MULTI-MODE SLED-II PULSE COMPRESSORS

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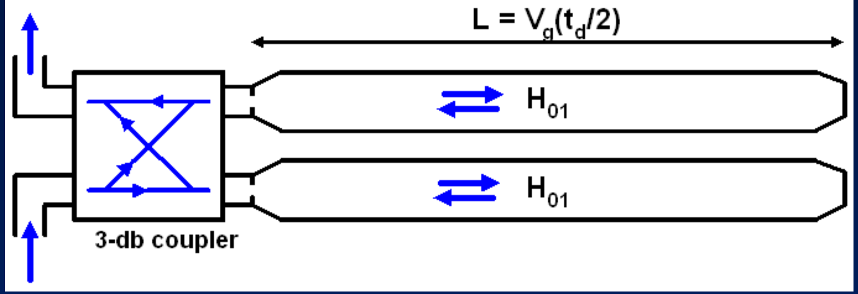
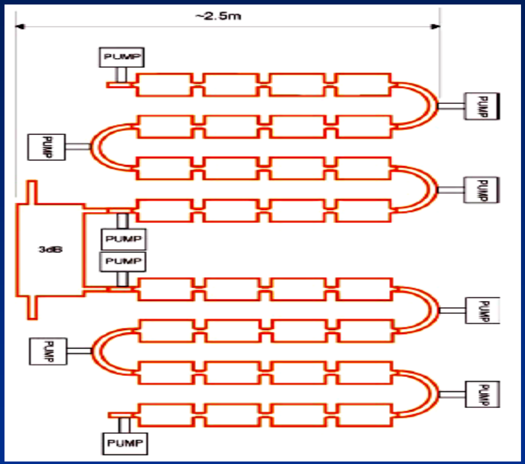
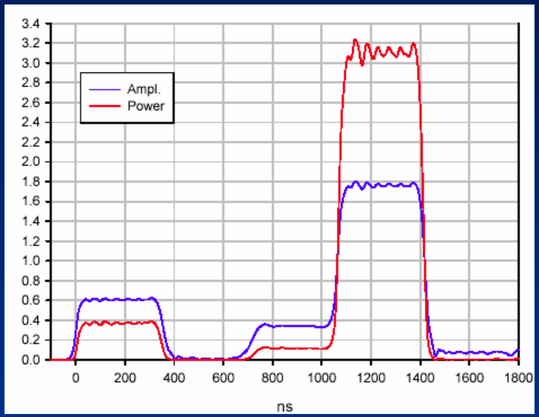
Outline

1. Pulse compressors based on a set of cylindrical multi-mode cavities:
   - Kazakov’s idea.
   - Low power tests of 4-cell pulse compressor.
   - Development of the primary idea.
2. One-channel SLED-II pulse compressor.
3. Compressors based on multi-mirror delay lines.

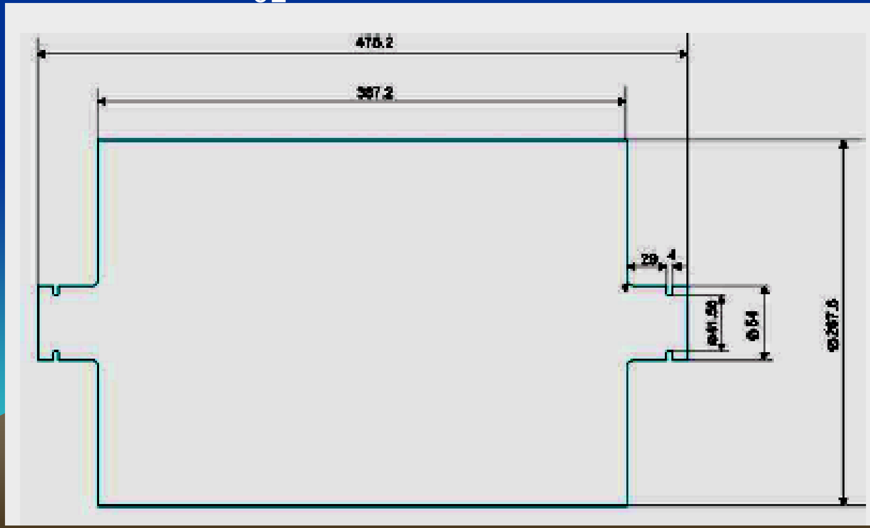


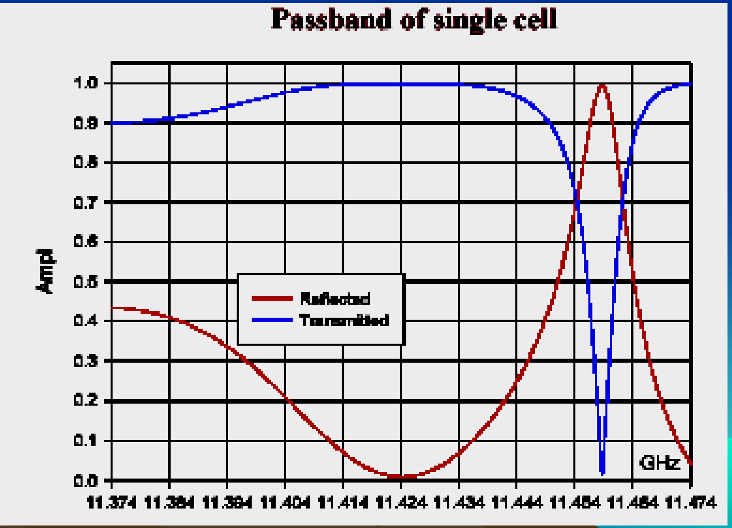
Classical SLED-II pulse compressor





In order to reduce the total length of delay lines, S. Kazakov suggested the idea to use a set of TE_{01} cavities which are to be an equivalent of the delay line.





•The necessary condition for the Kazakov's solution is to avoid spurious high-Q resonances in the frequency band which at least wider than spectrum width of the output compressor's pulse:

$$|f-f_0|>>\Delta f \qquad (1)$$

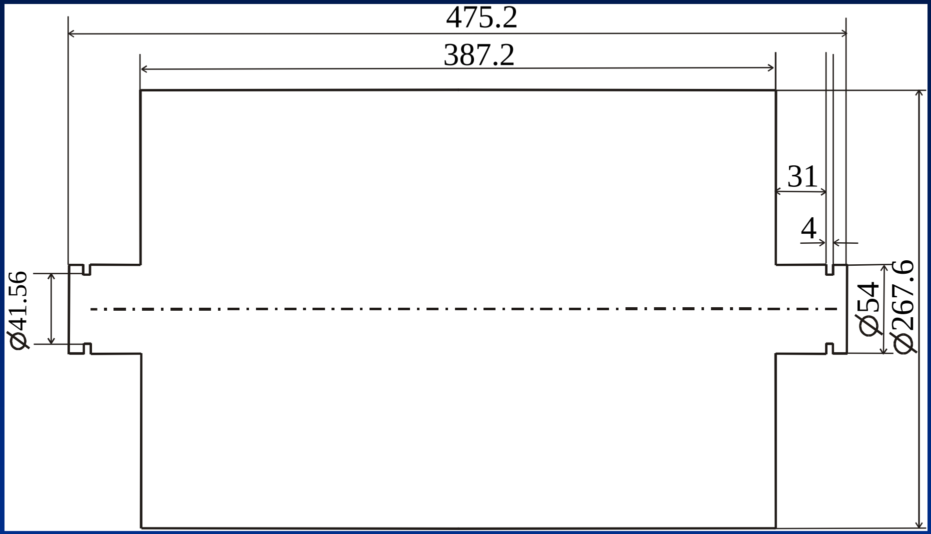
where f –is a real frequency of the nearest eigen mode, f_0 – is an operating frequency, and Δf –is a width of spectrum of the output pulse.

