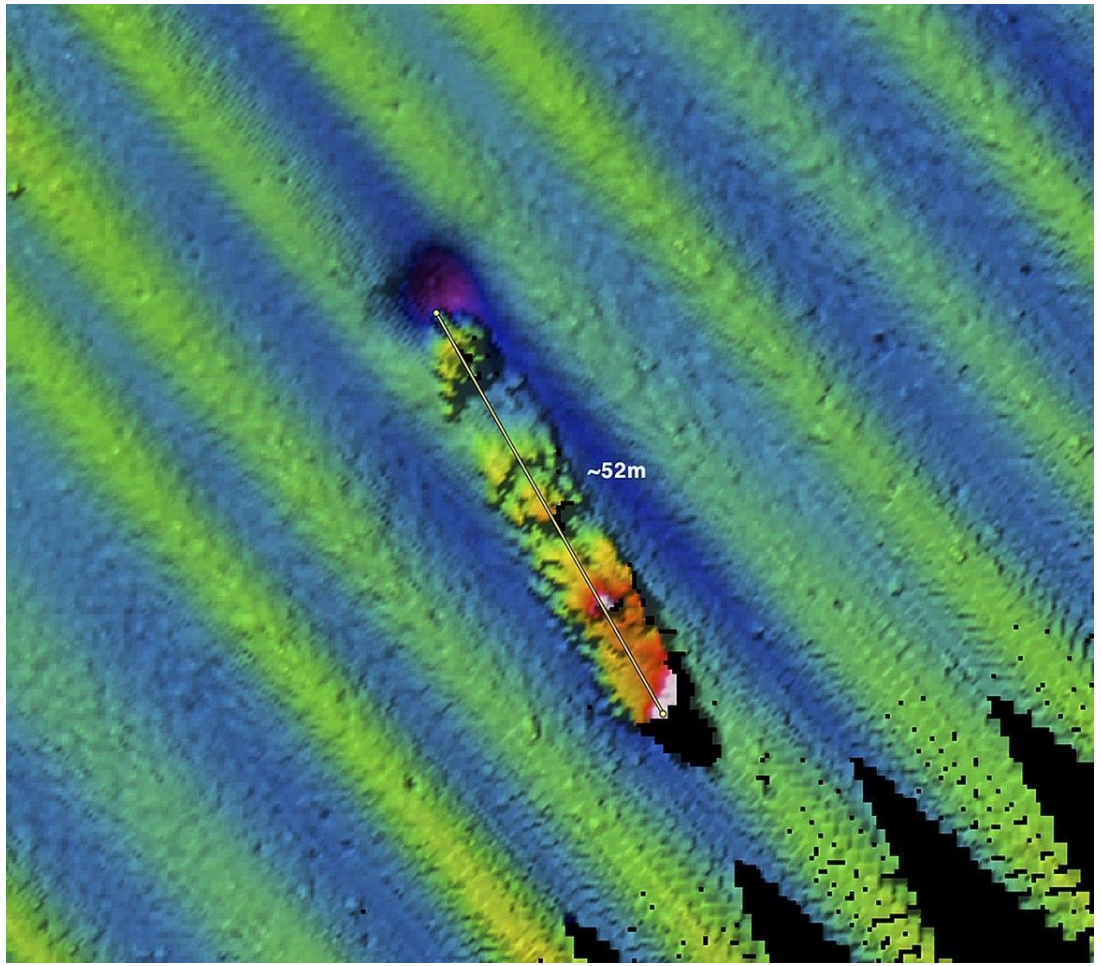
A Low-Cost Underwater Ultrasonic Phased Array

