Mesh Filters

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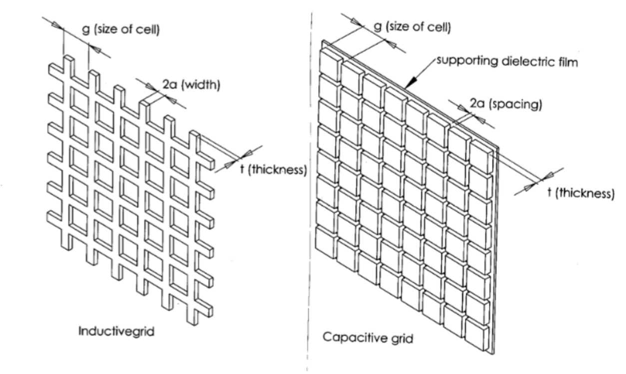
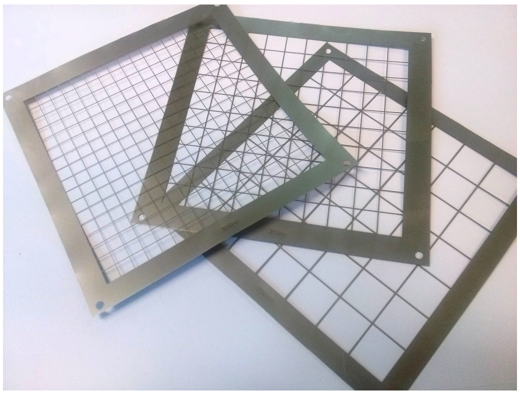
Precise measurements of beam profile with Smith-Purcell radiation require precise measurements of spectrum. To filter background signal from Smith-Purcell radiation we will use inductive mesh filters. Detector unit at each angle will have its own filter, which correspond to emitted wavelength of Smith-Purcell radiation.

1 Mesh filters

Metal-mesh filters are filters made from metal meshes (see fig. 1a). They working diapason is from far infrared to submilimeter regions of the electro-magnetic spectrum. We use inductive mesh filters. That's mean that they are band-pass filters. Transmissivity function is presented on figure 2. Using Ulrich's [1] theory we calculate mesh parameters (period, thickness of wire(strip); see fig. 1a) for certain frequencies. Example of manufactured filters present on figure 1b.

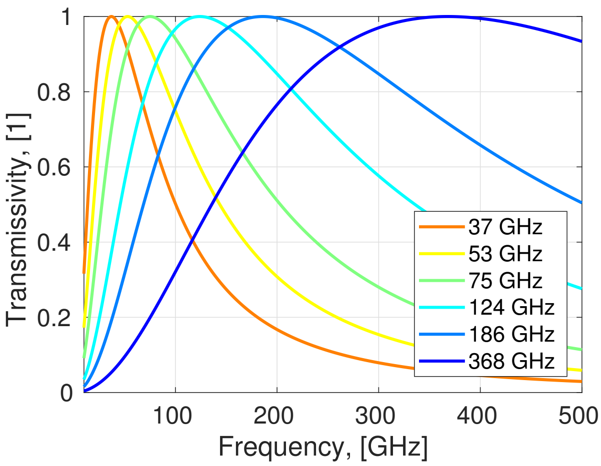


(a) Inductive and capacitive mesh filters (image source: wikipedia)

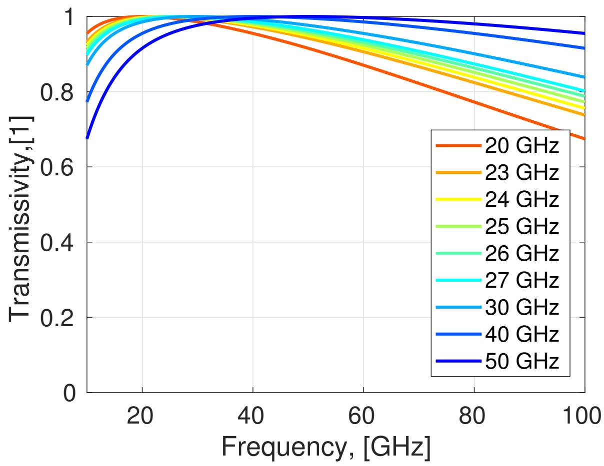


(b) Manufactured THz filters of 20, 30 and 50 GHz

Figure 1: Mesh filters



(a) First set of filters with 5x5 cm size



(b) Second set of filters with 10x10 cm size

Figure 2: Transmissivity functions of inductive mesh filters

2 Experimental check of filter properties

To test filters we use setup, as present on figure 3. We test filters with two GHz sources: GDO-2510F on 24GHz and SOL-3510-28-G1 on 35 GHz. Setup consist of source (S), chopper with frequency 25 Hz (result dont depend from chopper speed), filter frame (F) with or without filter, and detector (D) with connected Horn anthena (A). To acquire the signal we use RTM

