# Stochastic searches with LIGO/Virgo

Kamiel Janssens

Belgian Gravitational Wave Meeting - October 27 2020

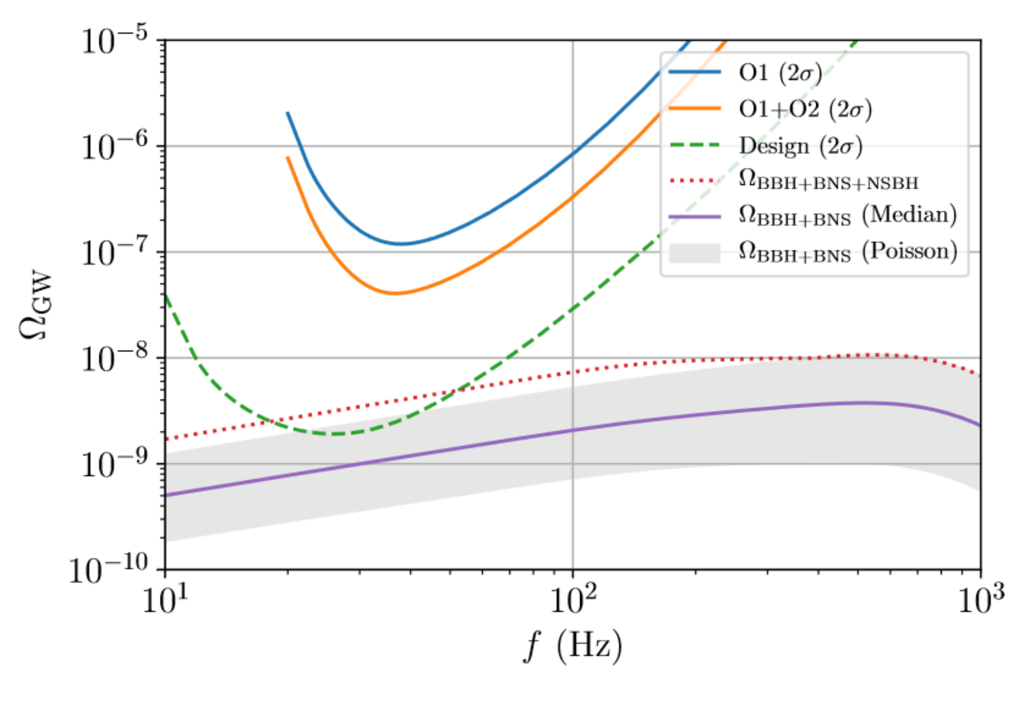
# Content

- Introduction
  - Possible sources
  - Types of searches
  - State of the art and outlook
- Efforts in noise characterization and modelling
  - Global corelated magnetic fields
  - GW geodesy

# Introduction

# Possible sources

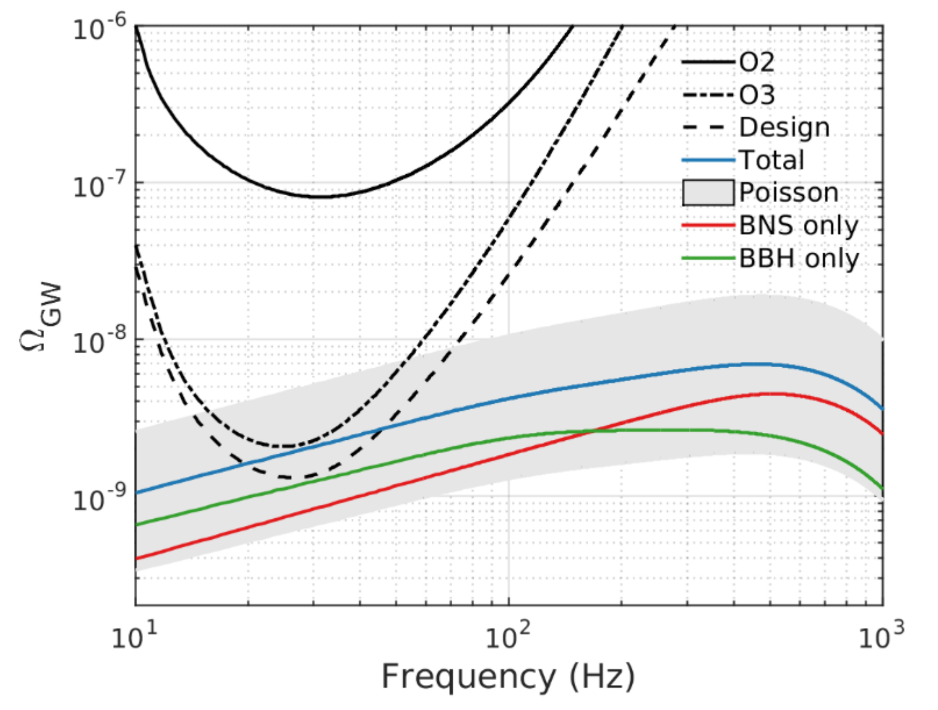
- Astrophysical:
  - Unresolved compact binary coalescence
  - Core collapse supernovae
  - …
- Cosmological
  - Cosmic strings
  - Phase transitions
  - Primordial black holes
  - …




