
Observation Strategies

Pointing and survey mode

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What happened

- General discussion of science issues.
 - _ Potential targets/source classes for pointed observations.
 - Drive timescales for study
 - Need to understand this to get estimate of advantages of pointed observations.
 - _ Potential science topics adversely affected by reduced exposure.
 - Needed to guide what fraction of the time should be reserved for survey mode observations.
- Semi-analytical description of the relative exposure for pointed and survey mode observations on a variety of timescales.
- Simulation of exposure as a function of time and position for some selected observations.
- Quantified some of the impacts on selected science topics.

GLAST Orbit and Survey mode

- Circular orbit, 565 km average altitude, 28.5 degree inclination.
- ~96.5 min orbit period.
- ~55 day precession period (so the ra, dec of the orbit poles trace a 28.5 deg radius circle on the sky).
- The field of view of the LAT is large (>110 deg diameter). The effective area varies as $\sim \cos(\text{angle from the center of the fov})$.
- The default observing mode is likely to be a sky survey mode. The current baseline is to rock the instrument axis 35 deg off zenith (north for one orbit, south for the next), to give fairly uniform exposure of the sky after two orbits.
- In general it is not possible to have a continuous monitoring of a source due to the SAA and to occultation by the Earth.

Pointed observations and Earth Avoidance

- Two types of pointed observations: planned (either scheduled or as a ToO) and autonomous (as a response to a GRB).
- Unless commanded otherwise, as the target source becomes occulted by the Earth, the LAT will be repointed to trace the Earth's limbs (so that we don't waste time staring at the Earth). In the studies which follow, the minimum angle between the Earth's limb and the center of the FoV is set to 30 degrees.

Science cases for pointed observations

- Pointed observations to maximize exposure
 - Blind pulsation searches for candidate pulsars (eg 1835+59). Collecting the flux needed to determine the pulse period as quickly as possible is good as it minimizes the systematic uncertainty introduced by not knowing \dot{p} , glitches, accurate position etc. (it also reduces the computational power needed to perform the analysis).
 - Resolve rapid, low-amplitude flares in AGN. May also help to extend the structure function of selected AGN to smaller timescales.
- Pointed observations to maximize time on source (particularly relevant when we are interested in timescales $< \sim 3$ hours).
 - GRB afterglows
 - Binary systems near periastron (eg PSR B1959-63, where we have a specific time where we know something interesting might happen.)
 - Binary systems with periods of \sim hours.
- With the exception of GRB afterglows, these scenarios might not be very common.

Potential disadvantages

- Loss/degradation of all-sky monitoring for the duration of the pointed observation. This could a big impact on multiwavelength campaigns which expect to get survey observations of their sources.
- Introduction of artifacts/reduction of sensitivity in higher level derived variability products such as structure function analysis etc.
- Loss in sensitivity for monitoring/measuring pulsar parameters such as pdot etc.
- Non-uniform sky coverage may introduce biases/difficulties for population studies?
- ~50% chance of missing a TDRS contact for an autonomous repoint and some ToOs -> increases data latency by 3 to 6 hours.

Studies

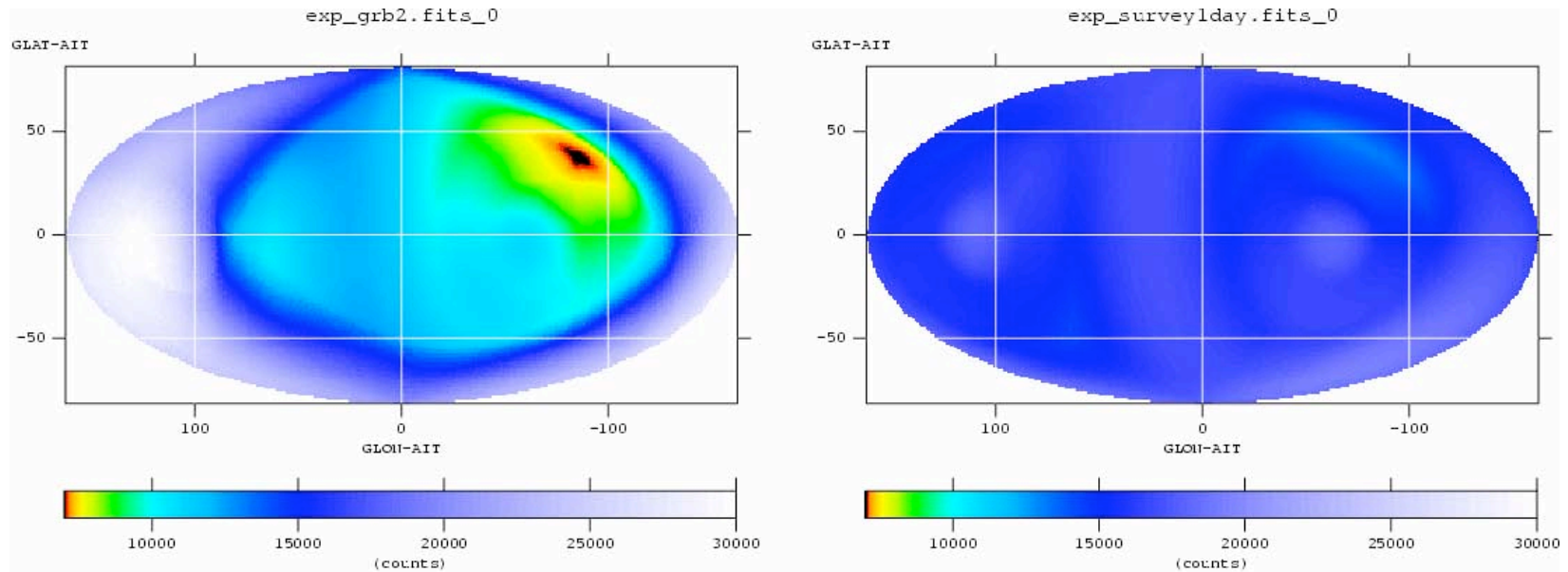
- We considered the effect of autonomous GRB repoint observations and planned pointed observations separately.

