Sensor Fusion for Early Detection of Mastitis in Dairy Cattle

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Outline

- Background
- On-Farm Data Acquisition
  - Behaviour Monitoring Collars
  - Milking Robots
  - Combination of Sensor Data
- Data Interpretation
- Conclusions
- Future Work

Mastitis

- verified as being one of the most damaging economic illness states which compromises milk yield

- if diagnosed, then the animal needs treatment through antibiotics which translates into days lost of milk production due to 'stripping'
  - the production per day lost is on average, 30 litres
  - it takes on average, 7 days to return the cow to production health dependent on the antibiotic

- the condition equates to 210 litres lost and at the current price is a loss of revenue of ~£70 per cow per occurrence

- on average, in the UK, 20% of the herd size suffer from critical Mastitis which for the 1.8M population of dairy cattle in the UK, translates to an industry loss of around £24M, not including the cost of the treatment

Integrated On-Farm Data

- multiple on-farm data integrated into one database

  - data streams are structured to enable cleansing, mining and analysis

- the combined data are analysed to determine correlations between input to output parameters for each individual animal

- basis for a range of services informed by both input/output features

- visualisation and dissemination of alerts through multiple channels
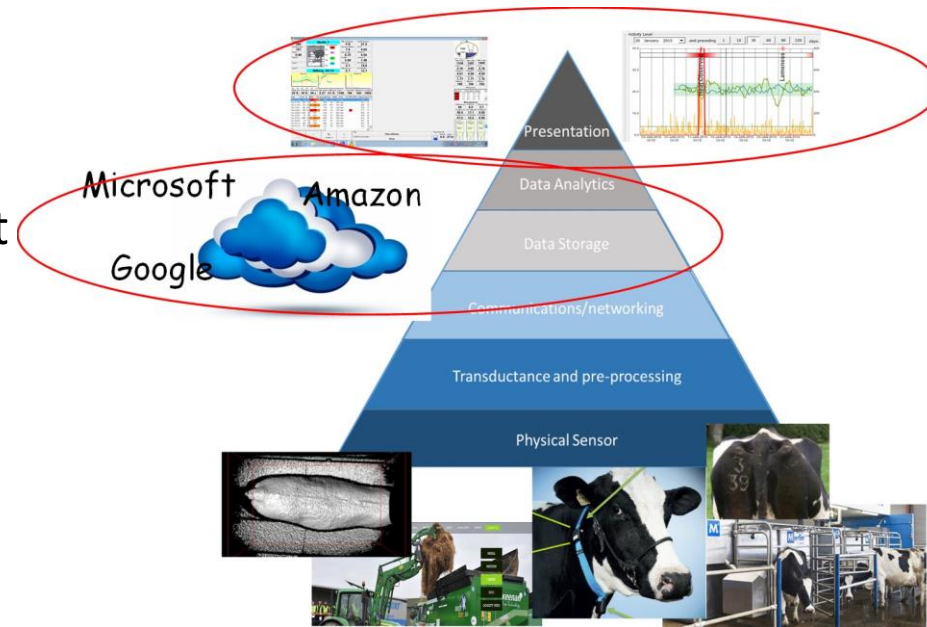
Farm Setting

- Parkend Farm
  - Cowdenbeath, Scotland
  - 285 Cows (HF)
  - 18 months

- Behaviour monitoring collars
  - Silent Herdsman (Afimilk)

- 4x Automatic milking robots
  - Merlin2 (Fullwood)

Prevalence of Health Alerts

Identified by farm staff

Health Alert	Count
Heat Observed	1173
Served	482
Mastitis(*)	71
Lameness	54
Treatment (farm)	25

(*) Many instances from a single sire; very high yielders, but also very susceptible

Behaviour Monitoring Collars

- captures per-animal trends in the time spent 'Ruminating' and 'Eating'

