# MD 4510 : Beam lifetime optimization with ML

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Generate data for machine learning

Motivation :

- Preliminary Machine Learning optimization study OP/EPFL gave encouraging results [1] but limited by available data
- Machine Learning SDSC/EPFL project: PACMAN
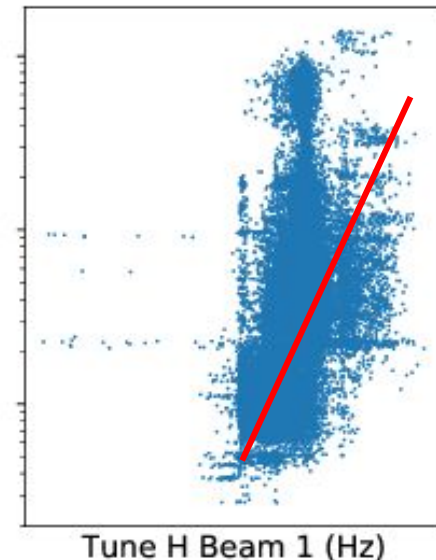
Objective :

- Generate data with relevant trends for machine learning based optimization applications to supplement and/or benchmark machine learning models
- Explore larger parameter space

Tune H Beam 1 (Hz)

[1] See presentation LBOC 4th September : LHC beam intensity lifetime optimization : ramp losses and machine learning applications

Sequence Control Interface

Qt interface using :

- PyQt
- pjlsa
- pyjapc

Generation and control of trim sequences :

- Random tune trims around +/- 0.01 of the nominal injection tunes H/V = 0.275 / 0.290
- The path of the trims was optimized to avoid far jumps crossing many lines.
- We move from one point to the other, both beams and H/V changed at the same time
- Scans repeated with different machine settings
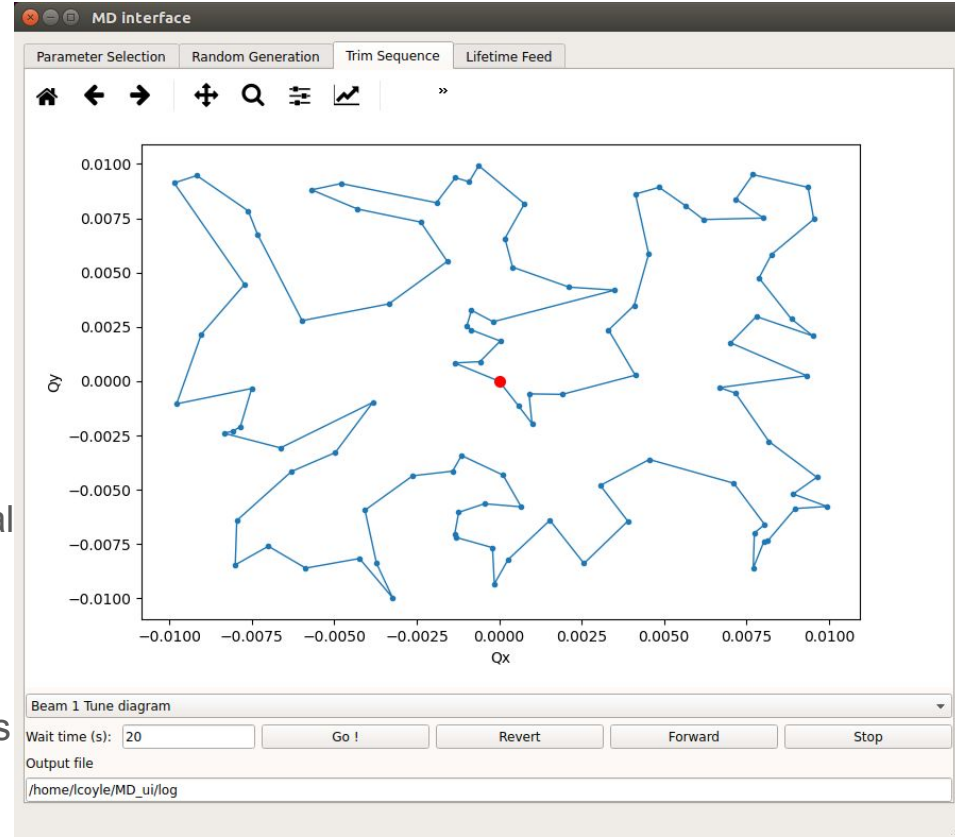
Overview

