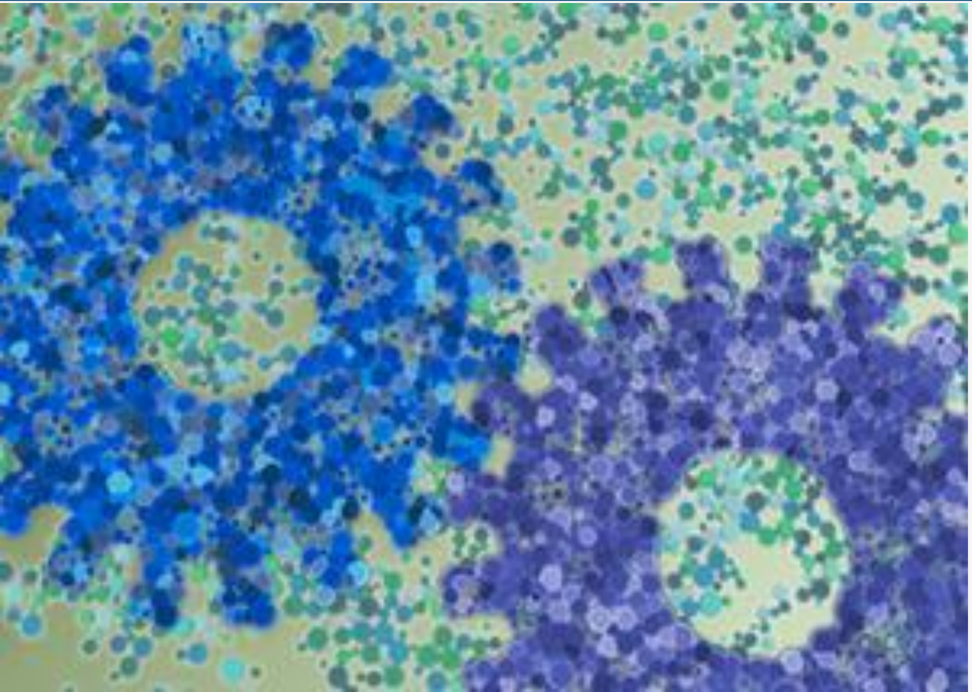
# Ecosystem for Collaborative Manufacturing Processes – Intra- and Interfactory Integration and Automation



## Big Data Management

### The use of Deep learning techniques in the COMPOSITON platform


Paolo Vergori

ISMB



Co-funded by the European Union


COMPOSITION

# Agenda

- Why deep learning for factory of the future?
- The COMPOSITION challenge
  - UC-BSL-2 Predictive maintenance
  - UC-ELDIA-1 – Contractual goods and recyclable materials management
- Deep Learning approach in COMPOSITION
  - intra-factory scenario
  - inter-factory scenario
- Future work

# Why deep learning for factory of the future?

- Prolific environment
  - large amount of potential data available
  - tangible results achievable in finite time span
  - potential market exploitation
- Overcoming current state of the art
  - outperforming statistical models
  - continuous learning for adapting to dynamic production environment
  - transferrable results in terms of research (not in terms of models or dataset)
- Strong correlation to upcoming existing technologies
  - improving of matchmaking results, supporting decision systems

# Deep Learning approach in Composition

- Deep learning toolkit
  - twofold application as both intra and inter-factory intelligent tool
  - intra-factory data analysis for predictive maintenance
  - inter-factory agent-based marketplace market estimation
- Continuous learning
  - triggered by inter-factory agents and learning framework
- Fits in a comprehensive ecosystem

# The COMPOSITION's challenge - UC-BSL-2 Predictive maintenance

BSL: predictive maintenance on production equipment

- 2 analyzed reflow ovens
- very complex dataset with ~625,000, ~350,000 samples
  - 60 sensors readings in 20 zones
  - 5 newly deployed sensors linearly independent
- few reported failures (~<<20) over recorded timeframe
- very demanding in terms of accuracy
  - tentative for ~2.5h timeframe
  - more realistically ~5 minutes timeframe

# COMPOSITION's challenge - UC-ELDIA-1 – Contractual goods and recyclable materials management

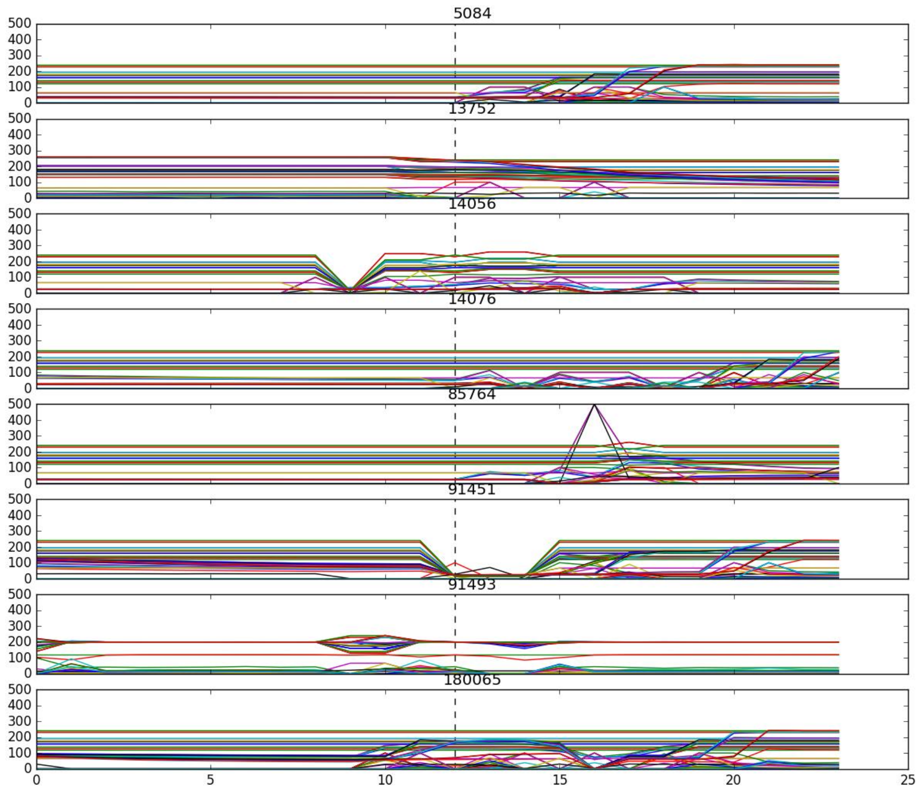
ELDIA: agent-based marketplace estimation

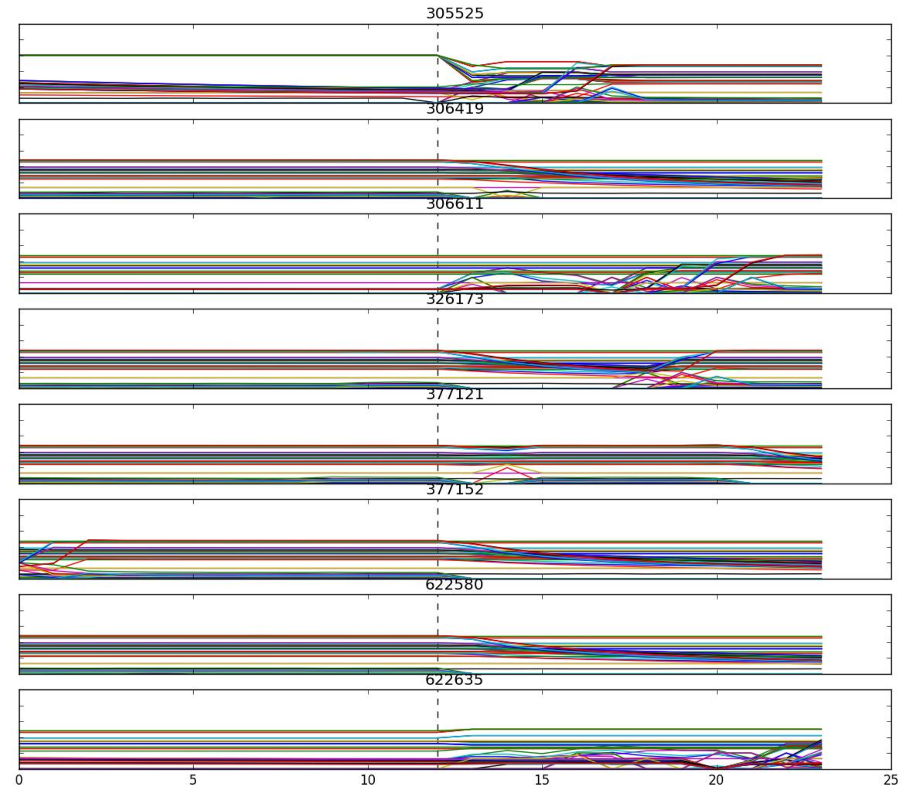
- 4 analyzed raw materials markets
- very small dataset with few samples
    - recording started in 2016 only
- less than 50 reported values
- very demanding in terms of prediction
- steady prices recorded before
- very little contextual data to the analyzed market

# Deep Learning approach in COMPOSITION – intra-factory scenario

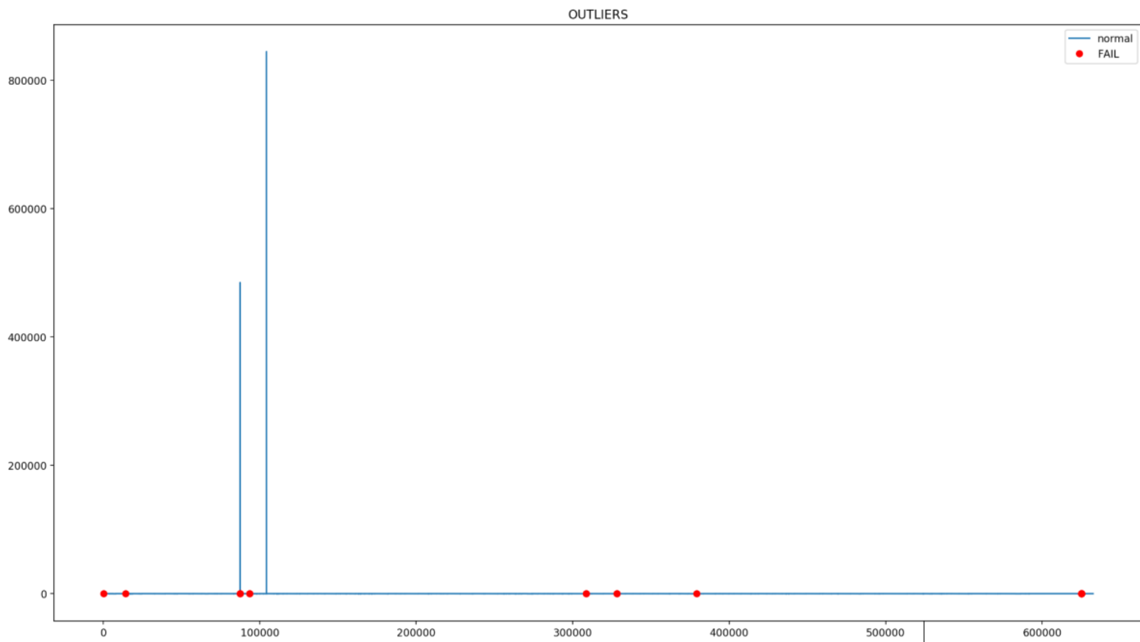
- Intra-factory data analysis for **predictive maintenance** from heterogeneous sources
  - data analysis of existing machinery, forming the **historical dataset**
  - **newly** deployed sensors for acquiring more information
- High risk challenge:
  - work with an **incomplete dataset** with no historical information on new measured parameters
  - have **unbalanced classes** in a nearly real-time environment
- Dichotomy of solution:
  - deploy **untrained ANNs** and rely on theoretical convergence forgetting the historical data
  - **balance the classes** and propagate new parameters backwards

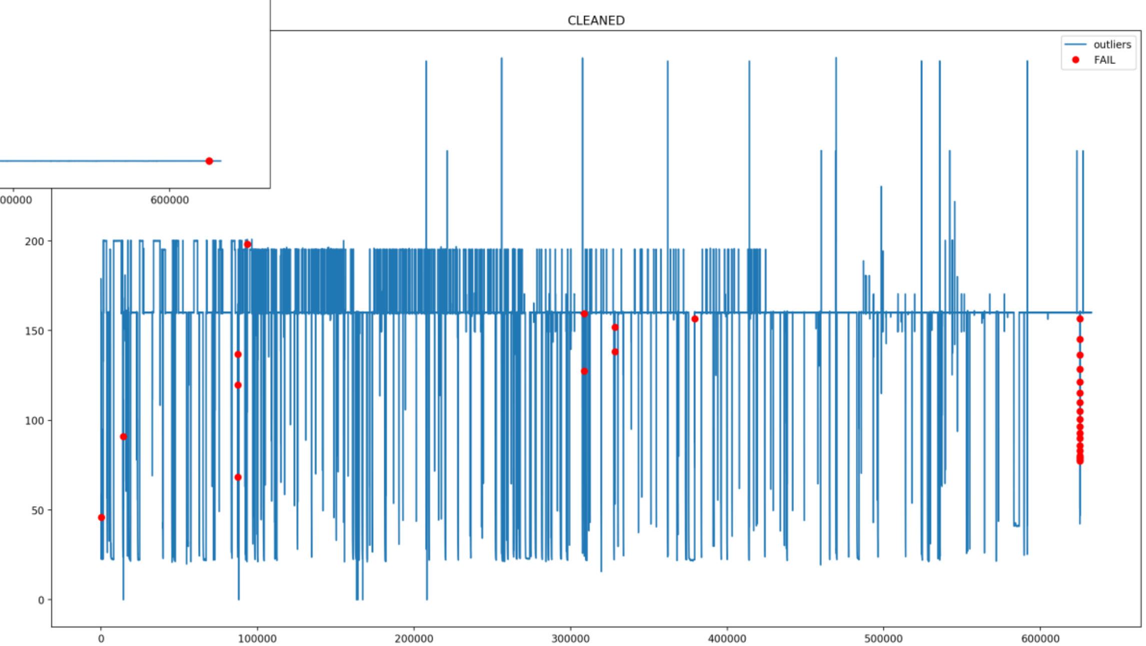
# DLT – intrafactory – historical dataset



