Designing and Building a High Energy Discharge Unit and Camera Triggering Unit

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The Big Picture

- experiments with high-speed fluid mechanics
  - microsecond(μs) timescale (millionth of a second)
- Examples:

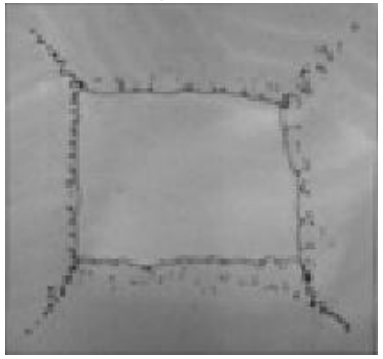
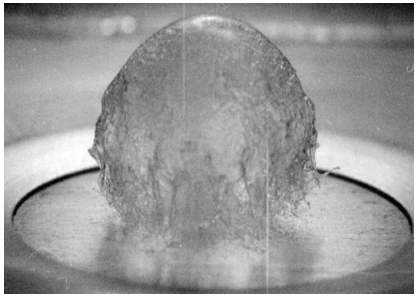


Photo From KFPL

Soap film outer edges boil and retract in



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Water Drop Atomization under high speed impact

What all of these project have in common are:

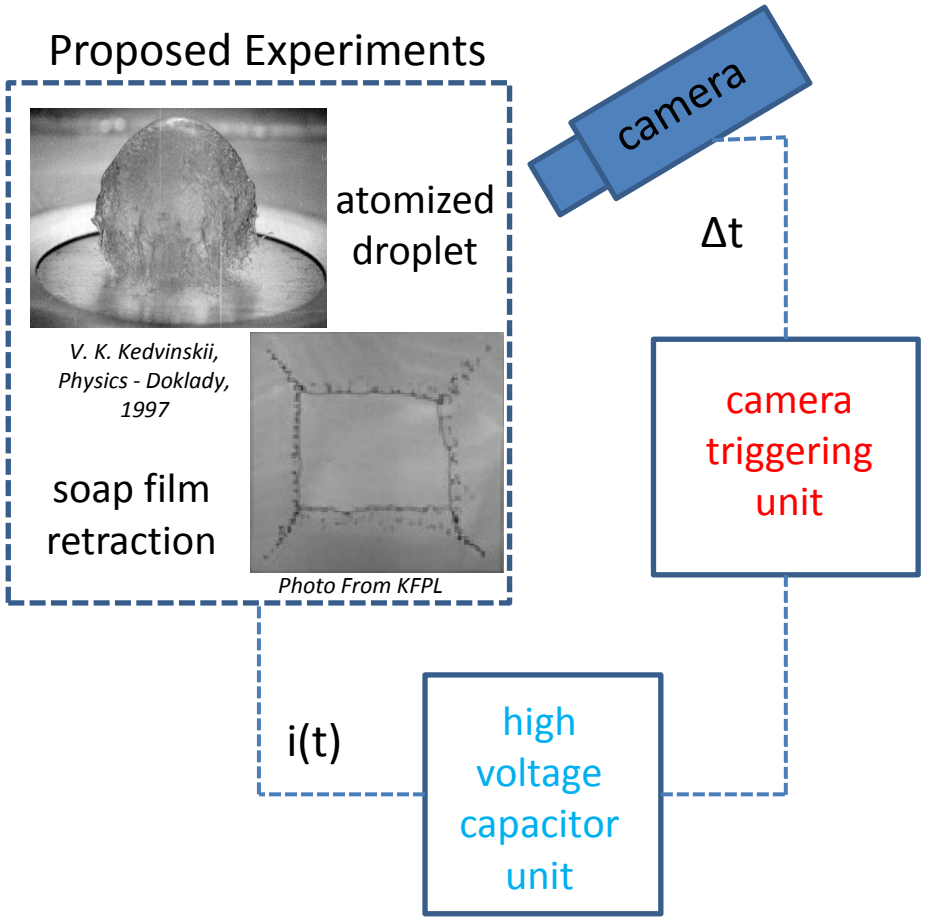
- require large currents (100's of Amps)
- high speed discharge (~1μs)
- imaging
  - high resolution at "high speed" (most high speed cameras have low resolution)

Goals

- Design and construct a device that is capable of discharging a high voltage capacitor.
  - Replacing the old spark gap unit in the lab.

