HELMHOLTZ AI | ARTIFICIAL INTELLIGENCE COOPERATION UNIT

Laser System Health Diagnostics at EU XFEL

A voucher project with DESY

HELMHOLTZ AI

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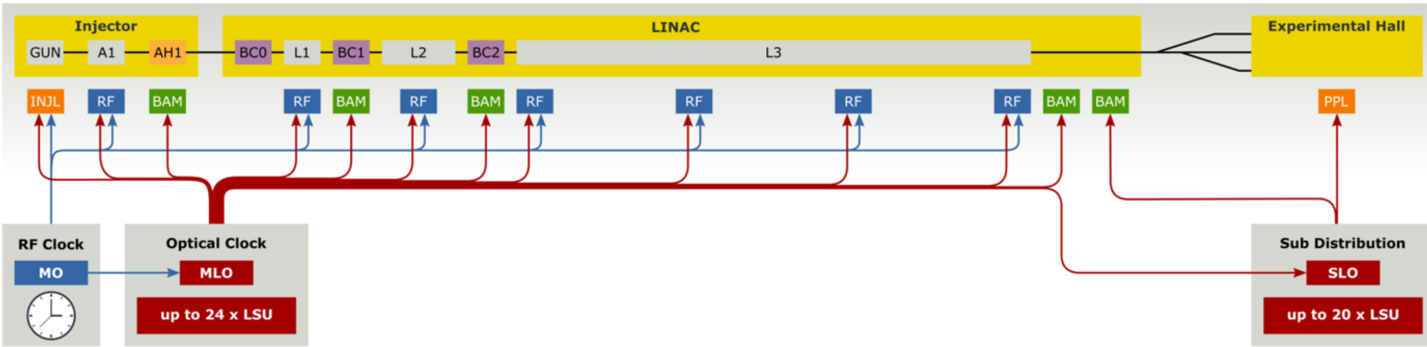
HZDR / 9 March 2021

Background

Background



- this is the EU XFEL
- synchronisation of all elements is crucial
- optical signals from lasers (MLO and SLO) are used for that

Objective

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- experiments need the synchronisation laser to work properly

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- damage of the synchronisation laser is not obvious