Several cases were considered:

- A day with two GRB repoints each lasting 5 hours. If the repoint rate is set to ~ 1 /week then this will probably happen a few times per year.
- A day in survey mode.
- A 55 day pointed observation of Mrk421. This is not quite realistic because we would probably have a secondary source when the primary one is occulted rather than the default Earth avoidance.
- 55 days in survey mode.

The effect of passages through the SAA is not included unless explicitly mentioned.

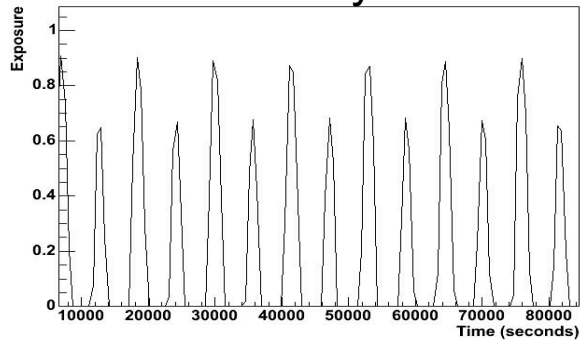
Day with 2 GRB reprints



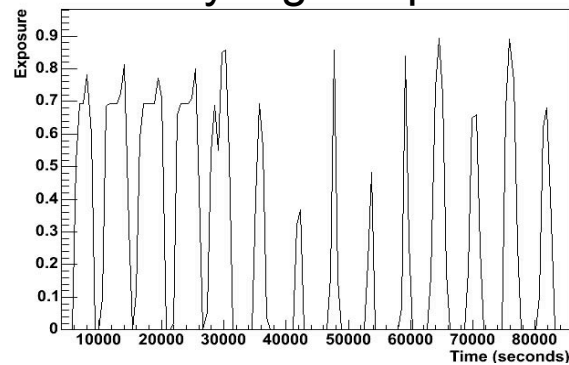
- The two GRB were at (ra,dec) 100,60 and 30,10 at 6000s and 40,000s.
- The plots show exposure (in arbitrary units) for a day long observation in survey mode (right) and in survey mode + 2 5 hour GRB observations (left).

Exposure vs time _ 2 grb case

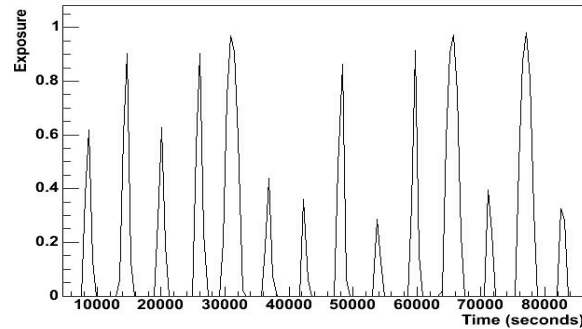
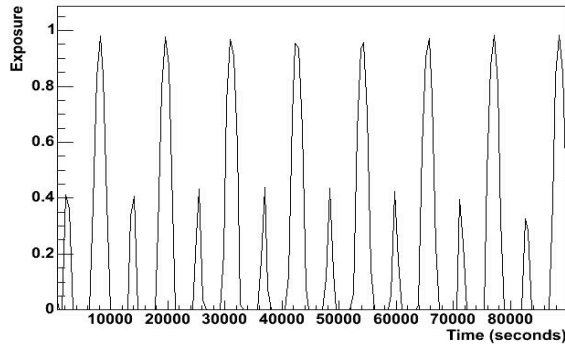
Survey



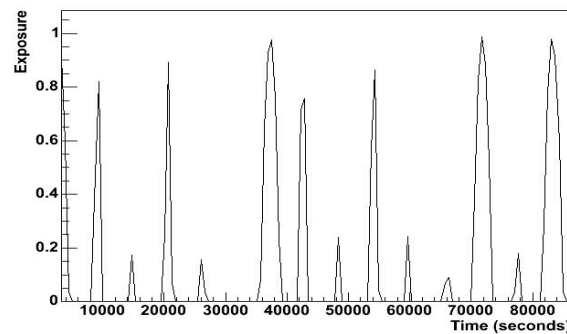
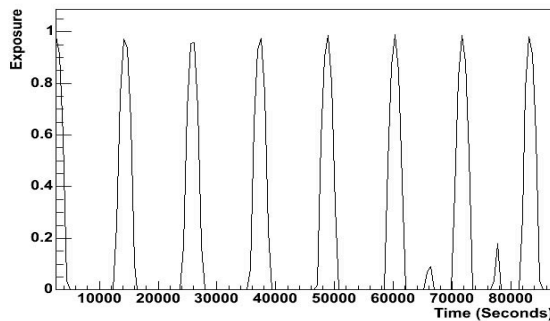
Survey+2grb repoints



Mrk421 (lies within the FoV for the first GRB pointing)



