OptiMIR: Use of MIR spectra to predict multiple cow status as advisory tools for dairy farms

Grelet.C[1], Gengler.N[2], Bastin.C[3], Vanlierde.A[1], Smith.S[4], Gelé.M[5], Soyeurt.H[2], Massart.X[3], Dardenne.P[1], Dehareng.F[1]

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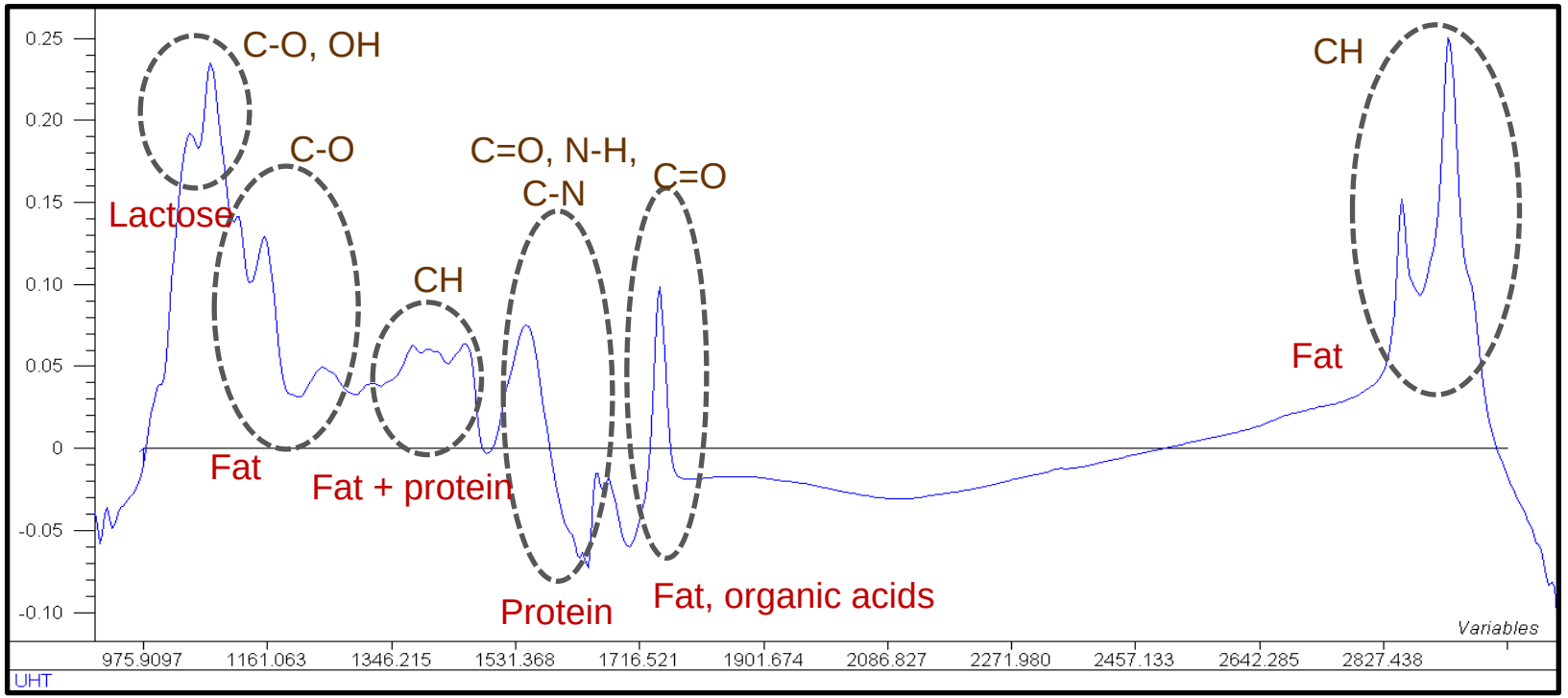
MIR technology

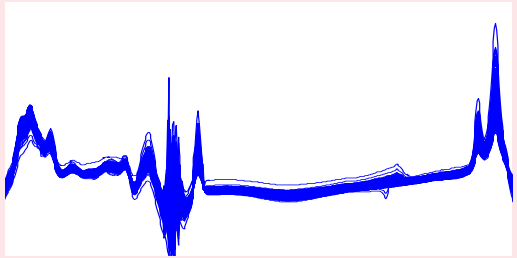


- **Position** of the peaks → **Qualitative** analysis
- **Intensity** of the peaks → **Quantitative** analysis

Classical use of MIR spectra

Milk control

MIR



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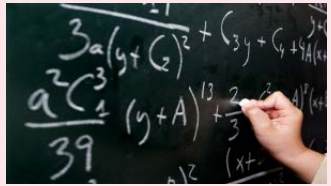
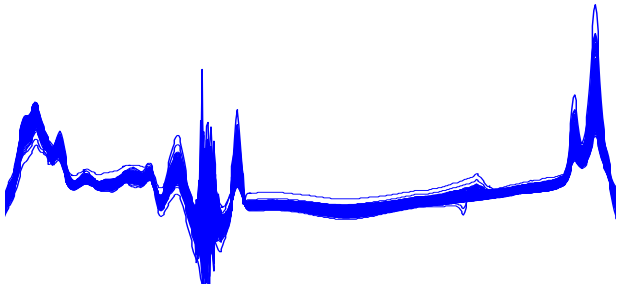


