Consortium building allowing the creation of common models for MIR based prediction of CH_4

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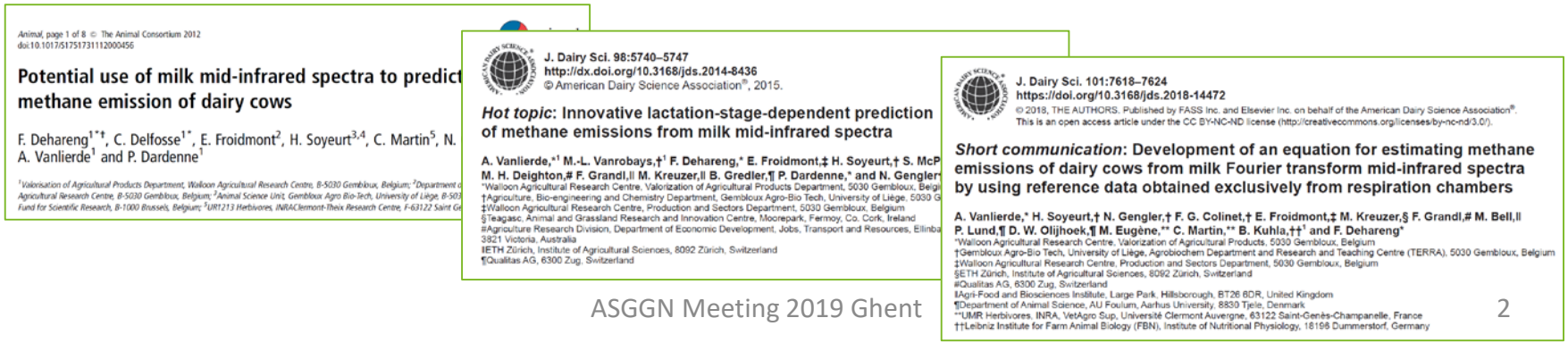
[2] Walloon Agricultural Research Center (CRA-W)

Context

- CH_4 ← large scale phenotyping
  - Difficult, time consuming, expensive
  - Proxies ?
- Use of a milk mid-infrared (MIR) spectra based proxy
  - Was illustrated as being a real opportunity



Animal, page 1 of 8 © The Animal Consortium 2012
doi:10.1017/S1751731112000456

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

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

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***Hot topic*: Innovative lactation-stage-dependent prediction of methane emissions from milk mid-infrared spectra**

A. Vanlierde,*[1] M.-L. Vanrobays,†[1] F. Dehareng,* E. Froidmont,‡ H. Soyeurt,† S. McP
M. H. Deighton,# F. Grandl,‖ M. Kreuzer,‖ B. Gredler,¶ P. Dardenne,* and N. Gengler

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***Short communication*: Development of an equation for estimating methane emissions of dairy cows from milk Fourier transform mid-infrared spectra by using reference data obtained exclusively from respiration chambers**

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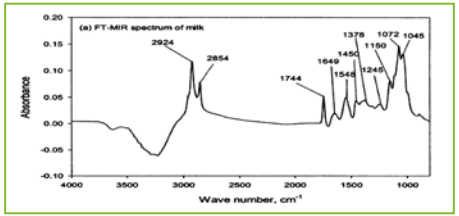
How Do MIR Based Predictions Work ?

Milk samples
(milk payment, milk recording)

MIR spectrometry analysis



Raw data = MIR spectra

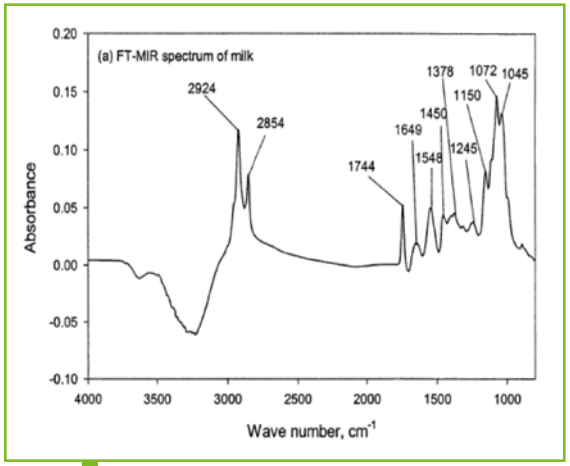
Calibration equations

Quantification:

Existing: fat, protein, urea,….

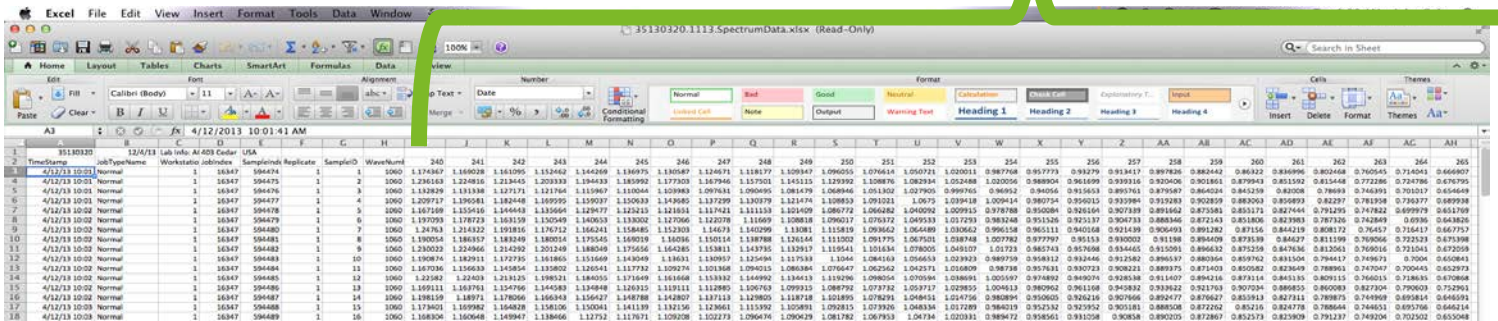
Calibration (Spectra ➔ Prediction)

