EMIraShield: Advancing Low-Field MRI Systems

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JOHNS HOPKINS BIOMEDICAL ENGINEERING

PROBLEM

Traditional MRI systems entail **high operational and maintenance costs**, restricting their accessibility in underserved communities:

90% Globally lack MRI[2]

81% Low-income U.S. lack MRI[1]

$1-3M Traditional MRI[3]

$100k Low-field MRI

Low-field MRI enables portable, low-cost imaging but is highly **susceptible to electromagnetic interference (EMI)** due to the **absence of shielding**, which reduces signal-to-noise ratio (SNR) and image quality. This reduces diagnostic reliability in nontraditional clinical environments.

APPROACH

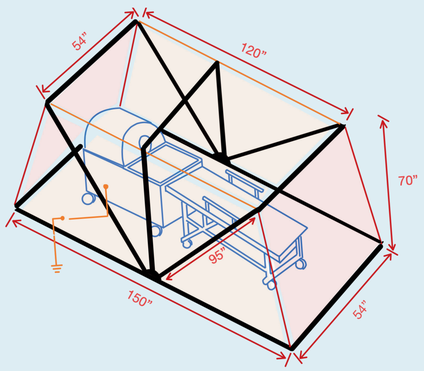


Fig. 1. Sketch of our final shield enclosure

To solve this, our team developed **EMIraShield**, a deployable EMI shielding system that reduces environmental noise without compromising usability or accessibility. We evaluated candidate materials and structural configurations.

Our resulting solution **improves imaging quality** in unshielded environments, expanding access to low-field MRI in low-resource settings.

EVALUATION TESTING

1. Benchtop testing

We initially simulated EMI conditions using a custom **benchtop testing chamber**. A **2.07 MHz signal** (the low-field MRI Larmor frequency) was transmitted through material samples, and signal amplitudes were measured before and after shielding. **Shielding effectiveness** was quantified via IEEE standard attenuation:

$$20\log_{10}(V_{unshielded} / V_{shielded})$$

Setup

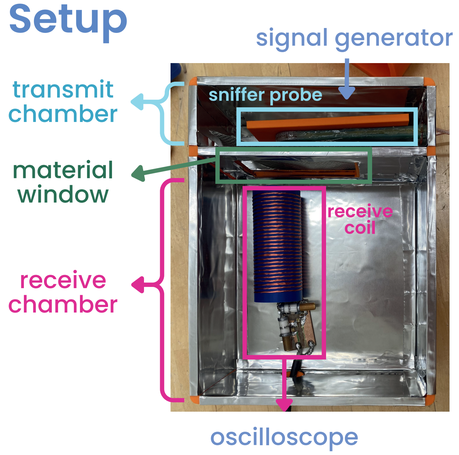


Fig. 2. Diagram of EMI testing box to evaluate signal attenuation of different materials

Results

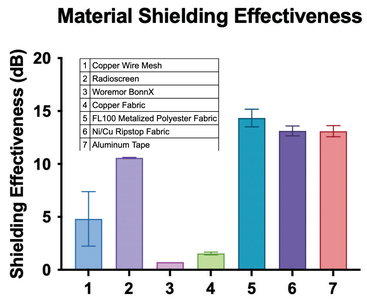


Fig. 3. Shielding effectiveness of individual materials

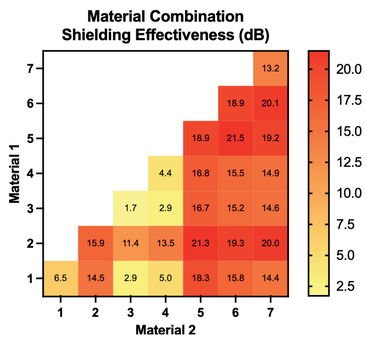


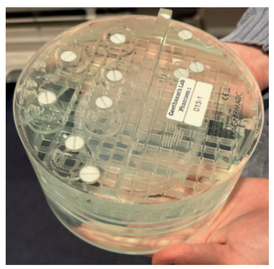
Fig. 4. Shielding effectiveness of combinations of 2 materials

Material testing showed an SE of 21.5 dB, indicating strong attenuation performance, validating our design's ability to improve signal quality.

2. Phantom testing

To determine the shielding effectiveness of our prototype in clinical settings, we imaged a **standardized phantom**[4] under controlled external noise and compared results to both the unshielded condition and the current shielding method.

a.



b.

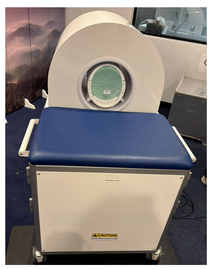


Fig. 5a. ProMRI Phantom (American College of Radiology)
Fig. 5b. Phantom positioned in MRI

Setup

Fig. 6. Image of phantom testing setup using tent made of Ni/Cu ribstop fabric

Results

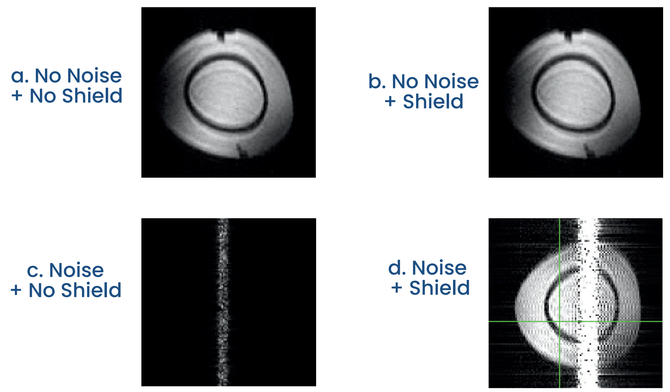


Fig. 7. Comparison of MRI scans across noise and shielding conditions: (a-d)

Phantom testing showed improved shielding efficacy in low-field MRI clinical settings.

CONCLUSION & NEXT STEPS

- **EMIraShield** offers a practical solution to **enhance diagnostic reliability** in unshielded care settings
- Implement internal features for comfortability and patient safety (e.g. lighting, a shielded window)
- Conduct **stress** and **durability testing** on materials
- Create a **full-sized tent** to be used in clinical study on human subjects receiving low-field MRI scans

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