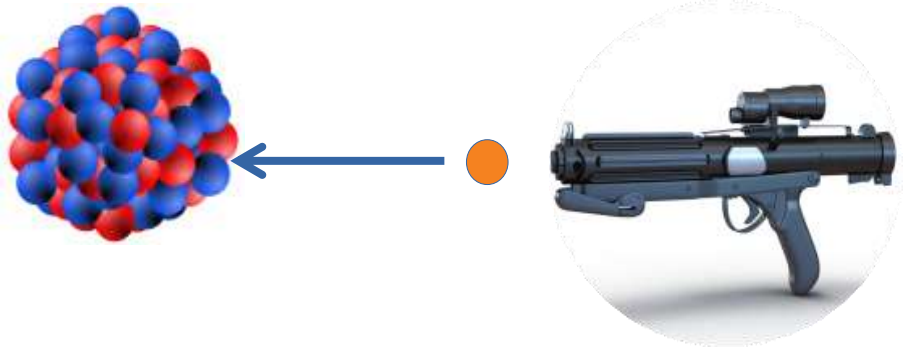
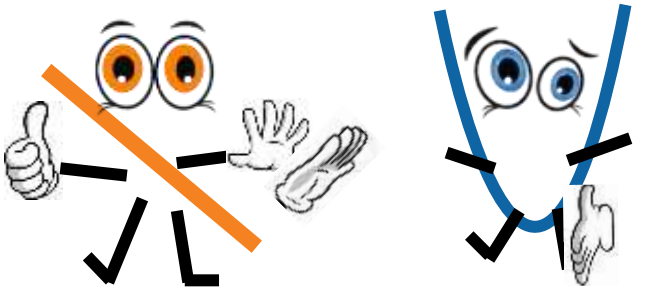
¿Cómo y con qué?

Diseño de experimentos y selección de modelos





Pablo Giuliani

giulianp@frib.msu.edu

BAND
Bayesian Analysis of Nuclear Dynamics

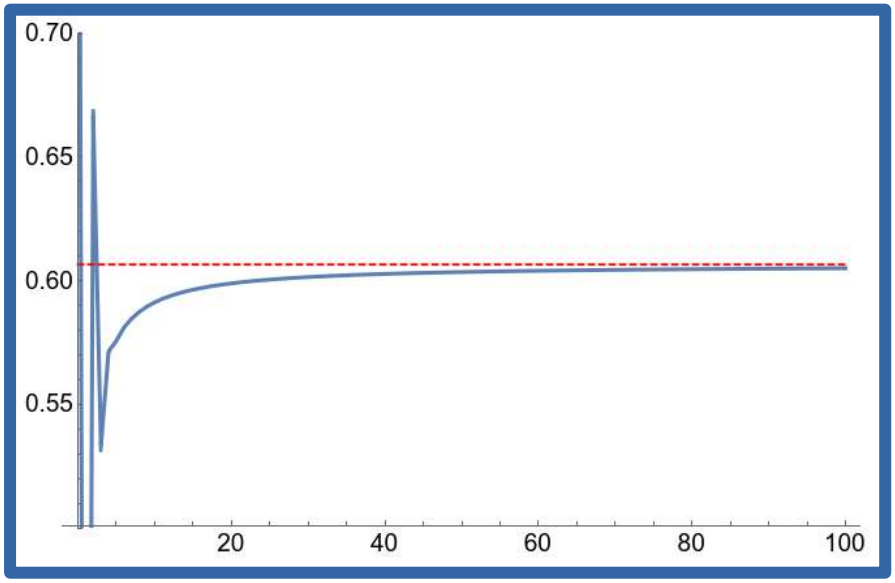
PHYSICS WITHOUT FRONTIERS: VENEZUELA

Pequeño paréntesis

$$L(N) = \sum_{k=0}^{N} \frac{(N!)^2[2(N-k)]!}{2^{(N-k)}[(N-k)!]^2} \frac{(-1)^k}{k!}$$

$$P(N) \longrightarrow \frac{1}{\sqrt{e}} \sim 0.6$$

$$N \longrightarrow \infty$$



Estructura

0) Algunas preguntas

1) Estadística Bayesiana

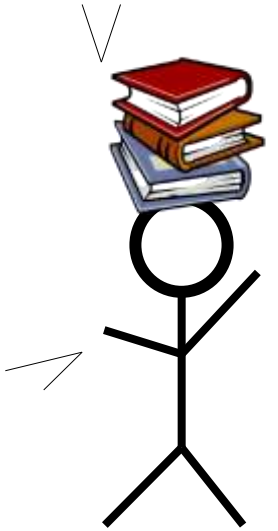
2) Lo más importante que aprendí en el doctorado: jugar con “pseudo-data”

(no hay empanadas en es

3) Una herramienta chévere: funciones de transferencia

4) Comentarios finales

Pregunten!



Estructura

Mate

0) Algunas preguntas

1) Estadística Bayesiana

2) Lo más importante que aprendí en el doctorado: jugar con “pseudo-data”

3) Una Una pregunta =  de tra ia

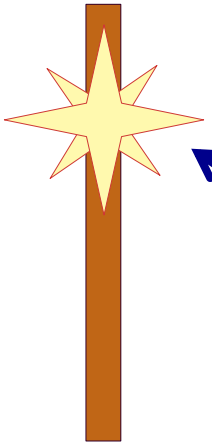
(no hay empanadas en es

4) Comentarios finales

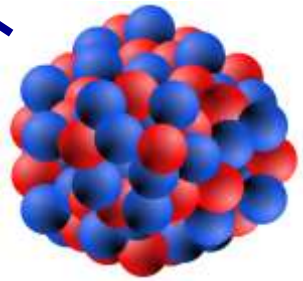
15

Pregunten!

Algunas preguntas: 1) ¿Dónde medir?



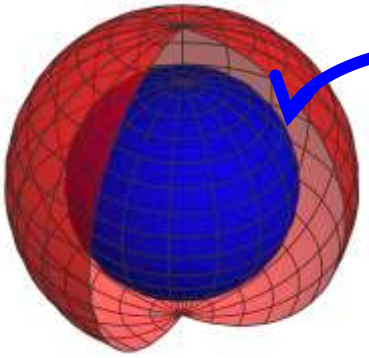
$^{208}\mathrm{Pb}$



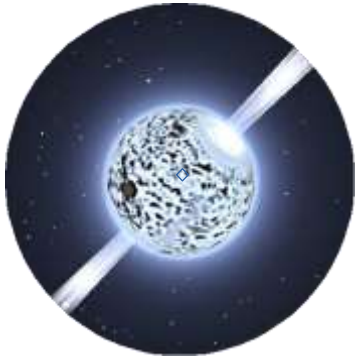
Dispara partículas

Neutrones

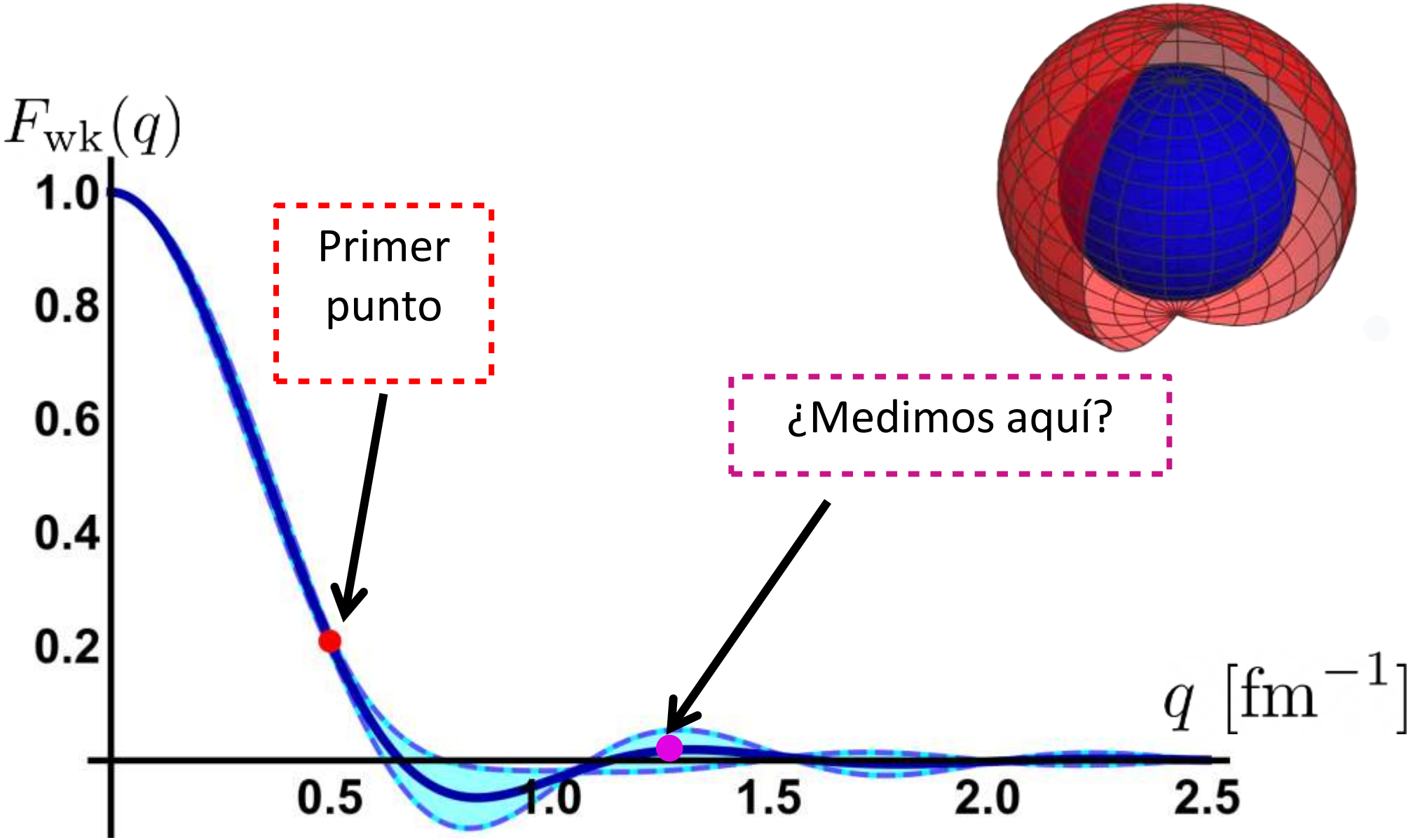
Protones



Estrellas de neutrones

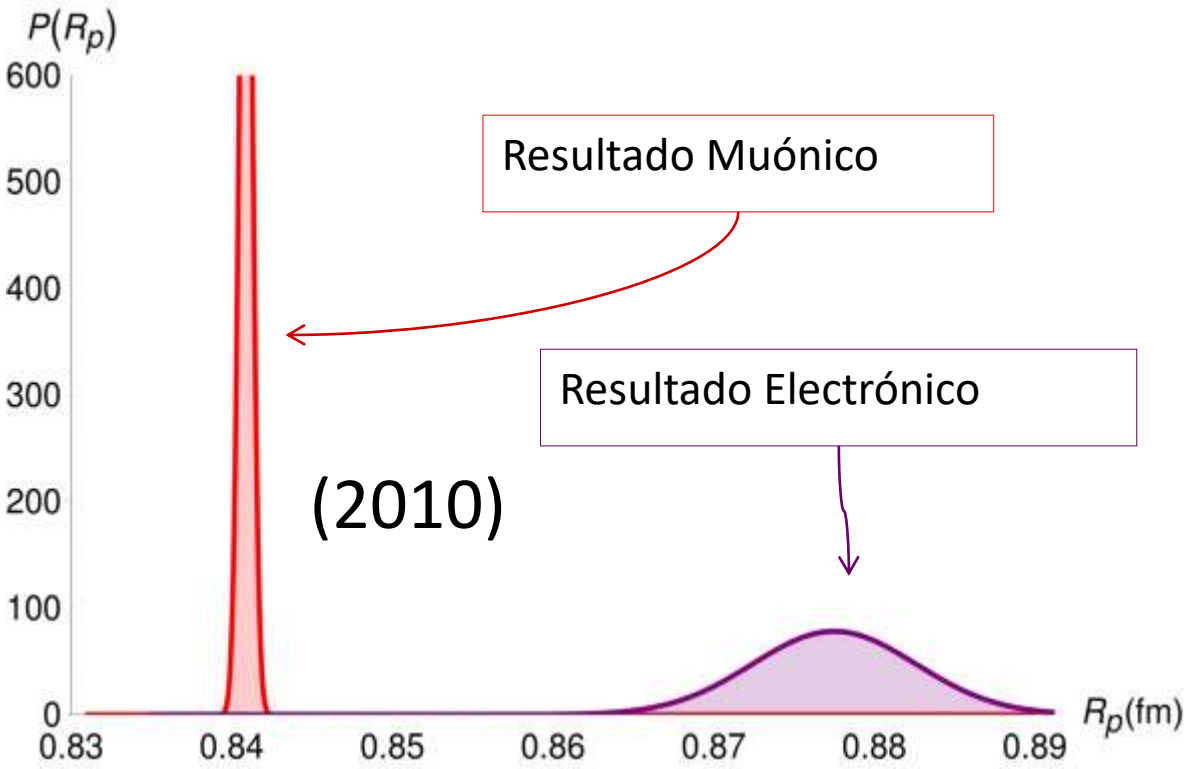


Algunas preguntas: 1) ¿Dónde medir?

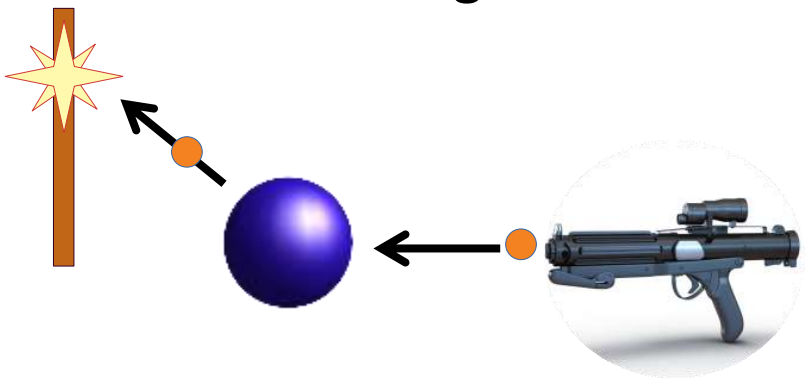


Algunas preguntas: 2) ¿Cómo extrapolar?

