

Detection for Core-collapse Supernova(CCSN) and Fast Data Preprocessing

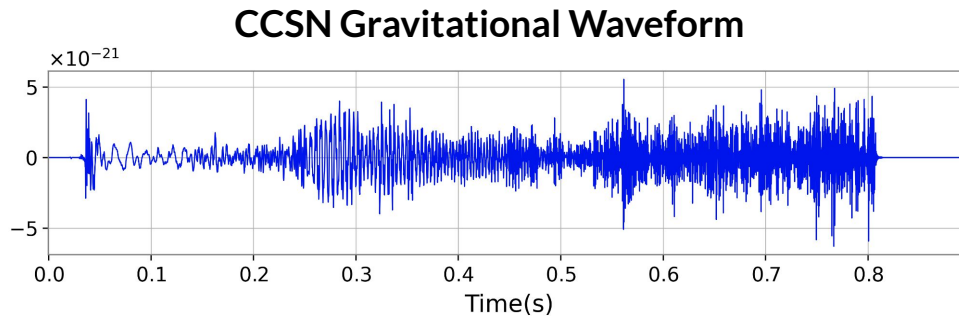
Speaker: Andy Chen

National Yang Ming Chiao Tung University, Taiwan
Institute of Physics & Department of Electrophysics

Collaborator: Chia-Jui Chou, Kuo-Chuan Pan, Shih-Chieh Hsu, Yang Yi, Alec Gunny, Ethan Marx

Fast Machine Learning for Science Workshop 2022

What is CCSN? & Why CCSN?



<https://www.ssfv.com/supernova-immediate-past-revealed-by-hubble-and-bess>



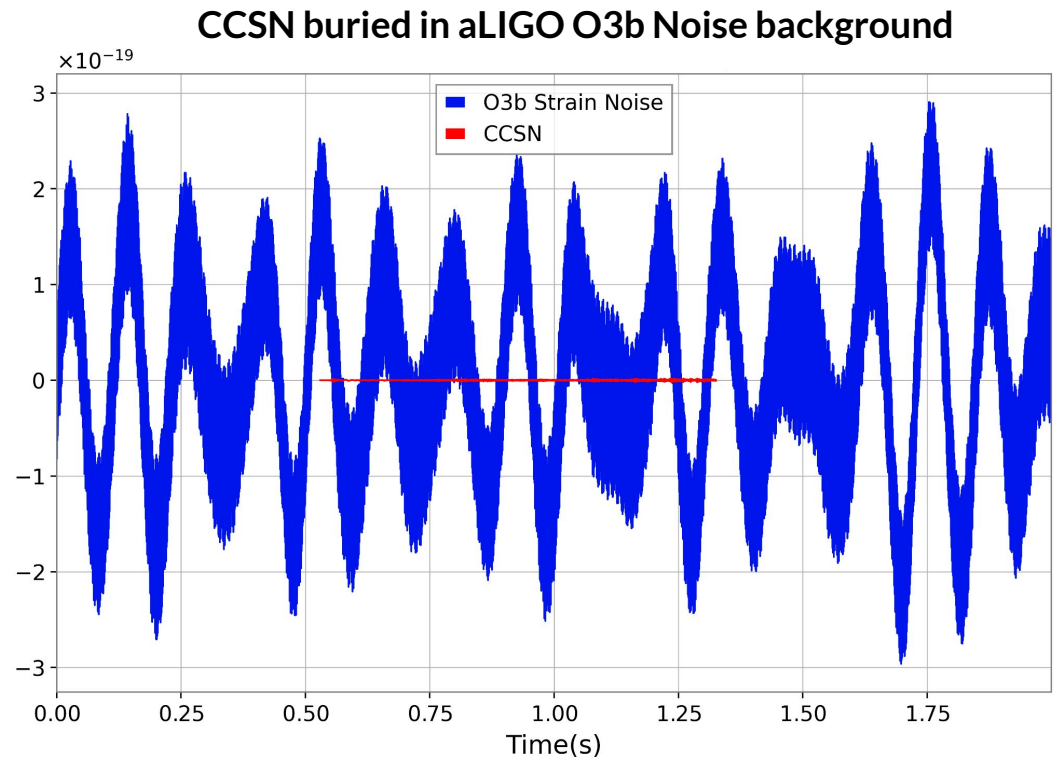
CCSN explosion
(Artwork)

