Timing and consistency of luteolysis detection based on milk progesterone

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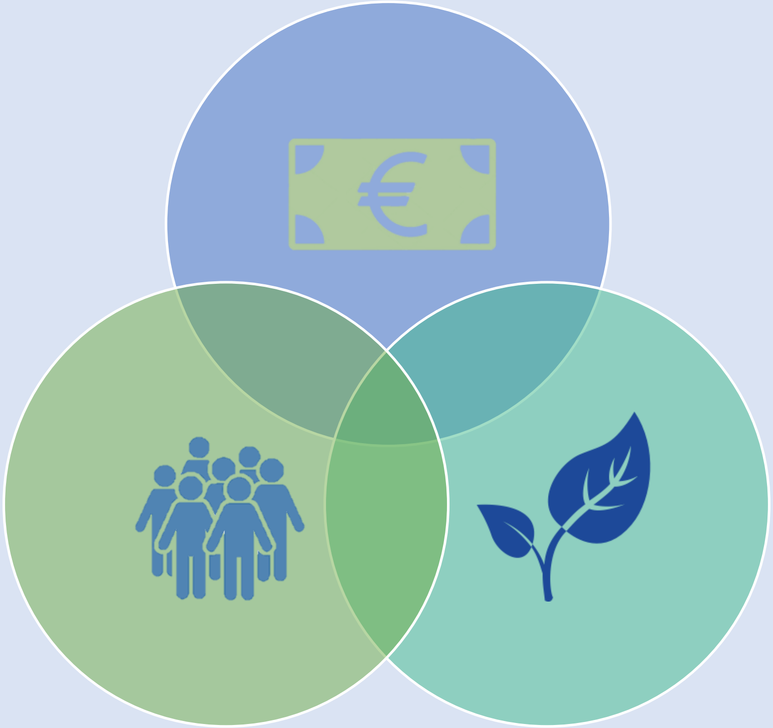
KU LEUVEN

INRA SCIENCE & IMPACT

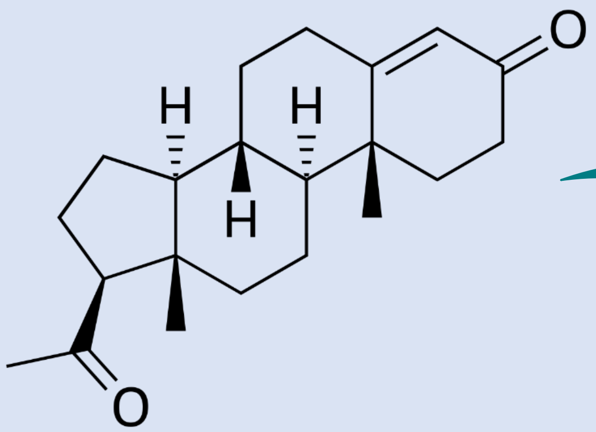
Fertility is important & detection becomes difficult