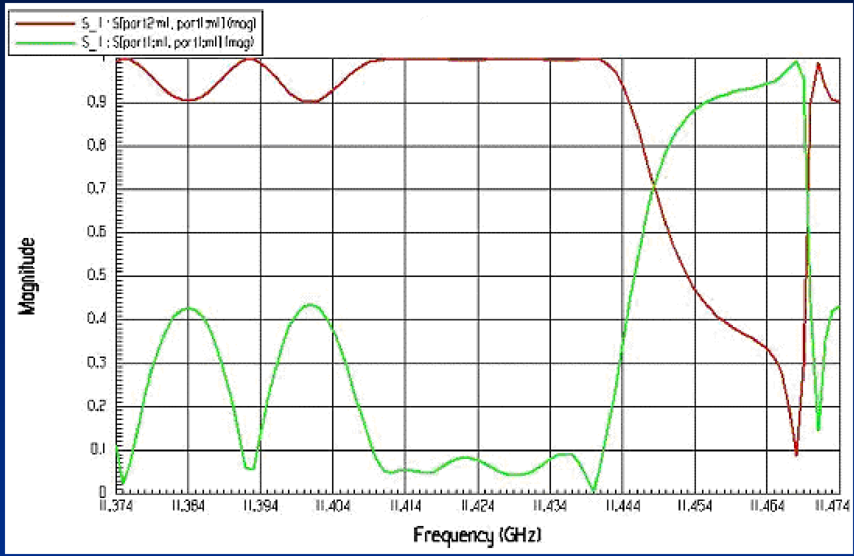
•The low-Q resonances are not dangerous while Q-factors are much less than:

$$Q^*=f_0/\ \Delta f \qquad (2)$$

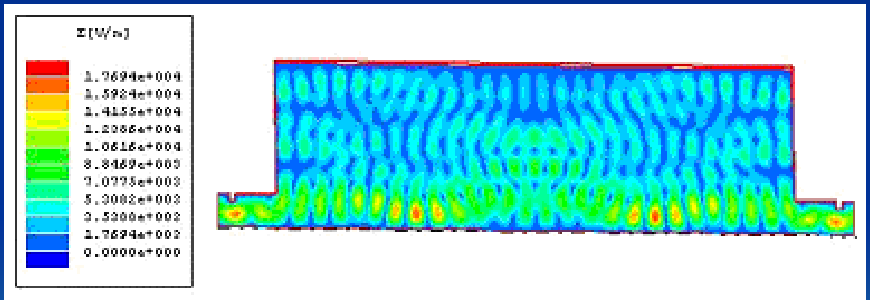
•**The conditions (1-2) are satisfied, in particular, if the cavity has spectrum of eigen modes consisted of the quasi-degenerated modes only.**

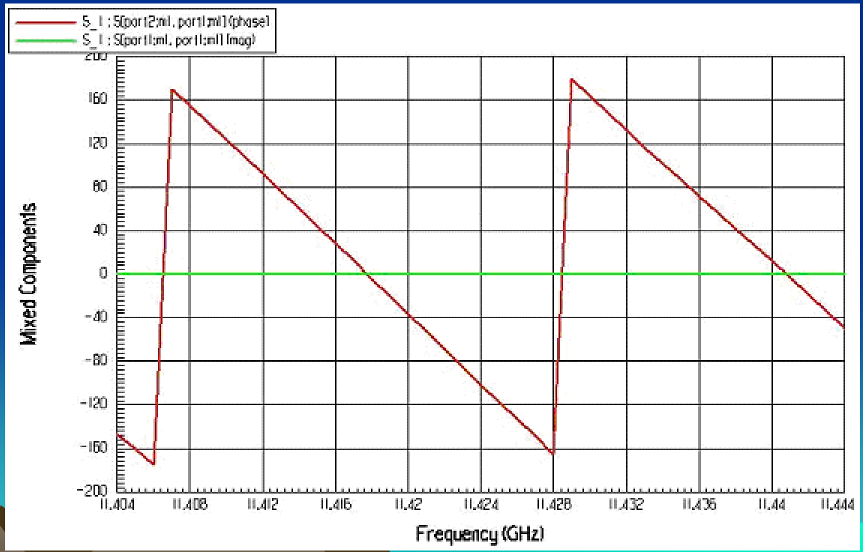
Delay cavity of Kazakov's type chosen for low-power tests





Reflection and transmission for the 4-cell chain

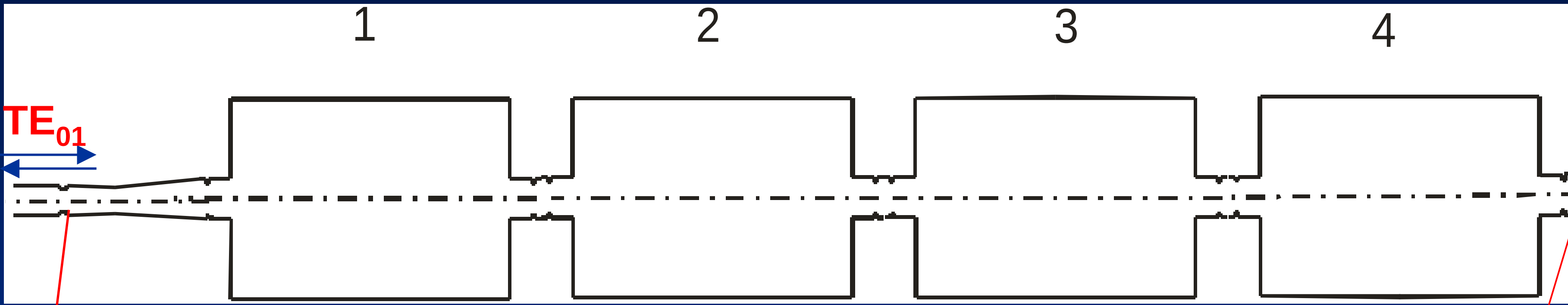




The delaying time at 11.4 GHz equals 23 ns/m.

