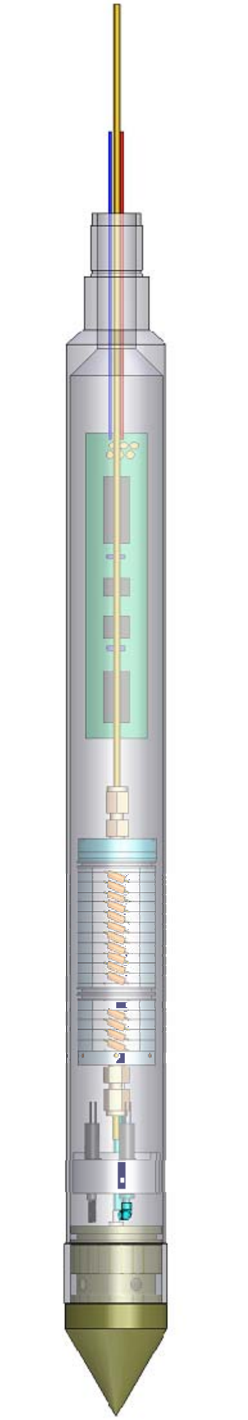
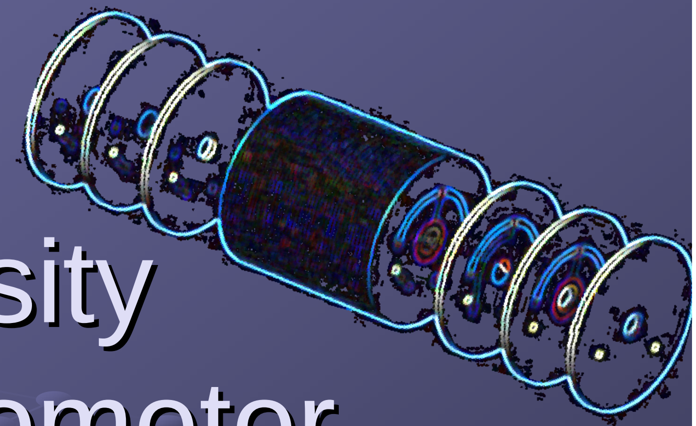




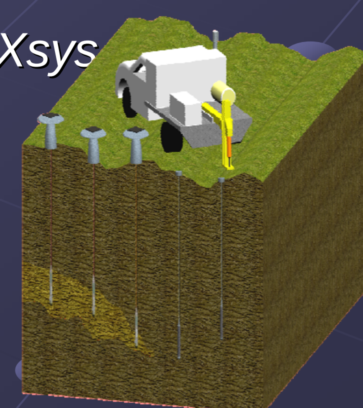
Boise State University Ion Mobility Spectrometer (IMS) Sensor Project

PIs: *Molly Gribb, Herb Hill (WSU), Jake Baker, Sin Ming Loo, Amy Moll*

Research Staff: *Robert Walters, Jerome Imonigie, Hong Feng (WSU), Abu Kanu (WSU), Don Plumlee, Dick Sevier*

Students: *Kevin Ryan, Jon Cole, Suren Eruvuru, Robert Youngberg, Kimberley Kaplan (WSU), Brian Jaques, Hope Weston*

Industrial partners: *Frank Riskey and Layne Simmons, TenXsys*



Environmental & Subsurface Science Symposium
Inland Northwest Research Alliance
Big Sky, Montana
Sept. 19-21, 2005

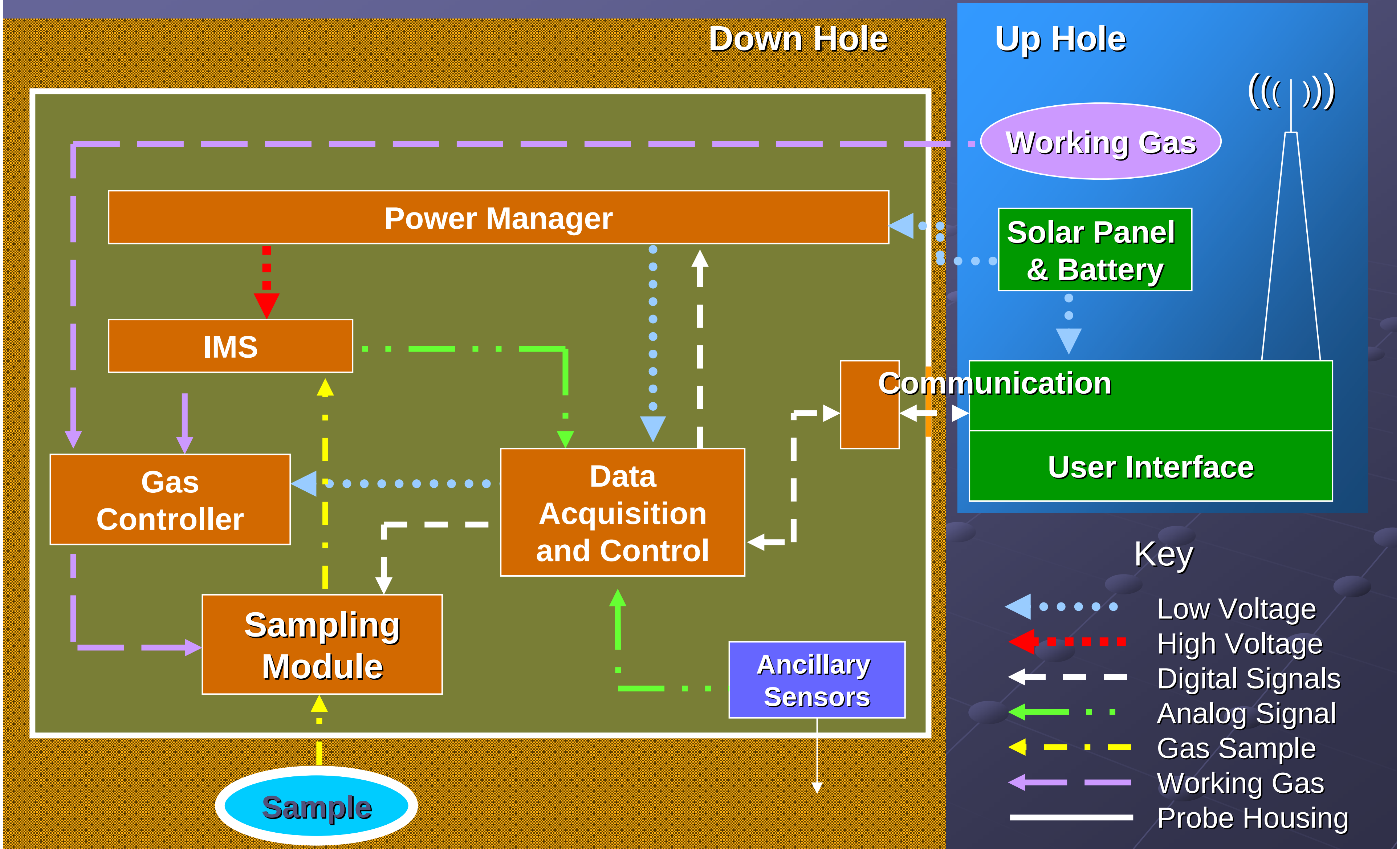
Overview of the IMS Sensor Project

The goal of this project is the development of a miniature, high resolution IMS sensor system for detecting gaseous volatile organic compounds in the vadose zone.

This sensor system will allow for in-situ measurement, unattended operation, and wireless or satellite transmission of data to the user via the Internet.

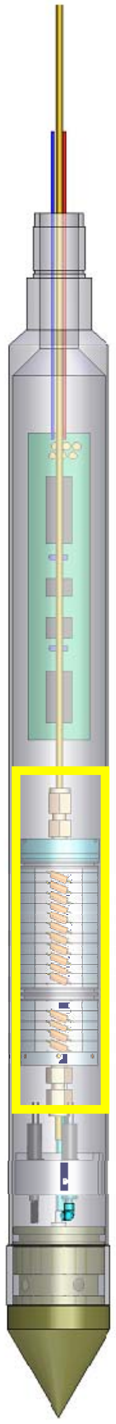
Can be used individually for characterization or in arrays for long-term monitoring of contaminated sites.

