Automating ATLAS Control Room Anomaly Detection with ML

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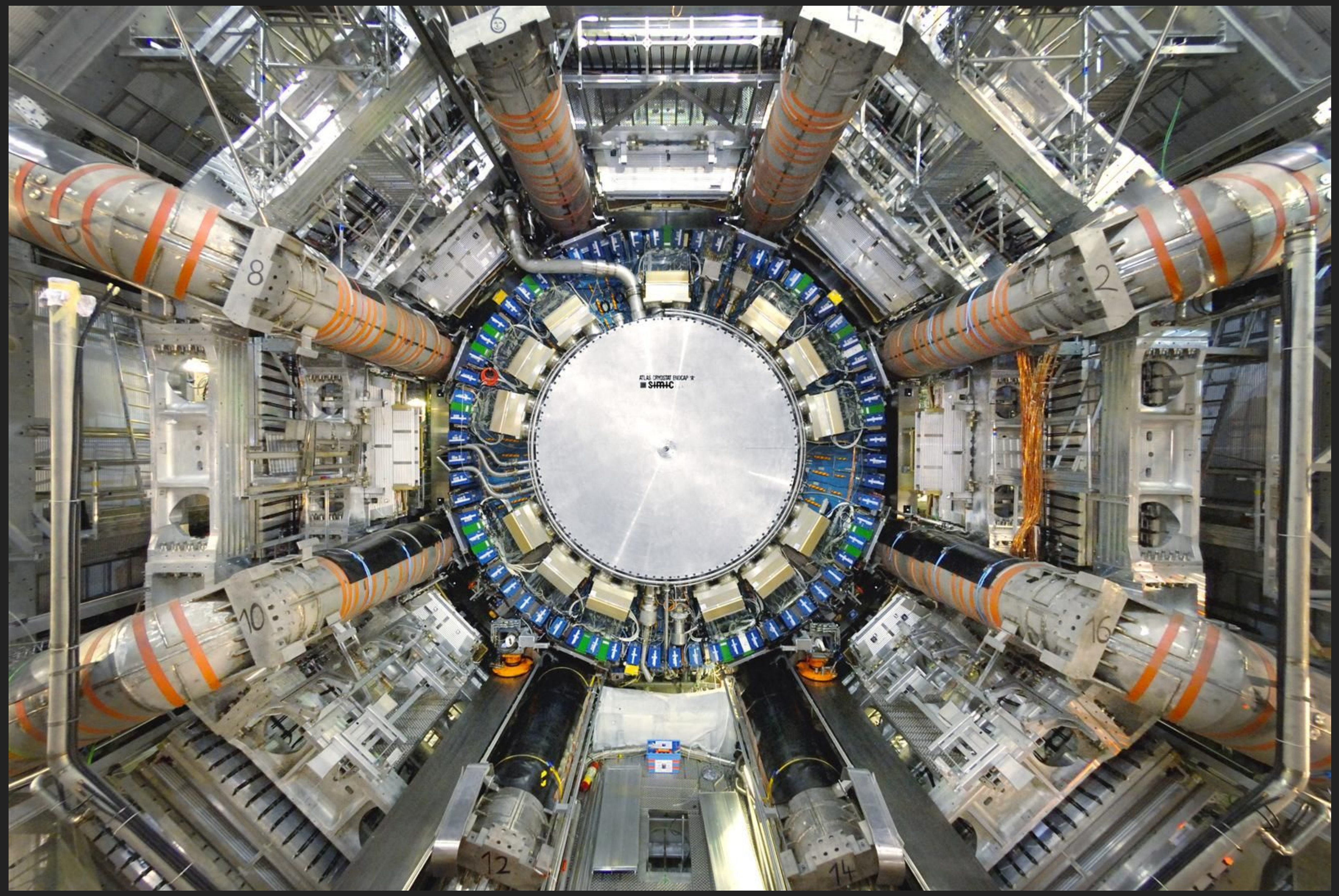
My Group

- ATLAS Experiment
  - Detector for collisions in LHC
  - Understand fundamental particles and forces
- UCL Centre for Data Intensive Science
- Mentors: Mario Campanelli, Antoine Marzin (CERN L1 CTP Group)