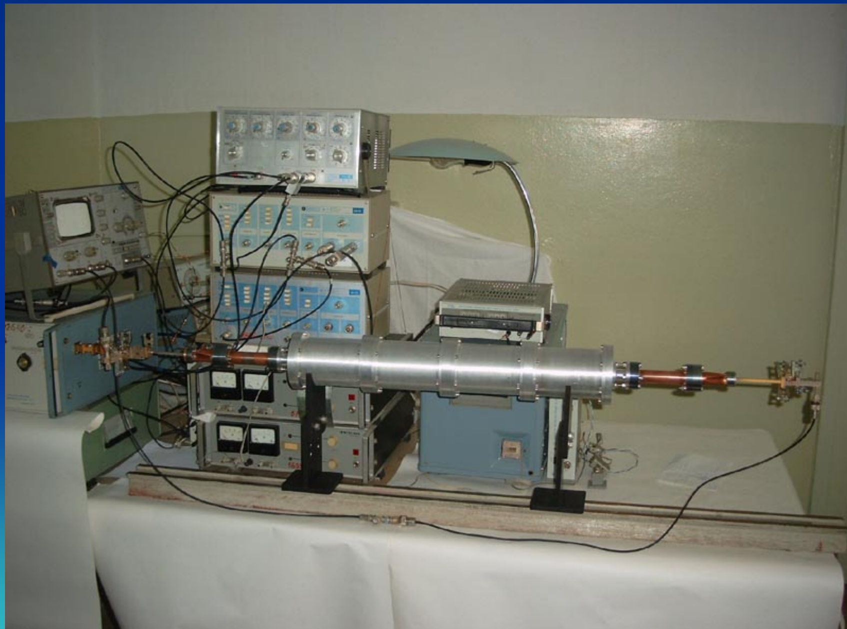
Phase of the reflected wave for the 4-cell chain.

4-cavity 34.27 GHz prototype of pulse compressor

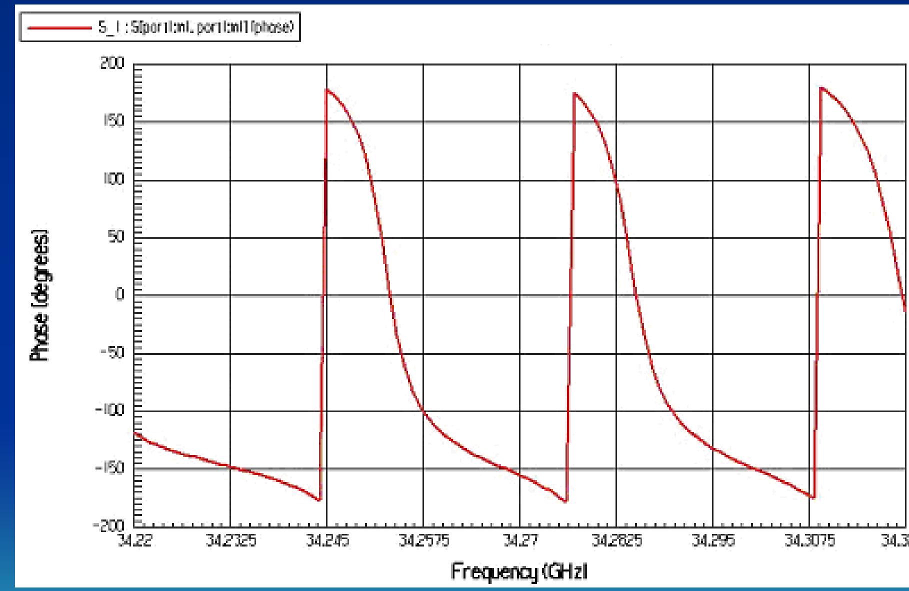


Movable 100% reflector

Coupling diaphragm

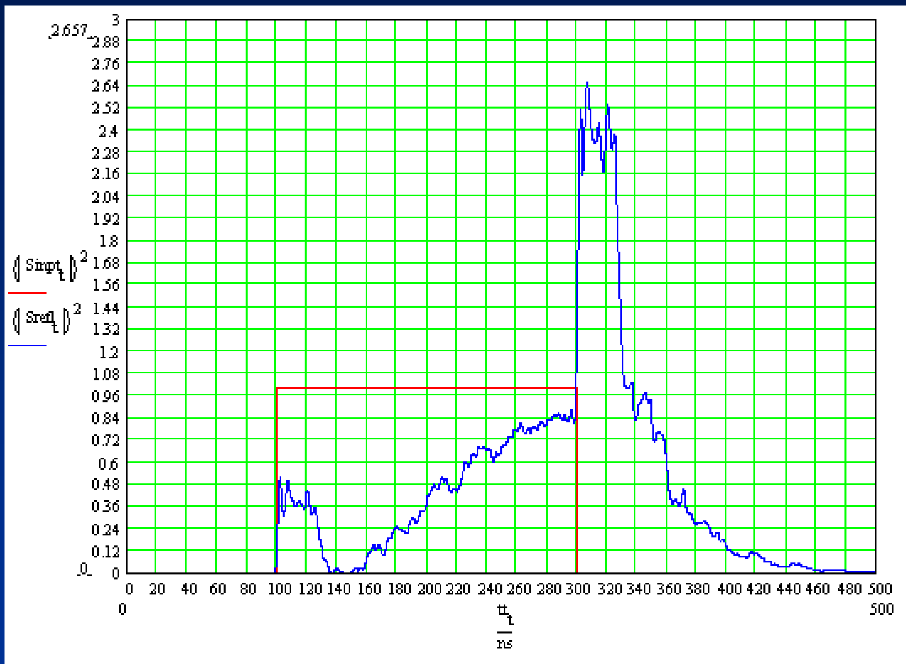


Experimental setup

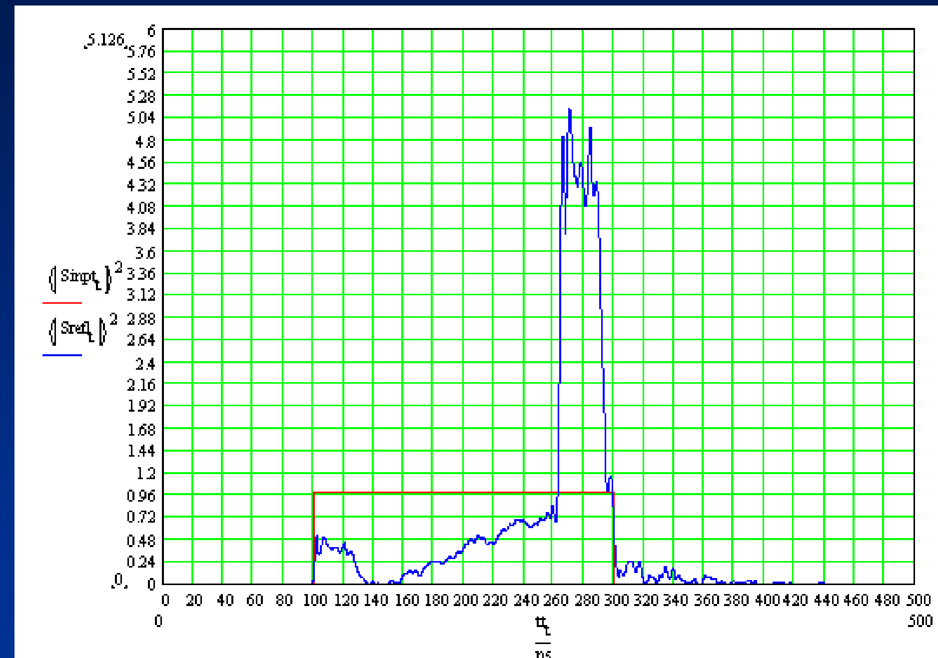


Phase of reflection from the compressor.
Here the resonant frequency is 34.253 GHz.

