intensity-sensitive and position-resolving cavity

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- Why is that needed?
- How to make one?
- How is the performance?

07.10.2015, Seville, Spain

principle of nuclear mass measurements

$$\frac{\delta f}{f} = \left(\frac{1}{\gamma^2} - \frac{1}{\gamma_t^2}\right)\frac{\delta p}{p}$$

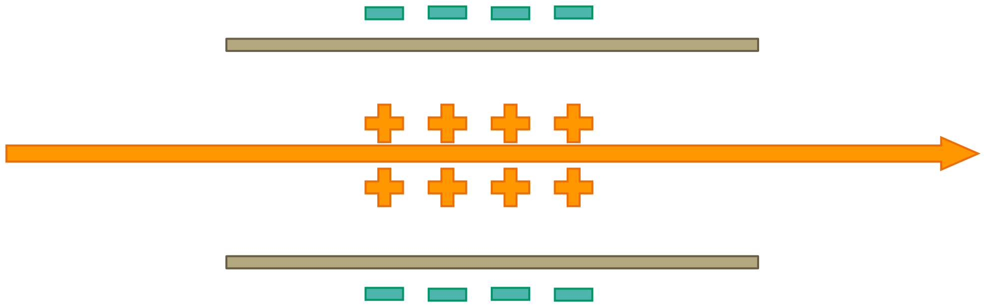
$$B\rho = \frac{p}{q}$$

$$\frac{\delta f}{f} = -\frac{1}{\gamma_t^2}\frac{\delta(m/q)}{(m/q)}$$

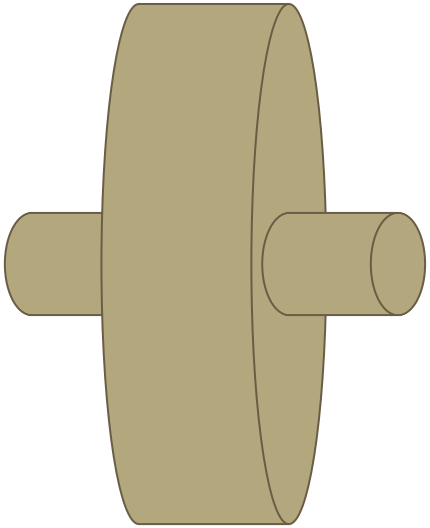