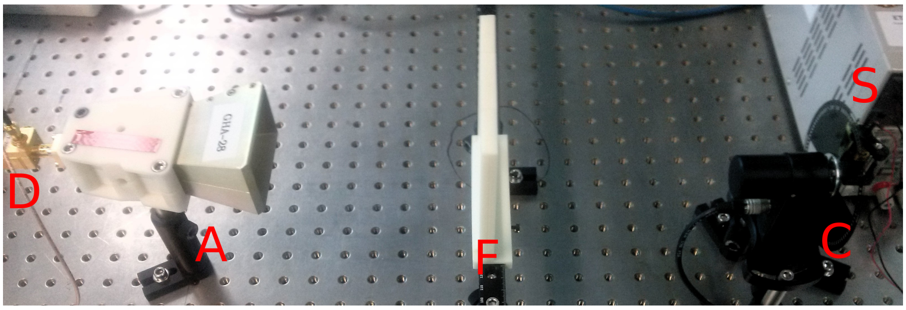


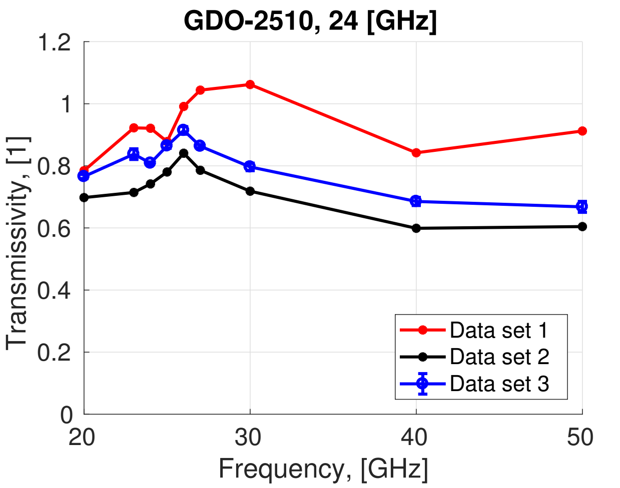
Figure 3: Experimental setup: S - GHz source, C - chopper (25 Hz), F - frame for filter, A - Gain Horm Anthena (GHA-28), D - detector (DET-28S)

2054 Oscilloscope. We measure peak-to-peak voltage (Vpp) on detector.

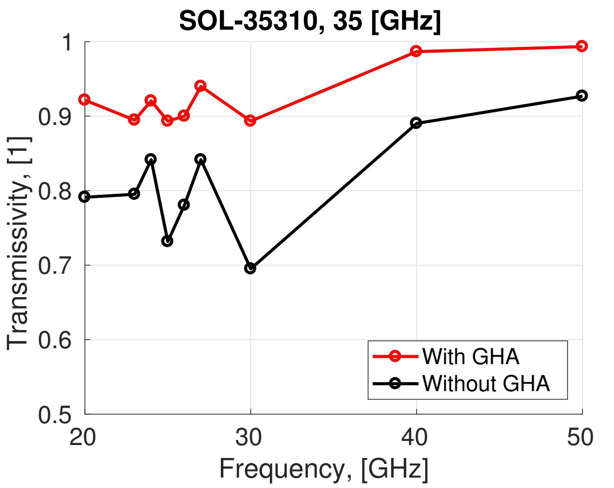
Order of measurements was following: measure Vpp without filter; install filter and measure Vpp with filter. Ratio with and without of Vpp gives Trasmissivity for current filter.

Due to big wavelength position of parts of experimental setup play big role. For example some inroduce of some part could change diffraction pattern and signal on detector could increase or decrease. This will be discussed later.

We make few sets of measurement in different configuration of experimental setup (see fig 4a). Result of measurements strongly depend from position on line of experimental tools (detector, filter etc). We make three sets of measurements (Data set 3) for 24 GHz source (see fig. 4a) and conclude, that they are quite reproducible for current setup. Also we make measurements with and without horn anthena for 35 GHz source (see fig. 4b). Change of results was caused by diffraction in plane of detectors anthena and necessity of usage near-field approach.



