

ANOMALY DETECTION IN GRAVITATIONAL WAVES DATA USING CONVOLUTIONAL AUTOENCODERS



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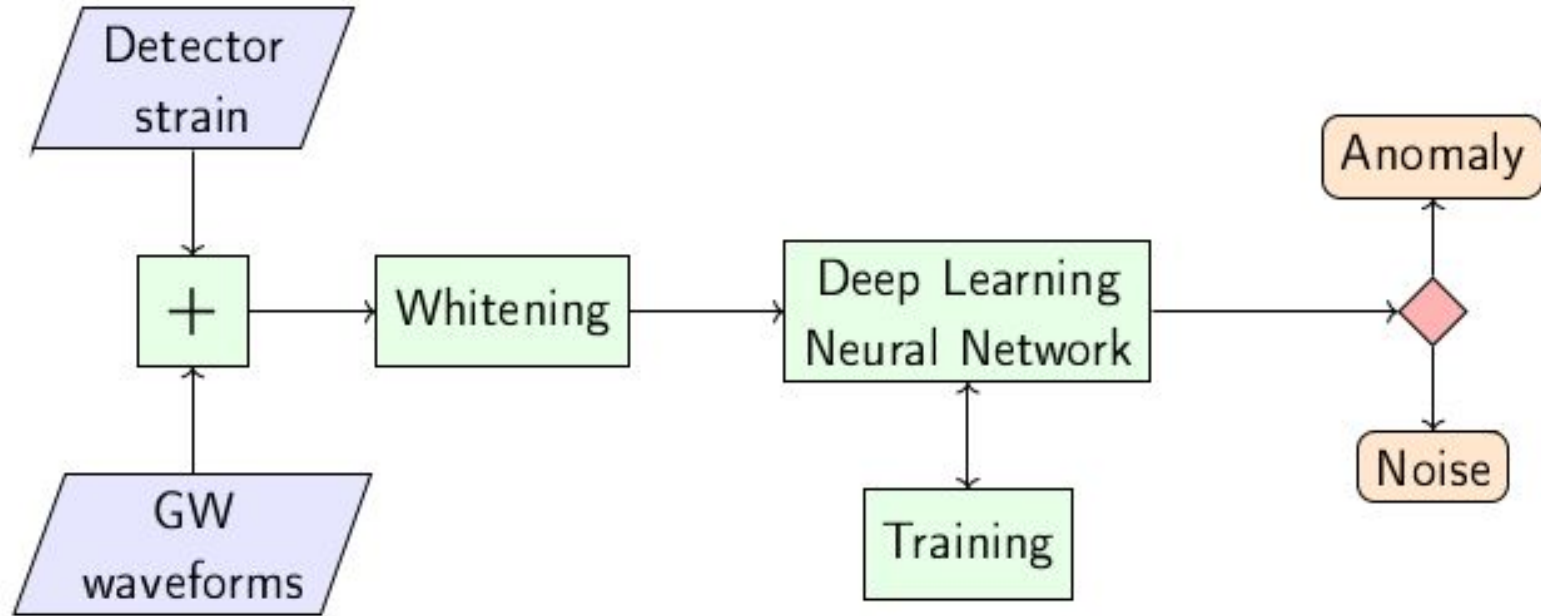
IWAPP

