

# Scientific Challenges in the Einstein Telescope era

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ET Industry Computing  
Workshop

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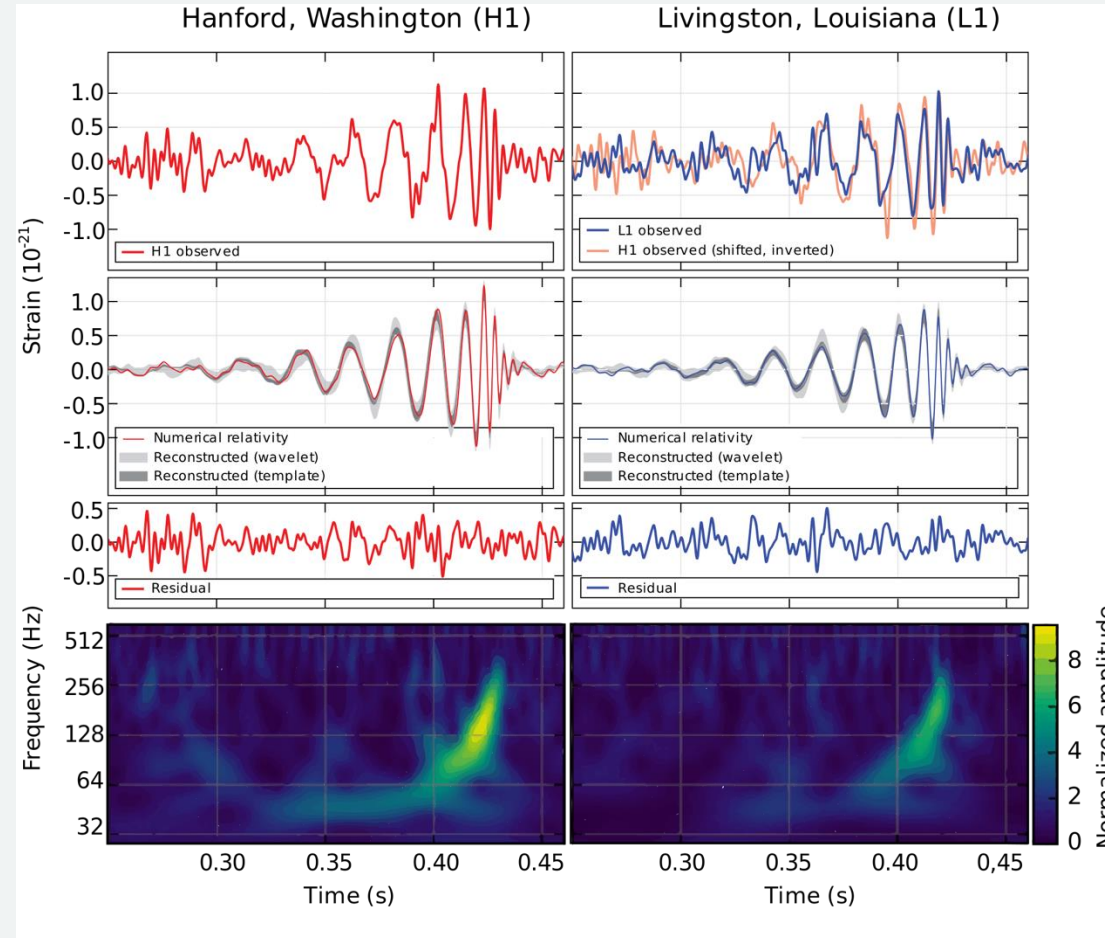


