Innovative and practical breeding tools for improved dairy products from more robust dairy cows

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http://www.robustmilk.eu

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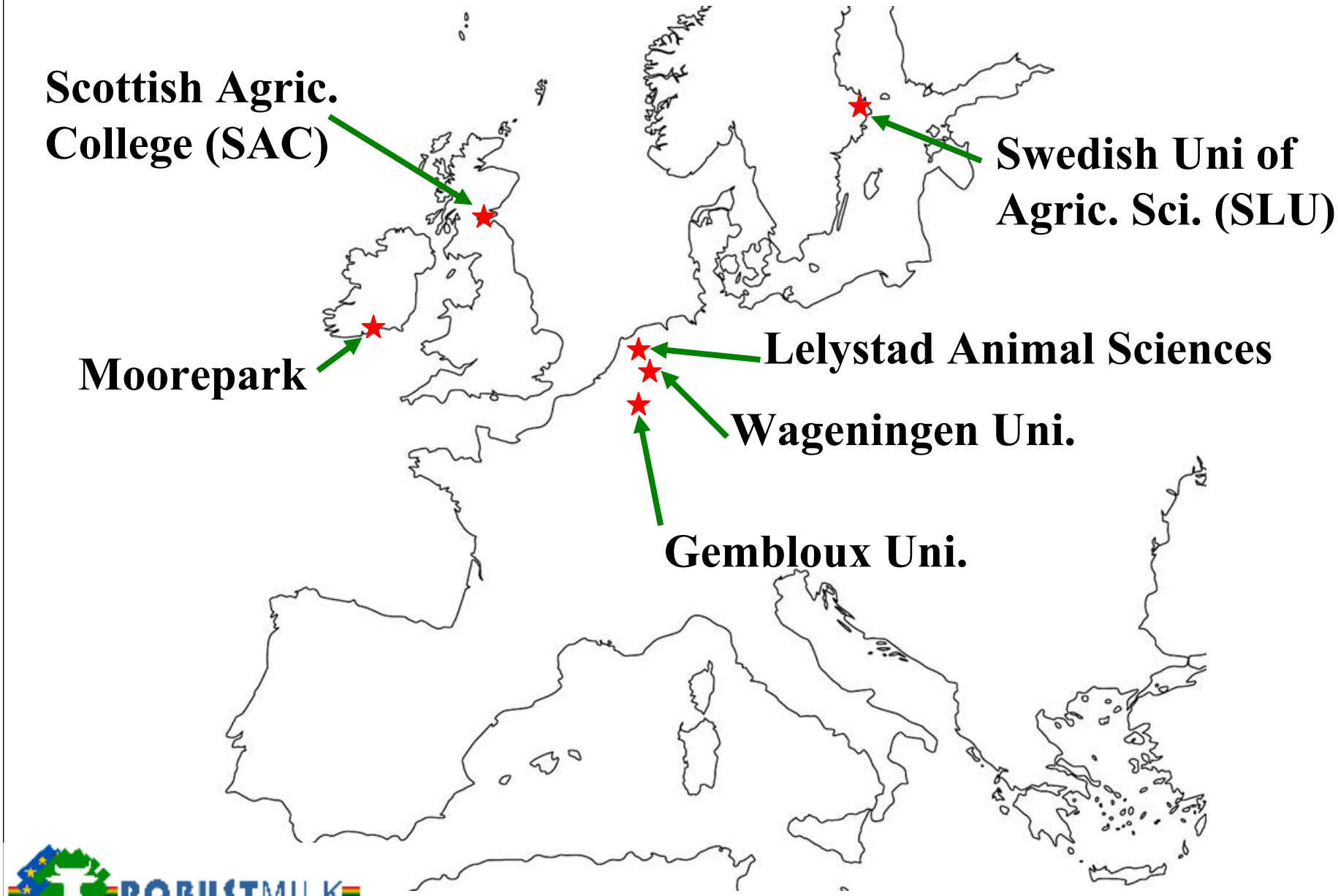
ROBUSTMILK

eagasc

What is ROBUSTMILK?

- EU small collaborative project
- Started April 2008
- Completed April 2012
- 6 Northern European partners

Partners



ROBUSTMILK

Objective

To **develop new practical technologies** to allow breeders to re-focus their selection to include **milk quality** and **dairy cow robustness** and to evaluate the **consequences of selection** for these traits taking cognisance of various milk production systems