- Between 850 – 1060 absorbance values (abs)



- "Calibration"
  - ➔ Obtaining **b coefficients**

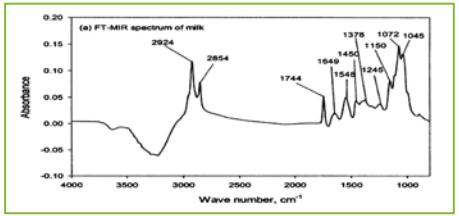
    e.g., $\mathbf{CH_4 = b_0 + \sum b_i\,(abs)_i}$



New MIR Predicted Phenotypes

Milk samples
(milk payment, milk recording)

MIR spectrometry analysis



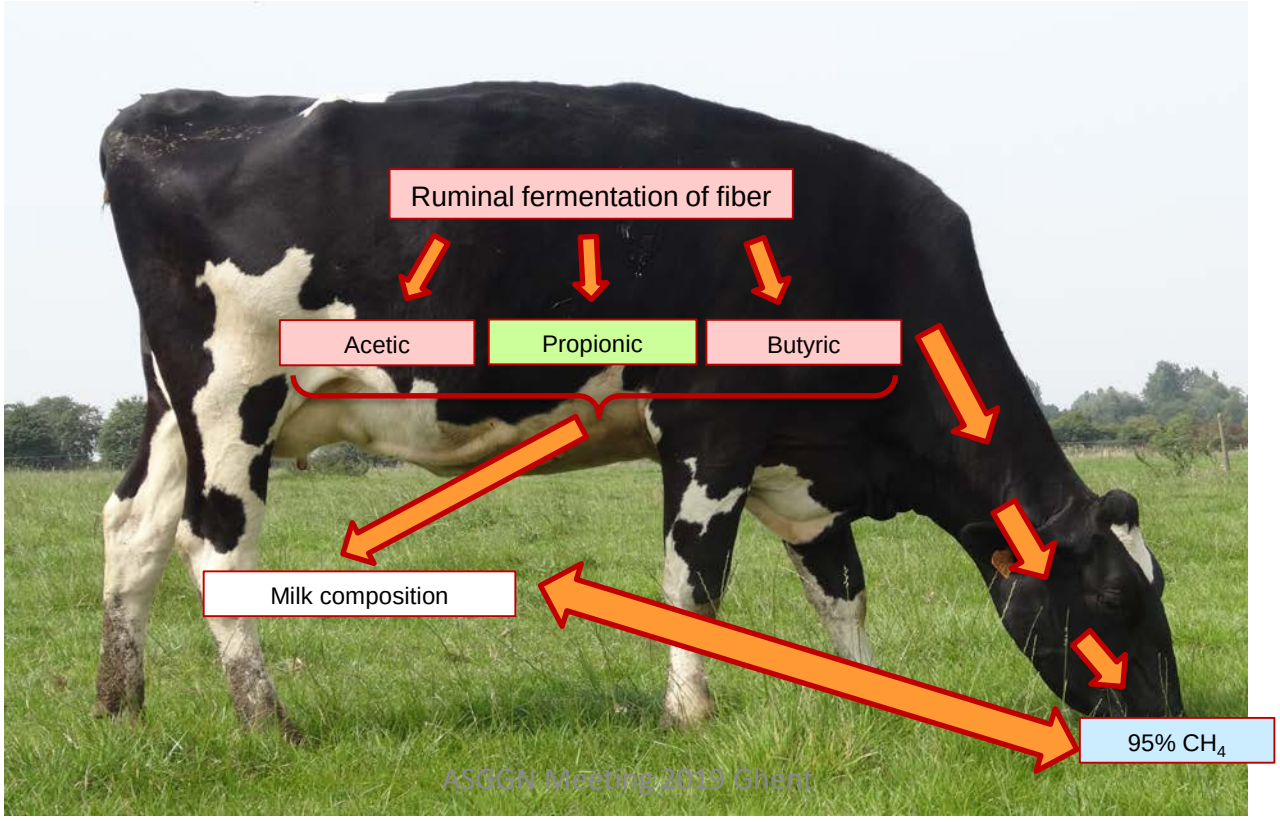
Raw data = MIR spectra

New calibration equations

Quantification:

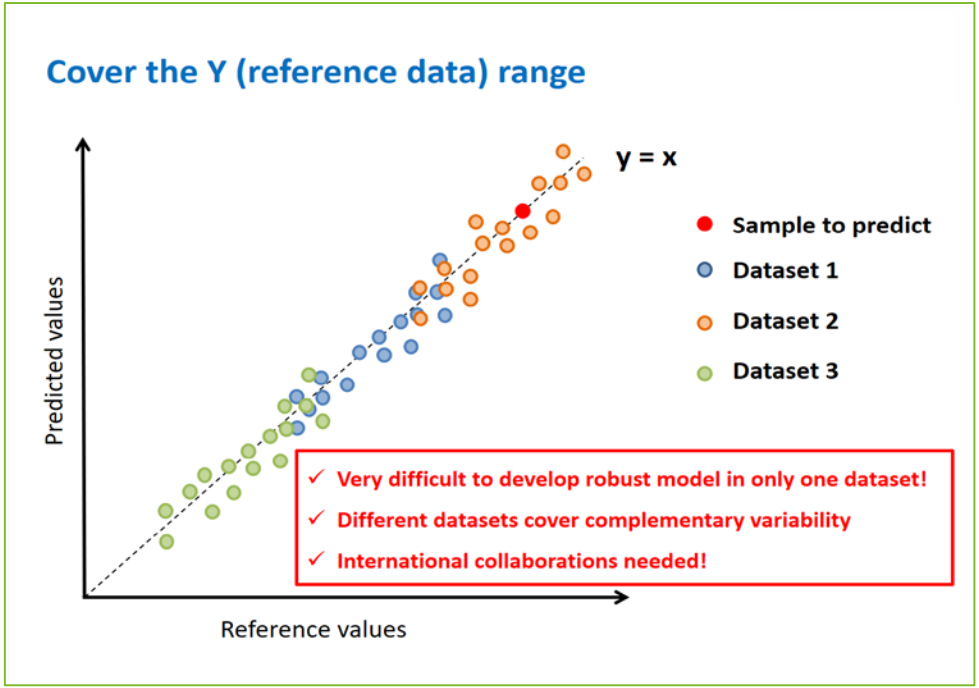
New: fatty acids, CH_4, ….

