THE PLACE OF USEFUL LEARNING

University of Strathclyde Engineering

Review of Diagnostic Testing of Mastitis

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Who Am I?

- Engineer (Electrical & Electronic)
- University Of Strathclyde – Research in data analysis & sensor integration in the Agri sector
- Finishing EngD – *"Decision Support Systems for Animal Welfare and Precision Livestock Farming"*)
- Previous work on Cows, Steers, and Engineers
- Detecting mastitis before skilled herdsman
- Predicting beef feed intake & identifying good growers
- Detecting heat stress in cattle
- Develop motion bolus to detect rumination *internally*

Introduction

- Prevalent
- Expensive
- Decreases Welfare
- At sub-clinical stage, many animals can self-cure
- Catch it early, and take steps to encourage it not to take hold? Increase frequency of milking?
- Farmers typically *won't* notice till **clinical** level
- Swelling, clots, reduction in yield

Tradition

- Somatic Cell Count
- Enzymatic Response
- California Mastitis Test
- Milk Conductivity

https://wi101.wisc.edu/2013/12/01/becoming-the-dairy-state/

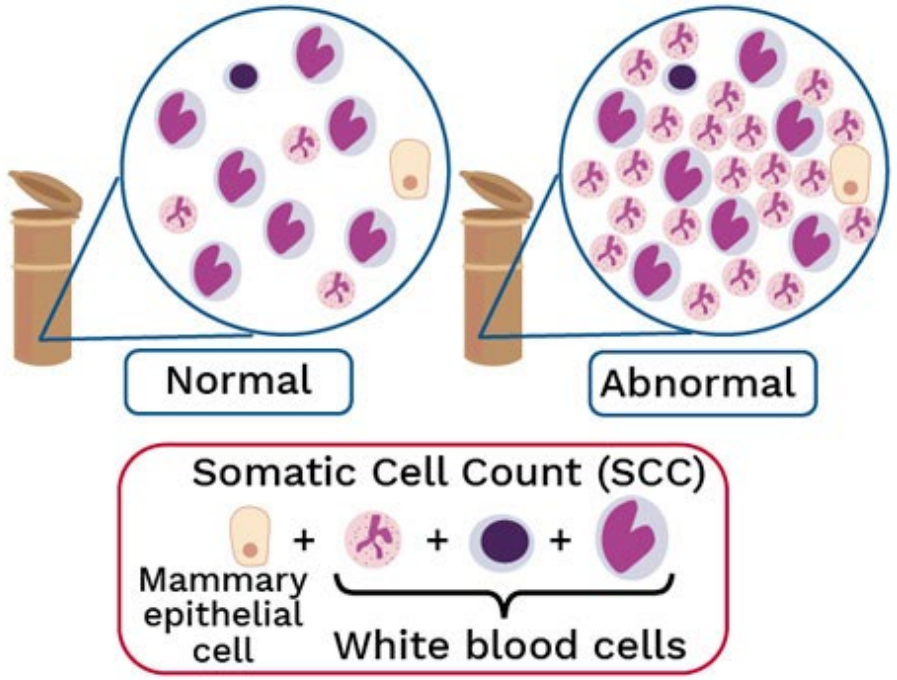
Traditional – Somatic Cell Counting

Usually a ***lab*** test, done at ***bulk*** level

- Indicator of ‘milk quality’
- **£££** and **time/labour**
- Can return –ve due to infrequent sampling
- Reactive, not proactive
- Bacteria breaches epithelial wall, leeching leukocytes into milk -> increased SCC count

Count varies based on pathogen, herd age, parity, stress, and day-to-day variation

FIGURE 1
Illustration of somatic cell count for normal and abnormal milk samples



[Progressive Dairy - Somatic cell counts]

Traditional – California Mastitis Test

- Fast (< 1min)
- Local, not lab
- *Rough* estimate of SCC
  - 5 scores, ranging from *negative* to *>5,000,000* SCC
- *Subjective*
  - Perhaps not too severe, given the approximate nature of the test
- Acute clinical mastitis can be missed as pathogens kill off somatic cells

