Swift Triggering

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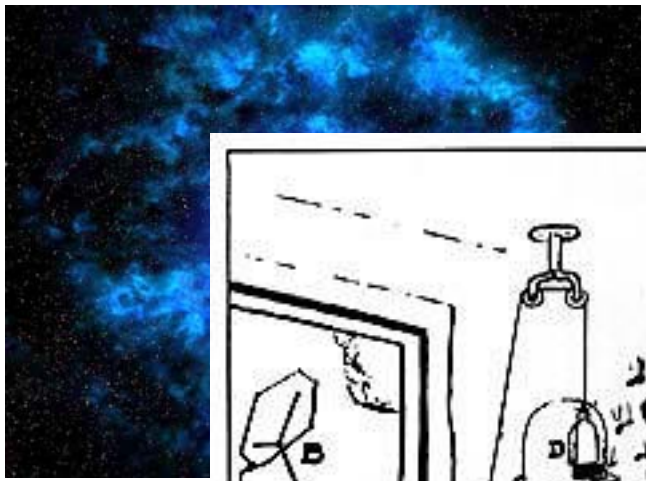
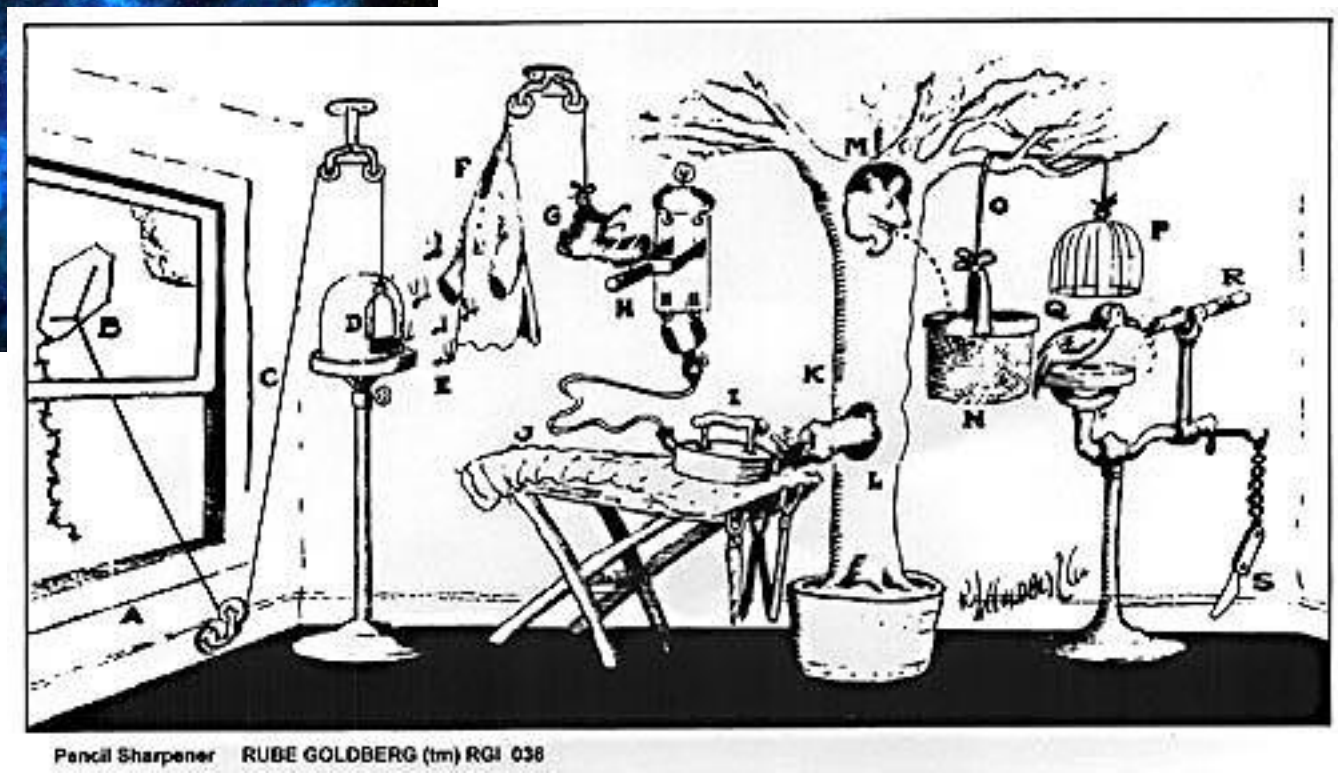
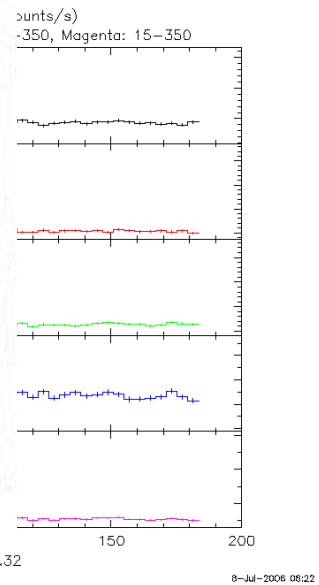






Why Bother?

- Capitalize on Swift's strengths
- Work around Swift's weaknesses
- Catch ***and locate*** as many GRBs as possible

