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Micrometeorological Measurement of Methane Emissions from Manure Management Systems and Fugitive Emissions from Biodigesters

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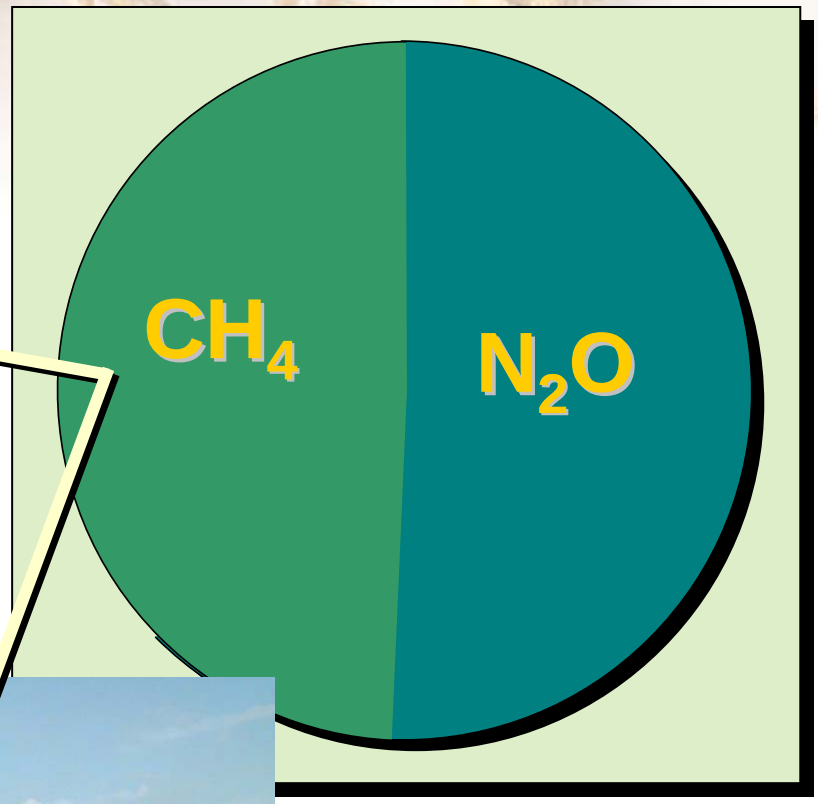
Methane to Markets

Canada

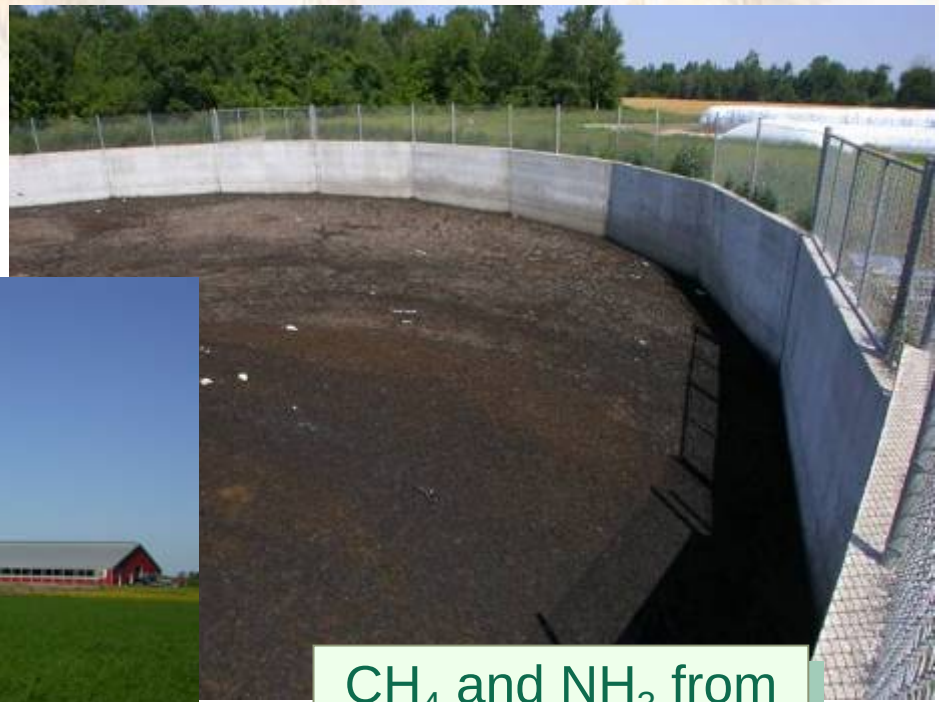
Methane emissions from the Canadian Agricultural Sector, 2004

Enteric Fermentation
86 % or 23 Mt CO_2 eq.

