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Online quality analysis of raw milk: potential of miniature spectrometers

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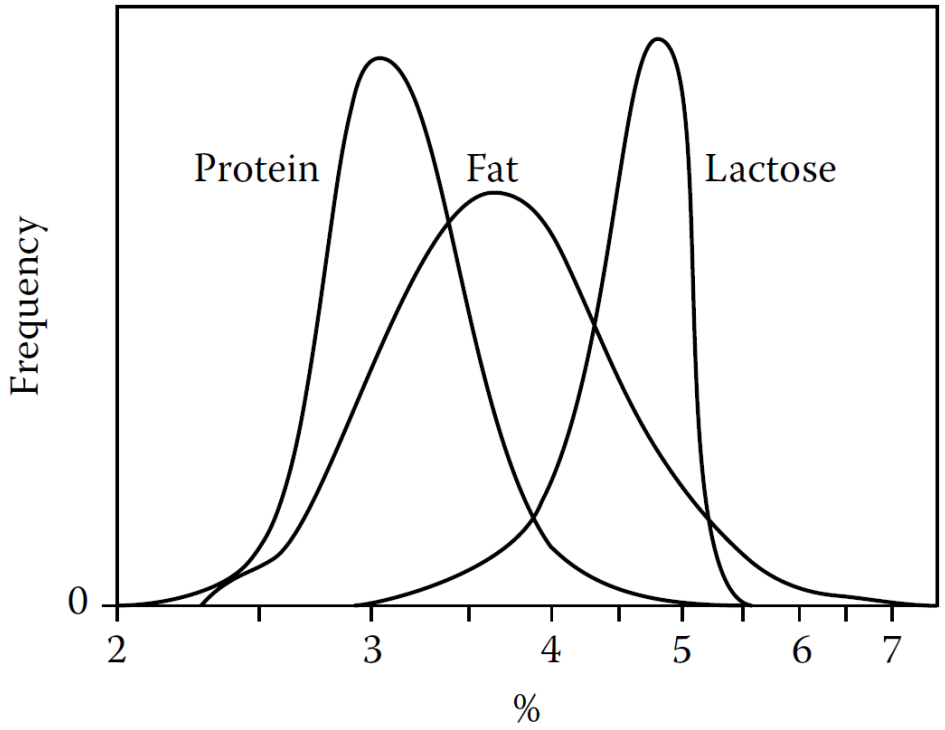
The role of milk production