- Build a triggering unit for a high resolution camera.
  - Senses current impulse remotely, sends signal to camera.
  - Most high speed cameras low resolution

- devices ensure repeatability of current and Δt (time delay)



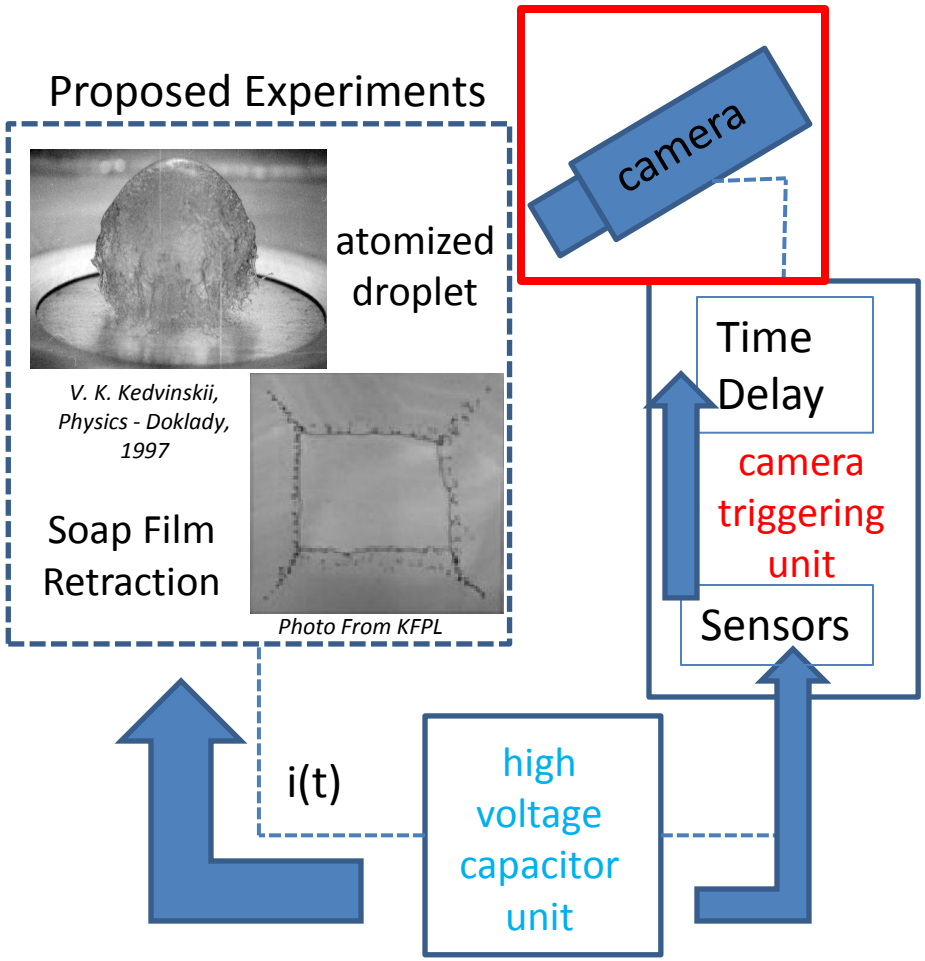
Overview

• The system first sends a current pulse from the high voltage capacitor to the chosen experiment.

• Then use current sensor and magnetic field sensor to detect the current pulse remotely.

•The signals from the sensors are picked up by the Delay unit.

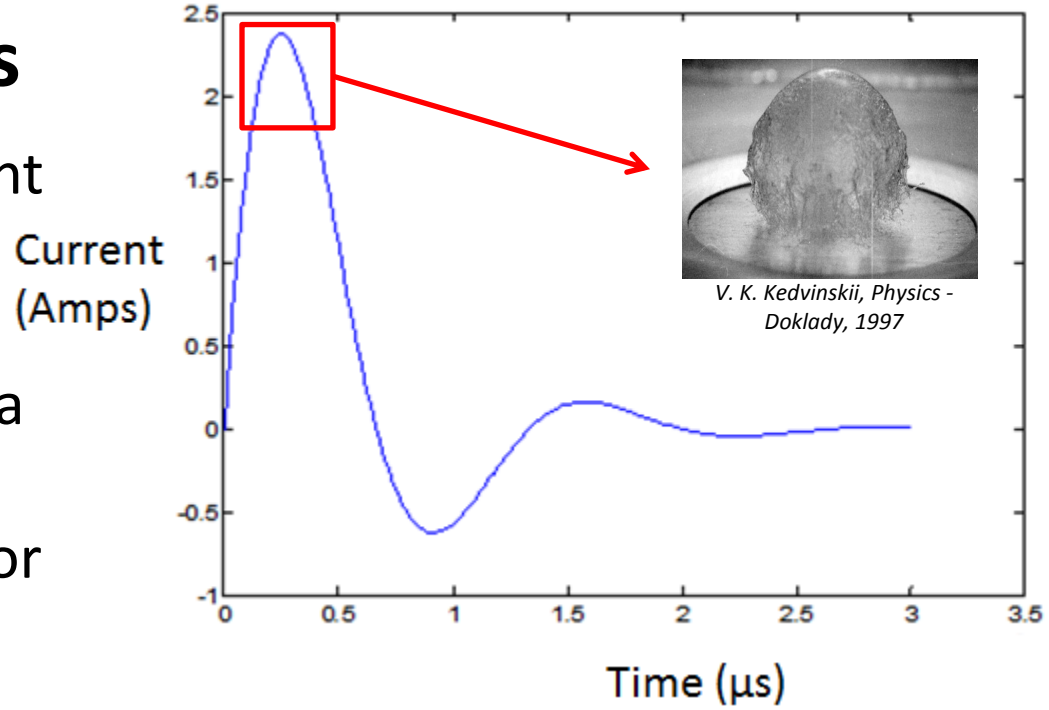
•Which then activates the camera.