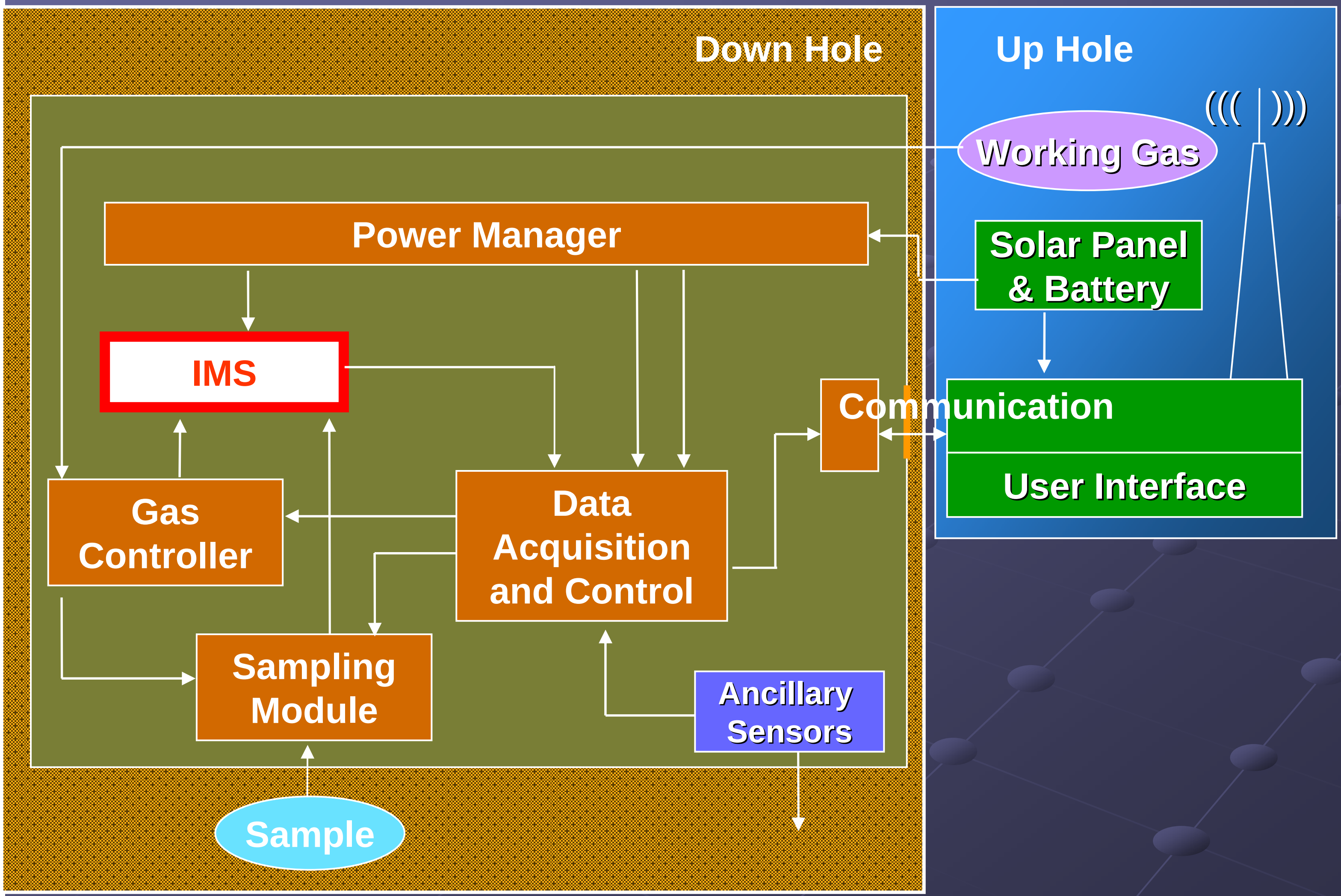
Block Diagram of the BSU IMS Sensor System



Probe Deployment

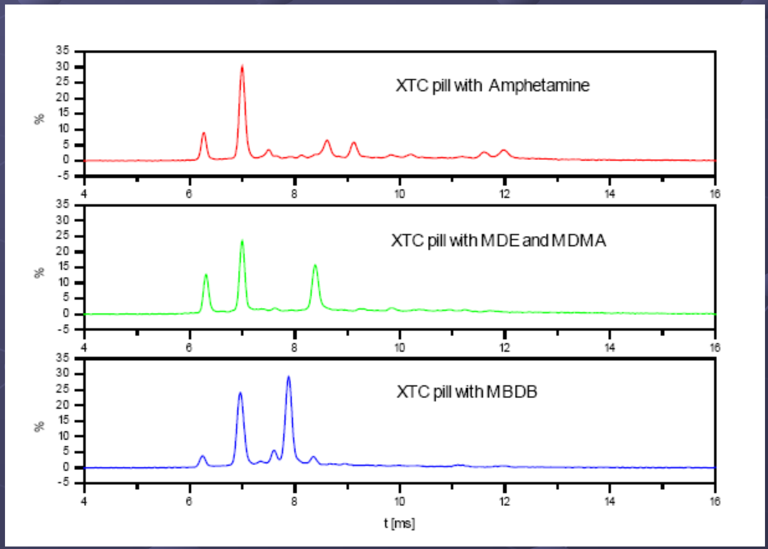
The IMS Sensor





IMS is Used for Rapid Analysis of

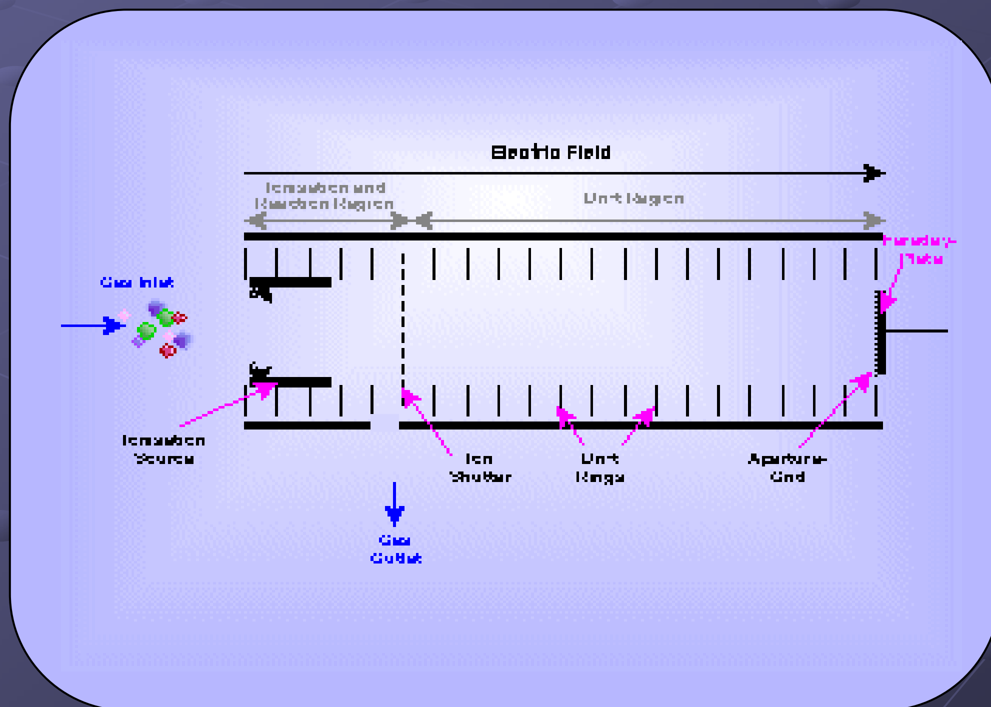
- Chemical warfare agents
- Narcotics
- Explosives
- Amino acids, peptides, etc.
- Pesticides



How an IMS works:

- A gaseous sample is introduced to the IMS reaction region, where it is ionized.
- The ion gate is activated to allow the ionized species into the drift tube.
- In the presence of an electric field and a counter-flowing drift gas, the ionized species travel through the drift tube toward the detector.
- The various ionized species separate due to charge and size differences, arriving at the detector at different times.

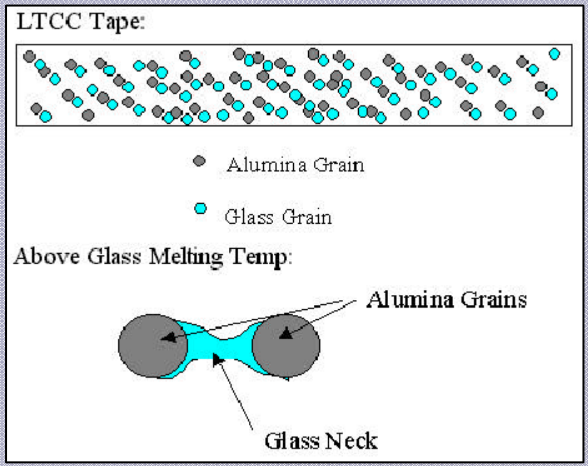
- As each ion discharges on the detector, a small current is generated.
- The measurement of this current over time yields a spectrum which is then used to identify and quantify the analytes in the sample.