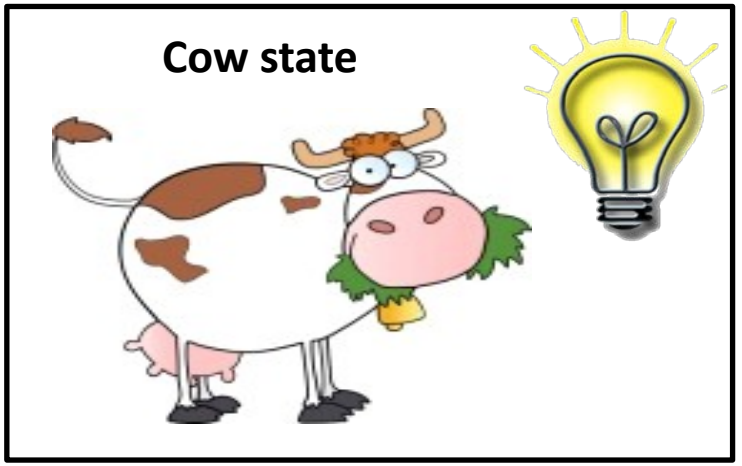
Composition

Fat
Proteins
Urea
Lactose
...

Innovative view of OptiMIR

MIR spectra





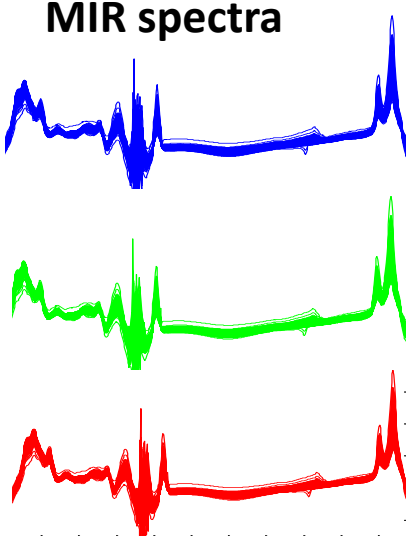
Prediction tools fast, cheap, via milk control organisations

Information on :

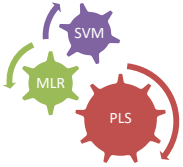
- **fertility** (pregnancy…)
- **feeding** (acidosis, ketosis, energy balance…)
- **health** (mastitis…)
- **environmental impact** (methane…)

