

# Physics of Neuromodulation

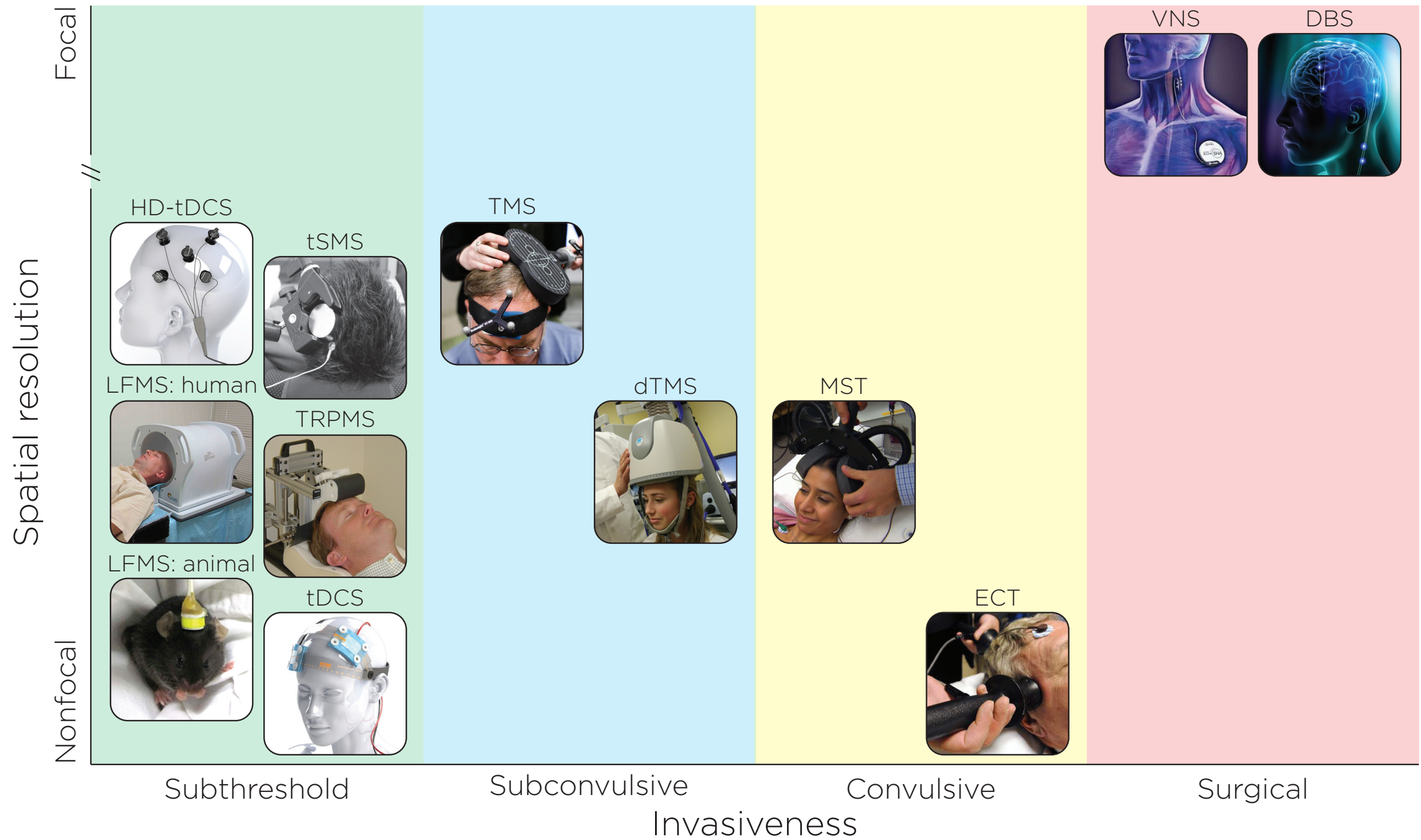
## Part II

Zhi-De **Deng**, Ph.D.

Noninvasive Neuromodulation Unit

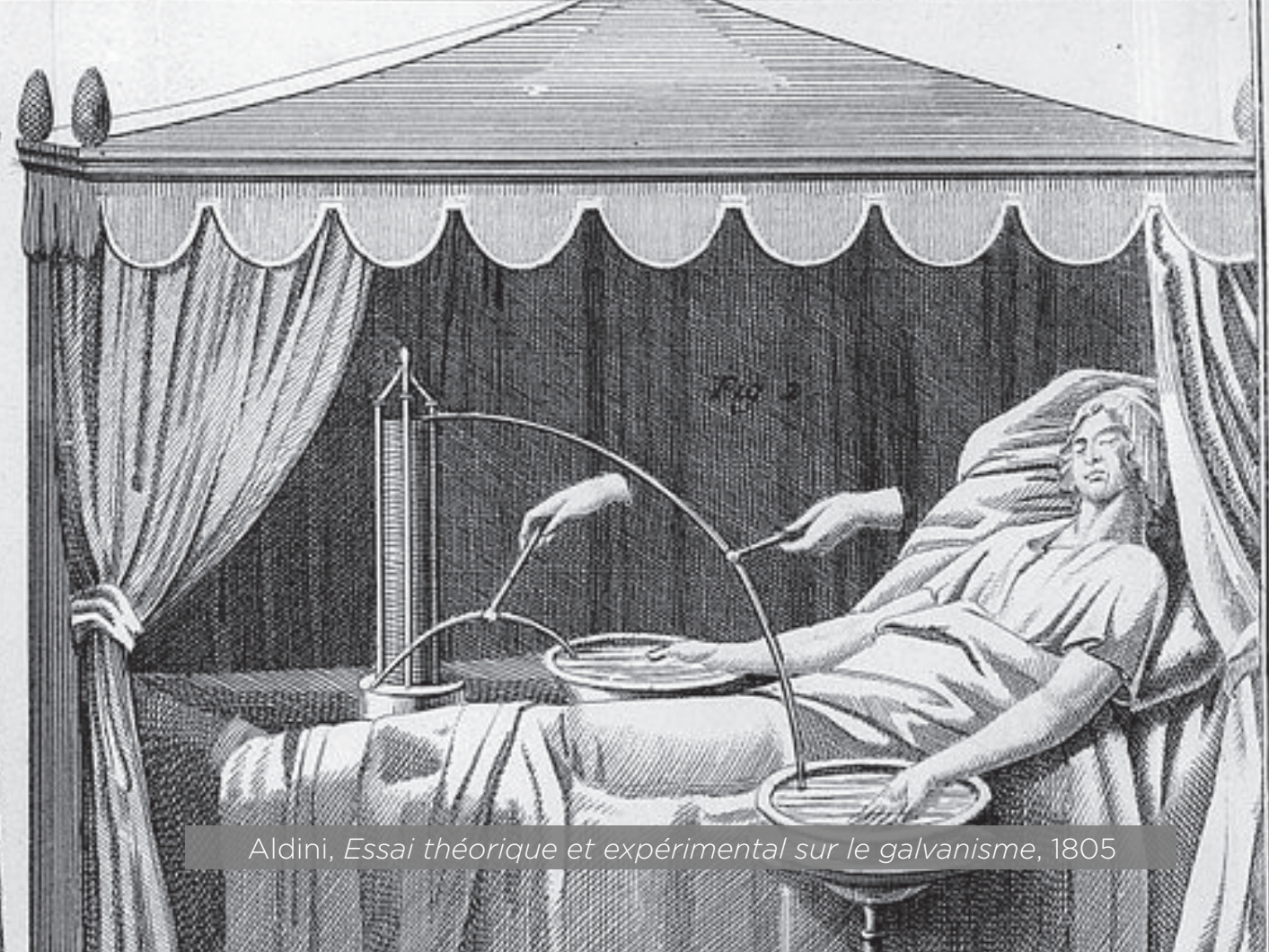
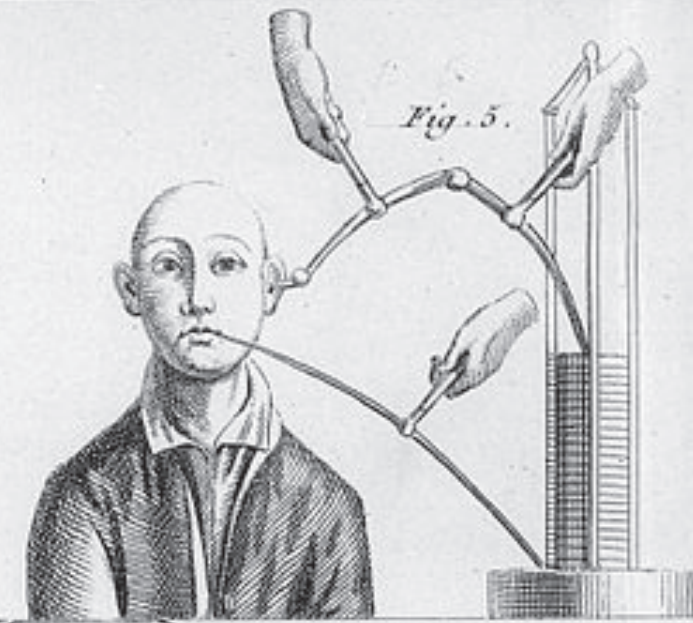
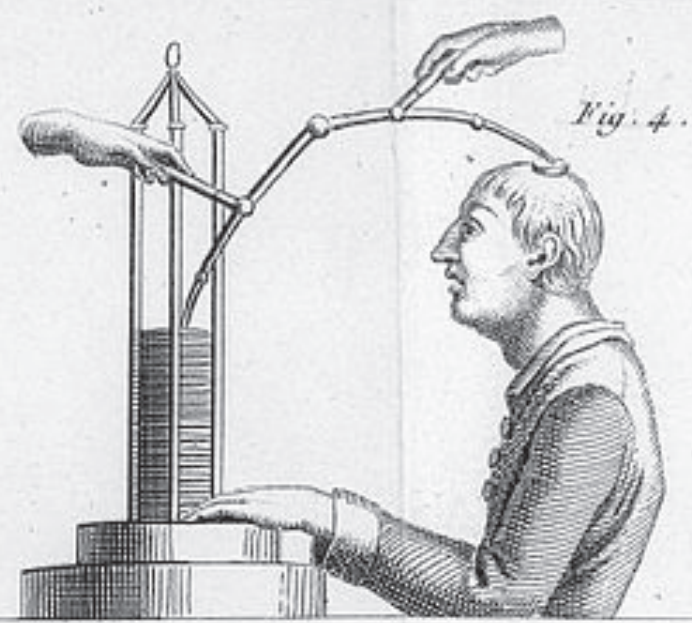
Experimental Therapeutics & Pathophysiology Branch

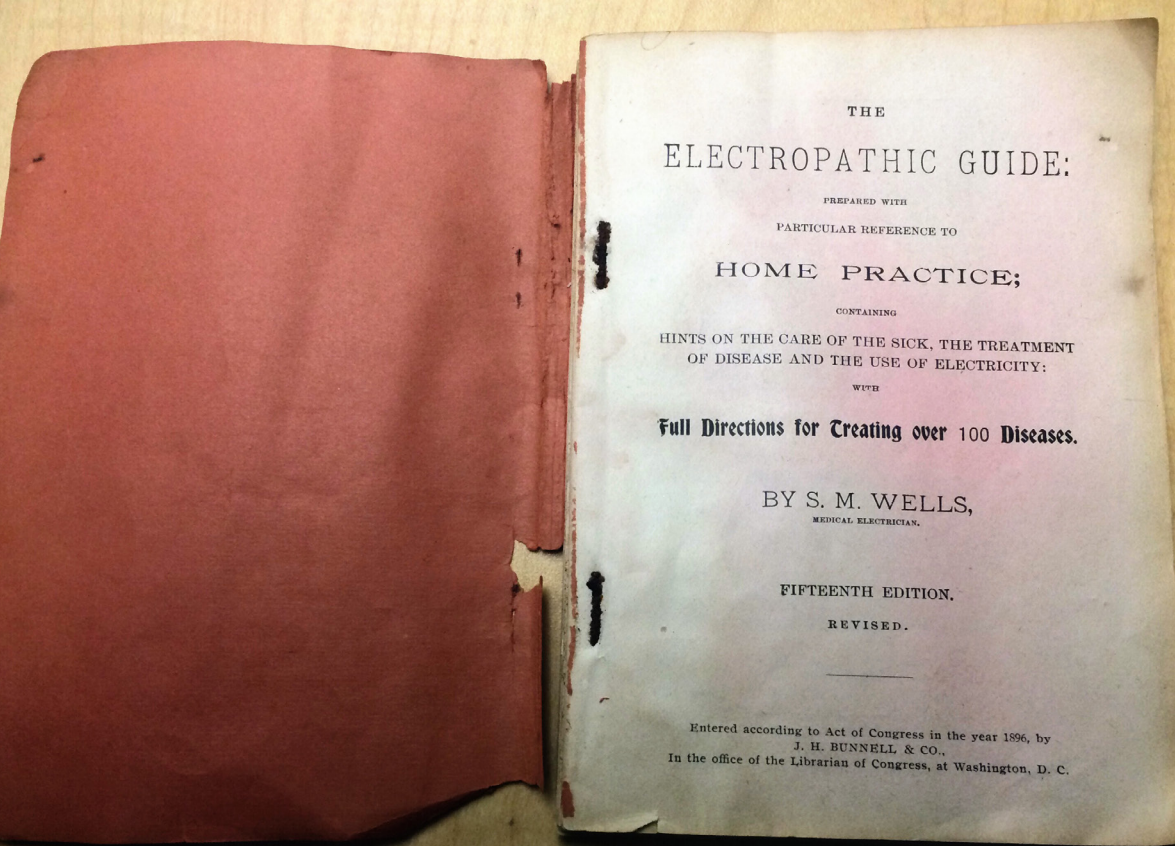
National Institute of Mental Health, NIH





Kellaway, *The Part Played by Electric Fish in the Early History of Bioelectricity and Electrotherapy*, 1946





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" sick .....	
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Inflammation .....	
Insanity .....	
Indigestion .....	
Indurations .....	
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" Bright's disease .....	
Leucorrhœa .....	
Liver, inflammation of.....	
" torpid .....	
" enlargement of .....	
Lockjaw .....	
Lungs, inflammation of.....	
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Menses, suppression of.....	
" painful .....	
" retarded .....	
" too copious .....	
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Mouth. ( <i>See Sore Mouth.</i> )	
Neuralgia .....	

