Comparing Configurations of Multiple Array Plasma Actuators by Velocity and Flow Visualization

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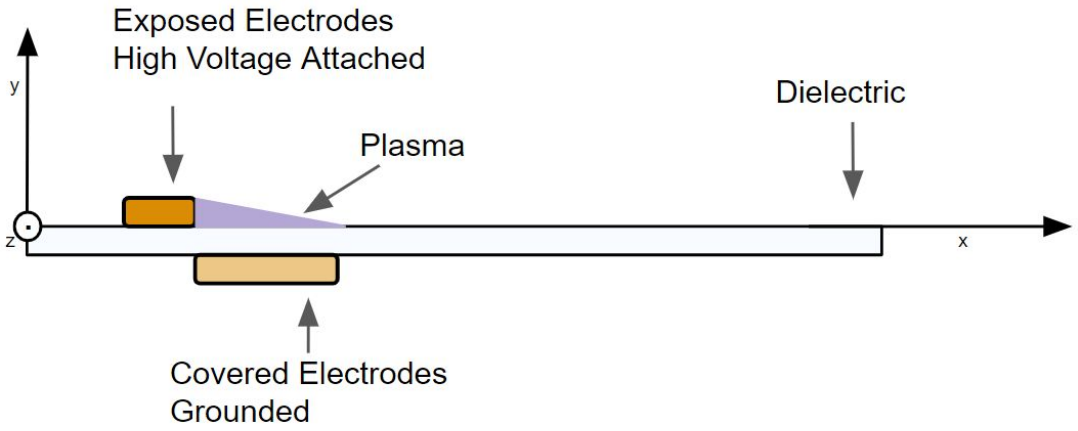
Overview

- Research on Plasma Actuators for flow and lift control
  - Add more arrays
    - Increase in control
    - Unwanted interactions
- Mitigating cross talk while using three arrays
  - Two possible ways shown
    - Insulation and Switching High Voltage Connections
  - Four Actuators Tested
- Schlieren, Pitot Probes, and Qualitative Photos
- Less Cross Talk using both methods
- Higher peak velocity

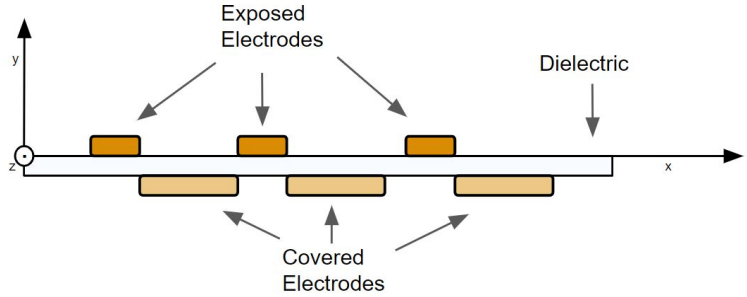
Introduction

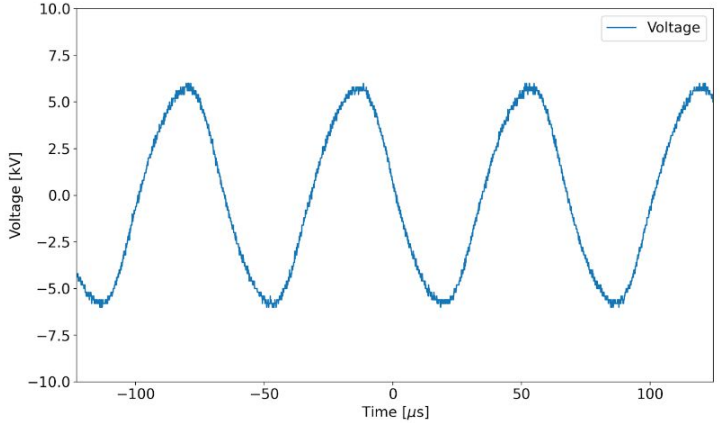
- Voltage Differential induces plasma and velocity
- Possible Advantages and Disadvantages seen in Multiple-actuator designs
  - Cross Talk/Back Plasma