CH_4 ⟷ Milk Composition



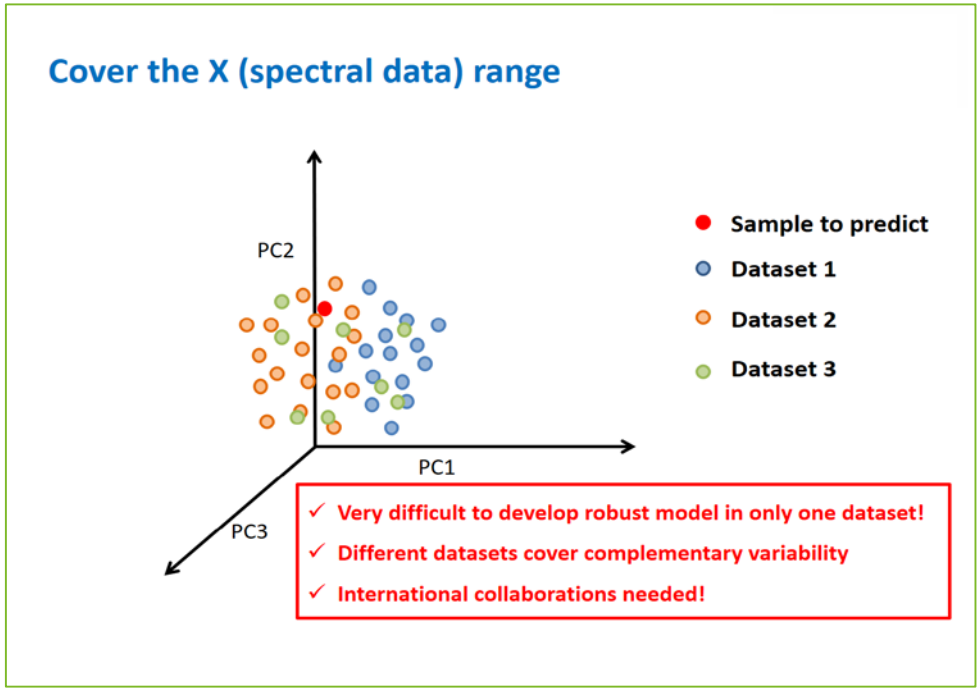
Calibration Needs….

- Largest possible (and expected) variability
  - In **reference phenotypes**
    - E.g., if values between 1 and 10 are expected, reference data from 1 to 10 are needed for calibration, potentially 1/10 of each



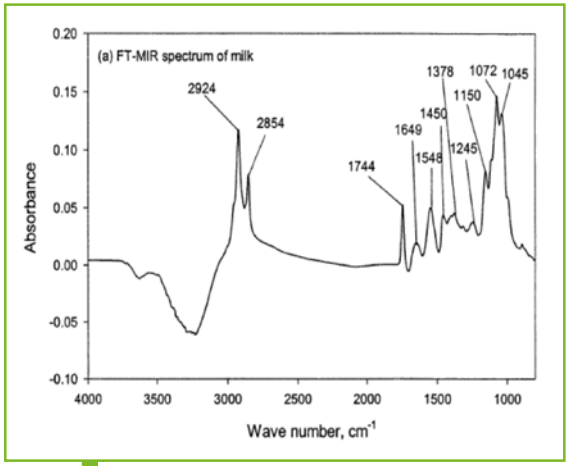
Calibration Needs….

- Largest possible (and expected) variability
  - In reference phenotypes
  - But also **in spectral data**
    - I.e., spectra used during calibration process should cover expected range of spectra used when predicting

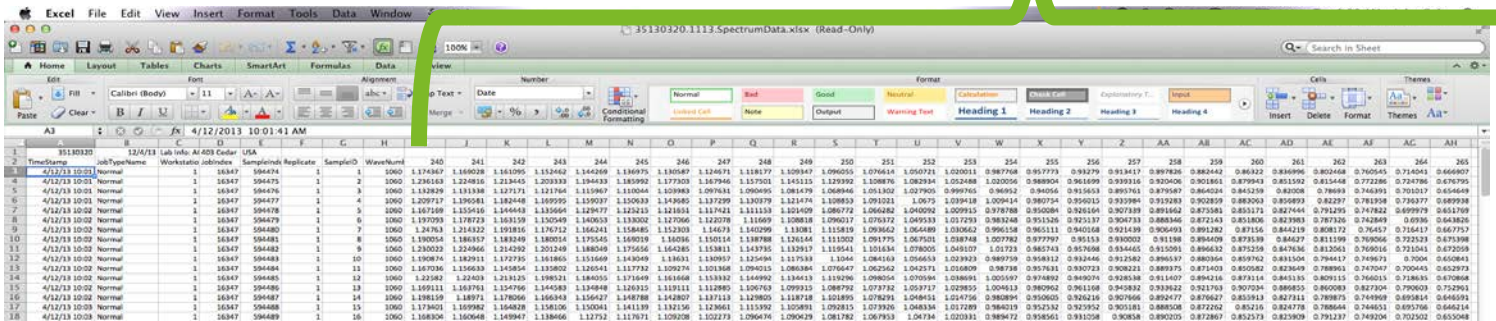


Calibration (Spectra ➔ Prediction)

