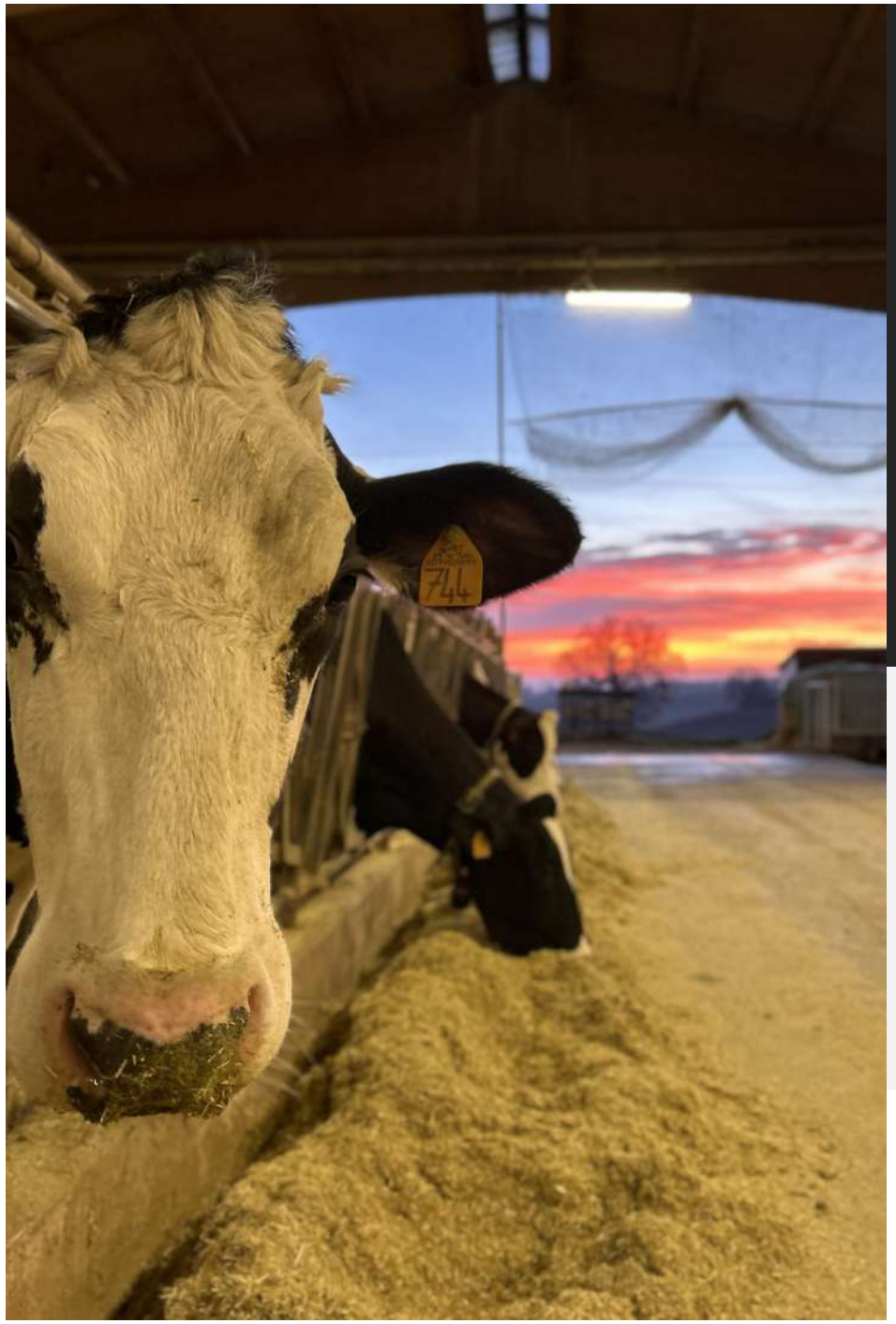

Role of environmental and signal parameters in stabilizing sniffer methane measurements in dairy cows

R. Colleluori[1], G. Visentin[1], V. Indio[1], D. Cavallini[1], L. Mammi[1], L. Zambianchi[1], M. Martini[1], F. Ghiaccio[1], M. Lamanna[1], A. Formigoni[1]

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EAAP Meeting – Artificial Intelligence 4 Animal Science

