Scheduling GLAST Observations

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GSSC and Scheduling

- A key role of the GSSC is to schedule observations with GLAST.
- Regular scheduled (i.e. not TOO or Autonomous Repoint) observations are of two types:
  - Sky-survey (almost exclusively for year 1)
  - Pointed observations
- From year 2 on, observing proposals may be submitted by the general scientific community.
- Proposals for pointed observations need to justify why sky survey data are not sufficient for science goals.

The Scheduling Process

- GSSC will produce two types of schedules:
  - Long term (~ 1 year) schedule. Targets placed in one week bins.
  - Short term (weekly) science timeline contains exact observing information (exact times of slew start times to targets, exact times for going into sky survey mode).
  - Timelines made available to the world via the web as described by David Band.
- Preliminary weekly science timelines are produced ~4 weeks before implementation to facilitate TDRSS scheduling.
- Additional science timeline changes may be made up to few days before load to spacecraft as long as scheduled TDRSS contacts are not disrupted.
- In exceptional circumstances science timeline may be changed even if *small* number of TDRSS contacts are disrupted.

Requirements for GLAST Scheduling Software

- List of requirements for scheduling software developed. Include:
  - Ingest targets from proposal data base along with any time constraints and priority assigned by peer review.
  - Accept manual additions to target list (e.g. calibration observations)
  - Able to create long and short term schedules.
  - Interactive schedule editor available.
  - Able to deal with variety of time constraints.
  - **Able to deal with large field of view instrument (doesn't just point at single target, able to keep Earth out of central field of view.) **
  - Able to predict and avoid Earth occultation of targets.
  - Able to predict SAA passages and not schedule observations at that time.
  - Able to predict slew times between targets.
  - Modifiable and maintainable.

Additional Desired Features of GLAST Scheduler

- Able to take TDRSS contacts into account in making schedules ("lock" on observations during TDRSS contacts, predict whether modifying timeline with attitude change during contact will result in loss of TDRSS contact).
- Able to include spacecraft "desirements" in scheduling. These may be violated, but potentially yield somewhat reduced performance (e.g. poorer attitude determination).
  - For sky survey choose flip between +/- zenith offsets to reduce spacecraft yaw flips.
  - If no science detriment, minimize Z axis getting close to Sun (reduces yaw flip rate)
  - Avoid Earth occultation of all 3 star trackers simultaneously.
- Able to schedule "advanced" observations such as simultaneous observations of several targets or survey/point (attitude changes while specified target stays within field of view).

GSSC Scheduling Software

- The GSSC will use “Tako” to schedule sky survey and pointed observations.
  - Tako means Octopus in Japanese and is not an acronym.
  - Written for Astro-E, modified for use with Swift (2004 launch) and will be used for Astro-E2 (2005 launch). Also being tested for RXTE.
- Needs of GLAST are very different from the typical astronomical mission:
  - Most of GLAST observations are sky survey, not pointed.
  - LAT has huge field of view. Enables more than one target to be observed simultaneously (“multiplexing”).
- Tako, like other software considered, does not, in present form, specifically deal with large FOV instruments.
- Tako is being modified to meet the special needs of GLAST that result from the LAT’s large FOV.

