Enteric methane emissions from ruminants: measurement techniques

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une
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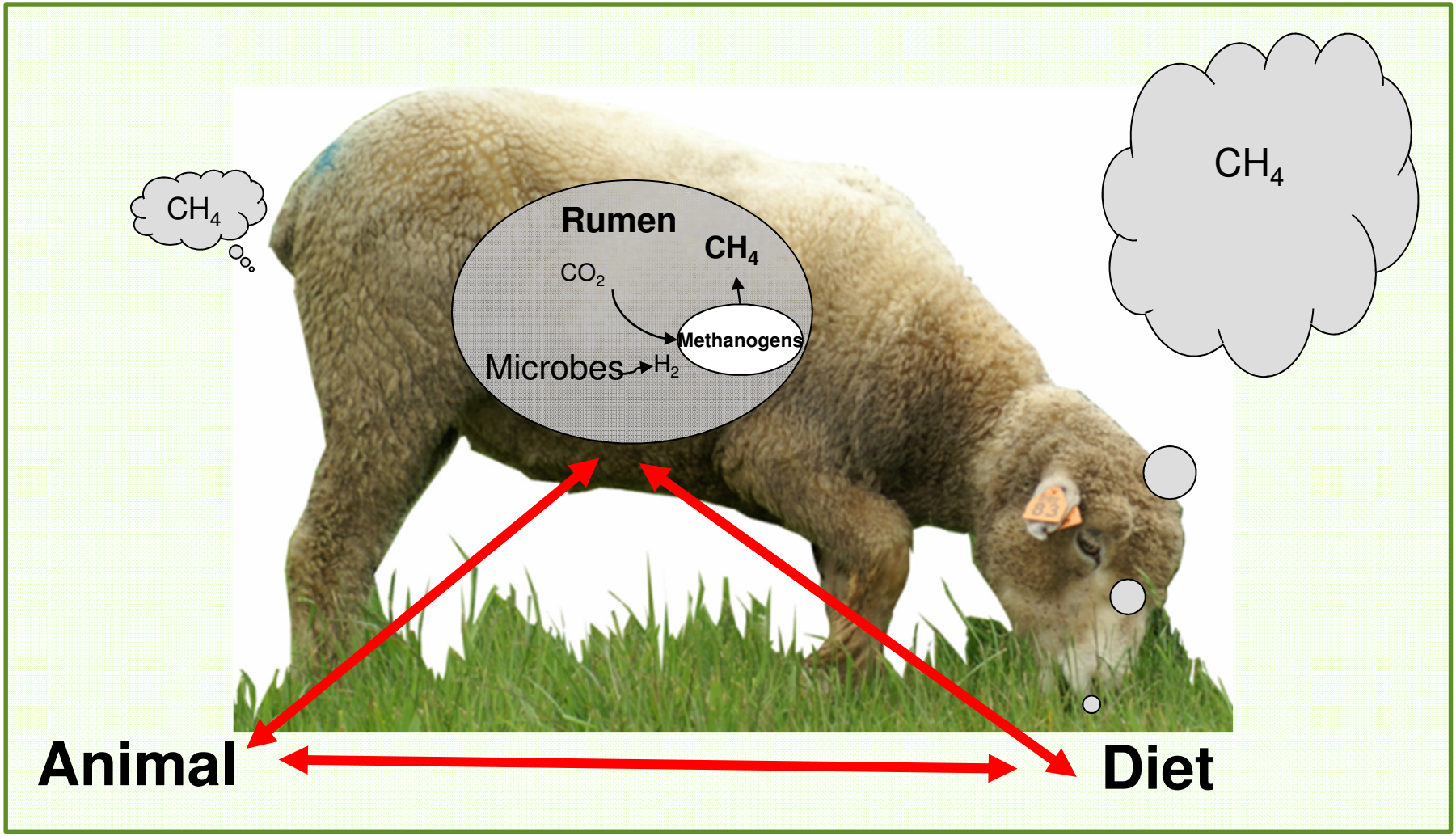
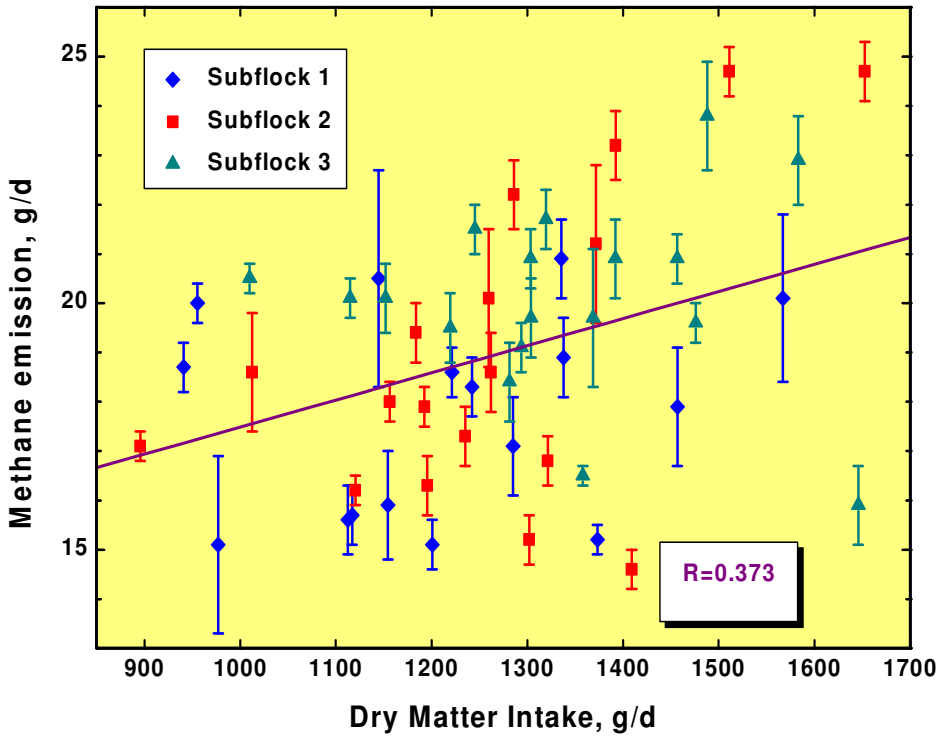
Contents

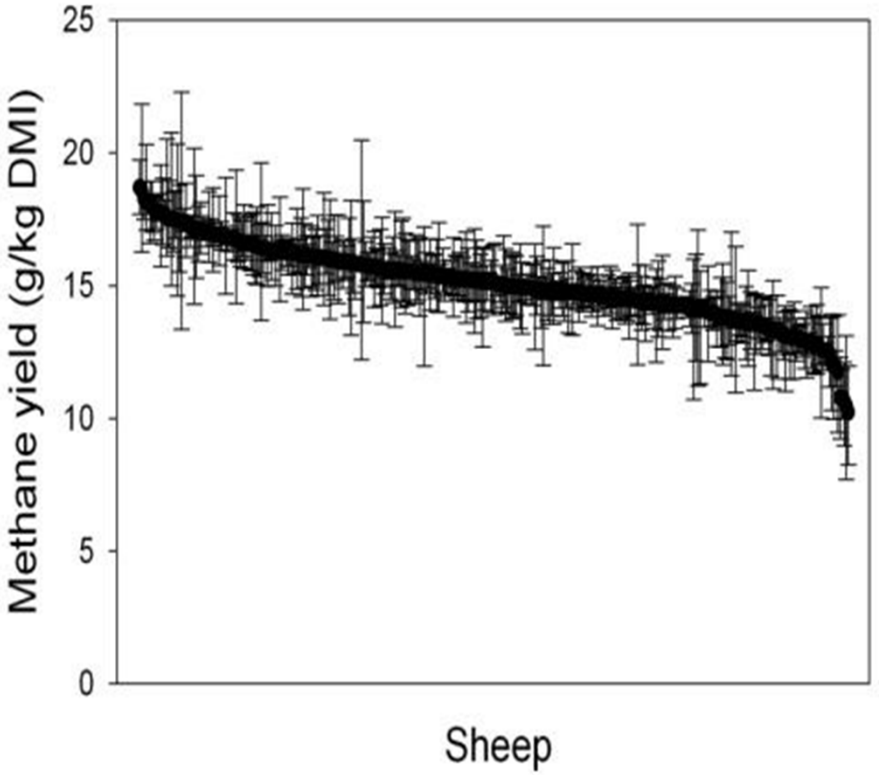
- Measurement techniques for individual animals
- Upscaling – from individuals to herds & flocks

Fact 1: CH_4 excreted at the front



Fact 2: Large animal-to-animal variation





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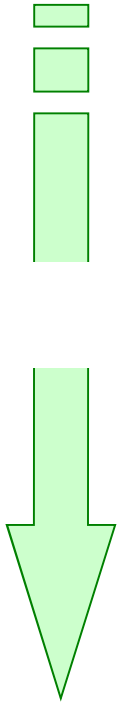
Development of techniques for CH_4 measurement/estimation



1960s

1970s

To improve energy efficiency
(CH_4, loss of 2-12% of GEI)
-Indirect calorimetry, use of enclosures

