VLBA Electronics Memo No. 46a

15 May 1985

To: VLBA Electronics

From: Tom Clark
Code 621.9
NASA/GSFC
Greenbelt, MD 20771

Subject: Cryogenics for VLBA

We have been following with some interest the discussions and deliberations on cryogenic hardware for use in the VLBA. I thought you might find it interesting to hear of our experiences in the NASA Crustal Dynamics Project (CDP).

About 3 years ago we saw the need to build additional dual S/X receivers for our geodetic work. GaAsFETs were obviously the way to go, so we gave a grant to Tap Lum and Dave Williams at Berkeley to develop amplifiers and cryogenic systems to meet our needs. One of the criteria which constrained our design was that we wanted the new receiver we were developing to be of a standardized design for use throughout our network; this in turn dictated that it be compact. I selected the OVRO 130' sized package (~19" diameter, 4' long) as a "universal" package that should be able to fit anywhere. We wanted the entire receiver to be self-contained including all power supplies, thermal control (assuming a steady supply of cooled air from an OVRO-style external air chiller) and a new monitor/control system based on a Mark-3 Microprocessor ASCII Transceiver (MAT); this latter system was supposed to give full control of all receiver functions thru two twisted-pair communications lines. Of course since the receiver was designed for geodetic use, the phase cal and LO systems had to be integral to the package and have very good thermal control.

All these extra "widgets" dictated that the dewar/refrigerator be quite compact and Tap recommended the small CTI model 21 refrigerator based on UCB's experience. When I mentioned this to the community, everyone seemed horrified that we would consider such a small, unproven and purportedly unreliable cryogenic system!

Tap produced two systems under this grant; one was destined for use at Hat Creek and the other was to go into our first prototype receiver which was to go onto our new Mojave (40') station. Both of these UCB systems were packaged in rectangular dewars manufactured of welded aluminum. The UCB supplied cryogenic/LNA system was integrated into a prototype receiver at Haystack for use at Mojave; this system went onto the 40' antenna in June 1983 and has performed faultlessly for nearly two years of continuous operation.

In the summer of 1983, based on the excellent performance at Mojave, I elected to go into mass production on this GSFC/UCB/Haystack design. Craig Moore had just joined Bendix Field Engineering Corp. (BFEC) and I gave him the task of re-engineering the dewar/LNA package. Based on our prodding, a commercial source for the UCB FET's became available from Berkshire Electronics (a.k.a. Tap Lum/Dave Williams enterprises -- at one time they thought of calling their new enterprise "FET Accompli"). Craig built up his staff with long-time BFEC'er Ralph Kriss and consulting services provided by Howard Brown.

BFEC re-designed the basic dewar to be more conventional by using cylindrical stainless steel techniques and re-engineered the FET-to-cold station mounting and heat shields. Stainless was chosen to minimize the surface entrapment of water so prevalent in aluminum. We committed to a "production" run of nine of the new dewar/LNA packages.

Meanwhile, Haystack under the direction of Brian Corey and Joe Carter, cleaned up packaging of the rest of the receiver and set up to integrate the BFEC-supplied dewars.

The BFEC/Haystack hardware has now been replicated and is on the air at a number of sites: Westford MA (60'), Richmond FL (60'), Fairbanks AK and Kauai HI. Systems are under construction for Ft. Davis TX (85'), Wettzell FRG (60'), Onsala Sweden (60') and a new unit for Mojave (the original Mojave receiver will be refurbished for our use at OVRO).

For me personally, cryogenic systems had always reflected a "black magic" art that required a set of skills that I really didn't want to learn. The performance and reliability of these systems have convinced me that the magic is gone! They have been excruciatingly reliable. After systems get onto telescopes, our experience indicates that cryogenics experts can become like the Maytag repairman -- the loneliest people in the world!

Let me cite one personal experience -- last summer when I brought the Fairbanks system into existence, I was pretty much on my own to make it work in a remote location away from the "world". After pumping the dewar down for a day, I connected the compressor, turned it on, and 5-6 hours later had a fully functioning cooled receiver working. Nothing could have been simpler. Just to document the performance that we are obtaining, the Fairbanks 85' antenna yields the following performance figures:

Frequency Range	Typical T_{sys}	Aperture Efficiency
8200 -8600	70 -75K	~50%
2200 -2300	60 -65K	~50%

Cool-down time for this system is a bit long (4-6 hours from room temperature depending on the cleanliness of the dewar) due to the small amount of margin available with the small Model 21/22 refrigerators. The "70K" first stage typically runs about 45-55K and the "20K" station runs about 18K in operation. Gain stability is excellent and radiometry on 1 Jy sources in a total-power mode is a breeze. S-band system temperatures are a bit higher than might be expected due to ohmic losses in our dual S/X prime focus feed (which was optimized for X-band use). Similar performance has been obtained on all the other systems employing this design. By the way, pointing accuracy at Fairbanks is about 0.007° -- the best I have ever seen on a generic Tatel/Blaauw-Knox/ Rohr telescope.

I have asked Craig and Ralph Kriss to document their experience with Model 21/ 22 systems. The attached memo* from Ralph dated April, 1985 contains their report. I hope this information will be of some use in VLBA planning.

Regards,

cc: Craig Moore, BFEC
Brian Corey, Haystack
Tap Lum, UCB/Berkshire
Bob Coates, GSFC/CDP

* see VLBA Electronics Memo No. 46