Healthy, fertile, long-living cow

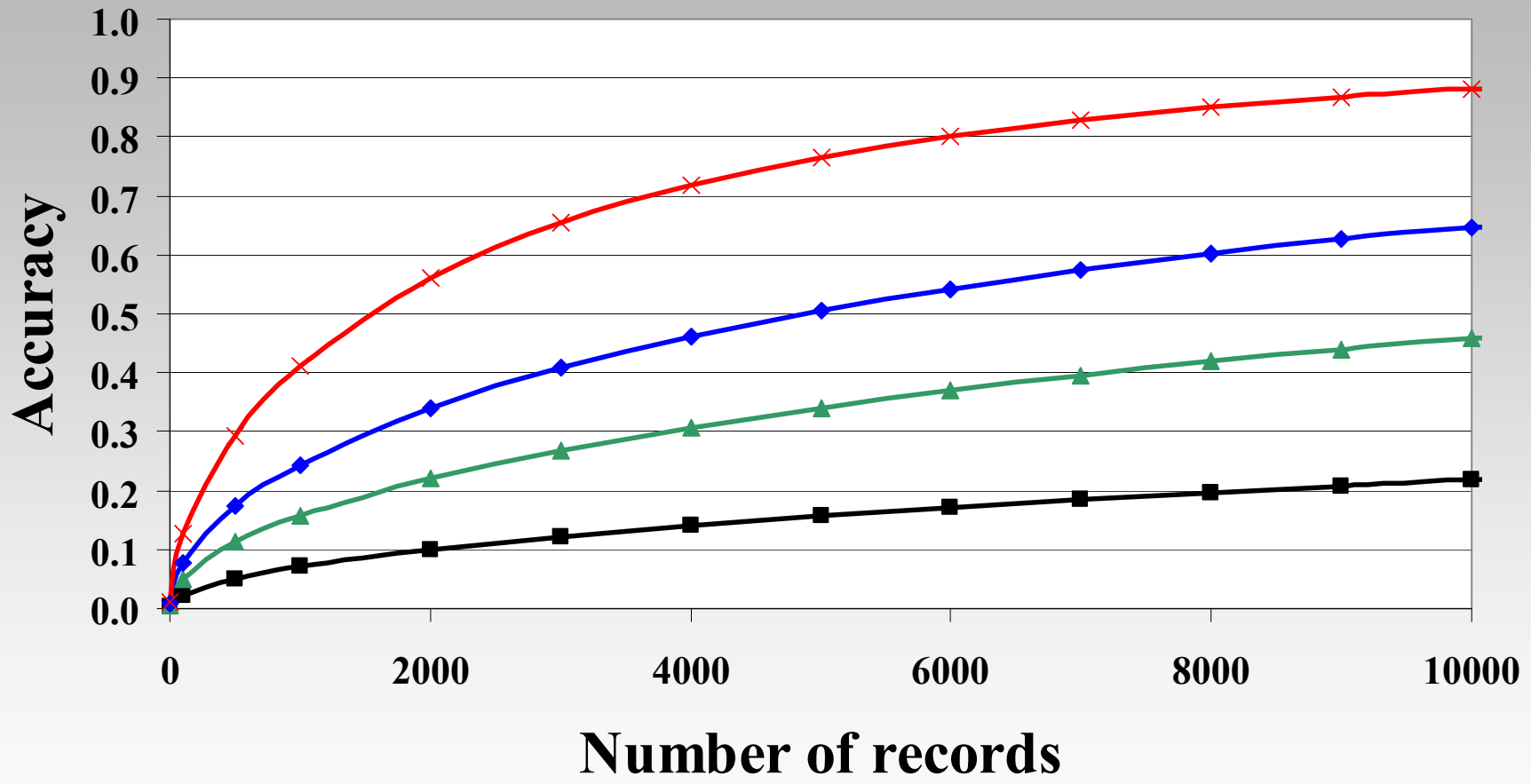
capacity to handle environmental disturbances

Project outline (6 WPs)

