Lactanet

RÉSEAU CANADIEN POUR L'EXCELLENCE LAITIÈRE
CANADIAN NETWORK FOR DAIRY EXCELLENCE

Canadian strategy to include methane trait in our breeding program

Filippo Miglior
Lactanet & University of Guelph
Guelph, Ontario, Canada

Building Environmental Traits Capacity Over Time

2012 - $1.2M

Milk Spectral Data

- Milk MIR pipeline and storage since 2013
  90% of milk recorded cows since 2018

2014 - $10.3M

Efficient Dairy Genome Project

- Feed Efficiency & Methane Emission DB
  4,500 cows with FE and 1,500 with ME

2018 - $12.8M

Resilient Dairy Genome Project

- Additional international partners
  12,000 cows with FE and 3,500 with ME

2022 - $6.2M

New regional initiatives

- Lactanet investing in FE and ME collection
  CH_4 sniffers in Canadian commercial farms

2024 - $16.2M

Net-zero Dairy Genome Project

- Additional international partners
  Roadmap for GHG mitigation

Since 2013, multiple projects ($4.2M) to genotype cows with medium-high density chips -> over 50,000 cows

UNIVERSITY of GUELPH

Lactanet

Why we focused on MIR strategy

- Early investment in MIR storage and MIR analysis since 2013
- EDGP project built with main objective of consolidating DMI data across international partners
  - Genome reference population large enough to build genomic evaluations for FE (~5,000 cows phenotyped and genotyped)
- Additional EDGP objective was to consolidate methane data across partners (N~1,300)
  - Heterogeneous CH4 recording across partners (GF, SF6, sniffers)
  - Not enough cows to build reliable genomic evaluations for methane
  - Only pathway was to focus on rigid methane collection protocol and accurate milk MIR prediction development

Milk MIR Data – R&D and Pipeline

- NSERC & Dairy Cluster projects (2012-2018)
  - **Milk Fat Globule Size** (Fleming et al 2017a JDS)
  - **Milk Fatty Acids** (Fleming et al 2017b JDS)
  - **Lactoferrin** & **Casein Micelle Size** (Fleming et al 2019 CJAS)
  - MIR standardization (Bonfatti et al 2017a JDS)
  - Prediction calculation comparison (Bonfatti et al 2017b JDS)
  - Pipeline (Miglior et al 2016 ICAR)
- EDGP & RDGP projects and collaborations (2015-2024)
  - **DMI** (Shadpour et al 2022a JDS)
  - **Methane production** (Shadpour et al 2022b JDS; Liu et al 2022 Animal; Van Doormaal et al 2023 ITB Bulletin; Oliveira et al 2024 JDS Comm)
  - **BCS Change** (Frizzarin et al 2023, 2024; JDS)

How we recorded methane

- Collected from the University of Guelph and University of Alberta under three international projects:

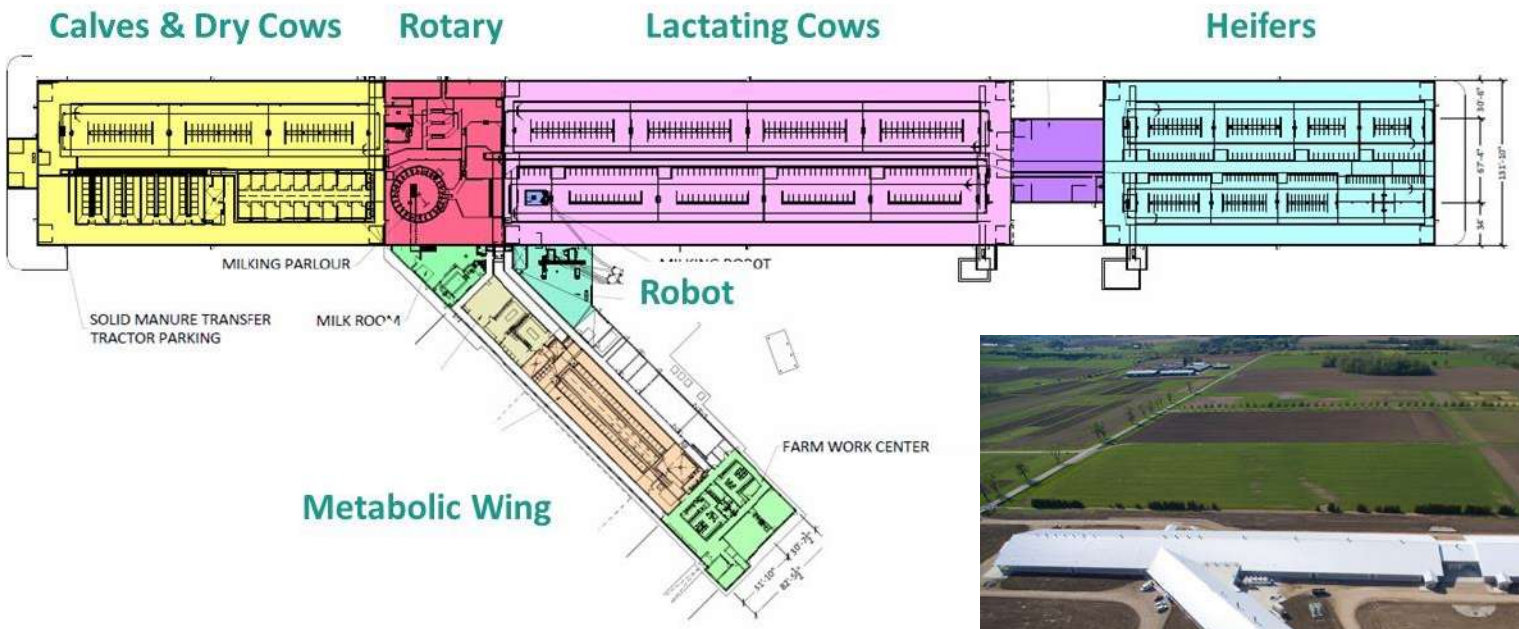
THE Efficient Dairy GENOME PROJECT

THE Resilient Dairy GENOME PROJECT

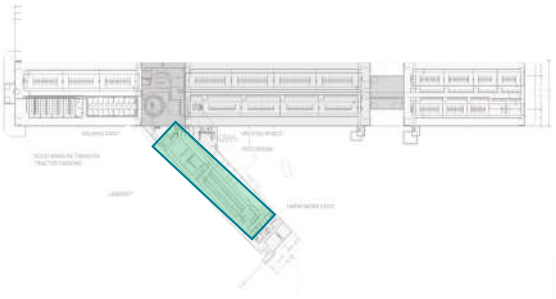
- Using GreenFeed system (C-Lock Inc., Rapid City, SD)

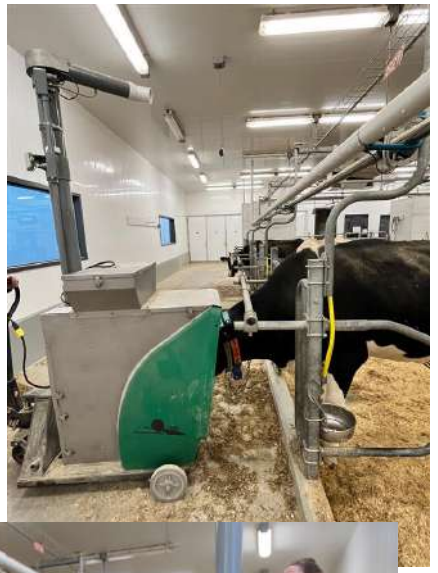
Net-Zero Dairy GENOME PROJECT

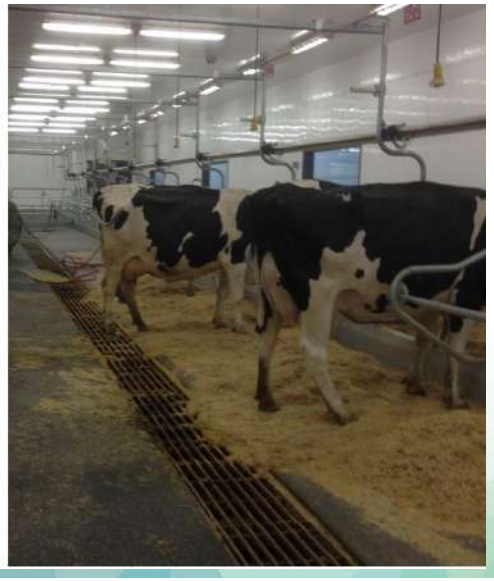
University of Guelph – Elora dairy herd (ODRC)