Tejus Rao, Alec Vercruysse, Rhea Zaverchand, Matthew Spencer

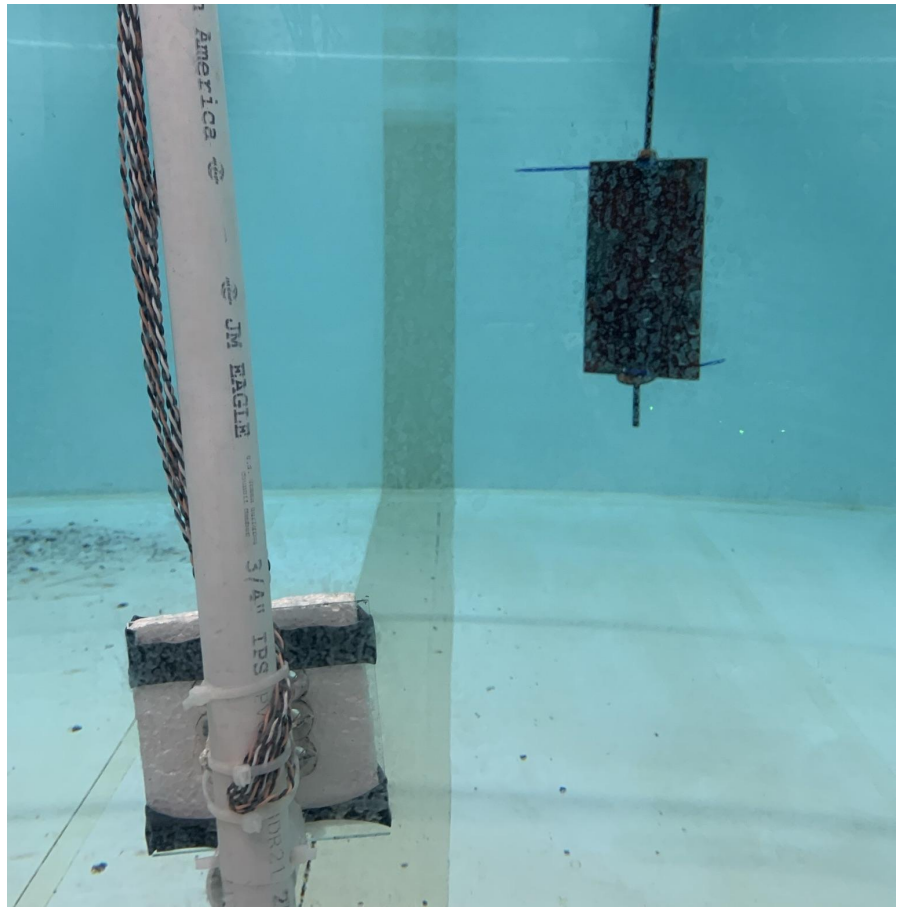
Underwater, Acoustic Propagation Wins

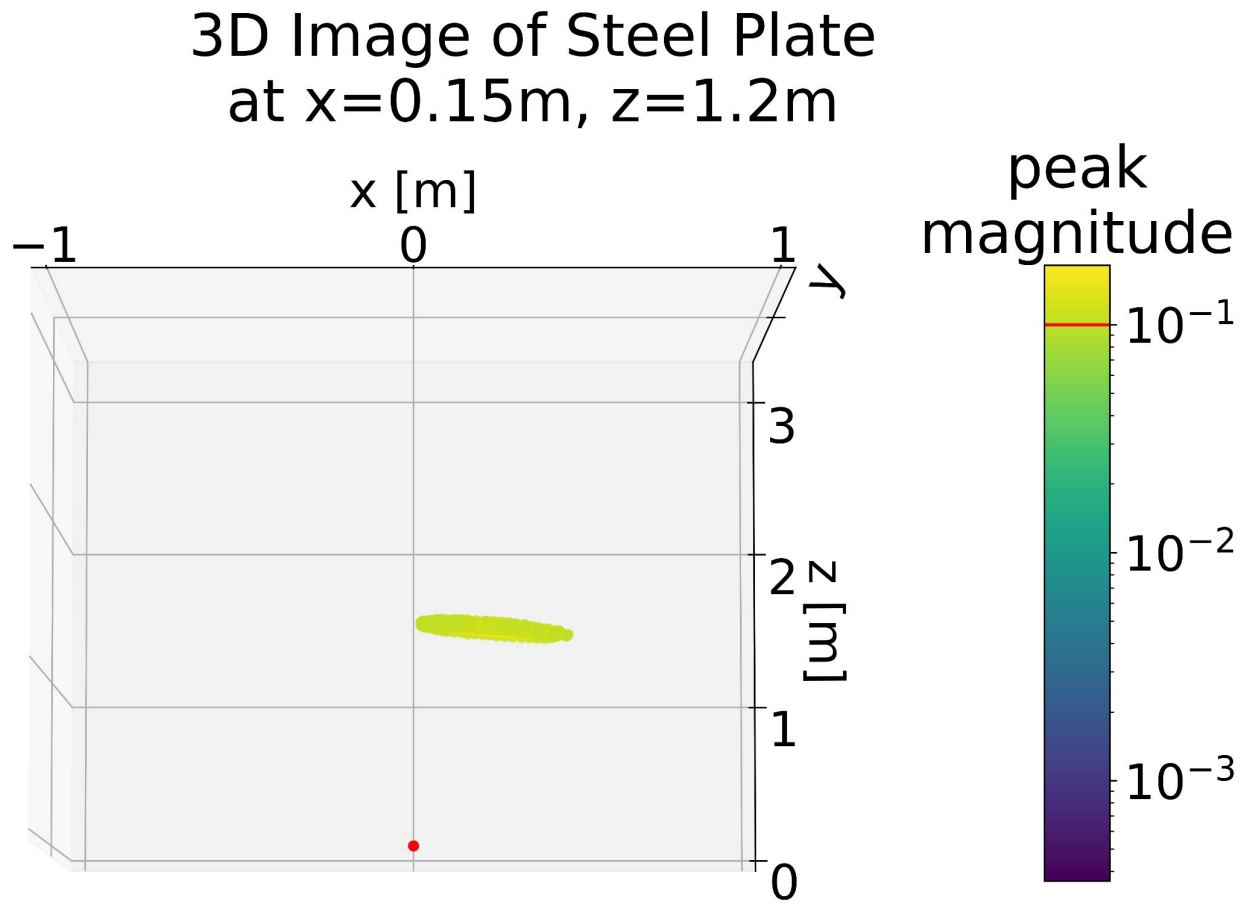


NASA/Lauren Maples, public domain, via Wikimedia Commons
https://commons.wikimedia.org/wiki/File:Supplemental_Lighting_Assesment_at_NBL_06.jpg

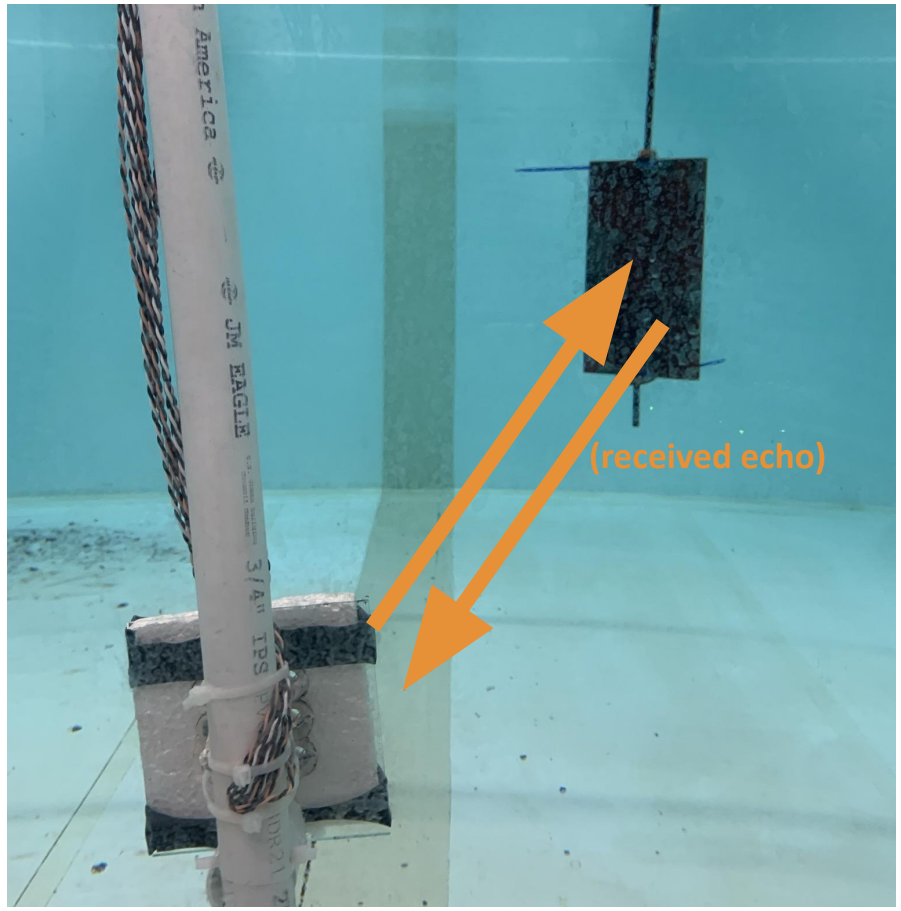
National Museum of the U.S. Navy, public domain, via Wikimedia Commons
https://commons.wikimedia.org/wiki/File:160323-N-ZZ999-301_(25979583551).jpg

