Tracking The Detector

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Image credit: https://www.rawpixel.com/image/5924106/photo-image-public-domain-stars-galaxy

What Are Cosmic Rays

- Particles produce by the sun or other stars

Muons

- Sub-atomic particle created by high energy protons collide with molecules in the air.
- This sub-atomic particle is being used to detect Cosmic Rays.

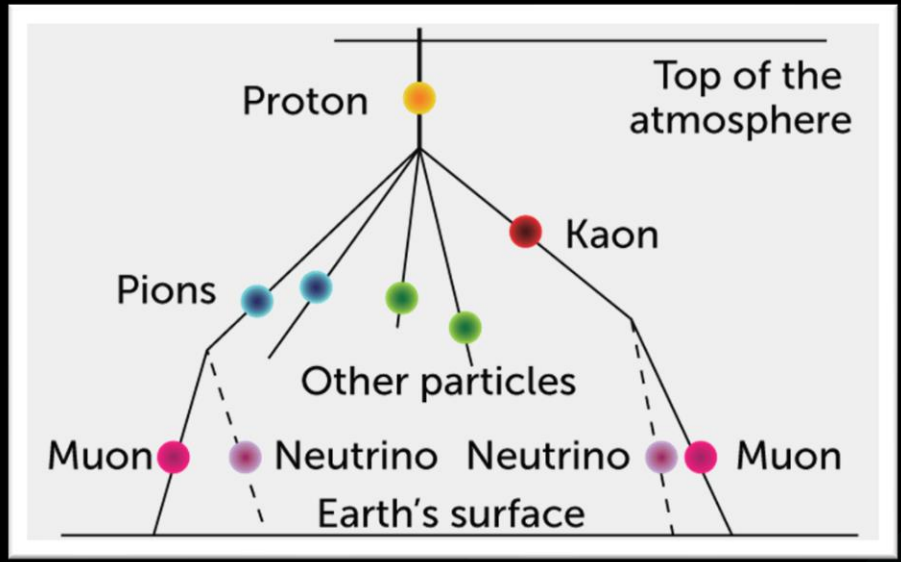


Image Credit: https://www.sciencenews.org/article/muon-subatomic-particle-volcano-pyramid-physics

The Cosmic Ray Detector Telescope

CRD Components

Scintillator:

- Passes ionizing radiation to produce light emission

Photomultiplier tube:

- Uses photon to knock electrons off specific metal
- Multiplies electrons and produces a detectable pulse

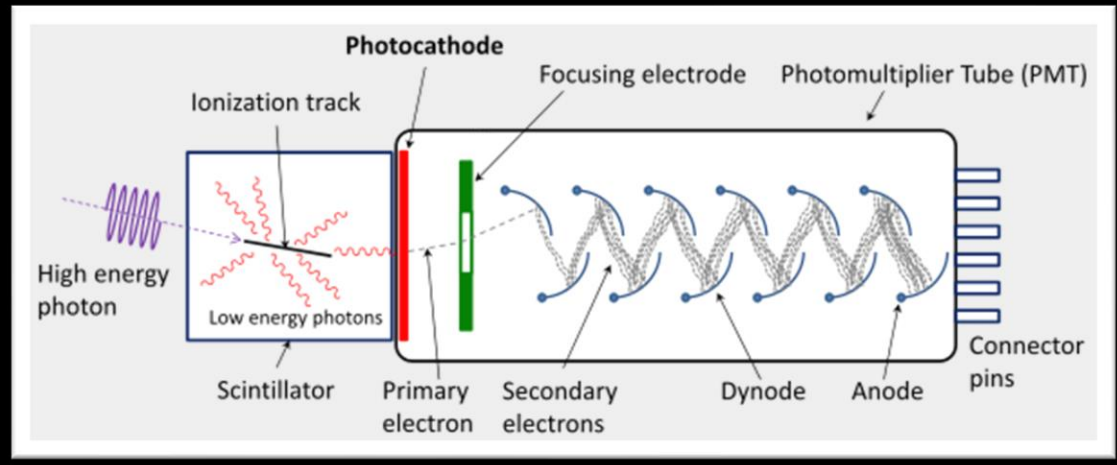


Image credit: https://en.wikipedia.org/wiki/Scintillation_counter

Track Position of detector

- Tracking the azimuth position(yaw axis) with an operating range of 0-360 degrees
- Tracking the tilt position(pitch axis) with an operating range of 0-90 degrees