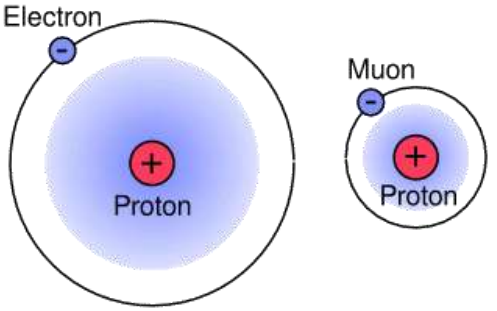
"Proton Puzzle"



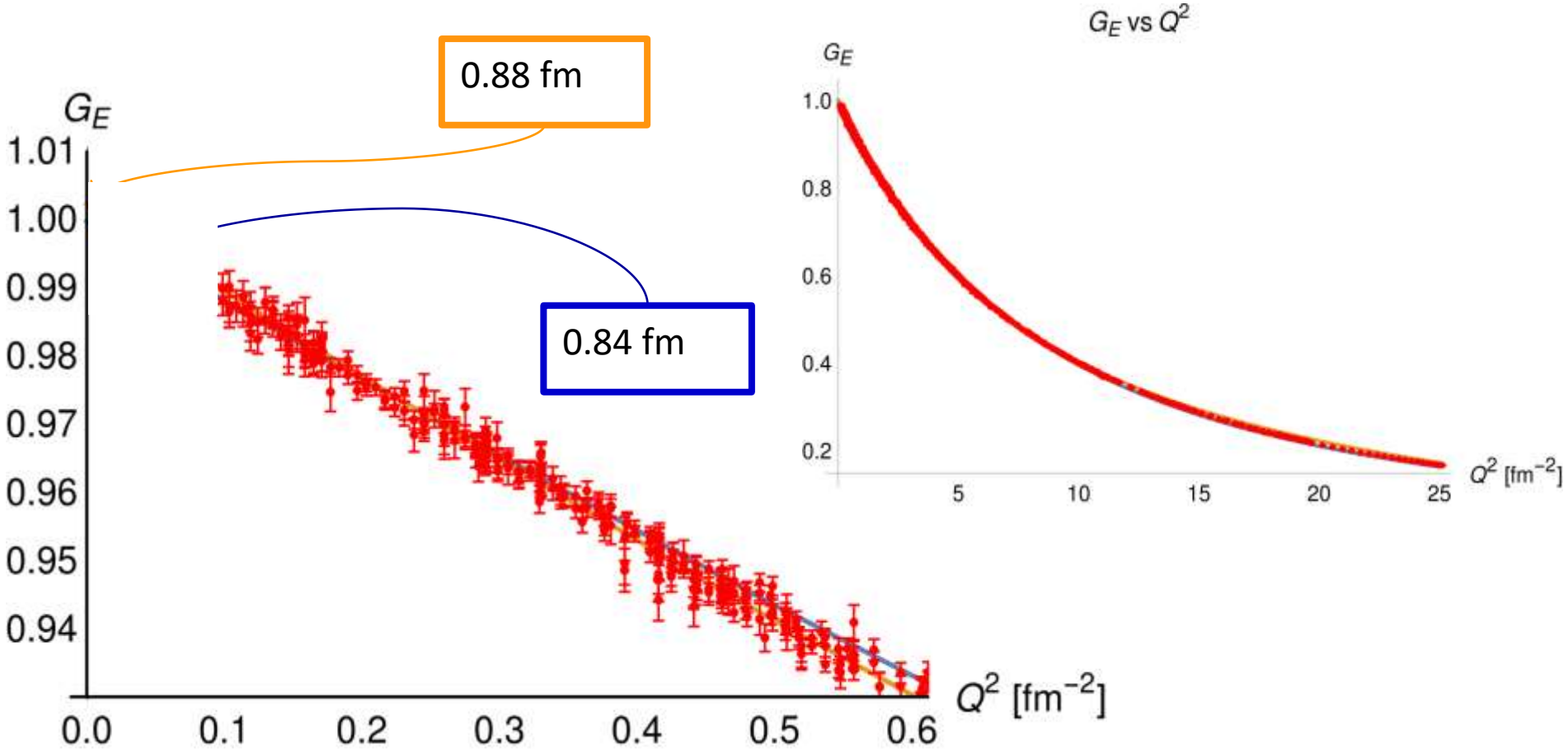
Scattering



Espectroscopía



Algunas preguntas: 2) ¿Cómo extrapolar?

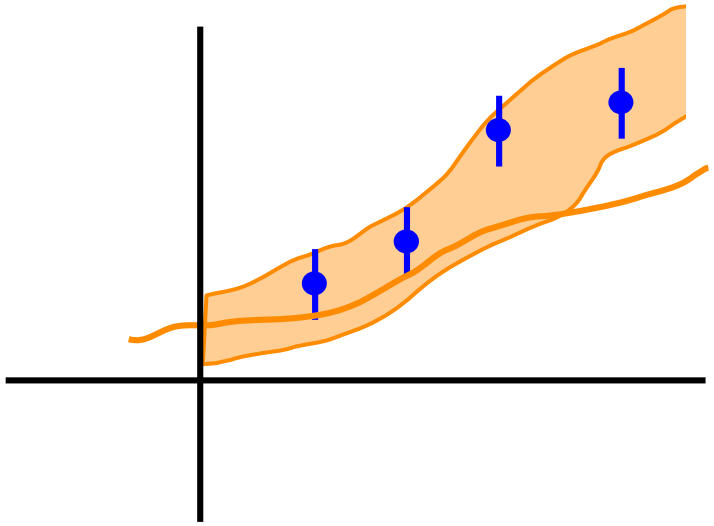


Súper sensible a qué modelo usas

Estadística Bayesiana

Dos características principales:

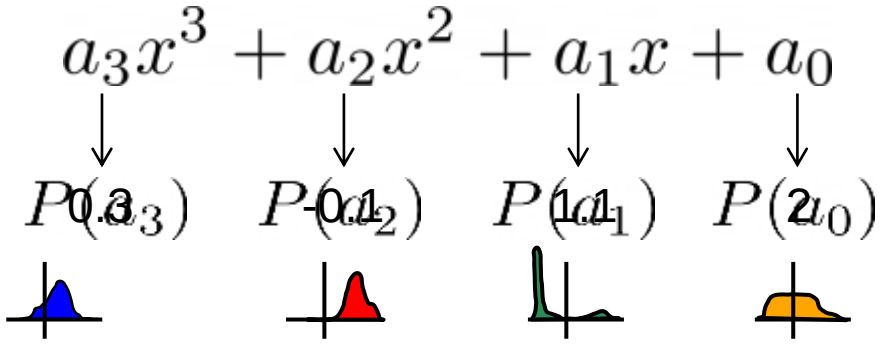
1) **<u>TODO</u>** debe ser una distribución/probabilidad



Estadística Bayesiana

Dos características principales:

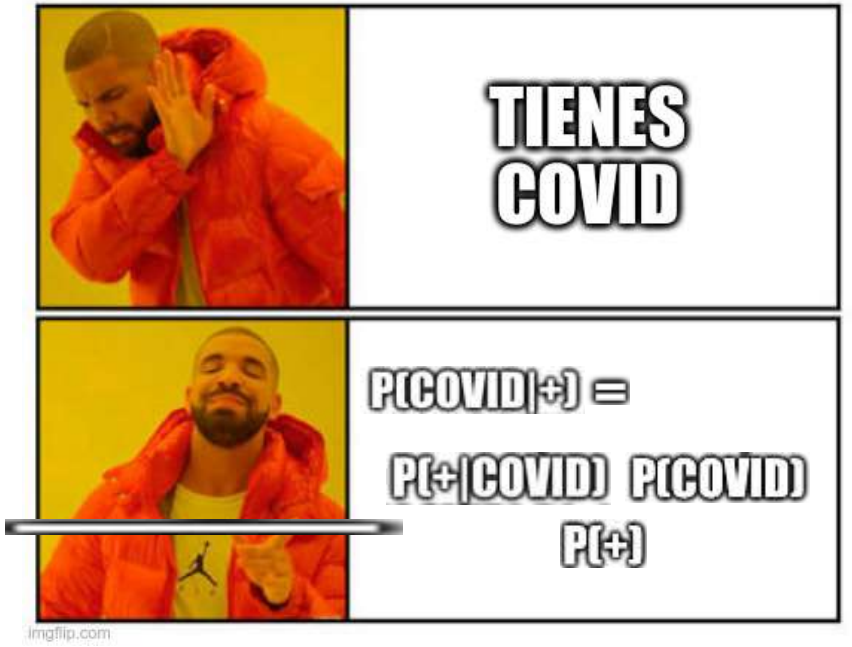
1) <u>TODO</u> debe ser una distribución/probabilidad



Estadística Bayesiana

Dos características principales:

1) <u>TODO</u> debe ser una distribución/probabilidad



Estadística Bayesiana

Dos características principales:

1) **<u>TODO</u>** debe ser una distribución/probabilidad

¿Te casarías conmigo?

Estadística Bayesiana

Dos características principales:

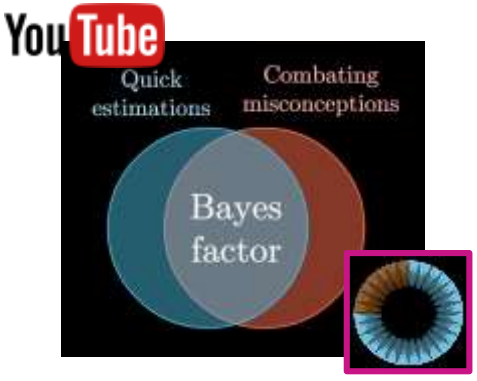
1) **TODO** debe ser una distribución/probabilidad

La leche sabe raro, ¿Está venc

2) Priors

$$P(\text{vencida} \mid \text{sabe raro}) = \frac{P(\text{sabe raro} \mid \text{vencida}) \; P(\text{vencida})}{P(\text{sabe raro})}$$

Importante



"Three blue one brown"

"The medical test paradox, and redesigning Bayes' rule"

Estadística Bayesiana

Dos características principales:

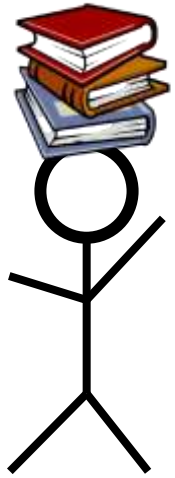
1) **TODO** debe ser una distribución/probabilidad

2) Priors

- Experimentos anteriores
- "Constraints"
- Opiniones de expertos

Debes usarlos bien

Usar priors no te deja ser objetivo



Estadística Bayesiana

1) **TODO** debe ser una distribución/probabilidad

2) Priors

Lenguaje ideal para hablar

Posterior

Likelihood

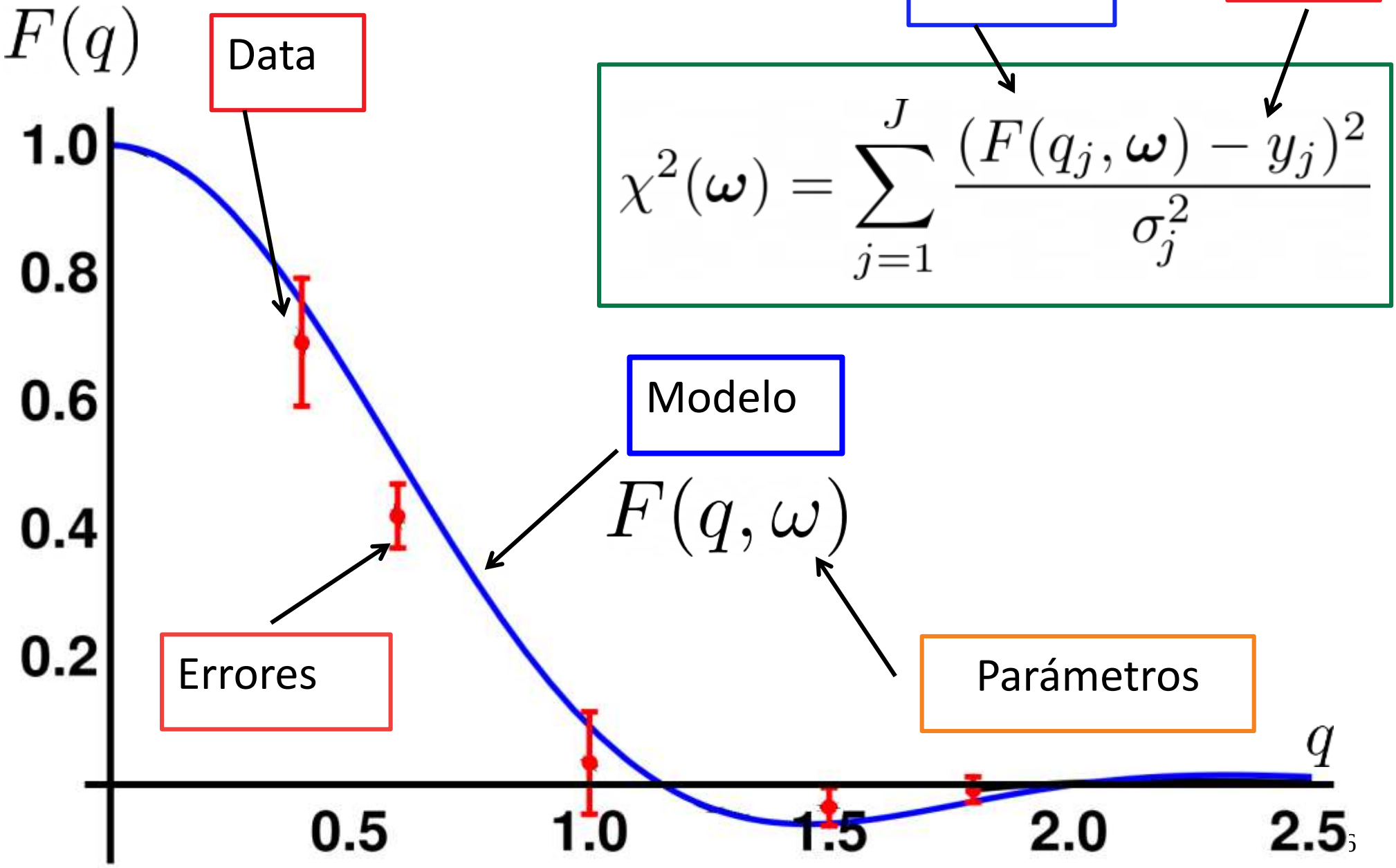
Prior

Distribución de los parámetros dados los datos

$$P(\omega|\mathbf{Y}) = \frac{P(\mathbf{Y}|\omega)P(\omega)}{P(\mathbf{Y})}$$

Evidencia

Estadística Bayesiana



Estadística Bayesiana

$F(q)$

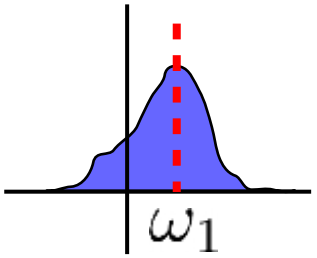
1.0
0.8
0.6
0.4
0.2

0.5 1.0 1.5 2.0 2.5

q

$$\chi^2(\boldsymbol{\omega}) = \sum_{j=1}^{J} \frac{(F(q_j, \boldsymbol{\omega}) - y_j)^2}{\sigma_j^2}$$

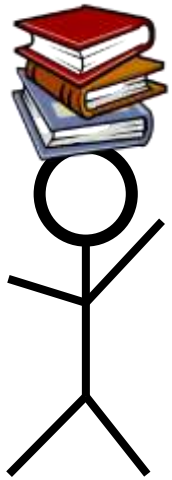
```
from scipy.optimize import curve_fit

best_vals, covar = curve_fit(model, x, y, p0=init_vals)
```



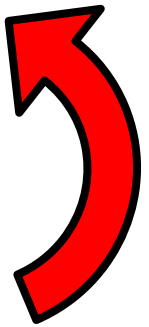
$$P(\boldsymbol{\omega}|\boldsymbol{Y}) = \frac{P(\boldsymbol{Y}|\boldsymbol{\omega})P(\boldsymbol{\omega})}{P(\boldsymbol{Y})}$$

