HARVARD METHANE INITIATIVE · RESEARCH RETREAT

# GRAZE-Tags

## An electronic nose for continuous methane monitoring on cattle

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# Enteric methane is hard to measure at scale

### Respiration chambers

Gold standard, but expensive and they isolate animals. Extremely low throughput.

### GreenFeed

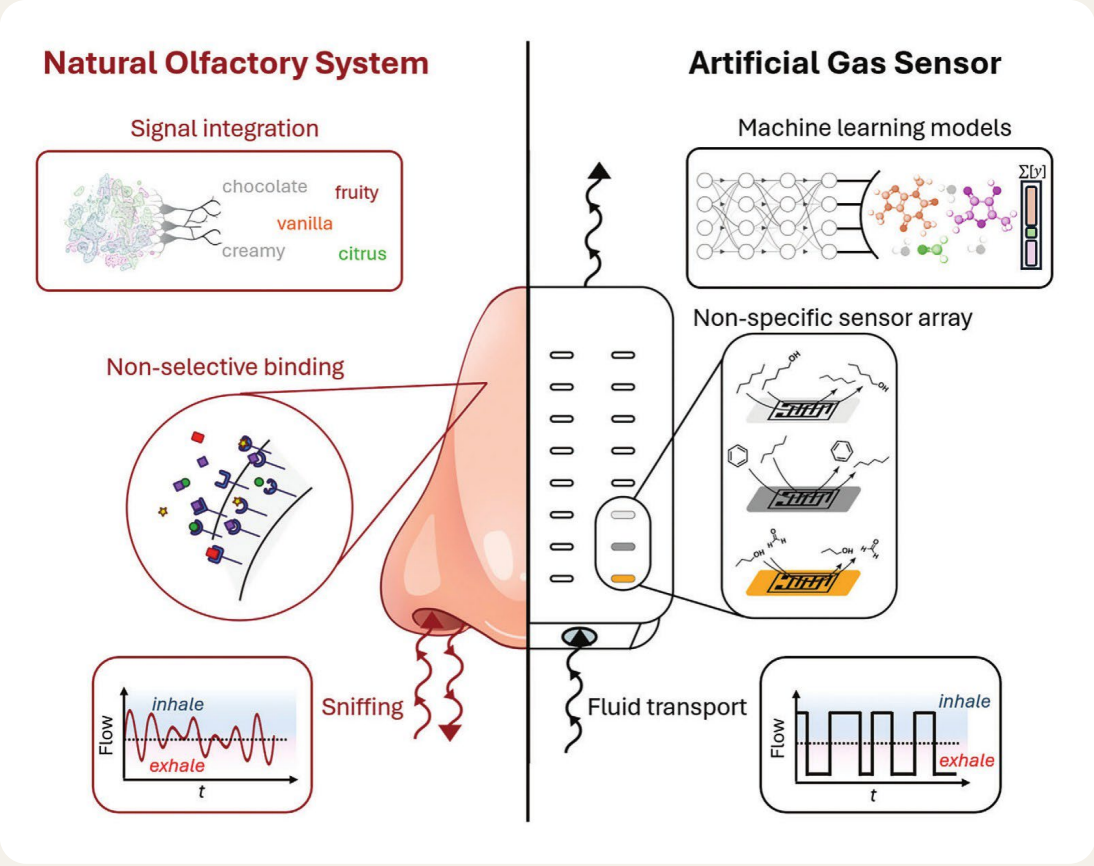
Easier, but still low throughput, and cows must visit a feeder.

### $SF_6$ tracer

More scalable, but invasive, labor-intensive, and no real-time feedback.

Typical studies: 10–50 animals, a narrow time window, periodic sampling.

# Our approach: copy how a nose works




## Biology

Smell receptors each respond to many odors. The brain reads the pattern across all of them.

## Electronic nose

Several imperfect sensors plus machine learning, reading the pattern of their signals.

# The sensing element: a heated metal oxide

1

## Gas arrives

Air drifts onto a small chip with a metal-oxide surface kept hot.

2

## It reacts

Methane and other gases react with oxygen on the oxide surface.

