CERN Theory department retreat: Profile and research interests summary

Mauro Pieroni

Conseil européen pour la recherche nucléaire (CERN)

mauro.pieroni@cern.ch

November 8, 2022

Education

- 2010 - 2013: **M.Sc. in Theoretical Physics**, Università degli Studi di Pisa.
- 2007 - 2010: **B.Sc. in Physics**, Università degli Studi di Pisa.

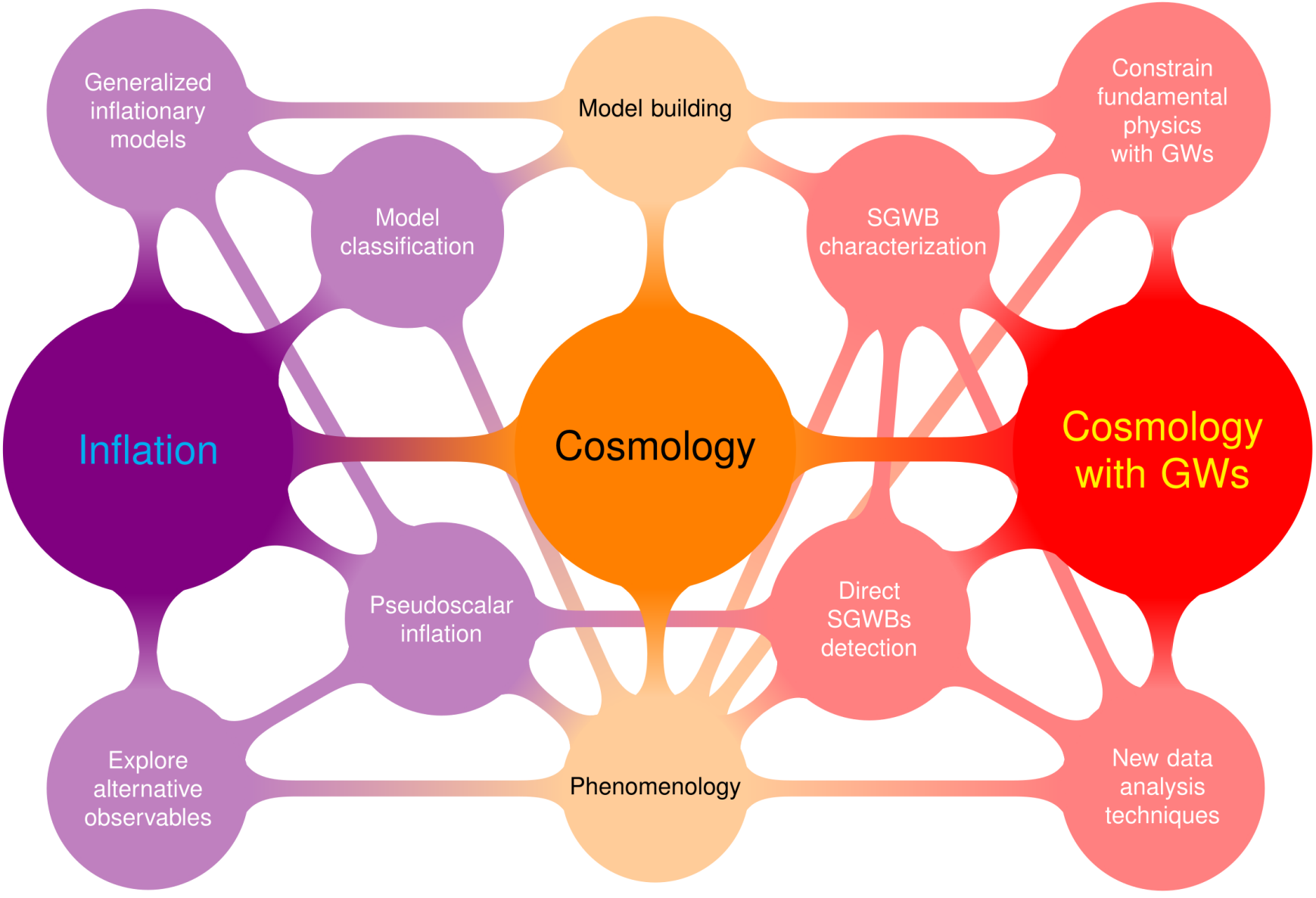
- 2013 - 2016: **Ph.D.**, Université Paris Diderot (APC/PCCP laboratory).
- Advisor: Prof. Pierre Binétruy.

