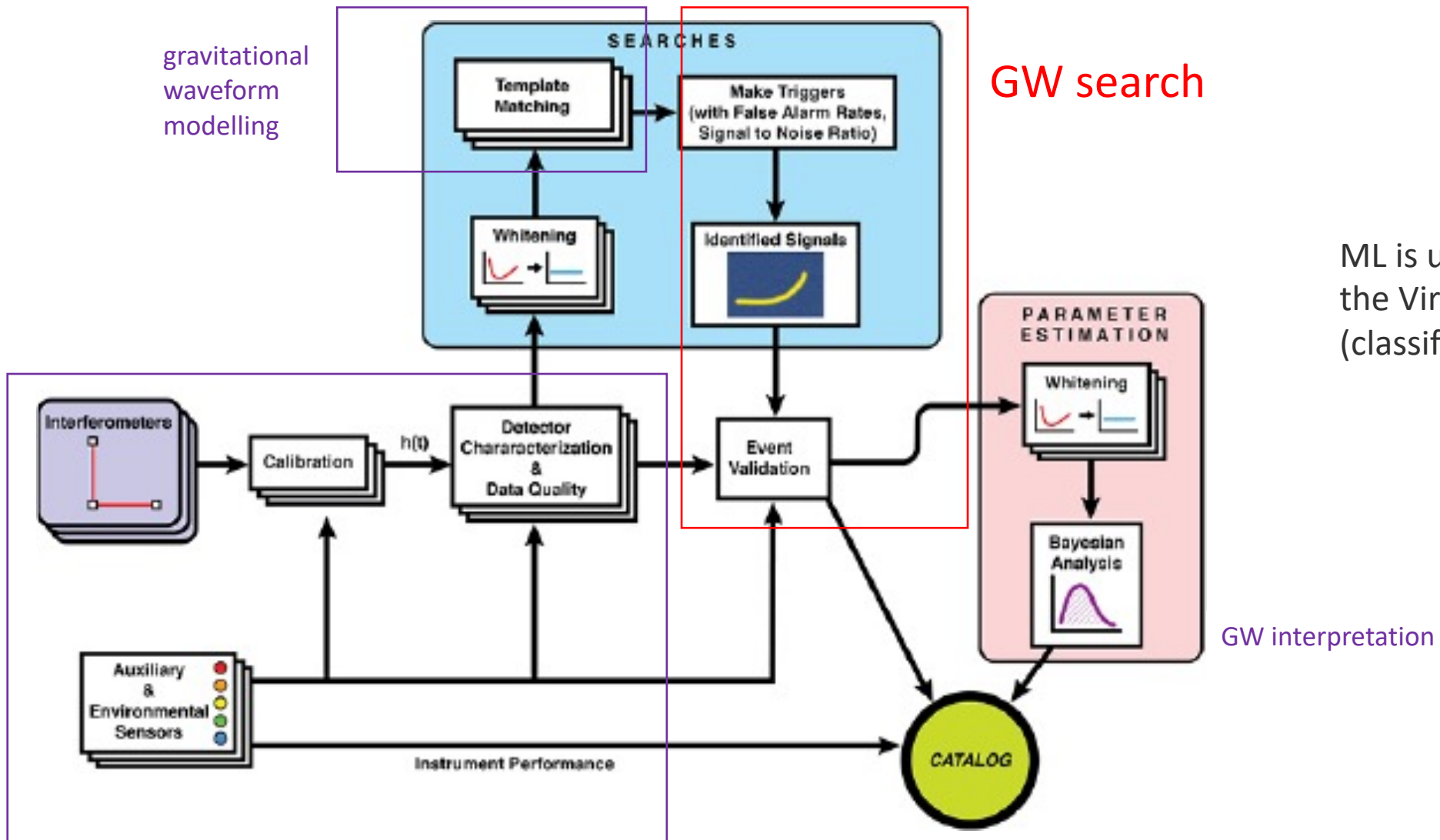


Deep Learning Algorithms for gravitational data analysis

M. Serra @ Virgo Rome Group

6-3-2023 - ML@INFN: machine learning activities at INFN Roma



ML is used in all the main steps of the Virgo/LIGO data pipelines (classification & regression)

algorithms for gravitational-wave data quality improvement – glitch classification

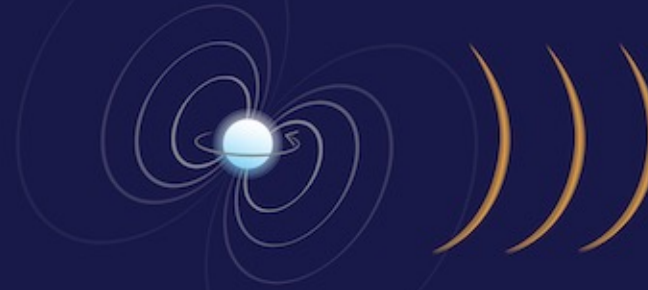
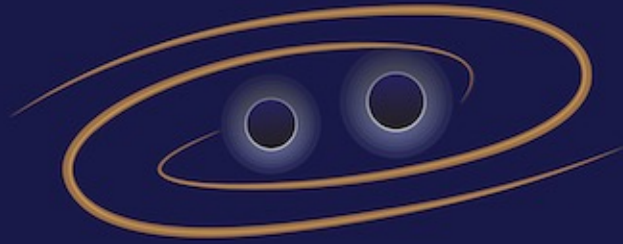
$T: ms \rightarrow s \rightarrow min$

