

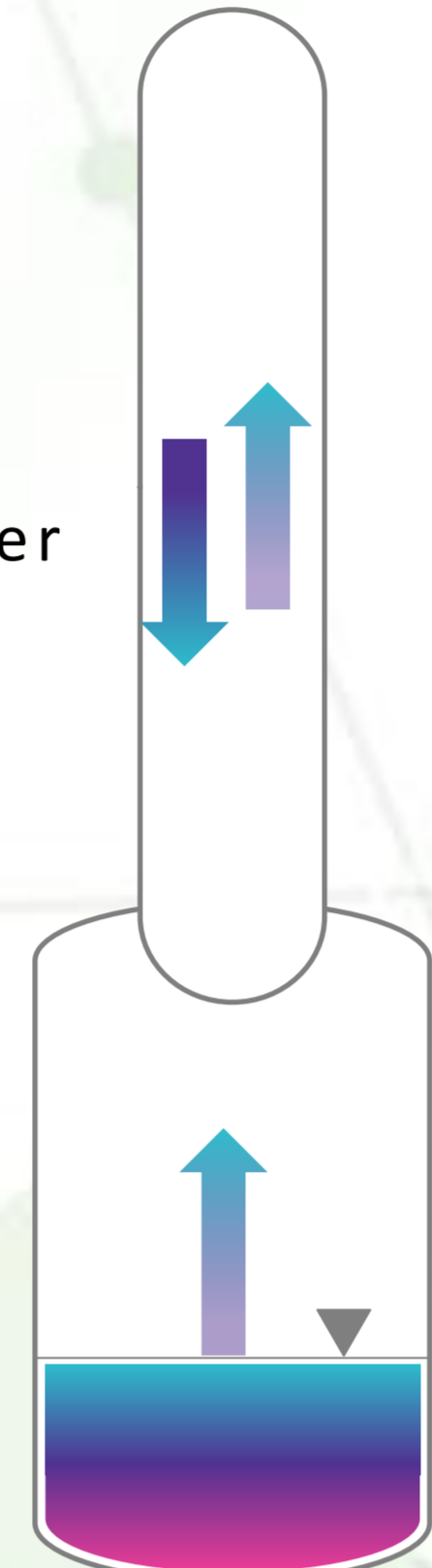
# Hybrid modeling and control of a batch distillation process of polymer solutions

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## Use case

- **Industrial process unit**
  - Batch distillation column
  - Used to separate ternary mixture containing polymer
- **Data characteristics**
  - Historic time series data of batch runs covering years of operation
  - Corresponding offline quality, and online process measurements

