Université de Liège

The nonlinear tuned vibration absorber in practice

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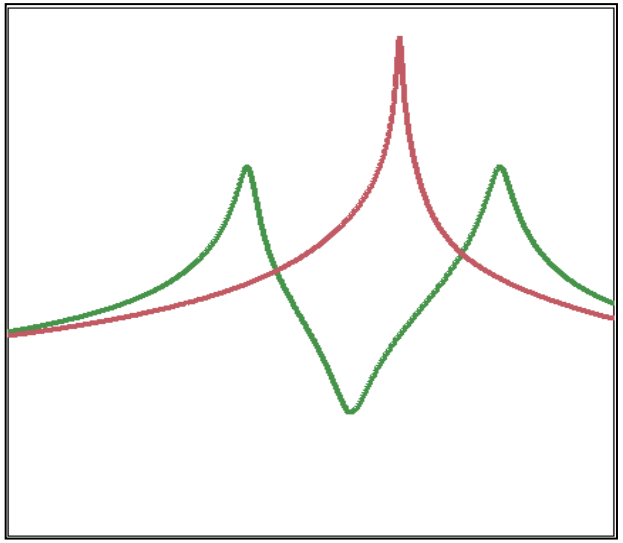
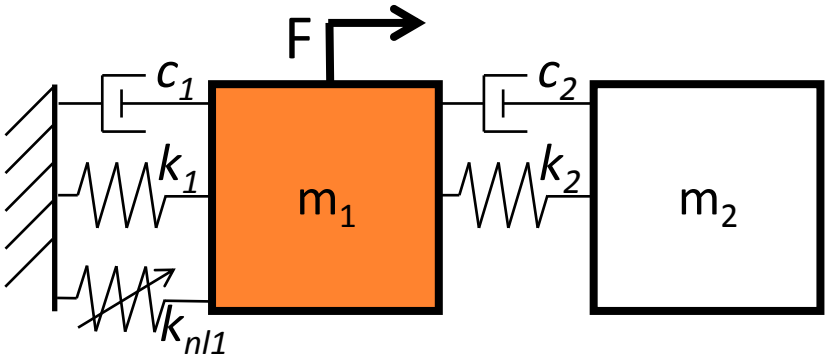
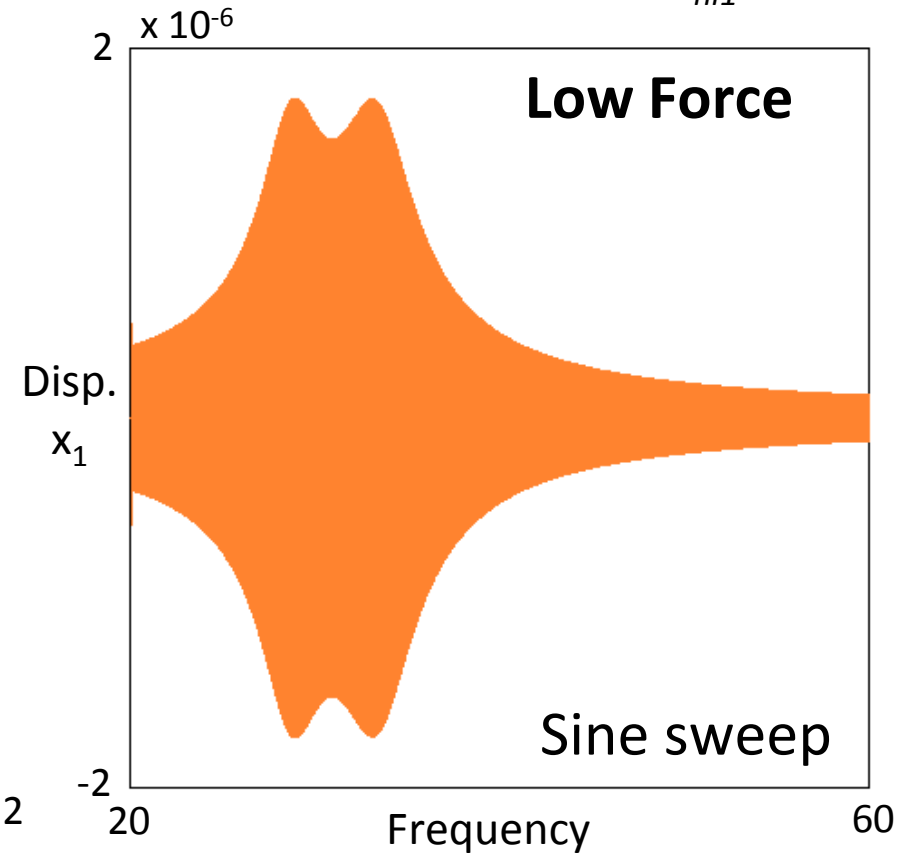
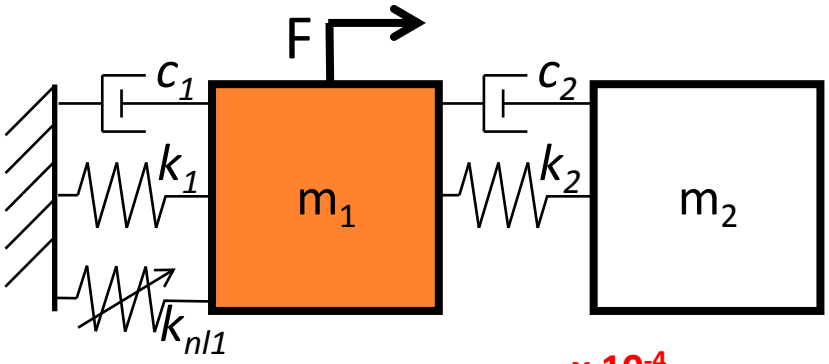