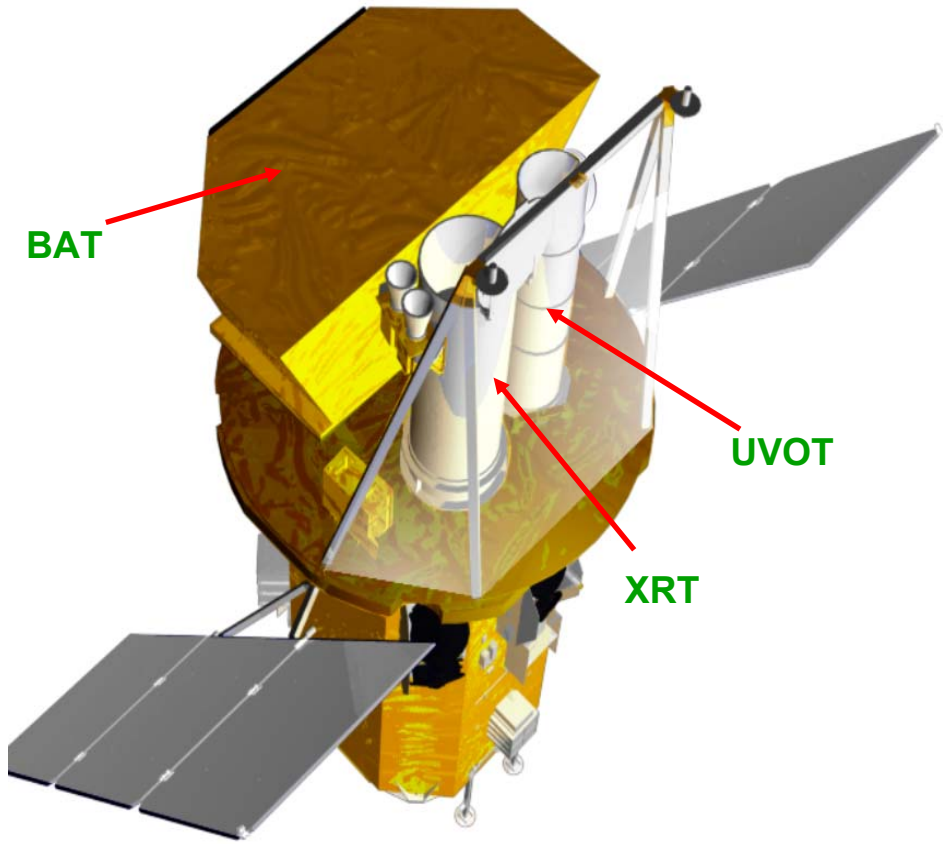
Swift

Burst Alert Telescope (BAT)
- 32,000 CdZnTe detectors
- 2 sr field of view

X-Ray Telescope (XRT)
- CCD spectroscopy
- Arcsec GRB positions

UV-Optical Telescope (UVOT)
- Sub-arcsec position
- 22 mag sensitivity

Spacecraft slews XRT & UVOT to GRB in <100 s

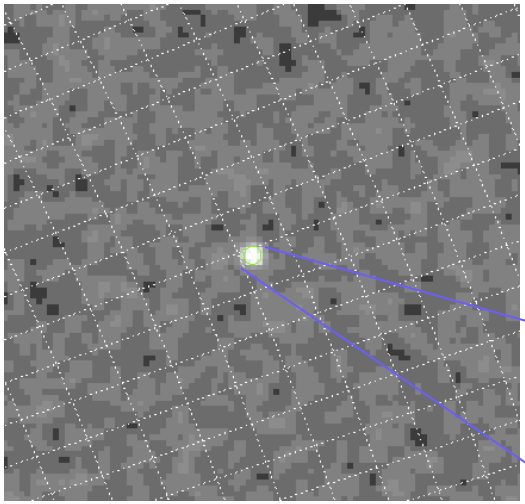


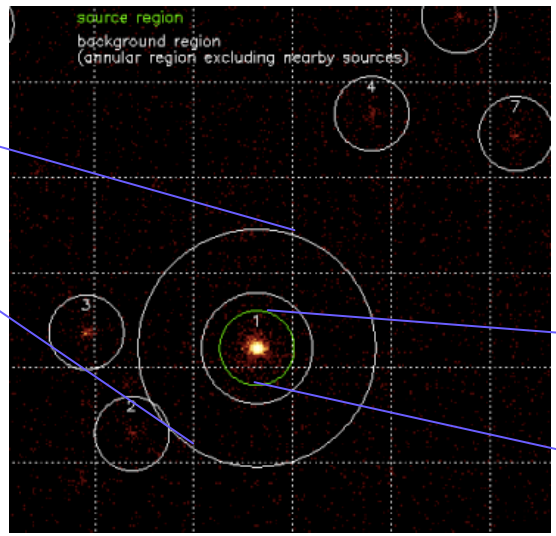
The Glamour Shots

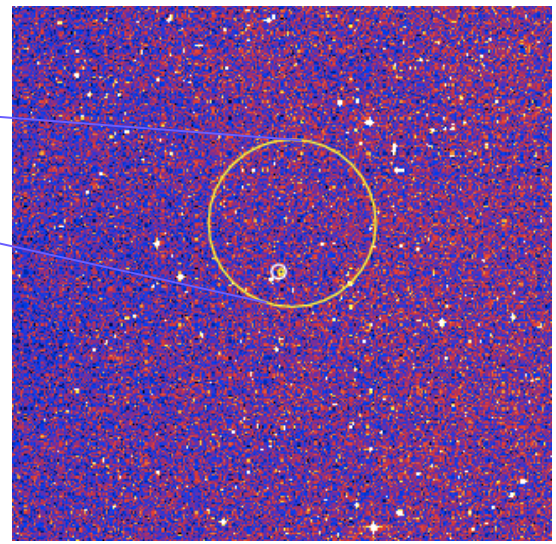
NNSA

Los Alamos

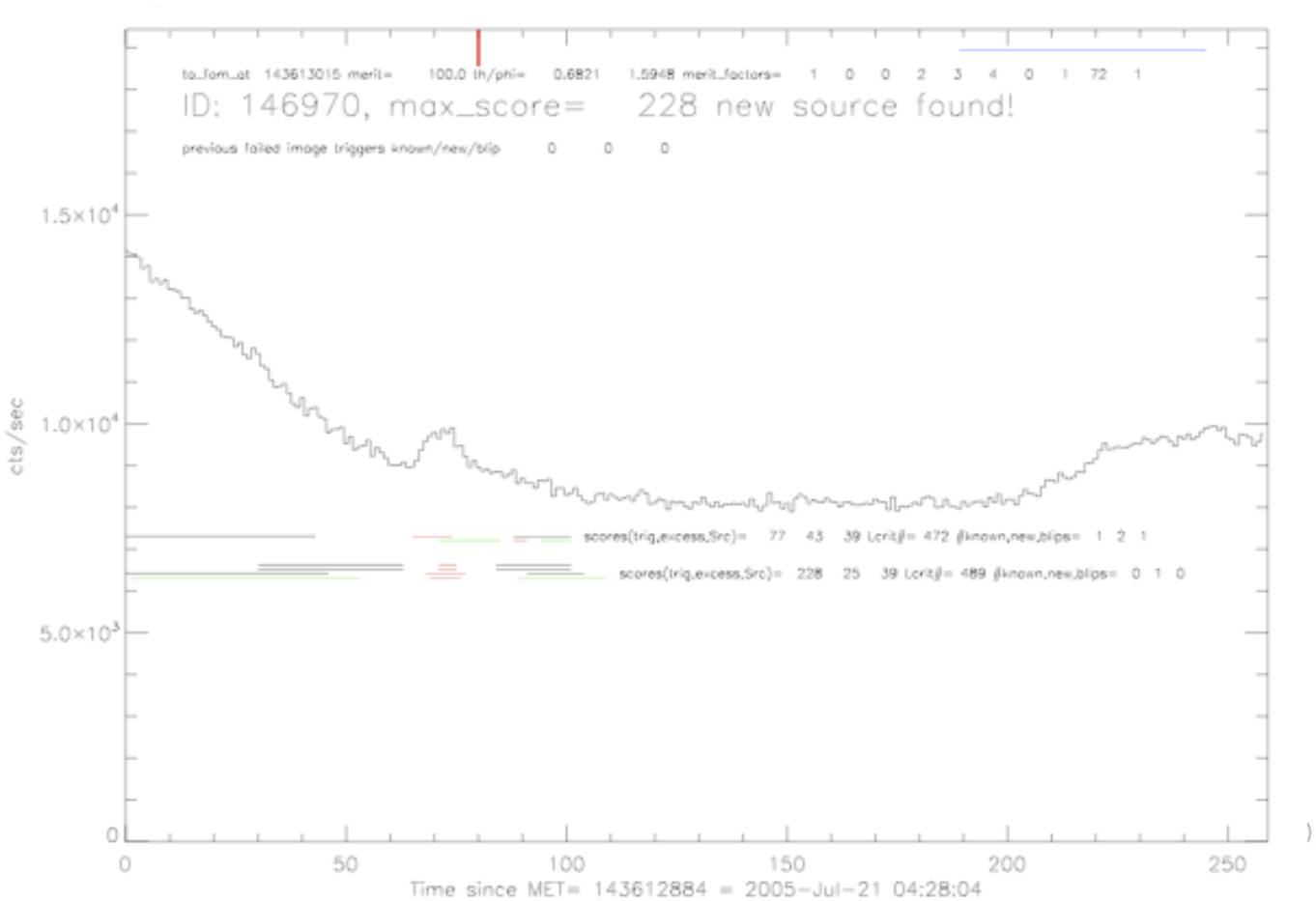
In the beginning, there was a trigger…





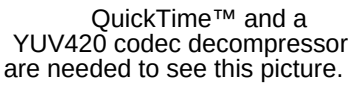


