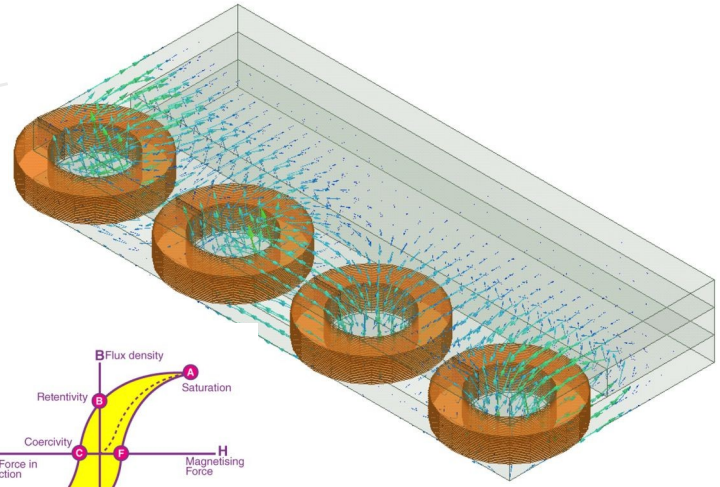
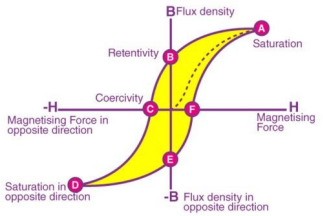
PADERBORN UNIVERSITY

Leistungselektronik und elektrische Antriebstechnik

Machine Learning Applications in Control Engineering

Nachwuchsforschungsgruppe





MAGNET CHALLENGE 2023

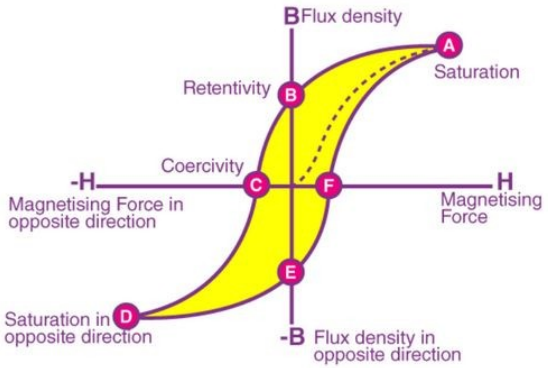
EXPLORATORY DATA ANALYSIS (EDA)

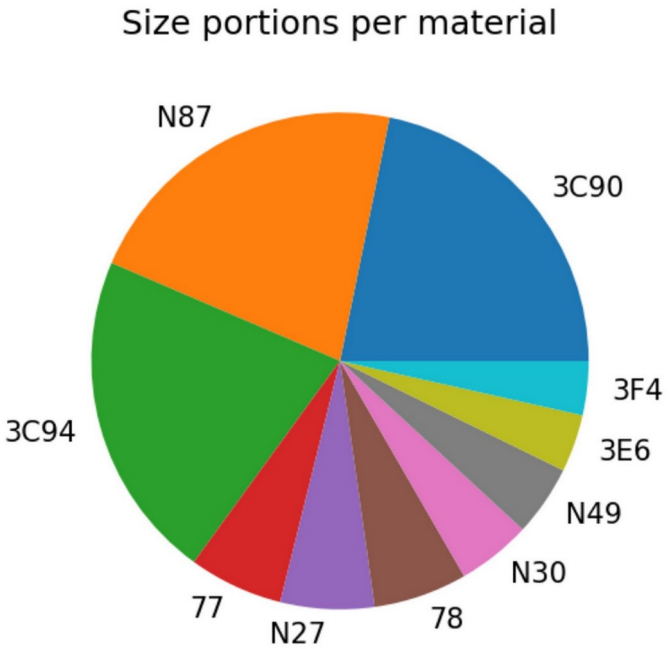
Project Kick-Off **4/24/23**

Wilhelm Kirchgässner

Data set in a nutshell

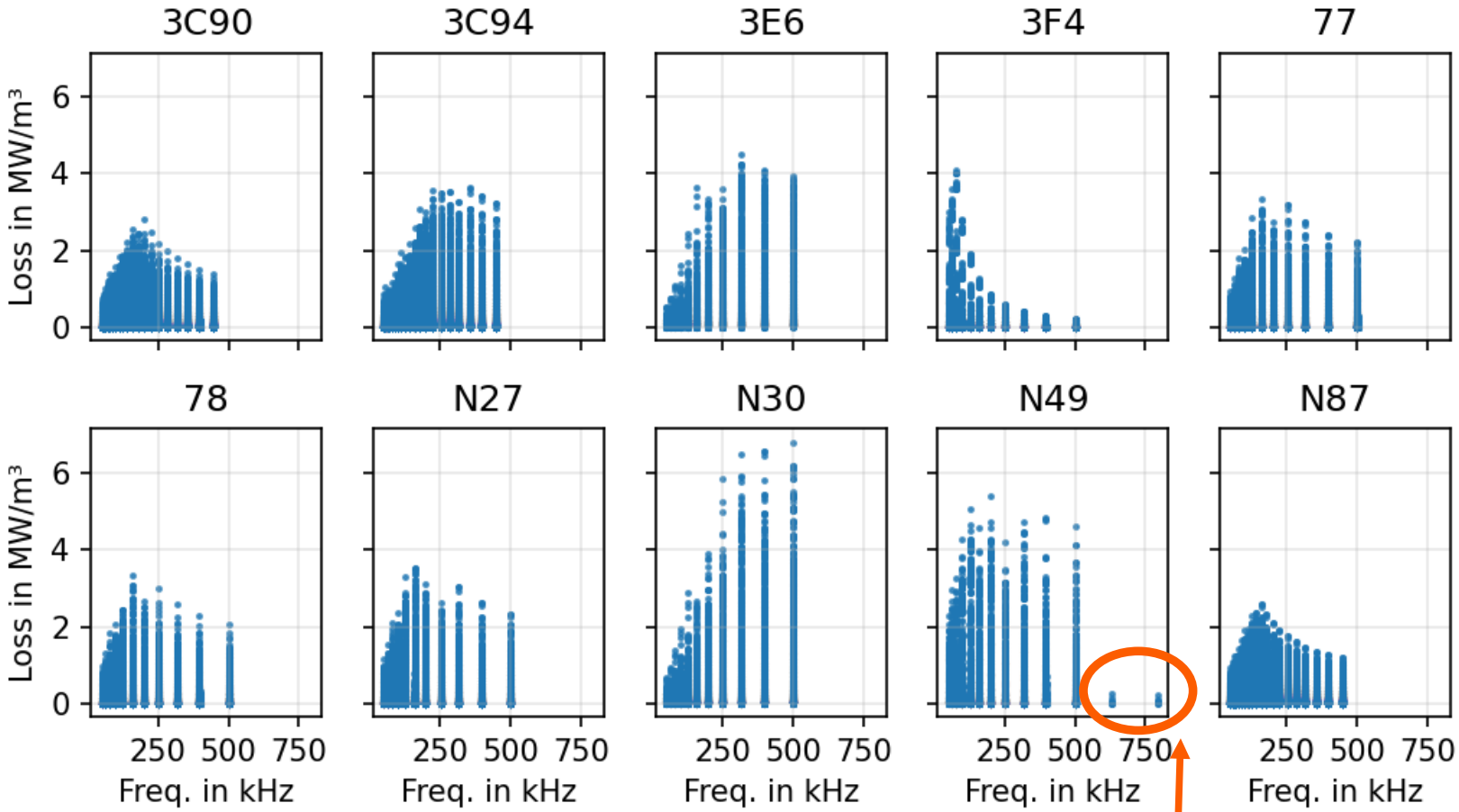
- 186747 operation points / samples
  - 2.8 GB disk space (serialized and compressed)
- Each sample consists of
  - Frequency, Temperature, B-curve (inputs)
  - Power loss, H-curve (targets)
  - A class label (material)
- Each curve consists of 1024 points





