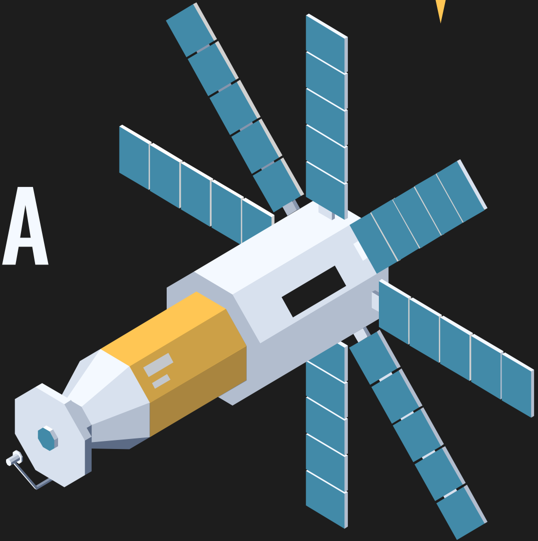
Supermassive Black Holes and SO2 Satellites: How NASA SEES 2022 Influenced our Passions and Future Careers



By Rishika Porandla & Hannah Singer

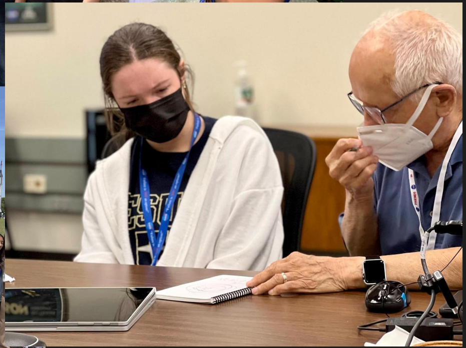
NASA SEES 2022: Learn About the Interns

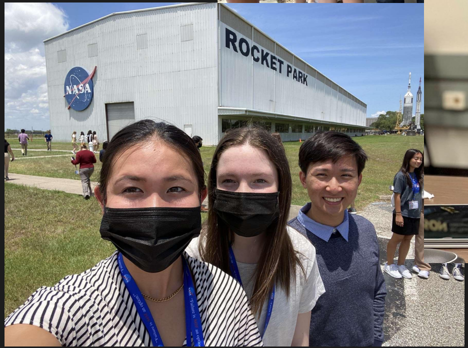
Rishika Porandla

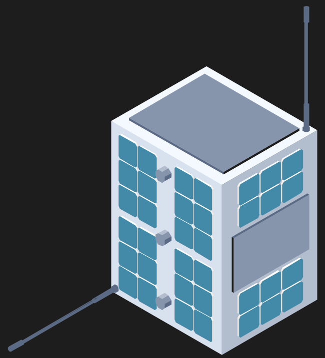
- 11th Grade at Coppell High School
- Planning to major in Physics and minor in Astronomy in college
- Specialize in Astrophysics and scientific research
- Founder and Director of Astrophysics outreach program "Spacetime Archives"
- 2022 NASA SEES intern in the Astronomy Team
- Vice President of Teen Texas Astronomical Society
- Team Lead of UT Austin's High School Experimental Particle Physics Research Group
- Astrophysics research mentor for high school research groups
- Winner of the U.S. Agency of International Development (USAID) Science Champion Award

Hannah Singer

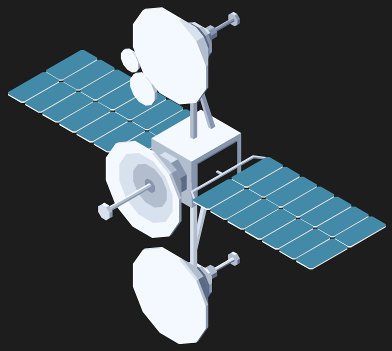
- Senior at Ursuline Academy of Dallas
- Attending the University of Pennsylvania in the fall
- Majoring in Mechanical Engineering
- 2022 NASA SEES Intern on the SO2 Satellite Aerospace Engineering Team
- Submitted heliophysics-based Great Lunar Expedition for Everyone (GLEE) satellite proposal
- Editor of school newspaper and avid Meals on Wheels volunteer







Hannah's Experience



Living and learning with the SO2 Satellite team in NASA SEES 2022.