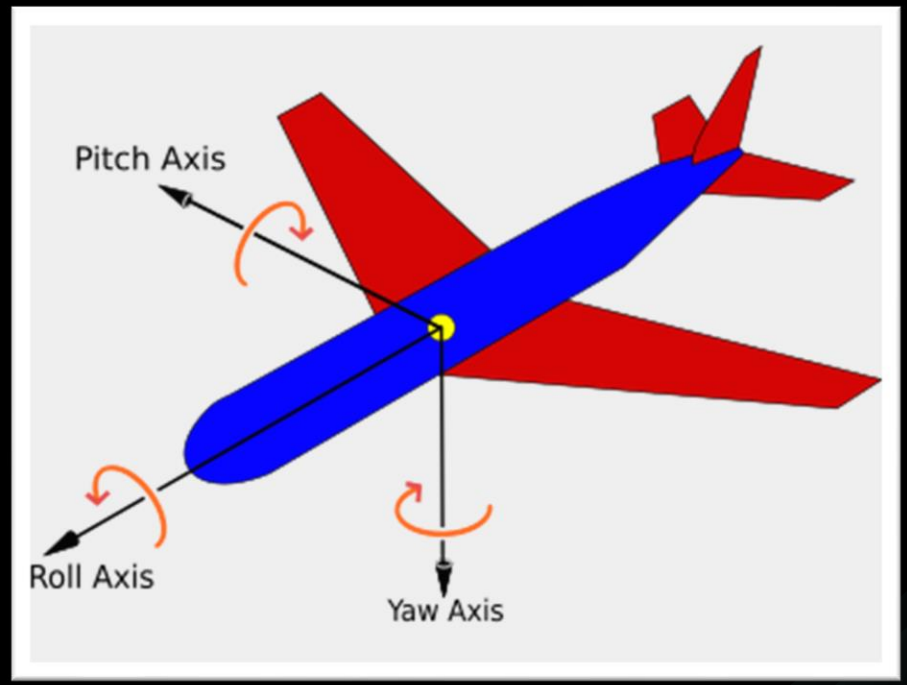
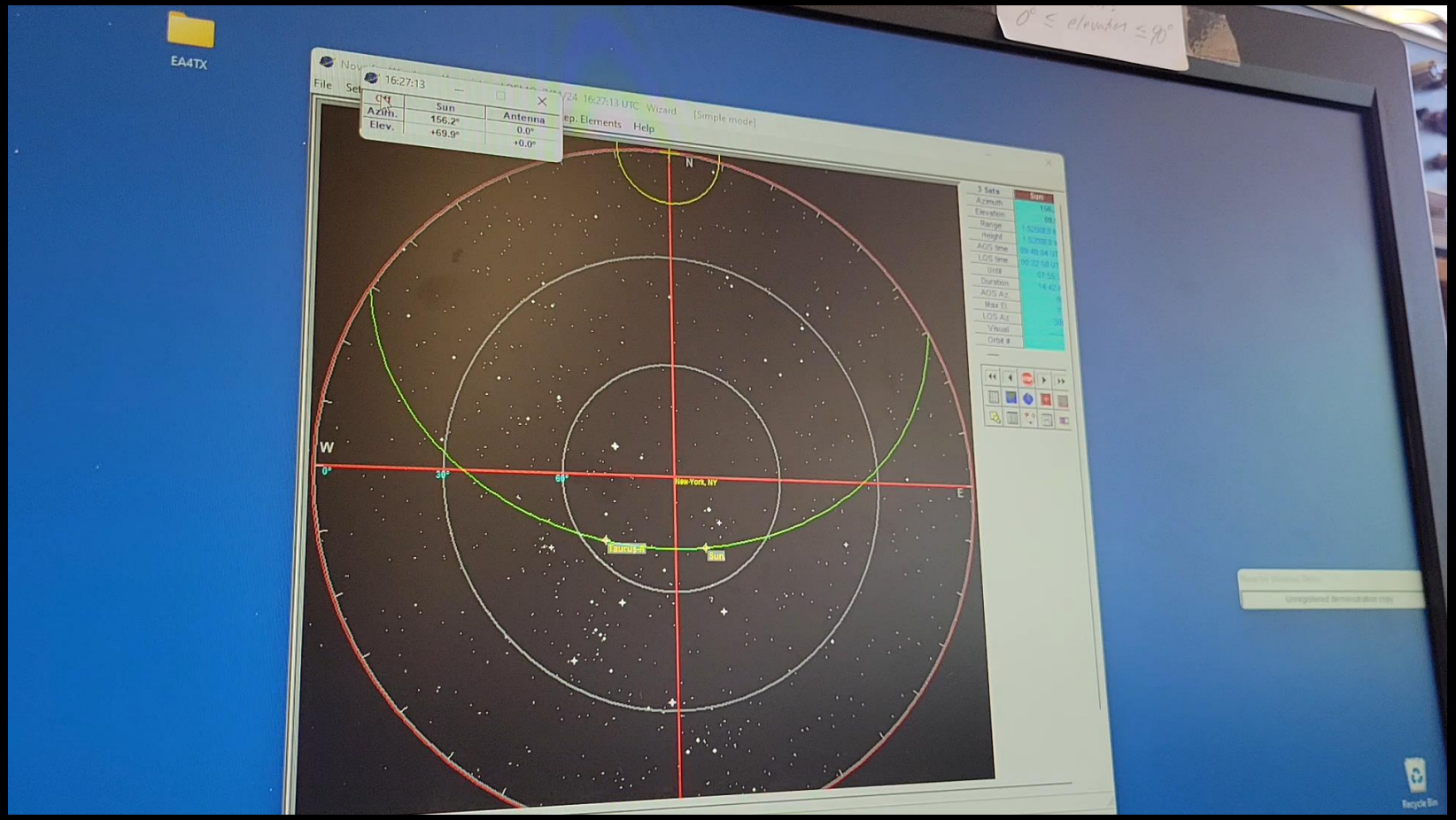


