A Data Analysis and Simulation Project

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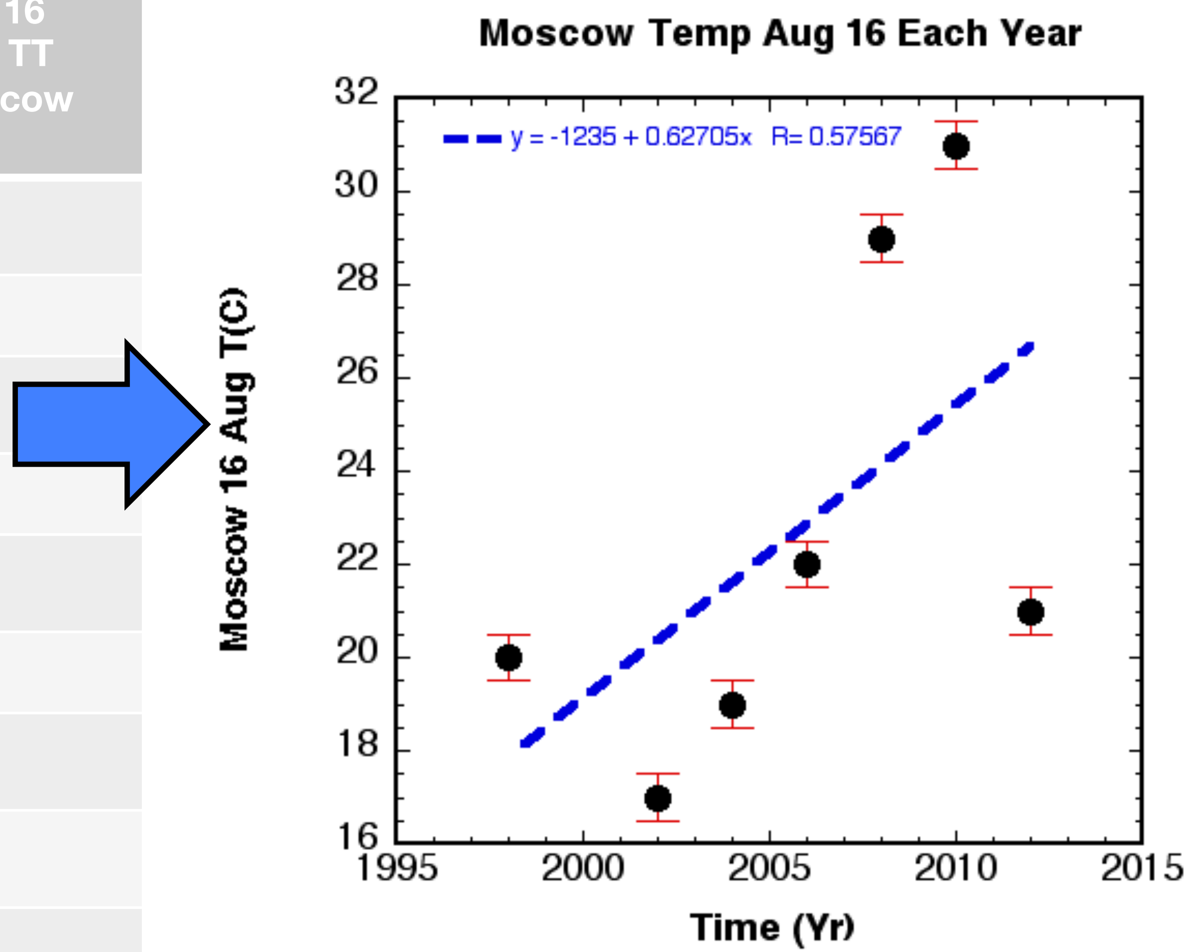
Data Analysis – What is it?

- Take columns of Numbers…
- Do something to them…
- Fit Data to Quantify

Yr	Aug 16 max TT Moscow (C)
2012	21
2010	31
2008	29
2006	22
2004	19
2002	26
2000	17
1998	20



Gets more complicated!

- Data NOT always easy to get
- Data often not in directly useful form
- Data often not in good computer format
- ➔ Your job: Find a way around all these problems

Instrument Simulation

- Start with Model of Instrument: X-ray detector H2RG HyViSI CMOS
  - Response @ 5 keV: N_{e-}=0.27*N_{phot} ; QE = 0.27
  - Assume 18 micron square pixels; 2048X2048

- Model noise
  - 15 e- / read
  - Rule-of-thumb 1 ct/s/cm^2 from cosmic rays on ground.

- Now, you can ask questions:
- How strong an Fe-55 (5 keV X-rays) source do I need to test my detector in one second, that is, to be sure I can make a detection?

Students…?

For detection in one second….

- Use typical criteria 5 sigma detection

- What is sigma?
  read noise 15e-/pixel
  cosmic ray background in lab: 1 count/s / ~ 25e4 pixels
  => read noise dominates short times = 15e-

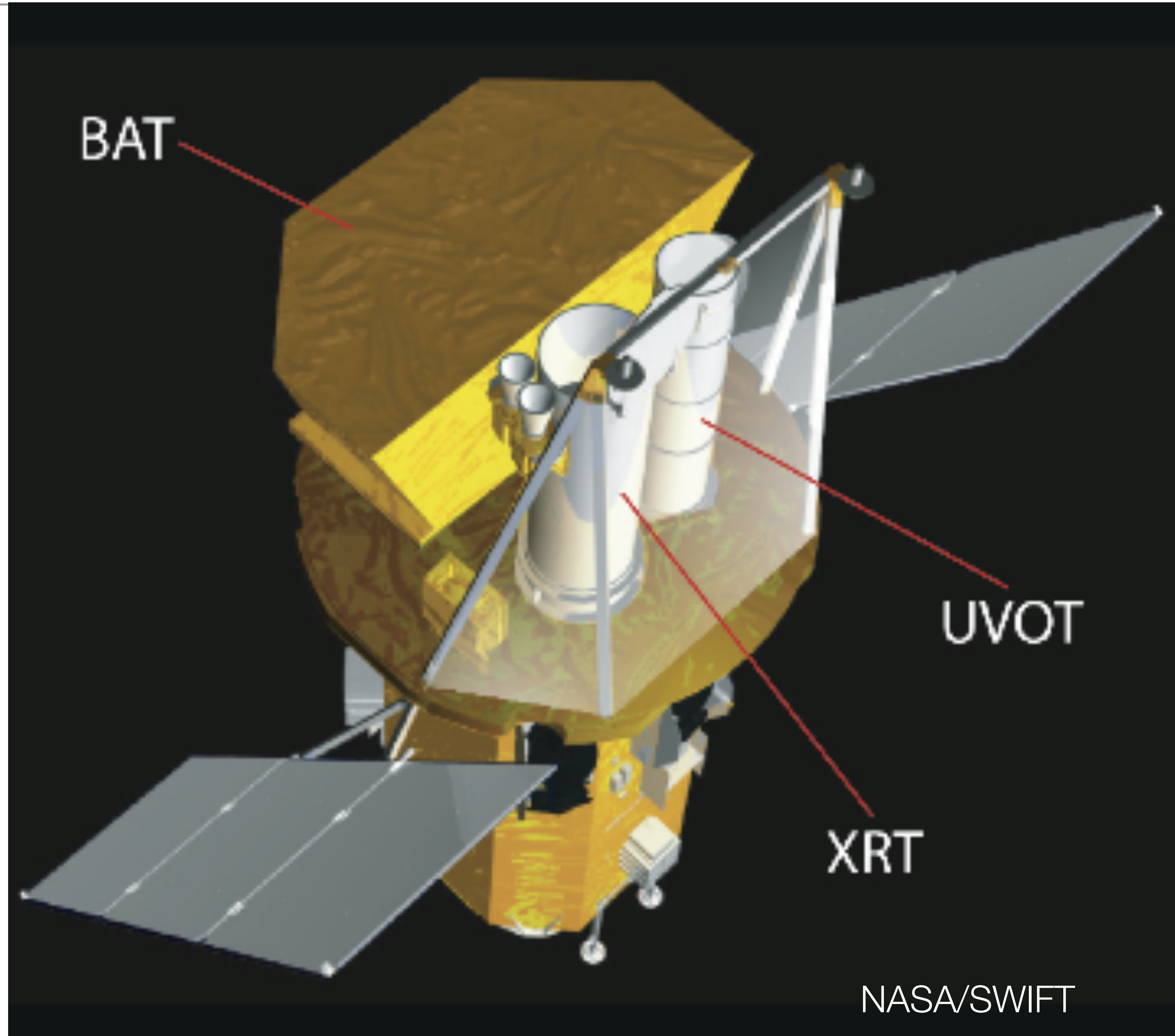
- What strength source gives S/N = 5 in one second?
  75 e- / pixel = 5* 15e-
  Nphot * QE = Ne- ; Nphot =75 / .27 = 278