Our Team!

- Professor Emeritus Wallace Fowler was our mentor
  - Served 51 years on the faculty of Aerospace Engineering at UT Austin
  - TSGC Director from 2002 until retirement in 2017
- Our 10 team members hailed from seven different states across the United States

Our Task

Our Objectives

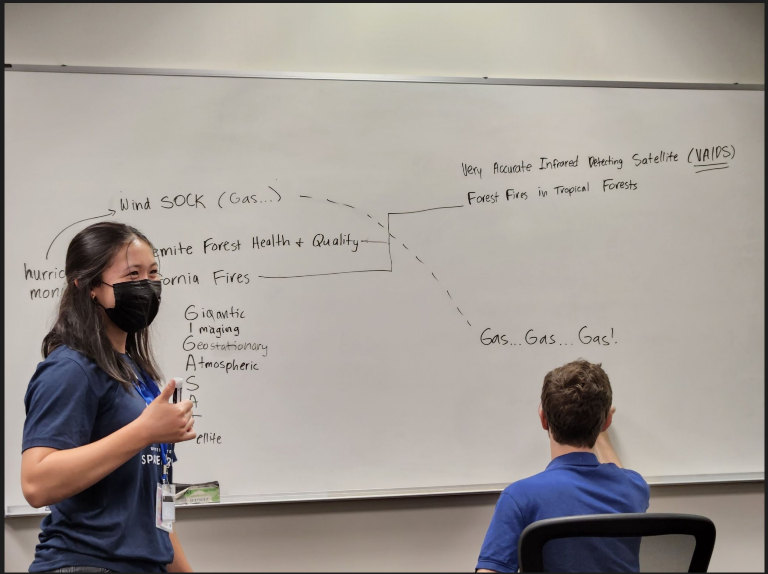
- Choose one or more aspects of Earth's environment to monitor
- Propose an instrument(s) to do the monitoring.
- Choose an appropriate satellite orbit
- Develop an approximate satellite system specification and mass allocation.
- Create a conceptual satellite layout for the satellite.
- Choose a potential launch vehicle

Our Satellite

- Giant Imaging Geostationary Atmospheric Satellite
    a. GIGASat
- The purpose of GIGASat is to track environmental factors from geostationary orbit utilizing remote sensing technology

How We Started

- Before arriving, everyone researched past satellite missions, orbital mechanics, and spacecraft assemblies and instrument (more in depth than the required SEES pre-work)
- Everyone also proposed at least two mission ideas prior to arriving in Austin
- When we arrived, we narrowed down our ideas and landed on three to tackle simultaneously
- The focal points we ultimately chose were wildfires, oil spills, and industrial/corporate carbon emissions
- Our team then split into two sub-teams: Hardware and Orbit
- I was on the Orbit team!



GIGASat's Hardware

GIGASat's Instruments

PLEDGE
a. AIRS
b. VIIRS
c. Satellie Vu's Infrared Satellite Technology

FREYA
d. AIRS
e. VIIRS

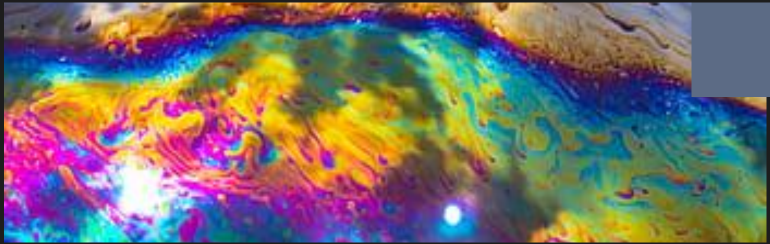
NJORD
f. Laser Fluorosensor
g. Full-range Spectrometer
h. Microwave Radiometer