1938 Cerletti and Bini developed ECT



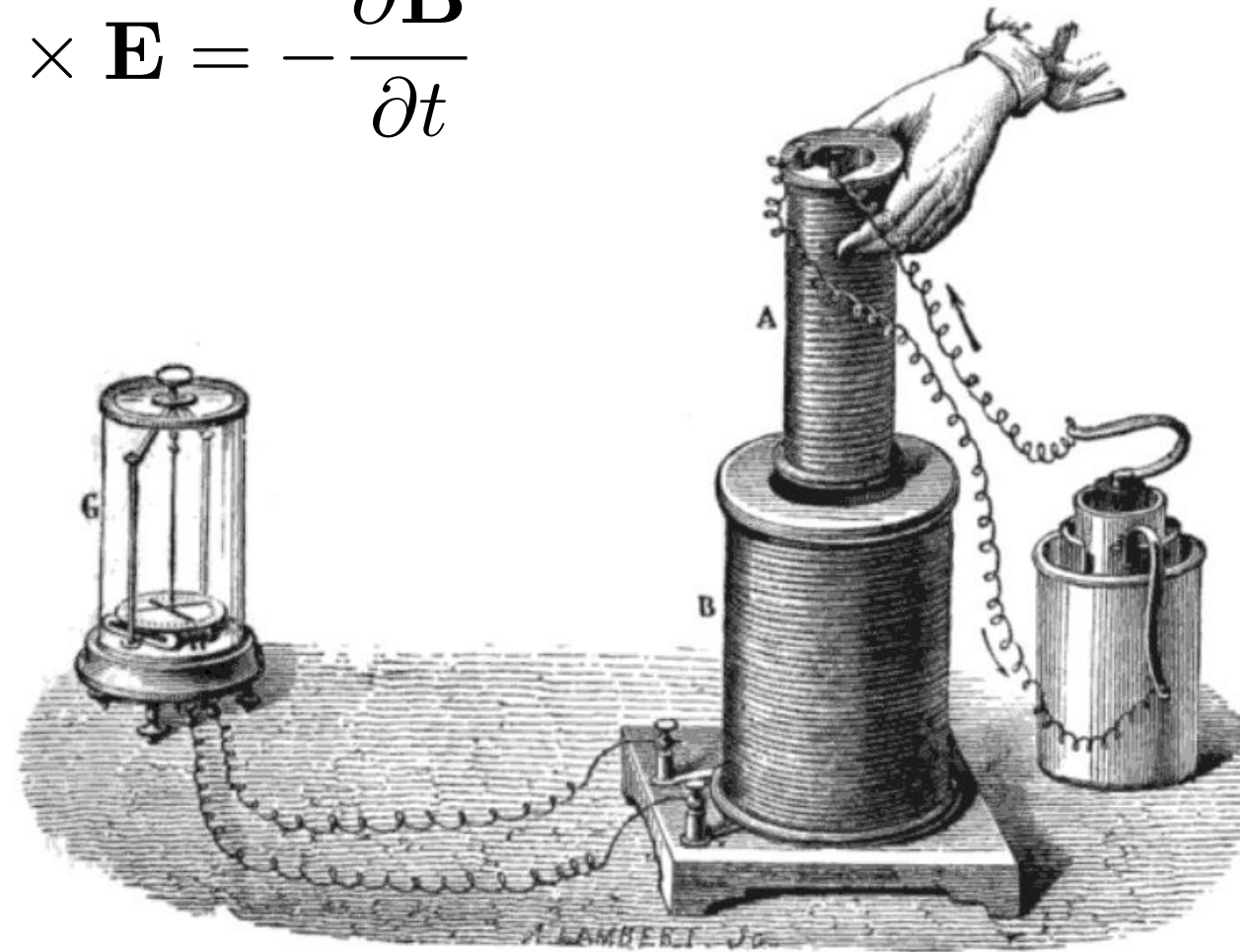
Modern day ECT



1985 Barker et al.



$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$



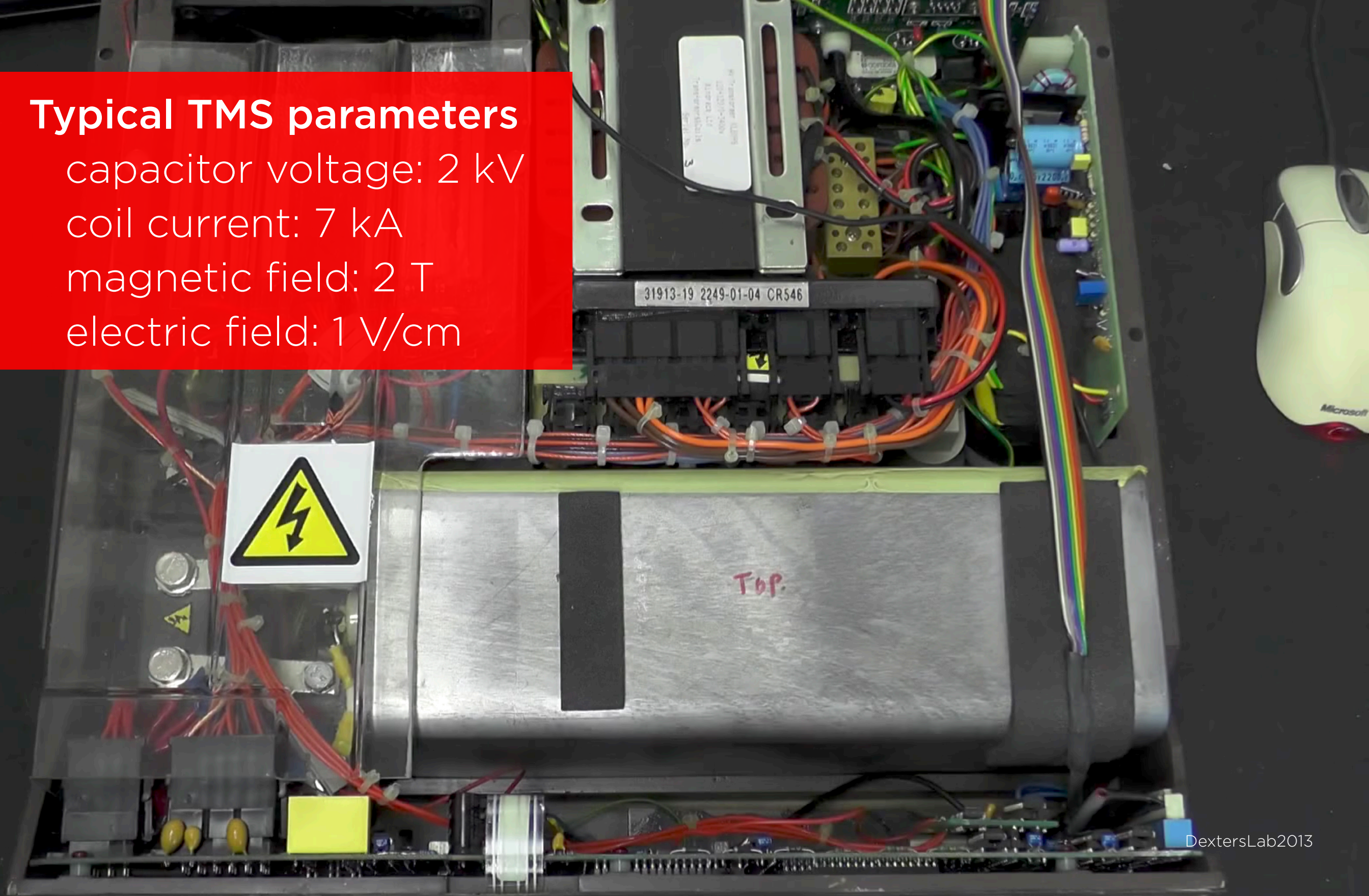
## Typical TMS parameters

capacitor voltage: 2 kV

coil current: 7 kA

magnetic field: 2 T

electric field: 1 V/cm

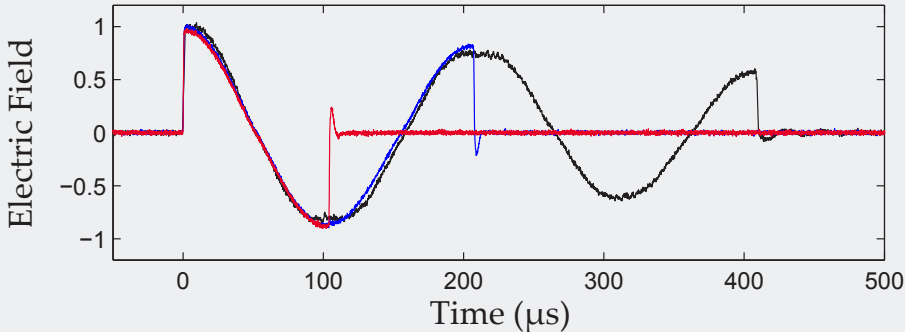
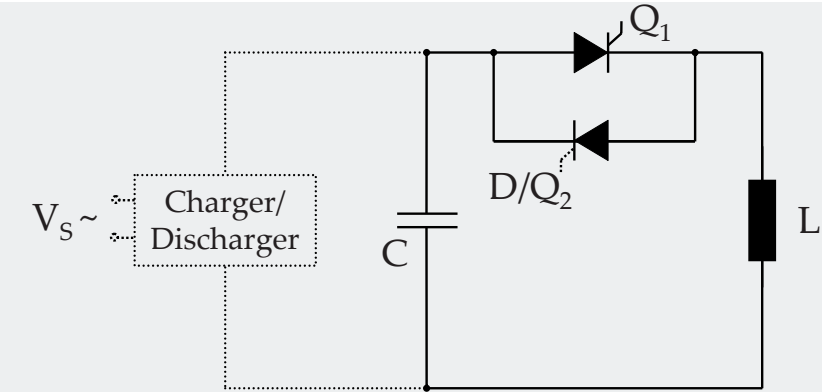
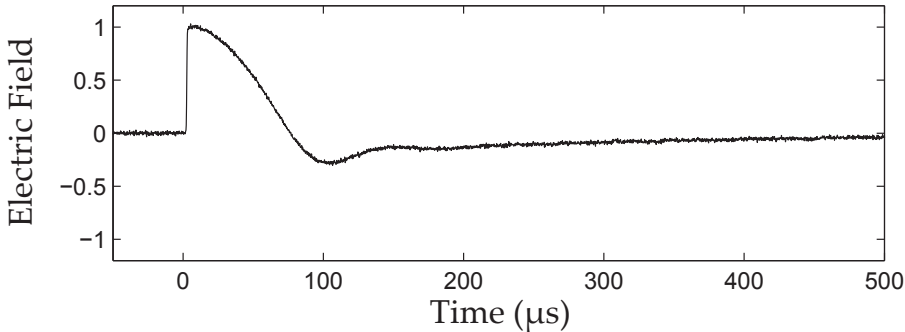
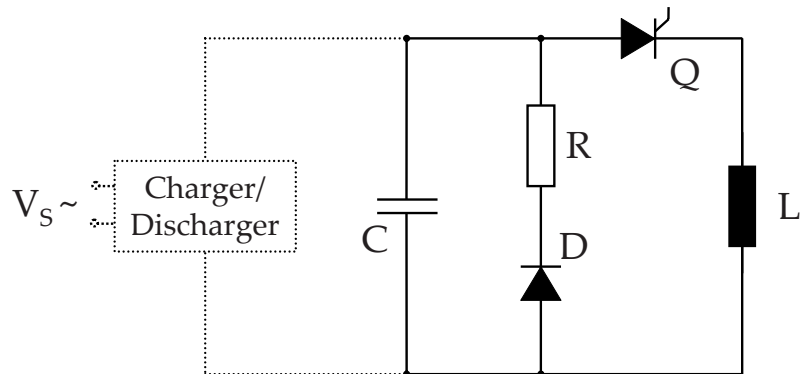




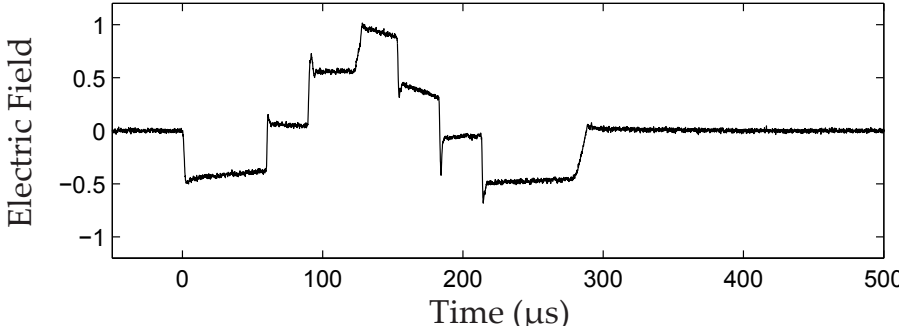
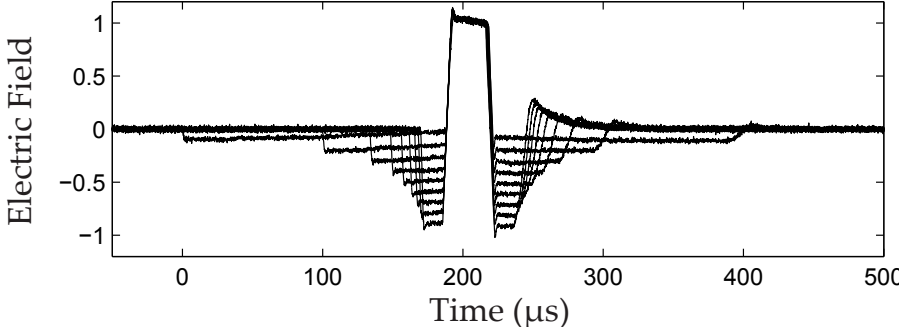
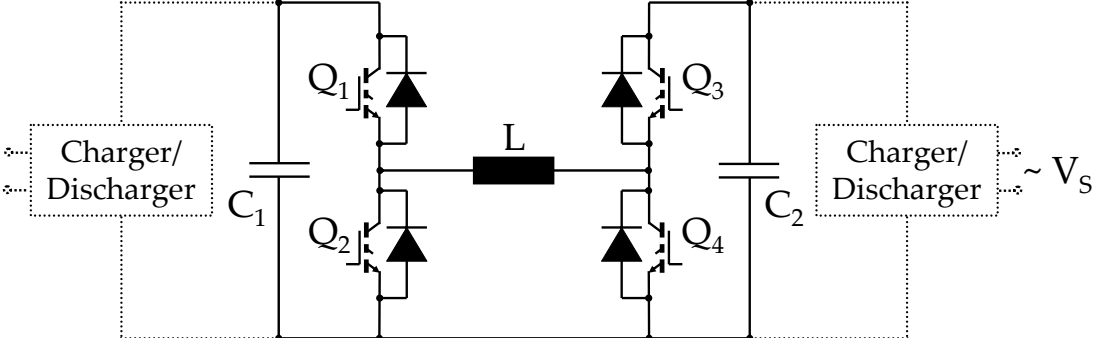