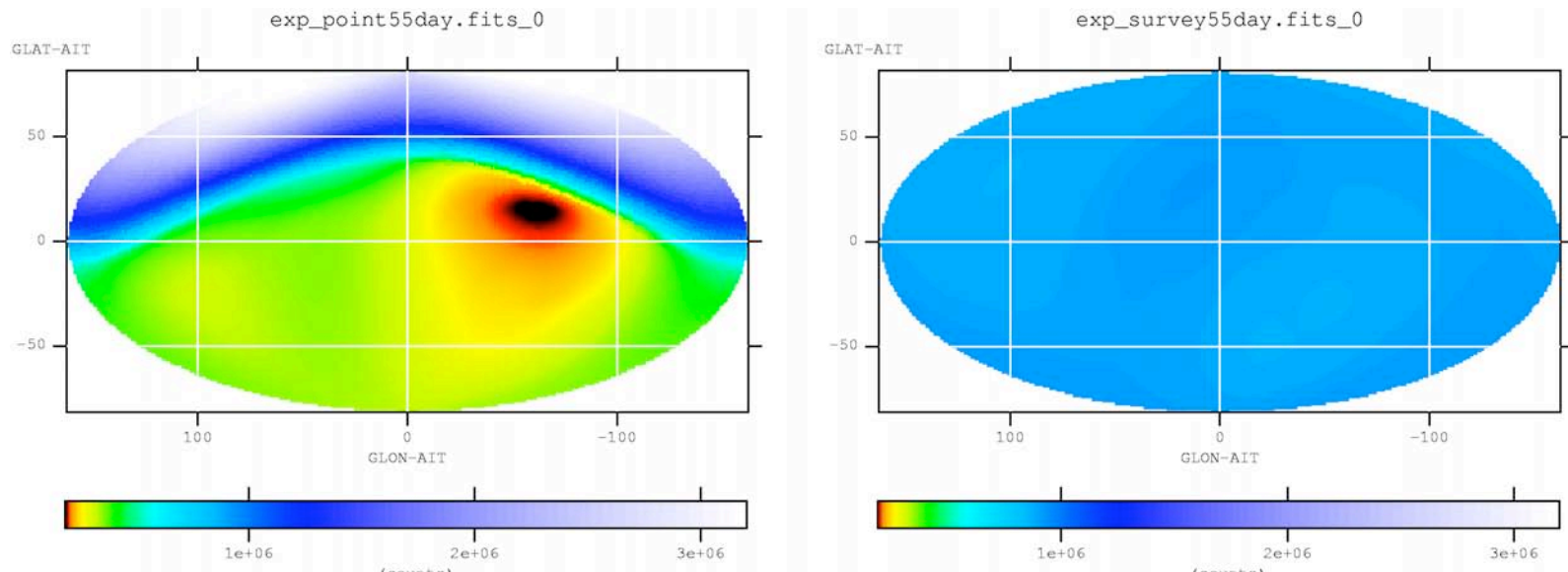
Mrk501 (minimal impact as mrk501 is visible when the GRB location is occulted)



PKS1622-29 (both GRB were in the northern hemisphere, so exposure on this southern source is reduced).

55 day pointed observation of Mrk421

Exposure for a 55 day survey observation (right) and a 55 day pointed observation of Mrk421 (left)

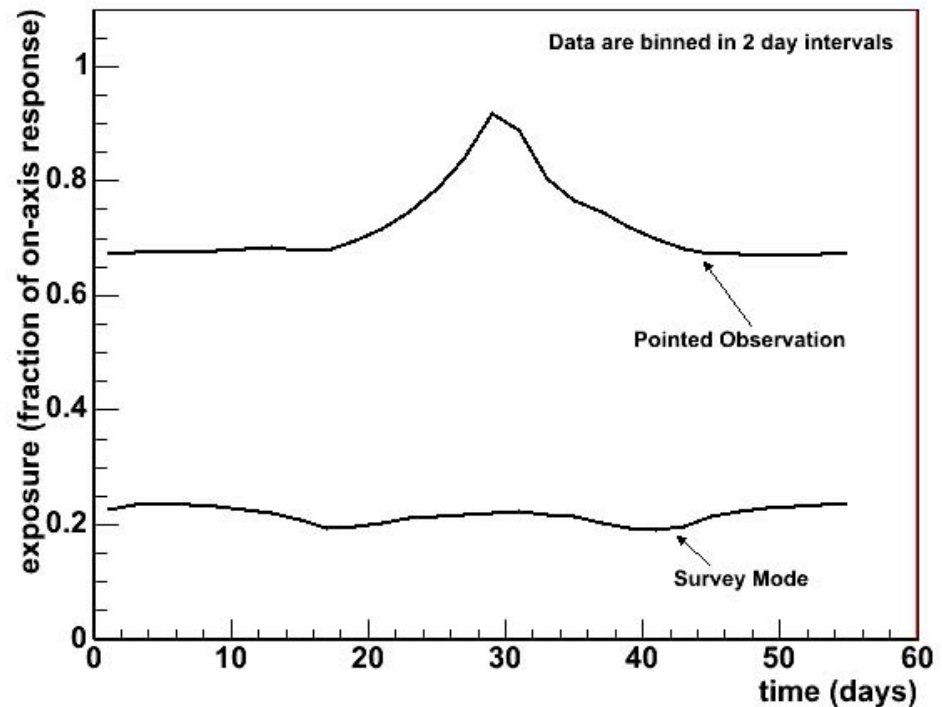


- The exposure at the location of Mrk421 increases by factor of ~ 3.5 relative to what it would achieve in survey mode.
- However, a large fraction of the sky loses more than a factor of 3 exposure relative to scanning mode.