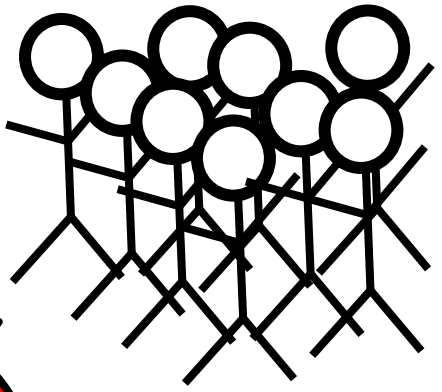
$$P(\boldsymbol{Y}|\boldsymbol{\omega}) \sim e^{-\chi^2}$$

Pseudo Data



yo

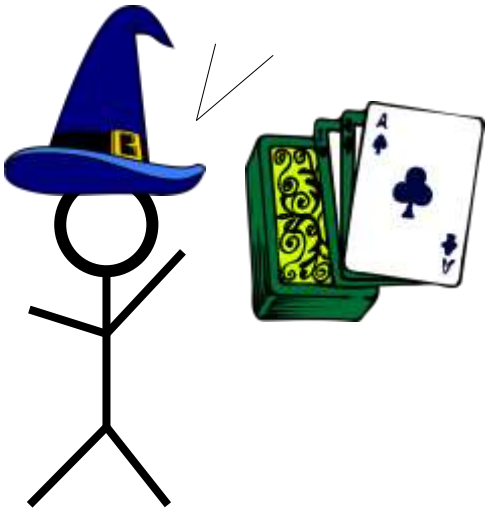




ustedes

Pseudo Data

Yo puedo predecir todas las cartas



Amiga

Traten de estimarlo

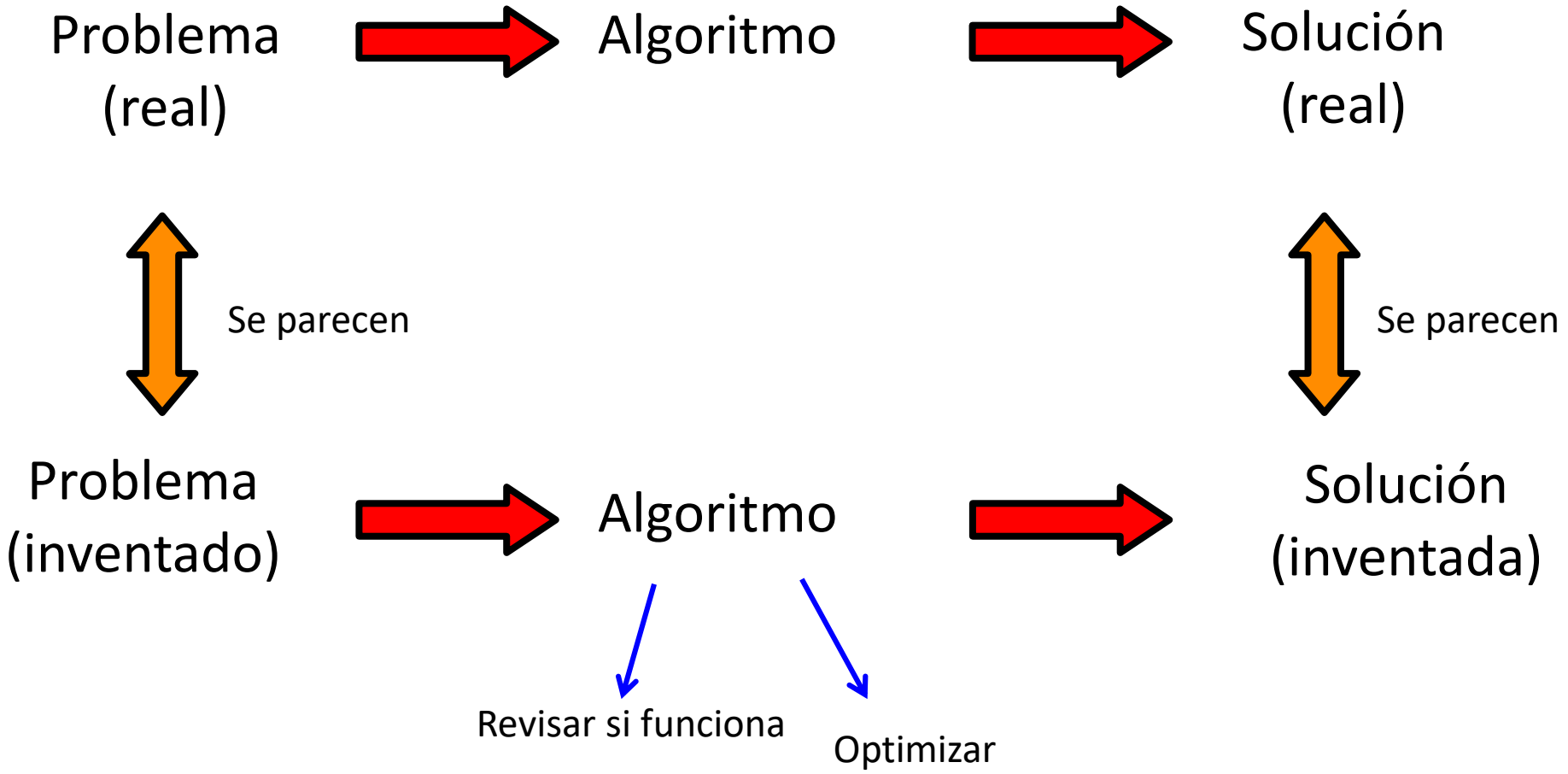
Predícemelas a mi

Tú

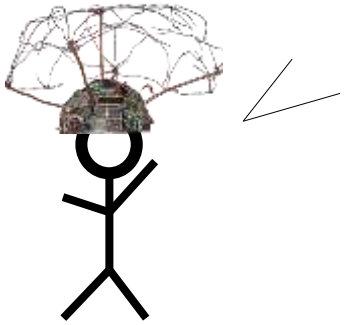
Simon

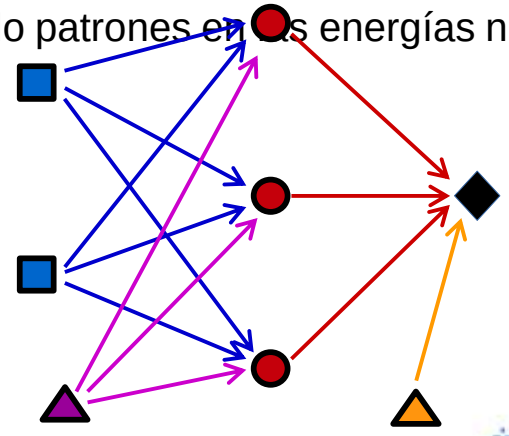
¿Cómo salvas a tu amiga de no hacer

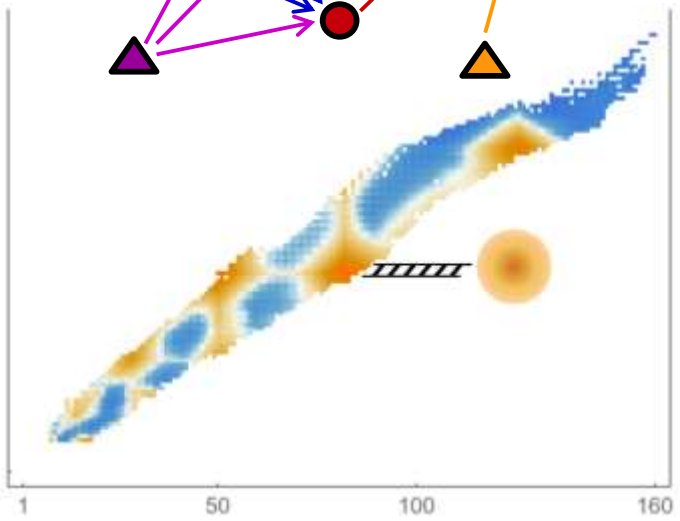
Pseudo Data


Problema
(real)
Algoritmo
Solución
(real)
Se parecen
Se parecen
Problema
(inventado)
Algoritmo
Solución
(inventada)
Revisar si funciona
Optimizar

Pseudo Data





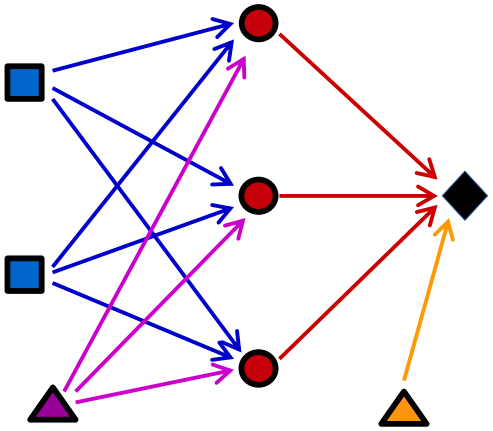


Problema (inventado) → Algoritmo → Solución (inventada)

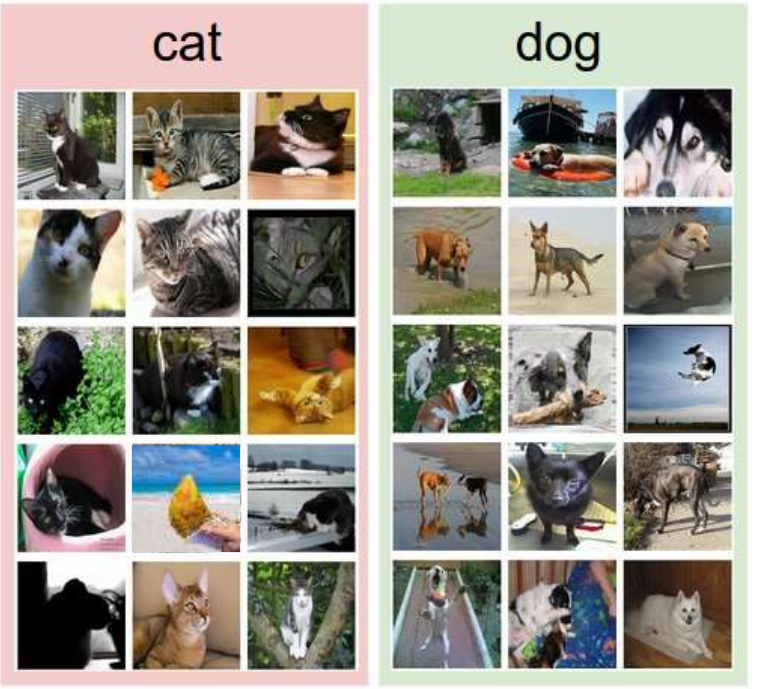
Algoritmo → Revisar si funciona

Algoritmo → Optimizar

Pseudo Data



¿Perro o gato



Problema (inventado) → Algoritmo → Solución (inventada)

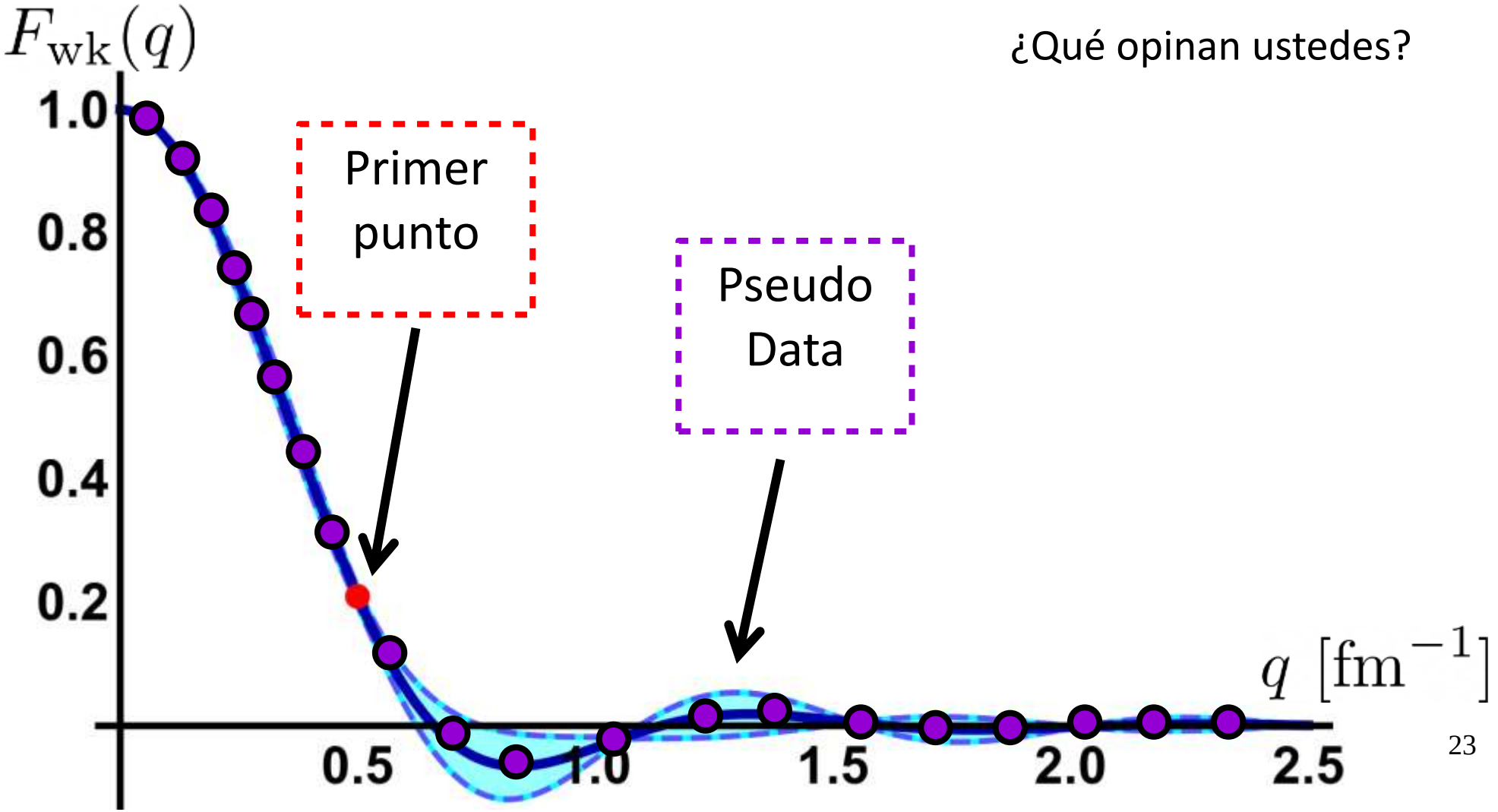
Algoritmo: Revisar si funciona; Optimizar

Pseudo Data

Aplicación concreta

¿Dónde Medir?

