Predicting Energy Balance Status of Holstein Cows using Mid-Infrared Spectral Data

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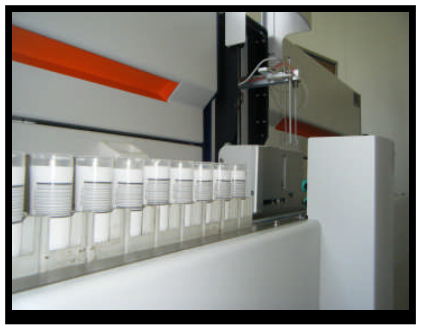
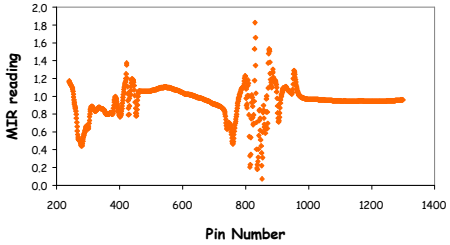
Introduction

- Energy balance (output-input) is a heritable indicator of health & fertility in dairy cows
- Useful for multi-trait breeding programme
- BUT
  - Expensive to measure (correctly)
  - Measurement not feasible on commercial herds
  - Little data available
- Methods to model energy balance exist
  - Require expensive phenotypes
  - Rely on phenotypes not always available

Example of Energy Balance Prediction

Potential errors





1

2

Milk fat content

Milk protein content

3

Predicted Energy Balance

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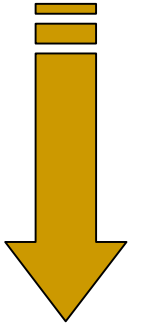
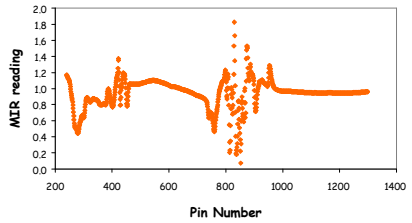
Objective

- Predict energy balance directly from milk using MIR spectral data

- Can we improve the accuracy of prediction?





Predicted Energy Balance

Materials and Methods

1. Data Collection

- Langhill experimental herd of Holstein cows (SAC, Scotland)
  - Two genetically divergent lines
  - Two feeding systems
- Routinely recorded phenotypic traits
  - Milk, fat, protein, DMI, live weight & BCS
- Random regressions fit to get daily solutions
  - Fixed effects: experiment group, year-season of calving, calving age, year-by-month of record
  - Random effect: cow*Σ(DIM)
  - Models fit within parity
  - Data retained between 1990-2010

Materials and Methods

2. Calculation of energy balance

- **Two separate measures** *(Banos & Coffey, 2010)*
  - Direct_EB = inputs – outputs

    incl. milk production, DMI, weight, BCS & diet
  - Body energy content (EC) = predicted protein and lipid weights from BCS and LWT