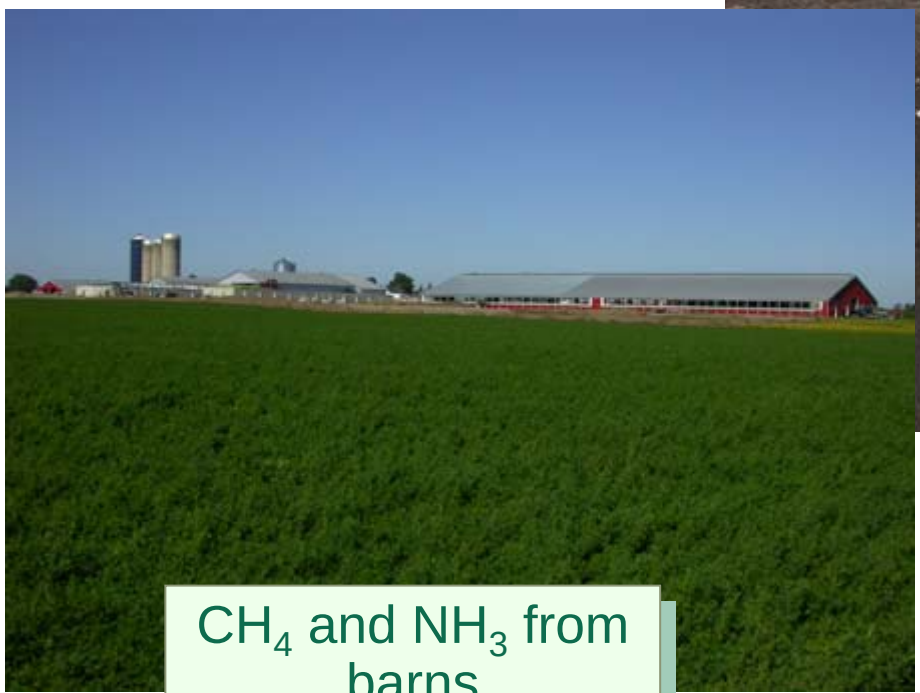


Manure Management
14 % or 4 Mt CO_2 eq.