  278 photons / s source into 18 X18 micron pixel would give detection, or ….

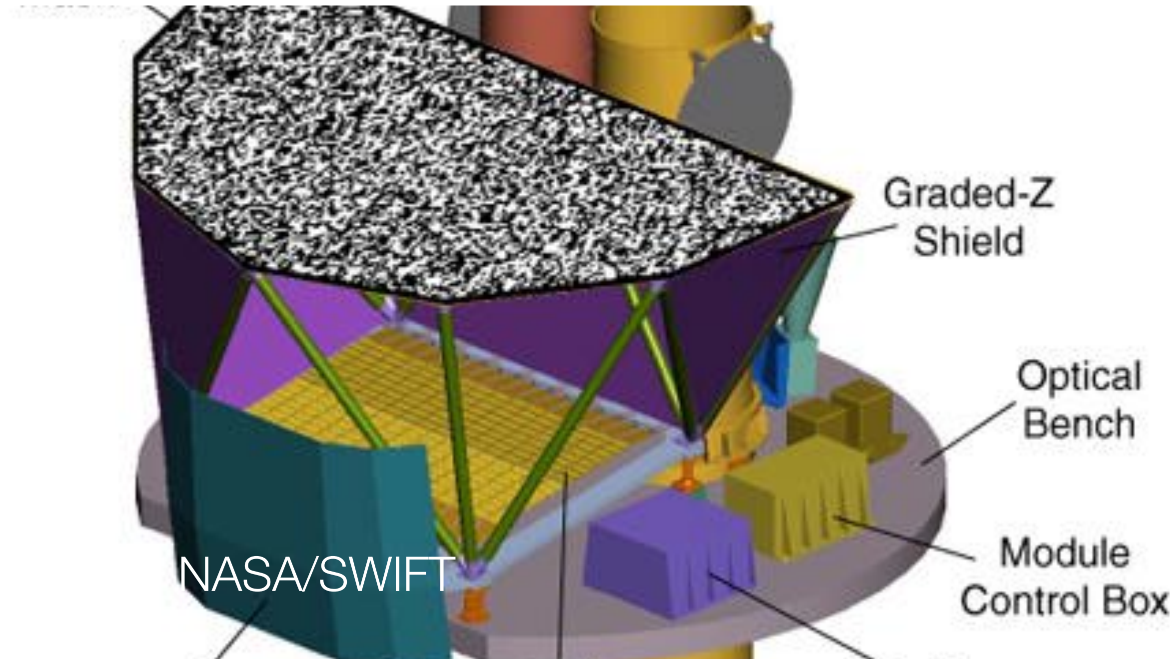
  For 2048 X 2048 array, to get a detection in every pixel in one second, how strong a source located how far away would you need?

- …. Students ?
  (For those of you reading over web, to figure this out. Now. Really.)

The Swift Spacecraft



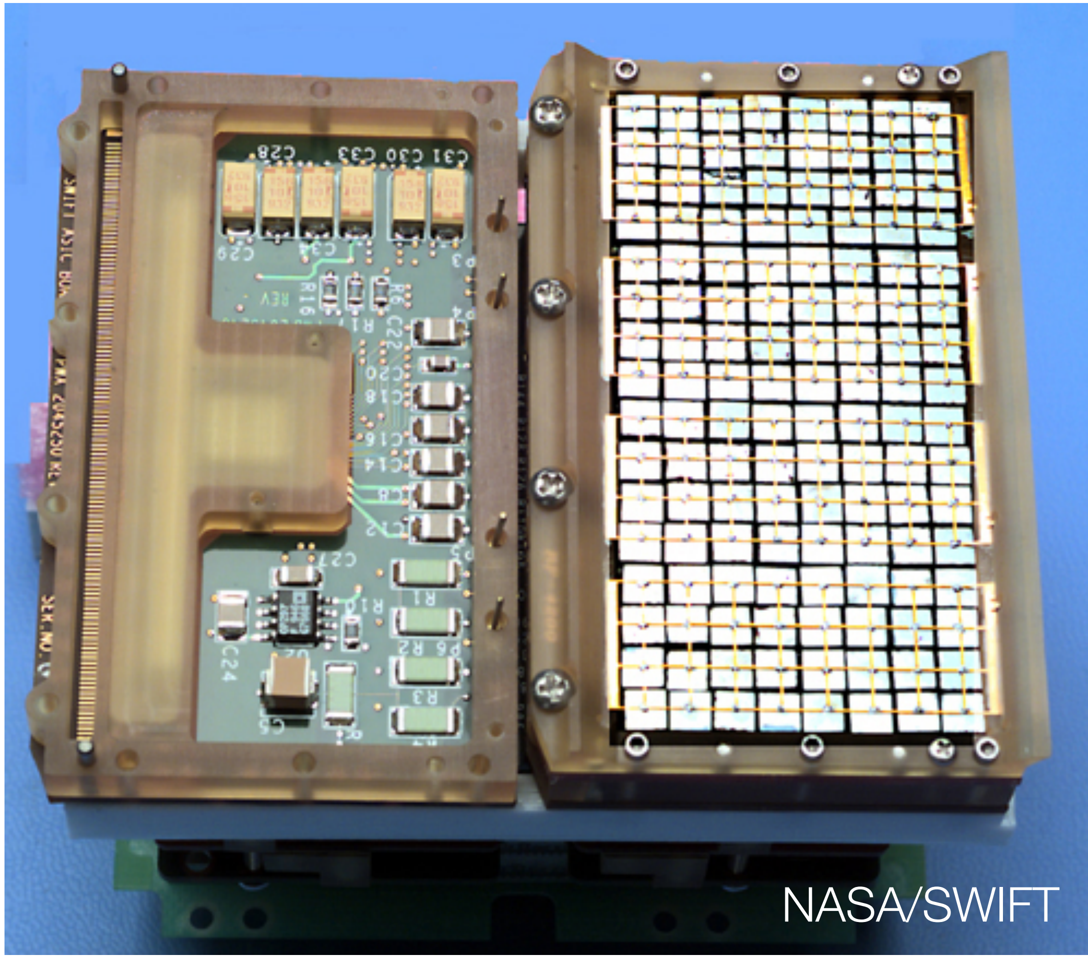
The Swift –BAT 1



Property	Description
Aperture	Coded mask
Detecting Area	5200 cm^2
Detector	CdZnTe
Detector Operation	Photon counting
Field of View	1.4 sr (partially-coded)
Detection Elements	256 modules of 128 elements
Detector Size	4 mm x 4 mm x 2mm
Telescope PSF	17 arcmin
Energy Range	15-150 keV

The Swift –BAT 2

- Just an empty box with Tiles on top, detectors on the bottom.



