Liquid Flow Measurements using a Pyroelectric Anemometer

Dr. J. N. Zemel

Rob Callan

Overview

- Purpose
- Theory of Operation
- Measurement System:

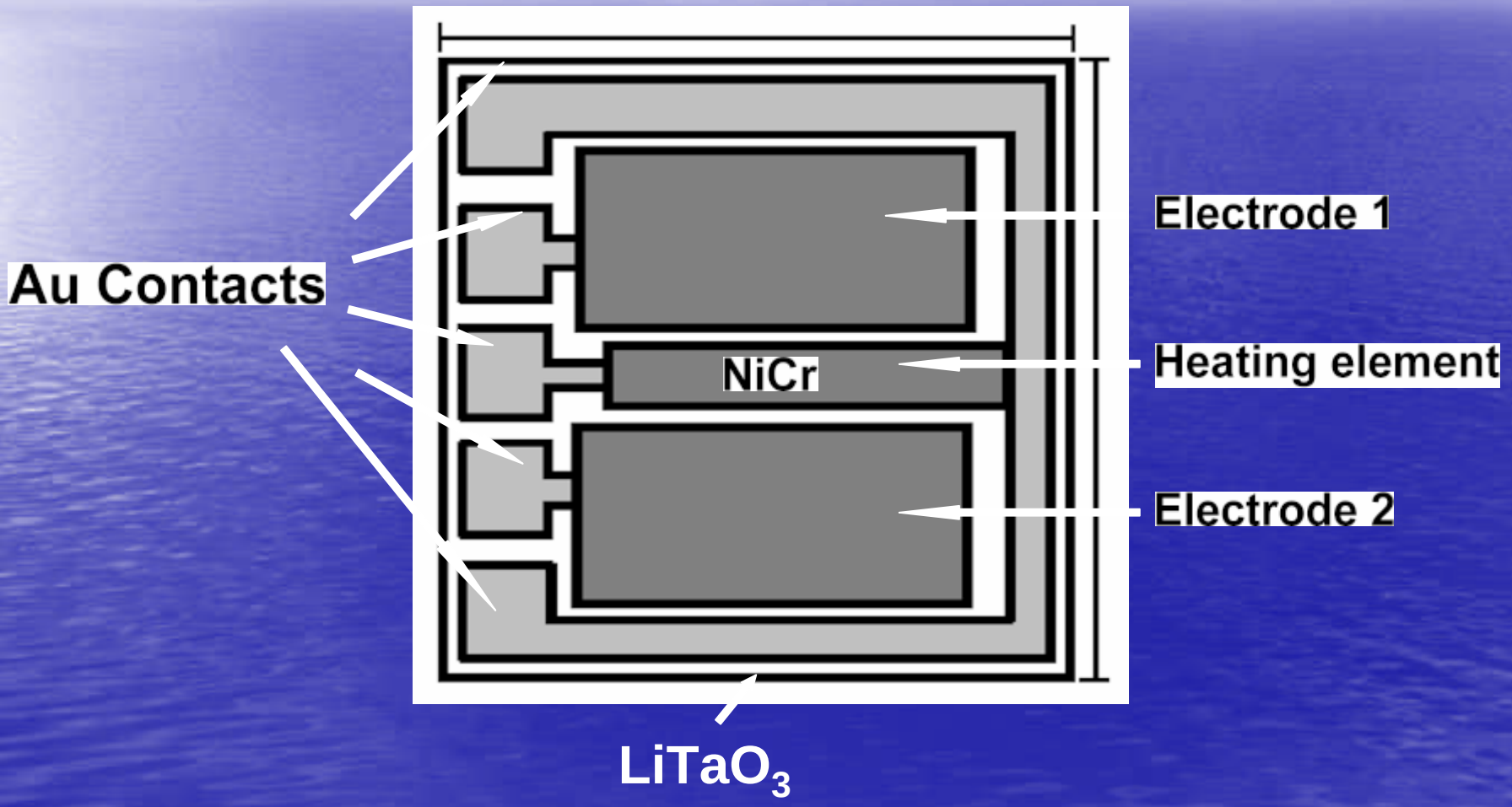
  1)Analog Processing Stages

  2)Digital Processing Stage
- Liquid Flow Systems
- Results
- Conclusions