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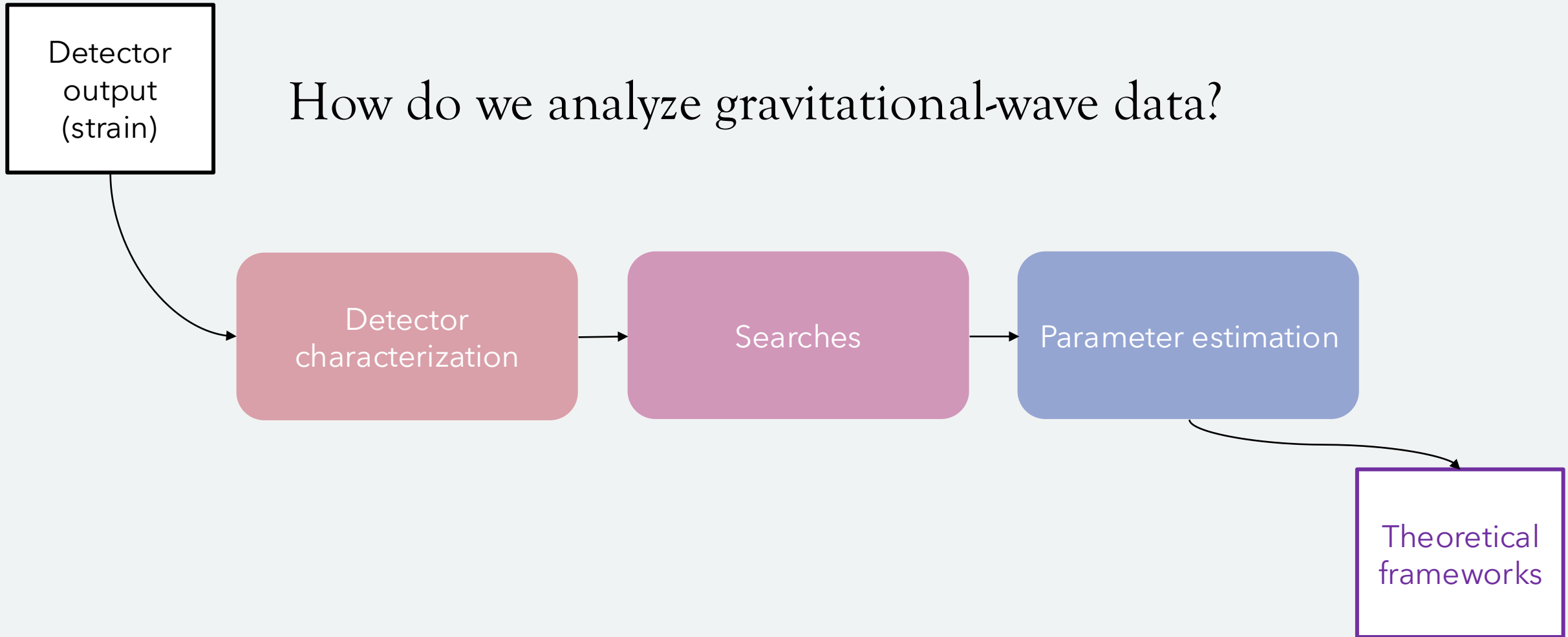
# What are gravitational waves (GW)?

