



UNIDAD DE RADIATIVIDAD AMBIENTAL Y VIGILANCIA RADIOLÓGICA

Ciemat

Departamento de Medio Ambiente

Unidad Radiactividad Ambiental y Vigilancia Radiológica

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Unidad Dosimetría Radiaciones

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**Benavente
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Expósito Suarez

José Antonio

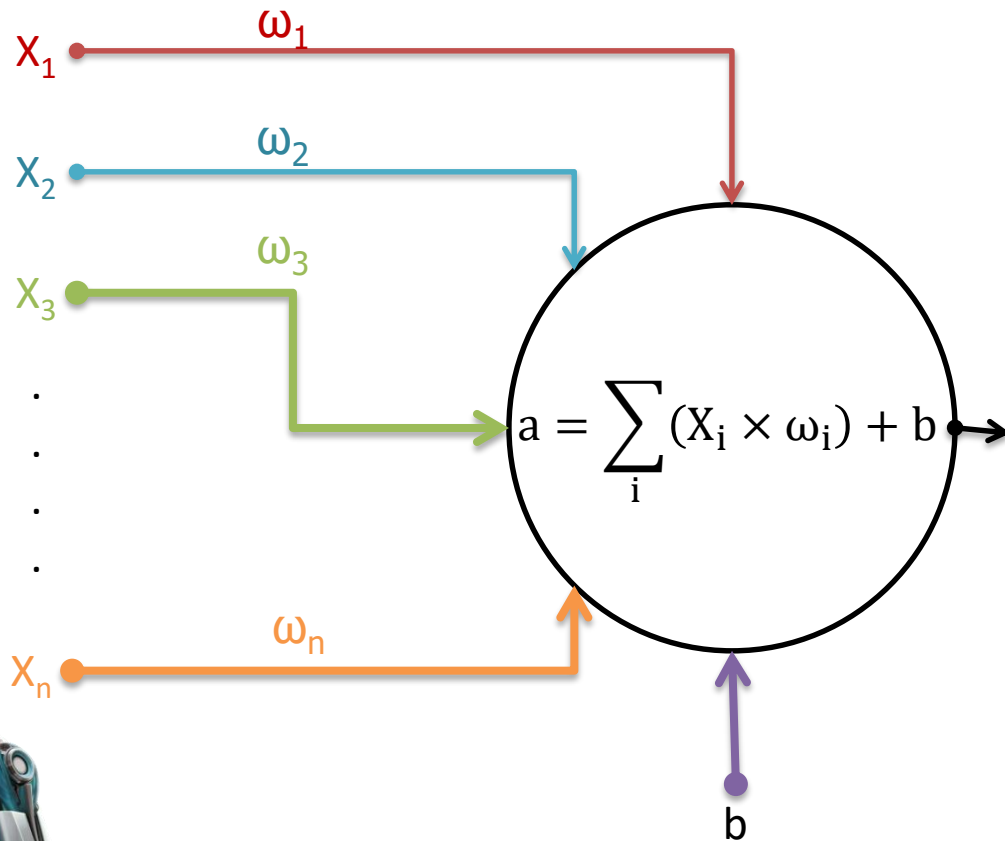
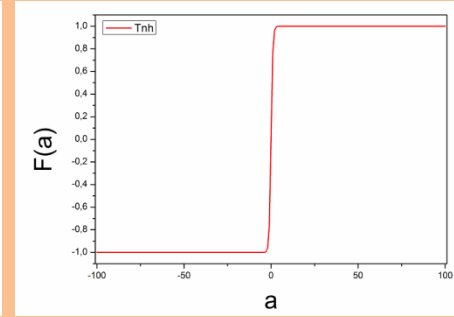
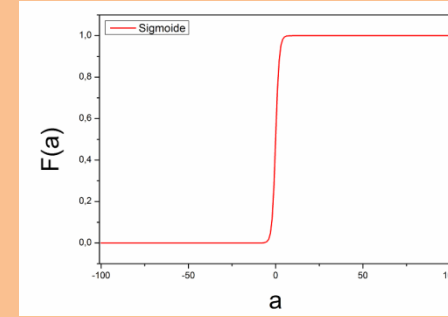
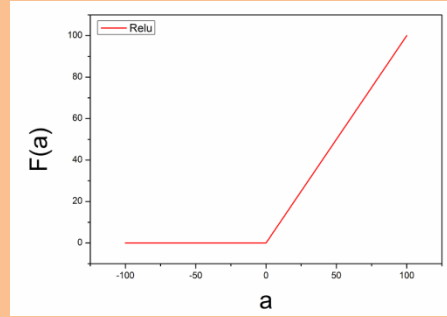
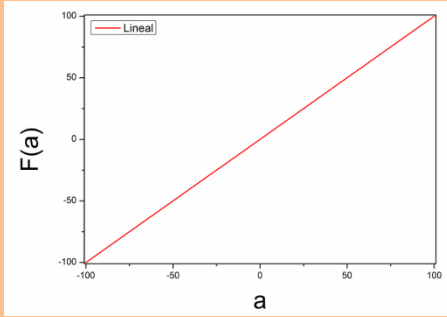
Suarez Navarro



