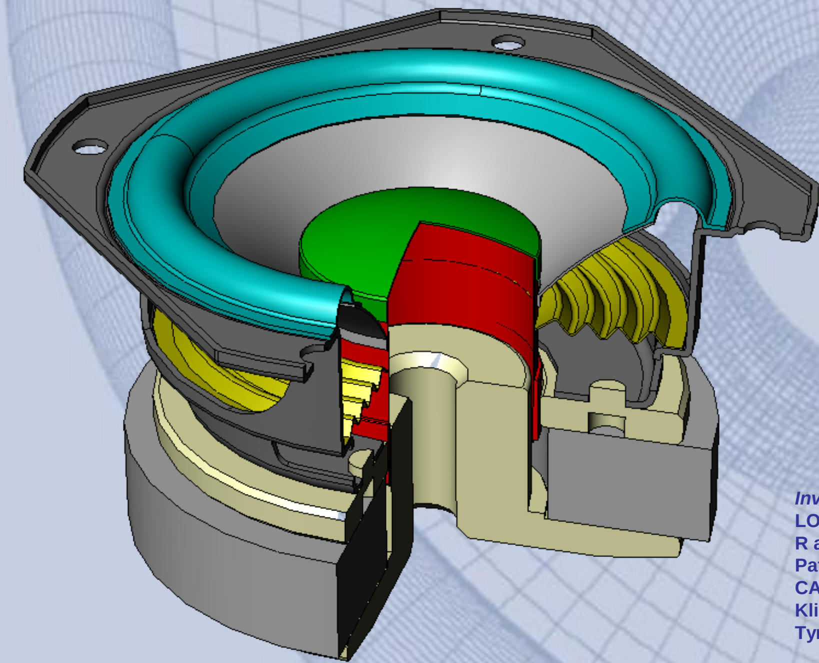
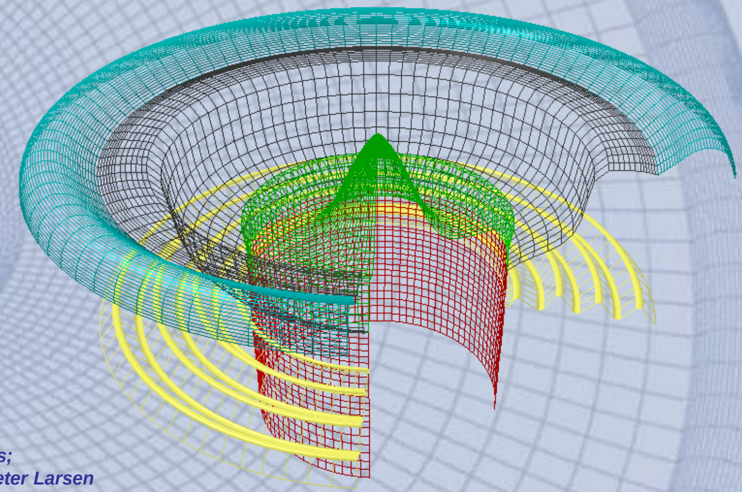
AES 126th Loudspeaker FEA/BEM Workshop

Panelist: Peter Larsen LOUDSOFT

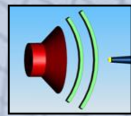




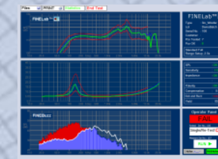
Invited Participant Companies;
LOUDSOFT *loudsoft.com - Peter Larsen*
R and D Team randteam.de - Joerg Panzer
Pafec vibroacoustics.co.uk - Patrick Macey
CAPA Wisoft.de - Hermann Landes
Klippel klippel.net - Wolfgang Klippel
Tymphany Tymphany.com – Richard Little

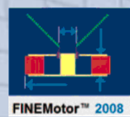
Loudspeaker FE/BE Modeling Workshop:

This workshop will explore FE/BE modeling of loudspeaker drivers. A case study of an existing loudspeaker driver will be modelled by each panellist to benchmark the capabilities of their modeling software package. A loudspeaker driver dimensions and material properties will be provided to panellists in advance of the convention so that they may develop a thorough model for presentation at the workshop. Results will be discussed along with measurement analysis of the real loudspeaker driver.

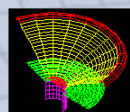


FINELab™QC
Loudspeaker/Transducer Production Test system

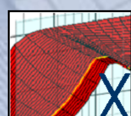




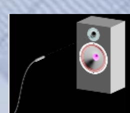
FINEMotor™
Magnet System & Voice Coil Design Program



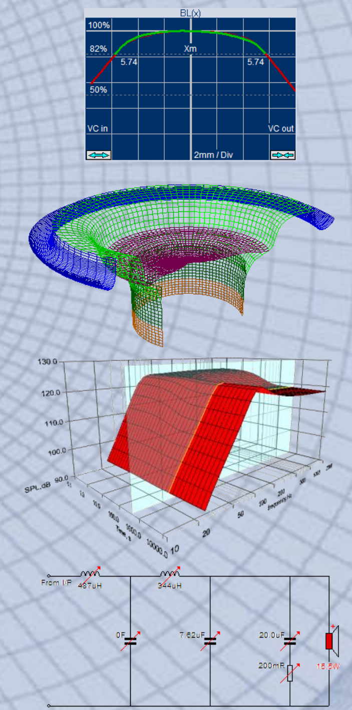
FINECone™
Acoustic Finite Element Dome/Cone Simulation



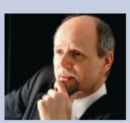
FINEBox™
Non-Linear High Power Box Design Program



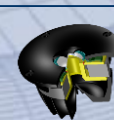
FINE X-over™
X-over Design Program



More than 500 software licenses worldwide



CONSULTING - *Peter Larsen*
Speaker design for customers using software and experience



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FINEMotor simulated TS parameters versus measured (Klippel)

Measurement in Vacuum

	In air			In vacuum	
Electrical Parameters					
Re	7.13	Ohm	Re	7.04	Ohm
Le	0.046	mH	Le	0.048	mH
L2	0.181	mH	L2	0.198	mH
R2	1.84	Ohm	R2	1.96	Ohm
Cmes	182.02	µF	Cmes	162.01	µF
Lces	5.38	mH	Lces	5.51	mH
Res	21.14	Ohm	Res	16.93	Ohm
fs	160.8	Hz	fs	168.4	Hz
Mechanical Parameters (using laser)					
Mms	1.277	g	Mms	1.095	g
Mmd (Sd)	1.244	g	Mmd (Sd)	1.062	g
Rms	0.332	kg/s	Rms	0.399	kg/s
Cms	0.767	mm/N	Cms	0.815	mm/N
Kms	1.30	N/mm	Kms	1.23	N/mm
Bl	2.649	N/A	Bl	2.600	N/A
Lambda s	0.096		Lambda s	0.094	
Loss factors					
Qtp	0.982		Qtp	0.854	
Qms	3.887		Qms	2.902	
Qes	1.311		Qes	1.207	
Qts	0.981		Qts	0.853	
Vas	0.2443	l	Vas	0.2596	l

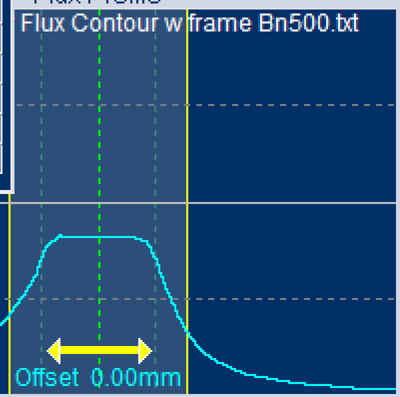
Klippel, Loudspeaker Analysis, Workshop AES 2009, 5