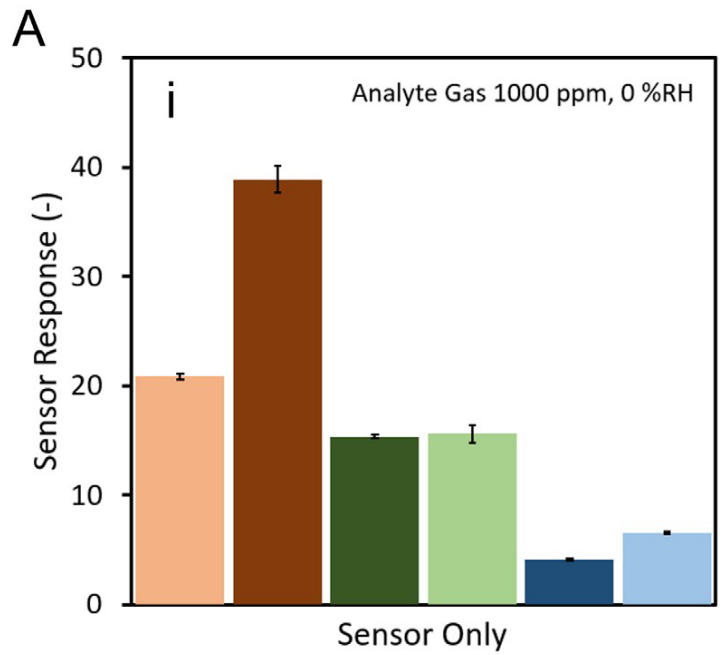
3

## Resistance drops

The electrical change is the signal: bigger change, more gas.

Cheap, tiny, low power. But it is not choosy: it reacts to many gases.

# The catch: it responds to everything




2×

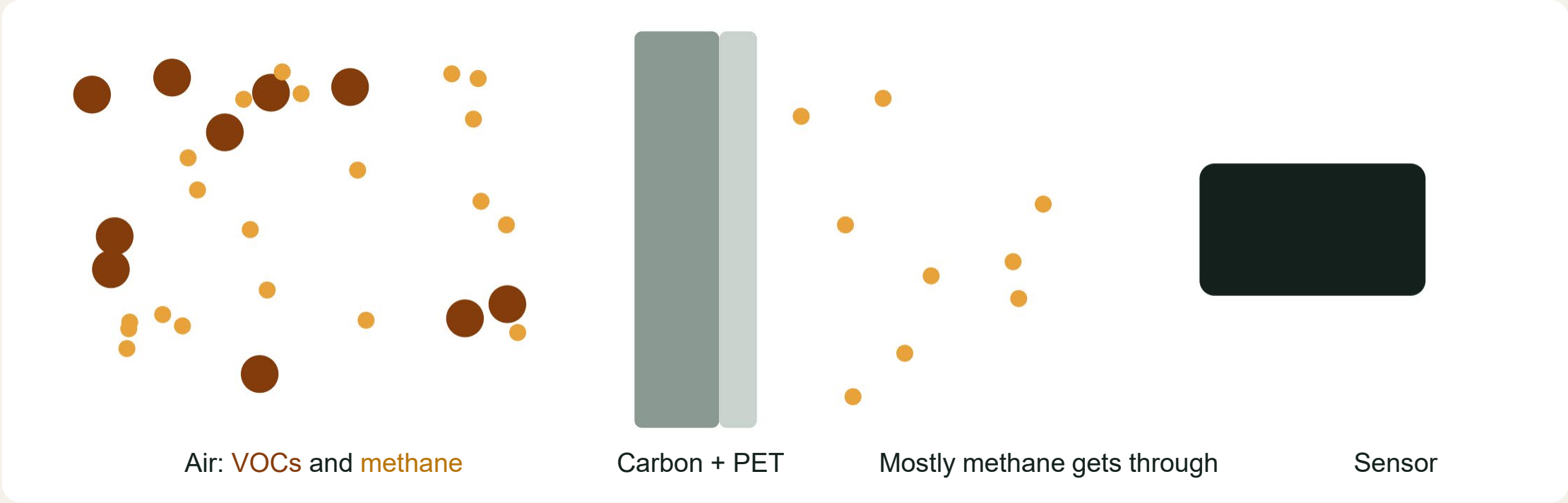
**Pentane beats methane**

A common farm VOC gives about twice methane's signal at the same 1,000 ppm.