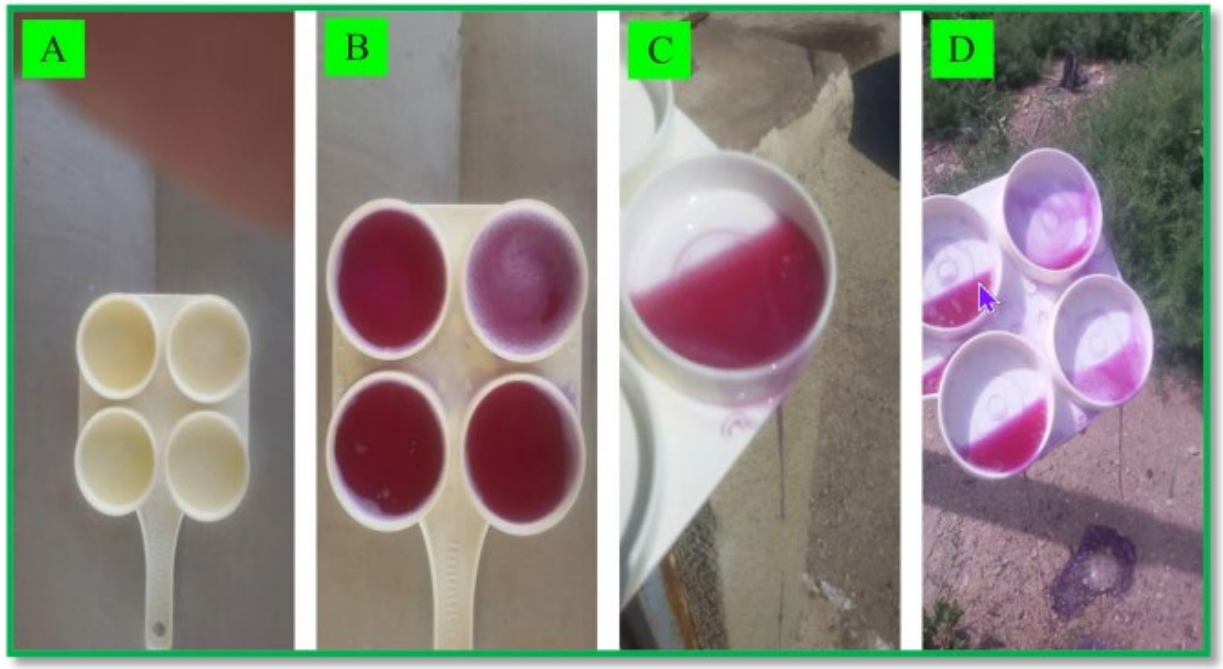


Figure (3-1): California mastitis test A- Paddle contain inflamed milk, B- Adding California reagent, C- Precipitation and gel formation in positive cases, D- Purple due to alkalinity and gel formed due to increased leucocyte presence.

Evaluation The Antifungal Activity of Lactobacillus Against Some isolates of Candida spp Isolated From Bovine Mycotic Mastitis

Traditional – Enzymes & Bacteriology

- Look for ***proxies***, that *typically* occur during mastitis -- proteins
- Typically ***lab-based***
- Slow, laborious
- On-farm variants can lack specificity
- Can’t target treatment to a specific pathogen. On-farm culture systems may detect Gram-positive/gram-negative, or aerobic vs coliform bacteria.
- Perhaps useful if your farm, or your geographic region, has a tendency toward specific pathogens

Traditional – Milk Conductivity

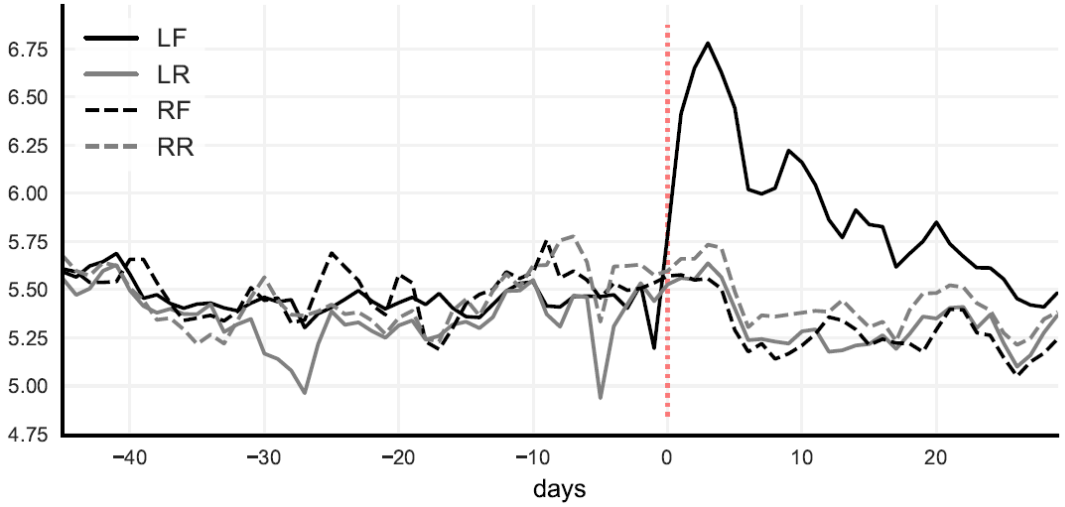
Milk conductivity kind of a ‘side effect’ of sensors already in place for Automatic Milkers (measuring milk constitutents).

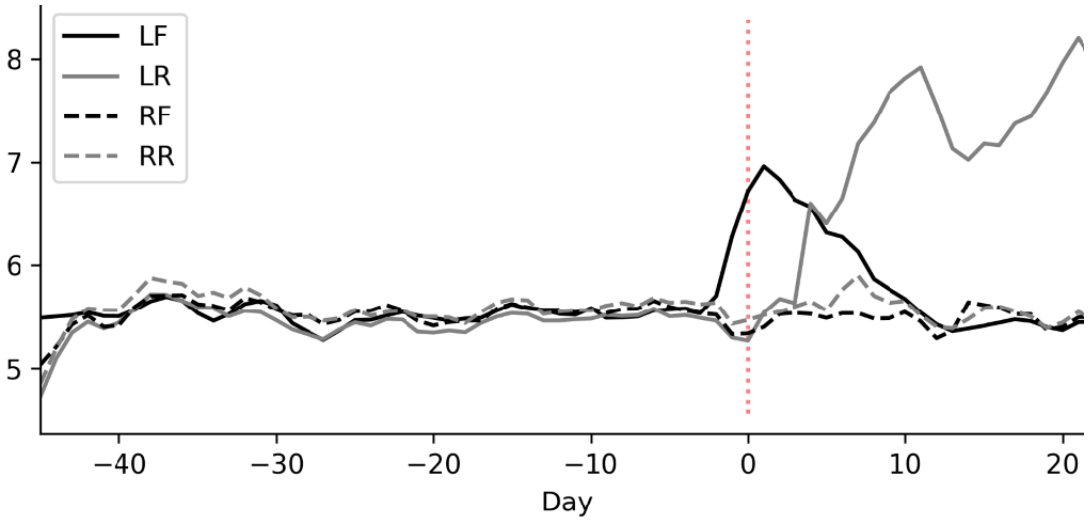
Electrical conductivity can be a sign of inflammation

- Increase in sodium, potassium, and calcium ions due to blood capillary permeability & destruction of ion-pumping systems

Can tell you which quarter to sample (if symptoms not outwardly visible to farmer)

