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Space-time adaptive FIR filtering with staggered PRI

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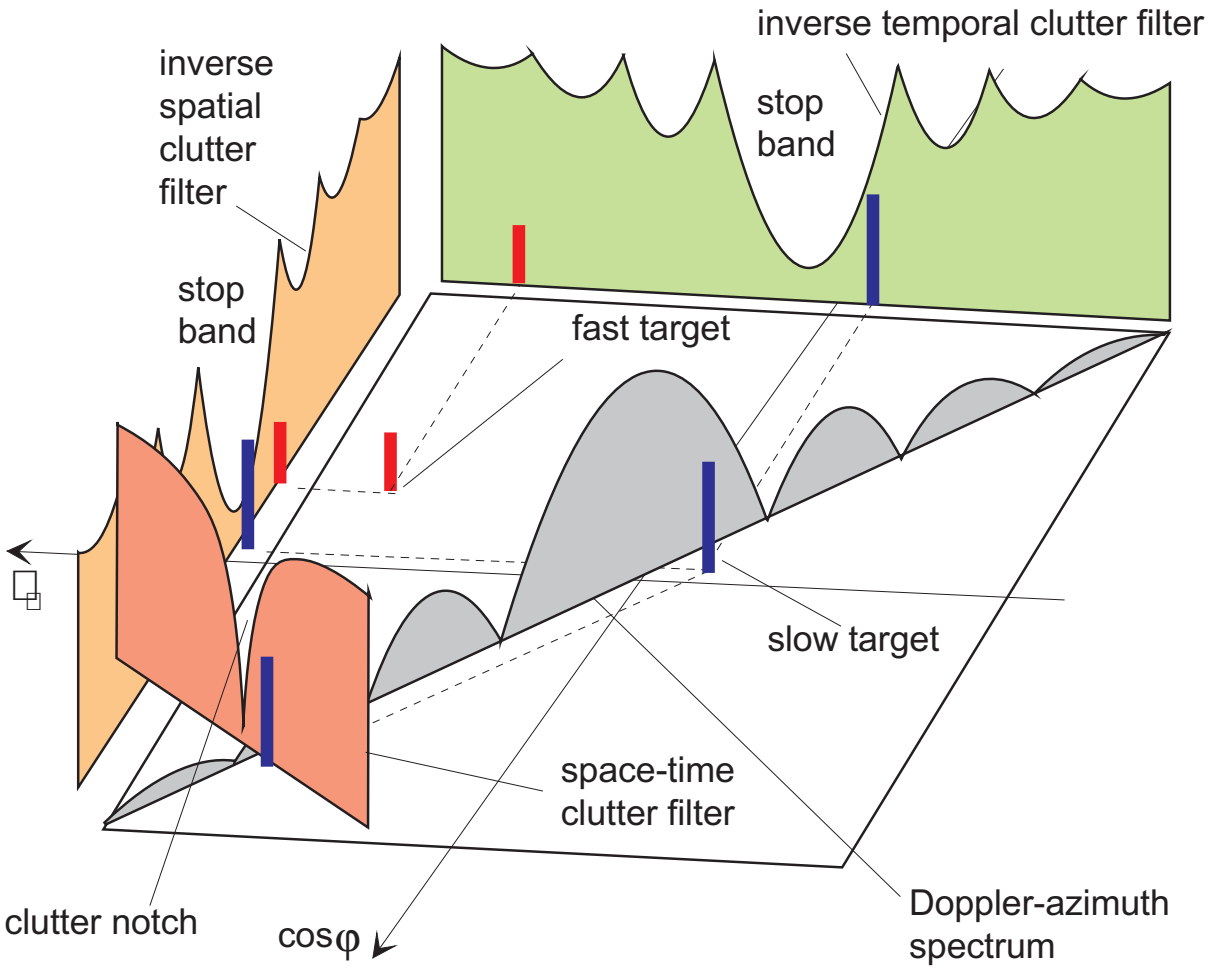
Space-time adaptive FIR filtering with staggered PRI