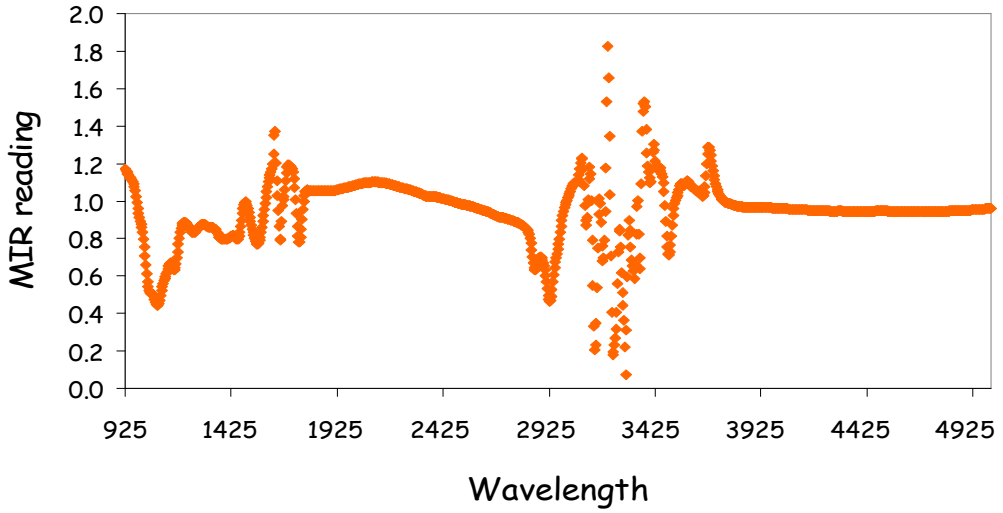
ALSO

- **Daily deviation from mean direct_EB (dev_EB)**
  - Cows own deviation within parity

Materials and Methods

3. Mid Infrared Spectral (MIR) data

- Monthly samples from all cows sent for MIR analysis
  - September 2008 – December 2009
  - Light shone through each milk sample
  - 1,060 wavelength readings for each sample



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Materials and Methods

4. Prediction equations

- Partial least squares analysis (PROC PLS, SAS)
- Two models – MIR only
  MIR + milk yield
  - AM, PM & MD yields analysed separately
    - 1,199 AM, 1,127 PM and 1,148 MD records available
  - Cross validation method (max 20 factors)
  - Also external validation
    - 25% of data set independently tested
  - Best model has the highest R^2 for EXT. validation

RESULTS

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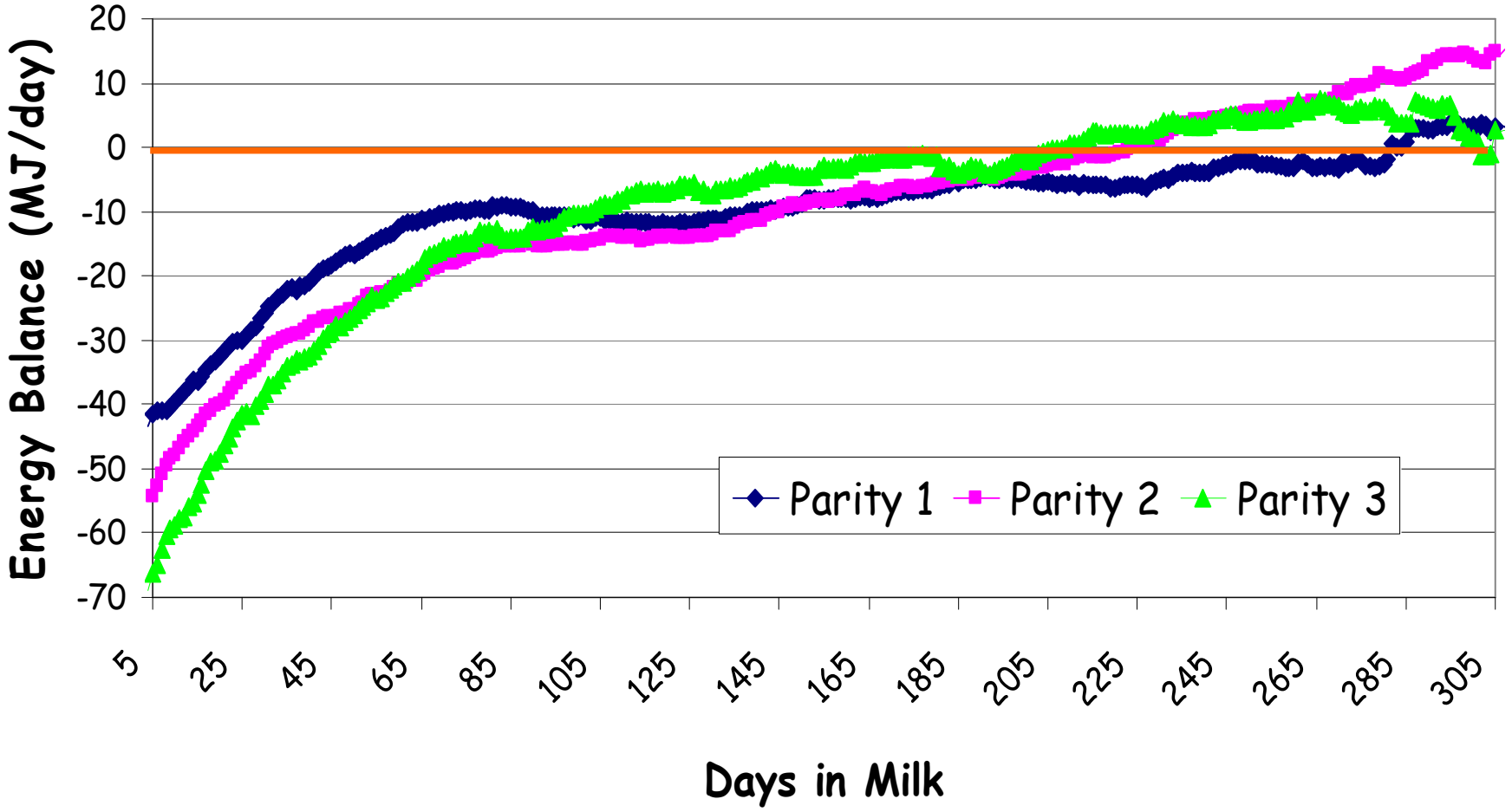
Energy Balance Lactation Curves