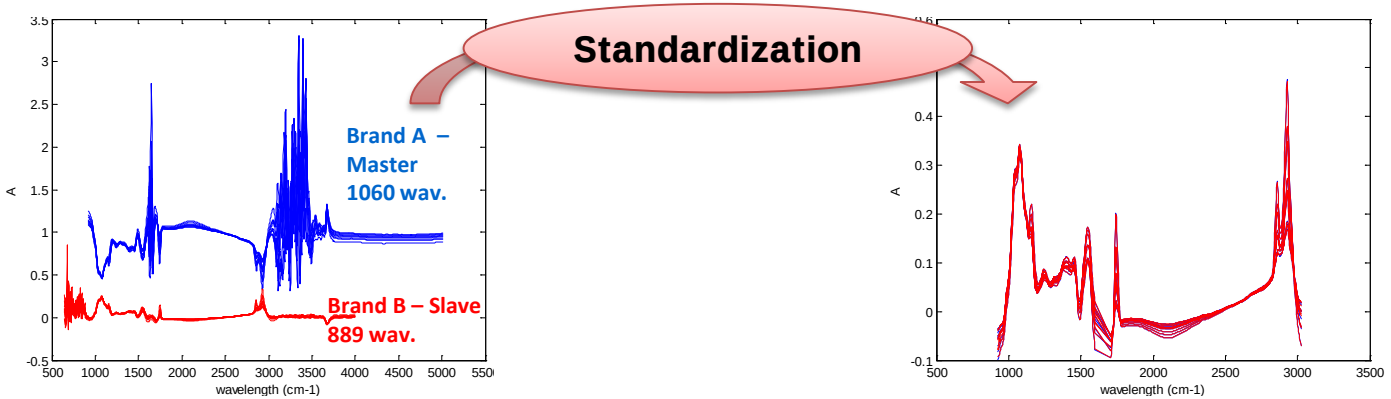
- Between 850 – 1060 absorbance values (abs)



different between brands and models ➔ additional steps necessary before calibration using different datasets

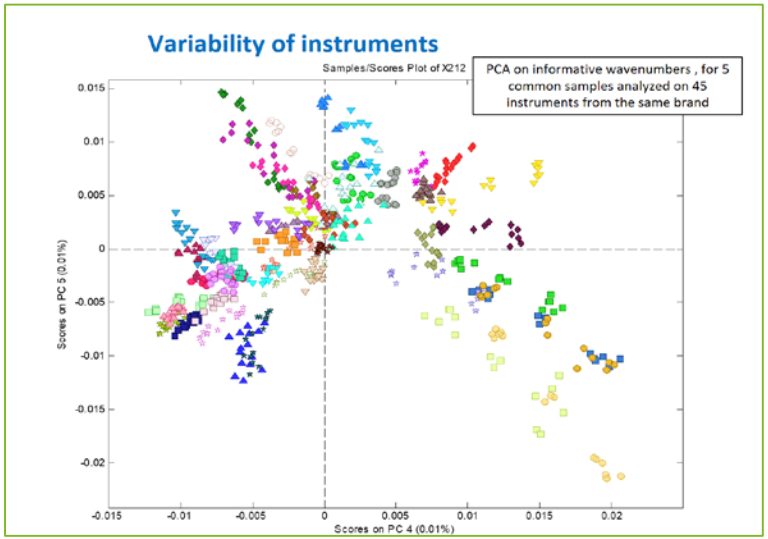


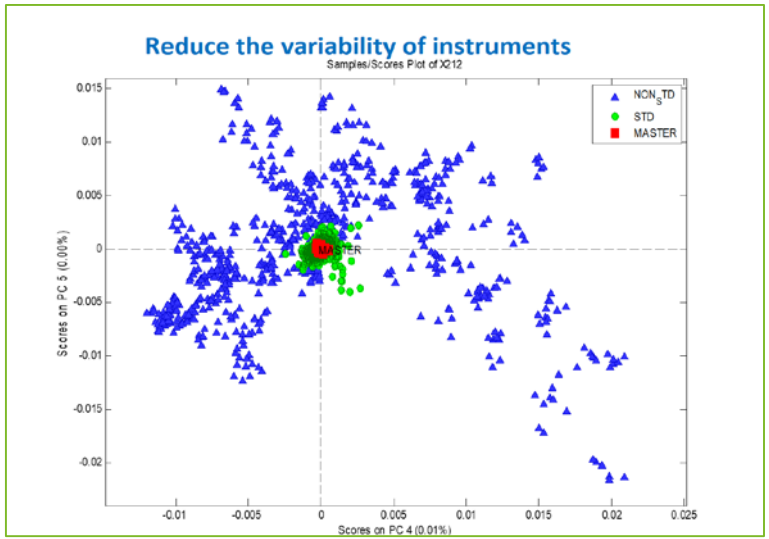
Standardization of MIR Spectra….



- Two steps to generate “standardized” (harmonized) spectral data
  1. Transforming from different ranges of wavelength to a common one
  2. Applying “bias“ and “slope” corrections for each wavelength

Standardization of MIR Spectra….





J. Dairy Sci. 98:2150–2160
http://dx.doi.org/10.3168/jds.2014-8764

Standardization of milk mid-infrared spectra from a European dairy network

C. Grelet,[1] J. A. Fernández Pierna,[1] P. Dardenne, V. Baeten, and F. Dehareng[2]
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J. Dairy Sci. 100:7910–7921
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Standardization of milk mid-infrared spectrometers for the transfer and use of multiple models