Roberts, *Anatomy of the Ship: The Battleship Dreadnought*, 1992

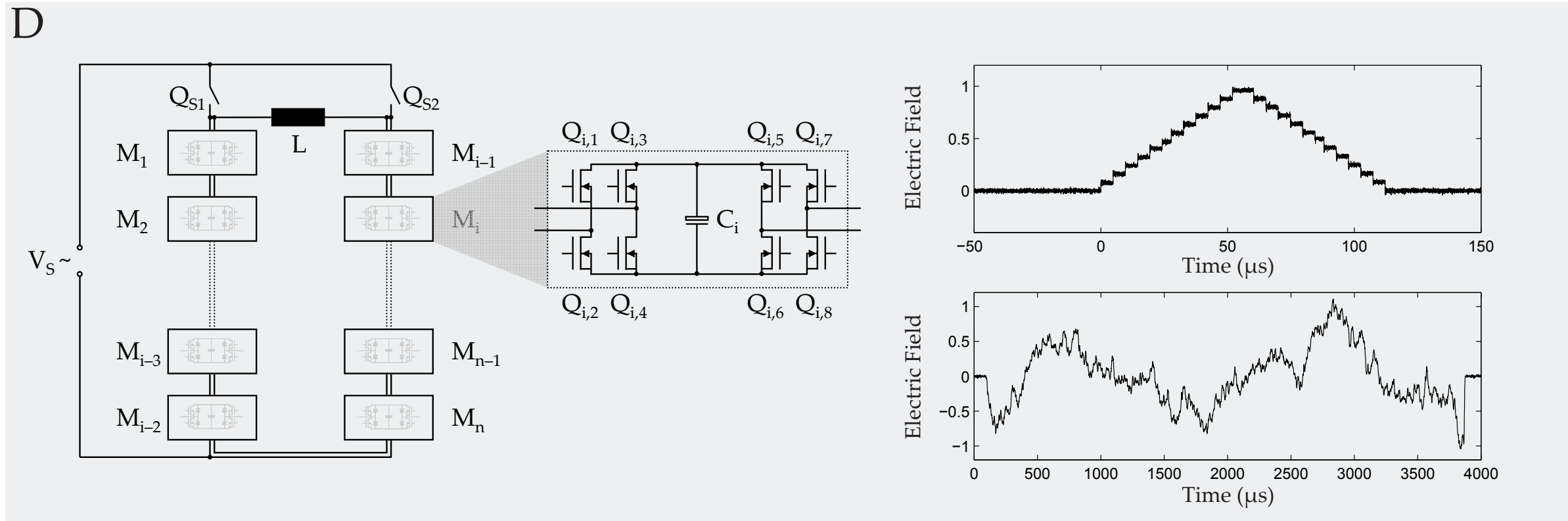
# Conventional TMS

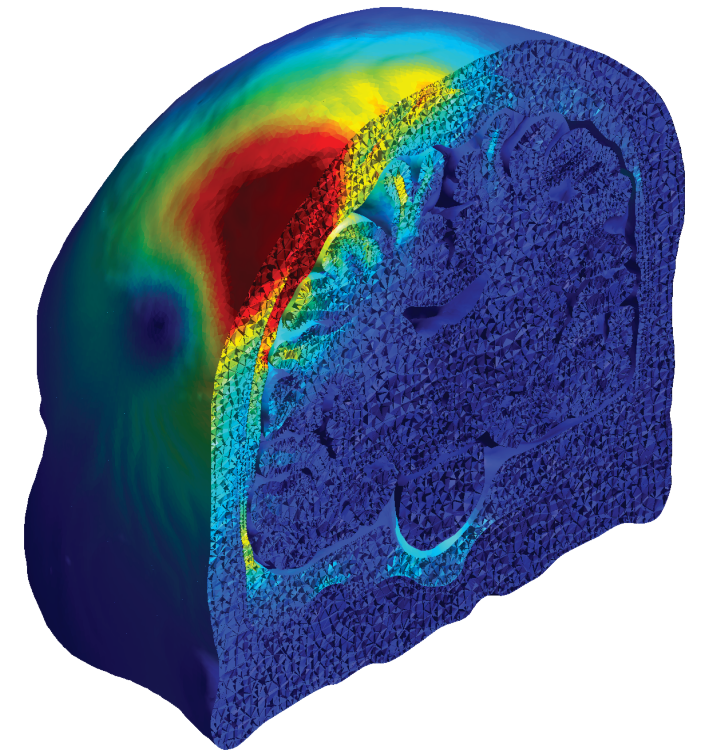
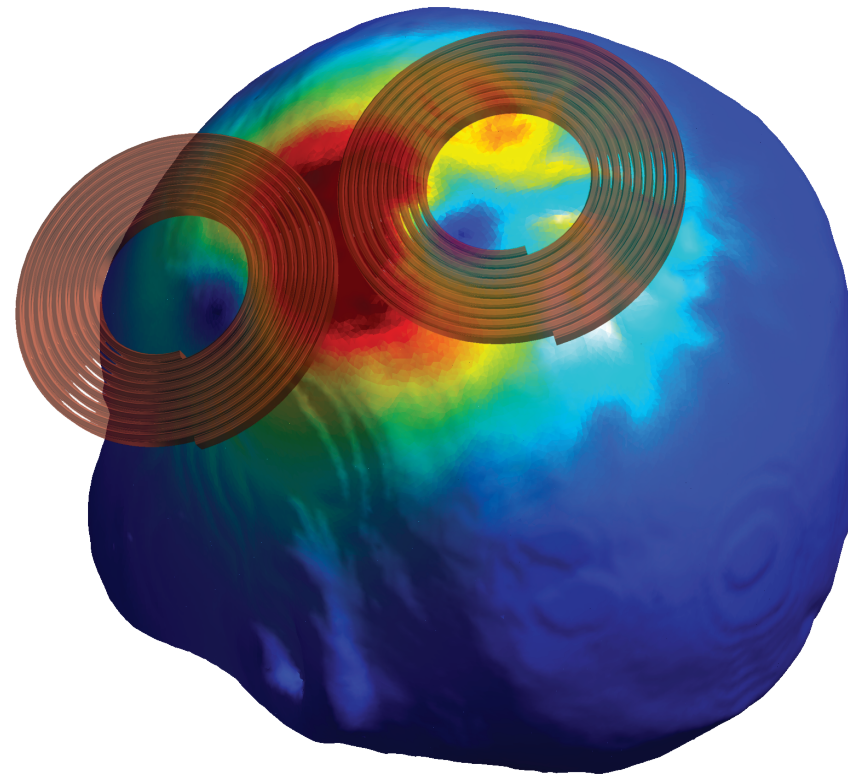
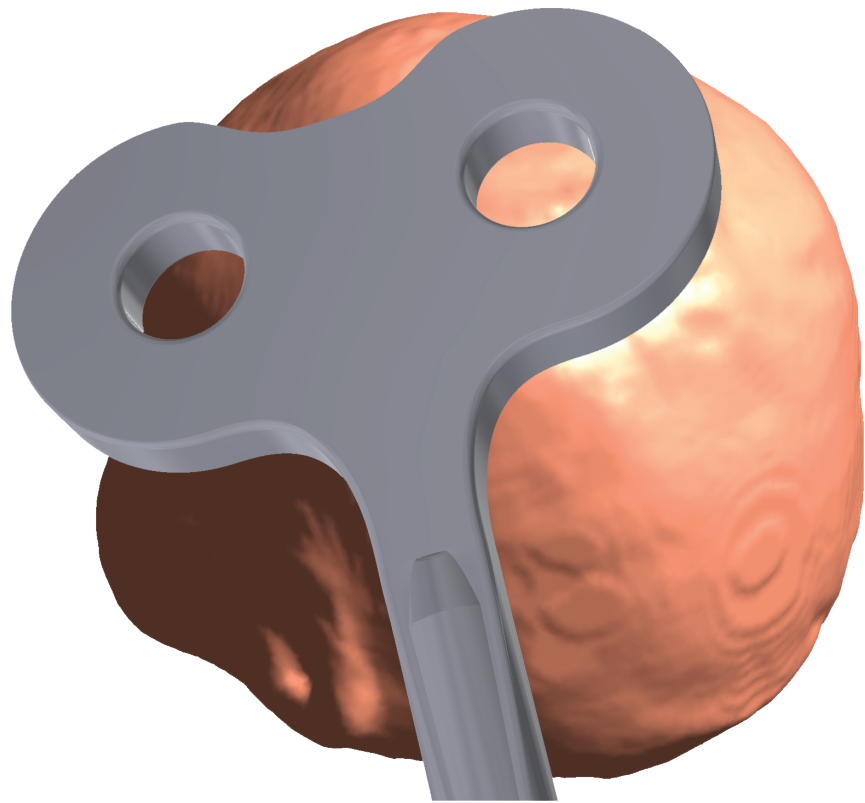


# Controllable pulse-width TMS



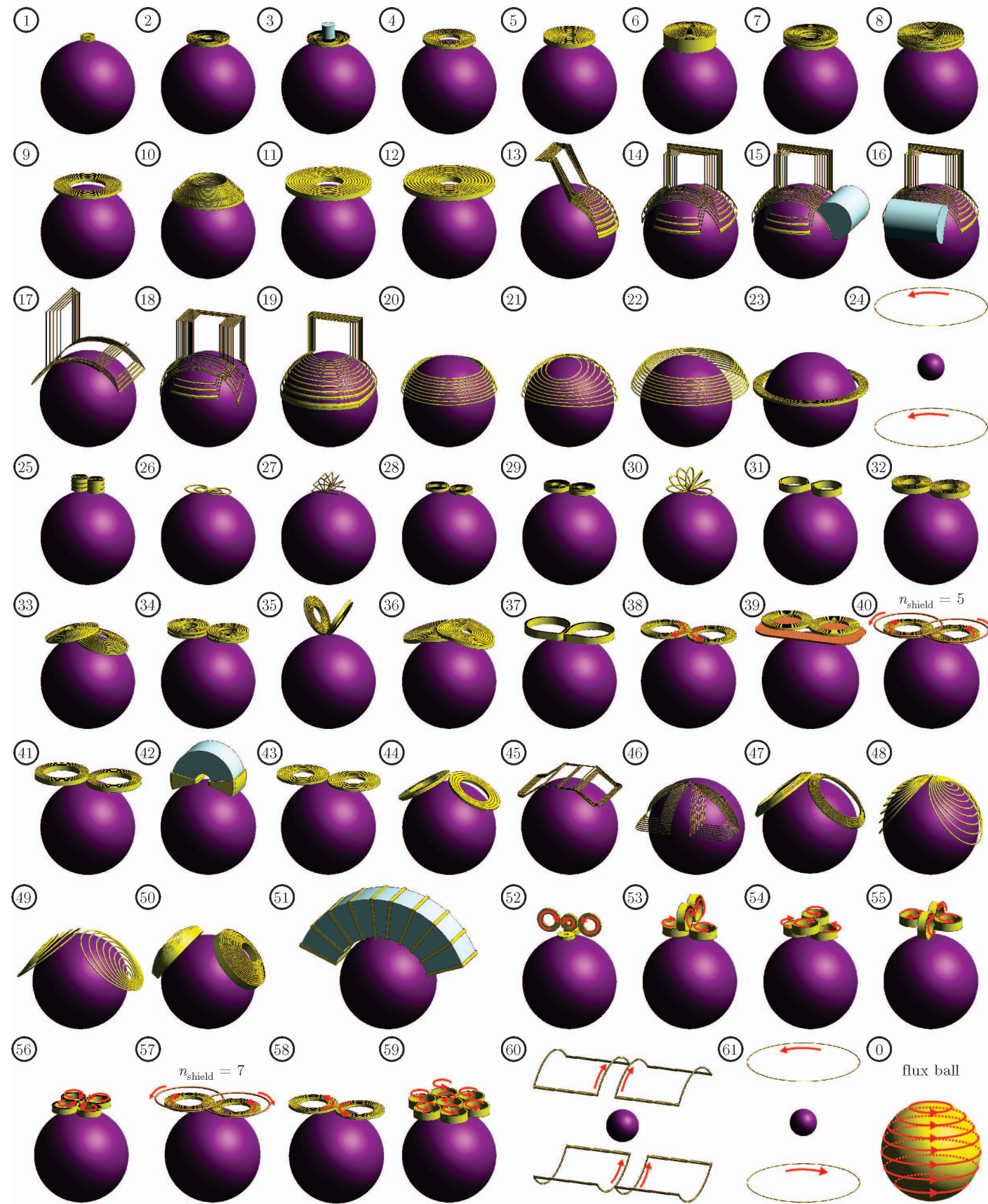
# Synthesizer





no 3D focusing in depth

conventional coils have low  
electric field penetration ~2-3 cm  
from head surface