Ghent, Belgium

June 29th 2026

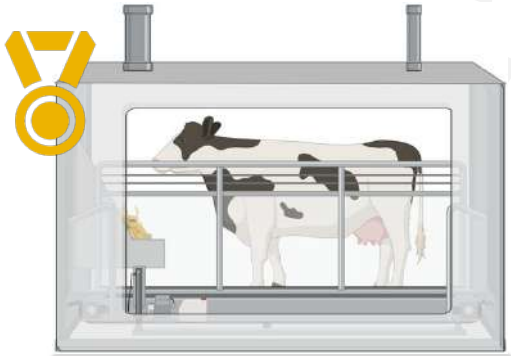
Sniffer technique

In vivo CH_4 assessment is essential to **understand enteric production** and **evaluate mitigation strategies.**

Obtaining accurate and **repeatable measurements** remains **challenging**, especially on commercial farms.

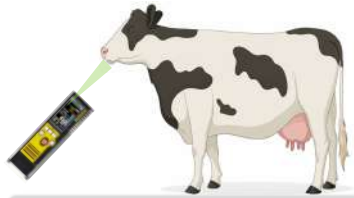
Respiration chambers are the **gold standard** but **not** always **fit** under **all circumstances.**

Alternative methods may **outperform chambers** for specific purposes, such as **large-scale phenotyping** or **on-farm applicability.**

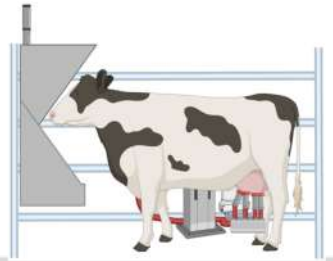


Respiration Chamber

GreenFeed®



Laser Detector



Sniffer Technique

Zhao et al., 2020; Garnsworthy et al., 2019; Massaro et al., 2024; O'Connor et al., 2024

