The pointlike package: localization, etc.

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Background

- Origin of the package: point source detection, initially using wavelets (Sean Robinson thesis). But:
- Cramer–Rao bound: no better unbiased estimator than maximum likelihood
- Byproducts: good (modulo binning) measurement of
  - Localization, spectra of sources
  - Full-sky analysis
- Requirements:
  - fast enough to be a viable source detection method
  - Unbiased enough to compare with gtlike/gtfindsrc

Making it fast

- Bin the data in energy and position
  - Issues:
    - Unbiased, but Cramer-Rao is for unbinned analysis
    - Angular resolution varies by a factor of 100!
  - Solutions:
    - Adopt nested HEALpix, with bin size correlated with energy
    - Adjust bin size to be smaller than angular PSF.
- Use dedicated fitting code
  - Simplified 2-parameter PSF
  - Newton-Raphson minimization, with explicit derivatives
- Combine front and back
  - Add back events to bins appropriate for resolution

Feature summary

- **Likelihood**: single point source + arbitrary background
  - counts in up to 9 energy bands with 1-parameter optimization
  - position – 2-parameter optimization of the total likelihood
  - significance TS
  - PSF parameters from collection of bright sources (or allgamma) includes dispersion
- **Detection**
  - Find sources, down to TS=10 in all sky (3 hours to detect 3200 in 1 year @ 10% spurious)
- **LAT Alignment**
 - Measure the rotation angles to ~15 arcsec in a day. [Actually currently separate code.]

Implementation: class hierarchy

- astro::**SkyFunction** – abstract base class defining a real function on the sphere (a function of a astro::SkyDir)
  - map_tools::**SkyImage** – implement SkyFunction with FITS image; also create from a SkyFunction
  - **SkySpectrum** – abstract, allow specification of energy spectrum at any point
    - **DiffuseFunction** – adapt a FITS cube. Used for the background for point source fits
    - **PhotonMap** – pixelized photon data
    - **PointSourceLikelihood** – perform, and then represent a fit
    - **Convolution** – convolution of a SkySpectrum object with another SkySpectrum, perhaps a PSF.
    - **CompositeSkySpectrum** – linear combination of SkySpectrum objects. Used to combine the galactic diffuse with nearby strong sources
    - [**Exposure** – planned]
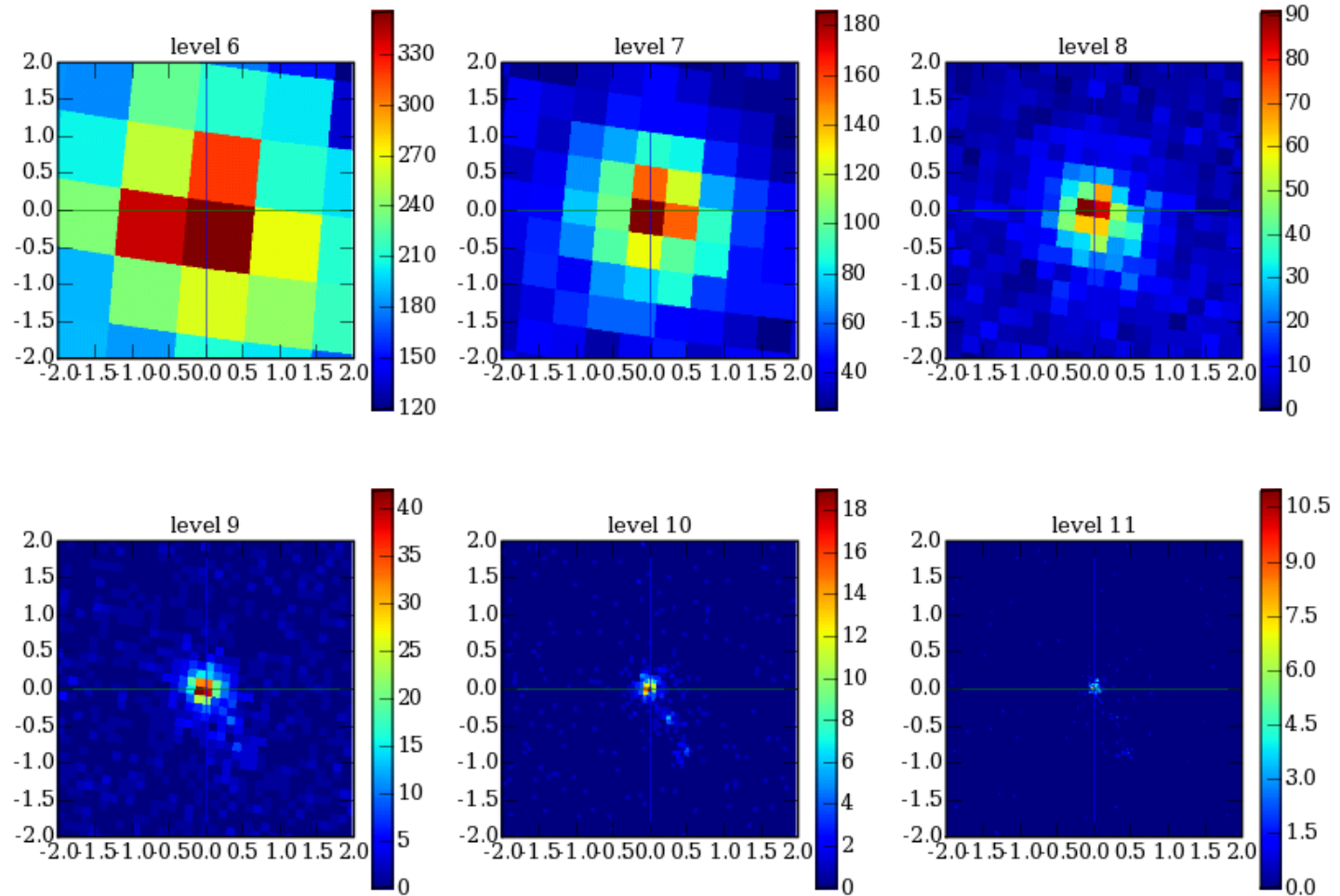
Some pictures, from 1-year obssim