Distributions

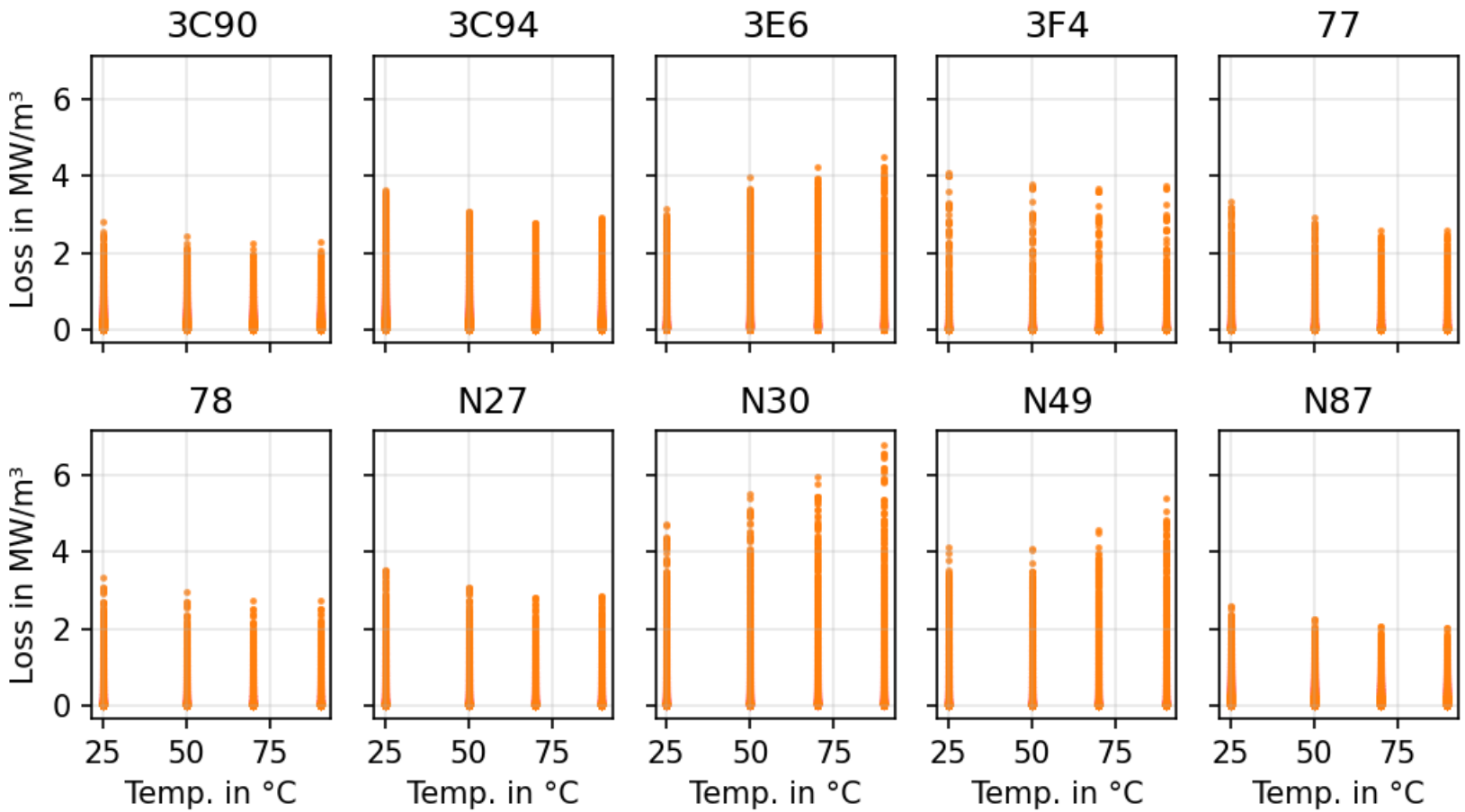
- Linear increase of max losses
- 1/freq bound for higher frequencies



