Detecting Cherenkov Radiation in an Acrylic Strip

Josh H-K, F. Henry Sottrel, Ben Turner | Carleton College Department of Physics, Northfield MN 55057

What is Cherenkov Radiation?

Cherenkov radiation is light emitted when a charged particle travels faster than the speed of light in a given medium. The intensity of the emitted light increases with greater particle energy or index of refraction.

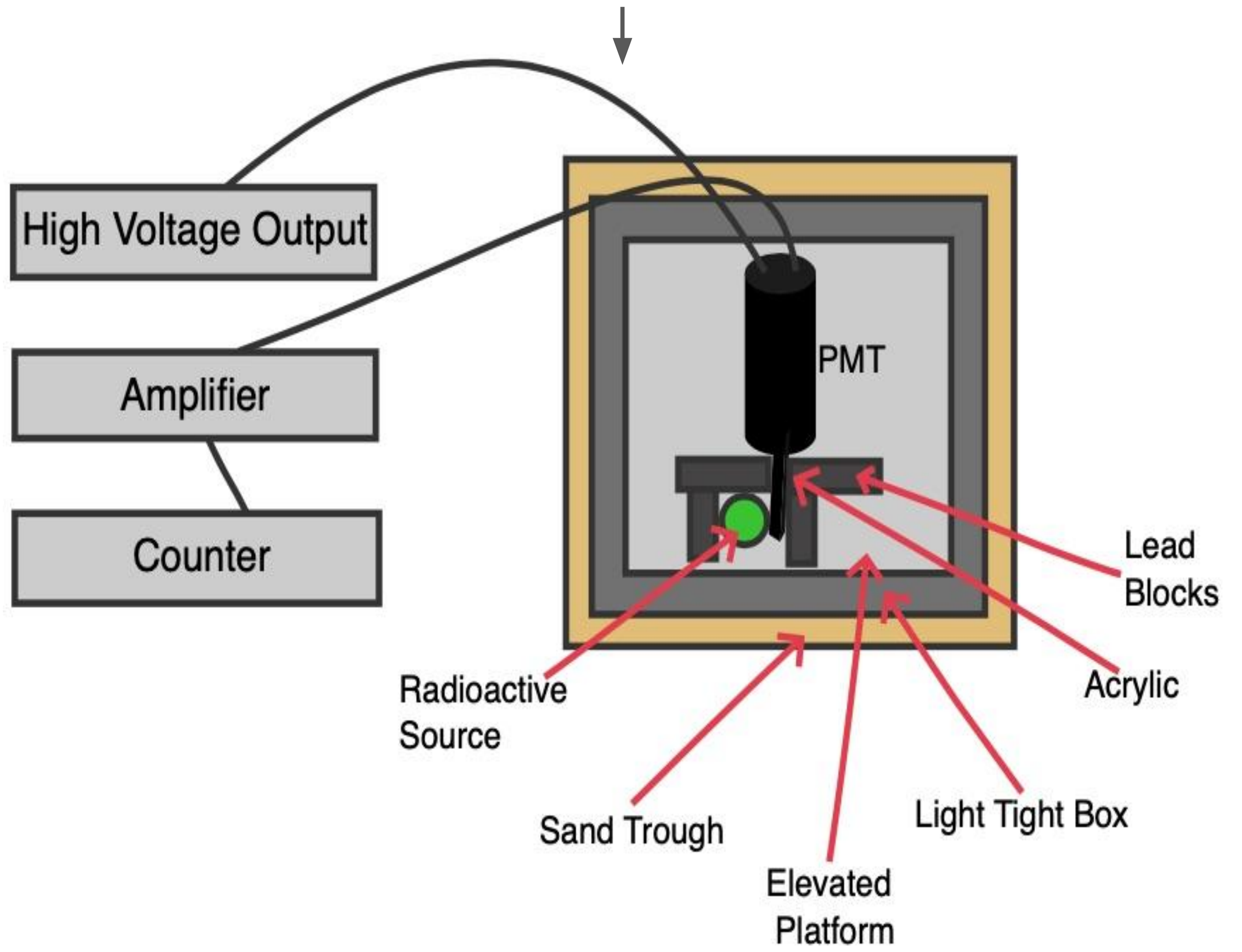
Experimental Goals

We aim to measure photons emitted via Cherenkov radiation as high-energy electrons pass through an acrylic strip (n=1.5). A radioactive sample acts as a source of high-energy electrons, and a photomultiplier tube (PMT) counts photons emitted in the strip.