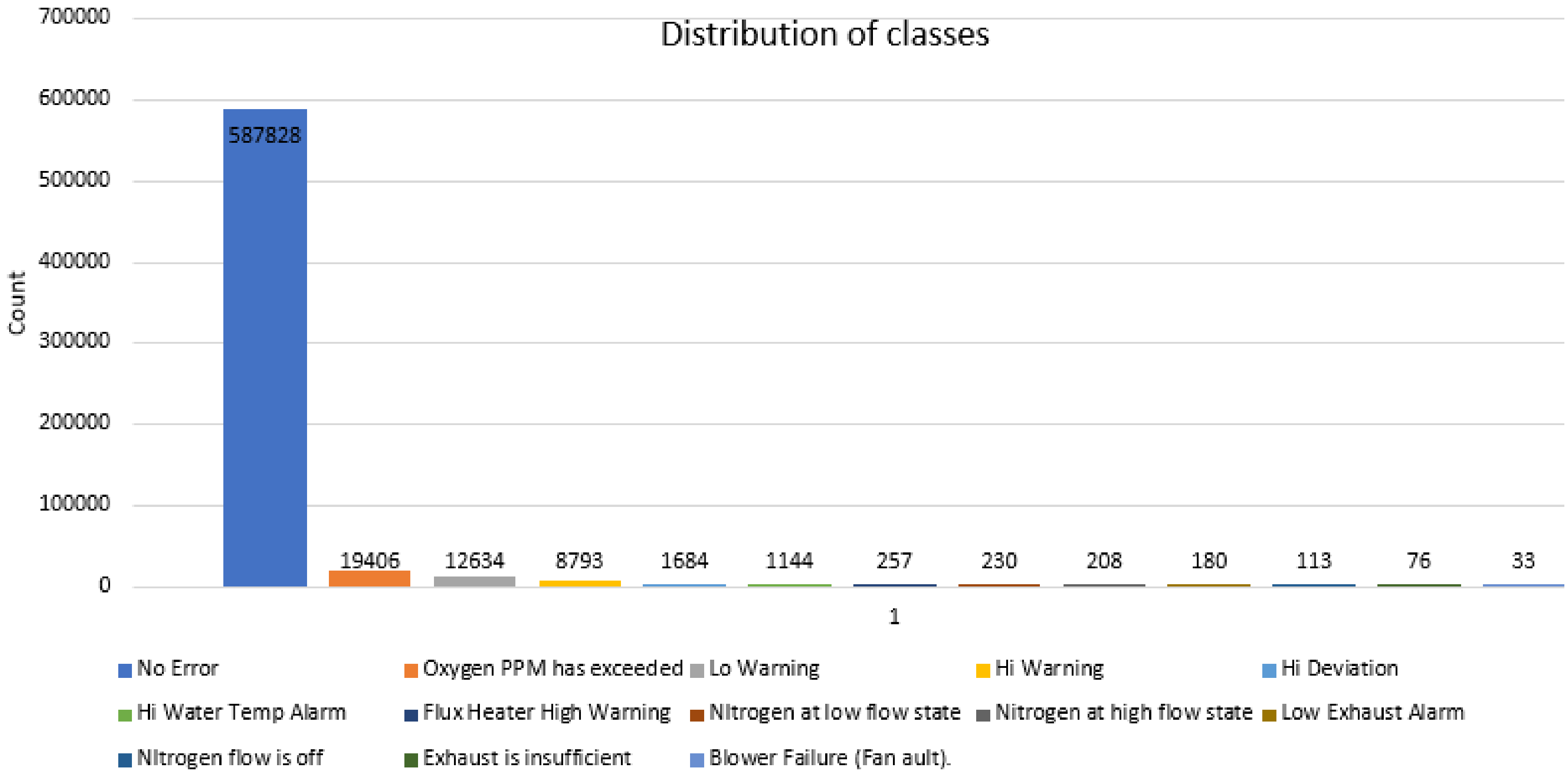



# DLT – intrafactory – outliers and cleaned data

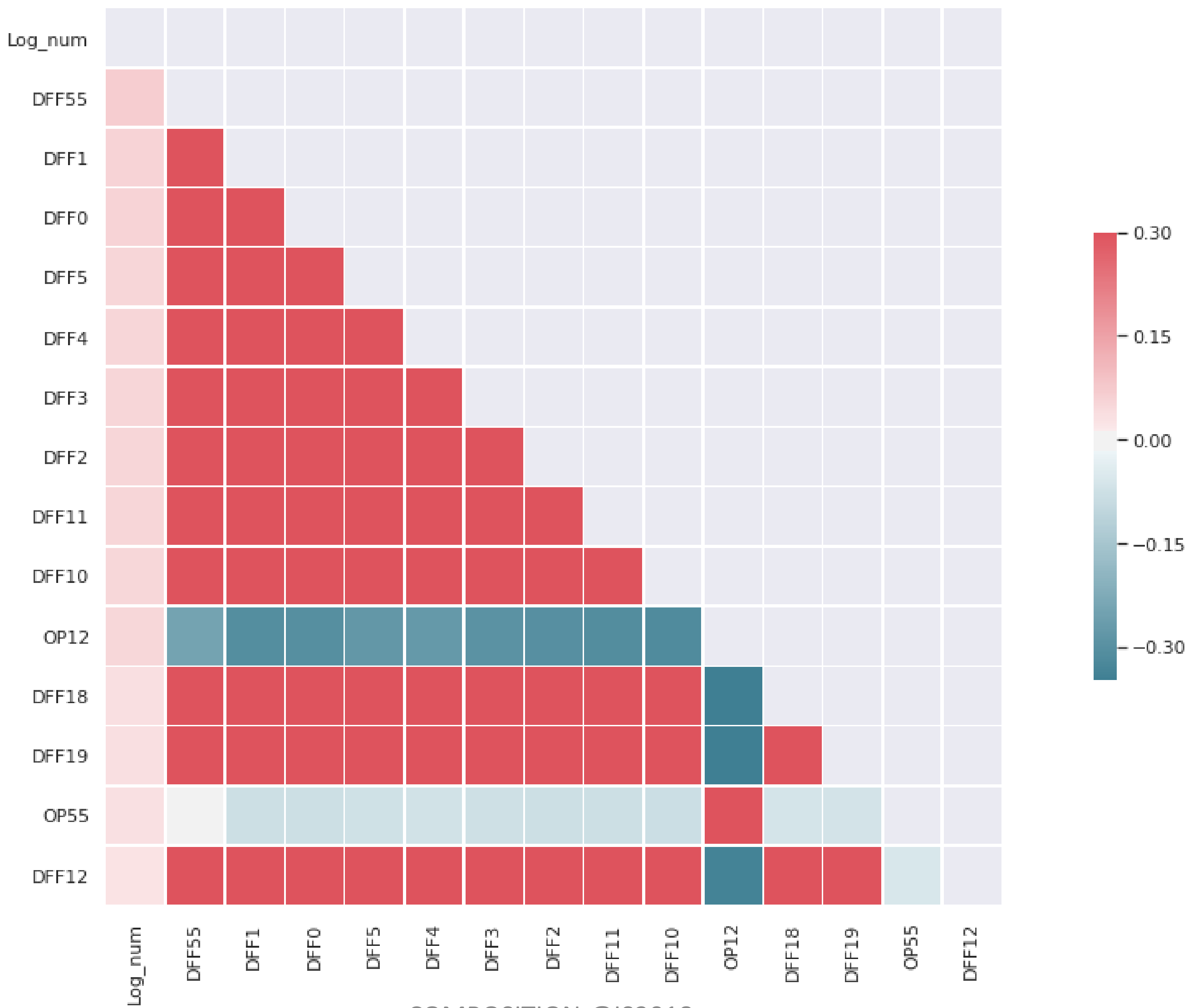


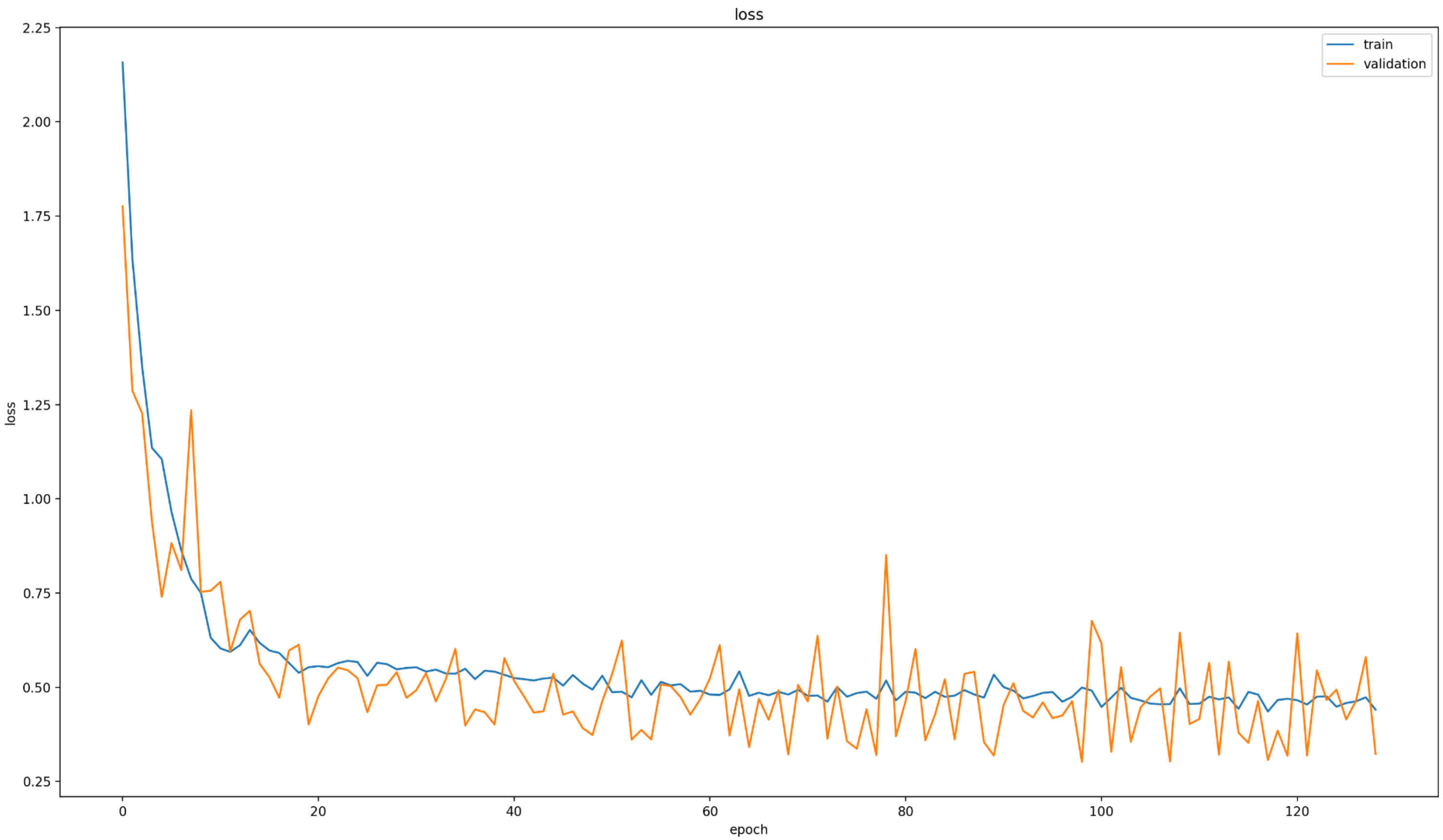
# DLT – intrafactory – dataset creation



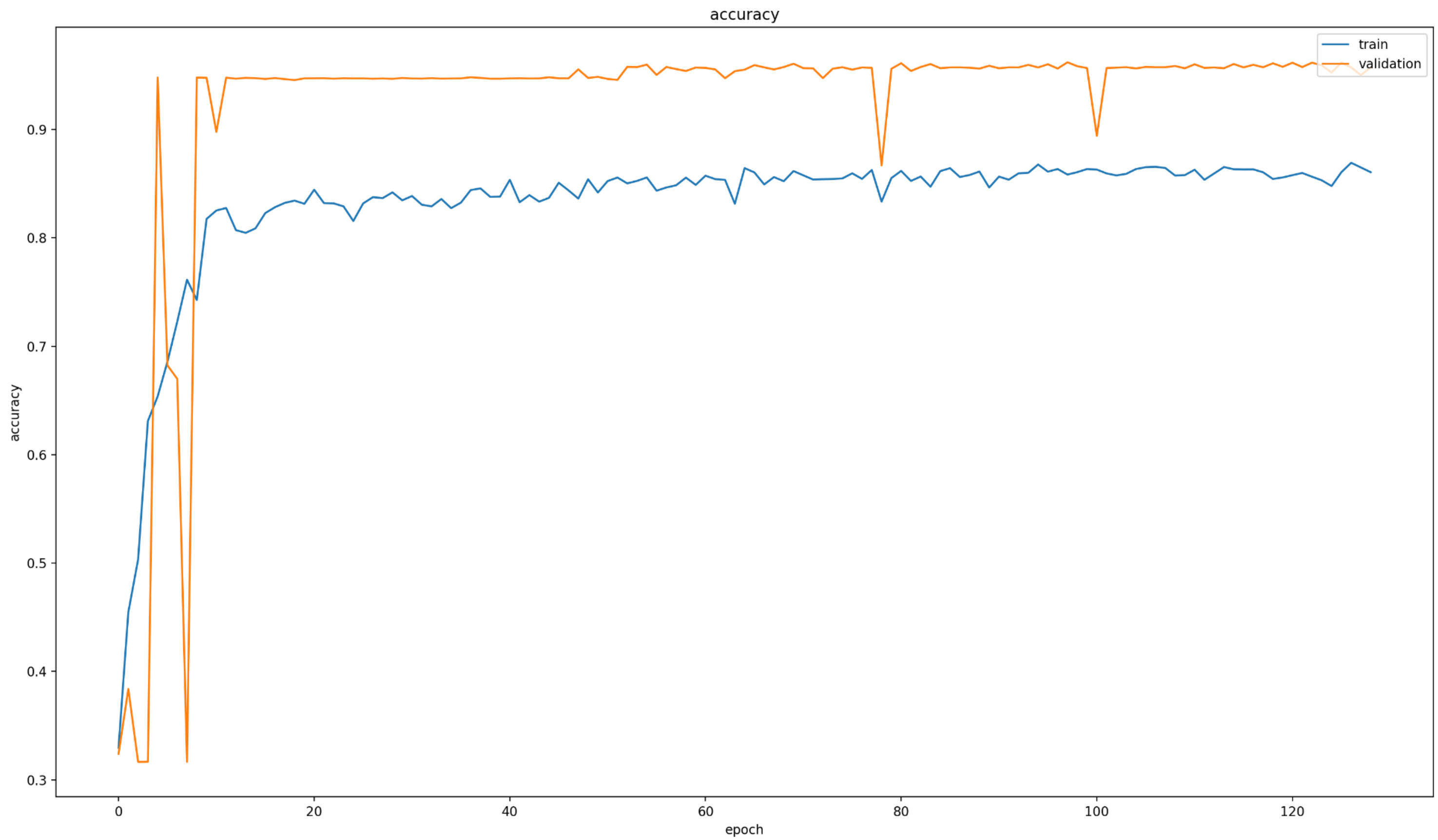
# DLT – intrafactory – correlation matrix



