INTRODUCTION TO THE DESIGN OF AN INFRARED MILK ANALYZER
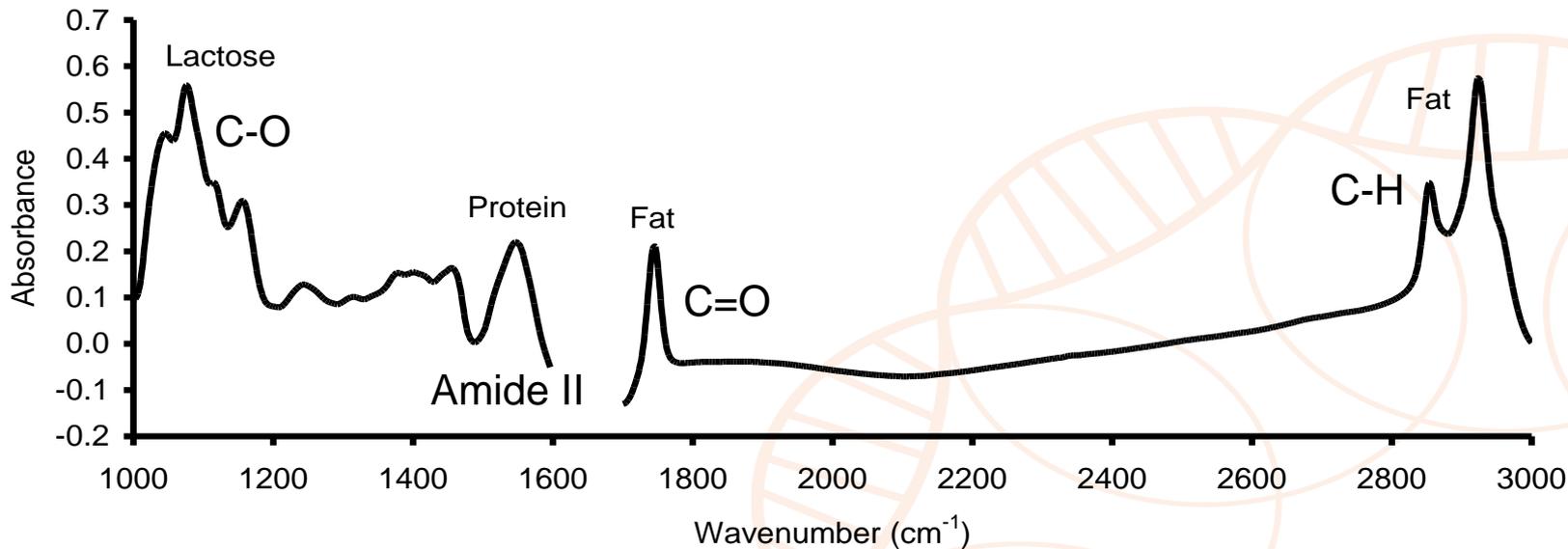
Per Waaben Hansen

Fellow Data Scientist, FOSS
Affiliated Associate Professor, University of Copenhagen
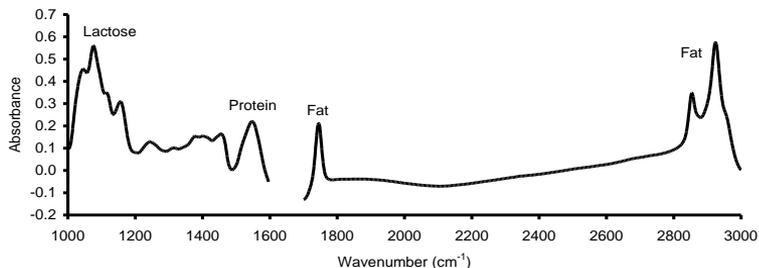
Outline

- Why is the infrared spectrum so interesting?
- History of infrared analysis of milk
- Designing an instrument for milk analysis
- Summary

