Photo Credit: BLAST-TNG, January 2019

Terahertz Intensity Mapper (TIM)

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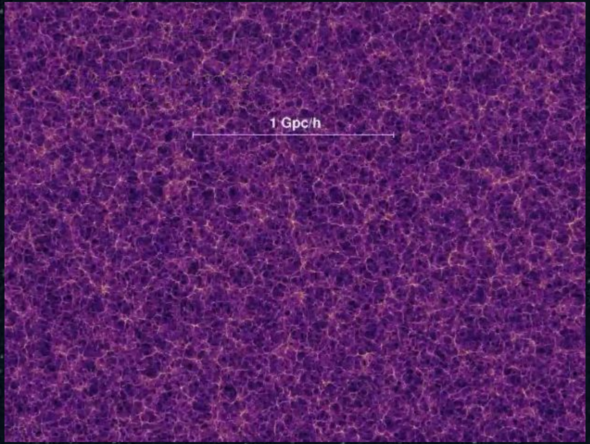
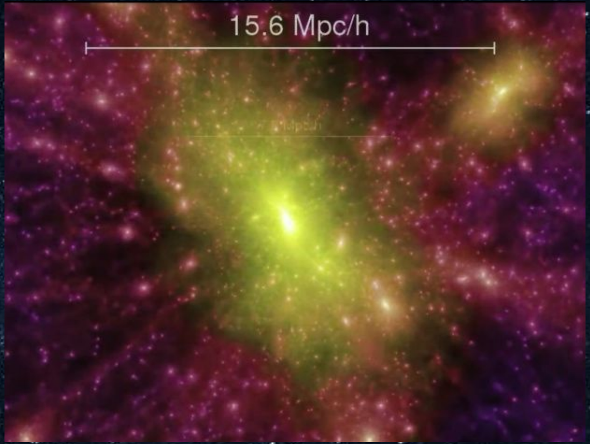
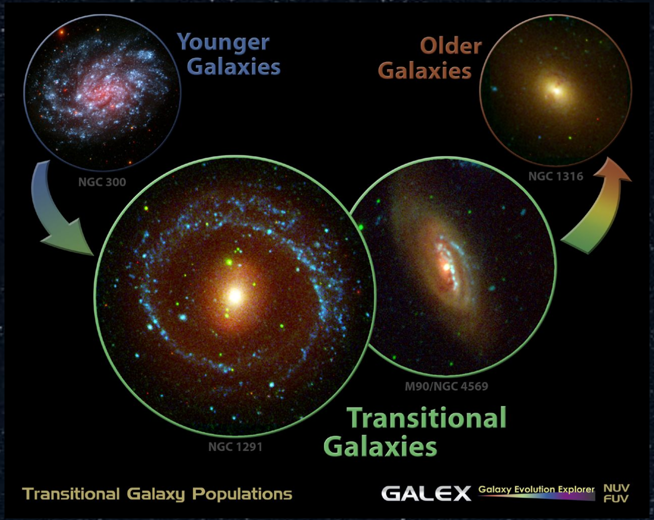
Gravitationally dense regions get denser over cosmic time…

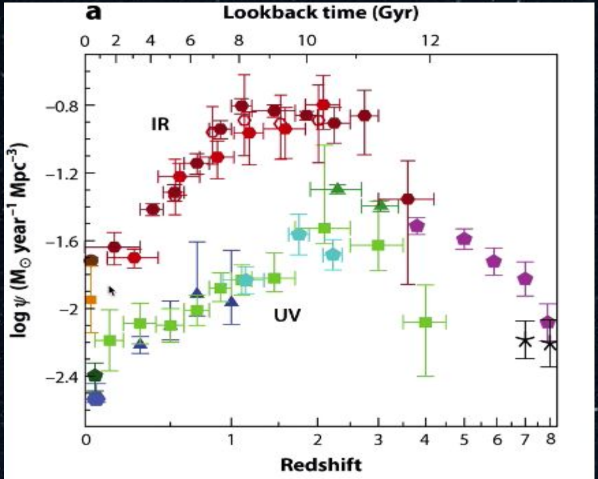
The Terahertz Intensity Mapper (TIM) is an experiment designed to study galaxy evolution. Researchers use this balloon-borne telescope to map star formation over the universe's history. Although the universe is in a constant state of expansion, the material within it is contracting. The top left image depicts our universe on an enormous scale, billions of light years across. From a zoomed-out perspective, our universe appears quite smooth. However, a slight filamentary structure is present due to gravitational forces. The bottom image represents a zoomed-in version of the top photo, where gravity has created a clustering of galaxies, giving the universe its filamentary structure. This is why gravitationally dense regions tend to get denser over time.





Why do galaxies change? Why has star formation slowed?