1990s

Focus, CH_4 as GHG

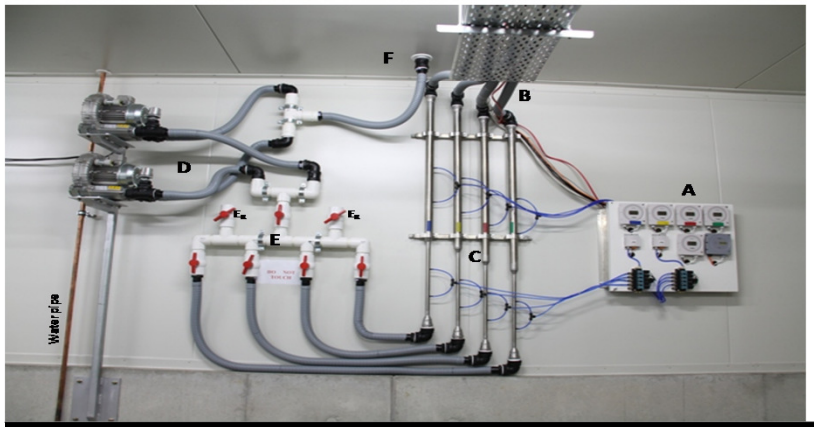
-use of SF_6 tracer technique-

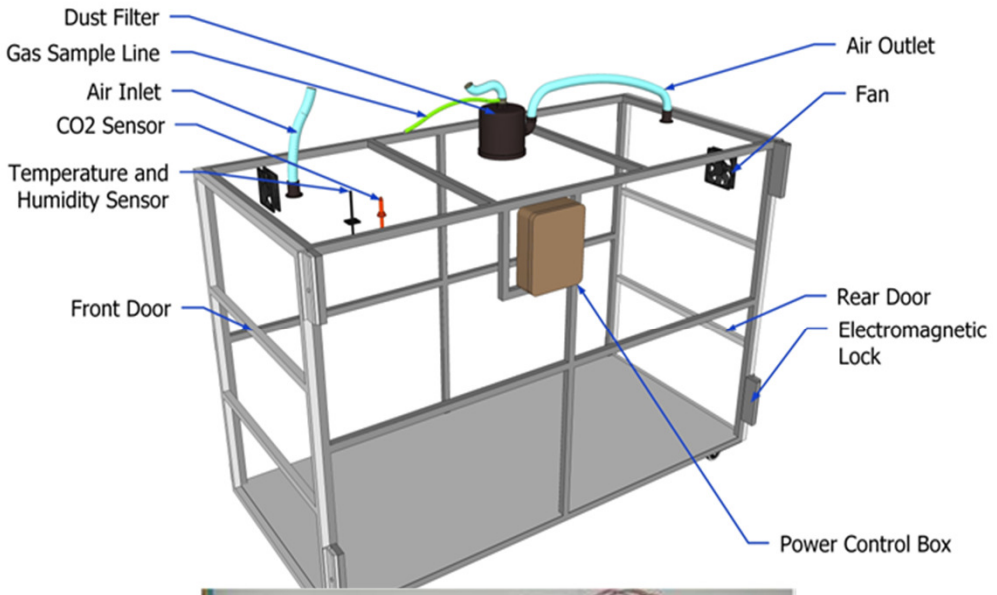
today

-respiration chambers-
New developments (e.g. GreenFeed)

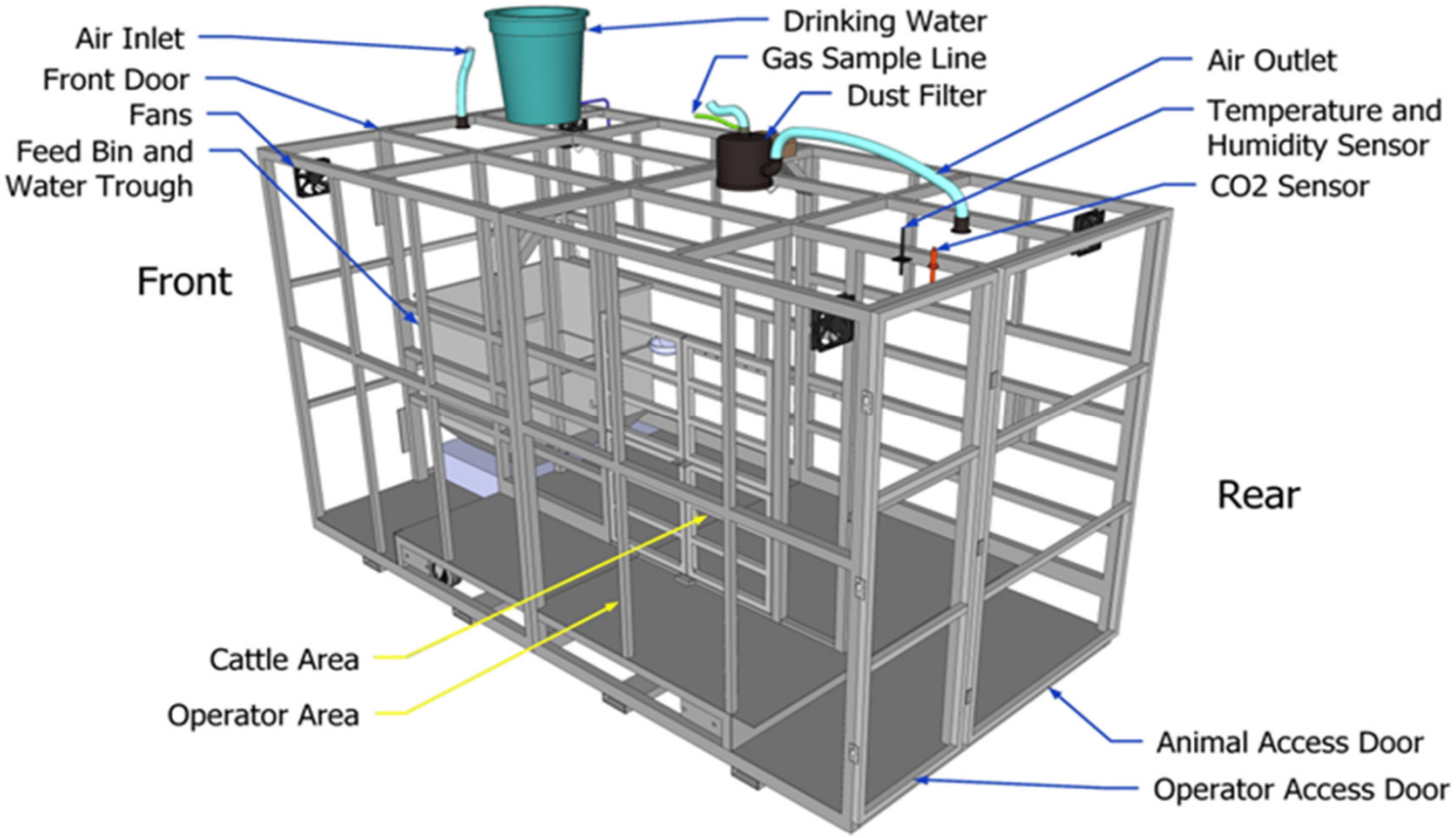
Animal Respiration Systems

Sheep chambers (at AgResearch)

