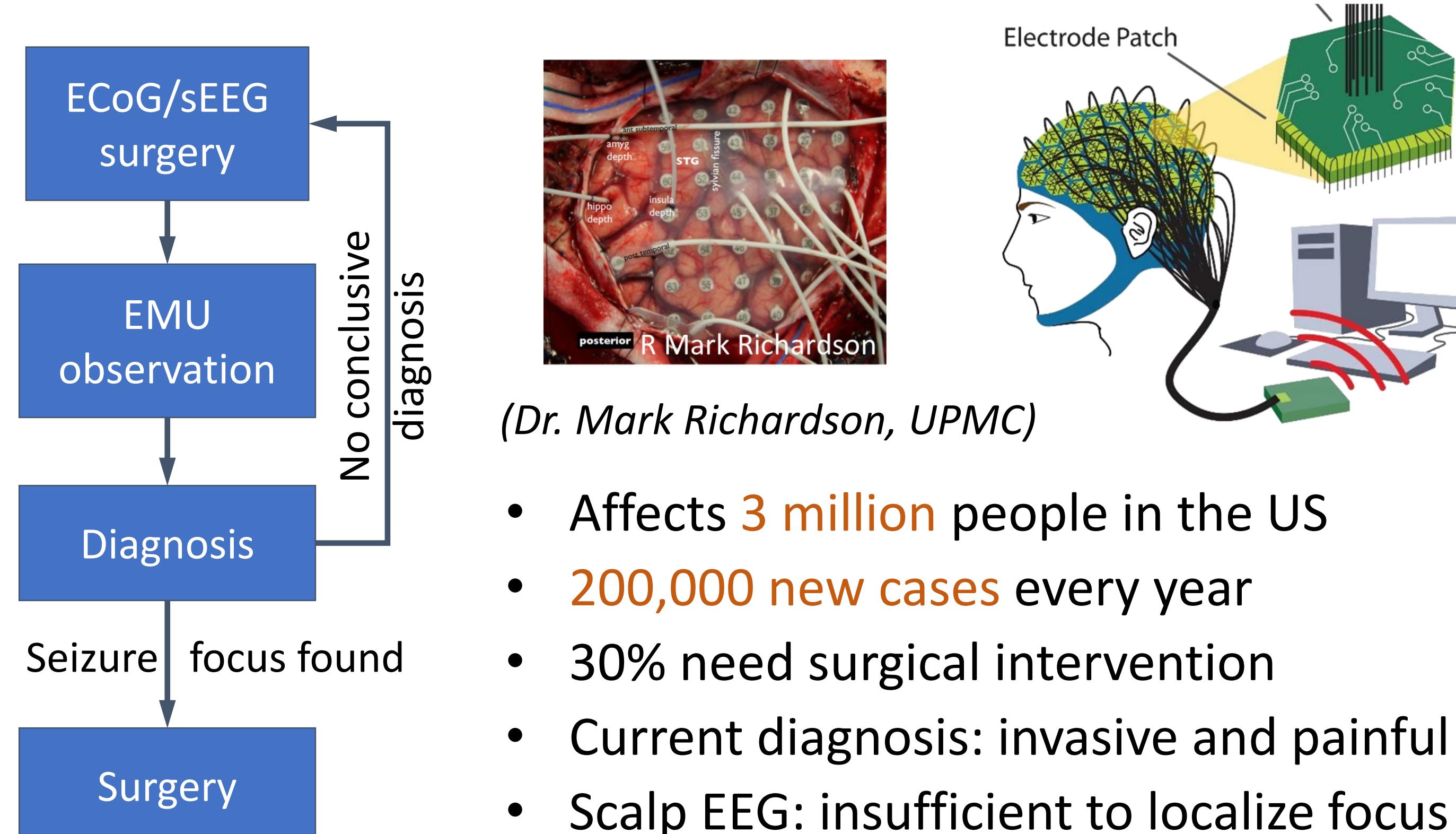


# Ultra-resolution Subdermal EEG: Long-term Minimally-invasive Brain Monitoring

Praveen Venkatesh, Ashwati Krishnan, Jeff Weldon, Shawn Kelly, Pulkit Grover

Dept. of Electrical and Computer Engineering, Institute for Complex Engineered Systems