CH_4 and NH_3 Emissions Measurement Techniques

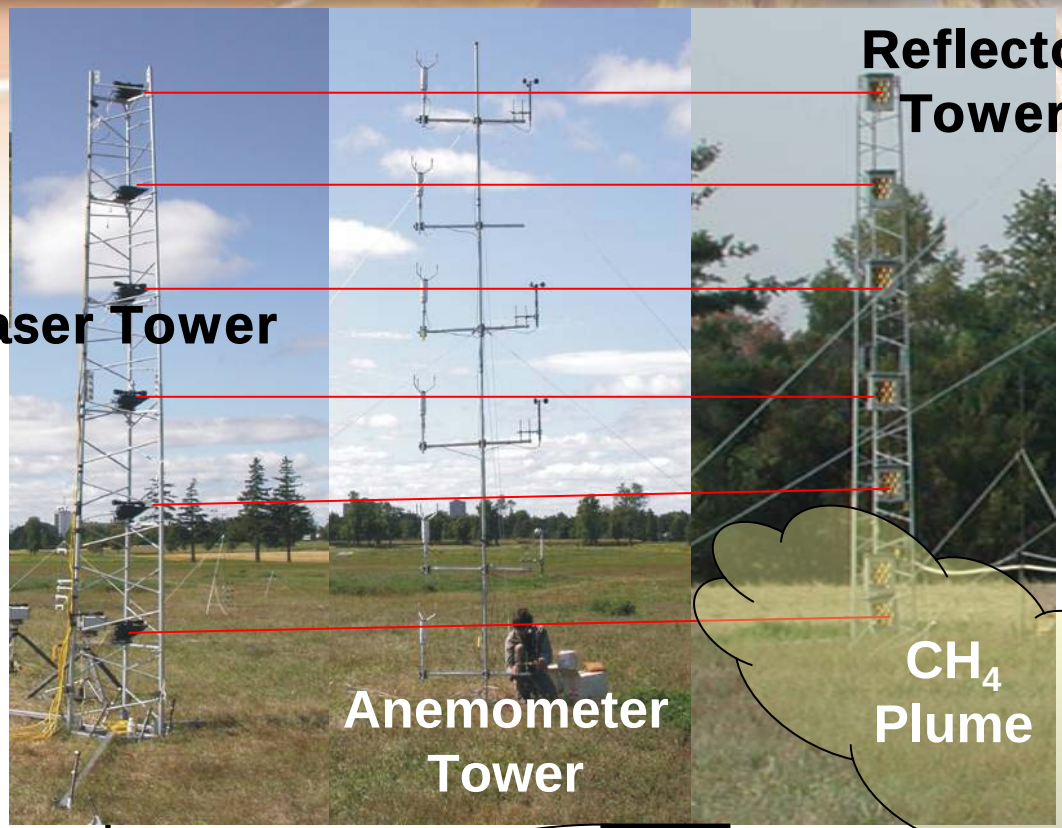


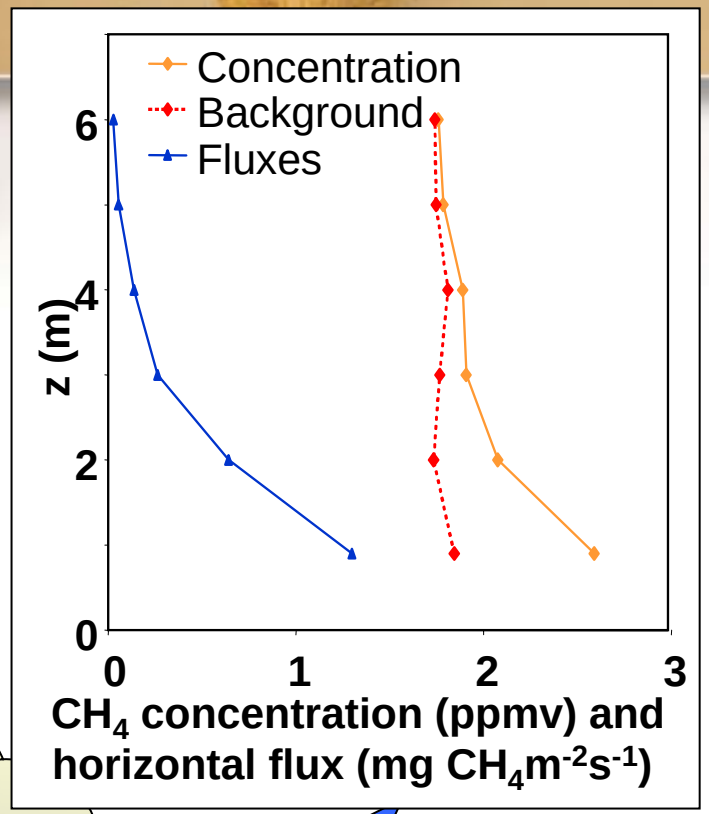
CH_4 and NH_3 from lagoons

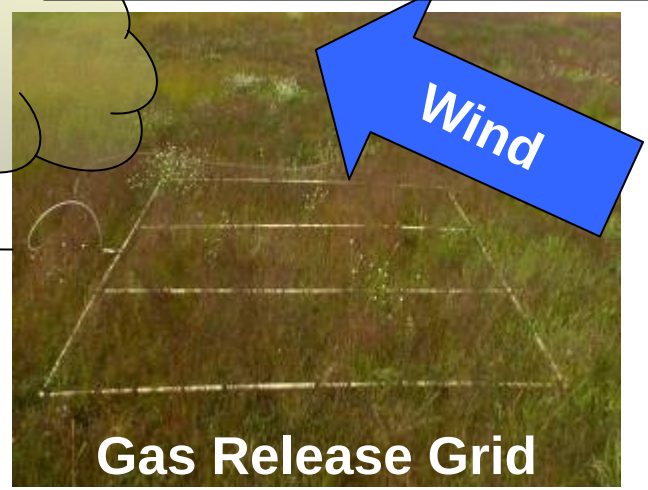