Milk production

Milk analysis as an efficient health screening tool

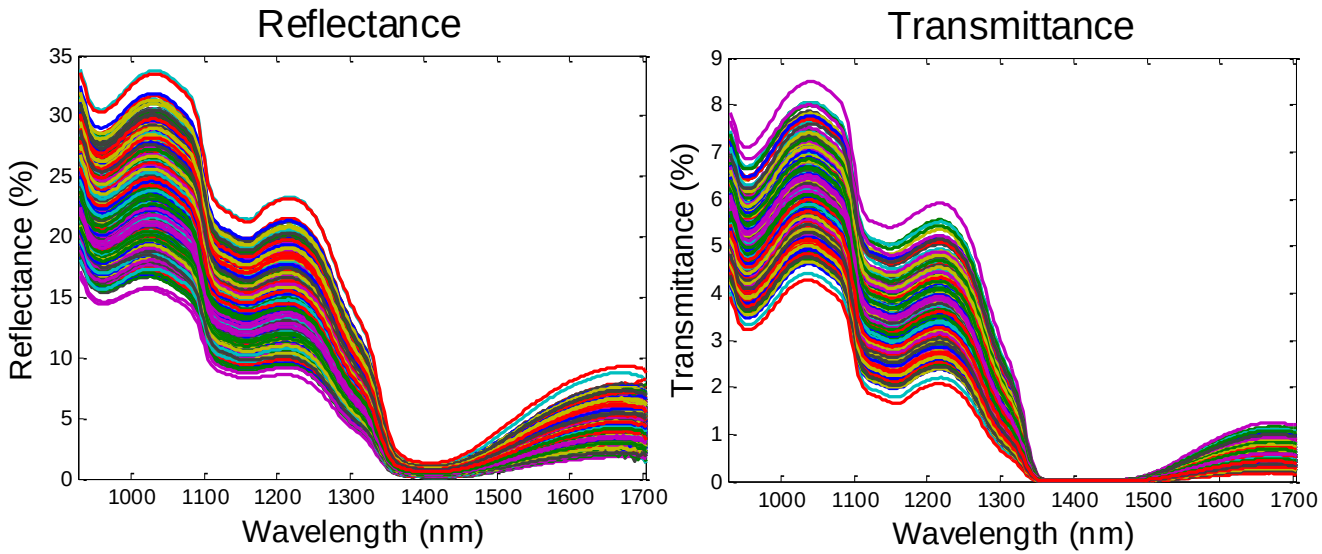
Implementation for on-line monitoring

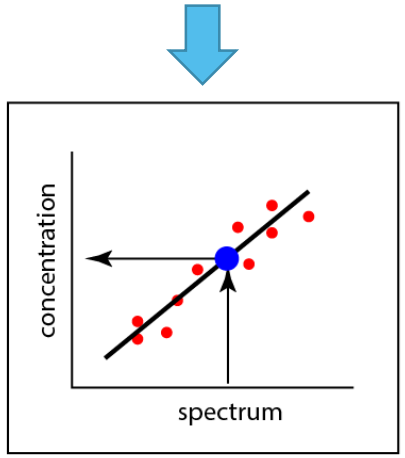


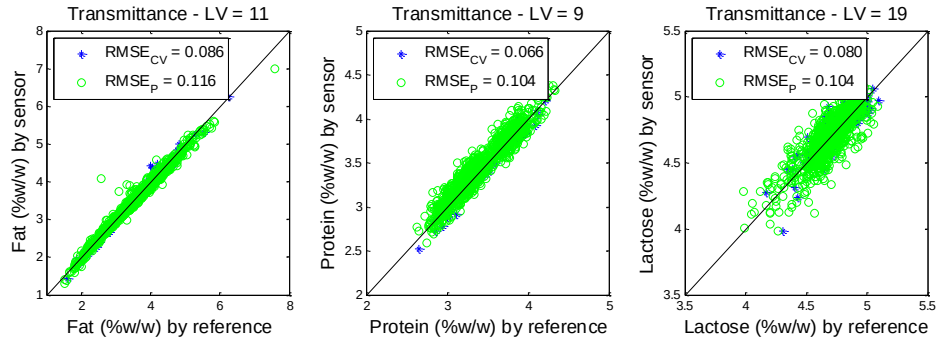
Walstra et al., 2006

Near-infrared (NIR) spectroscopy

- Non-destructive
- No sample preparation
- Cost-efficient
- Fast
- Accurate
- Robust





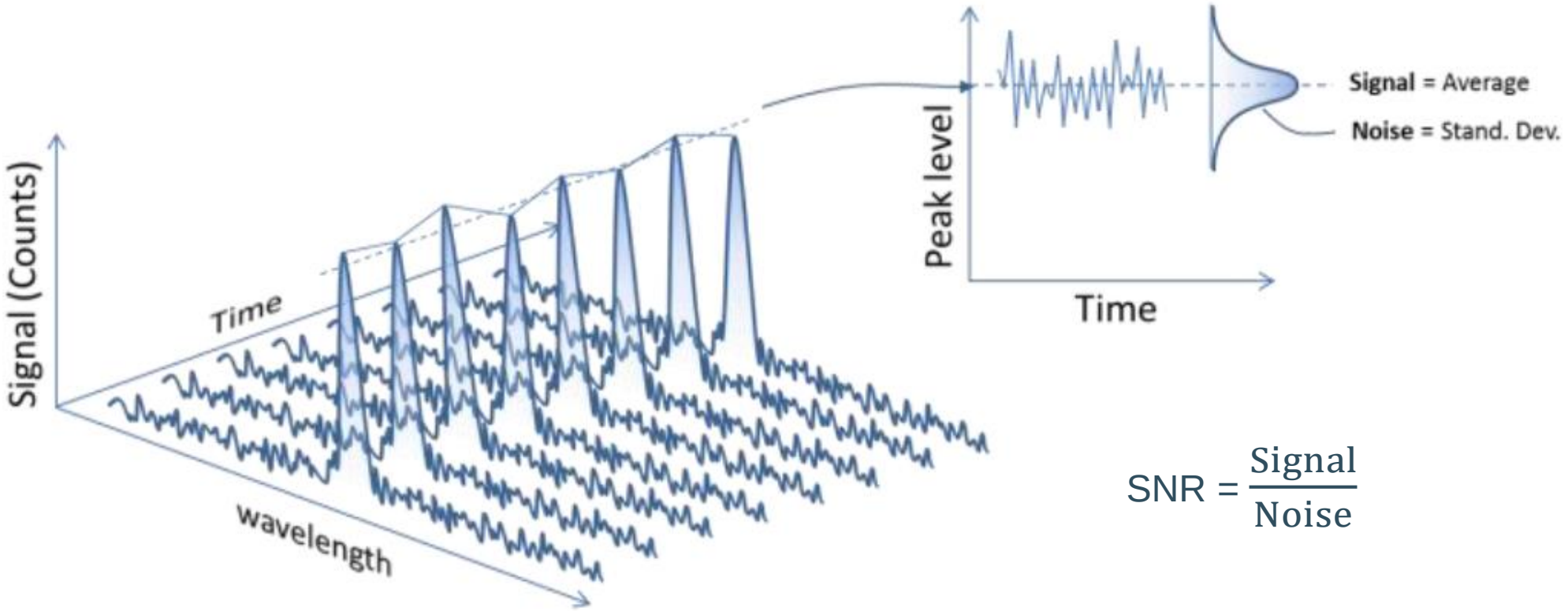


State-of-the-art vs miniature spectrometers

- ↑ Signal-to-Noise ratio
- ↑ Cost
- ↑ Volume and weight
- ↑ Prediction performance

