Losses in Loudspeakers

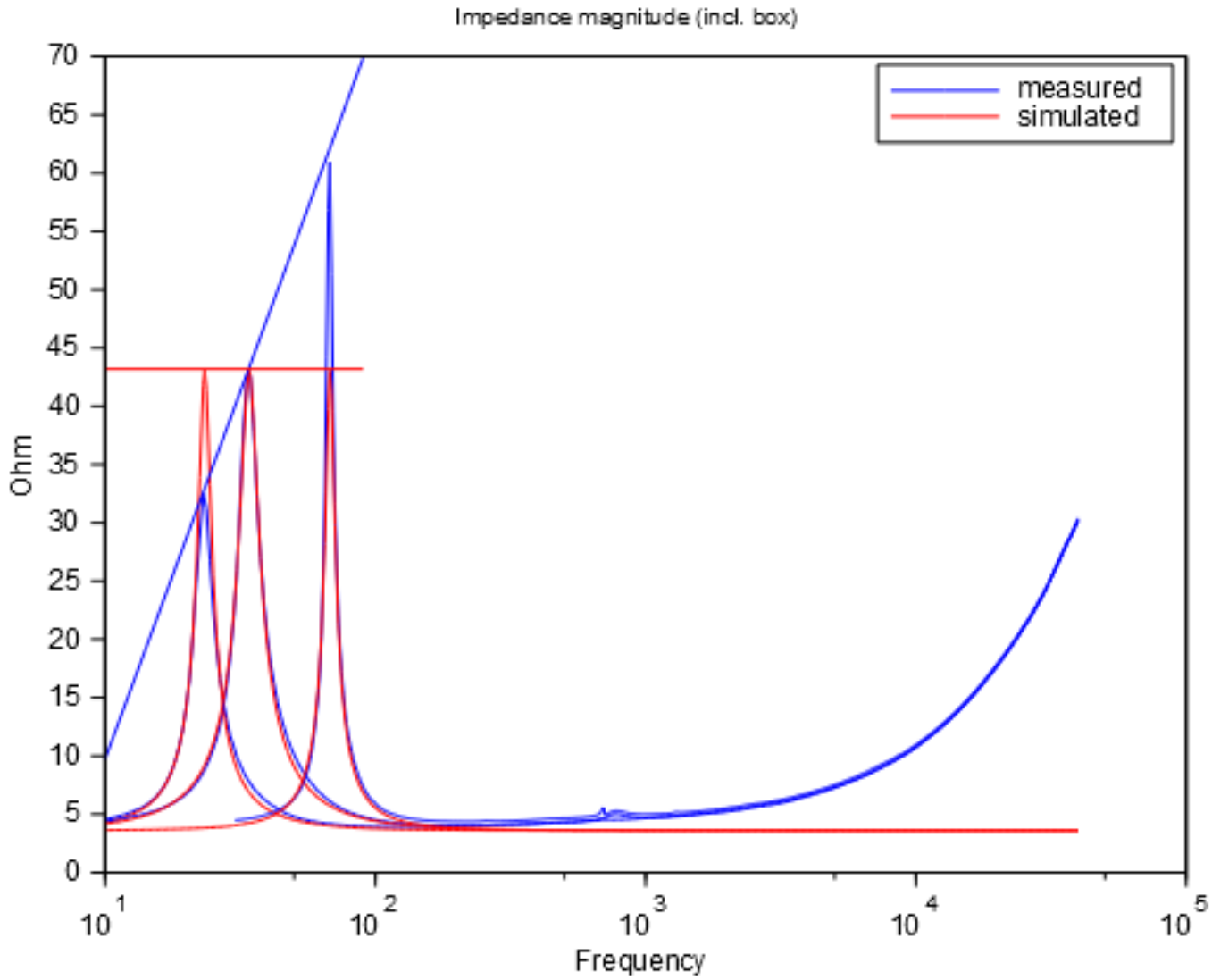
Claus Futtrup, MSc M.E.
Chief Technical Officer

Traditionally loudspeaker designs are simulated with electrical equivalent circuit following the Thiele/S

To see how good or bad the model is, let's build a box and measure, then compare to simulations.