Experimental Methods

- Calculations to optimize current to create one large impulse

- Collect and compare initial data taken with the remote, current, and magnetic sensor of capacitor discharge to calculations



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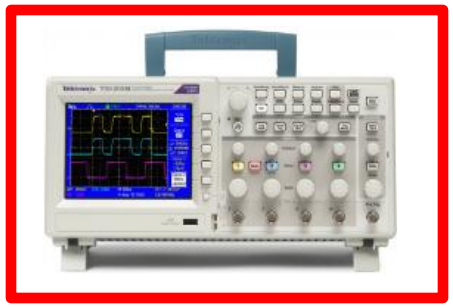
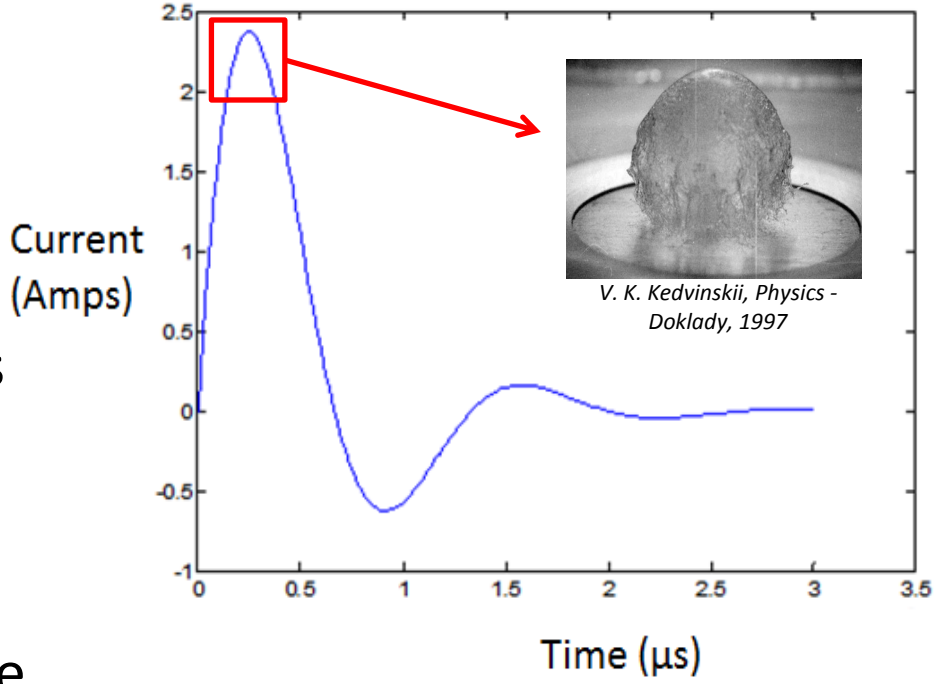


