GCRF Sustainable futures for the Costa Rica dairy sector – training workshop, CATIE, 5-6th October 2017

Measurement techniques for ammonia emissions from agricultural sources

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ROTHAMSTED RESEARCH

BBSRC bioscience for the future

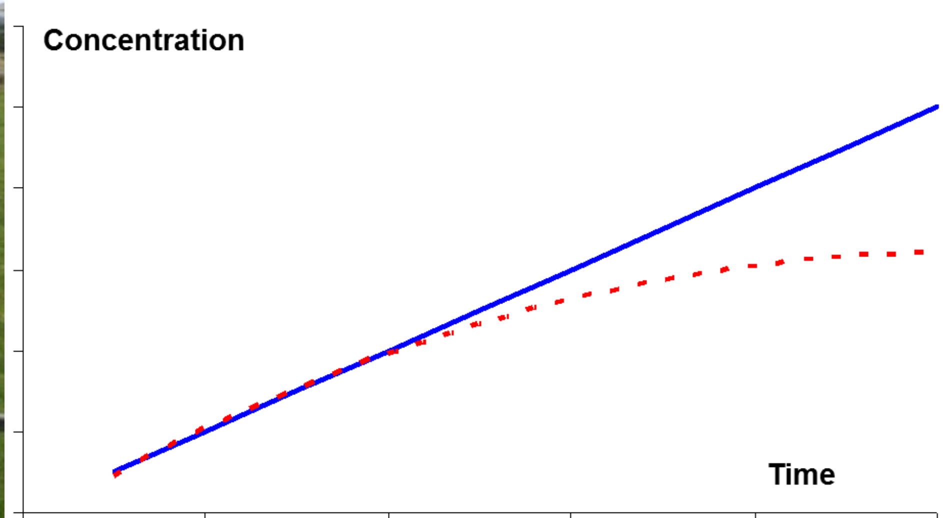
Lawes Agricultural Trust

Overview

- General principles of different measurement techniques
- Ammonia concentration and flux samplers
- Emissions from land sources
- Emissions from livestock housing
- Emissions from manure storage

Measurement techniques – general principles

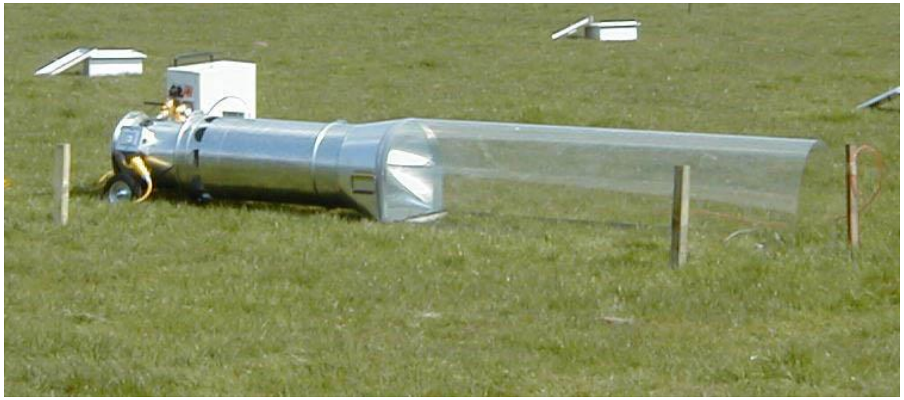
Static chambers



Advantages:
Simple, inexpensive
Ideal for multi replicate factorial experiments (lab, field)
Control

Disadvantages:
May influence emitting conditions – not good for absolute
Labour intensive
Lack of spatial/temporal representation

Dynamic chambers



Wind tunnel for ammonia emission measurement

Animal respiration chamber – CO_2 and CH_4 emissions

Advantages:

Ideal for multi replicate factorial experiments (lab, field)

Control

Disadvantages:

May influence emitting conditions – not good for absolute

Lack of spatial/temporal representation

Cost

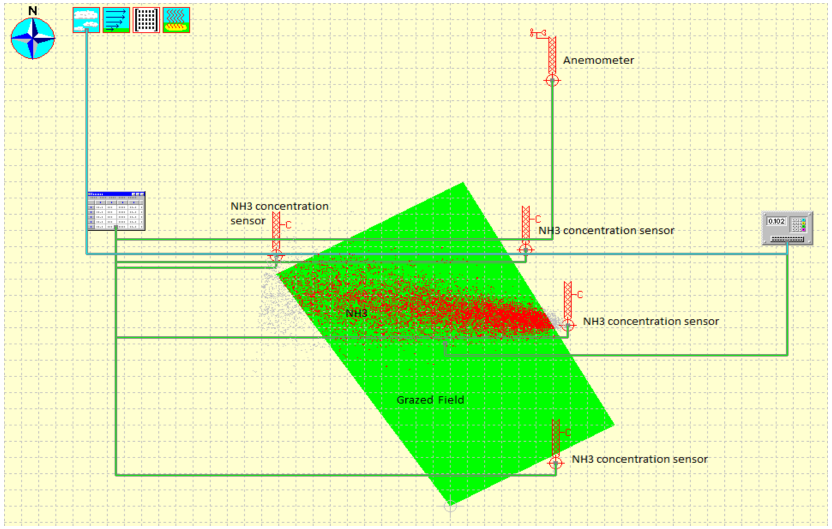
Tracer ratio techniques

Advantages:
Measurement under ambient conditions

Disadvantages:
Cost
Complexity

Micrometeorological techniques

IHF Mass Balance technique with passive NH_3 samplers



Backward dispersion modelling - WINDTRAX

Eddy covariance

Advantages:

Measurement under ambient conditions

Integrates spatial variation

Disadvantages:

Cost

Complexity

Ammonia concentration/flux samplers

Absorption flasks:

Pros – inexpensive, simple, large concentration range

Cons – require power, time-averaged, freeze/evaporation

Filter badges:

Pros – inexpensive, simple, no power requirement

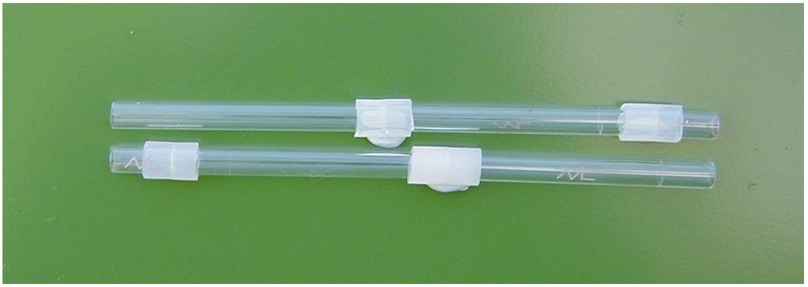
Cons – labour intensive, time-averaged, difficult to estimate suitable exposure time

Passive flux samplers (shuttles):