storage ring as a mass spectrometer

tune the ring to the isochronous mode, i.e. operate at the transition energy

signal pickup device, e.g. capacitive plates



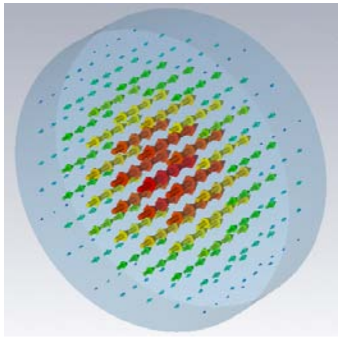
RF cavity

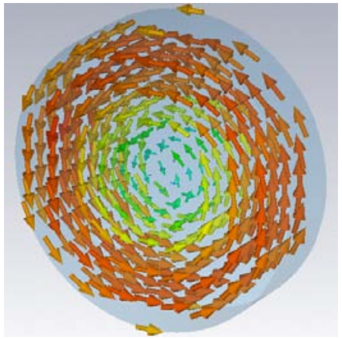


resonant frequency ω_0

quality factor $Q_0 = \frac{\omega_0 W}{P_l}$

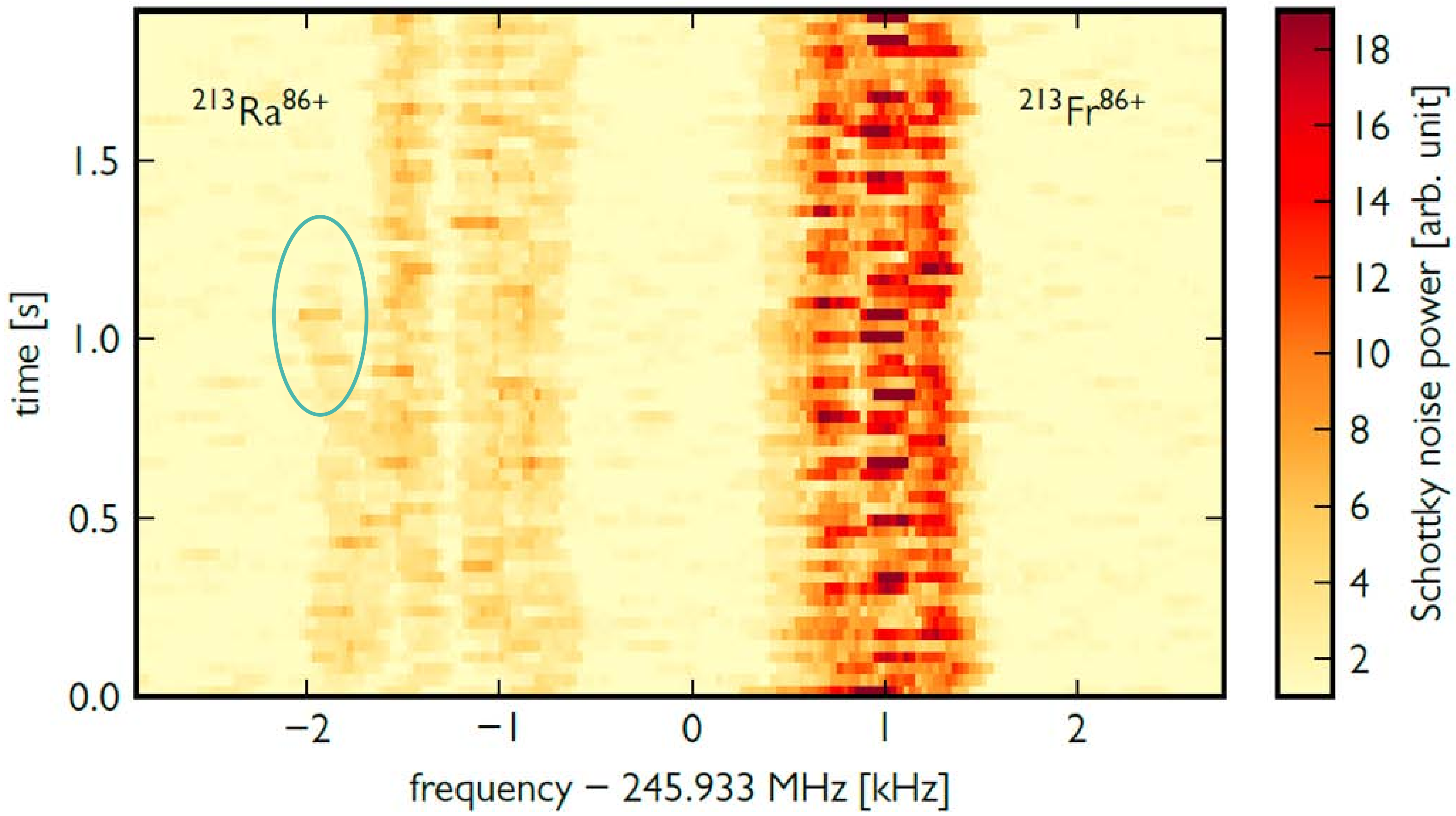
shunt impedance $R_s = \frac{(\int \mathrm{d}z E_z)^2}{P_l}$





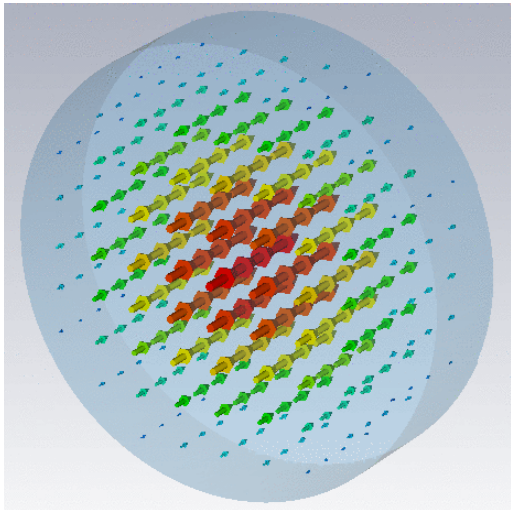
$$\frac{R_s}{Q_0} = \frac{(\int \mathrm{d}z E_z)^2}{\omega_0 W}$$

