Gembloux Agro-Bio Tech
Université de Liège

Using Milk Spectral Data for Large-Scale Phenotypes Linked to Mitigation and Efficiency

H. Soyeurt, A. Vanlierde, M.-L. Vanrobays, P.B. Kandel, E. Froidmont, F. Dehareng, Y. Beckers, P. Dardenne, N. Gengler

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EAAP – 26th August 2014

Introduction

Economically sustainable milk production

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- Appropriate milk production and composition
- Robust cows
- Milk with a good nutritional and hygienic quality

Introduction

Economically sustainable milk production

Appropriate milk production and composition

Robust cows

Milk with a good nutritional and hygienic quality

Lower environmental impact

Environmental Traits

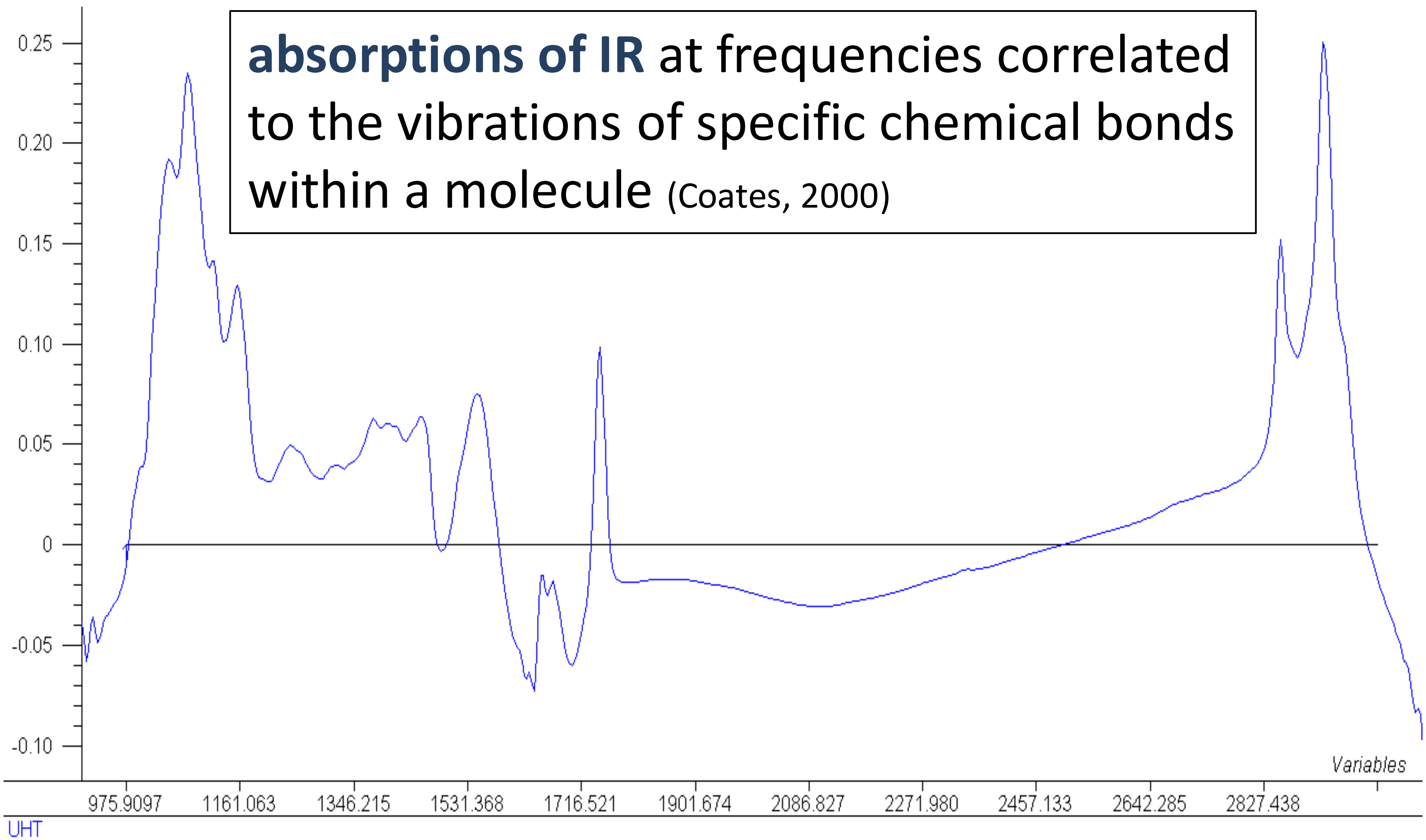
- 3 traits studied in this presentation:
  - **Eructed methane** (CH_4)
    - Contributor for greenhouse gases
  - **Dry matter intake** (DMI)
    - Represents the amount of feed consumed by the cows
  - **CH_4/DMI**
    - Permits to combine efficiency and greener aspect of milk production

Mid-Infrared Spectrometry (MIR)

- Fourrier Transform MIR spectrometry
- Advantages
  - **Non-invasive** technique
  - Fast and environmentally friendly

Mid-Infrared Spectrometry (MIR)

absorptions of IR at frequencies correlated to the vibrations of specific chemical bonds within a molecule (Coates, 2000)