- CCSN events are the explosions of dying star
- CCSN will emit **gravitational waves**, **electromagnetic(EM) waves**, and **neutrino flow signals**, so it's one of the most important cosmology events for Multi-Messenger Astrophysics/Astronomy(MMA)

CCSN waveform and Noise data



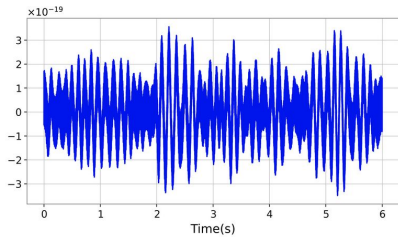
- Our goal is to **detect CCSN gravitational waveform** in the noisy detector data.
- We prepared CCSN waveforms ([2010.02453](#)) with different angular momentums, orientations, and sky localization for injection.



Workflow

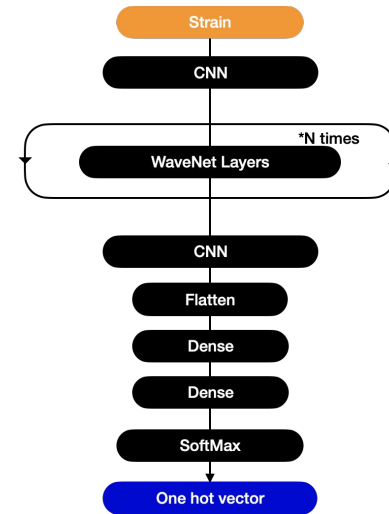


Data preprocess



Whiten, Highpass

ML Classifier



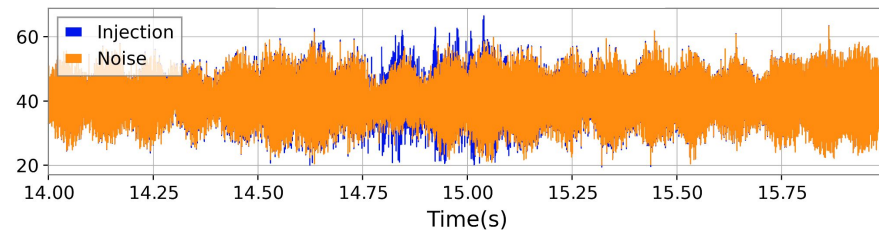
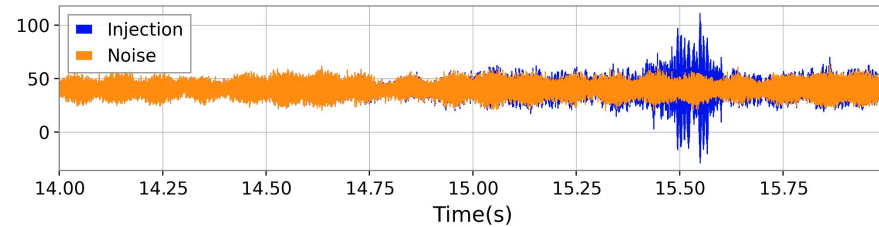
Noise or CCSN