**Barns are full of VOCs**

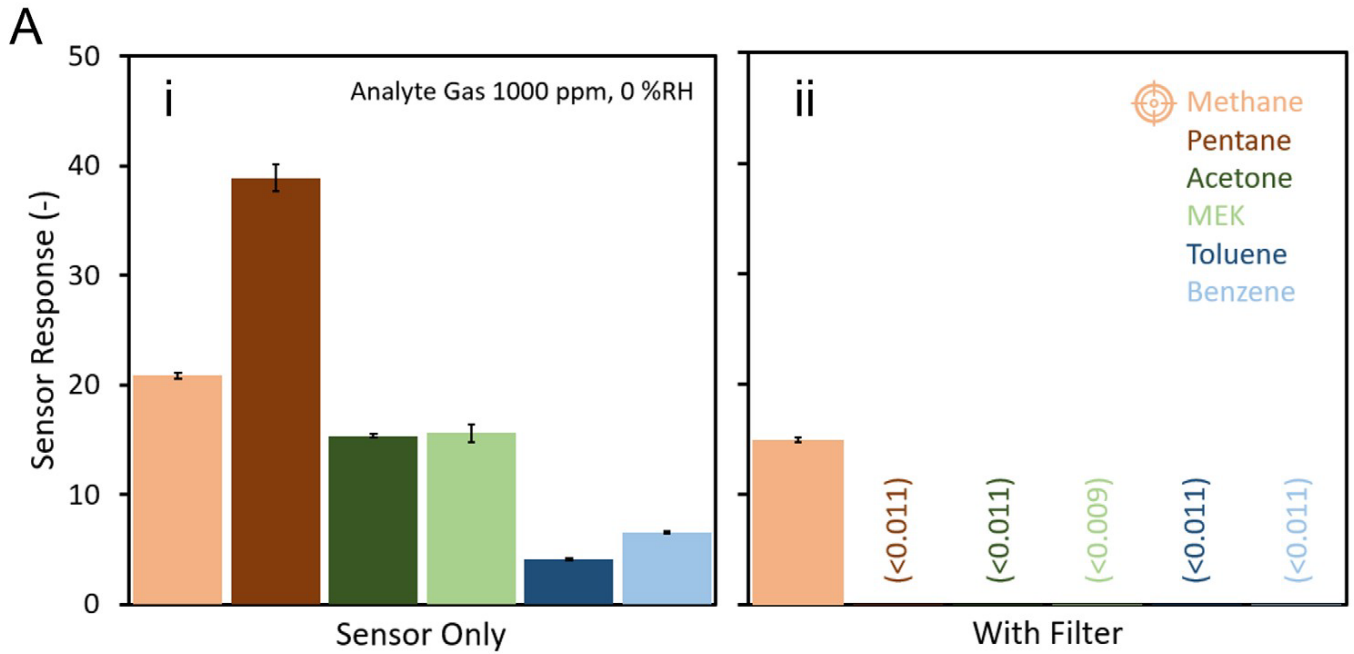
Manure, silage and animal breath release pentane, acetone, toluene and more.

# The fix: a filter in front of the sensor




Small, weakly sticky methane diffuses through. Larger VOCs get trapped.

