Integrazione non coerente Quadratica e Binaria per bersagli fluttuanti

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Bersagli con fluttuazioni lenta (SW I e III)

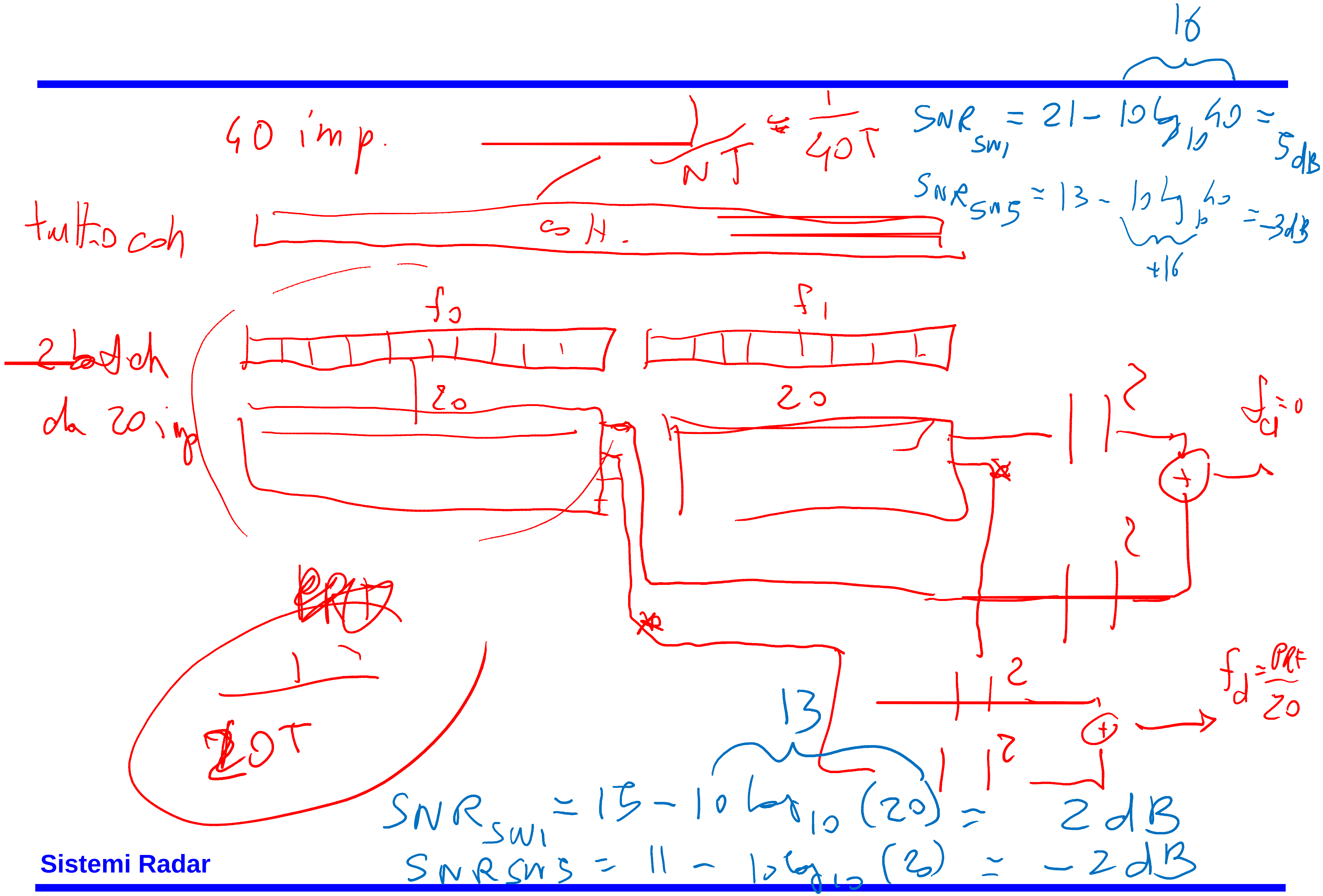
→ posso fare anche ~~int non~~ coh
ovviamente con perdite rispetto alla ~~coerente~~

Quando non posso effettuare int coh?

- con fluttuaz "veloce" (SW II e IV)