6h MD time

Sequences :

1: 100 points

2: 100 points

3: 50 points

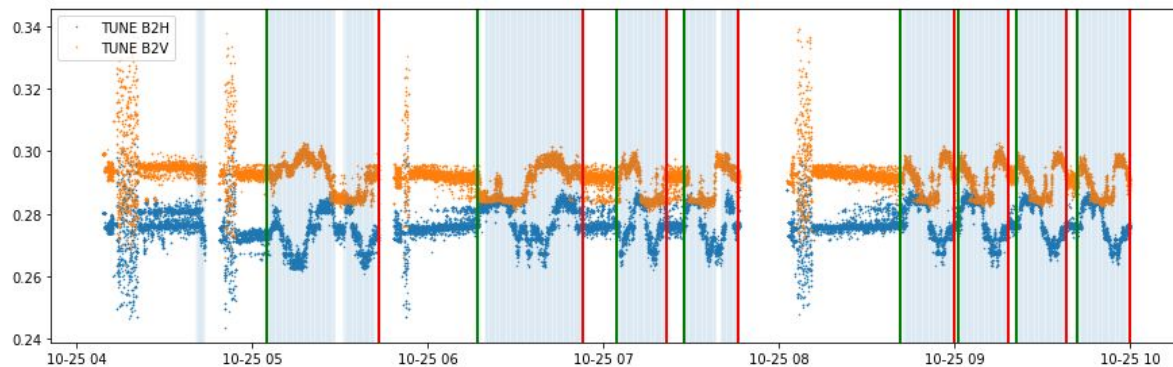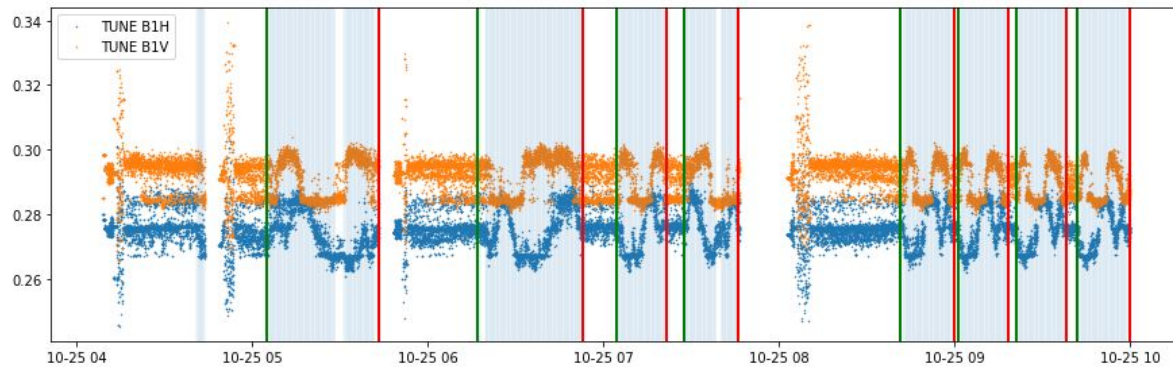4: 50 points, chroma 15 units

