

Direct, Fast Response
Measurements of Gas-Phase
Ammonia at a Swine
Production Facility

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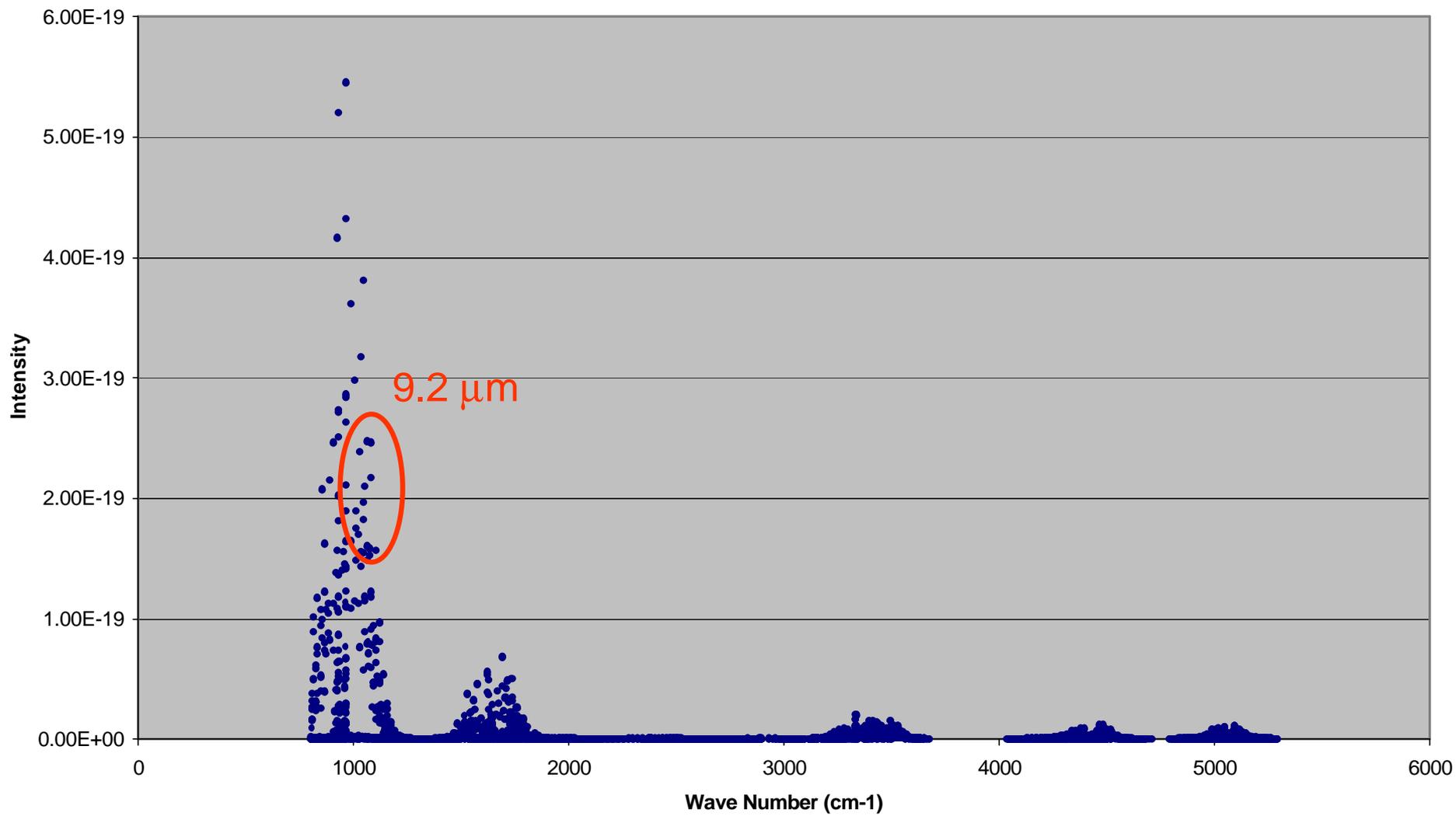
Why Measure Atmospheric Ammonia?

