Detecting Gamma-Ray Bursts in the DC1 Data

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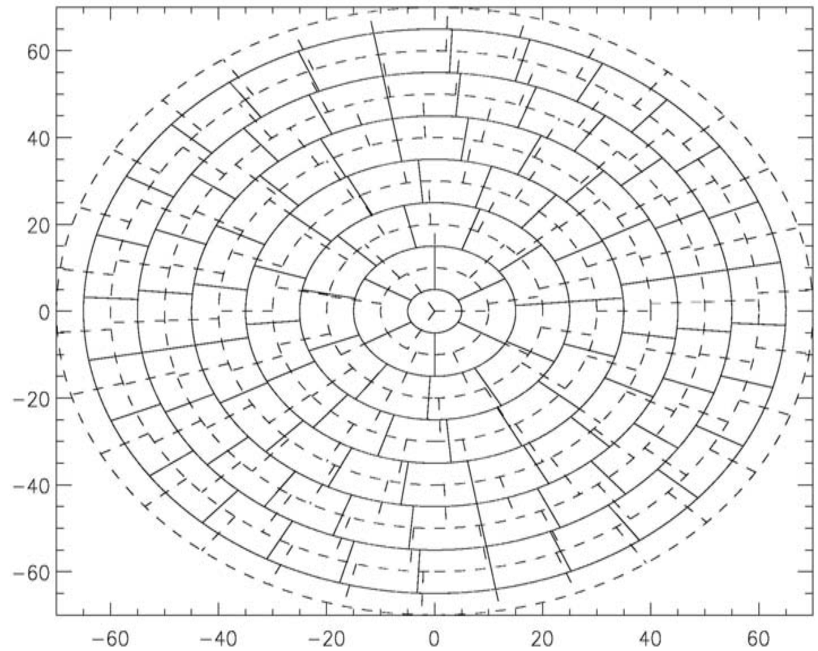
Goal

- Develop a LAT burst trigger for use on the spacecraft and on the ground. Ground-based trigger may be end of Level 1 pipeline or provided to users.
- Regimes:
  - Onboard burst photons are mixed with large non-burst event rate. Filtering to reduce the background will filter out burst photons.
  - Ground based—burst photons mixed with small non-burst event rate.
- Criteria:
  - Understand and control the false positive triggers
  - Understand the burst detection sensitivity
- Here: Method applied to DC1 data, therefore applicable to ground-based trigger.

Method

- Break up sky in instrument coordinates into regions, and apply rate triggers to each region. The regions are ~PSF in size (builds in knowledge of the instrument).
- Use two (or more) staggered regions so that the burst will fall in the interior of a region.
- Rate trigger—statistically significant increase in count rate averaged over time and energy bin.



