



*Genotype **plus** Environment*  
*Integration for a more sustainable dairy production system*

# Milk mid-infrared spectra based biomarkers contributing to genetic improvement for udder health, fertility and longevity

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# Genetic Improvement of Health Related Traits

- Becoming a **major focus**:
  - In many cattle genetic improvement programs
- However:
  - Achieving **early in life high reliabilities can be problematic** as
    - Fertility can only be assessed later during lactation
    - Udder health relies often only on somatic cells, or on potentially unreliable mastitis records (under reporting, only clinical cases)
    - Longevity only truly known at death (culling)
  - Also direct traits have **low heritability** → lower repeatability



# Genetic Improvement of Health Related Traits

- For these reasons **alternative, early indicator traits**
- To be useful:
  - **Available early** during productive life (lactation) of a given cow
  - **(High) genetic correlation** to direct health traits of interest
- In this study → **blood based biomarkers**
- Last requirement for novel indicator traits:
  - **Bring novel information** when considered with already used predictors



# Blood Based → Milk MIR Predicted

- Blood based biomarkers:
  - IGF-1, glucose, urea, cholesterol, fructosamine, BHB and NEFA
- But milk MIR based predictions of these blood biomarkers required to facilitate easier access to relevant data:
  - On a very large scale
  - At reasonable costs

→ One of the objectives of the EU FP7 GplusE project



# Novel Traits ← Blood Based Biomarkers

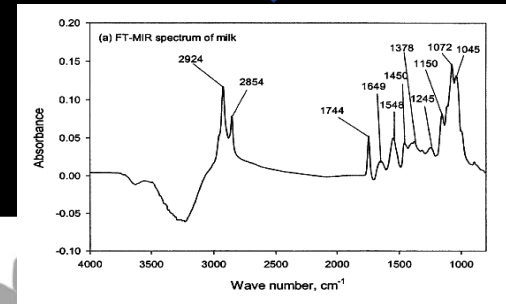


*Milk samples*

(milk payment, milk recording)



*MIR analysis*



*Raw data = MIR spectra*

*Novel Calibration equations*



*Quantification*

**Novel traits:  
here blood  
based  
biomarkers**



# Blood Based → Milk MIR Predicted

## Factors of influence determining cow health

**HERD**  
Housing  
Bedding  
Feeding  
Manure disposal  
Hygiene

**INDIVIDUAL COW**  
Genetic  
Yield  
Lactation stage  
Lactation number  
Milkability

**MILKING**  
Parlour type  
Equipment  
Routine  
Records  
Hygiene

**COW STATUS**

**MONITORING**

**Clinical changes**

Body weight  
Feed intake  
Behaviour

*Milk yield*

**Cow health**

**Subclinical changes**

**Reference** → Blood  
Lymph  
Urine

*Milk composition*

**Udder health**

**MIR**

Hamann & Krömker 1997. Livest. Prod. Sci. 48: 201-208.

# Developing Required Calibrations

- Assembling reference values and standardized spectra
  - Blood measurements collected on lactating Holstein cows
  - At DIM 14 (ranging from 11 to 20) and DIM 35 (ranging from 31 to 38).
  - In total 373 samples from 5 farms
- Still ongoing → first results
  - $R^2_{CV}$  ranging from 0.21 to 0.51 → used in this study
  - Still improving...