Image Credit: https://en.wikipedia.org/wiki/Aircraft_principal_axes

NOVA for Windows

- Used for cosmic ray telescope to track sun
- Connects to EA4TX ARS-USB to communicate motor on telescope with computer

Nova and Telescope motor in action



Why Track Telescope Position?

The Telescope is pointing the detector towards the sun

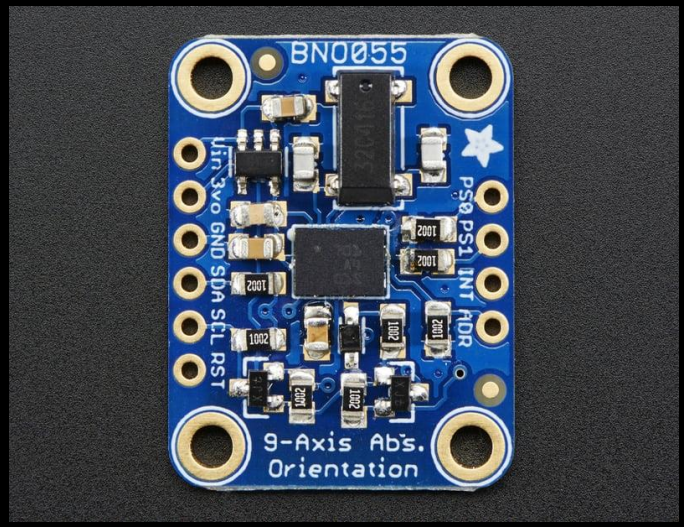
The Motor’s antenna does not always represent position of the detectors

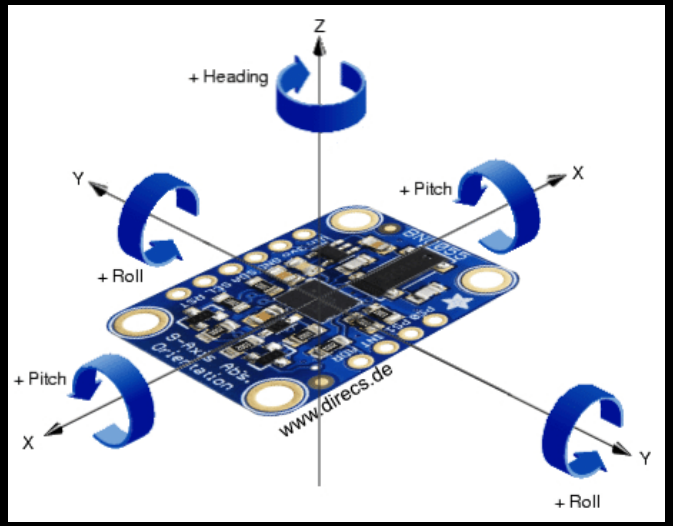
Keep motor reading independent from detector position

Monitor detector position for analyzing Cosmic Ray Data

The Position Sensor

- Adafruit BNO055 9-axis Absolute Orientation sensor
- It is being used to track the Pitch and Yaw axis of the Detector
- Can be used for relative position(useful for mag field disruption)
- Can be used as gyroscope
- Connects to Arduino