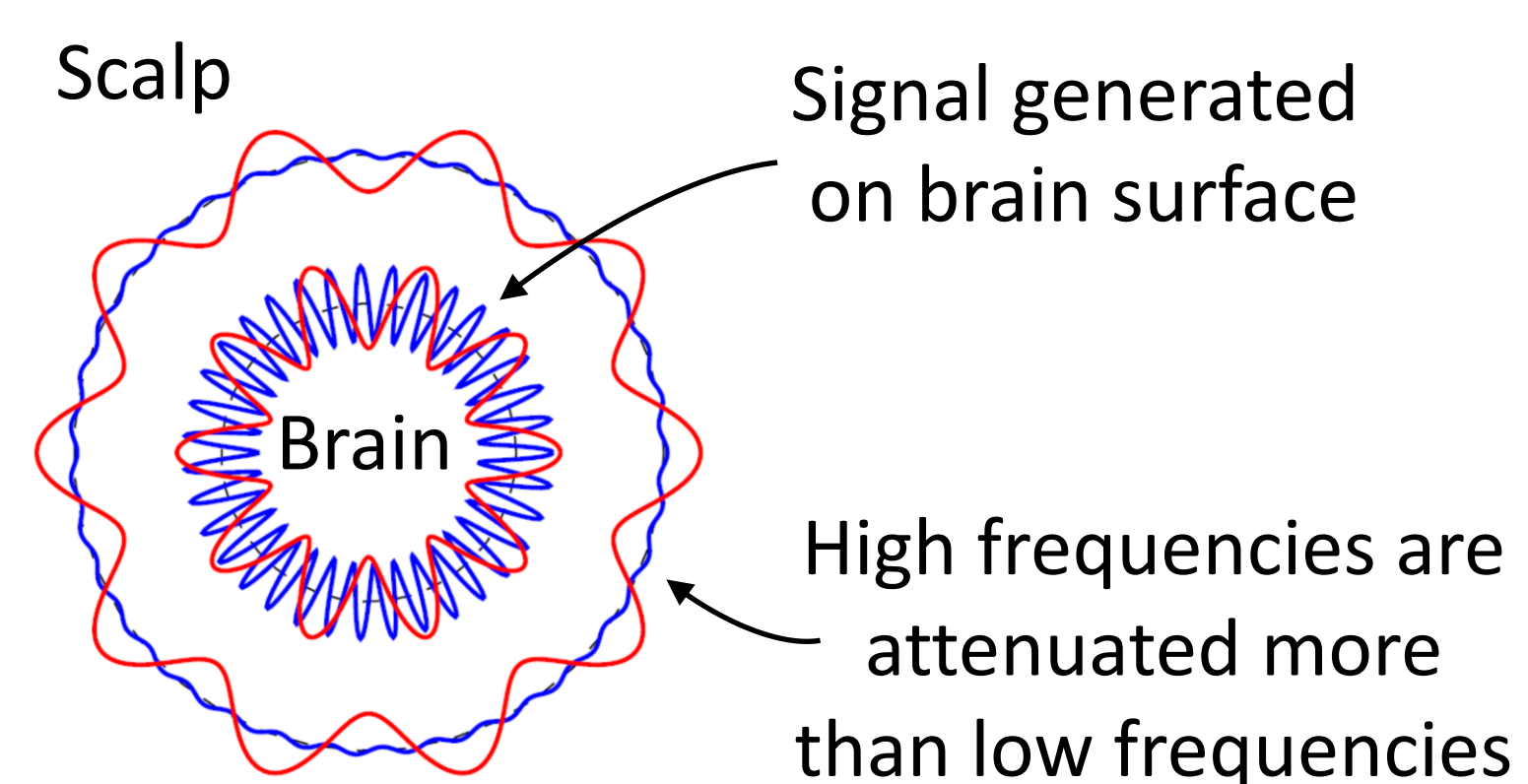
## Epilepsy: Locating Seizure Foci



## Problem: Low-Res Scalp EEG

Traditional scalp EEG has **poor spatial resolution**

Clinical EEG typically uses **only 20-32** electrodes!