Experimental Setup

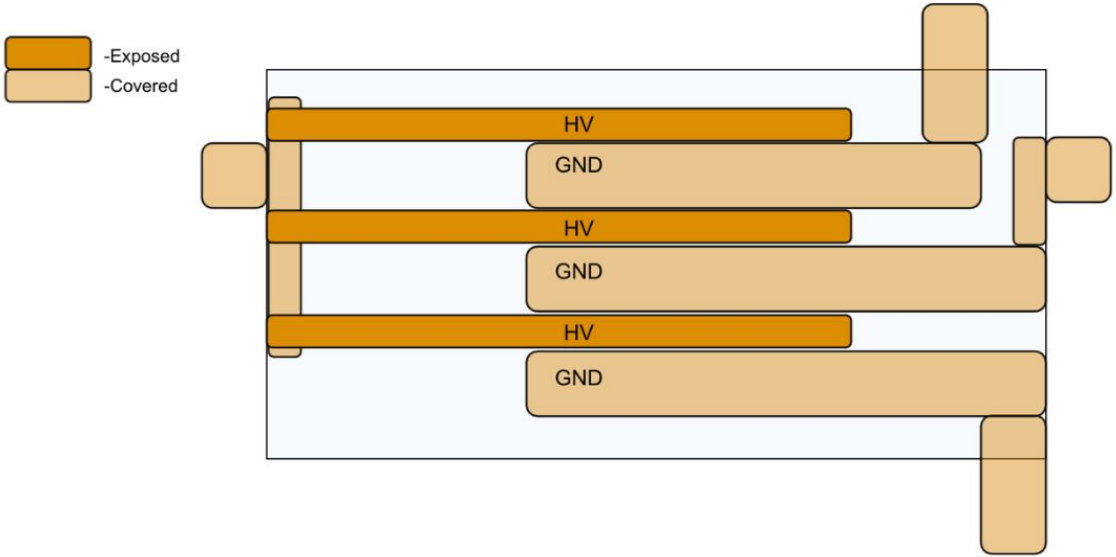
- DBD Actuators
  - Borosilicate glass dielectrics
  - Copper tape alternating between covered and exposed
  - No gaps between tape (x direction)
- Powered by an AC wave using a Minipuls
  - 12kV,15kHz





