From Emission to Detectors to Data: Natural View, Detector View, Scientific View

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Exercise: How should we trigger?
Answer: Find S/N of (ch1, ch2, ch1+2, ch 3, sum of all)

- Note Channel Definitions on Wiki

Your Phone Camera - What do you think it does?

- Everybody write down as many steps as they can think of, no sharing, two minutes, on what goes on in your phone camera.
- Two minutes, confer.
- After, let's see how you did.

Phone Camera - What goes on

- CCDs are cheap and ubiquitous - but they are sophisticated, complex devices

- $I'(x,y) = I(x,y)-b(X,y)$ probably there is a bias subtraction

- $I''(x,y)=I'(x,y)/R(x,y)$ - Certainly there is a “flat” correction - the response of every detector is not the same, so a picture of a uniform field (like a white wall) will appear “speckled” without this correction, even in bright light (not so important for bias.

- Color: $I_{color}'''=I_{color} * C_{color}$ for a color camera, you need to have some kind of a color response correction - most CCDs are not so sensitive in the blue, so perhaps you want to increase blue response compared to red.

- Probably these corrections are non-linear... $I_{color}'''=I''_{color} * C_{color} (<I''>)'$

- Probably there are fancy noise-reduction algorithms....?

Lesson: Consumer devices make us think the devices are “simple” and “easy”;

In fact, the basic devices, like cameras and cell phones are incredibly complex (more than the detectors we use) ... it is sophisticated **software** and super-miniature computing that makes them ***appear*** simple.

It is **our job** to do the same with the software/ algorithms for our instruments. It is our job to manage the complexity to make the science calculation as simple as possible.

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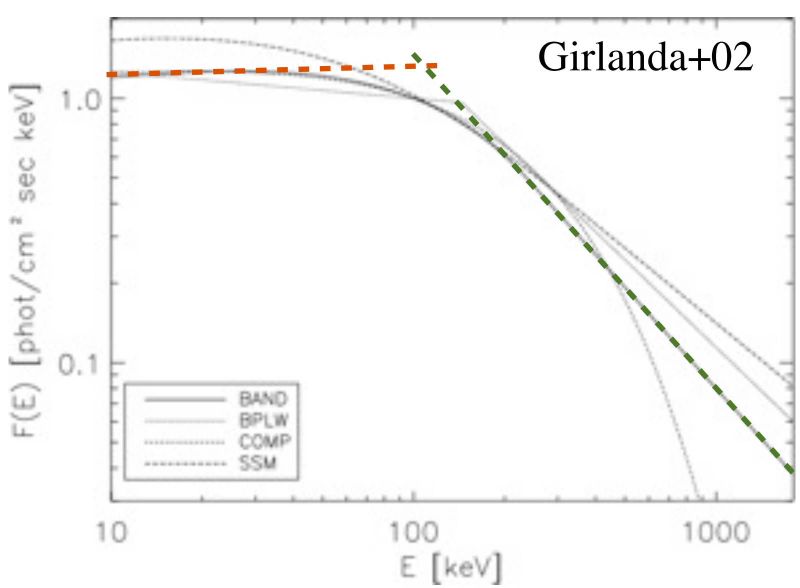
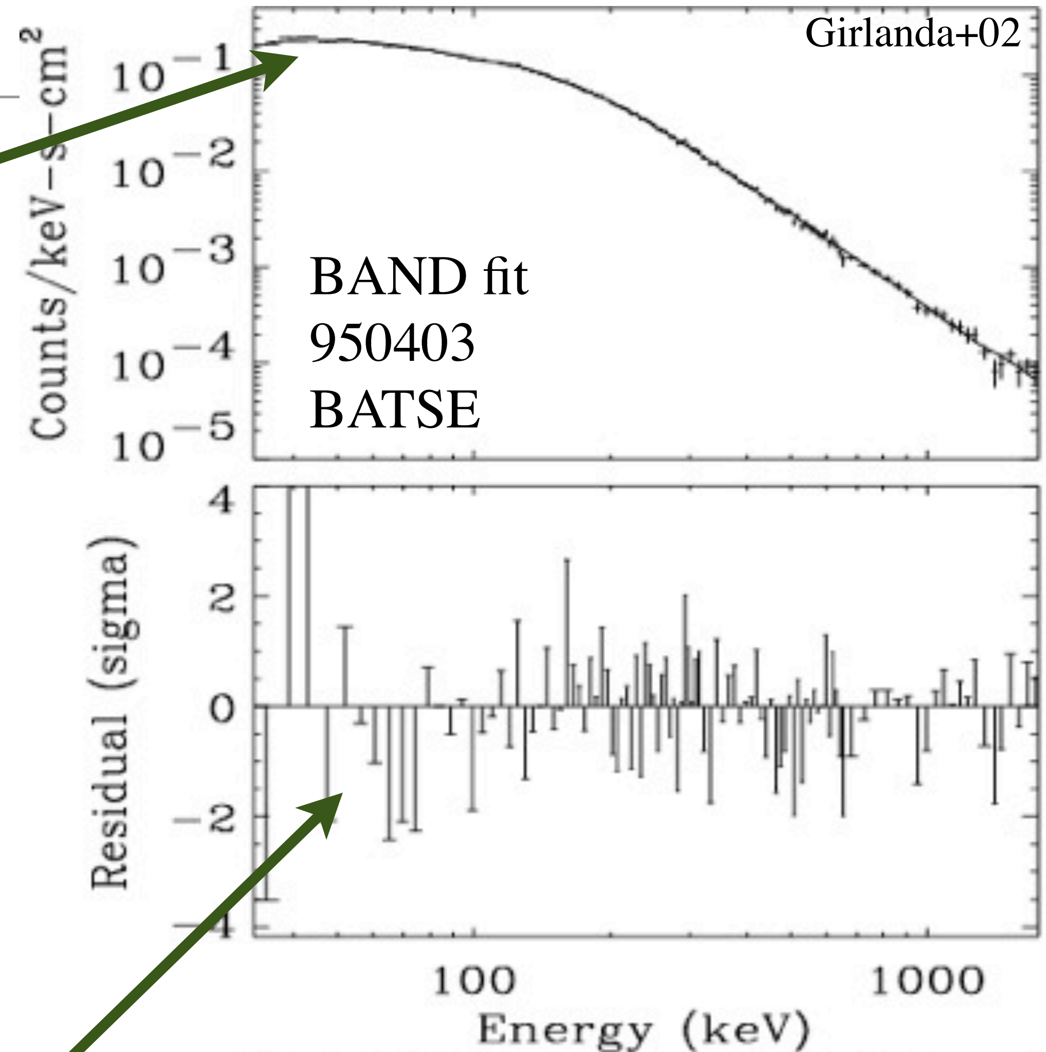
- The results of simplified models (e.g. power law spectra with one or two indices, or thermal spectra with one temp.) are usually the end product of what we want (the "scientific view").