Pros – direct flux measurement, simple, no power requirement

Cons – cost, time-averaged flux

Ammonia concentration/flux samplers

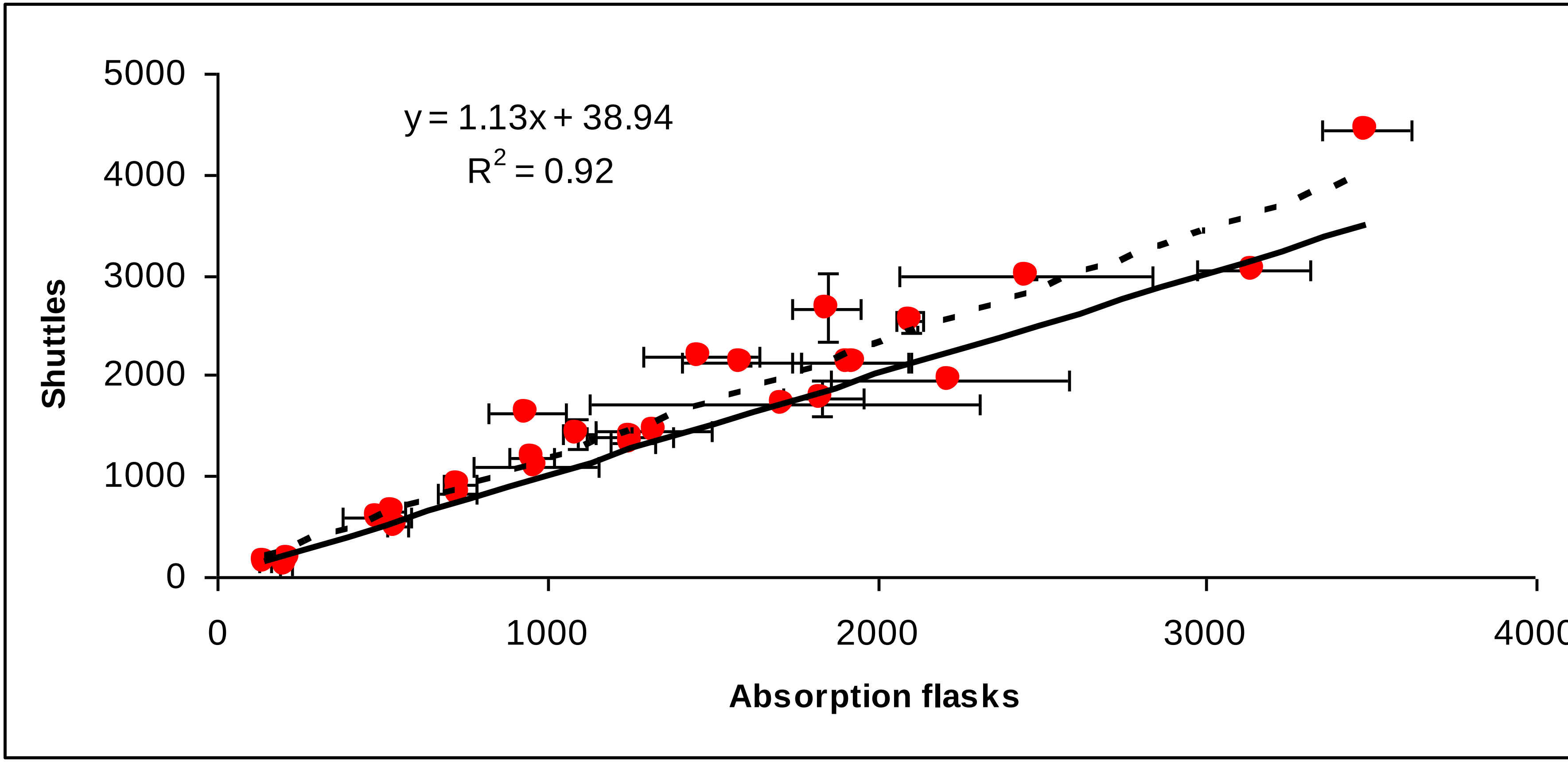


Ferm tubes:
Pros – simple, direct measurement of flux
Cons – labour intensive

Instrumentation e.g. lasers:
Pros – continuous/high frequency measurement, sensitivity
Cons – expensive, limited to 1/few sampling locations, calibration/drift