CH_4 and NH_3 from barns

Instrumentation for the Mass Balance Technique, Methane







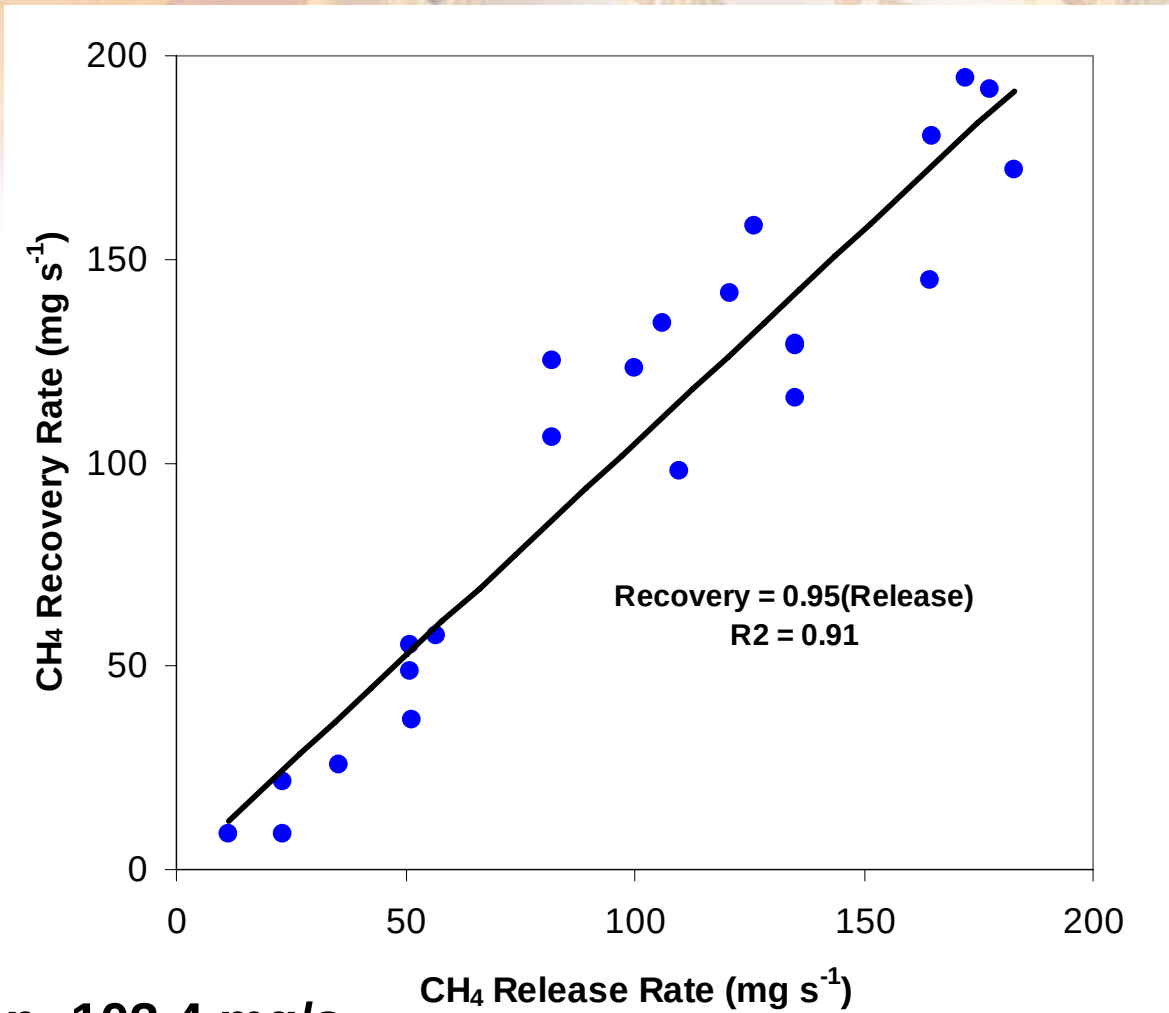
Cables to laser control and data logging units