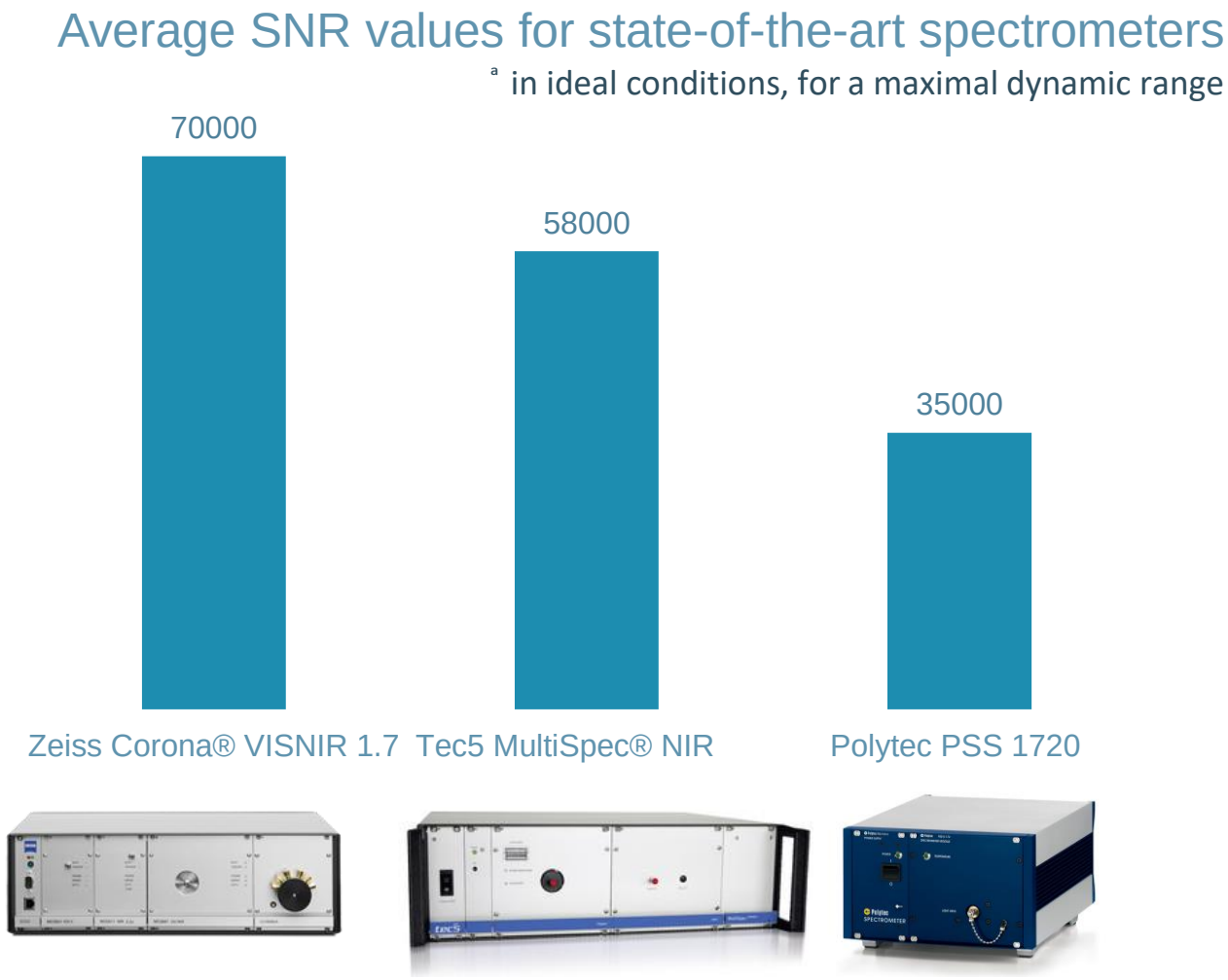
- ↓ Signal-to-Noise ratio
- ↓ Cost
- ↓ Volume and weight
- Prediction performance?

Signal-to-Noise Ratio (SNR) and Dynamic Range (DR)



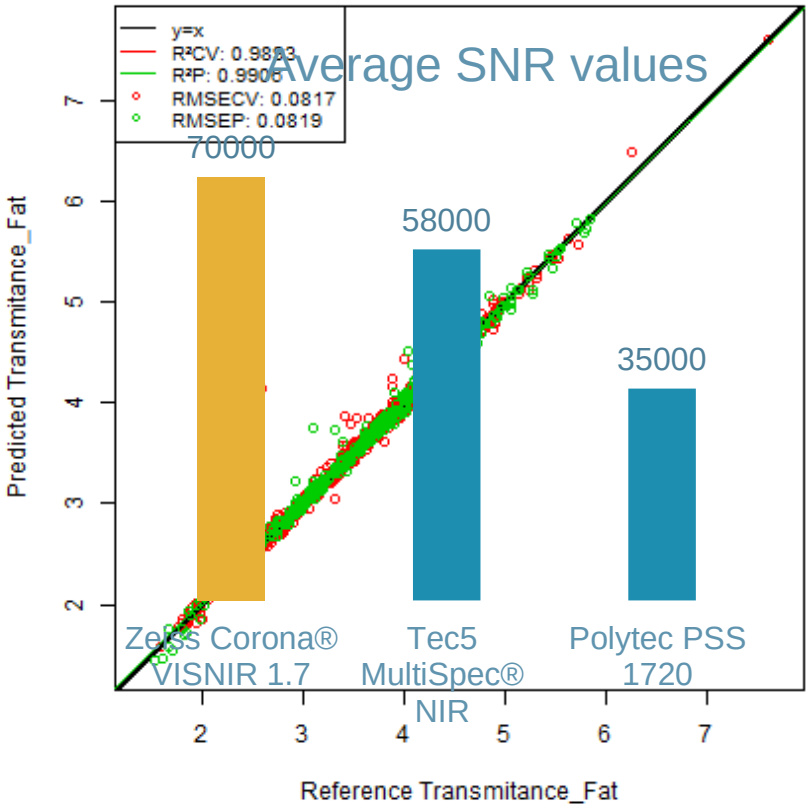
$$\text{SNR} = \frac{\text{Signal}}{\text{Noise}}$$

