Observation Strategy White Papers

- The Fermi Project is soliciting input, via white papers, from the community in an effort to optimize Fermi observational strategies in view of our evolving scientific knowledge.
- The technical details, as well as a scientific "cost-benefit" analysis should be discussed in these white papers.
- Timeline:
  - Jan 17: Open submission/documentation webpage
  - March 27: submission deadline
  - White papers will be evaluated by a panel consisting of project officials and scientific peers (this will include instrument team members)
- NOTE: This is not a competition, the outcome might be a recommendation for one of the strategies described in a white paper, or a combination of elements of several white papers or recommend no change.

Modes

- Autonomous repoint
  - 2.5 hour observation at location of bright GBM-detected GRB
  - Limb following while target is occulted
- Target of Opportunity
  - <week long unplanned observation
  - Transition to planned pointed observation if duration is more than a few days
  - Limb following while target is occulted
- Pointed mode observation
  - Survey mode, or secondary target when primary target is occulted
- Modified survey mode
  - stay rocked north, bias in favor of north or south, change rocking angle
  - Nadir observations, limb runs
  - Stay several orbits north to increase overlap with VERITAS (or south for HESS)

Some Definitions

- Earth Avoidance Angle (EAA) = 5 deg
  - The LAT boresight does not get closer than 1 EAA to the Earth limb during pointed mode observations
- Limb Following Angle (LFA) = 45 deg
  - When limb following, the SC tracks the limb starting 1 EAA from the limb, reaching EAA+LFF at the mid-point and then going back to 1 EAA
  - Maneuver speed is designed to have the SC get back to 1 EAA from, just as the target emerges from occultation
- Need to place "real" target at least 10 deg from LAT boresight to avoid possible systematics
- Default planned pointed mode has:
  - Survey mode while target is occulted
  - Target offset by 10 deg in Dec and 5 deg in RA
  - Choose direction in Dec to get closer to orbit equator, 5 deg in RA to mitigate acquiring target issue

Some limitations

- **Avoid TOO that are very close to orbit plane, as limb following will require a long, full speed slew to get around the Earth in time**
  - **Bad for reaction wheels**
  - **In practice, we simply choose the offset to avoid this problem**
- **Extended periods (~days) at small rocking (<40 deg) angles can cause thermal issues**

