



Gembloux Agro-Bio Tech
Université de Liège



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

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EAAP – 26th August 2014

Introduction

Economically sustainable milk production



Introduction

Economically sustainable milk production

Appropriate milk production and composition

Robust cows

Milk with a good nutritional and hygienic quality

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Economically sustainable milk production

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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

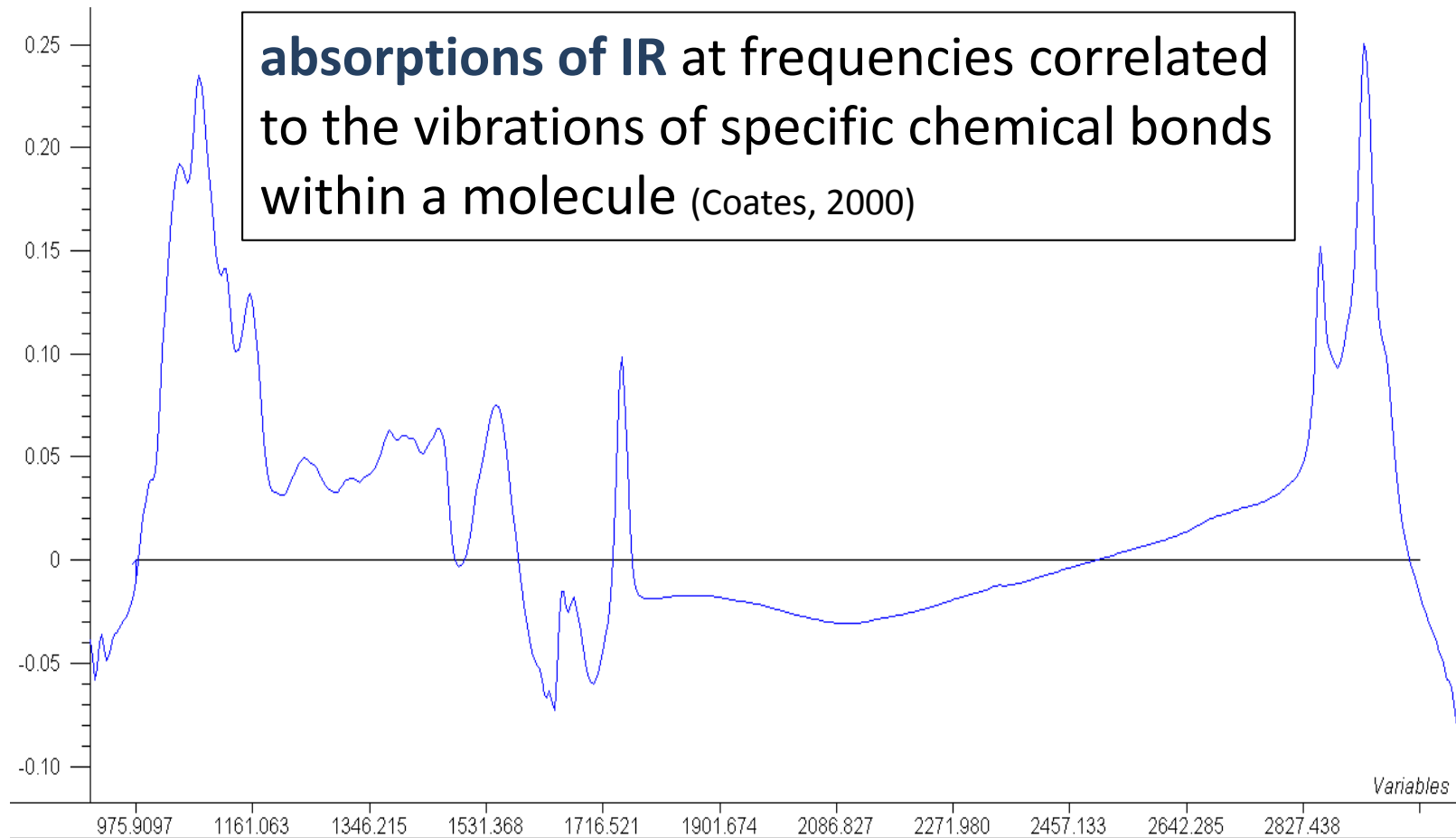


Mid-Infrared Spectrometry (MIR)

