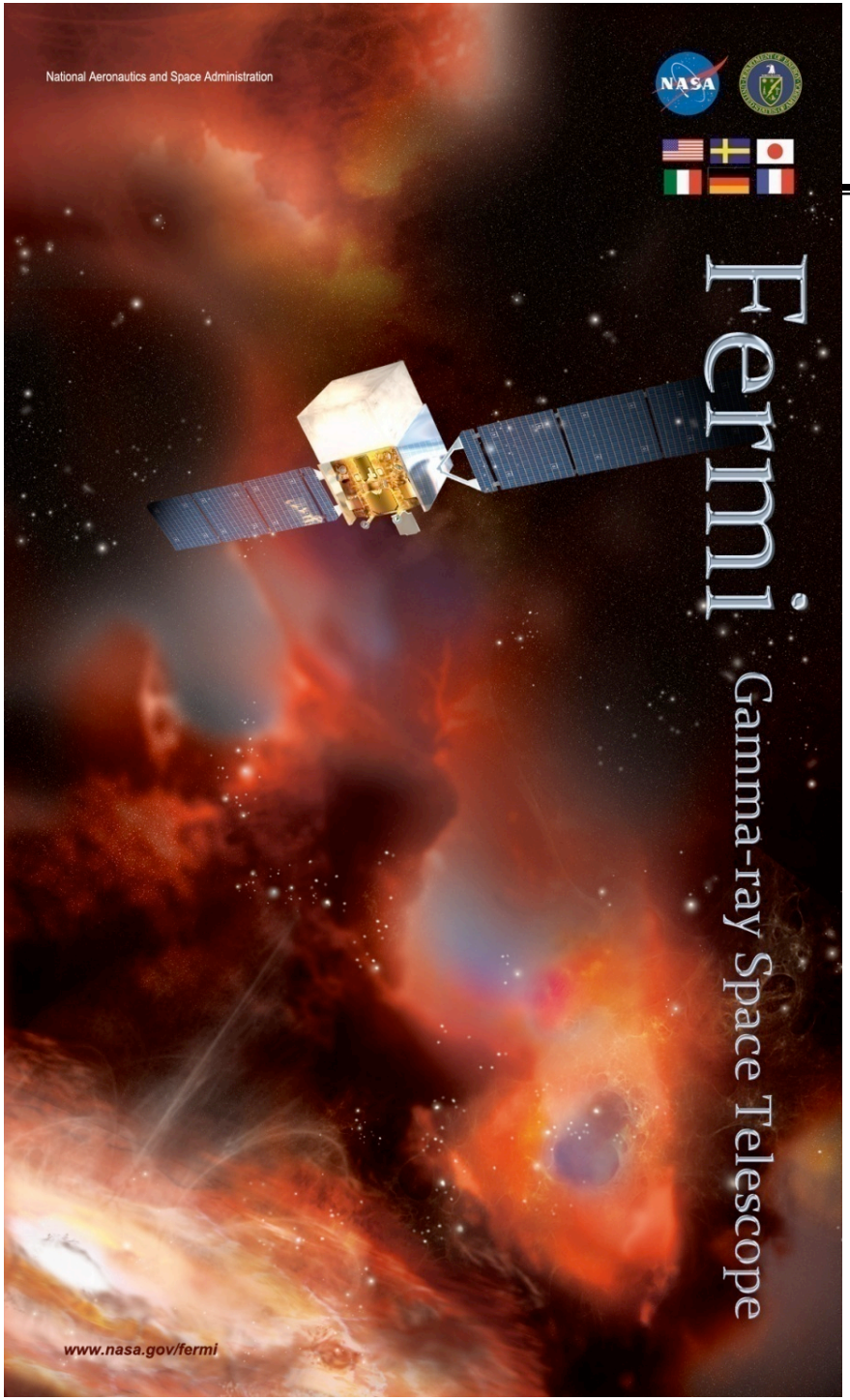


Fermi

Gamma-ray Space Telescope

Analysis Workshop
15 November 2010

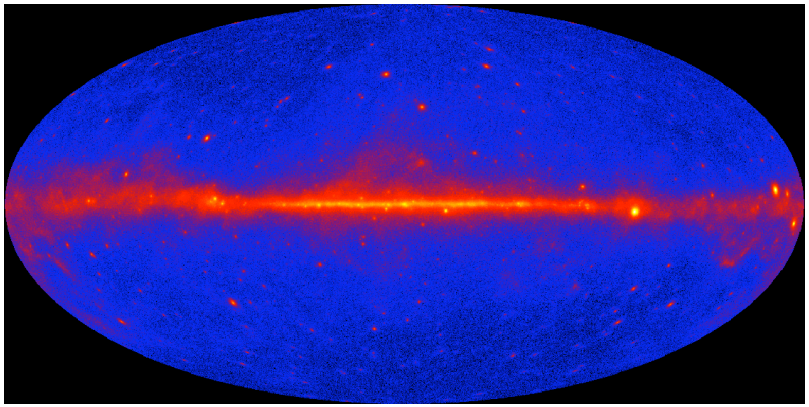
Livetime and Exposure

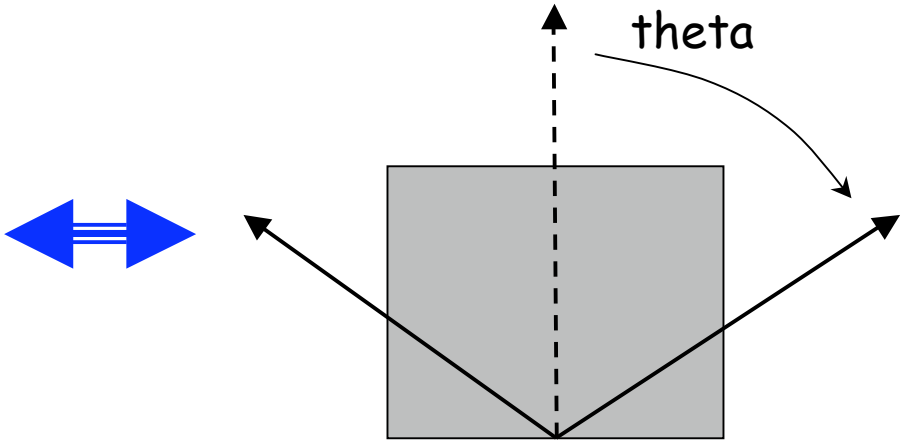
E. Hays

Handling Livetime and Exposure

- **LAT specifics**
  - **Calculating exposure is a two-step process**
  - **Livetime: formally the time when the detector is available to collect data**
    - **For analysis, additionally require good data quality and select to remove high background**
  - **Large field of view with varying response: need to know when and where**
  - **Exposure: for practical purposes, the number that converts counts to photon flux**
    - **Apply expected photon detection efficiency and angular resolution**
      - **Depends on event selection**
      - **Depends on direction of the photon relative to the instrument boresight and energy**