Example: X-ray Spectra





Plots from A&A 393, 409-423 (2002) ; Girlanda, Celotti, Ghisellini

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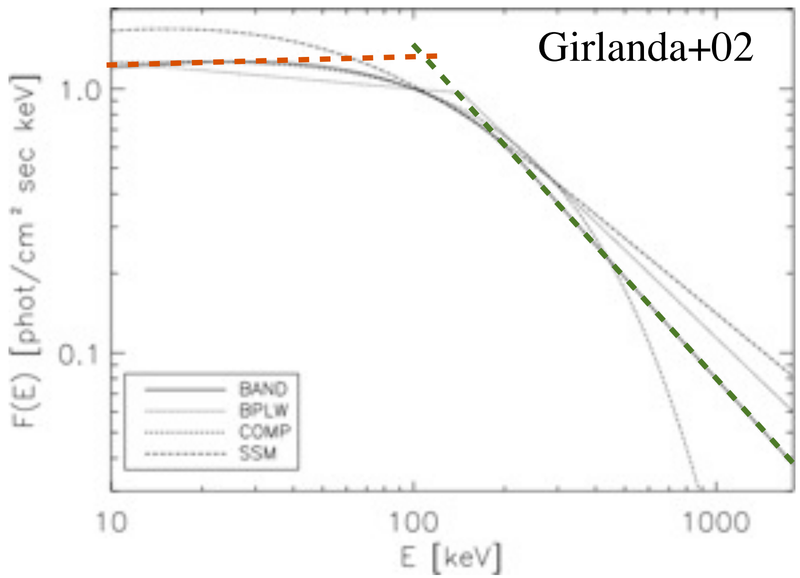
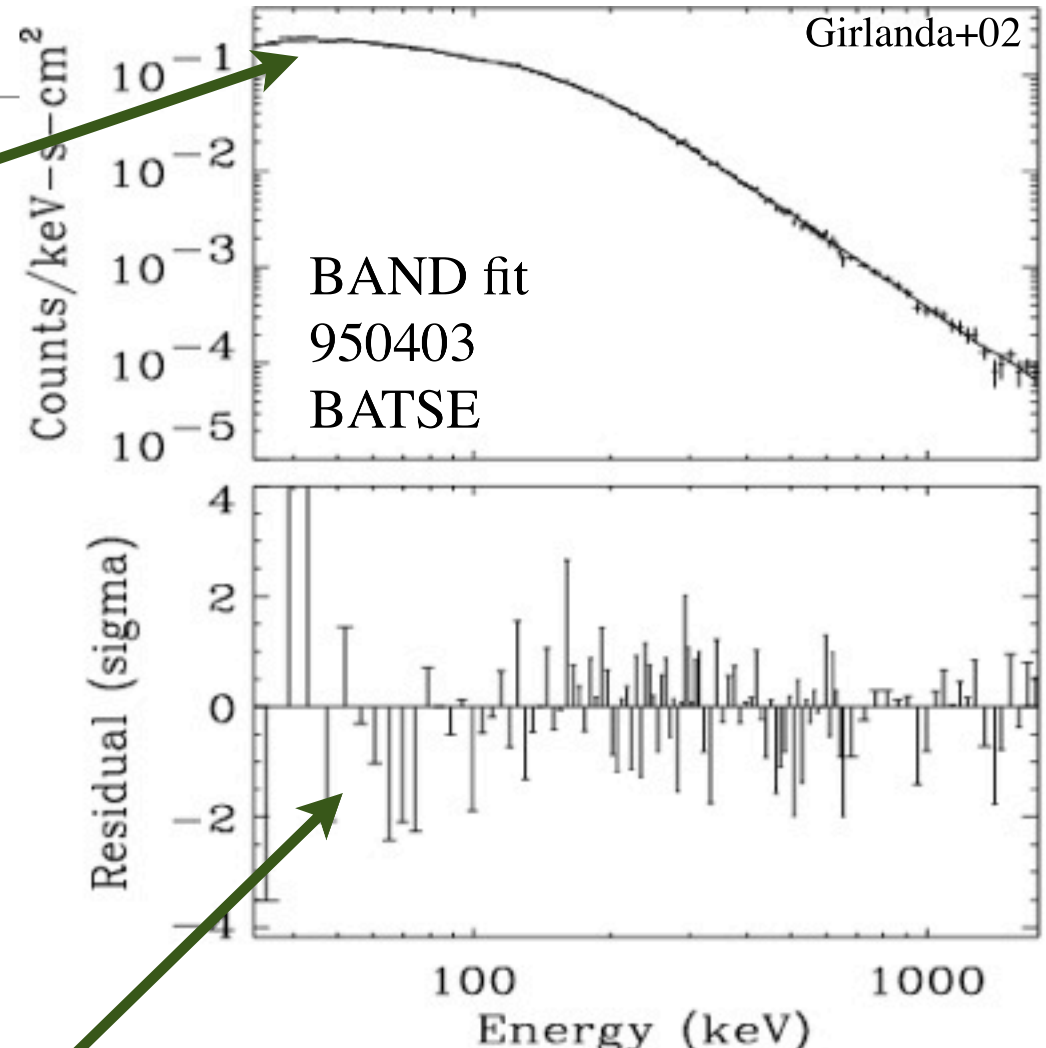
- Why is a power law not a straight line here?
  - “Spectral fits to the pulse time averaged spectrum. The spectrum is integrated over the time interval [3.008-6.976] s since the trigger time. The model fits and the residuals are for the BAND, BPLW, SSM and COMP model, displayed clockwise starting from the top left corner.





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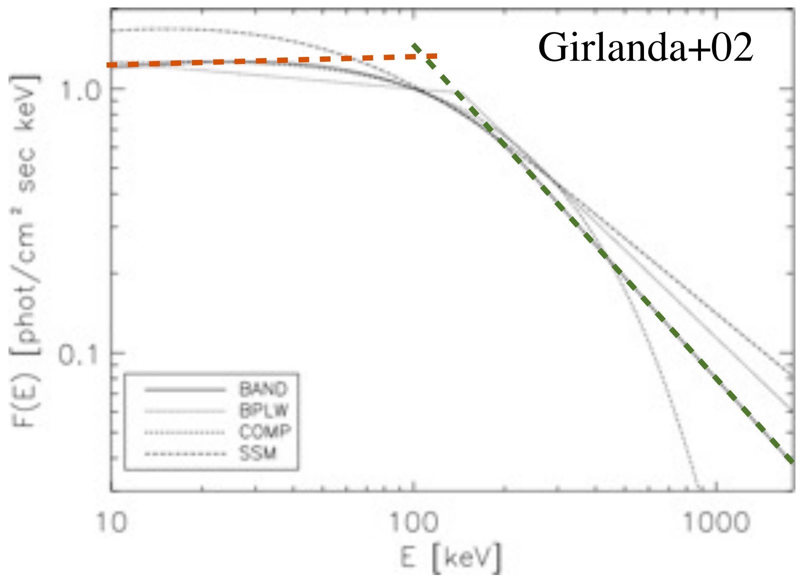