TS Parameters

Sensitivity (2.83V/1.00m)	SPL	79.72	dB
VC Resistance DCR	Re	7.00	Ohms
Resonance	Fs	161.00	Hz
Mechanical	Qms	4.00	
Electrical	Qes	1.27	
Total	Qts	0.96	
Equivalent air vol.	Vas	0.25	l
Compliance	Cms	0.77	mm/N
Moving Mass(incl. air)	Mms	1.27	g
Force Factor	Bl	2.66	Tm
Eff. diaphragm area	Sd	15.33	sq.cm
Lin. Excursion +/-	Xmlin	0.87	mm

FINEMotor Prediction of TS Parameters

Flux Profile



The predicted BL is really close to the Klipper Laser measurement

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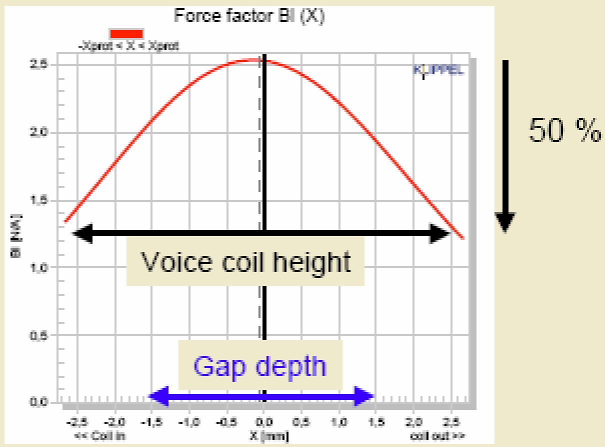
FINEMotor simulated BL(x) versus measured (Klippel)

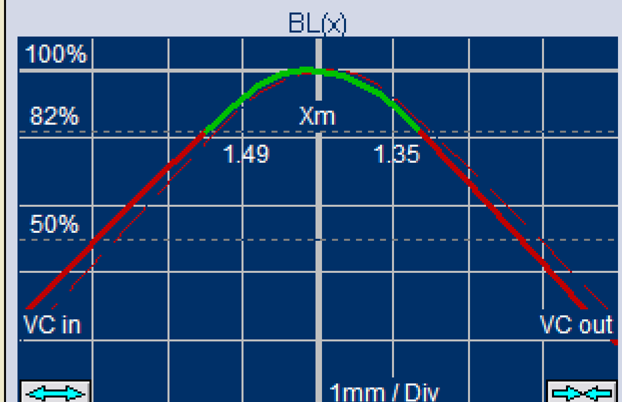
Dominant Nonlinearities: Bl(x)

Measured by using the LSI module



XBl=1.3 mm @ Blmin=82 % (10 % intermodulation distortion in SPL, mainly 3rd-order)

FINEMotor BL(x) Calculation



Predicted by FINEMotor:

XBL @ 82% BLmin =1.35mm.
The shape and symmetry of the BL(x) curve is extremely close to that measured by Klippel

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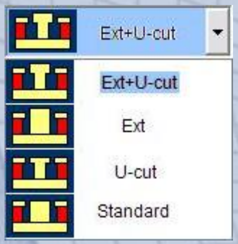
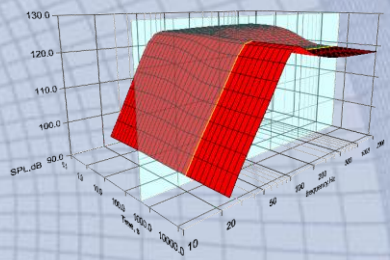
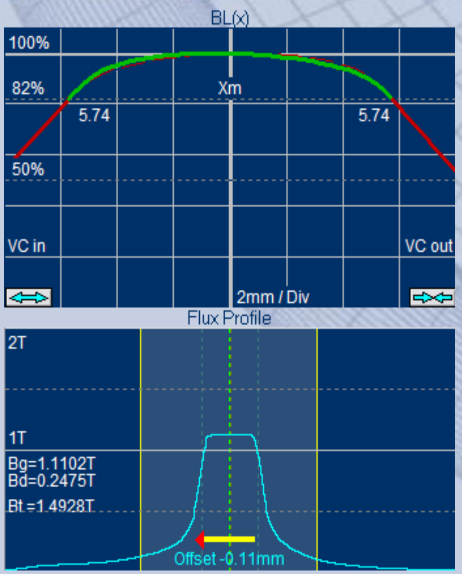
FINEMotor™



- *Instant TS parameters*
- *Non-linear BL(x) curves*
- *Flux profile with VC Offset*
- *Ferrofluid simulation*
- *Thermal compression model*



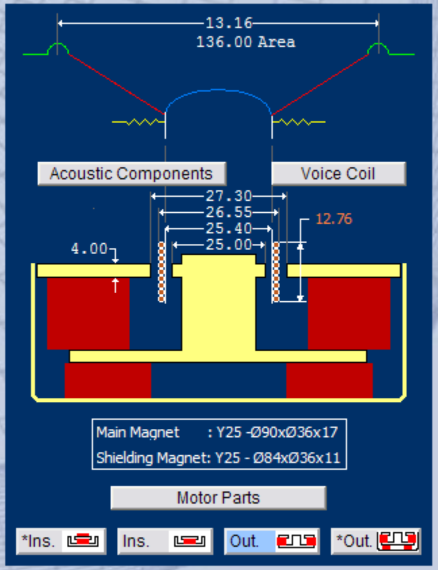


Mechanical Parameters

Layers	n	2	
Wire Material		Copper	
Wire Type		Round	
Wind Width	WW	15.55	mm
Number of Windings	N	133.67	
Nom.(bare) Wire diam	BWD	0.200	mm
Total Winding OD	WOD	26.63	mm
Total Winding Mass	Mvc	3.157	g
Stretch		4.00	%

TS Parameters

Sensitivity (2.83V/1.00m)	SPL	87.95	dB
VC Resistance DCR	Re	6.20	Ohms
Resonance	Fs	38.43	Hz
Mechanical	Qms	6.00	
Electrical	Qes	0.45	
Total	Qts	0.42	
Equivalent air vol.	Vas	39.35	l
Compliance	Cms	1.54	mm/N
Moving Mass(incl. air)	Mms	11.16	g
Force Factor	Bl	6.07	Tm
Eff. diaphragm area	Sd	134.99	sq.cm
Lin. Excursion +/-	Xmlin	5.28	mm