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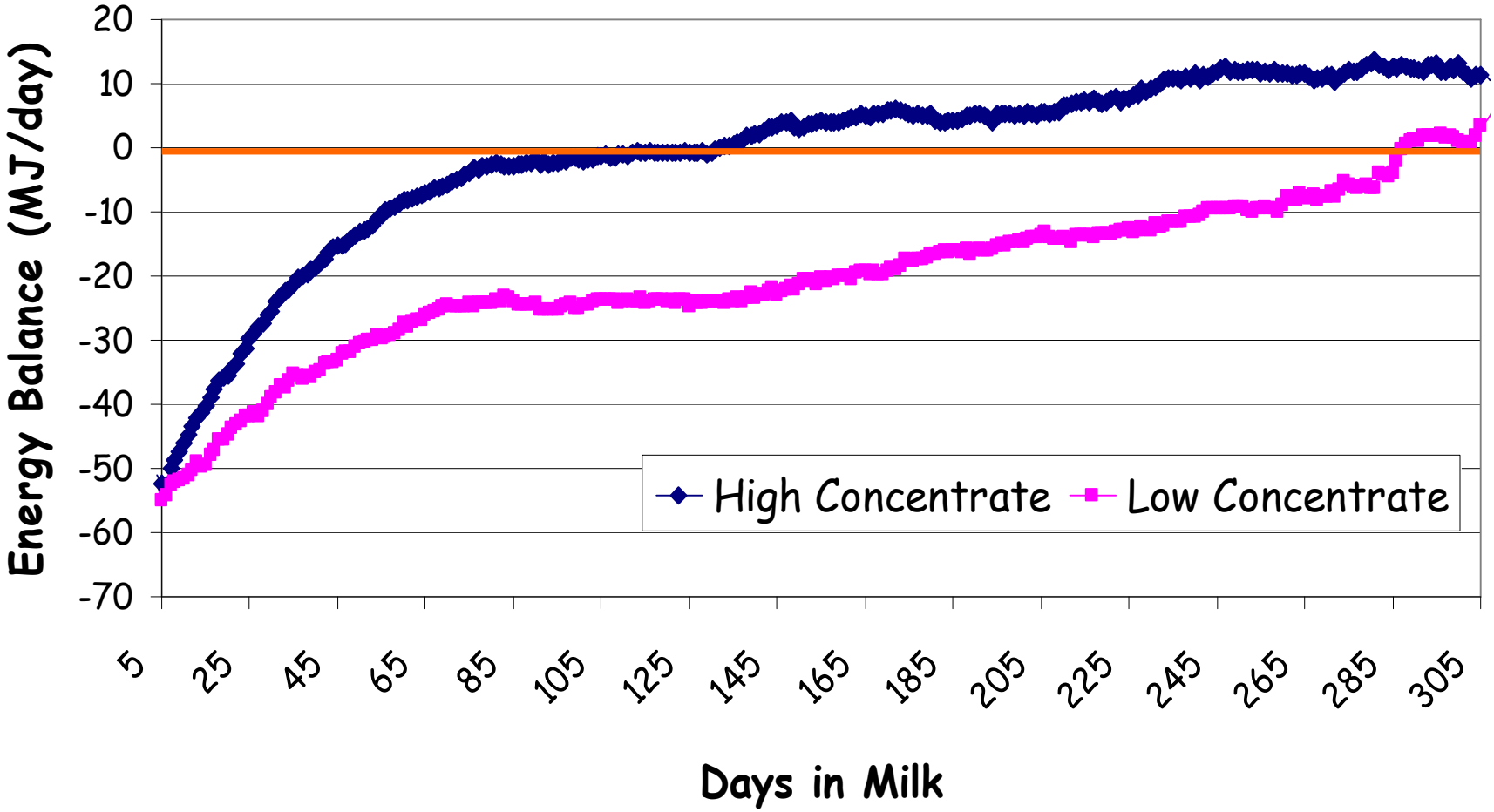