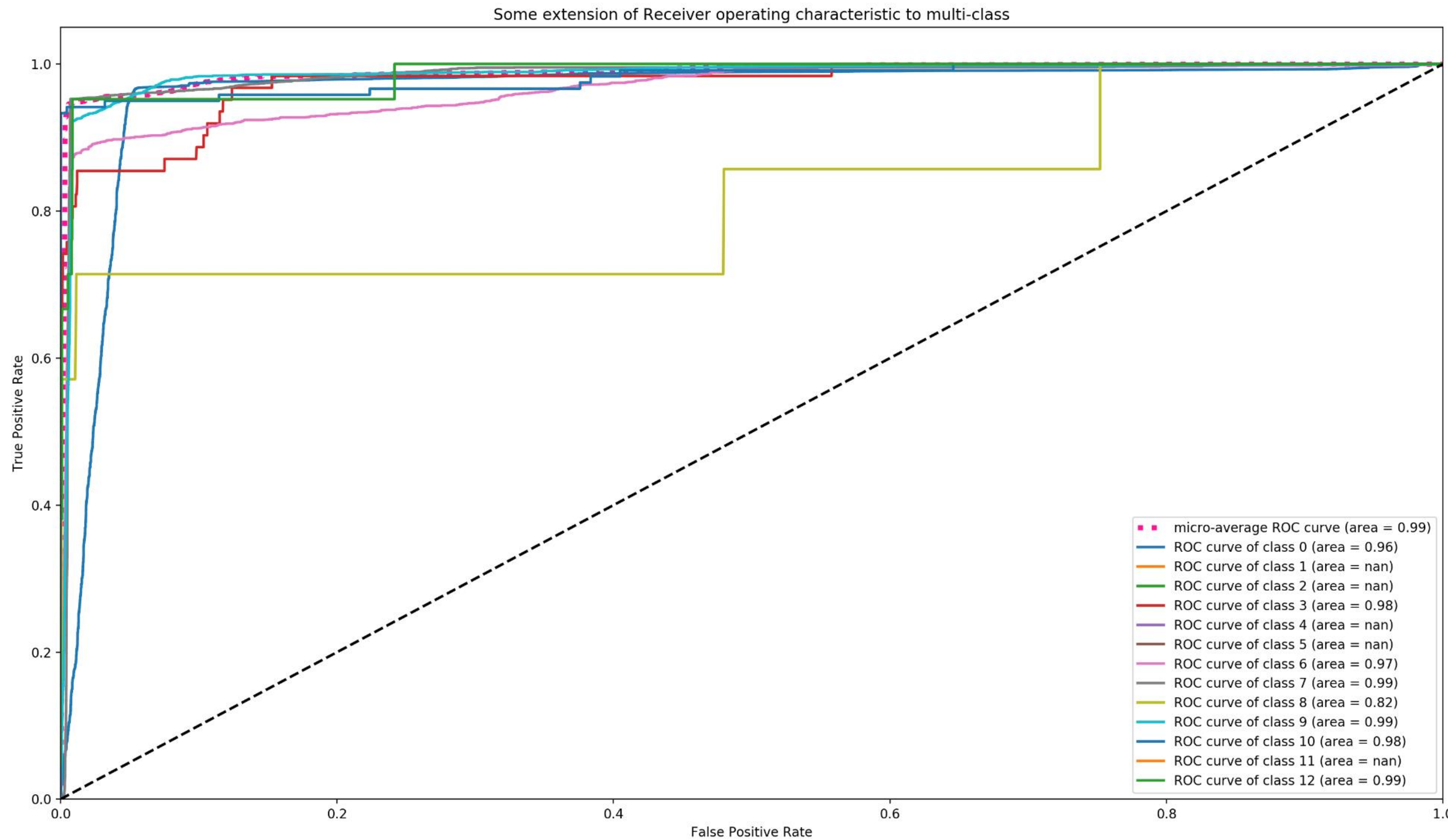
# DLT – intrafactory – loss function



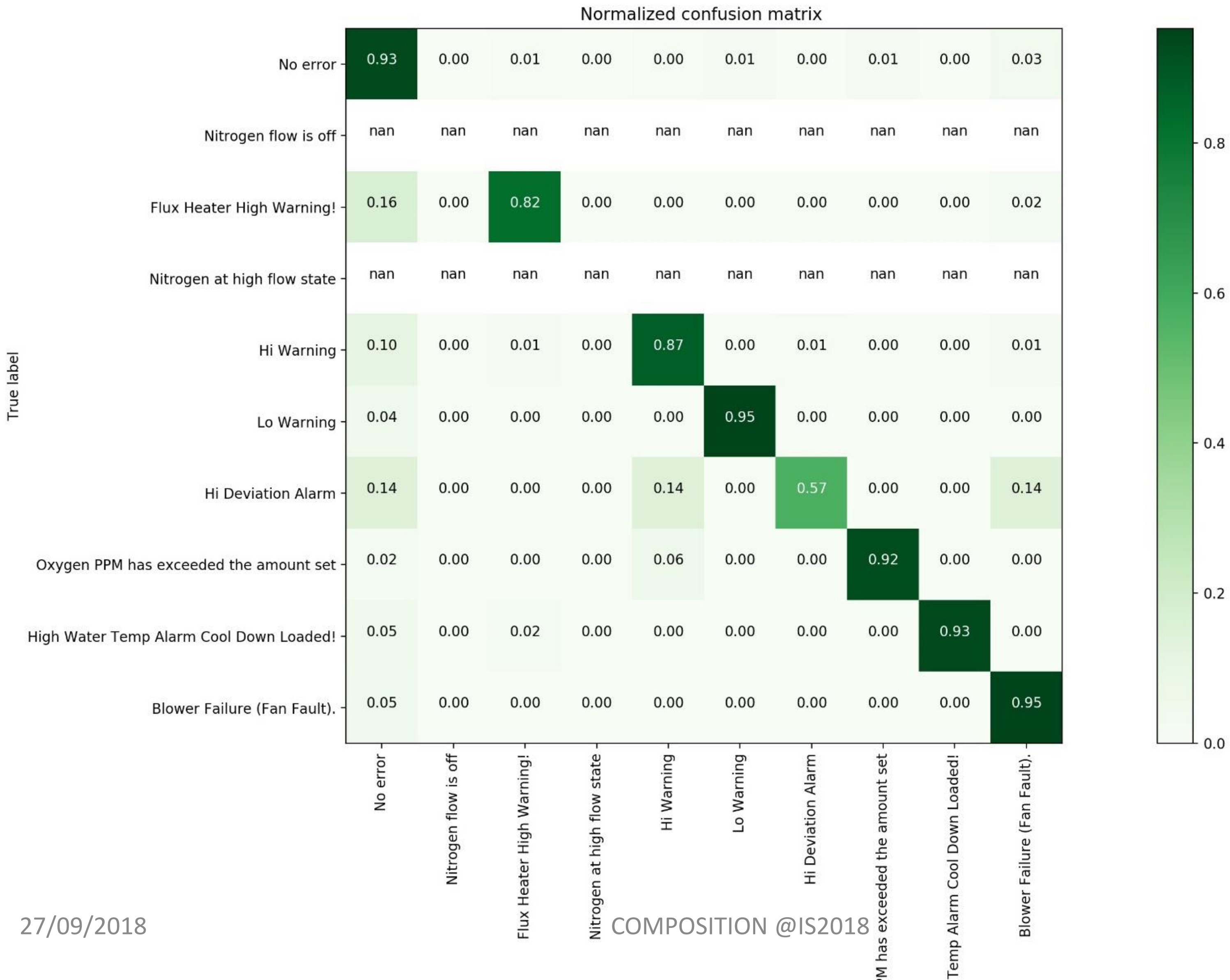
# DLT – intrafactory – accuracy



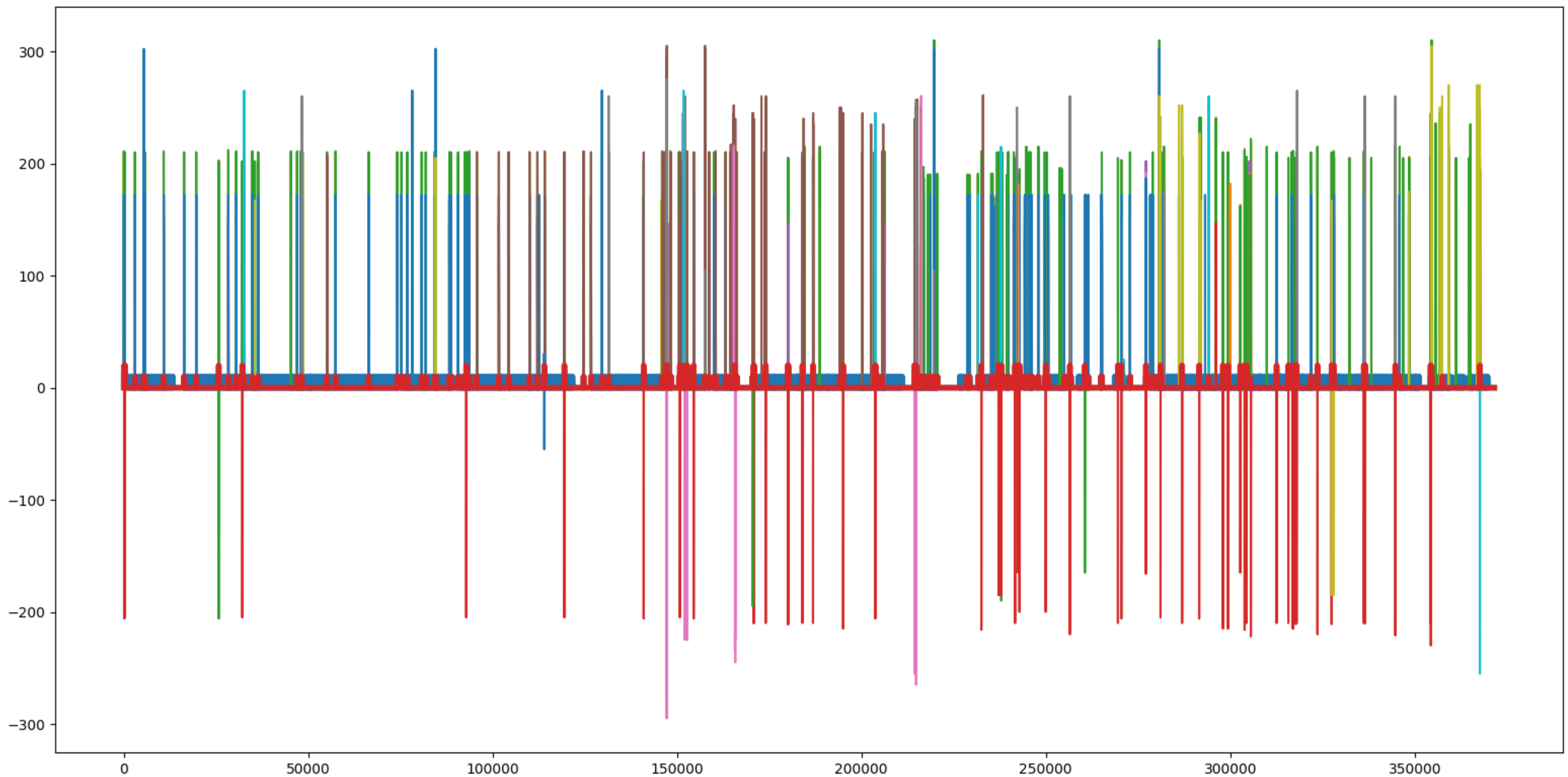
# DLT – intrafactory – ROC function



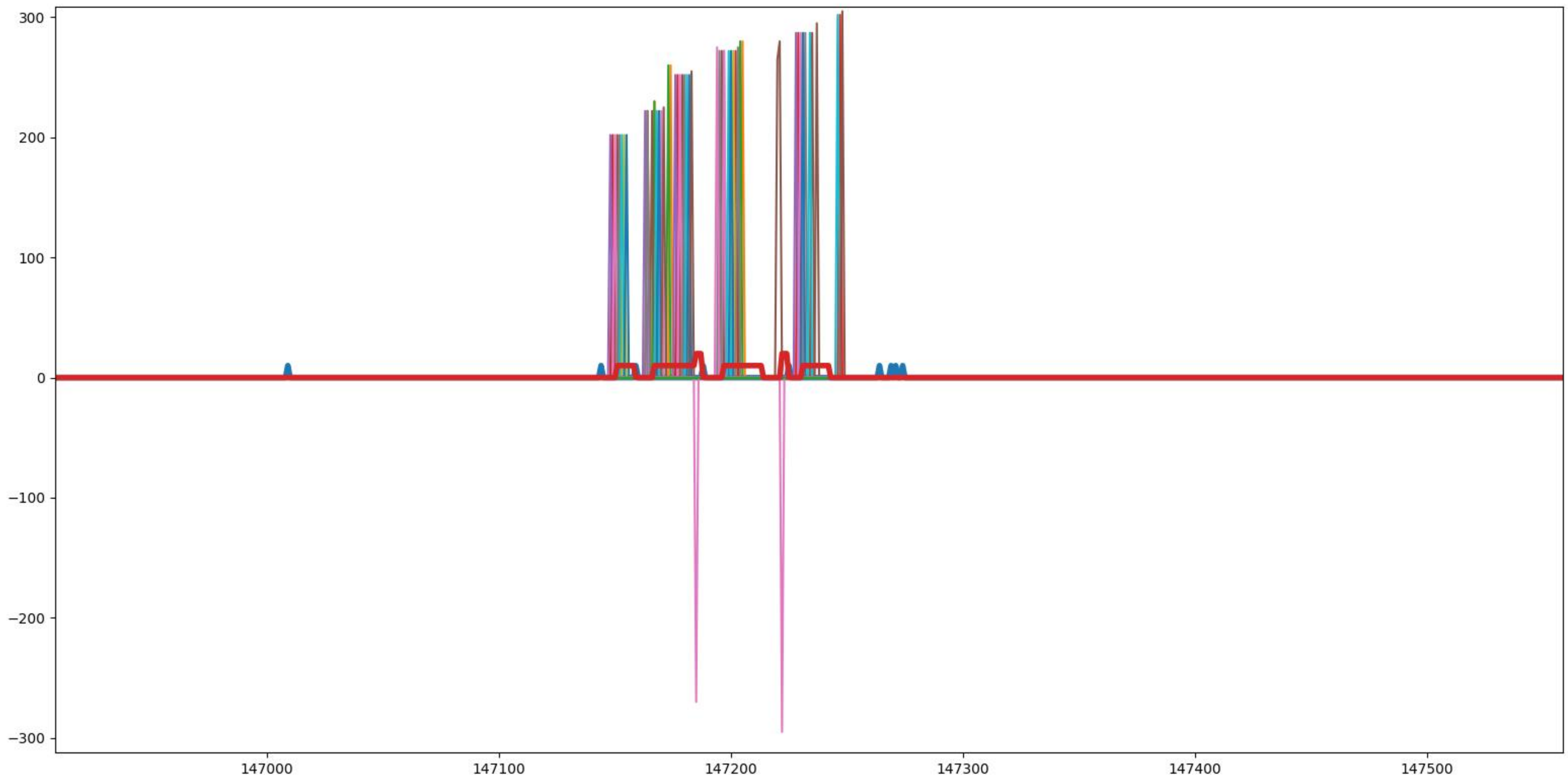