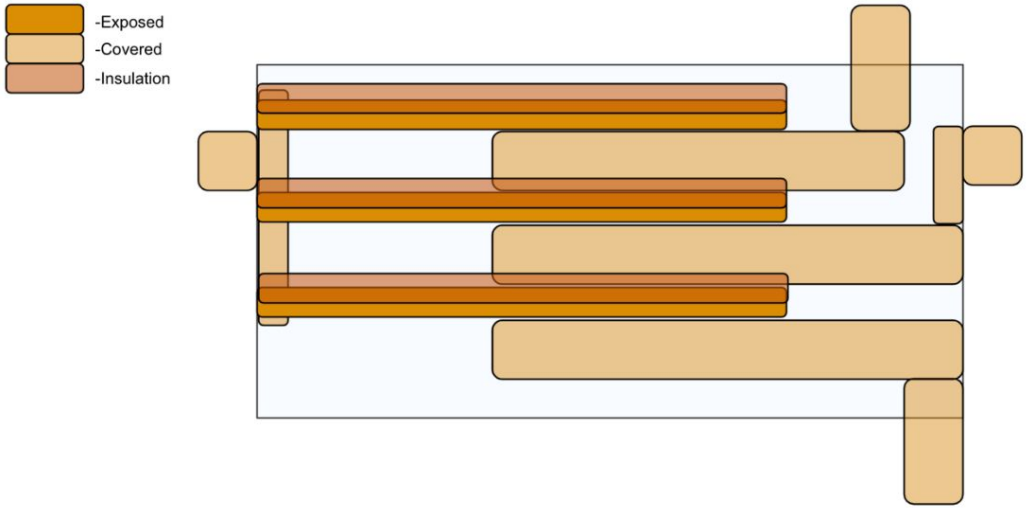
Experimental Setup

- Experiment 1
- Configuration 1
  - High Voltage connected alternating



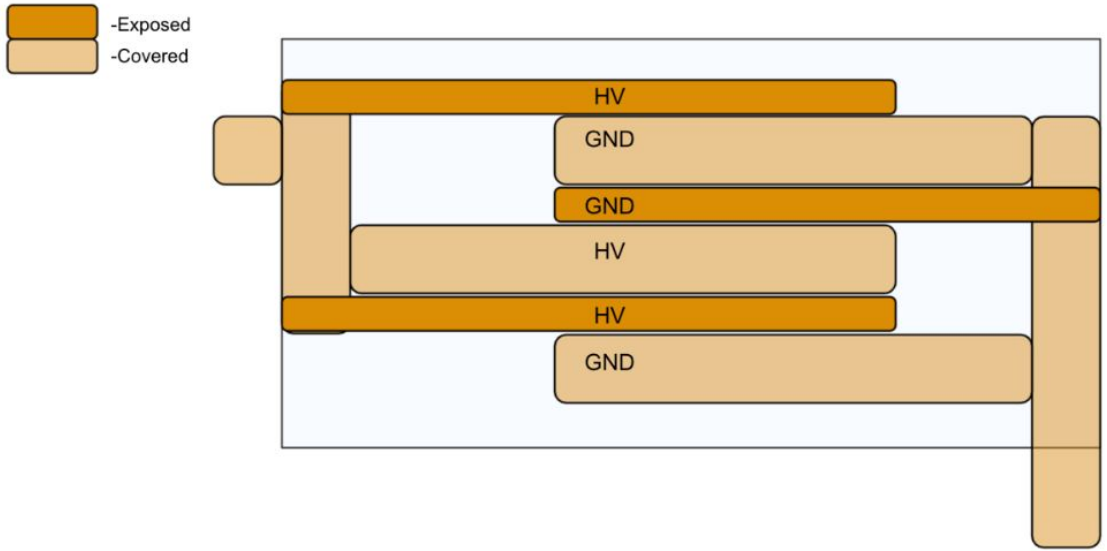
Experimental Setup

- Experiment 2
  - Uses Insulation on the leading edge of exposed electrode
- Configuration 1
  - High Voltage connected alternating



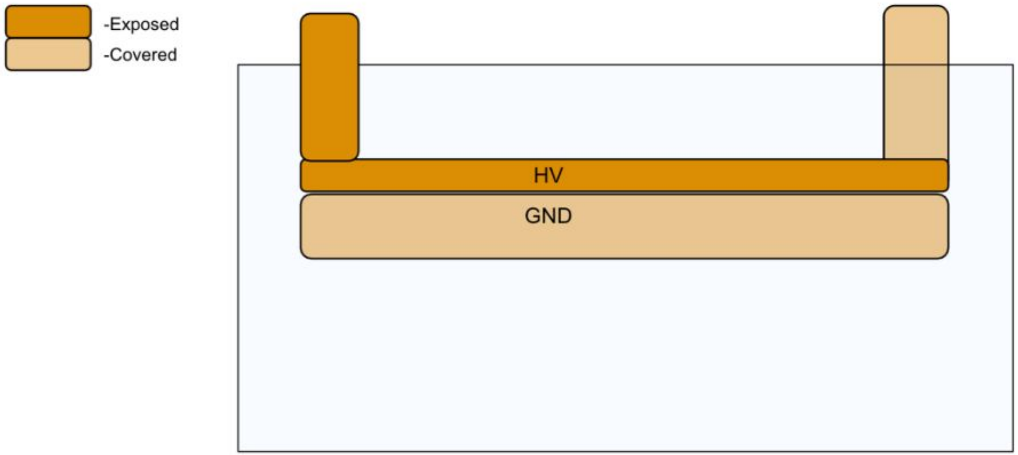
Experimental Setup

- Experiment 3
- Configuration 2
  - High Voltage connected to reduce cross talk between actuators