What if *Swift* were Smaller?

- The UFFO pathfinder is only ~ 12 kg.   EUL might be able to get other launch opportunities; smaller is easier, and spacecraft can often carry several *small* experiments – if they are small and light.   Making a smaller instrument makes it much more likely you will actually fly.

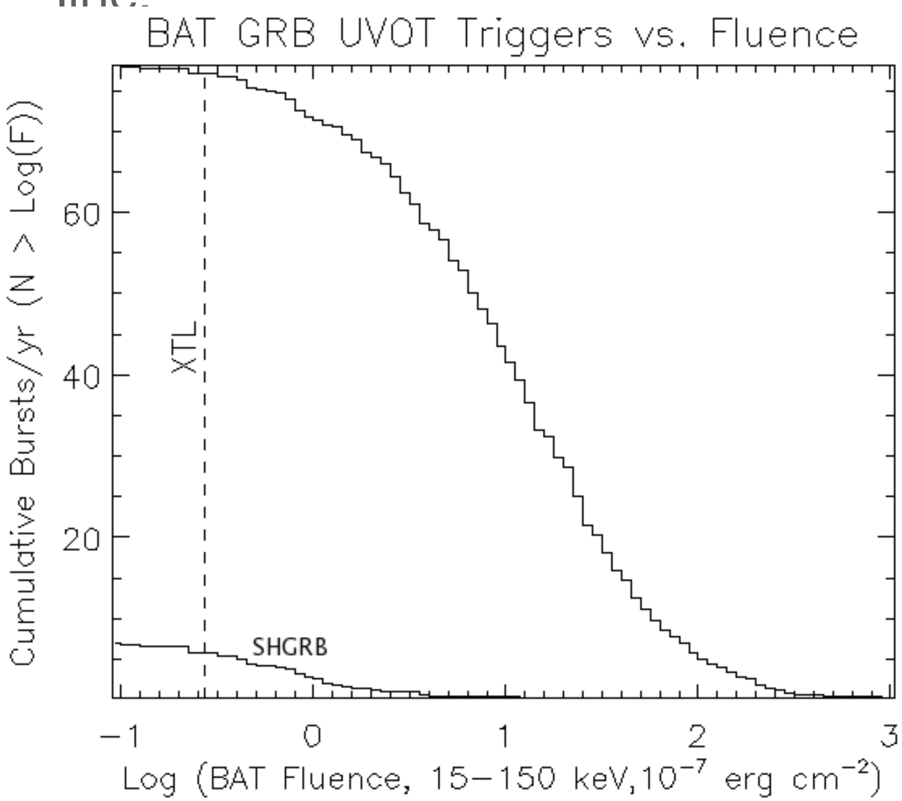
- What is the smallest Swift that would "work" ?

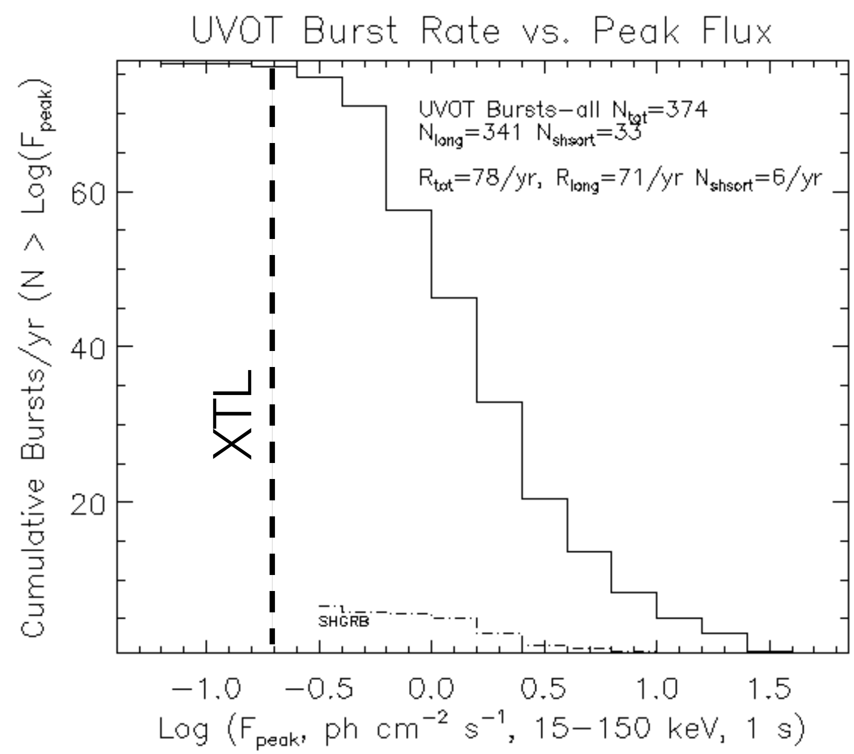
  What do we mean by "work"?

  - **-----→ Must detect enough GRB to answer your experimental question!**

Already Done… In *Theory*

- Theoretical Sensitivity ~ $A^{1/2}$
- Just Scale for A, then draw a line:
- Could also base this on the one-second trigger flux)