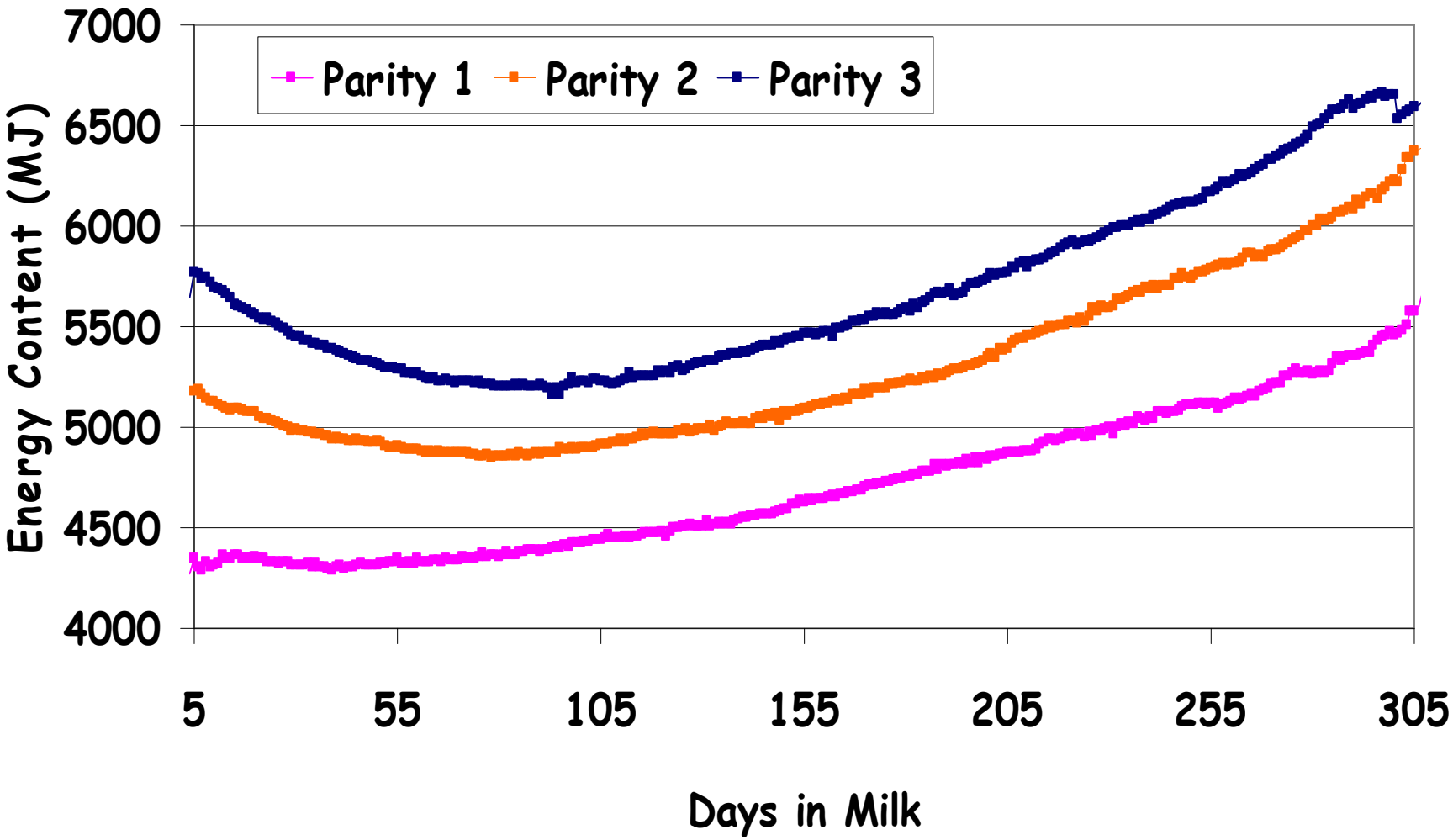
Energy Balance - Feed Group



