Cosmic Explorer

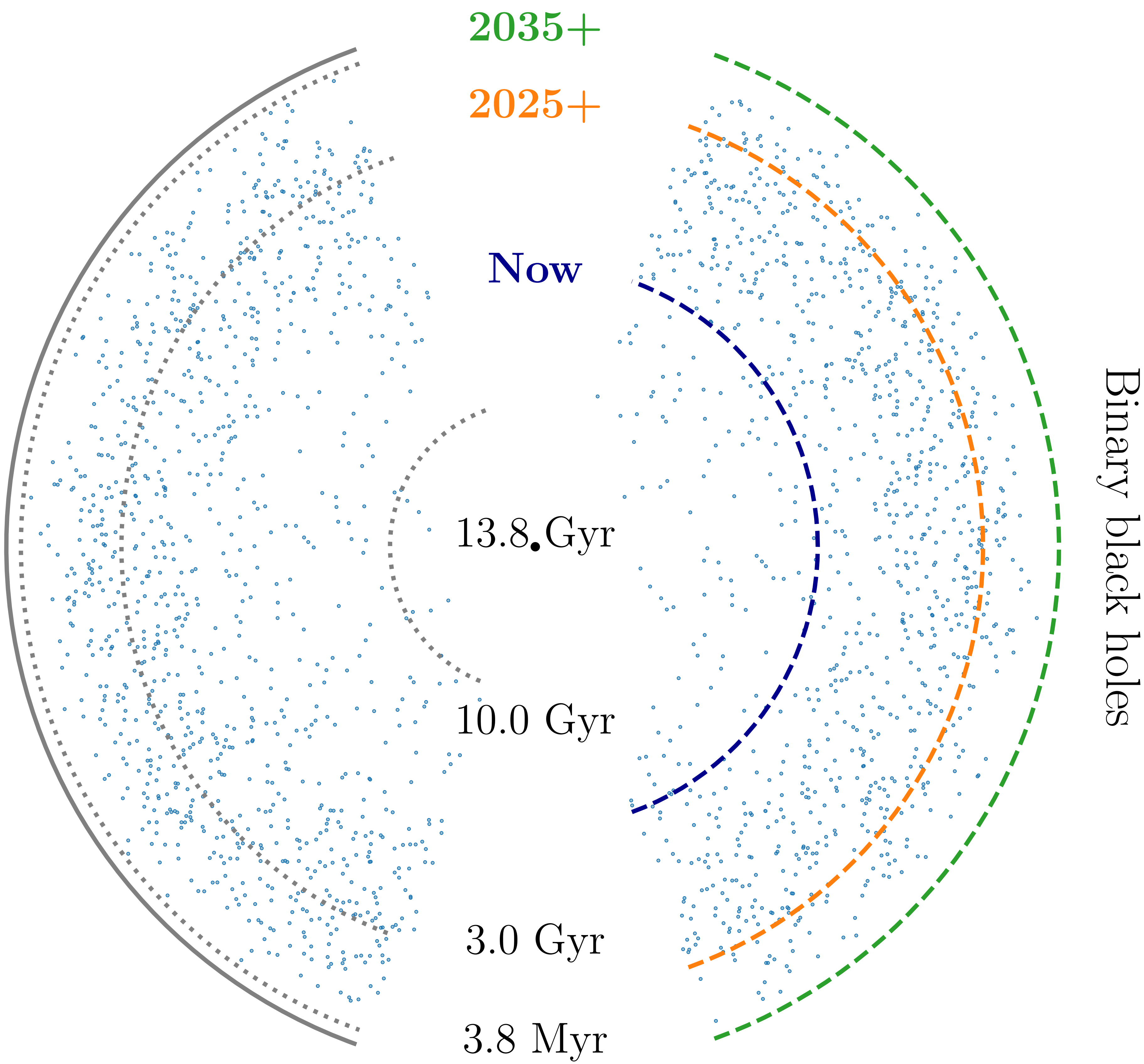
Jose María Ezquiaga
Niels Bohr Institute
&
Masha Baryakhtar
University of Washington

[Francis Miller, 1960]

