K-band Focal Plane Array Critical Design Review
January 30, 2009

The motivation for building a 7-pixel focal plane array receiver is to provide an instrument that increases the GBT K-band mapping efficiency, and to serve as a path finder instrument for a focal plane array program. The project team is tasked with designing an instrument that satisfies specific scientific objectives stated in an internal NRAO document titled, "Science Case for a K-Band Focal Plane Array for the Green Bank Telescope". At this writing, the construction of a single-beam prototype receiver is complete, and the instrument has undergone extensive laboratory testing. The receiver consisted of all first article EM components, a prototype noise source, both types of down-converter modules, the LO1 doubler, and the new monitor and control hardware. Two observing sessions on the GBT are complete. The observations compared system temperature with the original K band receiver, measured the baseline stability with long integrations, and produced a spectrum of the entire band with the GBT spectrometer.

Originally included in the design objectives was the requirement for allowing expansion to approximately 60 pixels. The size and weight of a full 60-pixel instrument requires solving complicated mechanical problems that could delay the project and constrain the GBT receiver arrangements. Since the FPA program will likely pursue a W band instrument, the emphasis is shifted to reducing risks with a simpler mechanical design and staying on schedule. The single pixel receiver shall be kept intact as a test bed and to allow continued innovations and testing of mechanical designs, however. In addition, much research and development is needed for expansion, including an upgrade of the IF system, and a spectrometer capable of processing the full bandwidth of all the pixels. Ongoing projects such as CICADA are addressing the processing problem, but no effort is applied to new IF systems. Currently, the 7 pixel instrument at 1.8 GHz bandwidth is at the analog IF system limitation.

Some mechanical design highlights of the instrument are: an arrangement that aligns all the microwave components inside the feed diameter, a reduction in waveguide length by employing a thermal gap in the output, and a sliding waveguide joint that compensates for thermal expansion. Another innovation is a noise calibration module generated from MMIC amplifiers for each pixel that ensures flat spectrum and easily adjusted calibration levels. An integrated down converter is designed with commercial active parts, with custom RF circuits for the passive components, all integrated into a single module conformal to the feed shadow and provides a stable frequency response. The monitor and control logic is based upon expandable I^2C technology with network based software. In addition, a software pipeline is being developed to allow data analysis for map generation and calibration when the receiver comes online. Performance of the components, as well as more established EM components, will be covered in the review.

The requirements for a software manager are being compiled, but progress on the manager is hampered by the lack of available software engineering. This has proven to be inconvenient for testing but not critical for obtaining GBT results. Additionally, a data pipeline for processing maps is progressing. Details of the design will also be covered in the review.

The charge to the panel is to ensure the following:

- Given the K-band Focal Plane Array system specifications are derived for a specific scientific case, did the single K-band pixel demonstrate satisfactory performance as the prototype for the seven pixel instrument?

- Is the final design of each component in compliance with the system specification? Is there any component that may compromise the instrument's scientific objectives?
- Are the compromises for expansion and decisions to simplify the design justified given the schedule and GBT turret constraints?
- Is the schedule achievable, budget and spending reasonable, and are there any obvious critical path items that will compromise the program?

- As defined by the observing-mode document, is the pipeline development ad data analysis reasonable in its approach? Are there any other modes to be considered?

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