Traditional – Milk Conductivity





However…

- May fluctuate
  - …due to cow physiology
  - …due to dietary factors
- May be a lagging indicator
  - **Image 1** shows conductivity rises *after* herdsman's diagnosis
- Cow-dependant
- (typically) performs worse on *sub-clinical* cases

Tradition – Pros/Cons

Method	Pros	Cons
Somatic Cell Count	• Industry standard (*) • Quantitative	• (Usually) lab-based • Reactive • Typically bulk-sampled
Enzymatic Activity	• (Can be) On-farm • Quick	• (typically) lab-based • (on farm) Not specific • Reactive
California Mastitis Test	• Farm-based • Quick • Cheap	• Subjective • Imprecise
Milk Conductivity	• Increasingly available ‘by default’ • Farm-based	• Can fluctuate • Not specific to mastitis

Novel Approaches

- Lateral Flow
- Automated PCR
- *Sensor Combinations*

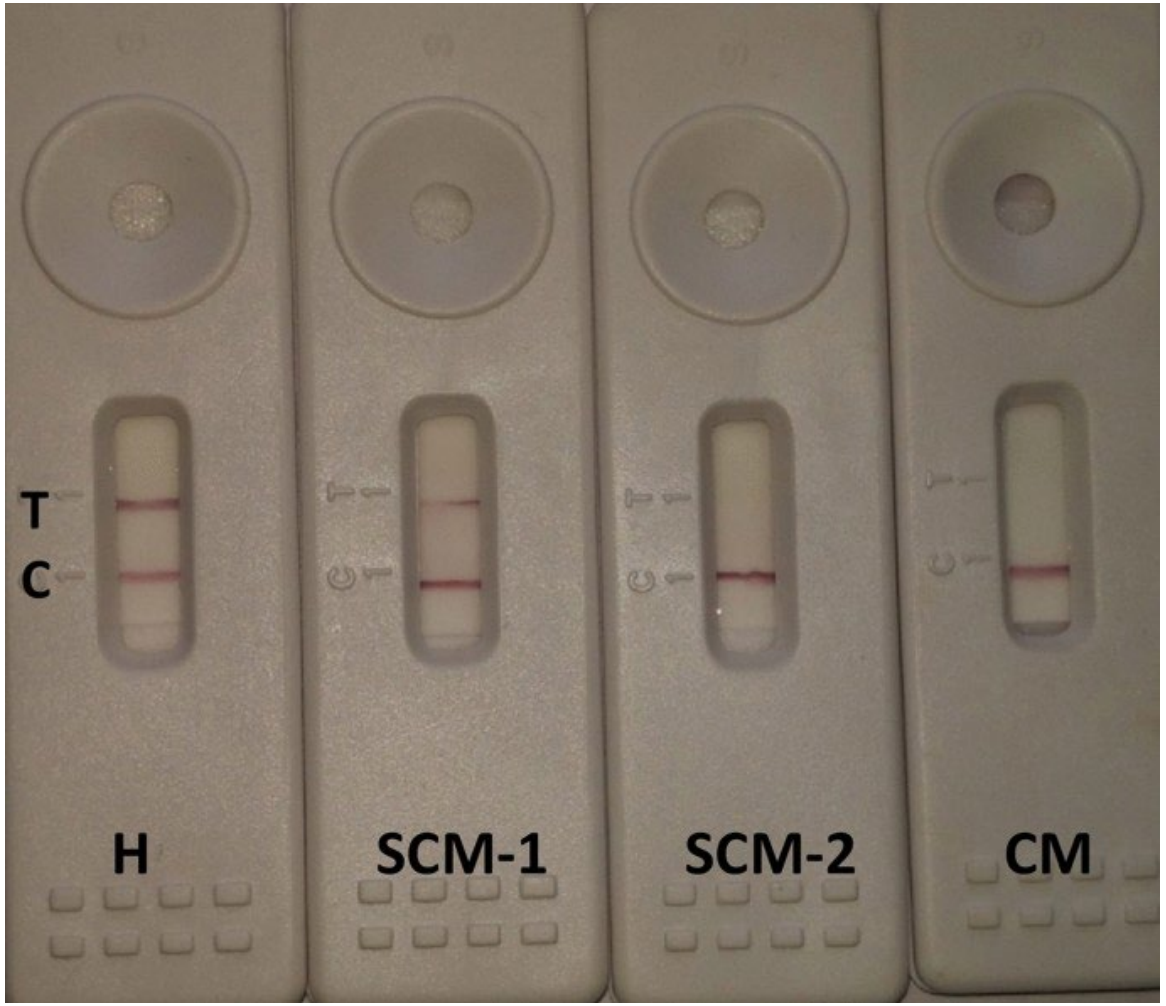
Why do we want novel?

- *reactive* → ***proactive***
- Wait until cow displaying symptoms visible to farmer, or otherwise reason to be suspicious. Leaves opportunity for cow's welfare to diminish, and milk (thus profit) to be lost. May require increase in use of medication long-term
- *subjective* → ***objective***
- Based on the interpretation of herdsman. If multiple people evaluate the herd, may get subtle differences over time
- Economically attractive
- Better able to judge when an animal is sick, or *not sick*, to potentially reduce amount of milk dumped and antibiotics used

Novel – Lateral Flow & PCR

- Lateral Flow
  - Identify specific bacteria, so can specify treatment
  - Ongoing InnovateUK project. Details sparse at the moment, but due to finish soon.