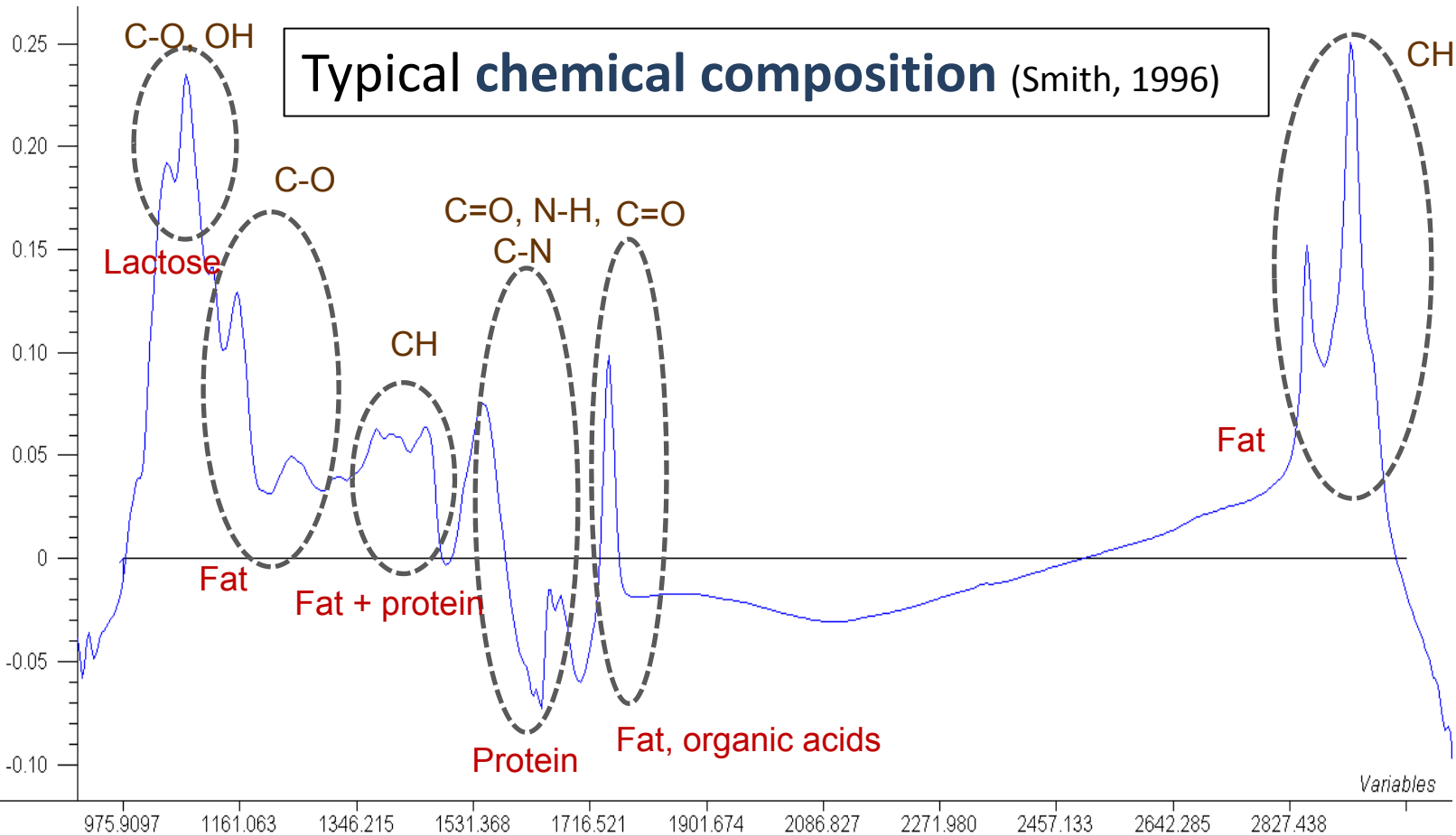
- Fourier Transform MIR spectrometry
- Advantages
 - **Non-invasive** technique
 - Fast and environmentally friendly



Mid-Infrared Spectrometry (MIR)



Mid-Infrared Spectrometry (MIR)



UHT

Vanlinder et al., EAAP 28th August



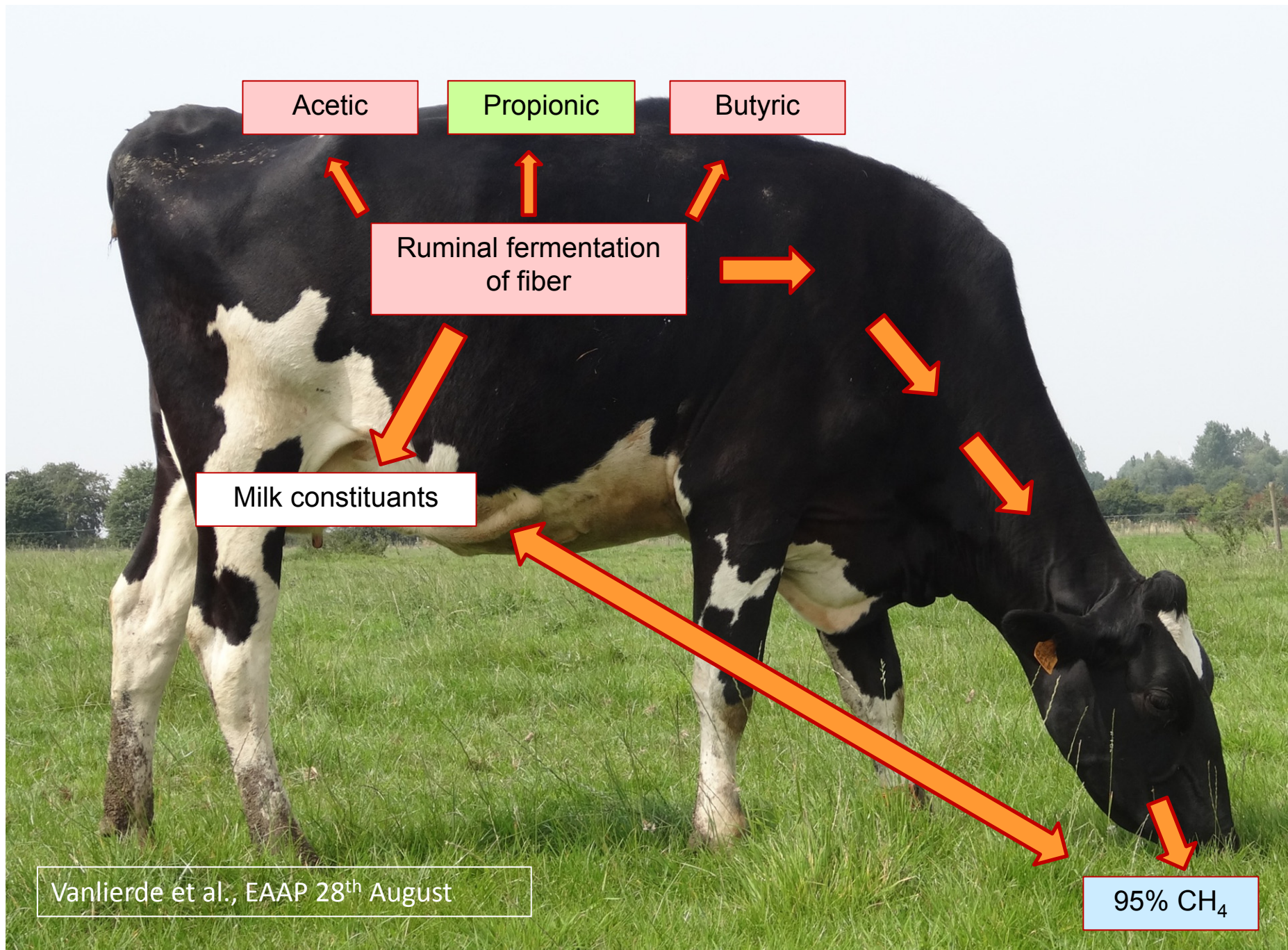
CH₄ – Milk - MIR

Innovative lactation stage specific prediction of CH₄ 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*

