Paper on Dielectric constants and 3D imaging

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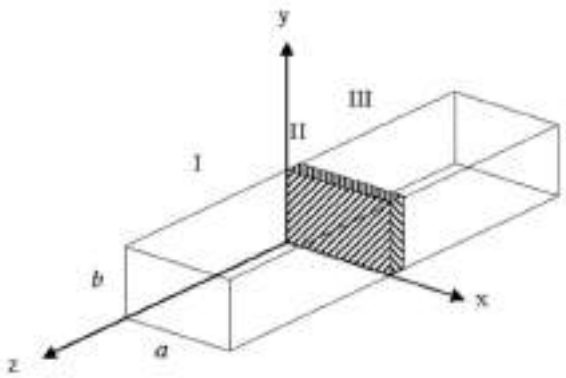
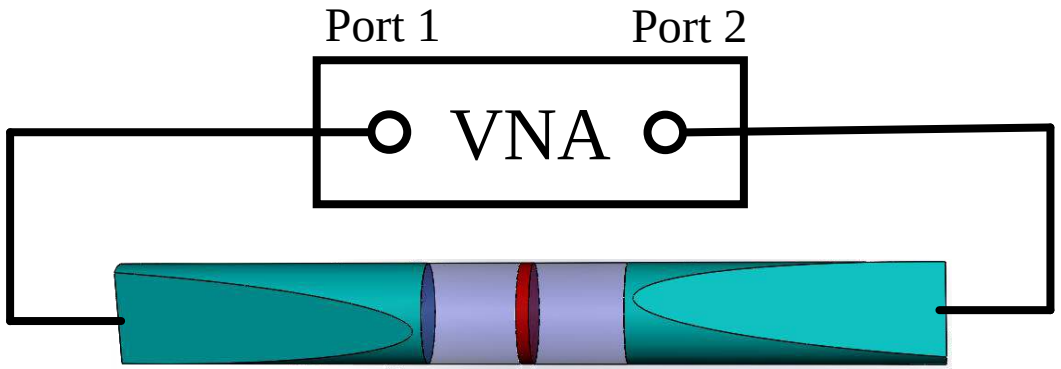
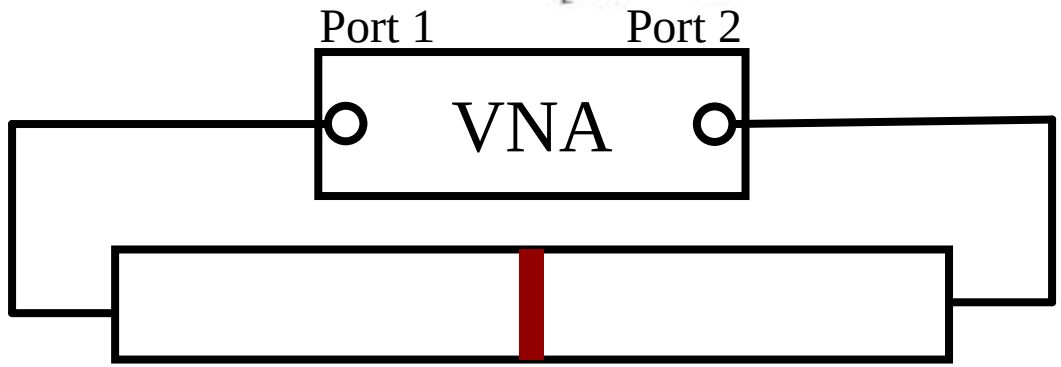
Dielectric constants

Relative permittivity at microwave frequencies(12 GHz -18 GHz)

