

## Use of a Cryo-tiger closed loop refrigerator for FEIC noise temperature measurements.

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Instead of using a liquid Nitrogen cold load for the FEIC noise temperature measurement system, it is proposed to use a closed cycle refrigerator cooled load inside a small vacuum container. This will reduce the need for liquid Nitrogen, and will insure that the load does not warm up during the large number of measurements that are required to be made of the front ends.

There are several difficulties with the proposed system:

- 1) A very wide band vacuum window (to cover all bands) is required. A thin sheet of Mylar or similar material is proposed. This could be backed by a foam material for stiffness, see ALMA memo 90.
- 2) A wide band cryogenically coolable (in vacuum) load is required. A cone of Emerson and Cumming material is suggested.
- 3) A small vacuum Dewar will have to be designed.
- 4) The cooling capacity of the cryo-head limits the size of the entry aperture to the Dewar.

The proposed cryo-head has a cooling capacity of 10 W.

Given

$$Q = \sigma * A * (T_{hot}^4 - T_{cold}^4) (\epsilon_1 * \epsilon_2 / (\epsilon_1 + \epsilon_2 - \epsilon_1 * \epsilon_2))$$

Where Q is the heat load in W,  $\sigma$  is  $5.67 * 10^8$ , A is the area of the window,  $T_{hot}$  and  $T_{cold}$  are the external and the cold head temperatures (300 K and 77 K) and  $\epsilon_1, \epsilon_2$  are the emissivity of the window and the load materials respectively (assumed to be close to 1).

This leads to a maximum area of  $0.023 \text{ m}^2$ , which is a diameter of 170 mm (for a circular window). If this is close to the receiver window (say 200 mm), and assuming a diameter of 4 w. then the maximum waist size that can be used is 42.7 mm.

This will permit the load to be used from approximately 40 GHz up. Covering all bands except the lower part of band 1. The lower part of band 1 will have a lower coupling efficiency.

All of these effects (window size, window material, and load material) will have to be calibrated at all frequencies, but this is also true for a liquid Nitrogen load.

## Conclusion

I would recommend purchasing an IGC Polycold CryoTiger closed loop refrigerator system for the FEIC test system. The price is approximately \$12,000 including cold head, refrigerator, long gas lines and electrical line isolators. A dewar, window and load will need to be designed and made. (A CTI-cryogenics 1020 cryogenic refrigerator could be used for extra cooling capacity but the price is then approximately \$20,000.)