Submillimeter Array Technical Memorandum

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CORRELATOR MODE SELECTIONS

Abstract

The basic layout of the correlator chip and board is now available, and we know which modes will be permitted. The correlator will have 4096 complex channels over each 2 GHz band, giving a resolution of 0.625 MHz if the lags are distributed uniformly. The coarsest resolution is 1.25 MHz, and the best resolution is 78 kHz in interferometer mode. In single-dish mode, the coarsest resolution is 0.625 MHz, and the finest guaranteed resolution is 78 kHz, although it might be possible to get 39 kHz if we ask for it. The correlator will be a hybrid, with 80 MHz chunks, spaced every 64 MHz. The basic plan calls for the chunks to be at fixed positions, but there may be options for some flexibility. The modes allow lags to be programmed from one receiver to the other, and for some chunks to be ignored, in order to increase the resolution on others.

Introduction

The correlator planned for the SMA is much more flexible and powerful than any planned for a similar instrument. In the basic mode, we will have a resolution of 0.625 MHz across the whole of 2 x 2 GHz receiver bands. The bands will be split up into 80 MHz wide chunks, separated by 64 MHz. The resolution of each chunk may be chosen separately, subject to some constraints. There will be a large number of modes. We now have a good understanding of the modes which will be allowed by the wiring of the correlator. They are very close to those described in the design study, with a couple of small variations due to a) the necessity to change resolutions by factors of 2, and b) limitations on the signal distribution connections. The biggest change since the design study is that the overall frequency resolution has been improved by a factor of 2, so that for most experiments reconfiguration of the correlator will be unnecessary.

General Considerations

The correlator digital modes are constrained by the number of chips and the number of pins on each board, as well as the internal connections and switches available on the board. Since signal wiring is a significant limit, no modes permit daisy-chaining of signals from one board to another.

The 2 GHz band will be divided into 32 chunks, each of 80 MHz bandwidth, spaced every 64 MHz. A separate memo by Andy Dowd will discuss the down converter scheme, and possible flexible modes there. The 160 Msample/s signals from each chunk will be demultiplexed into 4 parallel lines of 40 Msps each, and distributed to the boards. Each correlator chip has 16 internal sections, and can do a complete set of correlations on a single chunk. The chips may be daisy-chained to increase the resolution.

A board of 32 chips can handle 16 chunks total, but there are restrictions as to which chunks may be used. In order to do polarization measurements, signals from each of the 2 receivers must be present on each board, so the board must handle 8 chunks from each of the two receivers, and these chunks must be at matching places in the passband. Secondly, there is a shortage of input wires to the board (only 192!), so we must use 4 chunks from each of 2 baselines which have an antenna in common.

Within the board, very flexible configurations are available, since it is possible to connect any chip to any input and to daisy chain the chips to various lengths. Since signals from two receivers are present on one board, it is possible to steal lags from one receiver and give them to the other. This could be very advantageous when the receivers are at significantly different frequencies.

Summary of Constraints and Configuration Rules

Each board has 32 chips, and inputs for 8 chunks on each of 2 baselines.

To permit cross polarization operation, the 8 chunks are divided between 2 receivers, so that there are 4 from each receiver. These must be from matching parts of the passsband.

For the usual interferometer modes, we want the same resolution on each baseline, so we will ignore reprogramming of chips between baselines, although this is permitted.

Each board may be configured independently.

Rules for configurations of one board (interferometer, non-polarization)

1) The total number of available chips is 32, giving 16 for each baseline.

2) Each chunk must have a power of 2 chips behind it, so the resolution varies in steps of 2. Permitted numbers of chips per chunk are 0, 1 (1.25 MHz res), 2, 4, 8, 16 (78.125 kHz). All 32 chips could be used to get 39 kHz resolution, but only by discarding one of the two baselines.

3) Having chosen the set of resolutions, e.g. 4,2,1,1,2,2,2,2 chips/chunk, these can be

distributed to the 8 chunks in any permutation.

Comments

Note that 0 chips/chunk is a valid option, so that some chunks can be completely cut out in order to increase resolution on other chunks.

There is no restriction in switching chips between the two receivers.

The basic mode will be adequate for many observations, with 0.625 MHz resolution available over the entire band.

Examples

Some examples are shown in Figs 1-3. This is not an exhaustive list of modes, but illustrates the flexibility permitted under the rules.