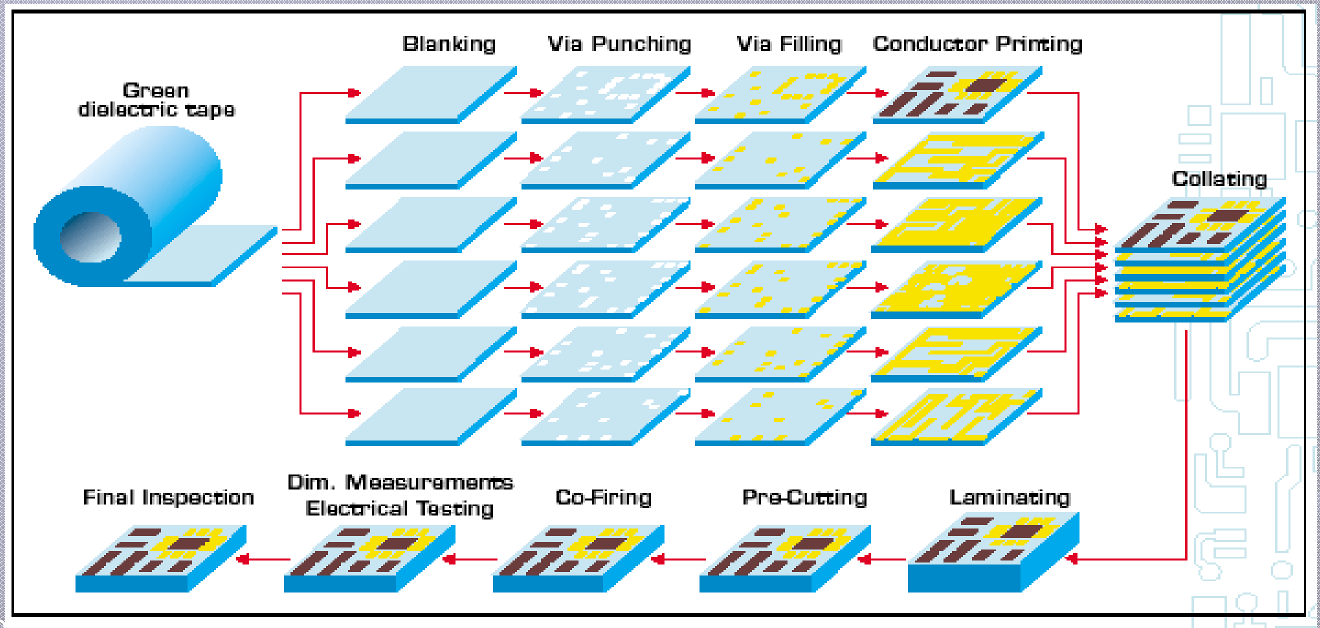
Parallel Paths of IMS Sensor Development

- Low Temperature Co-fired Ceramic (LTCC)
- Macor (Machinable Ceramic Material)

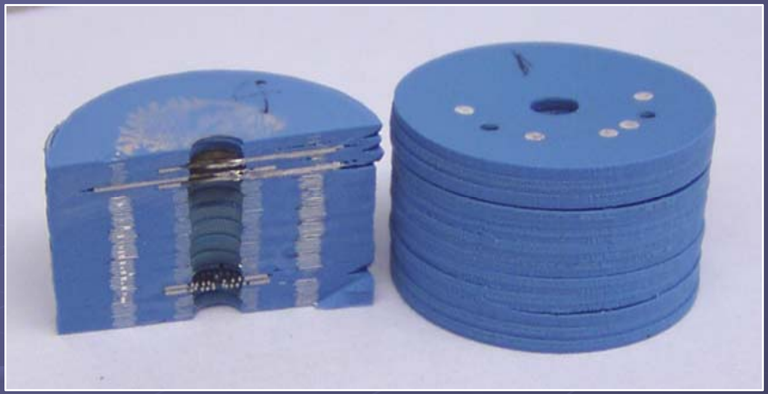
What is LTCC?



- **<u>L</u>ow <u>T</u>emperature <u>C</u>o-Fired <u>C</u>eramics**
- **Layered Structure of glass and alumina**
- **Sinters at *Low Temperature* (< 900°C)**
- **Substrate and embedded elements are *Co-Fired* in one step.**

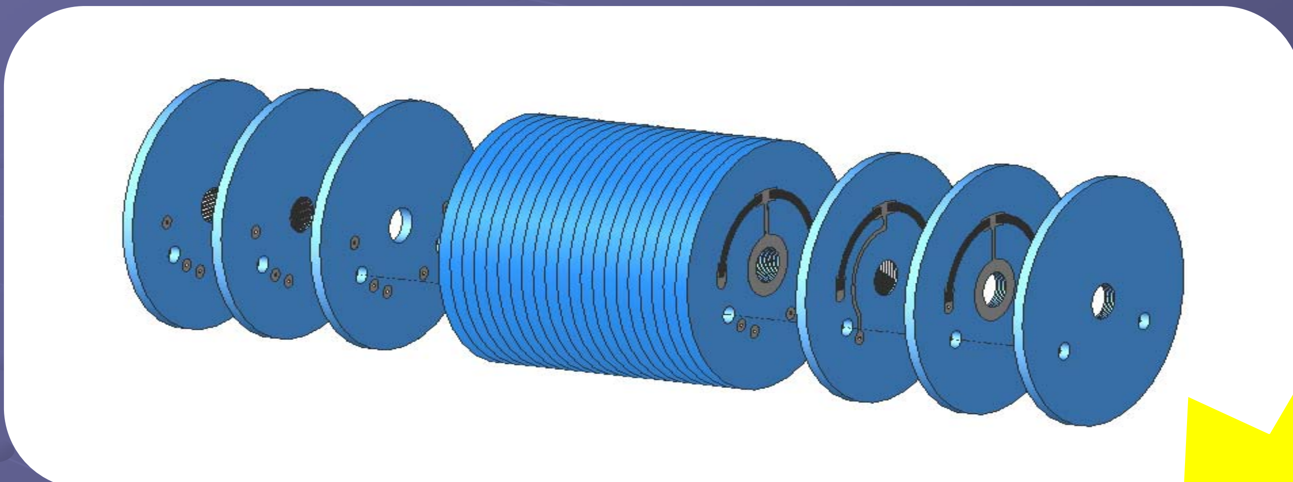


Why LTCC for this application?



- Closely-packed electrodes
  - ~ 50 electrodes/cm with circuitry printed on each layer
  - Provides very uniform electric field at ~500 V/cm
  - Reduces radial diffusion → higher resolution than typical IMS designs
- Integrated circuitry
- Robust and hermetically sealed

LTCC-IMS Test Article



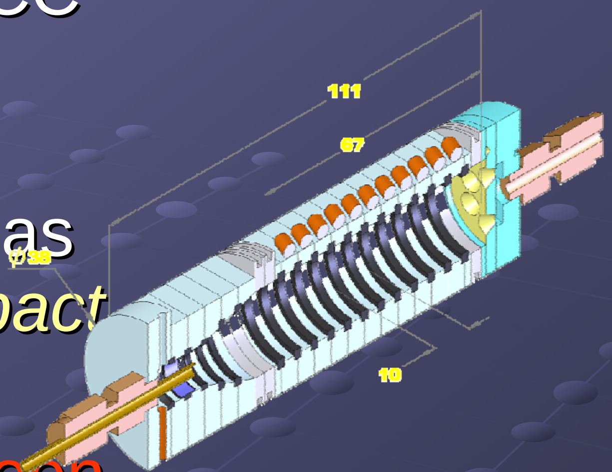
156 layers is the tallest known LTCC device

<u>Device Specifications:</u>

- **156 layers**
- **31.75 mm tall**
- **Full conductivity through all layers**
- **5 embedded metal ion gates**

