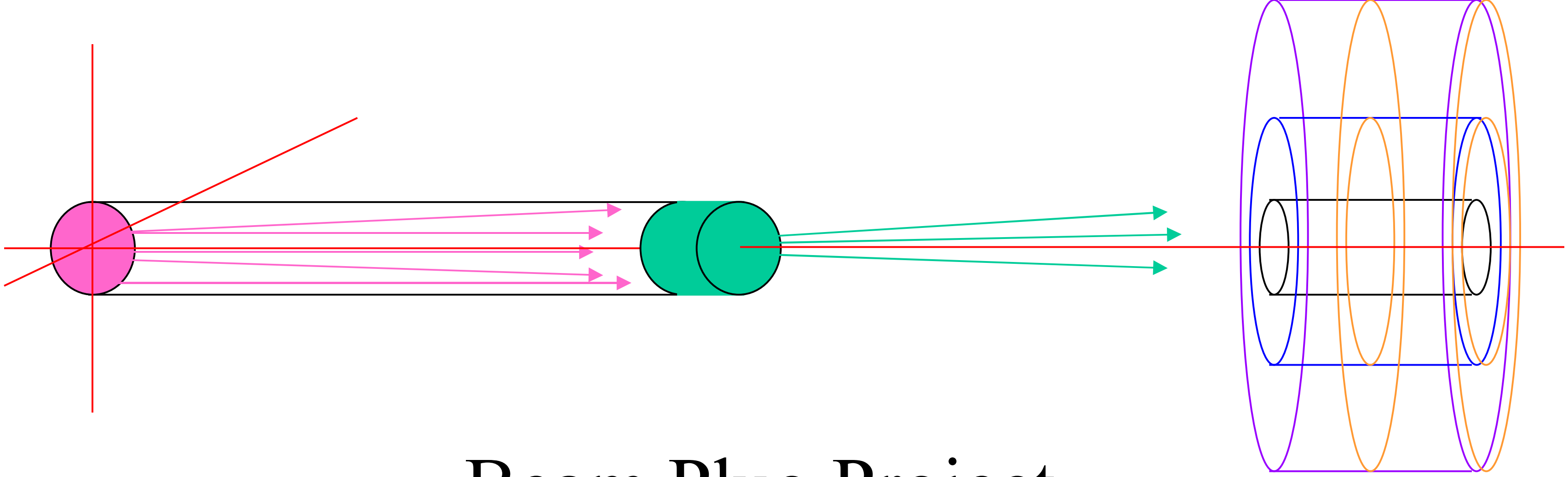
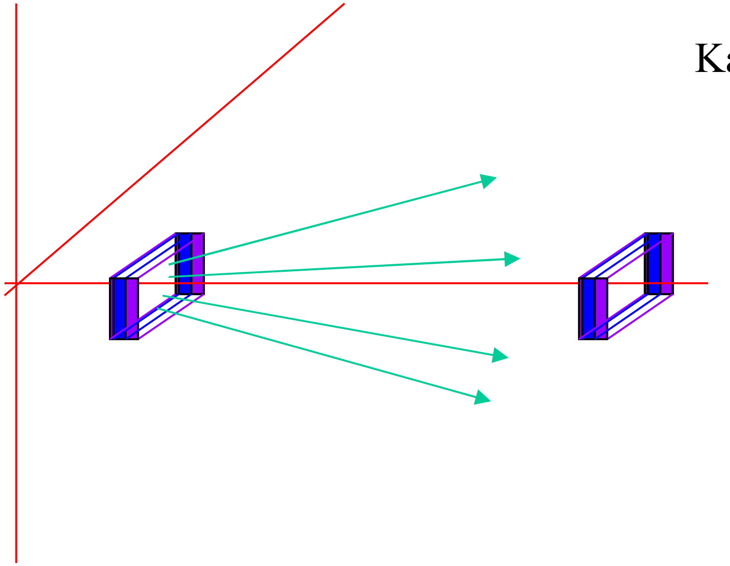
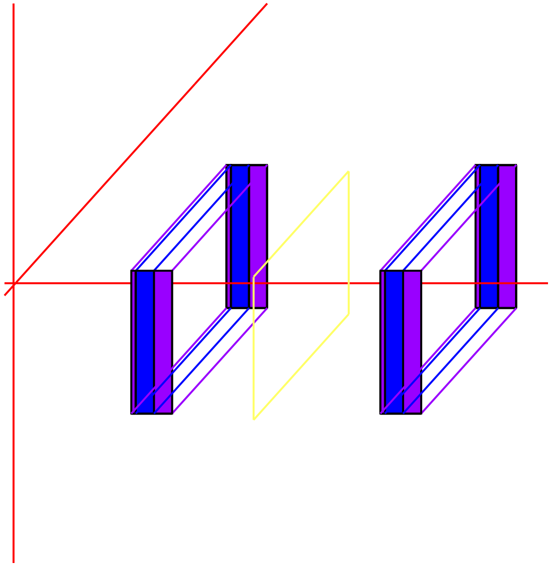


Beam Plug Project
and
Second Chip Project

Kathryn D. Huff





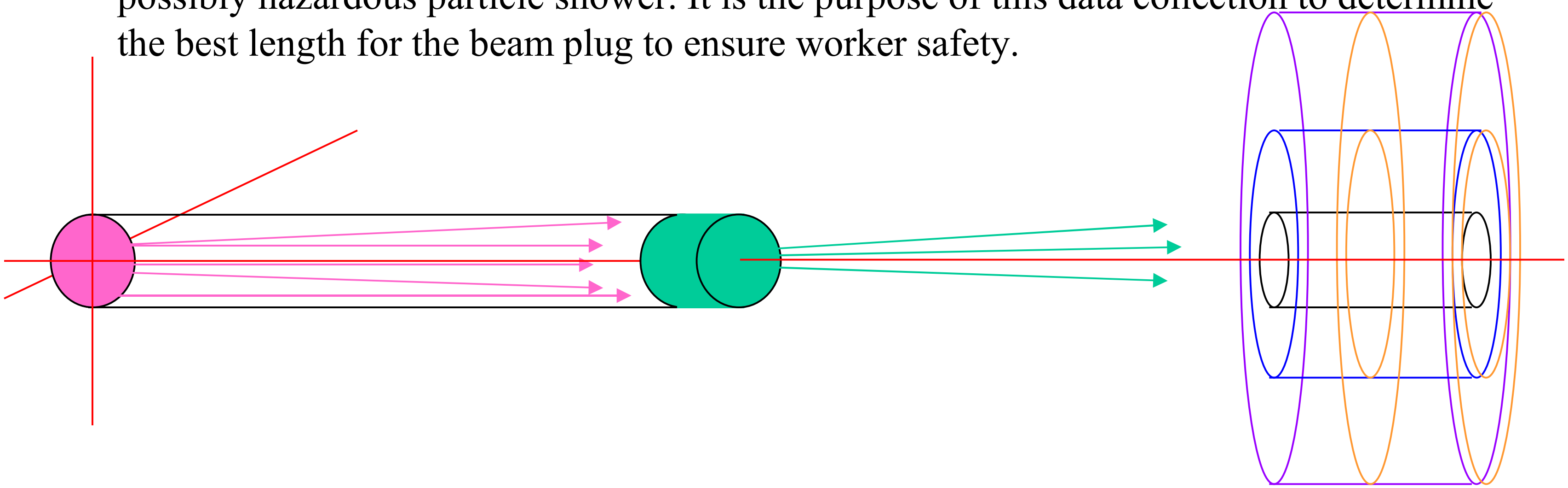
Beam Plug Project

Charles Kelsey was asked to run an idealized 800MeV proton beam plug situation.

The description was like this:

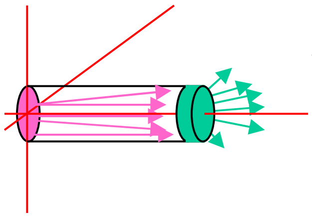
- Calculate charged particle flux and REM in 15cm aperture 10m downstream of a stainless steel plug with 1.0, 1.09, 1.19, 1.41, and 2 topping lengths. (Stopping Length is defined by the NIST-supported program PSTAR which claims the mean total stopping length of 800 MeV protons in iron is 335.5 g/cm^2.)
- Calculate the REM nearby (30cm radius) if residual flux hits Cu block placed in the aperture.

* This case represents a situation in which the beam pipe is closed but someone is working nearby when residual flux comes through the beam plug and hits the Cu block, causing a possibly hazardous particle shower. It is the purpose of this data collection to determine the best length for the beam plug to ensure worker safety.

