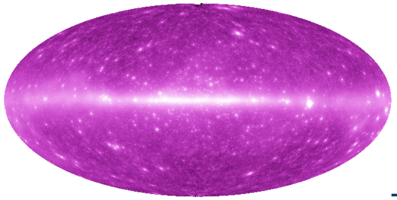
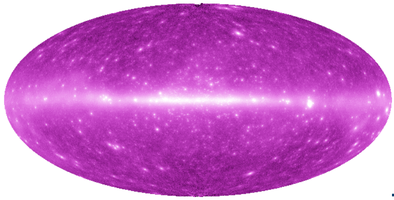




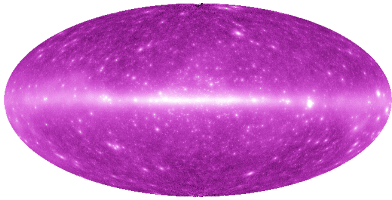
# Source Detection & Characterization

- What do we need to do?
- Rundown of parametric & nonparametric candidates
- Unbinned vs. binned likelihood
- Plan for validation, selection of methods
- Data simulator



# What Do We Need?

- Four related but distinct activities:
  - Monitoring [on board or on ground] for flares on timescales less than intervals between data dumps
  - All-sky searches to monitor for flares on timescales of orbits, establish flux histories
  - General analysis of point sources - positions, spectra, variability [not including pulsar-specific analysis]
  - Special analysis of extended emission
- Most appropriate analysis method may not be the same for all four, considering, e.g., time available,



# Rundown of Candidates

- Parametric
  - Likelihood analysis – binned and unbinned

  Tradeoffs – speed and numerical accuracy [Pat Nolan]
- Non-parametric
  - 2-dim Bayesian blocks [Jeff Scargle]
  - Wavelet transform processing [Regis Terrier]

  Advantages - an interstellar emission model is not needed

  TBD – sensitivity, statistical properties, how handle energy-dependent angular resolution

# Unbinned vs. Binned Likelihood

- Principal advantage of unbinned is sensitivity, but how great is the advantage?
- Results from simulation of the simplest non-trivial case: isolated point source against an isotropic background

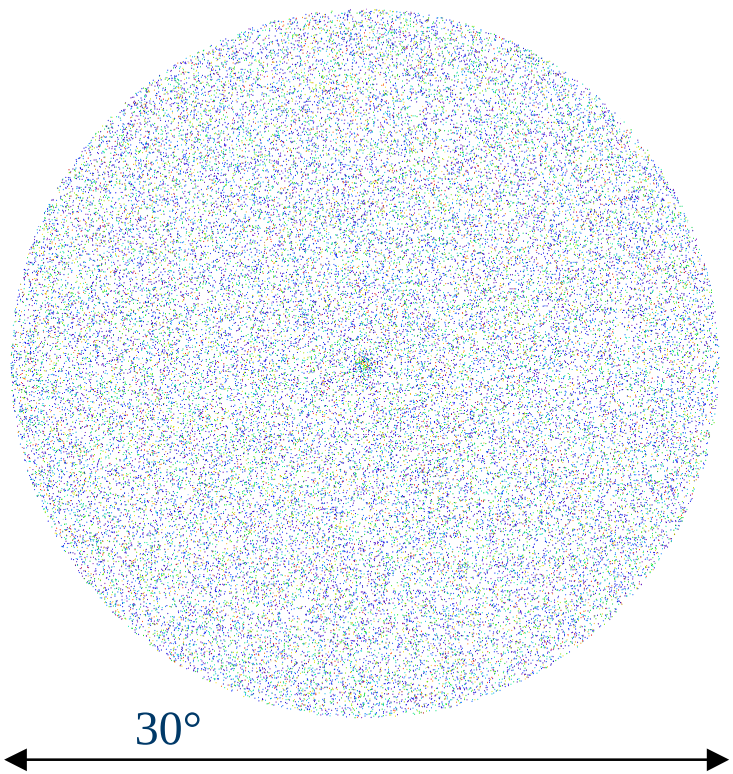
  *Remember, this is only one of many 'figures of merit' that could be used*