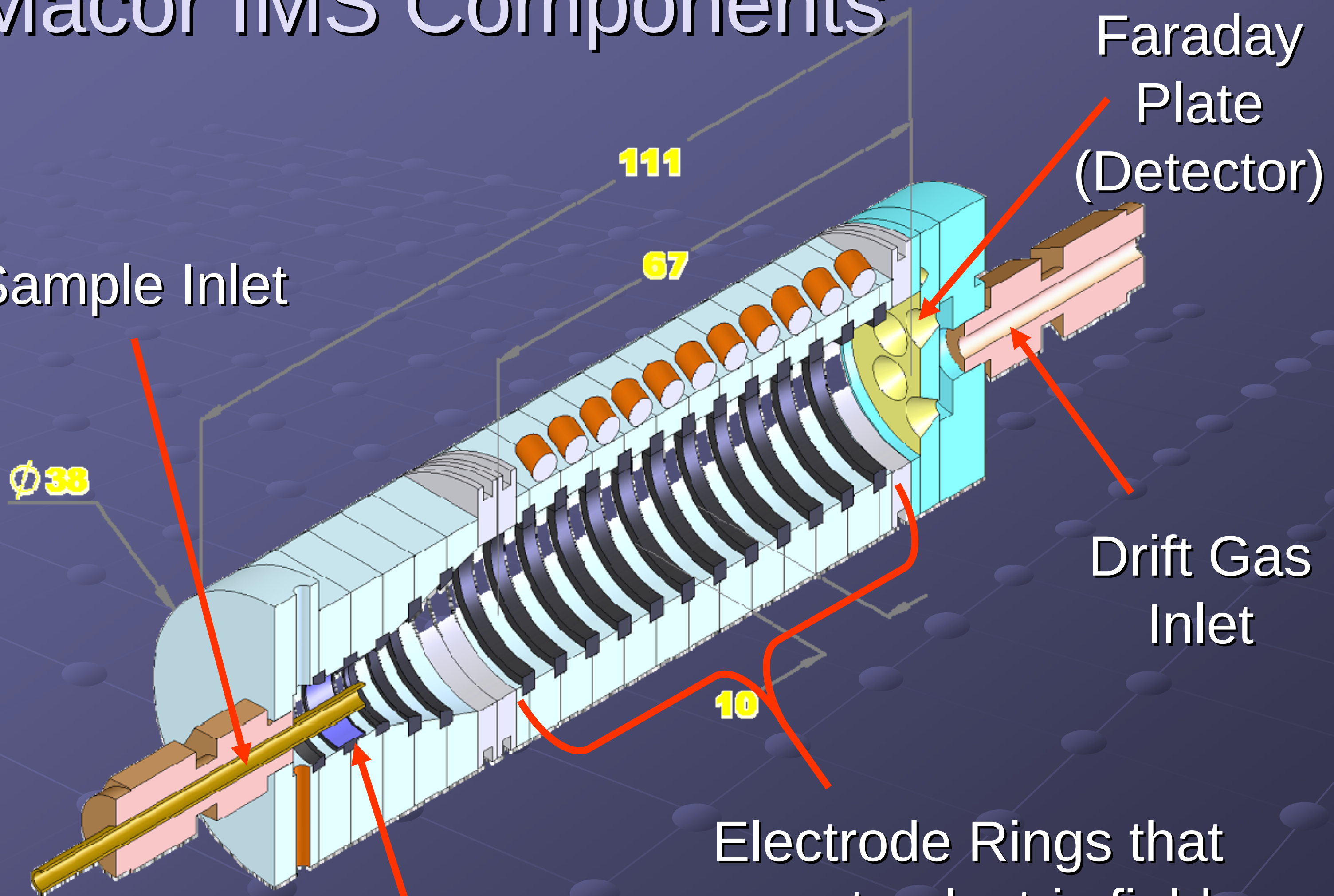
Macor IMS Path

- Electrode density ~ 1/10 that of LTCC IMS → *resolving power is reduced compared to LTCC device*
- Electrical components are discrete as opposed to integrated → *less compact than LTCC*, but…
- Complete Macor IMS sensor has been successfully fabricated
- Macor IMS has allowed us to verify other subsystems while LTCC design work continues

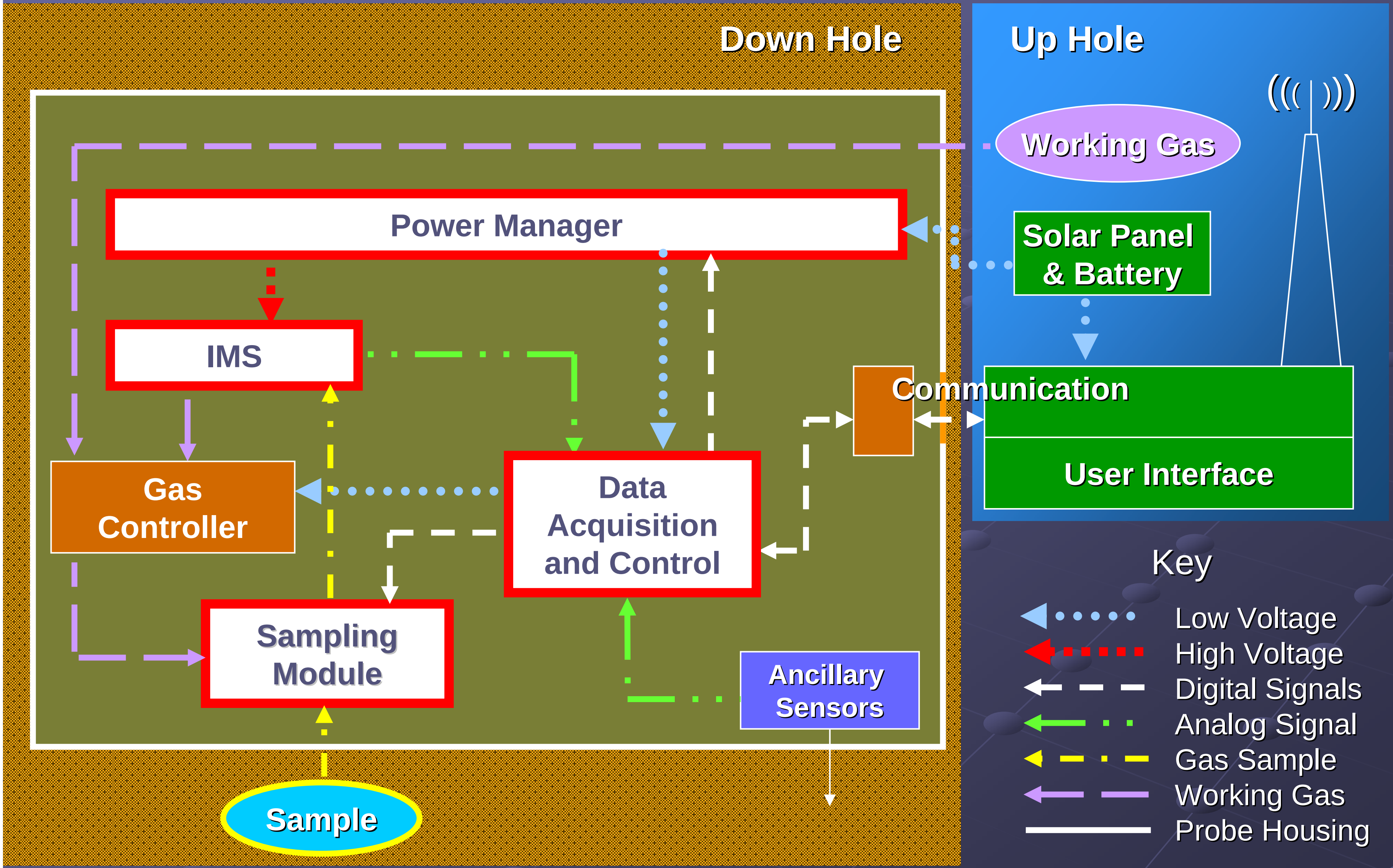


Experimental results shown here are for the Macor IMS

Macor IMS Components



Macor IMS Sensor System Lab Test



Prototype Testing Methodology

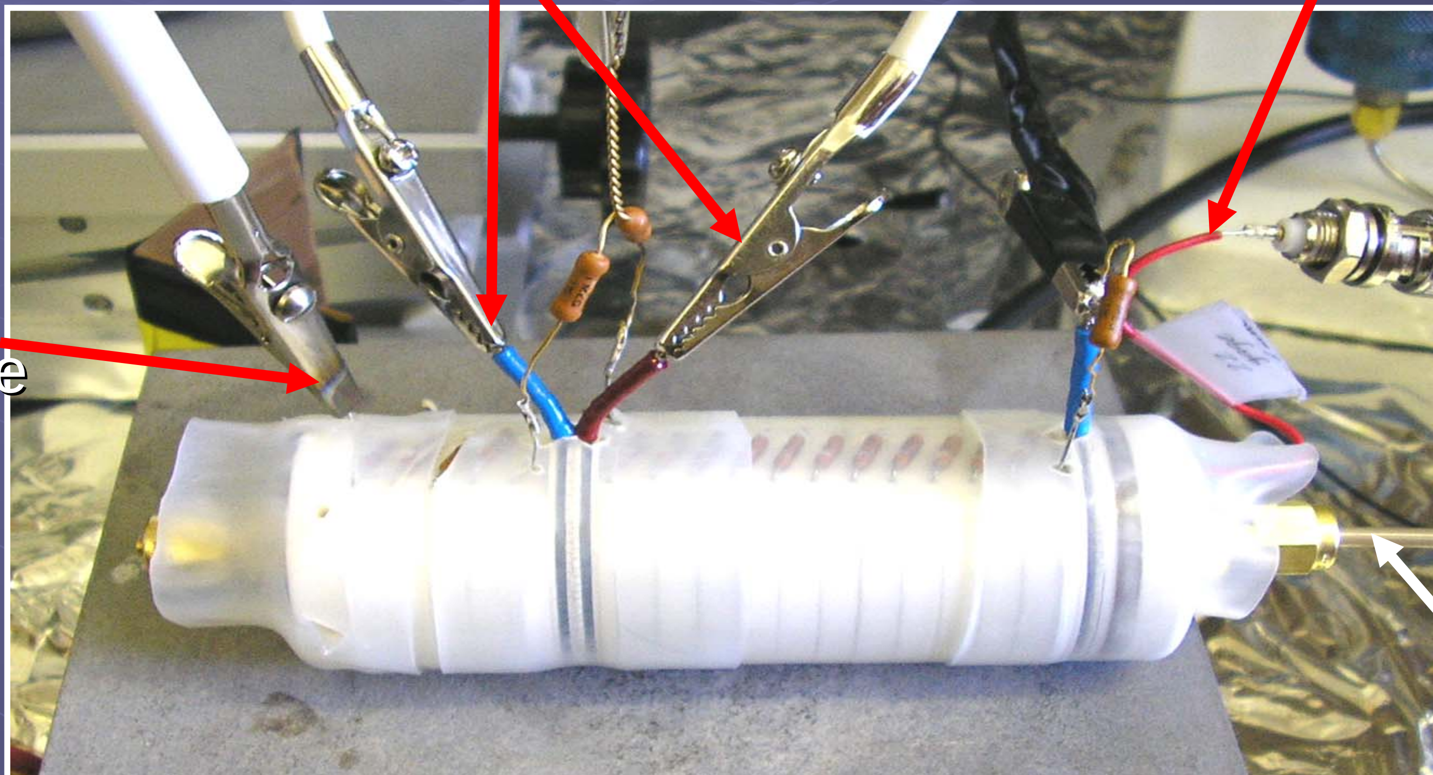
- Test Various Components
  - Macor IMS and Sampling Module
  - Our High Voltage Power Supply vs. Lab Supply
  - Our Preamplifier vs. Lab Preamplifier
- Test System
  - Macor IMS + Sampling Module + Data Acquisition System vs. Lab Data Acquisition System