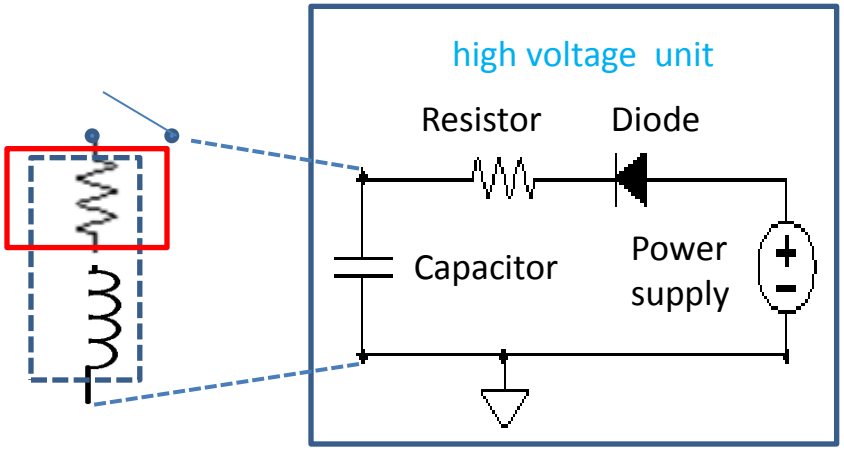
From Tektronix website

Experimental Methods

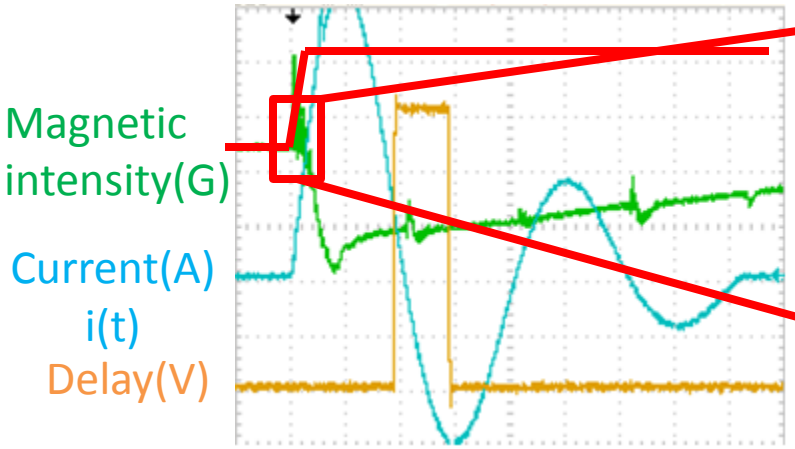


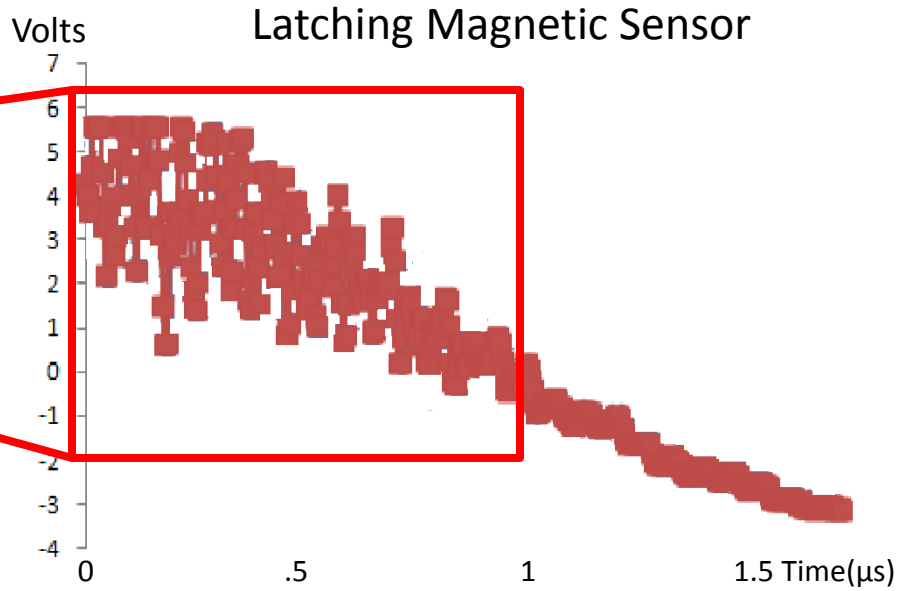
- Amend the arrangement of sensors for best camera trigger

- Alter resistance to adjust amplitude and time scales to achieve desired results.



