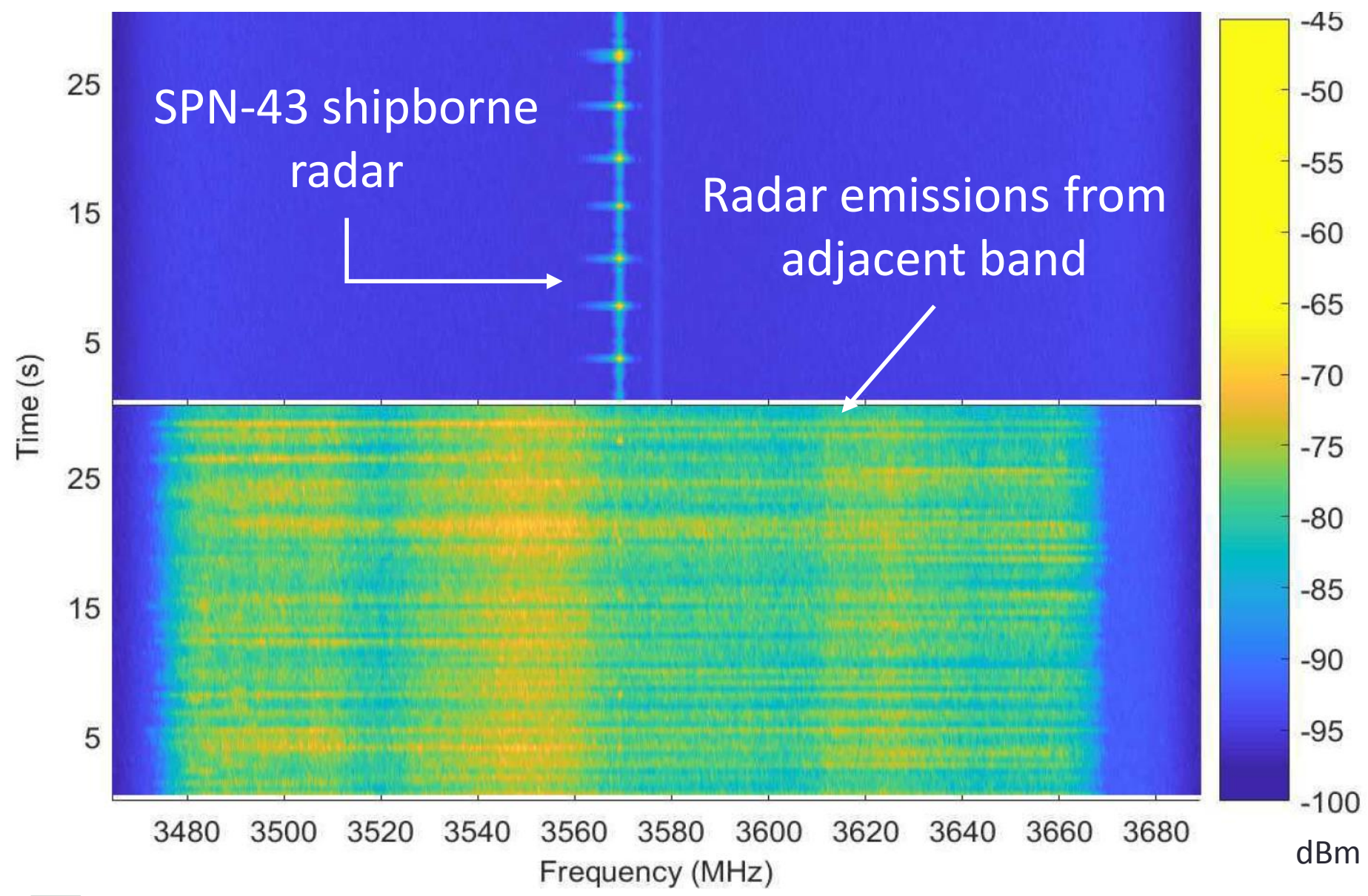
DETECTION OF INCUMBENT RADAR IN THE 3.5 GHZ CBRS BAND

Raied Caromi, Michael Souryal, and Wen-Bin Yang
National Institute of Standards and Technology
Communications Technology Laboratory
Gaithersburg, Maryland, U.S.