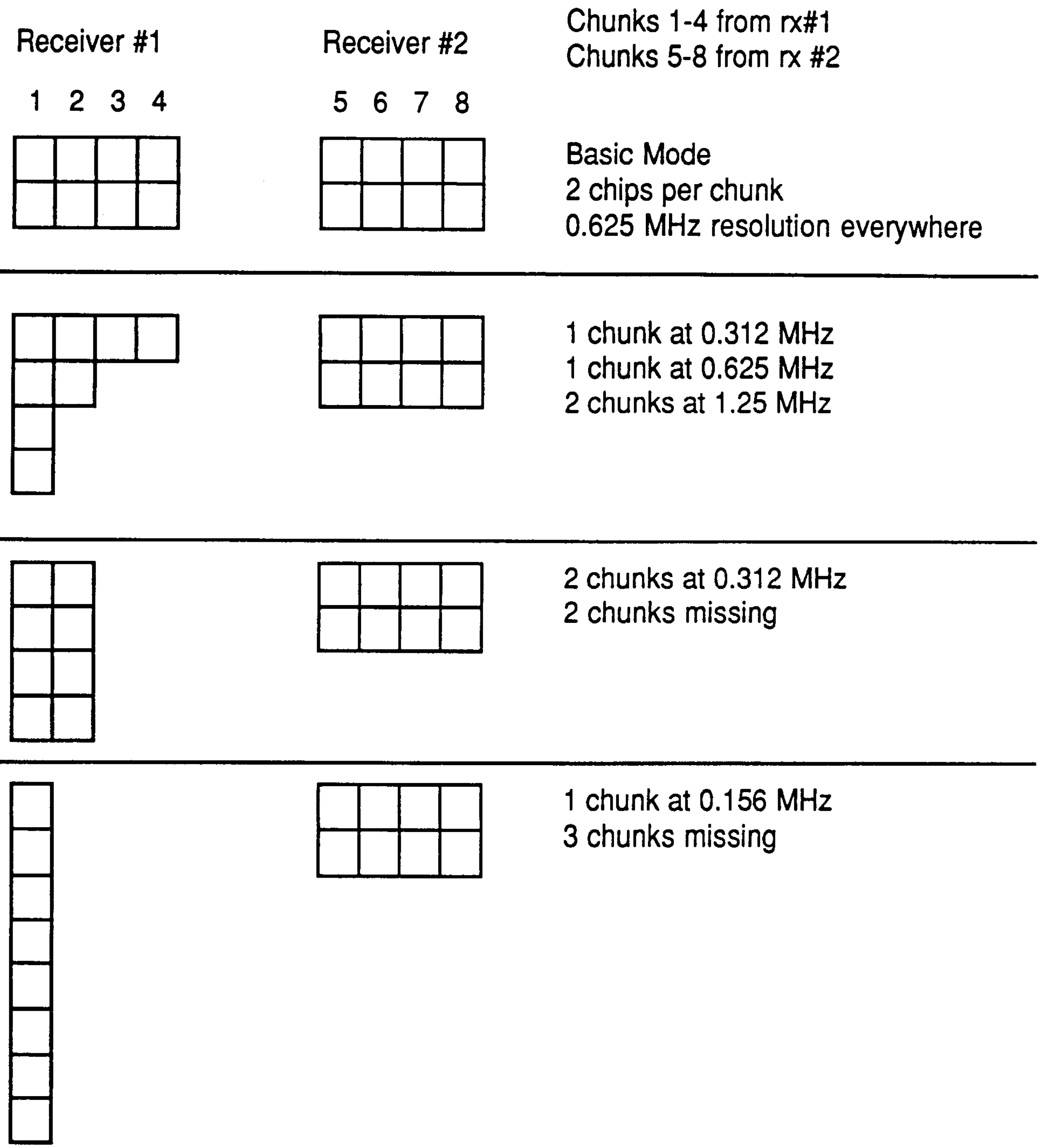

Figure 1 Examples of correlator modes in which chips are not reprogrammed between the two receivers. Each box represents one chip, with 128 effective lags (=64 complex channels). Note that there is no restriction on which of the input chunks are connected to which chains of chips. Note that some lags can be ignored completely to release chips to increase the resolution on other chunks. (These examples all show the same configuration for rx #2 for simplicity, but the configuration for #2 can be set independently of #1.)

