MMA INTERNAL PROJECT REVIEW JULY 1998: SUMMARY OF ISSUES RAISED

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Purpose of the Meeting:

The MMA Project Review was an opportunity for the participants in the MMA project to review critically the plan for the project as outlined in the MMA Project Book. Version 1 of the Project Book had been assembled by Darrel Emerson from contributions from all the MMA Division Heads. Since much of the work done in writing the first drafts for the Project Book was in fact done independently by the Division Heads it was important for all members of the project to have an opportunity to examine the material for inconsistencies or incompleteness. The MMA Internal Project Review provided that opportunity.

Meeting Attendees:

Invitations to attend the MMA Internal Project Review were made to all those people at the NRAO assigned to the MMA project, and those members of the NRAO staff that we expect to be so assigned in the future. In addition, individuals from the university groups who are participating in the MMA development by virtue of their affiliation through the MMA Development Consortium (MDC) were invited and attended. Two representatives from the MAC (the Millimeter Array Advisory Committee) attended. Finally, we were fortunate that Leonardo Bronfman from the University of Chile happened to be in the U.S. at the time of the meeting and he also participated. A complete list of meeting attendees is attached as Appendix A.

Meeting Agenda:

The meeting agenda, as it was distributed at the meeting, is attached as Appendix B.

Issues Raised for Action or Further Analysis, by Agenda Item:

1. Flowdown from Science Requirements to Technical Specifications (Brown)

- We should produce a list of those items that have been requested as part of the MMA but are not now included in the baseline MMA project, items such as baselines longer than 3 km and very high data rates for large-scale mapping. This will reinforce the fact that scientific priorities have already been set, and choices made, among scientific options for the MMA.

2. Computational Imaging: Astronomical Requirements and Data Products (Glendenning)

- Astronomer interaction with the MMA depends on suitable wideband communications to the Chile site. A plan needs to be developed to define "suitable wideband" and to provide that capability. A cost comparison should be done between satellite and ground (optical fiber) options that includes not only the costs of each option today but also makes use of the first derivative of those costs, respectively, for an extrapolation to the future.
- Minimum data product is "well calibrated" data. Doing more is a big cost item; is it necessary?
- How do astronomers get access to their data?

3. Computational Imaging: Array Configuration (Helfer)

- Is it necessary, or desirable, to minimize the total number of antenna stations? If so, a way of doing this is to reduce the number of compact (D) configurations from the planned three at the expense of sky coverage from the D-array.
- Is it possible to design configurations such that a maximum number of stations can be shared?

4. Computational Imaging: Phase Calibration (Butler)

- From experience on the VLA we know that fast switching for phase calibration will work on the MMA for timescales of ~10 seconds and longer. If we need phase calibration on even shorter timescales, then a radiometric technique is necessary. On the Chile site we need to know how well we need to calibrate the phase, and we need to know how well we can expect to do so using radiometric techniques.
- Which of the atmospheric water lines, 22 GHz or 183 GHz, is the better one to use for phase calibration on the Chile site? When does the answer to this question need to be available?

5. Computational Imaging: Amplitude Calibration (Mangum)

- Precise amplitude calibration is most important for D-array observations where one needs to tie together the interferometric amplitudes with the total power amplitudes. For the latter the chopper-wheel technique is inadequate. Need to do an order of magnitude better. What is the system design for an adequate total power system?

6. MMA System Design (Thompson)

- Baseline design for transmission of 16 GHz of IF bandwidth from each antenna is analog. Any reason to reassess this decision (i.e., change decision to digital)?
- To go to narrow IF bandwidths for spectroscopy with a digital filter will reduce the signal to noise by approximately 15 percent. Is this an acceptable loss (over analog filtering)?

7. MMA System: Monitor and Control (D'Addario)

- Is there any advantage in having the system intelligence distributed among devices (at the telescope) as opposed to it being in a central computer?
- If it is agreed that it is desirable for engineers to write their own diagnostic software for testing instruments that they are responsible for, does this imply anything about the distribution of intelligence in the system?
- What is the bandwidth required by the M/C system? What is the bandwidth desired in the M/C system? Diagnosing the performance of OTF observations provides a tangible example of a task that would require high M/C bandwidth. Can we use this example to help us define the requirement?

8. Correlator (Escoffier)

- Subarray capability is easily achieved in the correlator. But there would be a gain in design simplicity if the array could be broken into binary subarrays each with equal numbers of antennas. Would such a hard limitation be acceptable to the astronomers?

9. Computing: On-Line Requirements and Planning (Glendenning)

- Is monitor data to be regarded for the purposes of archiving as ephemeral or perpetual?
- Baseline plan is to do as little as possible in real-time computers. Is there any application that would argue otherwise?

10. IF, LO Distribution and Fiber Optics (Sramek)

- Conversion of IF to baseband by analog or digital filters? A decision is needed.
- A round-trip phase monitor is a necessary, and missing, part of the system design.