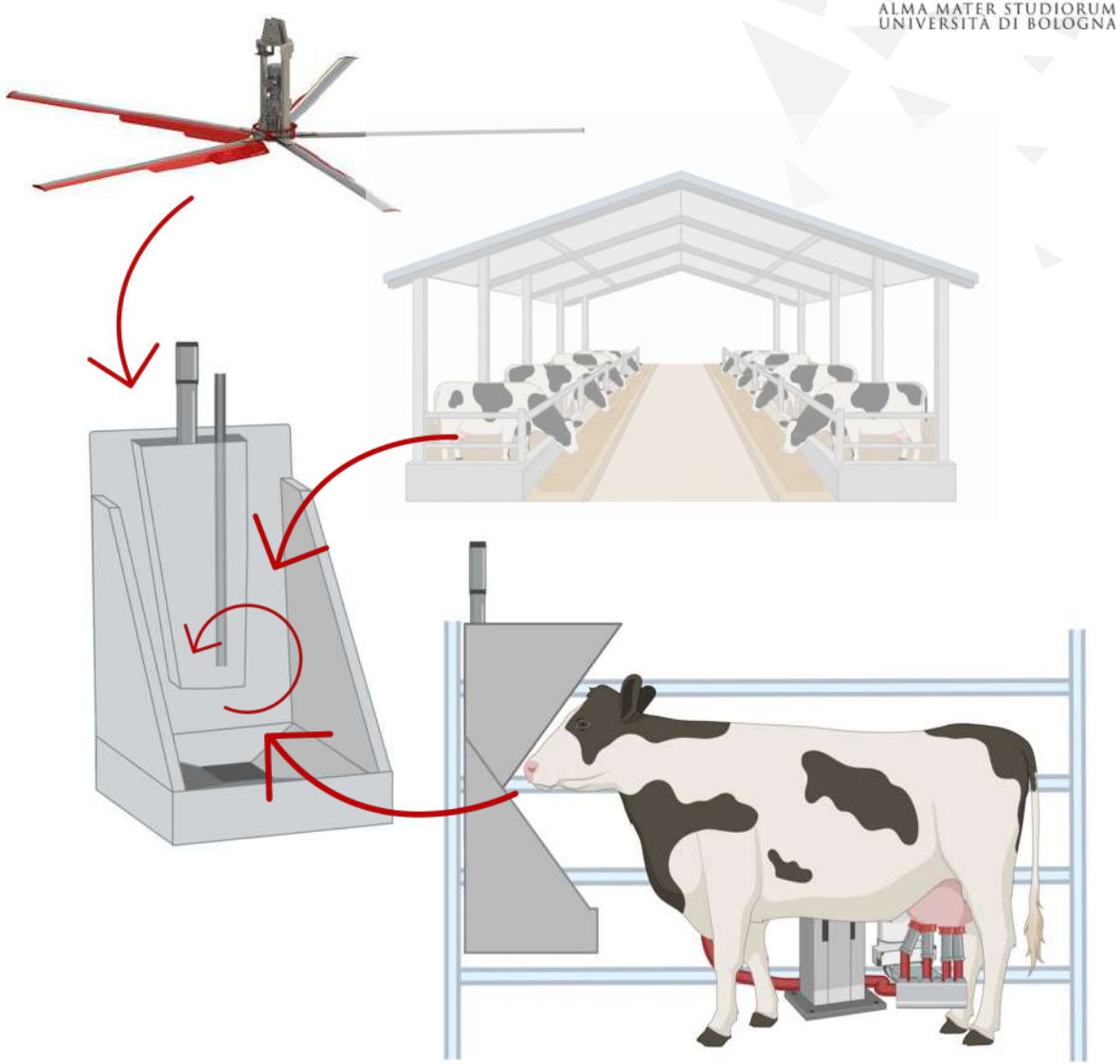
Sniffer technique

Opportunities

- **non-invasive** and **compatible** with **cow routine**
- **large-scale CH_4 phenotyping**
- **lower** implementation and maintenance **costs**
- applicable in **commercial farms**

Challenges

- **sensitive** to **air currents**
- **partial capture** of exhaled emissions
- **mixing** with ambient **background gases**
- **complex raw data processing**



Garnsworthy et al., 2019; Bekele et al., 2022; Zhao et al., 2020; Huhtanen et al., 2015; Wu et al., 2018; Tedeschi et al., 2022; Løvendahl et al., 2024; Ma et al., 2026.

Primary objective

1 **Develop** an **automated pipeline** to ensure **standardized synchronization, aggregation** and **parameter extraction** from sniffer recordings

How?

Integrating *heterogeneous* ***AMS*** *and* ***sniffer datasets*** *into a* ***unified measurement-level dataset.***

Experimental setting

Experimental-teaching dairy farm of the University of Bologna

- **2 free flow Merlin2 AMS units** equipped with **Moologger® sniffers**
  - **~ 100 Italian Holstein cows** (milk yield: 38-41 kg)
    - **2.7 milkings/cow/day** (average milking time: 7 min)
      - **[CH_4] and [CO_2] (ppm)** recorded **at 1 Hz**

Sampling probe (1) placed **10 cm** from the **cow muzzle** area

2: liquid feed dispenser;
3: pellet dispenser

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Pipeline architecture

Issues

- **Inconsistent cow-to-group information.**
- **No unified AMS file** containing both **entry** and **exit timestamps.**
- **Different time standards:** AMS local time vs sniffer UTC time.
- Need to **distinguish background concentrations** from **emission peaks.**

Sniffer raw data:
[CH_4], [CO_2] and RH

AMS reports:
cow entry logs,
cow exit logs,
milk yield and composition

dedicated Python-based pipeline

4 modules executed sequentially by a Bash script

Pipeline architecture

1. ***Temporal synchronization** between **AMS** and **sniffer data,** including **correction** for **sampling delay***
2. ***Identification** of **entry** and **exit time** and **classification** of **milking** and **non-milking intervals***
3. ***Calculation** of **hourly mean baseline gas concentration** and **detection of emission events***
4. ***Extraction** of **descriptive signal parameters** (mean, duration, peak amplitude…)*

