LIÈGE université Gembloux Agro-Bio Tech

Wallonie recherche CRA-W

ICAR 2023 TOLEDO SPAIN

# Milk MIR spectra to estimate individual $CH_4$ emissions : Strengths and limitations of a scalable model

Vanlierde A., Dehareng F., Soyeurt H. & Gengler N.

23 May 2023
Feed and Gas Working group

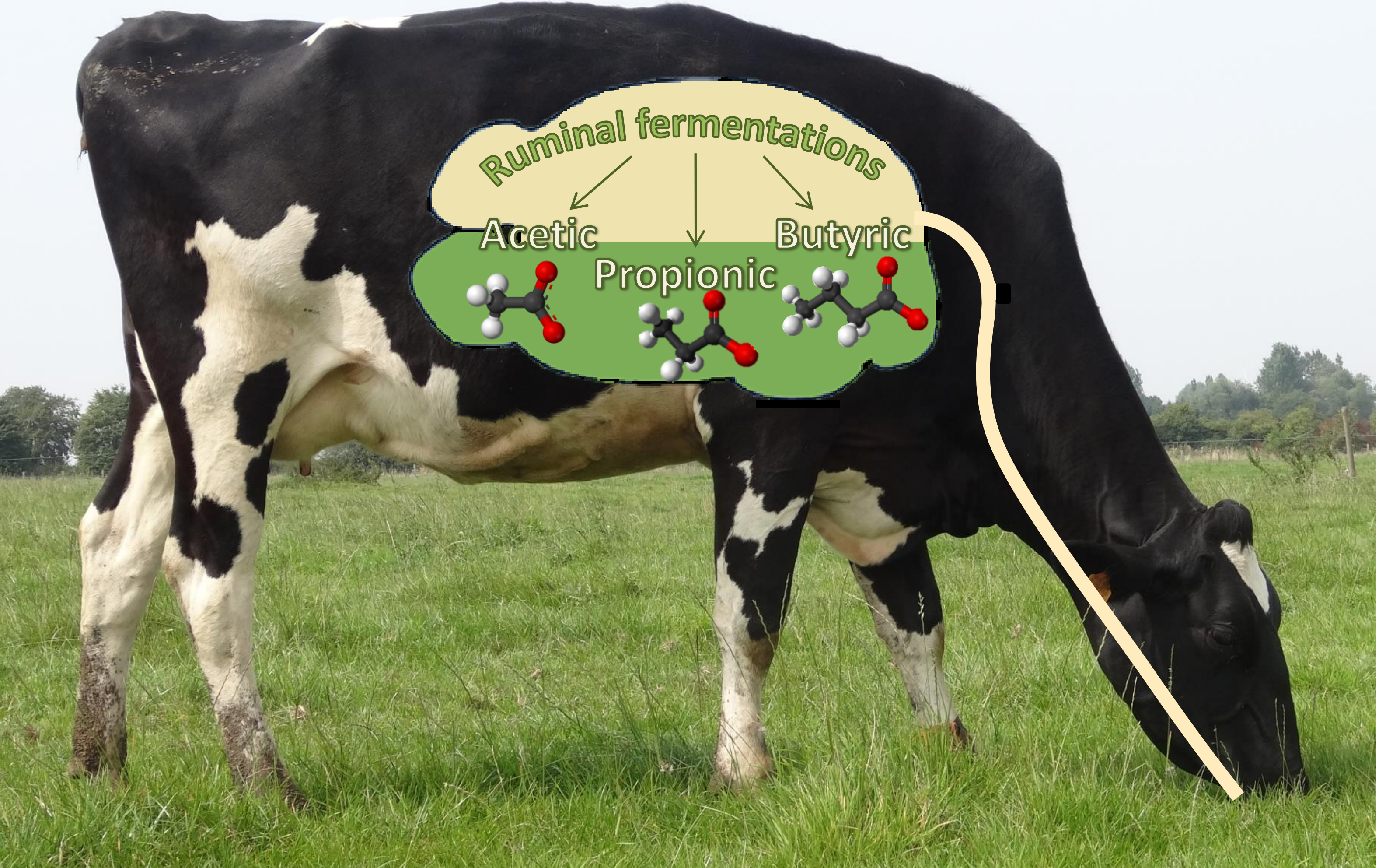
# Need of tools to quantify $CH_4$ emissions in routine

Possibility to perform large scale studies and routine uses to:  

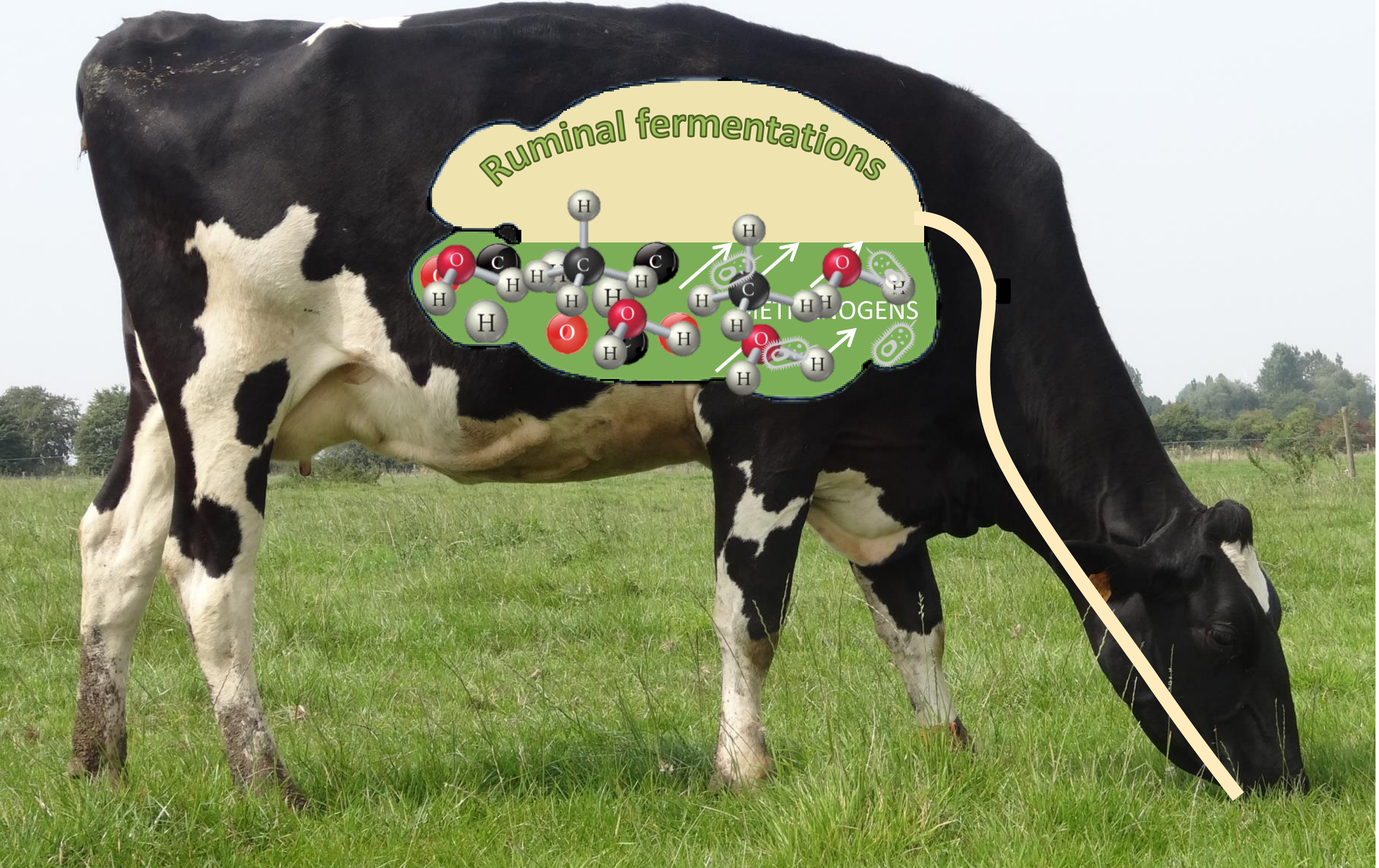
- Monitor $CH_4$ at ≠ scales : animal, herd, region, country
  - Inventory and follow-up in time (seasons, years, *etc*.)
  - Quantification of mitigation strategies impact

