2nd Year Report

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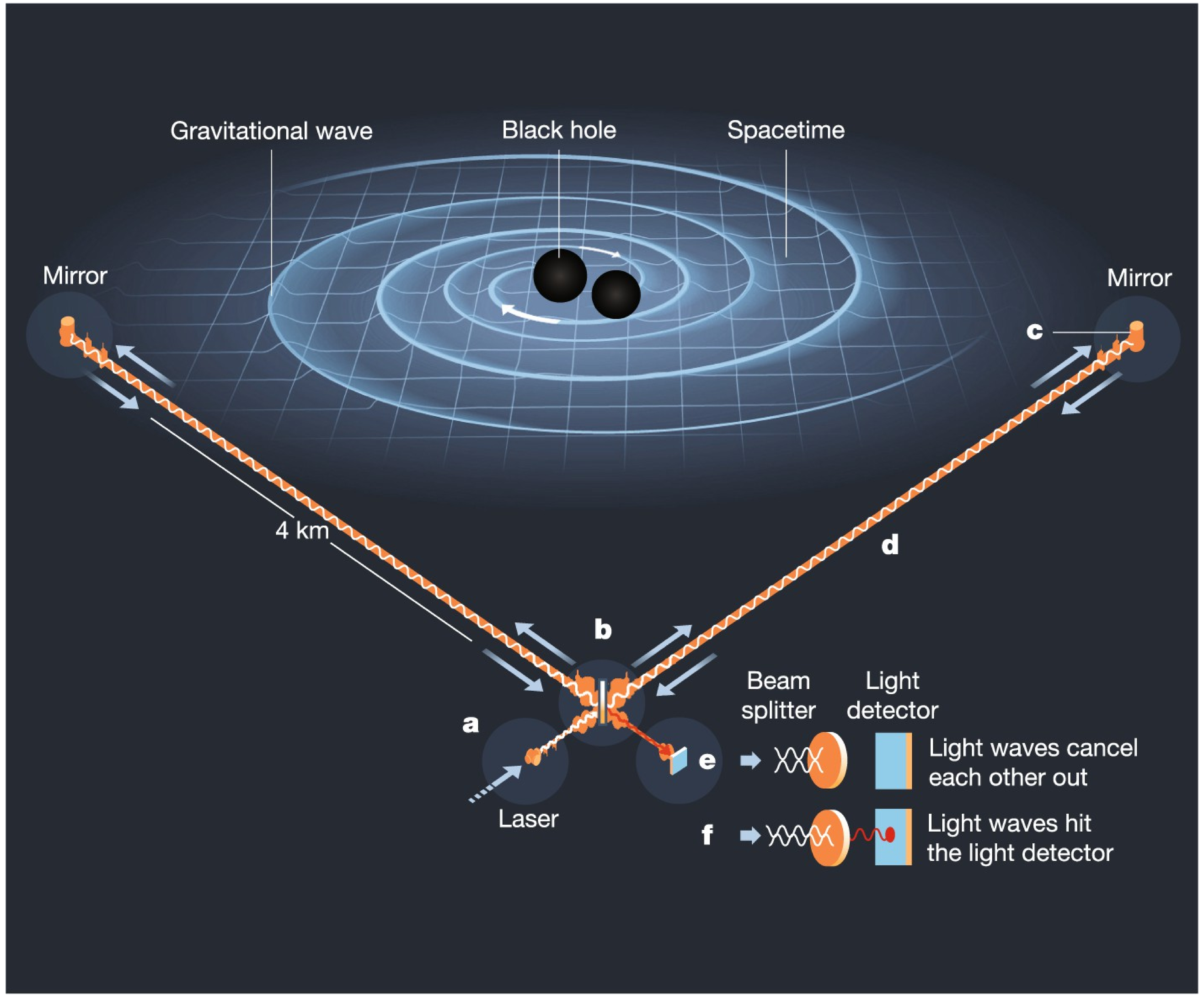
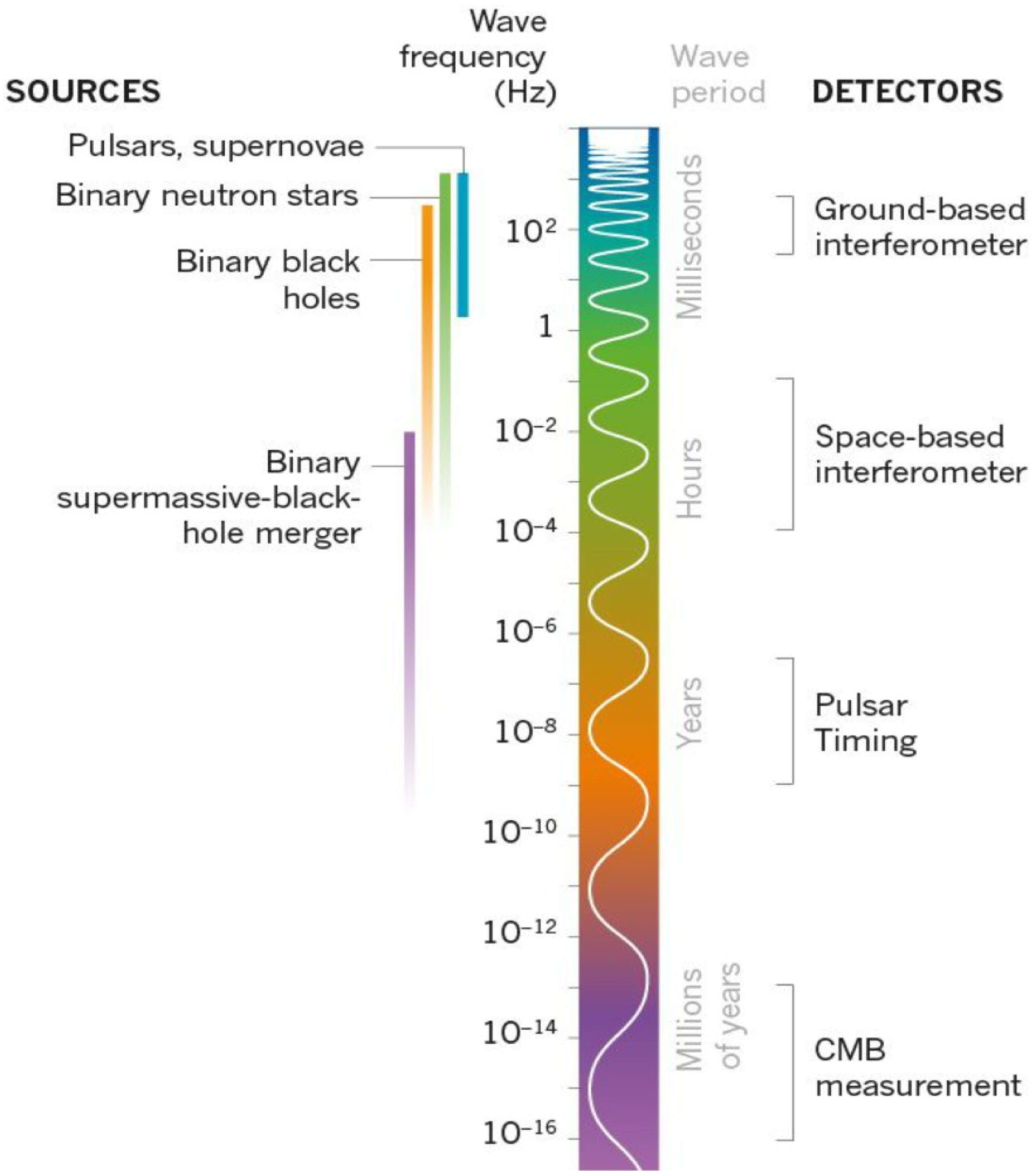
Structure

