An Investigation Into TRACKING COSMIC RAY SOURCES IN THE SKY (Black holes and Supernova Remnants)

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Abstract

A cosmic ray is basically a type of energetic radiation which its source generally is outside the Solar System, like distant galaxies. These rays are mainly composed of the high-energy protons, muons, and atomic nuclei. By analyzing the cosmic ray, the more information can be derived regarding their source. This process can be done through a system containing a *scintillating sheet* and *photomultiplier tubes* (PMT), which is called a Scintillating Detector, as a whole. When a muon, which is a charged particle, hits a scintillator sheet, the scintillator absorbs the muons, emits a photon and leads the photon to a PMT to be amplified and then converts it to a high-enough electrical pulse. Then the output signal is sent to an oscilloscope to be studied in a separate project. To accomplish this goal, the source of the muon must be tracked constantly. The purpose of this research is to keep the tracking devices constantly pointing to either of two main sources of these rays; Sagittarius A* and Crab nebula. Finding the path of these two celestial objects, based on their azimuth and elevation angle during a year, is one of the main steps of this project. The following and more challenging step is to find a software program that conducts such a tracking task automatically with dependable accuracy as long as the two mentioned objects are in the field of view of a local observatory.

Introduction:

At the beginning the purpose was to use an optical telescope to track the Sgr A* and Crab Nebula since this telescope can easily track many celestial objects to a high accuracy. In next step, by connecting the cosmic ray tracker to the telescope, the tracker was able to follow the telescope constantly. By using this method, the accuracy of the tracking device was guaranteed. However, this method was not as practical as it seemed. One problem was to find a software that could connect the two devices to each other and set them in such a way that the tracker followed the optical telescope continually. The other problem was the alignment of the optical telescope as the first step.

It turned out the alignment process must be done outdoors by looking through telescope tube to the stars. In addition to that, it should be fixed in place once it is aligned as any small displacement causes loss of alignment; consequently, it leads to reduction in aiming accuracy. Moreover, recently, due to some unclear reason the telescope is nonfunctional.

Crab Nebula is a expected source of high energy cosmic rays [1]
its celestial coordinates are: **RA =5h 34m 31.94s , DEC = +22° 00' 52.2"**

The black hole in the center of our galaxy is called Sagittarius A* and is an expected sources of high energy cosmic rays[2,3]

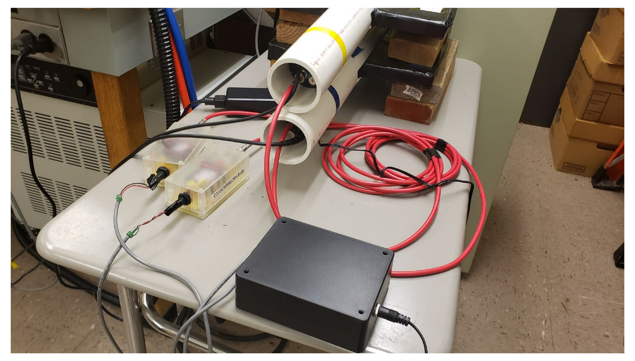
its celestial coordinates are: **RA = 17h 45m 40.04s , DEC = -29° 00' 28.2"**

Powering The Detectors

The primary source of power for the Scintillation Detector is a 15v laptop charger; however, this by itself is not enough to power the detectors. To power the detectors, the Laptop Charger was first in an **"Umbral Box" enclosure** which purpose is to safely enclose all components inside of it. Inside of the "Umbral Box" consists a **breadboard** which consist of 3 **terminal blocks** whose job is to split the 15v from the 1 Laptop Charger and allow us to be able to power 2 detectors. Also, inside this enclosure are 2 **LM317** variable voltage regulators which get their power from the charger through the terminal blocks. The purpose of these LM317's is to provide a user-selectable DC voltage of between 0V to 12V, and regulate (or maintain the value of voltage) going to two XP-**EMCO High Voltage Converters**. The EMCO High Voltage Converters convert the low voltage output from the LM317 into a high voltage into to the Photomultiplier Tubes connected to the Scintillation Detectors.