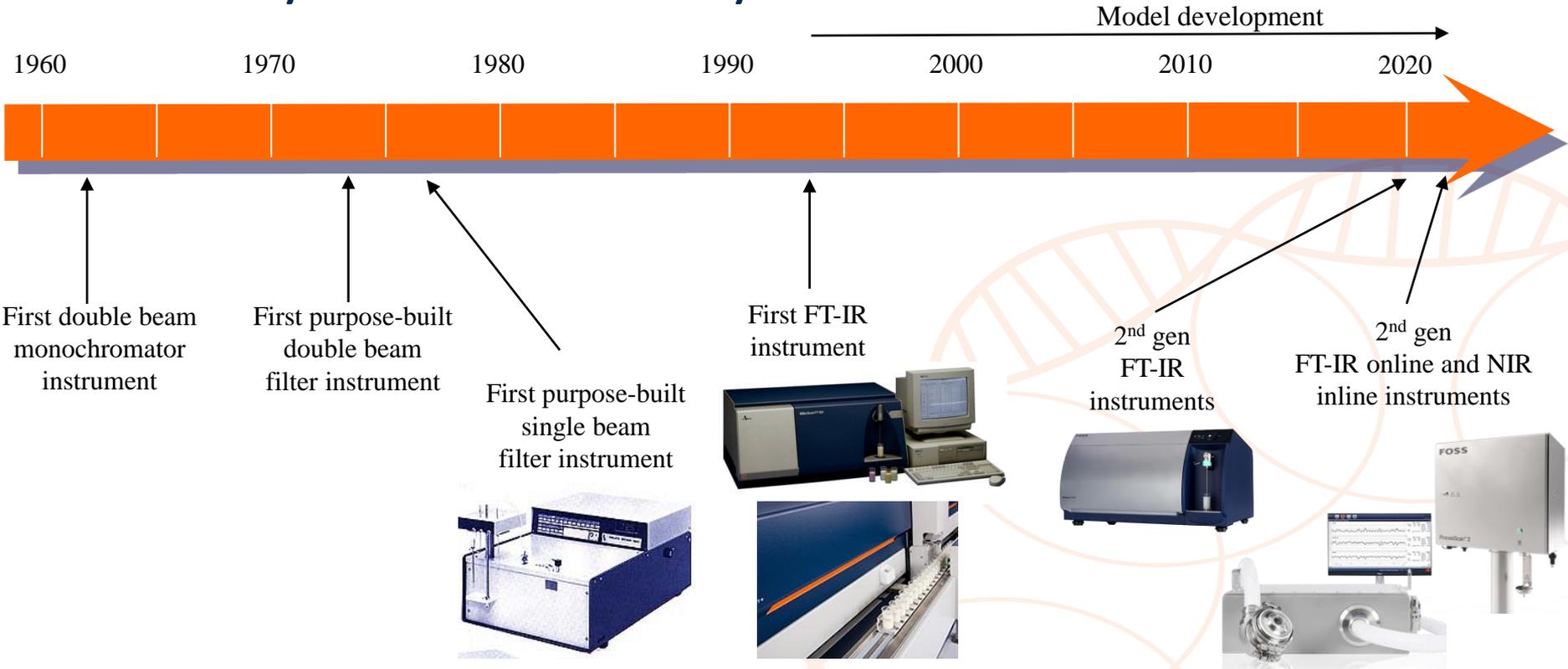# Why is the infrared spectrum so interesting?
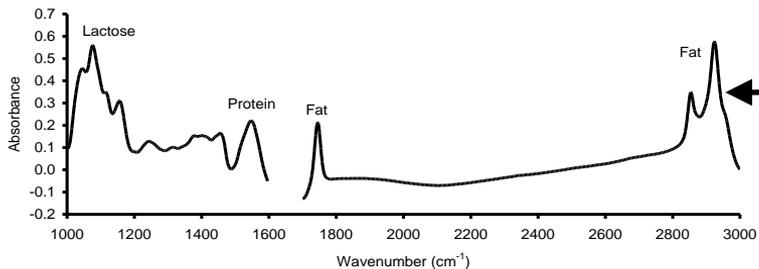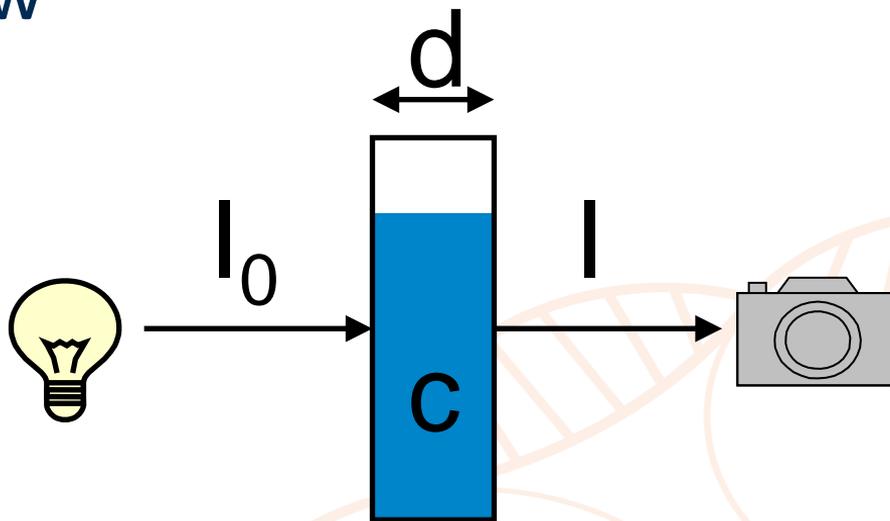
Why is the infrared spectrum so interesting?