<https://twitter.com/UrayvrCiemat>

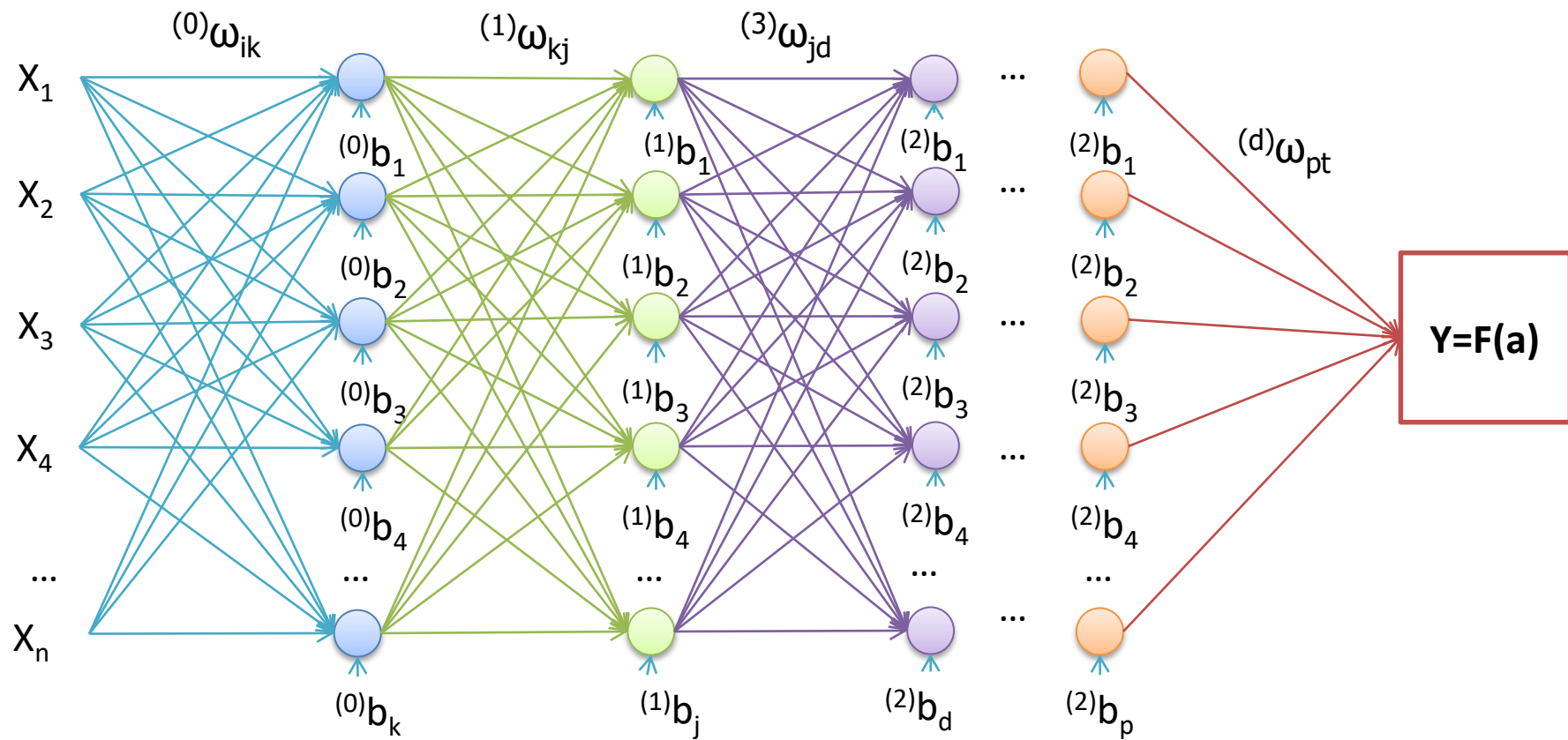
Diseño de una red neuronal completamente conectada para la interpolación de datos complejos, asociados a la caracterización radiológica de zonas impactadas por radionúclidos naturales.





$$F(a) = \begin{cases} \text{Lineal} := a \\ \text{Relu} := \begin{cases} a; & \text{si } a > 0 \\ 0; & \text{si } a \leq 0 \end{cases} \\ \text{Sigmoide} := \frac{1}{1 + e^a} \\ \text{Tanh} := \frac{e^a - e^{-a}}{e^a + e^{-a}} \\ \text{Softmax} := \frac{e^{a_i}}{\sum_j e^{a_j}} \end{cases}$$