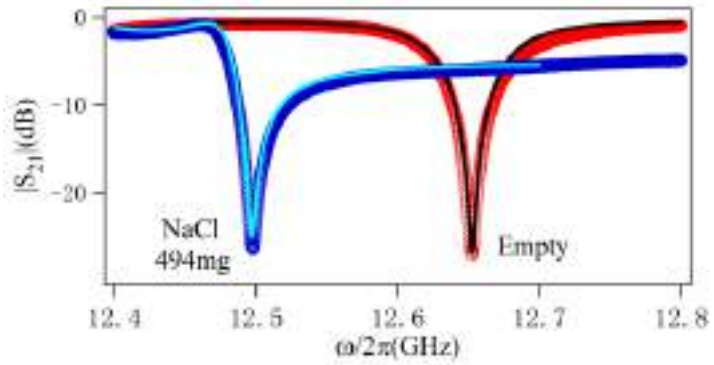


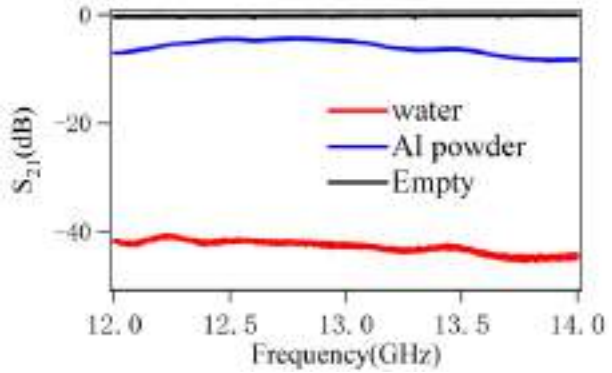




$$S_{12} = S_{21} = \frac{\cos(\theta) S_{AB}[-1 + R^2 e^{2i\phi_\gamma} S_{AB} S_{BA} + e^{i\phi_\gamma} R S_{BB} - e^{i\phi_\gamma} R S_{AA}(-1 + e^{i\phi_\gamma} R S_{BB})]}{-1 + e^{2i\phi_\gamma} \cos^2(\theta) R^2 S_{AB} S_{BA} + e^{i\phi_\gamma} R S_{BB} - e^{i\phi_\gamma} R S_{AA}(-1 + e^{i\phi_\gamma} R S_{BB})}$$

$$Tr(M_i M_0^{-1}) = Tr(T_{refi} T_i T_{refi}^{-1} \cdot T_{ref0} T_0^{-1} T_{ref0}^{-1})$$



