Optimal Signal Detectability using Discrete Fourier Transform Processing

J. B. Mead
ProSensing Inc., Amherst, MA

Problem: How should a radar be configured to maximize probability of detection for a given probability of false alarm?

Compare two options:

- spectral-based (DFT) processing
- conventional noise-subtracted power averaging

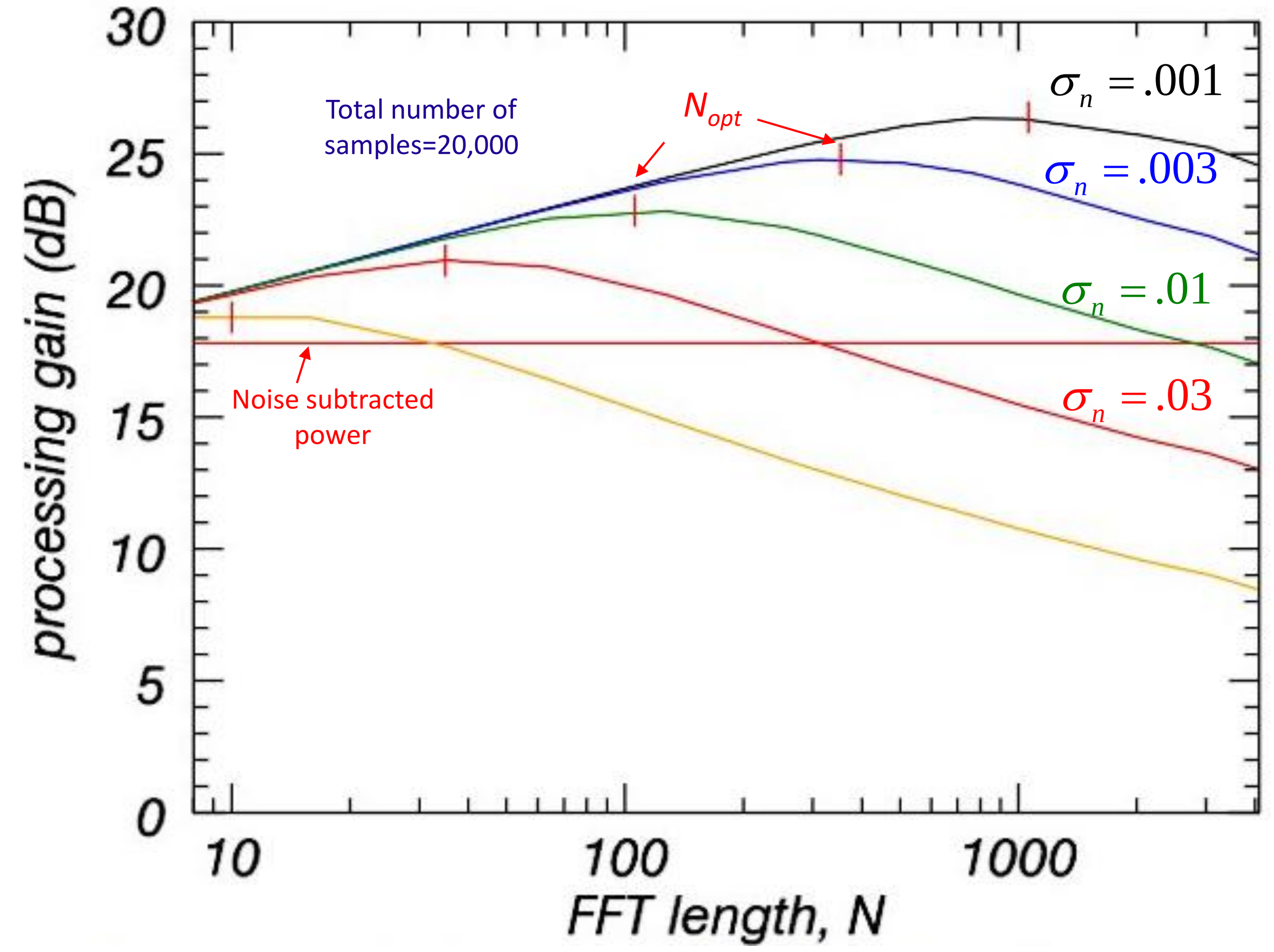