- Trasmissione in agilità di frequenza

Sistemi Radar



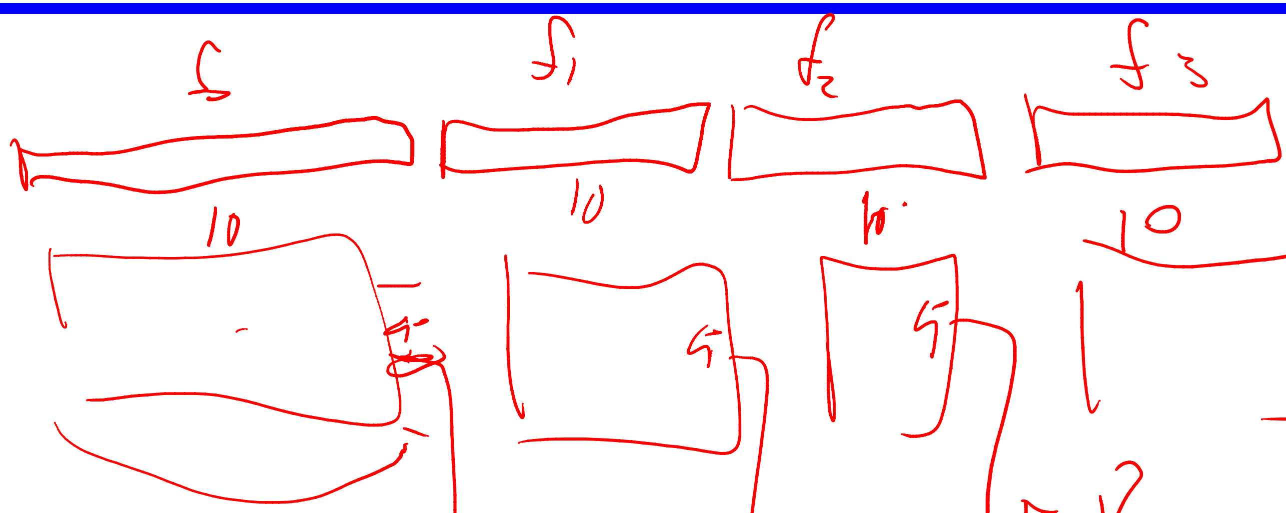
Sistemi Radar

$\frac{1}{10T}$

$SNR_{SW1} = 11 - 10\log_{10} 10 = 1\,dB$

$SNR_{SW5} = 8 - 10\log_{10}(10) = -2\,dB$

4 batch da 10 imp



5 batch da 8 imp → $9 - 10\log_{10}(8) \simeq 0\,dB$

$7{,}5 \qquad -1{,}5\,dB$

8 batch da 5 imp $\quad 7 - 10\log_{10}(5) = 0\,dB$

$6 \qquad = -1\,dB$

~~10 batch~~ da 4 imp → $7 - 10\log_{10} 4 = 1\,dB$

$5 - 6 = -1\,dB$

20 batch da 2 imp

~~40 batch~~ = agilità da imp. a imp.

Sistemi Radar

FL NF

Prs ul	$\frac{1}{8T}$	FL	NF
1 blocco di 40	40	SNR = 5 dB	SNR = -3 dB
2	20	SNR = 2 dB	SNR = -2 dB
4	10	SNR = 1 dB	SNR = -2 dB
5	8	SNR 0 dB	SNR = -1,5 dB
8	5	0 dB	SNR = -1 dB
10	4	SNR = 1 dB	SNR = -1 dB
20	2		
40	1	FL SNR = 1 dB	NF SNR = 1 dB

Sistemi Radar

Formula empirica di Shnidman (I)

Prestazioni per l'Integrazione non coerente quadratica

- Shnidman has developed a set of empirical formulae that are quite accurate for most 1st order radar systems calculations:

$$K = \begin{cases} \infty & \text{Non-fluctuating target ("Swerling 0 / 5")} \\ 1, & \text{Swerling Case 1} \\ N, & \text{Swerling Case 2} \\ 2, & \text{Swerling Case 3} \\ 2N & \text{Swerling Case 4} \end{cases}$$

0,2 dB

$$\alpha = \begin{cases} 0 & N \le 40 \\ \frac{1}{4} & N > 40 \end{cases}$$

$$\eta = \sqrt{-0.8\ln\left(4P_{FA}\left(1-P_{FA}\right)\right)} + \text{sign}\left(P_D - 0.5\right)\sqrt{-0.8\ln\left(4P_D\left(1-P_D\right)\right)}$$

Formula empirica di Shnidman (II)

$$X_\infty = \eta\left(\eta + 2\sqrt{\frac{N}{2}} + \left(\alpha - \frac{1}{4}\right)\right)$$

$$C_1 = \left(\left(\left(17.7006\, P_D - 18.4496\right)P_D + 14.5339\right)P_D - 3.525\right)/\,K$$

$$C_2 = \frac{1}{K}\left(e^{27.31\, P_D - 25.14)} + \left(P_D - 0.8\right)\left(0.7\ln\left(\frac{10^{-5}}{P_{FA}}\right) + \frac{\left(2N - 20\right)}{80}\right)\right)$$

$$C_{dB} = \begin{cases} C_1 & 0.1 \le P_D \le 0.872 \\ C_1 + C_2 & 0.872 \le P_D \le 0.99 \end{cases}$$