Data from RLC Circuit





Using the old spark gap unit to experiment on while the new unit is being built

We tested the magnetic sensor to send the time delay unit a signal

Latching sensor used to latch into one state or another

Use this to trigger the signal delay device to take a picture

Didn't get data uniform enough to trigger from

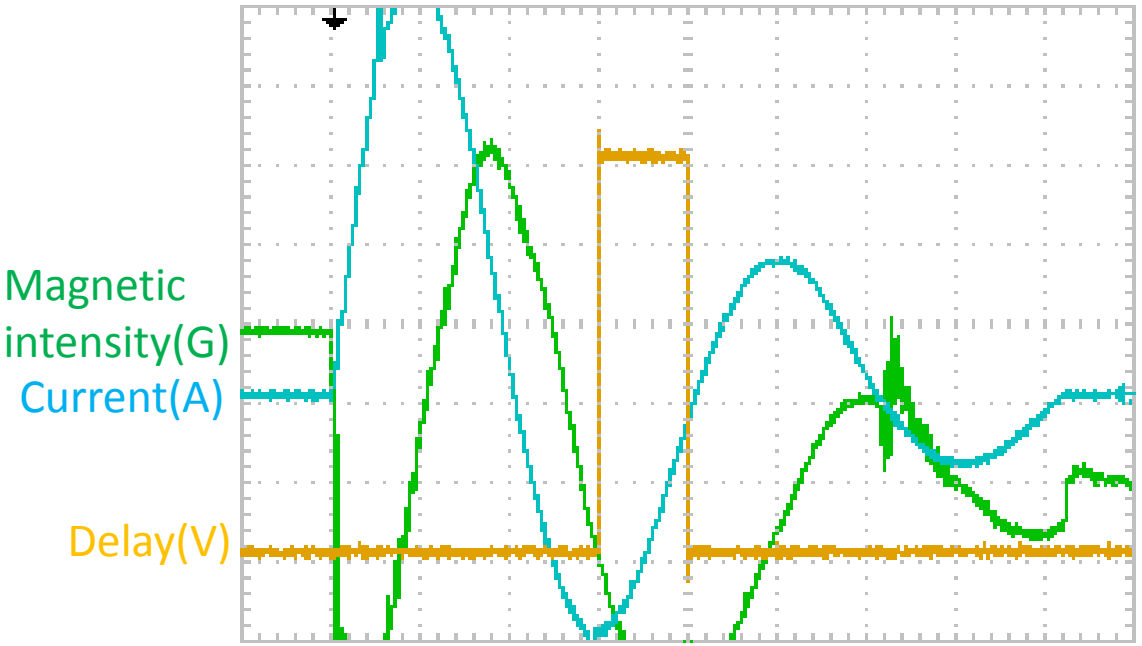
Continued…

Realized that the latching sensor wouldn't work

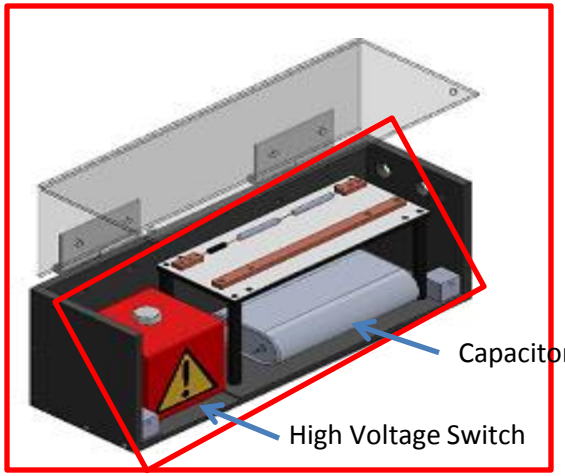
Decided to use a proportional magnetic sensor which outputs a signal proportional to the input magnetic field

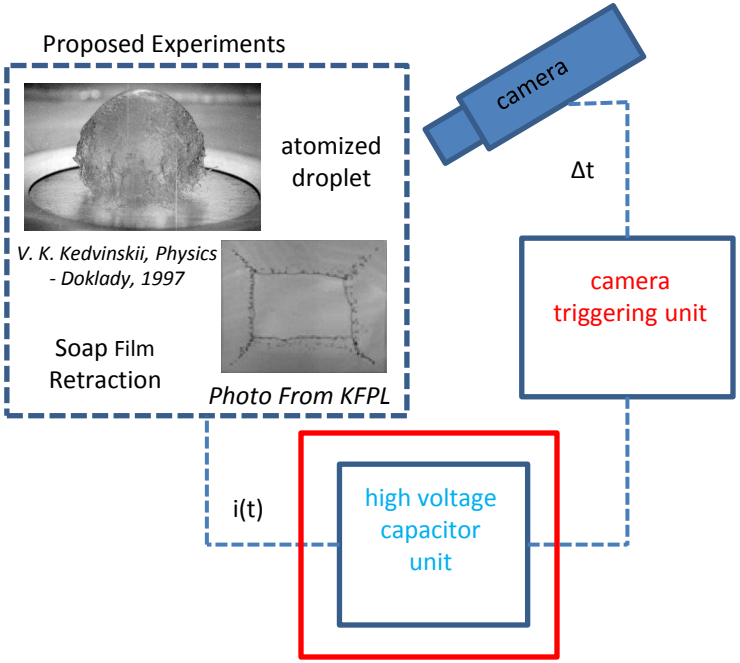
Using this we started to get a curve that was repeatable, and had a large enough magnitude to measure