**deliberate!**



# Genetic Evaluations

- MIR records → milk MIR based predictions
  - 144,623 records (closest to DIM25)
  - From 73,378 cows in Walloon region of Belgium
- Model
  - Single-trait, multi-lactation (1, 2, 3+)
  - Reliabilities (REL) based on diagonal of inverted coefficient matrix (PEV)
  - Variance components computed using EM-REML
  - $h^2$  ranging from 0.07 to 0.27, high correlations among lactations
- Estimated breeding values (EBV) for sires used
  - Based on at least 20 daughters with records and a REL of 70%





# Reference EBV

- Official Walloon EBV for the **same bulls when REL of min 70%**
  - 124 bulls qualified
- **Traits**
  - Udder health (UDH)
    - Based on somatic cell count, weighted random regression,  $h^2 = 0.14$
  - Fertility (FERT)
    - Based on daughter pregnancy rate,  $h^2 = 0.04$
  - Longevity (LONG)
    - Based on lactation survival (equivalent multi-trait model),  $h^2 = 0.11$



# Observed Correlations (i.e. lower bound estimates of genetic correlations)

- MIR biomarker EBV correlated to official EBV for somatic cell score (udder health - UDH), fertility (FERT) and longevity (LONG)
- **Observed correlations** diverse (in absolute values) ranging from 0.01 to 0.39
- Highest value was found between fertility and fructosamine in 3<sup>rd</sup> lactation
  - **individual correlations disappointing**
- **Hypothesis: targeted combination will do better**



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  - defining and computing pUDH, pFERT, pLONG as best linear predictors from MIR biomarker EBV



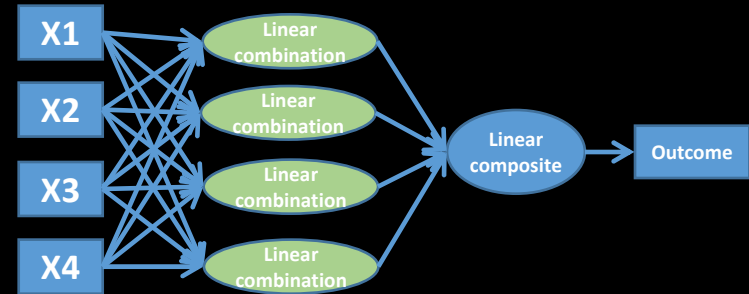
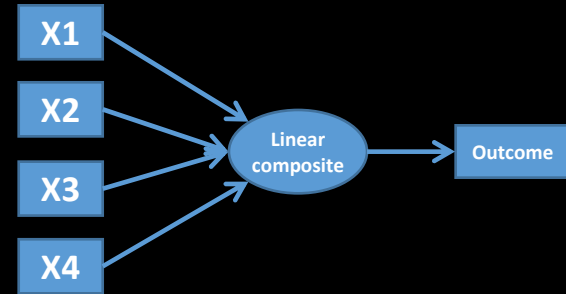
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- Highest value was found between fertility and fructosamine in 3<sup>rd</sup> lactation
  - ➔ but high correlations among variables ➔ multicollinearity
  - ➔ solution: **Partial Least Squares**



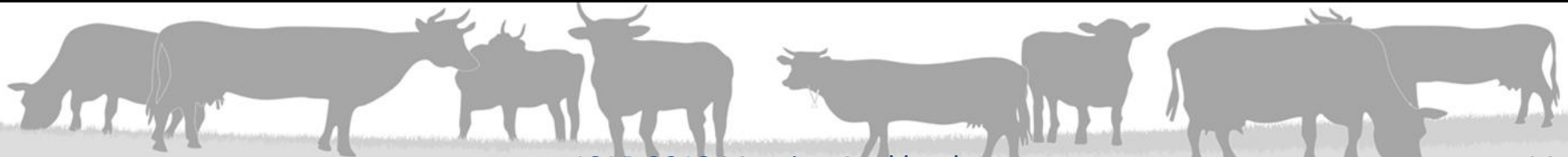
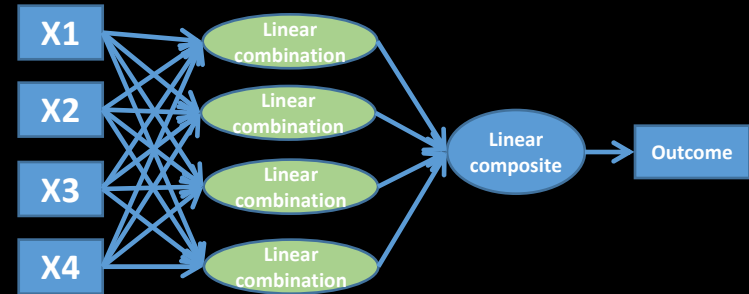
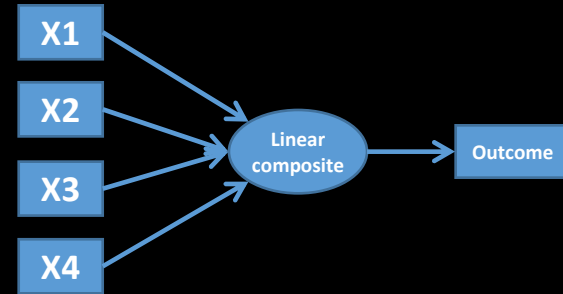
# Partial Least Squares vs. Ordinary Least Squares