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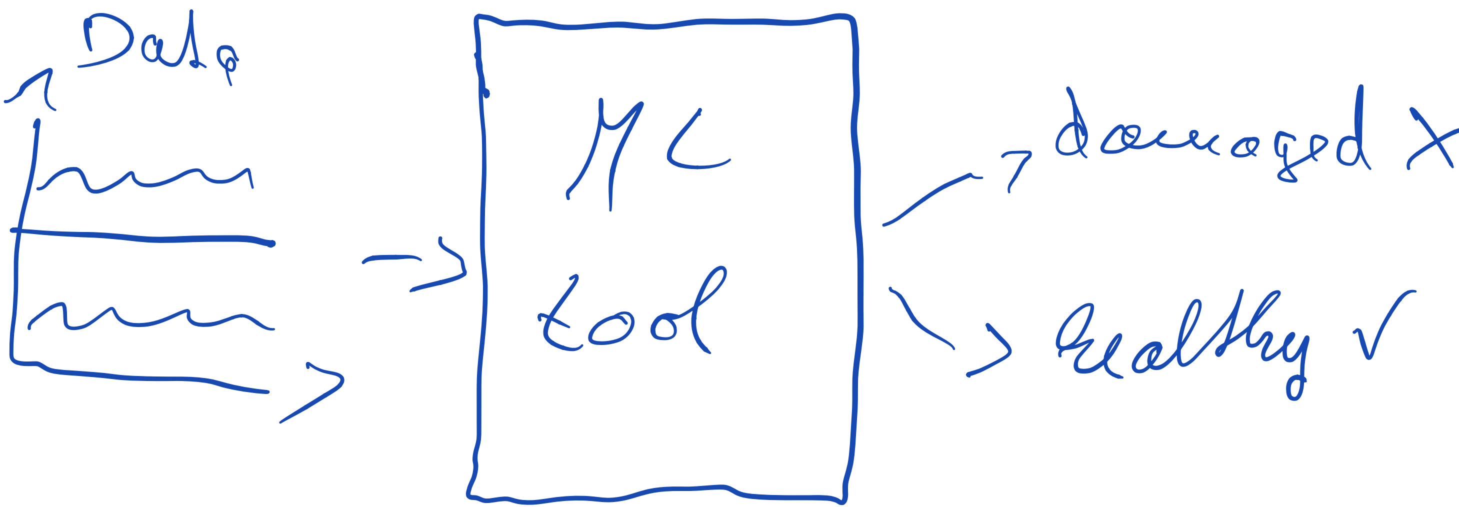
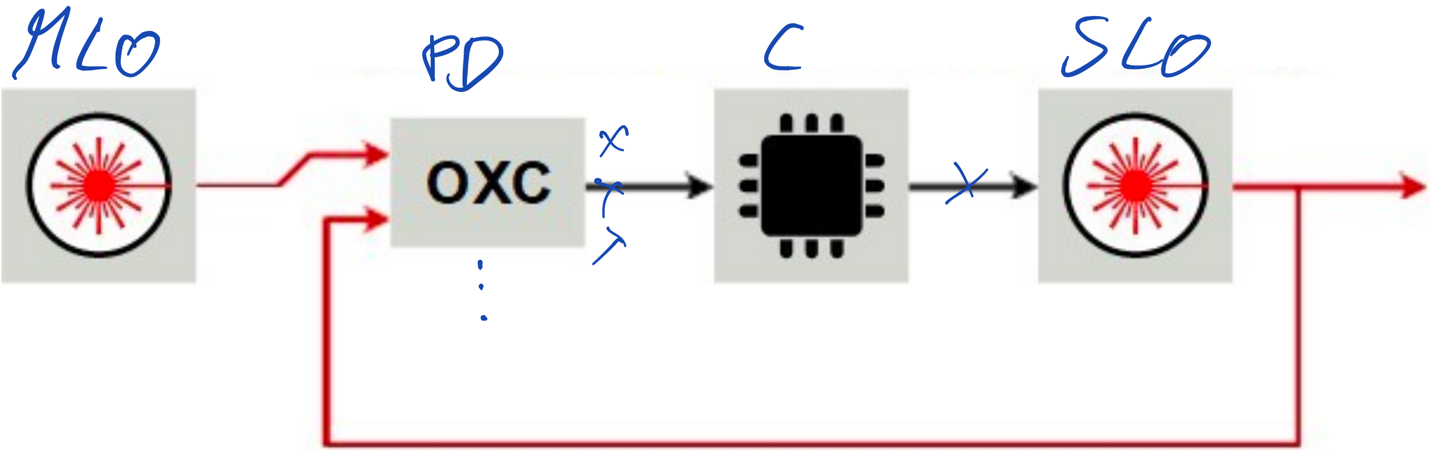
Goal:

Early and reliable damage detection for synchronisation laser



Data

Data source



Example Data - all channels

- time-series data

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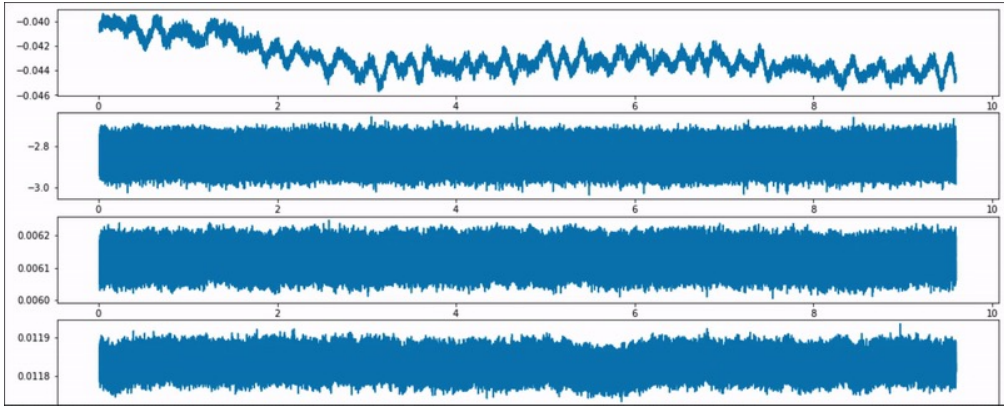
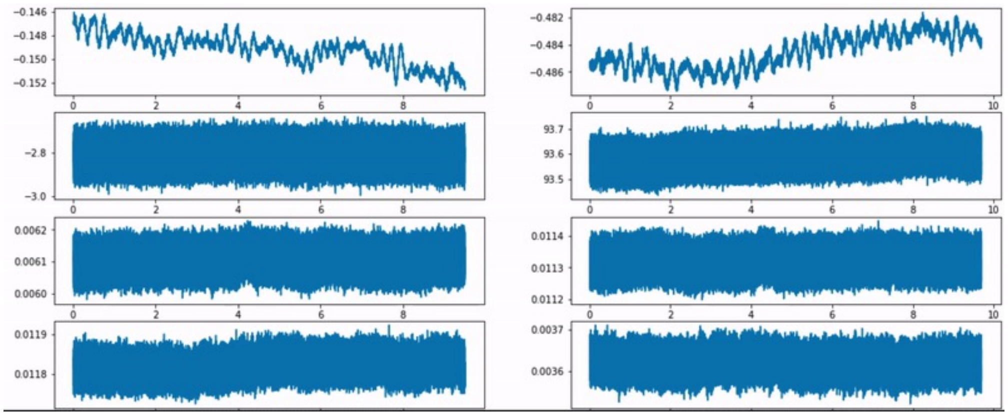