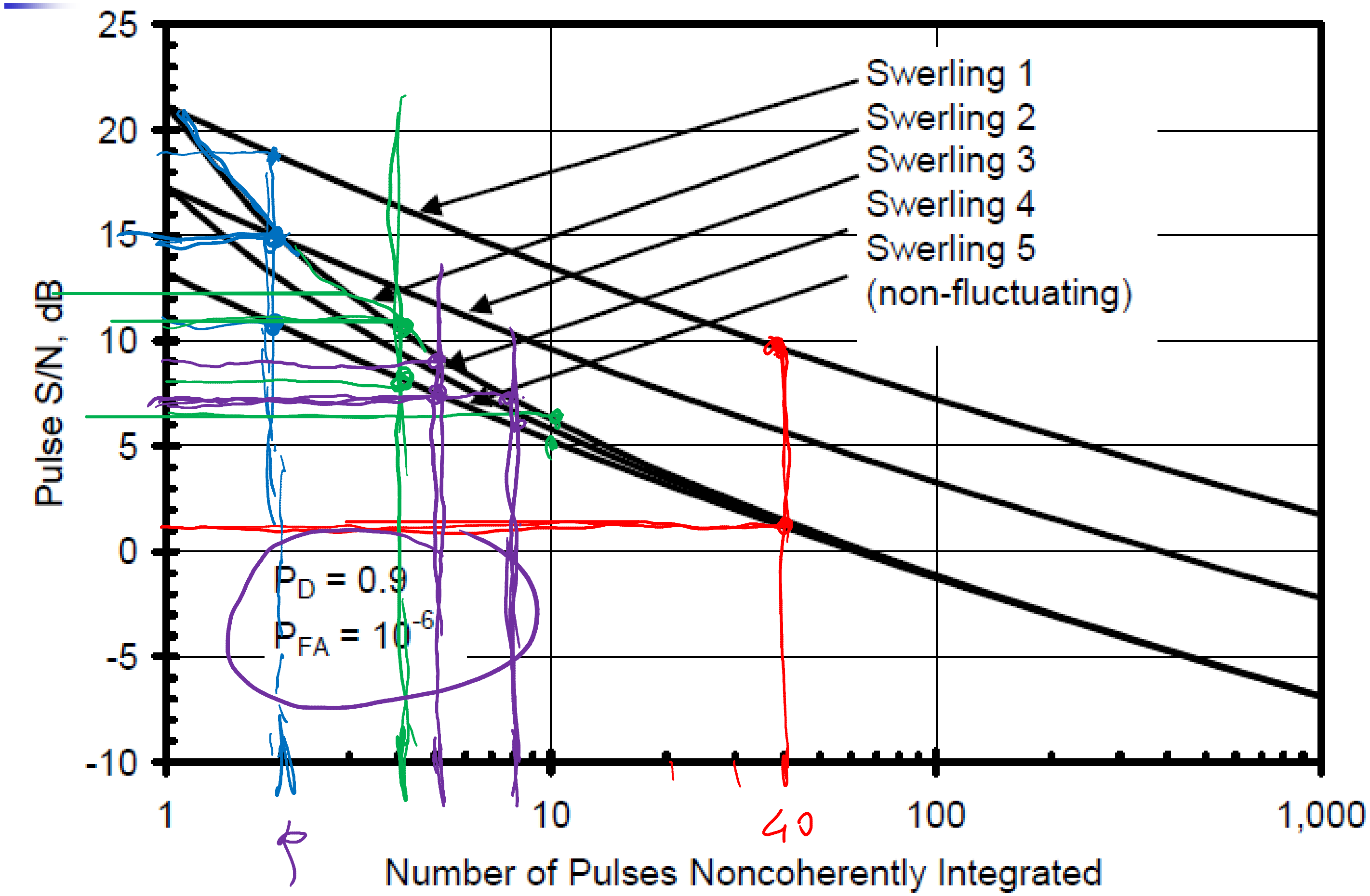
$$C = 10^{\frac{C_{dB}}{10}}$$

$$SNR(\text{natural units}) = \frac{C\, X_\infty}{N}$$

$$SNR(dB) = 10\log_{10}(SNR)$$

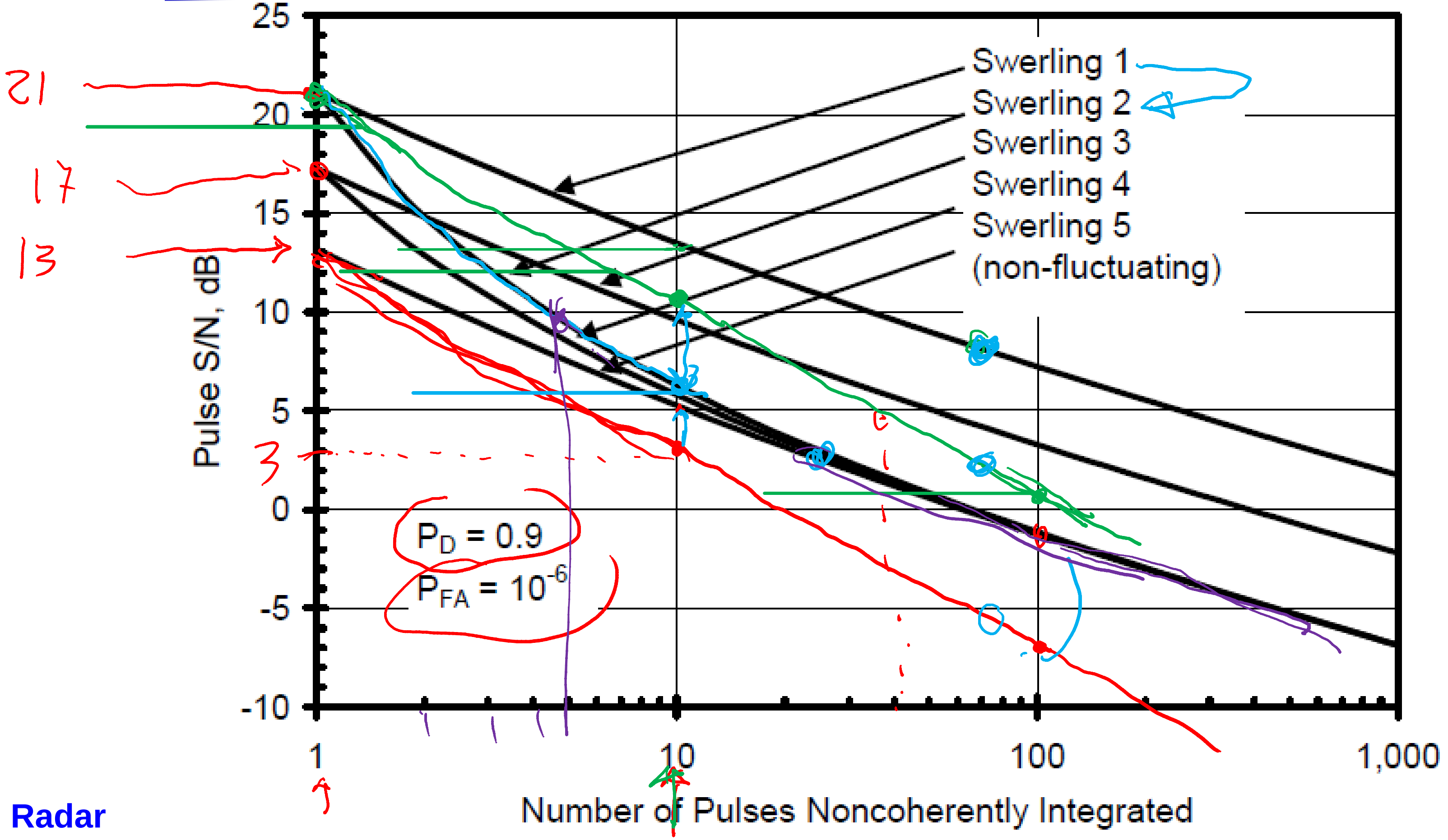
Integrazione Quadratica - bersagli fluttuanti (I)

Plots of S/N vs. Number of Pulses and Swerling Type



Integrazione Quadratica - bersagli fluttuanti (I)

Plots of S/N vs. Number of Pulses and Swerling Type



Integrazione Quadratica - bersagli fluttuanti (II)