Milk progesterone allows detailed monitoring

PROGESTERONE (P4) < *CORPUS LUTEUM*

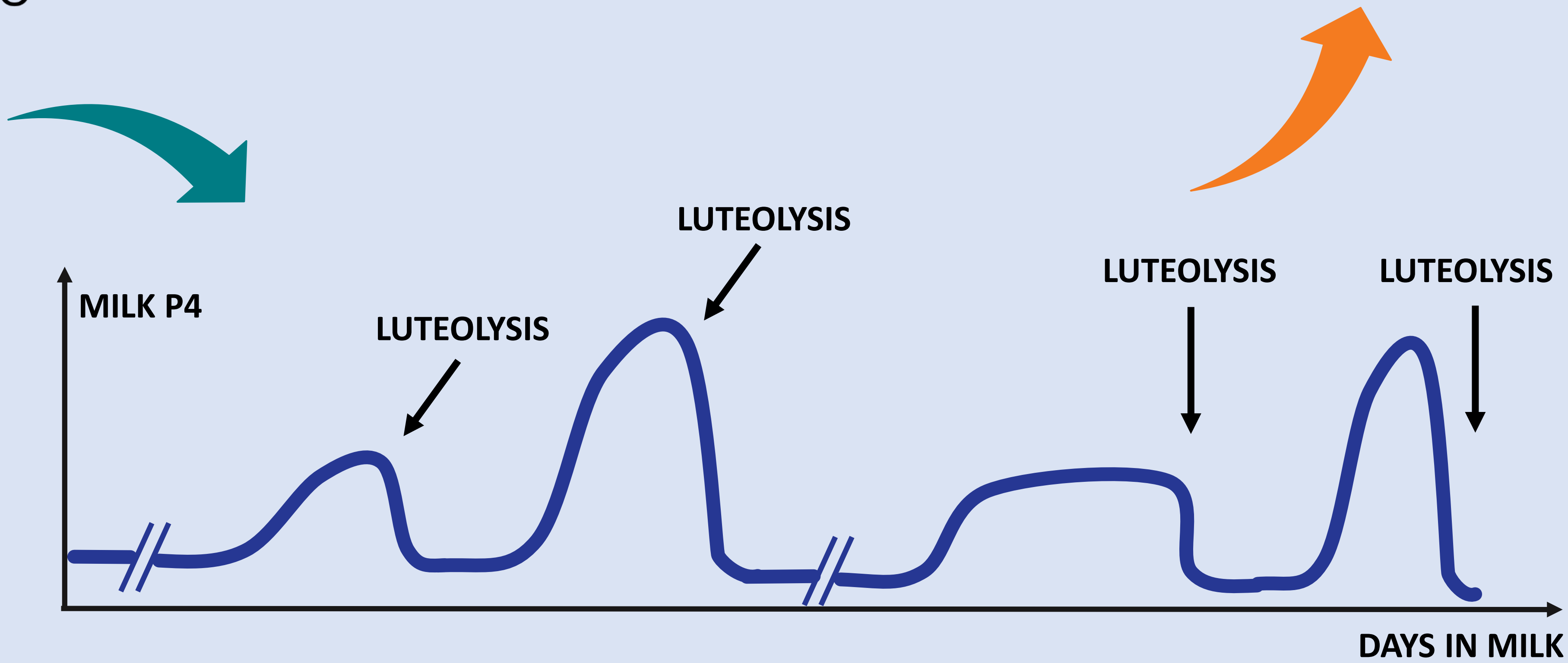
➔ TRANSFER BLOOD TO MILK



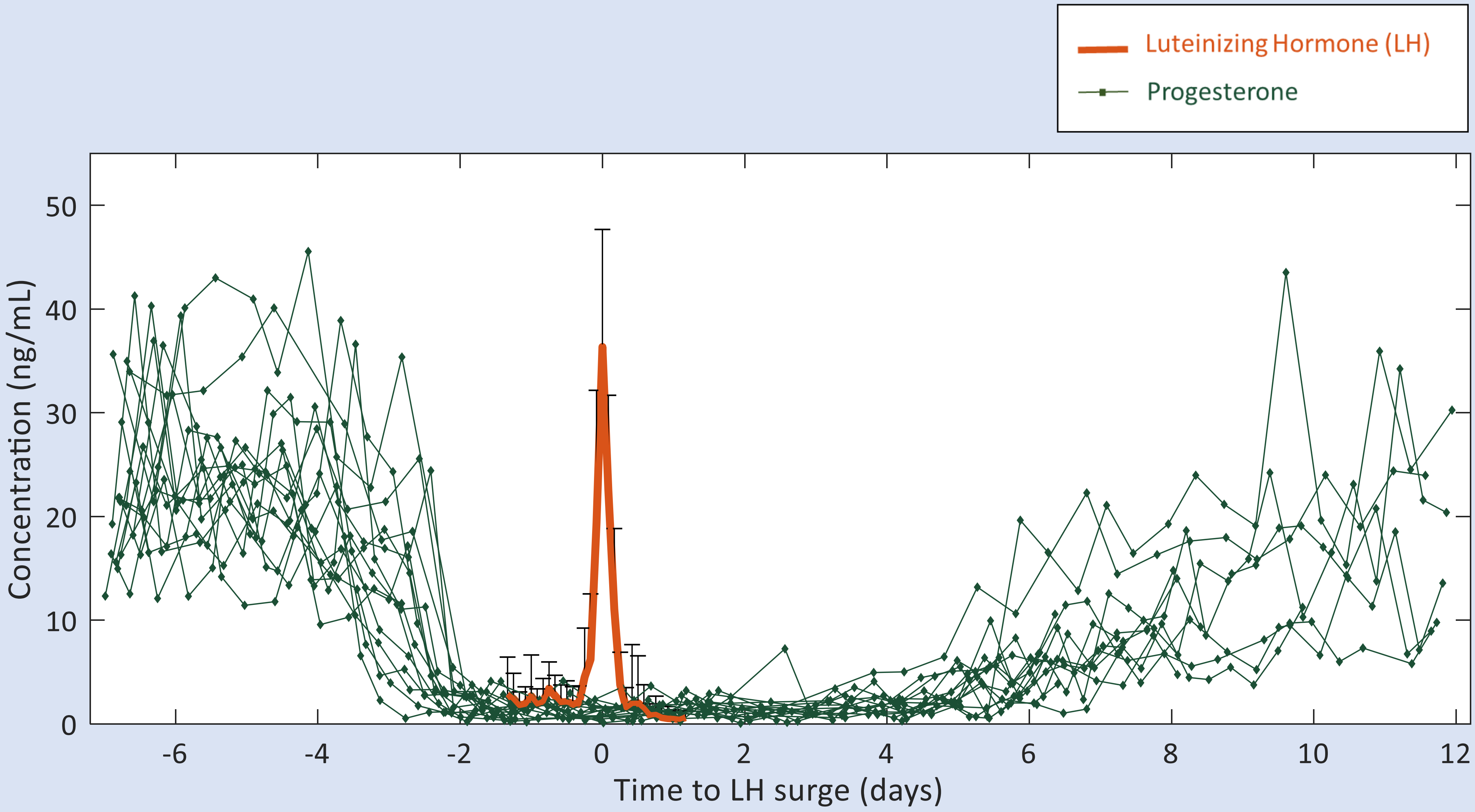
INSEMINATION

&

CONCEPTION