Macor IMS Test Setup

Ion Gate Control

Faraday plate output (detector)

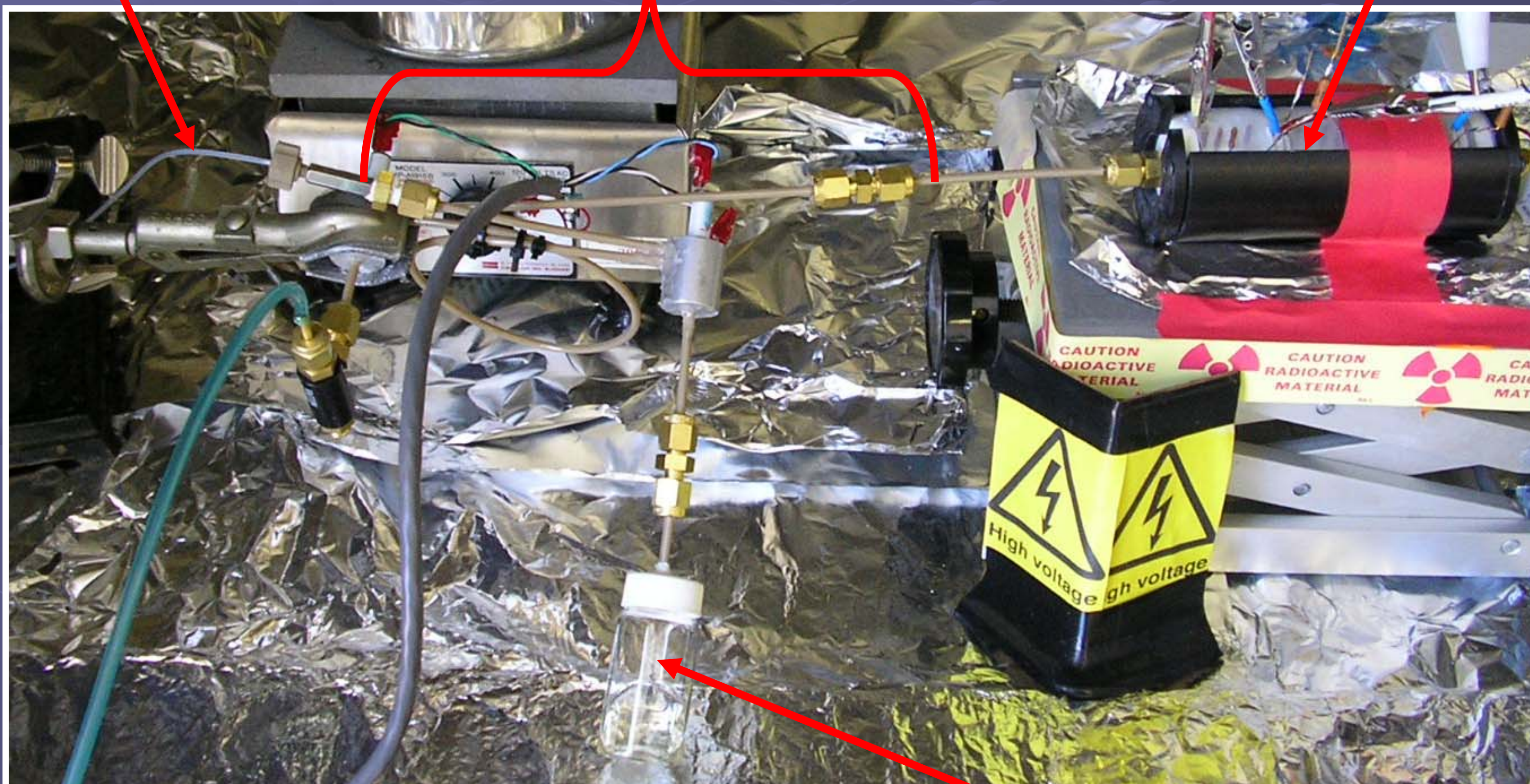
High Voltage In



Drift gas in

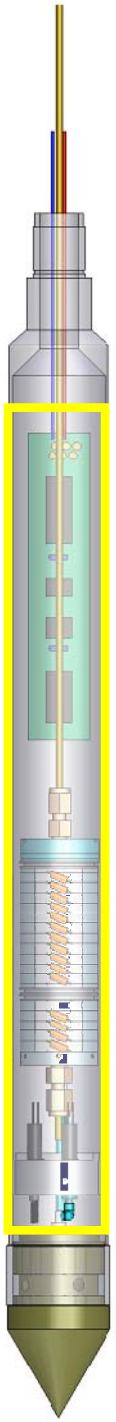
Macor IMS + Sampling Module Testing

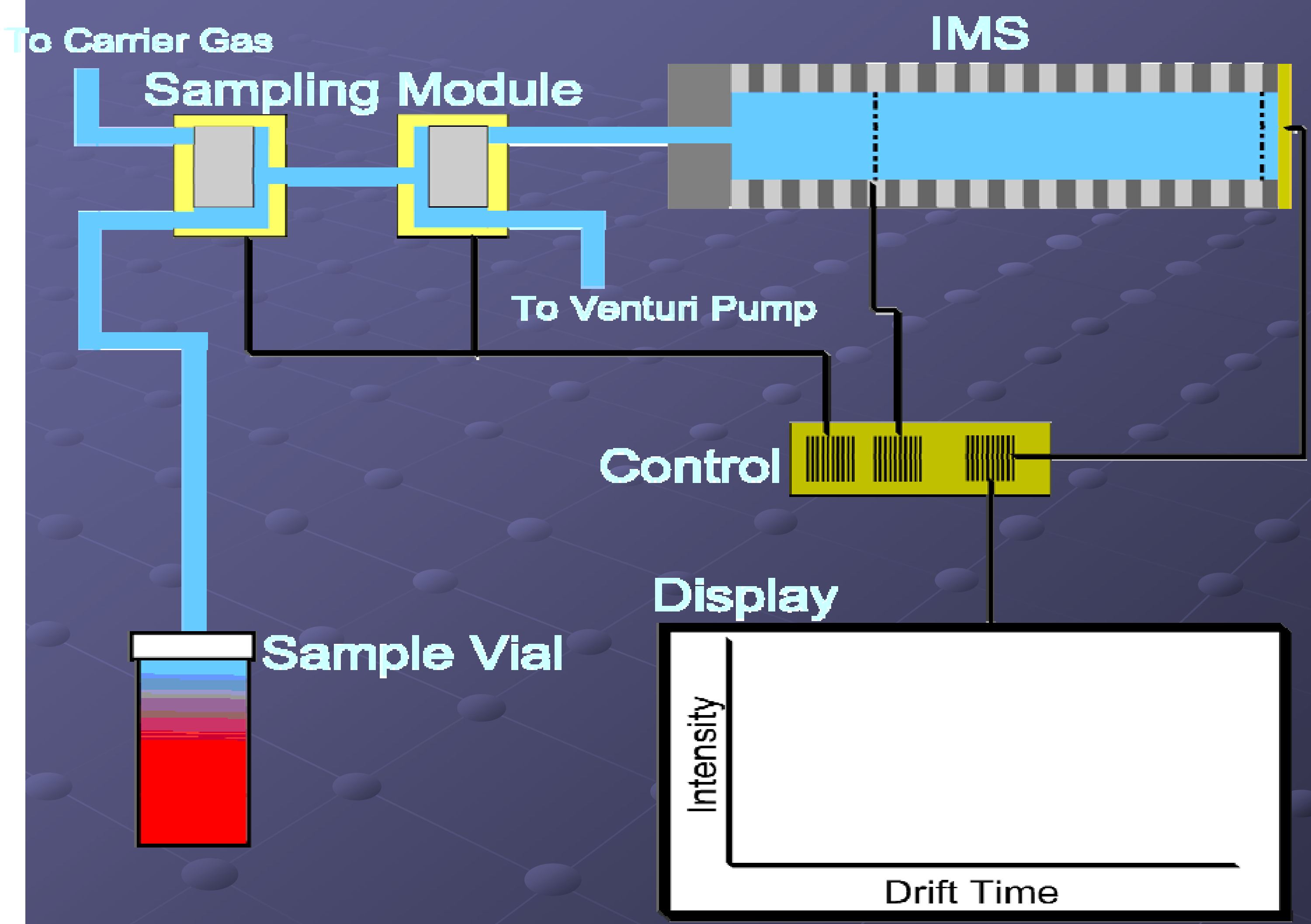
Carrier Gas In **Sampling Module** **Macor IMS**



