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From: Richard Vasquez <richard.vasquez@jpl.nasa.gov>
Subject: Response to concerns
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<fontfamily><param>Times</param><bigger><bigger>Tony,

Below are some brief responses to the concerns previously raised, to serve as a starting point for discussion at next week's telecon. Please pass this on to Bob Brown, I don't have an email address for him.

There may be a possible source of NASA cofunding, though it won't be available on a short enough time scale to meet your immediate needs. There will be a couple of research announcements, tentatively scheduled for release in January/February and July of 1999, for advanced technology development, and submillimeter detector technology is specifically mentioned in the draft. Unfortunately, JPL will not be permitted to compete in the first round, but probably will be able to in July. However, even if a proposal passes peer review and is funded, that support would not show up until FY'00. Still, it's something to consider.

Rick

>Purely technical issues:

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>1. Silicon substrates are not suitable for our mixer designs. We

> require fused quartz in order to benefit from its low

> dielectric constant. Is this a problem?

>2. We believe that e-beam lithography is required for the higher

> frequency mixers, and it is highly desirable for junction

> definition at all frequencies, as it greatly reduces one of

> the major process uncertainties. Improved definition of the

> junctions must, of course, not result in degraded junction

> quality. If we specify e-beam lithography for junctions, is

> process development needed, and if so, is it possible to

> estimate how long it will take?

These two items are related. Fused quartz has low thermal conductivity, which results in heating and thermal gradients when ebeam lithography is used. This results in degraded junction quality and poorer definition, as well as substrate stresses. An additional consideration is manufacturability. Although ebeam lithography on quartz substrates has been done here before, it has been a low yield process. Such a process is adequate when only a few devices are required. However, it is not suitable when the goal is to demonstrate that the required numbers of devices for a large array can be fabricated. A low dose ebeam process would therefore need to be developed. This is in principle a solvable problem, but the process development time required is uncertain. It would be helpful to obtain clarification on the technical requirement driving the need for fused quartz and ebeam lithography.

>3. The proposed alignment tolerance of +-1.5 microns is too

> large; we need this parameter to be +-1 micron. Is process

> development needed in order to achieve this tolerance?

Lower alignment tolerances should not be a problem with an ebeam process (but requires process development, see above). Alternatively, the stepper mask aligner could be used with an optical process to achieve the desired tolerance. Again, clarification of the technical drivers would be helpful.

>4. The tolerance on Jc of +-20% is high. We would prefer +-10%

> tolerance in order to land closer to the design. Is process

> development needed in order to achieve this tolerance?

A spread in Jc of +-10% is achievable if this refers to the spread across a single wafer. However, if this refers to run-to-run variability then the spread is typically larger and better process control may be needed. This would require additional wafer runs or process development to obtain lower spreads.

>5. The proposed ratio of subgap to normal resistance of >8 is not

> acceptable. We require that this parameter be >20. Is process

> development needed in order to achieve this?

The achievable ratio depends on the desired value of Jc. Ratios >30 are typical for Jc = 5 kA/cm2, but for 10 kA/cm2 ratios of 10-15 are

the best achievable. Higher ratios would likely require more than just process development, equipment modification/procurement may be necessary (e.g. for substrate cooling?).

>6. The assumption that the "...NRAO, SAO, CSO, and OVRO designs are
> sufficiently similar...so that common device processing is
> possible" is incorrect. We require additional resistor and
> insulator layers not used by other current designs, and,
> almost certainly, different Jc values. What is the impact of
> this fact on the proposed program?

We recognize that additional process steps are necessary for the resistor & insulator layers. As for Jc, how different is different? We have been assuming that a range of 4-10 kA/cm2, which is achievable by varying parameters in a single process, would meet the needs of all participants. Jc values which are significantly different, however, may require a totally different process, and would invalidate this plan.

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>Management issues:
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>1. The proposal is contingent upon SAO's continuing participation
> for 3 years beyond the end of their present contract.
> Furthermore, it is likely that much of the final 3 years of
> SAO work will not be in Nb--possibly NbTiN. Is SAO's position
> on these matters clear?

SAO seems willing to use devices from whatever our mainstream process is at any given time in order to keep their costs down. The larger question here is the degree of coordination required of all participants to ensure synergistic efforts. In the absence of a stand-alone program, this presents an inherent risk.

