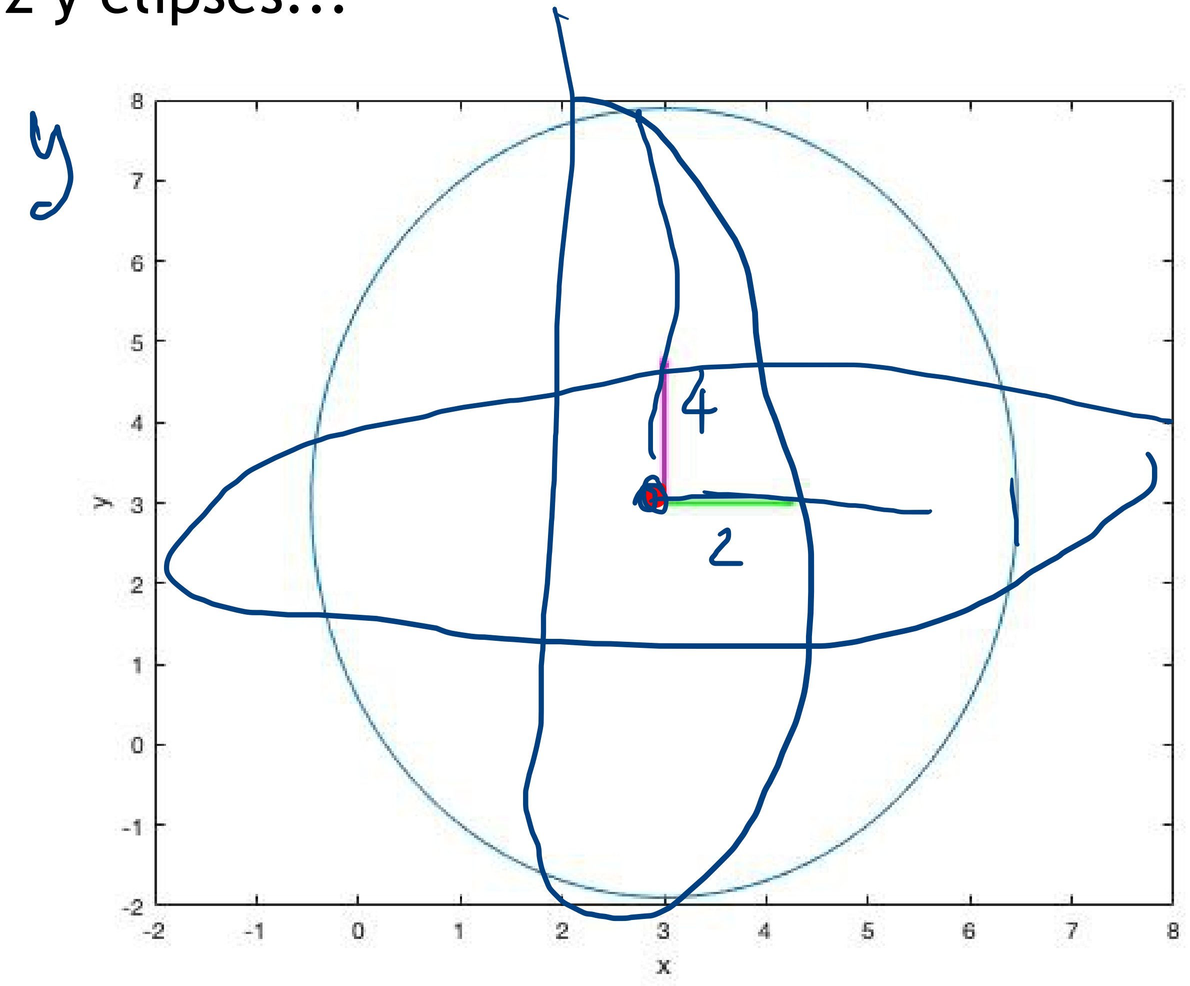
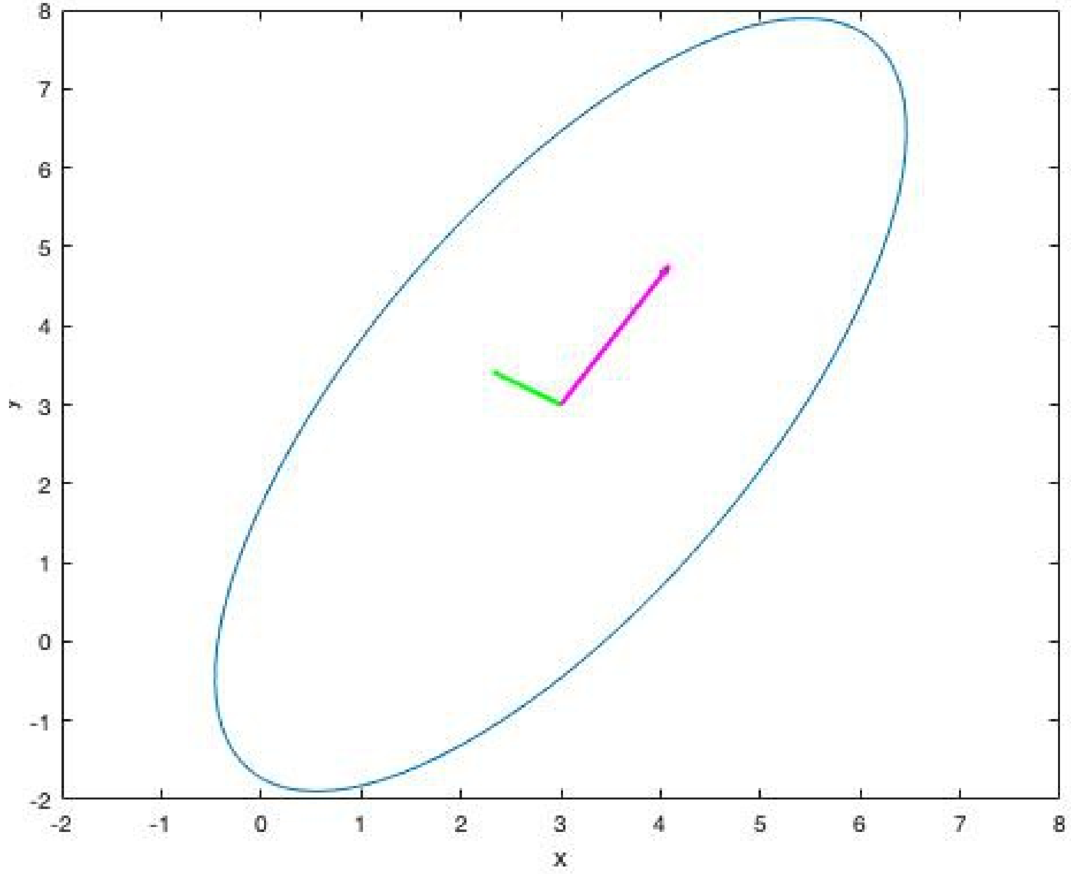
Matriz y elipses...





C ← $A = \begin{bmatrix} 2 & 0 \\ 0 & 4 \end{bmatrix}$

σ_x^2 σ_{xy}^2 σ_y^2

$\vec{v} = [1\ \ 0\ ;\ 0\ \ 1]$

$\lambda_{1,2} = [2\ \ 4]$

$A = \begin{bmatrix} 2 & 2 \\ 2 & 4 \end{bmatrix}$

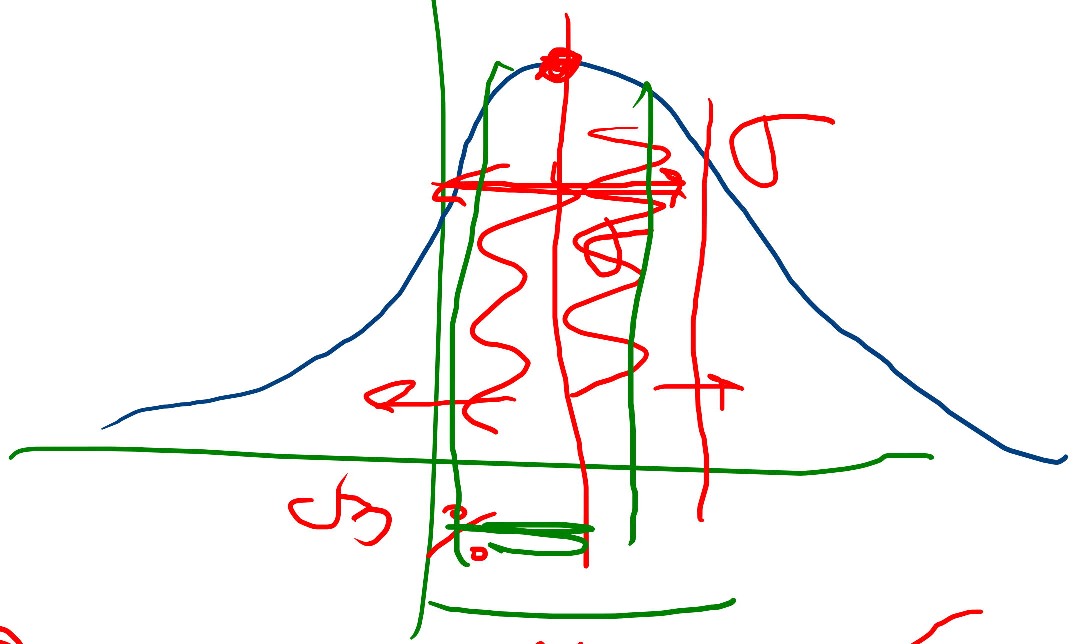
$\vec{v} = [-0.85\ \ 0.53\ ;\ 0.53\ \ 0.85]$

