



UWB Ranging in Dense Multipath Environments

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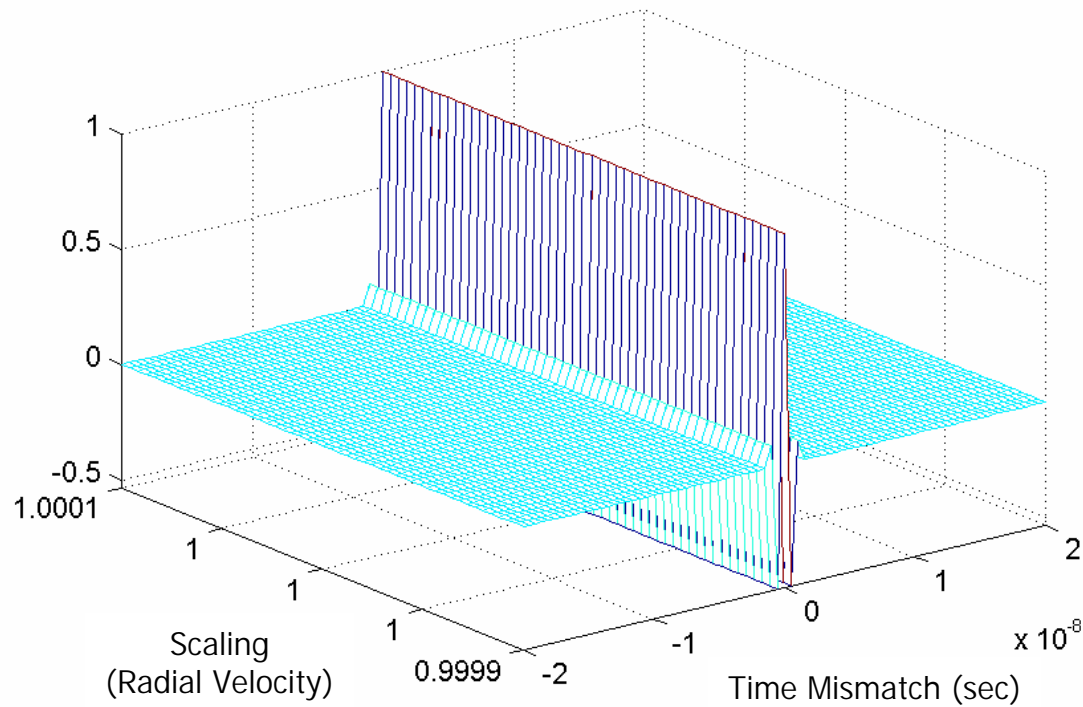




Potentials for Ranging

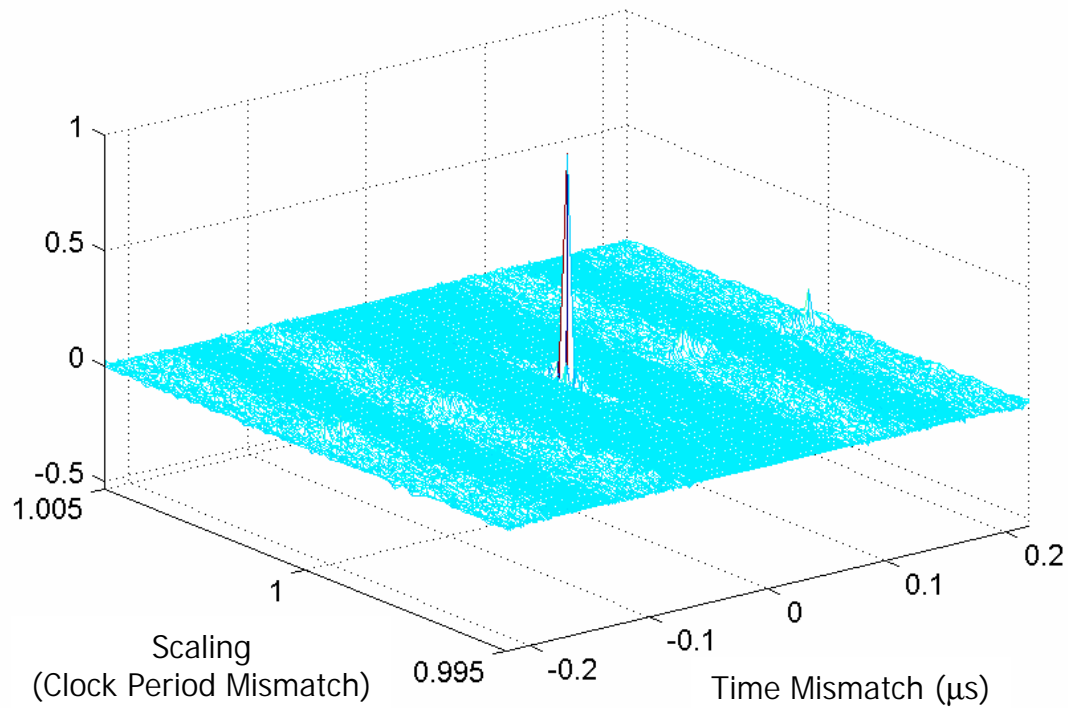
- Multipath immunity
 - 100~1000 times finer time resolution than conventional narrowband
- Penetration capability
 - Low center frequency for a given bandwidth
- Potential applications
 - Communication+location, tracking RF tags, ...

