



Electrical Head Phantom Testbed for Mobile EEG Validation

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OBJECTIVE

- To develop a realistic head phantom model for validating **EEG hardware and signal cleaning**.

BACKGROUND

- Electroencephalography (EEG) non-invasively measures **electrical brain activity**.
- EEG recordings are prone to biological, electrical, and mechanical **noise contamination**.
- Signal and noise separation requires validation based on knowledge of **ground truth signals**.
- Electrical head phantom devices have been used to **validate EEG signal cleaning**.



Figure 1: Gelatin head phantom [1]

Critical Gap:

Past head phantom designs:

- Homogeneous, lacked **multi-layer head structure**.
- Made of gelatin which breaks down rapidly.

Solutions:

- Identify **stable materials**.
- Match the **electrical and mechanical** properties of the human head.

METHODS

Selected Materials & Fabrication:

- Carbon nanotubes (CNT)**: electrical conductors.
- Polydimethylsiloxane (PDMS)**: nonconductive silicon-based polymer.

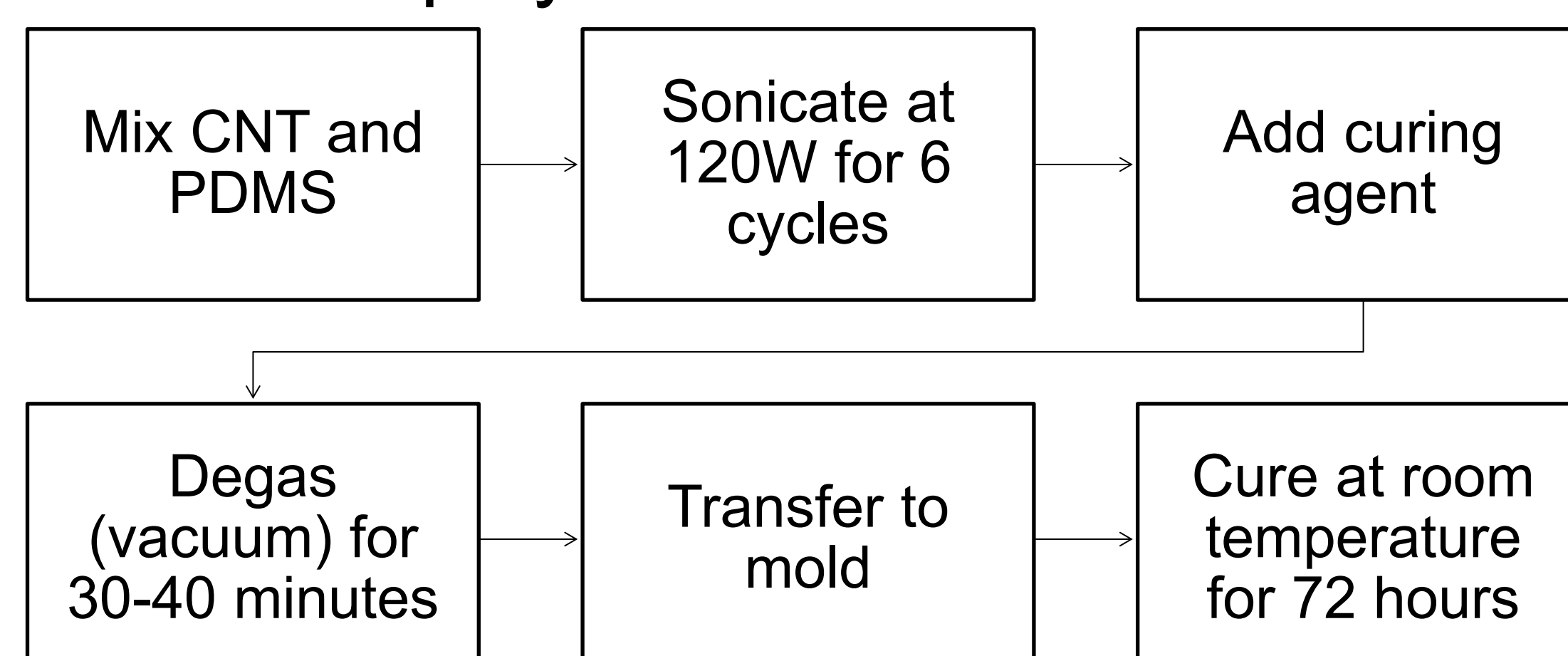


Figure 2: Material fabrication steps

Electrical Testing:

- Modified AC voltage divider circuit.
- Electrical conductivity**: complex impedance across EEG frequency range (1 - 50 Hz).