Data



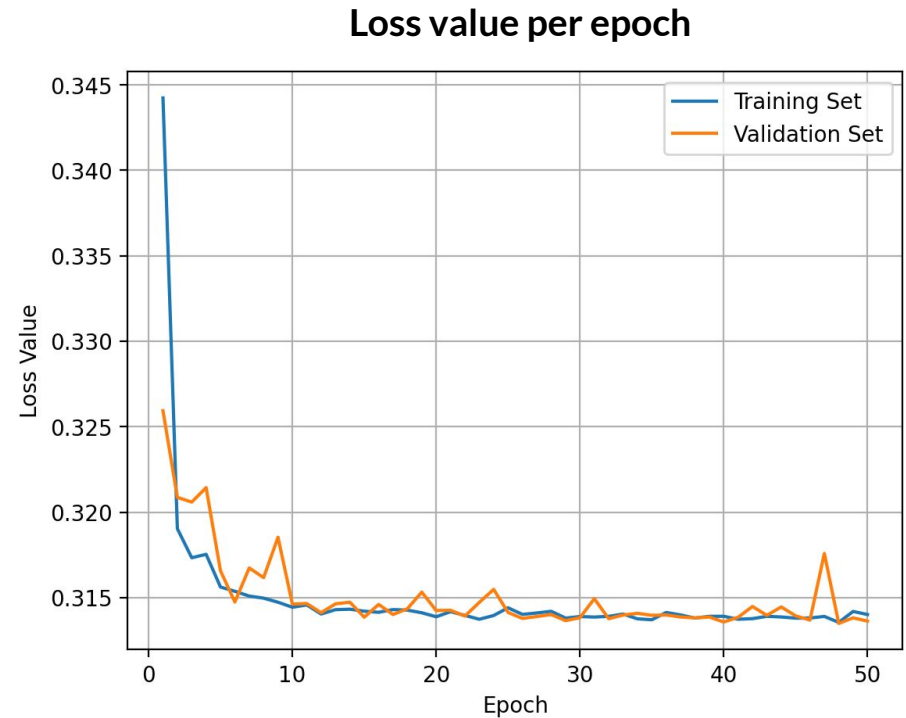
- The distance of the CCSN events were given according to the signal to noise ratio (SNR) we sampled.
- We injected CCSN with different SNR sampled from 8~30 uniformly.

Injected strain with different SNR



Data, Hyper-parameters & Loss curve

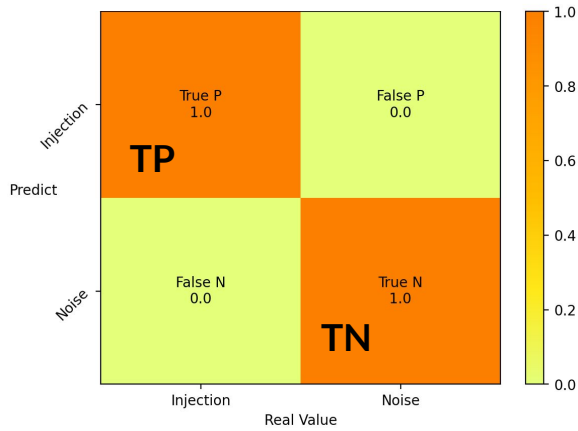
- Dataset
 - Training data: 180K
 - Validation data: 90K
- Model
 - Loss function : Cross entropy
 - Learning rate: 0.0003
 - Batch size: 256