Development of new tools

MIR spectra



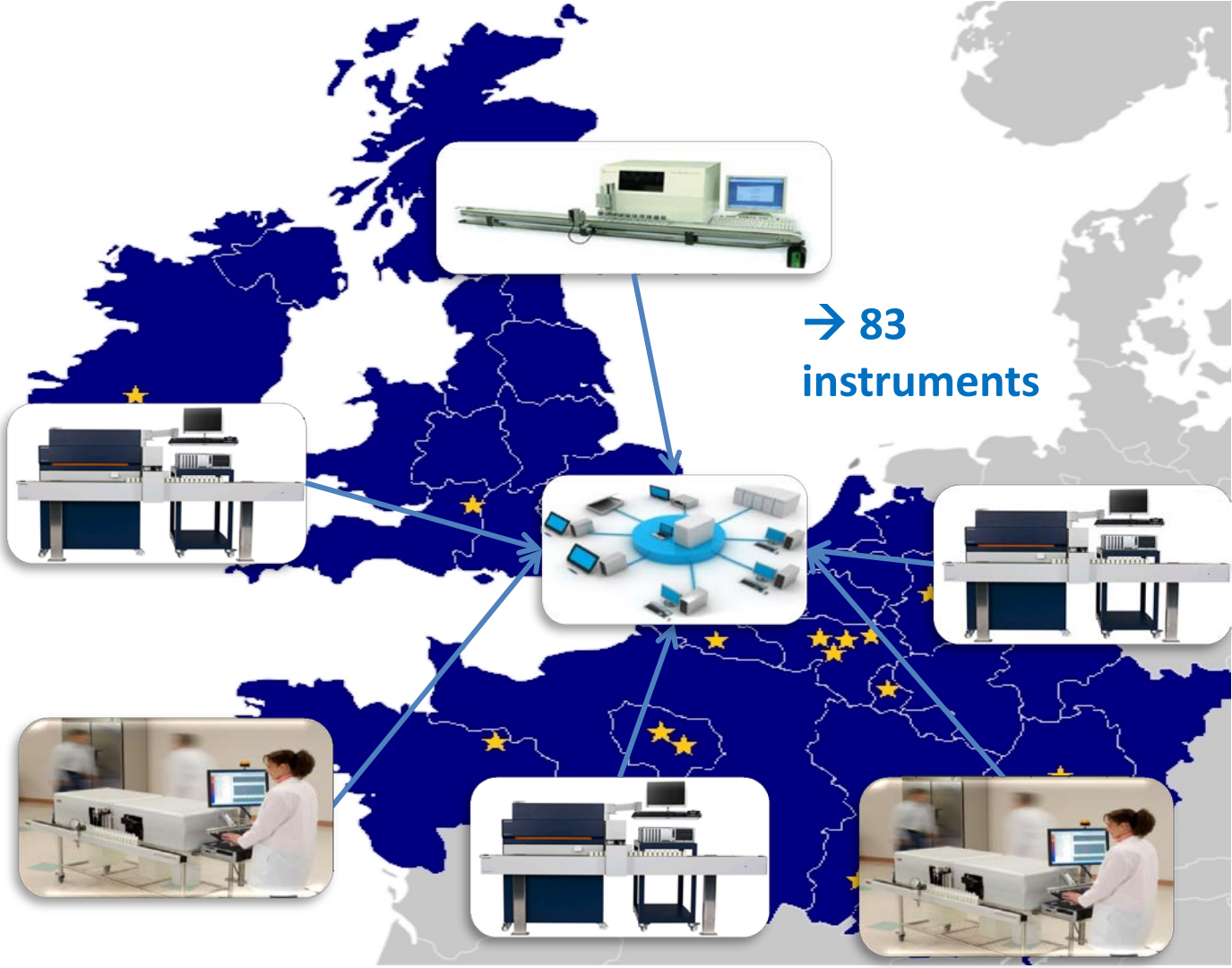
Reference analysis



Chemometric tools

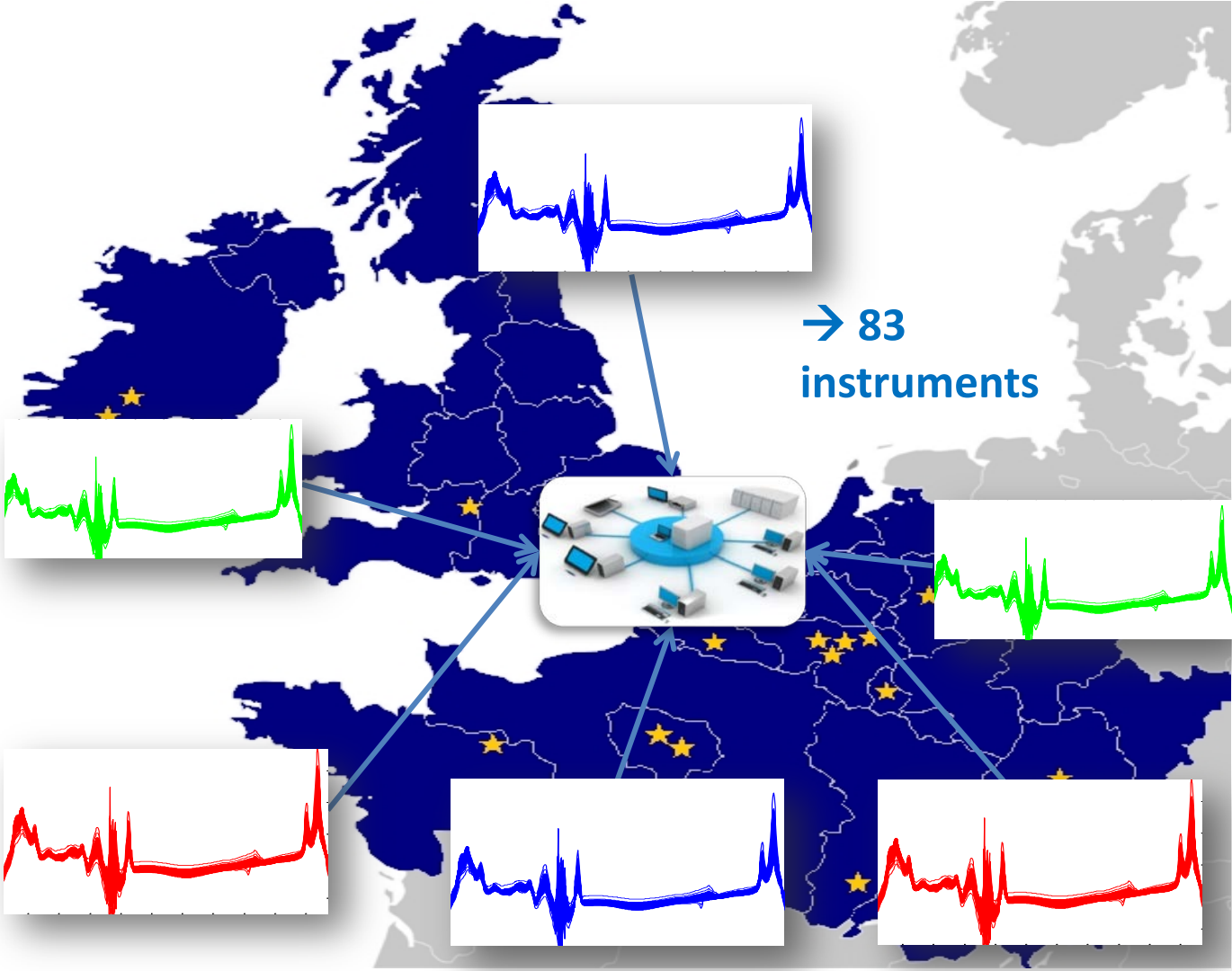
Model predicting reference analysis from MIR spectra