Highest frequencies only for one material

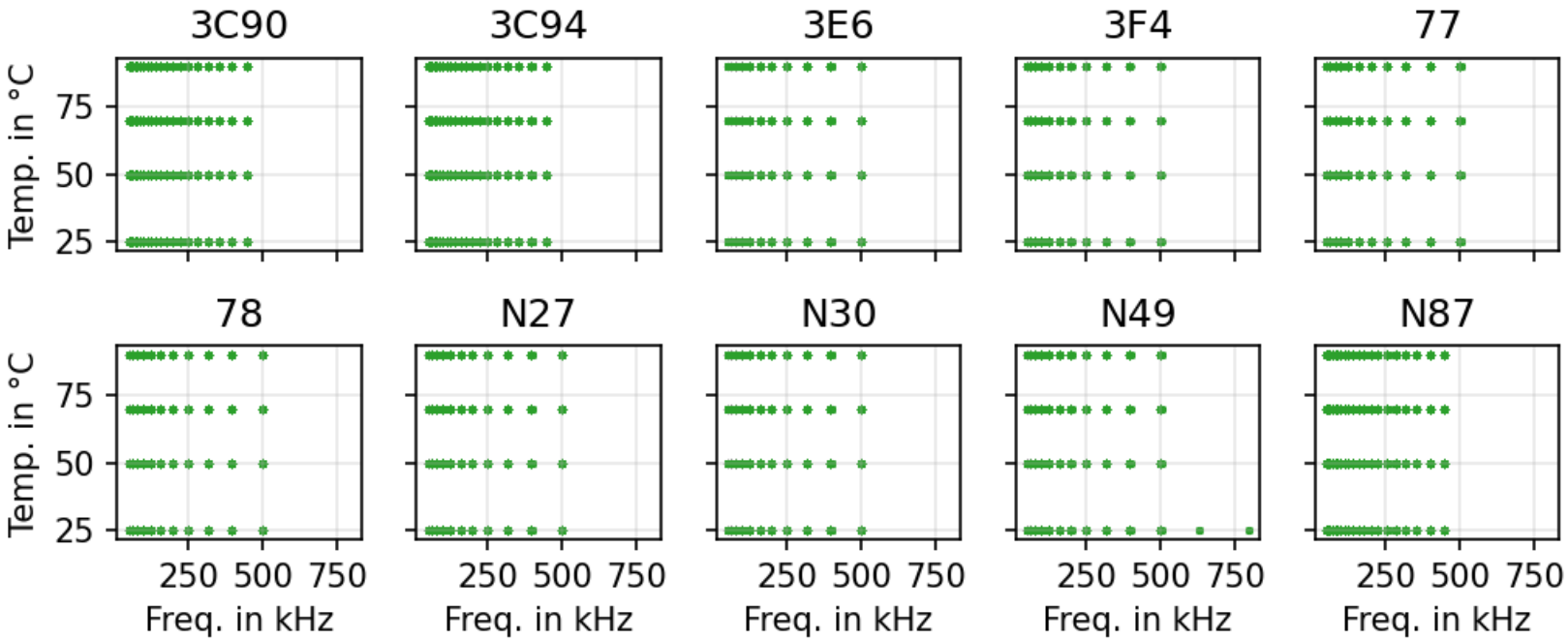
Distributions

- Only four distinct temperatures

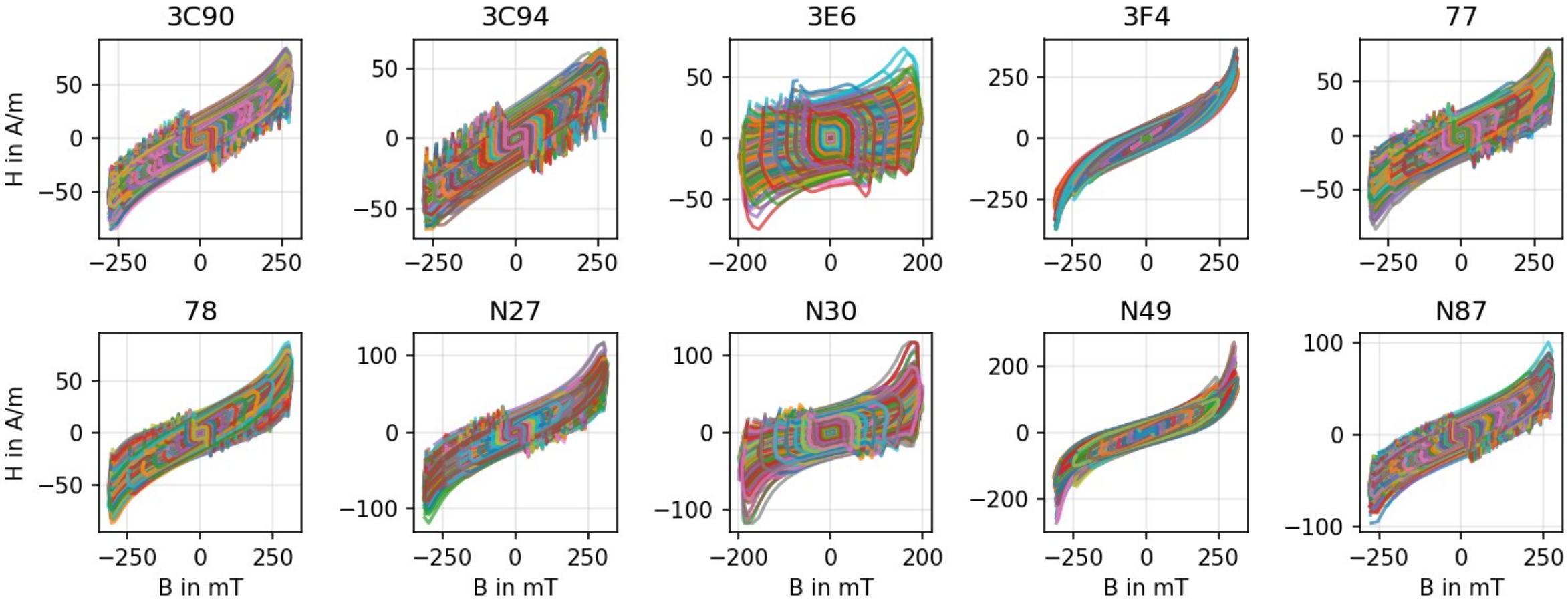


Distributions

- Highest frequencies only for coldest temp.
- Materials with less portion size have fewer different freqs. at the top range

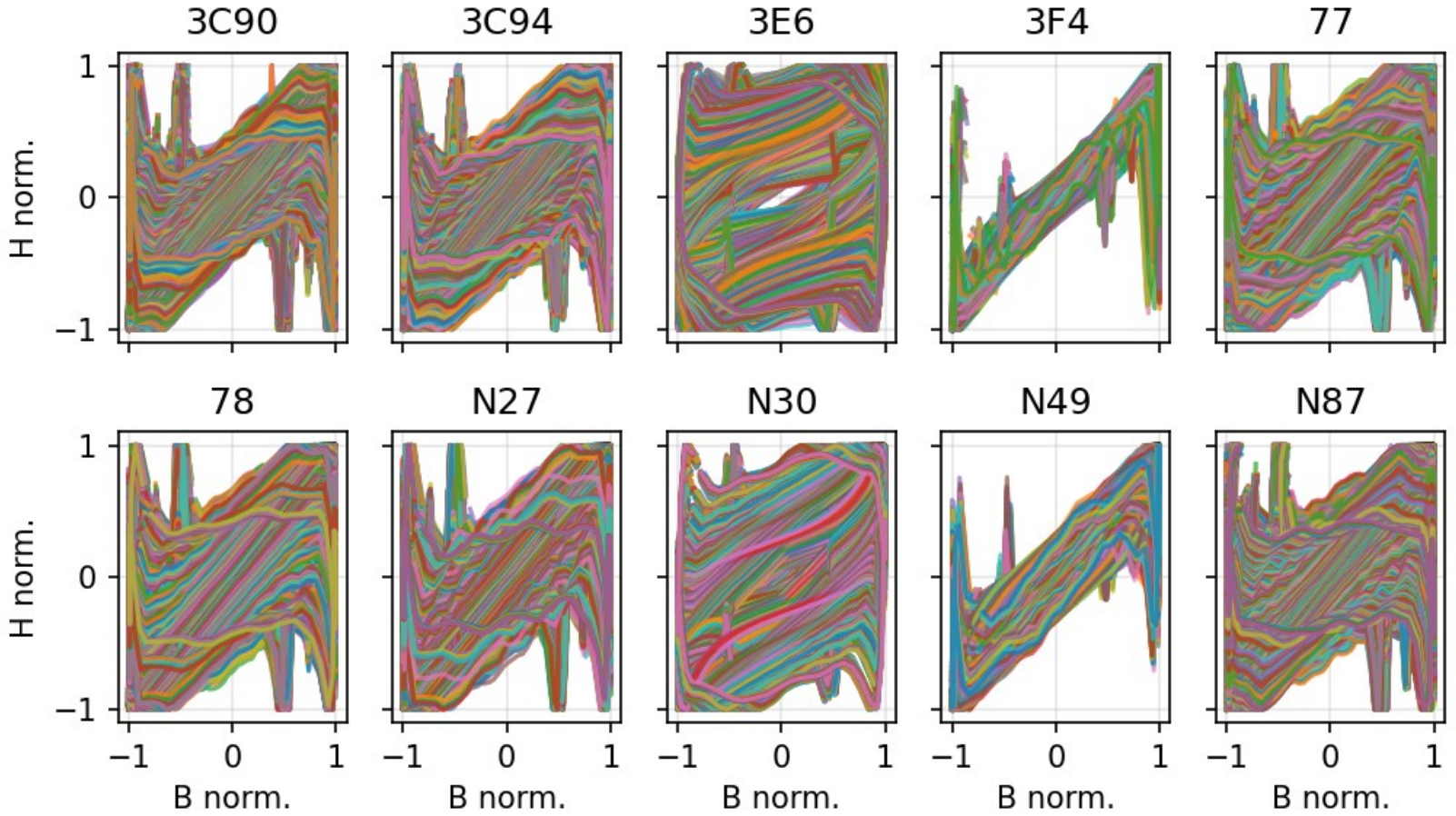


B-H-Curves per material



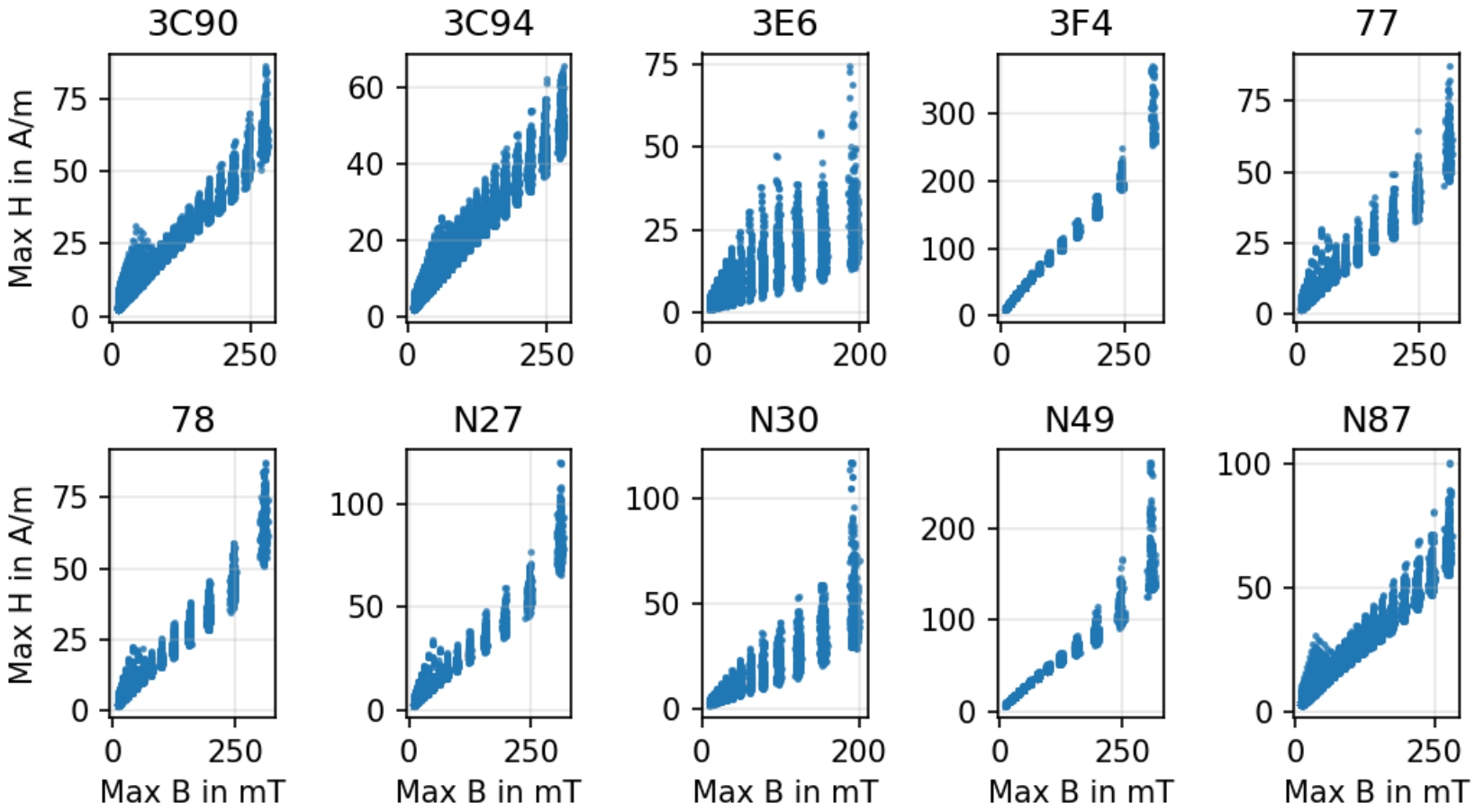
B-H-Curves per material - Normalized

- Materials with lower max(B) have less distinct fins
- Materials with high max(H) have the most concise fins



