Trapped Modes for Measuring Ecloud

C.Y. Tan

21 May 2009

The Motivation

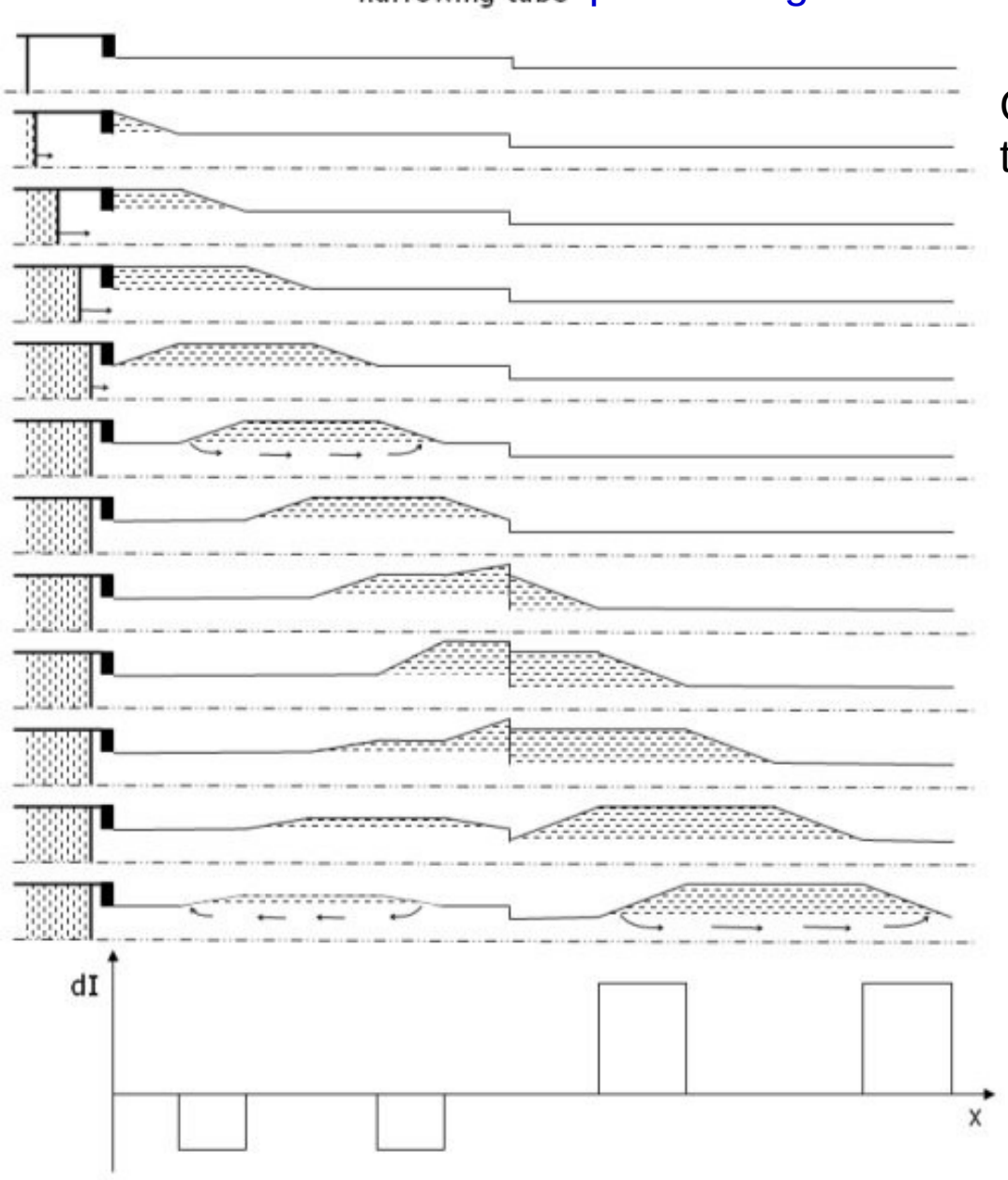
- The motivation is that the beam pipe which we will be installing is only 1m long for the measurement. Looking at the present data for 15m, the signal will be 23dB lower and it will be below the noise floor.