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





Vanlierde et al., EAAP 28th August

95% CH₄

CH₄ – Milk - MIR

Equation	N	SD	R ² c	R ² cv	SEC	SECV
CH ₄ (g/day)	446	127.5	0.75	0.67	63	72

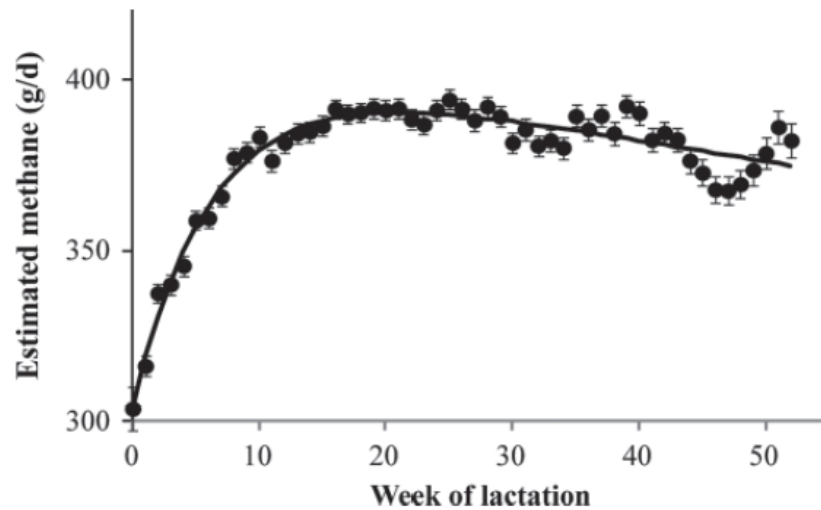
N= number of observations; SD=standard deviation; R²c= calibration coefficient of determination; R²cv= cross-validation coefficient of determination; SEC= calibration standard error; SECV= cross-validation standard error

$$R^2_c = 0.75 \rightarrow \mathbf{R_c=0.87}$$

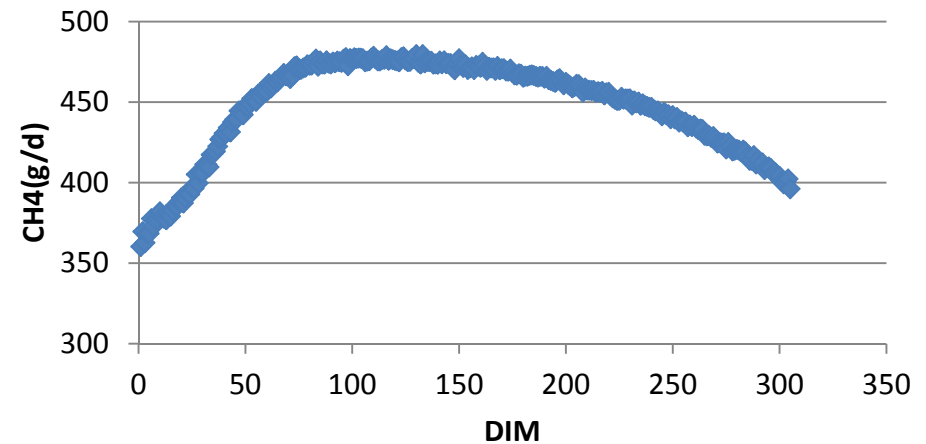
$$R^2_{cv} = 0.67 \rightarrow \mathbf{R_{cv}=0.82}$$

CH₄ – Milk - MIR

Garnworthy *et al.*, 2012



CH₄ and DIM



Vanlierde *et al.*, EAAP 28th August



DMI

- Prediction of DMI (NRC, 2001)

$$\text{DMI} = [(0.372 * \text{FCM}) + (0.0968 * \text{body_weight}^{0.75})] * (1 - e^{-0.192 * (\text{week_lactation} + 3.67)})$$