# With the filter, only methane is seen




**2,500×**

**Less pentane signal**

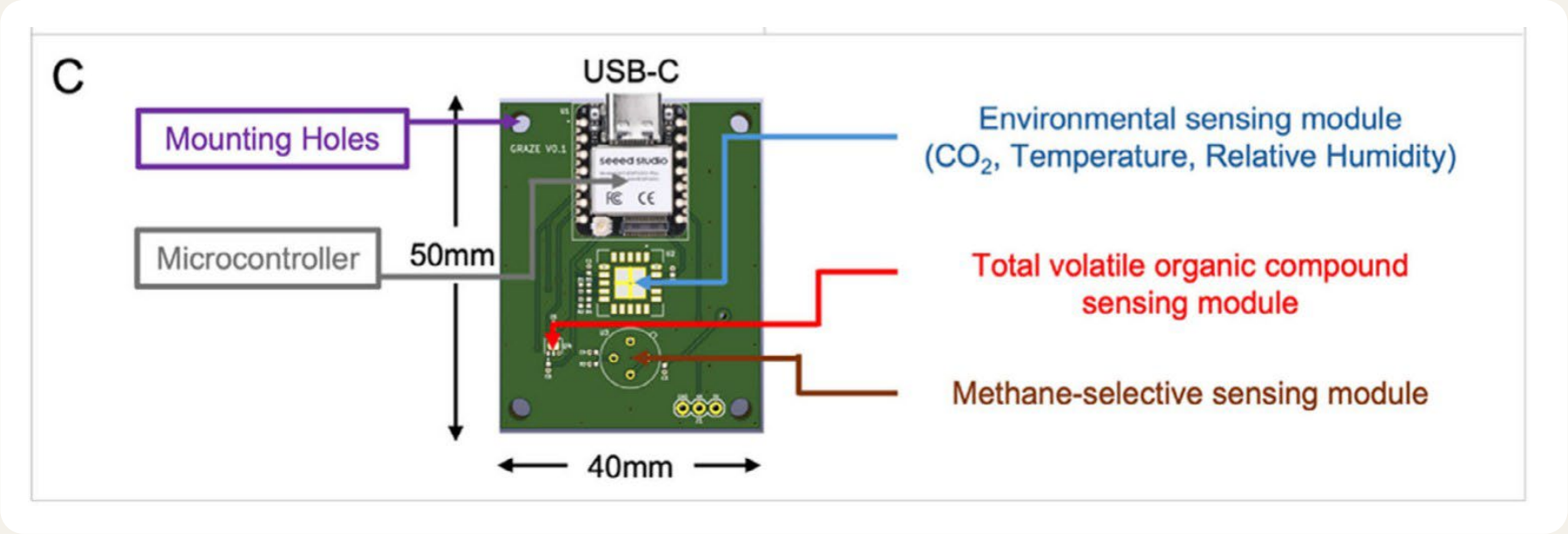
Interferents fall below the sensor's noise.

**7.8 ppm**

**Detection limit**

A clean, linear methane response, $R^2 = 0.999$.

# Three sensors, one board




**Methane-selective**

The filtered sensor you just saw.

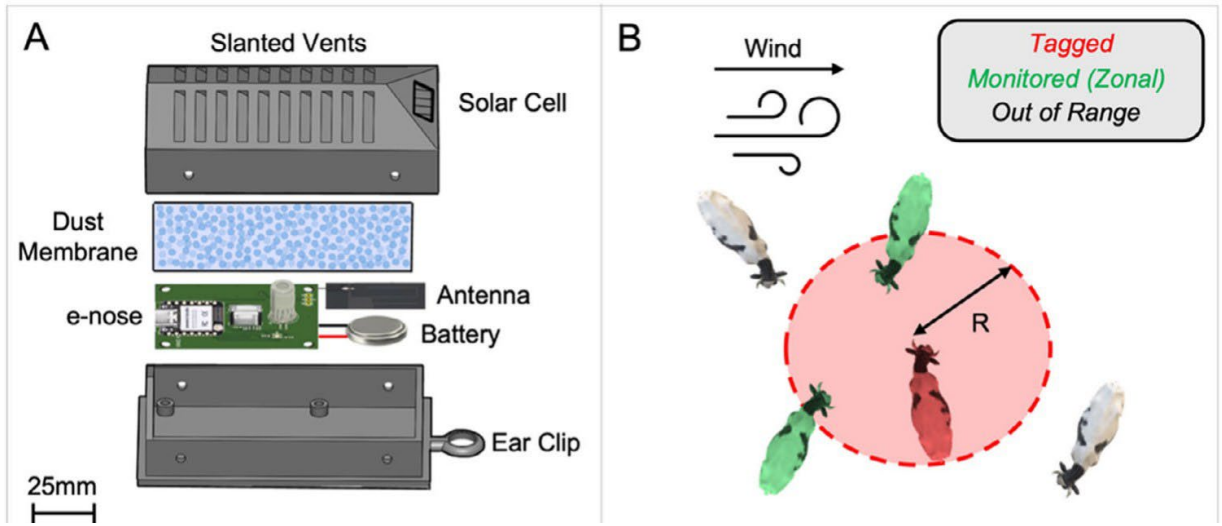
**General VOC**

Tracks interfering gases.

**$CO_2$, temperature, humidity**

Context. Humidity cuts the signal by over half across 4–81% RH, but predictably, so it is corrected.

# Packaged as an ear tag




**Breathes, stays dry**

Slanted vents plus a hydrophobic PTFE membrane.

**Wireless and solar**

About the size of a commercial GPS cattle tag.

**Battery: the open problem**

About 2 weeks in simulation. Lower-power sensors project 3× or more.