Variables independientes
(Medidas in situ)

Variables Dependientes
(Medidas en laboratorio – $Bq \cdot kg^{-1}$)

$[(^{(1)}H^*(10)_{c+b}, (^{(1)}H^*(10)_c, (^{(1)}H^*(10)_{1m}, (^{(1)}\alpha_{Total}, (^{(1)}\beta_{Total}, (^{(1)}\gamma|\beta_{Total})]$ $[(^{(1)}_{210}Pb, (^{(1)}_{234}Pa_m, (^{(1)}_{226}Ra, (^{(1)}_{214}Pb]$

$[(^{(2)}H^*(10)_{c+b}, (^{(2)}H^*(10)_c, (^{(2)}H^*(10)_{1m}, (^{(2)}\alpha_{Total}, (^{(2)}\beta_{Total}, (^{(2)}\gamma|\beta_{Total})]$ $[(^{(2)}_{210}Pb, (^{(2)}_{234}Pa_m, (^{(2)}_{226}Ra, (^{(2)}_{214}Pb]$

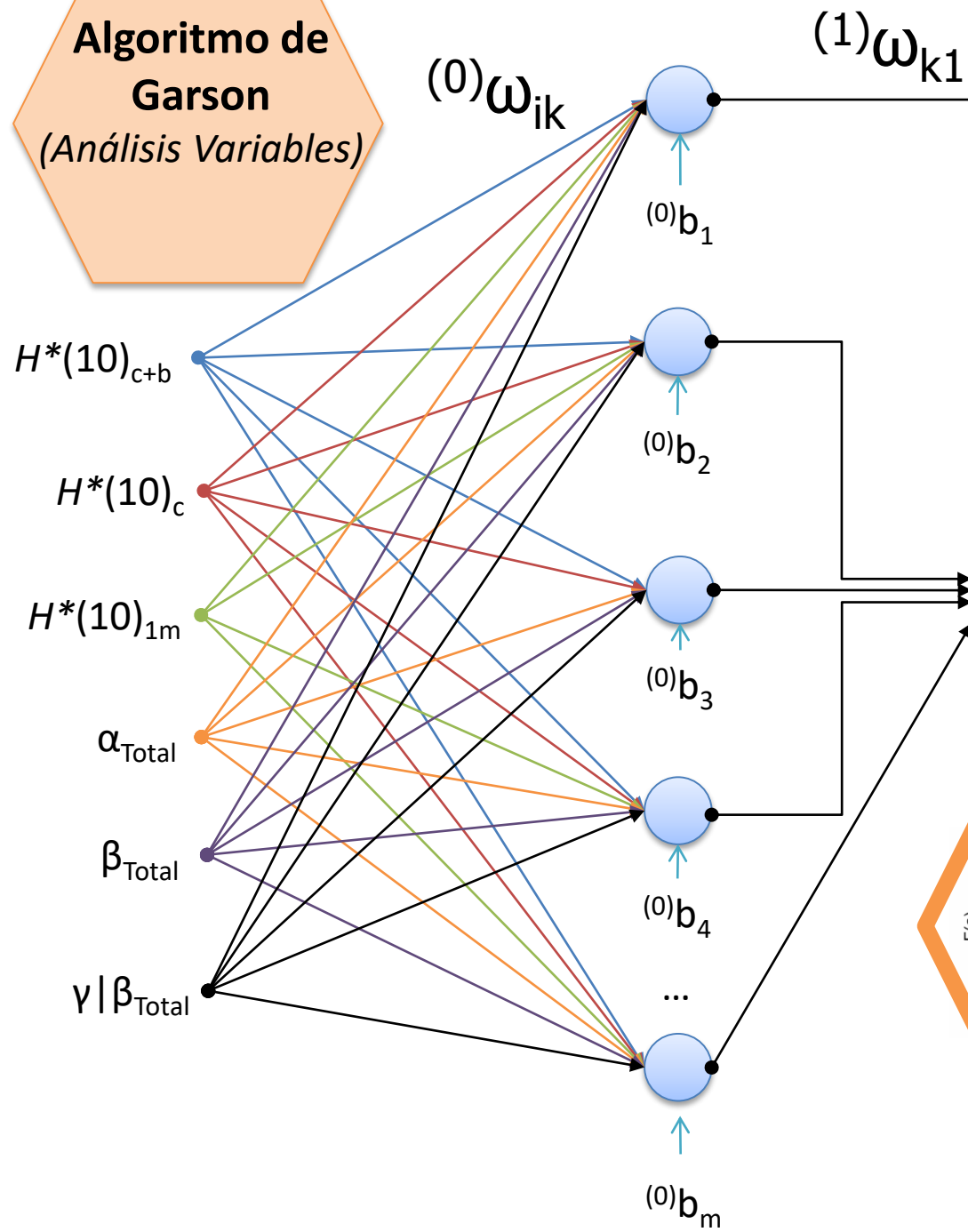
...