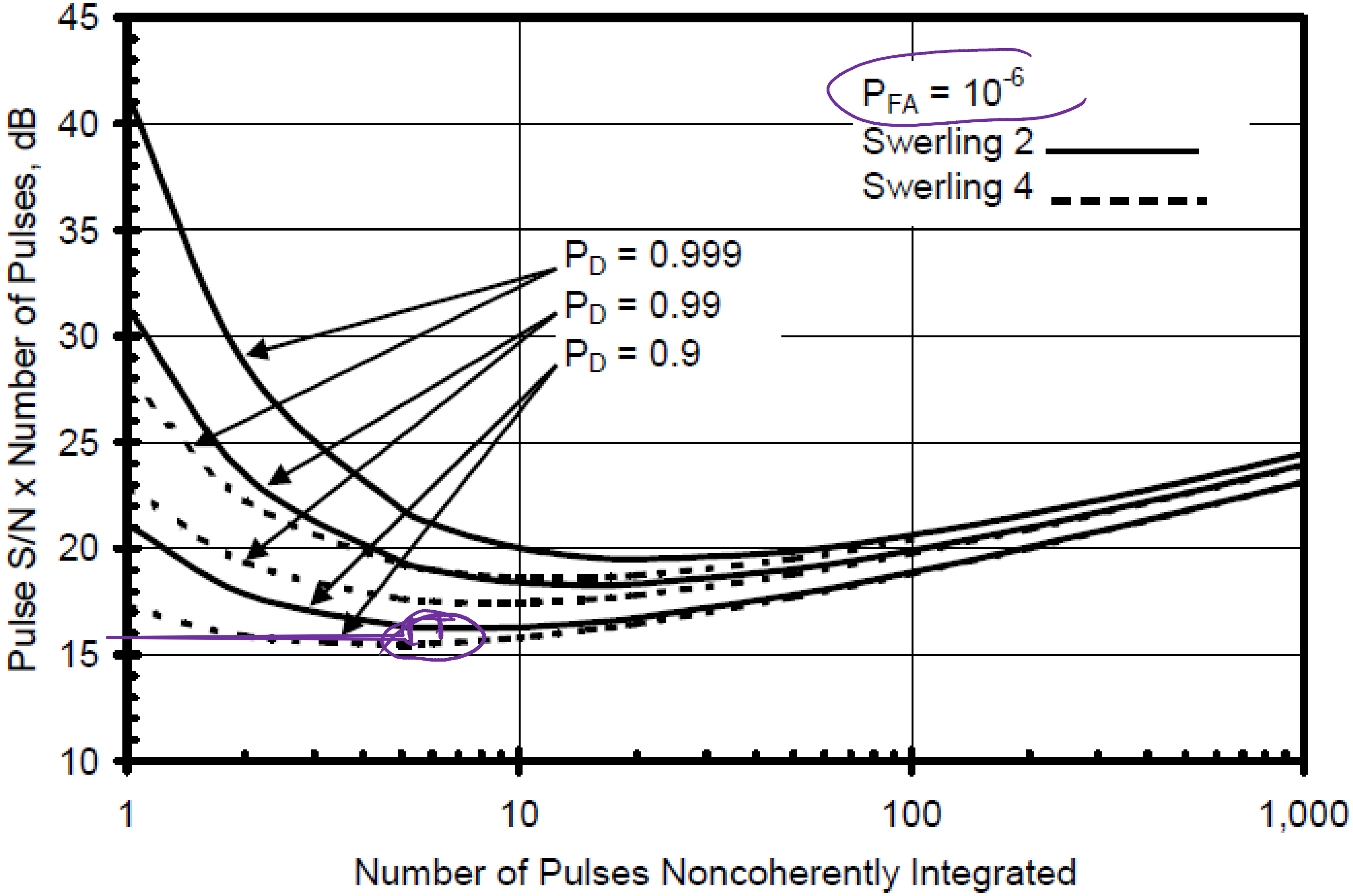
Noncoherent-Integration

Features

- Advantages Of Noncoherent Integration
  - Easier To Implement Than Coherent Integration
  - Requires Much Less Accuracy In Knowledge Of Radial Velocity
  - Can Provide Better Performance Against Fluctuating Targets
- For Correlated Target Signals (Swerling 1,3 and 5)
  - S/N Decreases More Slowly Than 1 / n
  - More Energy Needed Than With a Single Pulse or Coherent Integration
- For Fluctuating Target Signals (Swerling 2 and 4)
  - S/N Initially Decreases More Rapidly Than 1 / n
  - Produces Values of n Where NCI Requires Less Energy Than a Single Pulse or Coherent Integration

Integrazione Quadratica - bersagli fluttuanti (III)

Plots of n S/N vs. Number of Pulses NCI



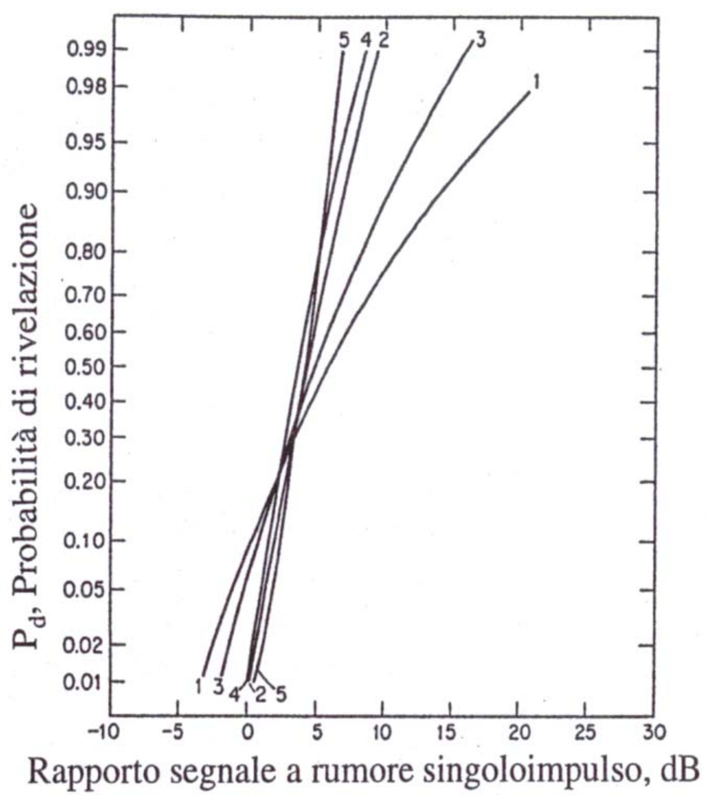
Integrazione Quadratica - bersagli fluttuanti (IV)