Our System

We use multiple features (sand and box) to limit background noise.

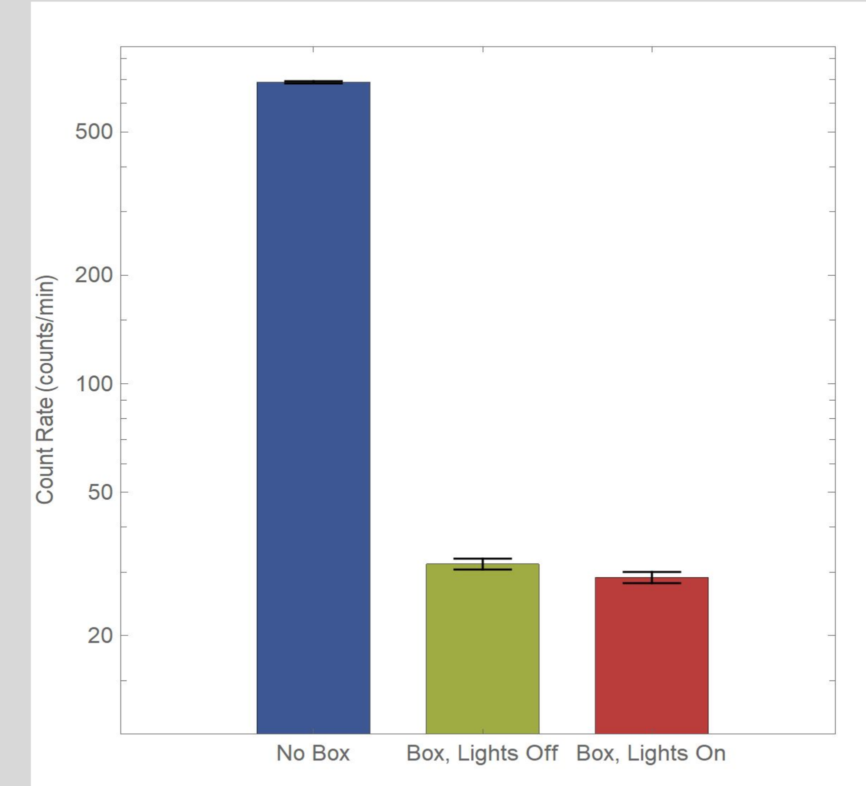
The photons produced in the acrylic induce a voltage spike from the PMT which is amplified and counted.



Our apparatus, which aims to detect Cherenkov radiation produced by electrons from a Co-60 source as they pass through an acrylic strip. Viewed from above. The light-tight box goes over the PMT and source.

Light-Tight Box Testing

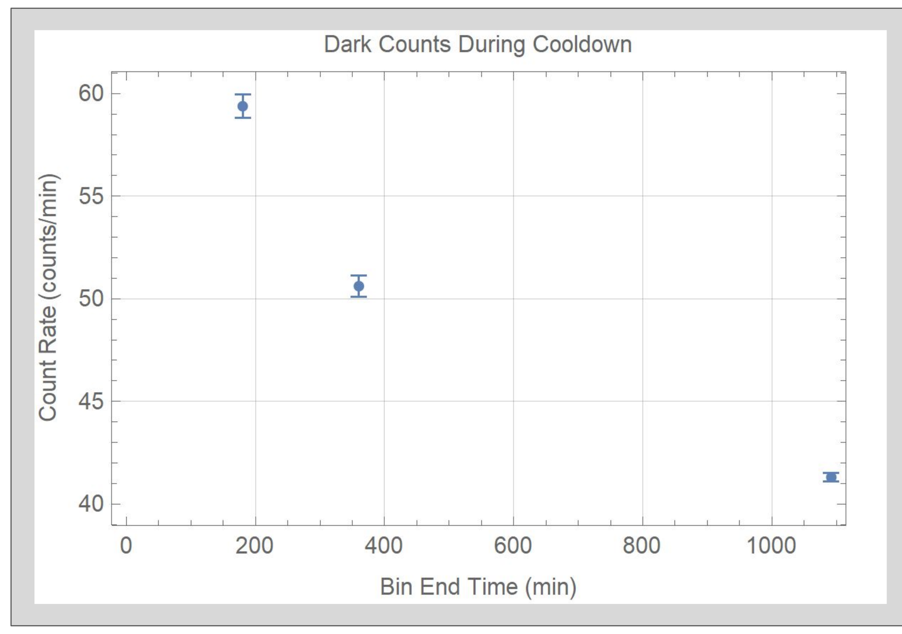
- Need to protect PMT from ambient light
- PMT covered by a box wrapped in black tape
- Lead bricks in front of the PMT also block radiation
- Box is effective enough that there is no significant increase in counts when the lights are turned on.



