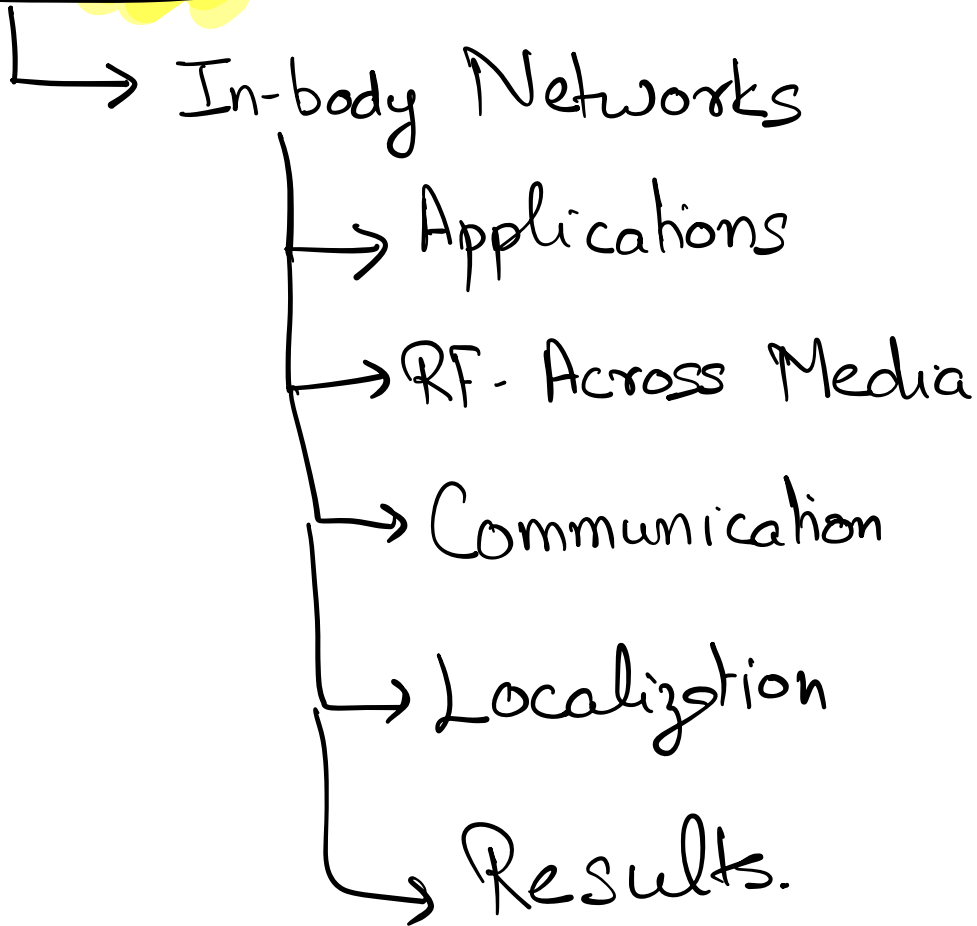


Today



Applications

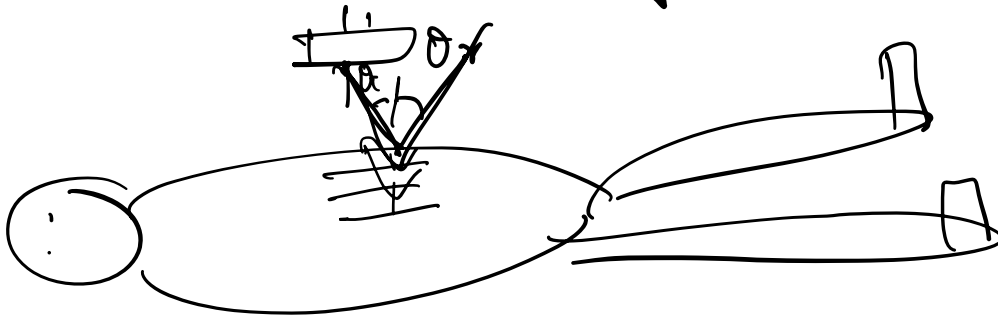
→ Radiation Therapy.

→ Continuous Glucose Delivery.

→ Capsule Endoscopy.
 battery.
 camera

→ Micro-robots.