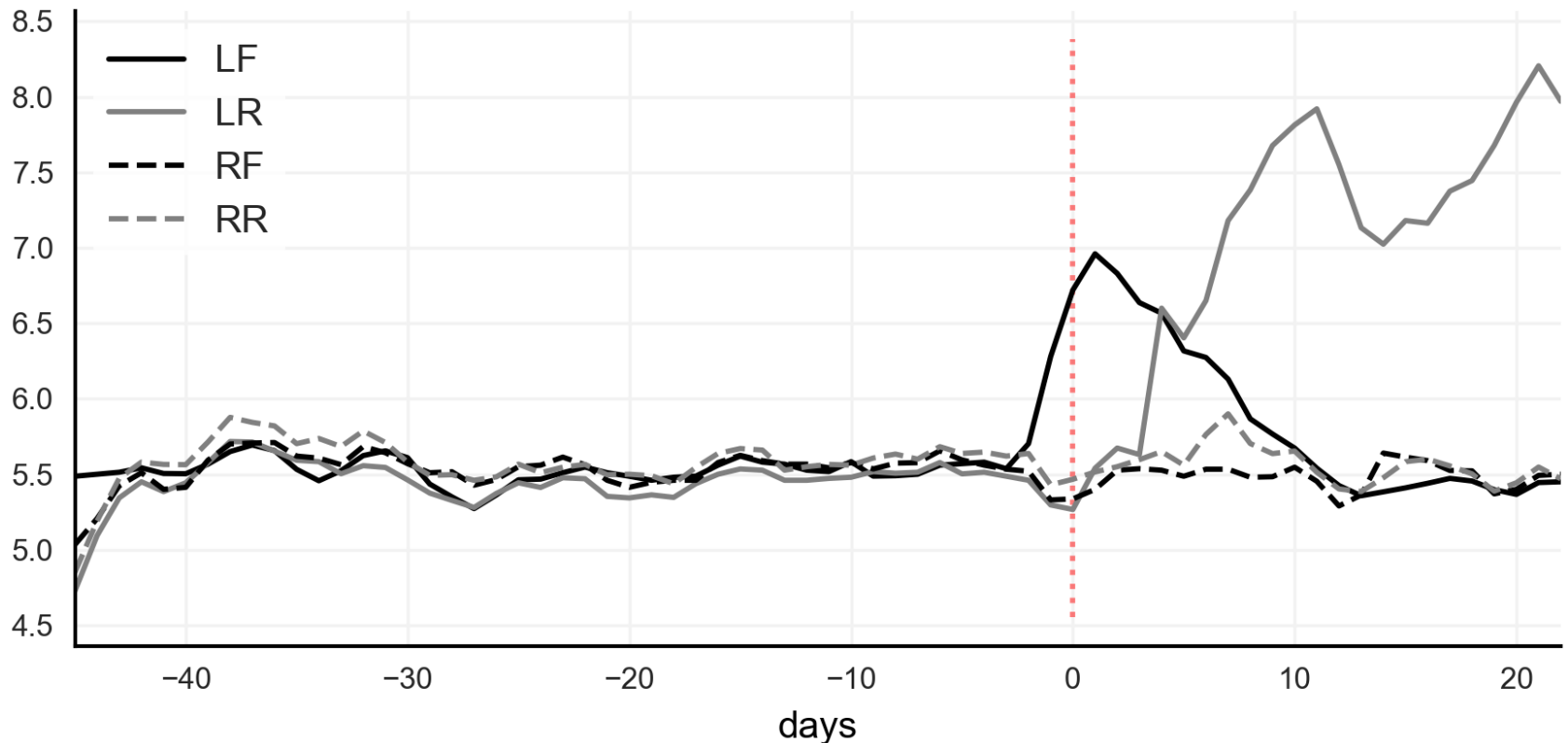- specific illness annotated by farmer
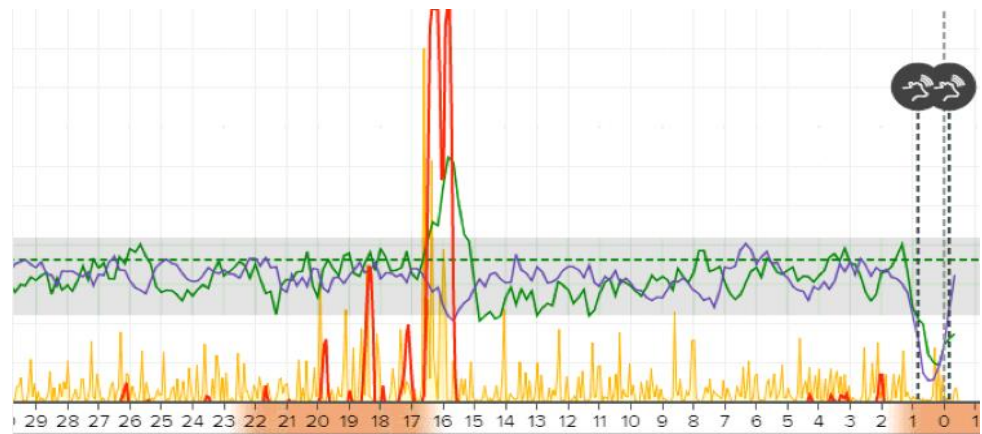
Milking Robots