VILLUM FONDEN

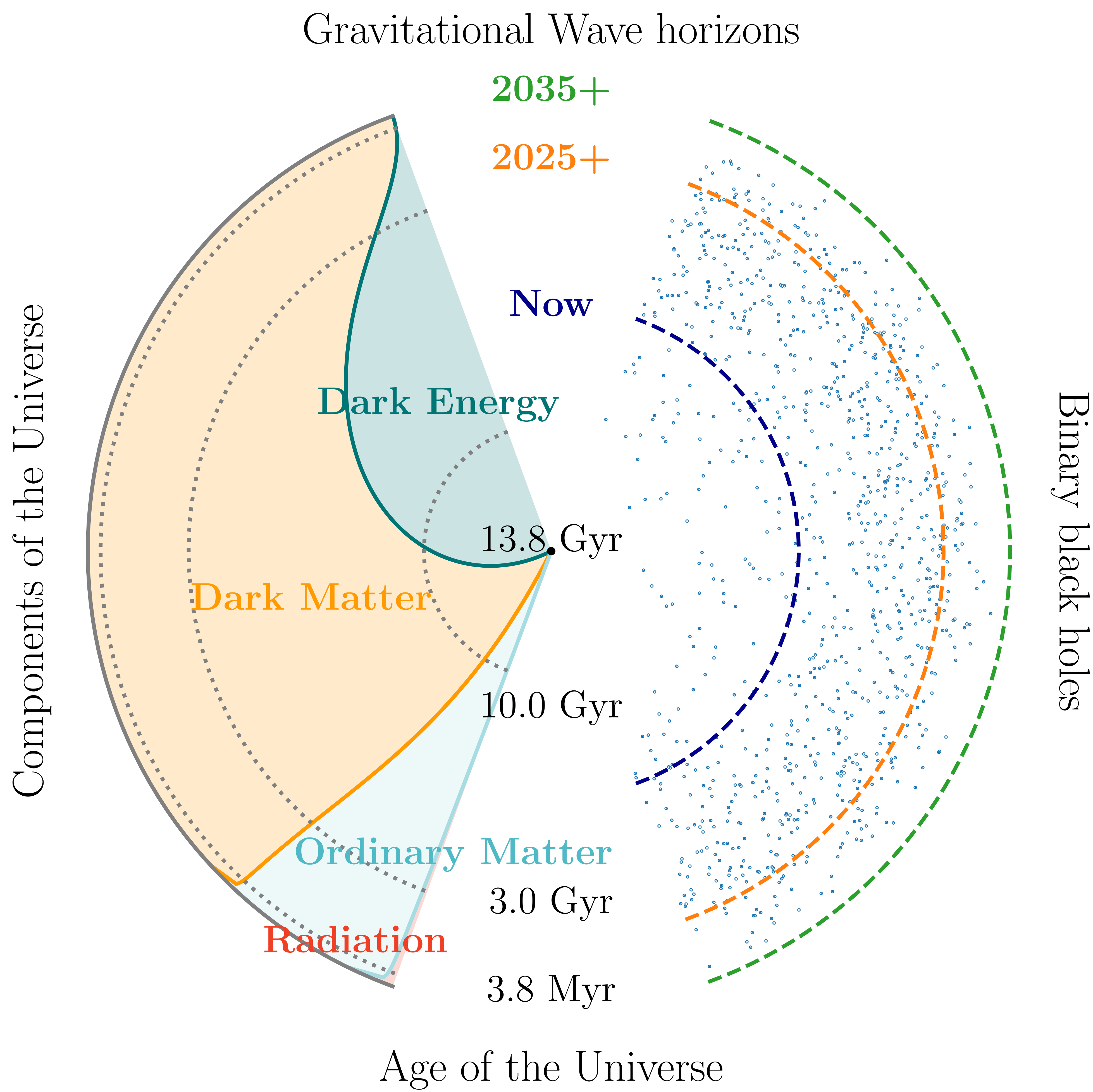
KØBENHAVNS UNIVERSITET

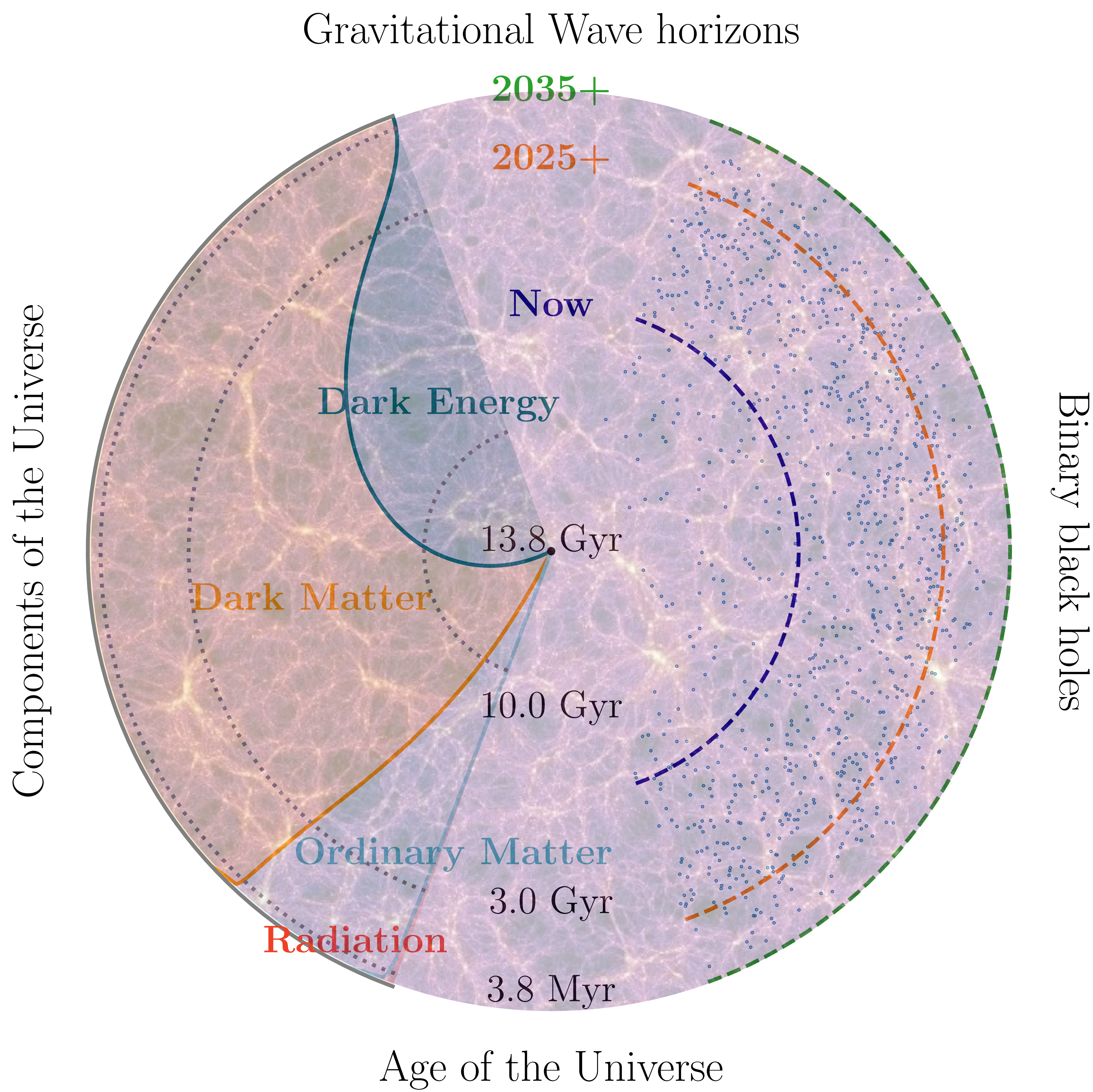
Gravitational Wave horizons



Age of the Universe

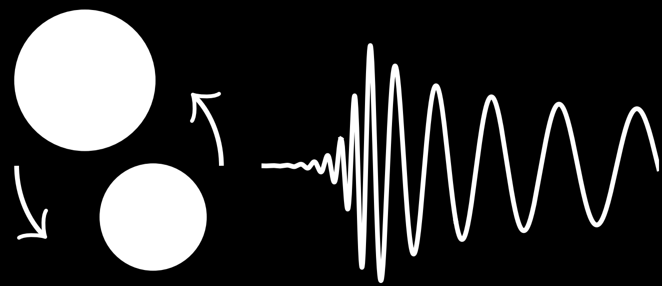
*stellar mass
binary black holes


Gravitational Wave horizons
2035+
2025+
Now
Components of the Universe
Dark Energy
Dark Matter
Ordinary Matter
Radiation
13.8 Gyr
10.0 Gyr
3.0 Gyr
3.8 Myr
Binary black holes
