



Decision support by Process Monitoring and Statistical Process Control

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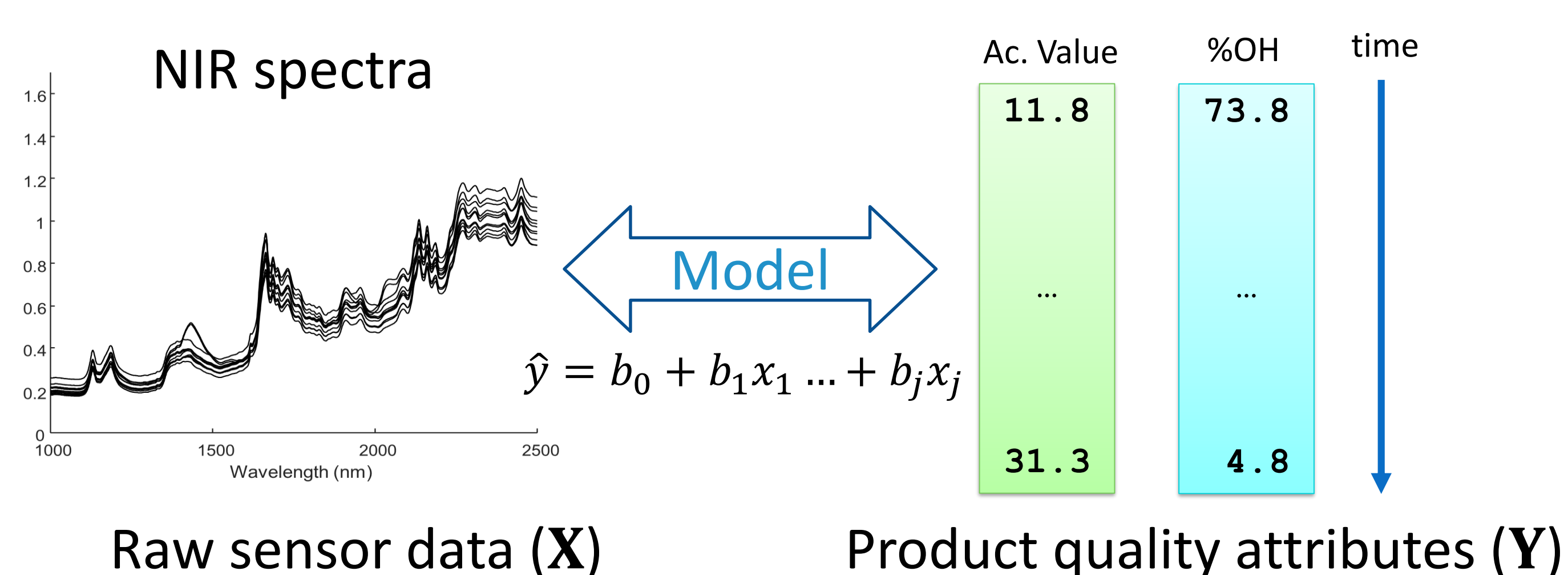
On-line (or in-line) measurements are information-rich data for process monitoring and control. Near-infrared (NIR) spectra of the process, measured at regular time intervals, can be used to monitor the process, either by considering the spectra alone, or from multivariate calibration models relating the spectra to key properties of interest.

The establishment of calibration models for process monitoring requires calibration data mimicking the process experimental domain and process conditions (sensor, environment, physical parameters). Sensor responses (e.g. spectra) and key properties must be determined in the same representative material to ensure that the calibration model can provide reliable predictions in real-time.

Process control models can be established from direct sensor measurements or predictions from calibration models. Control models are based on diverse and representative measurements defining the accepted boundaries concerning qualities of final products or process evolution. They allow detection of end-points, check of final properties and tracking deviations of process functioning while it is taking place.