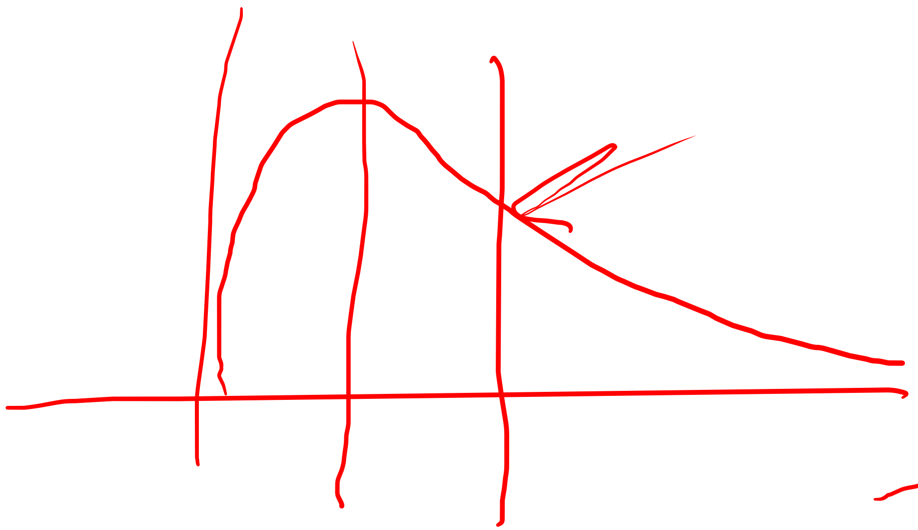
$\lambda_{1,2} = [0.76\ \ 5.24]$

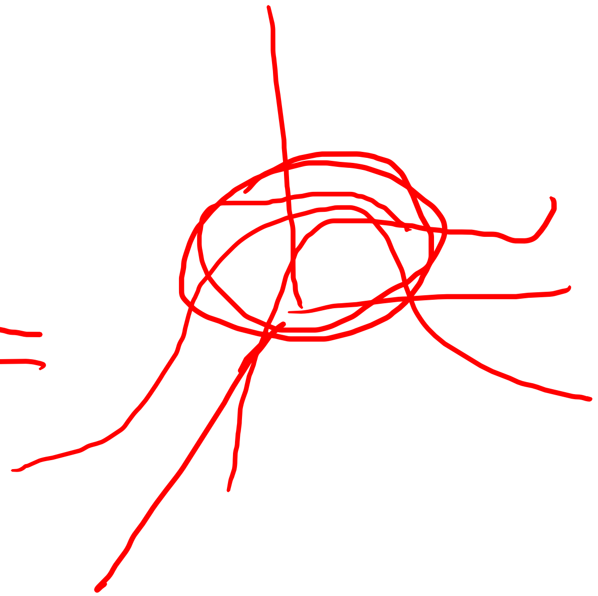
$$p(x) = \frac{1}{\sigma\sqrt{2\pi}}\, e^{-\frac{1}{2}\left(\frac{\mu - x}{\sigma}\right)^2}$$

$\pm 2\sigma \approx 90\%$

$\pm\sigma \rightarrow 68\%$



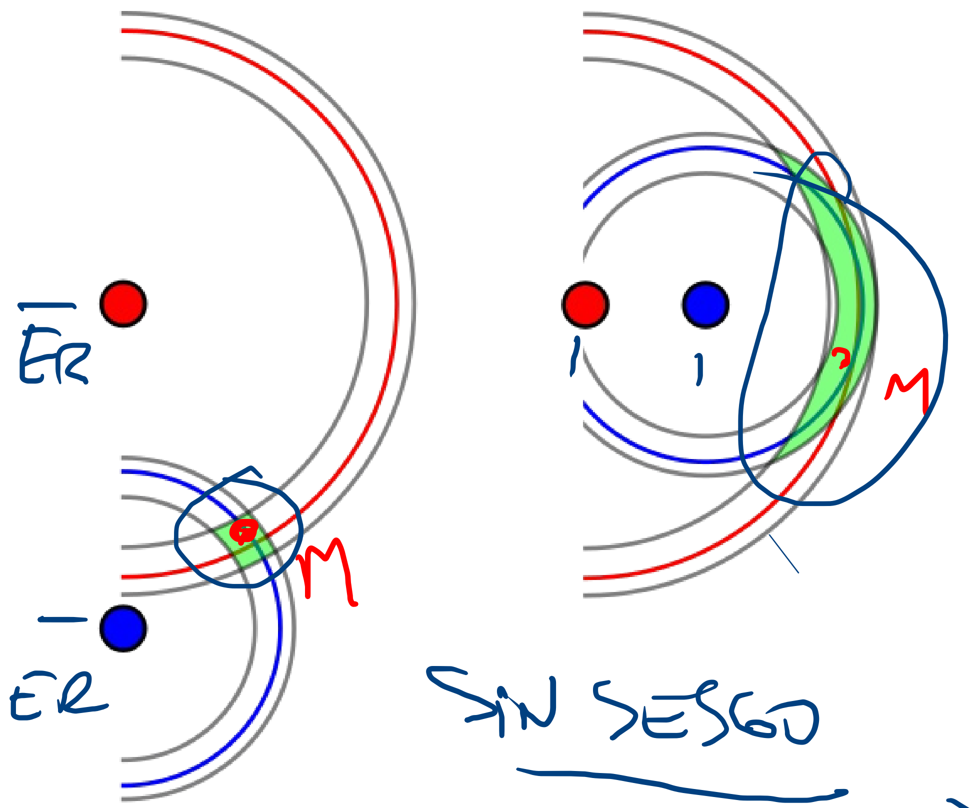




μ MEDIA

— MEDIANA

Precisión - Dilution of Precision



SIN SESGO

(x, y, z, b)

$$d_1 = \sqrt{(x_1-x)^2+(y_1-y)^2}+b$$

PSEUDORANGO

$$h = \begin{bmatrix} \sqrt{(x_1-x)^2+(y_1-y)^2+(z_1-z)^2}+b \\ \vdots \\ \sqrt{(x_N-x)^2+(y_N-y)^2+(z_N-z)^2}+b \end{bmatrix} \rightarrow \nabla h = \frac{\partial h}{\partial n_i}$$

$\hat{x}, \hat{y}, \hat{z}, \hat{b}$

$$A = (\nabla h^T \nabla h)^{-1} \sigma_d = \begin{bmatrix} \sigma_x^2 & \sigma_{xy} & \sigma_{xz} & \sigma_{xb} \\ \sigma_{xy} & \sigma_y^2 & \sigma_{yz} & \sigma_{yb} \\ \sigma_{xz} & \sigma_{yz} & \sigma_z^2 & \sigma_{zb} \\ \sigma_{xb} & \sigma_{yb} & \sigma_{zb} & \sigma_b^2 \end{bmatrix}$$