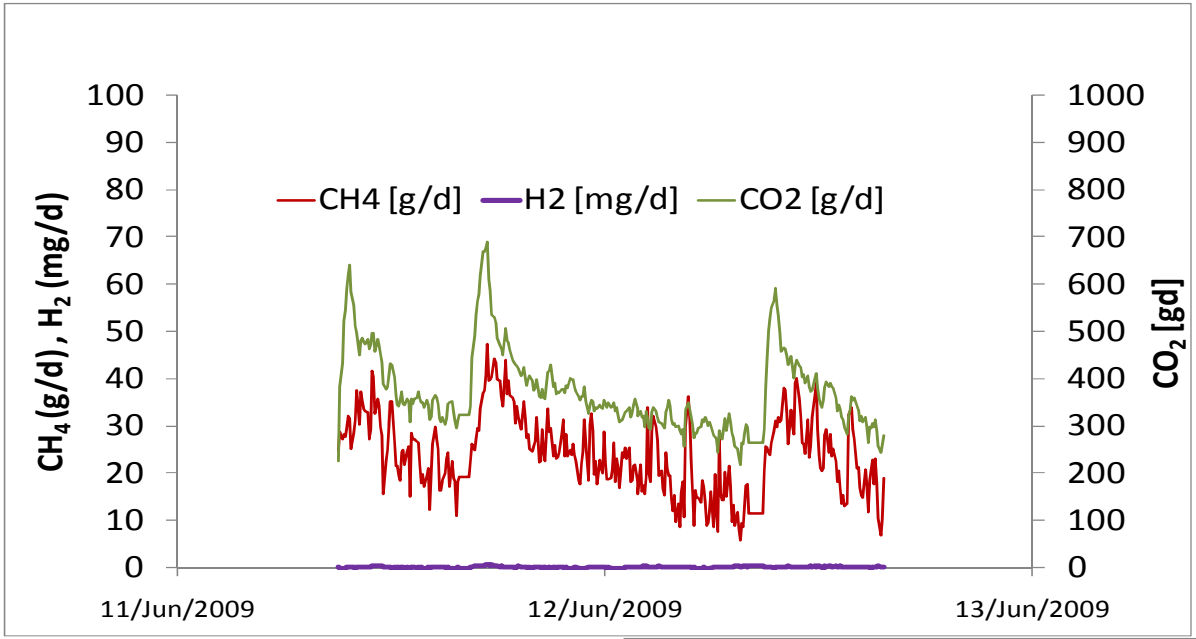




Cattle chamber

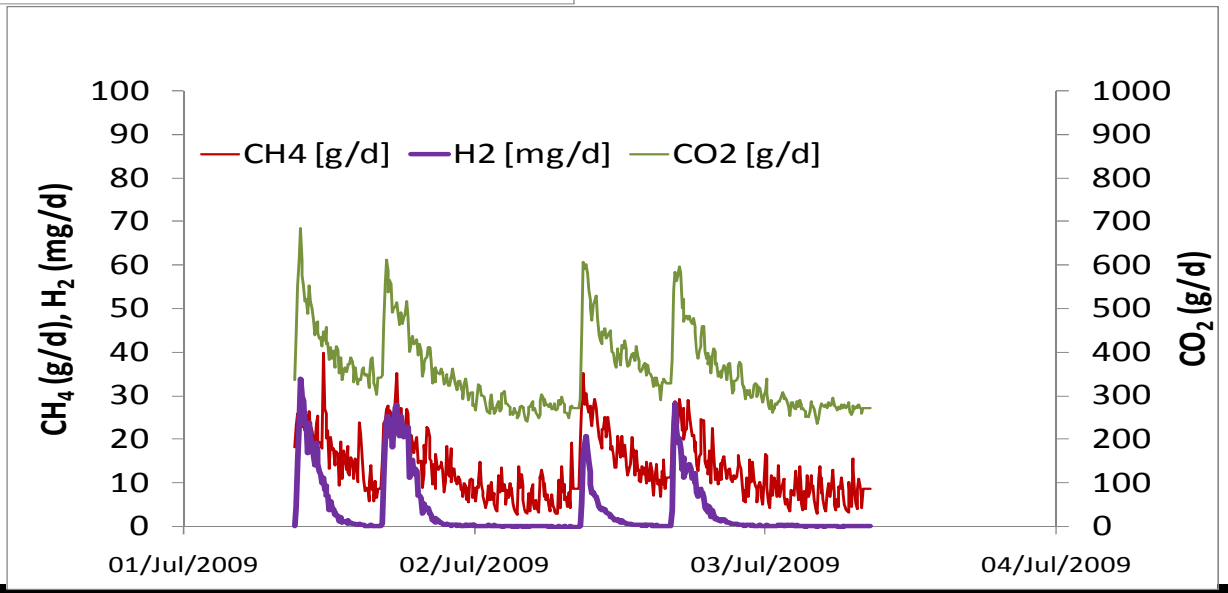


Feed Digestibility = Intake – Faecal Output



Sheep 202, GRASS diet
CH_4, 25 g/d

Sheep 202, MIXED diet
CH_4, 13 g/d



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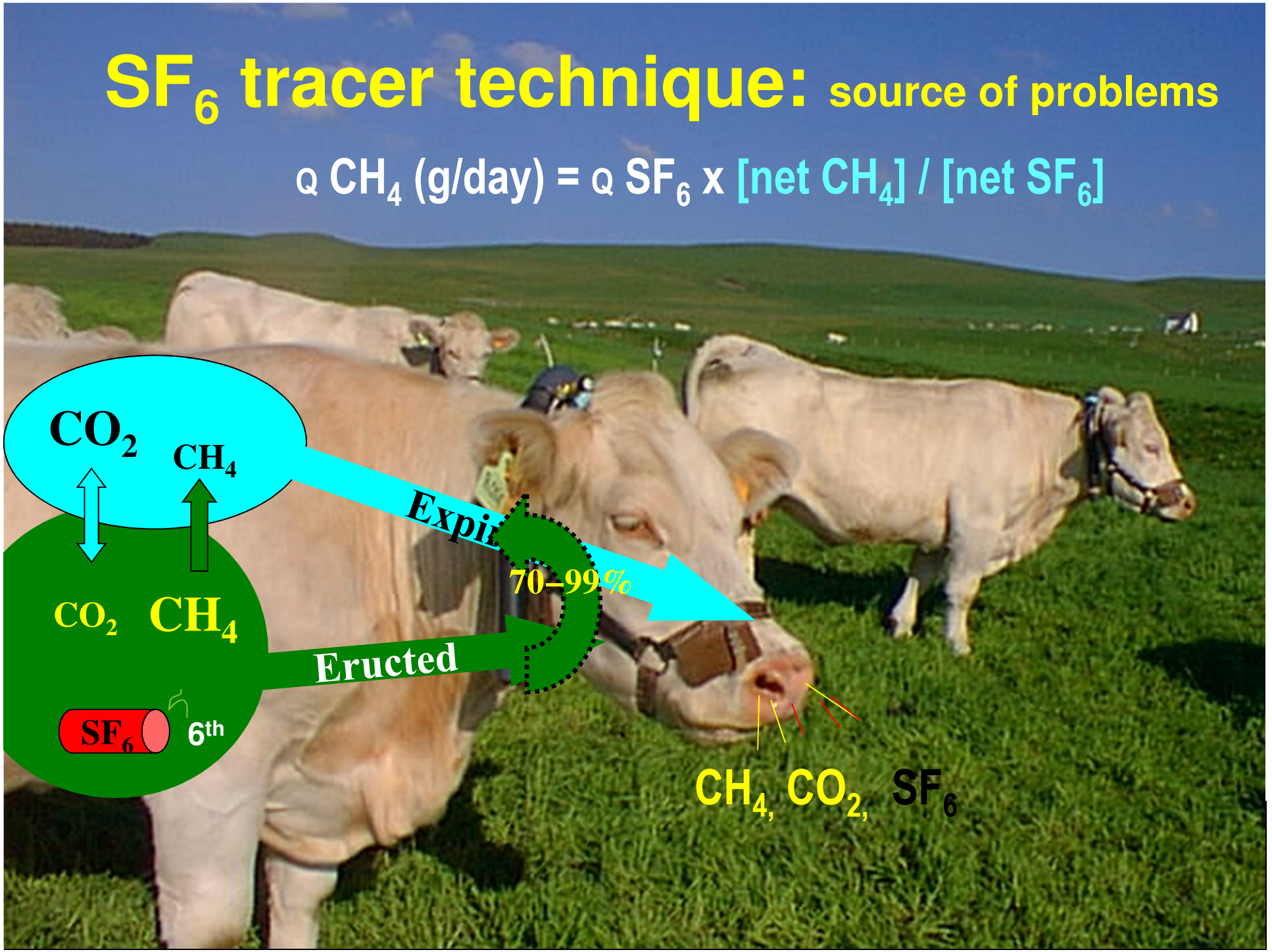
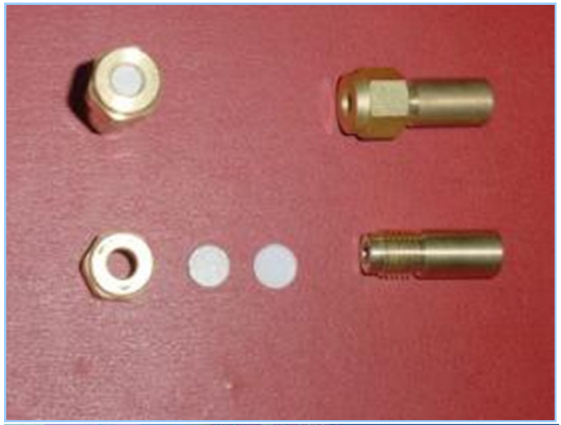
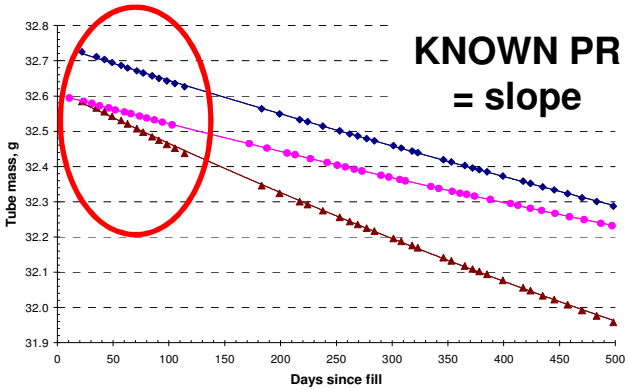
SF_6 tracer technique: source of problems