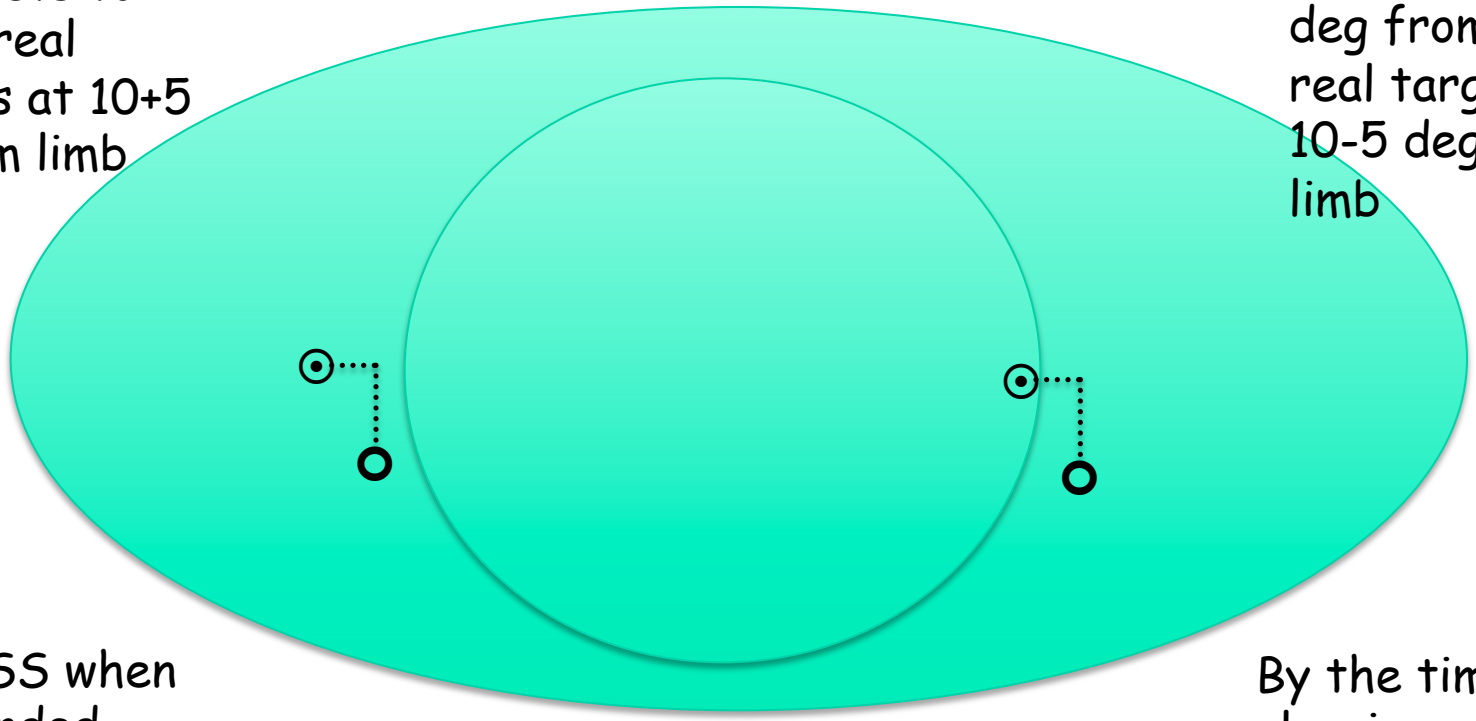
Acquiring Targets

- **If a target is occulted by Earth at the time it is commanded, the S/C does not immediately slew to acquire it.**
  - **This is good. No point looking at an occulted target.**
- **The slew to target does not begin until the target is one EAA from the Earth limb.**
  - **This can delay the slew to targets that are emerging from occultation.**
  - **If we only start the slew when the target we care about is at 1 EAA, we will arrive on-target late – use pseudo targets**
  - **If the EAA is larger than 23 deg (i.e. includes the orbit pole) then some regions of the sky are always in the "no-slew" zone.**

An Observation

Stop tracking when commanded target gets to 10 deg, real target is at 10+5 deg from limb

Exit SS when commanded target exits 10 deg from limb, real target is 10-5 deg from limb

