Intro to Calibration Concordance

Herman Marshall (MIT)
and the Harvard AstroStats Group

The Charge

- In-flight data show discrepancies
    - Cluster temperatures and fluxes
    - Blazar fluxes from simultaneous observations
    - SNR line fluxes
- Missions characterize systematic uncertainties internally and independently
- Assuming we *should*, how does IACHEC *change* a mission's calibration?

A Proposal

- Attend/read Prof. Meng's presentation (Wed. 9:00AM)
  - Start with C_{ij} = Counts for instrument i (1..N), source j (1..M)
  - Assume "true" areas A_i, "true" fluxes F_j
  - Estimate F_j by $f_j = C_{ij} / a_i$ (a_i = 1st estimate of A_i)
  - Method determines "best" $\underline{F}_j$, computes w, and "better" $\underline{a}_i = a_i^{w} (C_{ij}/\underline{F}_j)^{1-w}$, brings f_j closer *but not precisely* to $\underline{F}_j$
  - $w = 1/(1+M\tau^2/\sigma^2)$, τ = "a priori" st.dev. in ln(a), σ = st. dev. in $\ln(C_{ij})$
    - w = 0 means instrument is very uncertain
- IACHEC team sets τ for each instrument, runs Meng's analysis
  - IACHEC team recommends changes from a_i to $\underline{a}_i$
  - Process runs for each of many bandpasses "independently"