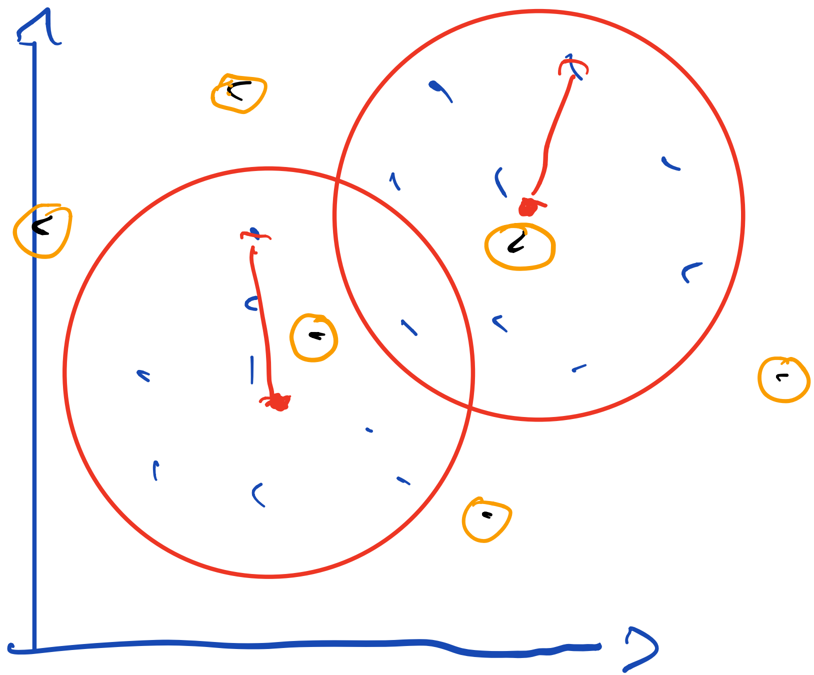
Example Data: healthy vs. damaged

- healthy data: for training + testing (58 samples), damaged data: for testing only (22 samples)
- one example comparison:



Algorithm

k-means



Data transformation

Feature extraction

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  - more sophisticated features: fft-coefficients, entropy, absolute energy, ...

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Dimensionality reduction

- reduce dimensionality of data using: principle component analysis (PCA)
- combines features into defined number of principle components

Results

Using the package

```
import anomaly_detection_package
from anomaly_detection_package.anomaly_detection import
    AnomalyDetectionDesy
data = AnomalyDetectionDesy()
data.load_data_desy()
data.train_test_set_creation(test_size = 0.2)
data.fit(PCA_n_components = 2)
data.get_most_important_features(n_features=10,component=0)
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```
feature             channel             PCA component_
-------             -------             --------------
maximum             RF_HARM_MAG.SPEC    0.162954
maximum             OXC_IN_N.SPEC       0.162324
maximum             RF_FUND_MAG.SPEC    0.162307
standard_deviation  OXC_IN_P.SPEC       0.157876
standard_deviation  RF_FUND_MAG.SPEC    0.157875
standard_deviation  OXC_IN.SPEC         0.157875
standard_deviation  OXC_IN_N.SPEC       0.157873
standard_deviation  RF_HARM_MAG.SPEC    0.157866
standard_deviation  RF_FUND_PHASE.SPEC  0.157857
mean                RF_HARM_MAG.SPEC    0.150212
```

