Stranded Copper Shielding

Stranded Copper Testing

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

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

out of phase and scaled by α

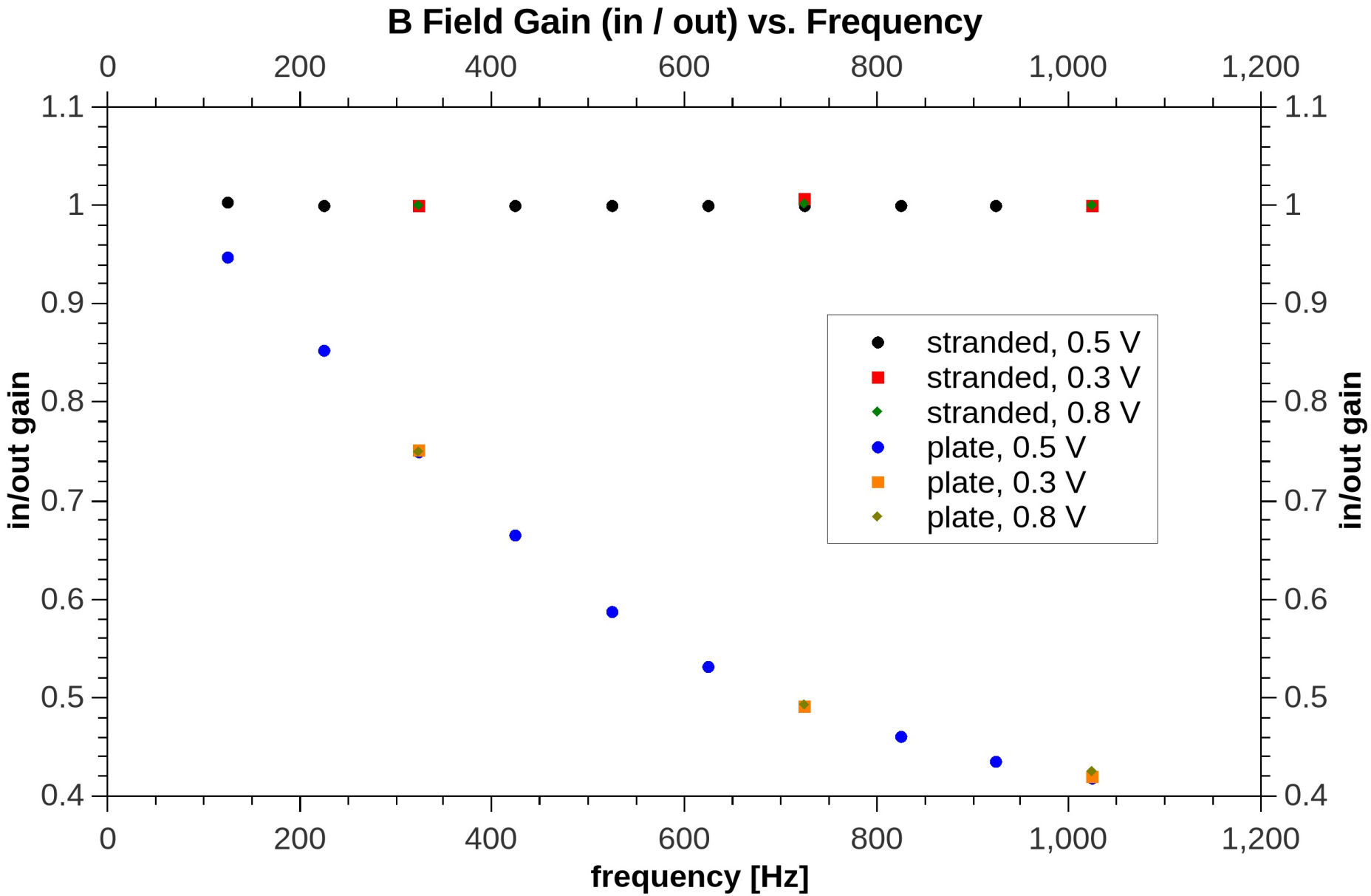
$$B = B_{\text{applied}} + B_{\text{induced}} = \beta B_0 \cos(\omega t + \phi)$$