- Ordinary least squares (i.e. multiple regression)
- Partial least squares (i.e. projection to latent structures)

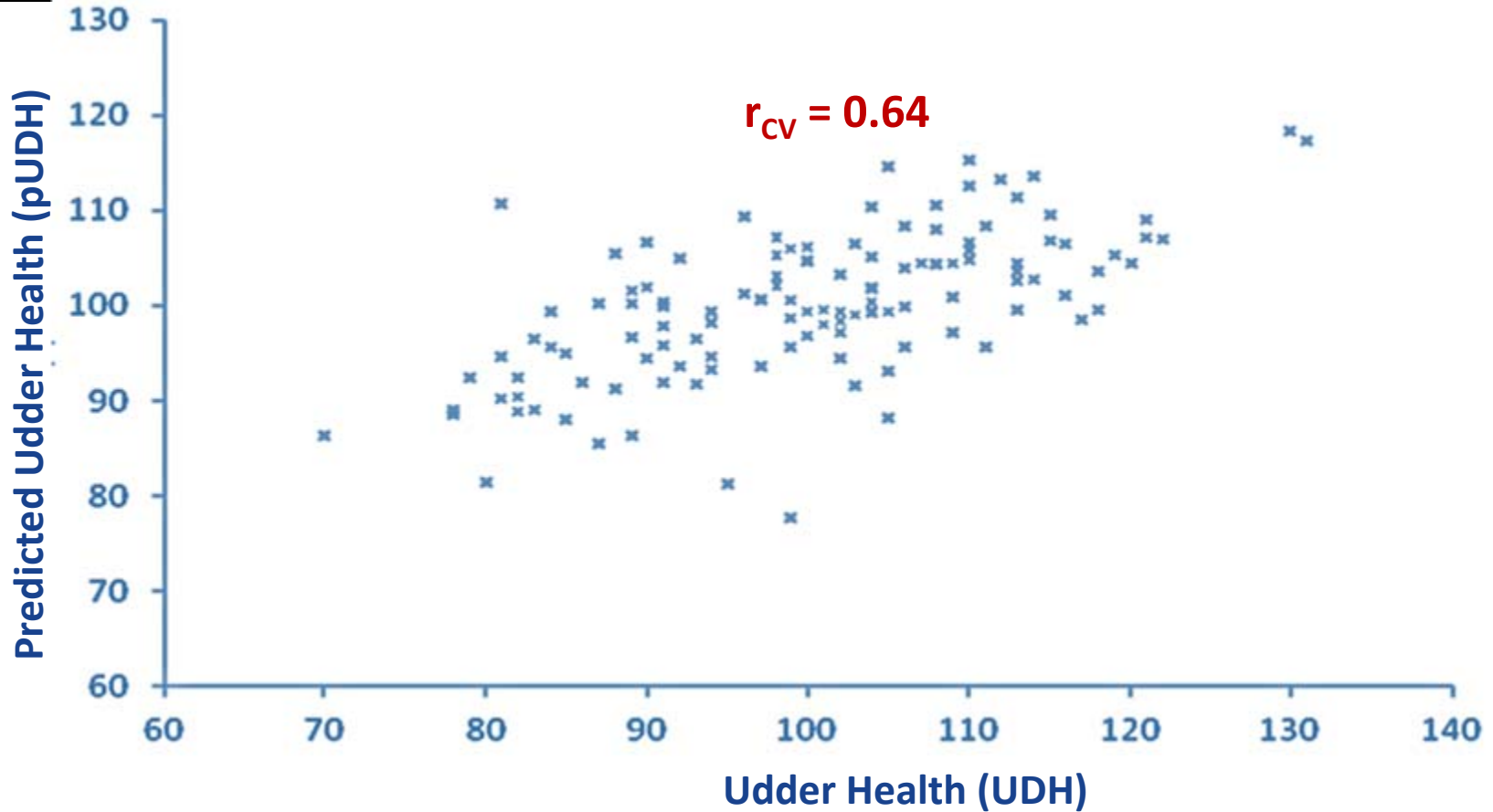


# Partial Least Squares vs. Ordinary Least Squares

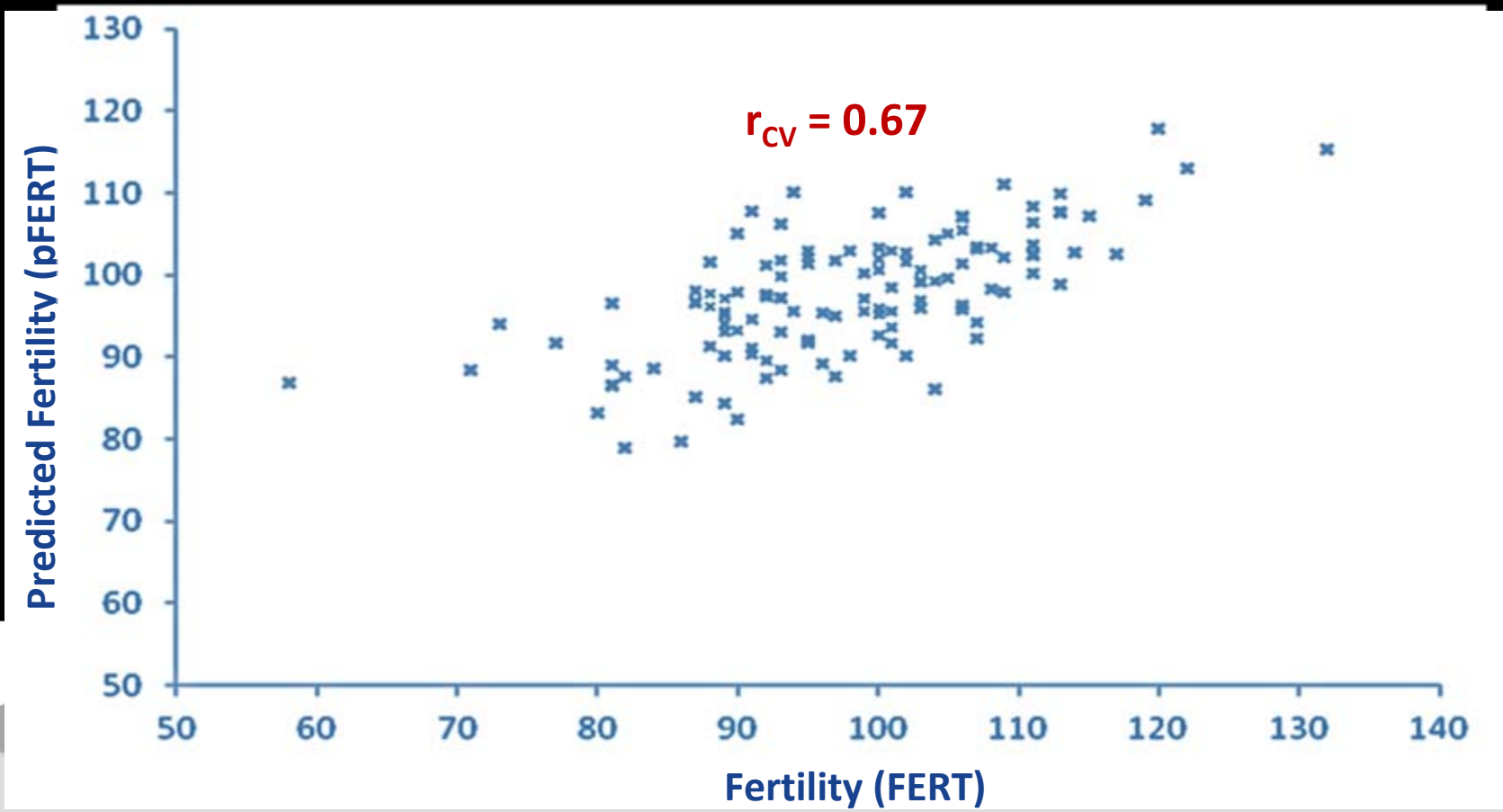
- Ordinary least squares (i.e. multiple regression)
- Partial least squares (i.e. projection to latent structures)
  - “Redistributes” coefficients between correlated traits → results not shown