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



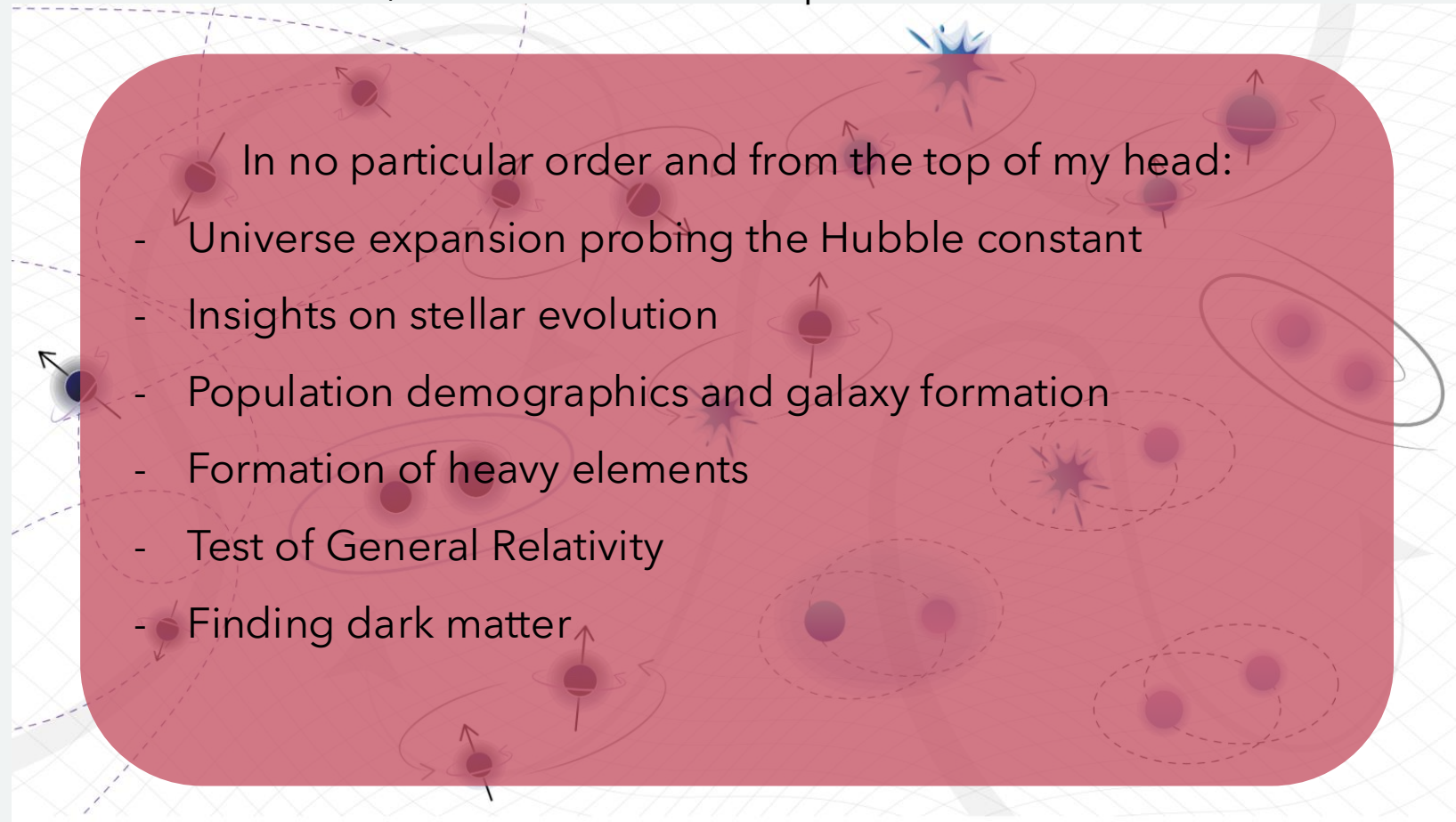
Credits: Shanika Galaudage

# How do we analyze gravitational-wave data?



# 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:

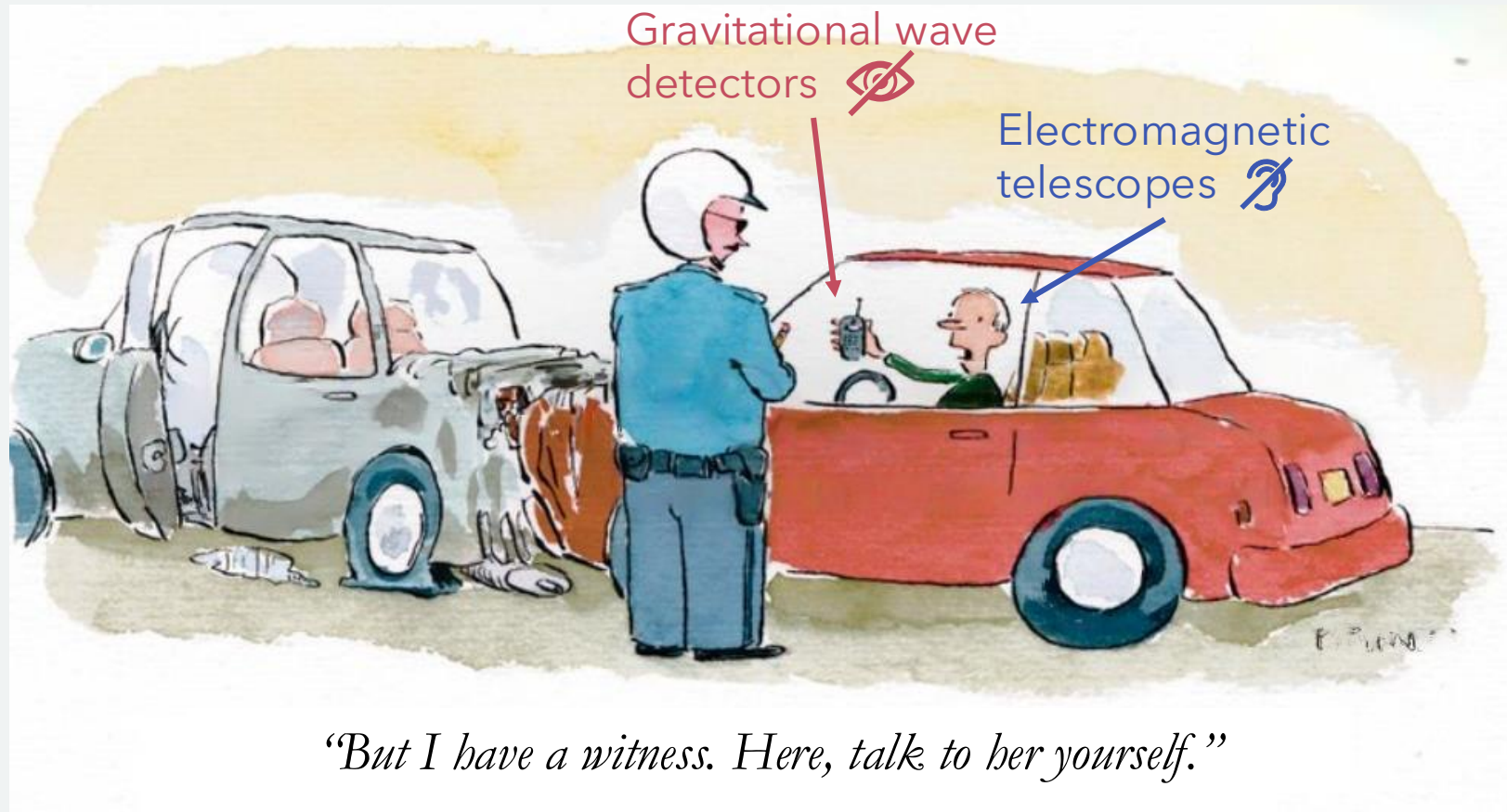