single-ion sensitivity



anisochronism effect

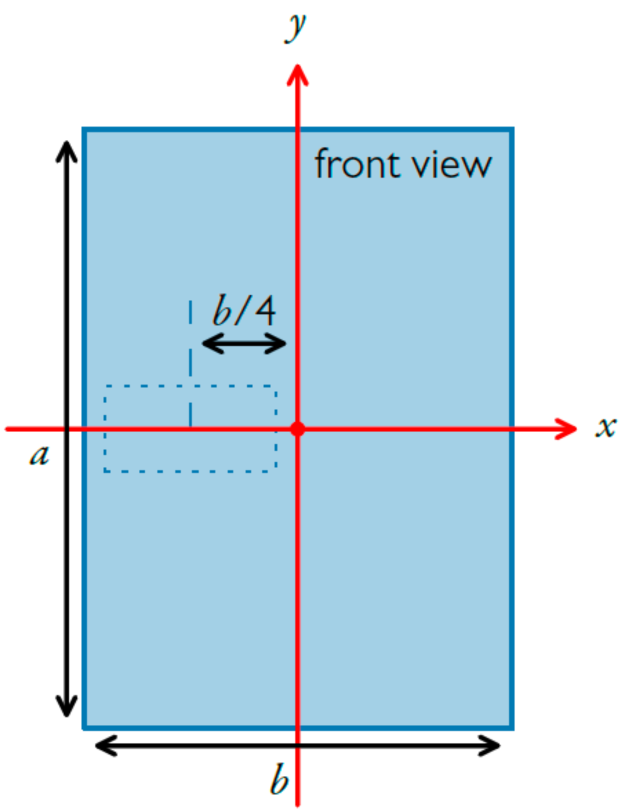
$$\frac{\delta f}{f} = -\frac{1}{\gamma_t^2}\frac{\delta(m/q)}{(m/q)} + \left(1 - \frac{\gamma^2}{\gamma_t^2}\right)\frac{\delta v}{v}$$



In order to minimize systematic errors, position detection is needed to correct for the anisochronism effect.

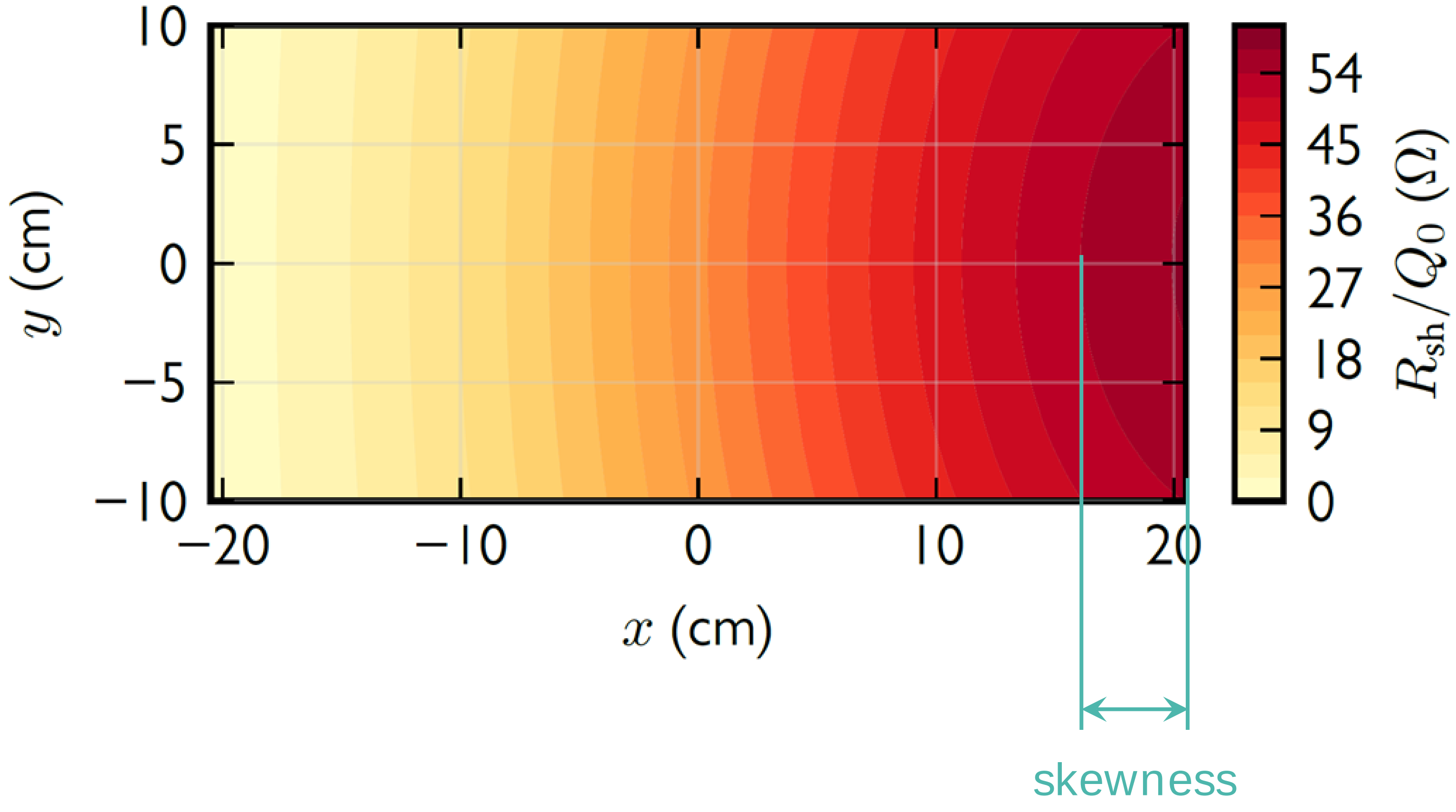
$$\frac{R_s}{Q_0} = \frac{\left(\int \mathrm{d}z E_z\right)^2}{\omega_0 W}$$