Test box - essentially lossless:

3 measurements, compared to 3 simulations (Thiele/

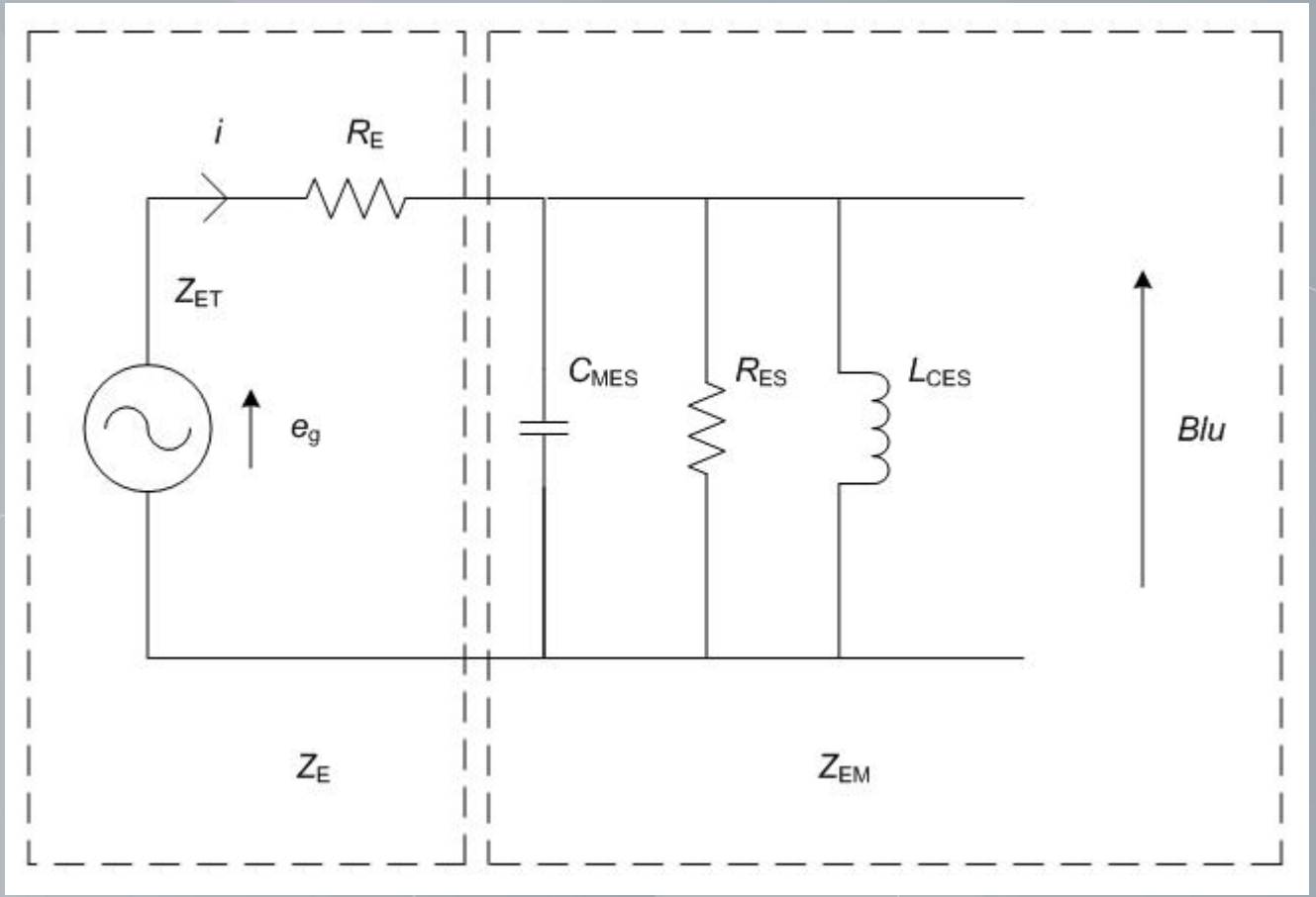


Simulations do not match real-world at all!

Why not?

What shall we

do about it?