55 day pointed observation of Mrk421

- Exposure is fairly uniform in survey mode.
- A pointed observation gains around a factor of 3 in exposure (a factor of ~ 1.7 in sensitivity, not accounting for variations of psf with inclination angle).
- Mrk421 is continuously visible (except for SAA outages) for a few days each precession period.

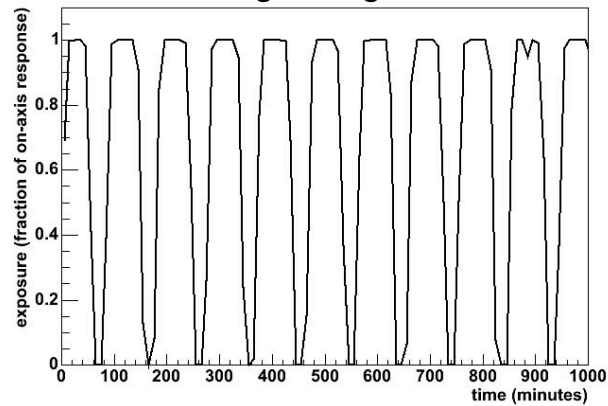
Exposure as a function of time for Mrk421



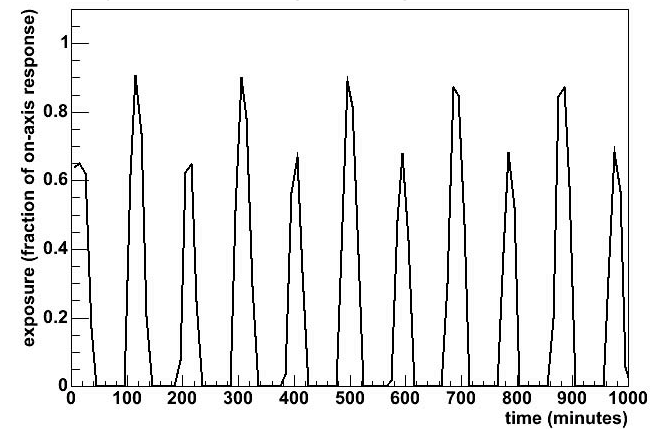
Pointed observation of Mrk421 _ effect of SAA

- Exposure as a function of time for Mrk421 averaged in 10 minute intervals.

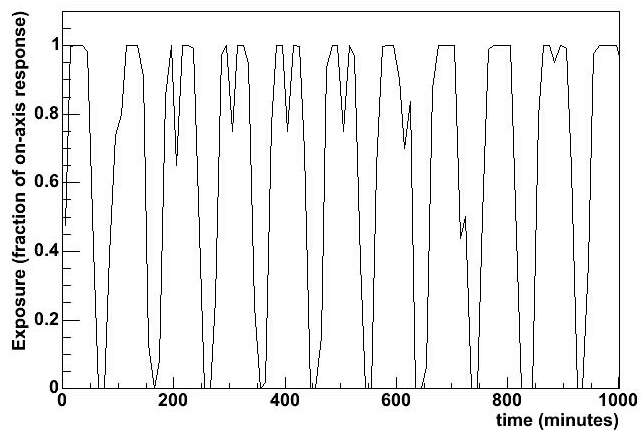
Pointed obs., neglecting SAA.



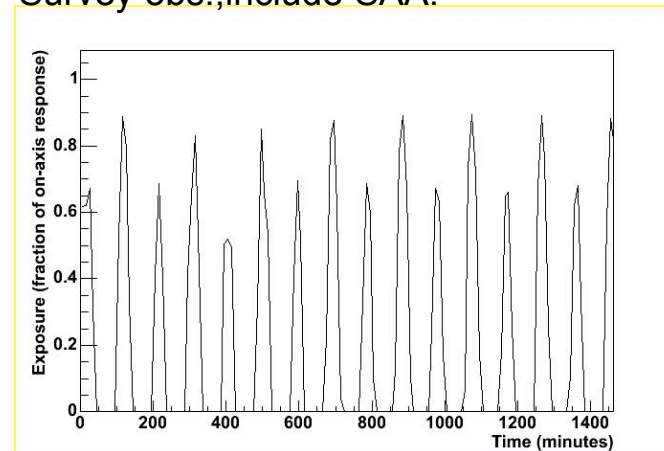
Survey mode, neglecting SAA.



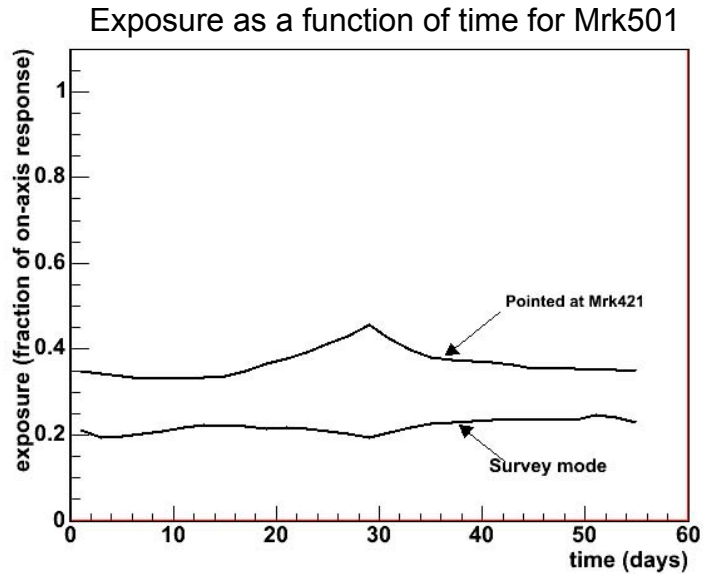
Pointed obs., include SAA.