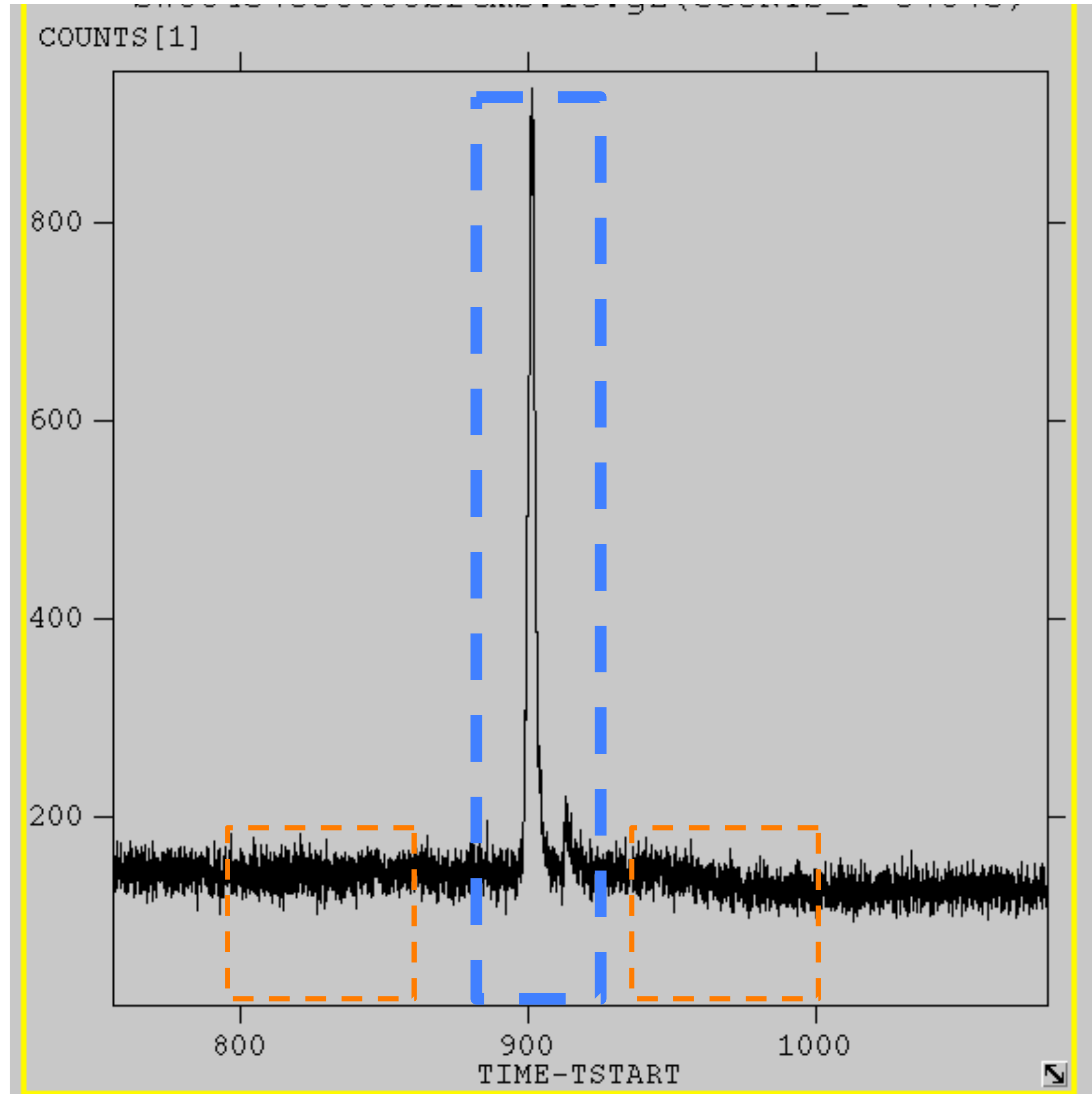




…but in reality: first you must **trigger**, then detect.

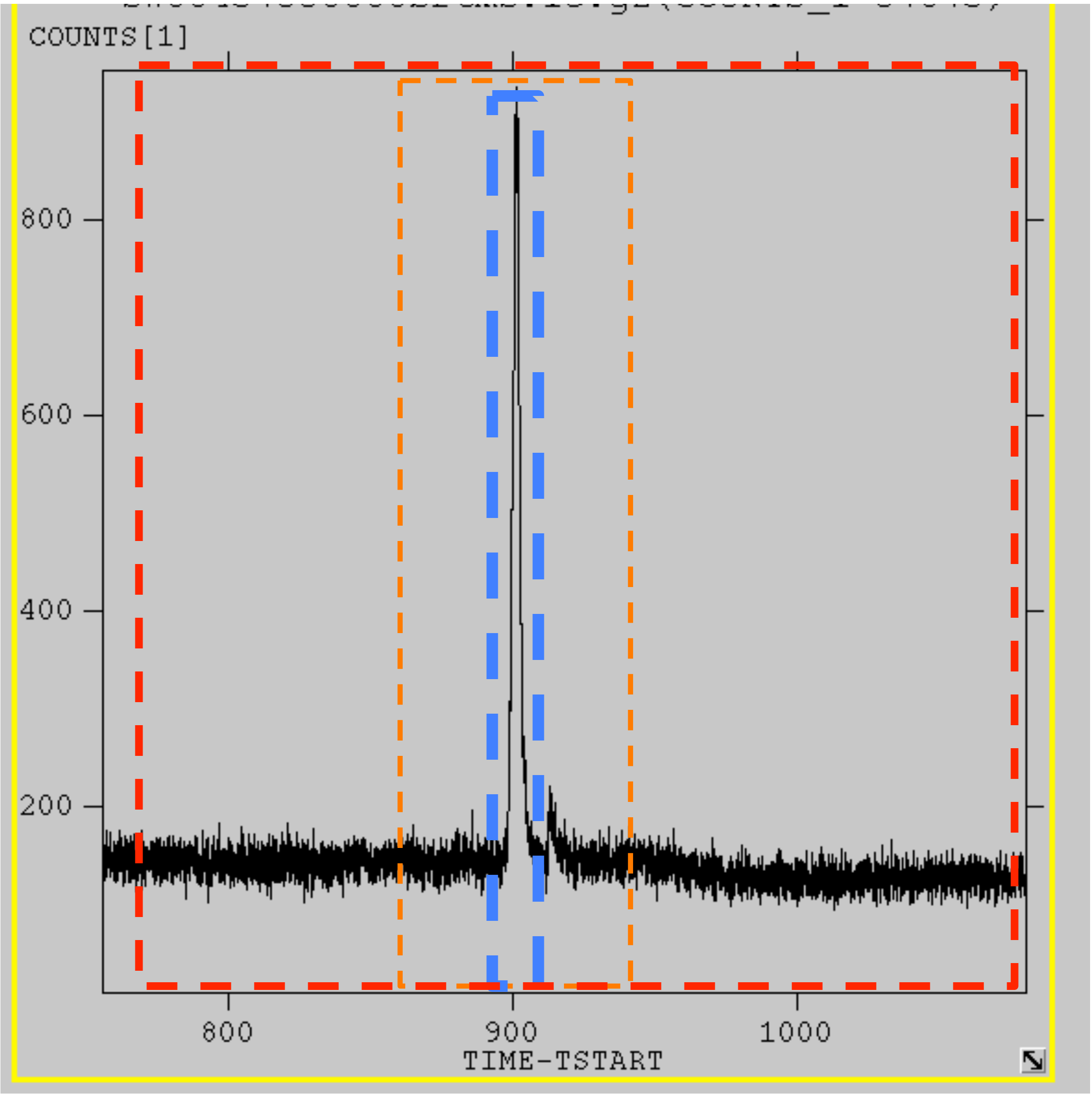
Trigger Time Windows 1

- Step 1: Measure Signal
- Step 2: Measure background
- Step 3: What is S/N?
  - Big: Issue trigger!
  - Small: Do nothing



Trigger Time Windows 2

- In a small time window, 10 bins, this burst might be >6X background, but…
- For 100 time bins, signal is barely 1/4 bgnd!
- ➔ Important how you choose trigger window.
    - **Simple way is to choose many!**
        - As data arrive, store in buffer, e.g. look ahead and behind 10, 20, 40, 80, 160 … time bins for trigger.



* based on 10 bin burst, 400 average, 150 bgnd

Why not answer this question (how small…) with *REAL* GRBs?

