Receiver system requirements for the Arecibo 12m telescope

D. Anish Roshi, F. Fernandez, P. Perillat, L. Quintero

March 23, 2021

A block diagram of the system required for the Arecibo 12m telescope is shown in Fig 1. Broadly, the system consists of cryogenic frontend, post-dewar RF stage, fiber optic transceiver, up/down converter (UDC) and filterbank. A list of requirements is given below -

1. System temperature (Tsys; sky+spillover+receiver temperature) vs frequency as specified by the black curve in the Fig. 2 below. Preference to bring down the Tsys near 3 GHz by 5 K. (The amplitudes of the intermodulation products due to RFI should be below 2 mK in units of antenna temperature. We will be producing the RFI spectrum.)
2. Dual linearly polarized feed covering frequency 2.3 to 14 GHz is required for the observations.
3. The cryostat needs to be located in the 12m feed support cylinder. A radome is needed to protect the frontend from water collection. Smart servo motor is required to position the feed at appropriate focal lengths.
4. Noise cal and phase cal injected before the first stage amplifier are required. The maximum switching speed of noise cal can be about 80 Hz. The noise cal should also have an on/off control. Noise cal value can be 4 to 5% of average Tsys and a second value of 40 to 50% of average Tsys. The same noise should be injected to the two polarizations. Phase cal specification can be same as the VGOS specification
5. The post-dewar RF stage will be split into two frequency ranges (2.3 - 5 GHz and 4 - 14 GHz). Options to insert three bandpass filters in each frequency range are required. Please explore the option of using a single filter bank. A switchable solar attenuator of 25/30 dB will also be required at this stage.
6. Monitor and control of the cryostat, its temperature, noise/phase cal and solar attenuator control are required. They will be controlled from the antenna control room through an ethernet link provided by Arecibo.
7. The combined outputs of the post-dewar RF stage filter banks from the 2 polarizations are brought to the backend room through 4 fiber links.
8. Two UDCs are connected to the 2.3-5 GHz and 4-14 GHz frequency ranges. They can be similar to the VGOS system
9. The output of the UDCs will go through a filter bank where the 2.0 GHz bandwidth will be divided into 4 using filters 0.5-1.0, 1.0-1.5, 1.5-2.0 and 2.0-2.5 GHz and additionally using one filter with frequency range 1.0-2.0 GHz.

Acceptable and delivery requirements:

1. We prefer to deliver the pre-fiber optic module at the earliest (6 months) for installment at 12m telescope and start observations with the existing UDC.
2. Arecibo engineers will be visiting CMW lab for an acceptance test. CMW engineers will visit Arecibo to make on-site Tsys measurement for acceptance.

Items provided by Arecibo:

1. Helium compressor, pressure sensors
2. 4 single mode fibers connecting the 12m antenna and control room
3. Will provide the input switching signal for the noise cal

4. Ethernet connection to the 12m antenna base.
5. 5 MHz sine wave standard at the 12m antenna base with +10 dbm power locked to hydrogen maser.

Project phases:

1. Front-end system will be supplied with monitor and control system along with a mechanical wheel for positioning. (6 months)
2. The remaining system and characterisation will be completed in 12 months from the start of the project.