DFT Processing

Optimal signal processing gain occurs when the DFT length, *N*, is

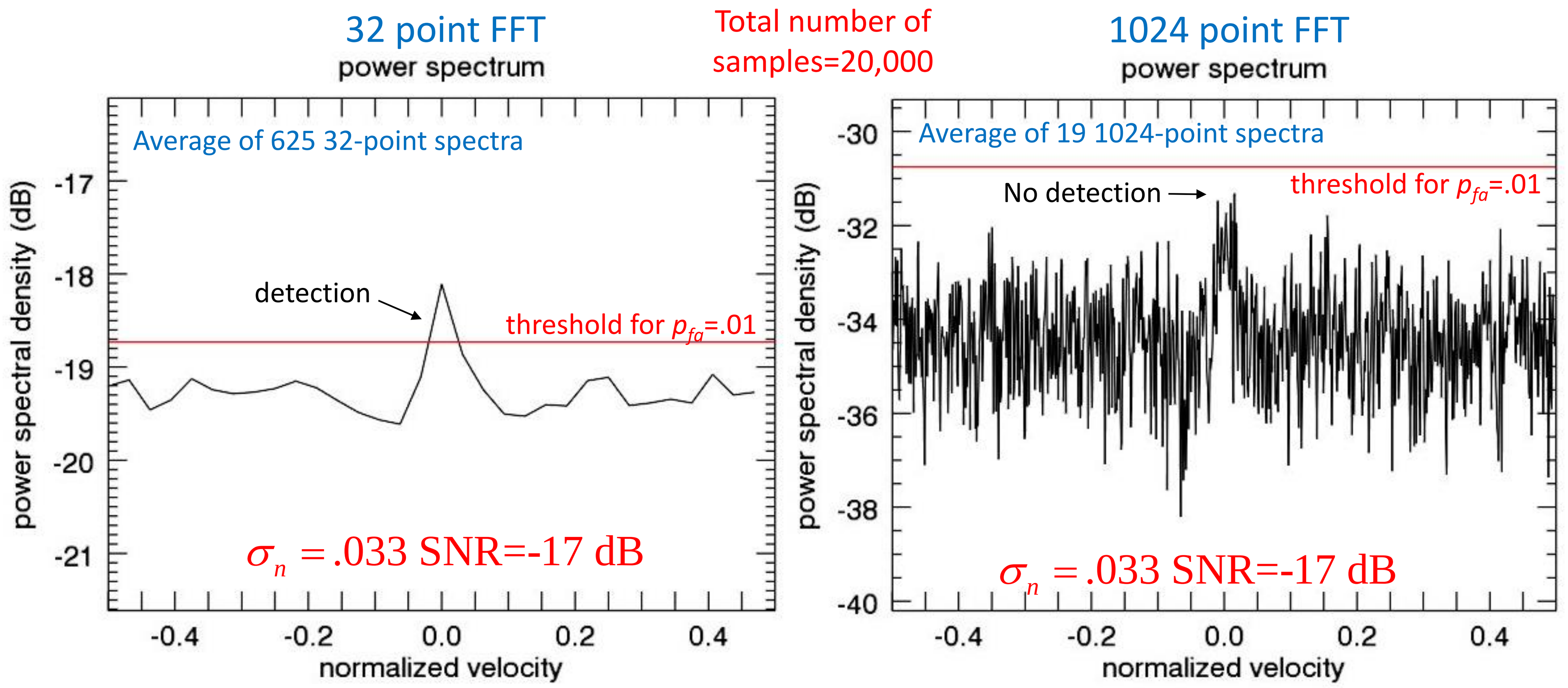
$$N_{opt} = \frac{K_{opt}}{\sigma_n} \quad \text{where } \sigma_n = \frac{\sigma_v}{2v_{un}} \text{ is the normalized spectral width}$$

$$K_{opt} = 1.06 \text{ for Hanning window } K_{opt} = 0.7 \text{ for uniform window}$$