11. Local Oscillator: Multiplier Chain (Webber)

- Source is an issue. Baseline plan is to use a microwave YIG with multipliers and power amplifiers to provide a source for the millimeter-wave multipliers and RF frequencies. This is an alternative to using Gunns that are thought to be costly, not widely available, and of limited tuning range. Any reason to revisit this decision?

12. Local Oscillator: Photonic (Payne/Shillue)

- Can the development of a photomixer that will give 10-50 microwatts of LO power over the range needed by the MMA (50-950 GHz) be developed in time for it to be a viable option for the initial MMA?

13. Receivers: Receiver System and Optics (Payne)

- What is the first receiver that will go on the first prototype antenna?
- Need to resolve the apparent conflict between antenna tests and receiver tests. Should develop one plan for prototype receiver testing and a separate (receiver) plan for testing of the prototype antenna.

14. Receivers: Cryogenics (D'Addario)

- If it is agreed that the refrigerator should be sized to the expected load for the sake of power efficiency, what margin should be designed in to the refrigerator capacity? Is it 50 percent over-capacity, a factor of two or what? What are the consequences of this decision?
- Since the refrigerators will be built commercially how much in-house design effort should be given to the refrigerator design?
- Is there to be one cryogenic dewar that includes all the receiver inserts (all frequency bands) or more than one?
- What temperature is desirable for the stage on which the SIS mixers are mounted? Is 4K sufficient? Lower than 4K?

15. Receivers: HFET Amplifiers (Pospieszalski)

- We can build, now, a 22 GHz room temperature receiver with T(Rx)=80K that could be used for phase calibration. Is there an interest/application on the MMA?

- Recommendation is to use discrete InP HFETs, as opposed to MMICs, for the IF to be integrated with the SIS mixers. This approach should give lower noise and less susceptibility to oscillation. Any reason to revisit this decision?
- HFET amplifier used with 8 GHz IF bandwidth per polarization will be limited by 1/f noise in very short integration. How is this to be avoided? Is a balanced receiver a viable solution? This question may have different answers/solutions for the 86 GHz and 35 GHz bands.

16. Receivers: SIS Mixers (Kerr/Pan)

- JPL converting from Nb to materials with higher gap energies such as NbTiN. Presently looking for another Nb fabricator in place of JPL. Options include SUNY-Stony Brook and TRW, both of which are reported now to have the capacity to fabricate small junctions with high current density.
- Given the rapid turn-around time required for MMA SIS development would it be better to support a single foundry rather than funding two groups?
- Is it possible to consider acquiring trilayer material from one source and contracting for the e-beam lithography and patterning from another source?

17. Antenna PDR: Requirements (Napier)

- Antenna requirements for the operating environment come as much from the need for the antennas to operate at the VLA test site as from their need to operate at the Chajnantor site in Chile. Are there (avoidable) cost implications here?
- Is there a requirement for 22 GHz phase calibration receiver to be in the focal plane? The sooner we know the answer to this question the sooner the antenna design can be complete.

18. Antenna PDR: Design #1 (Kingsley, Lugten, Cheng)

- Is the minimum dish separation of 12.5 m (for a 10 m dish) acceptable?

19. Antenna PDR: Design #2 (Woody, Lamb)

- How much space is really required for the receiver? That is, what is the necessary volume and dimensions of the receiver cabin?
- Wind is not a significant perturbation because the design is so stiff. But cannot meet the specs without the tiltmeter.
- RMS spec, for both designs, is a challenge to meet because it is made up of many contributions each of which is of order 3 microns.

20. Antenna PDR: Test Plans (Emerson)

- First prototype antenna pointing and tracking tests with a CCD camera, holography with an artificial beacon, and efficiency measurements at 230 GHz on astronomical sources to check for gross surface/setting errors. Interferometry tests to follow upon arrival of second prototype antenna.
- There is a concern over the level of staffing required to instrument and test the first prototype antenna. What are the plans to build the instrumentation needed for the tests in advance? Is it possible to use the 12 Meter to initiate techniques needed for the testing program?

21. Antenna PDR: Procurement Plans

- Is it desirable to proceed (and fund) two contractors through the design phase? This would allow us to see two presumably different designs before deciding how to proceed for fabrication of the prototype antenna(s).

22. Array Site Development Planning (Radford, Gordon)

- Need a specific plan for development of the site (roads, buildings, antenna pads, etc.).

23. Construction and Commissioning (Napier)

- There is a concern over the timescale for doing the in-house fabrication of production instruments. Recommendation is that we should get started (in the quantity production) as soon as the construction funds are approved.

24. Operations Planning (Gordon)

- Recommendation that planning remain flexible, don't decide options until necessary (in view of needs of potential partners, etc.).

25. Reconciliation: Summary of Issues and Concerns

The following is the list of the most important issues needing reconciliation as noted by the Project Review attendees. A response of the MMA Project to each of these issues is needed and should be made public together with the reasons or analysis that will lead to that response.