Development of Senor and Enclosure

Create program to extract position data and print position program

Create GUI for easy read for user

Develop enclosure for sensor

Code Development

- Set Axis definition
- Set operation mode(to disable magnetometer)
- Used as Gyroscope and Inclinometer(tilt)

```
#include <SPI.h>
#include <Arduino.h>
#include <Wire.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_BNO055.h>
#include <utility/imumaths.h>

#define BNO055_SAMPLE_DELAY_MS (100) //collects data every 100ms

Adafruit_BNO055 myIMU = Adafruit_BNO055();

void setup() {
  Serial.begin(115200); //prevent data pile up
  myIMU.begin();
  delay(100);
  myIMU.setMode(OPERATION_MODE_IMUPLUS); // Disables Magnetometer. Now works as gyro.
}

void loop() {
  imu:: Vector<3> pos = myIMU.getVector(Adafruit_BNO055::VECTOR_EULER); // Reads in degrees
  Serial.print(" AZ: "); //Azimuth
  Serial.print(pos.x());
  Serial.print(" Roll: ");
  Serial.print(pos.y());
  Serial.print(" ALT: ");//Altitude
  Serial.print(pos.z());
  Serial.println("");

  delay(BNO055_SAMPLE_DELAY_MS);
}
```

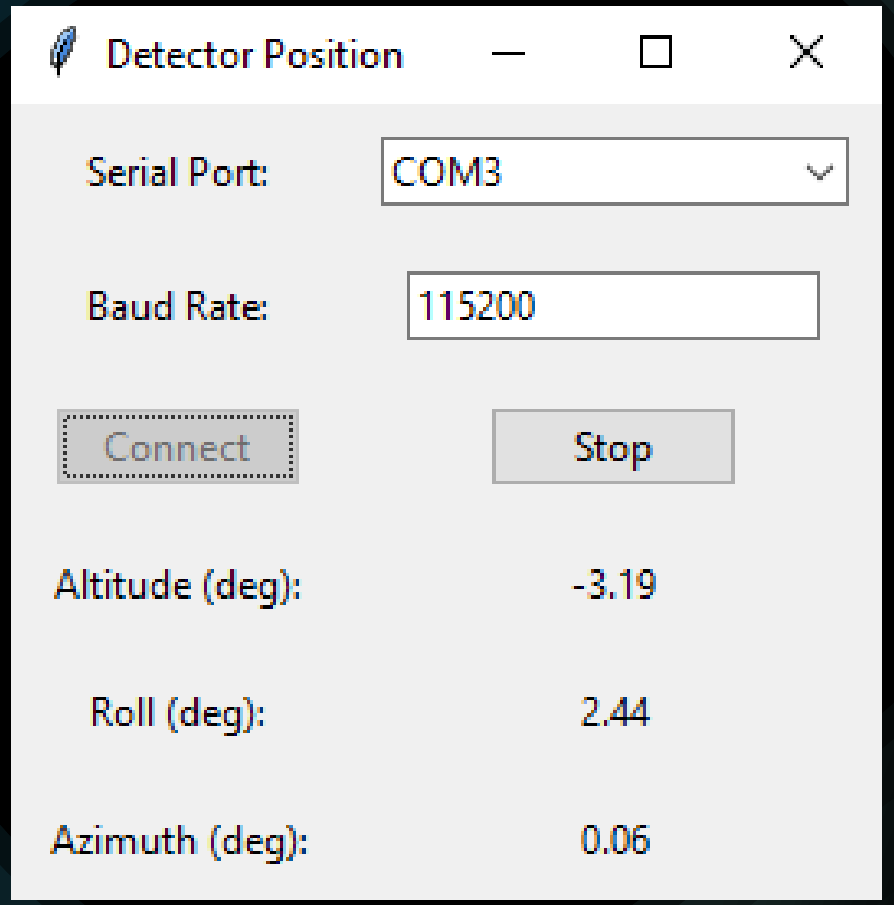
Operating Modes

Table 3-3: Operating modes overview

Operating Mode		Available sensor signals			Fusion Data	
		Accel	Mag	Gyro	Relative orientation	Absolute orientation
	CONFIGMODE	-	-	-	-	-
Non-fusionmodes	ACCONLY	X	-	-	-	-
	MAGONLY	-	X	-	-	-
	GYROONLY	-	-	X	-	-
	ACCMAG	X	X	-	-	-
	ACCGYRO	X	-	X	-	-
	MAGGYRO	-	X	X	-	-
	AMG	X	X	X	-	-
Fusion modes	IMU	X	-	X	X	-
	COMPASS	X	X	-	-	X
	M4G	X	X		X	-
	NDOF_FMC_OFF	X	X	X	-	X
	NDOF	X	X	X	-	X