Contents

- Introduction
- Principle of STAP FIR filters
- FIR filters with staggered PRI
- Numerical example
- Summary

Space-time adaptive FIR filtering with staggered PRI



Principle of STAP

clutter spectrum | temporal filter | spatial filter | STAP

Principle of STAP

Space-time adaptive FIR filtering with staggered PRI

The optimum processor

$$\mathbf{w} = a\,\mathbf{Q}^{-1}\mathbf{s}(j,\nu)$$

$\mathbf{Q}$ space-time clutter+noise covariance matrix

$\mathbf{s}$ space-time steering vector

For large dimensions N,M not realizable by various reasons (amount of computations, lack of training data, accuracy)

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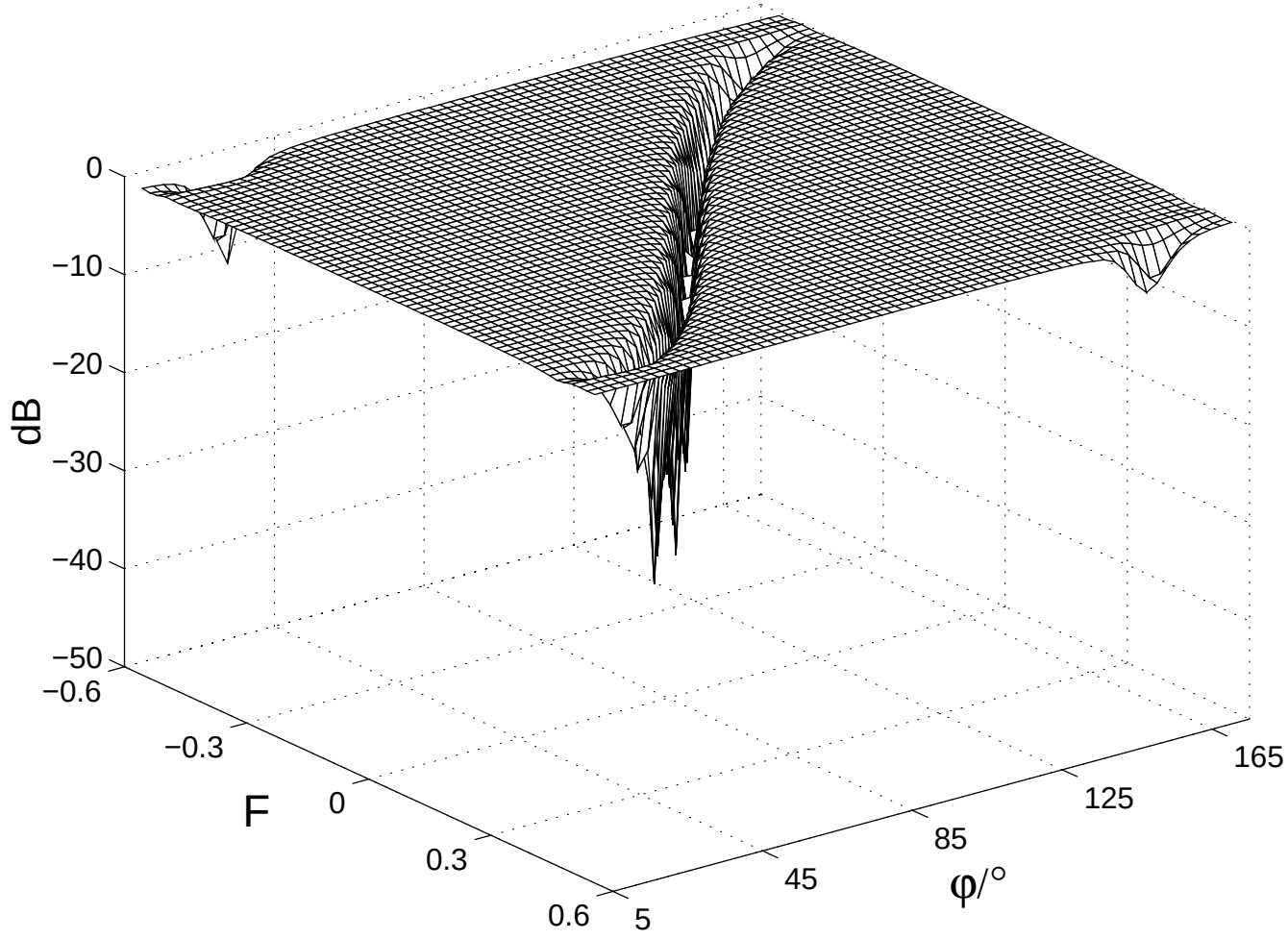
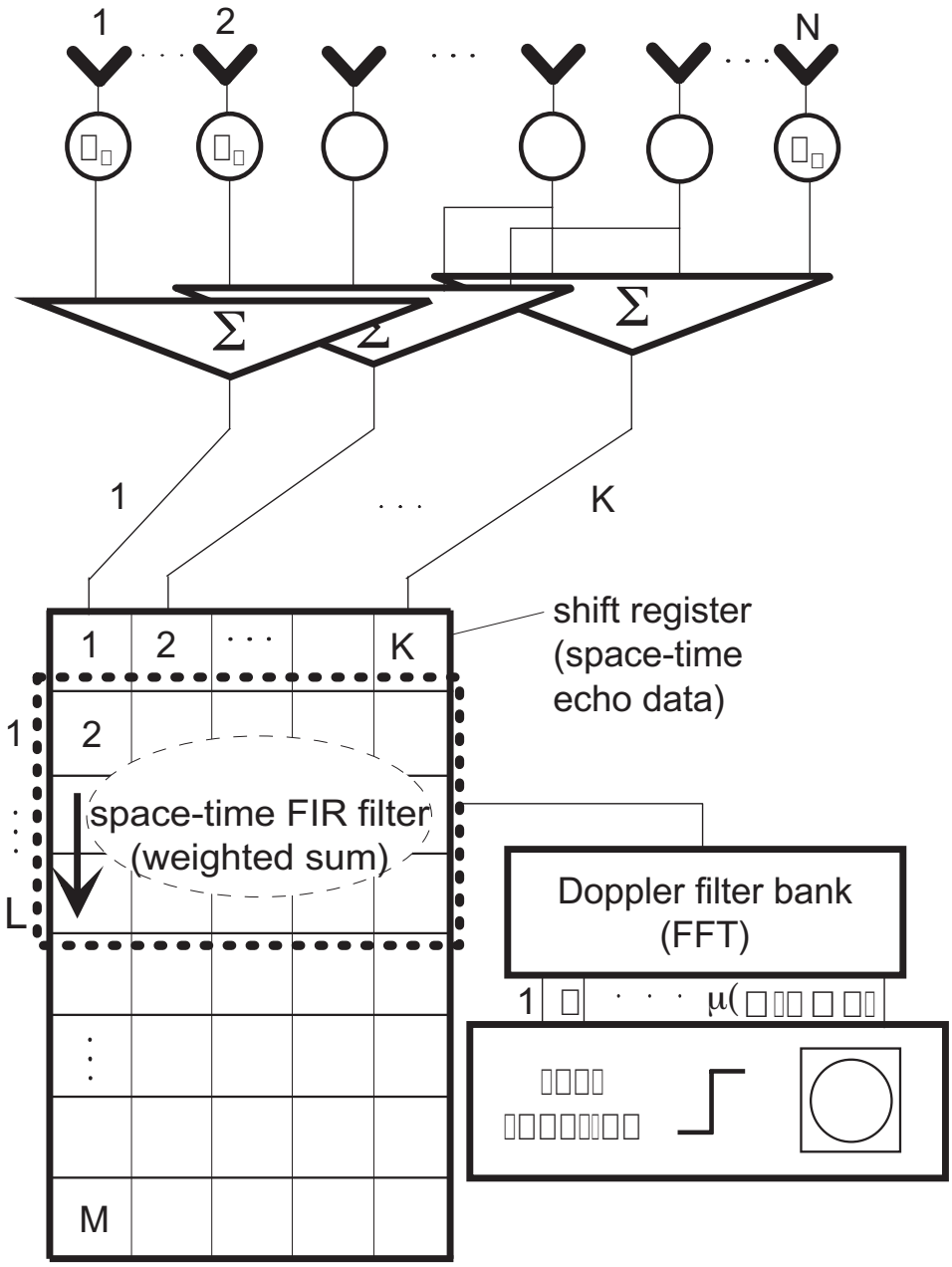