AIM

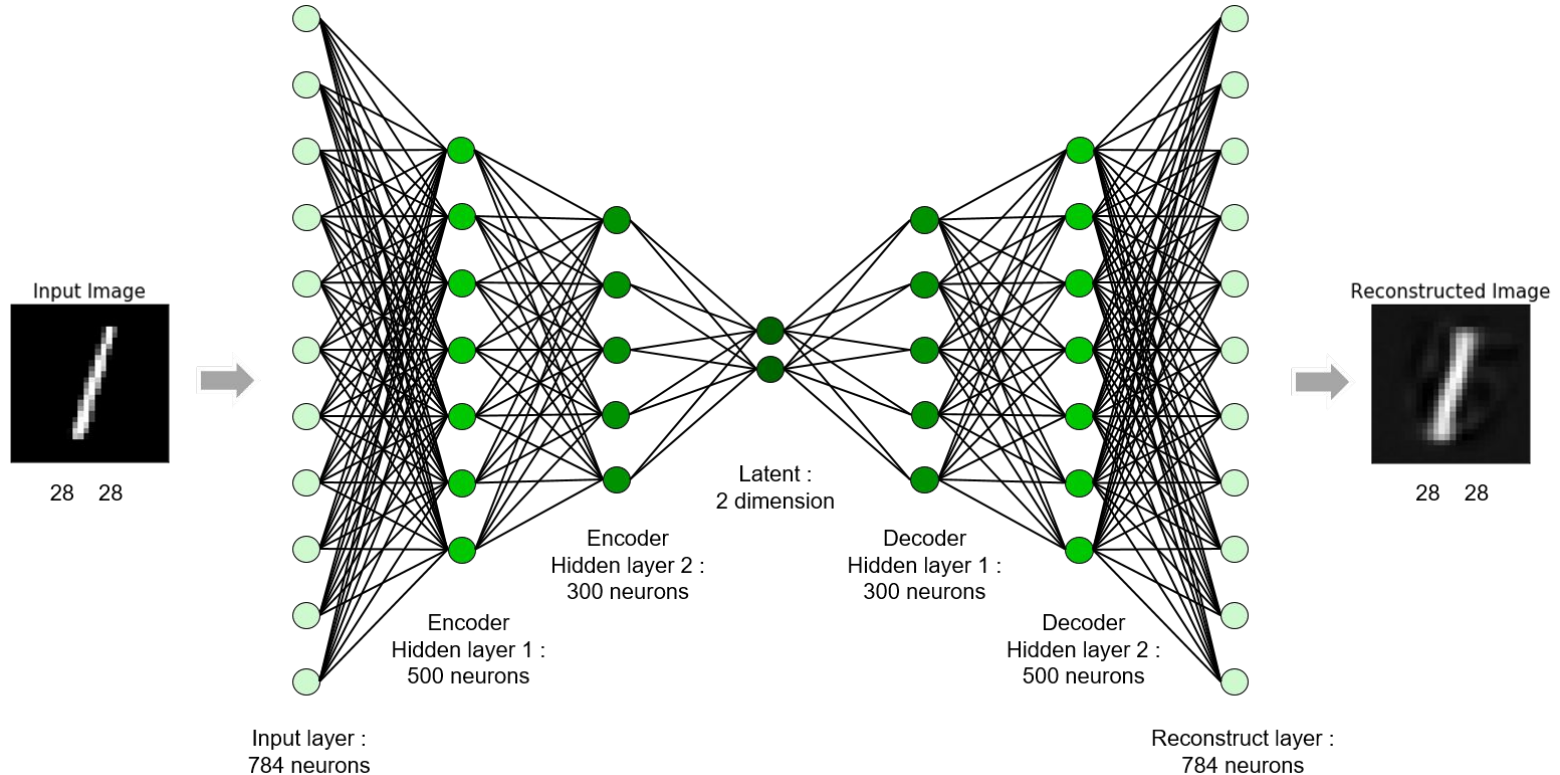
Create a deep learning pipeline allowing detection of anomalies defined in terms of transient signals: gravitational waves as well as glitches.

Additionally: Consider reconstruction of the signal for the found anomalies.

WORKFLOW



AUTOENCODER

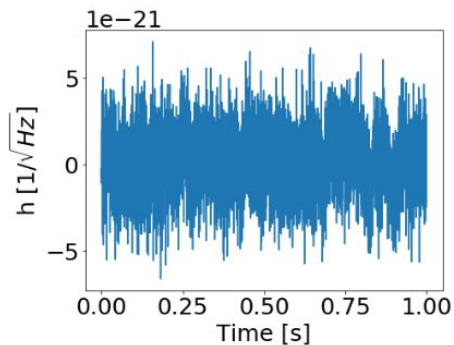
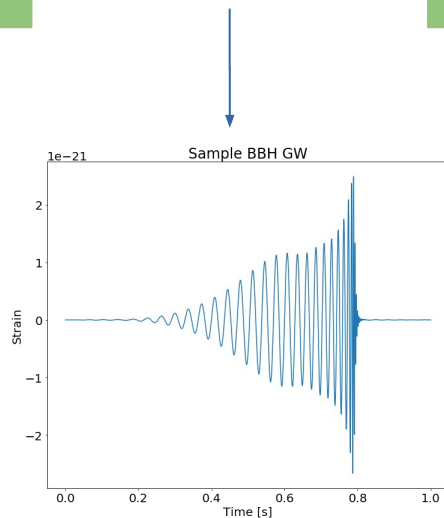
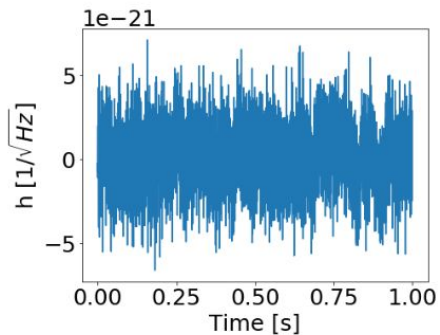


