

Gravitational waves & the Einstein Telescope

DANIEL G. FIGUEROA



On behalf of
Instituto de Física Corpuscular

What is IFIC

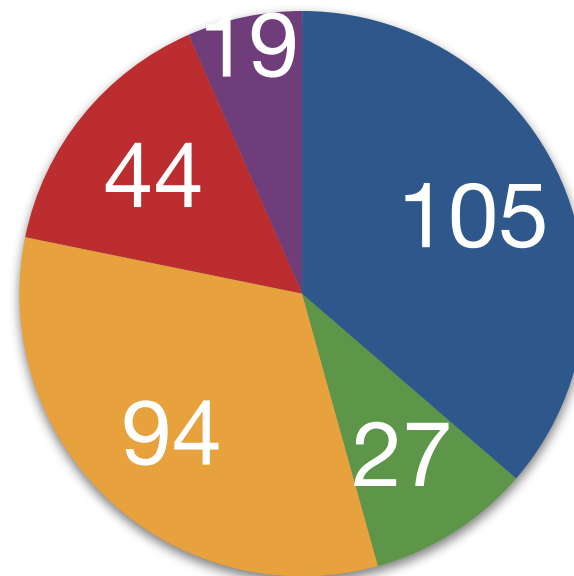


- The Instituto de Física Corpuscular (IFIC) is a **CSIC - U. Valencia joint research institute**
- It is dedicated to **theoretical and experimental research** in particle, astro-particle and nuclear physics, and its applications to both medical physics and other fields of science and technology
- IFIC singular infrastructures: computing center (CPUs, GPUs, disk storage), electronics laboratory, clean rooms for micro-electronics, mechanical workshop

IFIC in numbers

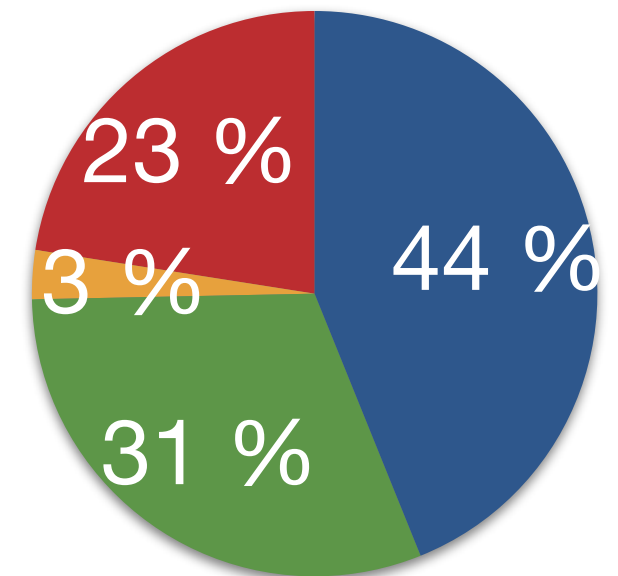
- **Personnel (2020): 289**
- **Annual Funding (2020): EUR 13.7M**
- **Scientific publications (2020): 421**
- **PhD theses (2020): 23**
- **Patent applications (2020): 2**

IFIC Personnel



- Scientific Staff
- Postdocs
- PhD students
- Engineers & Techs
- Administration

IFIC Annual Funding



- Regional
- National
- EU
- Other

IFIC, CSIC-UV
(Theory group)



**What do we do
related to GWs?**

IFIC, CSIC-UV
(Theory group)



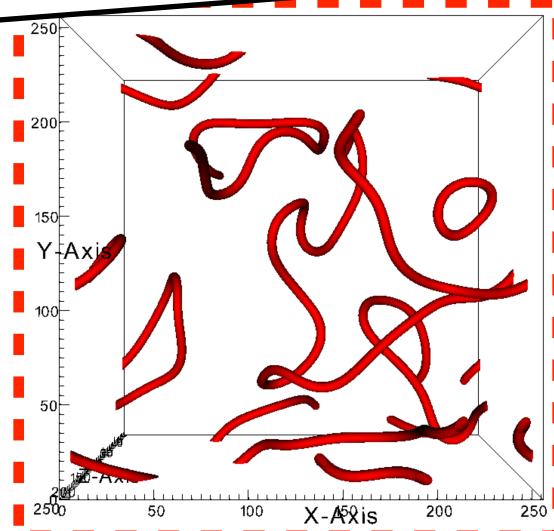
**What do we do
related to GWs?**

**GW backgrounds
Cosmology
Astro. Binaries**

IFIC, CSIC-UV
(Theory group)