Richard Small on Ql, Qp and Qa - conclusions

Qp – between 50 and 100

Qa – typically 100 or more

Ql – between 5 and 20

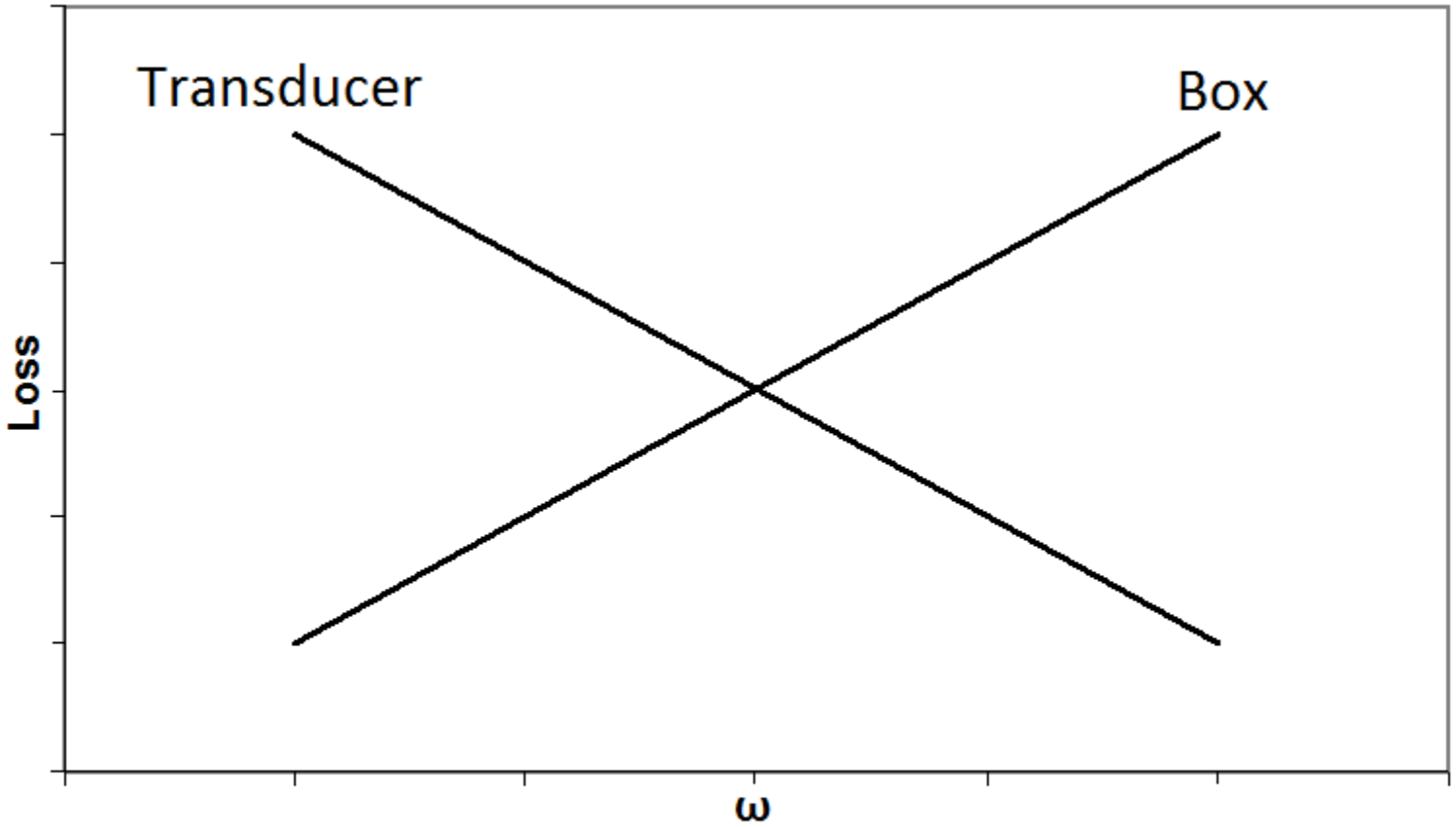
Link to paper (PDF) page 5

Small is looking for an explanation in the system enclosure – but the actual cause shall be found in the transducer.

