Evaluation of an Ear-Attached Sensor (Smartbow) for the Detection and Characterization of Estrus Events in Dairy Cattle

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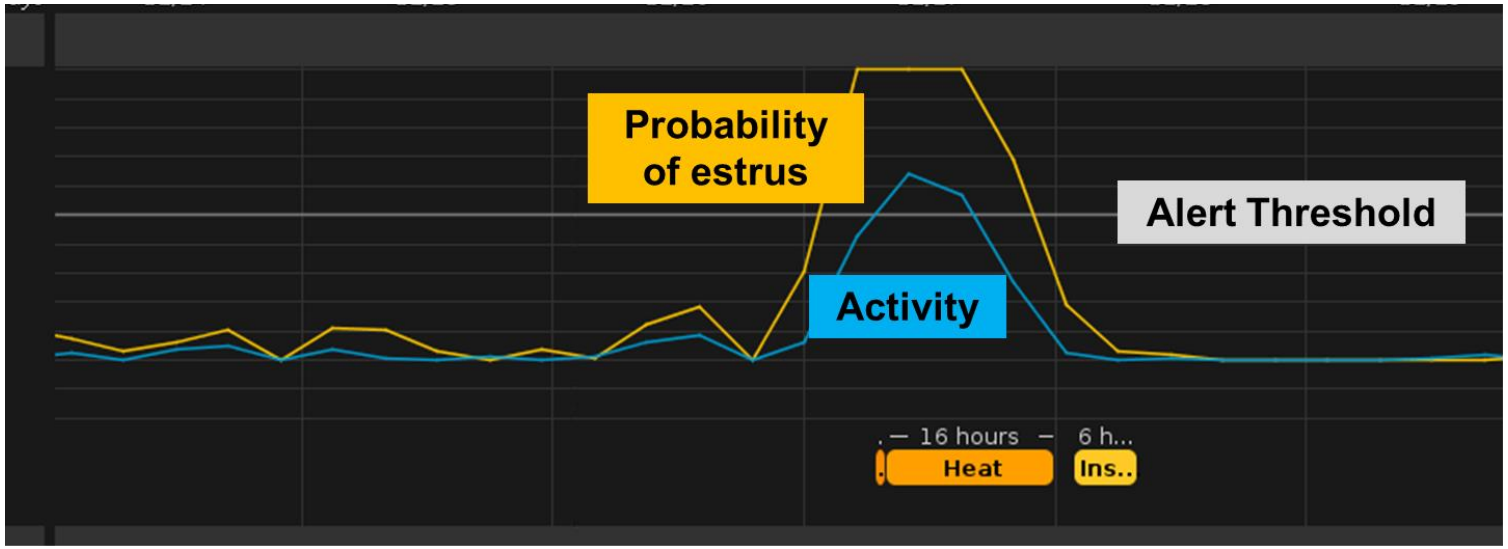
TAKE HOME

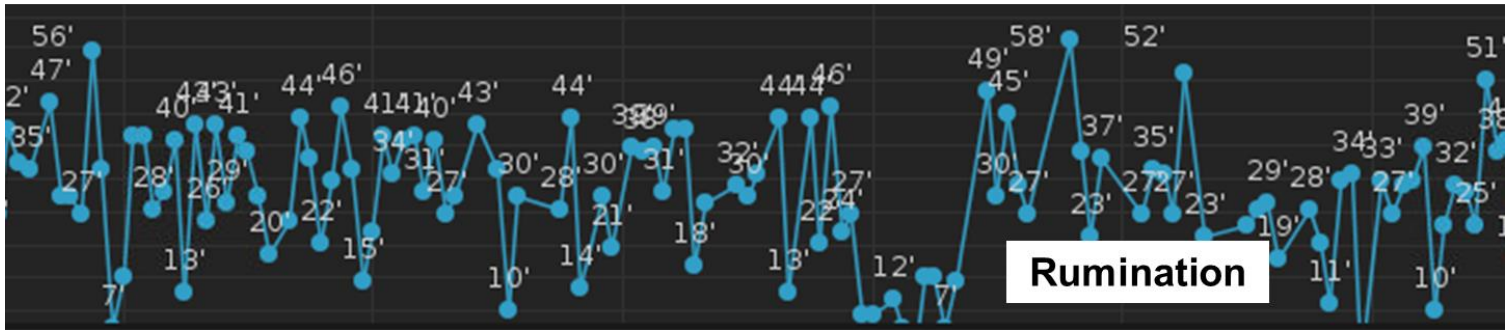
The Smartbow ear-attached automated estrus detection system was capable of generating estrus alerts for a majority of cows in estrus with a low incidence of false positive alerts

Cornell CALS
College of Agriculture and Life Sciences

Ear-attached Automated Estrus Detection Systems

Smartbow (Zoetis)





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3) Characterize estrus alerts features and timing of alerts in relationship to ovulation

Overview of Experimental Timeline

Trial conducted at CURC from **Dec 2018 – April 2019**

n = **216** lactating Holstein cows, eligible for first or a second/subsequent service

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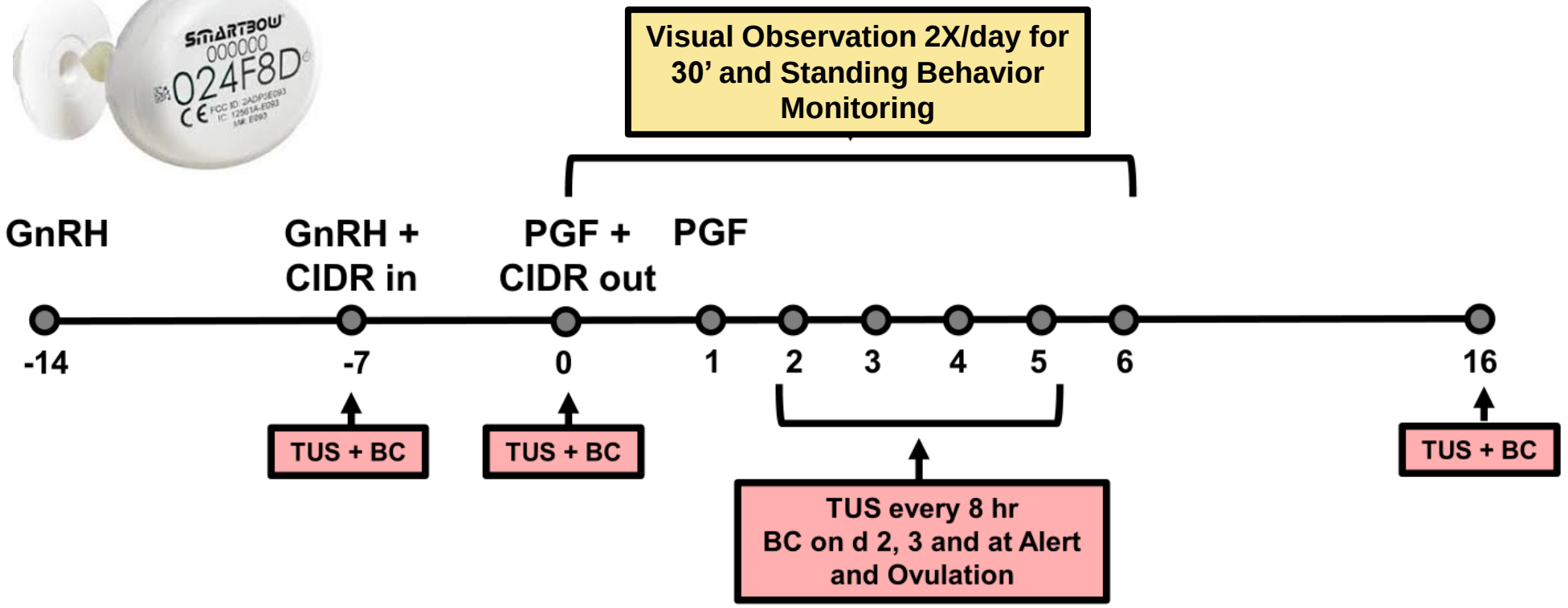