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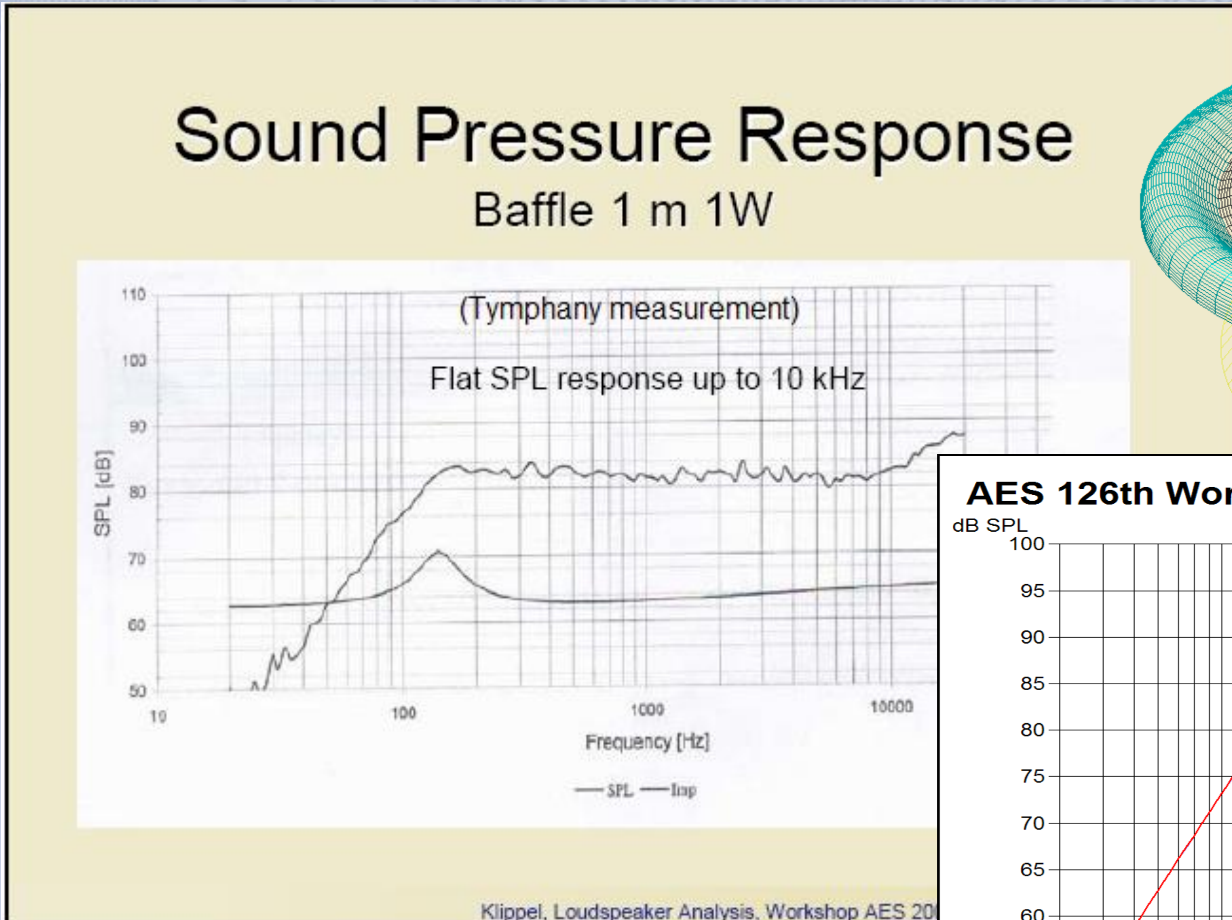
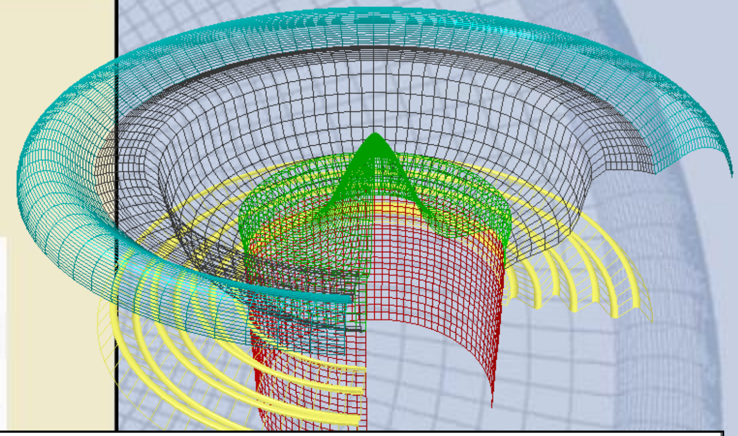
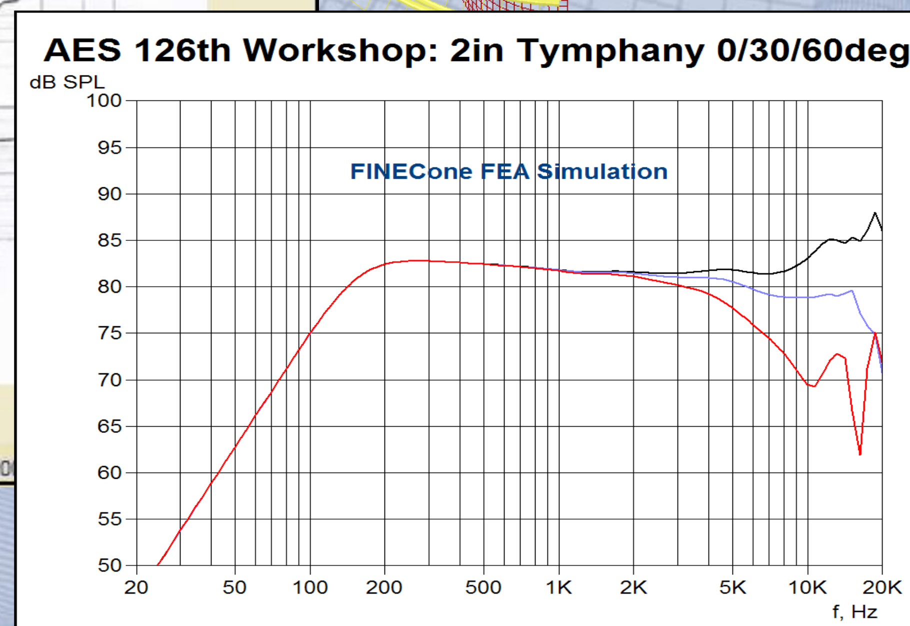
FINECone FEA versus measured response