FCM=fat corrected milk

DMI

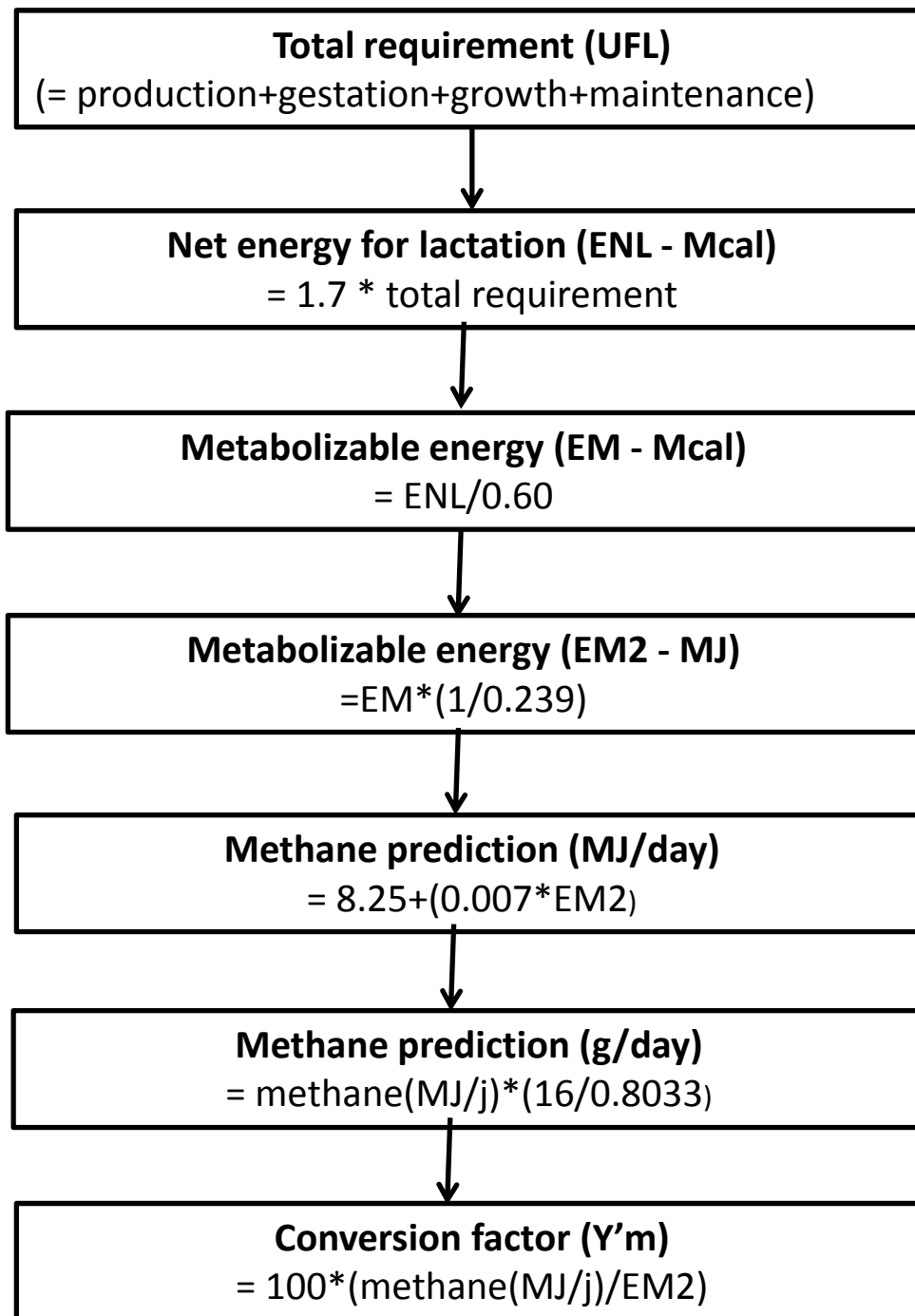
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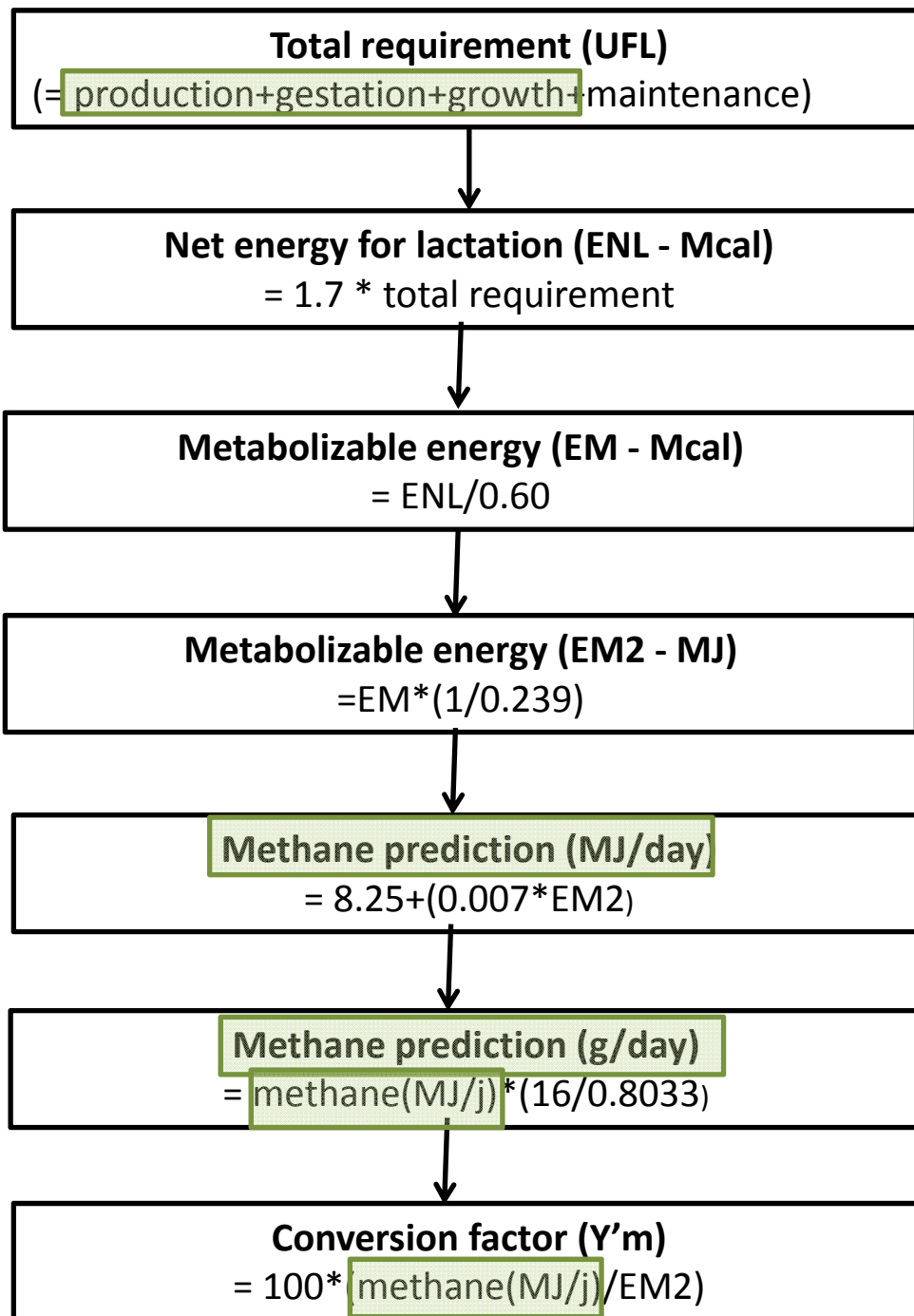
Body weight?