1. Common database
2. Phenotypic measurement tools
3. Statistical tools
4. Genomic tools
5. Dissemination
6. Management

WP1. Common database

Accuracy of genomic selection



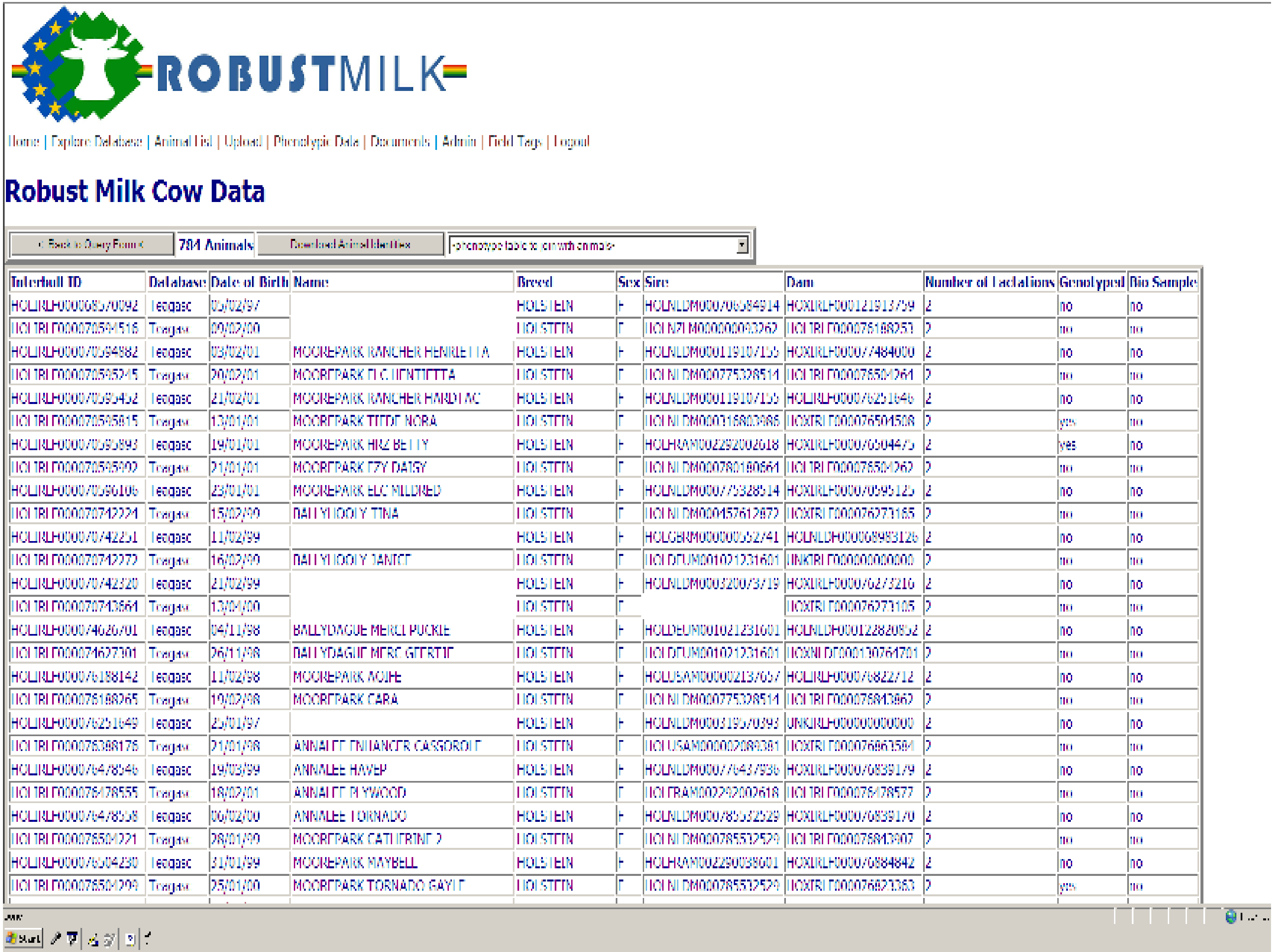
Objective

- To gather phenotypic and genotypic data (including fixed effects) from all partners into a single database with a single pedigree file
- Database available on password protected website

Database Name	Table Name	Description	Choose
T'Gen	hollandPhenoTable1	Wageningen phenotypic breed table	○
T'Gen	hollandPhenoTable2	Wageningen birthdate and genetic line	○
T'Gen	hollandPhenoTable3	Wageningen milk sample analysis data	○
Teagasc	irelandPhenoRbBreeds	Teagasc breed 1 and breed 2 composition of animals	○
Teagasc	irelandPhenoRbExperiments	Teagasc experiment period detail of animals	○
Langhill	langhillPhenoTable1	SAC Table of genetic line and feed group details	○
Langhill	langhillPhenoTable2	SAC Table of breeds and breed percentages	○
Langhill	langhillPhenoTable3Weekly	SAC Table of milk yields and content analysis	○
Langhill	langhillPhenoTable4	SAC Table of calving/service details	○
Langhill	langhillPhenoTable5	SAC Table of sporadic health events	○
T'Gen	hollandPhenoTable4	Wageningen calving/heat details	○
Teagasc	irelandPhenoRbFixedEff	Teagasc fixed effects of animals	○
Teagasc	irelandPhenoRbLactation	Teagasc lactation details of animals	○
Teagasc	irelandPhenoRbRoutine	Teagasc routine milk sample details	○
Teagasc	irelandPhenoRbSporadic	Teagasc sporadic codes and dates of events involving animals	○
T'Gen	hollandPhenoNBZMaster	Wageningen extra animals master table	○
T'Gen	hollandPhenoNBZPedBreed	Wageningen extra animals pedigree/breeds	○
T'Gen	hollandPhenoNBZTable1	Wageningen extra animals breed compositions	○
T'Gen	hollandPhenoNBZTable2	Wageningen extra animals genetic merit	○
Langhill	langhillPhenoProgesterone	direct transfer from langhill Progesterone table	○
	phenotypicAnimalsUnion	Union of animals with phenotypic data from all partners	○
	phenotypicMilkUnion	union of milk sample data from partners(Langhill,ASG and MPK)	○

View Table Contents

Logged in as Donagh Berry.



ROBUSTMILK

Home | Explore Database | Animal List | Upload | Phenotypic Data | Documents | Admin | Field Tags | Logout

Robust Milk Cow Data

< Back to Query Form < | 784 Animals | Download Animal Identities | <phenotype table to join with animals>