$Q\ CH_4\ (g/day) = Q\ SF_6 \times [net\ CH_4] / [net\ SF_6]$



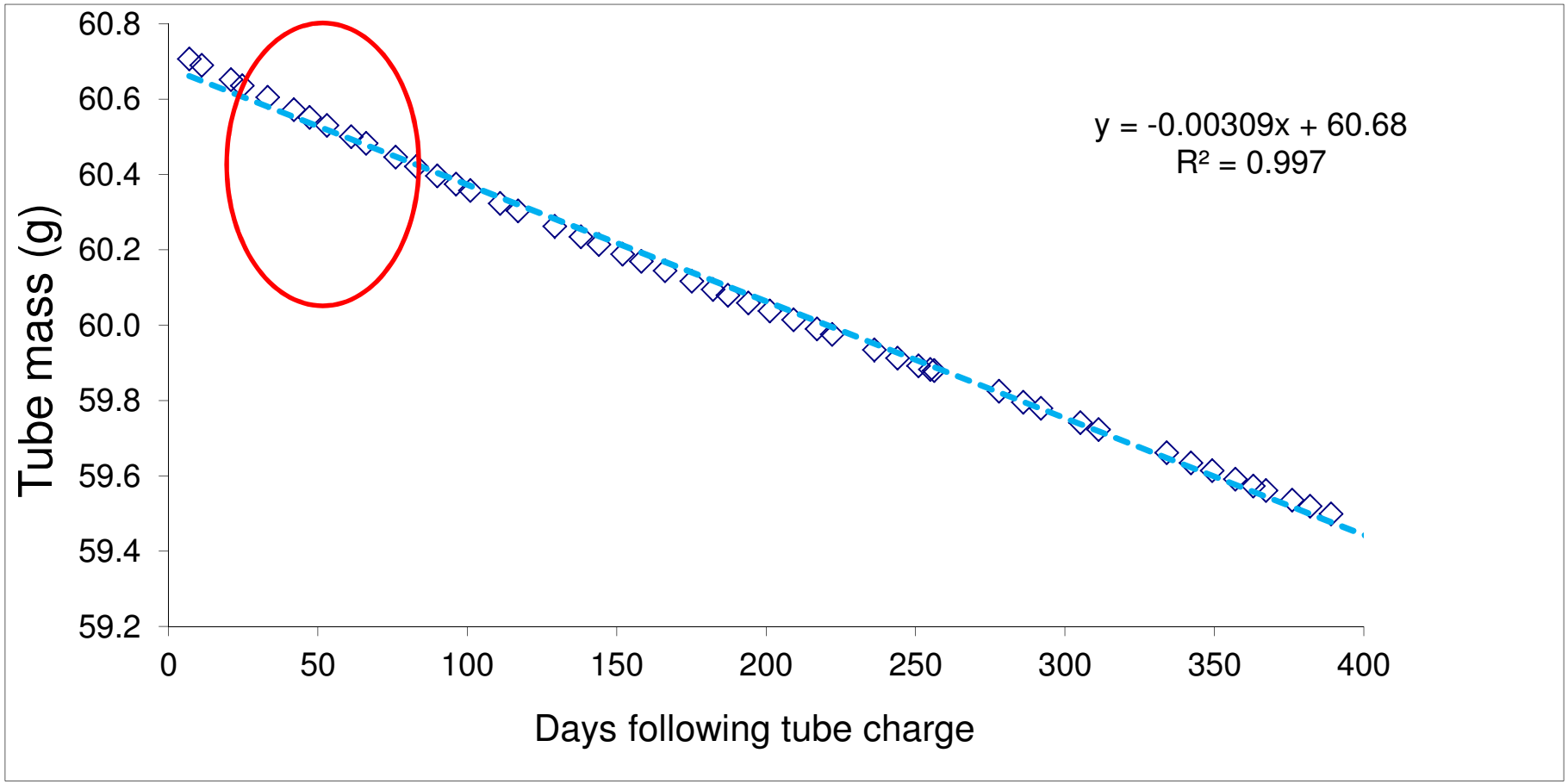
The SF_6 tracer technology



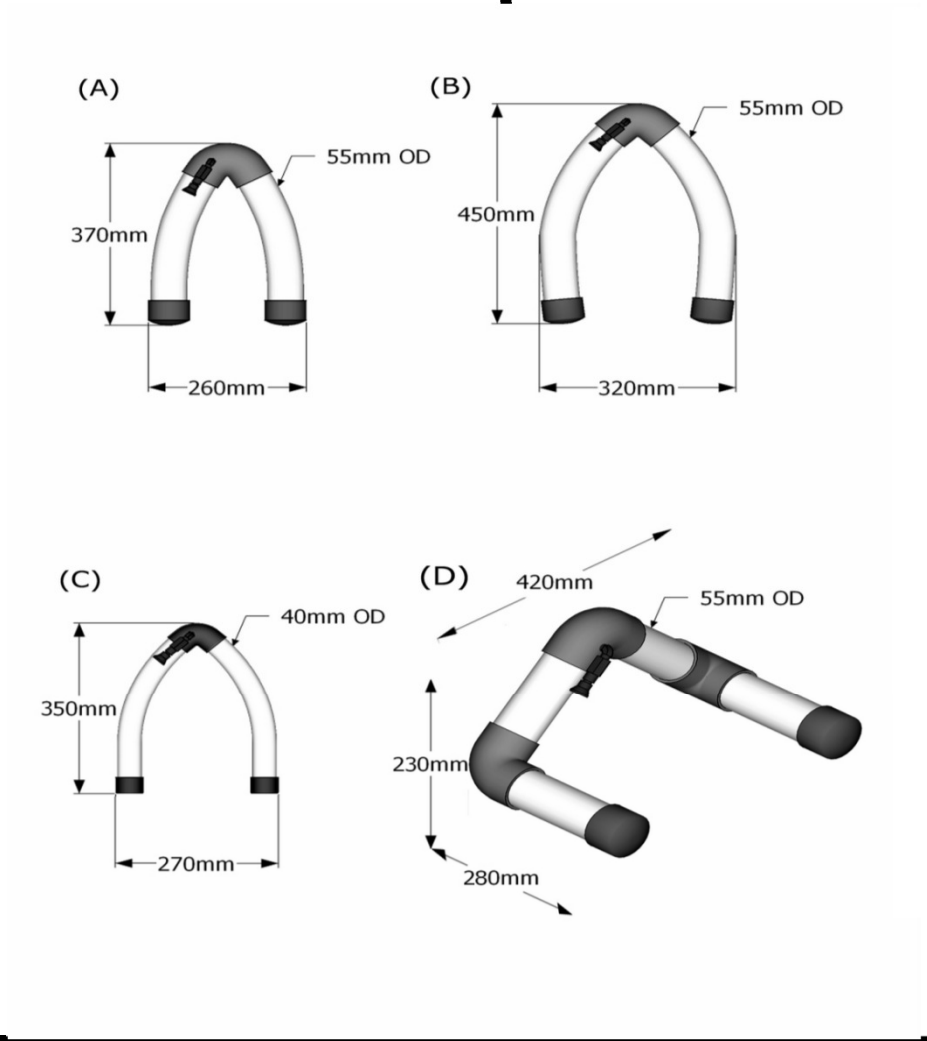


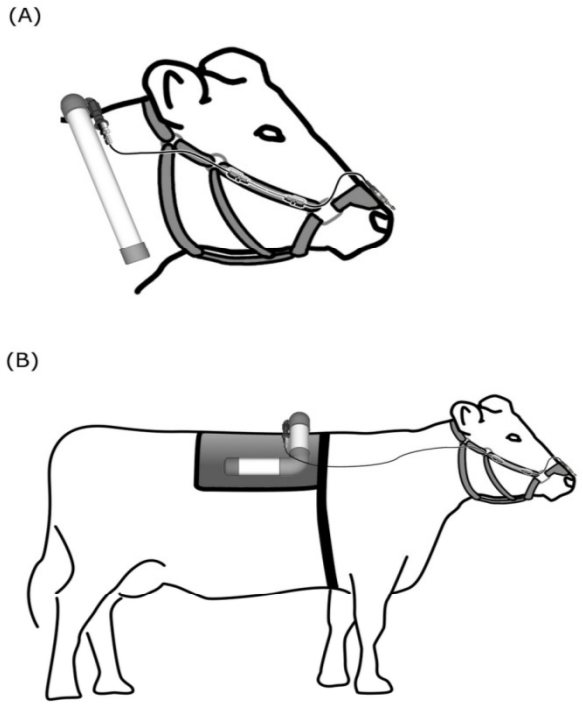
CH_4 (g/d)= PR x $[CH_4]/[SF_6]$

Permeation rate of SF_6

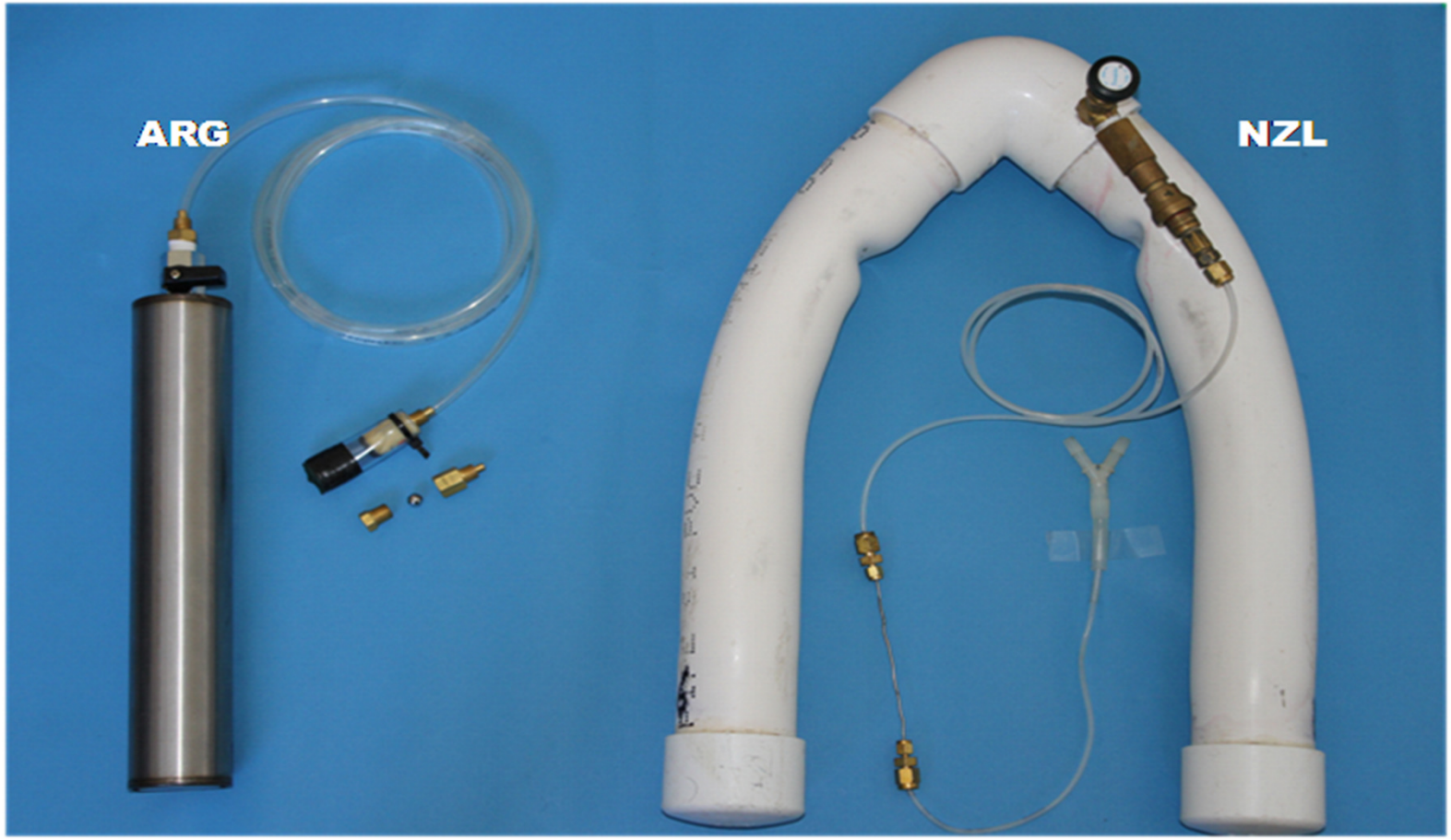