$T: h \rightarrow d \rightarrow m \rightarrow y$

Short duration

Long duration

Modelled



compact binary coalescence



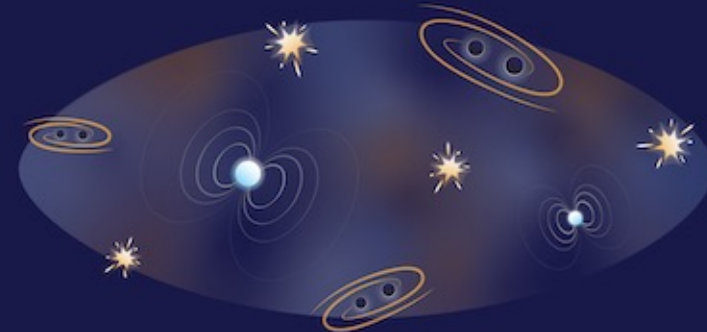
continuous



Unmodelled



burst



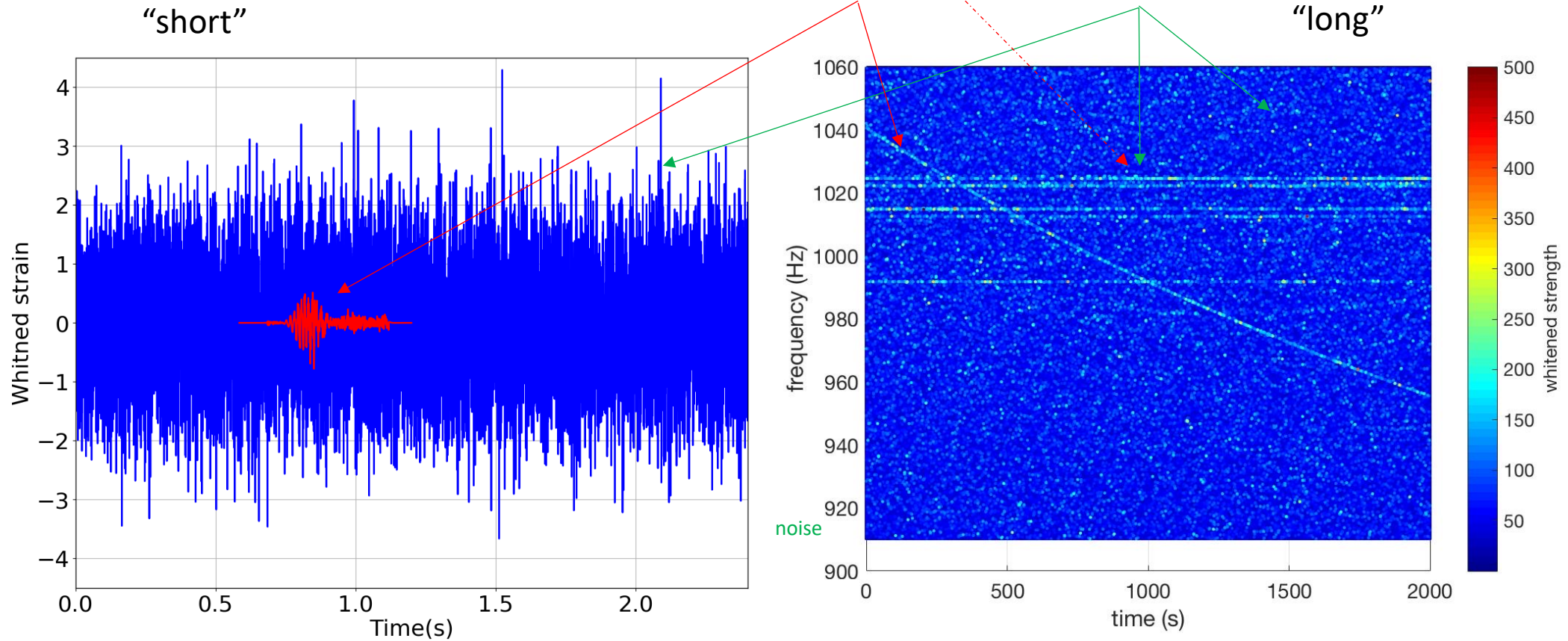
stochastic



coalescing binaries
BH/BH
BN/NS
NS/NS
(Roma)

spinning neutron stars, new born magnetar, boson clouds
(Roma)

