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Improving the Detector Fitting Algorithm for the TolTEC Camera and Characterizing its Thermal Behavior

Physics and Astronomy

Research Plan/Project Summary

A.

Rationale: TolTEC is a revolutionary millimeter wavelength camera being constructed that will be 100 times better than its predecessor camera the AzTEC. It is important TolTEC's detector fitting algorithm is improved, so TolTEC will be able to make all detections when commissioned on the LMT. Moreover, it is extremely significant that TolTEC has a functioning health monitor because if it ever malfunctions TolTEC's operators need to be notified so no false data is collected. TolTEC is crucial to be created because it will accomplish novel research experiments composed in legacy surveys. These surveys will have a vast impact on society because they will be available to the general public, so everyone in the world will be given the opportunity to analyze TolTEC's revolutionary data and contribute to the astronomical community's newest discoveries.

B.

Research Questions:

- How to improve the detector fitting algorithm for the TolTEC camera?
- How to align the thermometry data from the TolTEC camera to create a "Health Monitor" system for TolTEC?

Hypothesis:

- Scanning through many VNA sweeps to categorize any false detections will improve the detector fitting code.
- Aligning cooldown data and searching for anomalies will create a standardized temperature range, through python manipulation.

Engineering Goals: To engineer a system of analyzing and manipulating data to enhance the detector fitting algorithm. The detector fitting algorithm will be improved by after the anomalies are characterized in the collected data they will be recorded. Adjustments will then be made to the detector fitting algorithm based off the recorded data. For instance, the window to search for the detector in python might be decreased. Next, the health monitor will be created. The goal is to align all of the thermometry data from across 16 of TolTEC's thermometers from inside the cryostat. In the process of this channels taking in no reading will be identified in addition to channels with unusual outputs. Code in python will then be written using matplotlib to graph and manipulate the data to find a normal temperature range. Overall, the project's goal is to enhance the TolTEC camera.

Expected Outcome: The research will produce necessary improvements for the TolTEC camera to function at the LMT in Sierra Negra, Mexico. The outcome of the research will allow for all detections to be made in the sky and for a system to be put in place to alert the operators of

TolTEC whenever it is operating improperly. Its ultimate outcome is revolutionizing the field of millimeter wavelength astronomy.

C.

Methodology:

Detector Fitting Algorithm

- Scanning through the different network VNA sweeps to identify any false detections from the detector fitting code. A VNA sweep demonstrates the s21 values for the probed frequencies of the detectors. The lines drawn through the peaks from the detector fitting algorithm will represent the frequency at which the detector captured the data.
- The data then will be characterized into different categories about the type of line drawn by the detector fitting algorithm. The categories will include false detections, duplicate detections, offset detections, normal detections and resonances that are not detected. A false detection is one meaning the algorithm draws a line when no detection is made. A duplicate detection is when two lines are drawn by the algorithm, but a singular detection is made. An offset detection is misidentifying the peak, resulting in a line drawn slightly off center. A proper detection is made when the line is drawn correctly on the peak. When no resonance is detected the algorithm will not identify the detection made by the VNA sweep so, no line is drawn at all. This information will then be recorded by the frequency that the instance occurred. In addition, if the detector fitting algorithm draws a line for too small of a resonance it will be classified as "tiny" (Meaning noise detected). Once the detected frequencies match the designed frequencies the fitting code will be complete because it will accurately find all the detectors.

Health Monitor

- There is a total of 32 thermometers throughout the cryostat each in its own channel. For each cooldown, a data file will be complied with each thermometer's recorded temperatures. The location of each channel will then be analyzed to ensure that its position remained the same throughout all the cooldowns, so the data remains constant. The data files will then be analyzed by plotting each channel's temperature. All the channels that did not read any temperatures will be classified as "dead" thermometers.
- The data from the separate channels from all the cooldowns will be plotted against each other. Afterwards, it will be manipulated, so that the start of the cooldowns will be aligned and can be interpreted.
- This is significant because the known trends for each channel need to be established to ensure that the cryostat is running properly at all times. The goal for this is that a health monitor will be created for the TolTEC camera, so that if it ever malfunctions an automatic notification will be sent to the operators of TolTEC.

Risk Analysis:

- There is no risk assessment for this project because the proposed projects only analyze data from the cryogenics system to improve it but do not directly interact with the TolTEC camera.

Data Analysis:

Health Monitor

- The data collected by potting each thermometer's temperatures will be analyzed by aligning the data to establish a "normal" standard for consistent temperatures. For a cooldown, this normal standard will include a negative slope line that will indicate the cooldown of the MKIDs and their constant temperature of .1K on the 4K Stage, the cooling of the detector, an increase in temperature of the black body during testing, and a warmup that has a positive slope. These patterns exemplify the normal standards that TolTEC should demonstrate during a cooldown.

Detector Fitting Algorithm

- Recording the number of both tiny detections and duplicate detections to see if the algorithm will be enhanced before and after the algorithm was fixed. The goal will be to get the number of predicted and actual detections to be the same.

D.
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Post Summary

No Changes were made to the research plan.