Sample collection canisters

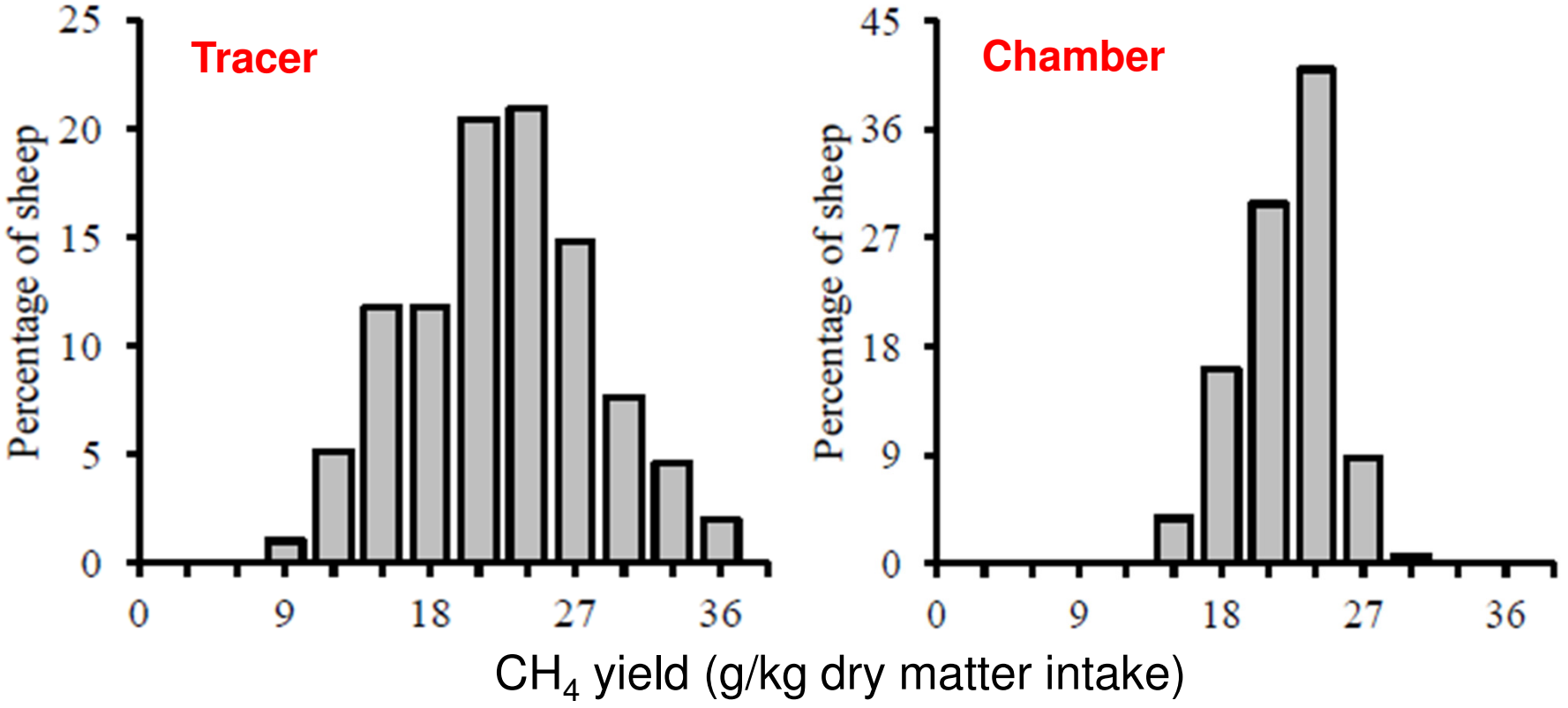




Collection canisters and sample flow regulators



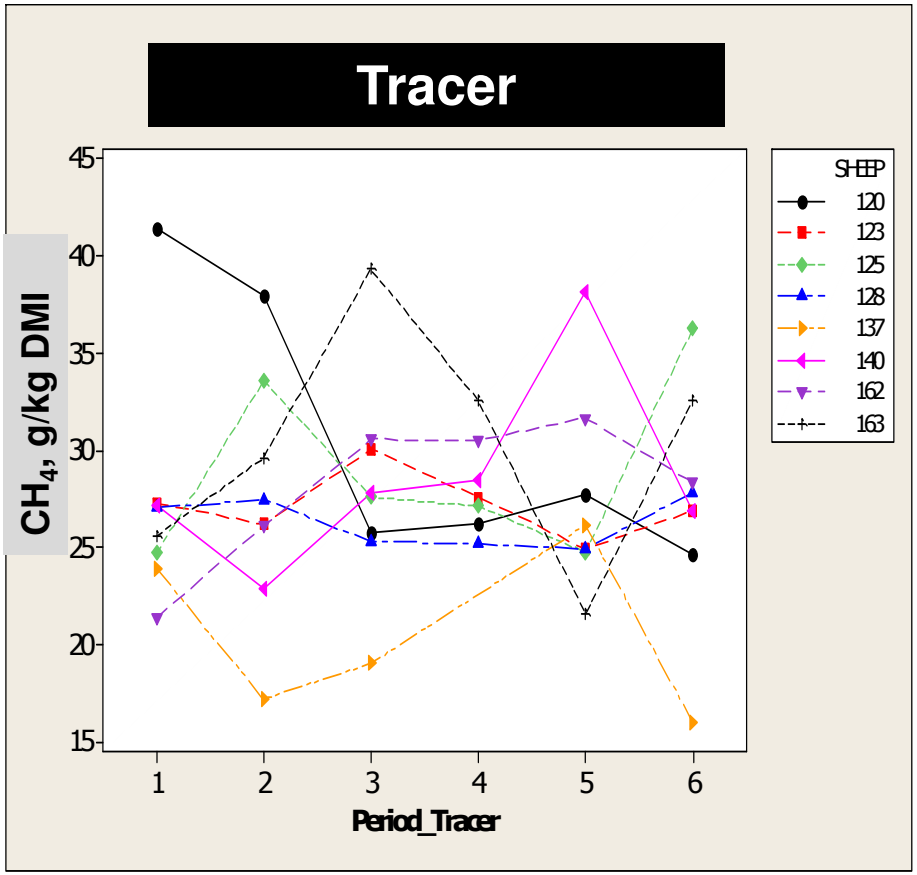
SF_6 tracer vs. Chamber: Fresh Grass

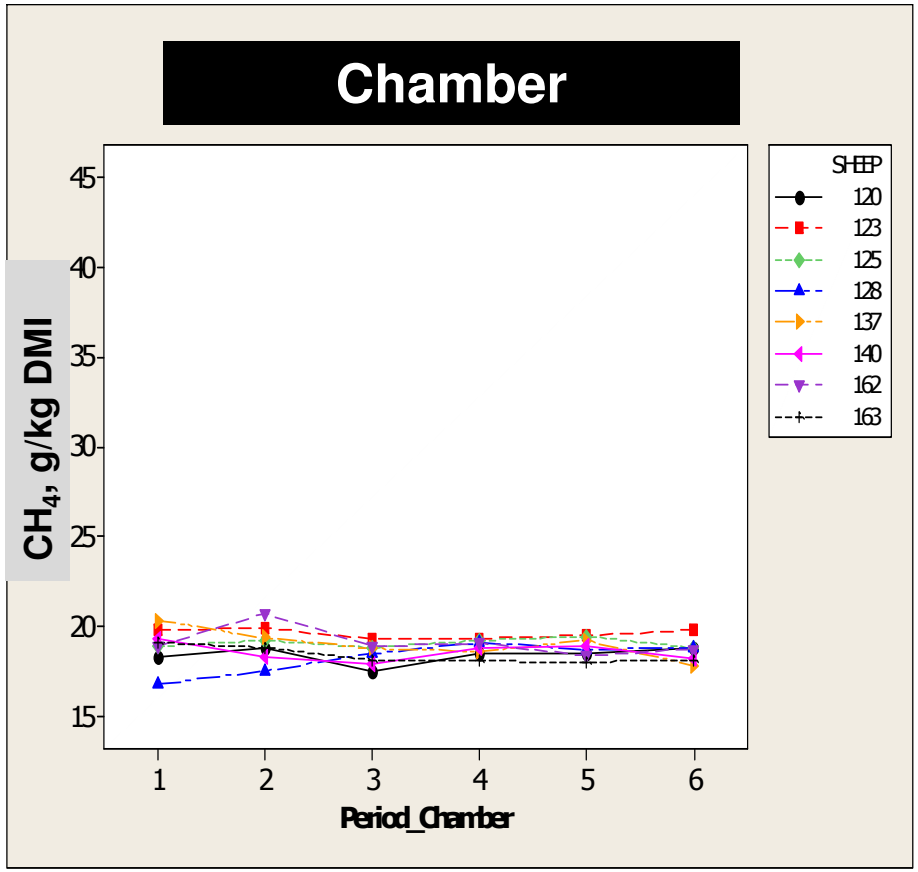


Hammond (2011)

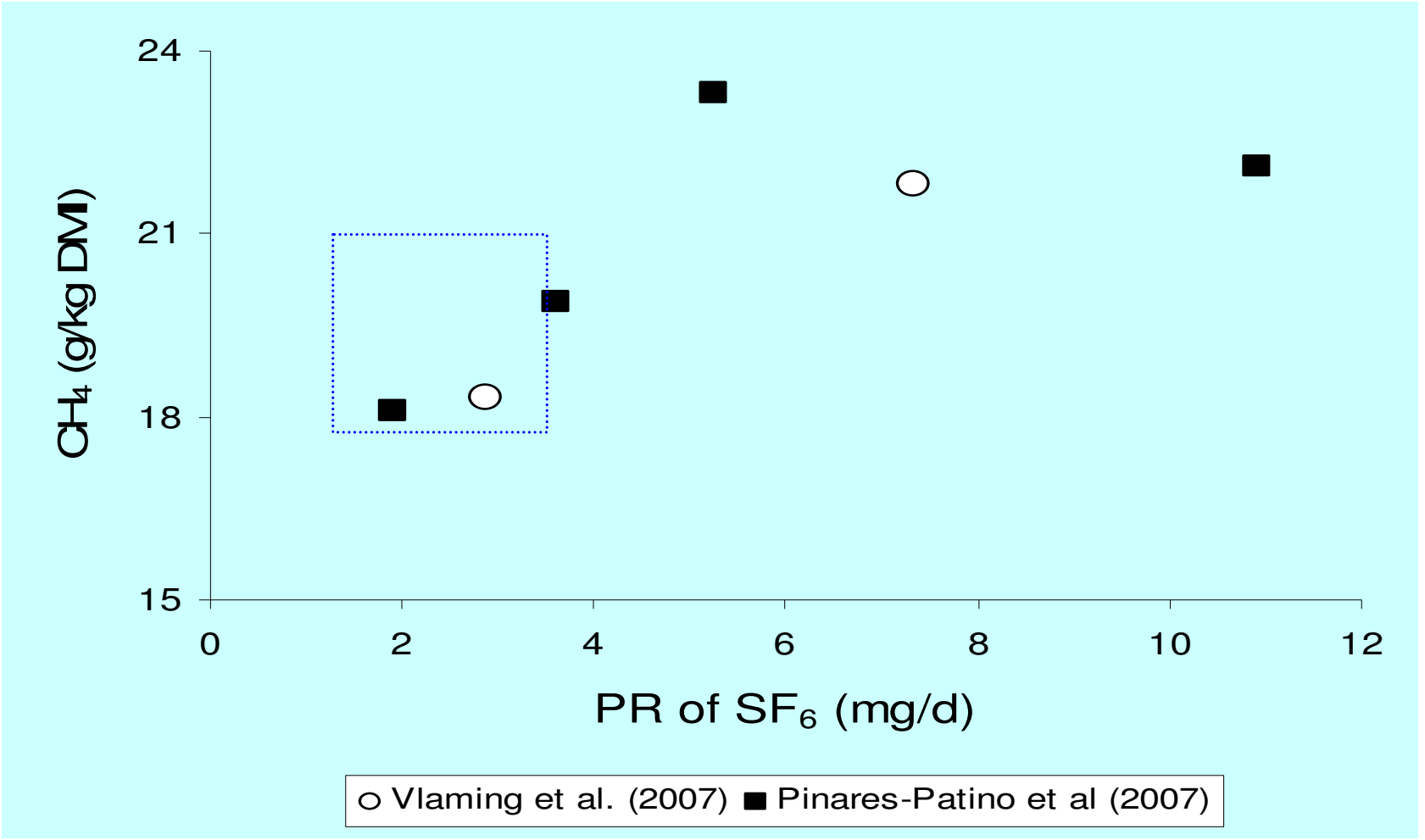
Worst situation

(very old perm tubes)