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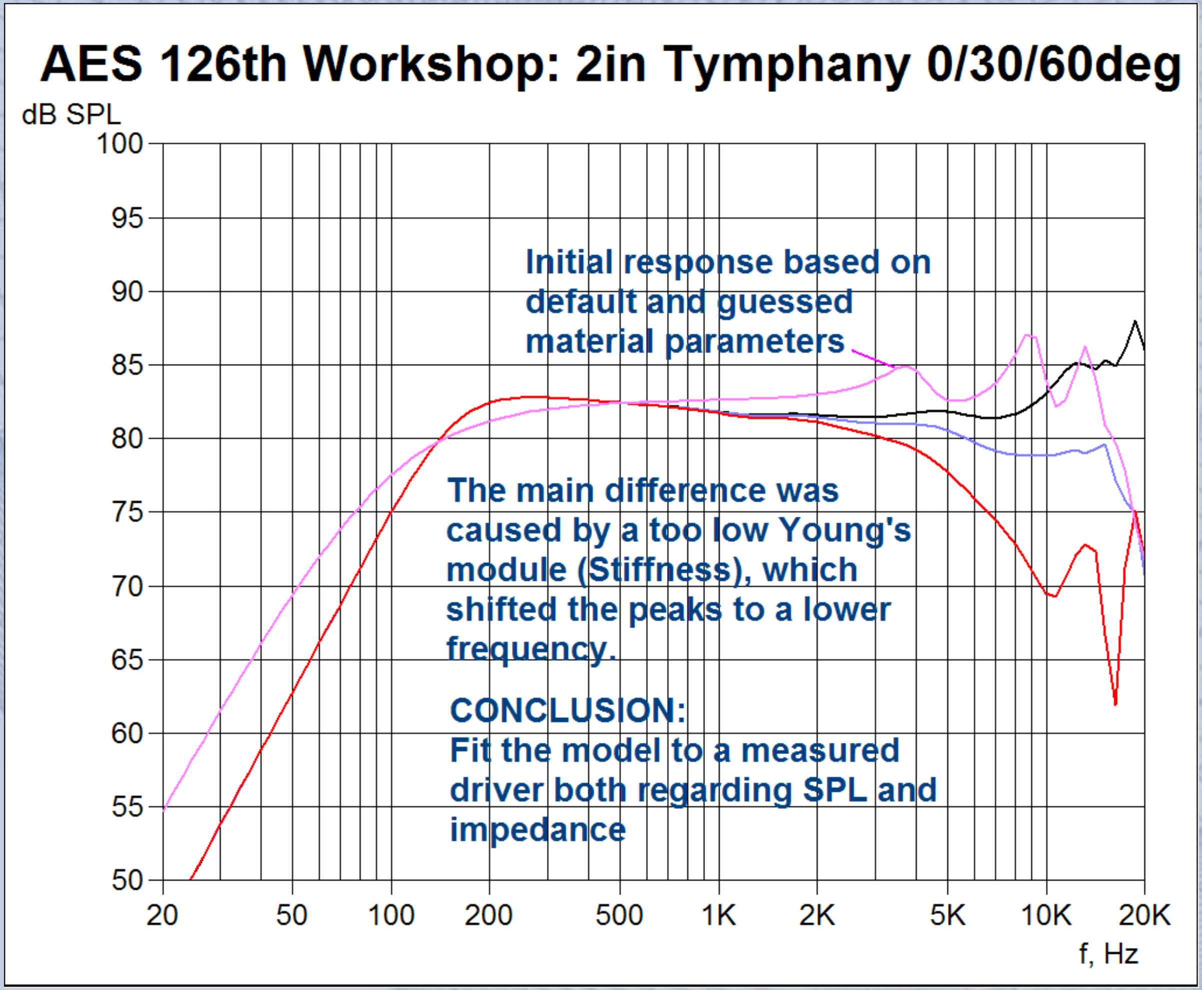
Influence of Initial and Final FEA Material Parameters



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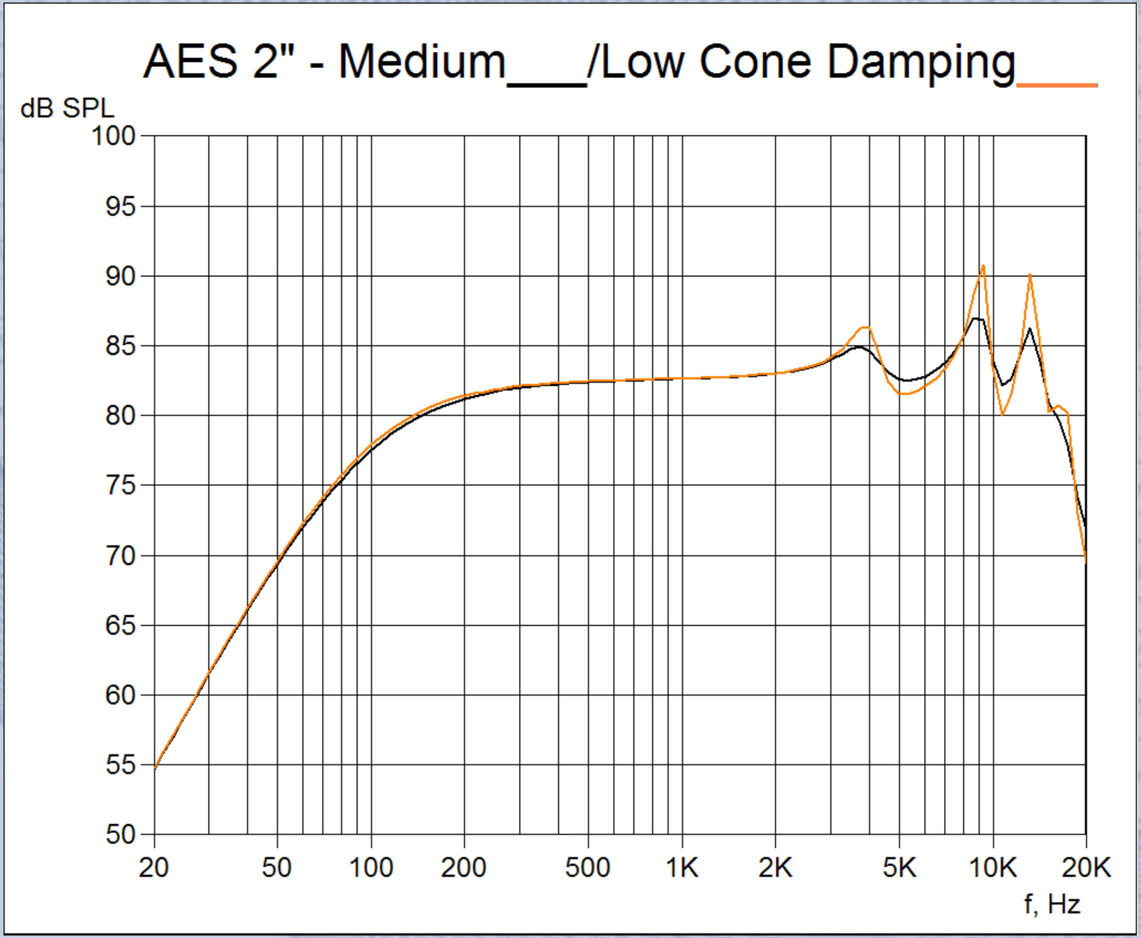
FEA Cone Damping



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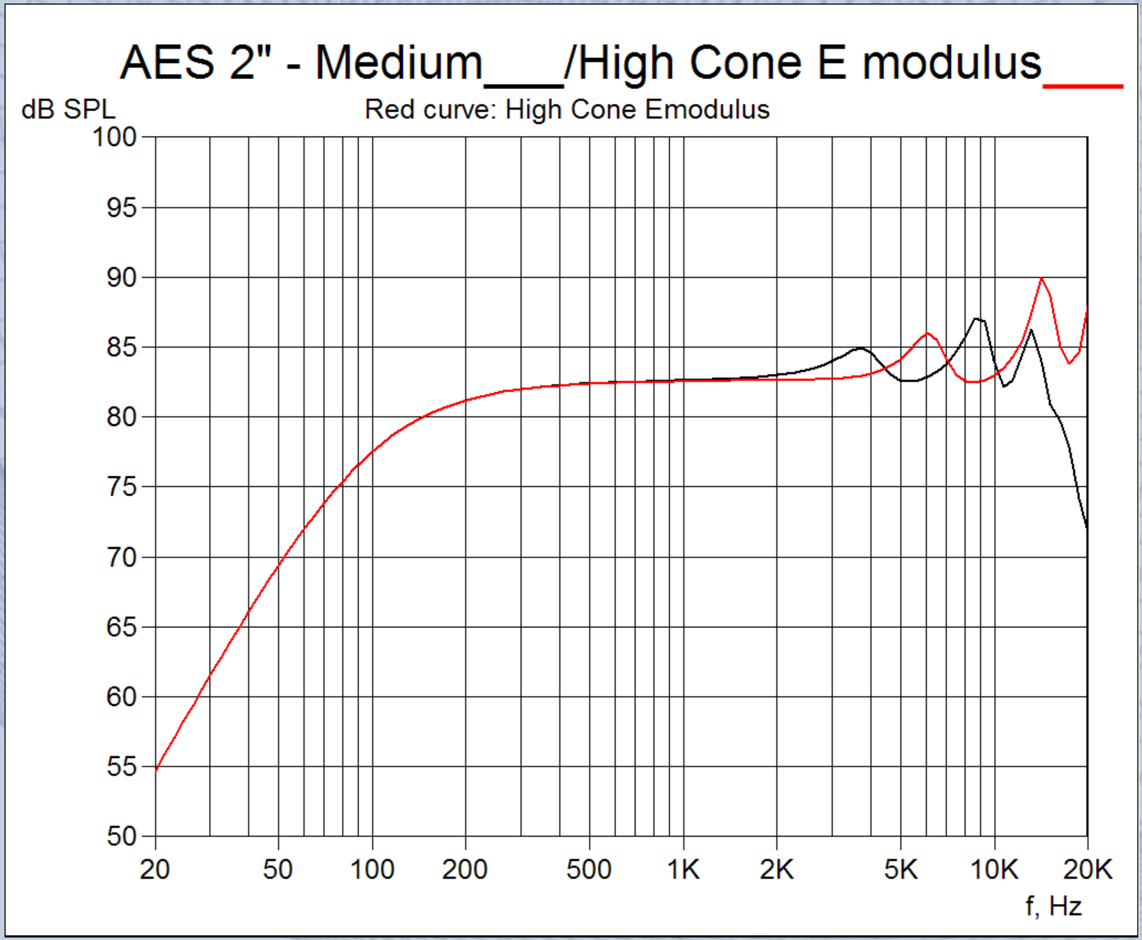
FEA Cone Young's Modulus