- Only significant basic gas in the atmosphere
- Highly soluble, forms sulfate and nitrate particles, cloud condensation nuclei
- Gas-phase ammonia may regulate ultra-fine particle growth
- Ammonium-containing particles scatter light more efficiently than sulfuric acid
- Light scattering by particles influences the global radiation budget - climate change

Photothermal Interferometry

- Ammonia absorbs CO₂ laser light at 9.22 μm, heating sampled air.
- A very sensitive interferometer detects the phase shift caused by this heating.
- Advantages of the photothermal technique:
 - NH₃ measured directly in the gas phase
 - Sensitive – 250 ppt in 1 second
 - Fast (seconds) time response
 - Not too big or expensive

Ammonia Absorption Intensities



Photothermal Interferometer Schematic Diagram

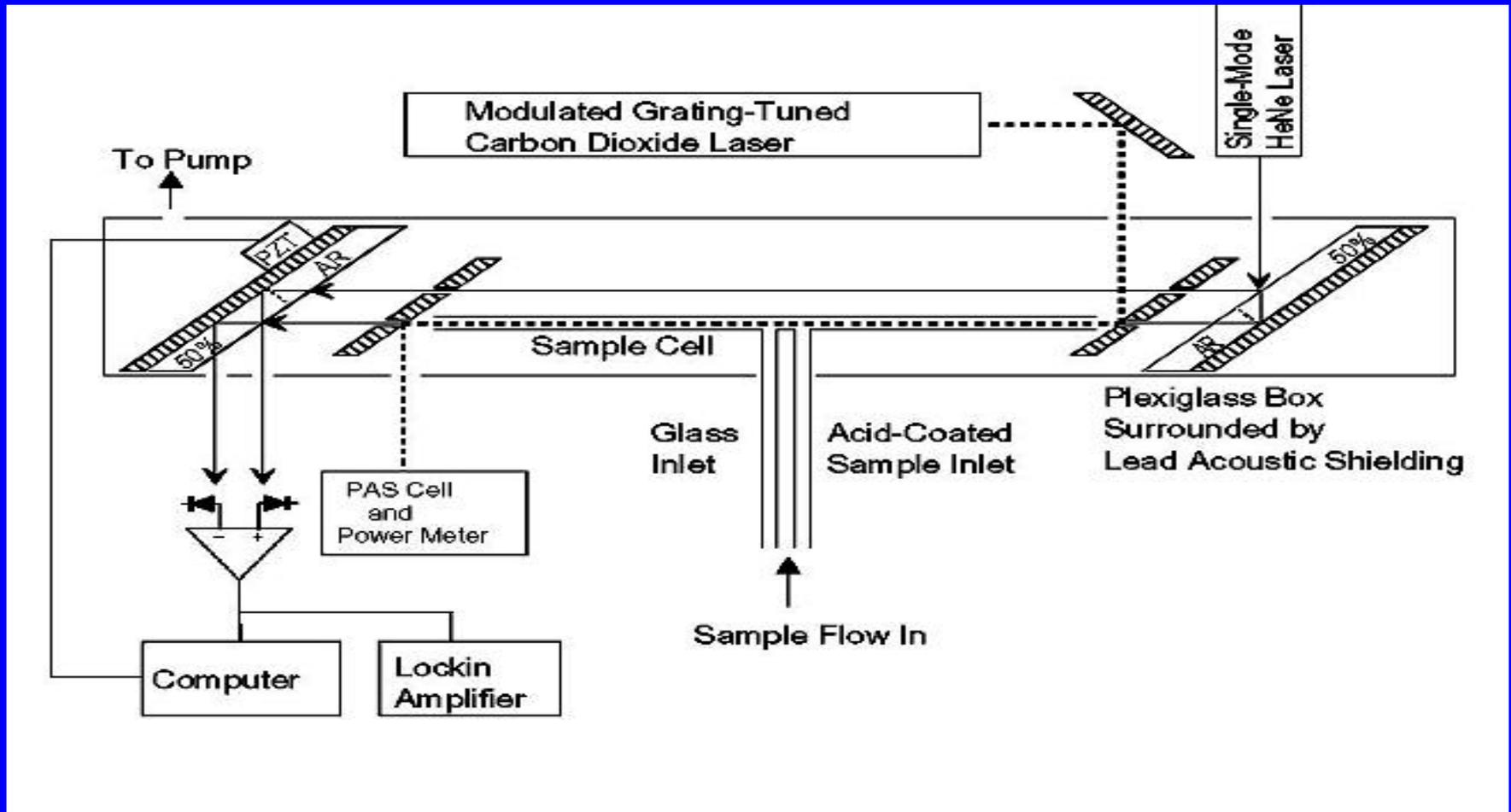
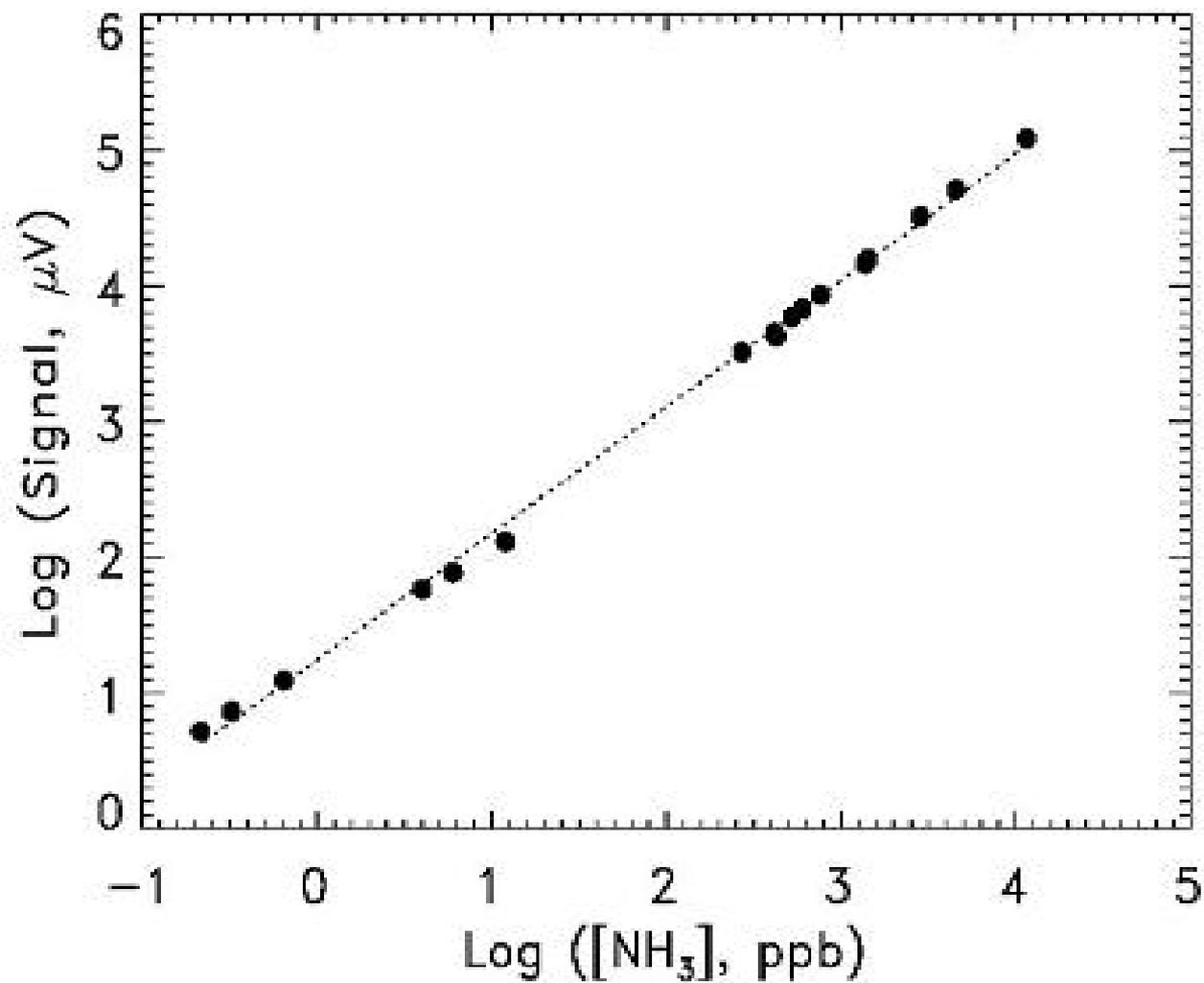
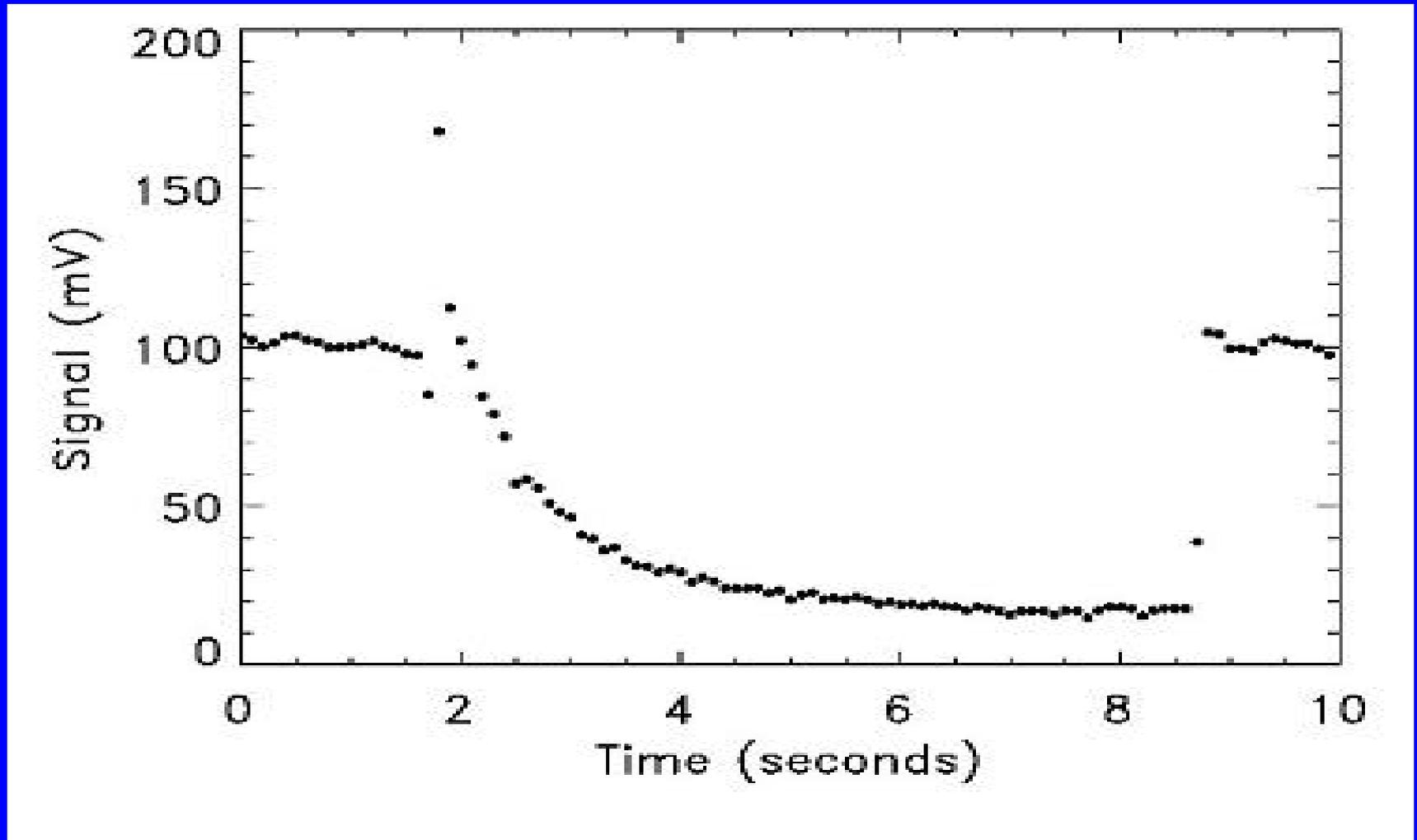