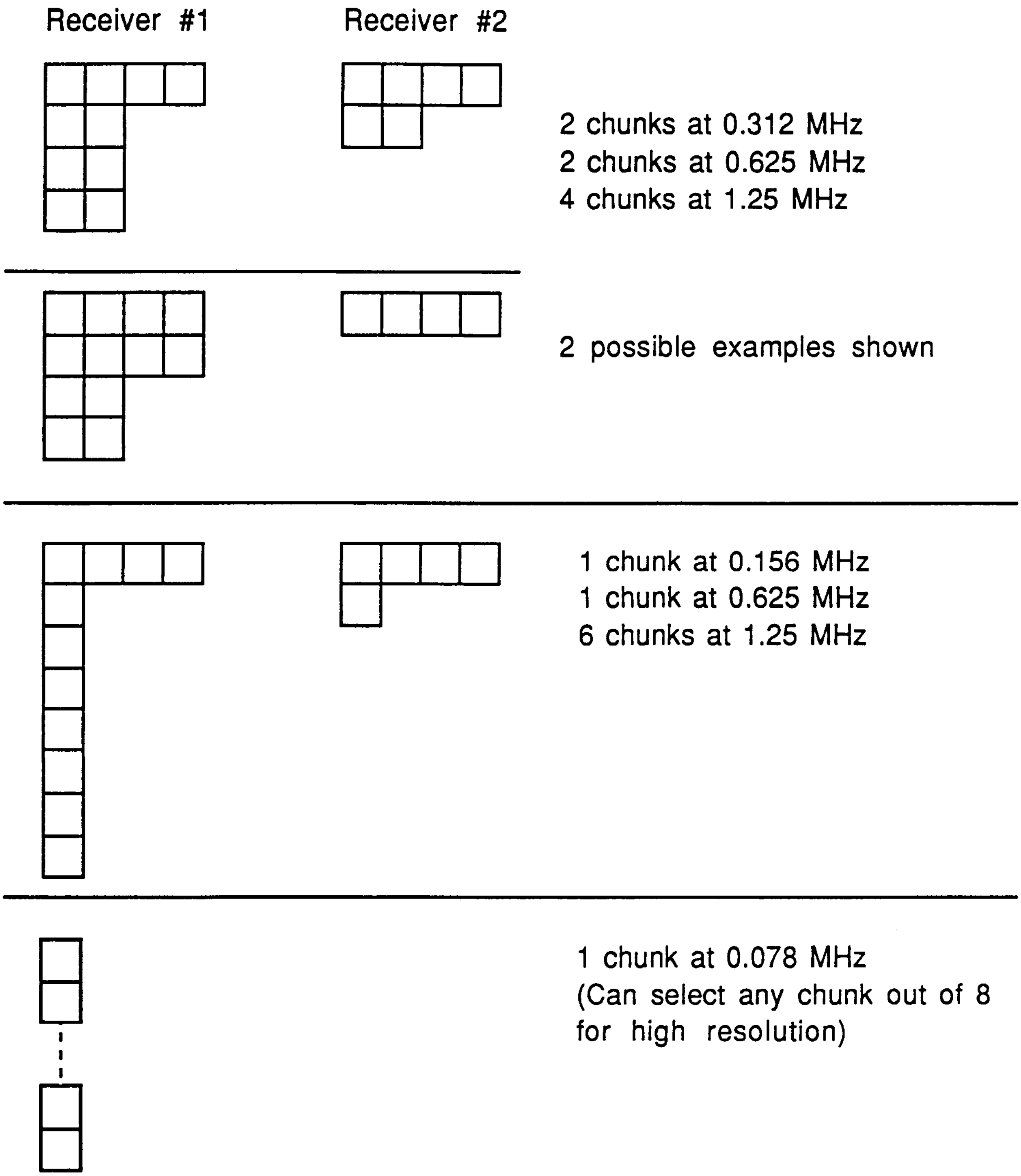

Figure 2 Examples of modes where chips are stolen from one receiver and moved to the other. Note that the chains of lags can be moved arbitrarily amongst the 8 input chunks, since the board makes no distinction between the two receivers.

