Aug. 14, 2005

CBN 05-20

RF couplers

Snowmass 2005

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We are exploring the possibility for SC linear collider operation at ~3*GHz*, with increase in repetition rate up to 50 Hz and proportionally decreasing the bunch train length.

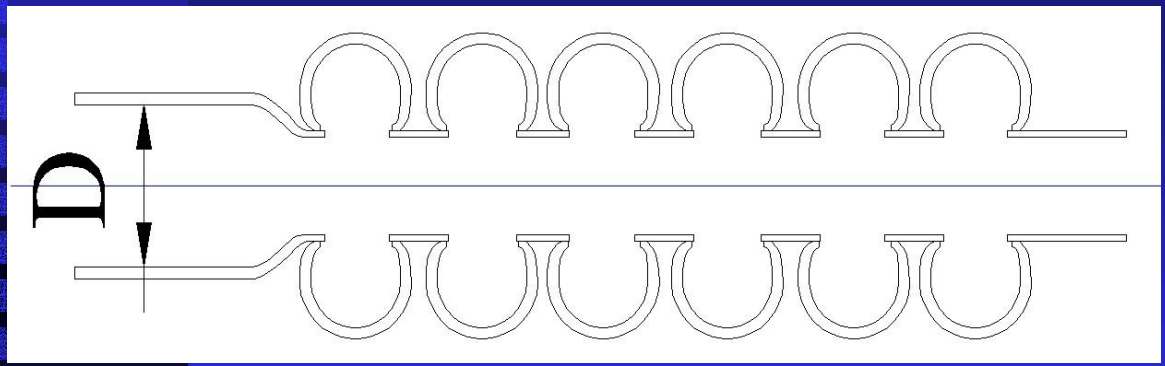
We found that RF inputs and HOM evacuators developed for our structure might be useful for official 1.3 GHz scheme of ILC

The latest is the subject of this talk

Electronic version at: http://www.lns.cornell.edu/public/CBN/2005/CBN05-20/CBN05-20.pdf

RF INPUT

A structure of our interest is shown here schematically ,Ω-shape. In line with REC



This shape comes from earlier days of RF activity (Klystrons, Accelerating Structures)

Reducing multipacting

Reducing wave impedance,

what is desirable for SC as the limits here lies in magnetic field strength

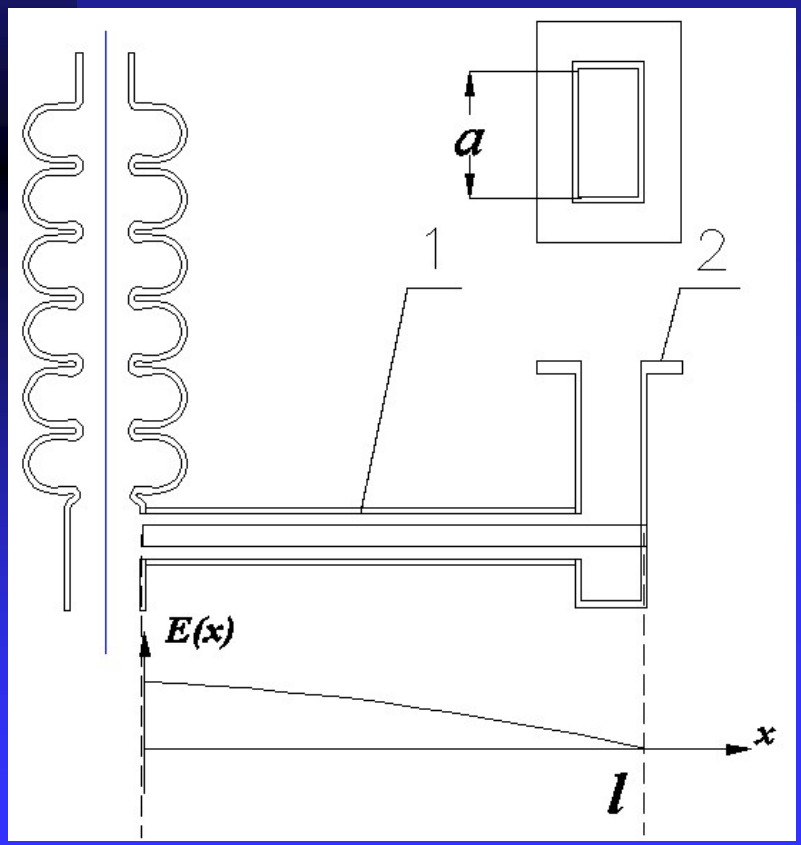
What is important here is that diameter **D** of the tube is chosen so that the transverse mode can propagate inside, i.e. its diameter, $D \geq Dcr = \lambda_{tr}/1.81$ where $\lambda_{tr} = c\, f_{tr}$