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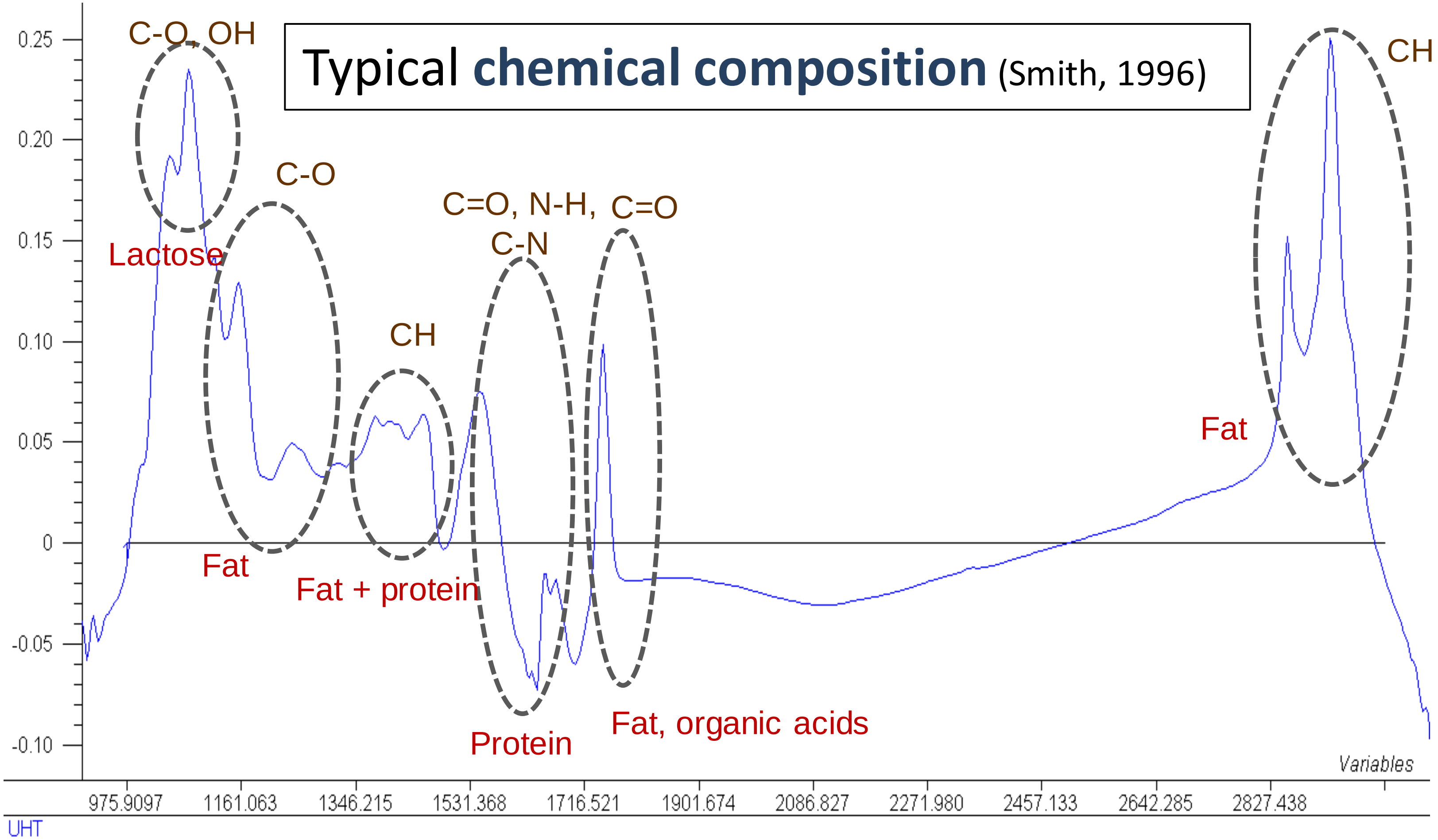


