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ALMA RECEIVER CONCEPTUAL DESIGN:

GUIDELINES FOR RECEIVER CONFIGURATION MEETING

2nd and 3rd December, Grenoble

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1. Introduction

During its first meeting on 30 September 1999, the Joint receiver design group (JRDG) decided to have a phase of conceptual ALMA receiver design, worked on by several groups in parallel. These conceptual designs will be presented and discussed at the JRDG's next meeting on 2 and 3 December 1999 in Grenoble. It is anticipated that various configurations will be presented, and it is hoped that the outcome of the meeting will be the selection of which configuration(s) to pursue and refine.

2. Purpose of this document

This document outlines the framework and gives necessary information for the conceptual design studies. Further information can be found in the ALMA memo series (http://www.mma.nrao.edu/memos), and the antenna contract documents, the ESO Call for Tender and the NRAO Request for Proposals – RFP - (which are identical). In case of doubt/questions/incomplete information, please contact W. Wild (wild@astro.rug.nl) or J. Payne (payne@nrao.edu).

3. Overall receiver specs

3.1 Optics: The telescope will provide a f/8 beam. Locating receiver windows at an offset from the optical axis is possible within limits, and has been shown to lead to negligible efficiency loss (see ALMA memo series). Details about the optical parameters of the telescope and distances in the receiver cabin are given in the ESO Call for Tender and the NRAO Request for Proposals (both documents are identical).

The optics design needs to allow the add-on of the 30 - 40 GHz channel (e.g. via a pick-off mirror), simultaneous 183 GHz water vapour monitoring, and fast phase switching, see 3.4 for details.

The optics design should include the outline of a calibration system for receiver calibration.

The receiver specs are not decided completely at this point, and may vary somewhat in the future. However, in order to be able to start on conceptual designs, the following specs should be assumed.

3.2 Frequency bands: There will be 9 frequency bands in the main dewar. Band no. 1 (30 – 40 GHz) will not be part of the main dewar, but possibly an add-on. If included, the 30-40 GHz receiver will be in a separate dewar and connected to the telescope optics by means of a moveable mirror when operation in this band is required.

The frequency bands according to the MMA project book are at present:

band	low freq	center freq	high freq	rel. bandwidth (high-low)/ctr	high/low
(1	*30*	*35*	*40*	*0,286*	*1,333)*
2	67	79	90	0,291	1,343
3	89	103	116	0,262	1,303
4	125	144	163	0,264	1,304
5	163	187	211	0,257	1,294
6	211	243	275	0,263	1,303
7	275	323	370	0,294	1,345
8	385	442	500	0,260	1,299
9	602	660	720	0,179	1,196
10	787	869	950	0,188	1,207

Bands 2 and 3 may possibly be HFET amplifiers, bands 4 to 10 will be SIS mixers. Each SIS mixer will have its own first stage IF amplifier. All frequency bands need to be dual linear polarization. It has been suggested to use OMTs at lower frequencies, and wire grids at higher frequencies for polarization separation.

The IF bandwidth for the SIS mixers is 4 GHz per sideband, with a goal of 8 GHz per sideband. For 8 GHz IF bandwidth, the IF will go from 4 to 12 GHz (TBD for lower IF bandwidth).

3.3 LO coupling: The baseline LO design for ALMA is at the moment a photonic reference (providing a 68 – 122 GHz reference) with tunerless multipliers. It is foreseen to provide 100 μW of LO power at each frequency. This would probably be enough LO power to allow using a beam splitter for LO coupling. However, given the risk of tunerless multiplier development, we would suggest to also consider the possibility of much lower available LO power (in particular at the higher frequencies) which would require a different LO coupling scheme (e.g. diplexers).

It has been discussed to cool the tunerless multipliers and include them in the frequency module. This may result in higher LO power, but also in lower reliability of the receiver system. This needs to be an issue for discussion.

