Targeted combination of estimated breeding values for lower accuracy mid-infrared biomarkers increases their usefulness in genetic evaluation of dairy cattle

N. Gengler, GplusE Consortium

Speaker: Nicolas Gengler

Targeted combination of estimated breeding values for lower accuracy mid-infrared biomarkers increases their usefulness in genetic evaluation of dairy cattle

N. Gengler[1] & GplusE Consortium[2]

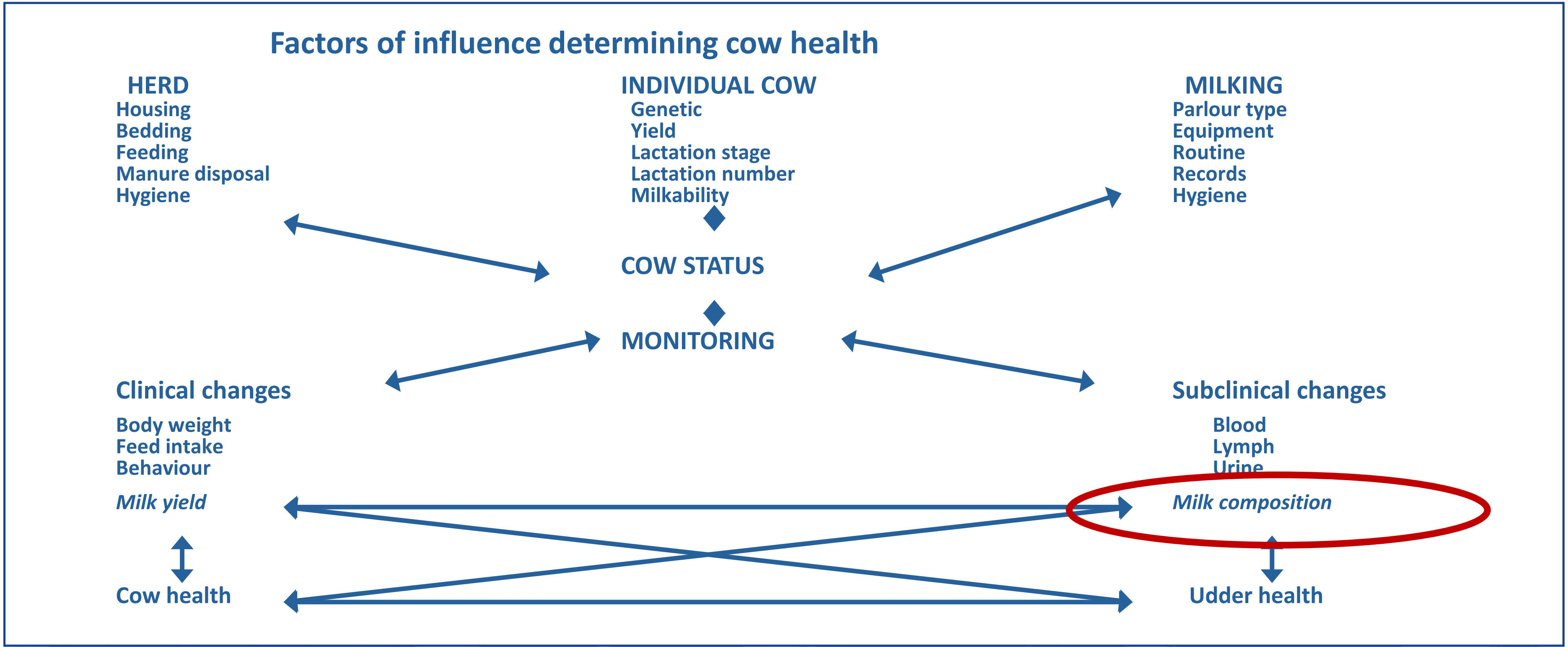
[1] *ULg-GxABT , Belgium (nicolas.gengler@ulg.ac.be)*

[2] *http://www.gpluse.eu (mark.crowe@ucd.ie)*

Major Challenge: Relevant Data

- Without data
  - No breeding or management possible!
- But data has also to be relevant
  - As close as possible to the processes we follow
- Here enters relatively new concept of biomarkers defined as:
  - "… objectively measured and evaluated … indicator of normal biological processes, pathogenic processes, or … responses to an … intervention" (National Institutes of Health)

Usefulness of Milk Composition!