Simulation of the compression (τ_{in}=200 ns, s=5)

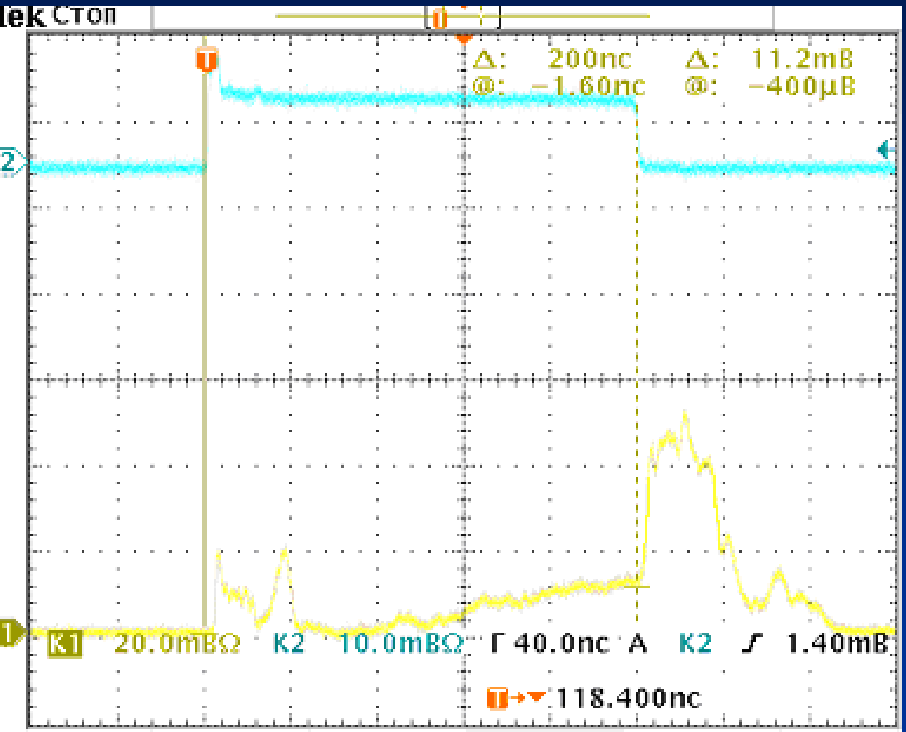


Simulation of the output pulse for the designed 4-cell compressor **(no phase reverse).**

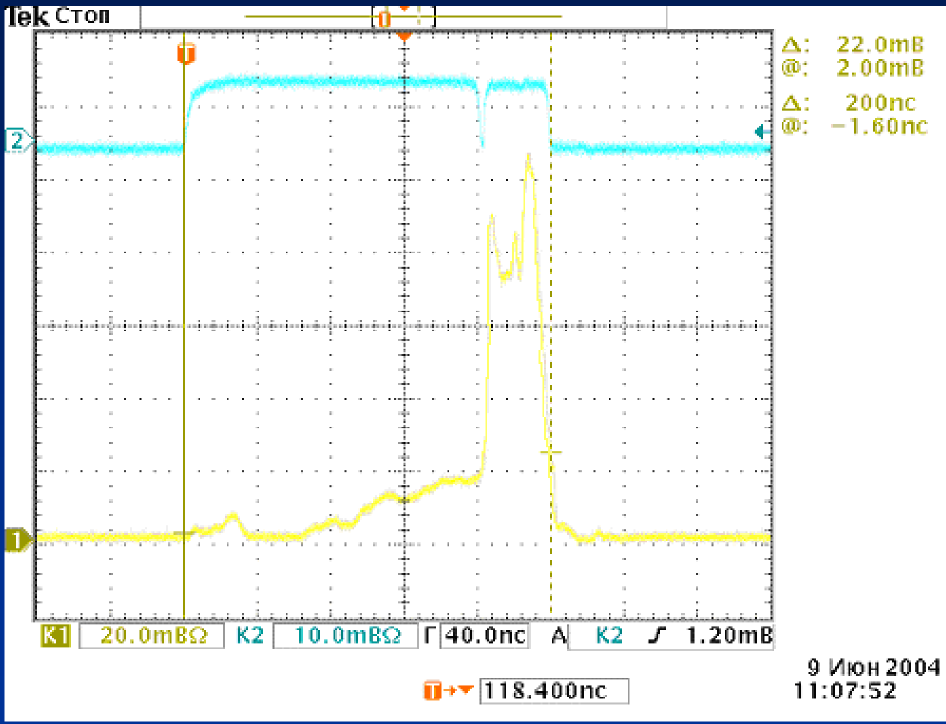


Simulation of the output pulse for the tested 4-cell compressor **(with π phase reverse).**

Low power test of the compressor



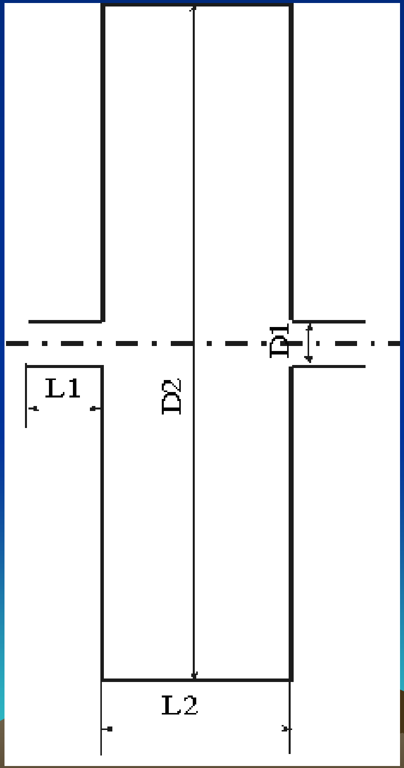
Experimental plot of the pulse (yellow) formed by the compressor **(no phase reverse).**



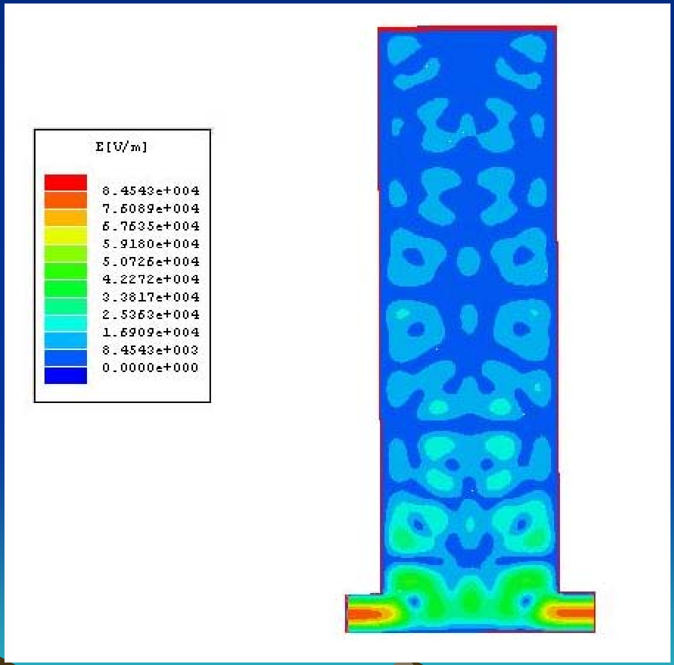
Experimental plot of the pulse (yellow) formed by the compressor **(with phase reverse).**