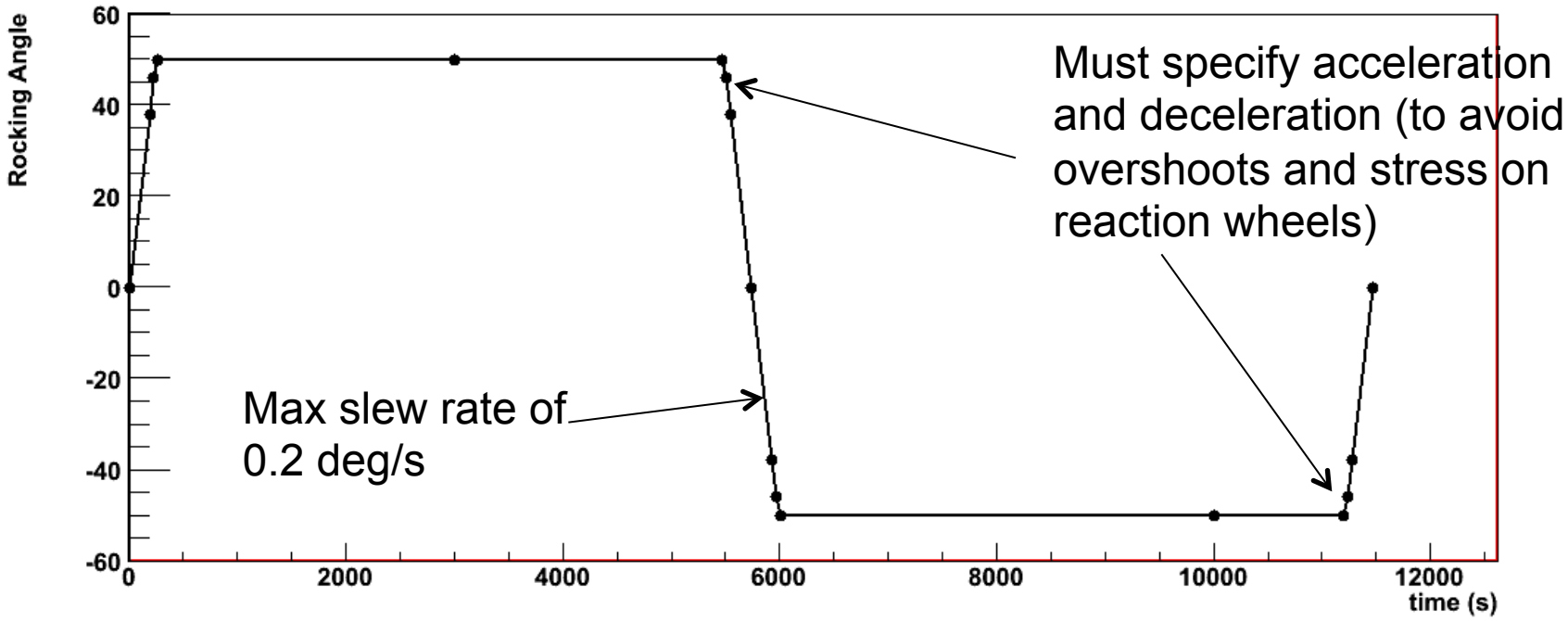


Start SS when commanded target is occulted, real target is at 5 deg from limb

By the time the slew is completed, the real target has just become observable

Survey Observations

- **Defined as a 17-point profile of time, rocking angle pairs**
- **http://fermi.gsfc.nasa.gov/ssc/observations/types/allsky/**



- **Allowed angles between -60 and 60 deg, but thermal issues if we spend substantial time <50 deg from zenith**
- **Timing of slew between +-50 deg must avoid orbit noon/midnight (i.e. cannot slew w.r.t. celestial coordinates**

Evaluating Observing Strategies – some ideas

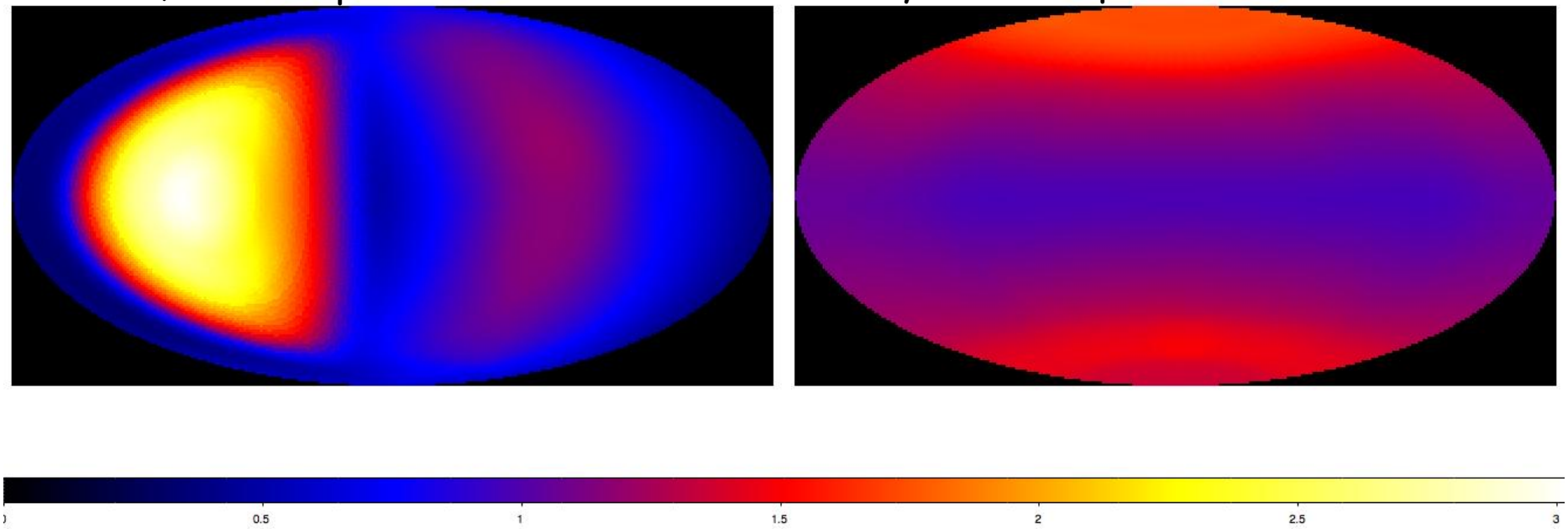
- Exposure uniformity integrated over a precession period
- Exposure uniformity as a function of time
  - Flare sensitivity – fraction of sky sensitive to a 1e-6 flare on dayscale integrations
- Exposure increase at location of source of interest
- Time in FoV (or within 45 deg) at location of source of interest
  - Catch bright flares (e.g. to monitor sun)
  - Line sensitivity ~uniform out to 45 deg off axis
- Exposure relative to Sun
  - Always away from Sun would be bad for solar science
  - Always towards Sun would be bad for MW science (because the sources Fermi would be observing would be too close to the Sun for optical/X-ray observations)
- Maximize average all-sky exposure
  - Observations that bring the LAT FoV across the Earth lose some exposure due to Earth blockage. Thus changing the observation strategy doesn't just redistribute exposure, it can also result in loss of exposure due to zenith cuts.