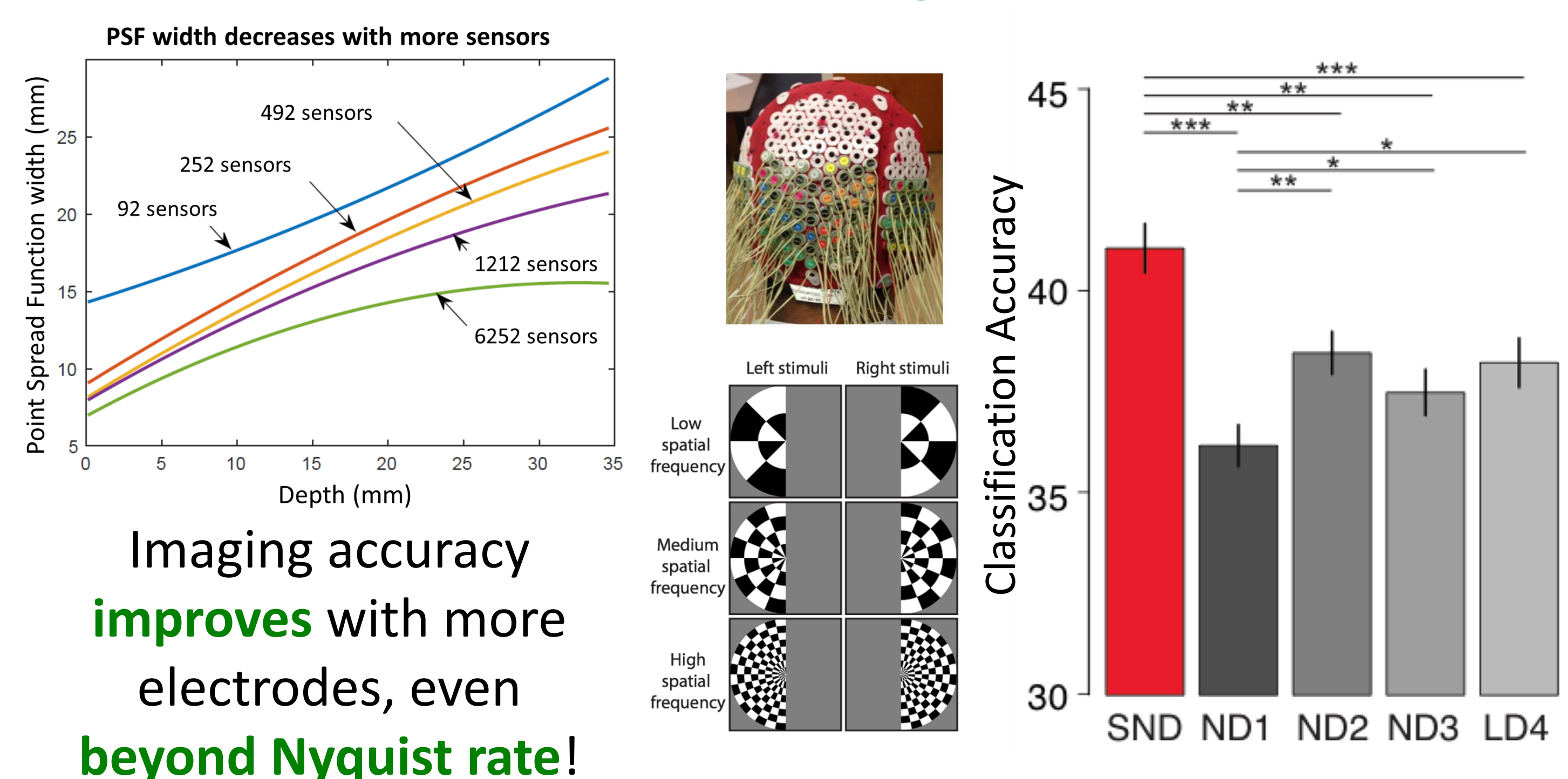


**Widespread misconception:**  
EEG is fundamentally limited to very