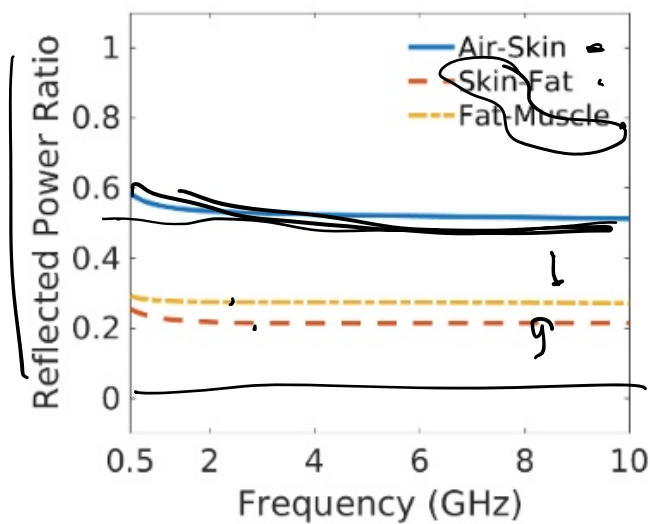
Reflections



$\epsilon_r \Leftarrow$ electrical permittivity of

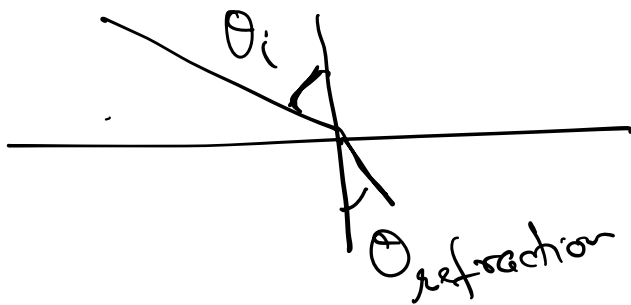
the medium

$$\frac{P_r}{P_t} = \frac{|\sqrt{\epsilon_{r_1}} - \sqrt{\epsilon_{r_2}}|}{|\sqrt{\epsilon_{r_1}} + \sqrt{\epsilon_{r_2}}|}$$

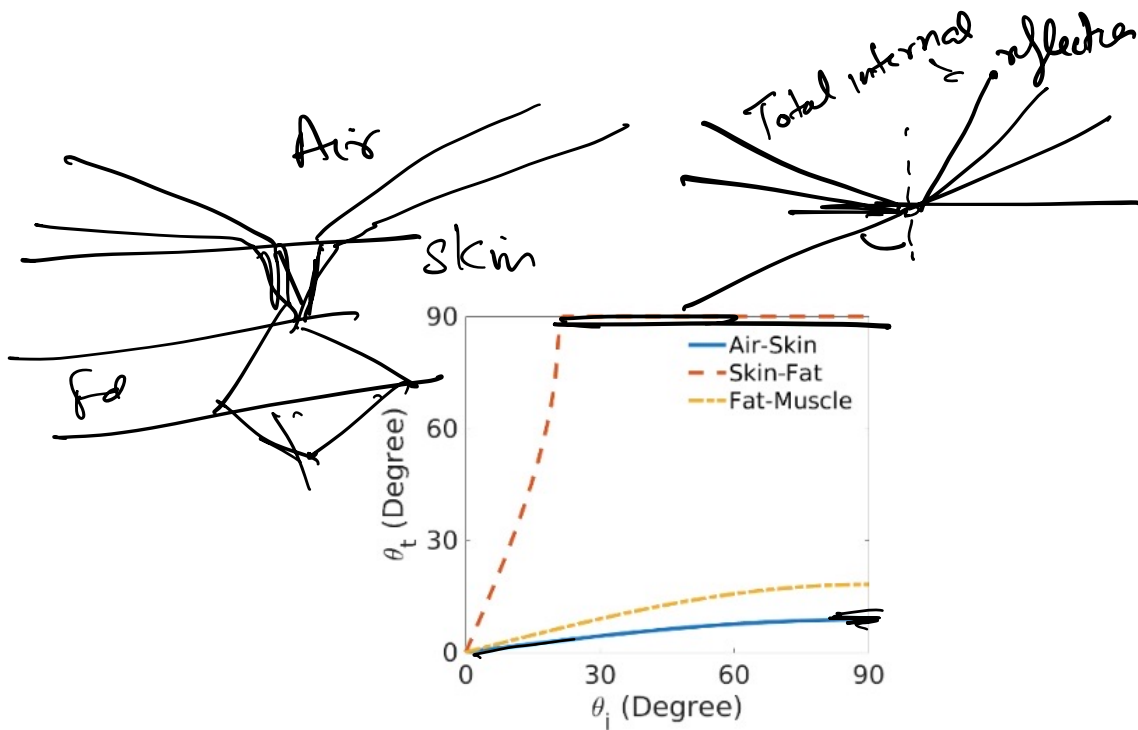


(c) Reflection

Refraction



$$Re(\sqrt{\epsilon_{\sigma_1}}) \sin \theta_1 = \text{constant} = Re(\sqrt{\epsilon_{\sigma_2}}) \sin \theta_2$$