40 60

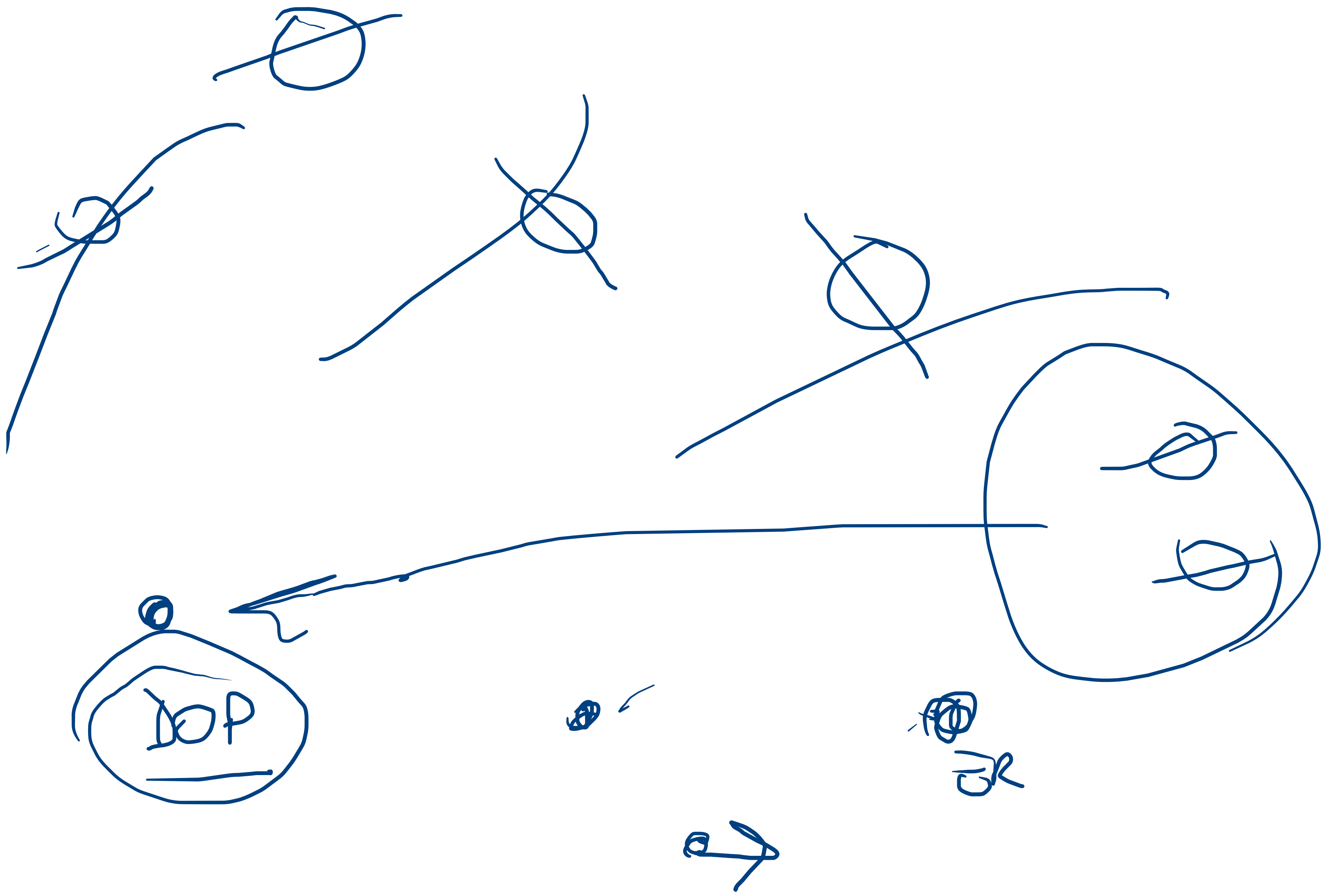
60

1000

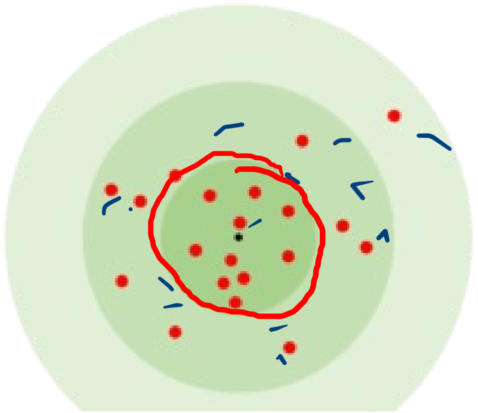
$DOPG = \sqrt{\sigma_x^2+\sigma_y^2+\sigma_z^2+\sigma_b^2}$

$DOPx = \sqrt{\sigma_x^2}$ 30

$DOPH = \sqrt{\sigma_x^2+\sigma_y^2}$ $DOPz = \sqrt{\sigma_z^2}$ $DOP_b = \sqrt{\sigma_b^2}$


DOP
JR

Circular Error Probability - Cramer Rao Lower Bound



R$_{95}$ (uncertain reading)

CEP

50% 2σ

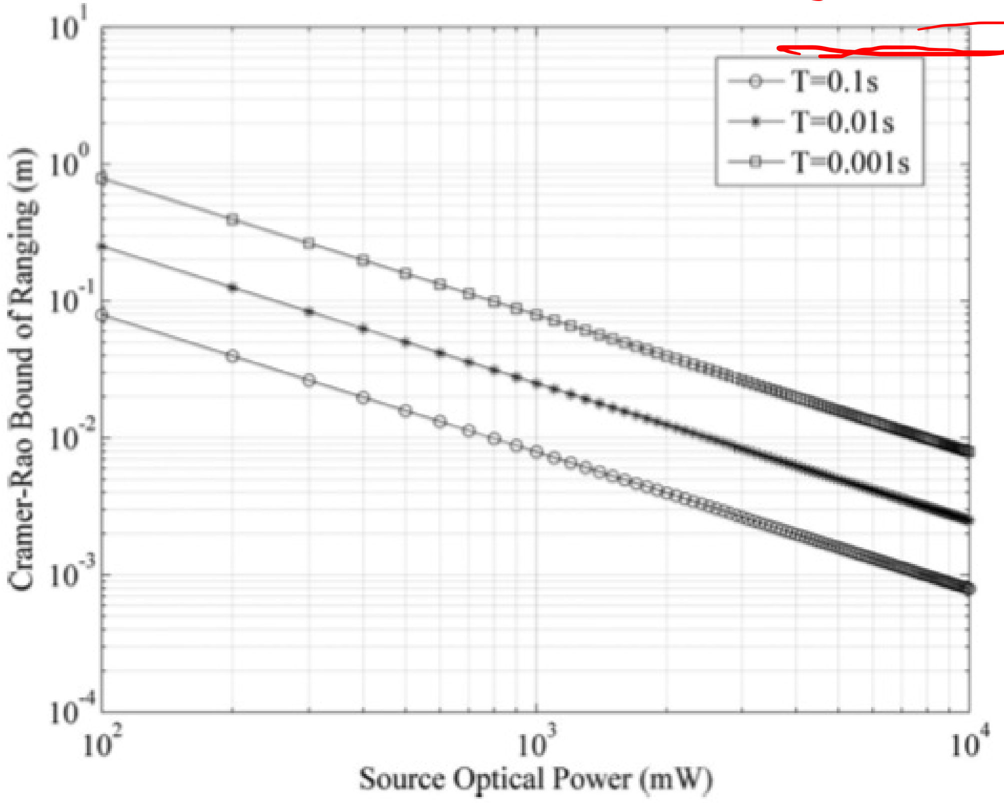
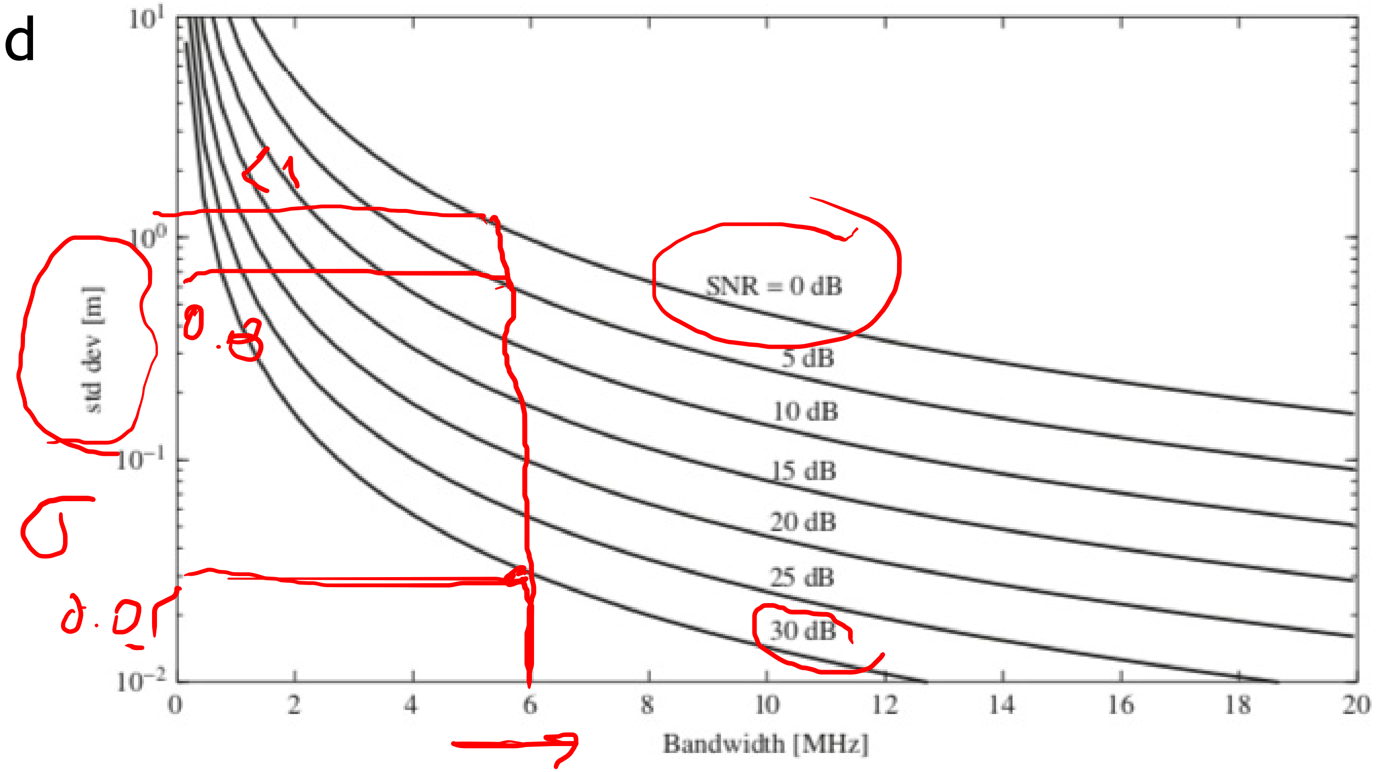


Fig. 4. CRB versus the emitted optical power with various time durations.