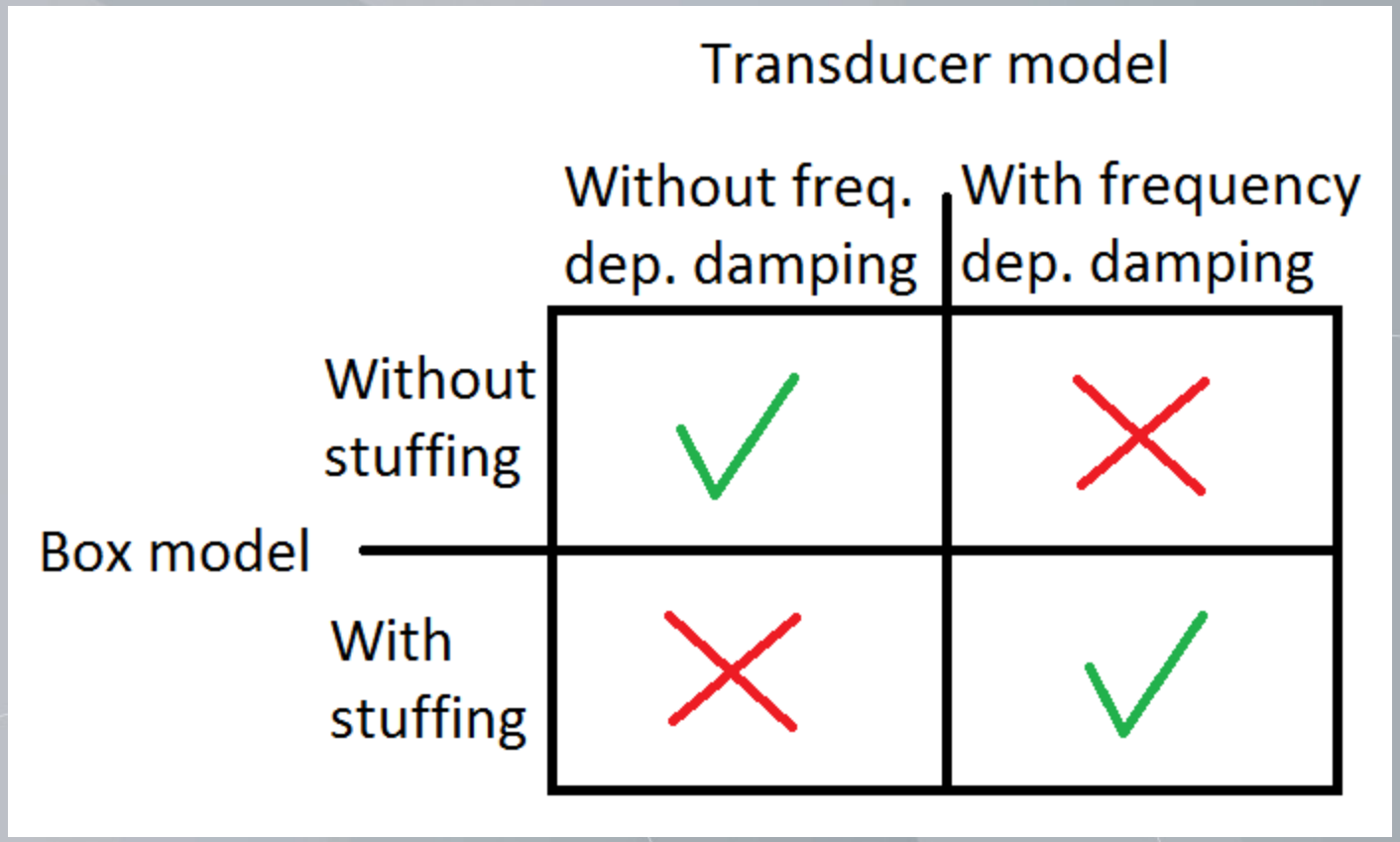
Quote: The last result is surprising, because the enclosure tested well built and appeared to be leak free…

Quote: … leads to the conclusion that the measured leakage in apparently leak-free systems is not an error of measurement but an indication that the actual losses in the system enclosure is not constant with frequency…