- PCR
  - Polymerase Chain Reaction
  - Detect DNA
  - Interpretation can be a little challenging (small amounts of DNA can result in a positive)
  - On-farm kits recently available



Sensitive and rapid lateral-flow assay for early detection of subclinical mammary infection in dairy cows

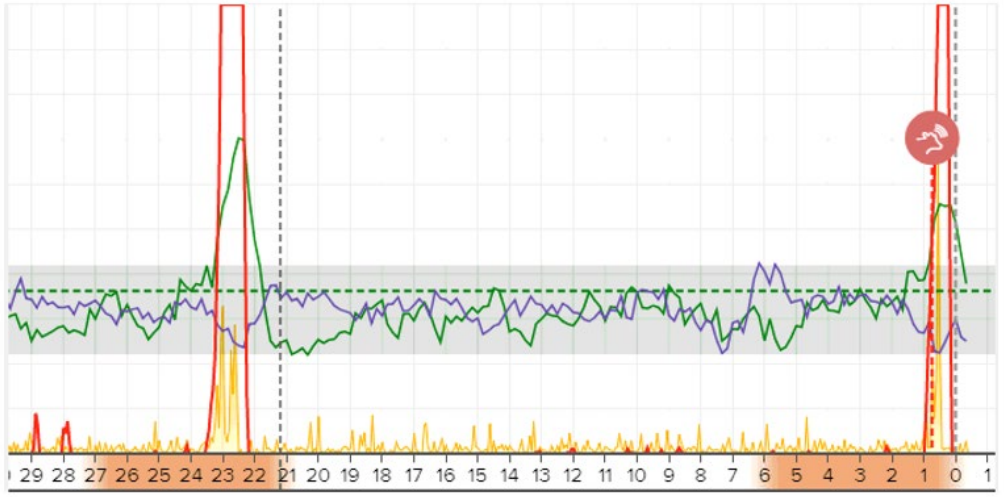
Novel – Sensor Combination

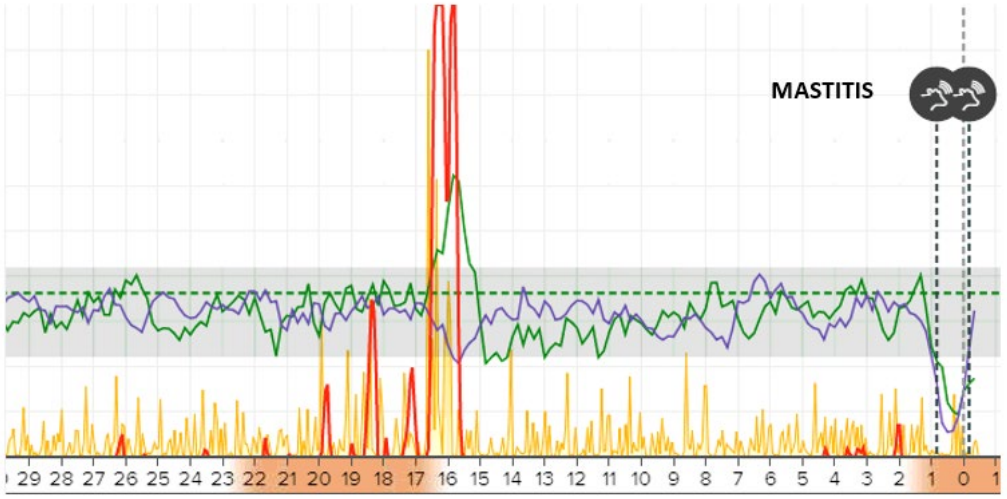
- Farms increasingly filled with technology
- Pedometers
- Behaviour monitoring collars
- Automatic Milking Systems

This work

- InnovateUK 102083 CowHealth & IoF2020
- Commercial Farm – 285 HF, 18 months of data, 4 Fullwood Merlin2, **71 Mastitis**

Behaviour Monitoring Collars





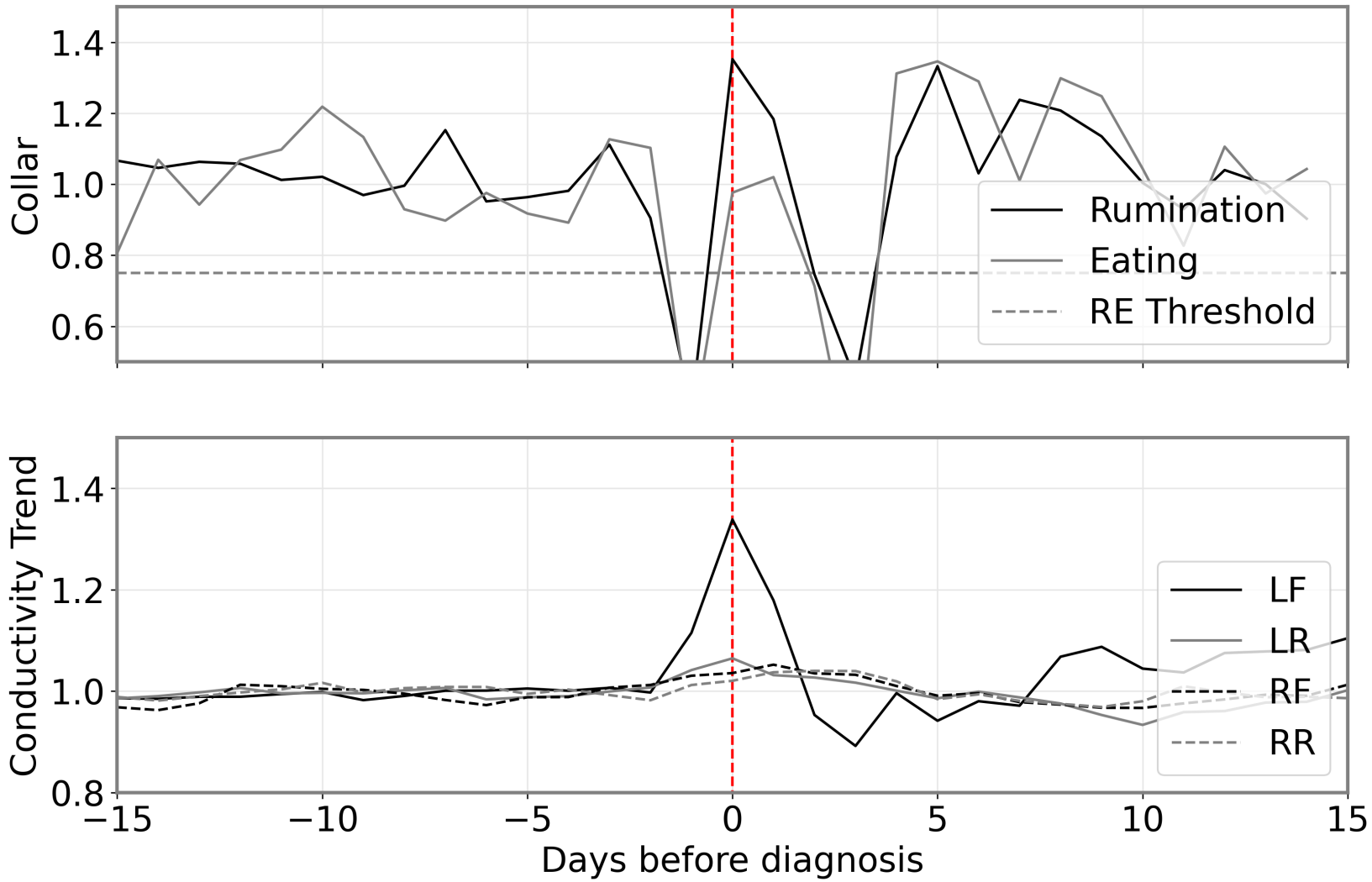
Used mainly for oestrus detection *(Image 1)*
- Rise in eating and activity, fall in rumination
- Orange is predicted oestrus window