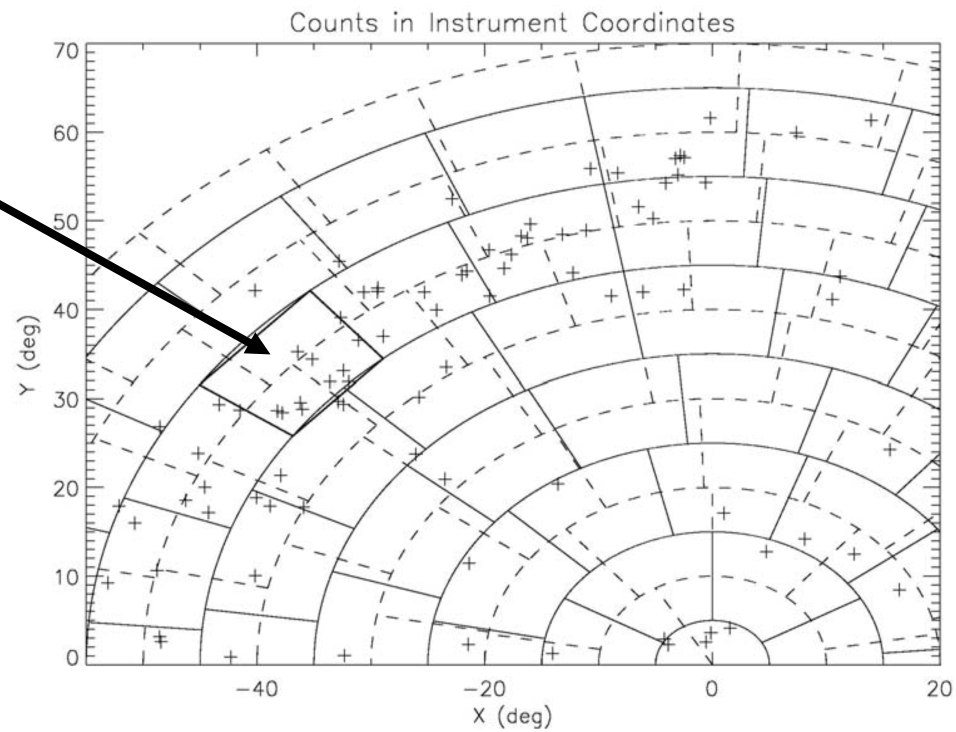
Estimating the Background

- The rate trigger requires an estimate of the background (=non-burst event rate). Typically the background is estimated from the non-burst lightcurve.
- BUT here the event rate is so low that a region's background estimated only from that region's lightcurve will be dominated by Poisson noise. The event rate per region is a few$\times 10^{-2}$ Hz.
- My current method is to average the background over the FOV, and apportion it to each region proportional to the effective area for that region.