Fat
Protein
Lactose
Citric acid
Urea
Fatty acid profiles
Free fatty acids
Adulteration screening
Ketosis/Acetone/BHB
Lactoferrin
Mastitis
Heat/Pregnancy
Blood properties
Exhaled methane
. . .

History of infrared analysis on milk

Model development

1960   1970   1980   1990   2000   2010   2020

First double beam monochromator instrument

First purpose-built double beam filter instrument

First purpose-built single beam filter instrument

First FT-IR instrument

2nd gen FT-IR instruments

2nd gen FT-IR online and NIR inline instruments

FOSS

ICAR — THE GLOBAL STANDARD FOR LIVESTOCK DATA

5

Beer-Lambert law
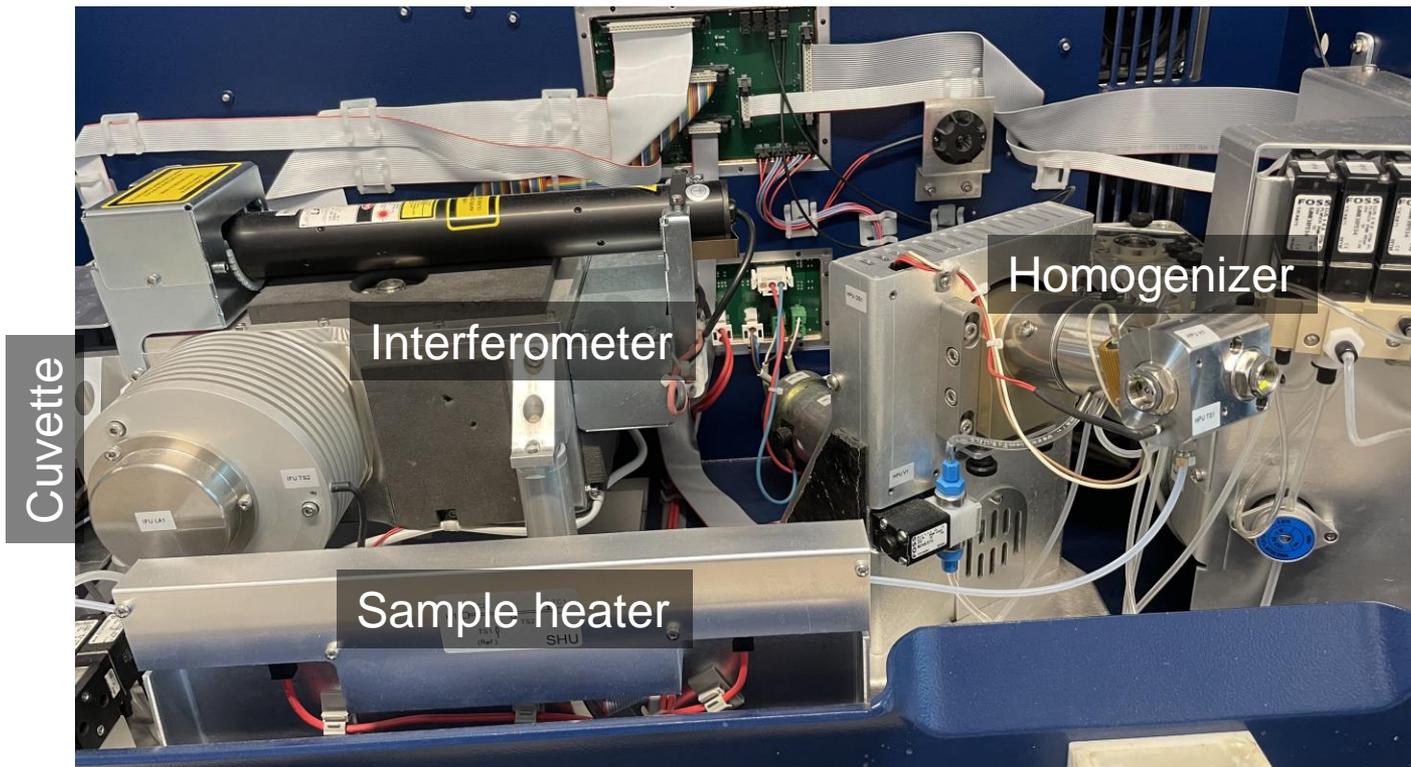

$$A = -\log_{10}(I/I_0)$$
$$A = kdc$$
$$c = A/(kd)$$

Designing an instrument for milk analysis

- Flow system

- Sample temperature

- Sample cell (cuvette)

- Sampling

- Spectral standardization

- Multivariate calibration

Flow system
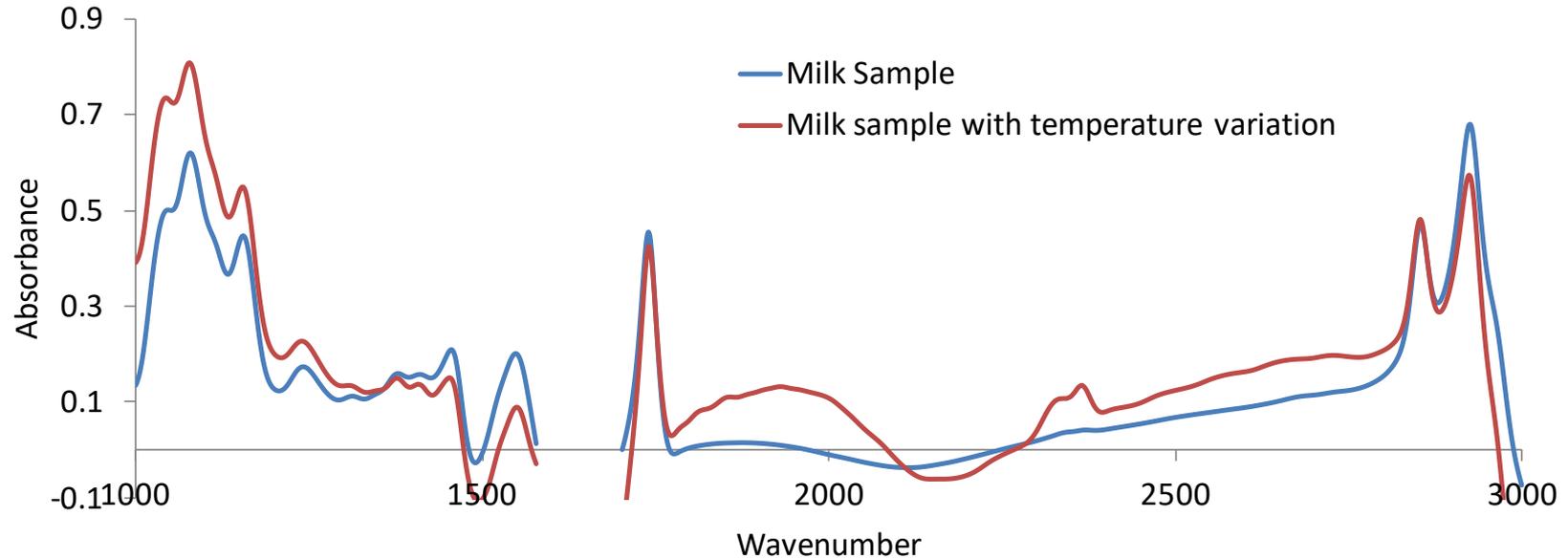
Designing an instrument for milk analysis

- Flow system

- Sample temperature

- Sample cell (cuvette)