LH surge follows 56,4 ± 11,2h after luteolysis

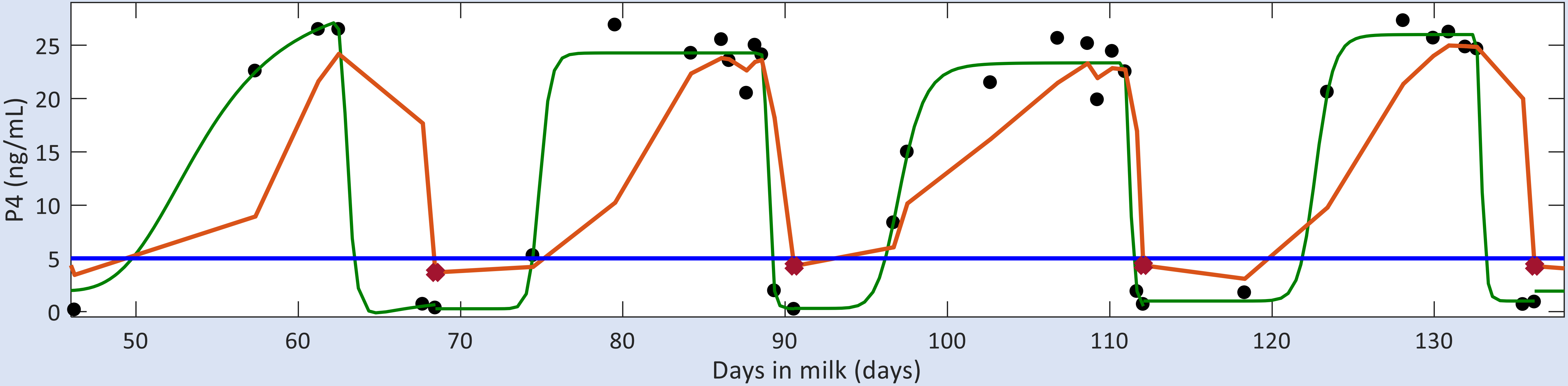


Adriaens et al. (2019) "SC: Sensitivity of estrus alerts and relationship with timing of the luteinizing hormone surge", JDS https://www.ncbi.nlm.nih.gov/pubmed/30594387