Age of the Universe

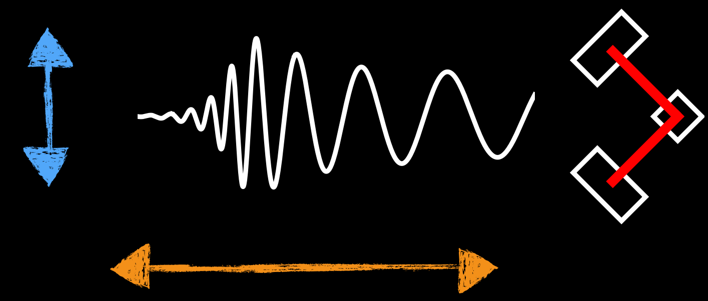

Gravitational Wave horizons
2035+
2025+
Now
Dark Energy
13.8 Gyr
Dark Matter
10.0 Gyr
Ordinary Matter
3.0 Gyr
Radiation
3.8 Myr
Components of the Universe
Binary black holes
Age of the Universe

GWs are standard sirens

[well understood selection effects]



[cosmo propagation]



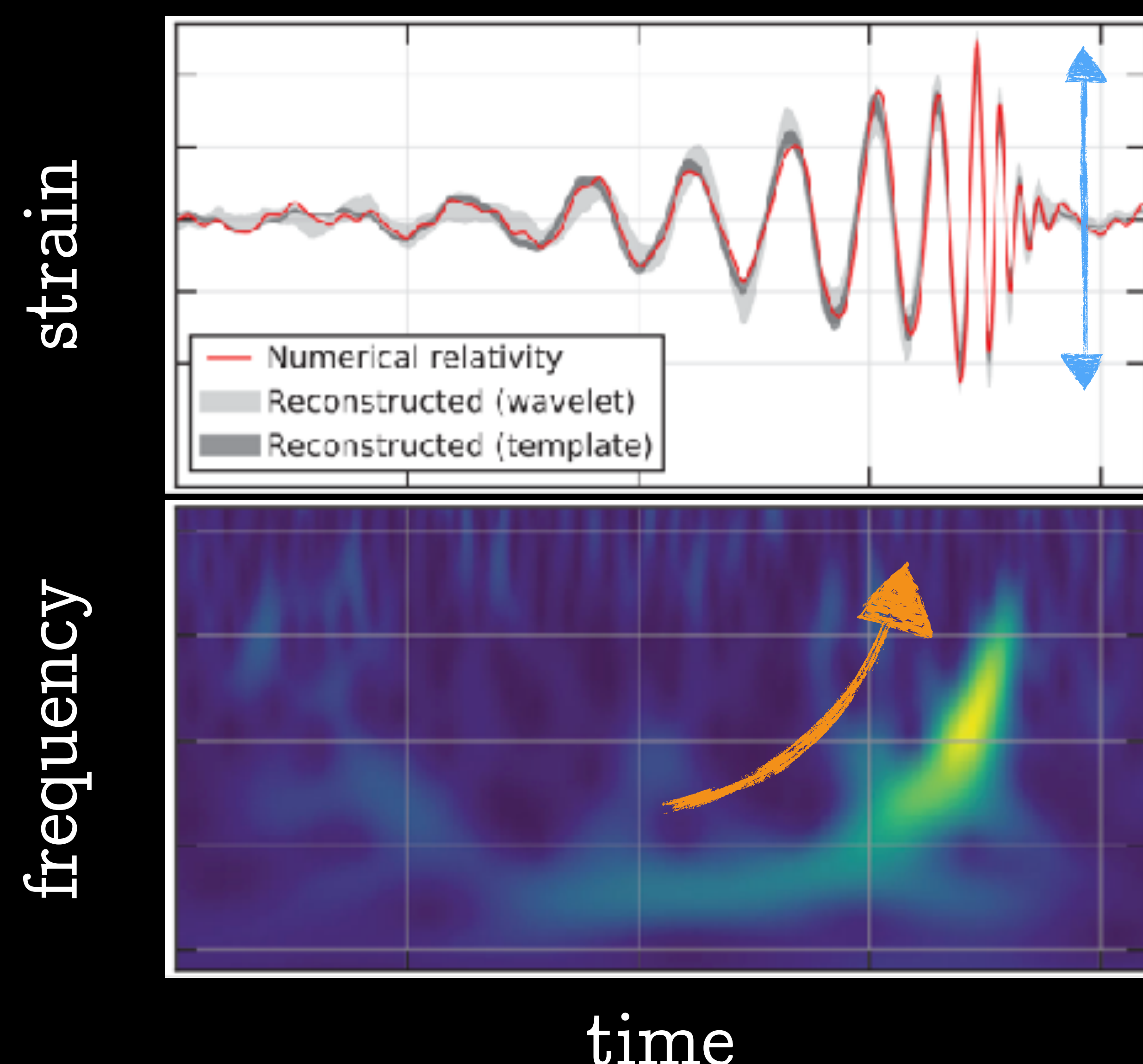
[GR predicts waveform]