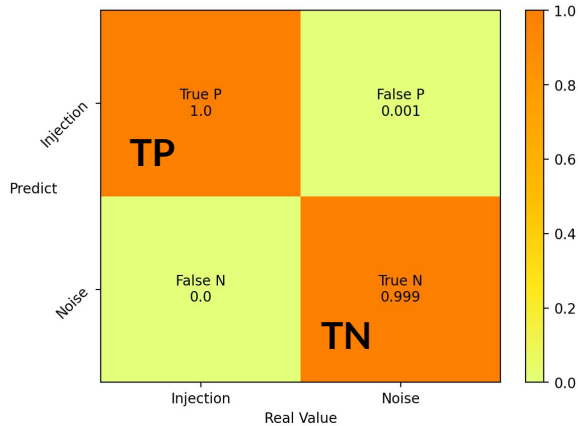
Performance of our model



Training Set

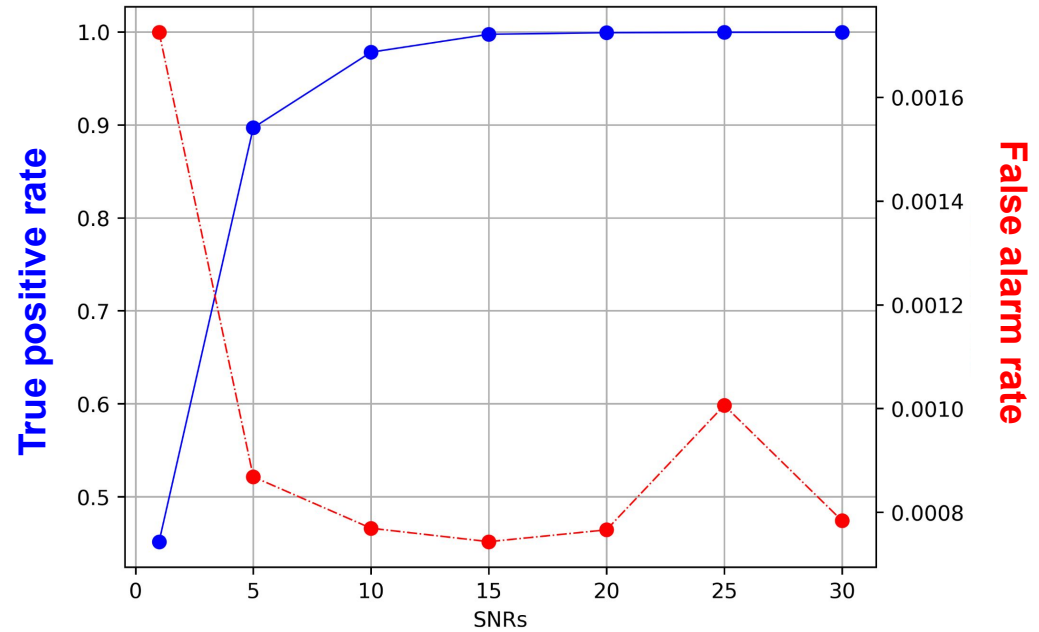


Validation Set



Testing Set

TPR and FAR at different SNR



Summary & Future Plan



- Our model can detect CCSN accurately with a low false alarm rate.
- The model will be tested using CCSN waveforms from other simulations.
- We are also interested in developing fast data preprocess([ml4gw](#)) for two reasons:
 - Efficient hyper-parameter tuning for the entire data analysis workflow.
 - **Stable performance of the model.**
- The real challenge will be classifying glitch signals from CCSN, and we will work on this shortly.

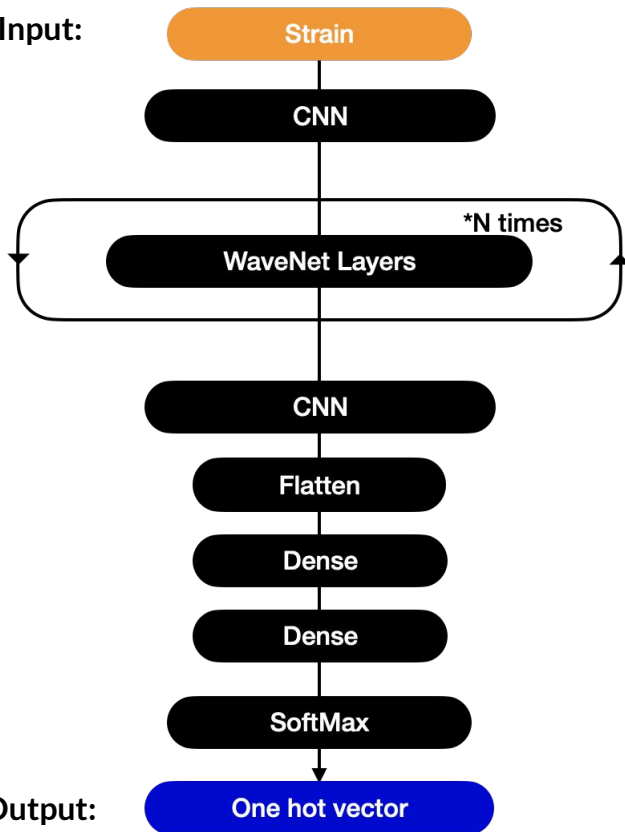
Thank You!

