- ICAR Conference 2024 -

Bled, Slovenia

Daily standardization of milk mid-infrared spectra in a comprehensive regression model framework considering animal related data

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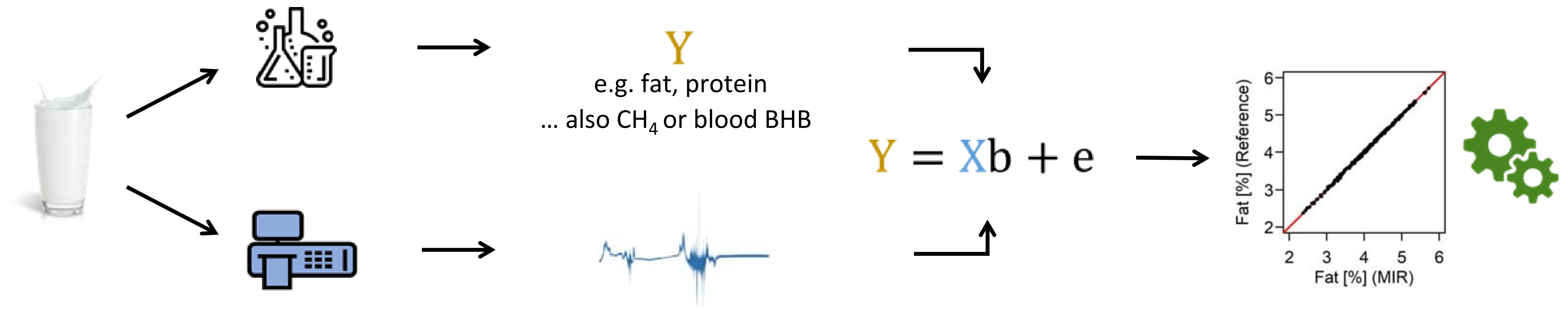
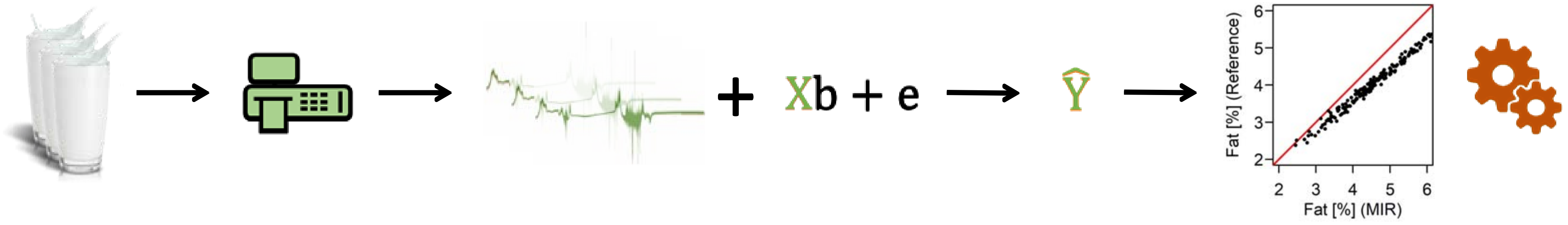
MIR spectrometry and its challenges



Other instrument, (same or other model type, other brand…)



MIR spectrometry and its challenges

General instrument effects

- Constructional differences
  - Wavenumber range and number
  - Cuvette material (CaF_2 or diamond)
  - Marginal deviations during production
  - …

Temporal instability or deviations

- Environmental effects like Temperature and humidity
- Technical wear and component changes
- Mechanical or electronic effects (sensor drift)
- …

Wang et al. (1991): Multivariate Instrument Standardization

Nieuwoudt et al. (2021): Monitoring of Instrument Stability

Compensation approaches so far

Post measurement correction of predictions:

•Slope/intercept correction using check samples ('standard milk') with known reference values

→ **Only applicable for known reference values!**

Spectral standard… …ion:

•Manufacturer's o… …e.g. FOSS standardization

•Standardization … …(EMR) according to Grelet et al. (2015)