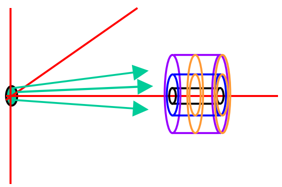


The Plan

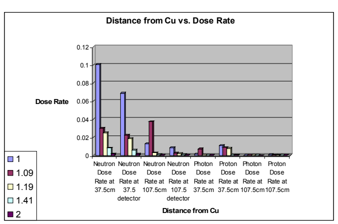
Basically, there are three steps to this plan.



2. Run simulations of just the protons hitting the beam plug at each stopping length, and detect the particles that make it through the beam plug.

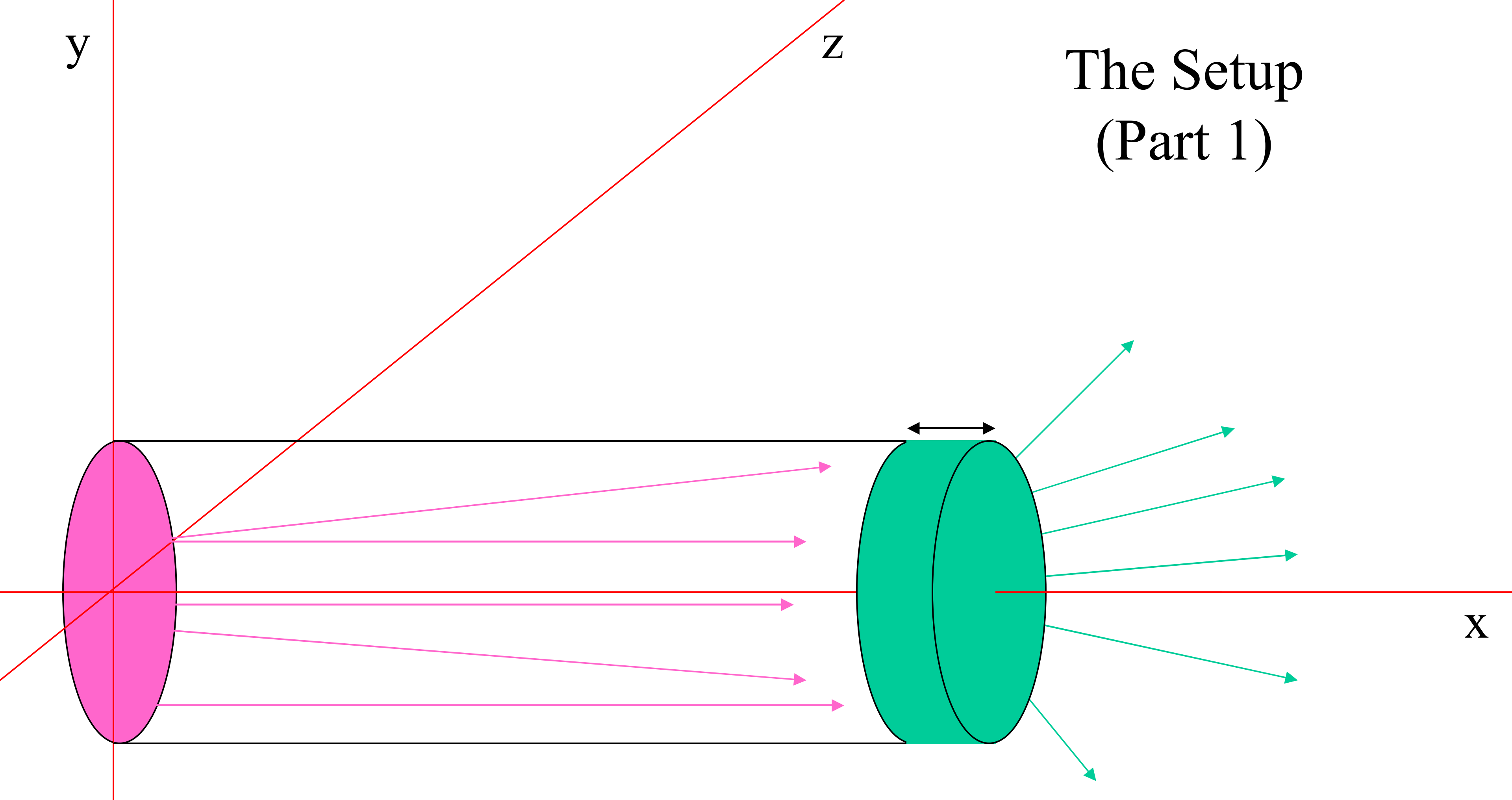


5. Set up a simulation in which there is only a Cu block and a source 10m away pointed straight at it and run this second simulation five times with different source definitions characteristic of the residual particles detected for each stopping length.



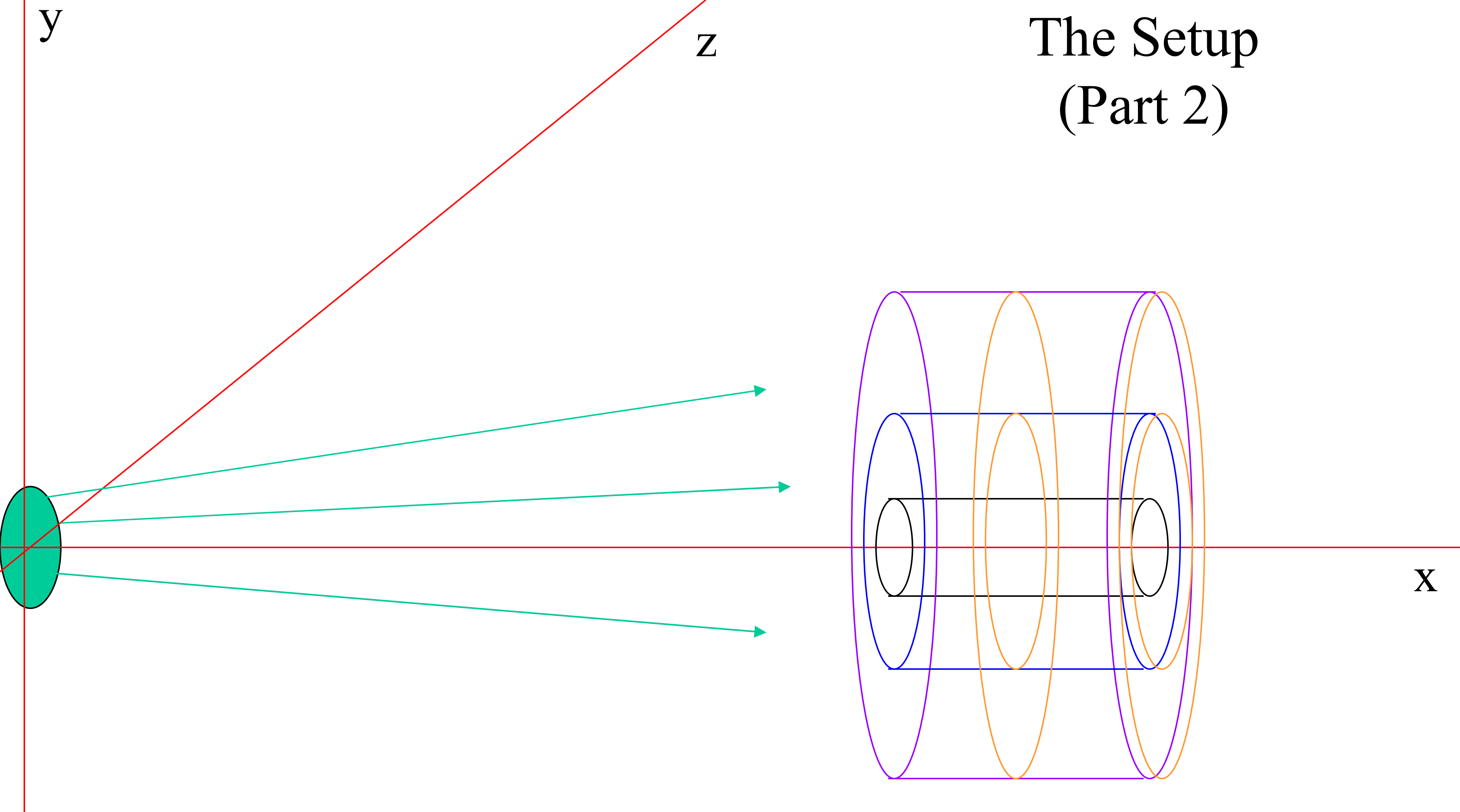
8. Analyze the data into graphical format to return to the requester.