GUI

- Developed with python code
- Can be used on computers other than source computers

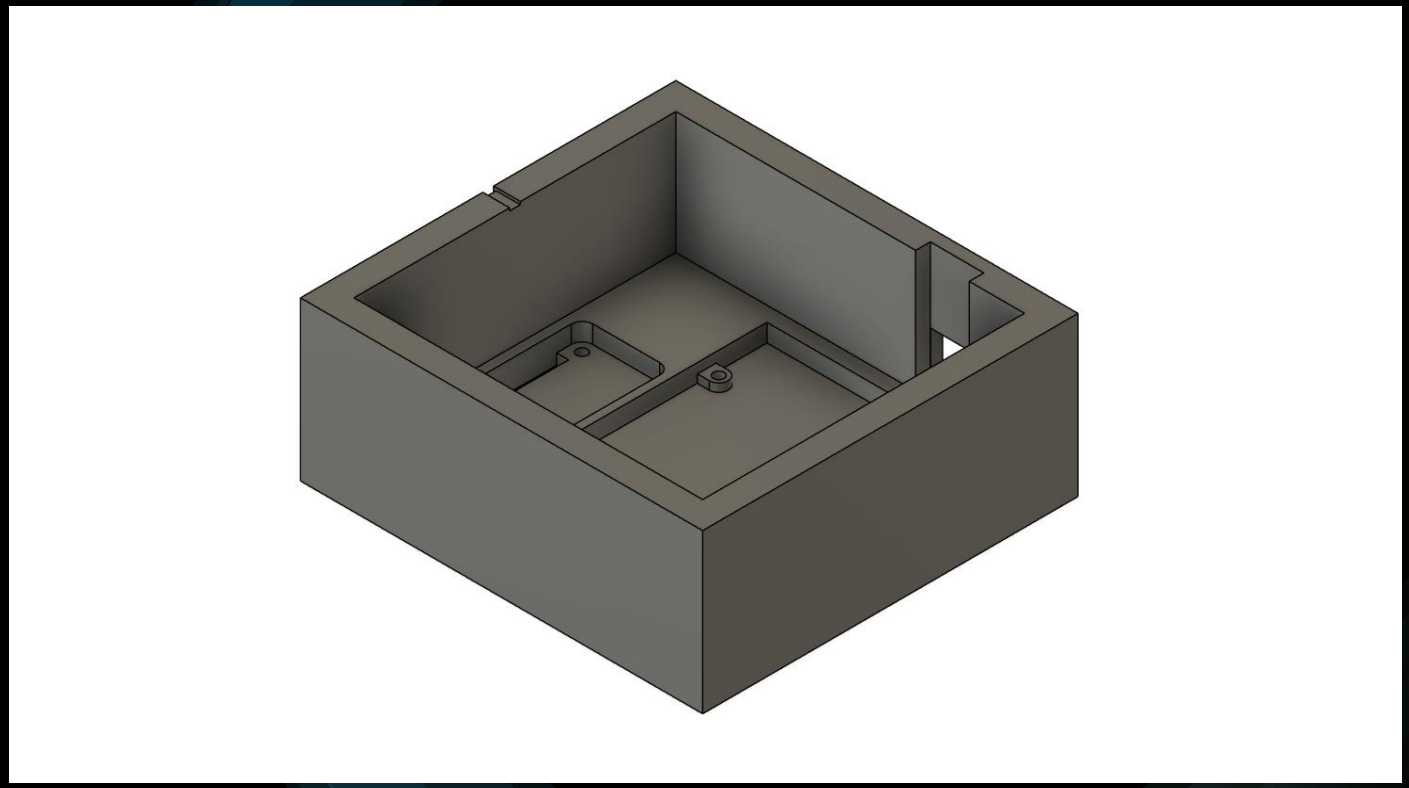


The Enclosure

- Used to house both the Arduino and BNO055 sensor
- To be mounted on the detector
- 3D printed using PLA
- Designed with serviceability in mind

3D Model of Encloser

- Designed using Fusion 360
- Has a notch that is centered and pointed to the front of the sensor