# MIR Biomarker EBV → pUDH (Latent variables = 13)

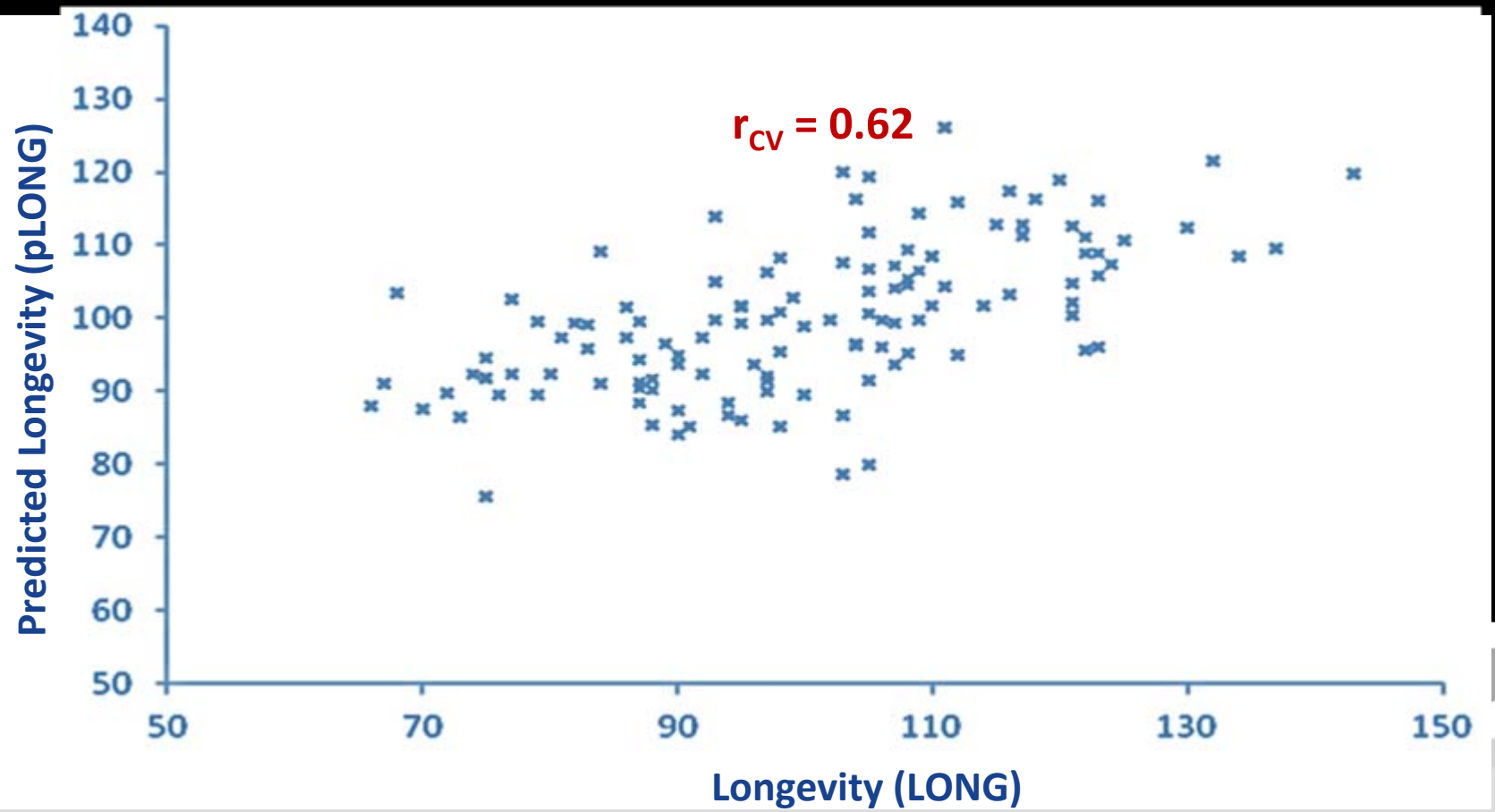