Elora dairy herd (ODRC) - Metabolic Wing



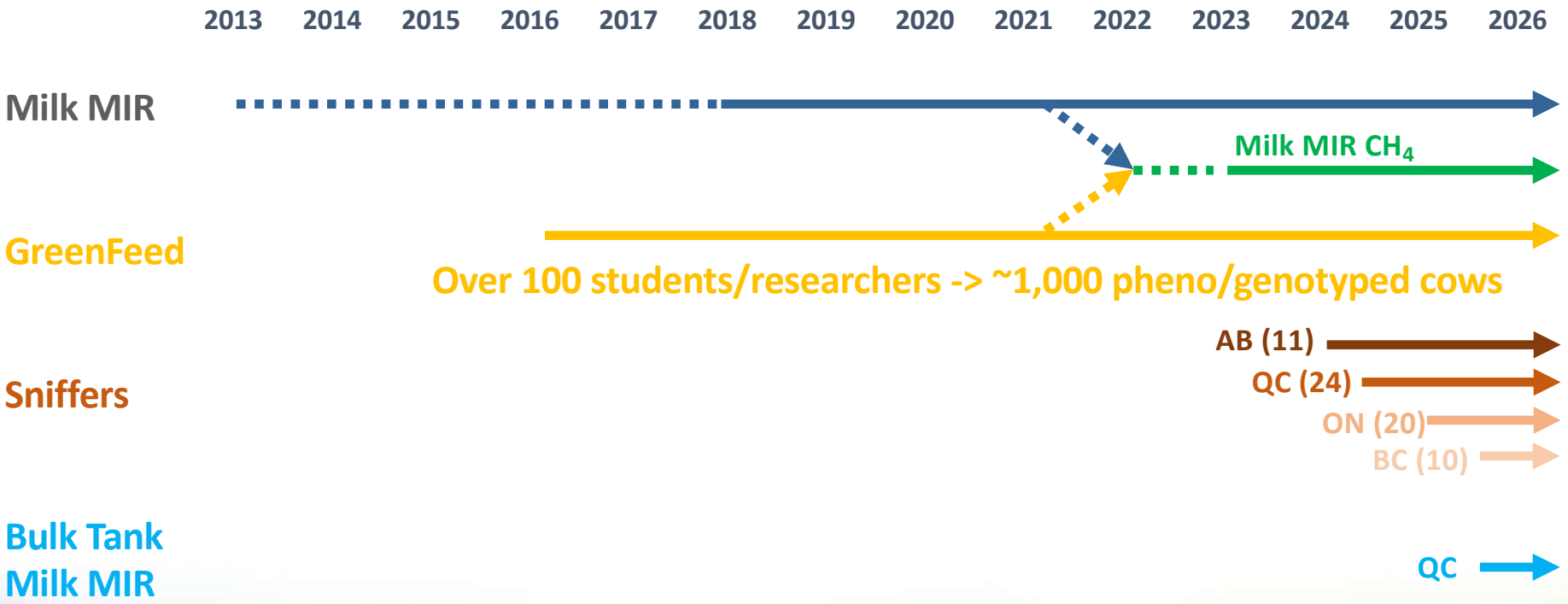




Methane Recording Protocol

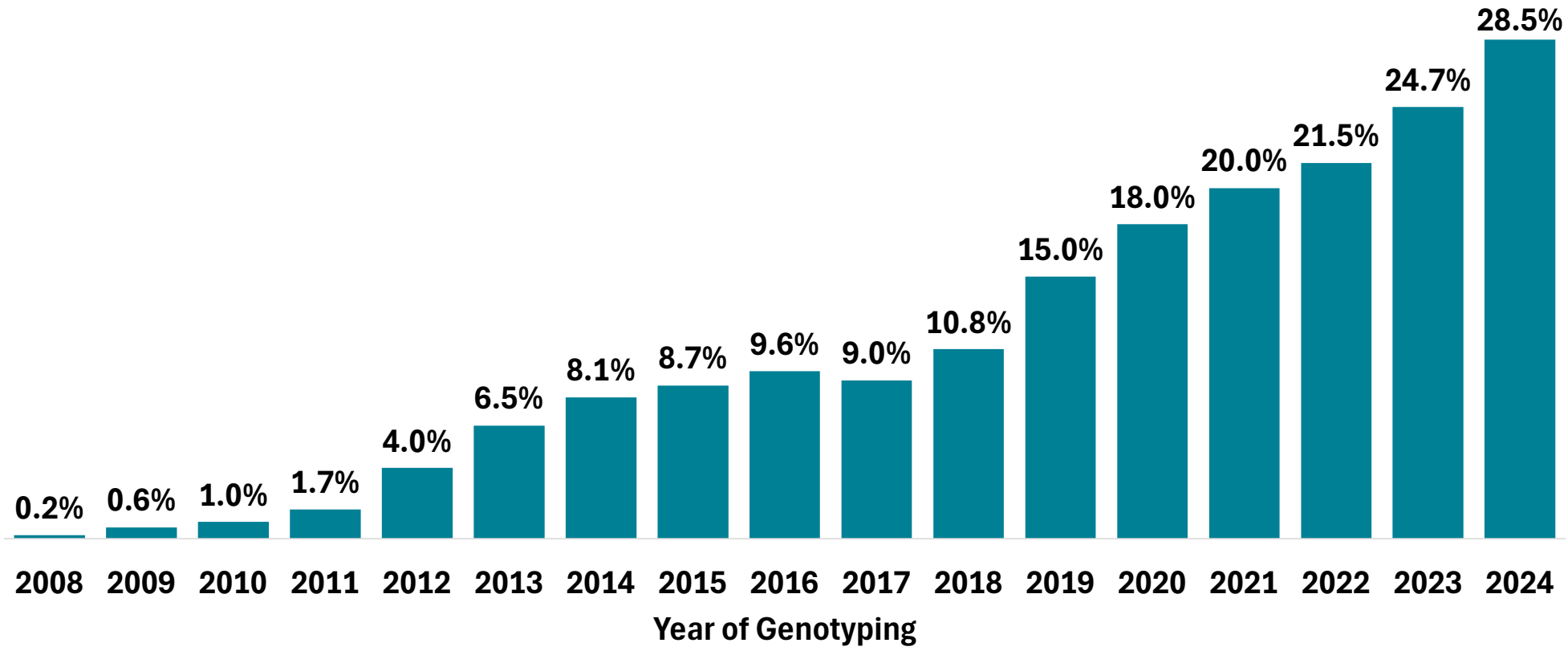
- First parity Holstein cows 120-150 days DIM moved in groups of 2 to 4 into a tie-stall area (Metabolic Wing)
- Cows habituated to the barn and testing protocol for 3 days before test
- Late Friday they enter metabolic wing, adaptation on the weekend, first test day on Monday, last test day on Friday
- 3 times a day (8am, 12pm, 4pm), 10’ each for 5 consecutive days
- GreenFeed moved away from animal and allowed to recalibrate for 3 min before testing the next animal
- DHI Test day on Wednesday (milk, fat, protein yield, lactose, BHB, MUN, SCC, MIR)
- Average daily g/d CH_4 production calculated for each animal (weekly average)

Methane Strategy Over Time



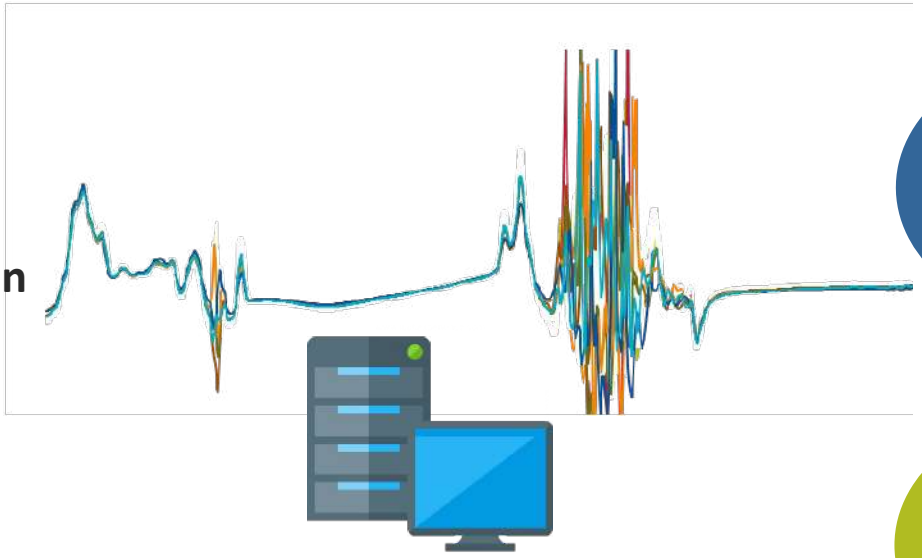
Genotyping Strategy

>75,000 Females



MIR Data Processing

Individual milk samples processed by FOSS Milkoscan FTIR spectrophotometers

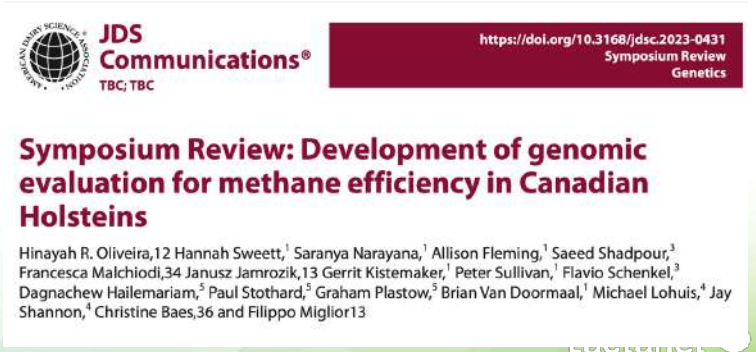


Predicting Methane

- MultiLayer Perceptron Artificial Neural Network based on Bayesian regularization model
- 241 MIR spectral datapoints used as input predictors
- Collected average daily methane from 496 cows from two herds between 5-305 DIM