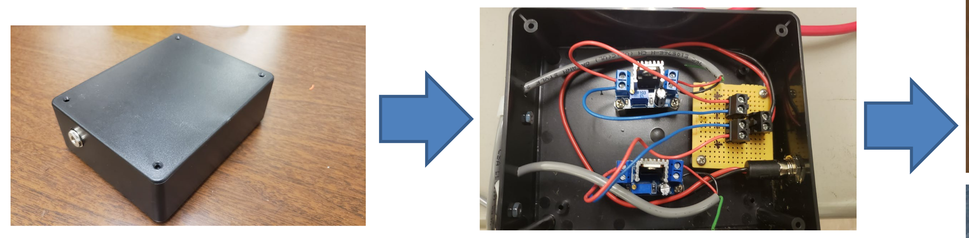
Detector: Scintillator Sheet and Photomultiplier Tube

Complete Setup

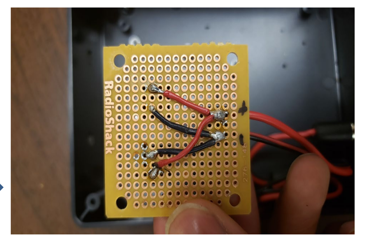


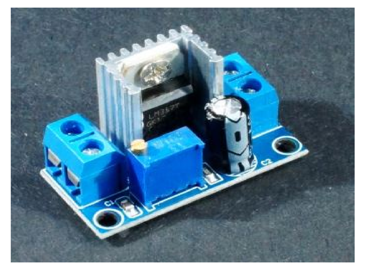
Laptop Charger plugged into the "Umbral Box" enclosure

Umbral Box Enclosure Components:

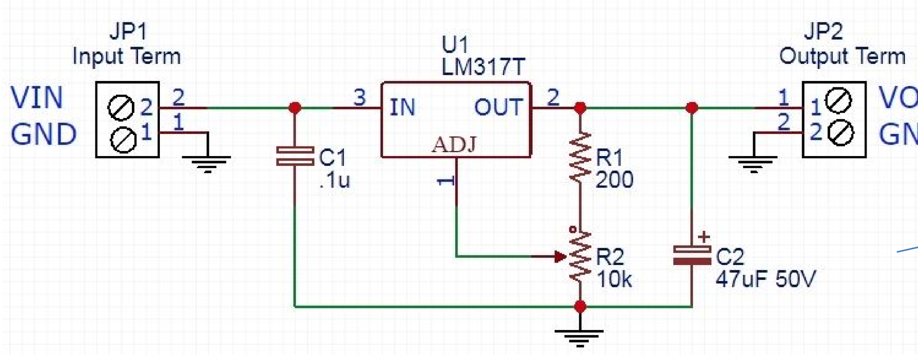


Breadboard





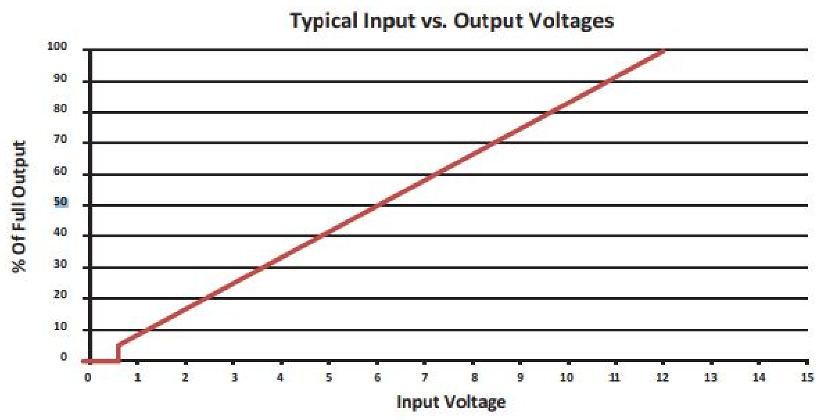
LM317



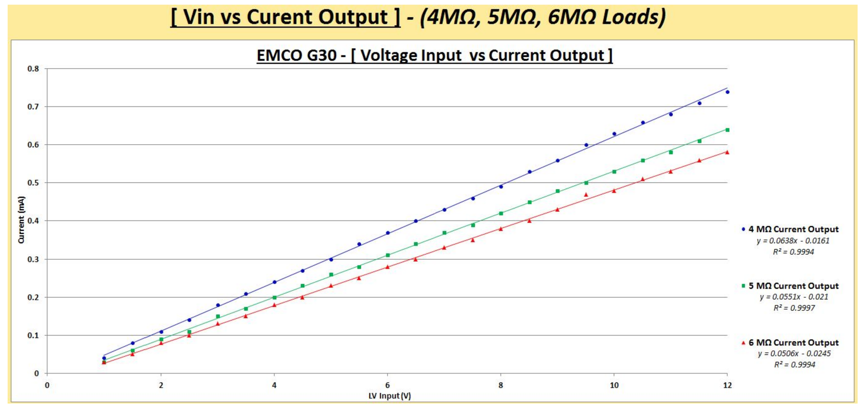
https://protosupplies.com/product/lm317-adjustable-linear-regulator-module/