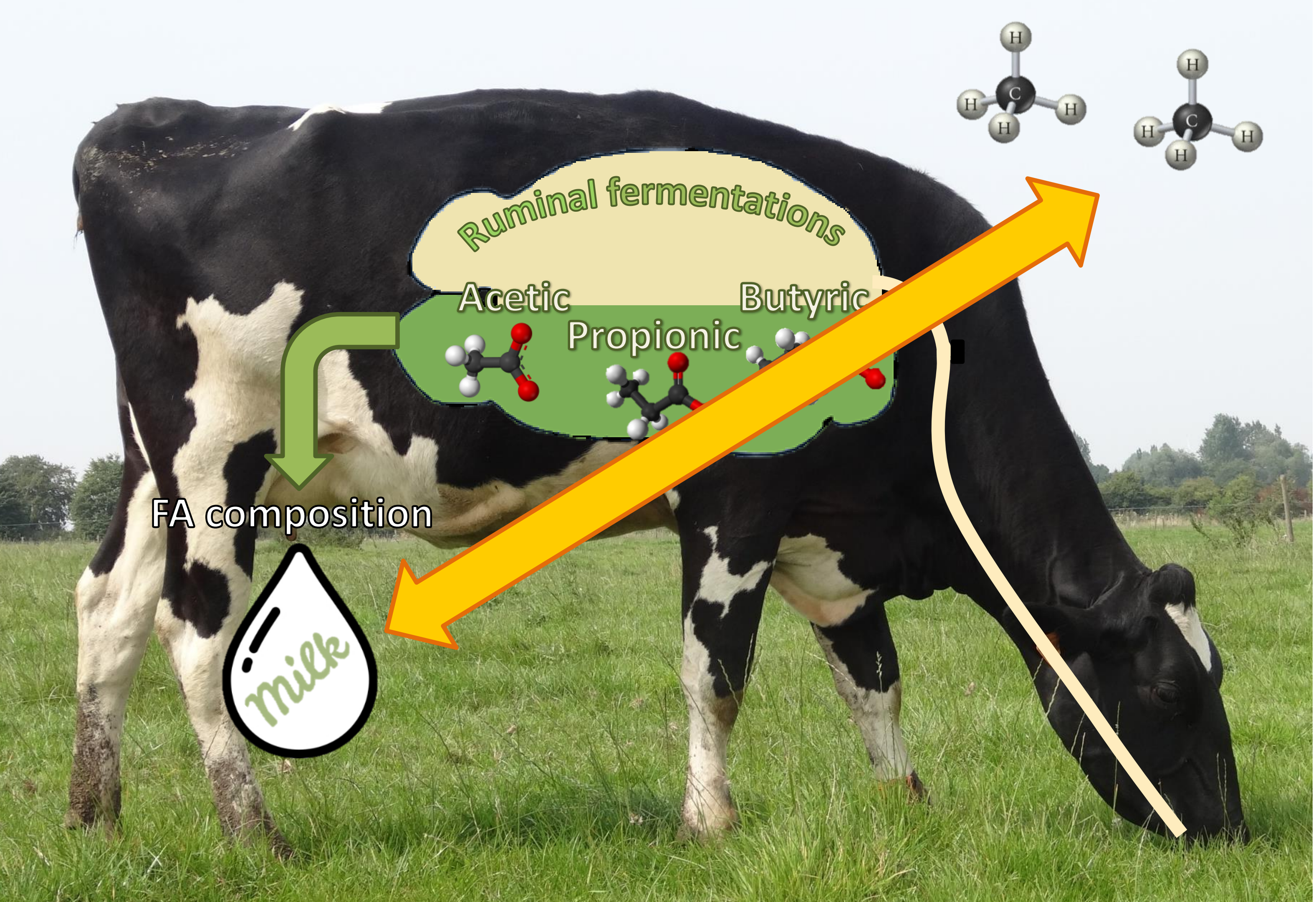
- Reduce $CH_4$ through breeding

# Back to basics : Methanogenesis



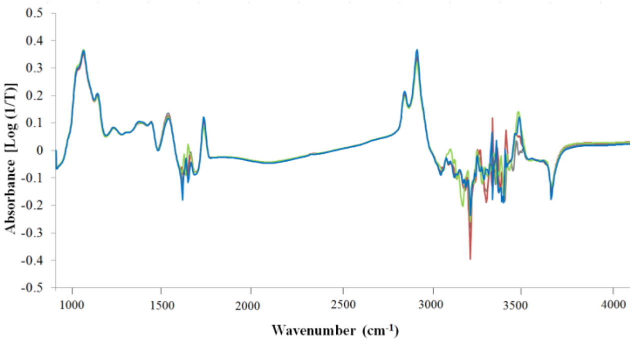

# Back to basics : Methanogenesis




Ruminal fermentations
Acetic
Propionic
Butyric
FA composition
milk

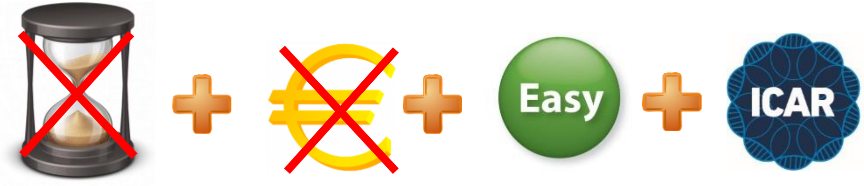
## Proxy

# Milk FT-MIR spectra as a proxy for enteric $CH_4$

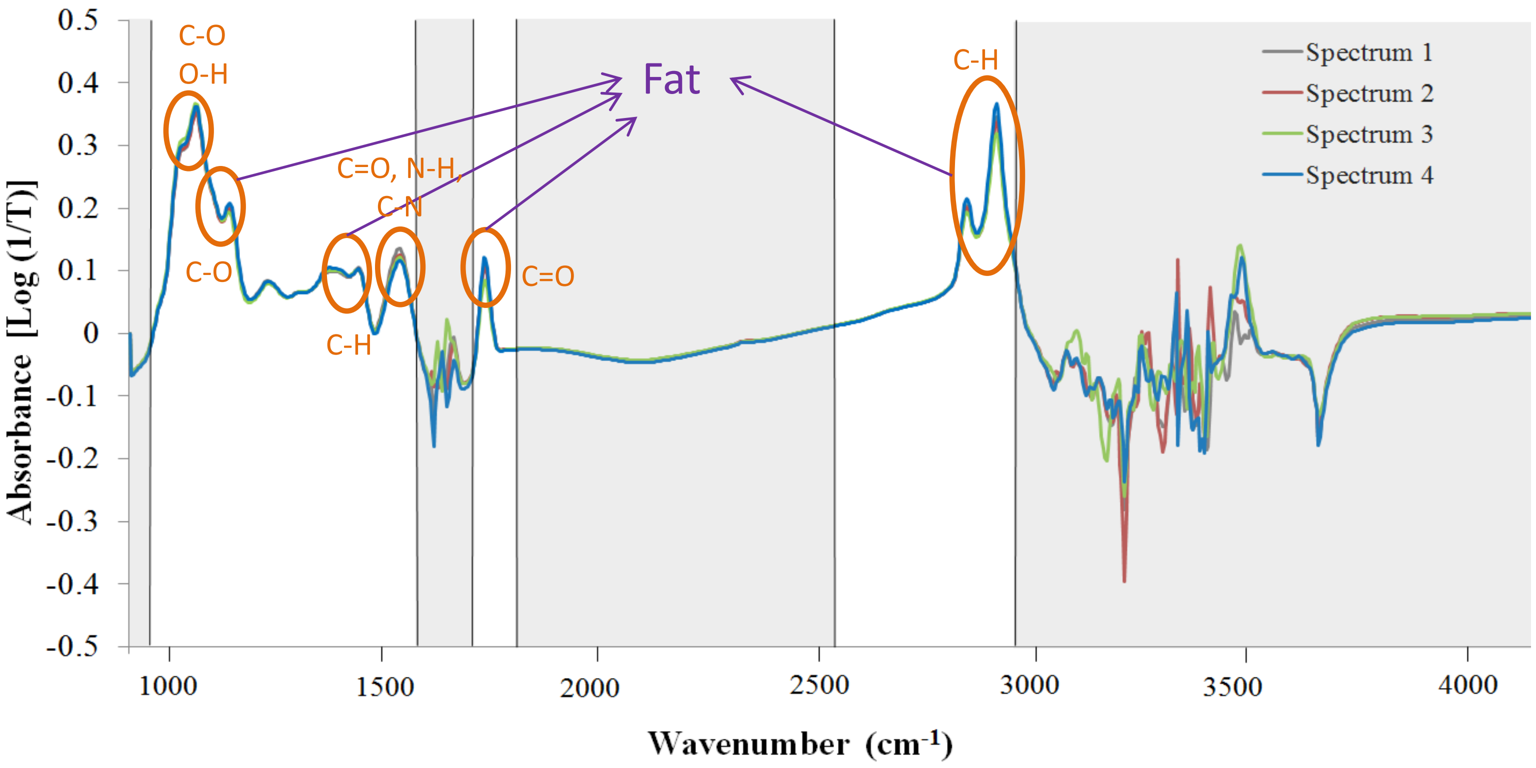




Milk samples are collected routinely

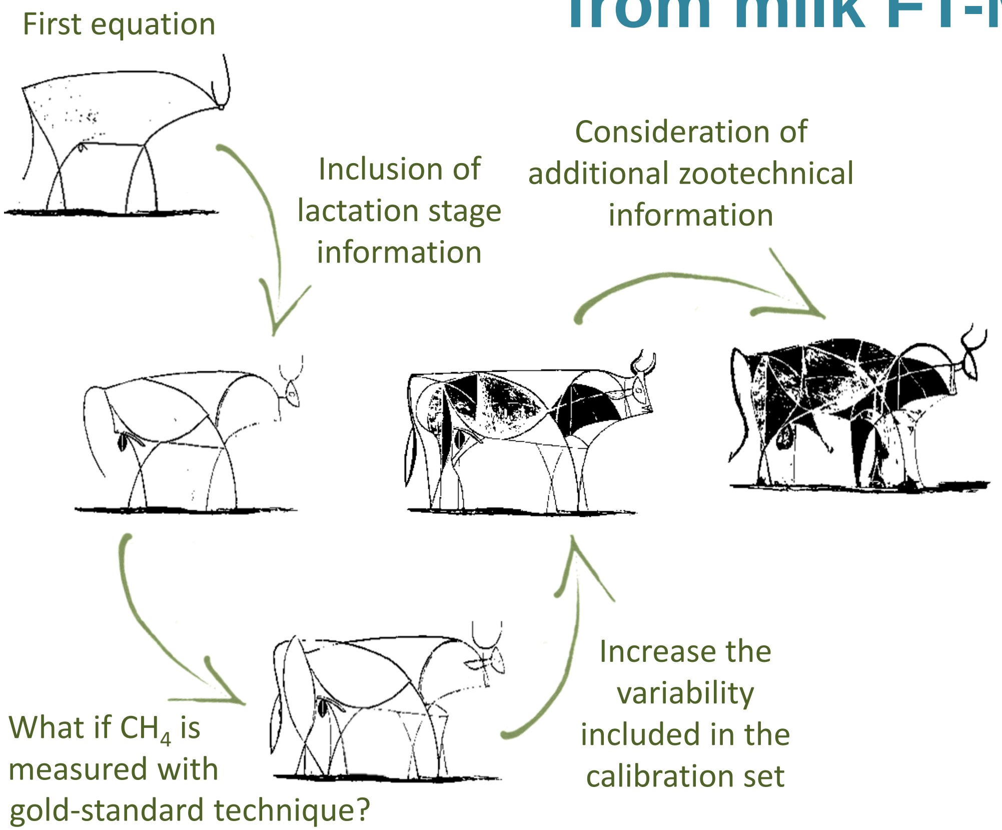
They are analysed by MIR spectrometry



# Milk FT-MIR spectra as a proxy for enteric $CH_4$



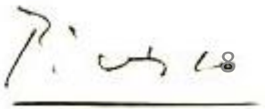
# Development of equations to estimate $CH_4$ from milk FT-MIR spectra




Journal of the Science of Food and Agriculture
SCI where science meets business

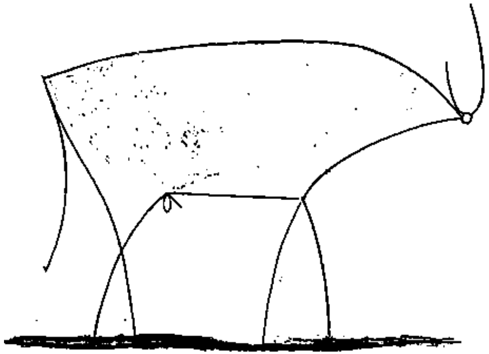

**Improving robustness and accuracy of predicted daily methane emissions of dairy cows using milk mid-infrared spectra**

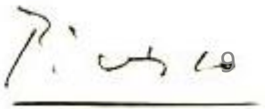