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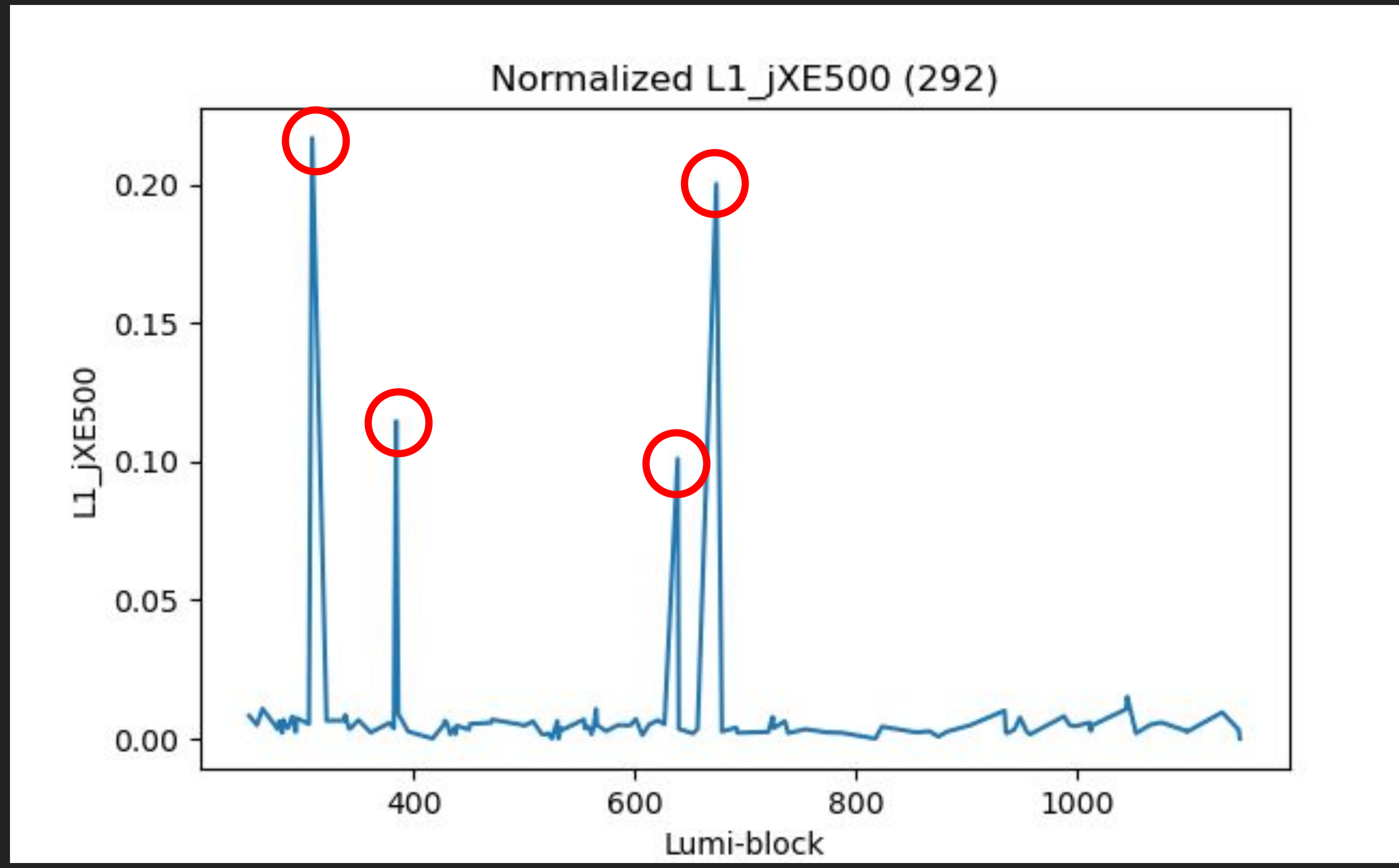
My Project

- Control room shifters watch data for anomalies indicating detector malfunction
- Online model monitoring data input and flagging anomalies
- Input time-series data on status of detectors and output whether normal or anomalous
- Experimenting with models and architecture
    - Autoencoder
    - Long short term memory (LSTM)