rectangular cavity

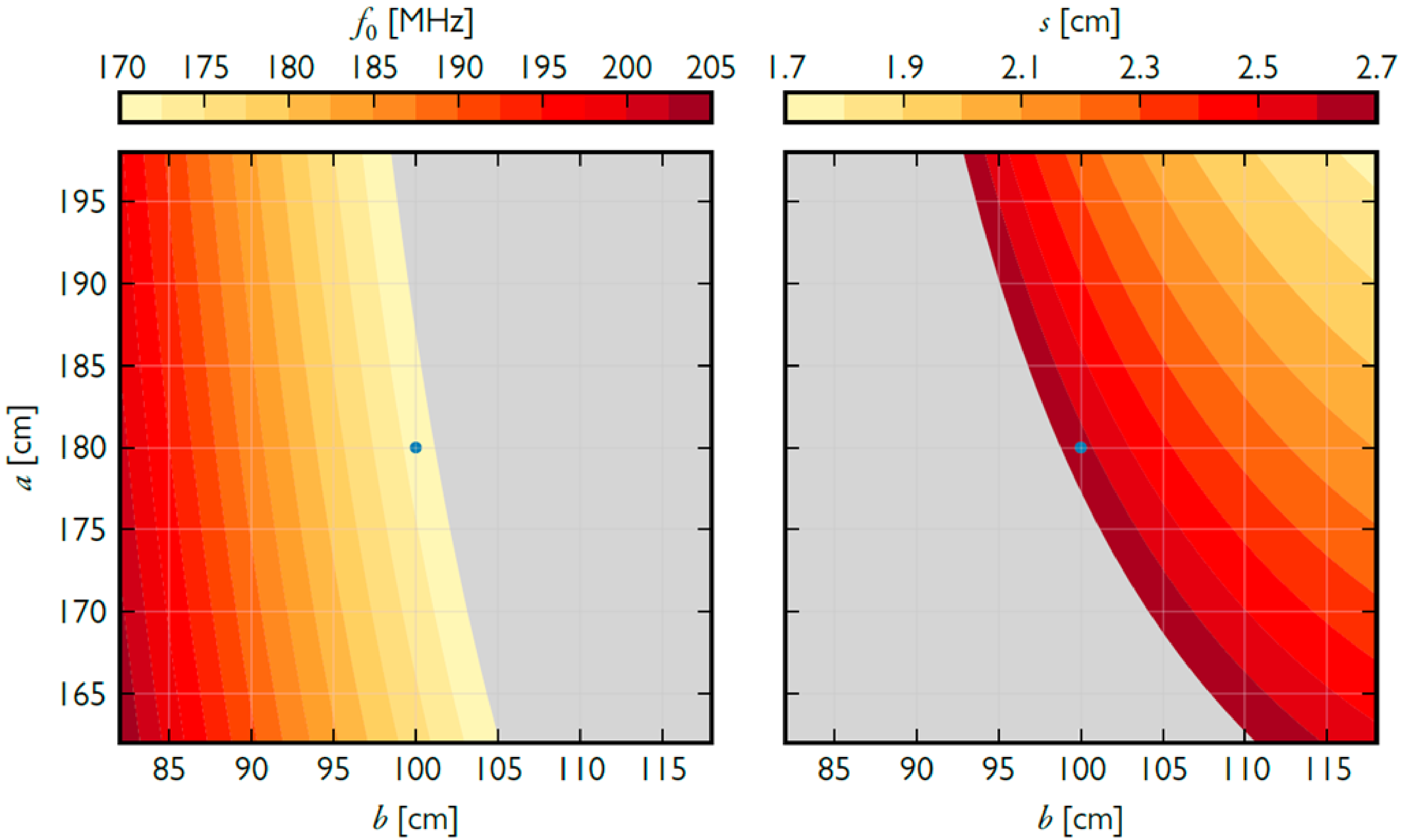


shunt impedance map

shunt impedance in the aperture region is a 2D function of the coordinates of the transverse cross section