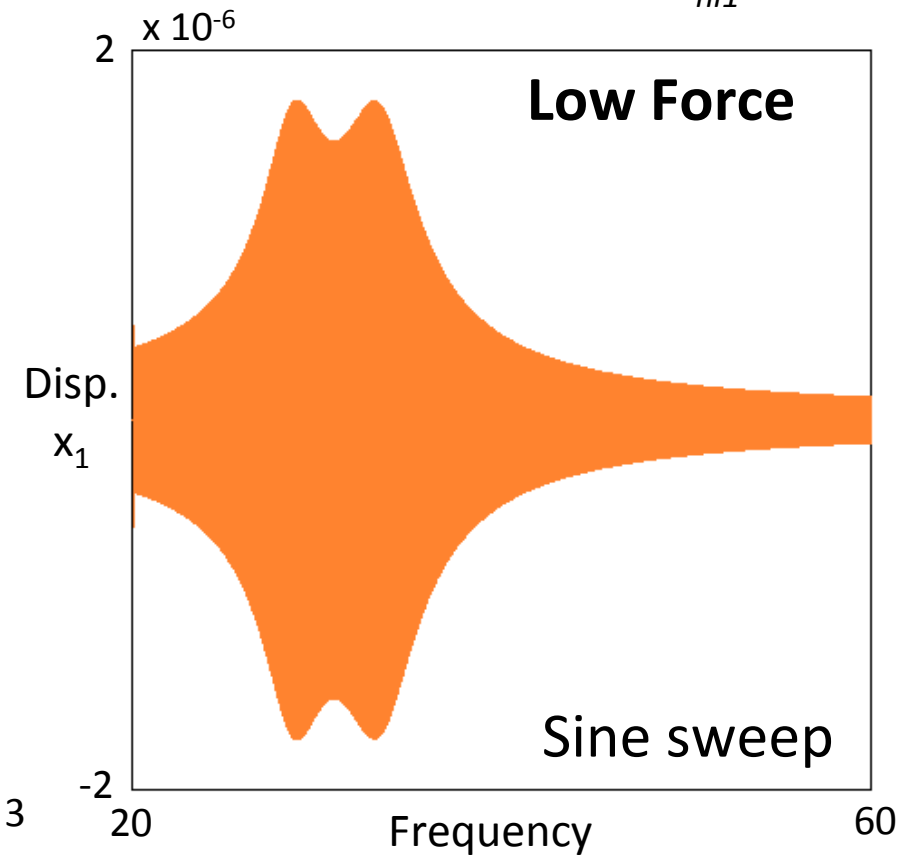
Detrimental effect of nonlinearity

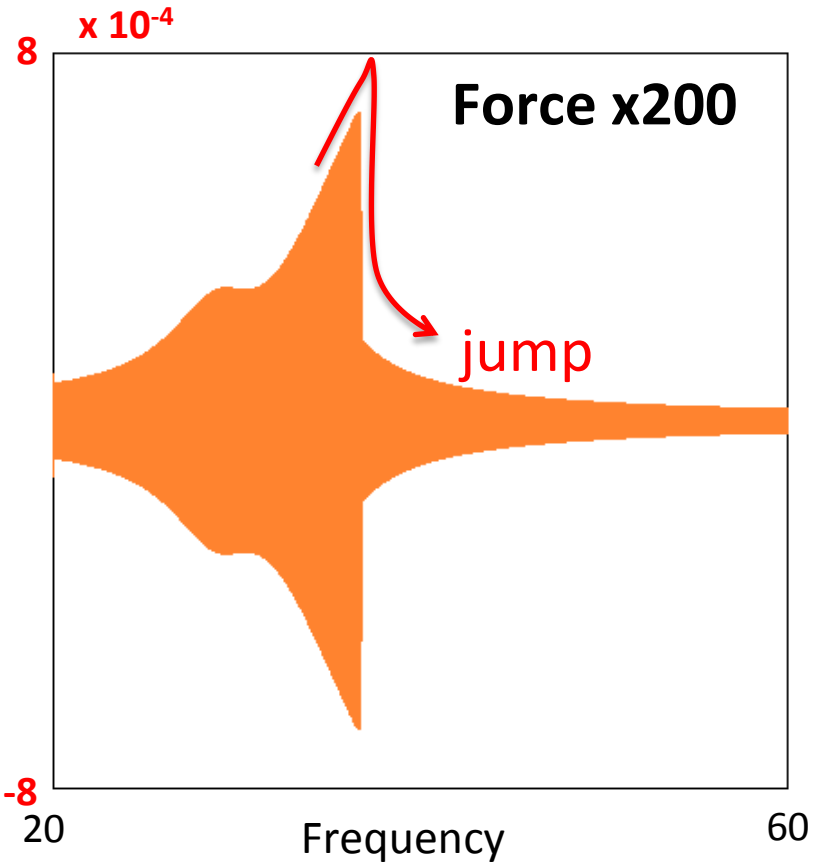




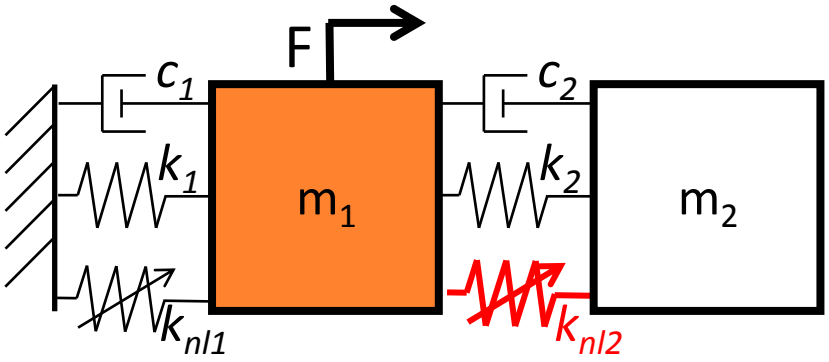
Detrimental effect of nonlinearity

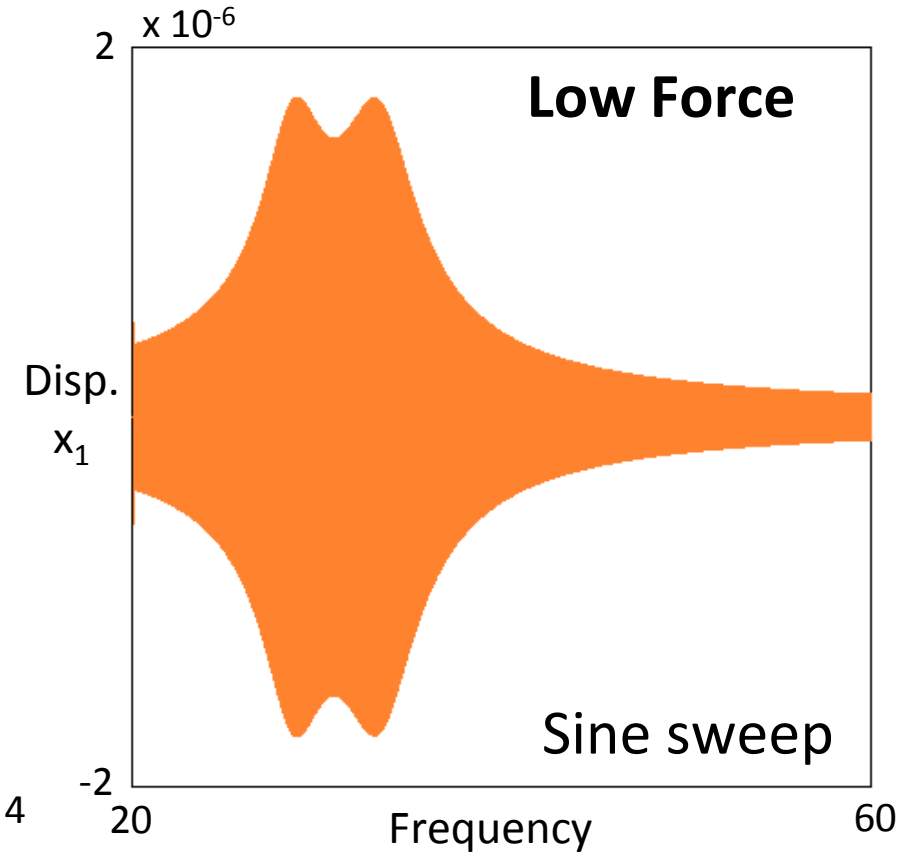


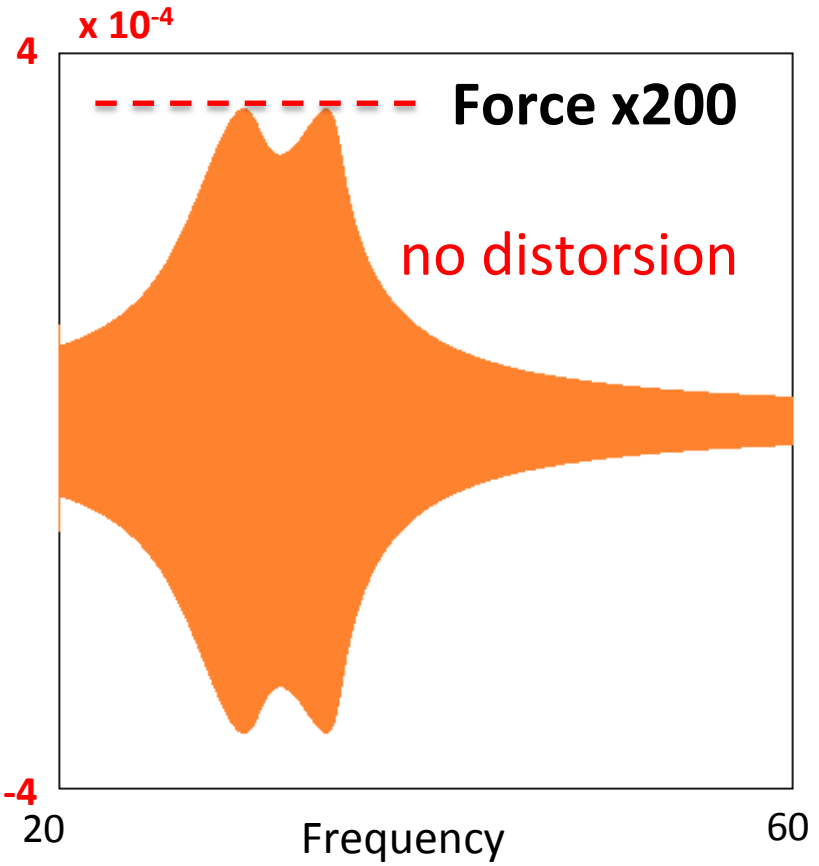




Beneficial effect of nonlinearity: NL + NL = LIN

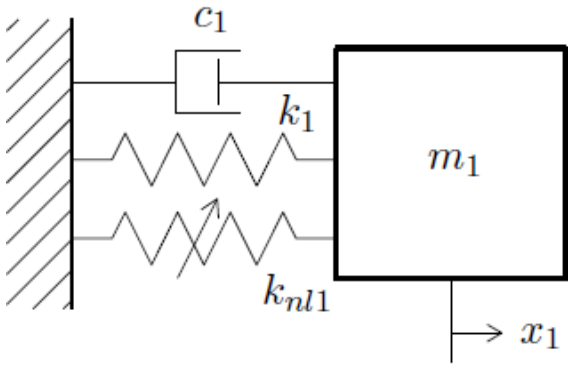




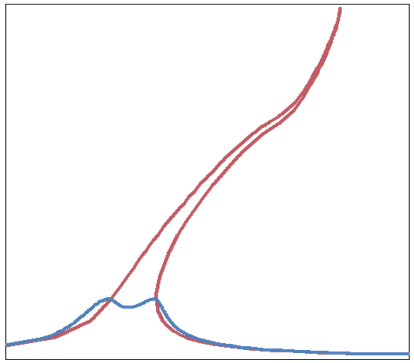


Outline

Nonlinear host structure



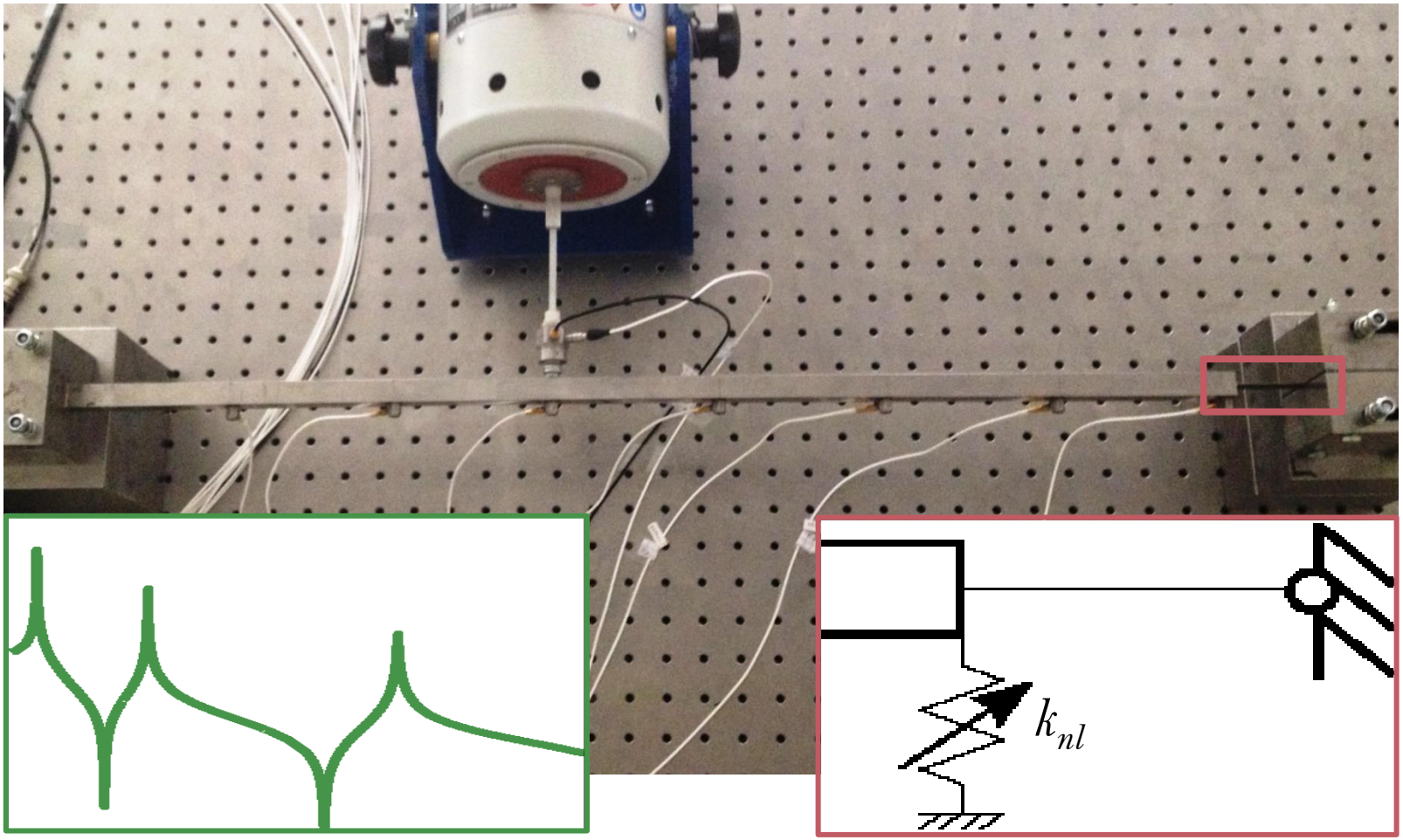
Absorber tuning & design



Testing on coupled system

Our nonlinear experimental host structure

Thouverez (2003) Presentation of the ECL benchmark. Mech Syst Signal Process 17:195–202