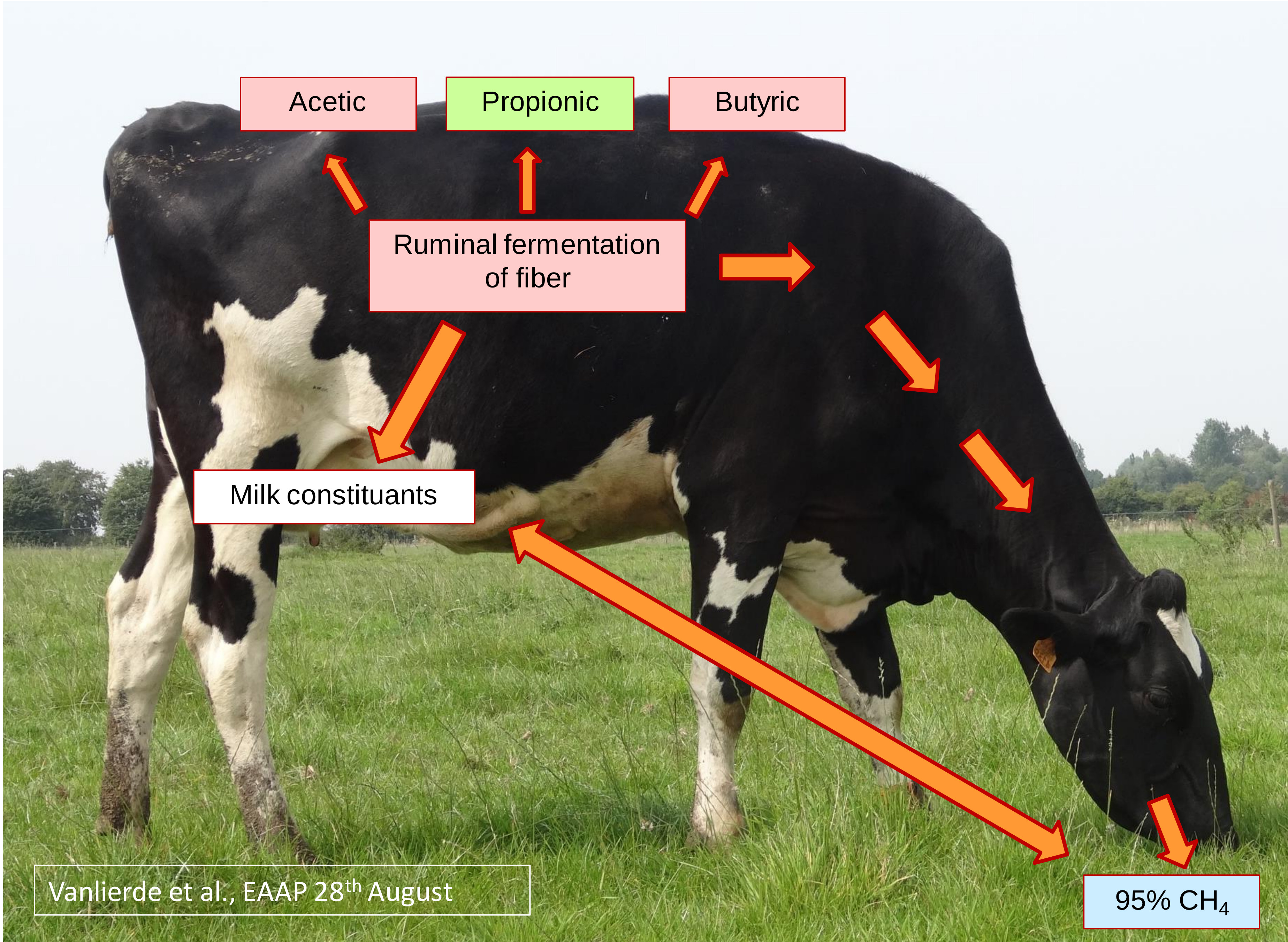
Vanlierde et al., EAAP 28th August

CH_4 – Milk - MIR

Innovative lactation stage specific prediction of CH_4 from milk MIR spectra

A. Vanlierde, M.-L. Vanrobays, F. Dehareng, E. Froidmont, N. Gengler, H. Soyeurt, S. McParland, E. Lewis, M.H. Deighton, P. Dardenne

Thrusday 28th August – 9:45 - Session 42 'Livestock effects on the environment'


Acetic
Propionic
Butyric
Ruminal fermentation of fiber
Milk constituants
95% CH_4
Vanlierde et al., EAAP 28th August

CH_4 – Milk - MIR

Equation	N	SD	R^2c	R^2cv	SEC	SECV
CH_4 (g/day)	446	127.5	0.75	0.67	63	72

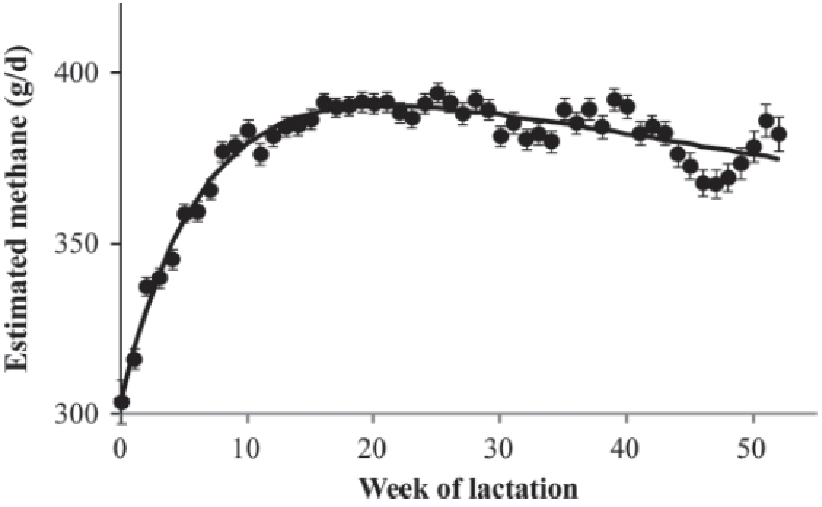
N= number of observations; SD=standard deviation; R^2c= calibration coefficient of determination; R^2cv= cross-validation coefficient of determination; SEC= calibration standard error; SECV= cross-validation standard error