- The data are there, for free *on the web*, **you just have to go get it!**

http://heasarc.gsfc.nasa.gov/cgi-bin/W3Browse/swift.pl

- Real Spacecraft are
  - Blocked by the earth
  - Go through high background regions
  - Are confused by other sources
- Using real data is ***much* more robust and believable** than just scaling by peak flux or fluence, both because of operational issues above, and because bursts are so unpredictable, so heterogenous.

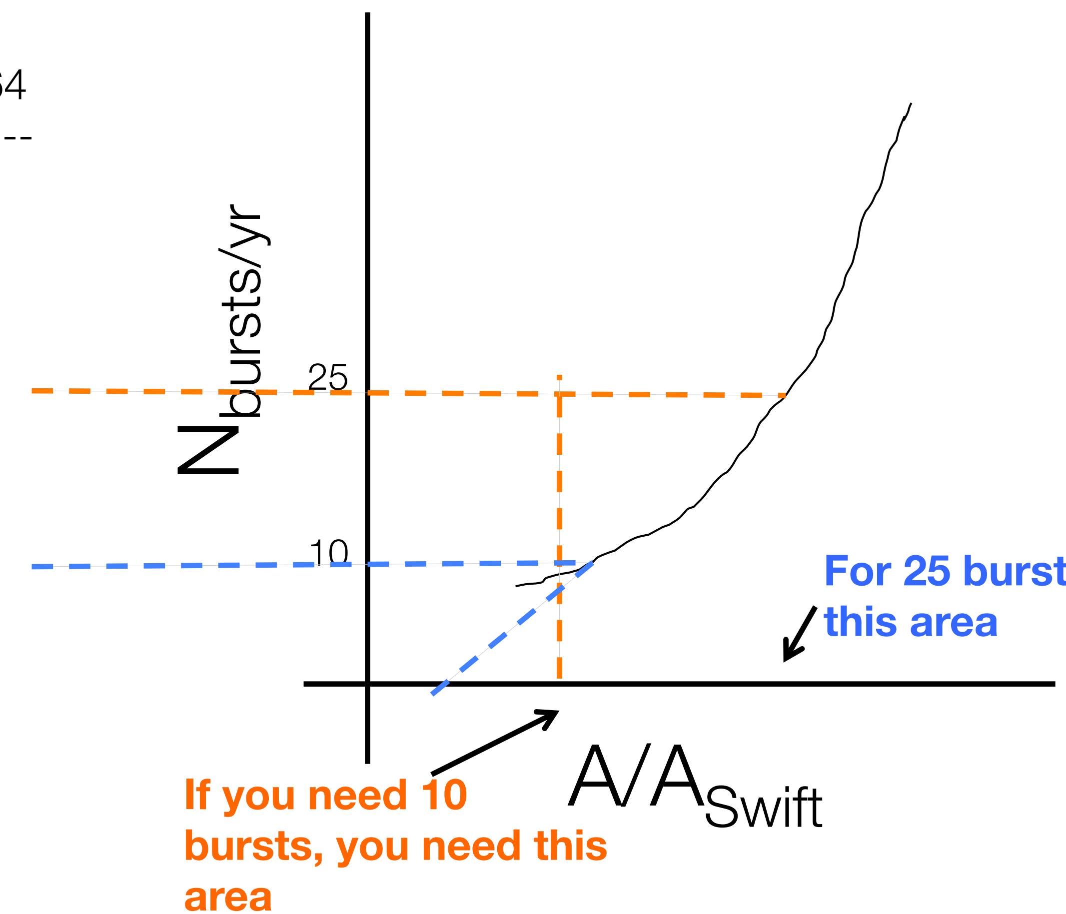
This data analysis project actually begun with help of students, published by B. Grossan + Students

What we want:
100 bursts – What is S/N? (i.e. how many detected)?

- Want a Table of bursts and S/N as function of Area

			SNR:		
Burst	A/4	A/8	A/16	A/32	A/64
-------	-----	-----	-----	-----	------
111229A	10.5	6.3	4.2	3.8	2.3
111228	19.2	12.3	7.4	4.9	3.3
…	…	…	…	…	…

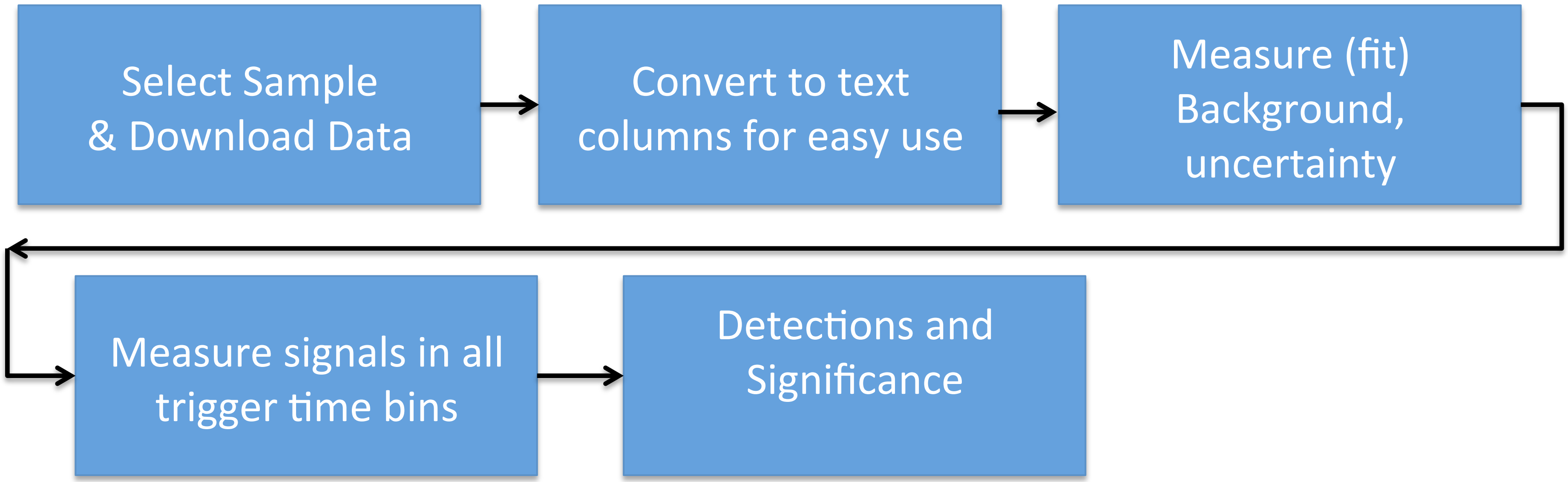
- Want a plot of Nbursts/year vs. Area



What do we have to do? How do we do this in 2 weeks?