Pure CH_4

Mass Flow Controller

Mass Flow Meter

Recovery and Release Rates Of CH_4 (half hour averages)

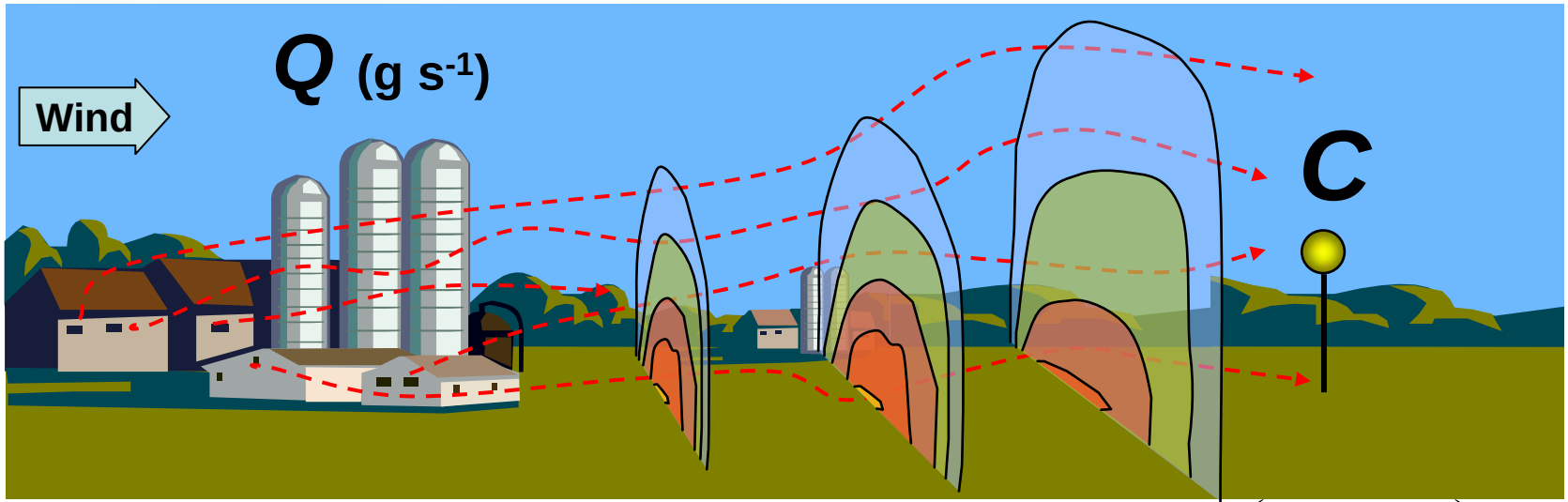


Mean emission: 103.4 mg/s
Mean recovery: 109.0 mg/s

Inverse Dispersion Modeling

Dispersion model relates concentration *C* to emission rate *Q* ("*C-Q relationship*") for prevailing winds

Measure *C* then infer *Q*



Using a line measurement:

$$Q_{bLS} = \frac{(C_L - C_b)}{(C_L / Q)_{sim}} \longrightarrow (C_L / Q)_{sim} = \frac{1}{P}\sum_{i=1}^{P}\left(\frac{1}{N}\sum\left|\frac{2}{w_0}\right|\right)$$