- Data
    - Milk: Fat, Protein, Lactose
    - Milk conductivity
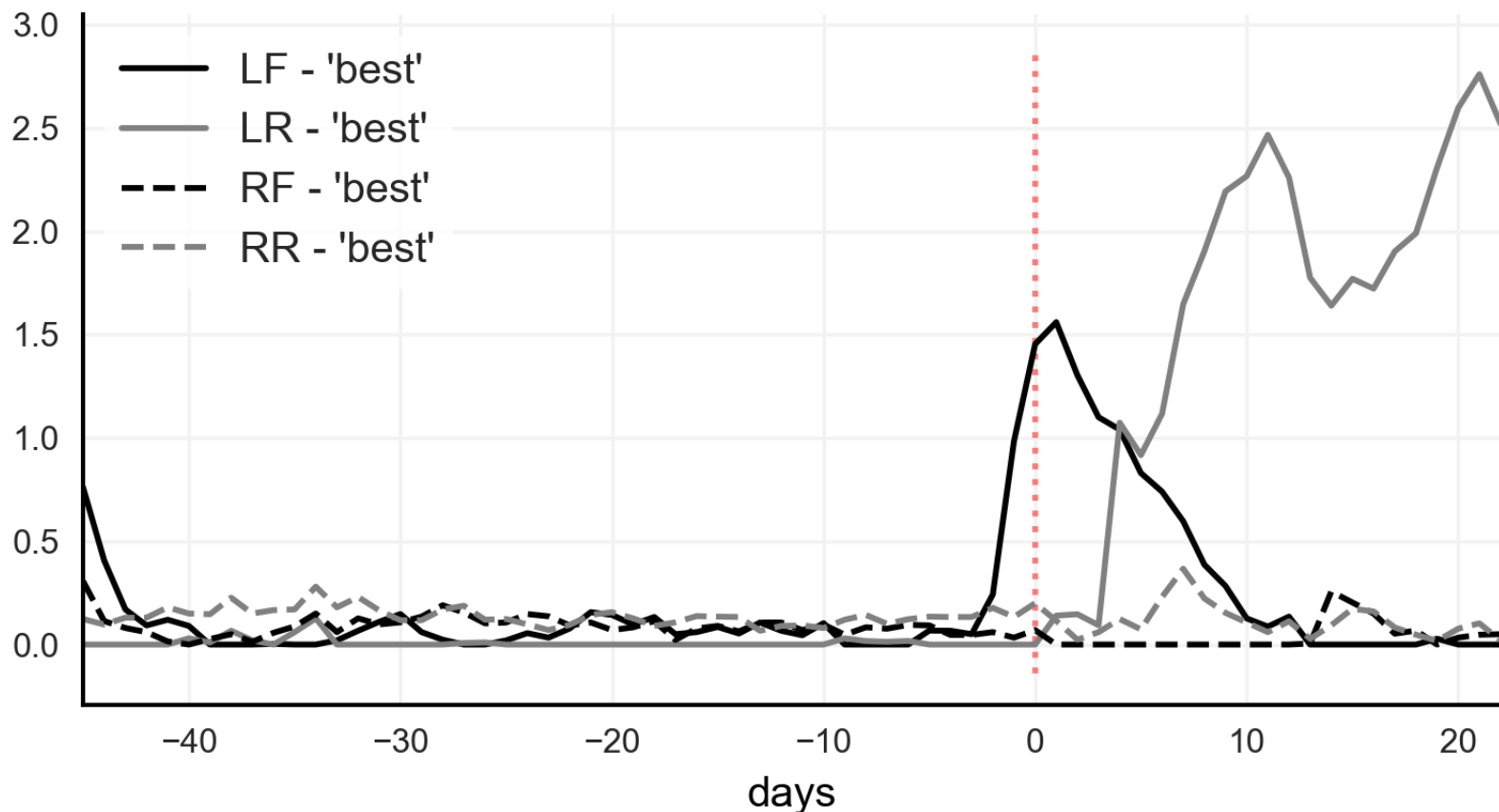   - Milking "behaviours": time between milkings, milking duration, yield