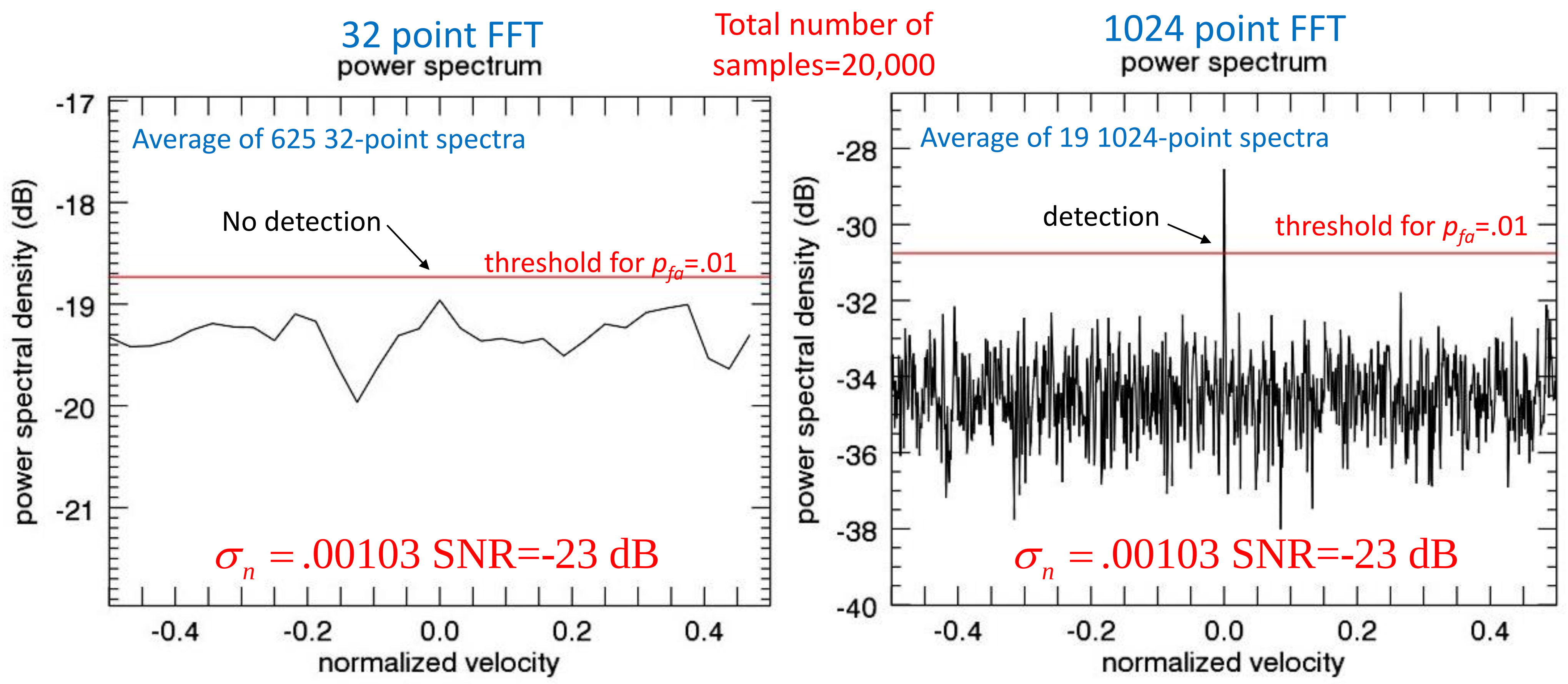
Signal processing gain for DFT and noise-subtracted average power
20000 samples & threshold for 1% false alarm