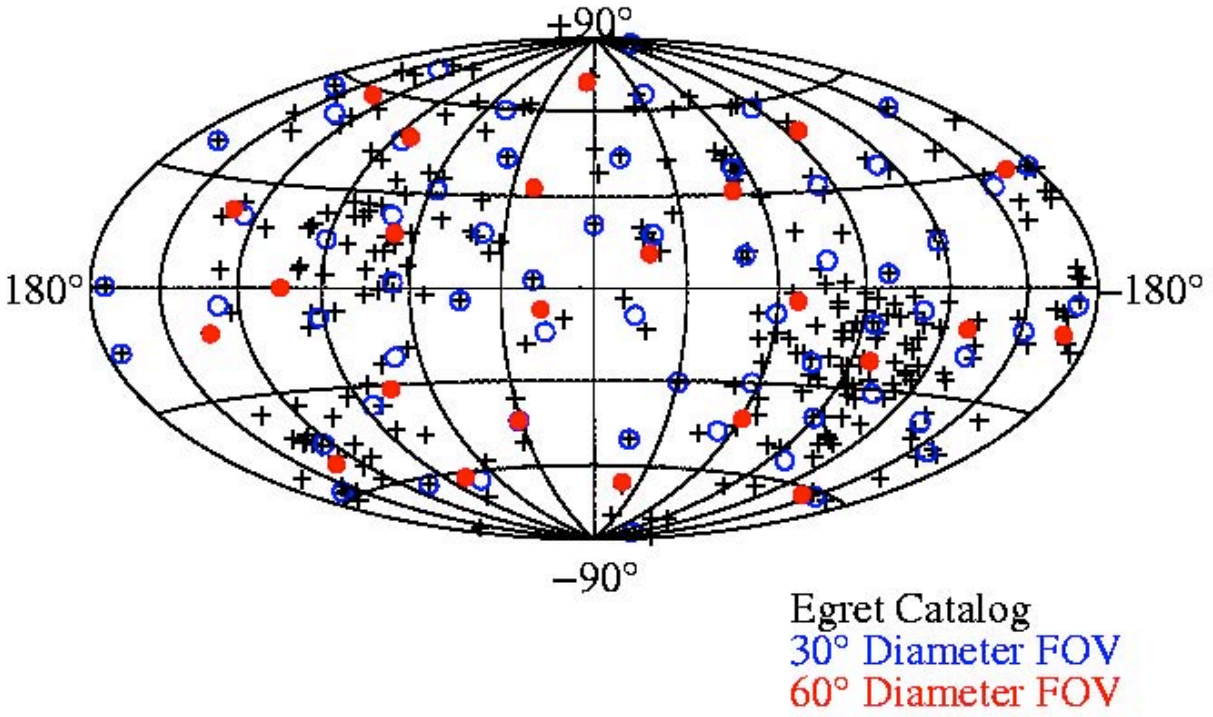
When Is Pointing at a Target Worthwhile?

- Pointing at a target gives only a relatively small increase in "return-rate" (exposure/elapsed time) compared to sky-survey.
- To obtain exposure of a target equal to that returned from just the first year's sky survey alone may need to look at that target for ~months.
- Observations purely to increase overall exposure time are thus rather inefficient.
- Pointed observation may be defined in two ways:
  - Target near center of FOV (to get higher count rate).
  - Target anywhere in FOV (to get more temporal coverage).
- Justification for pointed observations may come from:
  - Obtaining increased exposure within a certain time span (e.g. blind pulsar search).
  - Time critical observations such as outburst from source; coordination with other space- or ground-based observations; particular phase of binary star system.