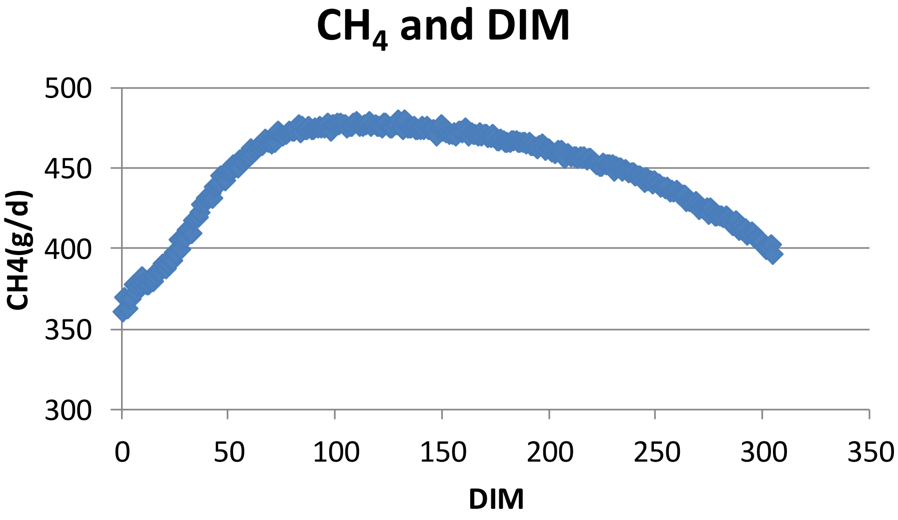
R^2c = 0.75 → **Rc=0.87**
R^2cv = 0.67 → **Rcv=0.82**

Vanlierde et al., EAAP 28th August

CH_4 – Milk - MIR

Garnworthy *et al.*, 2012





Vanlierde et al., EAAP 28th August

DMI

- Prediction of DMI (NRC, 2001)

$$DMI=[(0.372*FCM)+(0.0968*body\_weight^{0.75})]*(1-e^{-0.192*(week\_lactation+3.67)})$$

FCM=fat corrected milk

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FCM=fat corrected milk

Body weight?

Total requirement (UFL)
(= production+gestation+growth+maintenance)

↓

Net energy for lactation (ENL - Mcal)
= 1.7 * total requirement

↓

Metabolizable energy (EM - Mcal)
= ENL/0.60

↓

Metabolizable energy (EM2 - MJ)
=EM*(1/0.239)

↓

Methane prediction (MJ/day)
= 8.25+(0.007*EM2)

↓

Methane prediction (g/day)
= methane(MJ/j)*(16/0.8033)

↓

Conversion factor (Y'm)
= 100*(methane(MJ/j)/EM2)

Vermorel et al., 2008

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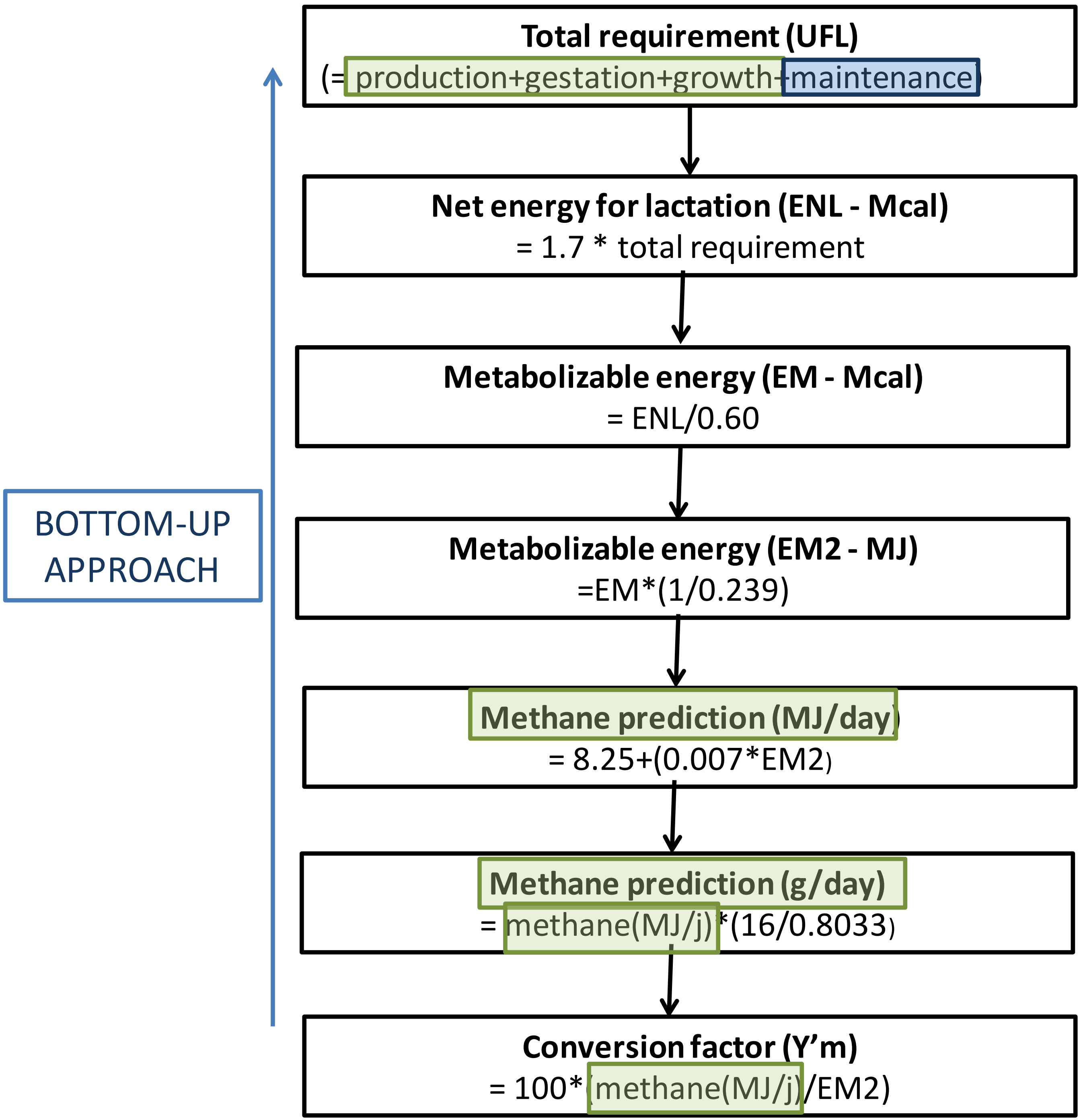
KNOWN