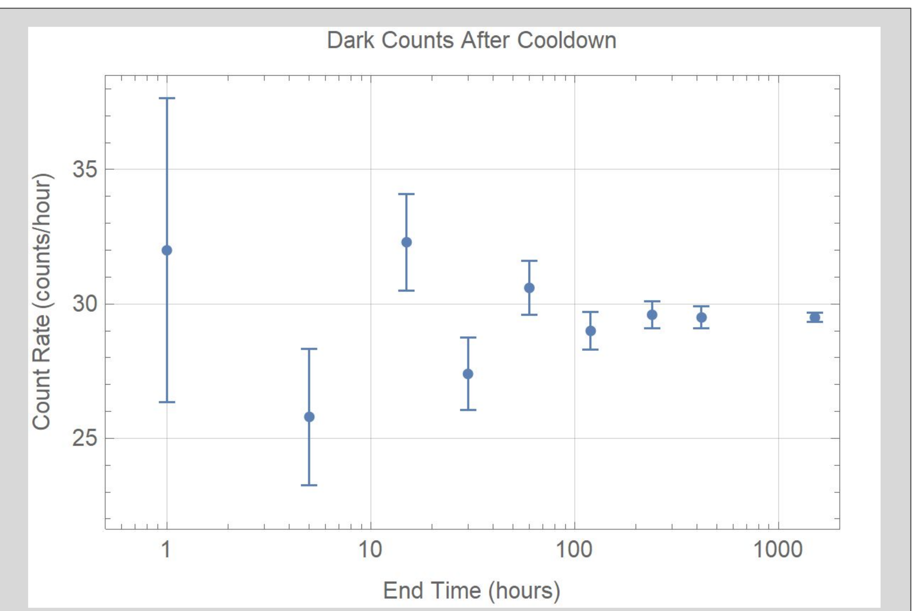
Counts over a 5 minute period for different environmental circumstances.

PMT Cooldown Time

- PMT has a 'cooldown' time after exposure to light
- Count rates are higher during cooldown.
- Measured dark counts after light exposure, and again after isolating the PMT from light for 24 hours.