CONCEPT

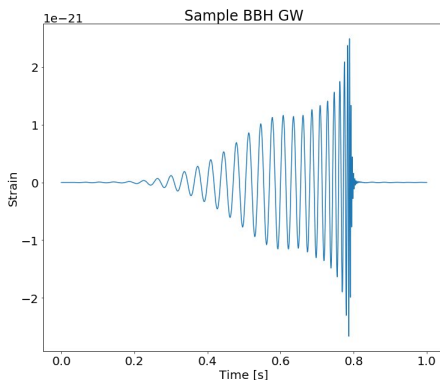
Model
input



Model
prediction



ANOMALY DETECTION METRIC



Mean Squared Error
at fixed
False Positive Rate



Detection threshold

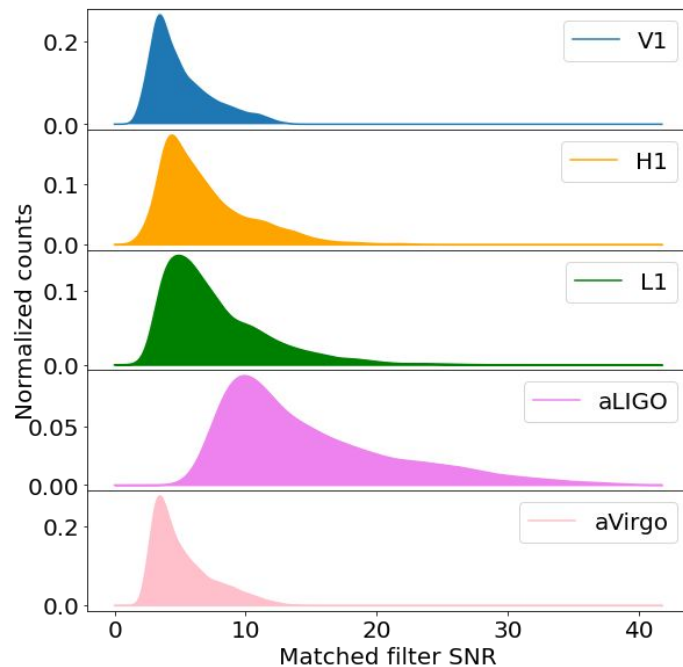
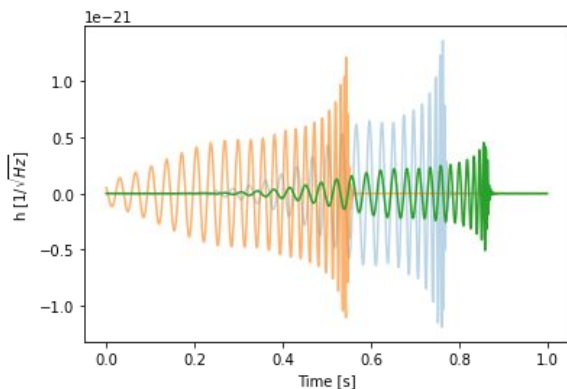
DATA

Real or simulated strain with injected anomalies – BBH GW.

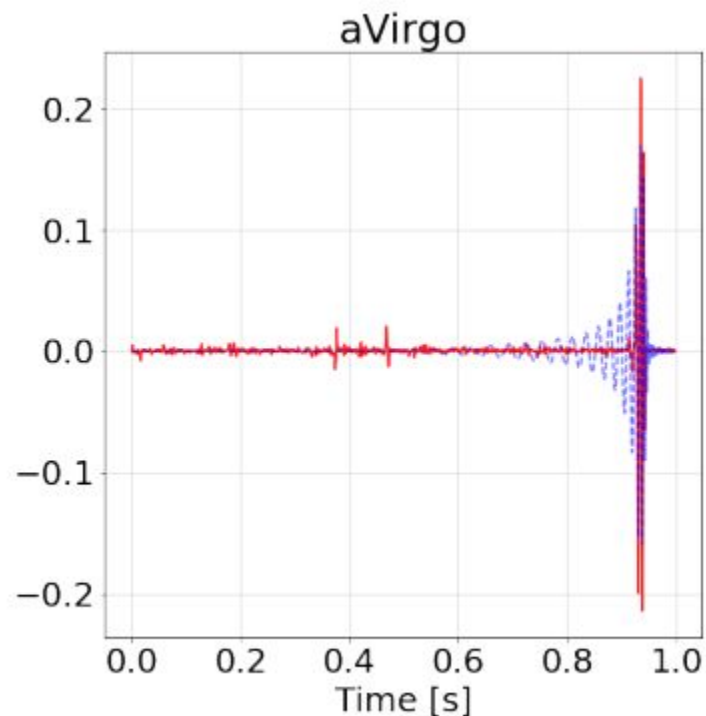
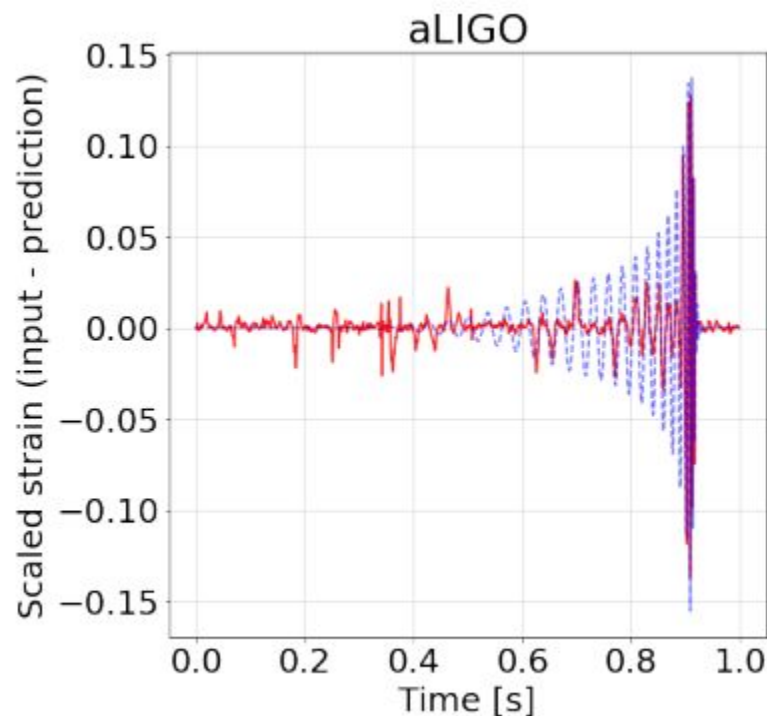
Mass range: 26–40 M_{\odot}