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

Blood
Lymph
Urine

Milk composition

Udder health

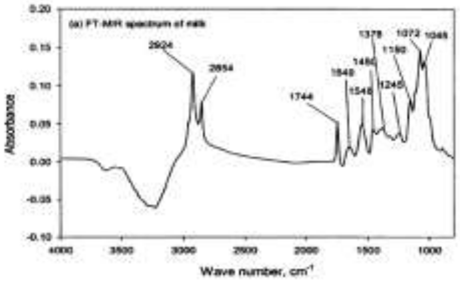
Hamann & Krömker 1997. Livest. Prod. Sci. 48: 201-208.

Major Milk Components (except SCC)

Milk samples

(milk payment, milk recording)

MIR analysis



Raw data = MIR spectra

Calibration equations

Quantification:

fat

protein

urea

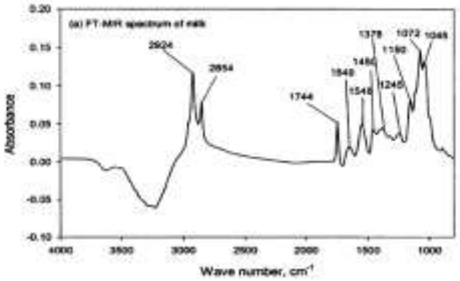
lactose

Novel Traits

Milk samples

(milk payment, milk recording)

MIR analysis



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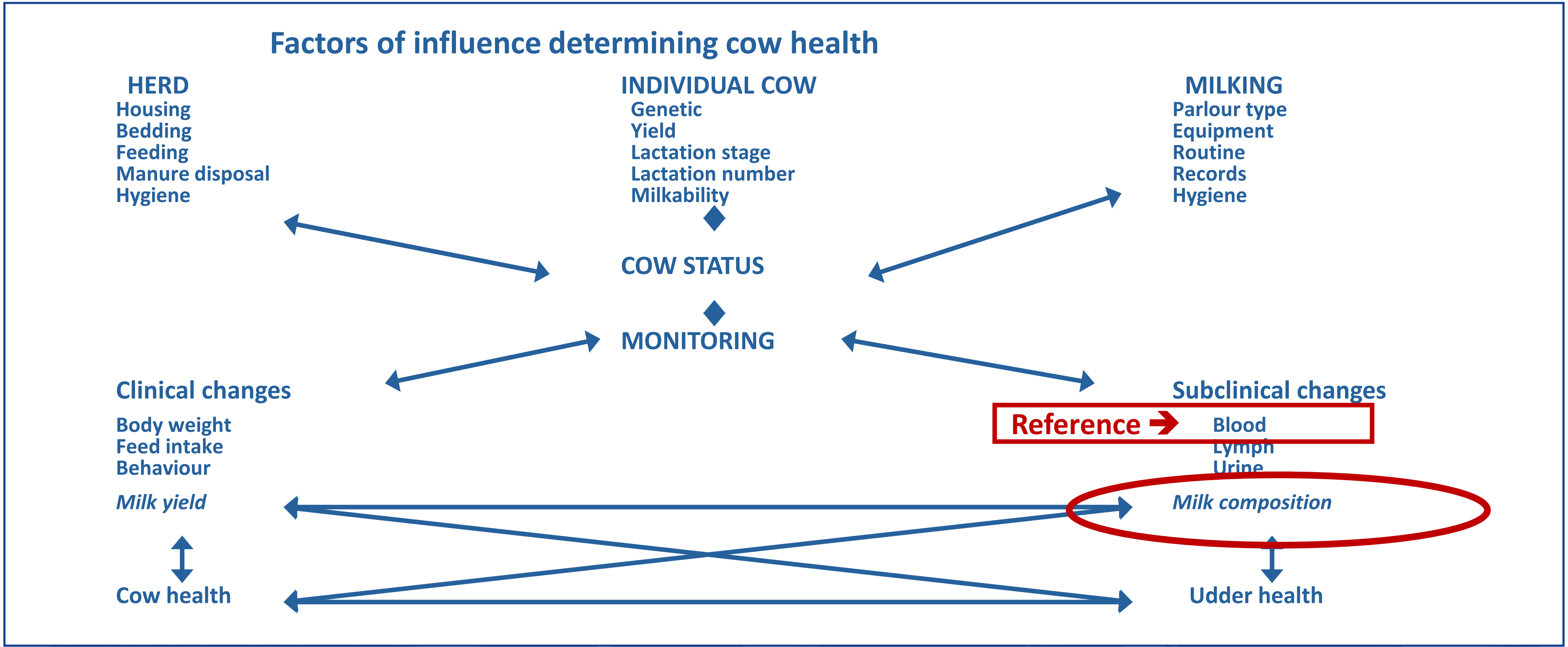
Calibration equations