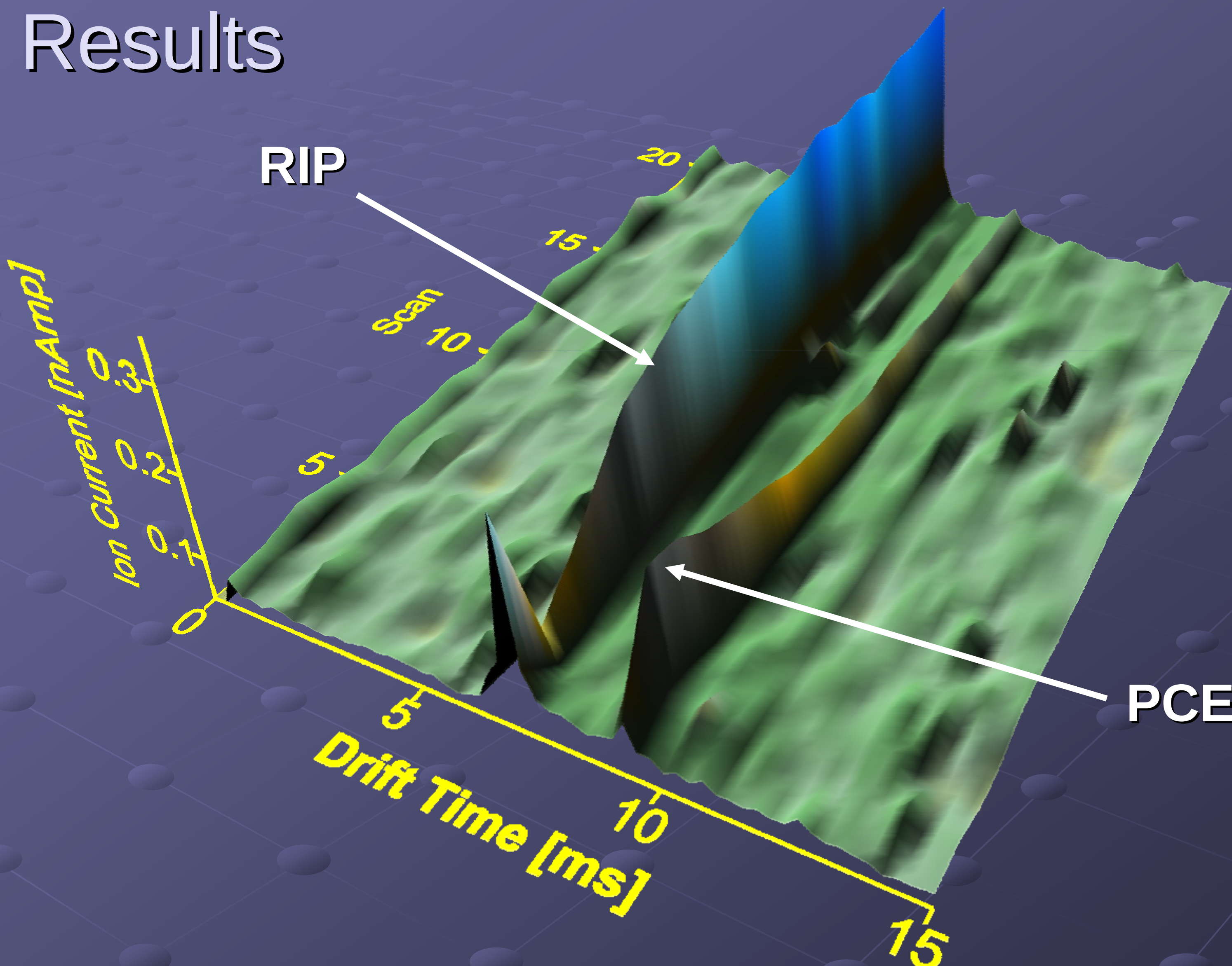
Sample

Macor IMS Sensor Testing

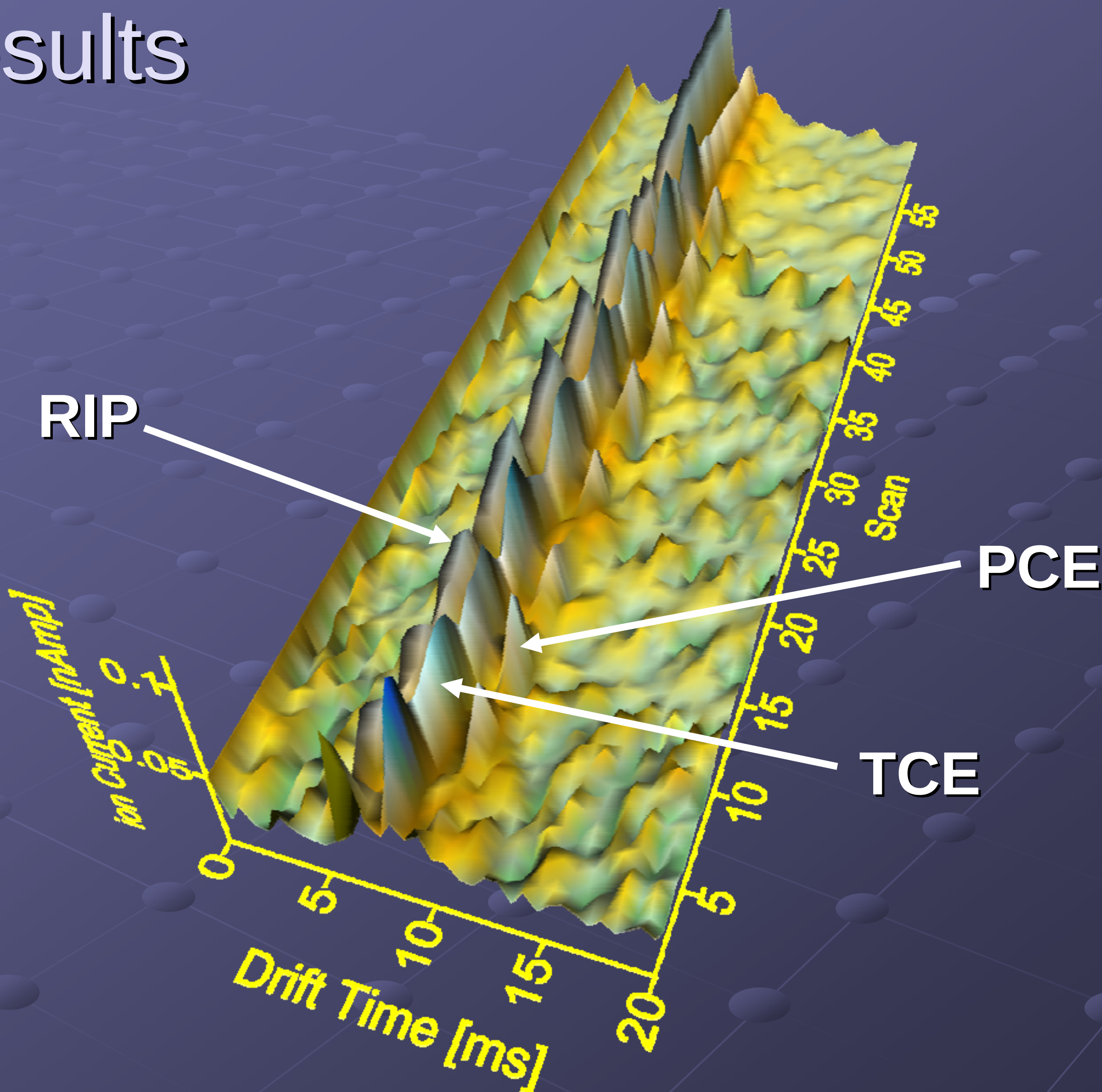




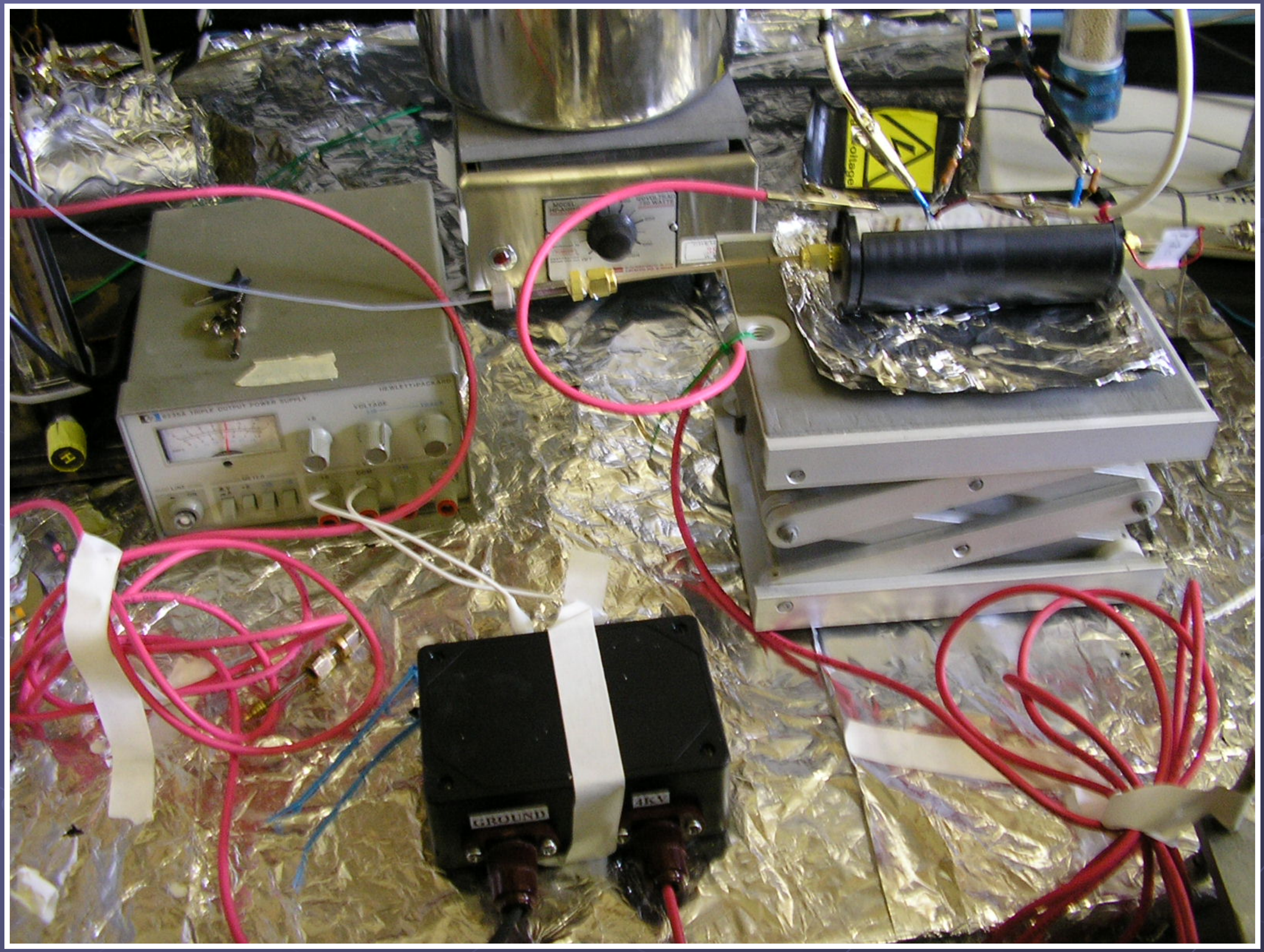