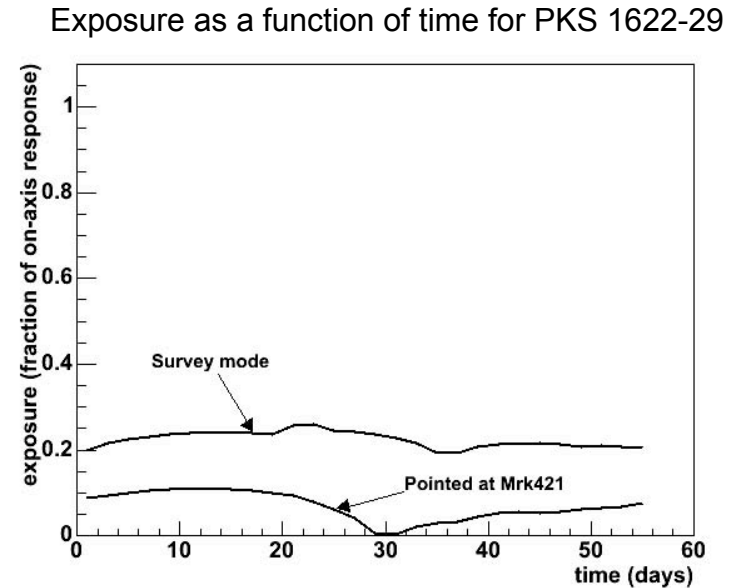
Survey obs., include SAA.



Effect on other parts of the sky



Mrk501 lies at the edge of the FoV when the LAT is pointed at Mrk421.



The Earth avoidance maneuver serves as a partial sky survey and fills in some of the sky. For most of the precession period this means that PKS 1622-29 will get some exposure. During the period when the LAT is continuously pointed at Mrk 421, PKS1622 receives no exposure at all.

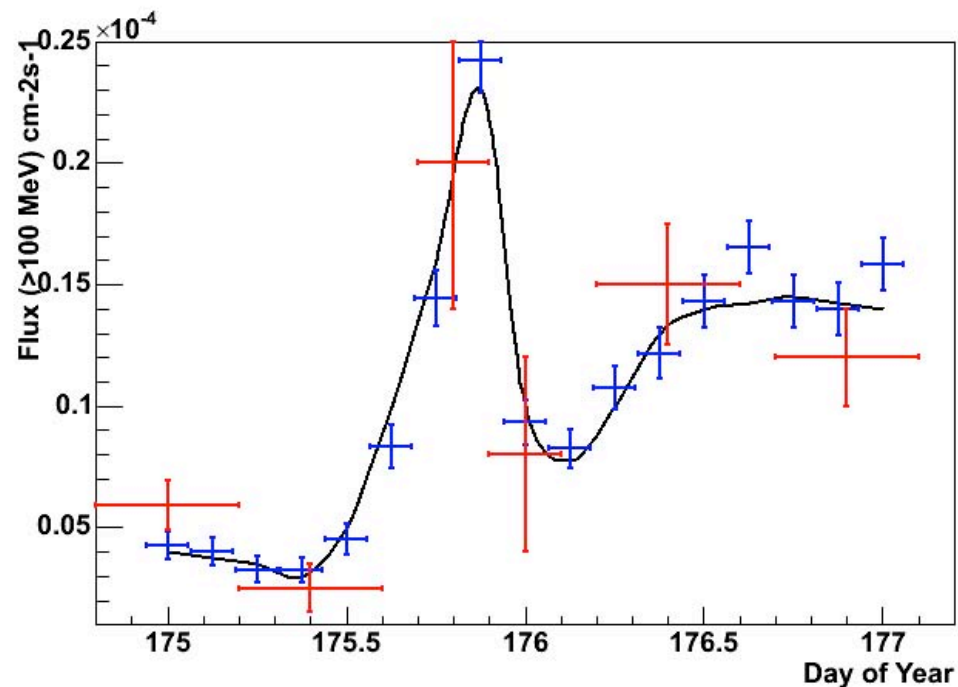
Potential effect on blind period searches

- Chandler et al (ApJ, 556, 59, 2001) derive that the number of pdot trials scales as T^2 (where T is the time between the first and last photon collected).
- If we had a 4 month pointed observation, we would collect as many photons as a year of scanning, but would incur 9 fewer statistical trials.
- What does this mean?
 - Less computational resources required for the search.
 - Our ability to find periodicity depends on the source flux, pulse fraction and pulse shape. If the statistics were Gaussian, then a 2.5 sigma excess with a year of scanning data would be just over 3 sigma with a 4 month pointed observation. For a given pulse shape the improvement in flux sensitivity would be $\sim < 20\%$.
- The above argument neglects possible constraints imposed by timing noise or non-infinite computing resources which may limit the data to a limited duration whether pointed or scanning mode data. This probably means that it is more realistic to compare pointing and scanning for observations of the same duration. In this case, we might expect to see a $\sim 70\%$ improvement in flux sensitivity.