Losses, Ql = ? : A mix of Qa and transducer admittan



Good vs. bad models



The conclusion is valid for all models, also State Variable Models, Finite Element Models, et

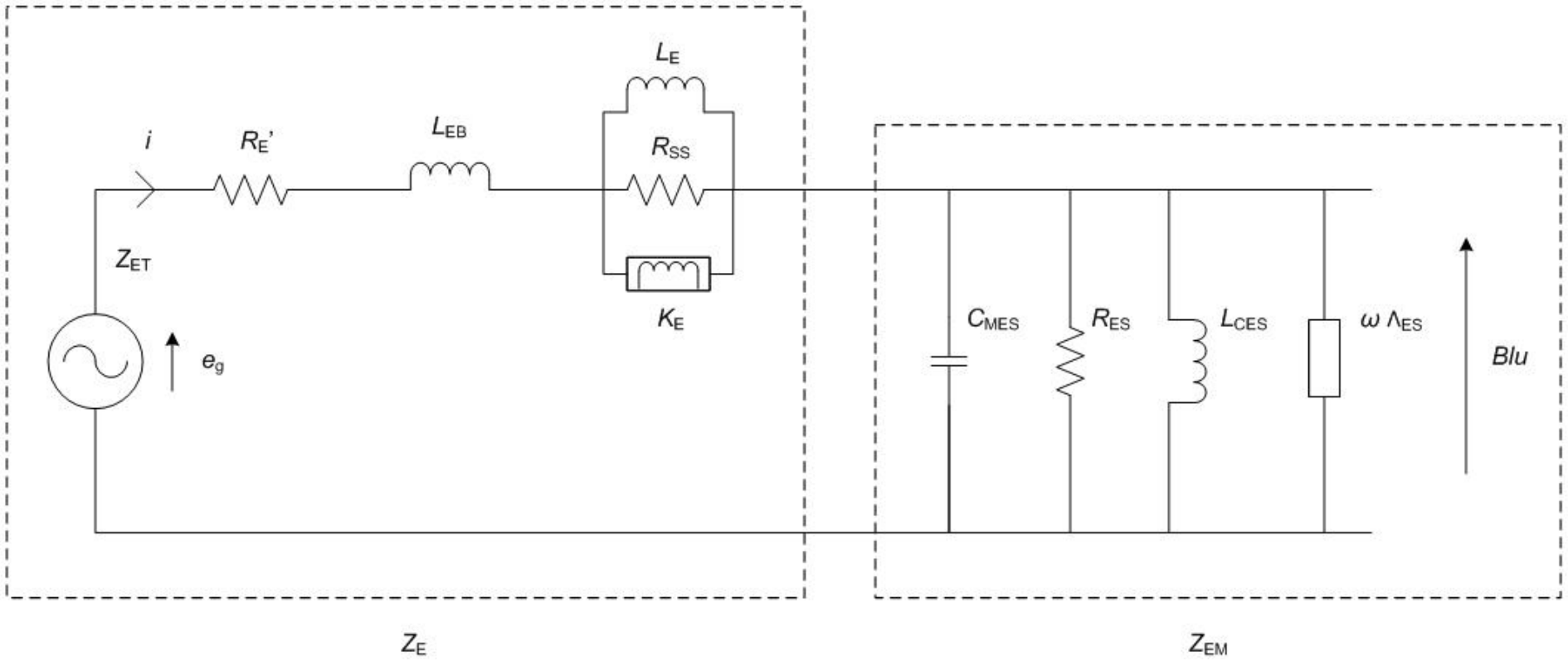
The end.

Questions?

