# Experimental Marchenko focusing in a variable diameter sound wave tube

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# **Focusing: motivation**

seismic imaging



(https://math.berkeley.edu/)

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# **Focusing: motivation**



(http://www.wikipedia.org/)

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(http://www.wikipedia.org)

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# **Focusing: motivation**

### seismic imaging



(spmphysics.onlinetuition.com)





### Redatuming the wavefield















## Sound wave tube: hardware



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## Sound wave tube: hardware



## Sound wave tube: hardware





(2) receiver: <sup>1</sup>/<sub>2</sub>" pressure-field microphone + pre-amplifier

## Sound wave tube: hardware



# Sound wave tube: theory

### Restricting wave propagation to planar mode:

$f_0 = 1.841 c (\pi d)^{-1}$	(*)	$d  [\mathrm{cm}]$	$f_0$ [kHz]
		2	10.0
<ul> <li><i>f</i><sub>0</sub>: cut-off frequency</li> <li><i>c</i>: propagation velocity in air</li> <li><i>d</i>: tube diameter</li> </ul>		<b>3</b>	6.7
		4	5.0
		5	4.0
		6	3.4

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Introducing impedance contrasts I

$$I = \rho c/S \quad (^{**})$$
$$R = (S_1 - S_2)(S_1 + S_2)^{-1}$$

S: cross-sectional area  $\rho$ : density



# Sound wave tube: attenuation



## Sound wave tube: attenuation





travel-time corrected arrivals

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## Sound wave tube: attenuation



### attenuation of 1 - 10 dB/m, depending on d and f

1

 $\times 10^{-3}$ 

# **Marchenko** focusing

Reflection response





# **Marchenko** focusing

### Reflection response

- simulating lossless medium by correcting for attenuation
- remove direct wave and remove source signature
- apply the iterative Marchenko scheme (\*) until convergence



# Marchenko focusing

• Focusing function  $f_1^+$ 





# **Marchenko** focusing

Experimental validation



# Conclusions

- first laboratory demonstration of 1D Marchenko focusing
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- first laboratory demonstration of 1D Marchenko focusing
- very good focusing quality, comparable to model driven focusing
- processing is very sensitive to deconvolution with source signature
- removal of direct wave and time-windowing: limits minimum layer thickness
- free-surface multiples must be removed
- correction for propagation losses: some model knowledge required

# Outlook

- increase model complexity
- imaging using Marchenko
- tube end reflections: Marchenko including surface multiples (\*)
- dissipative Marchenko scheme (\*\*)
- 3D experiments in WaveLab

# References

Thank you!

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