**What do we do
related to GWs?**

Cosmic Strings

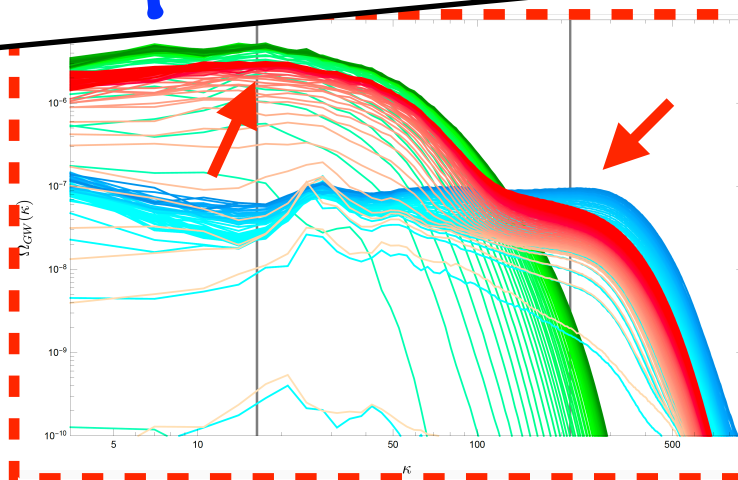


Field Th & Nambu-Goto
(Baeza, DGF, ...)

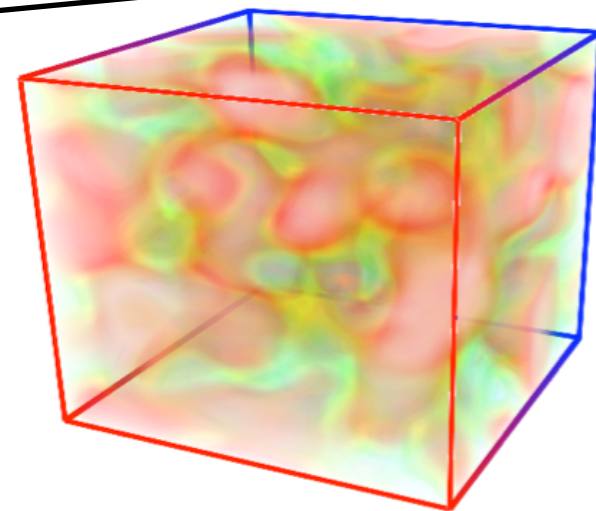
GW backgrounds
Cosmology
Astro. Binaries

Phase Transitions

(p)Reheating



Spectroscopy of particle couplings
(DGF, Loayza, ...)

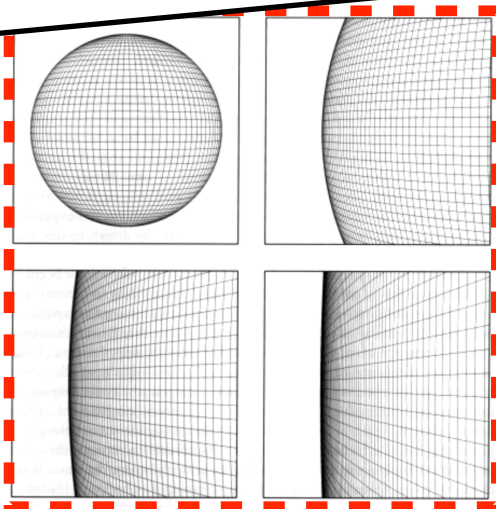


BSM Symm. Breaking
(DGF, Zaldivar, ...)