PLEDGE

Planned Emissions Detection Geographer

FREYA

Forest Fire Remote Environment Yield Assembly



NJORD

Nautical Jettisoned Oil Recovery Detector

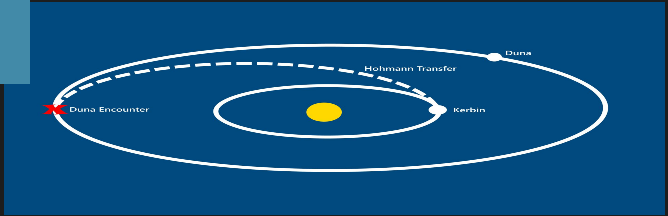
GIGASat's Orbit

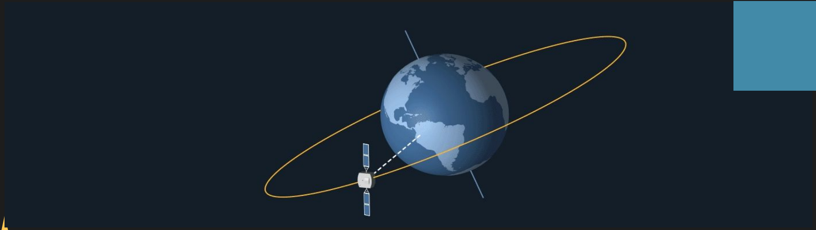
PHASE 1

GIGASat will be launched onboard the Falcon 9 rocket and placed in a Low Earth Orbit.

PHASE 2

GIGASat will perform a Hohmann Transfer alongside a plane change from LEO to GEO and will be placed at 70° W, 290° E





PHASE 3

GIGASat will monitor the targeted environmental factors for the next ten years or more, before being decommissioned into the GEO Graveyard.

GIGASat by the Numbers

LEO:

- Semi-Major Axis: 6,643 km
- Velocity: 7.746 km/s

Hohmann Transfer:

- Burn 1: 10.18km/s at 189° E
- Burn 2: 1.60km/s at 290° E

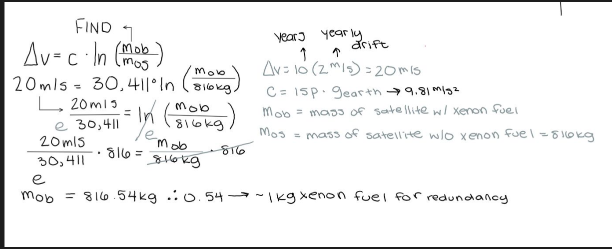
GEO:

- Semi-Major Axis: 42,164 km
- Velocity: 3.07km/s

How Our Teams Came Together

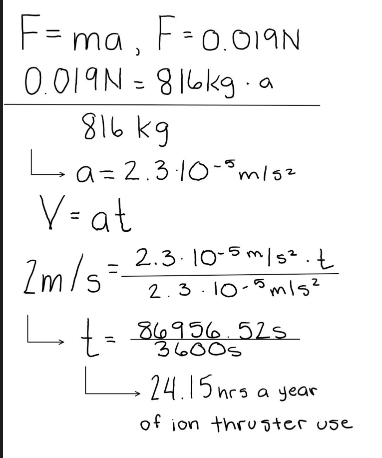
$$\Delta V_i = c_i \ln(m_{oi} / m_{fi})$$

