Genotype plus Environment
Integration for a more sustainable dairy production system

Gembloux Agro-Bio Tech
Université de Liège

Going beyond current limits in defining and using milk infrared spectra based phenotypes

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Last Presentation for Today ☺

- **Since 14:00 many aspects were presented in this session:**
  Novel milk-based phenotypes for use in breeding and management applications

THANK YOU
FOR STAYING !

Last Presentation for Today ☺

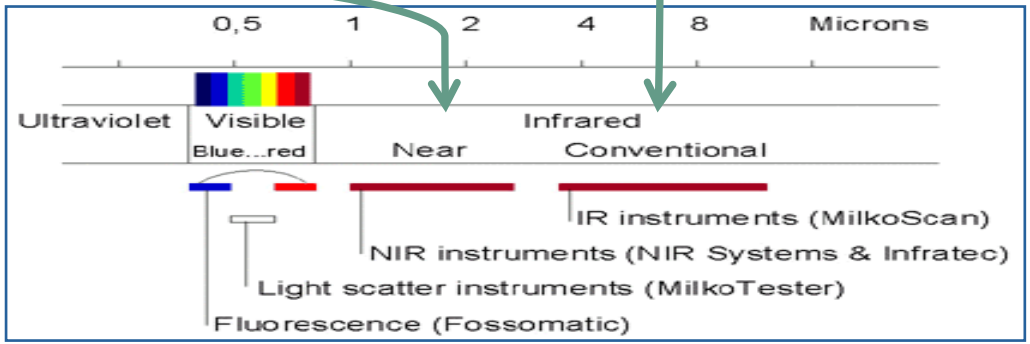
- **Since 14:00 many aspects were presented in this session:**
  Novel milk-based phenotypes for use in breeding and management applications in dairy production

- **Several presentations describing use of milk infrared data**

- **But: are there still issues we might have missed?**

Milk Infrared Spectral Data

- First issue: type of spectra (not aim of this talk)
  - Mid-Infrared (MIR)
    - Still spectrometers rather expensive !!
      → limits the use of MIR outside of labs
  - Near-Infrared (NIR)
    - On-farm on-line alternative
    - Appearing in commercial tools
    - More research needed to extend its use



FOSS

Milk Infrared Spectral Data

- **Second issue: defining phenotypes**
  - **Classically → calibrating against reference data**
    - **Spectral data is used as a predictor for a trait of interest**
  - **Alternatives**
    - **Spectra (wavenumbers) becoming traits describing phenotypic and genetic variations (already seen today)**
    - **But we can go even further (aim of this presentation)**