Amélie Vanlierde,[a] Frédéric Dehareng,[a*] Nicolas Gengler,[b] Eric Froidmont,[c] Sinead McParland,[d] Michael Kreuzer,[e] Matthew Bell,[f,†] Peter Lund,[g] Cécile Martin,[h] Björn Kuhla[i] and Hélène Soyeurt[b]

# Development of equations to estimate $CH_4$ from milk FT-MIR spectra

## First equation





# First equation

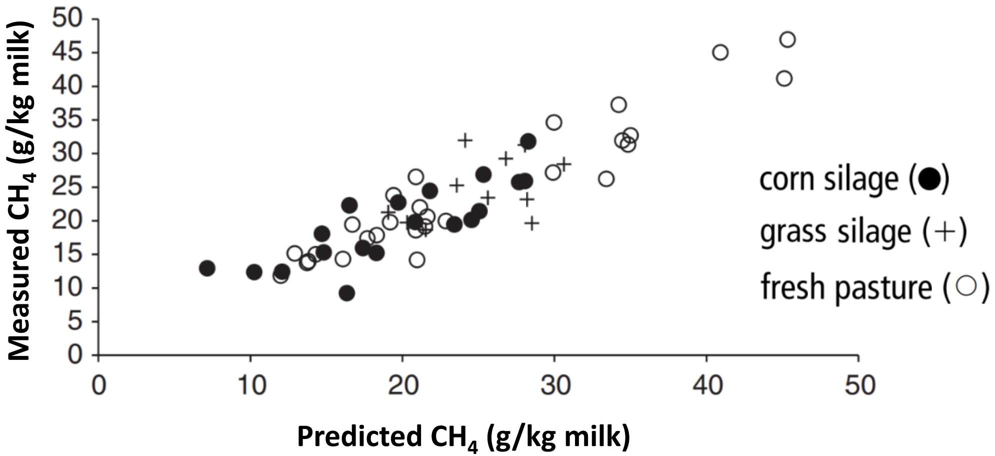
| Equation | N data | N cows | Origin | Pred. variables | $R^2c$ | SEC (g/d) | $R^2cv$ | SECV (g/d) |
|---|---|---|---|---|---|---|---|---|
| First equation | 77 | 11 | BE | S | 0.85 | 69 | 0.72 | 96 |

*Animal* (2012), **6:10**, pp 1694–1701 © The Animal Consortium 2012
doi:10.1017/S1751731112000456

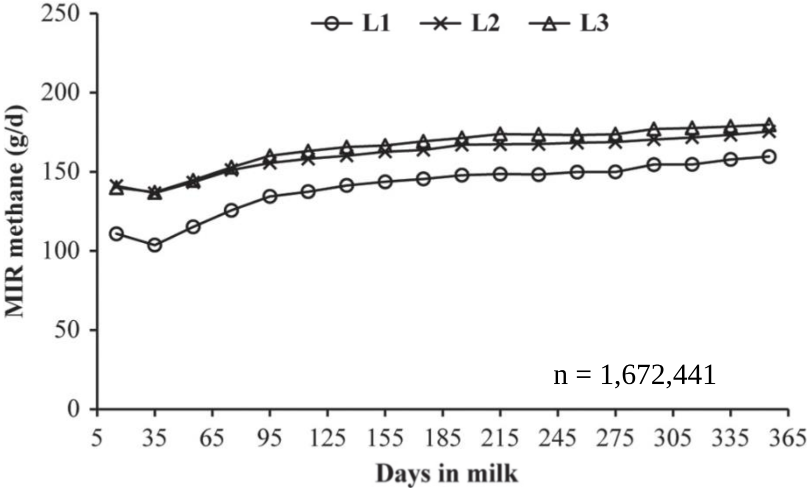
animal

**Potential use of milk mid-infrared spectra to predict individual methane emission of dairy cows**

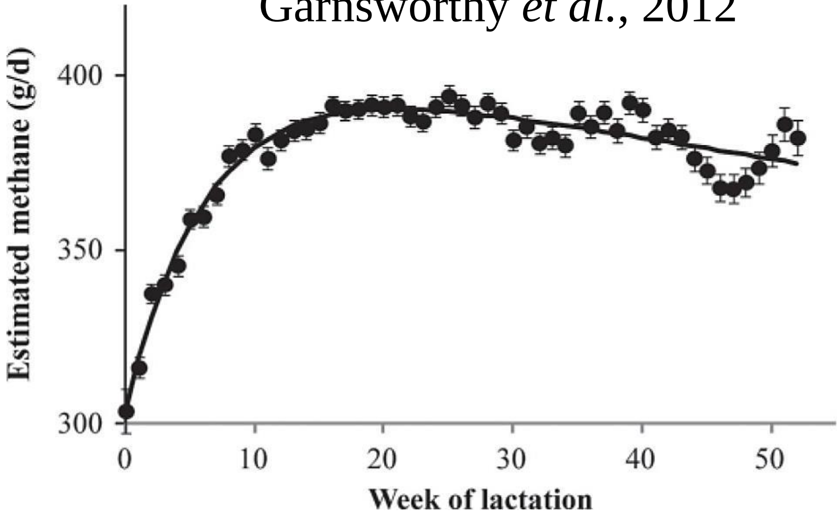
F. Dehareng[1*†], C. Delfosse[1*], E. Froidmont[2], H. Soyeurt[3,4], C. Martin[5], N. Gengler[3,4], A. Vanlierde[1] and P. Dardenne[1]