$$c = I_{sp} g$$



178

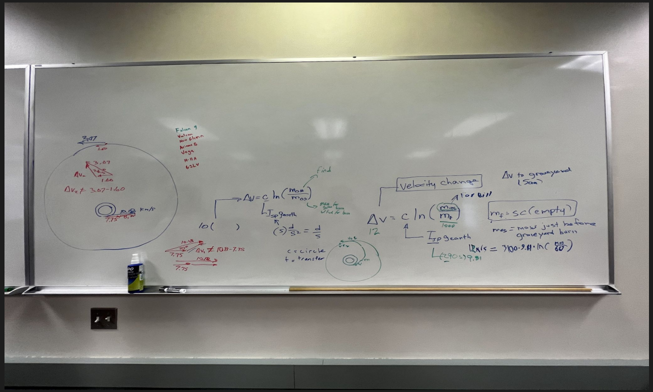
Spacecraft and Mission Design

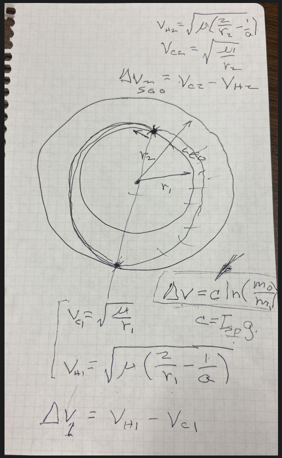


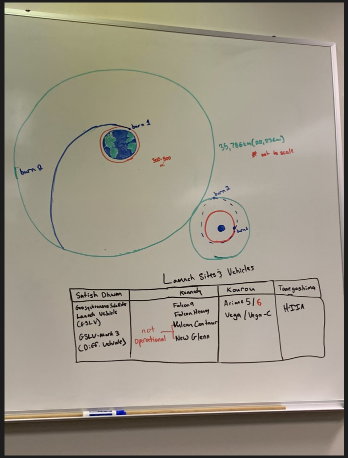
- This is the Rocket Equation
- The total mass of the spacecraft connected the two teams
- With that mass, we could use these two equations to calculate the extra fuel needed for redundancy and the amount of propellant needed given the mass
- These equations relate the change in mass to the change in velocity (Conservation of Momentum)

GIGASat & Research

- Allowed us to work with, learn from, and speak to industry professionals on a real-world, complex research project
- Gave us the opportunity to work on our social & collaborative skills to create a presentation with sources, reasoning, and analysis
- Had the chance to apply my knowledge to something so much greater than myself
- Introduced us to several different types of research and let us try a little bit of everything

