Updating and Revising Star Camera for Future Flights of Balloon Borne Experiment

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Introduction

The BLAST (Balloon-borne Large Aperture Submillimeter Telescope) experiment surveys the galaxy from altitudes of 100,000 ft in order to answer important cosmological questions, such as how stars are formed. This experiment is conducted above Antarctica to minimize unwanted noise. Two star cameras are used in the navigation systems to identify known stars. The cameras take pictures and match stars in the image to known star positions from a catalog stored in the star camera's computer. This is done using code written in C++, a computer programming language.

In order to modernize the system, the code needed to be updated. A camera that has flown multiple missions was switched from a legacy codebase that was used in past missions, to the star tracking and attitude reconstruction (STARS) code, designed for the E and B Experiment (EBEX), a similar, balloon-borne experiment.

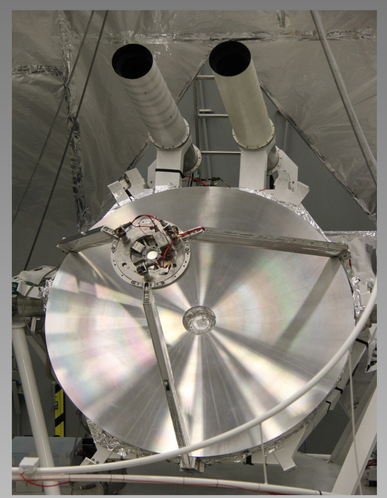

Figure 1. Both star cameras with BLAST telescope. Photo courtesy of Steve Benton.

Figure 2. Complete BLAST star camera assembly contains pressure vessel and baffle.

Procedure

In order to modernize the system, the following was completed:

- Catalog and document the components of the camera.
- Learn C++ programming language.
- Test the camera with the legacy code.
- Adapt the new code for the camera hardware.
- Test the code and camera compatibility with outside tests.

Results

The star camera is housed in a metal pressurized tube, which also contains the camera's computer stack, pressure and temperature sensors, and motors to control the focus and aperture. Every component was thoroughly documented and tested for functionality. It was then tested with the legacy code. When I got comfortable with the camera's functionality, then the camera was switched to the new code base, STARS.

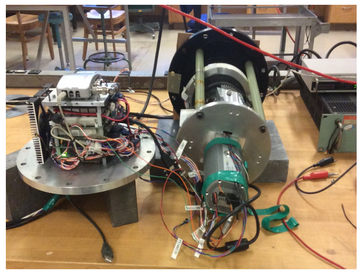

Figure 3. Computer stack and camera outside of pressure vessel.

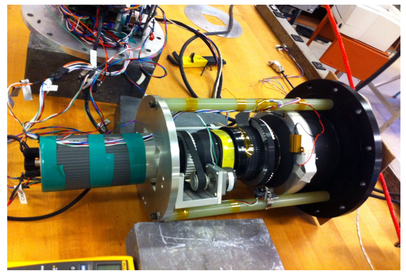

Figure 4. Camera, lens, and stepper motors.

STARS is a code base written in the C++ programming language specifically for the EBEX camera hardware. In order to implement the switchover, several compatibility issues had to be overcome, which involved writing new code specifically for the BLAST camera hardware. Additionally, it was discovered that this hardware had different failure modes than the previous system. These included:

- Camera required power cycling on startup before an image can be captured.
- Different image size required new variables to be added.
- Dead pixels display white, which make them look like stars. A new C++ class was written to fix this problem.

Figure 5. Enlarged dead pixels from star camera.

Figure 6.Sample of code written to fix dead pixel display problem.

Discussion

The desired final result is a program that identifies stars and displays the star name and position. The position is identified by the right ascension (ra) and declination (dec) of the center pixel. Each star name and position is recorded in the logger file.

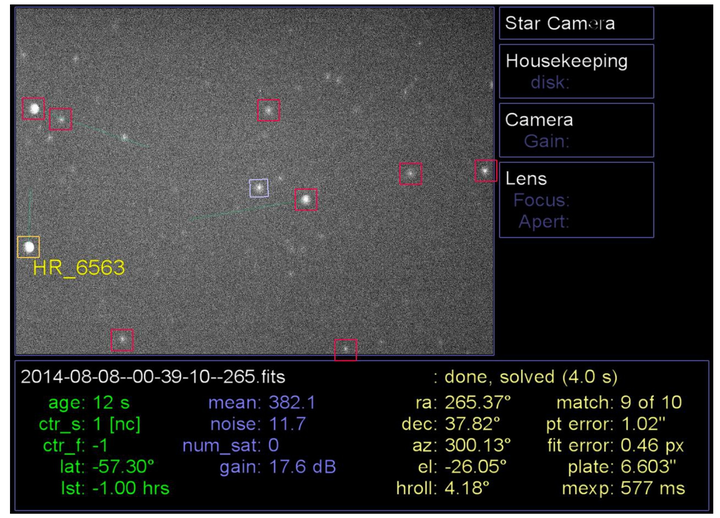

Figure 7. STARS displaying solution of image from camera. The name of the brightest star is displayed.

Next Steps

Now that STARS can be used for the BLAST camera, the following changes can be made:

- The previous camera had built-in focus, but the BLAST camera has external focus lenses controlled by stepper motors. The motors need to be written into the code.
- The housekeeping needs to be updated for BLAST specific temperature and pressure sensor hardware.
- The camera tested with the full BLAST system.

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