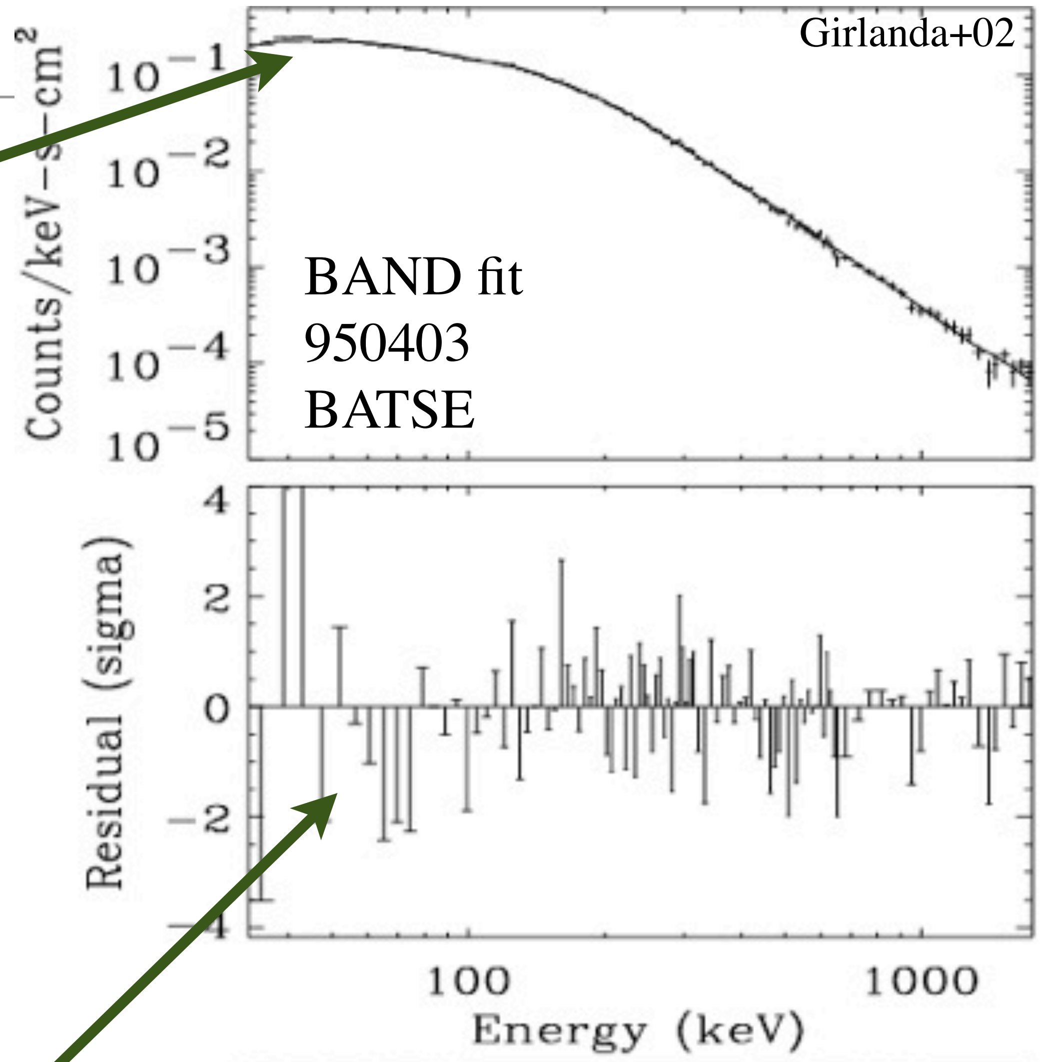

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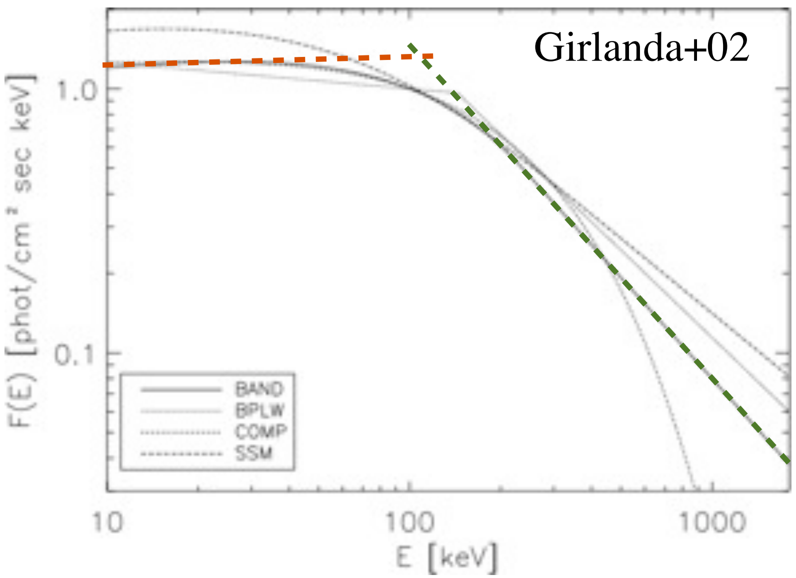
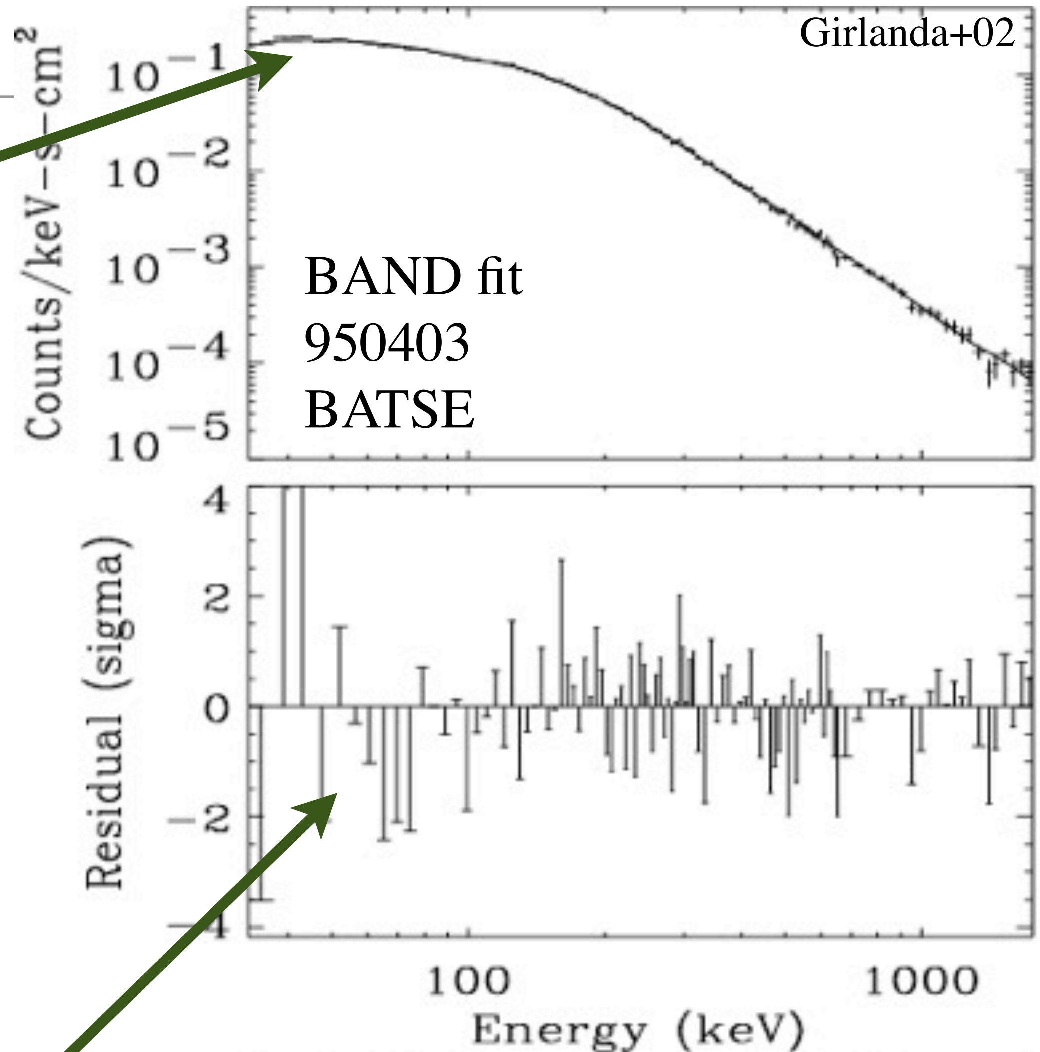
- 