For more info see: http://www.cfuttrup.com

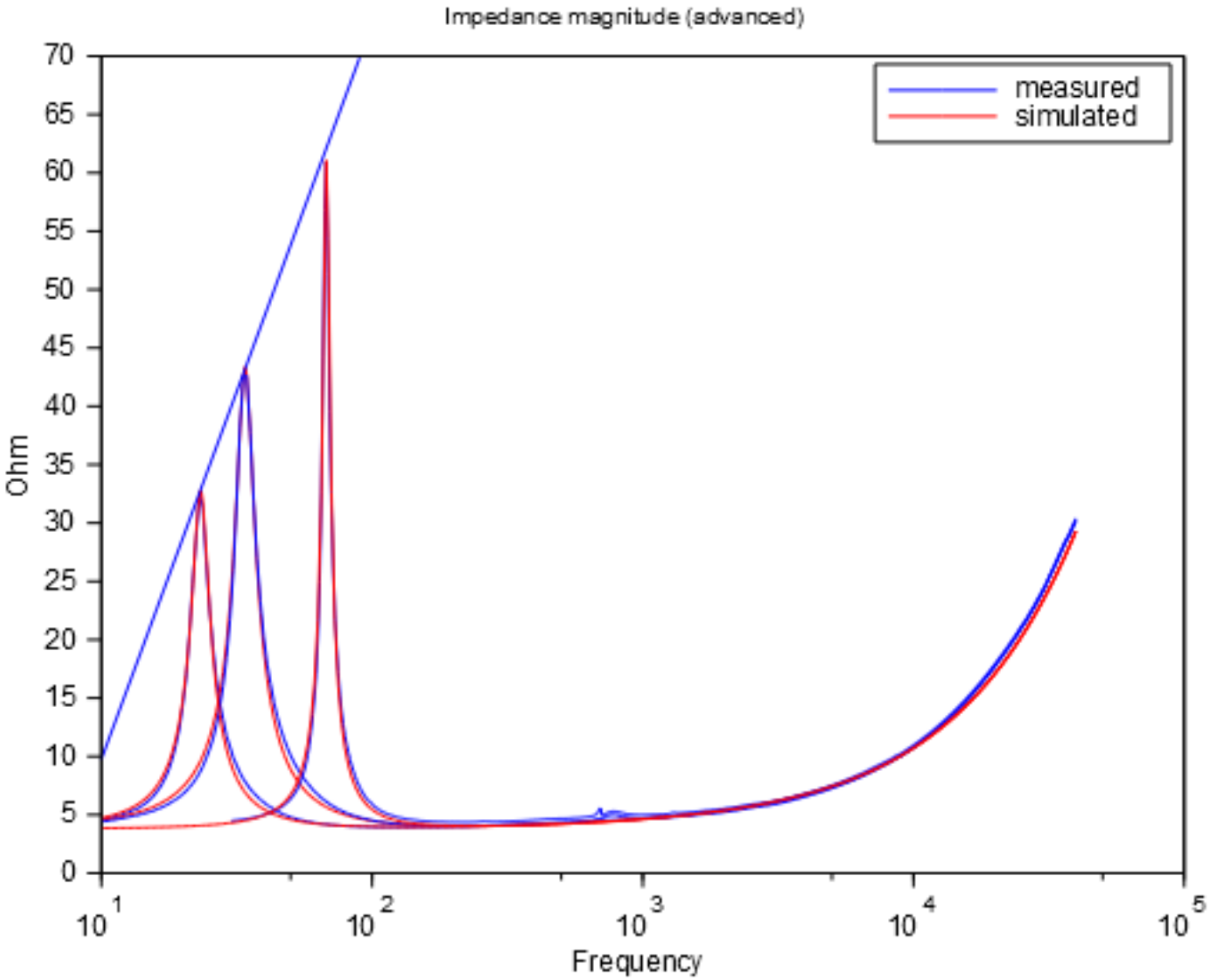
(I have some "bonus" slides, if we have time)