- Introduction
- Detectors
- Fisher-matrix formalism
- Analysis framework
- Segmented Fourier Transform
- Results:

  Stellar-mass BBHs
- Conclusion

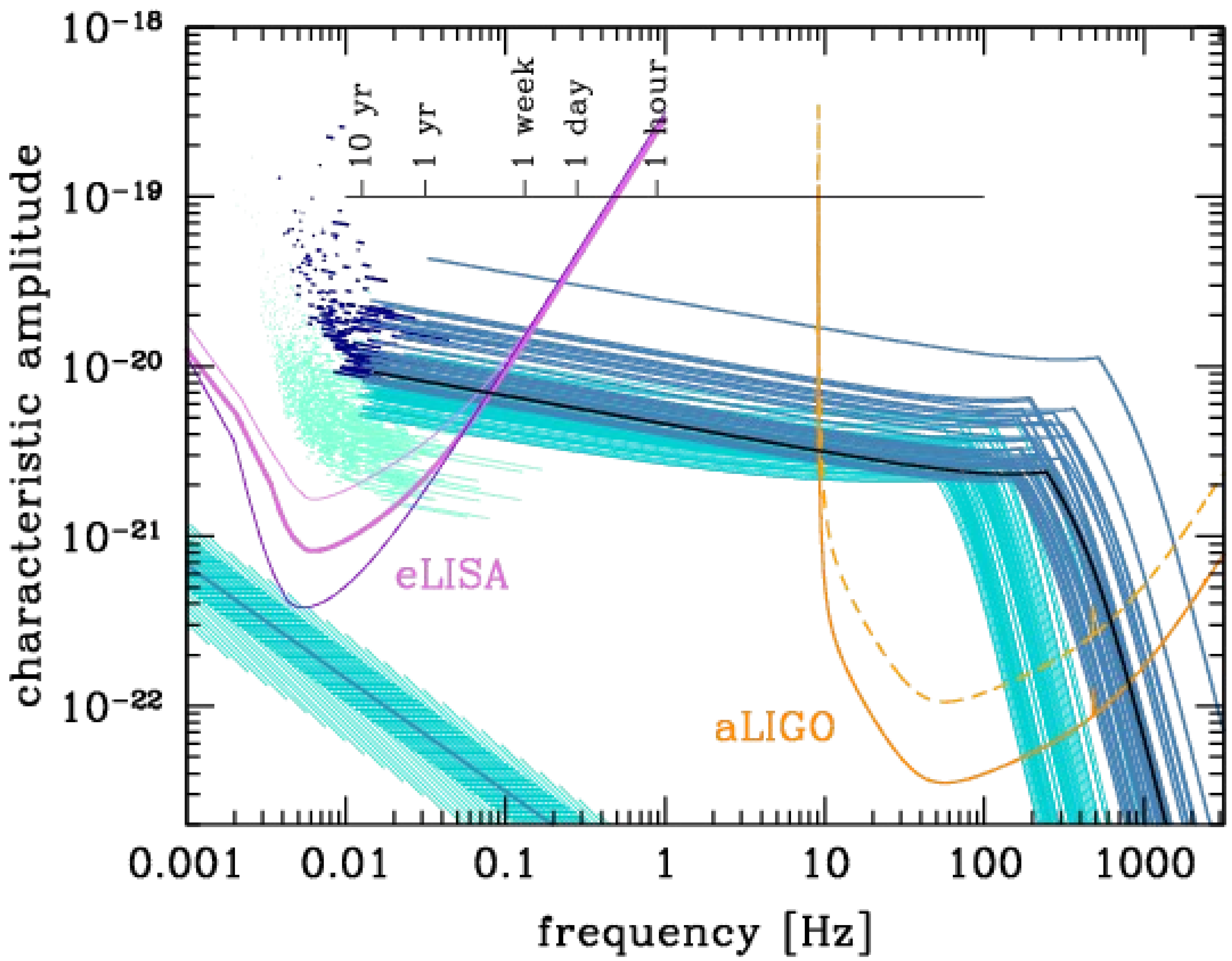
Introduction – GW Detection





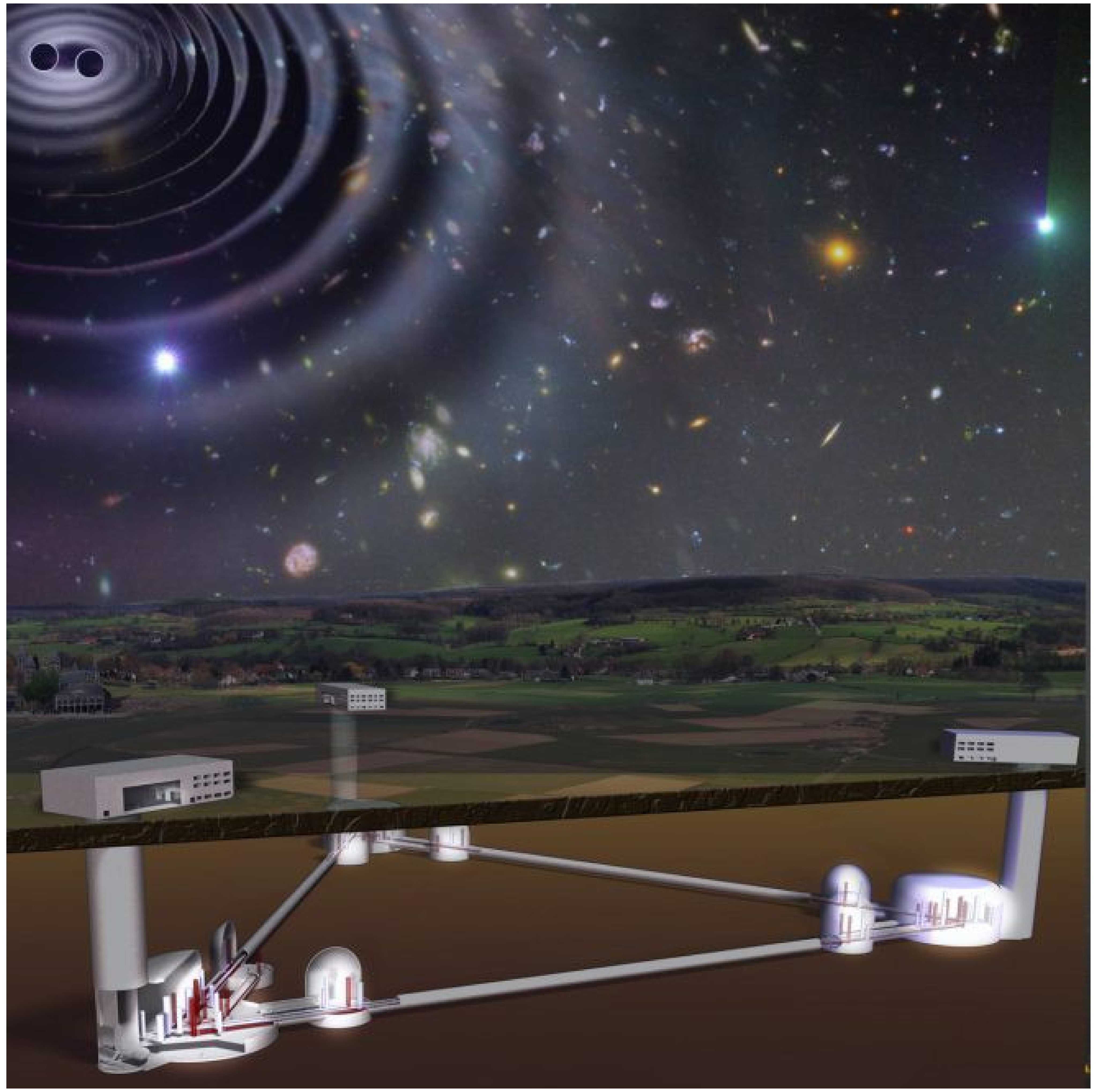
Introduction – Multiband approach

- Parameter estimation
- Multimessenger studies
- Testing GR

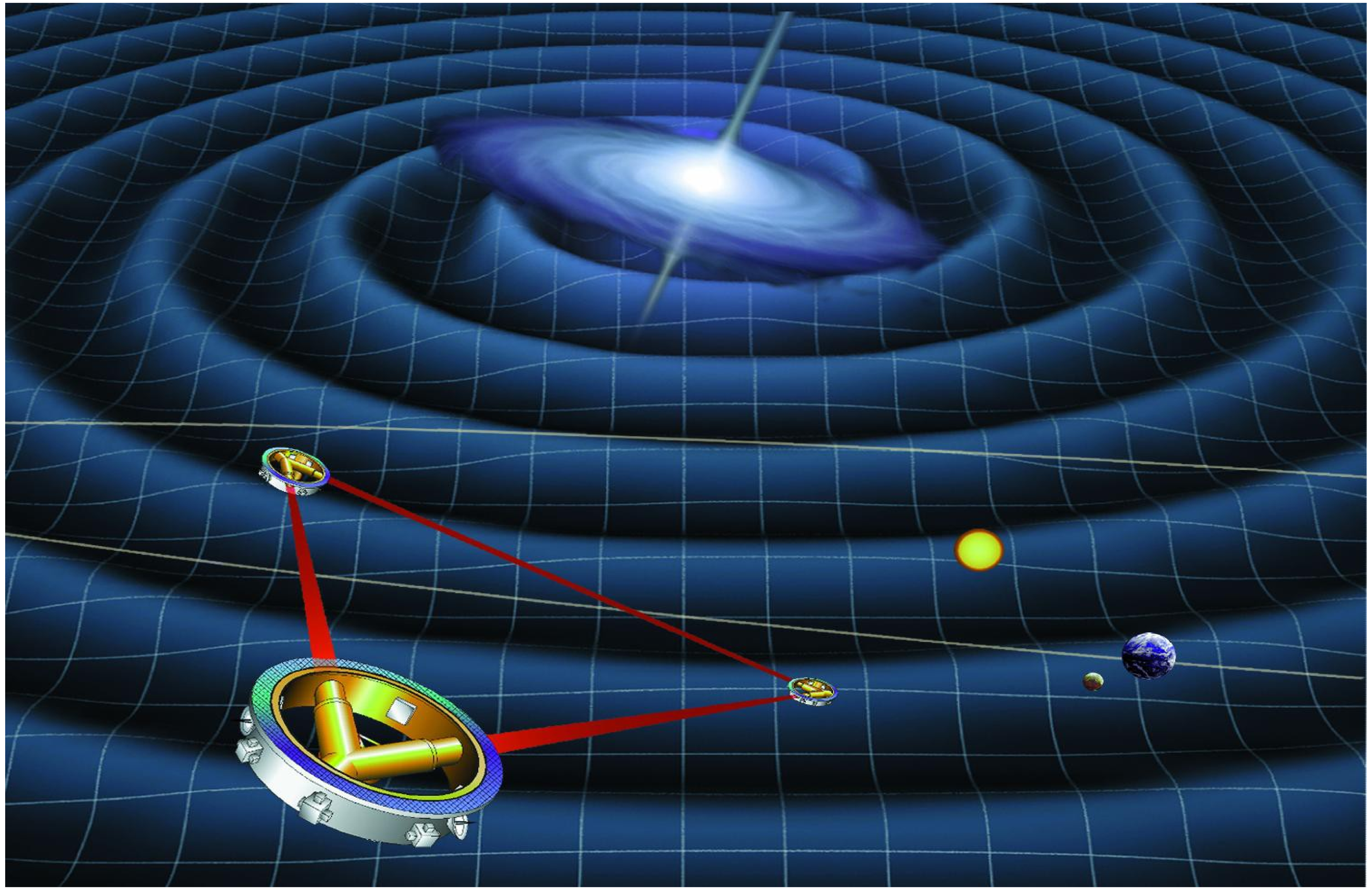


A. Sesana, PRL 116, 231102 (2016)

Introduction - Future Detectors



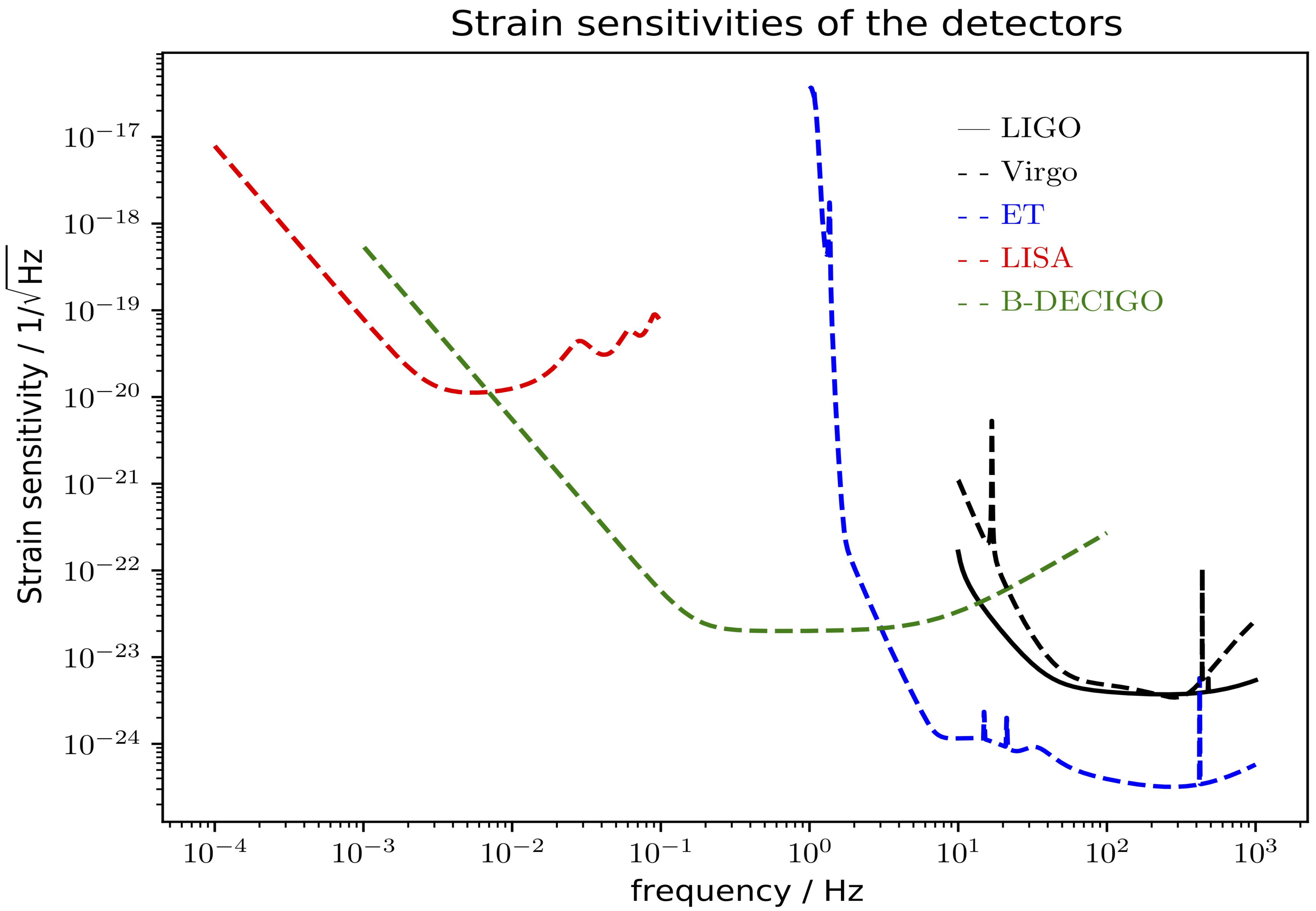