Previous postdoctoral positions

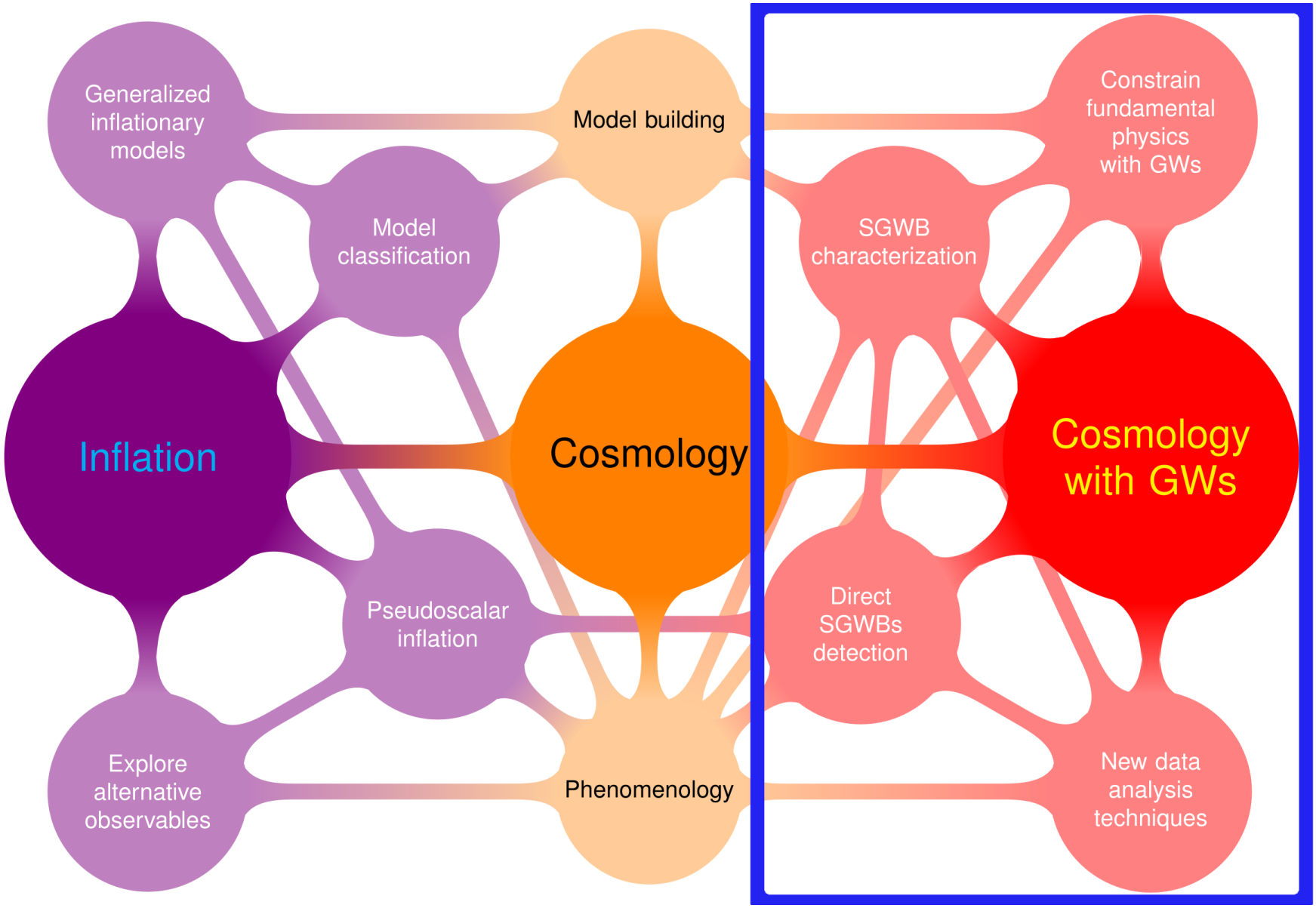
- 09/2017 - 08/2019:
  - Instituto de Física Teórica
  and
  Universidad Autonoma de Madrid
  Madrid, Spain.

- 10/2019 - 09/2022:
  - Imperial College London,
  London, UK.

Research interests



Cosmology with GWs



Involvement in large collaborations

Laser Interferometer Space Antenna (LISA)

- Full LISA consortium member involving $\sim$ 1400 international scientists
- Member of the LISA COSWG
- Member of the LISA Data Challenge
- Active participation in the LISA COSWG:
  - 6 official papers (3 coordinated)
  - 2 unofficial
  - several ongoing projects
- Organization of the 6th LISA COSWG Workshop, Madrid, January 2019
- Development of code: instrument modeling (response/noise) + data simulation + data analysis