BACKGROUND AND MOTIVATION

- Citizens Broadband Radio Service: 150 MHz **shared spectrum** at 3.5 GHz, commercial and military use
- Spectrum sharing enabled by a network of commercial **sensors** that detect military radar so that interference is avoided



- Interference sources: commercial LTE, out-of-band emissions from radars in adjacent bands
- **Question**: How well can sensors detect incumbent radar in this band?
- **Problem**: Sensors have only partial knowledge of radar waveform.
- **Approach**: Filter matched to known parameters, evaluated with field-measured waveforms of signals in and adjacent to the band

SIGNAL MODEL

- One or more sensors scan 100 MHz in 10 MHz channels.
- Simplified model of the received baseband signal in one channel

$$x[n] = s[n] + v[n]$$

- Statistical hypothesis test for single radar signal detection

$$\begin{cases} H_0 : x[n] = v[n], \\ H_1 : x[n] = s[n] + v[n] \end{cases}$$

- Signal and template cross-correlation

$$r_{xs}[m] = \sum_{n=-\infty}^{\infty} x[n]\hat{s}^*[n+m], -\infty < m < \infty$$

- Detection decision rule: $\mathcal{T}\{r_{xs}[m]\} \underset{H_0}{\overset{H_1}{\gtrless}} \gamma$

PERFORMANCE ANALYSIS

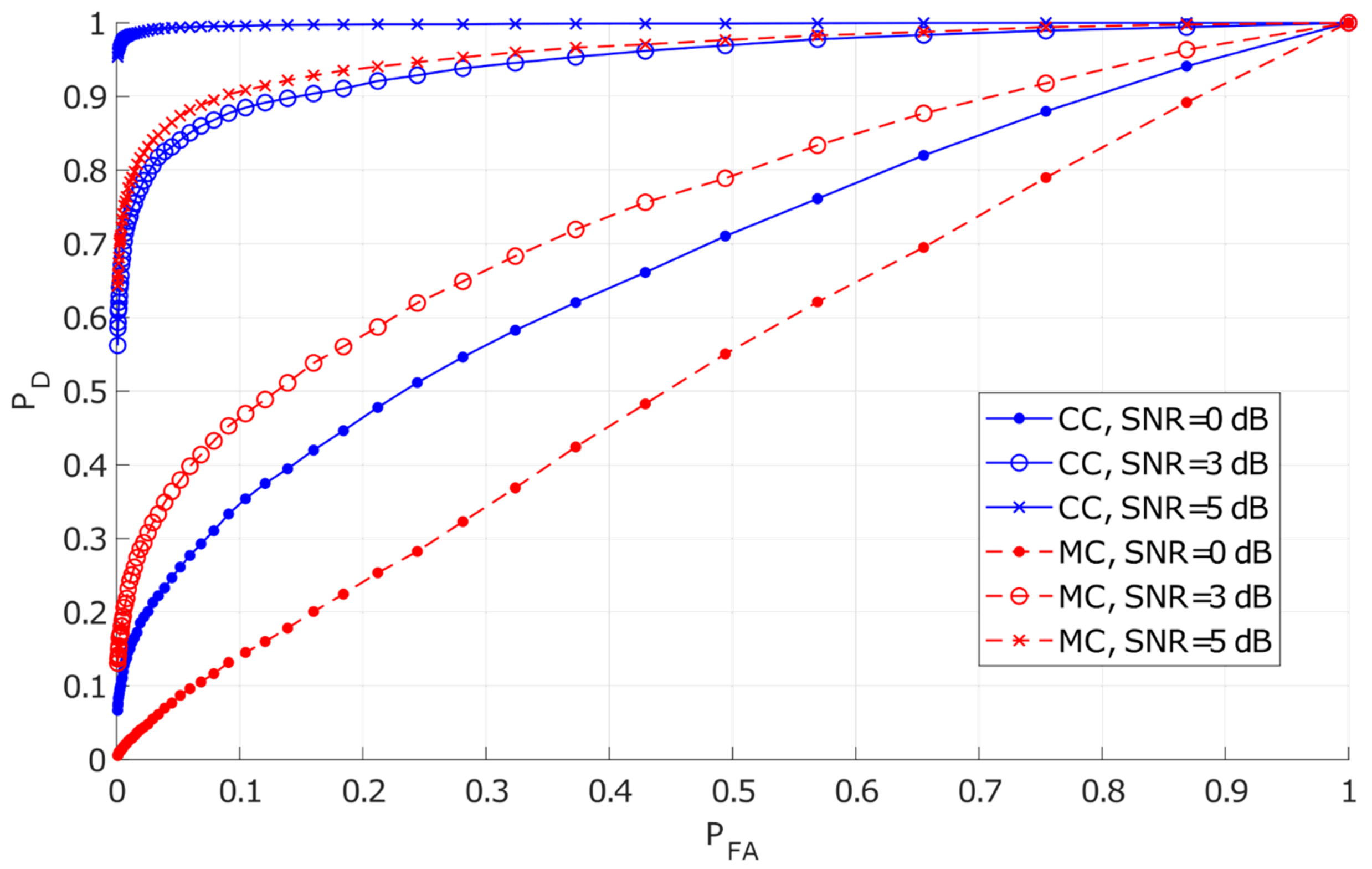
- Coherent and non-coherent matched filters: complex correlator (CC) and magnitude correlator (MC)
- Empirical methods used to estimate probability of detection and probability of false alarm in the absence of full knowledge of the signal, and with non-Gaussian interference

