Source Localization

An analytic approach based on measured PSF

Why it is important

- Short term: we intend to use bright sources (Vela, etc) for alignment with respect to star tracker
  - Optimize strategy (pointing vs. scanning)
  - How long is needed?
- Long term: how well do we do for source identification?
  - Science requirement: 30 arcsec radius for 1 year scanning, 1E-7 source with E^{-2} spectrum, constant background.

Monte carlo vs. Analytic

- Both are numerical integrals of the same quantity, so duplication represents a check of both methods: MC is more reliable, necessary to validate analytic.
- Analytic is much faster, allows study of effect of assumptions, dependence on subsets (front vs back, energy, changing source parameters, PSF)

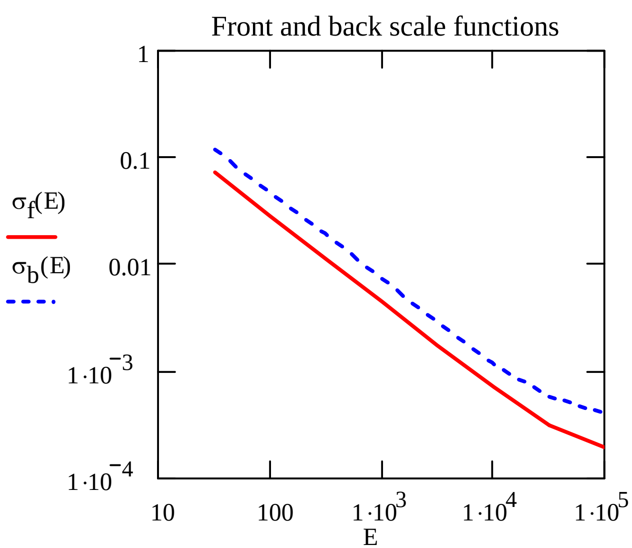
Ingredients, I: The PSF

Basic assumption: depends only on energy and front or back

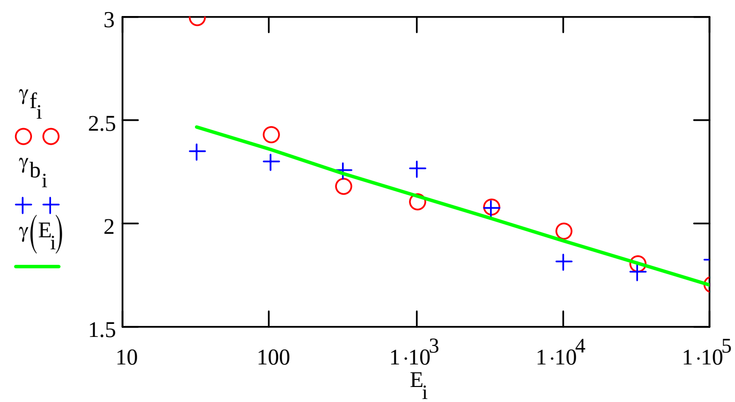
$$f(u,\gamma) = \left(1 - \frac{1}{\gamma}\right) \cdot \left(1 + \frac{u}{\gamma}\right)^{-\gamma}$$

Only an approximation: consequence is degraded estimate, so conservative
Not (yet) using event-by-event predicted error matrix