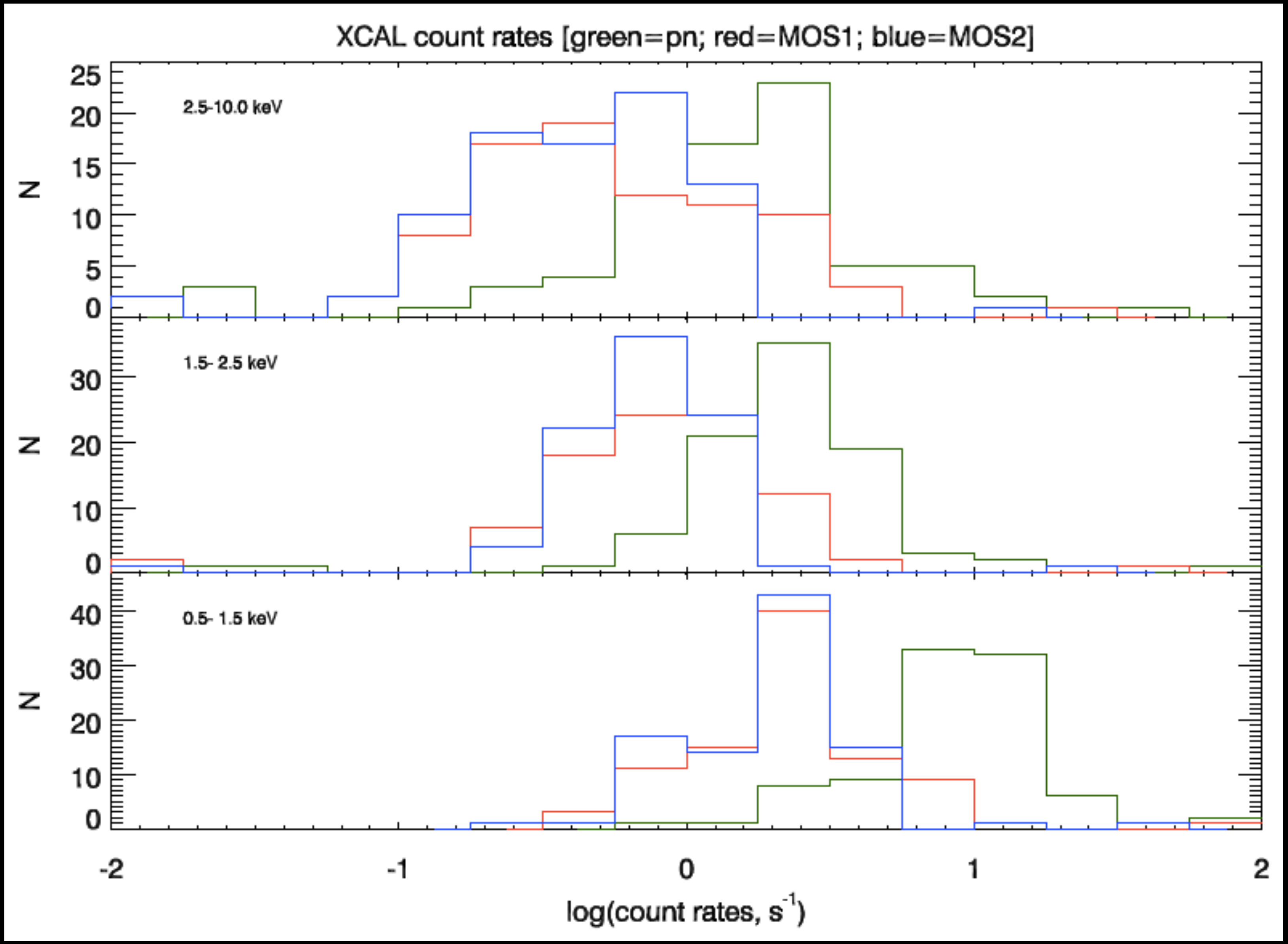
Practical Considerations

- What does an instrument *actually* do?
  - Measure counts, C_k in channel k
  - Response function gives k(E) mapping
  - Assume exposure times are extremely precise
- How do we *actually* measure fluxes?
  - Forward folding of model, test against C_k
  - Excise regions of pileup using PSF, obs'd data: factor Φ_{ij}
  - Flux definition: $N(E) = \mathcal{N}\, q(E;\alpha)$, α is uninteresting parameter
  - Need same assumed (fitted) α across instruments
- What do we *actually* fix?
  - Assume $A(E) = \mathcal{A}\, \rho(E)$, where A is target of adjustment

