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HOM-Damper Development for the S-Band Linear Collider

Content

1) Theoretical work

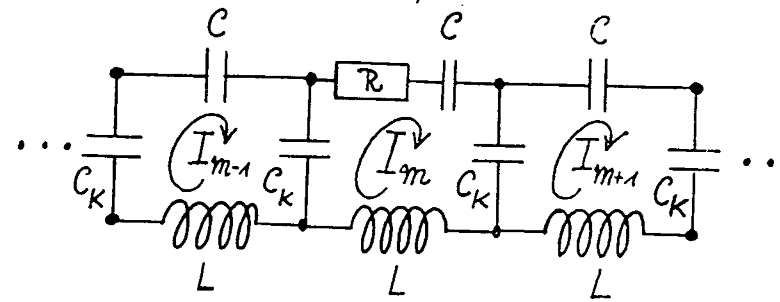
The effect of a single damper cell within a channel of undamped cells, calculated analytically using a simple equivalent circuit model

2) Measurements on a damped 12 cell constant impedance structure

The 12 cell structure is loaded by a single damper cell with wall slots. The damping effect of three different slot width was measured.

3) Conclusions

Circuit equations



N capacitively coupled circuits terminated by full end cells

$$(\Omega - \frac{K}{2}) I_1 - \frac{K}{2} I_2 = 0 \quad \text{(left end cell)}$$

. . . .

$$(\Omega - K - i \frac{\omega}{\omega_0} \frac{1}{Q}) I_m - \frac{K}{2}(I_{m-1} + I_{m+1}) = 0$$

. . . .

$$(\Omega - \frac{K}{2}) I_N - \frac{K}{2} I_{N-1} = 0 \quad \text{(right end cell)}$$

(Full end cells simulate electrical boundary conditions)

$$\Omega = \left(\frac{\omega}{\omega_0}\right)^2 - 1 \,, \quad \omega_0^2 = \frac{1}{LC} \,, \quad Q = \omega_0 \frac{L}{R}$$

$$\boxed{\text{Bandwidth} \quad K = 2 \frac{|\omega_\pi - \omega_0|}{\omega_\pi + \omega_0} \approx 2 \frac{C}{C_K}}$$

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From the equation of the damper all follows that

$$\boxed{\mathrm{Re}\left(\frac{1}{i\omega C_K}\left(I_{m-1}I_m^* + I_{m+1}I_m^*\right)\right) = R\, I_m I_m^*}$$

This is a statement regarding energy flow.

For all modes the dominant change in the field due to the presence of the damper turns out to be a phase shift in the argument of the field. We may then write:

$$\boxed{\mathrm{Re}\left(\frac{1}{i\omega C_K}\left(A_m A_{m-1} e^{i\Delta\varphi} - A_m A_{m+1} e^{-i\Delta\varphi}\right)\right) = R\, A_m^2}$$

A_{m-1}, A_m and A_{m+1} are the unperturbed amplitudes

In the case of full end cells with metallic boundary conditions we have simply:

$$A_m^q = C_q \cos\left(\frac{q\pi}{N}\left(m-\frac{1}{2}\right)\right) \quad \begin{pmatrix} m = 1,2,\dots,N \\ q = 0,1,\dots,N-1 \end{pmatrix}$$

$$\boxed{\frac{1}{Q} = K \sin(\Delta\varphi)}$$

$Q \triangleq$ Q value of the damper cell

$K \triangleq$ bandwidth of the passband

$\Delta\varphi \triangleq$ phase shift due to the damper

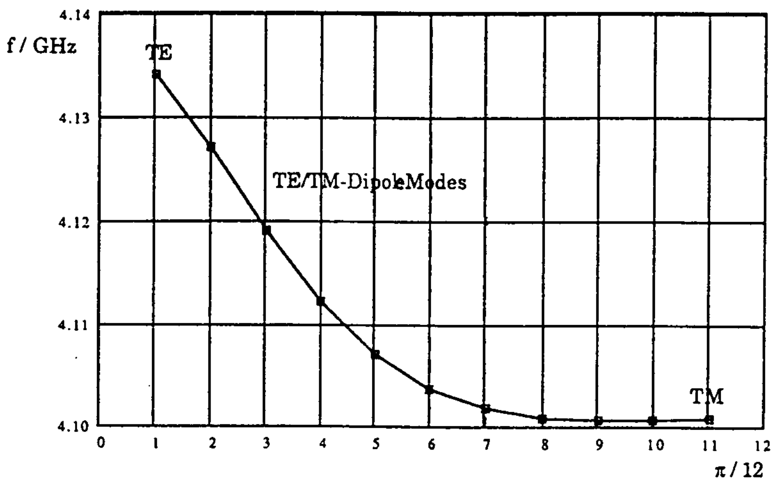
damping condition:

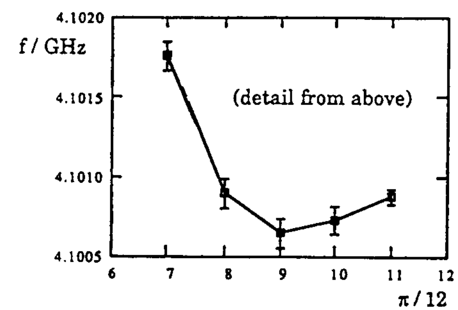
$\Delta\varphi$ has to be a real number

thus

$$\boxed{KQ = \frac{1}{\sin(\Delta\varphi)} \geq 1}$$

Modes of the 12-Cell-DESY/THD-Structure
(calculated with MAFIA)

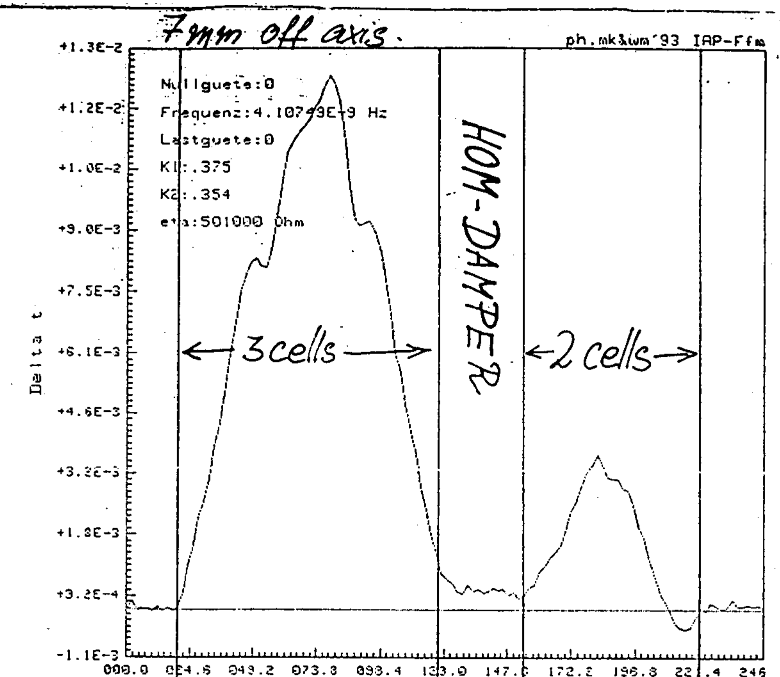


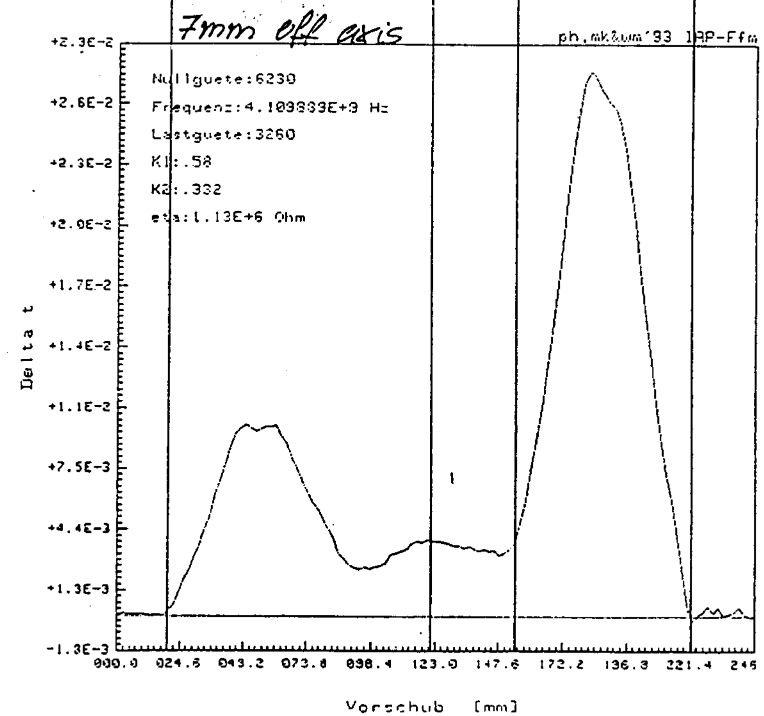


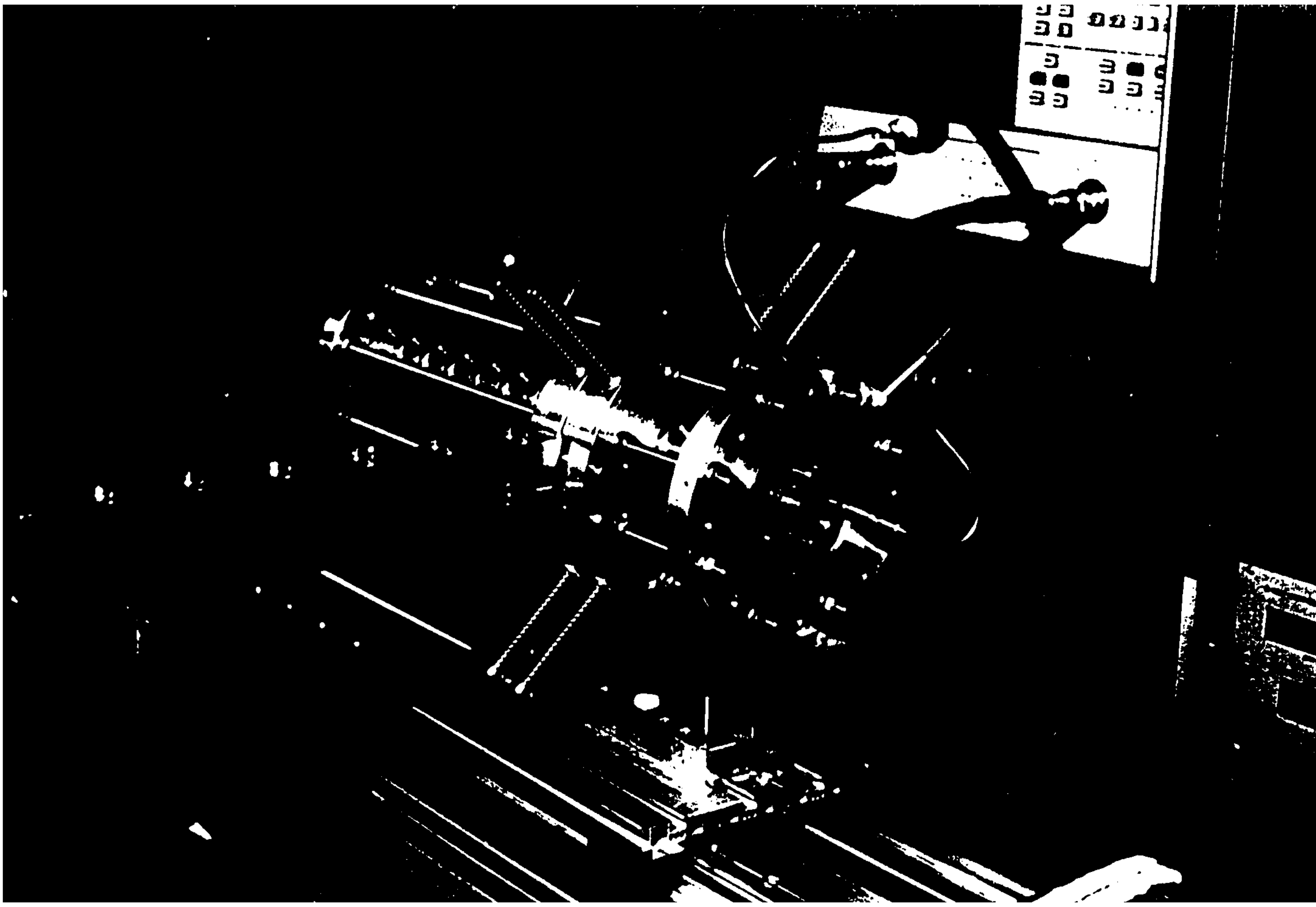
passband is extremely flat