5: 50 points

6: 50 points

7: 50 points, chroma 15 units oct 40 A

8: 50 points, chroma 15 units

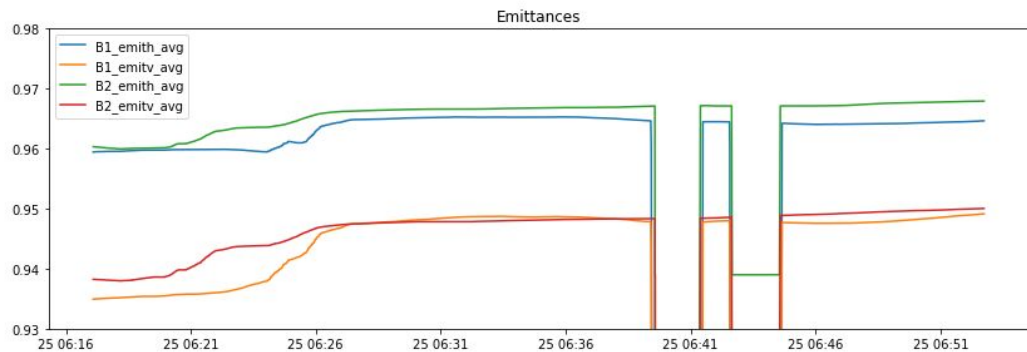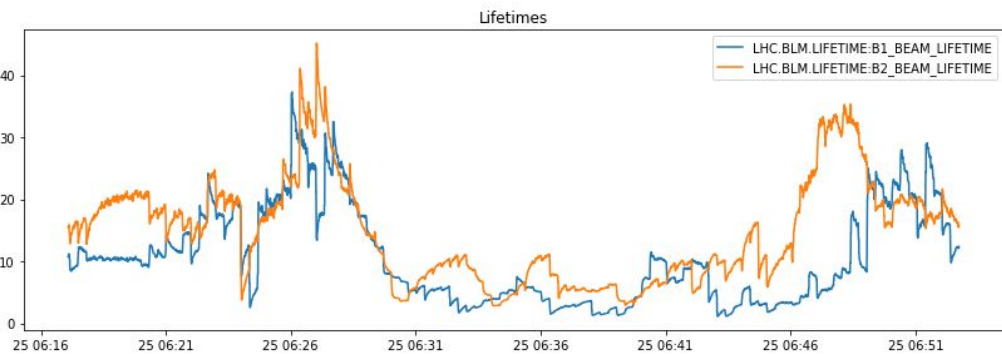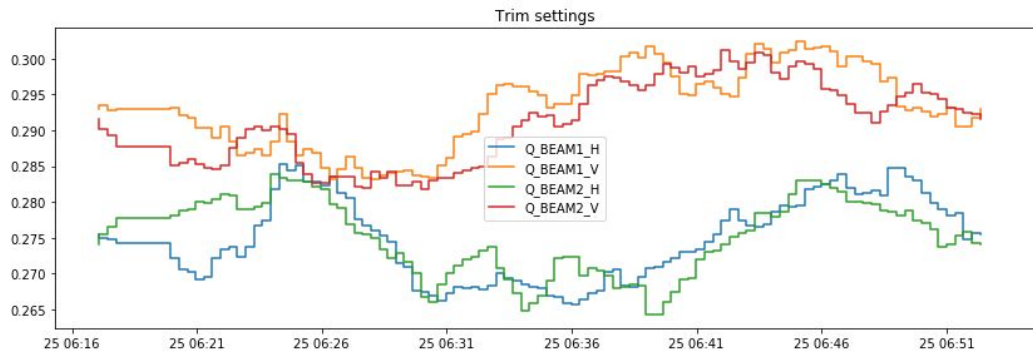Tune measurement vs time, with timings of the applied trims

Main trends

For the second 100 trim sequence :

Tunes close to resonance, small $\Delta Q \rightarrow$ High lifetimes and emittance increase.

Multi-objective optimization problem
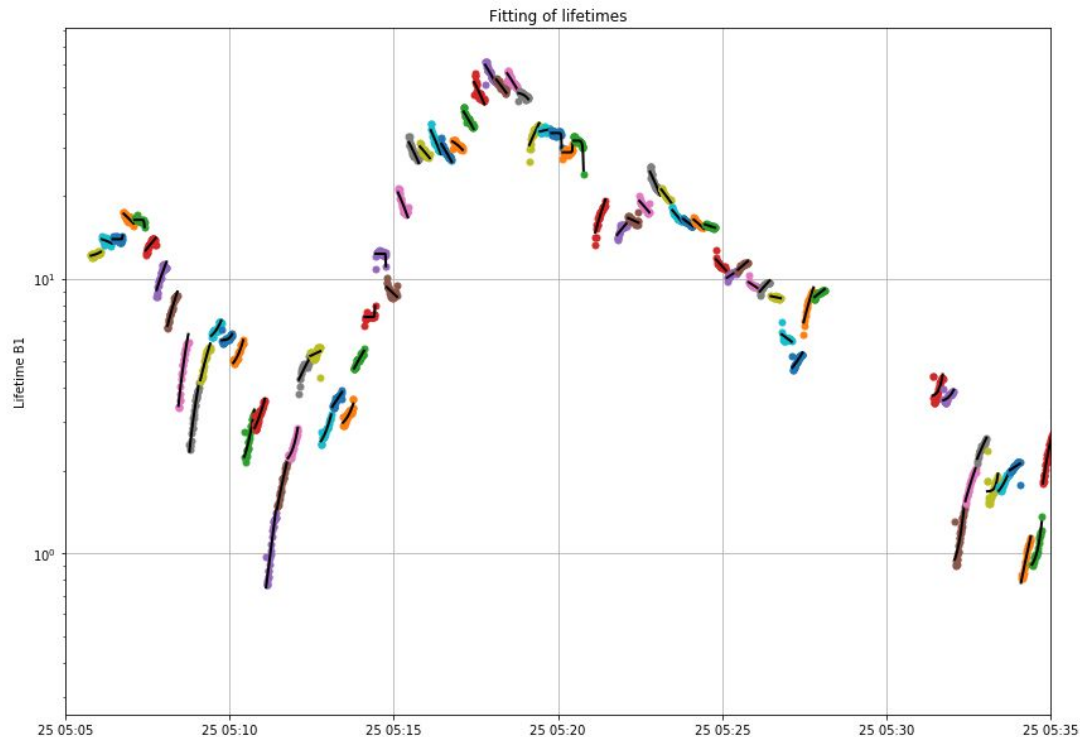
Lifetime data