Einstein Telescope (ET)



Laser Interferometer Space Antenna (LISA)

Detectors

- LIGO/Virgo detector network
- ET
- LISA
- B-DECIGO
  - geostationary orbit
- B-DECIGO
  - LISA-like orbit



Fisher-matrix formalism

- Signal in detector $s = h(\theta) + n$
- Noise-weighted inner product $(a, b) = 4\Re\int_0^\infty \frac{a(f)\, b^*(f)}{S_n(f)}\, df$
- Likelihood $P(s, \theta) \propto \exp(-(s - h(\theta), s - h(\theta))/2)$
- Expand around true source parameters
- Fisher-matrix $F_{kj} = (\partial_k h(\theta = \theta_0), \partial_j h(\theta = \theta_0))$
- Standard deviation $\Delta\theta_i = \sqrt{(F^{-1})_{ii}}$
- SNR $\mathrm{SNR} = \sqrt{(h, h)}$

Analysis framework

- Metric perturbation

$$\begin{pmatrix} H_+ & H_x & 0 \\ H_x & -H_+ & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$H_+ = \frac{c}{2r}\left(5\frac{M_c^5}{t_c - t}\right)^{1/4}\left(1+\cos^2(\alpha)\right)\cos\left(\phi(t)+\phi_c\right)$$

$$H_x = \frac{c}{2r}\left(5\frac{M_c^5}{t_c - t}\right)^{1/4} 2\cos^2(\alpha)\sin\left(\phi(t)+\phi_c\right)$$