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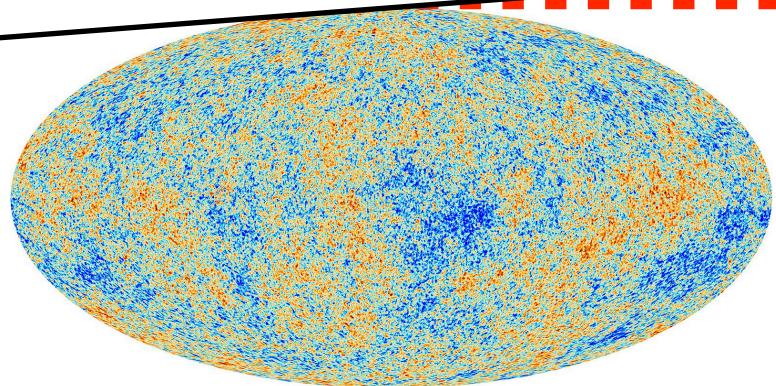
**What do we do
related to GWs?**

Inflation



Axion & PBH's
(DGF, Sanz, Zambujal, ...)

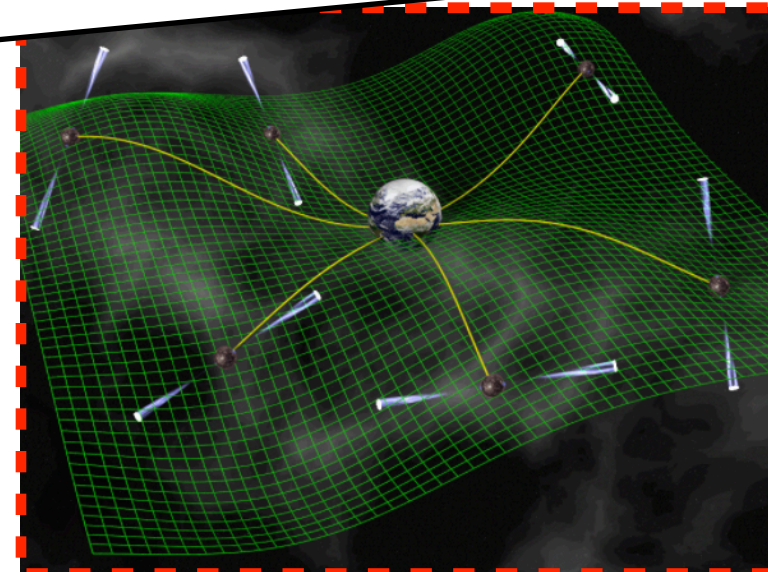
CMB & GWs



CMB and CMB+detectors
(DGF, Mena, Ruíz de Austri, ...)

GW backgrounds
Cosmology
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PTA & GWs

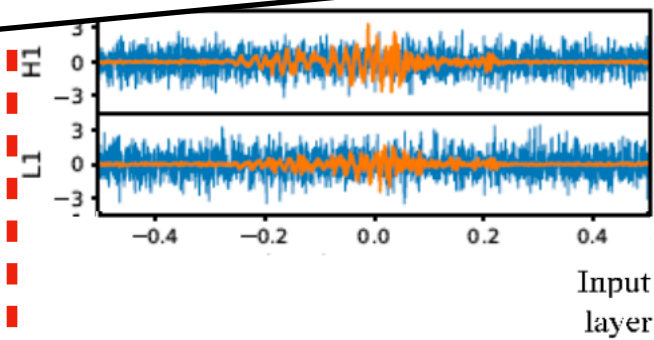


NanoGrav, SKA, others
(DGF, Gaggero, Mena, ...)

IFIC, CSIC-UV
(Theory group)

