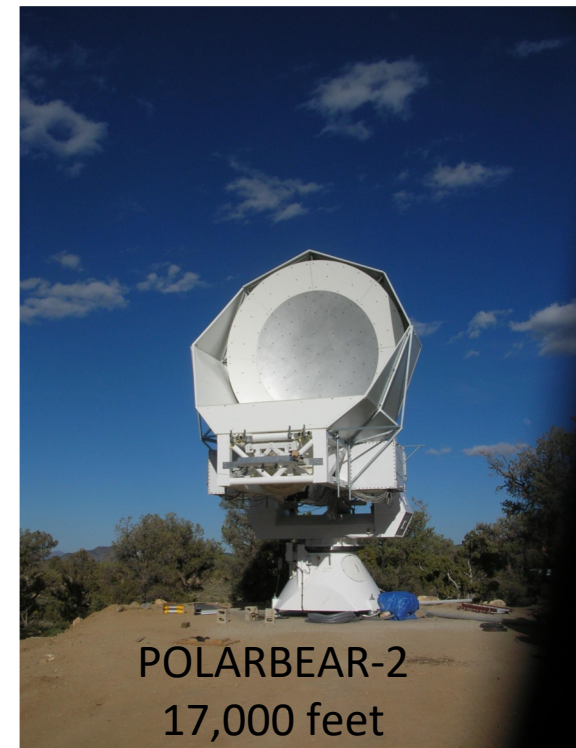
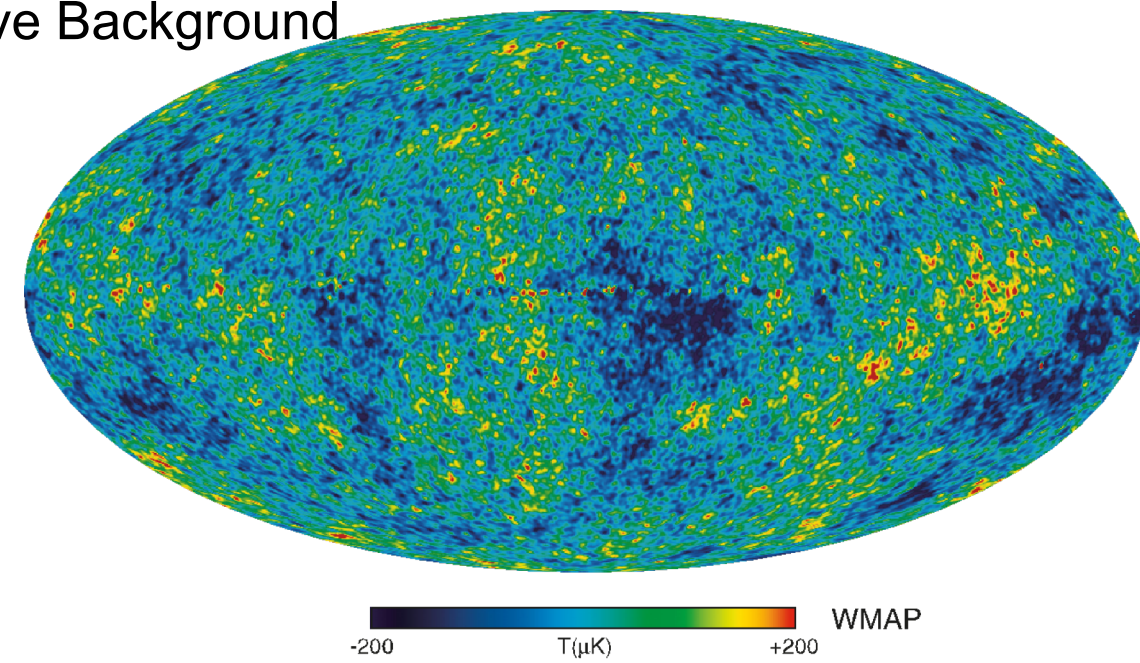


Halverson Research Group: Mapping the Cosmic Microwave Background

The CMB is a remnant of the early universe

- Looks like a 2.7K blackbody
- Emits light in the millimeter wave regime - peaks at 135 GHz
- Small variations in temperature and polarization give big clues to outstanding questions in cosmology