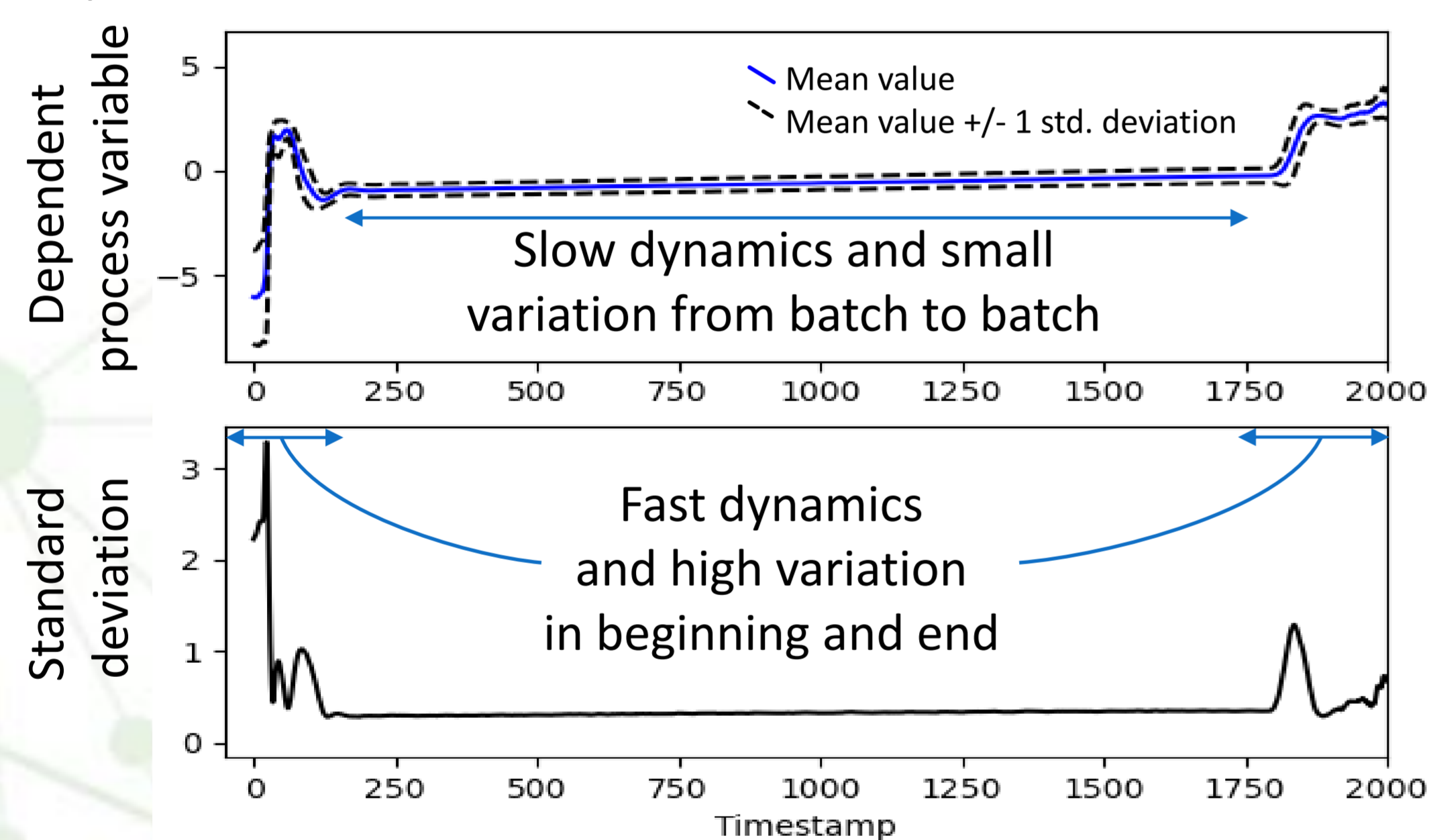


## Motivation

- **Objective:** Process optimization to decrease quality fluctuations using model-based advanced process control
- **Challenges:**
  - Fully data-based models only provide limited insight and optimization potential
  - Physical models are expensive to obtain when the components are complex