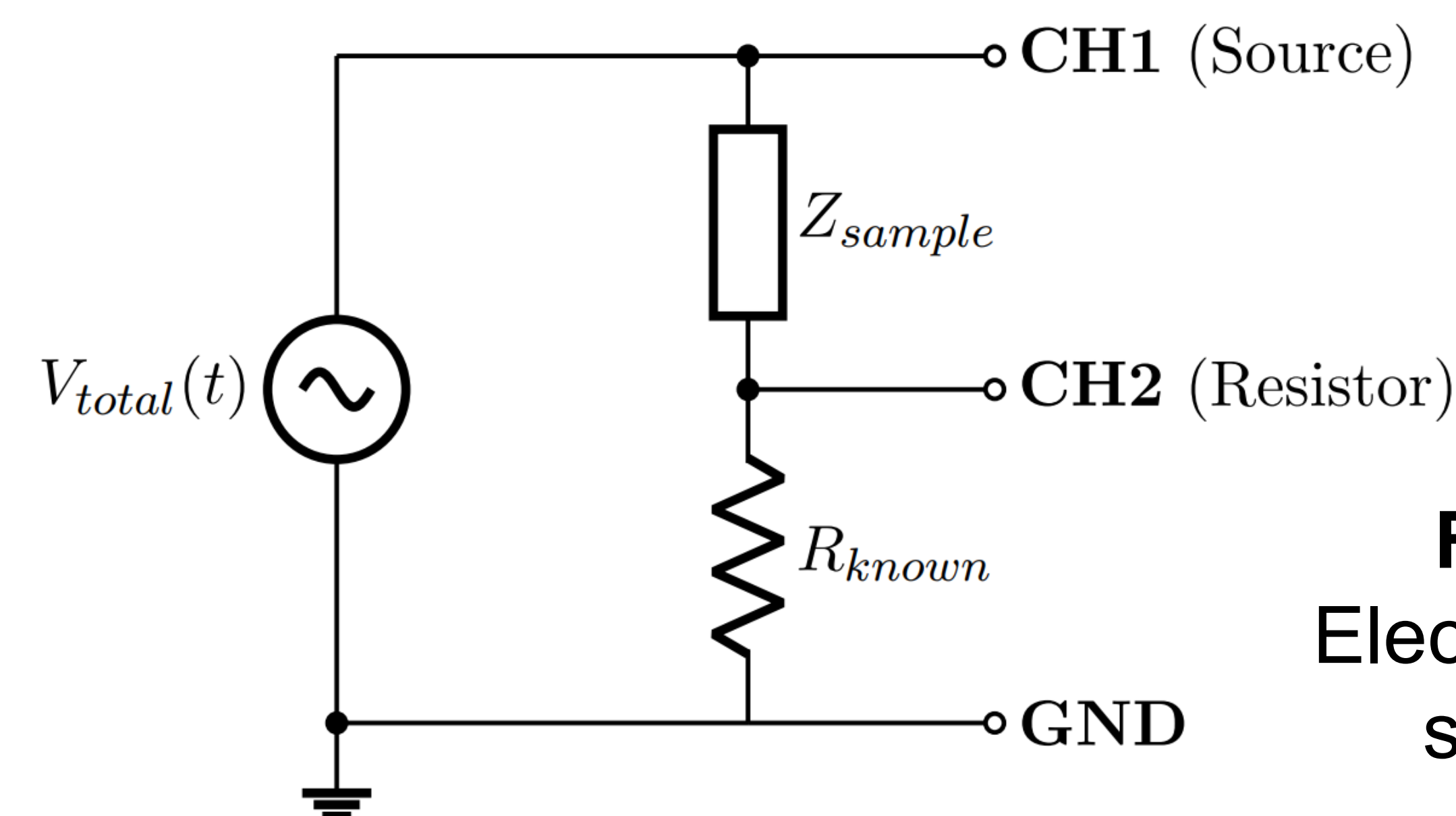


Figure 3: Electrical testing schematic

Design:

- Autodesk Fusion 360 model.
- Brain, cerebrospinal fluid (CSF), and skin layers.
- 3D printed skull and molds.