A Needle in a Haystack



How BAT Triggers

Coded Apertures 101



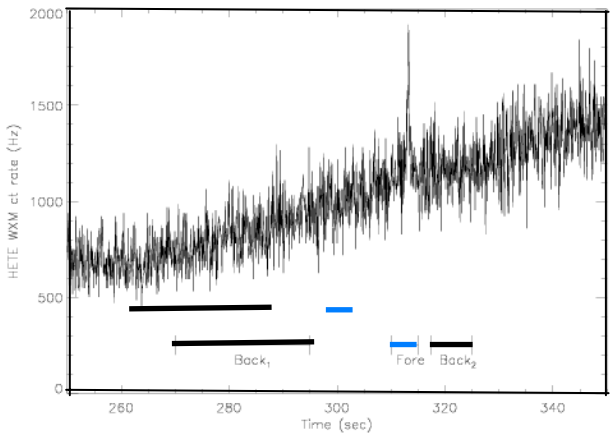
To Find a GRB: Constant Trigger Evaluation

- Every second, ~2700 rate trigger criteria evaluated on board
  - Individual criteria
    - detector area
    - energy
    - foreground duration
    - number of background samples
  - Fully explore GRB phase space

- Every minute, one image trigger evaluated
  - Looks for slow rising GRBs that rate criteria would have missed

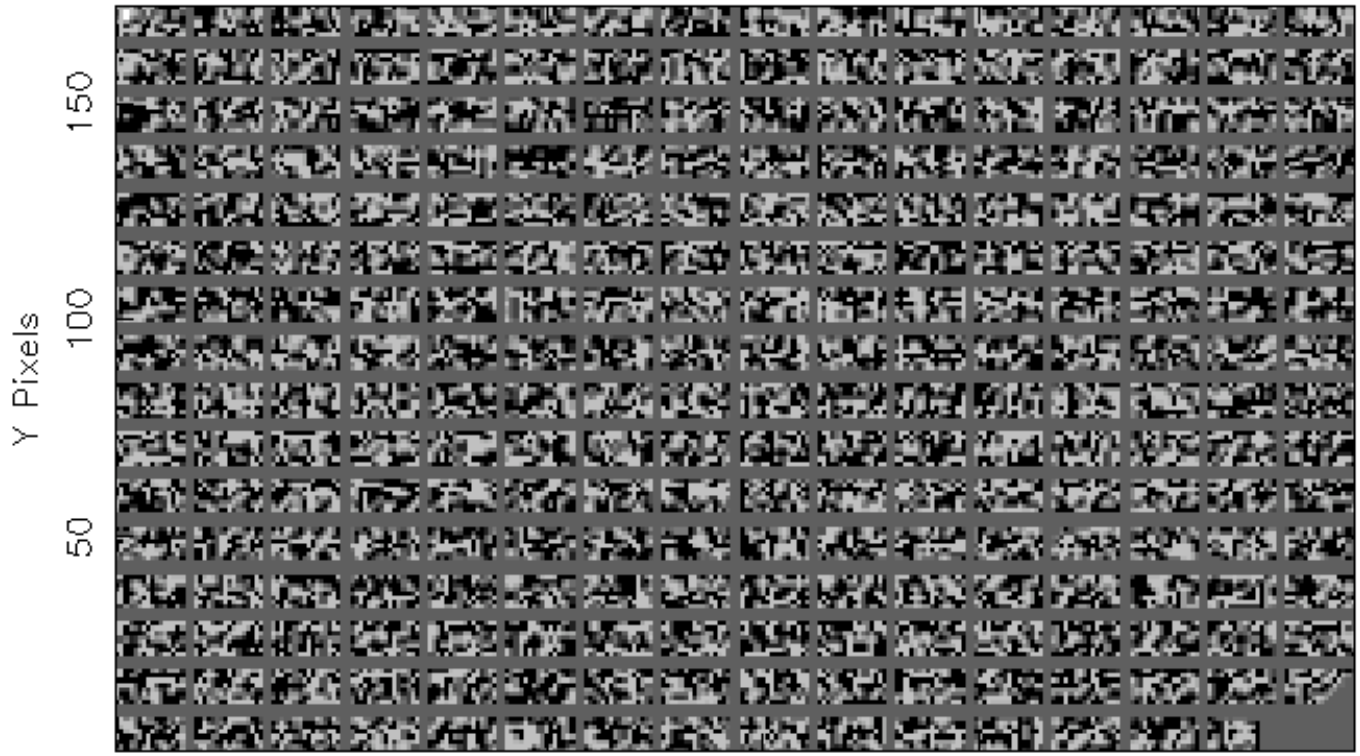
Dividing Phase Space: The Trigger Criteria