Purpose

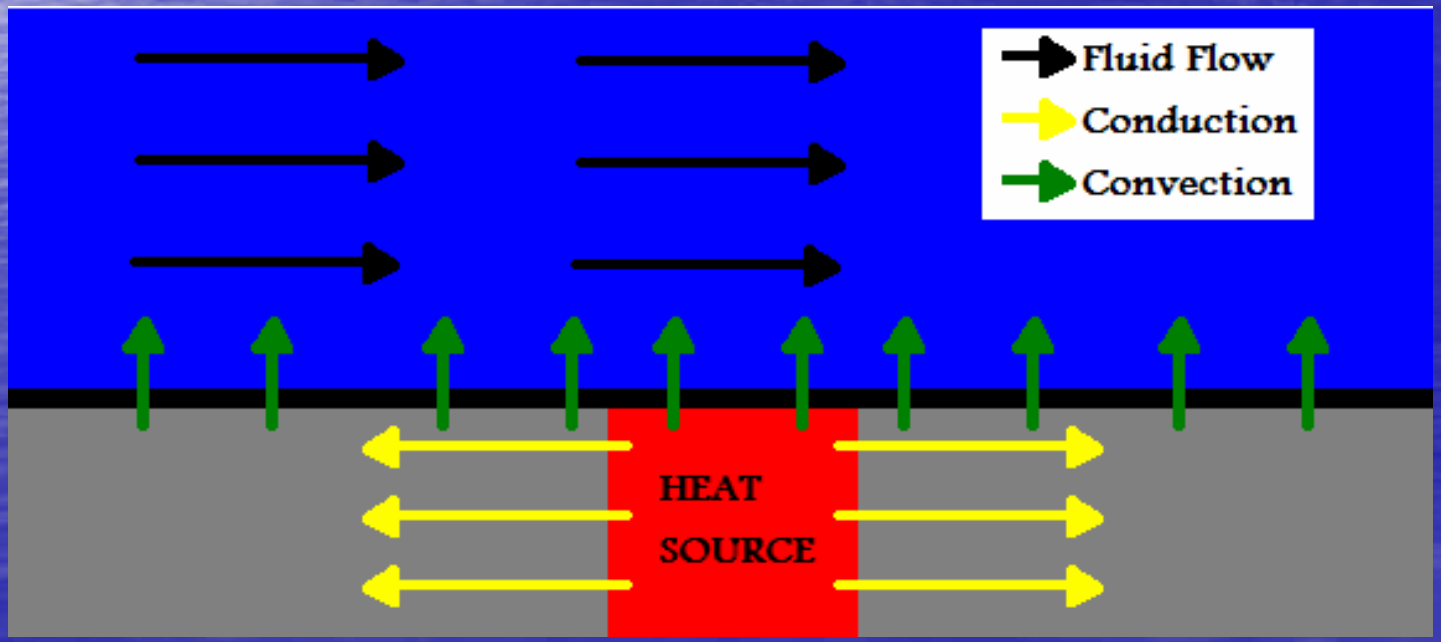
- The ideal mass flow sensor:
  - Is small and low cost
  - Requires minimal calibration
  - Does not restrict the flow
  - Works accurately over a wide range of flow velocities
- Previous research found the PA meets these requirements for gas flows