and f_{tr} stands for the frequency of the transverse mode in the structure.

Our intentions are to make the power input from this side *together* with the extraction of HOM.

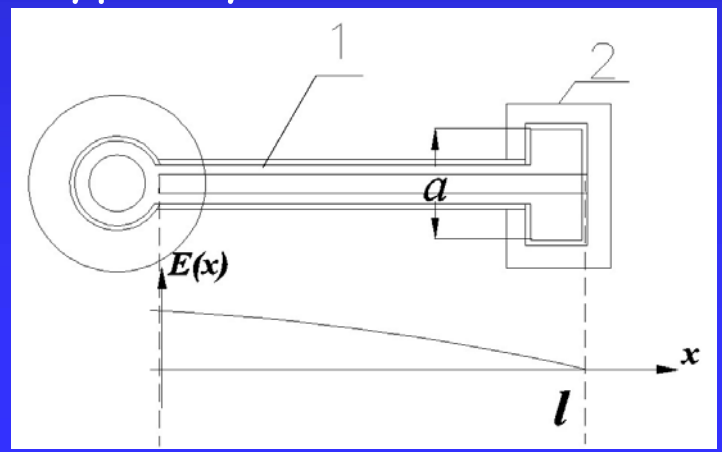
First, let us say why coupling with a coaxial coupler looking to the beam and further transferring to a waveguide, *is unacceptable* from our point of view.

Looking to the beam, a coaxial coupler acquires fields with spectrums starting from a frequency of zero (DC). This coaxial line transfered to a waveguide at some distance outside of cryostat. The waveguide has limited spectral transparency however, starting from the cut-off frequency $\omega_c = \pi c/a$, where *a* stands for the width of waveguide.



This means that part of the transmission line between the orifice looking to the beam and the coax-waveguide transition can trap RF waves with a spectrum within the bandwidth {0-$\pi c/a$}.

Typically it is 60 MHz



Action to the beam

If the cavity is coupled optimally, then the current I running in transmission line is defined by $I^2 = P/Z$, where P stands for transmitting power and Z for effective impedance.

The magnetic field could be estimated as $H=I/d$, where $d \sim D$.

Field integral

$$\int Hdl \approx \int \sqrt{\frac{P}{Z}} \times \frac{1}{D} dl \cong \sqrt{\frac{P}{Z}}.$$

Kick across the bunch

$$y' \cong \frac{\sqrt{\varepsilon\beta}}{D} \frac{\int Hdl}{(HR)} = \frac{\sqrt{\varepsilon\beta}}{D} \frac{\sqrt{P/Z}}{(HR)}$$

Perturbation of emittance :

$$\frac{\Delta\varepsilon}{\varepsilon} \cong \frac{\beta^2}{D^2} \cdot \frac{P}{Z} \cdot \frac{1}{(HR)^2} \quad \left[= (0.4\pi)^2 \frac{\beta^2}{D^2} \cdot \frac{P[W]}{Z[Ohm]} \cdot \frac{(300)^2 \cdot 10^{-18}}{(pc[GeV])^2} \right],$$

For parameters:

$Z=100\ Ohm,\ \beta = 20m\ D=0.05m,\ pc=10\ GeV$

$$\Delta\varepsilon / \varepsilon \cong 2.5 \cdot 10^{-7} /pass$$

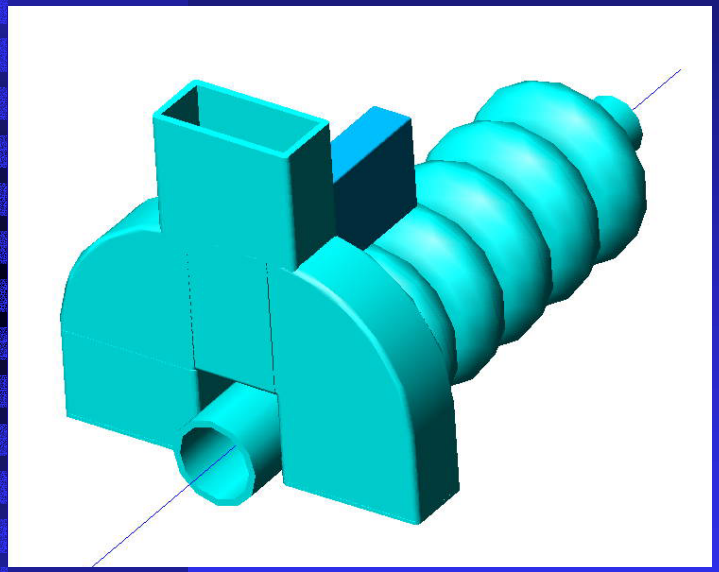
Coherent kick to the bunch:

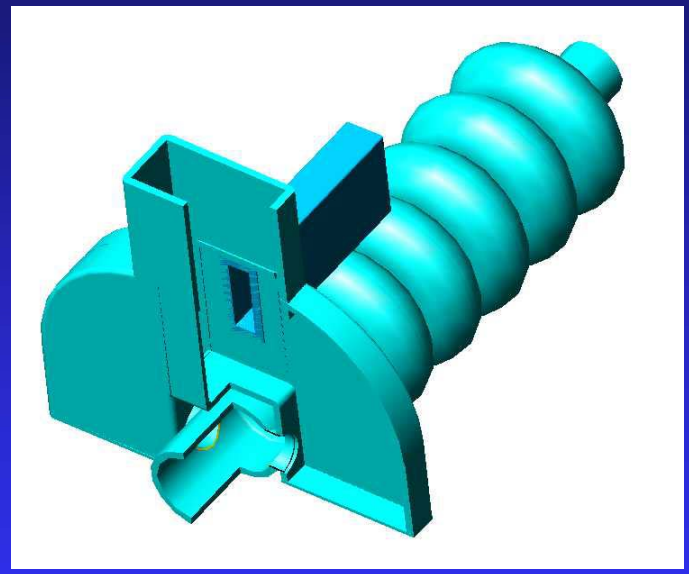
$$y' \cong \sqrt{P/Z}/(HR),\ y' \cong 1.2 \cdot 10^{-6}\ rad/pass.$$

This angle requires attention

The importance of this kick for a room temperature linear collider, where the input power is much higher, was recognized a long time ago.

S-band linear collider, developed at DESY, has had symmetrized coupler (DESY/Moscow). *We fulfilled this coupler to a magic T-bridge.*