(d) Refraction

Attenuation & Phase

$$\text{speed of light} = c = 3 \times 10^8$$

$$c = \frac{c}{\sqrt{\epsilon_r \mu_r}} \approx \frac{c}{\sqrt{\epsilon_r}}$$

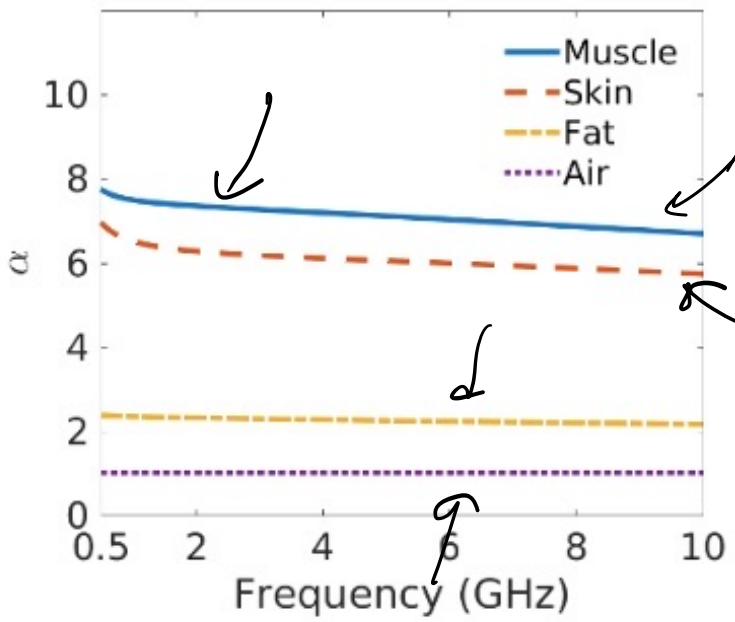
electrical magnetic

$$\sqrt{\epsilon_r} = \alpha + \beta j$$

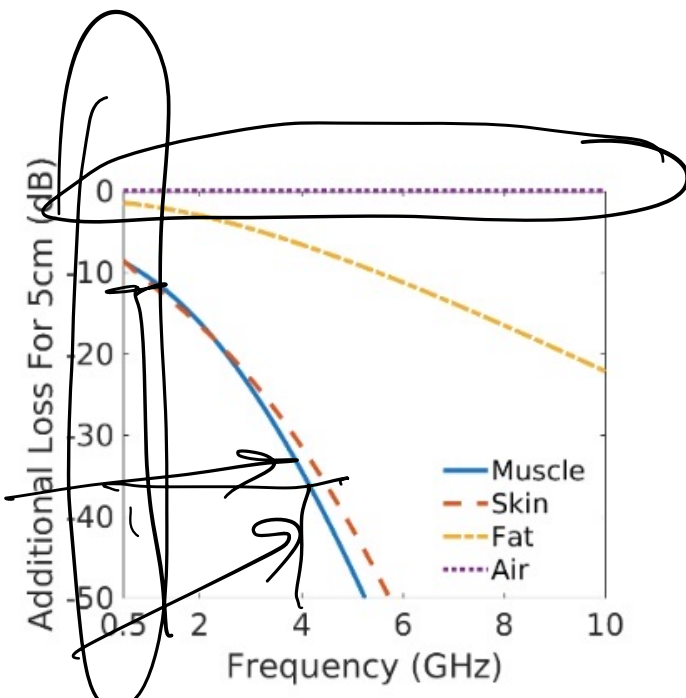
$$h = a e^{j \frac{2\pi}{\lambda} d}$$
$$= a e^{t j \frac{2\pi d f}{c}}$$