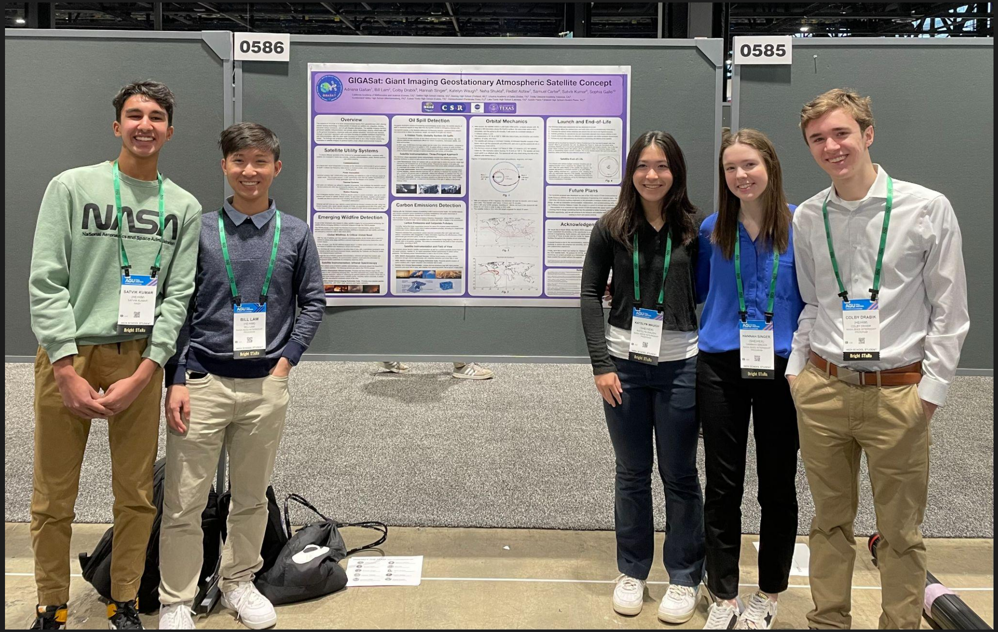






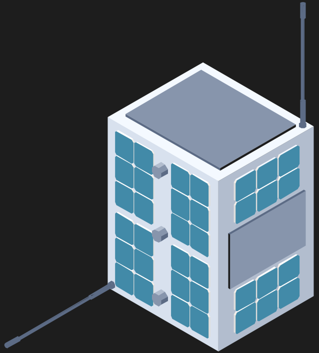
American Geophysical Union

- Had the opportunity to present to industry professionals and experts
- Received constructive criticism, inspiration, and motivation from people we looked up to
- Made connections with companies I hope to intern with or even work for in the future

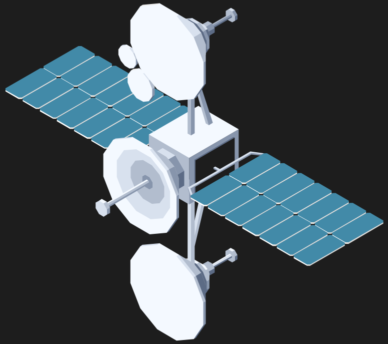


NASA SEES's Impact on Future Career

- First-hand exposure to engineering and the space industry helped to clarify my college and career trajectory
- Introduced me to careers and opened doors I never knew existed
- Inspired me to pursue a career in the space industry and fueled a passion for engineering and space science
- I left SEES with a deep appreciation for NASA's ingenious ideas and incredible dedication to furthering our knowledge about both space and our own planet
- Made lifelong friends that I still talk to all the time!
- I'm incredibly excited to continue exploring engineering and space science at Penn and beyond



Rishika's Experience



Living and learning with the Astronomy: Galaxy Classification team in NASA SEES 2022.

OUR TEAM

- Coming from 10 states across the U.S. and mentored by Dr. Judit Ries, a Professor of Astronomy at the University of Texas
- Split into three teams that investigated supermassive black holes, dark energy, and galactic velocities
- Worked for 14 days in person at the University of Texas, dorming with each other, and conducting our final NASA SEES Symposium presentation together.

Our Work As Astronomy NASA Interns

Our Objectives

- Our initial objective was to complete the classification of ~1000 galaxies using the Radio Galaxy: LOFAR software and use the collected data and images to answer fundamental questions like...
    a. Are the given galaxy images anomalies? (i.e., are they artefacts, blends, too zoomed in, have missing images, or do they have another issue)?
    b. Is there a clear optical counterpoint or source with visible **and** distinguishable jet(s)?
- Within our classification, we intended to ensure multiple revisions of the same image in order to verify our results.
- Considering our most ideal optical sources and corresponding jets, we aimed to continue further analysis that would determine the quantifiable and relative relationships between the radio jets of various images.
- Our final goal was to compare the ratio of the jet lengths of different supermassive black hole radio sources and possibly configure the approximate sizes of their corresponding optical sources.

Research Process

Our methodology was based on the idea of cross examining and referencing telescopic archives and analyzing prior research papers. Each member of our group followed a certain order of steps to ensure that we would yield comparable results later on when we analyzed our data.

PROCESS: GALAXY CLASSIFICATION

a. We analyzed about 1000 images by noting which radio contours are emissions of the source and which optical object is the source of the radio jets.

b. Such examples include:

  1. Artefact: where the radio sources are distorted due to calibration problems. This happens when a bright radio source is close by, therefore possessing an “explosion” like nature.
  2. Too zoomed in: where radio regions go far beyond the borders of the image.
  3. Blends: where the telescope views two or more separate sources as a whole
  4. Missing images: where the optical image is not seen but the radio sources are
  5. Diffuse radio source: where the image would be a diffuse radio source, which does not map any radio structures.