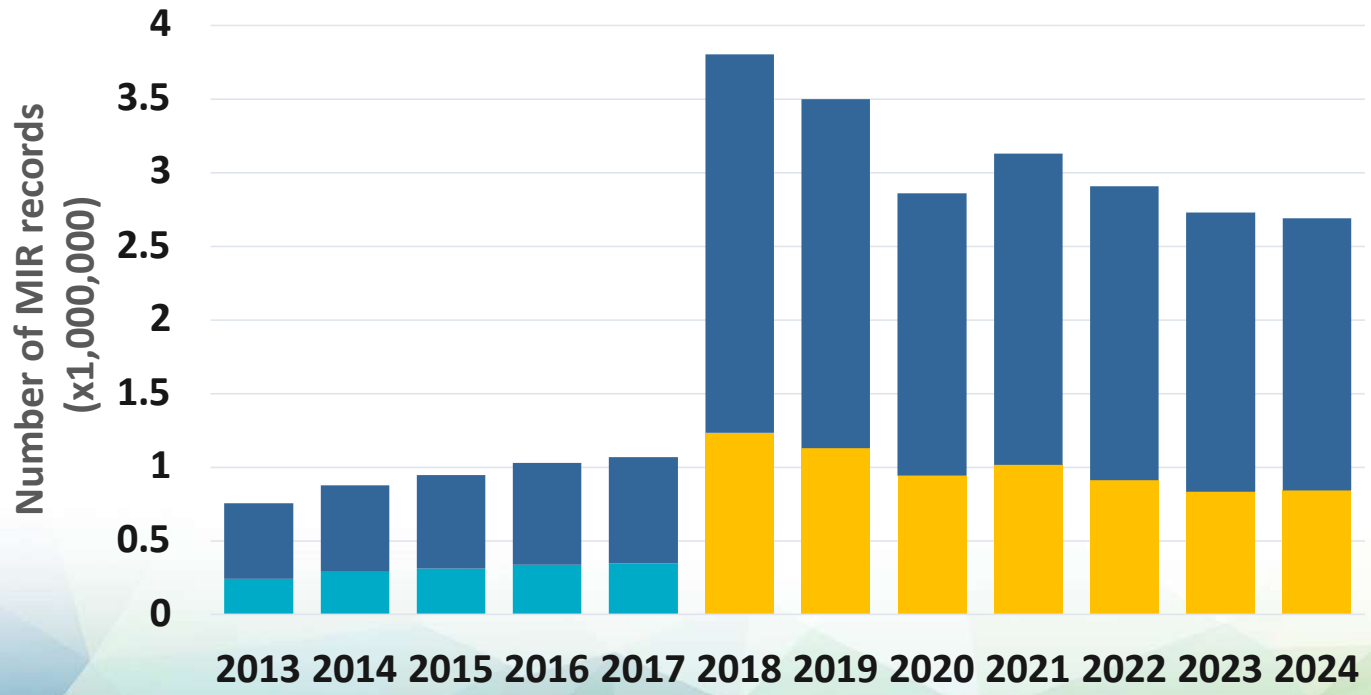
Prediction accuracy of 0.70

Genetic Correlation 0.92 (0.22)



Apply prediction to MIR population

- Great potential and availability – over **26M** records since 2013
- Milk MIR data on **90% of milk recorded cows** since 2018



≈7.2M records from 1st parity Holsteins in ~7,500 herds

≈1.7M cows

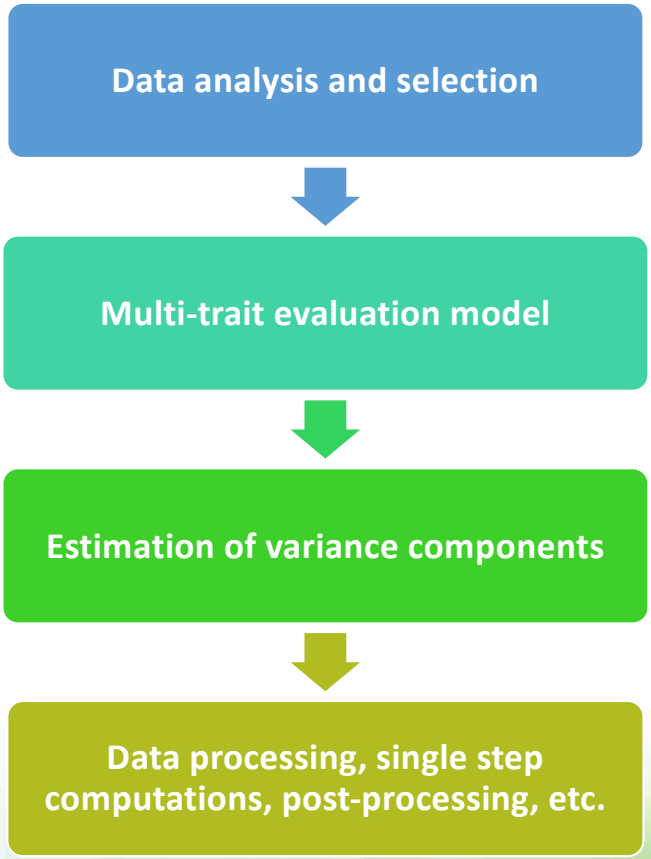
≈215,000 genotyped cows

UNIVERSITY of GUELPH

Lactanet

From research to service mode

Lactanet and Semex collaborated on the development of the prediction and a new, single step genomic evaluation system



Data Used for Genetic Evaluation

- First parity Holsteins from 6,128 herds
- Between 120 and 185 DIM

Records	1,026,133	**Genotyped Animals**	311,751
Cows	706,775	**Genotyped Cows**	151,892
Sires	11,491	**Genotyped Sires**	8,932

*Numbers for December 2024 evaluations

Genomic Evaluation for Methane Efficiency

- **Single-step four-trait repeatability Animal Model (using MiX99)**
  - MIR Predicted Methane (CH_4, g/d), Milk (kg/d), Fat (kg/d), Protein (kg/d)
  - Fixed: Age at calving, DIM, Year-Season of calving
  - Random: Herd-Test-Date, Permanent Environment, Animal
- **Post-evaluation, Methane Efficiency (ME) is calculated:**
  - Recursive re-parameterization, Jamrozik et al., 2017 JDS https://doi.org/10.3168/jds.2016-12177
  - Predicted CH_4 production genetically independent of Milk, Fat and Protein yields via linear regression

Methane Efficiency helps to reduce the methane production of the herd without impacting production levels

Genetic Parameters

	Predicted CH_4	Milk Yield	Fat Yield	Protein Yield
Predicted CH_4	**0.23**	-0.13	0.38	-0.11
Milk Yield	-0.06	**0.38**	0.48	0.83
Fat Yield	-0.18	0.66	**0.27**	0.71
Protein Yield	0.01	0.90	0.74	**0.28**

Heritabilities on diagonal, Genetic correlations above diagonal, Phenotypic correlations below diagonal

*all approximated SE are <0.033

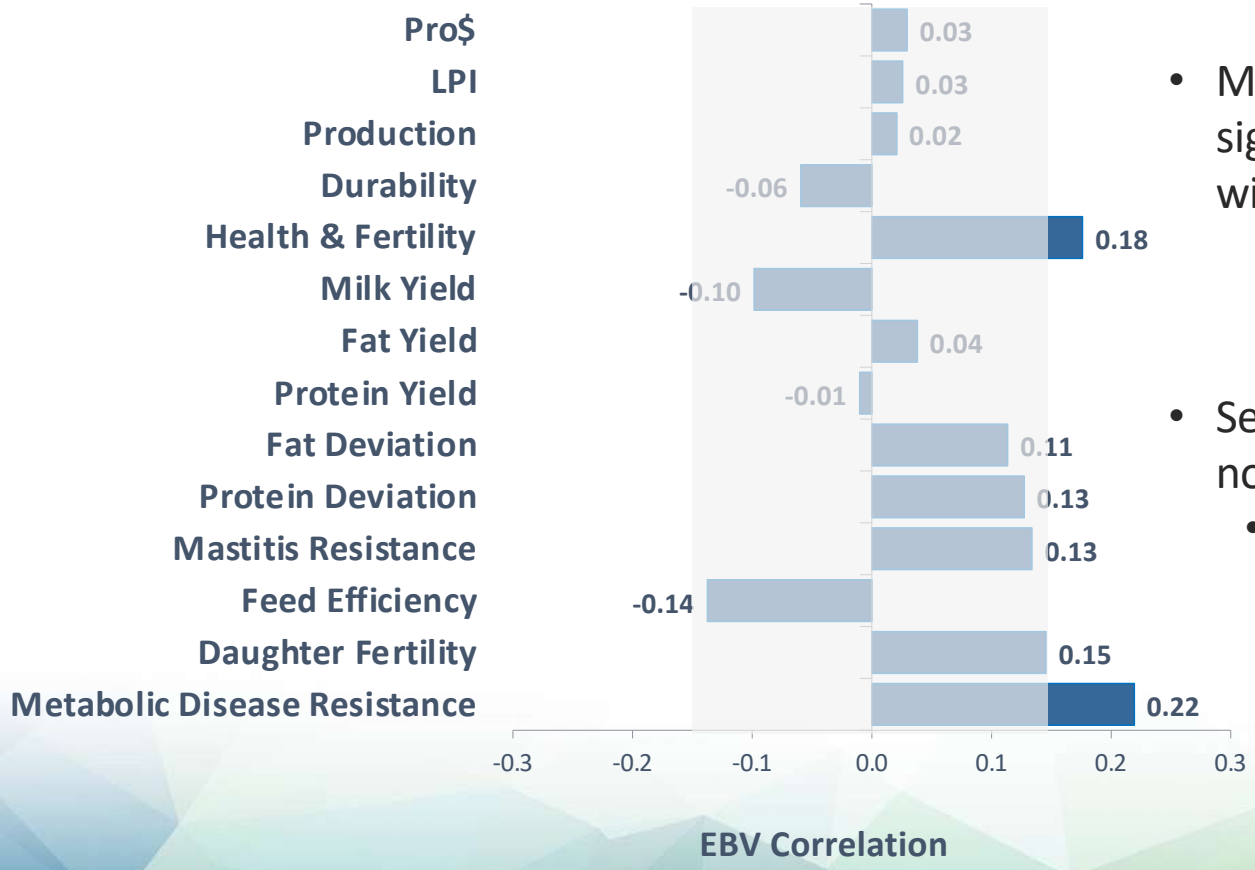
Methane Efficiency vs Methane Production