State-of-the-art spectrometers



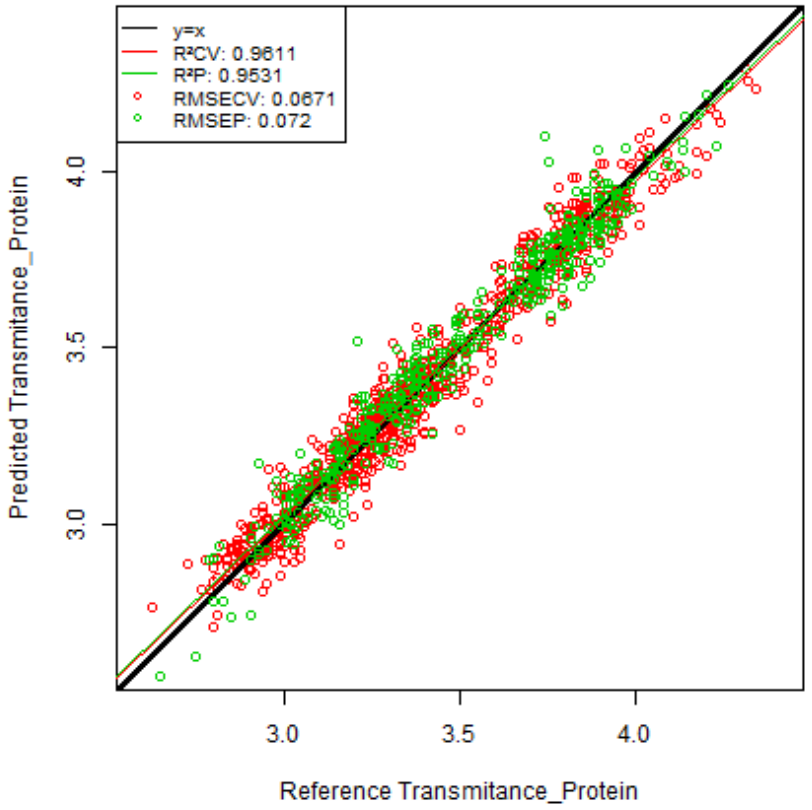
State-of-the-art spectrometers

Fat Prediction vs Reference



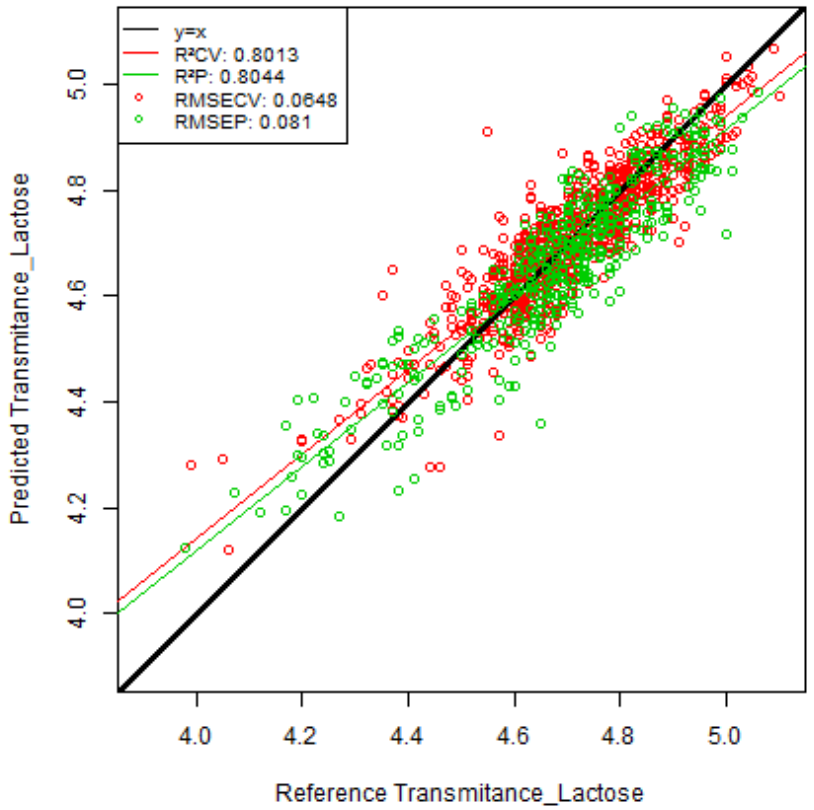
RMSEP: 0.0819 [%, w/w]

Protein Prediction vs Reference



RMSEP: 0.072 [%, w/w]

Lactose Prediction vs Reference



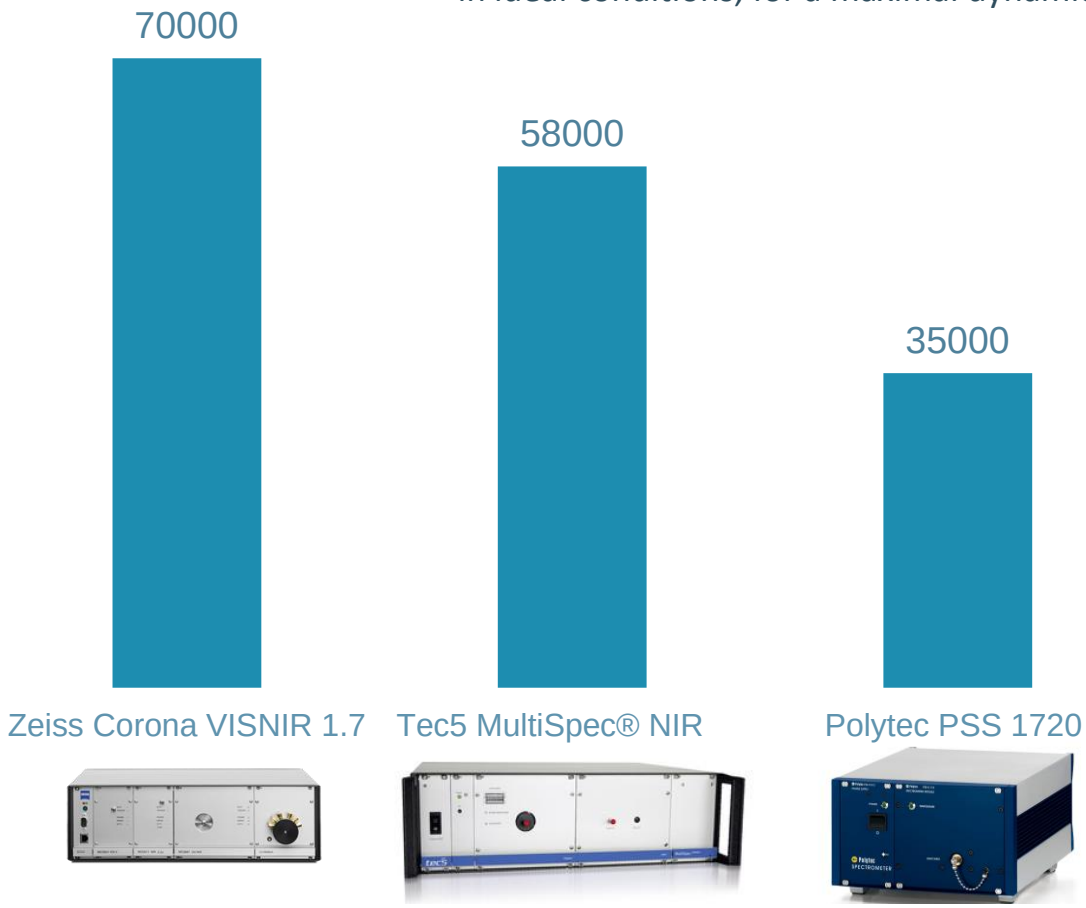
RMSEP: 0.081 [%, w/w]