Look at this EGRET blazar:
- 20 degrees from gal center
- Moderate flux(5e-7), much stronger than two other sources within one degree
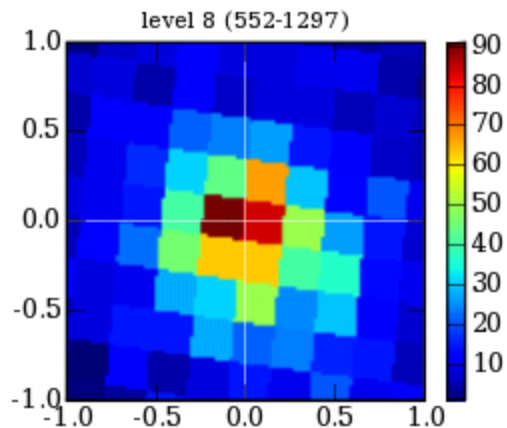

3EGJ1635m1751

Galactic center
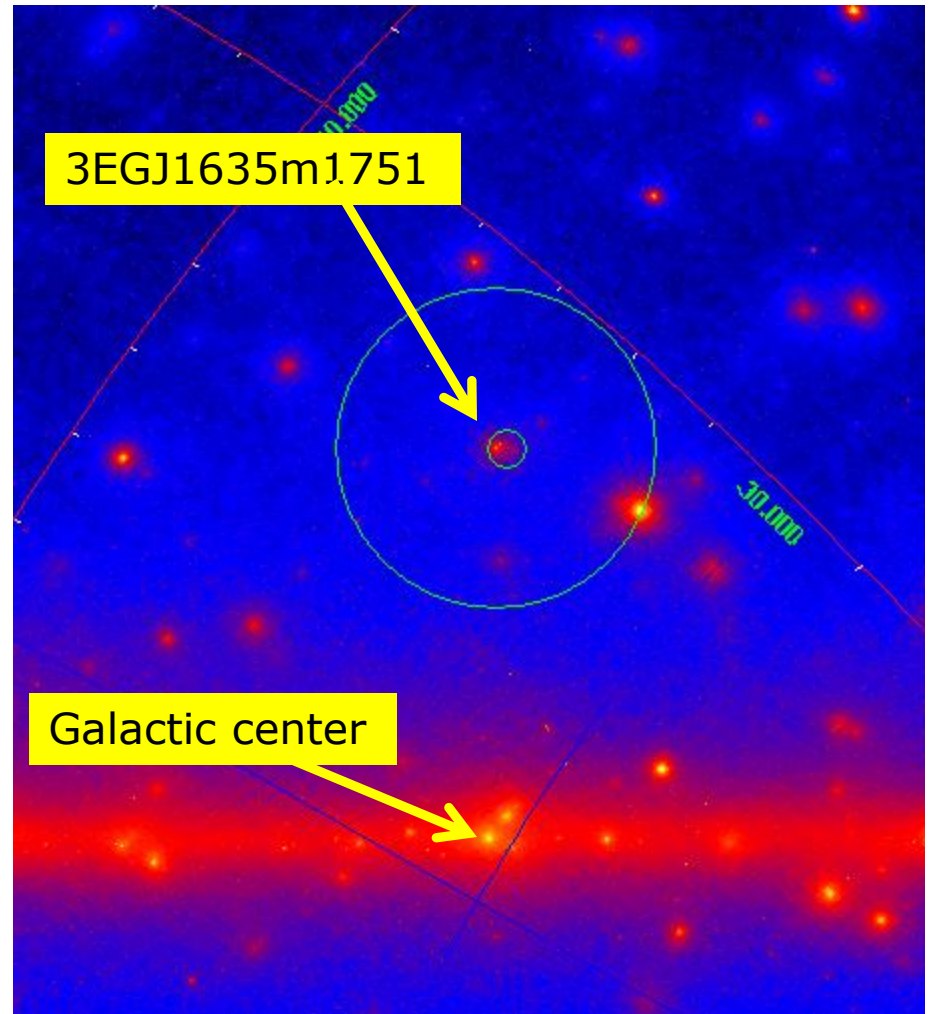
Data, showing nested pixels
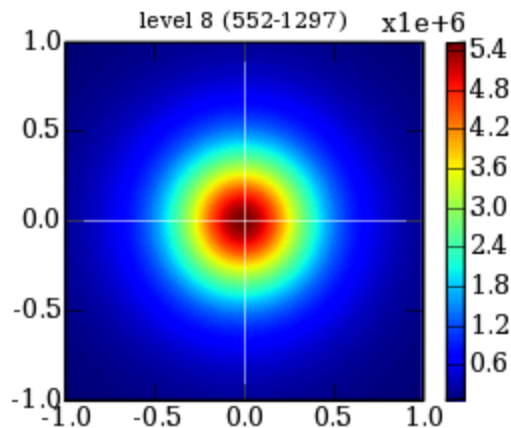