AGN lightcurves _ short timescales

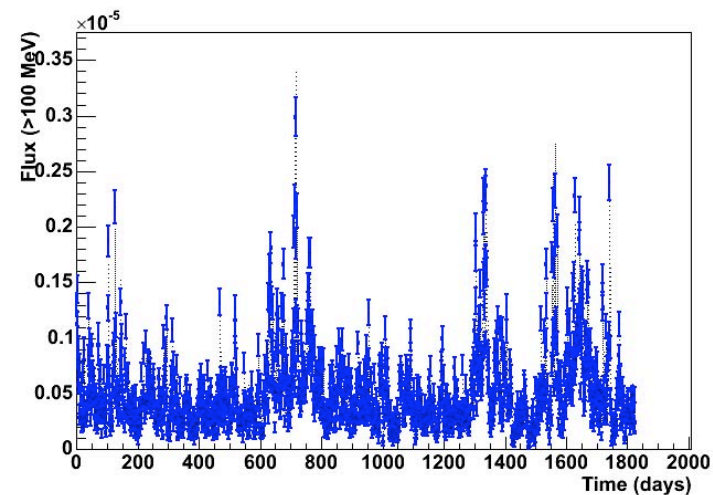
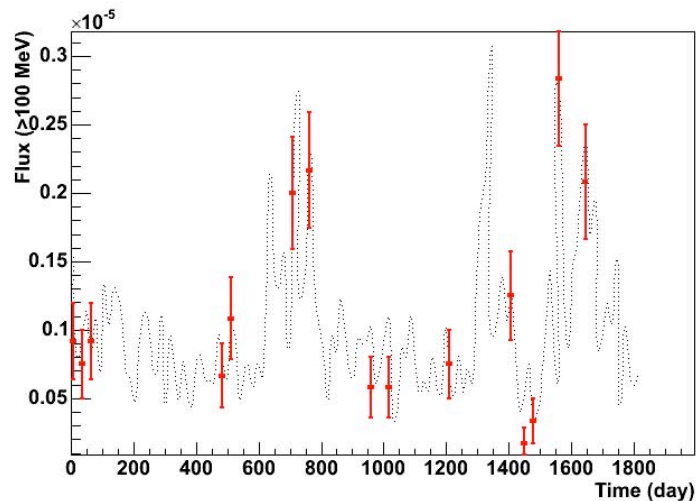
- PKS1622-29 during a flare in 1995. The red points are EGRET observations (Mattox et al), the black line is a lightcurve consistent with the EGRET observations and the blue points are simulated LAT observations.

- In survey mode, a flare like this could be observed from any location in the sky at any time.



AGN lightcurves long term monitoring

- Simulated 5 year AGN lightcurve with simulated EGRET (red) and LAT (blue) observations. The EGRET sampling pattern was the same as that actually performed for 0528+134 (one of the best observed EGRET blazars).
- In survey mode, the LAT will provide unbiased sampling of the lightcurves of a large number of objects.



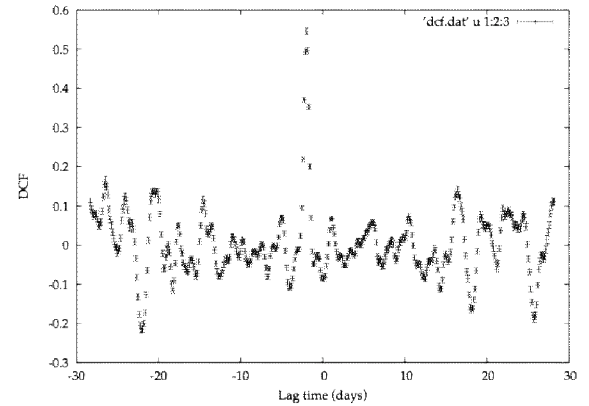
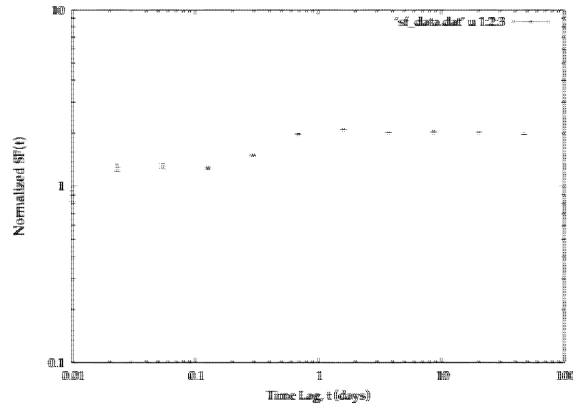
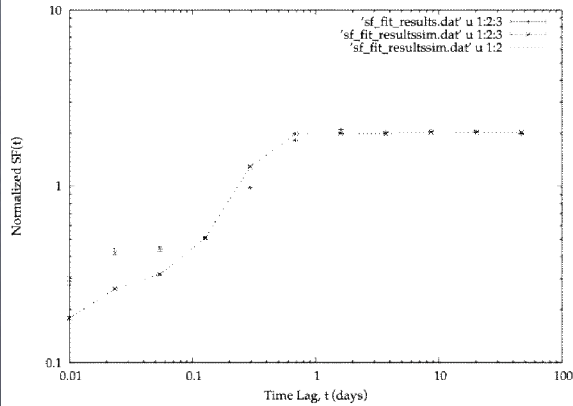
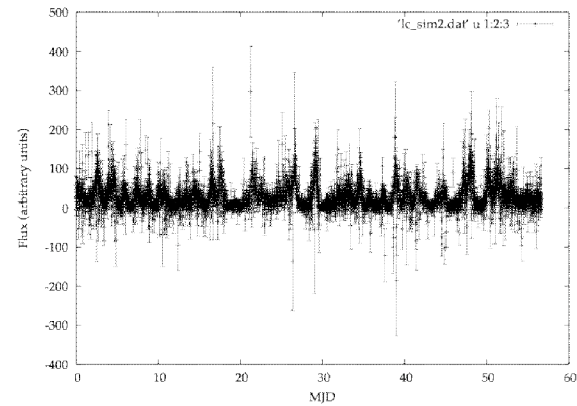
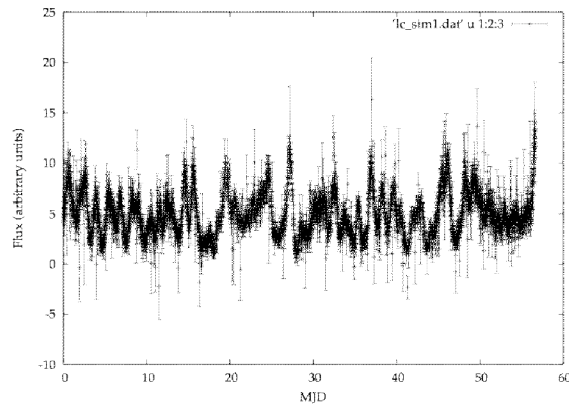
Some possible figures of merit