Training results

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data.plot_clusters_2D()
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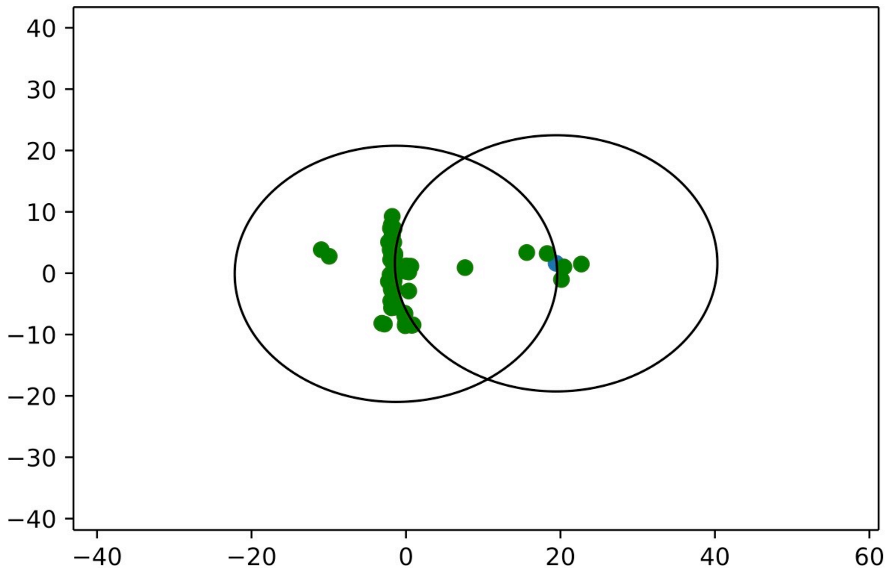

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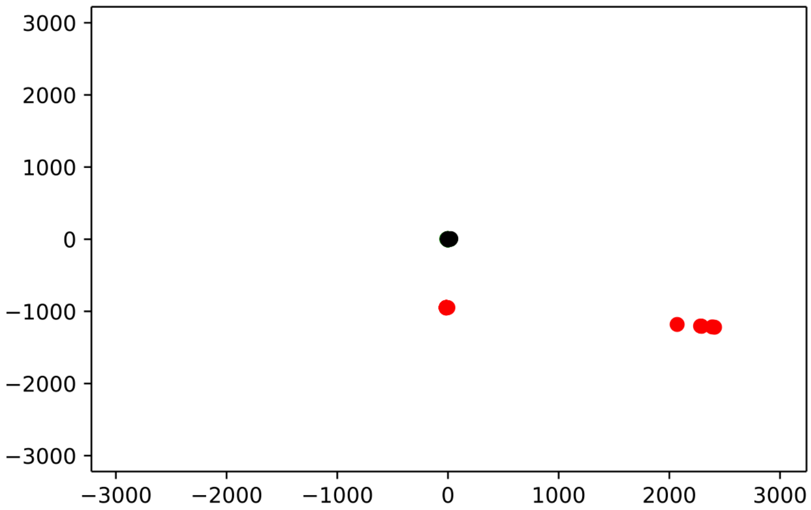

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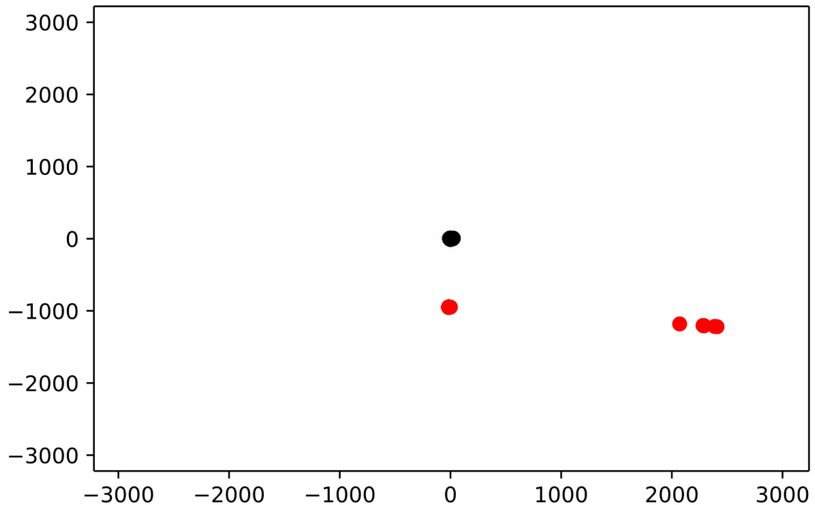

Accuracy:

Overall and reproducible accuracy:
1.0

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$\rightarrow$ Transferability can not be guaranteed

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