<1

0.8

σ

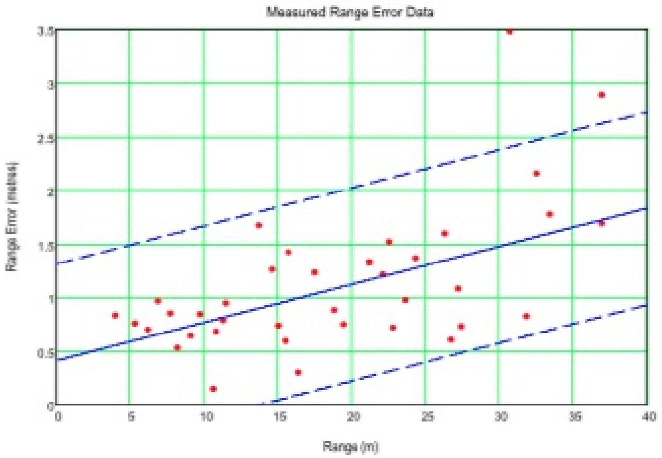
0.01

Koorapaty, Havish. "Cramer-Rao bounds for time of arrival estimation in cellular systems." 2004 IEEE 59th Vehicular Technology Conference. VTC 2004-Spring (IEEE Cat. No. 04CH37514). Vol. 5. IEEE, 2004.

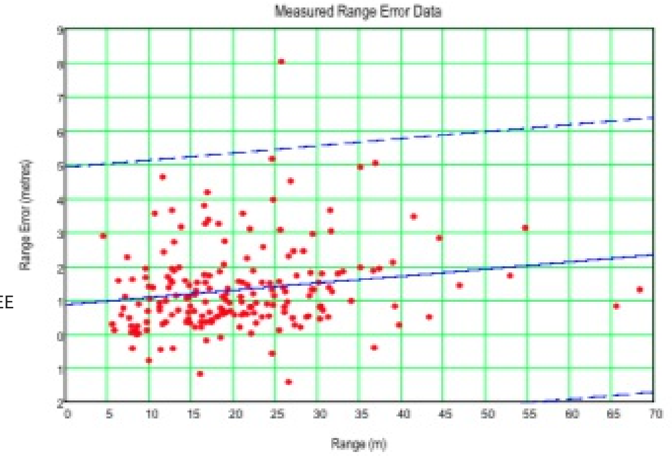
MONTE CARLO

$P(\|X_i - X\| < 0.5)$

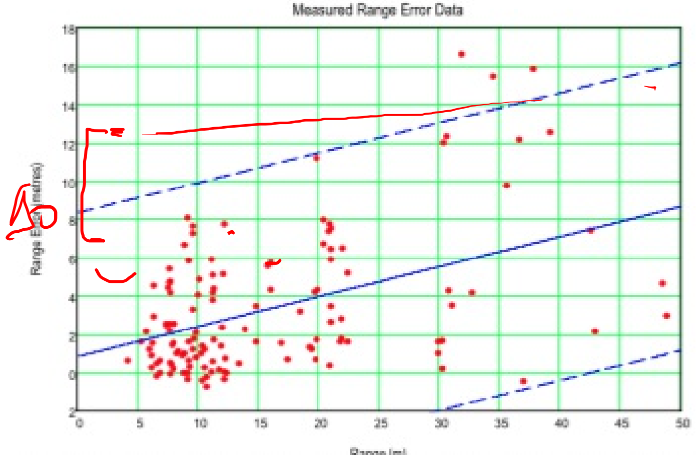
CRLB: COTA INFERIOR DEL ERROR



(a)



(b)



Evaluación a partir de medidas

Sharp, Ian, and Kegen Yu. "Indoor TOA error measurement, modeling, and analysis." IEEE Transactions on Instrumentation and Measurement 63.9 (2014): 2129-2144.

Parameter	UWB	WASP	PLS
RF Frequency	5 GHz	5.8 GHz	2.4 GHz
RF Channel	500 MHz	125 MHz	60 MHz
Bandwidth (3 dB)	250 MHz	65 MHz	40 MHz
Pulse rise-time	3 ns (0.9 m)	13.5 ns (4 m)	25 ns (7.5 m)
Coverage Area	800 m²	10000 m²	1500 m²