Macor IMS + Sampling Module Test Results



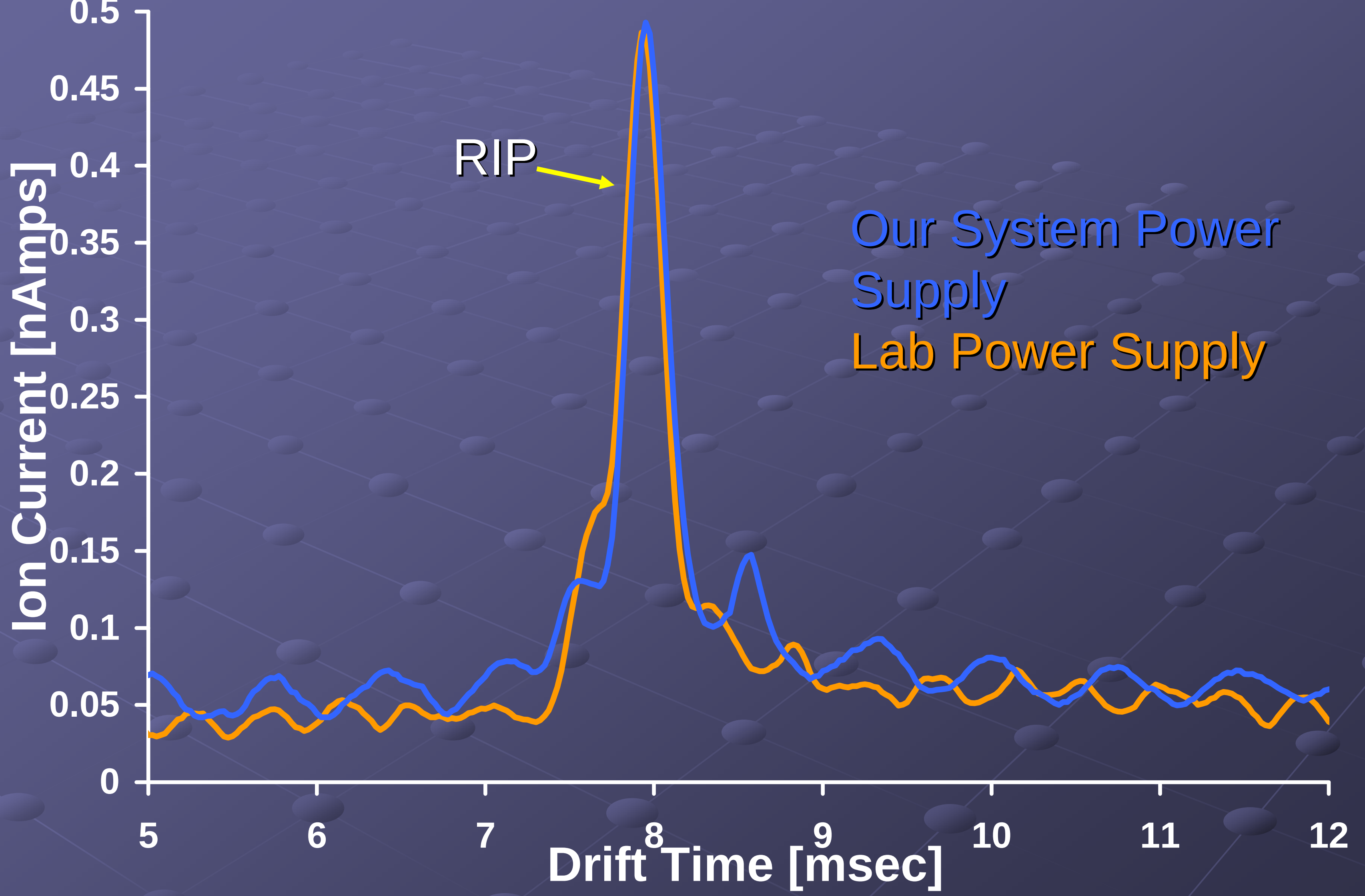
Macor IMS + Sampling Module Test Results