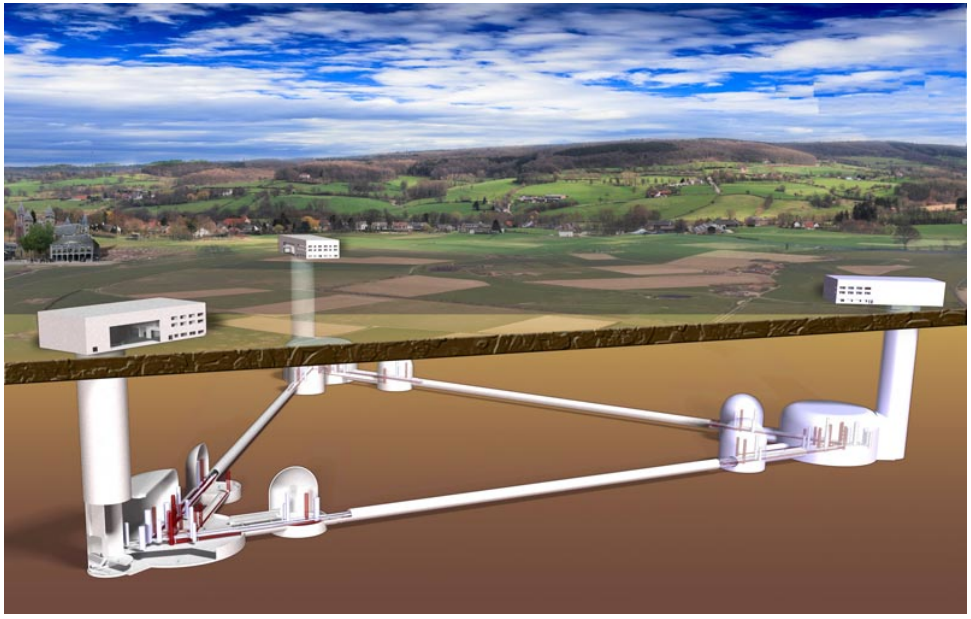
Einstein Telescope (ET)

- Invited joined ET Observational Science Board (OSB)
- Contributing to ET Cost Benefits Analysis (COBA)

Few details on LISA and ET

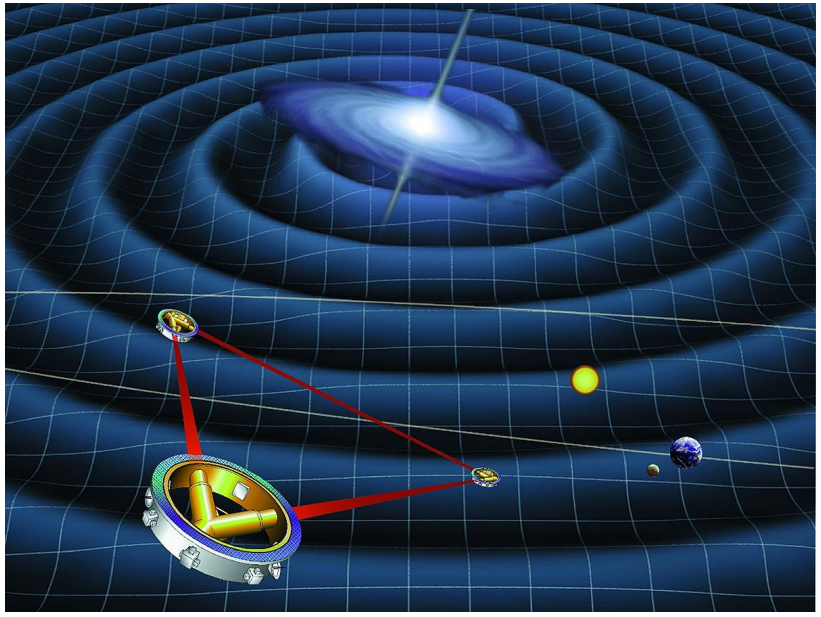
ET

- Next generation Earth-based detector
- 10 km arm lengths
- Peak sensitivity $10 \div 10^3$Hz
- Beginning of construction $\sim$ 2026
- Beginning of operation $\sim$ 2035



LISA

- First interferometer in space
- 2.5 million km arm lengths
- Peak sensitivity $10^{-2} \div 10^{-3}$Hz
- Expected launch in 2034
- Operating for 4yrs (nominal)