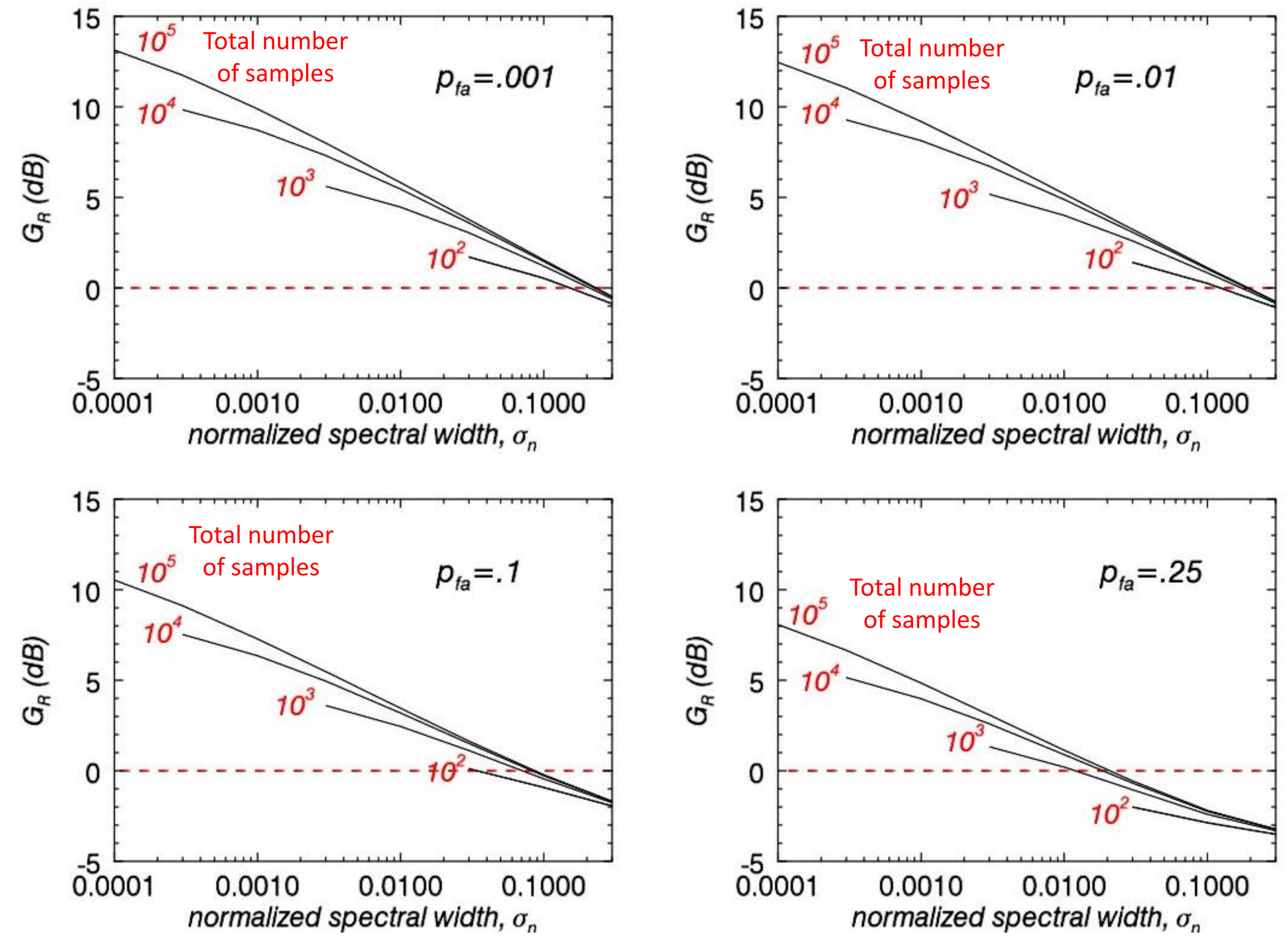
$$N_{opt} = 32 \text{ when } \sigma_n = .033$$



$$N_{opt} = 1024 \text{ when } \sigma_n = .00103$$



Ratio of processing gain between DFT processing and power averaging depends on number of samples available, spectral width and false alarm rate



DFT processing superior for low spectral width
Power averaging superior when spectral width is large

Optimal FFT length for Quadratic Phase Code (QPC) Radar is large
For example, the optimal FFT length for an X-band radar (9.3 GHz) for a spectral width of 0.5 m/s operating in QPC mode at 3 MHz PRF

$$\sigma_n = \frac{\sigma_v}{2v_{un}} = \frac{\sigma_v}{2(\mathrm{PRF}\lambda/4)} = \frac{2(.5)}{3e06 \cdot 0.032} = 1.041 \cdot 10^{-5}$$

$$N_{opt} = \frac{1.06}{1.041 \cdot 10^{-5}} = 101{,}800$$