- We started the discussion by considering science drivers for maximizing exposure and time on source.
- A figure of merit for quantifying the benefit of a pointed observations could include
 - _ Average exposure (or something closely related) per orbit. This would be directly proportional to the sensitivity on short timescales and at high energies (photon limited) and the sqrt of this is related to the sensitivity on longer timescales.
 - _ Average # seconds on source per orbit.
- We also need to come up with FoM to describe the “hit” on the rest of the sky caused by a pointed observation.

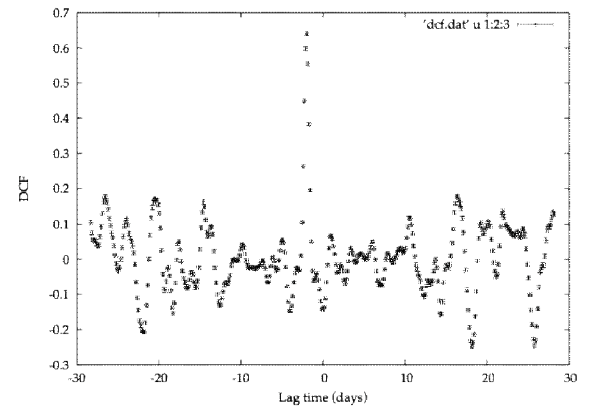
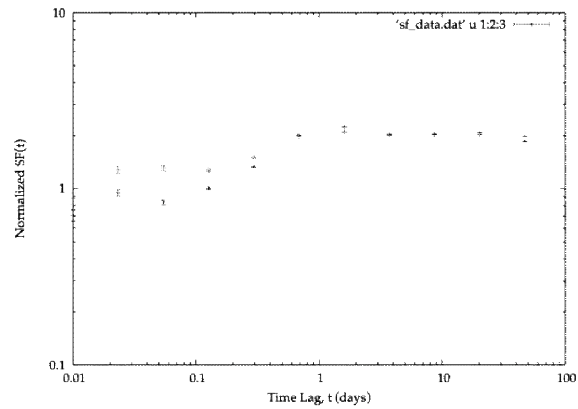
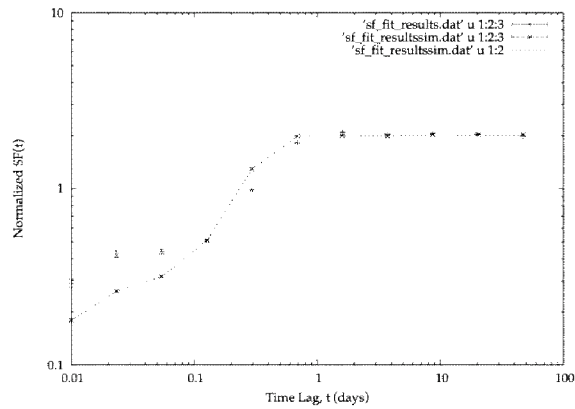
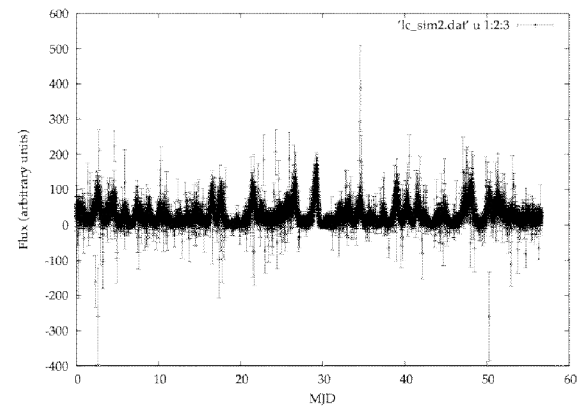
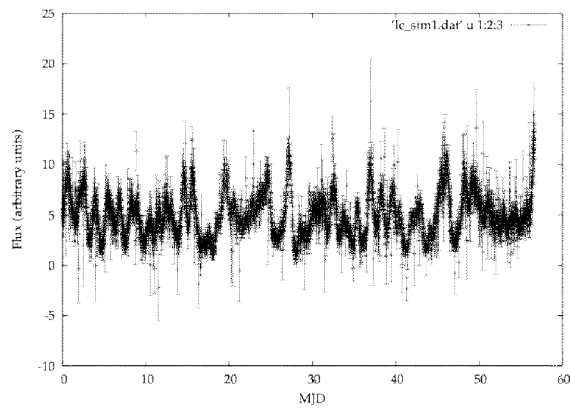
To Do