- **Time duration**
  - log coverage from 4msec to 32 sec
- **Energy range**
  - 15-25 keV, 15-50 keV
  - 25-100 keV, 50-350 keV
- **Area of the focal plane**
  - Full focal plane
  - 4 halves (top, bottom, left, right)
  - 4 quarters
- **Number of background samples**
  - One sided- BATSE-like trigger
  - Bracketed - removes trends in the data
- ***Over 600 unique criteria used on board***
  - Can command up to ~1000



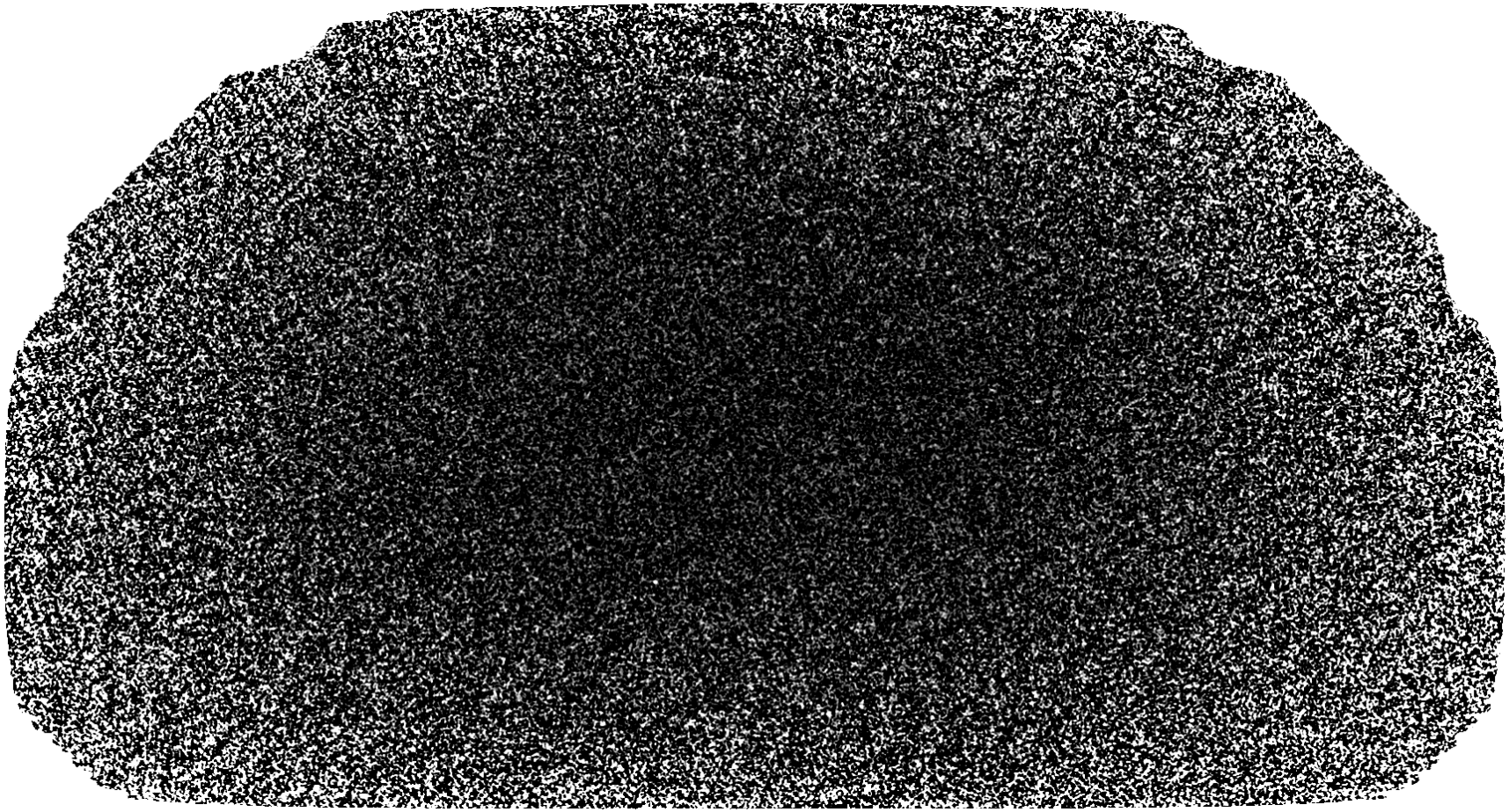
The Triggering process — the rate trigger