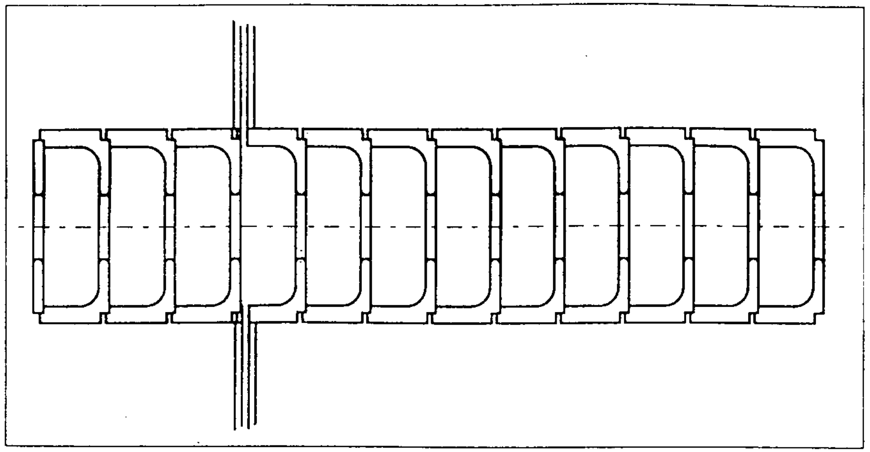
very low coupling between cells

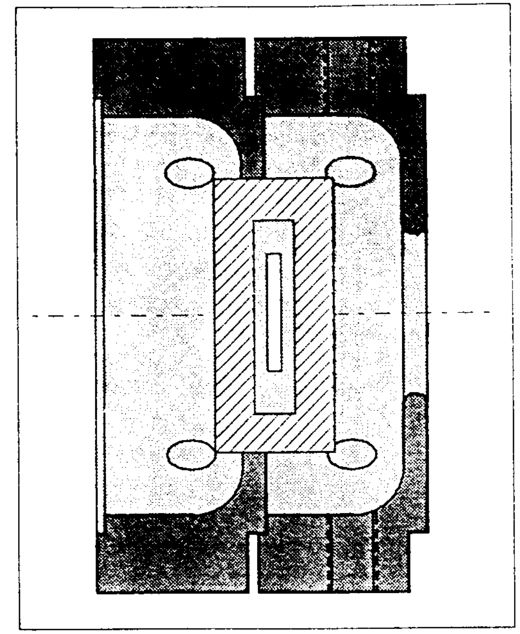
~ 35 MHz bandwidth

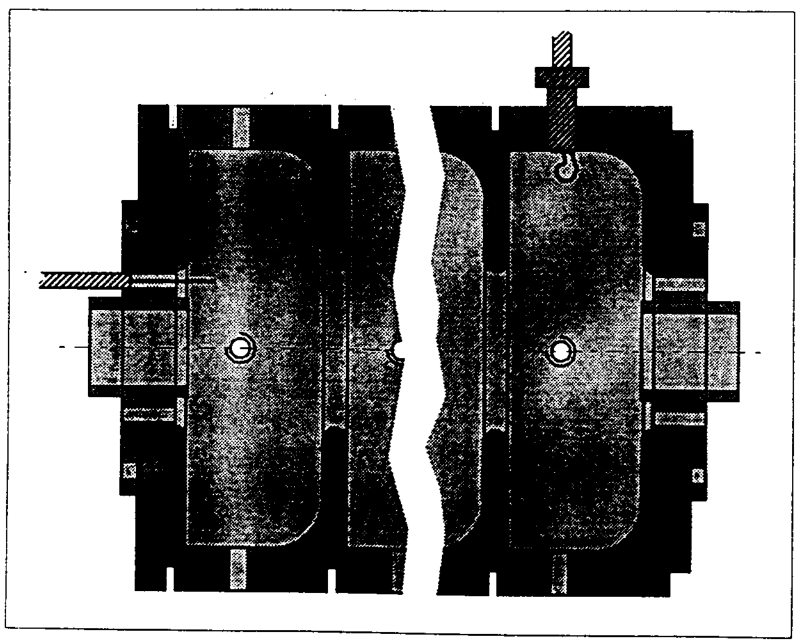


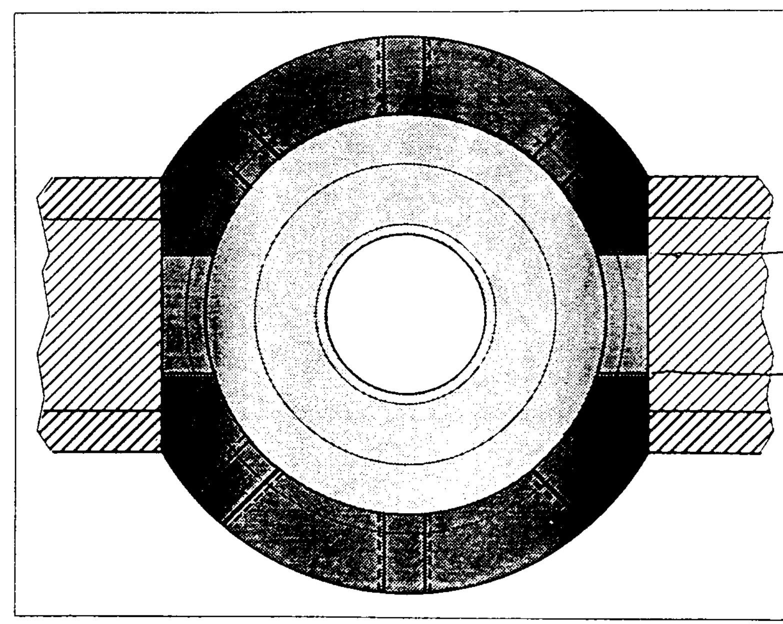