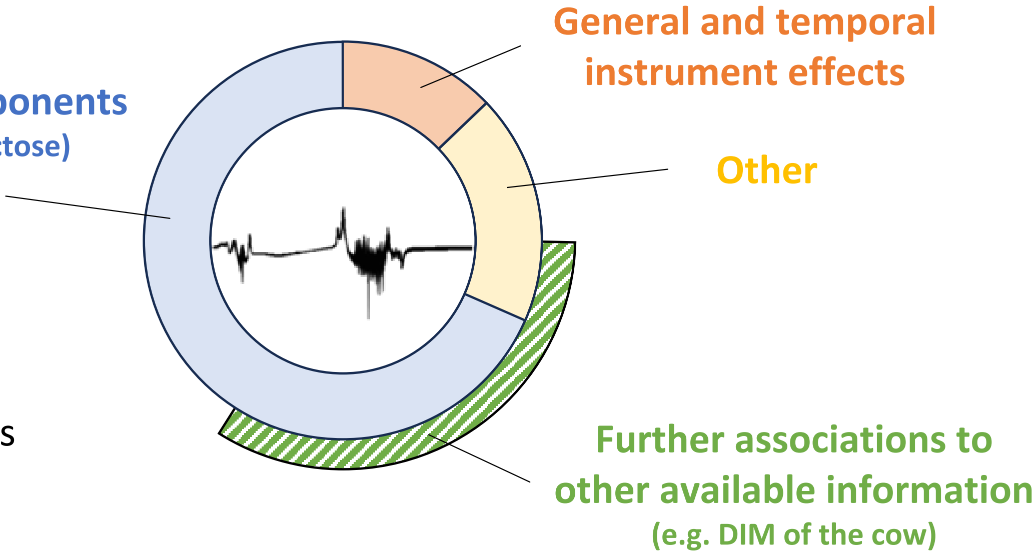
•Retroactive standardization accord… …t al. (2017)

But so far only monthly or in even larger time intervals!

→ **Enables the use of various models!**

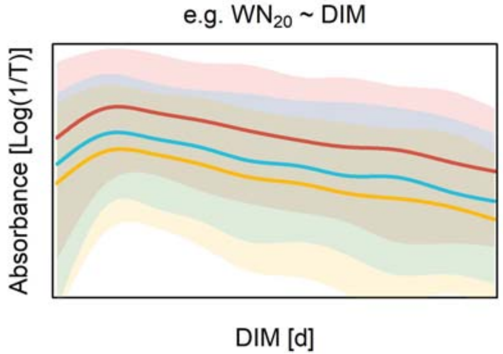
The concept of the vit-standardization

What can the observed variance of
raw spectra be attributed to?

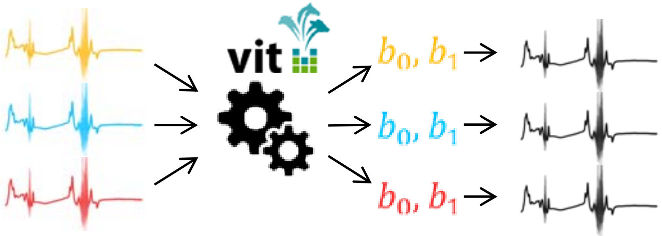


Aim: Quantify and eliminate variance related to general and temporal instrument effects

How?: Using a framework of regression models on DHI samples considering
- Slope/intercept-corrected laboratory values
- Data on sample origin like DIM and parity of the cow
- Information on the instrument and time of analysis



→ Instrument-wise daily standardization coefficients



Material and methods

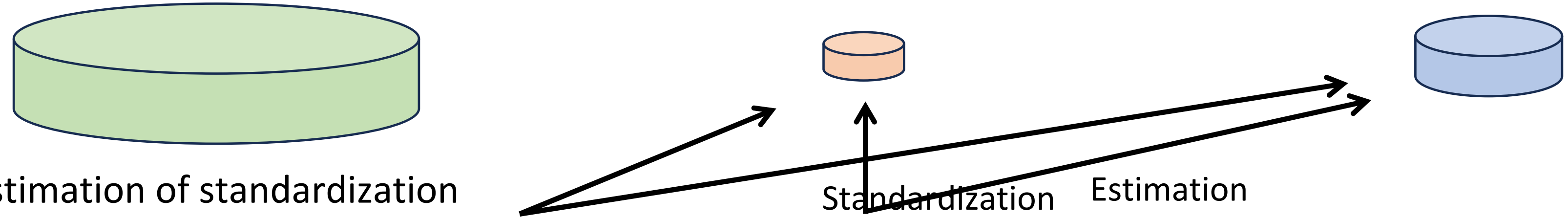
All data were provided by the LKV Niedersachsen