# MIR Biomarker EBV → pFERT (Latent variables = 13)

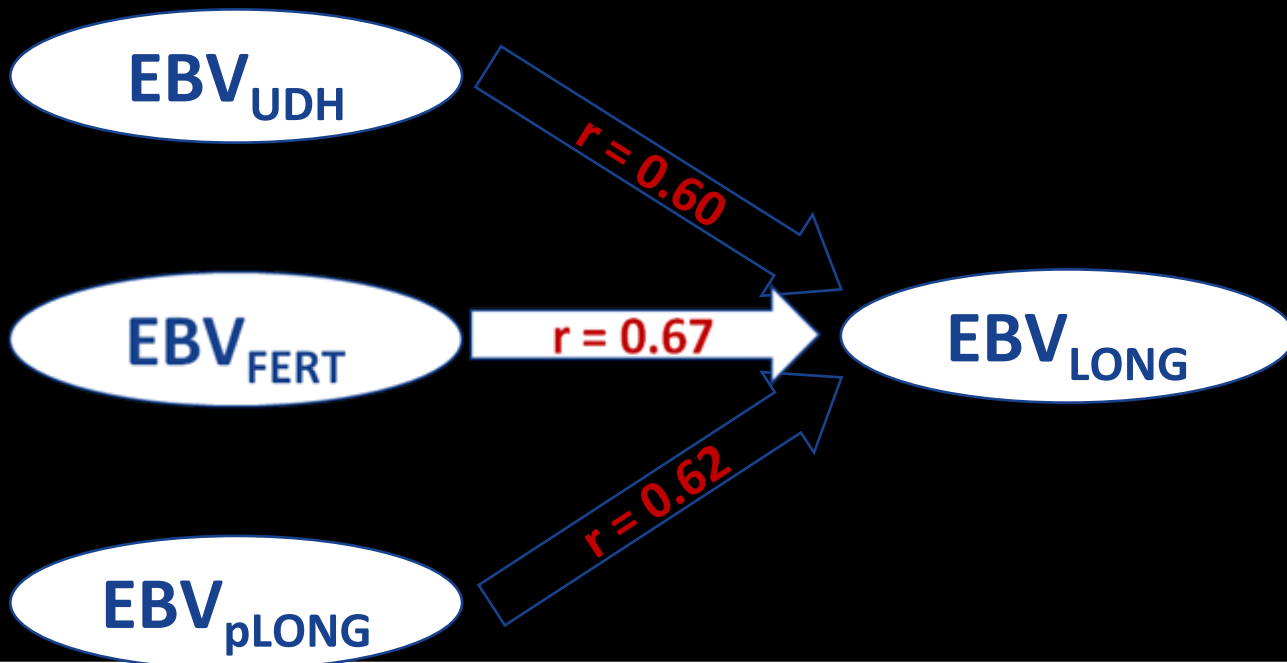