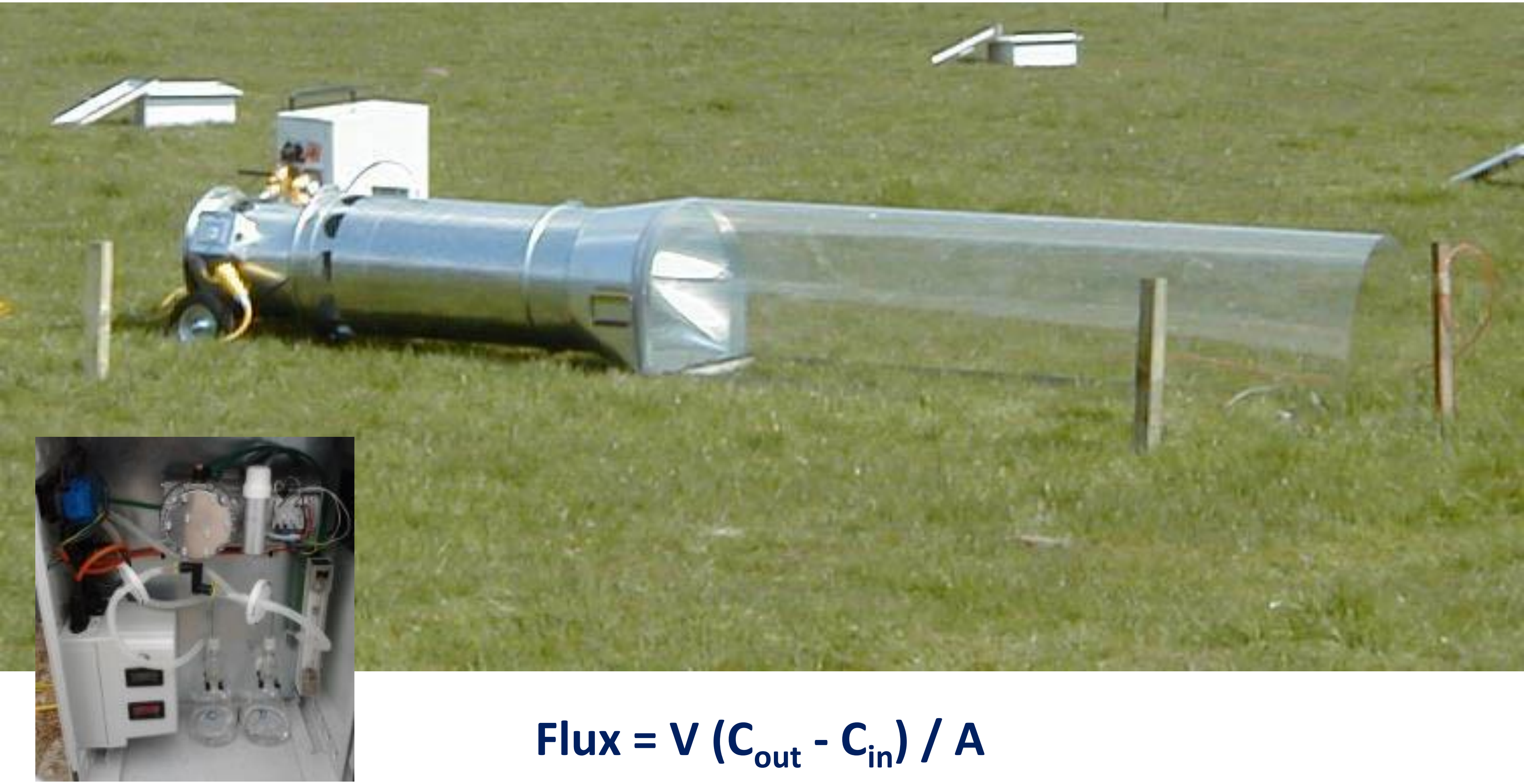
Sampler inter-comparison tests

Shuttles vs. absorption flasks



Emissions from land sources

1. Wind tunnels



Flux = V (C_{out} - C_{in}) / A

Lockyer 1984, JSciFoodAg

Emissions from land sources

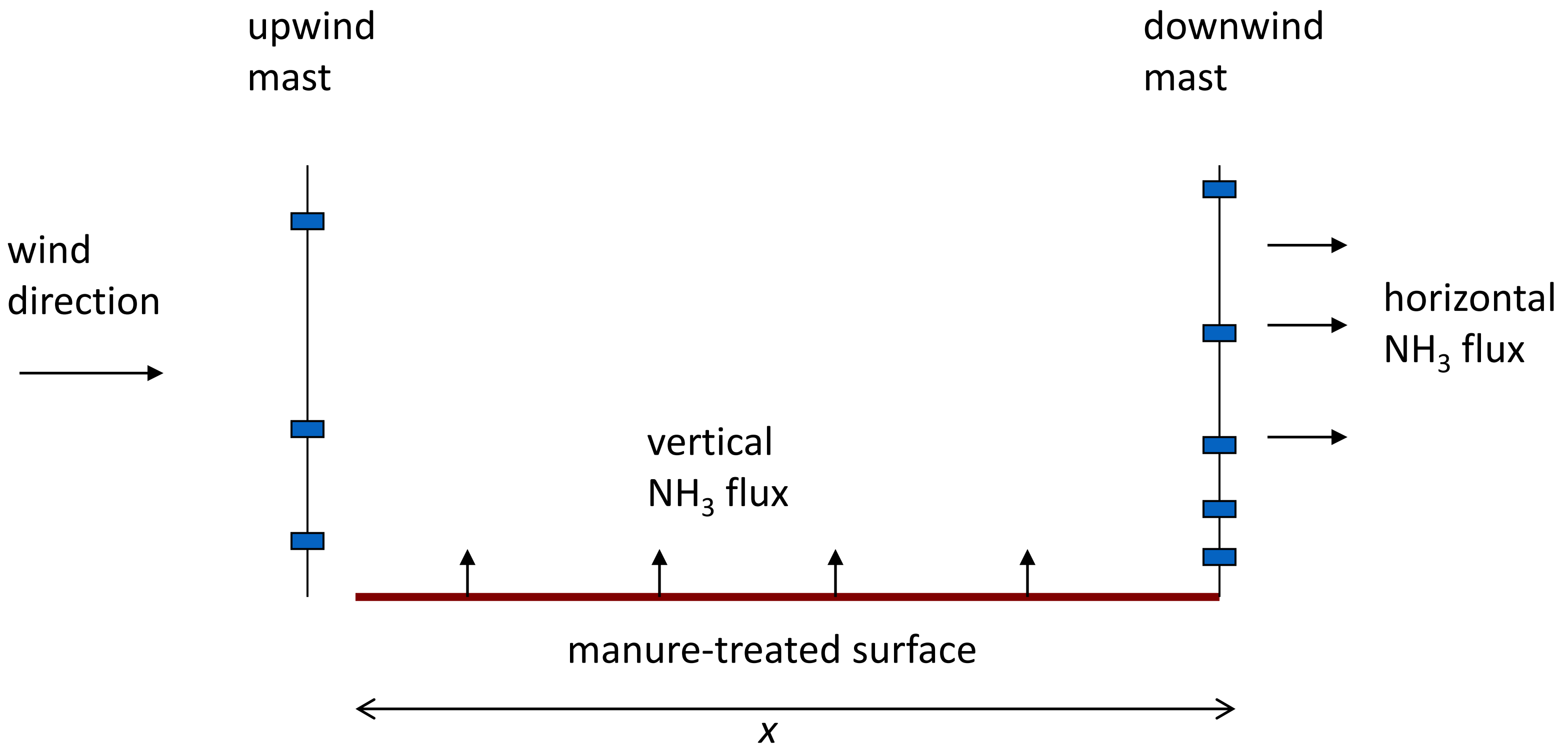