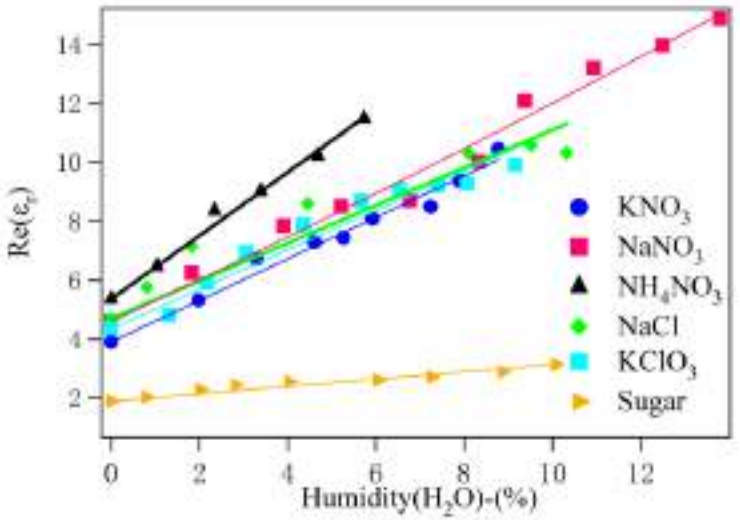


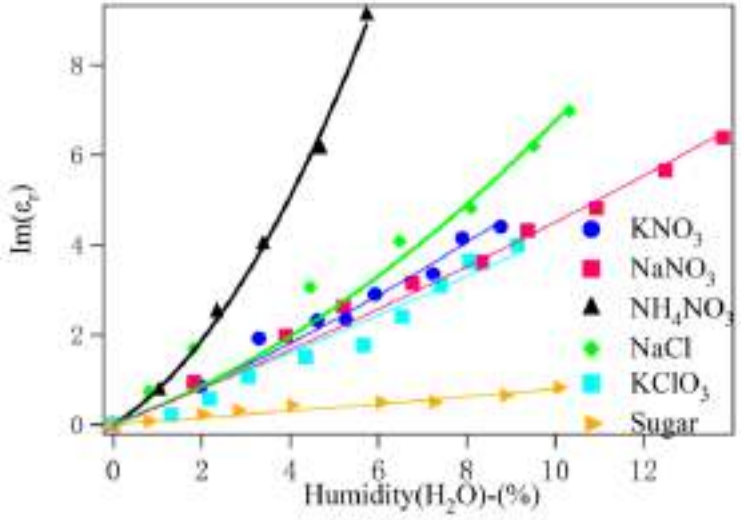
Large systematic Error

Empirical model for water content

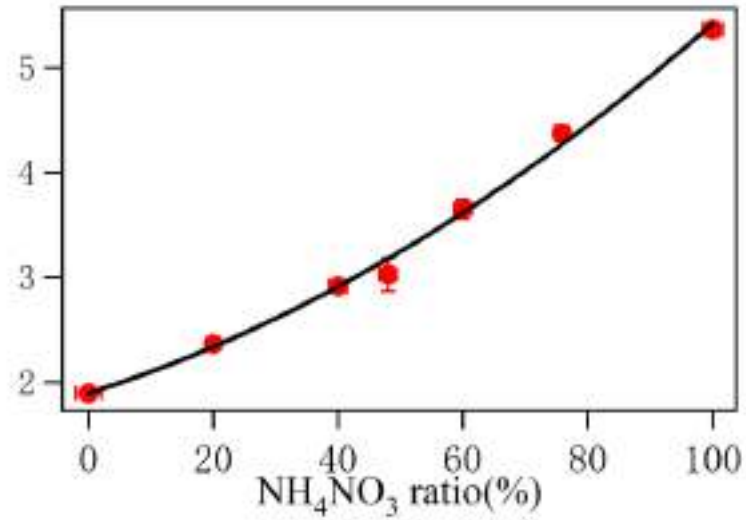
$$\epsilon = \epsilon_s + a\epsilon_w w_c + b\epsilon_w w_c^2 + i \cdot \alpha w_c^2$$