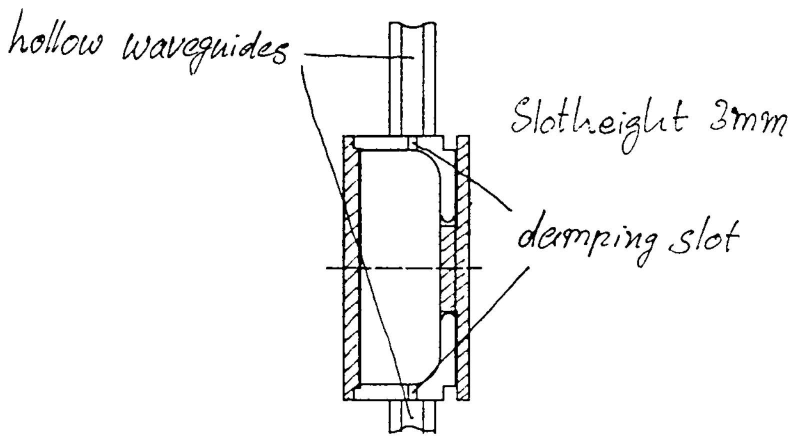


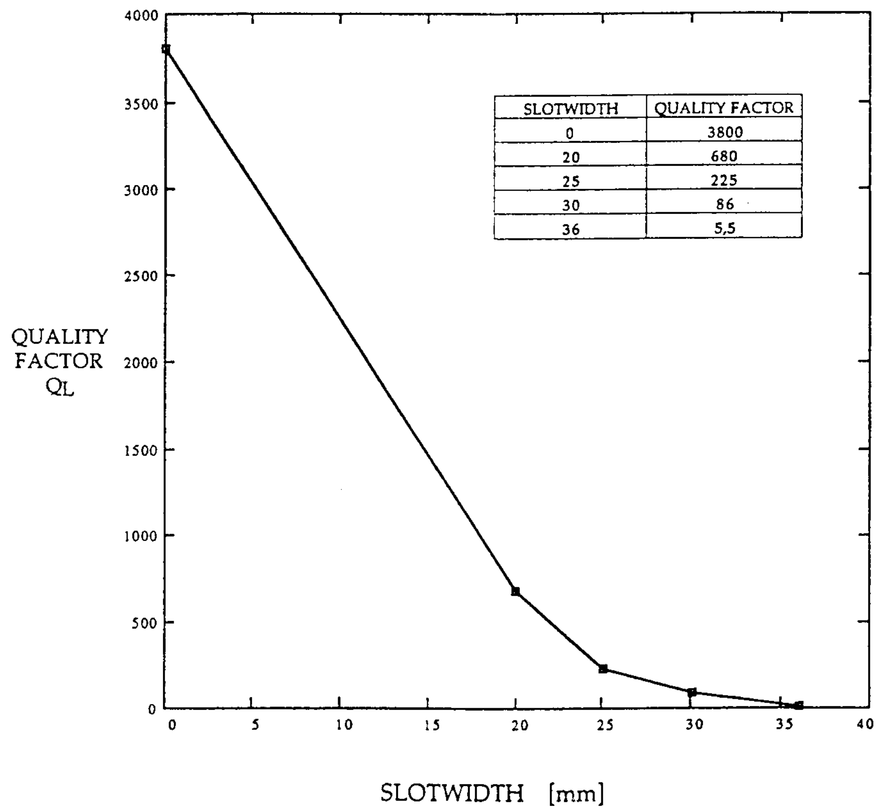




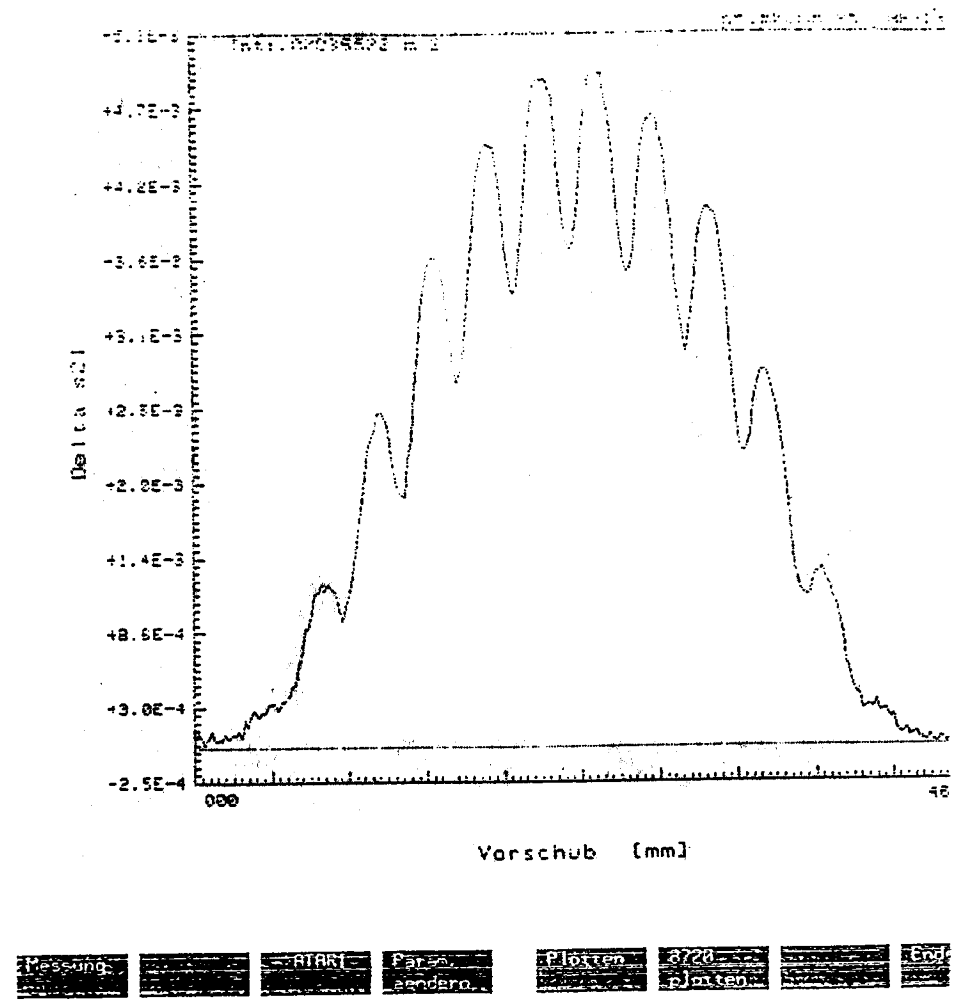

24mm
30mr

What slotwidth is needed ?