Robots: Milk Conductivity (1)

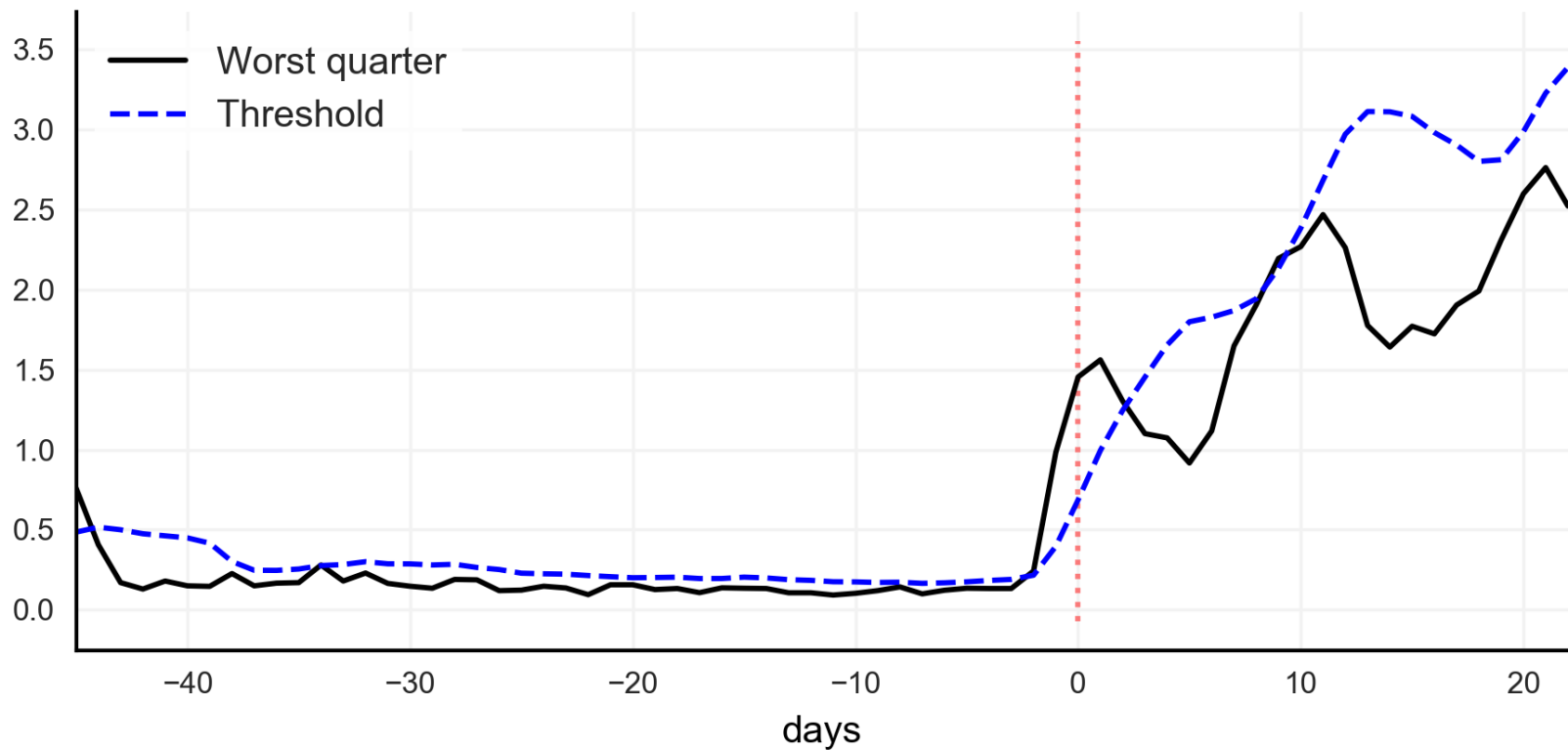- to a machine learning system, the 4 udders look like 4 entirely separate variables