Decision support requires fast, reliable & consistent alerts

METHOD 1 - CURRENT STATE OF THE ART

A MULTIPROCESS KALMAN FILTER + **A FIXED THRESHOLD OF 5 ng/mL**



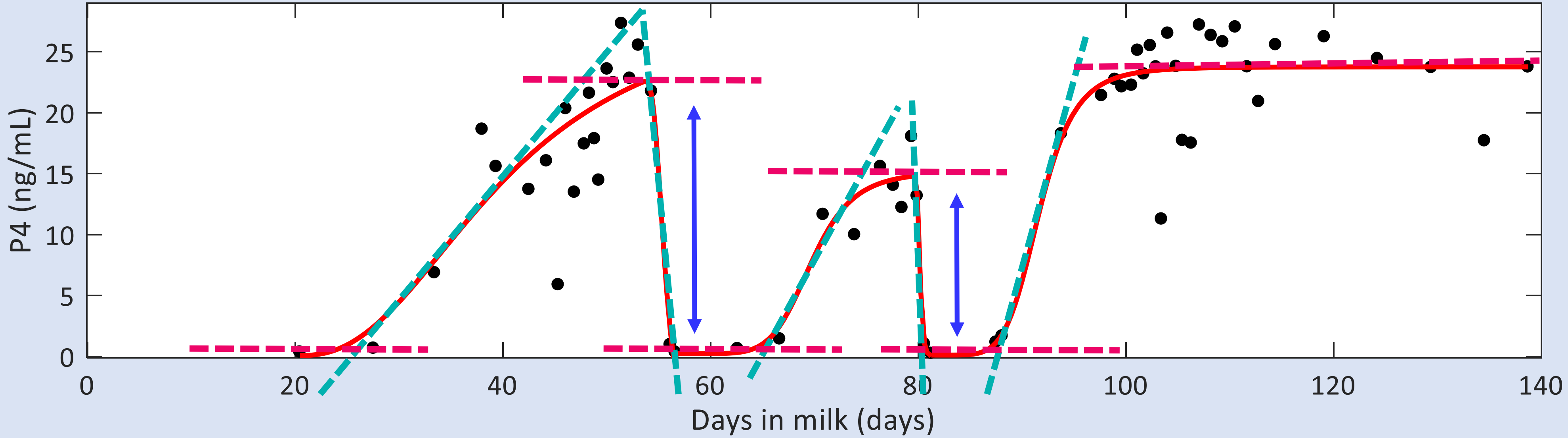
Friggens et al. (2007), US patent; Friggens & Chagunda (2005) ; Korsgaard & Løvendahl (2002); Smith & West (1983); West & Harrison (1997)

Decision support requires fast, reliable & consistent alerts

METHOD 2 – P4 MONITORING ALGORITHM USING SYNERGISTIC CONTROL - PMASC

PHYSIOLOGY-BASED MODEL OF P4 DYNAMICS + **CONTROL CHART** + **DATA-DERIVED THRESHOLD**

TB85 = ***moment*** **when P4 drops below 85% of the *upper horizontal asymptote* - the *baseline concentration***



Adriaens et al. (2017, 2018)