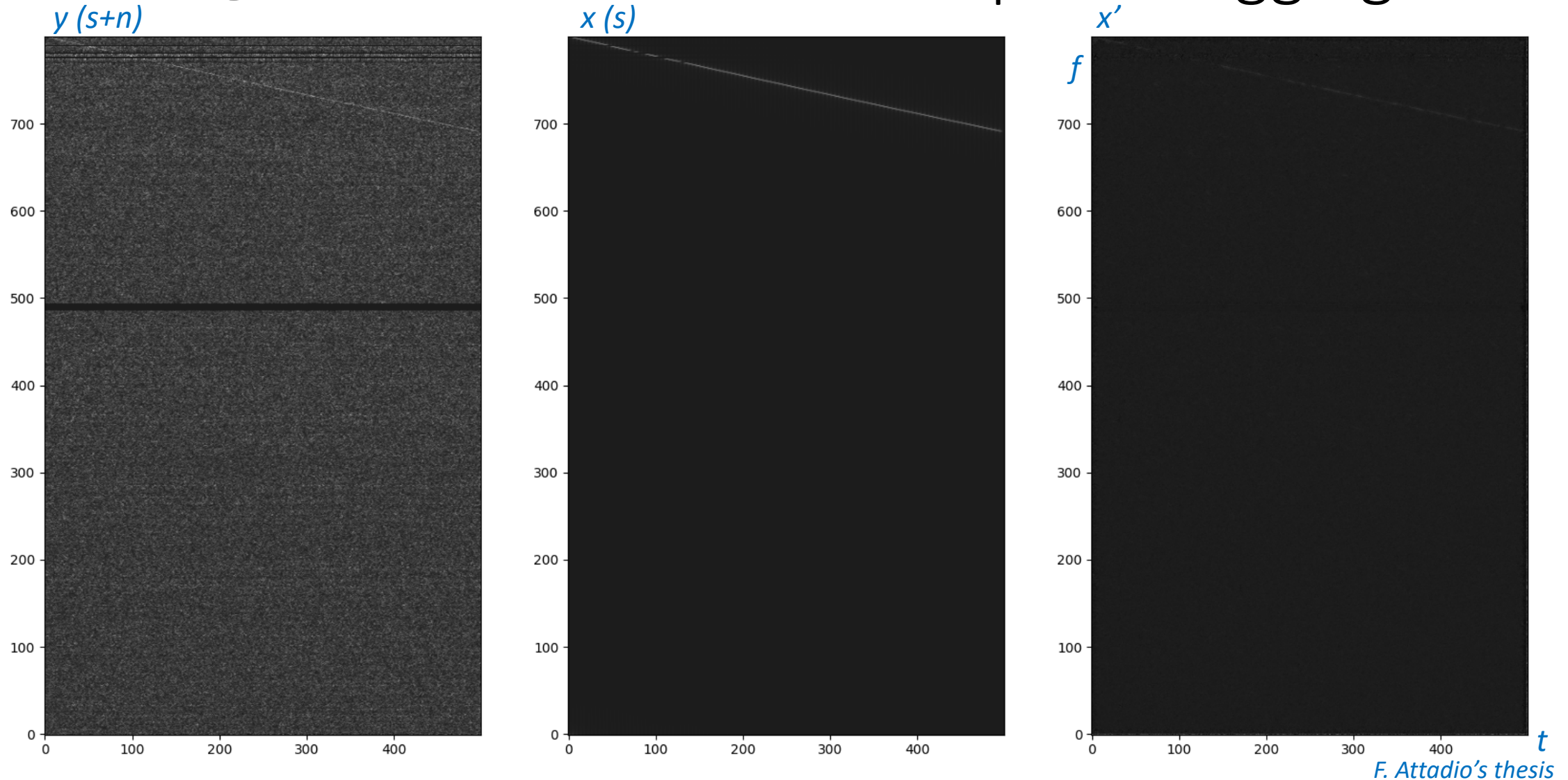
ML@GW – signal / noise



CNN 1D / 2D classifier:

- simulated/real noise vs simulated signal
- ML "faster"(!) respect to matched filter approach

ML@GW – denoiser → “to improve tagging”



Residual learning denoiser – DnCNN ([arXiv:1608.03981](https://arxiv.org/abs/1608.03981))

Residual learning formulation is adopted to train a residual mapping: $x \approx x' = y - R(y)$. $R(y)$ (\approx noise) is learnt

References (Rome Group)

- New method to observe gravitational waves emitted by core collapse supernovae (2018 - Phys. Rev. D **98**, 122002) ([CNN 2D classifier](#))
- How effective is machine learning to detect long transient gravitational waves from neutron stars in a real search? (2019 - Phys. Rev. D **100**, 062005) ([CNN 2D classifier](#))
- A Machine Learning-based Source Property Inference for Compact Binary Mergers (Deep Chatterjee *et al* 2020 *ApJ* **896** 54) ([Kneighbors classifier](#))
- Deep learning for core-collapse supernova detection (2021 – Phys. Rev. D **103**, 063011)) ([CNN 2D classifier](#))
- Search for gravitational-wave bursts in the third Advanced LIGO-Virgo run with coherent WaveBurst enhanced by Machine Learning (2022 - [arXiv:2210.01754](#)) ([decision-tree classifier](#))

- Enhancing gravitational-wave science with machine learning - *Mach. Learn.: Sci. Technol.* **2** (2021) 011002 (review)
- Gravitational Wave Data Analysis with Machine Learning (<https://iphysresearch.github.io/Survey4GWML/>)