Fine Range Resolution



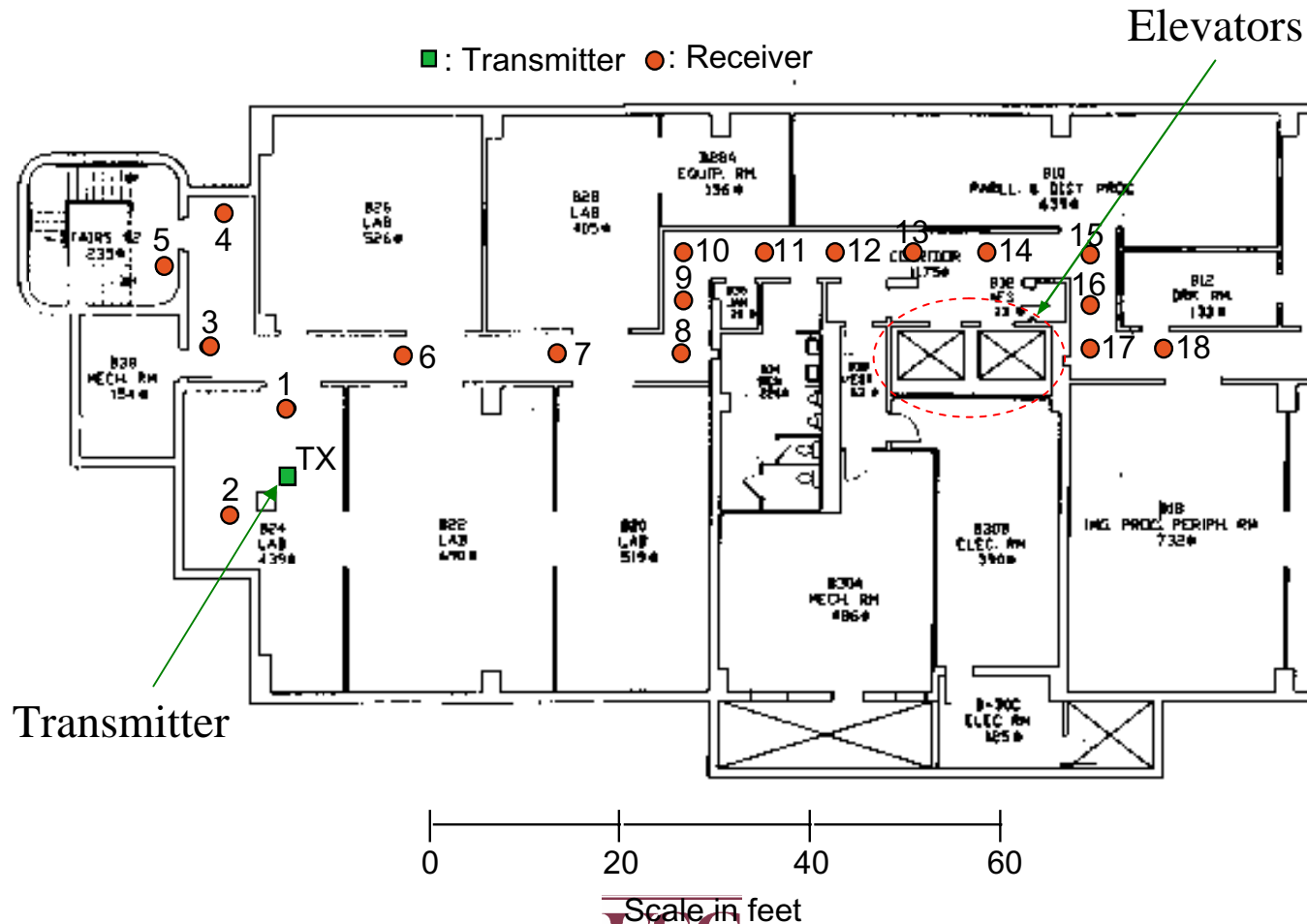
UWB ambiguity function of a single pulse

Fine Range Resolution

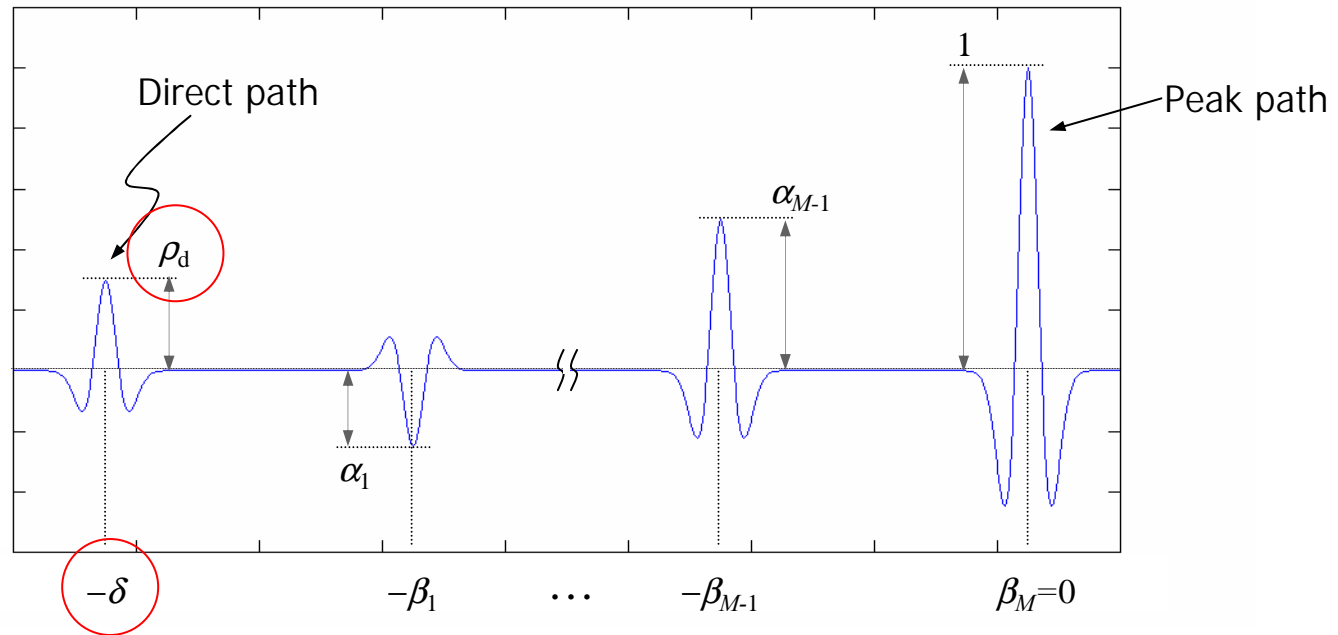


UWB ambiguity function of time-hopped pulses

Test Site (Basement, EEB, USC)