- 75% genetic correlation between Methane Efficiency and Methane Production
- Methane Efficiency is not genetically correlated with any production traits

	Milk	Fat	Protein
Methane Production	-0.13	0.38	-0.11
Methane Efficiency	0.00	0.00	0.00

Lactanet

Methane Efficiency is a New Trait



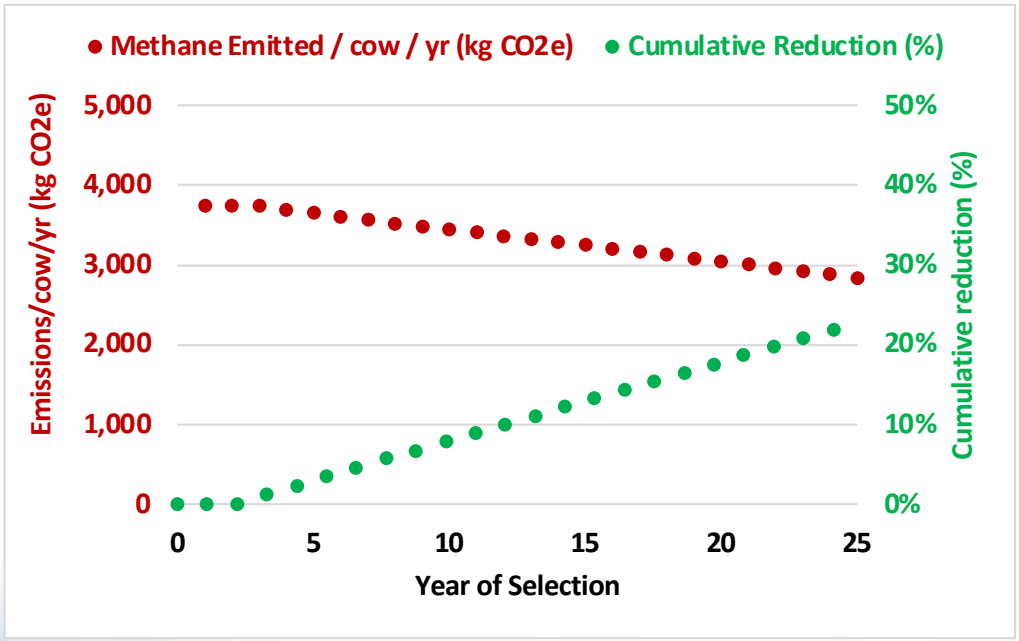
- Methane Efficiency does not have a significant unfavorable correlation with any other evaluated trait
- Selection for Feed Efficiency does not also improve Methane Efficiency
  - Both traits are independent of production yields

Reliability of Methane Efficiency RBV

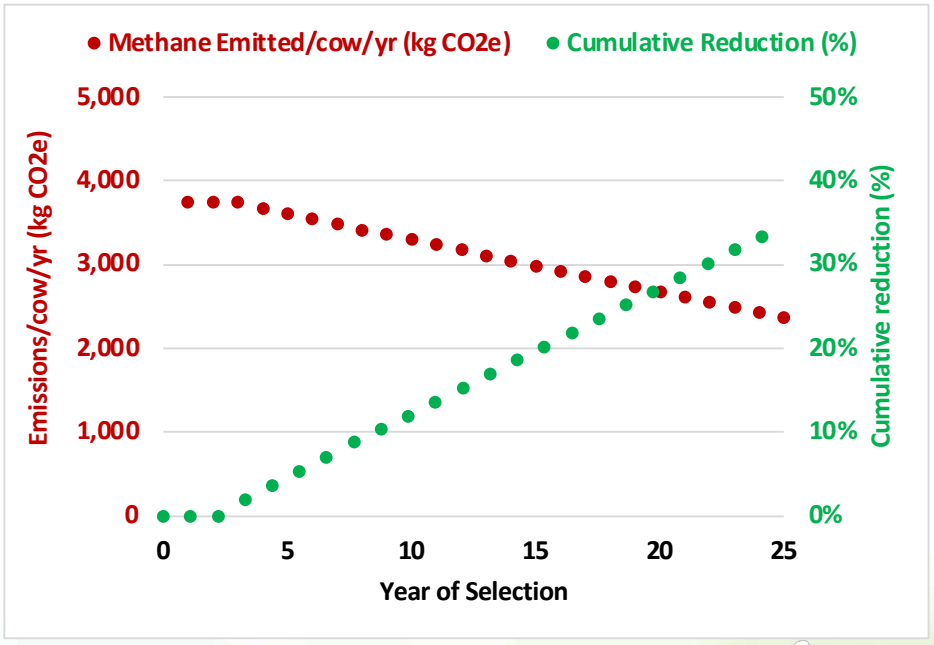
	Reliability
Genotyped cows with data	86.7%
Ungenotyped cows with data	56.3%
Proven bulls	95.9%
Genotyped young bulls	77.7%
Genotyped heifers	72.2%

Genetic progress over time

Bulls > 1 SD



Bulls > 1 SD & Cows > mean



Interpretation

Reduce CH_4 production by selecting for higher Methane Efficiency without impacting production traits

5-point ↑ in a sire's RBV for ME, daughters are expected to produce 3kg less CH_4 per year