**What do we do
related to GWs?**

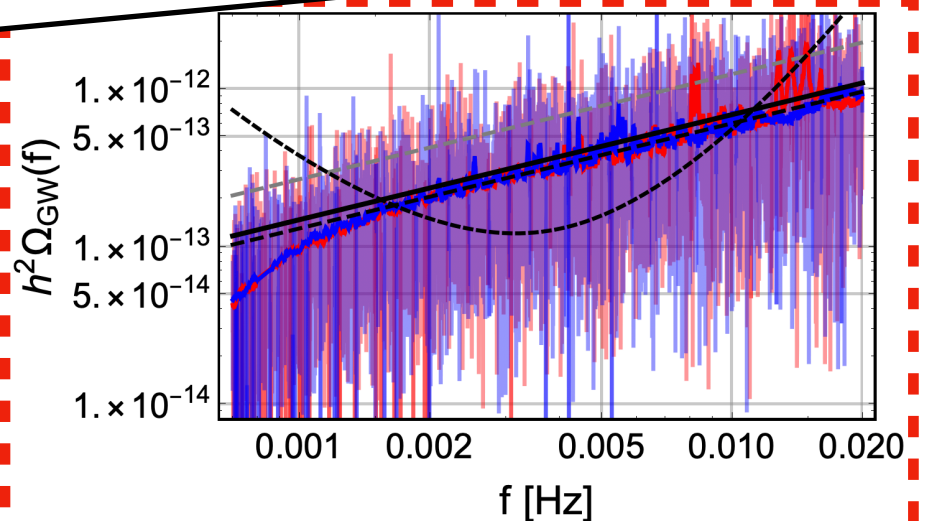
**Artificial Neural
Networks**



**Anomaly detection
with Deep learning**
(Ruíz de Austri, Zaldívar, ...)

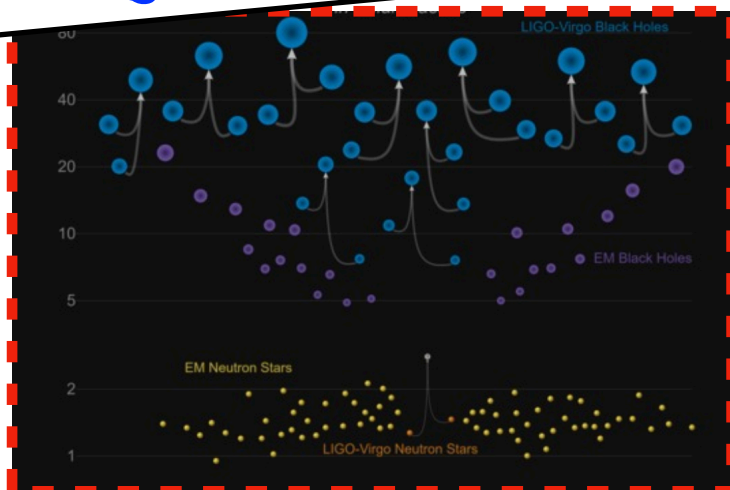
**GW backgrounds
Cosmology
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Unresolved Binaries



SGWB from unresolved binaries
(DGF, ...)

High-z mergers



PBH vs ABH discriminator
(Gaggero, ...)

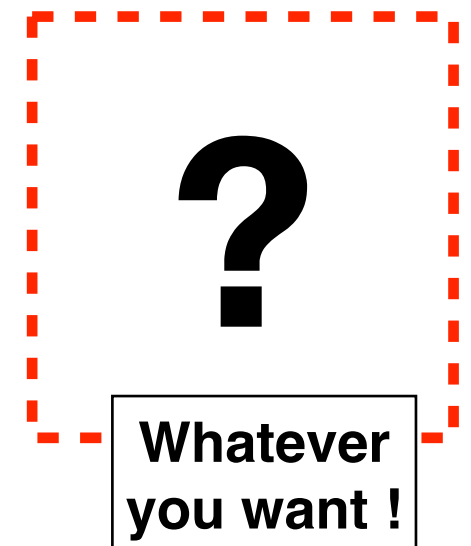
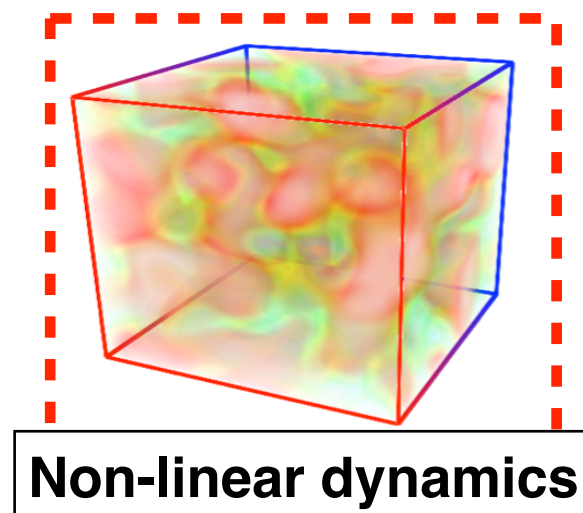
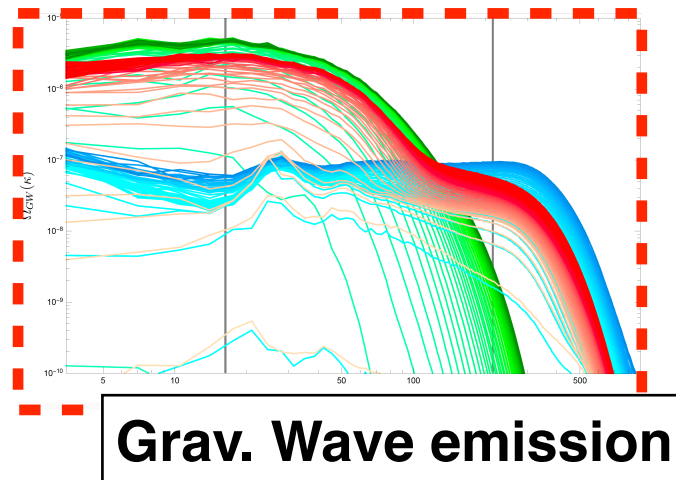
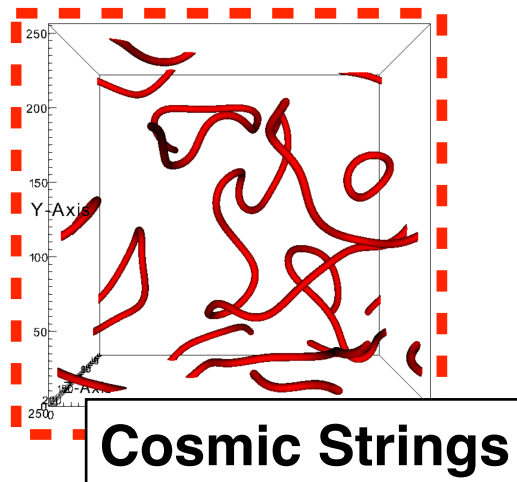
PROPAGANDA