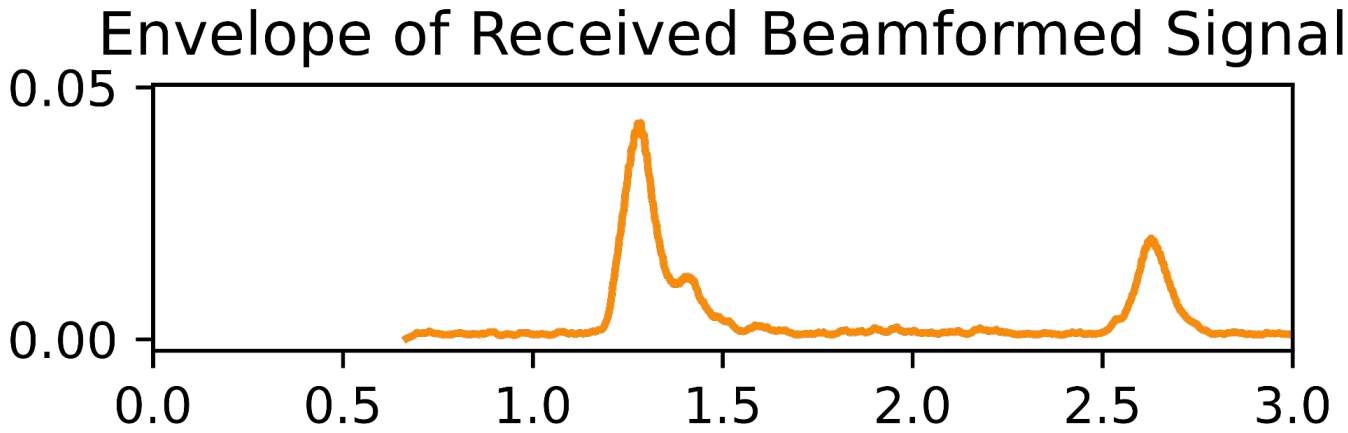
We Built an Underwater 3D Imager



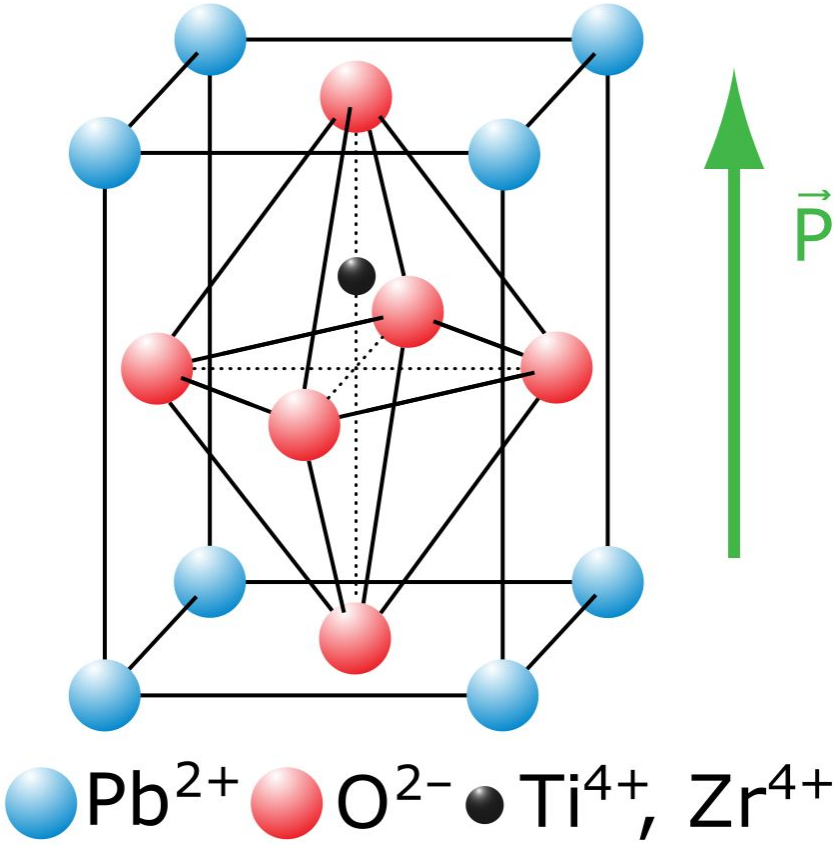


We Can Image in 3D by Sending and Receiving Directional Beams of Sound



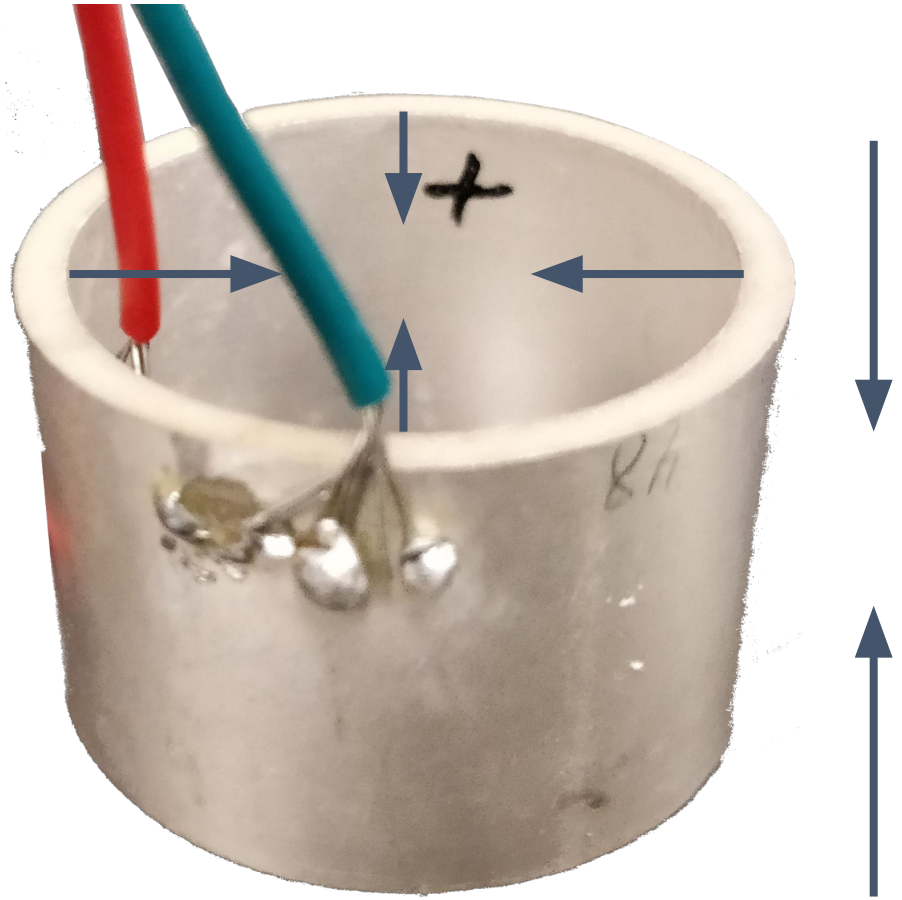


Piezoelectric Transducers Act as Both Speaker and Microphone



Unit cell of PZT, an extremely common piezoelectric material

(adapted from https://commons.wikimedia.org/wiki/File:Perovskite.svg)