where,

Q_{bLS} = Estimated emission rate

Q = Uniform but unknown emission rate

C_L = Line concentration

C_b = Background concentration

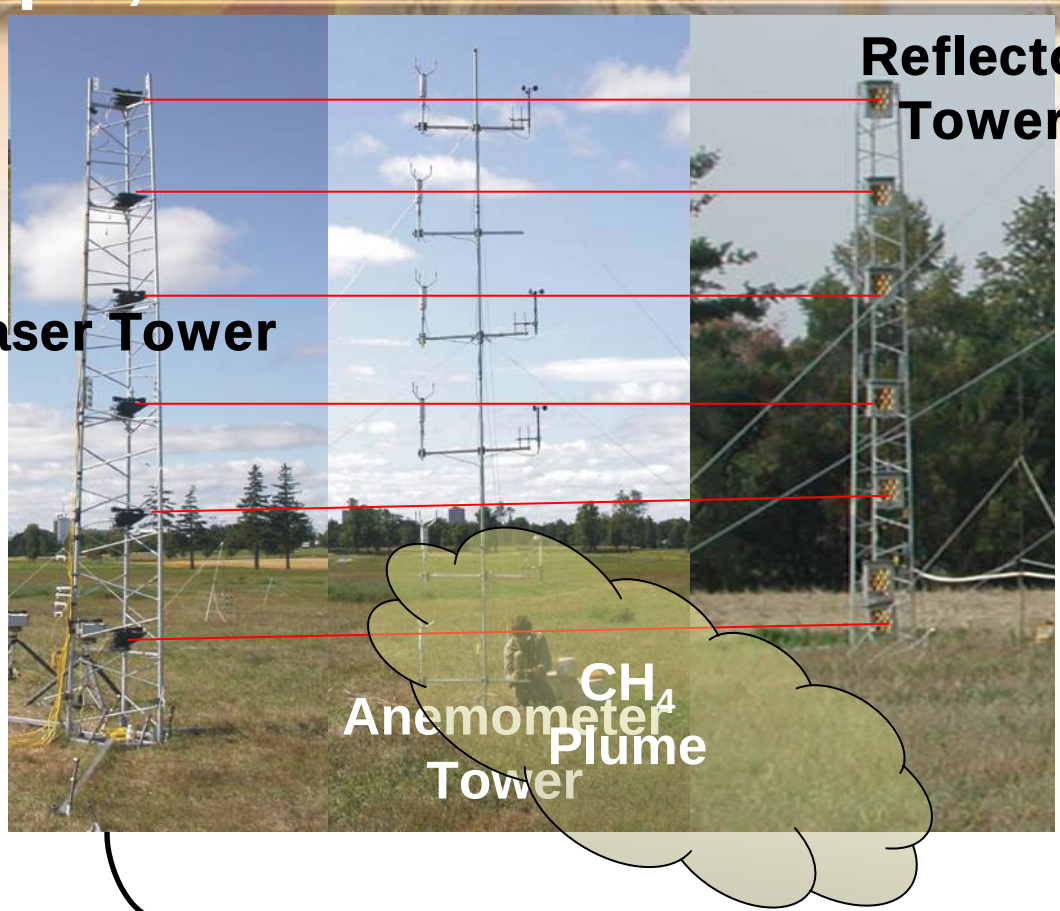
P = Point Concentrations equispaced along the path

N = Total number of particles released at each point

w_o = Vertical touchdown velocities

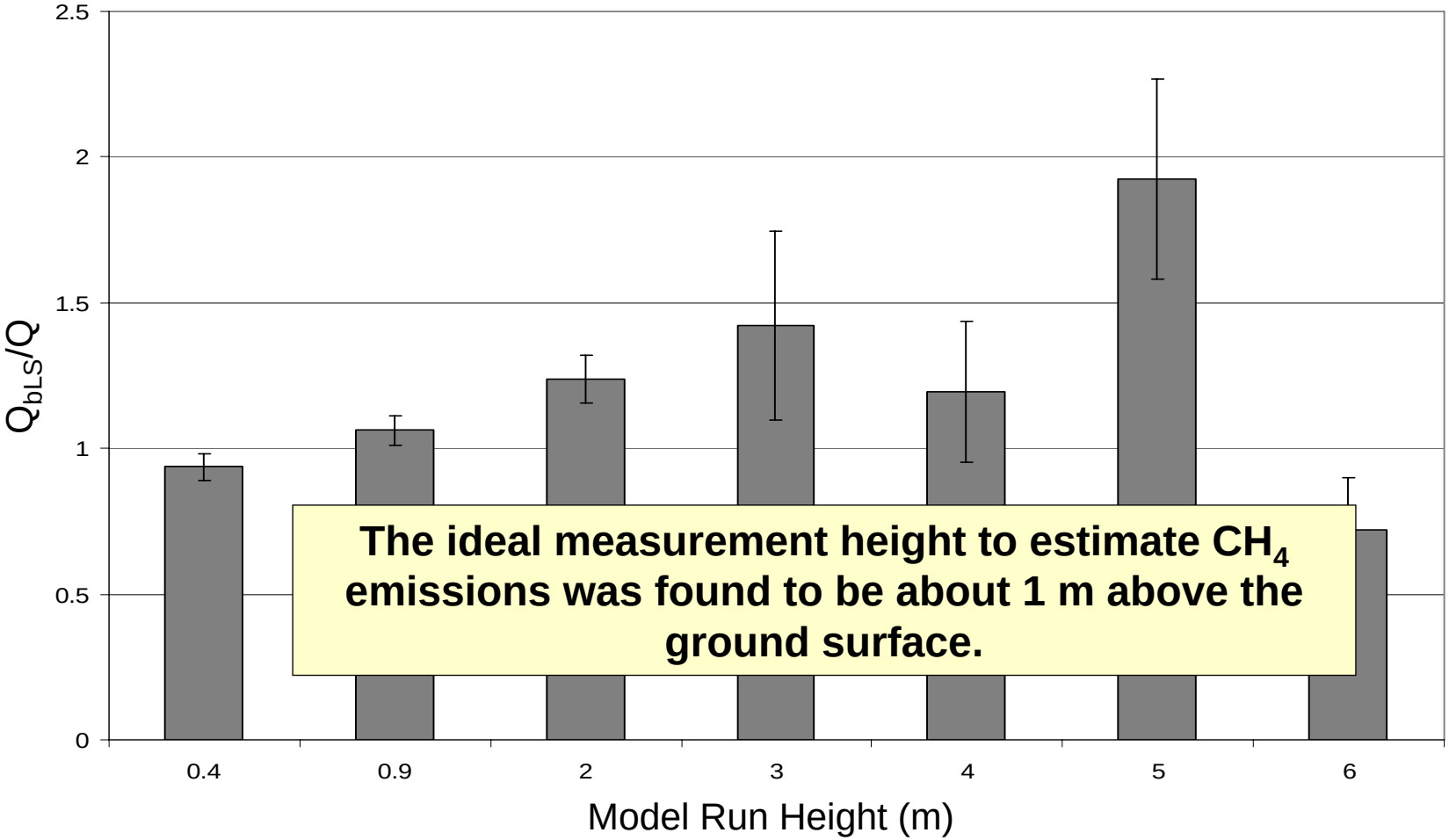
** The inner summation refers only to touchdowns within the source*