2. Equilibrium concentration technique

$Flux = (C_{eq} - C_{a,z})\, K_{z,a}$

Svensson 1994, ActaAgScand

Emissions from land sources

3. IHF Mass Balance



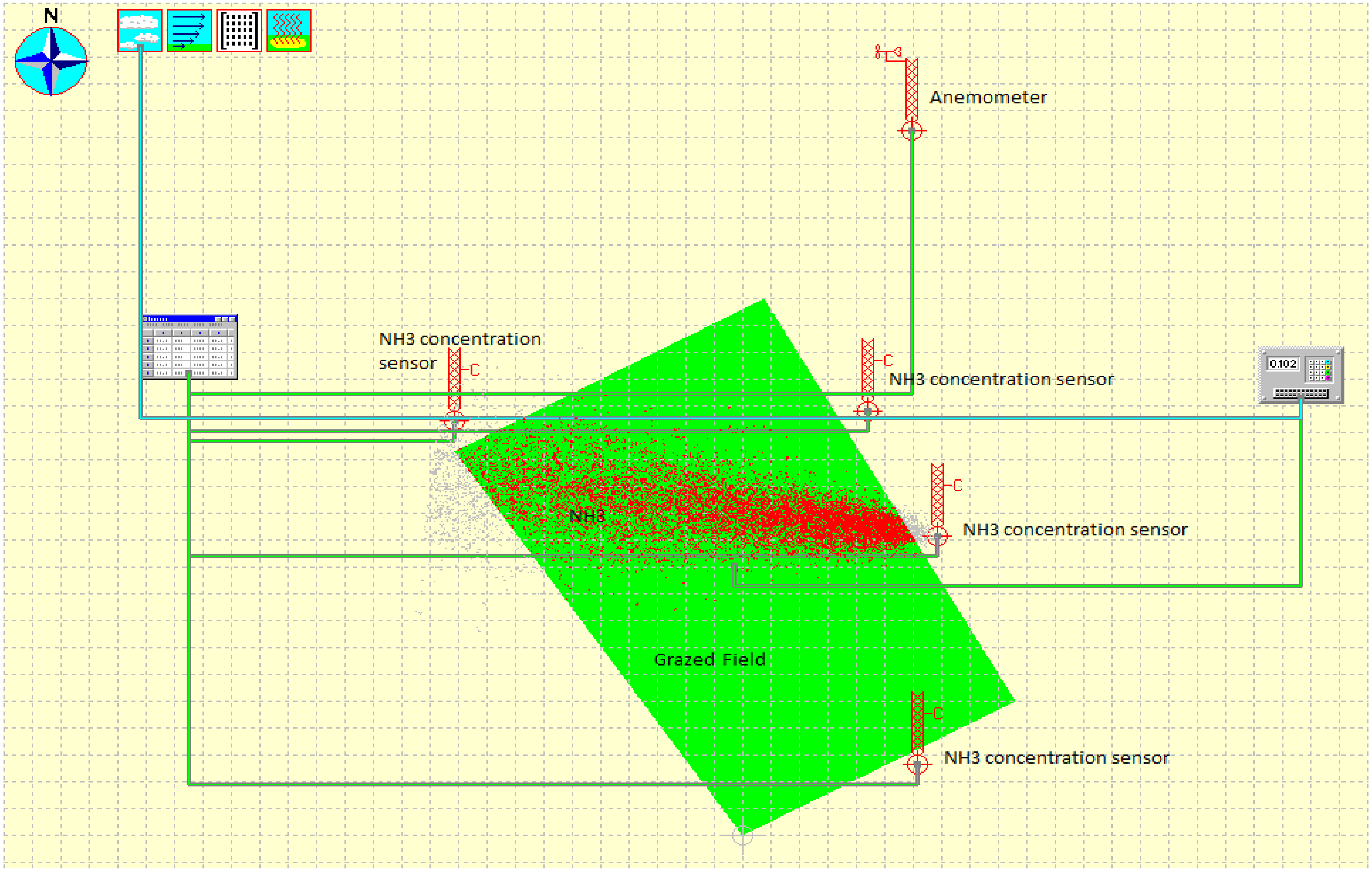
Flux from treated area = $(IHF_{dw} - IHF_{uw}) / x$