EMCO High Voltage Converter

Expected Output Voltage



Experimental Output Voltage



Maximum voltage and current out put when voltage in is at 12v

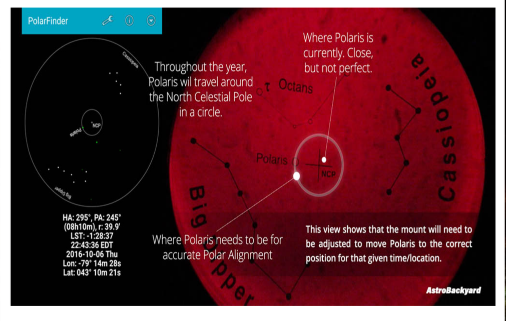
G30	3kV	0.50mA

https://www.xppower.com/Portals/0/pdfs/SF_G_Series.pdf

Equipment and Celestial Objects:

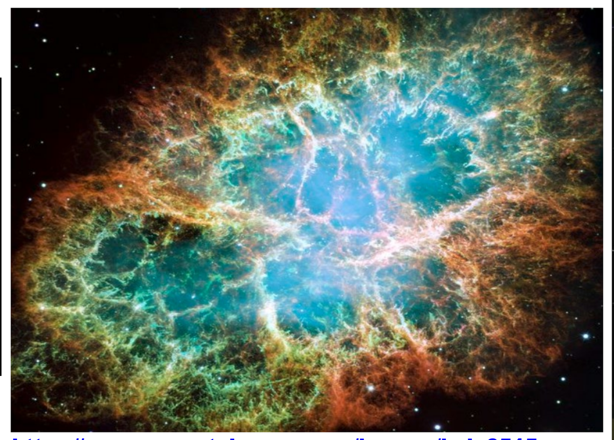
Optical Telescope

Alignment with Crosshair



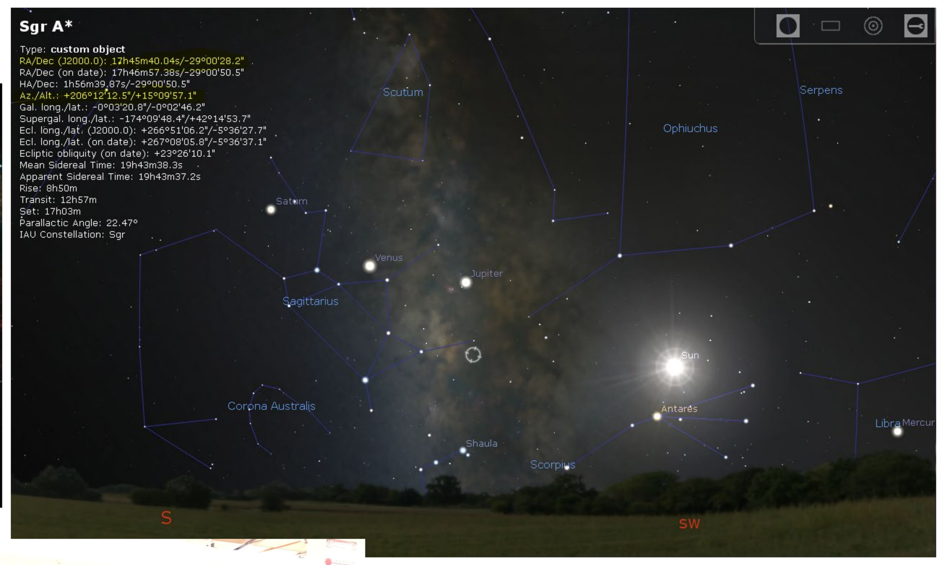
https://astrobackyard.com/polar-alignment/

