Penn Array Receiver

Penn Array Receiver CDR Document 2: Project Overview

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Revision History

Ver.	Changes	Date	Author
1	Draft	24 Sep 2003	Mark Devlin
2	Substantial revisions, addtions	25 Sep 2003	Brian Mason

Contents

Abstract

We review the Penn Array project, including project management issues, history, and our project plan.

1 Introduction

This document is intended to provide a description of the project management. After a brief history of the project, we will discuss:

- The scope of the work.
- The responsibilities of the major parties.
- Risks and risk mitigation.
- An outline of the project plan.

2 History & Approach

The PAR was first proposed by Mark Devlin to NRAO in 1999 as a way of taking advantage of an existing receiver at Penn and the soon to be completed GBT telescope. At the time, Penn had a liquid helium bolometer system with approximately eight conventional detectors which could be configured to operate at 90 GHz. After several discussions we realized that the exisiting receiver would be inappropriate for the GBT. We wanted to accomplish several goals at once:

- verify the functionality of the telescope at 90 GHz.
- test detector and receiver technology which might be appropriate for future large format arrays.
- build a facility instrument that will return significant scientific observations to the community

What was needed was a low-cost array receiver that used similar technology to the next generation of large (thousands of elements) bolometric receivers similar to the SCUBAII instrument.

A collaboration was forged to build the receiver. While some of the responsibilities have shifted around (described below), the basic structure has remained the same. Under this plan the University of Pennsylvania would be primarily responsible for the design, construction and commissioning of the instrument; NASA-GSFC would provide the detectors and readout electronics; NRAO-GB would support some aspects of construction and commissioning; and the Cardiff group would provide the filters. A proposal was submitted to NSF's ATI program in 2000 and rejected. In 2001 NRAO obtained funds to build such an instrument. UPenn applied for and received the award.

The total award from NRAO was for $530K for 3 years starting in March of 2002. $430K was to go to Penn and $100K was to go to GSFC. (This has since changed due to difficulties transfering money to GSFC, but the basic distribution of resources remains the same). This is a small amount of money for a major instrumental capability; it is made possible by leveraging the large investments that GSFC and NIST have made developing TES detectors and SQUID multiplexed readout. Furthermore the project is only providing funds to pay for the components of the array; GSFC's Penn-Array specific design and development work is essentially free. Cardiff is providing the filters at no cost. NRAO is responsible for control, data acquisition, and data analysis software. This approach has enabled the funding of the project but incurs significant schedule risk.

Subsequent to the NRAO award UPenn has applied twice to NSF (ATI) for funds to cover the addition of a filterwheel to the receiver. A filterwheel would enable higher sensitivity under a wide range of atmospheric loading conditions. Both proposals have included additional salary support for commissioning, integration, and software. The first proposal was rejected; results on the second are still pending.

Brian Mason joined the project in June of 2002 as NRAO project scientist and project manager. Prior to this there were effectively zero resources dedicated to the project at Green Bank. Subsequently we have been able to more effectively coordinate development (eg, to specify and negotiate telescope interfaces); to begin to address software issues; and to identify and deploy further Green Bank resources in support of the project.

3 Scope of Work & Responsibilities of Major Parties

The memorandum of agreement between NRAO and UPenn states:

"On a best efforts basis, UPenn will deliver a 64-pixel, 3 mm band, bolometer camera as described in the attached design document. Deliverables also include engineering documentation in hardcopy form and all CAD files in electronic form. At the time of delivery, the receiver becomes the permanent property of NRAO/NSF."

The project has grown since the original MOA; in particular, NRAO has taken on a much larger role in project management and software. The responsibilities are:

- UPENN: Management of the receiver production.
- UPENN: Design of the cryostat and control system.
- UPENN: Design and production of the optical system.
- UPENN: Documentation of receiver and electronics.
- GSFC: Array design and fabrication.
- GSFC/UPENN: Production of warm and cold TES electronics.
- NRAO: Analysis software; control & readout software for use with the GBT.
- NRAO: Machining of major receiver components.
- NRAO: Telescope Integration/Commissioning support.

Several items are explicitly beyond the scope of the Penn Array project:

- Telescope Performance: NRAO-GB will deliver, on a best-effort basis, usable 3mm capability with the GBT. This includes adequate aperture efficiency and pointing performance. Current capabilities would be sufficient for basic commissioning tasks (bright source observations) but not useful for astronomy.
- Dynamic Scheduling: Conditions suitable for millimeter observing are limited at the Green Bank; in combination with GBT and Penn Array operational constraints, the instrument is not likely to efficiently utilize 3mm conditions until significant effort is invested in automated dynamical scheduling procedures. GB intends to deliver this capability eventually, but not in time for commissioning (winter 04/05).