UNKNOWN but…

Vermorel et al., 2008



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Vermorel et al., 2008

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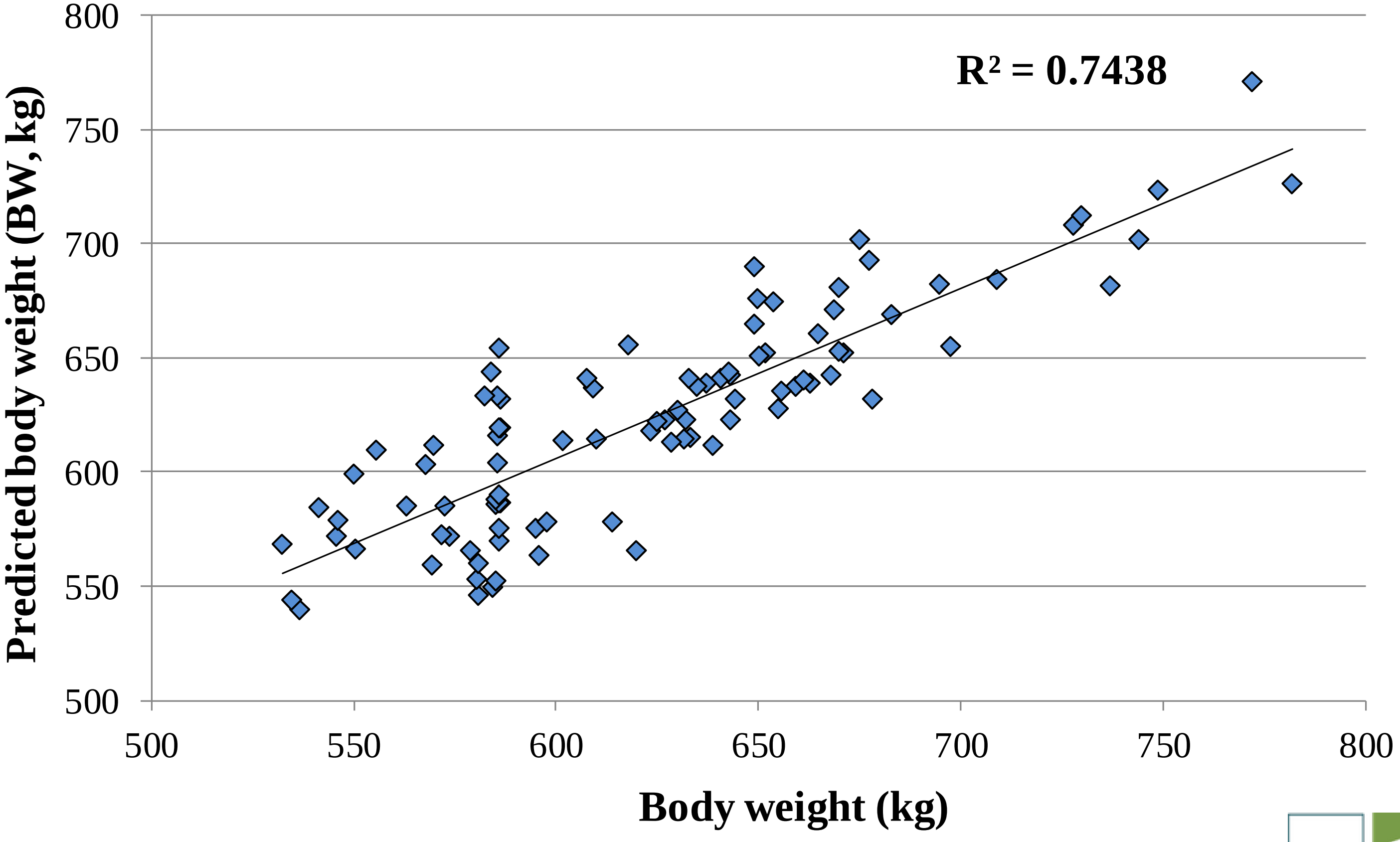
BOTTOM-UP APPROACH