- Universe expansion probing the Hubble constant
- Insights on stellar evolution
- Population demographics and galaxy formation
- Formation of heavy elements
- Test of General Relativity
- Finding dark matter

Credits: Shanika Galaudage

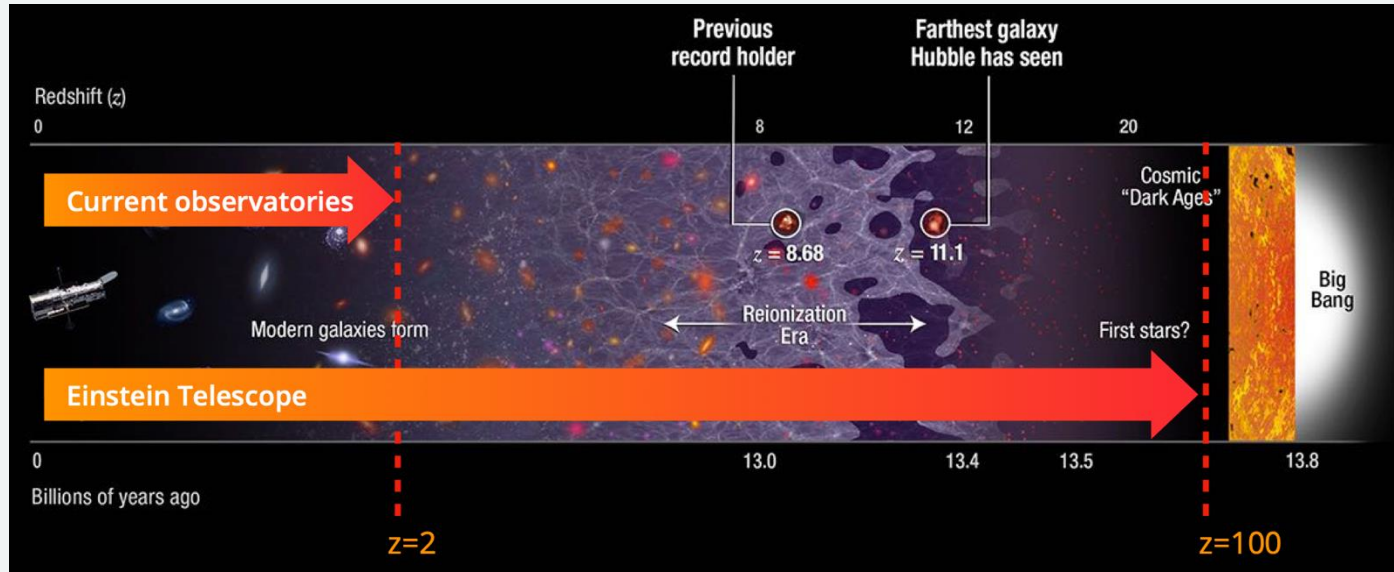
And what did a lot so far!