Figure 3: Linear Dynamic Range:
Log Plot of Signal vs $[\text{NH}_3]$



Detector Response to a Step Change in Ammonia Concentration of 6.7 ppm



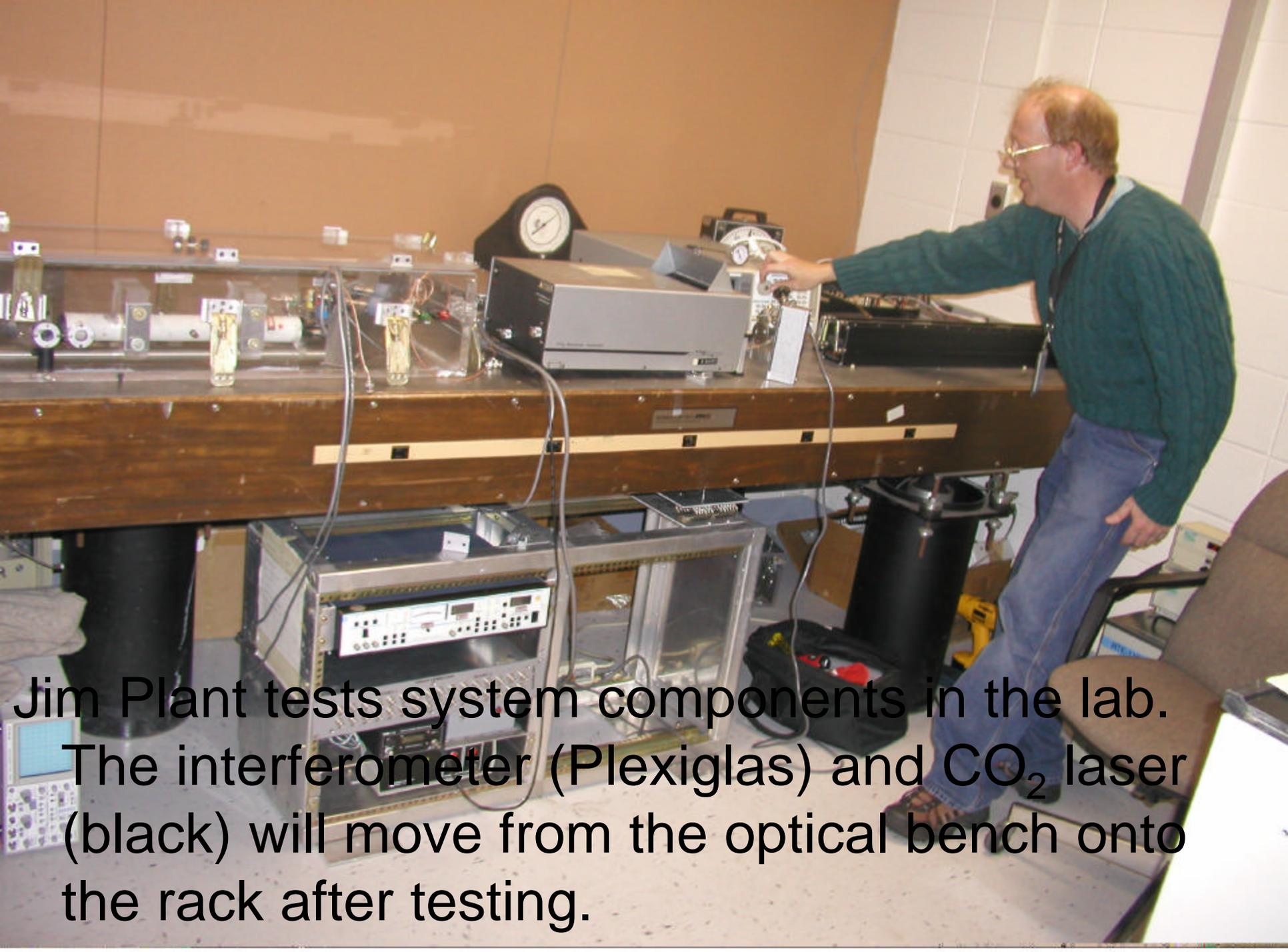
More Reasons to Measure Ammonia

- Ammonia emissions from animal husbandry are the largest anthropogenic source.
- Ammonia emissions from hog and chicken farms are poorly characterized.
- NRC report states these emissions may have an impact on global, regional and local scales.
- Agricultural scientists may be able to develop better practices given more and better information.
