Simulation of the Propagation of Low Energy Electrons

Taylor Billington, Dr. Martin Centurion

Department of Physics & Astronomy, University of Nebraska–Lincoln

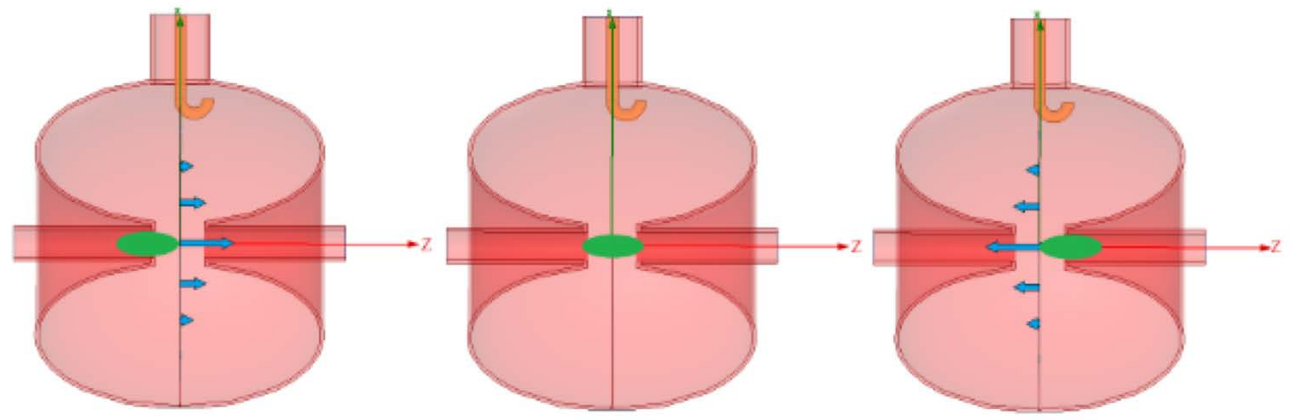
Introduction

When low energy electrons interact with molecules, they break them apart. The products of these interactions have been studied, but the physical process by which this occurs is not fully understood. With the use of ultrafast electron imaging, scientists can view these interactions and create "molecular movies." However, these molecular movies require a very short pulse to have a high enough resolution.

This study aims to develop an apparatus used to compress low energy electron pulses through the use of a radio-frequency cavity. The interactions of this pulse with molecules could then be studied with ultrafast electron imaging.

Background

- **Dissociative electron attachment**
  - Low energy electrons cause a degeneration of matter; the physical process is not fully understood
- **Ultrafast electron imaging**
  - Used to study in-between stages of reactions
  - Shorter pulses yield higher resolutions
- **Radio-frequency (RF) cavity**
  - Contains oscillating electric field
  - Expected use: to compress electron pulse



[1] O. Zandi, K.J. Wilkin, Y. Xiong, and M. Centurion, Structural Dynamics **4**, 044022 (2017).