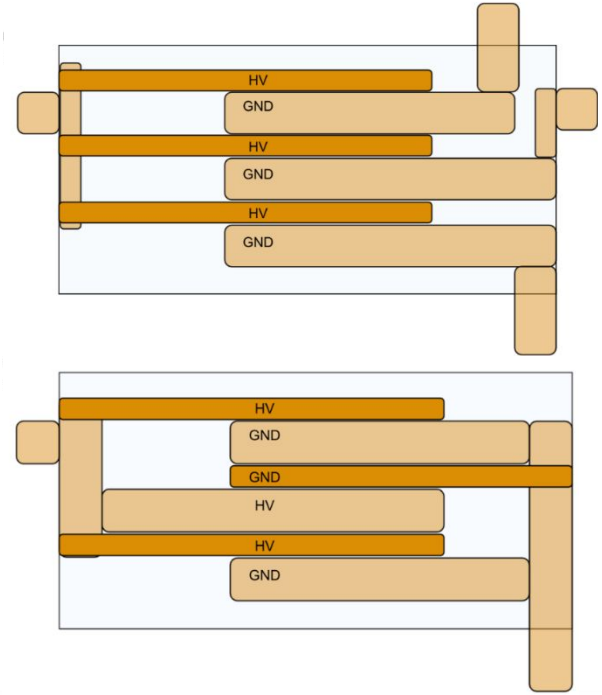
Experimental Setup

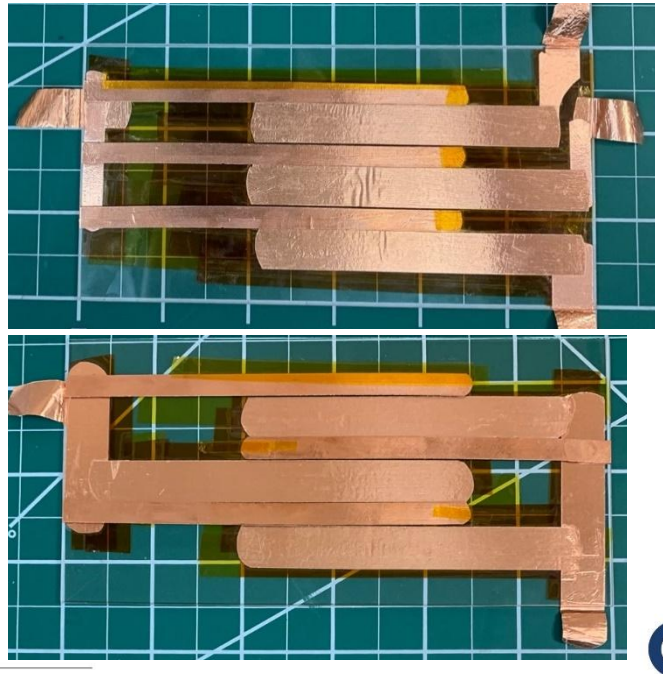
- Experiment 4
- Configuration 3
  - Basic One Actuator Array