- Period: 01/2022 to 06/2022
- Primary breed: Holstein (92%)
- 5 FOSS instruments (2 x MilcoScan™ 7 RM, 3 x MilcoScan™ FT+)

Routine DHI samples
(n = 2.3 M, 5 instruments)

Triple analysed DHI samples
(n = 5.3 k of 7 farms x 3 instruments)

Check samples
(n = 61.0 k , 5 instruments)



Estimation of standardization coefficients

$$\text{Fat (lab)} = \mathbf{X}b + e \ (\rightarrow \text{MIR raw})$$
$$\text{Fat (lab)} = \mathbf{X}b + e \ (\rightarrow \text{MIR standardized})$$

Milk fat as an example trait for demonstration purposes

Analysis

I. MIR raw vs. MIR standardized

II. Estimability of fat during calibration

III. Estimability of fat over time

Results I: MIR raw vs. MIR standardized

(⟶ Triple analysed DHI samples)

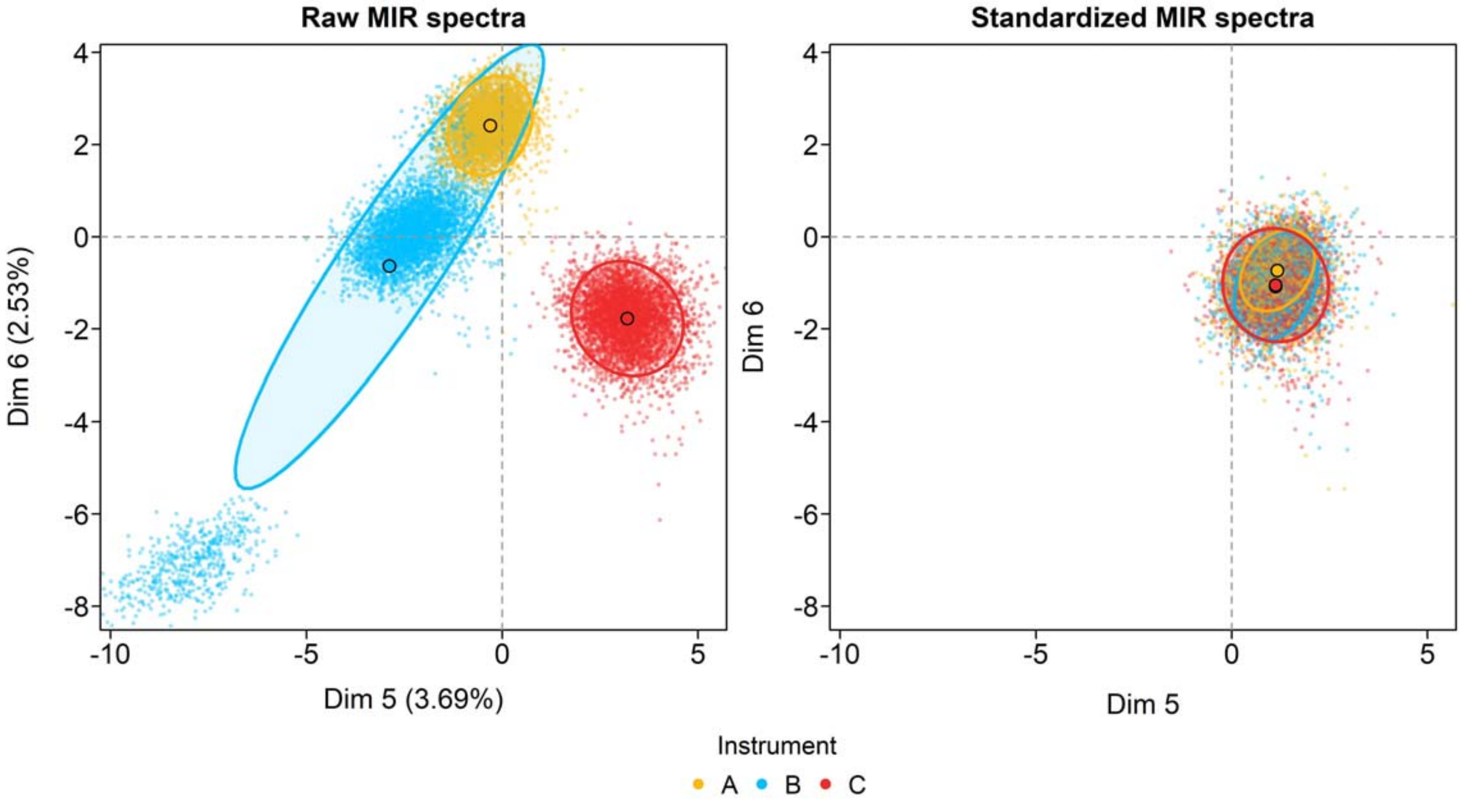
Principal Component Analysis

•n = 4,471 per instrument

•212 of 1,060 wavenumbers

⟶ Untreated absorbance values

⟶ 1^{st} gap derivative