Vermorel et al., 2008

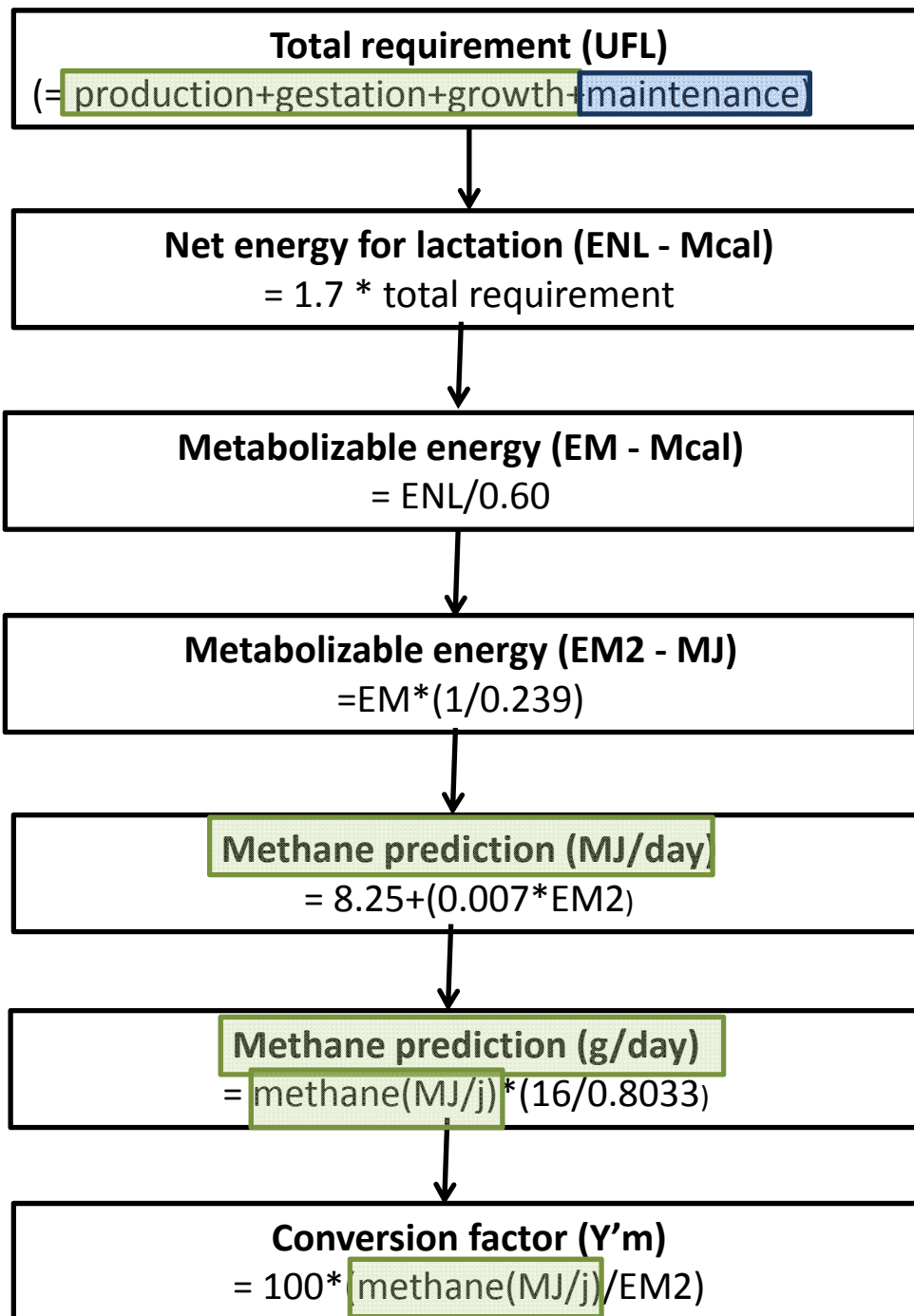




KNOWN

Vermorel et al., 2008

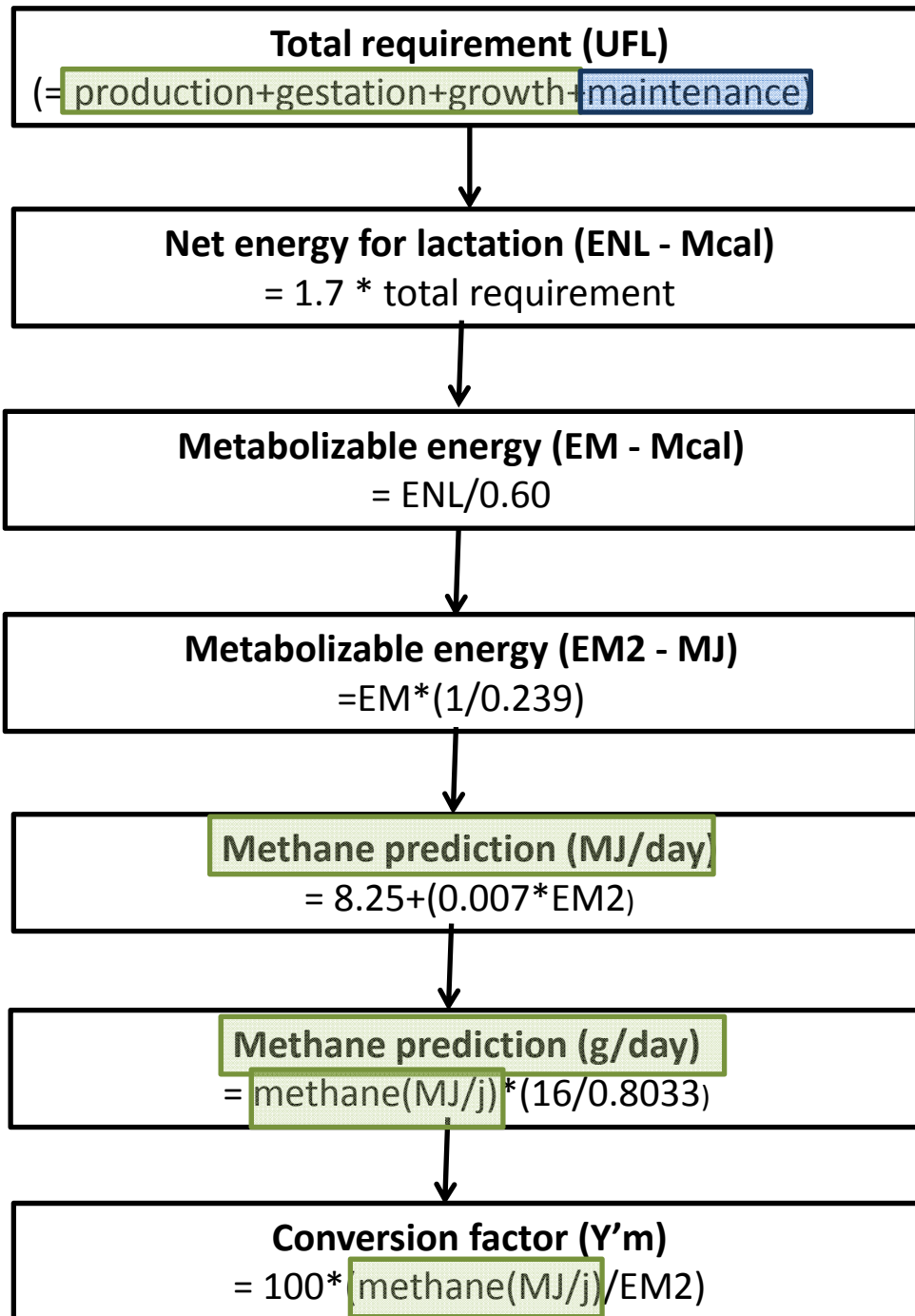




KNOWN
UNKNOWN but...