Prediction of **body weight** is therefore possible

KNOWN
UNKNOWN but…

Vermorel et al., 2008

DMI – Prediction of BW

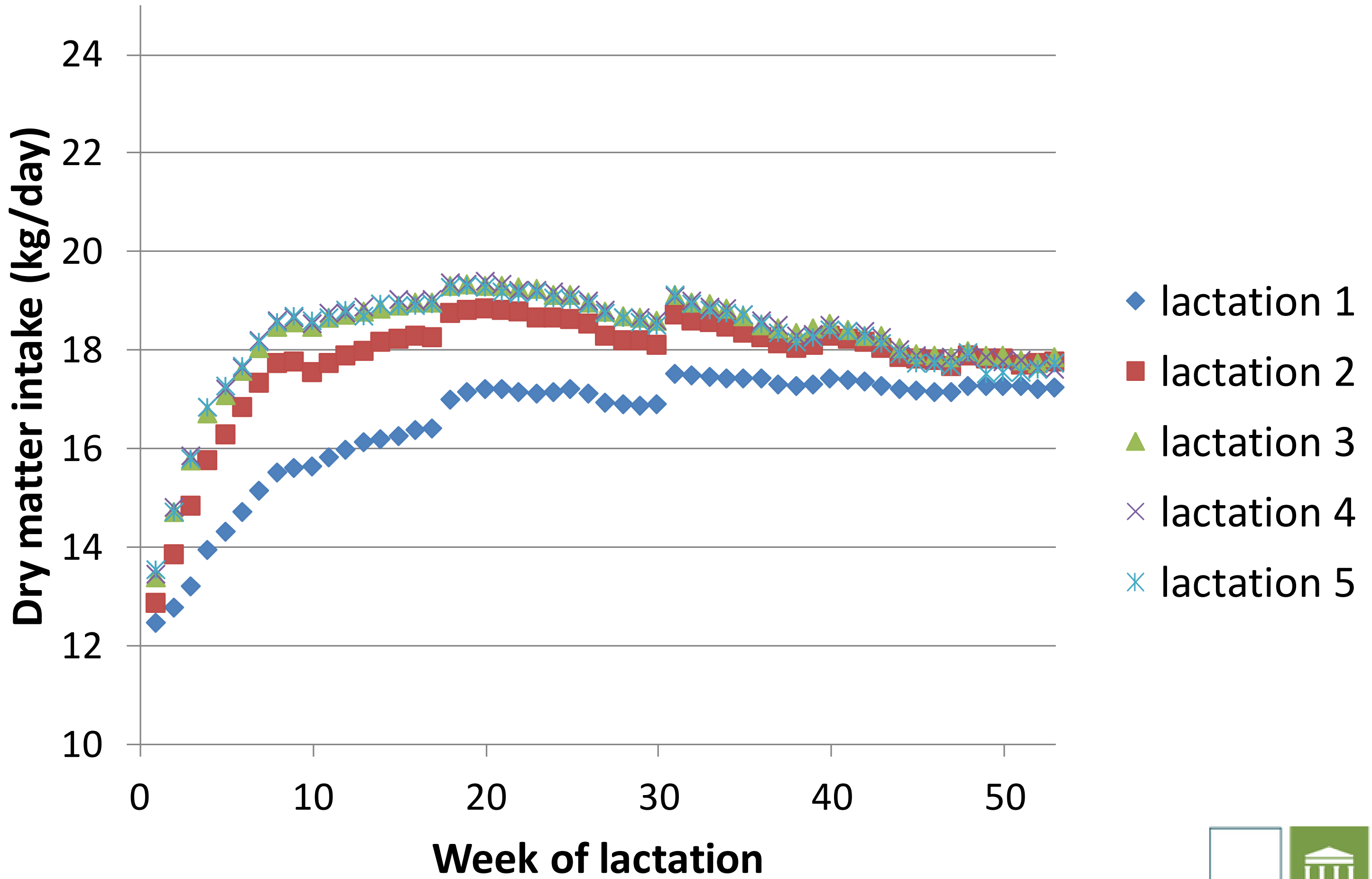


Estimation of Genetic Parameters

N=1,129,371	Mean	SD	Min	Max
Milk (kg/day)	24.84	7.75	3.1	76.6
%Fat	4.06	0.68	1.50	9.00
%Protein	3.42	0.37	1.12	6.96
DMI (kg/day)	17.63	2.03	11.79	22.82
CH_4 (g/day)	460.74	75.65	180.02	653.26

Multiple traits animal model from data colected on Hostein cows in their first five parities.