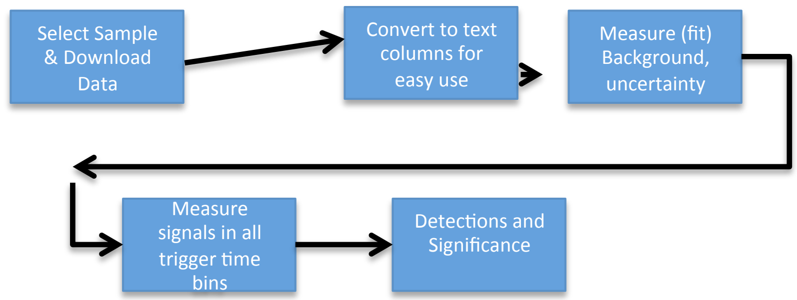
Project Overview

- Part I: Use Swift to Predict Similar Instruments

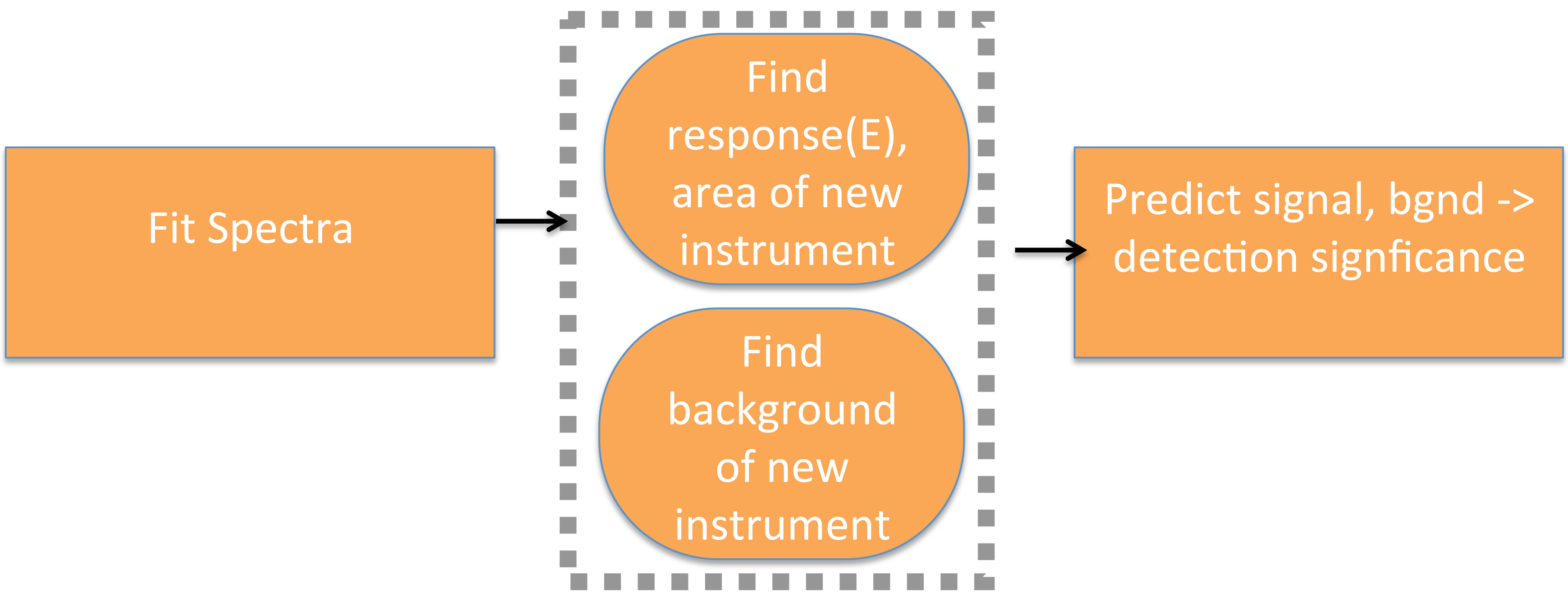


Now, Predict New Instrument Behavior

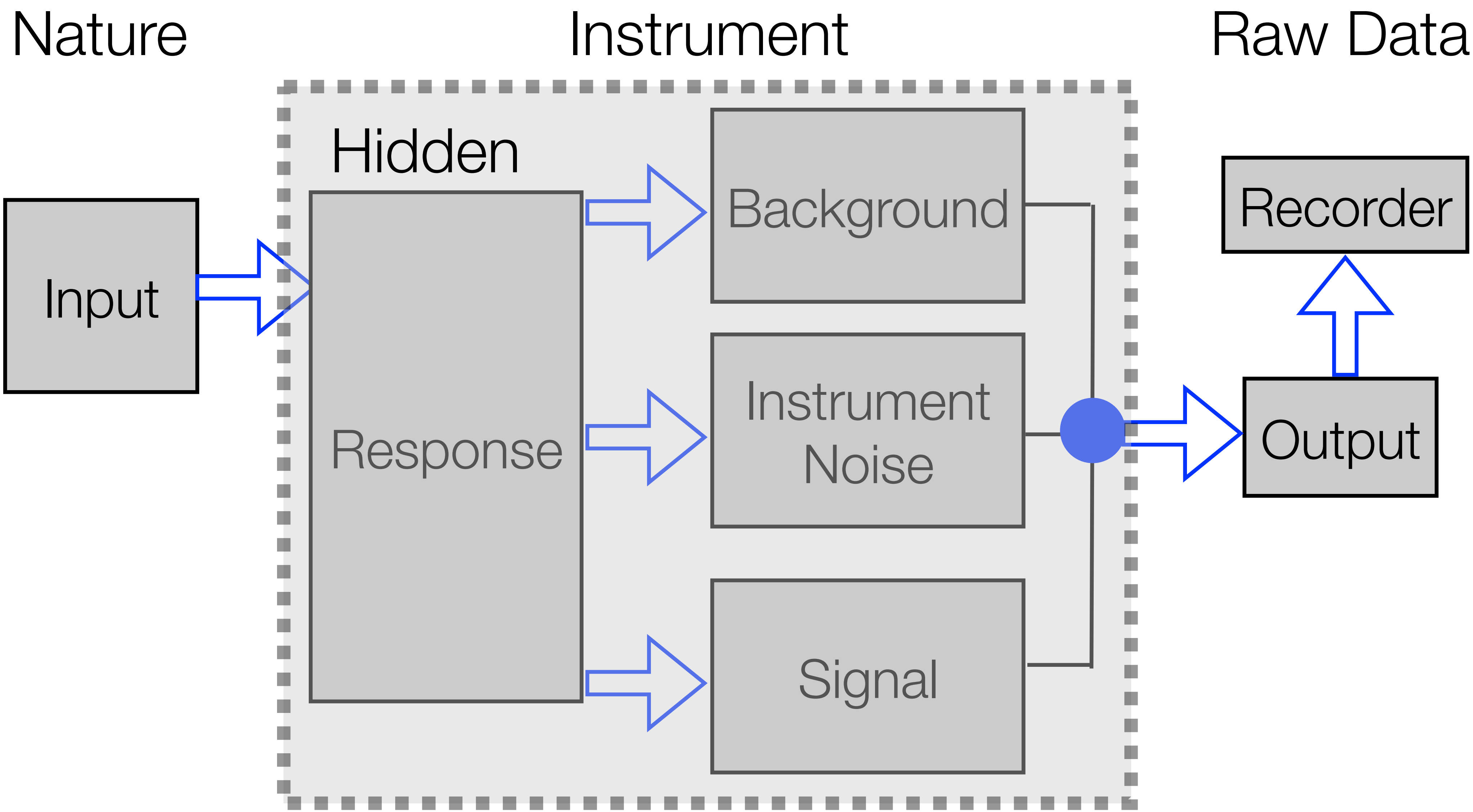
- Part I: Use Swift to Predict Similar Instruments