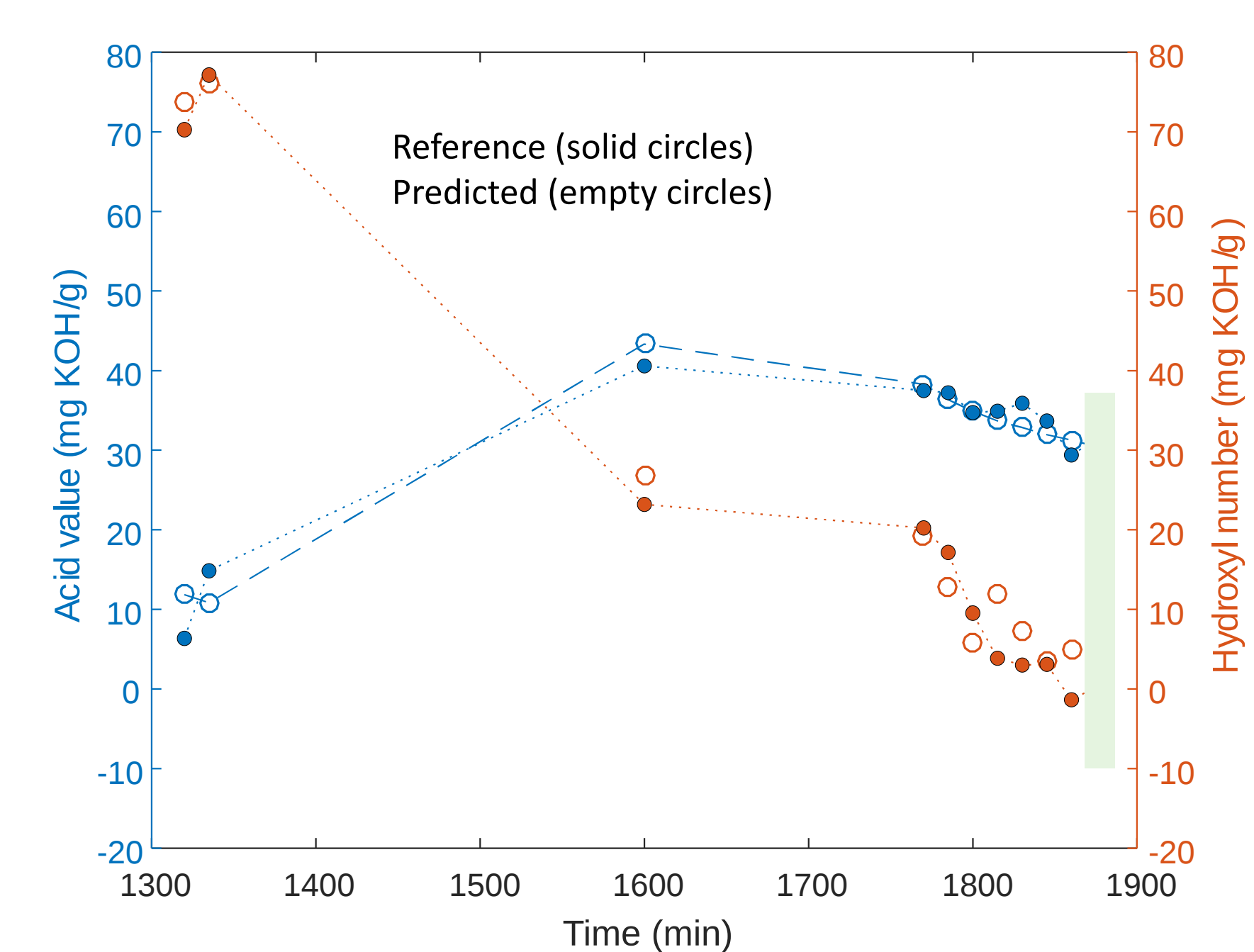
Process monitoring

Establishment of calibration model



Measurement conditions (instrument, probe, temperature, ...) for calibration data must be representative of measurement conditions in the working process.