Lifetime reaction to trim setting:

- Instantaneous response
- Longer term response

Can this be modeled with machine learning ?

Intensive post processing required

Study the transient of lifetime after a tune trim.
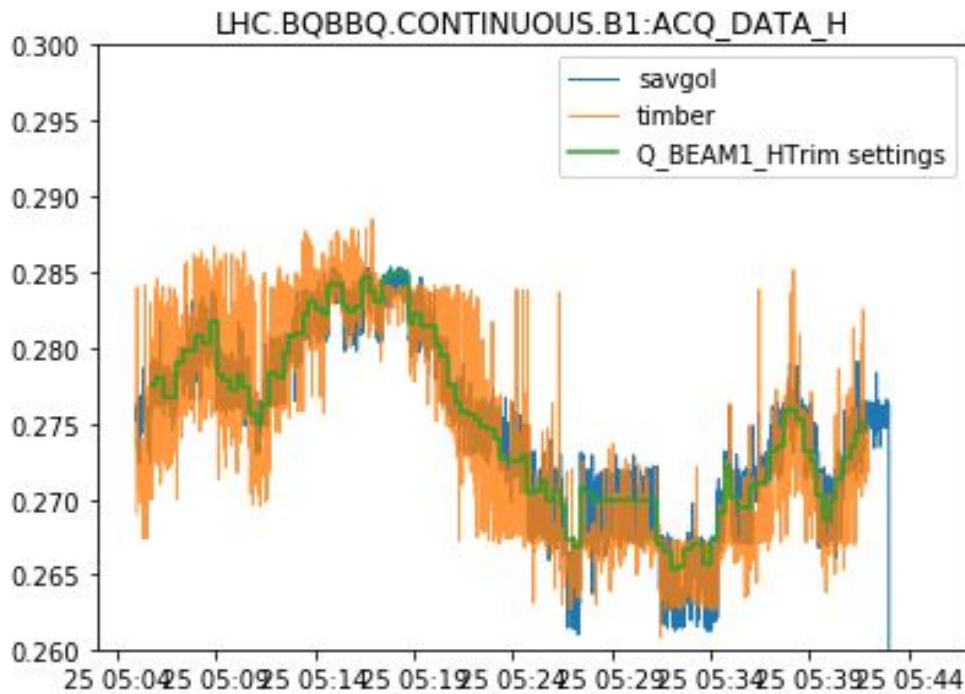

Fitting of lifetimes

Post processing - Tunes
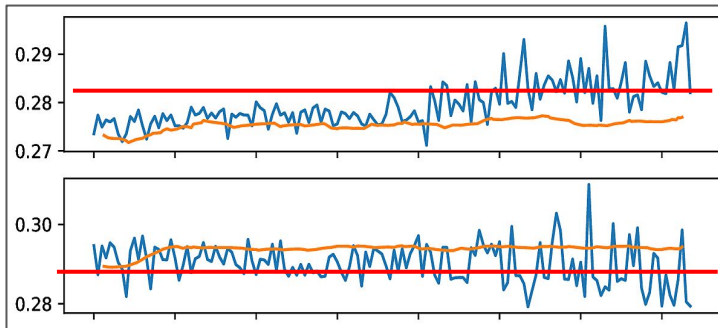
Post-processing ongoing :