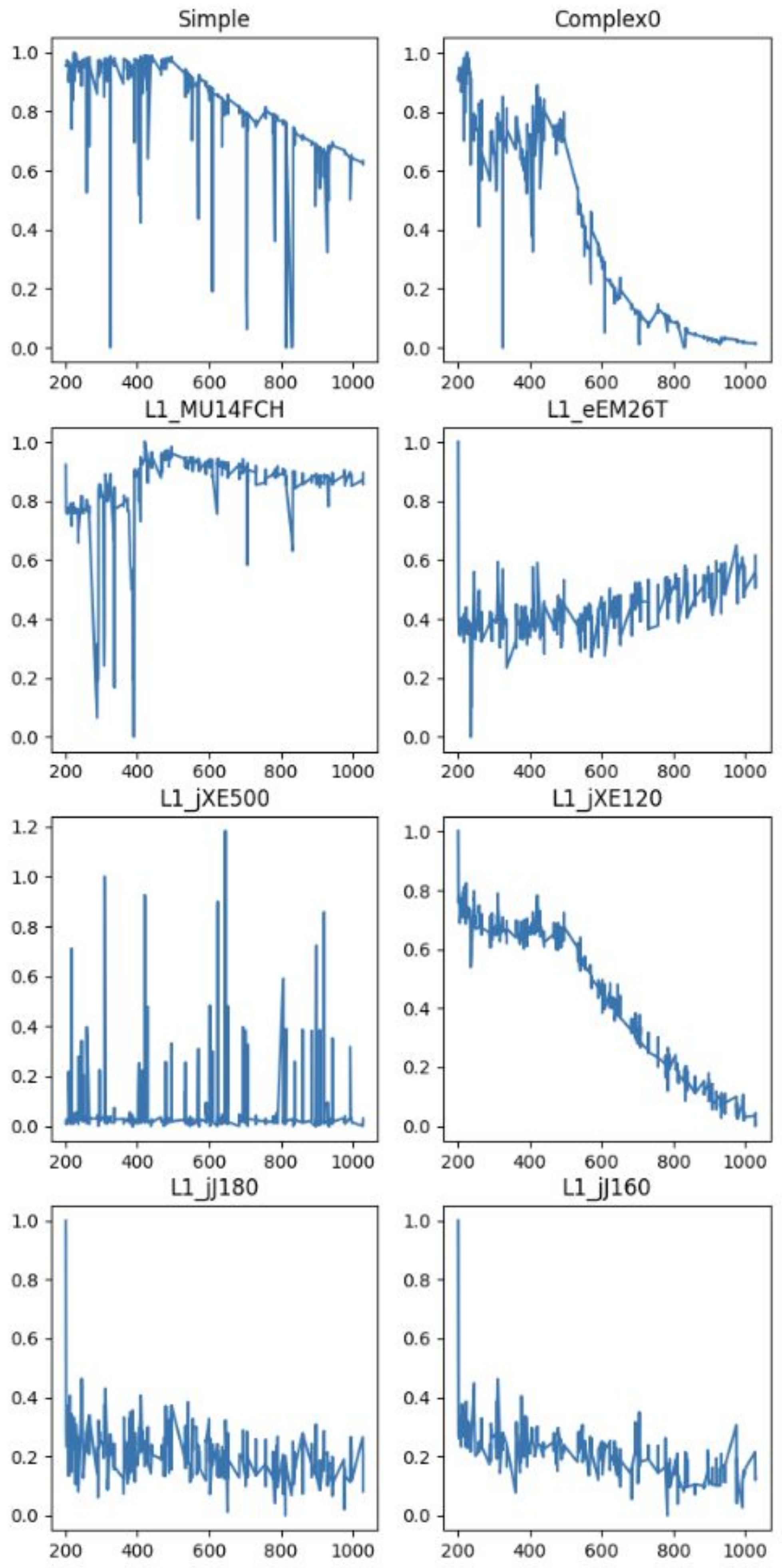


Example of input data (level 1 jet rate) with anomalies we'd like to detect circled in red