- Best practice is to simulate how you idea of nature would appear in your instrument, then judge if consistent . . .
  … and how inconsistent with other ideas.

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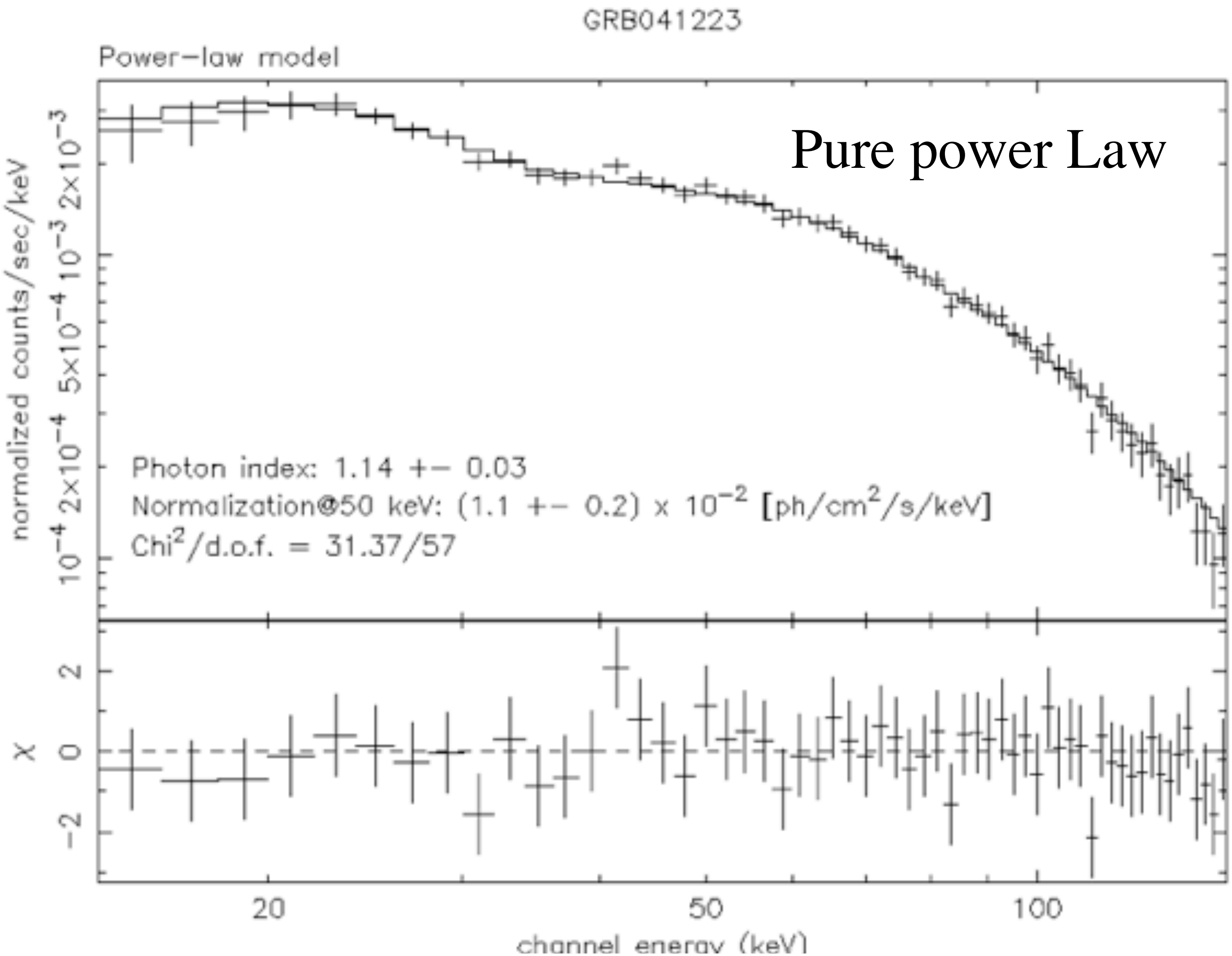
Swift Spectra