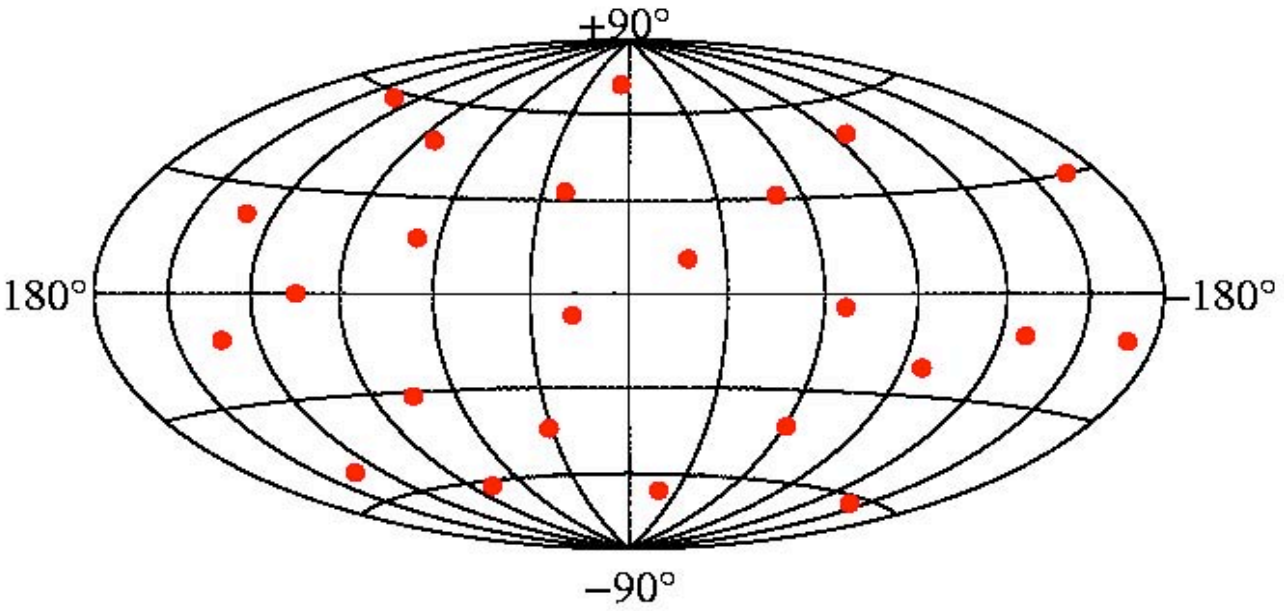
"Multiplexing" GLAST Observations

- For pointed observations with GLAST the extremely large field of view makes possible "multiplexing" of observations, i.e., more than one object can simultaneously be targets of "pointed" observations.
- As crude illustration of this the Egret catalog was taken and "super-targets" created looking for clusters of sources within 30° and 60° diameter fields of view.
- For 60° FOV analysis "super-targets" have fairly even distribution on sky – a sky survey! (But sky exposure not even for this case.)

Target Cluster Analysis for Tako



Super-Target Locations for 60° FOV



60° Diameter FOV

GLAST Scheduler (Tako) Development

- GSSC Operations Section is responsible for modifying Tako for use with GLAST.
- Two programmers are working on this code:
  - Marilyn Mix (50% MOC) – modified Tako for use with Swift.
  - Giuseppe Romeo – modified/bug-fixed Tako for use with RXTE.
- GSSC also coordinating work with Astro-E2 development team and we maintain a single multi-mission version of Tako via CVS

Milestones in Tako Development

- Writing formal development plan including:
  - Modified concept of “observation” for large FOV instrument
  - Implementation/tracking of spacecraft desirements
- Completing integration of different Tako versions (Swift, RXTE, Astro-E2)
- Validate basic functionality of integrated code.
- Add sky survey mode commanding/user interface.
- Simulate GLAST observing plans. The likely number and scope of proposed observations are unclear – we will examine extremes of number of targets. GUC input requested on possible scope of proposed observations.
- “Advanced” scheduling such as multiplexing of observations (already being investigated), combined survey/pointed observations.

Survey Strategies and Verifying Scheduler

- GLAST simulator written by Eric Stoneking.
- Dave Davis is investigating e.g. sky coverage uniformity using Stoneking simulator.
- Simulator will accept Tako-like output. We will exploit this to test Tako by checking e.g. slew length predictions, target occultations, SAA entry/exit times.

Summary

- The LAT is a different type of instrument from most astronomical instruments due to its very large FOV.
- Sky survey mode will provide such extensive data on individual sources that it will not be trivial to justify the types of pointed observations many people are used to requesting.
- A scheduling tool (Tako) has been chosen – exploits experience with Swift, RXTE etc.
- Development path with key milestones identified (our schedule ties in with overall GLAST Ground Readiness Tests)