Charged Fusion Product Detector Study

Ronald E. McNair Scholars Program

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Introduction

Plasmas are ionized gases, comprised of positive ions and negative electrons. Due to this property, they can be manipulated by magnetic fields, machines called tokamaks perform this fuction to force fusion reactions to occur inside of the plasma. The energy from these reactions is hoped to be used for commercial electricity production.

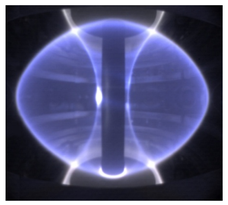

Figure 1: Plasma in a Spherical Tokamak

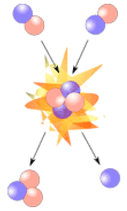

Figure 2: Fusion Reaction

Instabilities within the plasma can cause energy losses. In order to study these instabilities, a detector array was implemented to track protons as they are emitted by these reactions. The properties of these detectors were studied at the nuclear physics lab at FIU.

Materials and Methods

The object of study is the solid angle of acceptance of a silicon surface barrier detector. The solid angle is the segment of area of a sphere that an object covers.

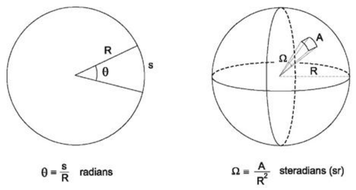

Figure 3: Standard vs Solid Angle

$$\Omega_{total} = \int_S \frac{dA}{R^2} = \int\int \frac{R^2 \sin\theta d\theta d\phi}{R^2} = \int\int \sin\theta d\theta d\phi \qquad (1)$$

The solid angle of a detector can change as a function of the geometry. In order to study this, numerical and experimental techniques are implemented to make the calculations.

Monte Carlo Programming

The algorithm tests one million data points against the equation of a circle and the fraction that pass is used to approximate the solid angle.

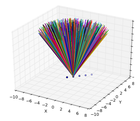

Figure 4: Emission 1

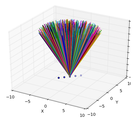

Figure 5: Emission 2

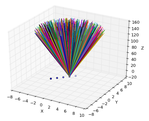

Figure 6: Emission 3

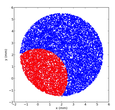

Figure 7: Projection 1

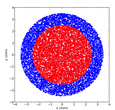

Figure 8: Projection 2

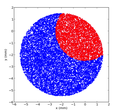

Figure 9: Projection 3

Alpha Particle Spectroscopy

A radiation source is placed on a track and allowed to decay at various positions relative to the position of a detector.

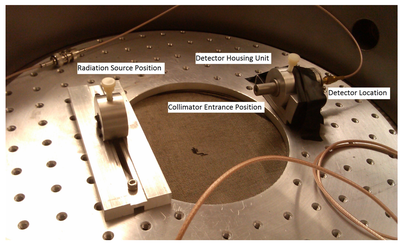

Figure 10: Vacuum Chamber

The electronics manipulate the signals according to this chart

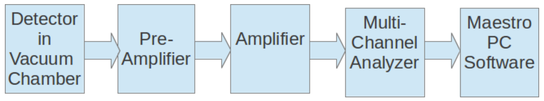

Figure 11: Experimental Procedure

The detector counting rate is the property of interest here, since it varies with the geometry it can be compared with the solid angle.

Results

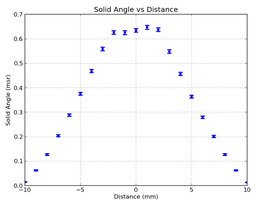

Figure 12: Computational Data

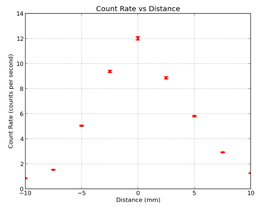

Figure 13: Experimental Data

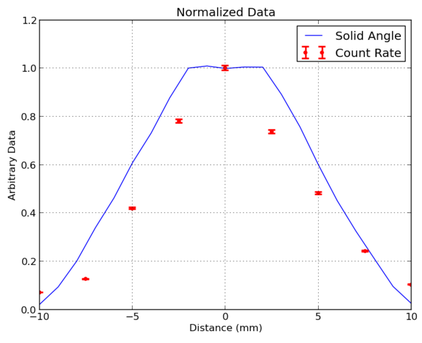

Figure 14: Normalized Computational and Experimental Data

Conclusions and Forthcoming Research

- A functional relationship between the solid angle of acceptance of the detetor and its distance from the radiation source was studied.
- Issues have arisen in the analysis that involve disconnects between the shapes of the computational and experimental data sets.
- The cause for this will be explored in ongoing data taking so as to calculate the true collection efficiency of the detectors.
- Attaining this information is crucial for the analysis of the data that comes from the tokamak diagnostic.

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