# DLT – intrafactory – confusion matrix



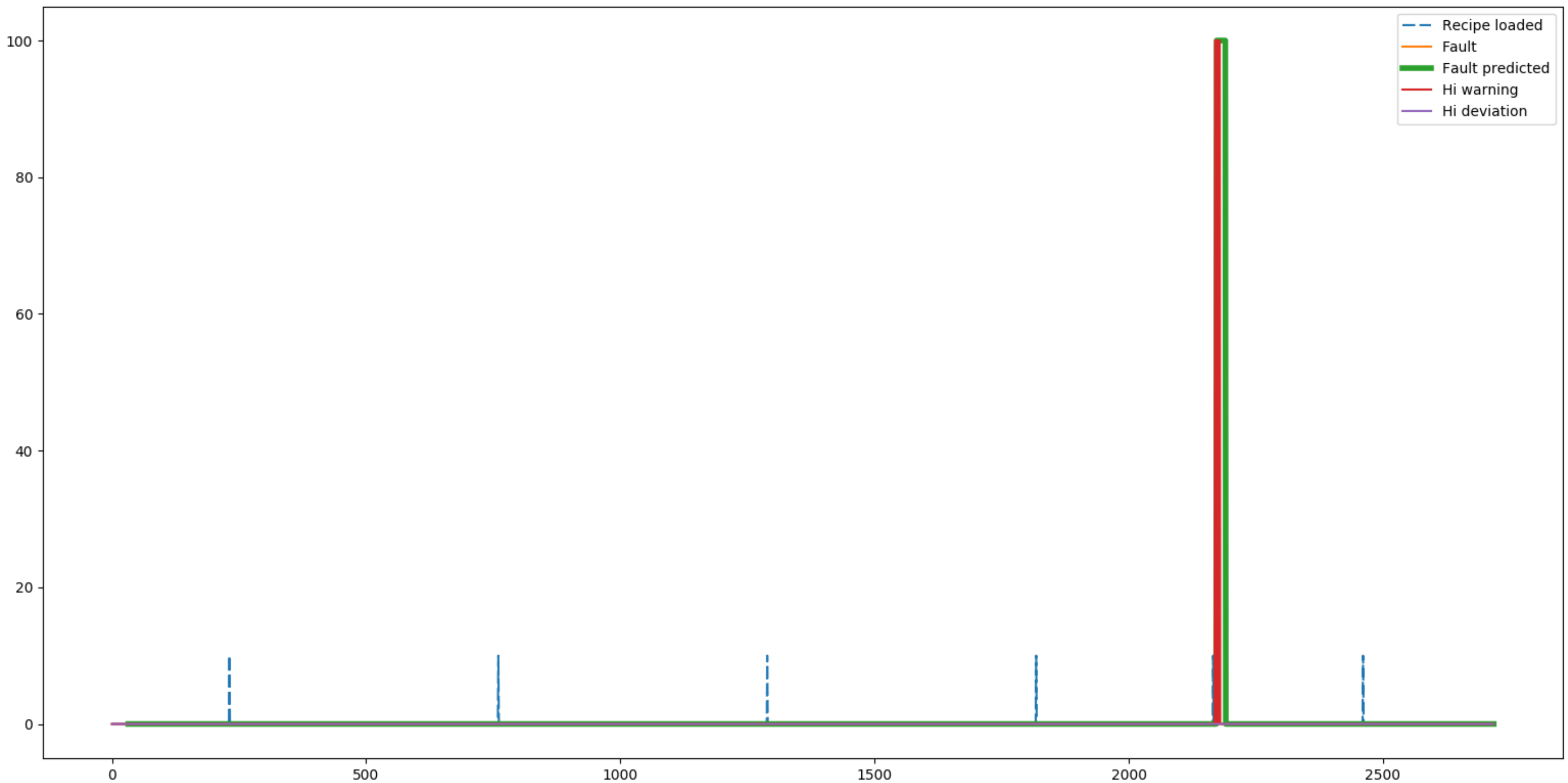
# DLT – intrafactory – training dataset [2013-2017]



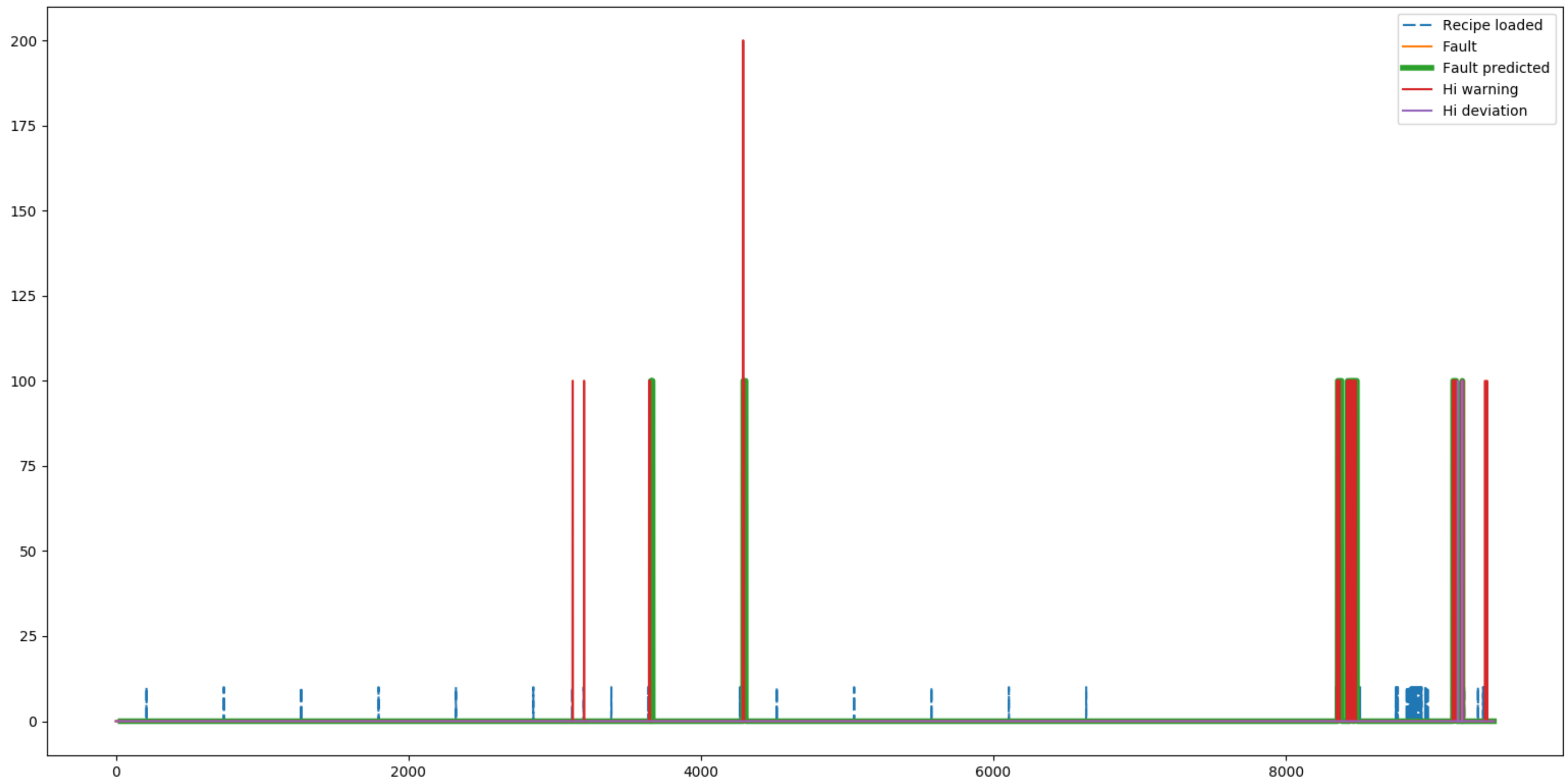
# DLT – intrafactory – zoomed training dataset



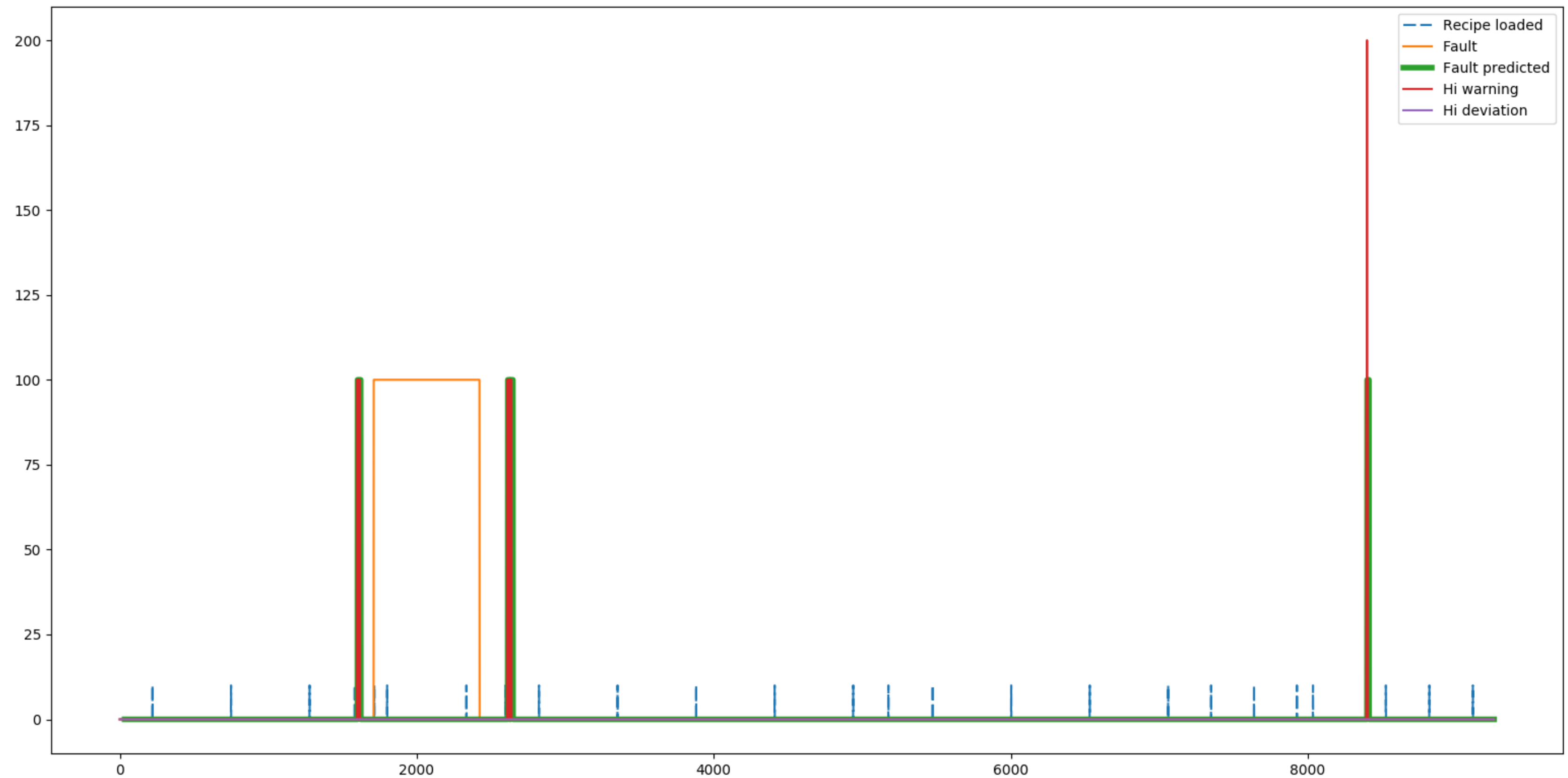
# DLT – intrafactory – test dataset – trial 2