Spectra becoming response variables to known factors: Response → Trait

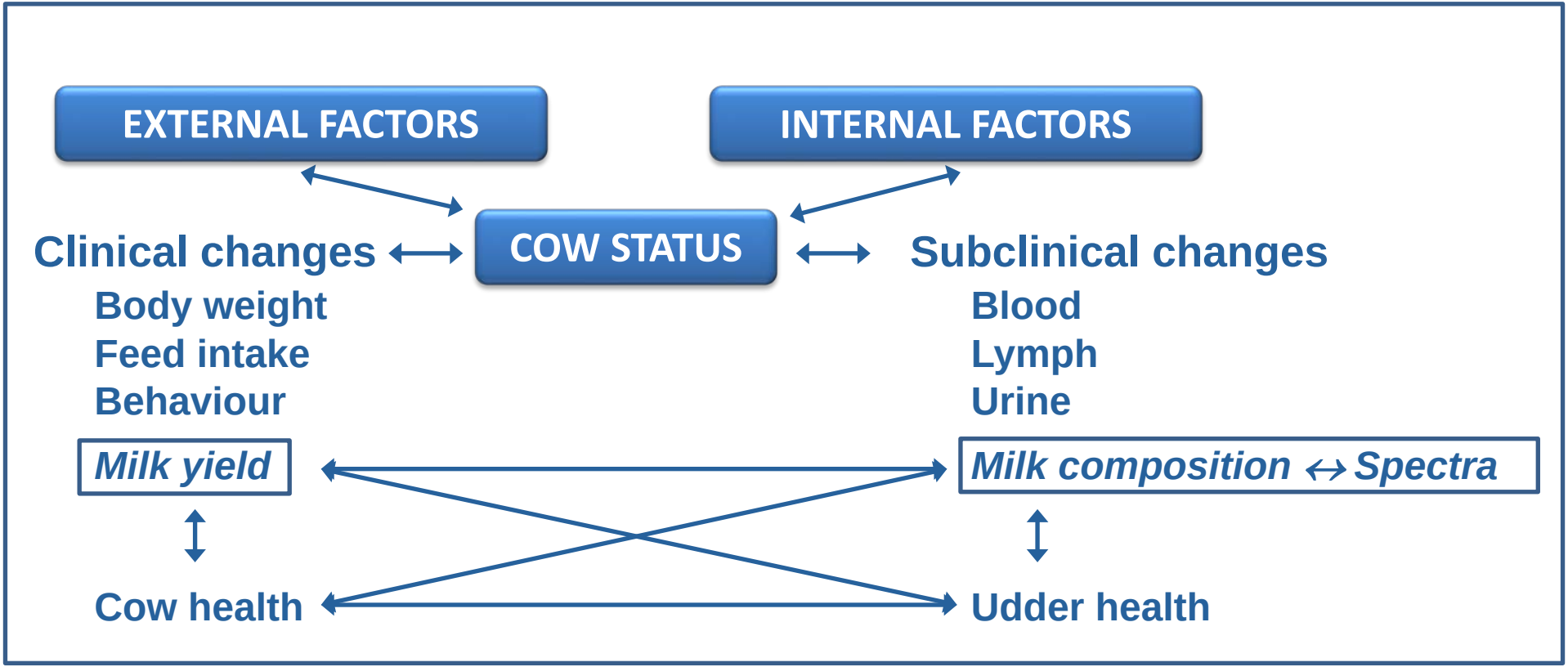
Spectra as Response Variables

- **Considering spectra (wavenumbers) as traits**
  - **Proof of significant phenotypic variation**
  - **But also genetic variation[1]**