Robots: Milk Conductivity (2)

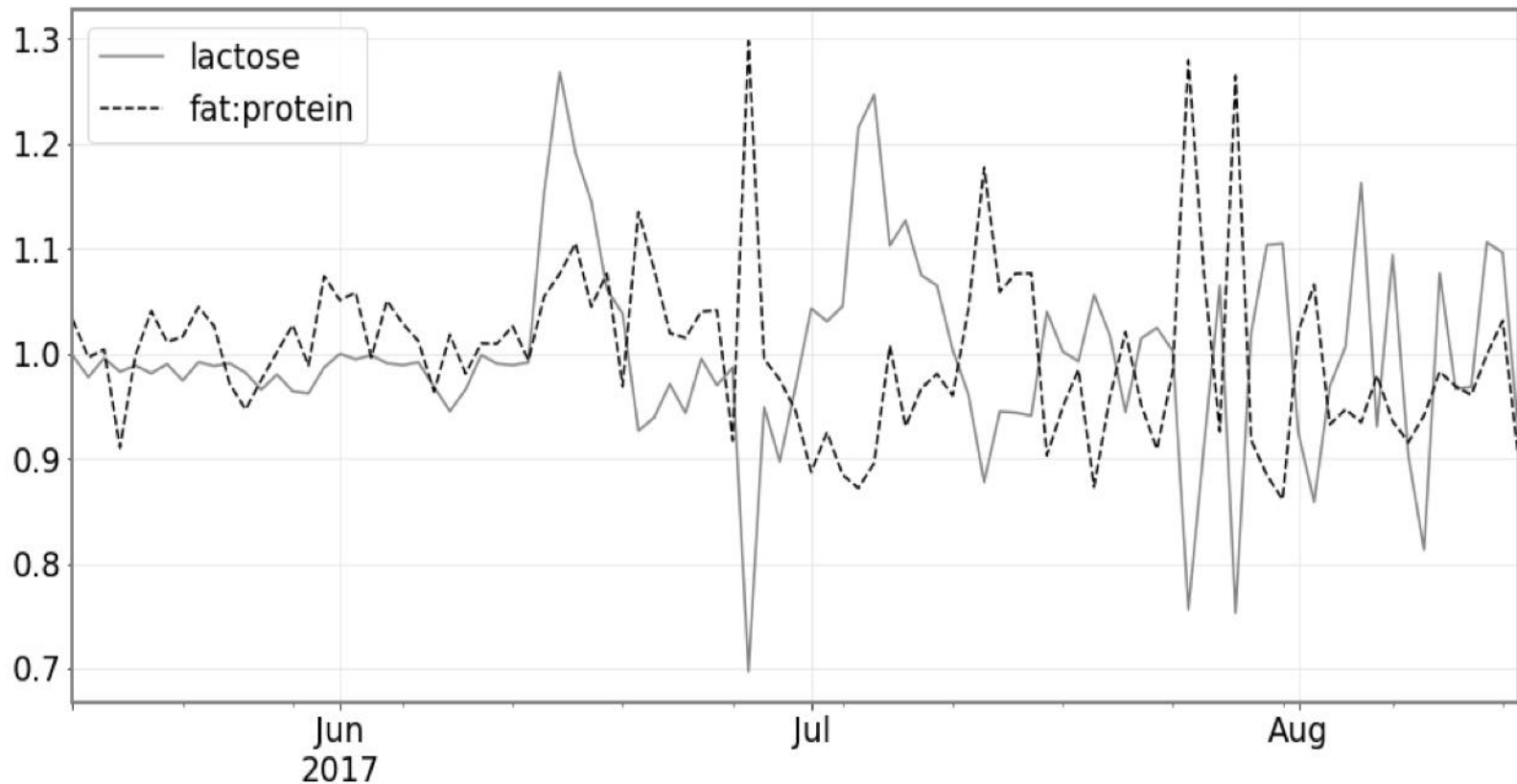- consider lowest conductivity 'best' quarter, and note deviation

Robots: Milk Conductivity (3)