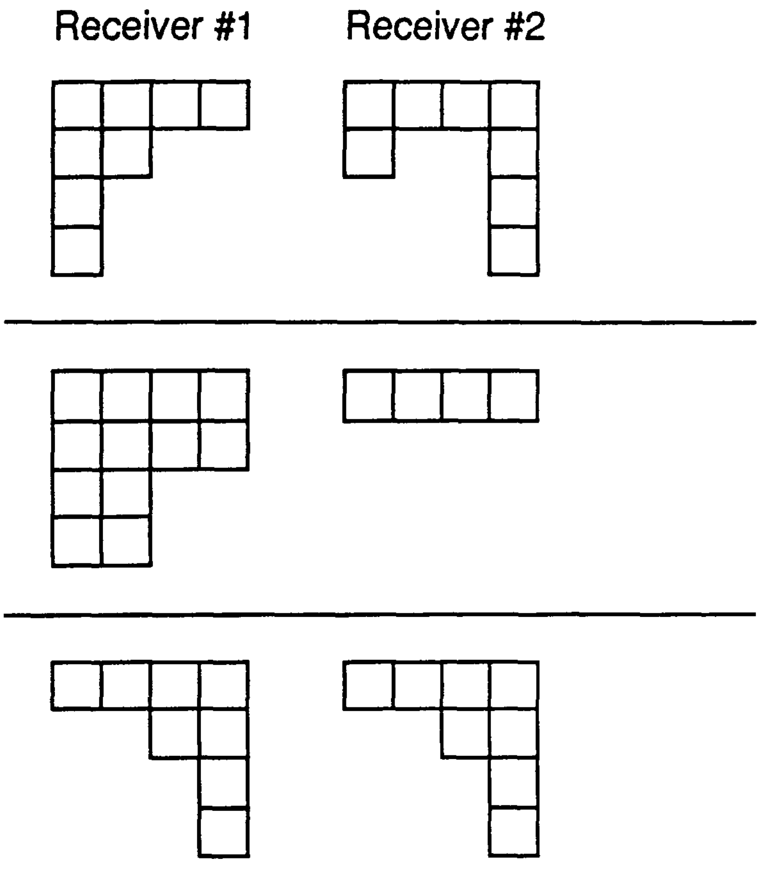

Figure 3 A few examples with the same set of resolution modes, distributed differently between the chunks.

Cross Polarization Modes

In cross polarization operation, 4 chips are required for each pair of chunks (1 from each receiver), and the board is fully used at a resolution of 1.25 MHz. However, higher resolutions are possible if chips are stolen from one or more chunks to increase the resolution on others. This would be a desirable mode, for example, for observations of masers.

Single-Dish Modes

In single dish operation, only one lag is needed per channel, so the available frequency resolution is improved by a factor of two. However, the signal paths on the board become more complex, and some of the highest resolution modes may not be achievable. We are guaranteed resolution down to 78 kHz, which should be adequate for essentially all of our observations, and it is hoped that we will have resolution down to 39 kHz, and maybe even 20 kHz. If anybody foresees a need for these higher resolutions it is important to state it now while the board layout is in progress.

Summary

A table of the available modes is attached. The numbers in the table are based on the assumption that all boards in the correlator are configured the same way in the reduced bandwidth modes. In practice, the total bandwidth is reduced by a small amount for each board which operates in the reduced bandwidth mode.

It appears that the digital section of the correlator will offer almost all the flexibility that one could ask for. The total number of modes is vast, and hard to describe in a simple memo. We will need some graphical way of selecting correlator setups. The only significant limitations on the flexibility are in a) the placement of the seams between the chunks, and b) the mapping between chunks and boards, which are both fixed in the simplest scheme. A companion memo by Andy Dowd on the down converter will describe some ways of providing more flexibility there, if we decide that it would be justified.

Table 3 - Auto. Mode (Single Dish), minimum external switching, 6 Antenna configuration

Single Dish Modes	Total BW per Polar. (Mhz)	# of Active Polar.	Highest Frequency Resolution (Mhz)	chips per chunk	Number chunks at High Resol.	Lowest Frequency Resolution (MHz)	chips per chunk	Number chunks at Low Resol.
Full Bandwidth	2,048	2	0.156	4	32			
	2,048	2	0.078	8	8	0.312 0.156	2 4	16 8
Reduced Bandwidth	1,024	2	0.078	8	16			
	512	2	0.039	16	8			
Single Polar-ization	2,048	1	0.078	8	32			
	2,048	1	0.039	16	8	0.156 0.078	4 8	16 8
Reduced Bandwidth 1 Polar.	1,024	1	0.039	16	16			
	512	1	0.020	32	8			

Notes
Shaded Modes are planned, but NOT guaranteed by board designer at this time.

Table 2 - Cross Polarization Modes, minimum external switching, 6 Antenna configuration. Measures Cross Power spectra AND cross polarization power spectra.

Cross Polar. Modes	Total BW per Polar. (Mhz)	# of Active Polar.	Highest Frequency Resolution (Mhz)	chips per chunk[1]	Number chunks at High Resol.	Lowest Frequency Resolution (MHz)	chips per chunk	Number chunks at Low Resol.
Full Bandwidth	2,048	2	1.250	1	32			
Reduced Bandwidth	1,024	2	0.625	2	16			
	512	2	0.312	4	8			

Notes -
1. Number of Chunks per Spectra, Each baseline/chunk produces two spectra: cross power and cross polarization power.