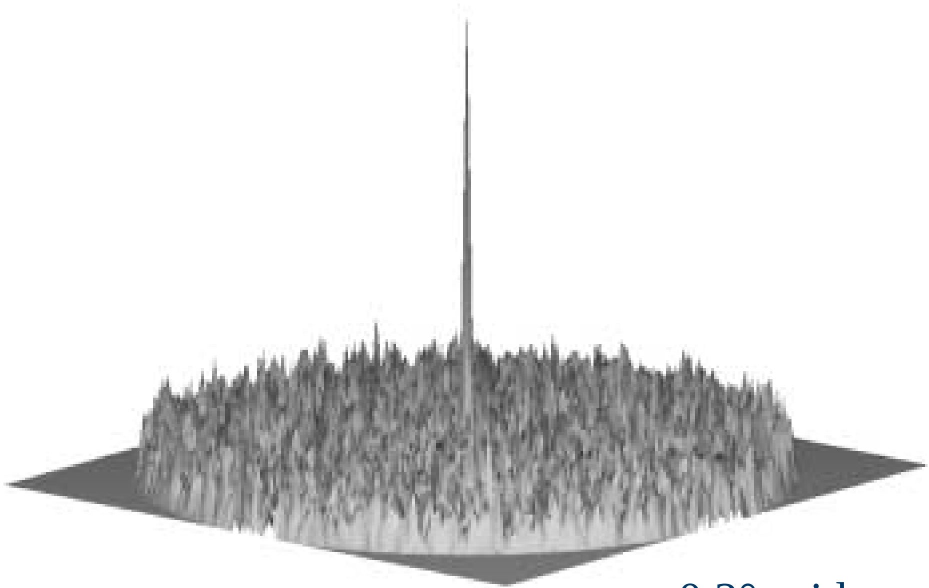
  Data from 1-year sky survey; exposure is spatially uniform, and dist. of obs. time with inclination angle is known