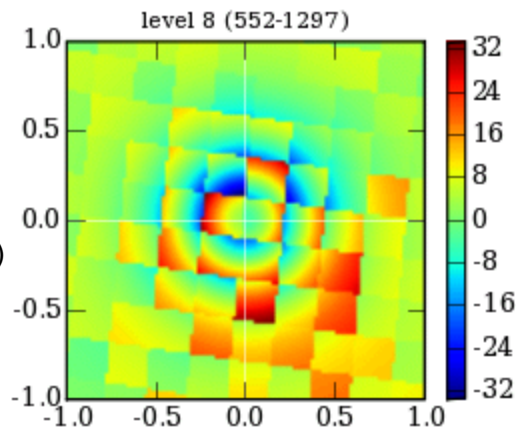F:\glast\data\SC2\obssim\allsky_noGRBs.fits at (248.79,-17.86)

Pictures: data, fit, etc.
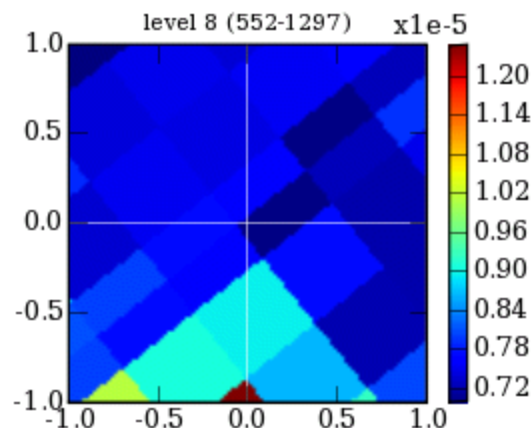

Data
(PhotonMap)

Fit
(PointSourceLikelihood)

Data-fit
(CompositeSkySpectrum)

Diffuse
(DiffuseFunction)