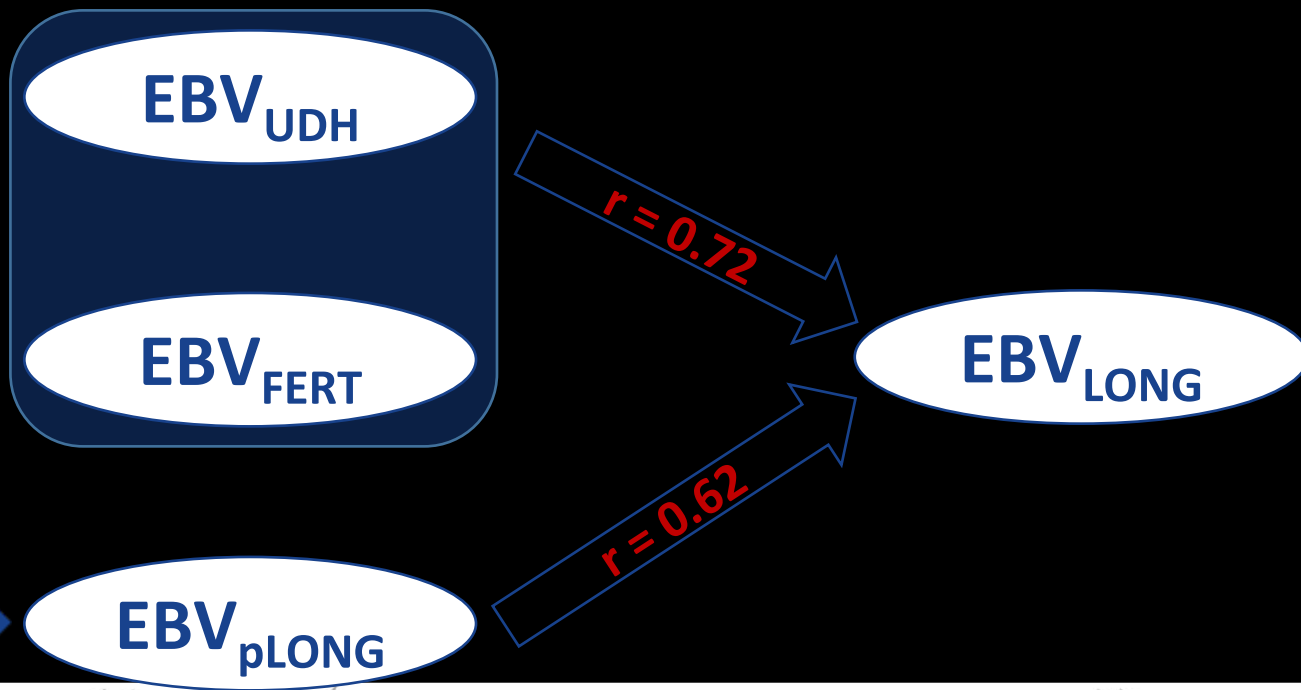
# MIR Biomarker EBV → pLONG (Latent variables = 13)