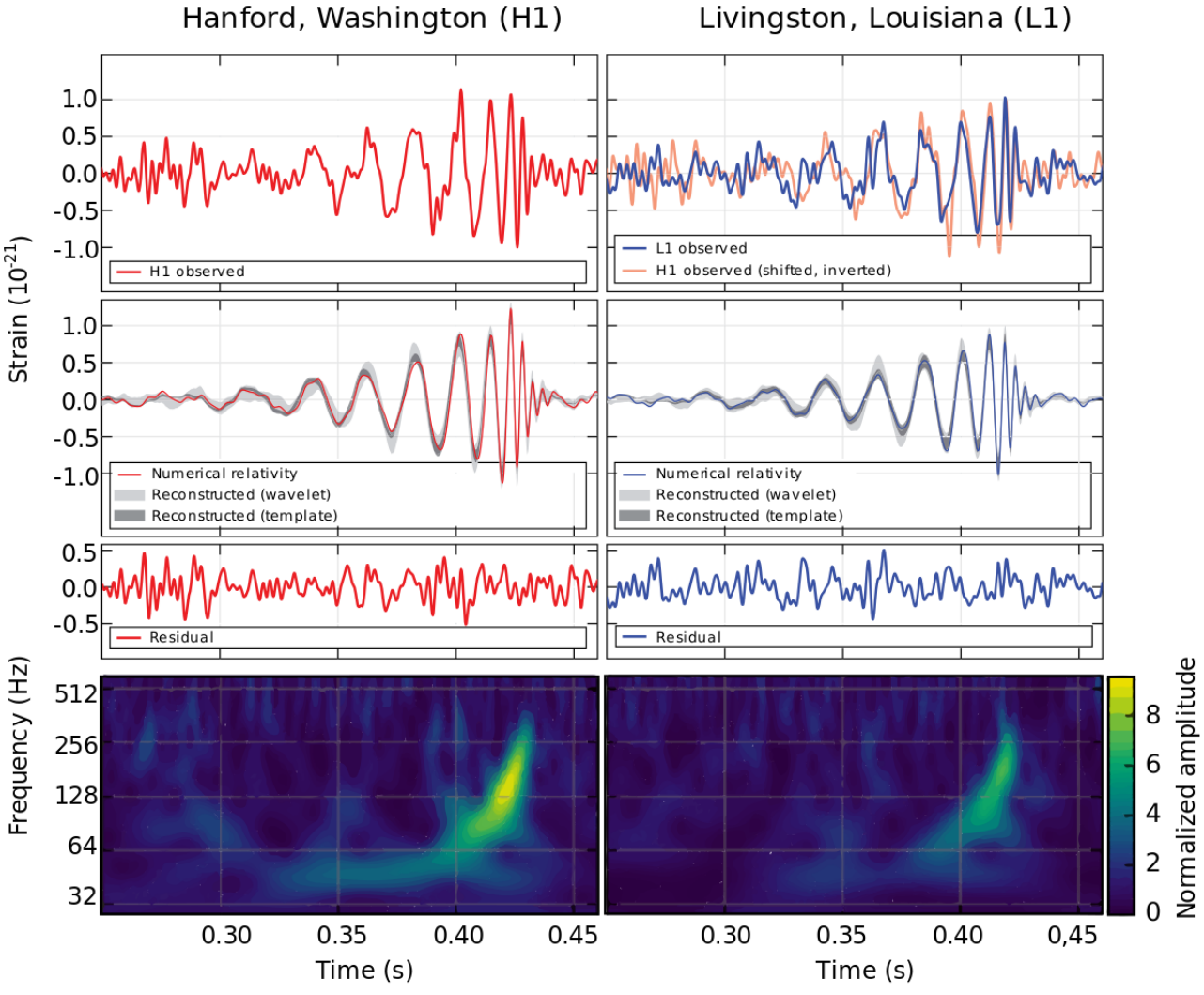
Individual (and possibly resolvable) sources

Signals having a predictable morphology in time and frequency

Loud sources can be seen individually (like LIGO/Virgo do)

Choose your favourite th (GR or something beyond) and reconstruct the parameters

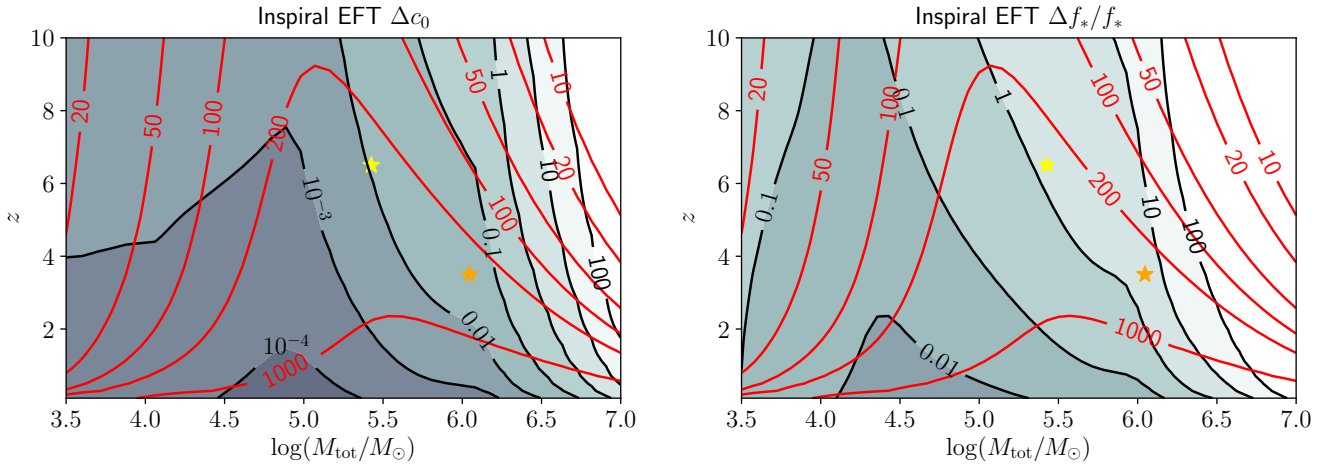
Combine single events to constrain the population parameters (or your favourite cosmological model)