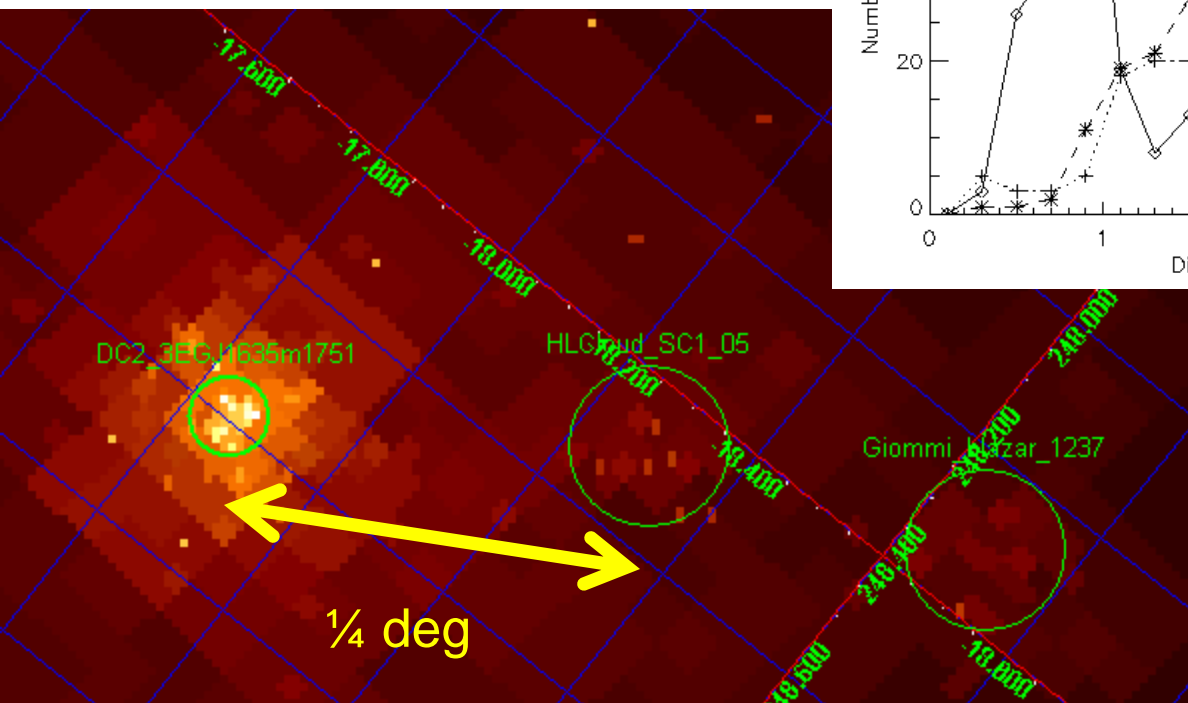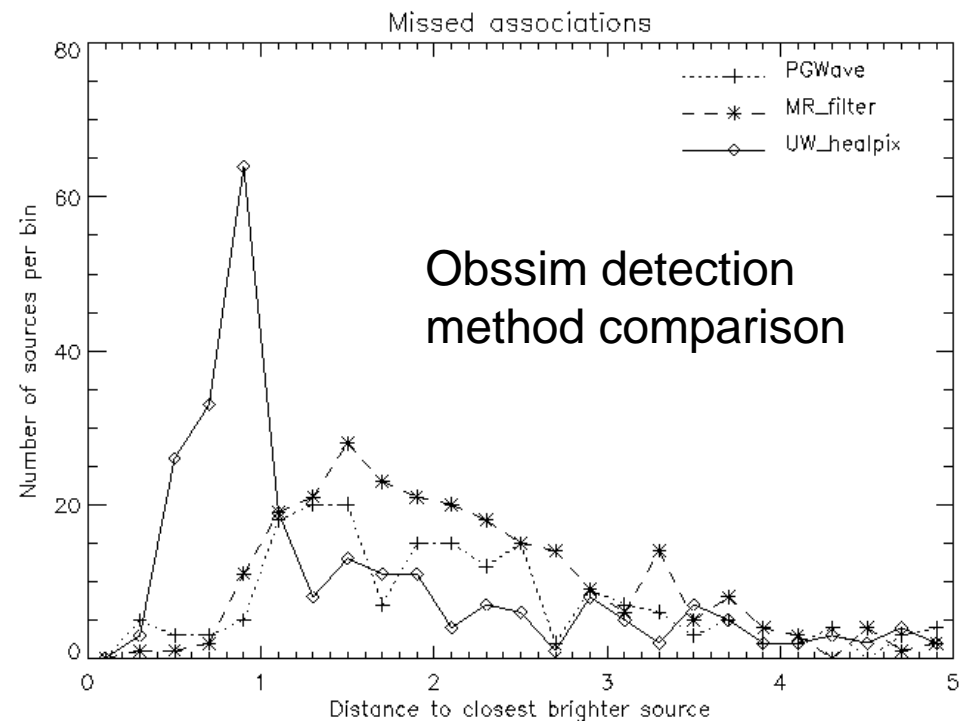F:\glast\extlib\extFiles\v0r7\galdiffuse\GP_gamma.fits at (248.79,-17.86)