Livetime

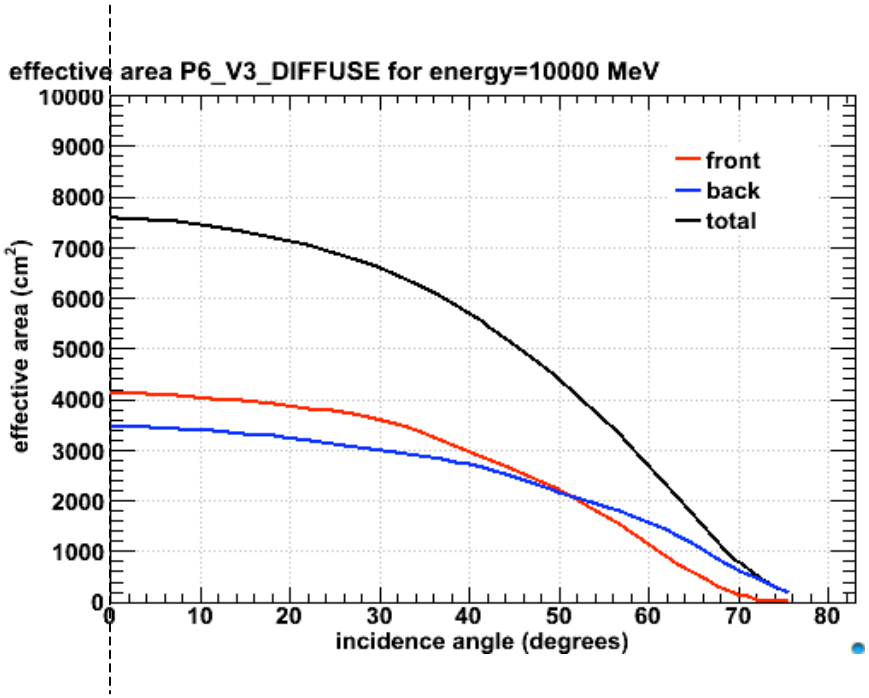


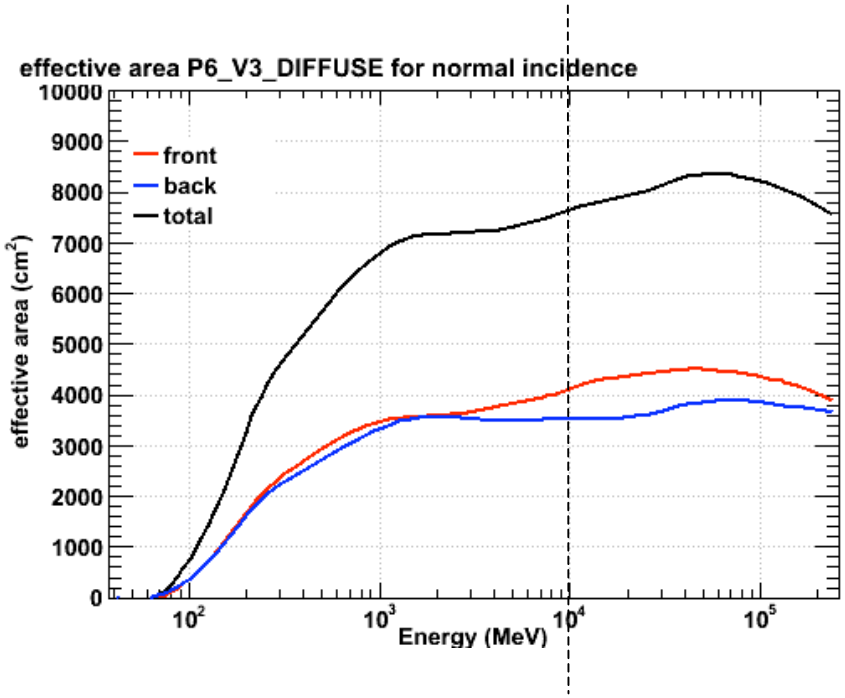


- **Sum up time spent in the field of view for each position in the celestial sky**
  - **Inputs are the photon and spacecraft files**
  - **Options are pixel size and step size for the instrument angles**
  - **Output is a livetime 'cube'**
  - **Respects time-based selection cuts made with gtmktime (GTIs)**

Exposure

- **For a position in the sky fold the time spent in each part of the field of view (from livetime cube) with the detector efficiency for that position**





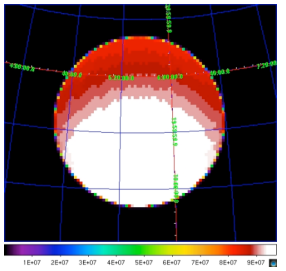
P6_V3 effective area is parameterized in theta and energy

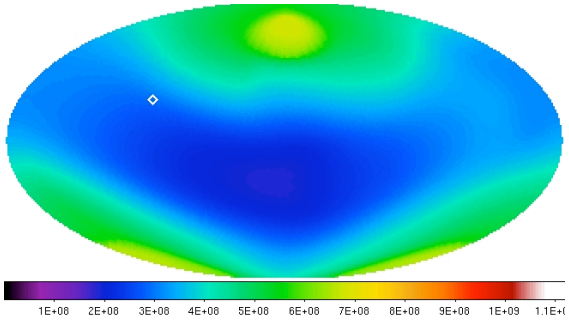
Binning Caveats

- **Response functions are minimally parameterized in the inclination angle (theta) and energy**
  - **Bin or step sizes used in exposure calculations should consider how quickly the efficiency changes in space or energy**
    - **At least 10 bins per decade in energy to avoid errors in estimation where the effective area changes rapidly**
    - **No single, strict recommendation on spatial binning**
      - **1 deg default sufficient for making maps**
      - **Binned likelihood matched to data binning - see threads**
  - **gtexposure invokes a spectral assumption - this has a noticeable impact**
    - **Remember that both the efficiency and angular reconstruction depend on energy**