- Part II: Move to other instruments, higher energies

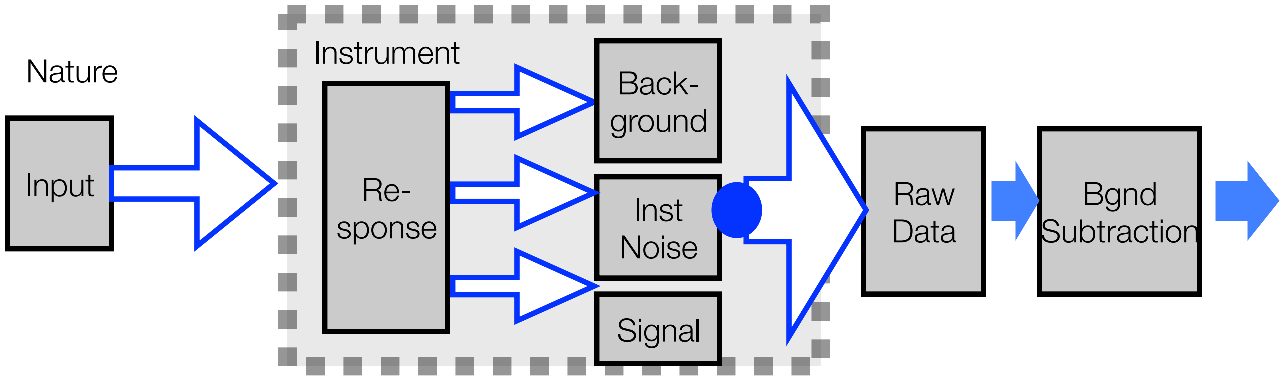


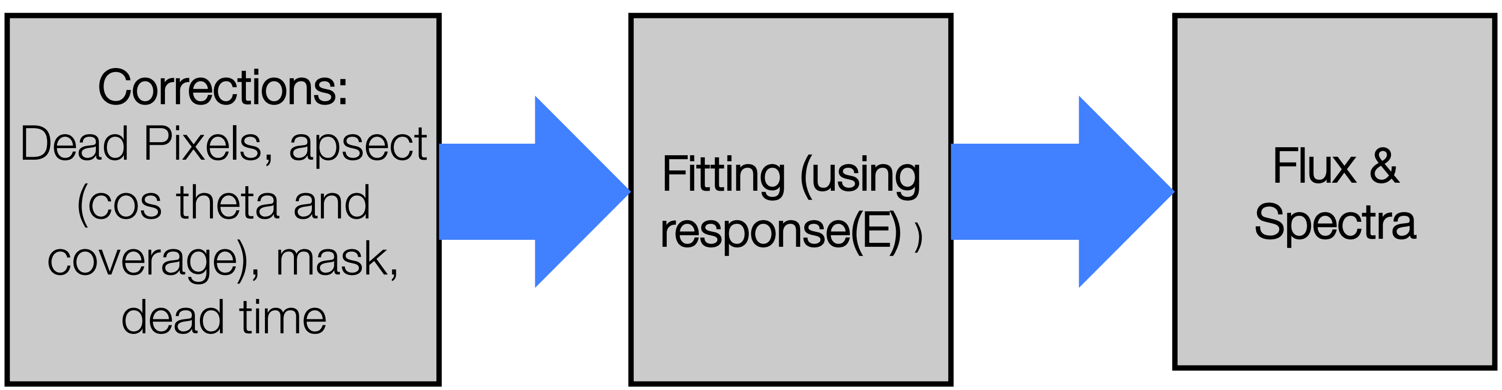
Instruments (Very General; maybe not the best way)



- B. Grossan. Use requires attribution of all sources -

Just Getting Started!!!! – Background Sub, corrections, efficiencies….





A Data Analysis & Simulation Project

- How do we predict what a GRB instrument will do?

Predicting GRB Instrument Performance

- Sensitivity
    - Internal & External Background
- Event rate
    - Duty Cycle
    - Natural Distribution of Events
    - Detection Efficiency

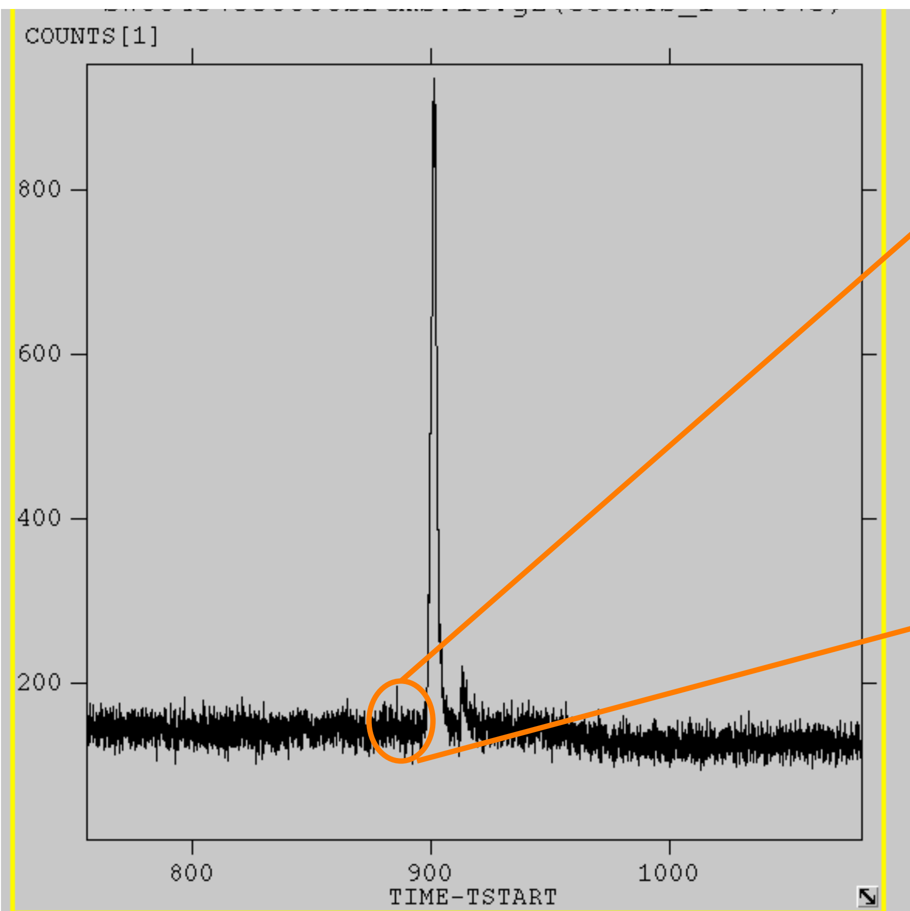
- The EASY WAY:

SCALE FROM DATA !