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Picking up those nearby sources

Missed associations
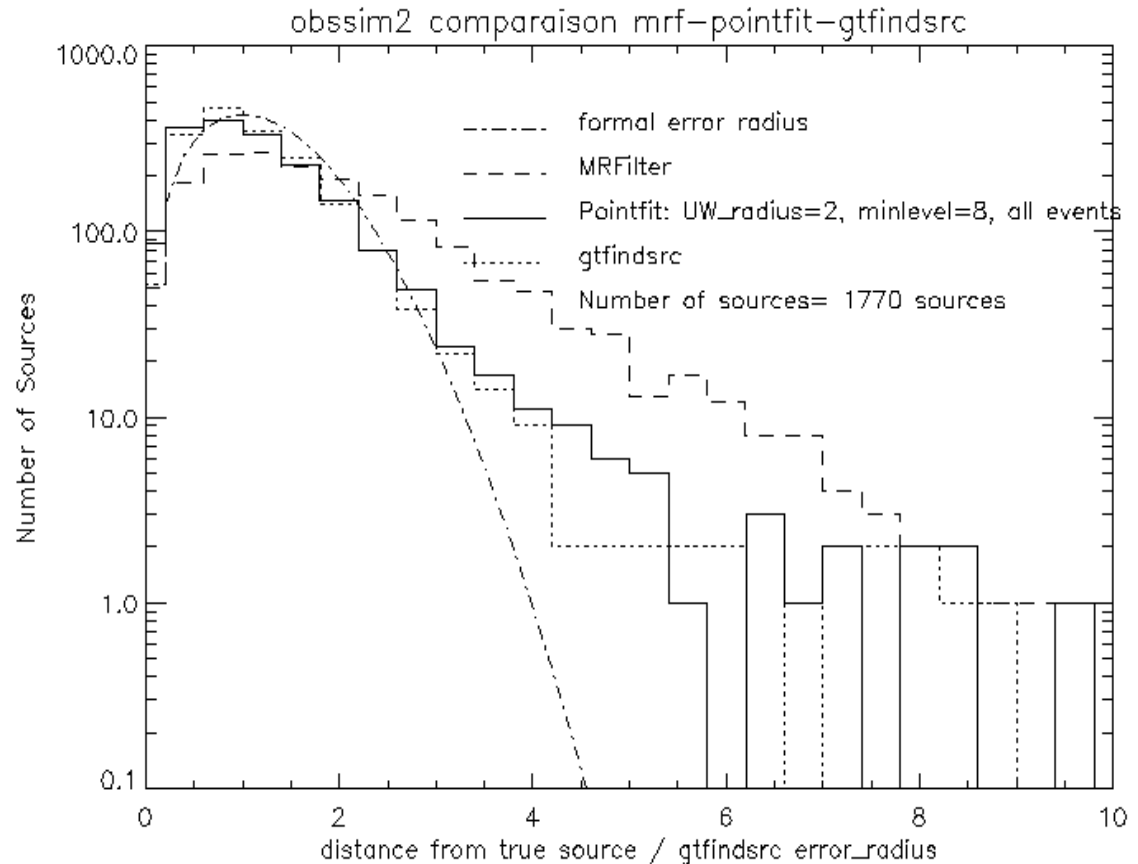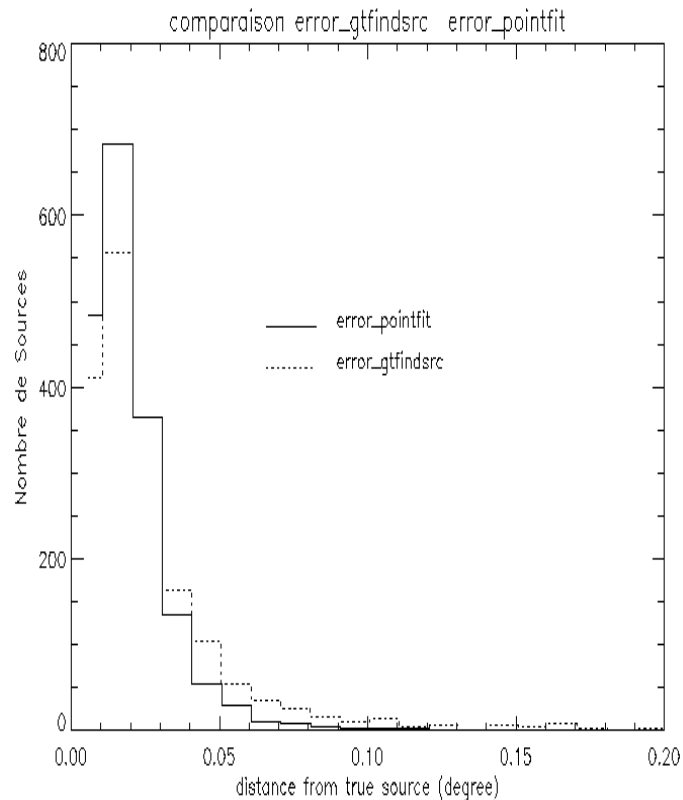
Obssim detection
method comparison

