Stranded Copper Shielding

Stranded Copper Testing

$$B_{\text{applied}} = B_0 \cos \omega t$$

$$B_{\rm induced} = -\alpha B_0 \sin \omega t$$

out of phase and scaled by α

$$B = B_{\text{applied}} + B_{\text{induced}} = \beta B_0 \cos(\omega t + \phi)$$

$$\beta = \sqrt{1 + \alpha}$$
gain

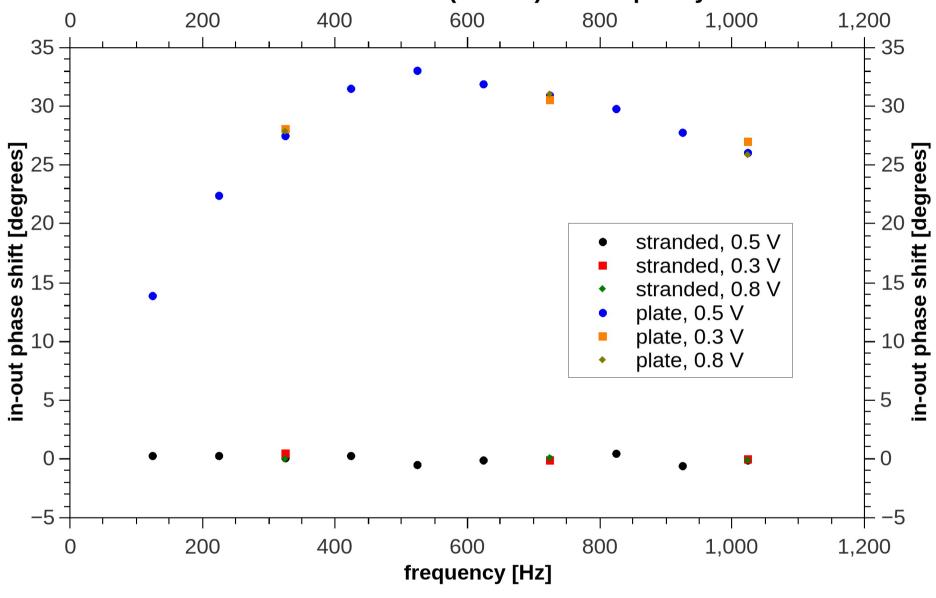
$$\phi = -\arctan(-\alpha)$$
phase shift

B Field Gain (in / out) vs. Frequency 0 200 400 600 800 1,000 1,200 1.1 - 1.1 1 1 0.9 - 0.9 stranded, 0.5 V in/out gain 8.0 8.0 stranded, 0.3 V 8.0 stranded, 0.8 V plate, 0.5 V plate, 0.3 V 0.7 plate, 0.8 V 0.6 0.6 0.5 0.5 0.4 0.4 -200 600 400 800 1,000 1,200 0

stranded =
$$1.0008 \pm 0.0005$$
 $\frac{\text{avg copper}}{\text{avg stranded}} = 0.592$

frequency [Hz]

B Field Phase Shift (in - out) vs. Frequency



stranded =
$$0.0375 \pm 0.0769$$

$$\frac{\text{avg stranded}}{\text{avg copper}} = 0.00135$$

Stranded Copper Analysis

$$\beta = \sqrt{1 + \alpha}$$
gain

$$\beta = \sqrt{1 + \alpha}$$
 $\phi = -\arctan(-\alpha)$
gain phase shift

$$\alpha \sim \omega$$

skin depth effect
$$\alpha \sim \int_0^h e^{-z/\delta} \ dz = \delta - \delta e^{-h/\delta}$$

$$\delta \sim \sqrt{1/\omega}$$

B0 Data Analysis

Current Procedure

- probe is offset from origin by $\Delta \mathbf{r} = (\Delta x, \Delta y, \Delta z)$
- pick a field "slice," usually the line x = 5 cm, y = 0
- compare simulated map to measured map
- transform measured map by $\mathbf{r} \to \mathbf{r} \Delta \mathbf{r}$
- compare again
- keep guessing $\Delta \mathbf{r}$ until agreement is good
- problem: done per slice, not for entire field

Automation

- run a densely-gridded simulation and interpolate to obtain an essentially continuous map
- calculate deviation as a function of $\Delta \mathbf{r}$

$$\chi^{2} = \sum_{\text{points}} \frac{|\mathbf{B}(\mathbf{r} - \Delta \mathbf{r}) - \hat{\mathbf{B}}(\mathbf{r})|^{2}}{|\boldsymbol{\sigma}|^{2}}$$

- MCMC algorithm to vary $\Delta \mathbf{r}$ until χ^2 is minimized
- moving measured map around in 3D until it fits