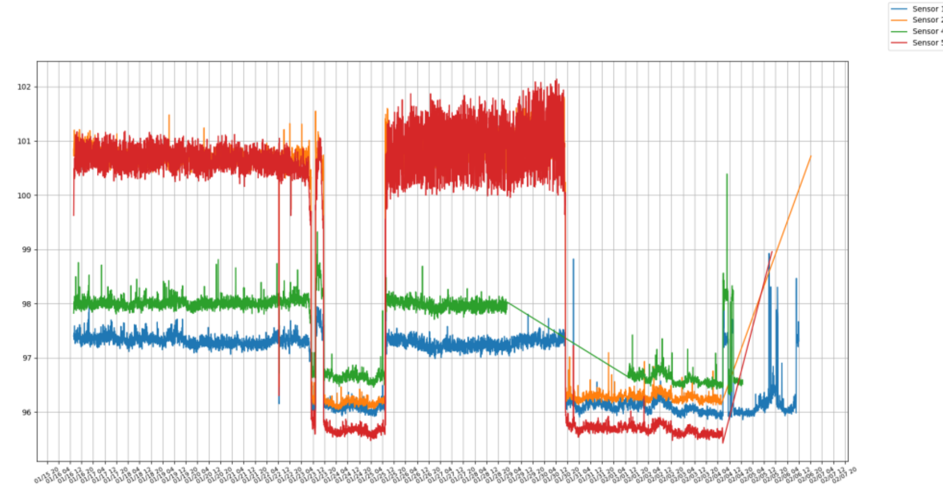
# DLT – intrafactory – test dataset – trial 3

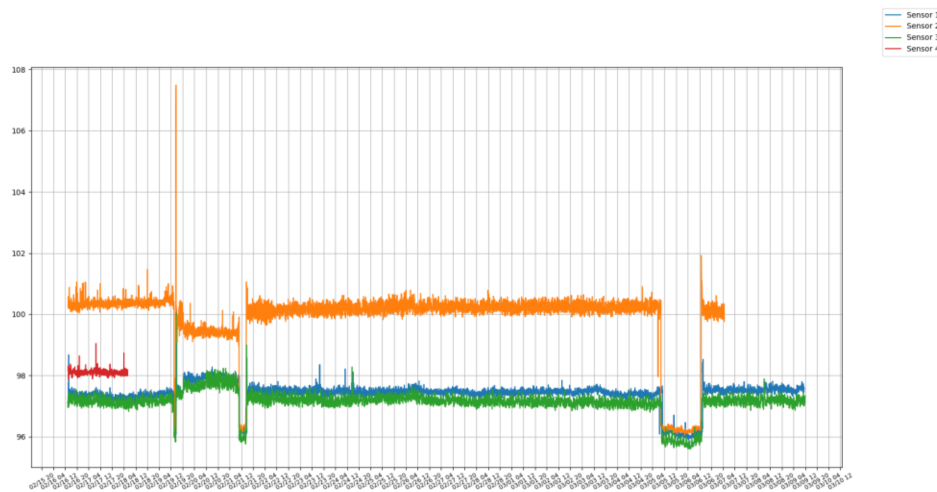


# DLT – intrafactory – test dataset – trial 4

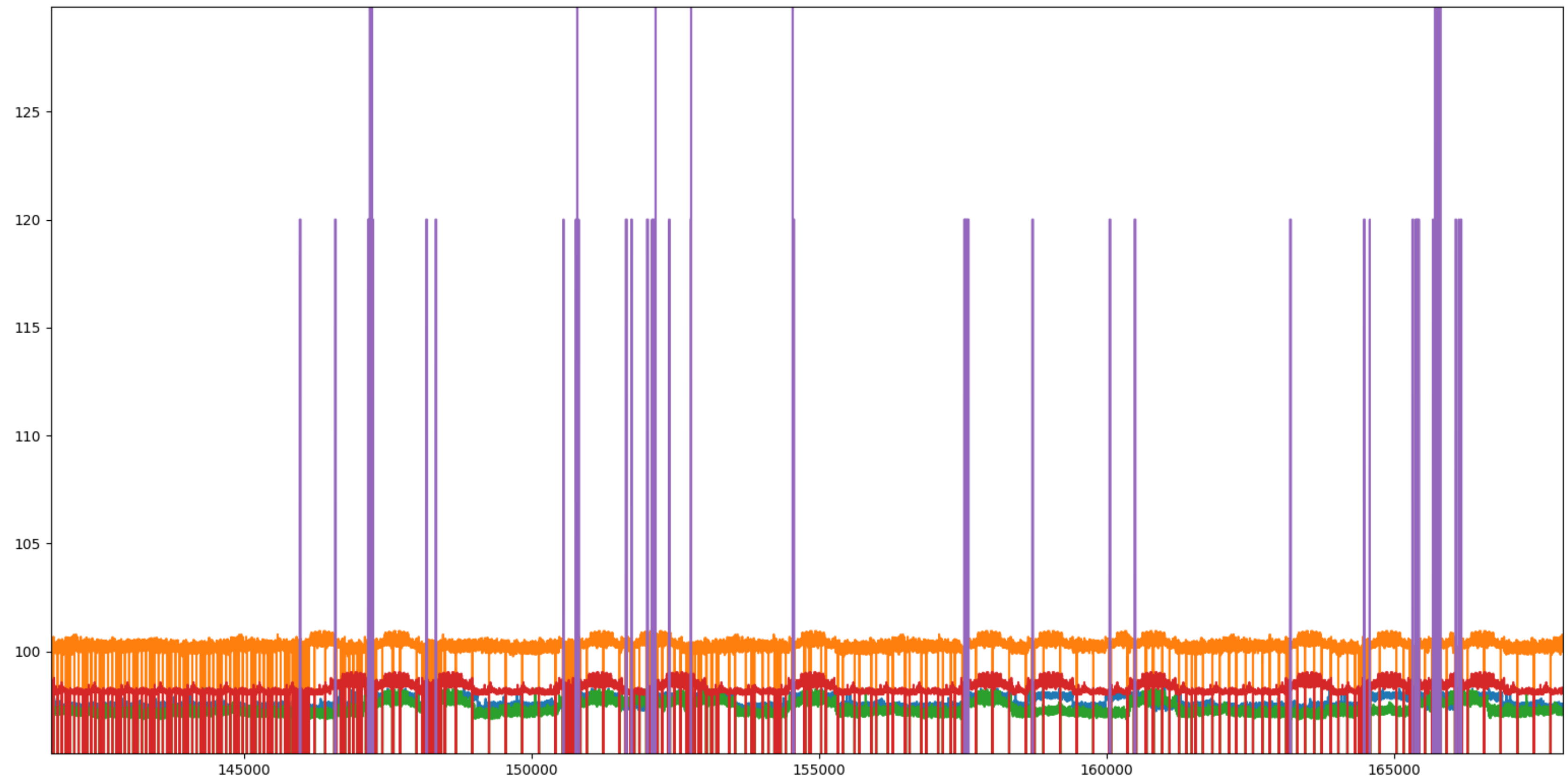


# DLT – intrafactory – newly deployed acoustic sensors

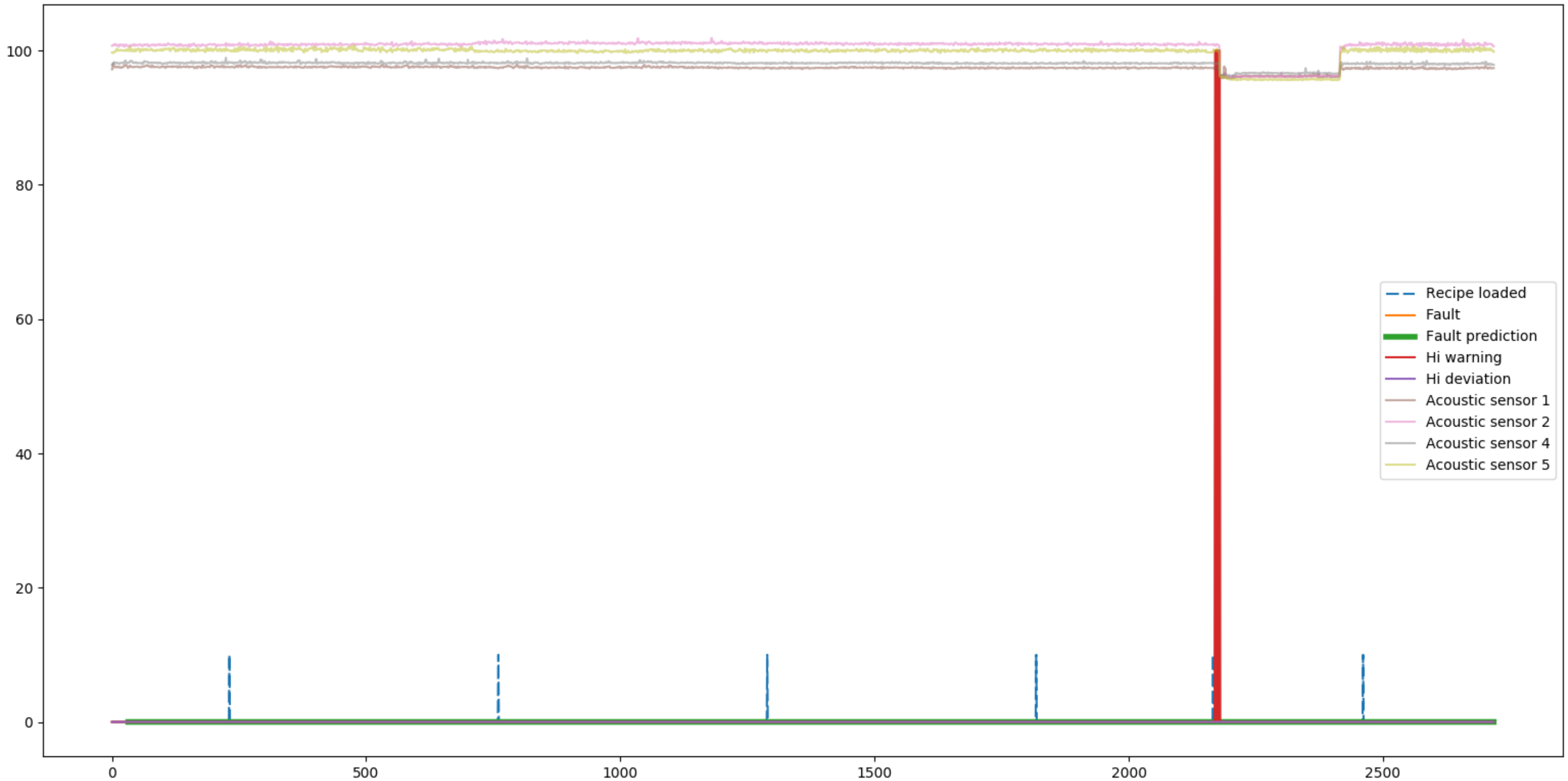



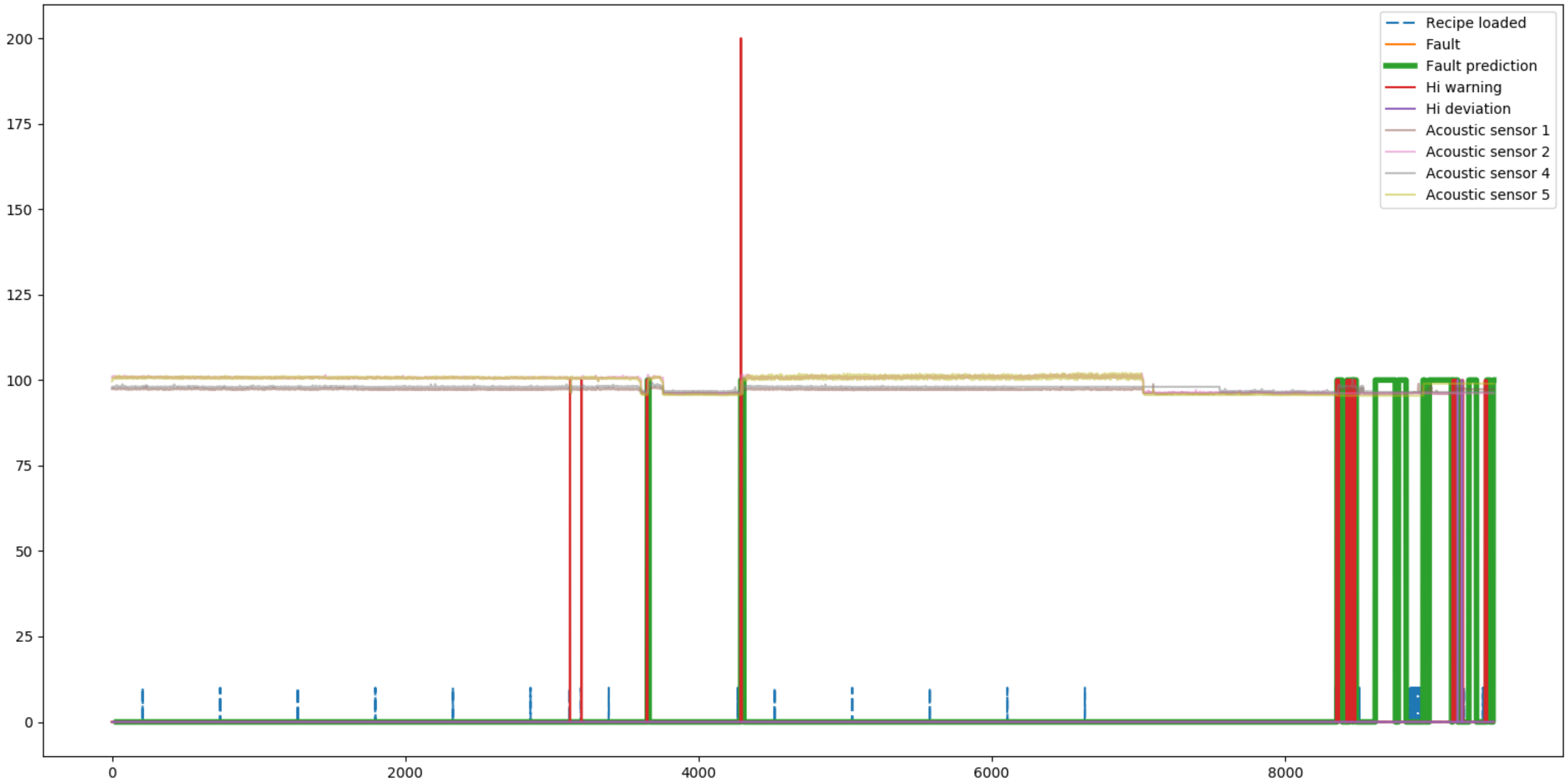
# DLT – intrafactory – zoomed training dataset with audio [2013-2017]