- Rotate into detector frame

$$H_{\mathrm{det}} = R\,H\,R^T$$

- Project onto detector arm vectors

$$h(t) = e_1^T H_{\mathrm{det}}\, e_1 - e_2^T H_{\mathrm{det}}\, e_2$$

Analysis framework

- Perform Fourier Transform

$$\partial_i h(t) \rightarrow \partial_i h(f)$$

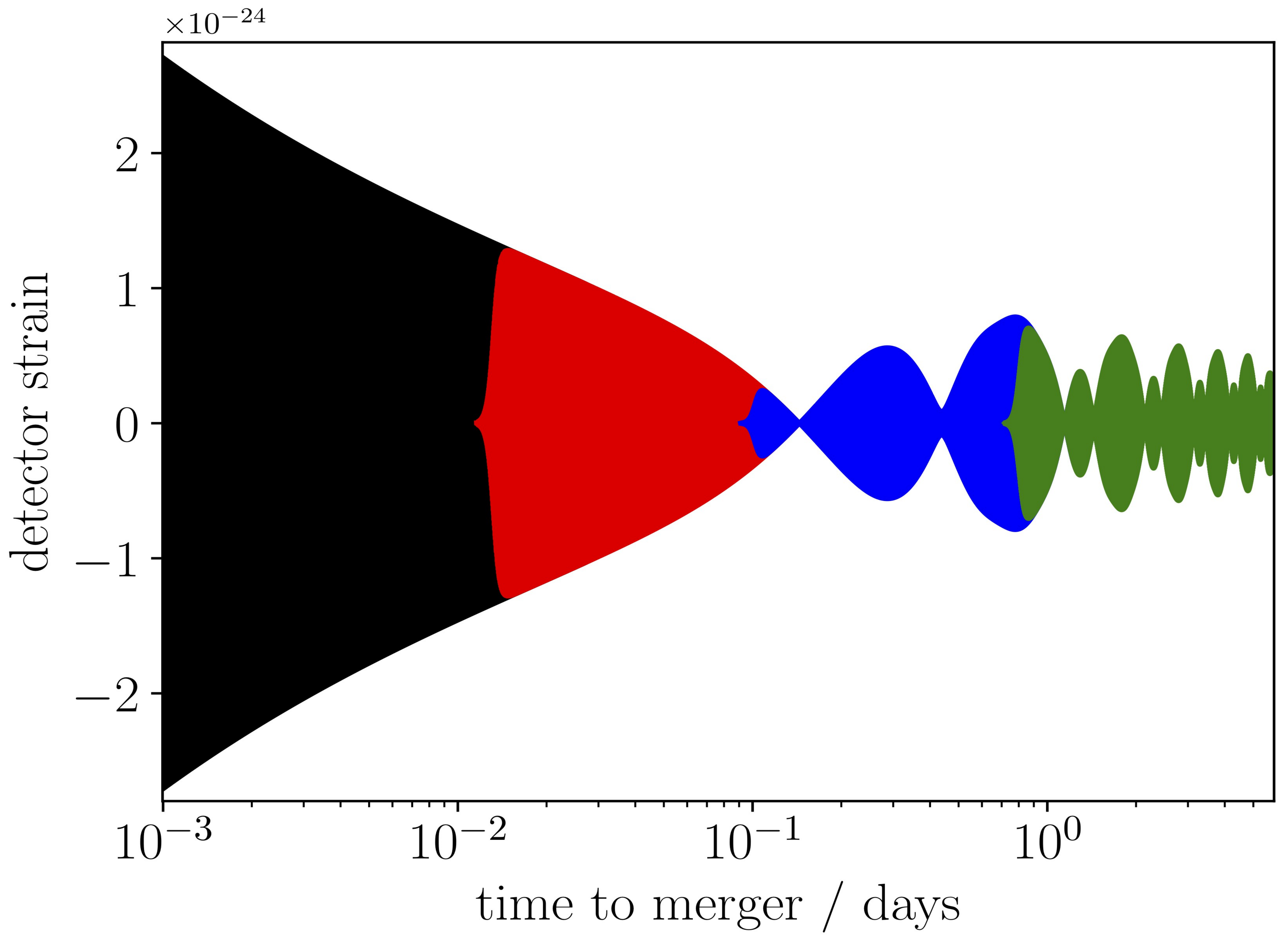
- Compute Fisher matrix

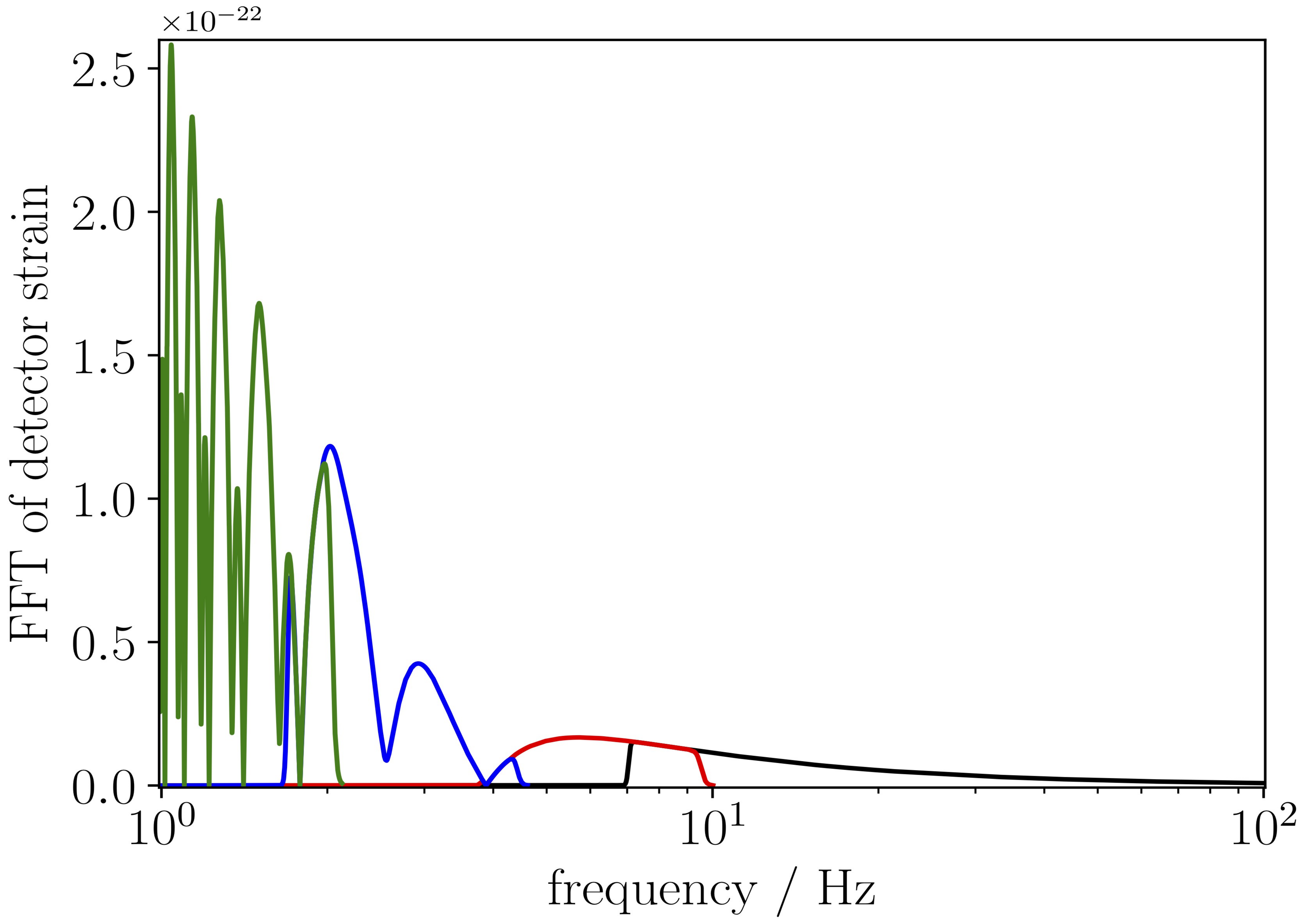
$$F_{kj} = (\partial_k h, \partial_j h)$$