OptiMir network

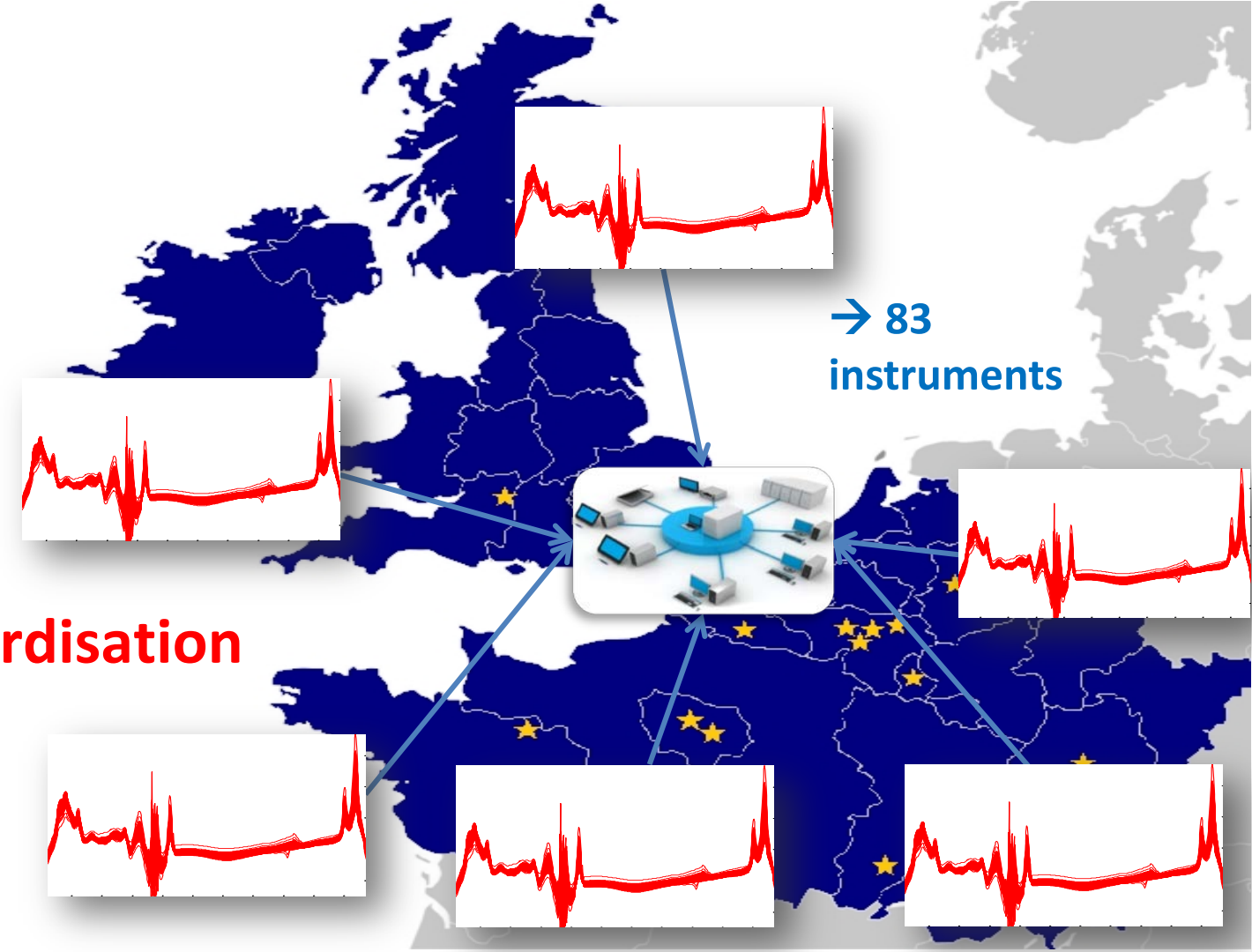


→ 83 instruments

OptiMir network



OptiMir network



→ 83 instruments

Spectral standardisation

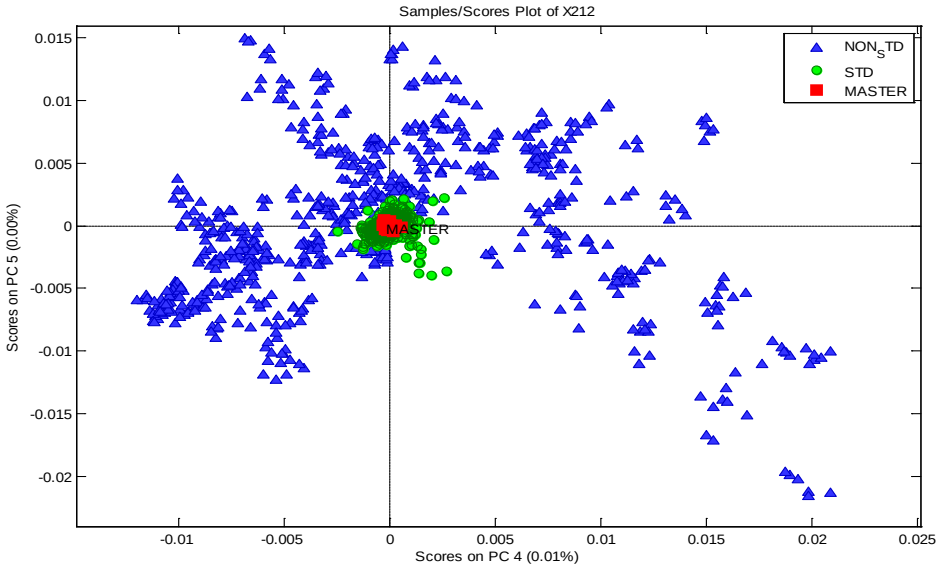
Impact of standardisation

-Harmonize the spectral format

-Allow merging of data

-Creation of common models

→Models can be used on all instruments



OptiMIR models

Grelet.C[1], Gengler.N[2], Bastin.C[3], Vanlierde.A[1], Smith.S[4], Gelé.M[5], Soyeurt.H[2], Massart.X[3], Dardenne.P[1], Dehareng.F[1]