Emission estimates: association with PR



Can we Measure Methane Yield (CH_4/kgDM)?



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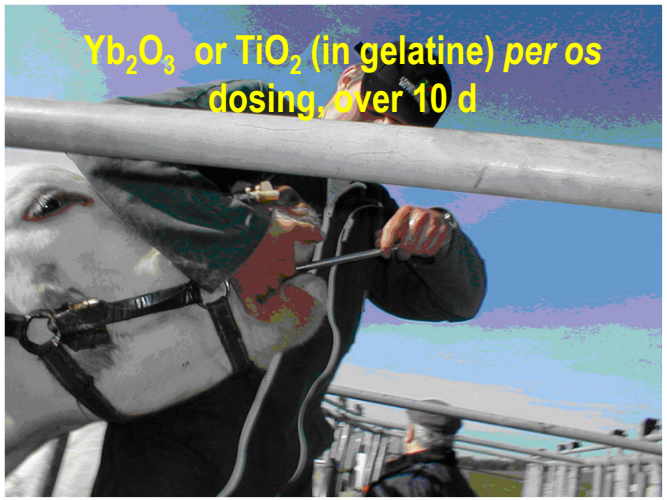
PARTNER LOGO

FEED INTAKE FROM FAECAL OUTPUT

$$\text{DMI (kg/d)} = \frac{\text{fecal DM output (kg/d)} \times 100}{(100 - \text{DMD})}$$