$$d_L(z)$$

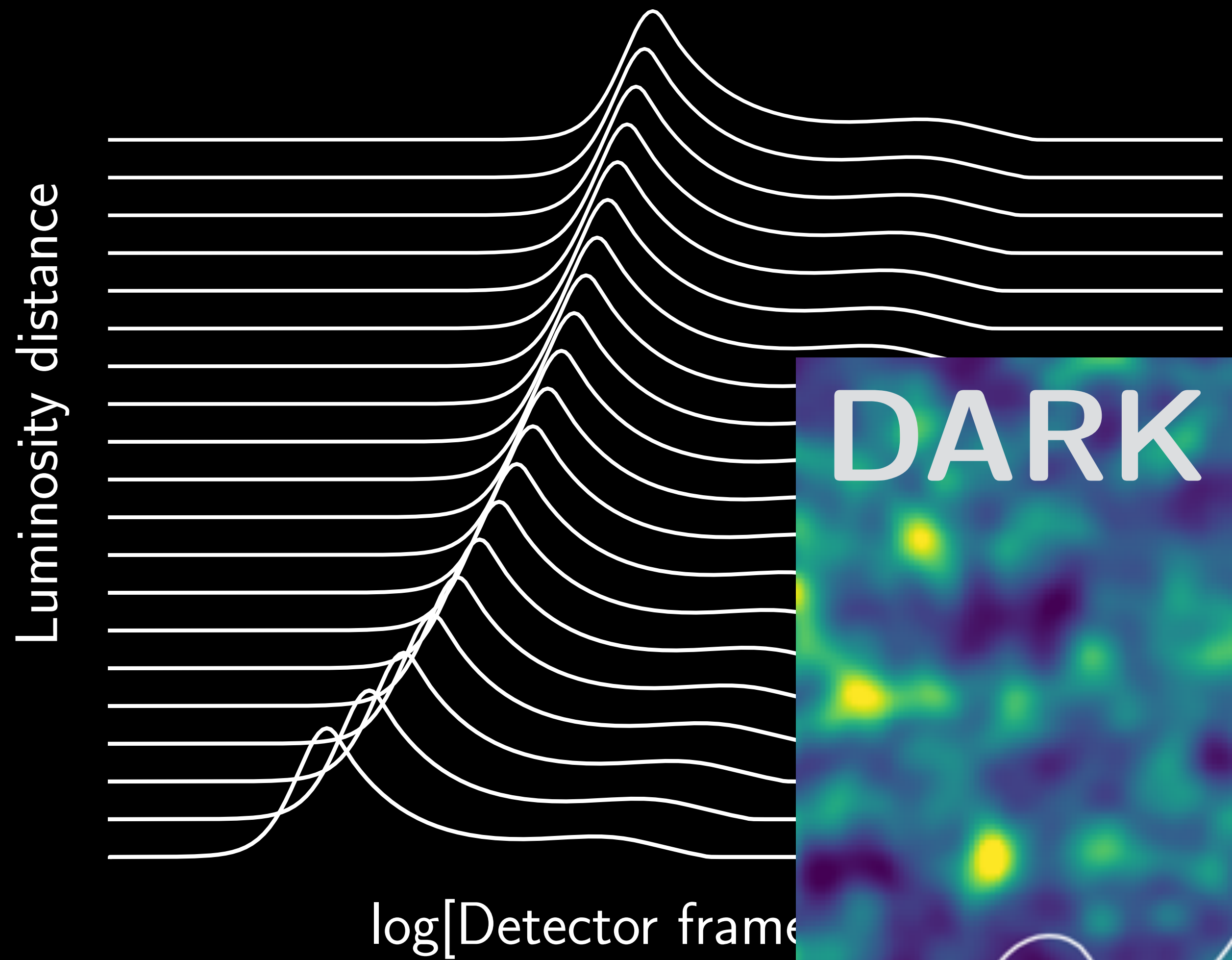
[GW Hubble diagram]

$$m_{\rm det} = (1+z)m$$

[Interplay with astrophysics]