Data requirements for hypothesis testing

- ON-FARM
- REALISTIC
- SMART SAMPLING

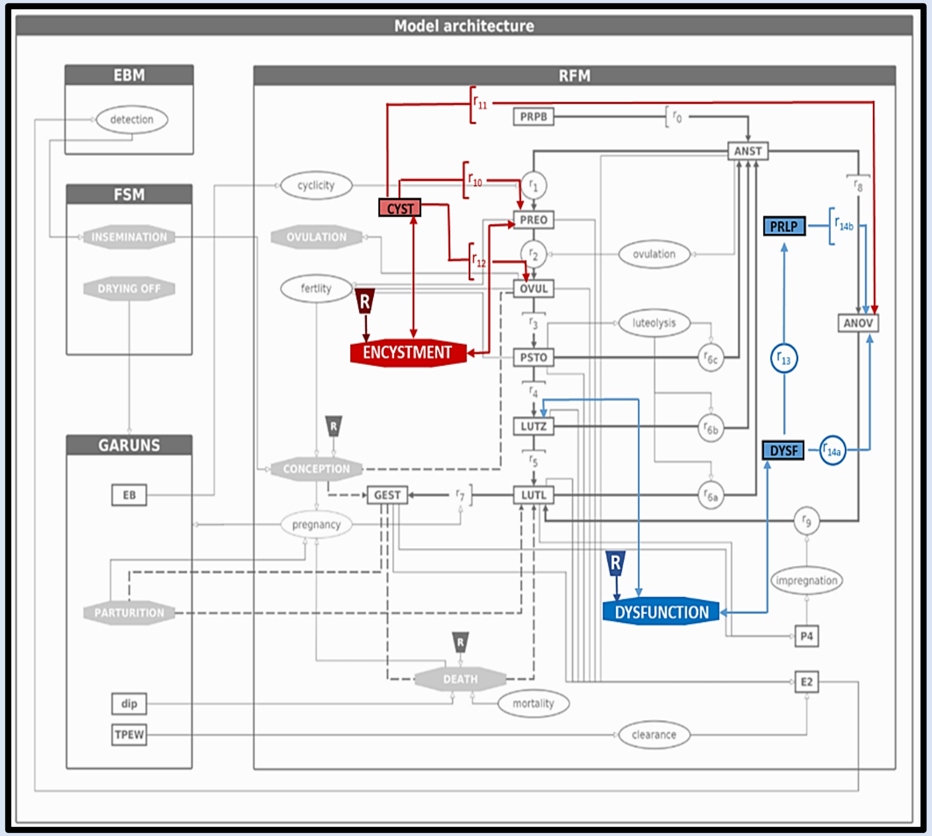
ON-FARM DATASET

- LARGE (N° ESTRUS & N° SAMPLES)
- HIGHLY VARIABLE
- WELL-CONTROLLED

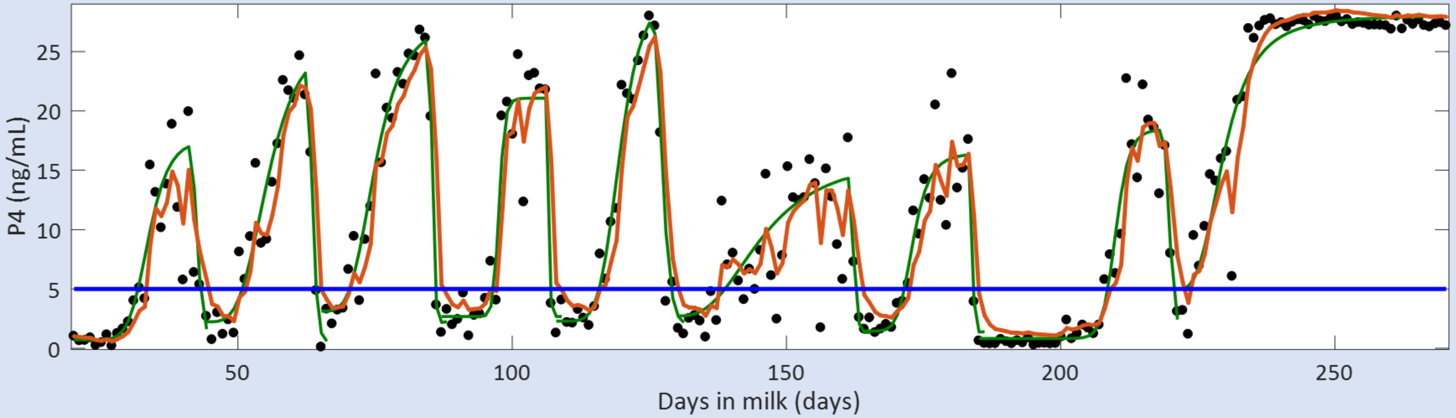
SIMULATED DATASET

Simulated dataset