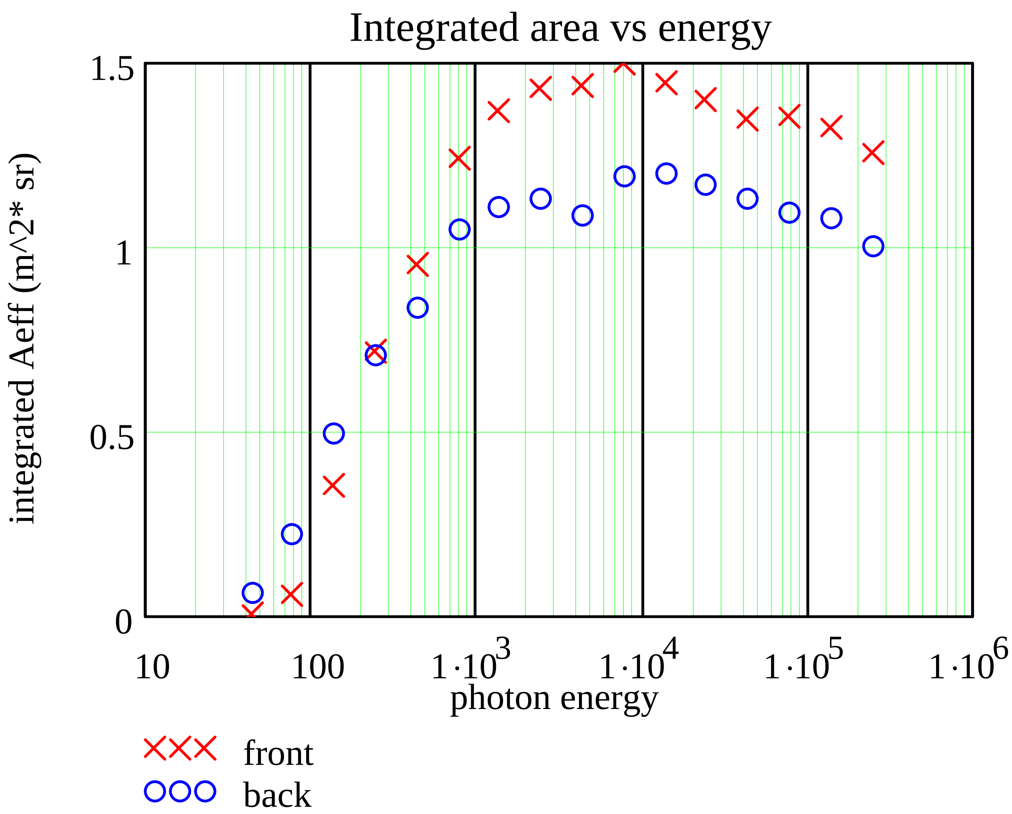
u is scaled radial deviation



$$\gamma(E) := 2.35 - 0.095 \cdot \ln\left(\frac{E}{100}\right)$$



Ingredients,II: Integrated acceptance w/ DC1 cuts



Ingredients,III: the SR source and EGRB background

$$\frac{df_{SR}}{dE} = F_{SR}\,\frac{(\gamma_{SR}-1)}{E_{\min}}\left(\frac{E_{\min}}{E}\right)^{-\gamma_{SR}}$$

$$\gamma_{SR} = 2$$

$$F_{SR} = 10^{-7}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$$

$$E_{\min} = 100\ \mathrm{MeV}$$

$$\frac{df_{EGRB}}{dE} = F_{EGRB}\,\frac{(\gamma_{EGRB}-1)}{E_{\min}}\left(\frac{E_{\min}}{E}\right)^{-\gamma_{EGRB}}$$

$$\gamma_{EGRB} = 2.1$$

$$F_{EGRB} = 1.57\times10^{-5}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{sr}^{-1}$$

Ingredients, IV: predicted resolution

- For a point source, and assumed PSF, the measurement error from a maximum likelihood fit is easily predicted. If P(x,y) is the normalized probability distribution describing angular deviations, and there are N signal photons, then the projected resolution* is

$$\frac{1}{{\sigma_x}^2} = N \int \frac{1}{P(x,y)} \left(\frac{\partial P}{\partial x} \right)^2 dx dy$$

*This is derived in the Jay Orear memo on statistics, see http://nedwww.ipac.caltech.edu/level5/Sept01/Orear/frames.html

Predicted resolution, cont.

In the case of no background, this integral is analytic: substituting

$$u(x,y) = \frac{x^2 + y^2}{2\sigma_0{}^2}$$

into the PSF function, we get

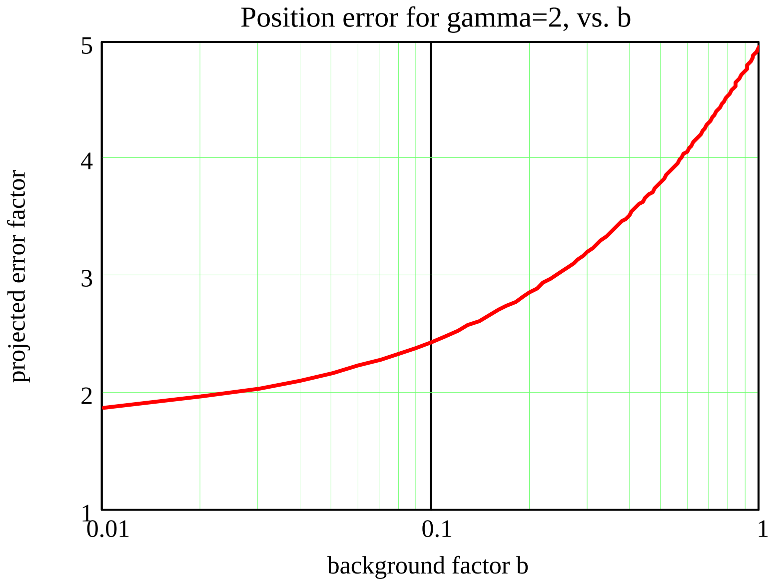
$$\sigma_x = \frac{\sigma_0}{\sqrt{N}} \sqrt{\frac{\gamma_0 - 1}{\gamma_0 + 1}}$$

where σ_0 and γ_0 are the PSF scale and power-law parameters: recall that $\gamma_0 \rightarrow \infty$ is the Gaussian limit.

This has been extensively checked with a MC.

What about a uniform background?

- The probability function has to be modified, with the addition of the constant term, parameterized by the ratio of the number of background in $2\pi\sigma^2$ to the total signal, denoted by b. The result:



Put it together

- Bottom line: σ_x=18 arcsec for T_{live}=1 year. The corresponding radius is 1.5 times this, or 27 arcsec.
- Background has little effect
- The distribution of the inverse variance peaks at 30 GeV: as there are only 58 events expected above 10 GeV, the result is subject to statistical fluctuations.