Distance: 200–800 Mpc

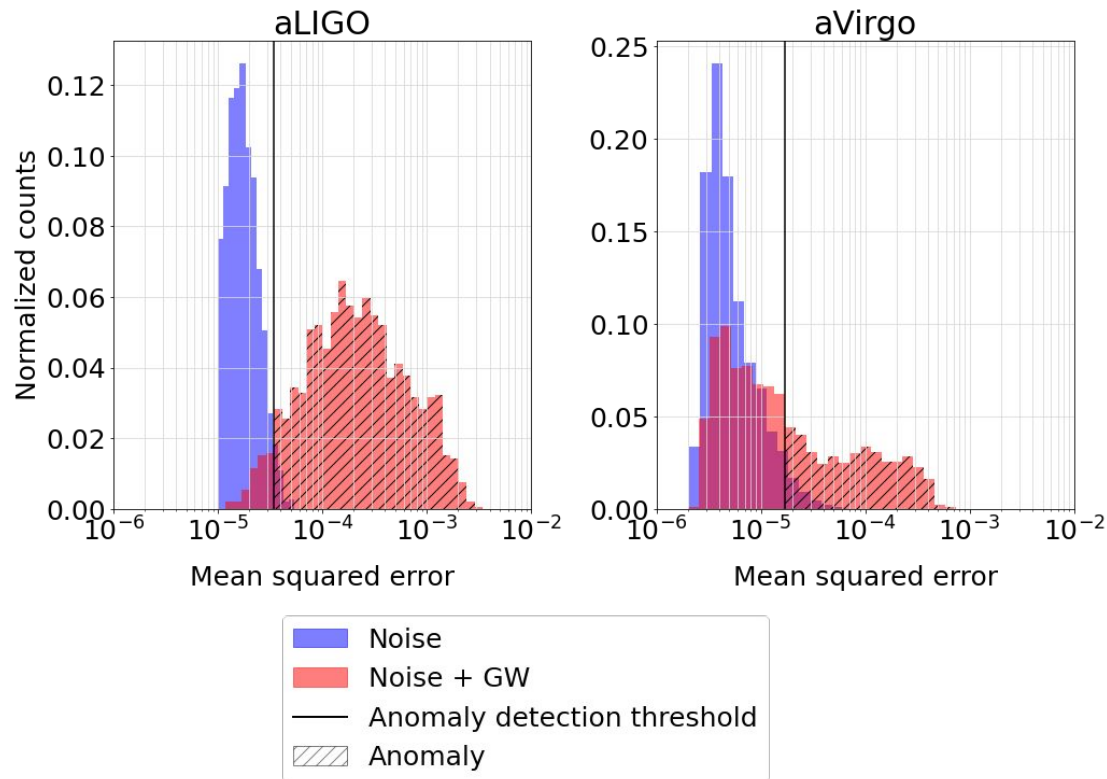
Sampling rate: 1024 Hz



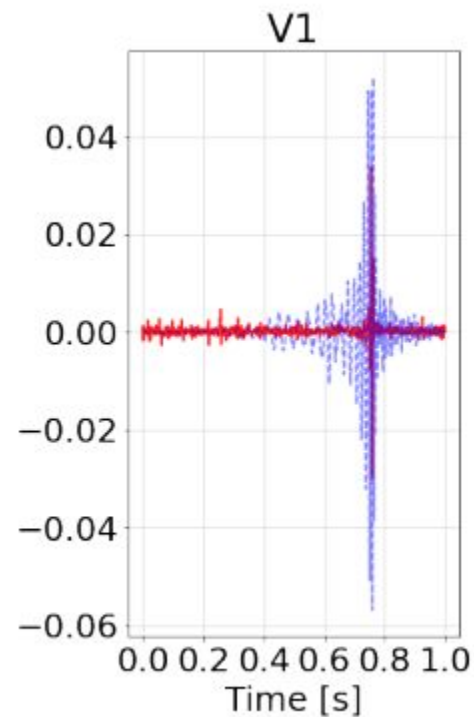
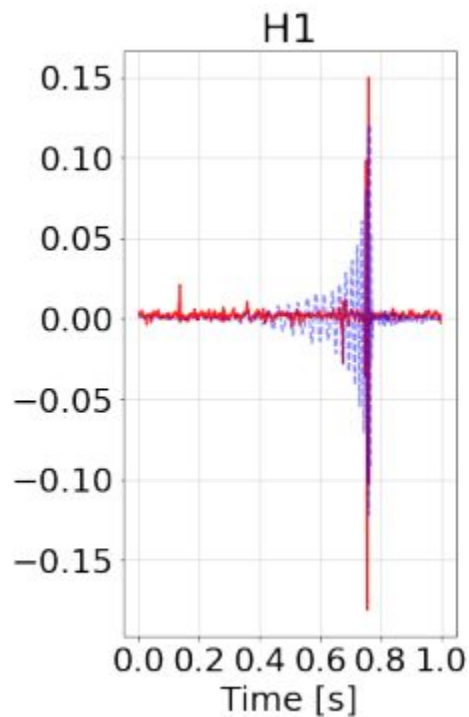
