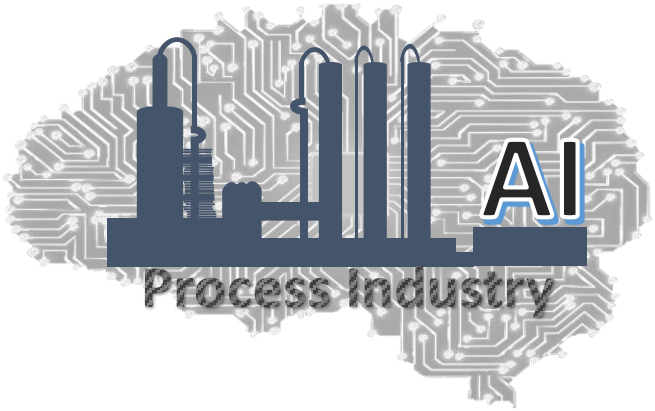
Statistical Techniques for Monitoring Industrial Processes



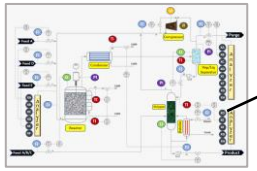
Lecture : Shewhart Control Charts

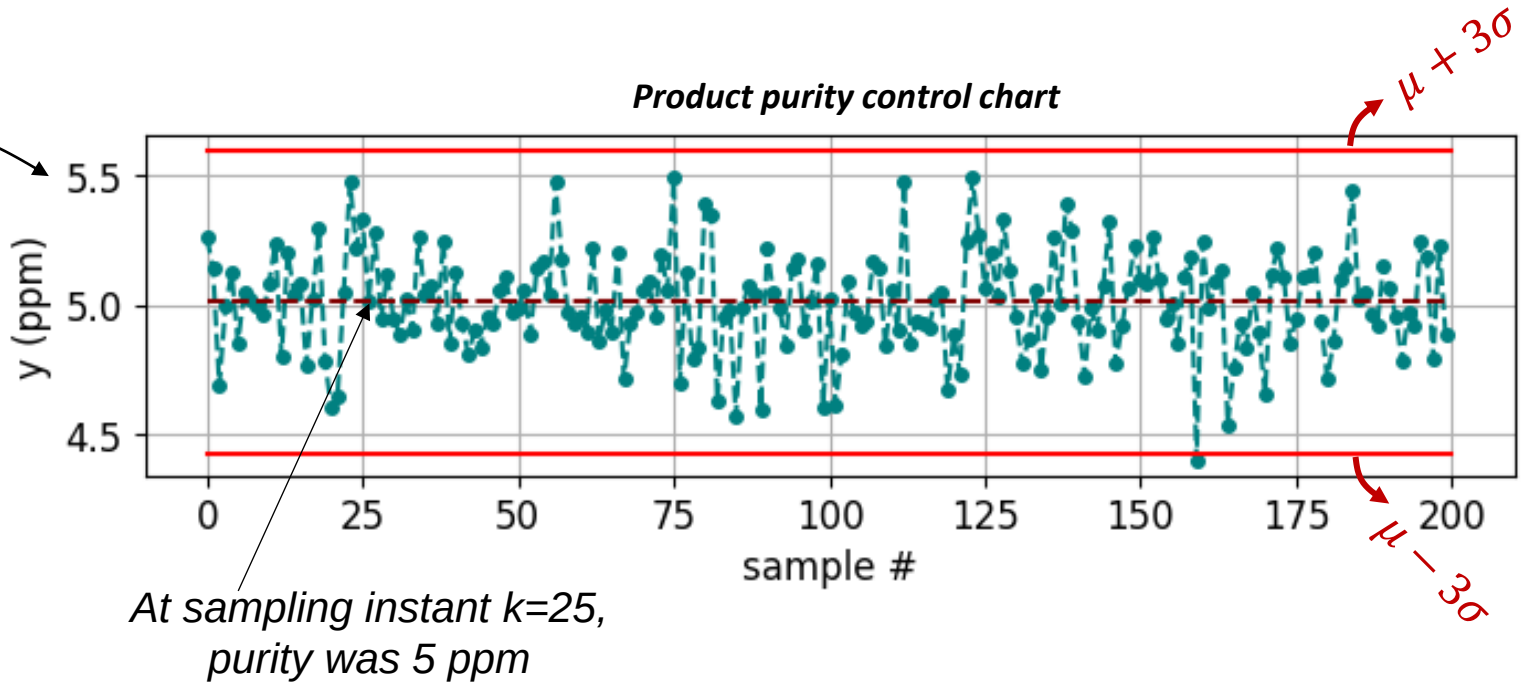
Module : Univariate SPM

Course TOC

- ❑ Introduction to Statistical Process Monitoring (SPM)
- ❑ Python Installation and basics (optional)
- ❑ Univariate SPM & Control Charts
  - ➢ Shewhart Charts
  - ➢ CUSUM Charts
  - ➢ EWMA Charts
- ❑ Multivariate SPM