The Setup (Part 1)



1. Run simulations of just the protons hitting the beam plug at each stopping length, and detect the particles that make it through the beam plug.

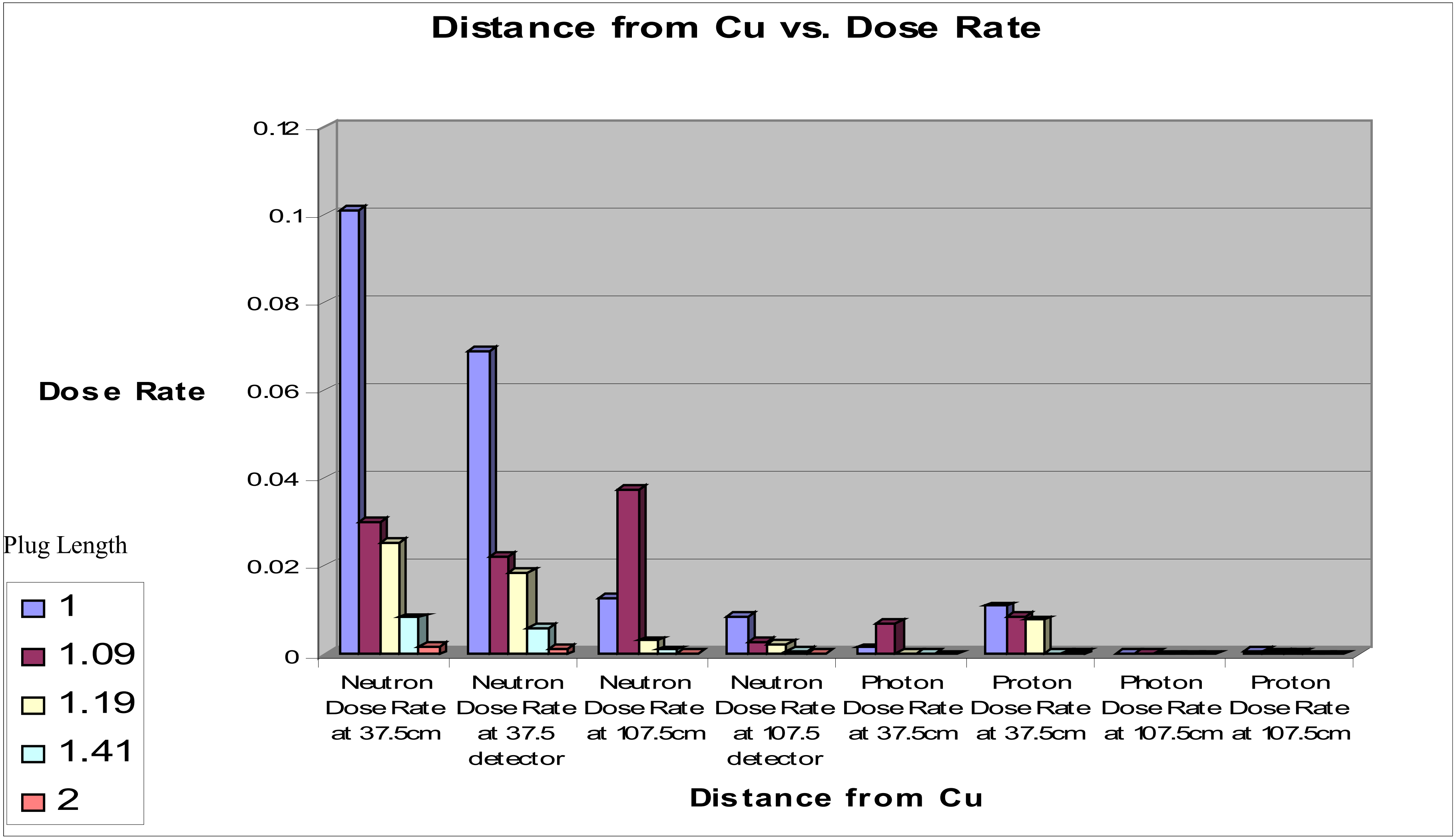
The Setup (Part 2)



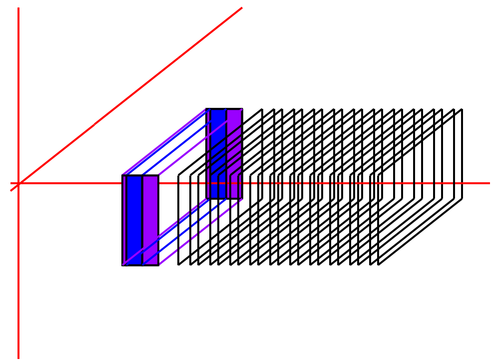
2. Set up a simulation in which there is only a Cu block and a source 10m away pointed straight at it and run this second simulation five times with different source definitions characteristic of the residual particles detected for each stopping length.

Results of Final Calculations

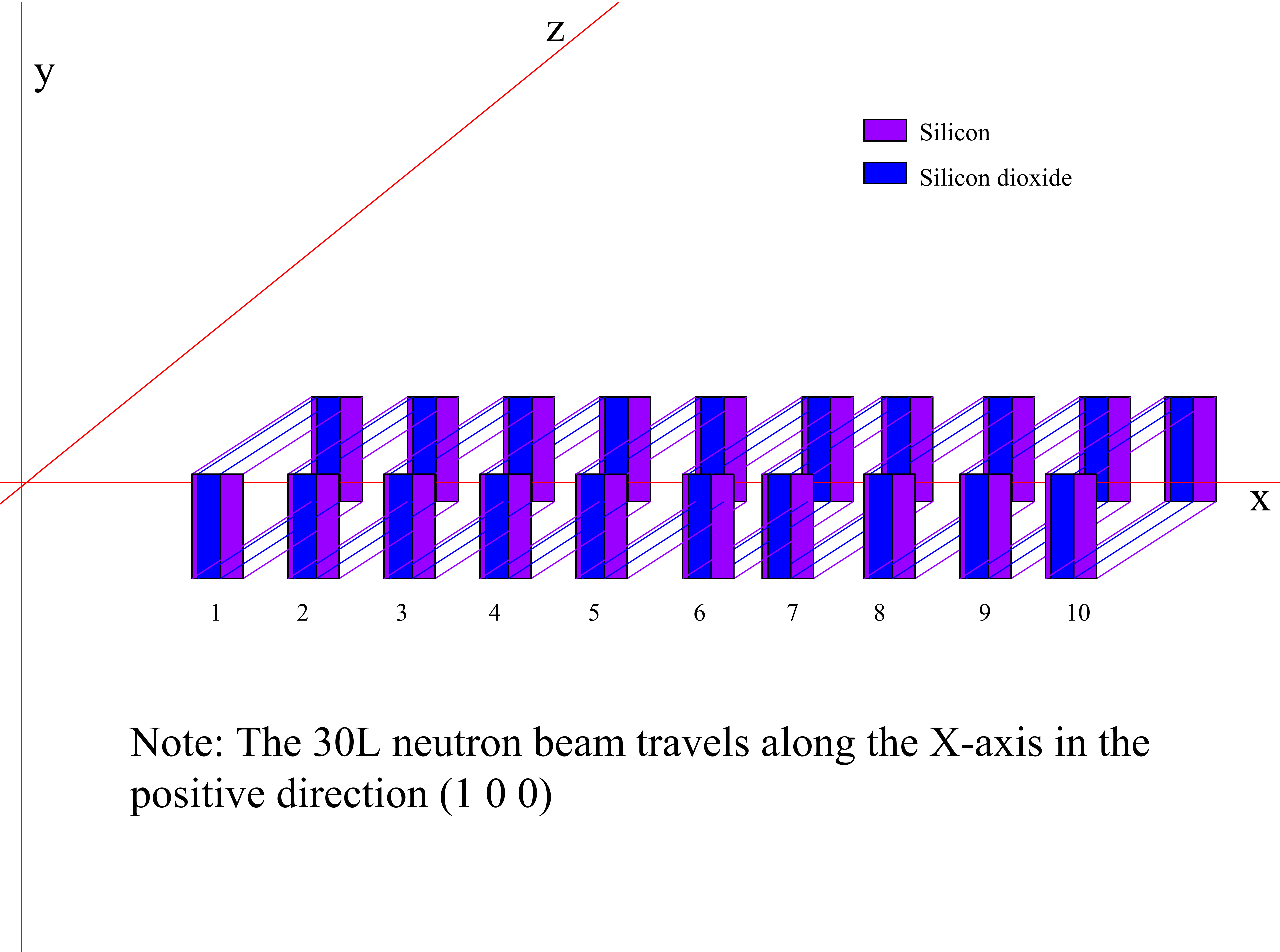
2. Analyze the data and put it into graphical format to return to the requester.