C. Grelet,* J. A. Fernández Pierna,* P. Dardenne,* H. Soyeurt,† A. Vanlierde,* F. Colinet,† C. Bastin,‡ N. Gengler,† V. Baeten,* and F. Dehareng*[1]
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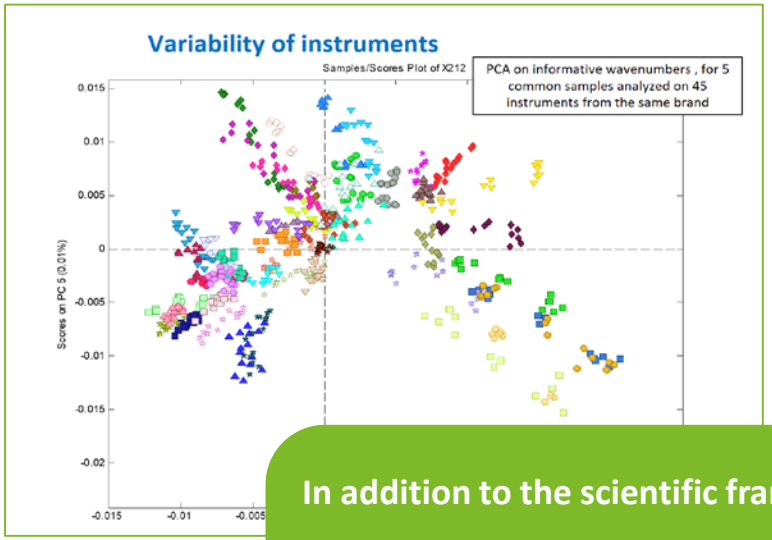
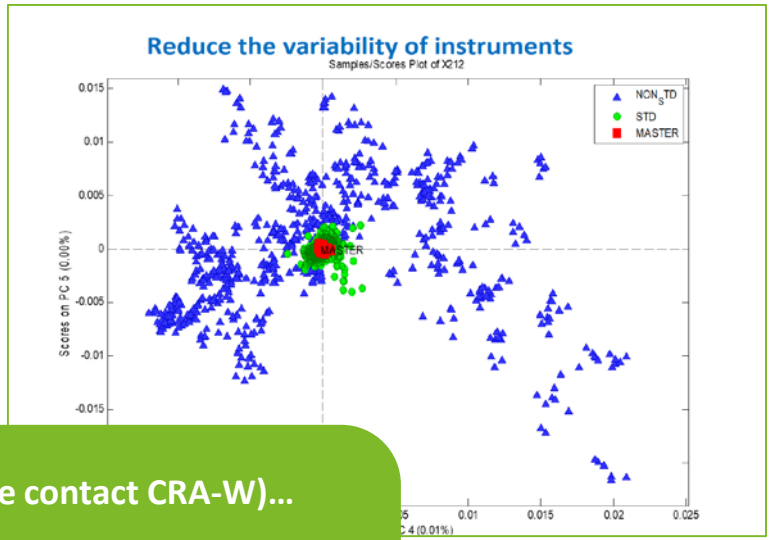
†Agriculture, Bio-Engineering, and Chemistry Department, University of Liège, Gembloux Agro-Bio Tech, 5030 Gembloux, Belgium
‡Walloon Breeding Association, B-5590 Ciney, Belgium

Standardization of MIR Spectra….





In addition to the scientific framework (please contact CRA-W)…

Commercial services were started by EMR (European Milk Recording)

please visit: www.milkrecording.eu

Calibration Needs….

- Largest possible (and expected) variability
  - In reference phenotypes
  - But also in spectral data

➔ Importance of **international collaborations** obvious

Needed: Consortium building allowing the creation of common models for MIR based prediction of CH_4

Innovative Consortium Building

- Why ➔ last slides!
- How ➔ building an efficient consortium ?
  - In the MIR world tradition of machine-builder equations 
- But inspiration from Near-Infrared Spectrometry (NIRS) world 
  - Existence of NIRS forage and feed testing consortia
    - A well documented example: NIRSC in the USA (see: http://www.nirsconsortium.org)

➔ “Open” consortium building

“Open” Consortium Building: Principles

- Defining calibration building organizations
  - Can be different for each equation, here CH_4: CRA-W and ULiège-GxABT
- Consortium members retain full ownership and control of their data
  - Providing their data only to equation builders
  - Data can only be used to improve equations under development
- By helping improving equations, consortium members get:
  - Access to calibrated equations
  - Access to all future updates when additional data from new members is included
- “Open” as everybody can join same conditions

As Scientists ➔ Why Joining?

- First interest in “Open” calibration process
  ➔ users of equations ➔ industry!

- But from a scientific point of view?
  ➔ interest for scientists?

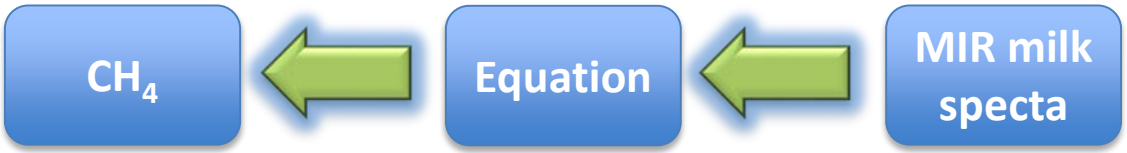
Creation and use of MIR based prediction (of CH_4 or other traits)
➔ additional contributions and research efforts needed