Interbull ID	Database	Date of Birth	Name	Breed	Sex	Sire	Dam	Number of Lactations	Genotyped	Bio Sample
HOLIRLF000068570092	Teagasc	05/02/97		HOLSTEIN	F	HOLNLDM000706584914	HOXIRLF000121913759	2	no	no
HOLIRLF000070594516	Teagasc	09/02/00		HOLSTEIN	F	HOLNZLM000000093262	HOLIRLF000076188253	2	no	no
HOLIRLF000070594882	Teagasc	03/02/01	MOOREPARK RANCHER HENRIETTA	HOLSTEIN	F	HOLNLDM000119107155	HOXIRLF000077484000	2	no	no
HOLIRLF000070595245	Teagasc	20/02/01	MOOREPARK ELC HENTIETTA	HOLSTEIN	F	HOLNLDM000775328514	HOLIRLF000076504264	2	no	no
HOLIRLF000070595452	Teagasc	21/02/01	MOOREPARK RANCHER HANDLAC	HOLSTEIN	F	HOLNLDM000119107155	HOLIRLF000076251646	2	no	no
HOLIRLF000070595815	Teagasc	13/01/01	MOOREPARK TITDE NORA	HOLSTEIN	F	HOLNLDM000316803986	HOXIRLF000076504508	2	yes	no
HOLIRLF000070595893	Teagasc	19/01/01	MOOREPARK HRZ BETTY	HOLSTEIN	F	HOLFRAM002292002618	HOXIRLF000076504475	2	yes	no
HOLIRLF000070595902	Teagasc	21/01/01	MOOREPARK EZY DAISY	HOLSTEIN	F	HOLNLDM000780180664	HOLIRLF000076504262	2	no	no
HOLIRLF000070596106	Teagasc	23/01/01	MOOREPARK ELC MILDRED	HOLSTEIN	F	HOLNLDM000775328514	HOXIRLF000070595125	2	no	no
HOLIRLF000070742224	Teagasc	15/02/99	BALLYHOOLY TINA	HOLSTEIN	F	HOLNLDM000457612872	HOXIRLF000076273165	2	no	no
HOLIRLF000070742251	Teagasc	11/02/99		HOLSTEIN	F	HOLGBRM000000552741	HOLNLDF000068983126	2	no	no
HOLIRLF000070742272	Teagasc	16/02/99	BALLYHOOLY JANICE	HOLSTEIN	F	HOLDEUM001021231601	UNKIRLF000000000000	2	no	no
HOLIRLF000070742320	Teagasc	21/02/99		HOLSTEIN	F	HOLNLDM000320073719	HOXIRLF000076273216	2	no	no
HOLIRLF000070743664	Teagasc	13/04/00		HOLSTEIN	F		HOXIRLF000076273105	2	no	no
HOLIRLF000074626701	Teagasc	04/11/98	BALLYDAGUE MERCI PUCKIE	HOLSTEIN	F	HOLDEUM001021231601	HOLNLDF000122820852	2	no	no
HOLIRLF000074627301	Teagasc	26/11/98	BALLYDAGUE MERC GERTIE	HOLSTEIN	F	HOLDEUM001021231601	HOXNLDF000130764701	2	no	no
HOLIRLF000076188142	Teagasc	11/02/98	MOOREPARK AOIFE	HOLSTEIN	F	HOLUSAM000002137657	HOLIRLF000076822712	2	no	no
HOLIRLF000076188265	Teagasc	19/02/98	MOOREPARK CARA	HOLSTEIN	F	HOLNLDM000775328514	HOLIRLF000076843862	2	no	no
HOLIRLF000076251649	Teagasc	25/01/97		HOLSTEIN	F	HOLNLDM000319570393	UNKIRLF000000000000	2	no	no
HOLIRLF000076388176	Teagasc	21/01/98	ANNALEE ENHANCER CASSEROLE	HOLSTEIN	F	HOLUSAM000002084381	HOXIRLF000076863584	2	no	no
HOLIRLF000076478546	Teagasc	19/03/99	ANNALEE HAVEP	HOLSTEIN	F	HOLNLDM000776437936	HOXIRLF000070839179	2	no	no
HOLIRLF000076478555	Teagasc	18/02/01	ANNALEE PLYWOOD	HOLSTEIN	F	HOLFRAM002292002618	HOLIRLF000076478577	2	no	no
HOLIRLF000076478558	Teagasc	06/02/00	ANNALEE TORNADO	HOLSTEIN	F	HOLNLDM000785532529	HOXIRLF000070839170	2	no	no
HOLIRLF000076504221	Teagasc	28/01/99	MOOREPARK CATHERINE 2	HOLSTEIN	F	HOLNLDM000785532529	HOLIRLF000076843907	2	no	no
HOLIRLF000076504230	Teagasc	31/01/99	MOOREPARK MAYBELL	HOLSTEIN	F	HOLFRAM002290038601	HOXIRLF000070884842	2	no	no
HOLIRLF000076504209	Teagasc	25/01/00	MOOREPARK TORNADO GAYLE	HOLSTEIN	F	HOLNLDM000785532529	HOXIRLF000076823363	2	yes	no

Start

Status

- Database complete
- Currently defining phenotypes (energy balance) from stored individual phenotypic components
- Estimation of variance components across countries – can the data be merged?

WP2. Phenotypic measurement tools

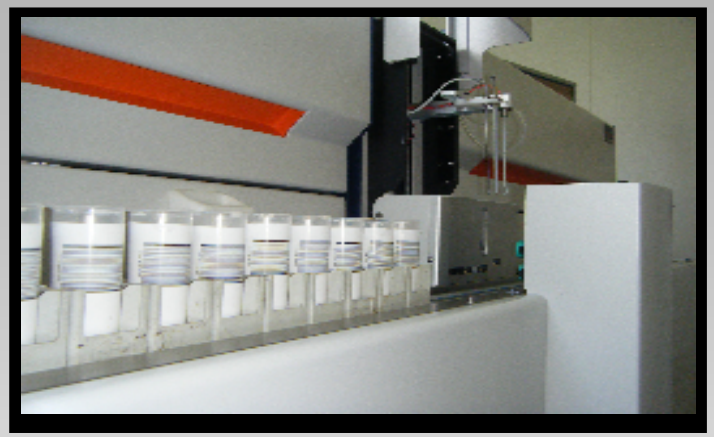
"In the era of genomics, the phenotype is king"