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INSTITUT DE L'ELEVAGE

awe association wallonne de l'élevage

EMR

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Wallonie

Negative energy balance – milk biomarker

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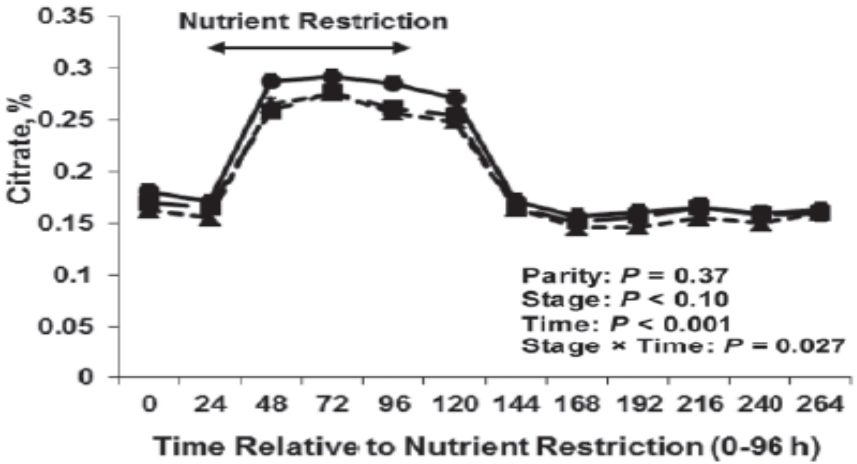
Bjerre-Harpoth (2012) : Induced nutrient restriction



« …greatest increase (58%) during restriction for all cows »

« …promising <u>early</u> indicator of physiological imbalance »

<u>Citrate</u> in milk as early indicator of physiological imbalance

Negative energy balance – milk biomarker

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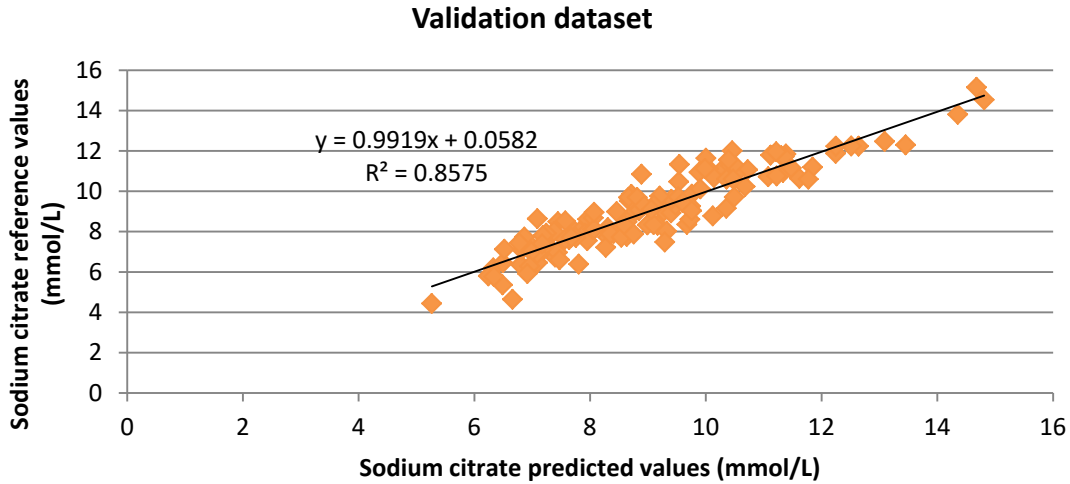
- **Statistics for citrate model (PLS)**

Item	N	No. of LV	No. of Outliers	Min	Max	Mean	SD	RMSE	R^2	RPD
Sodium citrate (mmol/L)										
Cross-validation	380	9	2	3.88	16.12	9.03	2.26	0.7	0.9	3.21
Validation	126	-	-	4.44	15.16	9.08	2.03	0.76	0.86	2.96



Allows screening, quantitative information

Negative energy balance – direct phenotype

Data :

- 526,509 daily records
- 962 cows were available from
- France and the UK

Data treatment

- Spectra standardized
- Smoothed data (S.Denholm 2015)
- PLS regression

	R^2cv	R^2cv
Energy Balance (MJ/d)	0.20	0.58
Energy Content (MJ/d)	0.22	0.24
Energy Intake (MJ/d)	0.32	0.48

S.Smith, 2015

S.Smith, 2016, personal communication

Ketosis – milk biomarkers

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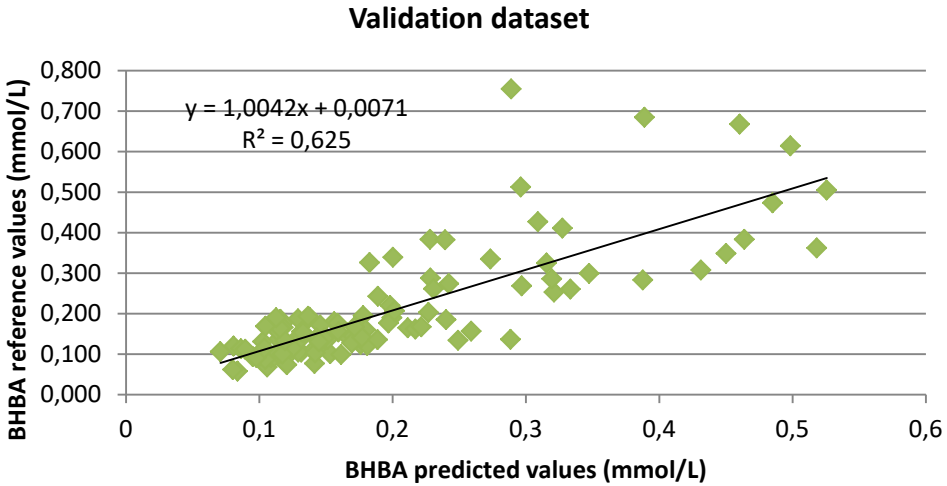
BHB and Acetone in milk known as biomarkers (Enjalbert et al., 2001)