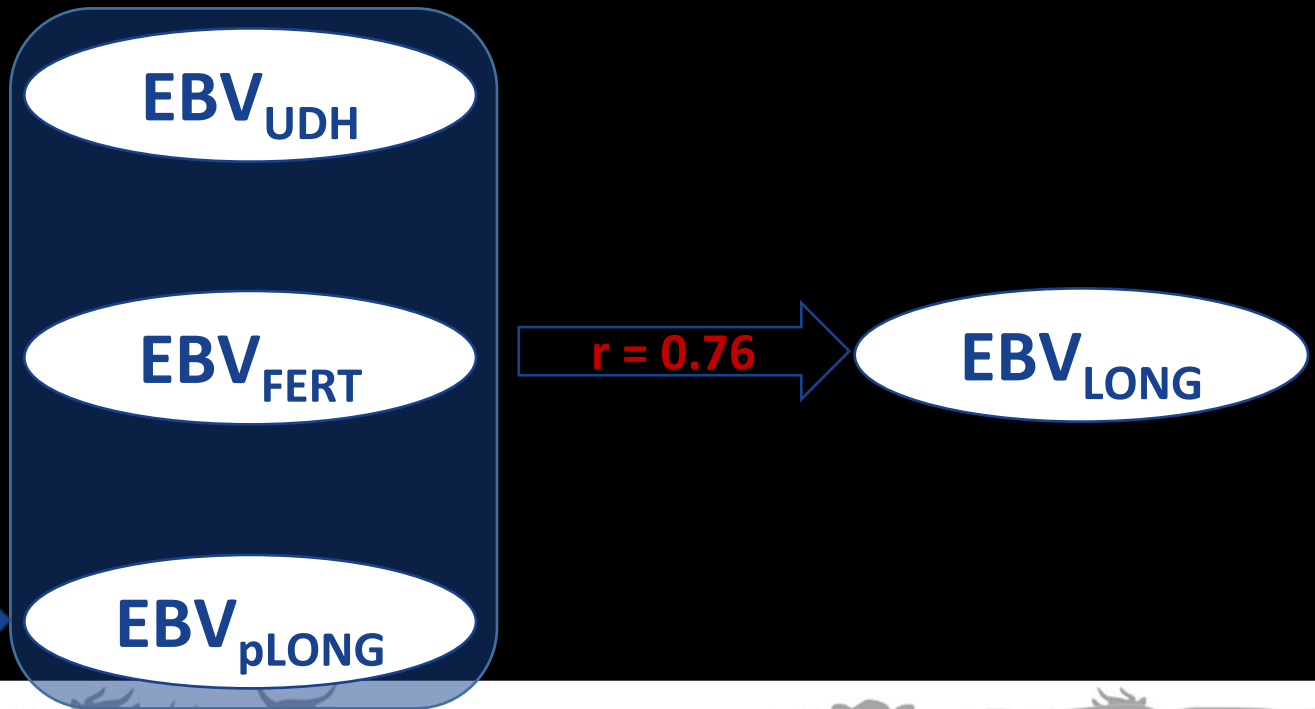
# Different Predictors of Longevity



# Combining Predictors of Longevity



# Adding pLONG ← MIR Biomarker EBV



MIR Biomarker  
EBV

$EBV_{UDH}$

$EBV_{FERT}$

$EBV_{pLONG}$

$r = 0.76$

$EBV_{LONG}$

# Conclusions

- Even lower accuracy predicted milk MIR based biomarkers can become useful in the context of animal breeding!
- Use of **Partial Least Squares** to obtain prediction coefficients overcame multicollinearity
- **Additional information** from milk MIR based biomarkers not yet contained in other predictors especially for FERT, but also LONG
- Milk MIR based biomarkers **based on first test-days**  
→ **early indicators**



# Acknowledgments and Disclaimer

- Support of the whole GplusE team, in particular
  - Clément Grelet CRA-W (for the ongoing calibration effort)
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- Support of European Milk Recording (EMR) providing access to MIR data standardization

\*Walloon Breeding Association, CRA-W, Milk Committee and ULiège-GxABT



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