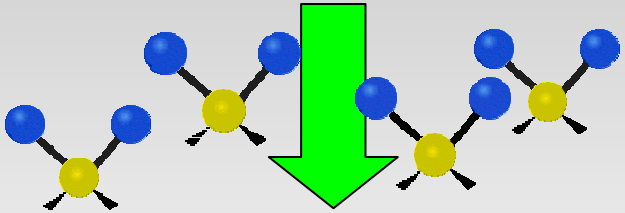
- *Mike Coffey (SAC)*

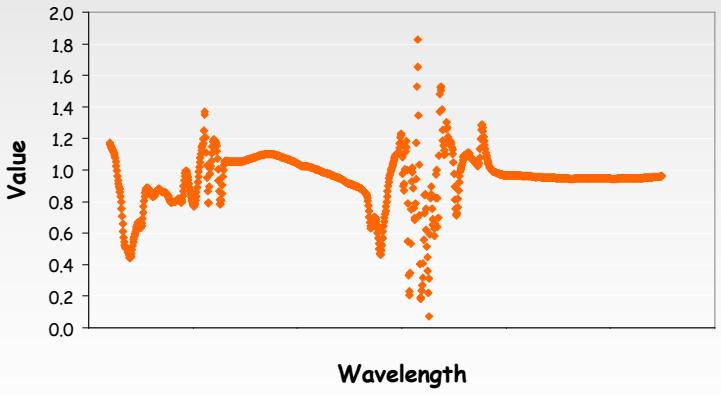
Objective

- To evaluate the usefulness of routinely measured milk mid-infrared spectrometry to predict
  - Milk quality (fatty acid content, lactoferrin)
  - Robustness (energy balance)
- Estimates of genetic parameters

What is "Mid infrared" MIR)?



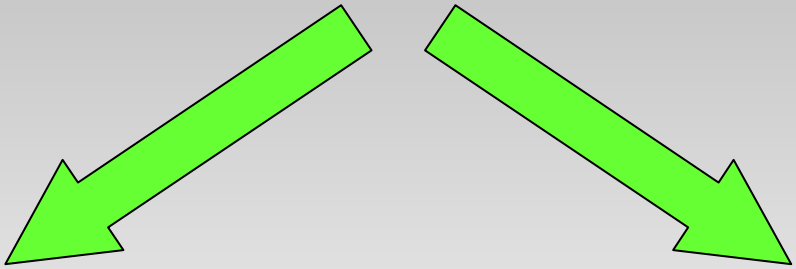




Group	Num of Cows	M Kg F Kg P Kg	F% P %	Surv% CI Days	Milk Solids % Contrib	Fertility % Contrib	Calving % Contrib	Beef % Contrib	Health % Contrib	EBI €
Overall Cows	81	158			€ 44	€ 2.7	€ 15.4	€ -7.4	€ -1.7	
		7.8	0.03	-0.1	70.8%	4.4%	24.8%	0%	0%	€ 53
		7.0	0.04	-0.3						
1st Lactation	16	167			€ 45.8	€ 2.5	€ 17.7	€ -7	€ -1.6	
		7.7	0.03	-0.2	69.4%	3.8%	26.8%	0%	0%	€ 57
		7.4	0.04	-0.4						
2nd Lactation	22	148			€ 39.6	€ -0.4	€ 14.4	€ -8.4	€ -1	
		6.5	0.02	-0.4	73.3%	0%	26.7%	0%	0%	€ 44
		6.5	0.03	-0.4						
3rd Lactation	18	156			€ 42.4	€ -14.6	€ 13.3	€ -9	€ -0.8	
		7.9	0.04	-0.5	70%	0%	30%	0%	0%	€ 31
		6.7	0.03	0.7						
4th Lactation	10	126			€ 39.2	€ 11.5	€ 13.1	€ -8.3	€ -1.6	
		8.0	0.06	0.0	61.4%	18%	20.6%	0%	0%	€ 54
		5.9	0.03	-0.9						
5th Lactation (+)	15	189			€ 53.6	€ 22.5	€ 18.6	€ -3.9	€ -3.8	
		9.4	0.05	0.9	56.6%	23.8%	19.7%	0%	0%	€ 87
		8.5	0.04	-1.1						

Milk fatty acid content

517 milk samples
(Belgium, Ireland, Scotland)



Calibration
267 milk samples

Validation
250 milk samples

$$X = TP^T + E$$
$$Y = TQ^T + F$$

Proportion of variance explained in external validation

Fatty acid	ROBUSTMILK
	n=250
C4:0-C12:0	0.83 to 0.90
C14:0	0.91
C16:0	0.86
Saturated	0.98
Mono-unsat	0.96
Poly-unsat	0.83
Short chain	0.91
Medium chain	0.91
Long chain	0.91

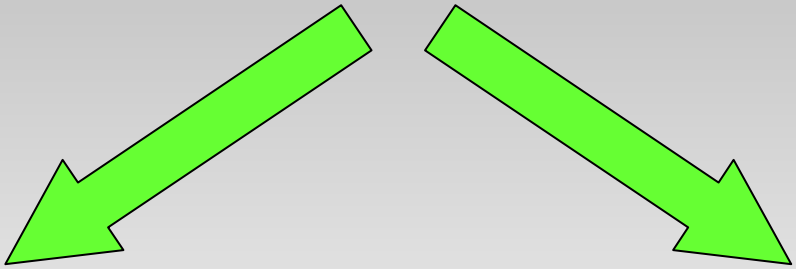
Soyeurt et al., JDS (In Press)