low spatial resolutions

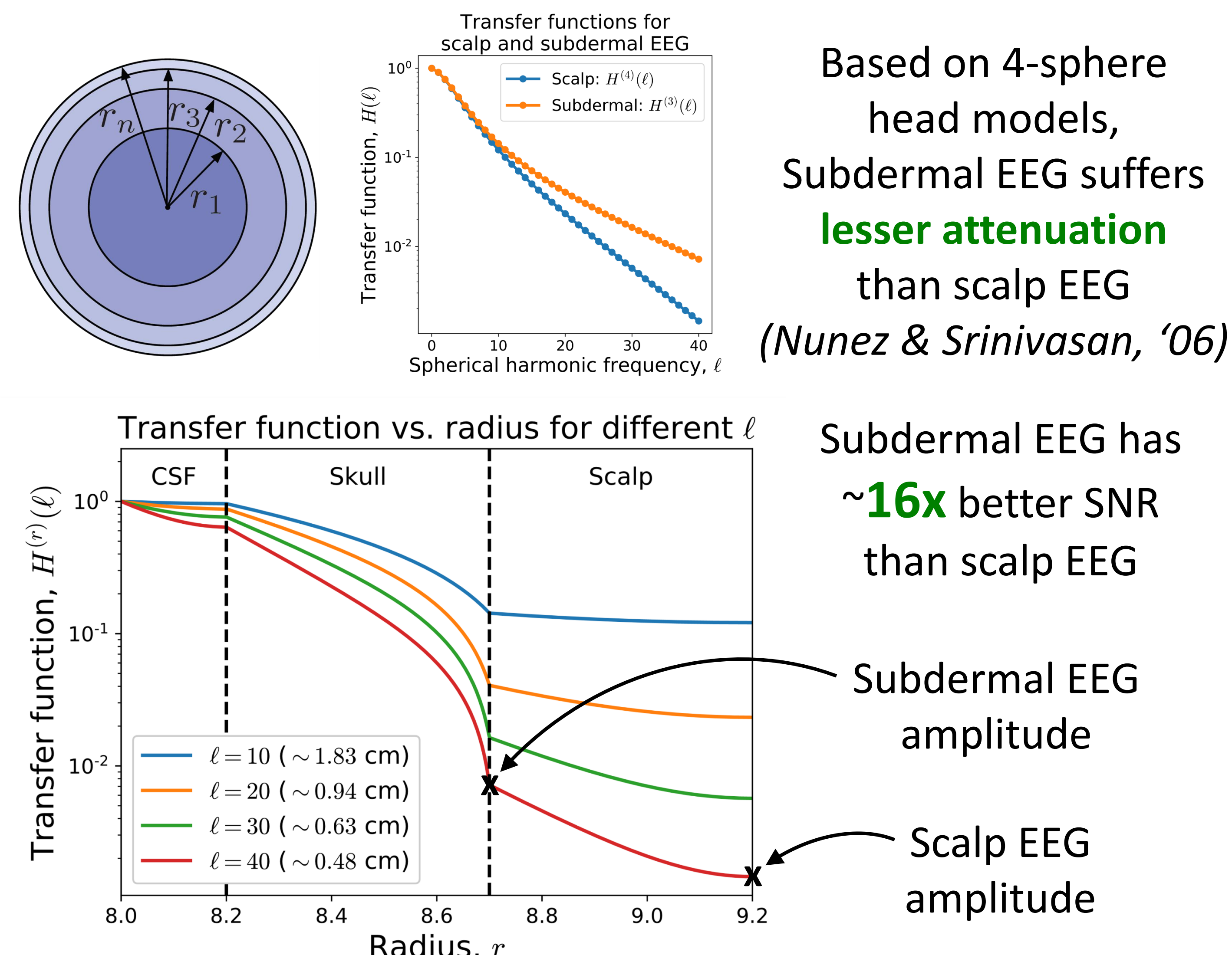
But scalp EEG has **practical limitations:**