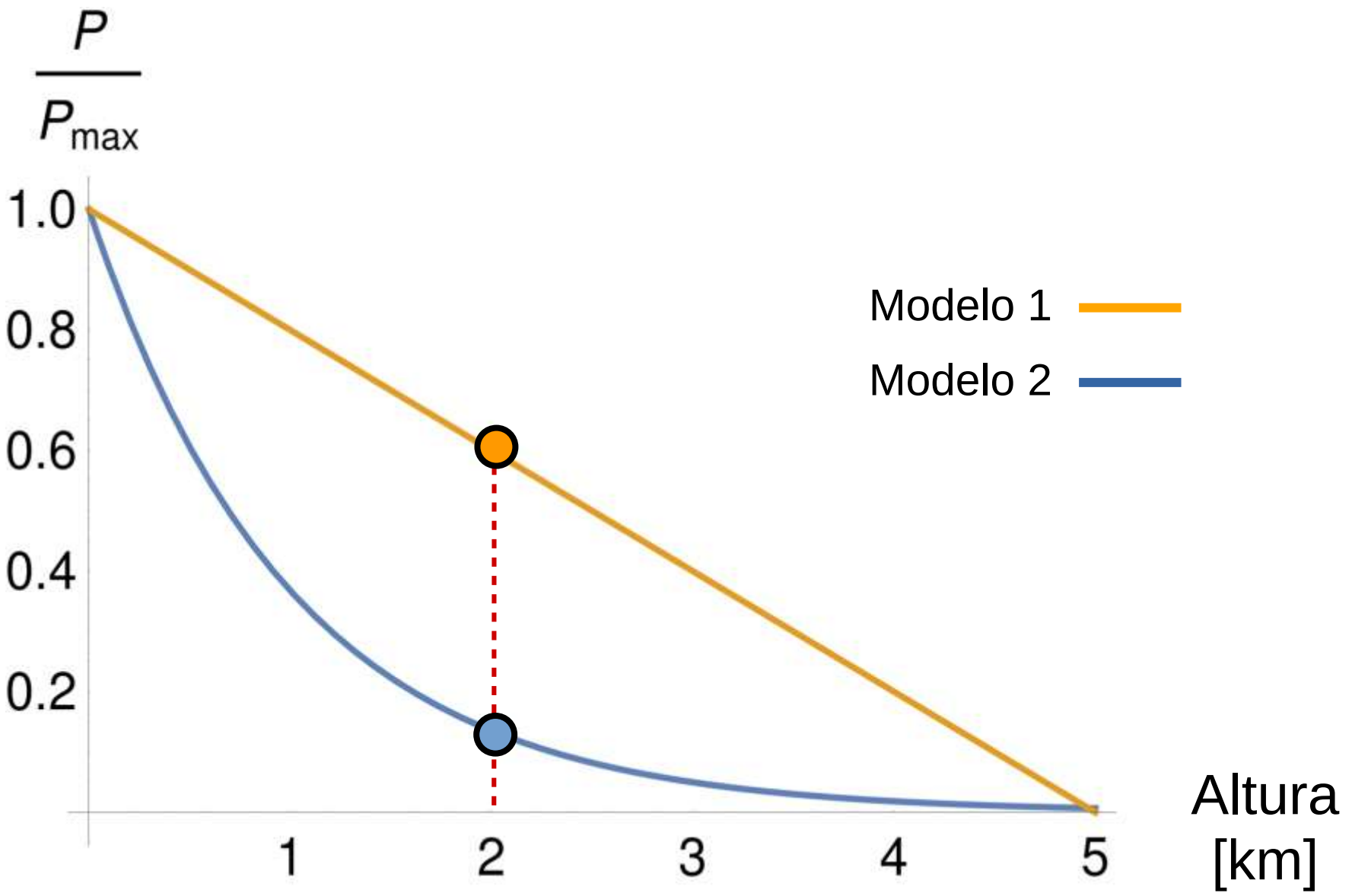
¿Qué opinan ustedes?



(Ejemplo)

Aplicación concreta

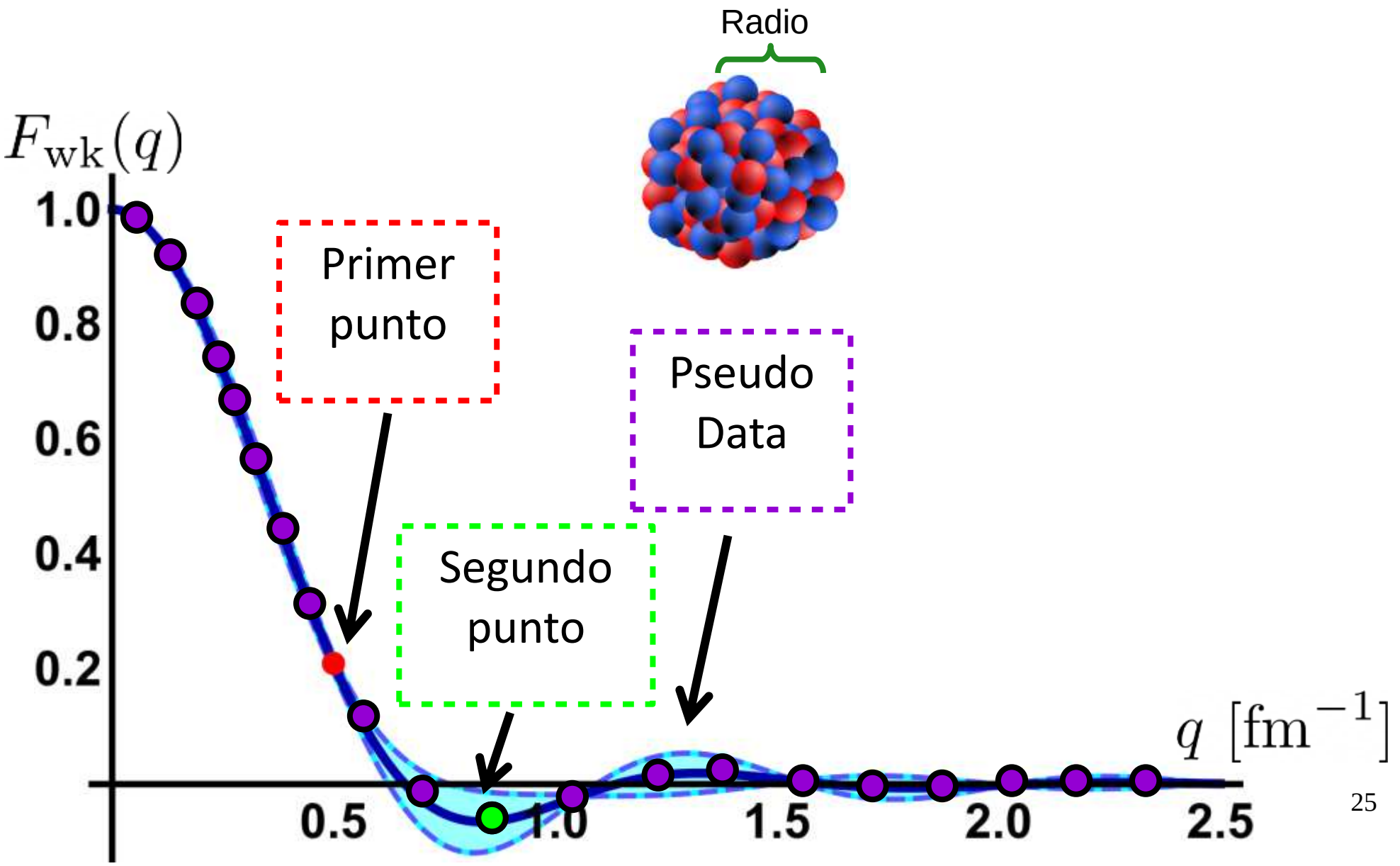
¿Dónde Medir?



Pseudo Data

Aplicación concreta

¿Dónde Medir?



Pseudo Data

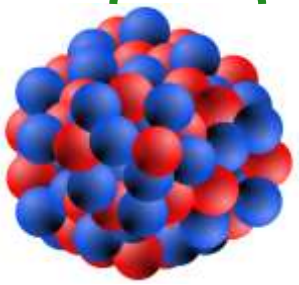
Aplicación concreta

¿Dónde Medir?

0.8 %

$\Delta R =$ 2.25 %

Radio



Pseudo Data

Aplicación concreta

¿Dónde Medir?

PHYSICAL REVIEW C **94**, 034316 (2016)

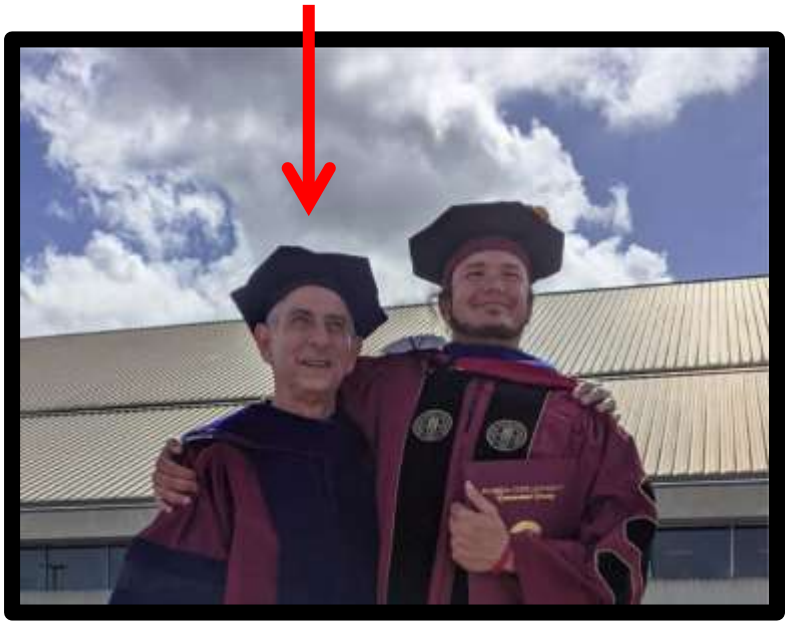
Power of two: Assessing the impact of a second measurement of the weak-charge form factor of ^{208}Pb

J. Piekarewicz,[1,*] A. R. Linero,[2,†] P. Giuliani,[1,‡] and E. Chicken[2,§]
[1]*Department of Physics, Florida State University, Tallahassee, Florida 32306, USA*
[2]*Department of Statistics, Florida State University, Tallahassee, Florida 32306, USA*
(Received 26 April 2016; revised manuscript received 1 July 2016; published 15 September 2016)

La persona mas chévere del planeta

To provide the connection between our own theoretical biases (encoded in the prior) and the experimental measurement (encoded in the likelihood) we invoke Bayes' theorem. That is,

$$p(\omega|F) = \frac{p(F|\omega)\,p(\omega)}{p(F)}, \qquad (19)$$

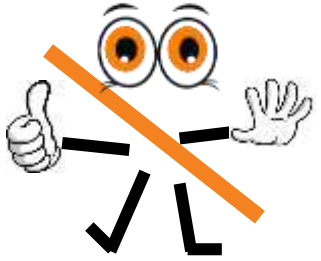


Pseudo Data

Aplicación concreta

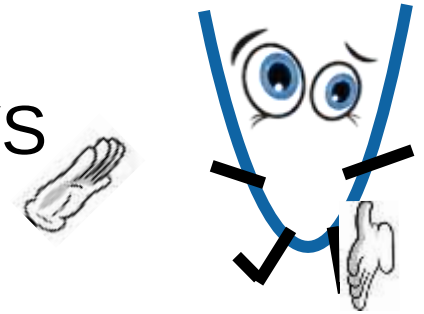
¿Cuál modelo usar?

Lineal

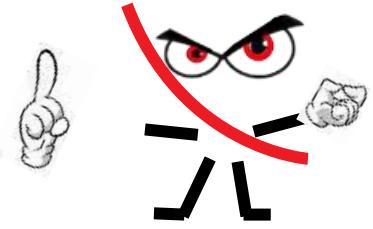


VS

Parábola



Dipolo

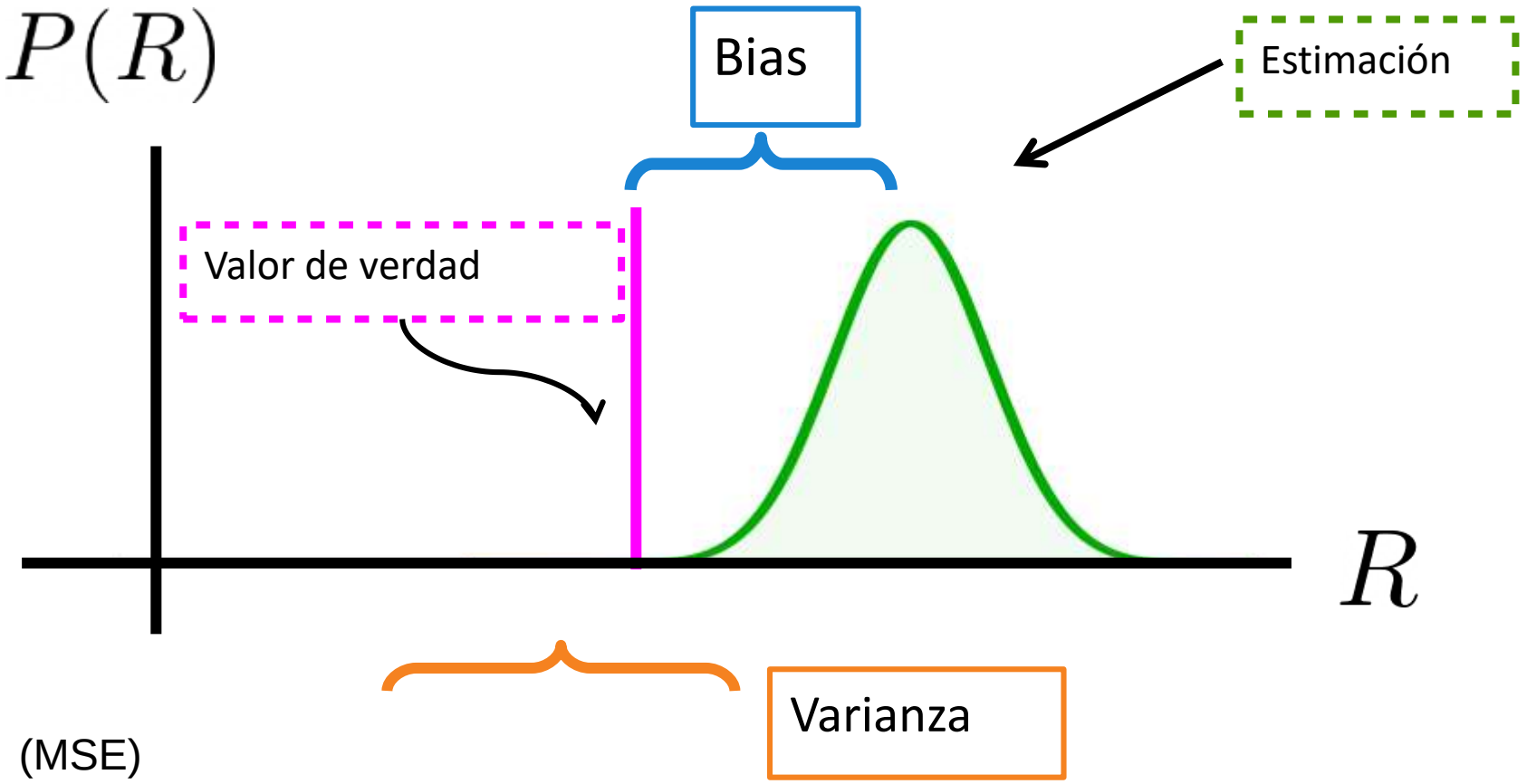


Generador de la pseudo data

Pseudo Data

Aplicación concreta

¿Cuál modelo usar?