Layout of the Sensor

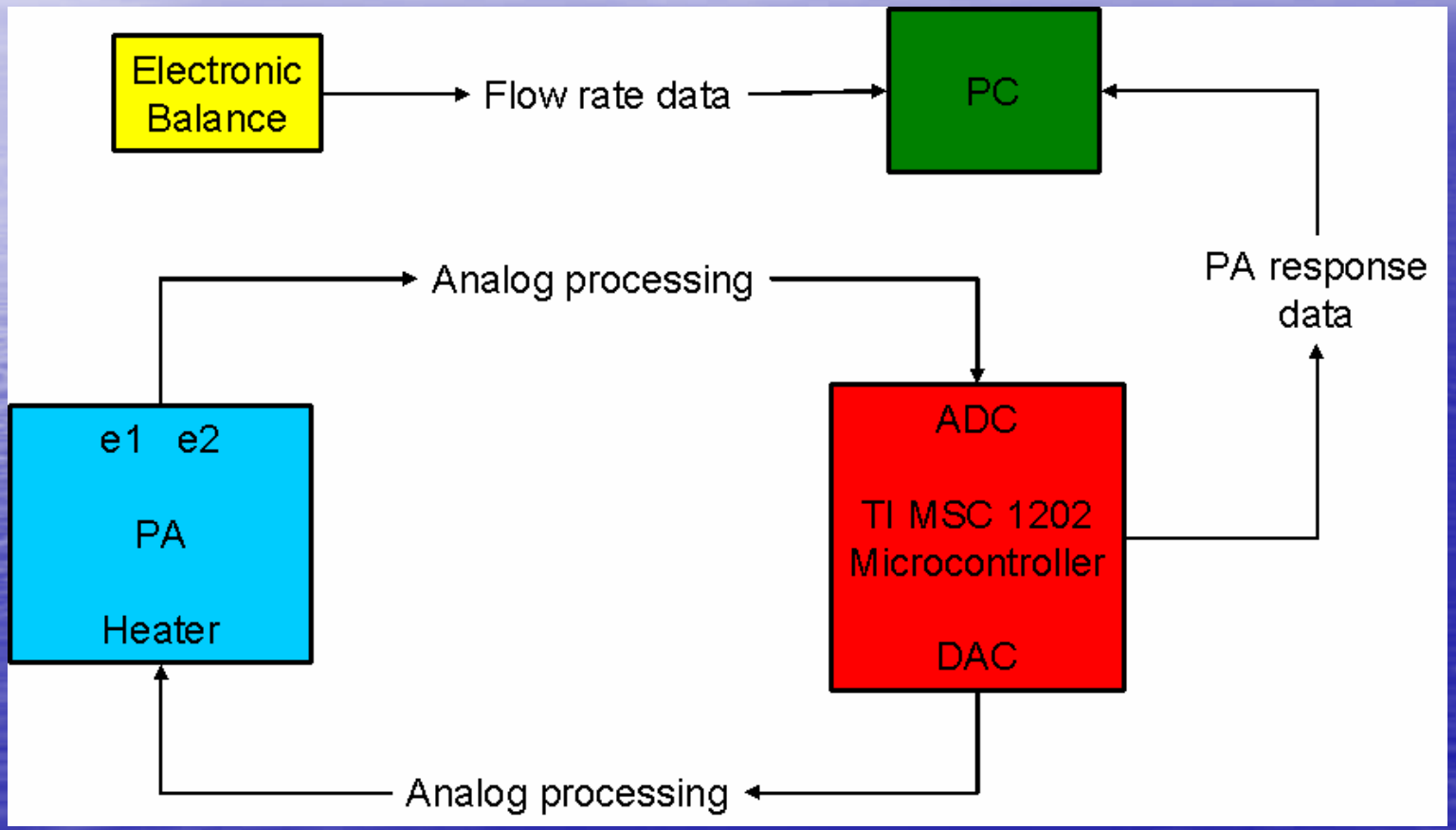


Theory of Operation

- Pyroelectricity: a change in heat content results in a change in surface charge
- Heat transfer through conduction and convection