Predictions over time from the calibration model



Spectra (X) and reference values of the key properties (Y) can be related with, e.g., partial-least squares (PLS) regression. The model equation can predict the modelled property from future measured spectra.

Multivariate statistical process control (MSPC) based on process monitoring information

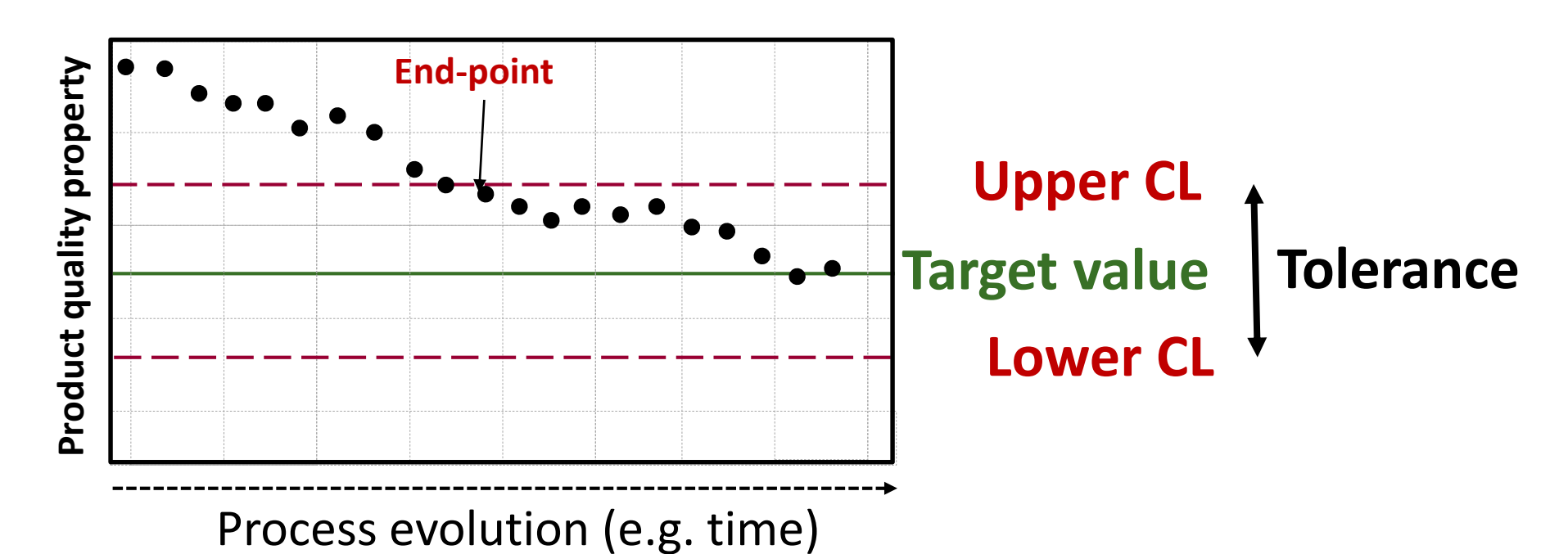
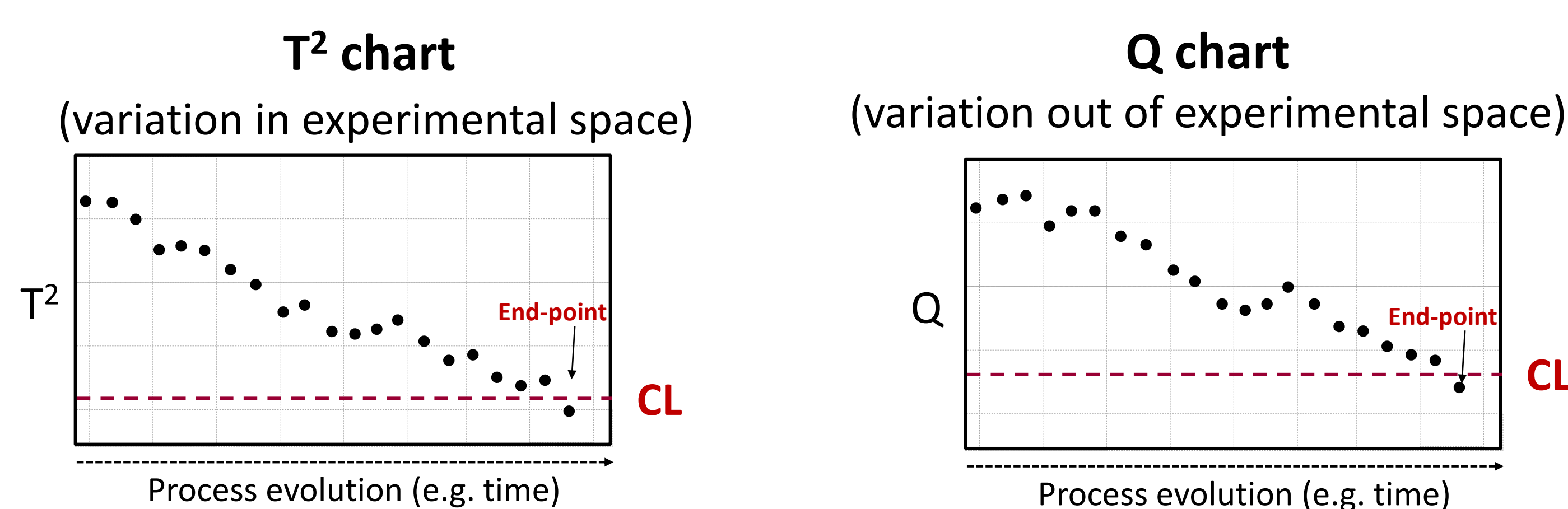
Detection of process end-point based on spectra or product quality properties