- only look at the worst quarter (largest deviation), and threshold on the trend in intra-quarter deviation
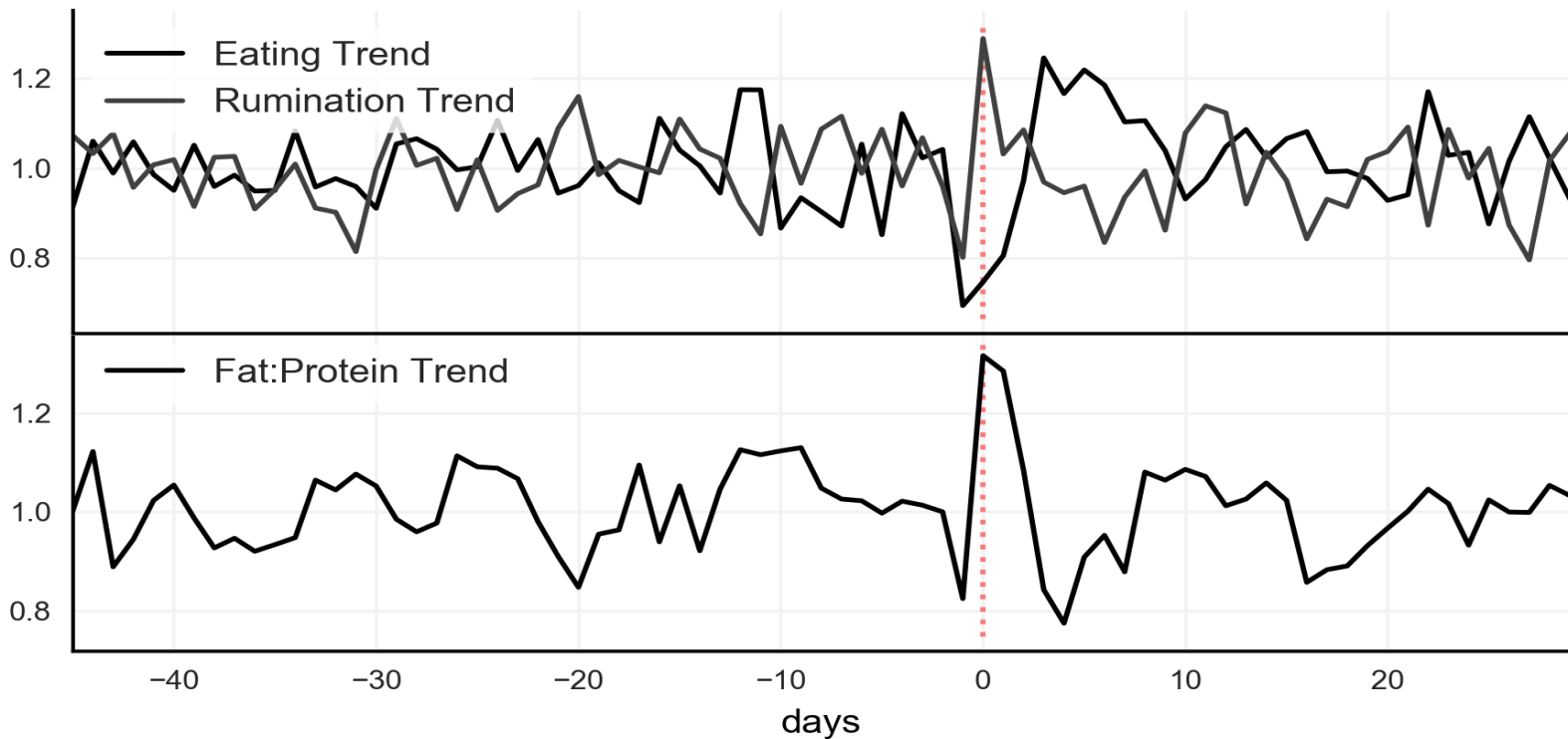
Robots: Milk Constituents