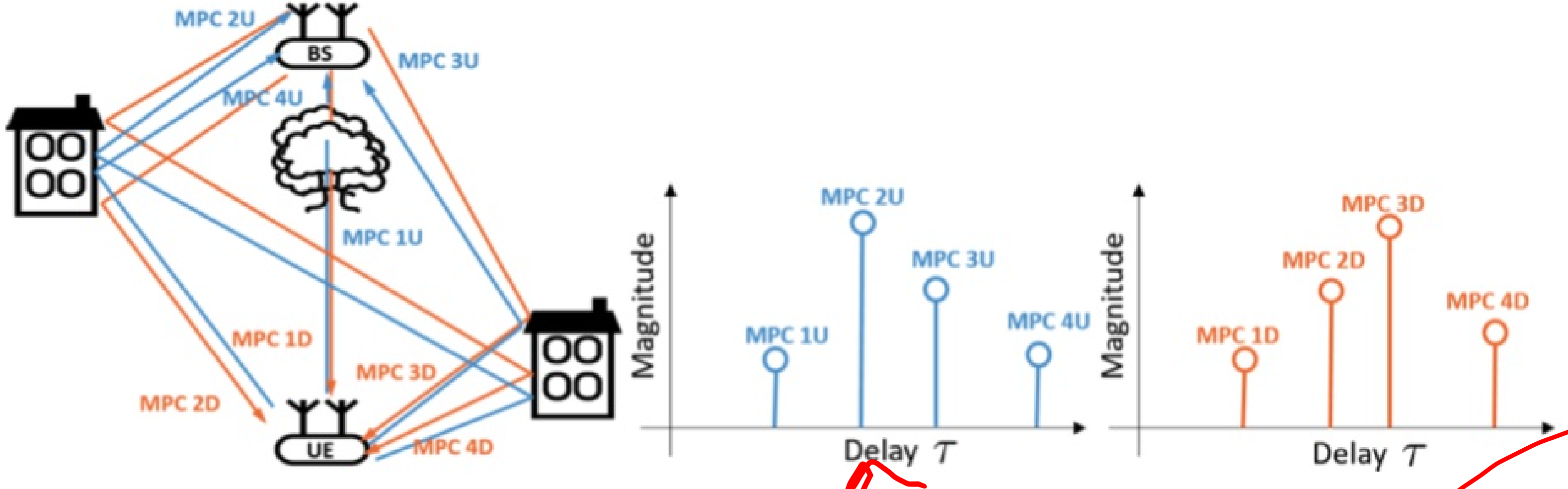
UWB RDS PLS

$$\varepsilon_{TOT} = \varepsilon(t) + \varepsilon(R, N_P, \sigma_S)$$

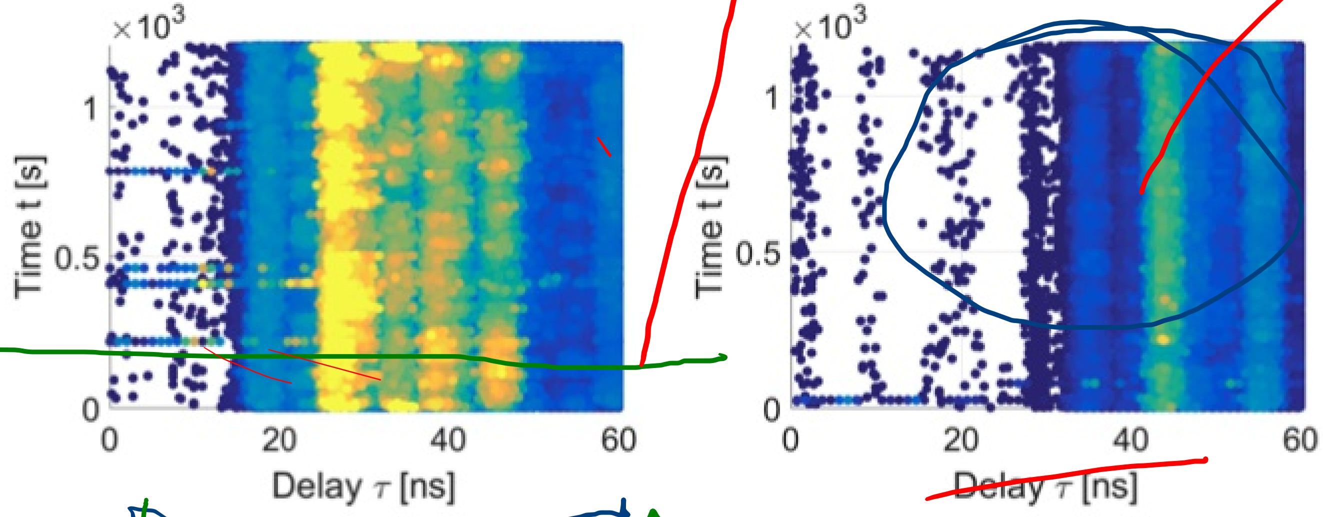
$$\varepsilon_{TOT} = \Delta 0 + m x$$

Evaluación por simulación

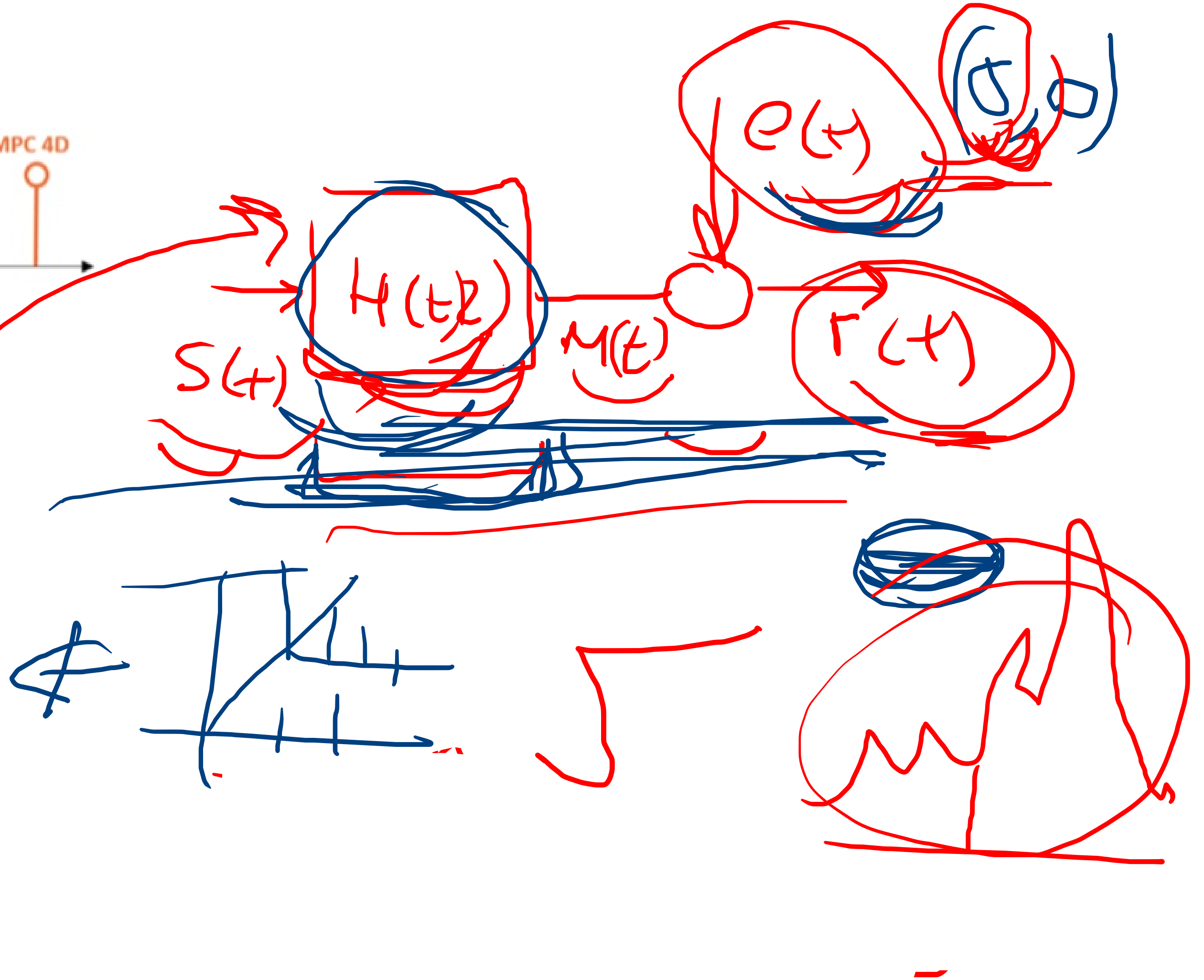
Bergström, Andreas, et al. "TOA estimation improvements in multipath environments by measurement error models." 2017 IEEE 28th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC). IEEE, 2017.

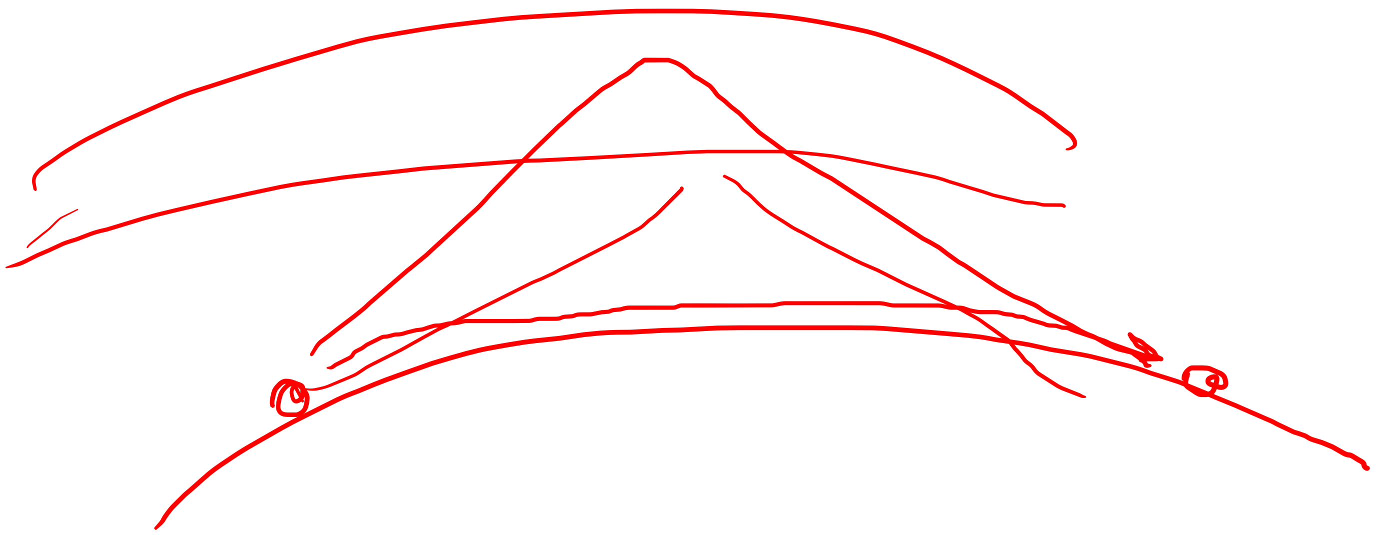


(a) (b)