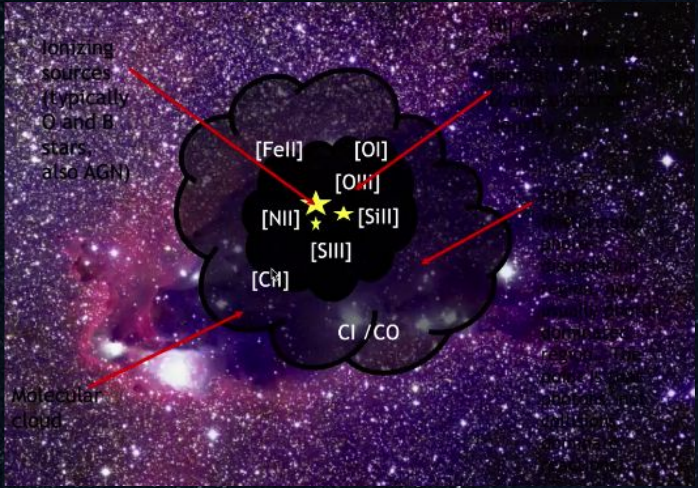




Star formation has not experienced a constant increase that is consistent with this principle. Instead, star production hit its peak in the first ⅓ of the universe's life, and has been steadily decreasing for the past 8 billion years. Researchers on TIM want to understand why star formation was so rapid in the beginning of our universe as compared to "recent" history. TIM not only measures the degree of star formation, but also assesses the shape and contents of our universe that are in a constant state of flux. As seen in the image on the left, older galaxies appear rounder, dustier, and are composed of colder red stars. On the other hand, newer galaxies take on the shape of a thin disk and contain hotter and newer blue stars.

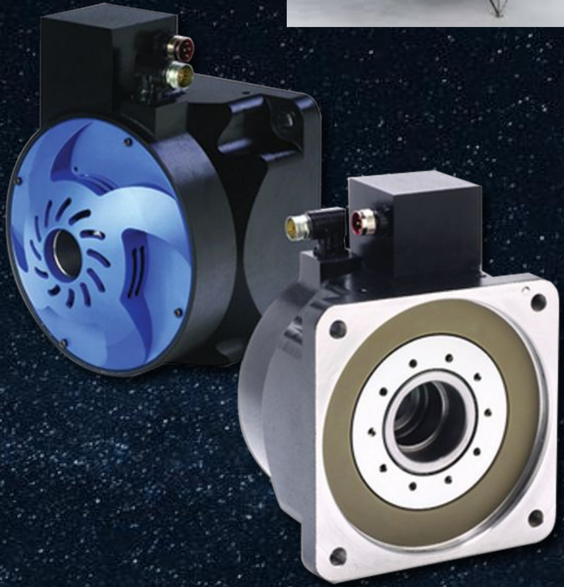
How TIM is designed to answer these questions...

To observe different types of galaxies and star formation, TIM measures the strength of the electromagnetic field and assesses its wavelength, frequency, etc. Atoms and ions present in the interstellar medium create far-infrared emission lines detected by the telescope. The strength of these emissions tells us information about star formation (i.e. mass of stars). To detect far-infrared light, the TIM must be above the atmosphere, necessitating a helium balloon designed to bring the telescope into a high altitude.



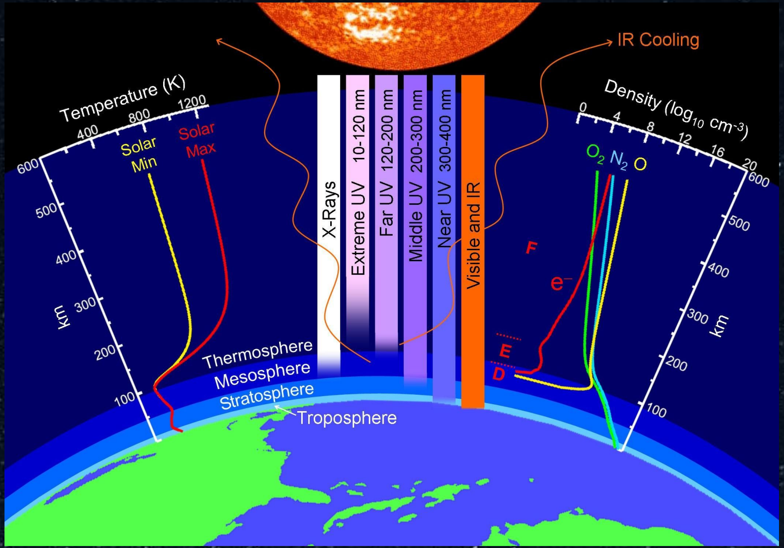
The role of the elevation drive...