  - ➢ Fault detection using Principal Component Analysis (PCA)
  - ➢ Fault detection using Partial Least Squares (PLS) regression
  - ➢ Fault diagnosis using PCA/PLS contribution charts
  - ➢ Strategies for handling nonlinear, dynamic, multimode systems
- ❑ Deployment of SPM Solutions

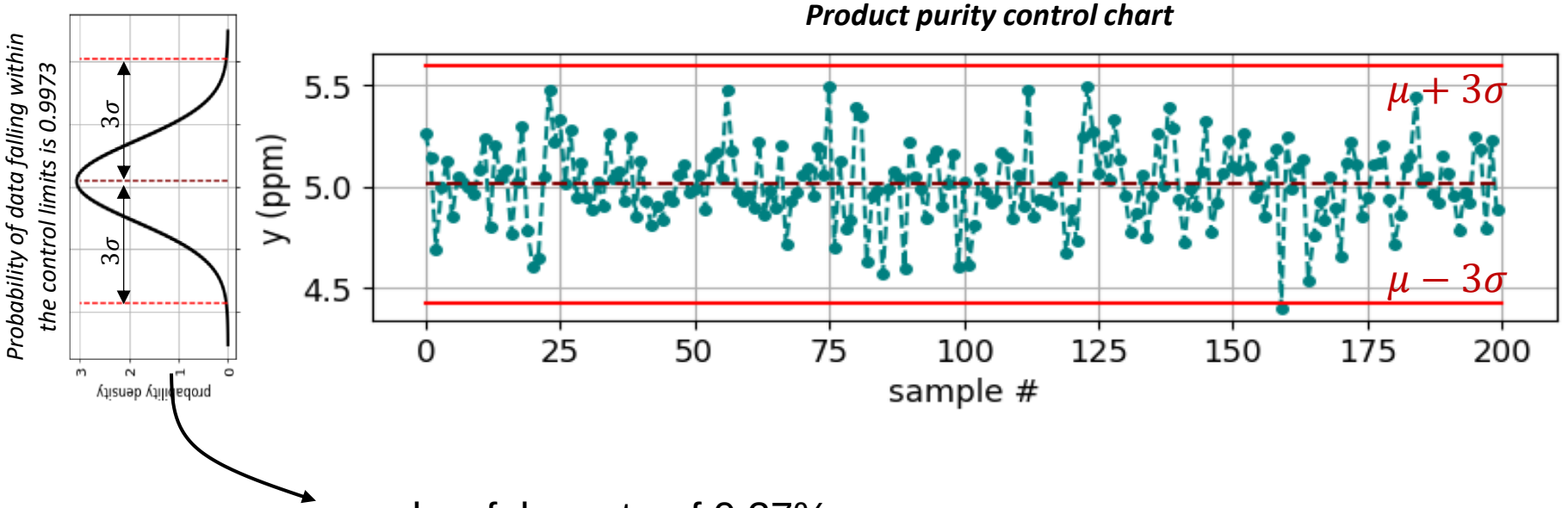
Shewhart Control Charts





μ = mean of purity distribution
σ = standard deviation of purity distribution

Shewhart Charts: Why 3σ?