$$= a e^{t j \frac{2\pi}{c} (\alpha + \beta j) f d}$$

$$= a e^{\frac{2\pi}{c} \alpha f d} e^{-\frac{2\pi}{c} \beta f d}$$

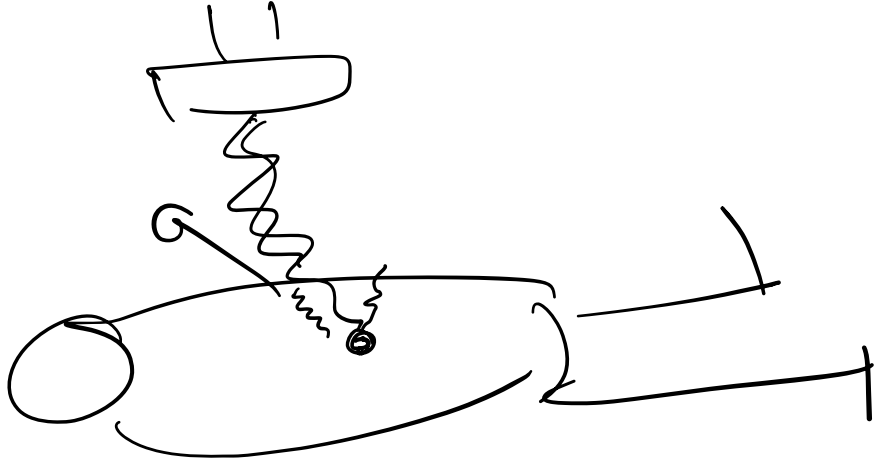


(b) Phase Change

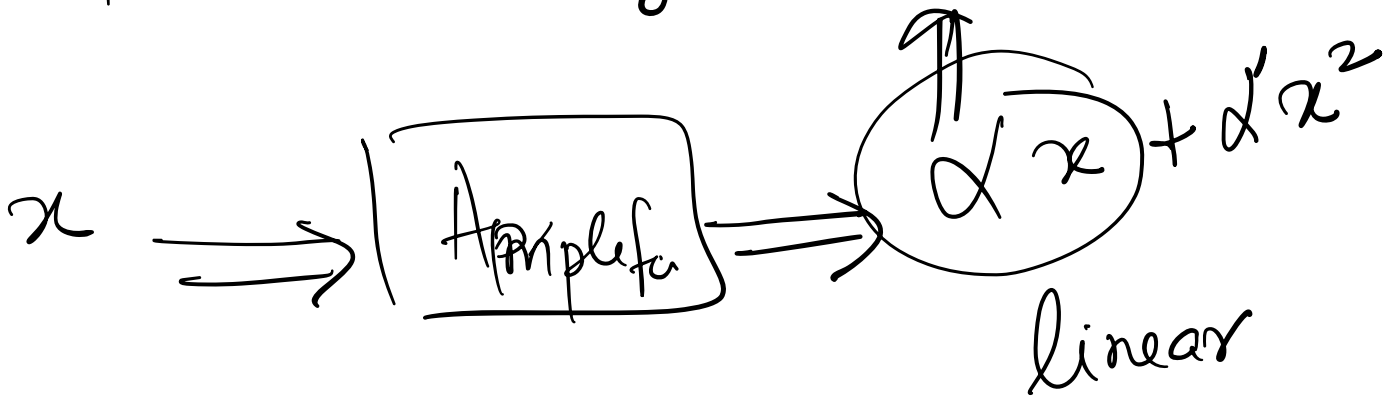


(a) Attenuation

Communication



Non-linearity.