Effect of Lactation Stage And Parity



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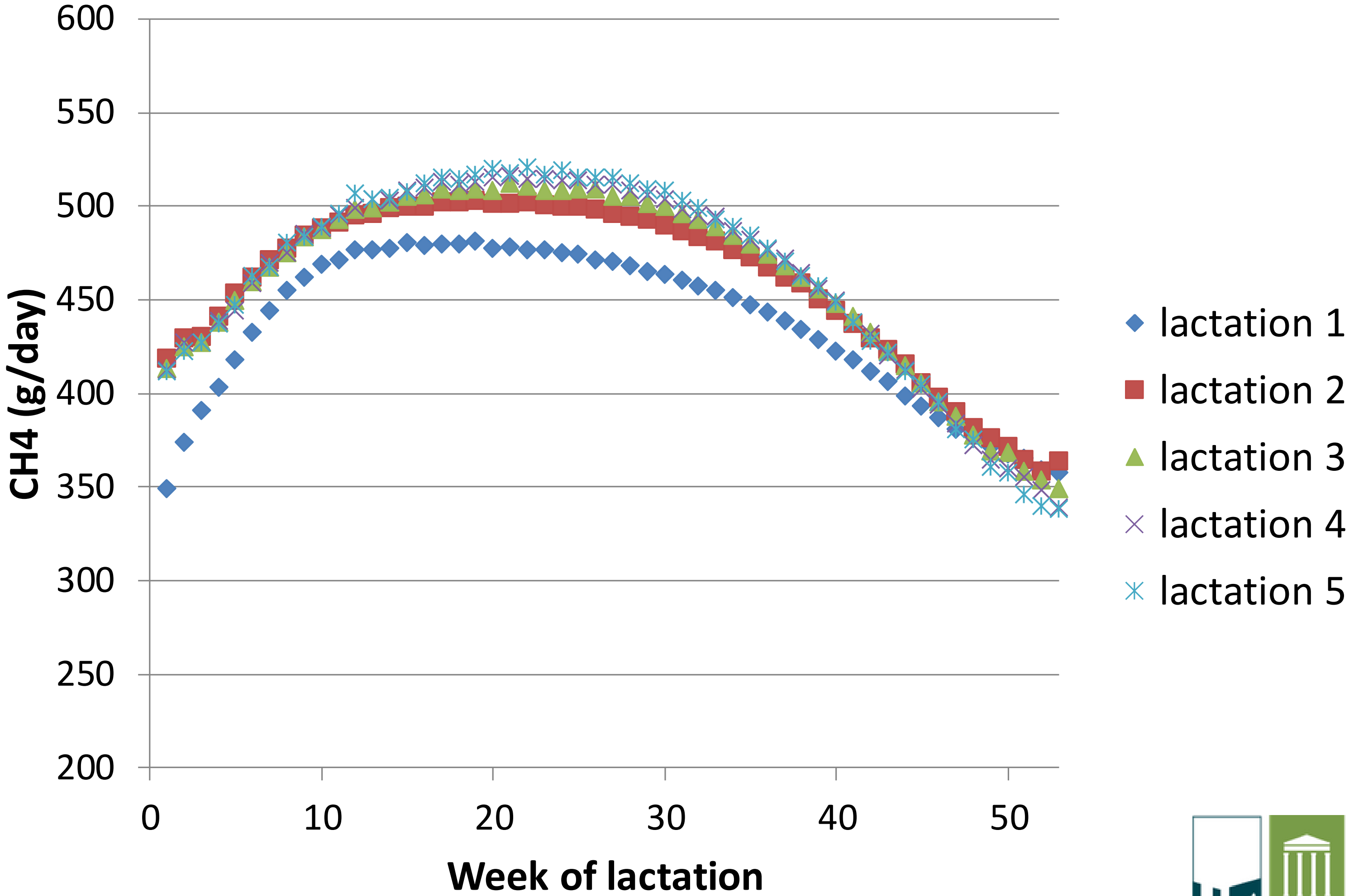

Genetic parameters

Heritability values, genetic and phenotypic correlations

	Milk	%Fat	%Protein	DMI	CH_4
Milk (kg/day)	**0.19**	-0.64	-0.62	0.51	-0.24
%Fat	-0.23	**0.46**	0.73	0.32	0.45
%Protein	-0.26	0.40	**0.43**	0.13	0.40
DMI (kg/day)	0.32	0.08	0.00	**0.10**	0.23
CH4 (g/day)	-0.04	0.15	0.14	0.04	**0.15**

Heritability CH_4

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Moderate heritability for CH_4 (g/day)

→ Animal differences in CH_4 between 7 and 18% from calorimetry studies (Boadi et al., 2002; Grainger et al., 2007)

→ 0.35 predicted from DMI (De Haas et al.,2011) however phenotypic correlation with DMI=1

→ 0.31 predicted from MIR FA (Kandel et al. 2013)

→ No studies about the heritability of CH4 measured from respiratory chambers

Heritability DMI

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Moderate heritability for DMI (kg/day)

→ 0.44 from first 26 weeks of lactation (Veerkamp and Brotherstone, 1997)

→ heritability between 0.10 and 0.30 throughout the lactation (Berry et al., 2009)

→ 0.18 ± 0.06 for measured DMI and 0.22 ± 0.05 for predicted DMI (Vallimont et al., 2010)

Genetic Correlations – CH_4

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As expected:

- → Negative correlation with milk
- → Positive correlations with fat and protein

