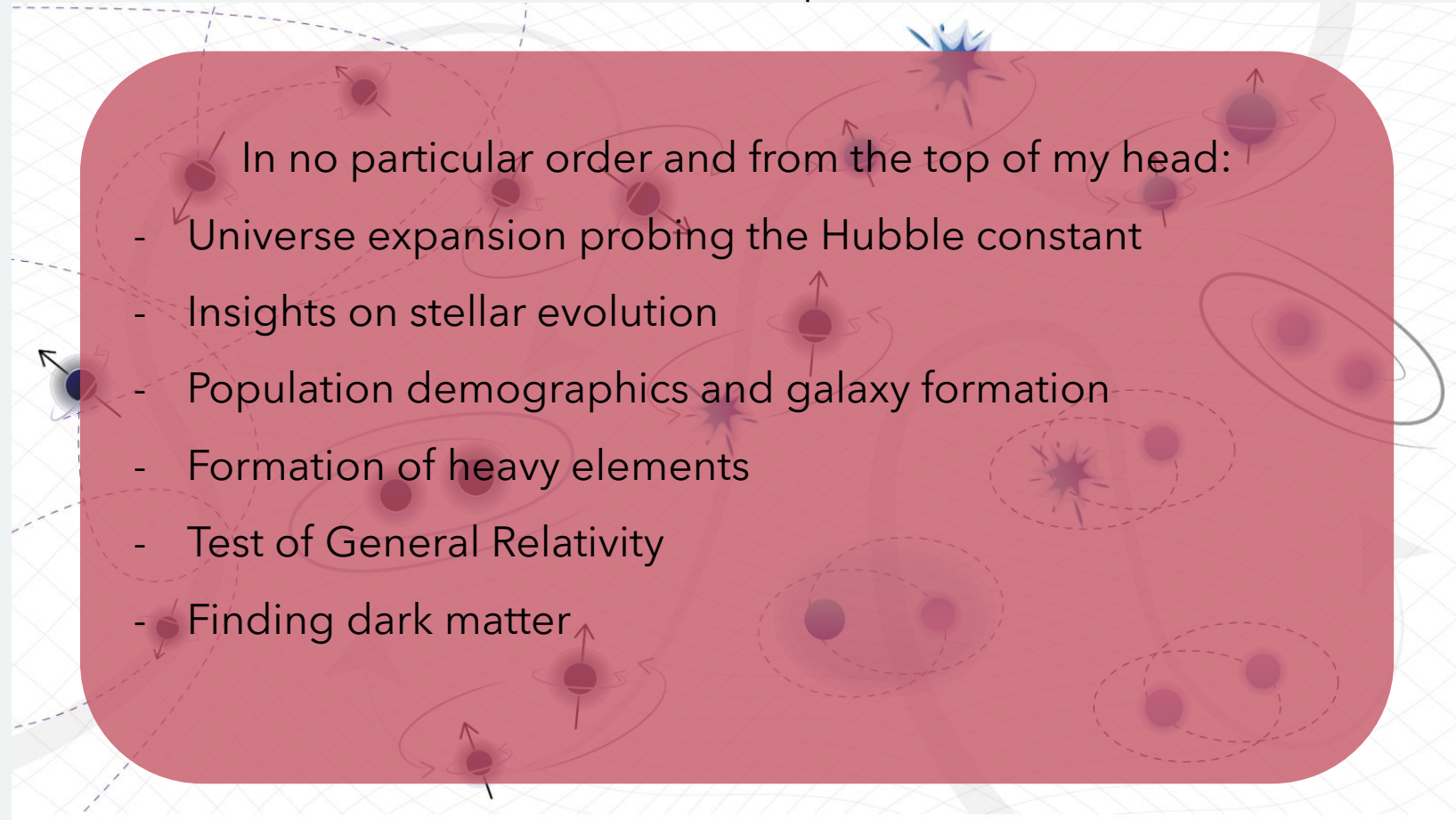
Searches

Parameter estimation

Theoretical
frameworks

What groundbreaking science can we do?