- Look at effect on populations of sources
 - _ average count rate for different classes of sources for different observing modes.
 - _ Number of sources detected for different sources classes (eg galactic or isotropic) for different observing modes.
- Further quantify effect for source monitoring (structure functions, resolvable timescales of variability etc).
 - _ A pointed observation allows one to detect weaker and shorter flares, while a survey mode observation provides greater sensitivity to catching “rarer” more intense events. Different observing modes will explore different areas of flare intensity, duration and frequency. However, it is not clear how to quantify this.

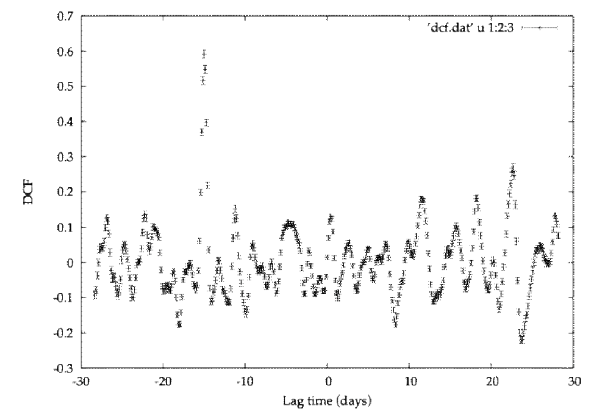
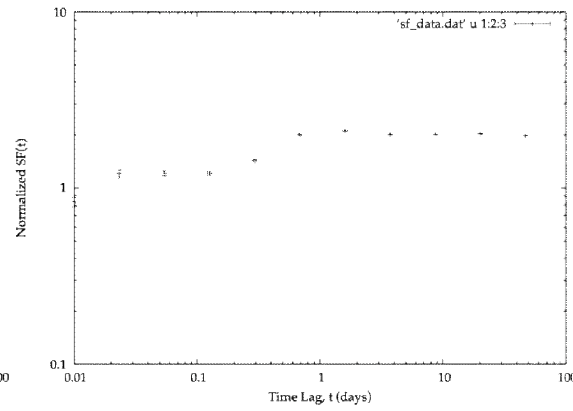
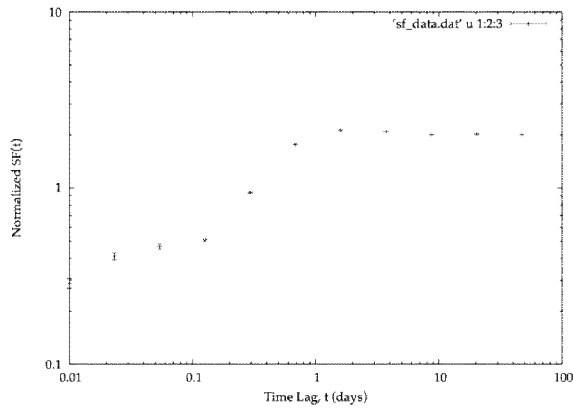
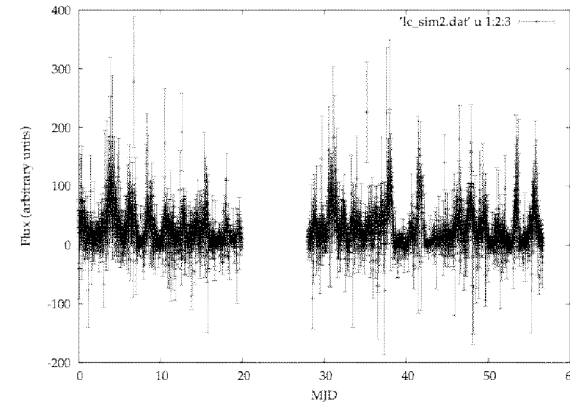
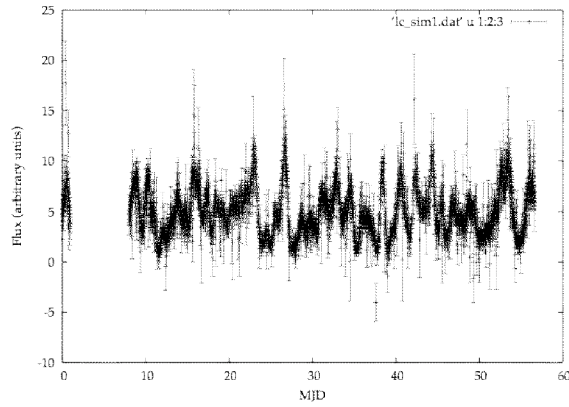
Effect of Observing
Mode on Timeseries
analysis of
Multiwavelength Blazar
Data



- Using Exposure vs. time from Julie McENEREY, calculate simulated lightcurves as pile-up of triangle flares at rate of 10 per day.
- Simulate other waveband using a simple kernel function (lightcurve2=lightcurve1² with a delay)
- Survey vs. Survey, quadratic kernel, 0.5 day rise, 2 day delay



- Survey vs. 55 day pointing, quadratic kernel, 0.5 day rise, 2 day delay



Survey vs. Survey, 8-day gaps, 0.5 day rise, 14 day delay