- Sampling

- Spectral standardization

- Multivariate calibration

Effect of sample temperature
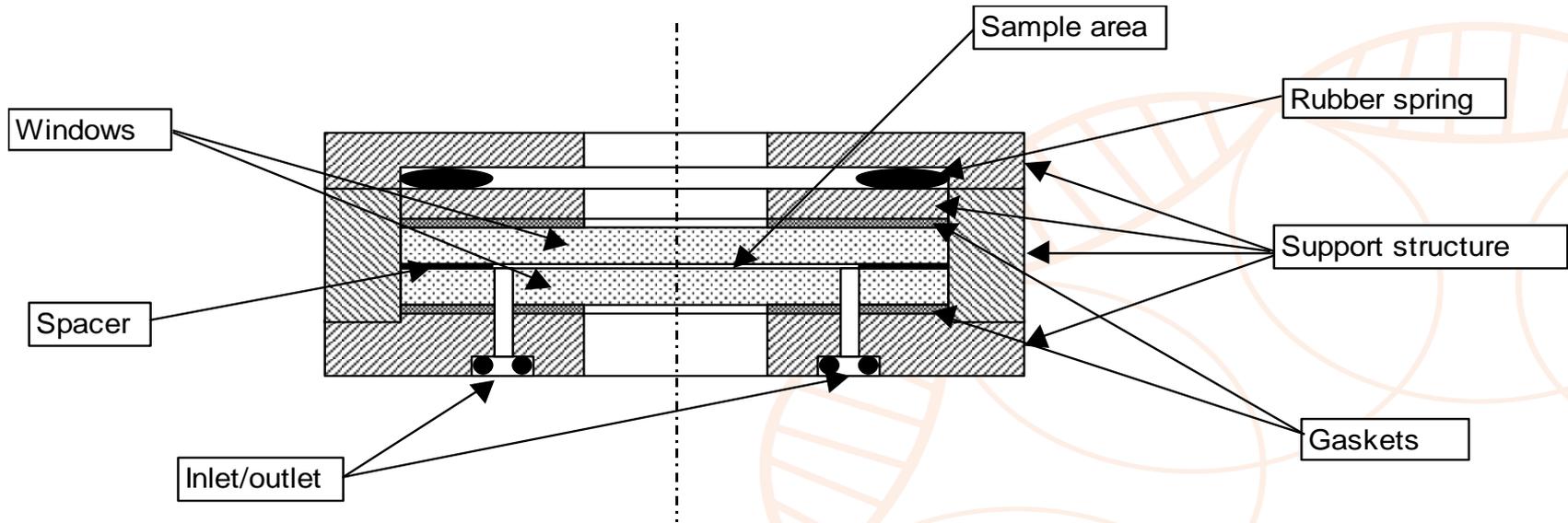
Designing an instrument for milk analysis

- Flow system

- Sample temperature

- Sample cell (cuvette)

- Sampling

- Spectral standardization

- Multivariate calibration
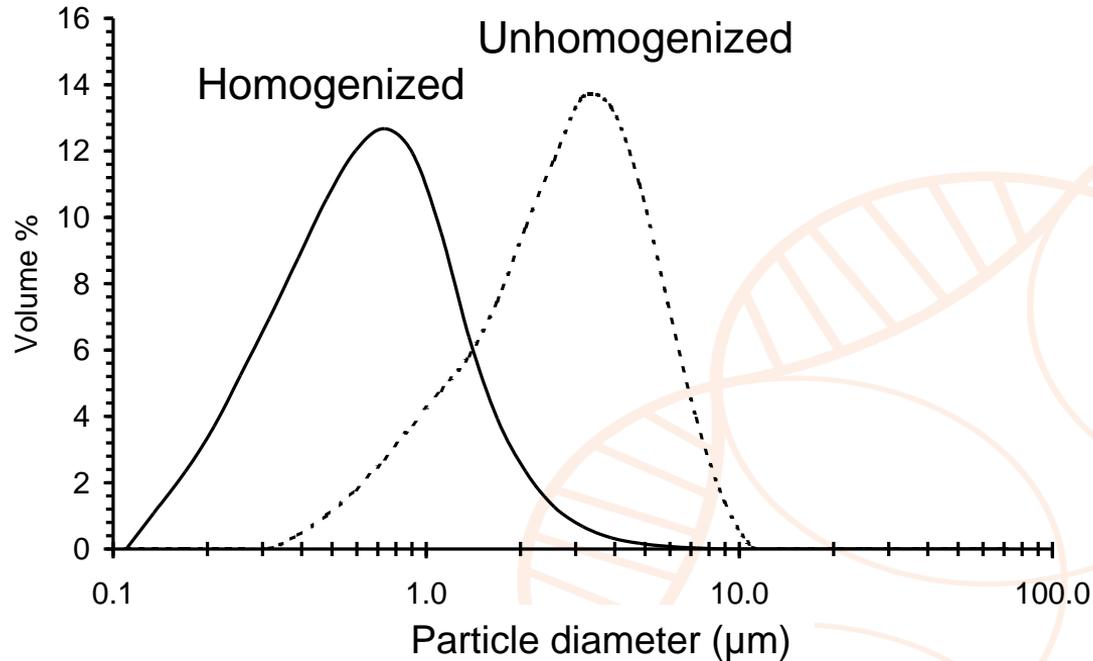
Sample cell (cuvette)