Proportion of variance explained in external validation

Fatty acid	ROBUSTMILK	Dutch	Ireland
	n=250	n=190	n=144
C4:0-C12:0	0.83 to 0.90	0.84 to 0.92	0.82 to 0.93
C14:0	0.91	0.94	0.92
C16:0	0.86	0.93	0.90
Saturated	0.98	0.99	0.98
Mono-unsat	0.96	0.92	0.90
Poly-unsat	0.83	0.48	0.69
Short chain	0.91	0.96	0.93
Medium chain	0.91	0.96	0.96
Long chain	0.91	0.87	0.91

Energy Balance

418 lactations from 268 cows
(Experimental herd in Scotland)



Calibration
306 milk samples

Validation
112 milk samples

$$X = TP^T + E$$
$$Y = TQ^T + F$$

Accuracy of prediction

- Energy balance
  - Across lactation = 0.71 to 0.76
  - Early lactation = 0.70 to 0.78
- Energy intake
  - Across lactation = 0.82 to 0.85
  - Early lactation = 0.80 to 0.88
- Body condition score
  - Across lactation = 0.45 to 0.48
  - Early lactation = 0.07 to 0.21

Next steps

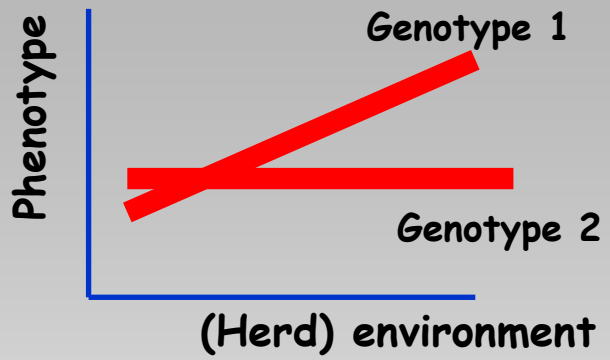
- Validate energy balance equations in Irish dataset
- Estimate (co)variance components

WP3. Statistical tools

Objective

- Develop the statistical tools to model robustness *(i.e., sensitivity to micro- and macro-environments)*
- Develop statistical tools for modelling milk quality (somatic cell count)
- Joint models for milk quality and robustness

Approach



Genotype by environment interaction
= Genetic variation in environmental sensitivity
= Non-parallel reaction norms

	Macro-environments	Micro-environments
Are environments identifiable?	Yes	No
How is it observed?	Multi-trait model $r_A < 1$ Reaction norm model $\sigma^2_{A_S} > 0$	Genetic heterogeneity of environmental variance $\sigma^2_{A_v} > 0$

Outcomes to date

- SCC>500,000 cells/mL and $\log\sigma_{SCC}$ better predictor of mastitis irrespective of whether measured weekly or monthly
- Genetic evaluations for probability of getting mastitis and probability of recovering from mastitis using just SCC data
- Number of somatic cells may be better than SCC
- Developed statistical methodology to estimate genetic variation in residual variance

Next steps

- Combine models to simultaneously estimate genetics of residual variance and environmental sensitivity across large environmental differences