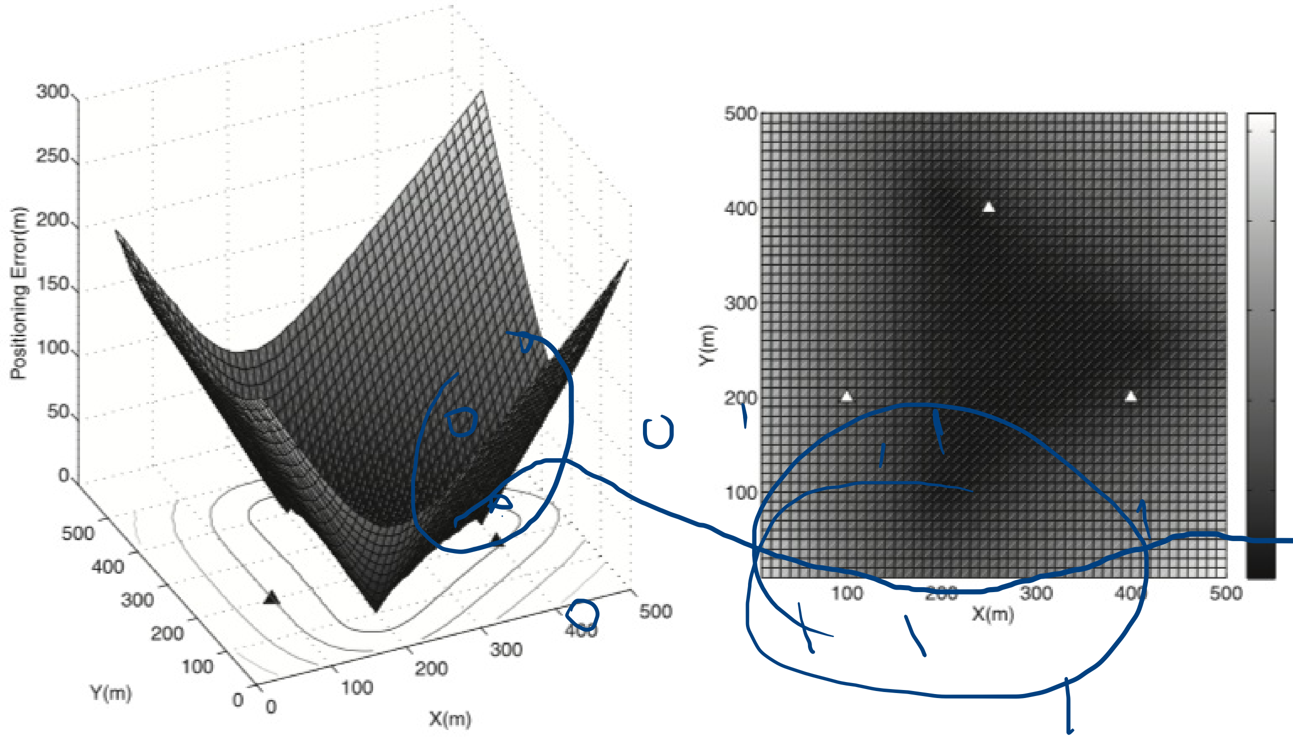


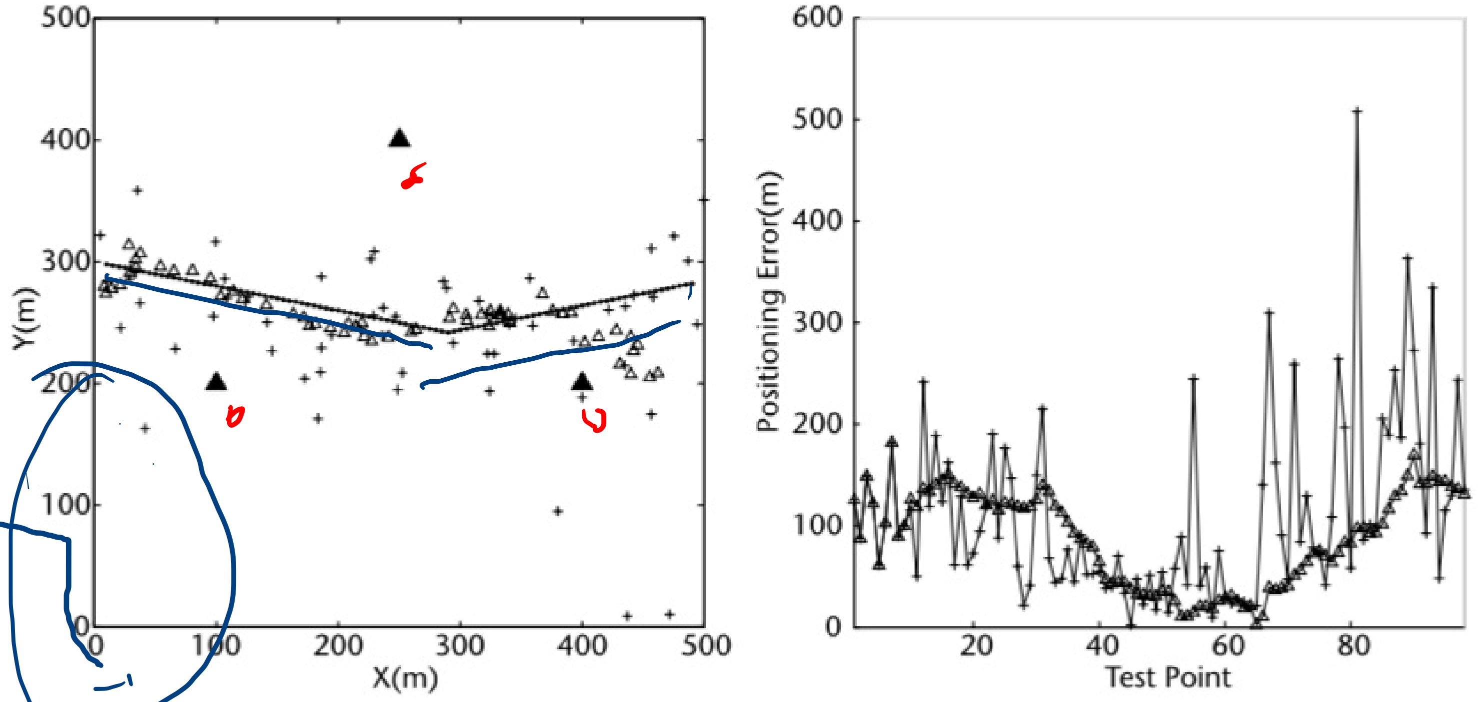
(a) LoS (b) NLoS





Evaluación por simulación





Ejercicio: Programa ch02fig05_06.m
(\toaErrorMaps\toaNlosErrorMap.m)