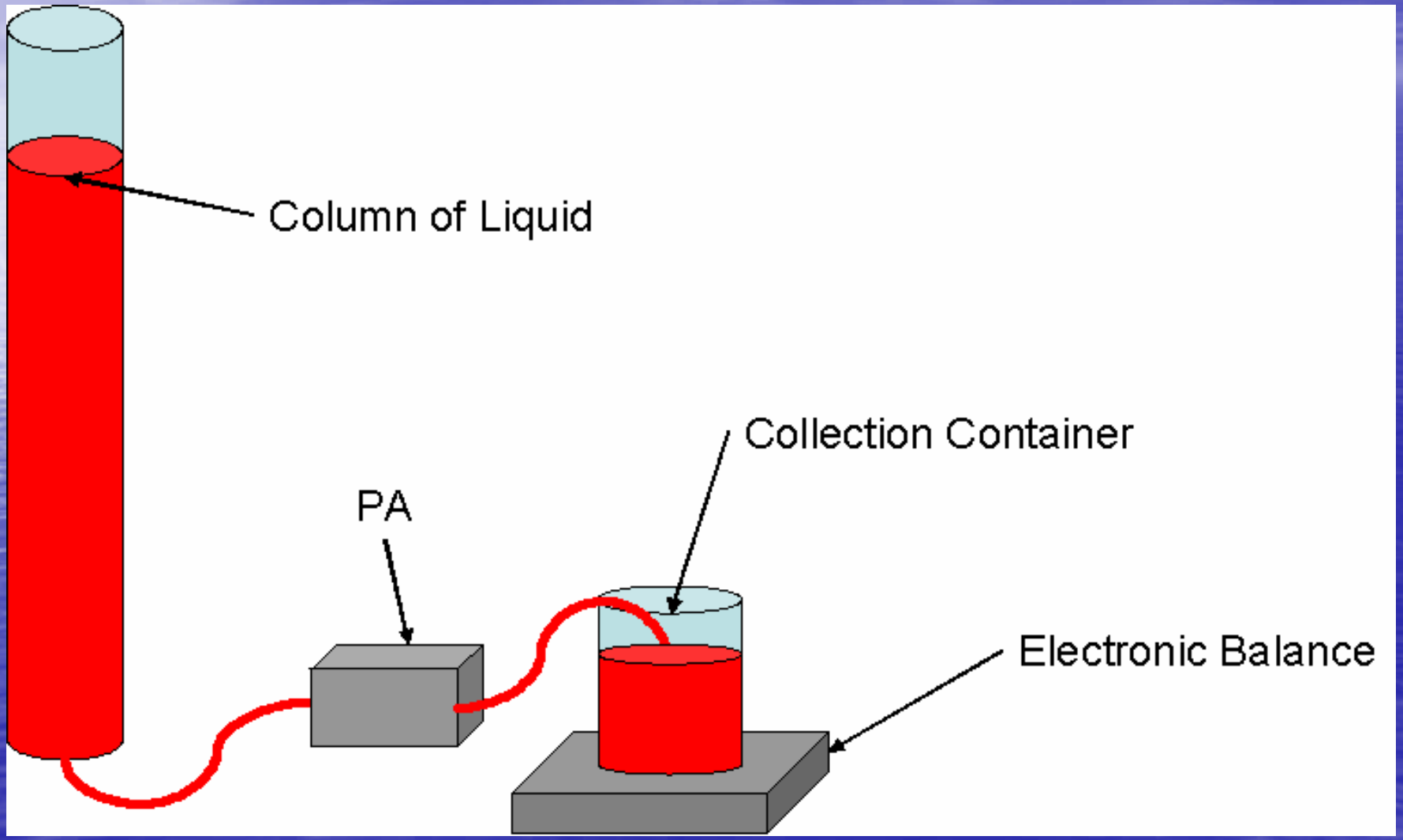
Measurement System



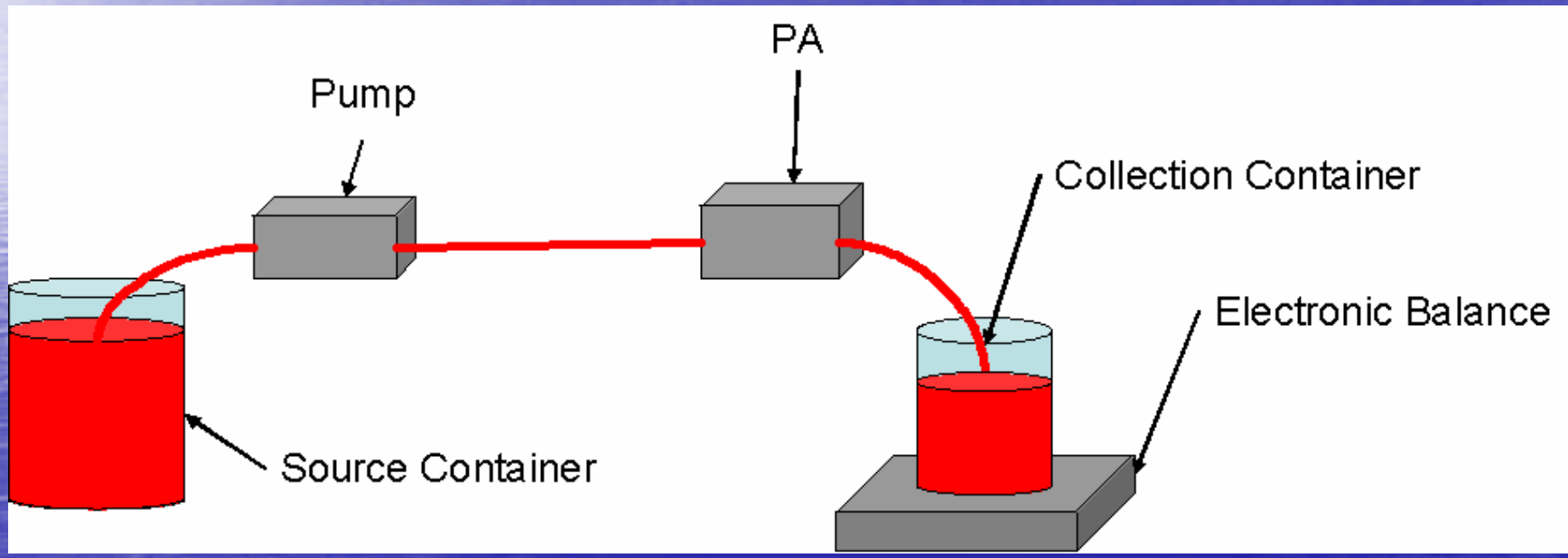
Liquid Flow Systems

- Steady, measurable flow rates over 2-3 orders of magnitude
- Rate must be known within .5% (estimated accuracy of PA)
- Calibration measurements must be absolute (collecting a volume over time)

