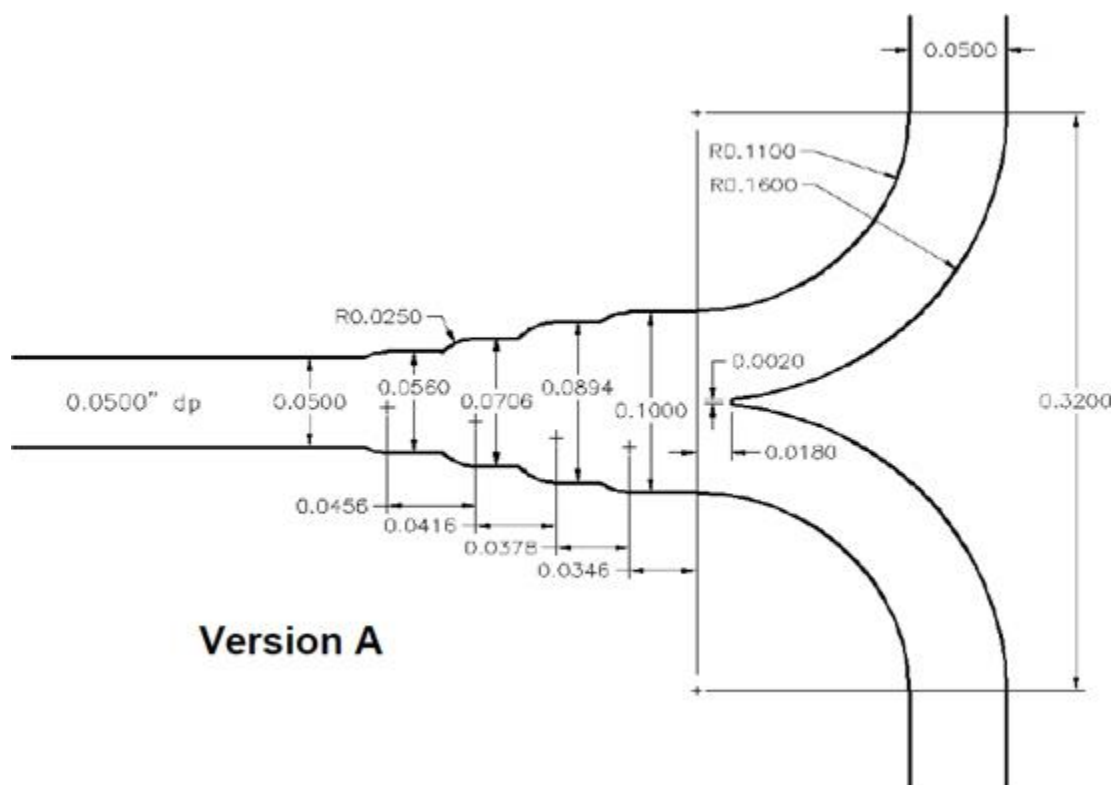


## E-Plane Y-junction

This paper is dedicated to E-plane Y-junction, which can be used as power divider or combiner in more complex circuits, when 4-port 180° hybrid is not required. Y-junction plays an important role in microwave circuit as it uniformly divides or collects power at the port.

The structure is in a form of a 3-section transformer from rectangular-to-square waveguide with two E-plane bends (2.54 x 1.27 mm) added to the large end of the transformer. The abrupt steps were rounded according to the waveguide height (WR-10) and the cusp at the junction of the curved waveguide arms is truncated at a width of 0.0508 mm.

Within this paper, we consider an E-plane Y-junction, which has been proposed in ALMA Memo 381 from 2001 [1]. It was designed for ALMA receiver as one of a building blocks. It has been designed and analysed with QuickWave FDTD software [2] and its dimensions are presented in the figure below.