ICAR laboratory analyzer standard: 0.1 [%, w/w]

Miniature spectrometers

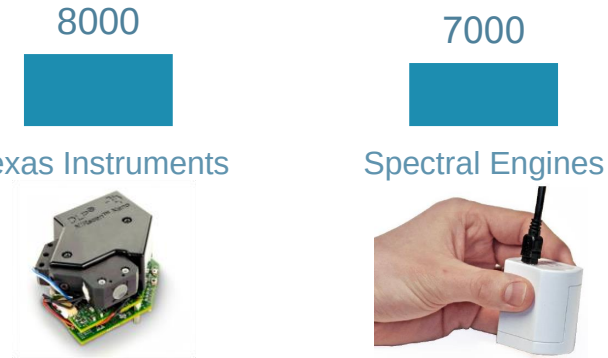
Average SNR values for state-of-the-art spectrometers

[a] in ideal conditions, for a maximal dynamic range



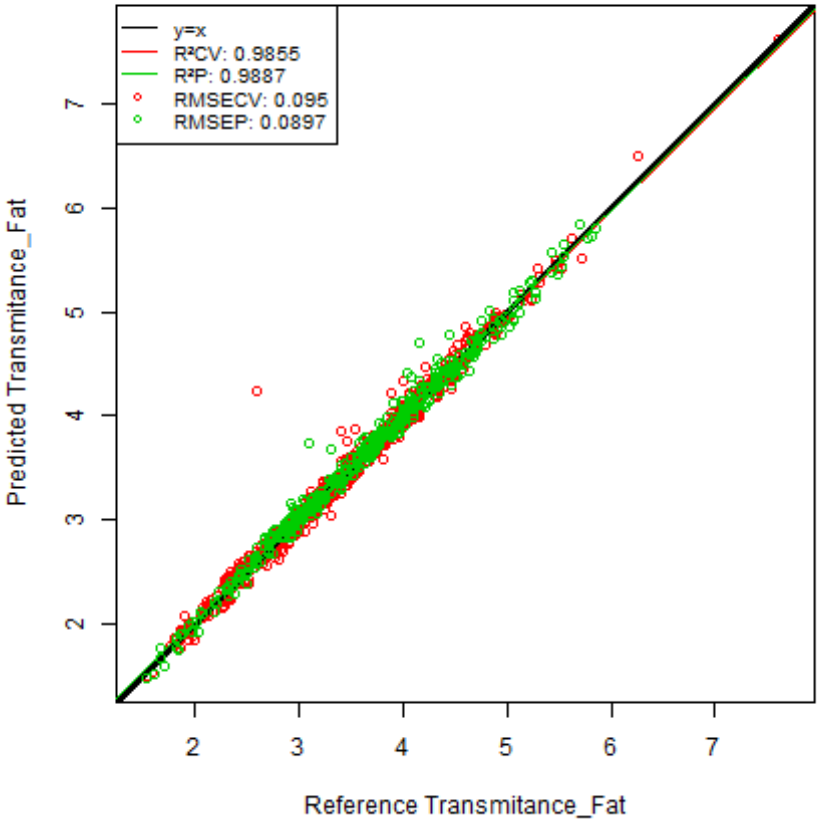
Average SNR values for miniature spectrometers

[a] in ideal conditions, for a maximal dynamic range



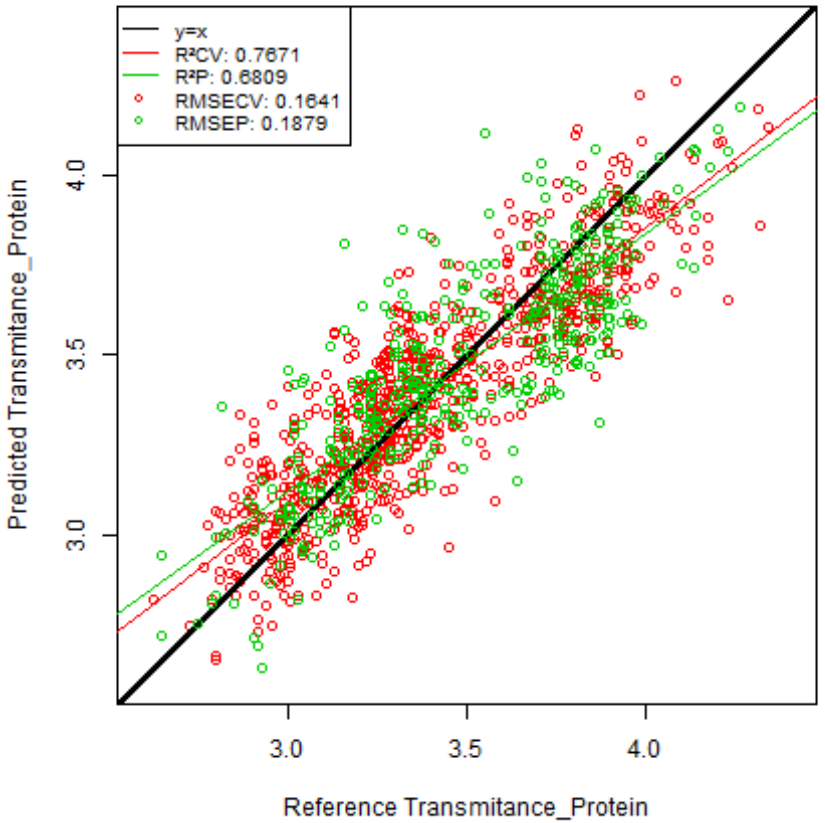
Miniature Spectrometers – Simulation Results