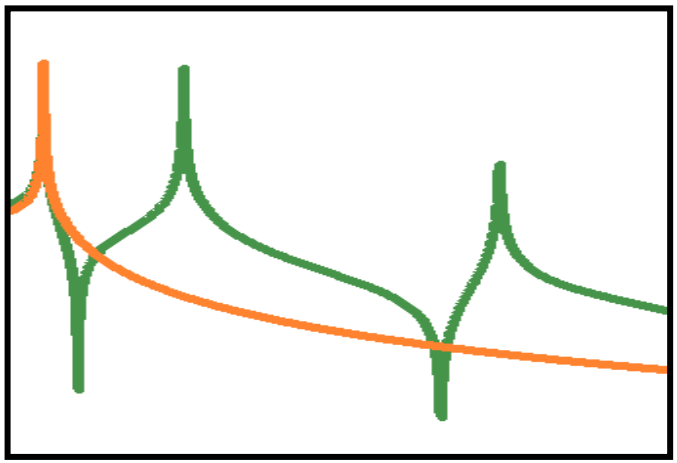


MDOF system

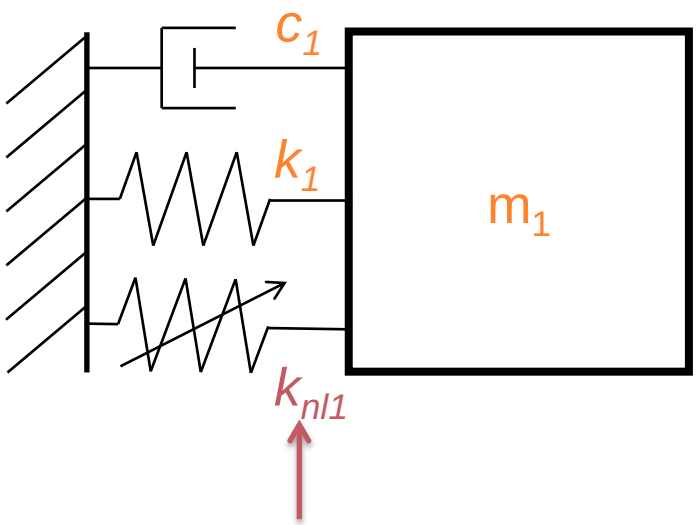
Concentrated nonlinearity

Our target is to mitigate the 1st nonlinear resonance

Nonlinear experimental host structure



SDOF system



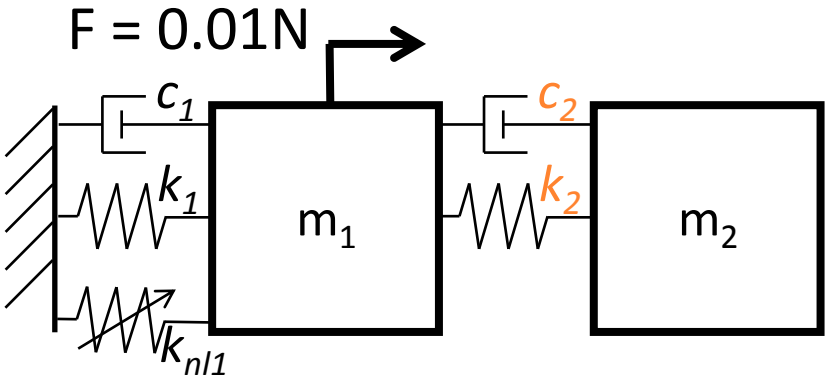
Concentrated nonlinearity

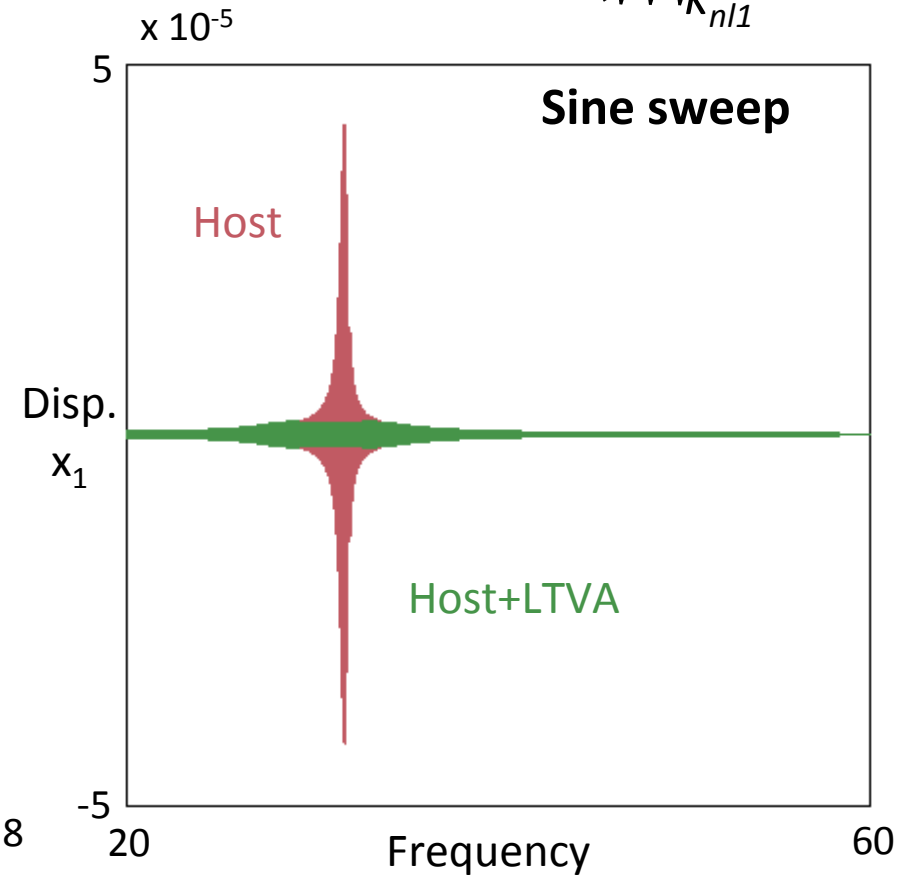
Nonlinear modal model

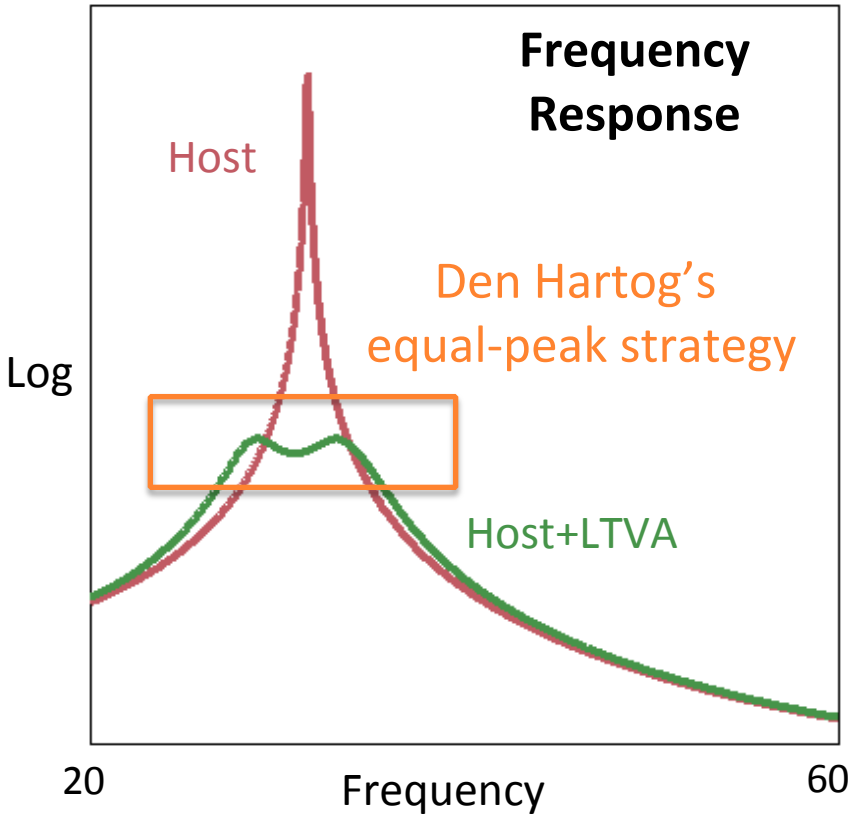
Mitigating resonant vibrations with a LTVA

[*Den Hartog*, 1928]
[*Brock*, 1946]
[Asami, 2003]