Development of the primary idea (f=34 GHz)

№	L1 (mm)	L2 (mm)	D1 (mm)	D2 (mm)	Delay time (ns/m)	Ohmic Loss/delay time (%/ns)
"Kazakov"	14.7	129.07	18	89.2	22.9	0.045
"Long"	5	100.27	13.98	69.3	52.8	0.059
"Short"	5	25.14	11.28	171.35	152.3	0.073

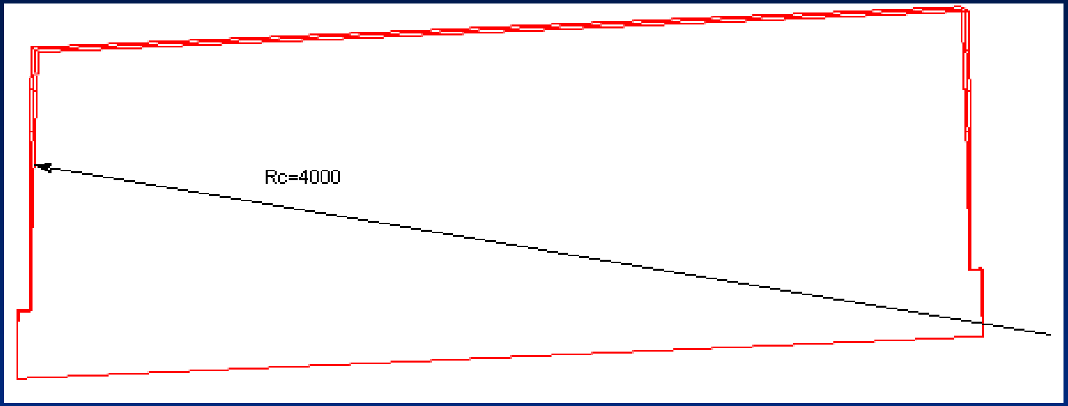


Sizes of the cavity

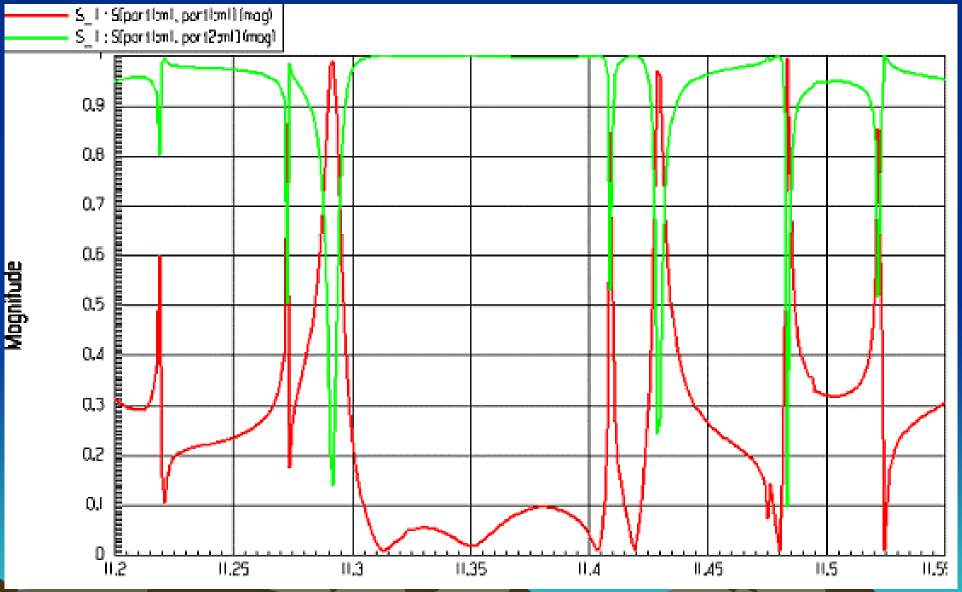


"Short" cavity allows to increase essentially the delay time per meter of structure.

The 11.35 GHz cavity with the curved end faces

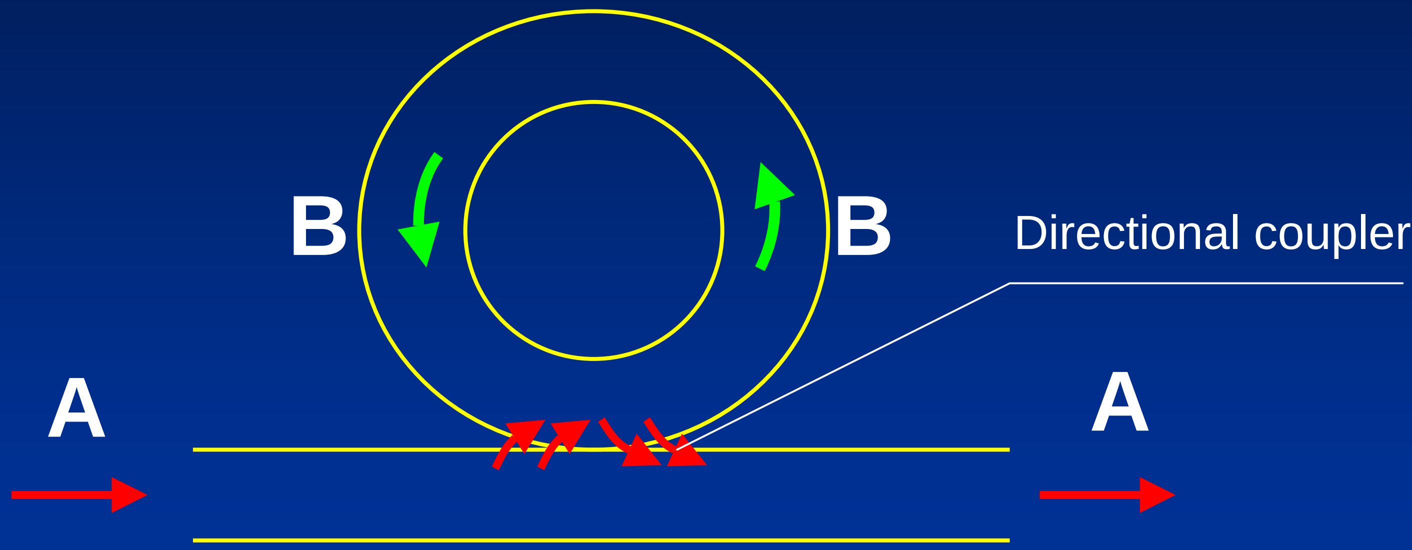


There are cavities those eigen modes are strictly degenerated.
Most known example from optics is a so-called confocal two-mirror cavity.