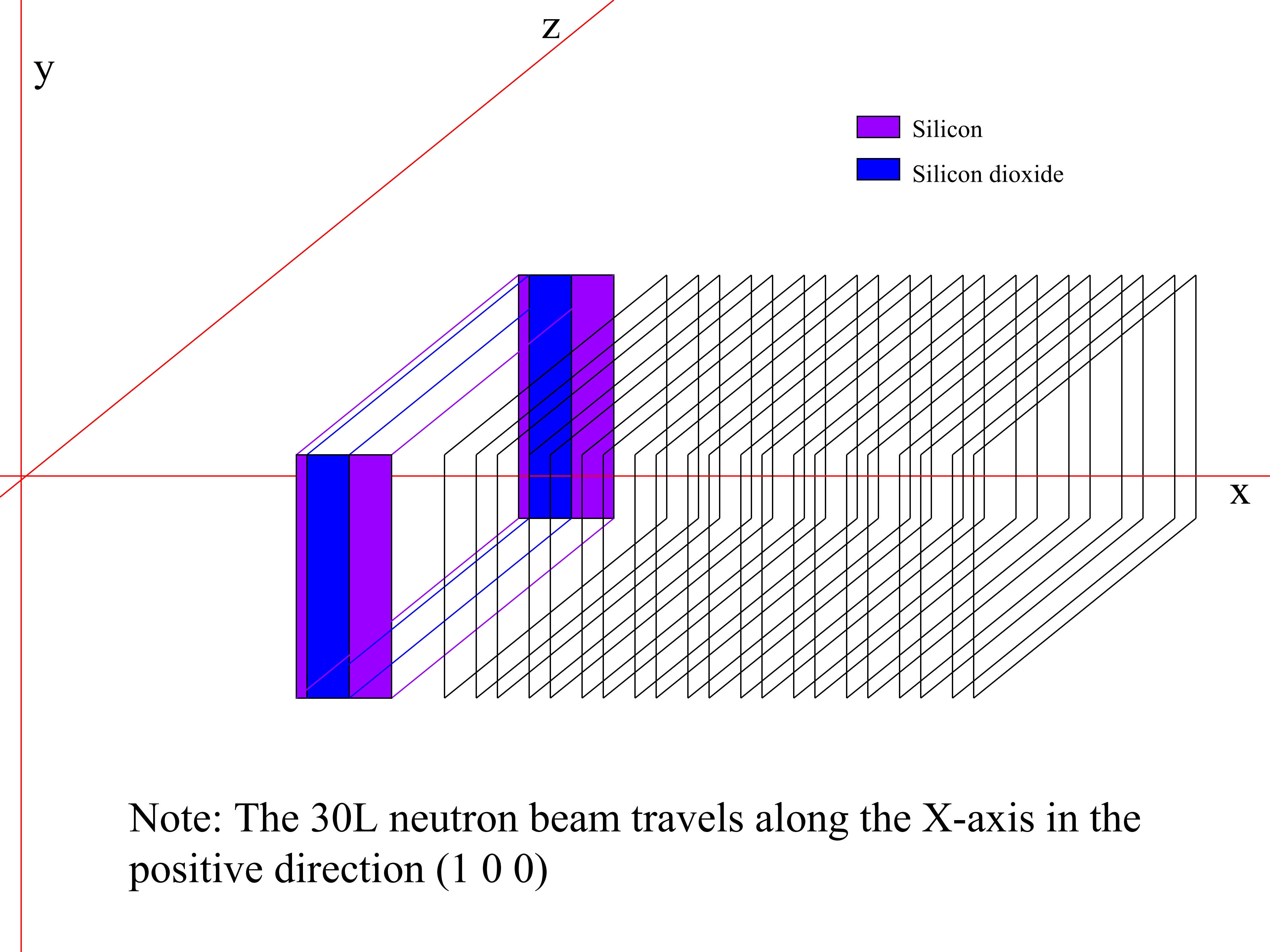
The Second Chip Project



Simulation of the situation surrounding Excess Single Event Effects in the second computer chip of a series, and possible solutions to the problem.



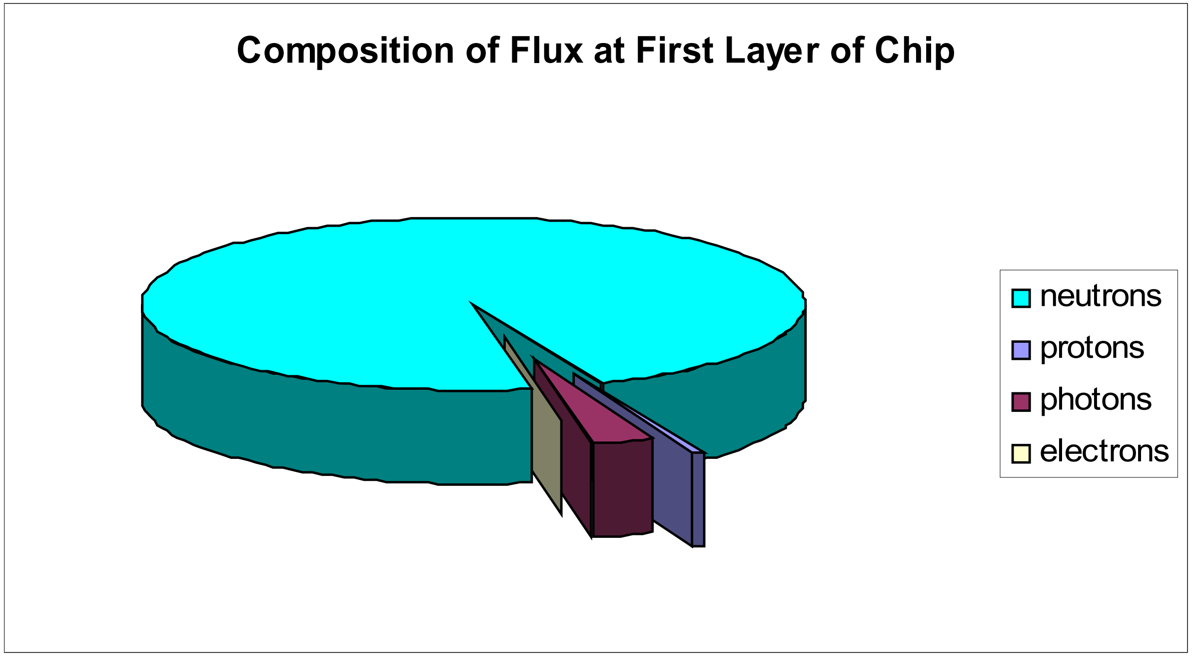
Note: The 30L neutron beam travels along the X-axis in the positive direction (1 0 0)