- Interagency cooperation – addresses a NASA goal of quantifying human impact on climate and a USDA goal of developing sustainable agricultural practices.

Ammonia Measurements at the Wye River Institute, Eastern Shore, MD



Measured diurnal variation of $[\text{NH}_3]$ (fertilized fields) in summer: 25 ppb (night) vs 7 ppb (after sunrise)



Jim Plant tests system components in the lab. The interferometer (Plexiglas) and CO₂ laser (black) will move from the optical bench onto the rack after testing.

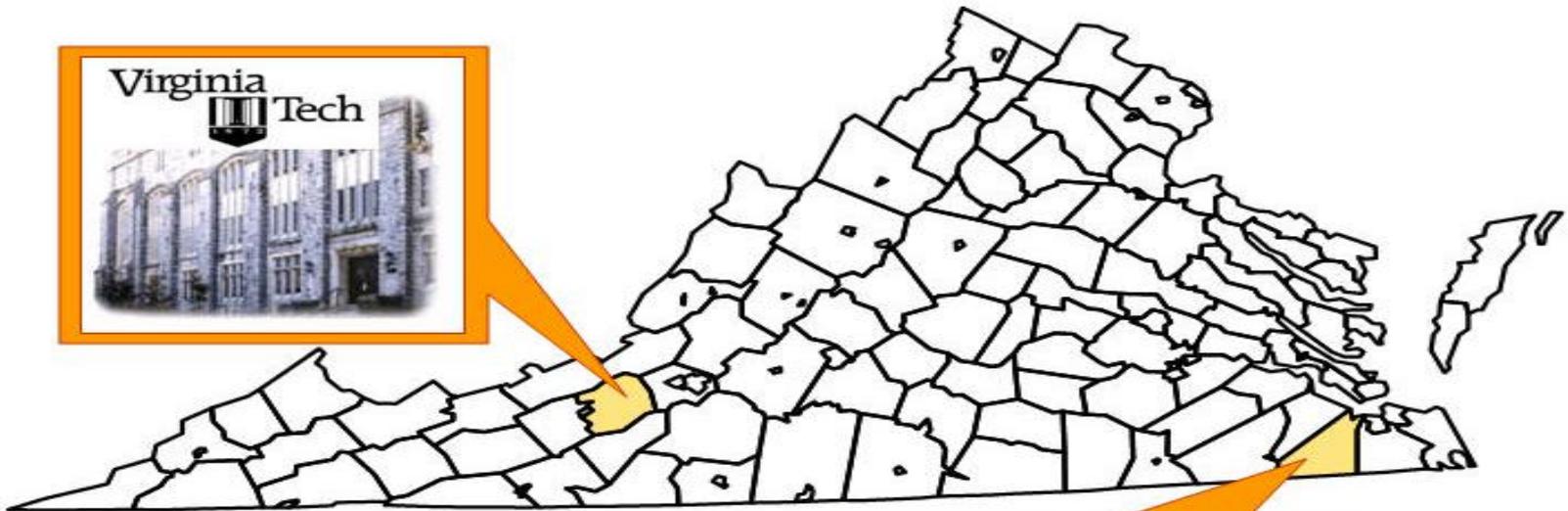
Progress Report:

- Purchase authority and lab obtained.
- Calibration system built and ready.
- CO₂ laser checked out and working.
- Interferometer checked out and working.
- Jeff Stehr from the UMD hired.
- About half of the needed equipment ordered.

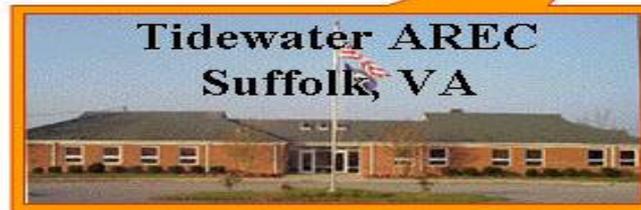
To work on Next:

- Experiment further with modulated signal zeroing techniques - Stark and Zeeman tuning, FM signal modulation.
- Engineering improvements - fiber beam delivery and CO₂ laser stabilization.
- Calibrate rack-mounted instrument in lab.
- Plan field segment of measurements, including Tidewater AREC site visit.
- Decide on data acquisition system.
- Plan/order meteorological sampling equipment.

Field Experiment Planning



VIRGINIA



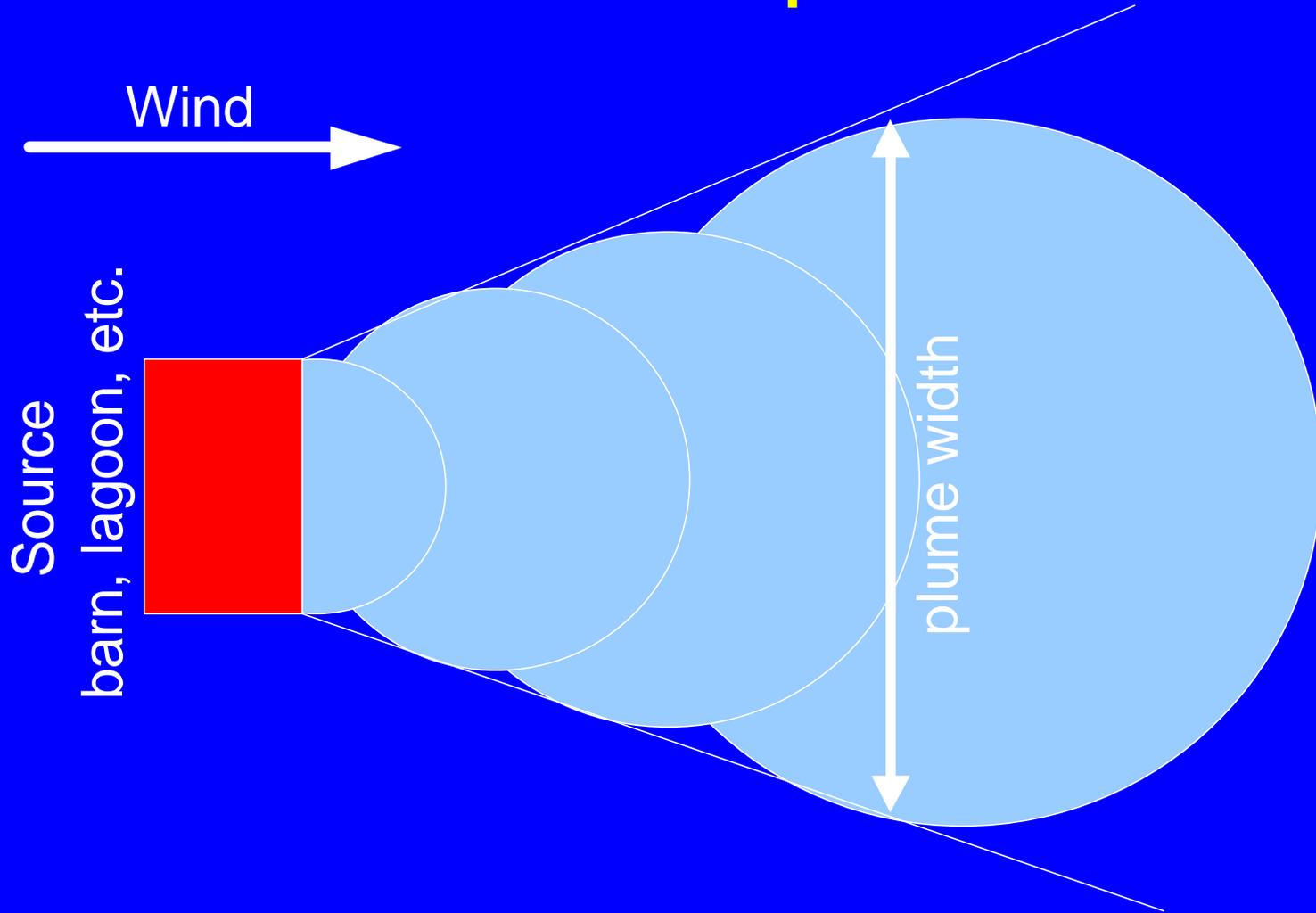
Swine Production Facility at Tidewater AREC