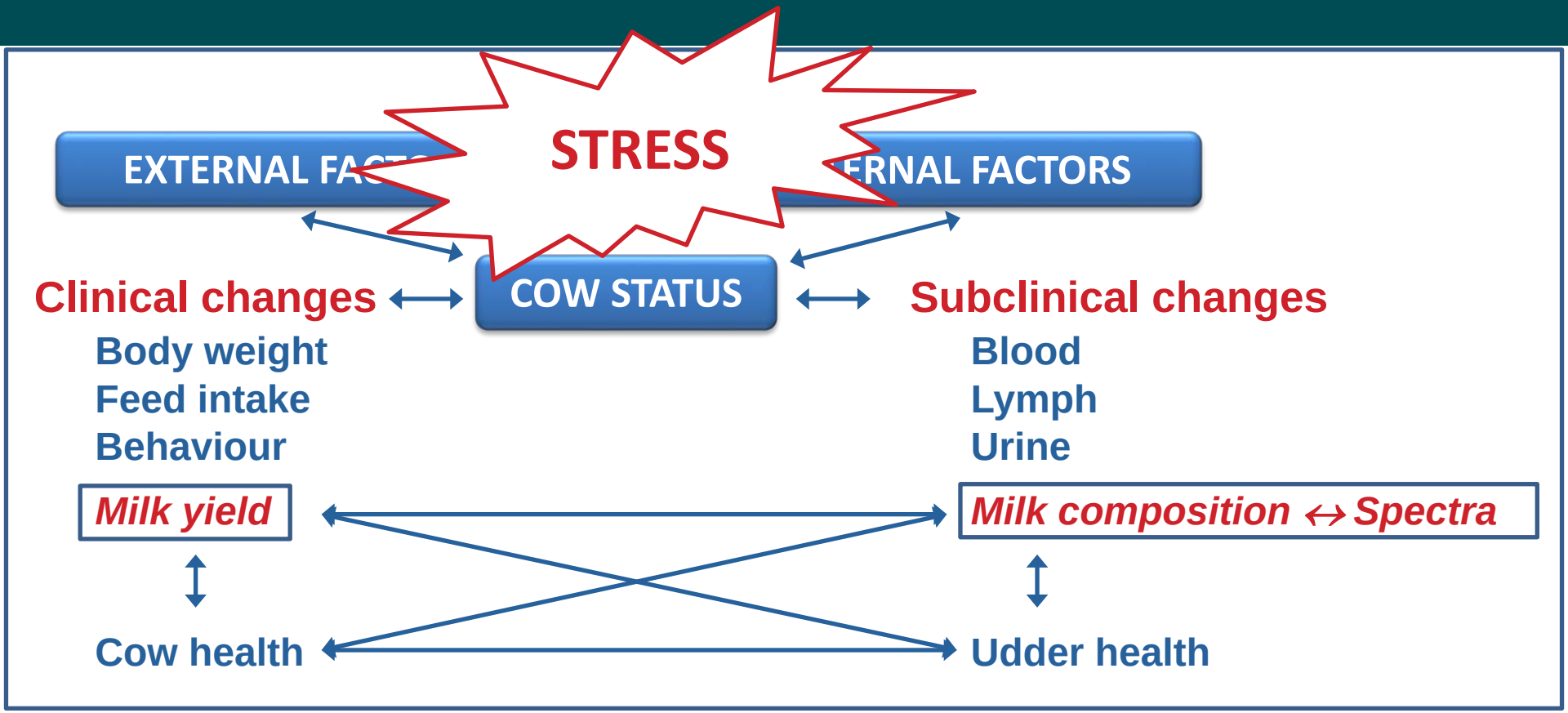
[1] e.g. Soyeurt et al. [2010] - JDS 93: 1722-1728; Dagnachew et al. [2013] - JDS 96: 3973-3985