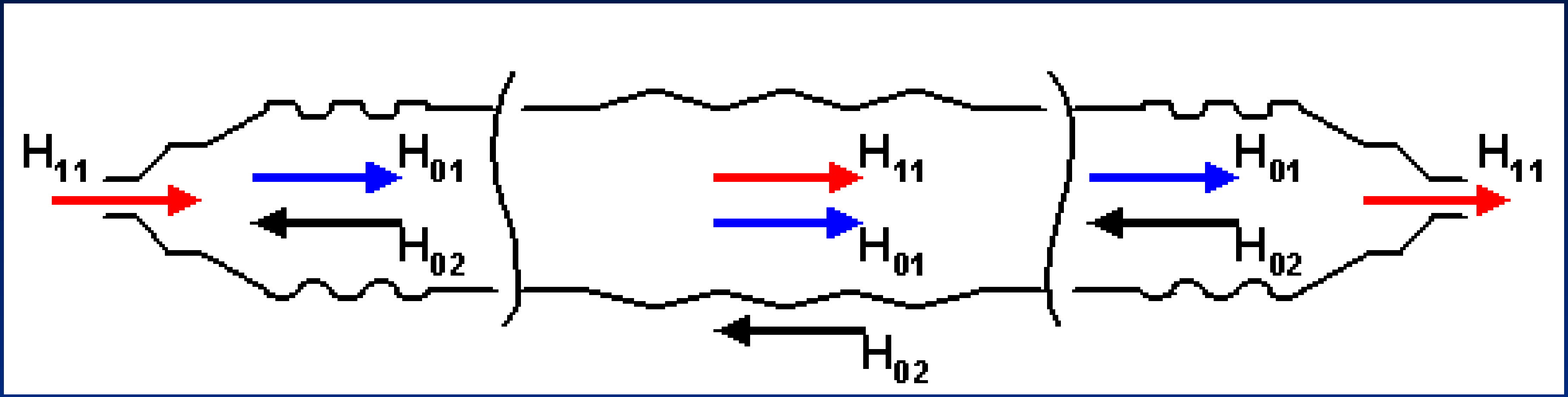
Reflection and transmission coefficients

Idea of one-channel SLED pulse compressor based on ring-like cavity



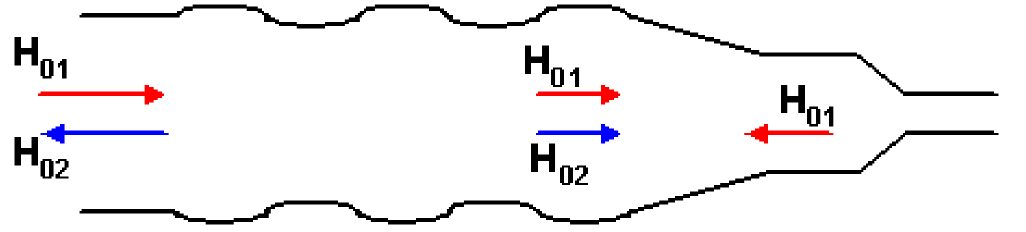
The ring-like cavity allows compression using single channel instead of double channels. The necessary condition is that the eigen mode **B** of storage cavity is coupled with the forward mode **A** only.

One-channel SLED-II pulse compressor

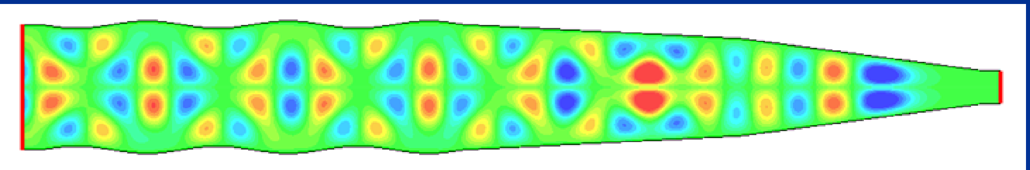


- The operating mode of the axis-symmetrical cavity consists of TE_{01} mode and TE_{02} mode which propagate toward each other. These modes are transformed each to other in the both ends of the delay line by means of special reflecting converters. The feeding wave is the TE_{11} mode which goes through the mentioned converters without conversion into any other mode.
- The transmitting TE_{11} mode is coupled selectively with the forward TE_{01} mode only by means of the serpent-like periodic mode converter included in the delay line. This converter should provide optimal mutual conversion TE_{11}-TE_{01} in order to obtain high compression efficiency. The backward TE_{02} mode should be not perturbed by the coupling converter.

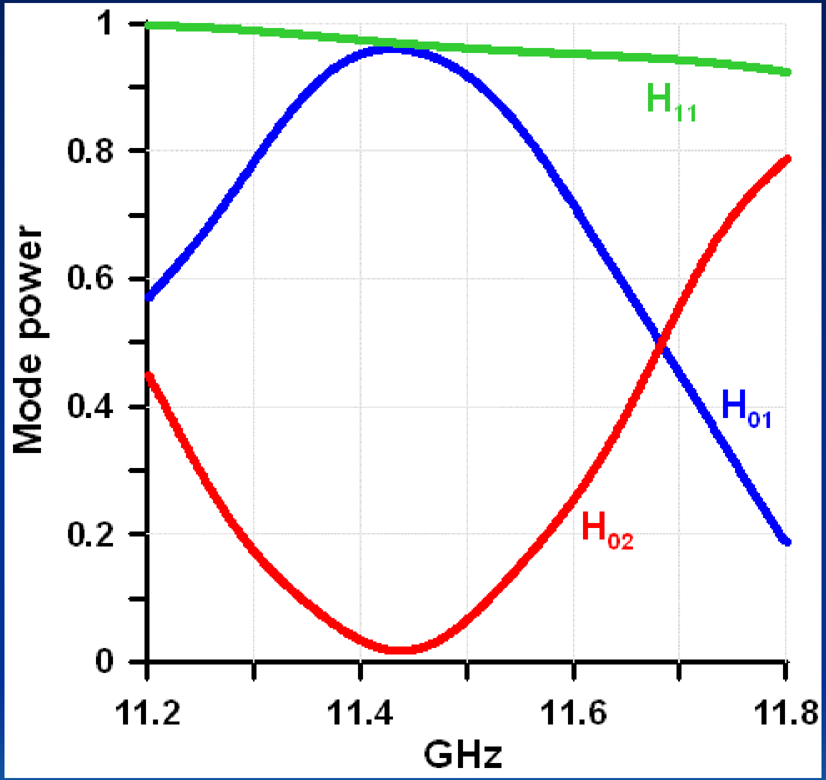
TE_{01}-TE_{02} mode reflector



The reflector does not perturb TE_{11} mode propagated through the compressor.