SWIFT BAT

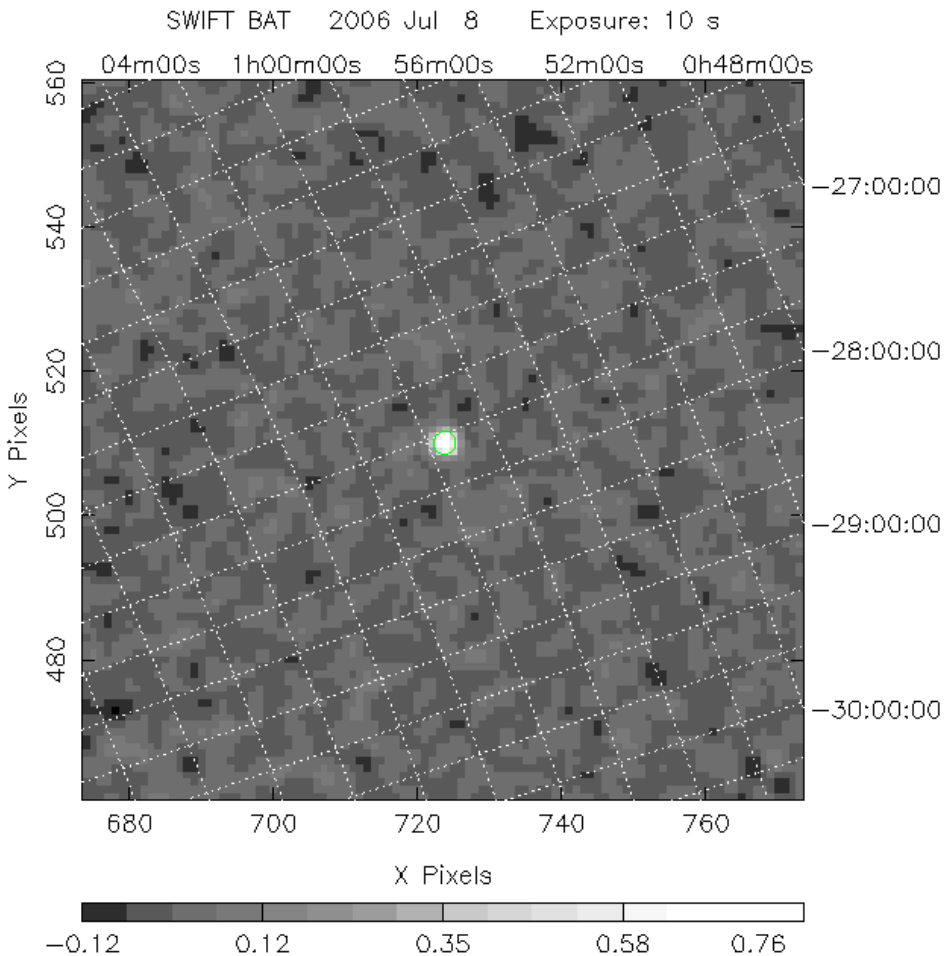


The Triggering process—FFT imaging

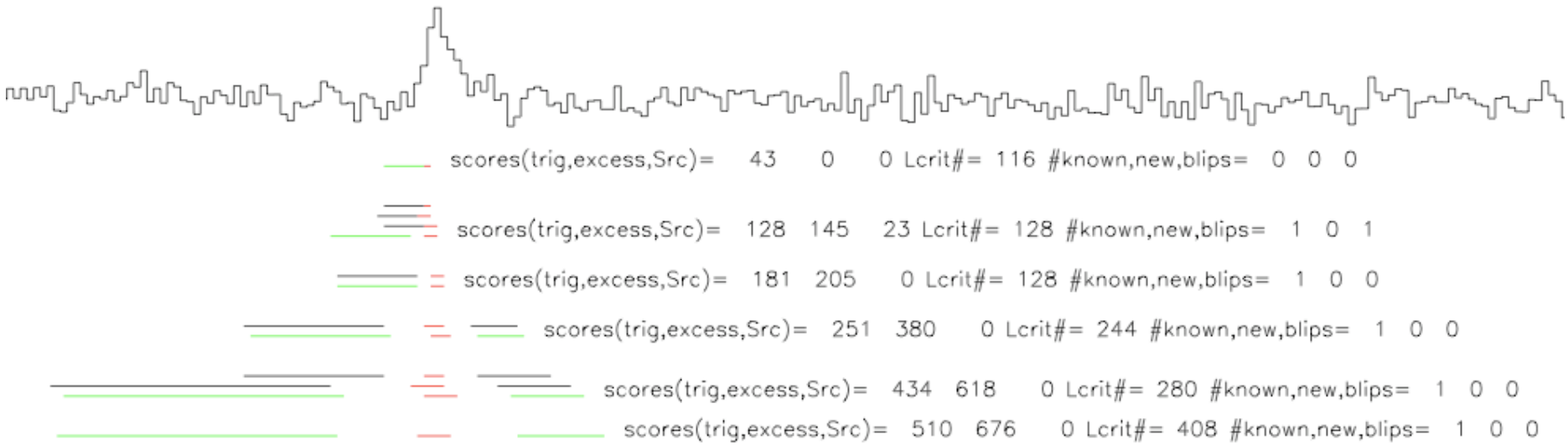
- Use the detector map to make a full-sky image by FFT convolution



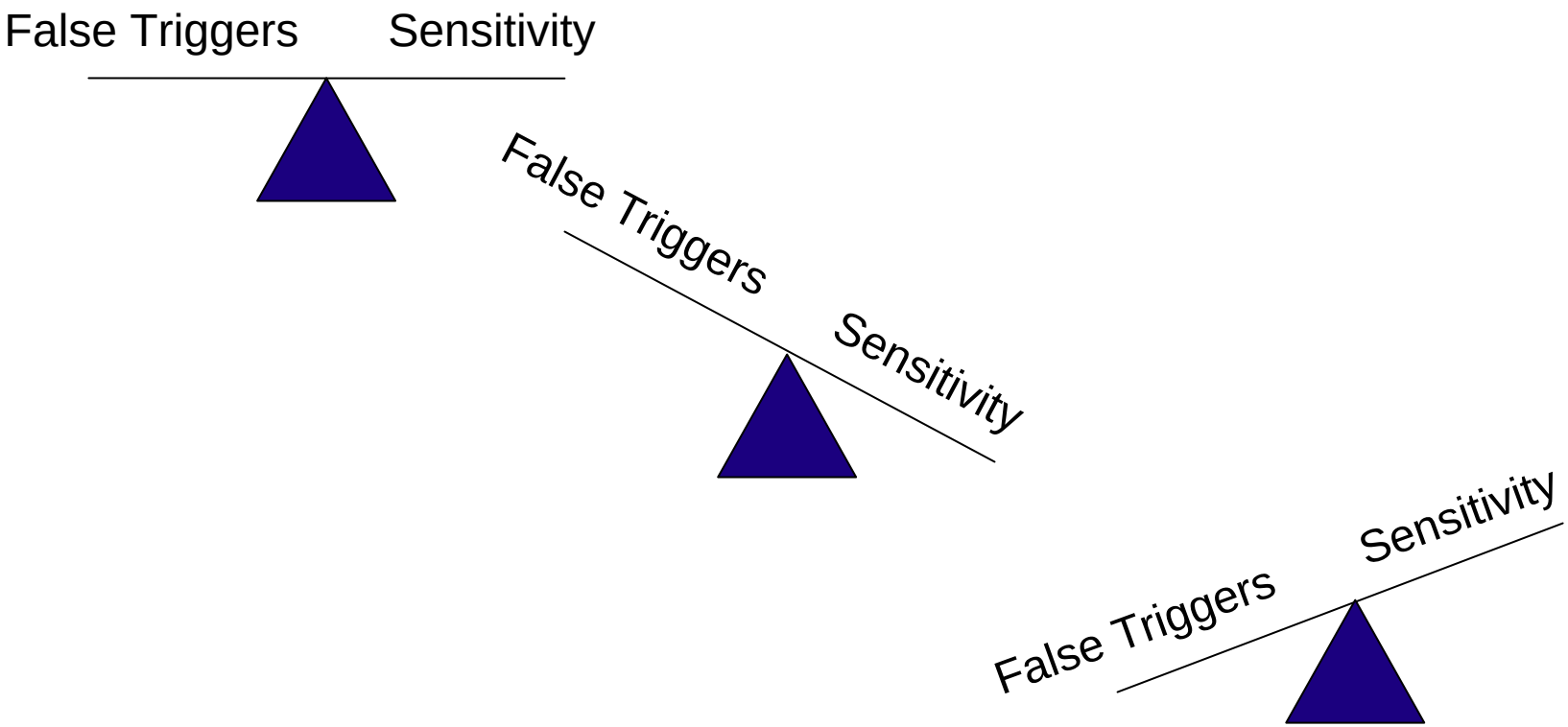
The Triggering process —back projections