- **Now the 1st question is:**
  - **What drives the phenotypic variation?**

Sources of Phenotypic Variation



Sources of Phenotypic Variation

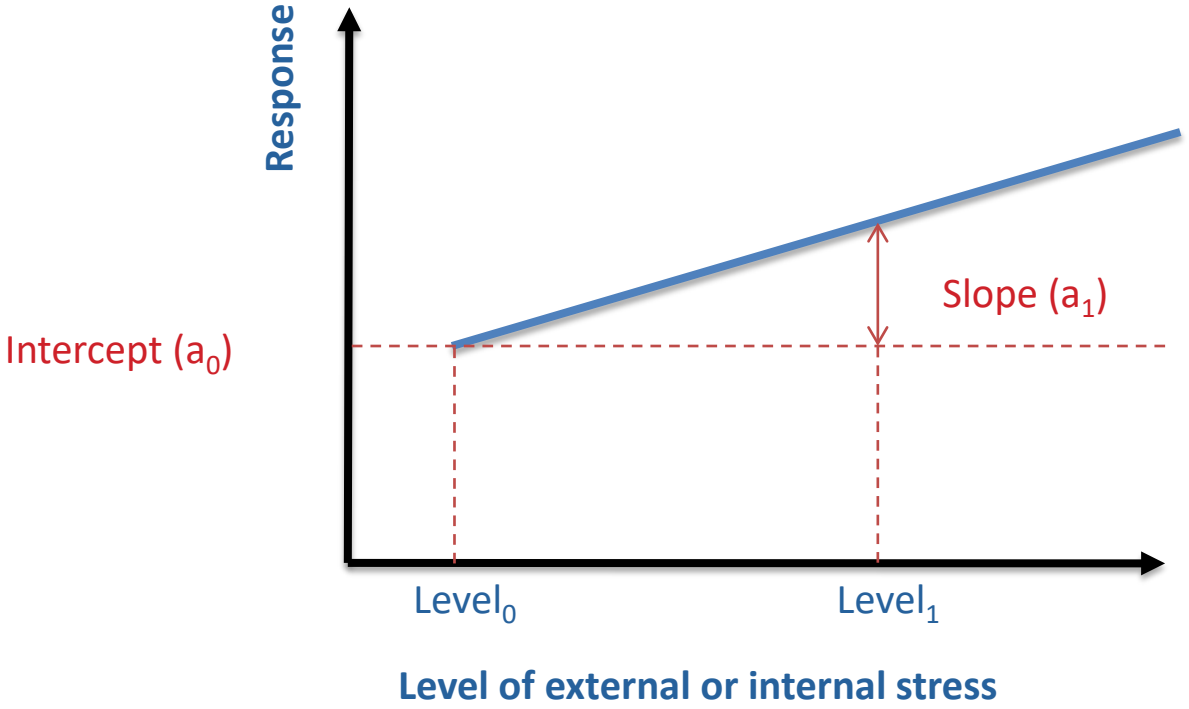


Spectra Responding to Stress

- **Leads to 2nd question:**
  - **How to link responses of milk yield and composition to external and internal stress factors ?**

- **Concept of "Reaction Norm" defined as:**
  - **Phenotypic expression of a "genotype" across a range of "environments"**

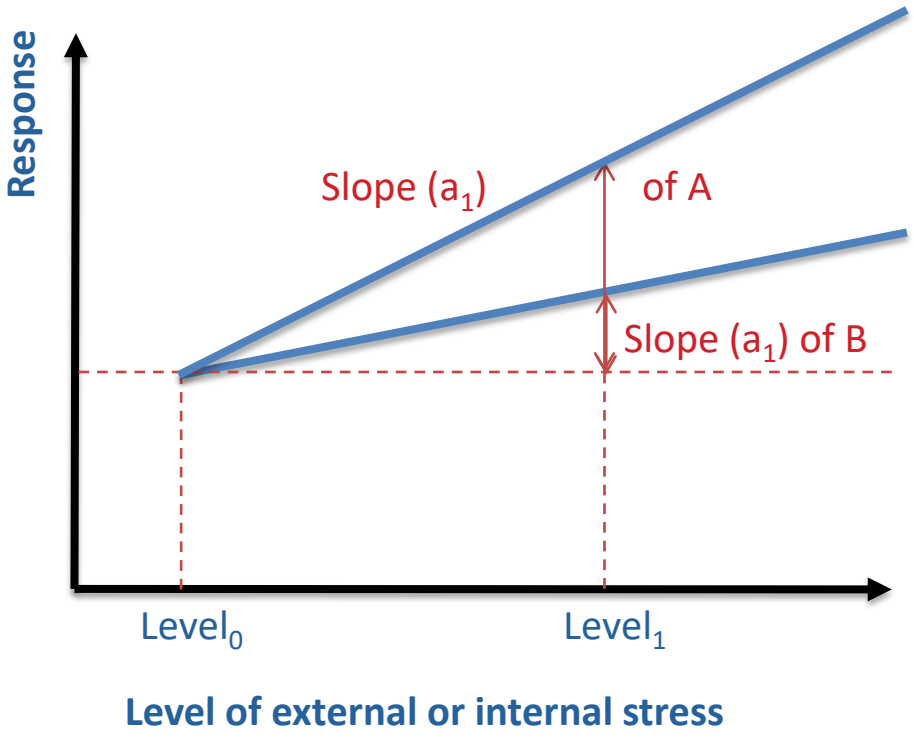
Reaction Norm



Two Examples

- Reaction of a given response variable to (2 examples):
  - External stress: **Heat Stress**
    - Response to a given level of temperature-humidity (THI)
  - Internal stress: **Gestation**
    - Response to a given length of gestation
- Leads to the 3rd question:
  - **How to pass from individual phenotypic responses to indicators of genetic robustness to external and internal stress factors**