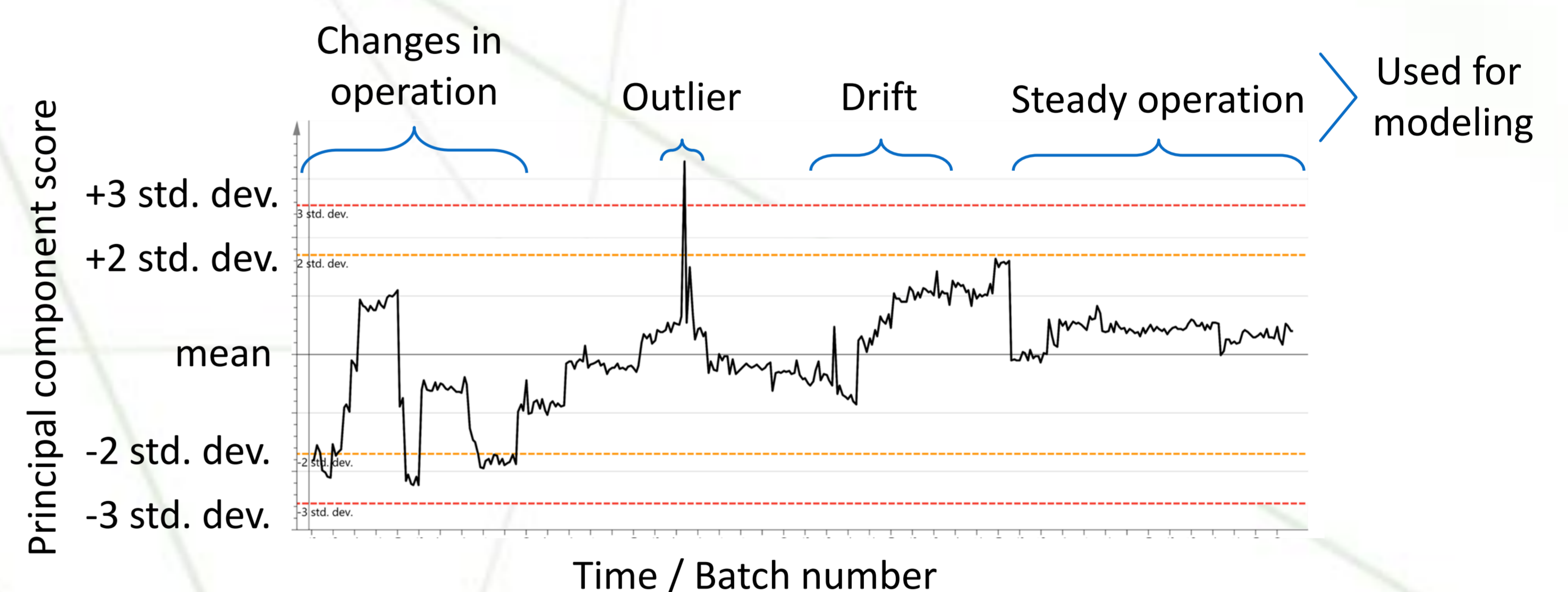
## Process dynamics

- Simultaneous occurrence of fast and slow dynamics
  - Challenge for modeling
  - High data variety of fast dynamics
- Late dynamic behaviour requires long term memory of states of the process