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TUS: Transrectal ultrasonography
BC: Blood collection

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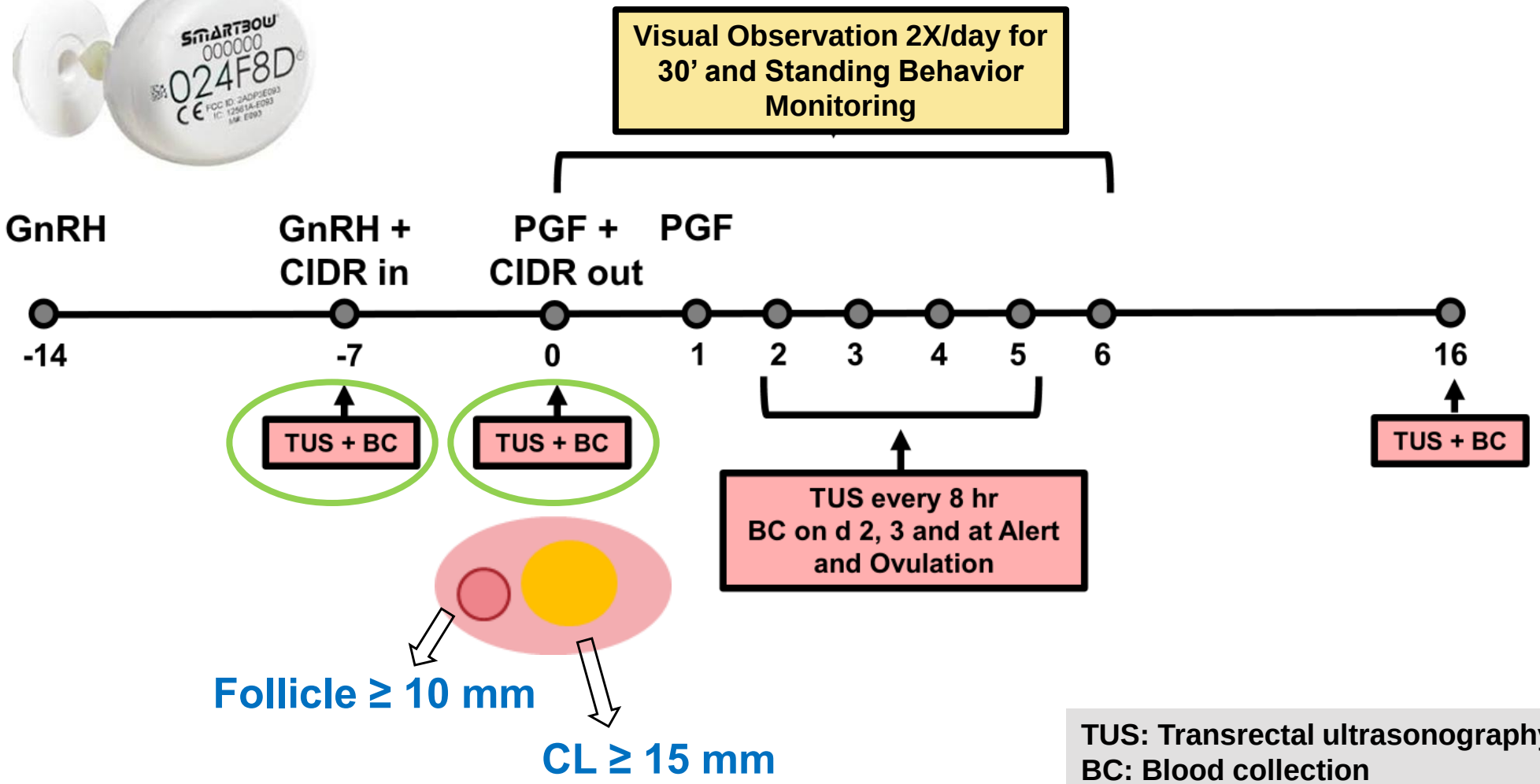

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Overview of Experimental Timeline

Visual Observation 2X/day for 30' and Standing Behavior Monitoring

GnRH

GnRH + CIDR in

PGF + CIDR out

PGF

-14 -7 0 1 2 3 4 5 6 16

TUS + BC

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TUS every 8 hr
BC on d 2, 3 and at Alert and Ovulation