http://swift.gsfc.nasa.gov/analysis/bat_digest.html

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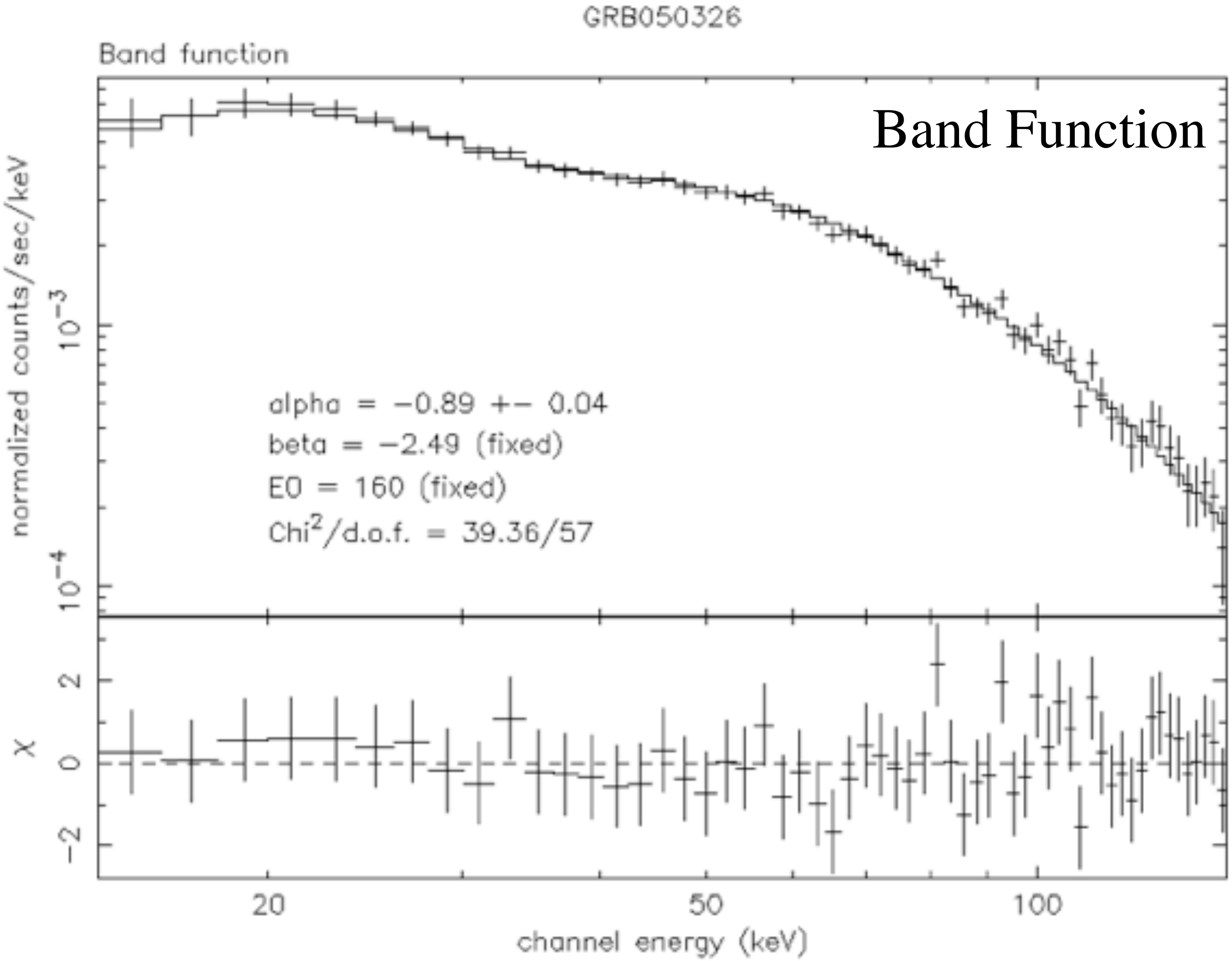

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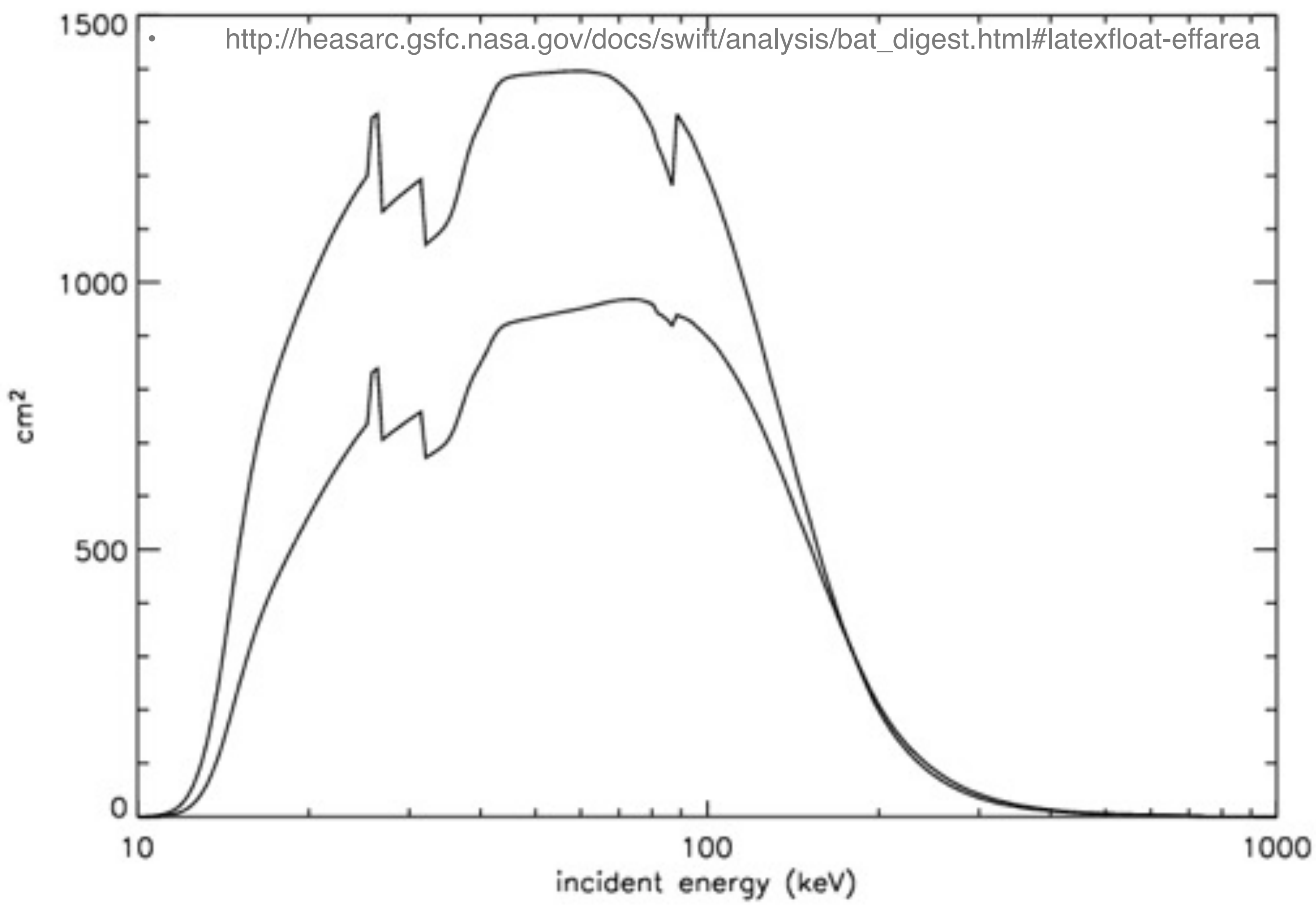
How do I predict Swift BAT performance?