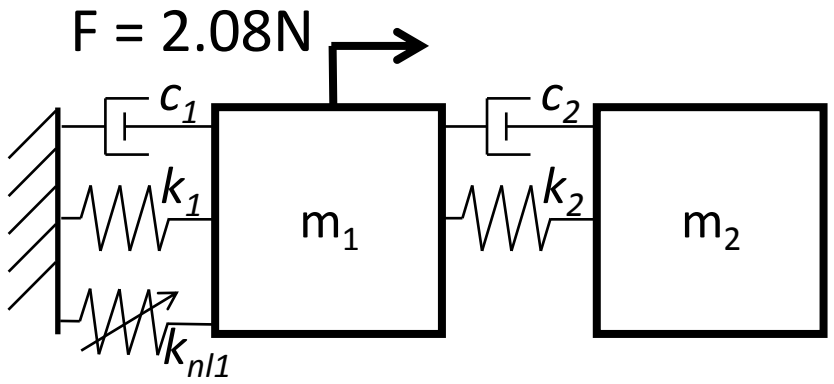
$m_2 = 1\%\ m_{beam}$



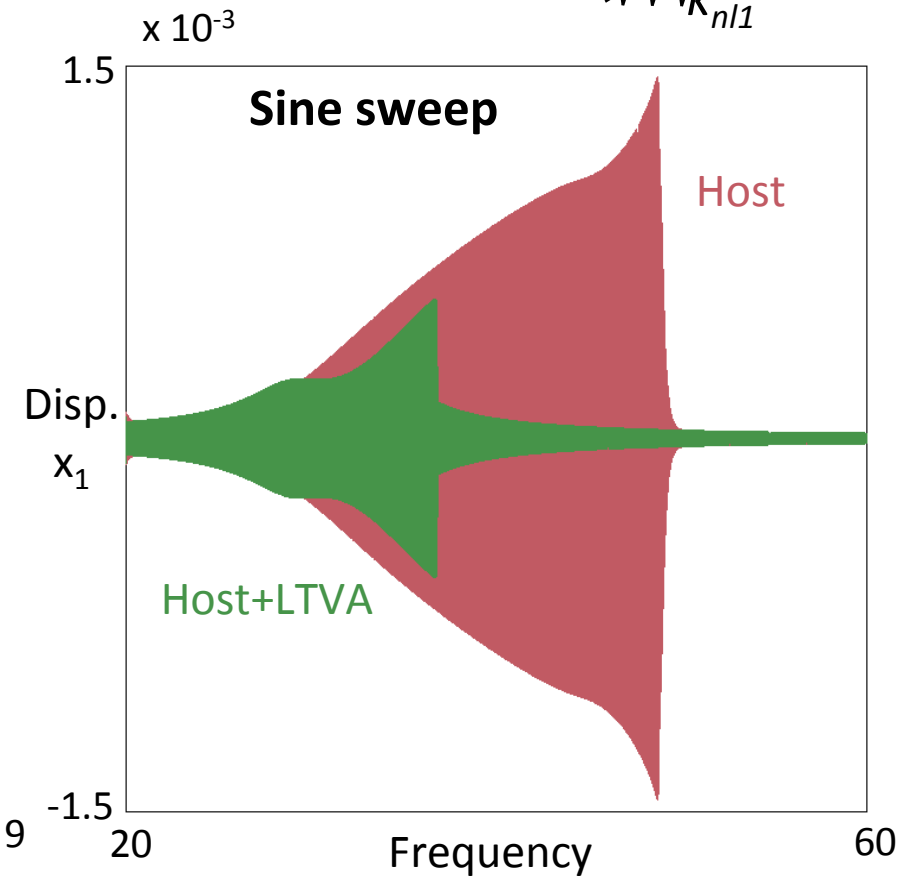


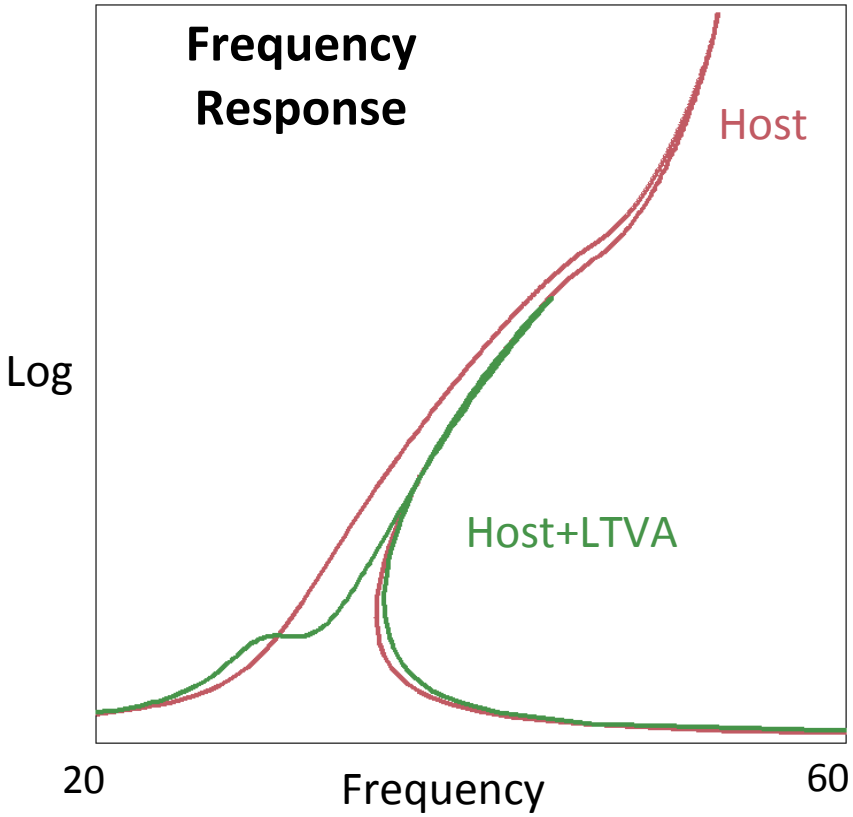


The LTVA detunes at high excitation

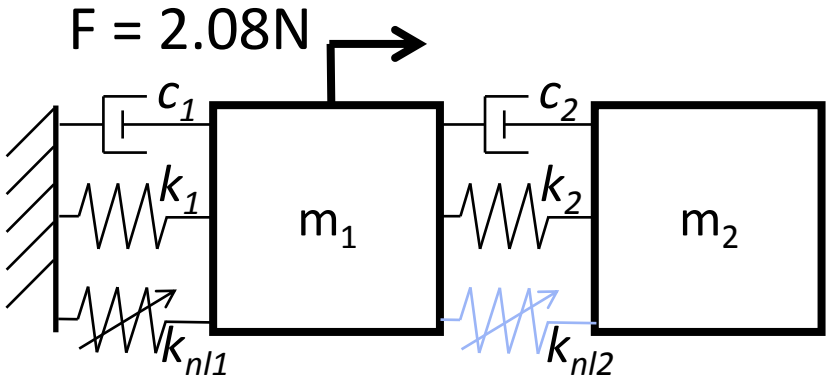


$m_2 = 1\% \, m_{beam}$

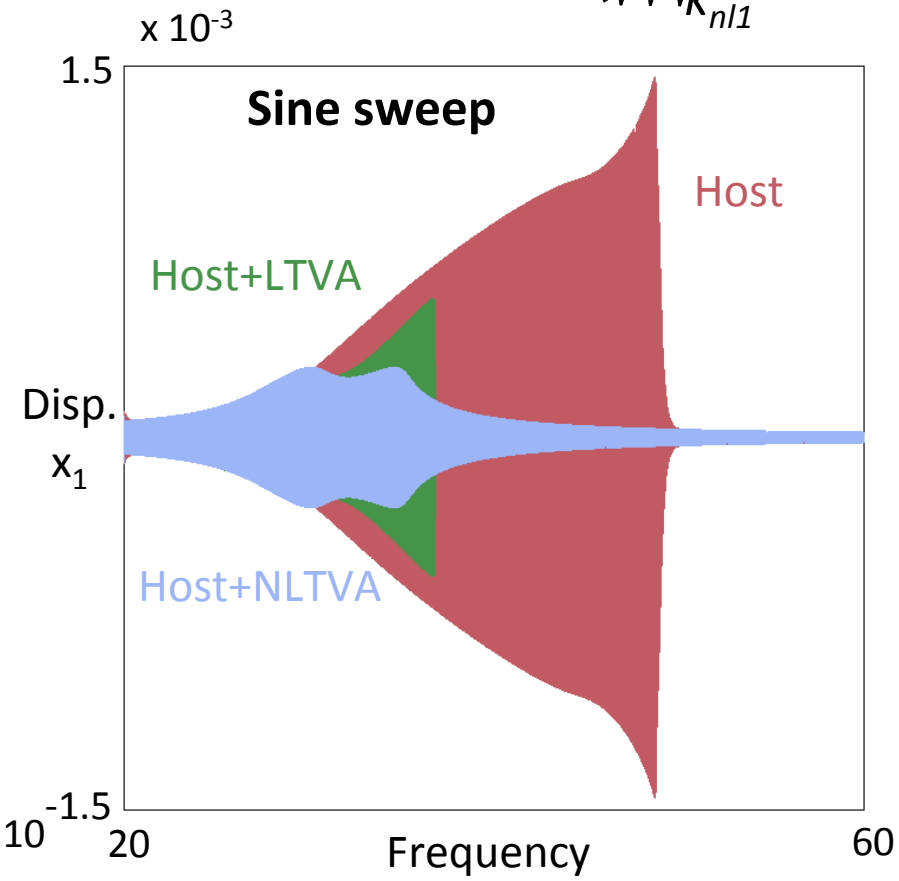


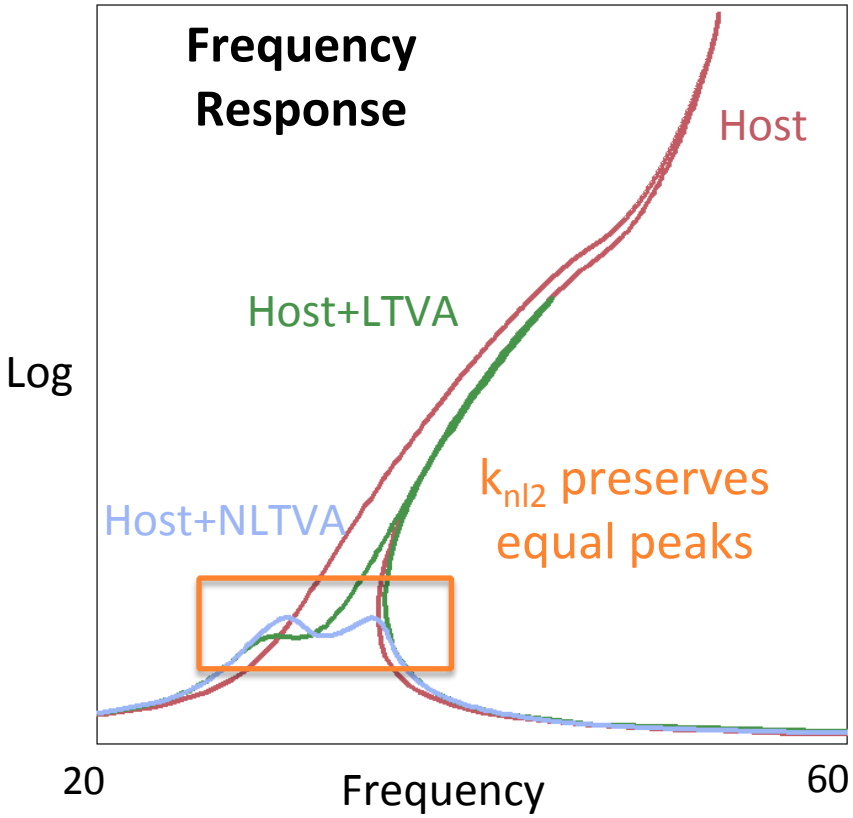


Mitigating resonant vibrations with a NLTVA

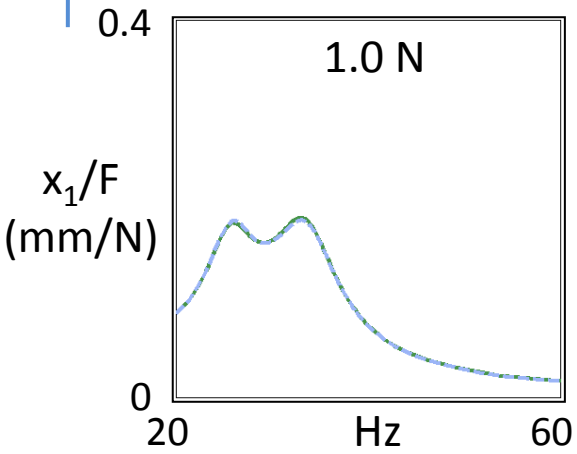


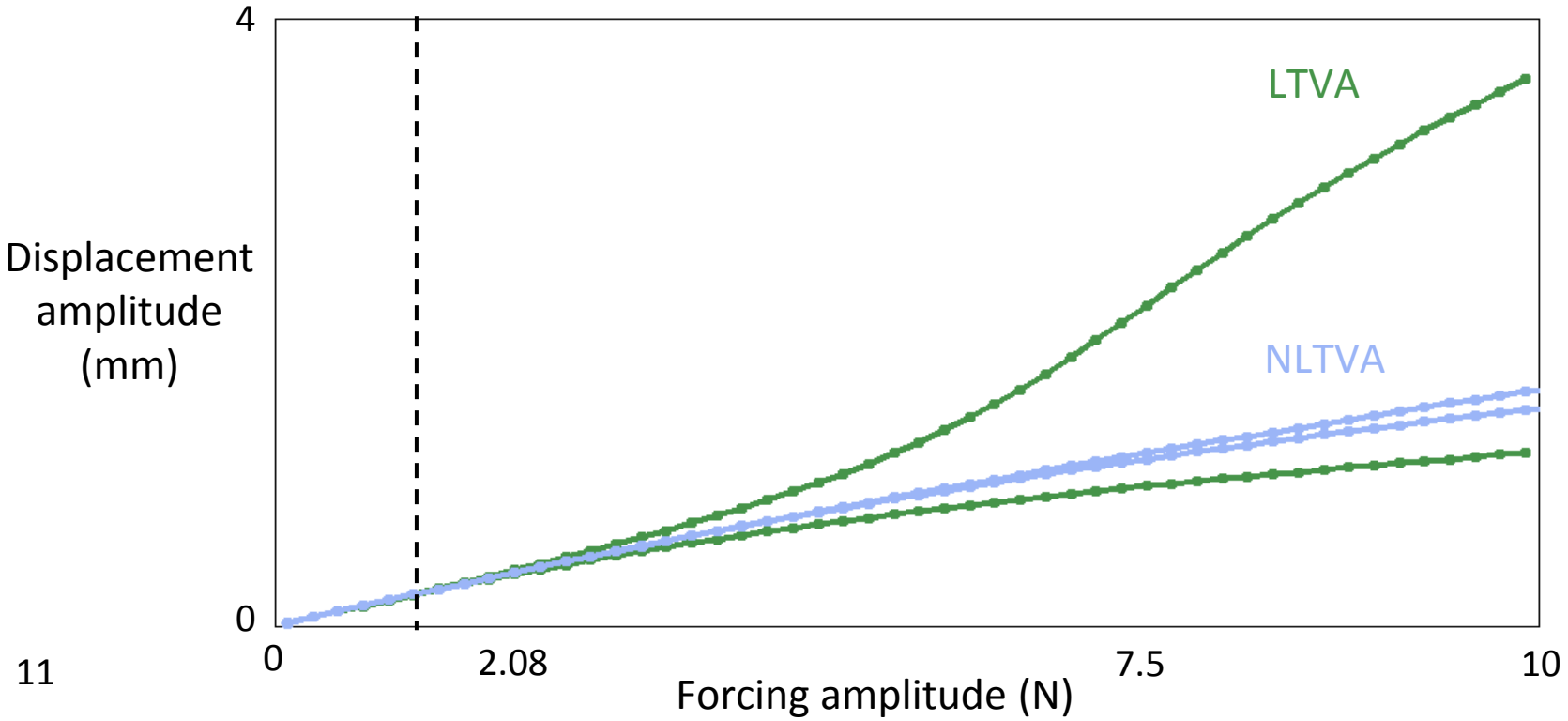
$$k_{nl2} = \frac{2\epsilon^2 k_{nl1}}{1 + 4\epsilon}$$