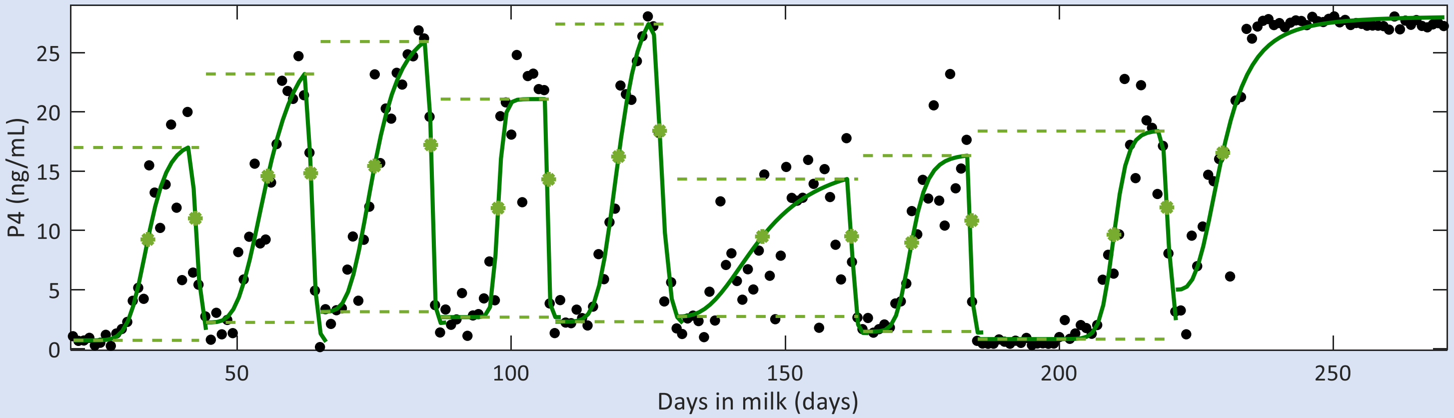
Exact moment of luteolysis = known



MULTIPROCESS KALMAN FILTER + THRESHOLD



PMASC + TB85



Martin et al. (2018); "Coupling a reproductive function model to a productive function model to simulate lifetime performance in dairy cows", ANIMAL