SLOTWIDTH	QUALITY FACTOR
0	3800
20	680
25	225
30	86
36	5,5



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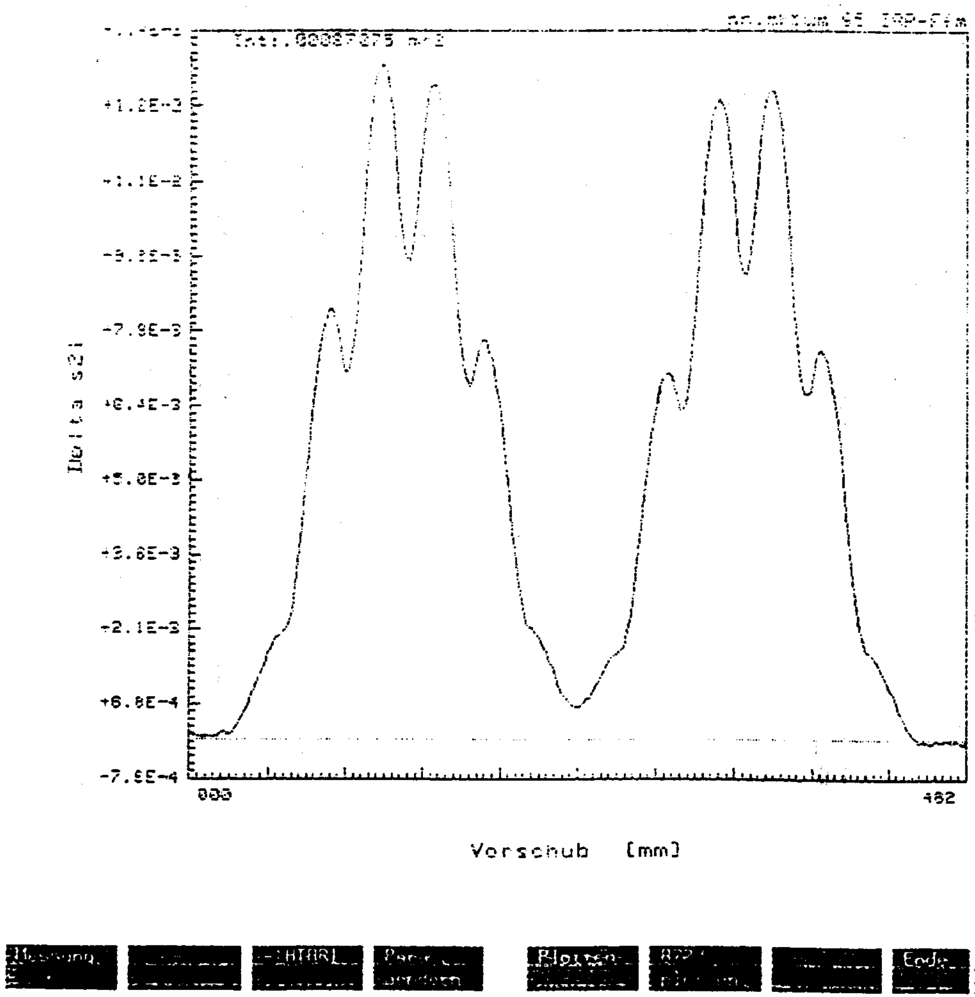
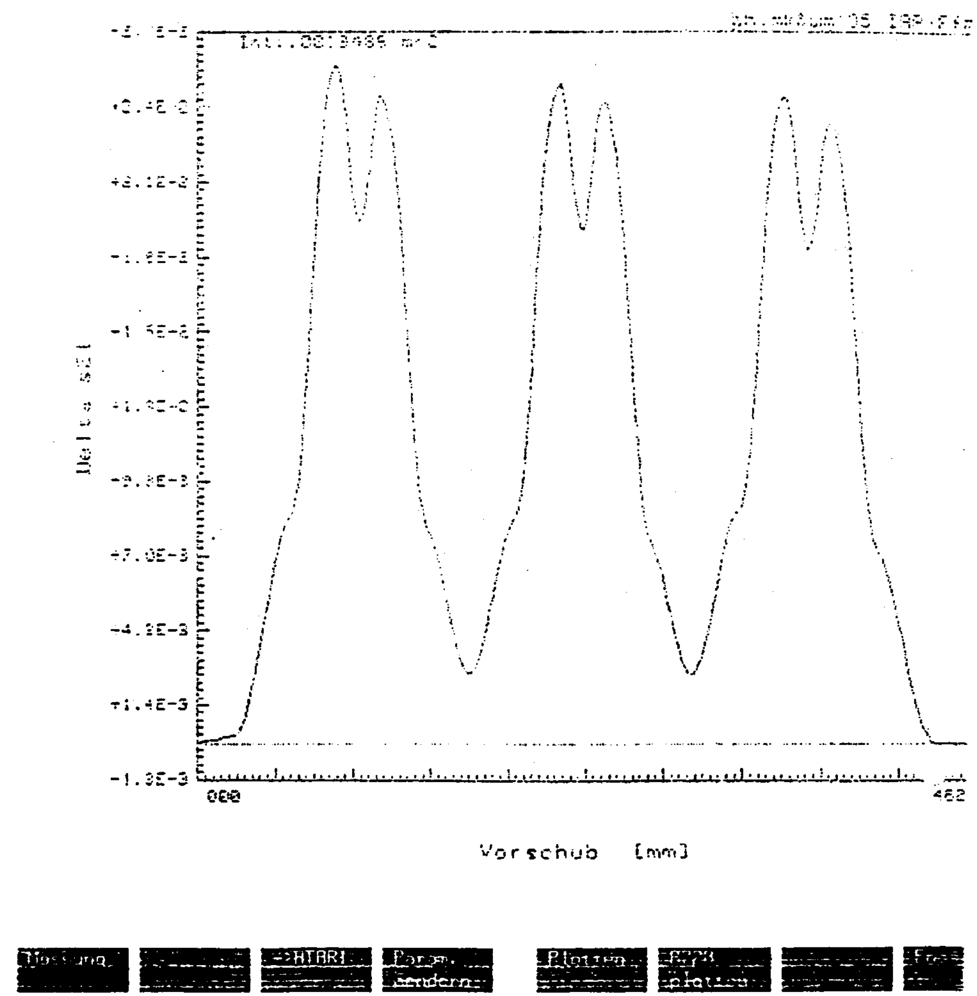
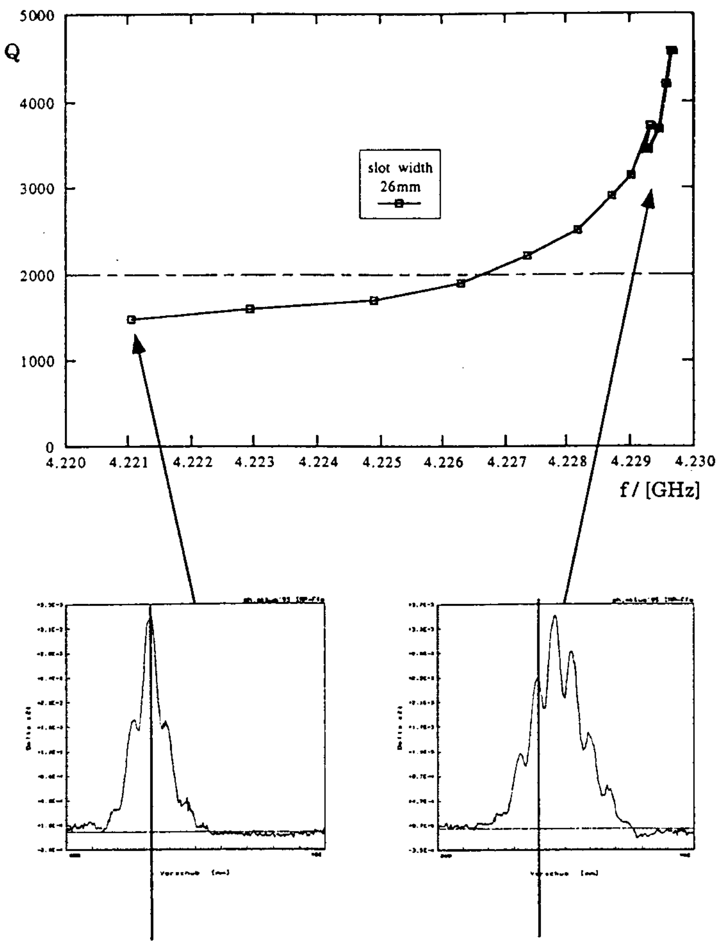