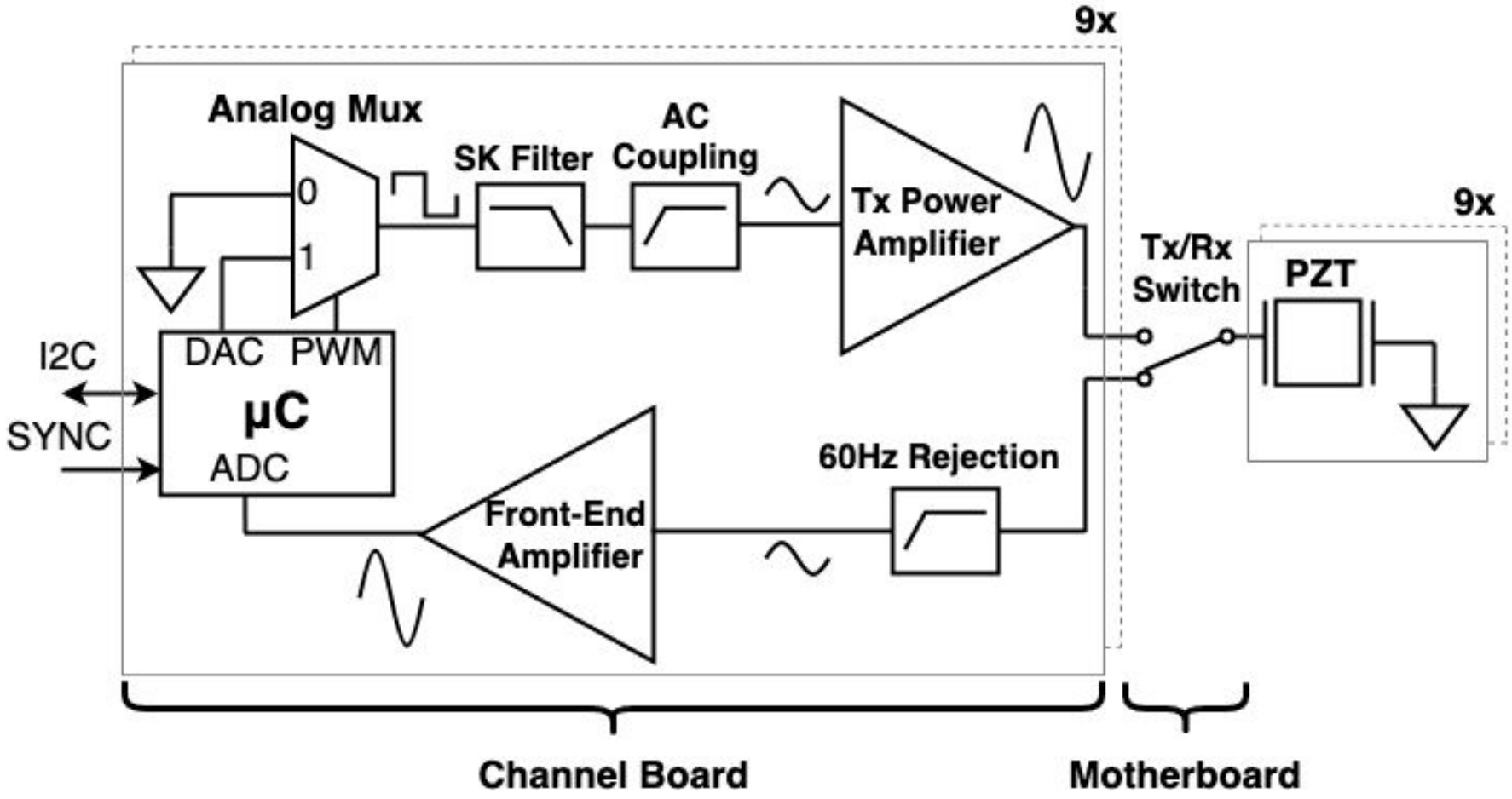


This hollow cylinder made of PZT contracts in the directions indicated by the arrows