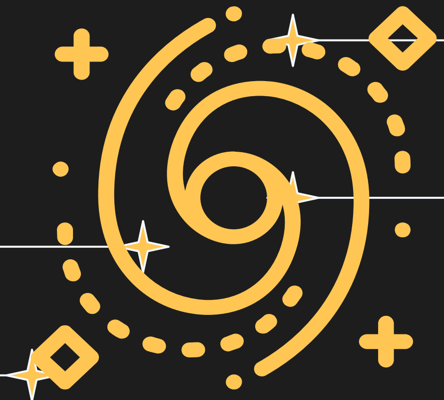
c. We will then examine the radio sources to see if the contour lines surround any visible optical source.

d. After we finish analyzing each source, we will note it’s information on a spreadsheet, with its name, position, whether or not it has jets, and what kind of source it is (ex. Double lobed, asymmetrical, etc.)

REDSHIFT ANALYSIS

We used Sloan and Simbad databases, along with the celestial coordinates of a said astronomical object to pinpoint its location in the night sky and overlay the optical image with the radio sources from the citizen science website at the same scale.

Using the Simbad database, and if the redshift of a source is given, we converted the redshift to a distance using a cosmological calculator created by Ned Wright from UCLA.



We used the given Hubble constant Ho (a factor to tell us how fast the universe is expanding: in this case 69.6), redshift z (from Simbad), and Omega matter and vacuum, OmegaM and Omegavac (0.286 and 0.714 respectively). We then found the angular distance to the object to account for the bending of light (given in Mpc or mega parsecs).

Once the distance was found, we used the value in a derived formula to determine the approximate length or size of the jet and of the AGN (using trigonometry).

Personal Experience Conducting Research With NASA

- SEES expanded on a variety of unfamiliar topics including blackbody radiation and supermassive black holes.
- I loved how in SEES I was able to visit multiple places, but my favorite location was Johnson Space Center where we were immersed into the Artemis exhibitions.
- I often had to apply my physics knowledge during SEES, which solidified my liking for astrophysics as my career path, in addition to improving my collaboration, scientific research, and problem solving skills.

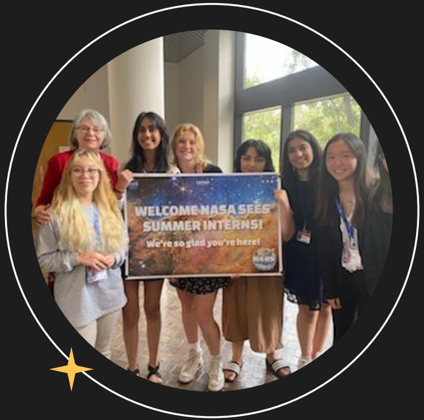
Lifelong Friendships & Further Research

- I still talk to some of the people I worked with at NASA SEES everyday! I gained multiple best friends and research partners from the experience.
- I even worked with my fellow interns (Bill, Dori, Siddhi, Angel, Zahra, Satvik) again in a separate project with UT Austin professors Dr. Timothy Andeen and Dr. Karol Lang where we developed a radiotherapy integration combining the FLASH ultra-high dosage procedure with VHEE electron beams to irradiate and destruct tumor-simulating organic compounds while sparing peripheral tissue.
- I just begun a continuation project with two of my prior team members, Siddhi and Sarah, and my NASA SEES mentor, Dr. Judit Ries!

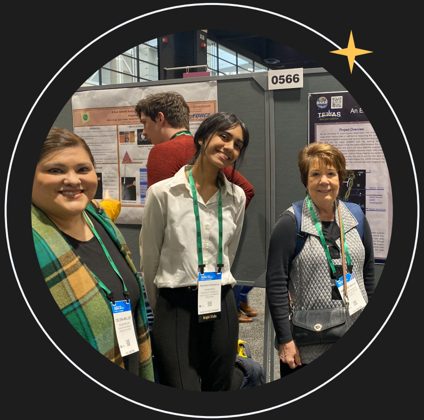
Living at UT Austin with Fellow Interns

- We dormed in a University of Texas residence hall, given access to all amenities and facilities that actual UT Austin students use.
- We would even run into actual undergraduates that were living in the same building during the summer!
- Our schedules were extremely packed, going from breakfast at Duren Hall to taking a bus to UT Austin's Center for Space Research and conducting lecture series, project work, and team-building activities until we would eat dinner together.