Uniform emission source and land area without obstructions (trees, buildings etc.)

Denmead et al. 1977, SSSAJ

Emissions from land sources

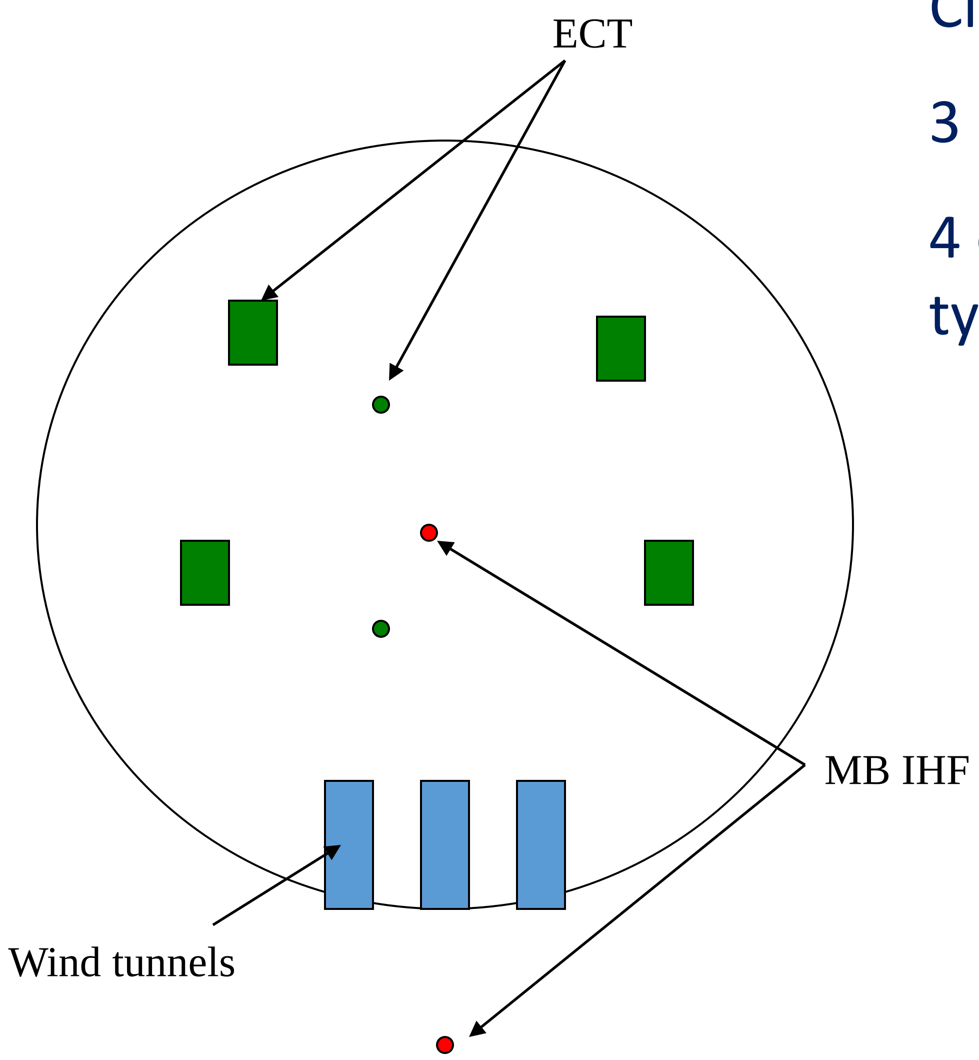
4. Backward Lagrangian Dispersion model



Use WINDTRAX software – freely available: *www.thunderbeachscientific.com*

Flesch et al. 2007, Ag For Met

Technique inter-comparisons



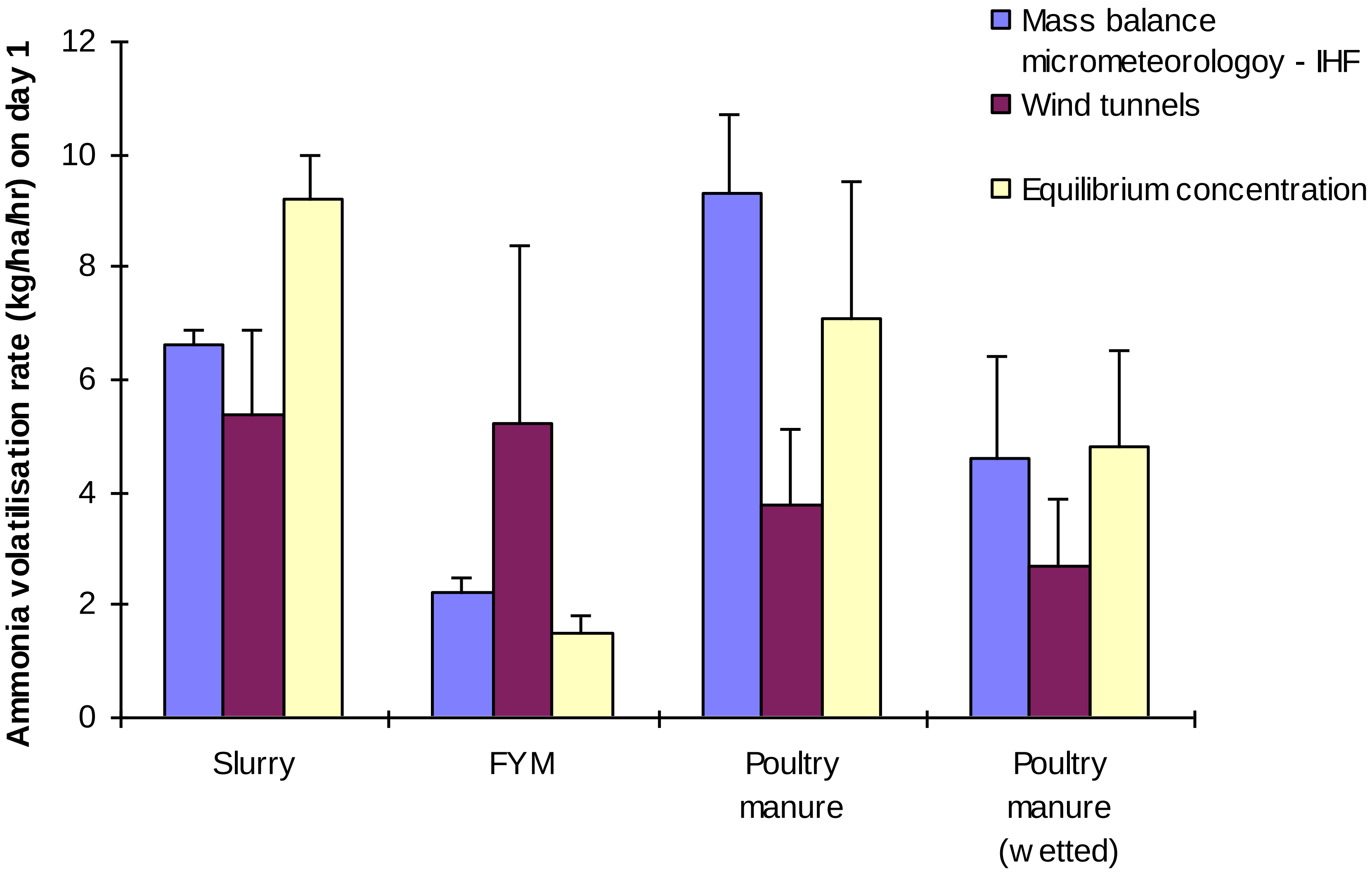
Circular manure-treated plot

3 replicate plots

4 experiments (different manure types)

Misselbrook et al 2005 Env Poll

Flux results – day 1

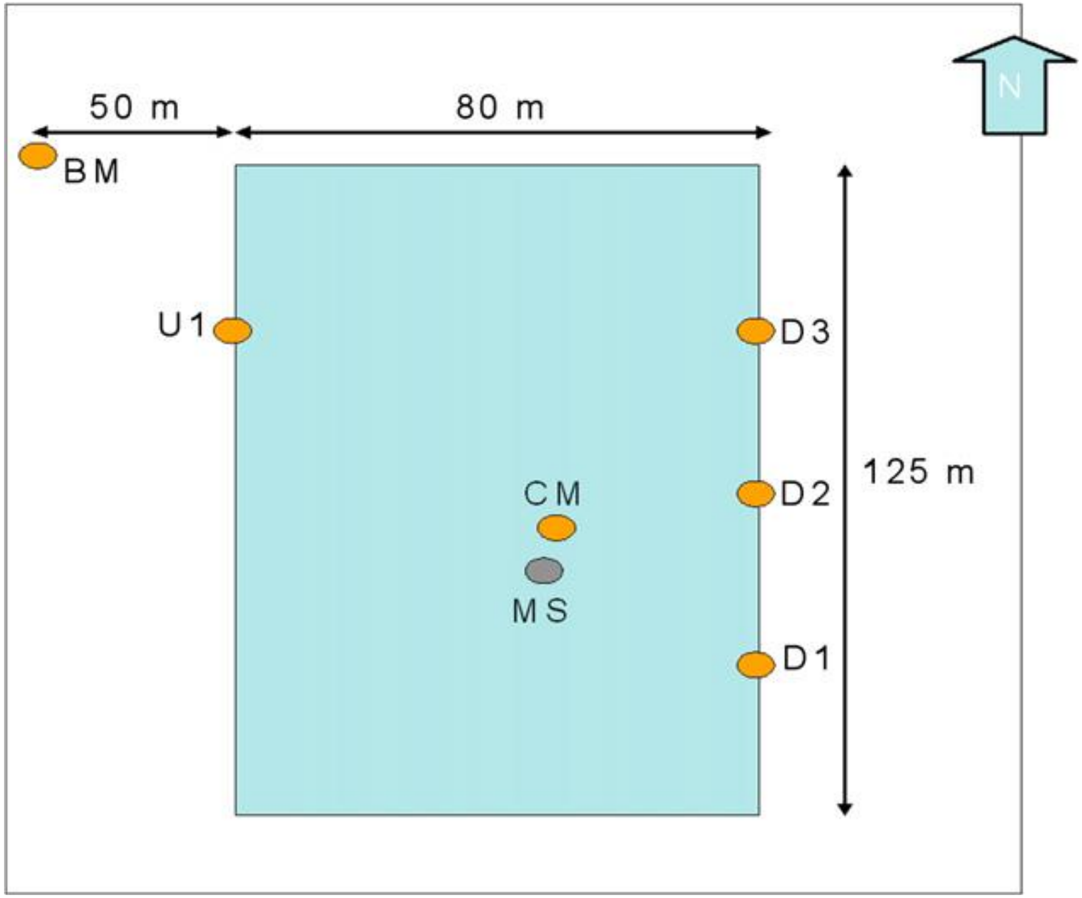


Coefficients of variation (%) in measured emission rates

Technique	Cattle slurry	Cattle FYM	Poultry (dry)	Poultry (wet)
IHF	23	24	37	52
Wind tunnels	46	84	74	61
ECT *	30	37	39	36