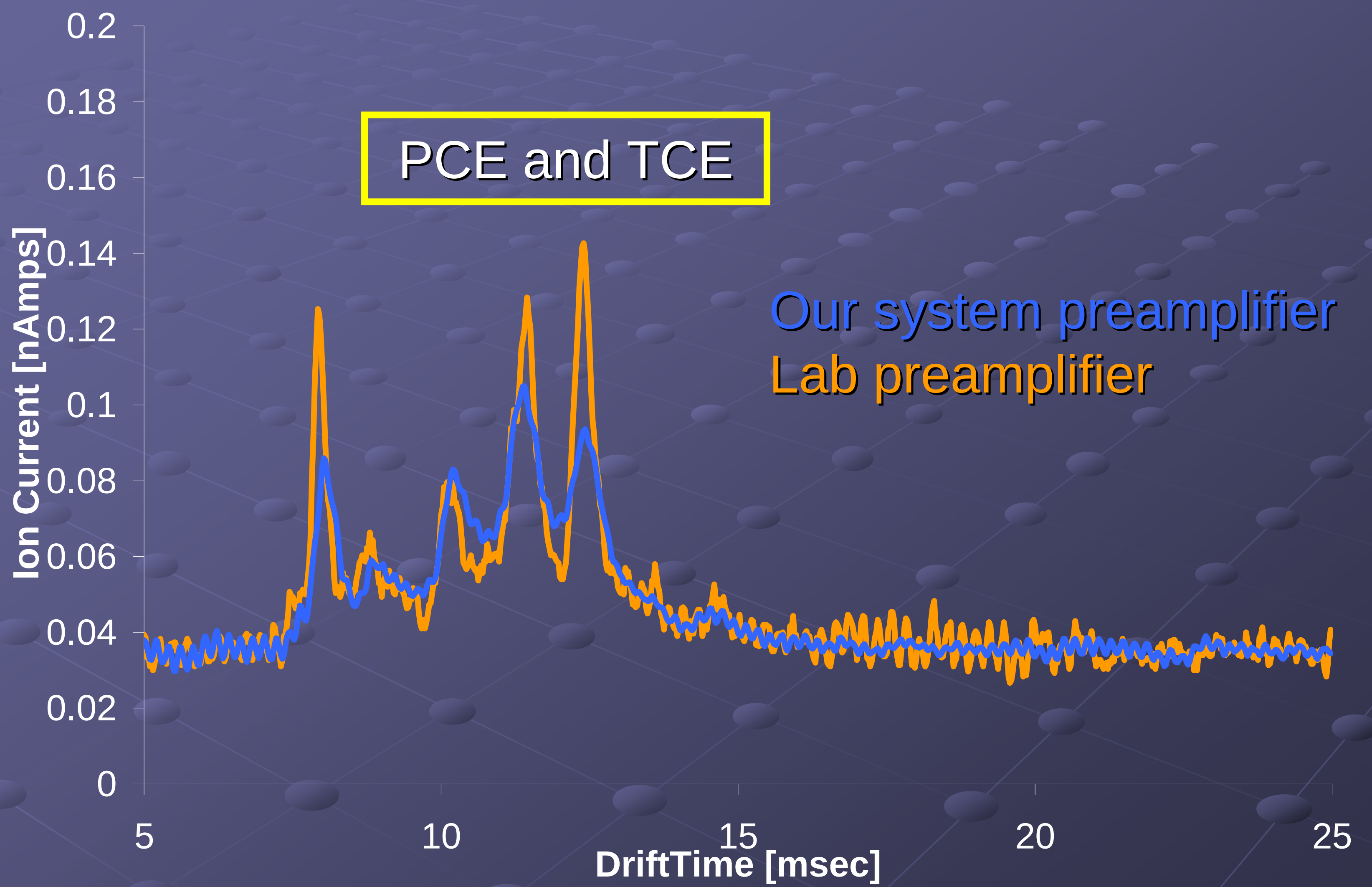
High Voltage Power Supply Test Setup



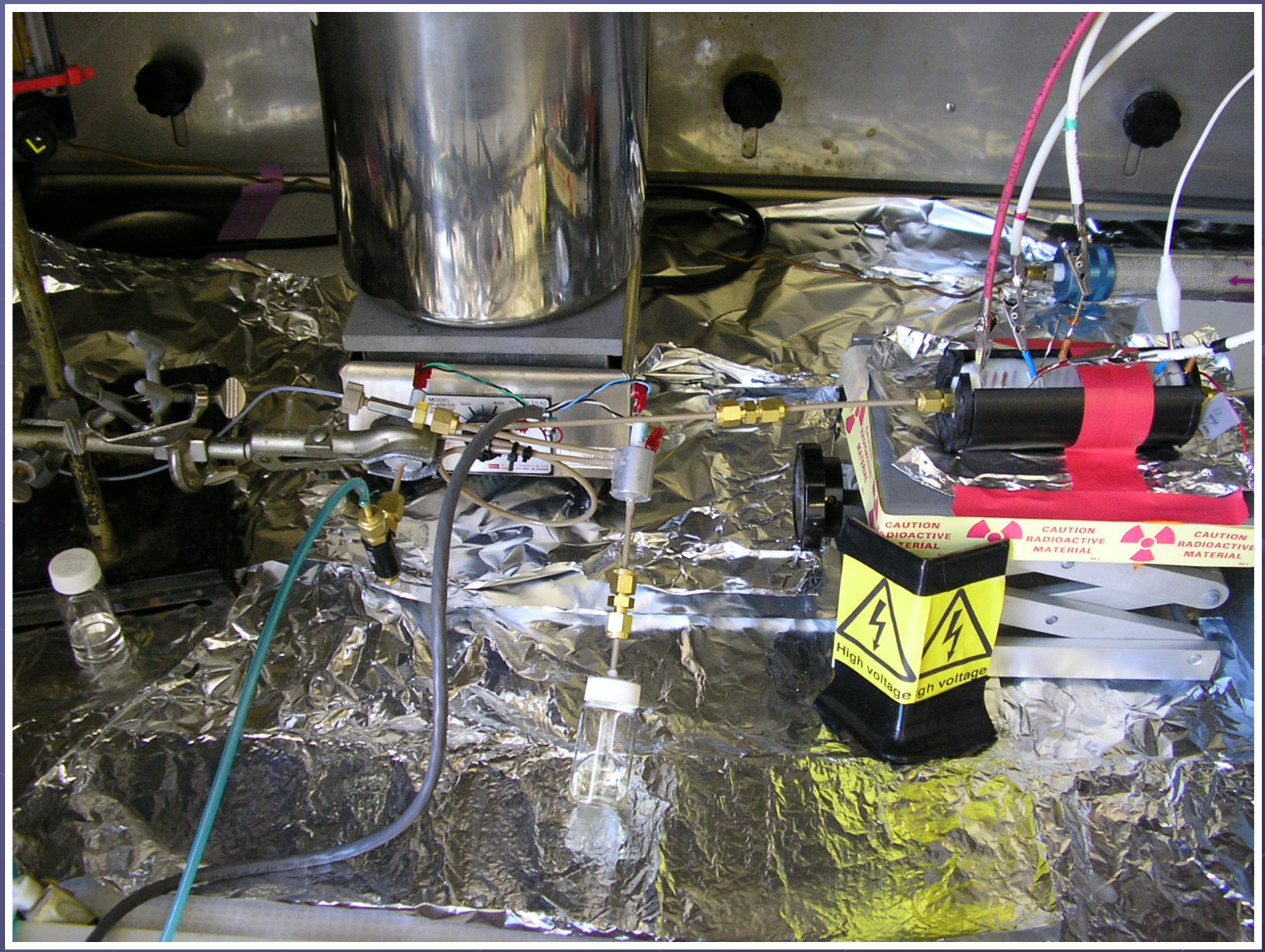
Macor IMS + Power Supply Comparison



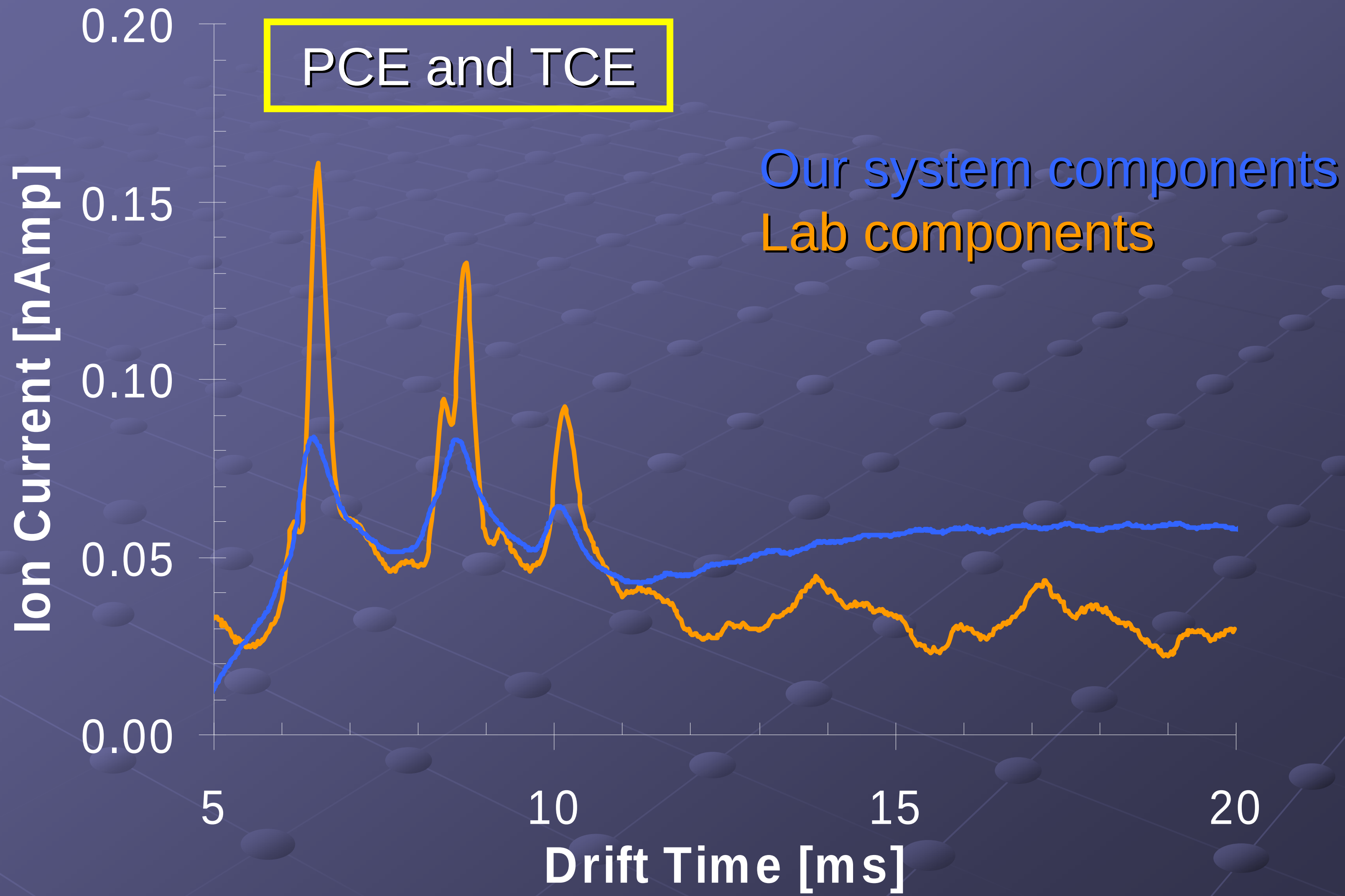
Macor IMS + Preamplifier Comparison



End-to-End Macor IMS Test Setup



End-to-End Macor Test Results



Summary of IMS Accomplishments

- Component Design and Test
  - ✓ Macor IMS
  - ✓ Sampling Module
  - ✓ High Voltage Power Supply
  - ✓ Preamplifier

- System
  - ✓ End-to-End (sample to spectra)

Next Steps…

The IMS sensor system has been proven and will provide a capable platform for work in the following areas:

- Improving quality of IMS output
- Field-scale design of components for probe integration
- Field-testing of probe system (invitation to demo at Savannah River in January 2006)

Thank you for your attention.

Any questions?