Water in Chemical powders



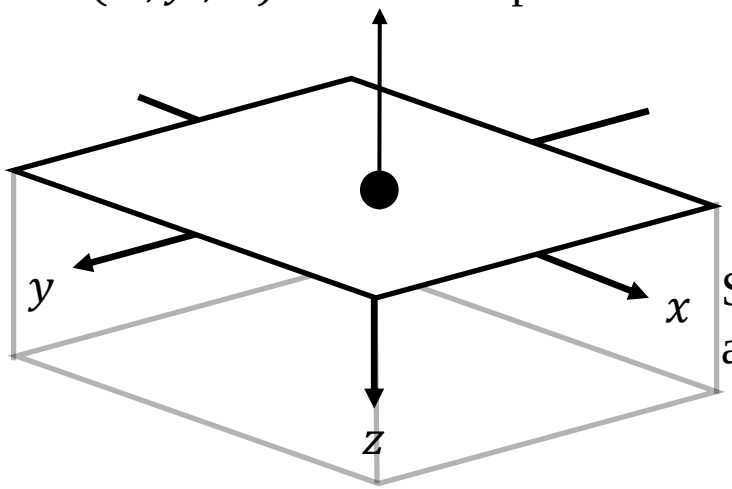


NH_4NO_3 in icing sugar

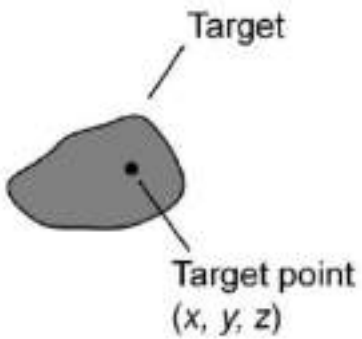


3-D Imaging

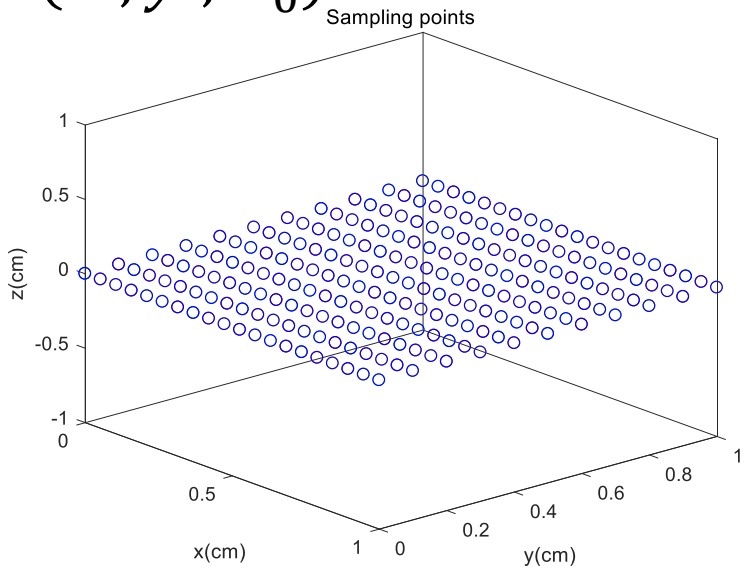
(x', y', z') transceiver position

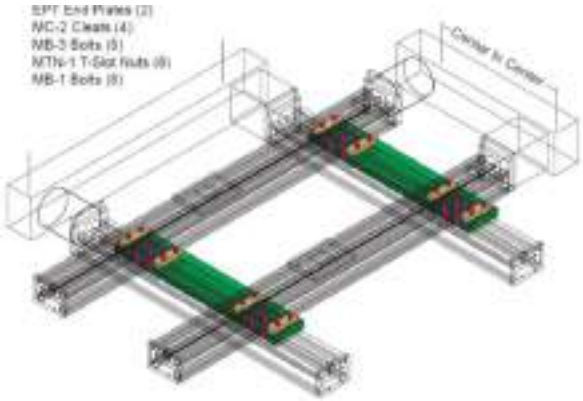


Scanned aperture

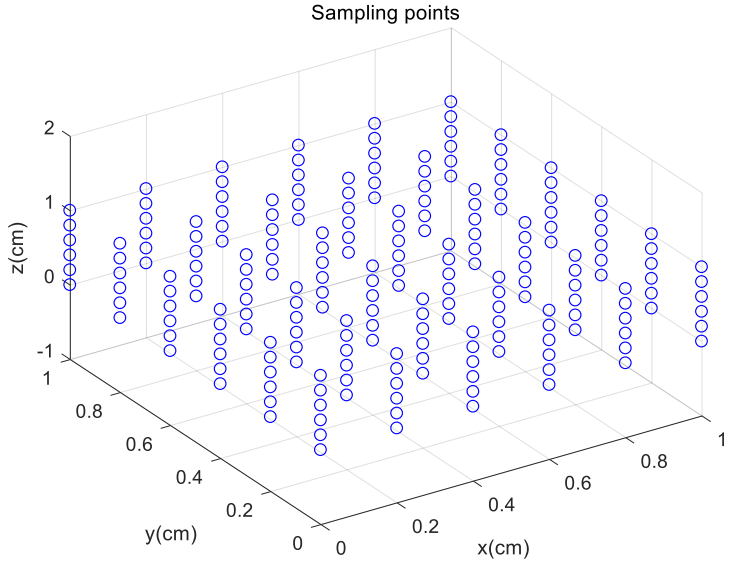


$s(x', y', \omega_0)$





$s(x', y', z', \omega)$



Algorithms

Reflectivity function Phase shift

$$s(x,y,z) = \iiint f(x,y,z)\, e^{-2ik\sqrt{(x-x')^2+(y-y')^2+(z-z')^2}} dxdydz$$

(wide band)

$$f(x,y,z) = FT_{3D}^{-1}\{FT_{2D}\{s(x,y,\omega)\}e^{i\sqrt{4k^2-k_x^2-k_y^2}h}\}$$

(3-D scanning)

$$f(x,y,z) = FT_{3D}^{-1}\{\frac{FT_{3D}\{s(x,y,z)\}}{FT_{3D}\{g(x,y,z)\}}\}$$

Reconstruction Images (wide band)

Fig. 4. (Color online) Photograph and wideband 3-D image of a Kiowa helicopter using an impulse radar with nominal 1–5 GHz frequency coverage.

