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Final tests the whole FEL resonator system

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1. The whole FEL resonator system has been assembled and measured as shown in Fig.1. All previous tests were obtained using excitation from the side of rotating grids.

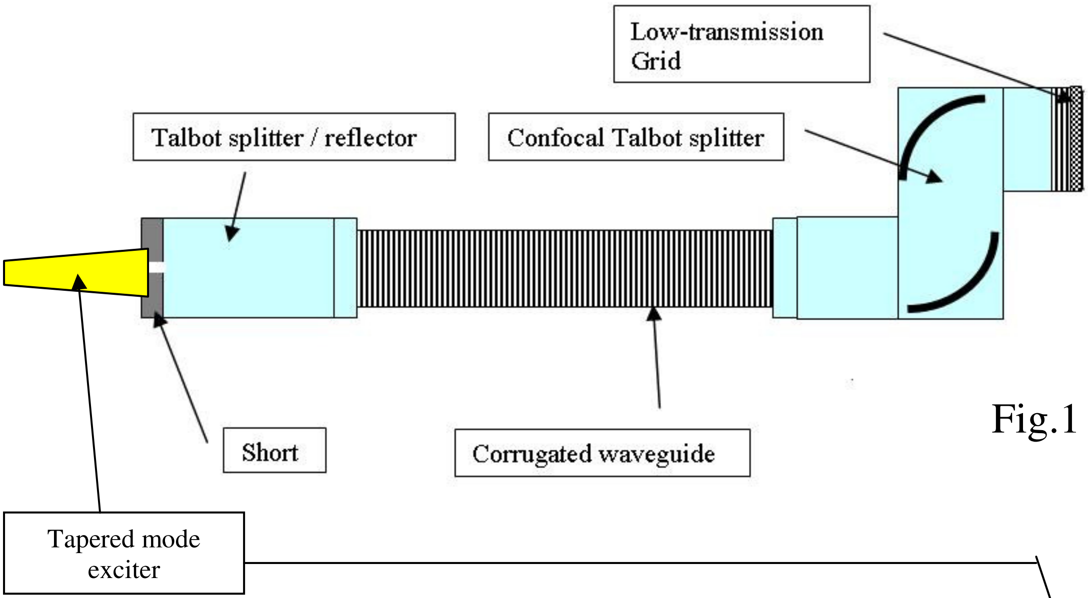


Fig.1

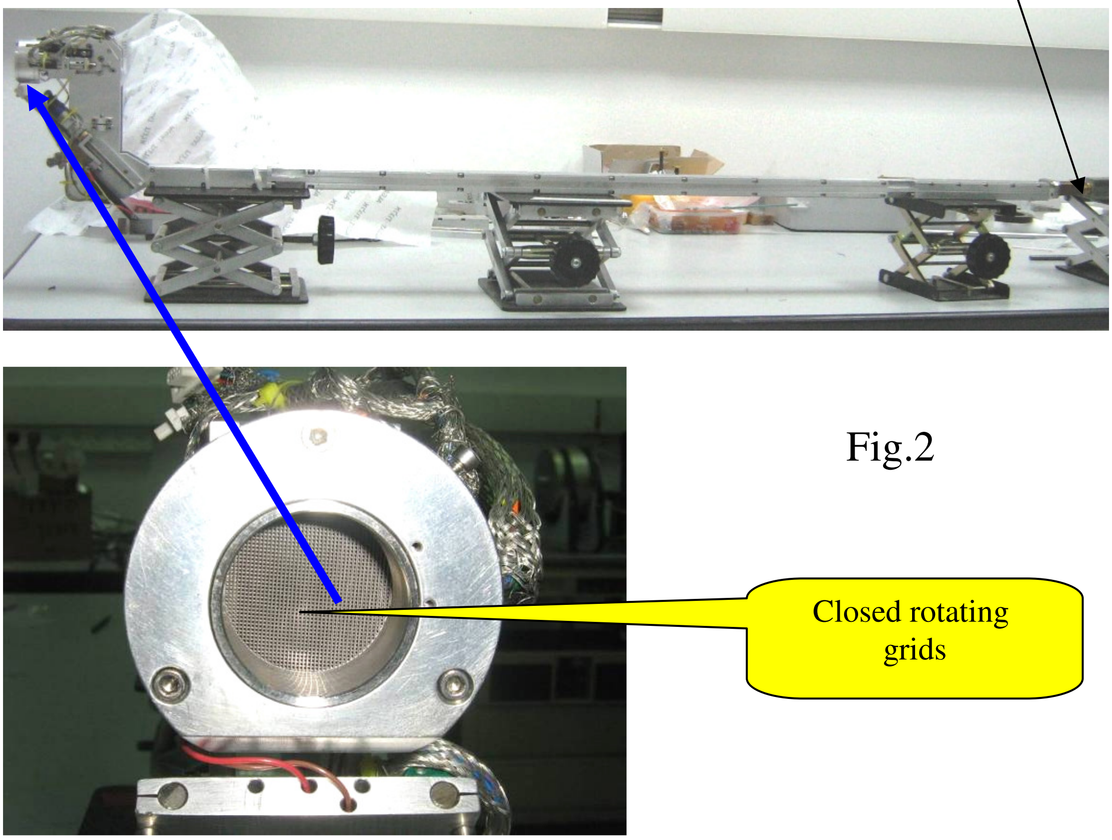


Fig.2

Since angular and spatial positions of mode exciter can not be accurately stabilized we decided to excite the resonator from opposite port where shorted mirror is installed using tapered mode exciter. Such a configuration of the setup allows reaching a good repeatability in comparison with excitation from the side of rotating grids. Theoretically, electric field strength in this aperture is zero, but due to imperfections of Talbot splitter the tangential E-field is non-zero creating a week coupling with transmission line. However it is quite enough in order to excite the tested system as shown in Fig.2 and to estimate the roundtrip losses. Rotating grids were installed in the position "CLOSED" in order to avoid additional losses RF energy penetrating via grids.

2. The measured return loss in dB is depicted in Fig.3 corresponding to the source EXEL file **<REFERENCE_Whole_System_01_07_2009.xsl>**