Vermorel et al., 2008





BOTTOM-UP
APPROACH

KNOWN
UNKNOWN but...

Vermorel et al., 2008



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

Prediction of **body weight** is therefore possible

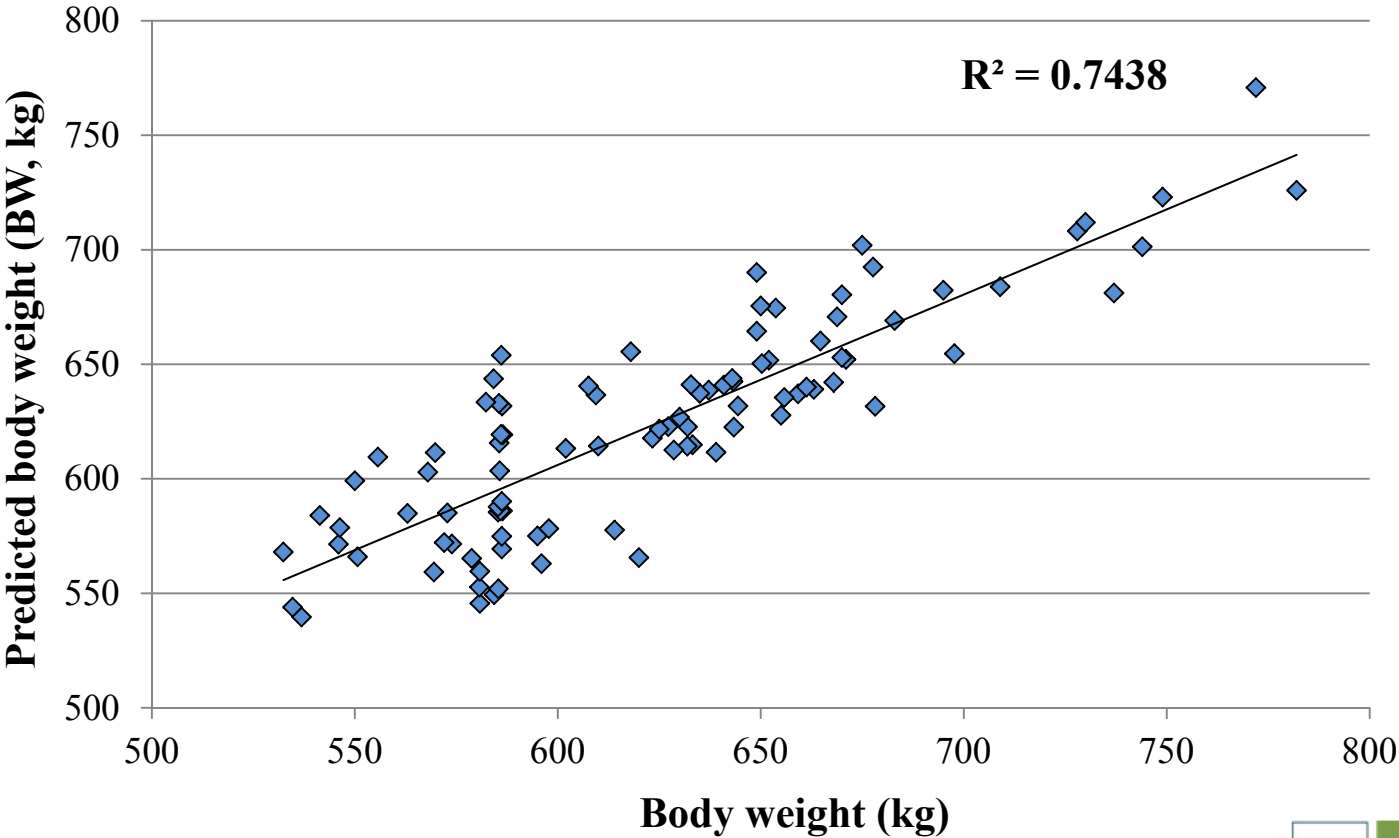
KNOWN
UNKNOWN but...