Azimuth-Doppler Characteristics of a STAP Filter for Sidelooking Array

Subspace STAP techniques

- Space-time transforms (e.g. GSC concepts)
- Spatial transforms (reduction in the spatial dimension)
- FIR filters (reduction in the temporal dimension, => very efficient solution)
- Multi-stage filters
- Frequency dependent spatial processing (for large CPI only)
- Angle-Doppler subgroups (e.g. JDL-GLRT)
- others

Space-time adaptive FIR filtering with staggered PRI



Overlapping subarray processor with space-time FIR filter

Space-time adaptive FIR filtering with staggered PRI

$$\mathbf{Q} = \begin{pmatrix} \mathbf{Q}_{11} & \mathbf{Q}_{12} & \cdots & \mathbf{Q}_{1M} \\ \mathbf{Q}_{21} & \mathbf{Q}_{22} & \cdots & \mathbf{Q}_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{Q}_{M1} & \mathbf{Q}_{M2} & \cdots & \mathbf{Q}_{MM} \end{pmatrix}$$

The space-time clutter+noise covariance matrix

$$\mathbf{K} = \mathbf{Q}^{-1} = \begin{pmatrix} \mathbf{K}_{11} & \mathbf{K}_{12} & \cdots & \mathbf{K}_{1M} \\ \mathbf{K}_{21} & \mathbf{K}_{22} & \cdots & \mathbf{K}_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{K}_{M1} & \mathbf{K}_{M2} & \cdots & \mathbf{K}_{MM} \end{pmatrix}$$

and its inverse

Space-time adaptive FIR filtering with staggered PRI

$$\mathbf{K} = \mathbf{Q}^{-1} = \begin{pmatrix} \mathbf{K}_{11} & \mathbf{K}_{12} & \cdots & \mathbf{K}_{1L} \\ \mathbf{K}_{21} & \mathbf{K}_{22} & \cdots & \mathbf{K}_{2L} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{K}_{L1} & \mathbf{K}_{L2} & \cdots & \mathbf{K}_{LL} \end{pmatrix}$$

The north-west $NL \times NL$ submatrix
(N number of antenna elements, L temporal filter length)

