“Matching” Coupler to Cavity

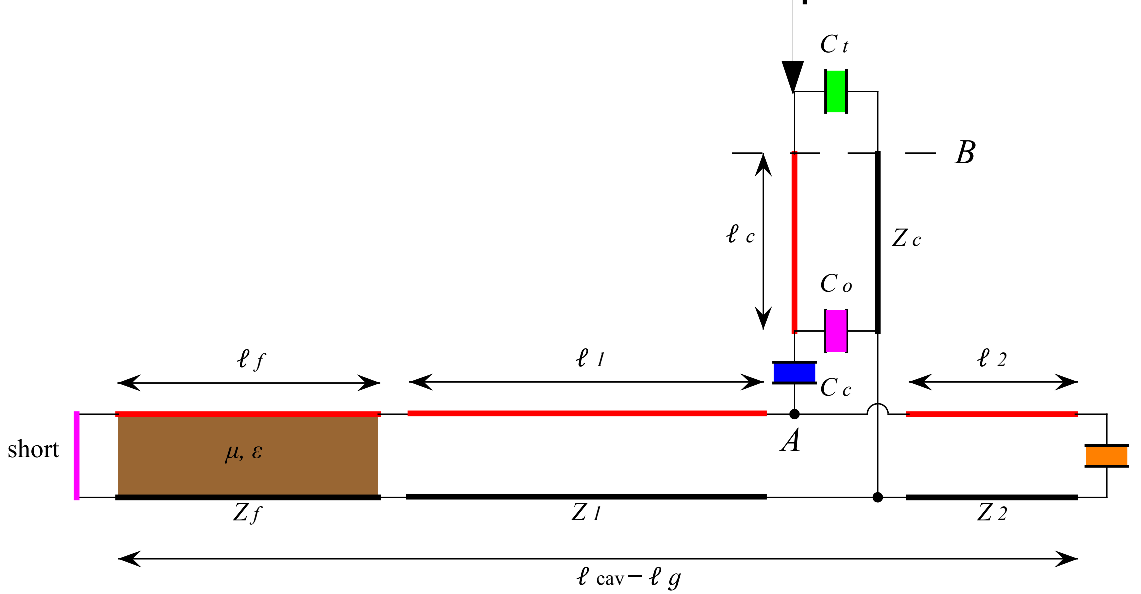
C.Y. Tan
21 July 2015

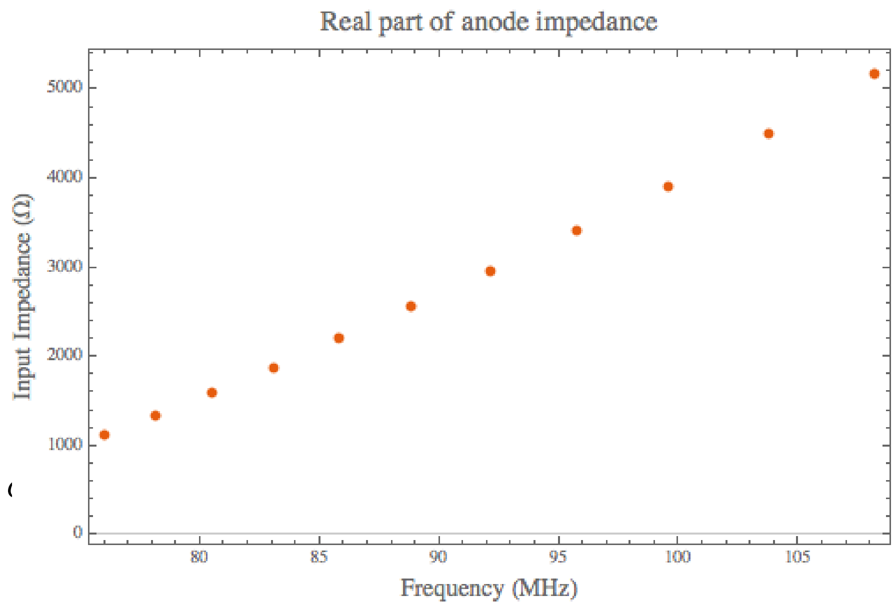
What does “matching” mean?

- In our case, we are strongly coupled which means that the entire structure is resonating.
- I am only considering “matching” at 76 MHz
  - Impedance seen at the power input point will change as resonant frequency changes. I am going call the impedance at this point as the “input impedance”
- Matching means that the input impedance must be real (or have a very small imaginary part) and lie in the range 1.2 kΩ to ~5 kΩ
  - In particular, @76 MHz, it should be 1.2 kΩ.
- 60 pF capacitor at the input point must be **fixed** and cannot be varied.
  - 60 pF is the anode to screen capacitance and does not change.