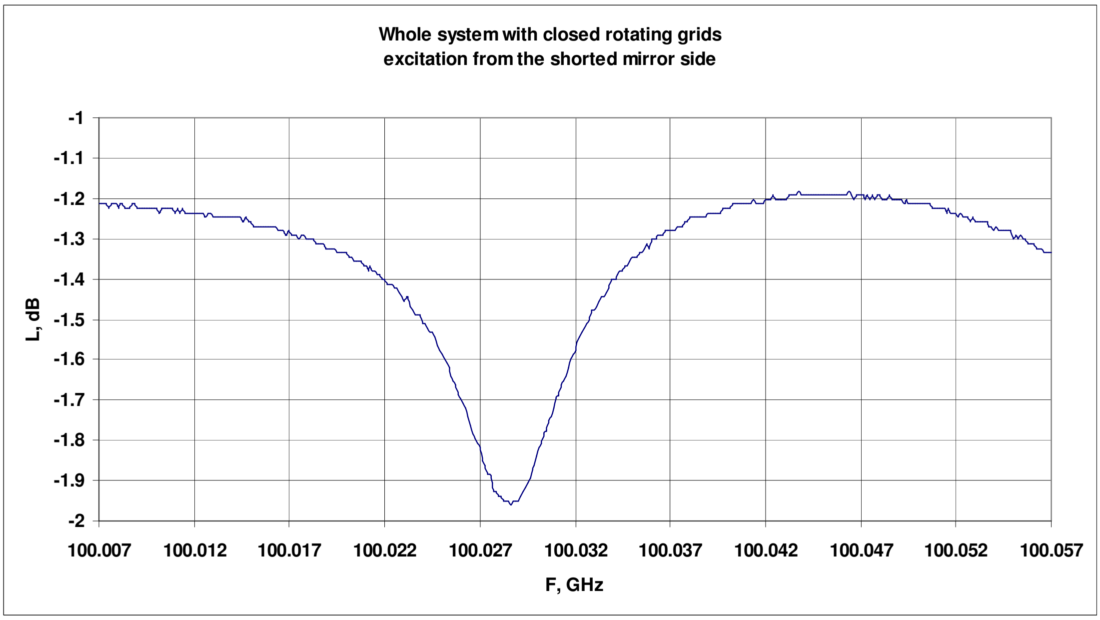


Fig.3

Based on these measurements we have calculated the following basic parameters of the whole system:

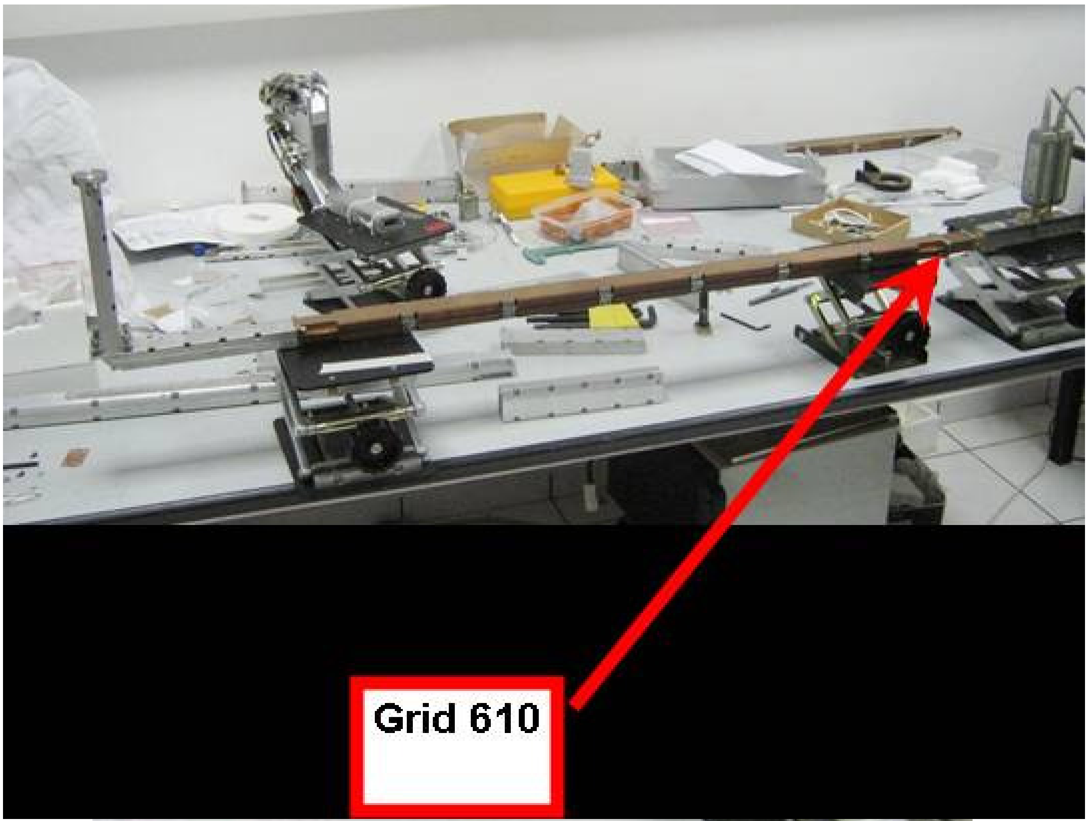
- Reference background = Rback = -1.2 dB;
- Returned loss on the resonance frequency = Rres = -1.95 dB;
- Absolute power transmittance at the resonance

$$T := 1 - 10^{\frac{-1.95+1.2}{10}} = 0.159$$

That corresponds to half-power transmittance T(0.5) = 0.08.

