Data science at EGO/Virgo. Exploring Machine Learning techniques.

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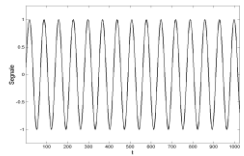
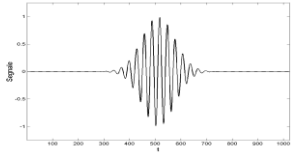
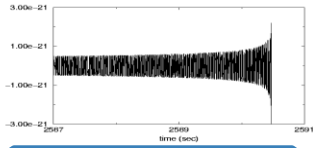
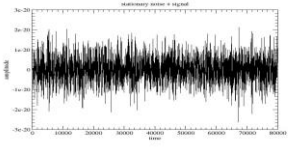
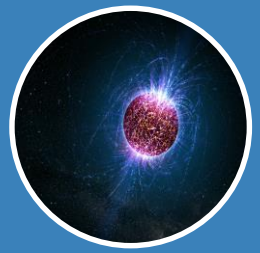
VIRGO

EGO EUROPEAN GRAVITATIONAL OBSERVATORY

Astrophysical Gravitational wave signals



Periodic signals

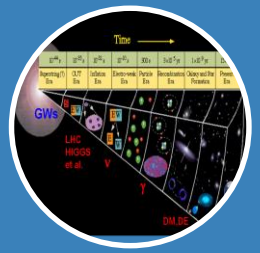
- Rotating Neutron Stars

Burst Signals

- Core Supernovae Collapse

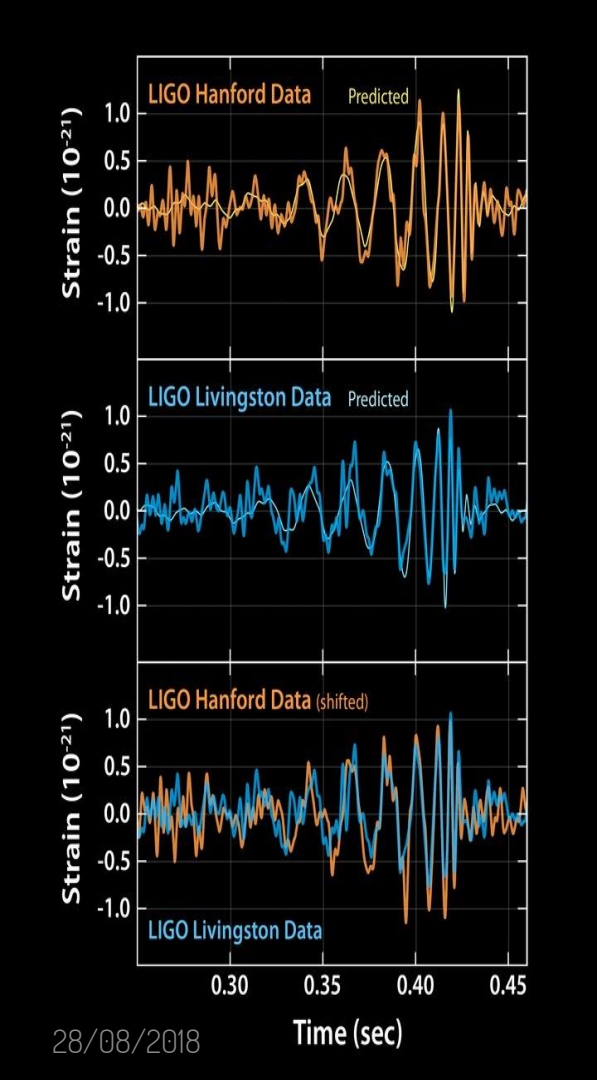
Chirp signals

- Compact binary coalescing

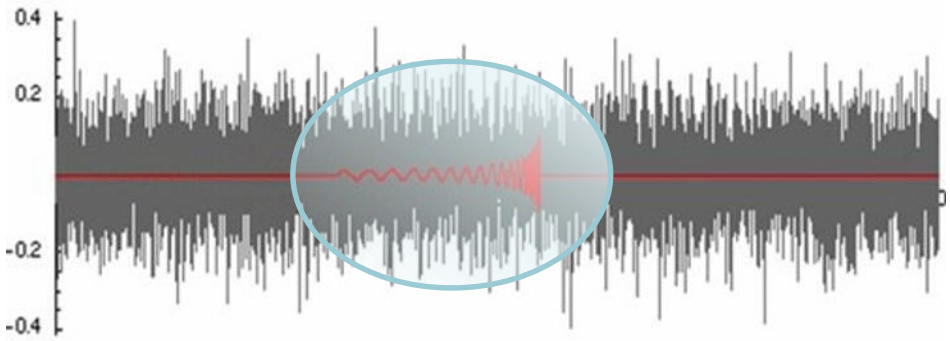


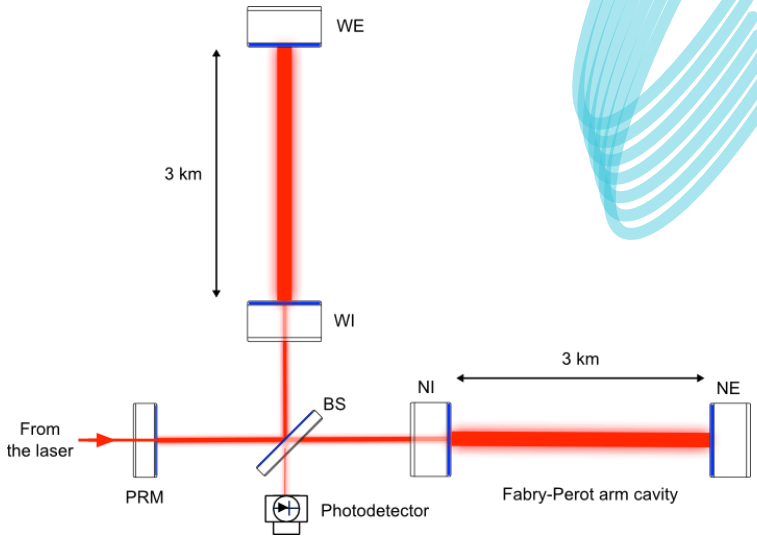
Broad band signals

- Cosmic GW background



Why Machine Learning in Gravitational Wave research





LIGO/Virgo data

are time series sequences… **noisy time series**
with low amplitude GW signal buried in

Our "signals"