¼ deg

nearby source as part of the model

before   after

true

spurrious
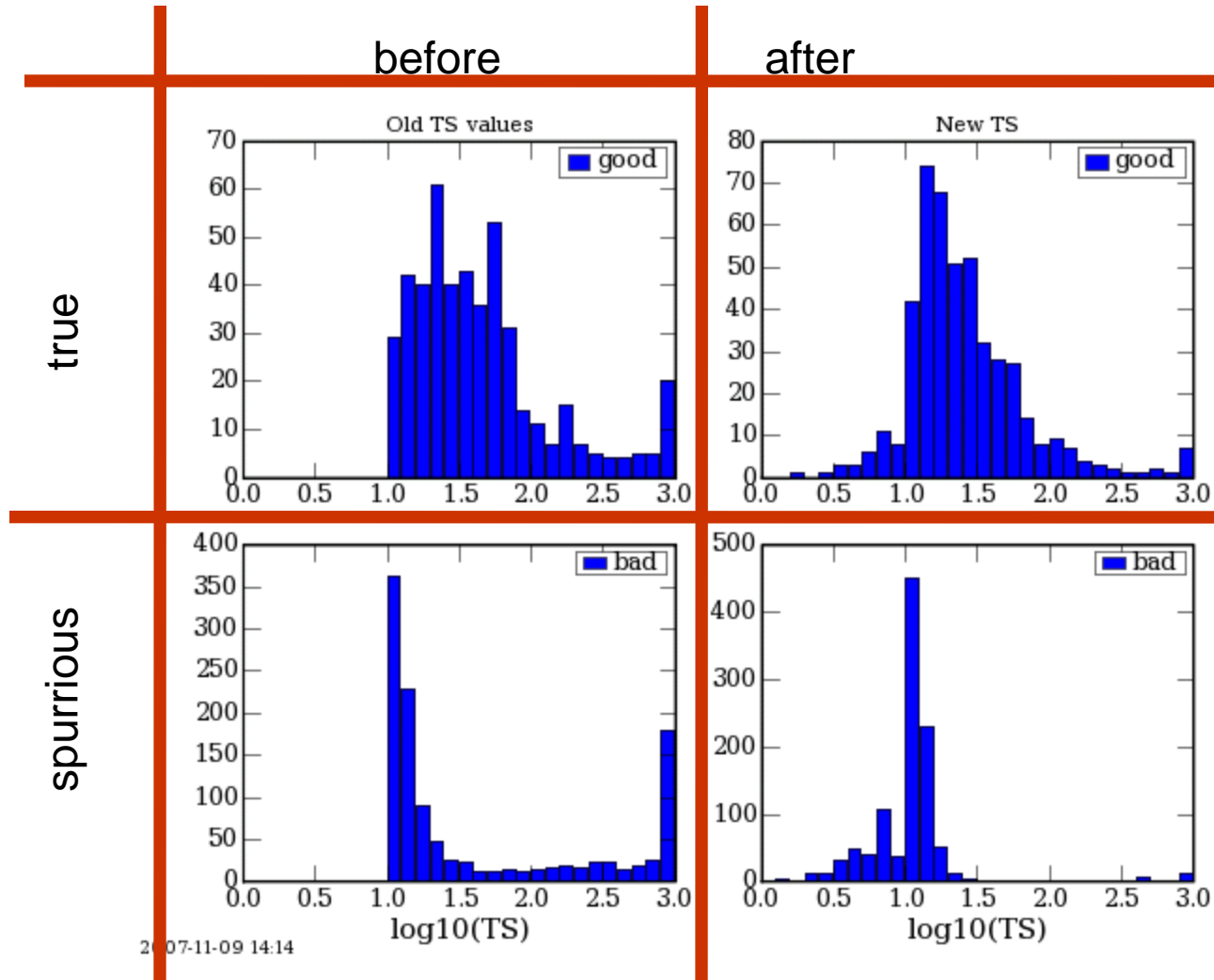
Gains 200 sources, 20 spurious