- Example: What is the countrate from the Crab?
  - photon index 2.5 with 10.17 ph/s/cm^2/keV @ 1 keV

Example: Swift BAT Predictions

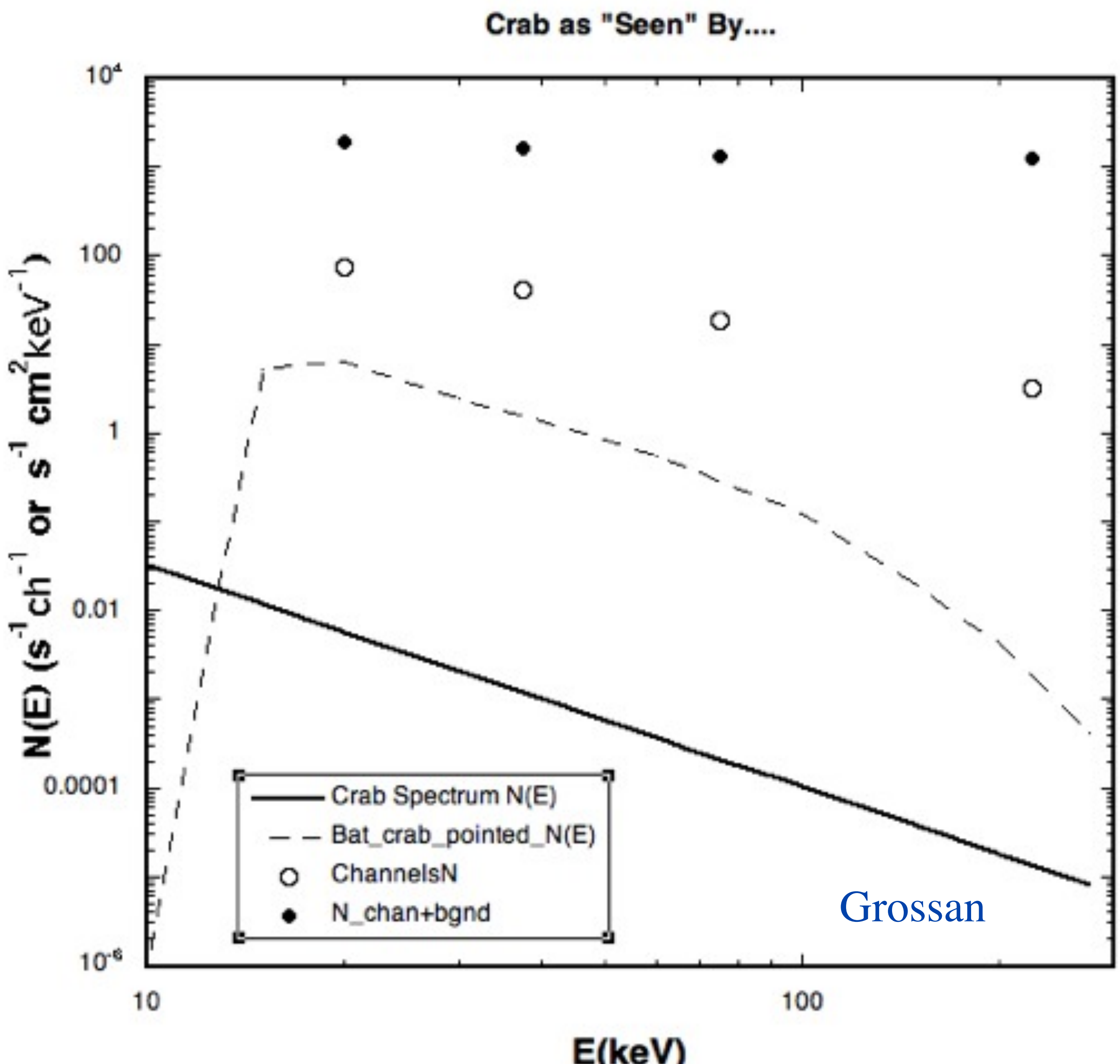
- Effective Area - From http://heasarc.gsfc.nasa.gov/docs/swift/analysis/bat_digest.html#latexfloat-effarea
- shows the effective area for a source (a) on axis, and (b) a source 45 deg off-axis. This effective area contains the Mask transmission and the 56% efficiency factor due to the cross-correlation technique used for imaging and mask weighted flux determination. Edge features include 25.5 keV (Ag), 26.7 keV (Cd), 31.8 keV (Te), and 88 keV (Pb). The extra silver absorption used to fit the Crab may have produced an unrealistically pronounced silver K edge in the matrix.



Prediction for the Crab

1. N'=N(E) *A_eff(E)
2. integrate N'*Delta E
3. Don't forget background!!!

What is S/N???