Known GW signals

Compact coalescing binaries has known theoretical waveforms

Optimal filter: Matched filter

Too many templates to test

Unknown GW signals

Core collapse supernovae

No Optimal filter

Parameters estimation

Noise

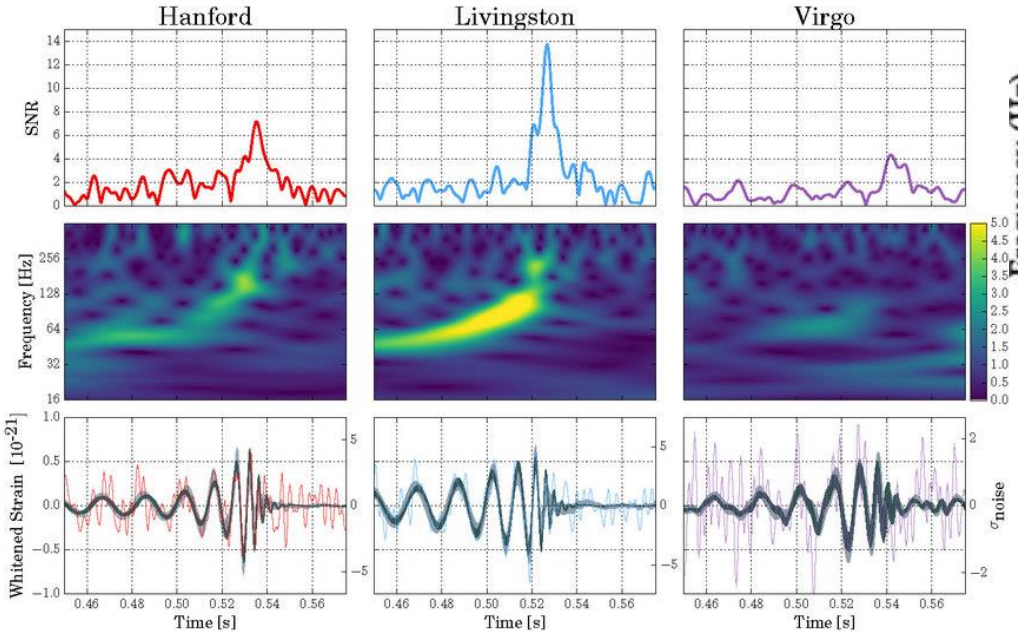
Moving lines