Possible Fix

- Instead of just passing through the ecloud once, use multiple reflections to pass through the cloud and thus increase the phase shift.

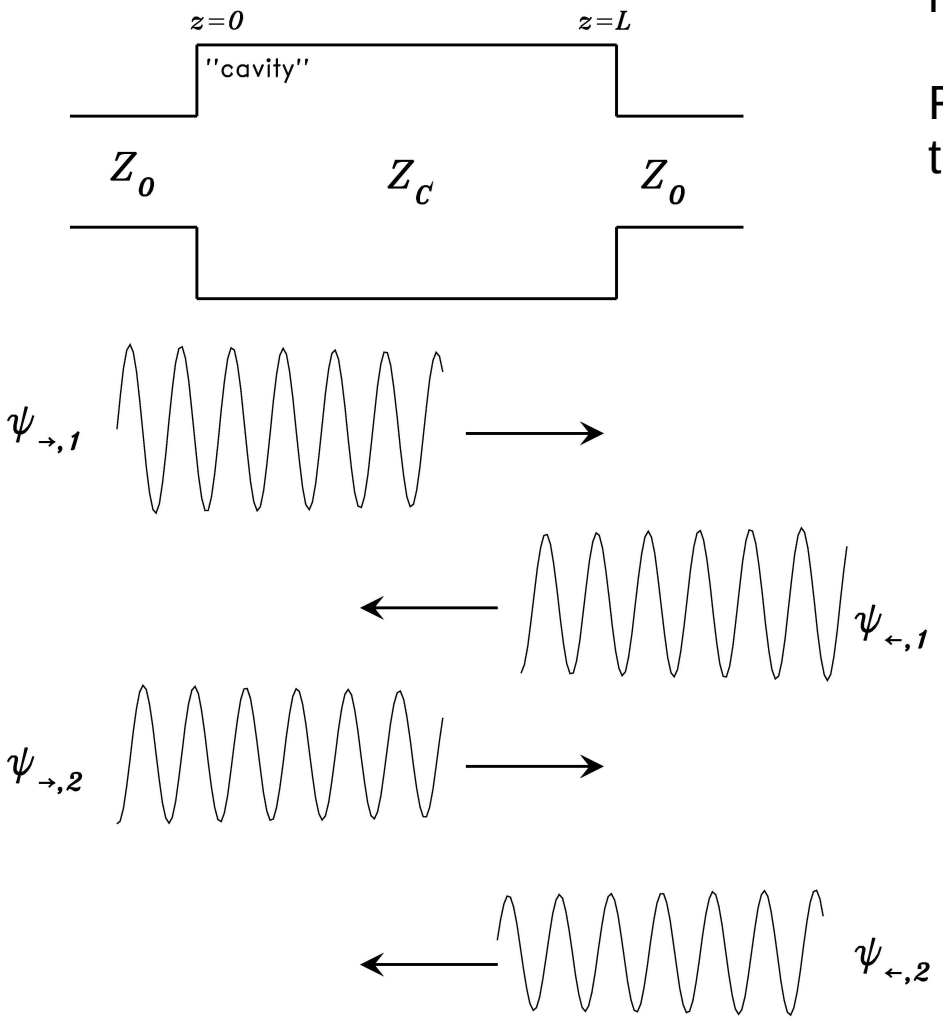
Conceptually

This is from http://www.bg.ic.ac.uk/research/intro_to_wia/wia-6-1.html



Of course, we will reflect multiple times to gain phase.

Calculate phase shift from reflected plane waves



Amplitude of plane waves determined by reflection coefficient.

Frequency of waves determined by mode of the cavity so that kL multiple of 2 pi.

Reflection coeff given by

$$R=\frac{Z_0-Z_C}{Z_0+Z_C}$$

Impedance of TE11.

$$Z_{\mathrm{TE}}=\frac{\eta}{\sqrt{1-\left(\frac{\omega_c}{\omega}\right)^2}}$$

η = 377 Ω.