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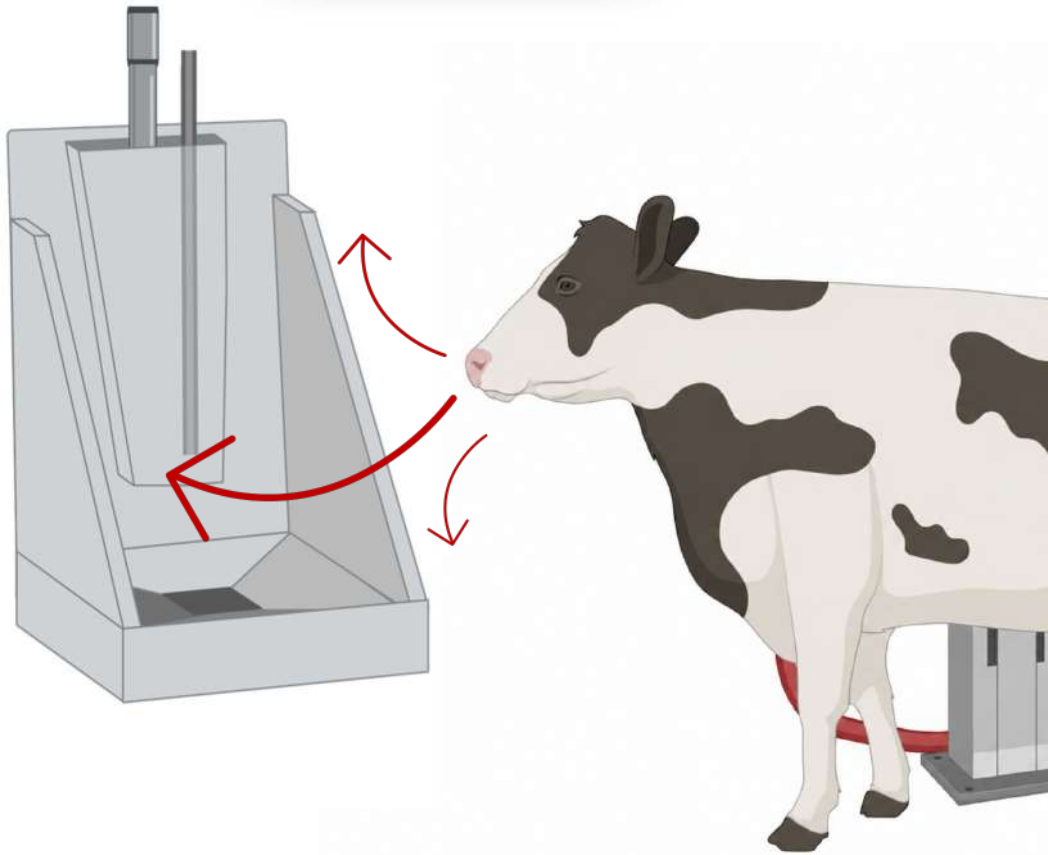

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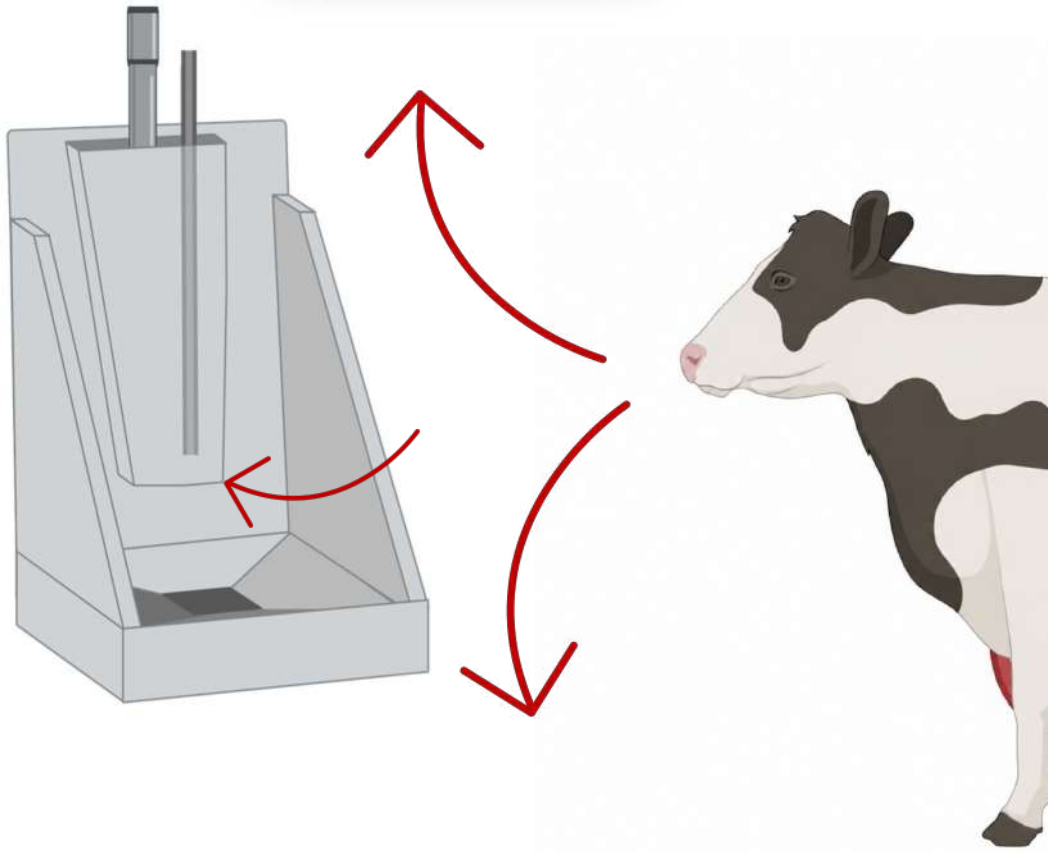