...

$[(^{(n)}H^*(10)_{c+b}, (^{(n)}H^*(10)_c, (^{(n)}H^*(10)_{1m}, (^{(n)}\alpha_{Total}, (^{(n)}\beta_{Total}, (^{(n)}\gamma|\beta_{Total})]$ $[(^{(n)}_{210}Pb, (^{(n)}_{234}Pa_m, (^{(n)}_{226}Ra, (^{(n)}_{214}Pb]$

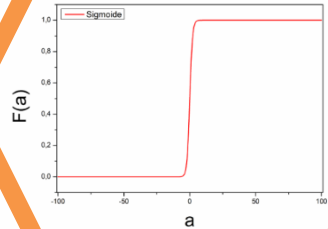
Algoritmo de Garson

(Análisis Variables)



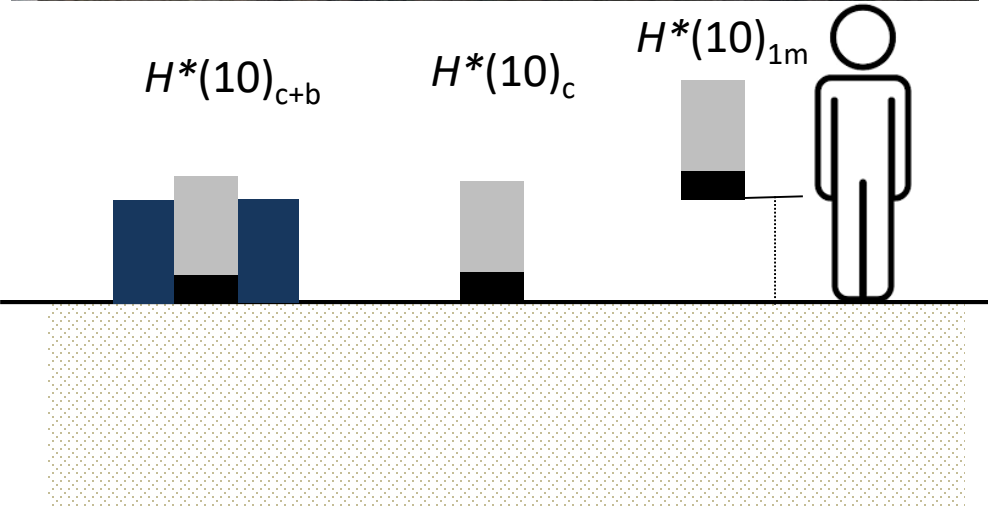
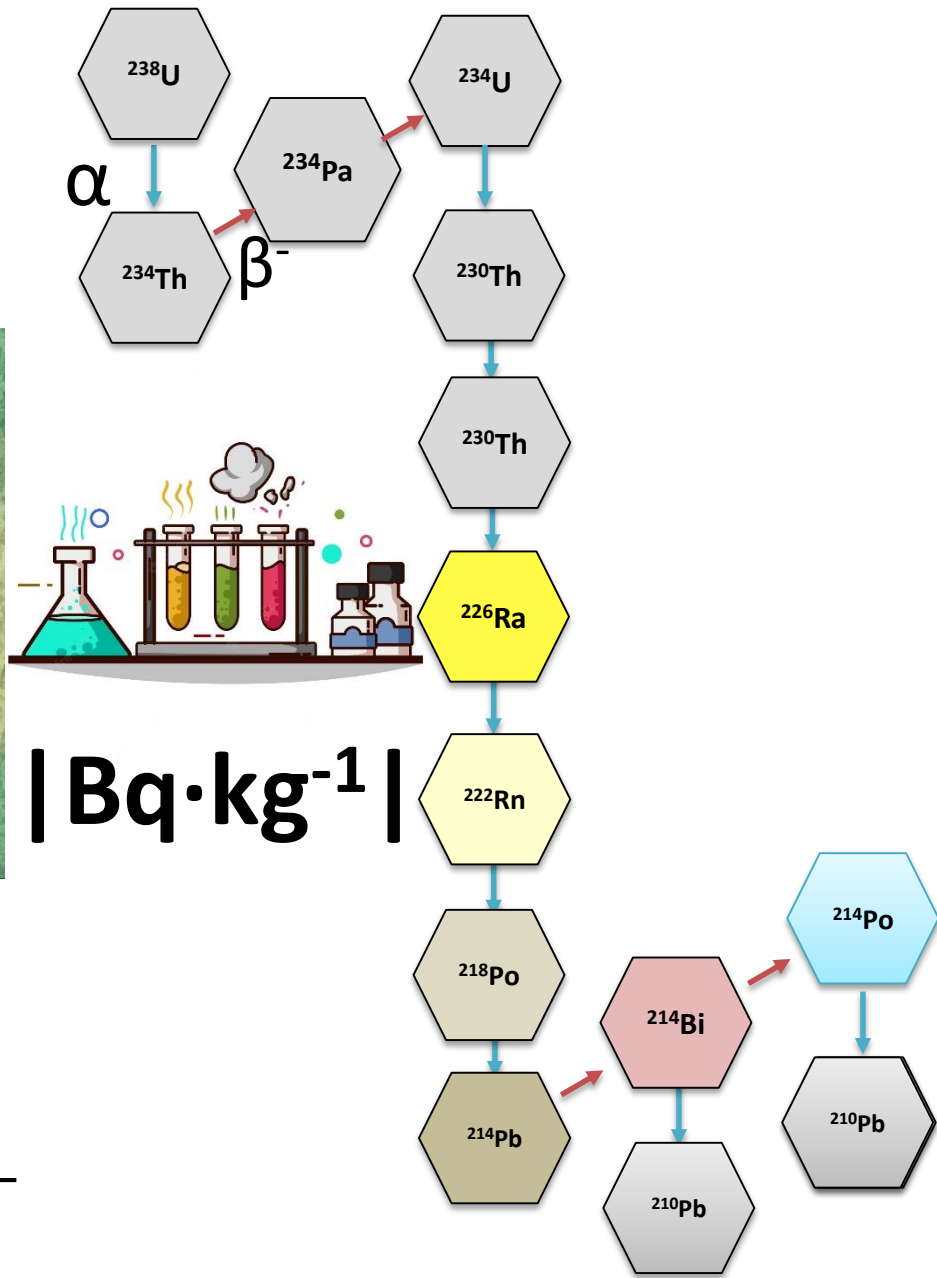
$$RI_i = \sum_{k=1}^m \frac{|(0)\omega_{ik} \times (1)\omega_{k1}|}{\sum_{i=1}^6 |(0)\omega_{ik} \times (1)\omega_{k1}|}$$