A strawman observation

- **Point at 261.4, 0.0 (5 deg offset in RA from GC, 28.9 deg offset in Dec). Transition into 50 deg sky survey when target is 10 deg from Earth, commence slew to target when target is exiting 10 deg from Earth. LAT boresight will track to within 30 deg of Earth limb and then hold steady until target reaches 10 deg to Earth limb**

Pointed, mean exposure 5.21e9

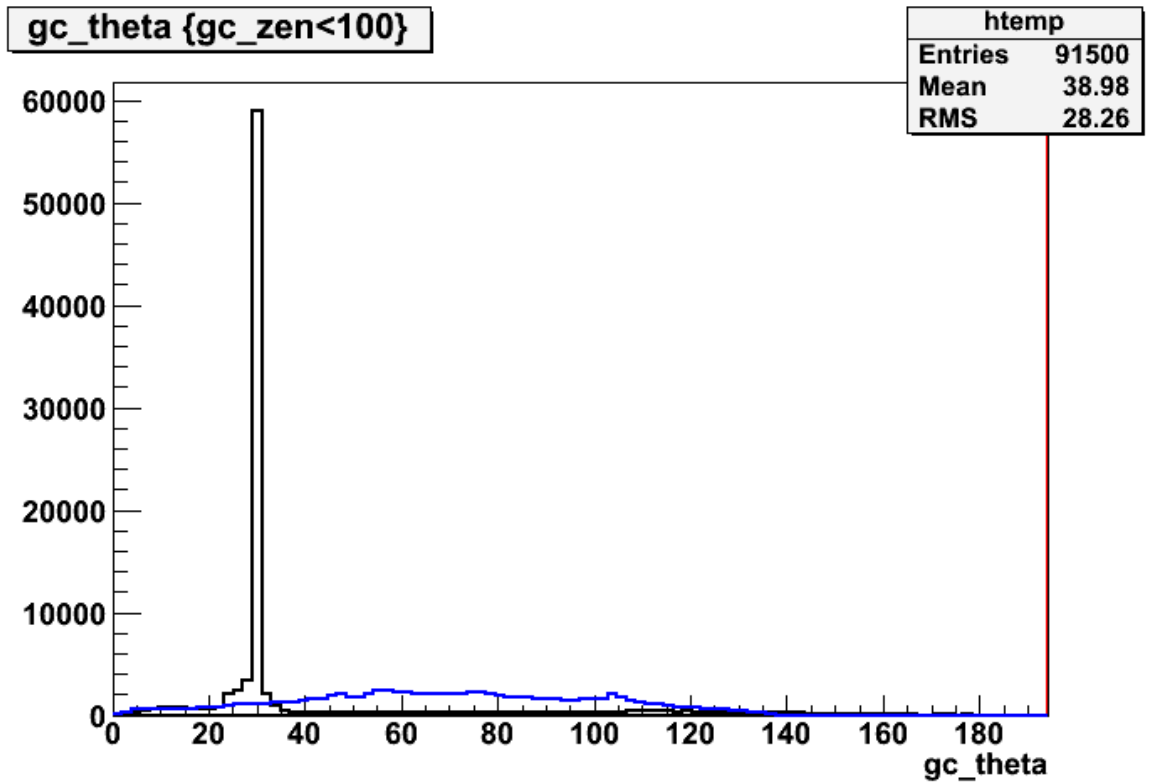
survey, mean exposure 5.54e9



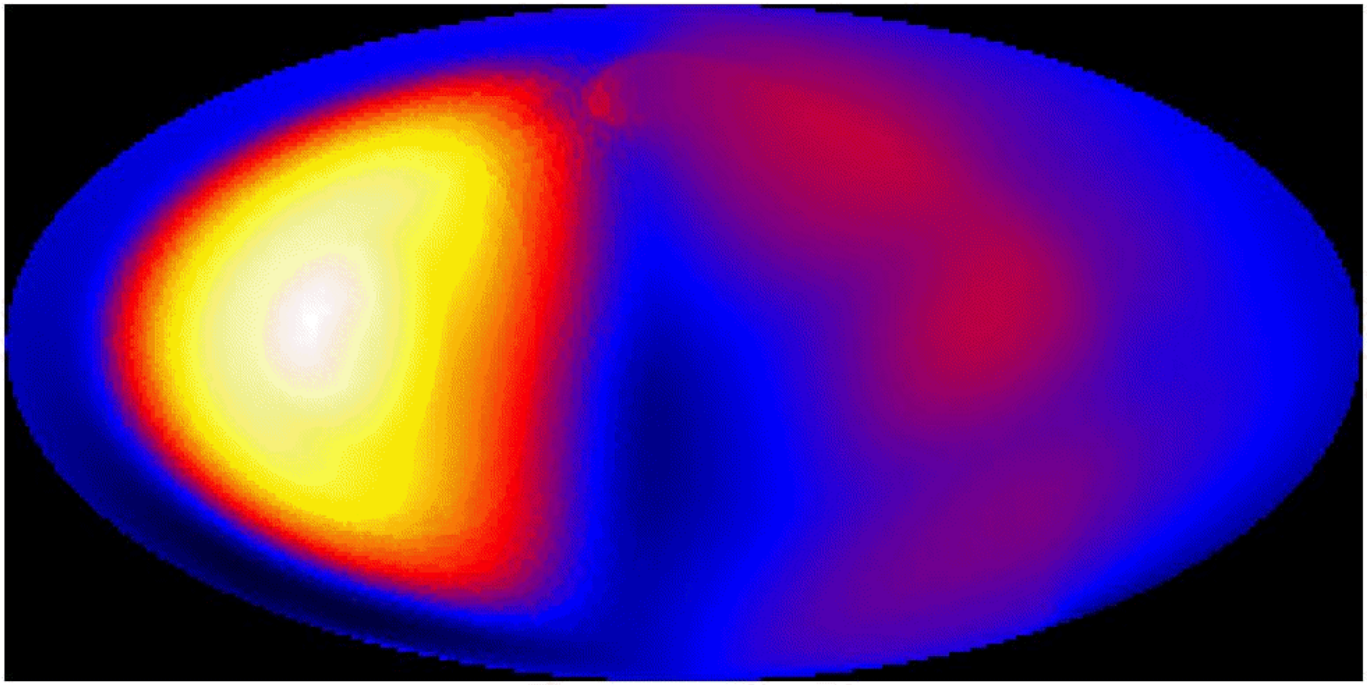
Exposure maps in units of survey exposure at GC,
ratio of mean exposures = 0.94 (i.e. 6% loss of exposure due to zenith cuts)

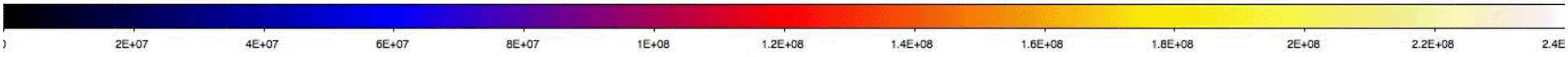
Galactic Center within 45 deg

- 26.9 days within 45 deg for pointed observation
- 7.0 days within 45 deg for survey
- Relative change: 3.8