Animal A vs Animal B



- **Hypothesis:**
  - **Animals that react less are more resilient**
- **Therefore:**
  - **Larger slope indicating stronger reactions**
- **In this figure:**

Slope A > Slope B

↓

Resilience A < Resilience B

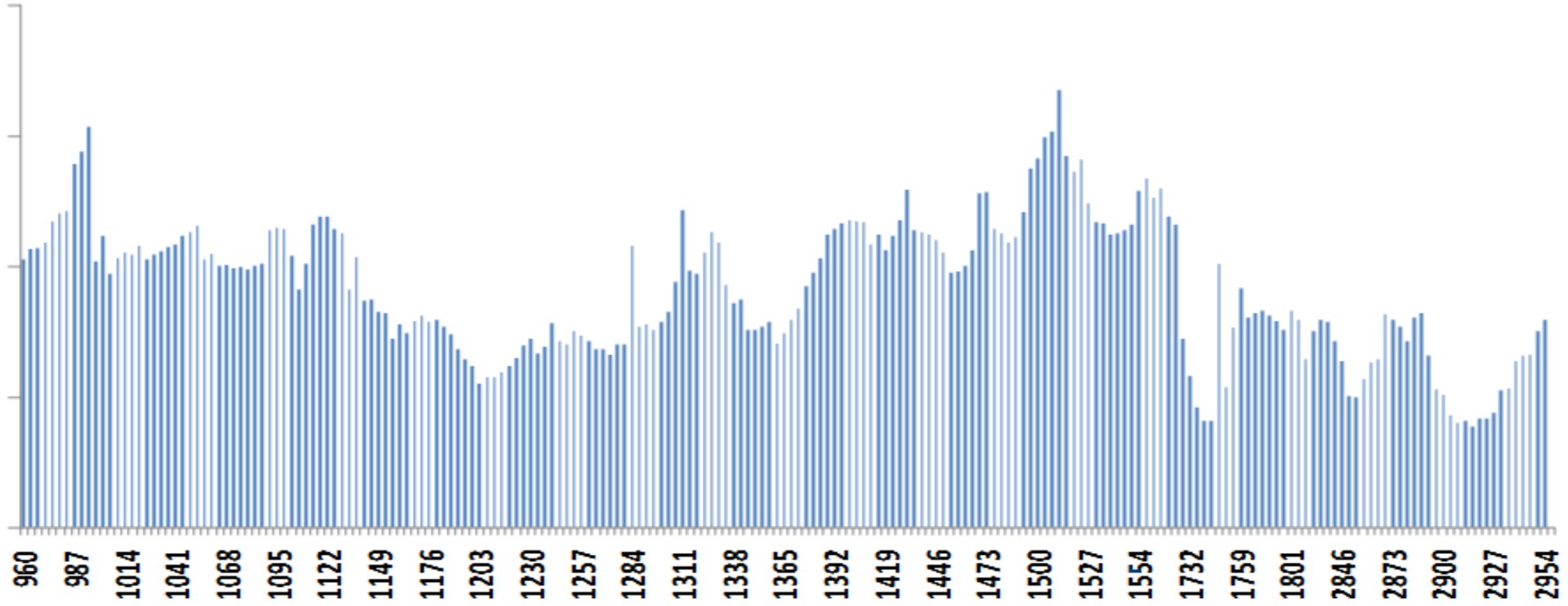
Genetic Reaction Norm Models

- y_{ij} = common factors …+ a_{0_i} + f(j) x a_{1_i} +…. where
  - Common factors = other needed fixed and random effects
  - y_{ij} = response j of animal i
  - a_{0_i} and a_{1_i} = random genetic effects of animal i
  - f(j) in our 2 examples:
    - f(j) = $THI(TD_j) - 62$ if $THI(TD_j) > 62$
      = 0 if $THI(TD_j) \leq 62$
    - f(j) = days carried calf at TD_j if pregnant
      = 0 if not-pregnant

