# The Impact of Snell's Law on the BeamLoc Approach for NLoS Indoor Localization


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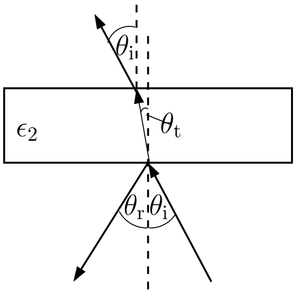
## BeamLoc & Snell's Law

In *Line of Sight* situations the *Direction of Departure* (DoD) and *Direction of Arrival* (DoA) of the *Direct Path* (DP) differ by $180°$.




For *Non Line of Sight* situations this is affected by Snell's Law. Nevertheless, the $180°$ difference holds approximately true.

## Signal Model

The transmit signal $p(t)$ passes through the transmit beamformer $b_{\mathrm{T}}(\theta_{\mathrm{T}}, \phi_{\mathrm{T}})$, where $\theta_{\mathrm{T}}$ is the steering direction of the beamformer and $\phi_{\mathrm{T}}$ is the DoD of the transmit signal. Next, the impulse response of the wireless channel

$$h(t) = \sum_{k=1}^{K} \alpha_k \delta(t - \tau_k)$$

has to be taken into account, where every summand represents a path $k$ with amplitude $\alpha_k$ and delay $\tau_k$.

As in the transmit case a receive beampattern is defined and denoted by $b_{\mathrm{R}}(\theta_{\mathrm{R}}, \phi_{\mathrm{R}})$. Hence, the received signal is

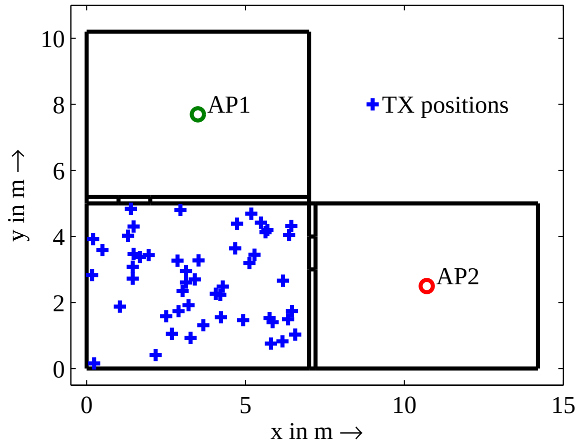
$$r(t) = \sum_{k=1}^{K} \alpha_k b_{\mathrm{T}}(\theta_{\mathrm{T}}, \phi_{\mathrm{T},k}) p(t-\tau_k) b_{\mathrm{R}}(\theta_{\mathrm{R}}, \phi_{\mathrm{R},k}),$$

assuming a DoD $\phi_{\mathrm{T},k}$ and a DoA $\phi_{\mathrm{R},k}$ for every path $k$.

The transmit signal is set to the second derivative of the gaussian pulse

$$p(t) = \left(1 - 2\,(t/\tau_{\mathrm{p}})^2\right) \mathrm{e}^{-(t/\tau_{\mathrm{p}})^2}.$$

## Simulation Setup




Default Settings:

Wall Thickness 20 cm

Dielectric Constant Wall $\epsilon_{\mathrm{w}} = 7$; Door $\epsilon_{\mathrm{p}} = 3$

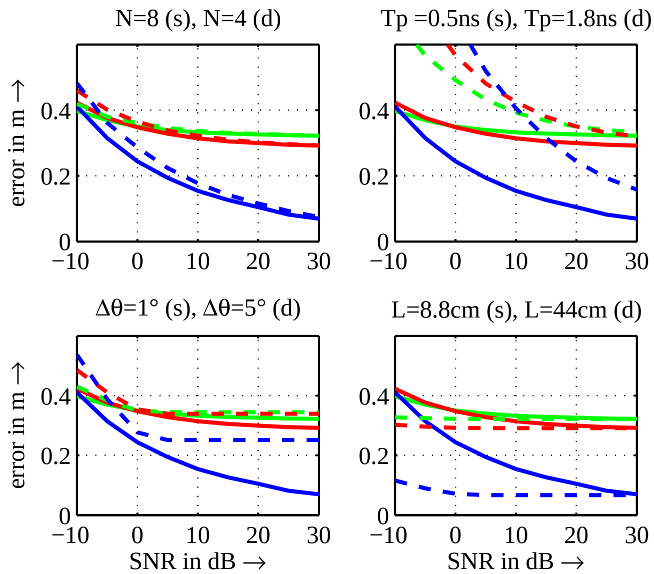
Number of Antennas $N_{\mathrm{T}} = N_{\mathrm{R}} = N = 8$

Array Size $L = 2\lambda_{\mathrm{c}} = 8.8\,\mathrm{cm}$

Pulse Length $T_{\mathrm{p}} = 0.5\,\mathrm{ns}$ ($\tau_{\mathrm{p}} = 0.233\,\mathrm{ns}$)

Rotation Step Size $\Delta\theta = 1°$

## Simulation Results




| $\hat{\theta}_{\mathrm{DP},1}$ | $\hat{\tau}_{\mathrm{DP},1}$ | $\hat{\theta}_{\mathrm{DP},2}$ | $\hat{\tau}_{\mathrm{DP},2}$ | color |
|---|---|---|---|---|
| x | | x | | blue |
| x | x | | | green |
| | | x | x | red |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