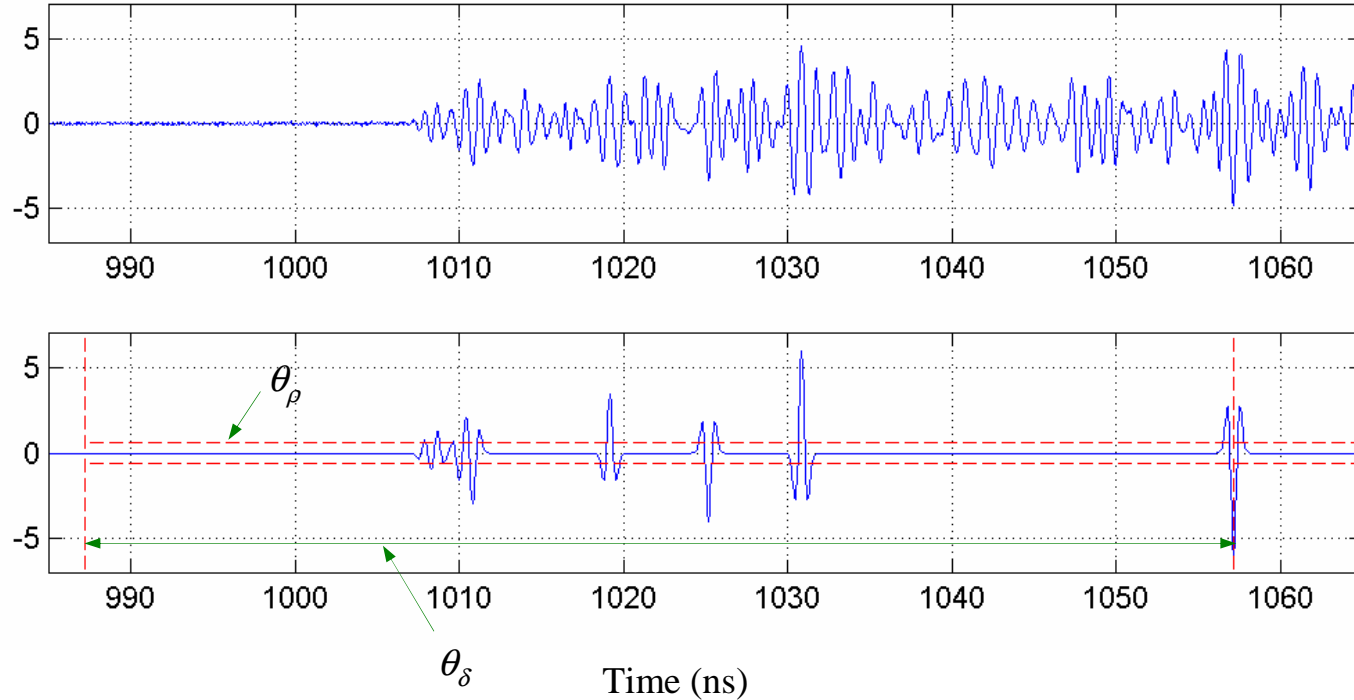
Direct Path Detection Using GML Estimation



$$\underline{r} = \rho_d \cdot \underline{s}_\delta + \sum_{k=1}^M \alpha_k \underline{s}_{\beta_k} + \underline{n}$$

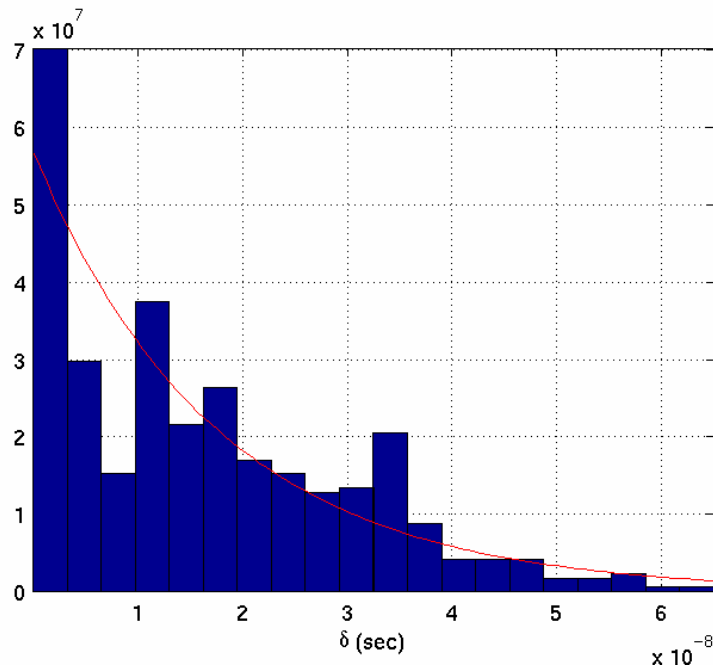
$$\hat{\delta} = \arg \max_{\delta} \left[\max_{\rho_d, M, \alpha, \beta} f(\underline{r} | \delta, \rho_d, M, \underline{\alpha}, \underline{\beta}) \right]$$