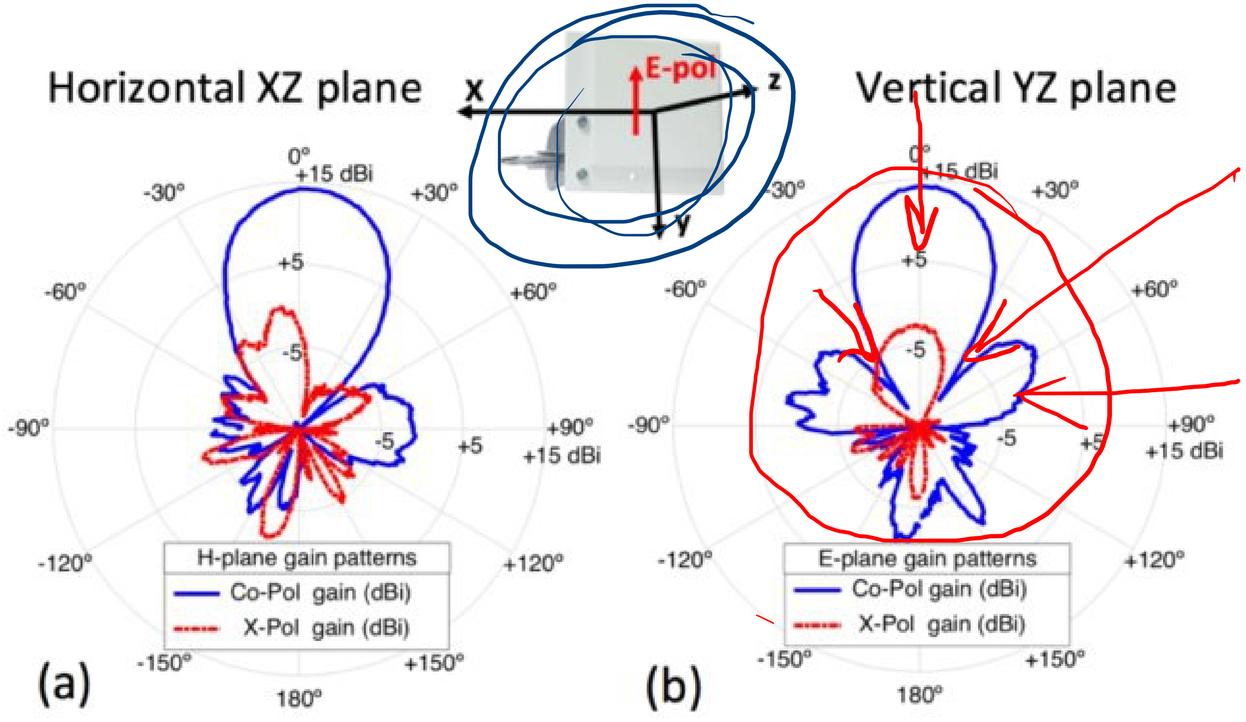
Ejercicio: Programa ch02ex02.m

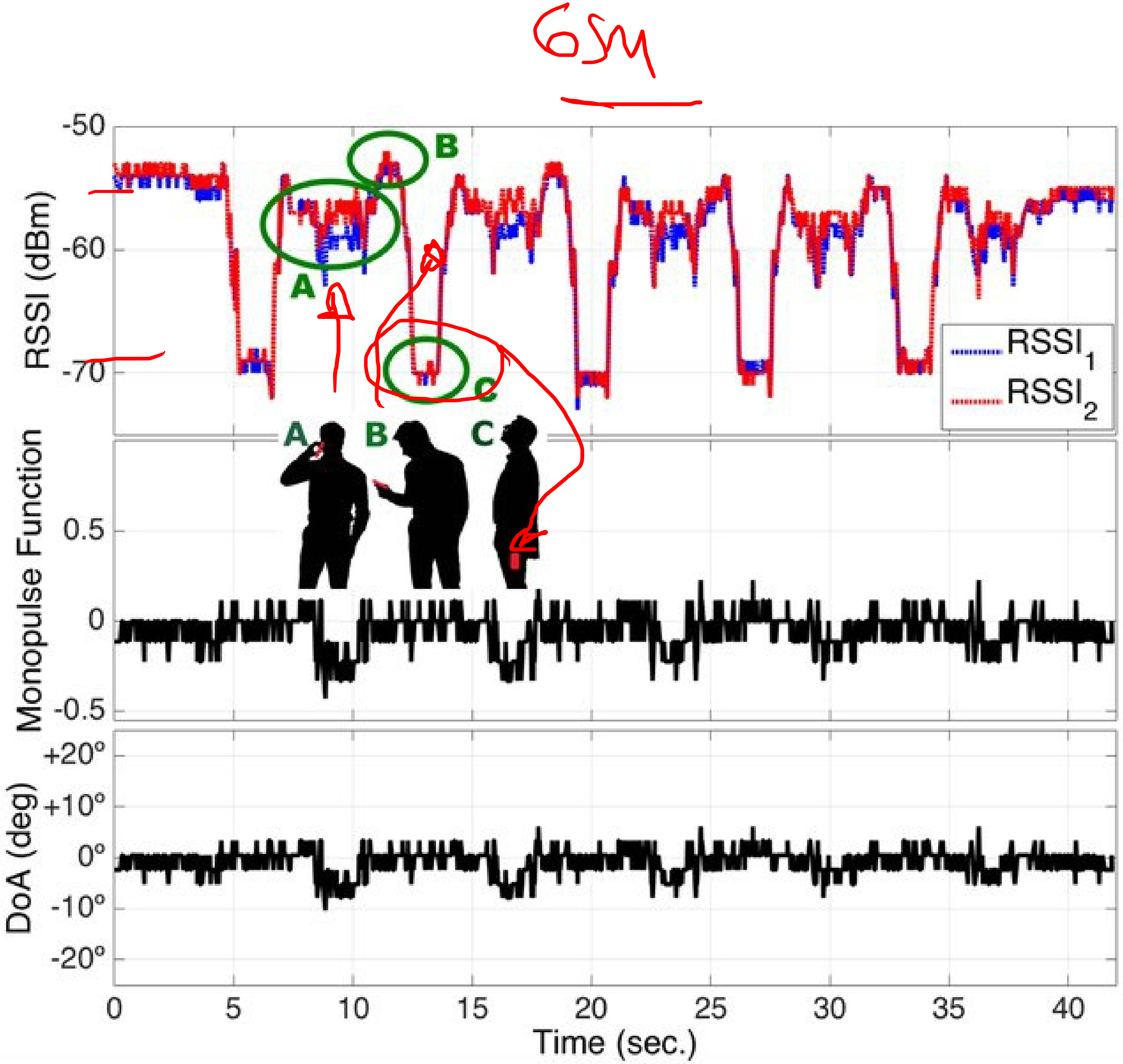
τ

→ Prop. $Z_m \rightarrow Z_{rms}$

. LogNorma $x \Rightarrow \log x$

Uso de RSS (RANGO) E R – M (TOA)



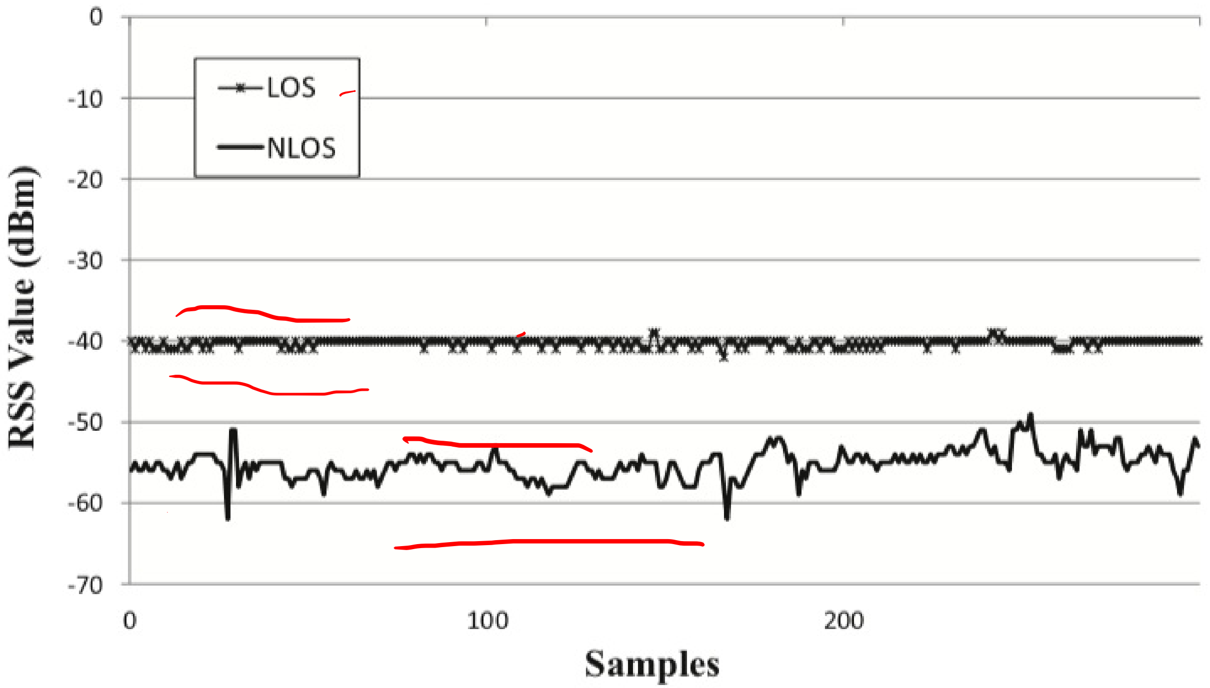


RADIO SIGNAL STRENGHT

Fácil de implementar, barato, se puede utilizar con varias tecnologías.

RSS

Propenso a desvanecimiento multicamino y al ruido ambiental, menor precisión de localización, la info es mas usada en otras técnicas (fingerprint)



Triangulación usando RSS

P_r $\quad$ P_0

$$RSS(d) = RSS(d_0) - 10\eta \log\left(\frac{d}{d_0}\right) + w$$

$$d = d_0 \, 10^{\frac{P_0 - P_r}{10\eta}}$$

$$P_0 = P_T + K$$

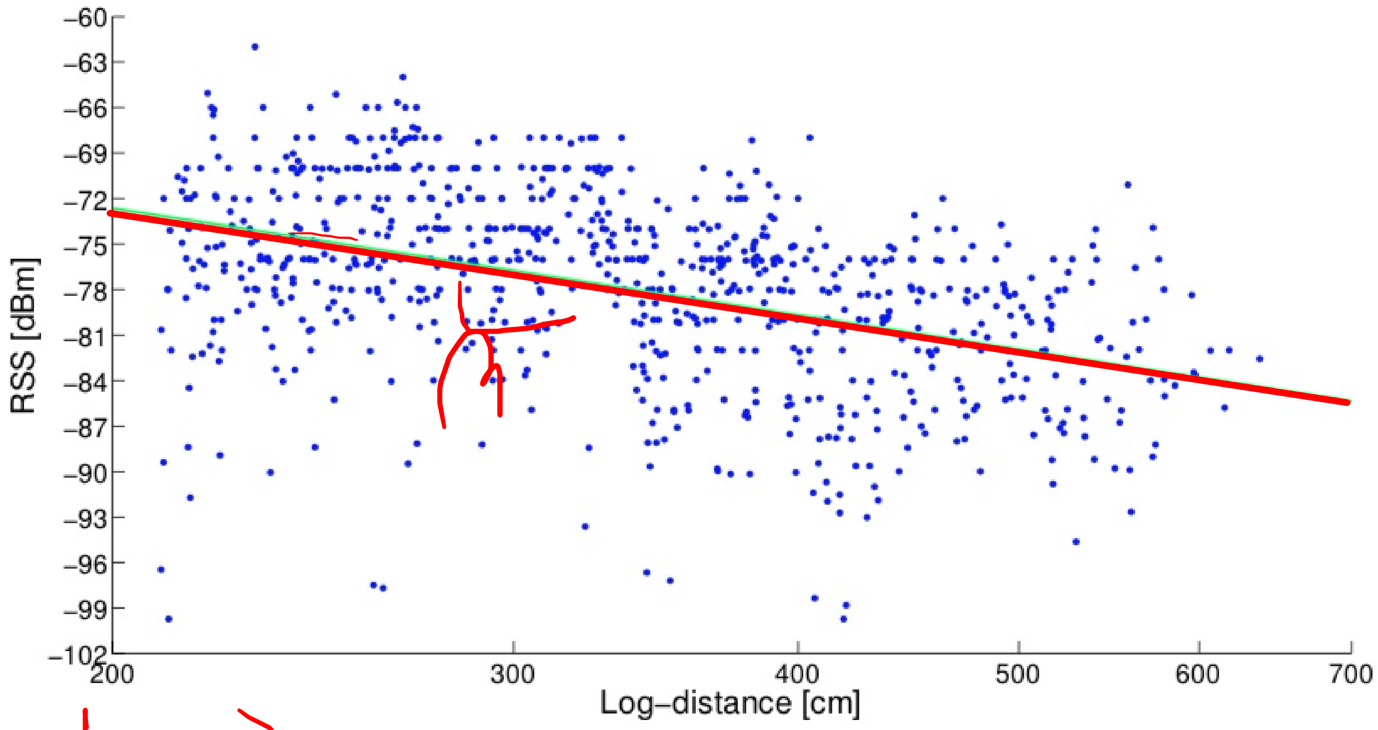


Fig. 3. Experimental RSS measurements for all anchors and related LSM model. Model parameters are $\eta = 2.3$, $K = -17.2$, $\rho = 0.42$, $\sigma_w = 6$ dB

$$A x = B$$

$$\hat{X} = (A^T A)^{-1} A^T B$$

$$A = \begin{bmatrix} 2 & 6 \\ 2 & 5.99999 \end{bmatrix}$$

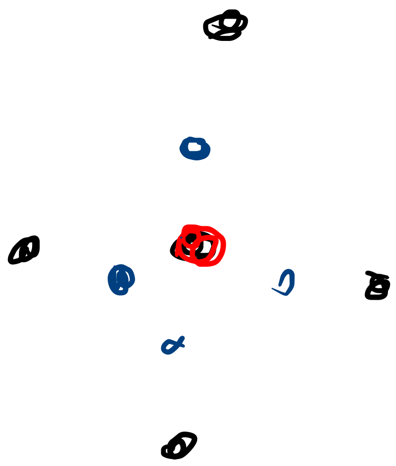
$$B = \begin{bmatrix} 8 \\ 8.00001 \end{bmatrix} \rightarrow B = \begin{bmatrix} 8 \\ 8.0001 \end{bmatrix}$$

$$A = \begin{bmatrix} 2(x_2 - x_1) & 2(y_2 - y_1) \\ \vdots & \\ 2(x_N - x_1) & 2(y_M - y_1) \end{bmatrix} \times \quad N \times 2$$

$$B = \begin{bmatrix} \hat{d}_1^2 - \hat{d}_2^2 + x_2^2 + x_1^2 + y_1^2 + y_2^2 \\ \vdots \\ \hat{d}_1^2 - d_N^2 + x_N^2 + y_N^2 + y_1^2 + y_2^2 \end{bmatrix}$$