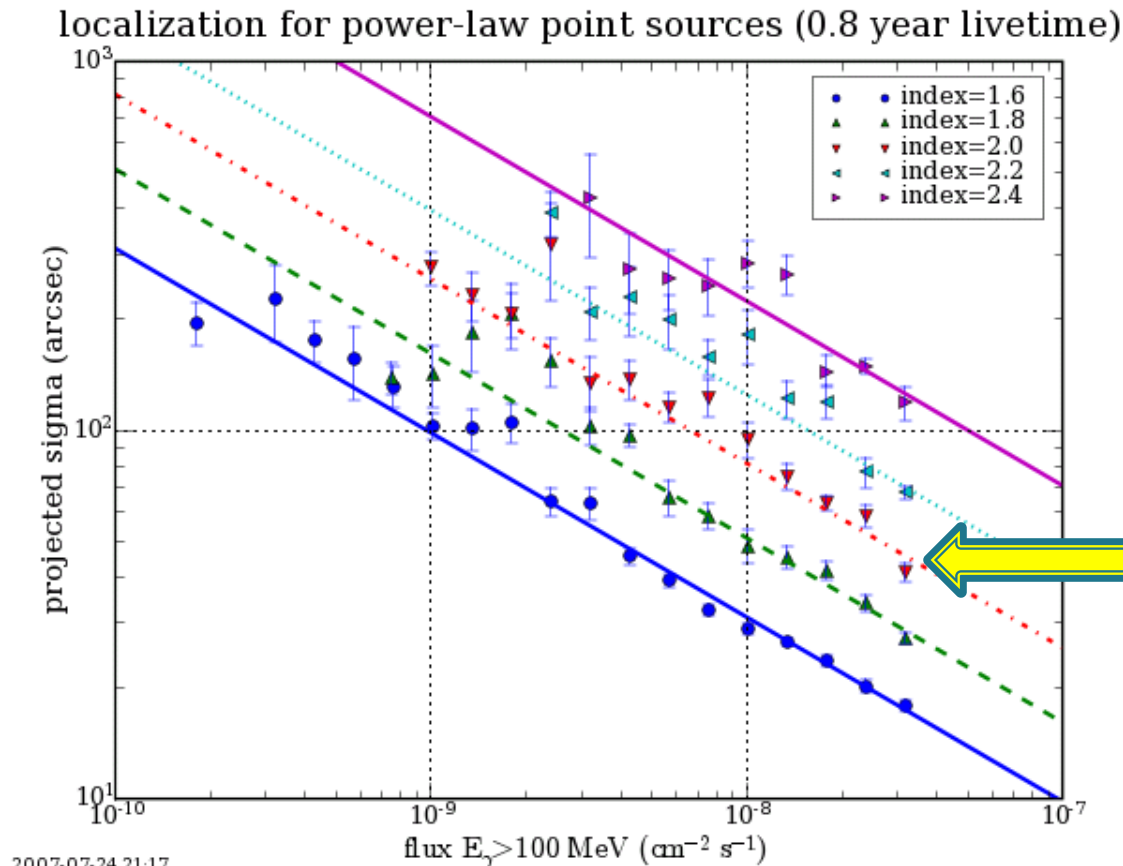Plotted: SC2 detections within 1 degree of higherTS source