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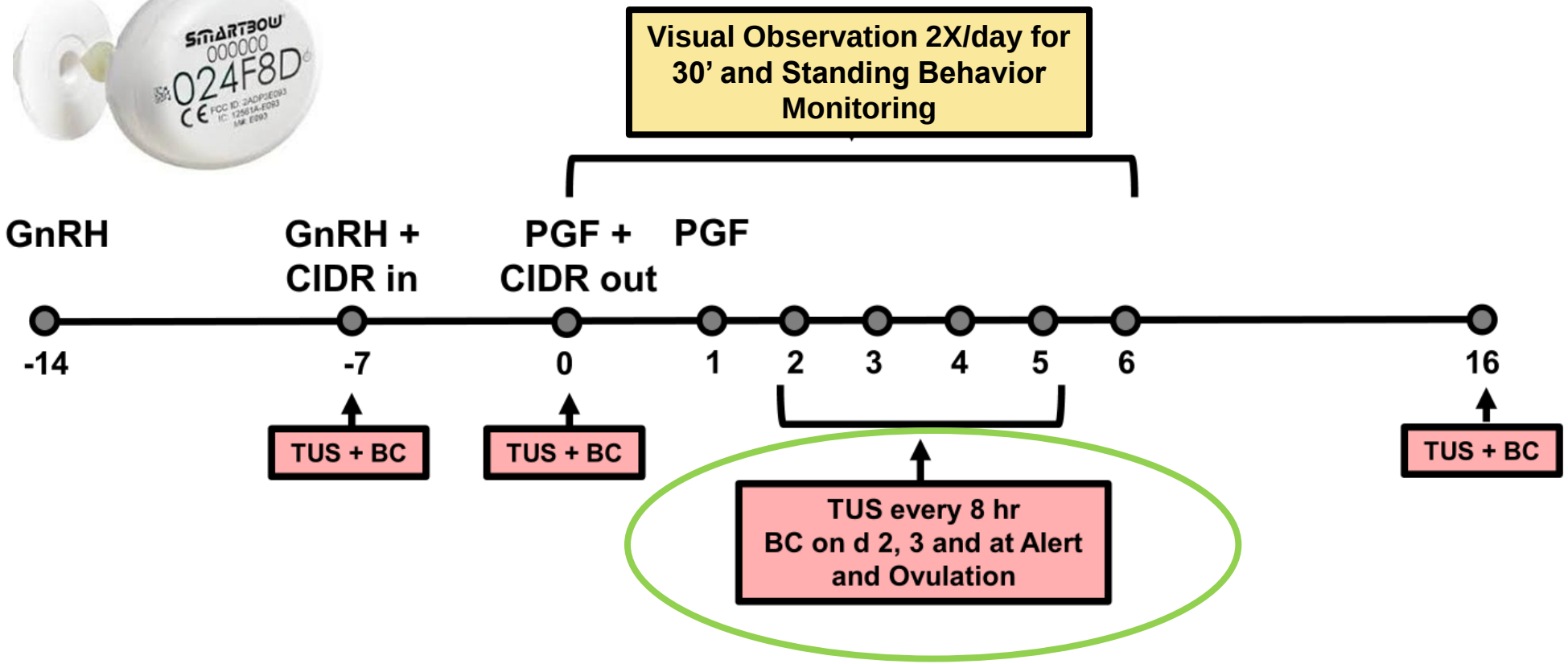
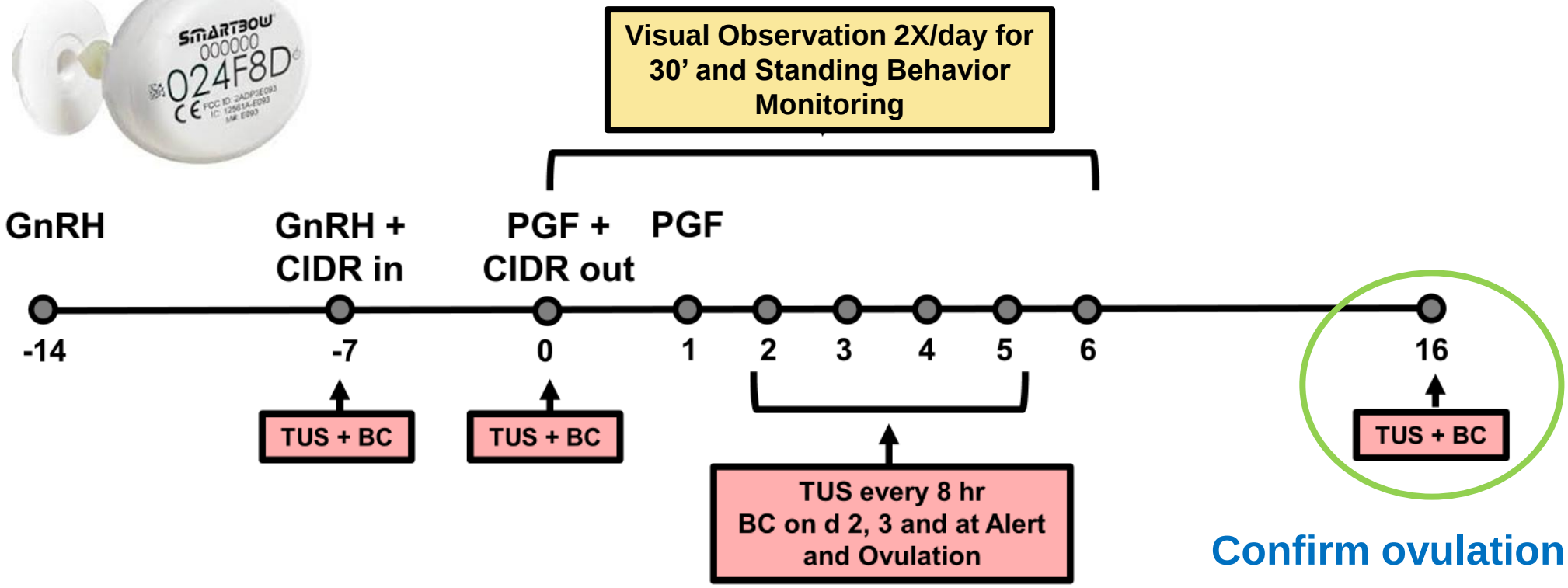


1) Ovulation monitoring – follicle disappearance
2) Confirm low progesterone

TUS: Transrectal ultrasonography
BC: Blood collection

Overview of Experimental Timeline



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Overview of Experimental Timeline

Visual Observation 2X/day for 30' and Standing Behavior Monitoring

GnRH | GnRH + CIDR in | PGF + CIDR out | PGF

-14 | -7 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 16

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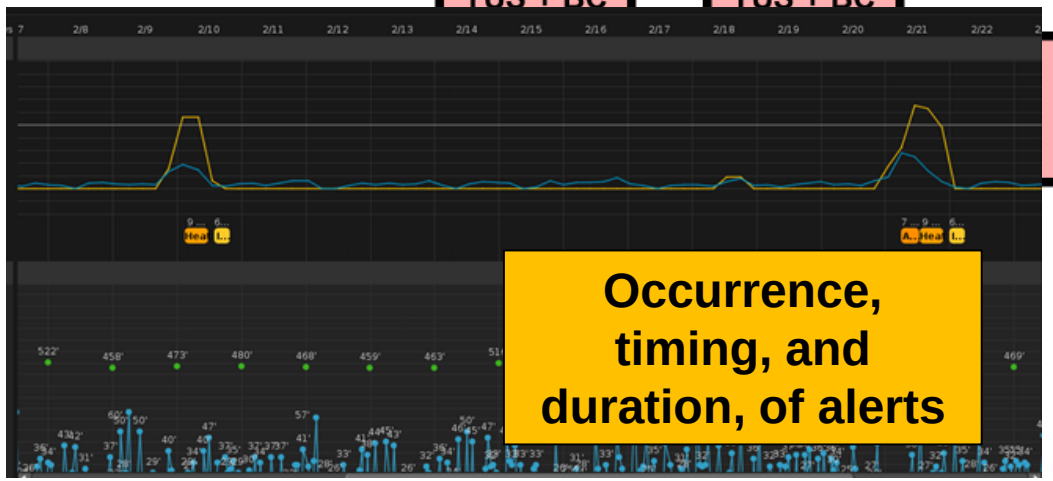

