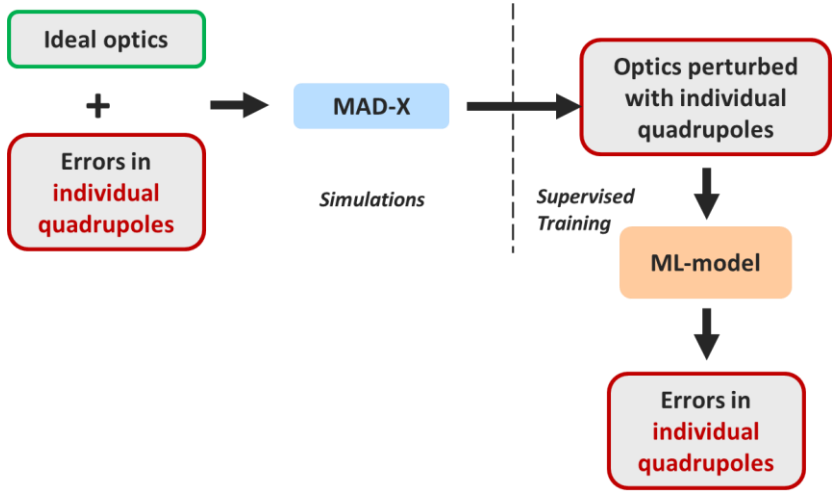
# Estimation of quadrupole errors using Machine Learning

- Linear Regression with regularization (*Ridge*)

→ Correlations between magnetic errors and optics deviations from design can be learned by ML-model from simulations data.

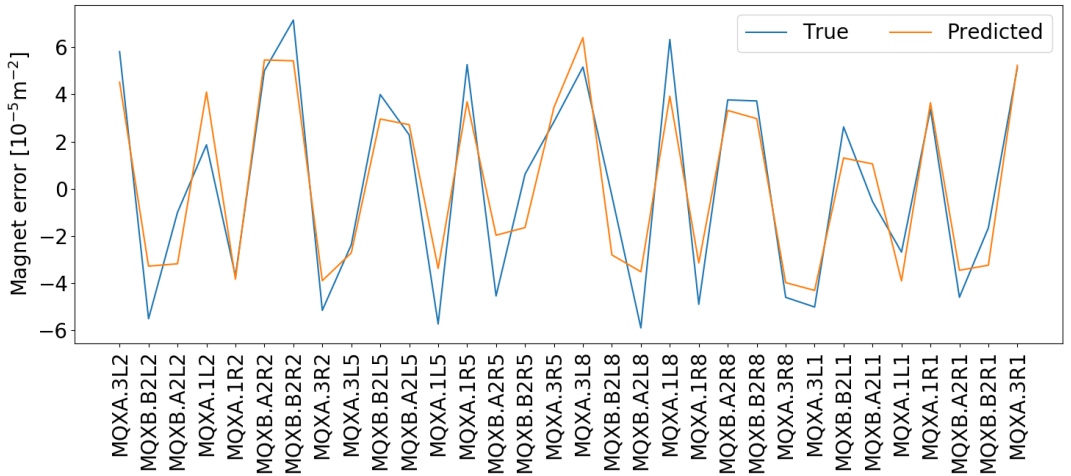



$\Delta\beta^*, \Delta\phi, \Delta D/\sqrt{\beta}$ (both beams) → 3304 input variables

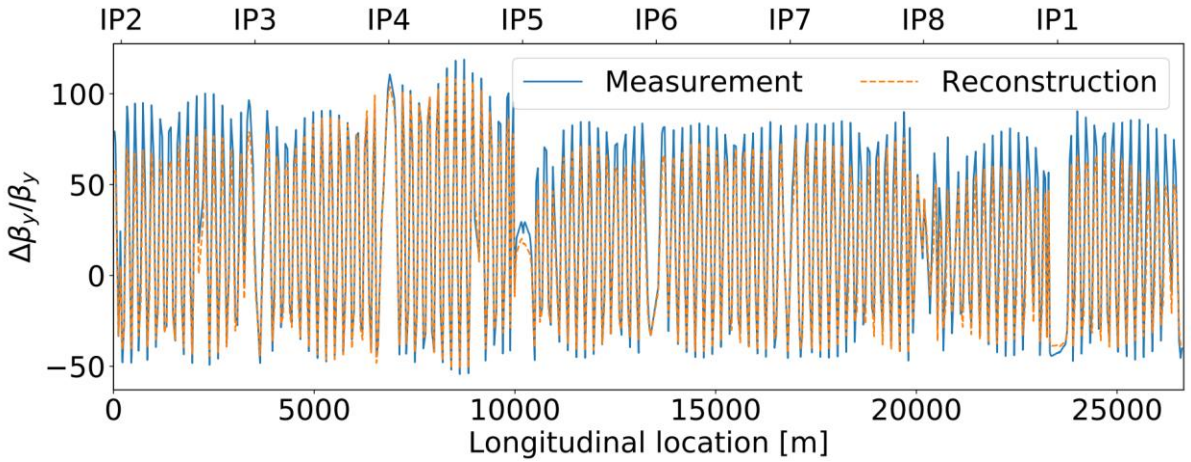
ΔK (all quads, both beams) → 1256 output variables.

**Prediction of triplet errors:**

*simulation*




*Example: Beam 1, vertical plane*




- **Results on LHC commissioning 2016 data, $\beta^*$ = 40cm:**

1. Predict magnet errors from the measurement data
2. Reconstruct optics using predicted errors and MAD-X

→ Magnet errors predicted with ML-model reproduce the measured β –beating in uncorrected machine with average rms error of 5%.