# Circular type

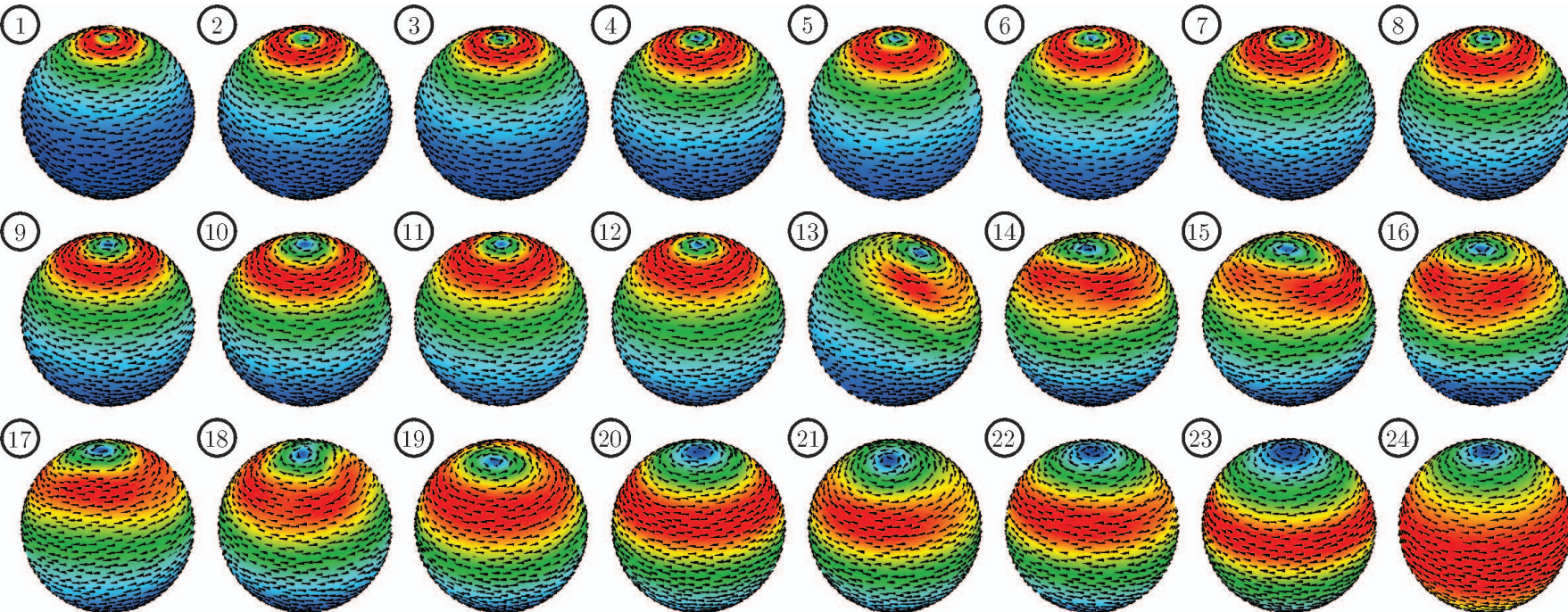
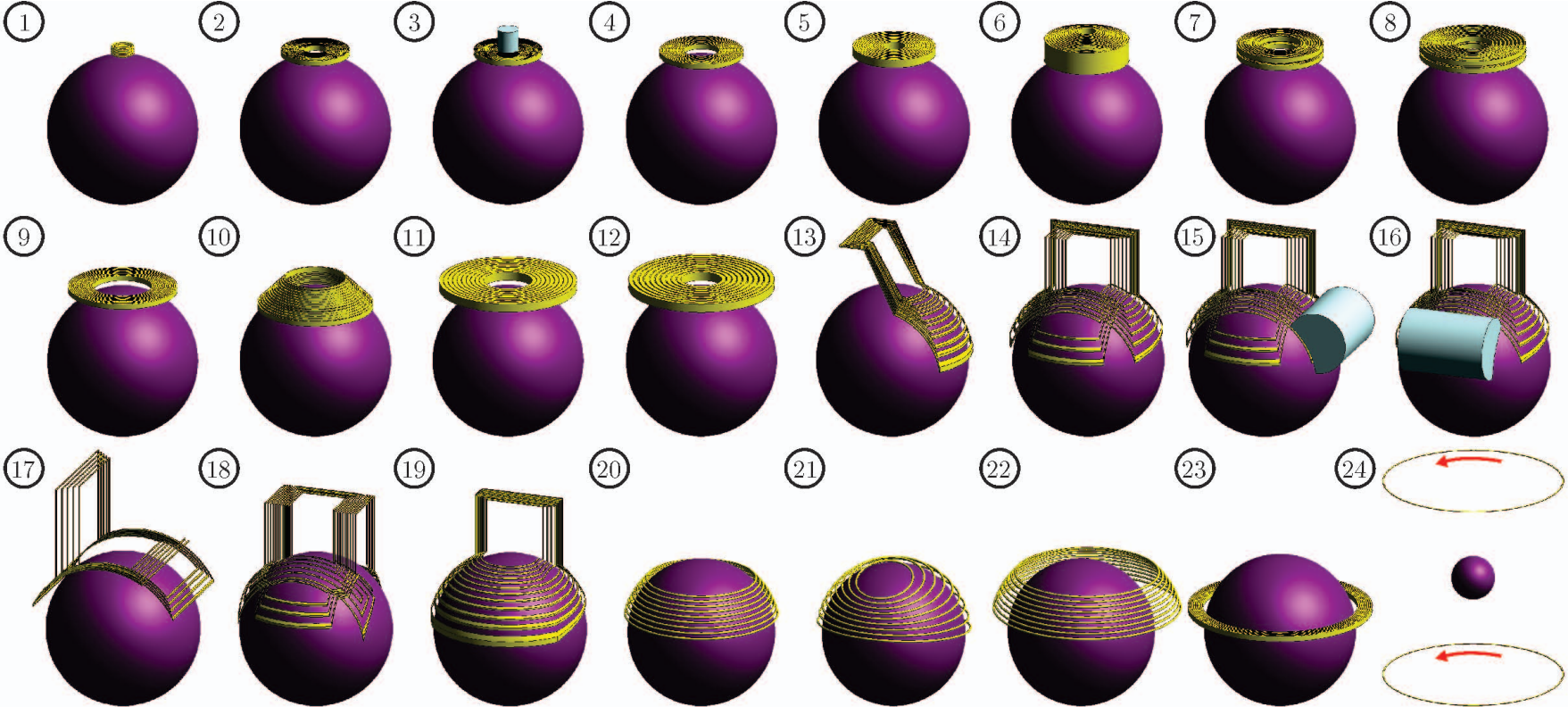
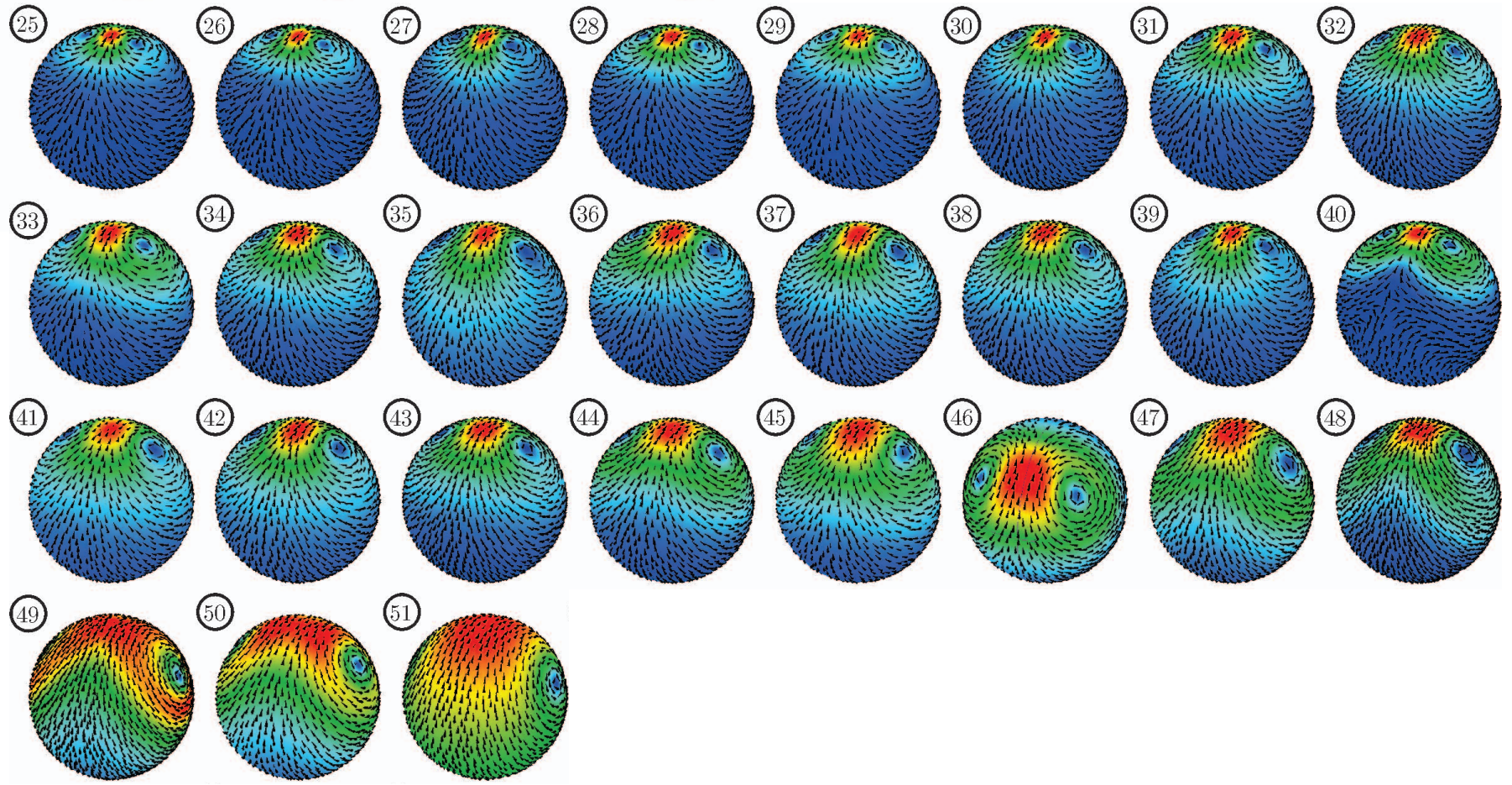
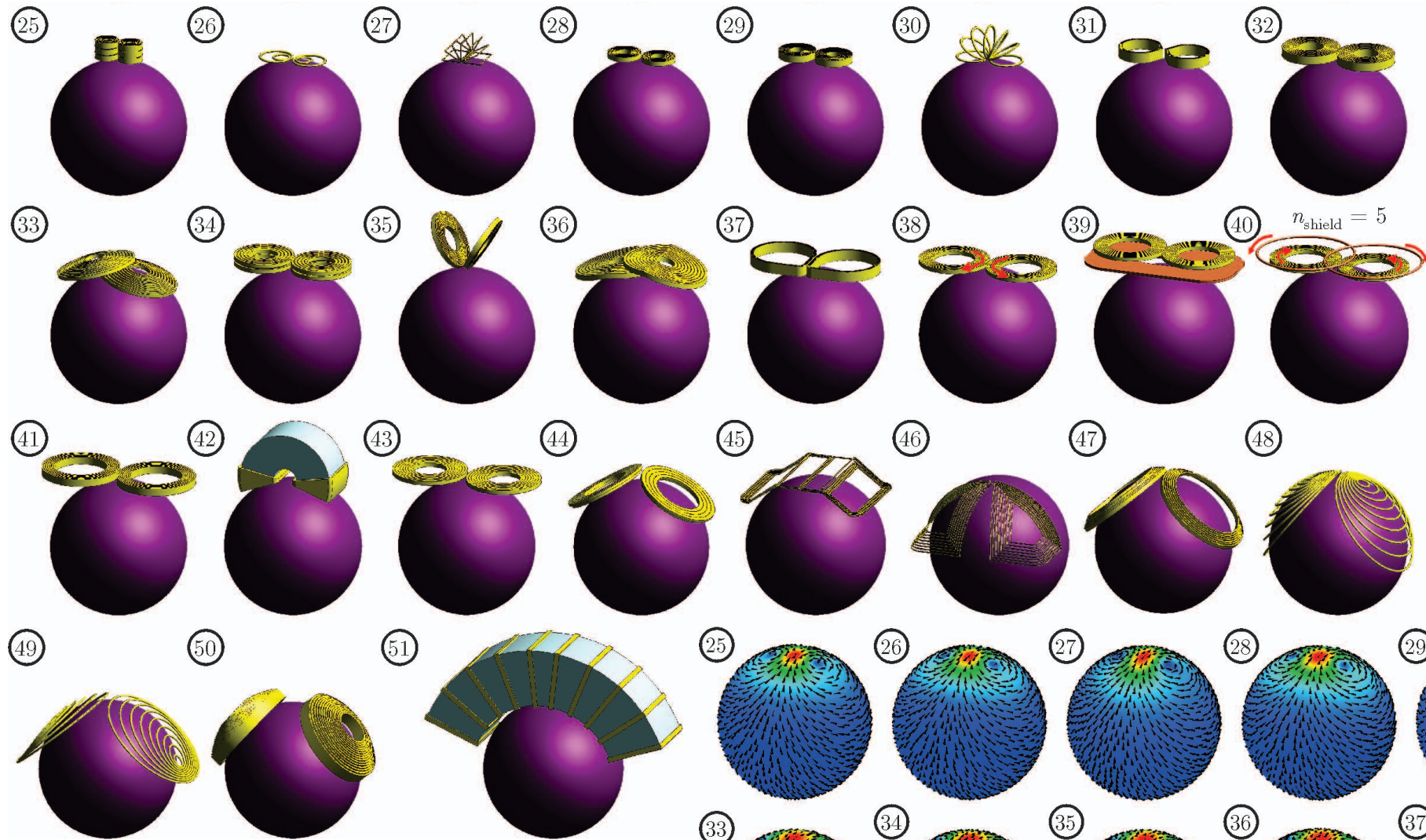
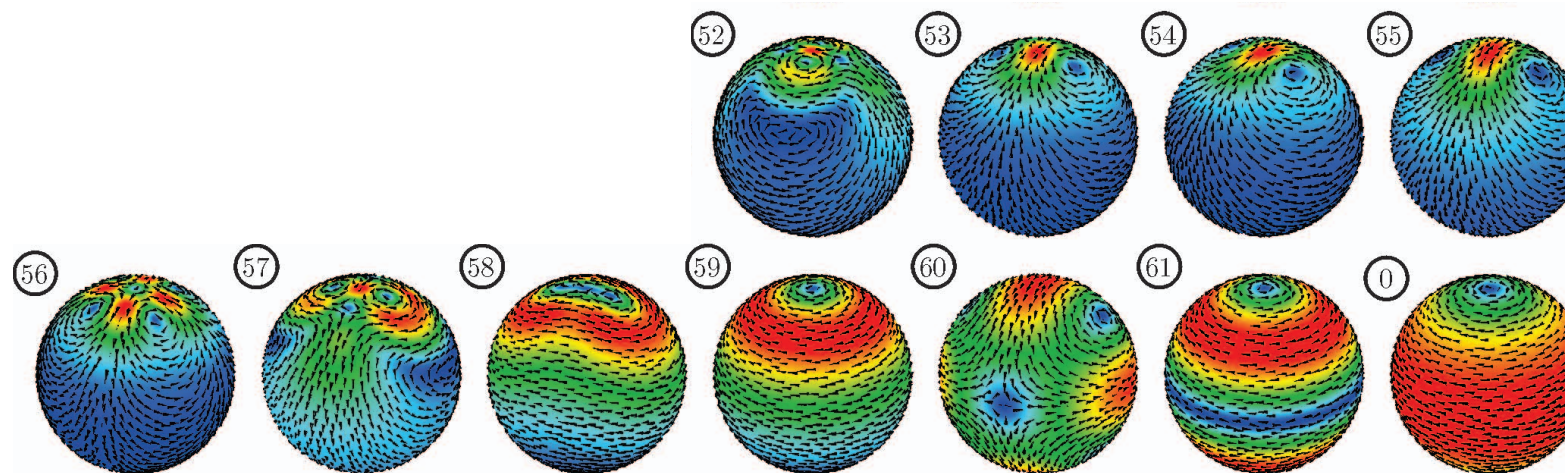
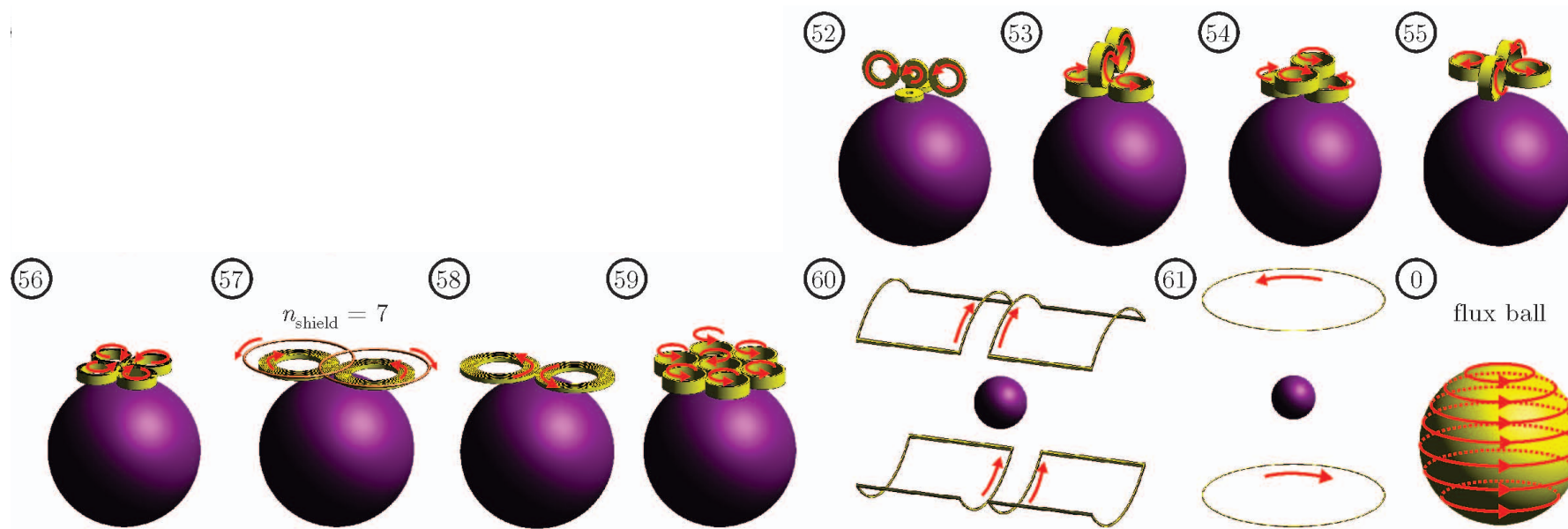