The NLTVA outperforms the LTVA by design





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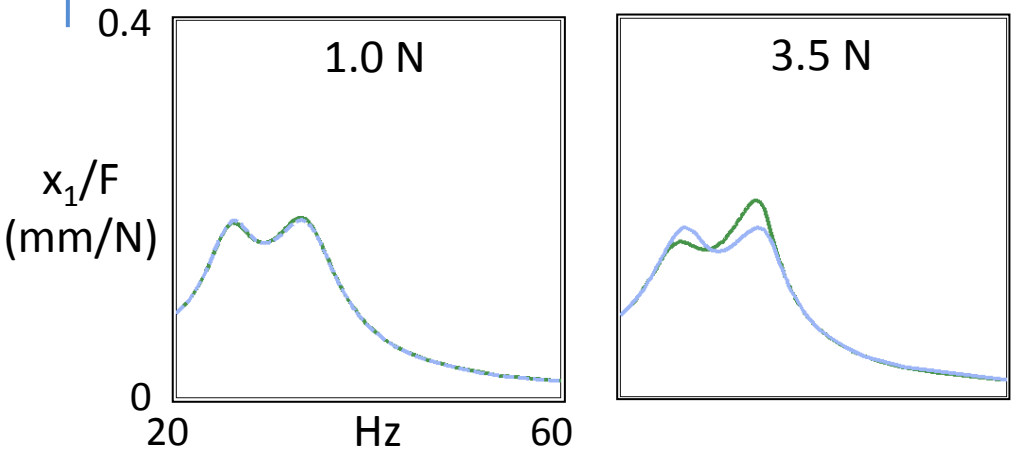

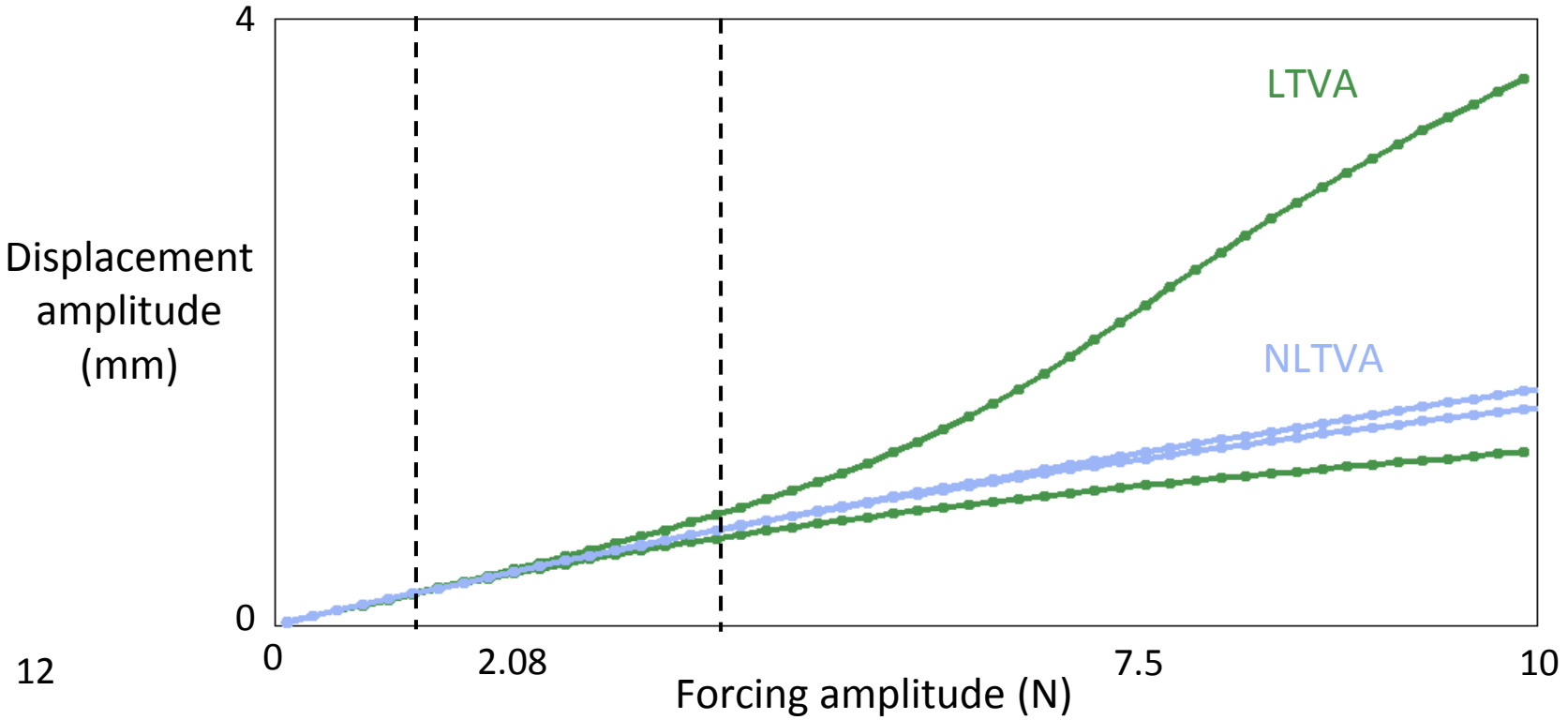

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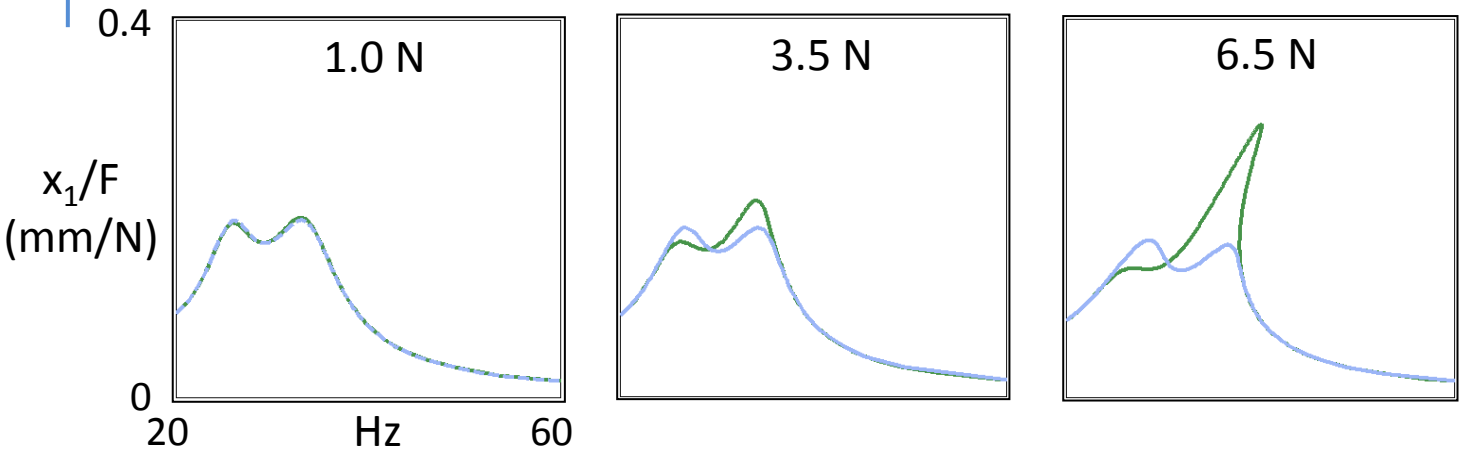