$$\sin(2\pi f_1 t)^2 \Rightarrow \alpha \sin(2\pi f_1 t)$$

$$\alpha_1 \sin(2\pi f_1 t)$$

$$+ \alpha_2 \sin(2\pi 2f_1 t)$$

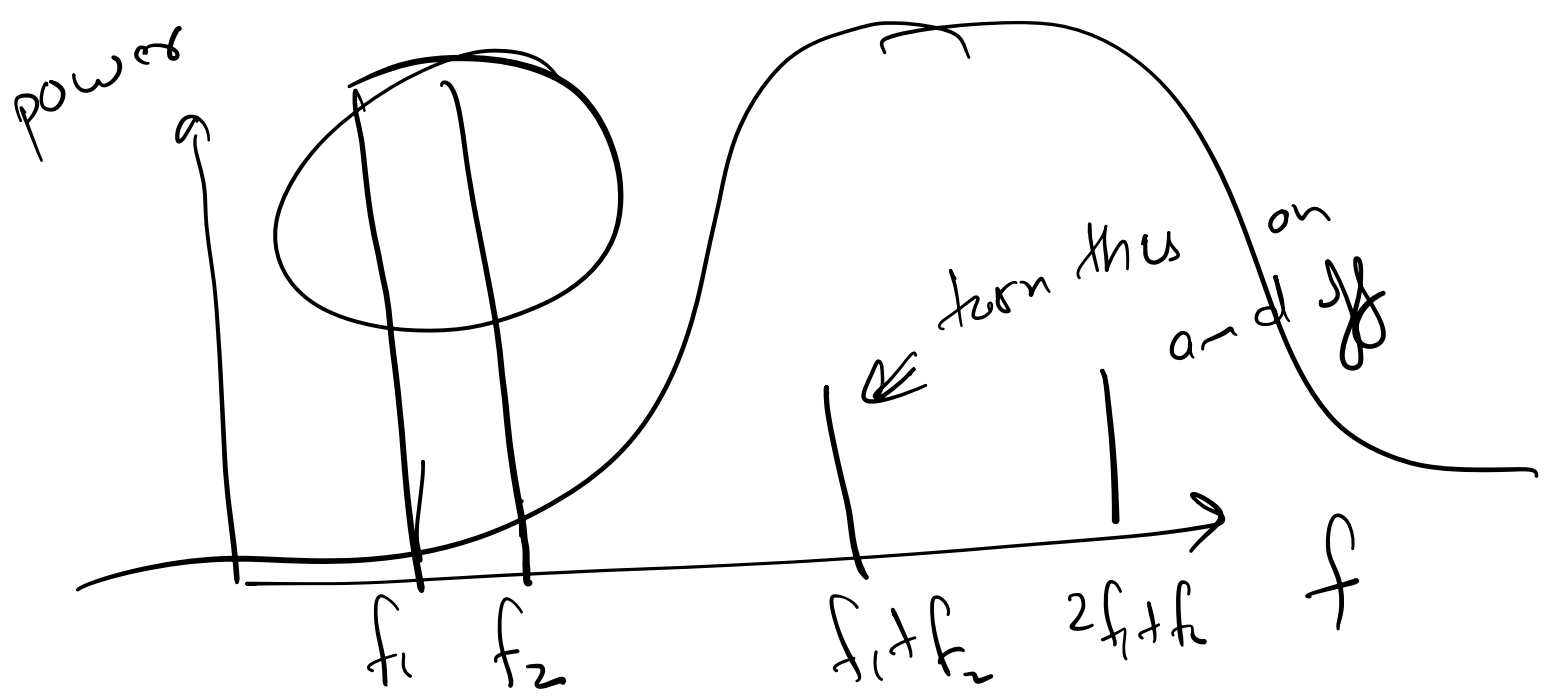
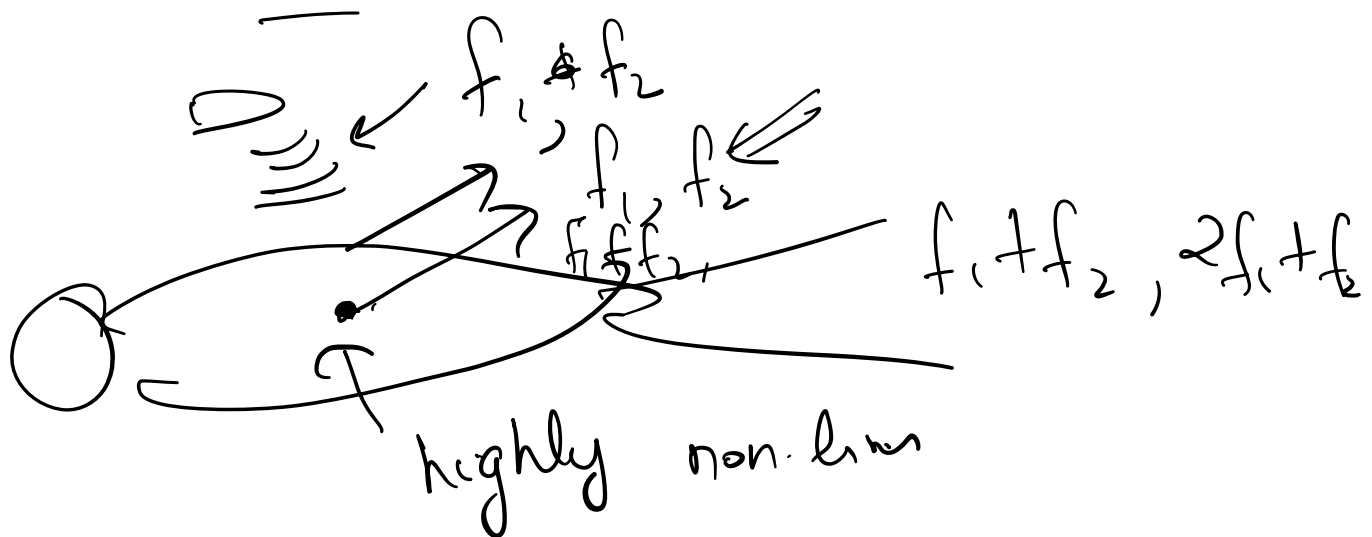
$$+ \alpha_3 \sin(2\pi 3f_1 t)$$