For you early universe numerics ...

CosmoLattice

Figueroa, Florio, Torrenti, Valkenburg, [arXiv: 2102.01031](https://arxiv.org/abs/2102.01031)

('GW computation' module about to be available)



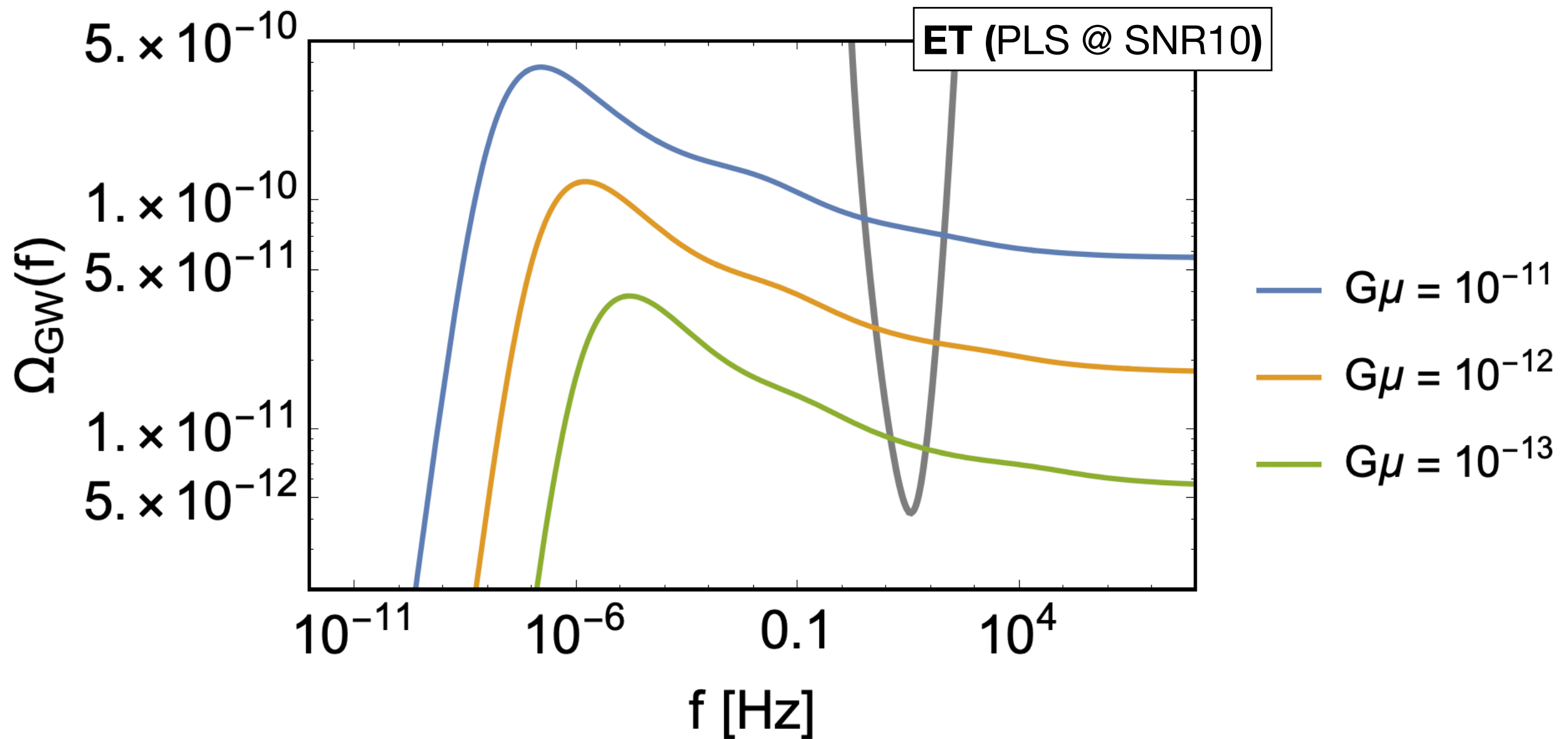
Detailed Cases

(Back slides)

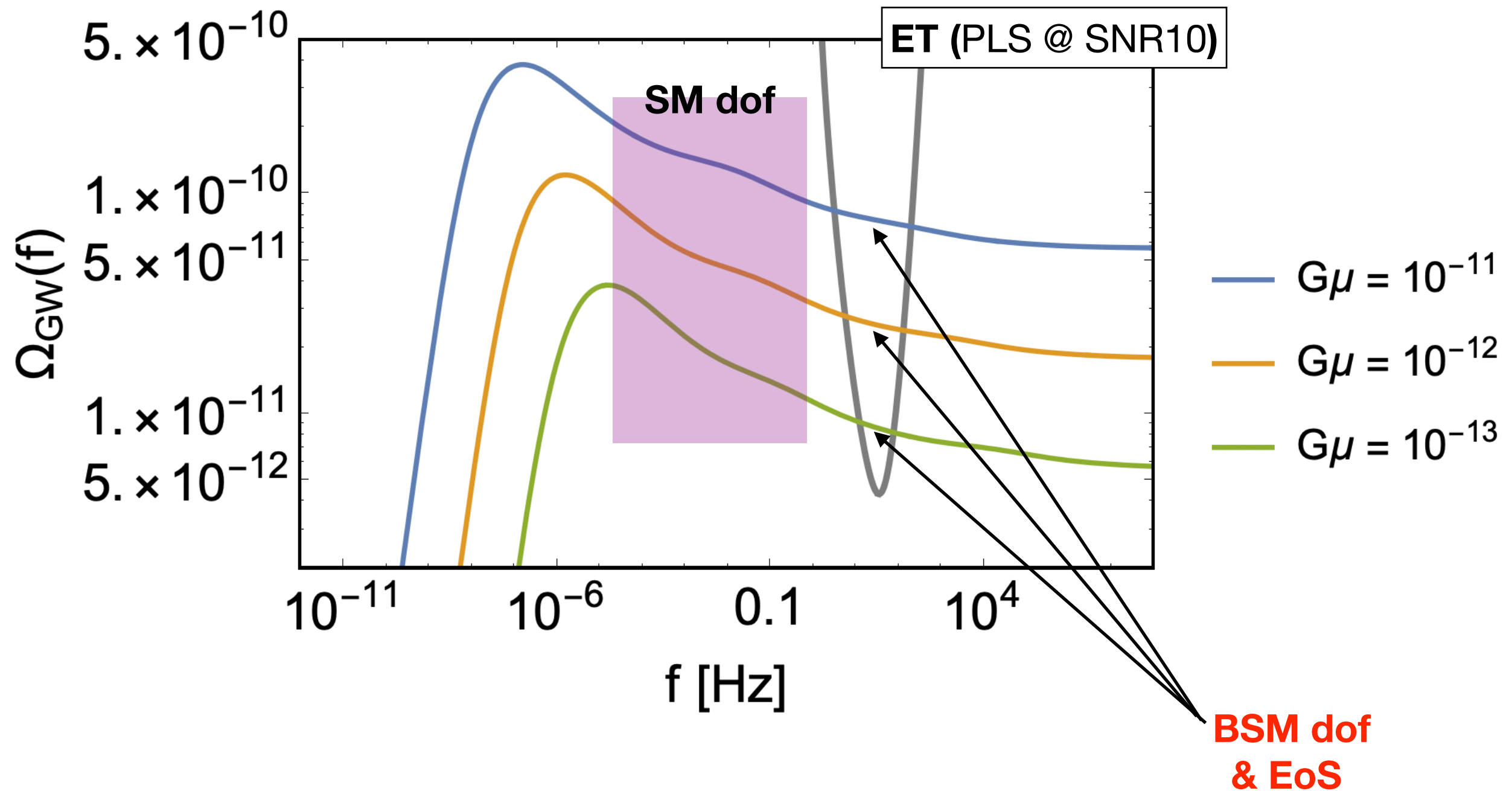
- * Cosmic Strings
- * Neural Networks
- * High- z mergers