Some systems provide indications of rumination, eating, and overall activity.
- **eating, rumination, activity**

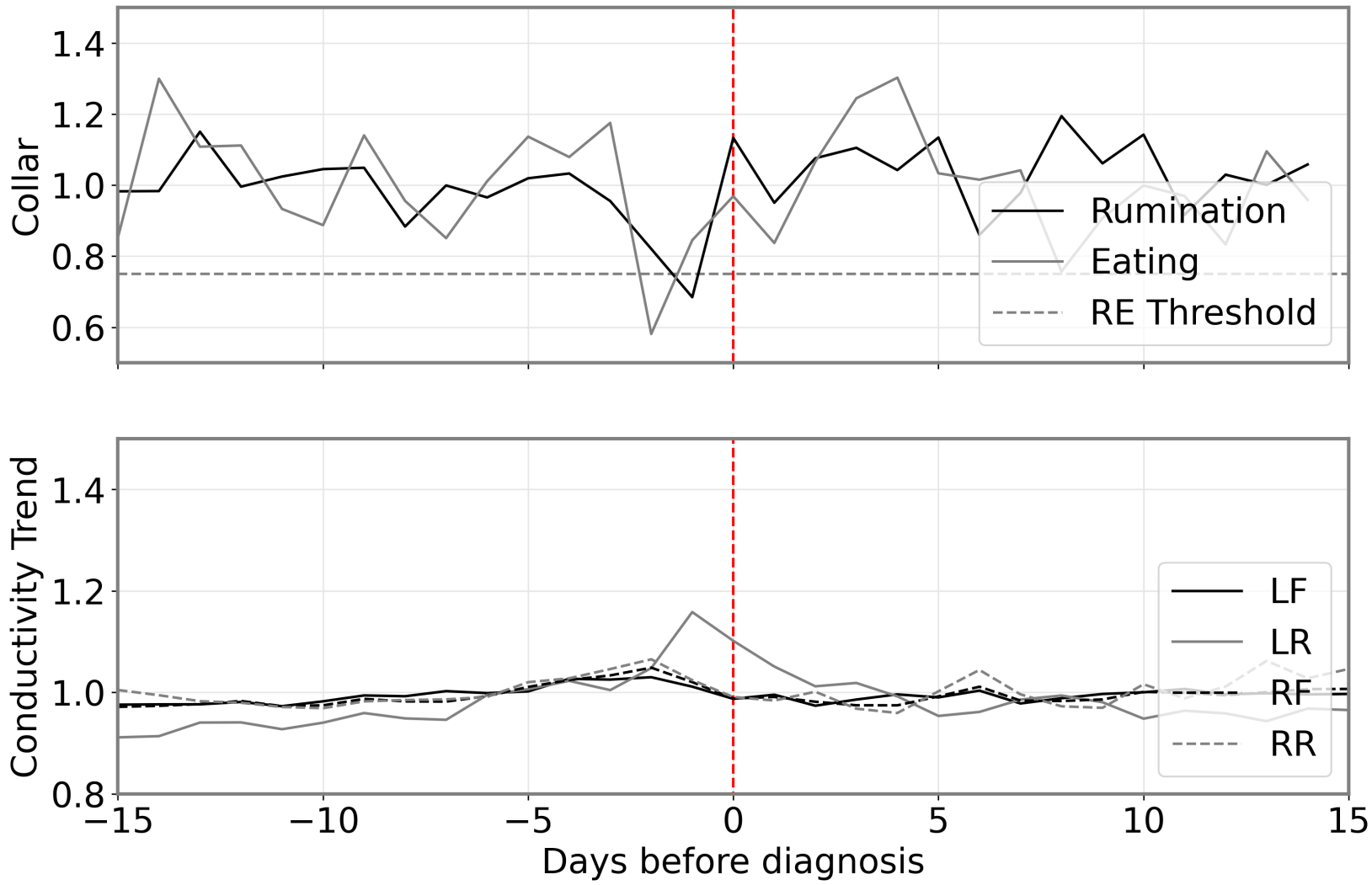
Can't be used *directly* for mastitis/disease inference, but gives a strong indicator of cow welfare
- >30% drop in **eating** + **rumination** observed