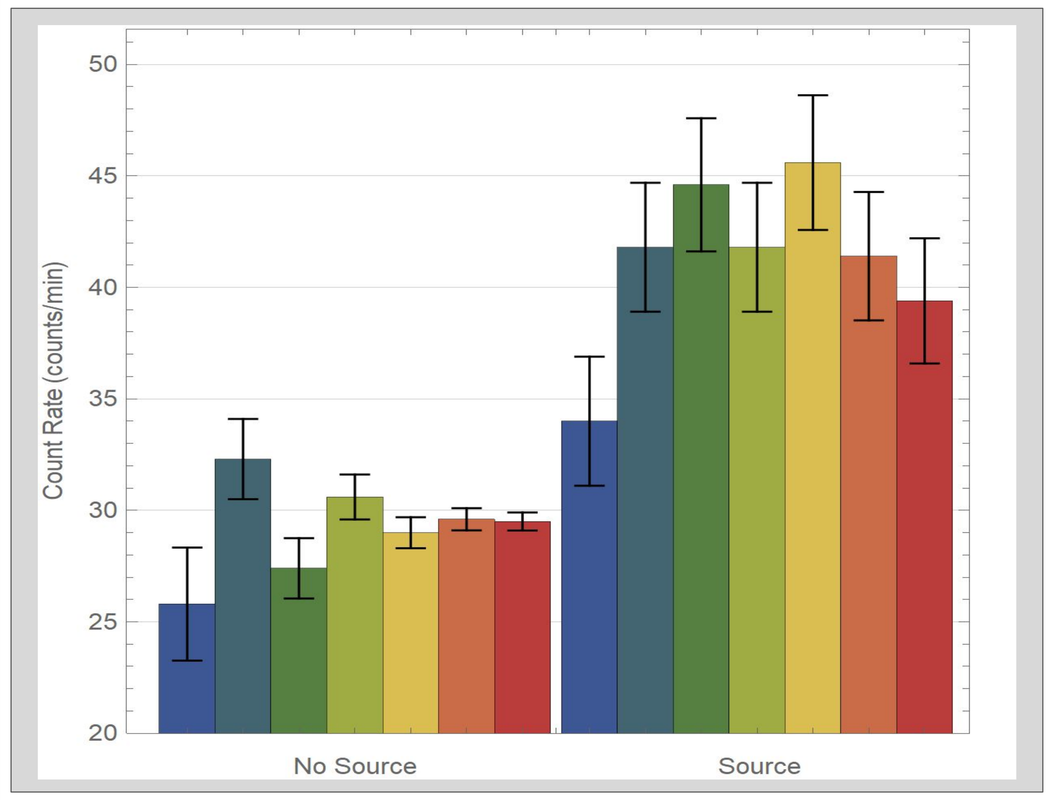


During the cooldown, the rate decreases exponentially to a limit.



After the cooldown, all variance is due to random variance in count numbers. Note the logarithmic time axis.

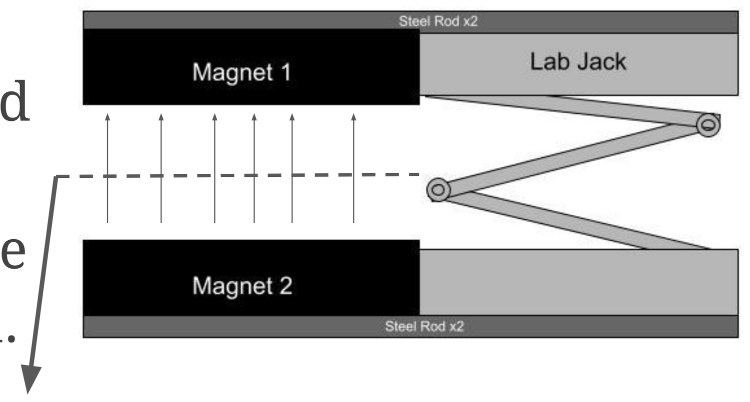
Early Results



- Measured counts for a number of bins, some with no source and some with a Co-60 source.
- Each bar represents one bin.
- Smaller uncertainties on some bins are due to variations in bin length.
- Difference between source/no source is likely due to Cherenkov radiation.

Beam-line Construction

- Two magnets produce a nearly-uniform field.
- Field bends particles based on their energy.
- Field strength is adjustable with change in separation.



83	104	103	105	88	
97	121	121	121	104	Lab Jack Side
92	122	123	122	102	
72	92	92	92	77	

Heatmap of the measured magnetic field strength (in milliteslas) at the center of a number of regions, at the midpoint between the magnets. The dimensions of the plane are (10.1 x 15.4)cm.

What's next?

- Integrate the beam line
  - ↳ adjust the energy of incident electrons
- More tests with longer bin lengths
  - ↳ confirm observation of Cherenkov radiation
- Add embedded sapphire lens (n=1.77)
  - ↳ test if it increases the count rate
- Integrate another PMT with a scintillator
  - ↳ measure coincidences between the two to distinguish between dark and 'real' counts

Acknowledgements

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References

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