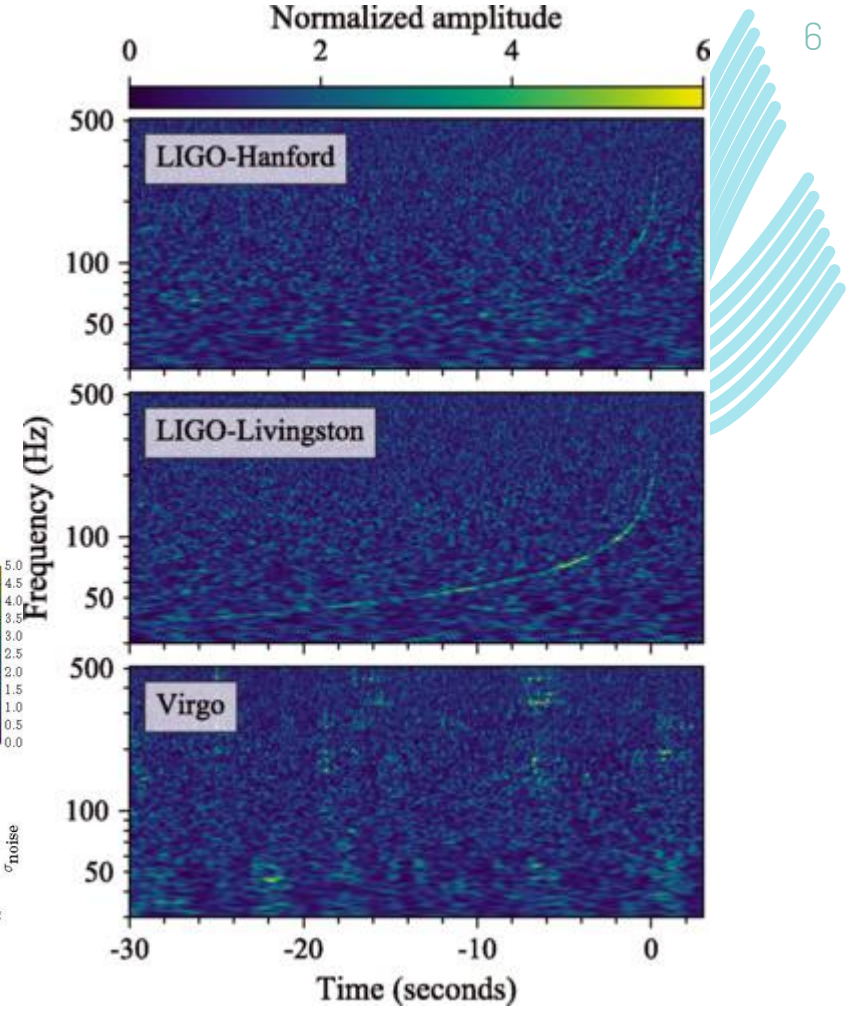
Broad band noise

Glitch noise

"Pattern recognition" by visual inspection

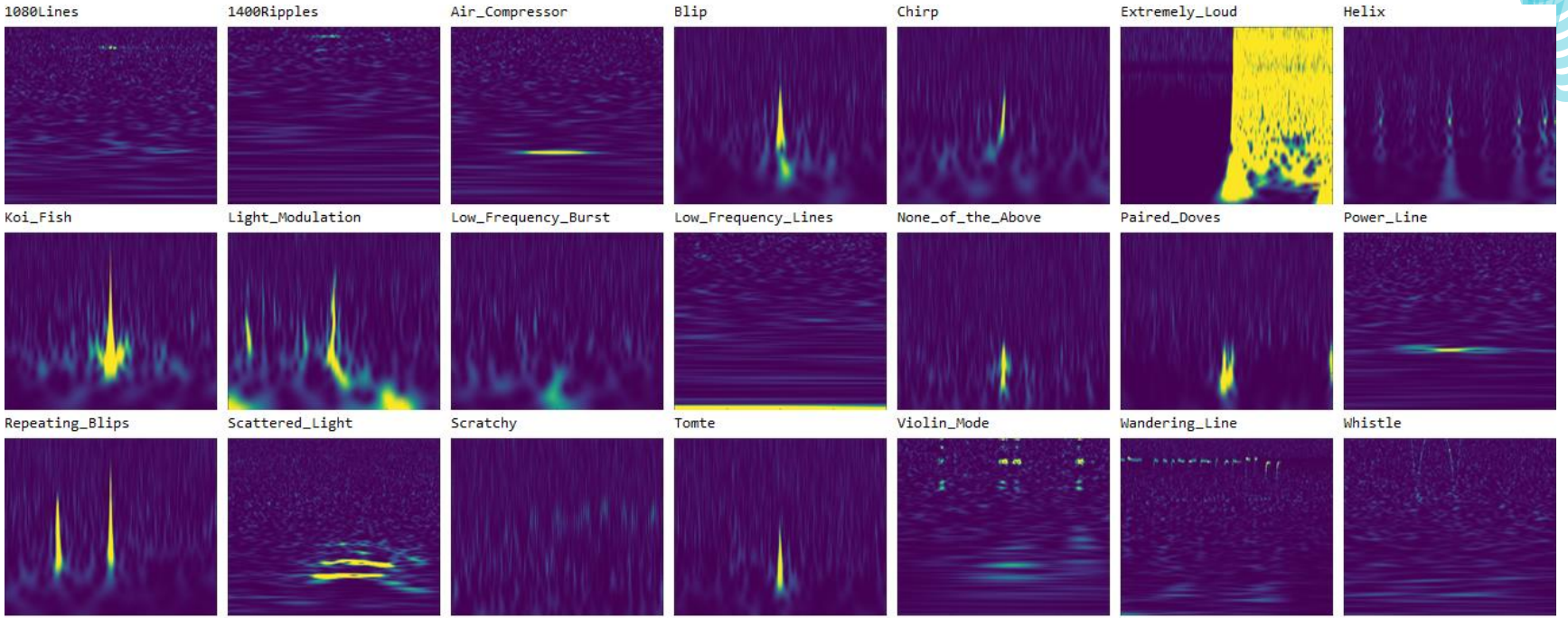
Example of GW signals



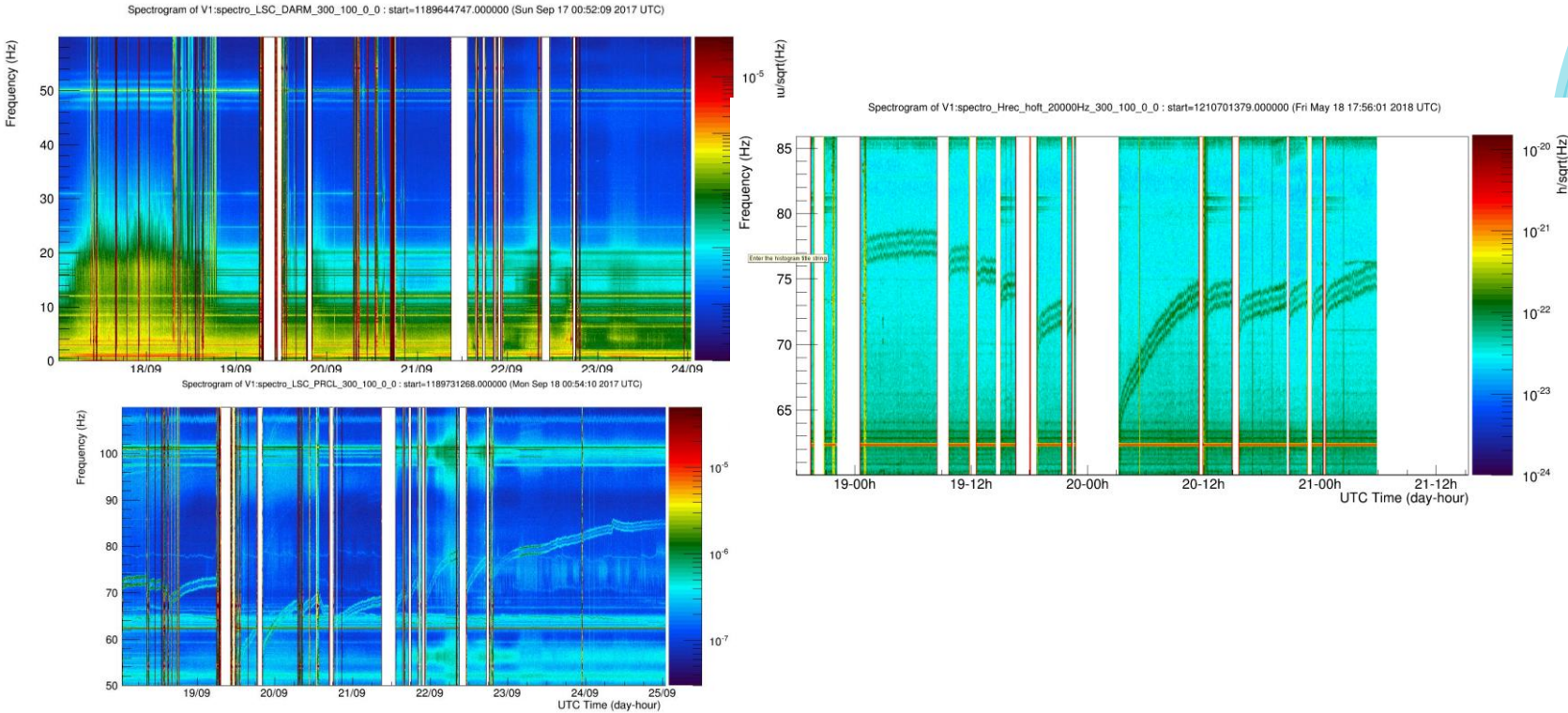


https://www.zooniverse.org/projects/zooniverse/gravity-spy

Example of Glitch signals