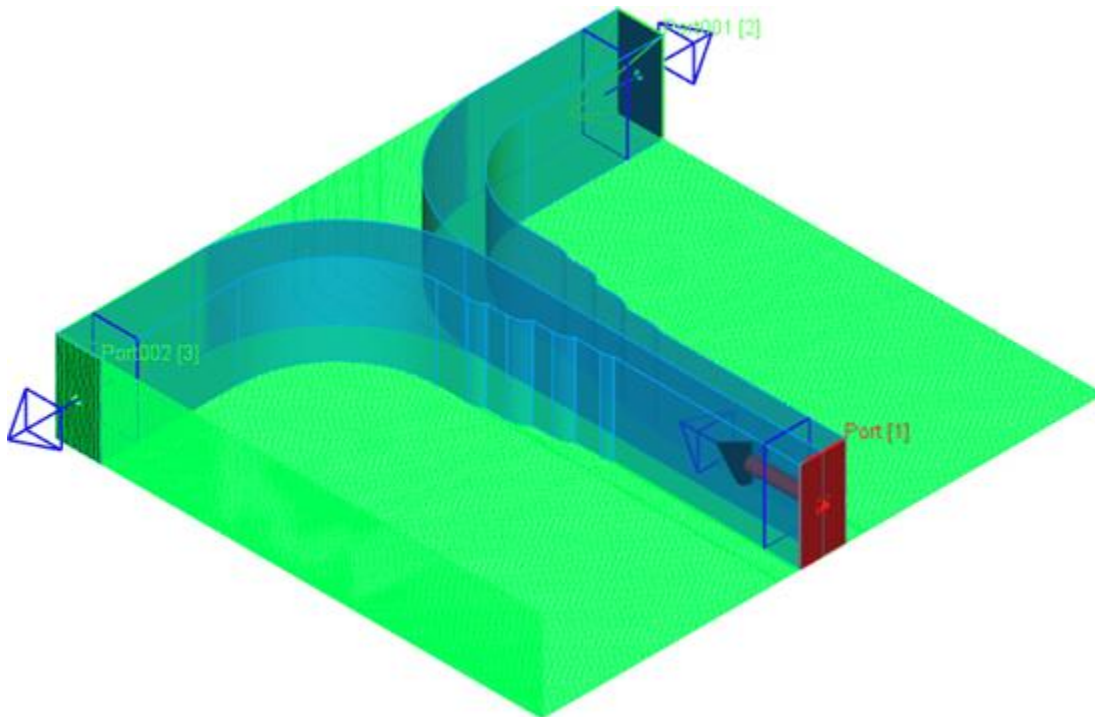
**Fig. 1** Scheme of E-plane Y-junction proposed in [1]. The junction is based on WR-10. All dimensions are given in inches.

## Simulation scenario

Simulation model consists of three input/output arms based on WR-10 waveguides (1.27 x 2.54 mm). The dimensions of the waveguide, bends and transition steps have been set according to their definition in [1]. The structure is excited in a frequency band of 75-110 GHz.

In order to simulate the model properly, a variable mesh size, adjusted to geometry is utilized. A maximum cell size, in all three directions, is 0.055 mm. The considered example is of a non-radiating type of structure, the background medium is therefore set to metal and only fields inside the structure are of interest.

The simulation scenario occupies circa 3.73 million of FDTD cells, which results in 356 MB of RAM memory usage. The FDTD simulation with QuickWave 3D takes 4 minutes when performing multicore computations on AMD Ryzen Threadripper 2950X 16-Core processor and 1 minute when launching calculations on graphic card nVidia GeForce RTX 2080 Ti.



**Fig. 2** Model of WR-10 E-plane Y-junction designed in QW-Modeller [3] based on scheme from Fig. 1.

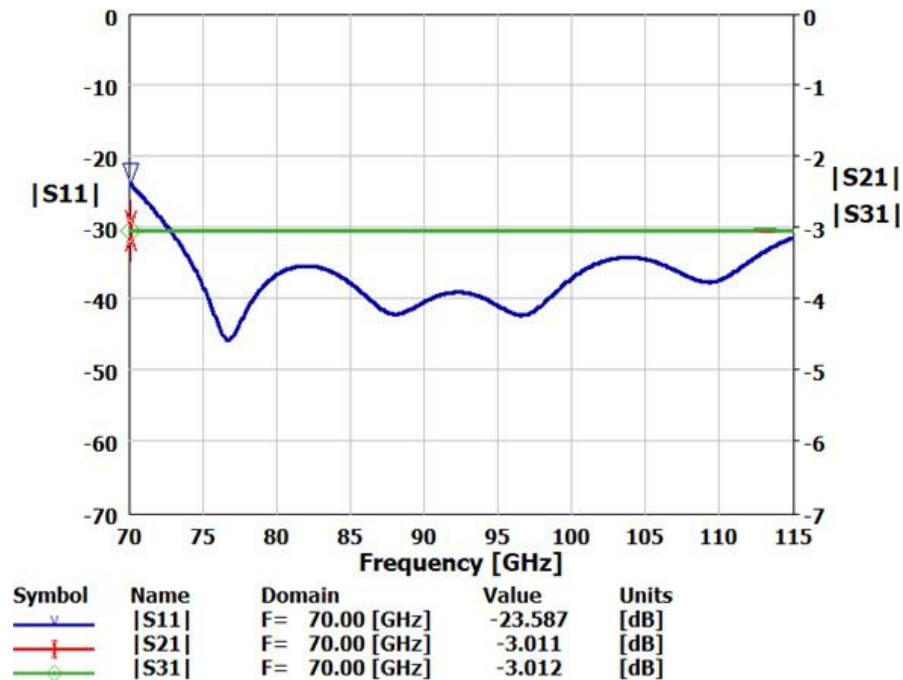
## EM simulation result

The  $S_{k1}$  postprocessing is used to extract complex reflection coefficient in the frequency band from 70 to 115 GHz.