$$Y = \frac{1}{1 + \exp(\sum_{k=1}^m (1)\omega_{k1} \times (0)a_k + (1)b_1)}$$



Clasificación Binaria

Descripción Problema



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Variables independientes
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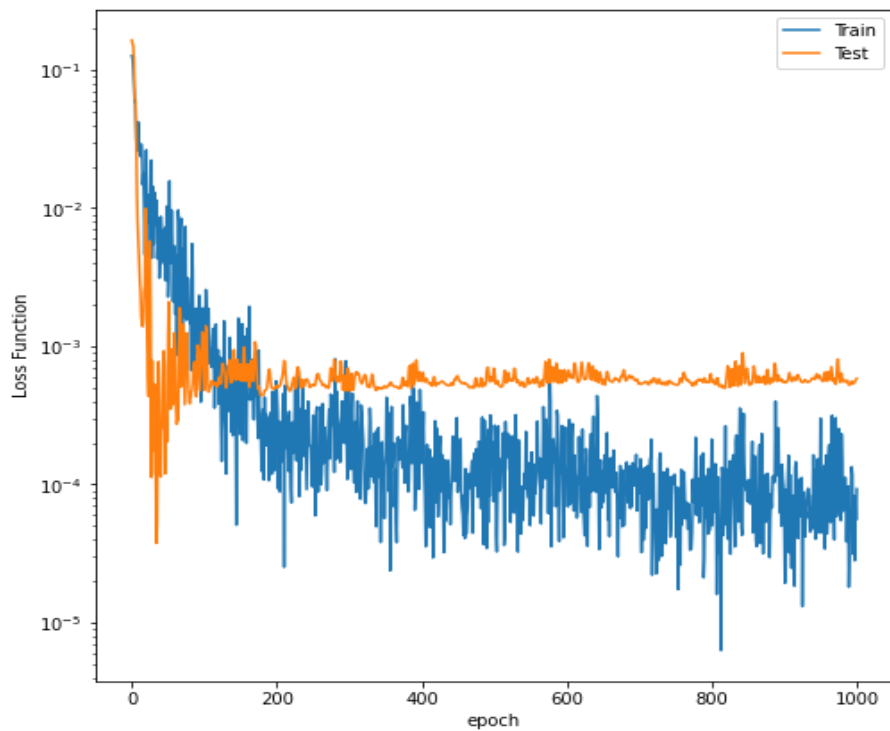
$^{(1)}H^*(10)_{c+b}, ^{(1)}H^*(10)_c, ^{(1)}H^*(10)_{1m}, ^{(1)}\alpha_{Total}, ^{(1)}\beta_{Total}, ^{(1)}\gamma \beta_{Total}$	$^{(1)}_{210}\text{Pb}, ^{(1)}_{234m}\text{Pa}, ^{(1)}_{226}\text{Ra}, ^{(1)}_{214}\text{Pb}$
$^{(2)}H^*(10)_{c+b}, ^{(2)}H^*(10)_c, ^{(2)}H^*(10)_{1m}, ^{(2)}\alpha_{Total}, ^{(2)}\beta_{Total}, ^{(2)}\gamma \beta_{Total}$	$^{(2)}_{210}\text{Pb}, ^{(2)}_{234m}\text{Pa}, ^{(2)}_{226}\text{Ra}, ^{(2)}_{214}\text{Pb}$
$^{(3)}H^*(10)_{c+b}, ^{(3)}H^*(10)_c, ^{(3)}H^*(10)_{1m}, ^{(3)}\alpha_{Total}, ^{(3)}\beta_{Total}, ^{(3)}\gamma \beta_{Total}$	$^{(3)}_{210}\text{Pb}, ^{(3)}_{234m}\text{Pa}, ^{(3)}_{226}\text{Ra}, ^{(3)}_{214}\text{Pb}$
$^{(4)}H^*(10)_{c+b}, ^{(4)}H^*(10)_c, ^{(4)}H^*(10)_{1m}, ^{(4)}\alpha_{Total}, ^{(4)}\beta_{Total}, ^{(4)}\gamma \beta_{Total}$	$^{(4)}_{210}\text{Pb}, ^{(4)}_{234m}\text{Pa}, ^{(4)}_{226}\text{Ra}, ^{(4)}_{214}\text{Pb}$
$^{(5)}H^*(10)_{c+b}, ^{(5)}H^*(10)_c, ^{(5)}H^*(10)_{1m}, ^{(5)}\alpha_{Total}, ^{(5)}\beta_{Total}, ^{(5)}\gamma \beta_{Total}$	$^{(5)}_{210}\text{Pb}, ^{(5)}_{234m}\text{Pa}, ^{(5)}_{226}\text{Ra}, ^{(5)}_{214}\text{Pb}$
$^{(6)}H^*(10)_{c+b}, ^{(6)}H^*(10)_c, ^{(6)}H^*(10)_{1m}, ^{(6)}\alpha_{Total}, ^{(6)}\beta_{Total}, ^{(6)}\gamma \beta_{Total}$	$^{(6)}_{210}\text{Pb}, ^{(6)}_{234m}\text{Pa}, ^{(6)}_{226}\text{Ra}, ^{(6)}_{214}\text{Pb}$
$^{(7)}H^*(10)_{c+b}, ^{(7)}H^*(10)_c, ^{(7)}H^*(10)_{1m}, ^{(7)}\alpha_{Total}, ^{(7)}\beta_{Total}, ^{(7)}\gamma \beta_{Total}$	$^{(7)}_{210}\text{Pb}, ^{(7)}_{234m}\text{Pa}, ^{(7)}_{226}\text{Ra}, ^{(7)}_{214}\text{Pb}$
$^{(8)}H^*(10)_{c+b}, ^{(8)}H^*(10)_c, ^{(8)}H^*(10)_{1m}, ^{(8)}\alpha_{Total}, ^{(8)}\beta_{Total}, ^{(8)}\gamma \beta_{Total}$	$^{(8)}_{210}\text{Pb}, ^{(8)}_{234m}\text{Pa}, ^{(8)}_{226}\text{Ra}, ^{(8)}_{214}\text{Pb}$
...
$^{(n-3)}H^*(10)_{c+b}, ^{(n-3)}H^*(10)_c, ^{(n-3)}H^*(10)_{1m}, ^{(n-3)}\alpha_{Total}, ^{(n-3)}\beta_{Total}, ^{(n-3)}\gamma \beta_{Total}$	$^{(n-3)}_{210}\text{Pb}, ^{(n-3)}_{234m}\text{Pa}, ^{(n-3)}_{226}\text{Ra}, ^{(n-3)}_{214}\text{Pb}$
$^{(n-2)}H^*(10)_{c+b}, ^{(n-2)}H^*(10)_c, ^{(n-2)}H^*(10)_{1m}, ^{(n-2)}\alpha_{Total}, ^{(n-2)}\beta_{Total}, ^{(n-2)}\gamma \beta_{Total}$	$^{(n-2)}_{210}\text{Pb}, ^{(n-2)}_{234m}\text{Pa}, ^{(n-2)}_{226}\text{Ra}, ^{(n-2)}_{214}\text{Pb}$
$^{(n-1)}H^*(10)_{c+b}, ^{(n-1)}H^*(10)_c, ^{(n-1)}H^*(10)_{1m}, ^{(n-1)}\alpha_{Total}, ^{(n-1)}\beta_{Total}, ^{(n-1)}\gamma \beta_{Total}$	$^{(n-1)}_{210}\text{Pb}, ^{(n-1)}_{234m}\text{Pa}, ^{(n-1)}_{226}\text{Ra}, ^{(n-1)}_{214}\text{Pb}$
$^{(n)}H^*(10)_{c+b}, ^{(n)}H^*(10)_c, ^{(n)}H^*(10)_{1m}, ^{(n)}\alpha_{Total}, ^{(n)}\beta_{Total}, ^{(n)}\gamma \beta_{Total}$	$^{(n)}_{210}\text{Pb}, ^{(n)}_{234m}\text{Pa}, ^{(n)}_{226}\text{Ra}, ^{(n)}_{214}\text{Pb}$