Phys. Rev. D 100, 061101 (2019)

# Possible sources

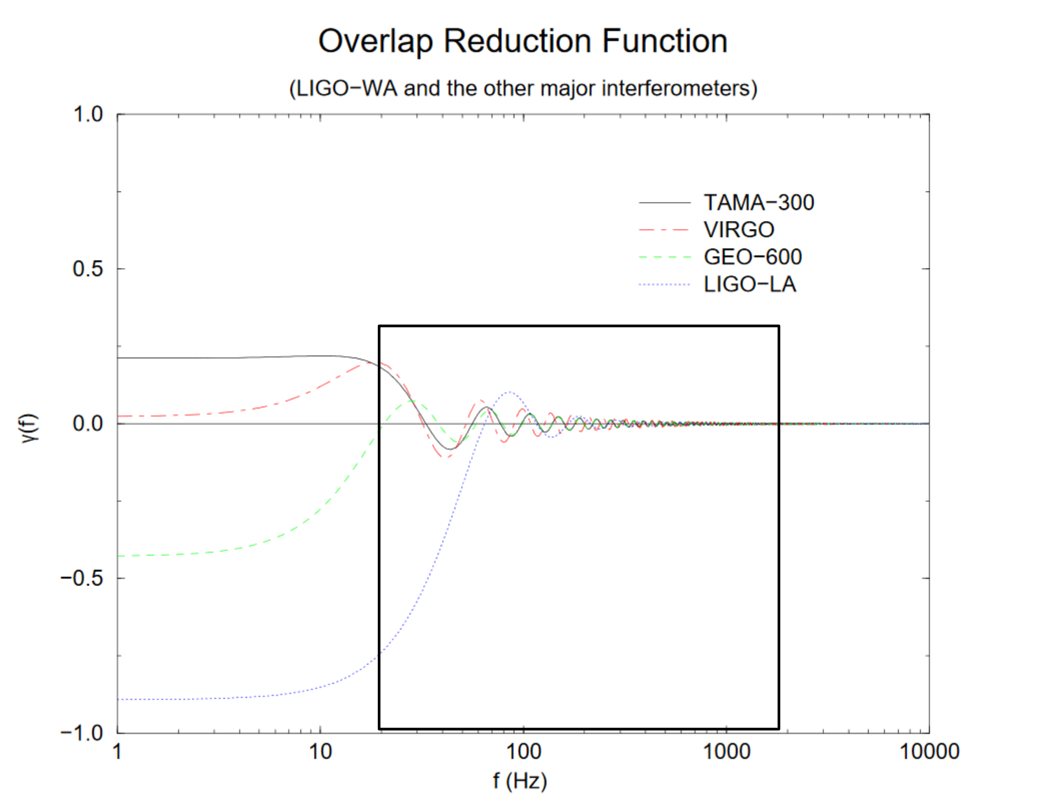
- Astrophysical:
  - Unresolved compact binary coalescence
  - Core collapse supernovae
  - …
- Cosmological
  - Cosmic strings
  - Phase transitions
  - Primordial black holes
  - …




Phys. Rev. Lett. 120, 091101 (2018)

# Types of searches

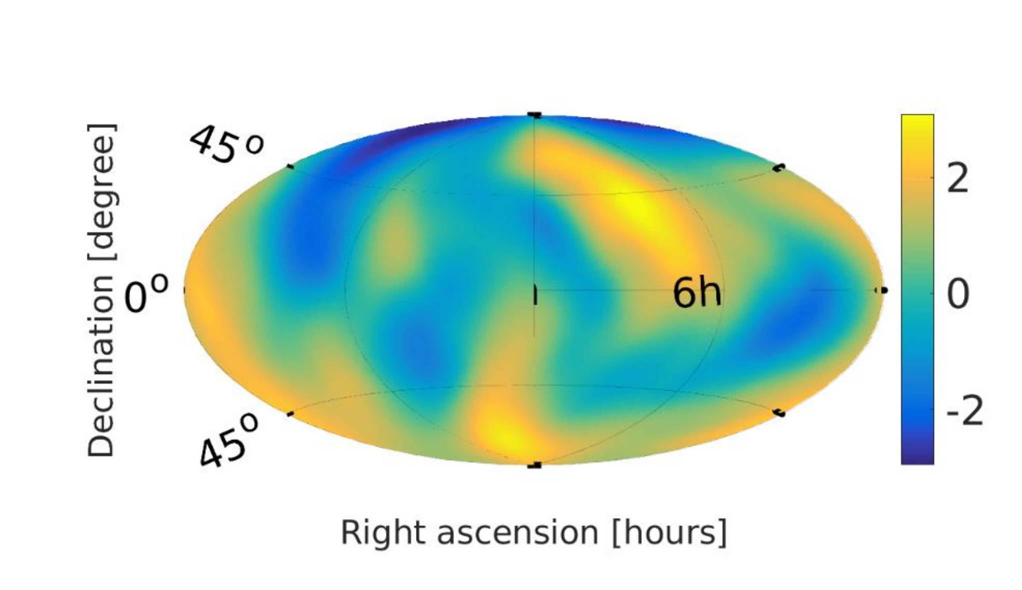
- Isotropic search
- Directional search
  - Spherical harmonic decomposition
  - Radiometer search
    - Broadband
    - Narrowband