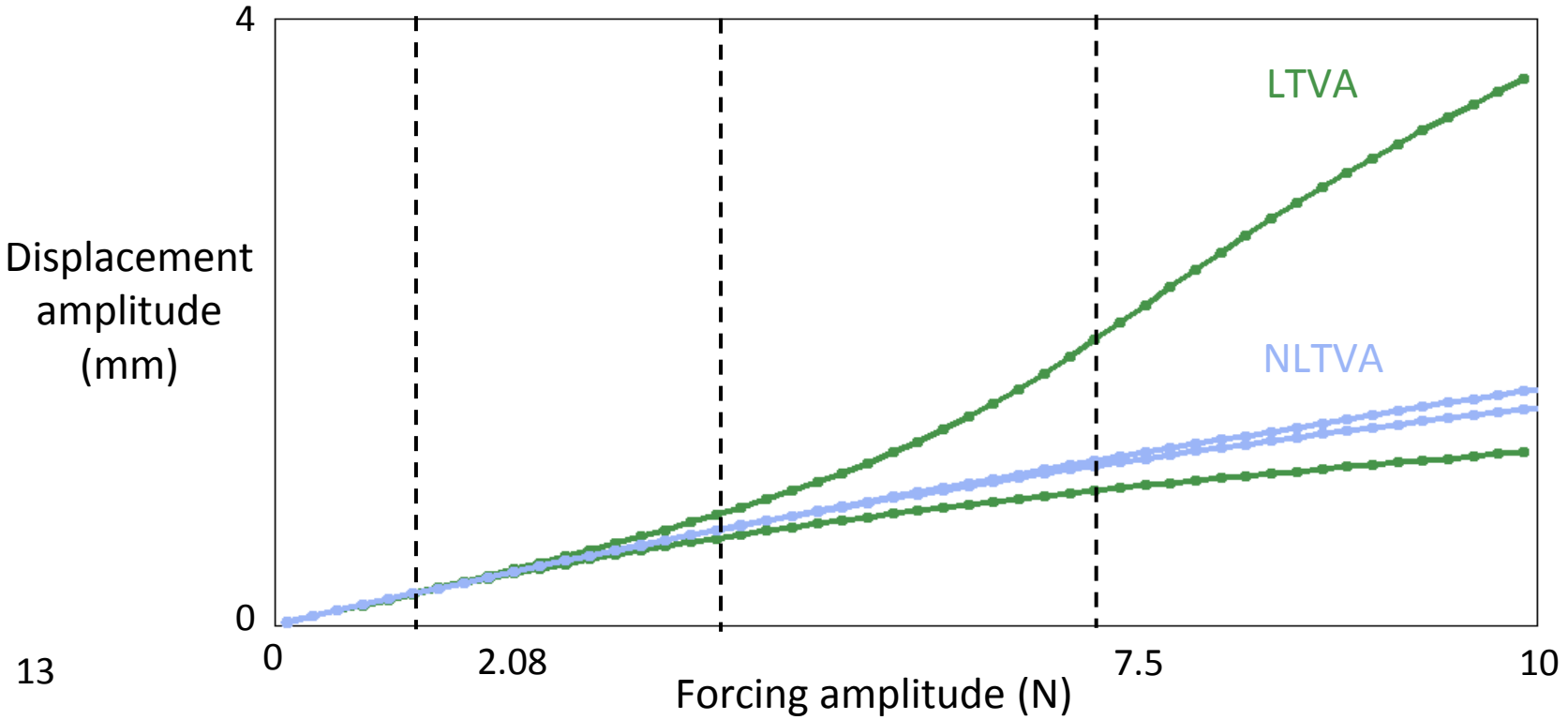

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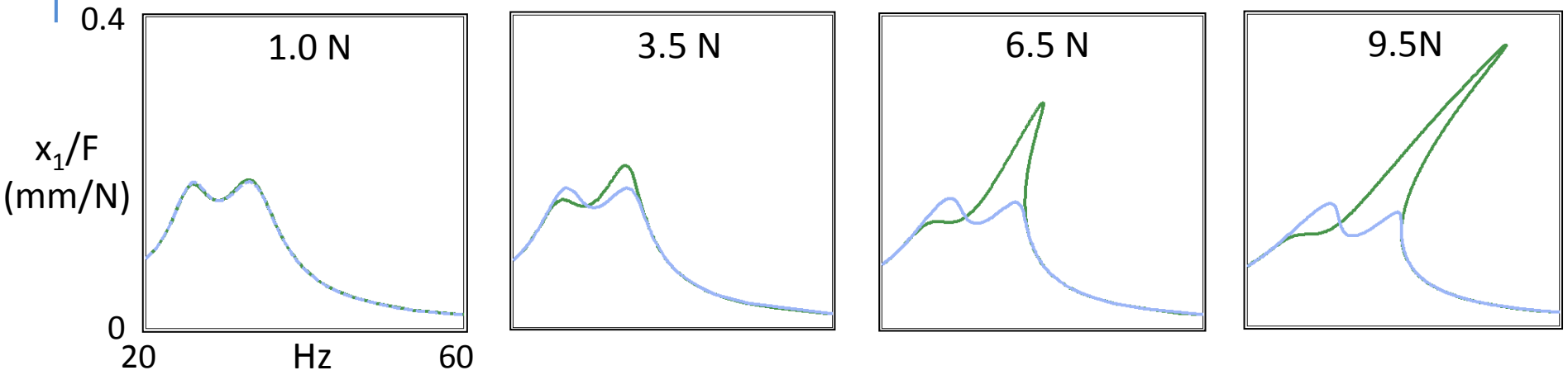
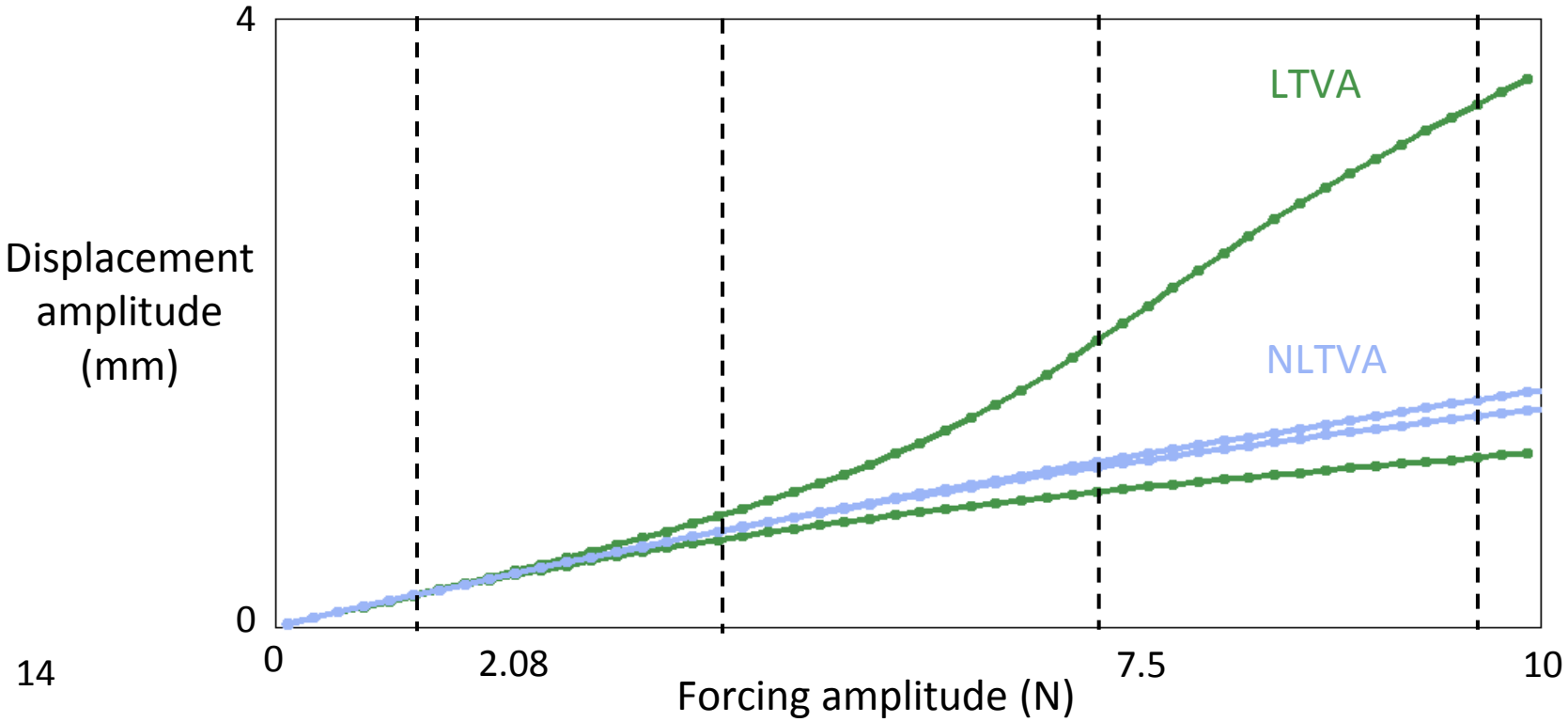
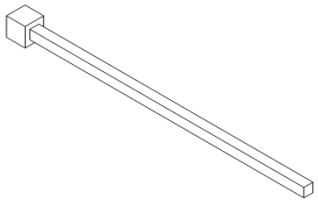




Practical realization based on “simple” beams

LTVA

linear cantilever beam

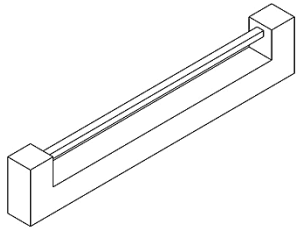


$$m_2 = \rho A L$$

$$\sqrt{\frac{k_2}{m_2}} = \sqrt{\frac{1.875^4 E m_2}{12 L^5 \rho^2}}$$

NLTVA

NL doubly-clamped beam



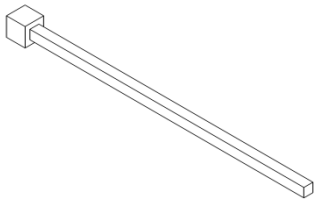
$$k_2 = \frac{2\pi^4 E I}{L^3}$$

$$k_{nl2} = \frac{\pi^4 E A}{8 L^3}$$

Practical realization using 3D printing

LTVA

linear cantilever beam



$$m_2 = \rho A L$$

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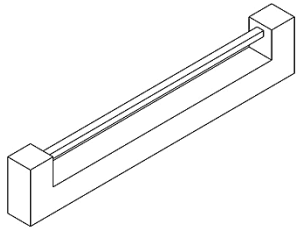
NLTVA