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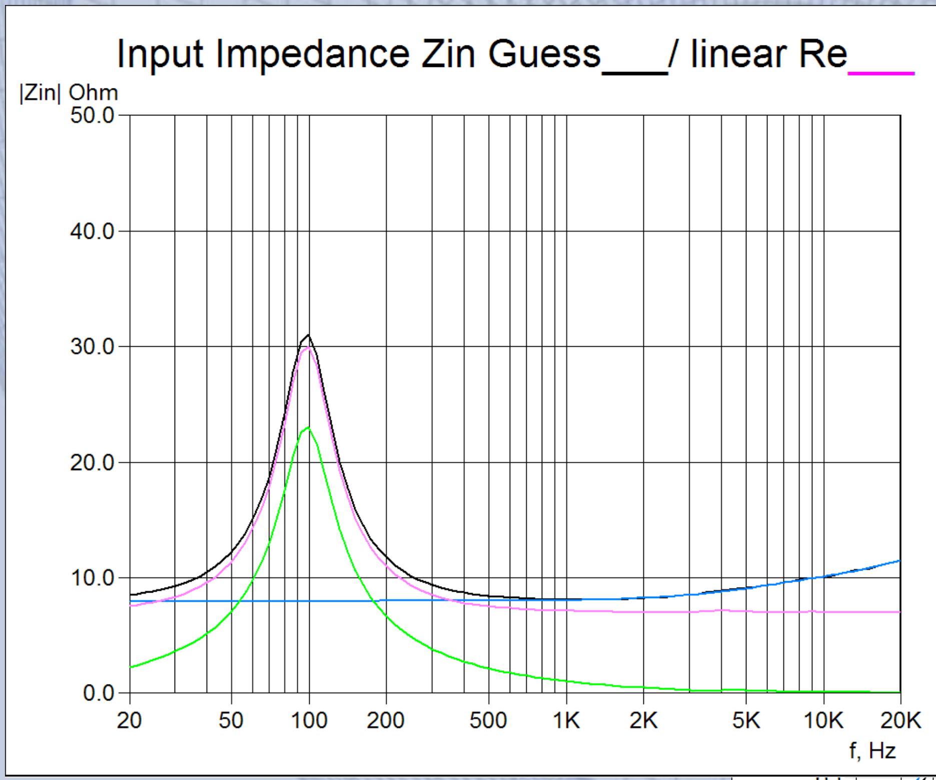
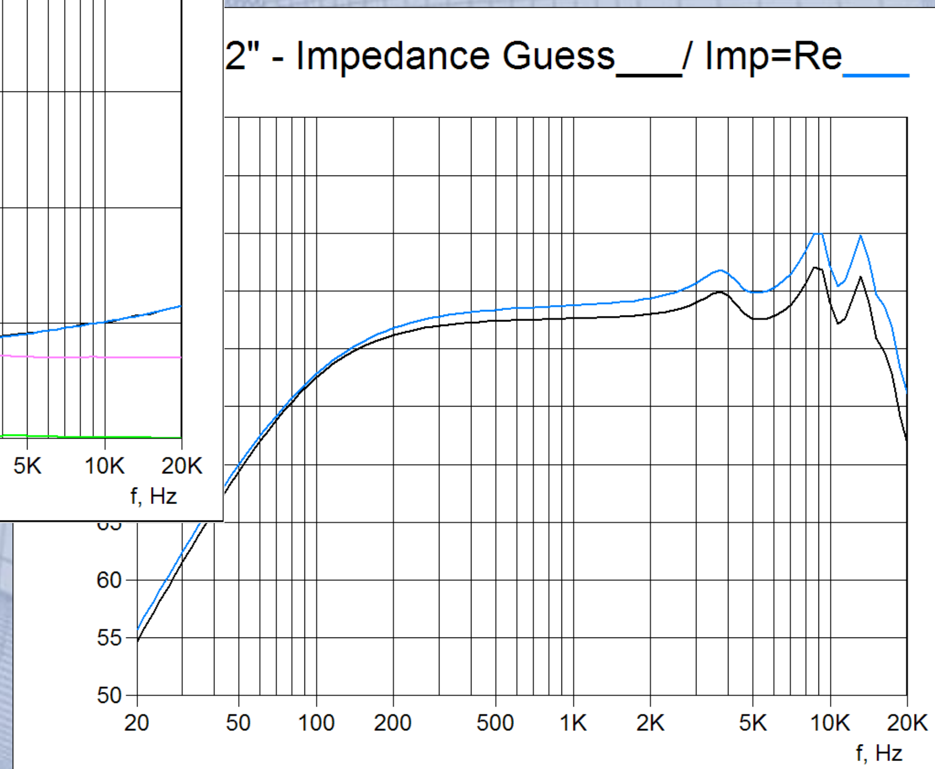
FEA Impedance Simulation