Location of RF input plane

Impedance seen
at this point





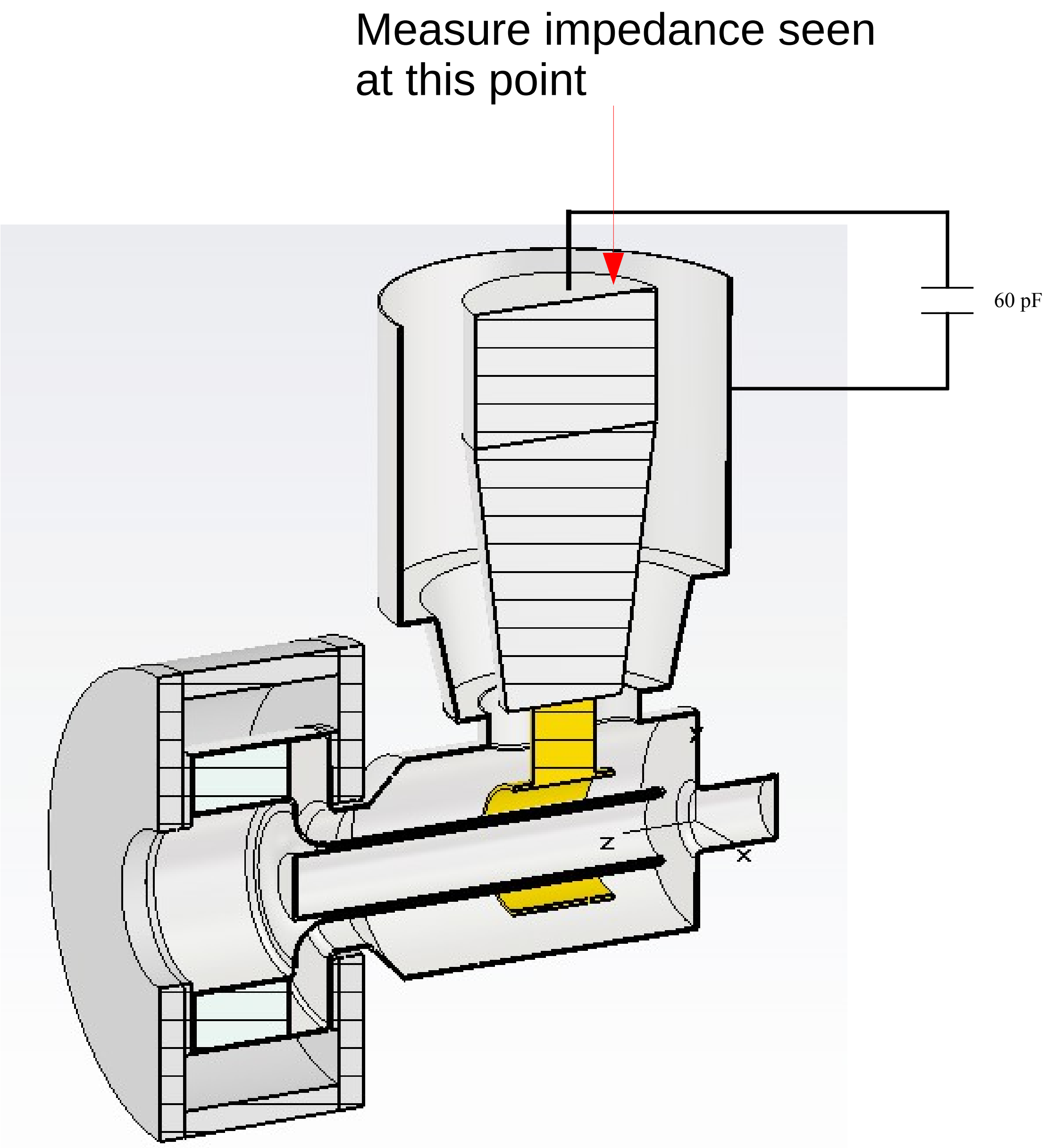
Note that the real part of the input impedance changes as a function of resonant frequency.

What is s11? See next page.

What is S11?