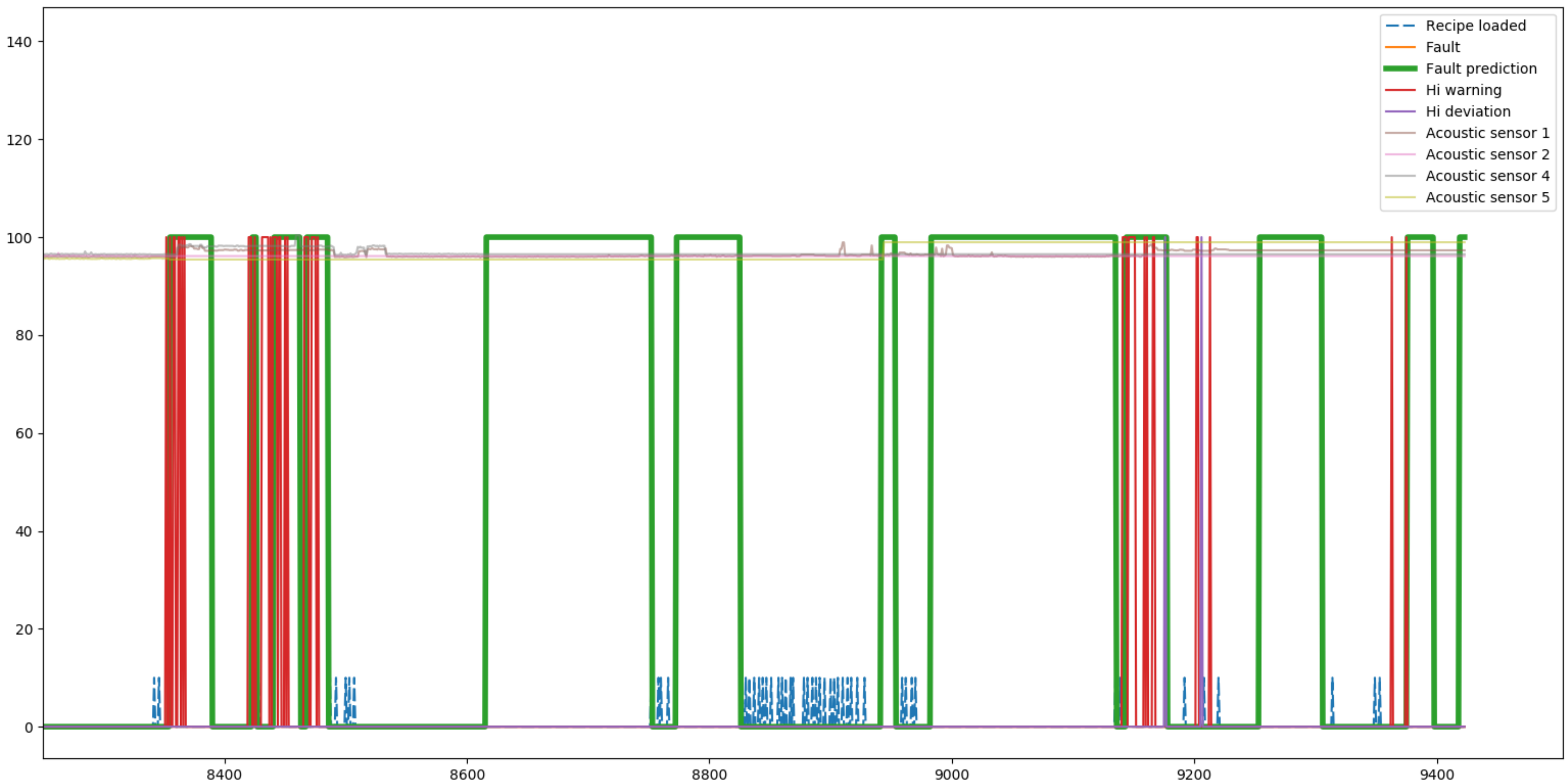
# DLT – intrafactory – predictions on test dataset with audio, look ahead 1 sample – trial 2



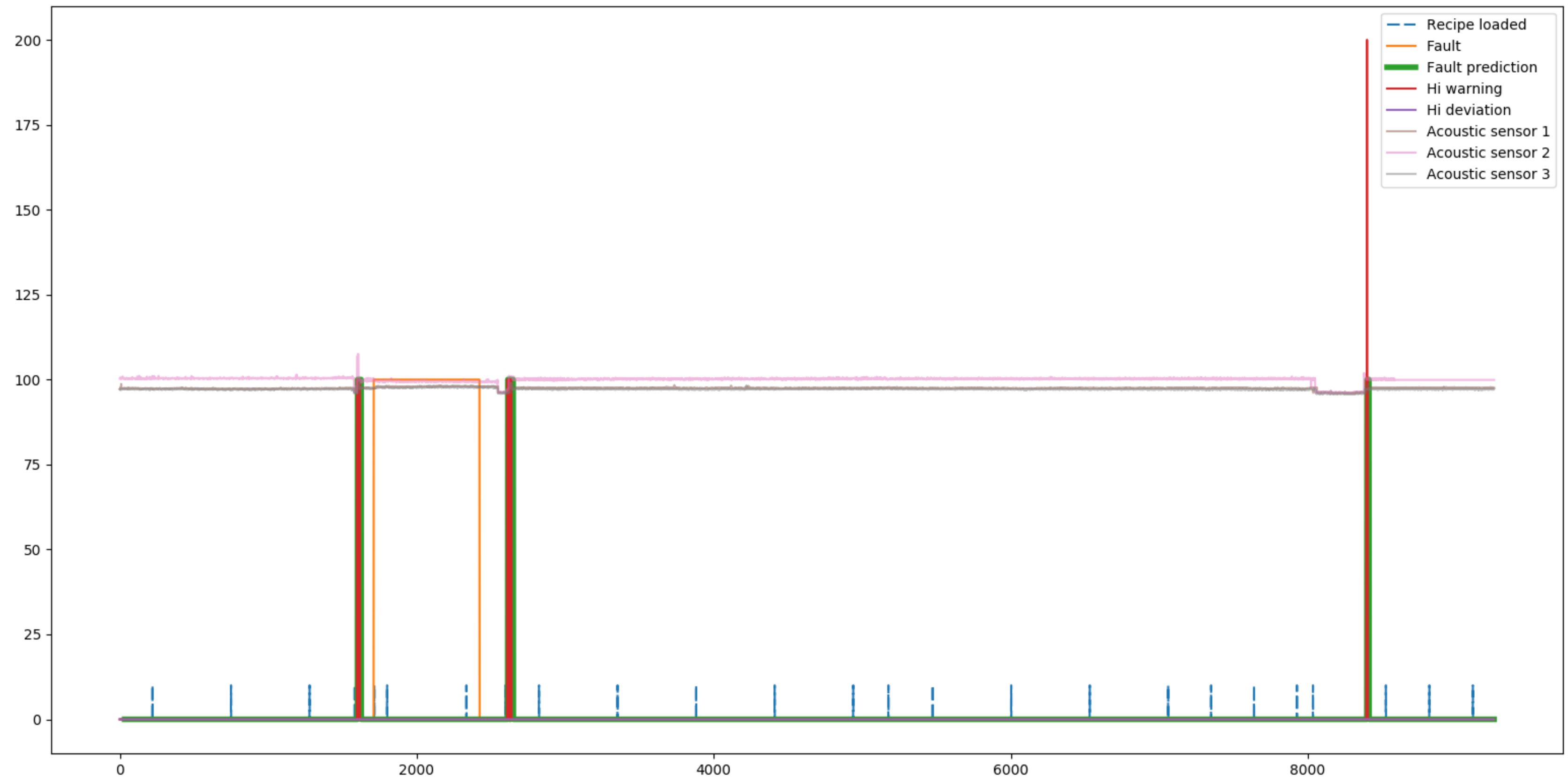
# DLT – intrafactory – predictions on test dataset with audio, look ahead 1 sample – trial 3



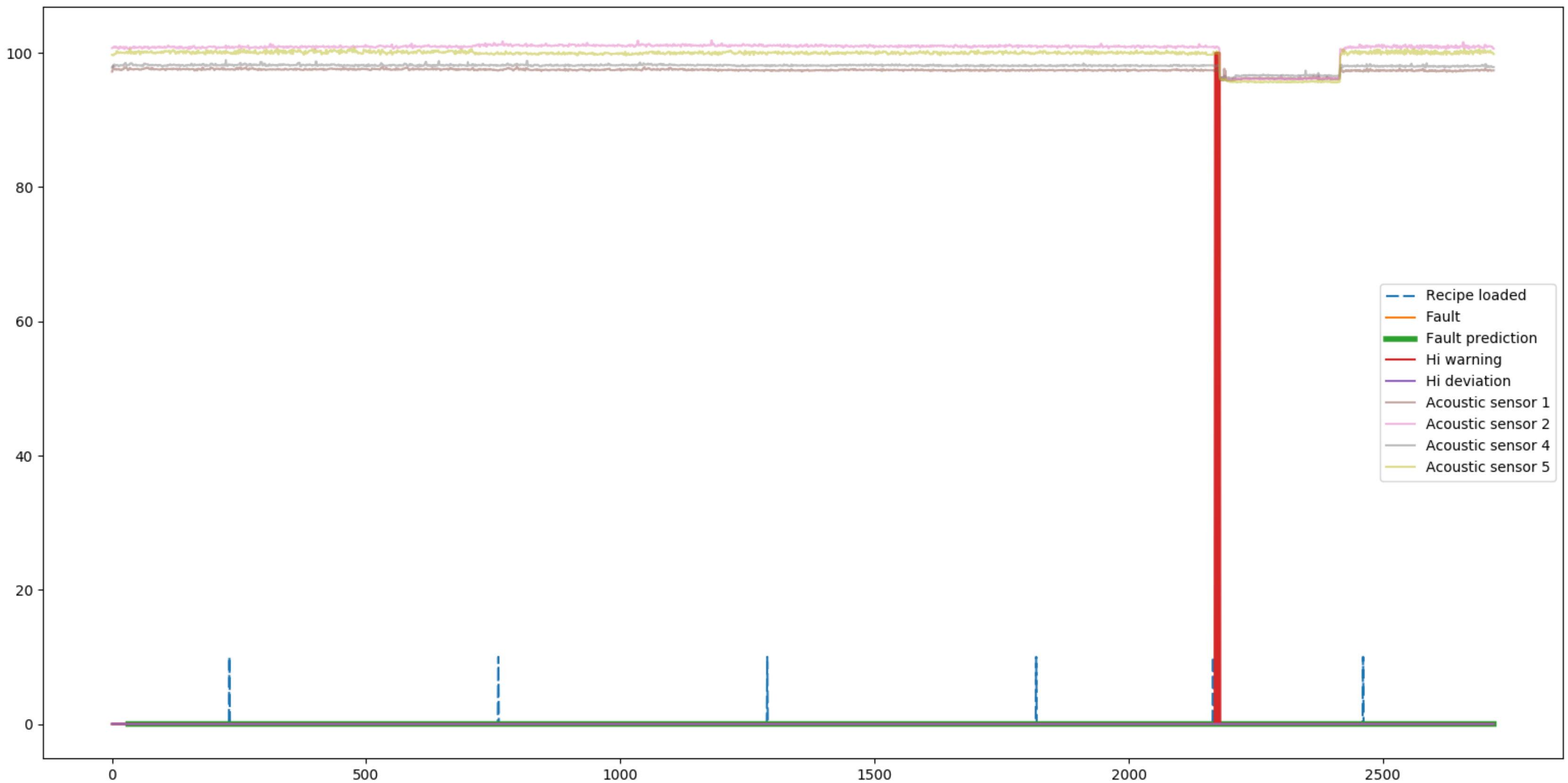
# DLT – intrafactory – predictions on test dataset with audio, look ahead 1 sample – trial 3 zoomed



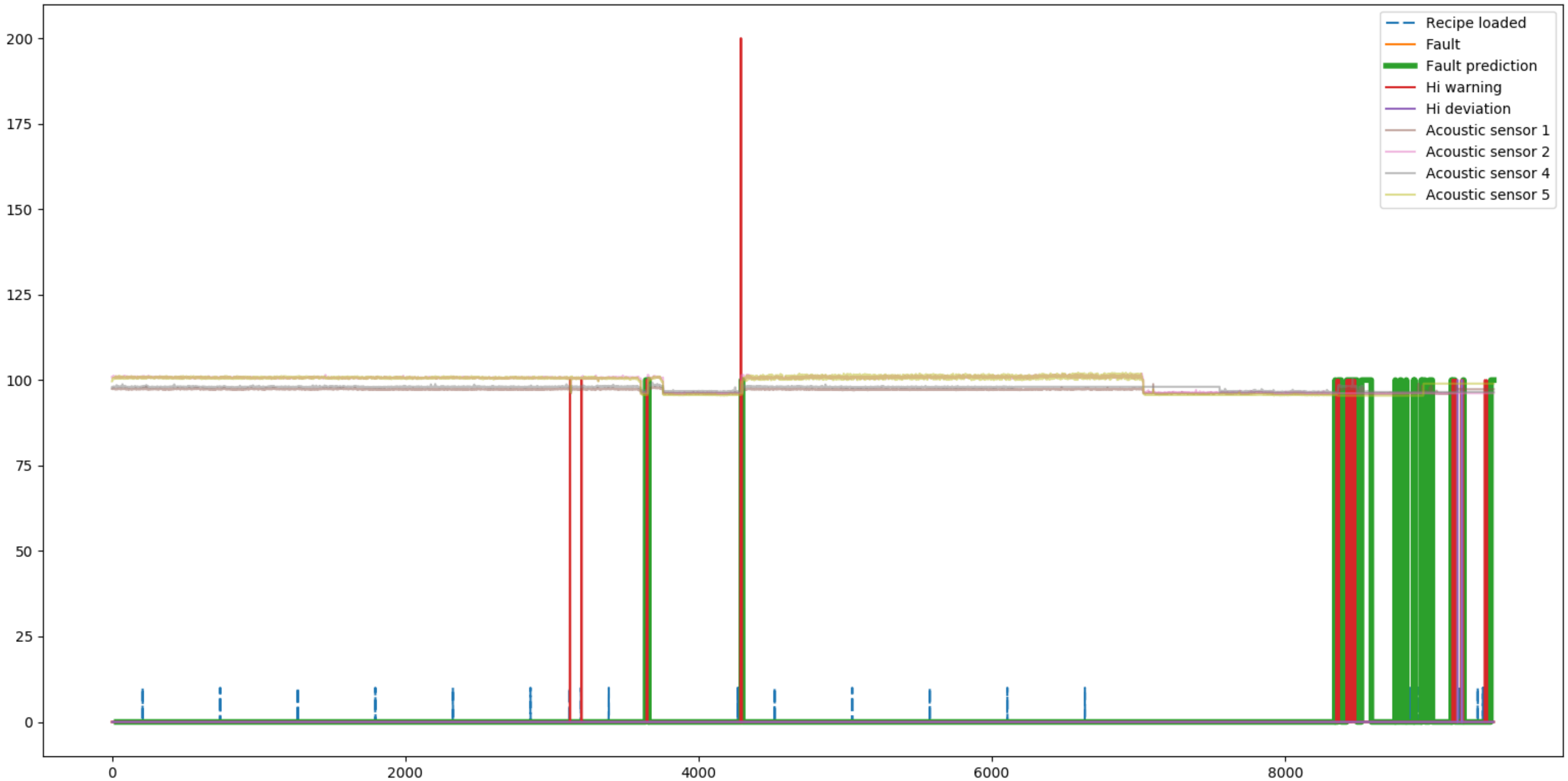
# DLT – intrafactory – predictions on test dataset with audio, look ahead 1 sample – trial 4