# Development of equations to estimate $CH_4$ from milk FT-MIR spectra

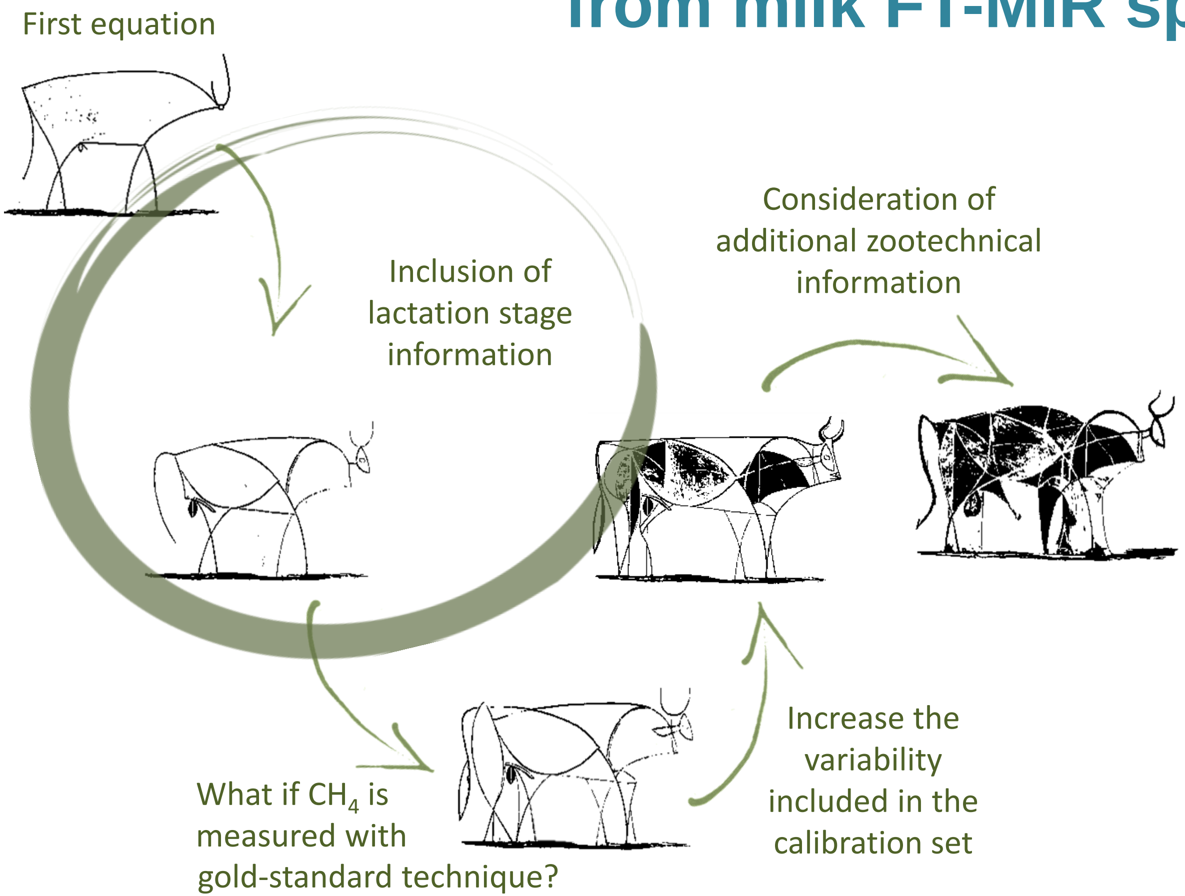



Garnsworthy *et al.*, 2012

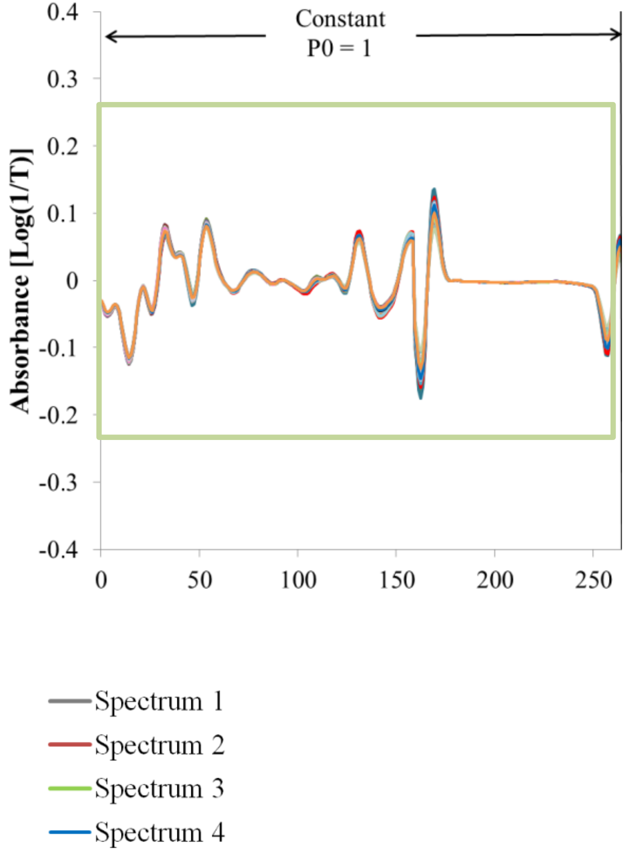



**! Not only focus on model statistics. Importance to observe consistency of predictions !**

# Development of equations to estimate $CH_4$ from milk FT-MIR spectra

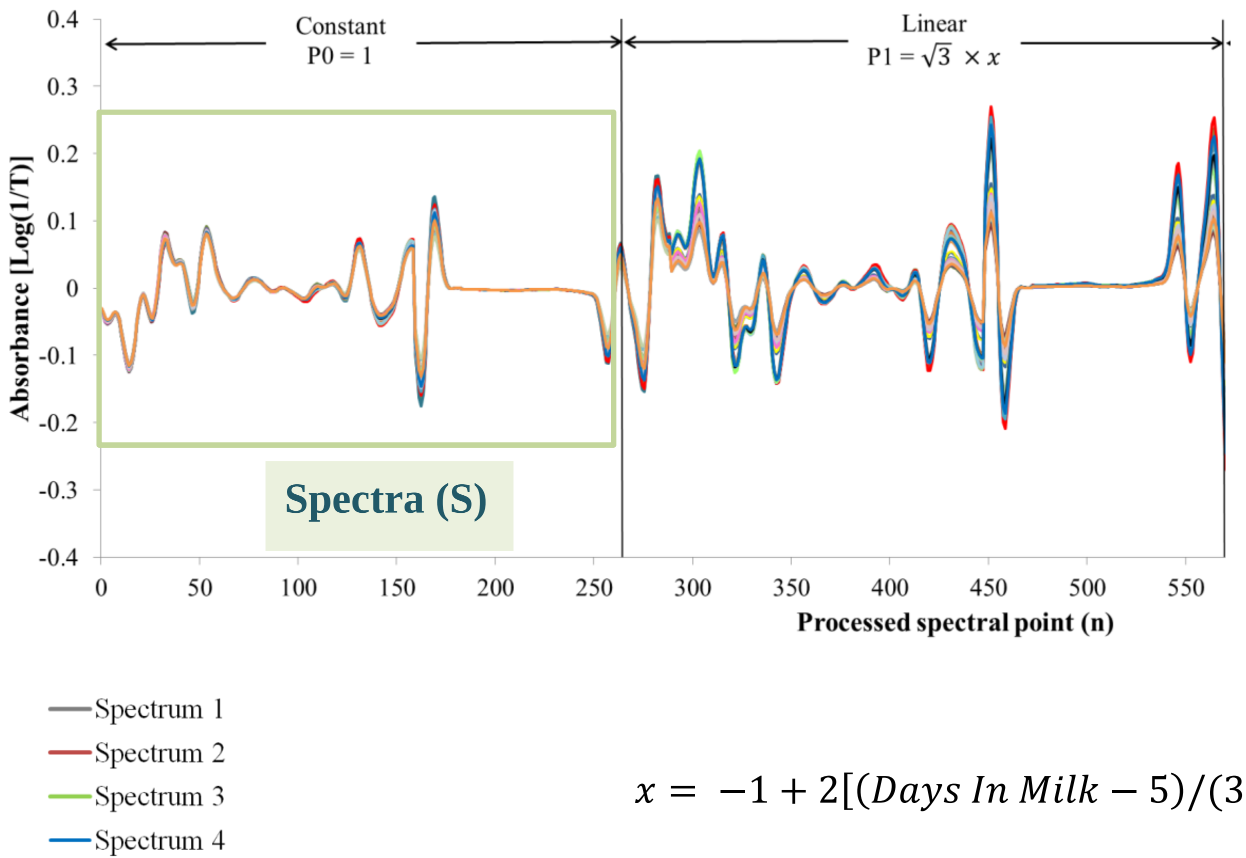


# Inclusion of lactation stage information to reflect changes in the metabolic status of cows



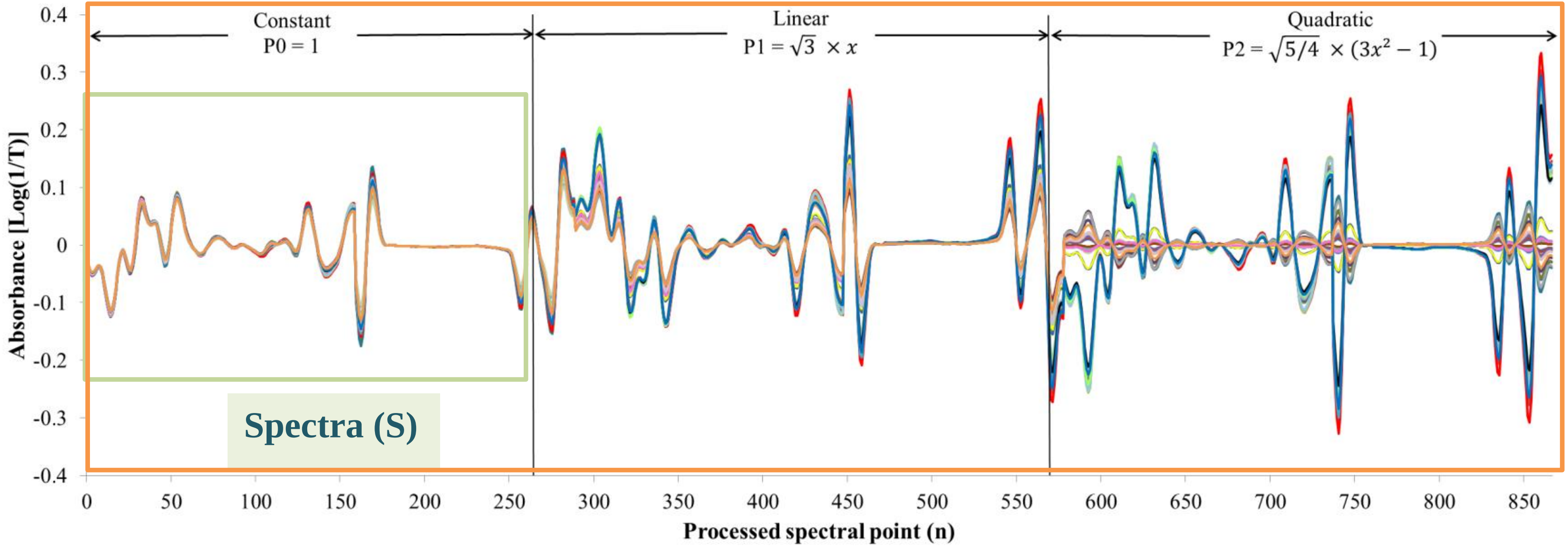

Spectra (S)

# Inclusion of lactation stage information to reflect changes in the metabolic status of cows




$$x = -1 + 2[(Days\ In\ Milk - 5)/(365 - 5)]$$