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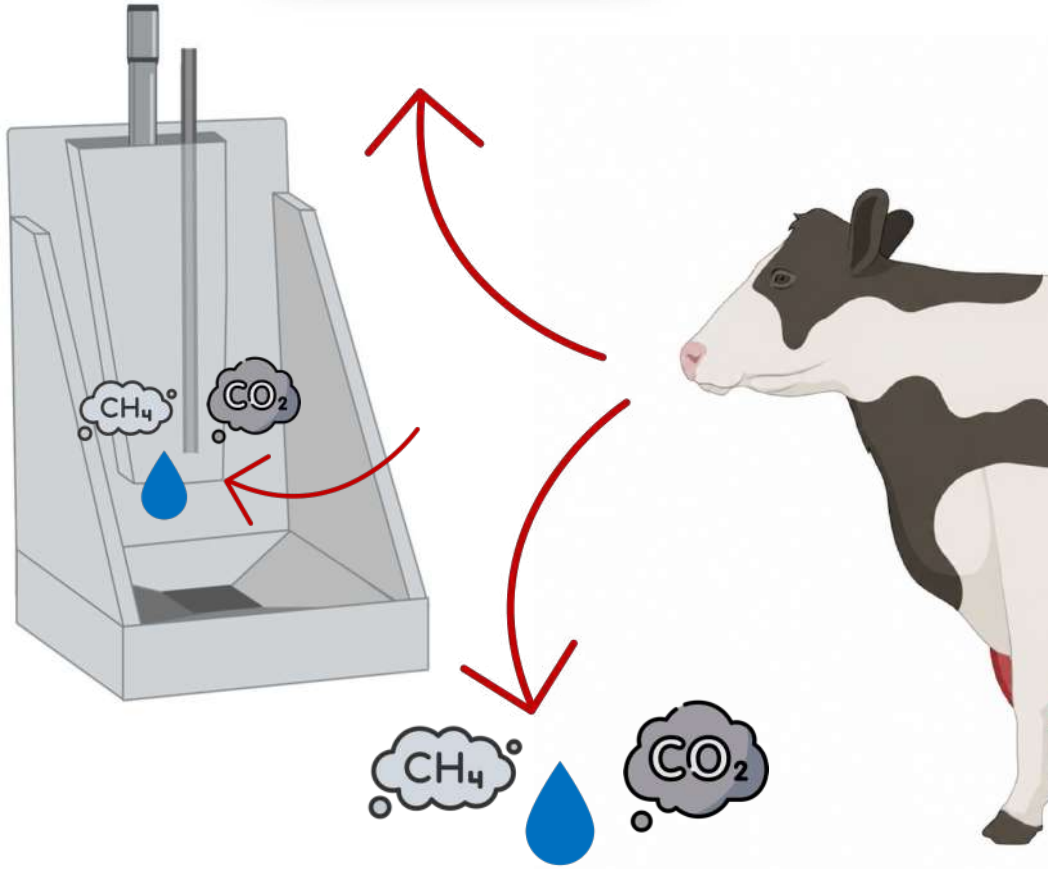