- **Statistics for milk BHB model (PLS)**

Item	N	No. of LV	No. of Outliers	Min	Max	Mean	SD	RMSE	R^2	RPD
BHB (mmol/L)										
Cross-validation	325	8	7	0.045	1.596	0.235	0.193	0.109	0.71	1.77
Validation	108	-	-	0.058	0.755	0.204	0.136	0.083	0.63	2.36



	Low BHB content (<0.200mmol/l)	High BHB content (>0.200mmol/l)	Global good classification
Validation	n=77	n=32	
Predicted low	90.90%	9.40%	90.80%
Predicted high	9.10%	90.60%	

Allows discriminate high or low levels

Ketosis – Direct phenotype

4 farms in France and Germany
1124 collected phenotypes on 214 cows

Prediction of the level of ketosis risk

- **High risk: blood BHB>1.2 mmol/L or NEFA>0.8**

vs

- **Low risk**

Results on cross validation (n=566)

Sensitivity = 84,5 %

Specificity = 84,2 %

		Prediction	
		Negative	Positive
Observation	Low risk	234	44
	High risk	43	235

M.Gelé, 2015

Other models

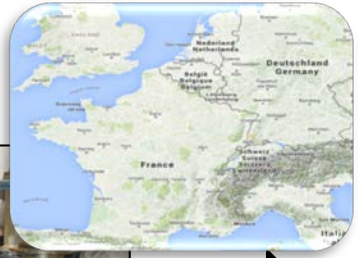
- Fatty acids profile (32 FA and groups of FA)
  - 1827 milk samples
  - 6 countries
  - 17 breeds

- Minerals in milk
  - 1181 samples
  - 4 countries

- Methane
  - SF6 and chambers
  - 7 countries

Use of new tools on field

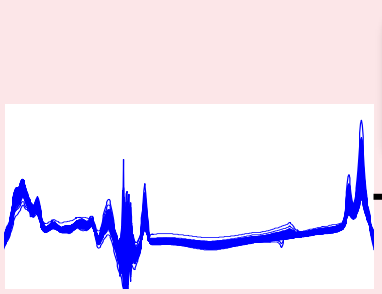
Milk control

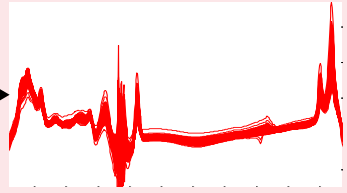


MIR

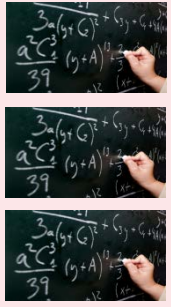
© Bentley

Standardization





New models



New phenotypes

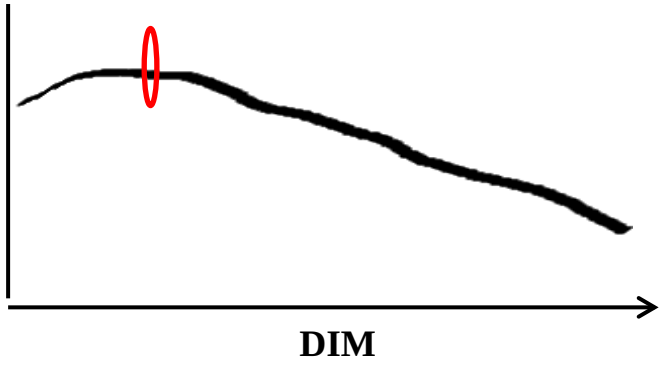
NEB

Ketosis risk

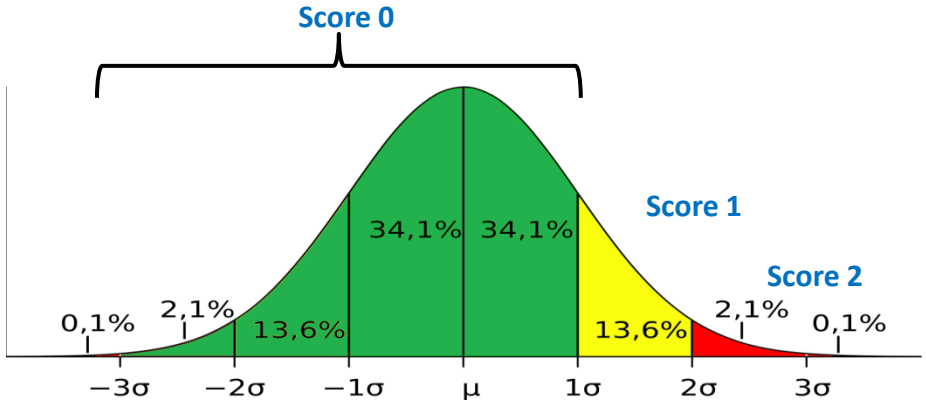
Methane…

Exemple of use by MROs

- Walloon breeding association (AWE) tool
- Global Ketosis index tool: Combination of BHB, acetone predictions and fat/protein ratio
- Relative approach for each biomarker: Cow value compared to population values at same DIM

