### Introduction

**Objective:**

In this work, we are trying to characterize the emission of cosmic rays from pulsars. In more detail, we are exploring if such a population of pulsars can make the cosmic-ray (CR) electrons that produce the gamma-ray emission seen by Fermi LAT. We are also investigating if such a population of pulsars can make the pulsed gamma-ray emission detected by Fermi LAT. We have characterized the PWN by the age of the pulsar and from its distance from the Earth. As a result, we found that as the pulsar furthered away from the Earth, the gamma-ray emissions produced by its CRs were harder to detect as well as the younger pulsars. This will be the basis to describe CR electrons produced by the pulsars in the Galactic center, and eventually the emission seen by Fermi LAT in the same region.

### Methods

- First, I had learned how gamma rays are produced and how Fermi is able to detect them in order to understand the reason for using Fermi and gamma rays to detect the emission of CRs.
- Secondly, I learned about Inverse Compton so that I would be able to understand how gamma rays are produced from CRs and the diffusion of the CR electrons.
- Lastly, we used Python to construct a program that resulted in graphs and predictions of the emission and propagation of CR electrons. The graphs were used to compare the distance and age of the pulsars to analyze the flux of the CRs emitted.

### Results

- Based on the data collected by Fermi, the main hypothesis was that the Galactic center is made up of pulsars so my objective was to use a Python program that simulated the emission and diffusion of the CR electrons and plot the data produced by this simulation in order to understand more about the sources of the CR electrons.
- As a result, I was able to plot two graphs shown in Figures 6 and 7. From these graphs, I was able to analyze the types of electrons that were being detected by the Fermi telescope according to the distance of the pulsars from the Earth and the age of the pulsar.
- In Figure 6, we took the hypothetical distance of 0.5 kpc and compared the different ages of the pulsar and found that a young pulsar emits a spectrum of very high energy electrons seen from Earth that result in low flux while a very old pulsar emits a wide spectrum of low and high energy electrons seen from Earth and the graph demonstrates that the low energy electrons have a higher flux and as the energy of electrons increases the flux reduces.
- In Figure 7, we took the hypothetical age of 1 Myr of the pulsar and compared the different distances of the pulsars with respect to the Earth. We found that if the pulsar is really close to the Earth, then Fermi is able to detect a very wide spectrum of low and high energy electrons and the flux is also higher for the low energy electrons and as the energy increases the flux decreases. In comparison to a pulsar at a large distance away from the Earth, there is a very small spectrum of high energy electrons, but it also has very low flux.

### Conclusions

- I was able to learn a lot of particle physics and cosmology. It was very helpful to learn about the behavior and propagation of high and low energy electrons emitted by pulsars.
- Provided more time, I would have constructed a program that graphed multiple pulsars and their effects on the propagation of the gamma rays to further our knowledge on these mysterious particles.

### Bibliography


### Acknowledgments