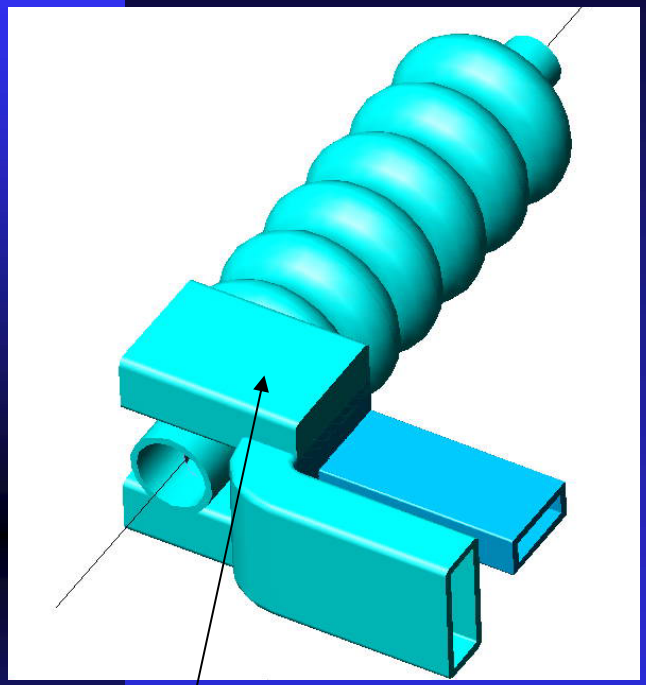
HOM evacuation waveguide made with reduced width, this prevents the leakage of RF power there. High order modes, having higher frequency, escape through this waveguide.

This type of coupler has increased magnetic field value, however.

It can not be recommended for SC structure

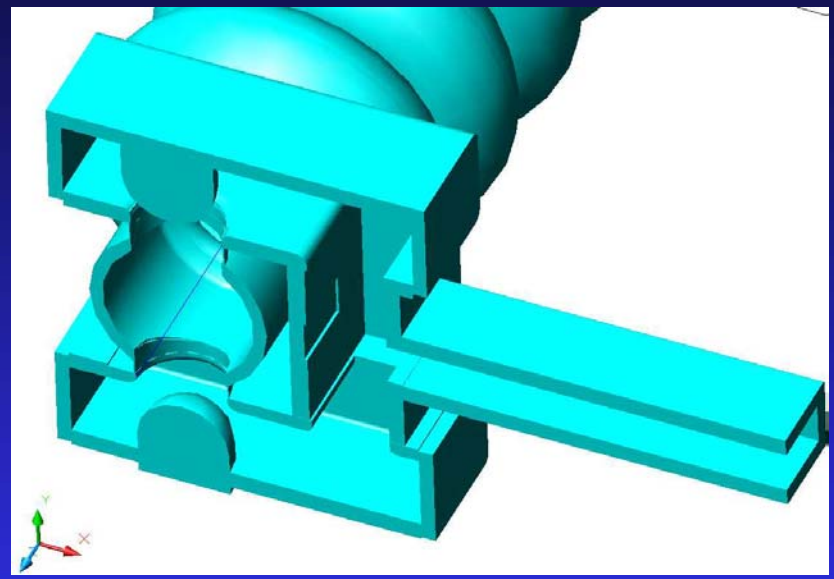
Coaxial coupler is an electric (capacitive) type one