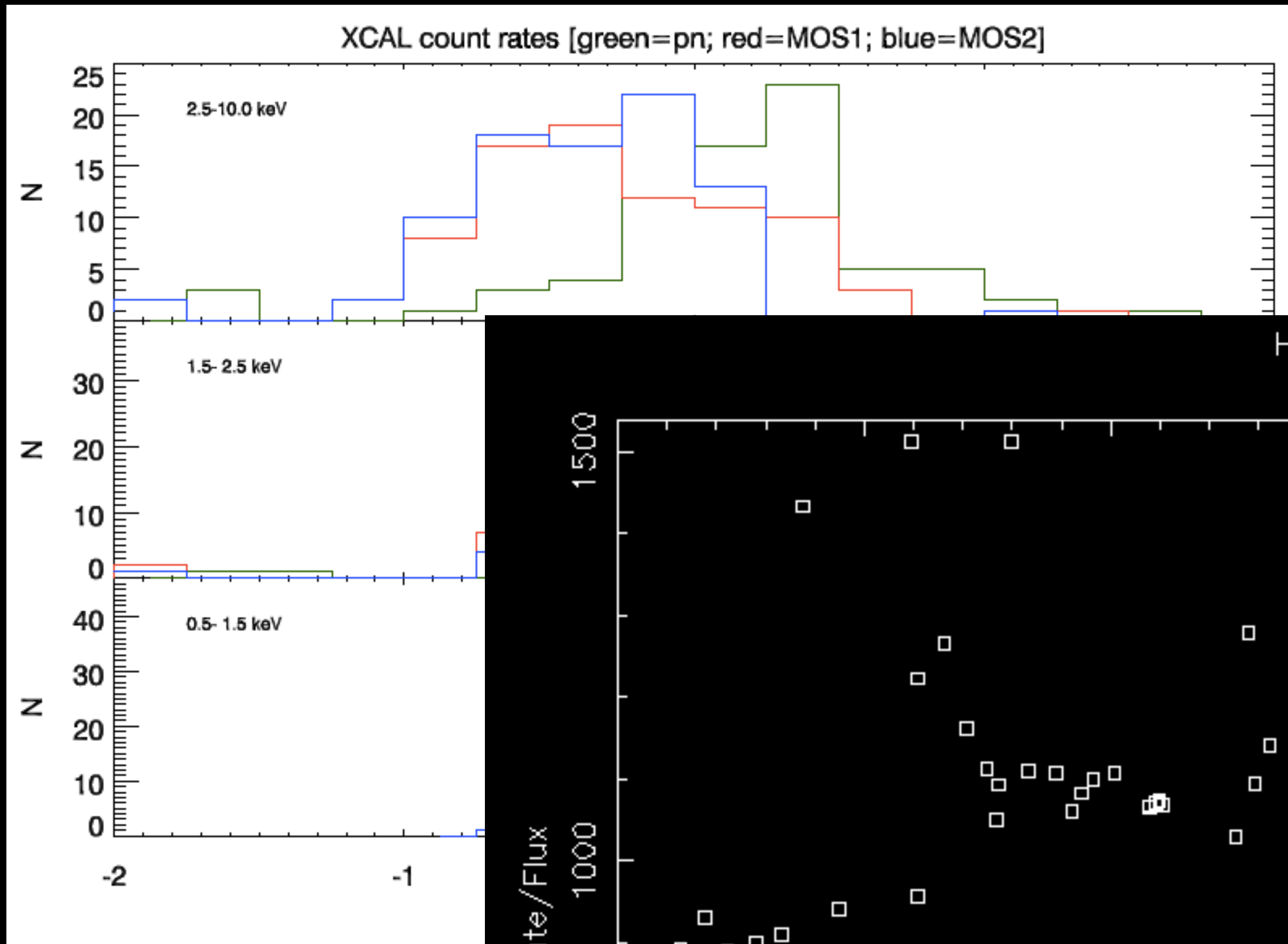
Expected Counts of instrument i source j, C_{ij}