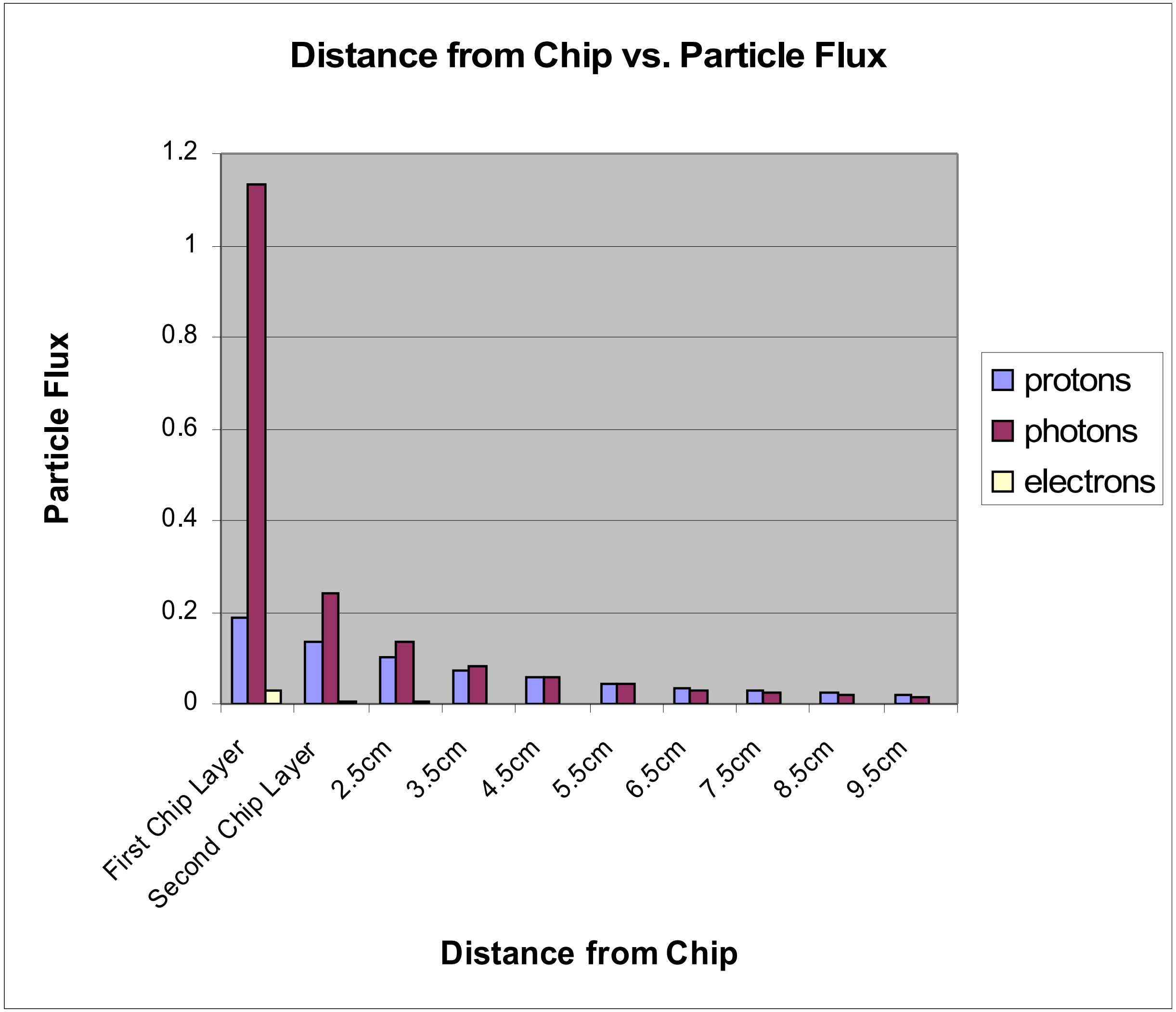
Note: The 30L neutron beam travels along the X-axis in the positive direction (1 0 0)

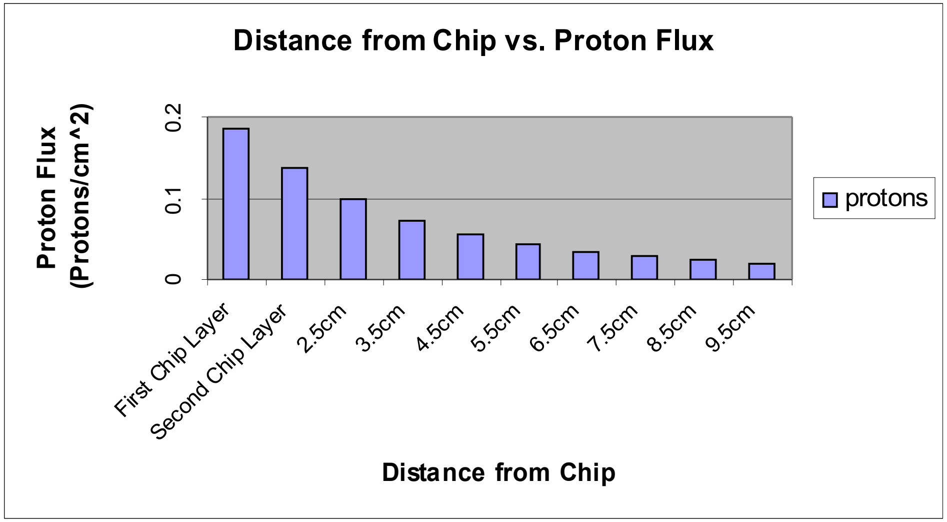
Composition of Flux at First Layer of Chip

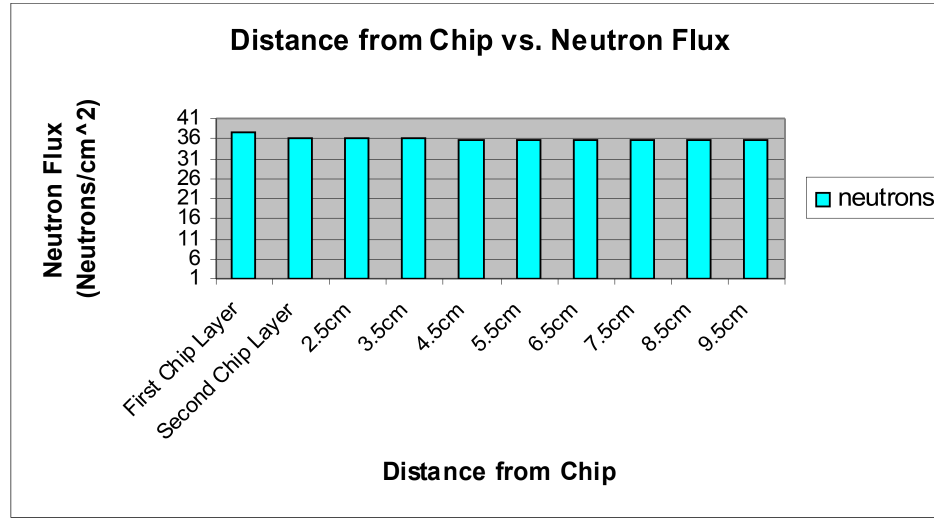
- The neutron composition of the flux in the thin first layer of the chip is approx. 97% of the entire flux.
- The photon composition of the flux in the thin first layer of the chip is approx. 3% of the entire flux.
- Both the proton and electron fluxes are less than 1%.



Distance from Chip vs. Particle Flux



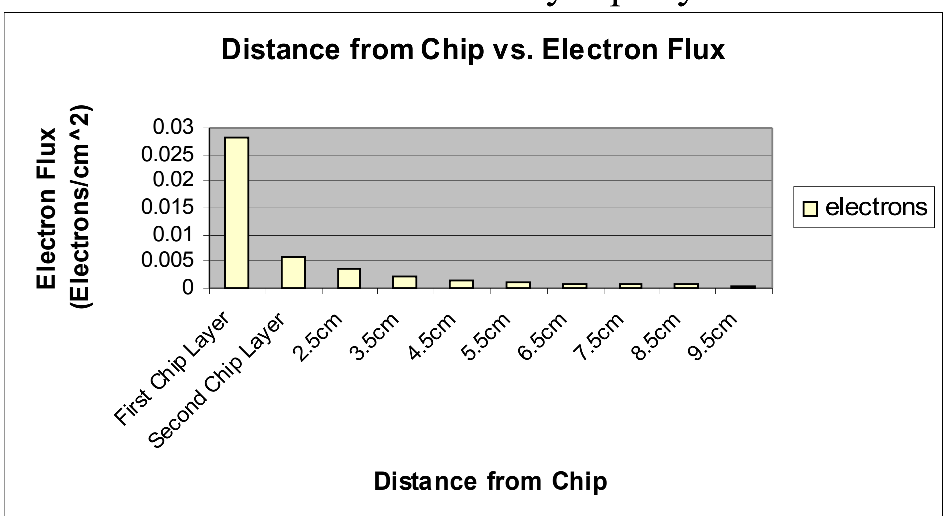




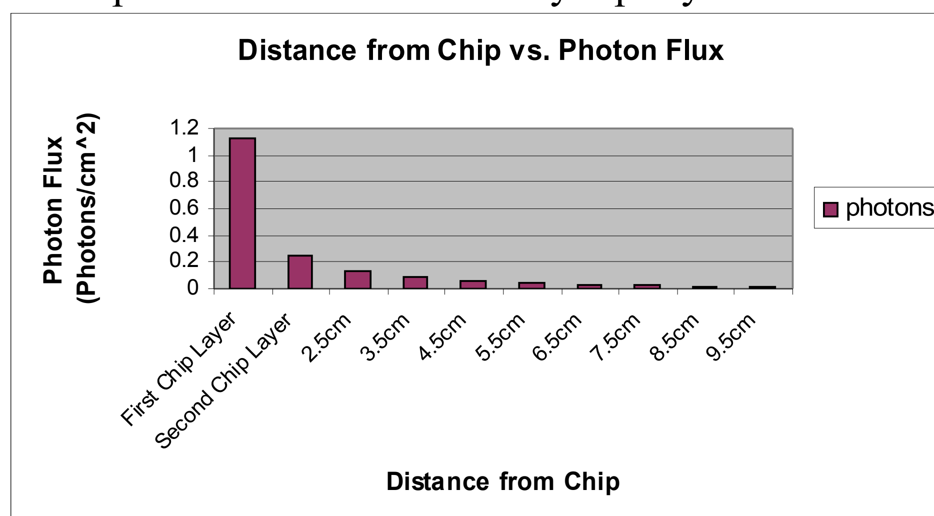
The proton flux descends slowly.