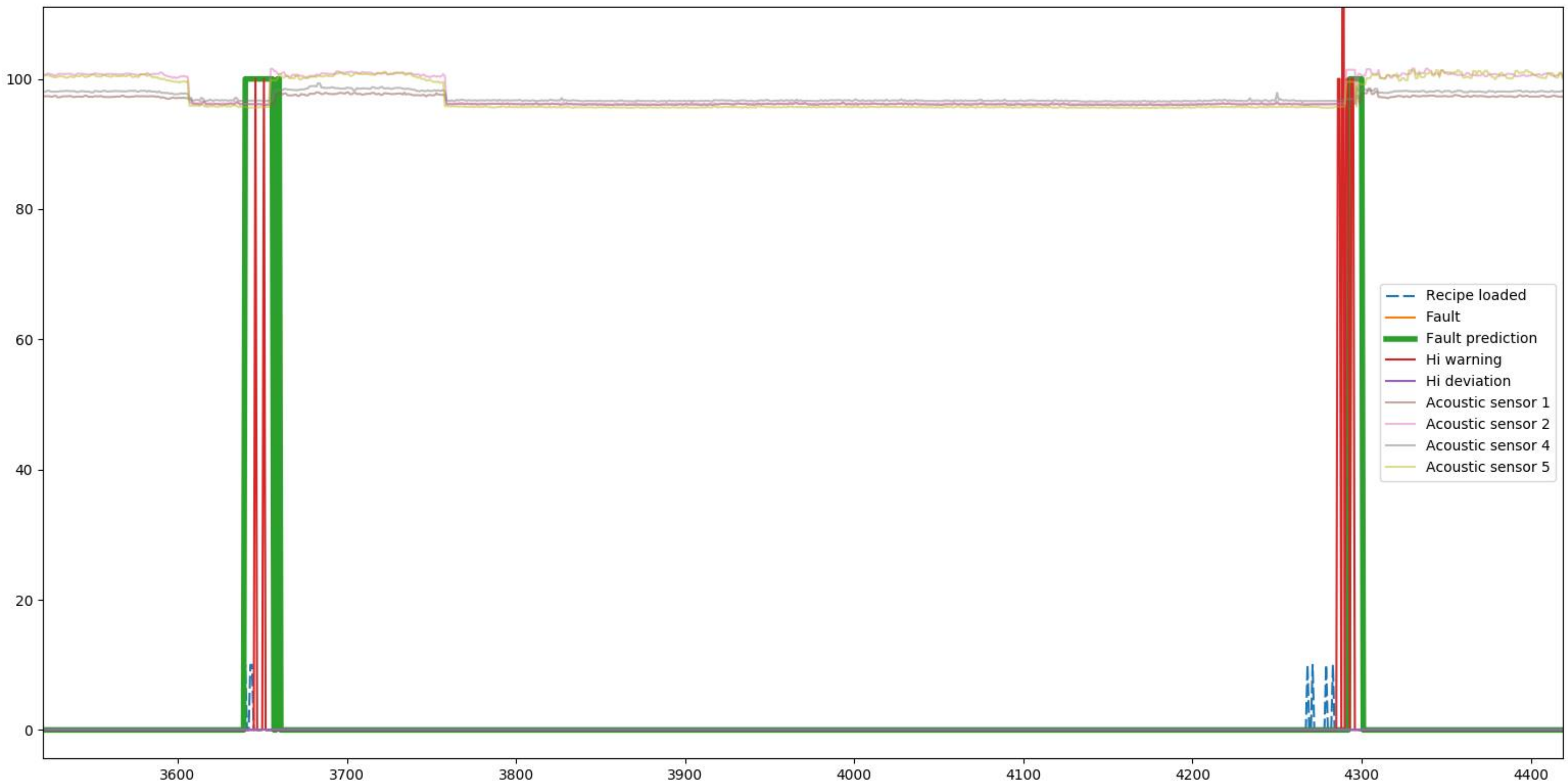
# DLT – intrafactory – predictions on test dataset with audio, look ahead 16 samples - trial 2



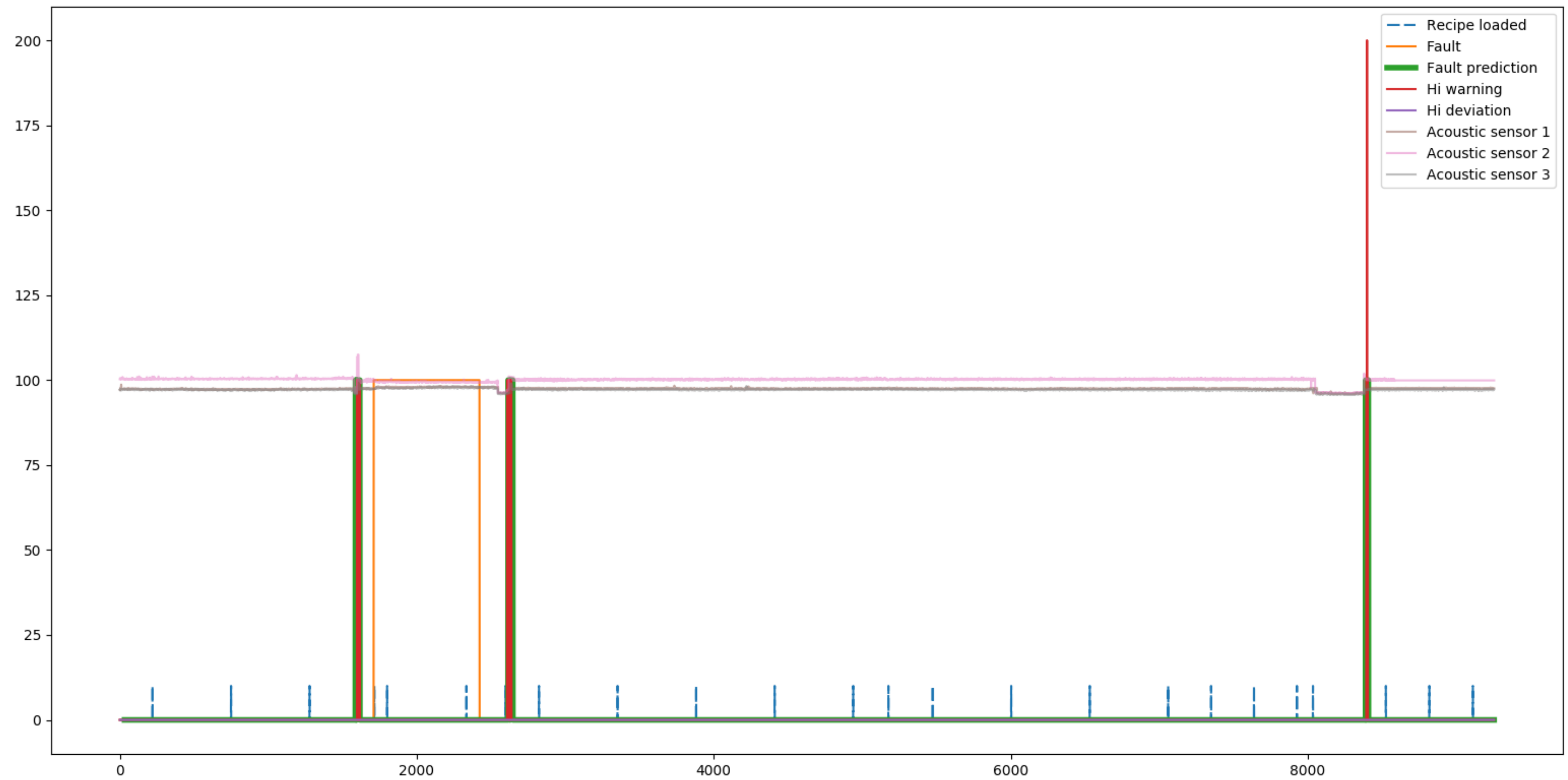
# DLT – intrafactory – predictions on test dataset with audio, look ahead 16 samples – trial 3



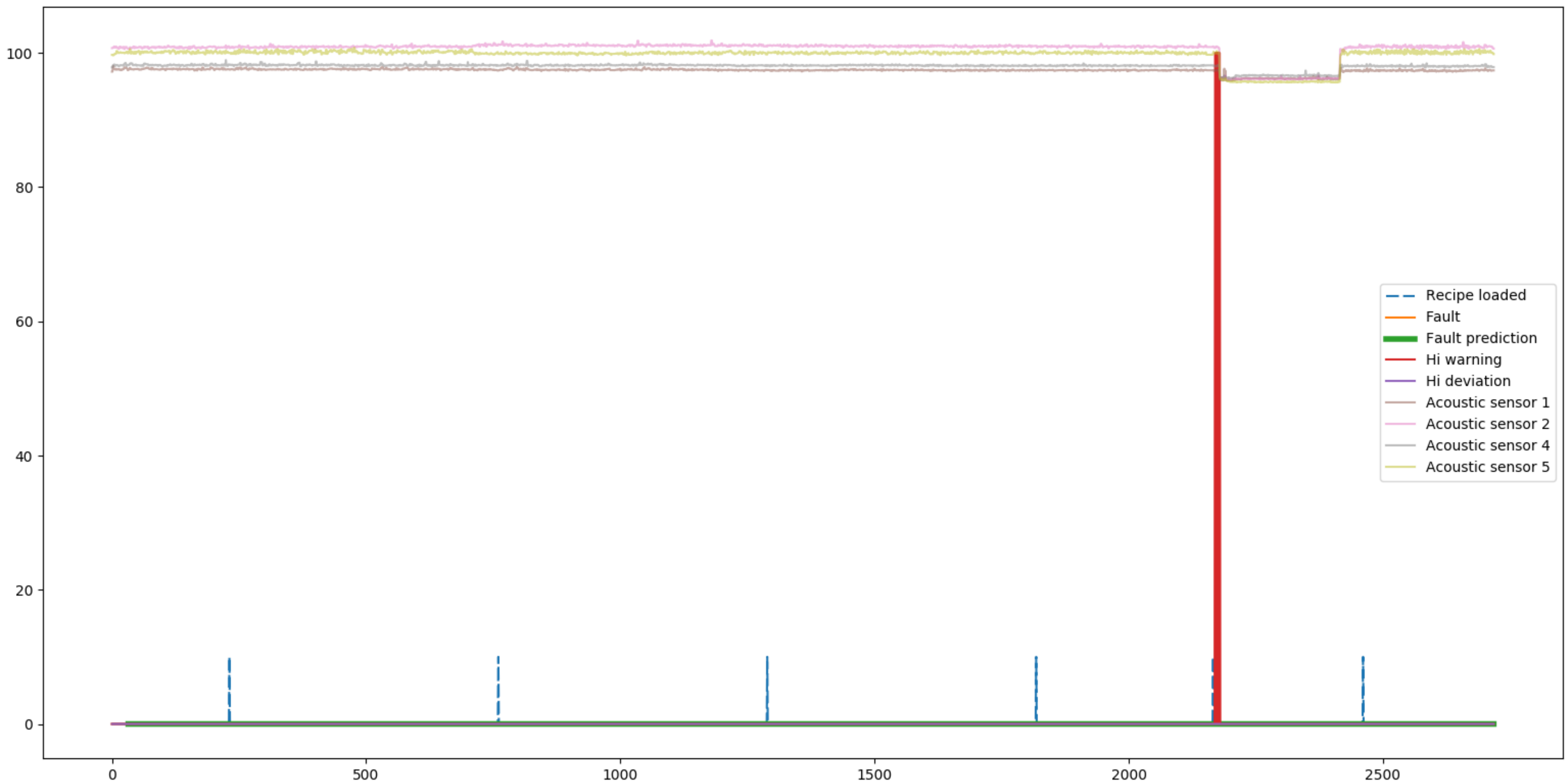
# DLT – intrafactory – predictions on test dataset with audio, look ahead 16 samples – trial 3 zoomed