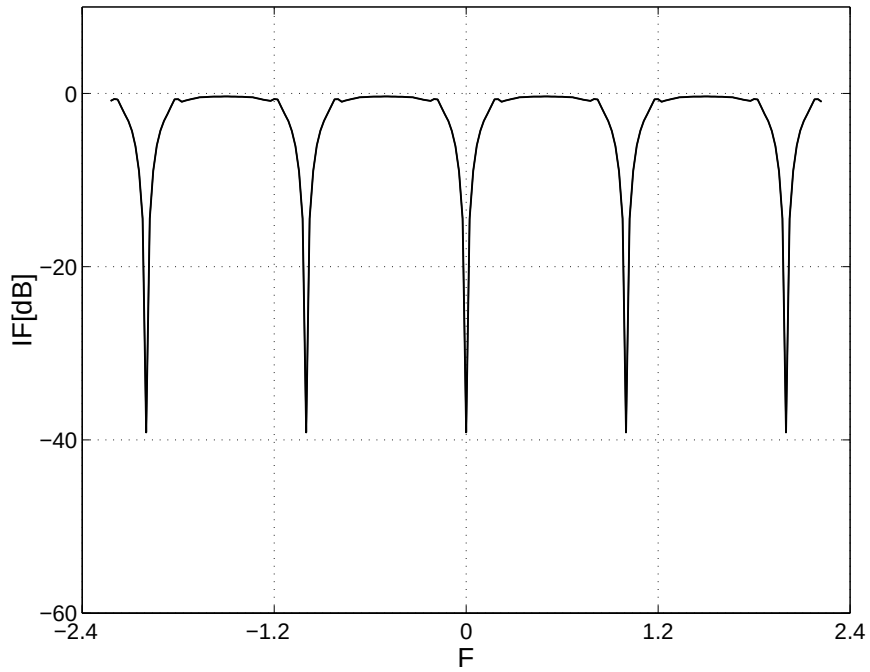
$$\tilde{\mathbf{K}} = \begin{pmatrix} \mathbf{K}_{11} \\ \mathbf{K}_{21} \\ \vdots \\ \mathbf{K}_{L1} \end{pmatrix}$$

The LS FIR filter matrix (1. Block column of inverse)

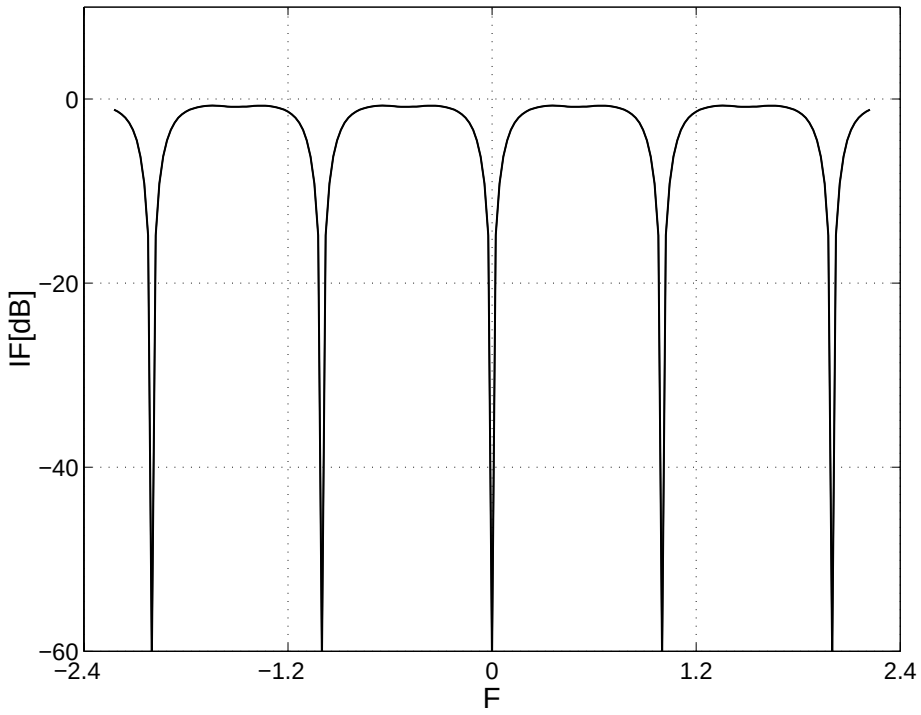
$$\mathbf{h} = \tilde{\mathbf{K}}\mathbf{b}$$