Tune from BBQ spectrum

BOSFU:TUNE signal unreliable, very noisy, when compared to the actual trim settings.
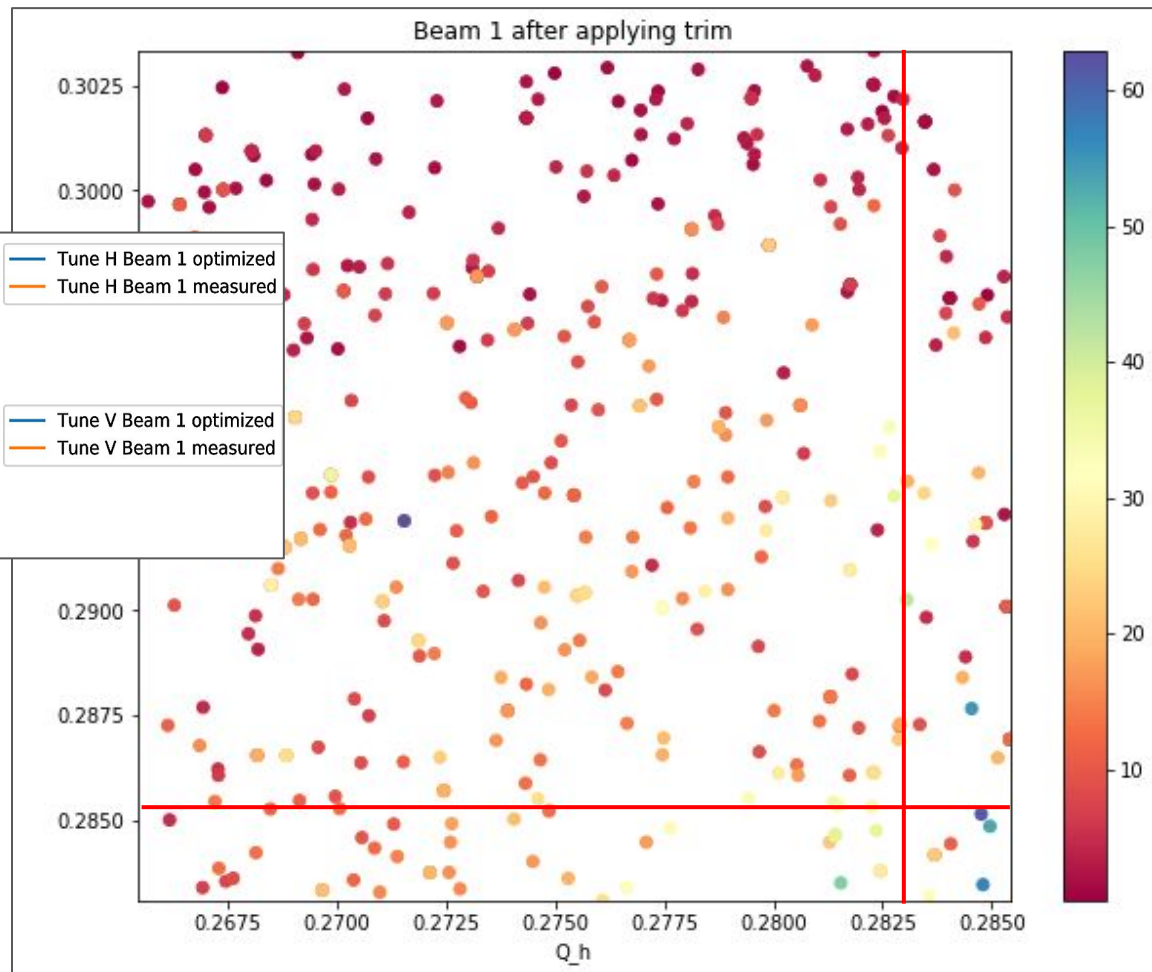
→ Custom post-processing method ?
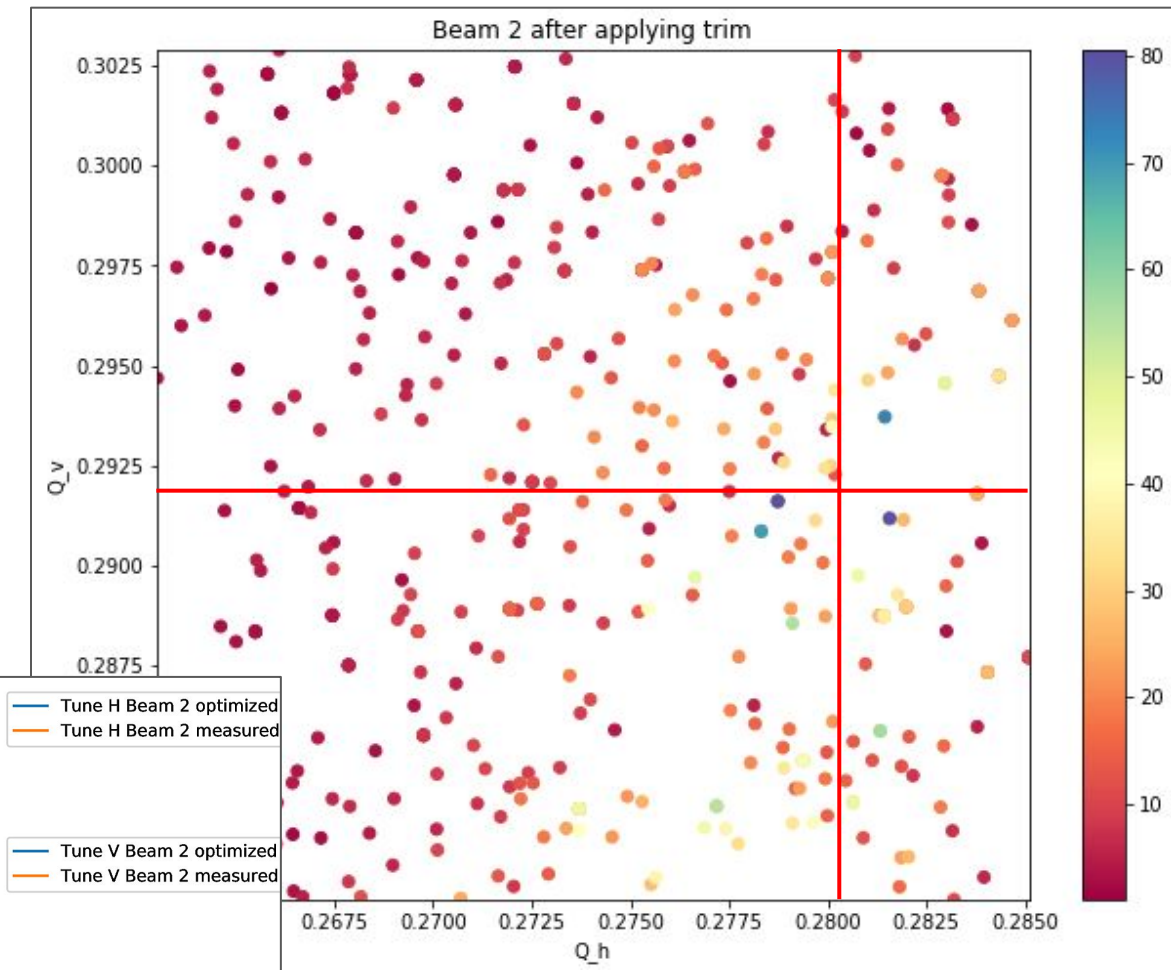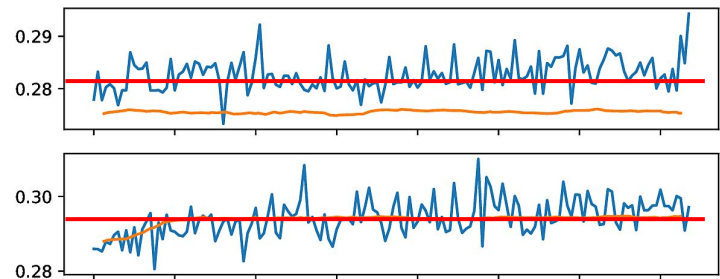
Comparison with ML model

The lifetime response seems to agree with the "optimal" tunes as given by previously trained Machine Learning model on 2018 data.

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Beam 2 after applying trim

Summary

- MD went smoothly with the Sequence Control Interface → MD successful
- Corroborates previous machine learning study
- Generated essential data for future models → large ranges of the parameters with the relevant trends
- Data exploration and post-processing ongoing
- Soon to be used in a new multi-objective Machine Learning model