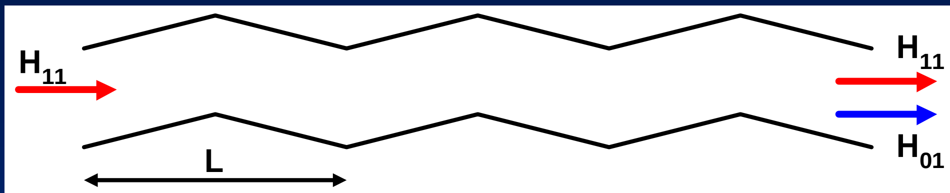


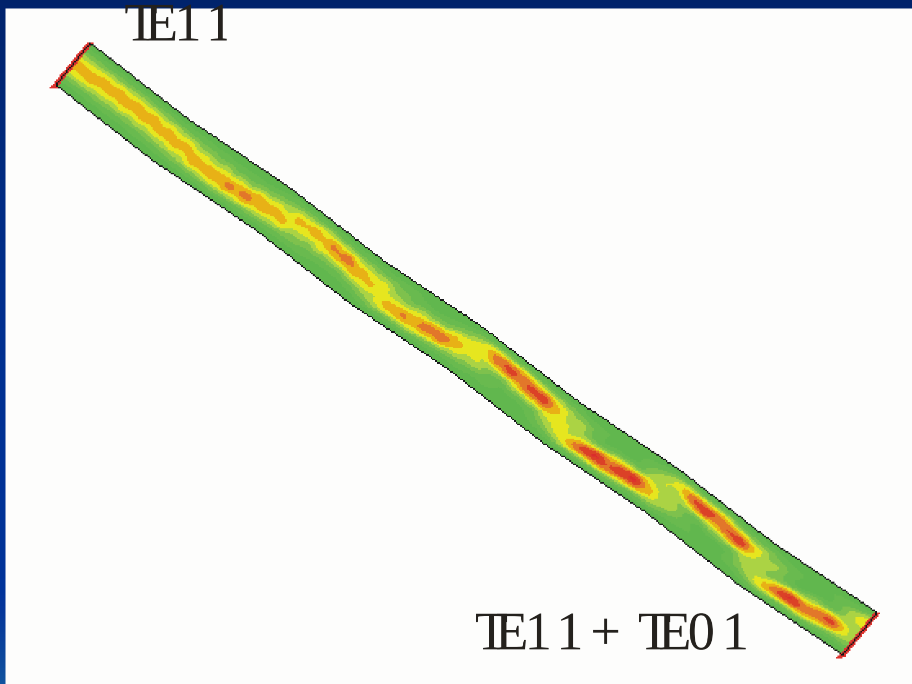
The field structure at the reflector under TE_{01} incidence.



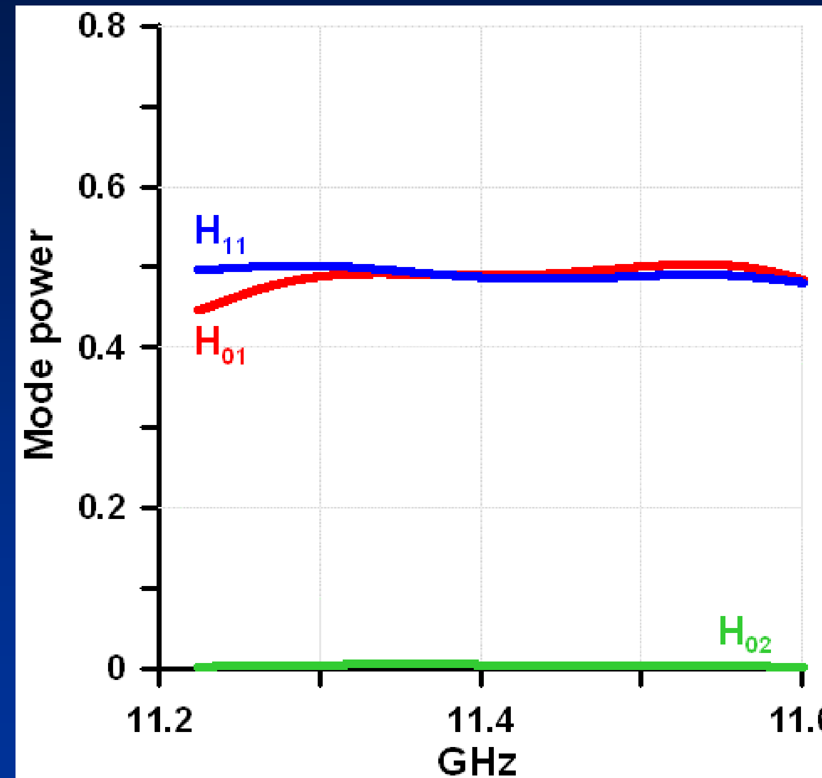
Calculation of modes at the TE_{01}-TE_{02} mode reflector

TE_{11}-TE_{01} (forward modes) mode coupler



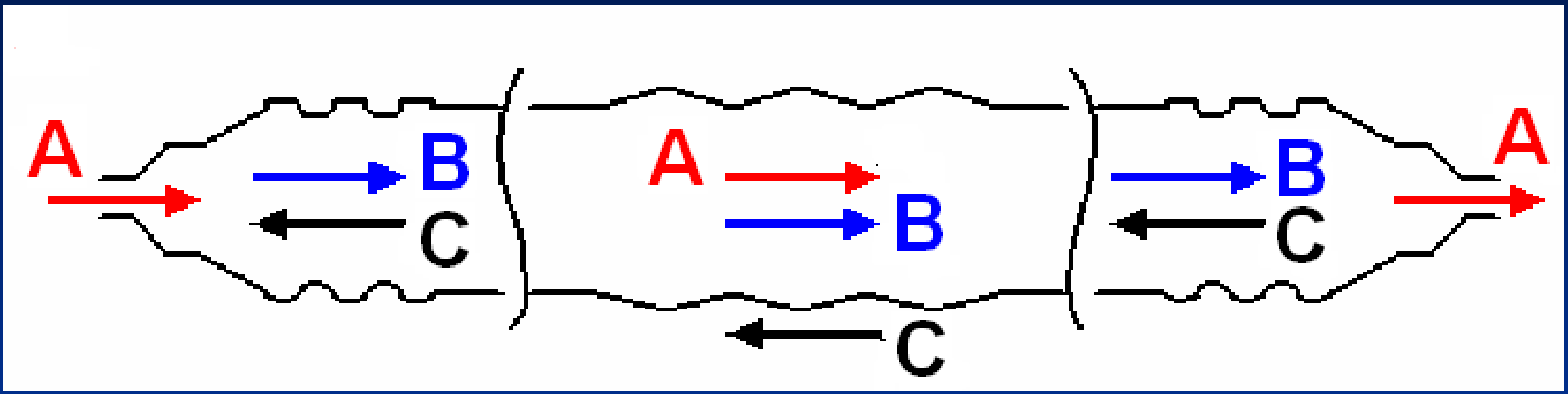


The field structure at the mode coupler under TE_{11} incidence.



The desired coupling coefficient is 0.5 on power for s=4.