Some results from recent papers

- Constrain modified GW propagation with LISA (+ LIGO/Virgo)

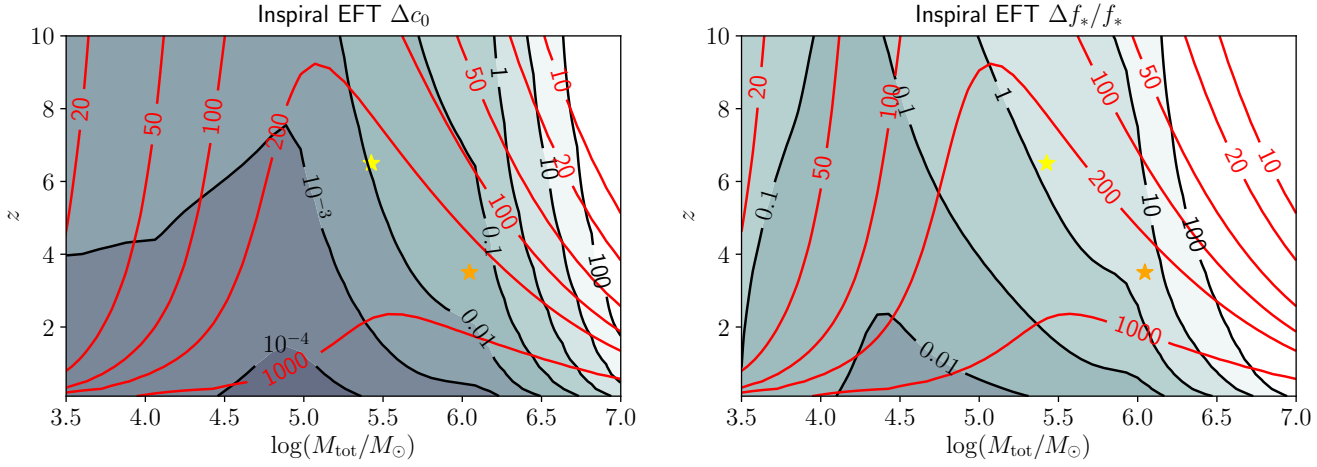
LISA Cosmology Working Group, JCAP 08 (2022) 08, 031. ArXiv: 2203.00566.



Some results from recent papers

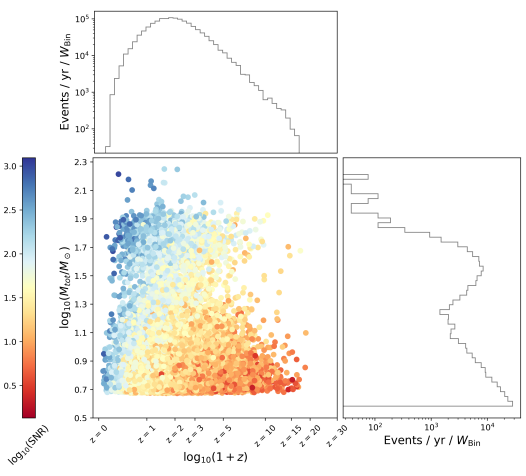
- Constrain modified GW propagation with LISA (+ LIGO/Virgo)

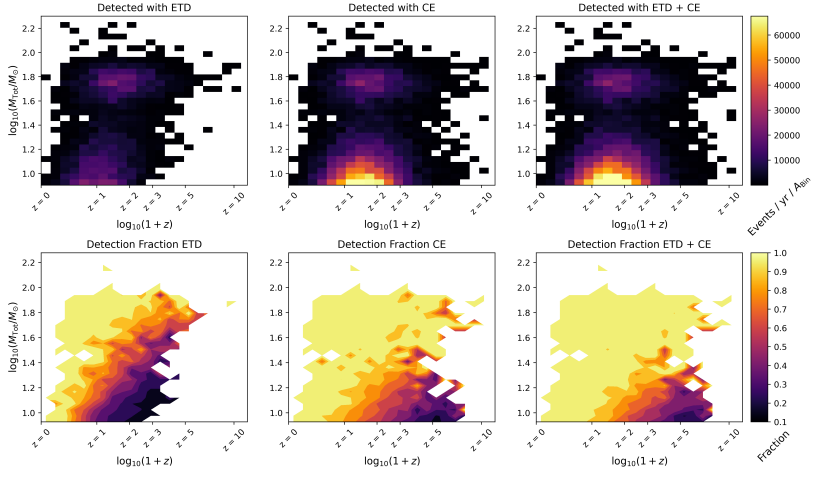
LISA Cosmology Working Group, JCAP 08 (2022) 08, 031. ArXiv: 2203.00566.



