Scattering in 2D

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1 Abstract

The object of this experiment to determine radius of cylindirical material. We shoot lots of steel balls to determine the scattering angles. We measured the value $2r = 5.74 \pm 0.01$ cm, so $r = 2.87$ cm. Our calculated value is $r_1 = 4,278 \pm 0.79cm$ and $r_2 = 2.65 \pm 0.047cm$.

2 Theory

Scattering events mostly known with CERN because of subatomic particles. We would like to know the nature of the particle behaviour and modeling the atom structure with scattering approach. Scattering angle is based on shape of the target object. Cross sectional area we would like to find is cylindrical material.

Cross section calculated as below:

$$\frac{d\sigma}{d\Omega} = \frac{Y}{Id\Omega} \tag{1}$$

I is the flux, $d\Omega$ is the solid angle and Y is the yield in $d\Omega$.

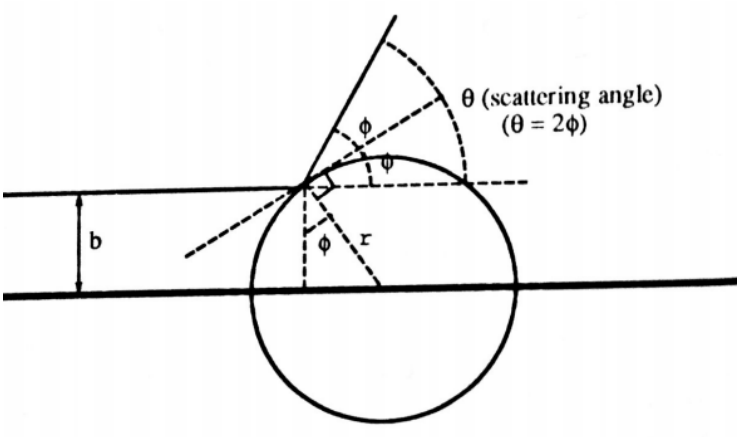

Figure 1: Scattering in 2D

$$\frac{b}{r} = cos(\frac{\theta}{2}) \tag{2}$$

If we derive last equation we got this:

$$db = -\frac{R}{2}\ sin(\frac{\theta}{2})\ d\theta \tag{3}$$

The number of particles at a given angle is;

$$dN = -I\ db = \frac{Ir}{2} sin(\frac{\theta}{2})\ d\theta \tag{4}$$

$$\int d\sigma = \int_0^{2\pi} \frac{r}{2}\, sin(\frac{\theta}{2}) d\theta \tag{5}$$

from 0 to 2 π would yield the total cross section which is: $\sigma = 2\, r$.

3 Apparatus

- Scattering Tray
- Pressure Sensitive Paper Tape
- 20 Steel Balls
- Air Pump for shooting
- Ruler
- Vernier ruler

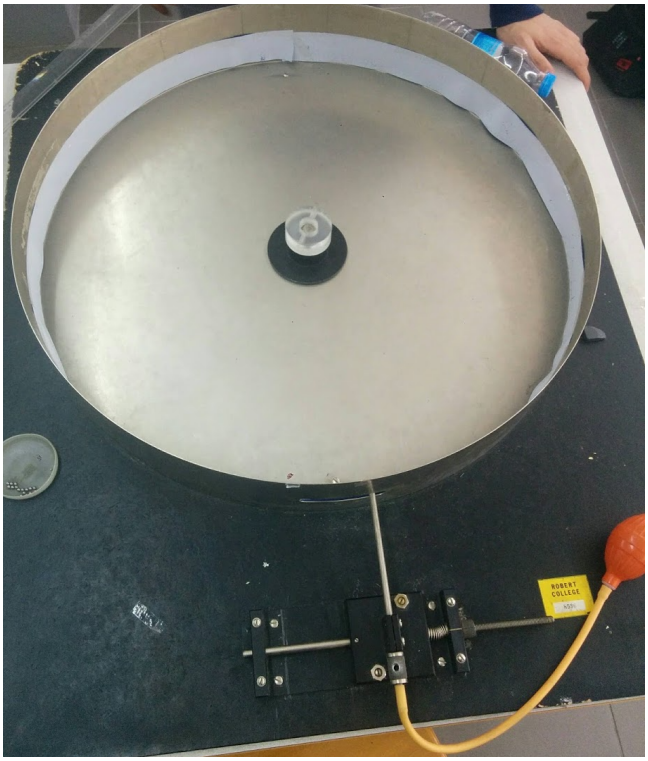

Figure 2: Experiment Setup

4 Procedure

We stuck the pressure sensitive paper to the rim of the tray. Then we set the shooter. We shoot 20 steel balls each time. We repeat this 48 times which is end of 360 degree. At the end of the day, we counted all dots on paper and write on excel sheet.