Note: *I was working with Afimilk as part of my industrial PhD*

Collar & Conductivity



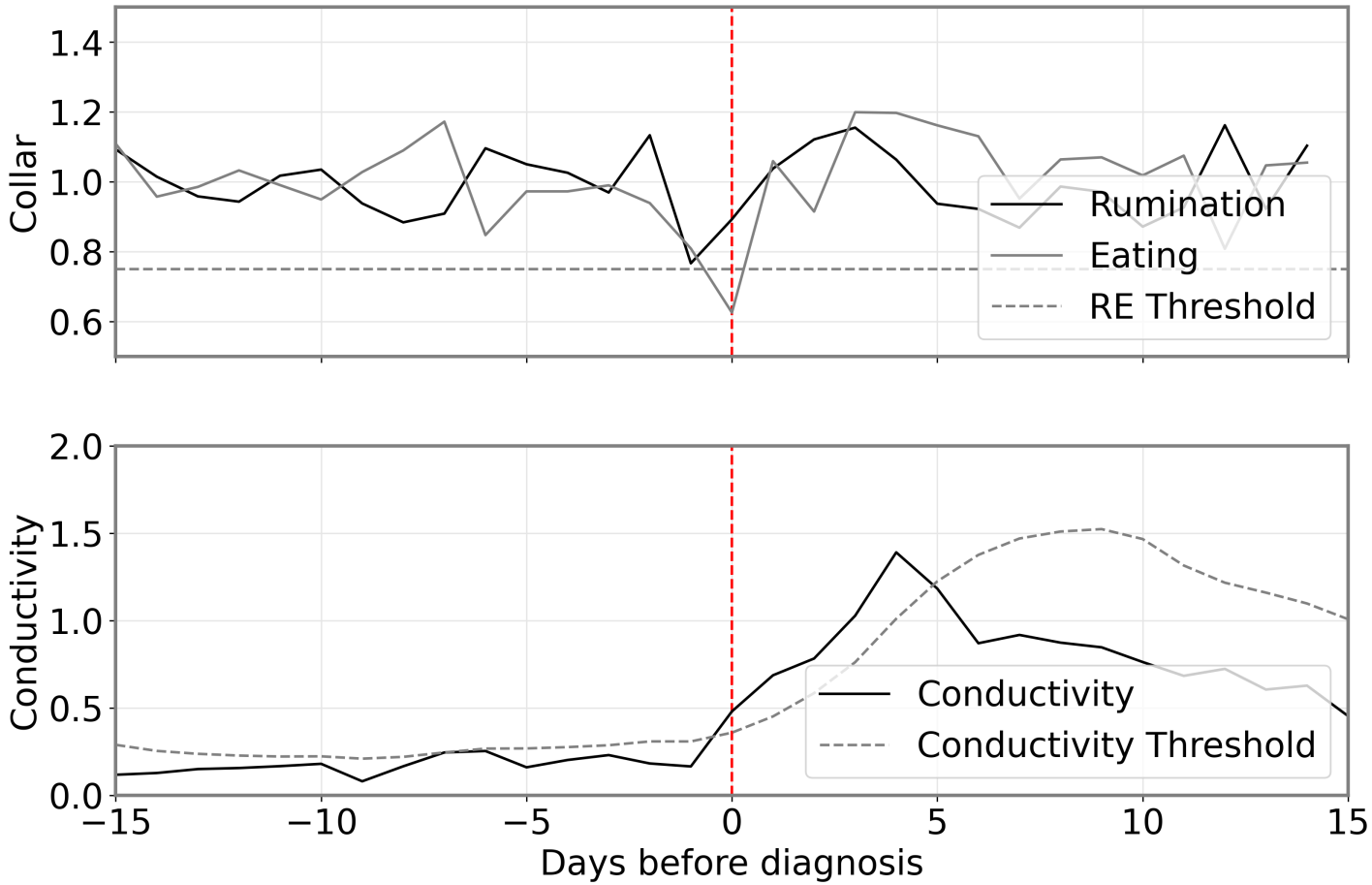
Collar & Conductivity



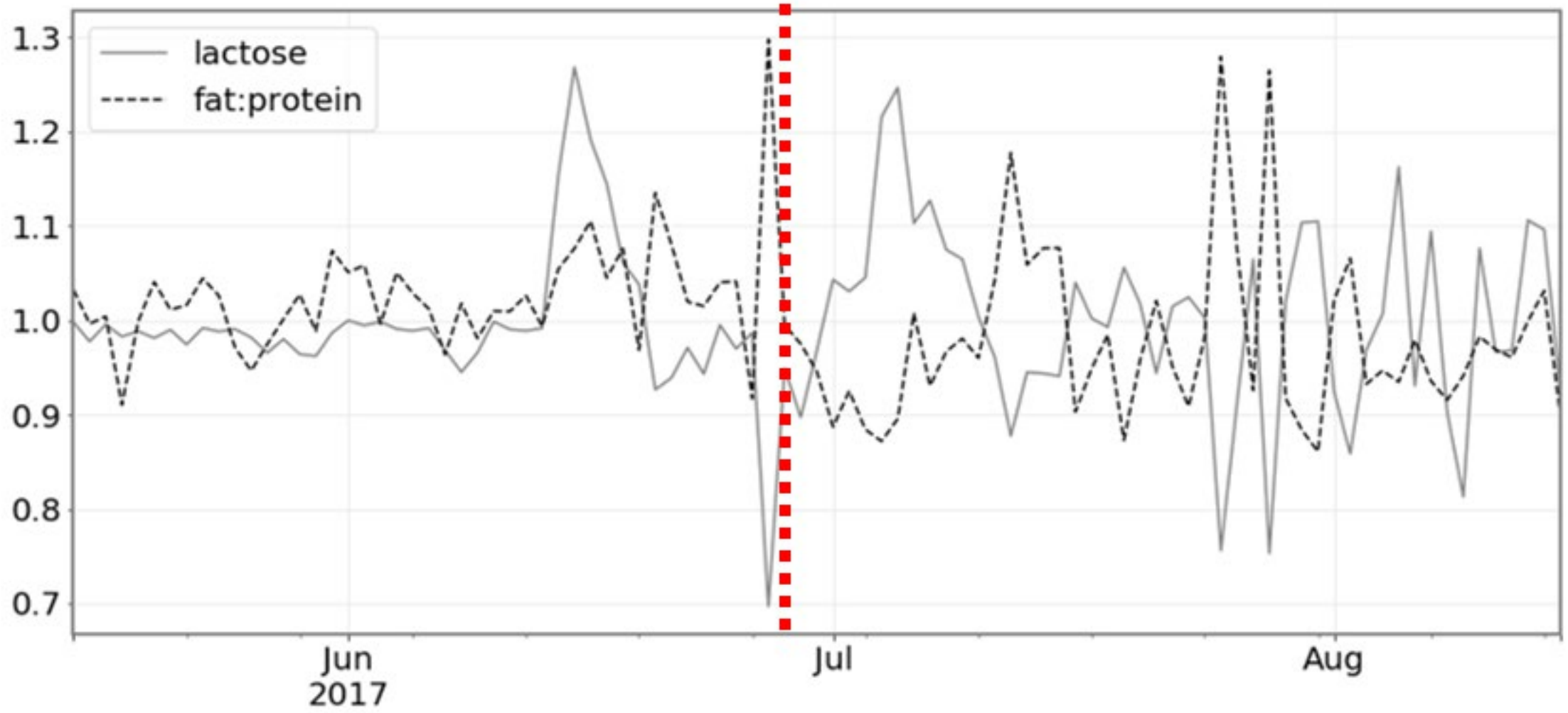