Direct Path Detection Using GML Estimation

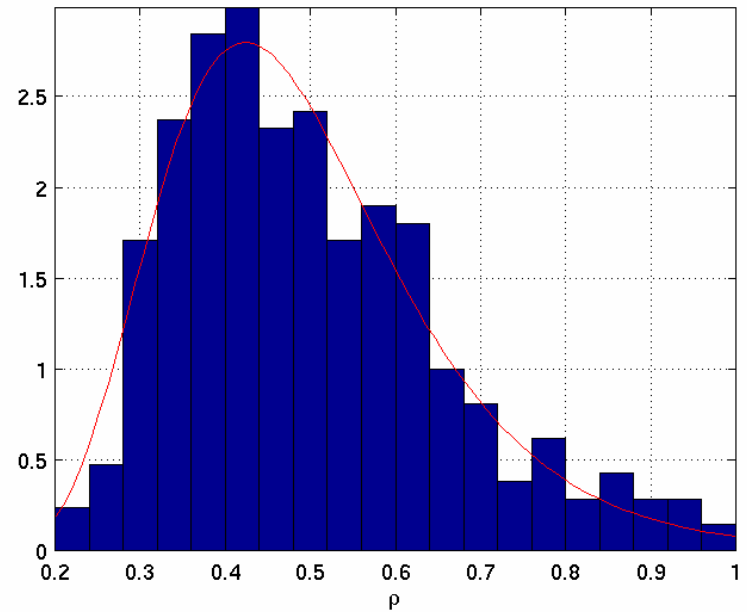


Statistical Modeling of Critical Parameters – Marginal Densities

Exponential fit for δ

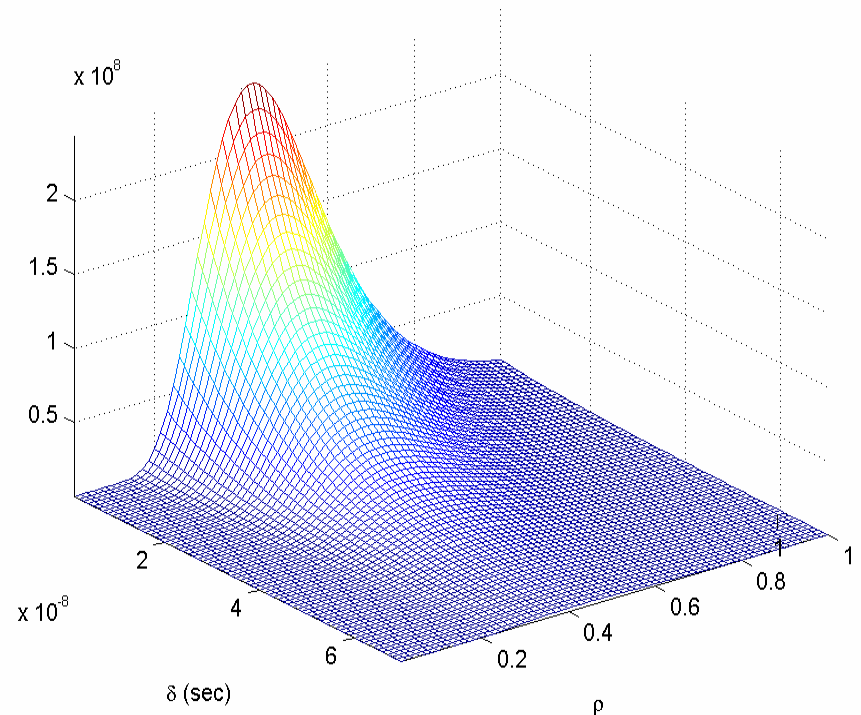
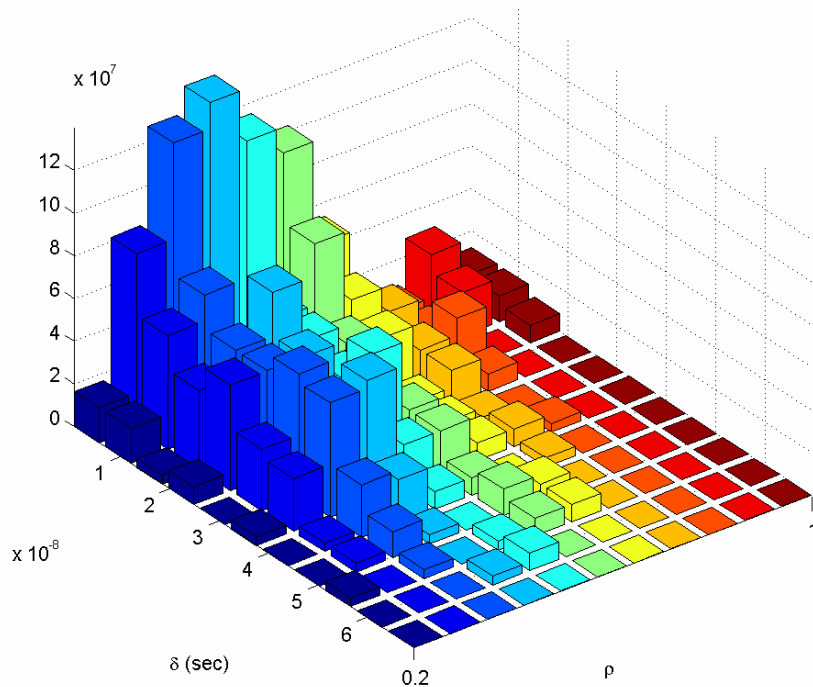


