Cutoff energies

March 12, 2018

1 Galactic plane, $b \in (-2°, 2°)$, latitude = 7

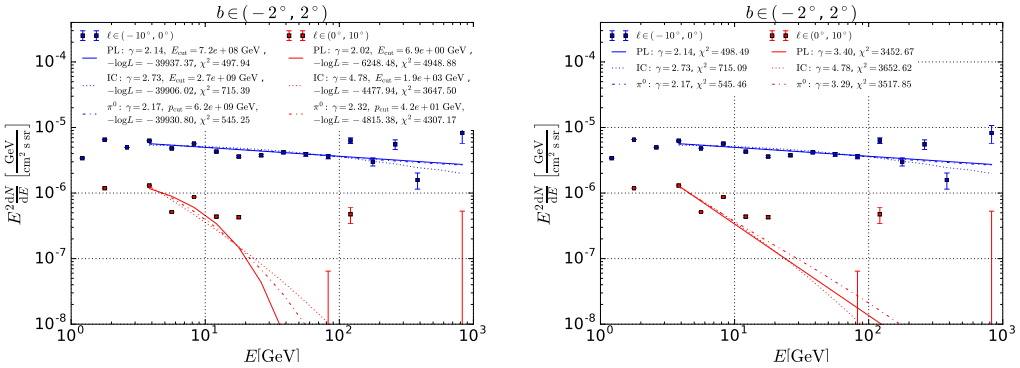

Figure 1: Fit with and without cutoff.

1.1 Right of GC, $\ell \in (-10°, 0°)$, blue

1.1.1 PL

Best-fit value $1/E_{\rm cut}$: 1.387E-09 1/GeV
Parameter error printed by MIGRAD: 0.0003918 1/GeV

Best-fit value $E_{\rm cut}$: 721 PeV
Upper limit for $1/E_{\rm cut}$: 0.00064445503804 1/GeV
Lower limit for $E_{\rm cut}$: 1.55 TeV

1.1.2 IC

Best-fit value $1/E_{\rm cut}$: 3.744E-10 1/GeV
Parameter error printed by MIGRAD: 4.072E-05 1/GeV

Best-fit value $E_{\rm cut}$: 2671 PeV
Upper limit for $1/E_{\rm cut}$: 6.69788140895e-05 1/GeV
Lower limit for $E_{\rm cut}$: 14.9 TeV

1.1.3 Pi0

Best-fit value $1/E_{\rm cut}$: 1.61E-10 1/GeV
Parameter error printed by MIGRAD: 7.208E-06 1/GeV

Best-fit value $E_{\rm cut}$: 6211 PeV
Upper limit for $1/E_{\rm cut}$: 1.18562659431e-05 1/GeV
Lower limit for $E_{\rm cut}$: 84.3 TeV

1.2 Left of GC, $\ell \in (0°, 10°)$, red

1.2.1 PL

Best-fit value $1/E_{\rm cut}$: 0.1458 1/GeV
Parameter error printed by MIGRAD: 0.7778 1/GeV

Best-fit value $E_{\rm cut}$: 6.859 GeV
Upper limit for $1/E_{\rm cut}$: 1.42516715104 1/GeV
Lower limit for $E_{\rm cut}$: 0.70 GeV

1.2.2 IC

Best-fit value$1/E_{\rm cut}$: 0.0005131 1/GeV
Parameter error printed by MIGRAD: 0.03755 1/GeV

Best-fit value $E_{\rm cut}$: 1949 GeV
Upper limit for $1/E_{\rm cut}$: 0.062277353692 1/GeV
Lower limit for $E_{\rm cut}$: 16.1 GeV

1.2.3 Pi0

Best-fit value $1/E_{\rm cut}$: 0.02393 1/GeV
Parameter error printed by MIGRAD: 0.03823 1/GeV

Best-fit value $E_{\rm cut}$: 41.8 GeV
Upper limit for $1/E_{\rm cut}$: 0.087 1/GeV
Lower limit for $E_{\rm cut}$: 11.52 GeV

2 Slightly below GP, $b \in (-6°, -2°)$, latitude = 6

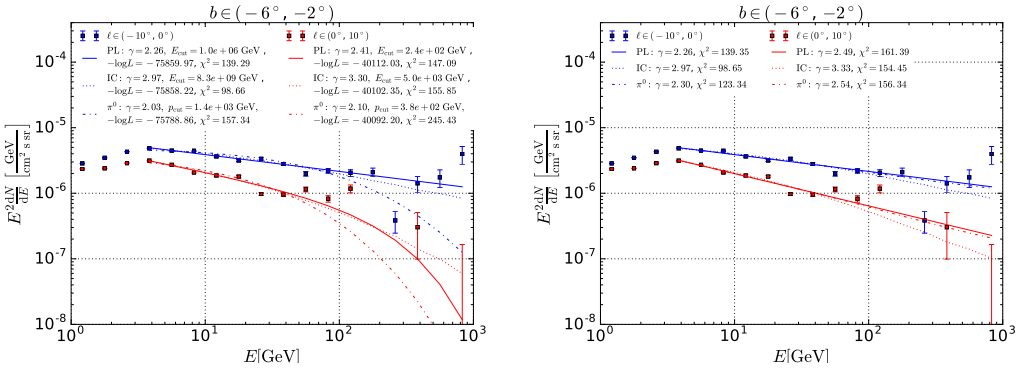

Figure 2: Fit with and without cutoff.

