The life of a box: Spark chamber design and optimization

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Introduction

Spark chambers, once at the forefront of particle physics research, have since shifted their focus to education. Paramount to the design of an efficient spark chamber is ensuring that it triggers on muons, and only muons. Among other things, this must take into consideration gas flow and edge sparking, as well as the design of the particle-identifying scintillation counters above and below the chamber. Construction and thorough testing of a prototype chamber factored largely in determining what to implement and improve upon in the final design.

What is a spark chamber?

- A set of metal plates a fixed distance apart from each other, held alternatingly at high and low potentials to spark on and "capture" the track of a throughgoing particle
- An insulated box bounded above and below by photon-emitting scintillators that send signals to coincidence and high voltage circuits to trigger sparks between plates
- A demonstration device highlighting the prevalence of physics all around us!

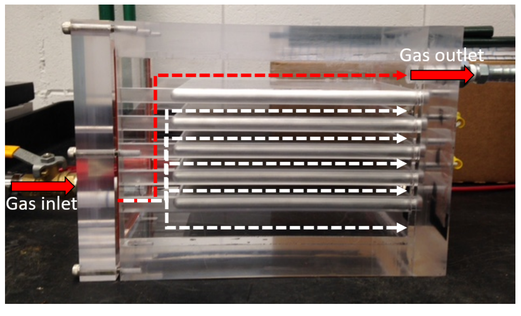

Figure 1: Gas flow diagram of our test box. White denotes "dead ends -" though gas may flow into these gaps, air has no way of exiting the chamber, as the O-ring screws provide a nearly perfect seal.

A big thank you to Evan Angelico, Young-Kee Kim, Mark Chantell, Mark Oreglia, and Luigi Mazzenga for all their support throughout this project!