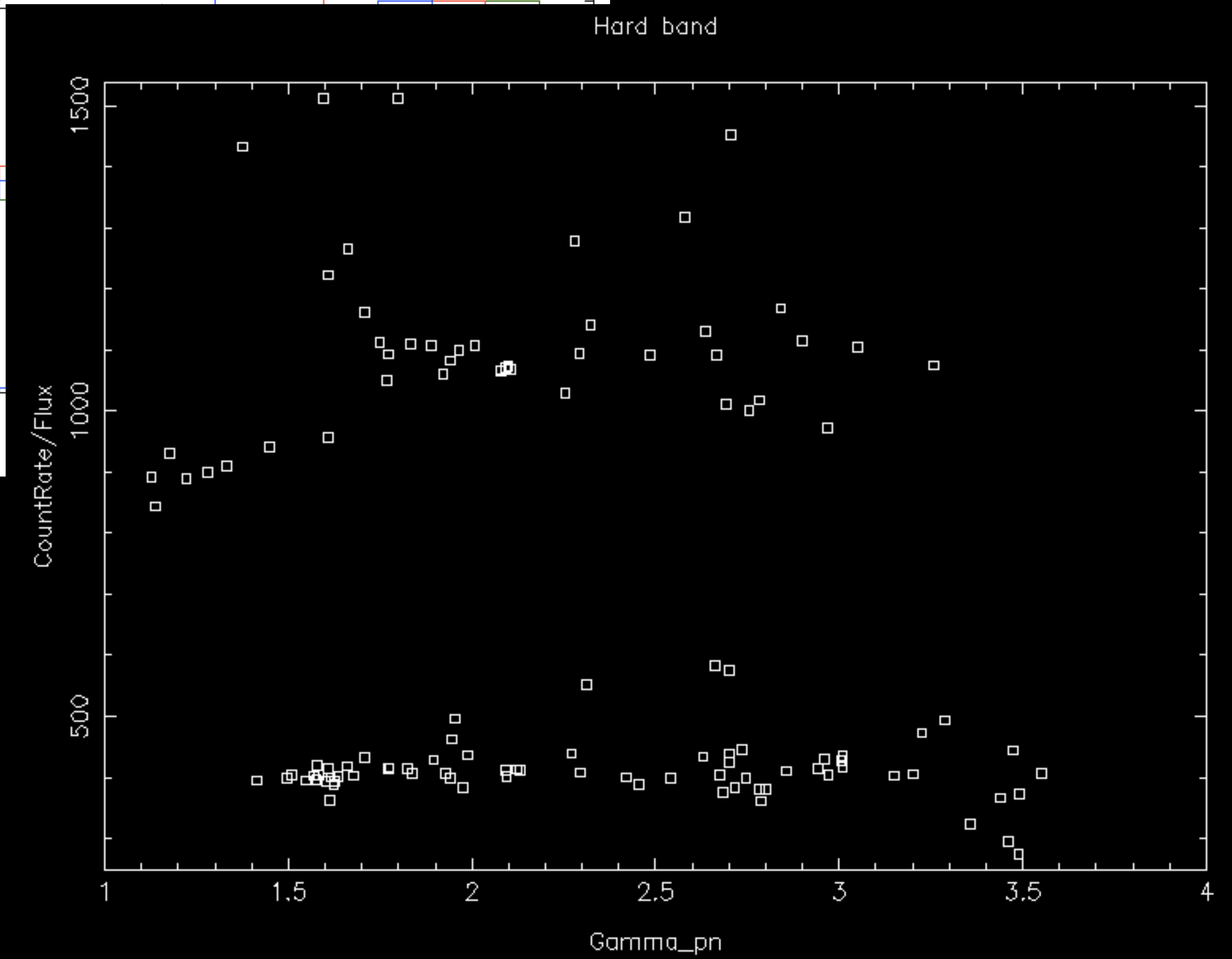
- The effective area $A_i(E) = \mathcal{A}_i \rho_i(E)$, where only $\mathcal{A}_i$ is unknown and $\rho_i(E)$ is a fixed function estimated empirically for $E \in [E_1, E_2]$.
- The flux $F_j = \int_{E_1}^{E_2} n(E;\theta_j)dE = N_j \int_{E_1}^{E_2} q(E|\theta_j^*)dE$, where $n(E;\theta_j)$ is the spectrum of source j at energy E. $q(E|\theta_j^*)$ is known.
- The response matrix function $r_{ik}(E)$ is the probability that a photon with energy E comes to channel k through instrument i; known.
- The exposure time for instrument i source j, T_{ij}, is measured precisely.

$$
\begin{aligned}
C_{ij} &= \sum_{\frac{E_1}{\kappa_i} \leq k \leq \frac{E_2}{\kappa_i}} T_{ij} \int r_{ik}(E) A_i(E) n(E;\theta_j) dE \\
&= \mathcal{A}_i N_j \left[T_{ij} \times \int_{E_1}^{E_2} \rho_i(E) q(E|\theta_j^*) \sum_{\frac{E_1}{\kappa_i} \leq k \leq \frac{E_2}{\kappa_i}} r_{ik}(E) dE \right].
\end{aligned}
$$