On-farm dataset: results

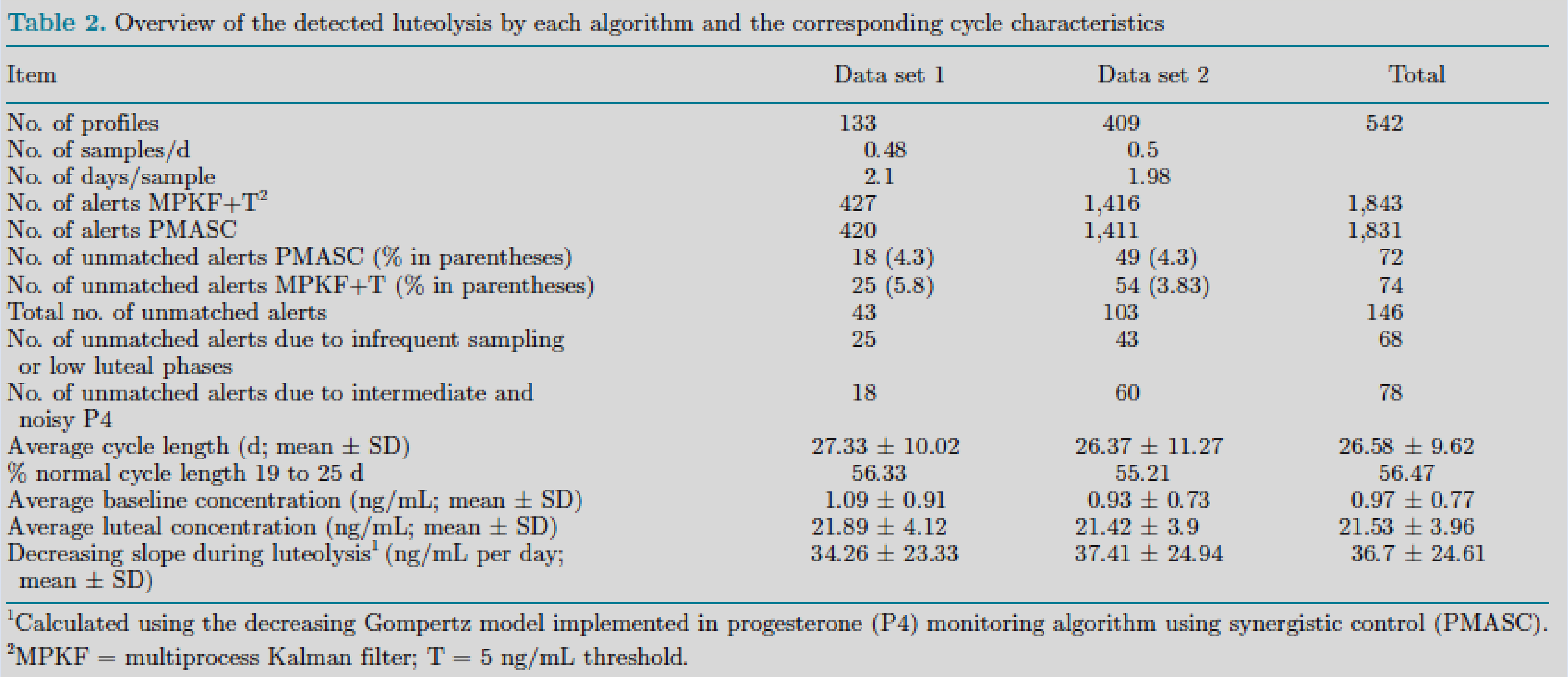


Table 2. Overview of the detected luteolysis by each algorithm and the corresponding cycle characteristics

Item	Data set 1	Data set 2	Total
No. of profiles	133	409	542
No. of samples/d	0.48	0.5	
No. of days/sample	2.1	1.98	
No. of alerts MPKF+T[2]	427	1,416	1,843
No. of alerts PMASC	420	1,411	1,831
No. of unmatched alerts PMASC (% in parentheses)	18 (4.3)	49 (4.3)	72
No. of unmatched alerts MPKF+T (% in parentheses)	25 (5.8)	54 (3.83)	74
Total no. of unmatched alerts	43	103	146
No. of unmatched alerts due to infrequent sampling or low luteal phases	25	43	68
No. of unmatched alerts due to intermediate and noisy P4	18	60	78
Average cycle length (d; mean ± SD)	27.33 ± 10.02	26.37 ± 11.27	26.58 ± 9.62
% normal cycle length 19 to 25 d	56.33	55.21	56.47
Average baseline concentration (ng/mL; mean ± SD)	1.09 ± 0.91	0.93 ± 0.73	0.97 ± 0.77
Average luteal concentration (ng/mL; mean ± SD)	21.89 ± 4.12	21.42 ± 3.9	21.53 ± 3.96
Decreasing slope during luteolysis[1] (ng/mL per day; mean ± SD)	34.26 ± 23.33	37.41 ± 24.94	36.7 ± 24.61

[1]Calculated using the decreasing Gompertz model implemented in progesterone (P4) monitoring algorithm using synergistic control (PMASC).
[2]MPKF = multiprocess Kalman filter; T = 5 ng/mL threshold.