Proportional Magnetic Sensor



What has been achieved

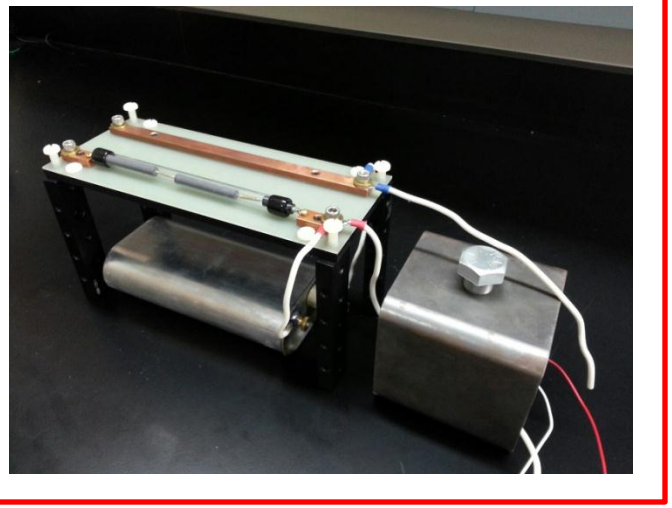




Designed the High voltage capacitor unit

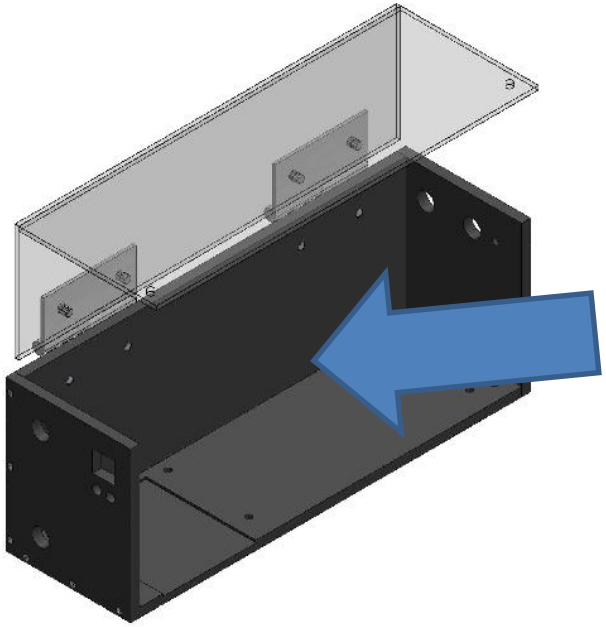
Built the circuitry, and components of the High voltage capacitor unit

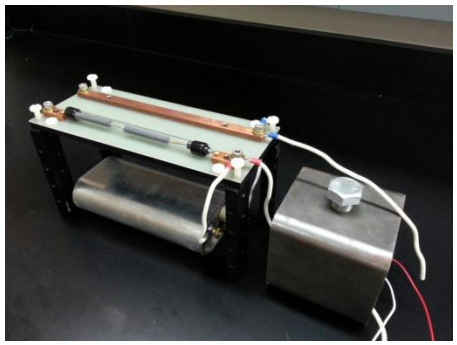
Tested magnetic sensors (~~Latching~~, ~~Switching~~, and Proportional)

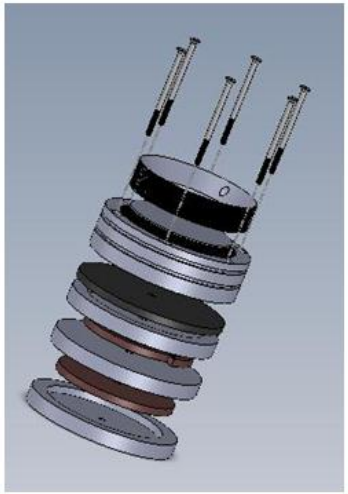


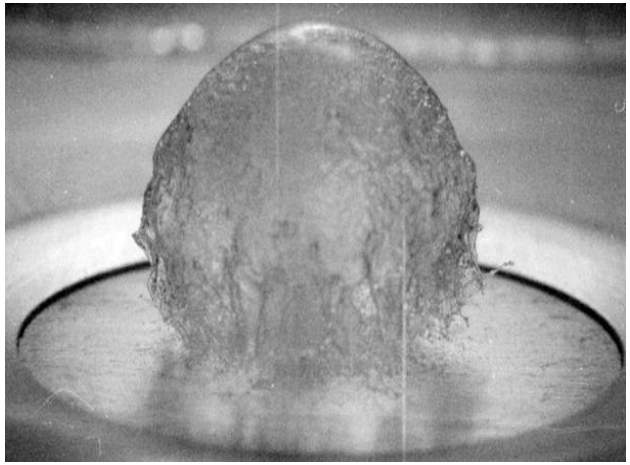
To do…

- build enclosure for the high voltage capacitor unit
  - safety feature.
- test high voltage capacitor unit with the coil/membrane assembly
  - Coil/membrane assembly atomizes the water droplet (made before this project)
  - Visible check to see atomization occurs
- take image sequence of atomization of the water droplet









