From PJACKSON@CVAX.CV.NRAO.EDU Fri Apr 19 13:38:55 1991
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Received: from CVAX.CV.NRAO.EDU by ccc.cx.nrao.edu (4.0/SMI-DDN)
id AA08712; Fri, 19 Apr 91 13:38:52 EDT
Date: Fri, 19 Apr 1991 13:37:11 EDT
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NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

April 18, 1991

M E M O R A N D U M

To: Addressee

From: R. L. Brown

Subject: MMA Scientific and Technical Issues

At a meeting on April 11 many of those involved with the Millimeter Array discussed a variety of operational, scientific, and technical issues that we need to evaluate in the near future. A partial summary of the issues is attached. Some of these issues are amenable to investigation in house while others, marked by an asterisk, would benefit by work in the Joint Development Group (JDG).

I've indicated the name of a NRAO person with many of the issues as one who may be most capable of providing insight or leadership in a particular matter. Before getting too involved, we should discuss this both at the scheduled MMA coordination meetings and, where appropriate, with the JDG. In the meantime I would appreciate it if you would look over this summary (we can criticize and amend it) and spend a little time thinking about whatever aspects may be of particular interest to you.

RLB/j

ANTENNA

1. Investigate Clear Aperture Designs

   - Benefit to mosaicing? (Mark)
   - Close packing limitations (James)
   - Cost increment (James)

2. Total Power Spectral Baselines

   - What measures should be incorporated for flat total power baselines? (Phil)
   - Path length modulator, using a cornercube or secondary motion, necessary? (Phil)

3. Blockage in a Conventional Antenna Design

   * - Tradeoffs in running the feed legs to the edge of the dish (JDG)

4. Illumination

   * - How do we achieve the flat illumination desirable for mosaicing applications? (JDG)
   * - Can the illumination be changed (e.g., for solar observations) by a lens or an optics package switched into the beam? What are the tradeoffs and implications for the antenna design? (JDG)

5. Beam Switching

   - What are the tradeoffs between switching the secondary or tertiary mirror? (James)
   - What is the design implication of a focal plane that will accommodate many feeds? Specifically, can we accommodate q 2 beamwidth array (9 beams) at the lowest frequency? (James)
   - What is the total power switching rate needed? Is switching to 3 (more?) positions beneficial? Implications? (Phil)

6. Actuators

   - Cost and utility of actuators for panel adjustment (not active correction)? (John)

POINTING

1. Optical/IR Pointing and Tracking

   * - What are the possibilities and limitations of optical/IR CCD systems? (Phil, JDG)
   * - What are the techniques needed to isolate those terms in the antenna pointing that describe the offset between radio and optical pointing. How often should they be measured? (JDG)
   * - How could an optical IR pointing and tracking system be built into the antenna design? (James, JDG)

2. * Generate a Thermal Model for the Antenna

   - How accurately can the model be used to correct pointing? (JDG)
   - What measurements need to be made with what precision? (JDG)

3. What are the possibilities for a fixed-rule measurement? (James)

4. * What precision pointing techniques are being pursued elsewhere? (Phil, JDG)

SOLAR OBSERVING

1. Techniques

- Observe the sun directly with the feed? (Would require an additional mirror in the system.) Limitations? (Darrel, James)
* - What modifications are required to the receiving system to observe the sun? (Tony, JDG)
- Attenuators needed ahead of the front-end? If so, how is calibration done? (Mike, Tony)

2. Surface Panels

* - Possibilities and limitations of machined aluminum panels for solar observing? (JDG)
* - CFRP panels made on a mold. How well do machining marks in the mold transfer in the panel replication process? (JDG)
* - How are antenna measuring techniques limited by panels in which irregularities for solar observing have been inscribed? (JDG)
* - Limitations of paint with small particulate matter? (JDG)

CORRELATOR AND SIGNAL TRANSMISSION

1. Fiber Optics Transmission Lines

- Create a fiducial design, including answers to the following questions:
  Analog or digital?
  How is dynamic range to be defined?
  AT approach useful?
  Implications of an expansion to greater bandwidth (Bob, Bill, Dick)

2. Continuum Correlator

- What is involved with increasing the continuum bandwidth of correlator?
- Cost implications?
- What are the limits? (Andy)

3. Spectral Line Correlation

- Does the need for spectral "flexibility" (e.g., different bandwidths in spectra analyzed simultaneously) pose a problem? (Andy)

4. * Technical Design Options

- What are the realistic possibilities (JDG)

RECEIVING SYSTEM

1. * Evaluate Local Oscillator Options (Tony, JDG)

2. * Cryogenics

- Possibilities for Gifford-McMahon 4K systems
- Hybrid G-M with JT system. Options and implications (Mike, JDG)

3. * Sideband Separation

* - For spectroscopy we usually want to reject the unwanted sideband so as to eliminate its noise ahead of the correlator. What is the best way to do this? (Tony, James, JDG)
* - For continuum observations it is often useful to observe in a DSB mode. Is there any way to switch between DSB and SSB? (JDG)
* - What is the prospect for SSB mixers (Tony, JDG)

4. Polarization

* - By what techniques could we achieve circular polarization? What are the limitations and costs? (Tony, James, JDG)

OPERATIONAL ISSUES

1. Simultaneous Multi-Band Observations

* - Is it possible to build a dichroic at millimeter wavelengths so that we can observe in two frequency bands with both polarizations simultaneously? (JDG)

* - Possibilities and limitations of splitting the polarizations and observing different bands with different polarization simultaneously (James, JDG)
- Hardware needed for time division multiplexing to achieve dual-band observations (James)

2. Simultaneous Cross-Correlation and Total Power Observing? (Darrel, Tim)

- Pick up some interferometer data in at least one switching phase while accumulating total power data
- Tie the total power and interferometer calibration together
- Implications?

3. Continuous-Scanned Mosaics

- Possibilities and implications (Tim, Mark)

4. Dynamic or Contingency Scheduling

- Implications for software capabilities and array staffing requirements

ACTIVE PHASE CORRECTION

How can we increase the phase coherence time on the long array baselines? We would like to design the solution into the array.

1. * Exploit the correlation between phase fluctuations and sky brightness fluctuations. Call this "total power radiometry." (JDG)

- How accurately can ~T be measured?
- How stable is the measuring system?
- What are the requisite timescales?

2. * Correct program source phases by alternating observations with a nearby phase calibrator (perhaps at a different frequency). (JDG)

   - How rapidly is switching necessary?
   - What are the limits of the technique?
   - How strong a calibrator is needed?
   - Experiment with the VLA (Frazer)
   - Investigate ~T as a function of switching distance on the 12-meter (Darrel)

3. Post-correlation averaging for different times for different baselines to maximize the coherence time on each baseline.

   - Possibilities? (D. Briggs)

ARRAY CONFIGURATION

1. Stretched Compact Configuration

   - Optimum distribution of antennas? (Frazer, Mark)

2. B-Array

   - Refine tests and arguments for the optimum antenna distribution (Tim, Frazer, B. Hjellming)