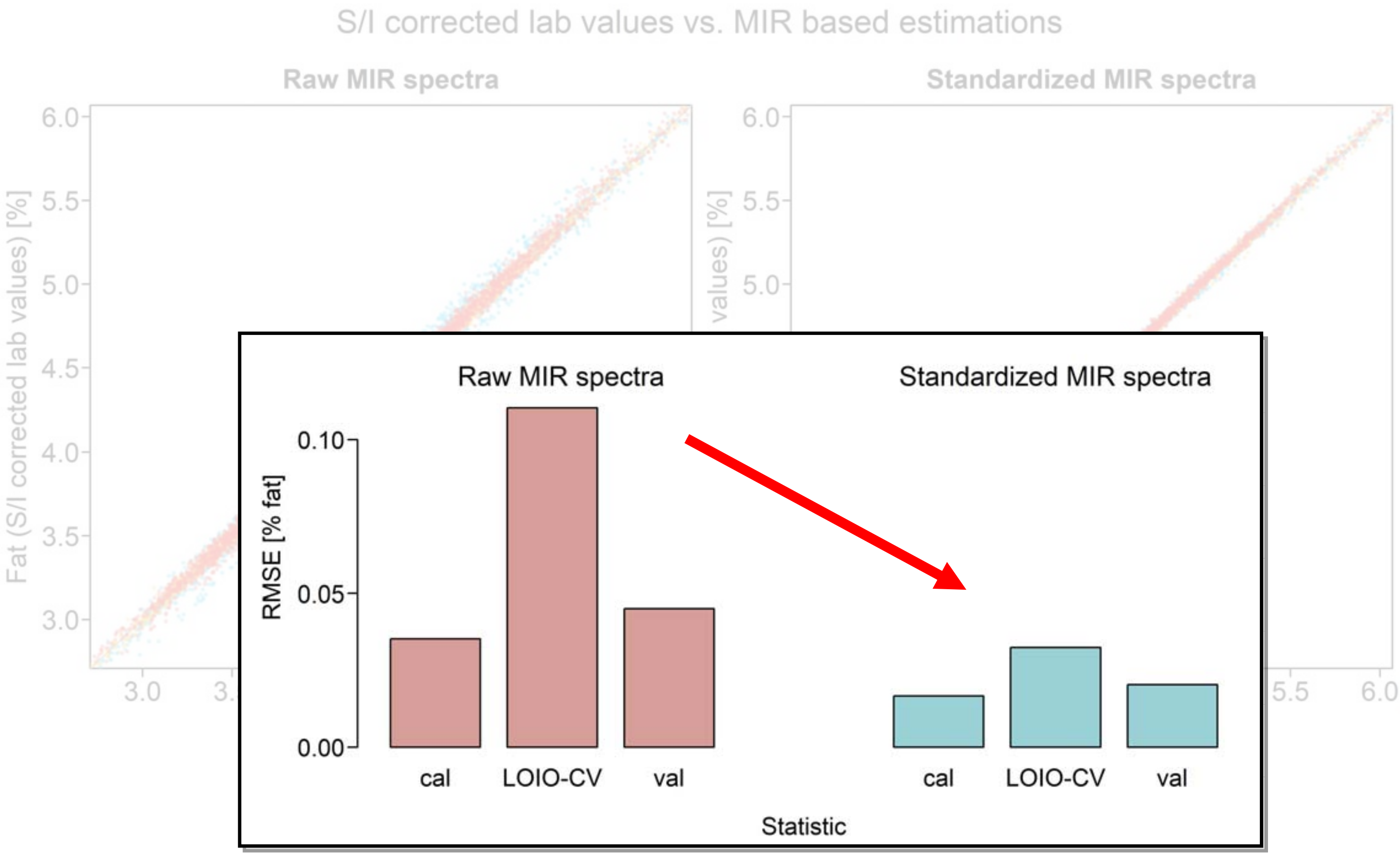


Results II : Estimability of fat

(⟶ Triple analysed DHI samples)

Background information

- Splitting of the data
  - 80% calibration, 20% validation
- Separate fat models for **raw** and **standardized** spectra
- PLS-regression model properties
  - 1^{st} gap derivative
  - 512/1,060 WN
  - n = 6 latent variables



Results III: Estimability of fat over time

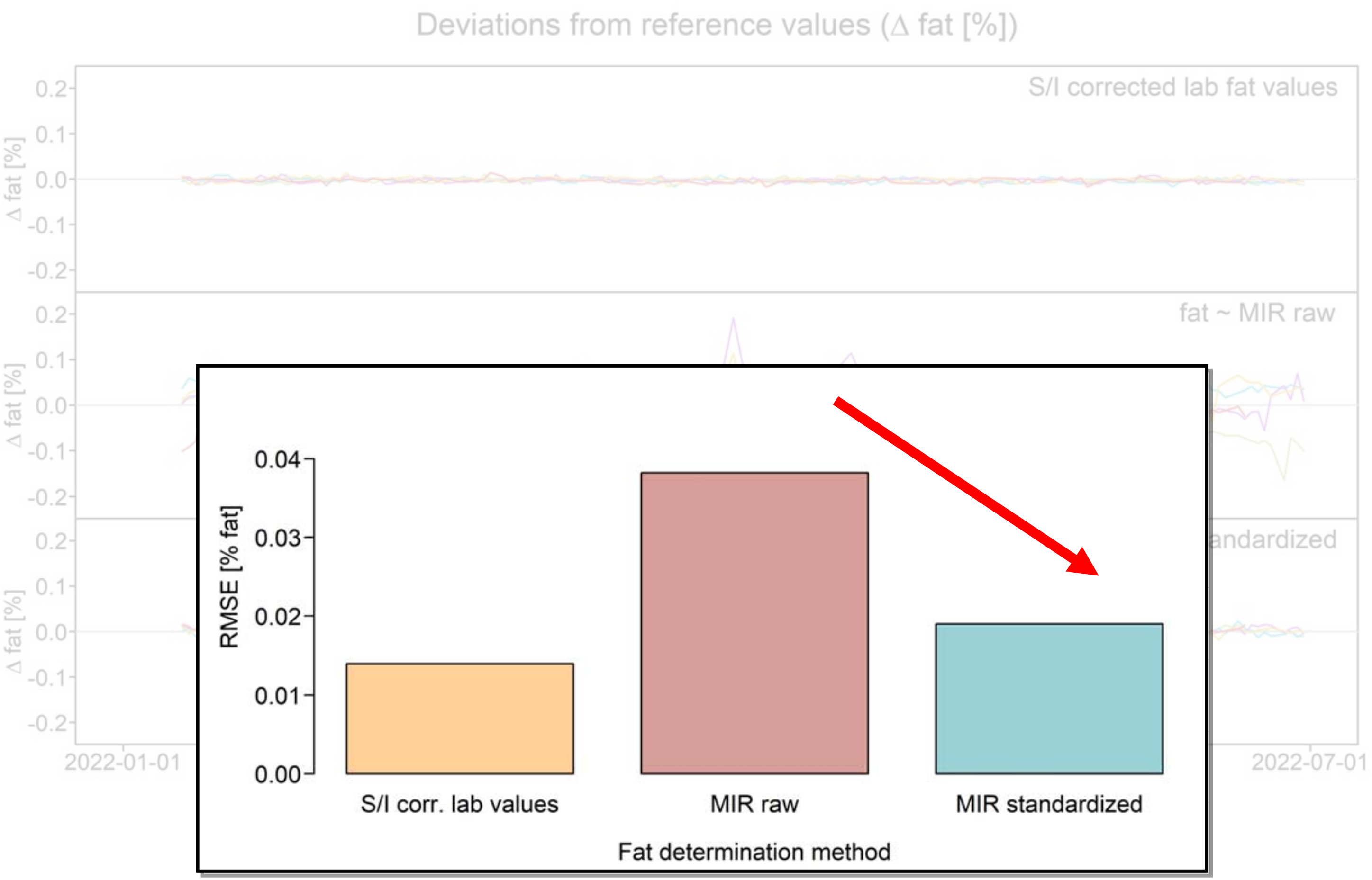
(⟶ Check samples)