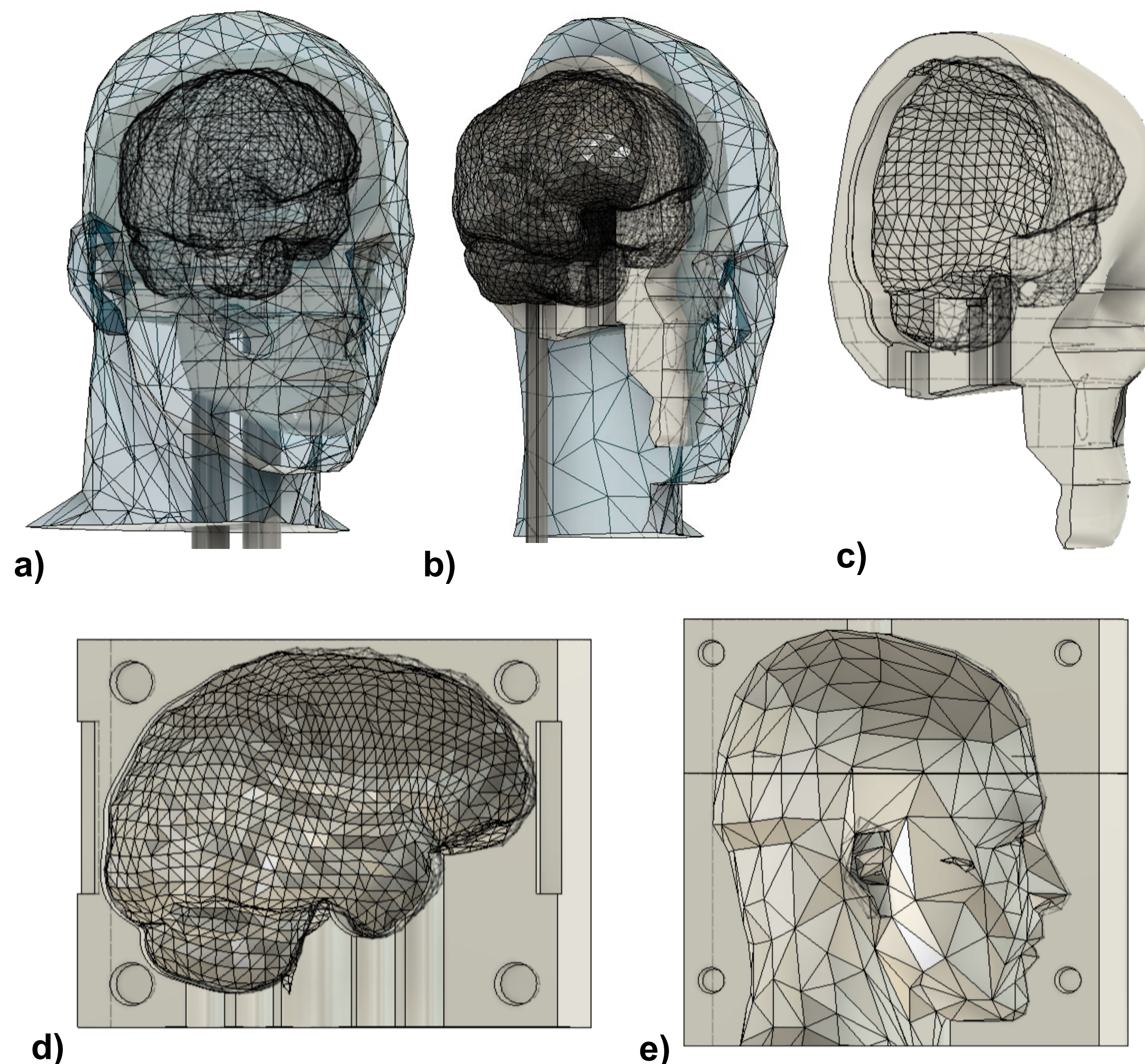


Figure 4: 3D overview of Assembled Head.