DMD: common value, predicted

Faecal DM output: e.g. twice daily dosing of 'external' marker



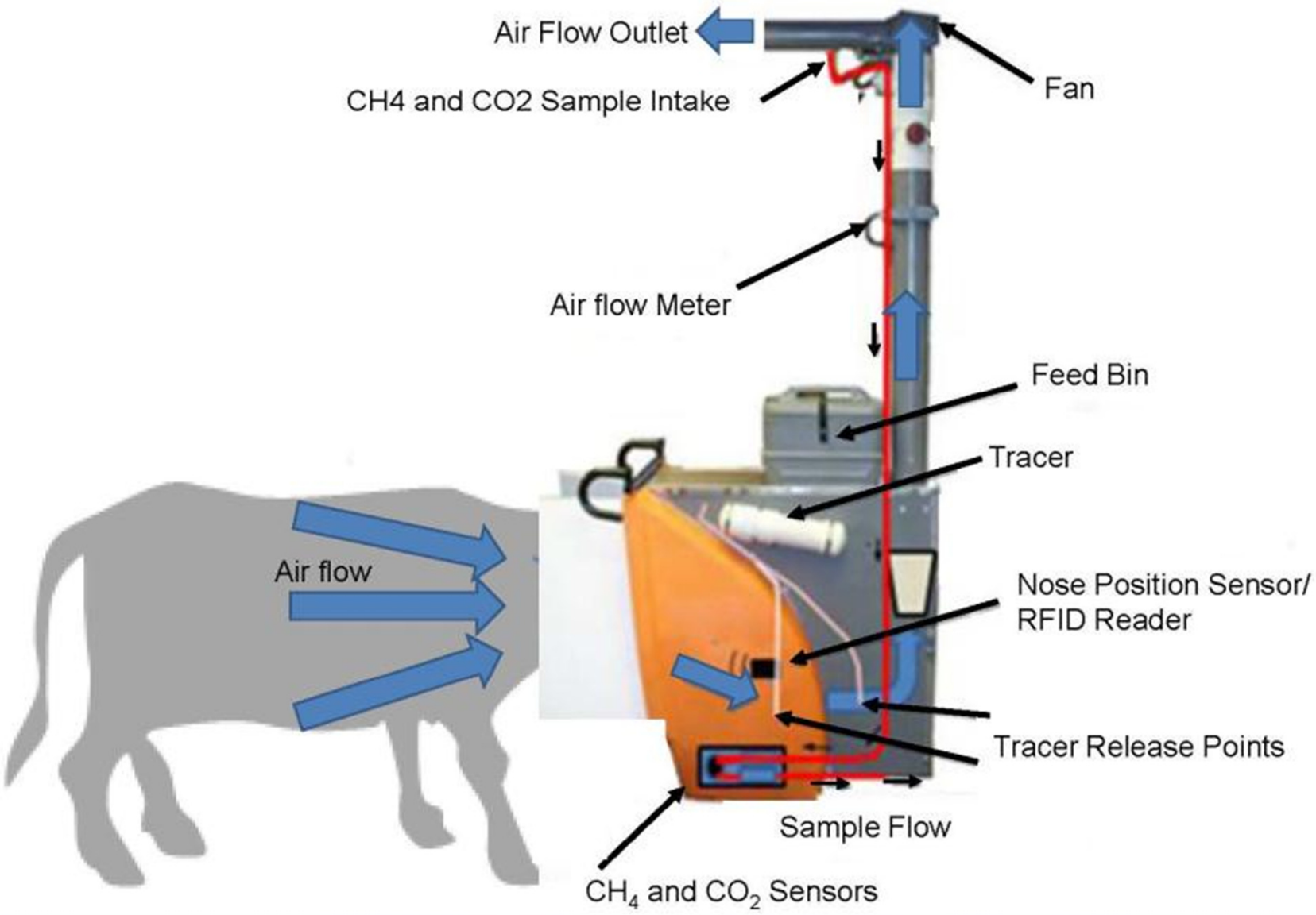
$$\frac{\text{Yb, Ti dose (mg/d)}}{\text{[Yb, Ti] faeces (mg/kg OM)}}$$

Upscaling – from one animal to the cattle on a thousand hills (options)

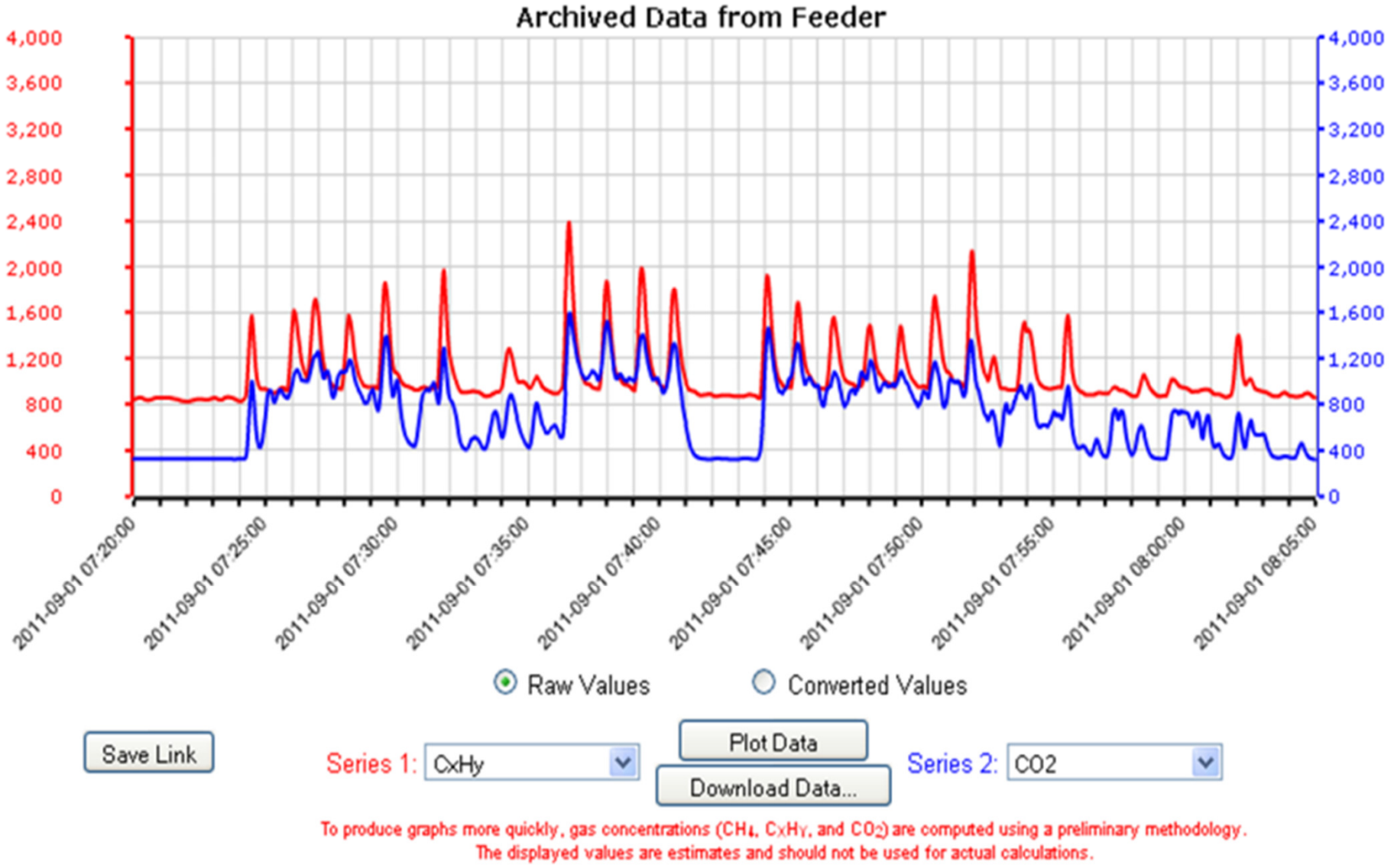
Measuring methane output of many individual cattle over a prolonged period (?) in their grazing environment

…by averaging lots of short term methane production measures

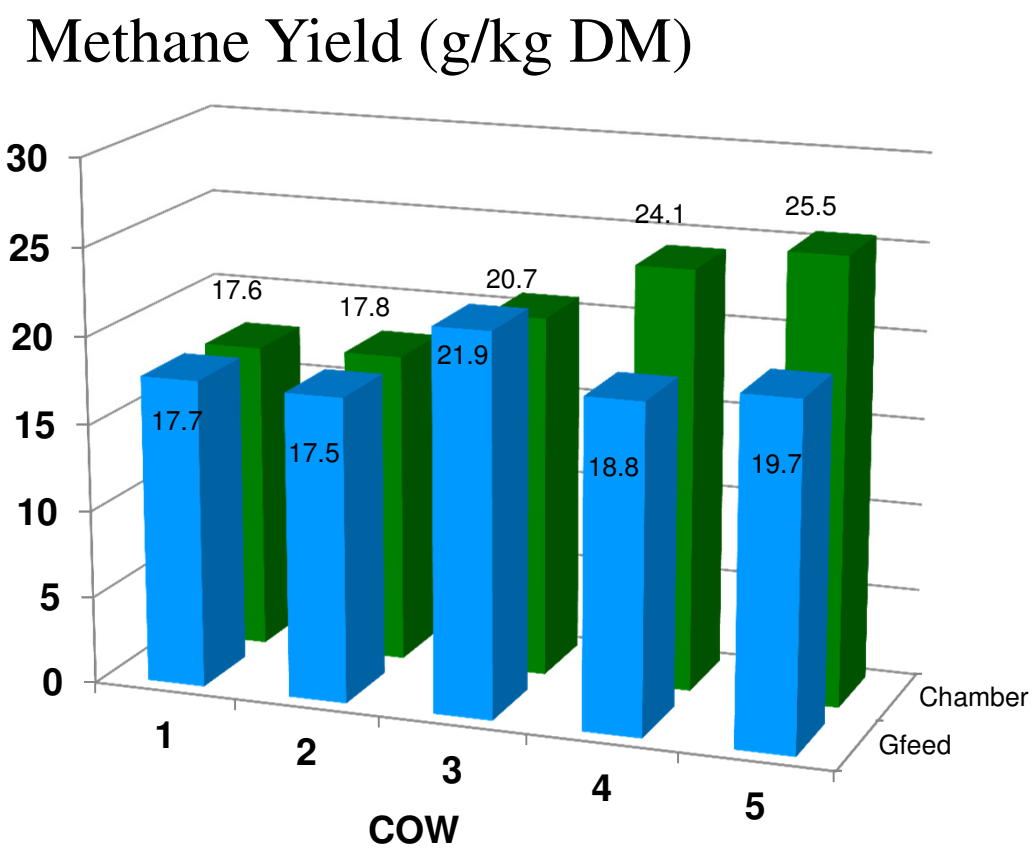
Layout of the GreenFeed™ System



What raw data looks like



Results



Data are mean of 5 x 2d measures for GEM & 5x 1d measures for chambers

Other short-term measures

Portable accumulation chambers (1hr enclosure)

Correlate well with daily methane production but coefficients depend on what time of day (relative to feeding) measurements are made

Small Groups of animals

POLY-TUNNELS

High flow rates (1m^3/second) sucked out 1 big exit ensures that air leaks into not out of the tunnel at other sites.