BOTTOM-UP APPROACH

Vermorel et al., 2008



DMI – Prediction of BW



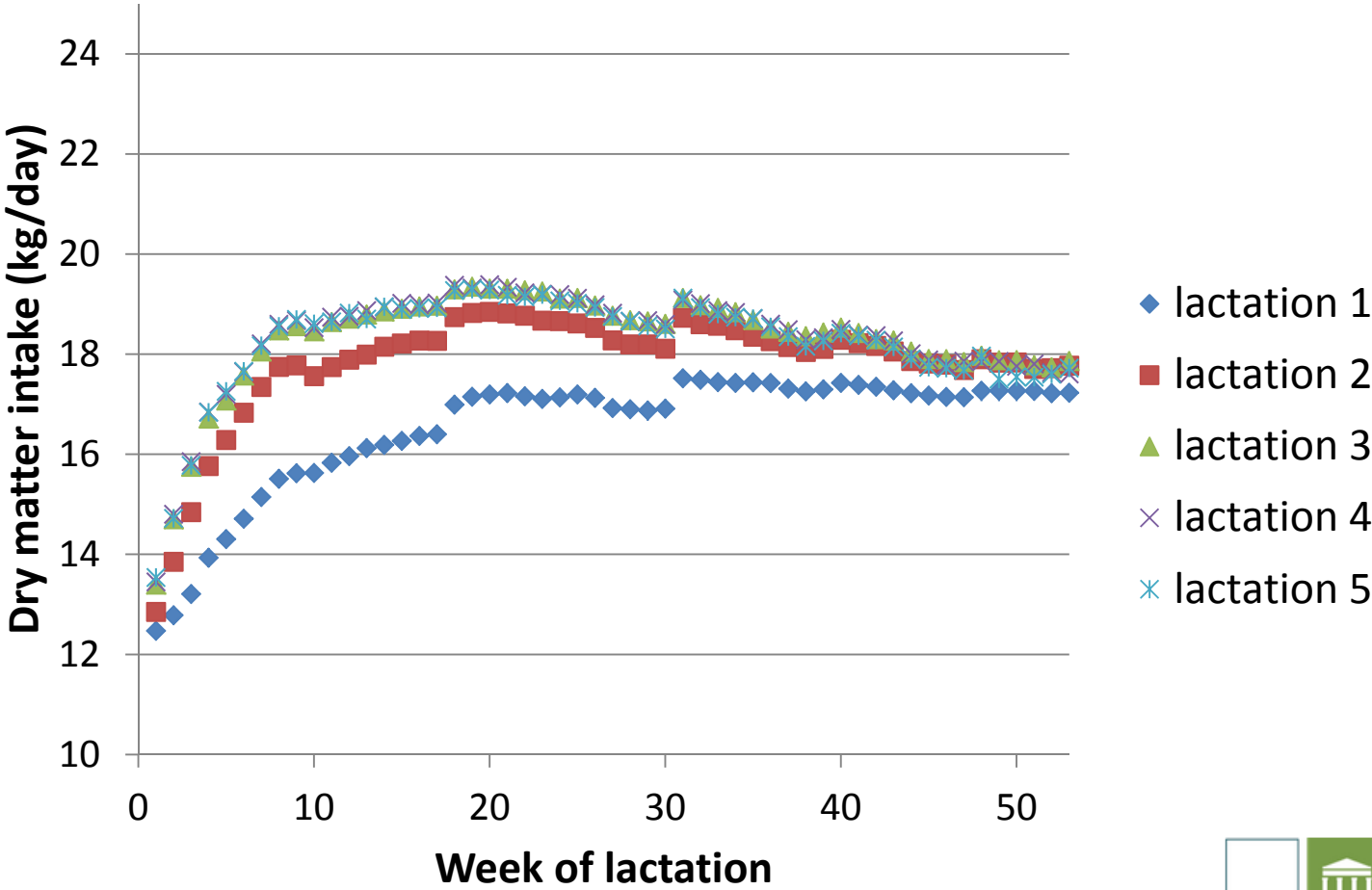
Estimation of Genetic Parameters

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

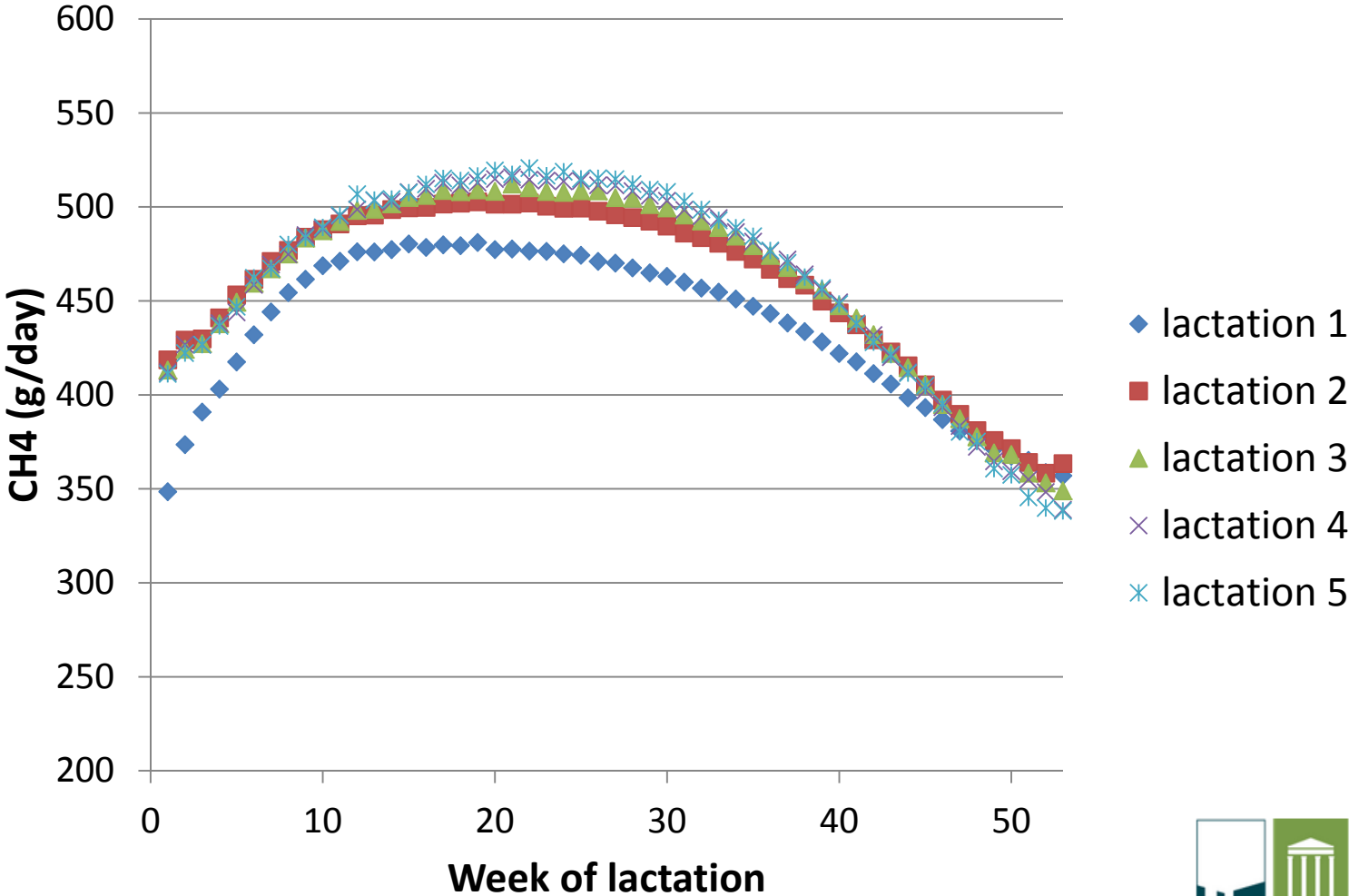
Multiple traits animal model from data collected on Hostein cows in their first five parities.