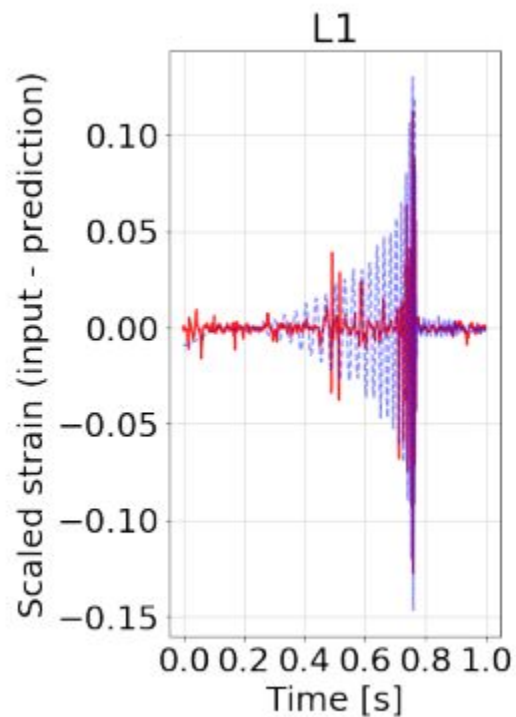
SIMULATIONS - RECONSTRUCTED SIGNAL



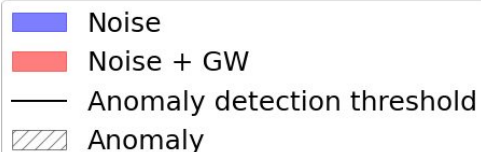
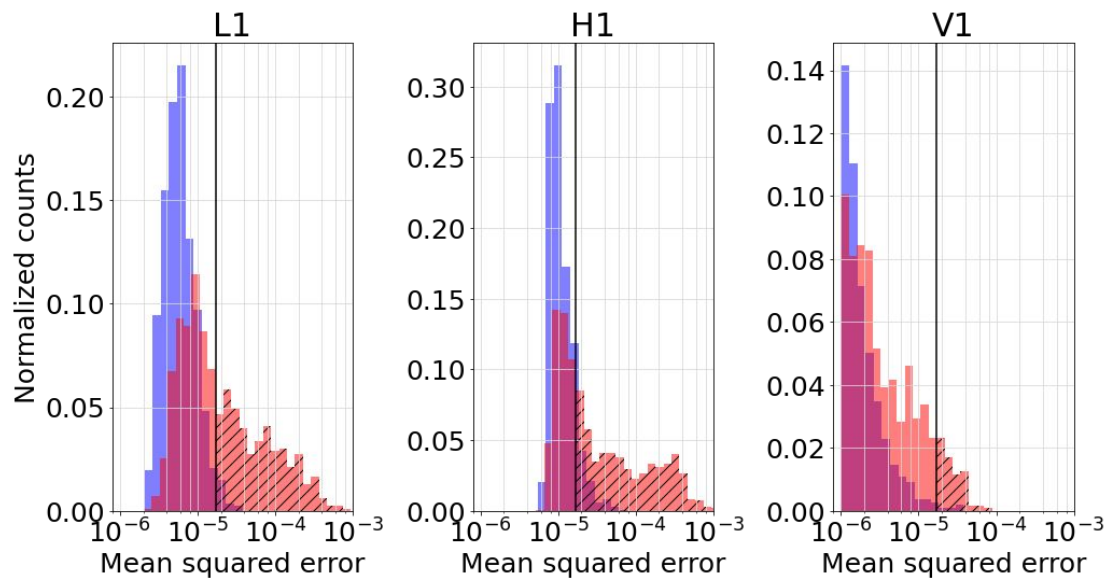
SIMULATIONS - MSE DISTRIBUTIONS