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Secondary objective

2

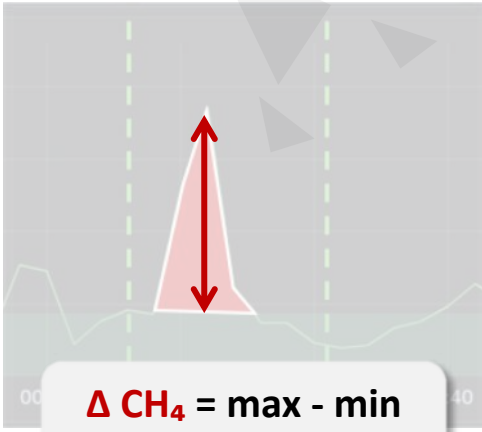
Assess the **influence** of **environmental** and **signal parameters** on the **reliability** of **sniffer recordings**

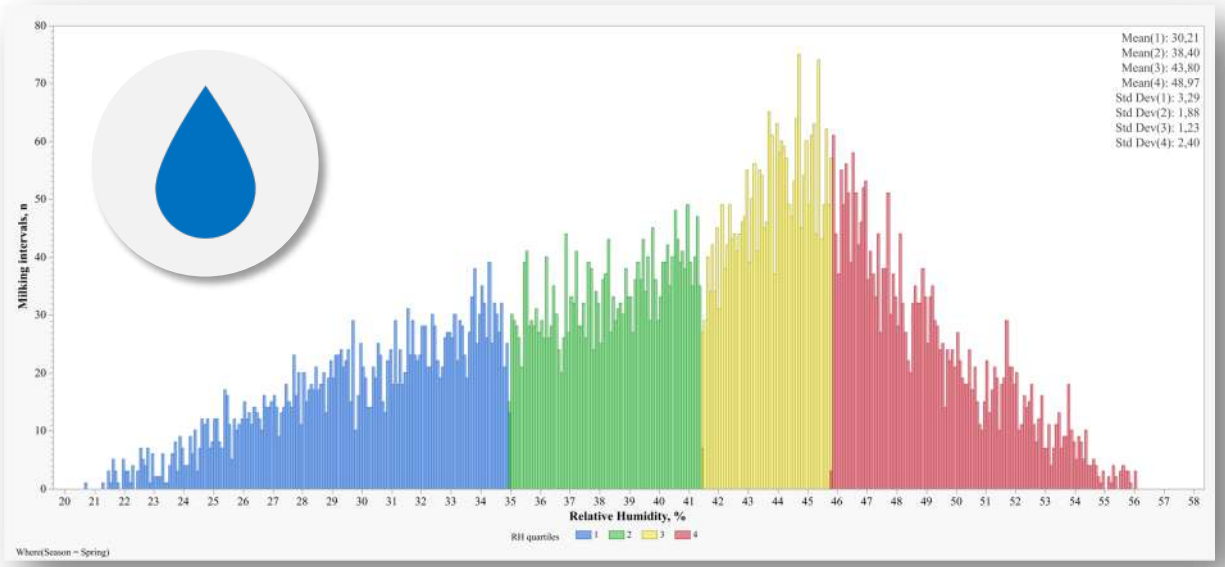
How?