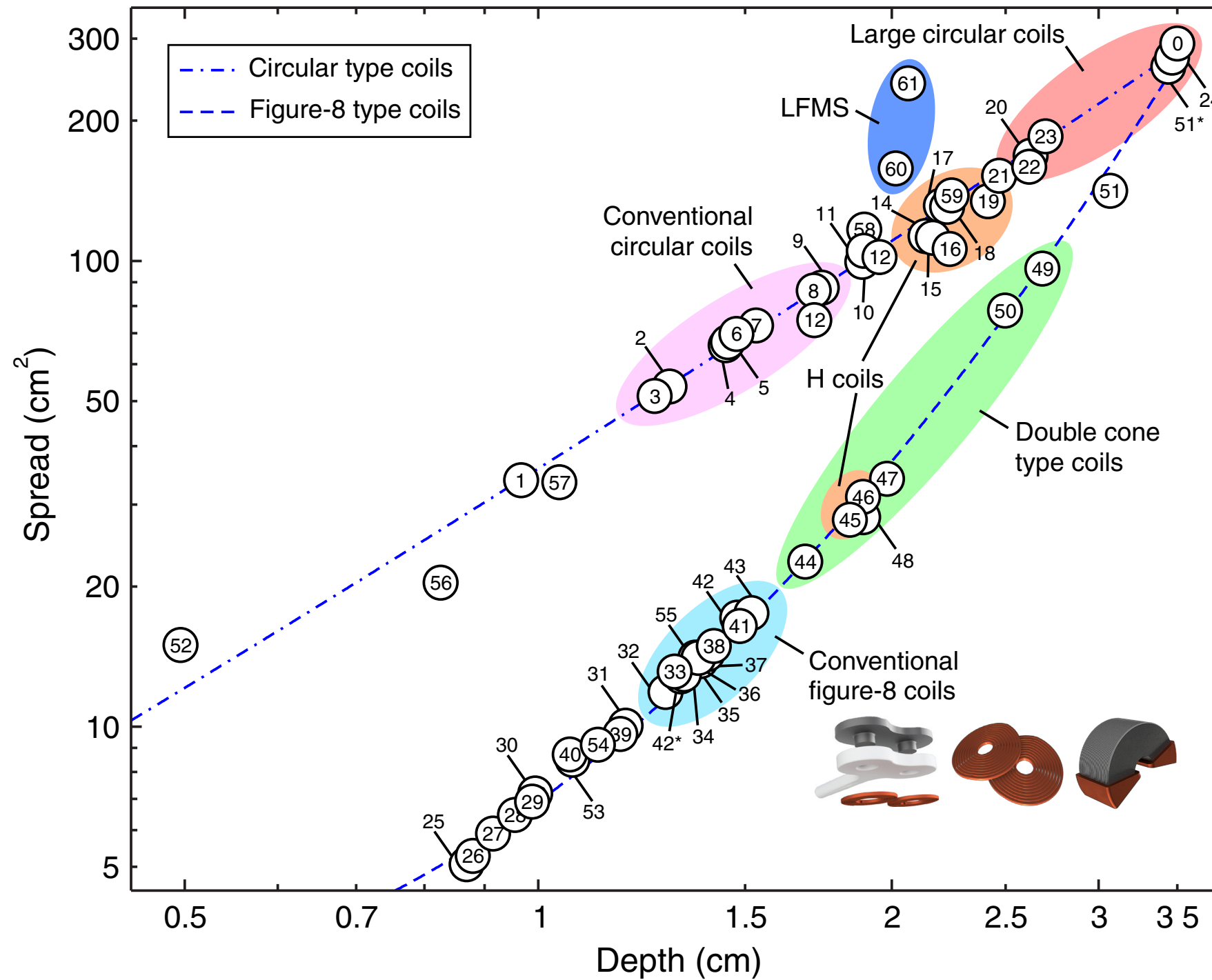
Figure-8 type

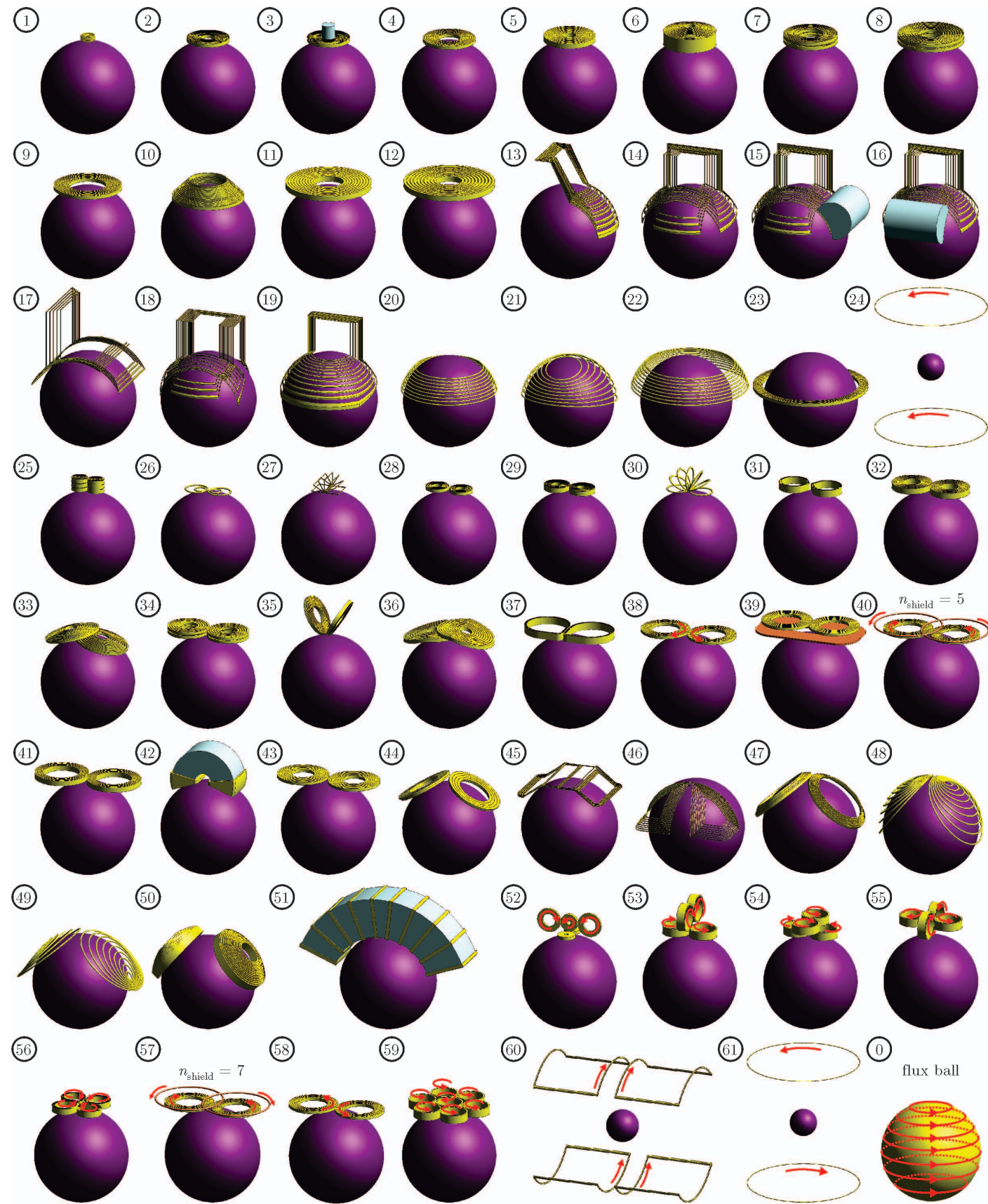


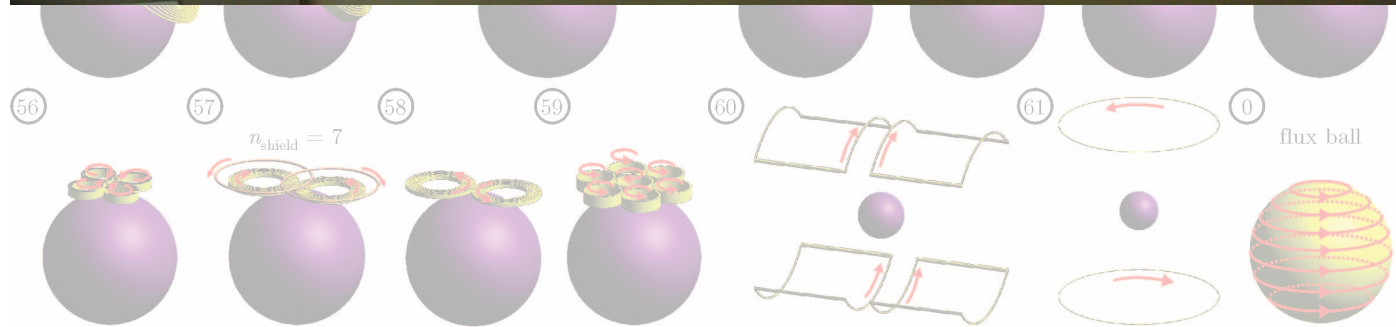
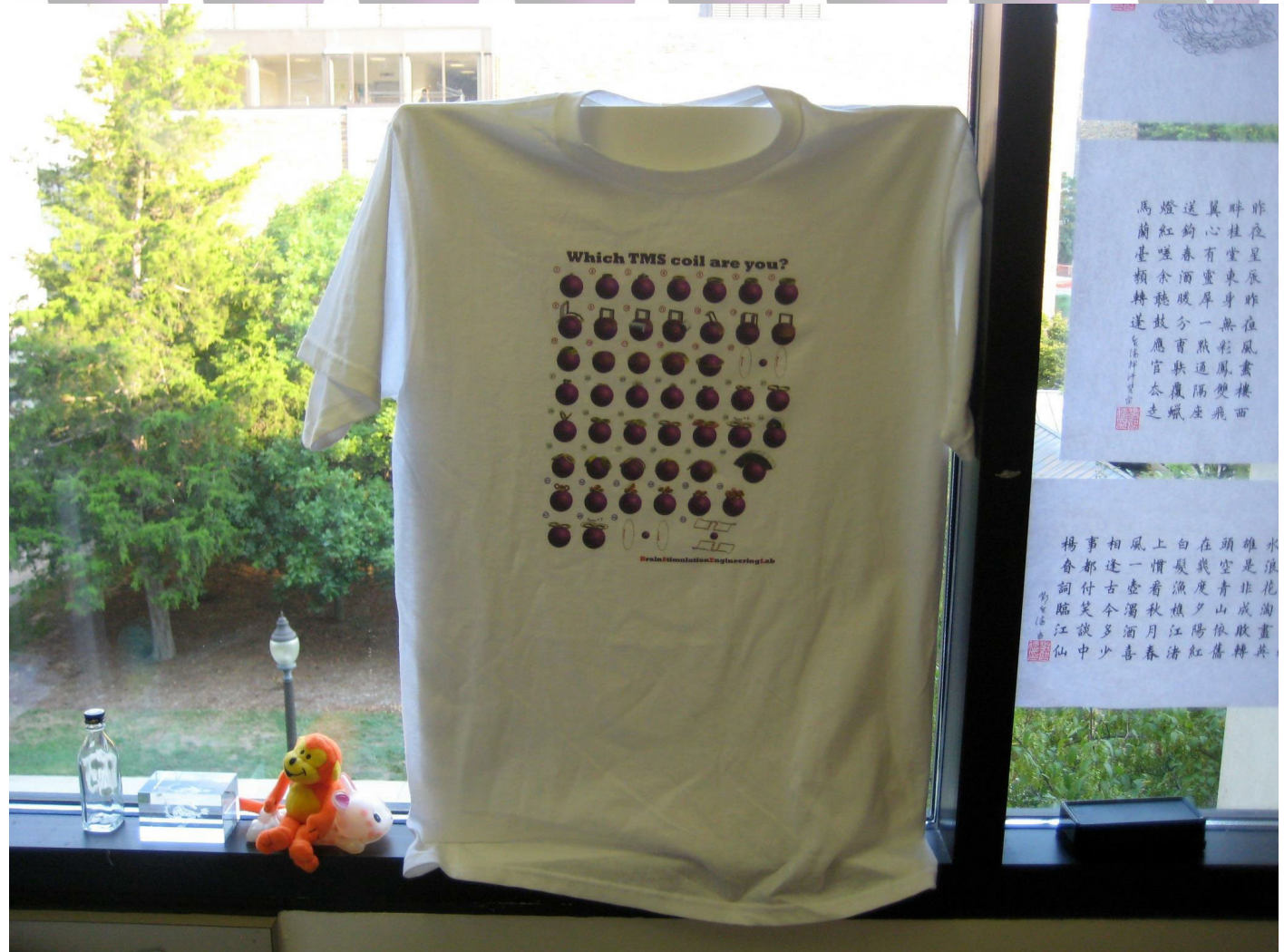
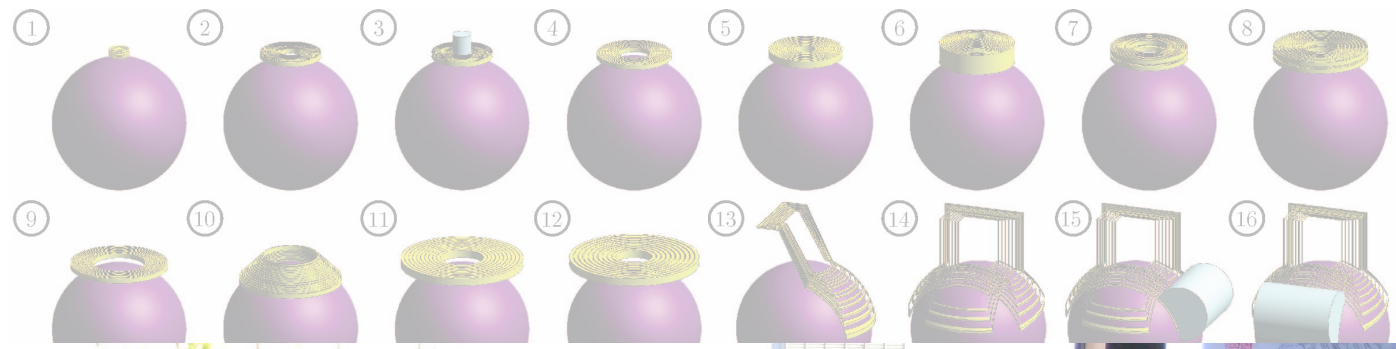