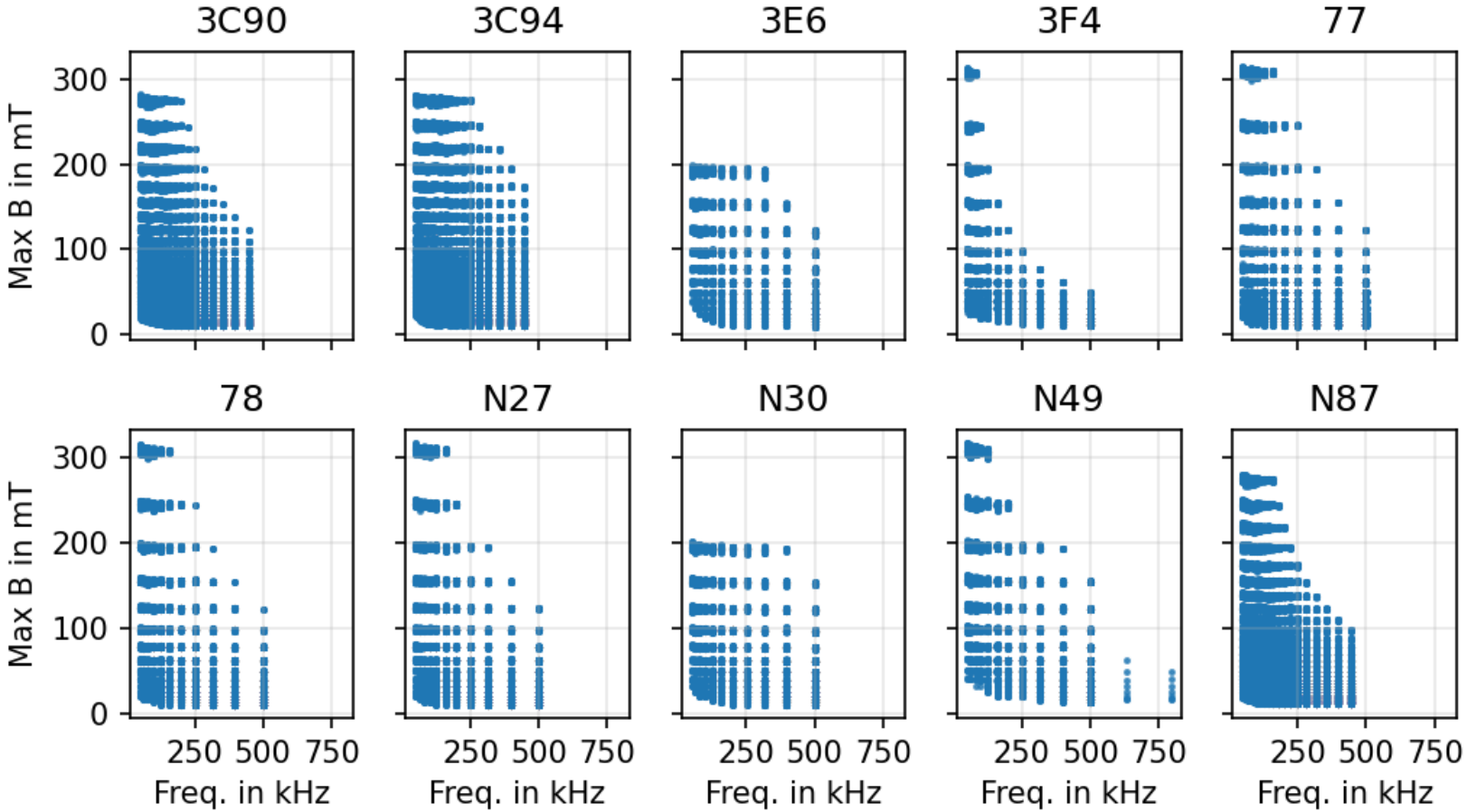
Distributions (2)

- Somewhat linear (except 3E6)



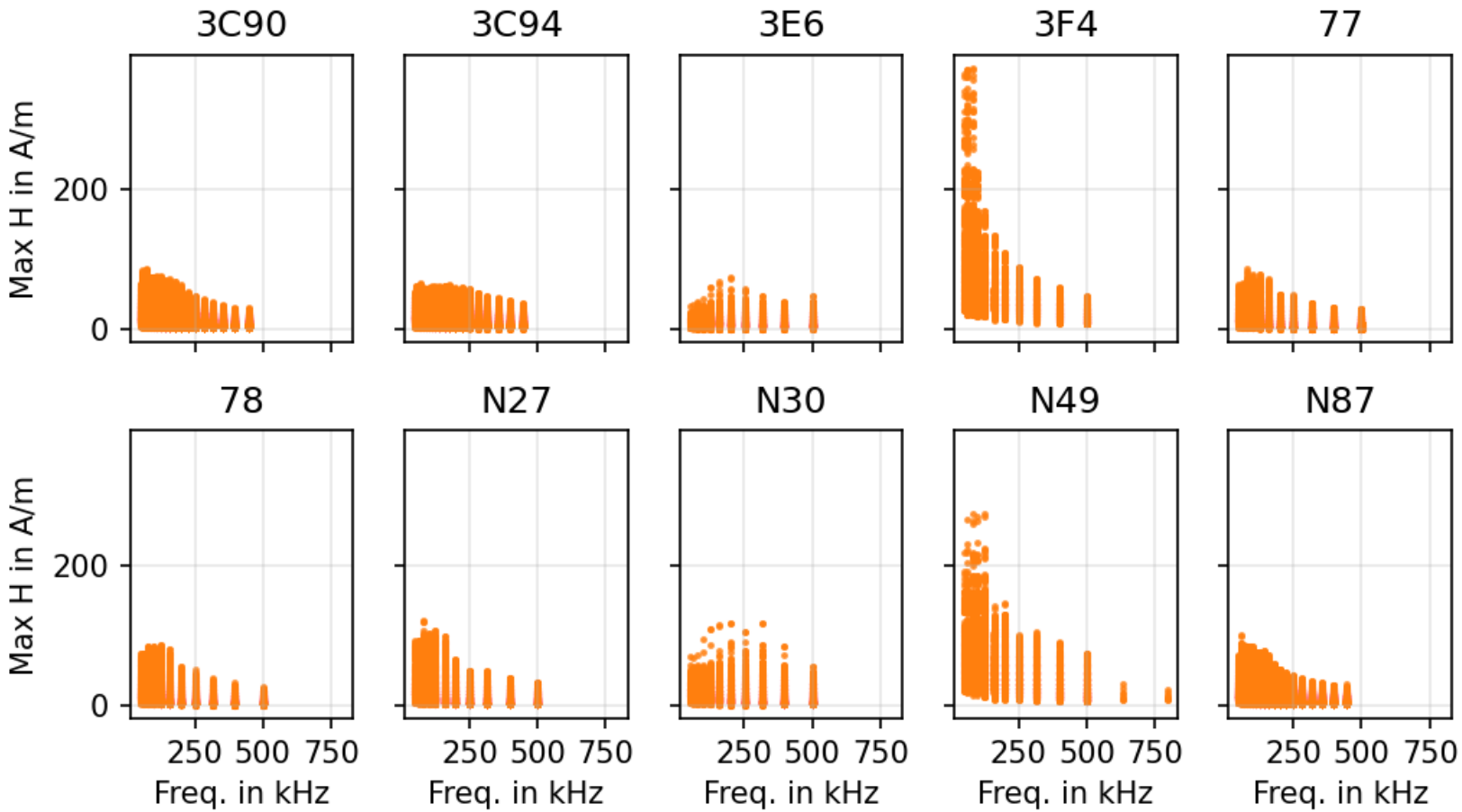
Distributions (2)