Experience Working With NASA Managers & UT Austin Professors



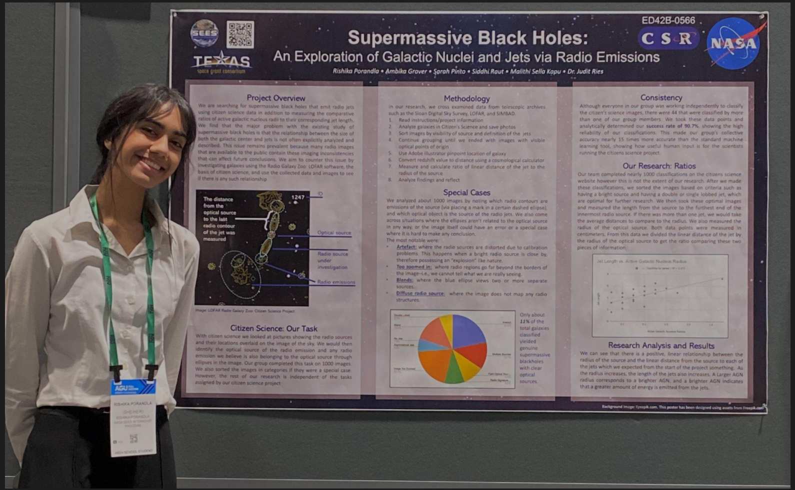
Dr. Judit Ries:
Professor of
Astronomy @ UT
Austin



Celena Miller &
Margaret Baguio:
NASA Program
Managers

American Geophysical Union Fall 2022 Conference

- As a part of the AGU BrightSTARS program, NASA SEES students were given the opportunity to present research posters of the work they completed at NASA SEES.
- We flew to Chicago on a free ticket to attend the AGU conference and presented to 25,000 conference attendees, including professors and experienced researchers.
- I personally loved the experience of attending a scientific conference because it gave me the opportunity to share my research with more than just the people who viewed the NASA symposium.



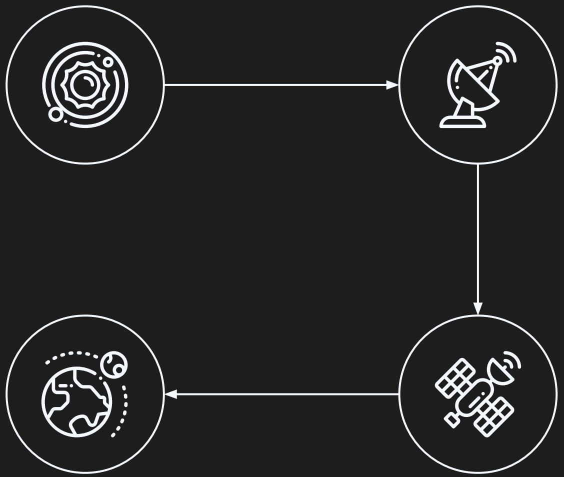
How NASA SEES Influenced My Future Career

Astronomy

I already was invested in astrophysics from the literature I read, but SEES reinforced fundamental astronomy concepts for me.

Particle Physics

Learning about the field of physics holistically helped me delve into concepts other than astronomy, fueling my growing interest in quantum physics.



Professor Connections

I have contacted the professor I worked with, Dr. Ries, on numerous occasions for research guidance, and I'm so thankful for the relationship I was able to build with her!

Work Ethic

The long nights and strict research submission deadlines in the NASA SEES program taught me to be a productive researcher and spearhead efforts with my team.

THANK YOU!

Any questions?