External Stress: Heat Stress

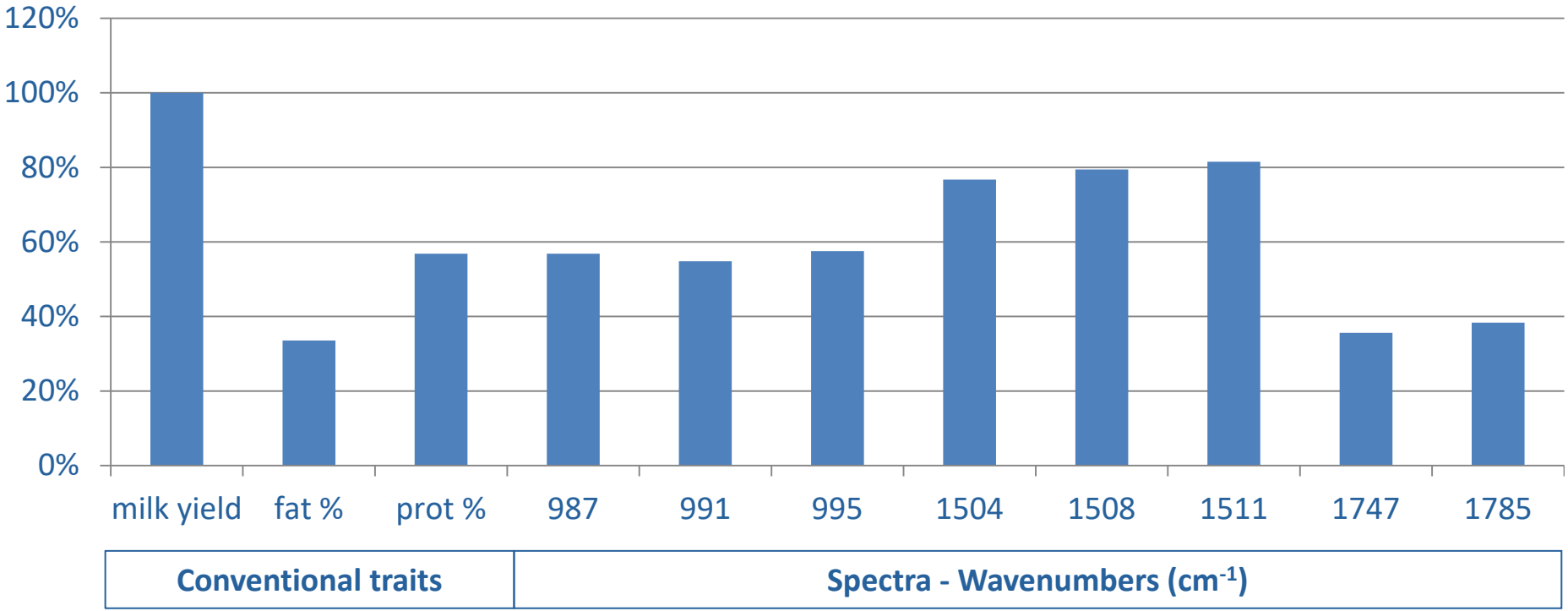
- Continuation of studies done by Hedi Hammami
  - Results here primers on material in the pipeline
- Data
  - 205,987 TD records
    - Milk yield, fat%, protein% and 1060 wavenumbers
  - THI values of 3-d lag correspondant to each TD
  - 29,467 primiparous Walloon Holstein cows