# Inclusion of lactation stage information to reflect changes in the metabolic status of cows

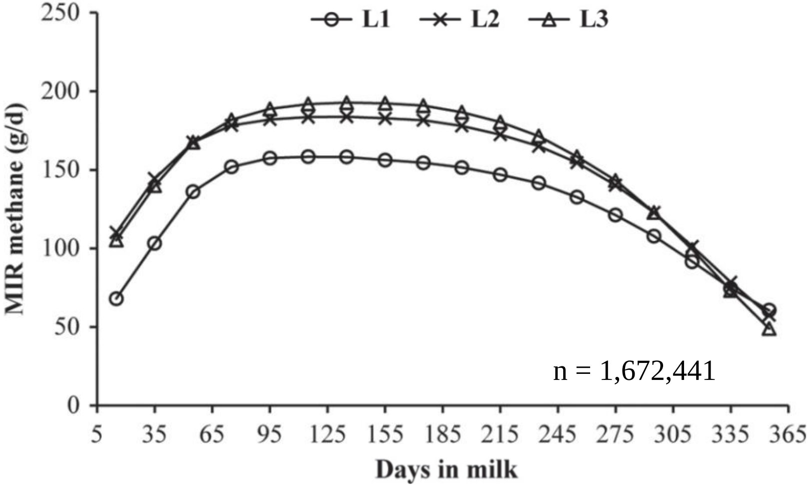



Spectrum 1
Spectrum 2
Spectrum 3
Spectrum 4

**Modified Spectra (MS) ➔ lactation stage dependent coefficients**

$$x = -1 + 2[(Days\ In\ Milk - 5)/(365 - 5)]$$

# Inclusion of lactation stage information to reflect changes in the metabolic status of cows

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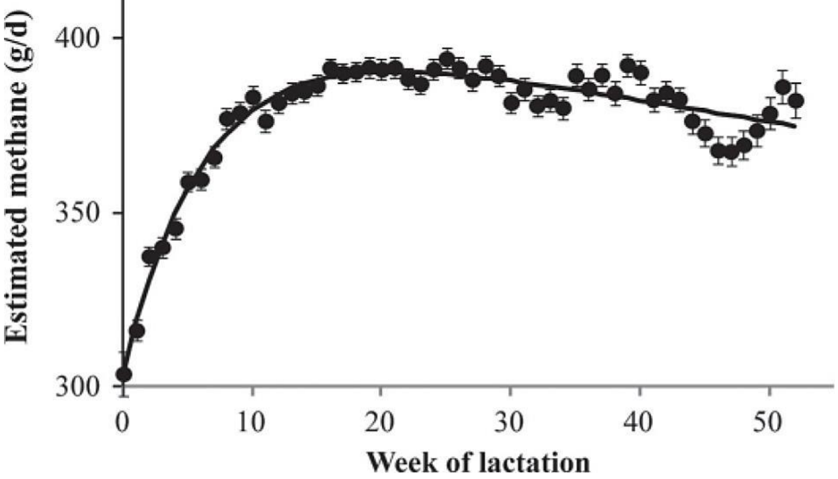

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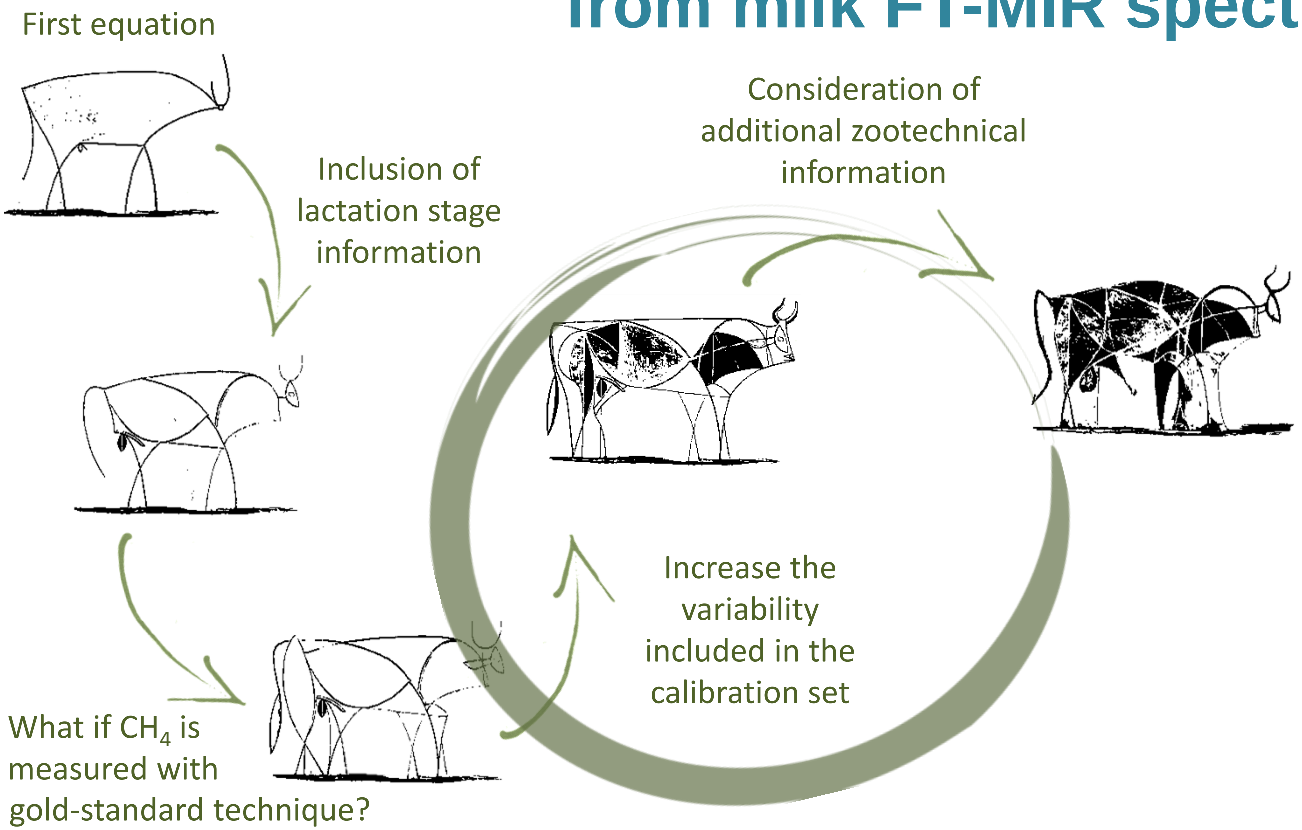