Occurrence, timing, and duration, of alerts

TUS: Transrectal ultrasonography
BC: Blood collection

Reference Test for Estrus Detection

- Combination of **HeatWatch data** and **Visual Observation**
- **Requirements:**

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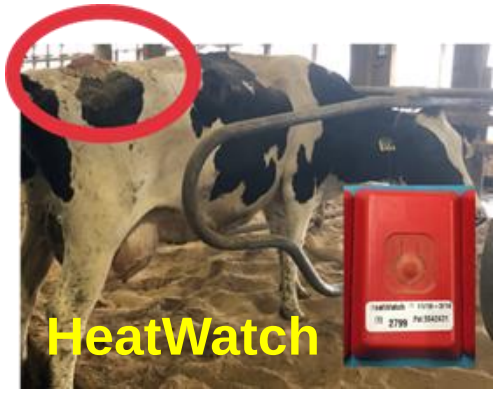

≥ 2 Standing events recorded
duration ≥ 1 second
within a 12 h window

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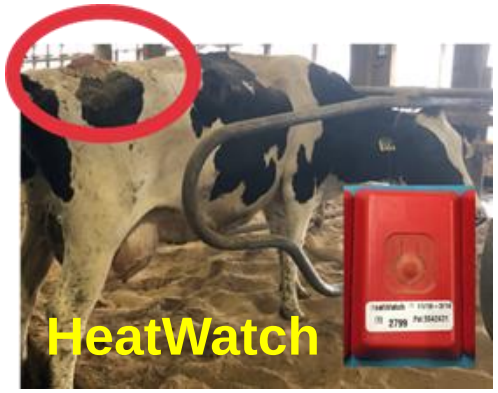

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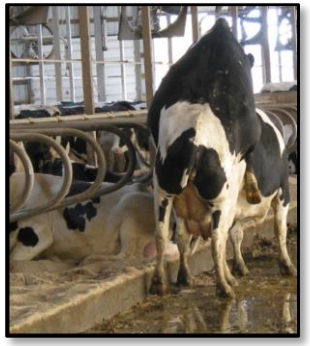
OR

Standing Estrus (Primary Sign)



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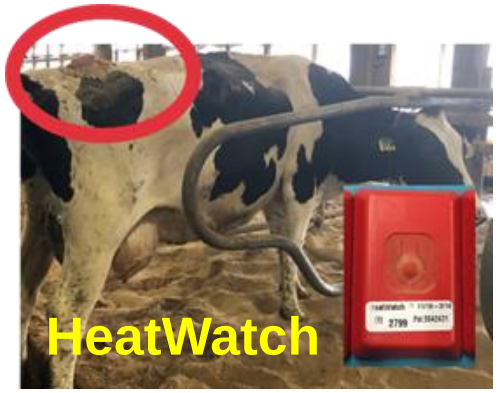

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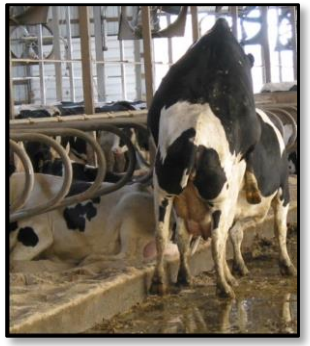

OR

≥ 2 <u>Secondary</u> Signs of Estrus

- Mounted, not standing
- Mounting other cows
- Resting chin on back of other cows
- Sniff vulva of other cows
- Increased activity/restlessness

Results

Objective #1

Evaluate ability of the Smartbow system to detect cows in estrus

Metrics of Performance for Detection of Estrus for the Smartbow System

Reference method used	Sensitivity	Specificity	NPV[1]	PPV[1]	Overall accuracy	Balanced accuracy
REF[3] (n = 216)						

[1]NPV.
[2]PPV
[3]RTE: combination of VO and standing behavior.
[4]RTE + Ovu: both the reference test and ovulation were used. Cows were excluded if had a putative false positive or false negative outcome for the reference test, failed to ovulate after detection of estrus by the reference test and the AED system, or ovulated and were not detected by either the RTE and the AED system.

Metrics of Performance for Detection of Estrus for the Smartbow System

Reference method used	Sensitivity	Specificity	NPV[1]	PPV[1]	Overall accuracy	Balanced accuracy
REF[3] (n = 216)	92 (87.6 to 95.5)	69 (51.5 to 87.0)	53 (36.2 to 69.7)	96 (92.6 to 98.6)	88 (83.6 to 92.3)	80 (69.6 to 91.3)

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Metrics of Performance for Detection of Estrus for the Smartbow System

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Ovulation (n = 216)	90 (85.3 to 93.8)	87 (69.5 to 100)	38 (21.9 to 54.6)	99 (97.4 to 100)	93 (89.7 to 96.5)	88 (77.4 to 96.9)

[1]NPV.
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Metrics of Performance Estimated after Removing Cows with Physiological or Reference Test Limitations

Cow	Smartbow alert	Reference Test	Ovulation	Physiological or REF limitation
1	NO	NO	YES	Silent ovulation
2	NO	NO	YES	
3	NO	NO	YES	
4	NO	NO	YES	
5	NO	NO	YES	
6	NO	NO	YES	
7	NO	NO	YES	
8	YES	NO	YES	False negative for reference test
9	YES	NO	YES	
10	YES	NO	YES	
11	YES	NO	YES	
12	YES	NO	YES	
13	YES	NO	YES	
14	YES	NO	YES	
15	NO	YES	NO	False positive for reference test
16	NO	YES	NO	
17	YES	YES	NO	Ovulatory failure

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REF+PHY LIMITATIONS REMOVED[4] (n = 199)	93 (88.7 to 96.3)	92 (76.0 to 100)	44 (24.5 to 63.5)	99 (98.3 to 100)	94 (90.7 to 97.3)	92 (82.4 to 98.2)