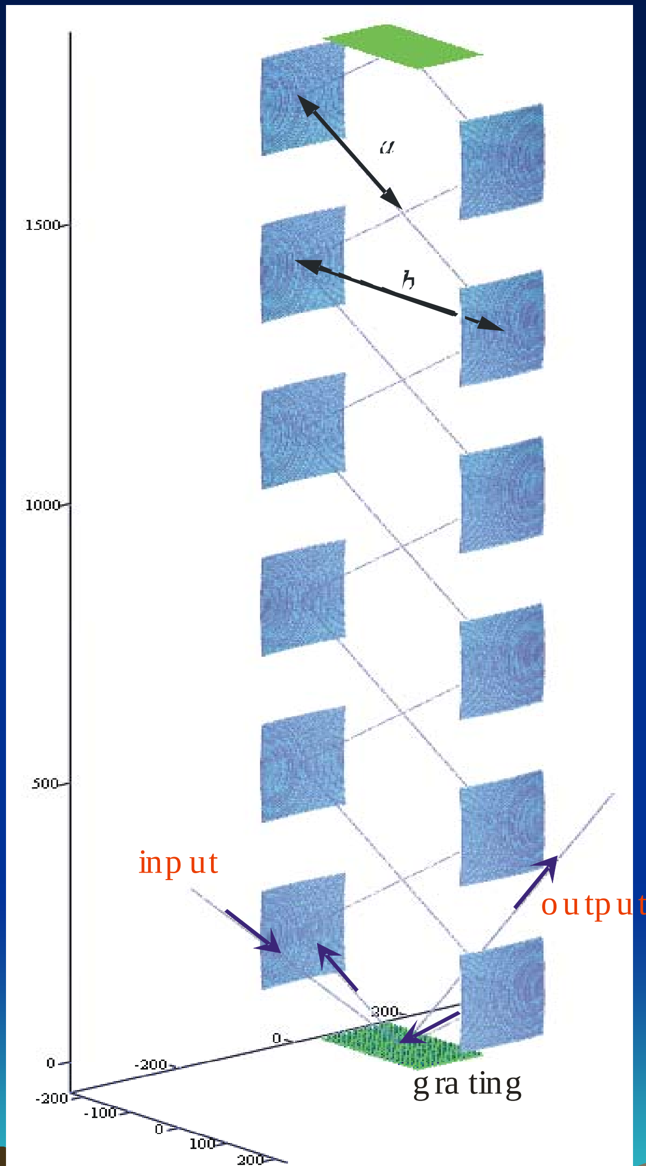
General scheme of one-channel SLED-II pulse compressor



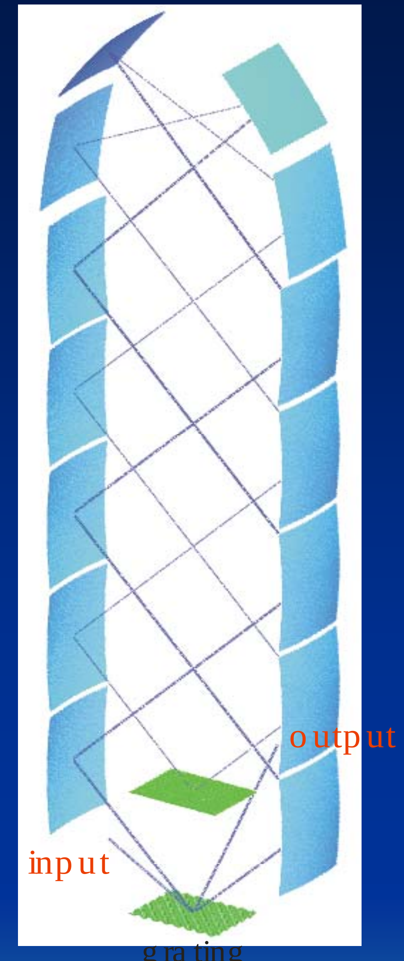
The modes A,B, and C could be arbitrary.

For example, scheme with axisymmetrical modes (A=TE_{01}, B=TE_{02}, C=TE_{03}) seems attractive.

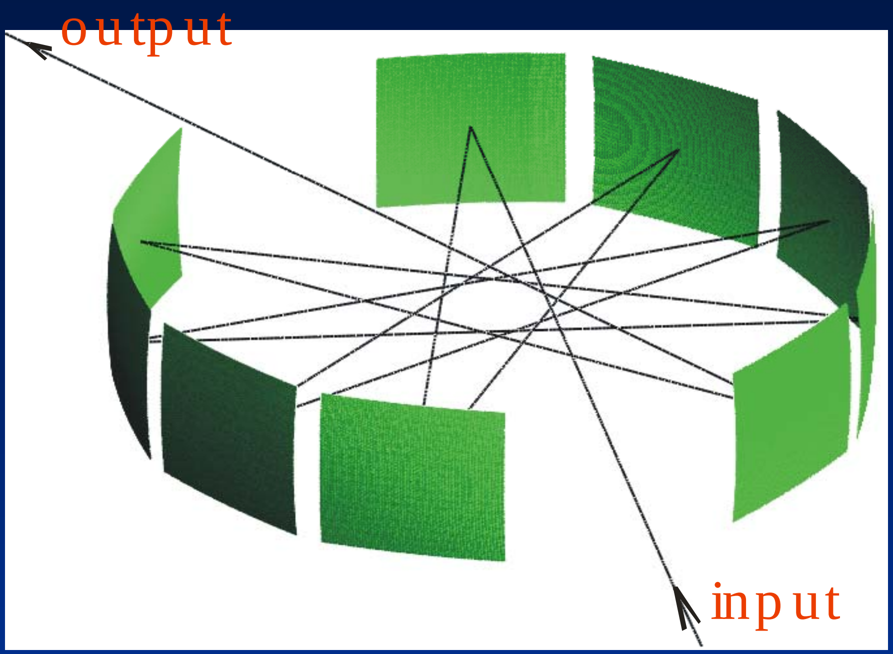
Compressors based on multi-mirror delay lines



SLED-II pulse compressor based on multi-mirror delaying lines



More compact modification of the previous pulse compressor



Compact star-type delaying line

Most compact delay lines are shaped by mirror systems where the traveling wave many times crosses itself. The example of such systems is a star-type mirror line. Under the delay time 25 ns the star diameter is 750 mm, the sizes of confocal mirrors are 187×180 mm^2.

Conclusion

- The SLED-II pulse compressor, based on TE_{0n} mode cavity chains, is the prospect idea. This allows to reduce 10 - 50 times the length of delaying lines. The main criteria for designing of such cavities are that the design should allow an existence of the quasi-degenerated modes only amongst high-Q eigen modes. The carried out simulations and low power tests at 34.27 GHz confirm good efficiency.
- The one-channel TE_{01}-TE_{02} SLED-II pulse compressor is suggested. It does not require 3 dB coupler. Possibilities to reduce the length require additional investigations.
- SLED-II pulse compressors, based on multi-mirror delaying lines, are suggested for frequencies 30 -100 GHz. They allow to provide high efficiency and excellent compactness. The main advantage is the flat output pulse shape.