We can “only” detect black holes, neutron stars and supernovae



In no particular order and from the top of my head:

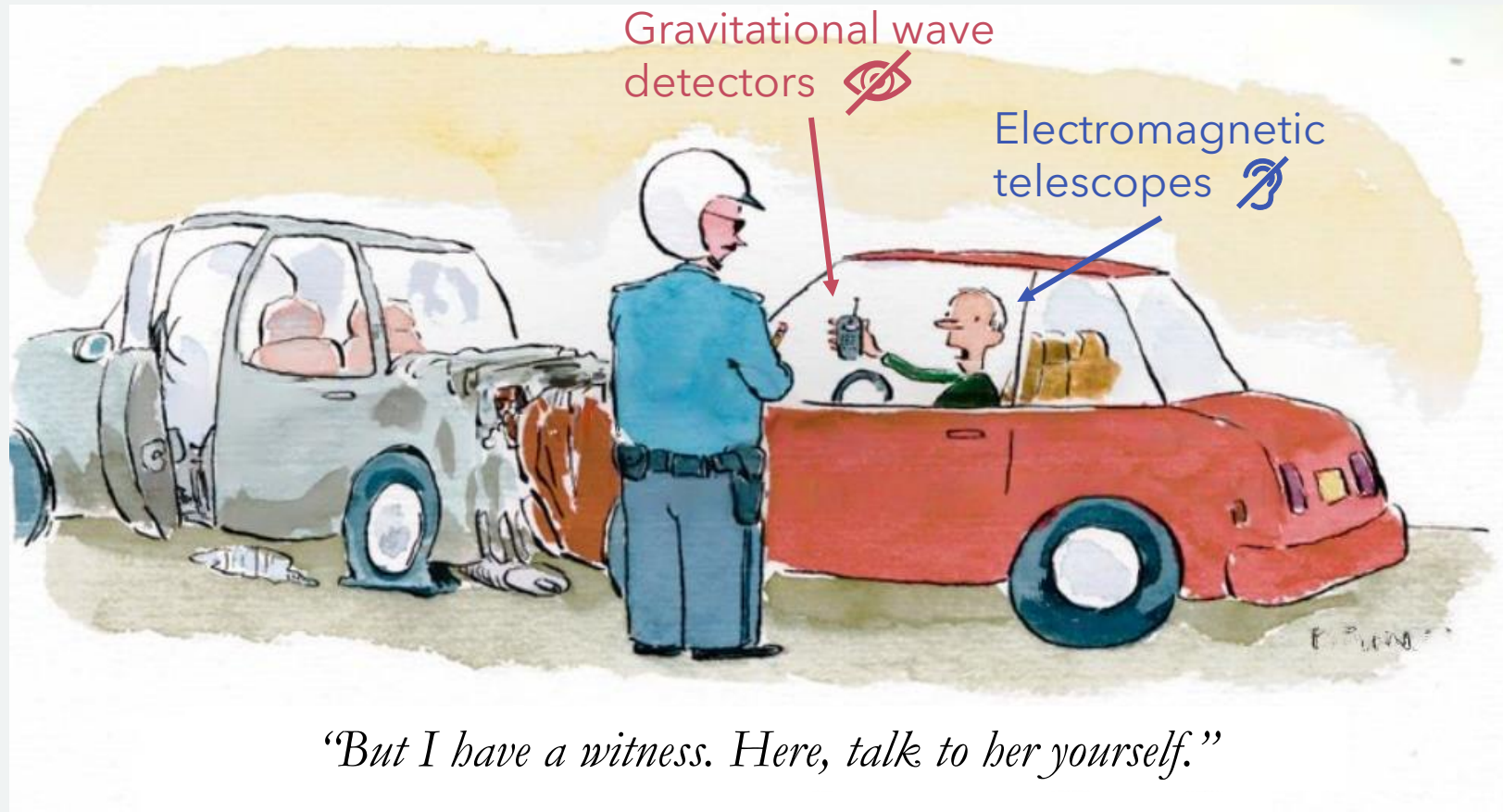
- Universe expansion probing the Hubble constant
- Insights on stellar evolution
- Population demographics and galaxy formation
- Formation of heavy elements
- Test of General Relativity
- Finding dark matter