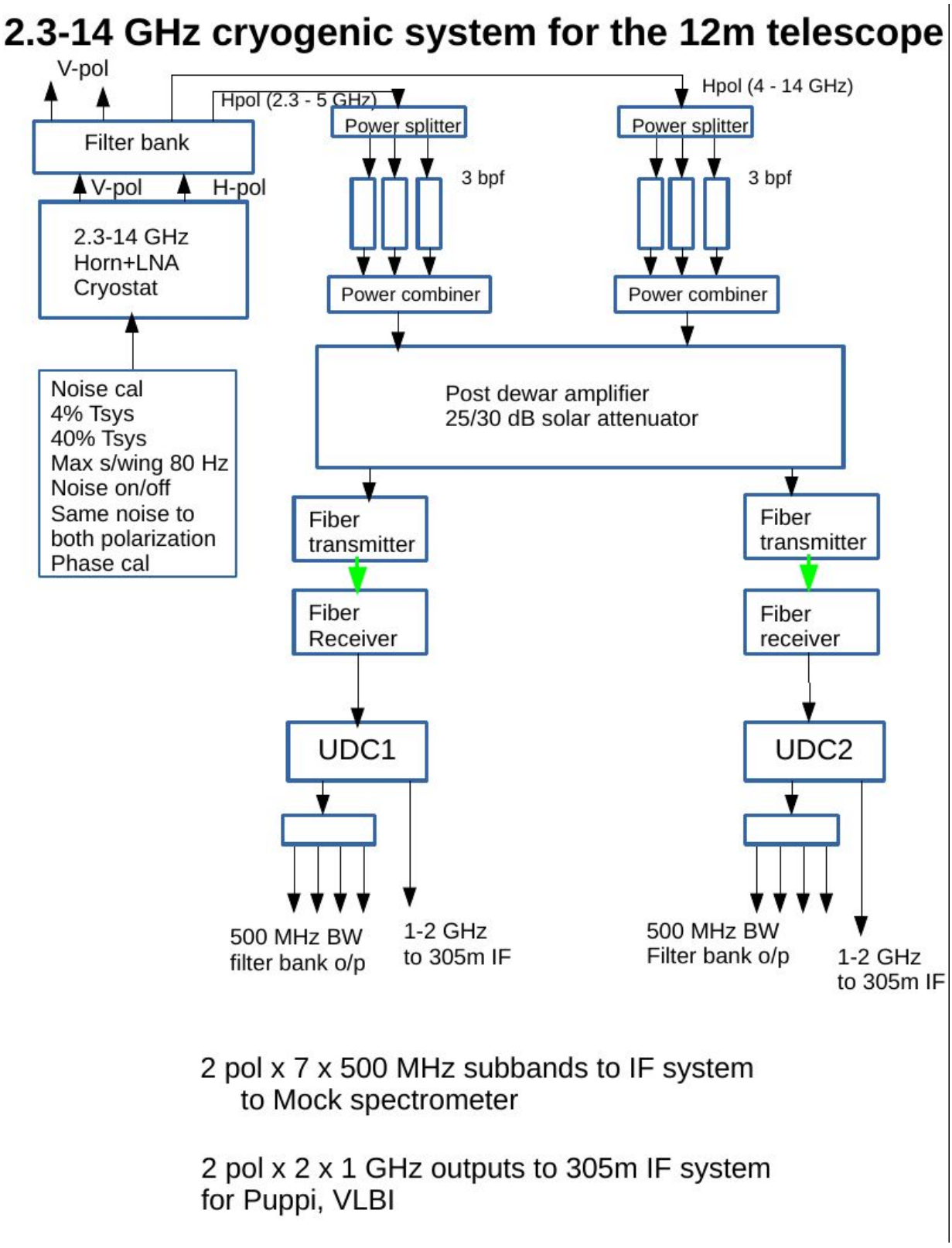

Figure 1: A block diagram of the Arecibo 12m receiver system. This system closely follows the VGOS front-end, fiber link and UDCs.

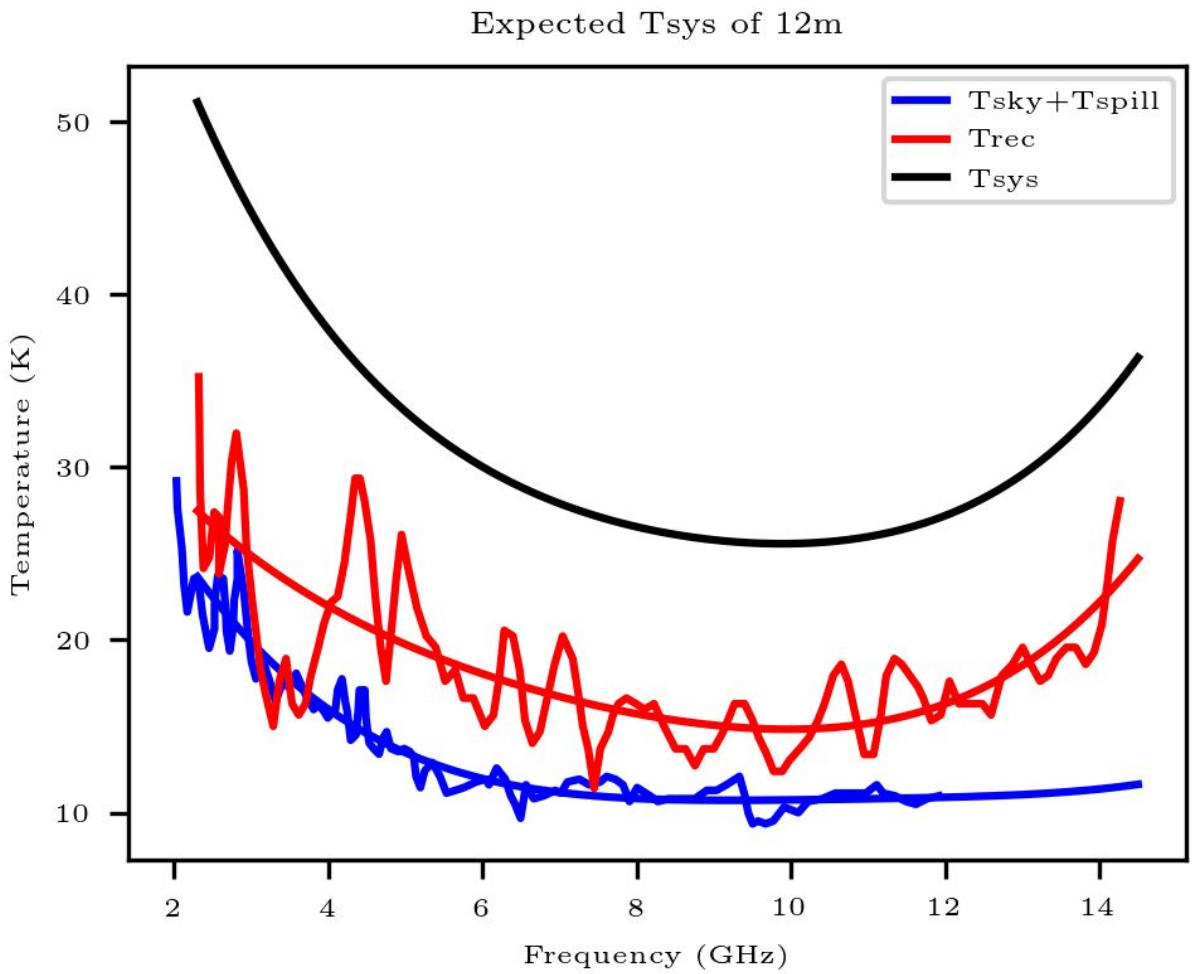

Figure 2: Expected system temperature (shown in black) of the 12m telescope equipped with the new cryogenic receiver system. The measured receiver temperature (shown in red) is provided by Ganesh, MIT and estimated sky+spillover temperature (shown in blue) is obtained from Akgiray et al. (2013).