Allocating, Finding, and Correcting systematic errors Instrumental Effective Areas

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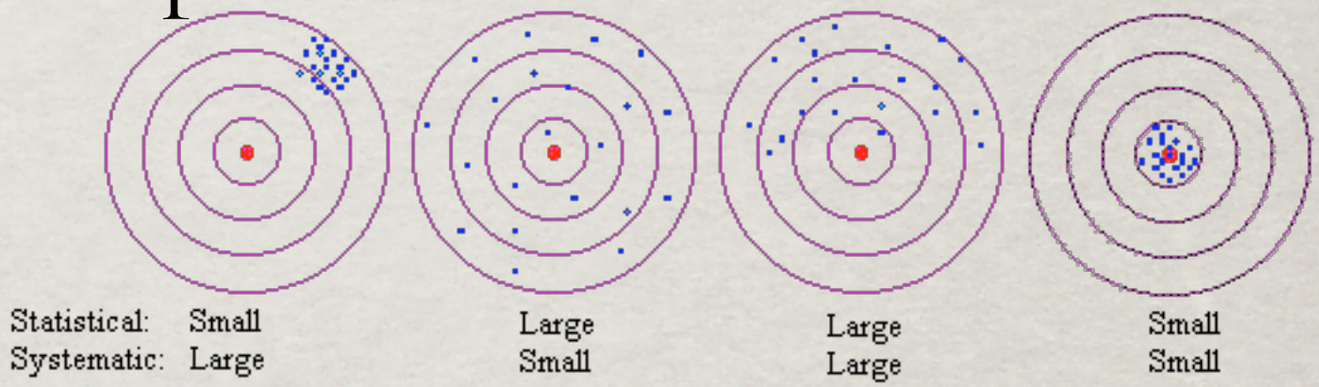
Definitions 1

- Statistical Errors (precision)
  - Dominated by random processes
  - Estimator bias
- Sample Errors
  - Physical outliers (e.g., getting WDs in QSO sample)
    - Bad measurements: cosmic rays, dead pixels
- Systematic Errors (accuracy)
  - Errors in system modeling (calibration)
  - Allocate (allow for), find (discover), correct (fix)
  - Cockroaches: hunt down and exterminate



Definitions 2

- Absolute Errors (0th moment)
  - Affect physical values: flux, energy, location, etc.
  - Allocate via modeling (inc. simulation)
  - Correct for zero point bias: background, noise...
  - Find, correct via external ref. (e.g. cross-cal)
- Relative Errors (high order moments)
  - Affect differences and ratios
    - Effective area: spectral slopes, line ratios
    - Energy scale: orbital velocities, cluster dispersion
  - Alternative definition: relative is only a percentage

Role of Physical Models

- With physical model:
  - Positivity generally ensured
  - Extrapolation beyond data is more reliable
  - Sharp features can be modeled (e.g. edges)
    - No longer a systematic error....
- Correcting errors without physical model:
  - Keep it simple (Bayesian....)
  - Generally want basis functions (nondegenerate)
  - Powerlaw or Chebyshev polynomials used most
  - Fourier decomposition is intuitive

Treatment of Systematic Errors

- Not random, not Gaussian, not symmetric!
  - Cannot "add in quadrature" with random errors
    - Exception: if system has uncorrectable excess noise
  - Answers are biased: repeating doesn't reduce error
  - Often merely estimated — not precise!
  - Relative vs. Absolute
    - Can eliminate one without fixing other
      - e.g. distortion correction v. mispointing telescope
      - e.g. flux of source with power law spectrum
    - Relative error depends on E, λ, t, x, α, ...

HETGS Effective Area

- Simulation
  - Model grating bars, facets, structure physical
  - Model implemented in *marx*
- Ground Calibration
  - Found model errors --> corrected efficiencies physical
- Internal Flight Calibration
  - MEG v. HEG --> corrected eff's non-physical
  - Check +1 against -1 --> fix ACIS BI QE physical
- Cross-calibration (with XMM)
  - No problems yet.... non-physical

General Suggestions

- Fix systematic errors physically if possible
- Fix systematic errors by any means
- Assign possible systematic errors
  - give a range of validity
  - give correlation of systematic errors
- Develop experience database
  - systematic errors are <u>everyone's</u> problems
  - communicate between users and correctors
  - keep public logs of issues, fixes