- Hyperbolic decrease of max(B) over frequency
- Different for each material



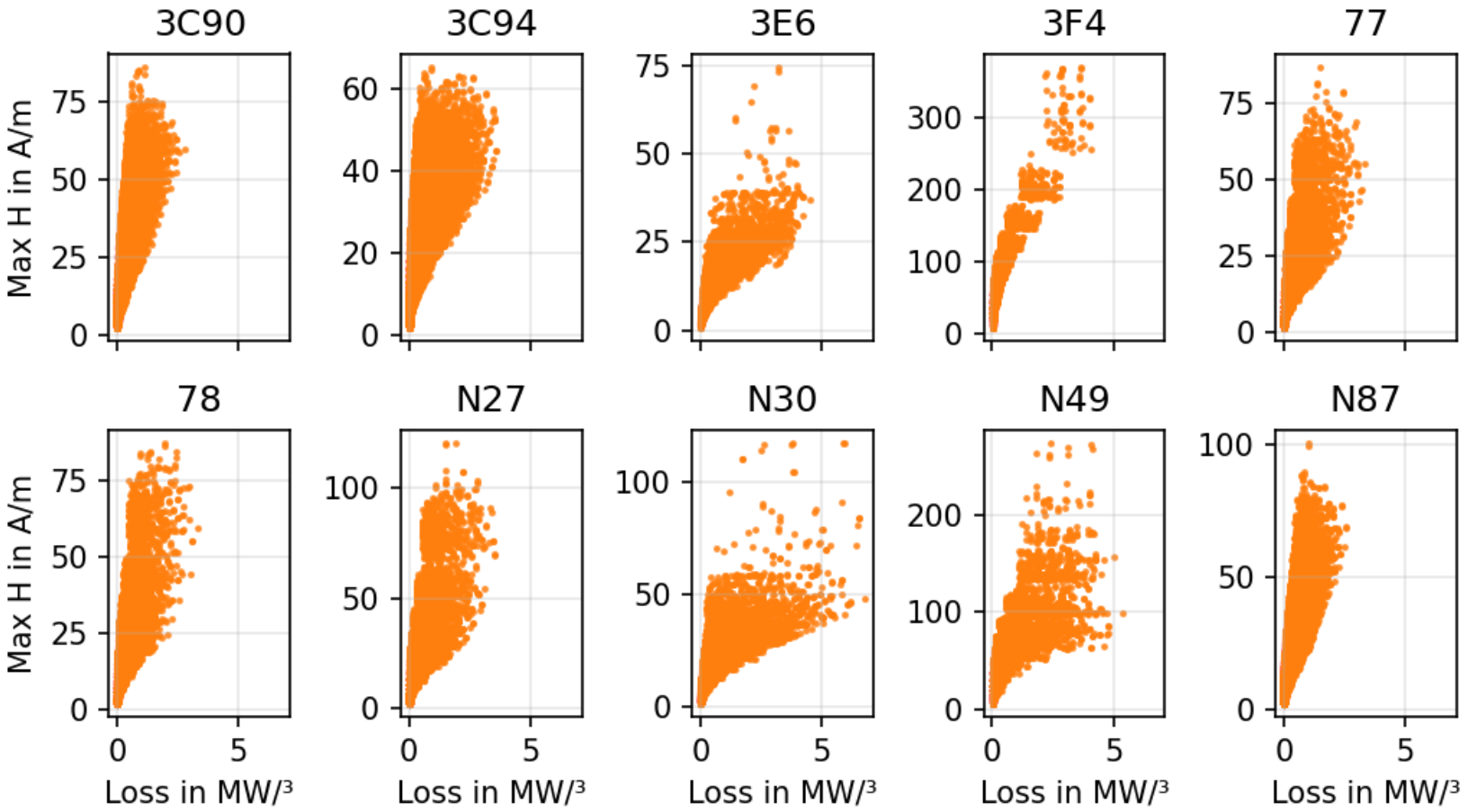
Distributions (2)

- High max(H) only at low frequencies, for only two materials



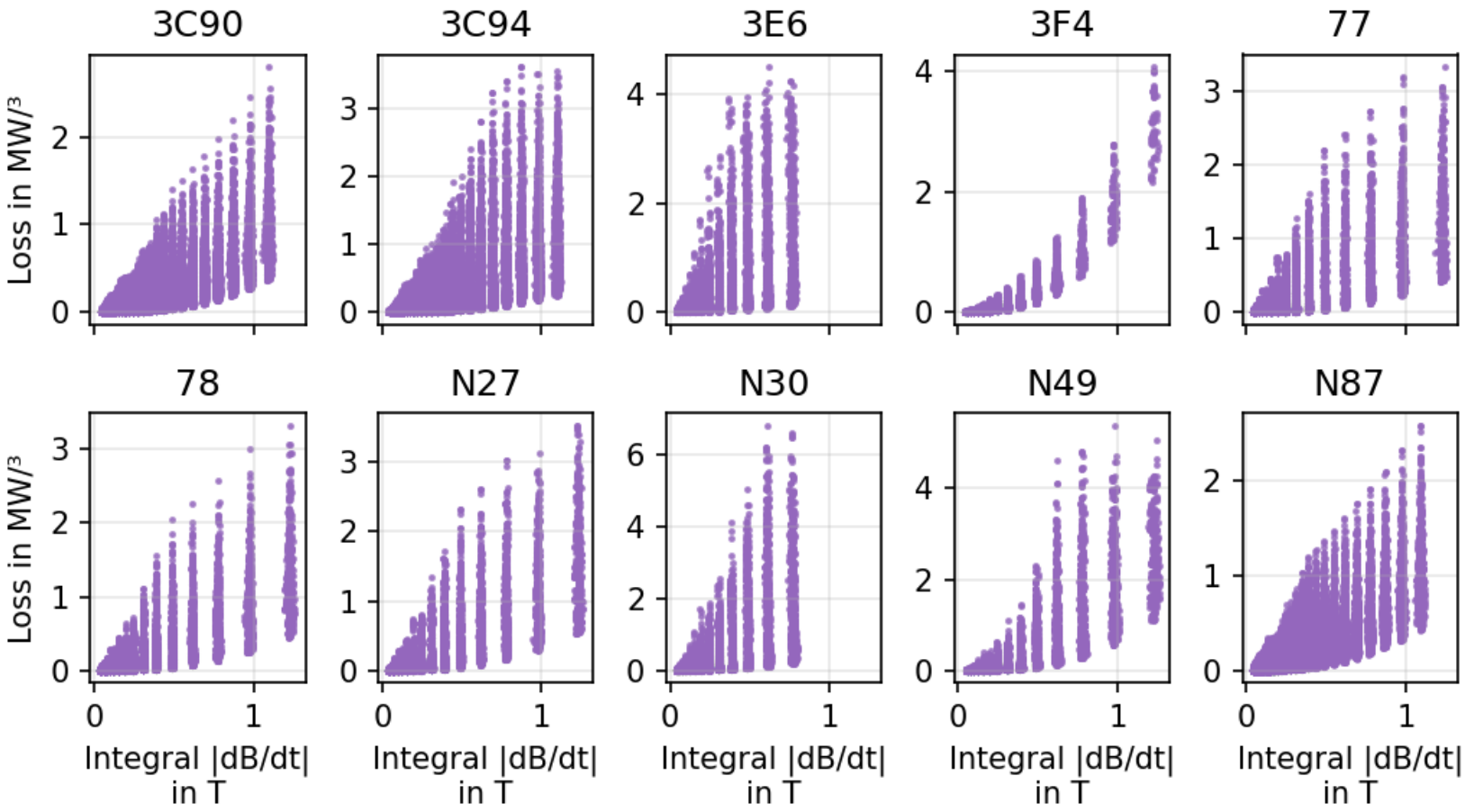
Distributions (2)