# Why are GW important?

Towards multi-messenger astrophysics

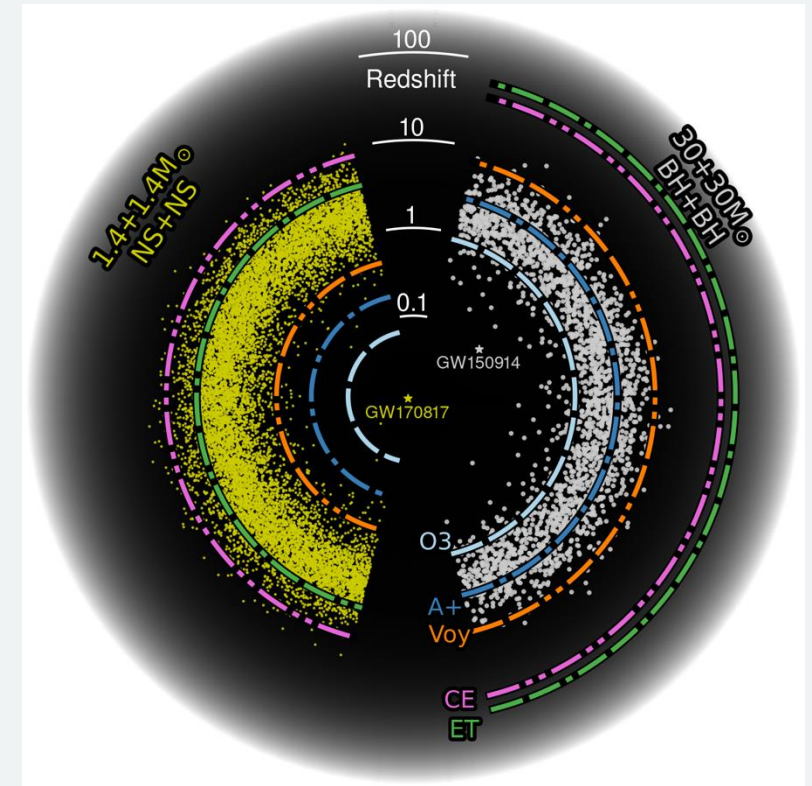


# The Einstein Telescope era



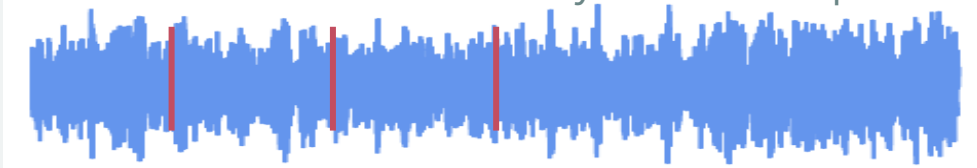
Towards the past

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



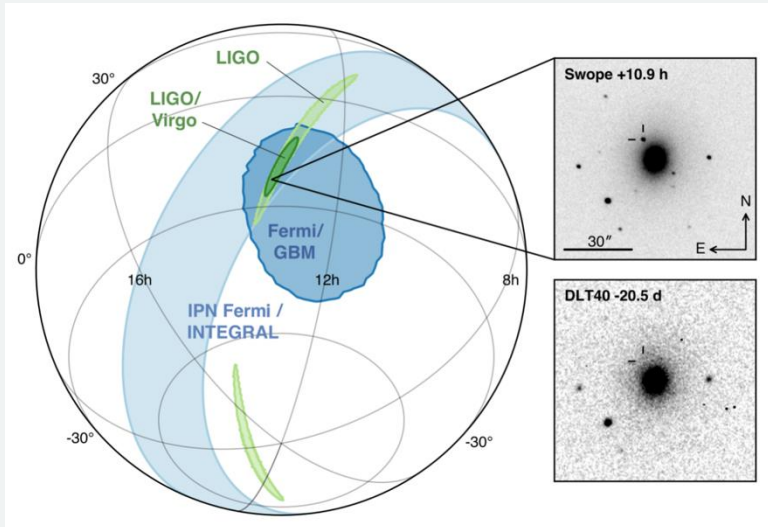
## PAST

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