The neutron flux remains relatively constant.

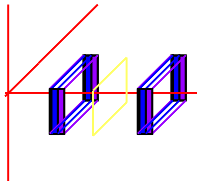
The electron flux decreases very rapidly.



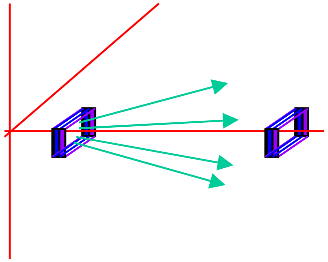
The photon flux decreases very rapidly.



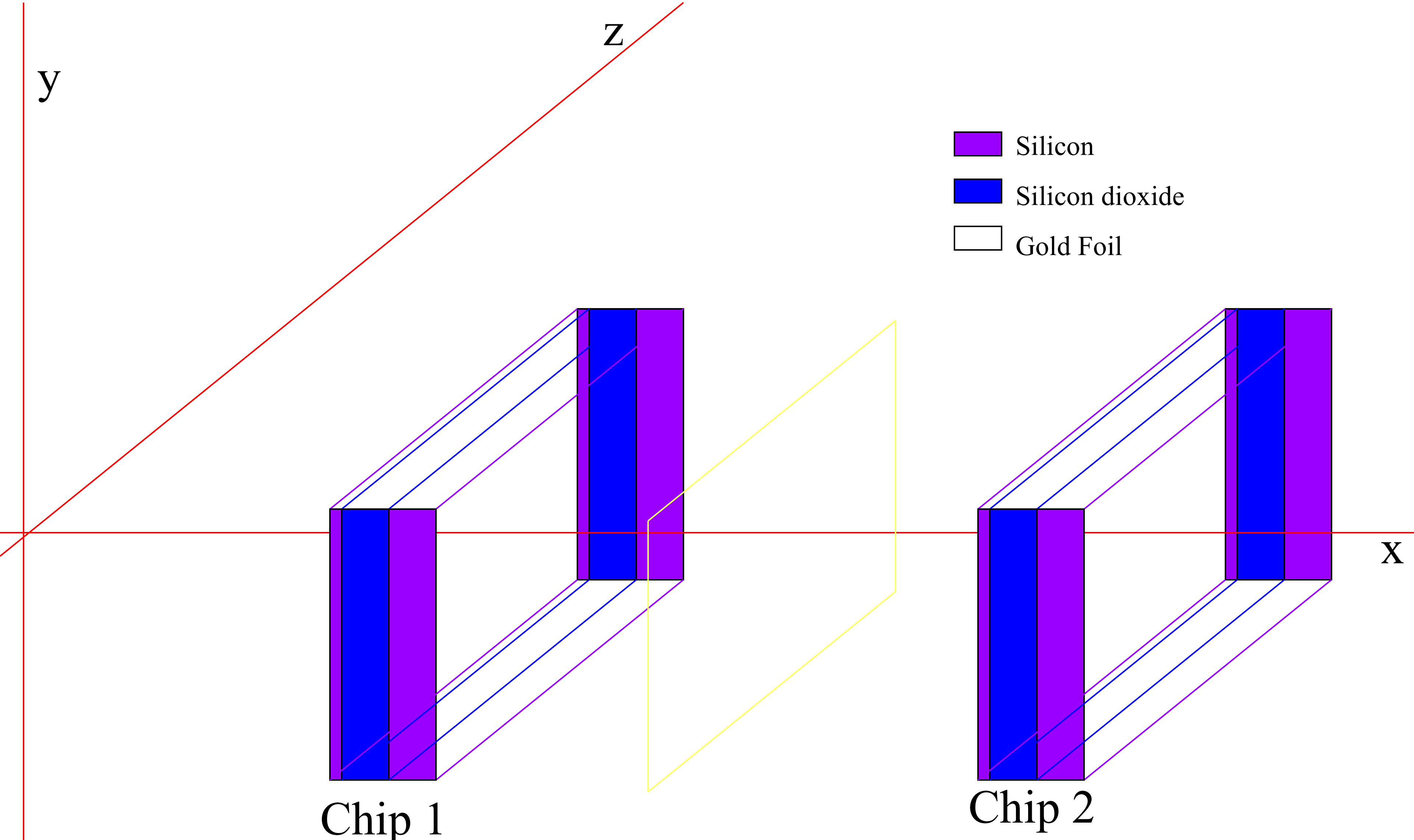
Possible Solutions



- **Foil:**
  - If the protons are of low enough energy, then a thin gold or tungsten foil might stop them, but not stop many of the neutrons.



- **Spacing:**
  - We could space out the chips so that most of the unwanted protons have scattered away from the path before they reach the next chip.

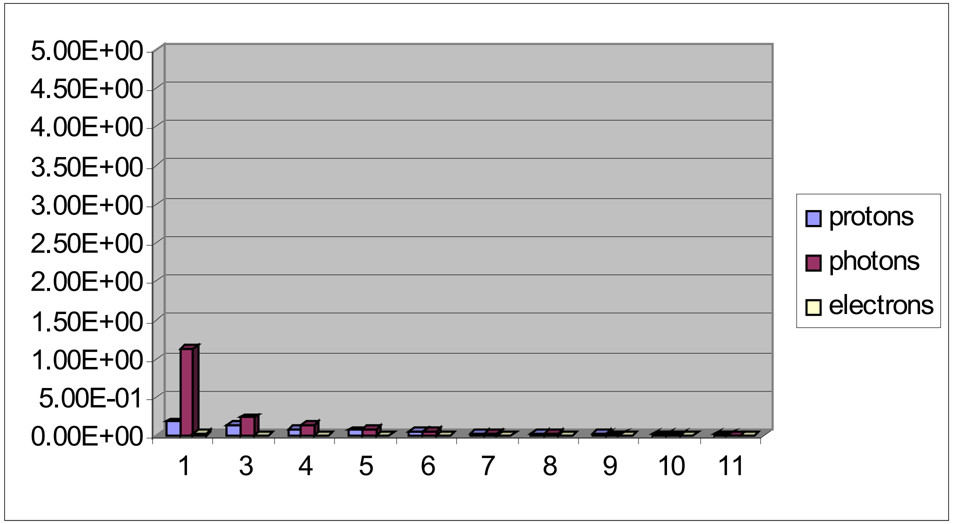


Note: The 30L neutron beam travels along the X-axis in the positive direction (1 0 0)

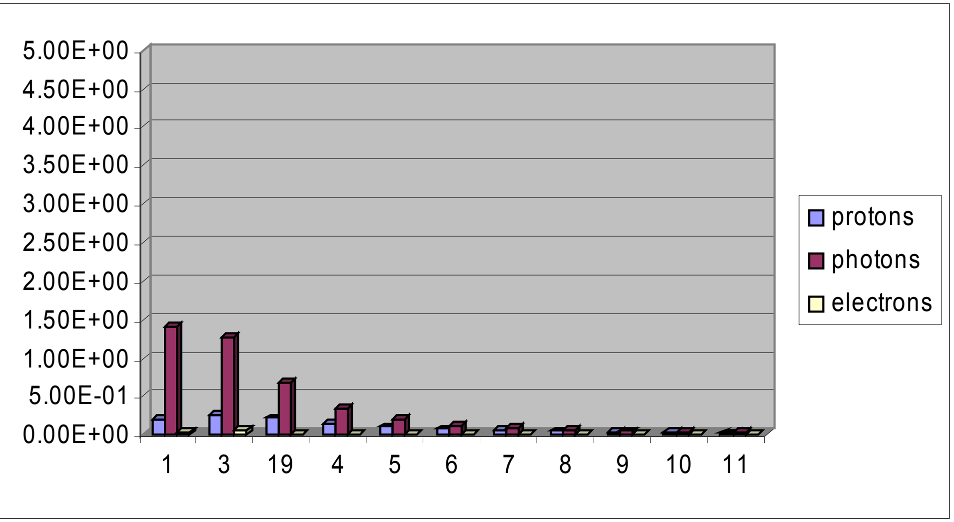
Problems With The Foil Solution

- The peak energy of the protons was calculated to be about 50 MeV, which calls for a 5mm thick foil.
- The thickness of the foil (5mm) causes more proton, photon, neutron, and electron production to occur, so I calculated the results with a 0.5mm thick foil, and these graphs illustrate my calculations.