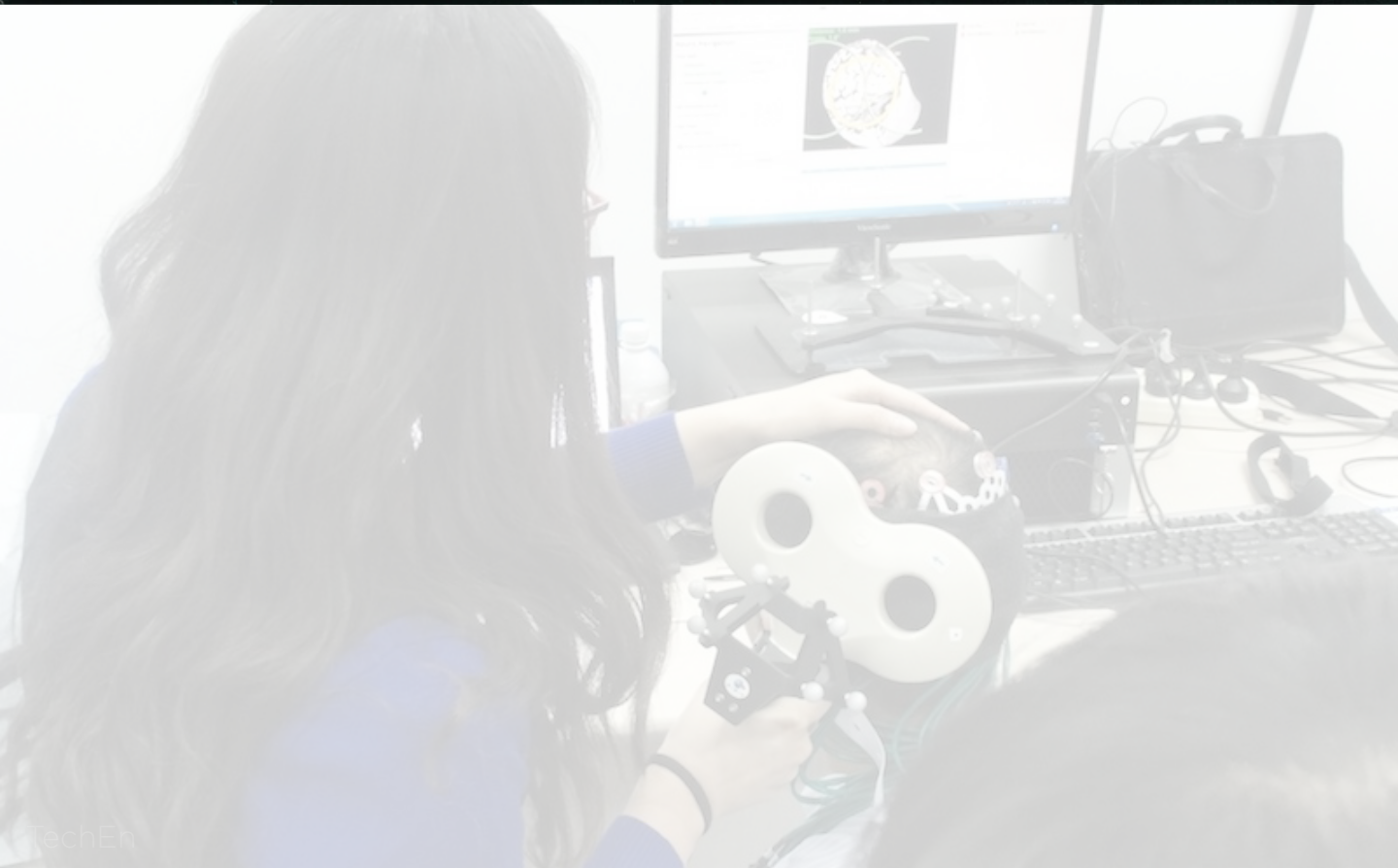
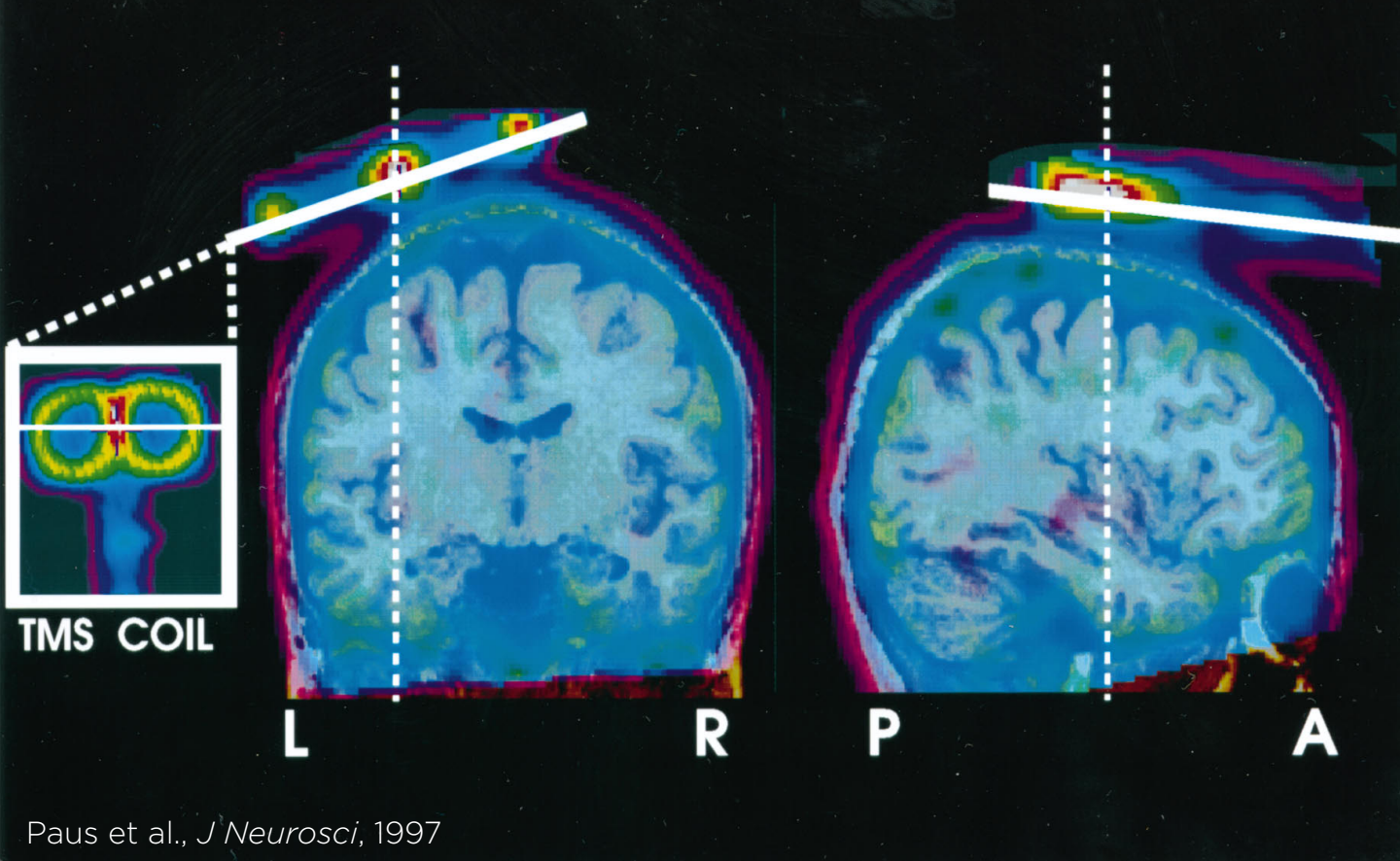