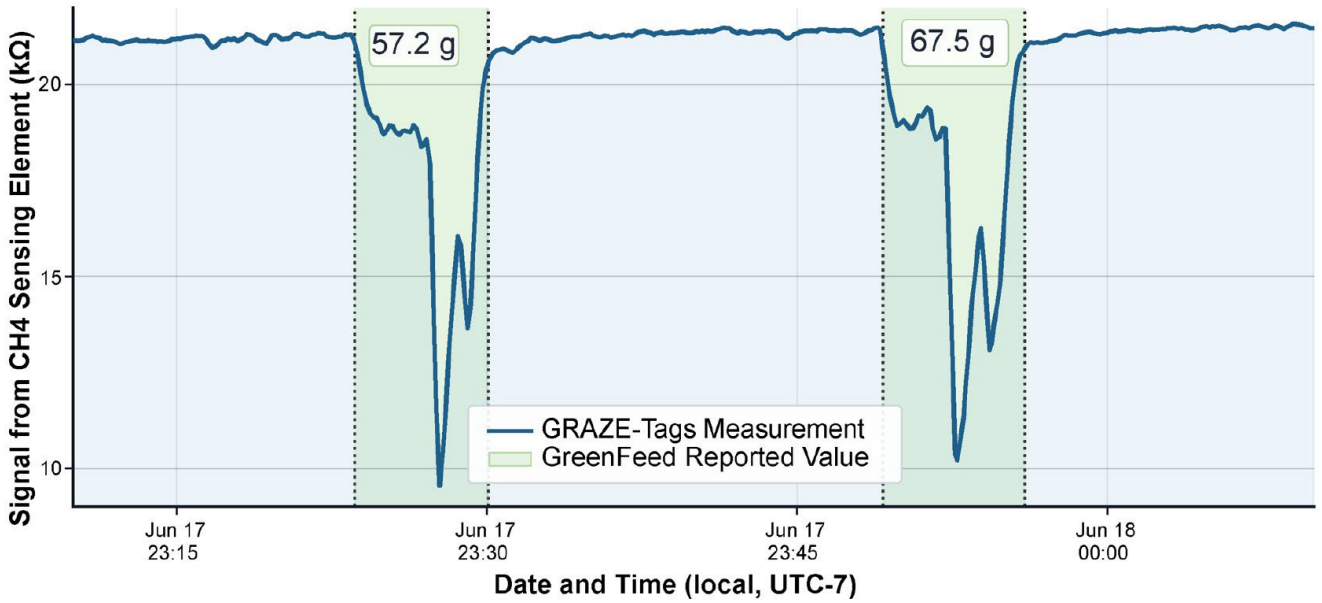
# The Davis study: a cow's whole life

At UC Davis, Prof. Ermias Kebreab’s lab:
Male dairy calves followed from birth to slaughter on a seaweed-based methane-reducing additive.

| 8 | 8 | 8 |
|---|---|---|
| **Control** | **Short-term** | **Life-time** |
| Typical diet, no additive. | Additive until 3 weeks after weaning, then withdrawn. | Additive from weaning until slaughter. |

About 18 months across three facilities. Calves enroll 2–4 per month.

# First field test: June to November 2026



**Setup**

Two tags beside a GreenFeed unit, installed ~June 16. Data flow wirelessly to cloud database.

57.2 g

**First match**

Signal dips line up with GreenFeed events of 57.2 g and 67.5 g. Data continue through November.

# What the Davis data will tell us

1

## Agreement

Does the tag signal track GreenFeed readings animal by animal?

2

## Treatment contrast

Can tags see a difference between control and additive-fed cattle?

3

## Durability

Do two tags stay consistent over months outdoors?

Planned analyses; update as results come in.

# Policy is moving toward measurement

## 40%

### California

SB 1383: dairy and livestock methane 40% below 2013 levels by 2030. CARB began information gathering in January 2026.

## 2026

### United States

EMIT LESS Act proposed for the 2026 Farm Bill. USDA is building enteric methane research capacity.

## 2024

### European Union

Regulation 2024/1787 mandates methane measurement for energy. Livestock approaches are under review.

# Where we go next

1

## Harden and shrink

Rain, dust and impact testing. Miniaturize, extend battery life.

2

## Model the air

Airflow simulations to link a signal to a specific cow.

3

## Freely moving cows

Longer validation on grazing and barn animals.

4

## Commercialize

Partners, manufacturing, calibration.

We welcome herd partners and policy input.

# A sensor on every cow, measuring all the time

Low-cost

Lightweight

Wireless & Solar-powered

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