Collar & Conductivity

Misses some

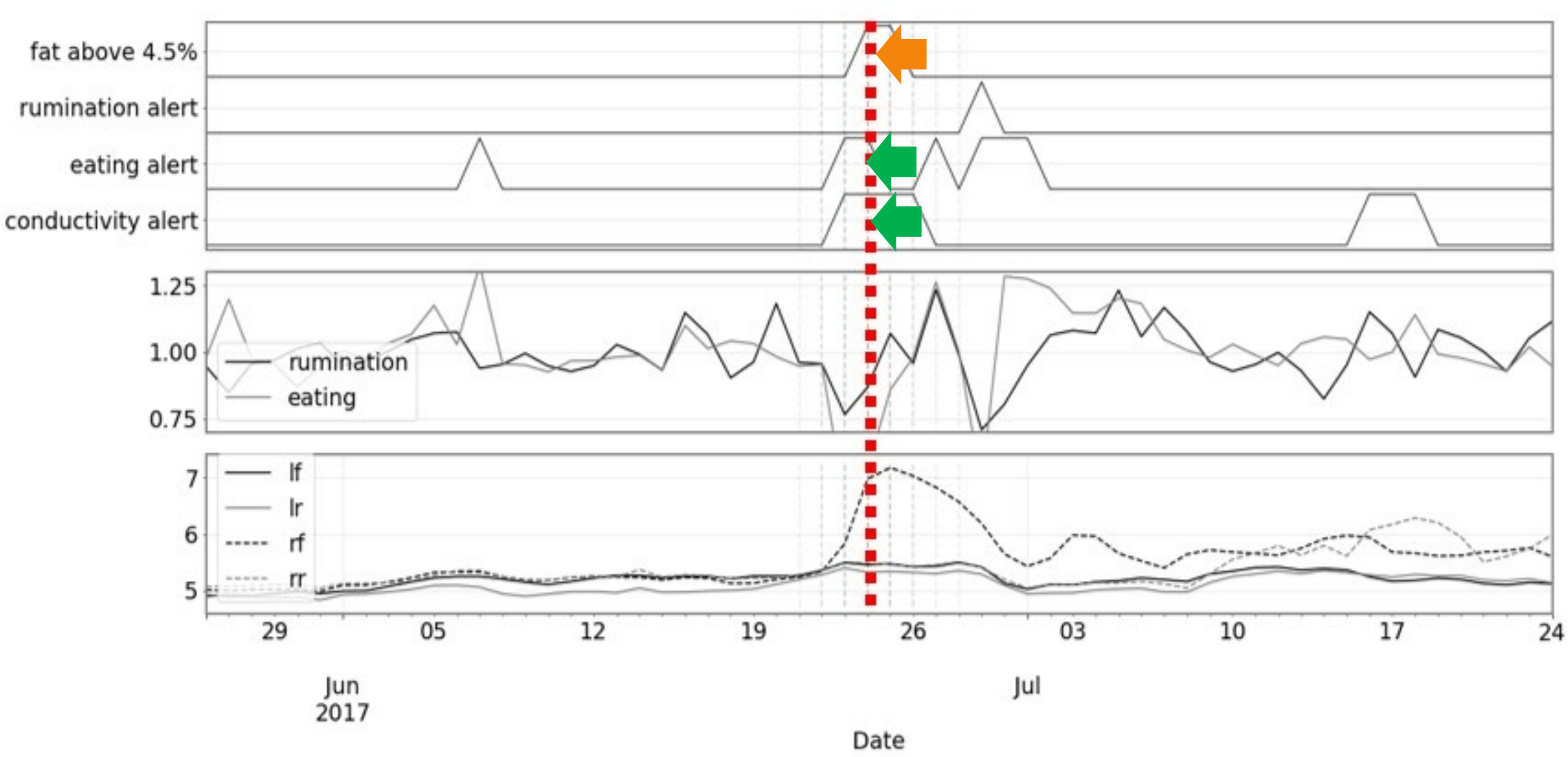
- Rumination didn't drop far enough
- Rumination dropped earlier than eating
- Eating & Conductivity *did* alert