Phys.Rev.D59:102001,1999

# Types of searches

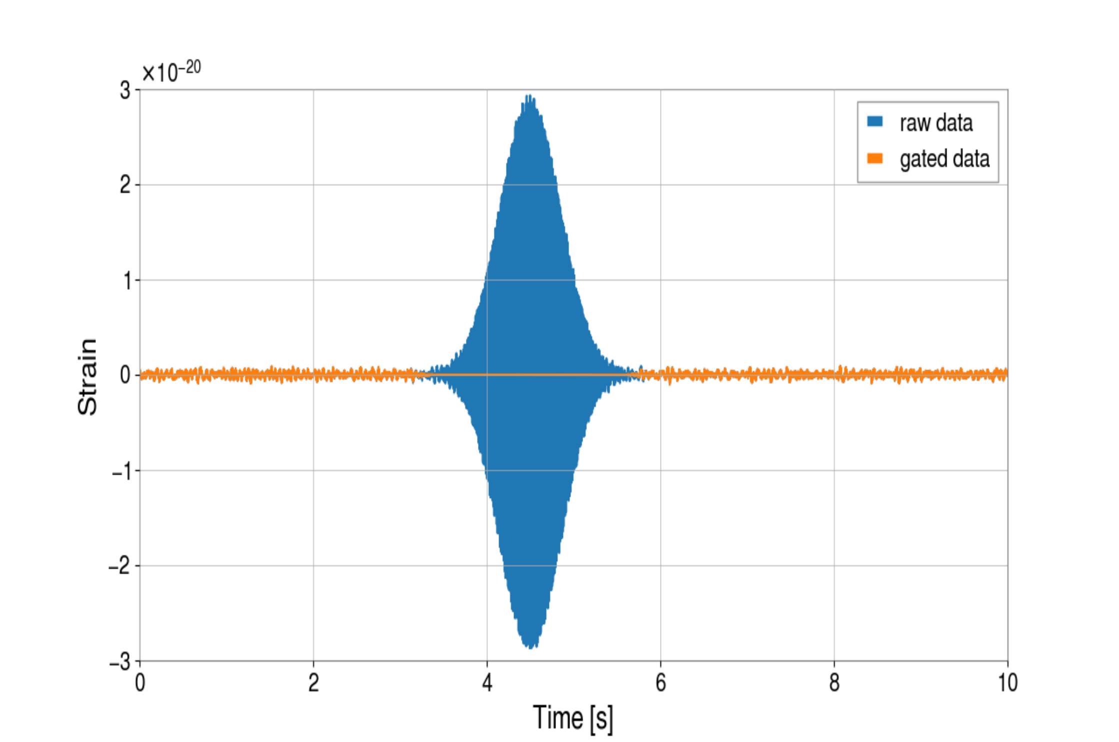
- Isotropic search
- Directional search
  - Spherical harmonic decomposition
  - Radiometer search
    - Broadband
    - Narrowband




Phys. Rev. D 100, 062001 (2019)

# State of the art and outlook

- New features:
  - First ever stochastic search including 3 detector network
  - Gated data
  - Integrate magnetic noise in one consistent Bayesian framework