pointfit – gtfindsrc catalog comparison

Analysis by Ludovic with
SC2 catalog sources

Another comparison

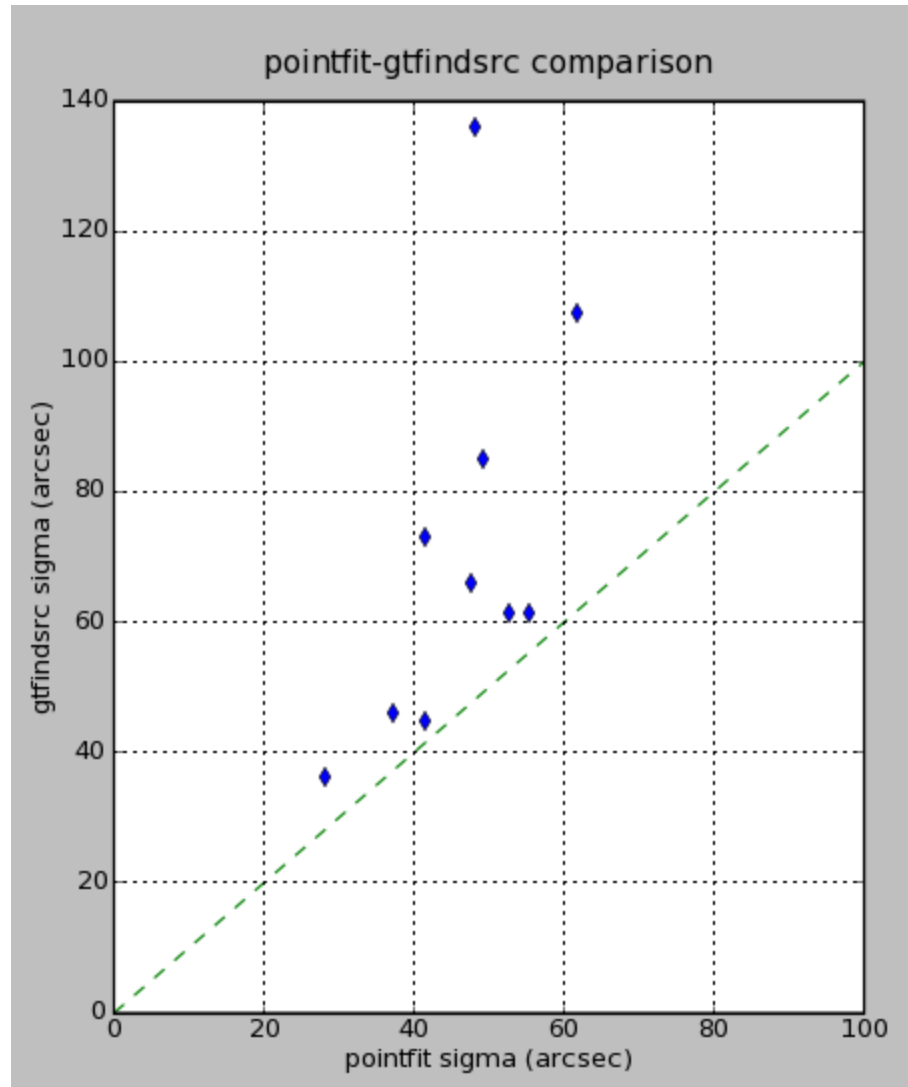▸ Look at the index 2 strongest "pattern" source

localization for power-law point sources (0.8 year livetime)

Plot was made using pointfit. Try gtfindsrc for this source, compare results and CPU time

Timing and resolution

application	Average time (s)*
gtlike	100
gtfindsrc	520
pointlike	~0.01

* All unoptimized code

pointfit-gtfindsrc comparison

Summary

- Localization performance seems to be the best we have
- Source detection comparable with other techniques (see Tom's talk) but 1-degree restriction now overcome
- Proposed class library for all-sky analysis
- Plan to add spectral analysis, using exposure