[1]NPV.
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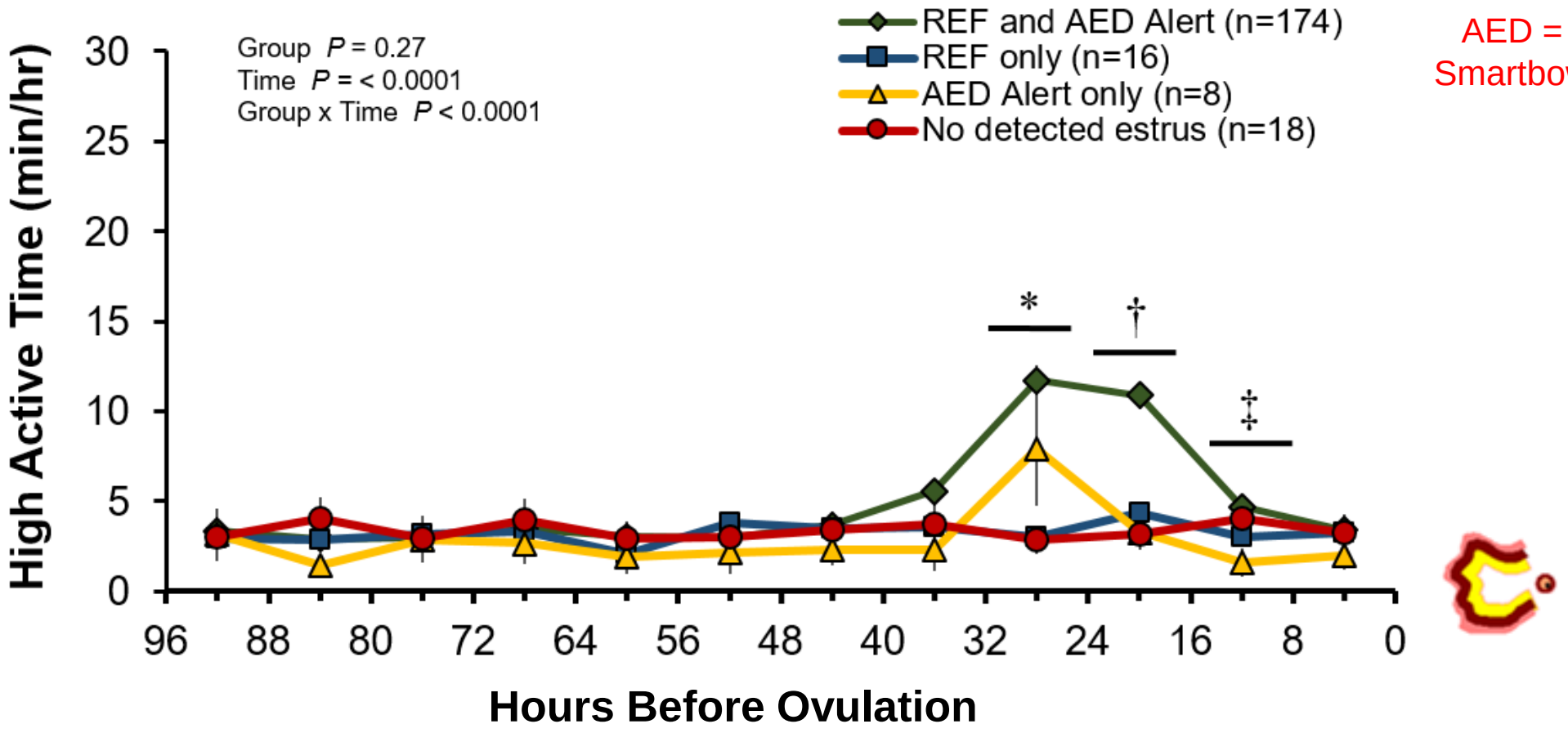
[3]RTE: combination of VO and standing behavior.
[4]REF + PHY LIMITATIONS REMOVED: Cows were excluded if had a putative false positive or false negative outcome for the reference test, failed to ovulate after detection of estrus by the reference test and the Smartbow system, or ovulated and were not detected by either the REF and the Smartbow system.

Results

Objective #2

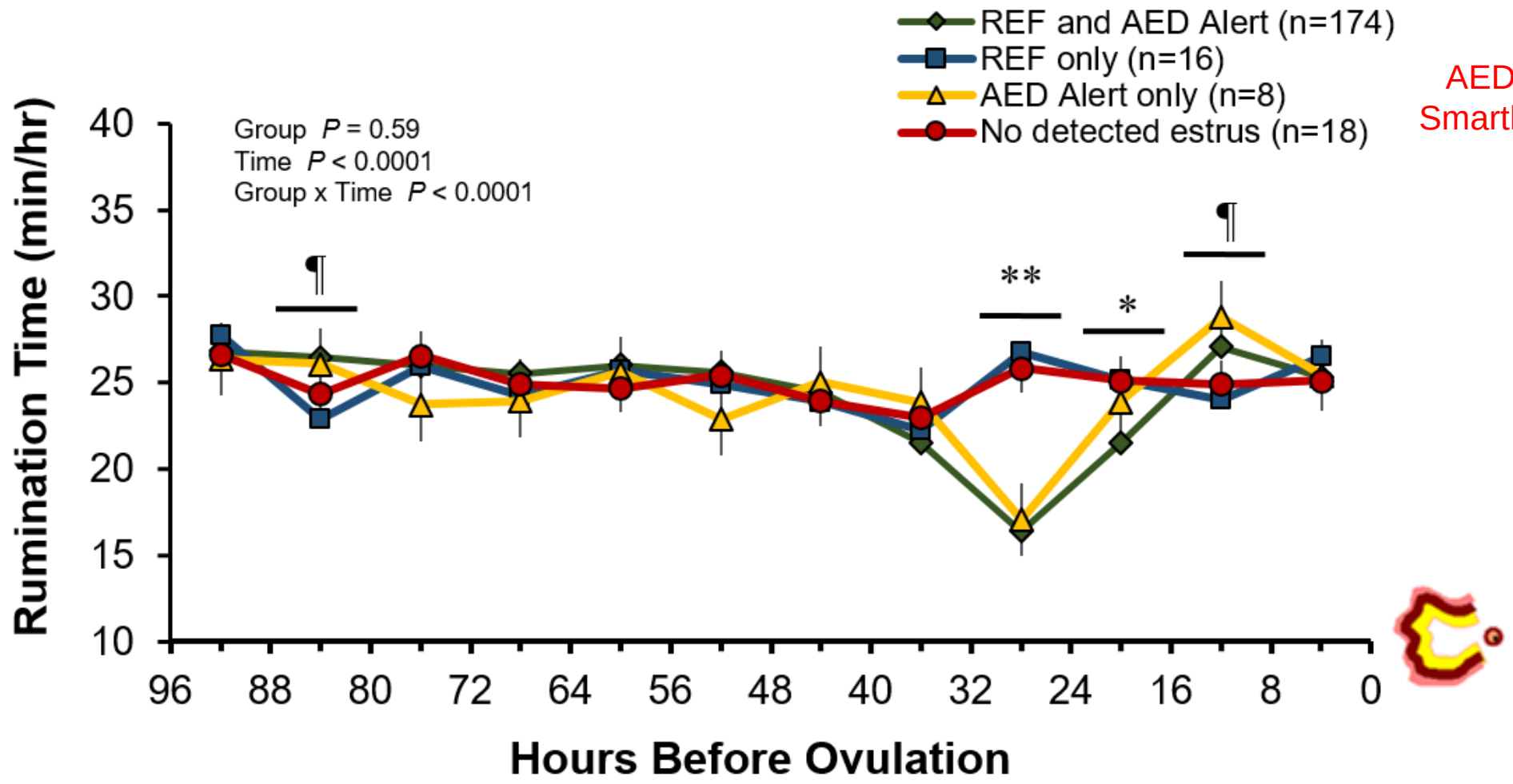
Characterize changes in physical activity and rumination in relationship to timing of ovulation