- Frequency f1 and f2 corresponding to this level are f1=100.02475GHz and f2= 100.032125GHz resulting in Δf = 7.375MHz;
- Loaded Q factor is Q_{load} = f0/ Δf = 13560;
- Since an excitation from the resonator's port having shorted mirror corresponds to very week coupling we assume that $Q_{load} = Q_{un}$ resulting in the attenuation coefficient alfa = $\beta_0/2Q_{un}$ = 0.077 [1/m] and roundtrip loss = 100% [1-exp(-4*alfa*L)] = 37% at the active resonating length L= 1.5m.

3. Following recommendations of the Group meeting (29_06_2009) we have re-assembled and tested the resonator's system with coupling grid "inside" using old Talbot's splitter consisting on the two strait (non-confocal) sections as shown in Fig.4. The measured RL(dB) is depicted in Fig.5 and Fig.6. The source exel file is ***06_07_2009_old_setup_grid_inside.xls***



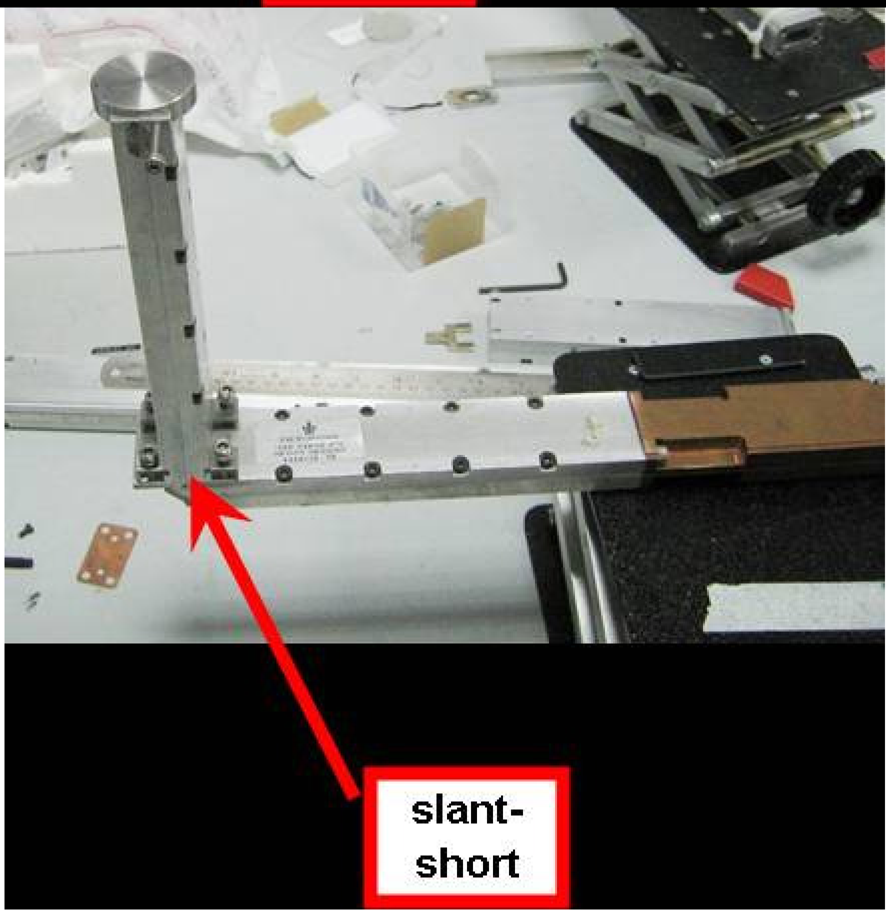


Fig.4

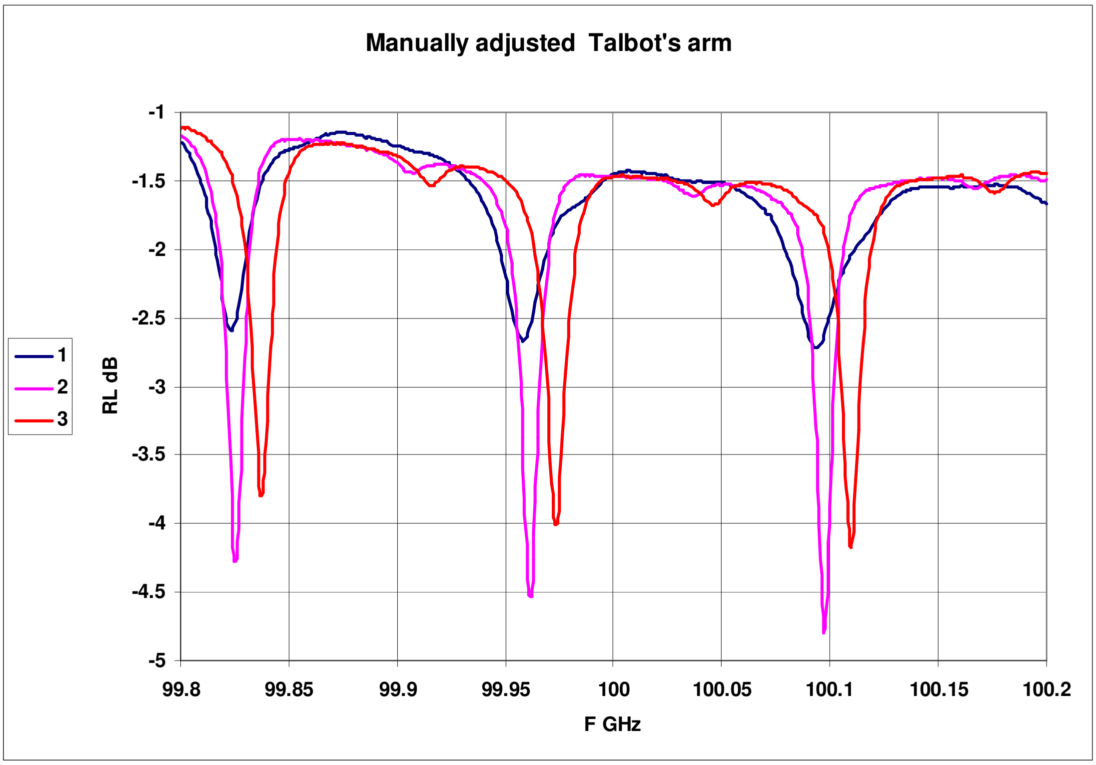


Fig.5

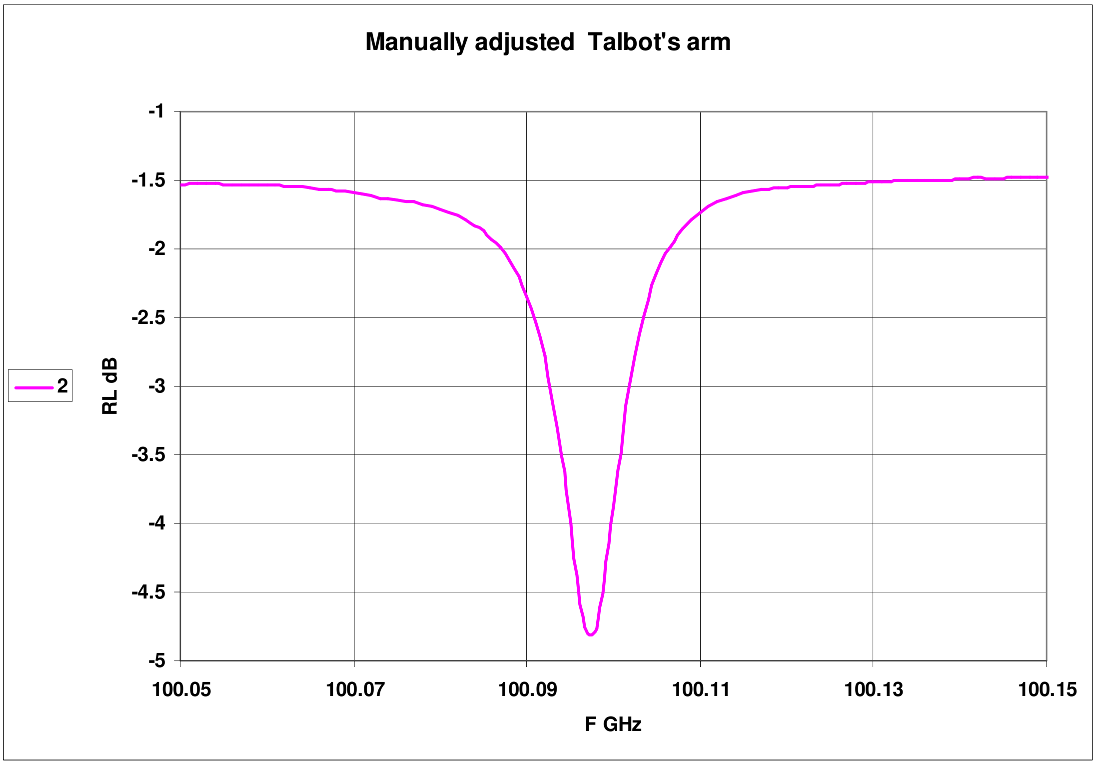


Fig.6

Based on the data of Fig.6 we have calculated the following basic parameters of the whole system:

- Reference background = Rback = -1.5 dB;
- Returned loss on the resonance frequency = Rres = -4.8dB;
- Absolute power transmittance at the resonance

$$T=1-10^{(-4.8+1.5)/10} = 0.532$$

That corresponds to half-power transmittance T(0.5) = 0.266

- Frequency f1 and f2 corresponding to this level are f1=100.092 GHz and f2= 100.102 GHz resulting in Δf = 10 MHz;
- Loaded Q factor is $Q_{load} = f0/ \Delta f = 10000$;

Assuming very week coupling so that $Q_{load} = Q_{un}$ resulting in the attenuation coefficient alfa = $\beta_0/2Q_{un}$ = 0.105 [1/m] and roundtrip loss = 100% [1-exp(-4*alfa*L)] = 41% at the active resonating length L= 1.3m.

