X-ray spectroscopy With LAXPC

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Spectrum

- What is spectrum?
  Distribution of the photons with energy.
  Plot of the histogram of events in Channel/Energy bin.

Spectrum

Suppose we observe **C(I)** counts in channel I from the source.

$$C(I) = T\int R(I,E)A(E)S(E)dE$$

- T: The observation length.
- S(E): The source flux
- R(I,E) (RMF): The probability of an incoming photon of energy E being registered in channel I.
- A(E) (ARF): The energy-dependent effective area of the telescope and detector system

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Spectrum

$$C(I) = T\int R(I,E)A(E)S(E)dE$$

- Here T, A(E) and R(I,E) are known and we want to find S(E).
- The energy range can be binned into small bins, and we get

$$C_i = T\sum R_{ij} A_j S_j$$

- Here, S_j is now the flux in the energy bin J. We
- We can calculate the inverse of R_{ij}, and get

$$S_j = \frac{1}{TA_j}\Sigma R_{ij}^{-1} C_i$$

- Such inversions tend to be non-unique and unstable to small changes in C_i. This amplifies the noise.

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Forward-fitting algorithm

$$C(I) = T \int R(I,E)A(E)S(E)dE$$

- We Choose a model spectrum, *f(E)* , which is described in terms of a few parameters (i.e., *f(E,p1,p2,...)*)

- For each *f(E)*, a predicted count spectrum $C_p(I)$ is calculated and compared to the observed data *C(I)*.

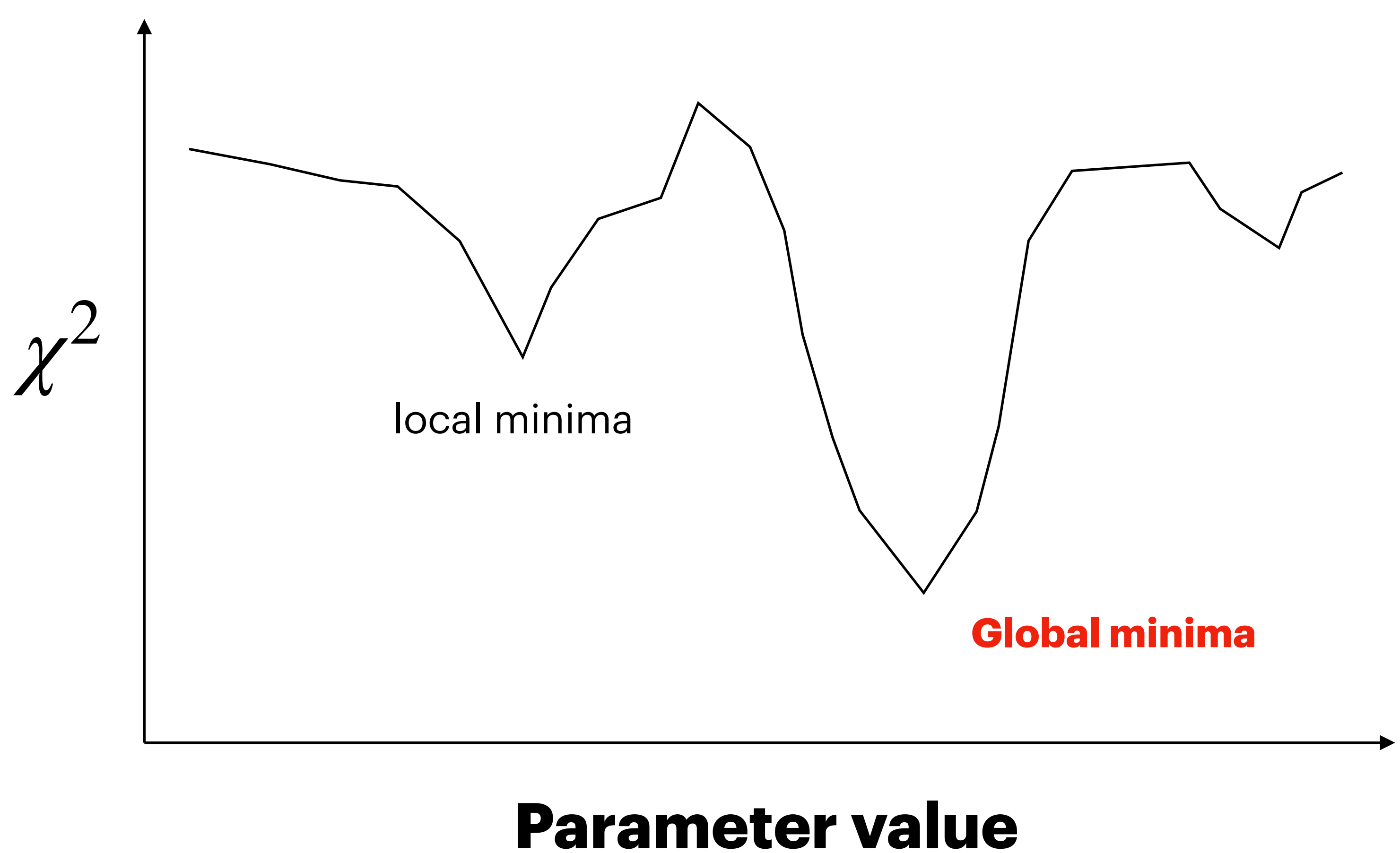
- The most common fit statistic in use for determining the "best-fit" model is "Chi-square" (χ^2), defined as follows:

$$\chi^2 = \Sigma(S_i - B_i T/T_b - (C_p)_i T)^2/((\sigma_s)_i^2 + (\sigma_B)_i^2)$$

Applicability of χ^2 statistics

$$\chi^2 = \Sigma(S_i - B_i T/T_b - (C_p)_i T)^2/((\sigma_s)_i^2 + (\sigma_B)_i^2)$$

- The χ^2 statistic fails in low-counting regime.
- Binned data, χ^2 statistics or the Gaussian statistics
- Unbinned data, C-statistics or Poisson statistics
- We can rebin the data so that each bin contains a large enough number of counts.



χ^2 in a nutshell

- Reduced χ^2 large

Errors are under-estimated
The model does not describe the data well

- Reduced χ^2 small

Errors are over estimated.

Too many parameters. Data is overfitted.

❋ The more complicated the model and the more highly correlated the parameters, then the more likely that the algorithm will hardly find the true minimum

Analysis Software

- **XSPEC:** or the Python version **PyXspec**.
- **Sherpa:** Multi-dimensional fitting program which includes the XSPEC model library. Python interface.
- **ISIS:** S-lang interface.