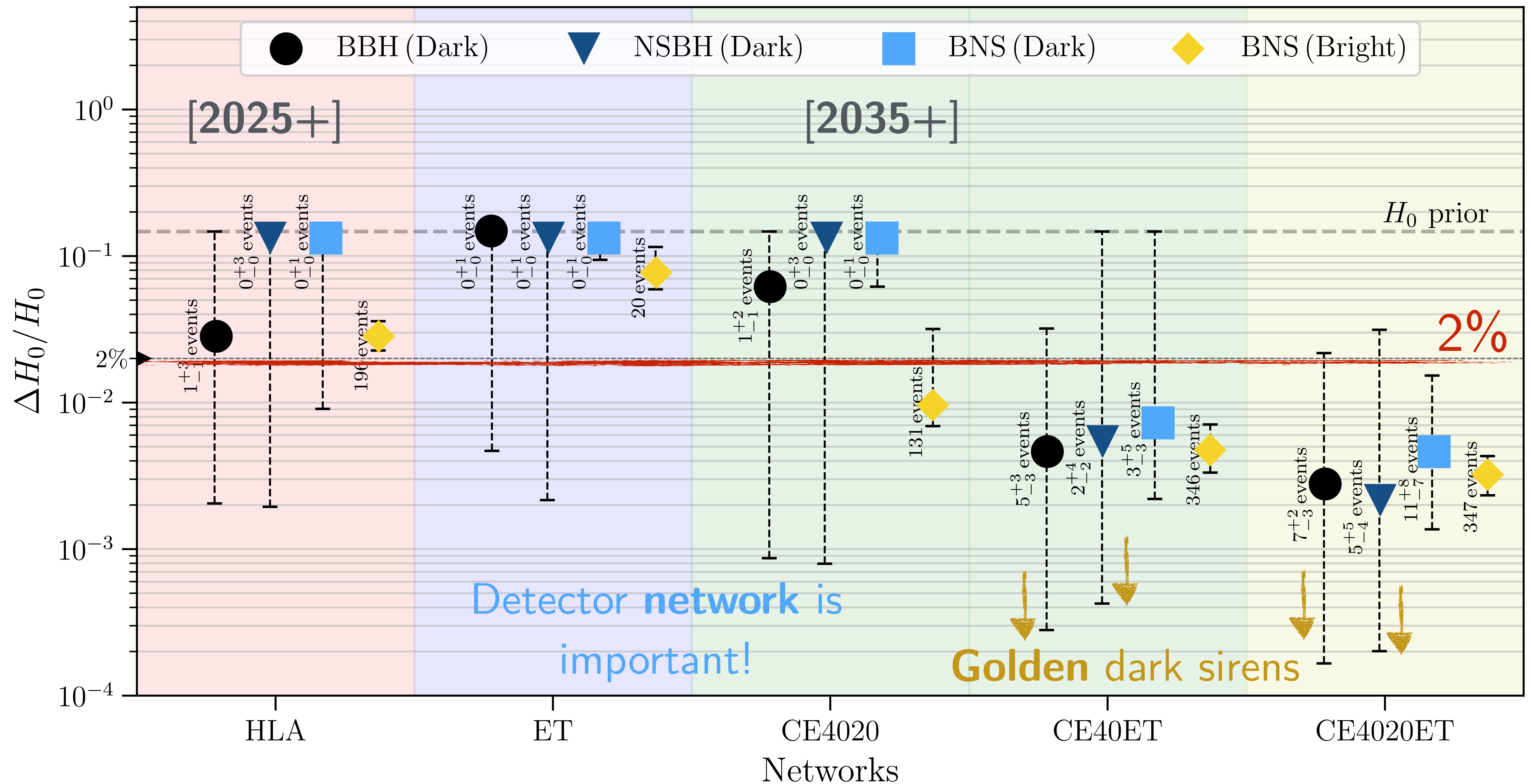
SPECTRAL SIRENS



Love sirens

1. H_0 (also) with dark sirens

H: Hanford (US)
L: Livingston (US)
A: Aundha (India)
ET: Einstein Telescope (EU)
CE: Cosmic Explorer (US)

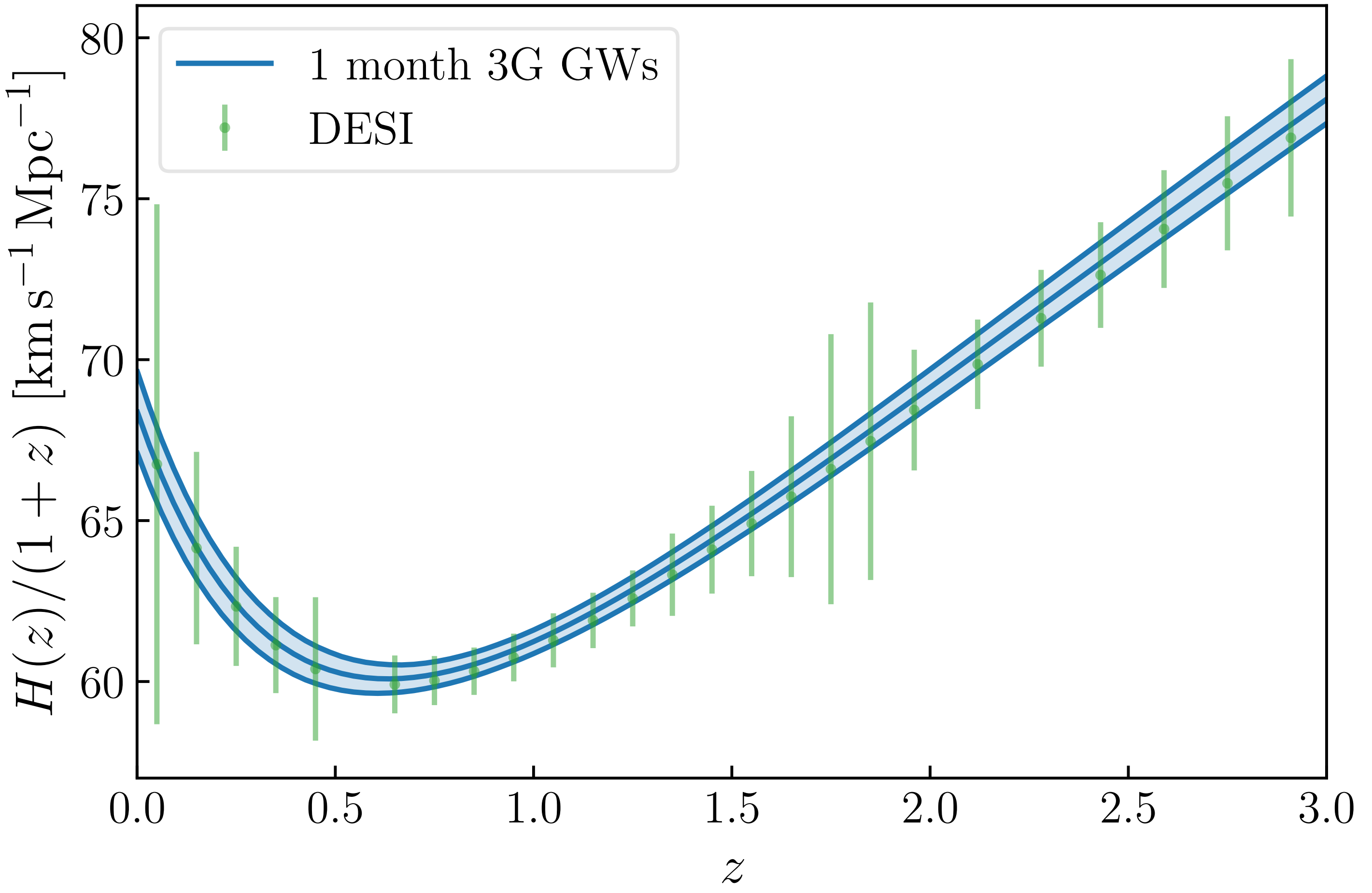


[Chen, **Ezquiaga** & Gupta (CQG'24)]