$$P_D = P_r\left(\mathcal{T}\{r_{xs}[m]\} > \gamma \mid H_1\right)$$

$$P_{FA} = P_r\left(\mathcal{T}\{r_{xs}[m]\} > \gamma \mid H_0\right)$$

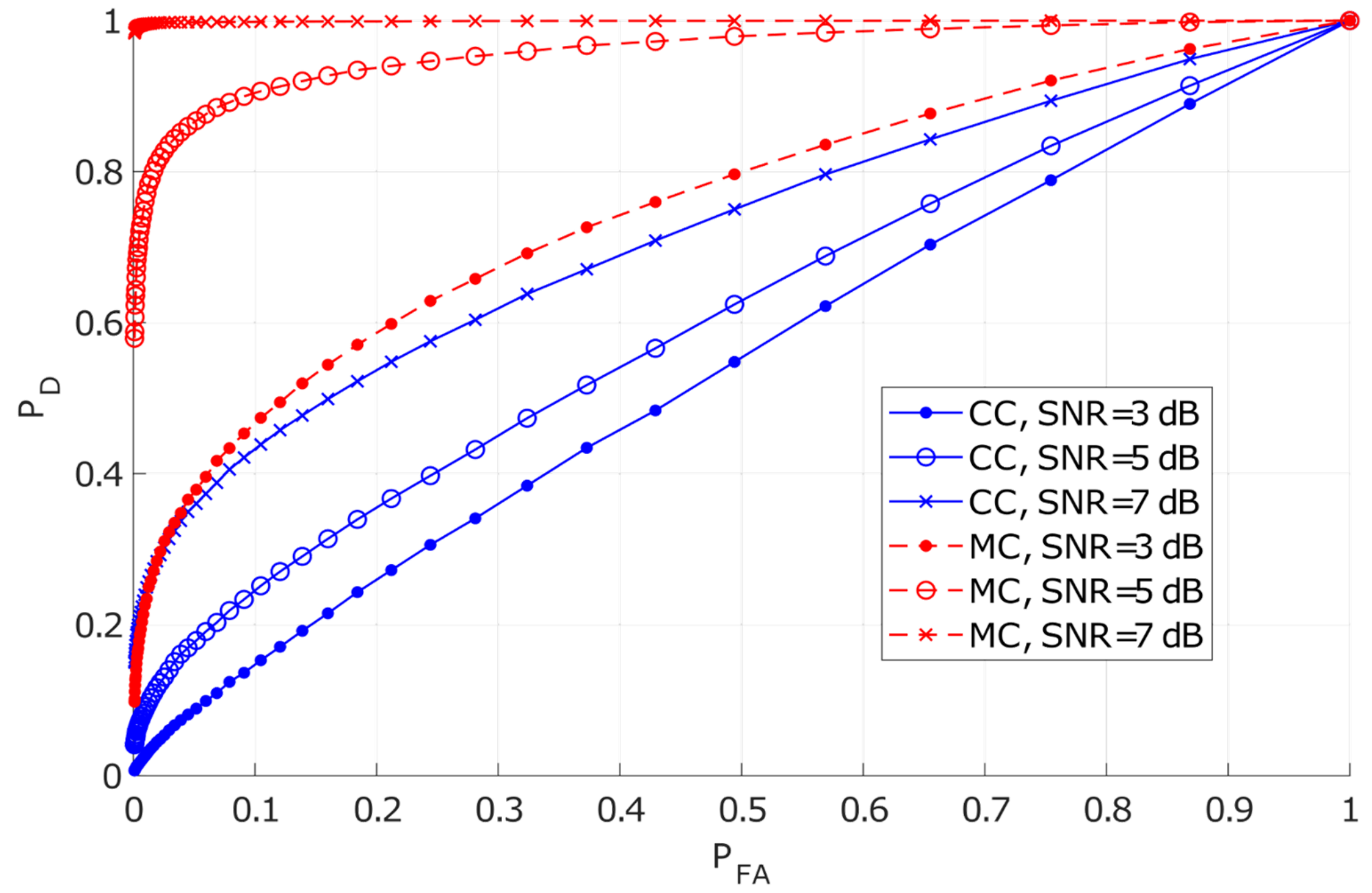
IDEAL SIGNAL DETECTION IN WGN

- Ideal template is the original signal amplitude and phase.
- Radar waveforms are randomly delayed and corrupted with WGN.
- CC performs better than MC since the template contains the original phase information and the coherent detector performs to its fullest.