Background information

- n = 53.5 k (balanced over 5 instruments)
- Weekly changed 'North German Standard Milk'
  - Correspond to bulk milk samples
  - Small range with 3.86 to 4.27% fat

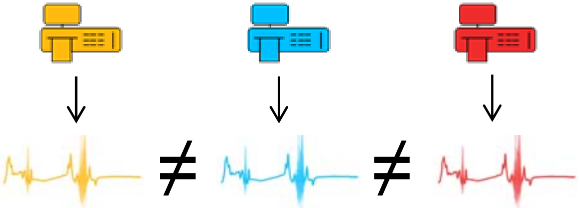
<u>Remark</u>

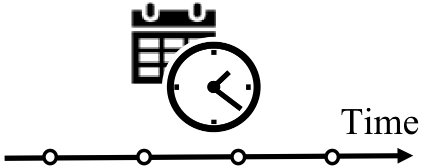
Check samples were <u>neither</u> used for standardization <u>nor</u> for fat model calibration!



Summary and conclusion

- MIR spectrometric measurements are often impacted by
  - general instrument effects and
  - within instruments over time





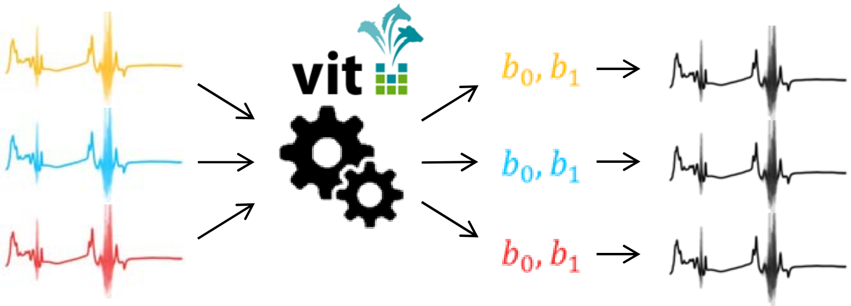
- Daily vit-standardization demonstrates
  - A harmonization of MIR spectra across machines and over time
  - An improved ability for the estimation of fat compared to the use of raw spectra
  - Almost similar accuracy as of slope/intercept corrected laboratory fat values

- Further advantages
  - Frequent standardization possible, e.g. daily
  - No need for common milk samples
  - No additional workload for the laboratories

- High potential for the provision of best possible MIR-based predictions as input for
  - genomic evaluations
  - herd management tools

Outlook

- In the meantime …
  – Adaptation of the vit-standardization so that it can handle daily incoming data
  – A first MIR-based tool for monitoring of ketosis on routine DHI-data is active for > 3000 farms
- Comparison with other standardization strategies within the ICAR ExtraMIR project
- Provision of MIR-based predictions as phenotypes for breeding purposes
- Use of vit-standardization coefficients for the qualitative monitoring of spectra?
- Applying the method on
  – bulk milk samples
  – data from other regions and other breeds
  – spectra from instruments of other manufactures



Thank you for your attention!