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→ 0.59 from first 26 weeks of lactation (Veerkamp and Brotherstone, 1997)

→ 0.52 between FCM and DMI (Vallimont et al., 2010)

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Positive correlations with %Fat and %Protein

Phenotypic correlations

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Positive correlation with CH_4
--> De Haas et al. (2011) predicted CH4 from feed intake → correlation equal to 0.99

Phenotypic correlations

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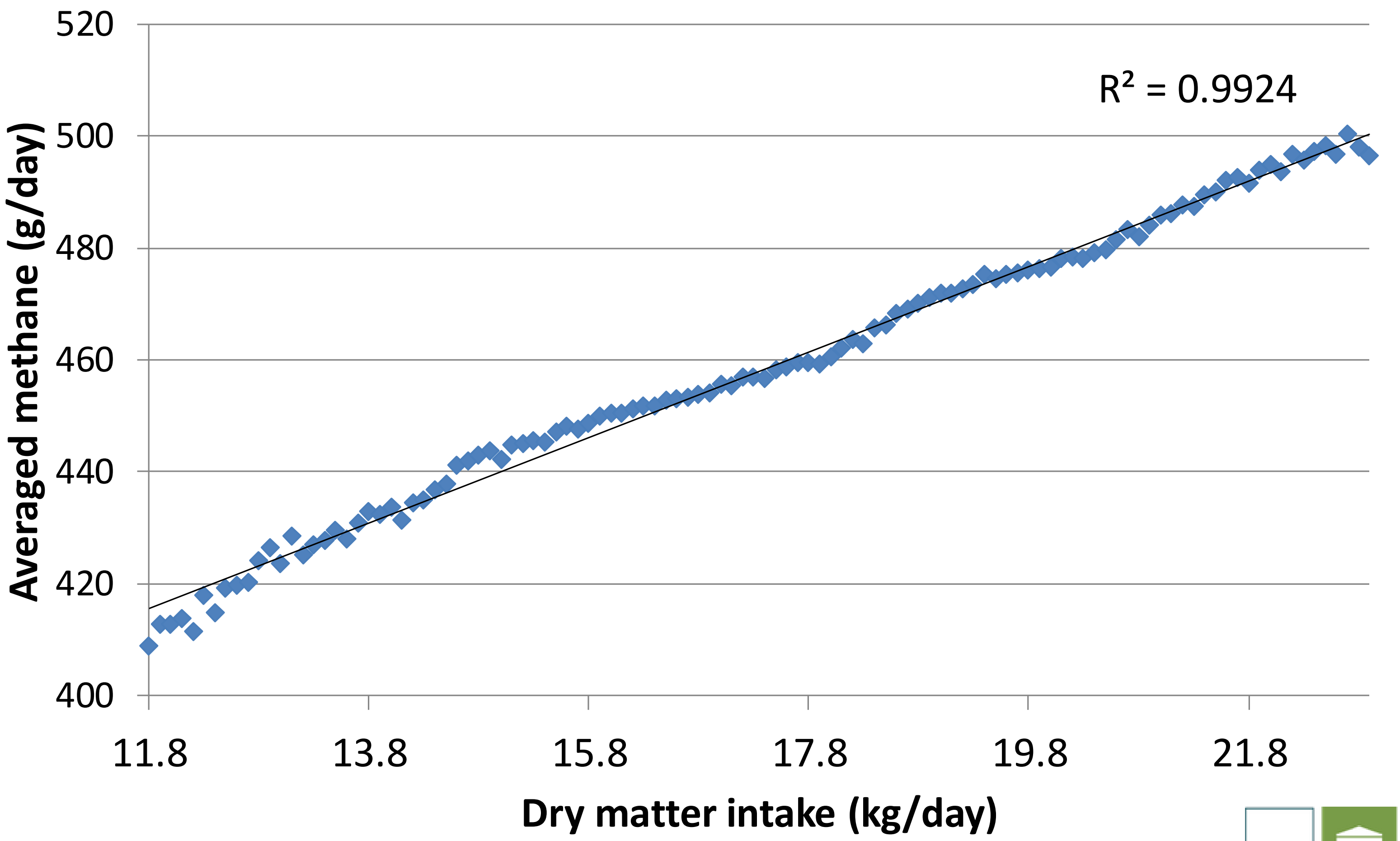
Why this value is not higher although correct relationship is oberved for DMI with the other studied traits?
Maybe extreme variability for methane emission…

Relationship between CH_4 and DMI



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CH_4/DMI	26.40	4.96	8.12	54.99

Single trait animal model from data collected on Holstein cows in their first five parities

CH_4/DMI

Heritability = **0.11**

Conclusion

- CH_4 predicted by MIR, DMI derived from MIR CH_4 and animal requirements are **heritable** as suggested by other studies
- The use of **MIR spectrometry** through the routine milk recording could permit to generate easily a large number of indicators useful to mitigate the **greenhouse gases** and to improve the **feed efficiency**
  - Walloon spectral database = more than 3,000,000 test-day records
  - Other countries have started the creation of a spectral database (ireland, UK, France, Germany, Finland…)
- The proposed strategy to create an efficiency trait could be used as **novel phenotype** for genomic selection

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