GWs from Cosmic Strings (Nambu-Goto modeling)

Cosmic Strings (a la Nambu-Goto)

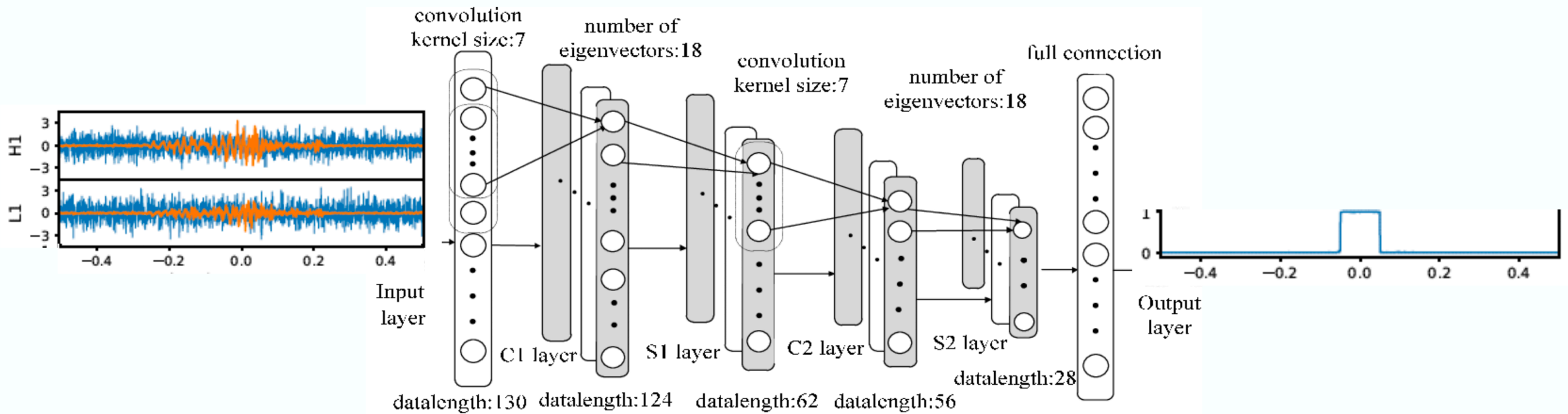


Cosmic Strings (a la Nambu-Goto)



GWs Detection with Artificial Neural Networks

Anomaly detection in time-series with Deep Learning



Supervised

- Data are labeled (signal and noise)
- 1D Convolutional Networks give impressive results: train on LIGO and Virgo O1 data and predict all events observed in O2