# Increasing the variability of the calibration set
# → Countries and reference methods

METHAGENE
GE PLUS
OptiMIR
GREENHOUSE MILK

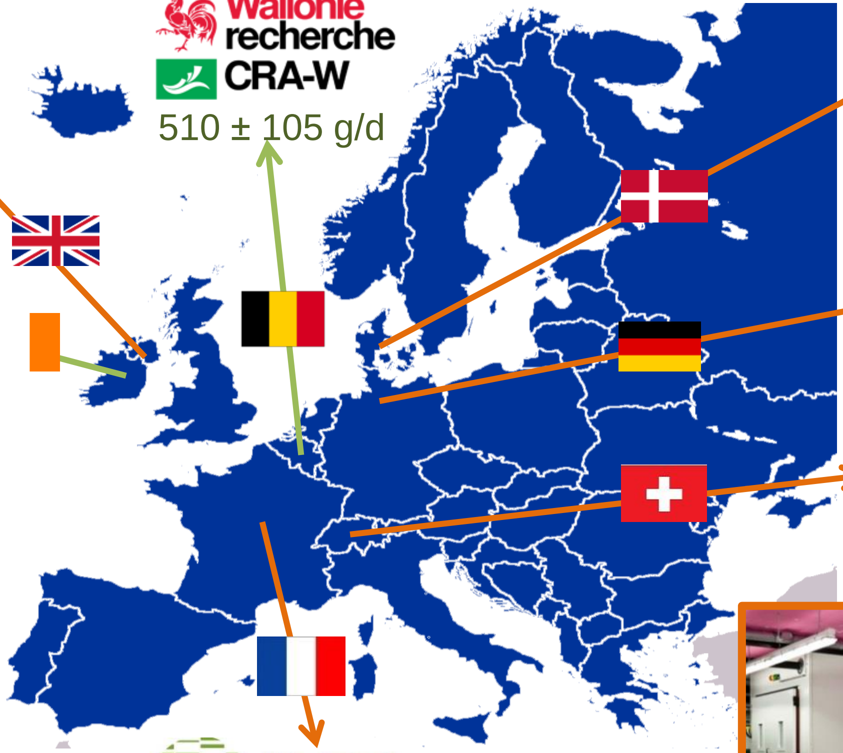
Wallonie recherche CRA-W
510 ± 105 g/d

afbi Agri-Food and Biosciences Institute
365 ± 44 g/d

AARHUS UNIVERSITY
367 ± 64 g/d

teagasc Agriculture and Food Development Authority
347 ± 89 g/d

FBN
405 ± 60 g/d



QUALITAS
ETH Zürich
451 ± 75 g/d

427 ± 127 g/d

INRA SCIENCE & IMPACT
366 ± 61 g/d

400 ± 72 g/d

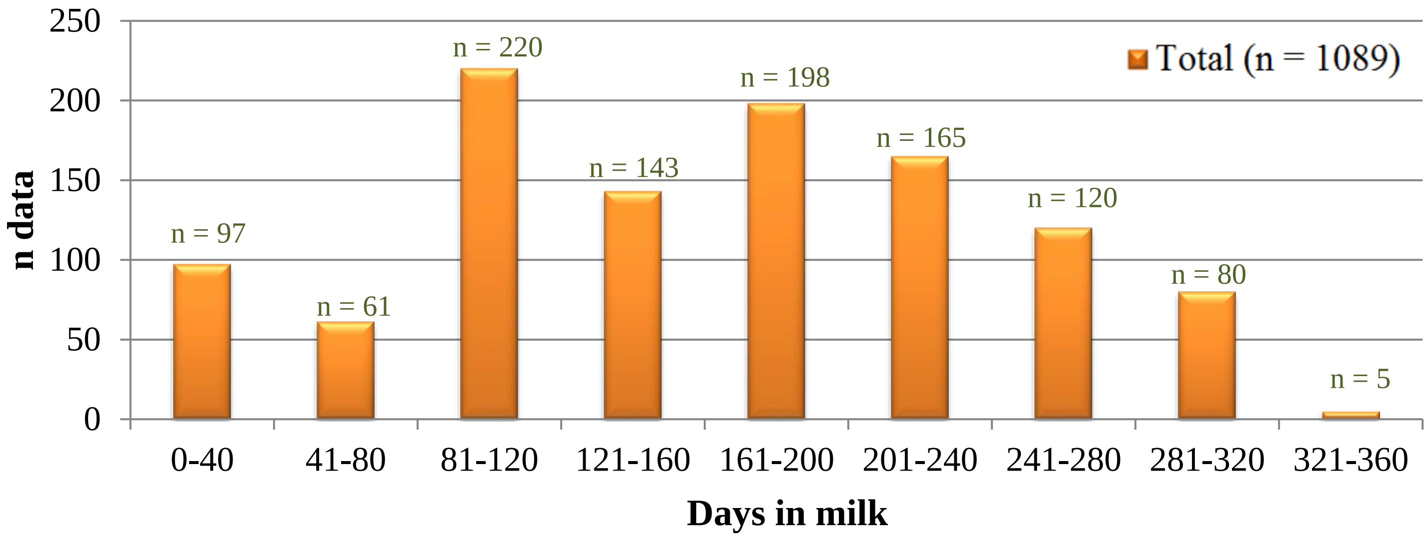
# Increasing the variability of the calibration set
# → Breeds



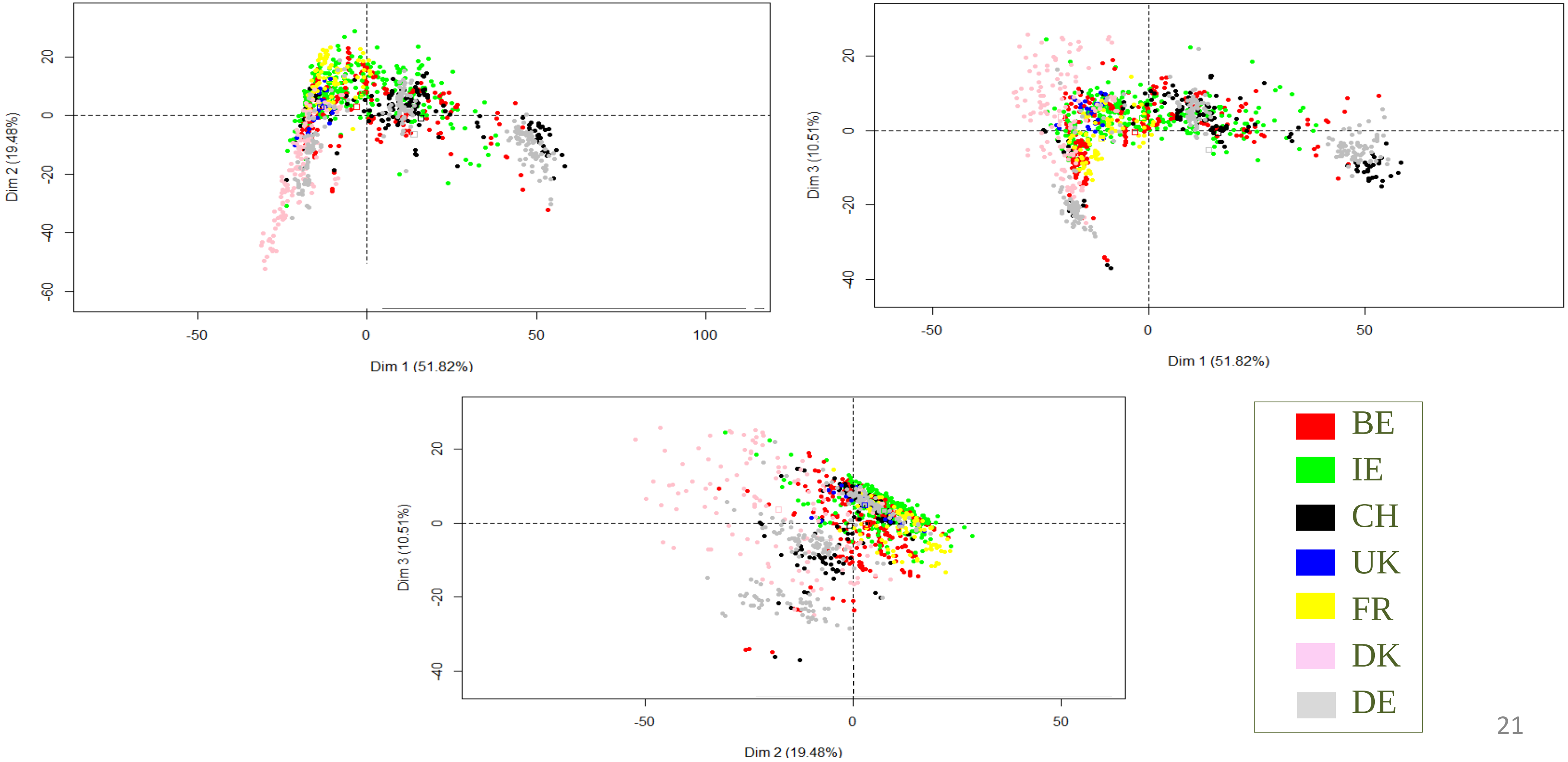


| Breed | n data | % of data | n cows | % of cows | $CH_4$ (g/d) mean ± SD |
|---|---|---|---|---|---|
| HOL | 891 | 82 | 222 | 74 | 415 ± 107 |
| JER | 67 | 6 | 10 | 3 | 342 ± 42 |
| BSW | 78 | 7 | 39 | 13 | 458 ± 69 |
| RED | 21 | 2 | 8 | 3 | 427 ± 74 |
| X | 32 | 3 | 20 | 7 | 391 ± 67 |