Fat Prediction vs Reference



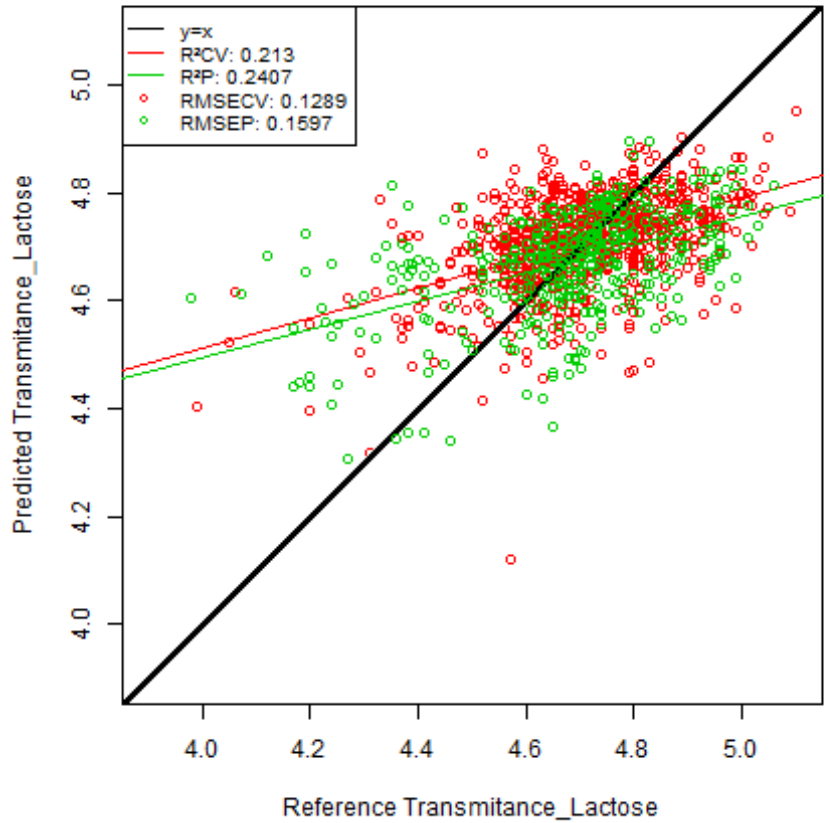
RMSEP: 0.0897 [%, w/w]

Protein Prediction vs Reference



RMSEP: 0.1879 [%, w/w]

Lactose Prediction vs Reference

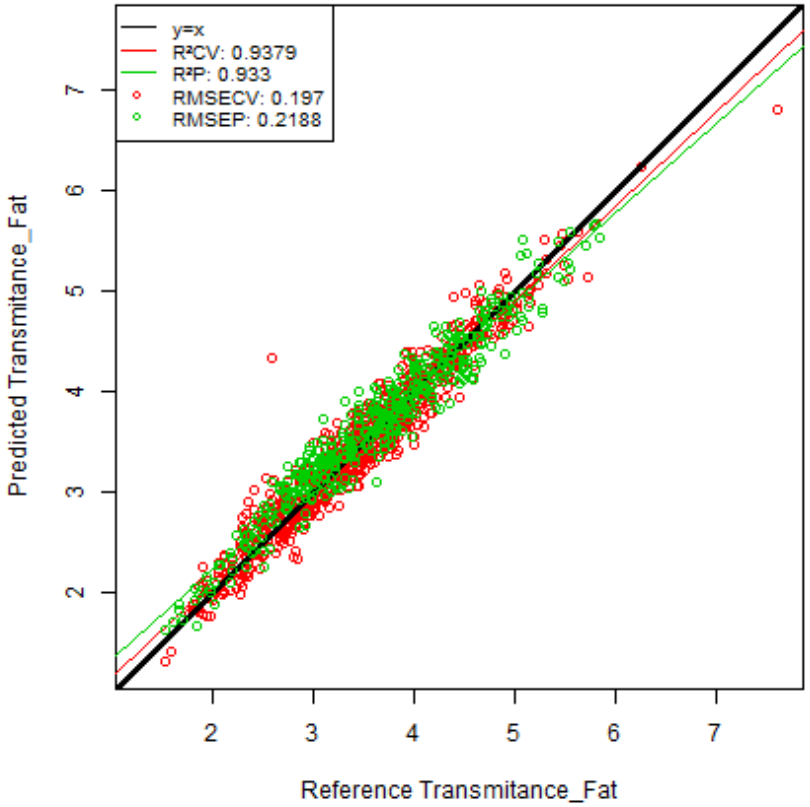


RMSEP: 0.1597 [%, w/w]

ICAR on-farm analyzer standard: 0.25 [%, w/w]