Additional Contributions and Research Efforts

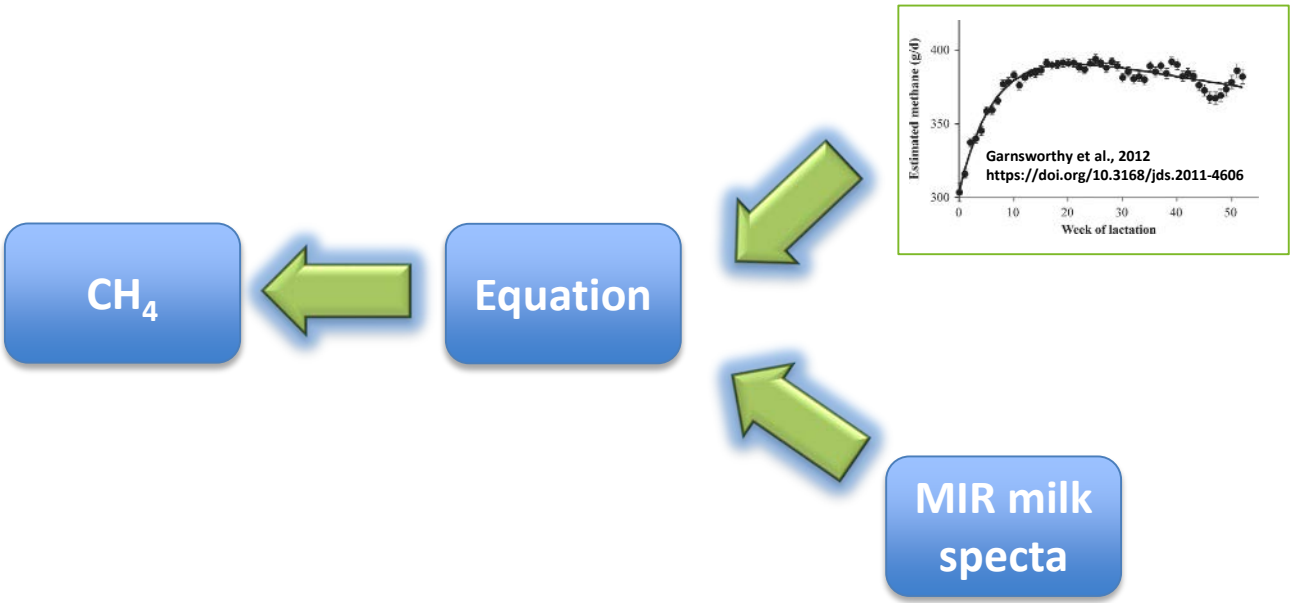
- Many aspects as development of CH_4 MIR based proxies large research needs as:
  - Different types of CH_4 reference traits ➔ alternative equations
  - Novel calibration strategies, e.g. machine learning
  - Important questions outside the direct scope of calibration (e.g. of usefulness of equations): genetic vs. phenotypic correlations ➔ breeding
- Leading to interesting publications during process