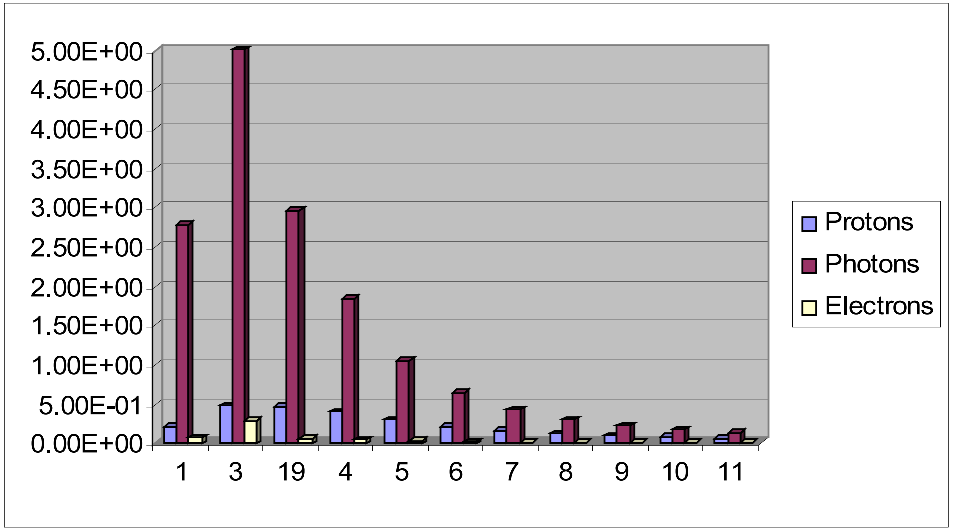
No Foil

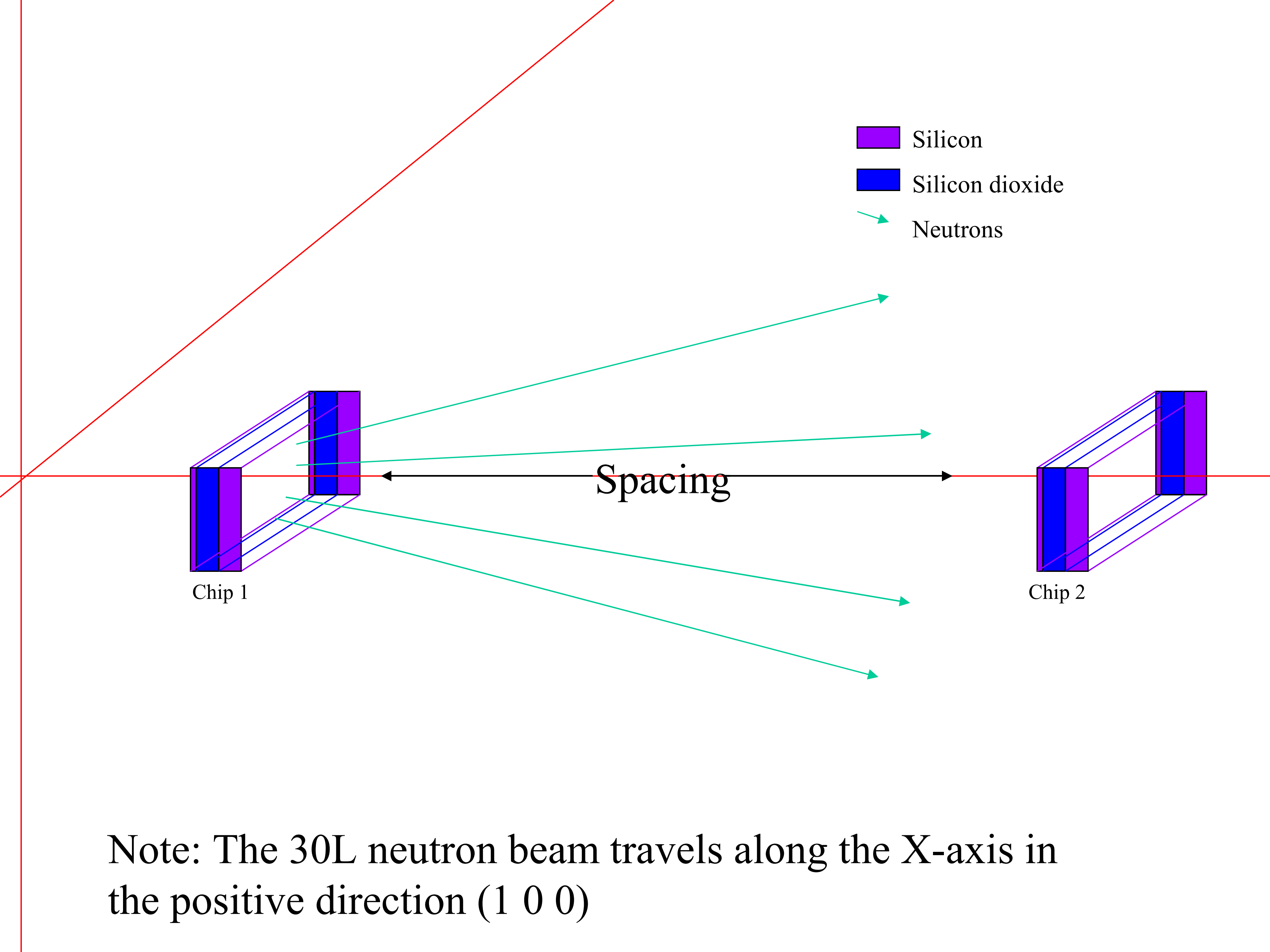


0.5mm Foil



5mm Foil

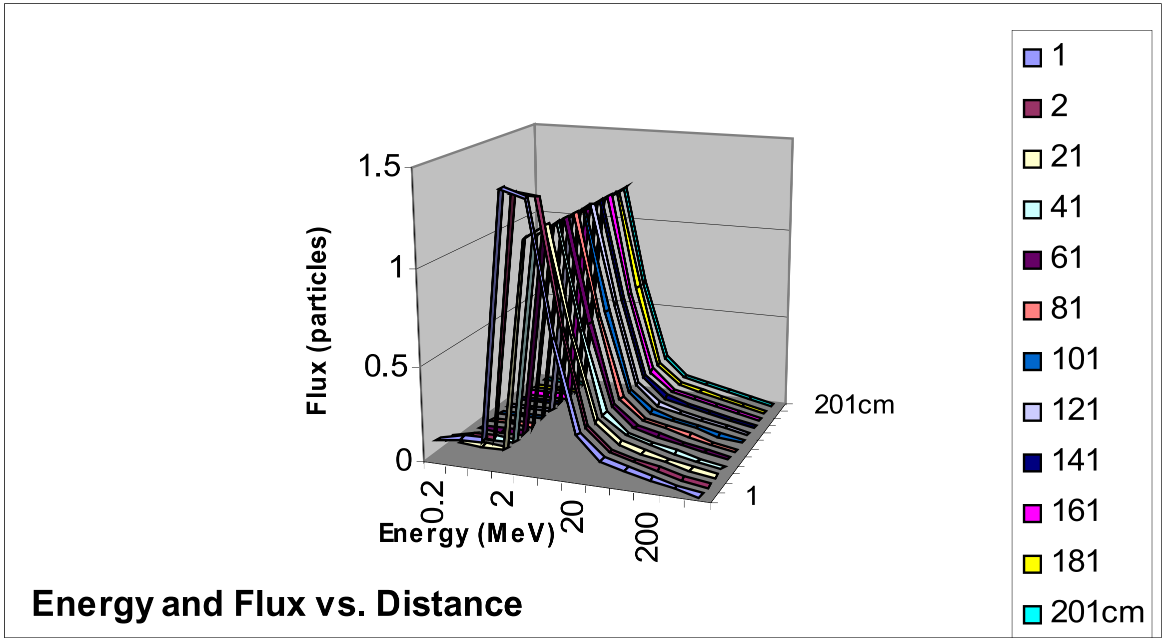


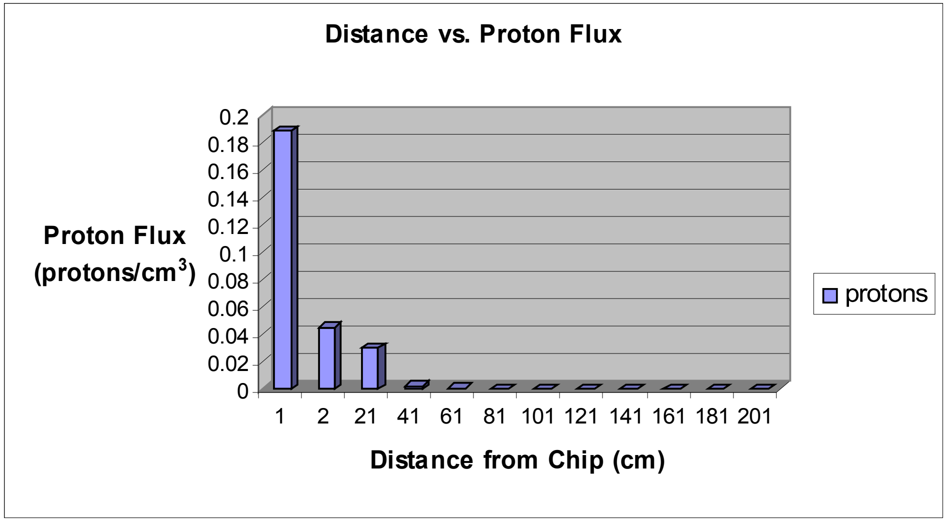


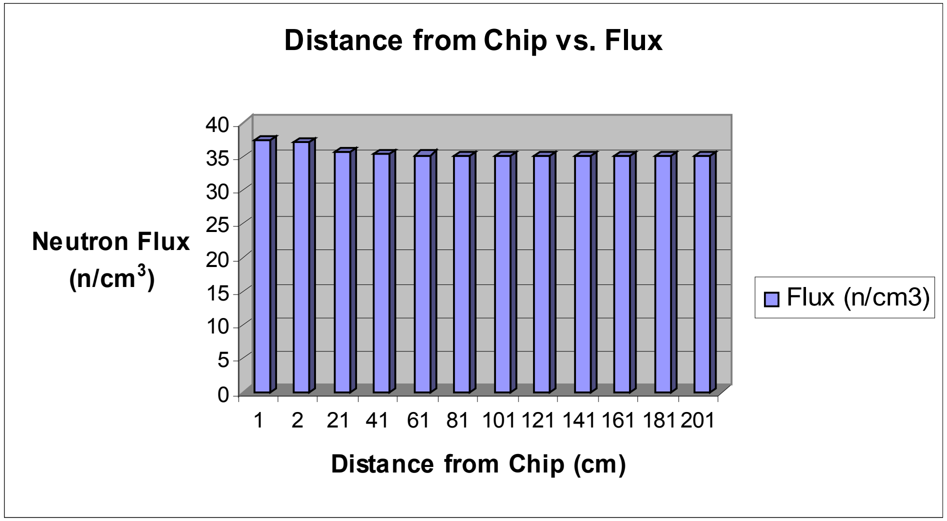
Note: The 30L neutron beam travels along the X-axis in the positive direction (1 0 0)

Results of Spacing Calculations

• If the neutron flux and energy range remain fairly constant through the span of a few meters it becomes realistic to space the chips apart enough to reduce the proton flux by a factor of a few hundred depending on the proton sensitivity of electronics.

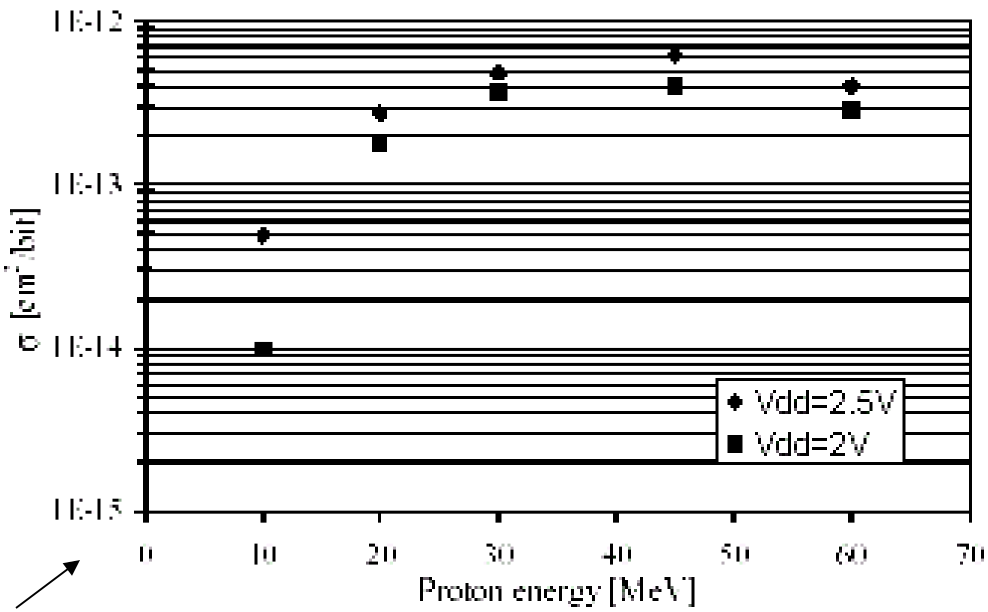






SRAM Sensitivity to Protons

According to a study done by scientists at CERN and INFN led by F. Faccio, the proton SEU cross section drops dramatically below 10MeV. Therefore, since the peak proton energy between 21 and 41 cm from the chip is less than 10 MeV and since there are far fewer protons in the higher energy ranges, it is feasible that this will reduce the error rate caused by protons by a factor of at least 100.



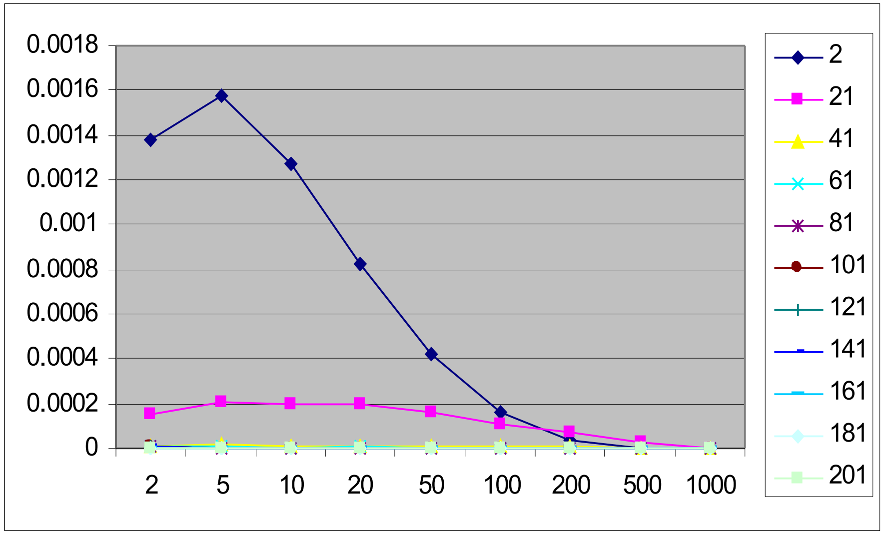


Fig. 1 :

F. Faccio, K. Kloukinas, G. Magazzù, A. Marchioro, “SEU effects in registers and in a Dual-Ported Static RAM designed in a 0.25 μm CMOS technology for applications in the LHC”, p. 5, http://lebwshop.home.cern.ch/lebwshop/LEB99_Book/Paperonly/Faccio.pdf

Conclusion

This paper analyzes the particle shower resultant of neutron collisions with a silicon based chip bombarded with a neutron beam characteristic of the 30L ICE House beam at the LANSCE-3 WNR facility at Los Alamos National Laboratory. In particular this paper has shown that:

- The high observed error rate in the second chip of the series can be attributed to protons in the particle shower produced by neutron-silicon interactions in the first chip.

  No thickness of high density foil will slow the protons without causing more new particles to be created through the neutron impact with it.

- The neutron flux remains stable throughout the span of 2 meters past the silicon based chip in question, therefore allowing spacing of experimental chips up to that length.
- The proton flux lowers significantly after a length of approximately 30cm, and so that has been determined as the most efficient spacing distance.