- Invert Fisher matrix

$$\Delta\theta_i = \sqrt{(F^{-1})_{ii}}$$

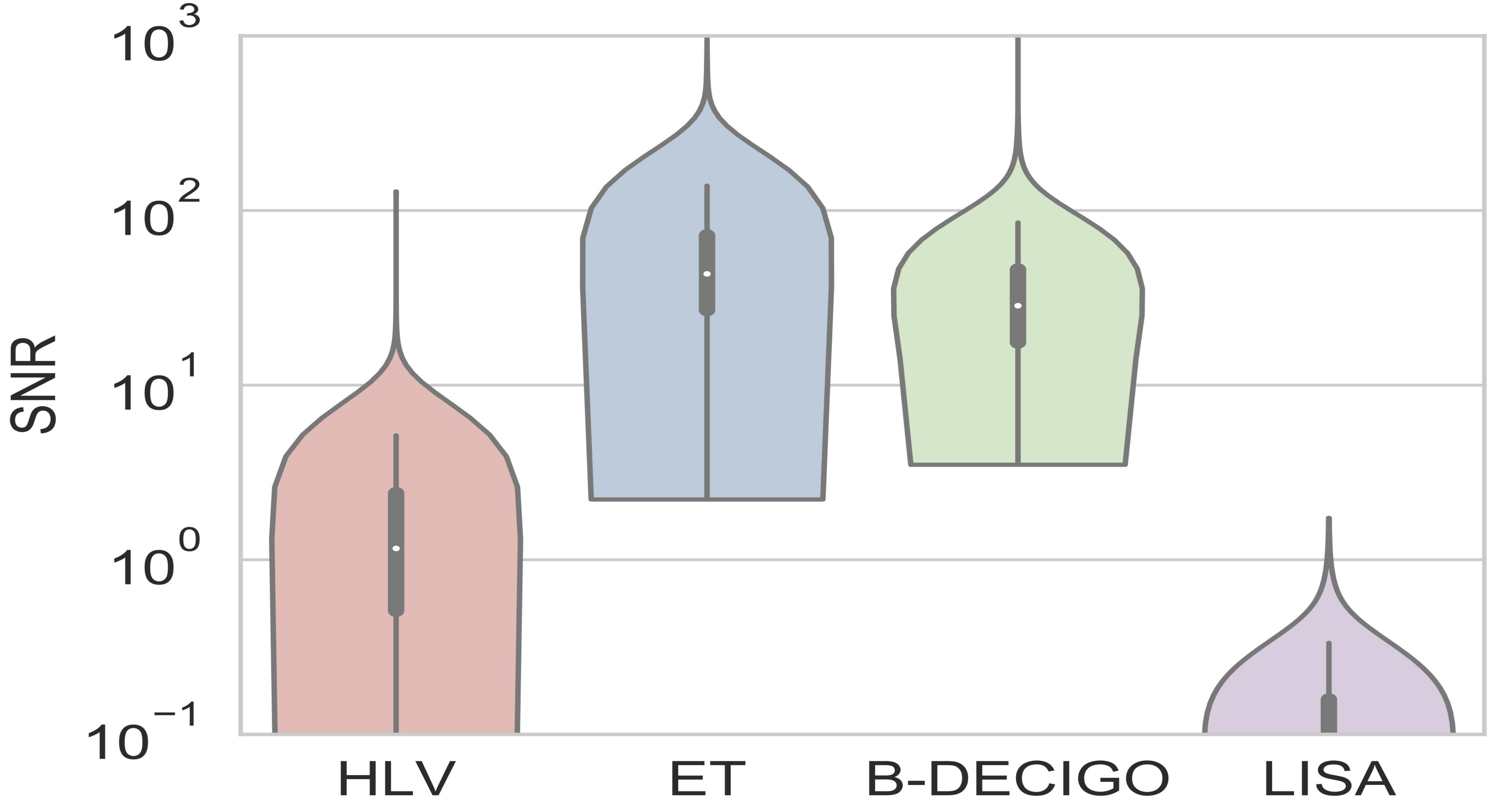
Segmented Fourier Transform





Choose in each segment the time resolution corresponding to the highest frequency in the segment!

Stellar-mass BBHs: detection capabilities



$SNR > 10$	13/1000	968/1000	938/1000	0/1000

BBH population: mass spectrum is power-law with index -1.6, $5\,M_{\rm solar} < M_{\rm BH} < 60\,M_{\rm solar}$