* many missing data

IHF vs bLS



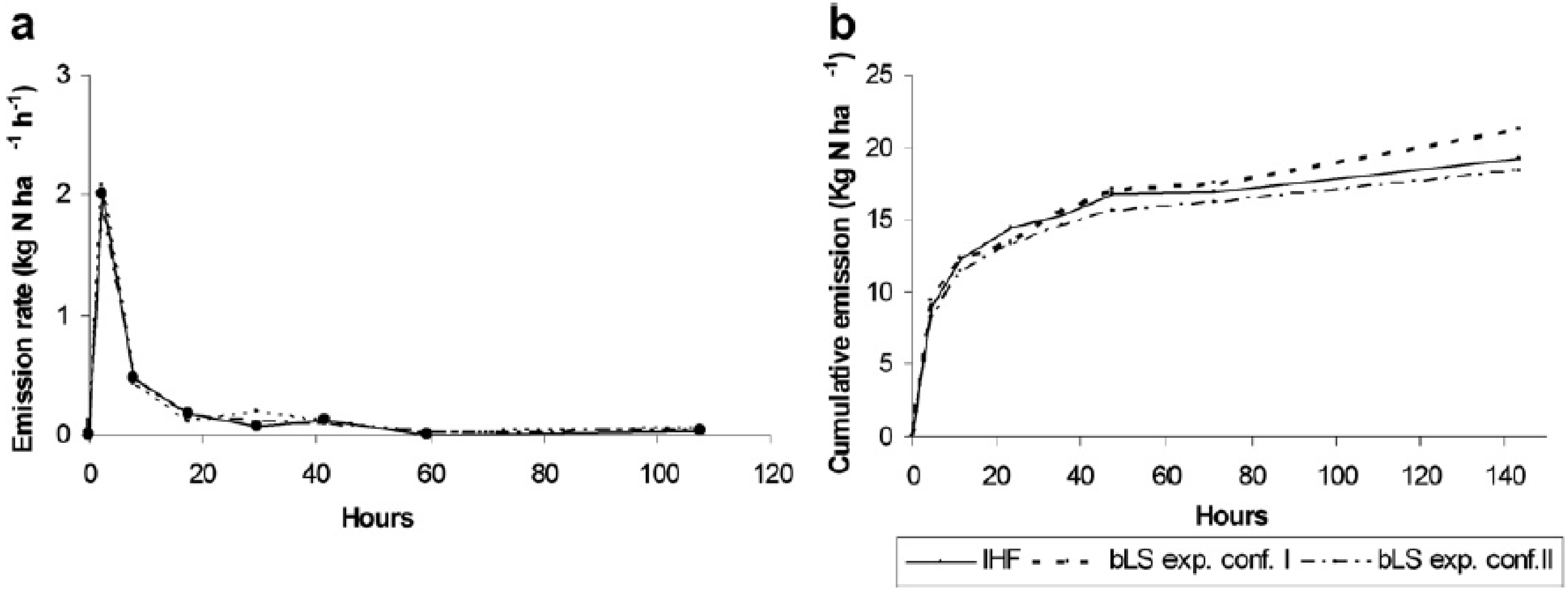
Pig slurry to bare soil

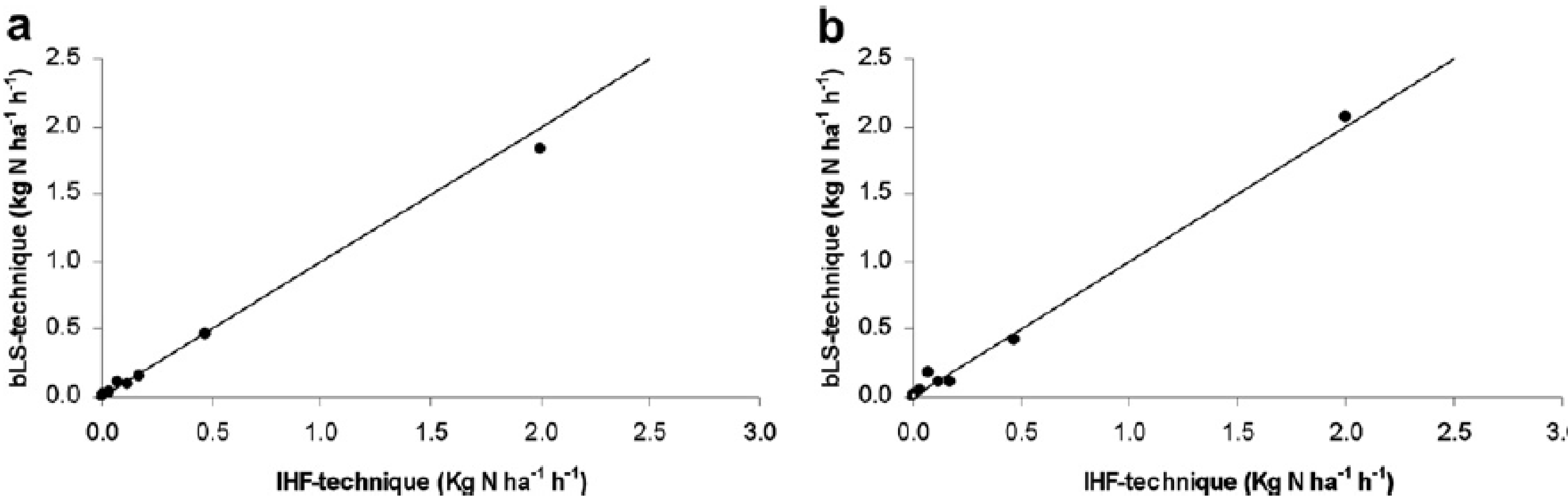
1 central and 1 background mast (5 shuttles) for IHF

Upwind and downwind masts for bLS (1 shuttle)