Credits: Shanika Galaudage

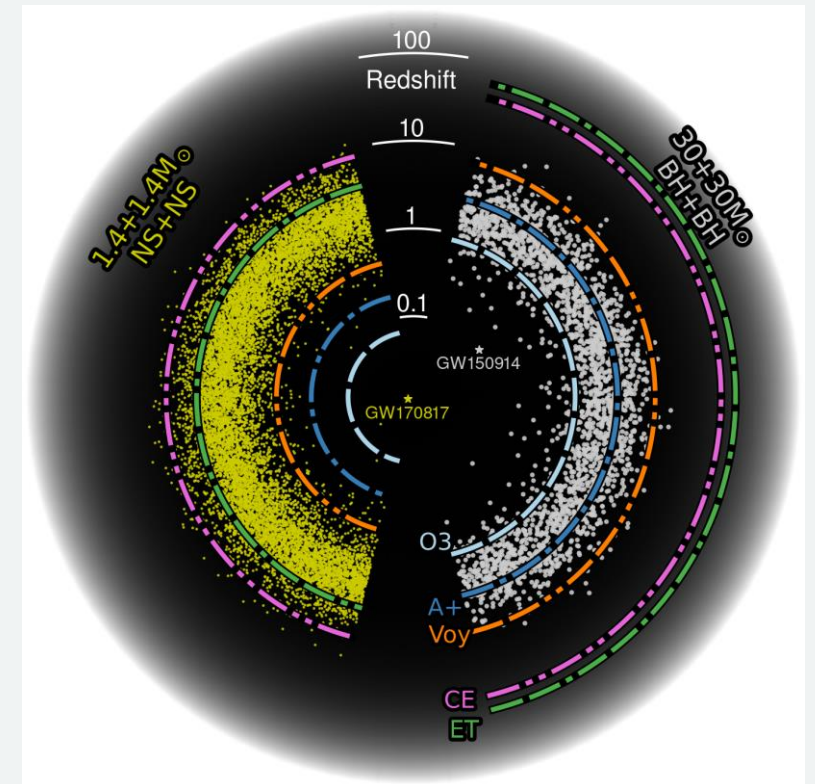
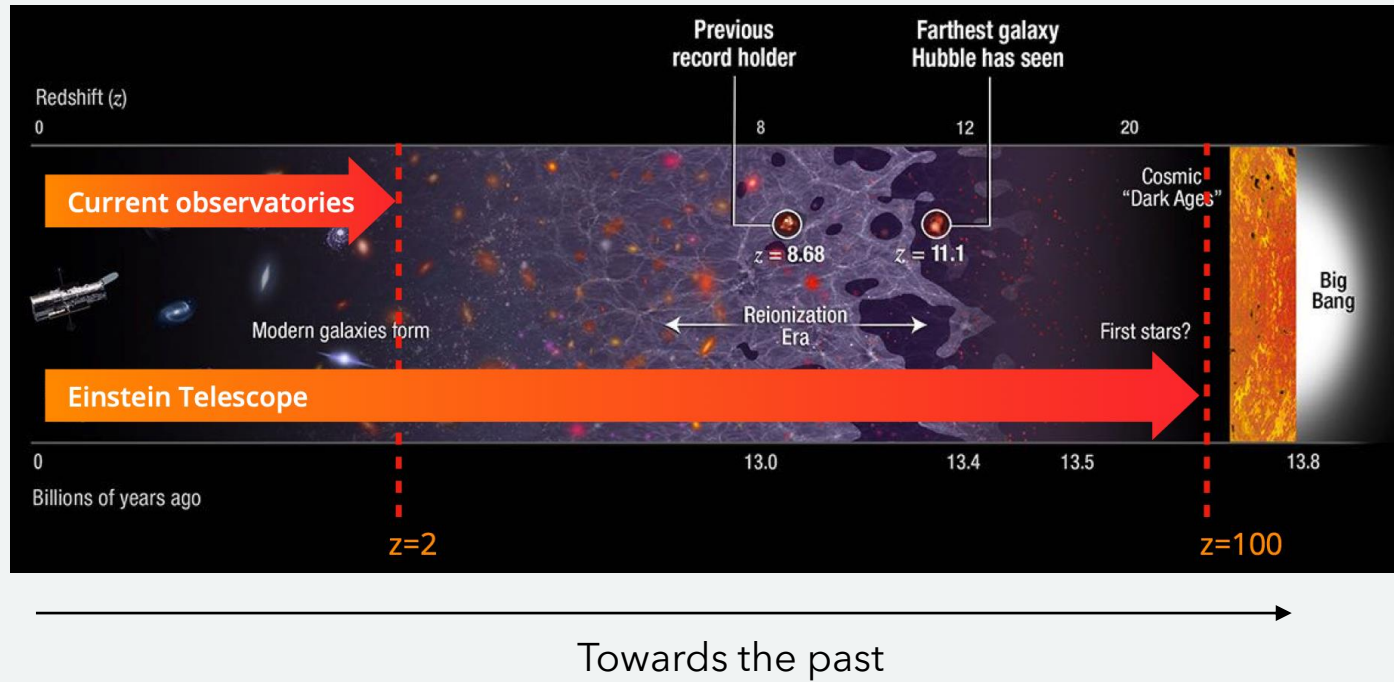
And what did a lot so far!