➔ **Some examples next slides**

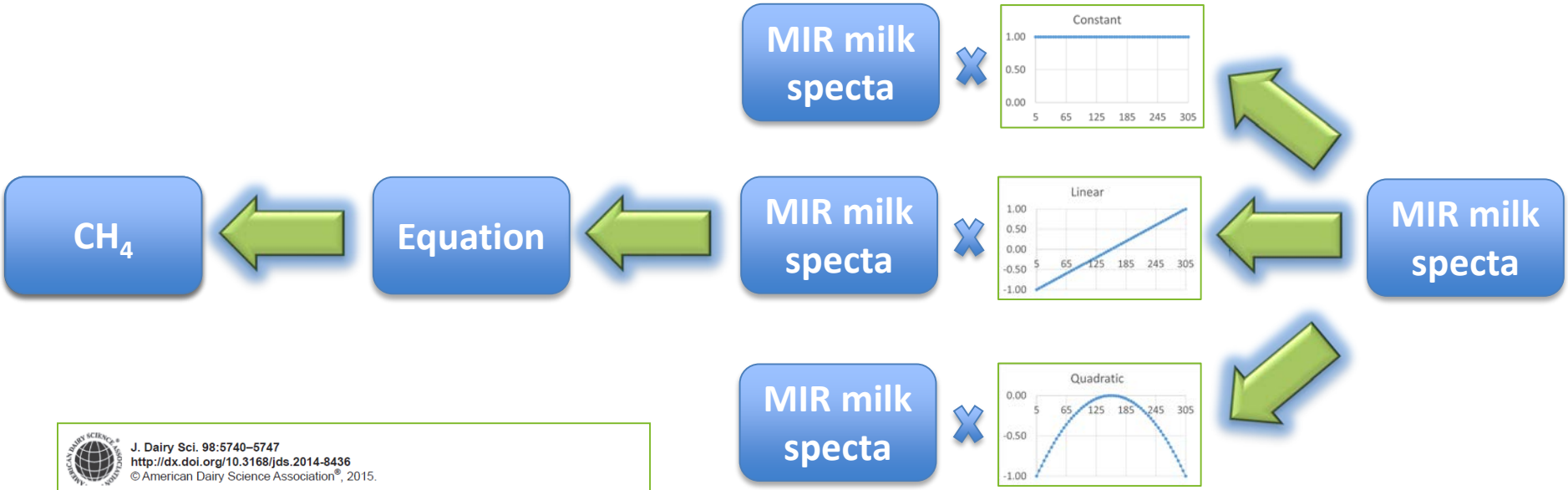
CH_4 Equation



CH_4 Equation ➔ Lactation Stage Dependent



CH_4 Equation ➔ Lactation Stage Dependent



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First Test of Chamber Data

- X chamber CH_4
- O reference SF_6
- Reported in

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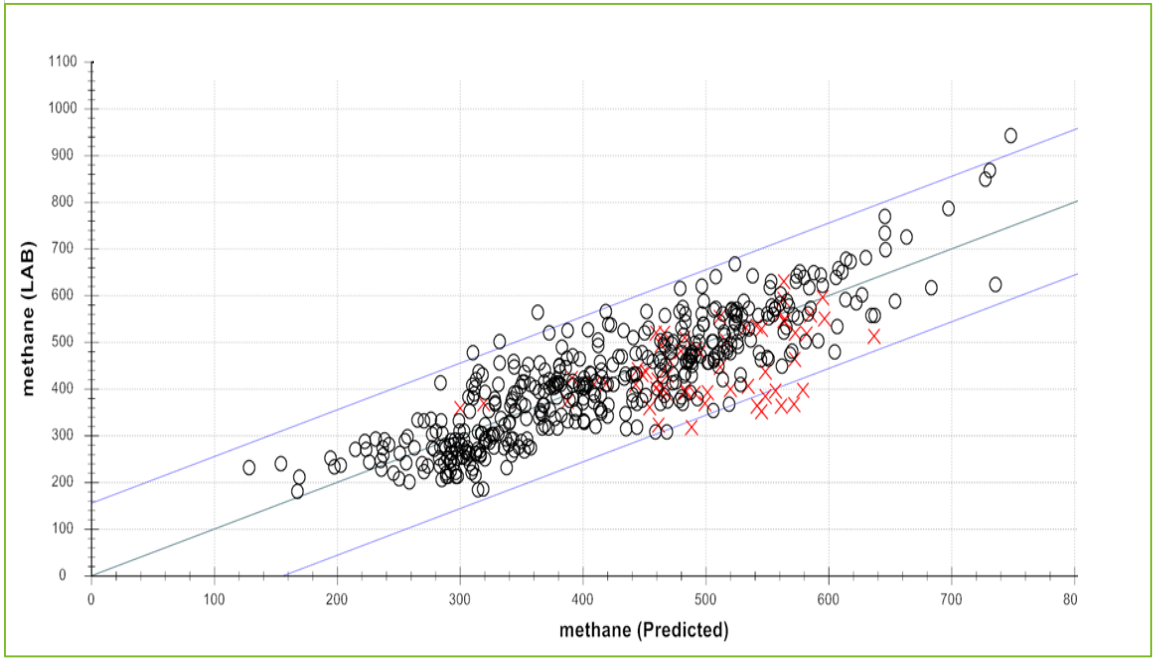
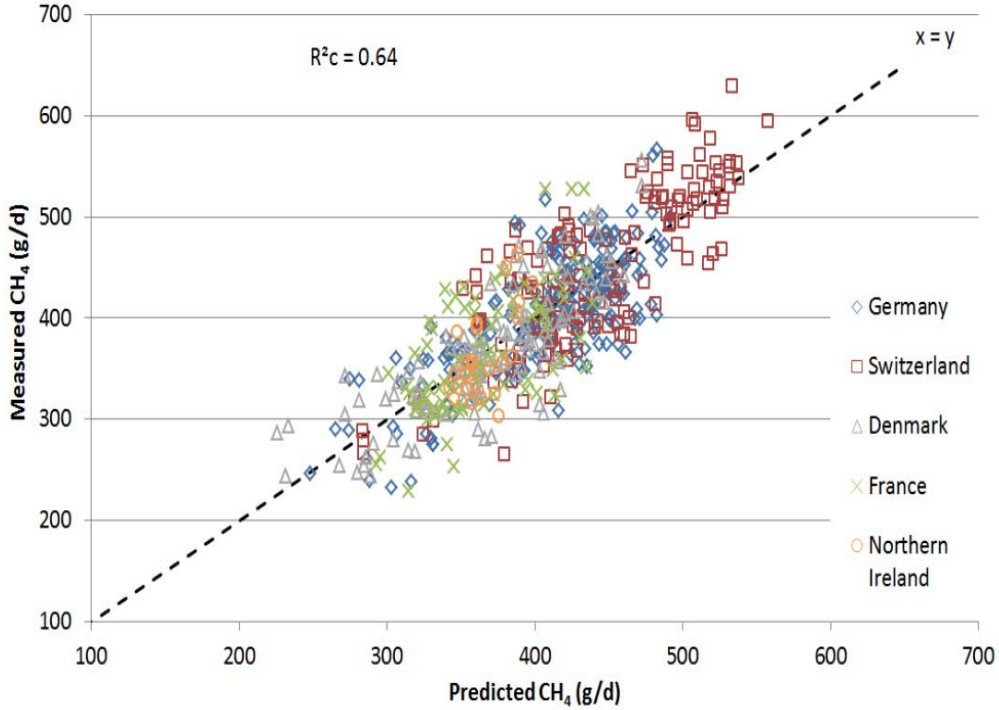


Use of Chamber Data

- Collaboration throughout GE PLUS and beyond (Switzerland and France)
- Created opportunity to generate first chamber equation
- Please see in:



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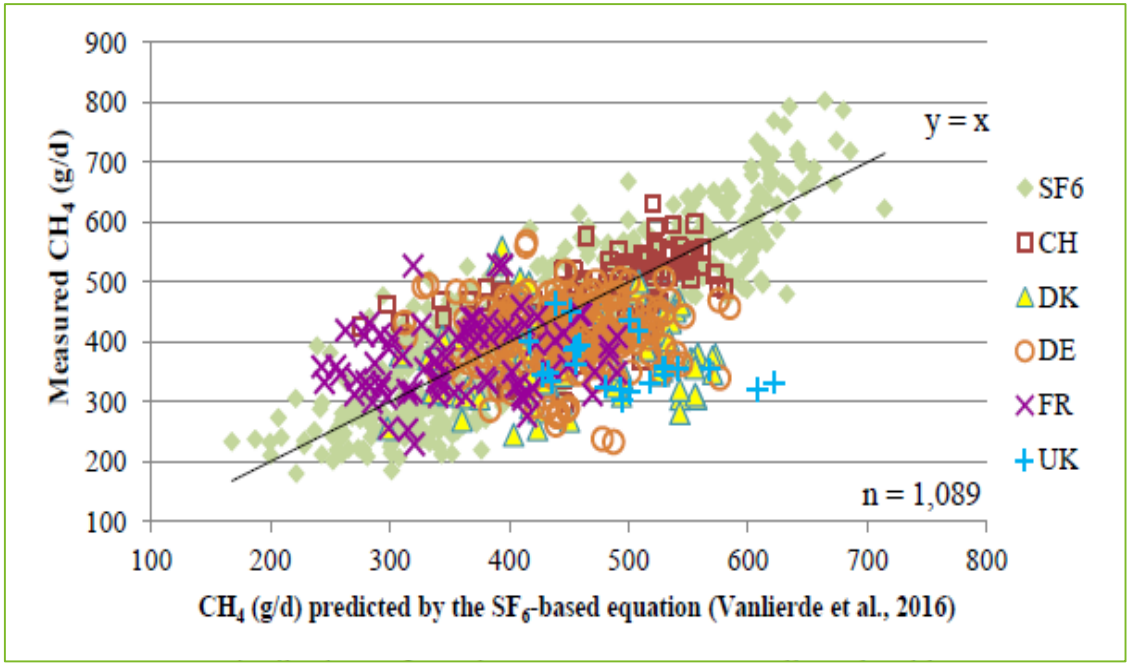
‖Agri-Food and Biosciences Institute, Large Park, Hillsborough, BT26 6DR, United Kingdom
¶Department of Animal Science, AU Foulum, Aarhus University, 8830 Tjele, Denmark
**UMR Herbivores, INRA, VetAgro Sup, Université Clermont Auvergne, 63122 Saint-Genès-Champanelle, France
††Leibniz Institute for Farm Animal Biology (FBN), Institute of Nutritional Physiology, 18196 Dummerstorf, Germany