# State of the art and outlook

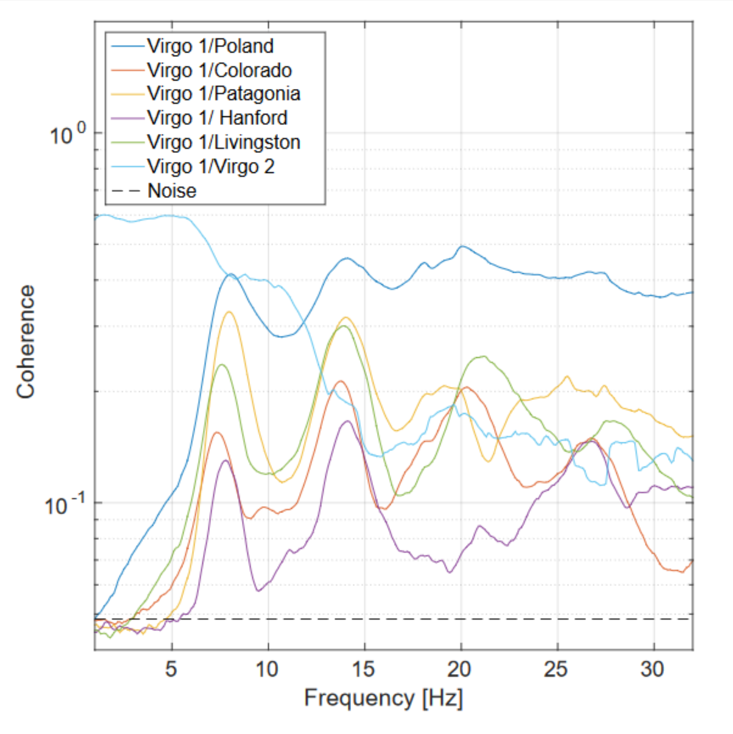
- Publication plans:
  - O3 isotropic ~ end of November
  - O3 phase transitions (short author) ~ end of November
  - O3 directional ~ end of December
  - O3 cosmic strings ~ April (might be moved forward)

# Efforts in noise characterization and modelling

# Global corelated magnetic fields

- Schumann resonances
- O3: new method to differentiate between a stochastic signal and magnetic noise
  - Model Magnetic noise
  - Magnetic transfer function
  - Apply in a Bayesian framework

  arXiv:2008.00789 [gr-qc]

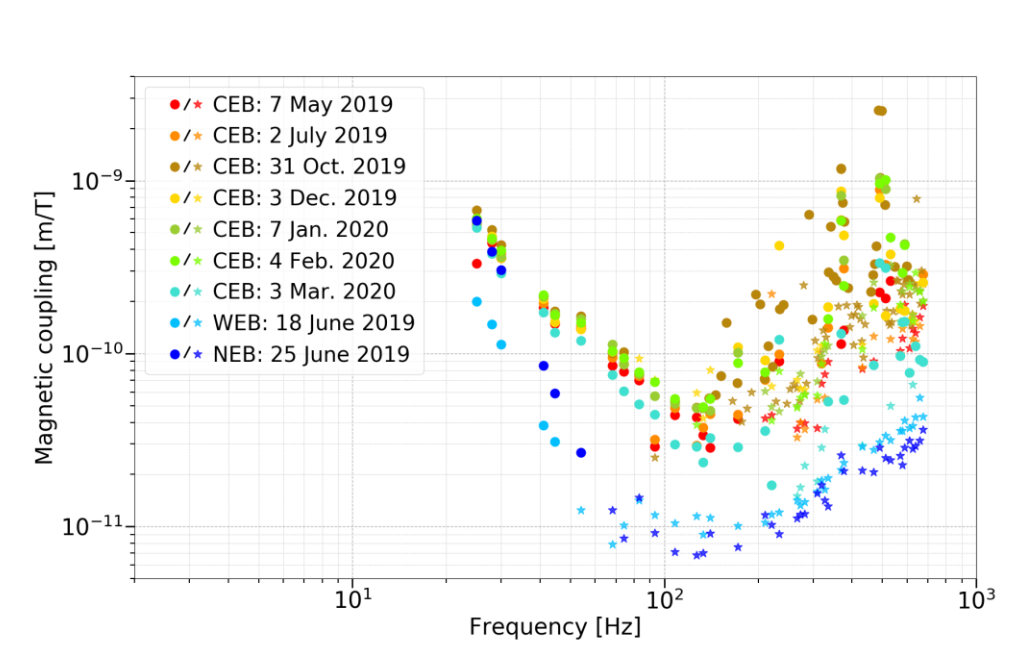



Phys.Rev.D 97 (2018) 10, 102007

# Global corelated magnetic fields

- Schumann resonances
- O3: new method to differentiate between a stochastic signal and magnetic noise
  - Model Magnetic noise
  - Magnetic transfer function
  - Apply in a Bayesian framework