Transducer model including frequency dependent dampi



Model proposed by Thorborg and Futtrup

Measurements and simulations - using the proposed mo



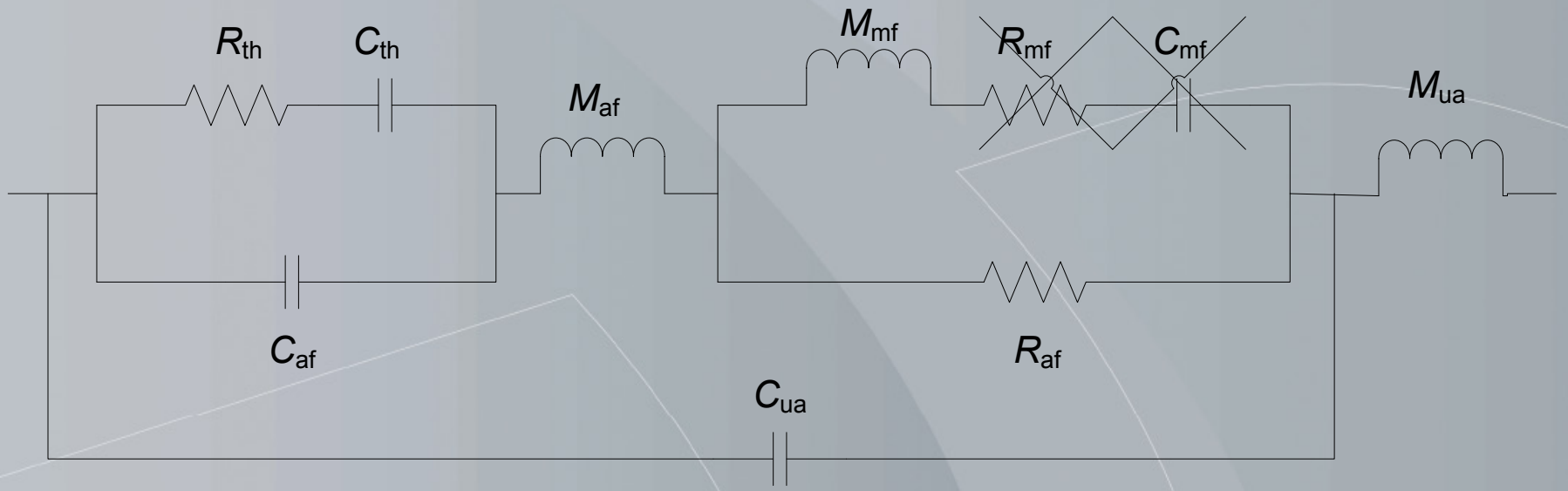
What does the box model look like?

When the transducer includes frequency dependent dam
then the box model must include effects of damping m

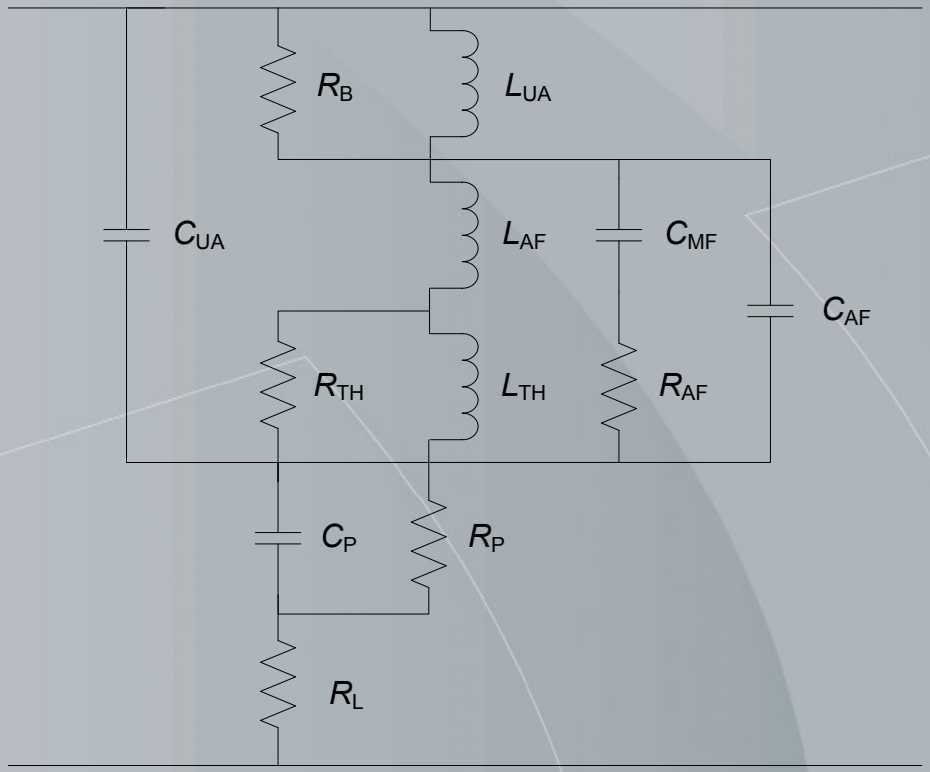
Source:
http://www.aes.org/e-lib/browse.cfm?elib=15791

