Compton Scattering Lab Book

March 11/13:

- began reading through lab manual and preliminary research

Theory:

- scatter of a photon causes a change in wavelength, a decrease in energy
- this change of wavelength is dependant on the scattering angle and independant on the initial wavelength

Goals:

- demonstrate the compton effect and quantization of light
- verify the Klein-Nishinaj formula

General Info:

- it will be difficult to find I0
    - can find my knowing when the source was made and calculate the current I0
    - or can use an attenuation material and account for that attenuation
- Cs source, Na source and Ba source
    - use Na, Ba and weaker Cs for energy calibration

- NaI scintillation detector
    - changes incoming gamma rays to photos which are measured by PMT
    - must take the relative efficiency when comparing results at different scattering angles
    - we know how the energy changes with angle so we can use this

- given aluminium, copper and stainless steel rod
    - same energy shift but photon density is different, gamma ray mass attenuation different

Procedure:

Energy Calibration:

- obtain a spectrum for each of the calibration sources
- perform a linear fit to get the channel number/energy relation
- this sets the bias and amplifier gain

Zero Angle:

- take measurements on both sides of the zero then adjust so it is symmetric

Frequency Shift:

- used to remove background by getting data both with the target and without

Differential Cross Section:
Measuring the Flux Density:

General Questions:

- gamma ray mass attenuation coefficient? Where does this come in? - extra?
- number of scattered photons for different rods, do we need it for comparing?
- what does the preamp do? How does changing the voltage effect data?
- Matlab function??
- is there attenuation due to the rod?

Lab Work Schedule:

Fri. March 15th:

- Look into the link for analysis : http://www.ugrad.physics.mcgill.ca/wiki/index.php/Alpha_Decay#Spectrum_Tools
- Familiarise with computer in lab + data acquisition software

Weekend work:

- Write introduction section for report done
- Write experimental methods section
- Get better idea of what we need to do for analysis

Mon. March 18th:

- Talk to TA about functioning of equipment
- Start data collection for calibration step

Wed. March 20th:

- Finish calibration / keep up data collection

Fri. March 22nd:

- Finish calibration / keep up data collection

Sun. March 24th: Interim Due

- *Experimental Method Section*
    - Research on how aparatus works / background info
    - Experimental setup figure done on inkscape
    - *should have introduction section for final report done*
- *Analysis*
    - Calibration (included in report)
    - *should aim to have section verifying compton relation and calculating electron rest mass done at this point* (probably will not be included in report due to the limited space)

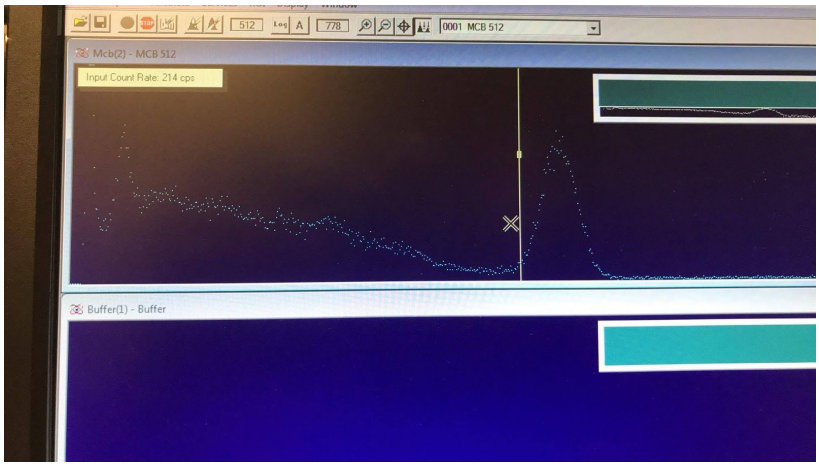
Background Information:
https://www.sciencedirect.com/science/article/pii/B978141605198500006X (section C)
To find accepted values:

- NIST (national institute of standards and technology)
- www.nndc.bnl.gov / https://www.nndc.bnl.gov/nudat2/

March 18:

Sources used for the calibration:
99 - Na22
97 - Ba133
29 - Cs 137

Calibration:
Cs 137:
Gain 1.6001 volts 1000

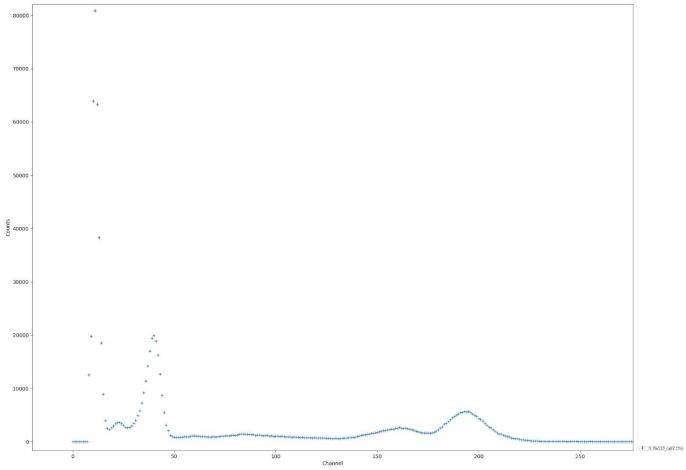


-can see peak
-near center so need to change gain/voltage to move it further right
-tried changing values but we found the best was 1.6001 and 1000V so will keep this throughout the lab
-ran for 180s (real) then exported data Cs137_cali2

Ba 133:
-Gain 1.6001 volts 1000
-ran for 189s (real) then exported data Ba133_cali2

Na22:
-Gain 1.6001 volts 1000
-ran for 180s (real) then exported data Na22_cali2

Importing Data:

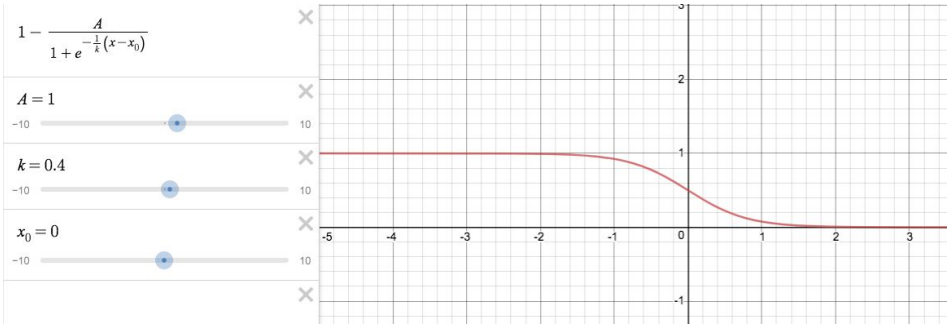


-is able to import data using Andres's code
-Ba has strong peak at 81KeV and 356KeV (lump on right)
-started to fit these with guassians

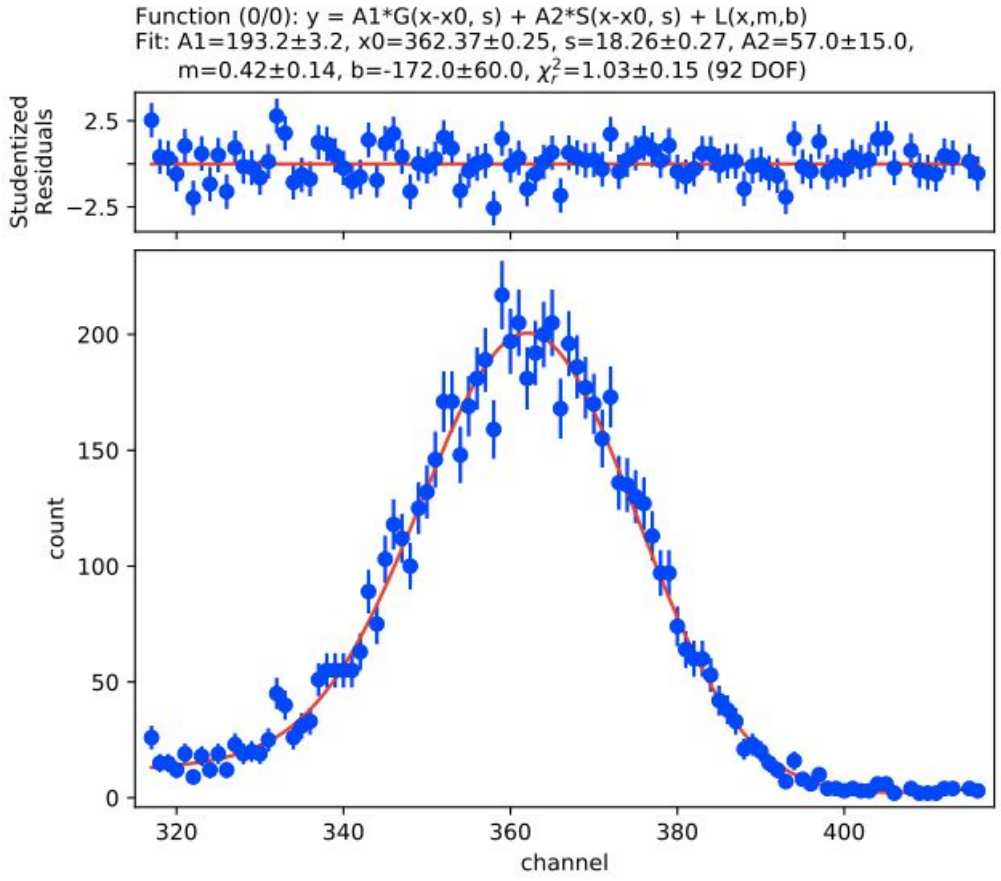
March 20:

Fits not working well with just gaussians.

- Re-collected data for calibration by counting gamma rays from each sample for 5 min. (In the hopes of that helping get better peaks).
- Talked to TA: suggested trying to fit with double peaks.
- Talked to Prof. Brunner:
    - Explained that gaussian is not the only type of function that we need to fit to our peaks.
    - Due to the nature of the detector and scattering that happens inside the detector's crystal itself, need to also fit a smeared step function.
        - This function should be centered in the middle of gaussian peak
        - It should have the same sigma
        - Used sigmoid curve:



    - Due to background noise (comes from scattering off lead, concrete, backscattering, presence of other radioactive sources etc.) also need to fit a line to the peak.
- Check on the nndc.gov site for the gamma ray energies emitted by these three sources. Some have various energy rays close to one another and so some peaks may need to be fit with a double peak or quadruple peak (most for Ba133).
- This gave the following result for Cs-137 peak:



March 25:

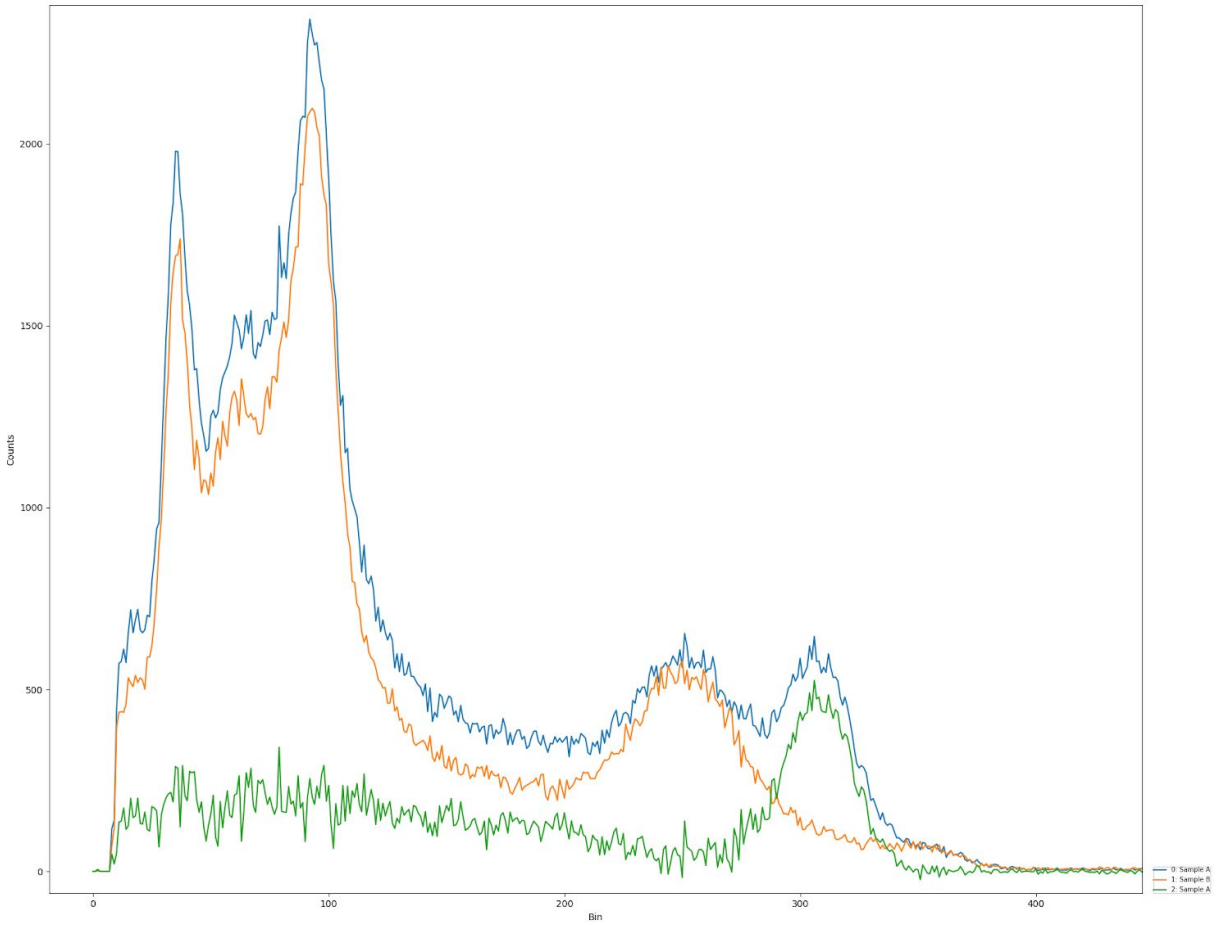
Zero Angle Determination:

- Starting at plus 15 degrees
- 1.6001 gain 1000V 120s
- Saved at zeroangle_15deg
- Negative 15 degrees
- 1.6001 gain 100V 120s
- Saved at zeroangle_-15deg
- 15 deg: 371.29 +- 0.16
- -15 deg: 368.14 +- 0.54
-

Frequency Shift:

Aluminium rod used: OI0381

- Plus 20 degrees (110 pm 0.5)
- 1.6001 gain 1000V 400s
- Saved as 30
- Preformed the same with no rod
- Saved as norod_30
- Plus 30 degree
- 1.6001 gain 1000V 400s



- initial subtraction for 30 degrees
- Green line is subtraction of orange from blue
- Orange line is without rod, Blue is with rod

March 27:

Aluminium rod used: OI0381

- Plus 15 degrees (105 pm 0.5)
- 1.6001 gain 1000V 400s
- Plus 25 degrees was accidentally done with stainless steel
- Plus 35 deg

April 1:

Aluminium rod used: OI0381

- Plus 20
- 1.6001 gain 1000V 400s

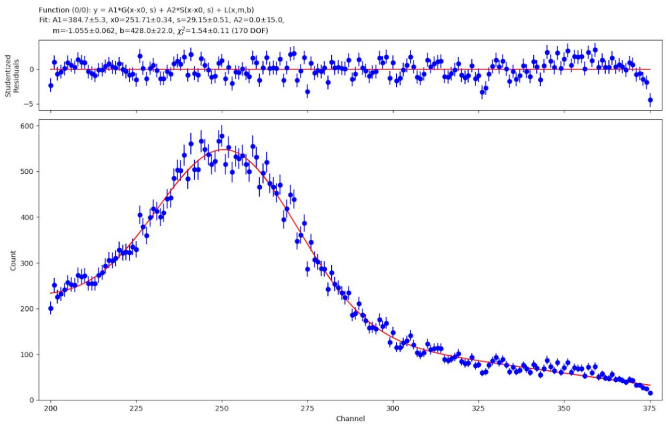
- Plus 40
- 1.6001 gain 1000V 400s

Obtained measured value of r_ts (distance from the target to the source). It was measured to be: 53.3 cm +/- 0.1cm.
The thickness of each concrete block used was measured to be all different widths. This data was measured as part of the determination of I_0. 3 trials were conducted: 1 brick, 2 bricks, 3 bricks, 4 bricks.
TRIAL 1: The brick was measured to have a width of 9.4 cm +/- 0.1
TRIAL 2: Two bricks. One of width 9.4 cm and one of width 6.8 cm.
TRIAL 3: Three bricks. One of width 9.4, one of width 6.8, one of width 9.2.
TRIAL 4: Four bricks. One of width 9.4 cm , one of width 6.8, one of width 9.2, one of width 6.8.

April 3:

Worked on fitting the scattered data

- Started by subtracting the no rod data from the rod data
- Unable to get consistent fit
    - Would change with how much data taken into account
- Tried to fit background data then keep that fit as constant and add it to scattered data fit
    - Was able to get better consistent results



Worked on fitting brick data

- Used same functions as scattered data and getting much worse chi squared
- Periodic pattern in residuals

April 5th:

- Still having problems with fitting data for analysis on determining I_0 (brick data)
- Prof. Brunner: suggested we try adding a skewed Gaussian
    - Improved the fit a lot!
    - Need to be careful with guess parameters because all the functions quickly become very strange as they try to compensate for one another.
    - *Note*: always plot all the functions against the data to make sure the fit is doing what we want it to do.
- Also improved the fit by trimming the data to the last data points and using those to fit for a linear background