Sanz et al 2010 Atmos Env

IHF vs bLS – Results





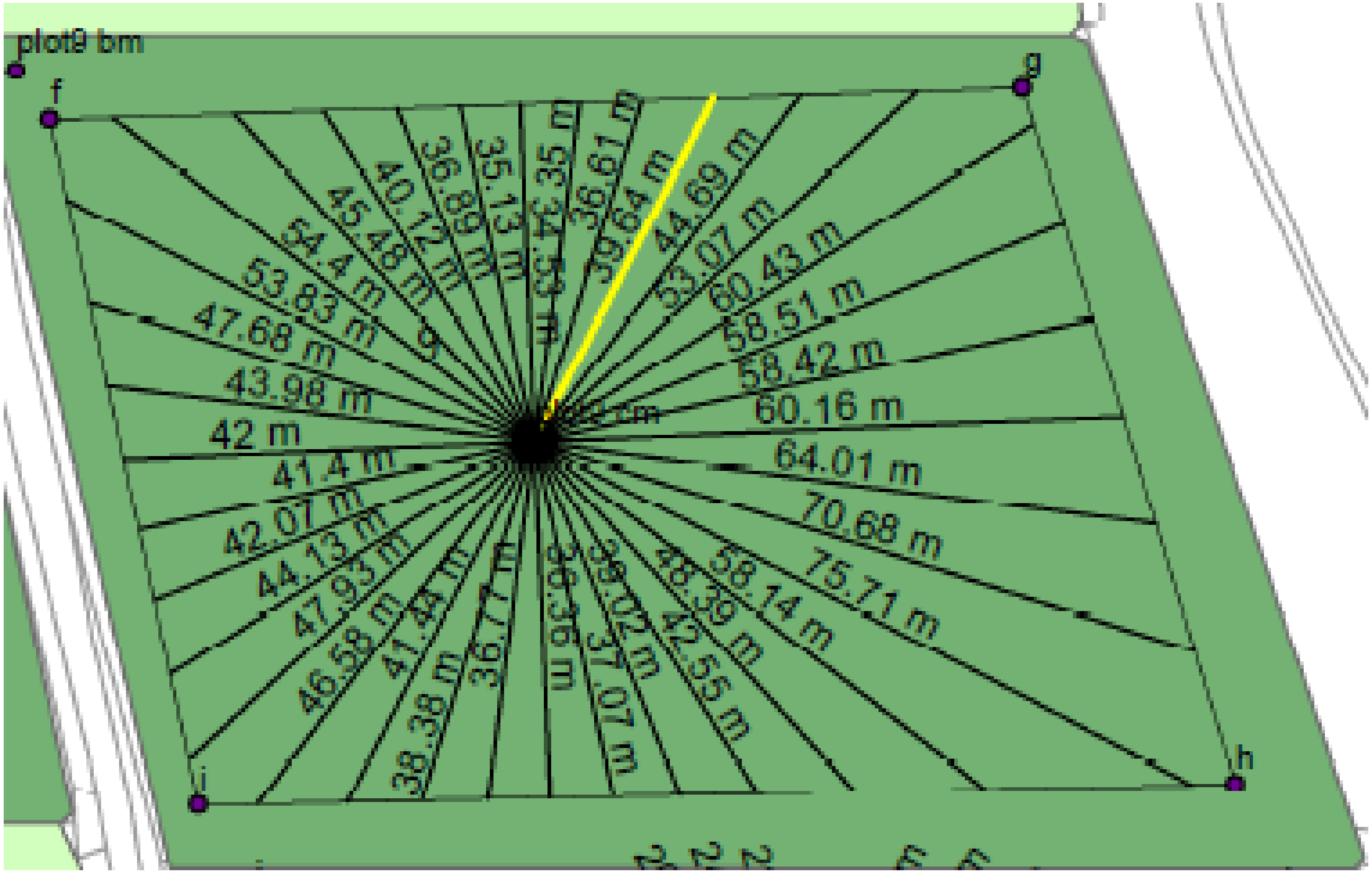
IHF Mass Balance Method – plot design

Flux from treated area = $(IHF_{dw} - IHF_{uw}) / x$

Circular plot – mast at centre

x = radius of plot; typically 20-25 m

IHF Mass Balance Method – plot design



Rectangular plot – e.g. 40 x 40m, 100 x 100m

x will vary according to wind direction

IHF Mass Balance Method – plot design

Sampler heights

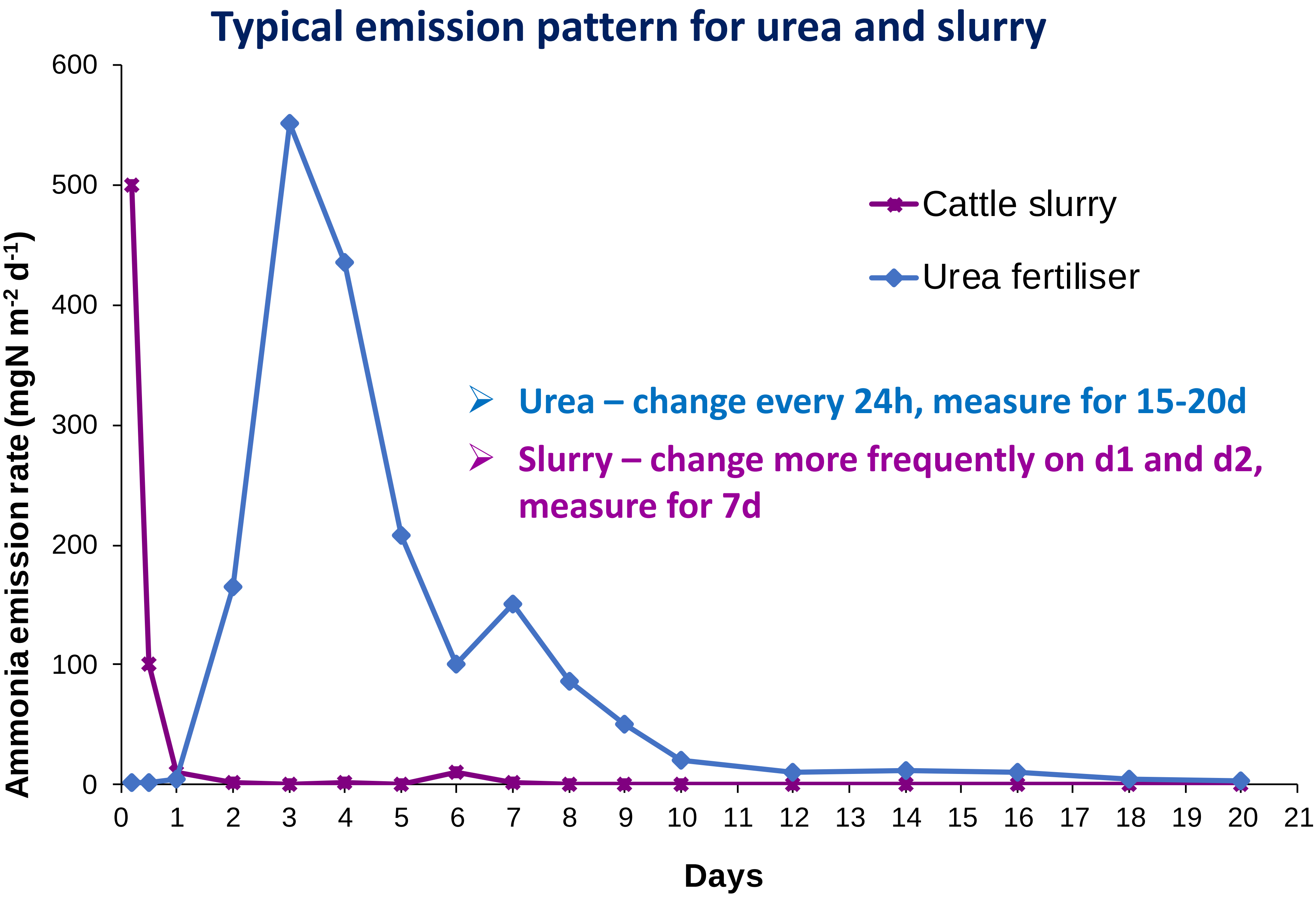
Maximum – c. 0.1 x fetch length

Closer spacing towards bottom

e.g.:

0.25, 0.5, 1.0, 2.0, 3.0 m

IHF Mass Balance Method – sampling periods



- **Urea – change every 24h, measure for 15-20d**
- **Slurry – change more frequently on d1 and d2, measure for 7d**

Flux calculation – Leuning passive flux samplers (shuttles)

Flux from treated area = $(IHF_{dw} - IHF_{uw}) / x$

Horizontal flux at each sampling height:

$F = M/At$

- M is mass of NH3-N collected in shuttle
- A is effective cross-sectional area of sampler (derived from calibration by Leuning)
- t is duration of sampling period