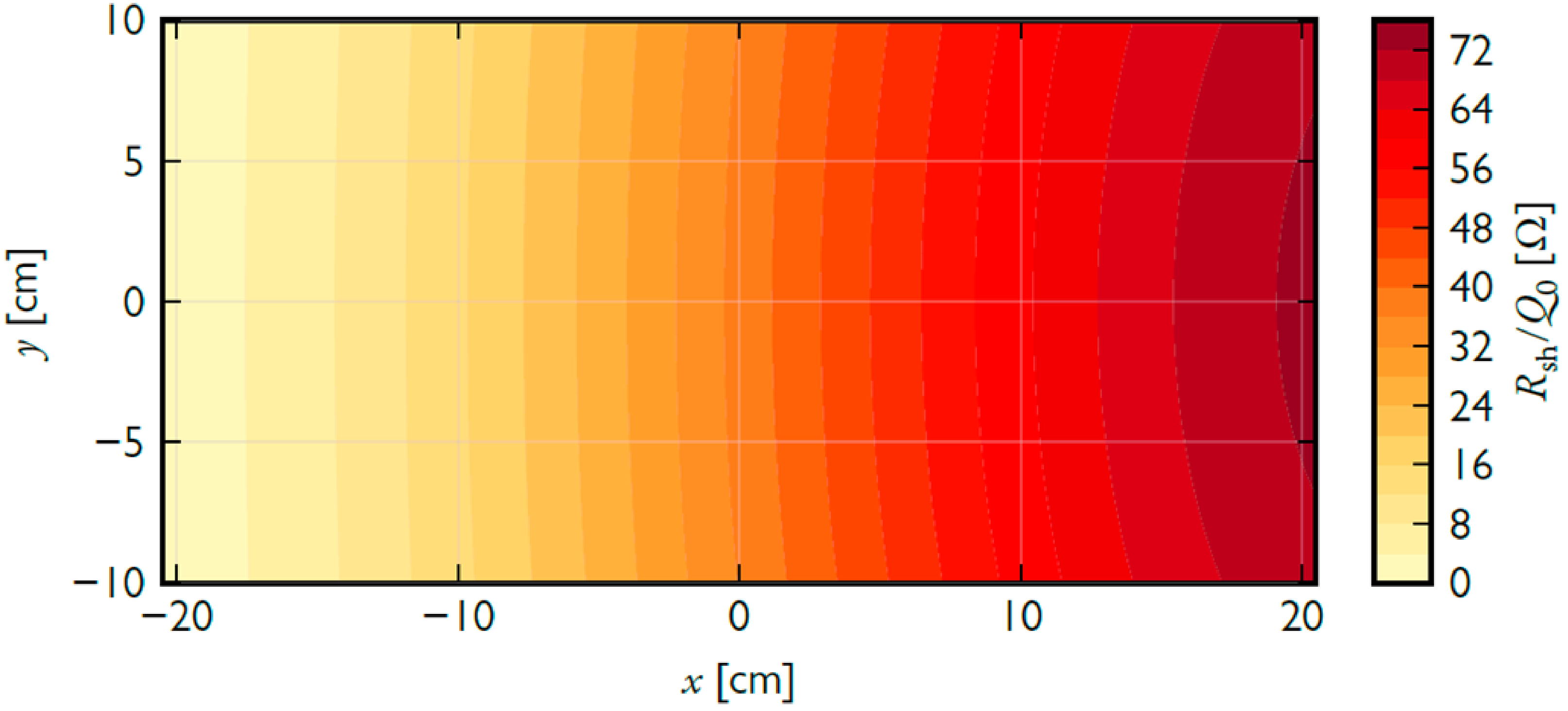


dependence graph