Quantification:

novel traits

Blood Based Biomarkers as Reference



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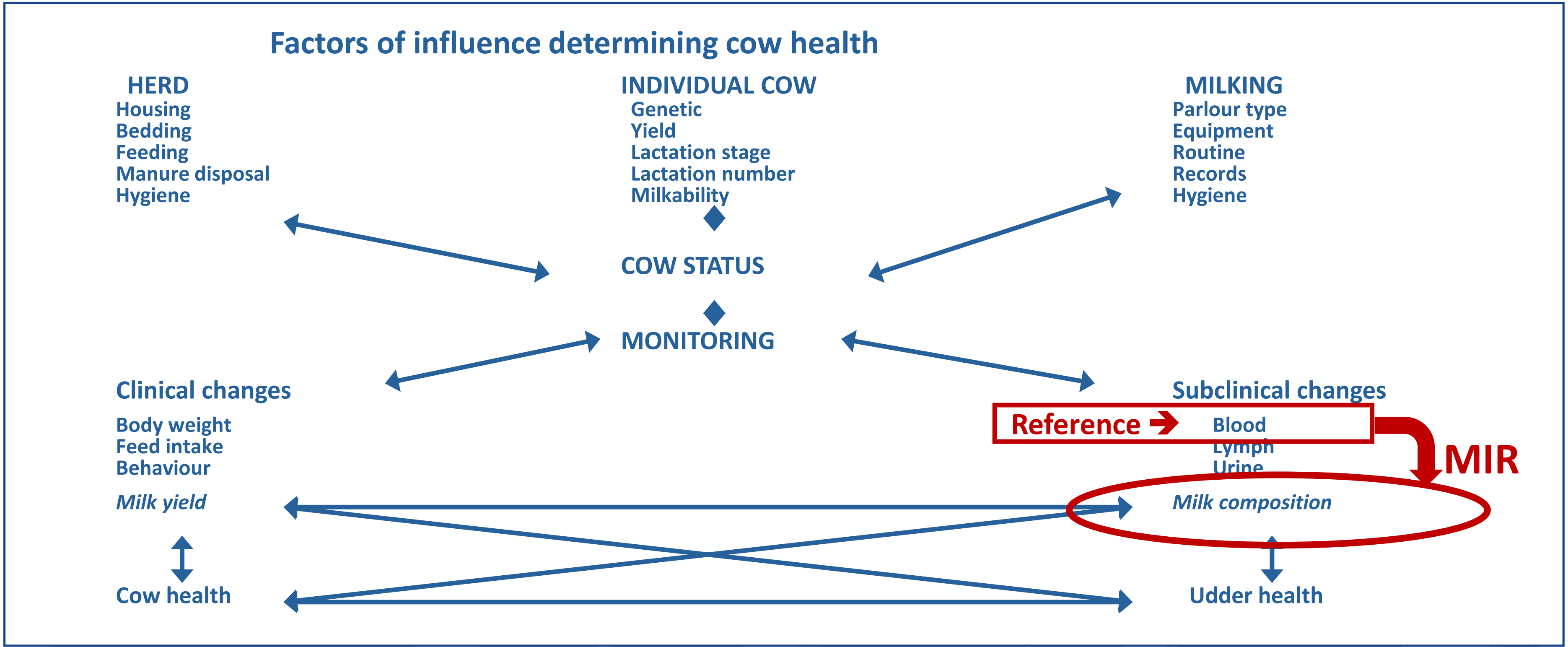
Blood Based → Milk MIR Predicted



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MIR

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Blood Based → Milk MIR Predicted

- Blood based biomarkers: IGF1, glucose, urea, cholesterol, fructosamine, BOHB and NEFA
- But milk MIR based predictions required to facilitate easier access to relevant data:
  - On a very large scale
  - At reasonable costs
- One of the objectives of the GplusE project

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
- Not one “calibration” ➔ process of calibration “model” development
  - Numerous different multivariate methods
  - Different pre-treatment of MIR data
  - Variable selection, etc….
- Still ongoing ➔ first results
  - R^2_{CV} ranging from 0.21 to 0.51 ➔ used in this study
  - Still improving…

Usefulness of Low-Accuracy Predictors

- Use for management ???