—

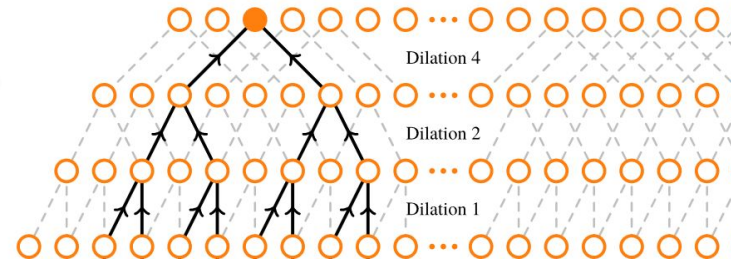
Appendix: ML Classifier architecture



Classifier Input:



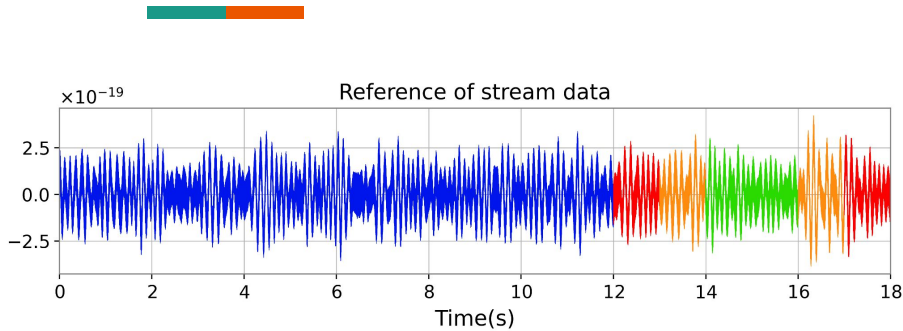
WaveNet layers without causal



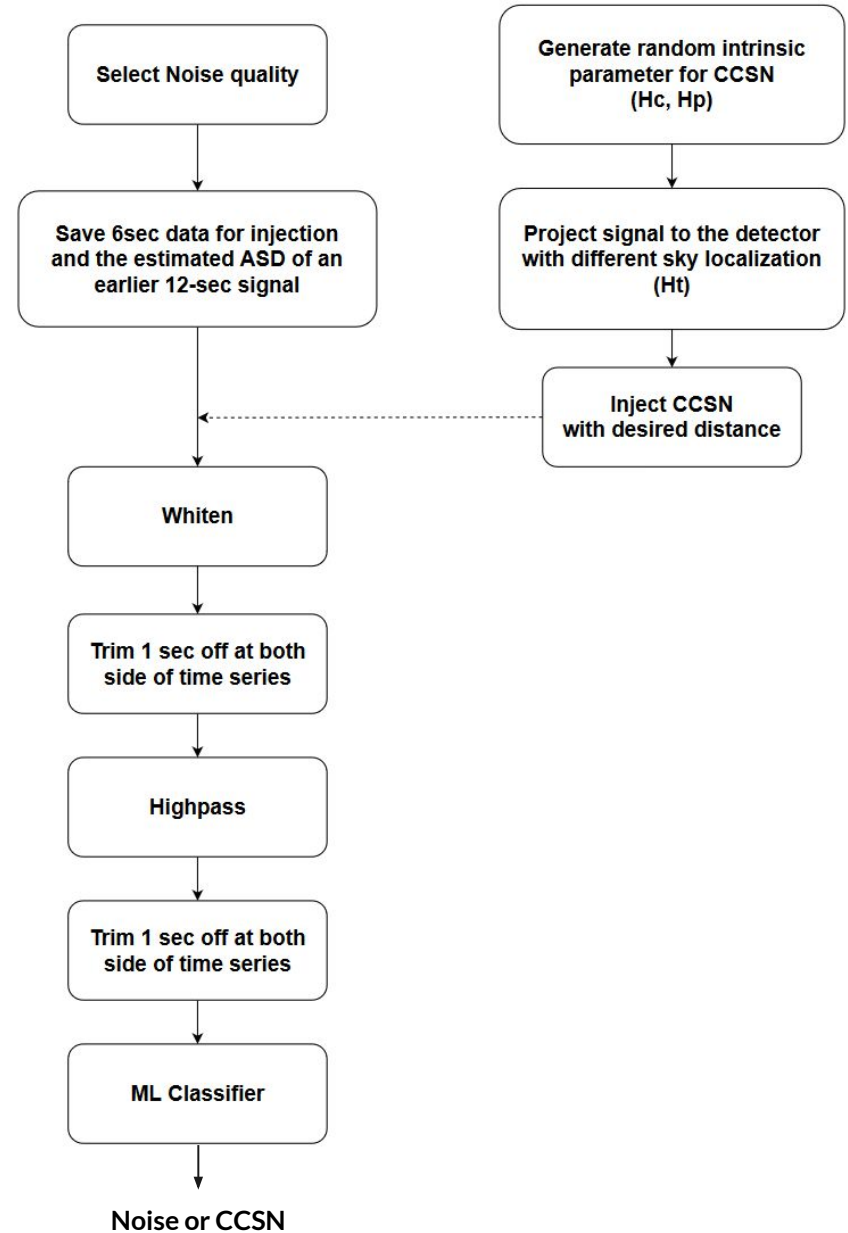
Classifier Output:

One hot vector

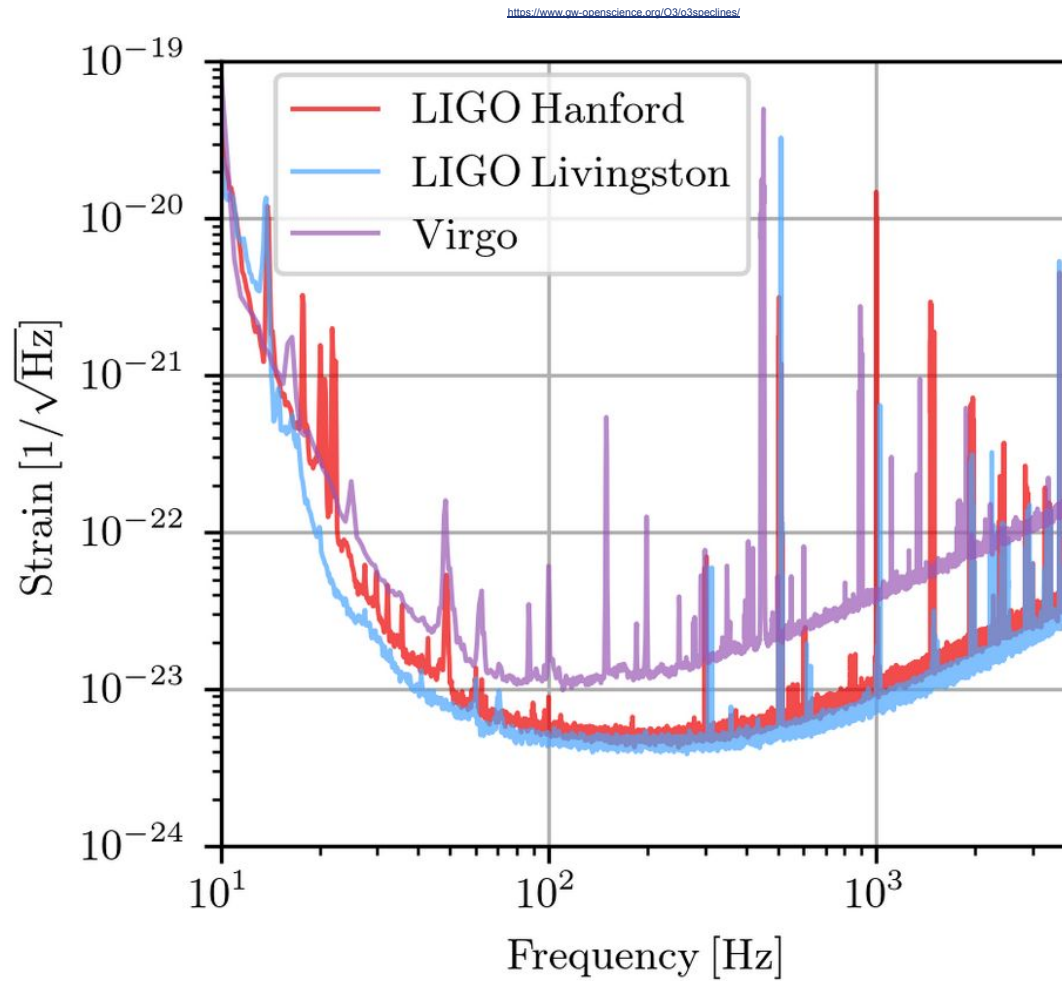
Appendix: Workflow



- Noise and injected data were prepared according to the diagram.
- The strain data will only go through the left part of the diagram in a real detection run.



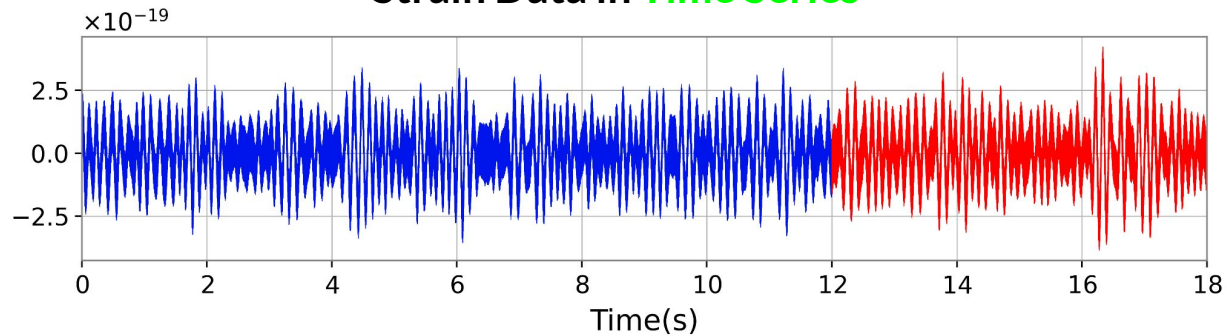