Parameter estimates

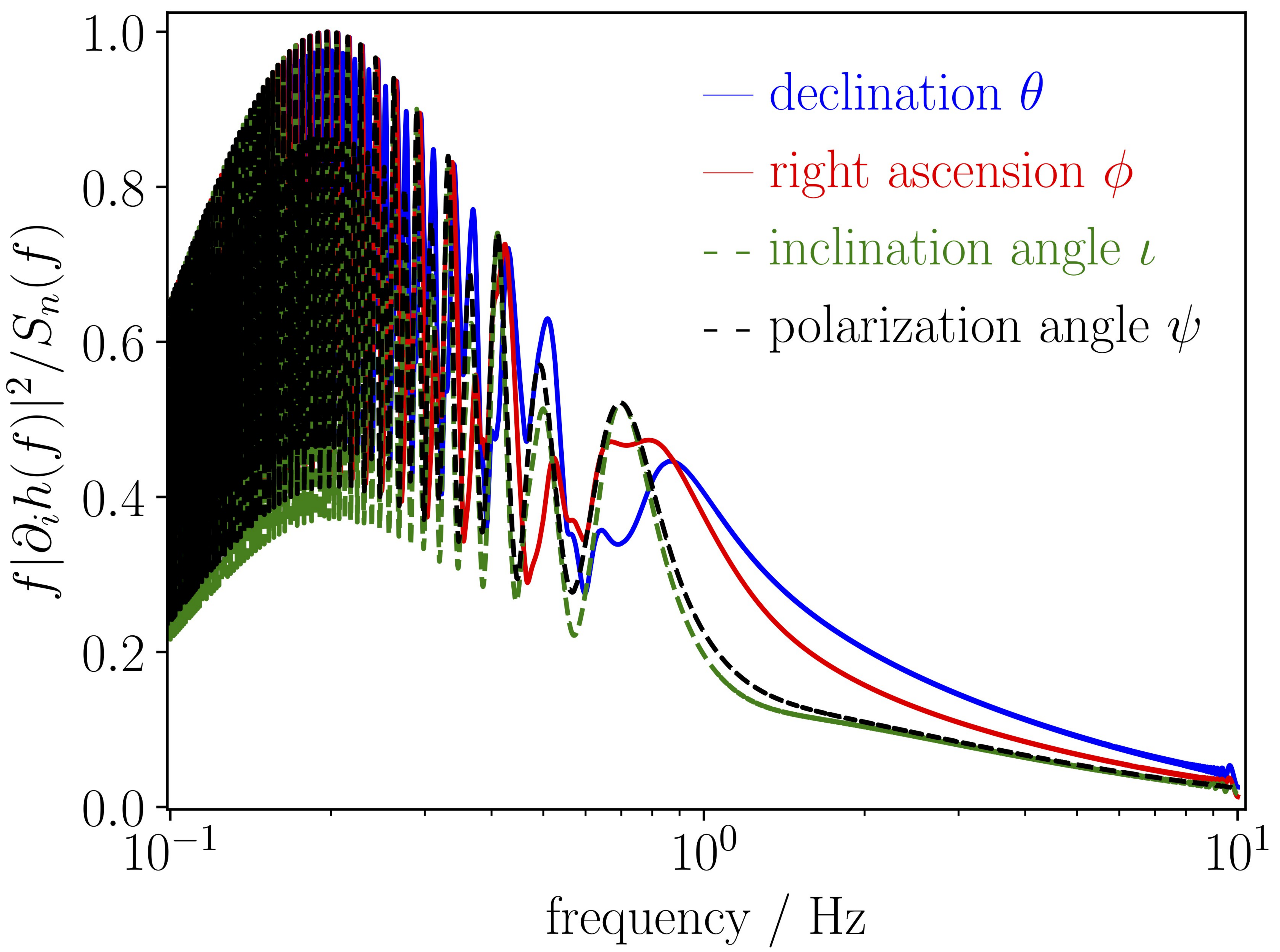
Results

- B-DECIGO: geostationary orbit is preferable over heliocentric orbit
- Estimate of mass parameters benefits from multiband parameter estimation
- LISA: no good candidate for multiband parameter estimation of stellar-mass BBHs

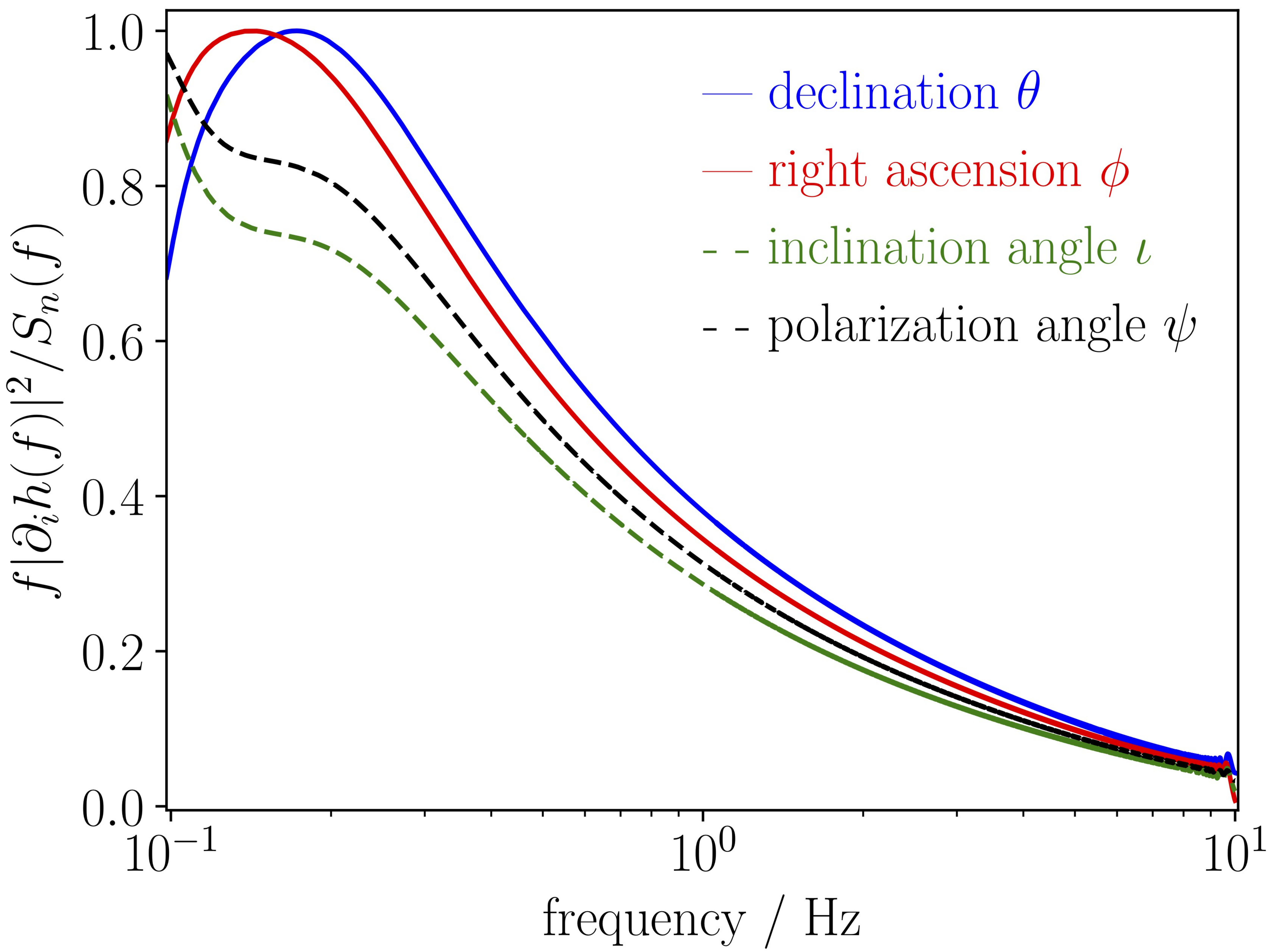
Outlook

- Investigate different detector designs
- Multi-messenger studies
- Perform studies involving large statistics