NL doubly-clamped beam



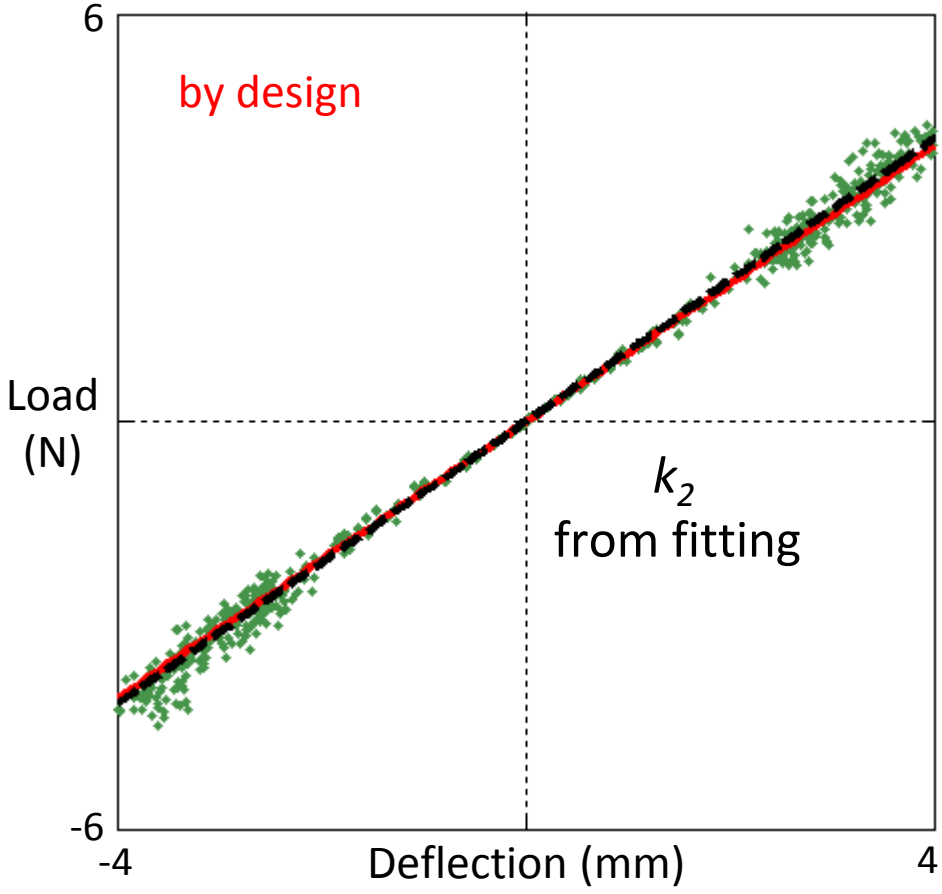
$$k_2 = \frac{2\pi^4 E I}{L^3}$$

$$k_{nl2} = \frac{\pi^4 E A}{8 L^3}$$

The printed TVAs follow the prescribed stiffness curves

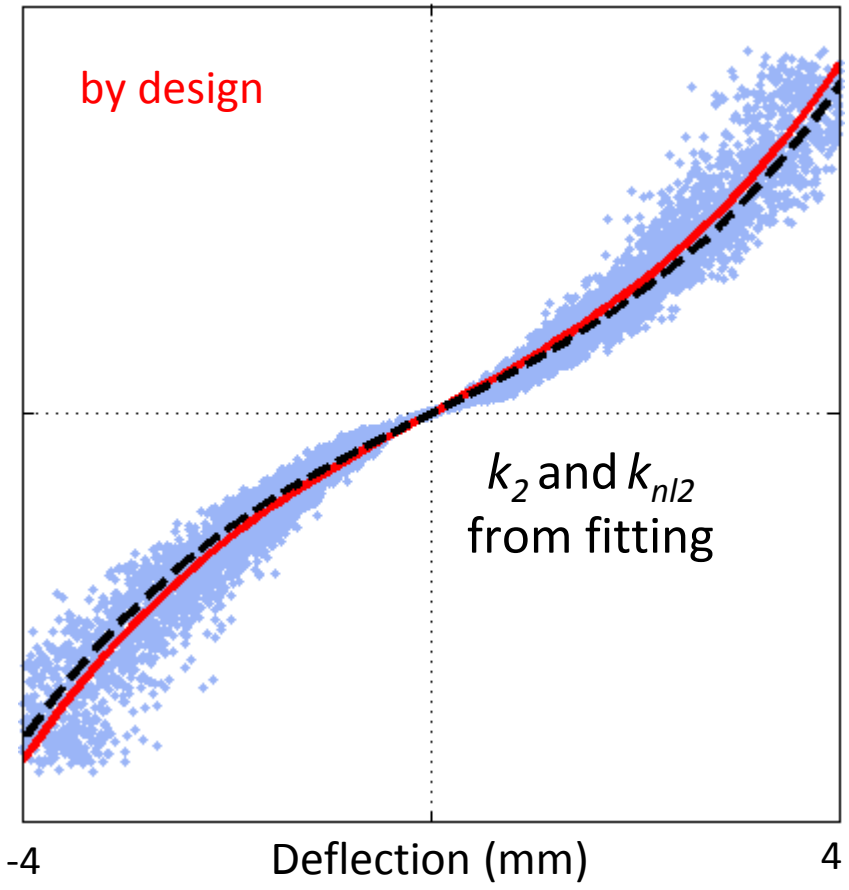
LTVA

linear cantilever beam

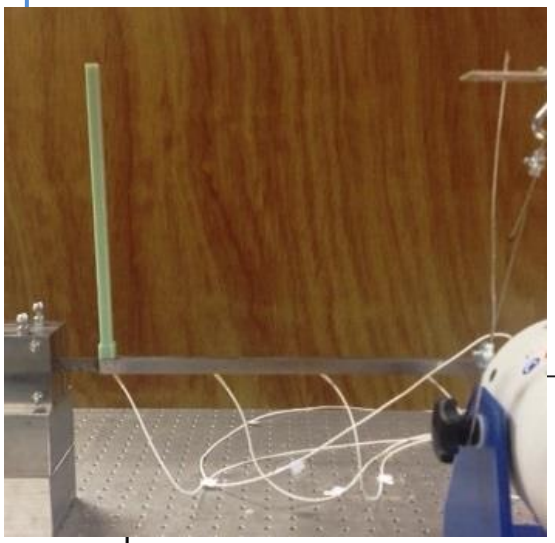


NLTVA

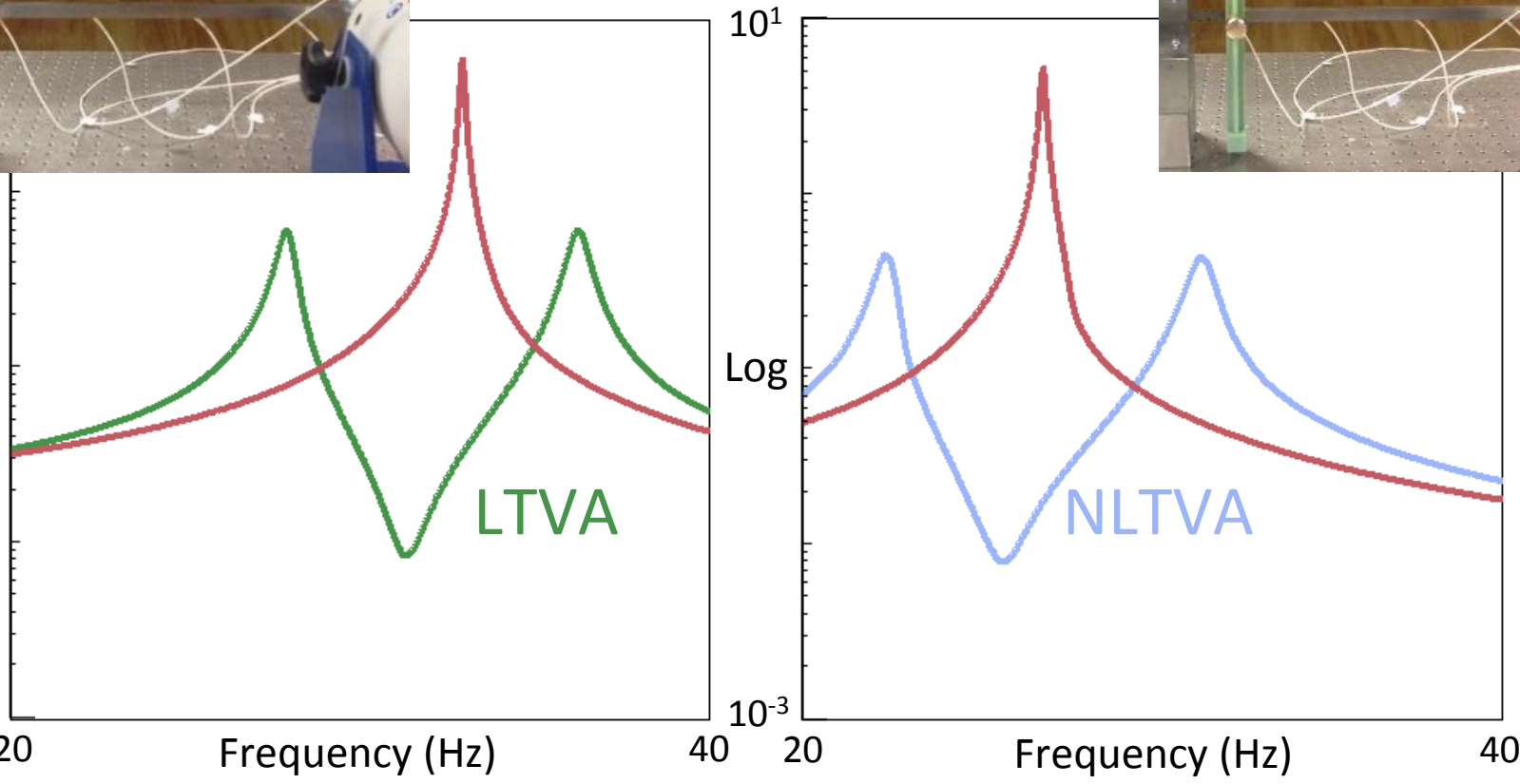
NL doubly-clamped beam



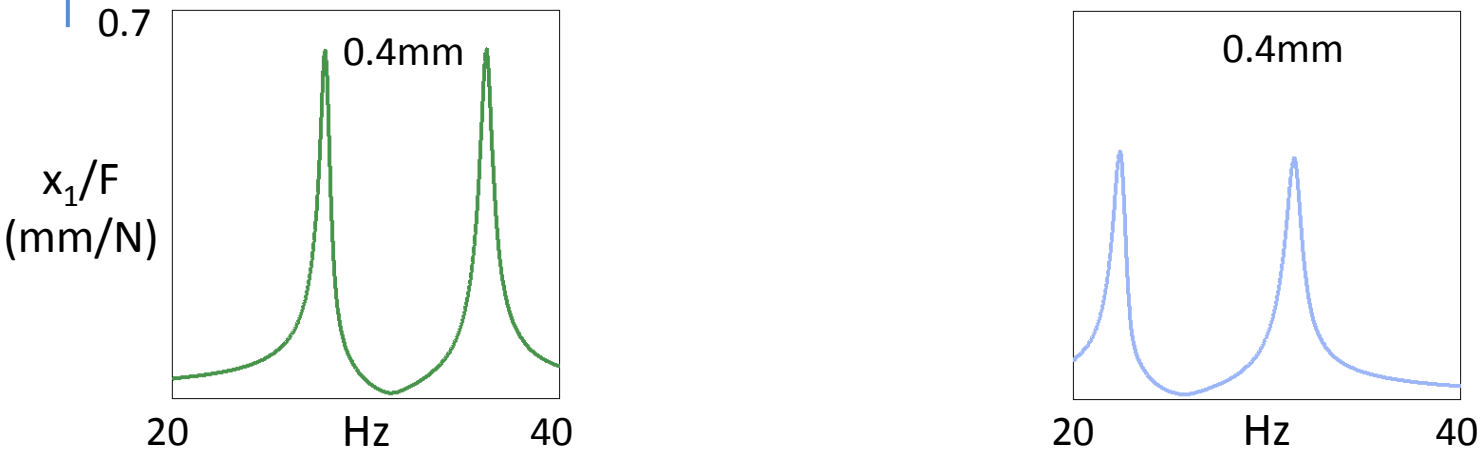
The effects of the **real** absorbers on the host structure

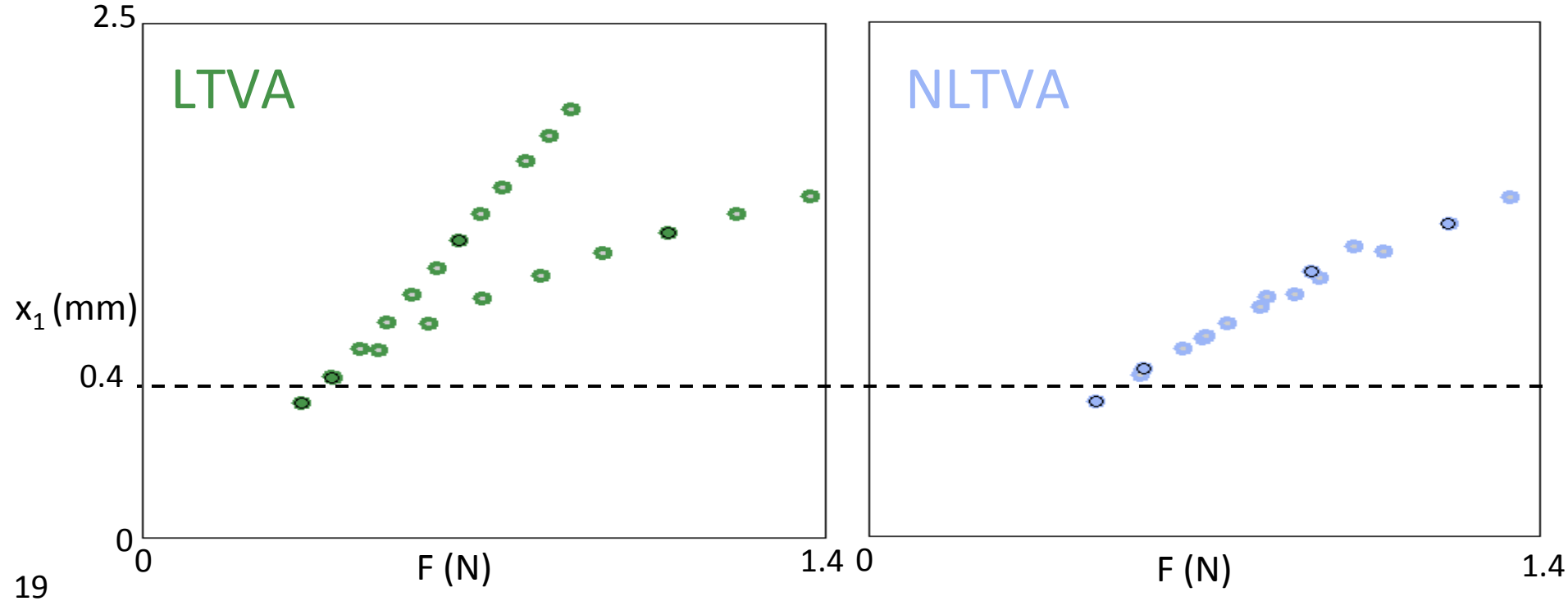


FRF amplitude
(mm/N)



The NLTVA outperforms the LTVA, for real!