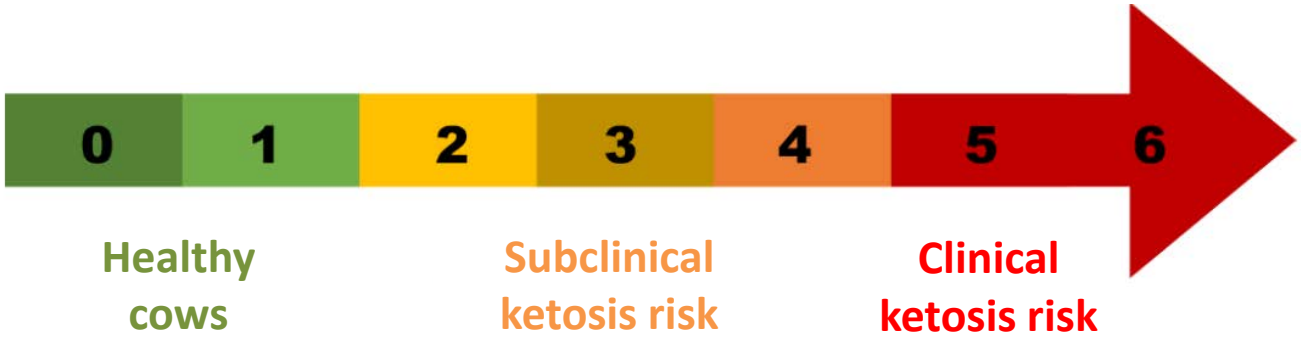


Score 0,1 or 2 for each component



Exemple of use by MROs

- Global score from 0 to 6 as a global indication for ketosis status



- Currently in test in 75 farms
- Good feedback from breeders

→ Cows to follow

Conclusion

- ✓ Prediction of NEB
- ✓ Prediction of ketosis risk
- ✓ Methane, fatty acids, minerals
- ✓ Network of 83 MIR instruments currently standardized in routine
- ✓ Possible to use all existing and future models on all instruments
- ✓ Creation of EMR (European Milk Recording)

Thank you for your attention!

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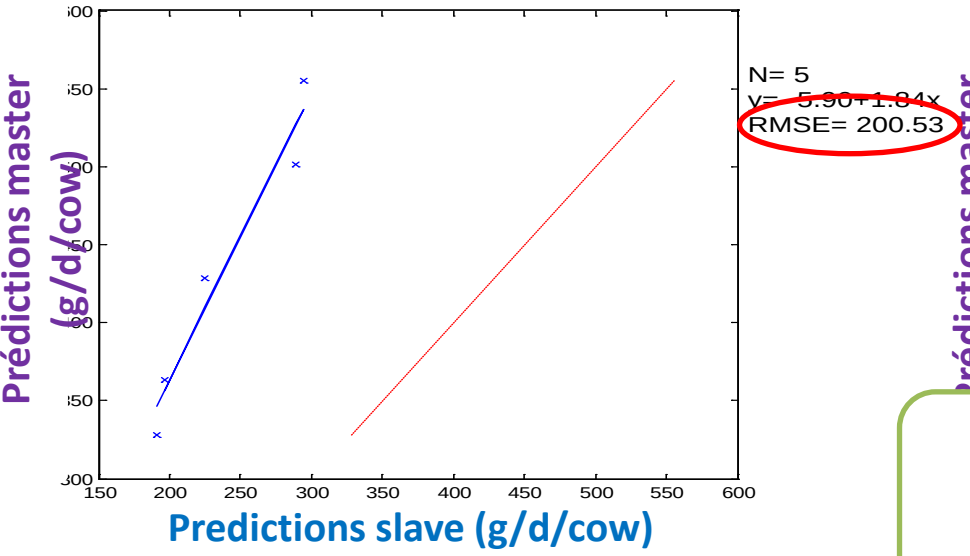
Impact of standardisation

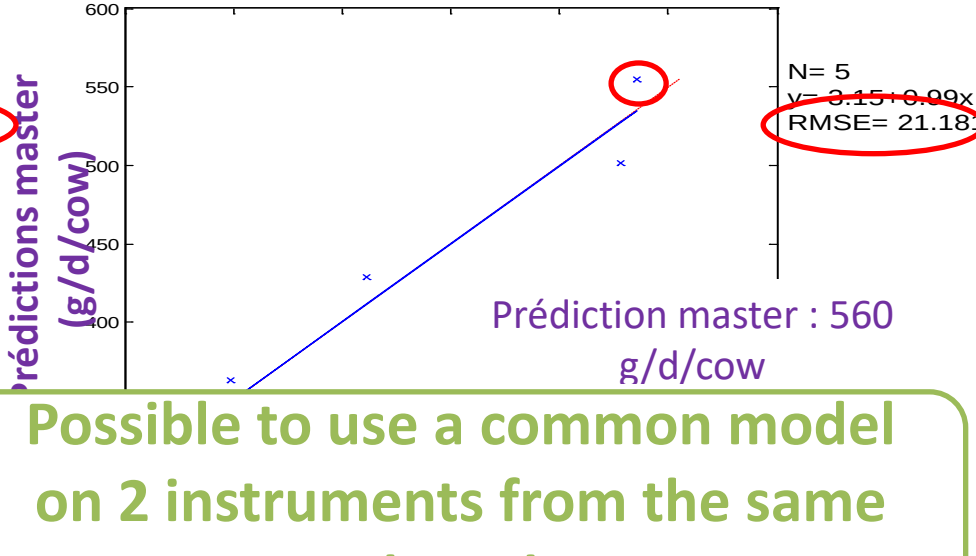
→Common milks analysed on the master and on a slave instrument **from the same brand**