Further reduction: beamforming

Space-time adaptive FIR filtering with staggered PRI

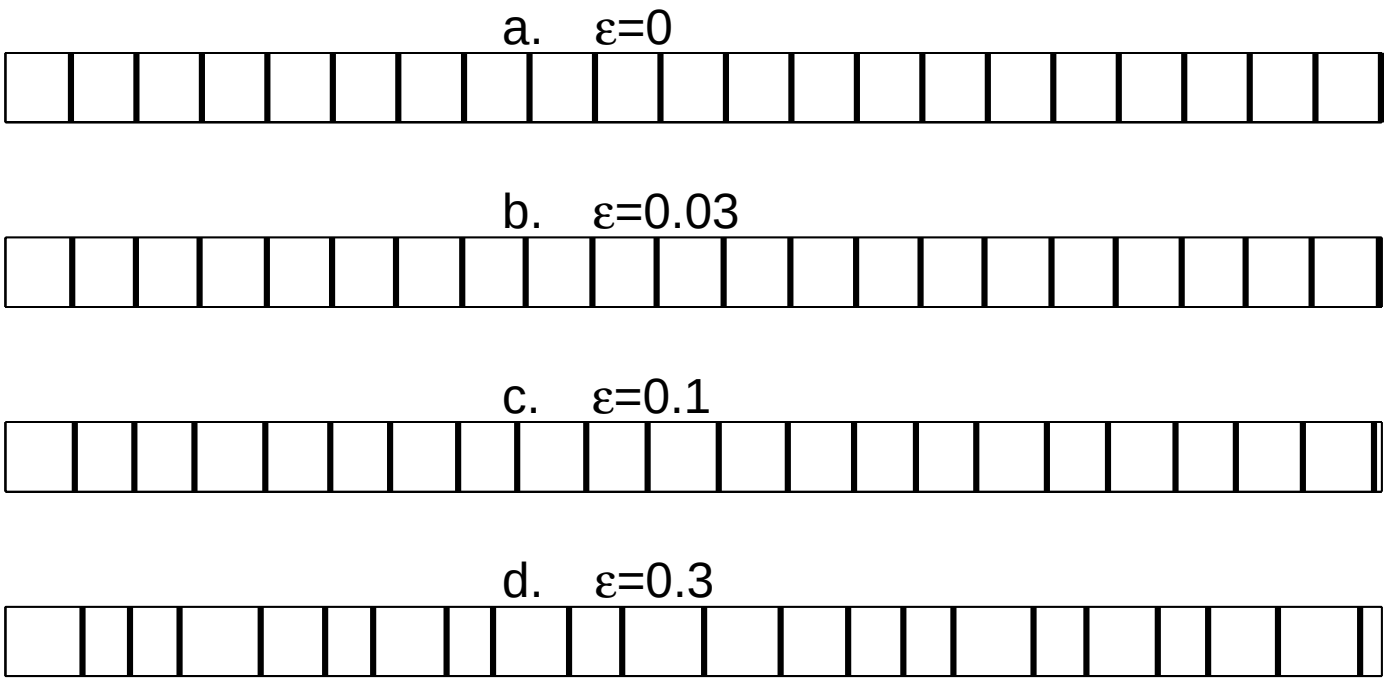


Fully adaptive processing, constant PRI



FIR filter, 5 taps, constant PRI

Space-time adaptive FIR filtering with staggered PRI

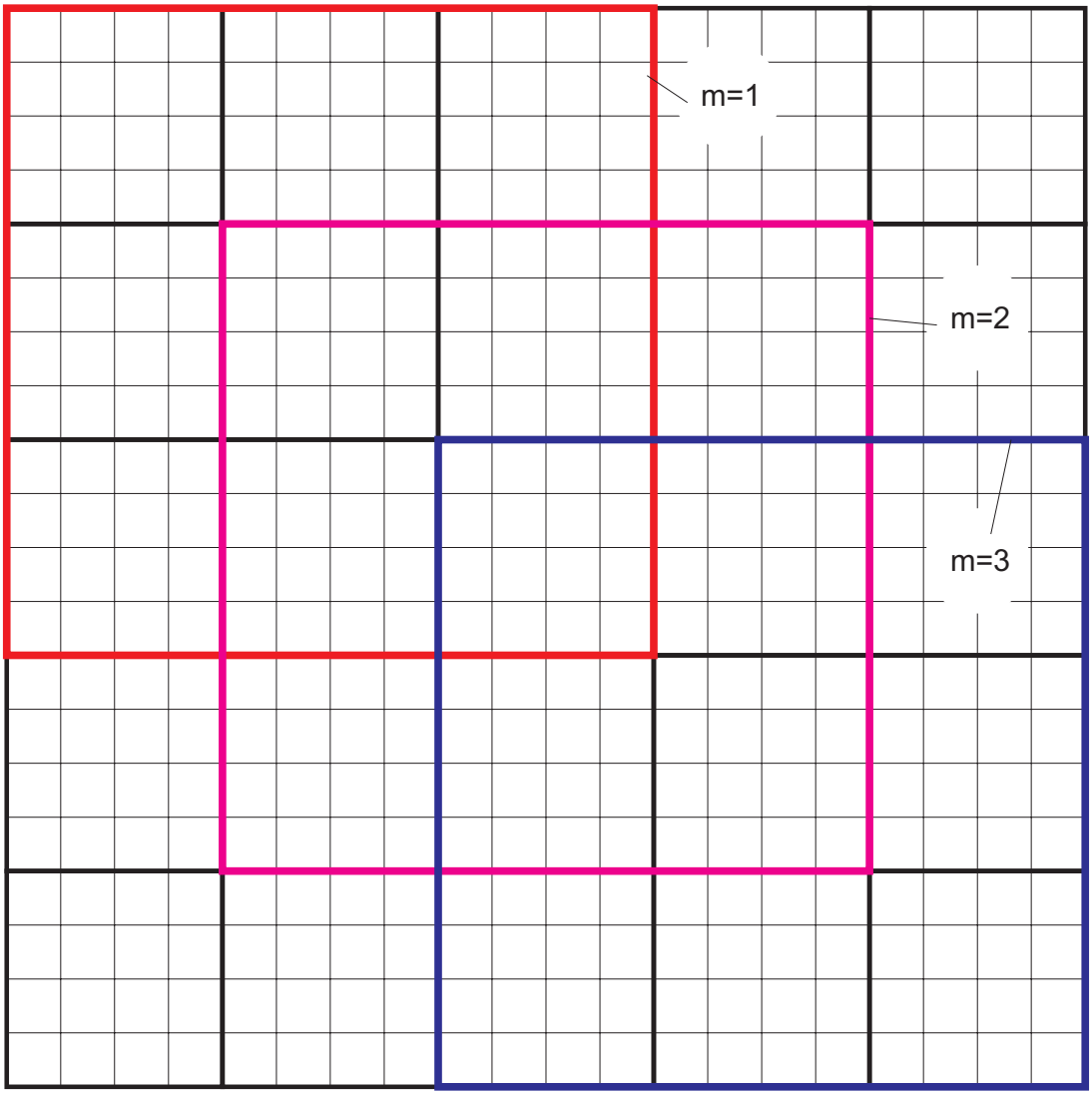


Pseudorandom PRI staggering

Properties of staggered PRI

- Avoidance of multiple clutter notches (blind velocities)
- Unambiguous target Doppler estimates
- Resistance against spot jammers
- However: no FFT for Doppler filter bank

Space-time adaptive FIR filtering with staggered PRI



Matrix scheme for space-time FIR filtering (K=4, M=5, L=3)