- No perfect linear relationship



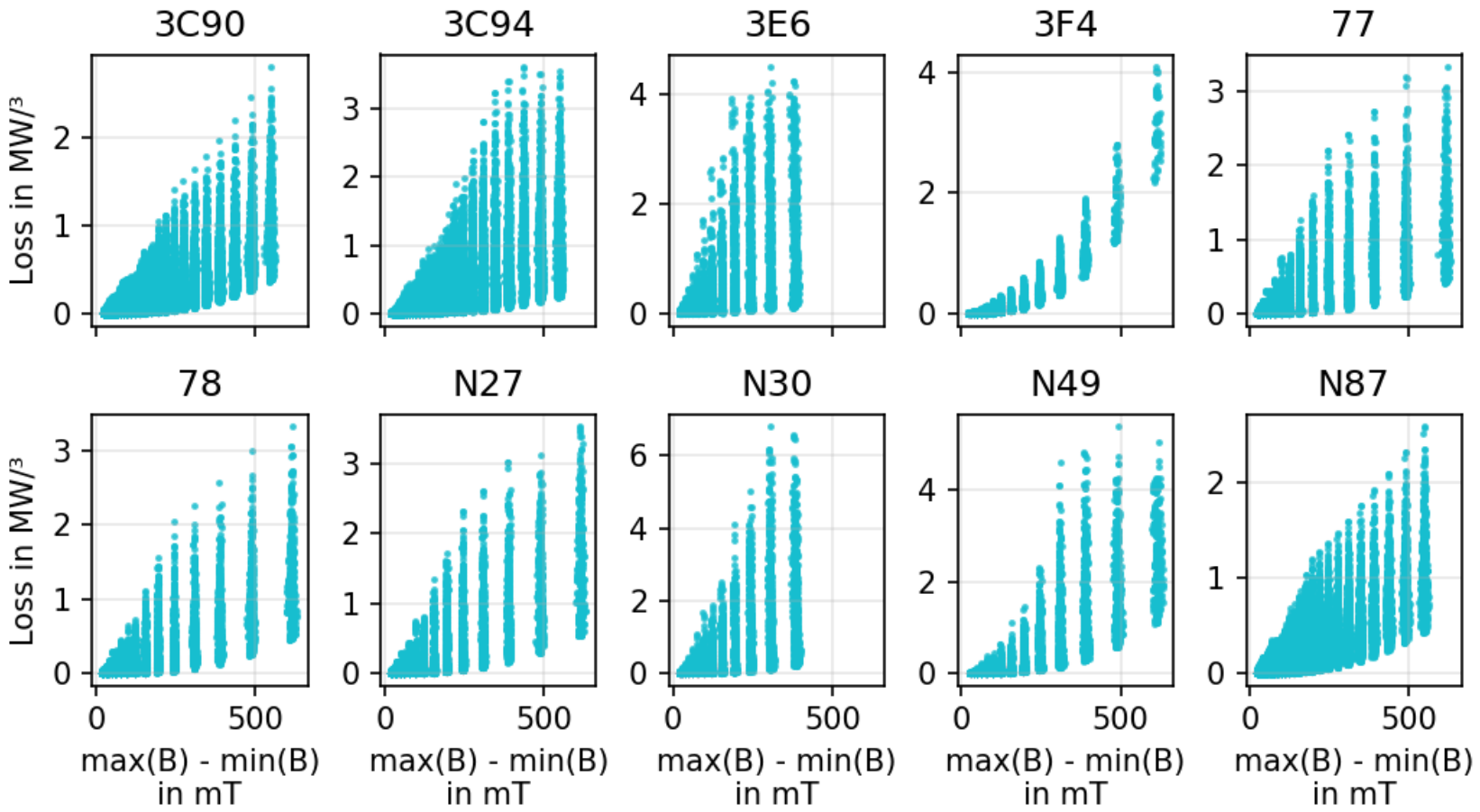
Distributions (2)

- Some linear to exponential relationship
- High scatter



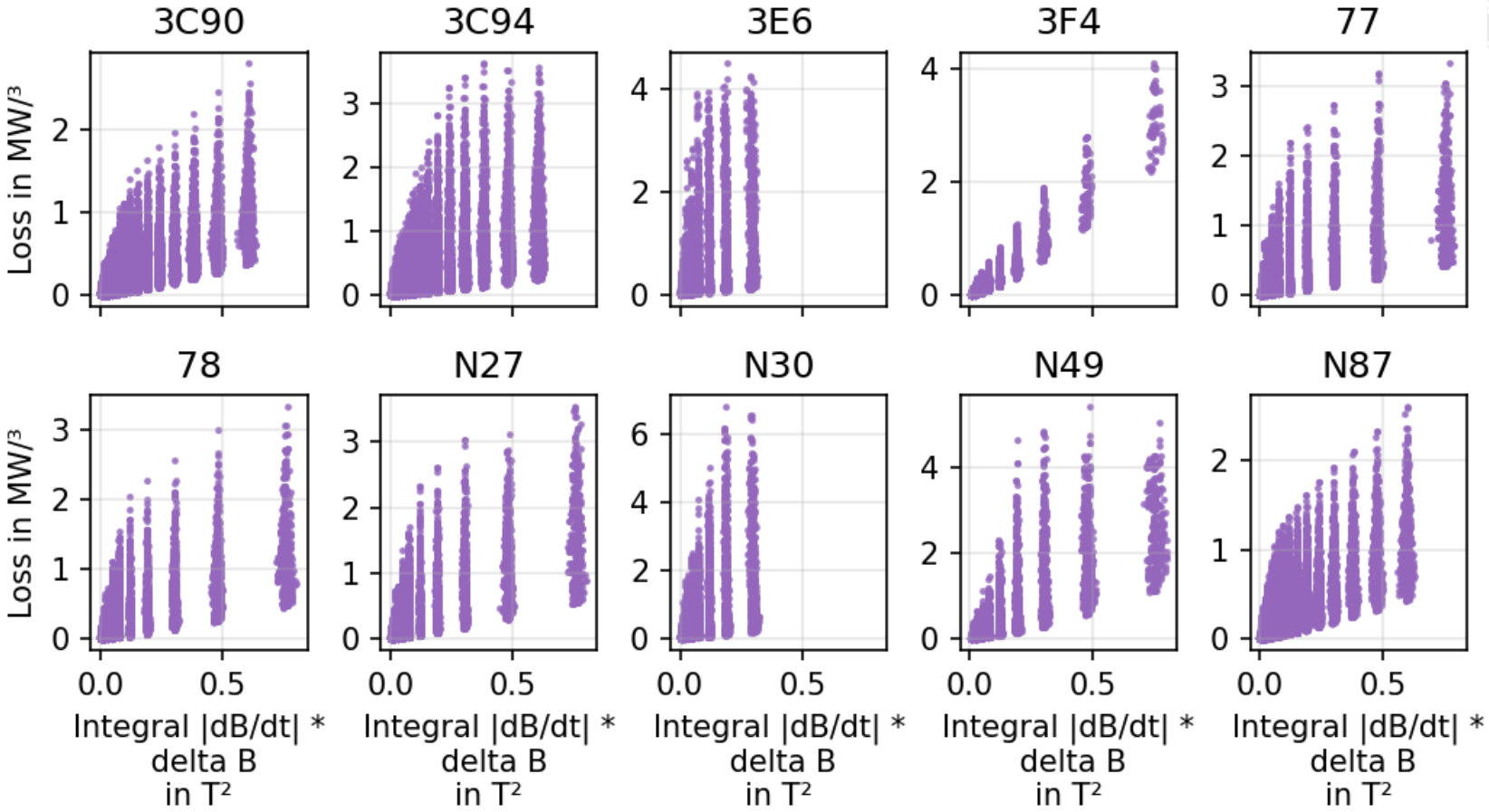
Distributions (2)