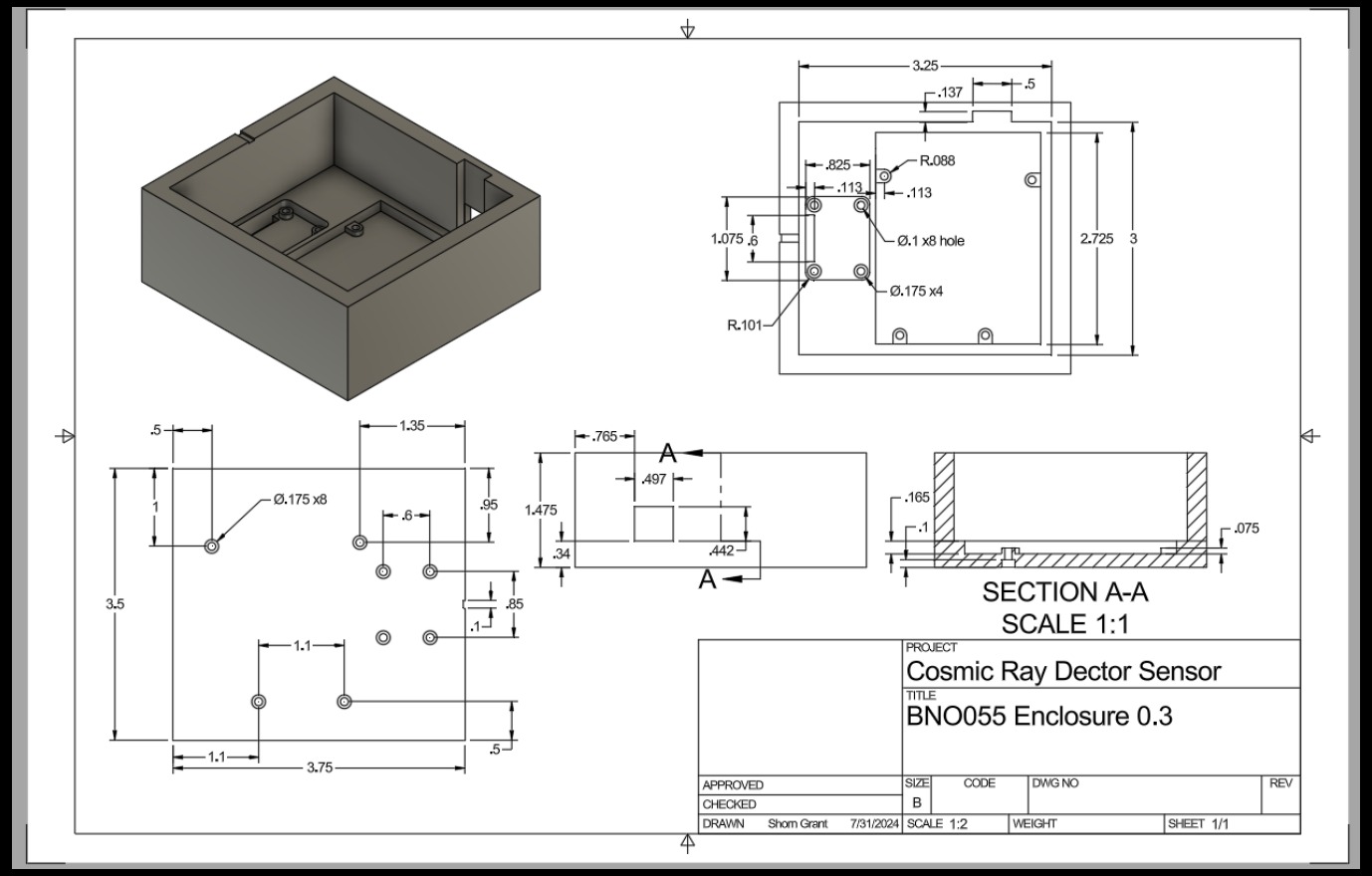


Dimensions

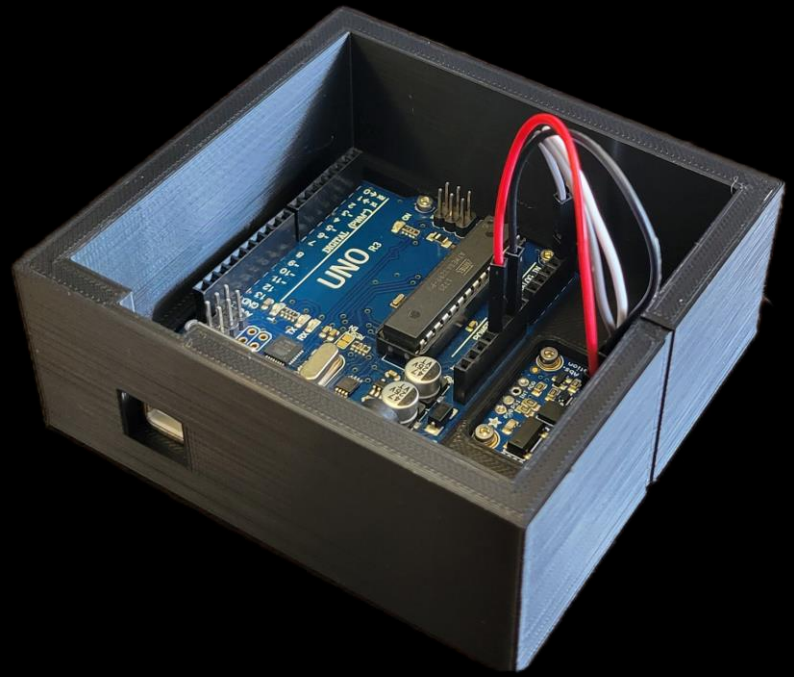
Dimension were found by using vernier caliper to measure components