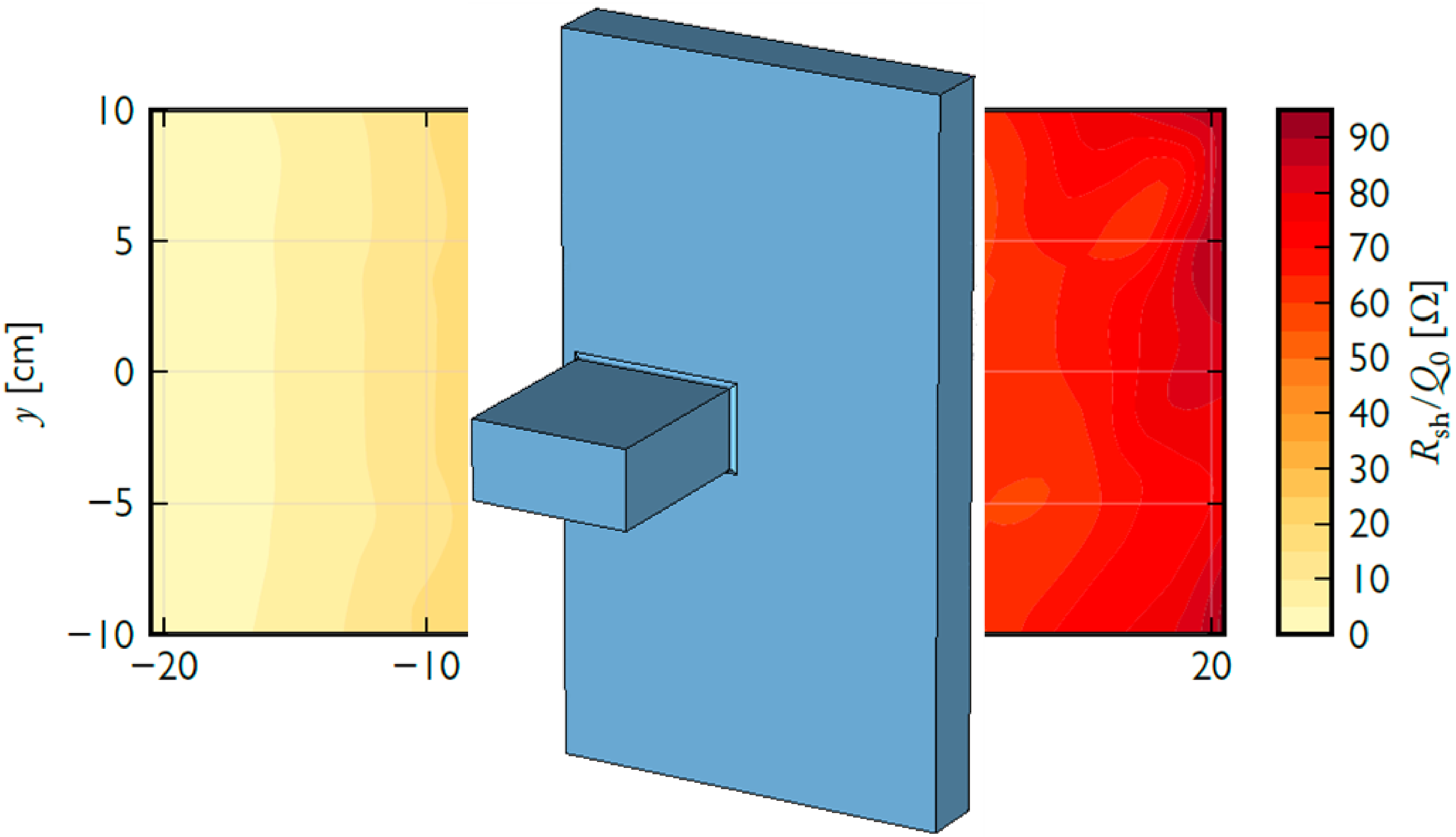


calculated shunt impedance

a = 180 cm, b = 100 cm, d = 16 cm