① $\hat{X} = \begin{bmatrix} 7 \\ -1 \end{bmatrix}$ ② $\hat{X} = \begin{bmatrix} 304 \\ -100 \end{bmatrix}$

1_ N medidas RSS



2_ ORDENO DE MAYOR A MENOR

$\boxed{3\_}$ ELIJO 3 (4) y armo A

4_ CALCULO EL COND(A) < U   Cond $\left[(A^T A)^{-1} A^T\right]$

5_ ELIJAS 3 (4) mejor cond. $\tilde{X}_k = X_{k-1} + \Delta X$

3_ $ER_1 \cdots ER_4$

$$\begin{array}{ll} A_1 = ER_1 ER_2 ER_3 & \hat{X}_1 \\ A_2 = ER_1 ER_2 ER_4 & \hat{X}_2 \\ \cancel{A_3 = ER_2 ER_3 ER_4} & \cancel{\hat{X}_3} \\ A_4 = ER_1 ER_3 ER_4 & \hat{X}_4 \end{array}$$

con > U

$$\hat{X} = \frac{1}{M} \sum_{i=1}^{M} \hat{X}_i w_i$$

$$w = \frac{P_i}{\sum_{j=1}^{N} P_j}$$

$w_i = \cancel{B}$ $\sum w_i = 1$

RSS - Minimos cuadrados iterativo

$$\hat{d}_i^2 = (x_i - x)^2 + (y_i - y)^2$$

$$\hat{d}_i = 10^{\frac{P_0 - P_{r,i}}{10\eta}}$$

1 - (x_0, y_0)

2 - $(x_k, y_k) = (x_{k-1}, y_{k-1}) + (\Delta x, \Delta y)_k$

3 - $\sqrt{\Delta x^2 + \Delta y^2} < \mu$

$$\delta d_i = \frac{(x_i - x)\,\delta x + (y_i - y)\,\delta y}{\sqrt{(x_i - x)^2 + (y_i - y)^2}} = \frac{x_i - x}{\sqrt{\ }}\,\delta x + \frac{y_i - y}{\sqrt{\ }}\,\delta y$$

$$\begin{bmatrix} \delta d_1 \\ \delta d_2 \\ \vdots \\ \delta d_N \end{bmatrix} = \begin{bmatrix} \frac{x_1 - x}{\sqrt{\ }} & \frac{y_1 - y}{\sqrt{\ }} \\ \vdots & \\ \frac{x_N - x}{\sqrt{\ }} & \frac{y_N - y}{\sqrt{\ }} \end{bmatrix} \begin{bmatrix} \delta x \\ \delta y \end{bmatrix}$$

$$\begin{bmatrix} \delta x \\ \delta y \end{bmatrix} = \begin{bmatrix} \frac{x_i - x}{\sqrt{\ }} & \frac{y_i - y}{\sqrt{\ }} \\ \vdots & \end{bmatrix}^{+} \begin{bmatrix} \delta d_1 \\ \vdots \\ \delta d_N \end{bmatrix}$$

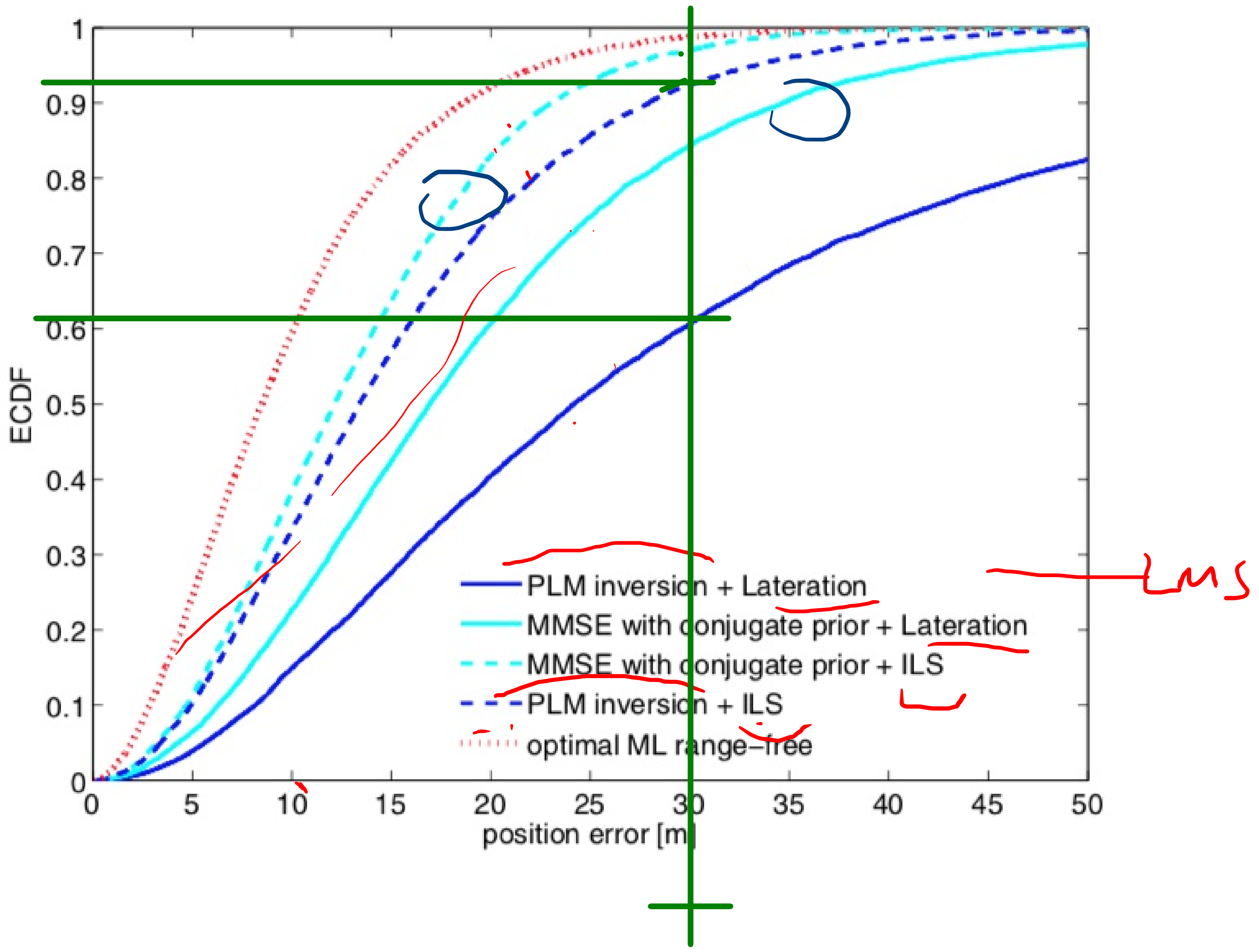
$(A^T A)^{-1} A^T$

(x_{k-1}, y_{k-1})

$$\delta d_i = \hat{d}_i - \hat{d}_{i,k-1}$$

RSS - Minimos cuadrados iterativo

Coluccia, Angelo, and Fabio Ricciato. "RSS-based localization via Bayesian ranging and iterative least squares positioning." IEEE Communications etters 18.5 (2014): 873-876.



RSS - Algoritmo Bayesiano

$r_i \to \mathcal{N}(0,\sigma)$

$$P_{r,i} = \theta_i + n_i$$

$$\theta_i = P_0 - 10\eta \log \frac{d_i}{d_0}$$

$\mathcal{N}(\bar{\theta}_i, \sigma_\theta)$

$$p(\theta_i|r_i) = \frac{p(r_i|\theta_i) \cdot p(\theta_i)}{p(r_i)}$$

APRIORI

LIKELIHOOD

VEROSIMILITUD

(MODELO DE LA SEÑAL)

LMS, A, B

ITERA, DX, DY

$$\hat{d}_i = 10^{\frac{P_0 - \hat{\theta}_i}{10\eta}}$$

$P_{R,i}$

$$\hat{\theta}_i = \hat{B}\bar{r} + (1-\hat{B})r_i \qquad \bar{r} = \frac{1}{M}\sum_{1}^{M} r_i$$

$$\hat{B} = \frac{\sigma^2}{\sigma + \nu^2}$$

$$\nu = \max(0, S^2 - \sigma^2)$$

$$S^2 = \frac{1}{M}\sum_{i}^{M}(r_i - \bar{r})^2$$