The ports for S-parameters extraction are numbered as follows:

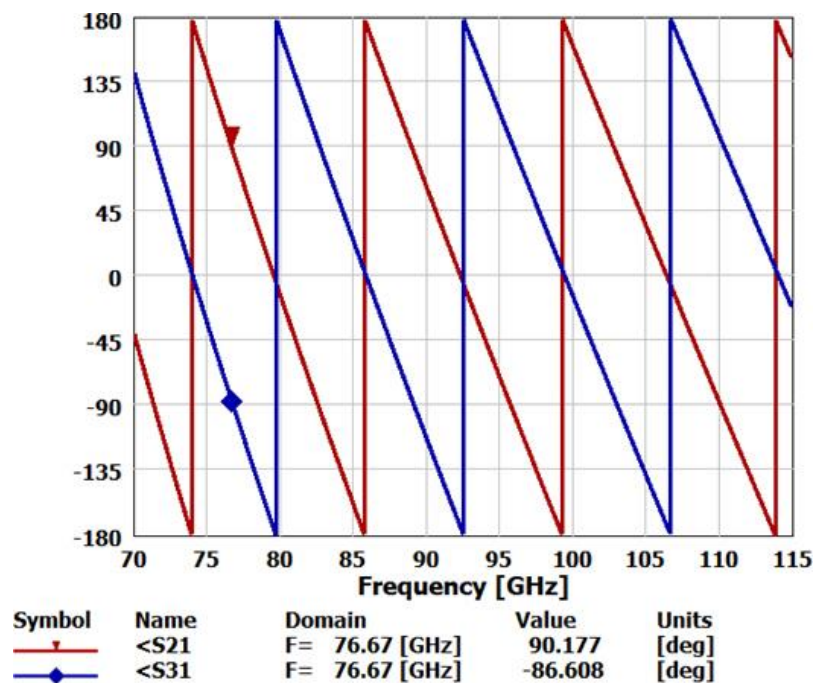
Port 1 – input port

Port 2, Port 3 – output (transmitted) ports



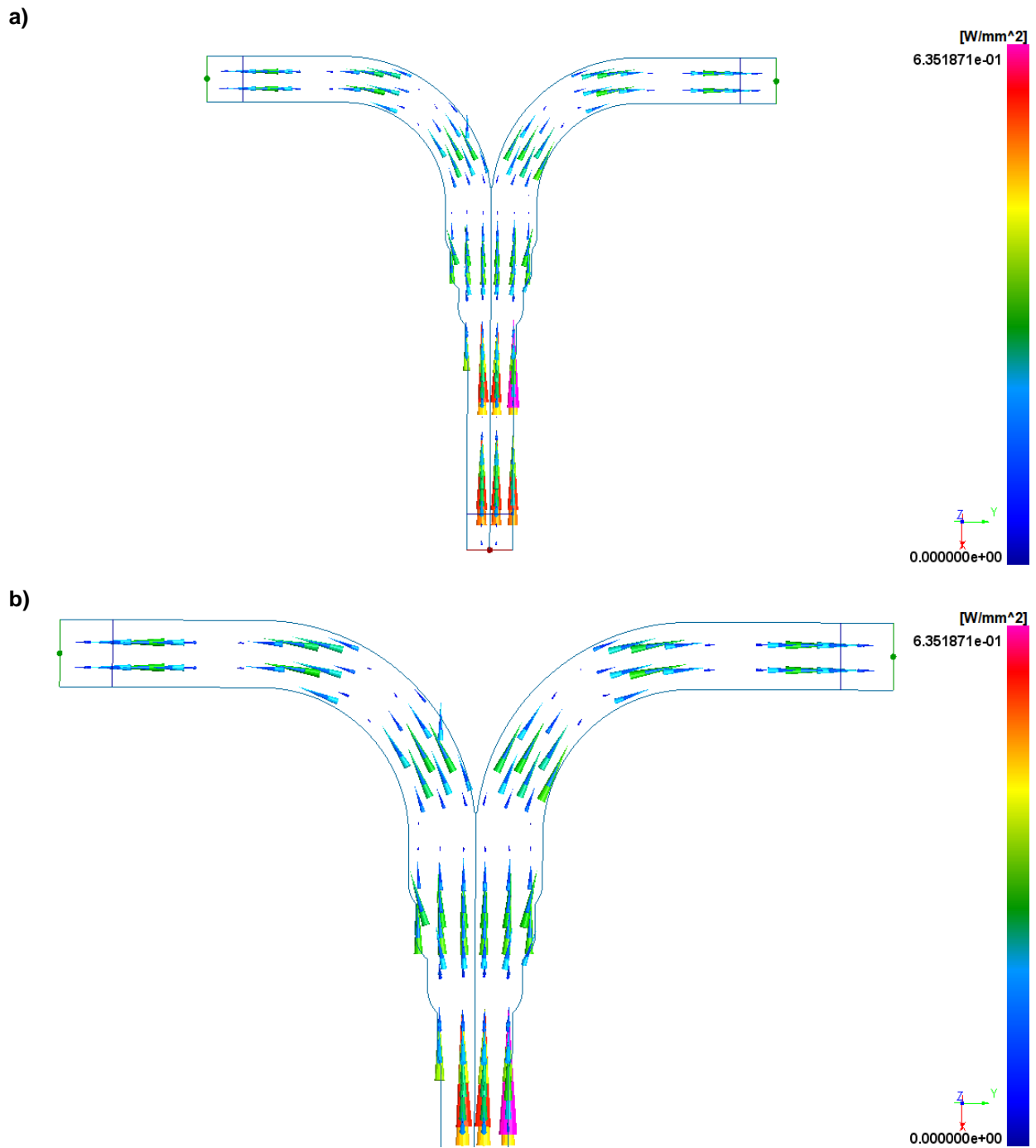
**Fig. 3** Magnitude of reflection ( $|S_{11}|$ ) and transmission ( $|S_{21}|$ ,  $|S_{31}|$ ) coefficients of E-plane Y-junction computed with QuickWave 3D.