Exposure Applications

- **Each type of analysis has a dedicated method to provide the exposure correction in the appropriate form**
  - **Aperture lightcurve -> gtexposure** xxx cm^2 s
  - **Unbinned likelihood -> gtexpmap**
  - **Binned likelihood -> gtsrcmaps/gtexpcube**
  - **All-sky exposure maps -> gtexpcube**





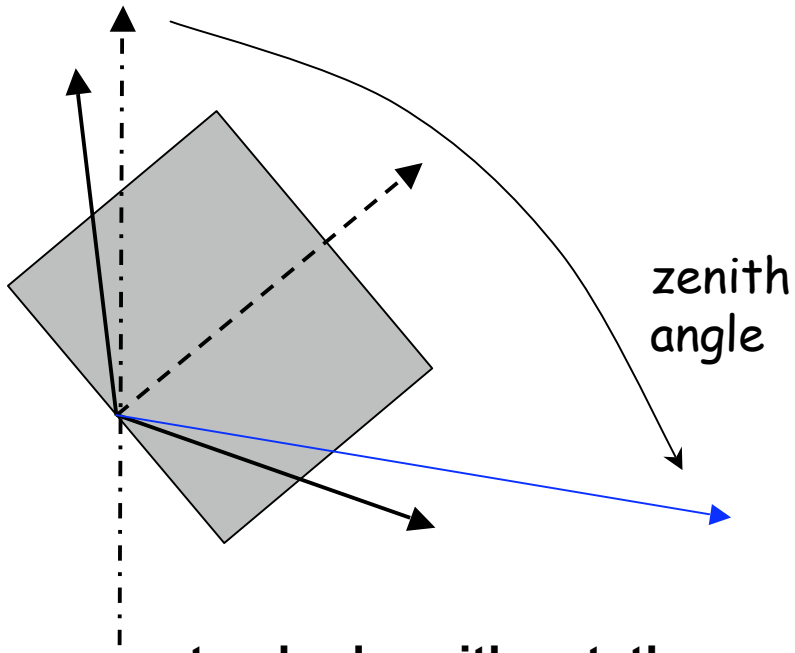
- **See the analysis threads and workshop presentations for details of these applications**

Livetime and maximum zenith angle

Gtltcube knows about the field of view and the spacecraft pointing and can make exposure corrections related to those coordinate systems

if you use
gtselect zmax=105 ...
and
gtmktime ... ROIcut=no

then you must use
gtltcube zmax=105 ...



- **If you are doing an all-sky analysis or non-standard zenith cut, the gtltcube can make a correction for exposure loss from a zenith angle cut in gtselect**
  - **Note this assumes perfect reconstruction**
- **If you are doing a basic source analysis and using the standard ROIcut in gtmktime, you don't need to do this.**

Exposure and Zenith Selection Menu

gtmktime inputs

1	GTI filter=DATA_QUAL==1 && LAT_CONFIG==1 ROI cut=yes Recommended for ToOs and ARRs	ROI cut
2	GTI filter=DATA_QUAL==1 && LAT_CONFIG==1 && ABS(ROCK_ANGLE)<52 ROI cut=no Used in LAT catalog analysis	Rocking angle cut **(Requires gtltcube zmax=105)**
3	GTI filter=DATA_QUAL==1 && LAT_CONFIG==1 && ABS(ROCK_ANGLE)<52 || angsep(RoIRa, RoIDec, RA_ZENITH, DEC_ZENITH) +ROI_radius<105) ROI cut=no Least recommended	Rocking angle cut or ROI cut **(Requires gtltcube zmax=105)**
4	GTI filter=DATA_QUAL==1 && LAT_CONFIG==1 && ABS(ROCK_ANGLE)<52 ROI cut=yes Most conservative and most commonly used	Rocking angle cut and ROI cut