  → not the topic here

- Use for genetic improvement
  - Usual to predict traits from other "information"
    → selection index
  - Hypothesis here: target combination of EBV for those traits increases their usefulness in genetic evaluations of dairy cattle

Genetic Evaluations

- MIR records ➔ predictions
  - 59,303 records (closest to DIM25) from 33,968 cows in Walloon region of Belgium
- Model
  - Single-trait, multi-lactation (1, 2, 3+)
- Variance components
  - h^2 ranging from 0.15 to 0.30
- Estimated breeding values (EBV) used when based on at least 20 daughters
  - A total of 171 bulls met these criteria

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 (FER) and longevity (LONG)
- Observed correlations diverse (in absolute values) ranging from 0.00 to 0.31
- Highest value was found between fertility and fructosamine in 3rd lactation

➔ individual correlations disappointing

- Hypothesis: targeted combination will do better

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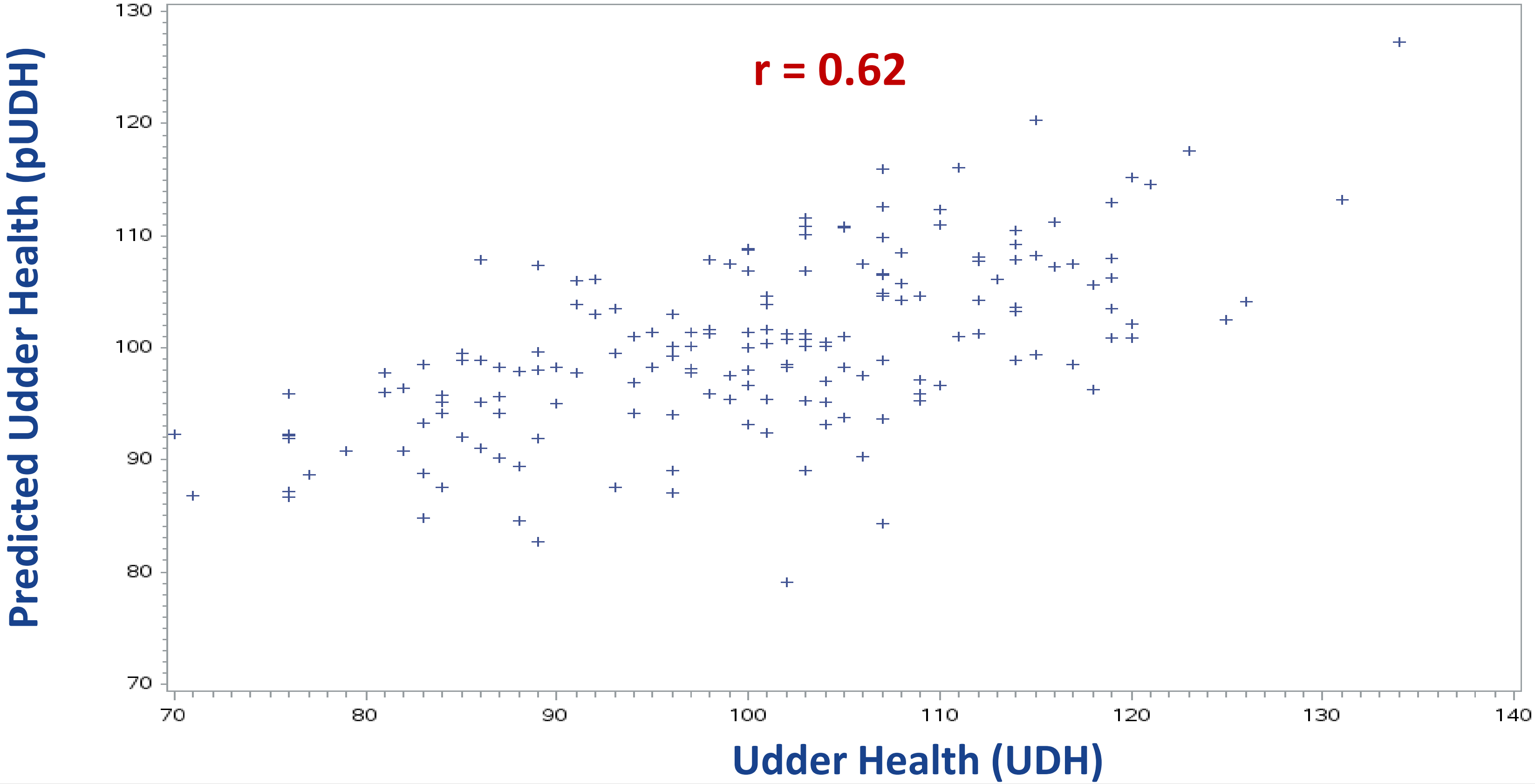
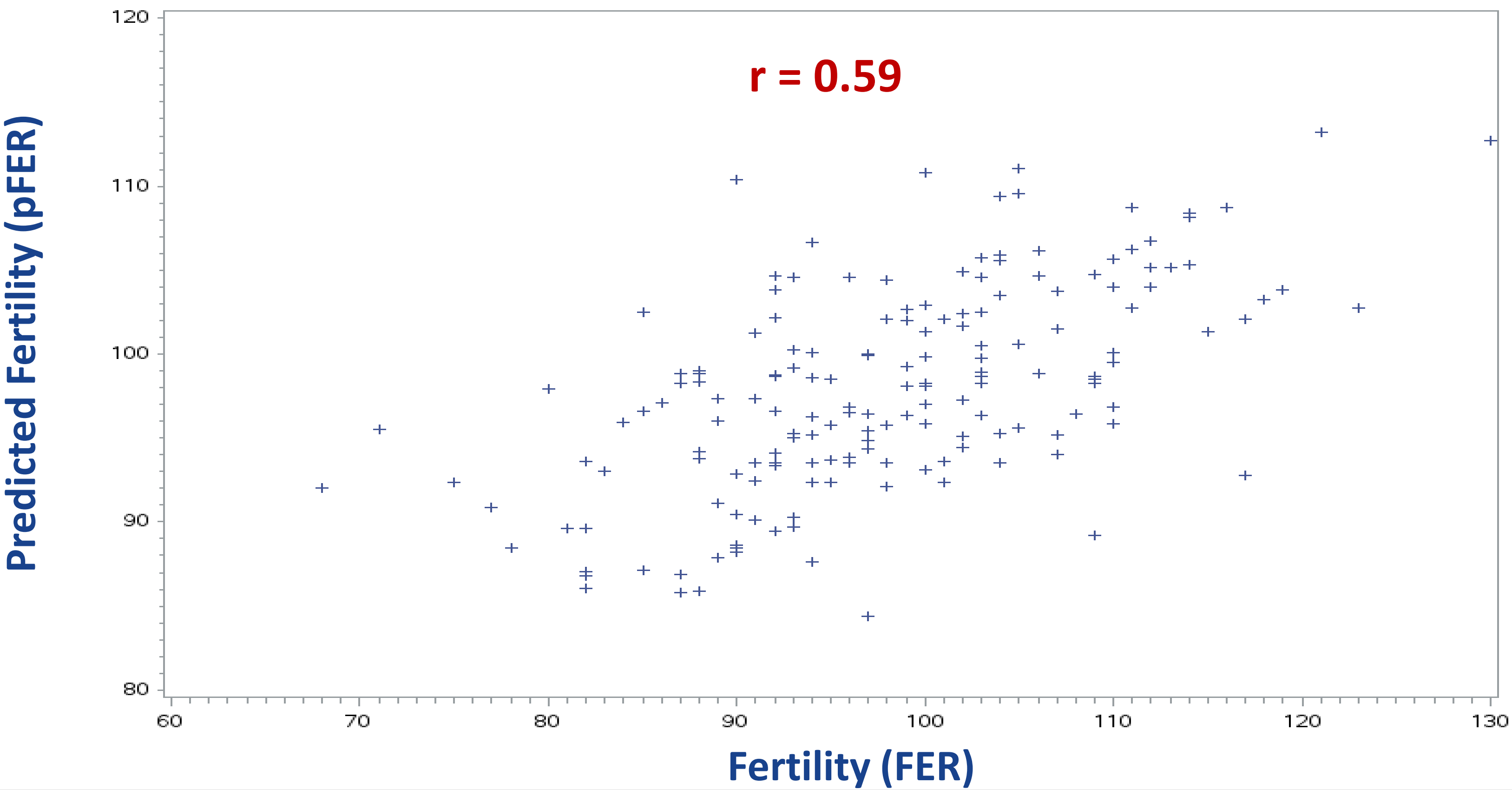
➔ defining and computing pUDH, pFER, pLONG as best linear predictors from Biomarker EBV