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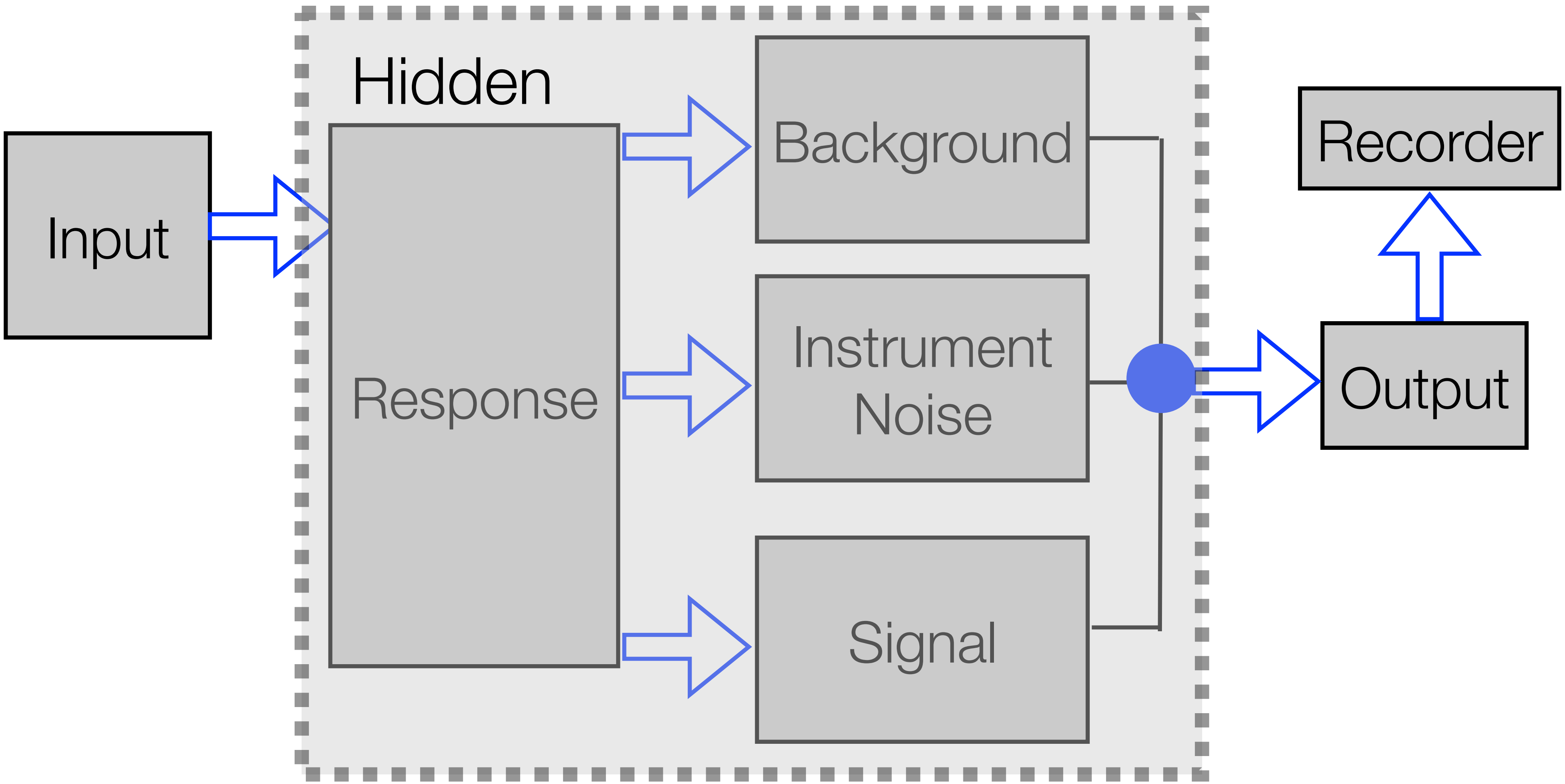
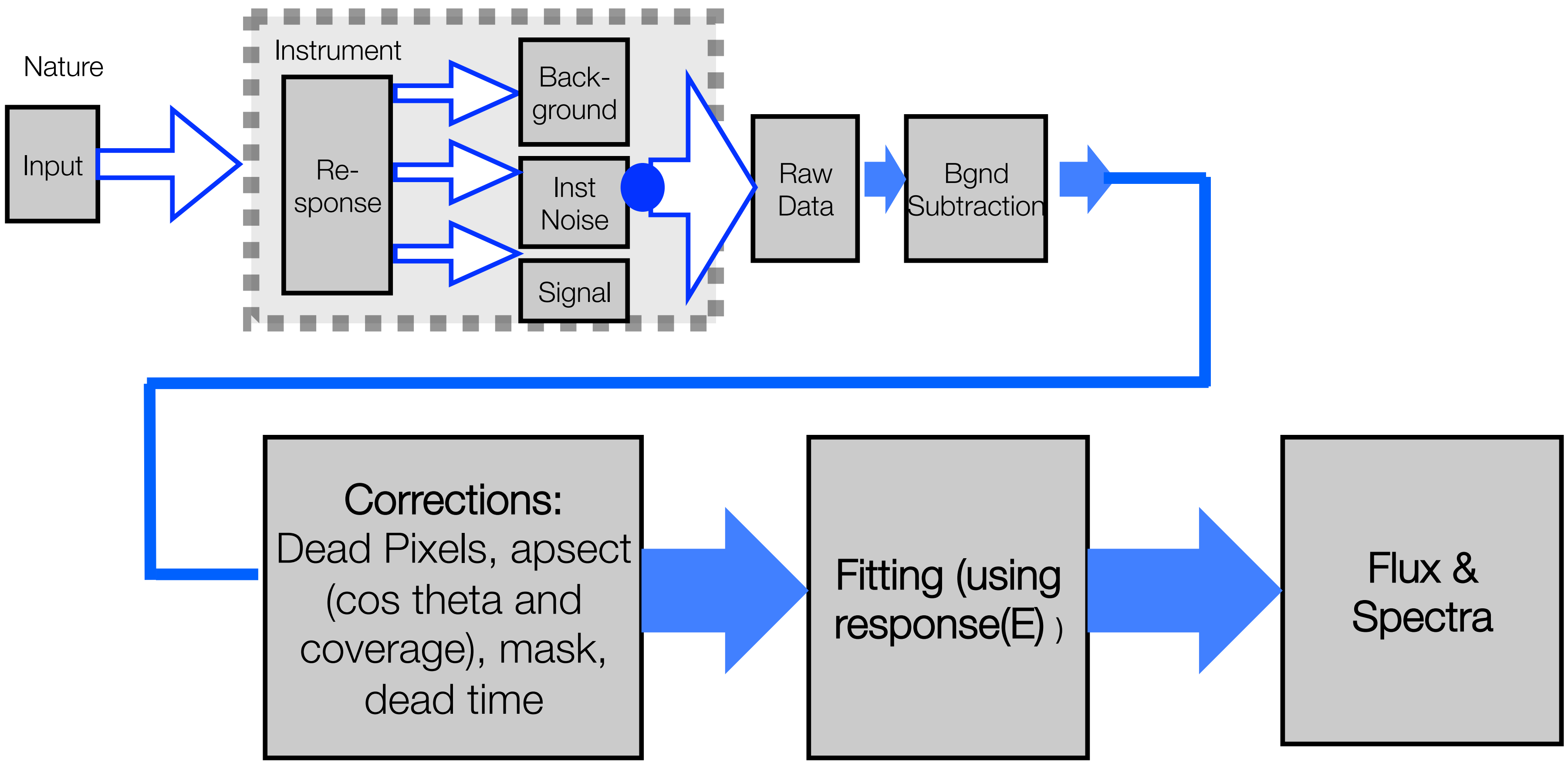
- Need spectra of source and BACKGROUND
- Use these to generate realistic Instrumental counts - instrument source counts + sum of backgrounds