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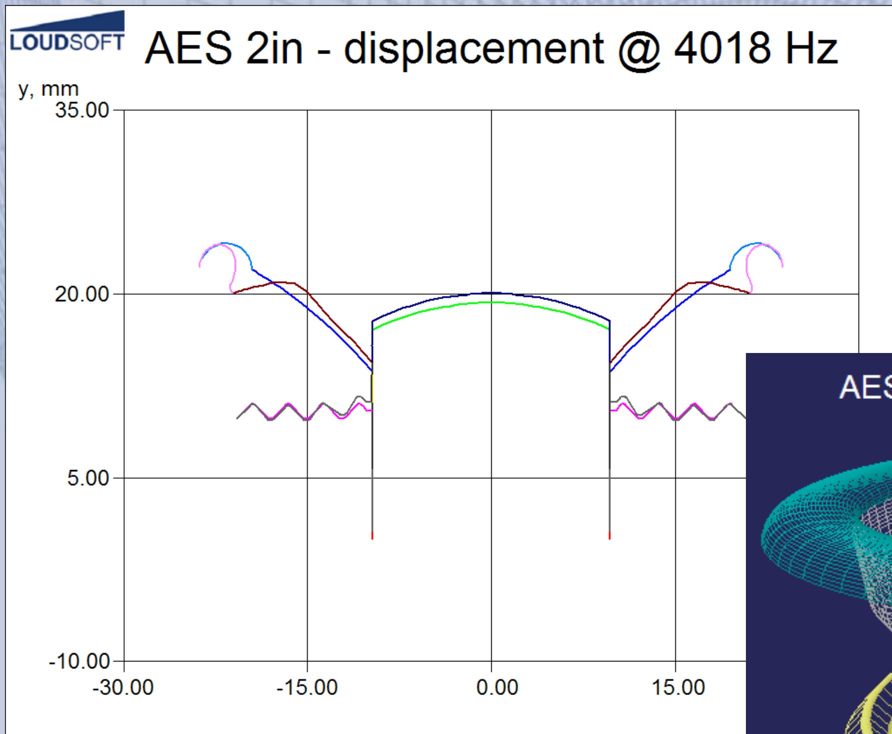
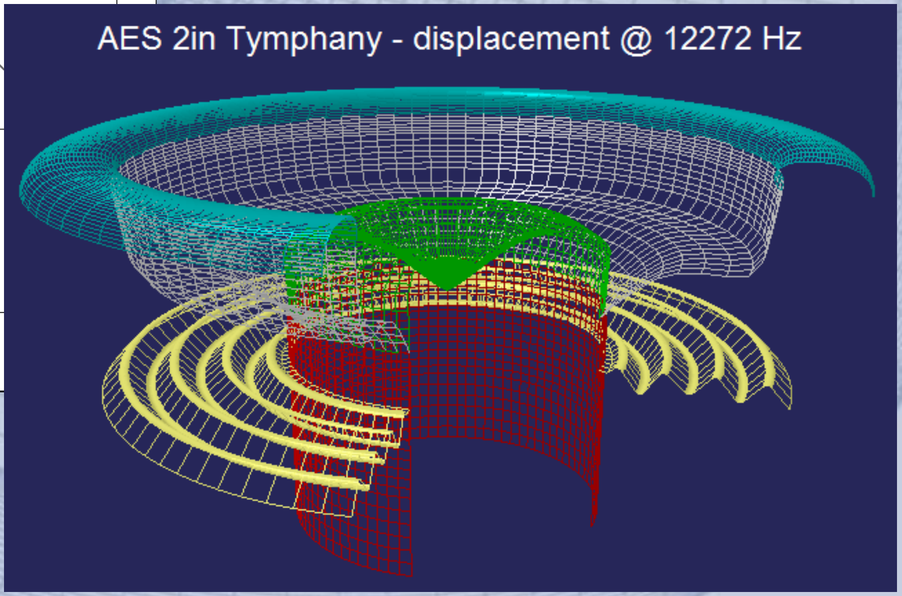
FEA cone Displacements





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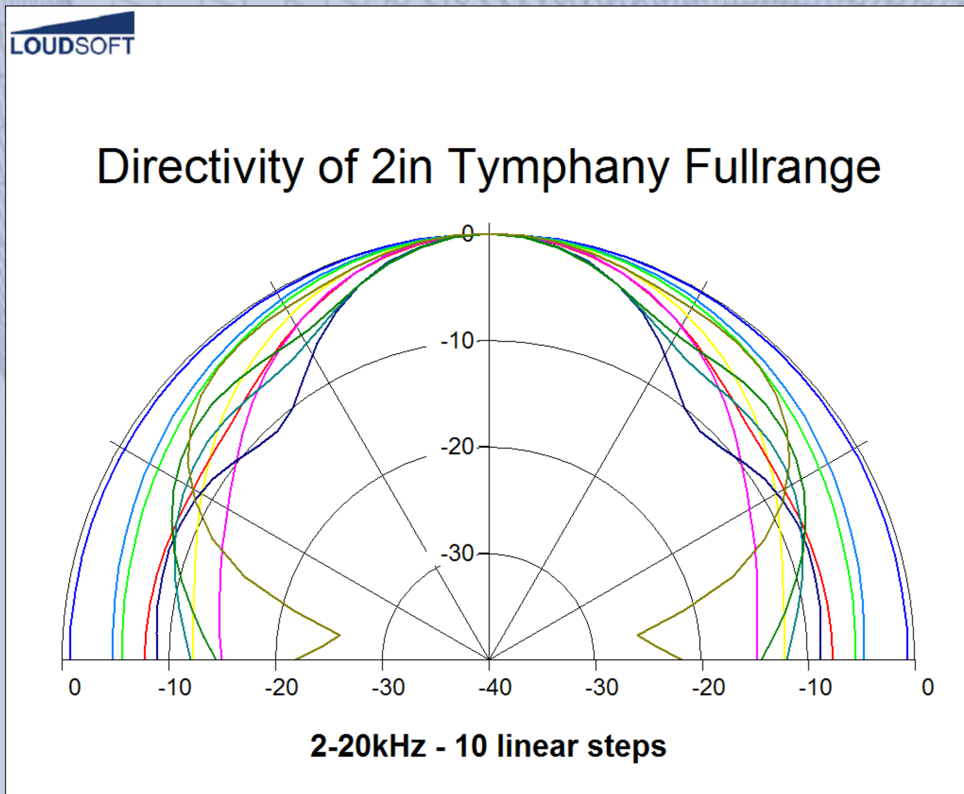
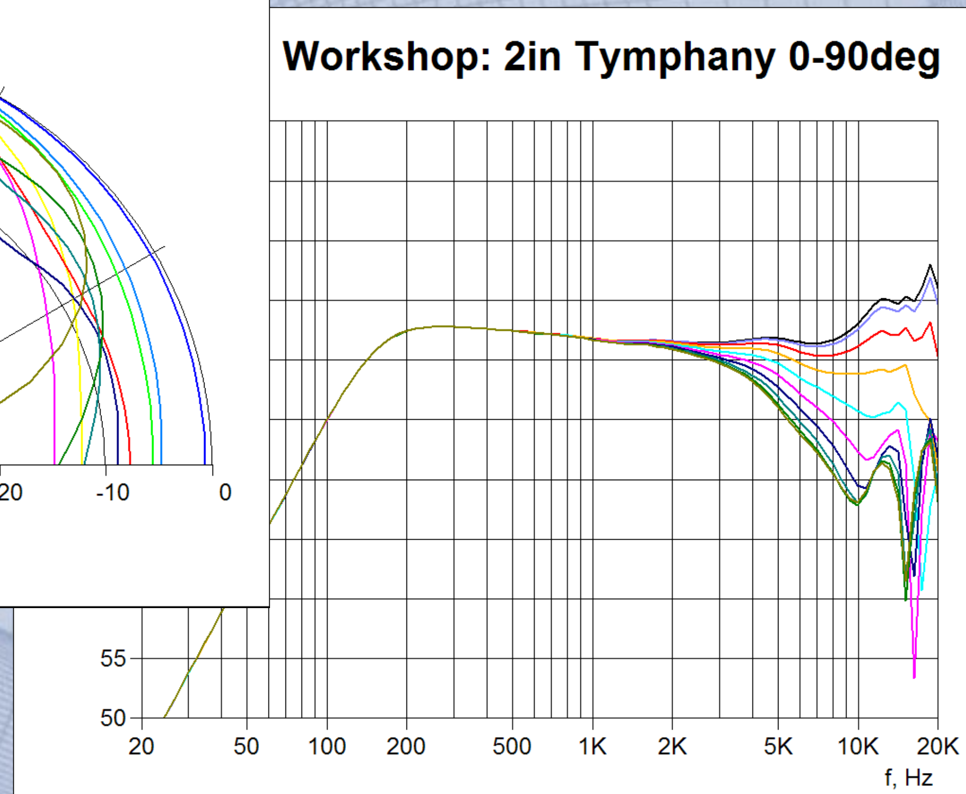
FEA Directivity and Dispersion