Instrumentation for the Mass Balance Technique, Methane

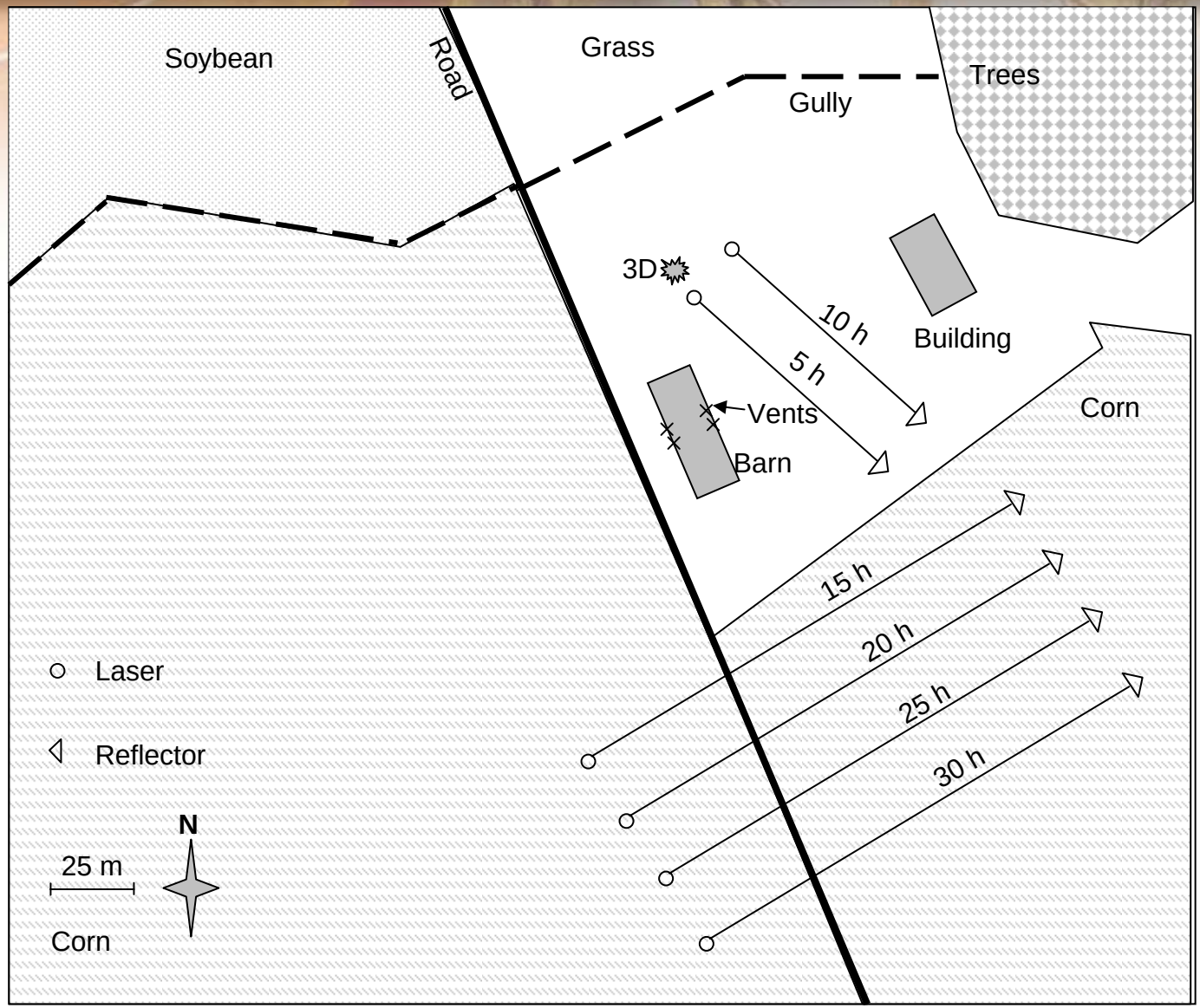


Cables to laser control and data logging units

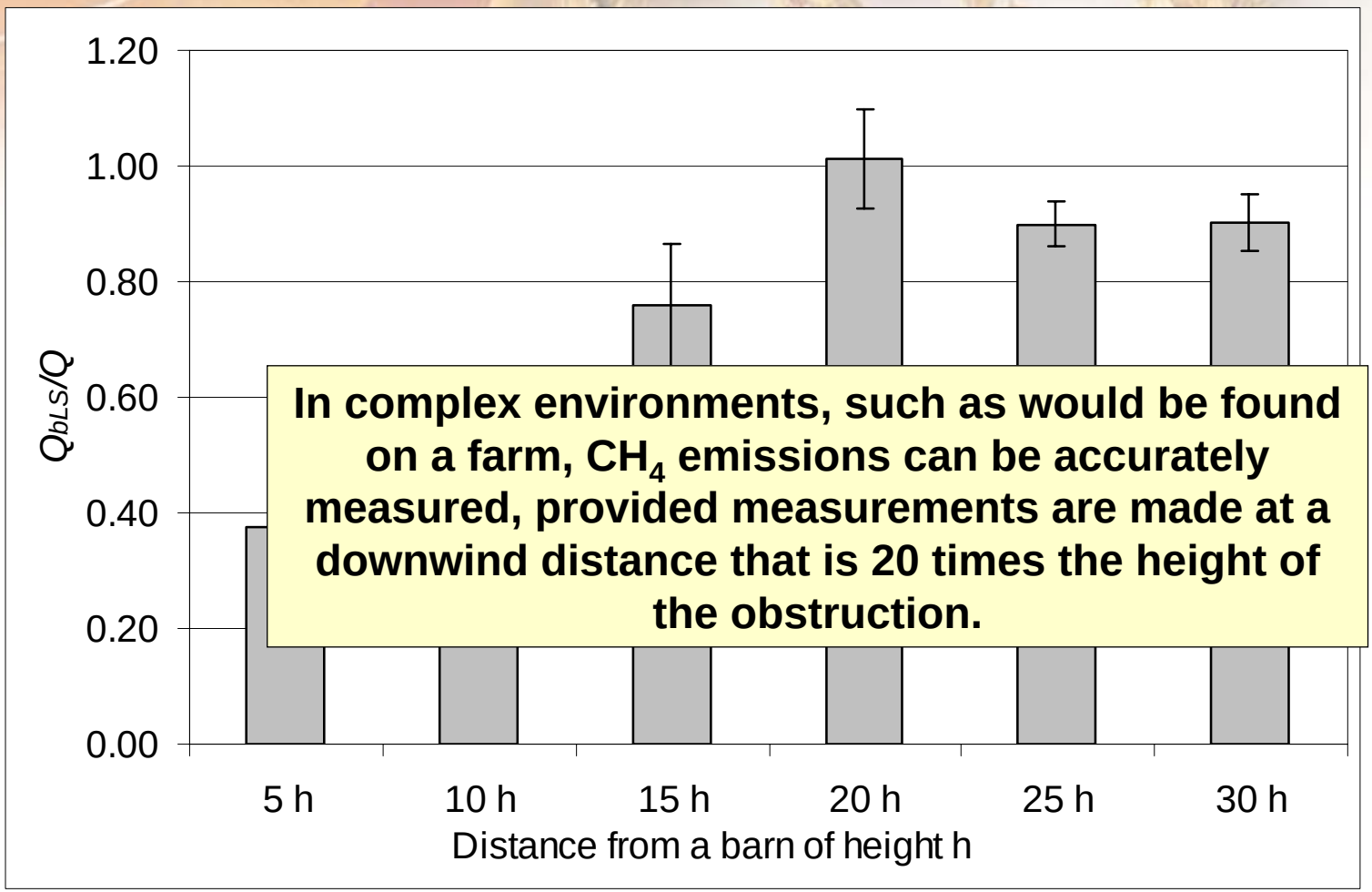
Ideal Measurement Height for the bLS Model



Experimental Set-up for Barn CH_4 Releases



Results from Barn Releases



Estimating On-Farm Methane Emissions from a Dairy Cow Lagoon

Manure Tank

Upwind Laser Line

Downwind Laser Line

- Dairy barn – 180 head – Liquid manure
- bLS technique used to quantify CH_4 emissions
- Results calibrated using on-site release data

Estimating On-Farm Methane Emissions from a Lagoon

	Q_{bLS} (kg CH_4 $head^{-1}$ $year^{-1}$)	*Calibration Coefficient*	*Corrected* Q_{bLS} (kg CH_4 $head^{-1}$ $year^{-1}$)
Average	**177.1** (N = 28, T = 7Hr)	**0.23** (releases made periodically, N = 6, T = 1.5Hr)	**41.0**
STD	**59.0**	**0.08**	**13.7**
SE	**11.1**	**0.03**	**2.6**