Exposure as a function of time





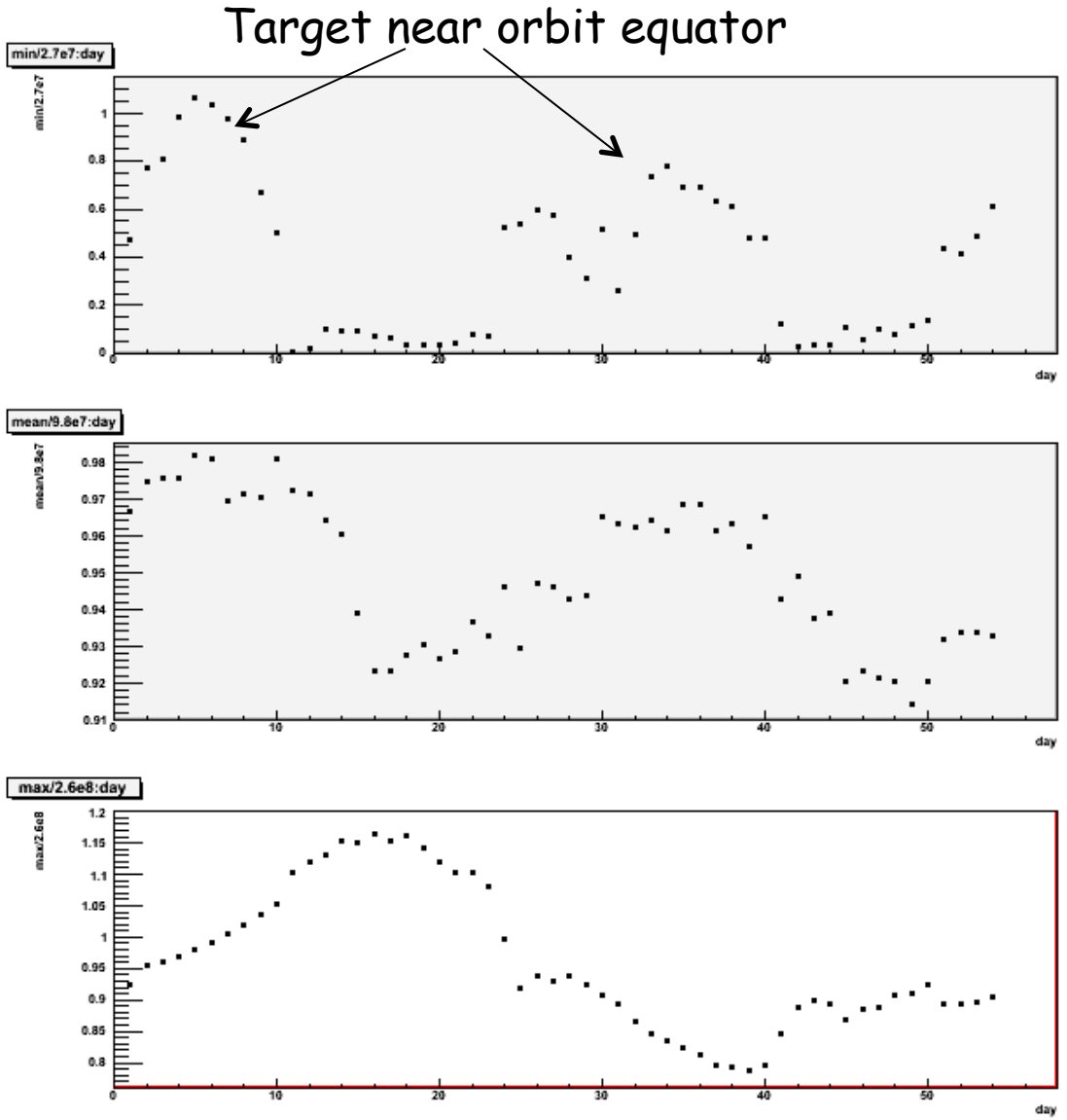
- **The movie (each frame is one day)**

Exposure as a function of time

Min

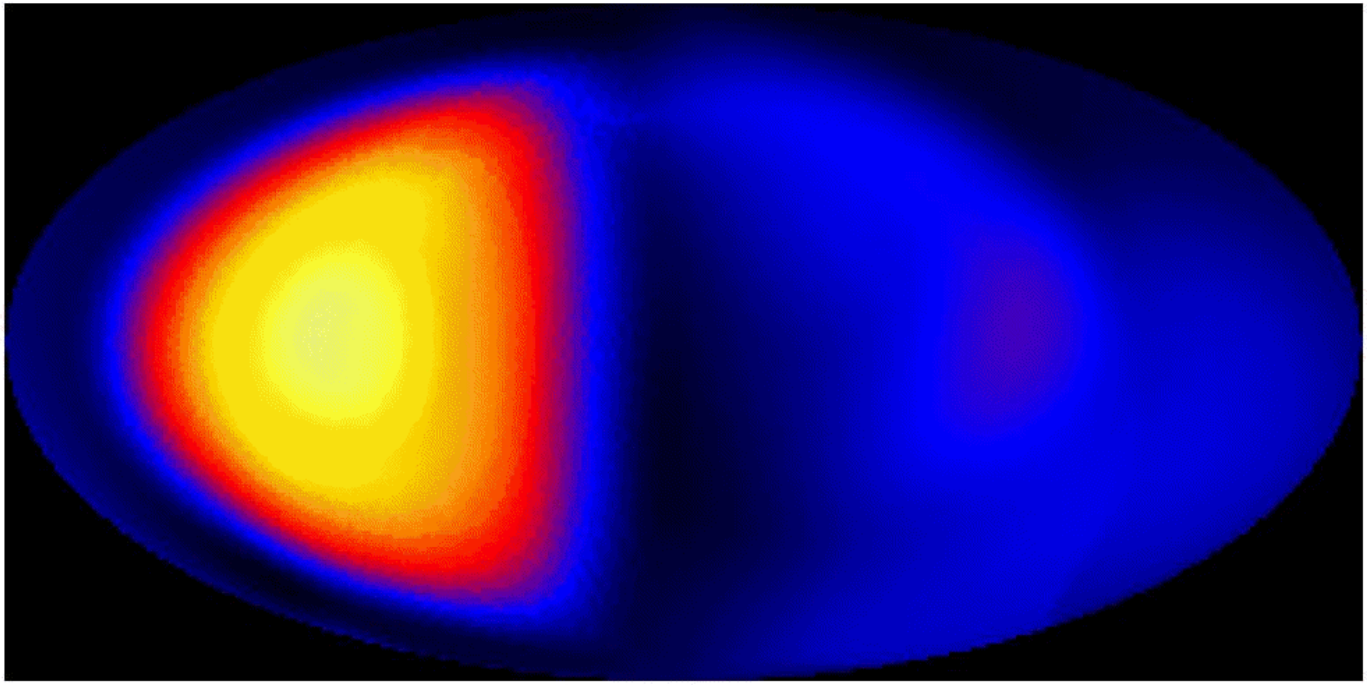
Mean

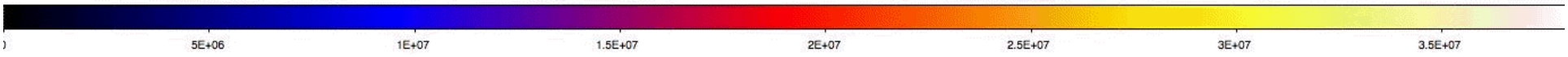
Max



- **The plots…**

Exposure vs time (2 orbit frames)





Evaluation of candidate obs.

- At Galactic Center
  - Factor 3.3 increase in coverage (target within 45 deg of boresight)
  - Factor 2.5 increase in exposure
- Complete sky coverage on timescales of days for about 50% of a precession period
- Broad sky coverage on timescales of 3 hours (albeit non-uniform)
- 6% loss in exposure efficiency (this is fairly modest)
- Shorter contiguous observations (because we are no longer keeping orbit pole within FoV for a whole orbit
  - May affect search for intermediate duration transients

Comments on Studying Observation Strategies

- **Difficult to use gtorbsim to create combined pointed+survey mode observation**
  - **Not straightforward to figure out times of command to IP and SS**
  - **FSSC is creating pre-canned cases at a variety of declinations, will provide spacecraft files and associated timeline, ephemeris files**
- **Documentation**
  - **Spacecraft capabilities**
  - **Analysis threads to produce some evaluation plot/numbers**