Why are GW important?

Towards multi-messenger astrophysics



The Einstein Telescope era



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

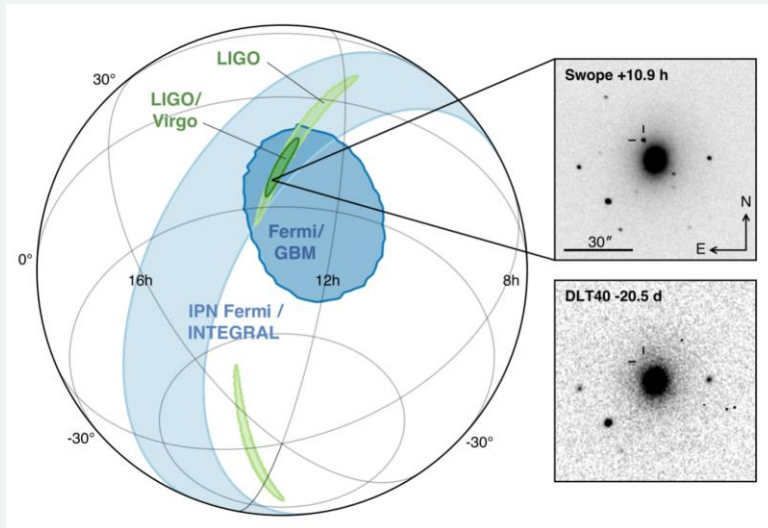
PAST

O1 (2015-2016) - 3 events
Anomaly detection problem



O2 (2016 -2017) - 8 events

Early alerts
for
telescopes

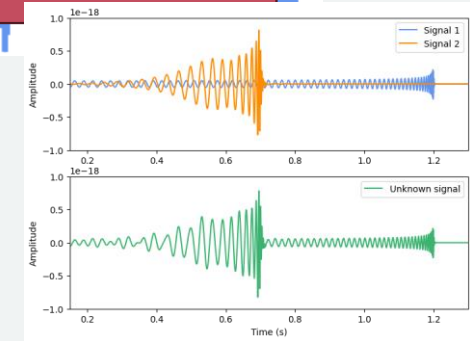


FUTURE

ET (2035?) - 10^5 per year



Anomaly detection



Early alerts for telescopes

We will move from **noise-dominated** domain to **signal dominated** domain *increasing computational complexity*