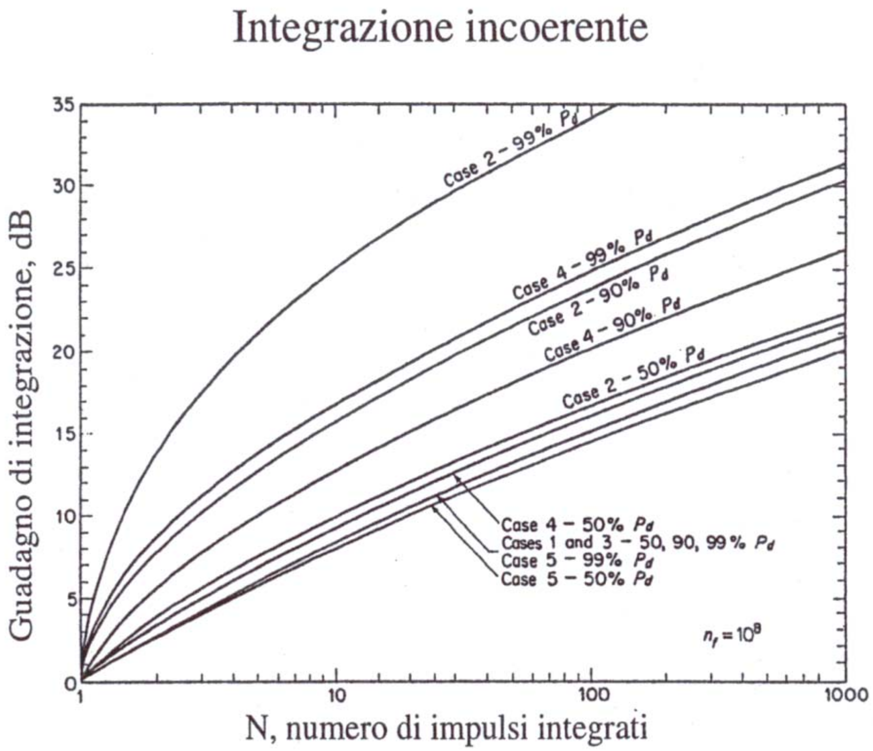
NCI Detection Examples

P_D	0.99	0.99	0.99	0.99
P_{FA}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
n	1	10	1,000	100 x 10*
Swerling	2	2	2	1 / 2
Pulse S/N	31.4 dB	8.4 dB	-6.1 dB	-11.6 dB
Relative Energy	1.0	0.05	0.18	0.05

* 10 Groups of 100 Coherently-integrated Pulses

Integrazione Quadratica - bersagli fluttuanti (V)





Portata radar

definita su σ_{av}, tenendo conto delle fluttuazioni e del guadagno di integrazione

$$R_{\max} = \left[\frac{E_t G A_e \sigma_{av}}{(4\pi)^2 L k T_0 F \, SNR^* L_f / \gamma} \right]^{1/4}$$

Integrazione Binaria - bersagli fluttuanti (VI)