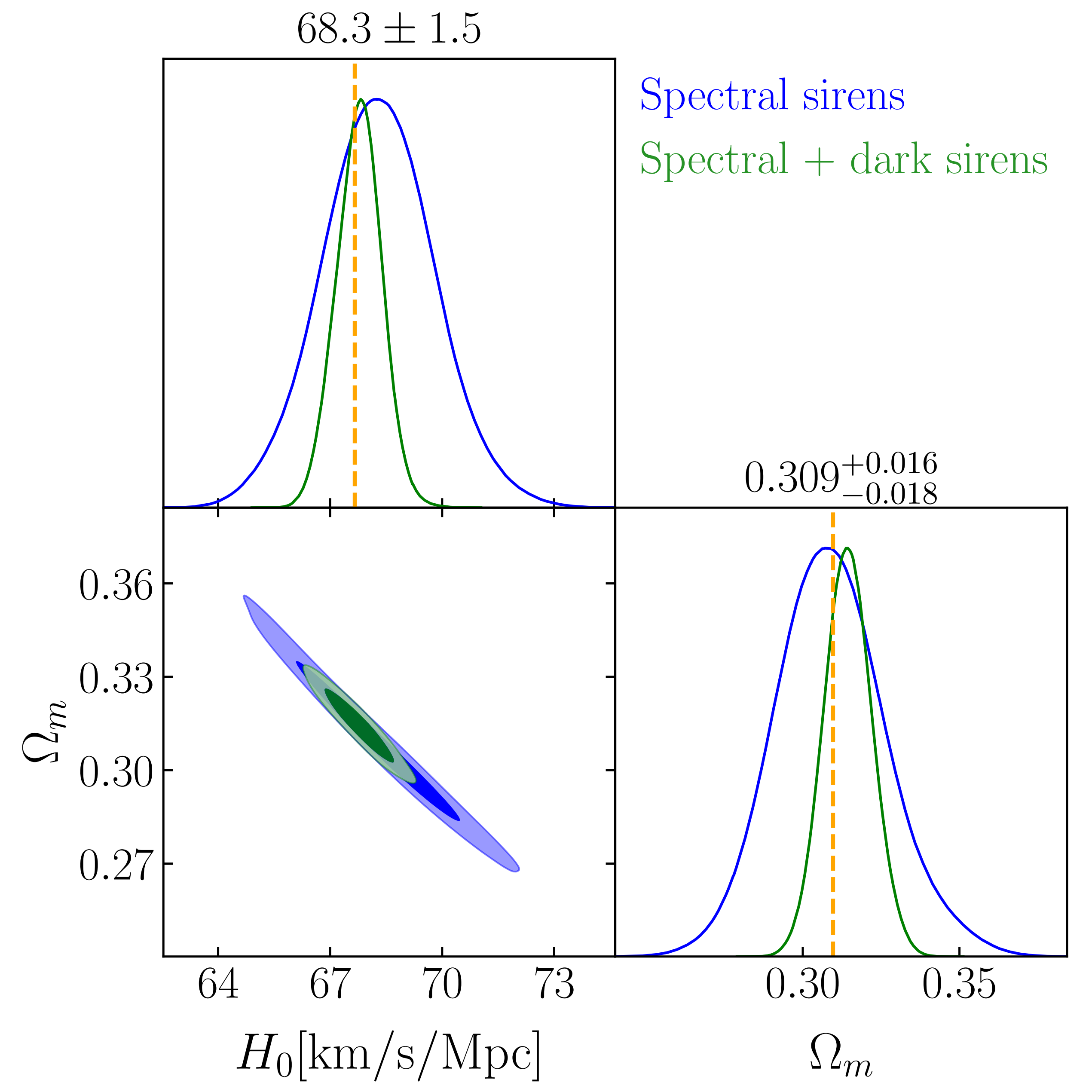
2. Expansion rate at high redshift *H(z)*

Combining sirens **sub-percent** precision across cosmic history!