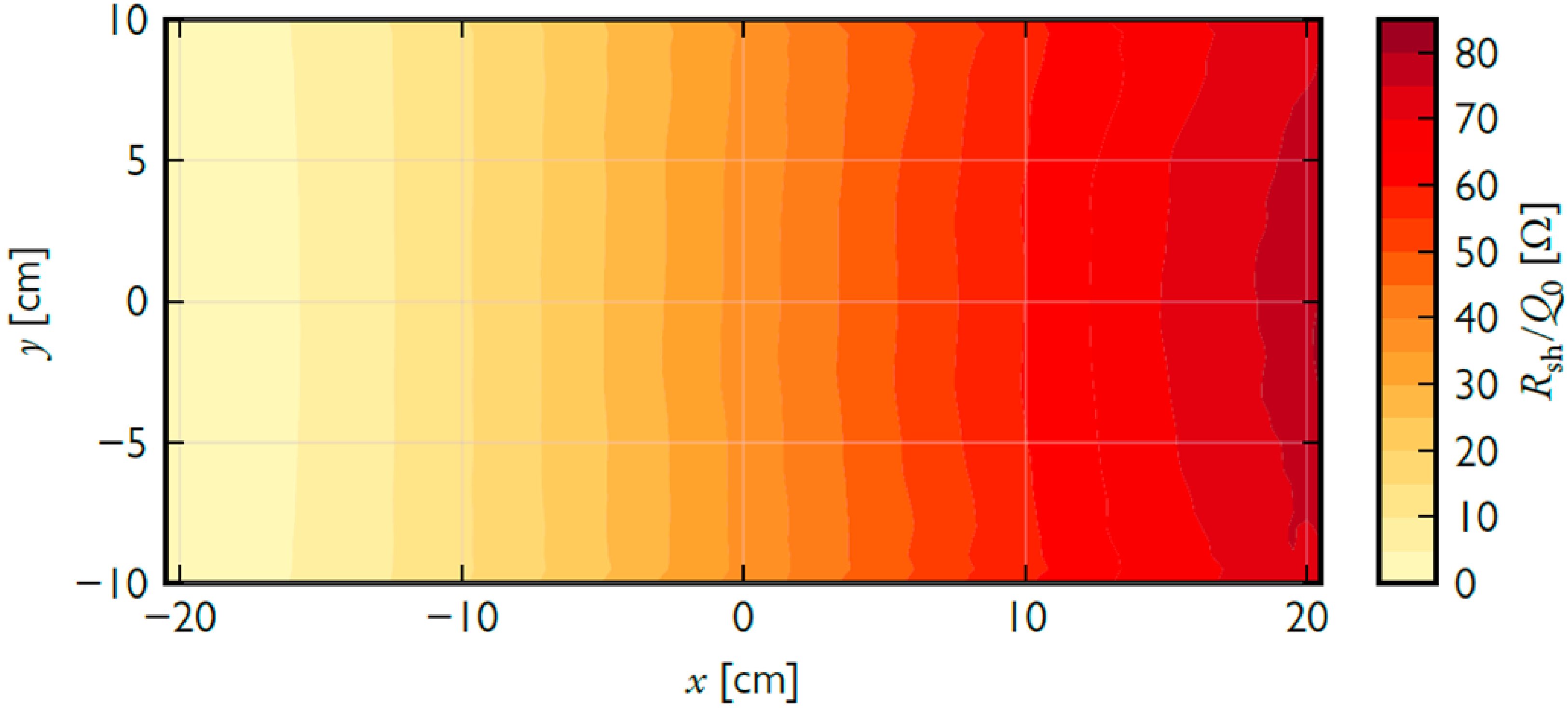


after pipes are attached...