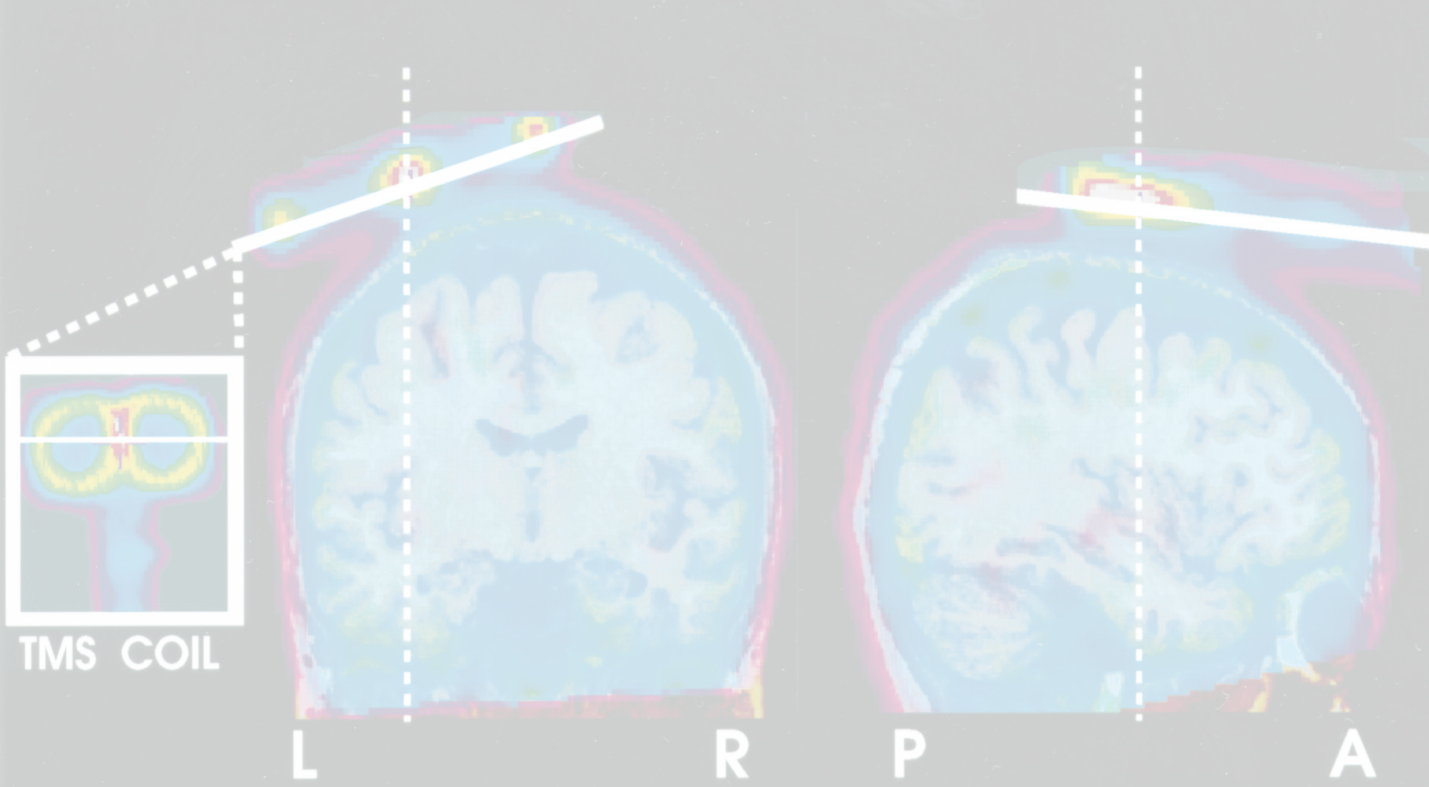
# Depth-focality tradeoff







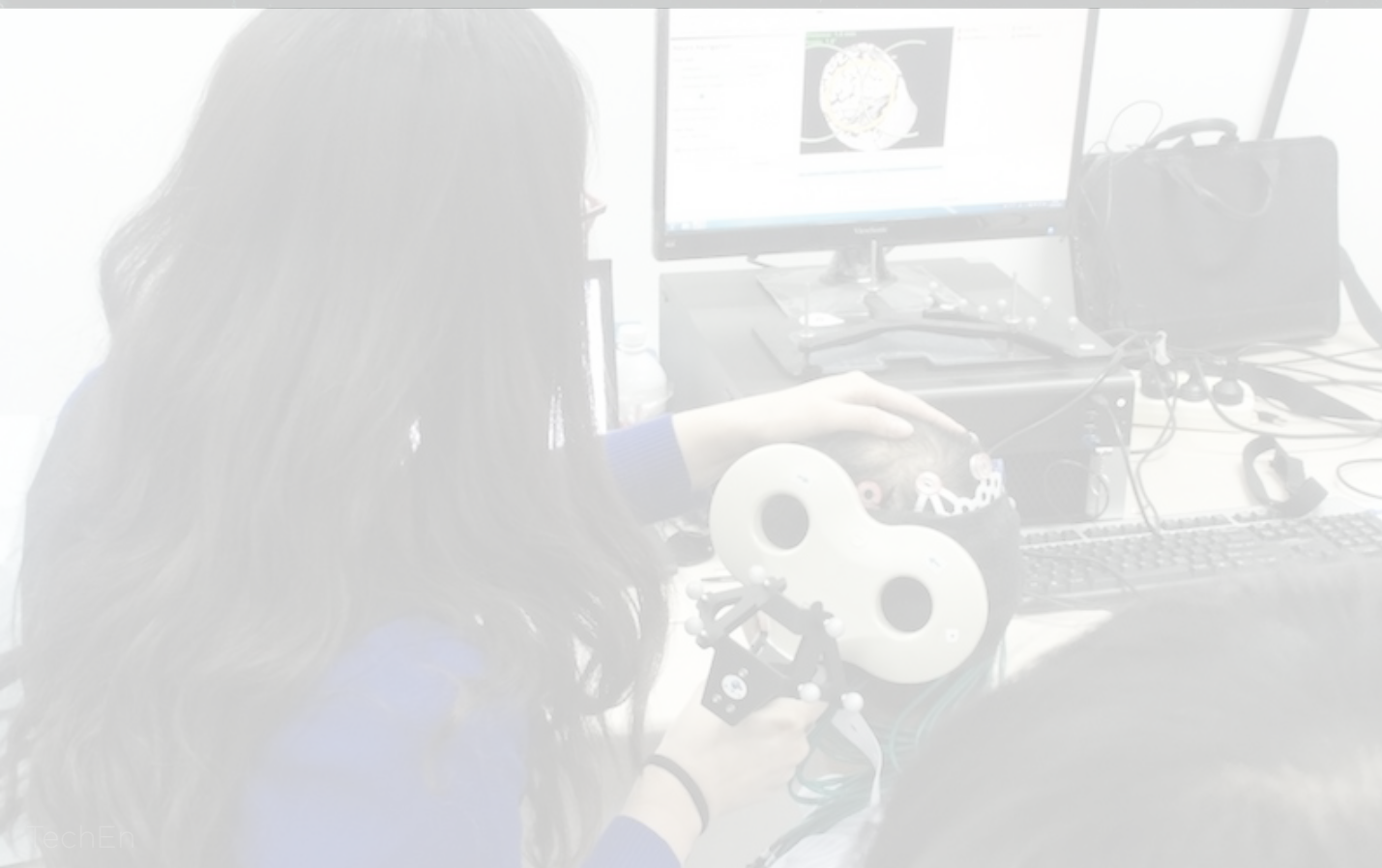




Paus et al., *J Neurosci*, 1997



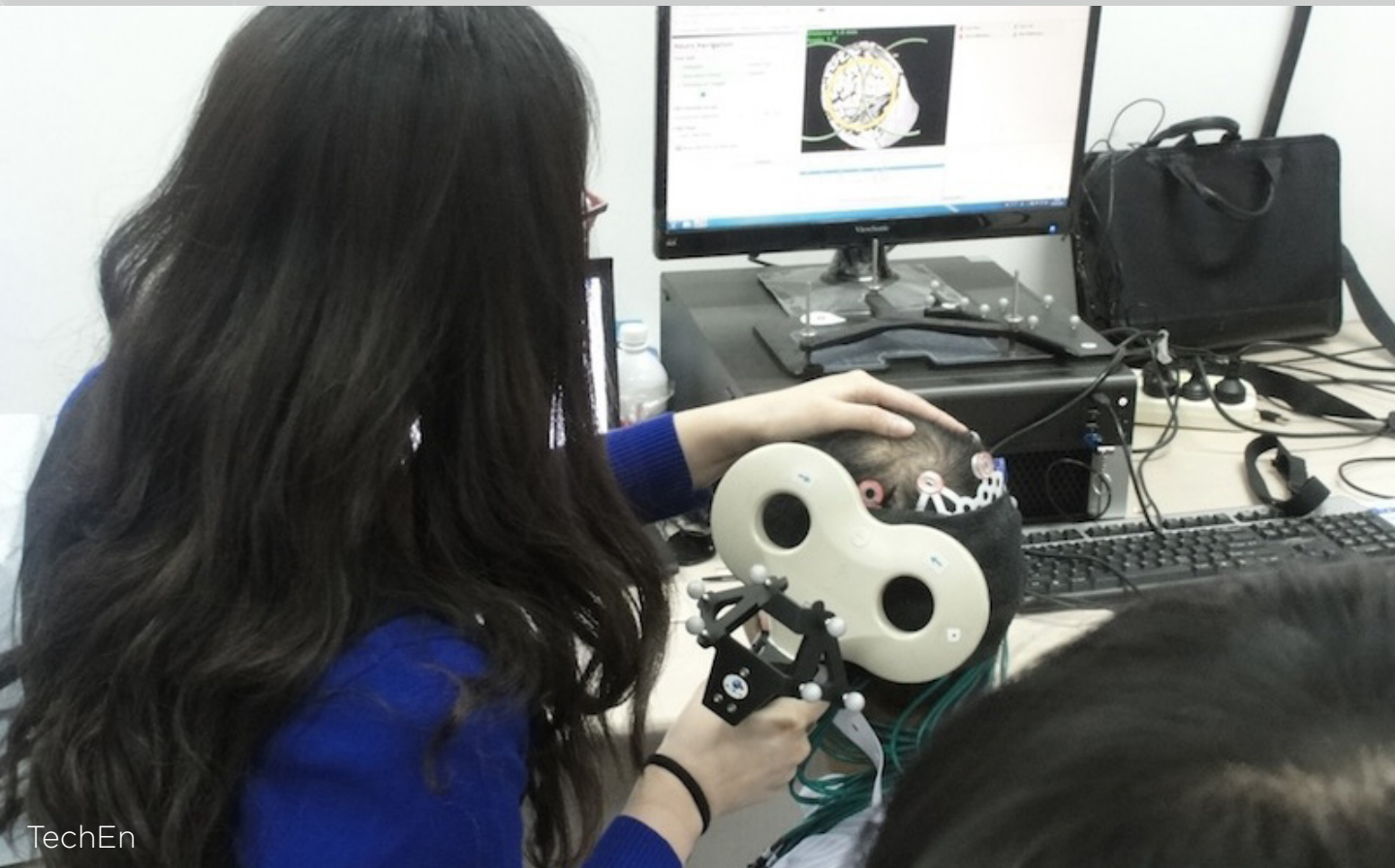
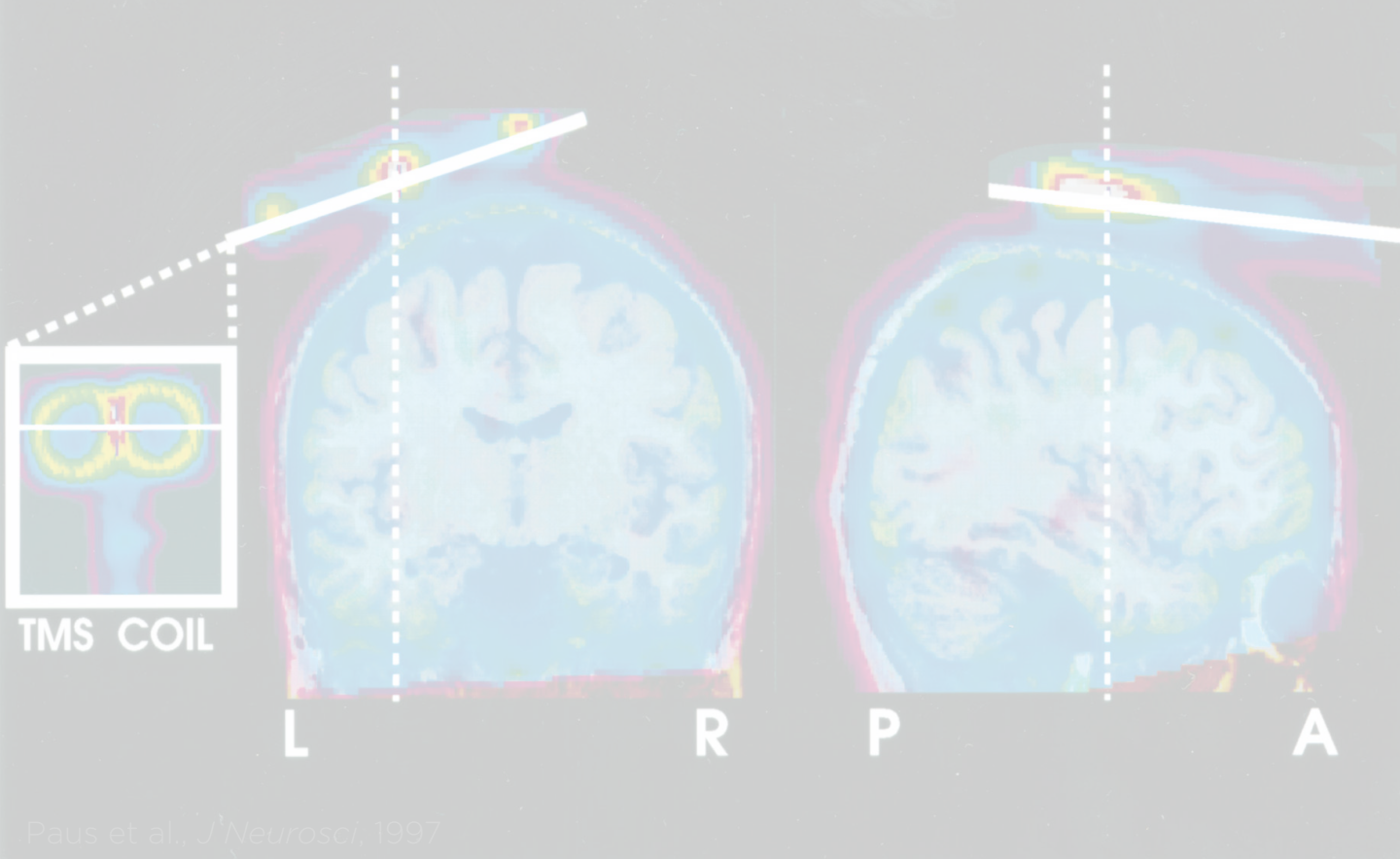
Brain Products

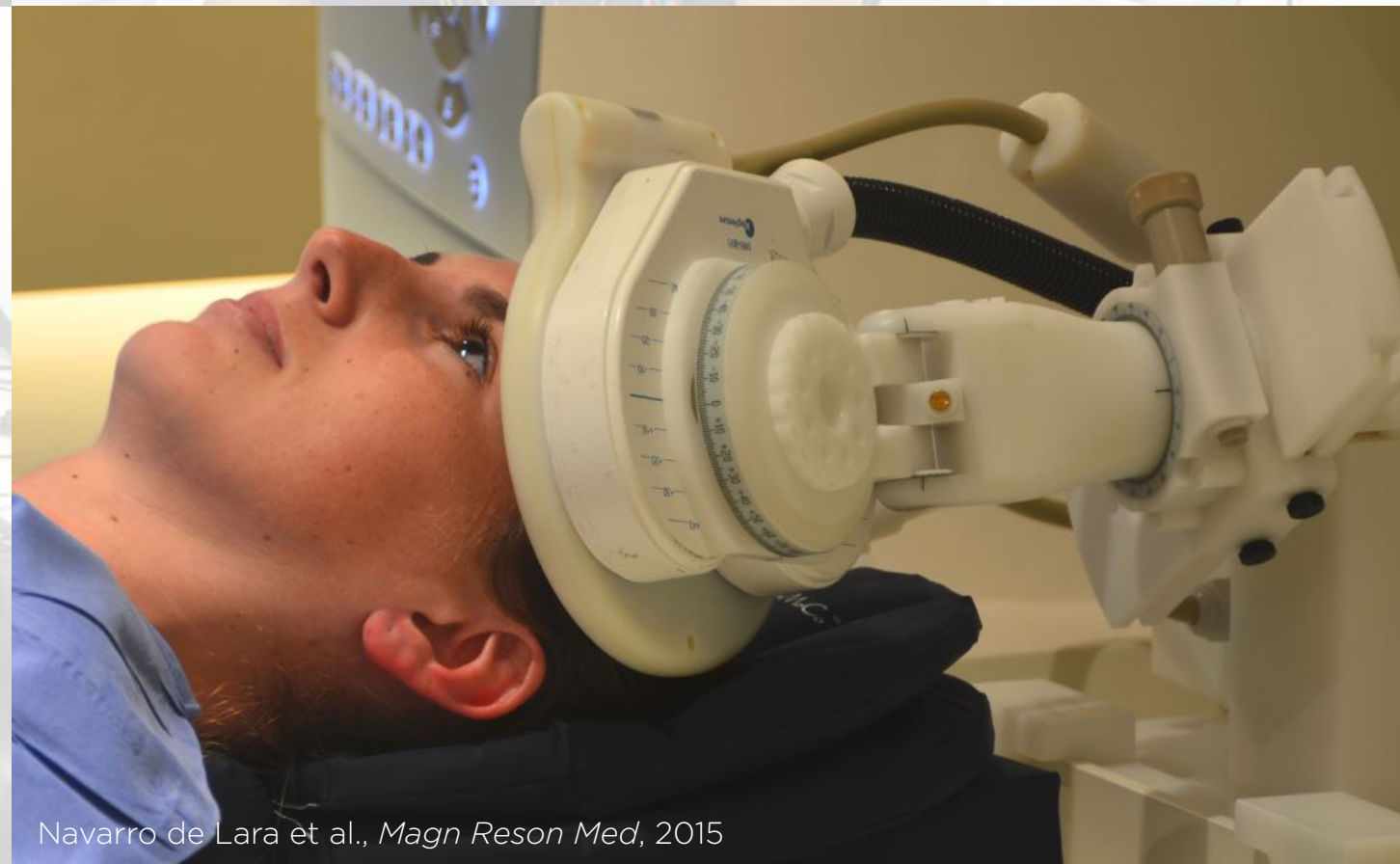
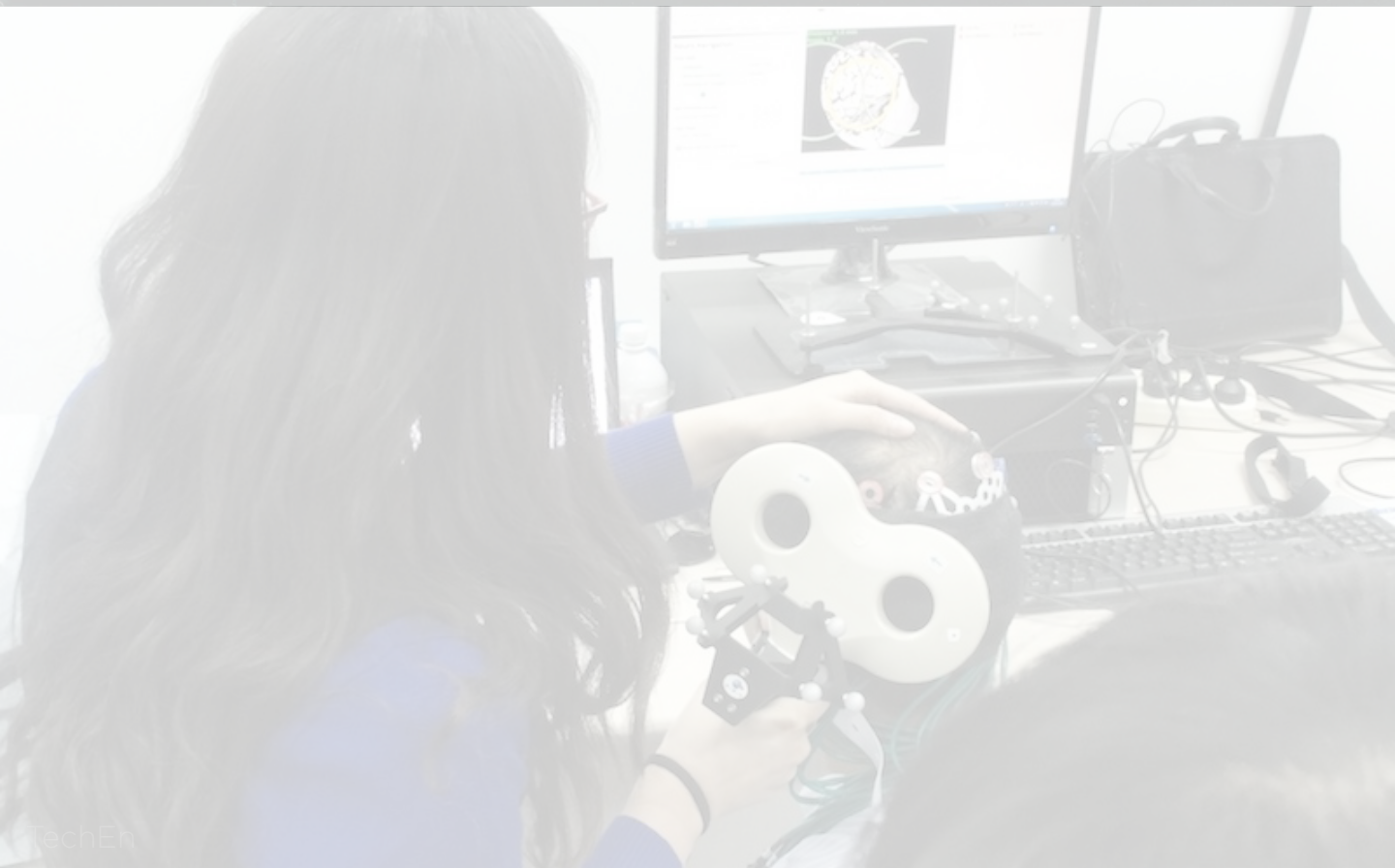
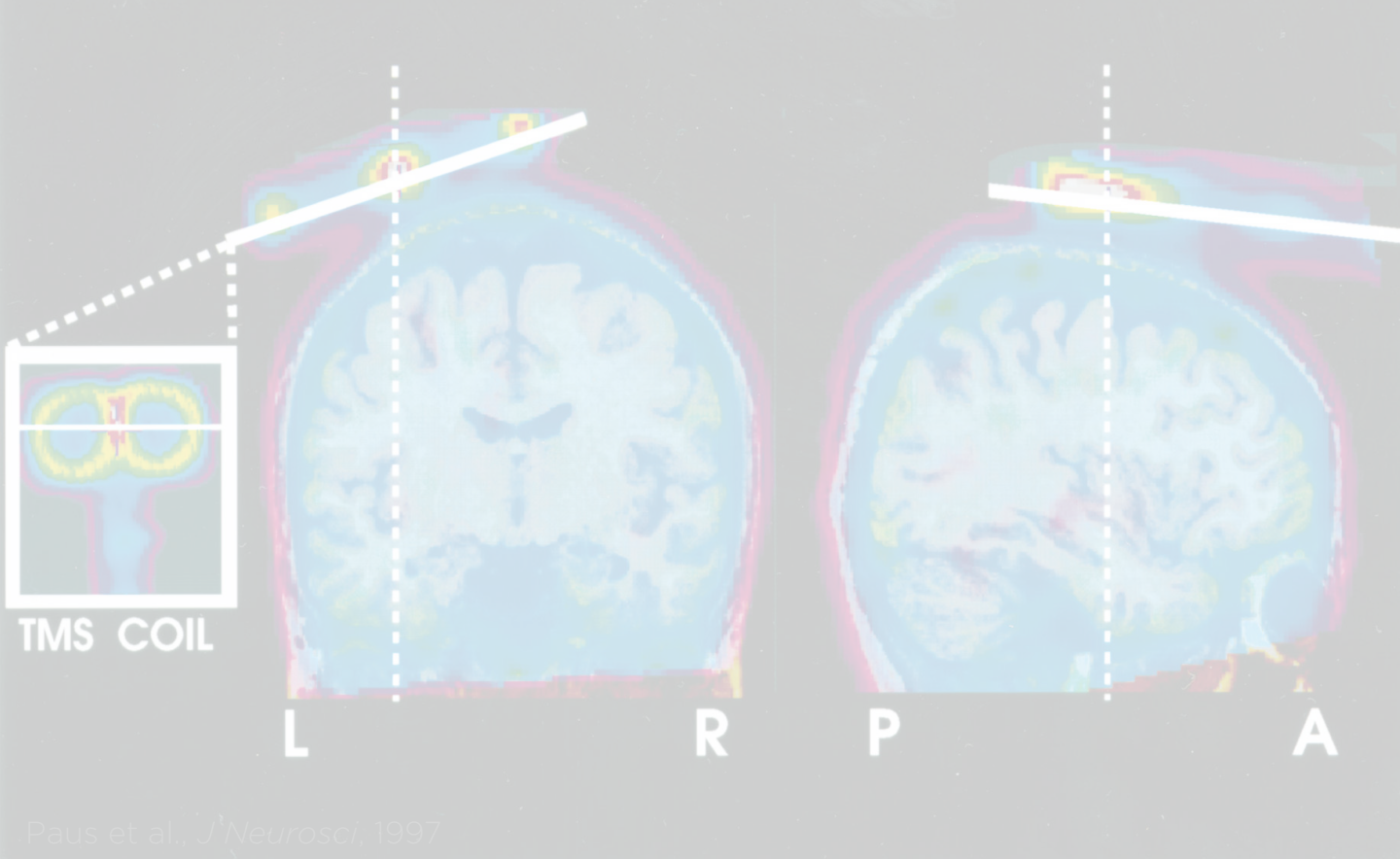