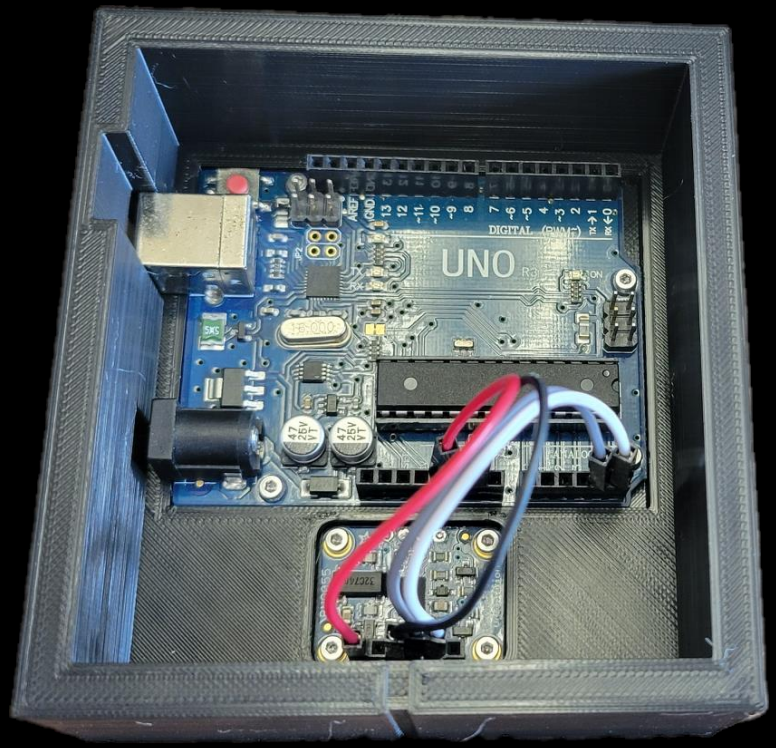
Units are in inches

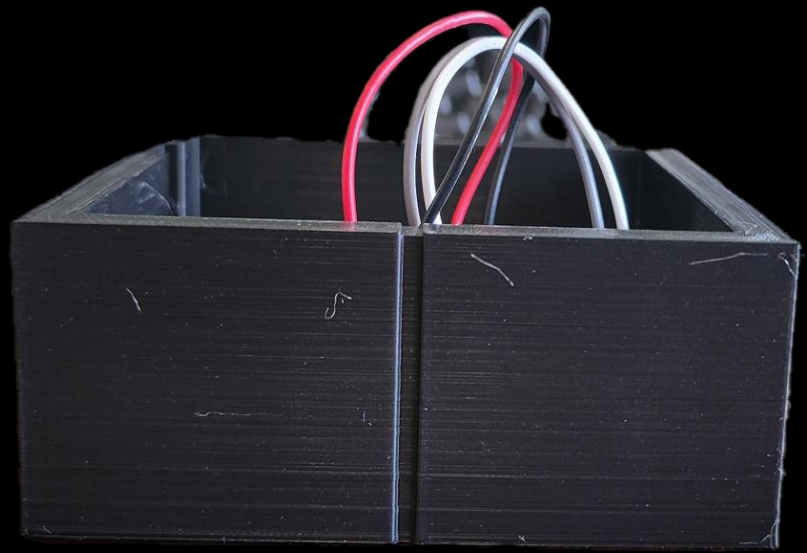
Measurements are over sized for clearance