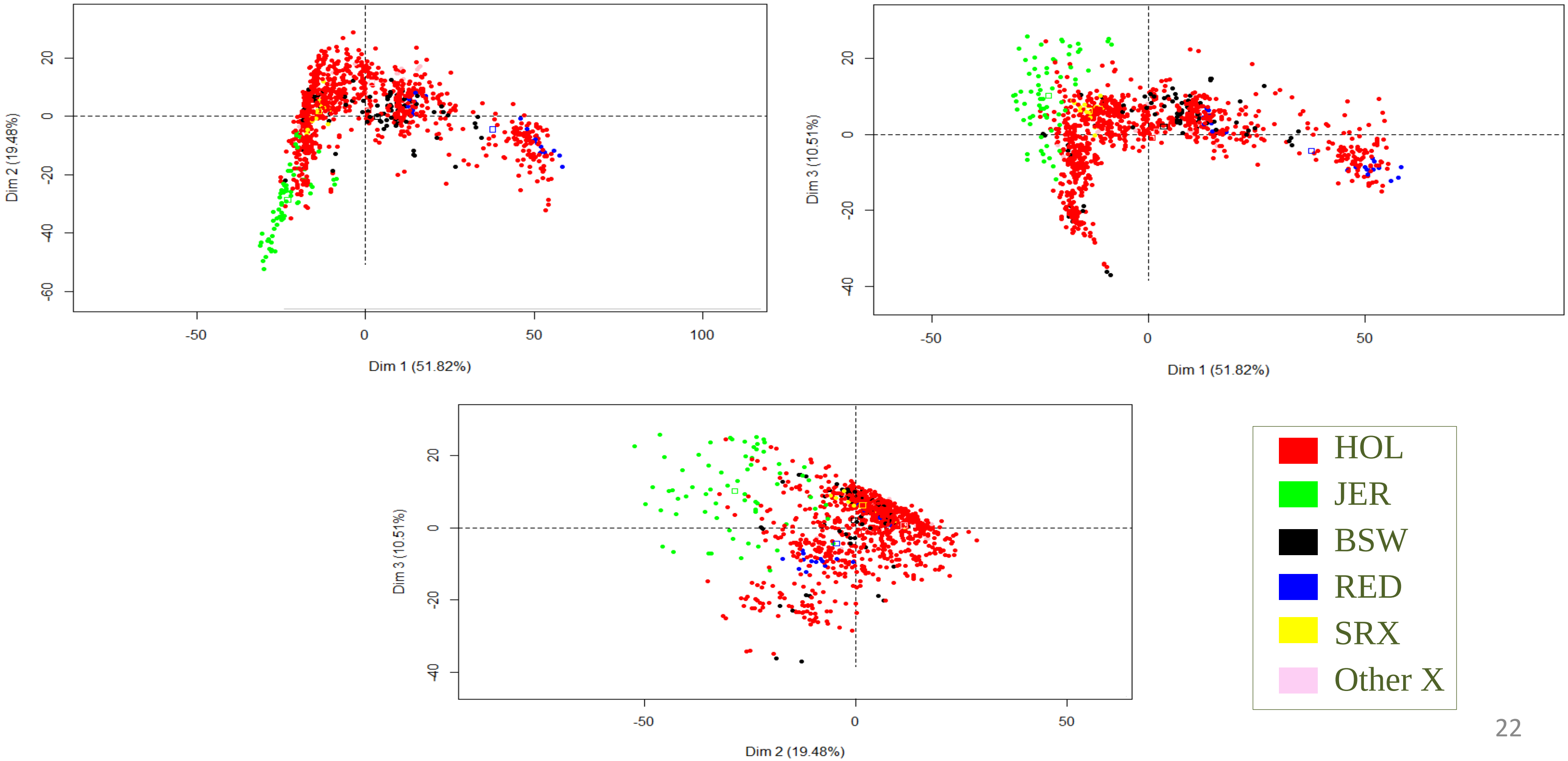
# Increasing the variability of the calibration set → Lactation stage



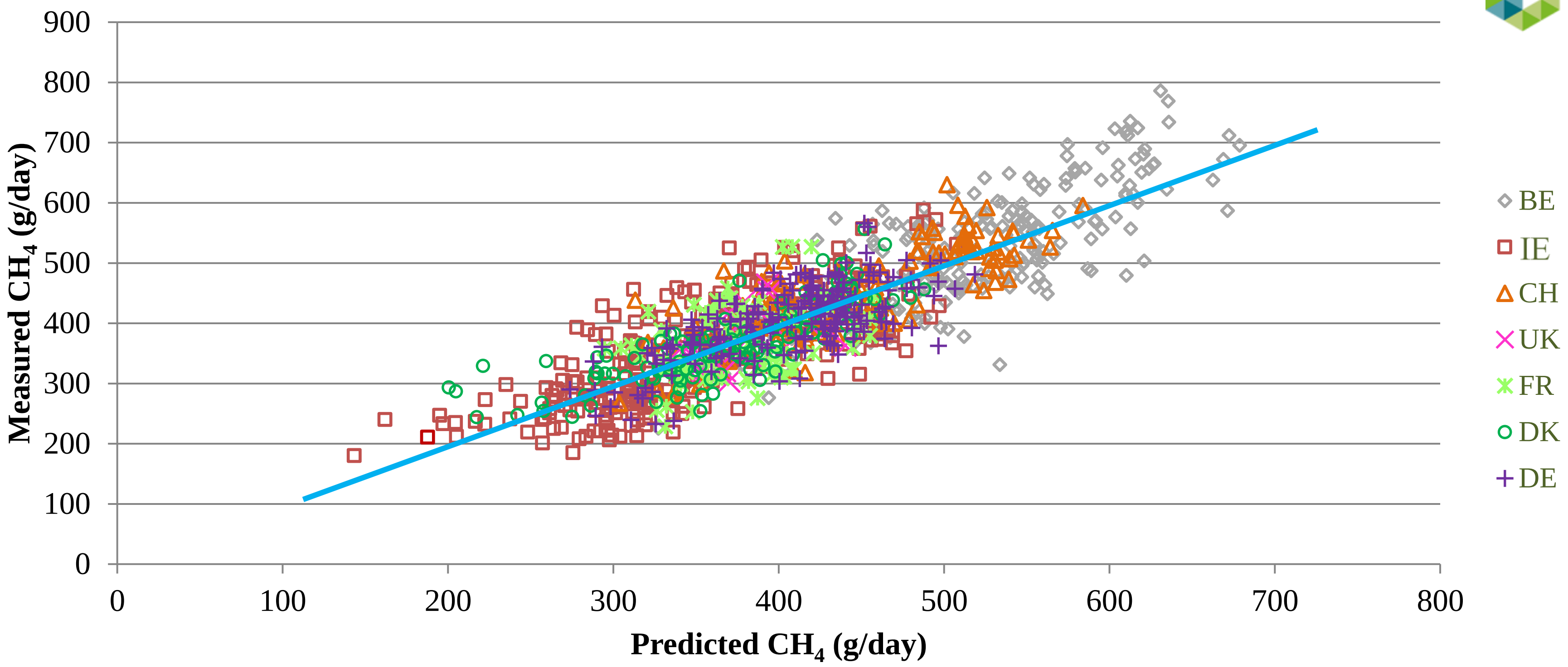
# Increasing the variability of the calibration set → FT-MIR spectra



# Increasing the variability of the calibration set → FT-MIR spectra



# Equation developped



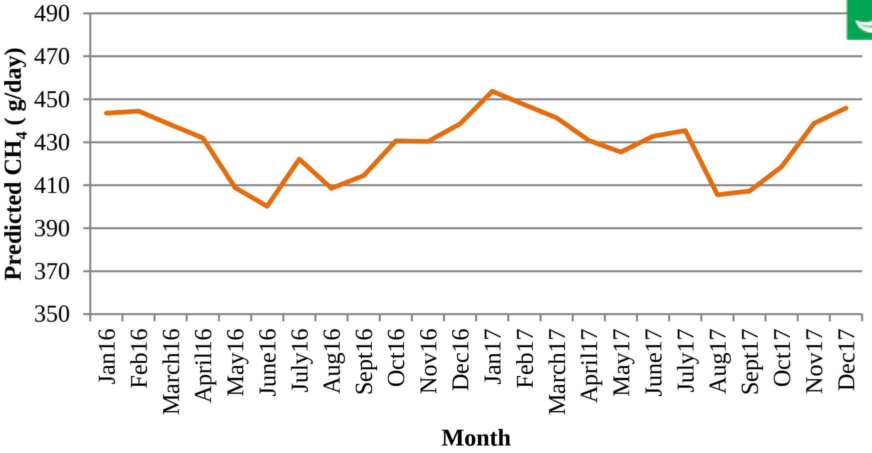

| $CH_4$ Ref. method | n data | n cows | Origin | $R^2c$ | SEC (g/d) | $R^2cv$ | SECV (g/d) |
|---|---|---|---|---|---|---|---|
| $SF_6$ & RC | 1,089 | 299 | BE, IE, CH, UK, FR, DK, DE | 0.73 | 53 | 0.68 | 57 |