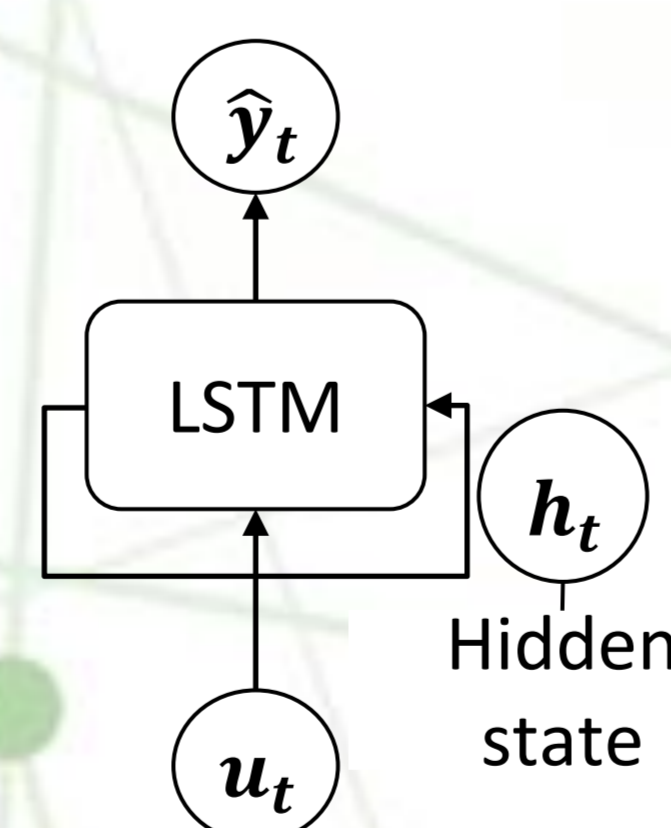
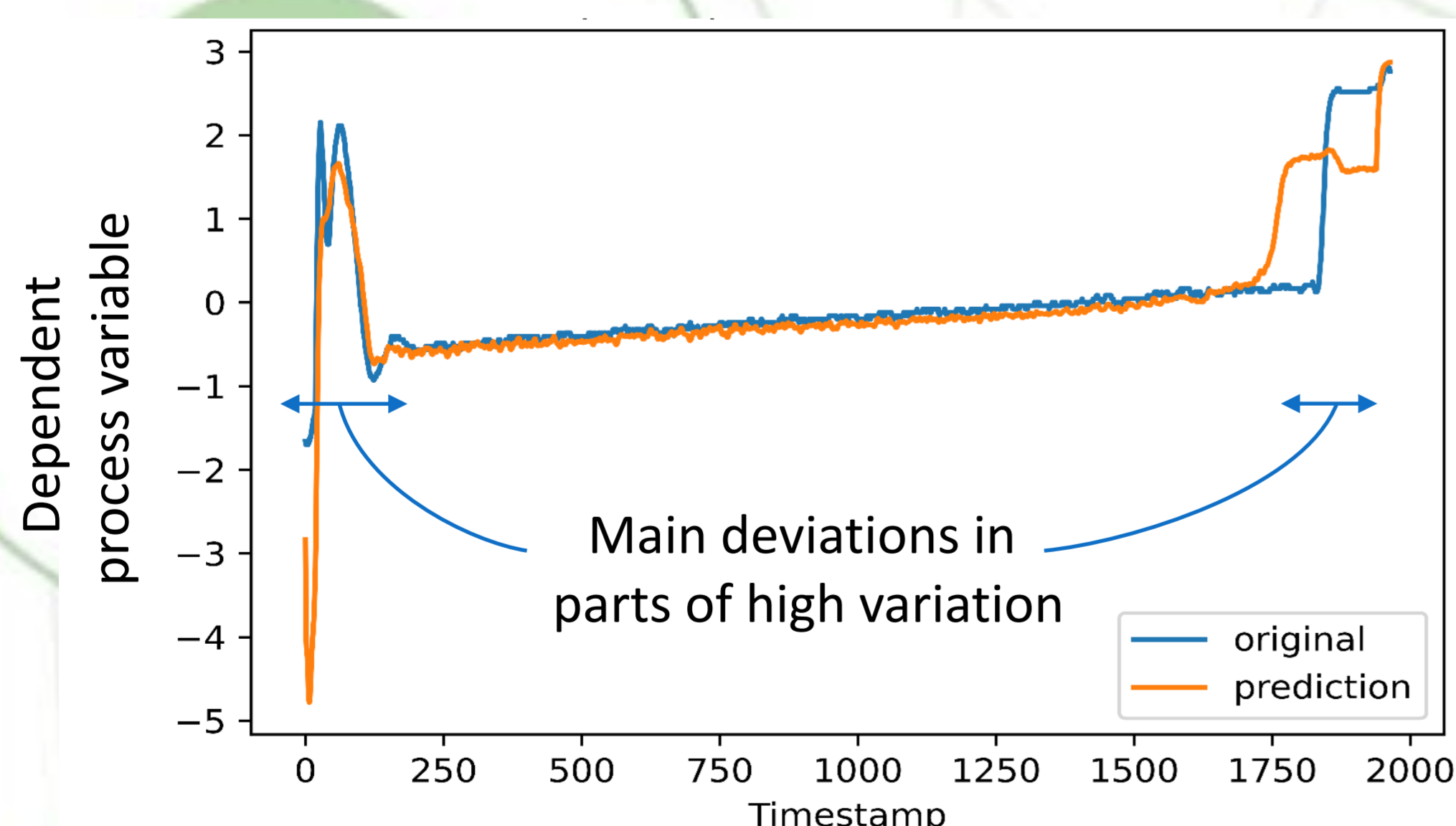
## Plant dynamics