Cutoff frequency, 6” OD cavity = 1.15 GHz,

10cm OD pipe = 1.76 GHz

Frequency is above cutoff

At steady state, the “amplification” in phase is a function of the reflection coefficient *R*.

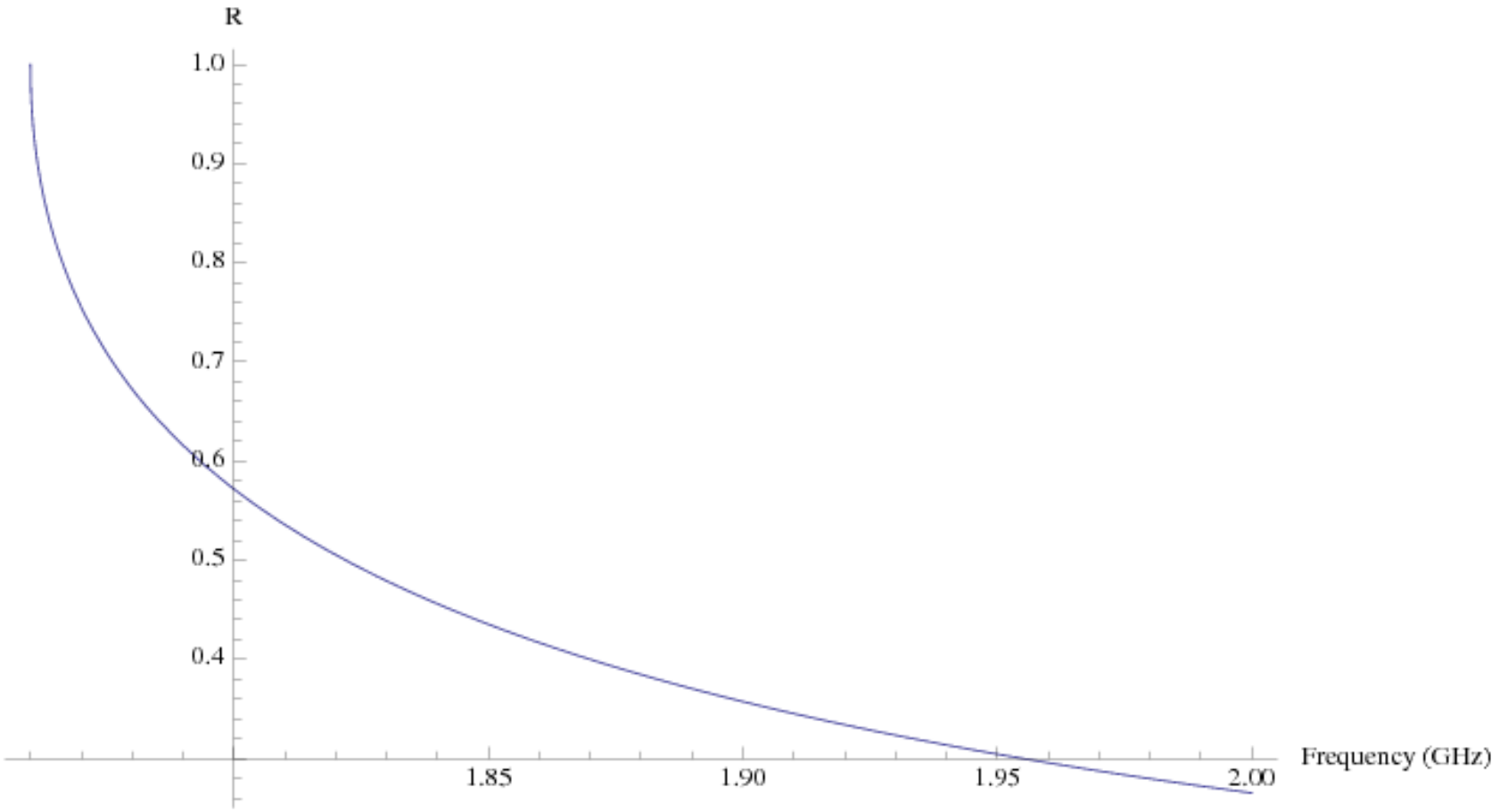
$$\Delta\phi = \frac{2R}{1-R^2}\phi$$

ϕ is the phase shift from the electron cloud.
$\Delta\phi$ is the amplified phase shift.
0<*R*<1 is real because the excitation frequency is above cutoff. NO CHANGE IN SIGN OF R for our geometry. See previous slide.