(a) Transmissivity of filters for 24 GHz source

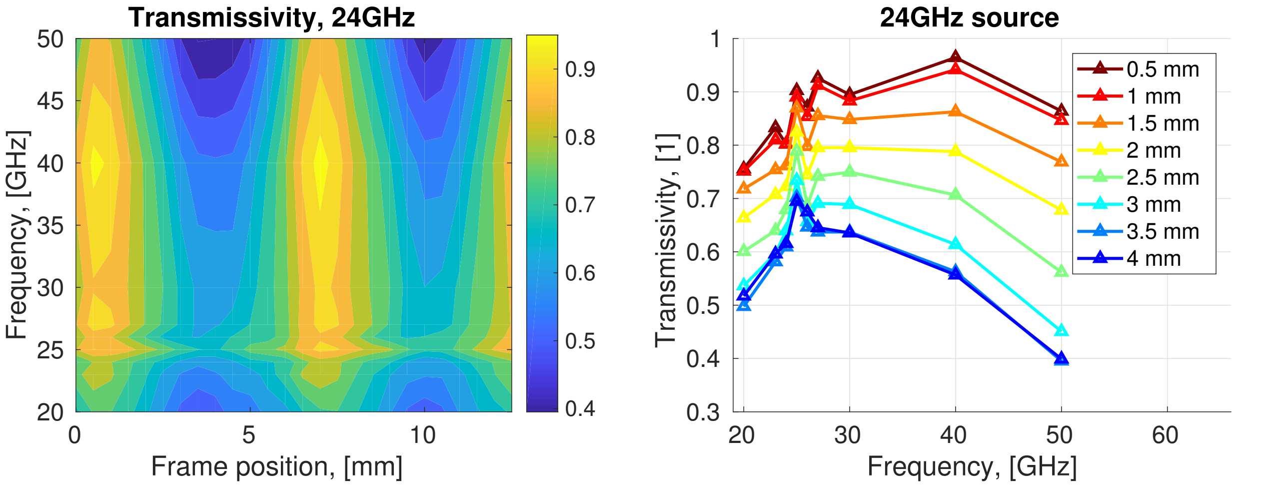


(b) Transmissivity of filters for 35 GHz source

Figure 4: Experimental results

To understand effect of diffraction, we change filter frame position wiht step 0.5 and measure transmissivity for filters. Results are presented on figure 5a. We clearly see that pattern with me measure repeat with step equal of half source wavelength. We find from this data that corresponding source frequency equal 2.34 ± 0.24 GHz with given in documentation of source

24 GHz. On figure 5b present transmissivity of filters form maximum to minimum. Why transmissivity is changing is not clear yet.



(a) (b)

Figure 5: Experimental results: Trasmissivity as function of filter position

To be able avoid diffraction effects we construct other setup, where we place components as close, as possible to each other. Also we install 1 inch tube in between chopper and filter.

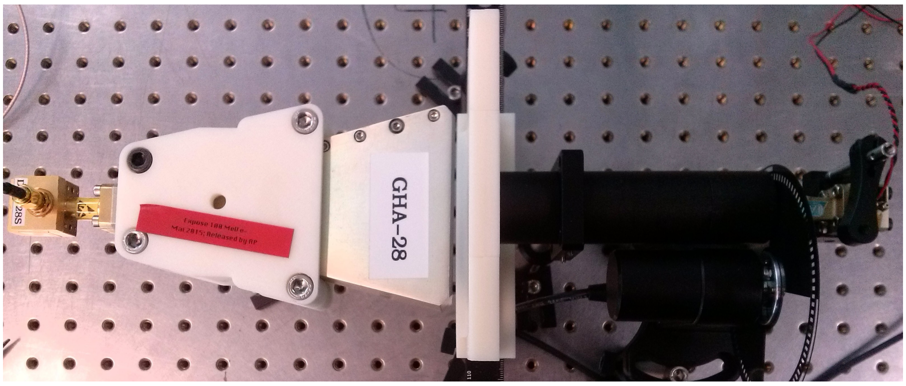
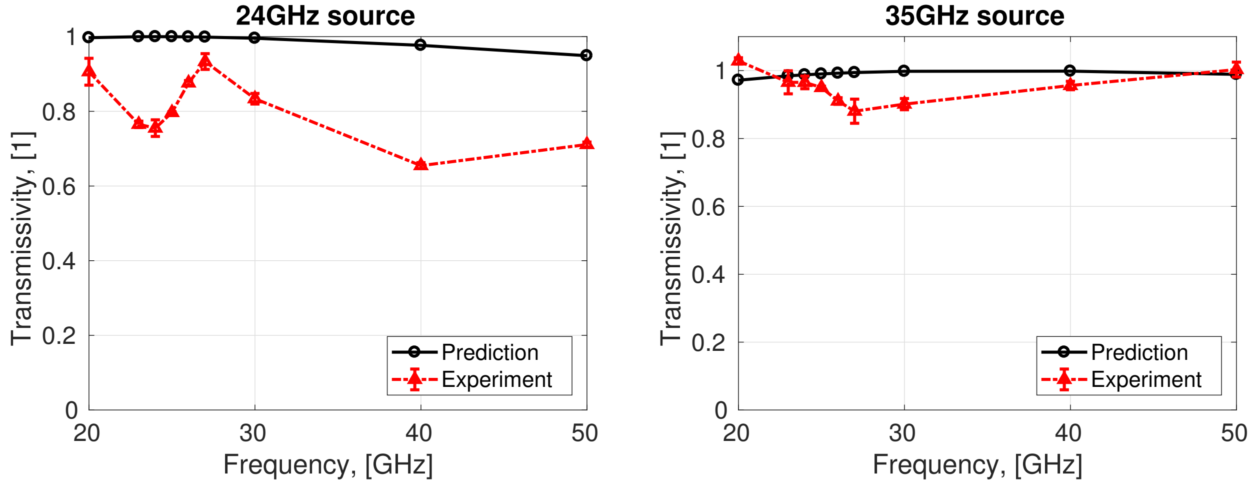