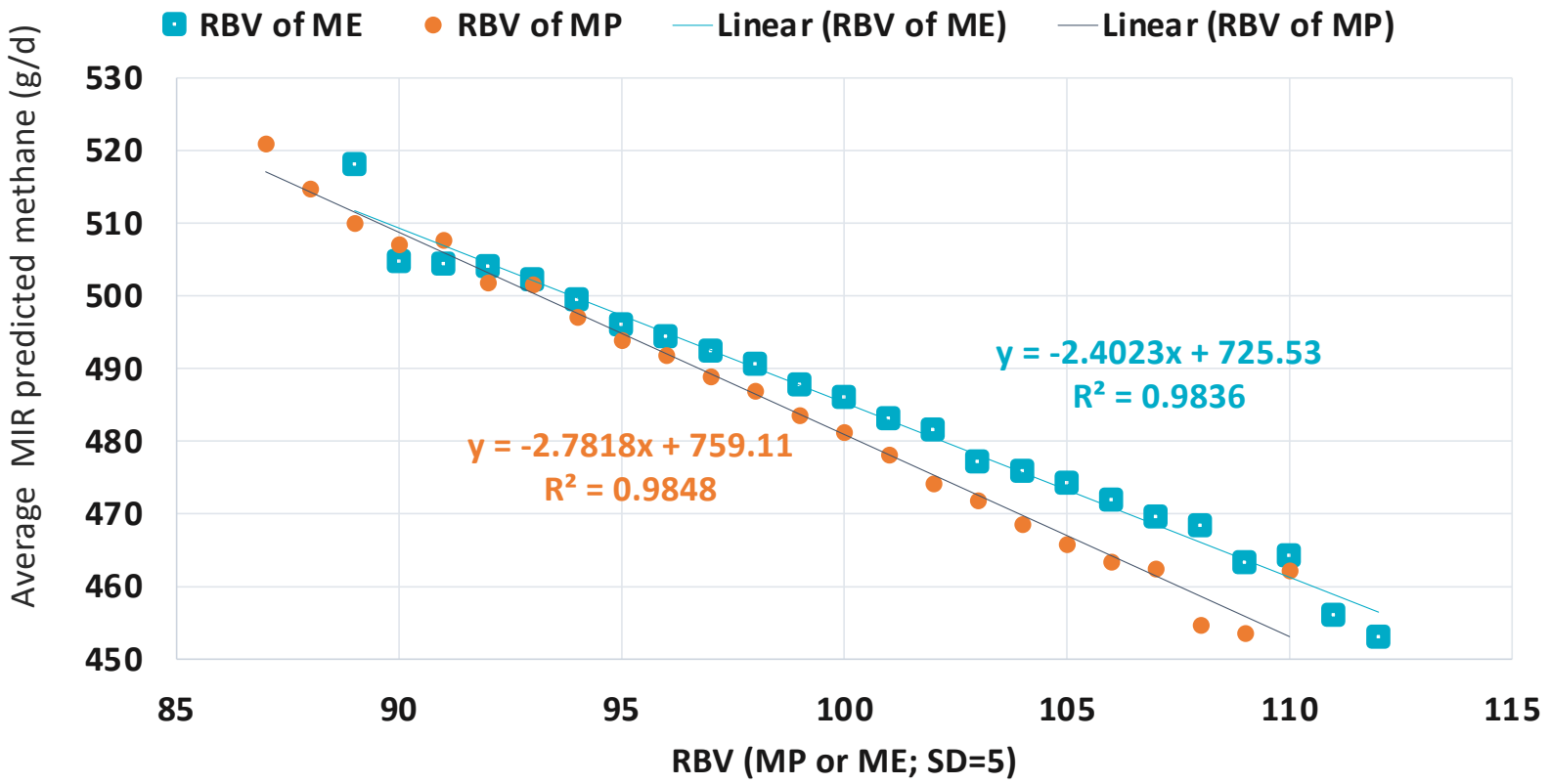
↓

1.5% decrease in CH_4 emissions per cow per year

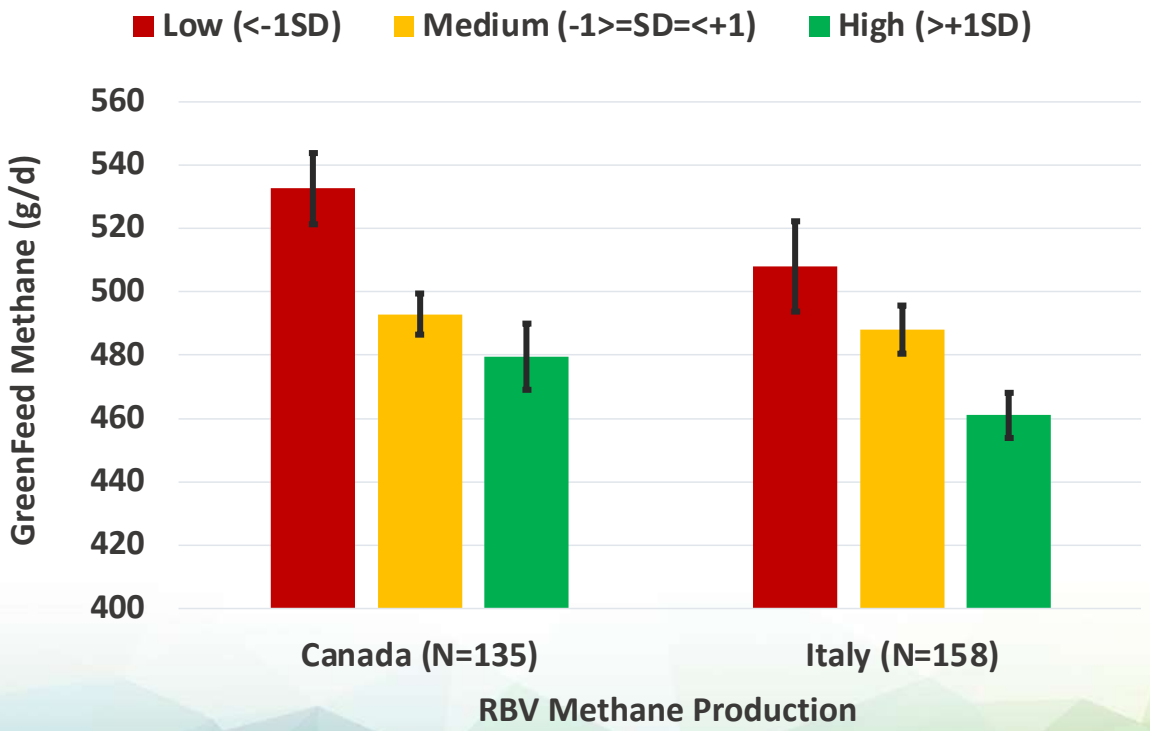
↓

Herd owners selecting for ME can achieve 20-30% reduction in CH_4 emissions from their herd by 2050

GE Validation – MIR predicted methane



GE Validation – GreenFeed Methane



A Team Effort

Allison Fleming
Janusz Jamrozik
Gerrit Kistemaker
Filippo Miglior
Saranya Narayana
Hinayah Oliveira
Hannah Sweett
Brian Van Doormaal

Christine Baes
Flavio Schenkel
Saeed Shadpour
And over 100 grad students and post-docs that every day, three times a day have been collecting CH4 data since 2016

Francesca Malchiodi
Mike Lohuis
Jay Shannon

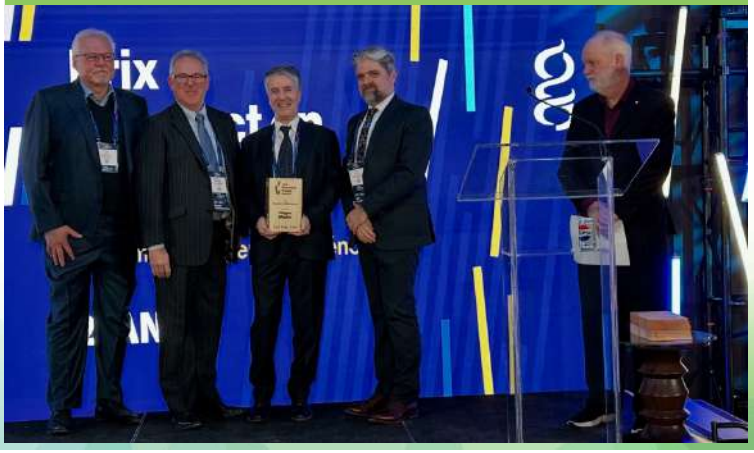
Dagnachew Hallemariam
Graham Plastow
Paul Stothard

2023 International Dairy Federation Innovation in Climate Action Award

2024 ADSA J.D. Lush Award in Animal Breeding

2023 University of Guelph Innovation of the Year Award awarded to team

2025 Genome Canada Genomics Impact Award for Industry Collaboration



UNIVERSITY of GUELPH

Lactanet

Development of GHG index

abacusbio.

Breeding for sustainability: development of an index to reduce GHG in dairy cattle

Invited talk at EAAP 2024 – Florence, Italy

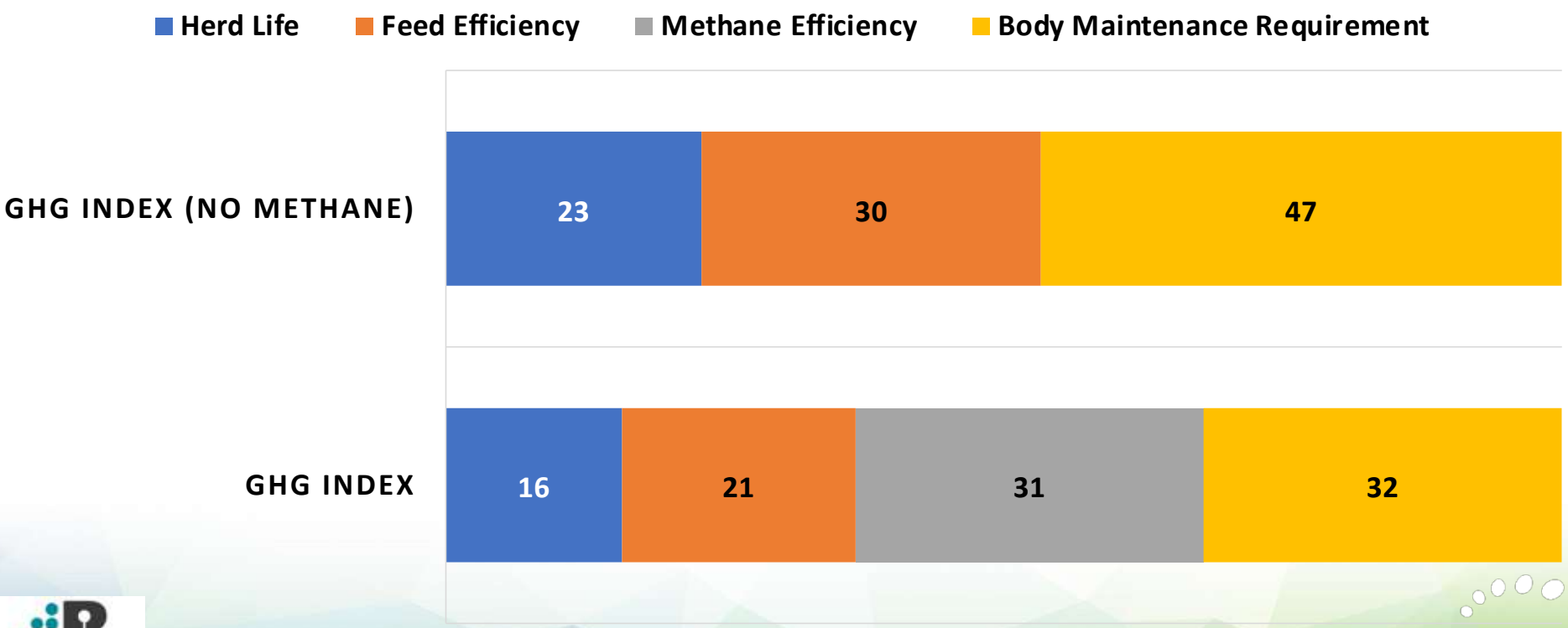
2024 Dairy Cattle Industry Forum - Toronto

Caeli Richardson, P. Amer, T. Oliveria, K. Grant J. Crowley, C. Quinton, A. Fleming, F.M. Miglior and F. Malchiodi