ATLAS EXPERIMENT

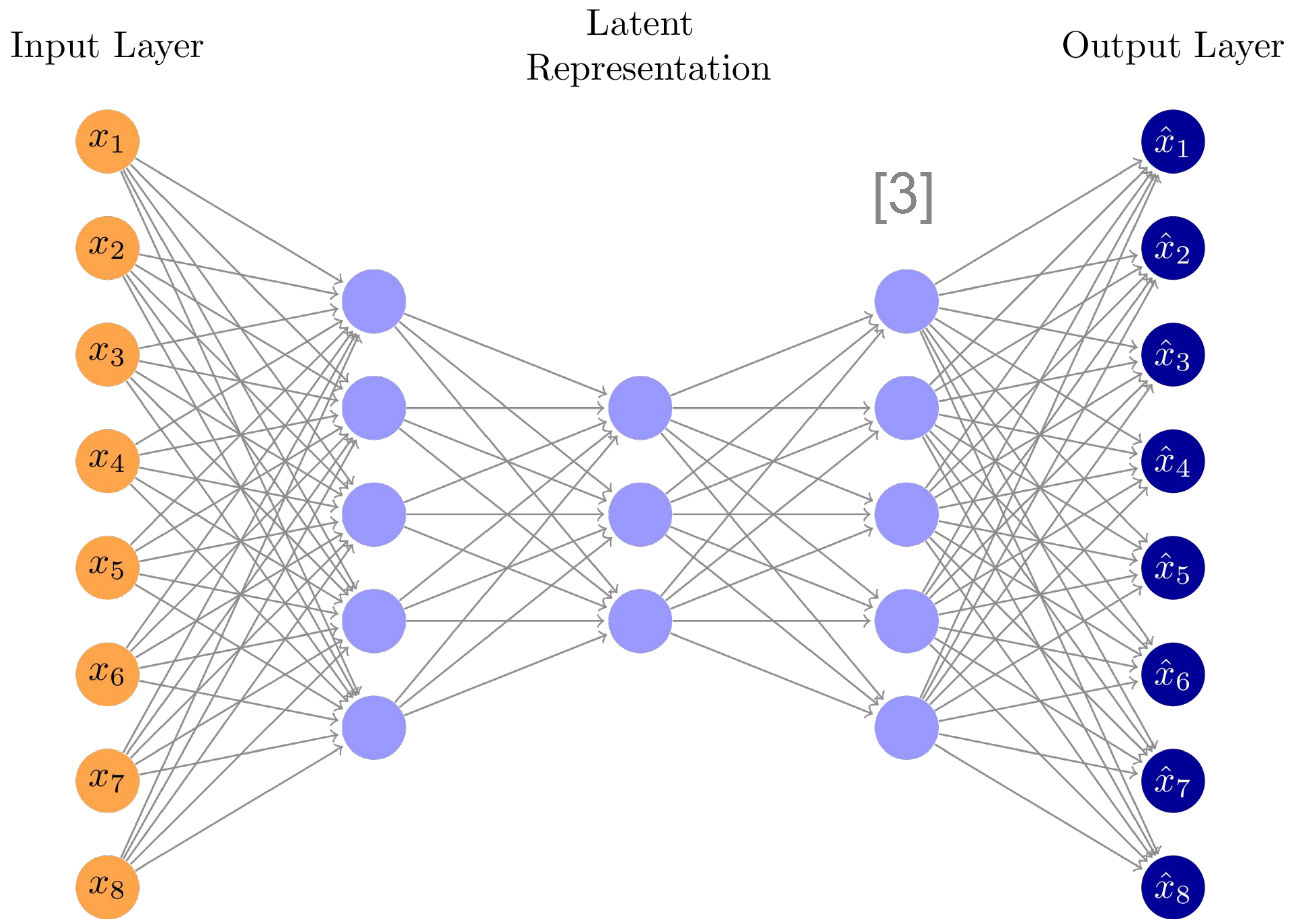
Autoencoder

Input:
Level 1 trigger rates (normalized by pileup), busy state, pileup

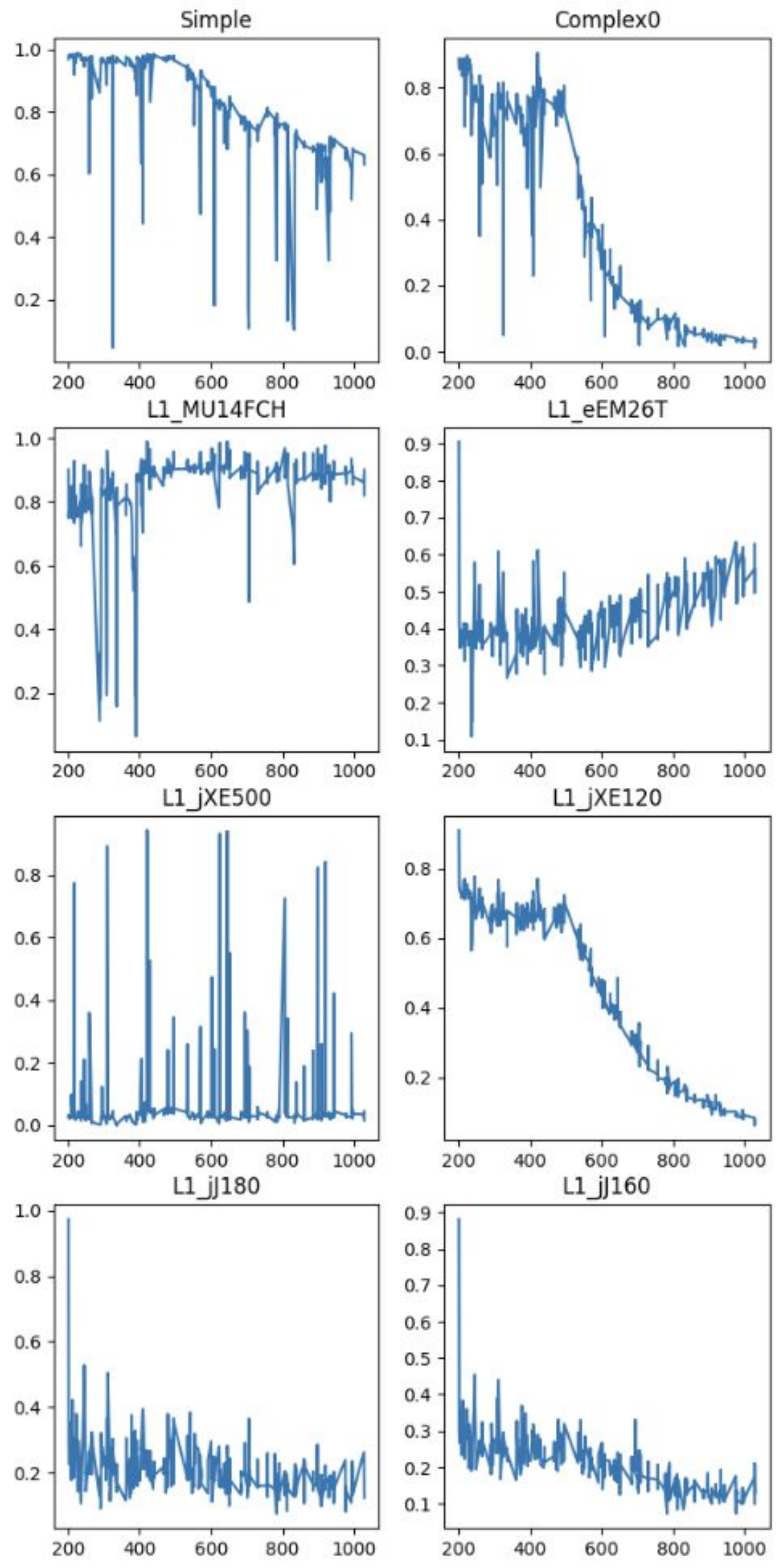


+8 additional inputs

- Goal: given input, reduce dimensionality, predict the same values as output
- Train on normal data minimizing MSE
- Anomalous data produces spikes in MSE