$$\left(\sin(2\pi f_1 t) + \sin(2\pi f_2 t) \right)^2$$

$$\Rightarrow \sin \underline{2f_1}, \underline{2f_2},$$

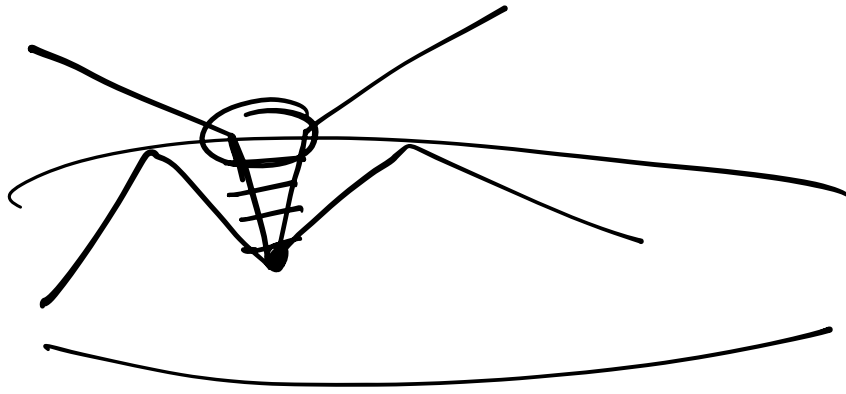
$$\underline{f_1 + f_2}$$

$$\underline{2f_1 + f_2}, \underline{2f_2 + f_1}$$

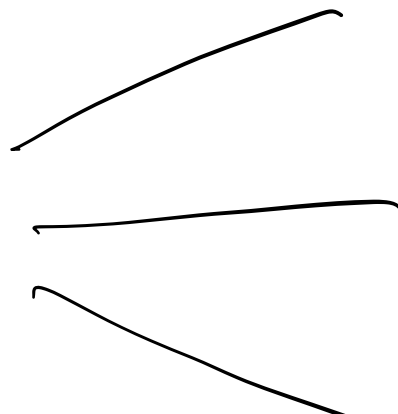
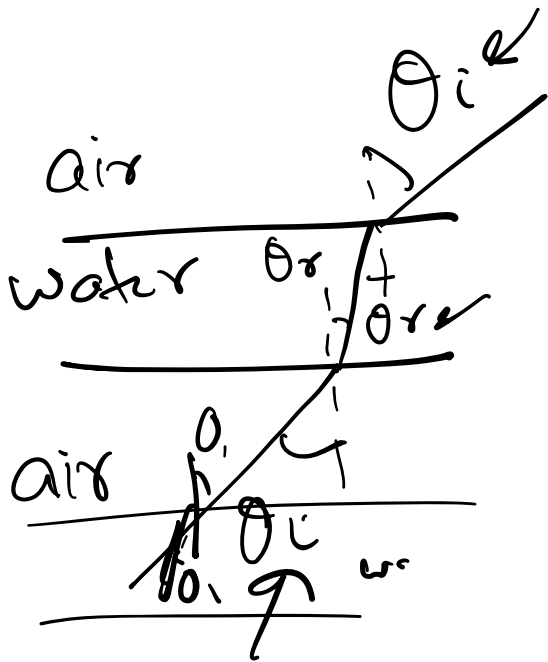


Localization

① Signal comes out at a small eye



② Order of layers does not matter for phase.

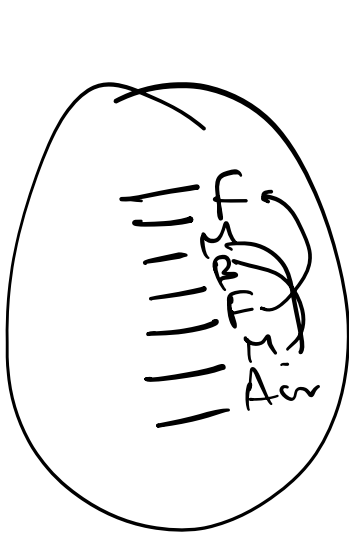
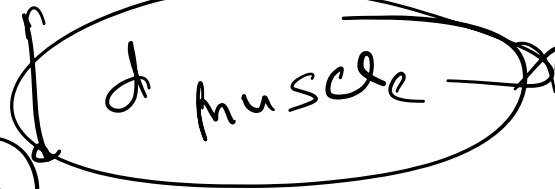


diere

Fat



muscle.