Computing

-The staffing level does not appear to be adequate to implement dynamic scheduling.

Phase Calibration

-Does a 22 GHz phase calibration receiver need to be in the focal plane?

Amplitude Calibration

-What is the plan to establish the antenna gain?
-What is the plan to make use of weather station information in the gain determination?
-There is a plan for accurate interferometer amplitude calibration, and a plan for accurate total power (single dish) amplitude calibration. What is the plan to assure that these two determinations are consistent?

Total Power Observing

-A system design for the total power system is needed.

System

-A system design of the coherent photonic instrumental phase calibration system is needed.
-A decision is needed as to whether conversion to baseband is analog or digital.

-A decision is needed about the distribution of intelligence in the Monitor and Control system. Similarly a decision is needed about the bandwidth of the M/C.
-A decision is needed about the IF transmission, analog or digital.

Correlator

-What are the plans for fast reconfiguration/flexibility?
-A decision needs to be made on the requirement for dump time.
-A decision needs to be made on the number of modes to be supported, at least initially.

Local Oscillator

-A plan needs to be developed to monitor the round-trip phase.
-It is recommended that the photonic LO be considered as a research topic with emphasis to be given on the higher frequencies. The initial MMA implementation should be the multiplier chain LO with first work done at the lower frequencies.

Receivers

-Decide whether 22 GHz is needed in the focal plane for phase calibration.
-Decide the optical arrangement.
-Decide the number of dewars.
-Understand the viability of 183 GHz radiometric phase calibration on the Chile site.

Cryogenics

-Concern that too much emphasis is being given to in-house refrigerator design. The recommendation is that the capacity be decided and that spec given to a refrigerator manufacturer.
-A reliability testing program (of commercial refrigerators) should begin soon.

HFETs and SIS with HFET IF Amplifiers

-Need to understand and decide how to make wideband total power (i.e., single dish) continuum observations that are not limited by 1/f noise in the amplifier.

SIS Mixers

-Understand the saturation issues regarding the number of junctions needed (for solar observations).
-Establish scientific goals for the frequency bands to be supported by each SIS mixer.

APPENDIX A:
MMA MEETING ATTENDEES

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APPENDIX B
MMA MEETING AGENDA

Sunday, 26 July

1000 Tour of NRAO downtown labs

1045 Drive to Kitt Peak

1200 Lunch at Kitt Peak

1500 Return to Hotel

1900 *Welcome Reception (Hospitality Suite of the Windmill Inn)*

Monday, 27 July (Pima Room)

0730 *Coffee, Tea, Juice and Bagels*

0800 Flowdown From Science Requirements to Technical Specifications . . . . . R. Brown

0900 Computational Imaging
- Astronomical Requirements and Data Products . . . . . B. Glendenning
- Array Configuration . . . . . T. Helfer
- Calibration: Phase . . . . . B. Butler
  Amplitude . . . . . J. Mangum

1030 MMA System Overview . . . . . D. Emerson
- System Design . . . . . D. Thompson
- Monitor/Control . . . . . L. D'Addario

1200 *Lerua's Mexican Buffet (Catalina Room)*

1300 Correlator . . . . . R. Escoffier

1400 Computing: On-line Requirements and Planning . . . . . B. Glendenning

1430 IF, LO Distribution and Fiber Optics . . . . . D. Sramek

1530 Local Oscillator
- Multiplier Chain . . . . . J. Webber
- Photonic . . . . . J. Payne/B. Shillue

1730 Adjourn

Tuesday, 28 July (Pima Room)

0730 *Coffee, Tea, Juice and Donuts/Muffins*

0800 Receivers
- Receiver System and Optics . . . . . J. Payne
- Cryogenics . . . . . L. D'Addario
- HFET Amplifiers . . . . . M. Pospieszalski
- SIS Mixers . . . . . A. Kerr/S. Pan

1200 *Eric's Sub Sandwich Assortment & Salads (Catalina Room)*

1300 Antenna Preliminary Design Review . . . . . P. Napier
- 1300 Antenna Performance Requirements . . . . . P. Napier
- 1500 Description of Design #1 . . . . . J. Cheng, J. Kingsley, J. Lugten
- 1630 Description of Design #2 . . . . . D. Woody, J. Lamb

1800 Adjourn

1830 *Dinner at El Corral*

Wednesday, 29 July (Pima Room)

0730 *Coffee, Tea, Juice and Bagels*

0800 Antenna PDR Continued . . . . . P. Napier
- 0815 Test Plans . . . . . D. Emerson
- 0900 Procurement Plans and Discussion . . . . . P. Napier

1000 Array Site and Development Planning . . . . . S. Radford/M. Gordon

1100 Construction and Commissioning . . . . . P. Napier

1140 Operations Planning . . . . . M. Gordon

1200 *Assorted Cosmic Pizzas & Salads (Catalina Room)*

1300 Discussion and Reconciliation . . . . . All

1700 Adjourn