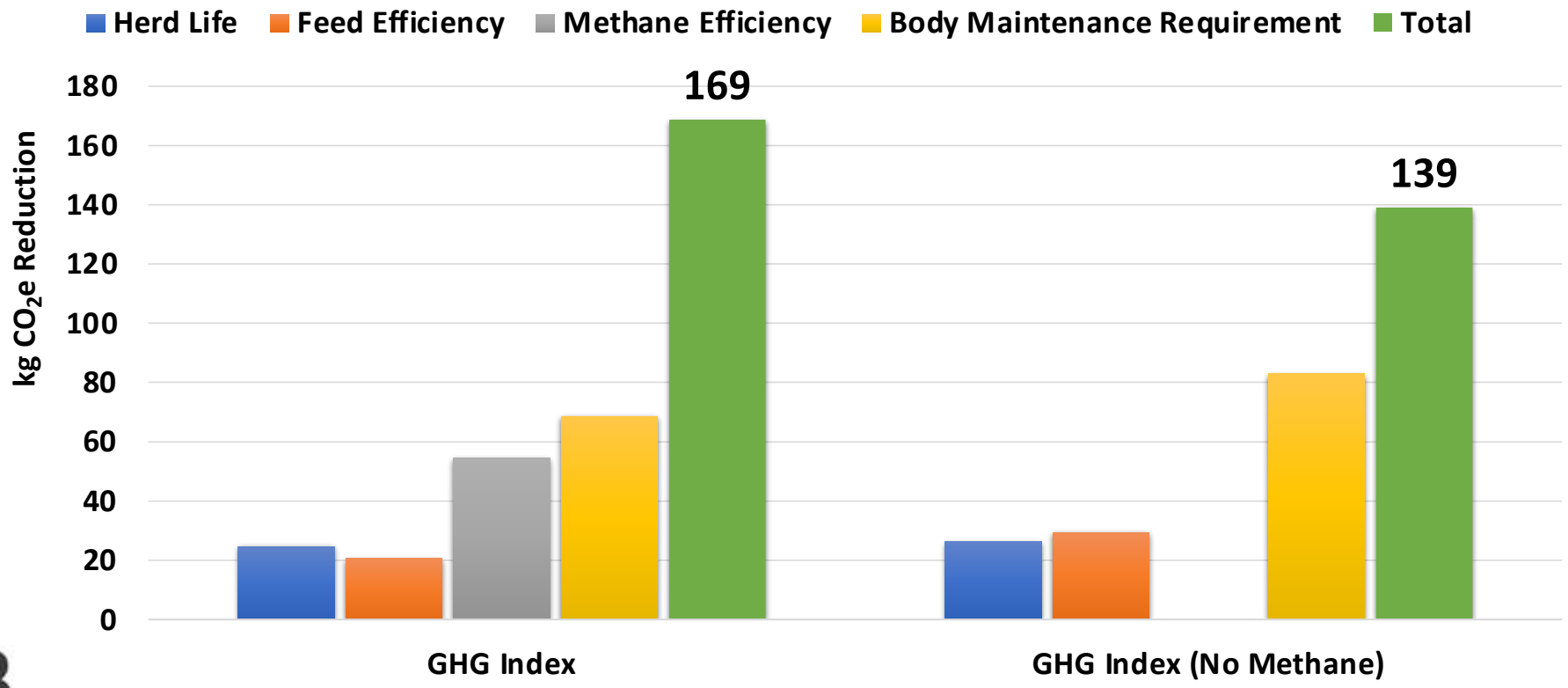
SEMEX Genetics for Life

Lactanet

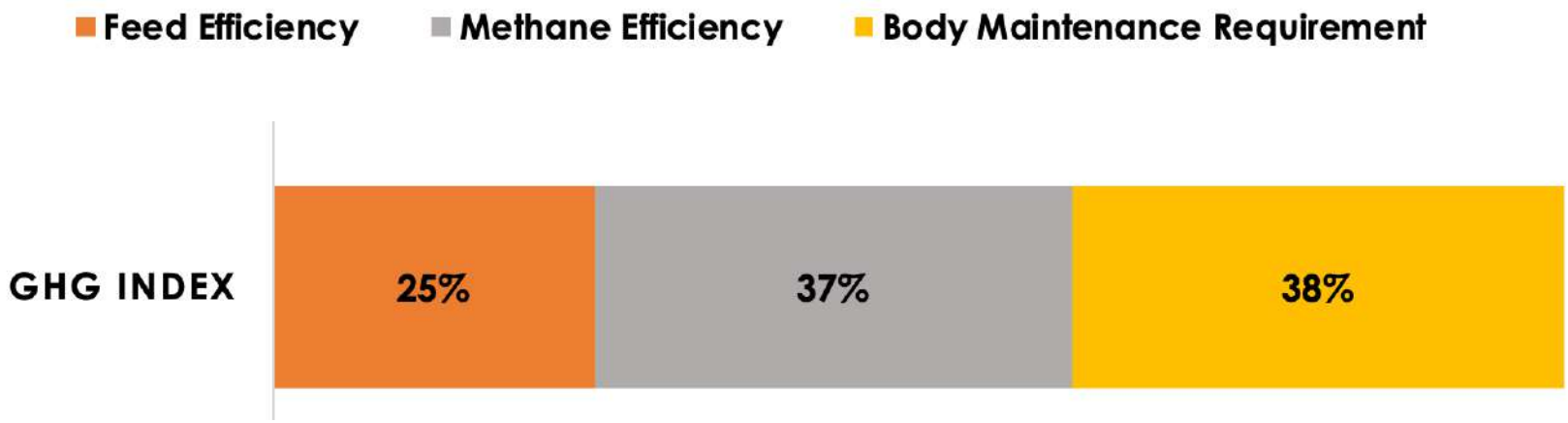
Trait Relative Emphasis in a GHG Index



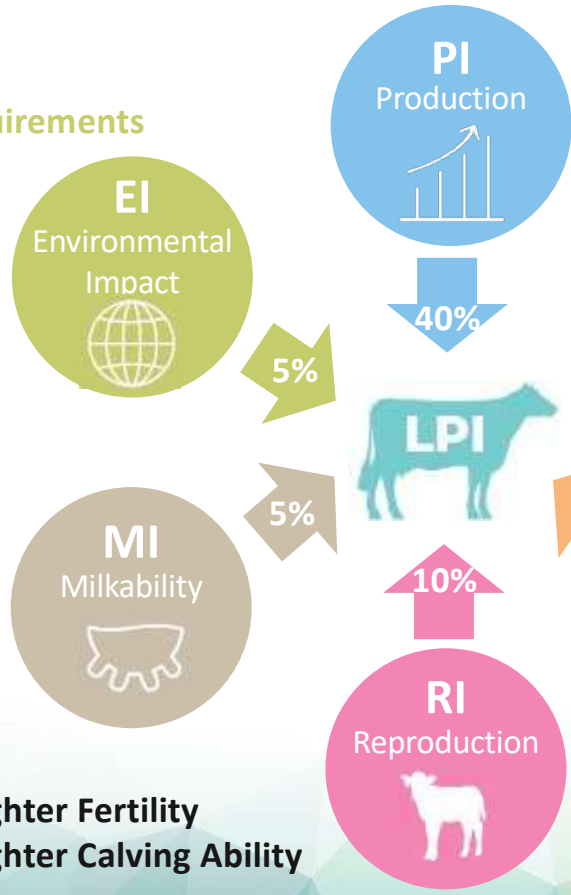
Genetic Gains in GHG Emission Reductions (kg CO_2e)



Trait Relative Emphasis in a GHG Index (w/o Herd Life)



Modernized LPI - April 2025



38% Body Maintenance Requirements
37% Methane Efficiency
25% Feed Efficiency

40% Protein Yield
60% Fat Yield

37% Mammary System
33% Feet & Legs
20% Herd Life
5% Dairy Strength
5% Rump

36% Teat Length
25% Milking Speed
18% Temperament
15% Udder Depth
-6% Udder Floor