Improving Robustness and Accuracy

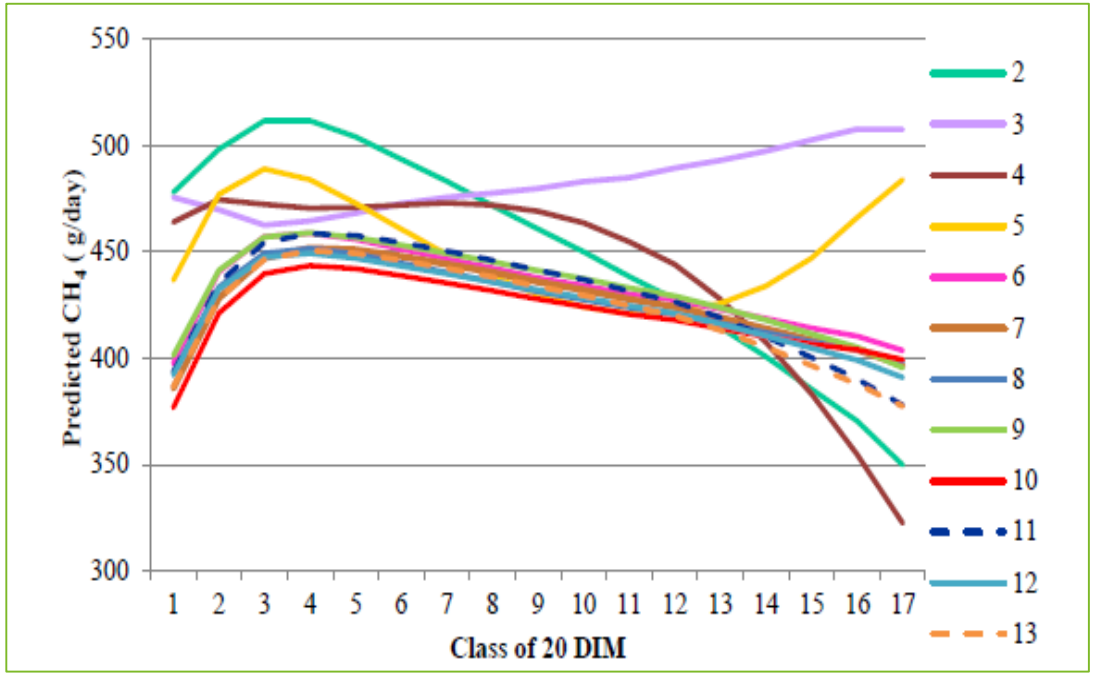
- Glimpse to ongoing research
- Here
  - How a SF_6-based equation predicts chamber data
    - Not included in calibration



Evolution of Equations Applied to ½ x 10^6 TDR

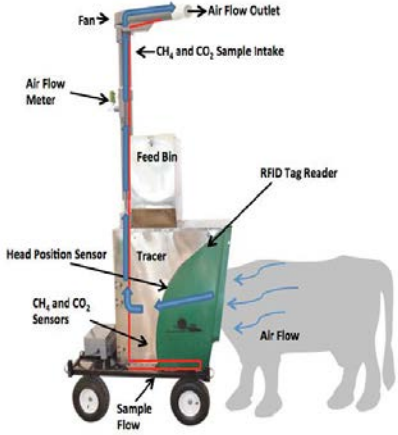
- Differences between equations:
  - Based on more data*
    - 2 to 5 ← SF_6
  - Chamber and SF_6
    - 6 to 13 ←RC + SF_6
  - Adding effects:
    - 6 → 13

*equation 3 not lactation stage dependent



Research Focuses ➔ Opportunities

- Equations with more data
- Equations with novel variables
  - Milk, live-weight, parity, breed,….
- Other methods….
  - Machine learning
  - Federated learning,…
- Opportunity widespread use of Greenfeed:
  - Creating Open “Greenfeed – MIR” consortium
- Important: adding genetic and genomic context
  - Phenotypic vs. genetic correlations ➔ interest of proxies



Hristov et al., 2015
https//doi.org/10.3791/52904

Other Advantages (And Disadvantages) of Our “Open” Type of Consortia

- Compared to “joint” databases
  - There partners contribute to, but also have (restricted) access
  - Mostly project linked where “few” partners ⇔ different objectives
- Our approach has one major advantage
  - We can accommodate many different data protection schemes
  - From highly proprietarian data (e.g. from industry projects) to publically available "open data"
- Should compensate major disadvantage as obviously
  - ➔ Use of this calibration database only for equation building
- But objectives different!
  - Situations where other type of consortia fit better

Belgian Motto

L'union fait la force – Eendracht maakt macht - Einigkeit macht stark

UNITY MAKES STRENGTH!

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- Support throughout the Futurospectre partnership
  - AWE – Comité du Lait – CRA-W – ULiège-GxABT
- CECI Consortium for computational resources
- Service Public de Wallonie (SPW – DGO3, Belgium)
- National Fund for Scientific Research
- Support by different European Projects:

ROBUSTMILK

GE PLUS Genotype plus Environment
Integration for a more sustainable dairy production system

GREENHOUSE MILK

OptiWR

WITH THE SUPPORT OF

Interreg North-West Europe HappyMoo

LIÈGE université
Gembloux
Agro-Bio Tech

Wallonie
recherche
CRA-W

Thank you

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