OUR SOLUTION FOR THE COUPLER/EVACUATOR

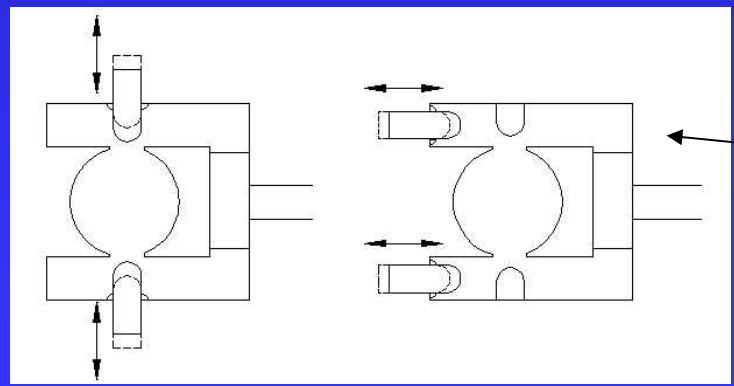


Magic T

Symmetrical electric coupler



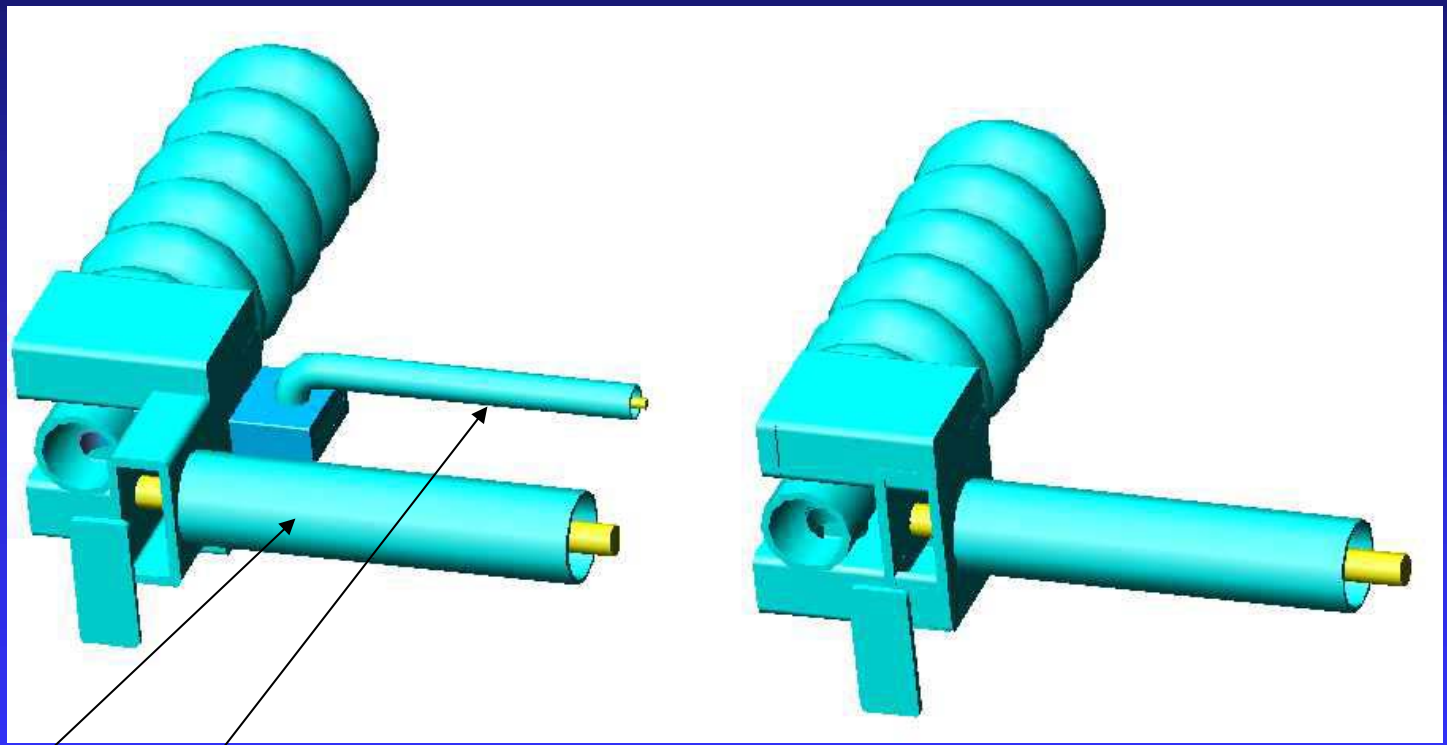
Can be coupled with mode having rectangular polarization



The way to tune coupling

There is a way to couple with coaxial guide.