Movement effects in B-DECIGO

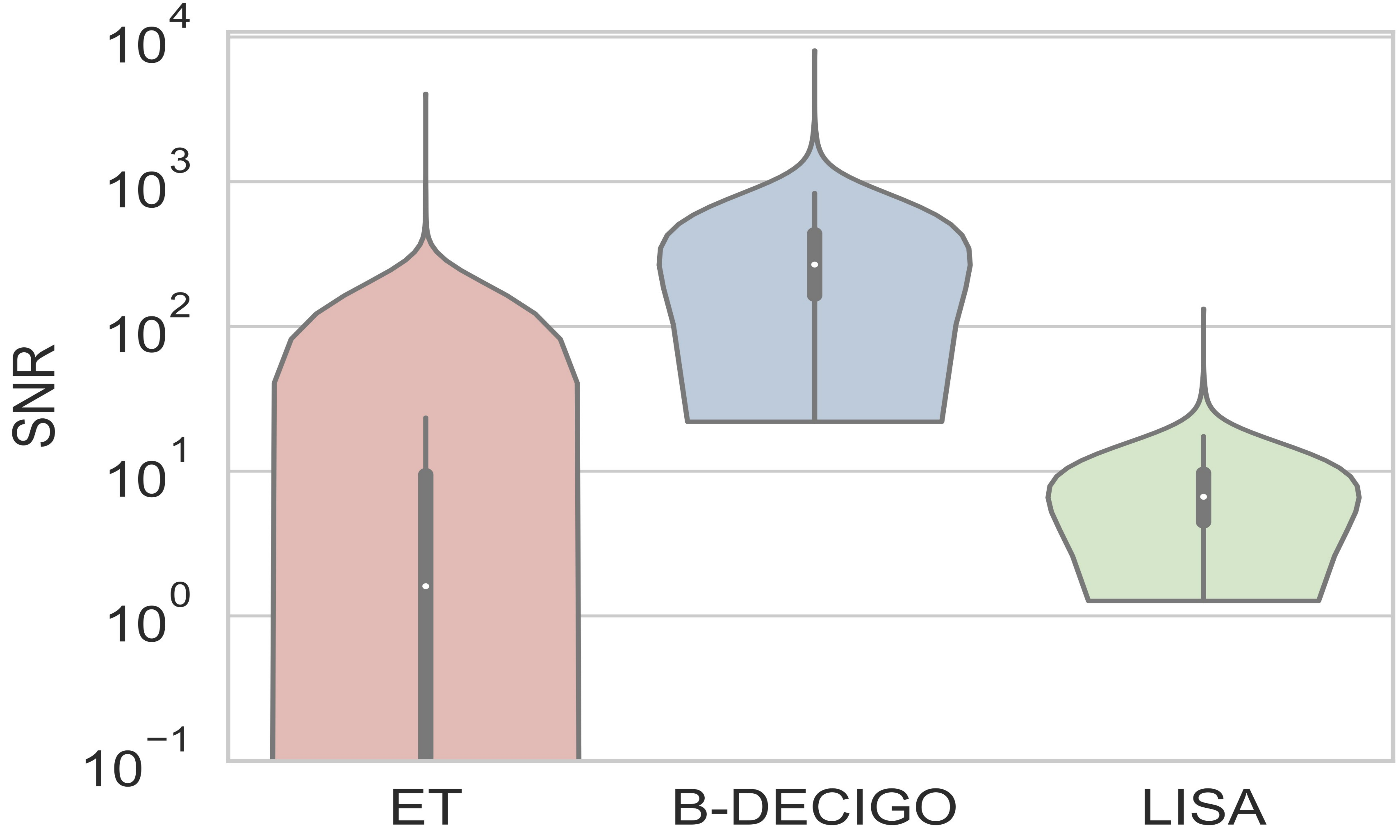


geostationary orbit



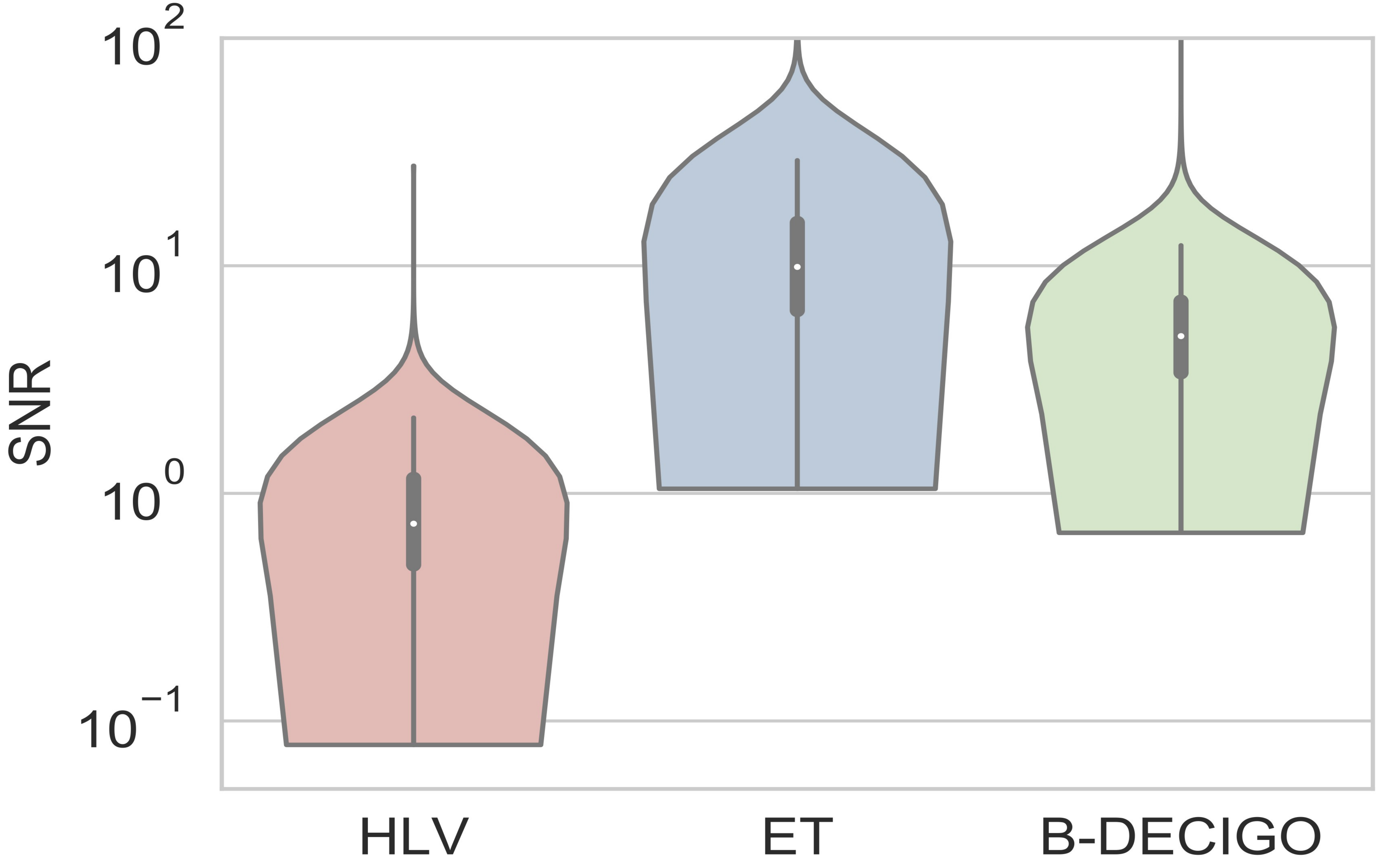
heliocentric orbit

Intermediate-mass BBHs: detection capabilities



$SNR > 10$ $241/1000$ $1000/1000$ $227/1000$

Neutron star binaries: detection capabilities



$SNR > 10$ $1/1000$ $492/1000$ $104/1000$