Sampling Strategy

- Using a Gaussian plume model
- Sample at several points within the plume
- Knowing wind speed and ammonia concentration across a cross-section of the plume gives the flux of ammonia from the source

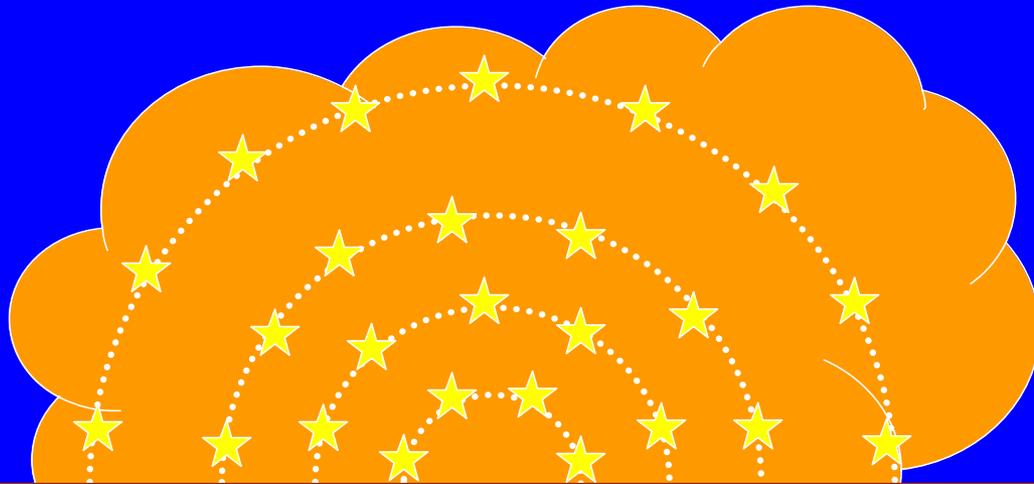
Conceptual layout of Gaussian plume



Measurements through the heart of the plume determine the concentration across the plume



The actual sampling scheme
is a little more complex, to
better sample the plume



Summary

- Making progress on year 1, instrument development, but there have been some significant delays.
- Need to finish putting instrument together and testing for the field.
- Will meet with Tidewater AREC faculty to plan field experiment.
- Field experiment to begin in about 6 months.