As the coaxial is separated from cavity by waveguide, there is no problems with the beam coupling

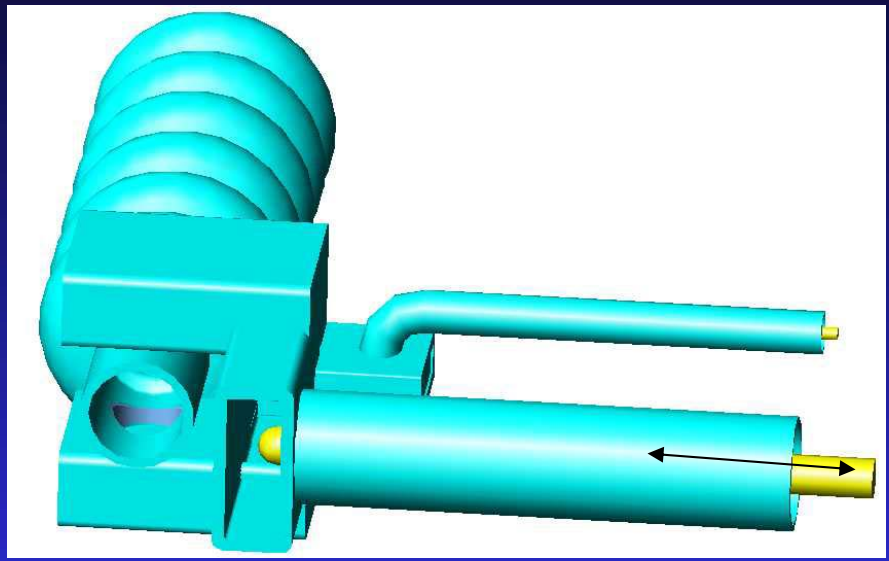


Main power

HOM coax

At the right –the holes are shifted azimuthally, the same coaxial used for evacuation of HOM

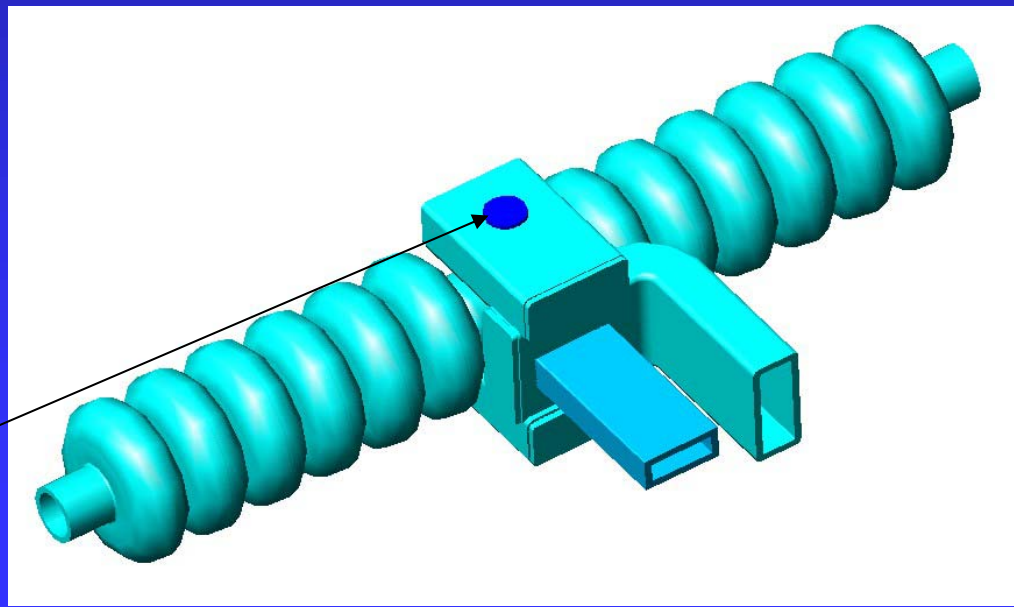
Magic T coupler with tunable coupling with coaxial input



Now as the coaxial has no direct view to the beam, it is possible to use it for coupling tuning.