- Forecasts how well future Earth-based detectors will see BH populations

M. P., A. Ricciardone, E. Barausse, ArXiv: 2203.12586

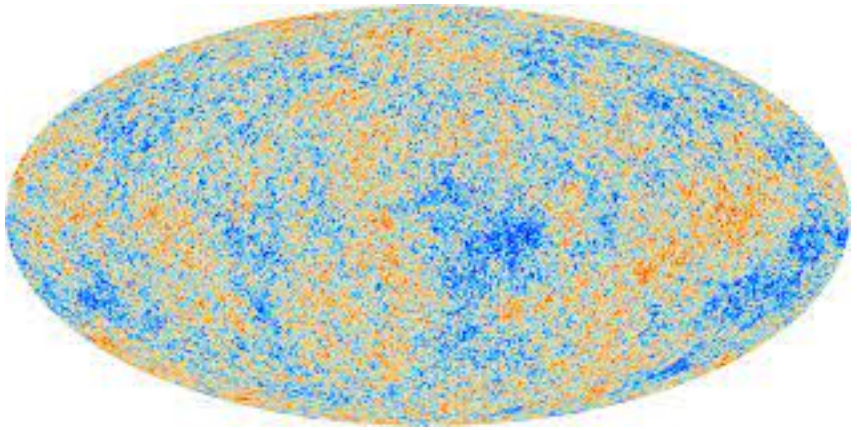




SGWBs characterization

SGWBs are:

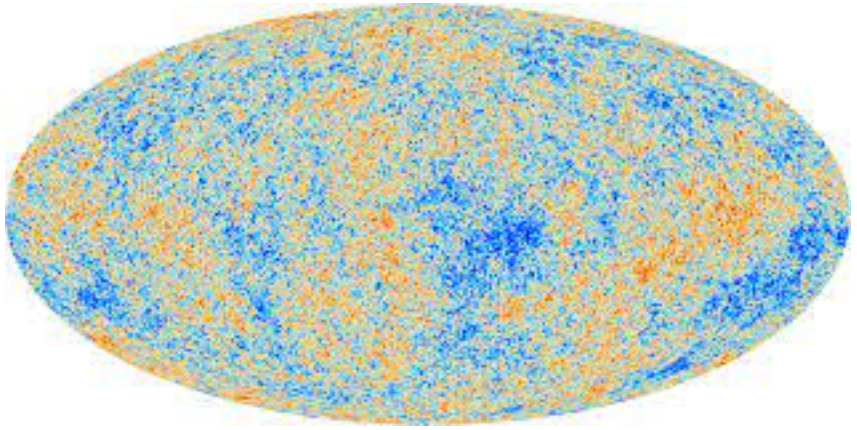
- Stochastic signals from the whole sky
- Either cosmological or astrophysical origin
- Invaluable source of information (HEP!)
- A target for all future detectors



SGWBs characterization

SGWBs are:

- Stochastic signals from the whole sky
- Either cosmological or astrophysical origin
- Invaluable source of information (HEP!)
- A target for all future detectors



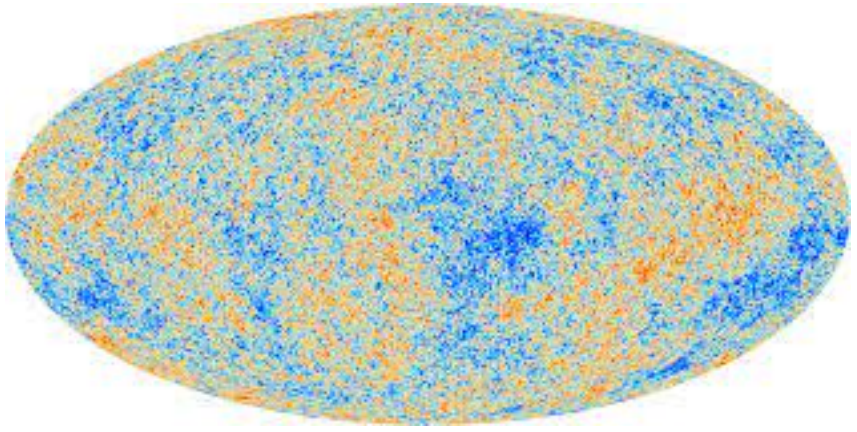
Few characteristics to classify SGWBs: $\longrightarrow$

- **Isotropy / Anisotropy**
- **Stationary / Non-stationary**
- **Polarized / Unpolarized**
- **Statistical properties**
- **Frequency shape**

SGWBs characterization

SGWBs are:

- Stochastic signals from the whole sky
- Either cosmological or astrophysical origin
- Invaluable source of information (HEP!)
- A target for all future detectors



Few characteristics to classify SGWBs: $\longrightarrow$

- **Isotropy / Anisotropy**
- **Stationary / Non-stationary**
- **Polarized / Unpolarized**
- **Statistical properties**
- **Frequency shape**