Example of other noise signals



I. Fiori courtesy

Numbers about data

Data Stream Flux	Data on disk	Number of events	Number of glitches
• 50MB/s	• 1-3PB	• 1/week • 1/day?	• 1/sec • 0.1/sec?

Should be analysed in less than 1min

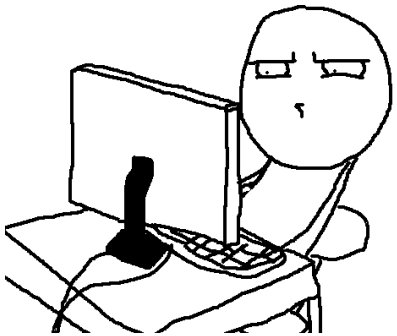
How Machine Learning can help

Data conditioning

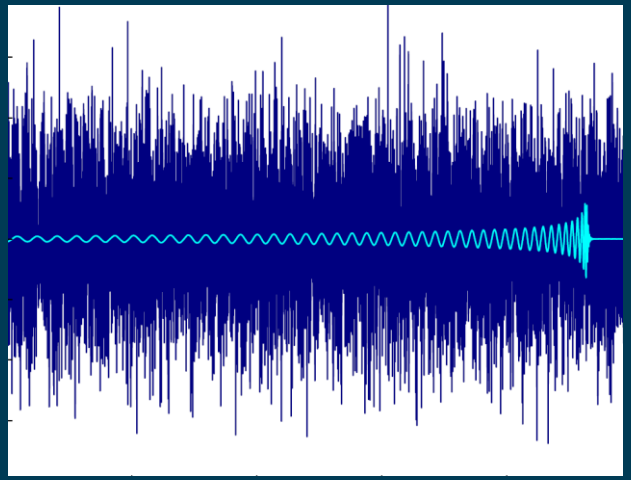
- Non linear noise coupling
- Use Neural Network to learn noise
- Use Neural Network to remove noise

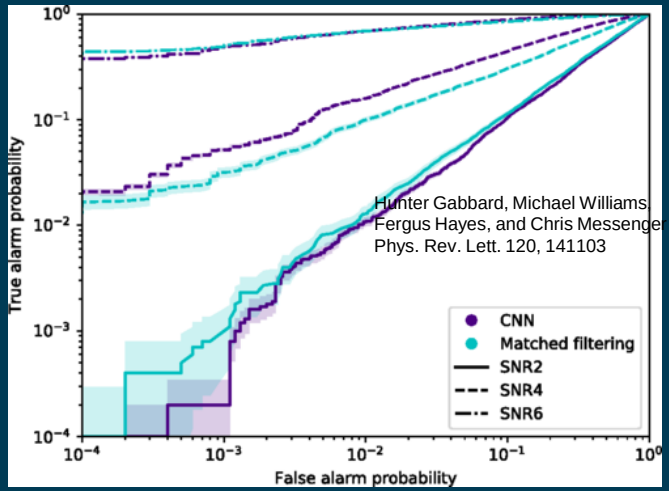
Signal Detection/Classification/PE

- A lot of fake signals due to noise
- Fast alert system
- Manage parameter estimation