Activity pattern prior to ovulation



AED = Smartbow

Rumination pattern prior to ovulation



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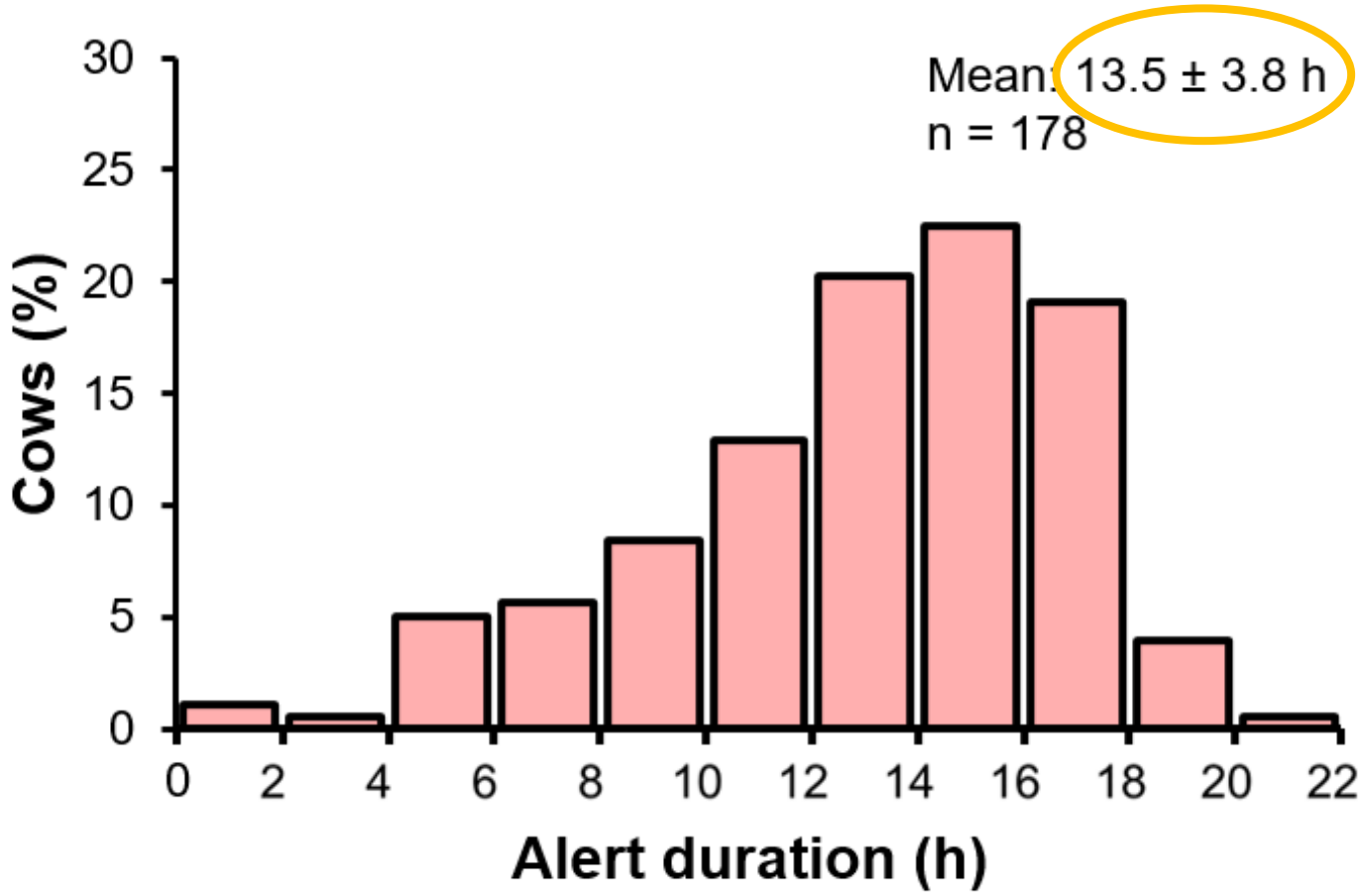
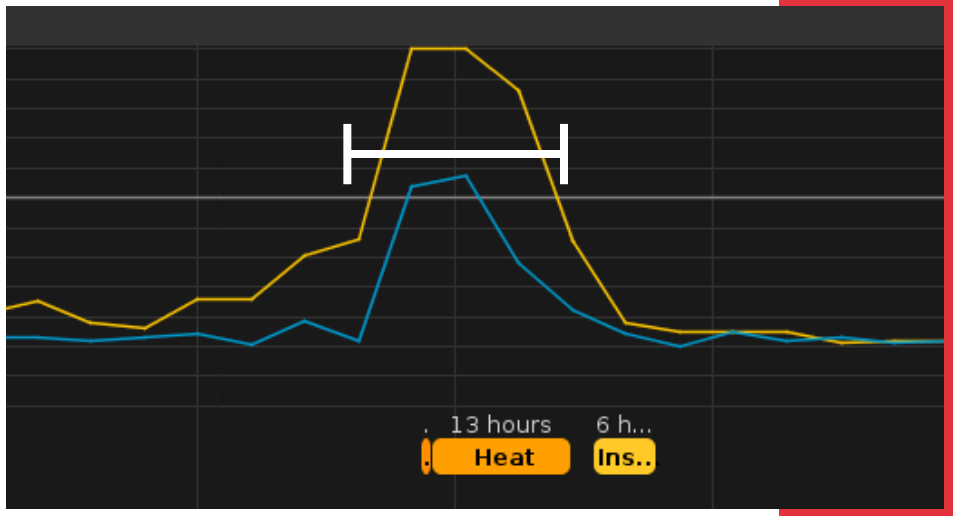
Results