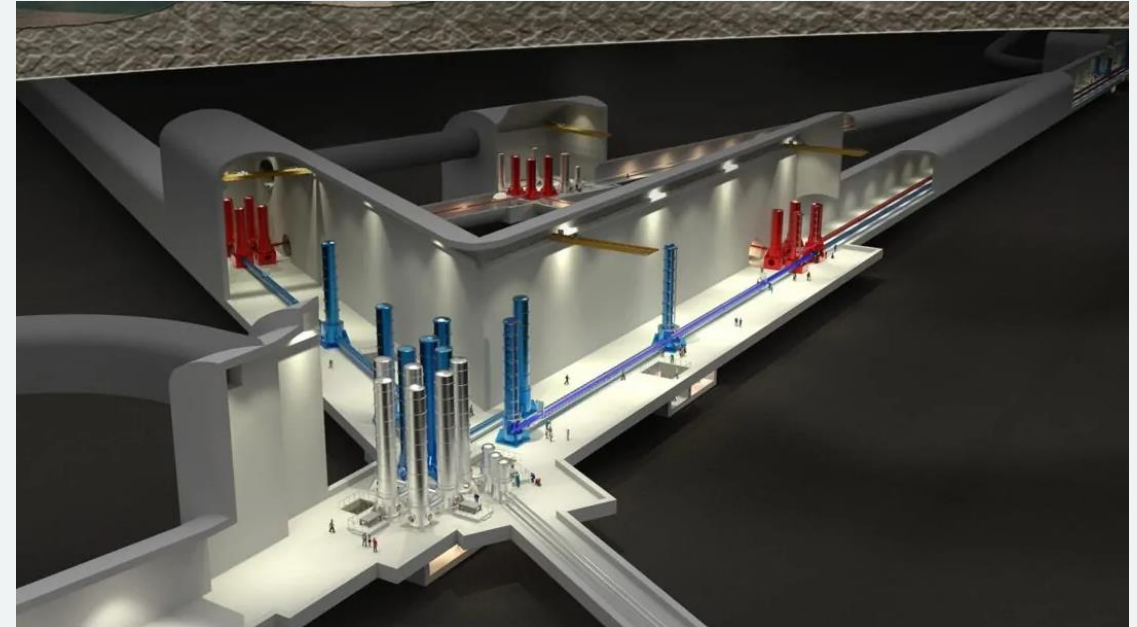
PAST

Monitoring sensors $\sim 10^6 \sim \text{Tb}$ per year



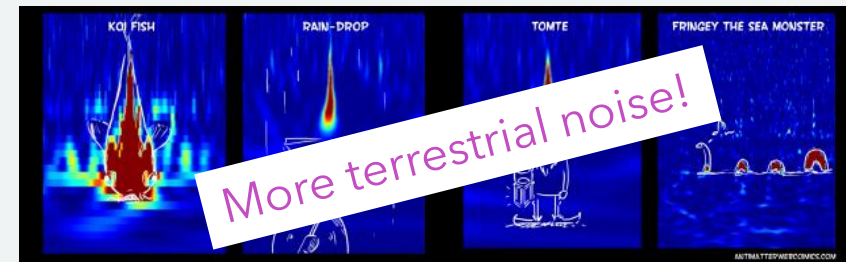
FUTURE

Monitoring sensors $\sim \text{Pb}$ per year



Higher detector complexity can lead to...

Note: gravitational waves detectors are evolutionary



The Challenges of Einstein Telescope era

- Massive increase in event rates
- Extended signal duration → overlapping signals
- Low-latency early alerts
- Prohibitive increase of memory and compute power
- And more!

We need **scalable, resource efficient** and **scientifically validated** algorithms to listen to the Universe with the Einstein Telescope