The behaviour of the TE/TM-$\frac{11}{12}\pi$-mode with respect to the tuning of the damper cell.

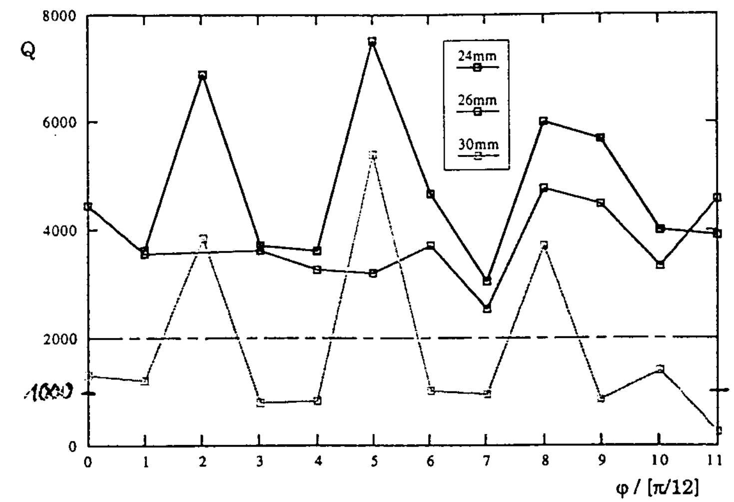
Q-values of the TE/TM-11π/12-dipole-mode



location of the damper cell

Results for different slotwidth

Q-values of the TE/TM-dipole-passband



Conclusion

1) Damping with one damper cell within a channel of undamped cells is a question of bandwidth.

2) Tuning of the damper cell with respect to the fundamental mode and the dipole modes is difficult

3) To increase the damping effect to a maximum we have to find the lowest possible single cell Q fullfilling the criterion