From Fig. 3 it can be noticed that transmission to output ports ( $|S_{21}|$ ,  $|S_{31}|$ ) is on the same level in the whole frequency band 70-115 GHz and it is equivalently divided by 2. Simulation indicates that reflection coefficient  $|S_{11}|$  is below -30 dB in considered structure.



**Fig. 4** Phase coefficients.

From the Fig. 4 it can be seen that signal is  $180^\circ$  out of phase between port [2] and port [3].



**Fig. 5** Distribution of momentary Poynting vector at 76.60 GHz: a) full structure, b) zoom on ports 2 and 3.

## Measurement results

The comparison between our simulated results and measured values of magnitude of reflection coefficient is shown in Fig. 6. The measurements were performed by Dr. Anthony R. Kerr and results are given in [1]. A very good agreement is observed between both sets of compared data, proving capabilities of QuickWave software to handle analysis of components designated to space technology.

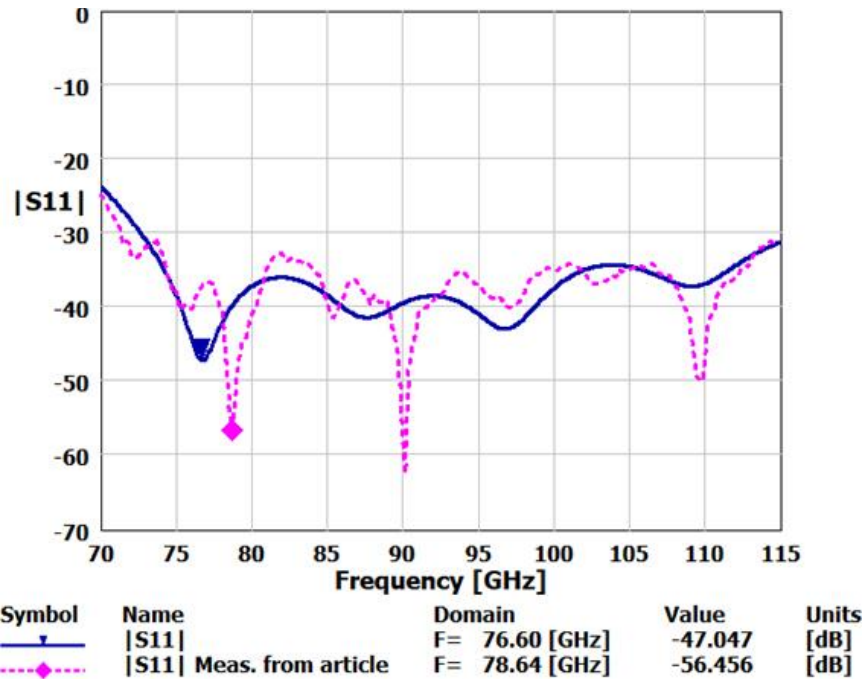


Fig. 6 Magnitude of reflection coefficient of E-plane Y-junction – simulated data and measurements from [1].

## References

- [1] A. R. Kerr, *Elements for E-Plane Split-Block Waveguide Circuits*, ALMA Memo 381
- [2] QuickWave software, <http://www.qwed.eu>
- [3] QW-Modeller for QuickWave software, [http://www.qwed.eu/qw\\_modeller.html](http://www.qwed.eu/qw_modeller.html)