Energy Content Lactation Curves



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Prediction using Fat : Protein

Lactation Stage	AM	MD	PM
Entire	0.01	0.02	0.02
Early	0.10	0.11	0.13
Middle	0.00	0.00	0.00
Late	0.01	0.01	0.01

Cross Validation Results

	R^2	RMSE	Factors
AM			
Direct_EB	0.41	25	18
Energy Content	0.25	1131	17
DEV EB	0.40	20	17

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Cross Validation Results

	R^2	RMSE	Factors
AM			
Direct_EB	0.41	25	18
Energy Content	0.25	1131	17
DEV_ EB	0.40	20	17
MD			
Direct_EB	0.35	26	16
Energy Content	0.23	1144	16
DEV_ EB	0.37	21	16

Cross Validation Results

	R^2	RMSE	Factors
AM			
Direct_EB	0.41	25	18
Energy Content	0.25	1131	17
DEV_ EB	0.40	20	17
MD			
Direct_EB	0.35	26	16
Energy Content	0.23	1144	16
DEV_ EB	0.37	21	16
PM			
Direct_EB	0.32	27	12
Energy Content	0.24	1129	16
DEV_ EB	0.38	21	10

Addition of milk yield as a predictor

Predictors	MIR only		MIR & Yield
AM			
Direct_EB	0.42	→	0.45
Energy Content	0.18		0.19
DEV_ EB	0.39		0.41
MD			
Direct_EB	0.44	→	0.46
Energy Content	0.19		0.19
DEV_ EB	0.40		0.41
PM			
Direct_EB	0.45	→	0.51
Energy Content	0.20		0.18
DEV_ EB	0.39		0.40