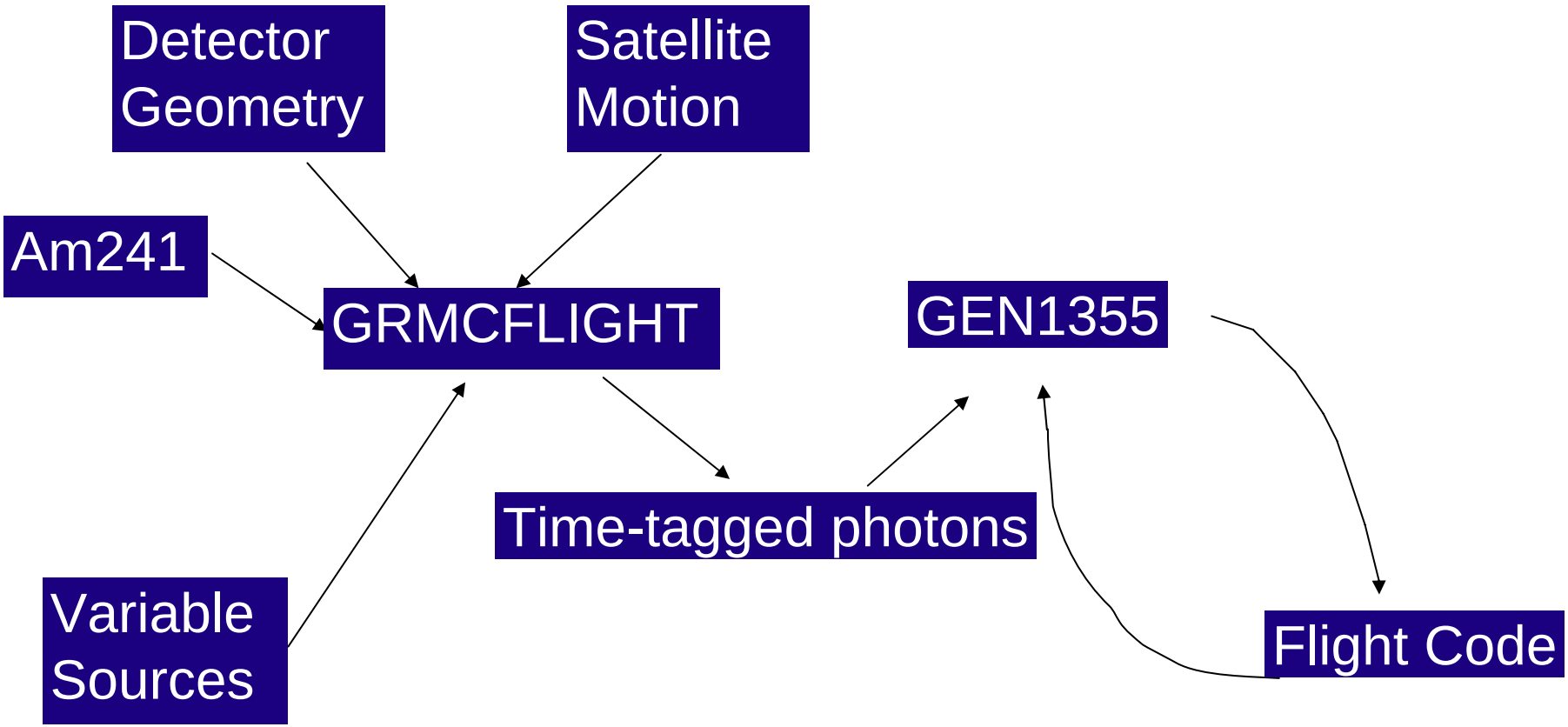
The Triggering process—Anything there?