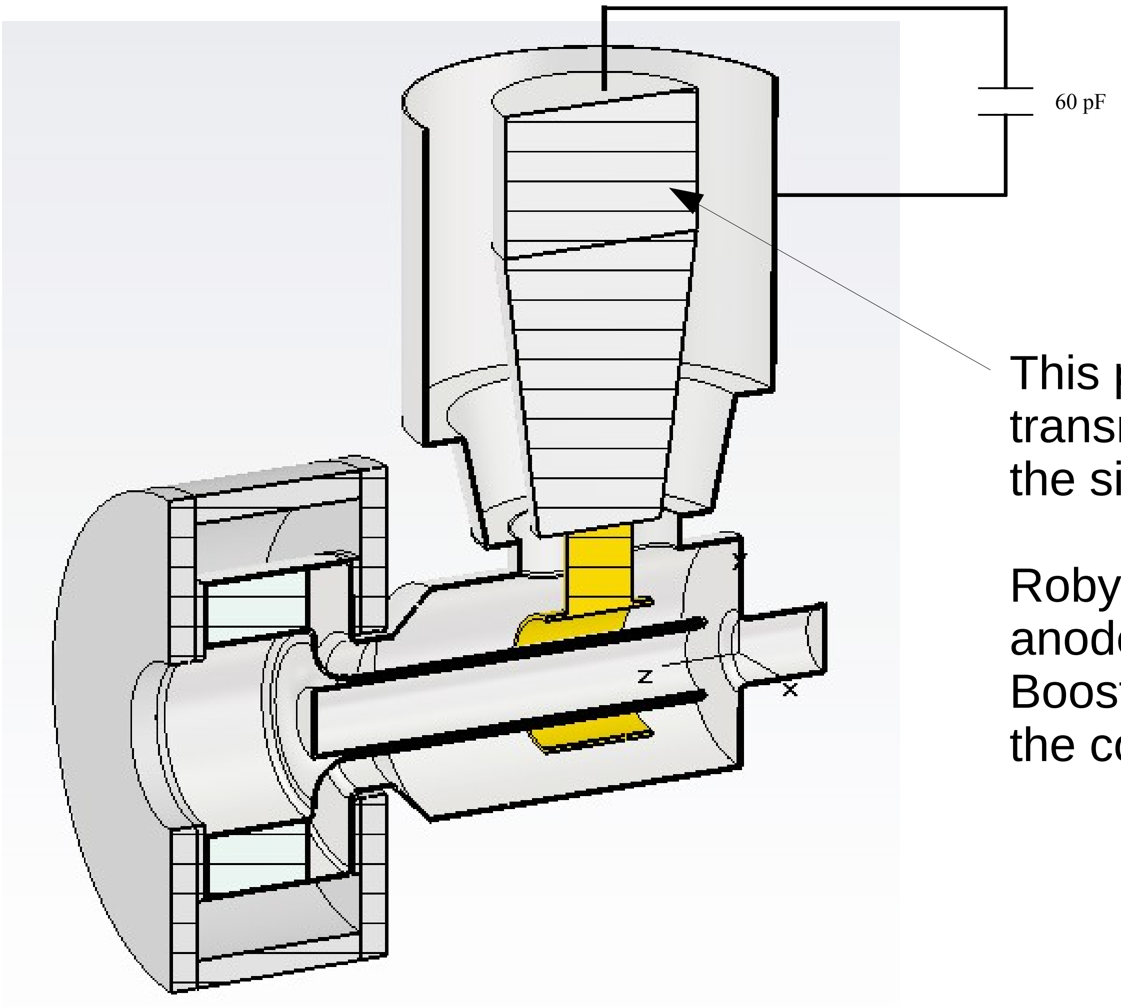
- Definition of s11 = (Z0-ZL)/(Z0+ZL)
- The tube will “move” its operating point in such a manner as to change its impedance. Therefore,
  - ZL is the ENTIRE cavity+power coupler + 60pF.
    - At 76 MHz, ZL = 1.2 kΩ
  - The tube will “move” in such a manner as to accommodate the impedance seen at the impedance point, i.e. it becomes the input impedance
    - 1.2 kΩ is very efficient for the tube. (72%, c.f. 75% theoretical efficiency)
    - 6 kΩ is not as efficient but is acceptable (67%)
  - For MWS simulations: Z0 should **not** come from the power coupler!!! It should be from the cable that connects the “network analyzer” to the impedance measuring point.
    - And at 76 MHz, for s11=0, Z0 = 1.2 kΩ, i.e. Z0 of the connecting cable is this value and **not** 50Ω.

In MWS



- Adding the coupler **will** *lower* the resonant frequency of the cavity.
- Transmission line simulations show that when cavity **with** coupler resonates at 76 MHz, this frequency goes to 90 MHz when the coupler is **removed**
- Since adding the coupler can shift the frequency by ~20 MHz, the cavity needs to be re-optimized to get back to 76 MHz.
  - In transmission line model, the length of the garnet is changed. The reduction is ~1 cm in transmission line model.
  - Therefore, in MWS, some physical parameter like the length of the garnet needs to decrease to get the frequency back to 76 MHz and not the 60 pF capacitor that represents the anode to screen capacitance.

Required part in MWS simulations



This part, the anode part of the transmission line must be included in the simulations.

Robyn found that without this part the anode resonator that is used for the Booster cavities does not resonate at the correct frequency.

Suggested procedure for optimization

- Add in coupler with 60 pF anode to screen capacitor.
- Re-optimize length (or some other physical parameter, like gap length) to get the entire structure resonating at 76 MHz
- Calculate the input impedance. It should look like 1.2 kΩ.
  - If it does not, change length of coupling capacitor.
- Change the bias field and calculate the input impedance to 106 MHz. It should be in the range 1.2 kΩ to ~5 kΩ.