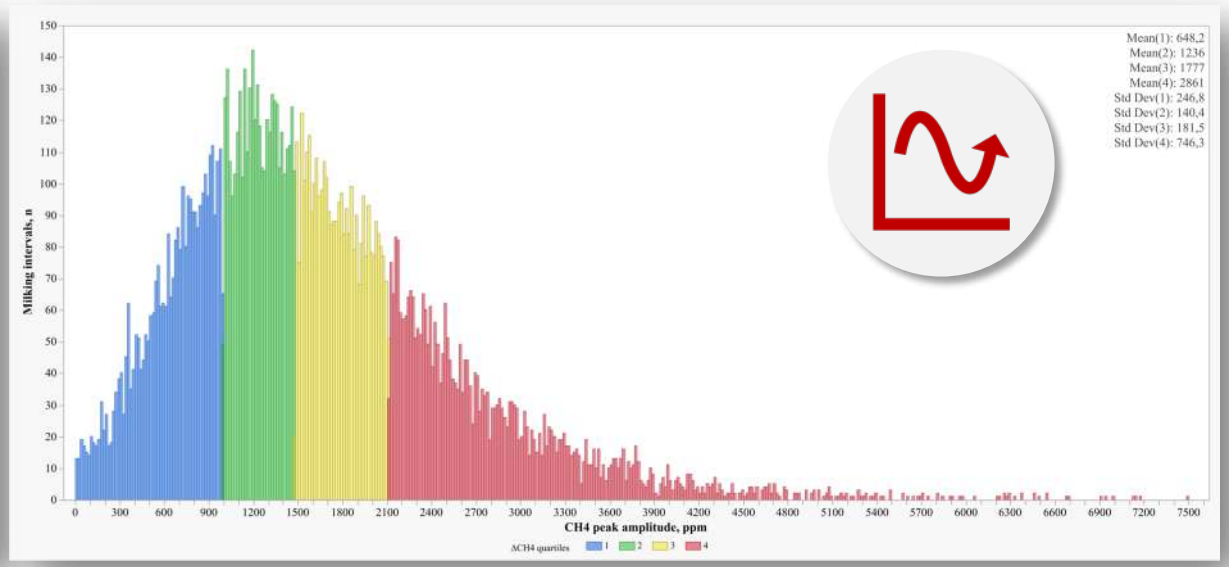
Exploring *their* ***impact*** *on* ***relative CH_4 concentration*** *and* ***variability.***

Clustering of recordings

- **13,801 robotic milking recordings**
- **total period** of **98 days**: from November to December and from March to June
- **stratification of recordings by:**
  - **relative humidity (RH) quartiles** (by season)
  - **ΔCH₄ quartiles**







Statistical analysis

Linear mixed model

- **Fixed effects**:
  - **RH quartiles**
  - **ΔCH_4 quartiles**

Random effect: **cow**

- **CH_4/CO_2 log-trasformed** to address heteroscedasticity
- **absolute residuals** used as **indicator** of **within-cow measurement variability**

Influence of CH_4 peak amplitude

	ΔCH_4 1	ΔCH_4 2	ΔCH_4 3	ΔCH_4 4	SEM	p-value
CH_4 mean, ppm	73.4^a	161.0^b	234.2^c	339.7^d	**3.94**	< 0.0001
CH_4 /CO_2 mean	0.090^a	0.088^b	0.093^c	0.101^c	**0.0014**	< 0.0001
Abs. residuals CH_4 /CO_2	0.037^a	0.025^b	0.021^c	0.021^c	**0.0009**	< 0.0001

Higher ΔCH_4 was associated with **stronger CH_4 signals** and **lower within-cow variability**.

Influence of relative humidity

	RH 1	RH 2	RH 3	RH 4	SEM	p-value
CH_4 mean, ppm	119.6^a	190.4^b	227.6^c	249.2^d	**6.52**	0.0009
CH_4 /CO_2 mean	0.106^a	0.092^b	0.085^c	0.088^c	**0.0015**	< 0.0001
Abs. residuals CH_4 /CO_2	0.031^a	0.027^b	0.023^c	0.023^c	**0.0009**	0.0049

Higher RH was associated with **stronger CH_4 signals** and **lower within-cow variability**.

Two complementary indicators of sampling quality

CH_4 peak amplitude

likely reflects **eructation detection**

Relative humidity

likely reflects **efficiency** of **breath sampling**

improved identification of high-quality sniffer recordings

Impact of RH and/or ΔCH_4 on CH_4/CO_2 recording stability

Model	Cow variance	Residual variance	Δ residual variance, %	ICC
$log(CH_4/CO_2) = (1 \mid cow)$	0.0197	0.1537	-	0.113
$log(CH_4/CO_2) = (1 \mid cow) + RH$	0.0198	0.1484	- 3.5%	0.118
$log(CH_4/CO_2) = (1 \mid cow) + \Delta CH_4$	0.0168	0.1458	- 5.1%	0.103
$log(CH_4/CO_2) = (1 \mid cow) + \Delta CH_4 + RH$	0.0159	0.1362	- 11.4%	0.105