It should also be noted that the original agreement does not provide resources for the software needed to operate the receiver as a facility instrument, or for significant salary support for UPenn personnel through commissioning. The was recognized prior to the signing of the MOA and NRAO has since provided internal resources to address the software issue. The commissioning issue will be addressed below.

It should be made clear that by "project" we mean the project as a whole, and not simply the contract under execution by UPenn and GSFC.

4 Risks and Mitigation

The major weak link in the project is the production of the array at GSFC. GSFC has enthusiastically supported the project from the beginning. However, were it not for the fact that the requirements of the PAR are similar to several other instruments, the resources that the project is providing to GSFC would be impossibly inadequate. As it is, we are relying on Dominic Benford paying specific attention to the design and production of the PAR-specific arrays without supplying direct support for his work. Penn has been able to mitigate most of this risk by sharing the common load of all the projects with the PAR. This has allowed Benford to spend the time required to design and start the production of our arrays.

It should be recognized that the project lacks the resources for any significant research and development of new technologies. With this in mind, we have attempted to utilize existing technologies whenever possible. However there remain several significant areas of risk. The major technical risks include:

- Operational procedures for the cryogenics, SQUIDs, or TES detectors are poorly understood by those responsible for commissioning and future operations (NRAO). There are several responses to this: a) As the contract (or further funding) allows, UPenn will assist with GBT commissioning; b) UPenn will, on a best-effort basis, deliver documentation of the necessary procedures; c) NRAO personnel will work closely with UPenn and GSFC throughout 2004, will assist in generation of the required documentation, and will spend significant time in residence at Penn and GSFC.
- The arrays may not yield robust detectors. GSFC is working on design and test production of the arrays. Significant progress has been made, including the successful fabrication of a mechanical prototype (sep 2003). In the case that the full 64 element array is not in place for integration, a "few" pixels could be placed on the focal plane to test the functionality of the electronics and optics. In an extreme case, the same test pixels could even function on the GBT for initial engineering and commissioning tests.
- Vibrations in the receiver cabin could interfere with the detectors. Reducing vibrations was a major design constraint for the cryostat, resulting in a working, low-vibration 300 mK system; this should address the zeroth-order concern. We have measured the vibration spectum of the cabin. This will be compared with lab performance. If a problem arises, steps will be taken to notch out the vibration bands from the receiver at the mount.
- The magnetic fields in the receive cabin could interfere with the SQUID multiplexers. This should not be a large risk since the sensitive electronics have been carefully shielded. We intend to make sensitive measurements of the magnetic fields in the GBT receiver room in the future, which will indicate if further mitigation is needed.

The major schedule risks include:

- The detector production could be delayed (discussed above).
- The lens and AR coating production may be delayed. Several groups are now considering AR coated Silicon lenses (PENN, Princeton, JPL, Cardiff). In response the Cardiff group has made significant progress with this technology. However, it is not clear that they will be able to implement the AR coating on our lenses in time for our testing. While the AR coating is essential for the proper operation of the final receiver, testing can proceed without them.
- The control and readout software could be delayed. We have attempted to address this by careful planning, but delays could still occur either if there were delays in finalizing the DAQ interface; or if inadequate support is available from GB software and electronics divisions; or if NRAO is unable to quickly enough obtain information describing the procedures required to operate the instrument. This could delay commissioning. Finalizing the DAQ interface is largely beyond NRAO/Penn control, and the project will have to stay in close touch with GSFC on this front.

Any of these delays could result in a risk to the project if Penn is unable to participate in commissioning and/or transfer its operational knowledge as a result, or worse, if the integration and delivery of the actual receiver is pushed past the end of the contract. Collectively these add up to a substantial risk; many of the factors are largely external to the project (detector production; DAQ electronics; lens coating) so a contingency plan needs to be formulated. At the beginning of Q3 2004 we will hold a project meeting to assess the status of the project. Should it be necessary and feasible, NRAO and UPenn will negotiate an equitable sharing of the expected liability.

5 Project Plan

Notes:

- **GBT commissioning** is contingent upon readiness of monitor and control software.
- **we will not announce Penn Array to observers until after it has been commissioned successfully**. Largely because the performance of both this array, and the GBT at 3mm, will be completely unknown; and our support for dynamic scheduling etc will be nil 1st season. potentially scientifically useful observations taken while commisioning would be made public as feasible but with no support.
- **briefly summarize milestones & dates w/relevant comments**