47% Mastitis Resistance
27% Metabolic Disease
21% Hoof Health
5% Cystic Ovaries

90% Daughter Fertility
10% Daughter Calving Ability

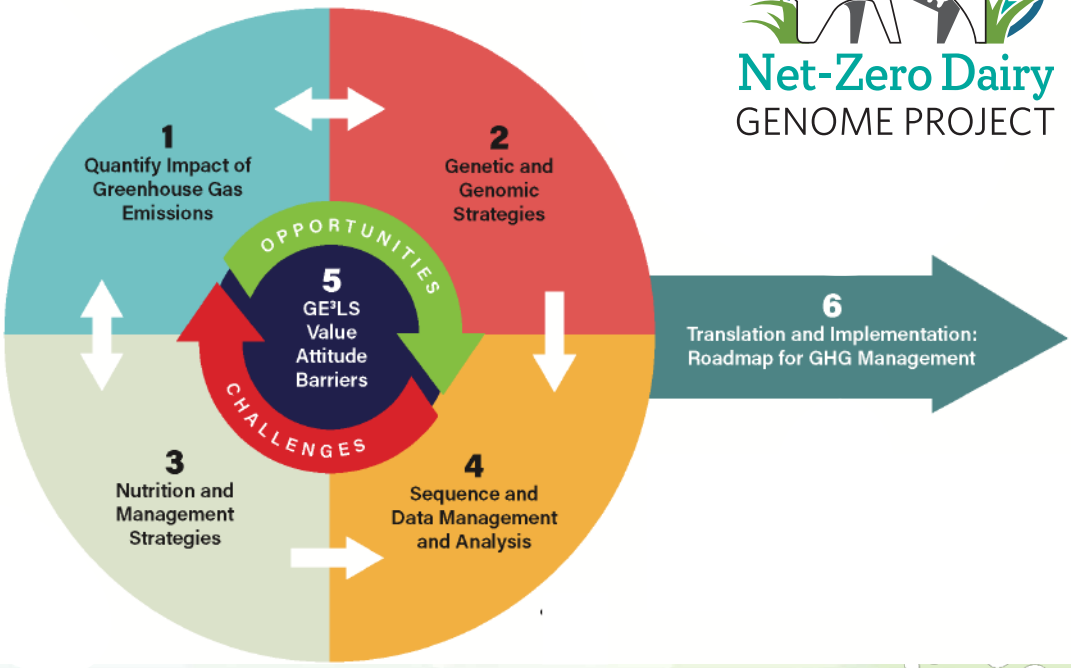
Net-zero Dairy Genome Project

GenomeCanada

Net-Zero Dairy
GENOME PROJECT

GOALS

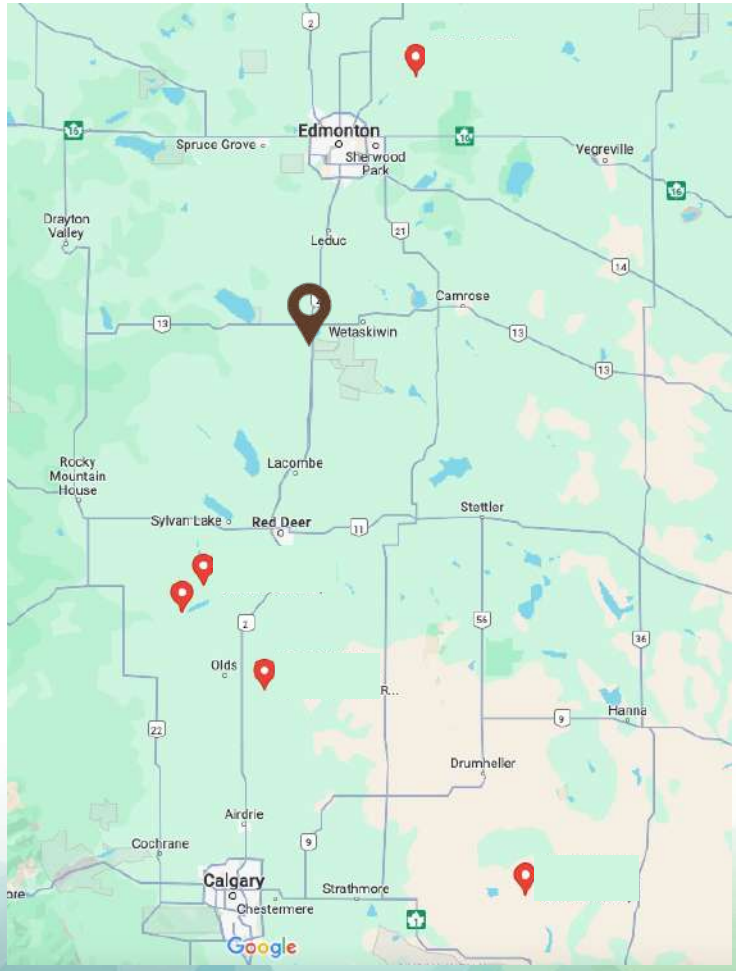
- Consolidation of existing methane emissions data (including beef)
- Estimate animal and herd-level emissions
- Quantify potential GHG reductions through genetic and nutrition strategies
- Enhance CH_4 genomic evaluations
- Understand public attitudes/behaviours to emissions reductions
- Develop and implement CH_4 herd monitoring and benchmarking tools
- **Develop a roadmap for CH_4 mitigation**



MooLoggers in Alberta - RDAR/Alberta Innovates

5 farms – 11 sniffers

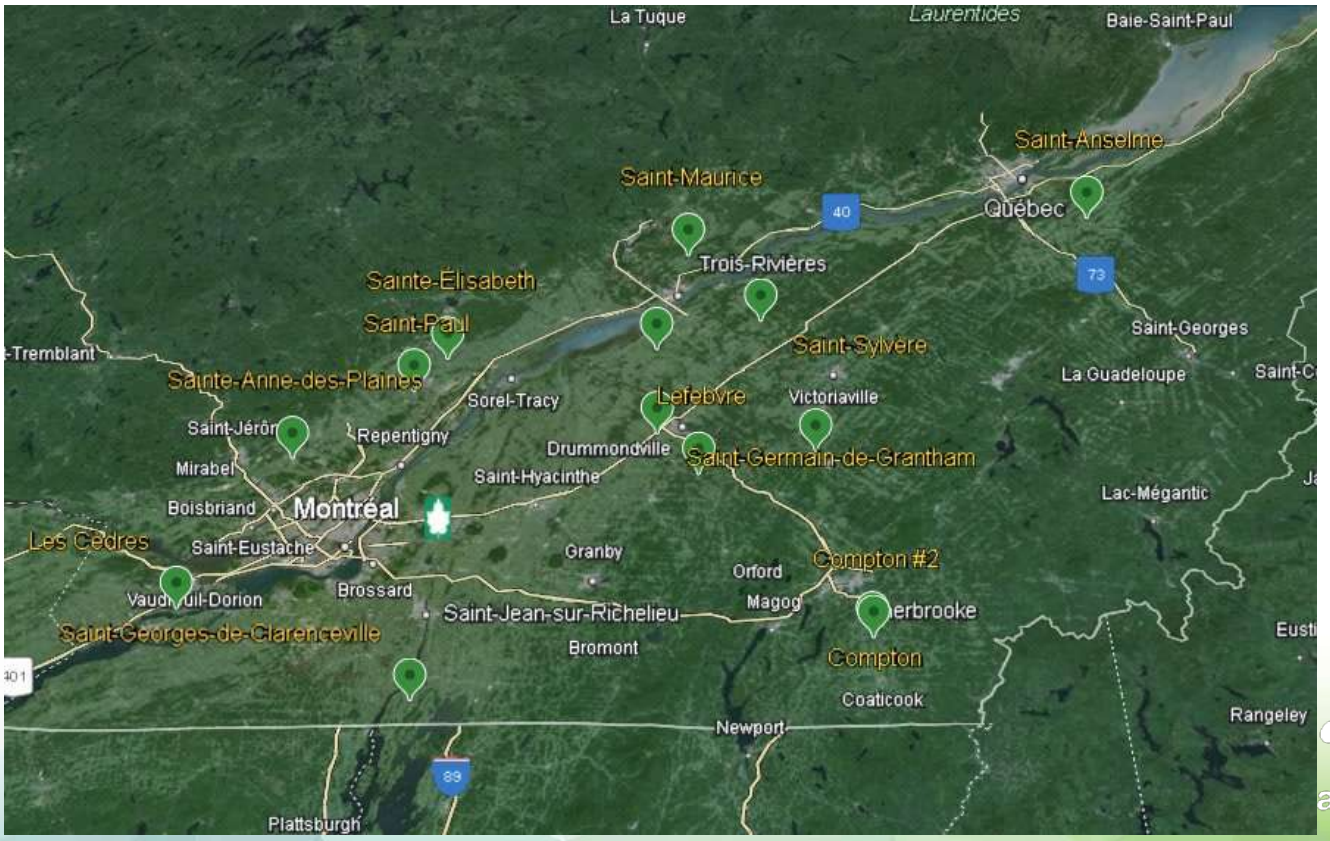
- **2-3 MooLoggers each**
- **4 Holstein**
- **1 Jersey**
- **Lely robots**



MooLoggers in Quebec – Methane Quebec

14 farms – 24 sniffers

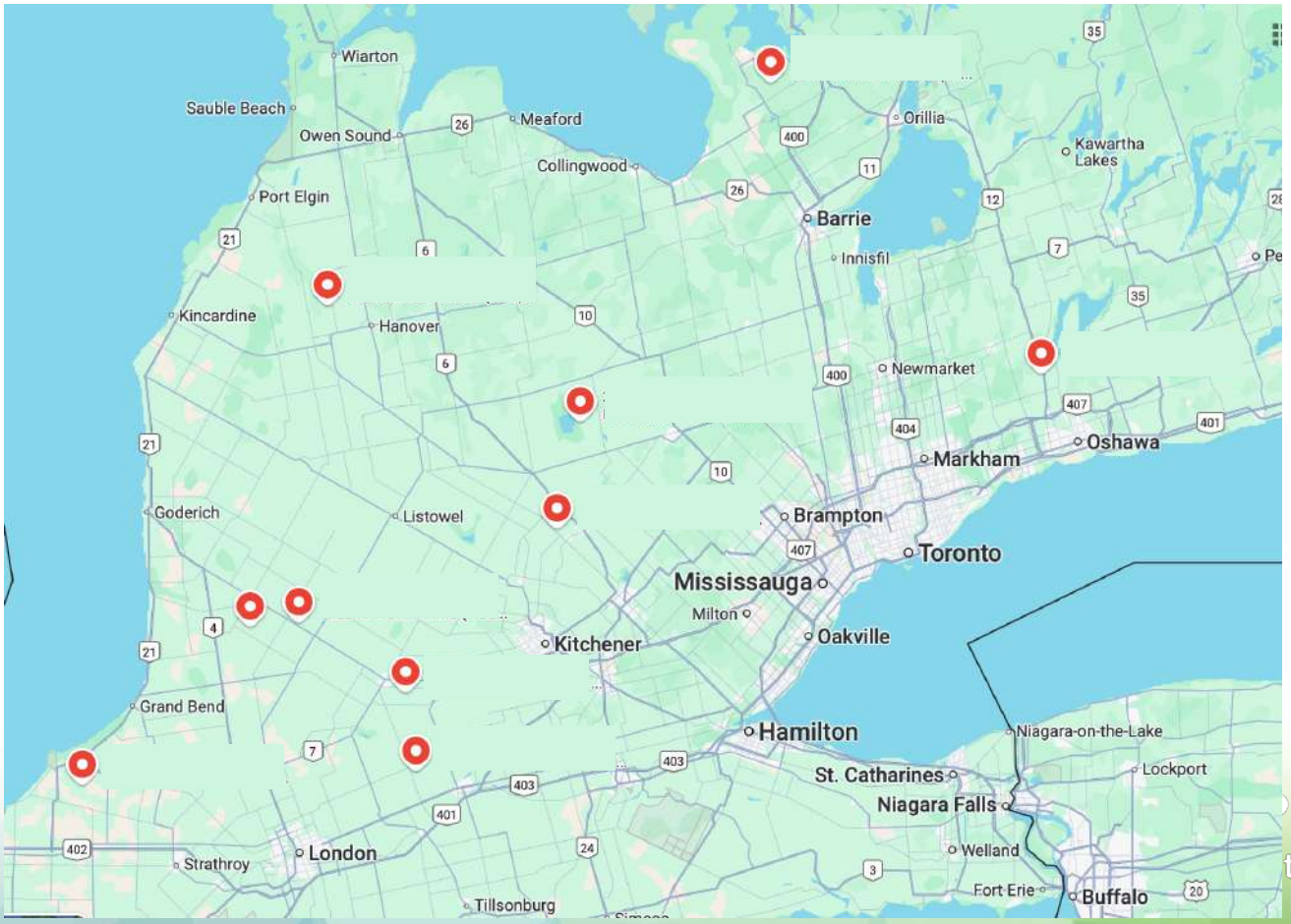
- **1-2 MooLoggers each**
- **10 Holstein farms**
- **2.5 Jersey farm**
- **1.5 Ayrshire farm**
- **Lely robots**