Lognormal fit for ρ

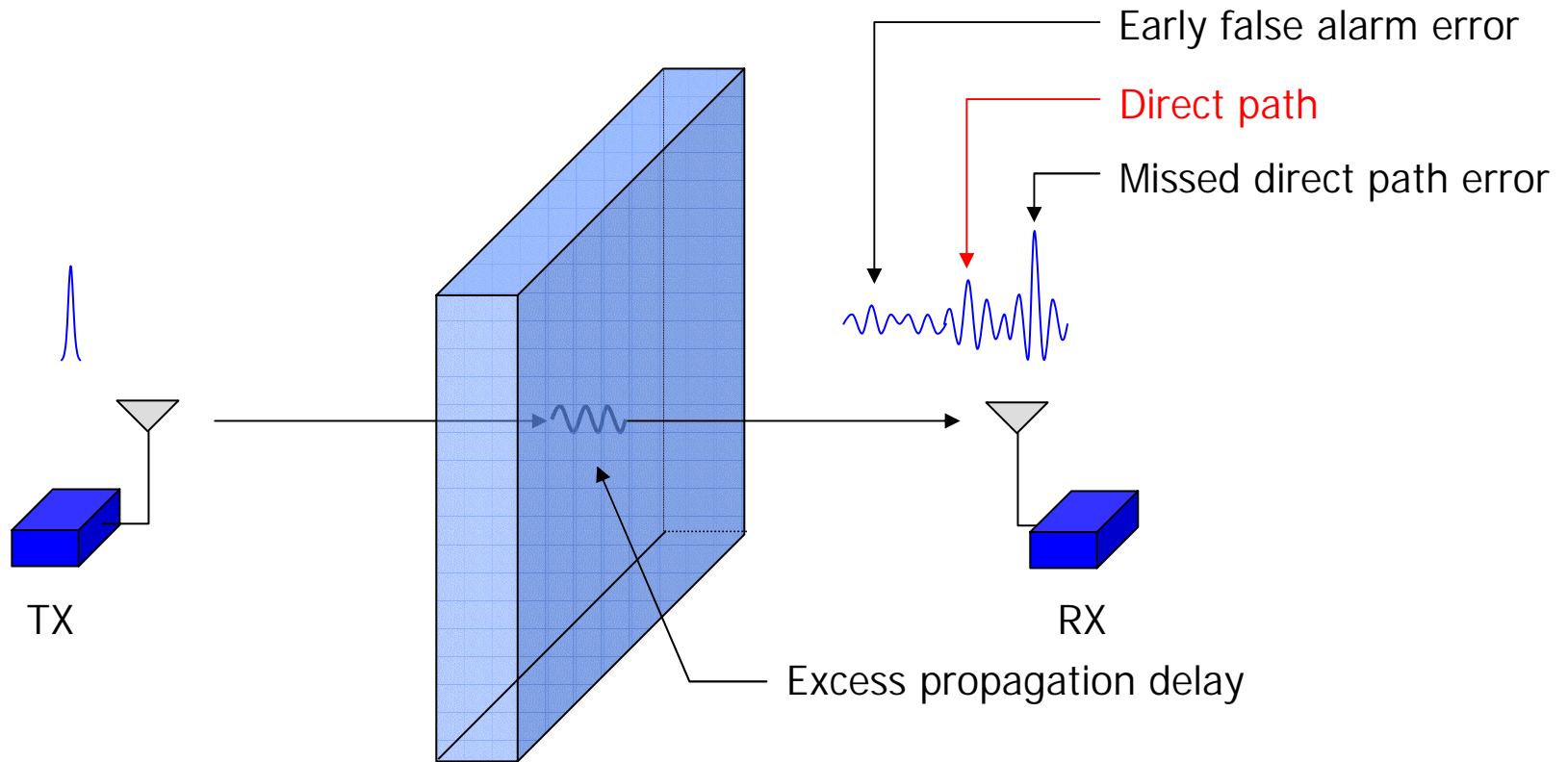


Statistical Modeling of Critical Parameters – Joint Density

- Independence between δ and ρ was test using χ^2 test.