➢ **Integrate over all sampling heights for upwind and downwind masts**

Leuning et al 1985 Atmos Env

Measuring emissions from livestock housing

1. Mechanically ventilated – e.g. pig and poultry housing

Concentration at ventilation outlet x ventilation rate

e.g. acid absorption flasks

Measure 8 – 12 times (24-48h) over the production cycle

Measuring emissions from livestock housing

2. Naturally ventilated – e.g. cattle housing

Use passive flux samplers – Ferm tubes

Representative sampling from each side and roof openings

Measure 8 – 12 times (24-48h) over the production cycle


www.riverford.co

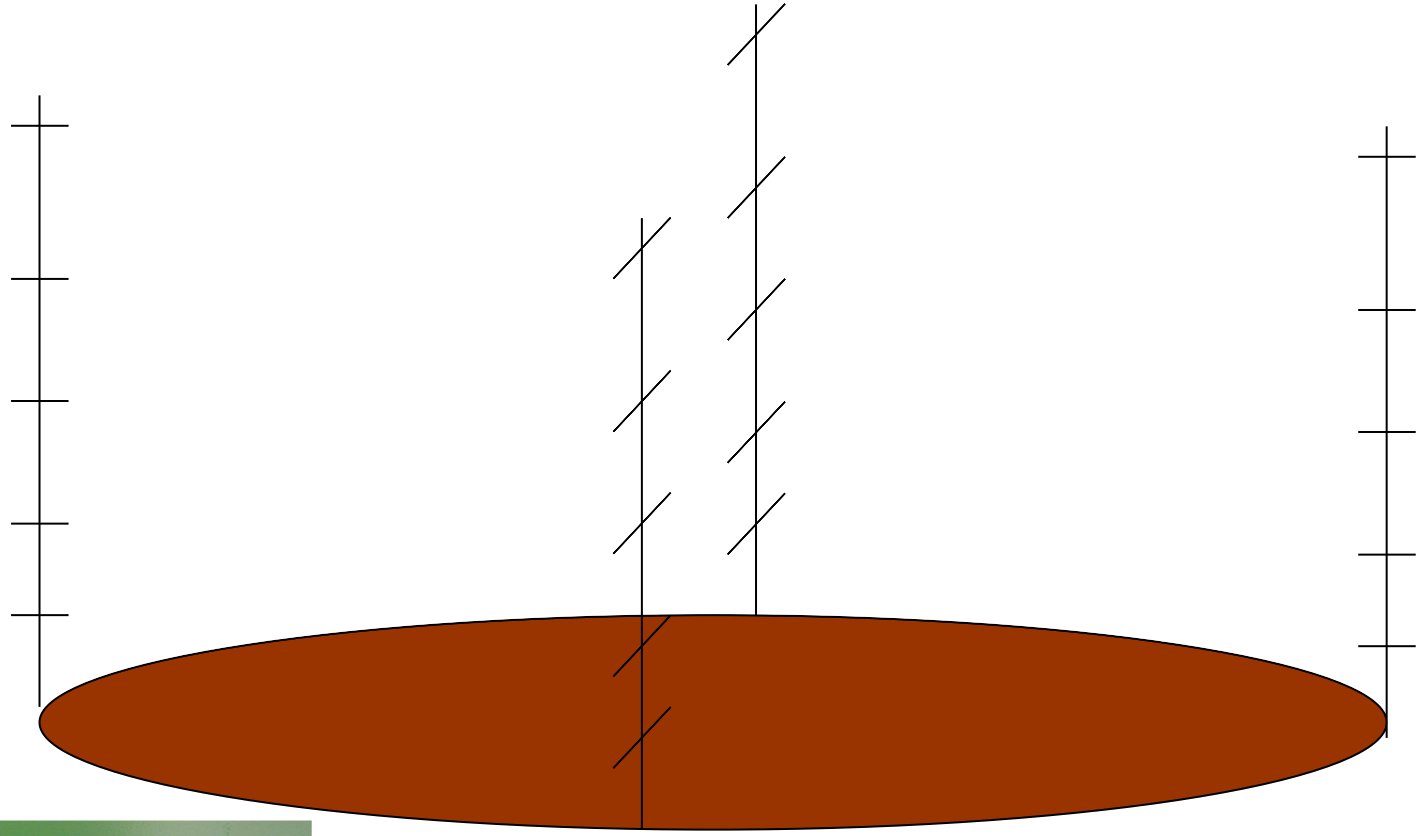
Measuring emissions from manure storage

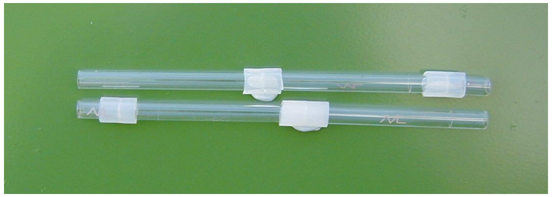
Pilot-scale storage facility

- 1 m^3 tanks with adapted ventilated lids
- Continuous ammonia concentration measurements – e.g. Los Gatos analyser
- Intermittent concentration measurements – absorption flasks
- Good for *comparative* studies

Pilot-scale manure storage - bunkers

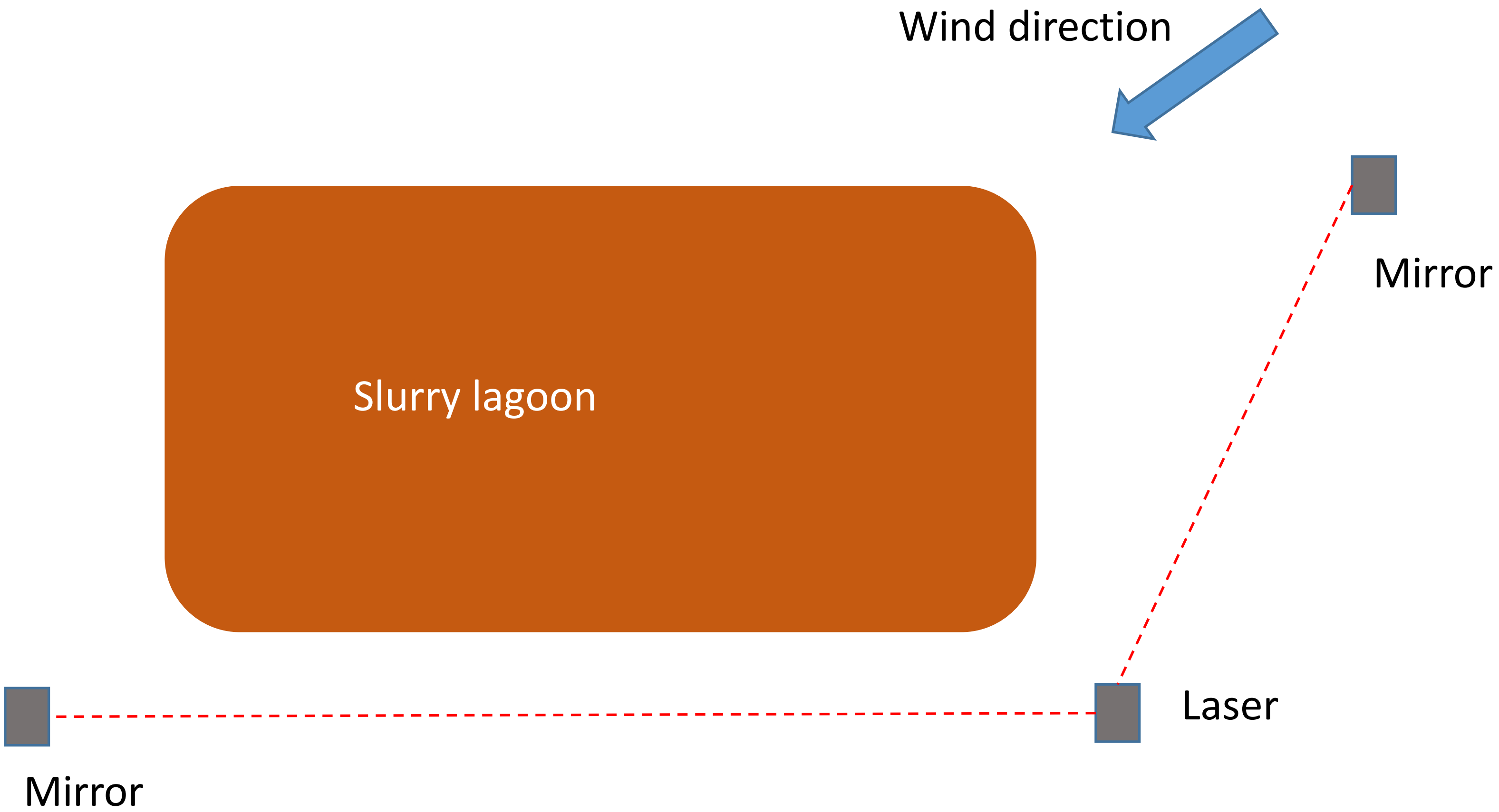
Perimeter profile method





- Passive flux sampler (Ferm tubes) mounted at heights on 4 masts around the store
- Integrated net flux from store at each mast

Backward Lagrangian Stochastic method



- Line-averaged background and downwind concentrations
- Ideally no upwind sources or obstructions

Questions?

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