- a) Overview of Phantom b) Cross-section Overview c) Skull Layer d) Brain Mold e) Scalp Mold

RESULTS & DISCUSSION

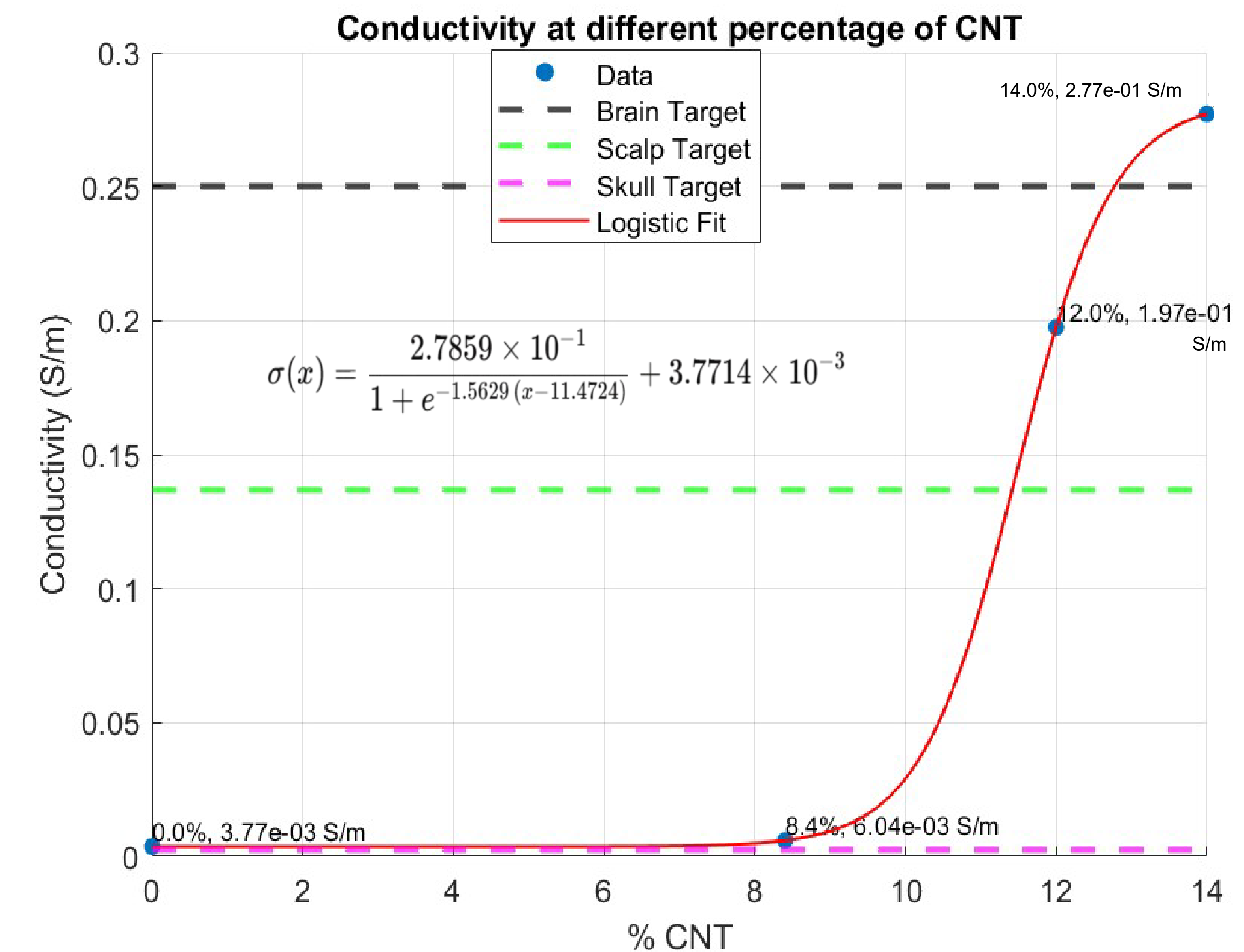


Figure 5: Sample conductivity at different % CNT vs. target conductivity for each layer

- We obtained desired conductivity for each target tissue layer.
- Our design advances neurotechnology development by providing an anatomical electrical standard.
- This enables researchers to test novel brain-monitoring devices against a model that accurately reflects the complexity of the human head.

FUTURE DIRECTIONS

- Model white and gray matter conductivity.
- Test mechanical material properties.
- Conduct mobile EEG validation experiments.

ACKNOWLEDGEMENTS & REFERENCES

- We thank capstone advisor Dr. Yuncheng Du.
- [1] Nordin et al. (2020). Motion and Muscle Artifact Removal Validation Using an Electrical Head Phantom, Robotic Motion Platform, and Dual Layer Mobile EEG.