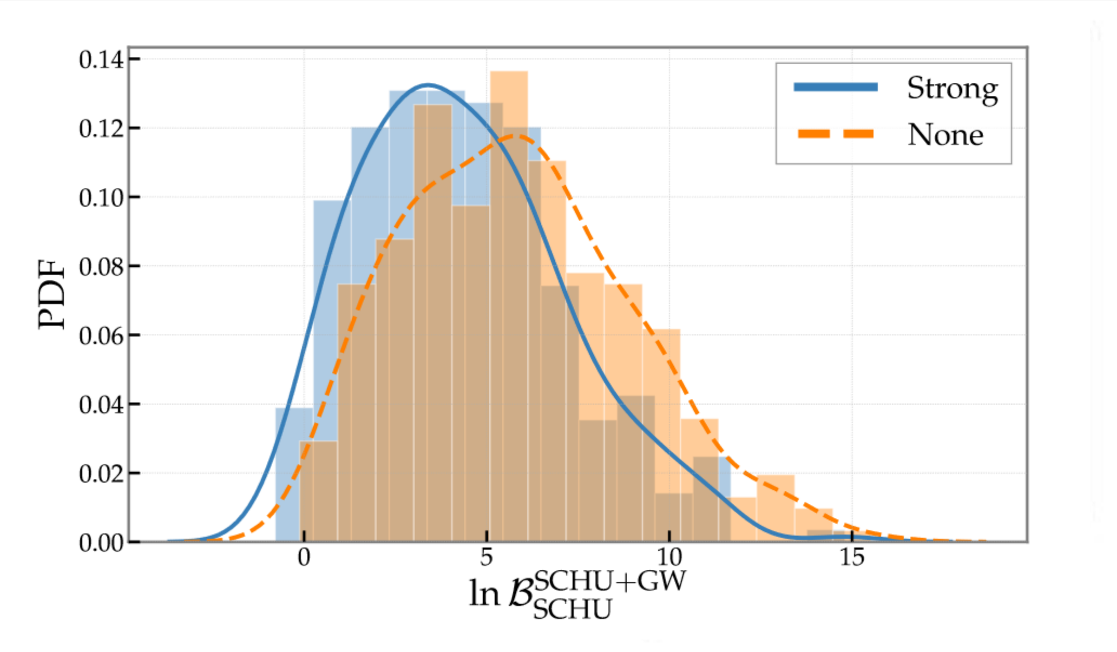
  arXiv:2008.00789 [gr-qc]



# Global corelated magnetic fields

- Schumann resonances
- O3: new method to differentiate between a stochastic signal and magnetic noise
  - Model Magnetic noise
  - Magnetic transfer function
  - Apply in a Bayesian framework

  arXiv:2008.00789 [gr-qc]



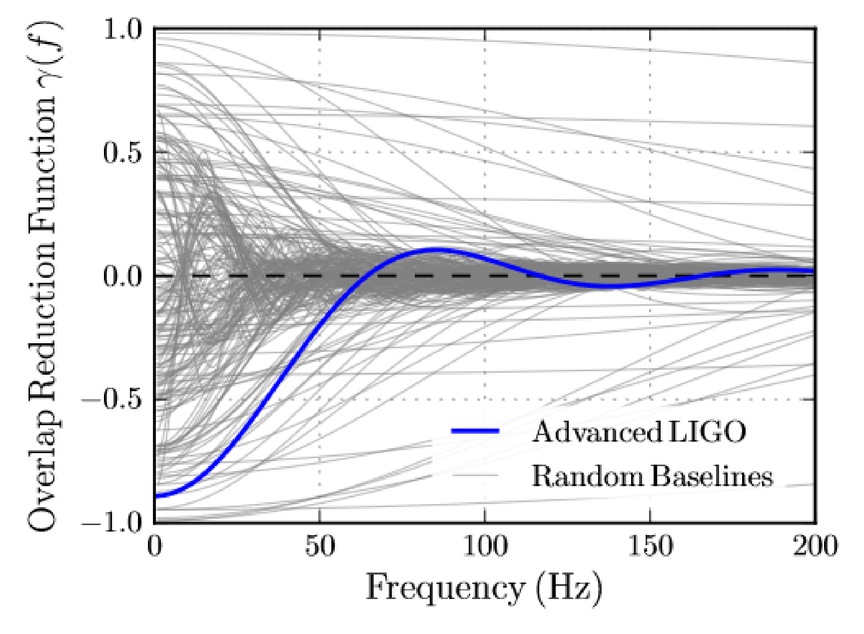

arXiv:2008.00789 [gr-qc]

# GW geodesy

$$p(\{\hat{C}\}|\Theta,\mathcal{H}) \propto \exp\left[-\frac{1}{2}\left(\hat{C}-C_{\mathcal{H}}(\Theta)|\hat{C}-C_{\mathcal{H}}(\Theta)\right)\right]$$

$$C_\gamma(\Omega_0,\alpha;f) = \gamma_{\mathrm{True}}(f)\,\Omega_0\,(f/25\,\mathrm{Hz})^\alpha$$

$$C_{\mathrm{Free}}(\Omega_0,\alpha,\Delta x,\phi_1,\phi_2;f) = \gamma(\Delta x,\phi_1,\phi_2;f)\,\Omega_0\,(f/25\,\mathrm{Hz})^\alpha$$