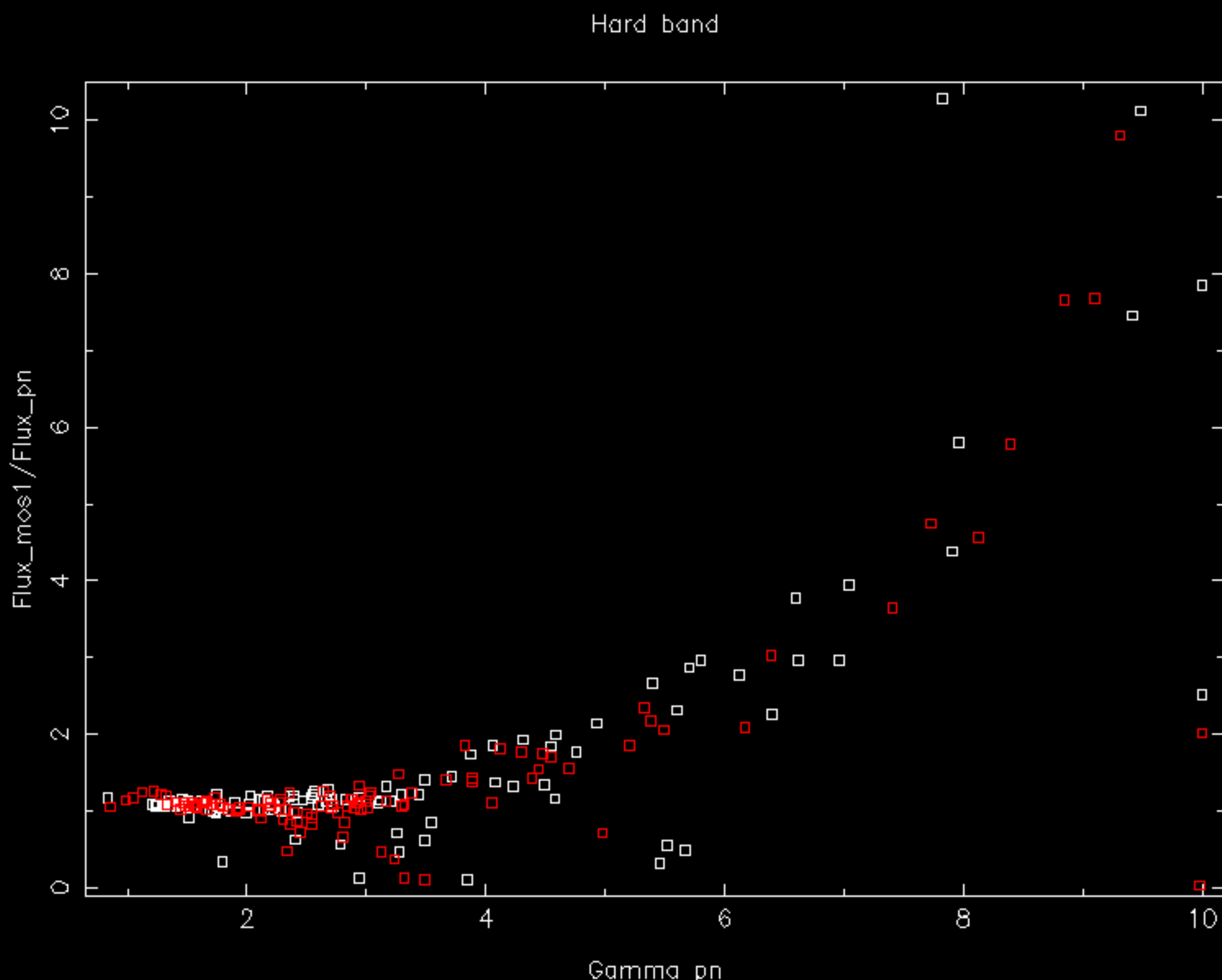


XCAL count rates [green=pn; red=MOS1; blue=MOS2]
2.5-10.0 keV
1.5- 2.5 keV
0.5- 1.5 keV
N
log(count rates, s^{-1})


XCAL count rates [green=pn; red=MOS1; blue=MOS2]
2.5-10.0 keV
1.5- 2.5 keV
0.5- 1.5 keV
N
-2
-1
25
20
15
10
5
0
30
40


Hard band
CountRate/Flux
Gamma_pn
1500
1000
500
1
1.5
2
2.5
3
3.5
4

XMM XCAL Data Handling



XMM XCAL Data Handling