In particular for $\Delta\phi$ = 15 ϕ, *R* = 0.94.

This requires *f* = 1.76048 GHz or 1.76 GHz + 480kHz.

Reflection Coefficient Above cutoff of pipe (1.76GHz)



Method

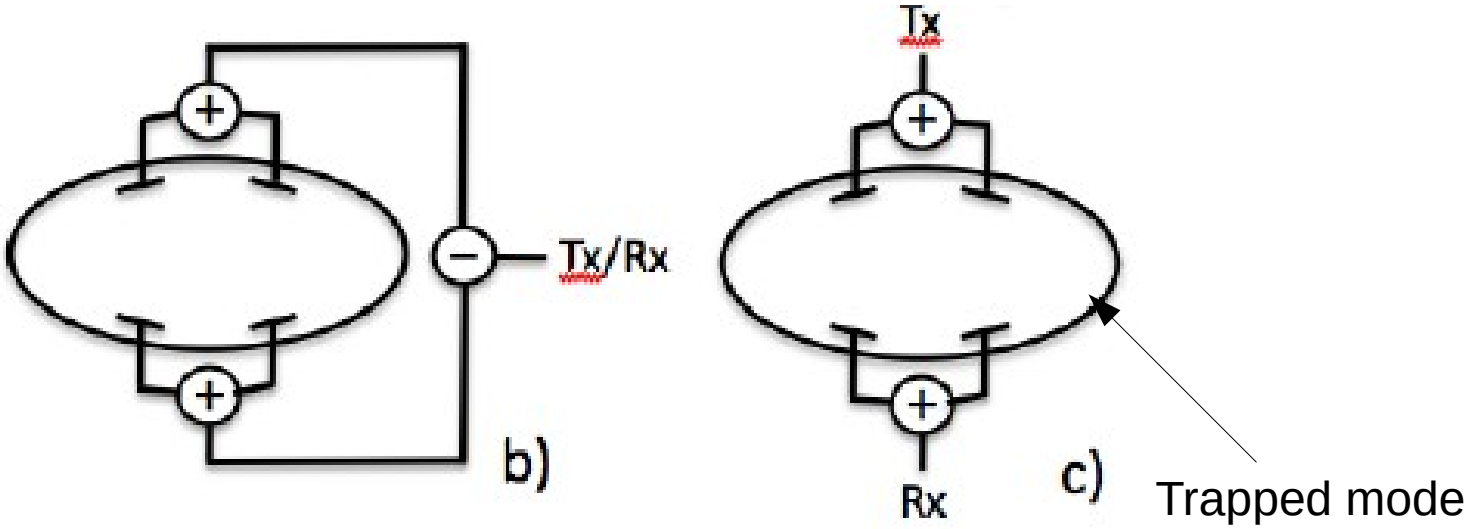
- Find a mode just above cutoff frequency of pipe (which will be above the cutoff frequency of the cavity). Must be mode because I want $kL = 2n\pi$.
- Mode is must be a low Q mode.
- Measure phase shift w.r.t. excitation.

Will it work?

- Conceptually, it should. Good news is that Stefano de Santis at LBNL has already done this!
- My maths is always a suspect.
- Can we test it now in the MI?
- Should we make this the primary method for our upcoming test?

LBNL has done this but not what I had described

- Seems to be a trapped mode that is evanescent outside the BPM plates.
- This seems contradictory to me! Smaller distance means higher cutoff, this means that wave should move down the beam pipe!



From de Santis, PAC2009.

LBNL Measurements at CESR-TA