Cumulative Detection (CD) Probability

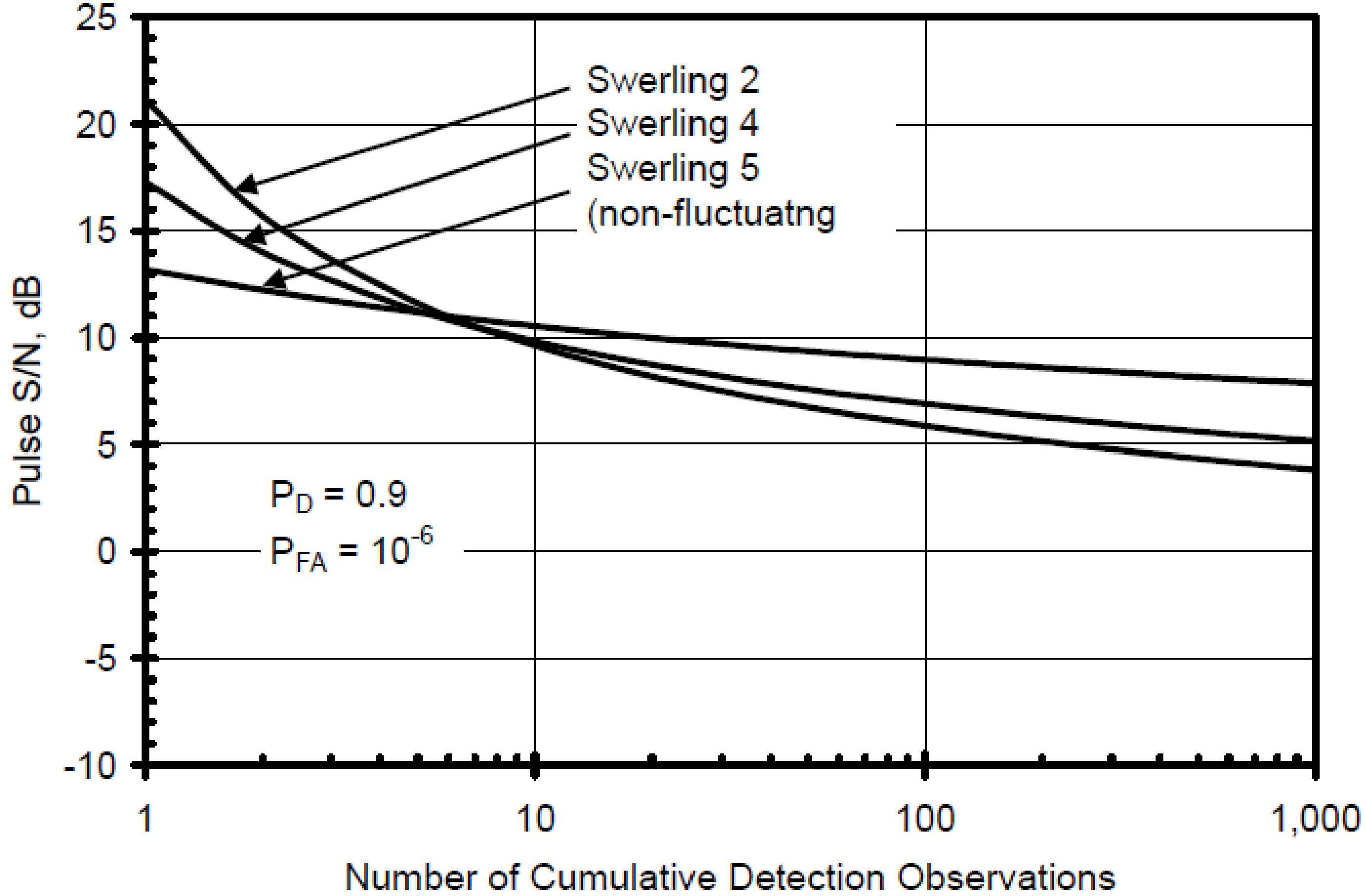
$M = 1$

$M_{opt} = 1,5\sqrt{N}$

- Cumulative Detection Involves
  - Transmitting and Receiving a Series of n Pulses
  - Detection Is Declared If at Least One Return Exceeds the Threshold
  - Special Case of m Out of n Detection (Binary Integration)
- False-Alarm Probability for Each Observation, P_{FAO}, adjusted
  - $P_{FAO} = P_{FA} / n$