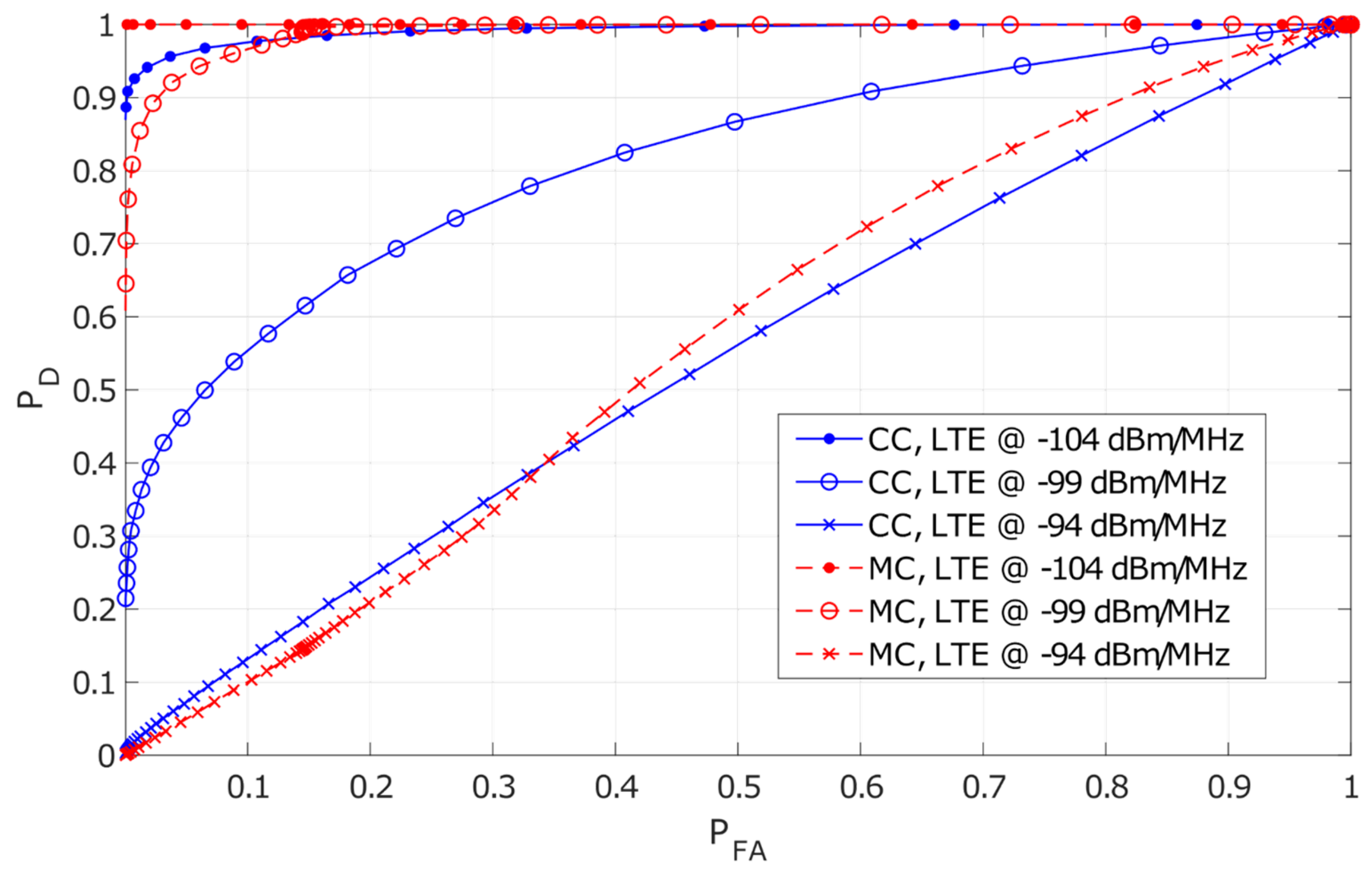
SIGNAL IN WGN

- In practice, a sensor will not have *a priori* access to the actual signal for use as the template, but will rather use a synthetic template.
- MC performs better than CC due to phase mis-match between CC template and the radar signal.
- About 2 dB in SNR represents the loss from using the synthetic template instead of a perfectly matched detector.



