

Unfolding – Quantification for physics applications

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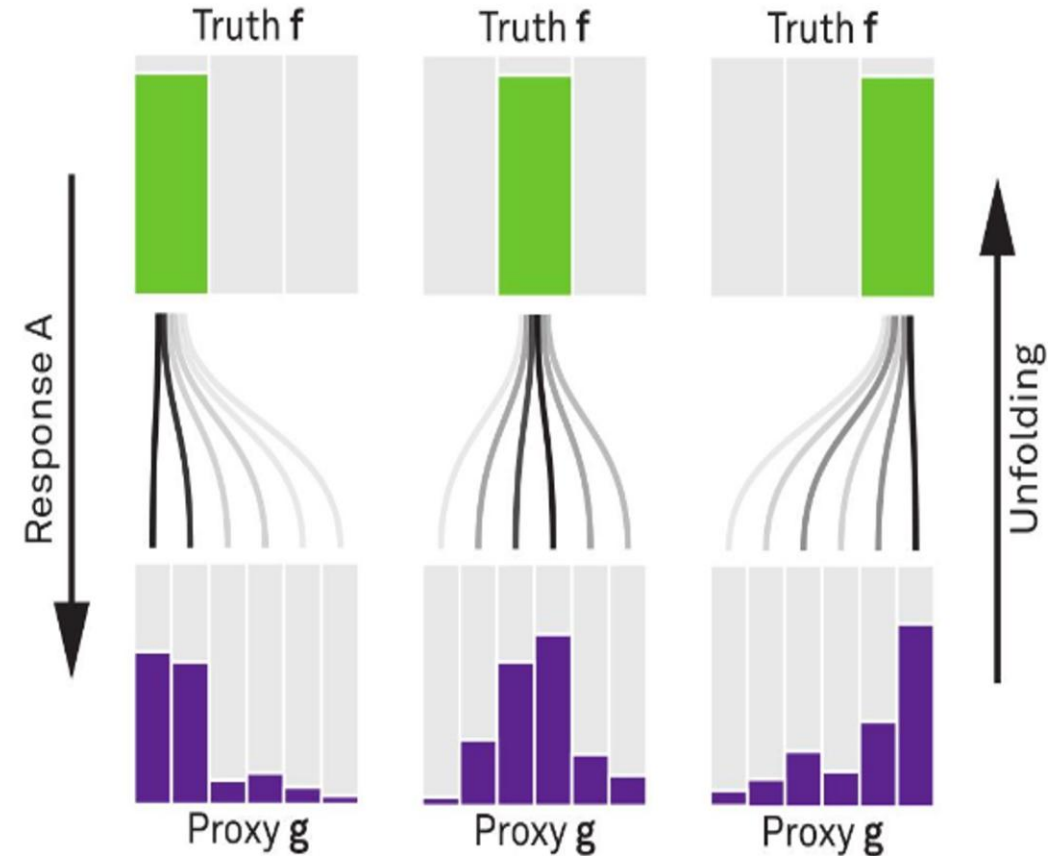
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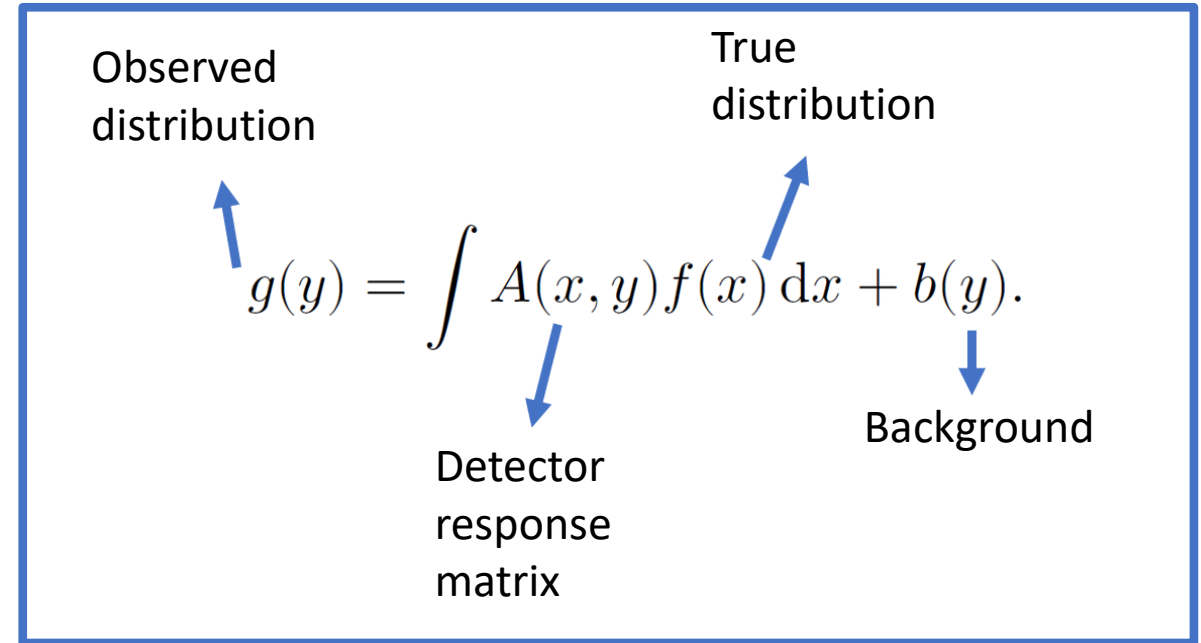
Unfolding: From spectrum of observable to spectrum of quantity in interest

- Common physics desire: Measuring a spectrum f of some quantity.
- However, f is often not directly observable.
- What is observable is some proxy g , derived from measured times, locations and charges. For example: An AI-derived estimate correlated with f .
- Requires: Simulated f and g to learn bin migration.



Unfolding in practice

- Solve the Fredholm integral equation:
- Done by minimizing negative log likelihood function:
- However, the problem is *ill-posed*. One needs regularization to avoid strong oscillations due to statistical flukes in the proxy.



$$\ell(\mathbf{f}|\mathbf{g}) = \sum_i \left((\mathbf{A} \cdot \mathbf{f})_i - g_i \ln((\mathbf{A} \cdot \mathbf{f})_i) \right) + \mathcal{R}(\mathbf{f})$$

$$\mathcal{R}(\mathbf{f}) = \frac{1}{2} \tau^{-1} \mathbf{f}^\top \mathbf{C}^\top \mathbf{C} \mathbf{f} \quad \mathbf{C} = \begin{bmatrix} 1 & -2 & 1 & & & \\ 0 & 1 & -2 & & & \\ & & & \ddots & & \\ \vdots & & & & -2 & 1 & 0 \\ & & & & 1 & -2 & 1 \end{bmatrix}$$