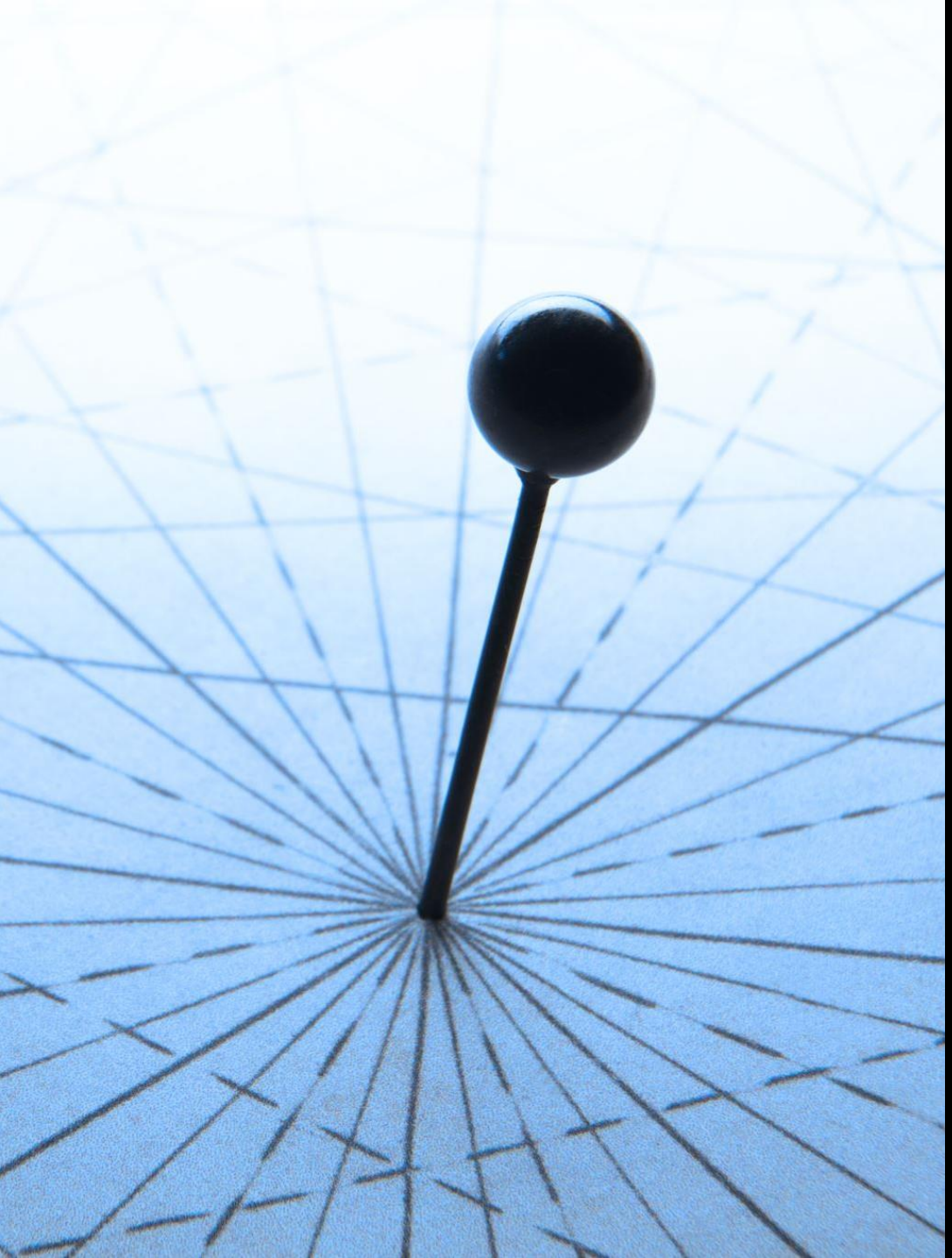


3D Printed model









Limitation of Sensor

- Uses relative position for azimuth
- Setting azimuth to zero is manual
- Pointing to geometric North is manual
- Precision of notch is within 1 degree
- Human error will effect starting direction

Future Plans

- Find a mounting solution
- Update enclosure (making lid)
- Refine any bugs in program
- Better test accuracy of BNO055
- Possibly use Stellarium or NINA for telescope tracking
- Find gyro-compass for always showing true north