Designing an instrument for milk analysis

- Flow system

- Sample temperature

- Sample cell (cuvette)

- Sampling

- Spectral standardization

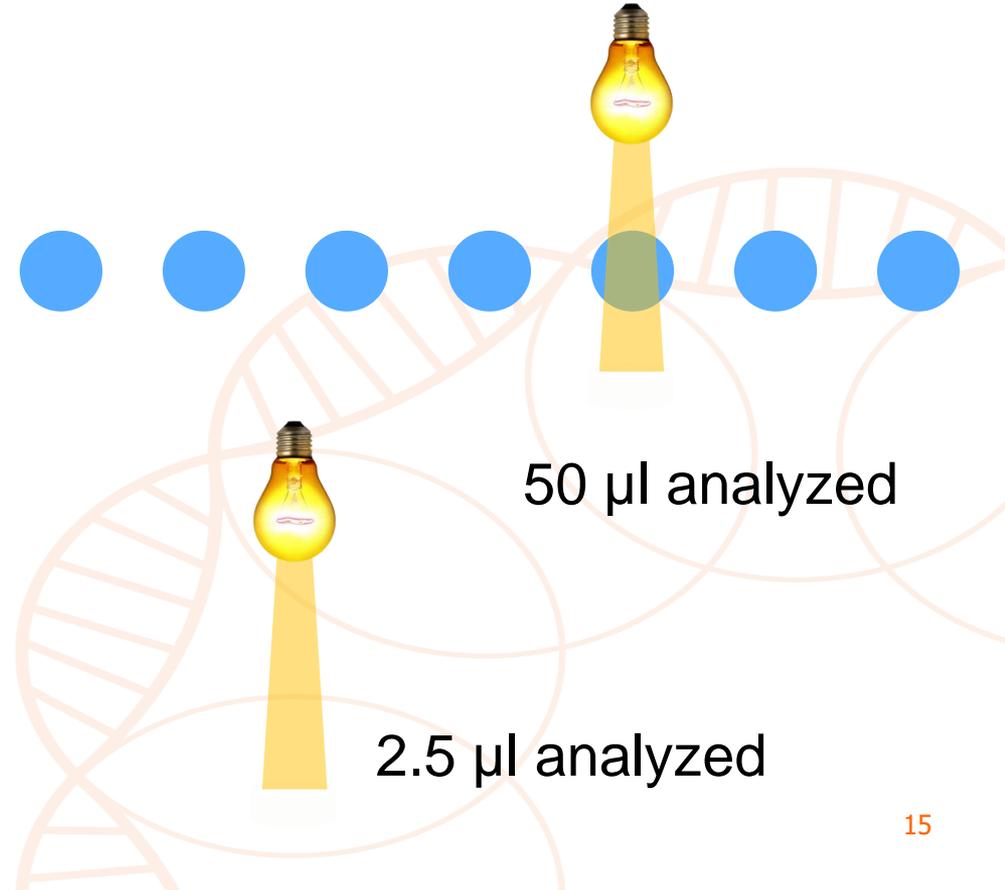- Multivariate calibration

Fat globules in milk

Sampling – two options

Subsampling

Homogenization

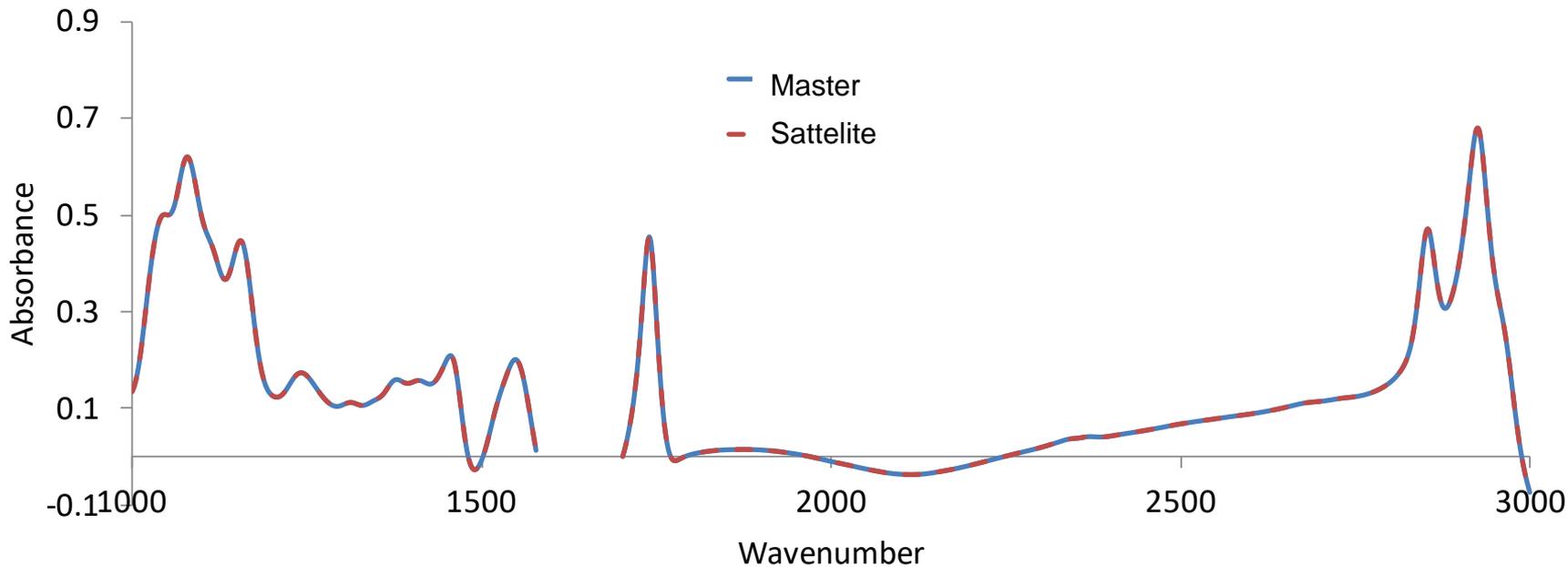50 µl analyzed

2.5 µl analyzed

FOSS

Designing an instrument for milk analysis

- Flow system

- Sample temperature

- Sample cell (cuvette)

- Sampling

- Spectral standardization

- Multivariate calibration

Spectral standardization

FOSS patented methods:
US 5,933,792
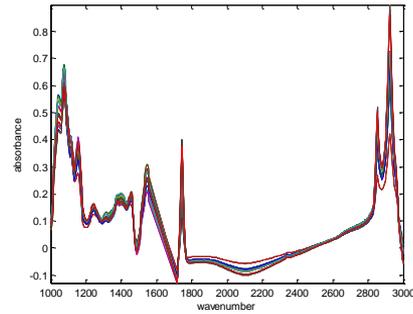US 9,874,515
Patents pending

17

Designing an instrument for milk analysis

- Flow system

- Sample temperature

- Sample cell (cuvette)

- Sampling

- Spectral standardization

- **Multivariate calibration**
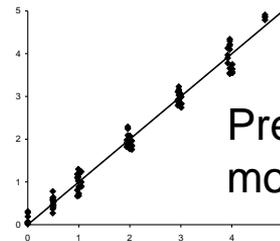
Multivariate calibration

References
3.78
6.50
2.85
4.23
3.88
...

Modelling

Prediction
model

THE GLOBAL STANDARD
FOR LIVESTOCK DATA

Summary

- The infrared range contains useful concentration information on the constituents in milk
- The instrument design is critical for achieving reproducible results
  - Properties such as temperature control, sampling/homogenization, cuvette design, etc., are critical
  - Instrument standardization allows for the use of data between instruments

Thank you!