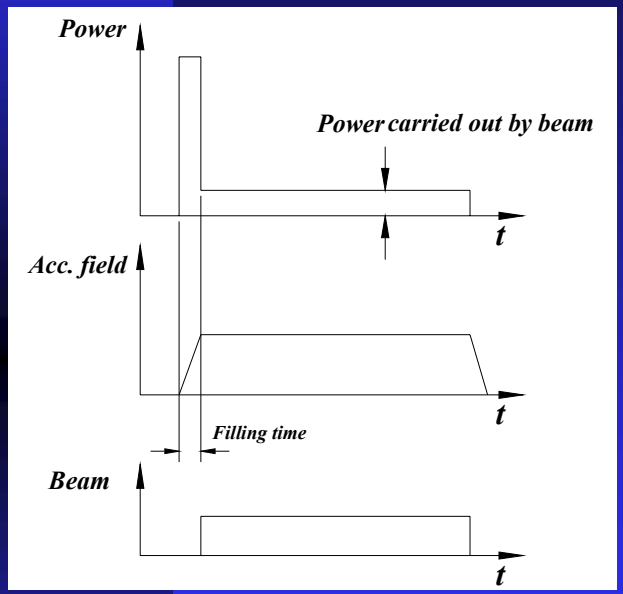
As the coupler can handle with high power it can be used for feeding of two structures

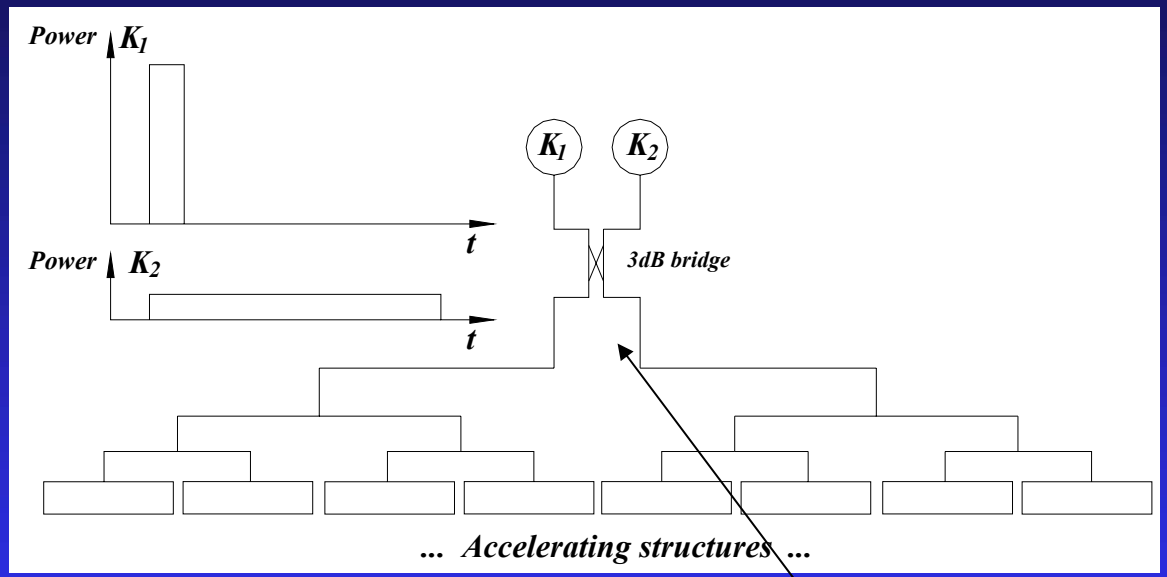
Mechanical tuning for evenly split power



As the coupler is an electric one, it allows high power input

RF filing scheme





At the beginning the power excides the one required for the steady beam acceleration;

Significant pump and reflection from structure at this moment

Two klystrons operated through 3 dB bridge used for profiled RF filling

CONCLUSIONS

Magic T coupler delivers electric (capacitive) coupling

Well protected from the beam excitations

Could be used for ramping the filling the structure by RF

This device effectively evacuates HOM also

REFERENCES

A. Mikhailichenko, "*New approach to design of SC NLC*", Cornell U., LEPP CBN 03-14, July 31, 2003.

A. Mikhailichenko, "*New approach to design of SC Linear Collider (II). RF Power input and Filling*", Cornell U., LEPP CBN 04-8, Oct. 1, 2004.