Large impedance, No chronic recordings, Movement artifacts

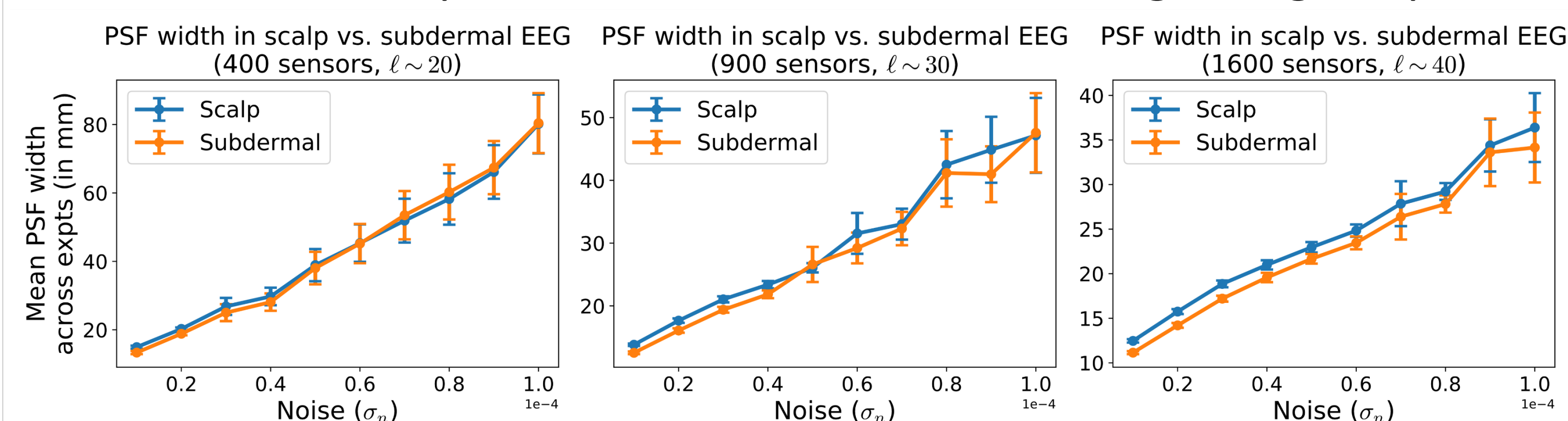
## Ultra-res EEG achieves **higher resolution**



