MILLIMETER ARRAY
MEMO NO. 23

To: R. Ekers, F. Owen

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Subj: Wide bandwidth correlator

For both the millimeter array and for broadbanding the VLA, one of the pressing problems is to correlate the very wide bandwidths. Merely extending our current technology would make the correlator more expensive than the data transmission systems by a large factor, if, for instance, we chose to broadband the VLA only for the C and D configurations.

We should perhaps consider handling only the spectral line case with the current technology, and consider something different for the continuum case, to process very wide bandwidths for raw sensitivity.

It seems to me that such an alternative would be a hybrid digital-analog system, like the Green Bank interferometer. Gigahertz clocked samplers would have to be developed, data transmitted digitally (optical fibers?), and delayed digitally. It would then be converted back to analog for correlation. In particular, an optical analog correlator might be feasible and affordable.

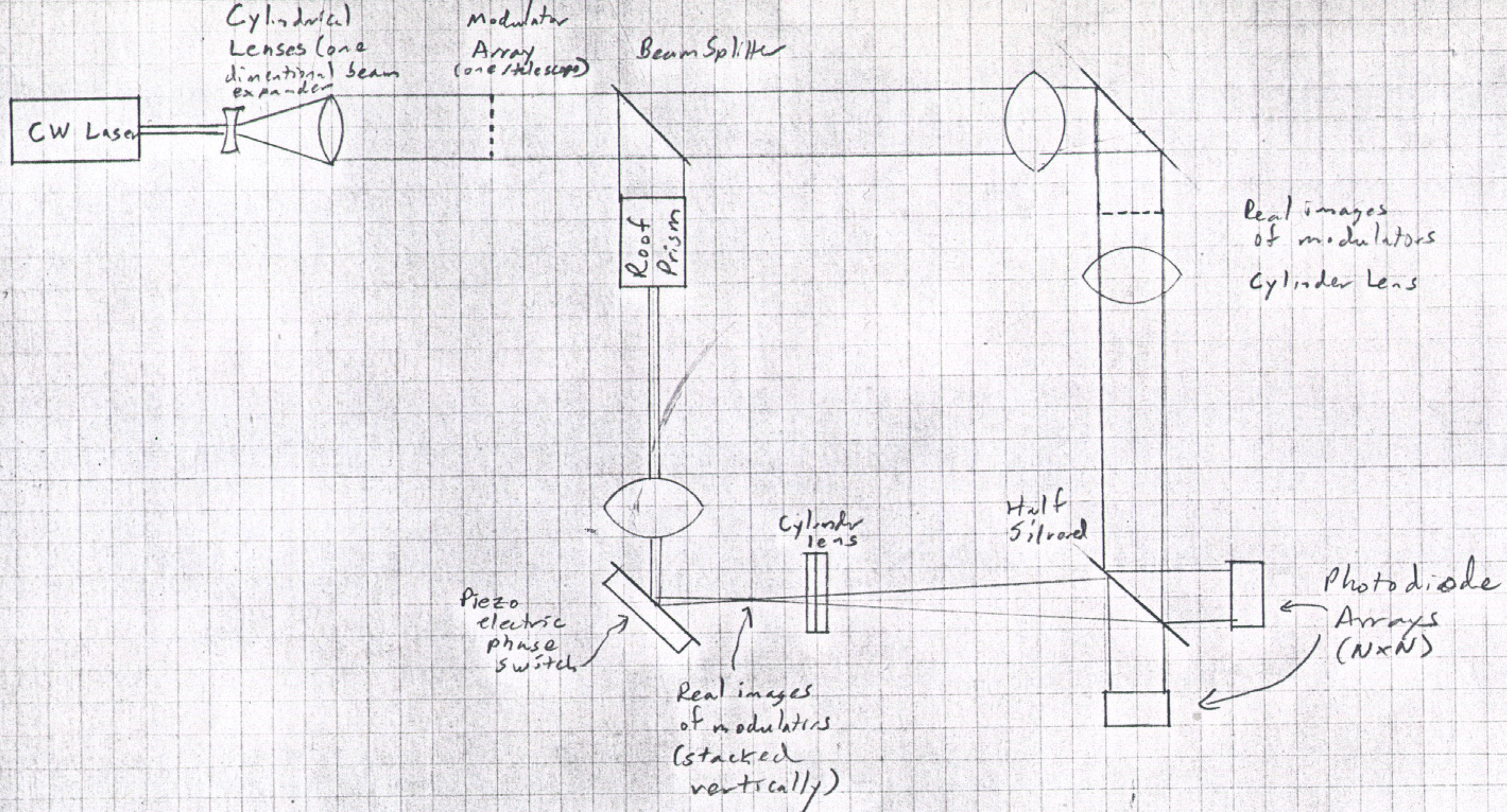
Attached is a diagram of a Michelson interferometer correlator which might do the job (or part of it). The modulators (digital to analog converters) would probably be SAW devices, but bulk acoustic is possible too. I don't think Kerr cells could be made small enough. Any of the devices could handle about one gigabit (a bit less for the bulk acoustic modulators, problems on the low frequency end for the SAW devices might require the use of biphase encoding or some other scheme to convert from baseband up to the bandpass beloved of the SAW devices). The optics image the modulators on the detector planes, each modulator as a vertical stripe by one path, and as a horizontal stripe by the other. A photodiode at the intersection of the stripes is the detector for a quarter-square multiplier. One photodiode array gives the square of the sum of the bits and the other gives the square of the difference. The piezo-electric phase switch would occasionally insert a half wavelength, to reverse the roles of the diode arrays and cancel systematic effects.

Order of magnitude estimates look like the device would require a milliwatt of laser power and a readout rate of the order of one kilohertz. The former is quite reasonable, but the latter would strain the capabilities of the usual way of doing such things, with analog multiplexors and a single A/D converter. It may be that the device could not be integrated in the usual fashion, but might require a separate amplifier/integrator for each baseline, or at least each antenna.

The device would not be bulky. I think it would come out, except for the laser, within a factor of two (in either direction) of the size of the drawing.

In practice, a real device would probably have the optics shown here separately in each arm inserted between the modulator and beam splitter, eliminating the necessity for having a pair of lenses closely matched in properties.

As drawn, the device simply correlates a bit stream from one antenna with that from another. However, one would probably have several bit streams per antenna: right, left polarization; phase, quadrature sampling; sign, magnitude sampling. One can either build multiple copies of the device (64 devices to process the above eight bit streams in all combinations, which sounds rather prohibitive), or can simply double the number of modulators in the modulator plane and quadruple the number of photodiodes to process all combinations of two bit streams per antenna. How far the later process can be carried I do not know without a better analysis than I am willing to give it. I strongly suspect that you will run out of either laser power or diode array readout speed before you can process eight gigabits per antenna.



CW Laser
Cylindrical Lenses (one dimentional beam expander
Modulator Array (one/telescope)
Beam Splitter
Roof Prism
Real images of modulators
Cylinder Lens
Half Silvered
Cylinder lens
Piezo electric phase switch
Real images of modulators (stacked vertically)
Photodiode Arrays (NxN)