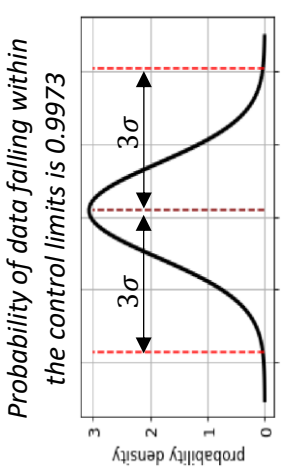


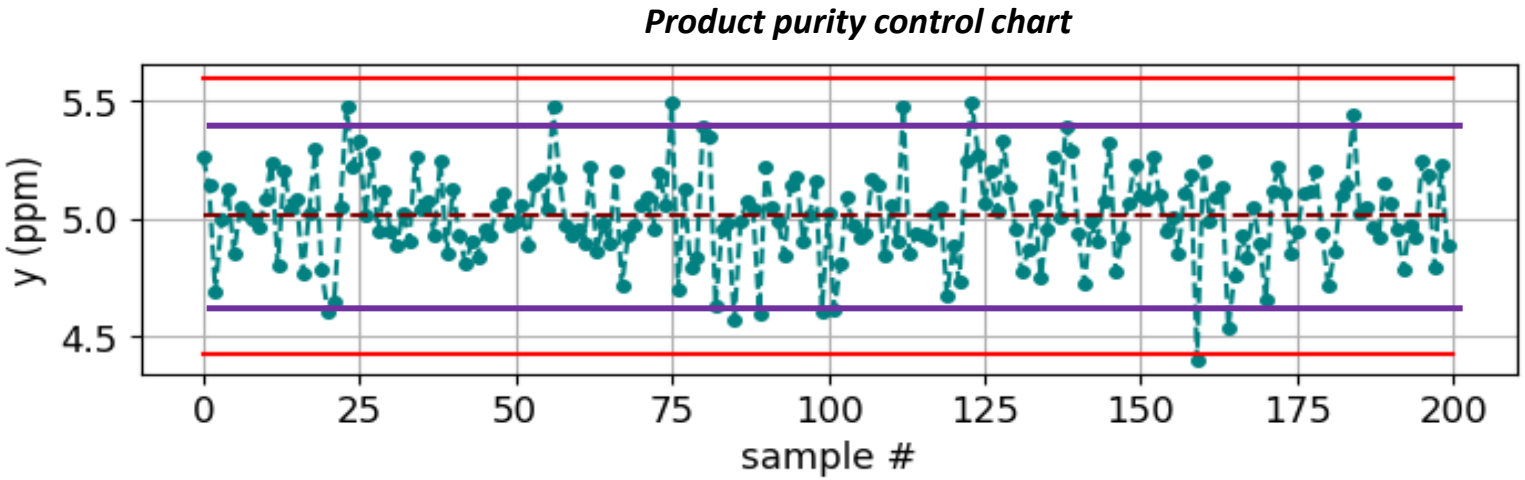
⇒ very low false rate of 0.27%

i.e.,

roughly, only 3 samples out of 1000 sample will violate the thresholds when the process is *'in-control'*

Shewhart Charts: 2σ or 3σ?



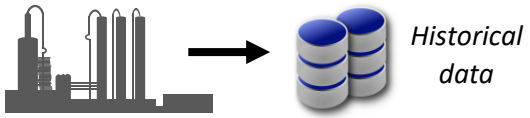


Stricter control limits ⇒ FAR ↑ ☹

Sensitivity ↑ ☺

trade-off

Shewhart Charts: Estimating μ and σ



Large number of historical samples

$$\hat{\mu} = \bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

sample mean

$$\hat{\sigma} = s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{N-1}}$$

sample standard deviation

Small number of historical samples

$$\hat{\mu} = \bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

$$\hat{\sigma} = \frac{s}{c_4} = \frac{1}{c_4}\sqrt{\frac{\sum(x_i - \bar{x})^2}{N-1}}$$

*Correction factor**

N	c_4
2	0.798
5	0.94
10	0.972
100	0.997

*https://en.wikipedia.org/wiki/Unbiased_estimation_of_standard_deviation

Shewhart Charts: Implementation Demo

2 Case studies

1. Product purity mean value changes by 0.5σ due to process upset

2. Product purity mean value changes by 2σ due to process upset

Shewhart Charts: Pros & Cons

Pros

- Easy to interpret
- Easy to implement
- Quick detection of large shits in mean values

Cons

- Poor detection of small shifts in mean values

CUSUM charts can help with these scenarios

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Next Lecture : CUSUM Control Charts

Module : Course Introduction