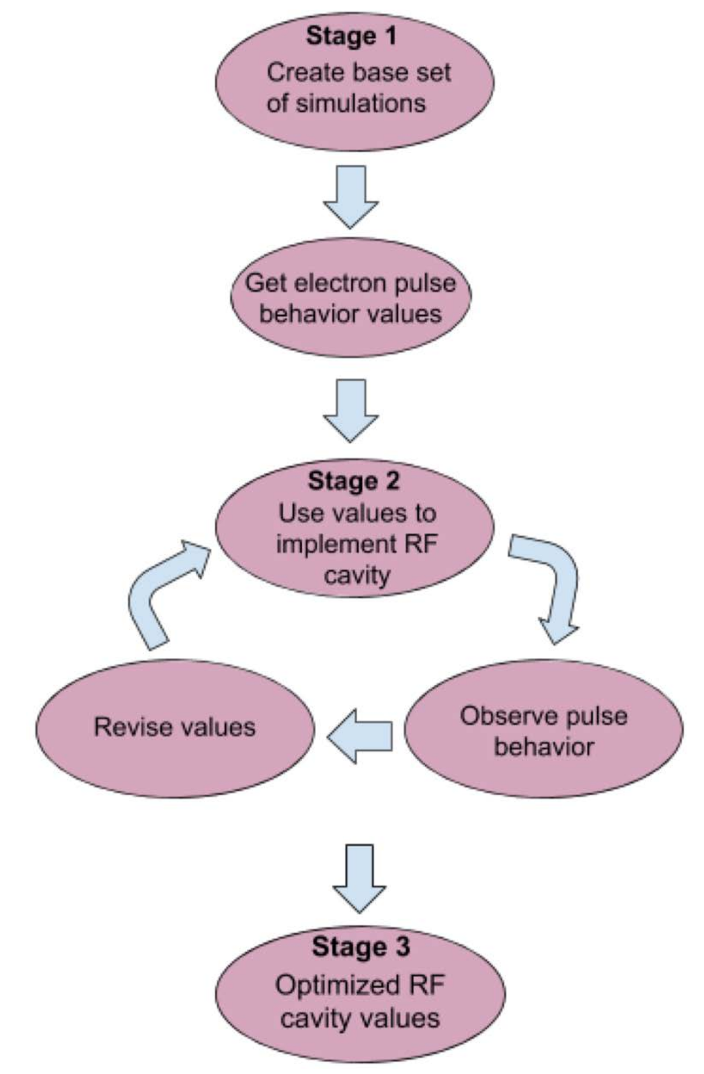
Purpose

- Use simulations to find:
  - Optimal amount of electrons per pulse
  - Best position of radiofrequency cavity
  - Amplitude and phase of field inside RF cavity
  - Position where beam is most compressed to place sample of molecules
- Develop device capable of producing short, low energy electron pulses
  - Will allow the use of ultrafast electron imaging to study reaction with matter

