

# WG3 → Machine Learning for Advanced Control Techniques

*Luigia Petre and Andrea Chincarini*



# Who are we

- 23 members
  - Francesca Badaracco, Dr. Eng. Mateusz Bawaj, Dr. Valerio Boschi, Prof. Peter Butka, Sotirios Chatzis, Dr. Andrea Chincarini, Alessio Cirone, Dr. Jan Harms, Alberto Iess, Dr. Natalia Korsakova, Dr. Luca Longo, Dr. Nikhil Mukund, Dr. Conor Muldoon, Franco Maria Nardini, Dr. Eng. Andrea Paoli, Dr. Luigia Petre, Luca Rei, Dr. Maria Tringali, Dr. Catia Trubiani, Dr. Gabriele Vajente, Rob Walet, Andrei Utina, Dr. Catalin Leordeanu
- WG3 email: [wg3-g2net@ego-gw.it](mailto:wg3-g2net@ego-gw.it)
- Our slack channel
  - <https://app.slack.com/client/TT226125S/CT51XP57Y>
  - Working plan, meeting notes, slides, links to seminar recordings
- We meet regularly
  - Last Friday of the month, at 14:00 CET



# Our focus

- Use of Machine Learning (ML) in control and noise mitigation for scientific experiments
  - specifically for Gravitational Wave (GW) detectors
- GW detectors → uniquely complex instruments
  - specific and new challenges in terms of control and noise issues
  - both currently running and the space-borne foreseen detectors
- Significant adaptation and ingenuity in ML approaches
  - seldom used as textbook cases
  - often coupled with simulations
  - burden with heavy experimental constraints
- We need diverse expertise and interaction
- Our goal → develop ML algorithms
  - as part of the detectors' feedback-control systems
  - for the feed-forward cancellation of noise



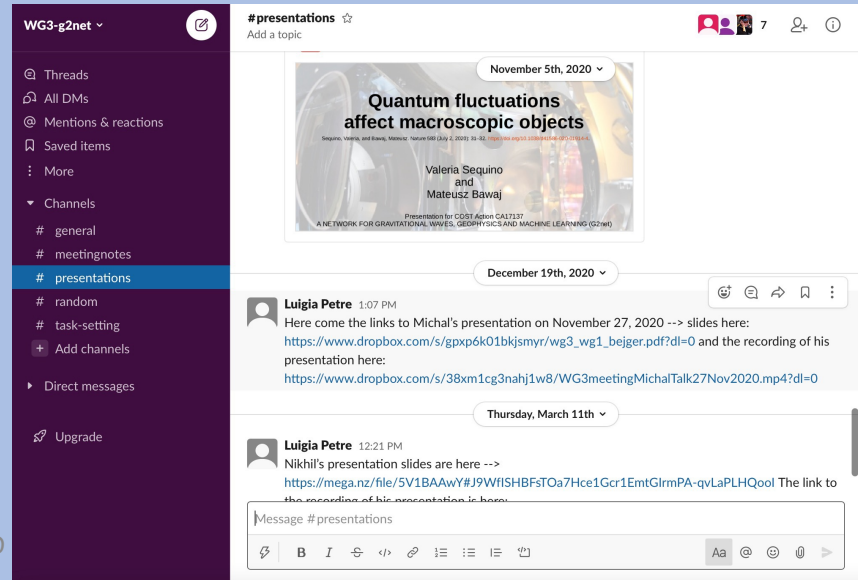
# Our tasks

1. ML for glitch removal
2. Newtonian noise cancellation with ML
3. Data pre-processing with reinforcement learning
4. Deep learning for noise removal
5. Laser cavity control to optimise locking time and stability




# Slack repository for WG3

- Minutes of the meetings
  - Links to videos of scientific presentations
    - Since April 2020
  - Slides of scientific presentations
- <https://app.slack.com/client/TT226125S/C0113MG7JQP/thread/C0113MG7JQP-1588084369.000900>





# Gitlab repository

- Links to videos of scientific presentations
  - Since April 2020
- Slides of scientific presentations
- <https://gitlab.com/g2net/wg3-g2net>

g2net >  wg3-g2net

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**wg3-g2net** 


Group ID: 10191942 [Leave group](#)

Repository for Working Group 3, "Machine Learning for Advanced Control Techniques", of the EU-funded g2net COST ACTION (CA 17137): A network for Gravitational Waves, Geophysics and Machine Learning. <http://www.g2net.eu>

[Subgroups and projects](#)
[Shared projects](#)
[Archived projects](#)

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**Presentations - slides and video link when available** 