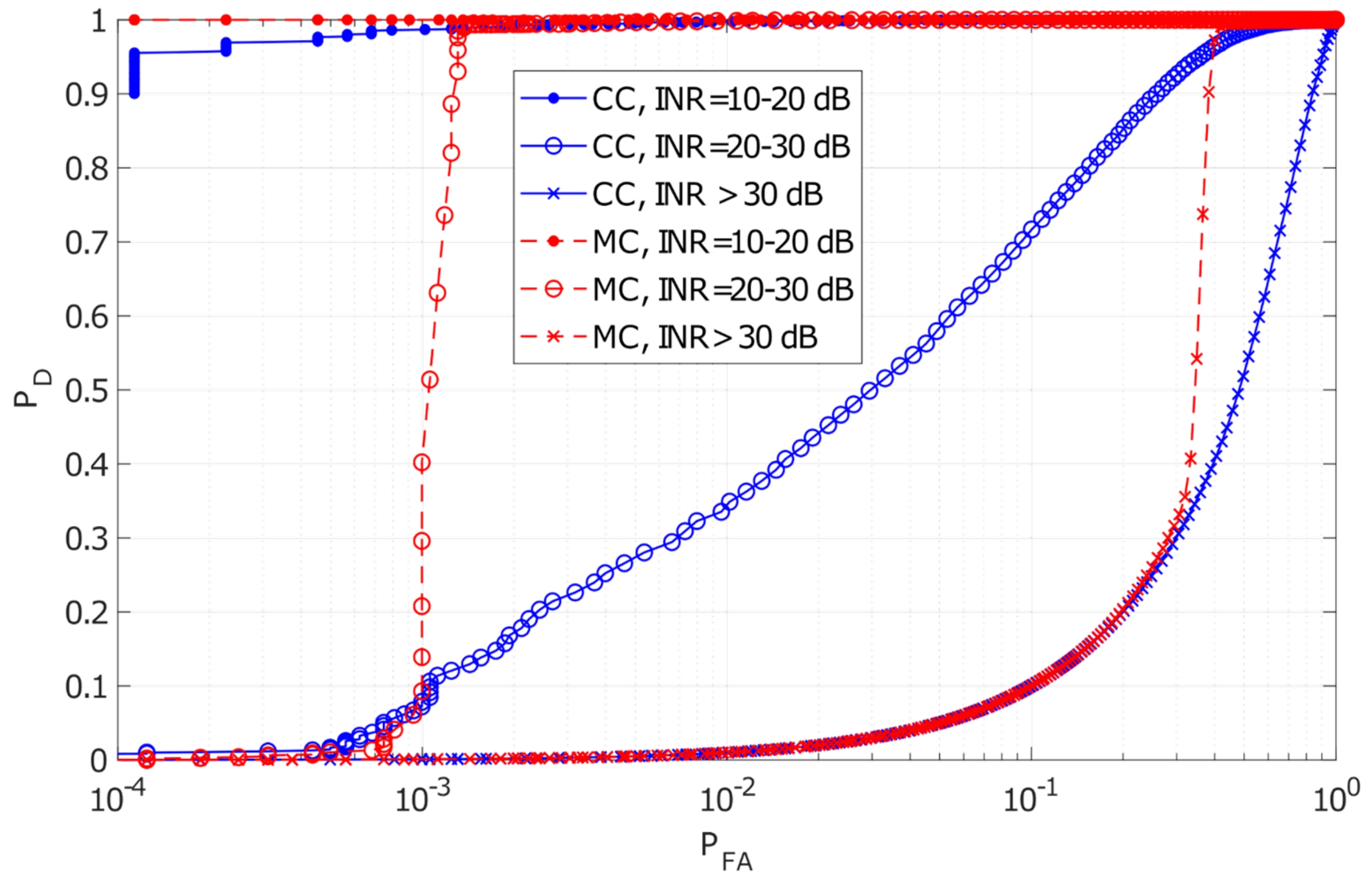
LTE INTERFERENCE

- Radar waveform plus a single interfering LTE time division duplex (TDD) signal, representing a nearby dominant interferer
- LTE frame structure with 7 different TDD configurations
- Peak power of the radar signals is set at -89 dBm/MHz.
- Sensors are required to tolerate interference of only -109 dBm/MHz.



ADJACENT-BAND INTERFERENCE

- Measured adjacent-band signals are added to the in-band radar signals.
- SNR for the in-band radar is set to 19 dB.
- MC detector can achieve near perfect detection with a false alarm probability of only 10^{-3} with adjacent-band emissions at peak interference-to-noise ratios of 20 dB to 30 dB.
- At higher interference levels, the false alarm rate increases to 40%.



SUMMARY

- Analysis of federal incumbent detectors for the 3.5 GHz shared-spectrum CBRS band using field-measured signals of the in-band incumbent radar
- The magnitude-correlation detector performs well at a peak SNR of 5dB in gaussian noise.
- With interference from commercial CBRS (LTE) devices, a peak SIR of only 10 dB is needed (current requirements are 20 dB).
- The proposed detectors exceed the requirements for performance in the presence of co-channel interference from commercial LTE signals, meaning that more commercial devices can use the band in the proximity of sensors.
- The detectors are robust to out-of-band emissions into this band from adjacent-band radars, which prior studies have found can be significant.