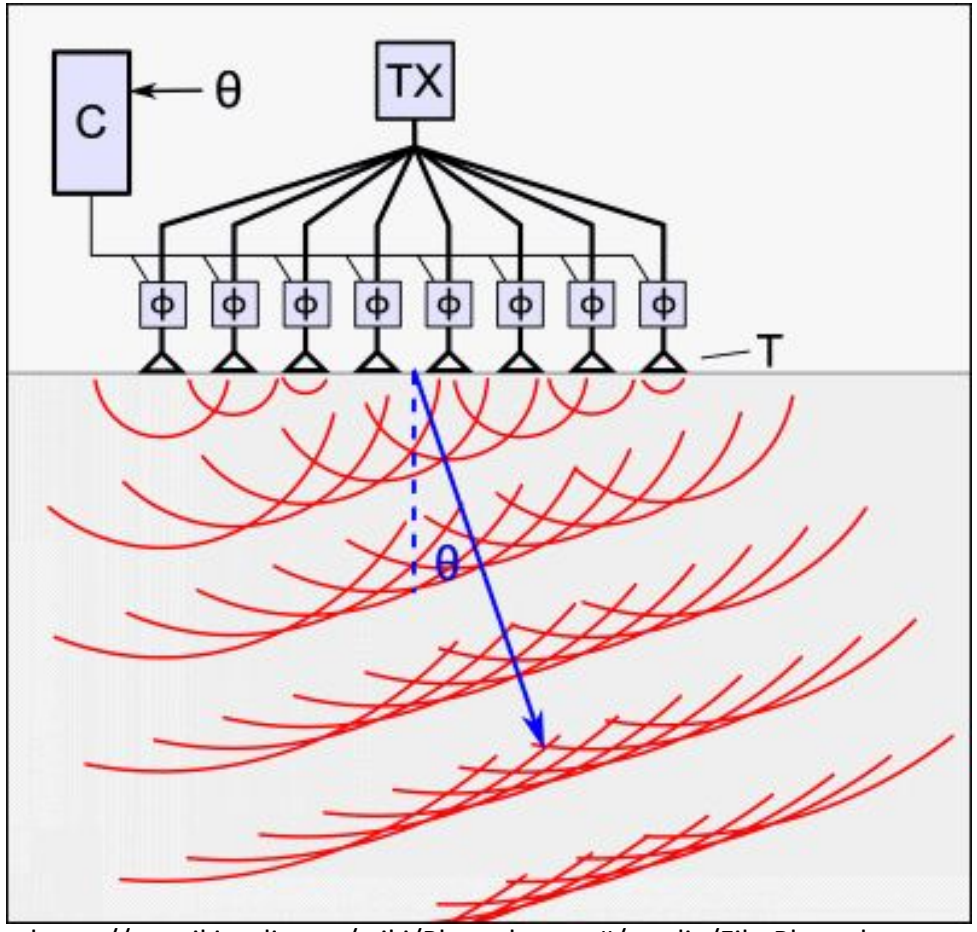
We Perform Acoustic Impedance Matching

HARVEY MUDD COLLEGE

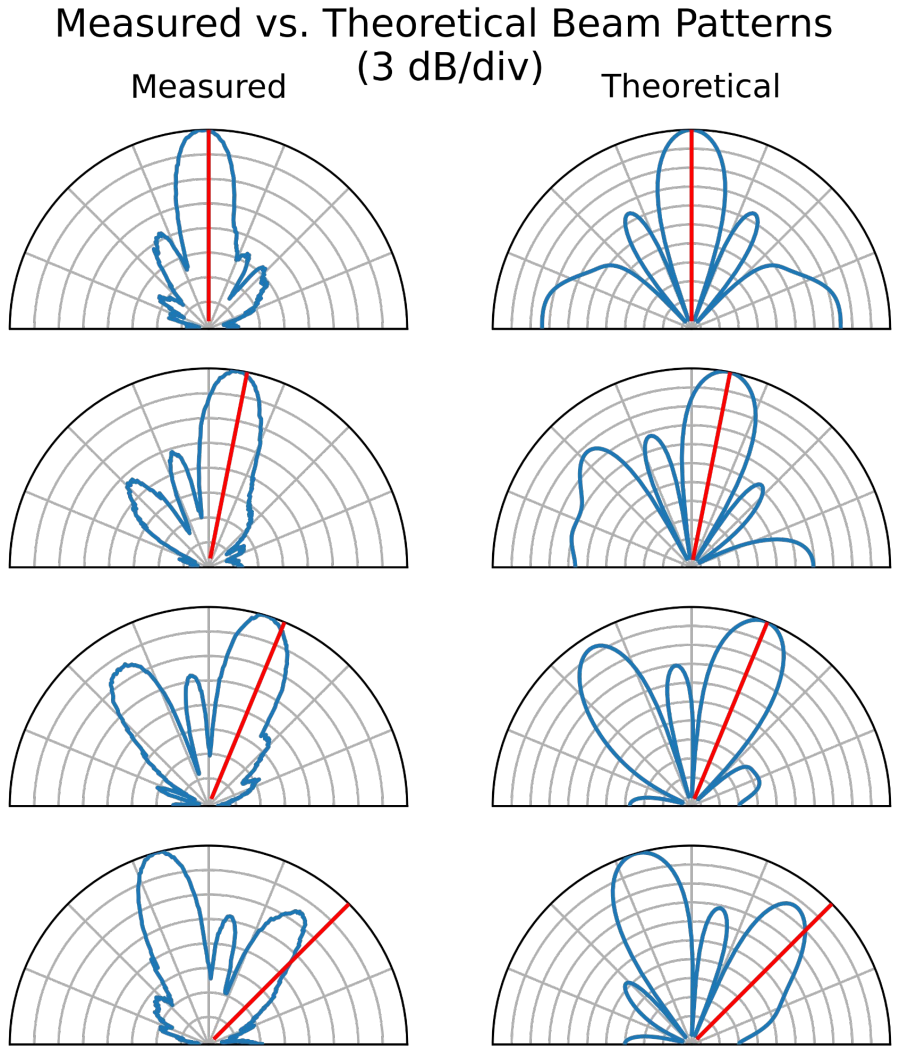
Here's a Board that Drives One PZT



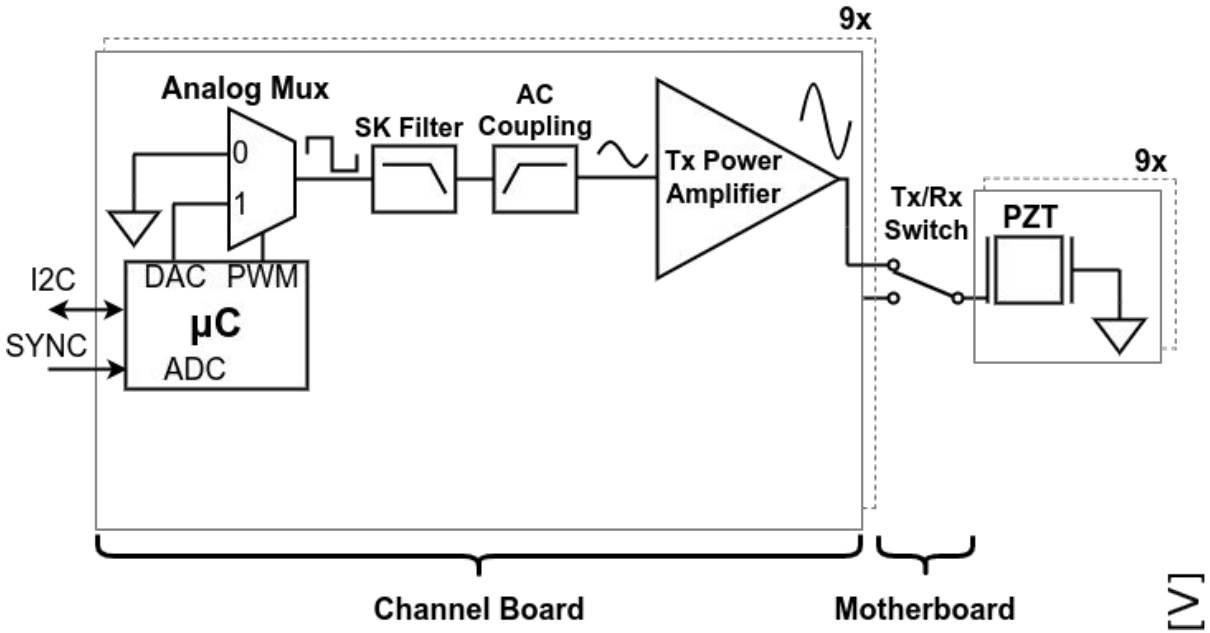
Phased Arrays Let us Make the Beam from the Last Picture

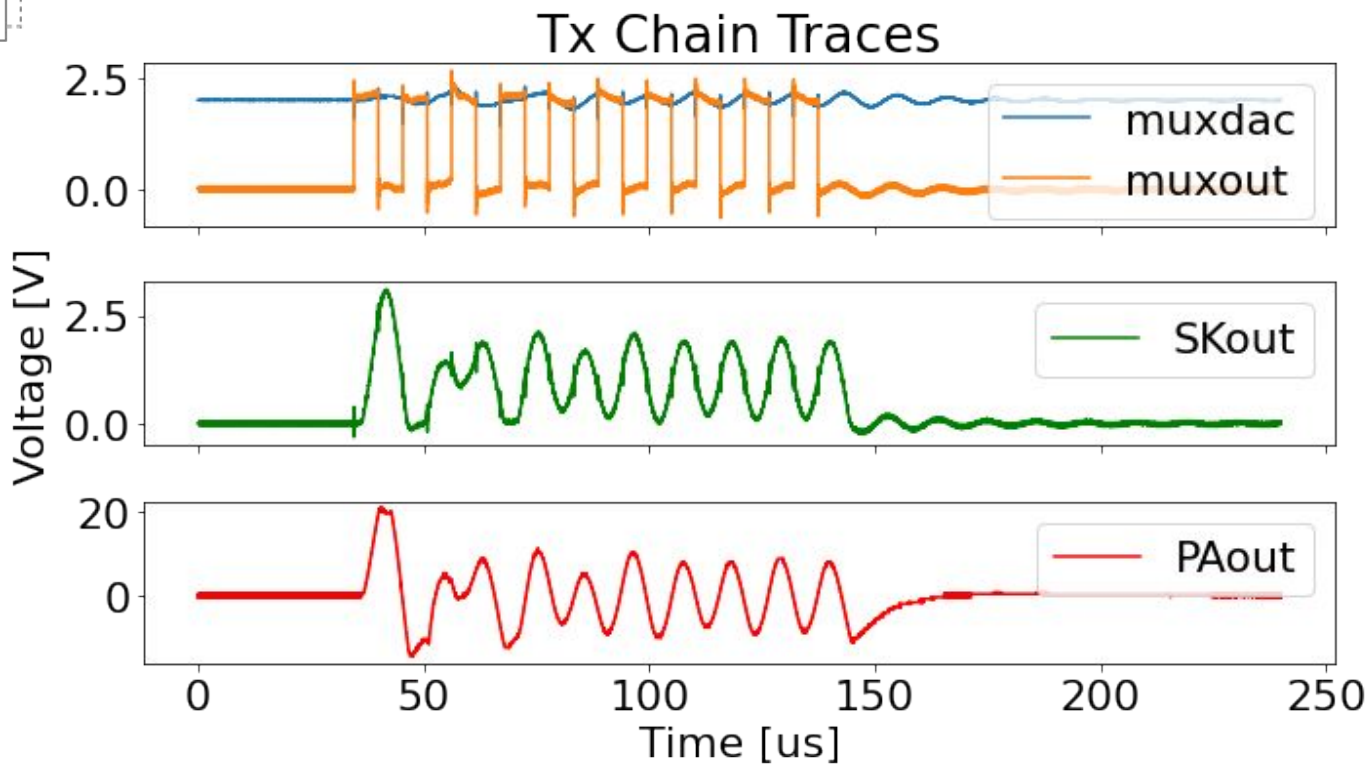


https://en.wikipedia.org/wiki/Phased_array#/media/File:Phased_array_animation_with_arrow_10frames_371x400px_100ms.gif