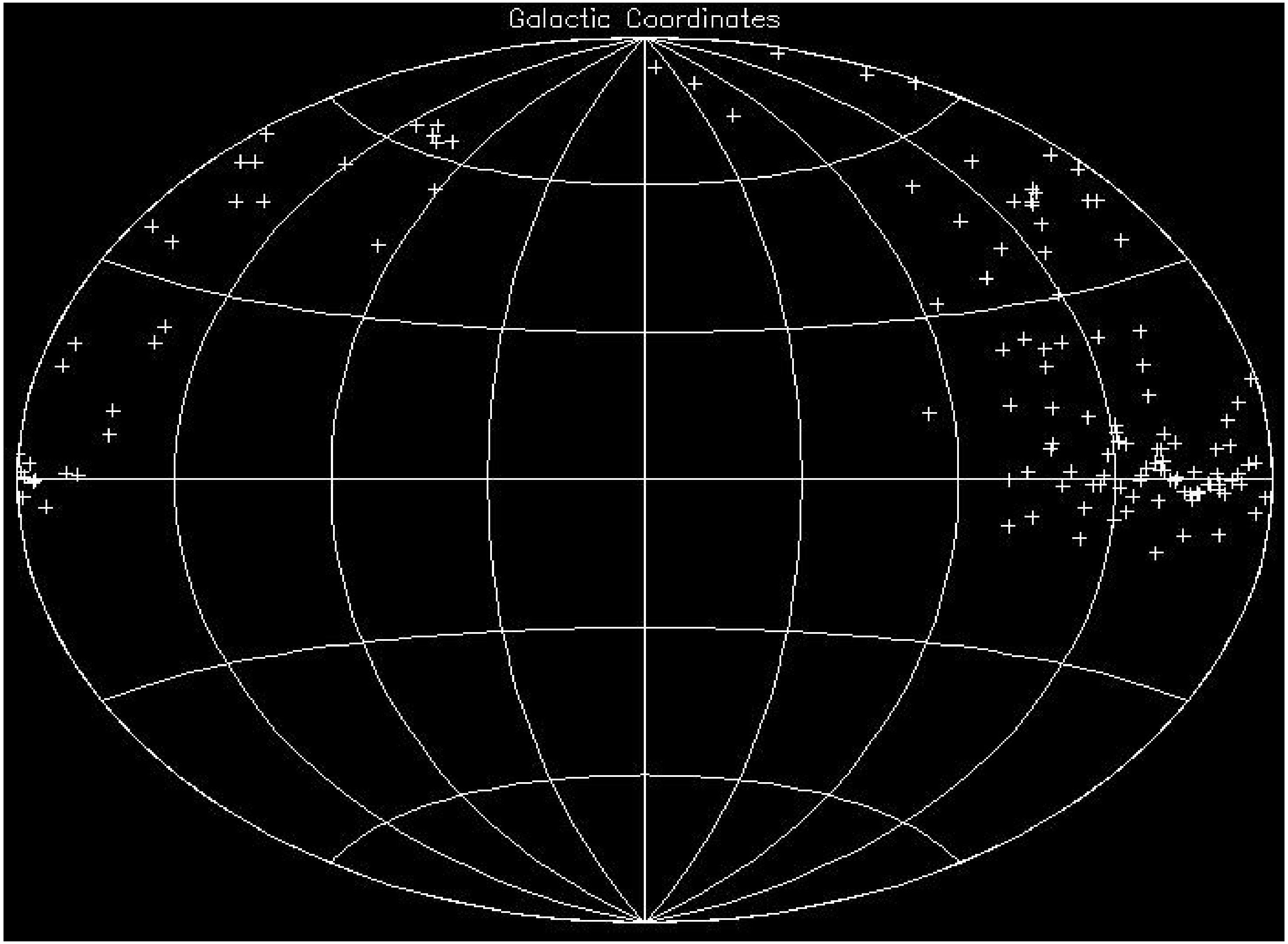
Problem with Background Estimation

- **Problem: On short (~100 s) timescales the background is NOT uniform over the FOV. The ridge of emission along the Galactic plane causes many false triggers.**
- **Solution (not implemented yet): Better model of the background.**

Region with false trigger



Region in Galactic Coordinates

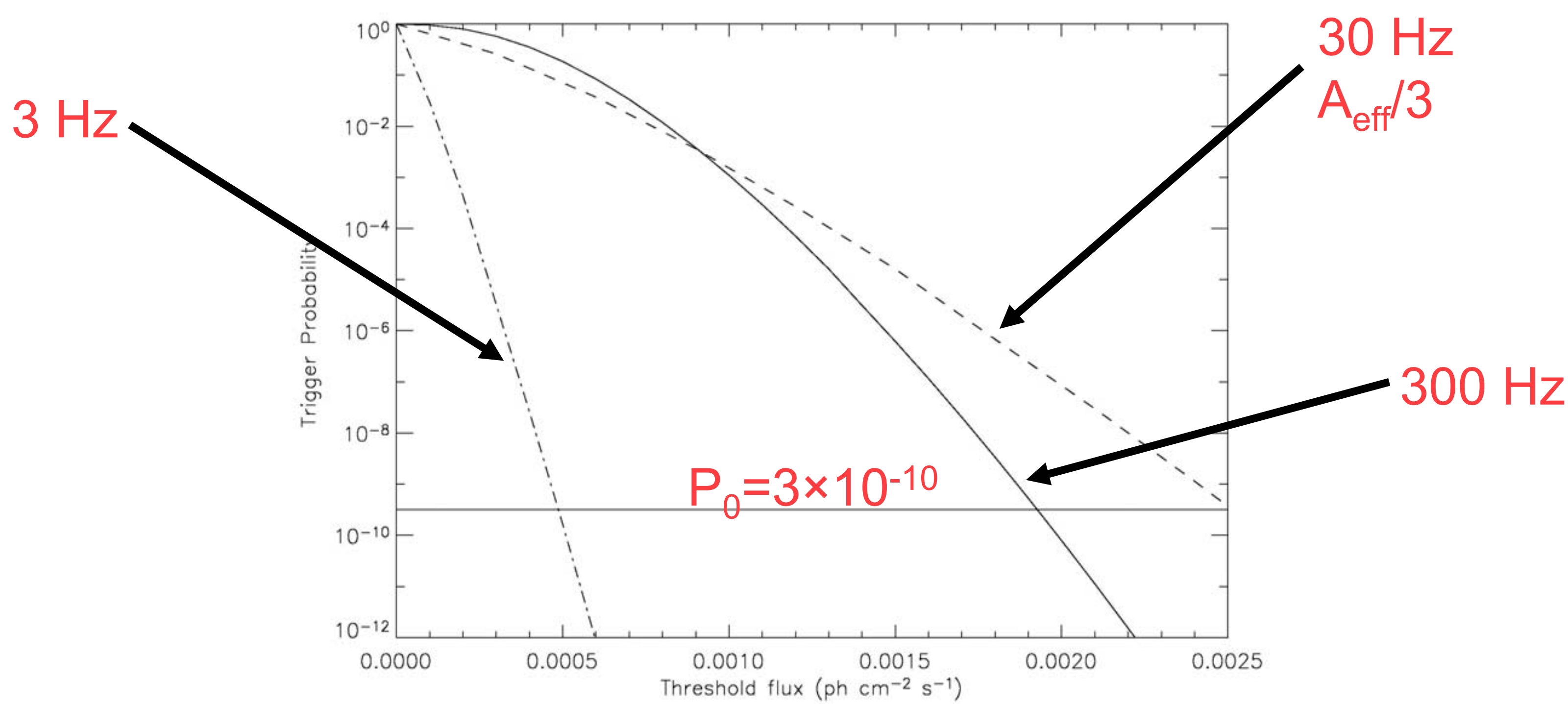


Rate Trigger

- I use Δt=1, 2, 4, 8, and 16 s applied every second.
- The trigger is disabled for 100 s after each trigger.
- Because the expected number of events per region is much less than 1, I use Poisson probabilities.
- If there are 100 regions over the sky, Δt=1 s, and we allow one false positive per year, then $P_0 < 3\times10^{-10}$. This was the threshold I used; fainter bursts might be found if I used a larger P_0.
- Because of the problems estimating the background the false positive rate was much higher.
- See LAT_trigger_DC1.pdf or LAT_trigger_DC1.ps at http://glast.gsfc.nasa.gov/ssc/dev/grb_tools/