- Single-observation Detection Probability, P_{DO}, Given by
  - $P_{DO} = 1 - (1 - P_D)^{1/n}$
  - Calculated Using Single-pulse or Integrated Dwell Techniques
- Overall P_D given by
  - $P_D = 1 - (1 - P_{DO})^n$

Integrazione Binaria - bersagli fluttuanti (VII)

Plots of S/N vs. Number of CD Observations



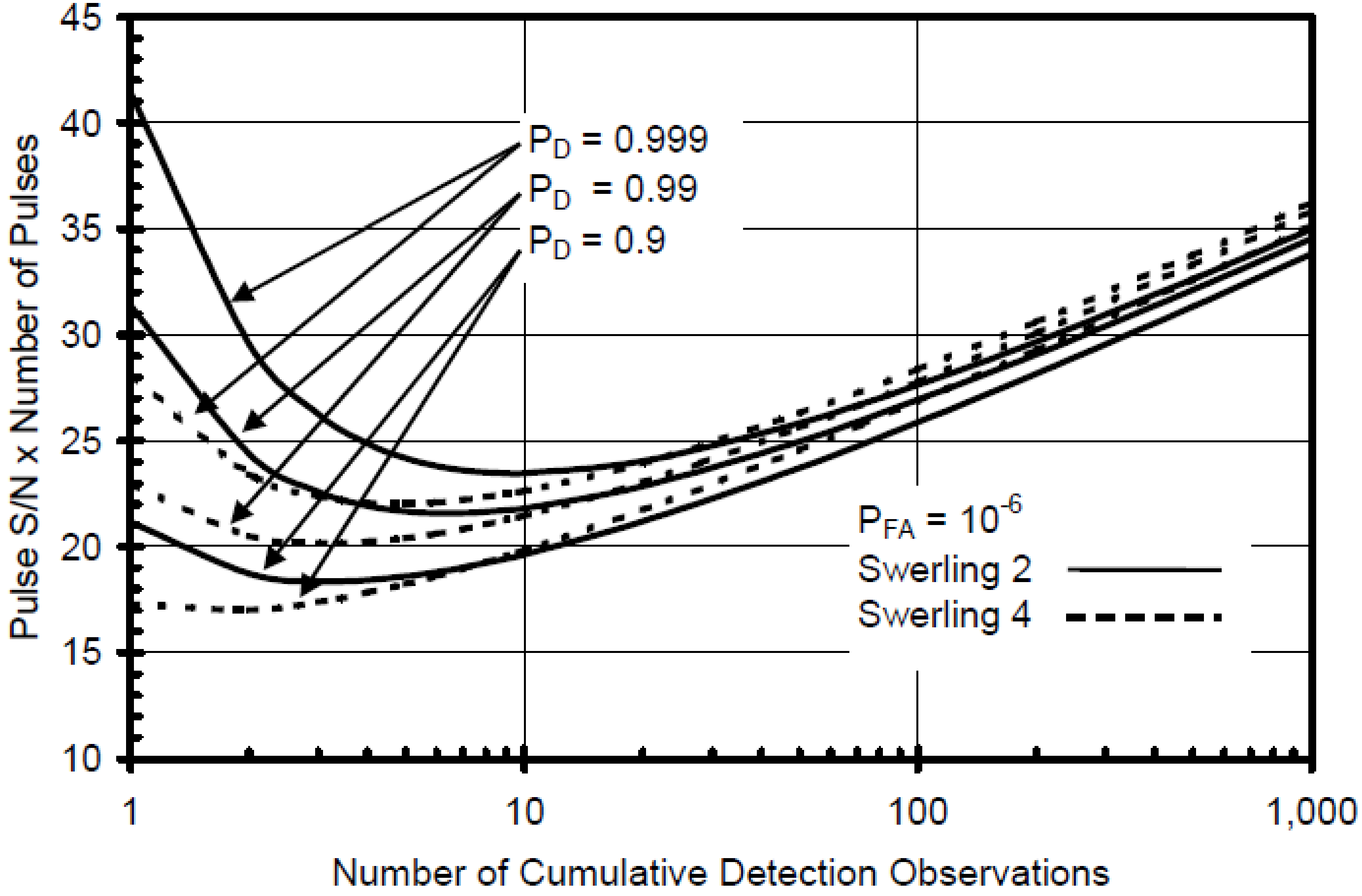
Integrazione Binaria - bersagli fluttuanti (VIII)