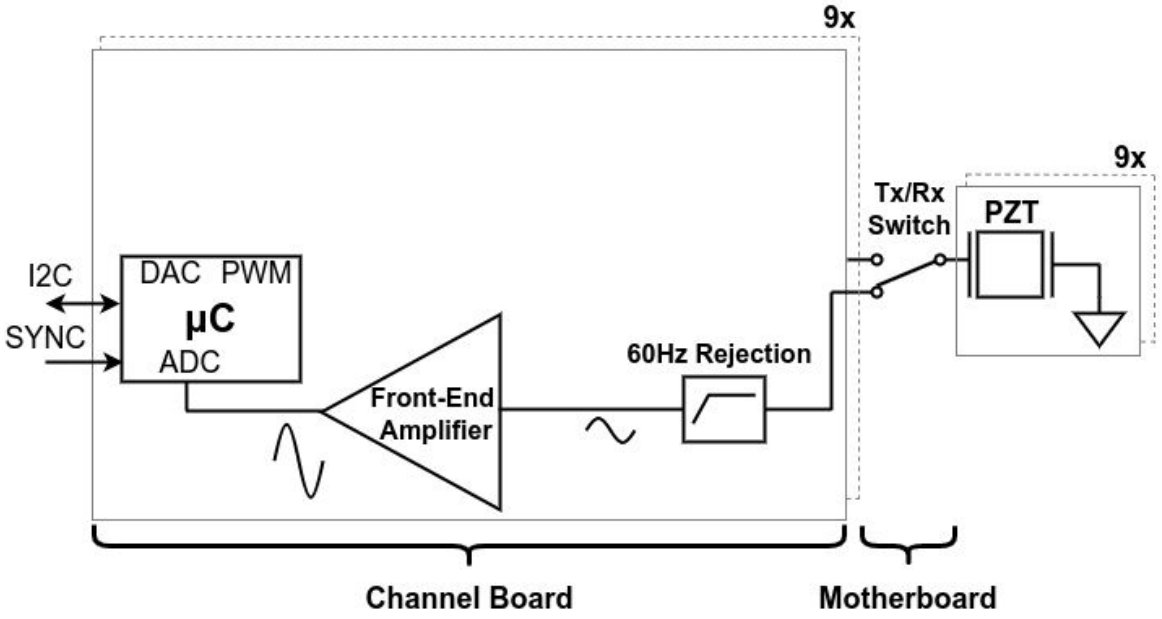


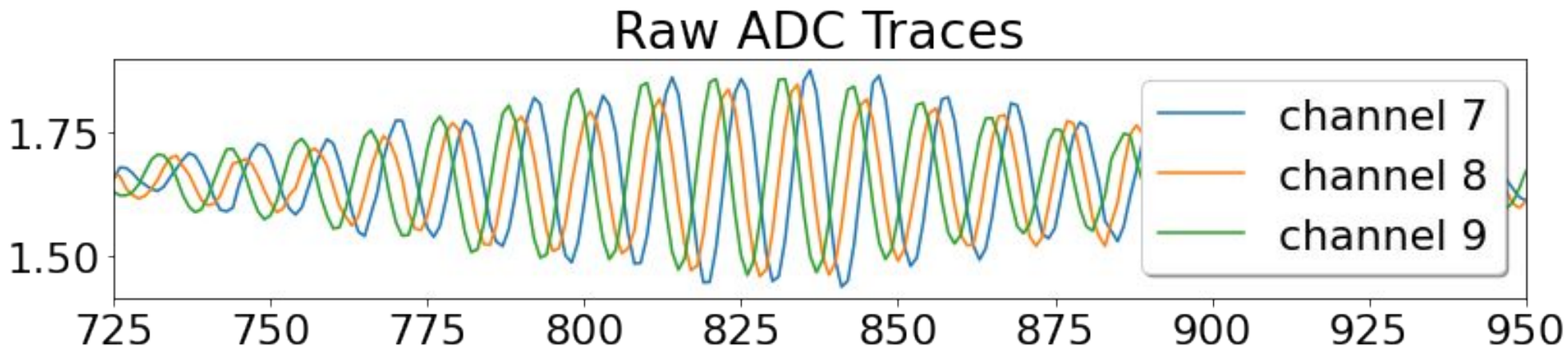
The MCU Generates an arbitrary-length Pulsed-Sine Wave