3.4 Observing modes: The following observing modes need to be supported:

- Single frequency, dual linear polarization. No simultaneous dual (or multiple) frequency observing is foreseen.
- In parallel and during all observations: a 183 GHz cooled Schottky water vapour monitor, wvm, (single or dual polarization, depending on the required sensitivity, TBD), as well coaligned as possible with the beam at the observing frequency. At present, a maximum of 3 arcmin between the observing beam and the Schottky beam seems acceptable. Two options can be considered: the 183 GHz wvm in the main dewar, or in a separate dewar. Since the 183 GHz wvm is required at all

times during observations, it would present a single-point failure of the whole receiver system when placed in the main dewar.
- Fast phase switching: the receiver has to allow fast switching (settling time less than 1.5 sec) between the observing frequency, and a (fixed, predetermined) frequency in the 3 mm band. The switching has to preserve the phase.
- Frequency switching in single dish mode.

3.5 Cryogenics: The JRDG thinks that cooling the mixers (and junctions) to 4 K will be sufficient. Consequently, a 4 K system should be considered in the conceptual design. The required cooling power clearly depends on many parameters, such as the dewar design, the number of input windows, the dissipated power inside the dewar, the LO coupling etc. It is hoped that the conceptual design will result in first estimates and calculations of the required cooling power for each of the proposed configurations. The JRDG favours a single dewar design for the main observing frequencies (i.e. without the 35 GHz channel, and possibly with the 183 GHz wvm in an extra dewar).

For practical and maintenance reasons, the cycle time of the dewar (pumping, cool down, warm up) should not be more than 5 days, ideally shorter.

3.6 Modular design: Given the large number of frequency channels, and groups to provide them during the construction phase of ALMA, a modular approach seems inevitable. One option here is to provide one module per frequency band. Another possibility is to provide two larger modules: one for frequencies below 350 GHz, the other for the higher frequency bands. The frequency modules in the first case should be self-contained, testable units (dual linear polarization, RF in, IF out). Sufficient space needs to be reserved in the dewar for the frequency modules. The exchange of whole modules and components should be as easy as possible.

3.7 Mechanical considerations: The size of the receiver cabin is given in the antenna RFP. The minimum cabin door size is 1 m wide by 1.6 m in height. The maximum weight of the receiver is 550 kg. Details about the receiver cabin can be found in the antenna call for tenders, e.g. Chapter 3.5.4. and appendices. Ideally, the receiver system is a fairly self-contained package (containing electronics, pump, etc.) with minimum connections to the antenna. It should be possible to change receivers easily and with minimum effort (e.g. sliding the receiver on rails to the cabin door is a possibility).

3. Receiver conceptual design

In general, the conceptual design should provide enough information to allow evaluation of the different options. More specifically, the following points should be addressed:

- optical layout, number of dewar windows, options for LO coupling,
- overall receiver system layout: mechanical configuration, size and location of LO and electronics modules,
- modular design: ease of exchanging modules, size and location of modules and components inside the dewar, required interfaces,
- LO coupling possibilities

- thermal calculation (or, if not possible at this stage, an estimate of the thermal loads)
- ease of maintenance and refurbishing of receivers
- weight estimate of the receiver system
- pro and cons of the chosen design

4. Issues for discussion

Be prepared to discuss the following issues:

- Dewar – round or rectangular ?
- Dewar material – aluminium or stainless steel ?
- Dewar size.
- Refrigerator specifications.
- Band selection – appear to be two main possibilities
    a) Pointing change – many windows – no moving parts.
    b) One (possibly two) windows, plus a moving mirror within the dewar.

A variation on b) would be a high frequency window and a low frequency window with a selection mixer for each band.

• Windows	Ideas on low loss, low leakage windows will be discussed.
• LO injection another	Various methods. One system for high frequencies, and for low?
• LO system Alternative?	Is the plan outlined in the project book acceptable?
• Optics	What are the criteria here? Is it to minimize G/T? James Lamb has some ideas on this.
• Polarization diplexing	The two orthogonal linear polarizations will be separated in the diplexer. We believe that OMTs in waveguide will be possible up to 300 GHz, although that has to be proven. Above 300 GHz we will probably use cooled, free-standing wire grids.