Joint inclusion of **RH** and **ΔCH_4 reduces within-cow measurement noise**

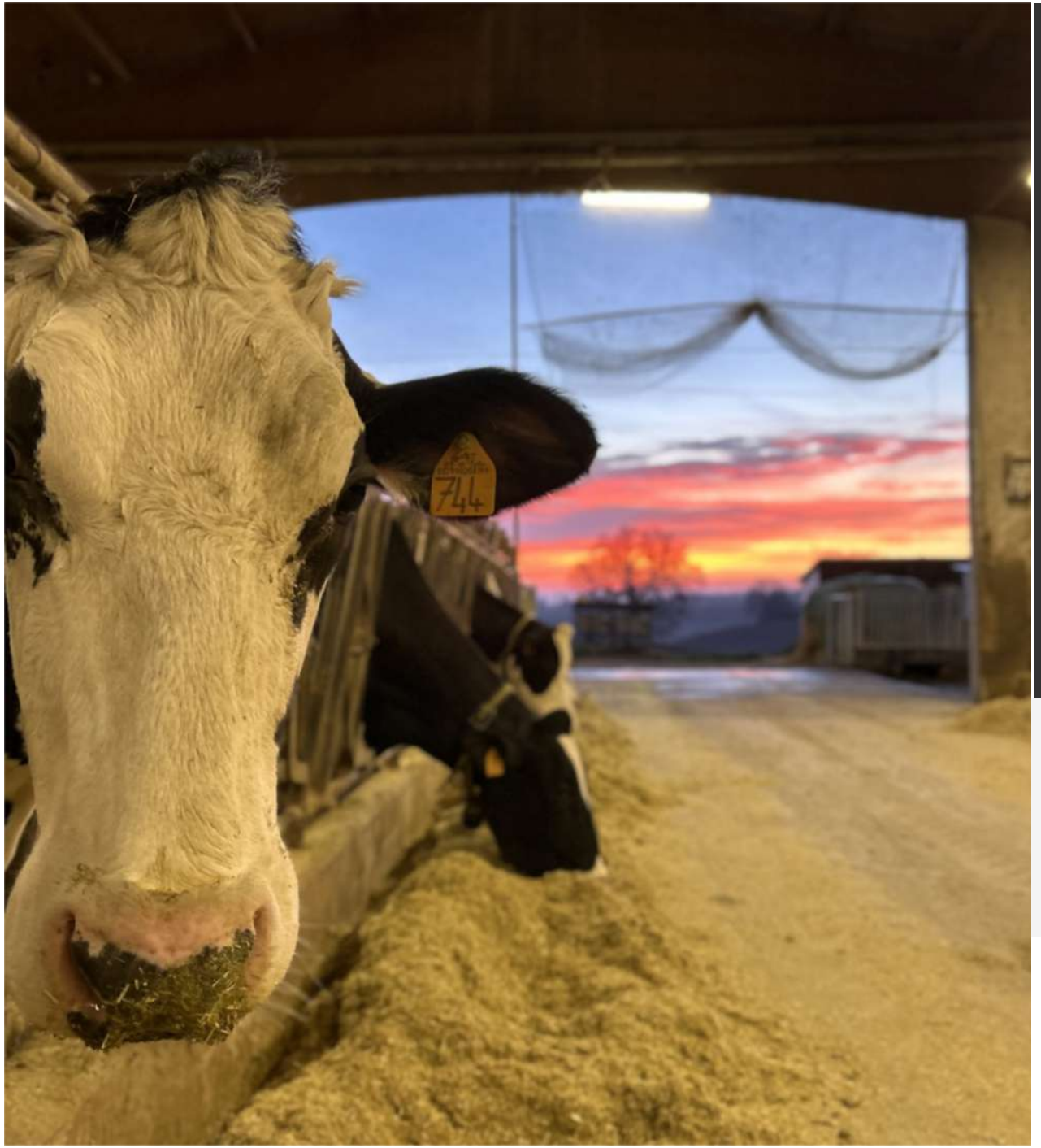
Take-farm messages

1. **High-quality sniffer recordings** require **robust data processing** and **signal-based quality control.**

2. **RH and ΔCH_4** identified **recordings** with **stronger methane signals** and **reduced intra-cow noise.**

3. **RH and ΔCH_4** appear to provide **complementary information.**

These **environmental** and **signal-derived parameters** may support the **development** of a **«sniffer recording-quality index».**



Thank you for your attention

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