WP4. Genomic tools

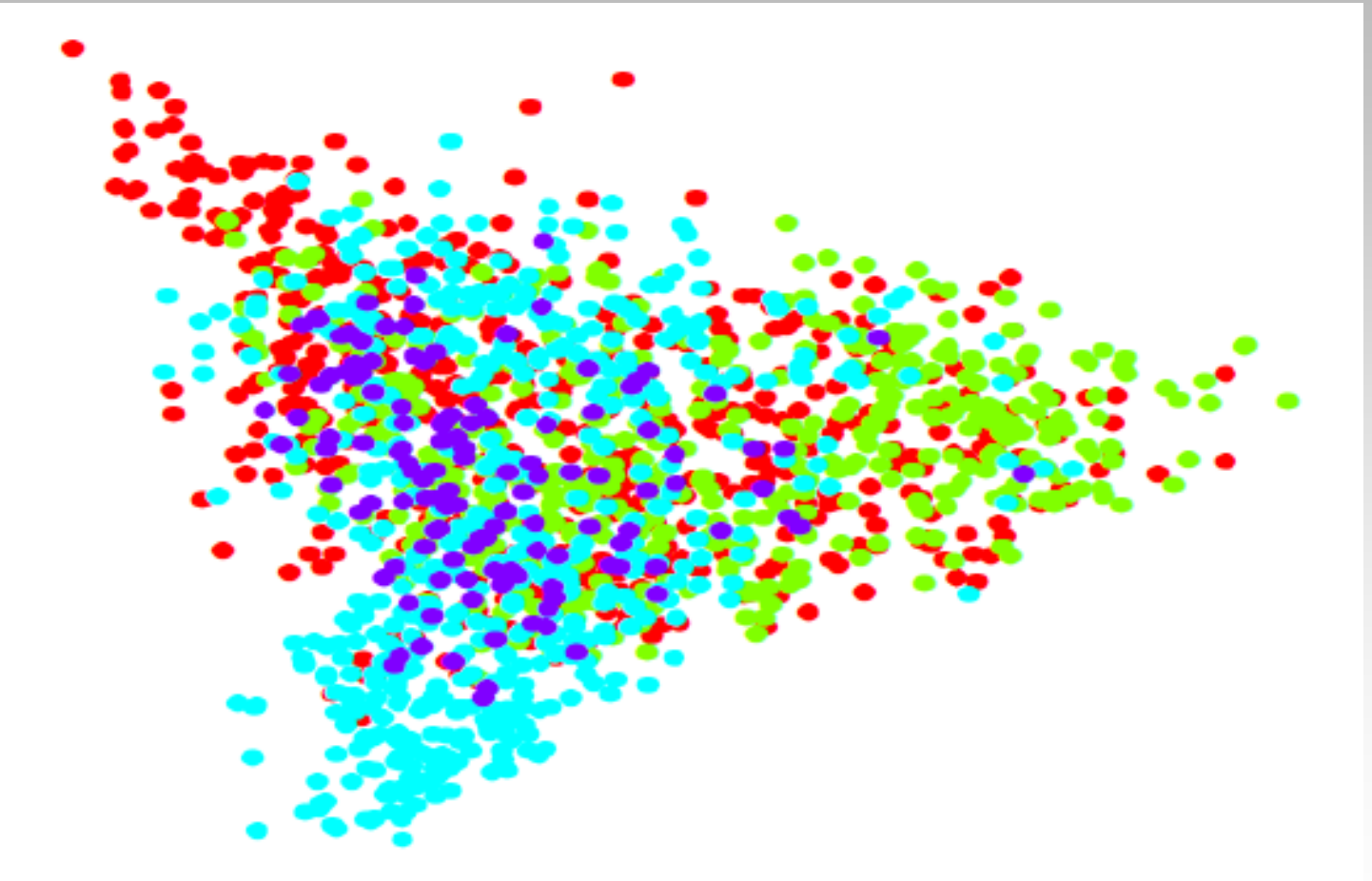
Objective

- Undertake whole genome associations for milk quality and robustness in research dairy cows across consortium members