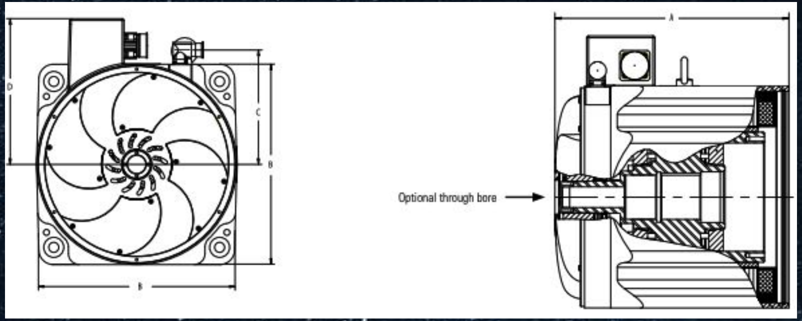
1. Elevation motor (Kollmorgen C053A)
    a. Rotary motor controlling elevation of TIM’s inner frame
2. Elevation motor encoder (built-in device)
    a. Measures the angular position of the inner frame relative to the outer frame; feedback allows the motor to adjust to the correct position with extremely high precision
3. Servo Drive (Kollmorgen P01206)
    a. A controller; inputs battery power and sends signals



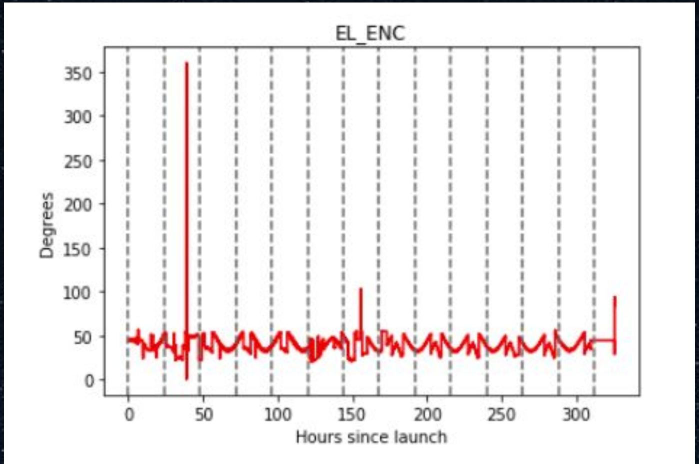
Collecting information & seeking alternatives

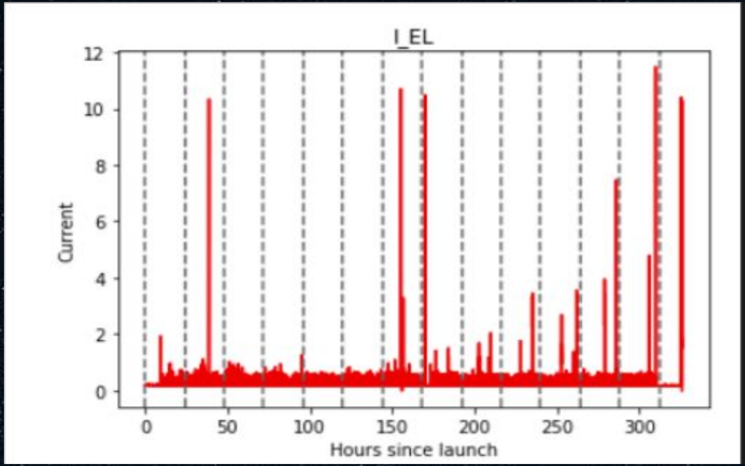
To decide which rotary motor to use, thorough research on the device is necessary to ensure it provides peak performance during TIM's flight. From previous balloon telescope projects, such as BLAST-TNG, and reaching out to manufacturers, I gathered information on accuracy, temperature range, mass and dimensions, data rate, and other useful measurements. The encoder has a repeatability accuracy of 0.7 arc-seconds, which is suitable for TIM because 1 arc-second and below is considered highly accurate. The operable temperature range for this device is 0 to 140 degrees Celsius. A wide temperature range is necessary in-flight because constant exposure to the sun and a lack of atmosphere can cause the gondola to overheat. Noting mass and dimension is extremely important when assembling TIM and ensuring that the motor is mounted appropriately.





Plotting BLAST 2012 data





Median:
0.1948

Peak Values (Estimated):
10.35
10.70
10.45
7.40
11.50
10.30
10.25

To access information on in-flight data from the elevation drive, I ran code through a jupyter notebook and graphed information from the BLAST 2012 flight. Over the 300 hours BLAST was in flight, I plotted the motor's elevation (as shown in the image on the left), current (right hand image), temperature, and voltage from the batteries. Measurements on elevation tell us what we should expect during TIM's flight, and taking median values from plotting current and voltage allowed me to calculate total power draw (P = I*V).

What’s next?

The next step for TIM’s research team is to purchase the sensors we have been researching all summer and get them set up in the lab. Once everything has been received, we will begin testing sensors and brainstorming how they will be oriented onto TIM. Additionally, we would like to rethink the gondola design as compared to previous BLAST missions. This summer marked the first year of a five year project, so there is a long way to go before TIM is flying above the atmosphere, studying our universe’s galaxy formation.