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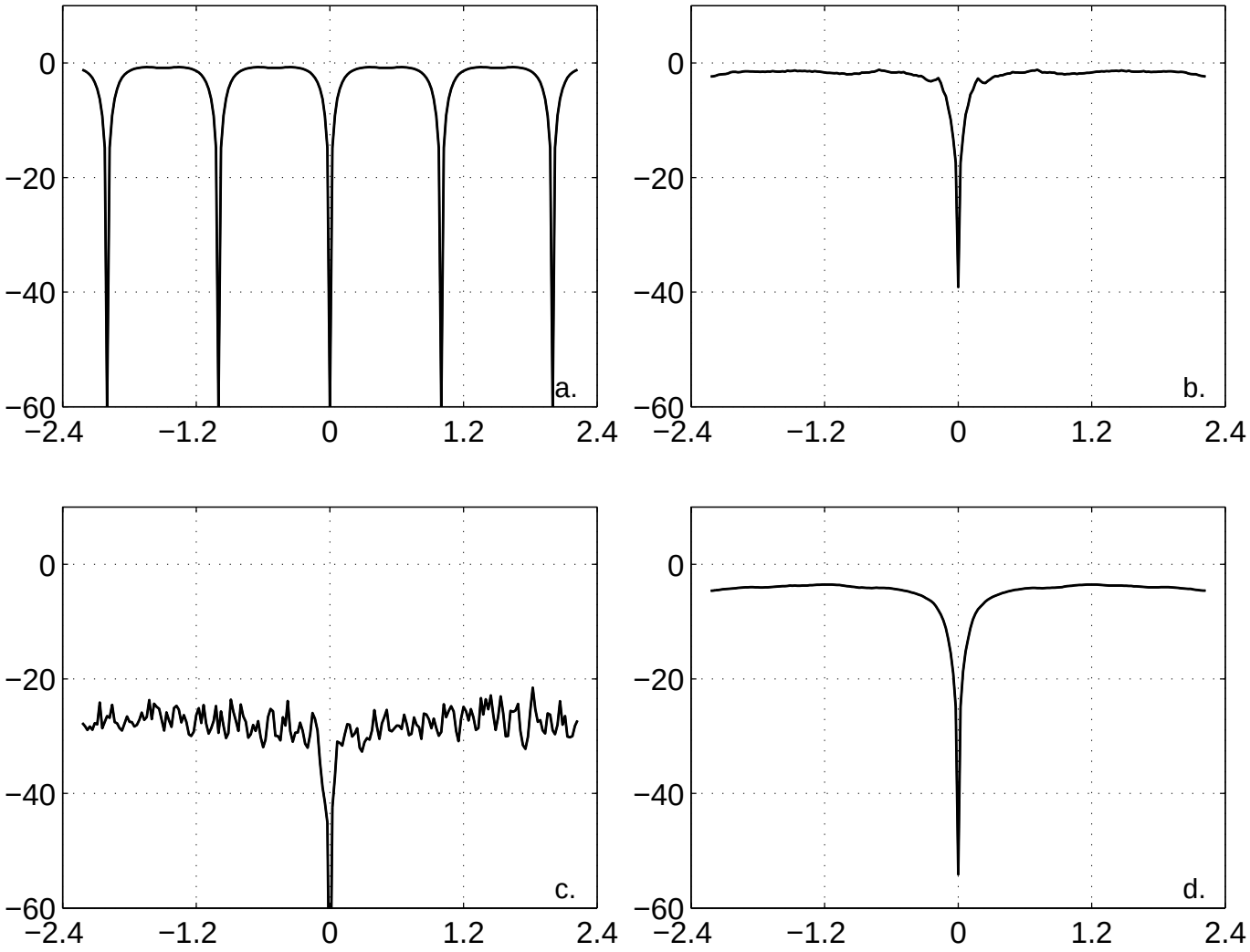

Space-time FIR filter with staggered PRI

a. optimum processing, no staggering, Nyquist sampling in space & time
b. optimum processor, staggered PRI
c. fixed ST FIR filter, staggered PRI
d. STAP FIR filter with variable coefficients

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Summary

- Staggered PRI: avoiding blind velocities (ambiguous) clutter notches, unambiguous estimation of target Doppler, resistance against spot jammers
- The optimum (LR) STAP processor can cope with staggered PRI
- The STAP FIR filter is a most efficient tool for real-time clutter rejection
- FIR filters with constant coefficients are mismatched to staggered echo sequences
- FIR filters with varying coefficients (readaption at every PRI)
- Loss compared with constant FIR filter and constant PRI: a few dB