Experimental Setup

Photos of the Plasma Actuators



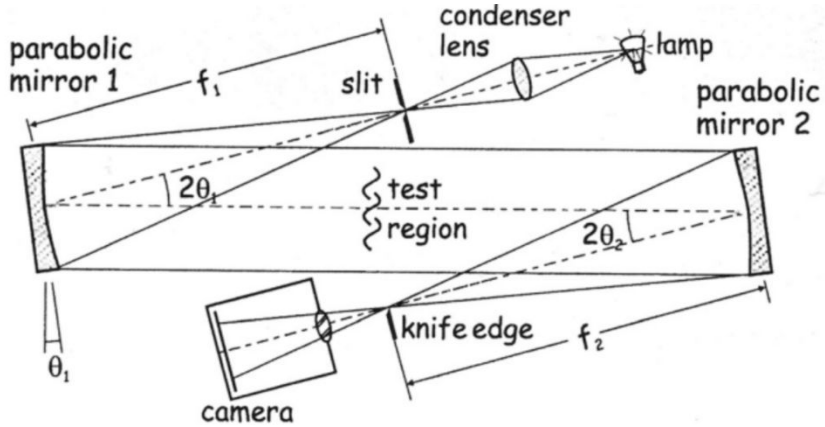


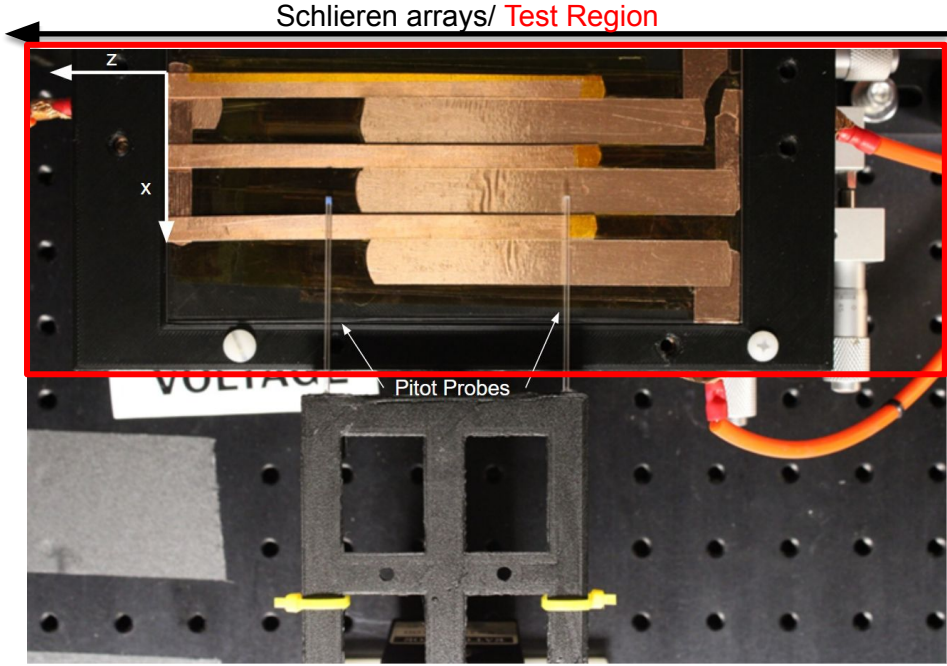
Experimental Procedure

Pitot Probe Setup allows for translation in the x axis

- Rotated for negative flow

Z type schlieren setup to visualize the flow

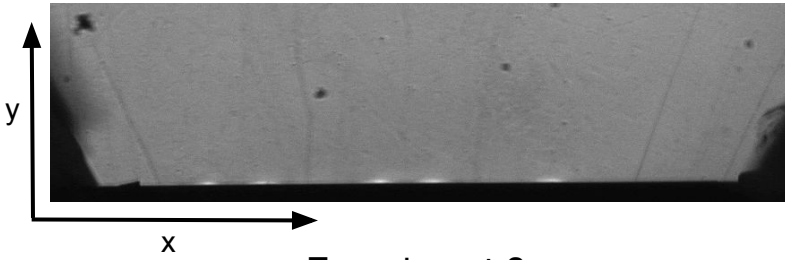




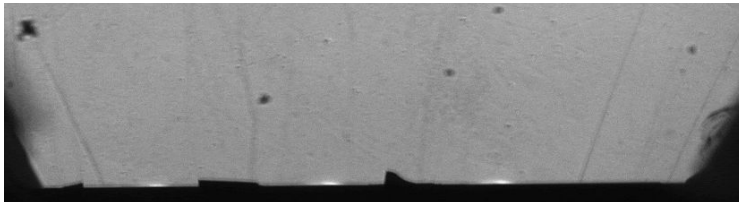
Schlieren Results

Start up procedures of each experiment (0ms-10ms)