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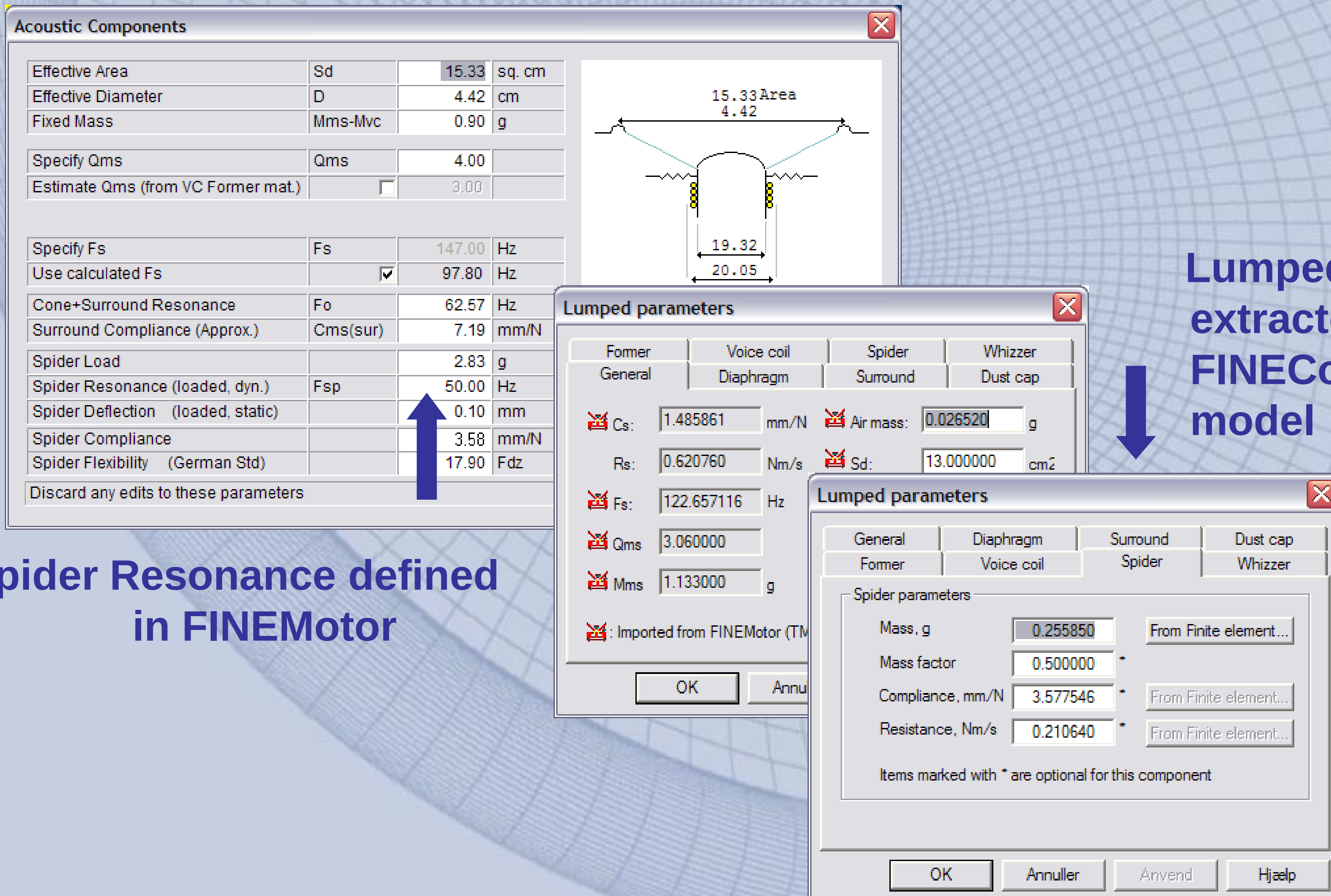
Lumped Parameters to/from FEA



Lumped Elements extracted from FINECone FEA model

Spider Resonance defined in FINEMotor

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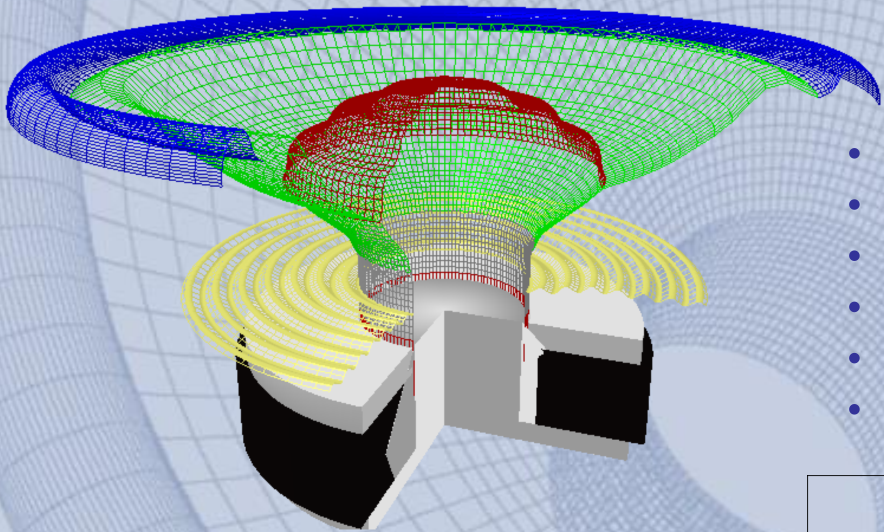
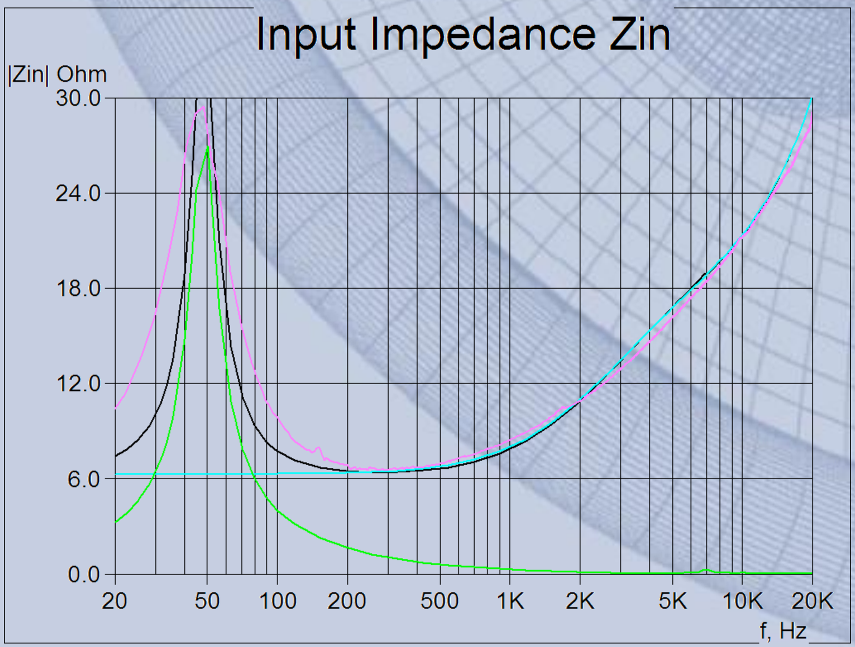
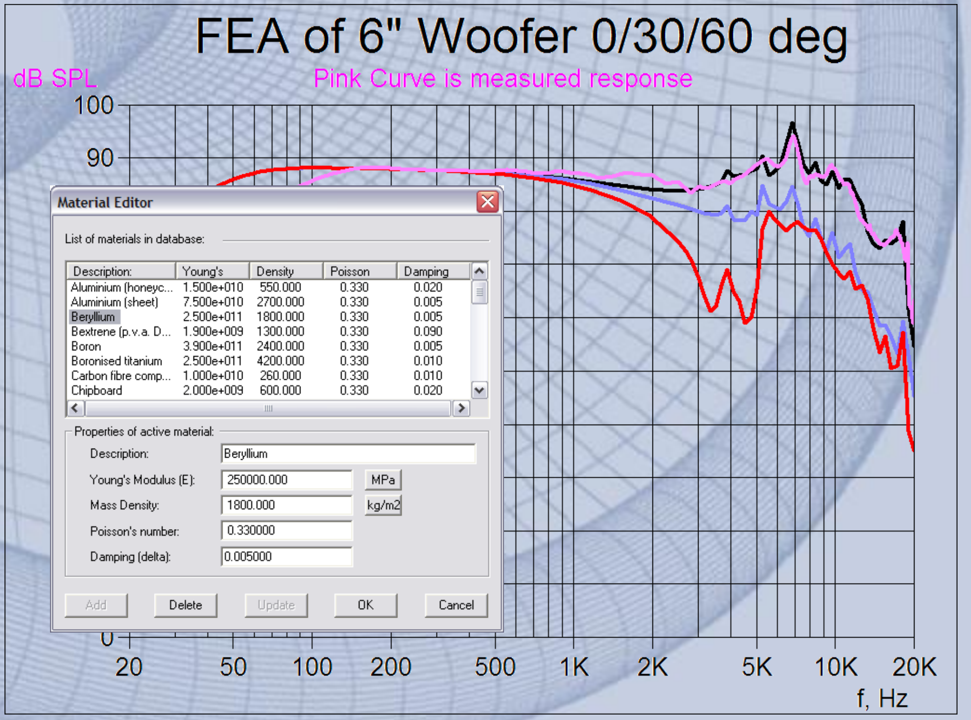