Effect of Lactation Stage And Parity



Effect of Lactation Stage And Parity



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
CH ₄ (g/day)	-0.04	0.15	0.14	0.04	0.15

Heritability CH₄

Heritability values, genetic and phenotypic correlations

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Moderate heritability for CH₄ (g/day)

- Animal differences in CH₄ 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

Heritability values, genetic and phenotypic correlations

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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 – CH₄

Heritability values, genetic and phenotypic correlations

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As expected:

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

Genetic Correlations – DMI

Heritability values, genetic and phenotypic correlations

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CH ₄ (g/day)	-0.04	0.15	0.14	0.04	0.15

- 0.59 from first 26 weeks of lactation (Veerkamp and Brotherstone, 1997)
- 0.52 between FCM and DMI (Vallimont et al., 2010)

Genetic Correlations – DMI

Heritability values, genetic and phenotypic correlations

	Milk	%Fat	%Protein	DMI	CH ₄
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Positive correlations with %Fat and %Protein

Phenotypic correlations

Heritability values, genetic and phenotypic correlations

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0.31 between FPCM and DMI (De Haas et al., 2011)

Genetic Correlations – DMI

Heritability values, genetic and phenotypic correlations

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DMI (kg/day)	0.32	0.08	0.00	0.10	0.23
CH ₄ (g/day)	-0.04	0.15	0.14	0.04	0.15

Positive correlation with CH₄

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

Phenotypic correlations

Heritability values, genetic and phenotypic correlations

	Milk	%Fat	%Protein	DMI	CH ₄
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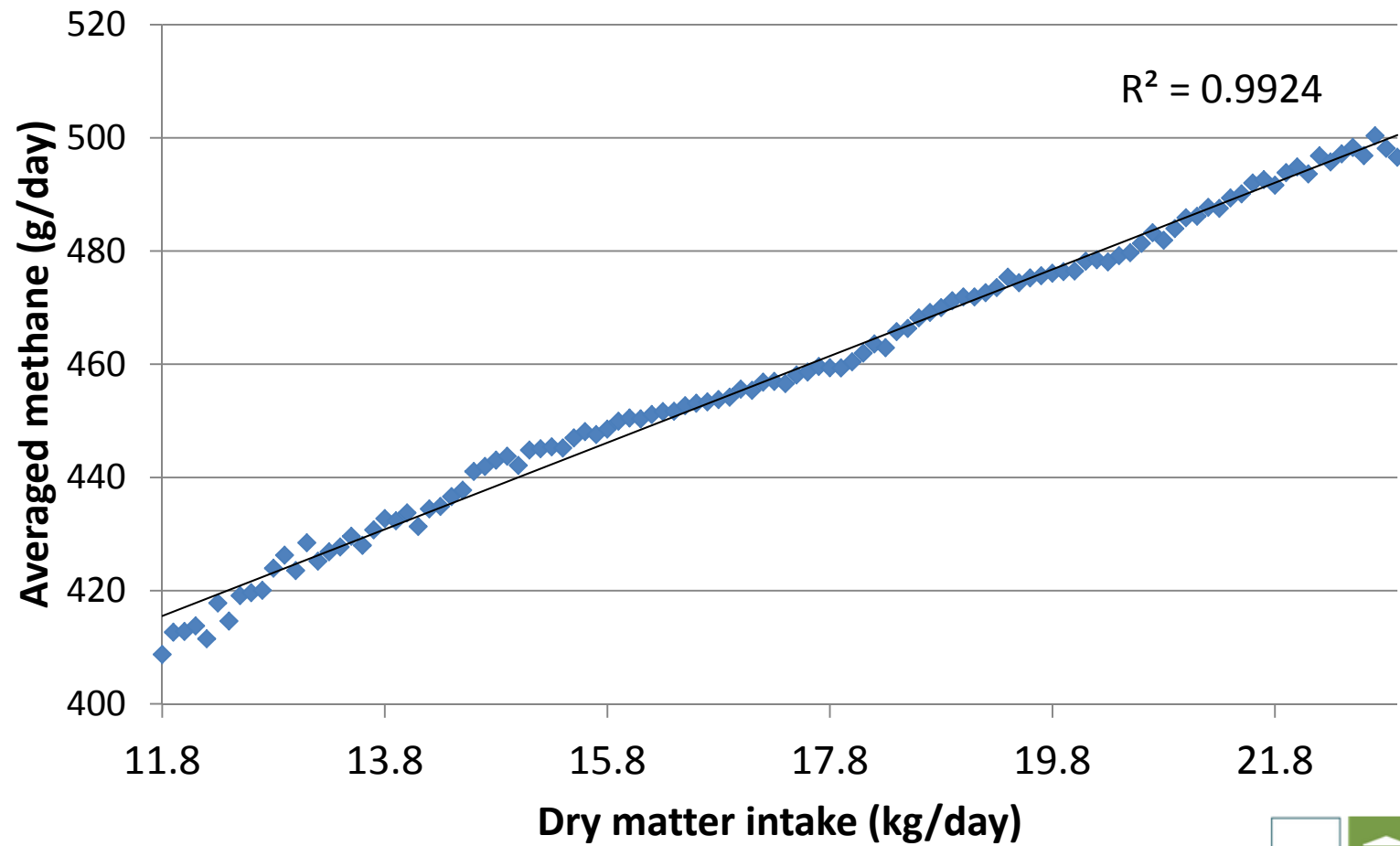
De Haas et al. (2011) predicted CH₄ from feed intake → correlation = 0.99

Why this value is not higher although correct relationship is observed for DMI with the other studied traits?

Maybe extreme variability for methane emission...



Relationship between CH₄ and DMI



CH₄/DMI

N=1,129,371	Mean	SD	Min	Max
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%Fat	4.06	0.68	1.50	9.00
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DMI (kg/day)	17.63	2.03	11.79	22.82
CH ₄ (g/day)	460.74	75.65	180.02	653.26
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



CH₄/DMI

Heritability = **0.11**



Conclusion

- CH₄ predicted by MIR, DMI derived from MIR CH₄ 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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