Annex 1 – Technical information on the W band receiver and on the INAF SRT radio telescope

CARUSO is a multi-feed W band receiver, which will be installed in early 2022 at the Sardinia Radio Telescope located in San Basilio (CA). The receiver is composed of 16 individual dual polarization receivers, organized in a 4x4 grid, with a grid spacing of 43 arc-seconds (fig. 1).

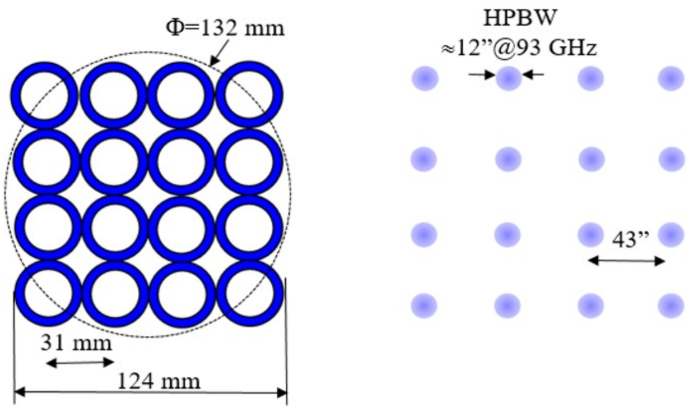

Fig. 1: Physical spacing of the receiver feeds and resulting beam spacing

HPBW of the individual receiver beams depend on the observing frequency, and is about 12 arc-seconds at the center of the frequency band. This results in an undersampling factor of about 4, which matches with the number of receivers per row. The receiver can be used for complete sampling of the sky using on-the-fly mapping with the array tilted by 14 degrees ($\tan^{-1}(1/4)$) with respect to the scan direction.

CARUSO frequency band is comprised between 75 and 116 GHz, including the CO J=1-0 transition at 115.3 GHz. Several other molecular transitions are observable in this frequency range (e.g HCO+, HCN, SiO, CH_3OH, CS, CH_3CN, CH_3CH_2CN, $(CH_3)_2CO$), providing a rich set of probes for studying the chemistry, dynamics, and physical properties of the interstellar medium. The receiver can observe simultaneously two sidebands (upper and lower sideband: USB & LSB) of 8 GHz each, separated by 8 GHz. The sideband separation is 10 dB, which requires specific observing techniques to avoid sideband contamination. Single sideband system noise temperature is expected to be less than 60K.

Each receiver has two linear polarizations, in the direction of the grid spacing. The receiver is derotated, to keep both the grid orientation and the linear polarizations fixed with respect to the sky. It is not in general possible to simultaneously observe the whole bandwidth for both polarization and all beams, due to limitations in the back-end electronics. Only 32 of the total 64 bands (2 sidebands, 2 polarizations, 16 beams) can be simultaneously processed. A list of the possible combinations is shown in table 1.

Table 1

Mode	Sidebands	Polarizations
Single polarization	USB+LSB	H or V
USB only	USB	16
LSB only	LSB	16

The back-end system includes both continuum and spectroscopic back-ends. The continuum back-end divides each 8 GHz band into 4 x 2GHz sub-bands, and perform polarimetric measurements (4 Stokes parameters) on each sub-band. In single polarization modes only total power is measured. A subset of the 2 GHz sub-bands (up to 40) are processed in two spectroscopic back-ends (BACK-Q, Abaco, and BACK-W, Skarab), according to the modes listed in table 2.

Table 2

Mode	Feeds	Polarizations	Band
Imaging	16	2	2 GHz
Restricted imaging	10	2	2x2GHz
Beam switching, single polarization	2	1	8 x 2 GHz USB+LSB
Beam switching polarimetric	2	2	4 x 2 GHz USB or LSB

The BACK-W spectropolarimeter is composed of 10 programmable boards. Each board can analyze up to 4 signals of 1.5 GHz each (thus less than the 2 GHz bandwidth) but may implement very high spectral resolution. The BACK-Q spectropolarimeter is composed of 8 boards which can analyze up to 8 (5 used) signals at the whole 2 GHz band. These boards can operate in different observing modes, listed in table 3. Modes will be further defined during the commission phase.

Table 3

Mode	Feeds	Polarizations (Stokes)	Band (GHz)	Resolution (kHz)	Integration time (s)	Data rate (MB/s)
Quasi continuum	16	4	2	2000	0.01	52
Low resolution	16	4	2	18	0.2	284
Spectral survey	2	2	16	2	0.2	284
High resolution	16	2	1.5	2	1	192
Very high resolution	16	2	1.5	0.4	5	192

Detailed technical information on the Sardinia Radio Telescope can be found in Chapter I of the report "Receivers for Radio Astronomy: current status and future developments at the Italian radio telescopes" (ISBN: 978-88-9898-504-3), available at the following link: http://pulsar.oa-cagliari.inaf.it/~pulsar/RX2017/review.html. A summary of the main characteristics is listed in table 3.

Table 3

	K-band			Q-band			W-band		
Frequency (GHz)	**18**	**22**	**26**	**34**	**42**	**50**	**80**	**98**	**116**
System temperature (kelvin)	85,6	109,3	94,1	100,7	115,9	194,2	175,8	173,8	255,9
(Partial) Aperture efficiency (%)	75,9%	76,3%	76,5%	76,8%	77,3%	76,9%	76,0%	76,5%	76,7%
RMS efficiency (%)	98,7%	98,1%	97,4%	95,5%	93,3%	90,6%	77,7%	68,4%	58,8%
Blockage efficiency from struts (%)	97,6%	97,6%	97,6%	97,6%	97,6%	97,6%	97,6%	97,6%	97,6%
(Total) Aperture efficiency (%)	73,1%	73,1%	72,7%	71,6%	70,3%	68,0%	57,6%	51,1%	44,0%
Antenna gain from (total) aperture efficiency (kelvin/Jy)	0,85	0,85	0,85	0,83	0,82	0,79	0,67	0,60	0,51
Insertion loss of quasi-optics and feed system	0,72	0,72	0,72	0,72	0,72	0,72	0,69	0,69	0,69
Gain correction for opacity (at zenith)	0,93	0,90	0,93	0,94	0,94	0,82	0,82	0,82	0,57
Antenna gain including insertion loss and opacity (kelvin/Jy)	0,58	0,56	0,57	0,57	0,56	0,47	0,38	0,34	0,20
SEFD (Jy)	**148,7**	**195,7**	**164,4**	**176,8**	**207,2**	**412,9**	**461,8**	**514,7**	**1262,3**
Sensitivity (mJy)	**2,4**	**3,1**	**2,6**	**2,8**	**3,3**	**6,5**	**7,3**	**8,1**	**20,0**

To achieve good surface efficiency, SRT primary mirror surface is actively controlled. Current surface accuracy is 290 µm RMS. An active metrology system will be installed as part of the PON project, with an expected goal of better than 150 µm RMS.