A Few Steps from Data to Nature

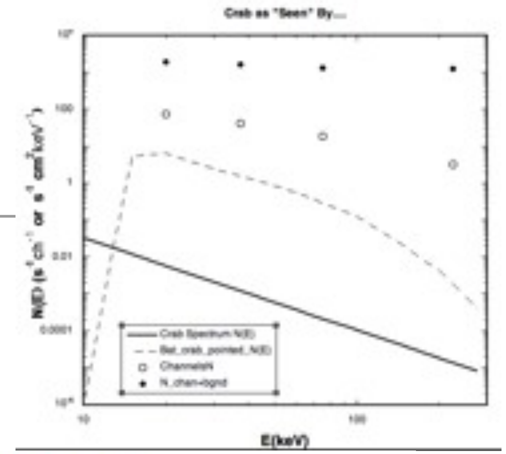
- Simplified version



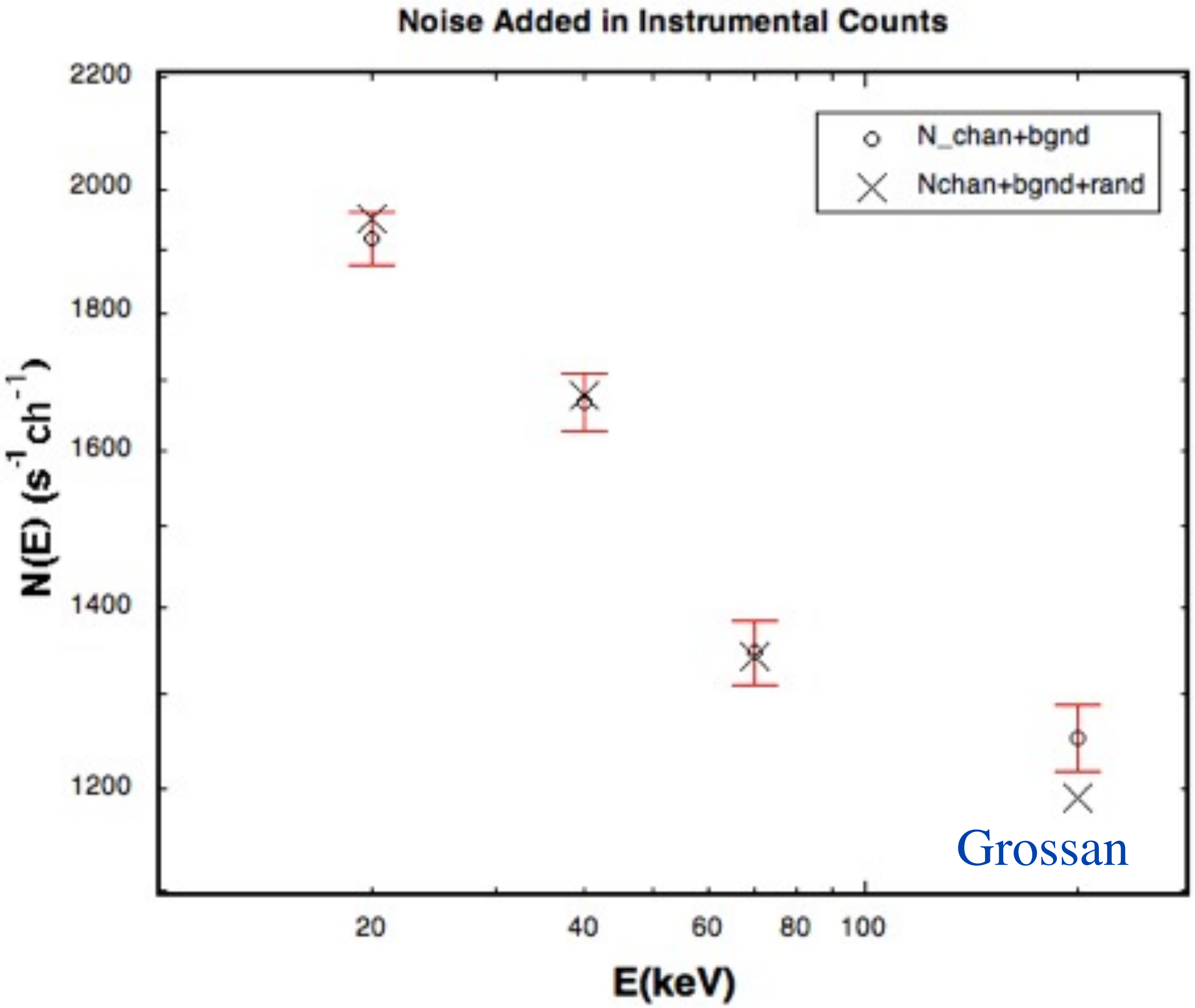
There can be even more steps:



Add Noise to Crab



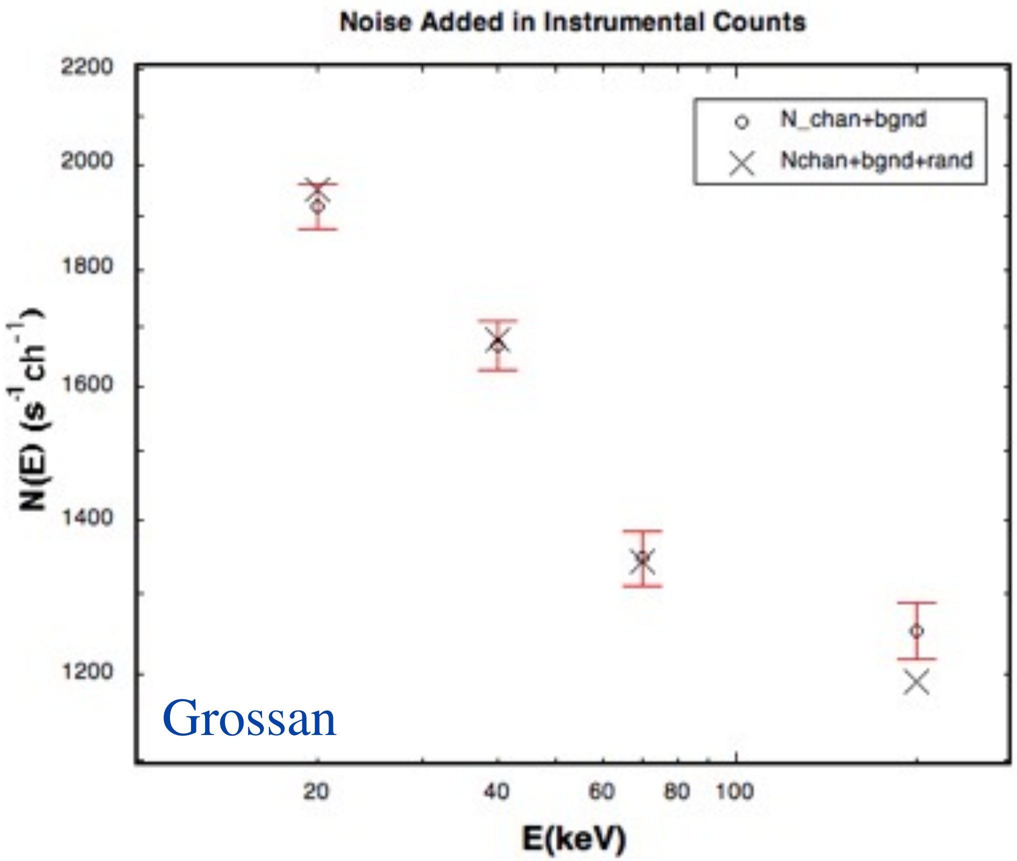
1. N’=N(E) *A_eff(E)
2. integrate N’*Delta E
3. Add background
4. Add noise (e.g. datum= sigma*randomn



Now how do you fit?

- **chi-squared= Σ (data-fit)^2/σ^2 ... so just minimize chi-squared!**

- **A little more tricky to fit in instrumental space, usually need custom software (see HESARC website for HERA, or see XSPEC)**



chi-squared/nu = .50, so even with noise a fit will not be fooled!!!

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- ... so you need to have information about
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  - natural background
- To simulate, add the effects above to expectation of nature
- When you're done, you can measure anything by fitting - see the BigBOSS cosmology plots later this week!