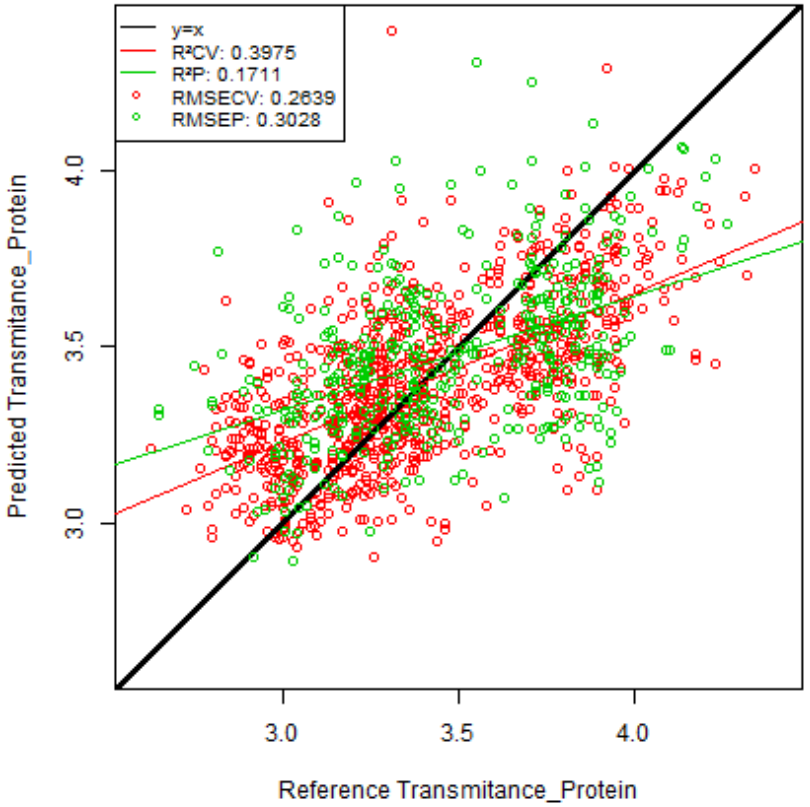
Miniature Spectrometers – Simulation Results

Fat Prediction vs Reference



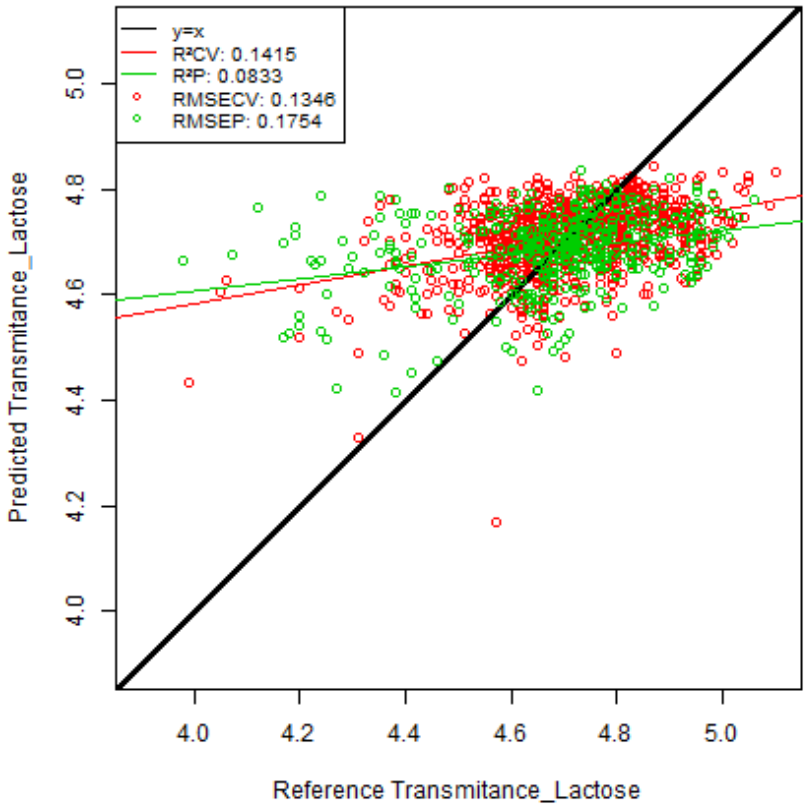
RMSEP: 0.2188 [%, w/w]

Protein Prediction vs Reference



RMSEP: 0.3028 [%, w/w]

Lactose Prediction vs Reference

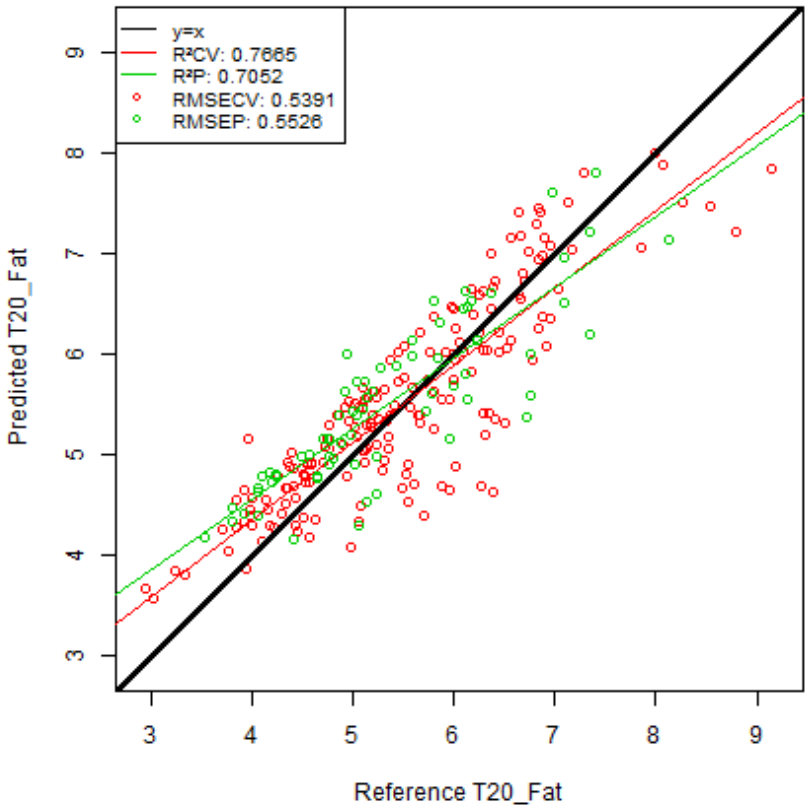


RMSEP: 0.1754 [%, w/w]*

ICAR on-farm analyzer standard: 0.25 [%, w/w]