Spectral sirens are competitive with cosmic surveys

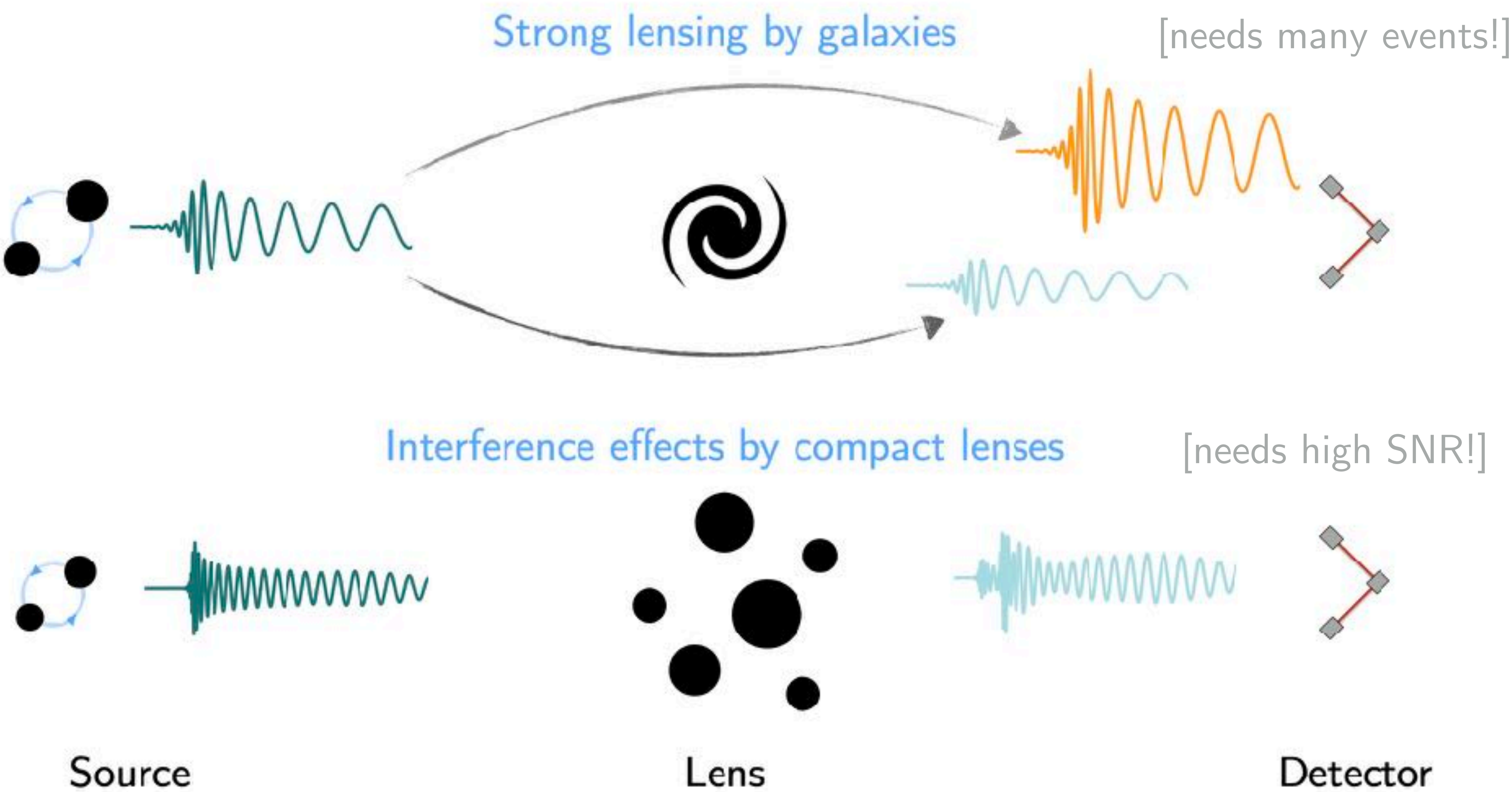


[**Ezquiaga** & Holz (PRL'22)]



[Chen, **Ezquiaga** & Gupta (CQG'24)]