Appendix: Spectrum of LIGO-Virgo noise



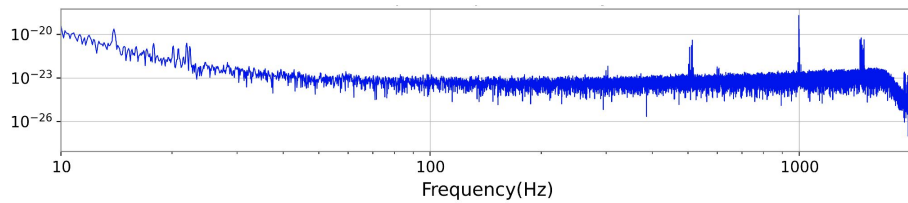
Appendix:Fast Fourier Transform of Strain



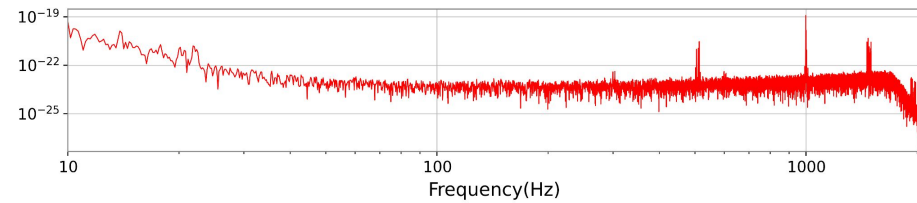
Strain Data in Time Series



Strain Data in Frequency Series



Strain Data in Frequency Series



Appendix: Frequency Filter of Strain