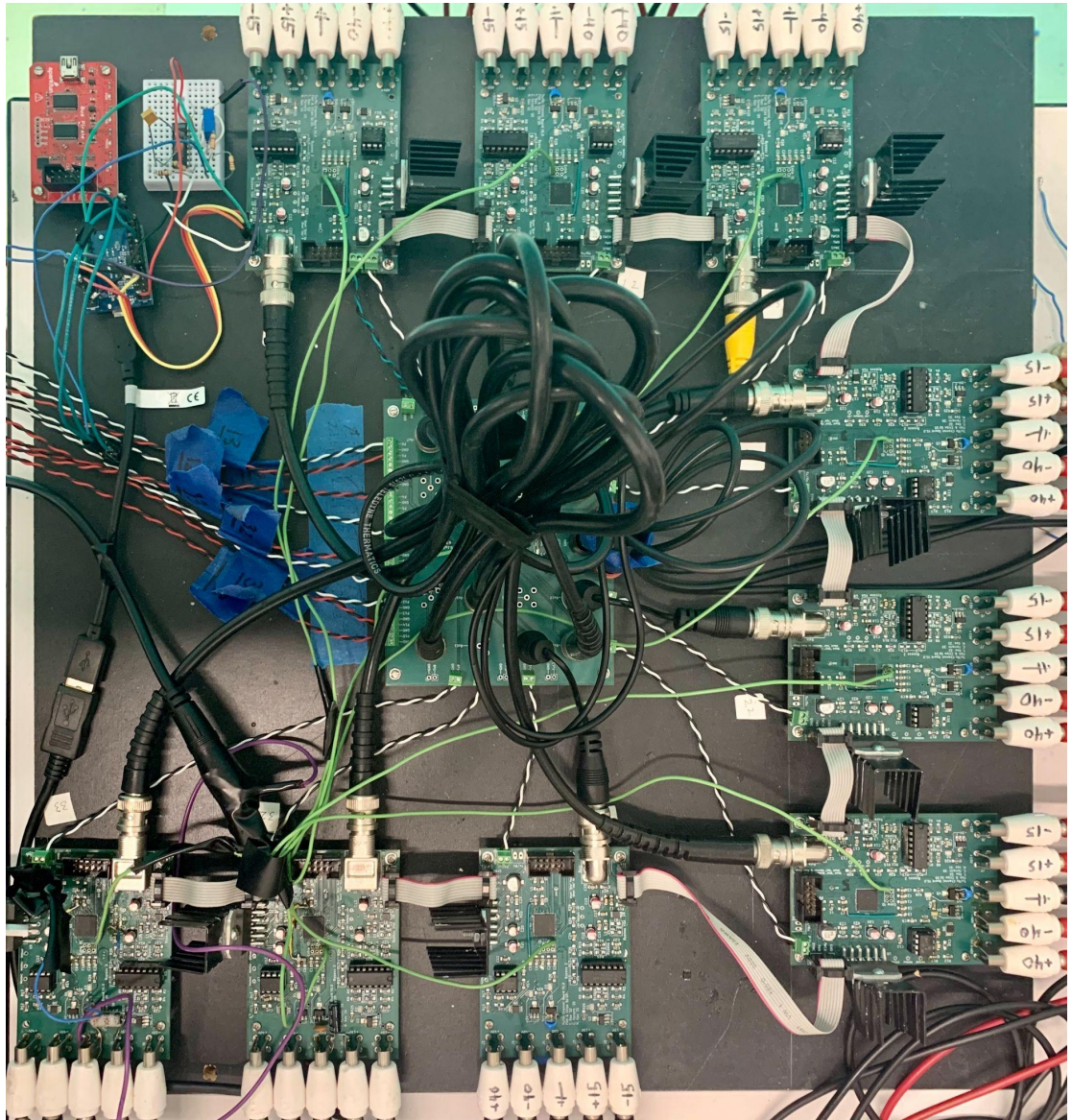


The MCU Samples the Received Signal

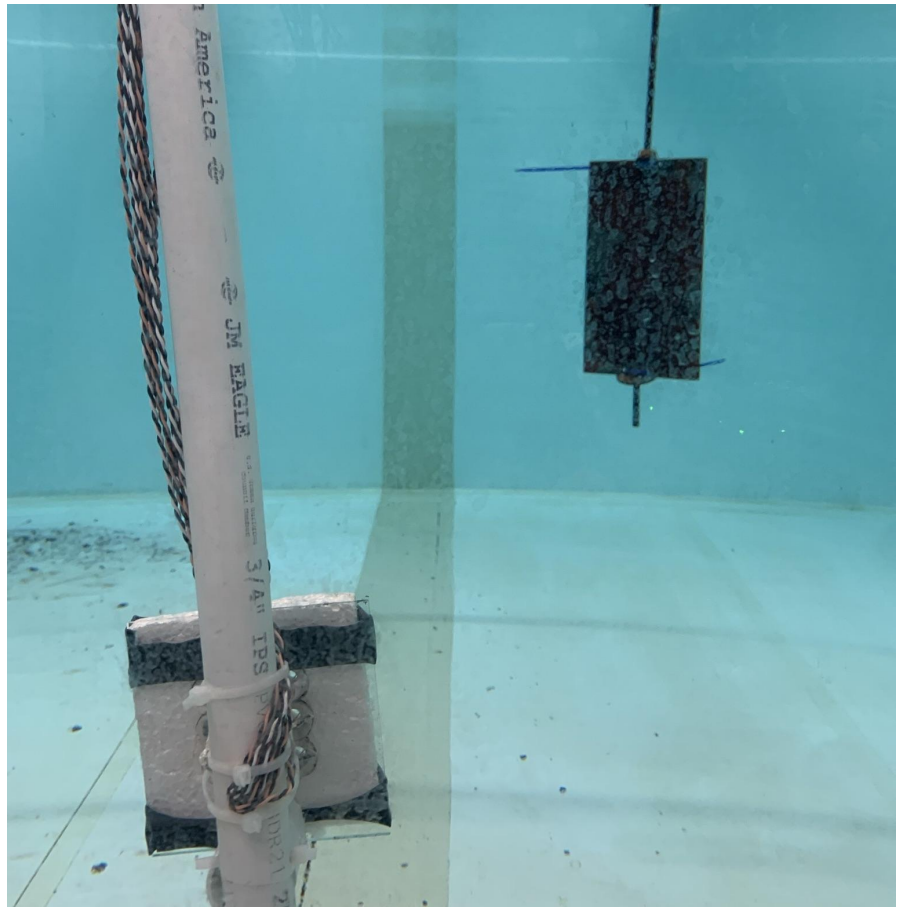


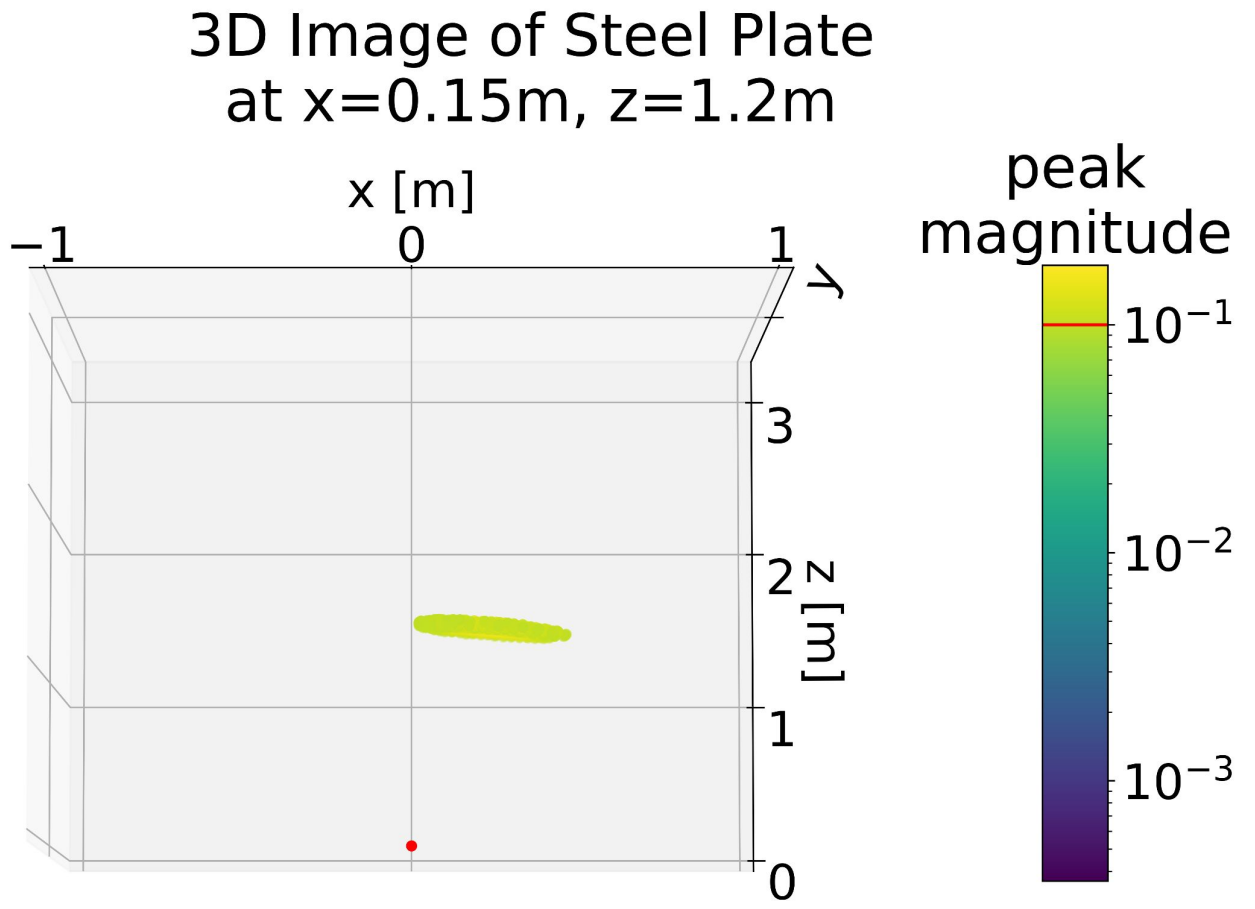


Test Setup: PCBs

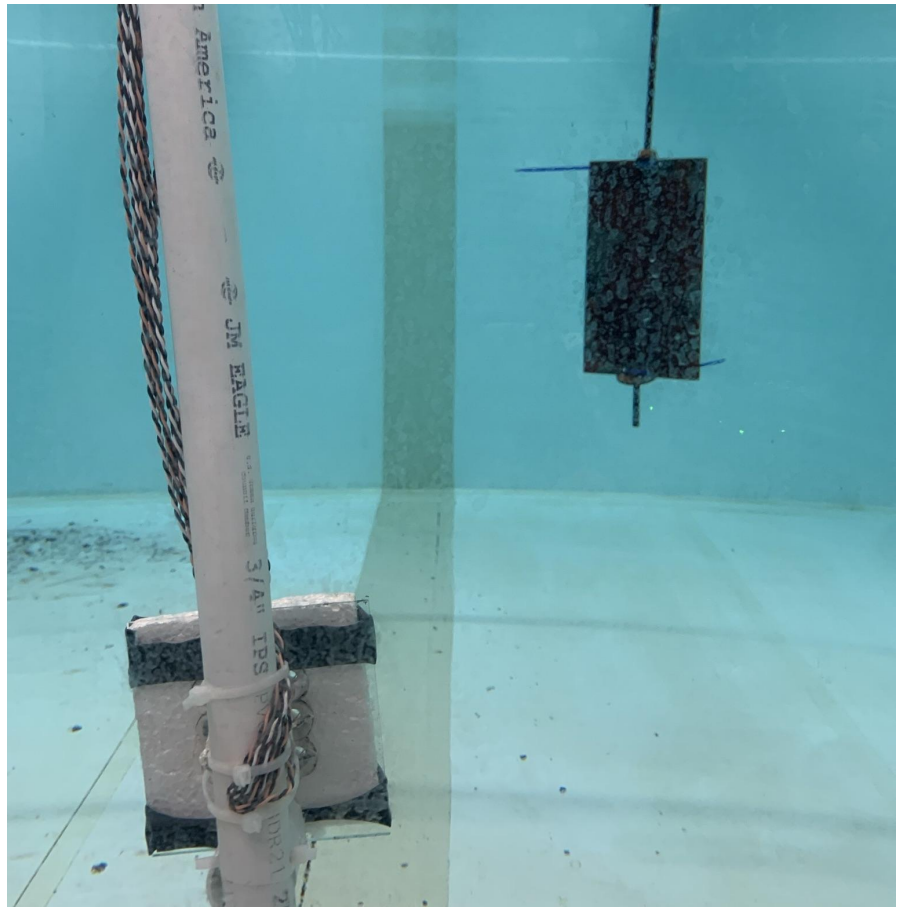