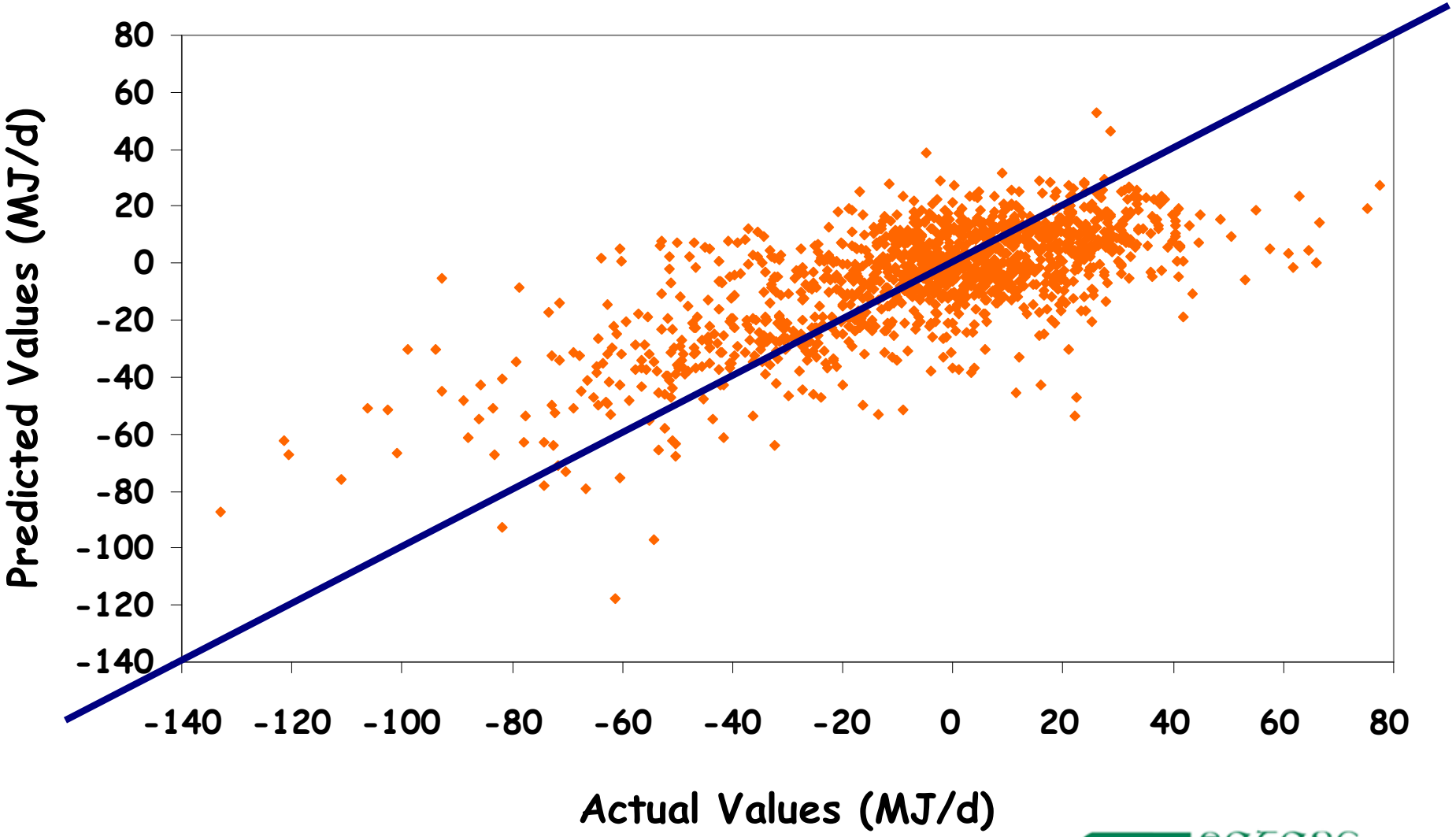
Update

- Data collection on-going
- Since collation of results presented, data size (MIR) has doubled
- Analyses re-run

Results updated -

	Previous Results	New Results	
Validation	Cross	Cross	External
AM	R^2	R^2	R^2
Direct_EB	0.32	0.43	0.42
Energy Content	0.24	0.34	0.18
DEV_ EB	0.38	0.45	0.39
MD			
Direct_EB	0.35	0.47	0.44
Energy Content	0.23	0.36	0.19
DEV_ EB	0.37	0.47	0.40
PM			
Direct_EB	0.41	0.53	0.45
Energy Content	0.25	0.38	0.20
DEV_ EB	0.40	0.48	0.39

Actual vs Predicted – direct_EB



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Conclusion

- Greater predictive ability when milk yield included in the model
- New data aided improved predictive ability
- Predictive ability for external validation <50%
  - Still a lot of unexplained variation
  - "Noisy" phenotype as measured here
- Work on-going to improve equations

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