Two approaches for the spectral shape reconstruction:

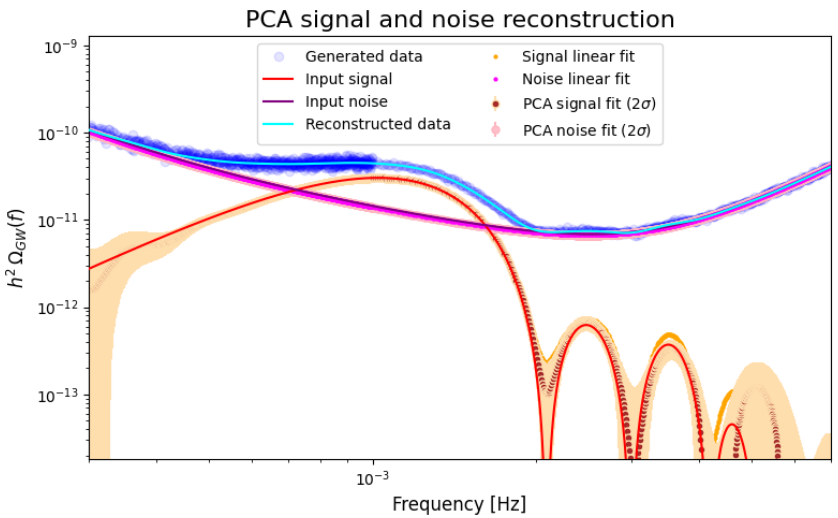
- Template searches
- Agnostic techniques

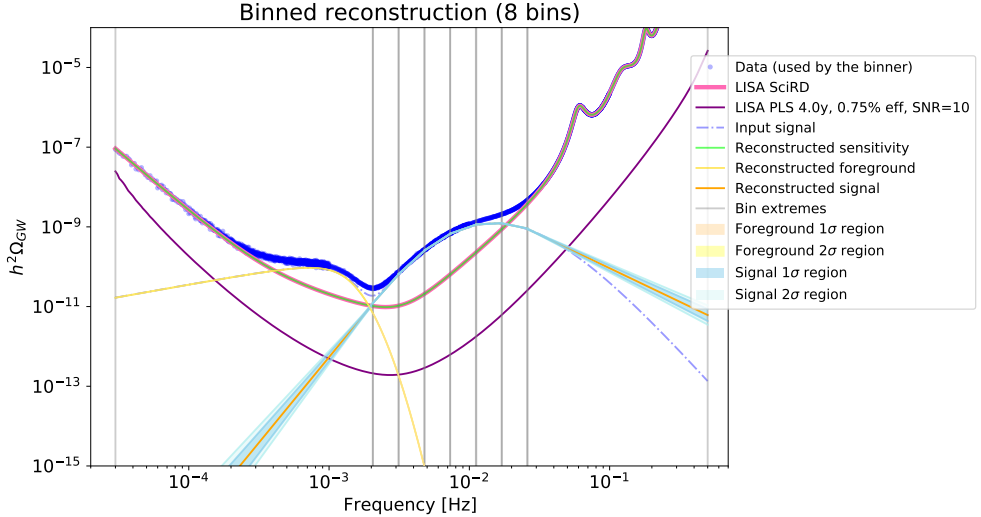
C. Caprini, D. G. Figueroa et al., JCAP 11 (2019) 017. ArXiv: 1906.09244. M. Pieroni, E. Barausse, JCAP 07 (2020) 021. ArXiv: 2004.01135. R. Flauger, N. Karnesis et al., JCAP 01 (2021) 059. ArXiv: 2009.11845.

Some forecasts / examples of reconstruction

- An example of agnostic reconstruction (left) and of template search (right) with LISA:

J. Fumagalli, M. P., S. Renaux-Petel, L. T. Witkowski, JCAP 07 (2022) 07, 020. ArXiv: 2112.06903



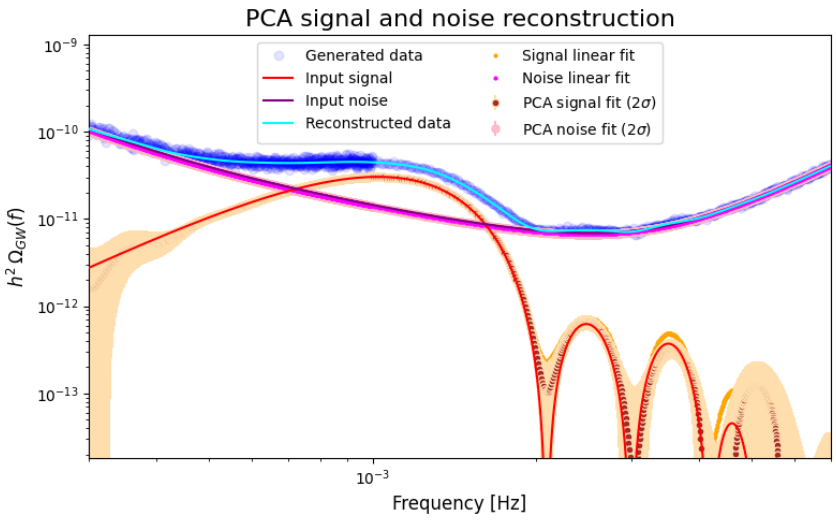


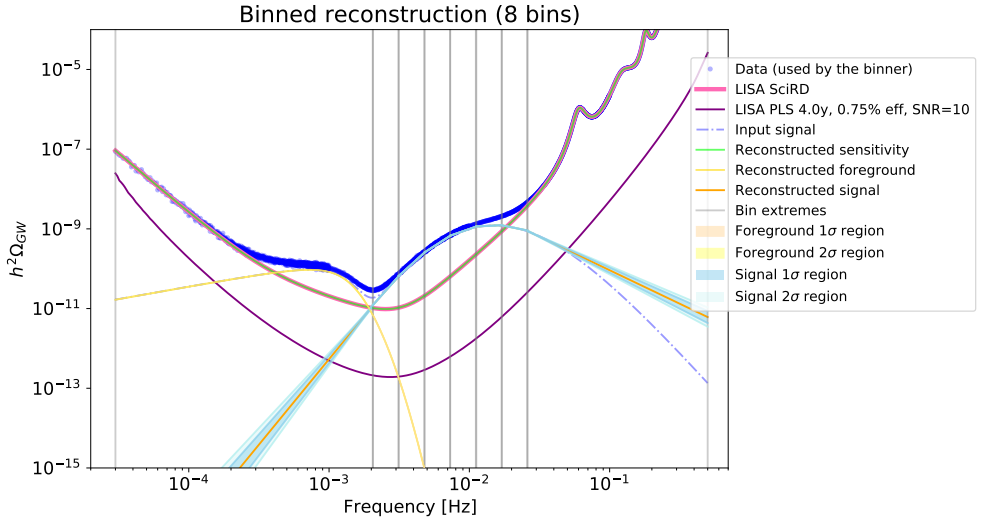
R. Flauger, N. Karnesis et al., JCAP 01 (2021) 059. ArXiv: 2009.11845.

Some forecasts / examples of reconstruction

- An example of agnostic reconstruction (left) and of template search (right) with LISA:

J. Fumagalli, M. P., S. Renaux-Petel, L. T. Witkowski, JCAP 07 (2022) 07, 020. ArXiv: 2112.06903

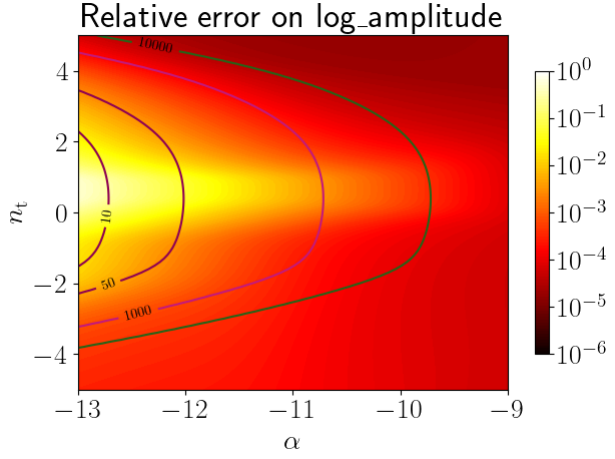


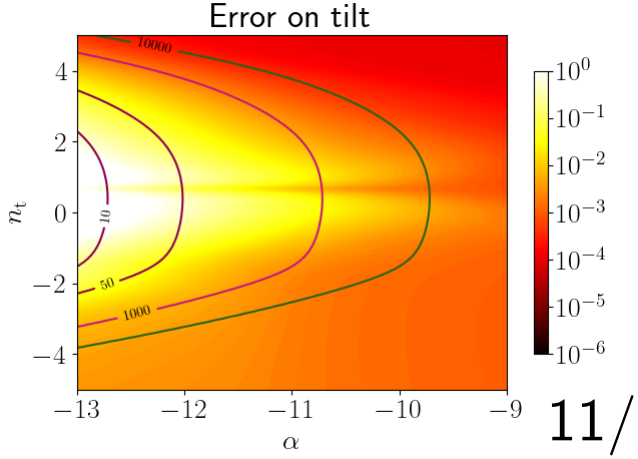


R. Flauger, N. Karnesis et al., JCAP 01 (2021) 059. ArXiv: 2009.11845.

- Forecast constraints on some models (LISA + foregrounds):

i. e. choose your signal (e. g. a power law) $\Omega_{\rm GW}h^2 = 10^{\alpha}(f/f_*)^{n_{\rm t}}$ and see how well you can reconstruct the parameters





Last slide

Thank you for your attention!