O2 (2016 -2017) - 8 events

Early alerts  
for  
telescopes

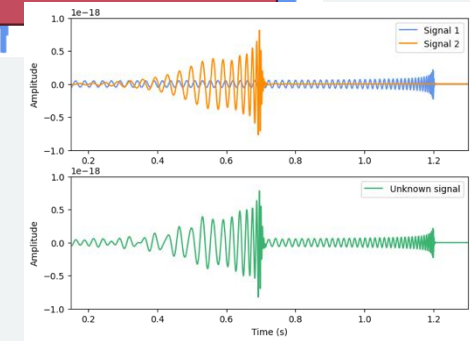


## FUTURE

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*

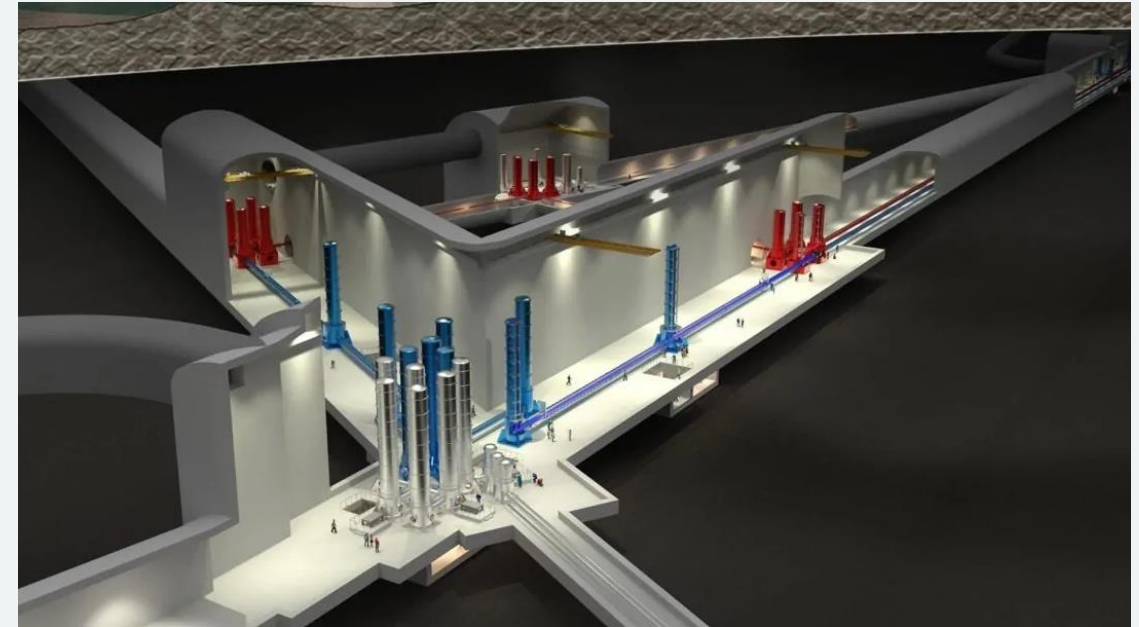
## PAST

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



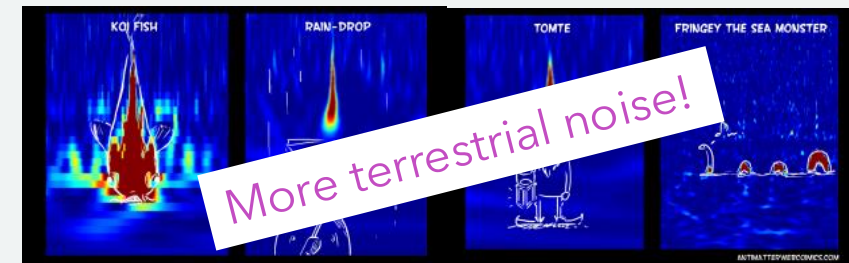
## FUTURE

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