4. We have also assembled the setup with the coupling grid installed "outside" as shown in Fig.7.

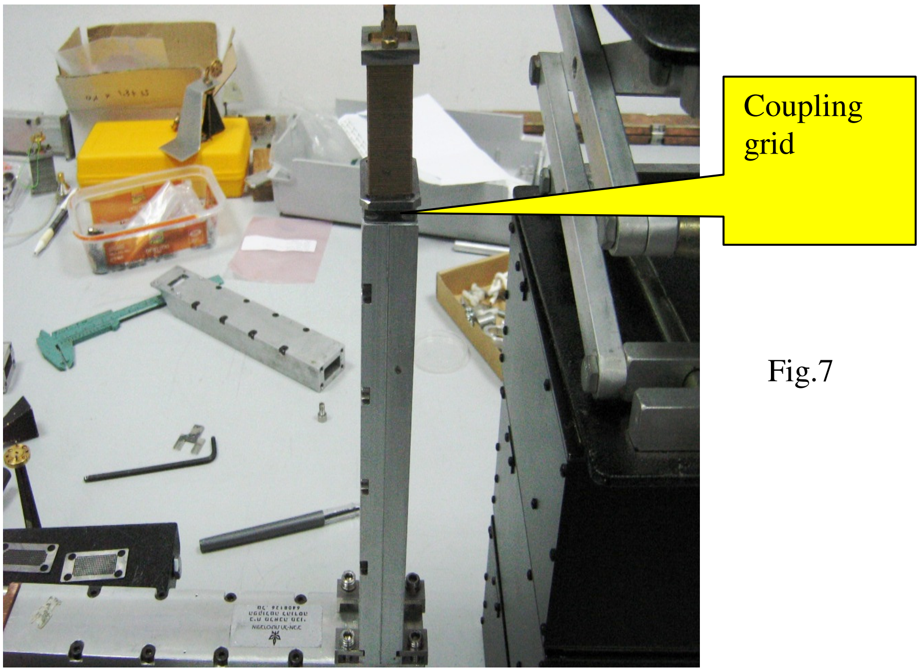


Fig.7

The measured RL(dB) is shown in Fig 8 and 9. The source Exel file is ***06_07_2009_old_setup_grid_outside.xls***