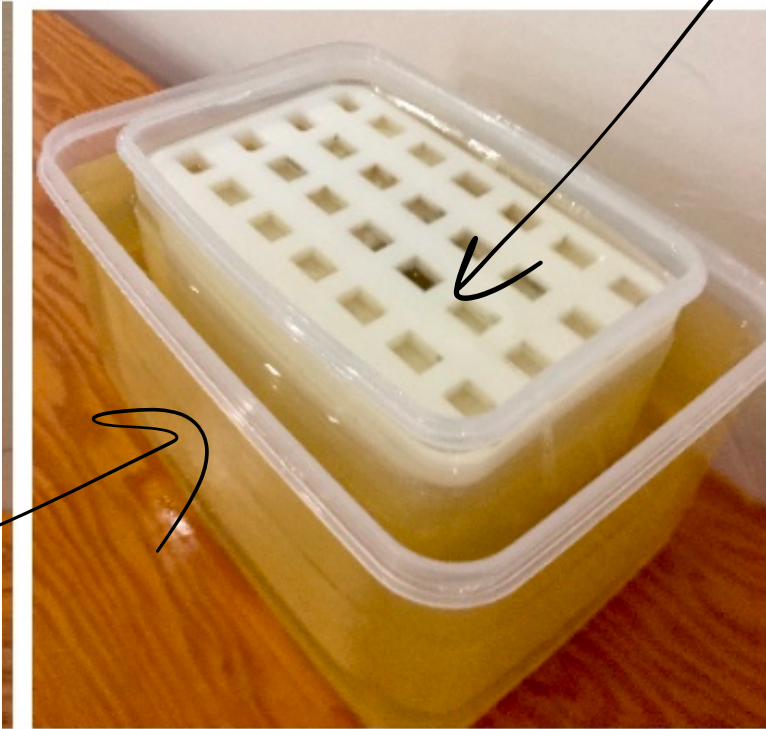


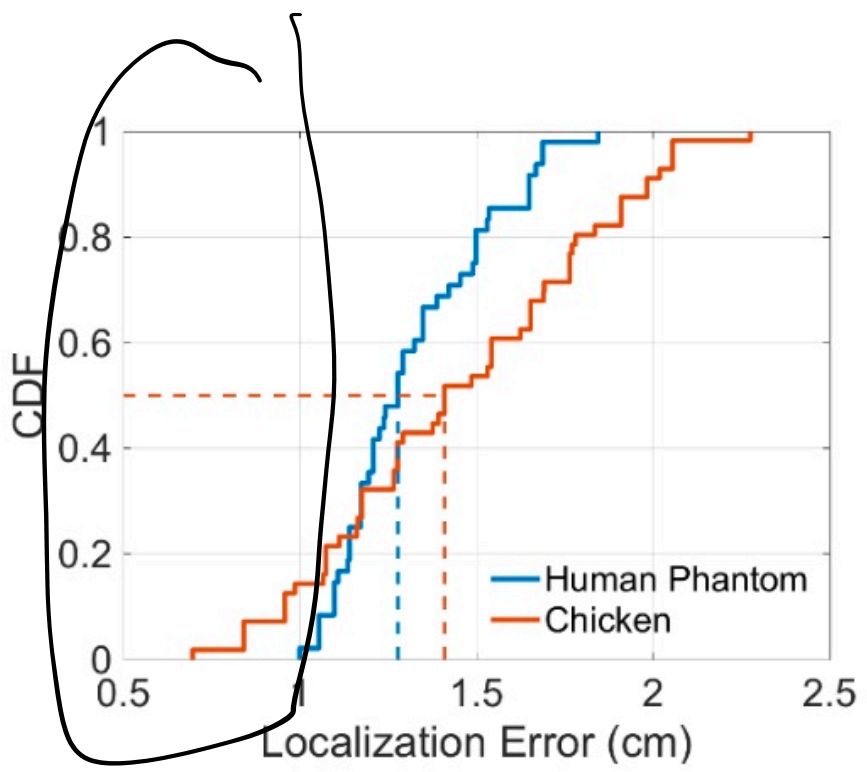
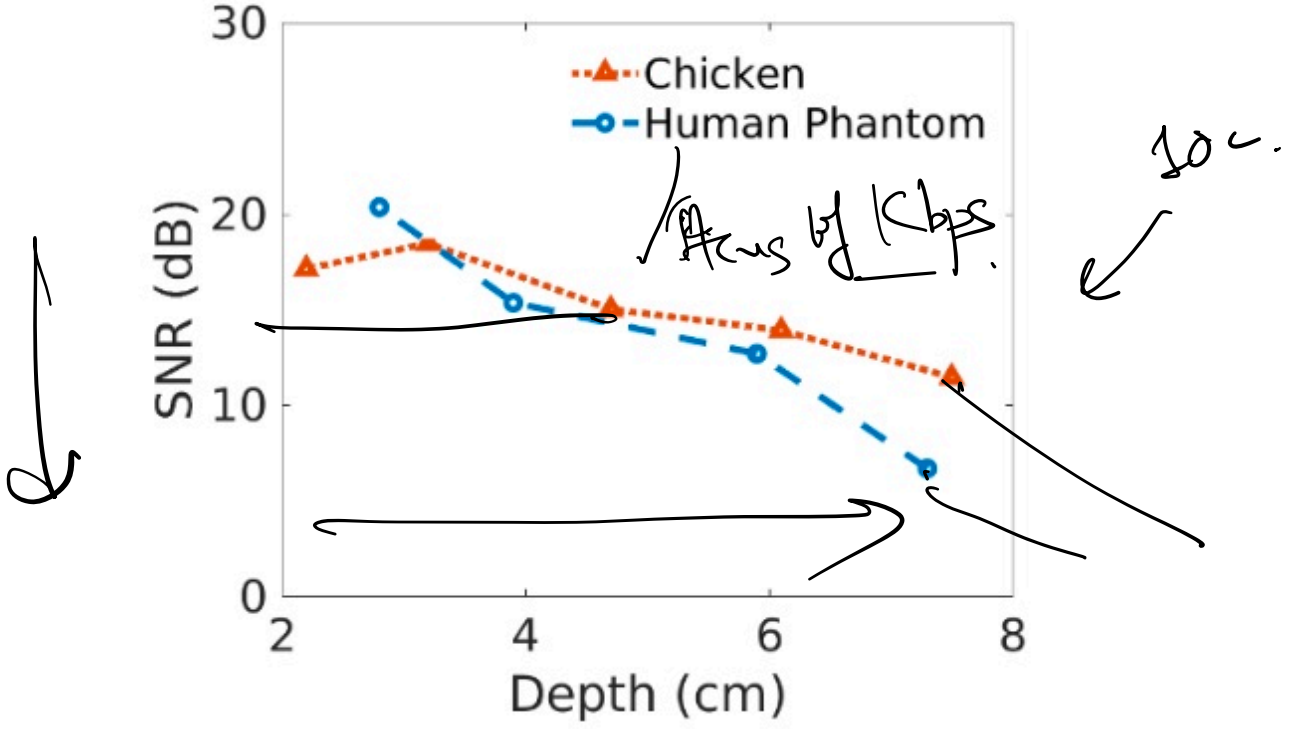
Evaluation