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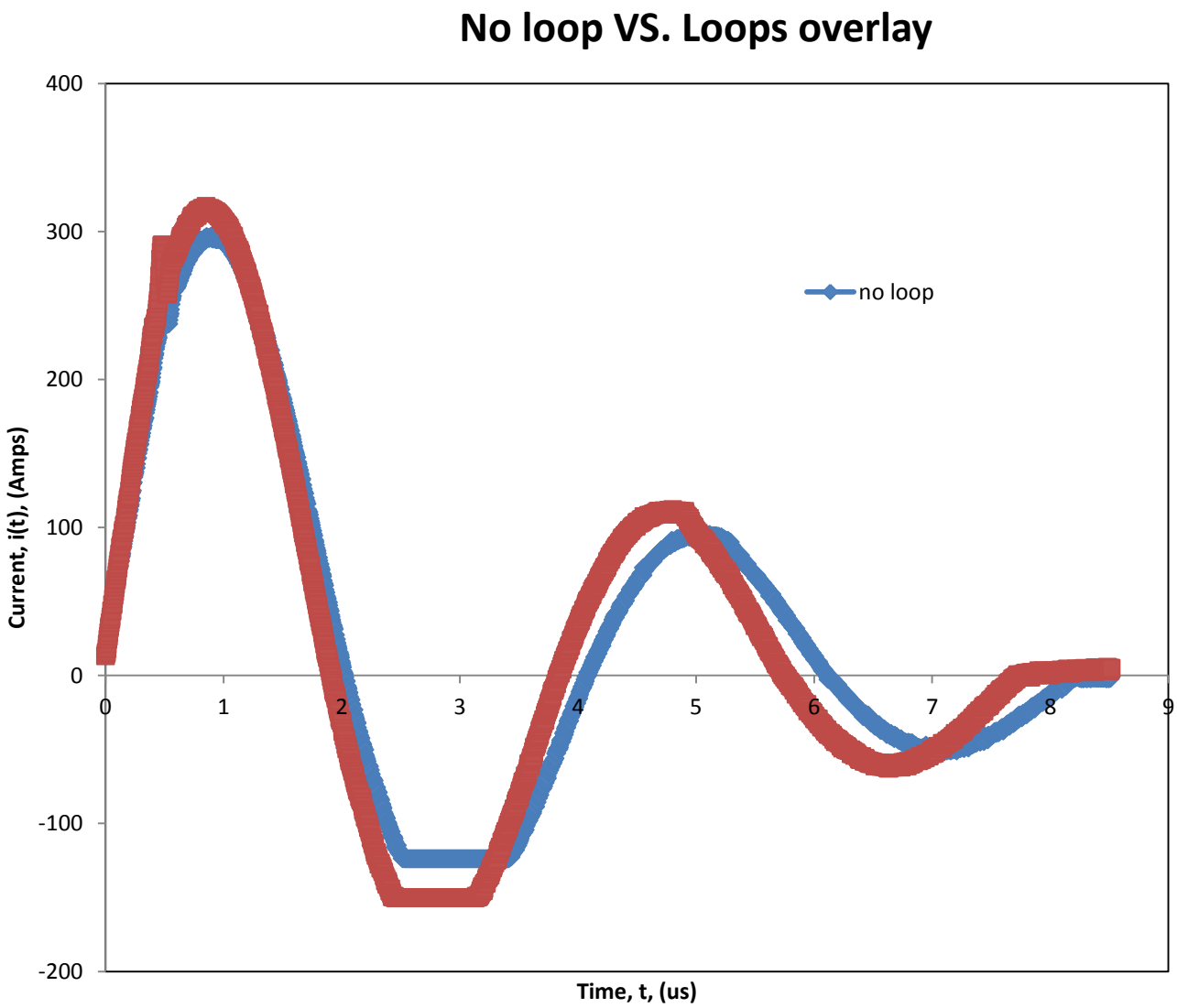
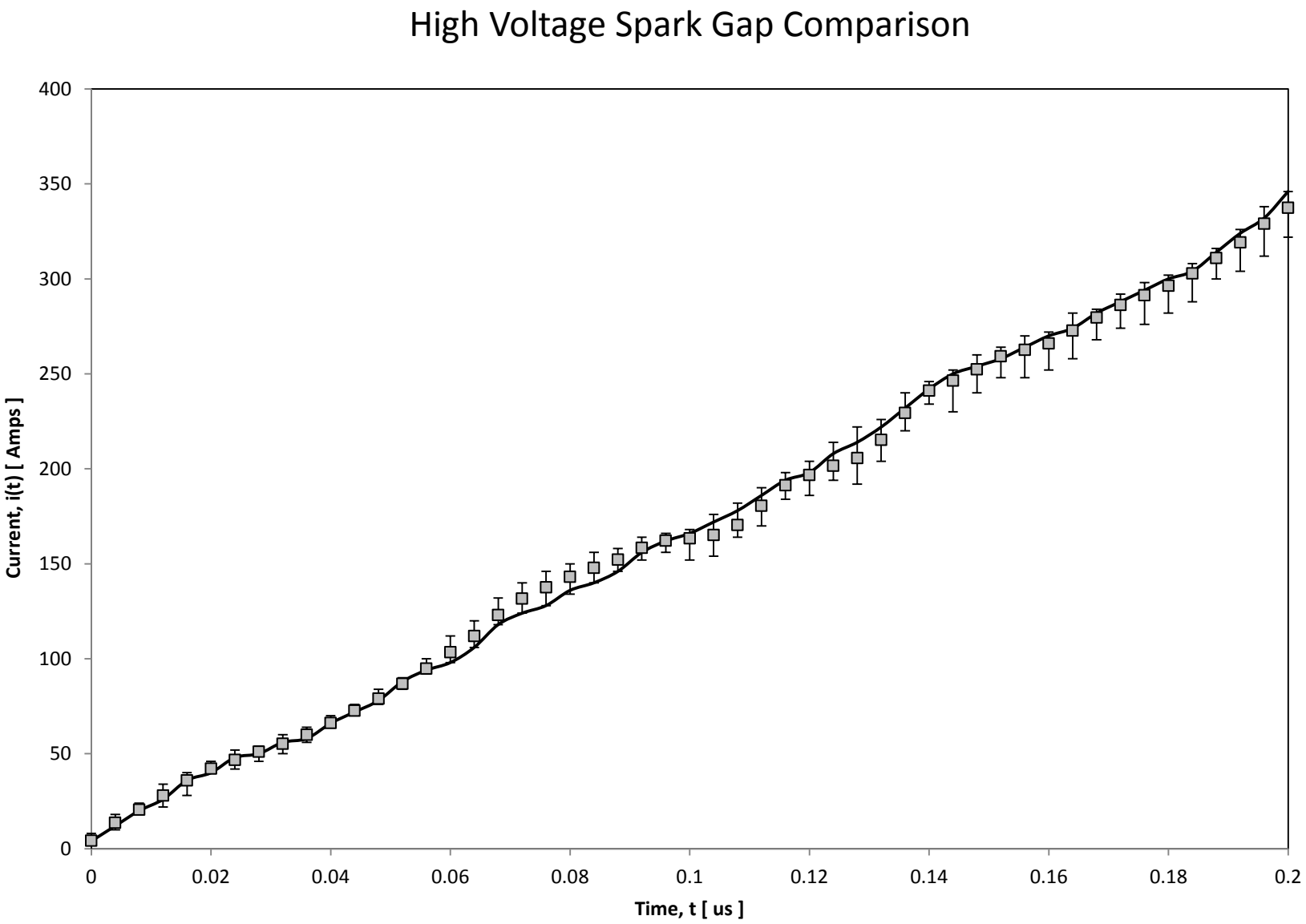
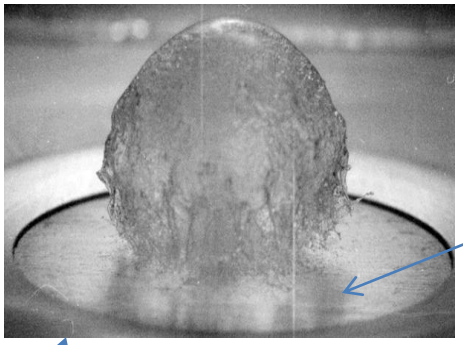
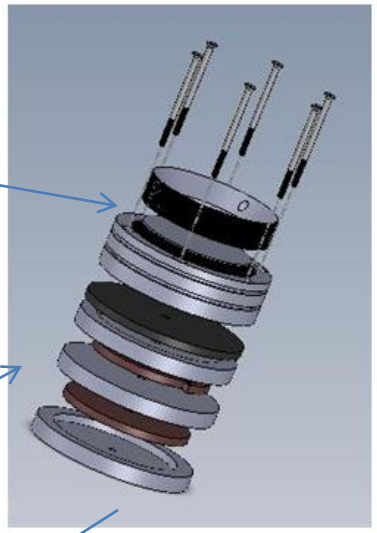
My family for helping me prepare for presentations, and giving me great insights throughout this internship.