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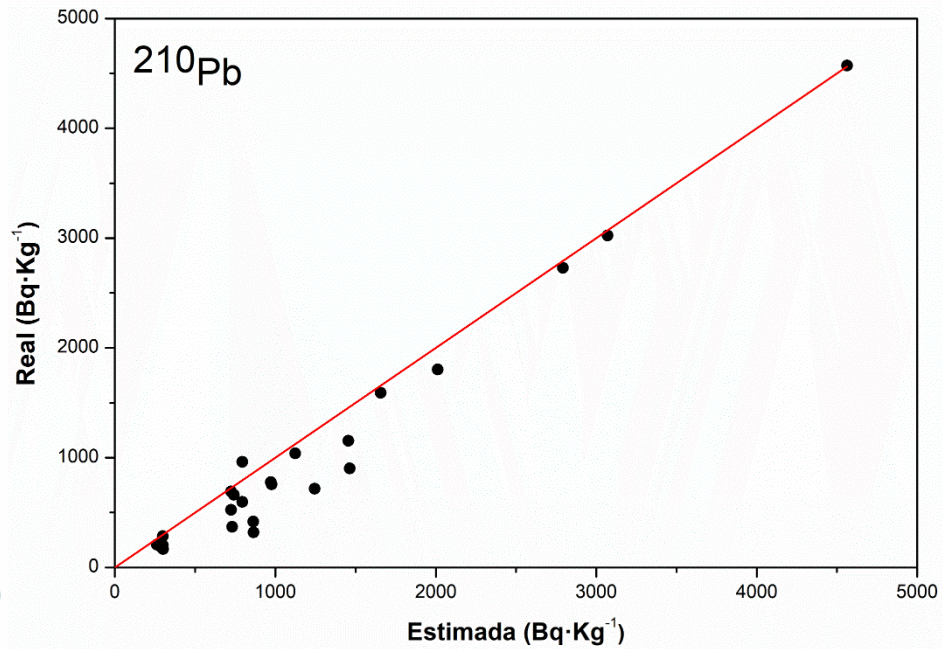
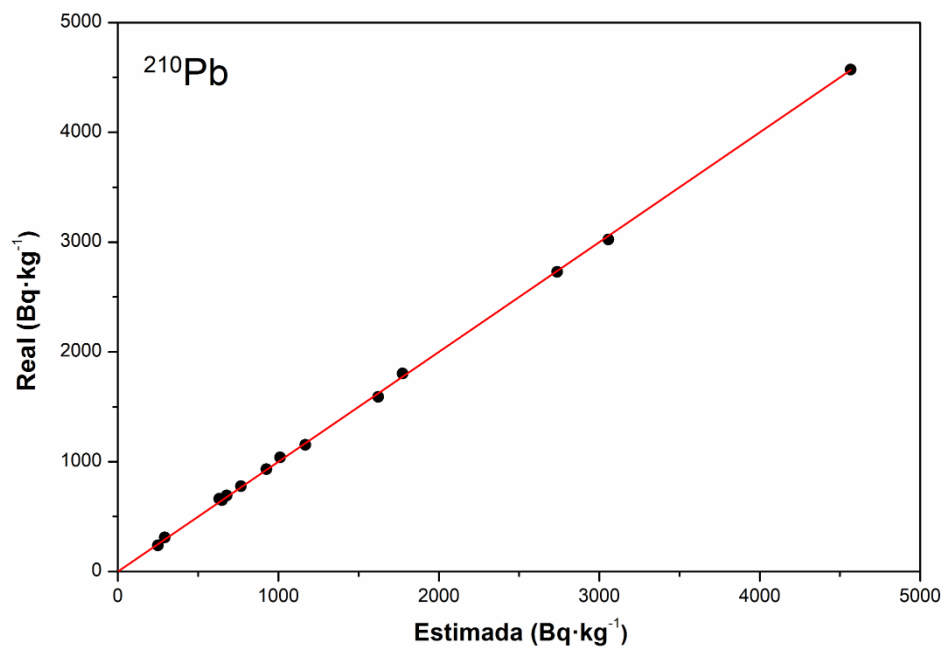
$[^{(1)}H^*(10)_{c+b}, ^{(1)}H^*(10)_c, ^{(1)}H^*(10)_{1m}, ^{(1)}\alpha_{Total}, ^{(1)}\beta_{Total}, ^{(1)}\gamma \beta_{Total}]$	$[^{(1)}_{210}\text{Pb}, ^{(1)}_{234m}\text{Pa}, ^{(1)}_{226}\text{Ra}, ^{(1)}_{214}\text{Pb}]$
$[^{(F)}H^*(10)_{c+b}, ^{(F)}H^*(10)_c, ^{(F)}H^*(10)_{1m}, ^{(F)}\alpha_{Total}, ^{(F)}\beta_{Total}, ^{(F)}\gamma \beta_{Total}]$	$[^{(F)}_{210}\text{Pb}, ^{(F)}_{234m}\text{Pa}, ^{(F)}_{226}\text{Ra}, ^{(F)}_{214}\text{Pb}]$
$[^{(3)}H^*(10)_{c+b}, ^{(3)}H^*(10)_c, ^{(3)}H^*(10)_{1m}, ^{(3)}\alpha_{Total}, ^{(3)}\beta_{Total}, ^{(3)}\gamma \beta_{Total}]$	$[^{(3)}_{210}\text{Pb}, ^{(3)}_{234m}\text{Pa}, ^{(3)}_{226}\text{Ra}, ^{(3)}_{214}\text{Pb}]$
$[^{(I)}H^*(10)_{c+b}, ^{(I)}H^*(10)_c, ^{(I)}H^*(10)_{1m}, ^{(I)}\alpha_{Total}, ^{(I)}\beta_{Total}, ^{(I)}\gamma \beta_{Total}]$	$[^{(I)}_{210}\text{Pb}, ^{(I)}_{234m}\text{Pa}, ^{(I)}_{226}\text{Ra}, ^{(I)}_{214}\text{Pb}]$
$[^{(5)}H^*(10)_{c+b}, ^{(5)}H^*(10)_c, ^{(5)}H^*(10)_{1m}, ^{(5)}\alpha_{Total}, ^{(5)}\beta_{Total}, ^{(5)}\gamma \beta_{Total}]$	$[^{(5)}_{210}\text{Pb}, ^{(5)}_{234m}\text{Pa}, ^{(5)}_{226}\text{Ra}, ^{(5)}_{214}\text{Pb}]$