FINECone™

Acoustic Finite Element Modelling:

- ***Very Fast Calculation < 12 sec (100 points)***
- ***Axi-Symmetric modes most important***
- ***Simple 2D input geometry (DXF)***
- ***Built-in Material Database (+ Kurt Müller)***
- ***Extracted Lumped TS parameters***
- ***Low Cost FEA Software***





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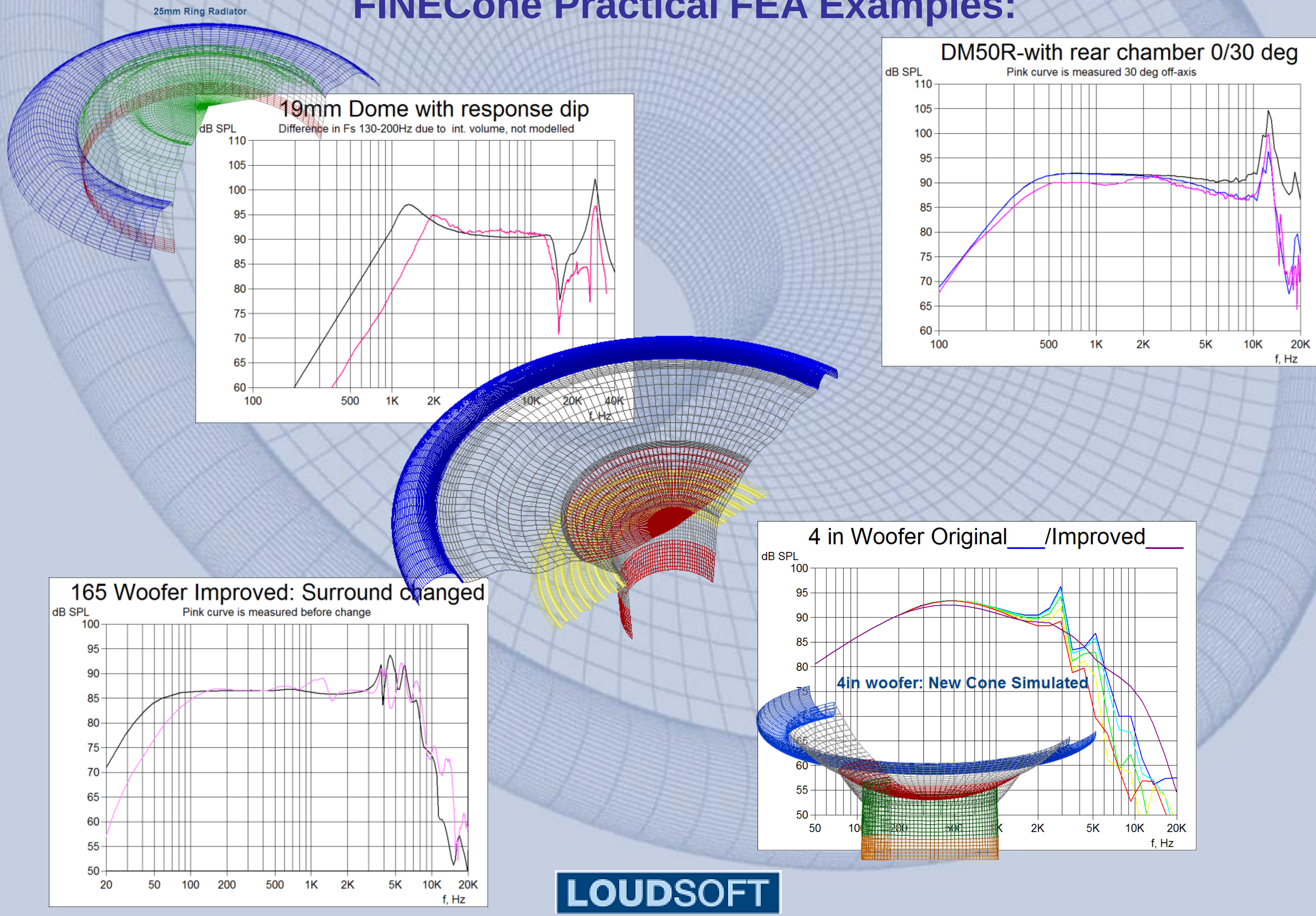
FINECone Practical FEA Examples:



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1. *Precise information about E-Modulus, and damping of the cone, surround and dust cap was not available for the initial study.*
2. *The previous slides illustrate the very large response variations that are possible when the material parameters are unknown.*
3. *Consequently the 2nd FINECone/FEA Iteration was performed with adjusted mechanical data using the measured Tymphany response as reference*

General FEA Conclusion of the Workshop:

The most productive FEA Simulation is done by using SPL response and Impedance measurements as a reference to find the material parameters

LOUDSOFT Conclusions

- *Complete FINECone FEA is setup in few hours*
- *High resolution response solved in seconds*
- *Simple 2D drawings as input*
- *Standard Windows PC (XP/Vista)*
- *FINECone: Problem Solving + Guide Development*
  - *Save Development Time*
  - *Save Tooling & Costs*