The Balancing Act



The Simulation Setup

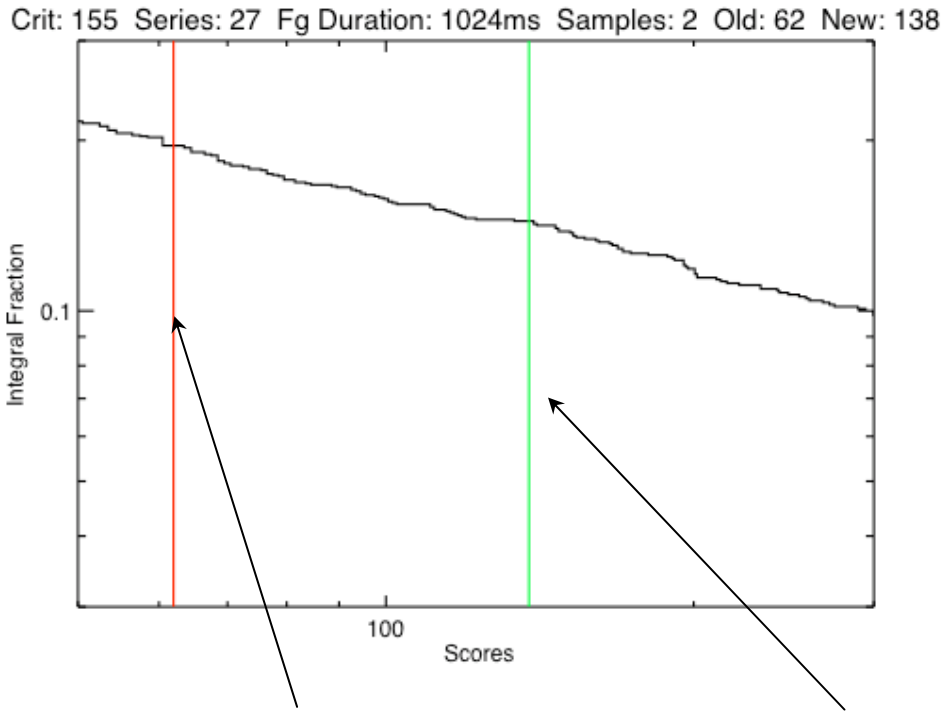


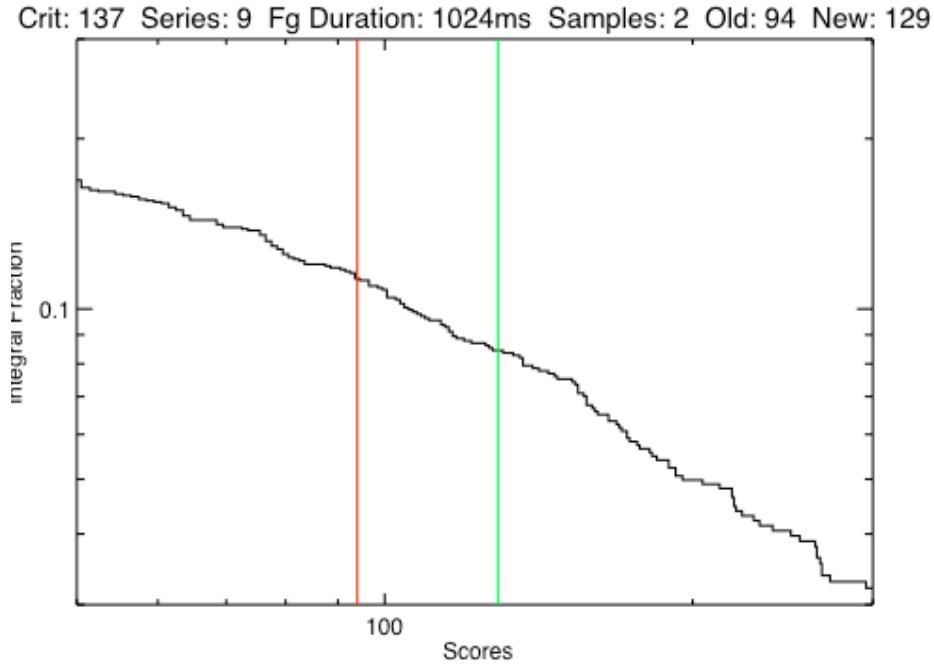
Setting Thresholds, part 1

- Get distribution of rate scores at high background
- From distribution of thresholds for each criteria
  - Calculate mean of scores
  - Calculate stdev of scores
- New threshold = mean of scores + 2*stdev of scores

- Tolerate false rate triggers
  - Caught by image check -> no TDRS/GCN message and no slew
  - More photon tagged data for ground analysis

The Threshold Reality Check





Ground Simulation

Flight Data

Setting Thresholds, part 2

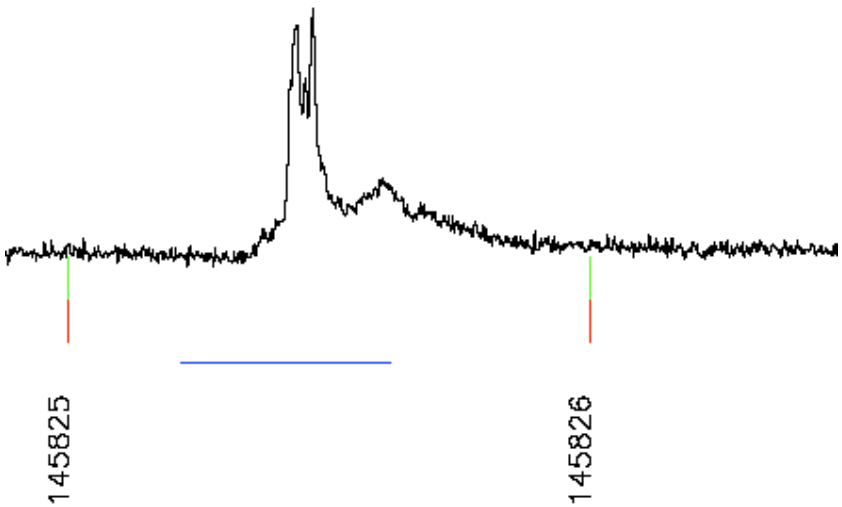
- Onboard scores included those from cosmic ray showers, realy GRBs, bright sources, etc.
- Simulation data only included a high count rate background
- Mean and stdev susceptible to outliers, thus unnecessarily raising the thresholds

- Threshold = median_scores + 7*interquartile range
  - removes the effect of outliers on threshold setting

Triggering tweaks:

- Adjust the significance thresholds for each criteria
- Adjust the threshold in FFT image for back-projection
- Adjust threshold for certainly and possibly interesting detection
- Ratcheting duration
- Adjust the times and thresholds for speculative imaging

Missed Bursts, Known Sources, and Solar Flares, oh my!



QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

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How are we doing?

- We see short GRBs and long GRBs
  - With short trigger criteria (≤64 ms)
  - With long trigger criteria
  - With 1 minute image triggers
- We see other bursting sources
  - E.g. SGR 1806-20, H1608-522
- We see slower known and unknown sources
  - E.g. SWIFT 1753.5-0127
- I have looked through months of light curves
  - No blatant cases where we should have triggered but didn't
  - Many things that looked like bursts in rate data
    - Working on locating them with IPN