- Similar to dB/dt

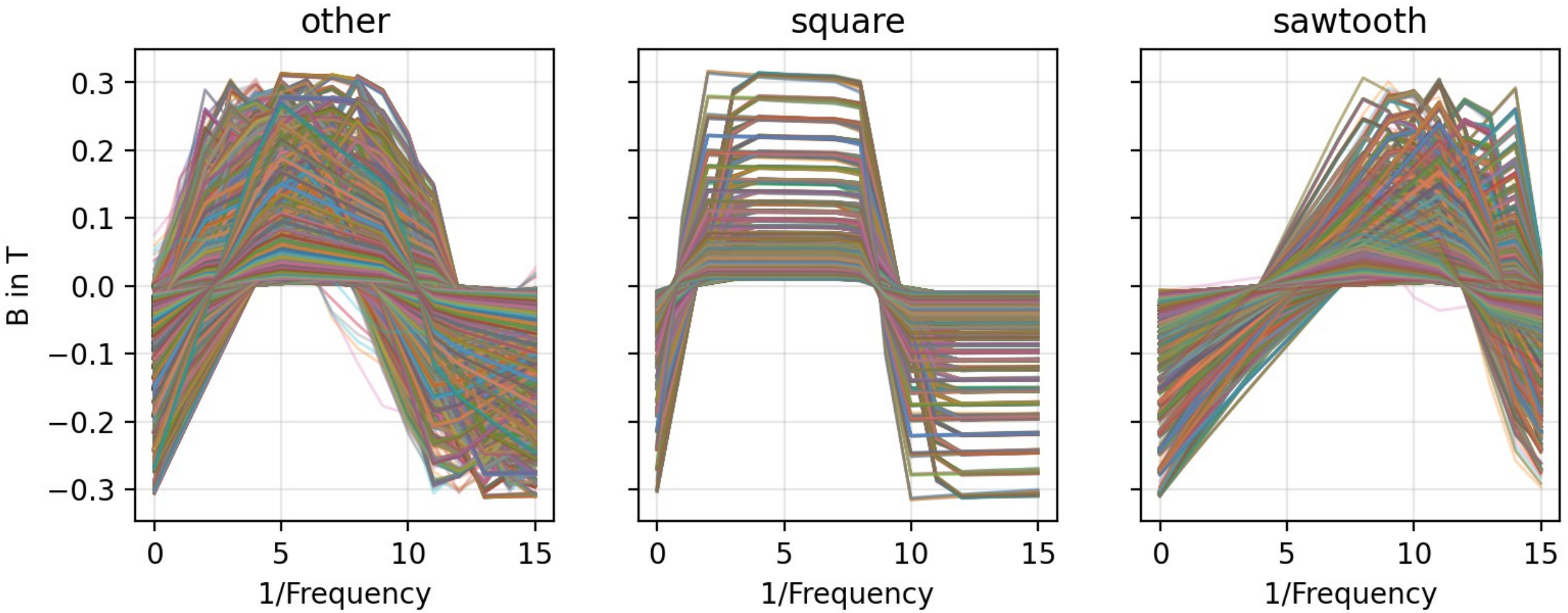


Distributions (2)

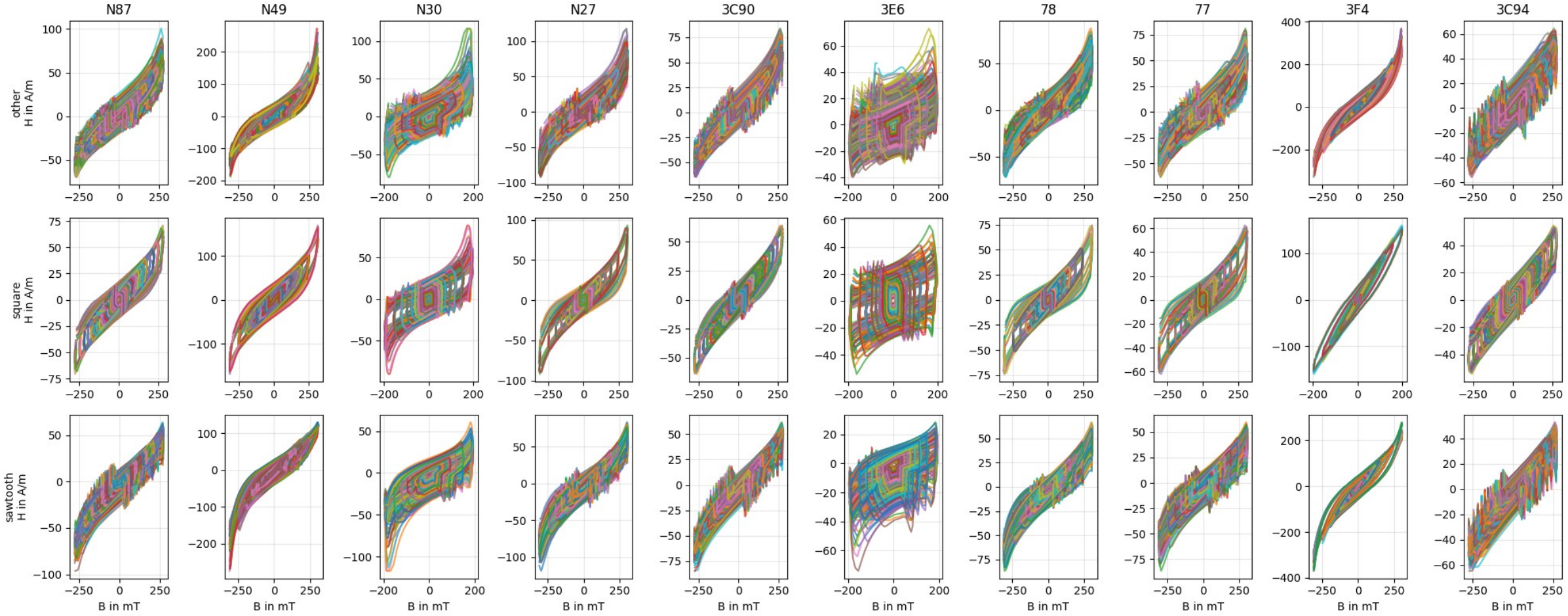
- Exponential relationship becomes more linear
- Scatter does not reduce



Waveforms need to be estimated (here, template matching/ threshold-based)