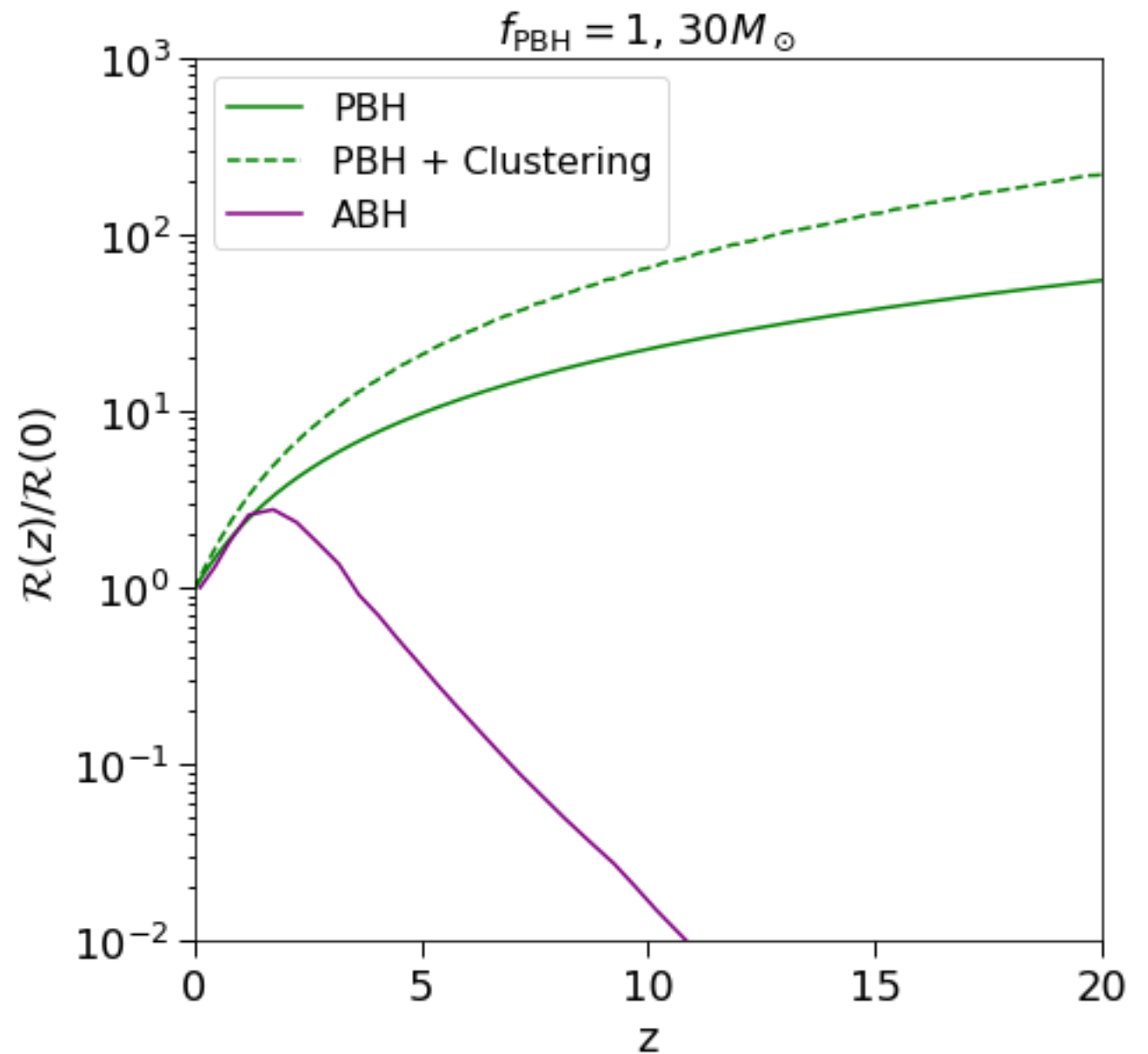
Unsupervised

- Source agnostic
- Train just on noise
- Signal leads to high scores compared to noise in the reconstruction (ie. autoencoders)
- Potential to find departures from GR

High-redshift merger rate

High-redshift merger rate

- **High-redshift merger events** may reveal the presence of a (possibly sub-dominant) population of **Primordial Black Holes**
- **Very different behavior** of the merger rate as a function of redshift for **Primordial** and **Astrophysical** Black Holes
- **Modeling Challenges:**
 - *Effect of clustering*
 - *Impact of different mass functions*
 - *Uncertainties in the astrophysical rate*



C. Fernández, P. Fleury, D. Gaggero,
B.J. Kavanagh, M. Martinelli, F.
Scarcella, *in preparation*