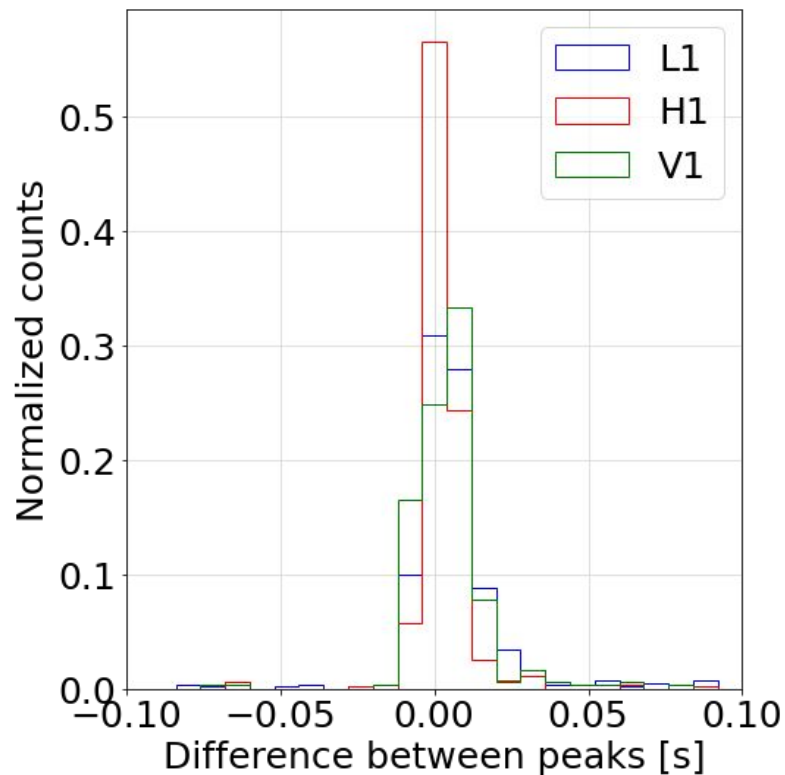
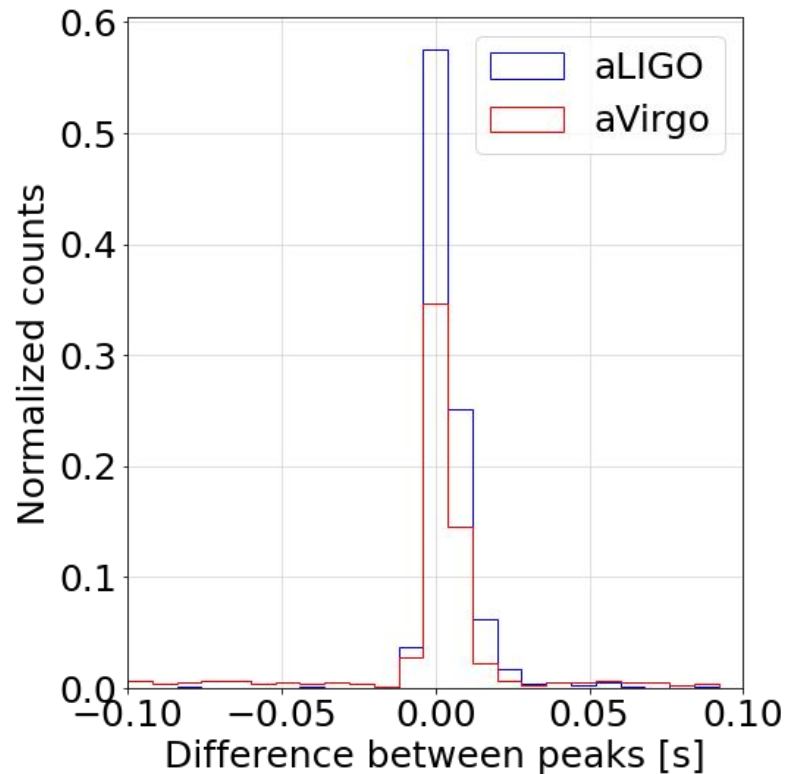
02 DATA - RECONSTRUCTED SIGNAL