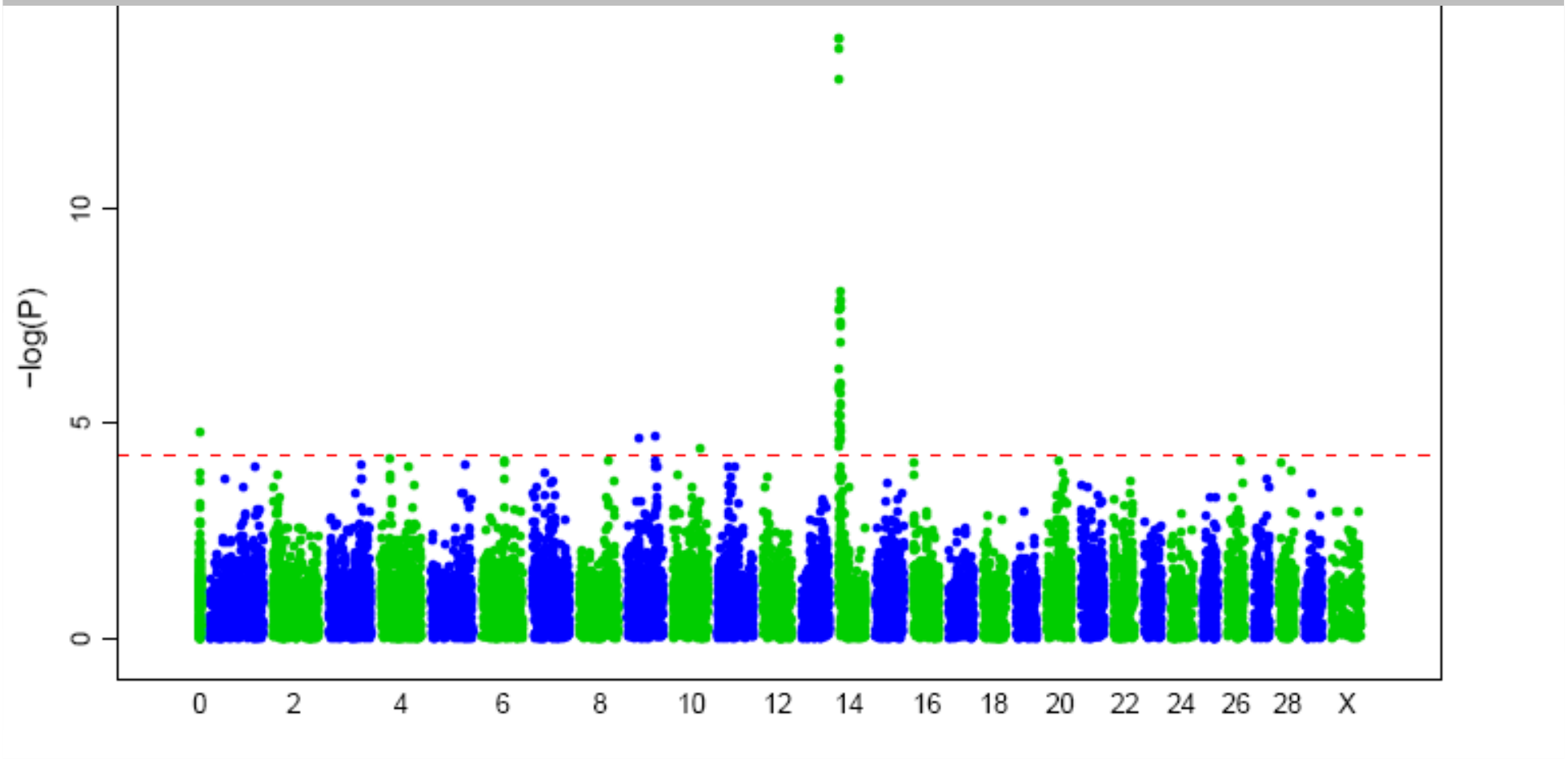
Approach

- Holstein cows from four countries
  - Ireland: 546
  - Scotland: 653
  - Sweden: 144
  - The Netherlands: 590
- Illumina Bovine50 Beadchip

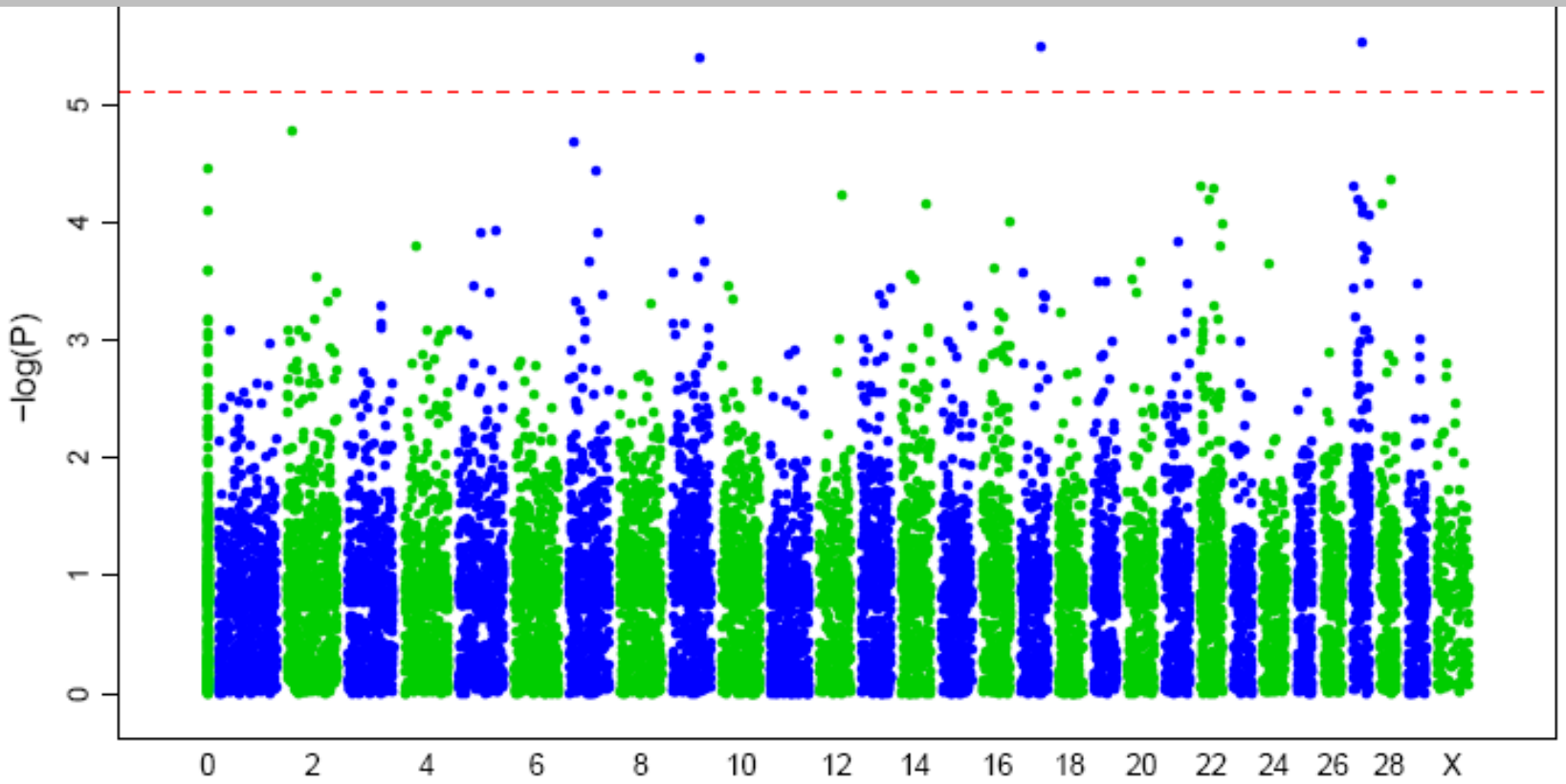
Two-dimensional scaling of identity by state among genotypes



Associations – milk yield



Associations – fat:protein ratio



Future work

- Expand the number of phenotypes
  - Actual energy balance
  - Dry matter intake
  - Fertility
  - Somatic cell count
- Develop new methods of undertaking associations
  - Bivariate analyses

Conclusions

- Progress can only be achieved by working together and intellectual property should be left at the door
- Huge potential for developing phenotypic tools…just a bit of clear thinking
- Improved models for evaluating udder health
- Significant genomic associations detected with ~1,500 cows


http://www.robustmilk.eu
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