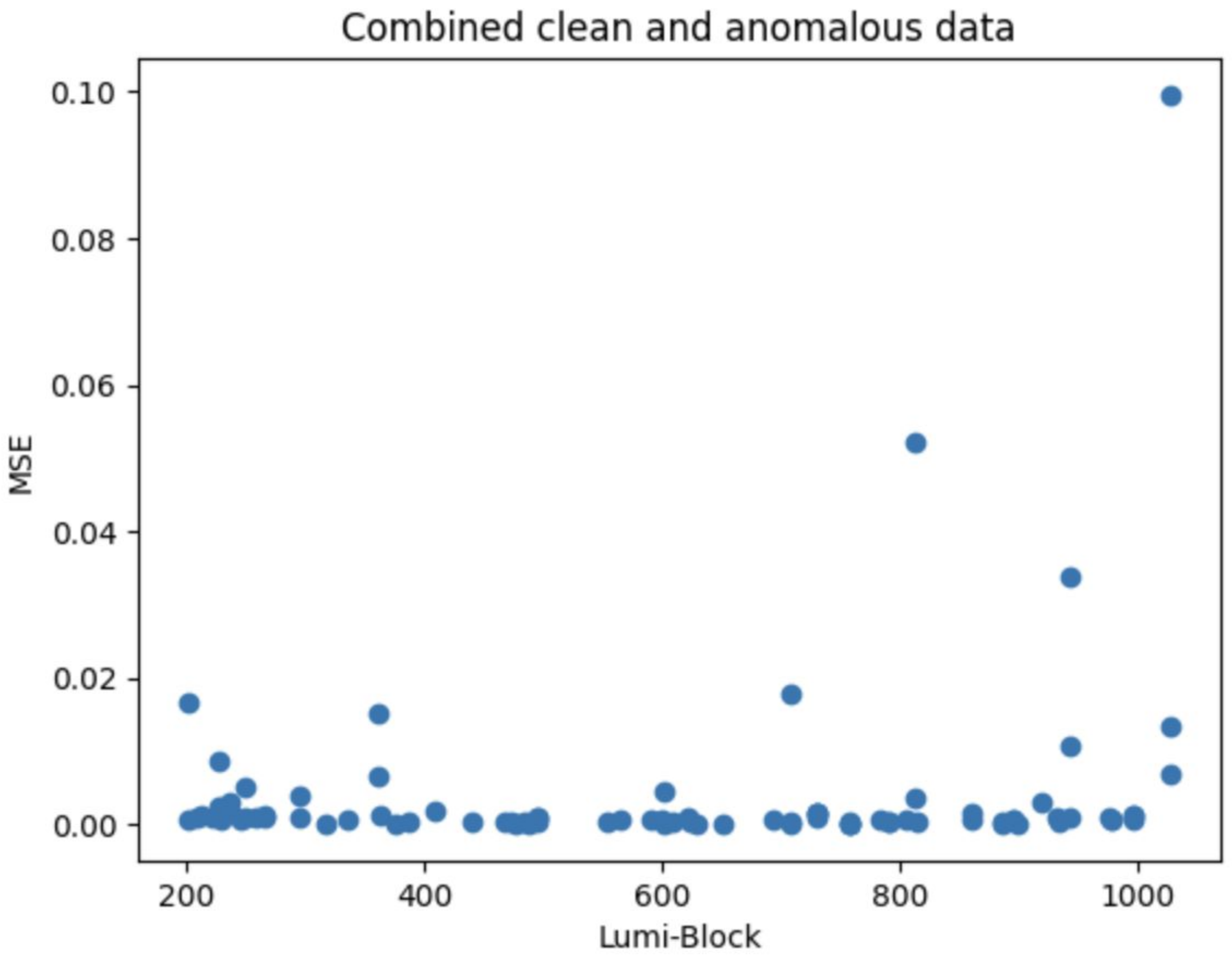


Output:
Mirror of input

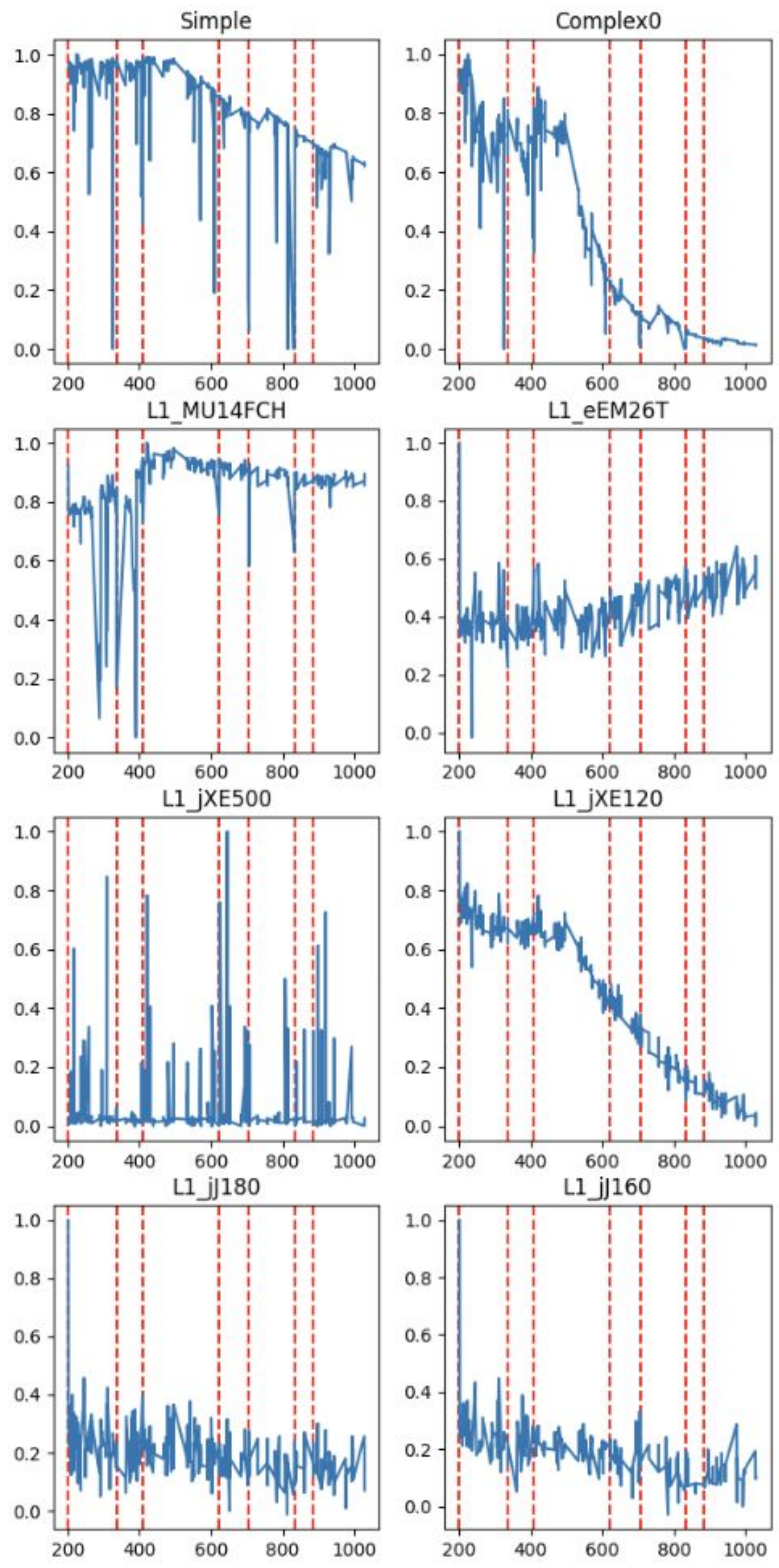


+8 additional outputs

Autoencoder

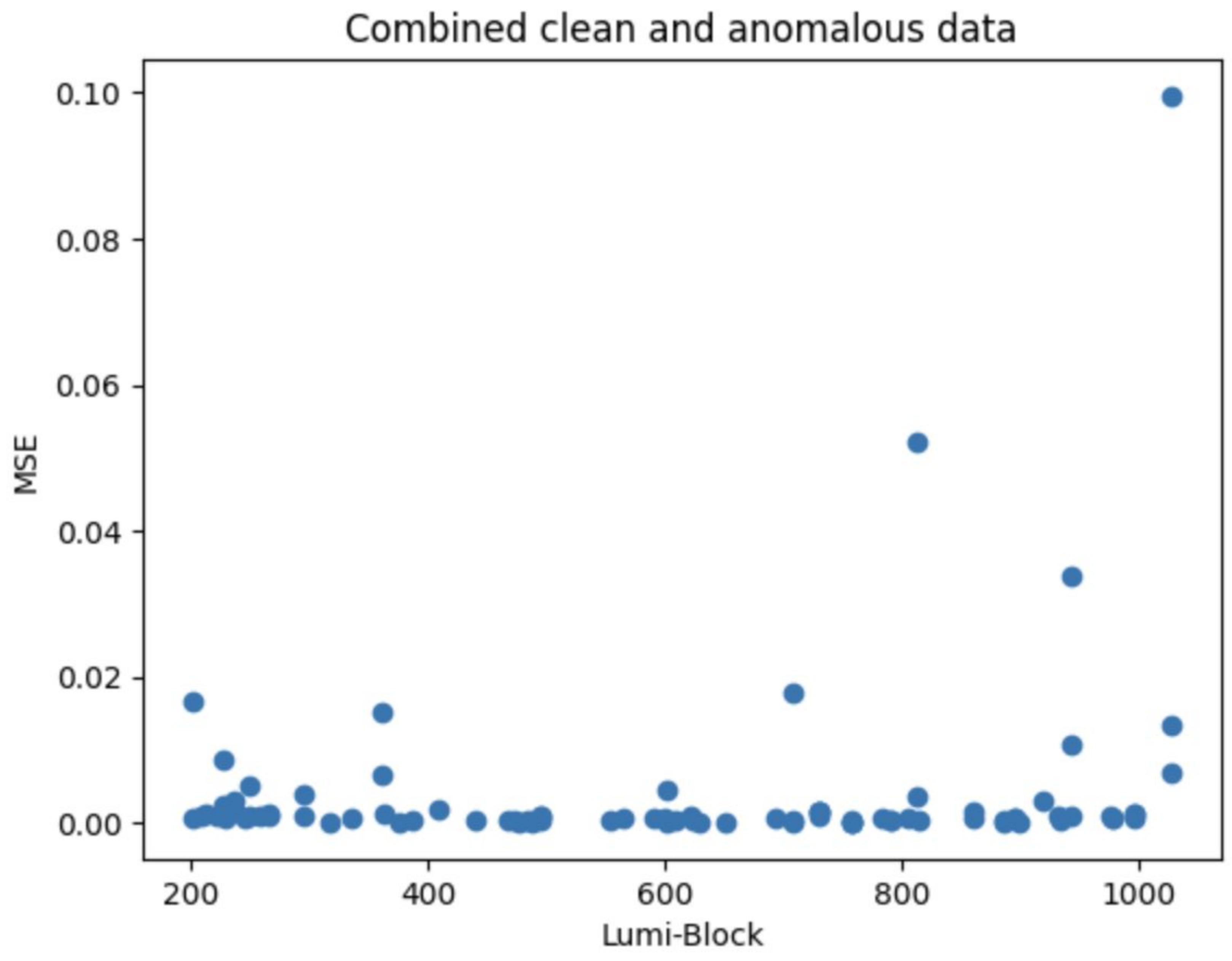


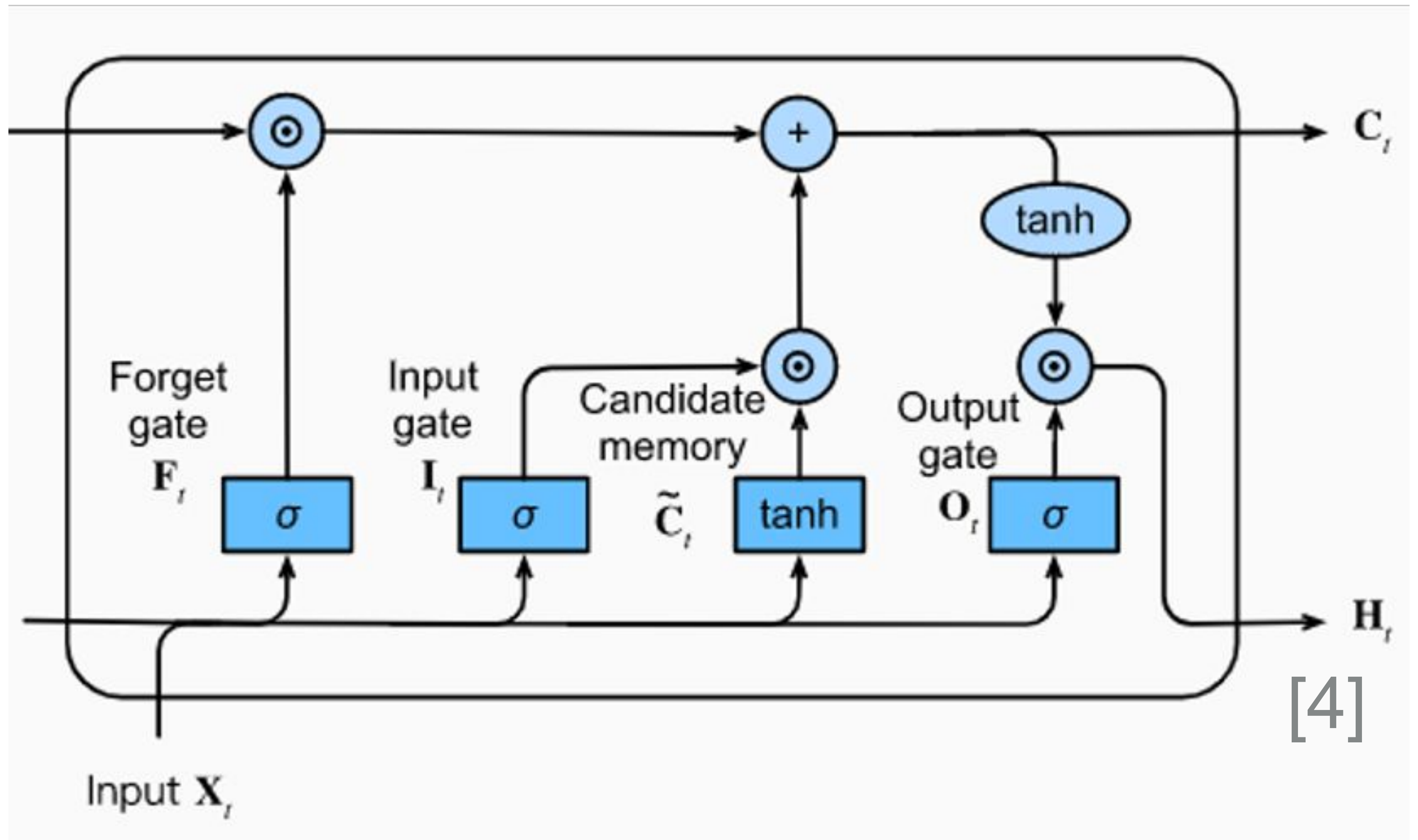
- MSE distance between input and output of autoencoder
- Inputs producing high MSE correspond to anomalies in data



Long Short Term Memory

- Anomalies can last longer than one time unit (about 1 minute) so LSTM allows us to build in memory
- Based on last 5 data points, predict next data point
- Compare prediction with next input and use mse to decide if normal or anomalous
- Train on normal data, so that high mse corresponds to anomalies