02 DATA - MSE DISTRIBUTIONS

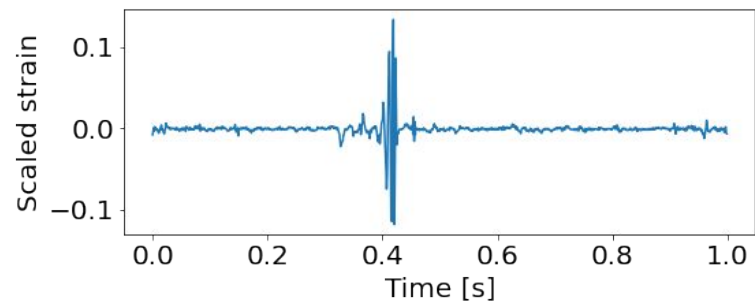
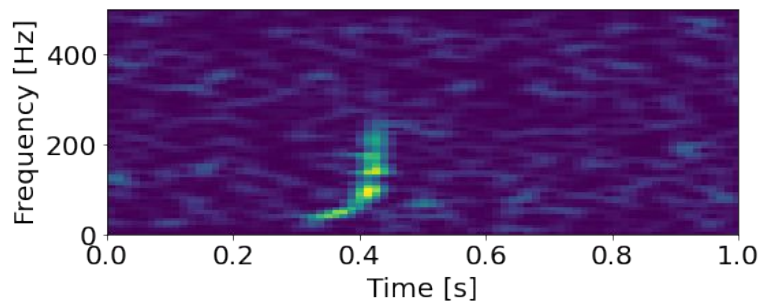


TIME LOCALIZATION

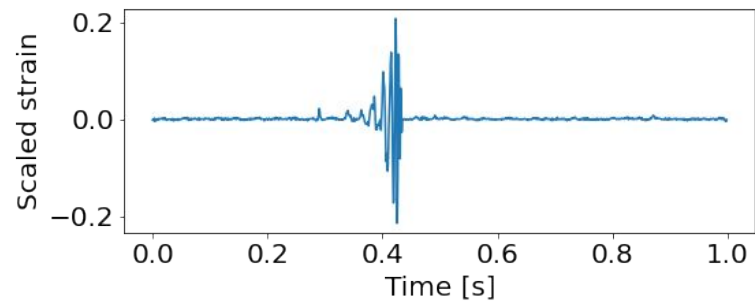
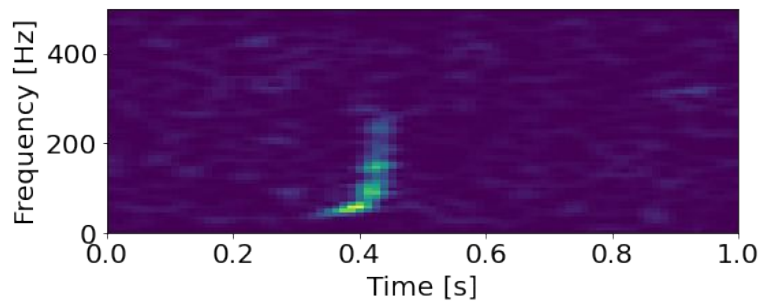