TechEn



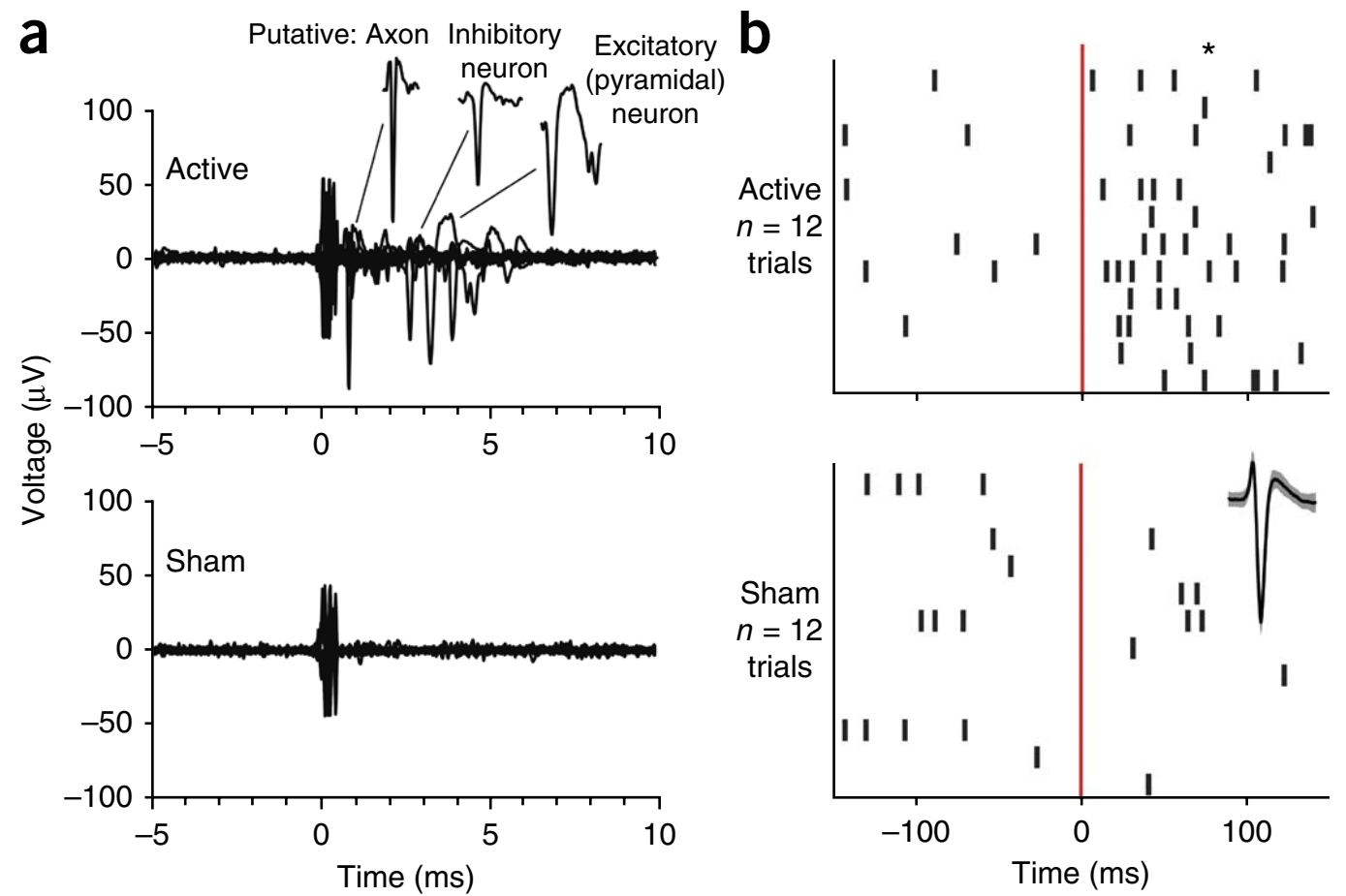
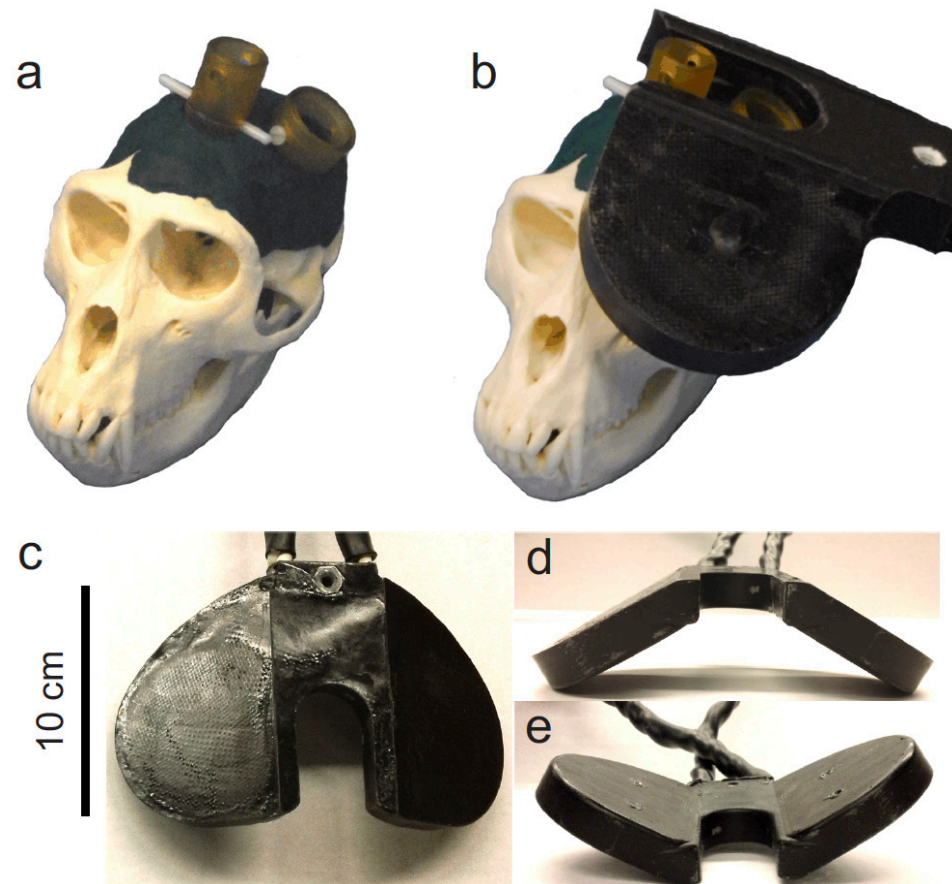
Neyens de Lara et al., *Magn Reson Med*, 2015

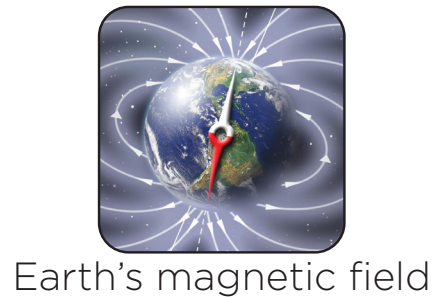
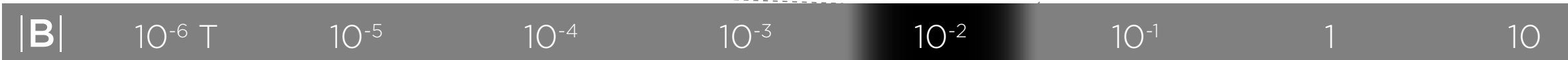
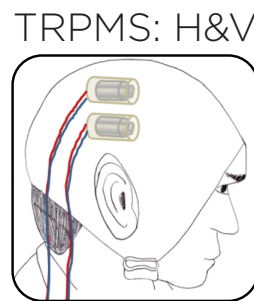
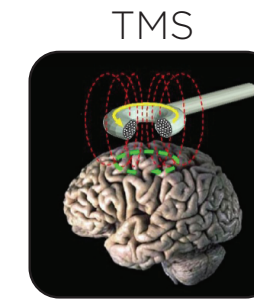
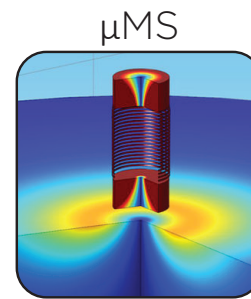
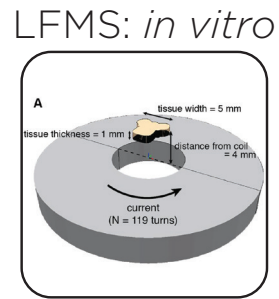
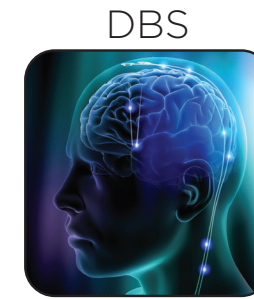
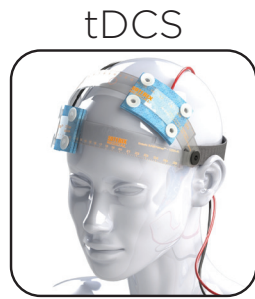




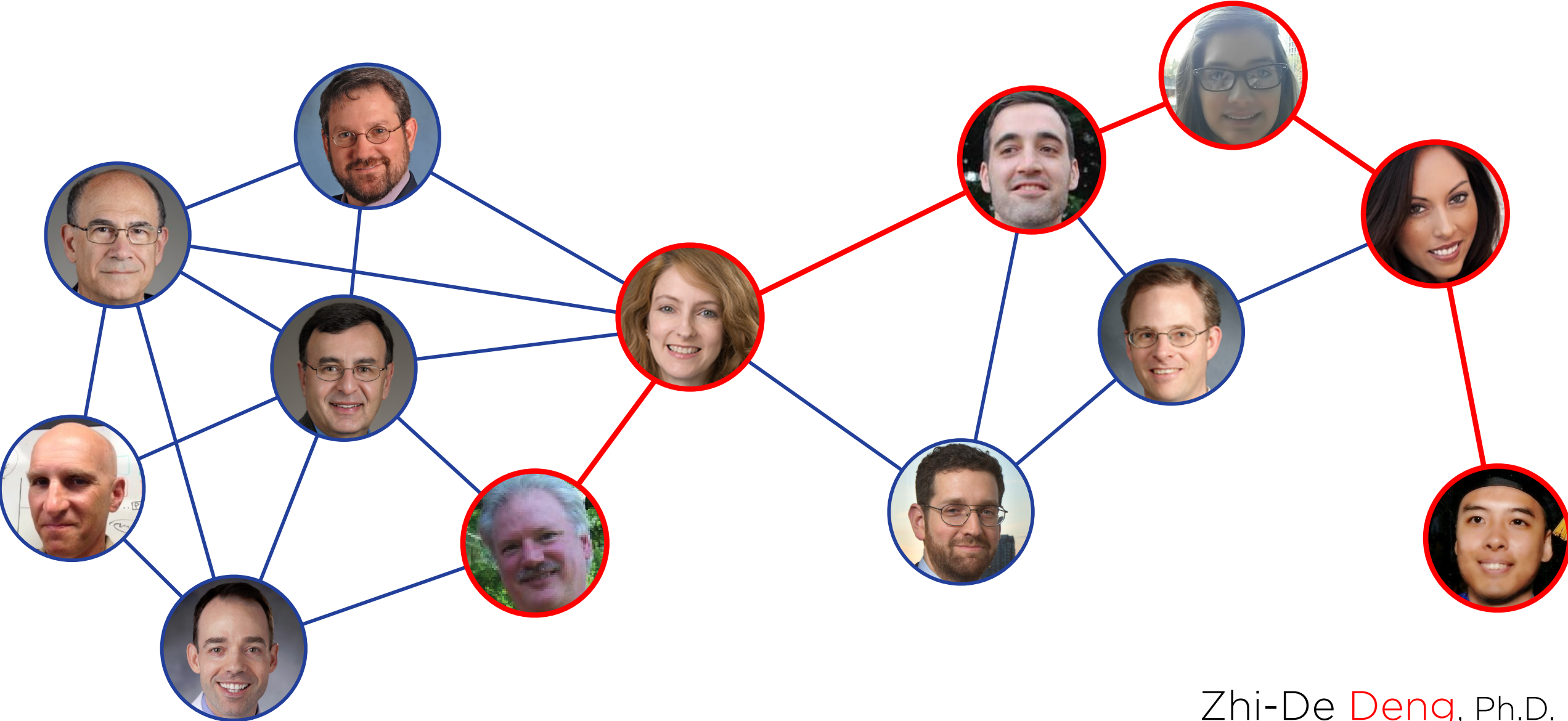


# TMS neural recording





# Noninvasive Neuromodulation Unit, NIMH



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