Link: (PDF)

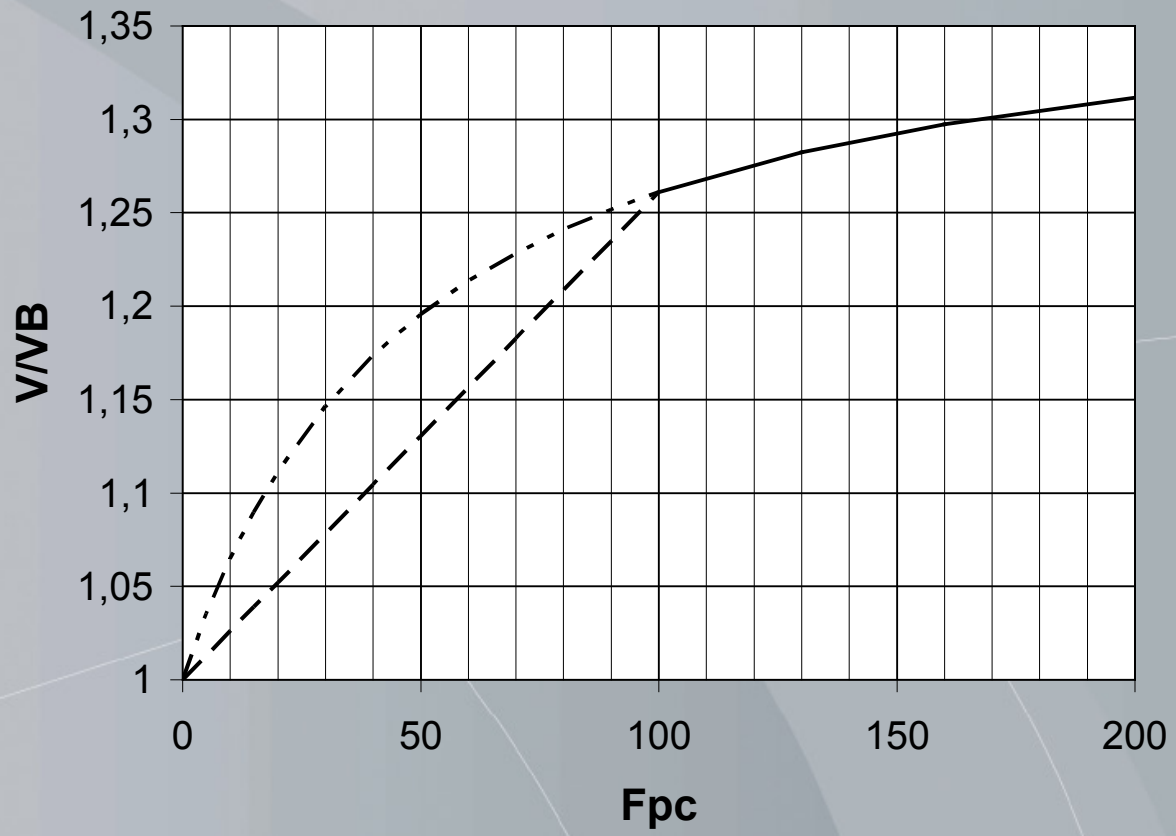
Model of damping material (mechanical domain)



Box mode, Electrical Equivalent, with Rb



Volume expansion graph



Mechanical model, Tarnow

$$R_f = \lambda = R_{\mathrm{cr}}{}^{2/3} \cdot R_{\mathrm{lr}}{}^{1/3}$$

$$= \frac{16 \cdot \eta}{d_{\mathrm{f}}{}^{2}} \cdot \frac{f}{0{,}806 \cdot LN(1/f) - 0{,}929 + 1{,}26 \cdot f}$$

Thank you.

Questions?

Claus Futtrup

futtrup@seas.no