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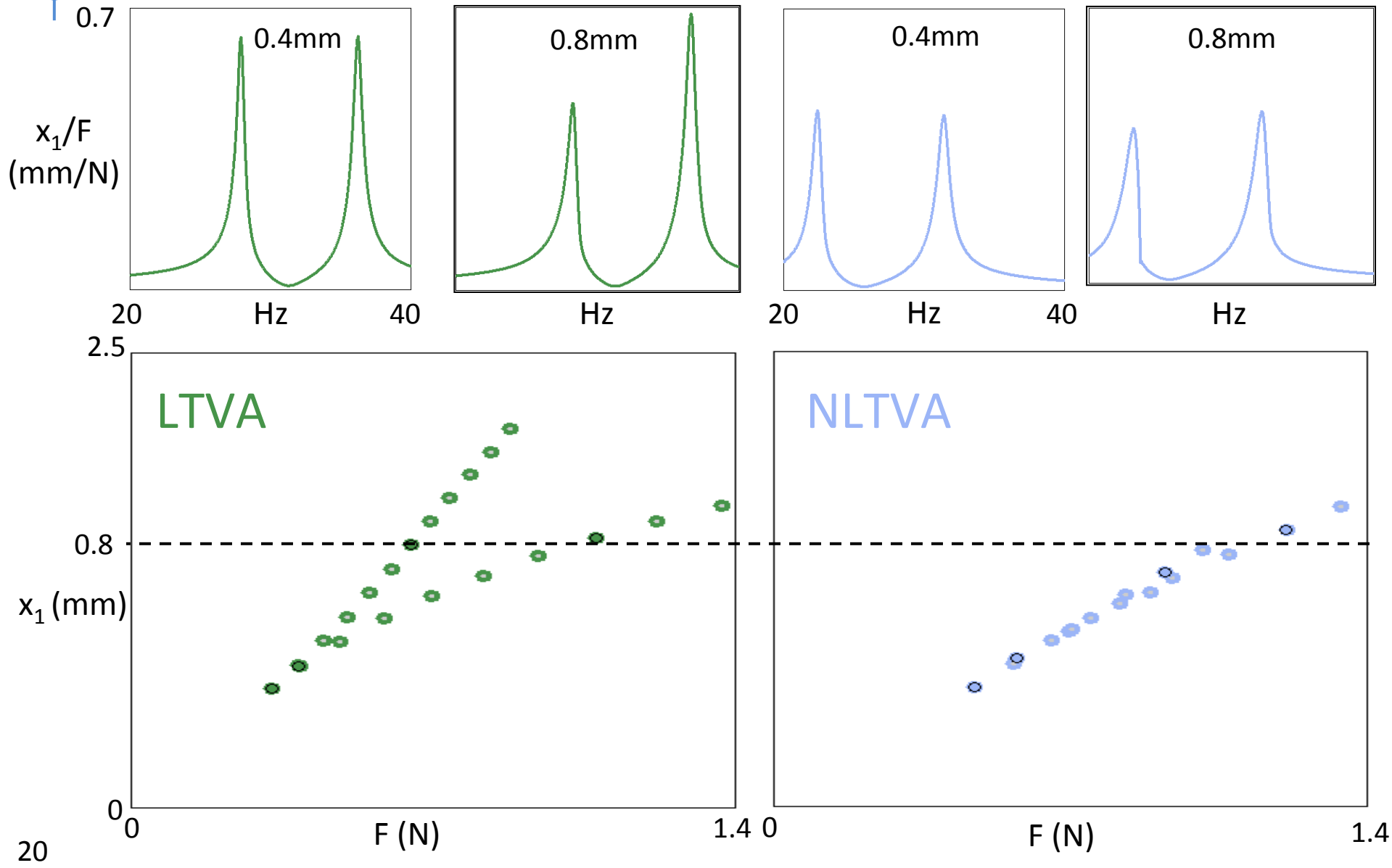
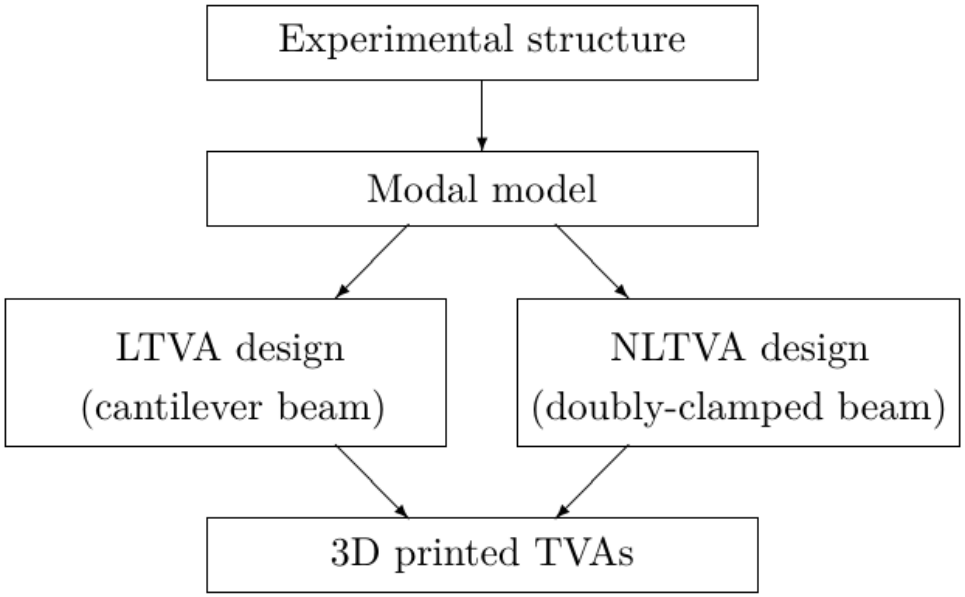
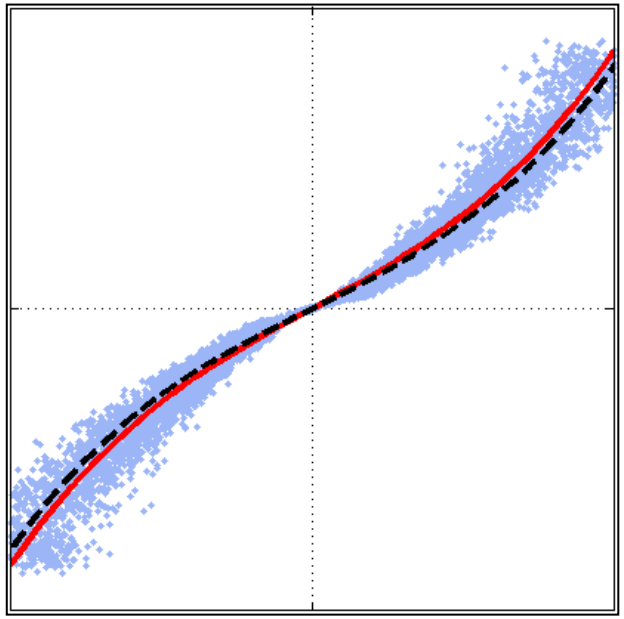


Conclusions

The TVA can be designed analytically:

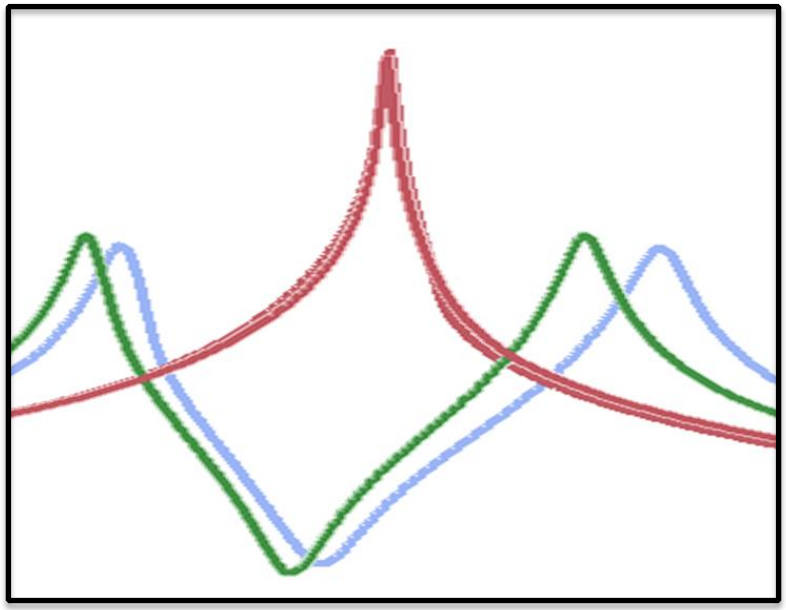


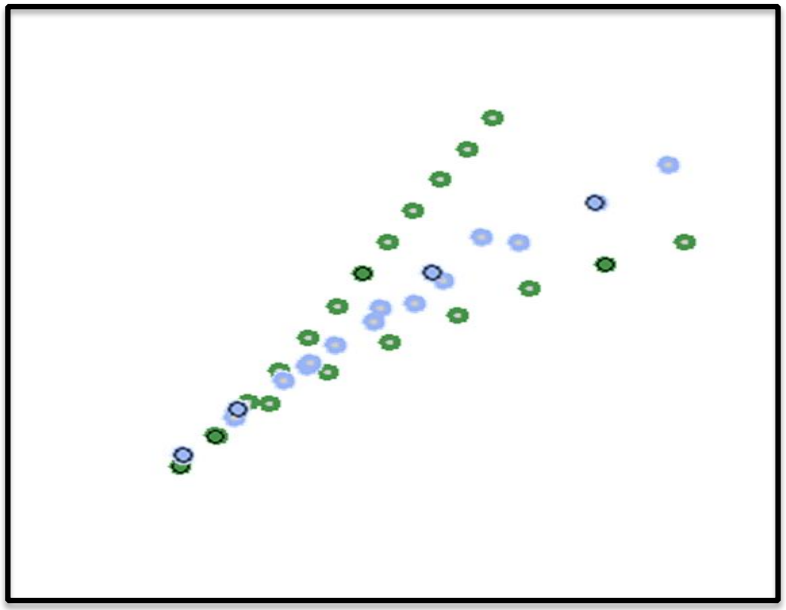


and the real TVAs follow the objective NL load-deflection function

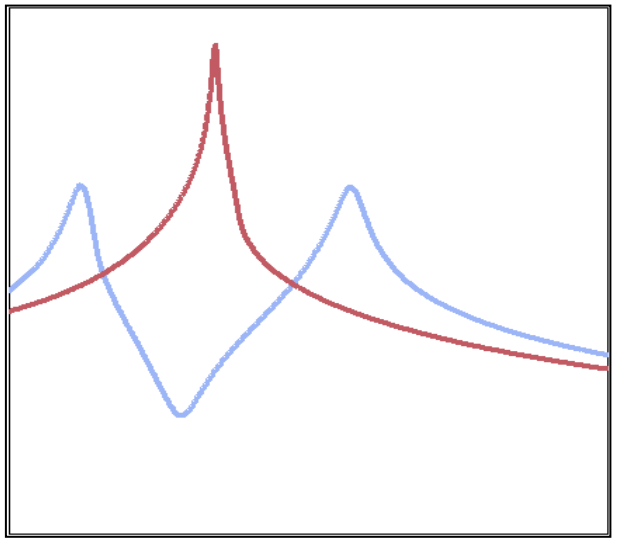
Conclusions

NLTVA allows to maintain equal peaks in nonlinear regimes





and the experiments validated the concept: NLin + NLin = Lin



Thanks for your attention

ACKNOWLEDGEMENTS:

- financial support of the European Union (ERC Starting Grant NoVib 307265)
- LMS A Siemens Business provided access to the LMS Test.Lab software