→Methane model

Without standardisation



With standardisaton

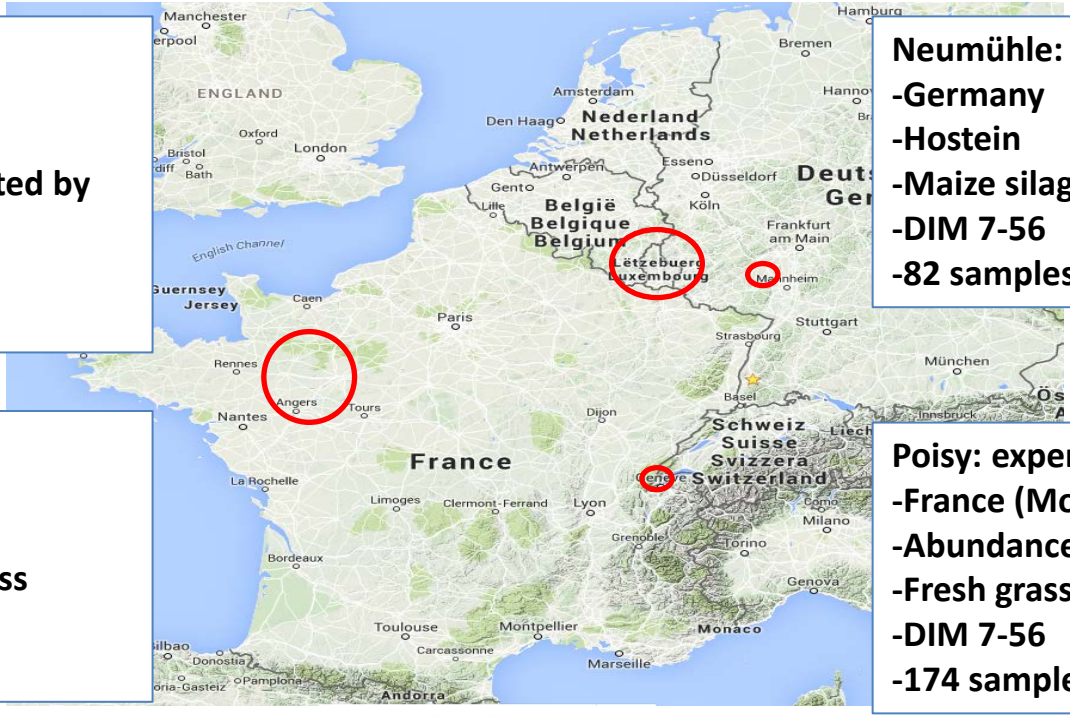


Prédiction master : 560 g/d/cow

Possible to use a common model on 2 instruments from the same brand

Collect of samples

Convis: MRO
-Luxembourg
-Hostein
-Maize silage supplemented by grazing in summer
-DIM 5-60
-110 samples



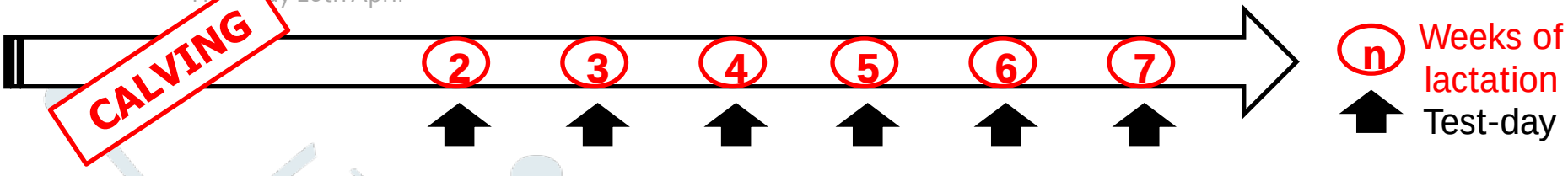
Neumühle: experimental farm
-Germany
-Hostein
-Maize silage
-DIM 7-56
-82 samples

CLASEL: MRO
-France
-Hostein and Normande
-Maize silage or fresh grass
-DIM 7-305
-200 samples

Poisy: experimental farm
-France (Montain area)
-Abundance and Montbéliarde
-Fresh grass or hay and maize silage
-DIM 7-56
-174 samples

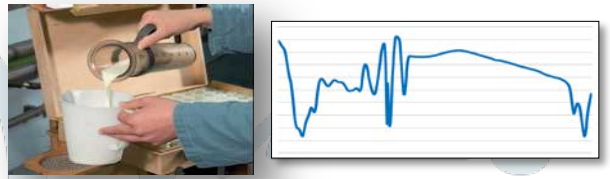
- Harmonized protocol by IDELE
- ICAR approved sampling systems
- Morning and evening samples pooled
- 566 * 2 identical samples generated → MIR and chemical analysis

1,124 collected phenotypes on 214 cows



Data collected during each test-day:

LDHVet. Nantes (FRA):
Blood BHB & NEFA



Milk Recording Organizations:
Milk fat and protein contents

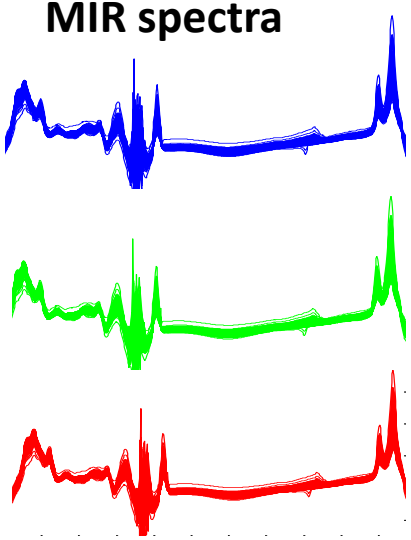
+ Spectra

Experimental farm:
- **Weight**
- **BCS**
- **Diet**

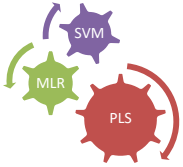
BHB : beta hydroxybutyrate - NEFA : non esterified fatty acids

Development of new tools

MIR spectra



Reference analysis



Chemometric tools

Model predicting reference analysis from MIR spectra