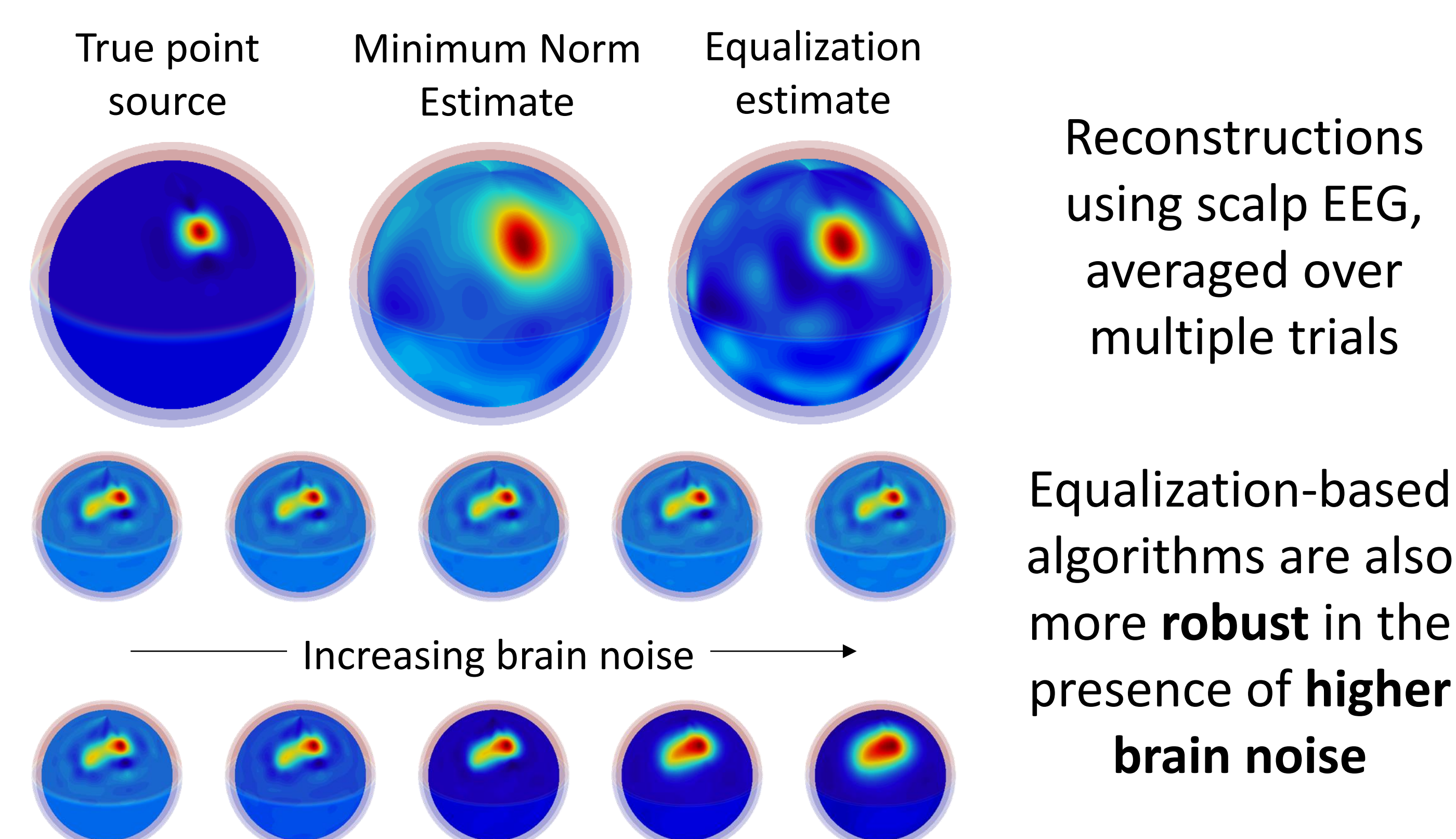
## Approach: Ultra-Res Subdermal EEG



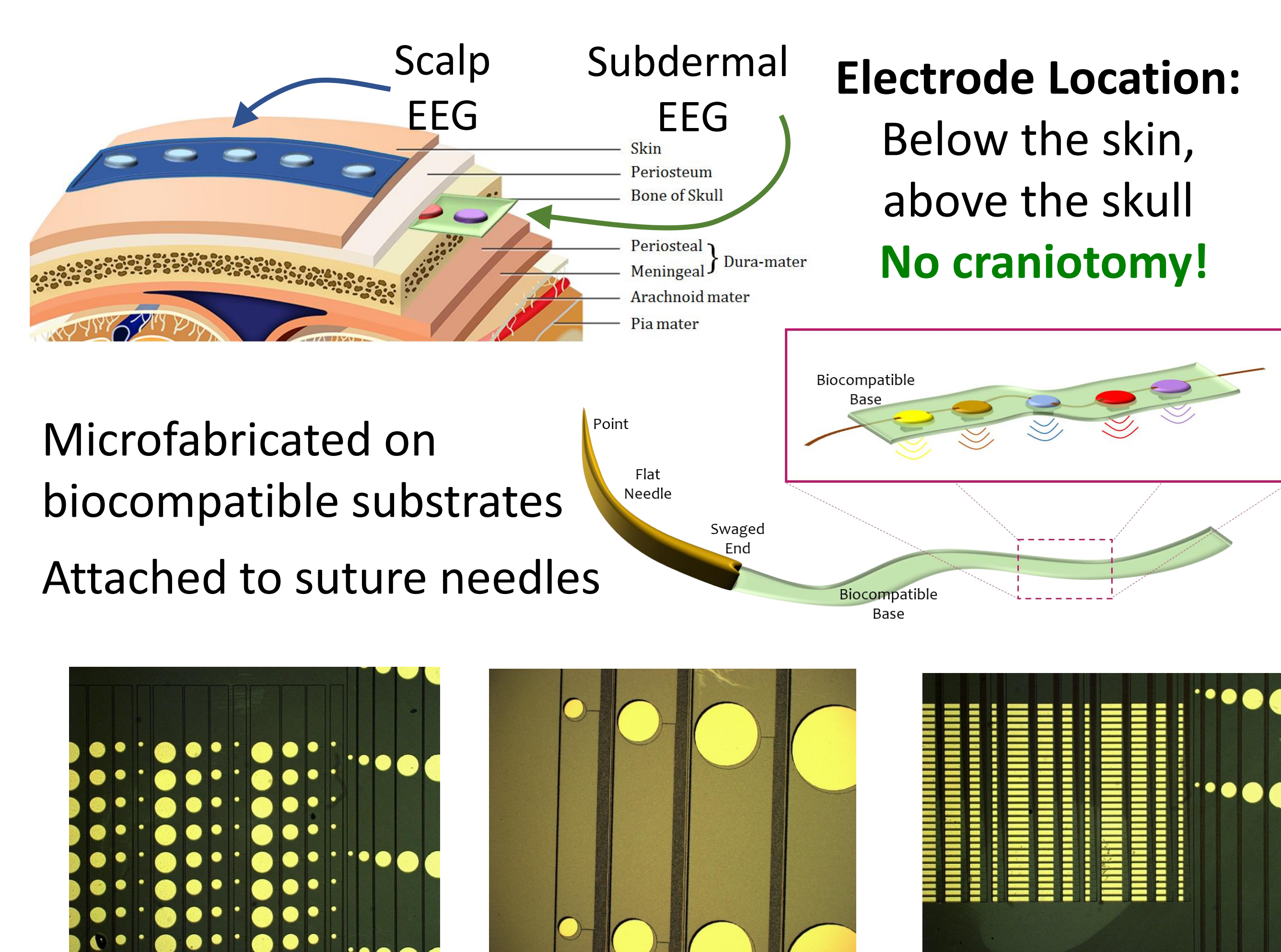
## Width of Point Spread Function in reconstructing a single dipole



## Source Localization with Ultra-res Arrays



## Physical Realization



## Ultra-Res Subdermal EEG: **Outcomes**

- Lower impedance** interface for signal acquisition
- High spatial resolution** for brain signals
- Accurate localization** for seizure foci
- Portable**, with **minimal movement artifacts** (compared to scalp EEG)
- Low risk of infection** (compared to ECoG)

## Acknowledgements

We thank Prof. Maysam Chamanzar, Jay Reddy, Kaustubh Deshpande and **Zabir Ahmed** for their contributions in the upcoming implementation of the subdermal electrodes. We also acknowledge **Dr. Amanda Robinson**, **Prof. Marlene Behrman** and **Prof. Michael Tarr** for their guidance in the neuroscientific validation of our work.

Praveen Venkatesh was supported in part by the Dowd Fellowship from the College of Engineering at Carnegie Mellon University. The authors would like to thank Philip and Marsha Dowd for their support and encouragement.

## References

- P. Grover, P. Venkatesh, "An information-theoretic view of EEG sensing", *Proc. IEEE*, 2017
- Praveen Venkatesh and Pulkit Grover, "Lower Bounds on the Minimax Risk for the Source Localization Problem", *ISIT 2017*
- P. L. Nunez and R. Srinivasan, "Electric fields of the brain: the neurophysics of EEG". *Oxford University Press*, 2006.
- Amanda Robinson, Praveen Venkatesh, Matthew Boring, Michael Tarr, Pulkit Grover, Marlene Behrman, "Very High Density EEG Elucidates Spatiotemporal Aspects of Early Visual Processing", *Nature Scientific Reports*, 2017 (in press)