3. Probing inhomogeneous Universe

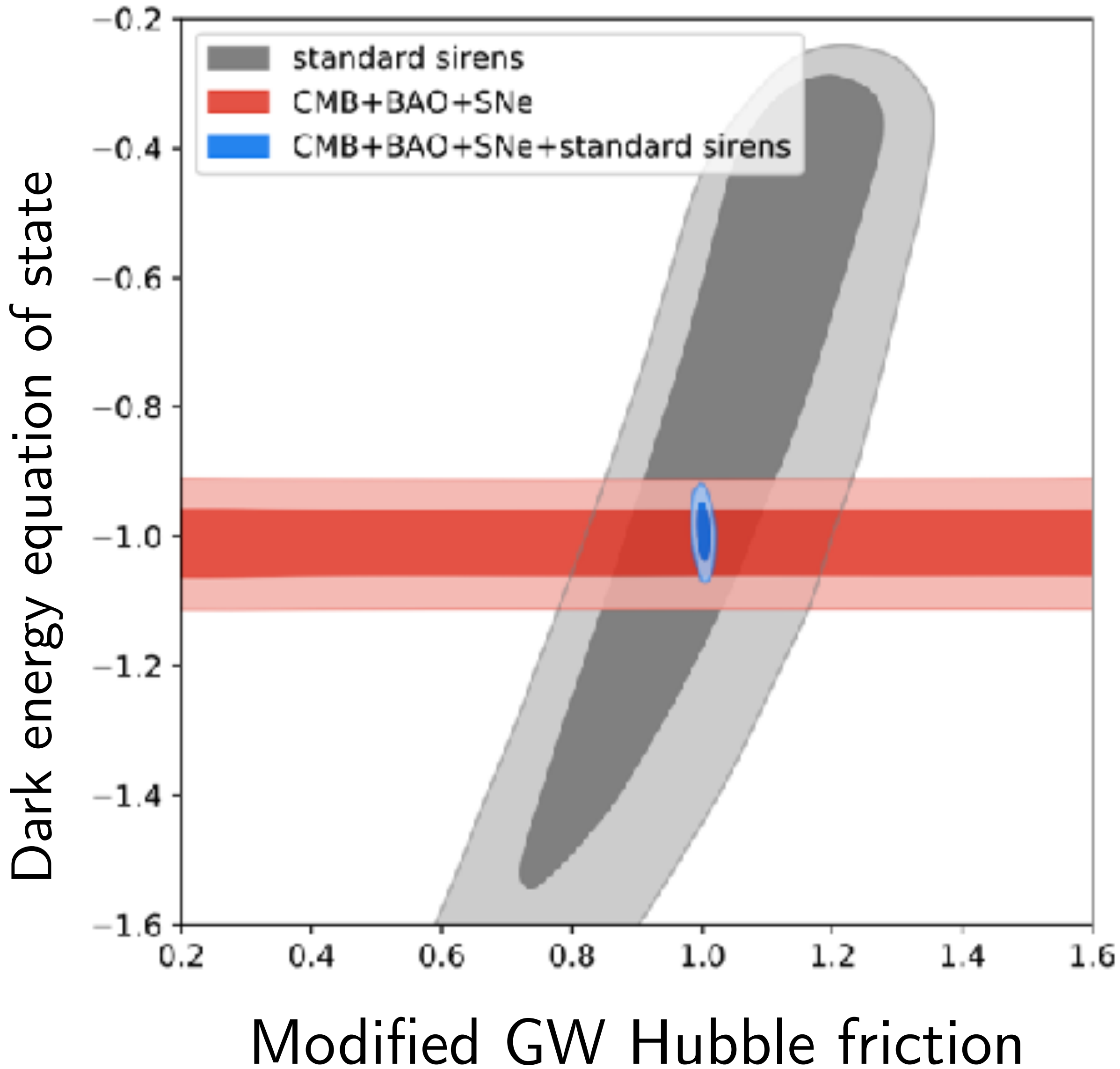


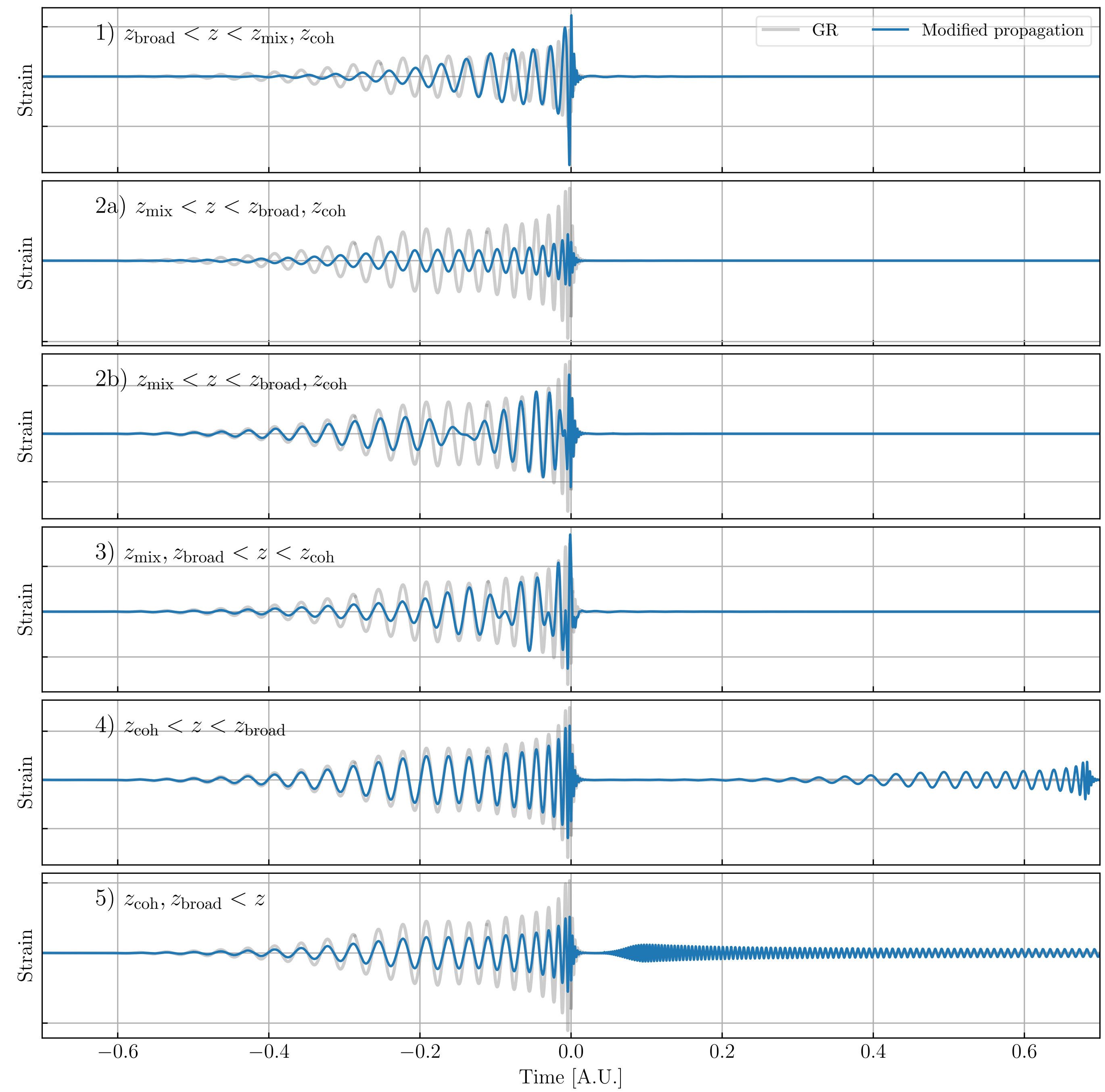
[lensed detection ~$1/10^3$ events, probe source & lens population; Xu, **Ezquiaga**, Holz (ApJ'22)]

4. Testing gravity at large scales

Modified propagation has *rich phenomenology* of waveform distortions

A gravity test *unique* to GWs!





[Belgacem et al. (PRD'18)]

[**Ezquiaga** et al. (JCAP'21)]

jose.ezquiaga@nbi.ku.dk

Conclusions

Cosmic Explorer will exploit gravitational waves as **standard sirens**

1. H_0 (also) with **dark sirens**
2. Expansion rate at high redshift $H(z)$ with **spectral sirens**
3. Probing inhomogeneous Universe via **lensing**
4. Testing gravity at large scales

... as **dark matter probes**

1. Extreme environments are a unique source of feebly interacting DM and new particles
2. Sensitive to even (sub-)gravitational interactions
3. Searches ongoing with current detectors
4. Next generation detectors can extend the reach to particle parameter space

Medfinansieret af Den Europæiske Unions Connecting Europe-facilitet

VILLUM FONDEN

Join us!

ezquiaga.github.io/joinus