Signal detection



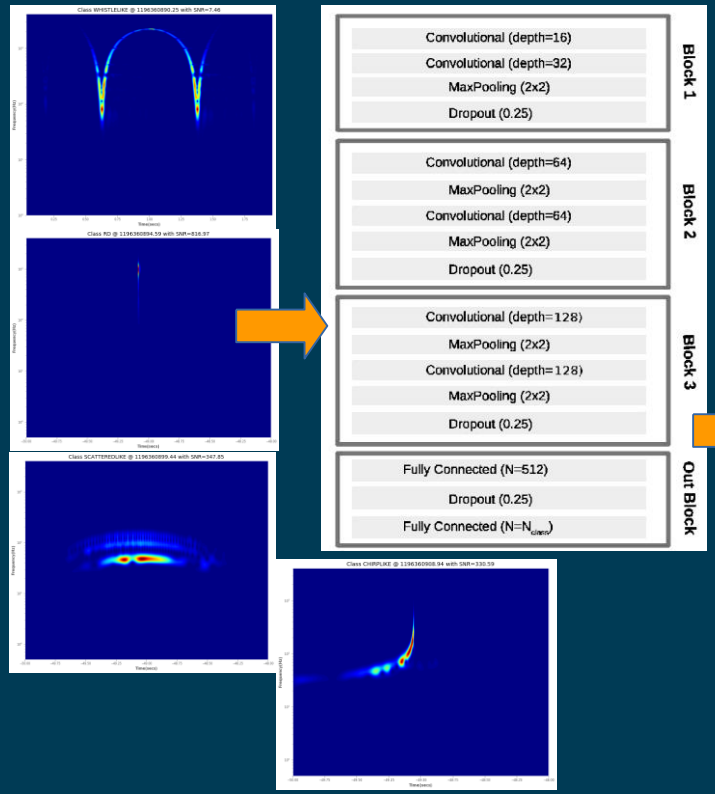


- Deep learning procedure requiring only the raw data time series as input with minimal signal pre-processing.
- Performance similar to Optimal Wiener Filter

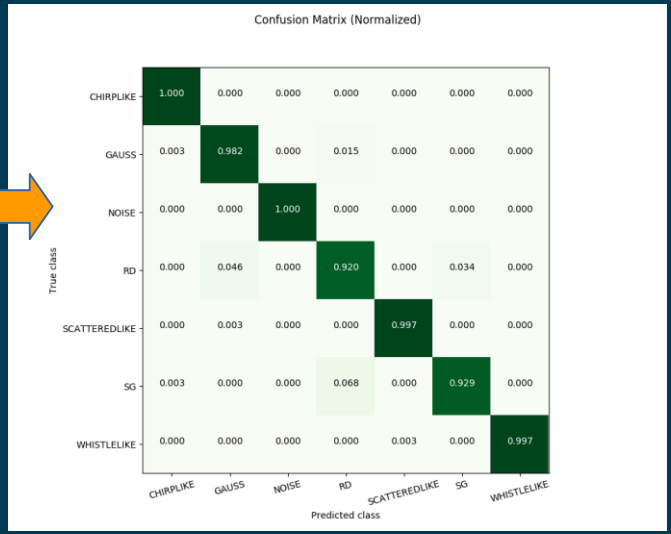
Glitch classification example

Massimiliano Razzano and Elena Cuoco

2018 Class. Quantum Grav. 35 095016



Deep learning with CNN



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CA COST Action CA17137

Parties

Action details

MoU	048/18
CSO Approval date	13/04/2018
Start of Action	18/10/2018
End of Action	17/10/2022

Participations

Country	Date	Status
Bosnia and Herzegovina	31/07/2018	Confirmed
Croatia	04/06/2018	Confirmed
France	02/05/2018	Confirmed
Greece	16/05/2018	Confirmed
Hungary	14/05/2018	Confirmed
Ireland	19/07/2018	Confirmed
Italy	09/05/2018	Confirmed
Malta	14/07/2018	Confirmed
Netherlands	06/07/2018	Confirmed
Poland	25/06/2018	Confirmed
Portugal	01/06/2018	Confirmed
Romania	25/06/2018	Confirmed
Serbia	13/07/2018	Confirmed
Spain	13/06/2018	Confirmed
United Kingdom	22/05/2018	Confirmed
Total: 15		

COST Association COST Action CA17137

- Description
- Parties
- Management Committee

General Information*

Proposer of the Action:
Dr Elena Cuoco

Science officer of the Action:
Dr Ralph STUEBNER

Administrative officer of the Action:
Ms Rose CRUZ SANTOS

Downloads*

Action Fact Sheet
Download AFS as .RTF

Memorandum of Understanding
Download MoU as PDF

Elena Cuoco

G2net: A network for Gravitational Waves, Geophysics and Machine Learning (COST Action 17137)

Main Proposer: E. Cuoco, EGO

EGO European Gravitational Observatory

G2net: goals of the ACTION