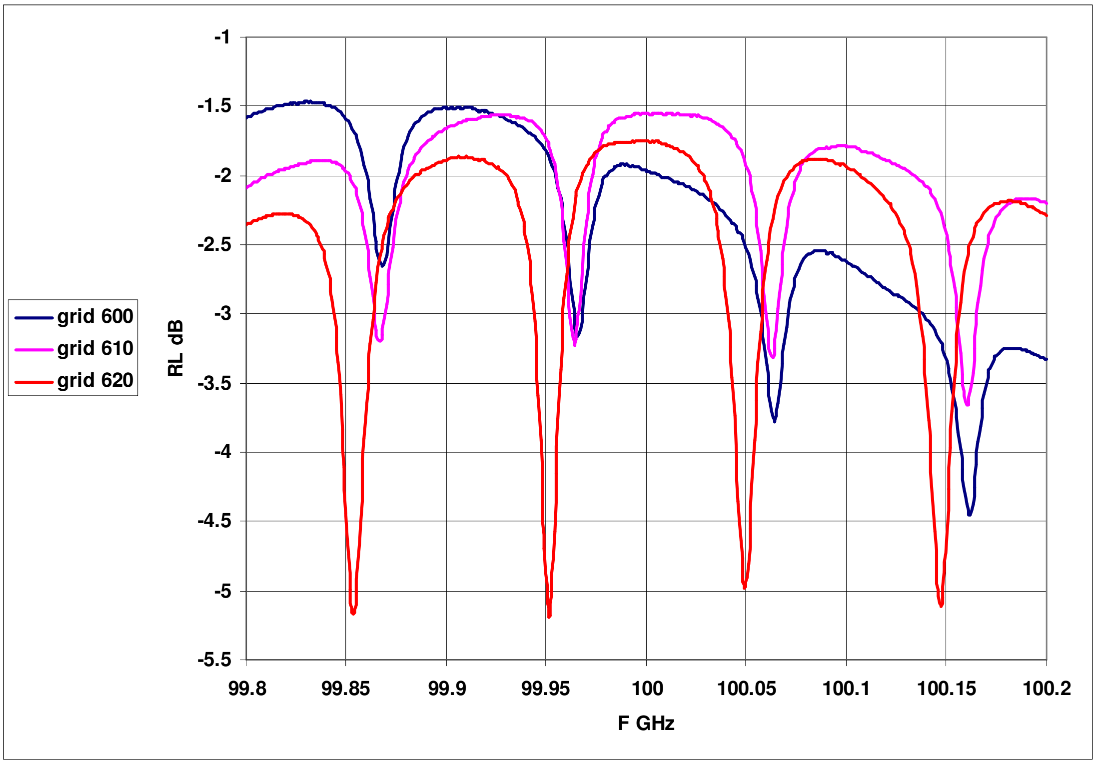


Fig.8

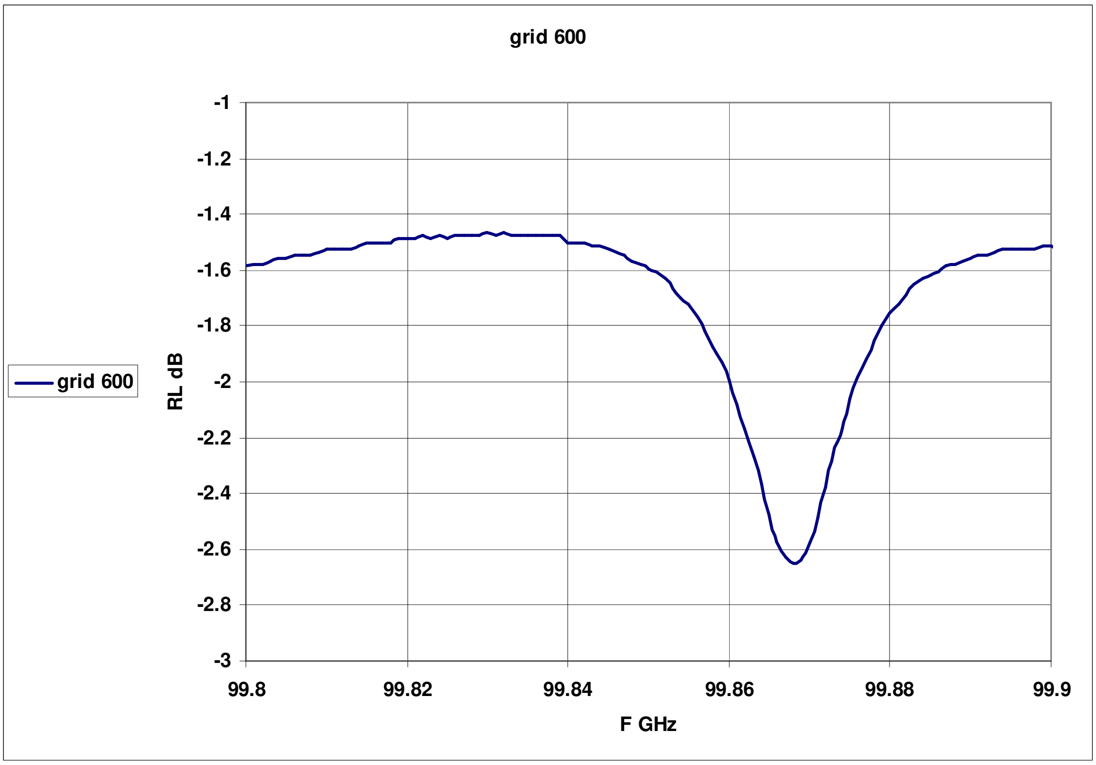


Fig.9

Based on the data of Fig.9 we have calculated the following basic parameters of the whole system:

- Reference background = Rback = -1.48 dB;
- Returned loss on the resonance frequency = Rres = -2.65dB;
- Absolute power transmittance at the resonance

$$T=1-10^{(-2.65+1.48)/10} = 0.236$$

That corresponds to half-power transmittance T(0.5) = 0.118

- Frequency f1 and f2 corresponding to this level are f1=99.86 GHz and f2= 99.875GHz resulting in Δf = 15 MHz;
- Loaded Q factor is Q_{load} = f0/ Δf = 6600;

Assuming very week coupling so that $Q_{load} = Q_{un}$ resulting in the attenuation coefficient alfa = $\beta_0/2Q_{un}$ = 0.157 [1/m] and roundtrip loss = 100% [1-exp(-4*alfa*L)] = 61% at the active resonating length L= 1.5m.

Conclusion:

1. The value of roundtrip measured for whole confocal setup is 37% that is closed to the reported earlier. Since the tests were done with closed rotating grids and excitation from opposite port, this value can be considered as the Physical Limit. However, inaccuracies caused by non-symmetry of the resonance curve and low frequency resolution of W-band network analyzer may lead to variation of this parameter within +- 3-5% depending on the experimental conditions.
2. The value of roundtrip measured for the setup with CPP resonator and coupling grid "inside" is 41% for active length of resonator = 1.3m.
3. The value of roundtrip measured for the setup with CPP resonator and coupling grid "outside" is 61% for active length of resonator = 1.5m.