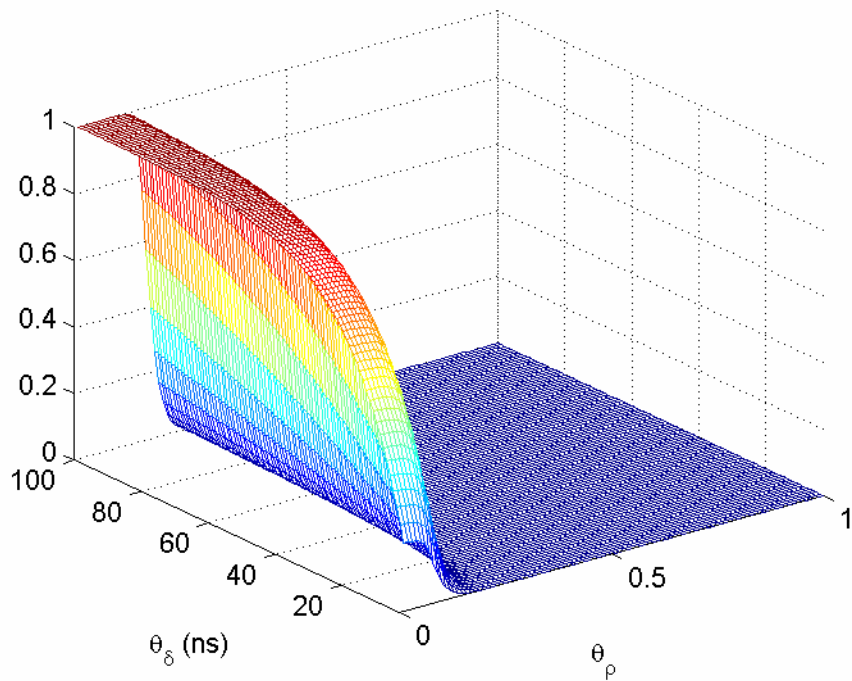


Ranging Errors

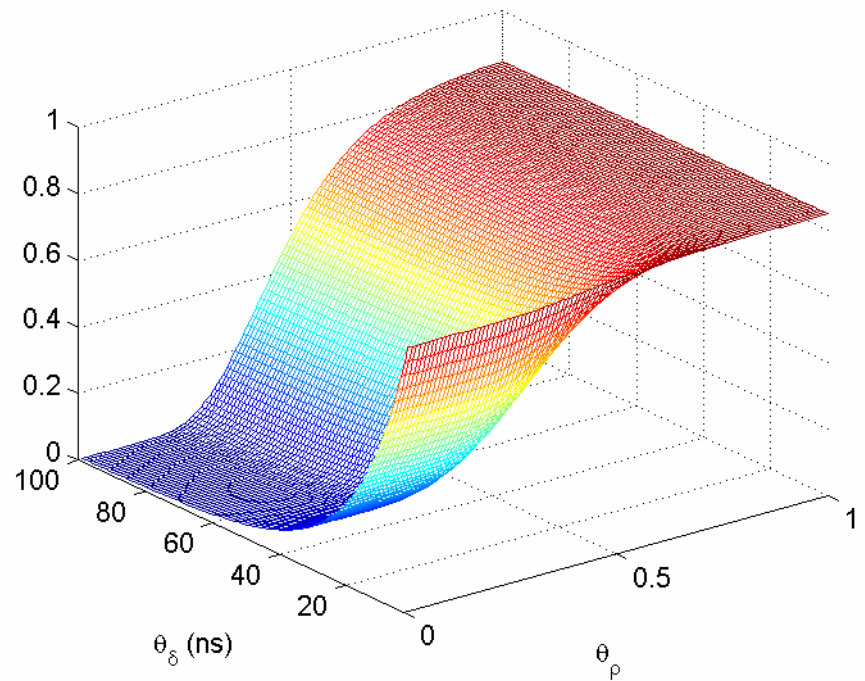


ToA Estimation Errors

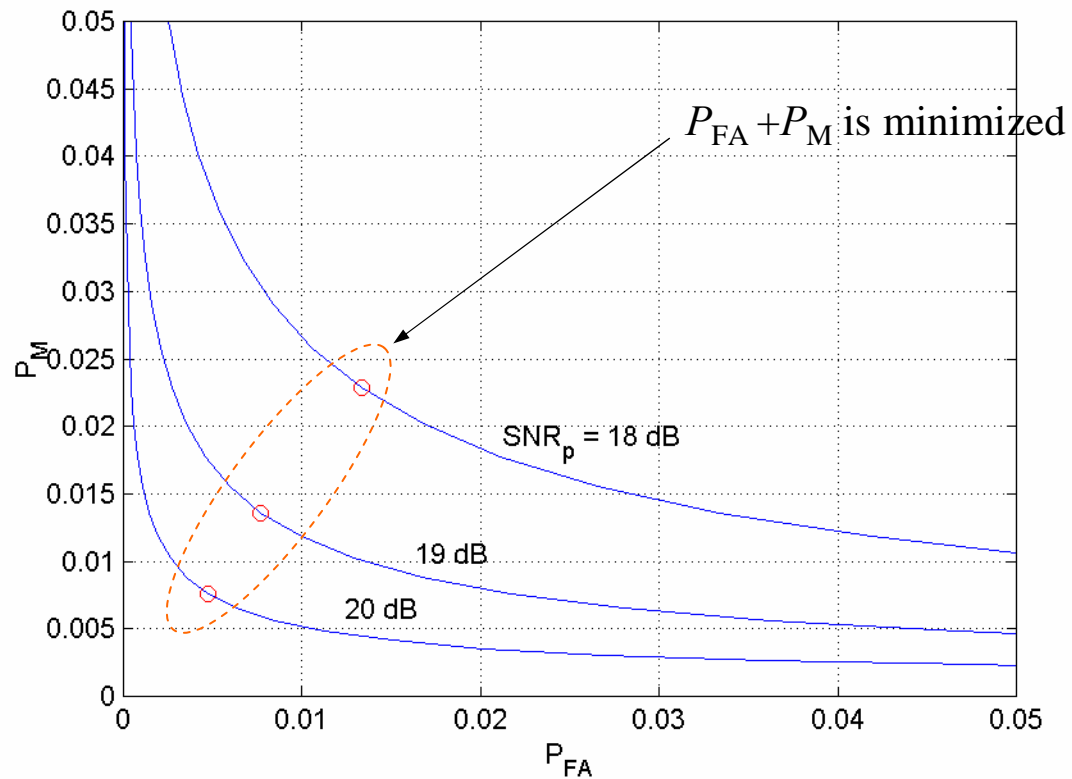
P_{FA}



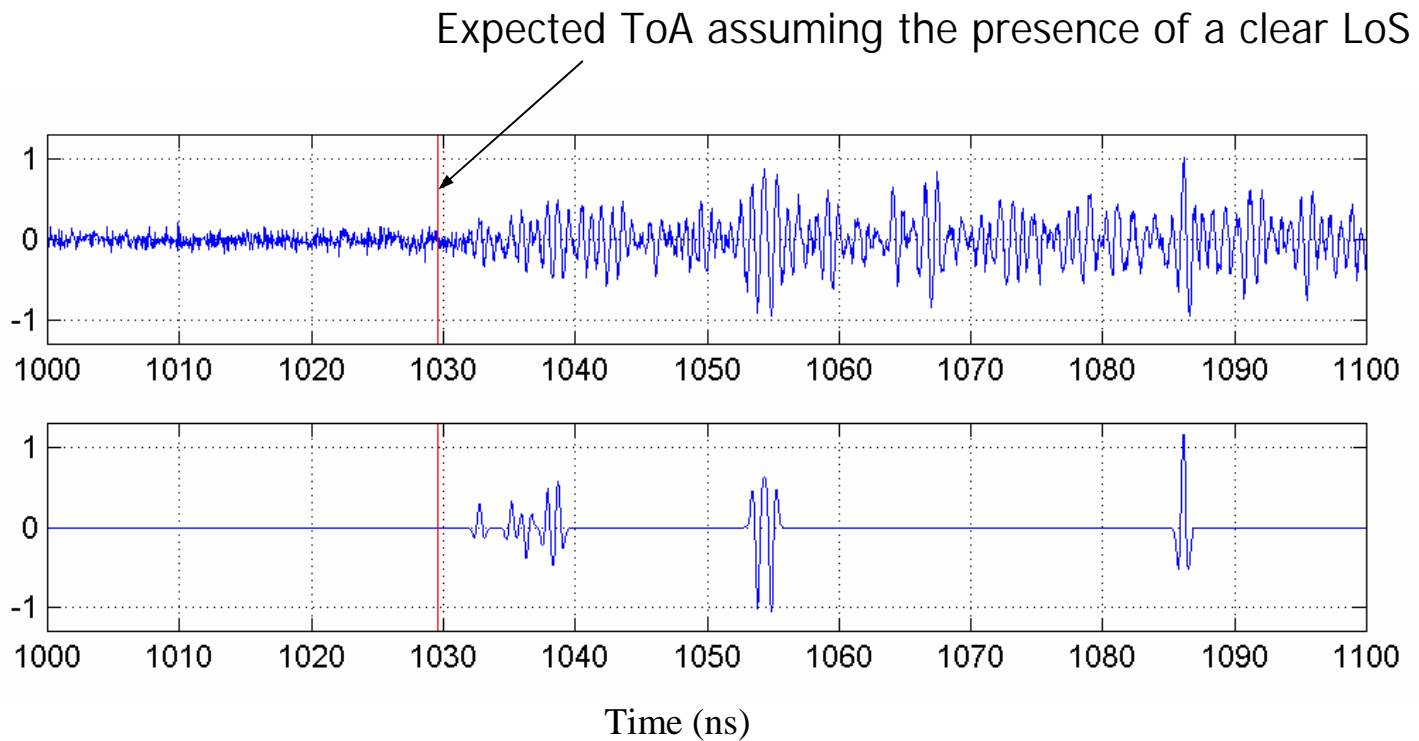
P_M



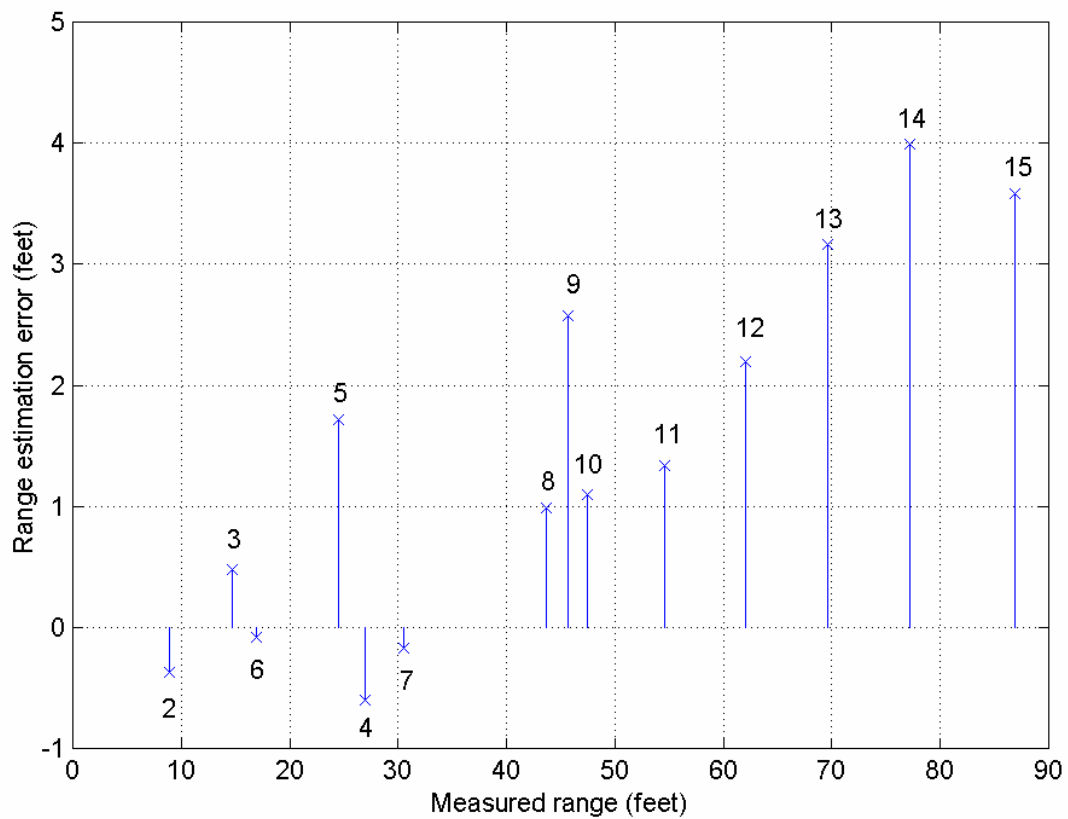