(MSE)

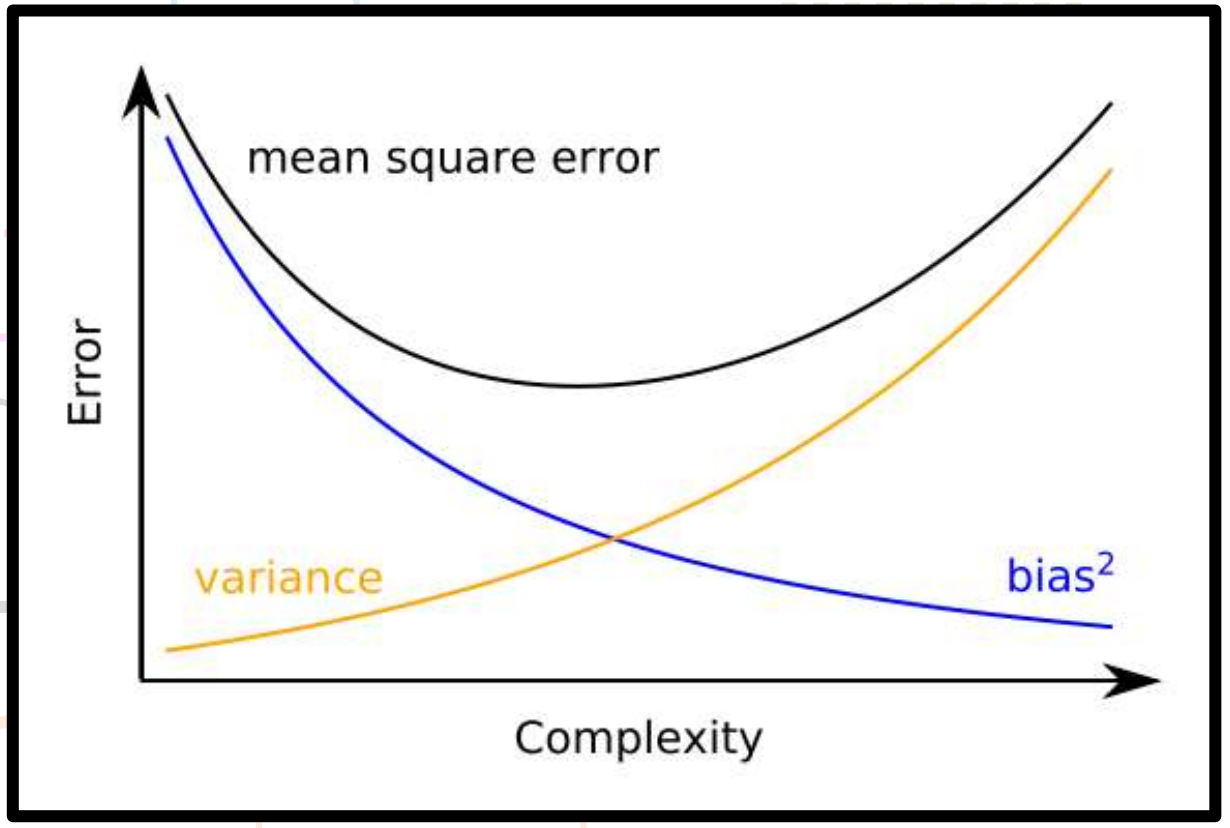
Error Cuadrático Medio

$$ECM^2 = Bias^2 + Varianza$$

Pseudo Data

Aplicación concreta

¿Cuál modelo usar?



(MSE)

Error Cuadrático Medio

$$ECM^2 = Bias^2 + Varianza$$

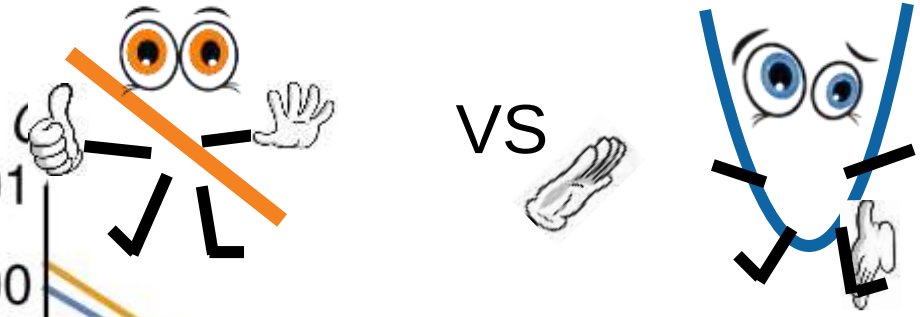
Pseudo Data

Aplicación concreta

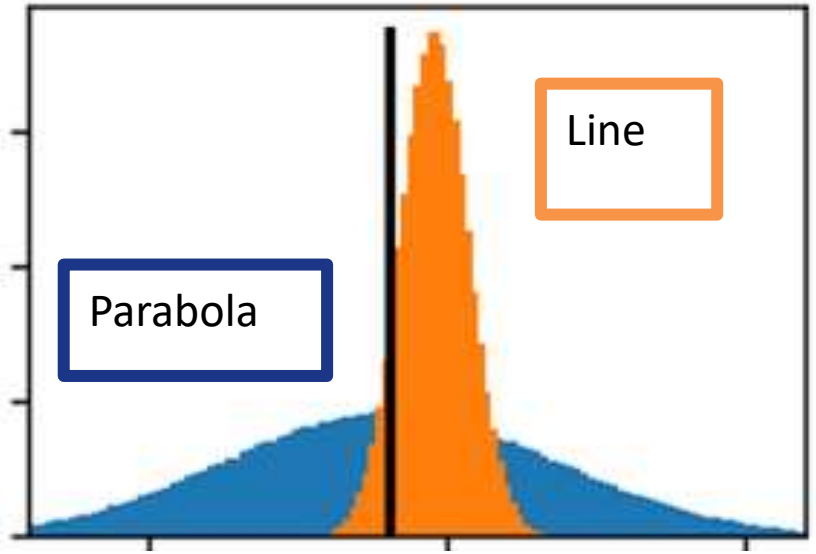
¿Cuál modelo usar?

Lineal

Parábola



VS



Ganador depende de:

- Número de puntos
- Sus errores y localizaciones
- Rango utilizado

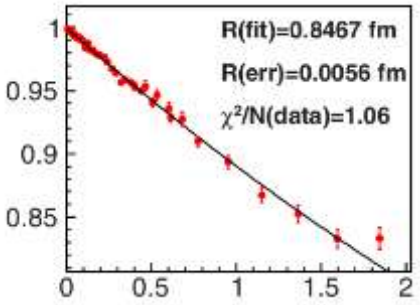
Pseudo Data

Aplicación concreta

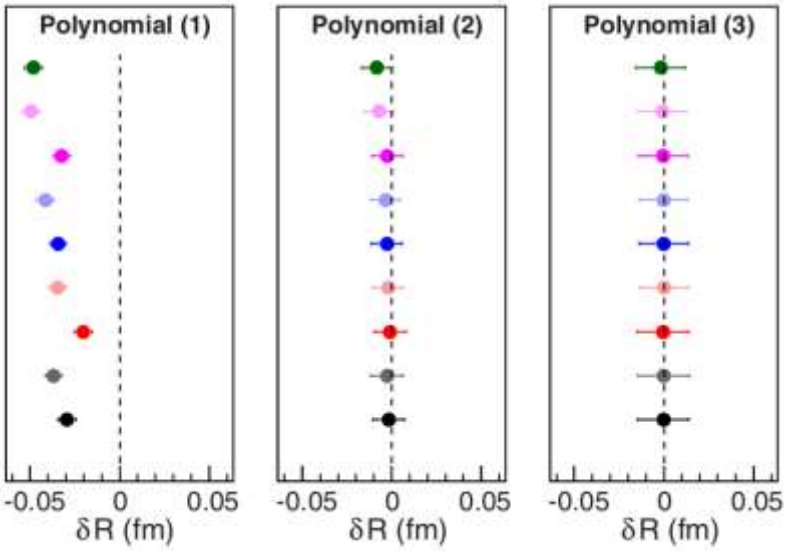
¿Cuál modelo usar?

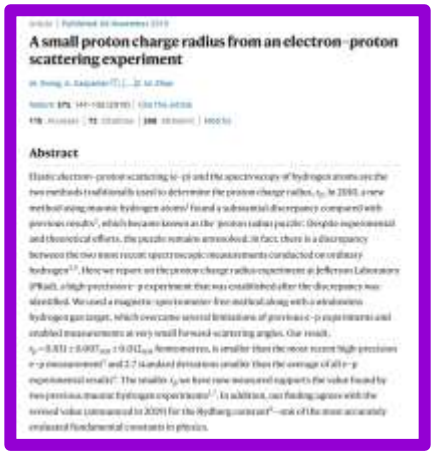
Robust extraction of the proton charge radius from electron-proton scattering data

Xuefei Yan,[1,2,*] Douglas W. Higinbotham,[3] Dipangkar Dutta,[4] Haiyan Gao,[1,2,5] Ashot Gasparian,[6] Mahbub A. Khandaker,[7] Nilanga Liyanage,[8] Eugene Pasyuk,[3] Chao Peng,[1,2] and Weizhi Xiong[1,2]