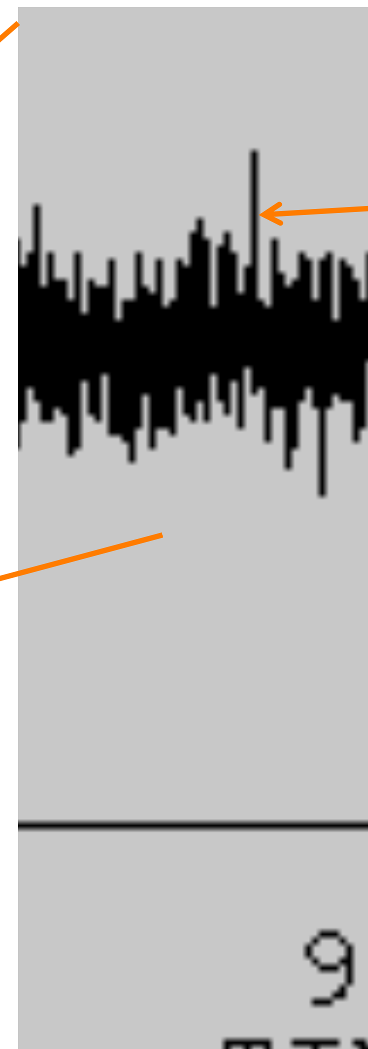
- $N_{phot} \sim$ Area
- $N_{noise} \sim \text{background}^{1/2} \sim A^{1/2}$
- Scale these in simulation to get answer

Detection = certainty of reality

- This is engineering:



- This is cutting-edge science:



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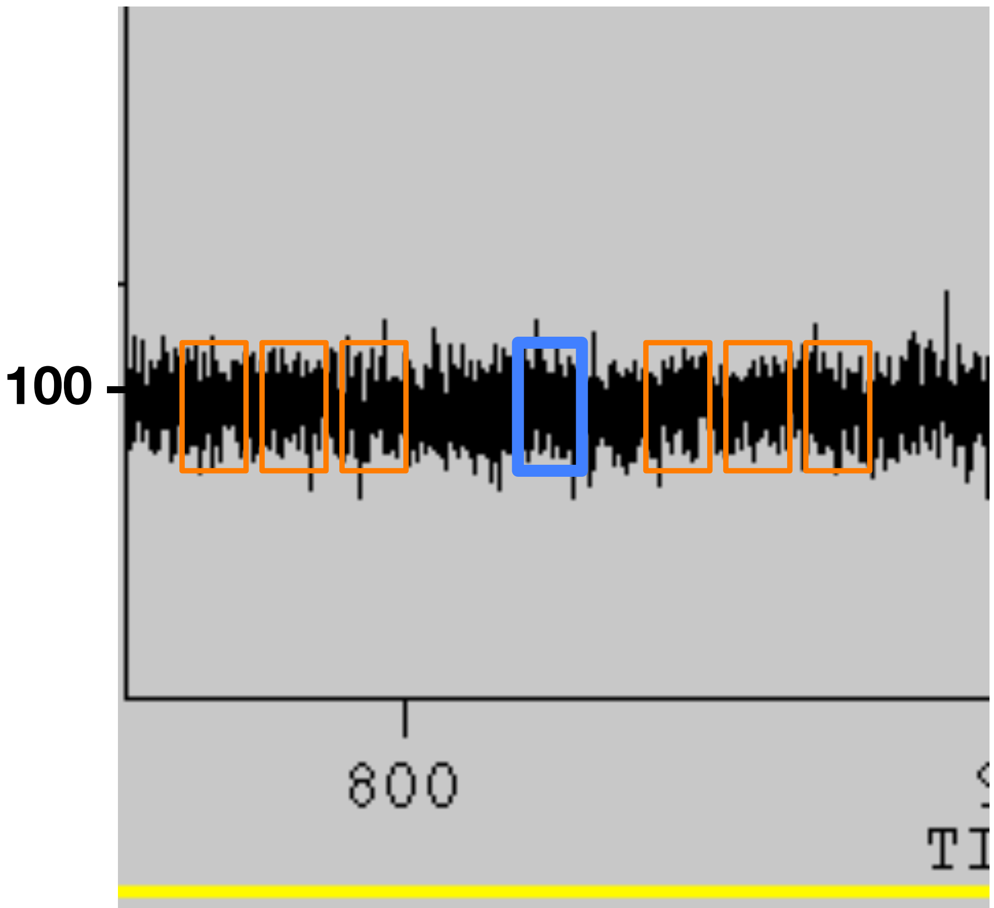
Detection Example

- What is noise? What is signal?



- Bgnd = 100+/- 10
- Blue Area = 110
- Blue Area – Average bgnd = 10 +/- 10
- Answer: 32% probability random data would produce as great or greater positive fluctuation. **Poor Detection!**

Downloads

- First, let's select some bursts
- Next, let's download some data

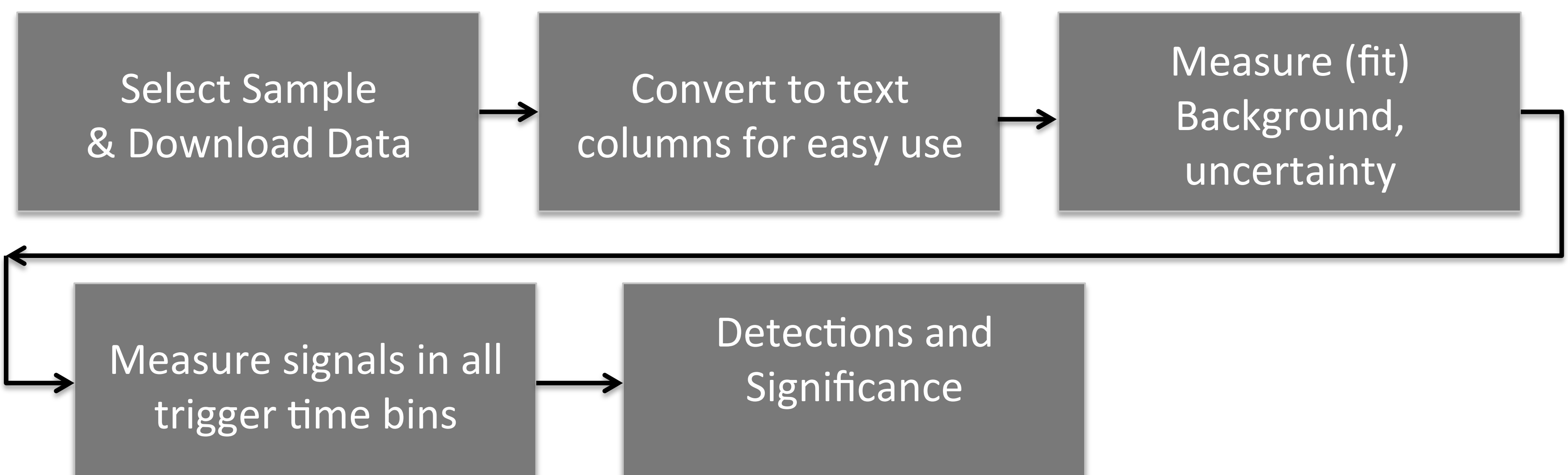
Use fv to plot and convert data to text

- Instructions on Course Page:
  (Originally at Bruce UBAT Wiki http://cosmos.lbl.gov/brucesubatwiki/index.php/Simple_Swift_Analysis_Links)

- You download FITS files: a very well-defined format that contains both “header” data (information about how the data were obtained) and binary image data. It’s like an experimental notebook that can be read automatically while you read the data.)

Summary

- Download 100 bursts, ~2 years of UVOT Triggered Bursts
- Work step-by-step, select data, convert to text, measure background, measure signals in all time bins, scale, measure significance.
- Make a plot of N_detections vs. Detection Area - FINISH PART I



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The rest is up to YOU and your computer skills

- How will you measure backgrounds?
- Do you have a program that can fit simple lines or curves to background?
- Can you program this to run through a list of files, to automate it?

- End

Thank You