Handling Systematic Errors

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Goal: avoid two problems

A: claims of new physics due to calibration errors
B: features ignored due to presumed systematics

Triage for handling systematic errors

Easy and hard cases are clear
- line fluxes, energies, ratios should be easy
- separating source and instrument edges may need PI help

Middle ground requires new tools

Multiple adjustment functions (HLM) — bad
Vary instrument models (Drake et al.) — good
Summary: IACHEC-1

Recommendations to Cal scientists
- Tell users to avoid xspec syserr generally
- Try a (Drake-type) multi-RF method
- Publish methods to estimate parameter errors using simulated data
- Maintain user feedback and post as needed

Recommendations to missions
- Develop caveats or “watch out” pages
- Provide standard reductions
- Provide background models
- Provide examples of handling systematic errors
Adjustment Method

Method proposed: Use penalty function

Minimize

\[ \Lambda = \sum_j A_j^2 + \exp\left( \frac{(\chi_{\nu_j}^2 - 1)^2}{\nu_j} \right) \]

where

\[ \chi_{n\nu}^2 = \frac{1}{\nu_n} \sum_{i=1}^{I_n} \left[ y_{in} - f(x_{in}; \vec{\alpha})(1 + \sum_j A_{n,j} g(x_{in}; \vec{\beta}_j)) \right]^2 \frac{s_{in}^2}{s_{in}^2} \]

Problems:

- \( \min \chi^2/\nu \) achieved jointly: 2.62, 1.48
- Model is “ugly”

Solutions?

- Different basis functions
- Evolve toward Drake et al. method
Multiple Fit Methods

Monte Carlo method (Drake et al. 2006)

- Systematic errors assigned to each component of the effective area (mirror, detector, filter, ...)
- EAs are perturbed within bounds in piecewise continuous fashion, weighted by truncated Gaussian
- RMFs also adjustable via a separate model
- Run model fits with many EAs

Library method (Drake et al., in prep.)

- Use PCA to make EA perturbation basis vectors
- Proceed as in MC method
Multiple Fit Results

Drake et al. 2006
Uses of MC/PCA Method

- Calibration work is setting bounds
  - Adjust bounds until $\chi^2/\nu = 1$ for bright sources
  - Still requires expert knowledge of source

- Observation planning
  - Observer guide gives bounds on systematic errors
  - Users may try out different systematic errors before proposing

- Analysis would be “correct”
  - Can detect model errors if $\chi^2/\nu > 1$
  - Parameter error estimates are valid