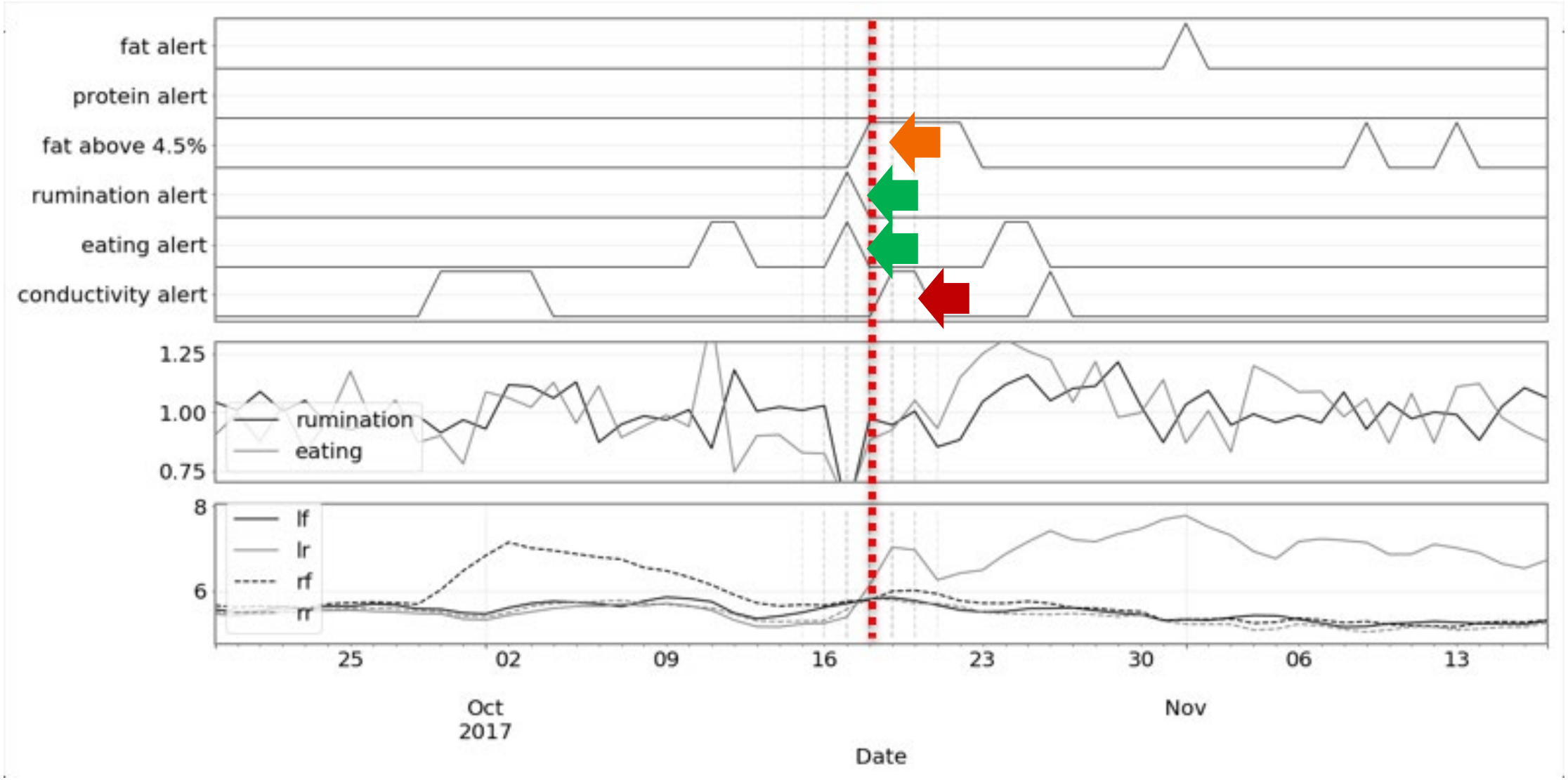
Milk constituents?



Mastitis Detection #1 – 4QC & Collar



Mastitis Detection #2 – 4QC & Collar



How good is sensor combination?

Alert	Alerts within ± 3 days (*)		Alerts up to 3 days before (*)	
Rumination drop (R)	72	84%	66	77%
Eating drop (E)	74	86%	71	83%
Simultaneous R&E	53	62%	51	59%
Conductivity	44	51%	32	38%
Lactose	60	70%	51	59%
Fat	42	49%	33	38%
Protein	28	33%	14	16%
Fat:Protein Ratio	41	48%	33	38%

In 67% (58) of cases, a combination of 2 or more alerts was generated

Discussion / Conclusions

No *real* gold-standard

- SCC the ‘standard’, but not rapid or cheap enough for frequent widespread application

Automatic PCR testing in robotic milkers?

- Sensor fouling? Cost? What about non-AMS farms?

Benefit of automated systems

- We know when some cows are more susceptible. Tune the system to account for this.

Difficulty of sensor combination

- Equipment providers (often) don’t want to cooperate. Want to corner the market. Little ‘standards’ for data exchange (brittle).

Long-term … breeding of mastitis-resistant cows?

- Hard to predict what knock-on consequences this could have…yield, health etc?

Acknowledgements

- Weatherup Farm
  - Home of most of our data gathering efforts
  - Cooperative, communicative, and enthusiastic
- InnovateUK 102083 CowHealth

SRUC

glas data

afimilk®
Vital know-how in every drop

AGRIEPICENTRE
Engineering • Precision • Innovation

Fullwood Packo

SRUC Dumfries, Primary School Child's collage

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