No loop VS. Loops overlay
400
300
200
100
0
-100
-200
0
1
2
3
4
5
6
7
8
9
no loop
Current, i(t), (Amps)
Time, t, (us)

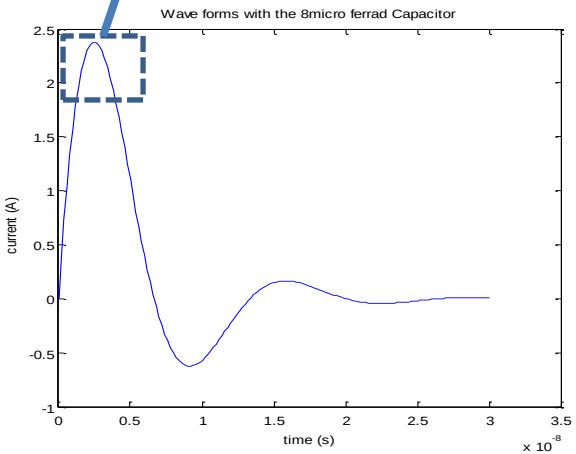

High Voltage Spark Gap Comparison
Current, i(t) [Amps]
400
350
300
250
200
150
100
50
0
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
Time, t [us]



membrane

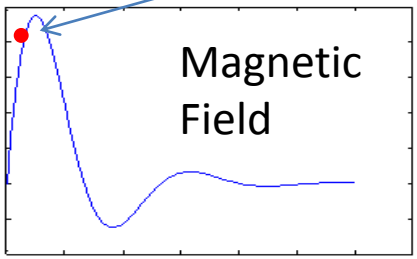


The current causes deflection



i(t)

Triggering point



Time Delay

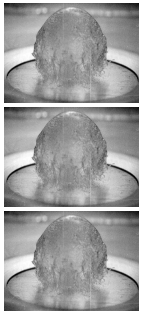


Image sequence