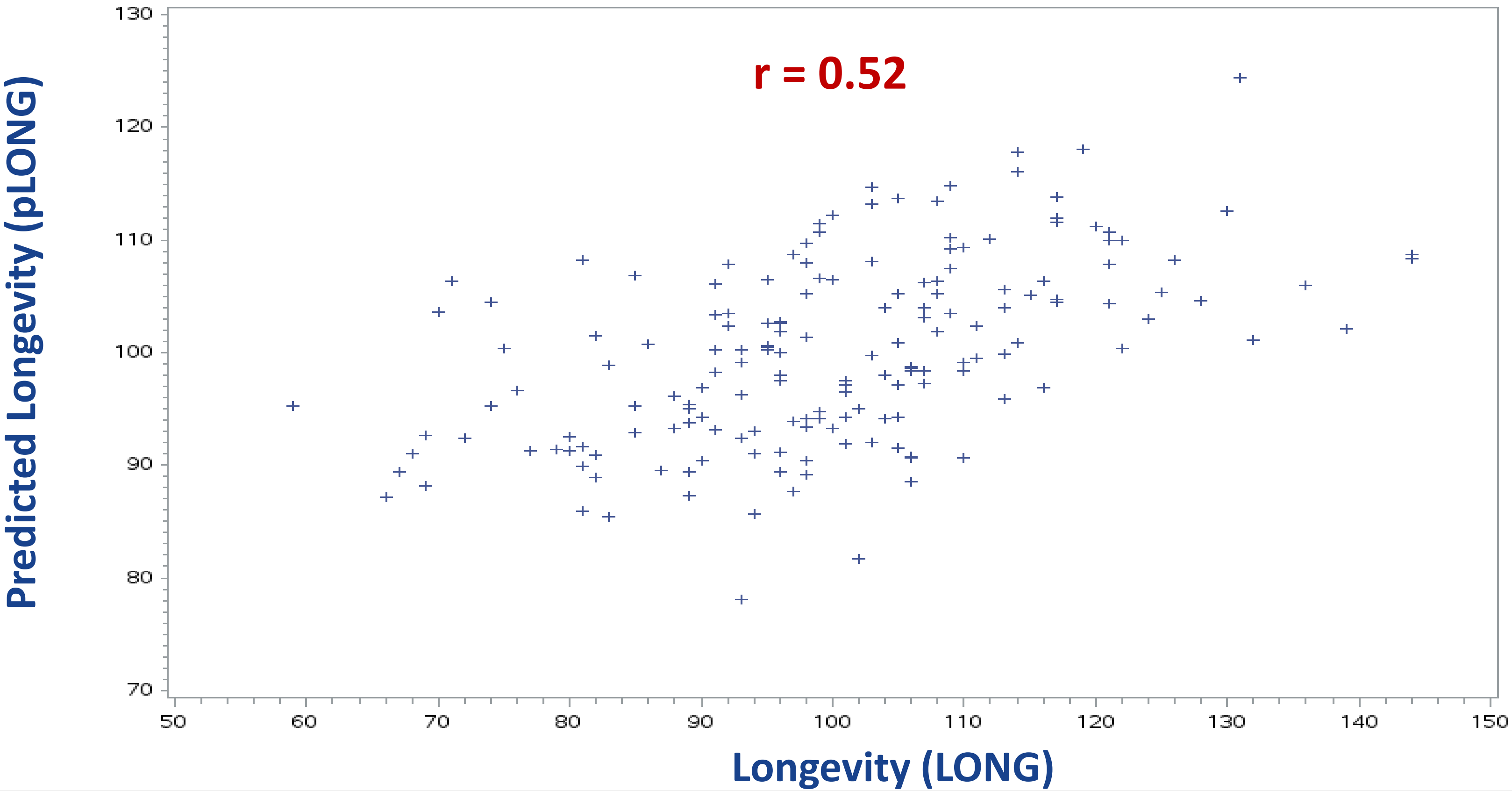
MIR Biomarker EBV ➔ pUDH



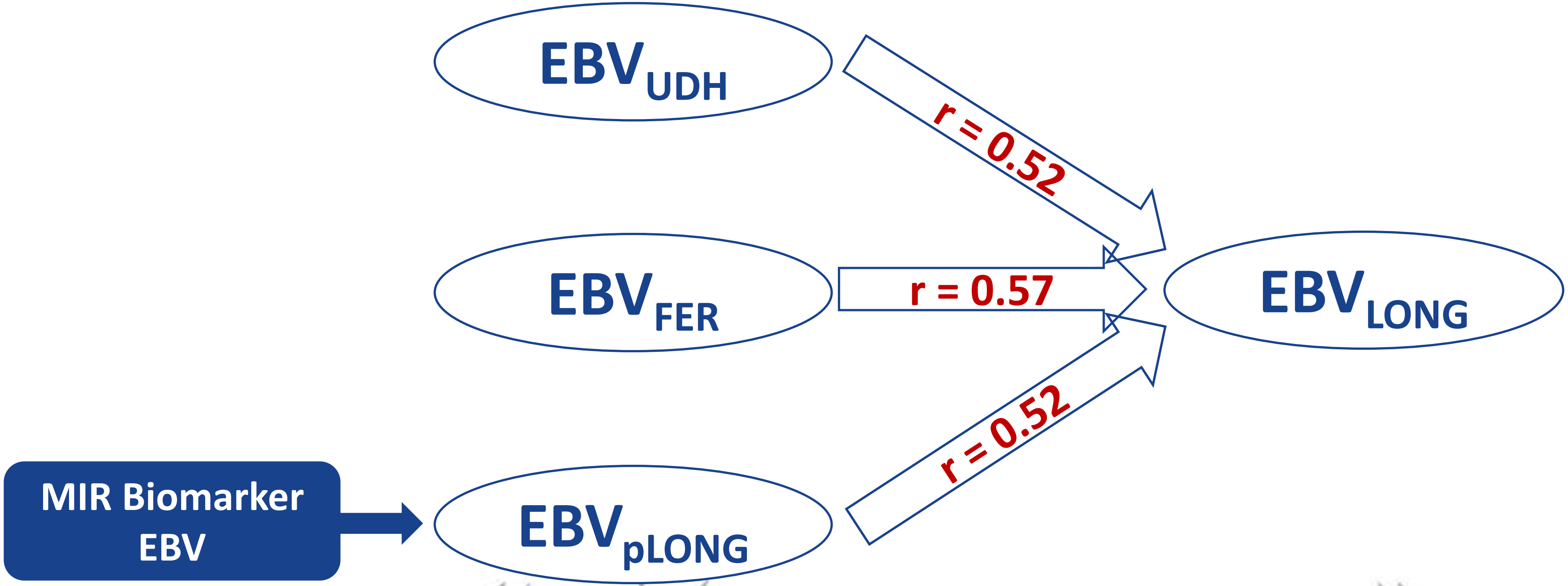
MIR Biomarker EBV ➔ pFER



MIR Biomarker EBV ➔ pLONG



Different Predictors of Longevity



$\mathrm{EBV}_{\mathrm{UDH}}$

r = 0.52

$\mathrm{EBV}_{\mathrm{FER}}$

r = 0.57

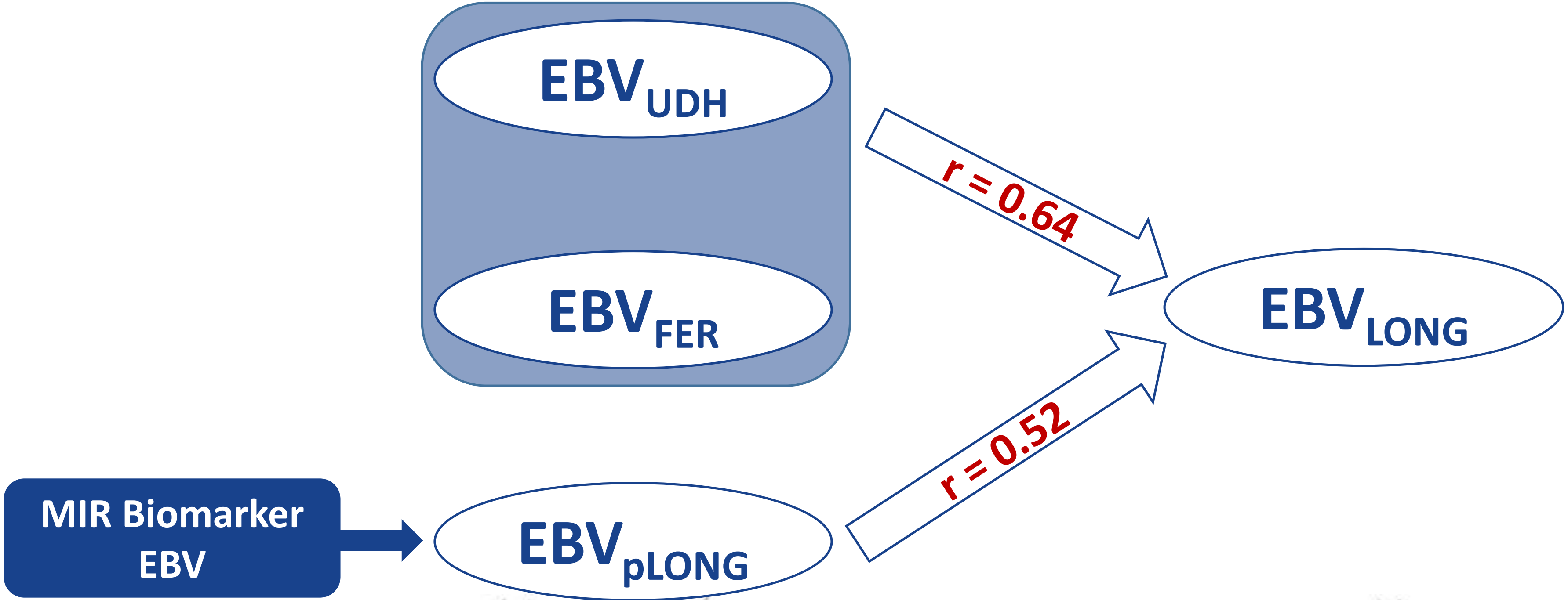
$\mathrm{EBV}_{\mathrm{LONG}}$

MIR Biomarker EBV

$\mathrm{EBV}_{\mathrm{pLONG}}$

r = 0.52

Combining Predictors of Longevity



EBV_{UDH}

EBV_{FER}

$r = 0.64$

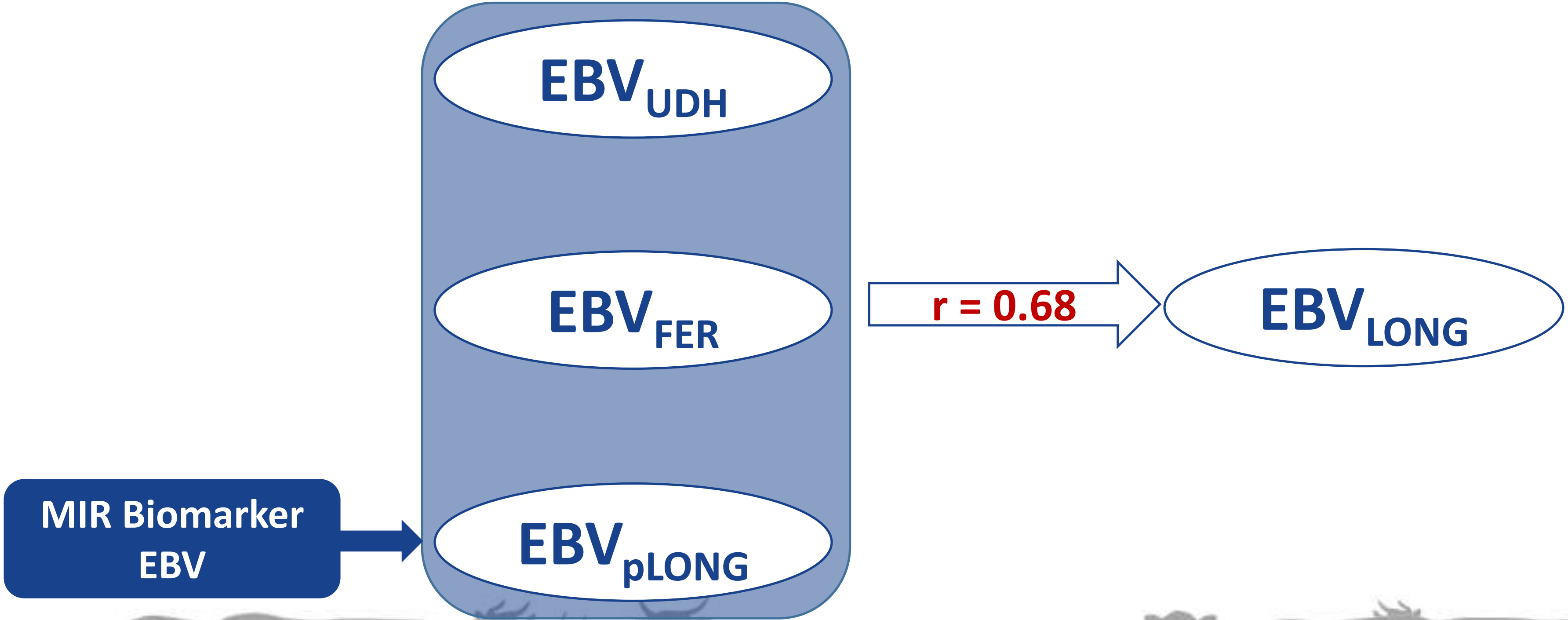
EBV_{LONG}

$r = 0.52$

MIR Biomarker
EBV

EBV_{pLONG}

Adding pLONG ← MIR Biomarker EBV



MIR Biomarker EBV

EBV_{UDH}

EBV_{FER}

EBV_{pLONG}

r = 0.68

EBV_{LONG}

Conclusions

- Even lower accuracy milk MIR based biomarkers can become useful in the context of animal breeding
- Targeted combination of associated EBV increased their correlation to breeding goal traits and therefore their usefulness for genetic evaluation
- Demonstrated in the context of longevity

Potential Improvements in Strategy

- Alternative phenotype definitions directly targeting desired phenotypes (e.g. metabolic status)
- Better calibration models
- Multi-trait genetic and genomic evaluations
  ➔ massive multivariate models 🡐 direct use of MIR
- Optimized selection index procedures to combine individual information sources

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    - Clément Grelet CRA-W (for the calibrations)
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*Walloon Breeding Association, CRA-W, Milk Committee and ULg-GxABT

- Support of European Milk Recording (EMR) providing access to MIR data standardization

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