Adriaens et al. (2019a): "SC: Validation of a novel milk progesterone based tool to monitor luteolysis in dairy cows. Performance on cost-effective, on-farm measured data", JDS

On-farm dataset: results

- **PMASC works on on-farm measured data**

- **PMASC performs well with a cost-effective sampling frequency**
  - 1843 luteolyses detected by multiprocess Kalman filter + threshold
  - 1831 luteolyses detected by PMASC (4% not detected)

  ➔ On-farm sampling frequency: not optimized for PMASC

- **Alerts PMASC 20 ± 16,1 h and 2,6 ± 2,1 milkings earlier**

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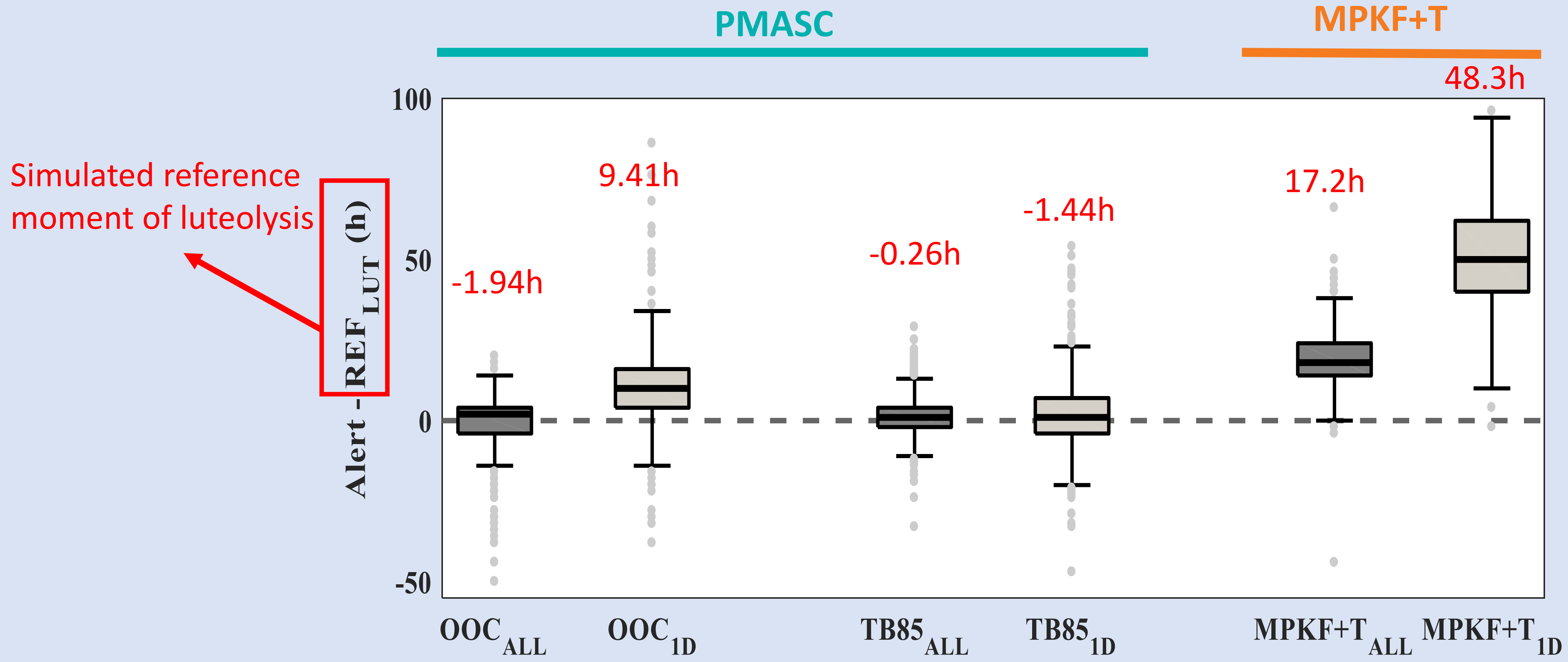
Simulated dataset: results



Adriaens et al. (in press): "Validation of a novel milk progesterone based tool to monitor luteolysis in dairy cows. Timing of the alerts and robustness against missing values", JDS

Simulated dataset: results

- **Using TB85, estrus detection is consistent + has higher sensitivity**
- **PMASC captures luteolysis at onset = close to simulated reference**
- **PMASC is more robust for missing samples during luteolysis**

Adriaens et al. (in press): "Validation of a novel milk progesterone based tool to monitor luteolysis in dairy cows. Timing of the alerts and robustness against missing values", JDS

Thank you!

LIVESTOCK TECHNOLOGY TEAM 2019