Ratio of Slope / Intercept Variances for Wavenumbers

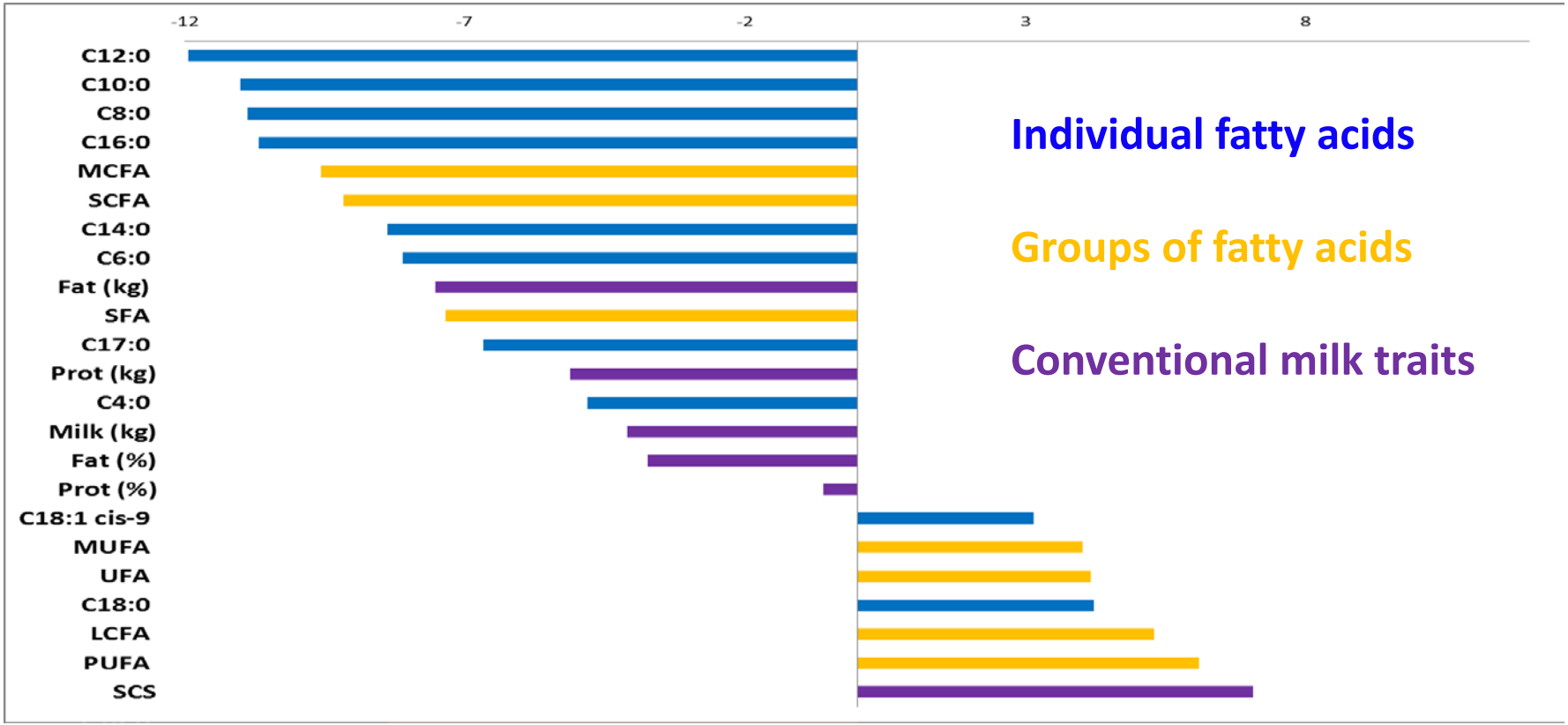


Spectra - Wavenumbers (cm^{-1})