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

gain

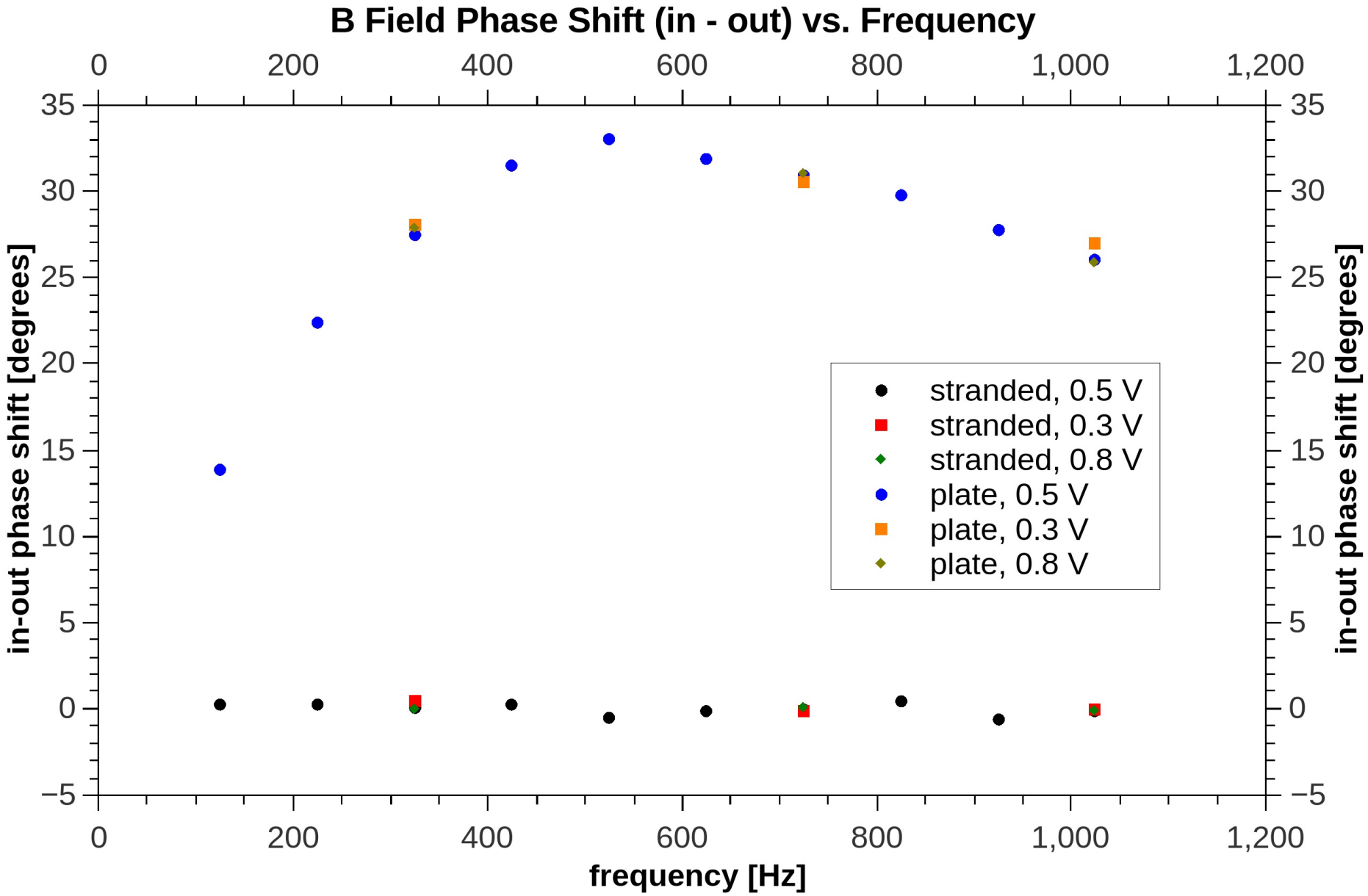
$$\phi = -\arctan(-\alpha)$$

phase shift



$$\text{stranded} = 1.0008 \pm 0.0005$$

$$\frac{\text{avg copper}}{\text{avg stranded}} = 0.592$$



$$\text{stranded} = 0.0375 \pm 0.0769$$

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

Stranded Copper Analysis

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

gain

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

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 $\mathbf{r} \longrightarrow \mathbf{r} - \Delta\mathbf{r}$
- 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