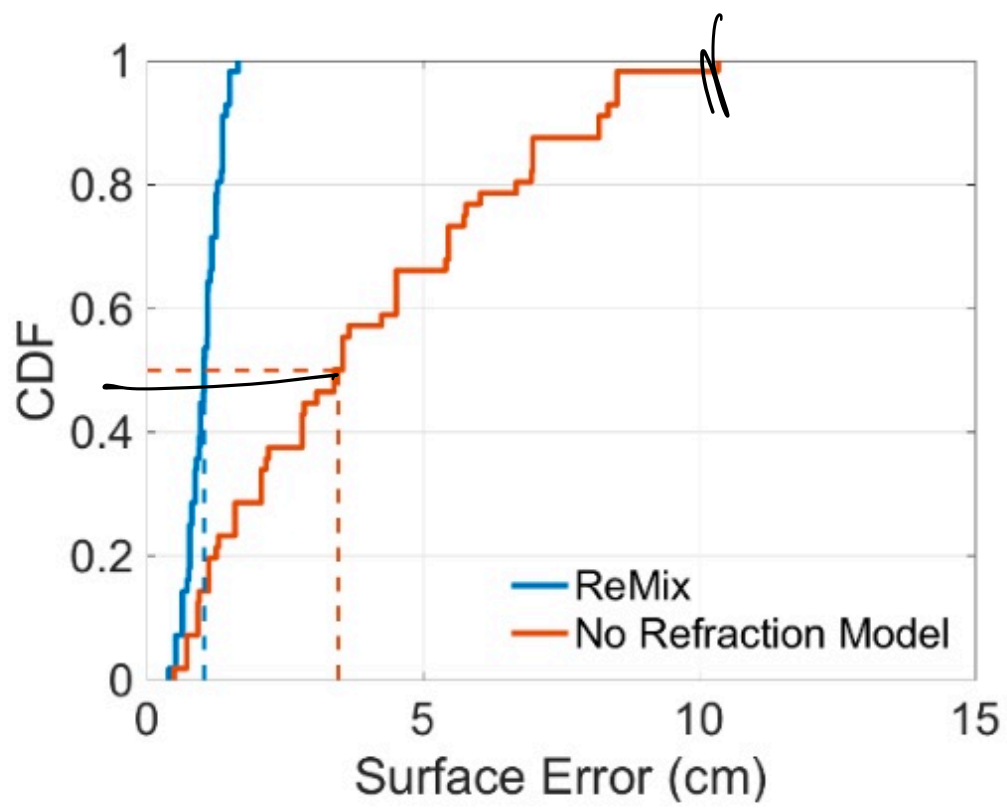




phantom







Limitations

- Assumption
- Magnetic vs. RF
vs. Acoustics.
- Power transfer