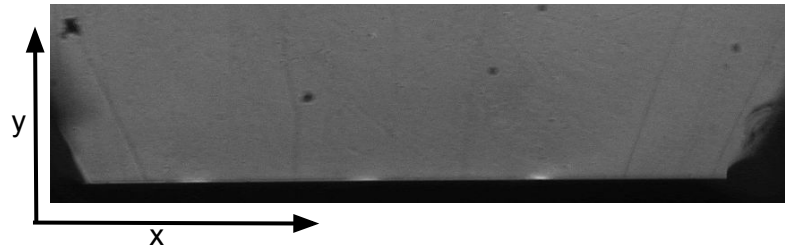
Experiment 1



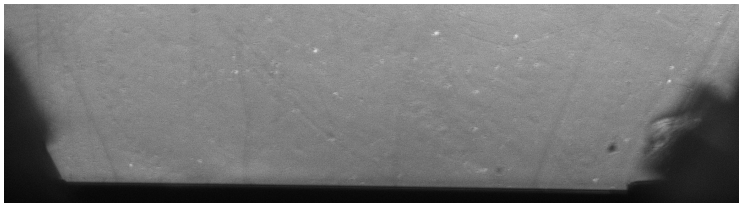
Experiment 2



Experiment 3



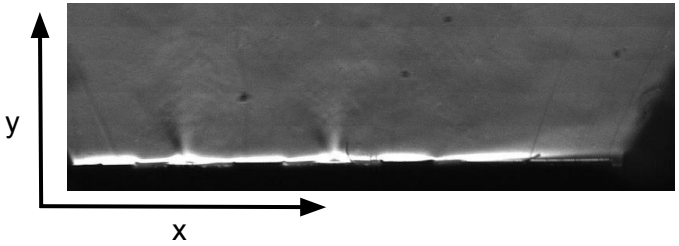
Experiment 4



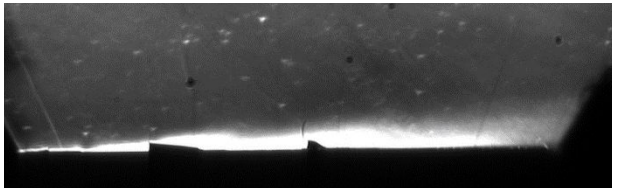
Schlieren Results

Steady State Flow

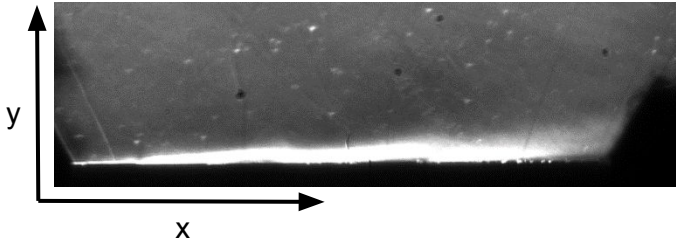
Experiment 1



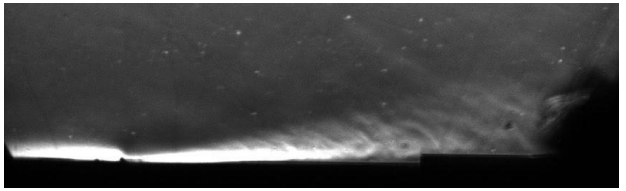
Experiment 2



Experiment 3



Experiment 4

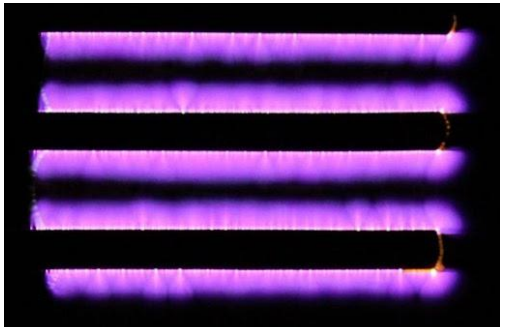


Plasma Photos

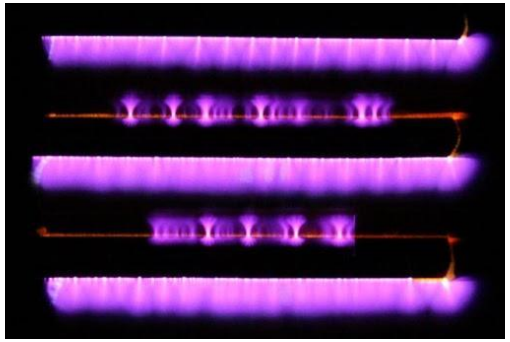
Photos going down the y axis, facing the actuators