Here we collect the materials of our presentations held at online WG3 meetings

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5 months ago





# What happened since the last MC meeting in May 2021

- Marco Cavaglia's zoom talk
- Training school (online)
  - August 30 - September 2, 2021



# Some history of WG3

- Fall 2019 → Andrea and Luigia appointed as new chairs
- 2020 → Re-started monthly seminars
  - Jan 2020 → reconvention meeting
  - Feb 2020 → Natalia Korsakova, LISA, FR
  - March 2020 → Andrea Chincarini, INFN, IT
  - April 2020 → Luigia Petre, ÅA, FI
  - May 2020 → Eftim Zdravevski, North Macedonia
  - June 2020 → Jan Harms, GSSI, IT
  - September 2020 → Filip Morawski, Warsaw, Poland
  - October 2020 → Mateusz Bawaj, Univ of Perugia, IT
  - November 2021 → Michal Bejger, Warsaw, Poland
  - Jan 2021 → Velimir Ilic, Belgrade, Serbia
  - Feb 2021 → Nikhil Mukund, Max Plank Institute, Germany
  - May 2021 → Jade Powell (ML for GW data), Melbourne, Australia
    - <https://iopscience.iop.org/article/10.1088/2632-2153/abb93a>





# Our main events

- Monthly online seminar
- Online workshop
  - 22-23 March 2021
  - <https://indico.ego-gw.it/event/172/>
- Online Training School
  - August 30– September 2 2021
  - <https://indico.ego-gw.it/event/217/>



# WG3 workshop

- Speakers
  - Diego Bersanetti, INFN Genova (IT)
    - Interferometer Cavities: locking strategies and improvement possibilities
  - Francesca Badaracco, GSSI (IT) & UCLouvain (Belgium)
    - Surrogate Wiener filtering for the prediction and optimized cancellation of Newtonian noise at Virgo
  - Rob Walet, Nikhef (The Netherlands)
    - The experiment of the table top interferometer
  - Gabriele Vajente, LIGO Laboratory Caltech (US)
    - Non stationary noise removal from LIGO data
  - Fiodor Sorrentino, INFN Genova (IT)
    - Squeezed light benches and optical alignment issues
  - Marco Cavaglia, Missouri University of Science and Technology (US)
    - Glitch removal in ground-based gravitational-wave interferometric detectors
- Workshop page
  - <https://indico.ego-gw.it/event/172/>
- 31 registered participants
- All presentations recorded



# WG3 Training School (1/2)

- 7 speakers
  - 5 from Europe, 1 from UK and 1 from US
    - Dr Francesca Badaracco, UCLouvain, Belgium
      - Topic: Newtonian Noise Cancellation Strategies and Optimisation Problems
    - Dr Luca Naticchioni, INFN, Italy
      - Topic: Einstein Telescope site characterisation measures and their impact on the third generation GW detectors
    - Prof Stefan Hild, Maastricht University, The Netherlands
      - Topic: Einstein Telescope: technical & scientific challenges for the future GW detectors
    - Dr Razvan Pascanu, DeepMind, UK
      - Topic: Deep learning Taxonomy
    - Prof Marco Cavaglia, Missouri Univeristy of Science and Technology, US
      - Topic: Fractal analysis for interferometer control
    - Dr Natalia Korsakova, Artemis, France
      - Topic: LISA talk on disentanglement
    - Dr Fabio Bonsignorio, HeronRobotics
      - Topic: Possible Utilization of Intelligent Robotics Technologies in GW detection and in the Einstein Telescope
- Each lecturer → 2-hour slot for their lecture and interaction with participants
- We recorded each slot



# WG3 Training school (2/2)

- 39 registered participants
  - 1 Early Career Investigator (ECI) speaker
  - 1 International Partner Country (IPC) speaker
  - 3 /8 women involved in the organisation
    - Francesca, Natalia, Luigia
- Our estimation
  - About half of the participants
    - ECI
  - About one third of the participants
    - women



# WG3 contributes to

- Deliverable 7
  - Report on Design study for application for robots to adaptively monitor seismic noise around GW detectors
- Deliverable 9
  - Report on solution to be adopted to address the impact on Newtonian Noise in GW data records
- Deliverable 10
  - Report on the application of ML methods in the control systems for GW detectors
- Deliverable 11
  - Report on new ML method application in seismological problems for GW detection and related experiments



# Some statistics since Spetember 2019

1. Number of publications  $\rightarrow 5 + 5$
2. Number of meetings  $\rightarrow 12 + 1$
3. Number of STSM grants  $\rightarrow 2+1$
4. Presentations  $\rightarrow 12 + 1$
5. Online workshops  $\rightarrow 1$
6. Training schools  $\rightarrow 1$







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