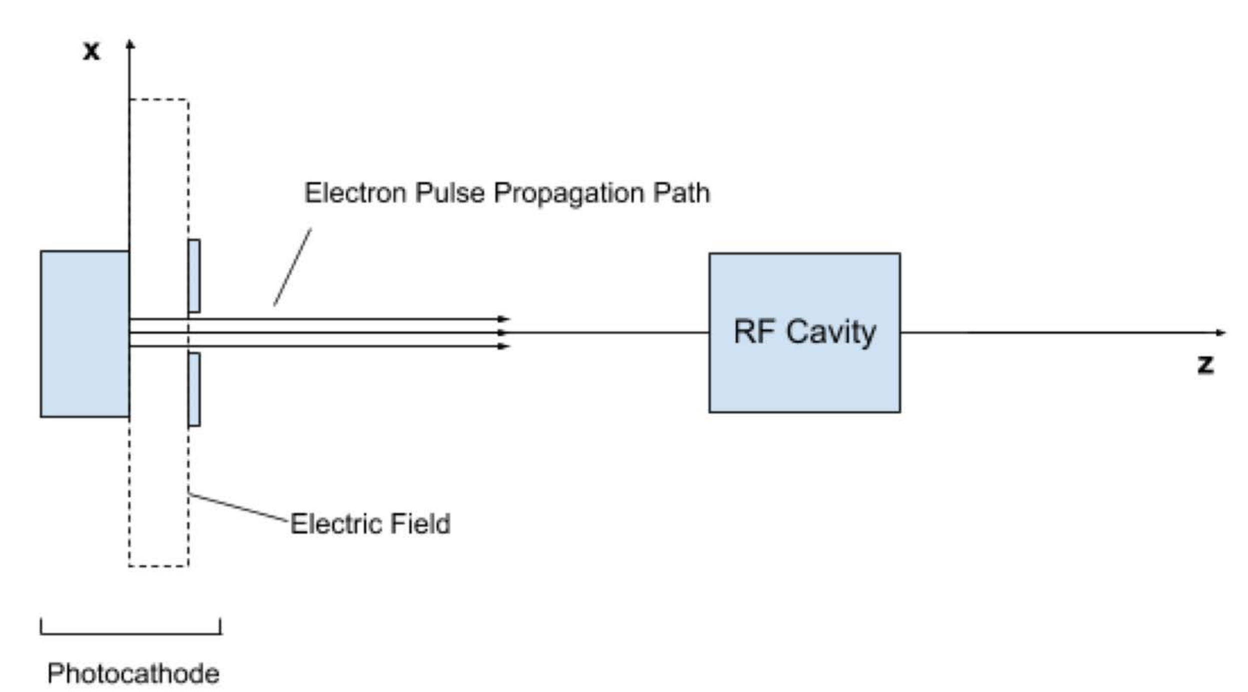
Materials & Methods

General Particle Tracer (GPT)
- Code used to simulate particle behavior

Flow of Testing



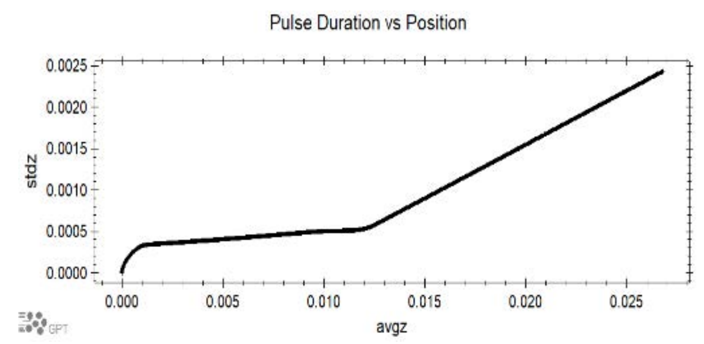
Simulation Setup



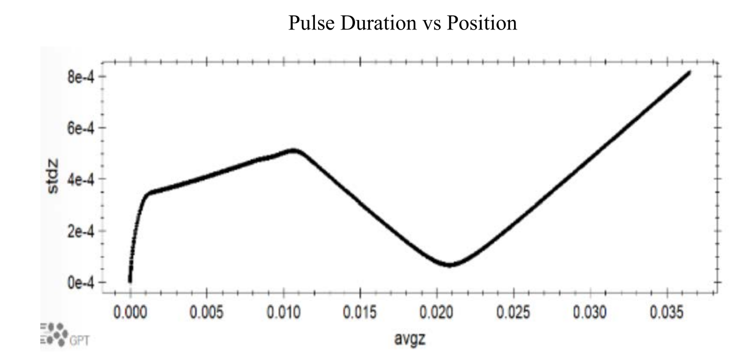
Results

Experimental setup parameters
- **Electron Pulse**
  - Amount of electrons: **100,000***
  - Starting energy: **0.2eV**
  - Length of photocathode: **1 mm**
- **RF**
  - Position on z axis: **1 cm**
  - Length: **2 cm**
  - Radius: **1.149 m***
  - Amplitude of field: **9334 V/m***(after preliminary calculations)
  - Phase of field: **-2.480***(after preliminary calculations)

Expected experimental outcome
- Starting pulse length: **15 fs**
- Pulse length before RF cavity: **2 mm**
- Minimum pulse length after RF cavity: **-***



Current Graph



Optimized Graph
(correct parameters not yet found)

***Indicates values will change with further optimization testing**

Summary

Conclusions
- Pulse can be compressed with RF cavity
- Parameters identified to build experimental setup

Future Work
- Build apparatus
- Make molecular movies of reactions

Acknowledgements

- Dr. Martin Centurion, UNL Faculty Mentor
- Kyle Wilkin, UNL Graduate Mentor
- UNL McNair Scholars Program

MCNAIR SCHOLARS PROGRAM