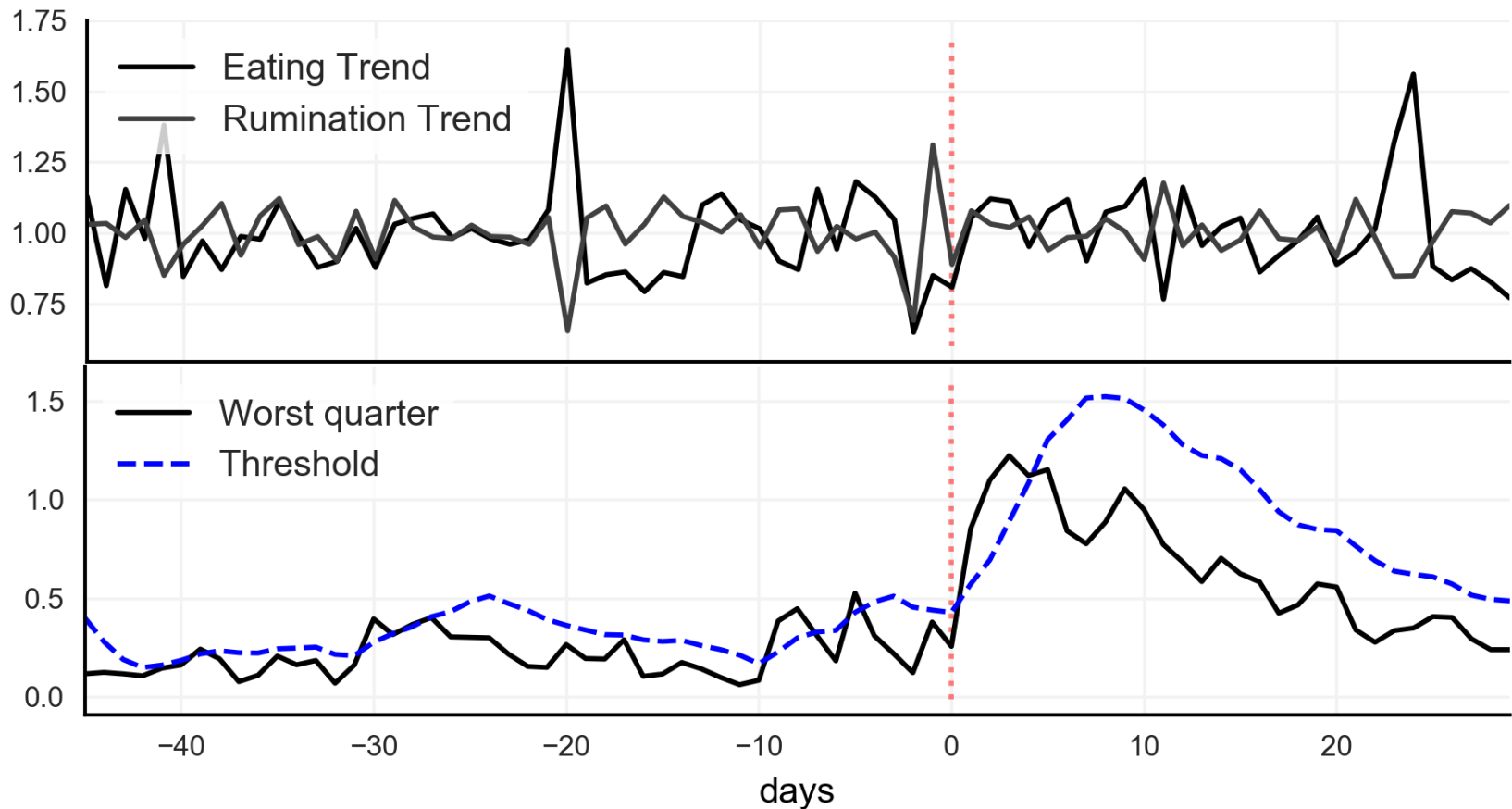- sensitive to non-health effects e.g. diet, time out of robot