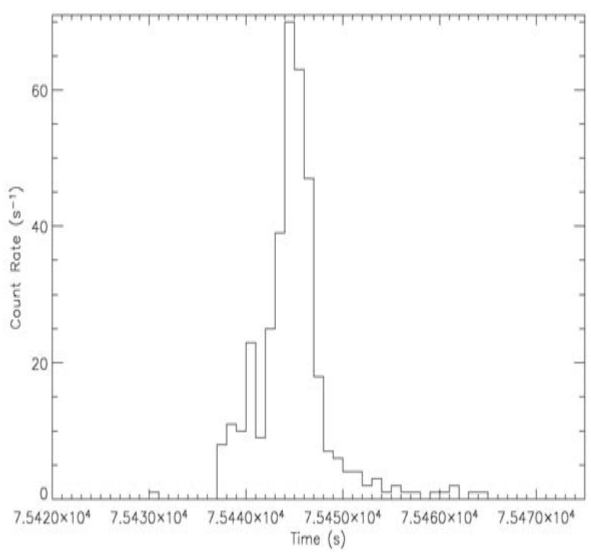
Sensitivity and Significance

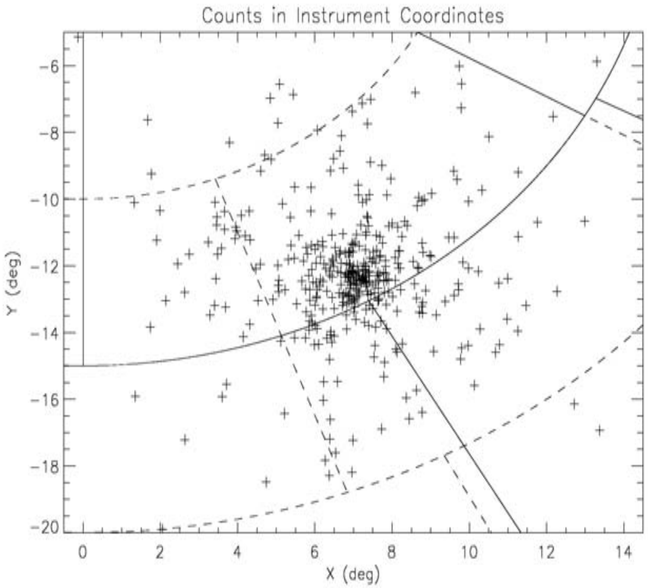
- Given Δt, P_0, A_{eff}, and the background rate (here 3, 30 or 300 Hz), one can estimate the burst flux for a trigger.
- Here $\Delta t=1$ s, $A_{eff}=10^4$ cm^2.



Results

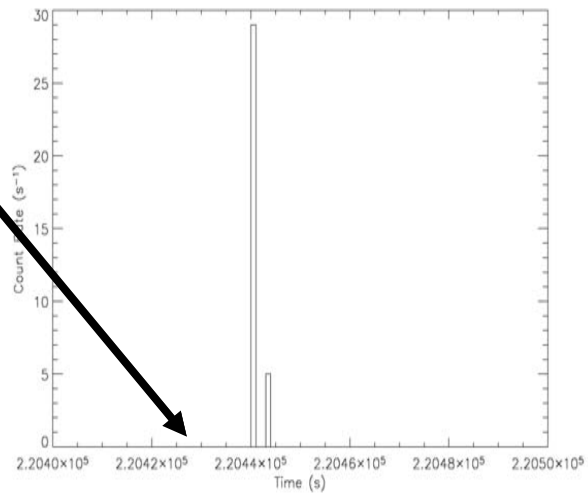
- In the ~6 days of DC1 data, I found 16 bursts and 29 false triggers.
- Note that my spatial grids extend to inclination angles of 65º and 70º.
- The software I used was all home-grown IDL procedures.