5 Data Data Analysis

θ°	$\#ofballs$	$\sigma(dN)$
10-30	43	6.56
30-50	23	4.8
50-70	25	5
70-90	32	5.66
90-110	46	6.78
110-130	55	7.42
130-150	55	7.42
150-170	72	8.49
170-190	73	8.54
190-210	92	9.59
210-230	73	8.54
230-250	56	7.48
250-270	37	6.08
270-290	54	7.35
290-310	33	5.75
310-330	26	5.1
330-350	16	4

θ°	$\sum ofballs$	$\sigma(sum)$
20	59	7.681
40	49	7.0
60	58	7.615
80	86	9.273
100	83	9.11
120	111	10.535
140	128	11.313
160	164	12.806
180	146	12.083

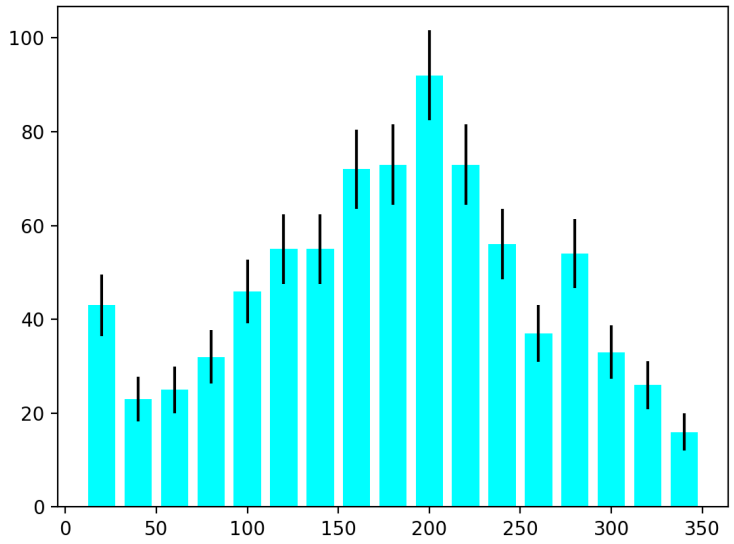

Figure 3: Histogram number of balls - θ

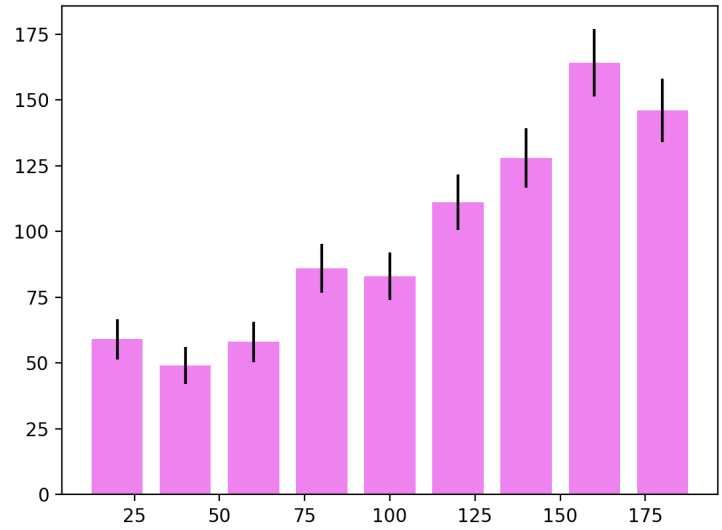

Figure 4: Histogram symmetric summation of balls

$2r$= 5.74 ± 0.01 cm

$d_1 = 0 \pm 0.01cm$
$d_2 = 5.76 \pm 0.01cm$
$\sigma_d = 0.01cm$

$$\frac{d\sigma}{d\theta} = \frac{dN}{I\,d\theta} = \frac{r_1}{2}\ \sin(\frac{\theta}{2}) \tag{6}$$