Sensor Fusion (1); Collar AND Robot

- re-inforces *positive* health alerts (Collar AND Milk Constituents)
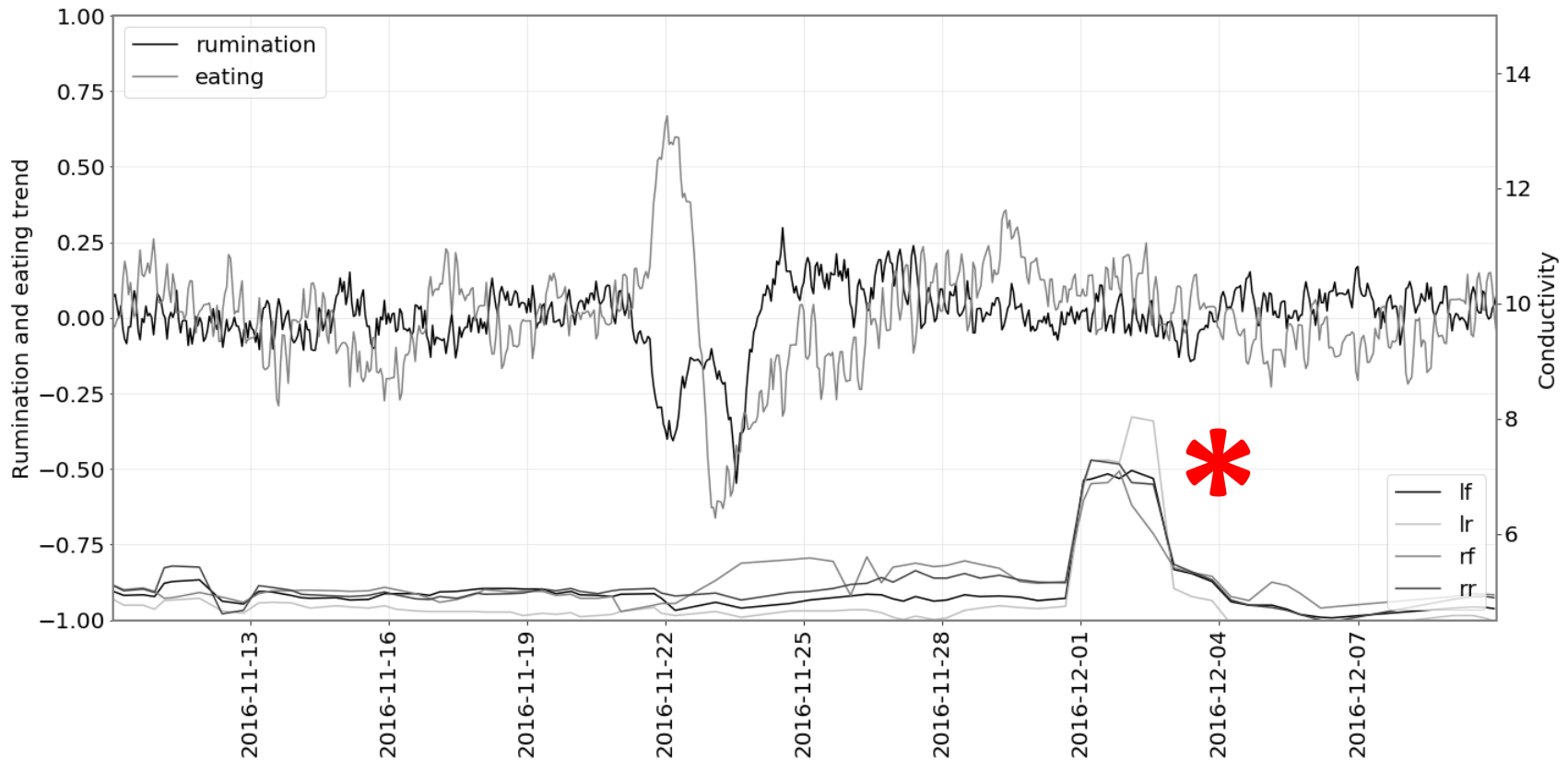
Sensor Fusion (2)

- re-inforces *positive* health alerts (Collar AND Conductivity)

Sensor Fusion (3)

- suppresses **negative** health alerts (hormone treatment AND time out of pen)

Variable Predictive Ability

- *Collar **early***

- *Robot **more specific but weaker detection***

Variable	Before	Before/ Equal	Detected?
Rumination	68%	84%	84%
Eating	71%	94%	95%
4q conductivity	26%	49%	63%
Fat	23%	68%	78%

*n.b. considering **3 days** either side of farmers' day of diagnosis*

Conclusions

- activity collars provides welfare events *before* skilled herdsman observations (1-3 days)
- robot measurands provide the specificity to identify the specific disease

- *however* further feature engineering needed to get earlier robot detection and prevent false positives

Future Work

- same pattern across...
  - breeds?
  - climates/farm settings/practices?
- how can this be used to guide/automate farm management?
- application to other health events
  - Lameness
  - Ketosis

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