La segunda persona mas chévere del planeta



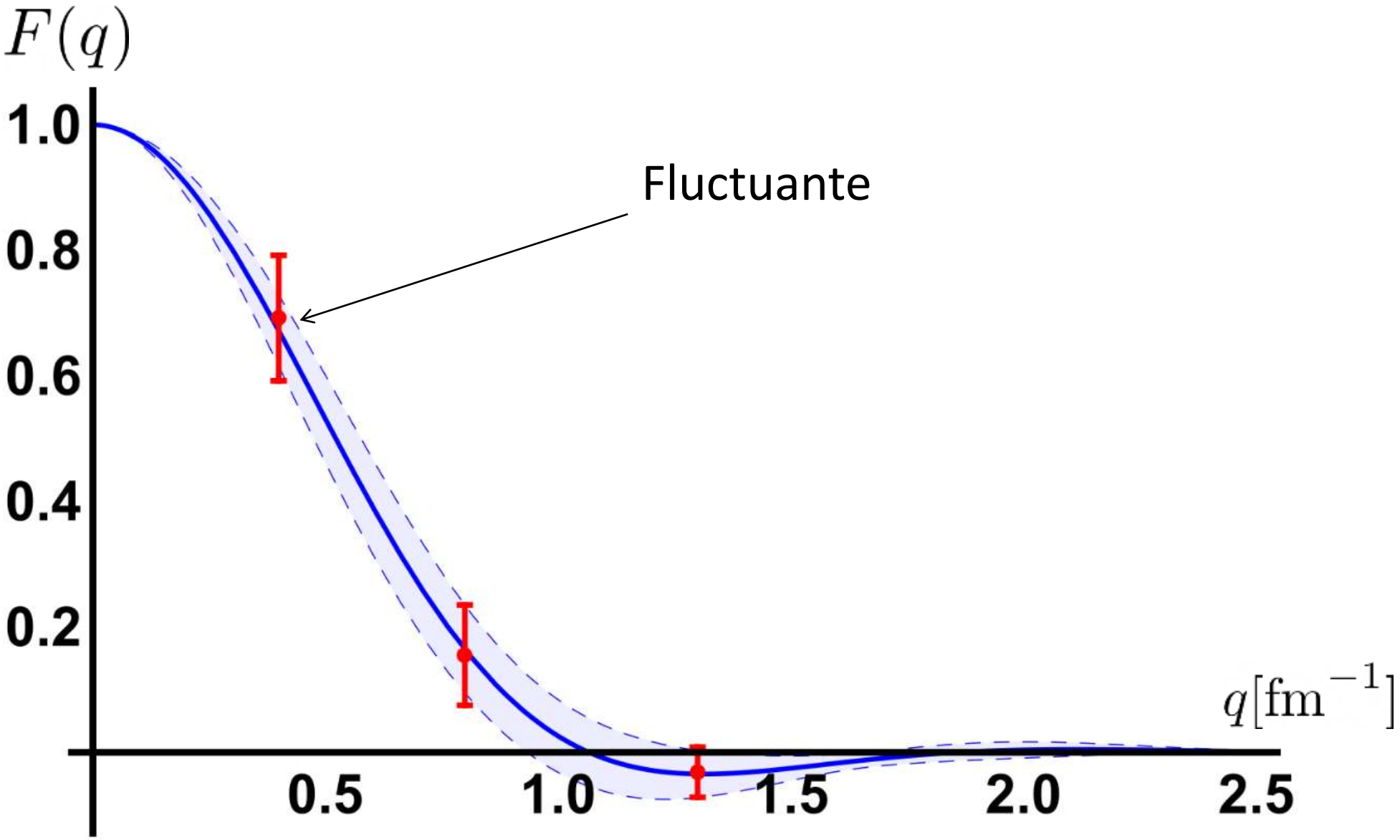


A small proton charge radius from an electron–proton scattering experiment

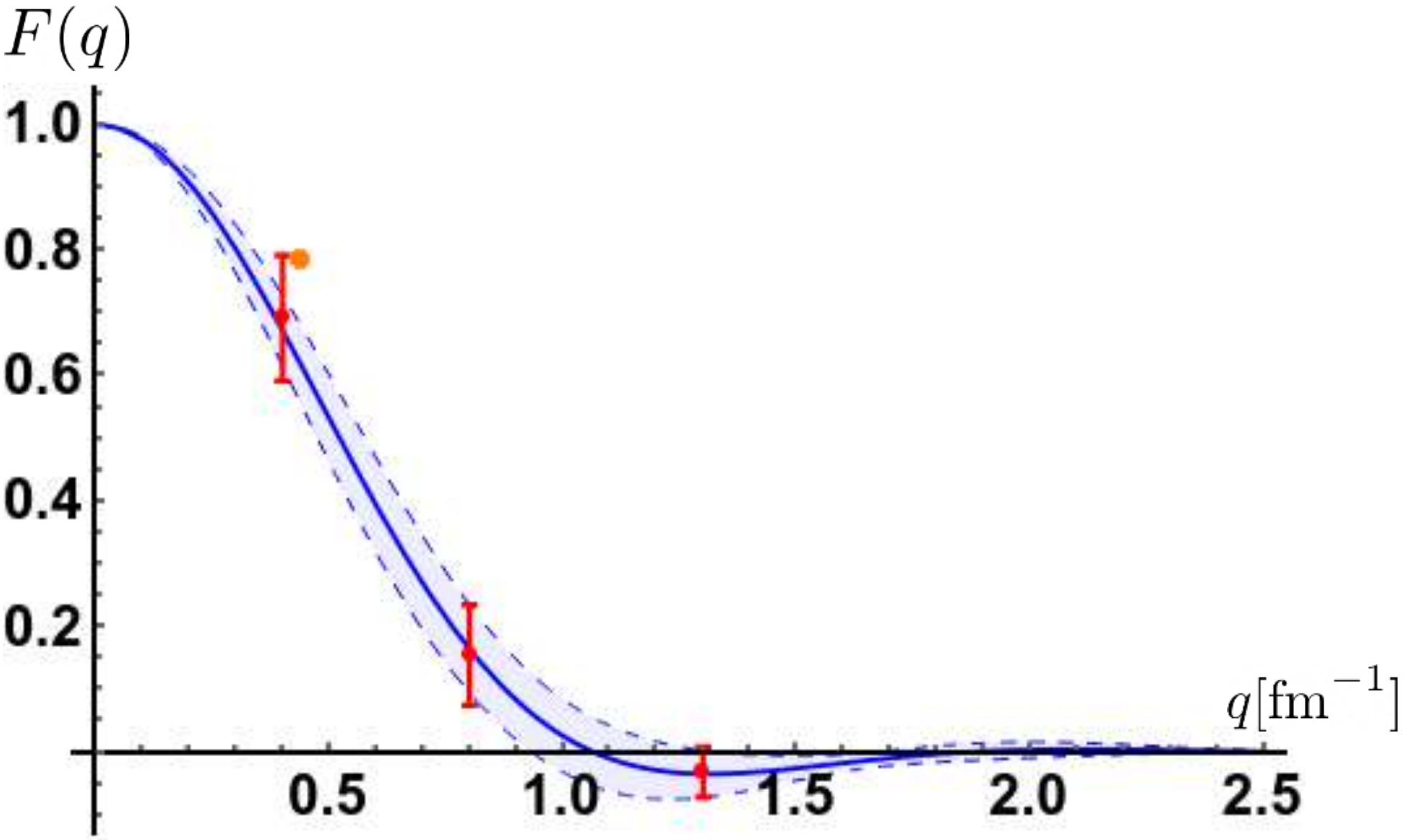
Abstract

Jefferson Lab

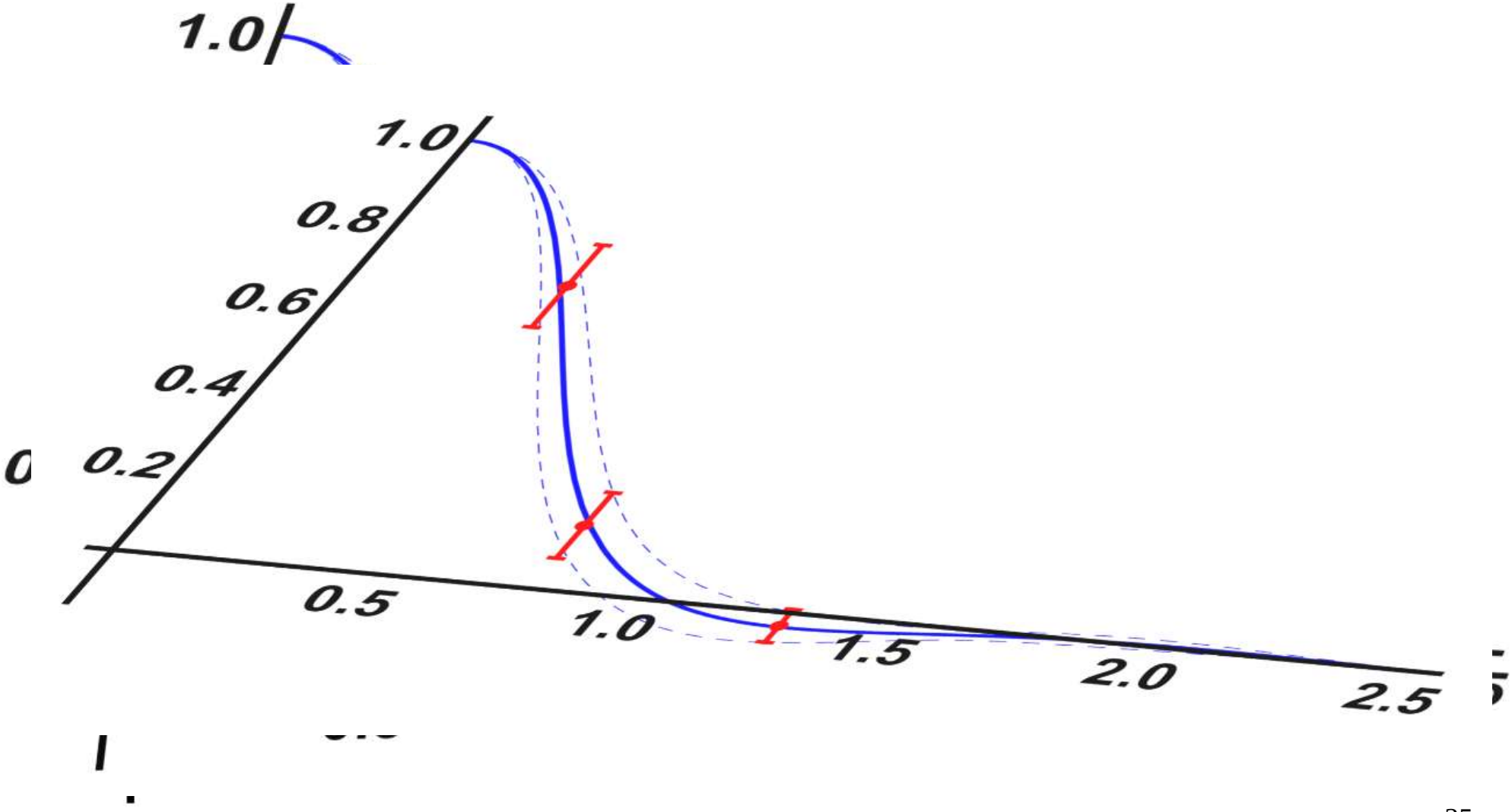
Funciones de Transferencia



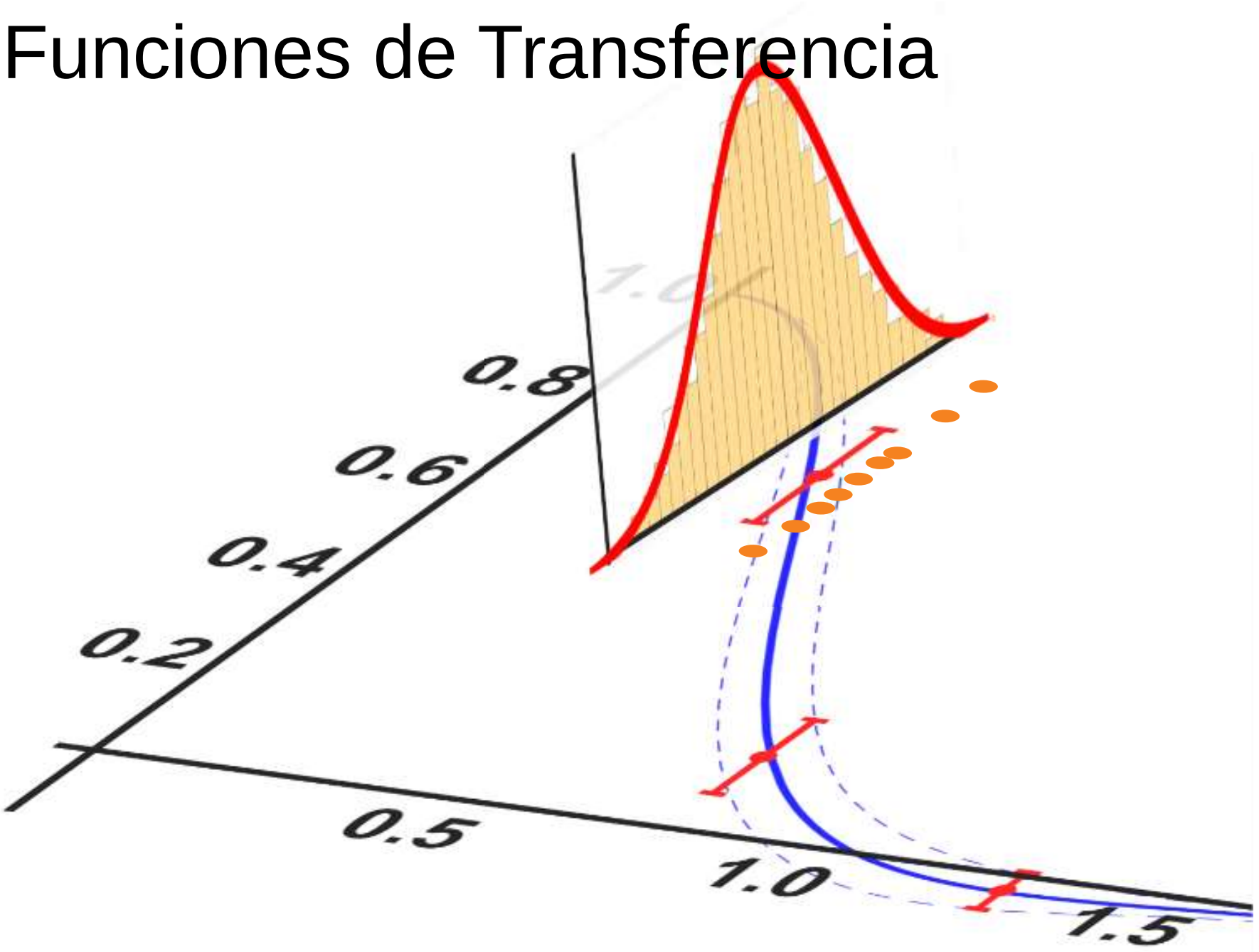
Funciones de Transferencia



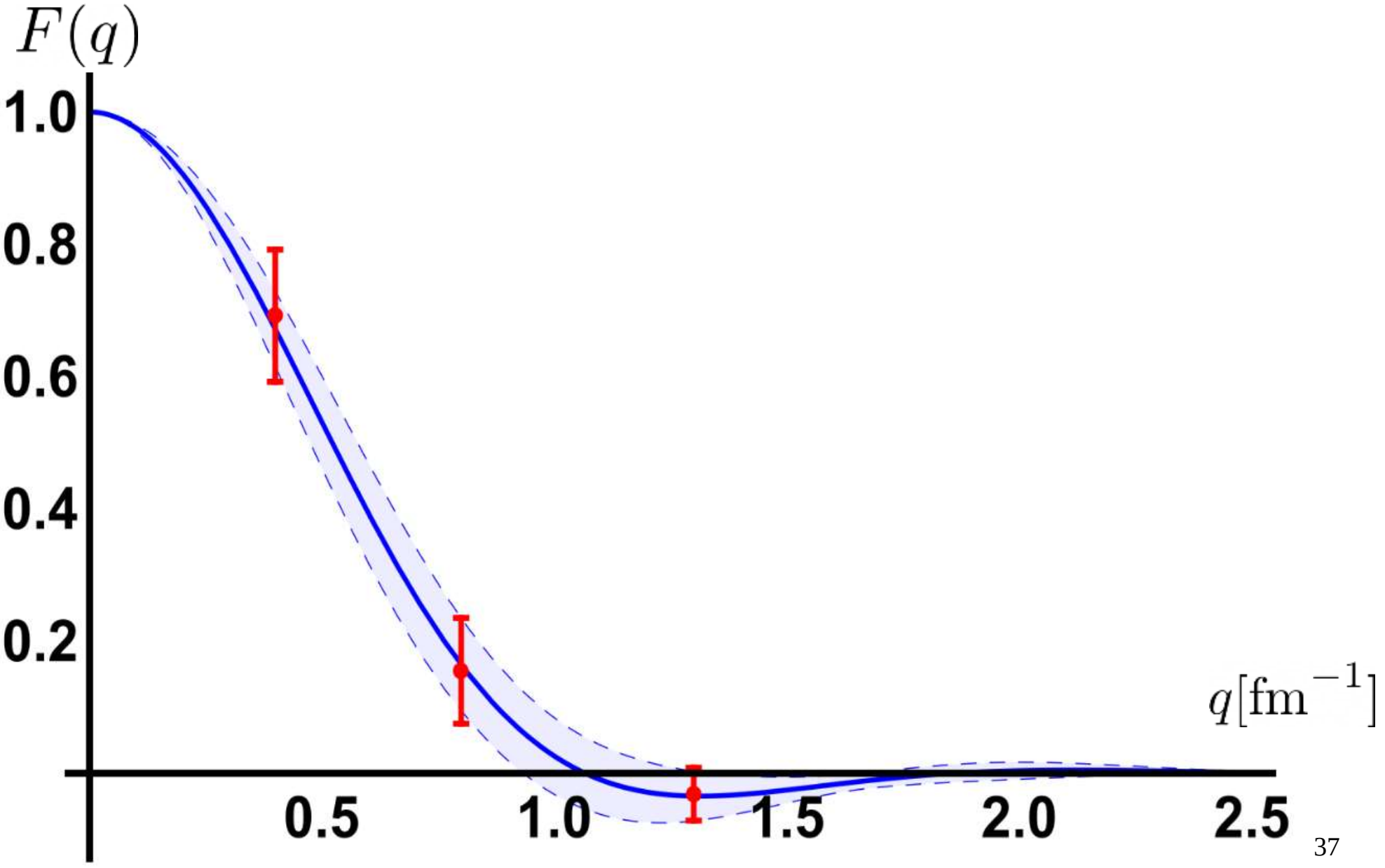
Funciones de Transferencia



Funciones de Transferencia

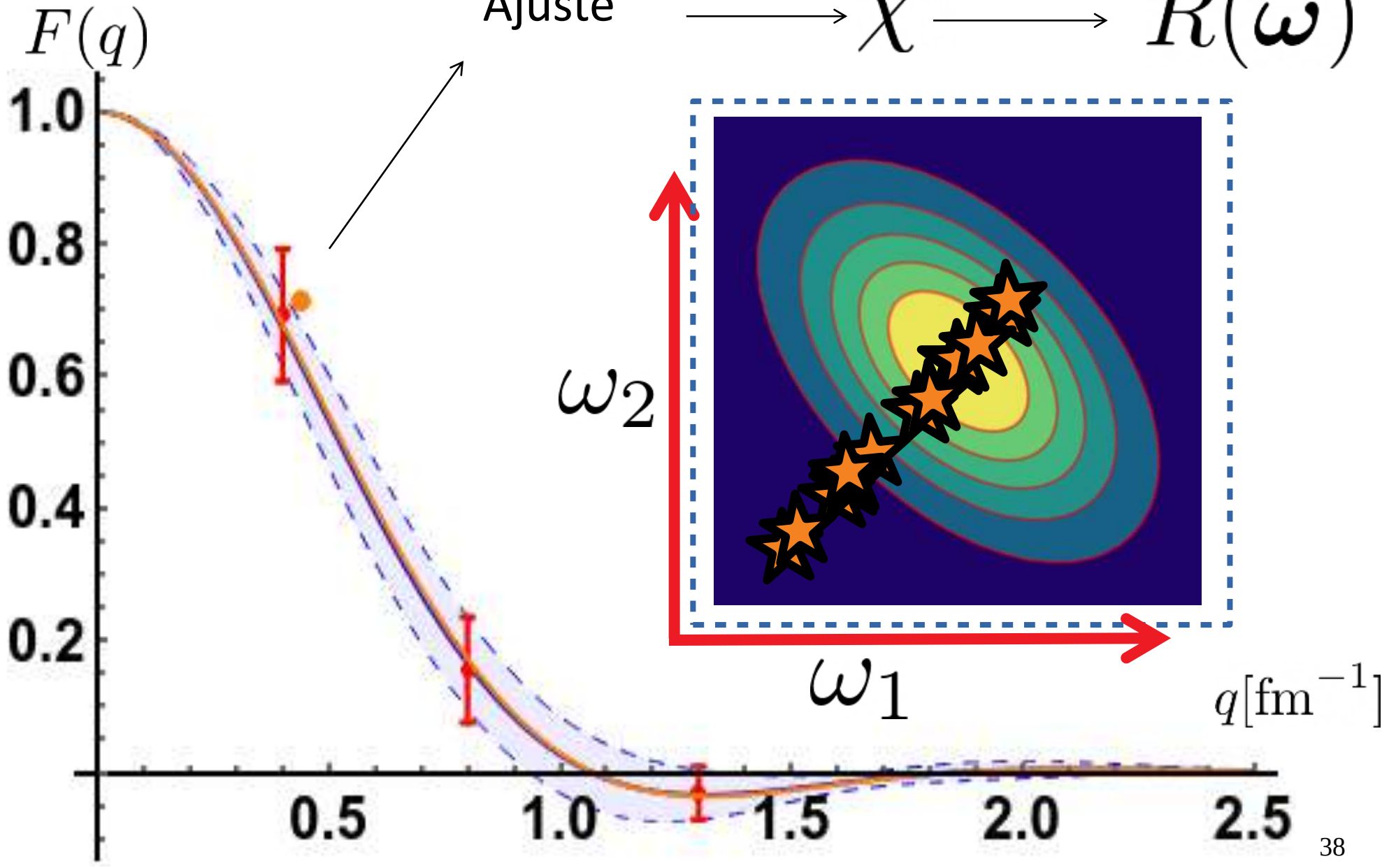


Funciones de Transferencia



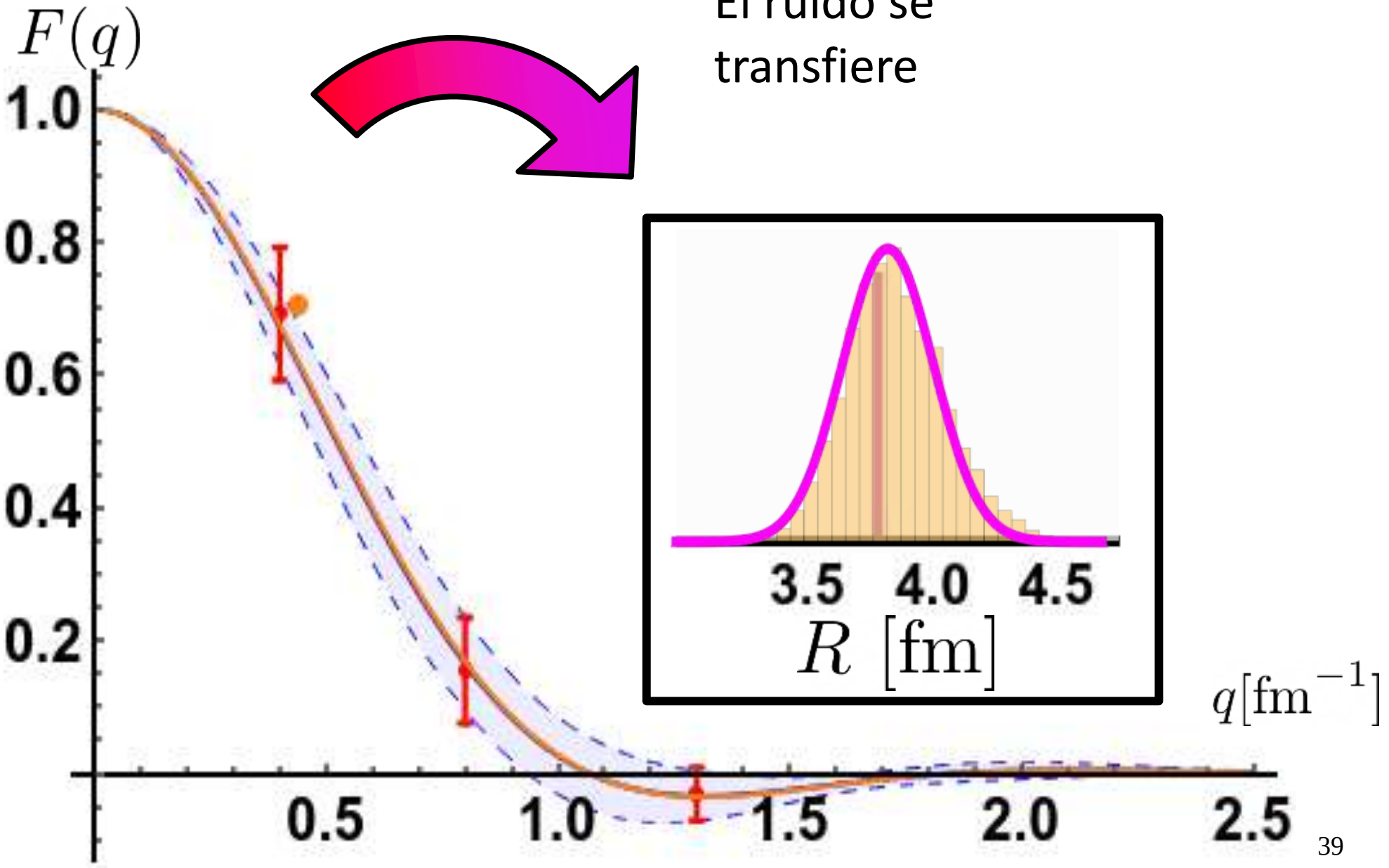
Funciones de Transferencia