Figure 6: Experimental setup #2

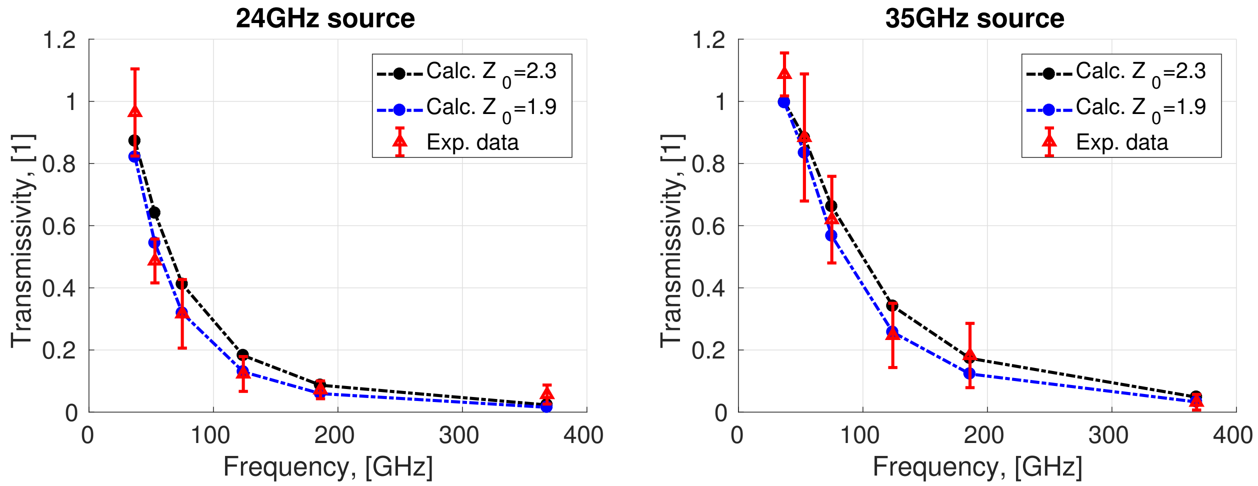
Due to unknown spectral characteristics of detector and both sources, we could not compare experimental results with our calculation, but can assume gaussian spectrum of the source and flat frequency sensitivity of detector. With new setup we repeat measurement for both sets of filters and and both sources we have. Results are present on figures 7 and fig. 8. We still don't have good agreement with 20-50 GHz filters (see fig. 7), which was caused due to near-field effects, we suspect.

But we have good agreement of calculation and experiment for other set of filters (see fig. 8). With small correction of filter impedance, agreement even better for both sources.



(a) (b)

Figure 7: Experimental results: big filters



(a) (b)

Figure 8: Experimental results: small filters

Conclusion

Experimental check of filter properties gives good agreement between calculation and data for small filters.So this code could be used for calculation filters for Smith-Purcell experiment at CLIO.

References

[1] R. Ulrich, *Far-infrared properties of metallic mesh and its complement- ary structure*, Infrared Physics, Vol. 7, pp. 37-55, Pergamon Press Ltd. 1967, Printed in Great Britain.