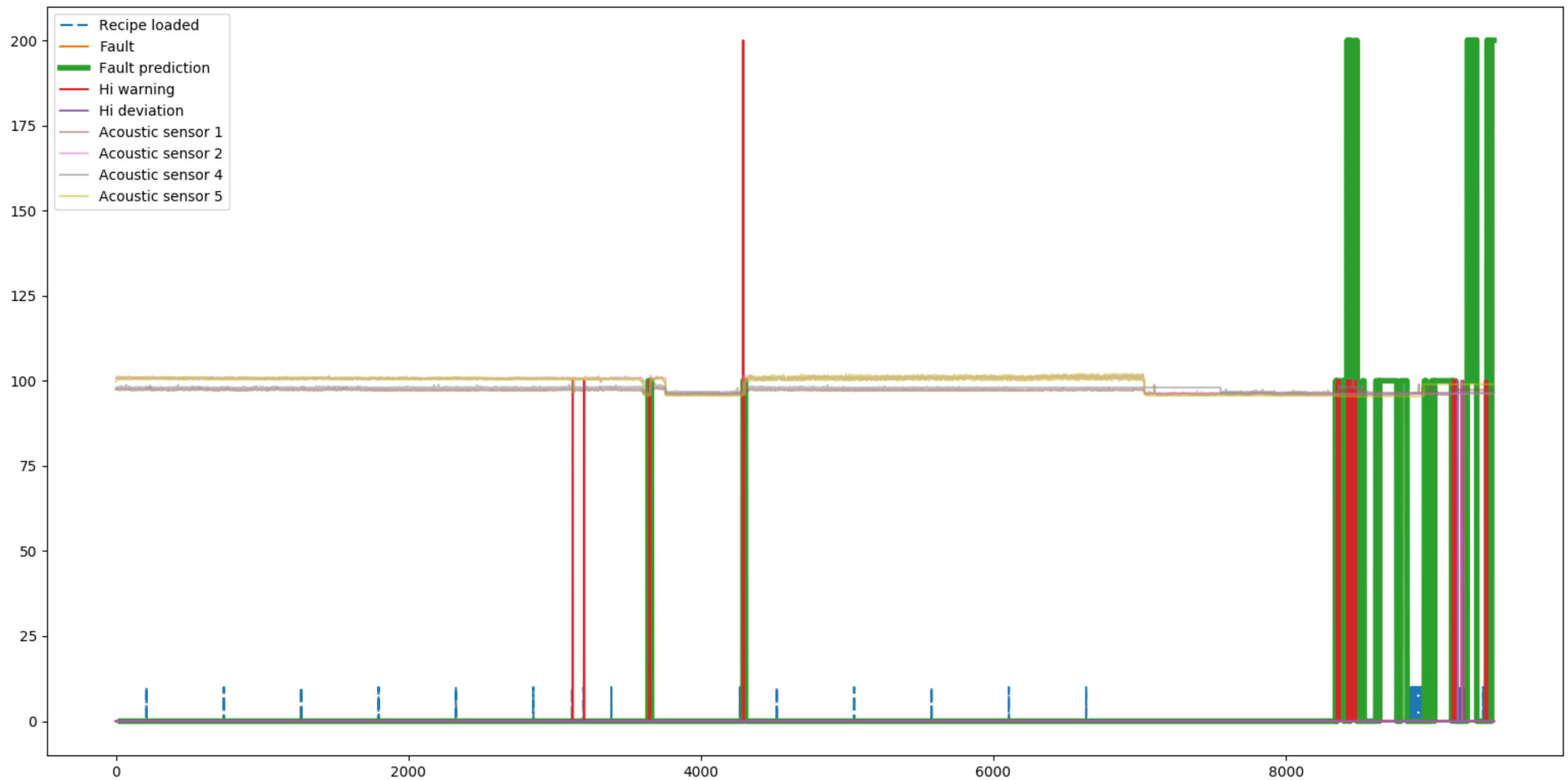
# DLT – intrafactory – predictions on test dataset with audio, look ahead 16 samples – trial 4



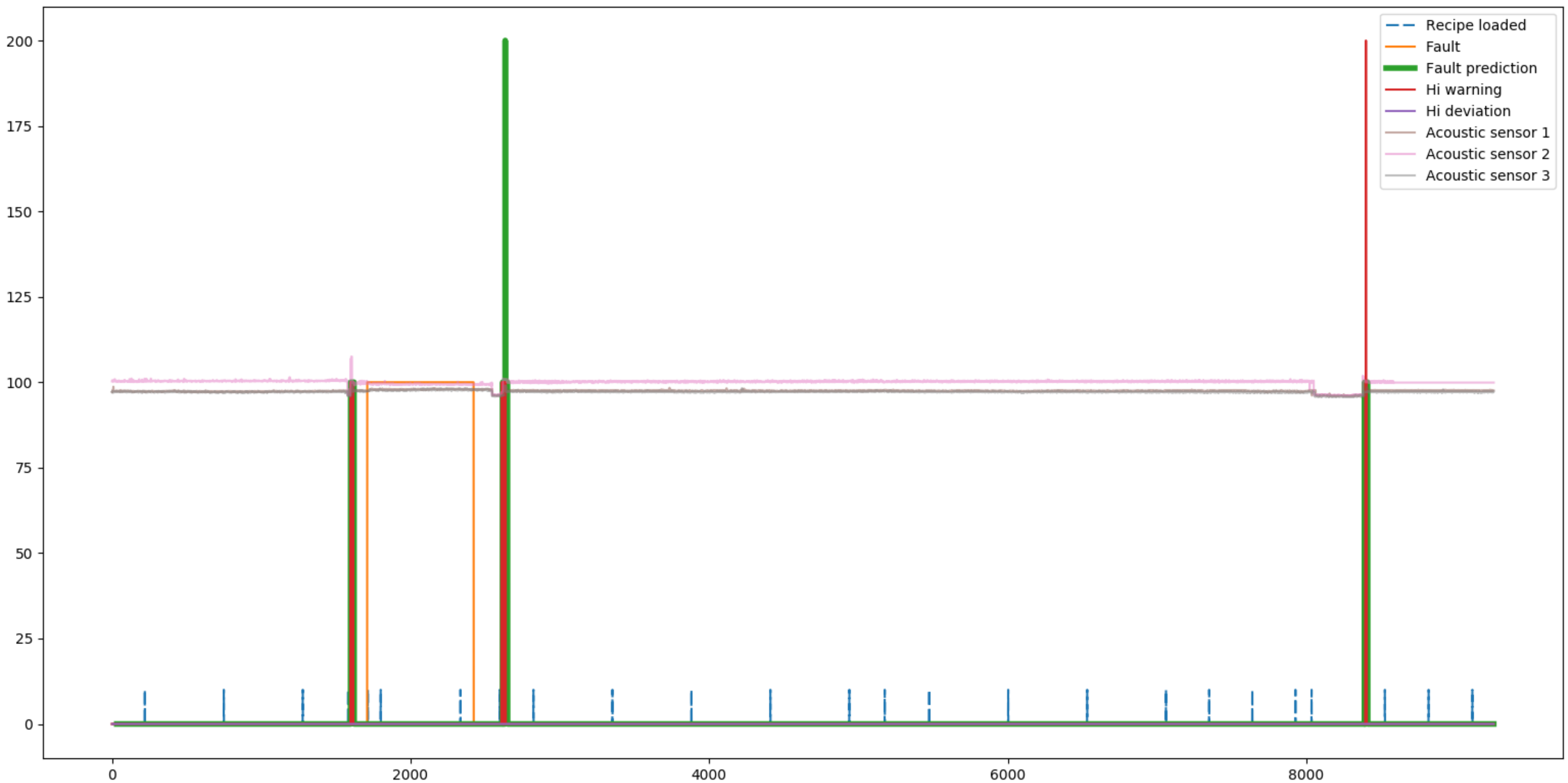
# DLT – intrafactory – predictions on test dataset with audio, look ahead 16 samples weighted – trial 2



# DLT – intrafactory – predictions on test dataset with audio, look ahead 16 samples weighted – trial 3



# DLT – intrafactory – predictions on test dataset with audio, look ahead 16 samples weighted – trial 4

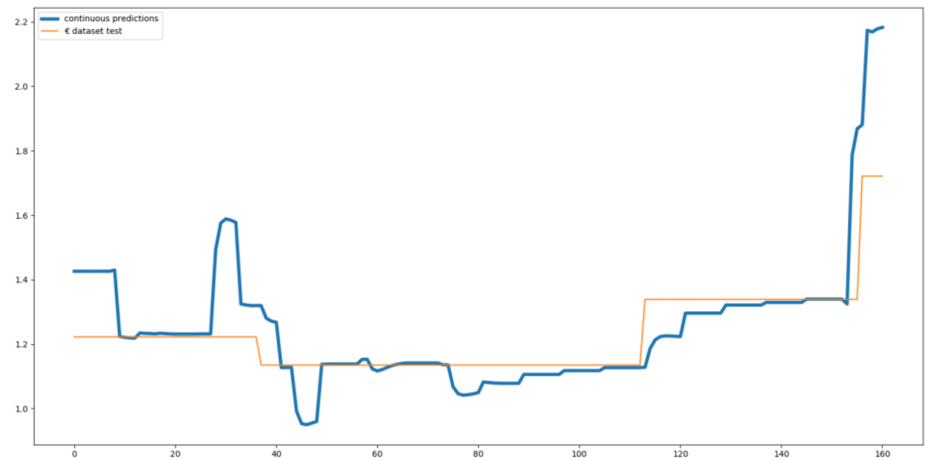


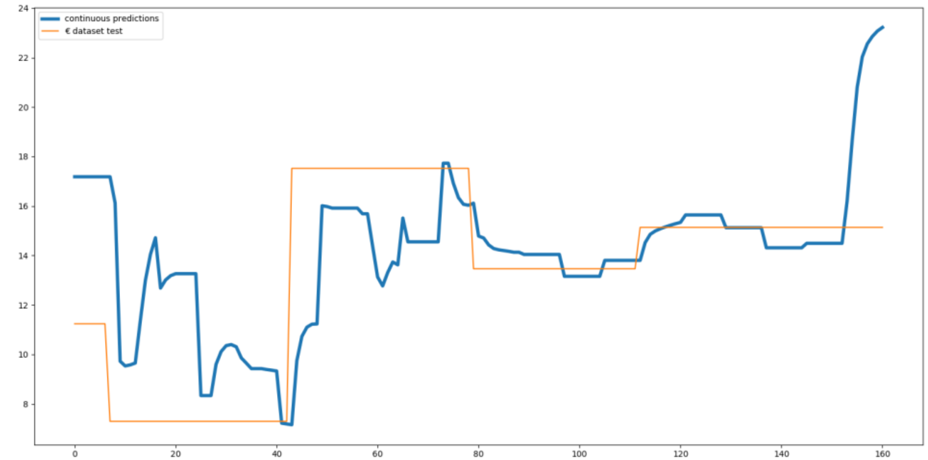
# Deep Learning approach in COMPOSITION – inter-factory scenario (I)

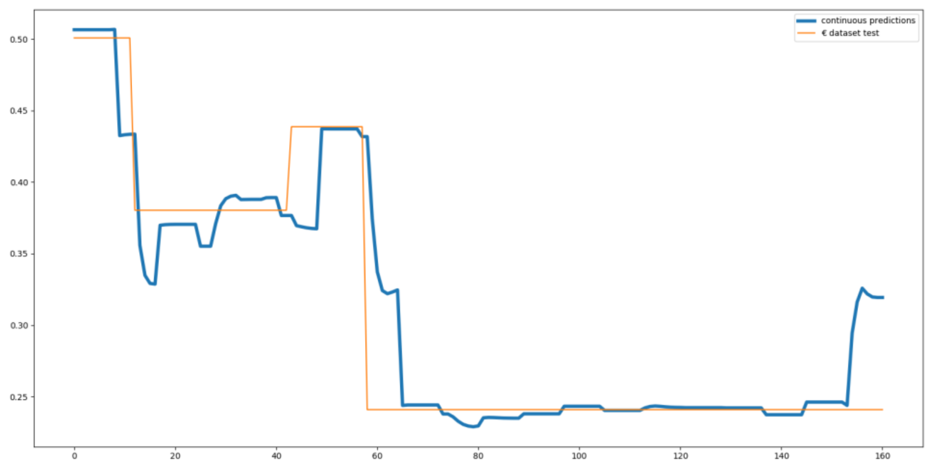
- Provide intelligence to the agents that form the agent-based marketplace
  - marketplace parameters estimation
    - historical data
    - matchmaking policies
    - learned transaction
- Continuous learning
  - triggered by inter-factory agents and learning framework

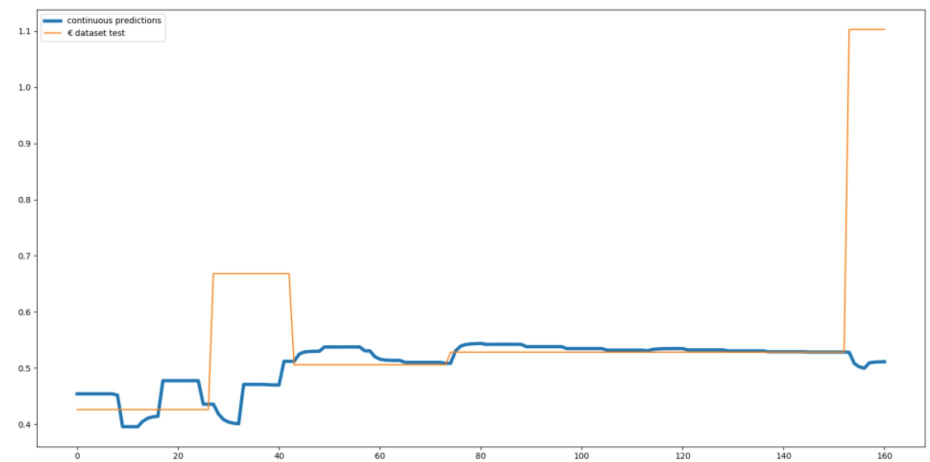
# Deep Learning approach in COMPOSITION – inter-factory scenario (II)

# Deep Learning approach in COMPOSITION – intra-factory scenario (III)



# Future work (I)

- Experiment novel ANNs topologies
- More datasets to be evaluated alongside contextual markets information
- Enhance connection with matchmaking for extending the available information to be evaluated, consolidating the accuracy and improving reliability
- Extend current ontologies for supporting a broader range of possibly market correlated information, coming from heterogeneous sources (e.g. factors that influence stock market)

# Future work (II)

Other challenges might be faced in different use cases by the DLT, based on different requirements:

UC-KLE-1: polishing machine predictive maintenance

- existing historical dataset with few recorded parameters
- no reported failures

UC-KLE-4: agent-based marketplace intelligence

- round trip time calculation and estimation by statistical models in simulation and forecasting tools
- bin fill level estimation with new deployed sensors

COMPOSITION

# Thanks for your attention



COMPOSITION has received funding from the European Union’s Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement No 723145.



Please see us here: www.composition-project.eu