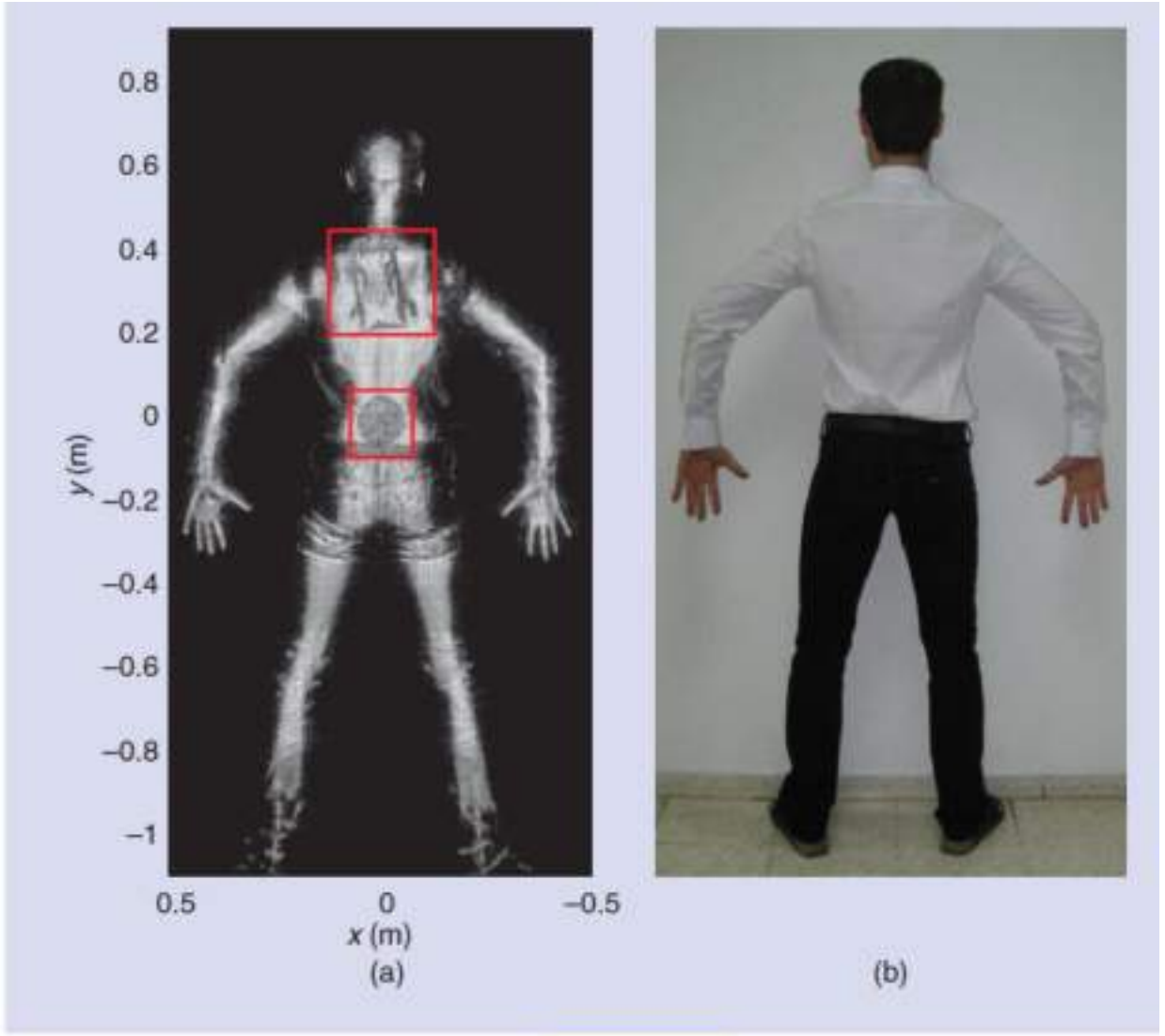


Figure 23. *Image of a person taken from 70 to 80 GHz [55]. Image shows the magnitude information after being projected along range direction. Two concealed dielectric objects, liquid bag (up) and explosive simulant (down), are marked with red rectangles.*