>2. The proposal is contingent upon obtaining a loan from JPL
> administration for purchase of a new Nb system. We are unable
> to evaluate the likelihood of this and would appreciate

> clarification.

We have verbal assurance from a member of the capital equipment committee that this should not be a problem.

>3. We believe that 10% of Rick LeDuc's time is insufficient to
> ensure high quality mixers. Our past experience strongly
> indicates that intensive participation of a highly experienced
> fabricator is needed in order to obtain consistent high
> quality.

We plan on having experienced fabricators working on this, at least one of which will be a Ph. D. level person (two good candidates have been identified). We believe that interaction with other group members working on mixers for other projects, together with Rick LeDuc's involvement in a technical oversight role, should be sufficient to solve the inevitable problems that will be encountered.

>4. Based on our past experience, we believe that two technicians
> on maintenance and fabrication are unlikely to provide
> sufficient labor to meet the combined needs of the NRAO, SAO,
> CSO, and OVRO.

Our original estimate for a stand-alone effort, with 2 people fully committed to NRAO, is the lower risk option. The cost-sharing option in the more recent estimate lowers the financial cost, but the price is a lower level of effort, higher risk, and coordination of effort with SAO, CSO, and OVRO. This is an unavoidable trade-off, the deliverables have to scale with the available resources.

>
>Schedule issues:
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>1. It is important that we obtain new, good wafers as soon as
> possible. We are in the design and development phase of the
> Millimeter Array, and have a short timetable to meet.
> However, we believe the time required to acquire a new Nb

>   system, commission it, and calibrate it for SIS junction

>   fabrication will be at least six months. Is our evaluation

>   incorrect?

That evaluation may be optimistic. However, we believe that in the short term (between initiation of a contract and having a fully functional new system), Nb fabrication needs can be met utilizing existing equipment.

>2. According to your proposal, a new hire for Nb fabrication

>   would not even start until mid 1999. Even for an experienced

>   fabricator, there will be a considerable period of training

>   before high quality SIS mixers can be expected. Please

>   address training and its impact on the schedule.

One of the people working on Nb fabrication is likely to be the person currently working on the SAO task, who is already trained, so some effort can be devoted to NRAO as soon as funding is received. The second person would be a new hire. We plan to speed up the hiring process by initiating a job offer as soon as a guarantee of funding is obtained, and we are hoping to minimize training time by hiring someone with experience fabricating SIS junctions (both of the candidates we are interviewing have such experience).

>3. Scheduling problems are almost inevitable if "common device

>   processing" is required.

Yes, this would require close coordination of efforts.

>

>For all these reasons, we are afraid that it will be early 2000

>before we get anything useful under the proposed plan--and this

>is too late to do us any good.

Early 2000 seems pessimistic, since some effort can begin as soon as funding is received.

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>Cost issues:

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>1. We are concerned that development will be required in at least
>   some of the areas listed as technical concerns, and that this
>   will involve additional delays and consequent expenditure of
>   funds by the NRAO.

>2. Two wafers from each of two mask sets per year is not
>   sufficient. We require at least two wafers from at least 3
>   mask sets per year, which will be an additional cost.

>3. Under the proposal, the NRAO is responsible for the masks
>   (mask designs and mask fabrication) separately from the JPL
>   contract. This also affects the budget.

NO - just designs

>4. The total amount of funds requested from the NRAO even in the
>   context of a joint program with CSO, OVRO, and SAO already
>   exceeds the amount available for SIS mixer fabrication by a
>   large amount. The additions required to the proposed program
>   in order to address the concerns listed above, we believe,
>   will drive these costs even higher.

>5. The NRAO's budget contribution increases with time, whereas
>   that of other participants does not. However, there is no
>   corresponding increase in what we get for our money.

We were planning on mask fabrication here, NRAO would need to supply the design as a computer file (as Tony has already done in the past). The other concerns related to cost are for the most part valid. This is not an off-the-shelf technology, the devices are custom and require process development, which certainly affects cost and schedule. Both concept papers reflect our best estimate of the level of effort which can be supported within the available resources, and deliverables must scale with the resources provided by each participant. Finally, the NRAO budget only appears to increase with time because it does not start at the beginning of FY'99 (10/98), while the other participants are assumed to contribute a full year's funding in FY'99 (this is certain for SAO, for which there is an existing task with FY'99 funding already provided).

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