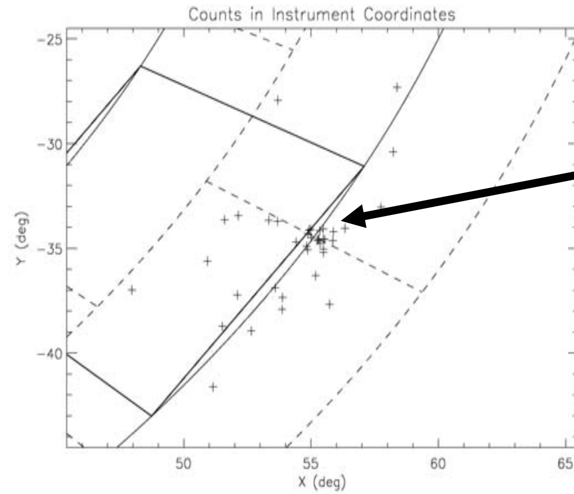




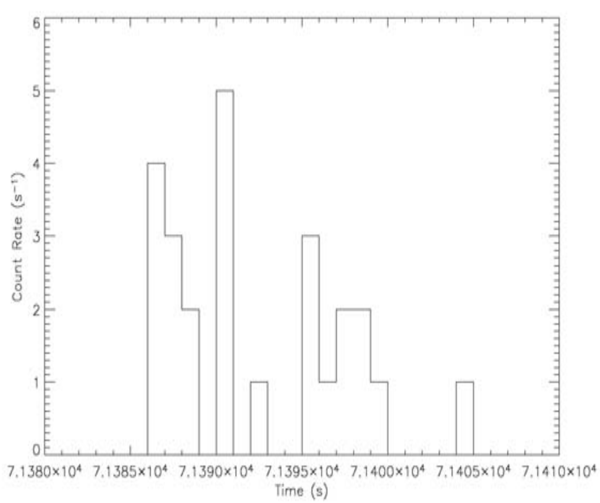
More Plots

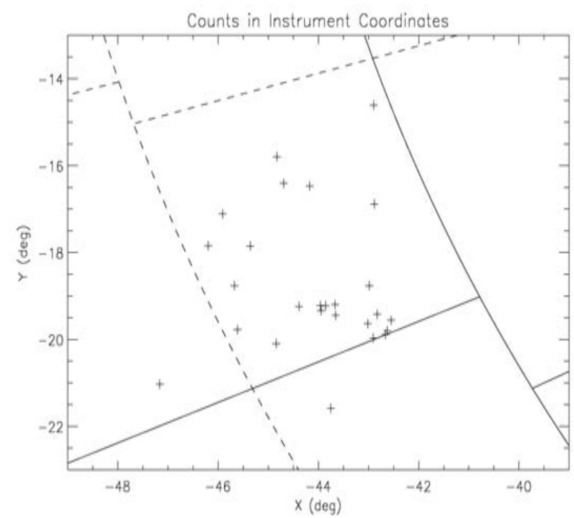
Note the absence of non-burst events!





Grids inappropriate for this burst





The Detected Bursts

Time given=end of time bin that first triggered

Cts=cts within 5º

Day	Time (s)	RA (deg)	Dec (deg)	Cts
1	3001	200.166	-32.2983	51
1	11045	326.629	27.3368	12
1	19064	138.961	-34.7865	15
1	23140	19.0295	25.6420	12
1	27212	259.142	-15.8457	12
1	35237	259.142	-15.8457	15
1	43256	145.960	33.9054	14
1	71387	225.893	-33.7395	26
1	75438	92.0570	56.3619	363
1	83511	200.164	-32.4890	21
3	176749	128.730	64.5720	257
3	215701	251.497	27.6858	161
3	220441	134.975	-2.80631	35
5	386296	198.924	33.8185	14
5	402116	128.528	-44.1544	14
5	410281	236.190	41.7744	108

Improvements to THIS Method

- Better background
- Improve grid
  - Better staggered or more grids?
  - Different region size?
  - Alternatively, HTM or HEALPIX pixels?
- Time bin stride—test time bins every ½ time bin?
- Operationally, increase P_0 when GBM triggers?

Lessons Learned

- The major issue for this method (and probably all spatial-temporal triggers) is estimating the background (=non-burst event rate). The event rate is NOT uniform over the FOV on short timescales.

- Useful plots:
  - Count map of sky in different coordinate systems (instrument, celestial, Galactic) over specified time range. Control over plotting limits necessary.
  - Lightcurve of counts from specified spatial area (e.g., circle around burst location). Control over plotting limits, circle radius, burst location necessary.