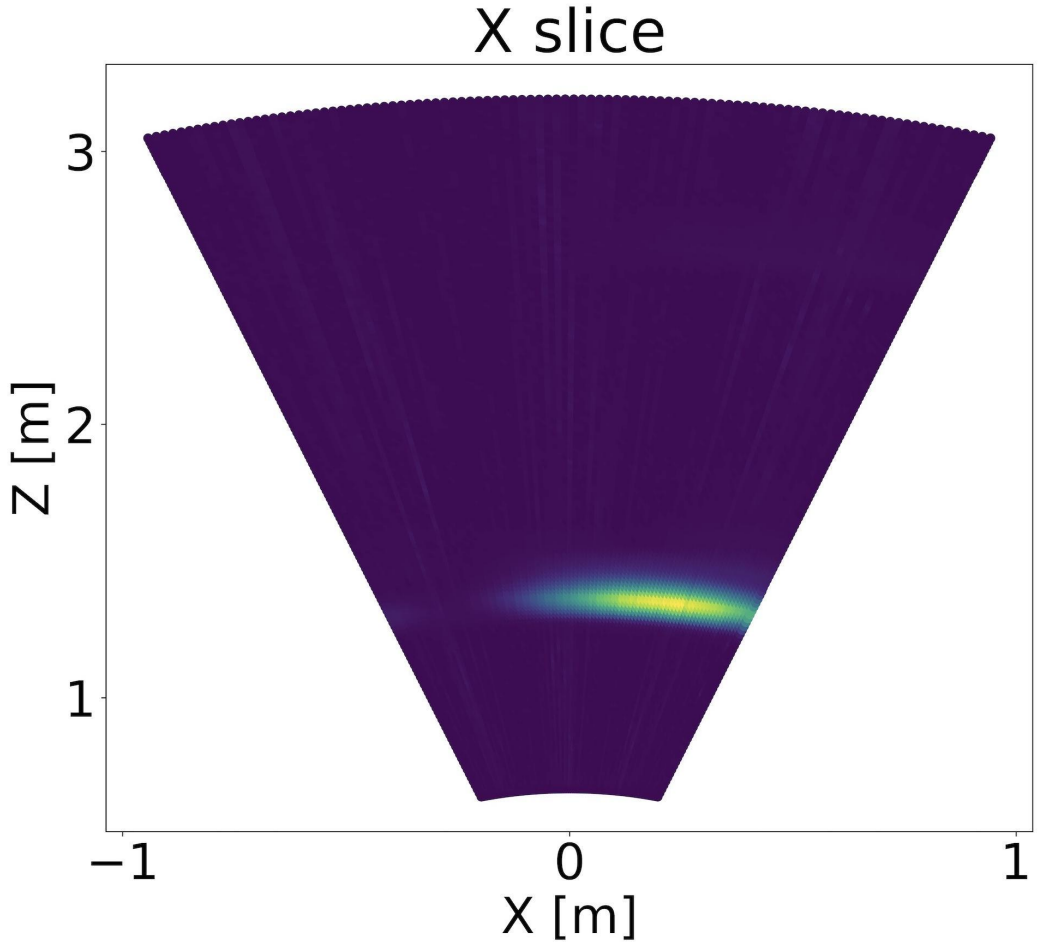
Results: We Can Take 3D Images





Results: We can take 2D images





Conclusion

Project Files on Github:
HMC-ACE/muddUltrasound

Email:
avercruysse [at] hmc.edu