$[^{(F)}H^*(10)_{c+b}, ^{(F)}H^*(10)_c, ^{(F)}H^*(10)_{1m}, ^{(F)}\alpha_{Total}, ^{(F)}\beta_{Total}, ^{(F)}\gamma \beta_{Total}]$	$[^{(F)}_{210}\text{Pb}, ^{(F)}_{234m}\text{Pa}, ^{(F)}_{226}\text{Ra}, ^{(F)}_{214}\text{Pb}]$
$[^{(7)}H^*(10)_{c+b}, ^{(7)}H^*(10)_c, ^{(7)}H^*(10)_{1m}, ^{(7)}\alpha_{Total}, ^{(7)}\beta_{Total}, ^{(7)}\gamma \beta_{Total}]$	$[^{(7)}_{210}\text{Pb}, ^{(7)}_{234m}\text{Pa}, ^{(7)}_{226}\text{Ra}, ^{(7)}_{214}\text{Pb}]$
$[^{(II)}H^*(10)_{c+b}, ^{(II)}H^*(10)_c, ^{(II)}H^*(10)_{1m}, ^{(II)}\alpha_{Total}, ^{(II)}\beta_{Total}, ^{(II)}\gamma \beta_{Total}]$	$[^{(II)}_{210}\text{Pb}, ^{(II)}_{234m}\text{Pa}, ^{(II)}_{226}\text{Ra}, ^{(II)}_{214}\text{Pb}]$
...	...
$[^{(II)}H^*(10)_{c+b}, ^{(II)}H^*(10)_c, ^{(II)}H^*(10)_{1m}, ^{(II)}\alpha_{Total}, ^{(II)}\beta_{Total}, ^{(II)}\gamma \beta_{Total}]$	$[^{(II)}_{210}\text{Pb}, ^{(II)}_{234m}\text{Pa}, ^{(II)}_{226}\text{Ra}, ^{(II)}_{214}\text{Pb}]$
$[^{(F)}H^*(10)_{c+b}, ^{(F)}H^*(10)_c, ^{(F)}H^*(10)_{1m}, ^{(F)}\alpha_{Total}, ^{(F)}\beta_{Total}, ^{(F)}\gamma \beta_{Total}]$	$[^{(F)}_{210}\text{Pb}, ^{(F)}_{234m}\text{Pa}, ^{(F)}_{226}\text{Ra}, ^{(F)}_{214}\text{Pb}]$
$[^{(I)}H^*(10)_{c+b}, ^{(I)}H^*(10)_c, ^{(I)}H^*(10)_{1m}, ^{(I)}\alpha_{Total}, ^{(I)}\beta_{Total}, ^{(I)}\gamma \beta_{Total}]$	$[^{(I)}_{210}\text{Pb}, ^{(I)}_{234m}\text{Pa}, ^{(I)}_{226}\text{Ra}, ^{(I)}_{214}\text{Pb}]$
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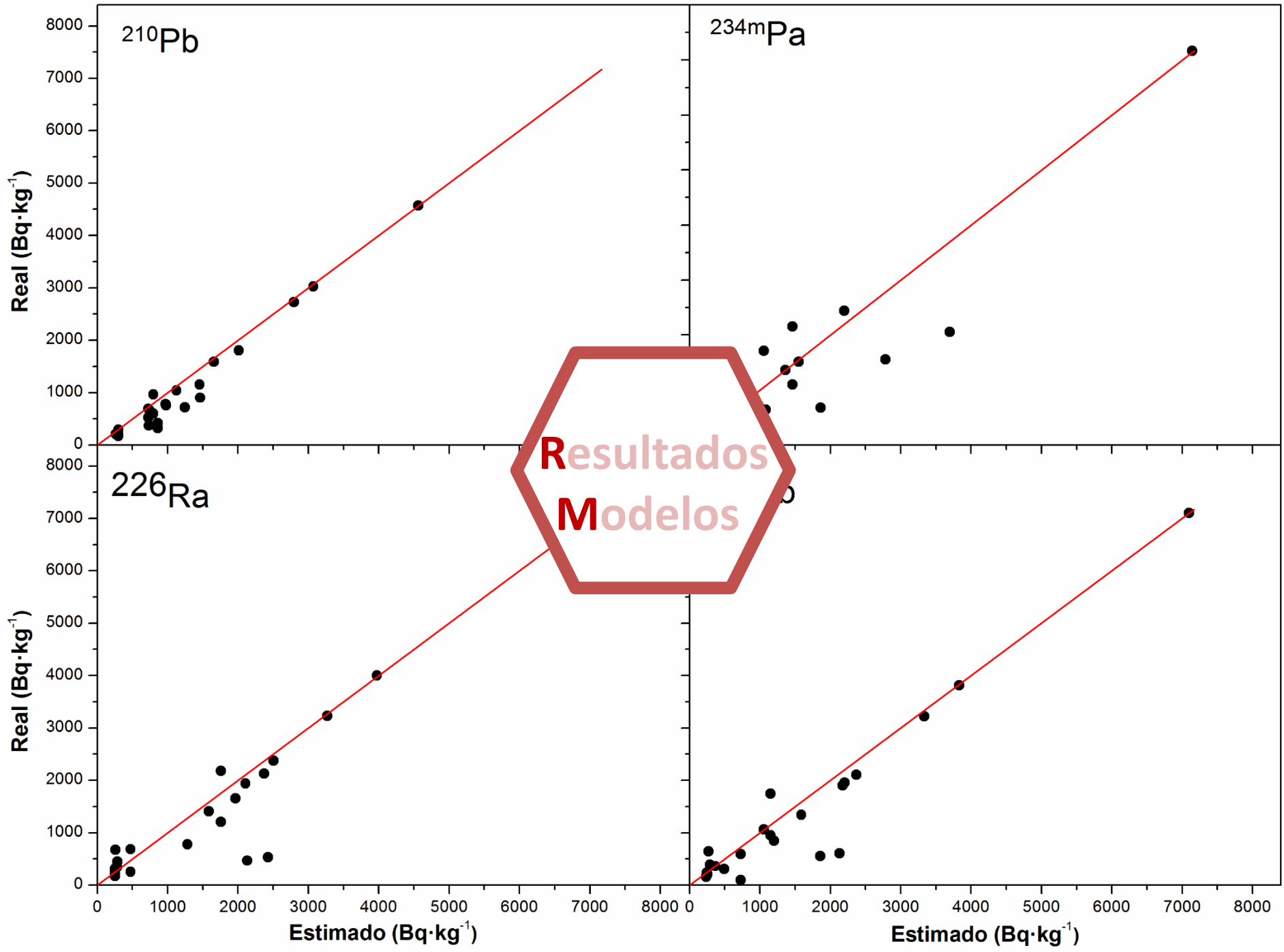