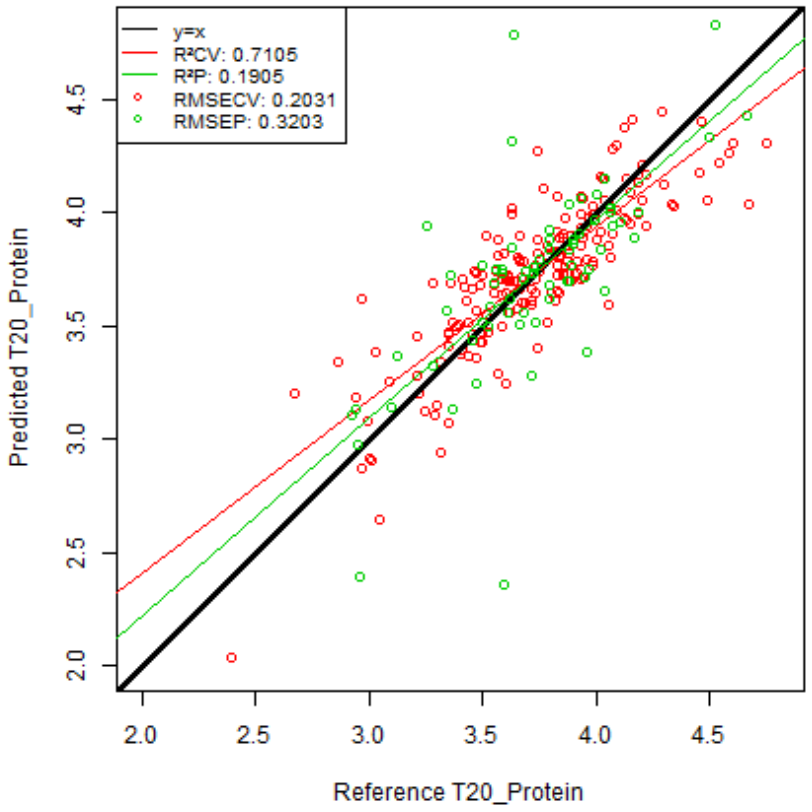
Miniature Spectrometers – Experimental Results

Fat Prediction vs Reference



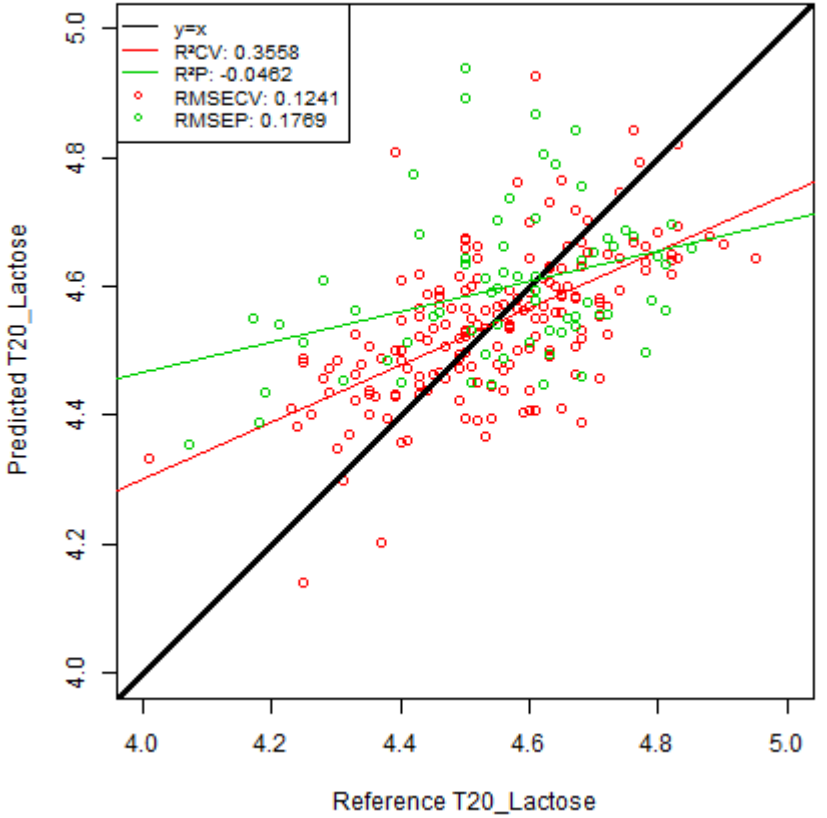
RMSEP: 0.5626 [%, w/w]

Protein Prediction vs Reference



RMSEP: 0.3203 [%, w/w]

Lactose Prediction vs Reference



RMSEP: 0.1769 [%, w/w]

ICAR on-farm analyzer standard: 0.25 [%, w/w]

Conclusions

- Miniature spectrometers as a potential on-farm tool for the prediction of milk components
- Decreased performance against benchtop spectrometers in the same conditions
- Consideration of these limitations in on-farm applications in order to approximate to ideal performance

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