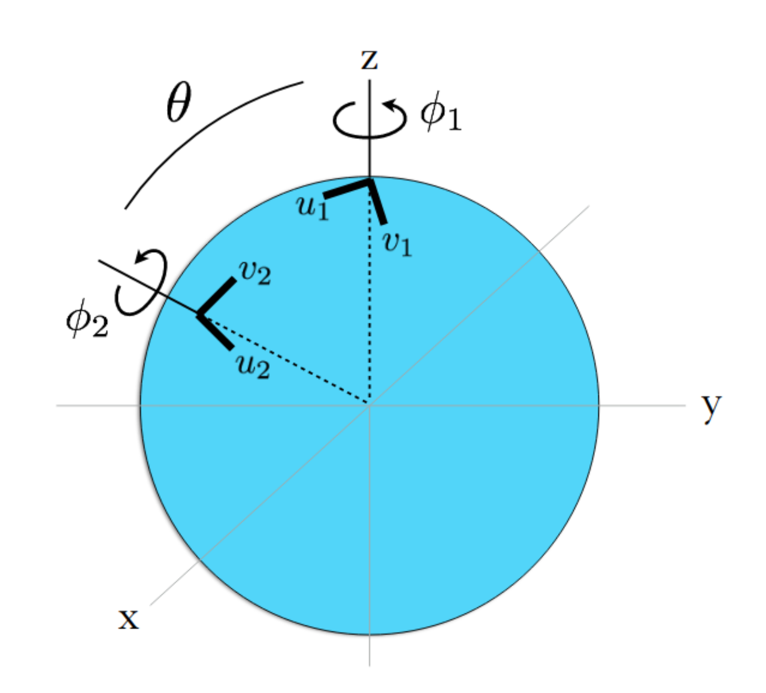

Astrophysical Journal Letters, 869(2), [L28] (2018)

# GW geodesy

$$p(\{\hat{C}\}|\Theta, \mathcal{H}) \propto \exp\left[-\frac{1}{2}\left(\hat{C} - C_{\mathcal{H}}(\Theta)|\hat{C} - C_{\mathcal{H}}(\Theta)\right)\right]$$

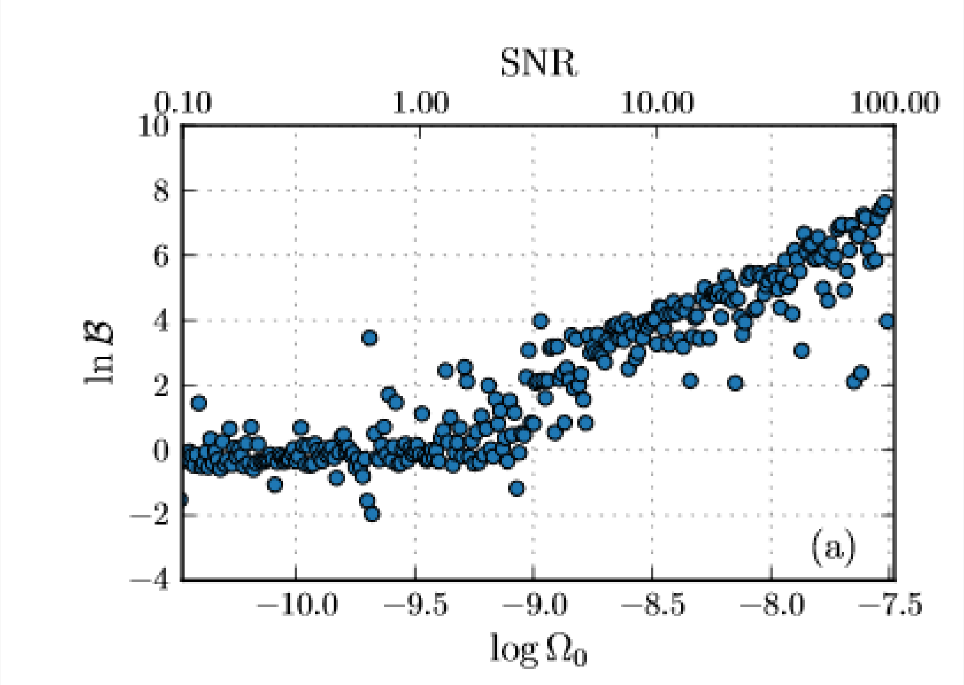
$$C_\gamma(\Omega_0, \alpha; f) = \gamma_{\text{True}}(f)\, \Omega_0\, (f/25\,\text{Hz})^\alpha$$