N = number of 15min averages used

T = Total time

IPCC CH_4 Emission factor for a liquid storage system with Dairy Cow Manure:

87 kg CH_4 $head^{-1}$ $year^{-1}$

Estimating On-Farm Methane Emissions from a Dairy Manure Digester

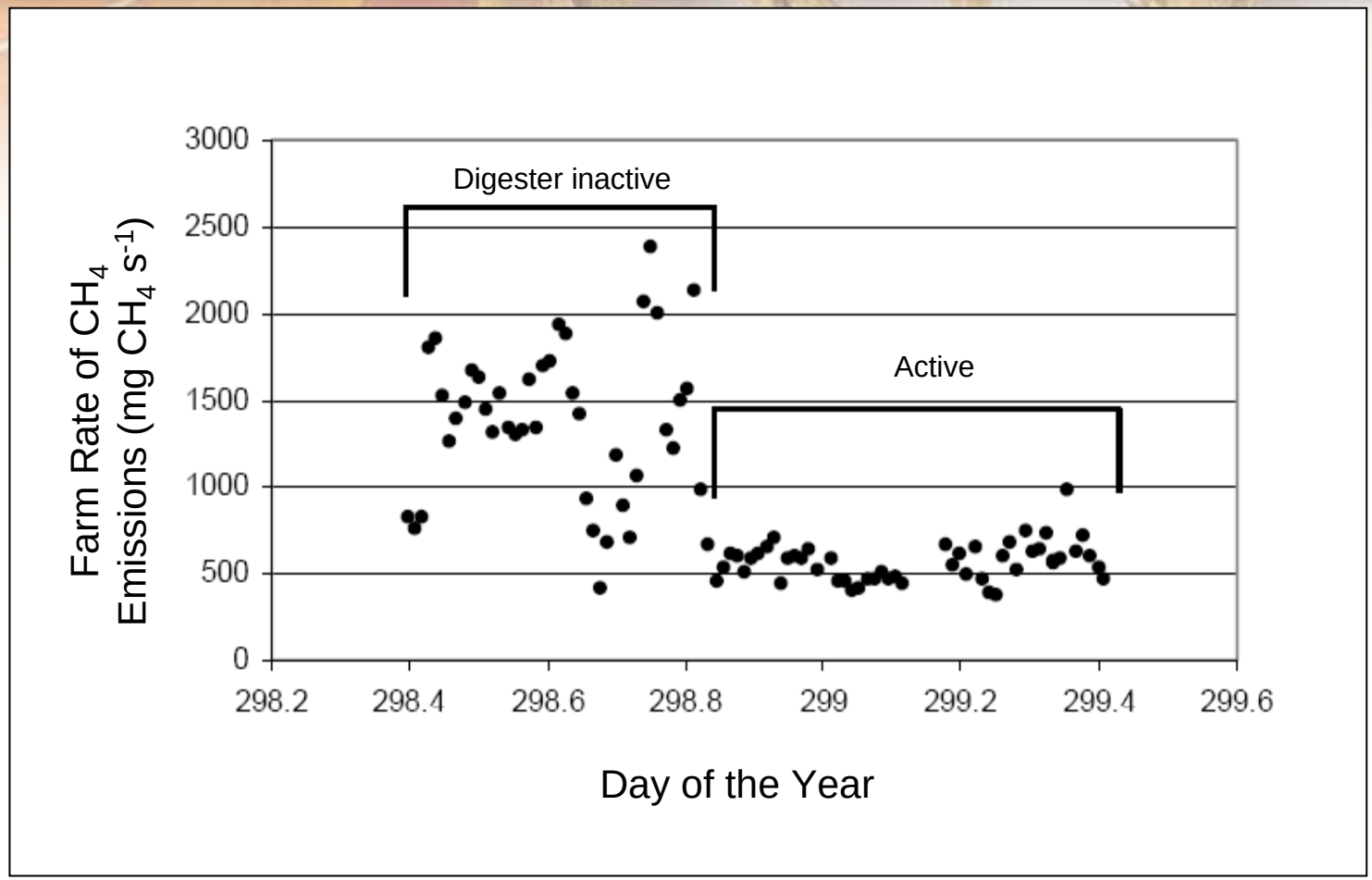
Generator Room

Flexible biogas storage membrane

Digested manure

Mixing motors

Methane Emissions from the Dairy Digester



Methane emissions were on average, three times greater when the digester was inactive, as compared to when it was active.

Typically, life cycle analysis of farm scale biodigesters assumes 2 to 13.5 % loss of biogas produced due to fugitive emissions. IPCC in the past has assumed 5 to 15 % loss due to fugitive emissions. These assumptions are based on very little field data.

2-15 % of biogas production?

How can we evaluate whole farm fugitive emissions from the biodigestion processes?

Summary

- With micrometeorological techniques, we can improve our estimates of CH_4 emissions from manure storage systems
- We should also be able to quantify if there are any fugitive CH_4 emissions around biodigesters

Methane to Markets