Low flow system



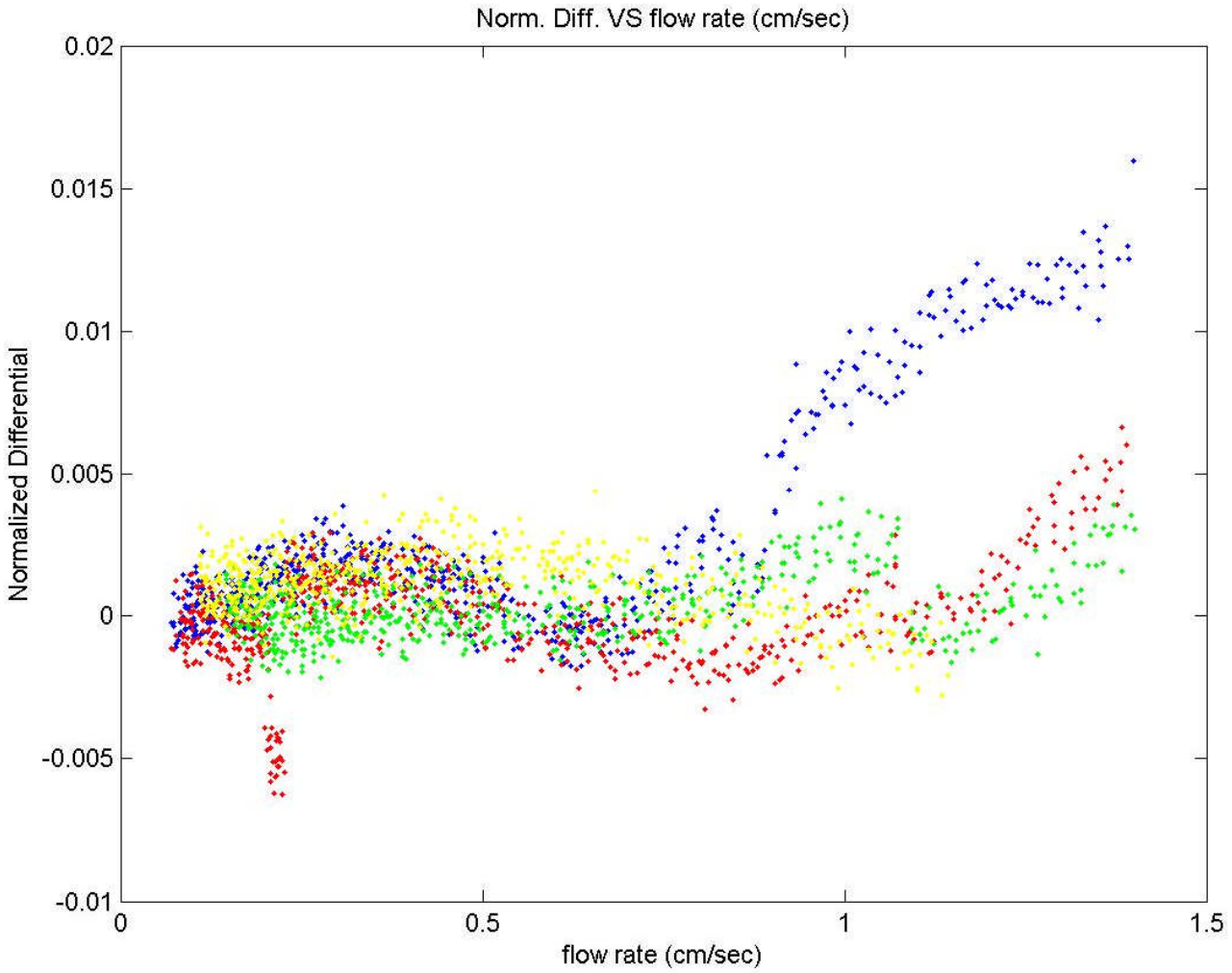
High flow system



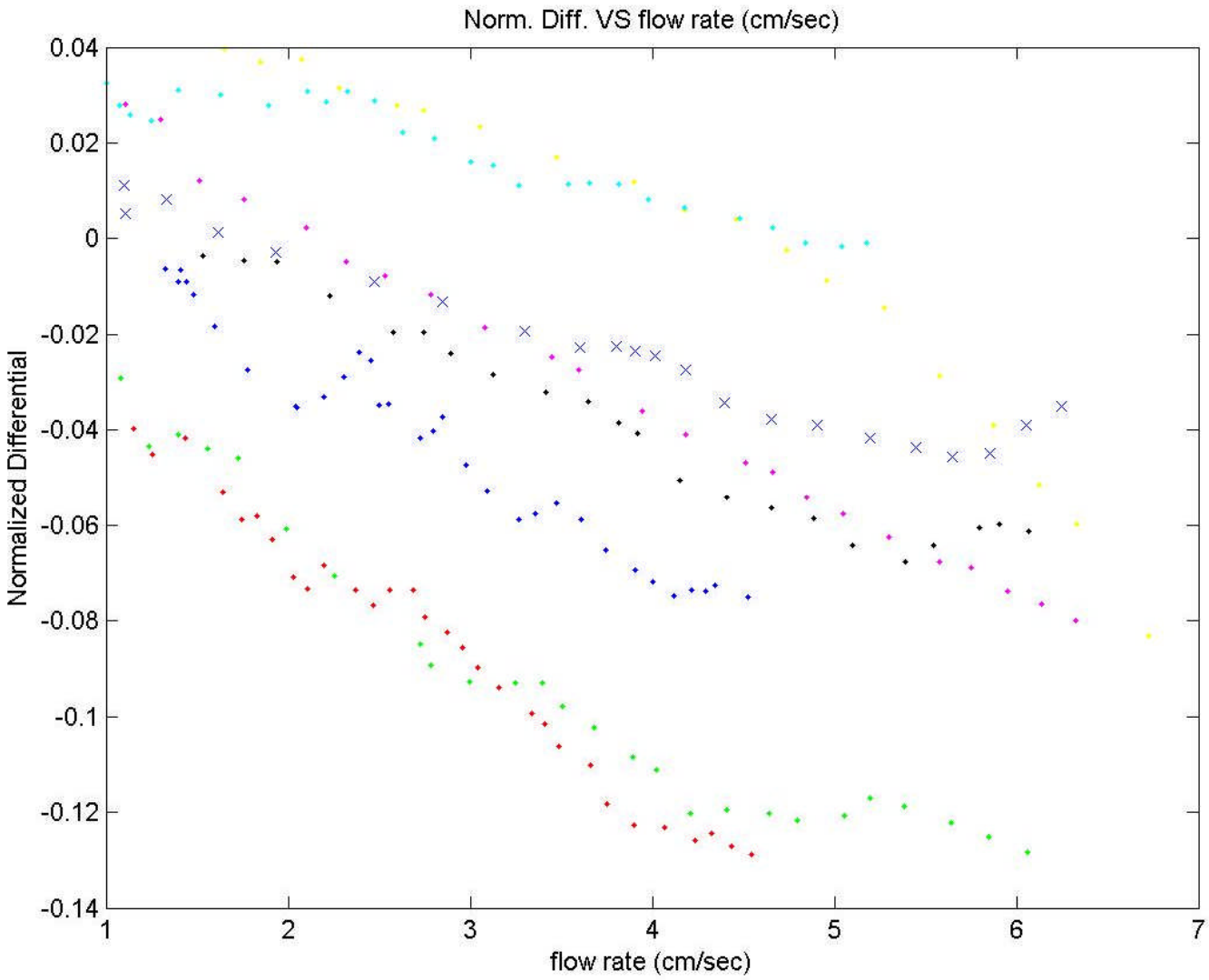
Experimental Results

- Low flow measurements
- High flow measurements
- Constant flow measurements

Low flow measurements



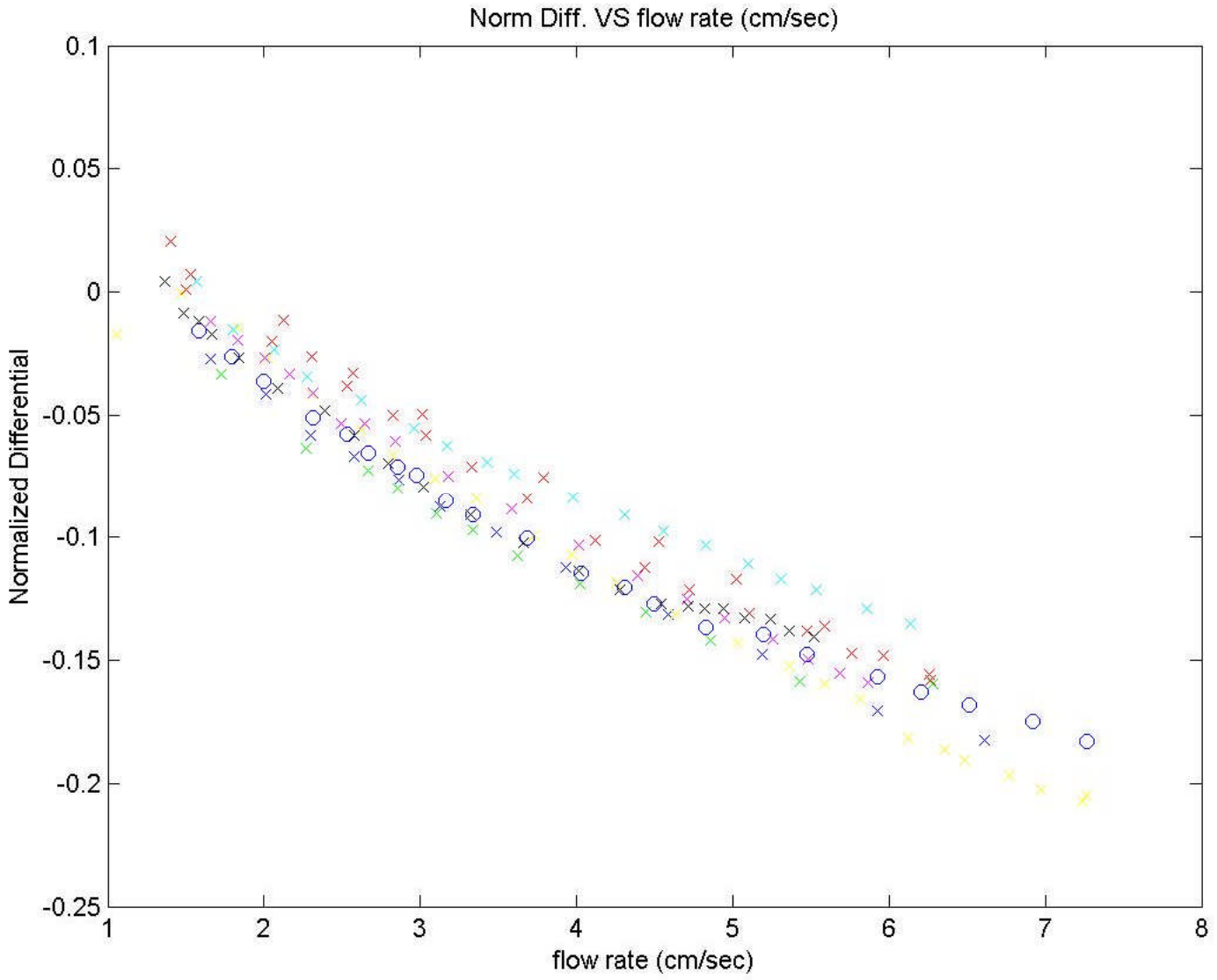
High Flow measurements



Constant flow measurements

Observations:

- PA requires a period of time for responses to stabilize
- Responses drift over time
- Temperature dependence: Single Electrode, also possibly by viscosity and density


Norm Diff. VS flow rate (cm/sec)
Normalized Differential
flow rate (cm/sec)
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
1
2
3
4
5
6
7
8

Conclusions

- Responses to flows under 1 cm/sec appear to be too small to measure
- Responses to flows in the 1-7cm/sec range appear to show a linear response (similar to previous research)
- Response appears to have a strong dependence on temperature (.87 mV/^{o}C at 20^{o}C) unlike response to gases
- The viscosity possibly varies by 30% over temperature range-viscosity inversely proportional to Reynolds number
- Important to keep temperature as stable as possible over the course of measurements