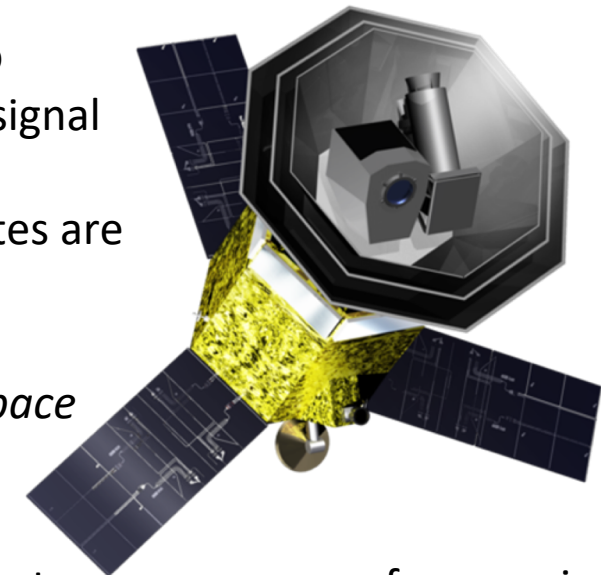
The Halverson Group is currently involved collaborations to measure the polarization of the CMB to gain insight in to inflation – a theory that explains the rapid expansion of the universe after the big bang



POLARBEAR-2
17,000 feet

Why do we need better detector technology?

- Looking at very faint signals
- Using detectors that operate ~ 0.2 degree above absolute zero
- The CMB is 2.7K – even warm telescope parts can swamp our signal with unwanted blackbody radiation
- We want to get every possible photon – telescopes and satellites are expensive to run, and people want results sooner.
- *We are currently involved in a ground based telescope and a space borne telescope projects*



Even higher: LITEBIRD – a satellite to measure many frequencies

What skills are used to carry out this research?

Programming

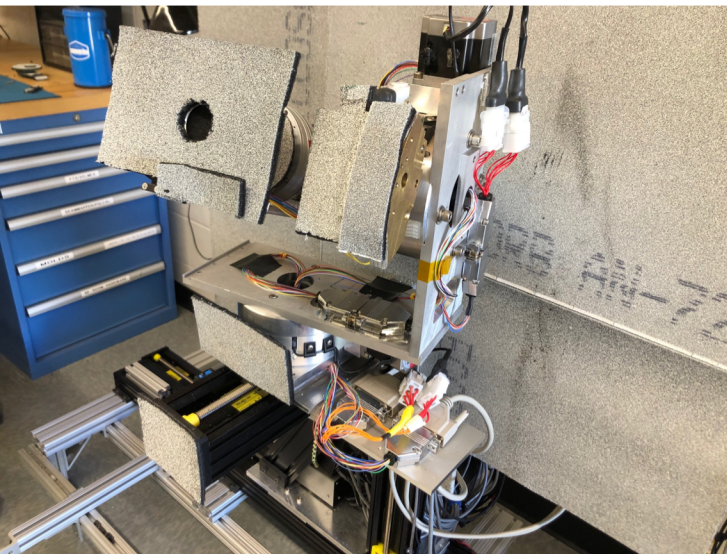
- Controlling hardware
- Simulations
- Data analysis

Design

- Pen + Paper + All kinds of measurement tools
- Machine shop – build things ourselves!
- Solid Works

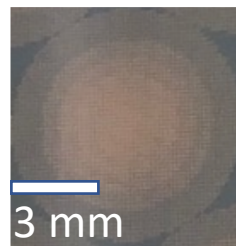
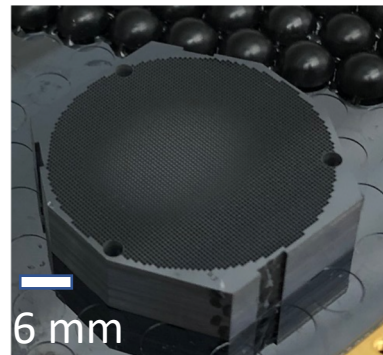
Physics and Math

- How much power from a blackbody?
- Order-of-magnitude design work
- Fourier analysis to convert time domain data to frequency data



From big: this “beam mapper” allows us to measure a lens by moving a source along a hemispherical surface. We can move along (X,Y,Z) and Az+El angles, as well as polarization. Undergraduates have been involved in:

- Mechanical design and building parts in the machine shop
- Soldering – over 400 wire connectors to control all axes
- Programming – Controlling the source + synching with detector response



To small: Developing metamaterial lenslets which control light with sub-wavelength (micron-scale) features to make lenses which are superior to current hemispherical lenses.

Day to day lab work provides an assortment of challenges, problems and skills. We are looking for people eager to learn new skills on a regular basis, from soldering to analyzing optical data.