Reference information for control model (X):
Spectra of accepted final products (on-specification)

Reference information for control model (Y):
Target value for property with accepted tolerance

Multivariate control charts

Univariate Shewhart control charts (variation around target value)



----- Control limit (CL) of charts is constant and defined by reference information

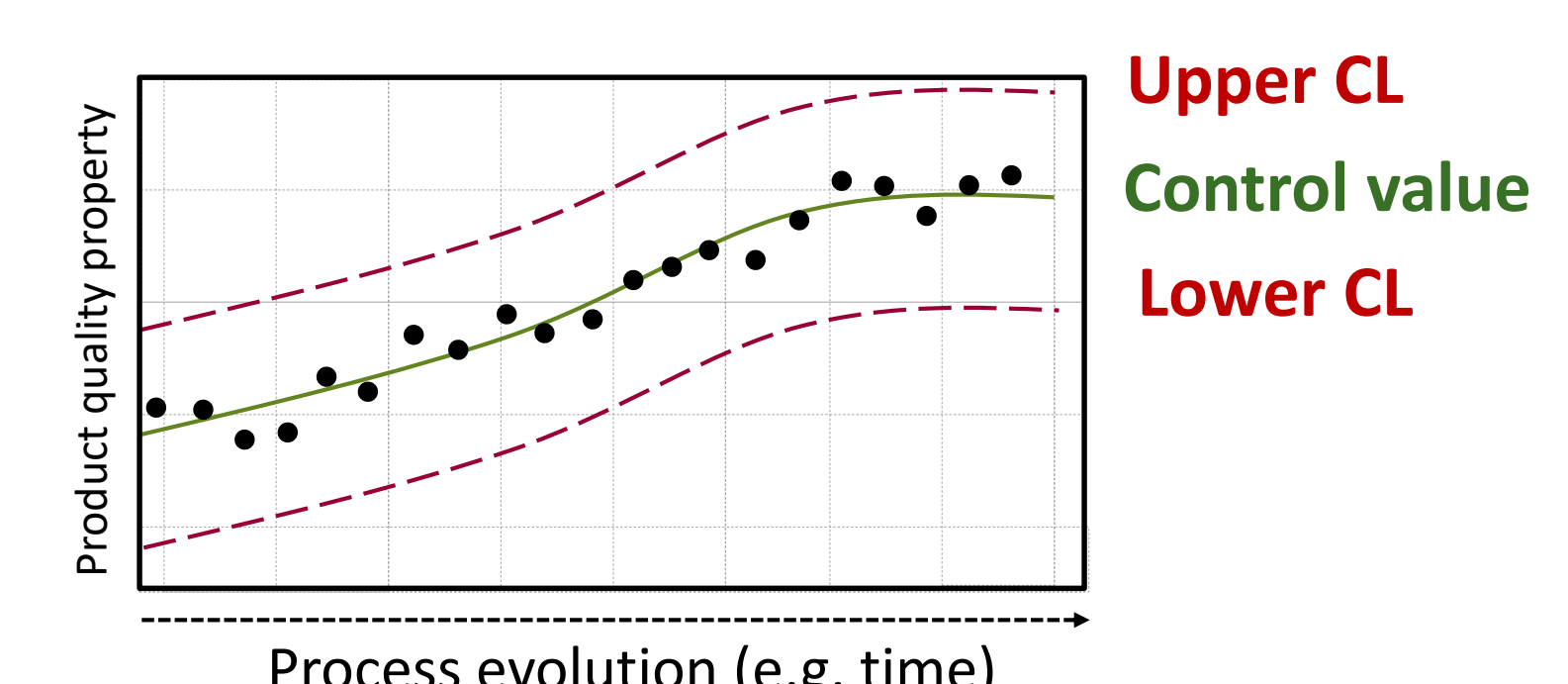
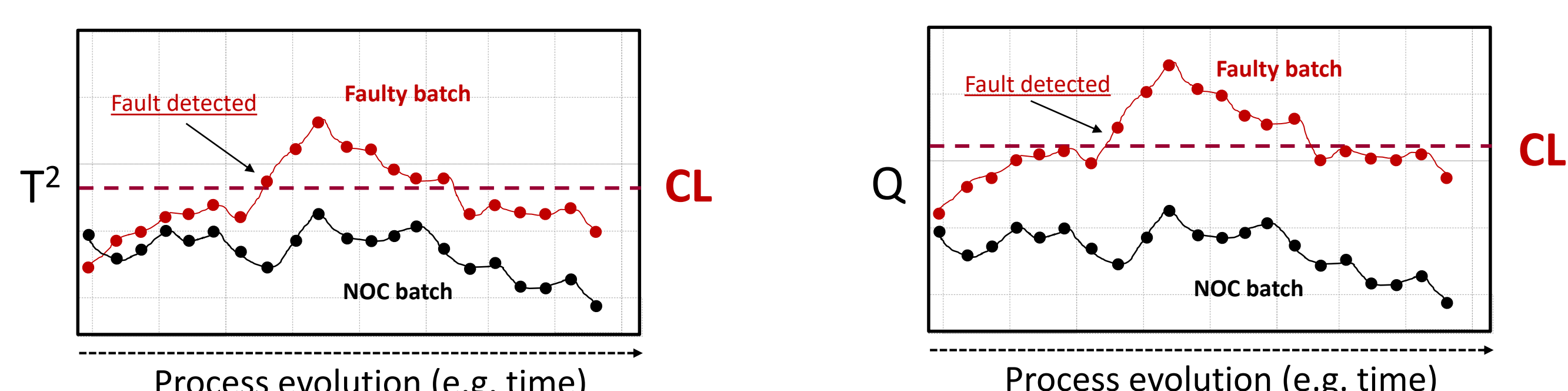
Tracking process evolution (trajectories)

Reference information for control models:
Spectra of complete batches in NOC (normal operating conditions)

Reference information for control models:
Product quality attribute values and its precision over the process evolution from several NOC batches

Multivariate control charts

Univariate Shewhart control charts



----- Chart control limits are defined by reference information and change as a function of process evolution