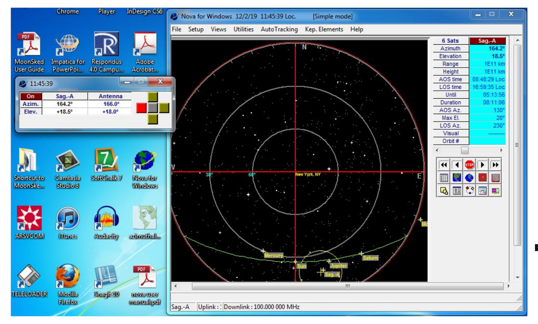
Crab Nebula



https://www.spacetelescope.org/images/heic0515a

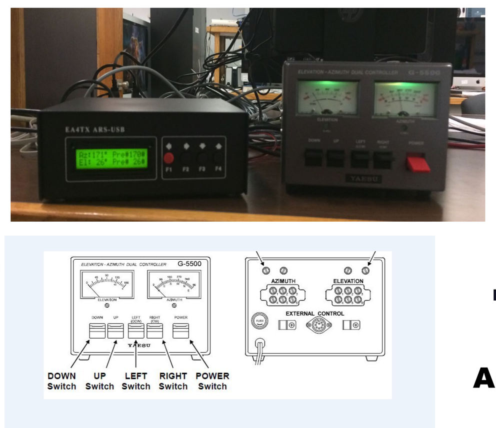
Stellarium **showing Crab Nebula and SGR A* Celestial and Horizontal Coordinates**





Nova for Windows :
Performing The Auto-Tracking Process

Manual Controller And Antenna Rotator

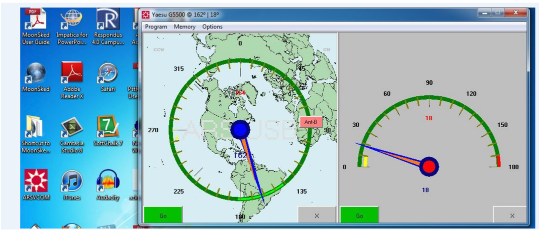


Tracking Device

Antenna Rotor

Photomultiplier Tube

ARSVCOM SOFTWARE



One day path tracking:

Crab Nebula (Taurus A) from 12 / 02 / 2019 to 12/ 03/2019:

Rise:	17:24	AZI: 60°	ELE: 0°	(North East)
	20:00	AZI: 84°	ELE: 28	
Peak:	00:42	AZI: 178°	ELE: 71°	(High in the Southern Sky)
	04:00	AZI: 260°	ELE: 44°	
	06:30	AZI: 285°	ELE: 16°	
Set:	08:05	AZI: 299°	ELE: 0°	(Between North and North West)

Sagittarius A * on 12/02/2019:

Rise:	08:52	AZI: 129°	ELE: 0°	(South East)
	11:30	AZI: 160°	ELE: 17°	
Peak:	13:05	AZI: 181°	ELE: 20°	(Low in southern Sky)
	15:00	AZI: 207	ELE: 14°	
SET:	17:02	AZI: 299°	ELE: 0°	(South West)

One day tracking sample

Procedure:

Later, another method was applied to check the accuracy of the tracker which involved using two softwares: *Nova for Windows* and *Stellarium.* The first one was already installed in one of the computers in lab room, but the second one was downloaded later. NfW enabled the auto-tracking mode for the tracking device and Stellarium was used to check the celestial and horizontal coordinate's precision. Also, Stellarium software has the feature to render the path of any celestial object on any date and any time which makes this project more convenient.

One important steps that truly has improved the accuracy of the tracking procedure was changing the geographical coordinates of the observatory place in both programs' settings.

Also, due to wiring system in every building it is suggested that the tracking procedure is conducted outdoors.

Future Work:

I. Troubleshooting and connecting the optical telescope to a PC.
II. Making the PC a mediator between the optical telescope and the Muon tracker
III. Repurposing 30 computers for the Cosmic Ray Undergraduate Research Lab. 15 Macs with Windows 10, and 15 Mac with Mac OSX High Sierra.

Acknowledgement :

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Reference:

1) First Detection of Photons with Energy Beyond 100 TeV from an Astrophysical Source, arXiv:1906.05521v1, 13 June 2019
2) Acceleration of petaelectronvolt protons in the Galactic Centre, doi:10.1038/nature17147
3) On the Galactic Center being the main source of galactic cosmic rays as evidenced by recent cosmic ray and gamma ray observations, Yi-Qing Guo *et al* 2013 *New J. Phys.* 15 013053
4) https://stellarium.org