Moologgers in Ontario – NDGP & Dairy Cluster

13 farms – 26 sniffers

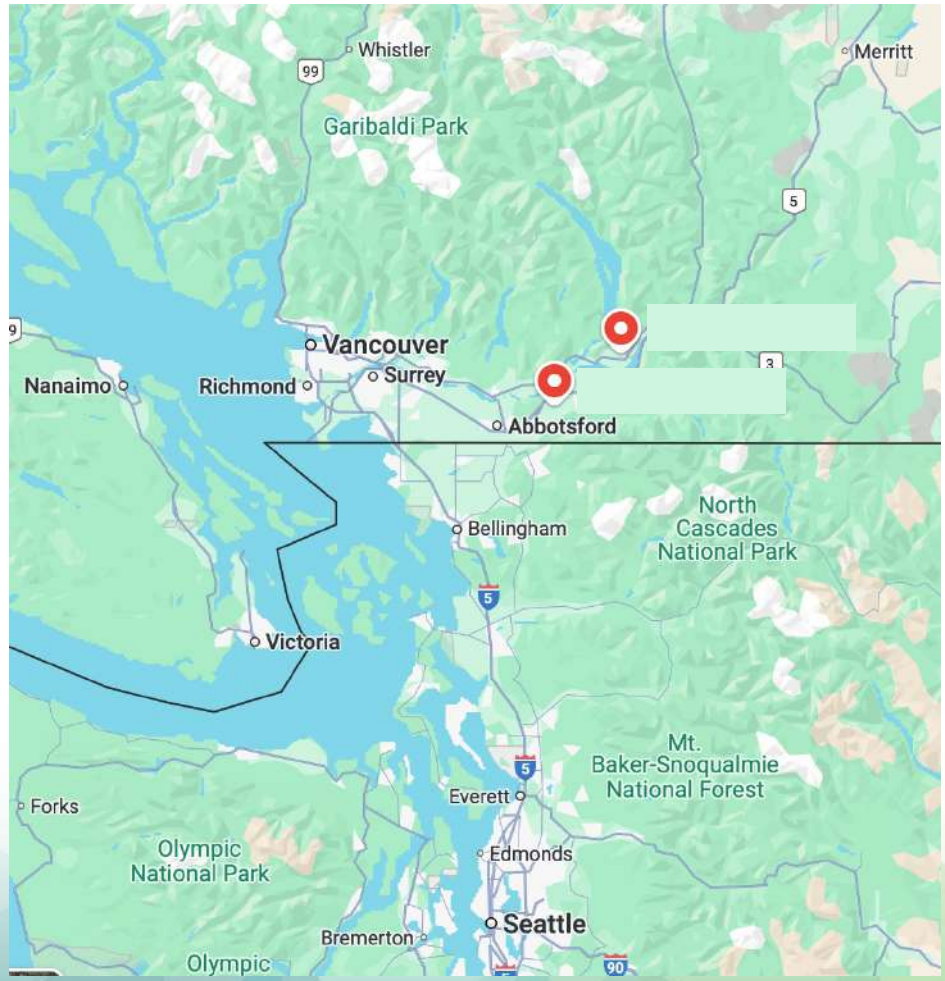
- **2 MooLoggers each**
- **7 Holstein farms**
- **5 Jersey farm**
- **1 Ayrshire farm**
- **Lely robots**



Moologgers in British Columbia – NDGP

2 farms – 10 sniffers

- **4-6 MooLoggers each**
- **2 Holstein farms**
- **Lely robots**



Just to put things in perspective … ☺

Proposals in the Pipeline

Agriculture Funding Consortium - $1.3M

- Estimate the relationship between adaptability (heat tolerance) and mitigation (methane production)
- Optimize relationships between adaptation and mitigation traits within a genetic breeding strategy
- Quantify risk/benefit associated with breeding for reduced emissions on adaptable and suitable animals for future production systems

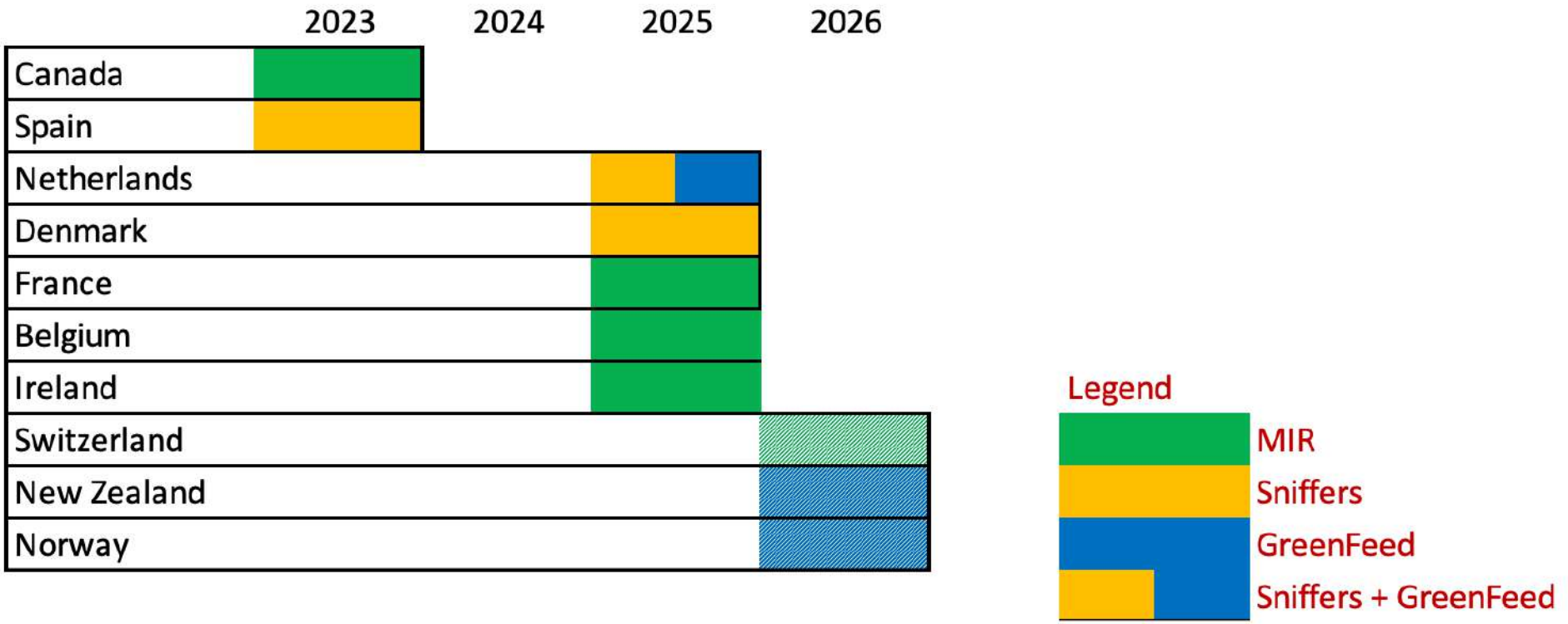
Agriculture Agri-food Canada Methane Reduction Challenge - $2 M

- Quantify change in methane production from daughters sired by low emitting bulls
- Validation of ME evaluations by applying ME breeding value predictions to external populations
- Include breeding values in herd calculators and national inventories

Global Methane Genetics

- Methane phenotyping and breeding in Jerseys - $1.7M – 6 sniffers for CAN
- Methane phenotyping and breeding in Ayrshires - $3.4M – Nordic data to CAN

International Outlook - *Launch Date*



Acknowledgements