  Photon spectral index for source: -2, for background: -2.1, both non-breaking

  Used GLAST25 PSF, A(eff), i.e., AO-response versions

# Unbinned vs. Binned (2)



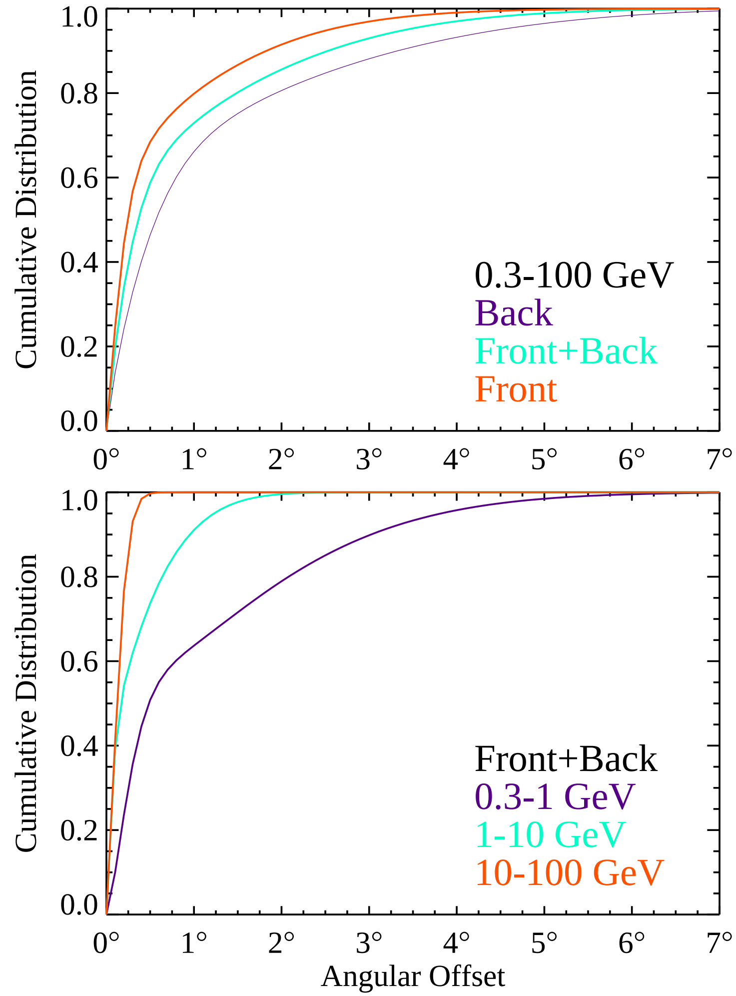

- ~53,000 photons >300 MeV, high-latitude background, $2 \times 10^{-8}$ $cm^{-2}$ $s^{-1}$ (>100 MeV) source

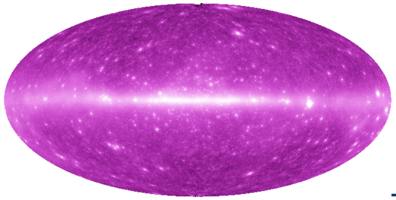
# Unbinned vs. Binned (3)

- Different kinds of binning possible:  spatial, inclination, energy, front vs. back, ...
- Considered several spatial grid sizes, 1 or 3 bins in energy, and subdivision into front vs. back photons
- For binned analysis, the ‘effective’ PSF is relevant, averaged over energy, with weighting by distribution of inclination angles & A(eff), for the assumed spectrum.

# Unbinned vs. Binned (4)

- Profiles of effective PSFs:
- Immediate inferences (easier with hindsight):
  - Sensitivity of binned likelihood decreases for bin sizes >~0.3°
  - Decrease is even more dramatic if have subdivided the energy range
  - Expect to TS to have a fairly strong dependence on energy binning





# Unbinned vs. Binned (5)

- Bottom line, average Test Statistics for source detection:

**Unbinned:** 512

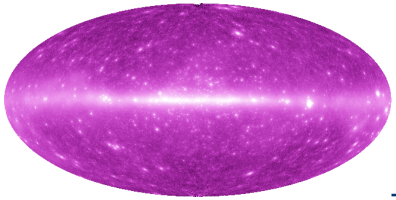
| Grid Size (deg) | Combined Front+Back | Separate Front & Back | Combined w/ 3 Energy Ranges |
|---|---|---|---|
| 0.1 | 380 | 390 | 440 |
| 0.2 | 370 | 370 | 410 |
| 0.5 | 280 | 290 | 320 |
| 1.0 | 220 | 230 | 190 |

# Unbinned vs. Binned Summary

- Sensitivity of unbinned analysis can be approached relatively rapidly with binned analysis *in the case of detecting an isolated point source*
- Tompkins (1999) was right that can approach sensitivity of unbinned analysis by choosing the right binning.
  - His analysis predicted greater sensitivity advantages (factor ~10 in TS) for binning in energy, but started at 100 MeV and used early GLAST params. (with gaussian PSF).

# Plan for Selection of Method(s)

- GLAST science is more than just detecting an isolated point source
- Describe requirements and constraints (time available, computer power) for the source detection activities
- Time in schedule is another constraint
- Test the methods
  - Also, for binned analyses, need to define optimum binning
  - The data simulator will be useful for validation: including interstellar emission model, transient sources, and ideally also pointing/livetime information for exposure generation



# Data Simulator

- Also needed for Mock Data Challenges
- Ideally, will not stand alone from Glastsim, although full implementation including absolute time and orbit/attitude of GLAST will be challenging