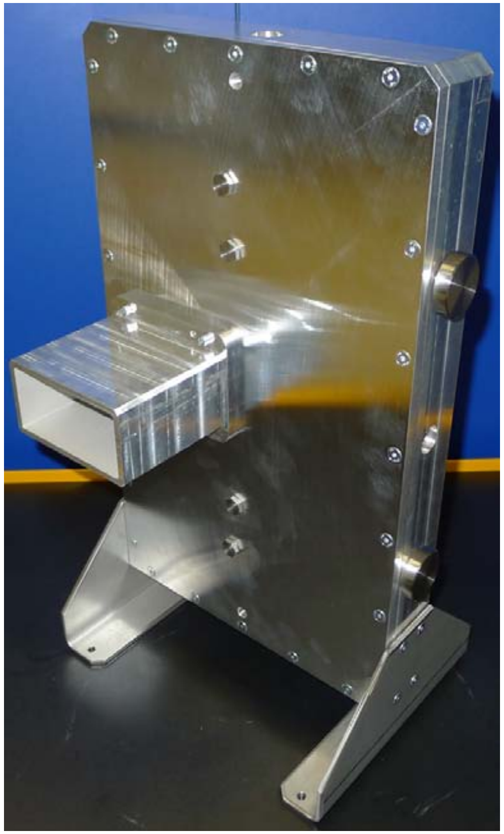
simulated shunt impedance

the edges are rounded by 1.2 cm



benchtop test

prototype cavity, scaled down by 4



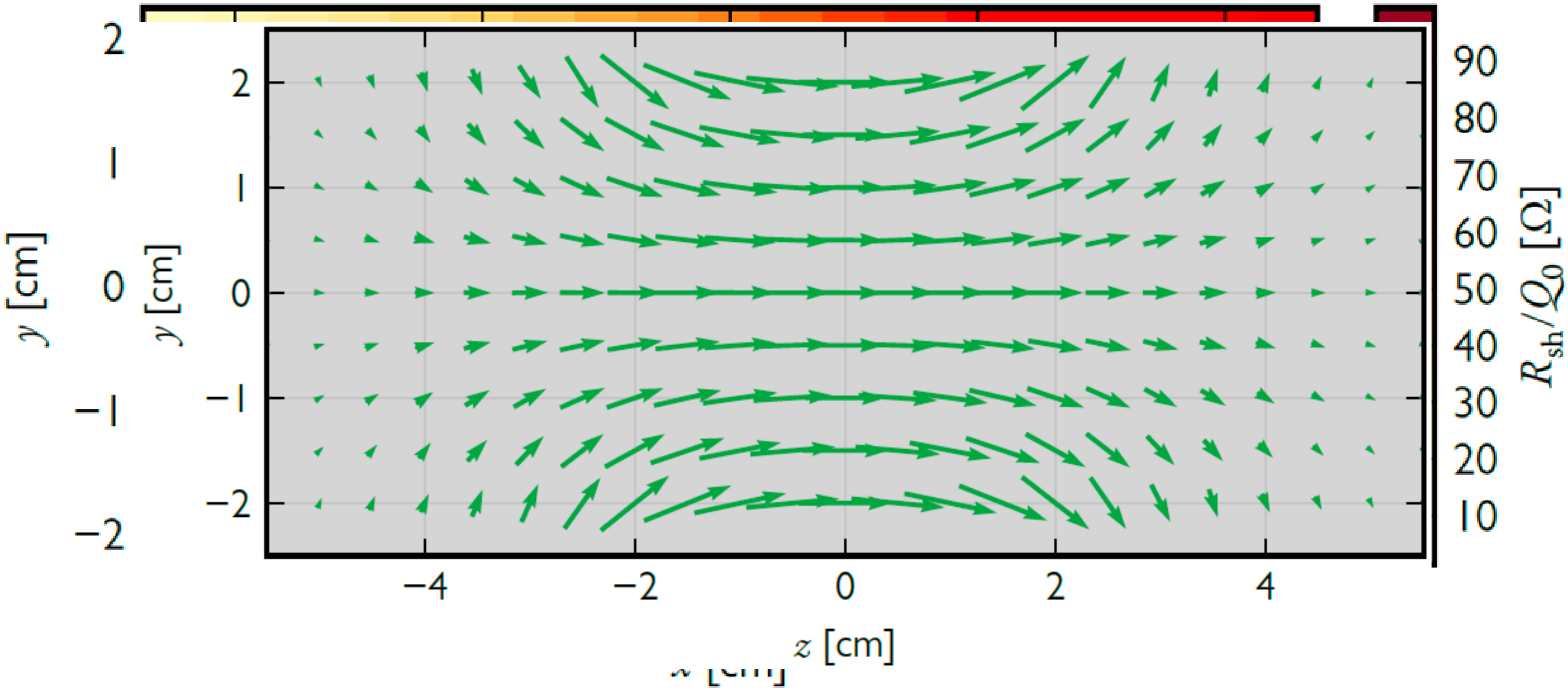
bead-pull perturbation method

$$\frac{\Delta f}{f_0} = -\frac{\alpha_b E^2}{W}$$

test bench setup

measured shunt impedance

lateral excess is due to an artifact of the perturbation method



$$\frac{\Delta f}{f_0} = -\frac{\alpha_b E^2}{W}$$

$$\frac{R_s}{Q_0} = \frac{\left(\int \mathrm{d}z E_z\right)^2}{\omega_0 W}$$

conclusion

- Why is that needed?

  to correct for the anisochronism effect

- How to make one?

  offset the pipes in the horizontal direction
  stretch the cavity in the vertical direction

- How is the performance?

  looks promising
  awaiting beam time

Thank you!

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design specifications

objective:

mass resolving power of the order of **10^6** within a short period of **20 ms**

requirements:

frequency resolution

$$\delta f = 50 \text{ Hz}$$

resonant frequency

$$f_0 = \frac{\gamma_t^2 m \delta f}{\delta m} = 169.28 \text{ MHz}$$

shunt impedance

$$\frac{R_s}{Q_0} = 37.7 \ \Omega$$