Objective #3

Characterize estrus alerts features and timing of alerts in relationship to ovulation

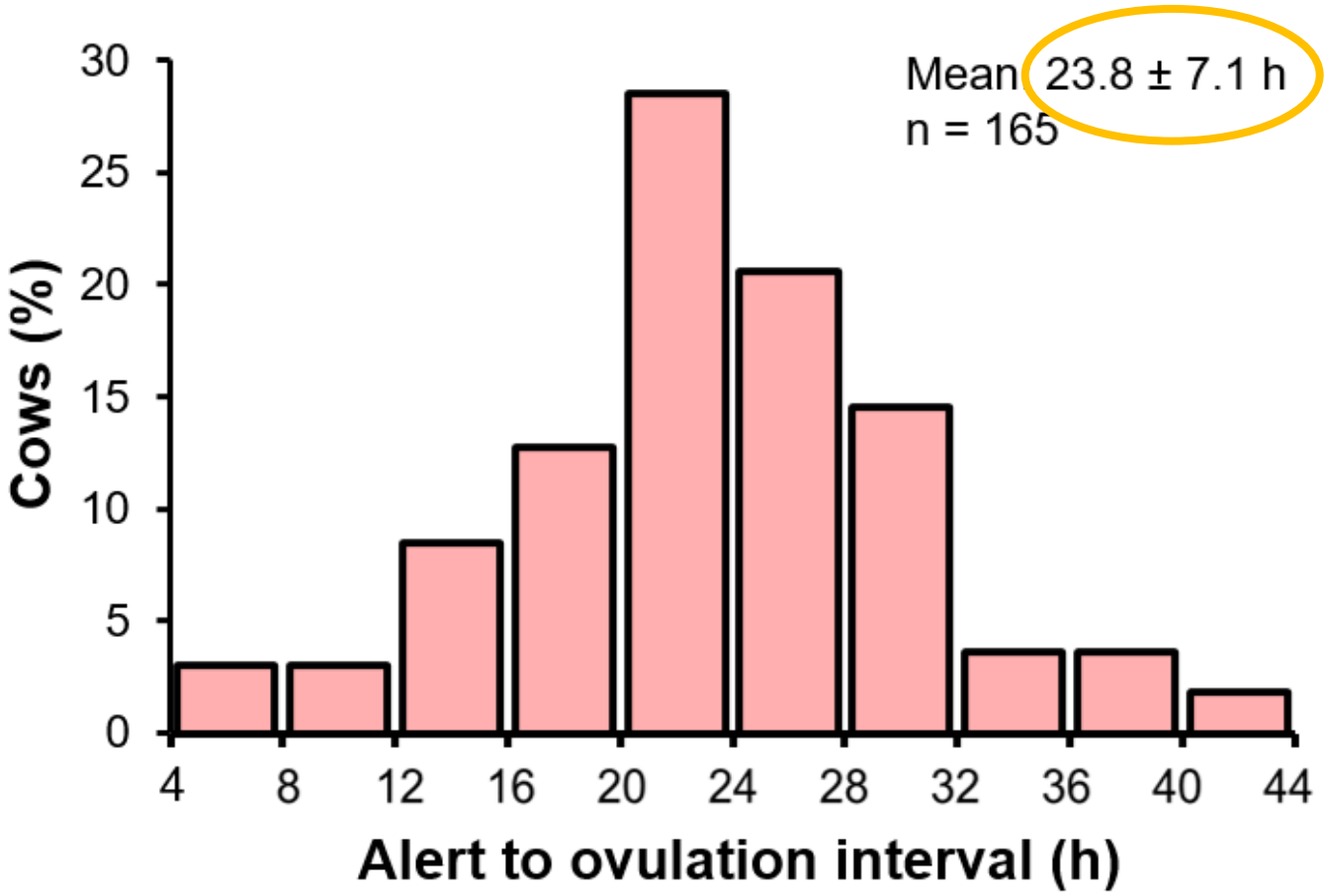
Distribution of Estrus Alert Duration





***High milk producing cows tended to have shorter alert duration than low producing cows (P = 0.08)**

Distribution of Alert to ovulation intervals



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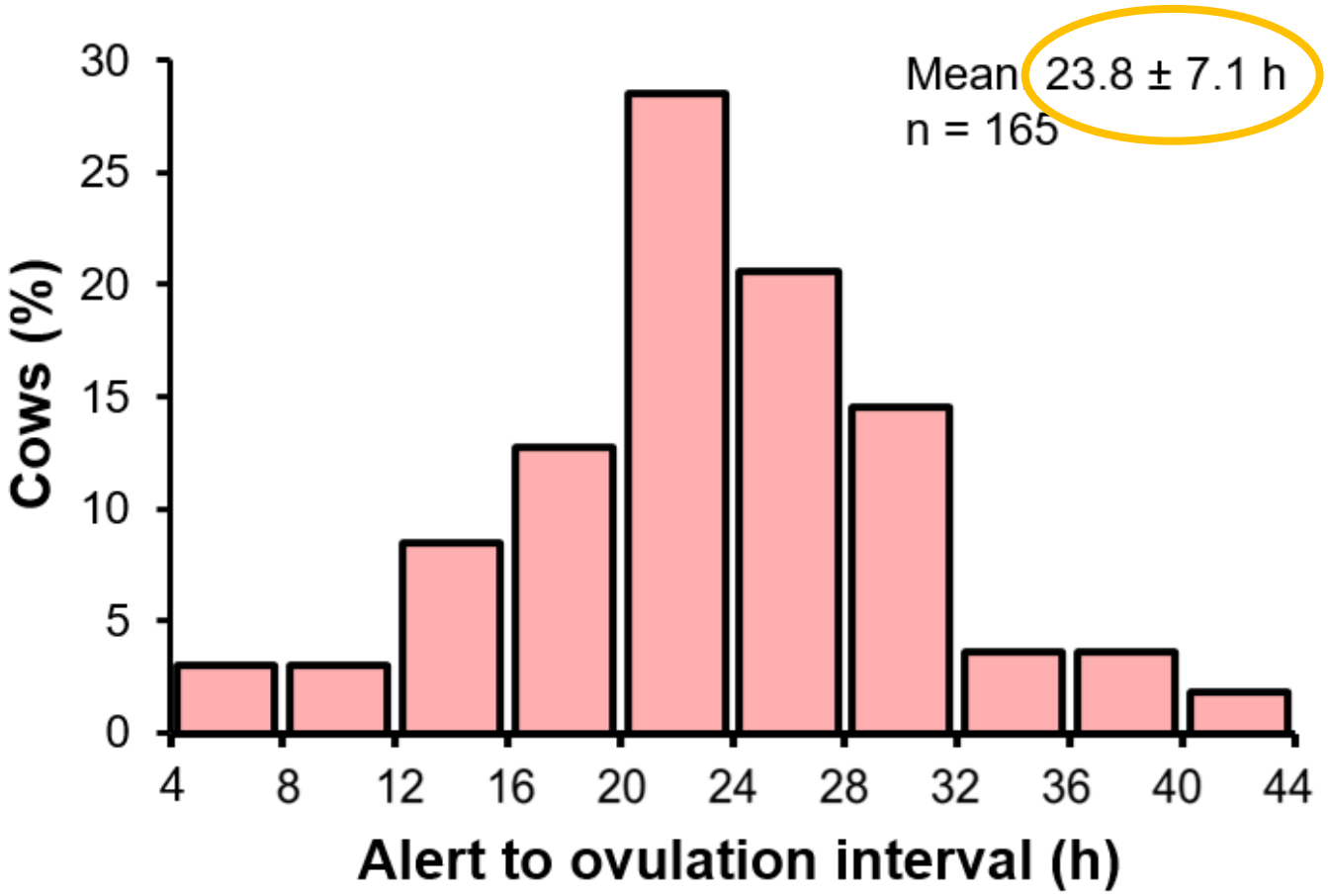
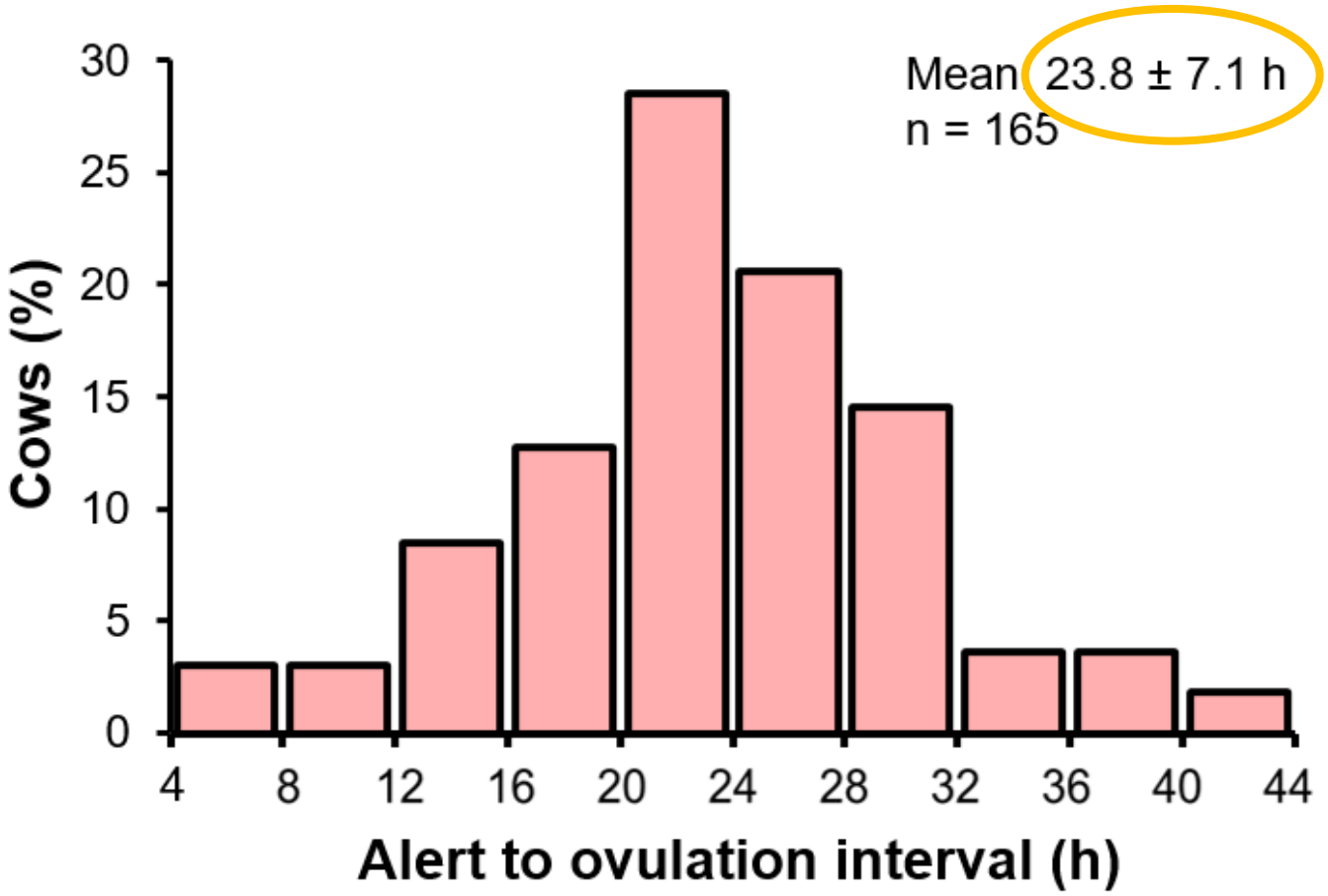


***Milk production level had a significant effect on alert to ovulation interval**

Distribution of Alert to ovulation intervals



***High producing cows tended to have shorter interval than low producing cows (P = 0.07)**

Summary

- The **Smartbow** ear-attached automated estrus detection system generated **estrus alerts** for the **majority of cows in estrus** with a **low incidence of false positive alerts**
- **Metrics of performance** for the Smartbow system varied depending on the **outcome used as reference test**
- As expected, **activity levels increased and rumination time decreased** for the **majority but not all cows** detected in estrus by the REF method → Smartbow may not detect estrus in some cows detected by other methods
- Some cows not detected by the REF method had an estrus alert and ovulated suggesting that the **Smartbow system may correctly identify** some cows **not detected by other methods**

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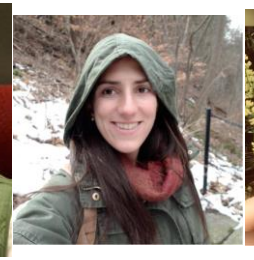


Undergraduate students

zoetis

Research partially funded by Zoetis

Thank you!

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Questions?