- Long time horizon of historic data: past events have to be considered
- Plant behaviour analysed using PCA



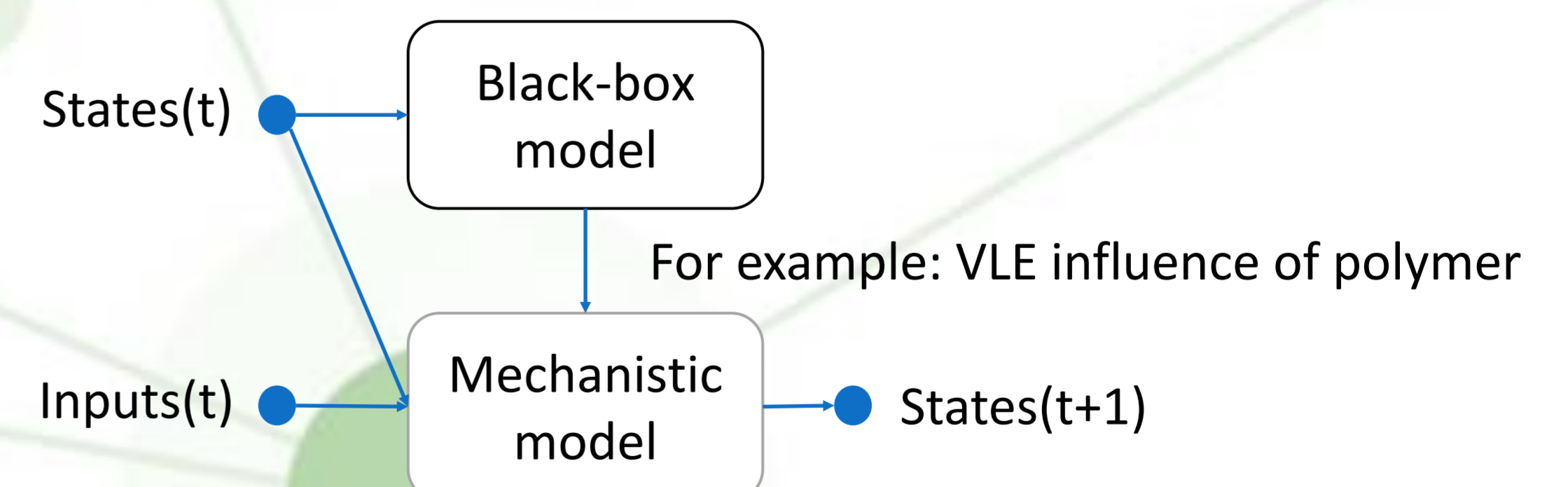
## Data-based dynamic model

- Recurrent neural network model consisting of one LSTM unit [1] for dynamic system identification, similar to [2]
- 87 batches of the stable operating period used for training



## Outlook

- **Hybrid modeling**
  - Use the mechanistic model of the system to train a black-box model with the historic sensor data
  - Train model to describe complex effects resulting from polymer-solvent interactions, similar to [3]
- **Control**
  - Apply advanced process control using a hybrid process model



Dynamics towards the end especially important for reliable production due to high influence on final state

[1] Hochreiter, S., & Schmidhuber, J. (1997). Long short-term memory. *Neural computation*, 9(8), 1735-1780.

[3] Igbokwe, P. K., & Egemba, K. C. (2018) Hybrid Mechanistic Neural Network Modeling of Chemical Processes: Application to Crude Oil Distillation. *Journal of Scientific and Engineering Research*, 5(2):25-31

[2] Kwon, H., Oh, K. C., Choi, Y., Chung, Y. G., & Kim, J. (2021). Development and application of machine learning-based prediction model for distillation column. *Int J Intell Syst.* 2021, 36:1970-1997