Cumulative Detection Features

- Advantages of Cumulative Detection
  - Easy to Implement
  - Range-walk Compensation Not Needed
  - Can Provide Good Performance Against Fluctuating Targets
- For Fluctuating Target Signals (Swerling 2 and 4)
  - S/N Initially Decreases More Rapidly Than 1 / n
  - Produces Values of n Where CD Requires Less Energy Than a Single Pulse or Coherent Integration
- Not Effective Against Non-fluctuating Targets
  - With Correlated Returns, All Will Likely Be Either Detected or Not Detected
  - Threshold Increase Increases S/N Needed

Integrazione Binaria - bersagli fluttuanti (IX)

Plots of n S/N vs. Number of CD Observations



Integrazione Binaria - bersagli fluttuanti (X)

Cumulative-Detection

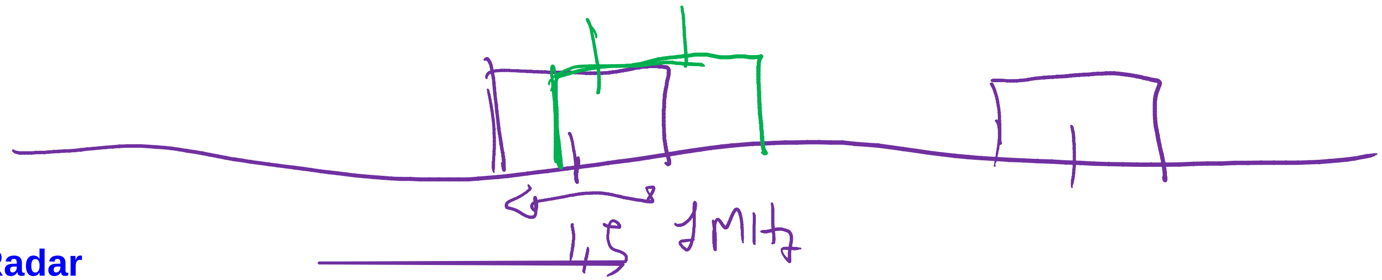
P_D	0.99	0.99	0.99	0.99
P_{FA}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
n	1	10	1,000	100 x 10*
Swerling	2	2	2	1 / 2
Pulse S/N	31.4 dB	11.8 dB	4.6 dB	-8.2 dB
Relative Energy	1.0	0.11	2.09	0.11

* 10 Groups of 100 Coherently-integrated Pulses

Integrazione Binaria - bersagli fluttuanti (XI)

Detection Comparison

	SP	CI	NCI	CD
P_D	0.99	0.99	0.99	0.99
P_{FA}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
n	1	10	10	10
Swerling	1 or 2	1	2	2
Pulse S/N	31.4 dB	21.4 dB	8.4 dB	11.8 dB
Relative Energy	1.0	1.0	0.05	0.11



Integrazione Quadratica - bersagli fluttuanti (I)

Plots of S/N vs. Number of Pulses and Swerling Type