Finalized Design

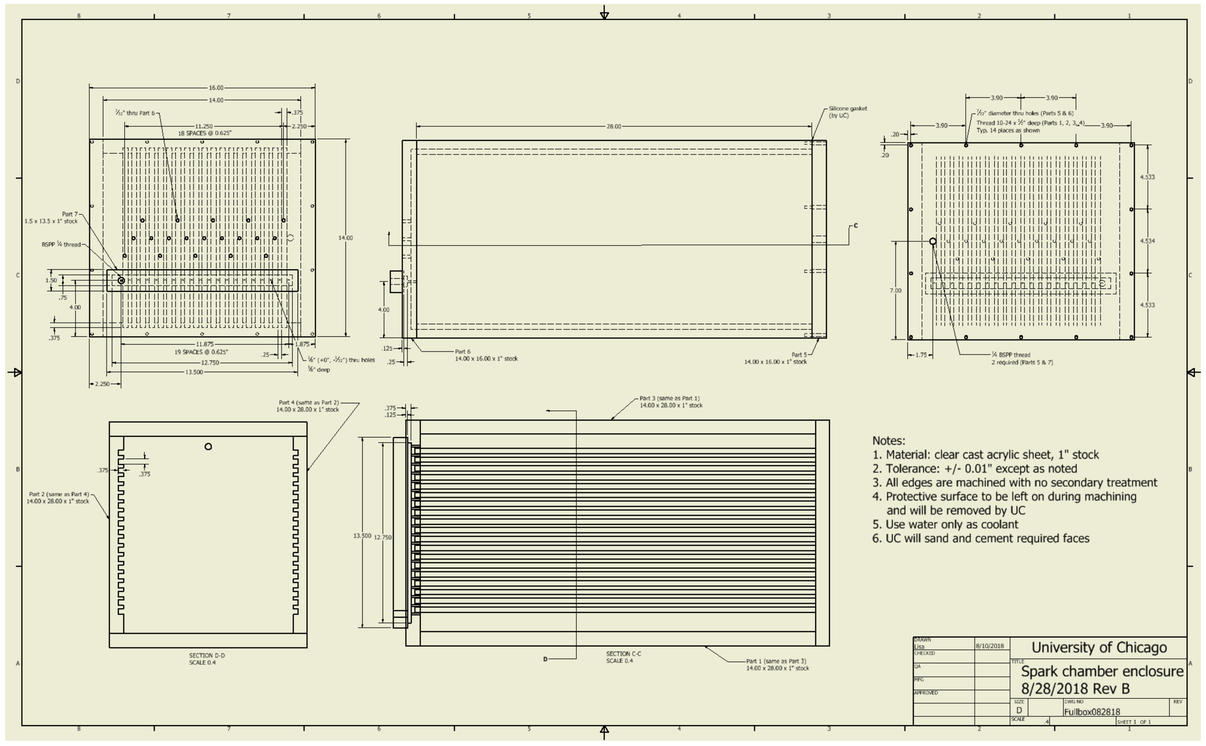

Figure 2: The final assembly CAD for the full-size chamber.

Gas Flow

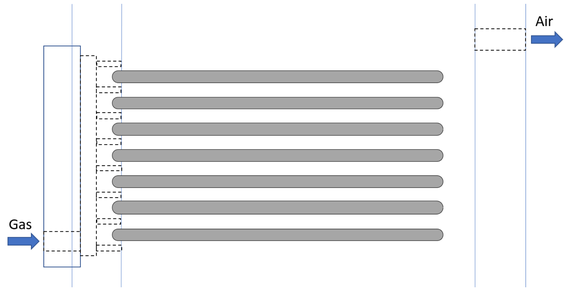

Figure 3: The gas flow schematic for the full chamber. Gas enters through a hole in the gas manifold and flows to all gaps between plates via smaller gas inlets in the back face. Air can then be pushed out through the gas outlet on the front face.

Edge Sparking

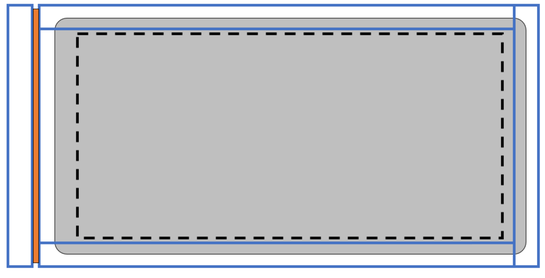

Figure 4: A bird's eye view of the chamber. Rounded aluminum plates are embedded in three of four acrylic (blue) sides; the fourth accounts for O-ring (orange) compression. Black dashed line marks the scintillator-imposed fiducial volume.

Assembling the counters

Figure 5: (Left-to-right) Visible ring of rubber glue on PMT lens before scraping; after scraping; scintillator, before polishing; after polishing with 600, 800, and 1200 grit sandpaper.

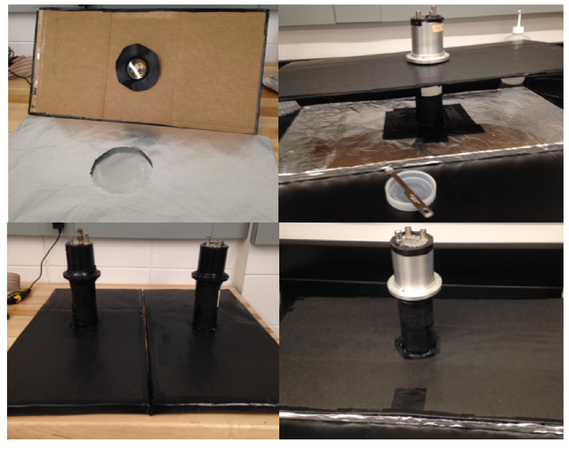

Figure 6: (Left-to-right) The PMT is insulated from contact with foil by a rubber ring, while cardboard helps keep it in place; the PMT is taped down after applying optical cement, and any visible scintillator covered; keeping the edges of the black cardboard just shy of the scintillator edges ensures good contact with the black tape used to seal the assembly; final assembly.