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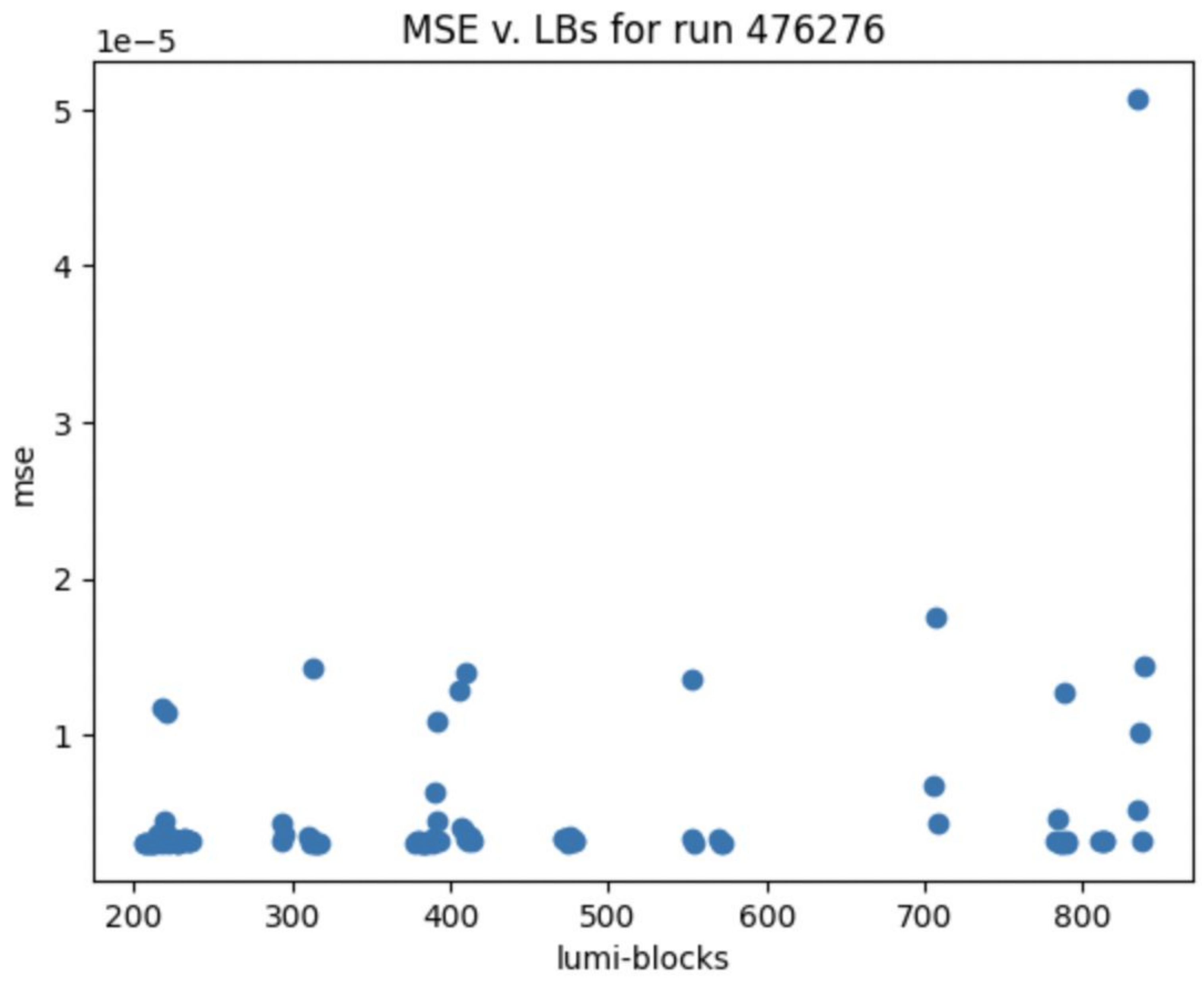
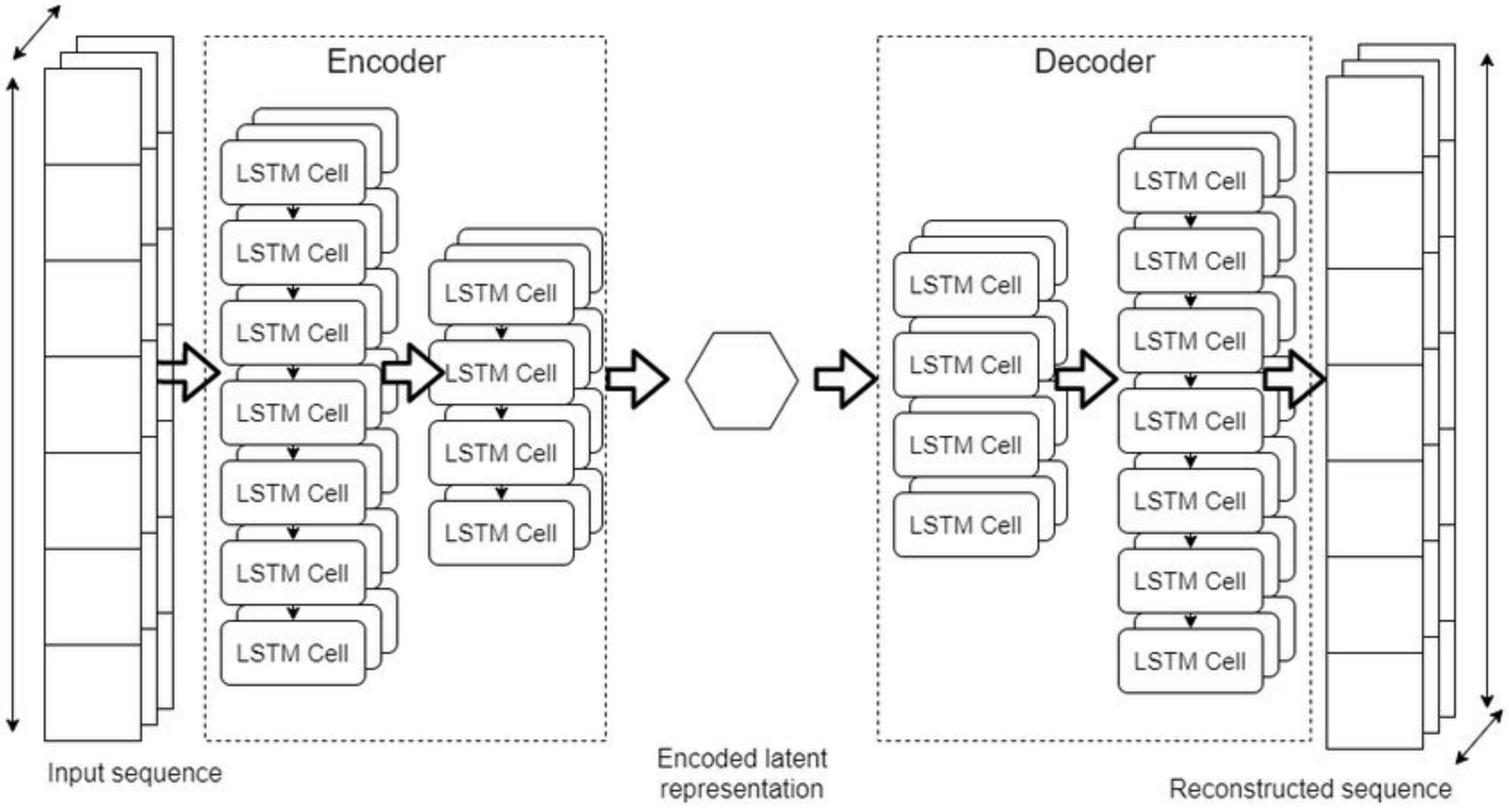


Next Steps

- Expand data for training
  - Number of runs
  - Additional features
- More extensive testing
  - Assess performance on real anomalous runs
- LSTM Autoencoder
  - Build in memory around original inputs rather than autoencoder output



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EXPLORING

Image Credits

[1] Romainbehar, CC0, via Wikimedia Commons

[2] CERN; https://www.home.cern/science/experiments/atlas

[3] Riebesell, Janosh; https://tikz.net/autoencoder/

[4] Dive into Deep Learning; https://d2l.ai/chapter_recurrent-modern/lstm.html

[5] Unsupervised marine vessel trajectory prediction using LSTM network and wild bootstrapping techniques - Scientific Figure on ResearchGate. https://www.researchgate.net/figure/Architecture-of-LSTM-autoencoder_fig1_352898971 [accessed 24 Jun, 2024]

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