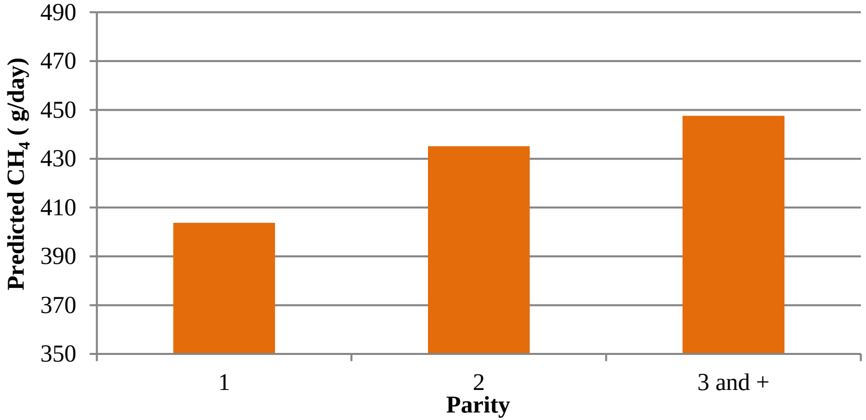
# Practical applications : Large scale studies

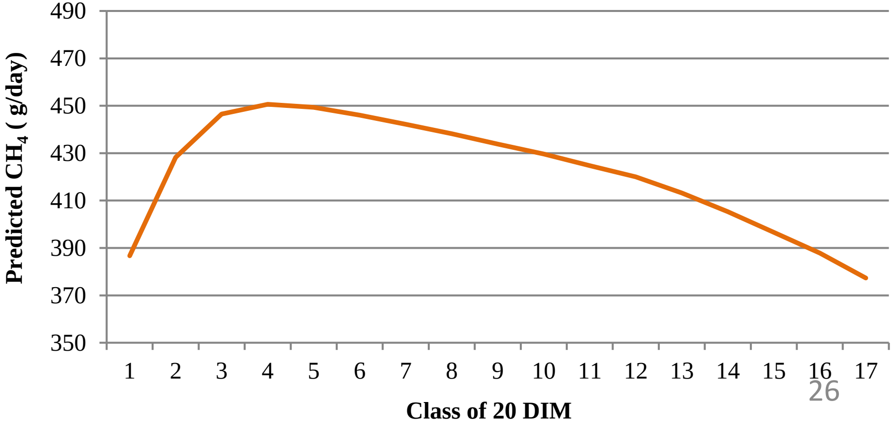
Walloon milk recording Jan. 2016 → Dec. 2017

5 – 365 DIM

GH < 5
Holstein cows in RW
→ n = 538,510



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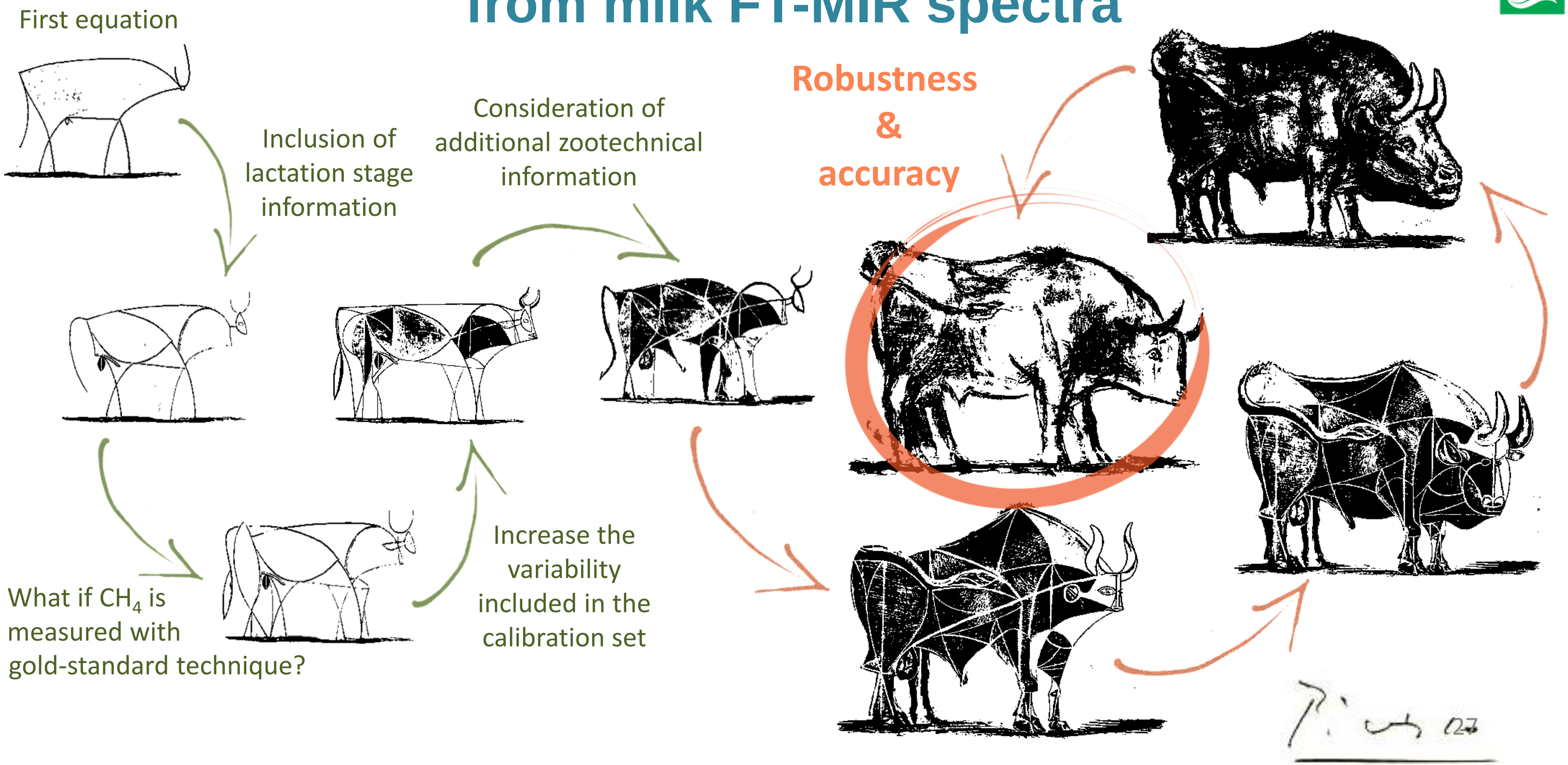

# Main strenghts and limitations of milk MIR spectra as a proxy for $CH_4$ emissions?

## Strenghts

- Milk sampling and MIR analyses already implemented in routine
- Fast
- Cost effective
- Error of prediction known
- Scalable
- Maybe closer to physiology (H → $CH_4$)

## Limitations

- Specific variability need to be included to avoid extrapolation (GH spectra, diet, breed, THI conditions, etc.)
- Effect of some diet additives on $CH_4$ emissions can not be considered
- Need standardized milk MIR spectra
- Only for lactating dairy cows

# Getting access to the model?

**2 Options**

a) <u>Research collaboration</u>

Provide reference data ($CH_4$ + Milk MIR spectra)
- from a country not yet included
- from cows receiving an innovative diet/additive
- from a breed/lactation stage… not covered
- *etc.*

Win/Win situation

Reference data never shared,
only updated coefficients of the equation

Need of standardized spectra

b) <u>European milk recording</u>


www.milkrecording.eu

# In the future?

- Keep improving the model - respiration chamber & $SF_6$ tracer gas methods
- Same collaborative approach with greenfeed data on its way - challenge about $CH_4$ values

J. Dairy Sci. 105:9271–9285
https://doi.org/10.3168/jds.2022-21890


**Methodological guidelines: Cow milk mid-infrared spectra to predict reference enteric methane data collected by an automated head-chamber system**

M. Coppa,[1] A. Vanlierde,[2] M. Bouchon,[3] J. Jurquet,[4] M. Musati,[5,6] F. Dehareng,[2] and C. Martin[5]*

- Merging Greenfeed system data with respiration chamber and $SF_6$ tracer gas ?
- Considering other informative values as predictors ?
- Extension towards genomics (← new opportunities for collaborations)

# Take home messages

- Prediction of $CH_4$ emissions from milk MIR spectra : **indirect** and **scalable** model.
- Importance to observe model **statistics** AND **consistency** of predictions.
- **Collaborations** are the key to join efforts and obtain robust models.
- Need to **standardise** spectra to merge reference datasets and to apply the model.
- **Limitations** are known (SE, additives with late impact on methanogenesis process,…).
- To be validated: MIR predictions closer to **physiological $CH_4$** (H generation potential).
- You can use it with different purposes if you are a **nutritionist**, a **geneticist**, etc.

Keeping that in mind to ensure a wise use, milk MIR spectra is a very effective proxy to predict indvidual $CH_4$ emissions from lactating dairy cows.

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## Thank you for your attention