Ajuste $\longrightarrow \chi^2 \longrightarrow R(\omega)$



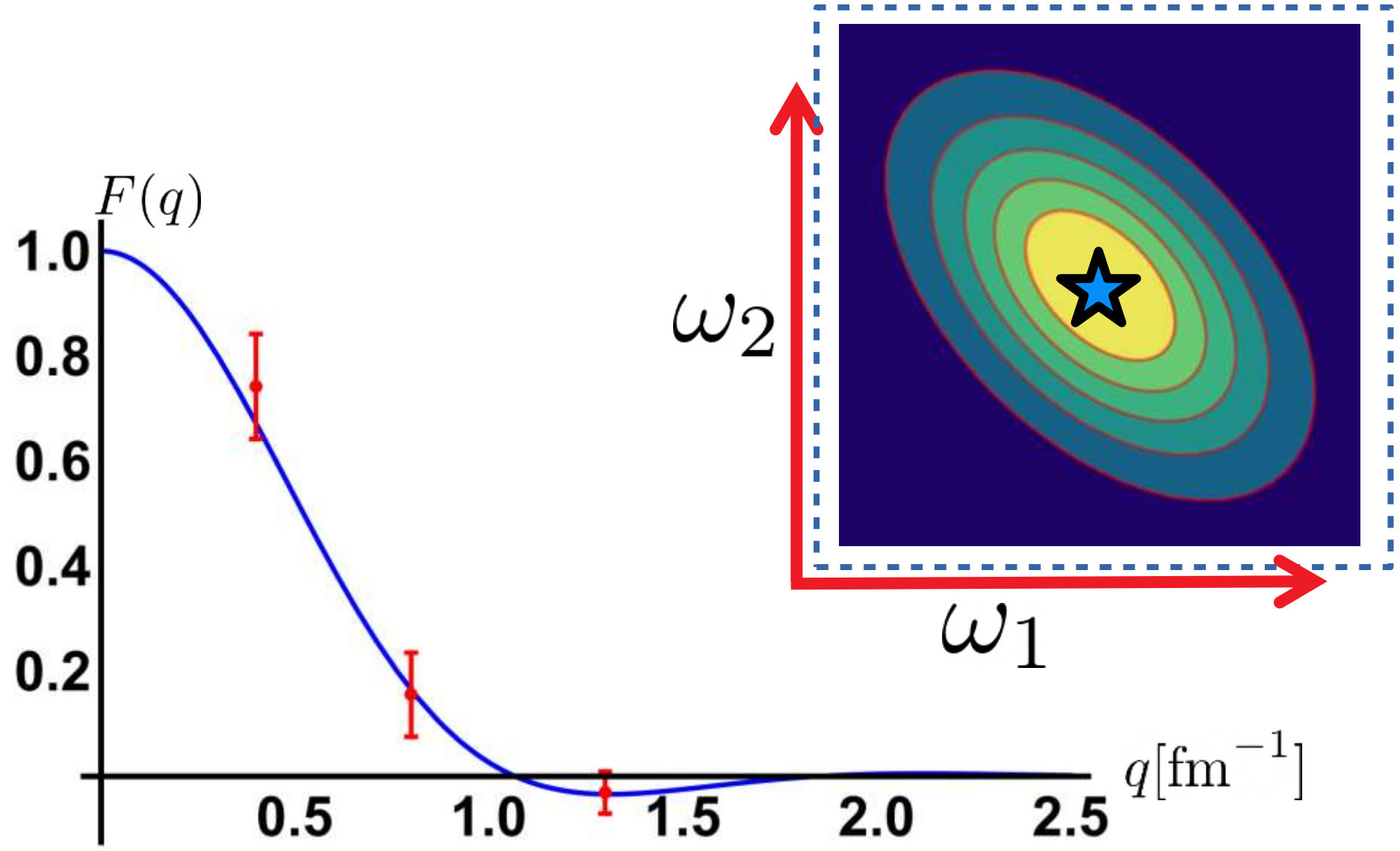
Funciones de Transferencia

El ruido se transfiere



Funciones de Transferencia

Minimiza χ^2 $\leftarrow$ ω -space

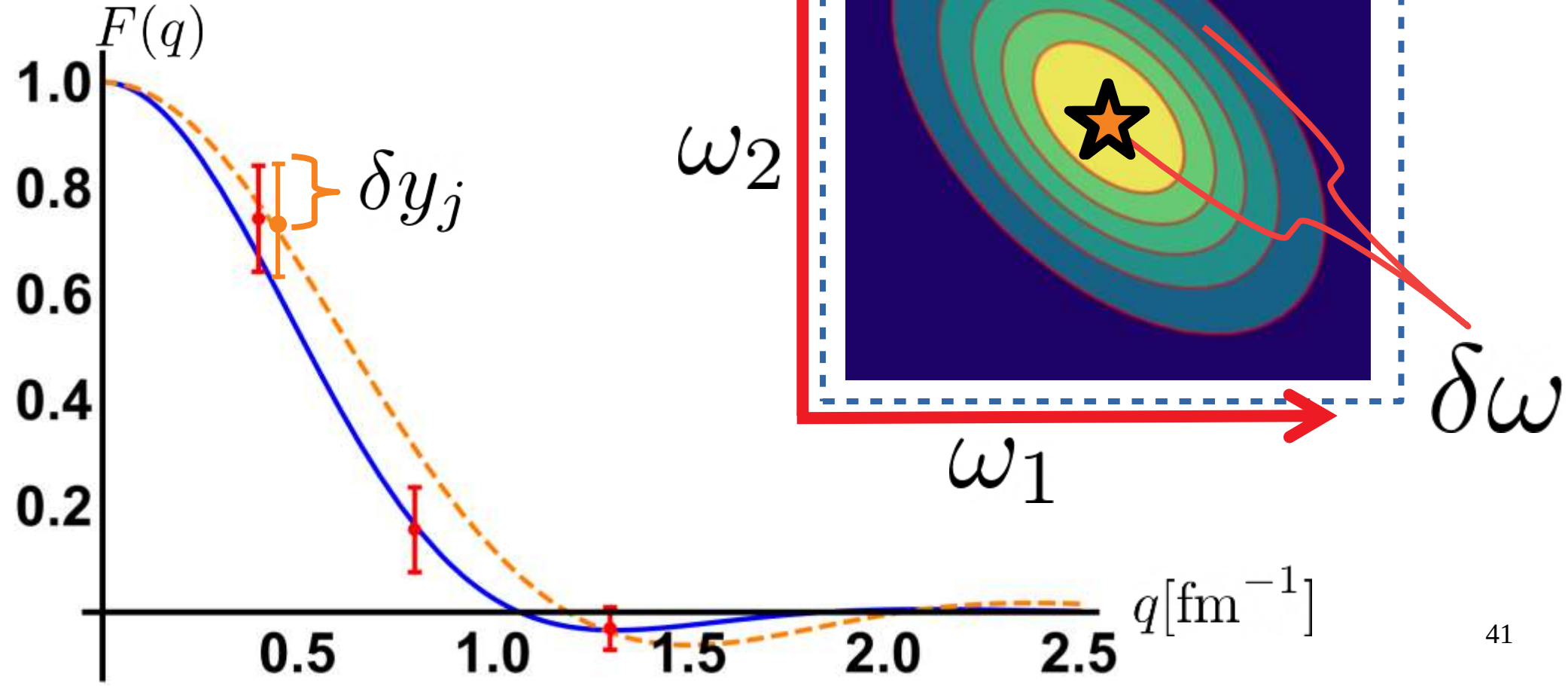


Funciones de Transferencia

$$\delta\vec{\omega} = \sum_{j=1}^{n} \frac{\partial \vec{\chi}^2}{\partial y_j} \delta y_j$$

Minimiza

ω -space



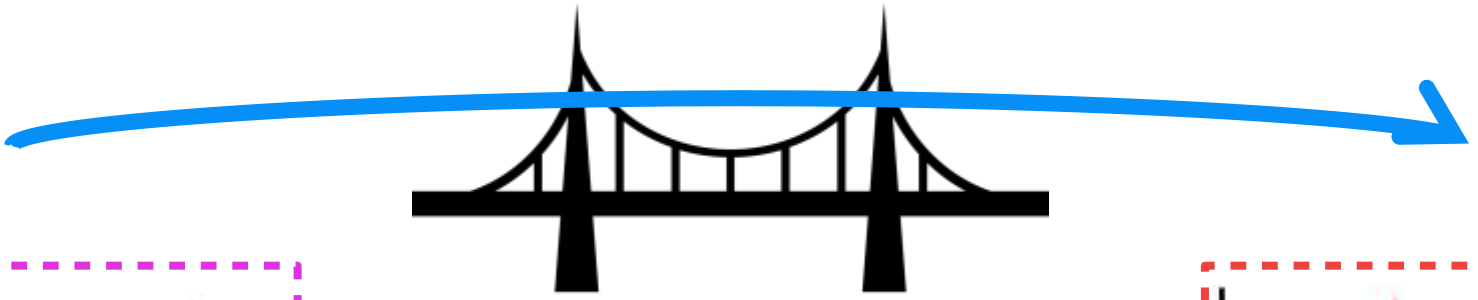
Funciones de Transferencia

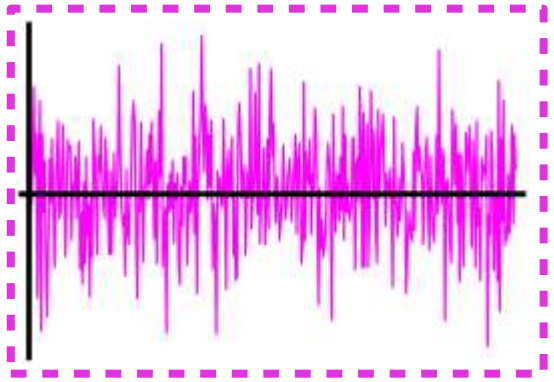
$$\delta\vec{\omega} = \sum_{j=1}^{n} \frac{\partial\vec{\omega}}{\partial y_j}\delta y_j$$