z

x



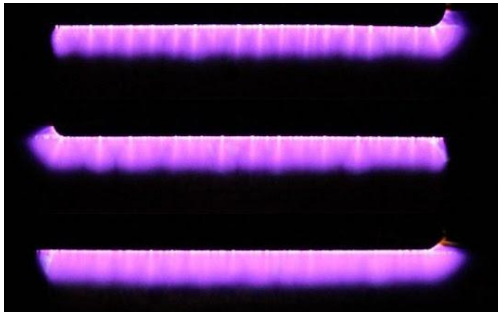
Experiment 1



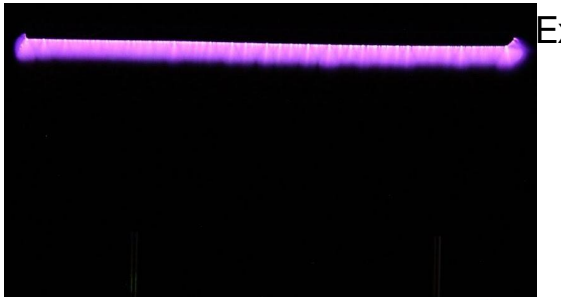
Experiment 2

z

x



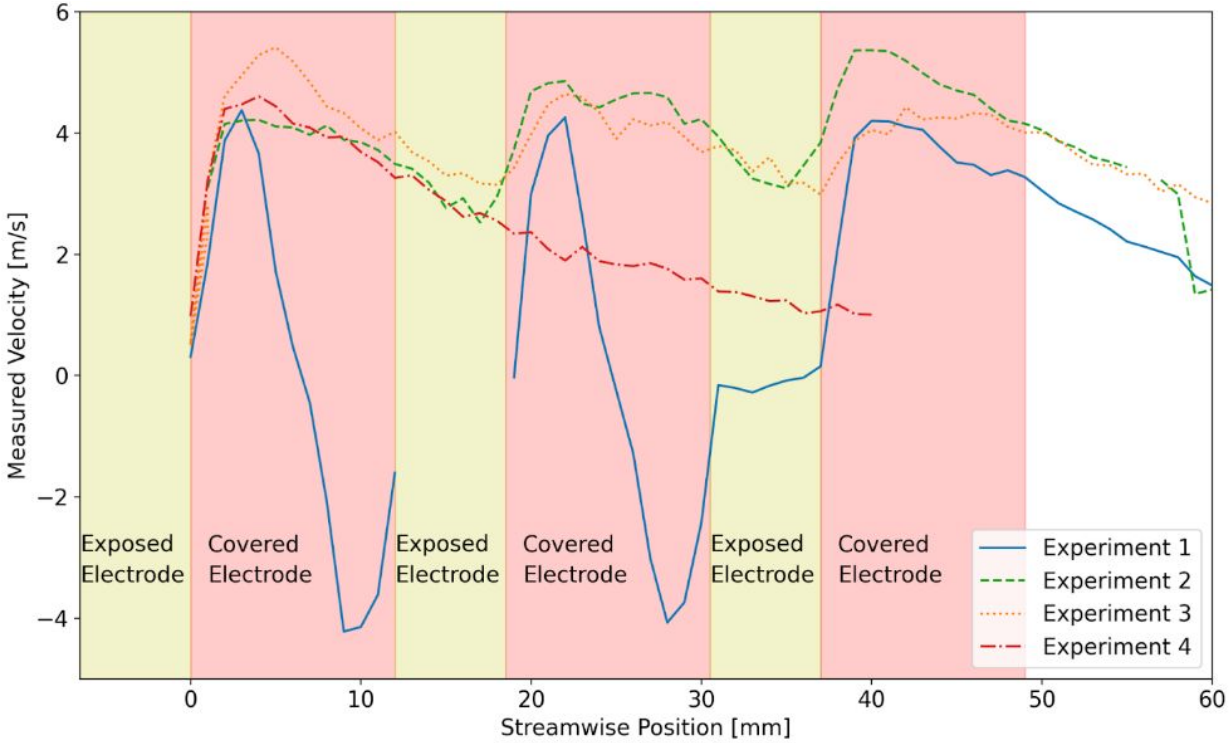
Experiment 3



Experiment 4

Pitot Probe Results

Going down the x-axis



Pitot Probe Results

Configuration	Pitot Probe Position (mm)	Peak Velocity, U, (m/s)
Experiment 1: No Insulation	4 +-1	4.47 +-0.05
Experiment 2: Insulation	40 +-1	5.37 +-0.20
Experiment 3	5 +-1	5.42 +- 0.13
Experiment 4	4+-1	4.61+-0.22

Summary

- Four experiments
  - Three Three-Array Actuators
    - Insulation vs None
    - High Voltage Connections
  - One Array Actuator
- Reduction in Cross Talk with Experiment 2 and 3
- Higher Max Velocity in the three-actuator arrays (2 and 3)
- Back Plasma and Cross Talk cause velocity in the positive and negative x direction
  - Causes multiple actuator array advantages to be lessened

Acknowledgments

- Arctura, Inc
  - John Cooney and Pascal Mickelson
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Questions?