Polytunnel v Respiration Chamber

- The tunnel is not sealed, outside air may leak in through lots of sites
- It uses a much higher flow rate so that no methane escapes out the sides/doors
- It is (meant to be) portable so can move around the paddock
- Air flow is measured by air SPEED through a fixed diameter pipe, not by a VOLUME meter
- Can become a portable oven

Open Paddock emission measures
(>6 cattle)

- Also need (matching) concentration and airflow measurement technologies to calculate methane production per day.
- Both requirements are challenging
  - ppb differences in gas concentration
  - Airflow is over a wide front..not just a pipe
  - Large land area of variable windspeed
  - Diurnal variation in windspeed

Measuring Concentration(upwind & downwind)

Long path length (50-100m) to detect ppb CH_4

Continuous monitoring / 10 min averaging

FTIR Spectrometer

Methane laser

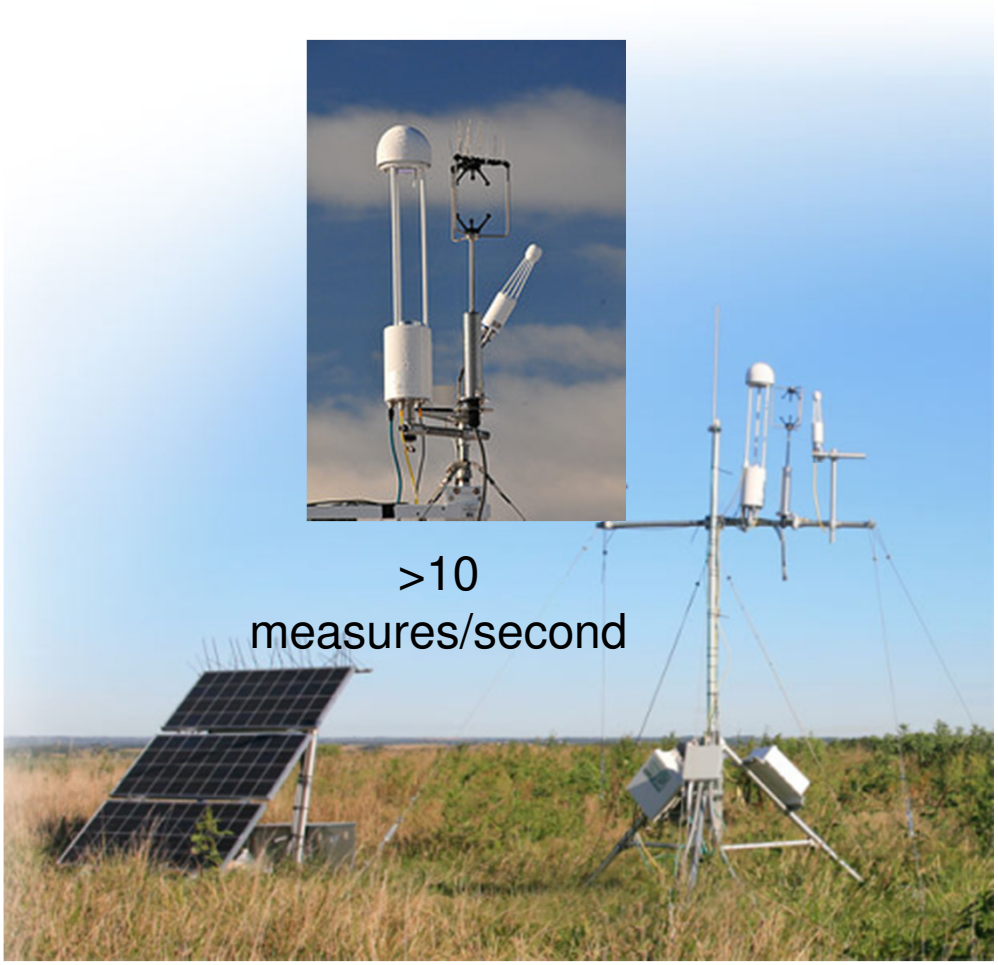
Getting air flow measures

- Sonic 3D anemometer measures air turbulence & a computer air-dispersion model calculates air flow over site and CH_4 production

or

- The weight of N_2O lost from the canister is measured daily & multiplied by the Methane/N_2O ratio as measured by FTIR or lasers

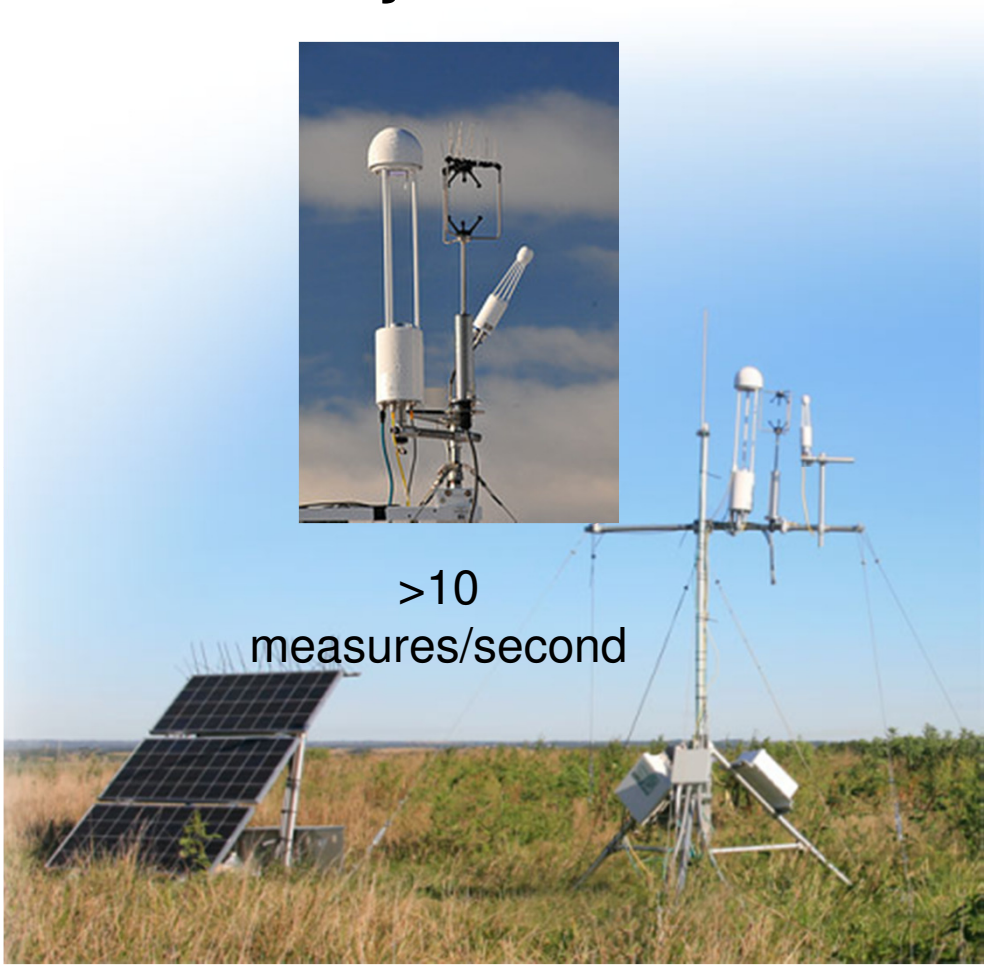
Measuring Concentration @point



>10
measures/second

Measuring Concentration @point(s)

Eddy covariance



>10
measures/second

Micrometeorology

(Flux tower)
Methane concentration,
windspeed and direction
measured at range of heights

Getting air flow measures

- Sonic 3D anemometer measures air turbulence & a computer air-dispersion model calculates air flow over site and CH_4 production

Constraints to paddock methods

- Cost (FTIR + Sonic anemometer ~US$150k)
- Wind !!! not too much, not too little
- Long periods at night with no data
- Concentrations of N_2O from paddocks too low for FTIR or normal laser to get N2O flux
- Measurement campaigns are conducted in short 1-3 week periods

- Sonic + Licor fast IR sensor to give continuous flux over extended periods (year?)

Conclusions on measurement

- Accurate emissions of a few animals/d readily possible
- Upscaling is possible…but still assessing how confident we are in the values obtained.
- There are a suite of new methods being developed/tested
- The Licor methane sensor + Sonic anemometer may give possibility for perpetual measurement of CH_4 emission from an area.
- The Greenfeed emission monitoring system may also offer long term measure in paddock situation…we shall see
- Good help is easy to find & god training.