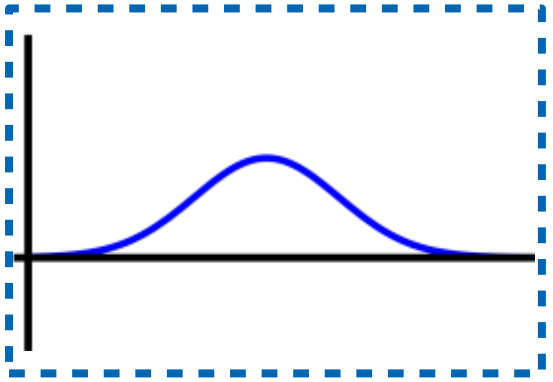
Funciones de Transferencia

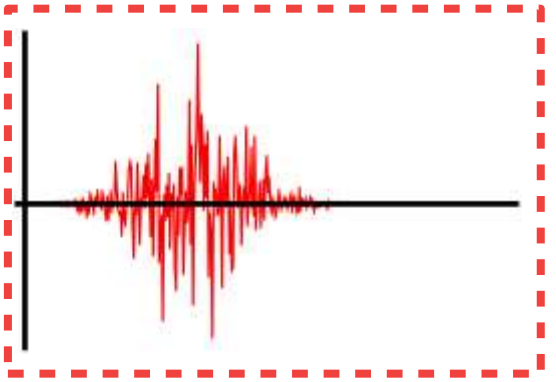
Funciones de Transferencia

$$\delta\vec{\omega} = \sum_{j=1}^{n} \left[\mathcal{TF}_j^{(\omega_k)} \right] \delta y_j$$









Input ruidoso

TF

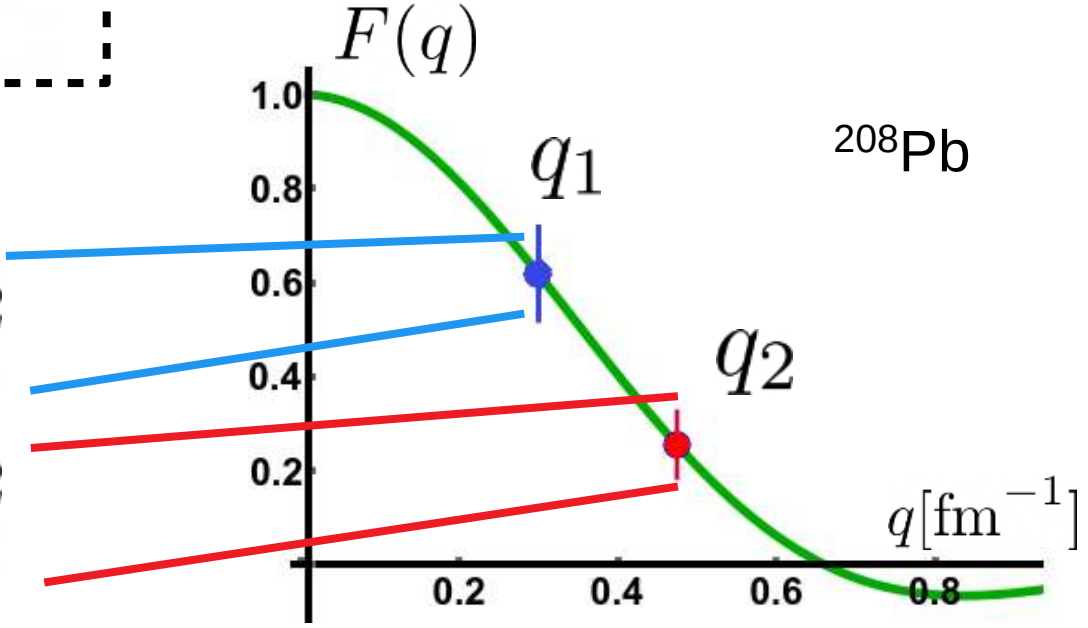
Output ruidoso

Funciones de Transferencia

$$\delta R = \sum_{j=1}^{2} \left[\mathcal{TF}_j^{(R)}\right] \delta y_j$$

$$\Delta R^2 = \sum_{j=1}^{2} \left[\mathcal{TF}_j^{(R)}\right]^2 \sigma_j^2$$

$$\Delta R^2 = \left[\mathcal{TF}_1^{(R)}\right]^2 \sigma_1^2 + \left[\mathcal{TF}_2^{(R)}\right]^2 \sigma_2^2$$

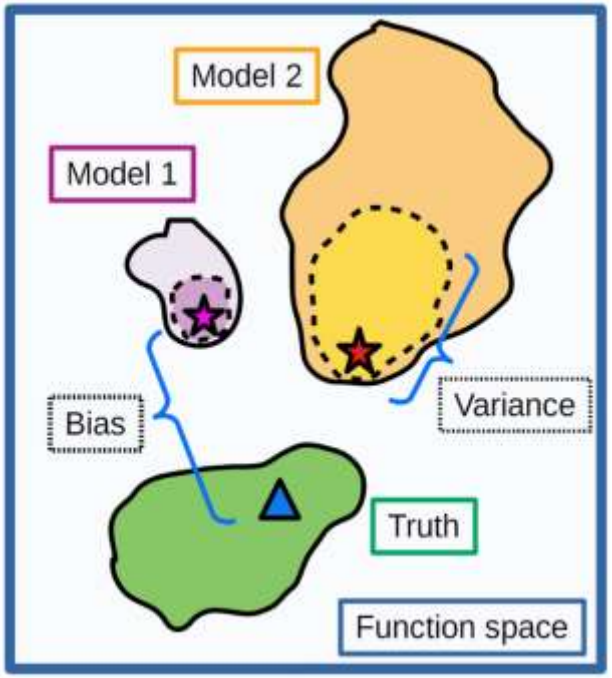


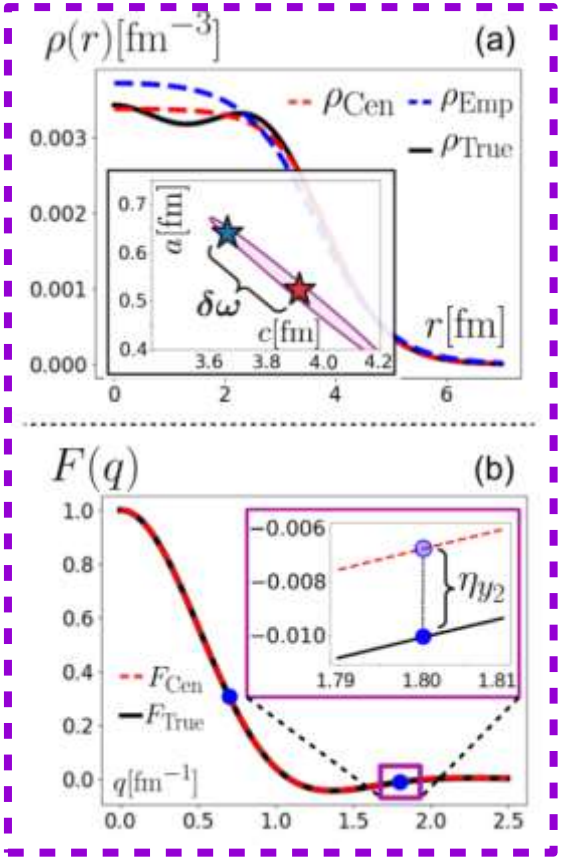
Funciones de Transferencia

Editors' Suggestion

From noise to information: The transfer function formalism for uncertainty quantification in reconstructing the nuclear density

P. G. Giuliani [1,2,*] and J. Piekarewicz [1,†]





$$\mathcal{TF}_j^{\omega} = \mathcal{H}^{-1}\nabla F(q_j, \boldsymbol{\omega})\sigma_j^{-2},$$

$$\mathrm{MSE}^2 = \left((m_c - m_t) + \sum_{j=1}^{J}[\mathcal{TF}_j^{(m)}]\eta_j\right)^2 + \sum_{j=1}^{J}[\mathcal{TF}_j^{(m)}]^2\sigma_j^2.$$

Comentarios finales

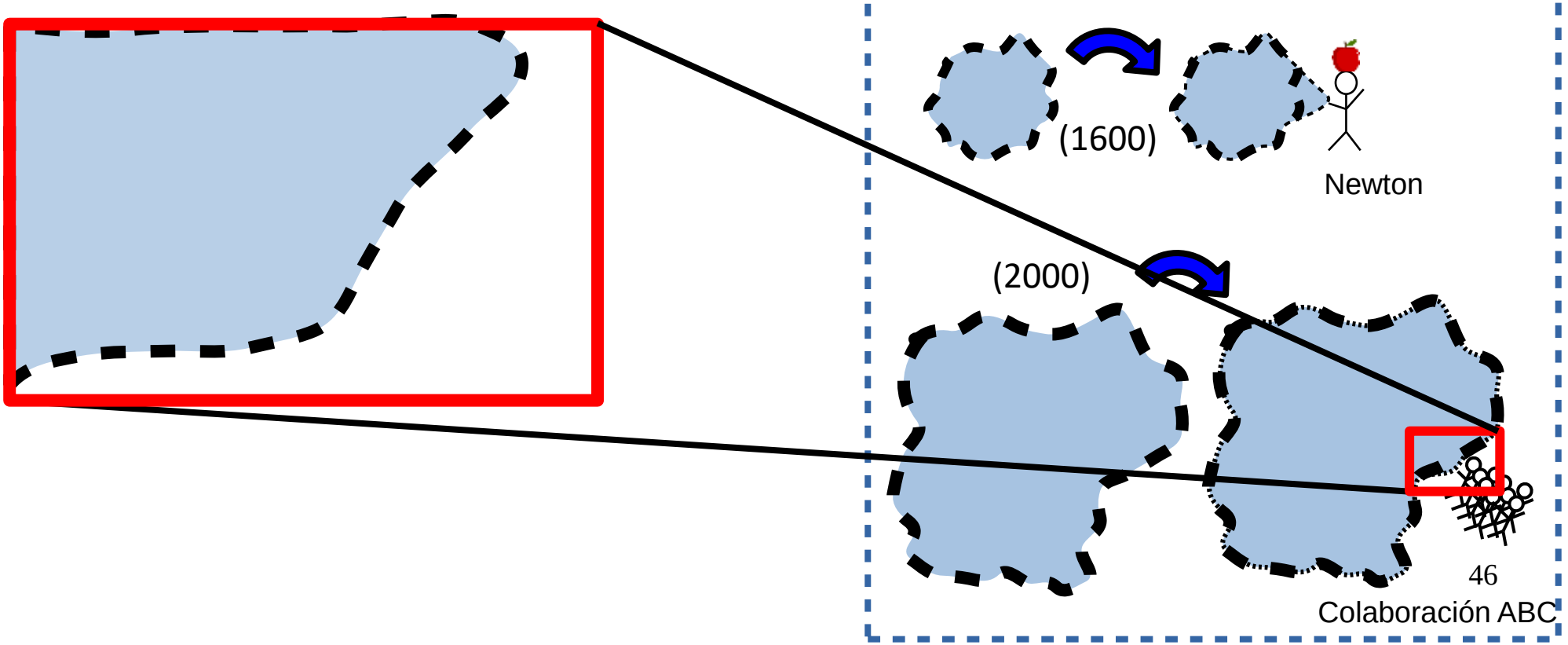
Preguntas como:

¿Dónde medir?

¿Cuál modelo usar?

¿Cómo maximizar la información?

Cruciales



Comentarios finales

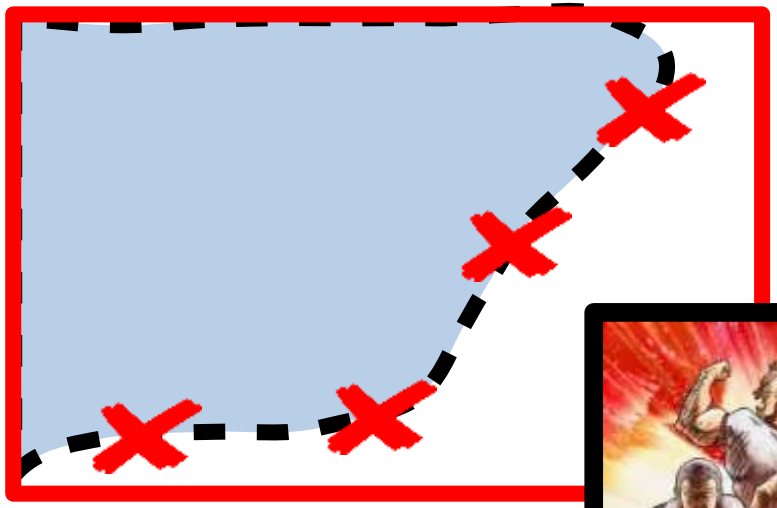
Preguntas como:

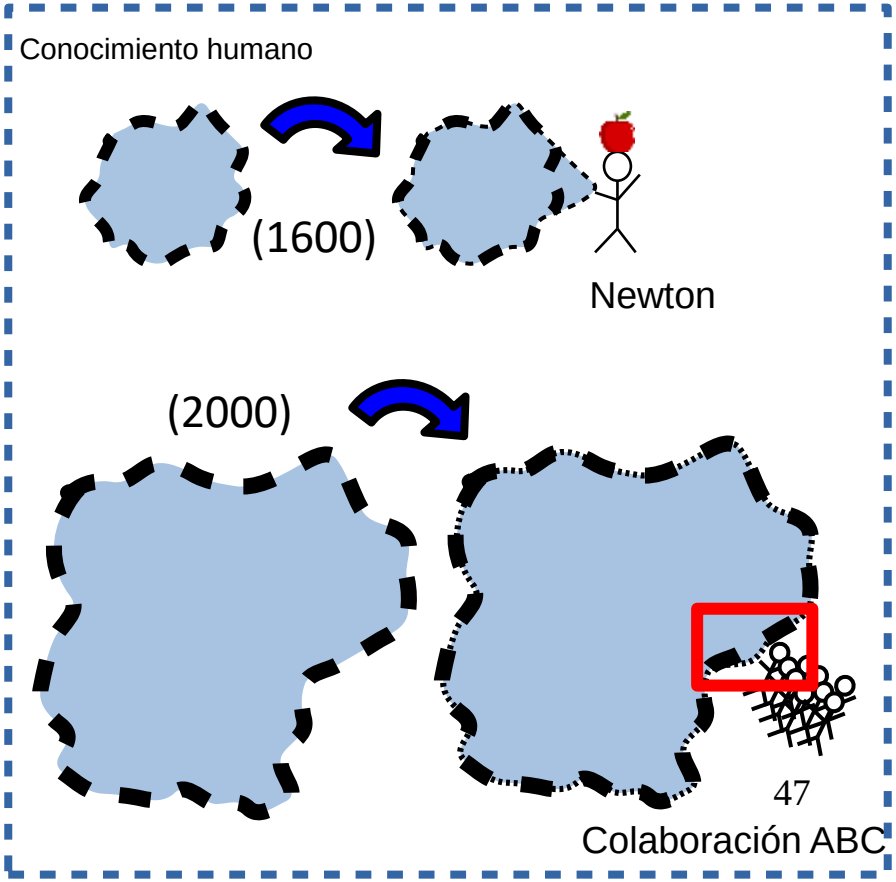
¿Dónde medir?

¿Cuál modelo usar?

¿Cómo maximizar la información?

Cruciales





Y terminamos!

¿Vieron la empanada secreta?