Threshold Setting



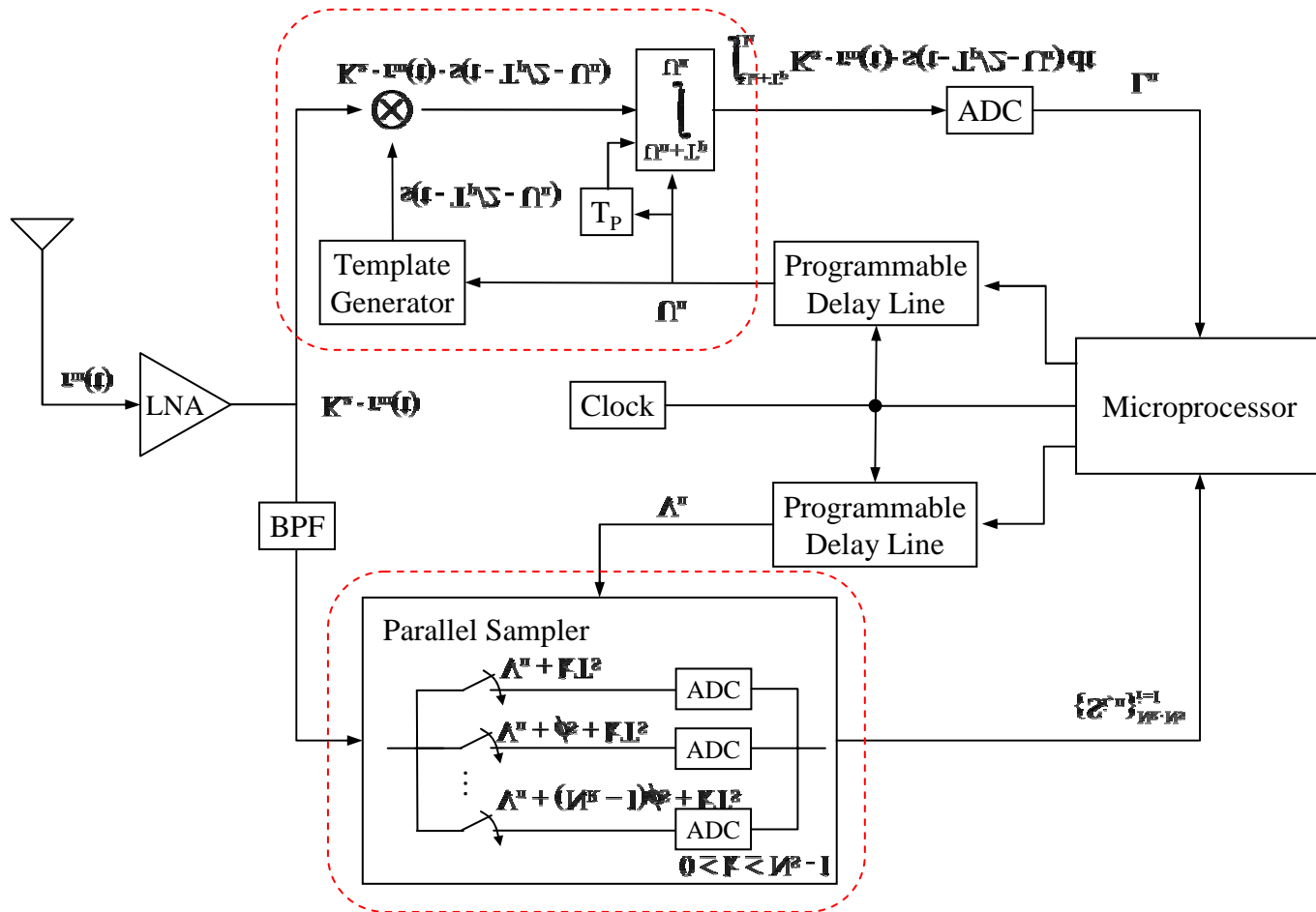
Test Result (Location 13)



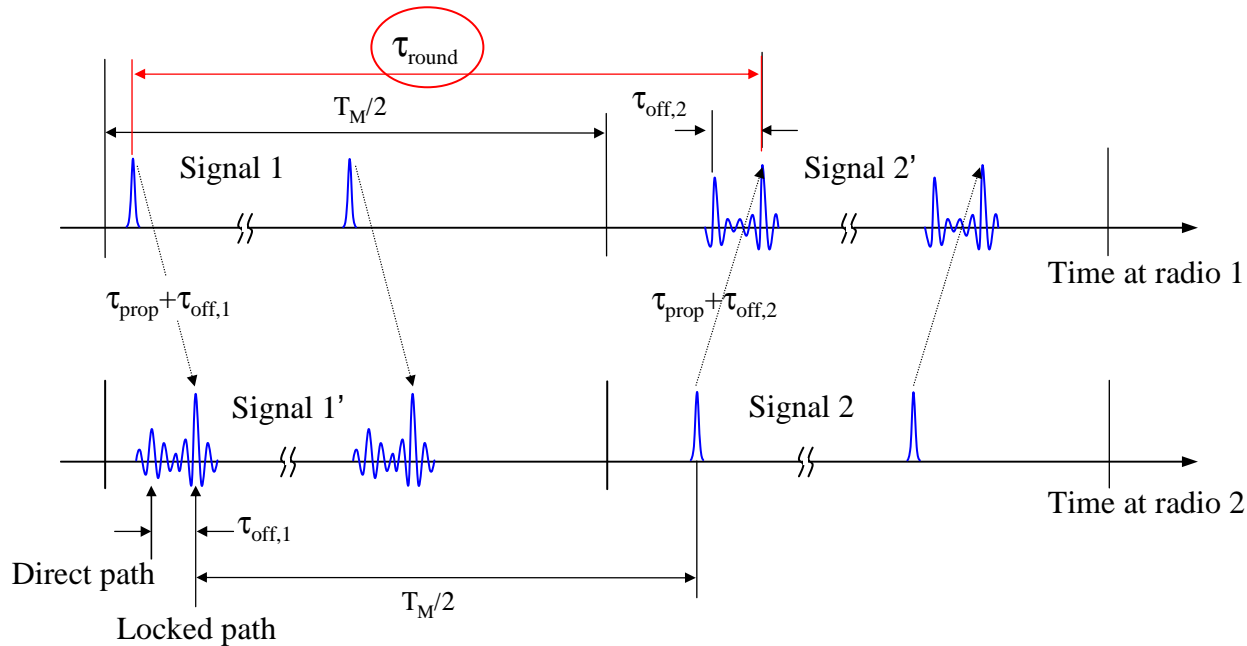
Range Estimation Errors



UWB Ranging System



Two-Way Ranging Scheme



$$\tau_{prop} \approx \frac{\tau_{round} - T_M/2 - \tau_{off,1} - \tau_{off,2}}{2}$$



More Issues

- Detection of LoS blockage
- Estimation of the excess propagation delay in LoS blockage
- Clock synchronization
- Utilization of a reasonable channel model for the refinement of ranging algorithm