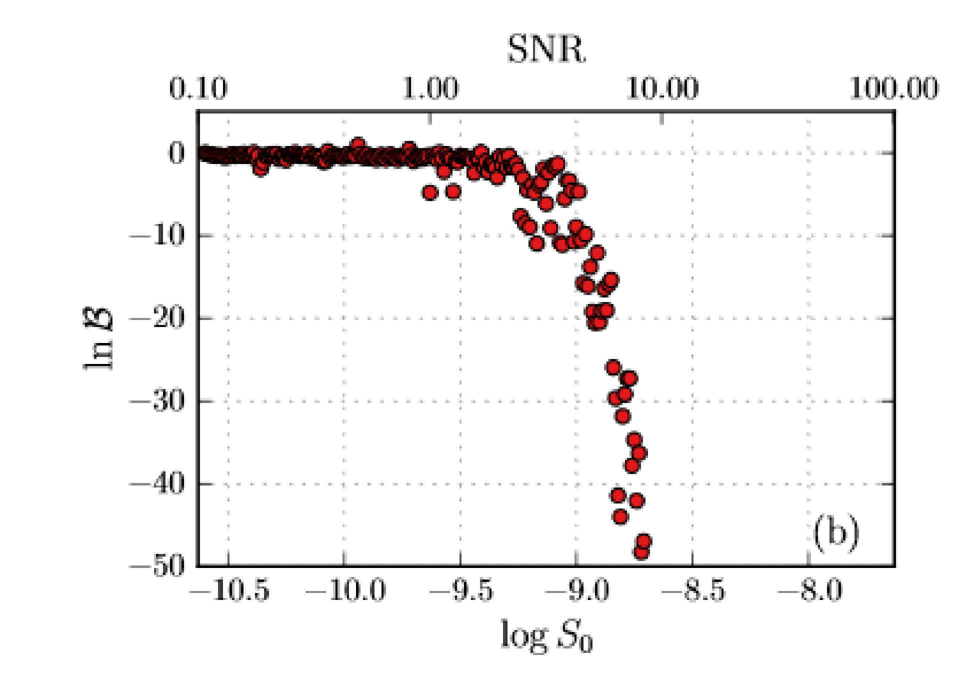
$$C_{\text{Free}}(\Omega_0, \alpha, \Delta x, \phi_1, \phi_2; f) = \gamma(\Delta x, \phi_1, \phi_2; f)\, \Omega_0\, (f/25\,\text{Hz})^\alpha$$




Astrophysical Journal Letters, 869(2), [L28] (2018)