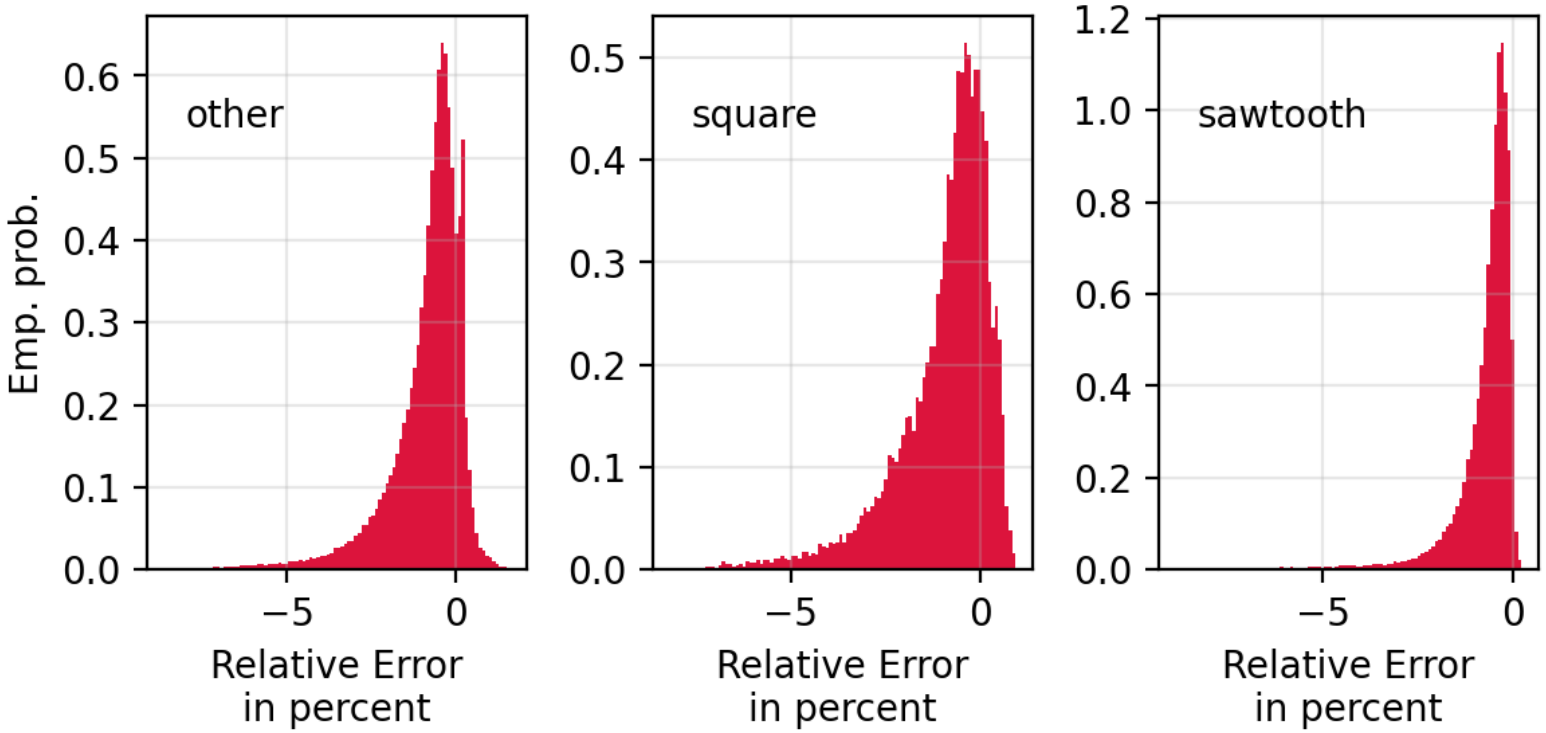
B-H-Curves per waveform



- Square waveform has less distinct fins

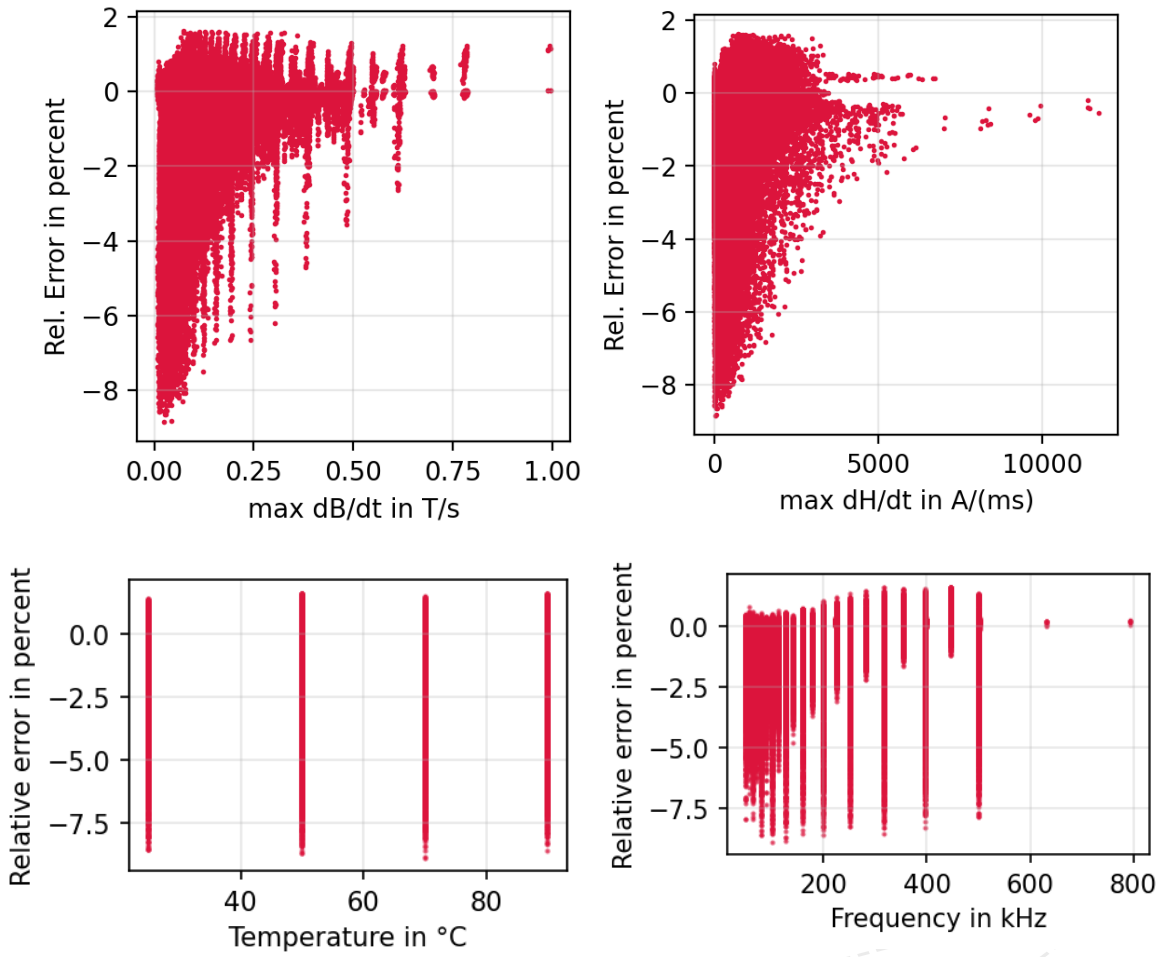
B-H-Area vs. Power loss

- Square waveform exhibits largest errors
- Sawtooth the smallest
- BH-Area tends to underestimate the loss
- Peaks are not at 0



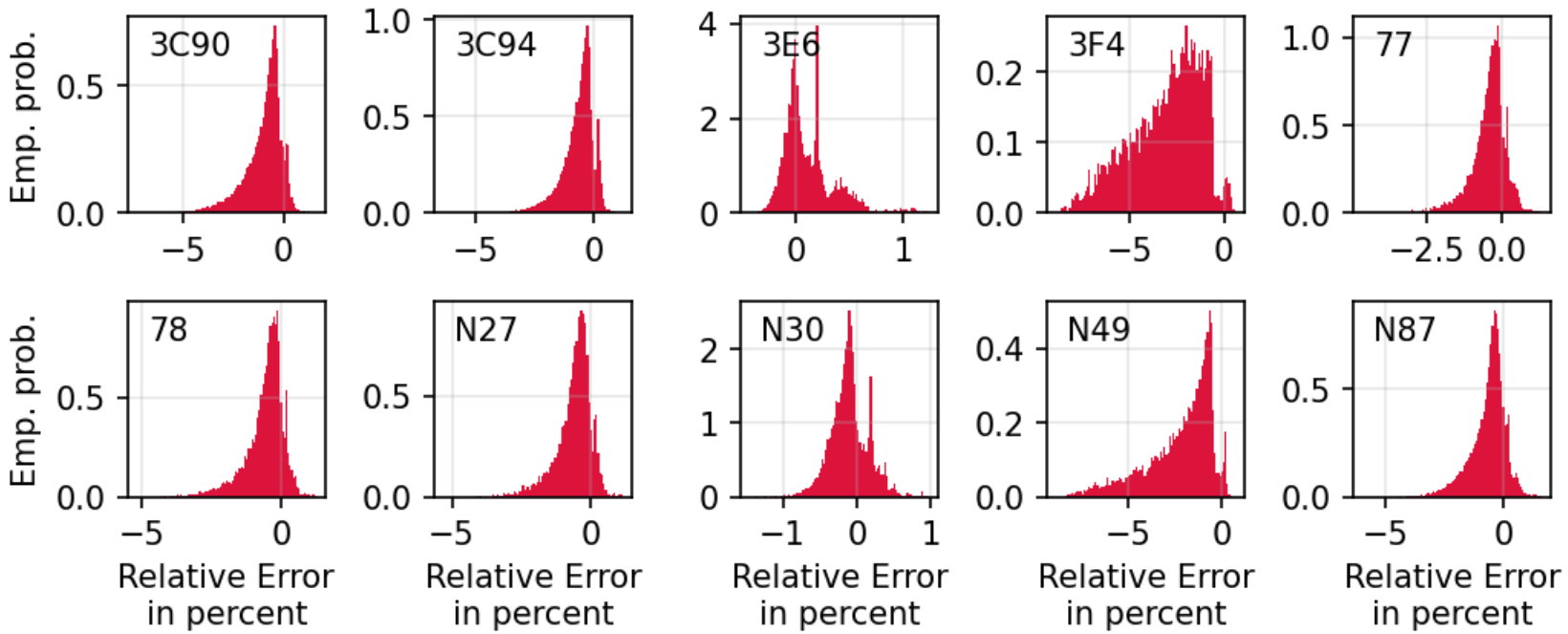
B-H-Area vs. Power loss

- Higher errors occur for small max(dB/dt) and max(dH/dt)
- Modes become visible
- Error has no correlation with temperature
- Error has two modes with frequency



B-H-Area vs. Power loss per material

- 3E6, N30, and 77 show smallest errors
- 3F4 has the highest



https://git.uni-paderborn.de/lea-git/magnet-challenge-2023

Conclusion

- Estimating the H-curve is only a proxy of the loss at ~5% accuracy
- B-H curves look different for different materials (shape, max values, etc.)
- No strong linear or quadratic correlation evident yet (except max(B) → max(H))
- Modeling should consider
  - One model for all materials vs. one model per material
  - Approximating curves by subsampling (less data)
  - Merge Seq2Seq modeling B-curve → H-curve + correction with a regression model
  - Strong static modeling techniques such as Gradient Boosting Machines (XGBoost, LightGBM, CatBoost, etc.)
  - Initial value problem solvers forward/backward for estimation of H-curve

Thank you

https://git.uni-paderborn.de/lea-git/magnet-challenge-2023