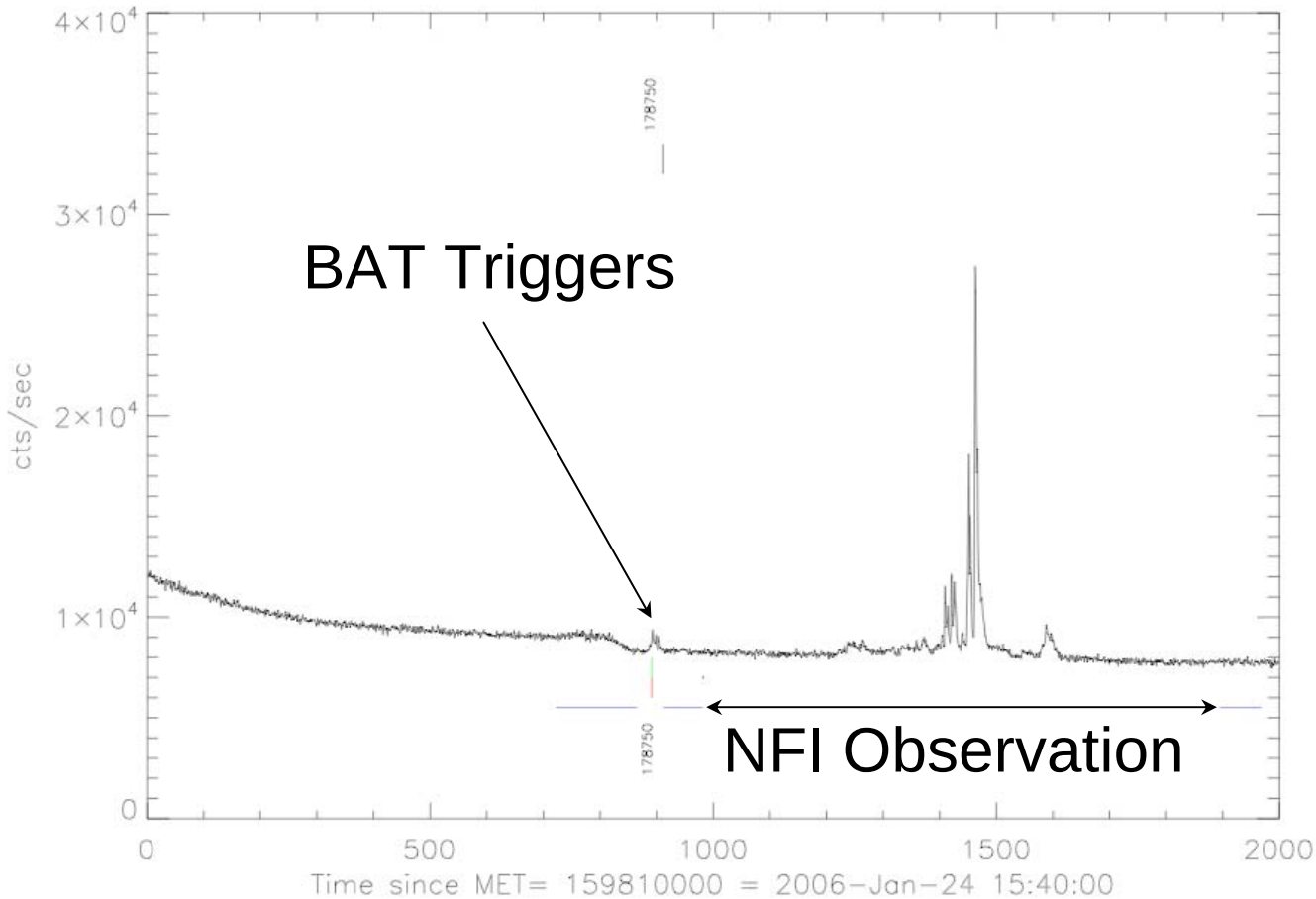
We are doing very well

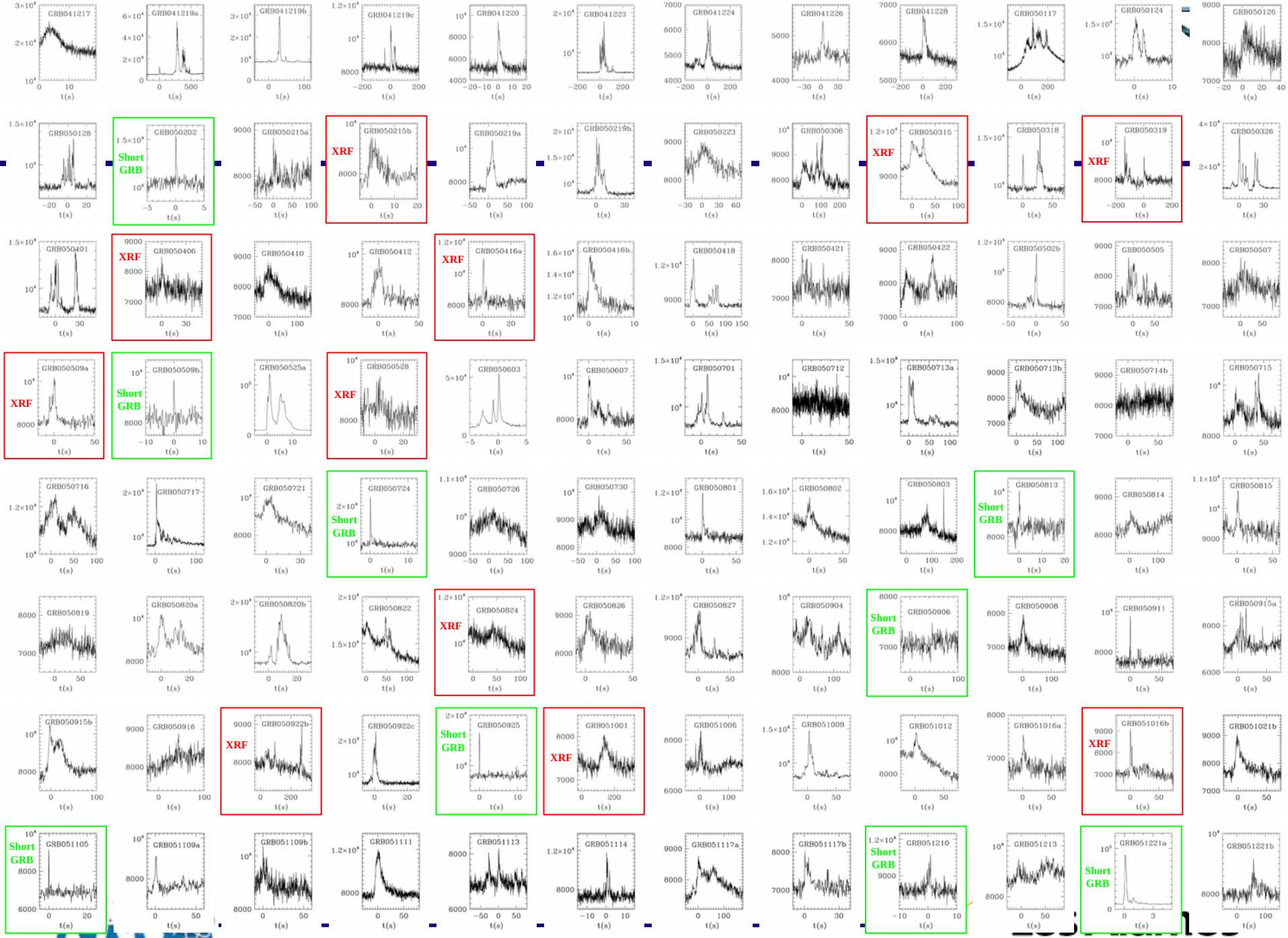
Room for Improvement

- Find optimal energy ranges that yield the highest image significance

- Find best time structures that yield the highest rate significance
  - space between background and foreground samples

Why have such a complicated triggering system?

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GRB041219b
GRB041219c
GRB041220
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GRB041224
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GRB050117
GRB050124
GRB050126
GRB050128
Short GRB
GRB050202
GRB050215a
XRF
GRB050215b
GRB050219a
GRB050219b
GRB050223
GRB050306
XRF
GRB050315
GRB050318
XRF
GRB050319
GRB050326
GRB050401
XRF
GRB050406
GRB050410
GRB050412
XRF
GRB050416a
GRB050416b
GRB050418
GRB050421
GRB050422
GRB050502b
GRB050505
GRB050507
XRF
GRB050509a
Short GRB
GRB050509b
GRB050525a
XRF
GRB050528
GRB050603
GRB050607
GRB050701
GRB050712
GRB050713a
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GRB050730
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Short GRB
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