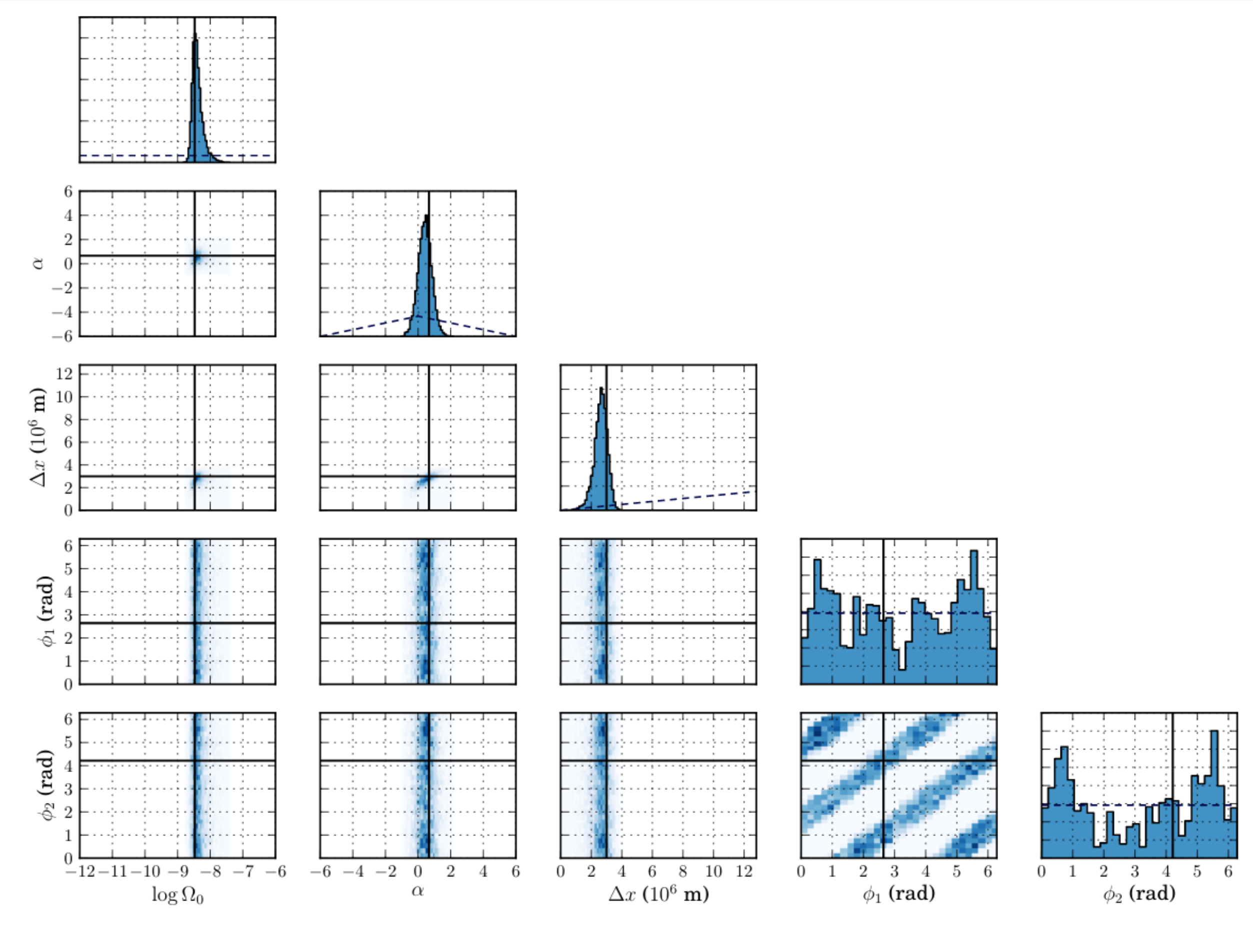
# GW geodesy



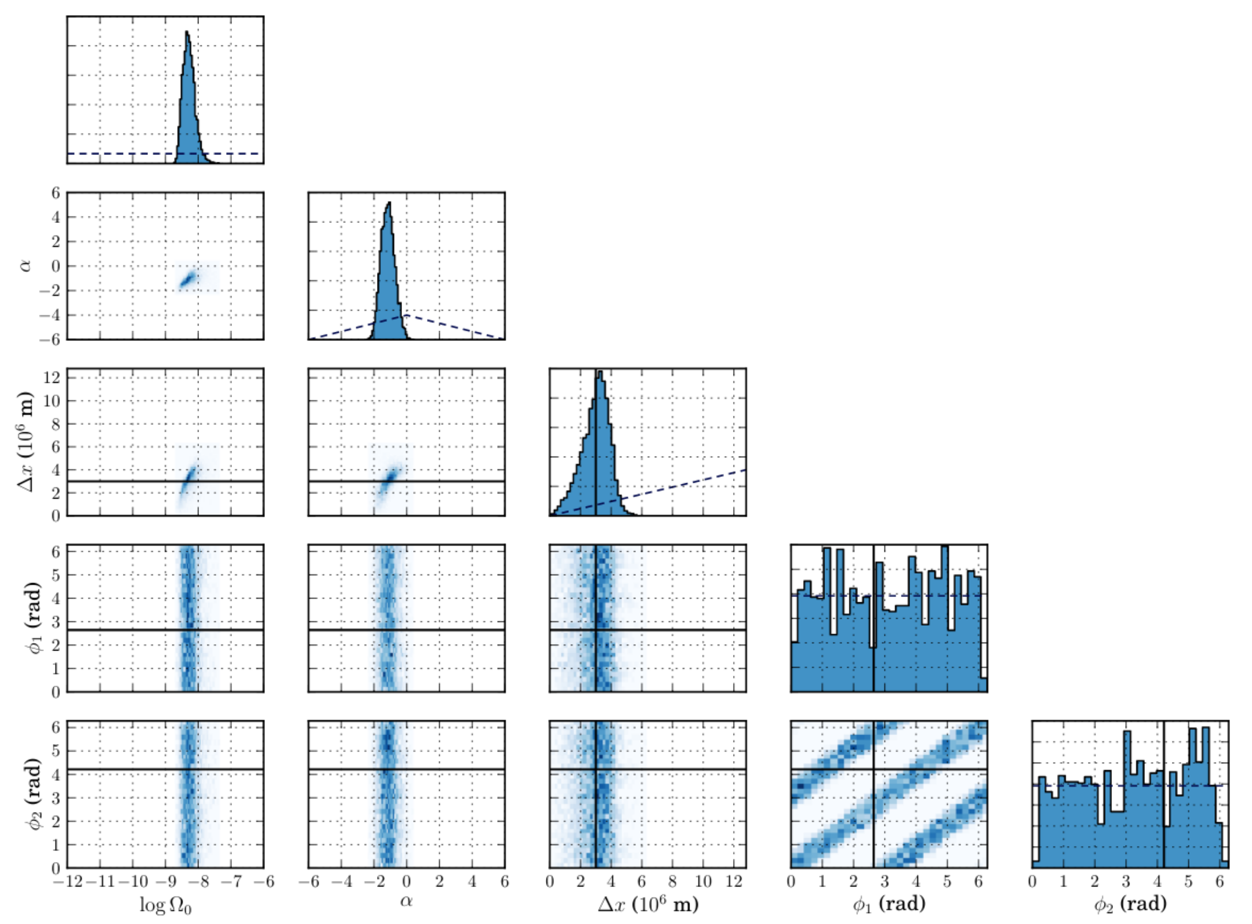

Astrophysical Journal Letters, 869(2), [L28] (2018)

# GW geodesy




Astrophysical Journal Letters, 869(2), [L28] (2018)

# GW geodesy




Astrophysical Journal Letters, 869(2), [L28] (2018)

# GW geodesy

- New extensions:
  - Define a "False Alarm Rate"
  - Extend framework to directional searches
  - Include Virgo (KAGRA)