Relative Ratio of Slope / Intercept Variances



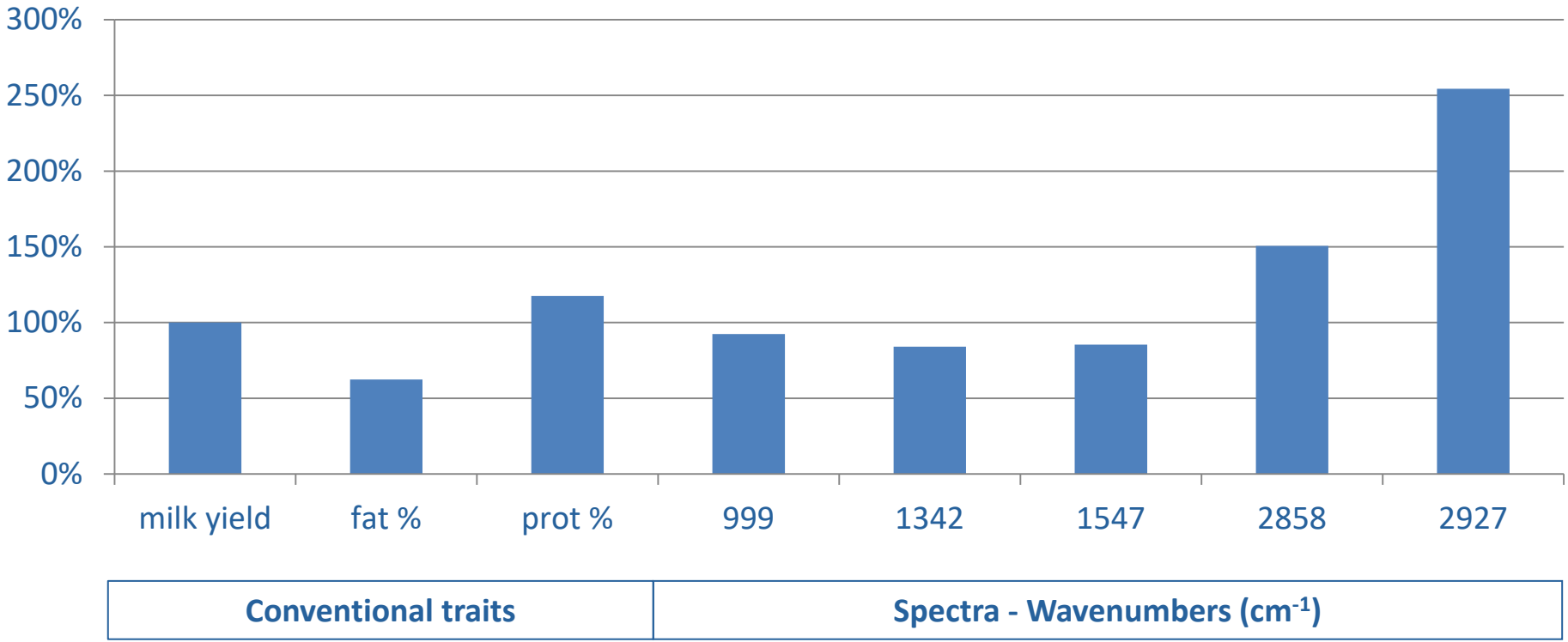
Other Opportunities (HS+ vs HS-) !



Internal Stress: Gestation

- Continuation of studies done by Aurélie Lainé
  - Results here primers on material in the pipeline
- Data
  - 56,902 TD records
    - Milk yield, fat%, protein% and 5 wavenumbers, identified for showing highest phenotypic response
  - Confirmed gestations → confirmed days carried calf
  - 9,757 primiparous Walloon Holstein cows

Relative Ratio of Slope / Intercept Variances



Conclusions - I

- Examples showed alternative “model based” definition of MIR spectra based “phenotypes”
  - Reaction to “stress”

Novel class of “model-based” biomarkers

Conclusions - II

- First results of on-going studies
- Comparison of MIR wavenumbers with yield and traditional components showed potential
- Heat-stress:
  - Optimizing MIR signal necessary (and possible)
- Gestation:
  - Some wavenumbers showed stronger signals than conventional traits

Next Steps

- Validation of basic hypothesis
  - Are animals reacting less also more resilient ?
- Moving models to genomics → single-step GBLUP
  - Straight forward for “model based” phenotypes
- Developing correct use of this novel class of phenotypes (biomarkers):
  - Transferring genetic slopes into EBV for resilience (specific and/or general)
  - Using EBV directly or indirectly (most likely) in breeding programs (and dairy cattle management)

Acknowledgements

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

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