$$LF = \sum_{i=1}^k \sum_{j=1}^6 \frac{({}^{(i)}X_j - {}^{(i)}S_j)^2}{2}$$



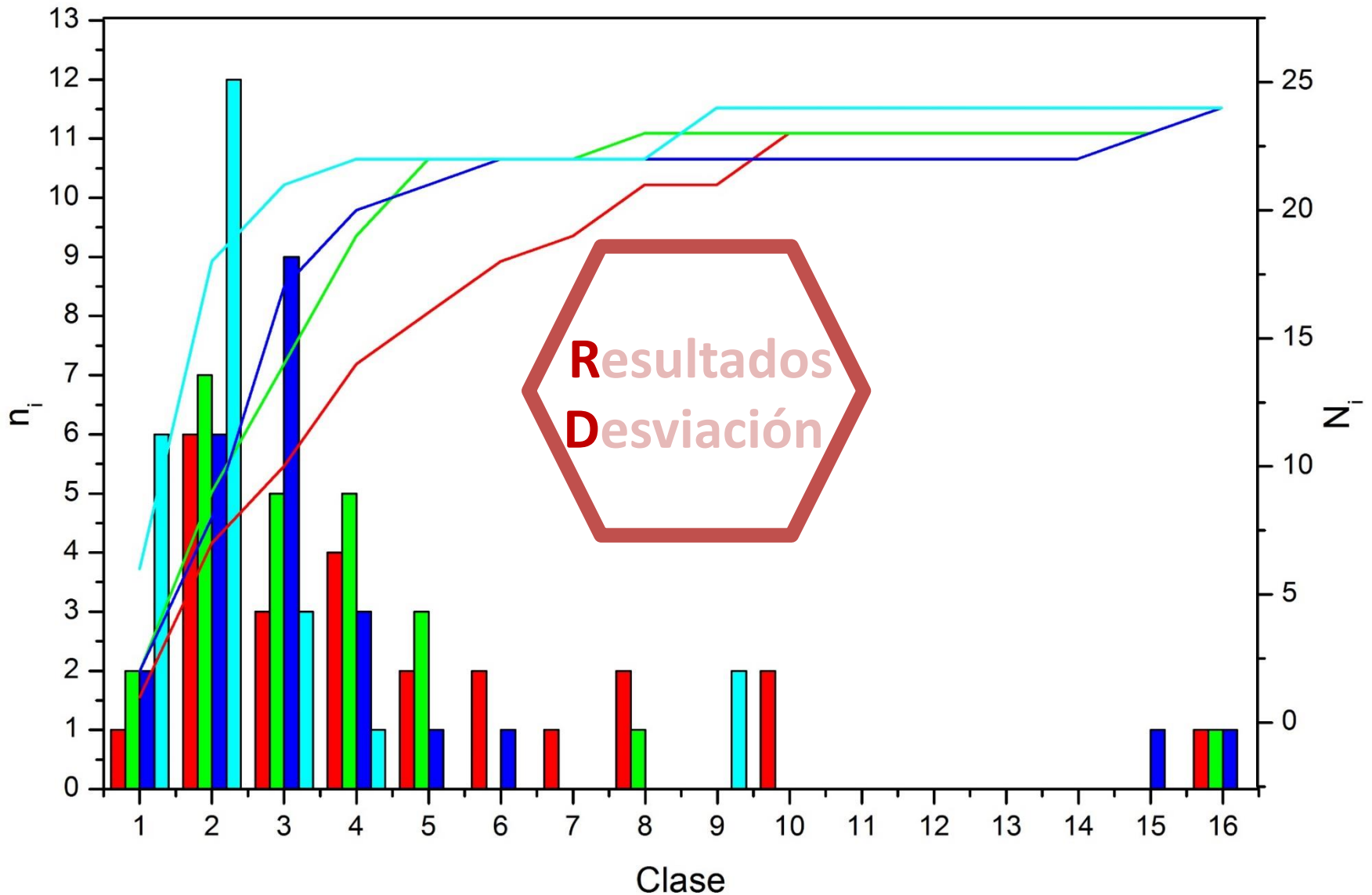
$${}^{(k)}W_{ij}[t+1] = {}^{(k)}W_{ij}[t] - \alpha \cdot \left. \frac{\partial(LF)}{\partial({}^{(k)}W_{ij})} \right|_{[t]}$$

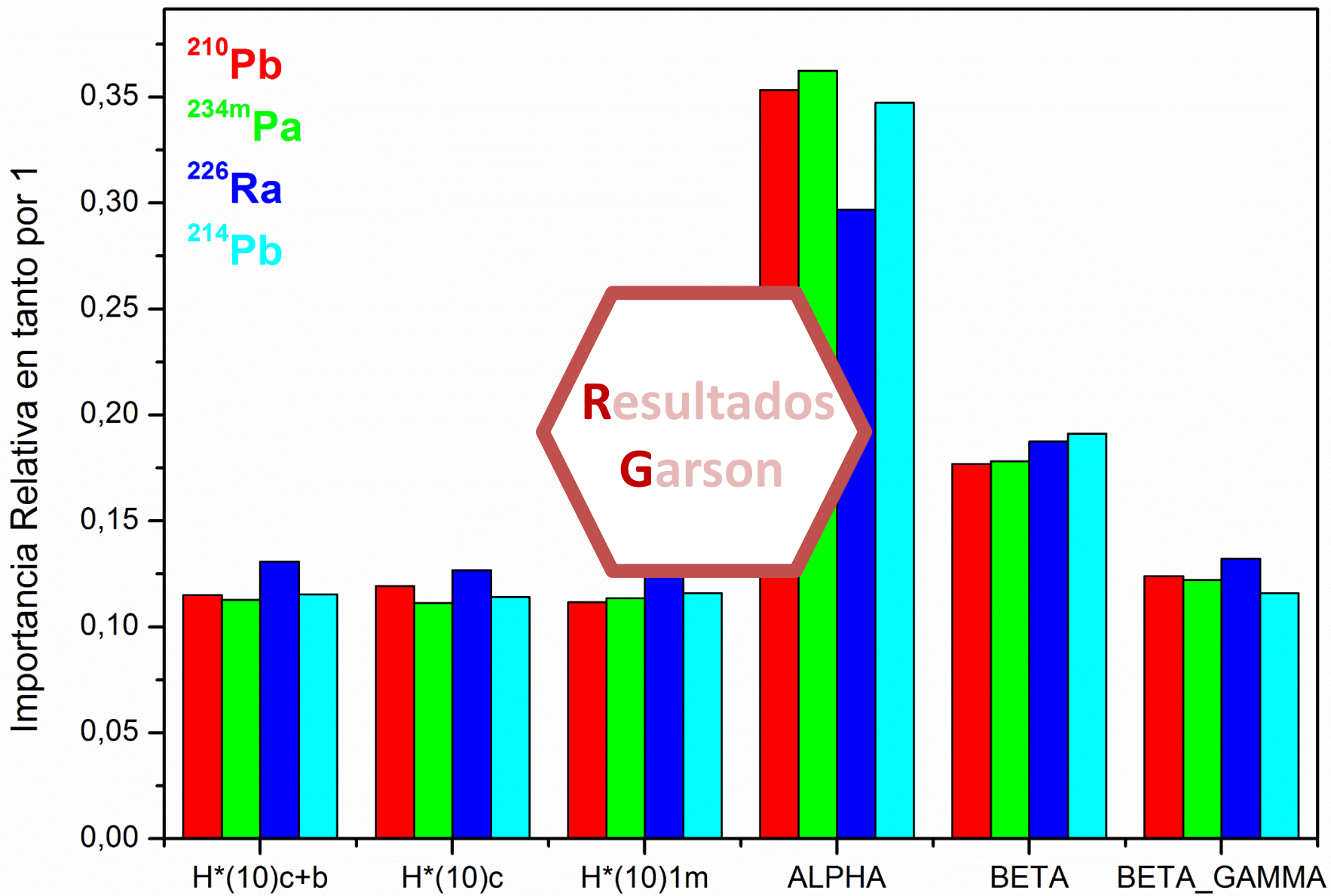




$$\text{Desviación} = \frac{\text{Estimada} - \text{Real}}{\text{Real}}$$

^{210}Pb (C2)	$^{234\text{m}}\text{Pa}$ (C2)
^{226}Ra (C3)	^{214}Pb (C2)





Diseño de una red neuronal completamente conectada para la interpolación de datos complejos, asociados a la caracterización radiológica de zonas impactadas por radionúclidos naturales.