GW150914

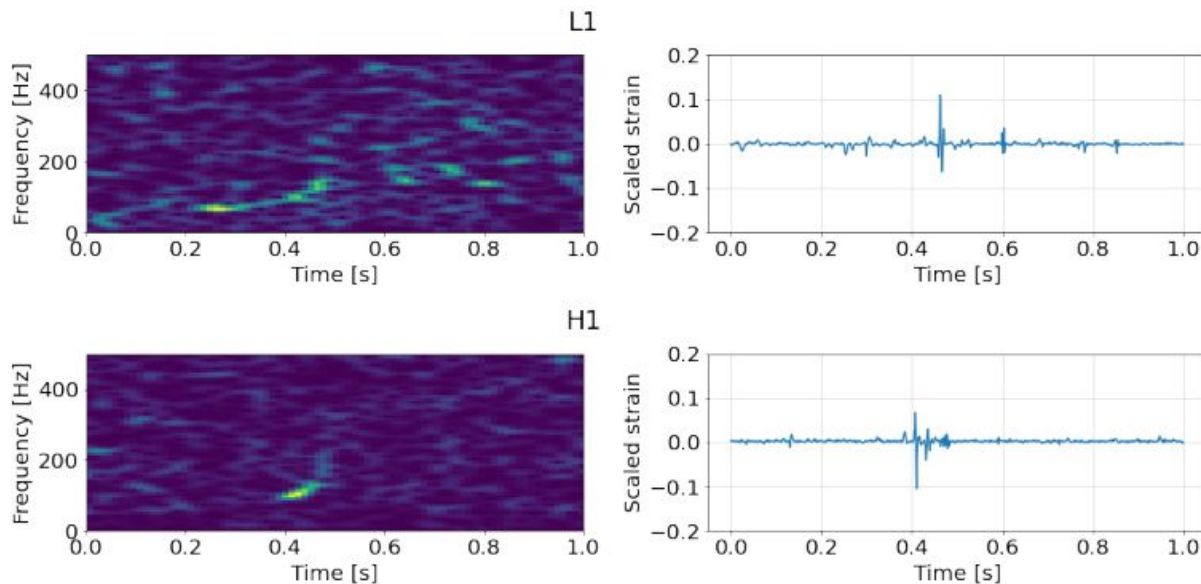
LIGO Livingston



LIGO Hanford



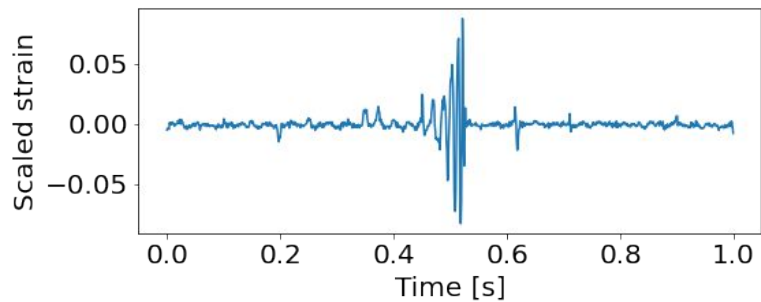
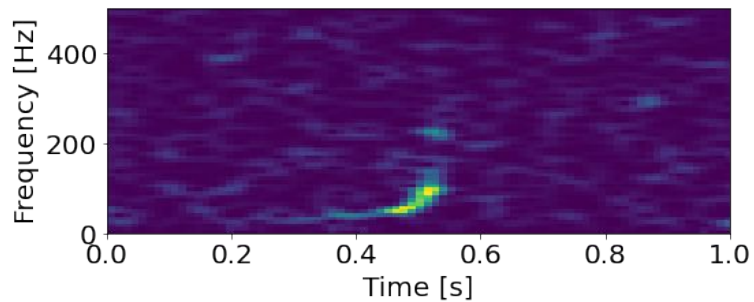
GW170806



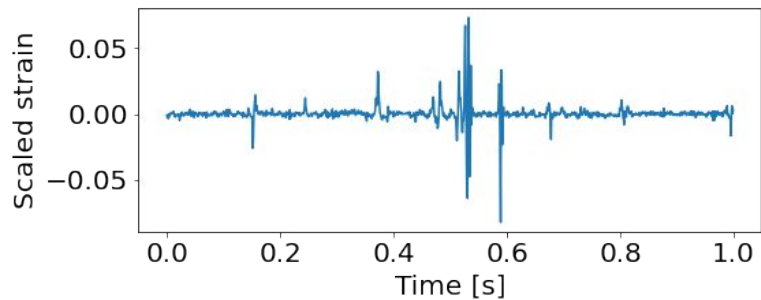
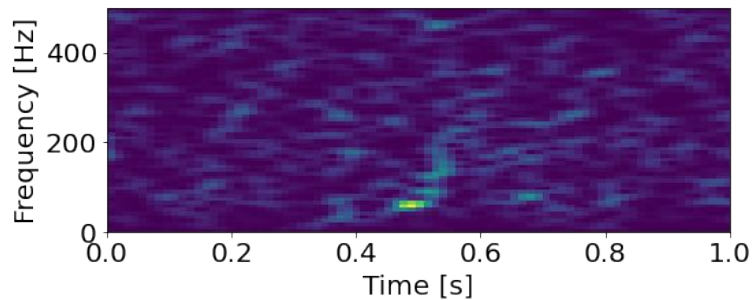
INTERESTING! GW170806 HAS MUCH LOWER MASSES!

GW170814

LIGO Livingston



LIGO Hanford



SUMMARY

- Autoencoders seem to perform well in the anomaly detection in the gravitational wave data
- Reconstructed signal is limited to the merger part

To be done in the future:

- anomaly searches on O3 data
- searches for anomalies on BBH signals of different masses
- application of the method in the studies of glitches