$$r_1 = \frac{2}{I\,d\theta}\ \frac{dN}{\sin(\frac{\theta}{2})} \tag{7}$$

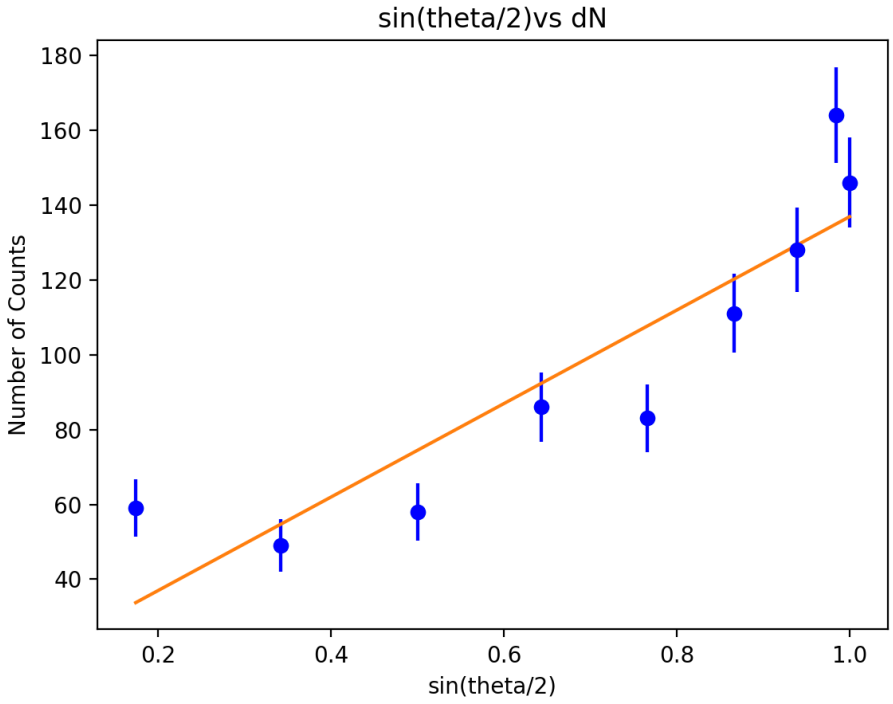

Figure 5: Linefit

Slope of line can calculate as below:
$\frac{dN}{\sin(\theta/2)}$
slope = 124.81

σ_m = 22.95

Difference between shot positions 5.76 ±0.01cm

$$I = \frac{Numberof Shots}{\frac{Difference}{\#\ of Turns}} = \frac{20}{\frac{5{,}76}{48}} \tag{8}$$

I = 166.67$shots/cm$

$$\sigma_I = 0,289cm \tag{9}$$

$$I = 166.67 \pm 0,289 shots/cm \tag{10}$$

$$d\theta = 20^\circ \tag{11}$$

By using equation 7;

$$r = 4,278cm \tag{12}$$

After calculation of error propagation;

$$r = 4,278 \pm 0.78667cm \tag{13}$$

$$Error = \frac{|r_0 - r|}{\sigma_r} = 1,79\sigma \tag{14}$$

Another method for calculation;

$$\frac{\sigma}{d\theta} = \frac{dN}{Id\theta} = \frac{r}{2}\ \sin(\theta/2) \tag{15}$$

$$\int d\sigma = \int \frac{dN}{I} \tag{16}$$

$$\sigma = \frac{\sum\limits_i dN_i}{I} \tag{17}$$

$$r = \frac{1}{2}\ \frac{\sum\limits_i dN_i}{I} \tag{18}$$

$$r2 = 2.65 \pm 0.047cm \tag{19}$$

$$Error2 = \frac{|r_0 - r2|}{\sigma_{r2}} = 1.78\sigma \tag{20}$$

6 Conclusion

We use scattering approach to determine radius of target object. We found as 1,79σ error and 1,78σ for error2 from nominal value. We thought our approach is performed well but due to configuration of experiment we have systematic errors. Pressure sensitive paper missed some of dots. This leads to lack of lots of dots(about 10%) Another possible cause stems from shooter spring. Each turn can be different from each other.

- E. Gulmez, "Advanced Physics Experiment", Bogazici University Publication
- http://web.physics.ucsb.edu/ fratus/phys103/LN/Scattering.pdf

A Appendix

Codes are given link below:
https://github.com/samilokan/442/blob/master/arr.py