2.1 Right of GC, $\ell \in (-10°, 0°)$, blue

2.1.1 PL

Best-fit value $1/E_{\rm cut}$: 9.537E-07 1/GeV
Parameter error printed by MIGRAD: 0.01005 1/GeV

Best-fit value $E_{\rm cut}$: 1049 TeV
Upper limit for $1/E_{\rm cut}$: 0.0165317326509 1/GeV
Lower limit for $E_{\rm cut}$: 60.49 GeV

2.1.2 IC

Best-fit value $1/E_{\rm cut}$: 1.203E-10 1/GeV
Parameter error printed by MIGRAD: 2.761E-05 1/GeV

Best-fit value $E_{\rm cut}$: 8312.6 PeV
Upper limit for $1/E_{\rm cut}$: 4.54145289401e-05 1/GeV
Lower limit for $E_{\rm cut}$: 22.0 TeV

2.1.3 Pi0

Best-fit value $1/E_{\rm cut}$: 0.0007014 1/GeV
Parameter error printed by MIGRAD: 0.0001887 1/GeV

Best-fit value $E_{\rm cut}$: 1426 GeV
Upper limit for $1/E_{\rm cut}$: 0.00101178387941 1/GeV
Lower limit for $E_{\rm cut}$: 988.4 GeV

2.2 Left of GC, $\ell \in (0^\circ, 10^\circ)$, red

2.2.1 PL

Best-fit value $1/E_{\rm cut}$: 0.004113 1/GeV
Parameter error printed by MIGRAD: 0.003641 1/GeV

Best-fit value $E_{\rm cut}$: 243.1 GeV
Upper limit for $1/E_{\rm cut}$: 0.0101019120557 1/GeV
Lower limit for $E_{\rm cut}$: 98.99 GeV

2.2.2 IC

Best-fit value$1/E_{\rm cut}$: 0.0002016 1/GeV
Parameter error printed by MIGRAD: 0.0006471 1/GeV

Best-fit value $E_{\rm cut}$: 4960.3 GeV
Upper limit for $1/E_{\rm cut}$: 0.001265984782 1/GeV
Lower limit for $E_{\rm cut}$: 789.9 GeV

2.2.3 Pi0

Best-fit value $1/E_{\rm cut}$: 0.002605 1/GeV
Parameter error printed by MIGRAD: 0.0009566 1/GeV

Best-fit value $E_{\rm cut}$: 383.9 GeV
Upper limit for $1/E_{\rm cut}$: 0.00417846697954 1/GeV
Lower limit for $E_{\rm cut}$: 239.3 GeV

3 Slightly above GP, $b \in (2^\circ, 6^\circ)$, latitude = 8

3.1 Right of GC, $\ell \in (-10^\circ, 0^\circ)$, blue

3.1.1 PL

Best-fit value $1/E_{\rm cut}$: 0.000318 1/GeV
Parameter error printed by MIGRAD: 0.0008268 1/GeV

Best-fit value $E_{\rm cut}$: 3144.65 GeV

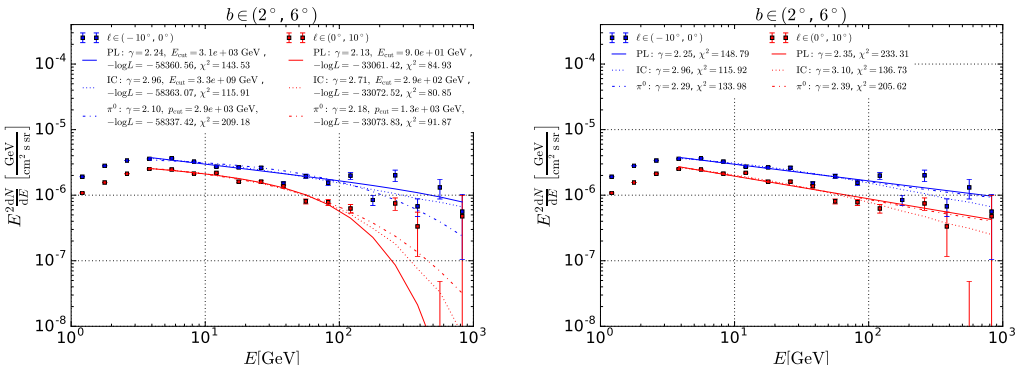

Figure 3: Fit with and without cutoff.

Upper limit for $1/E_{\rm cut}$: 0.00167796497876 1/GeV
Lower limit for $E_{\rm cut}$: 595.959994789 GeV

3.1.2 IC

Best-fit value $1/E_{\rm cut}$: 2.995E-10 1/GeV
Parameter error printed by MIGRAD: 7.637E-05 1/GeV

Best-fit value $E_{\rm cut}$: 3338898163.61 GeV
Upper limit for $1/E_{\rm cut}$: 0.00012561777099 1/GeV
Lower limit for $E_{\rm cut}$: 7960.65709586 GeV

3.1.3 Pi0

Best-fit value $1/E_{\rm cut}$: 0.0003408 1/GeV
Parameter error printed by MIGRAD: 0.0001545 1/GeV

Best-fit value $E_{\rm cut}$: 2934.27230047 GeV
Upper limit for $1/E_{\rm cut}$: 0.000594929885364 1/GeV
Lower limit for $E_{\rm cut}$: 1680.87034221 GeV

3.2 Left of GC, $\ell \in (0^\circ, 10^\circ)$, red

3.2.1 PL

Best-fit value $1/E_{\rm cut}$: 0.01105 1/GeV
Parameter error printed by MIGRAD: 0.006745 1/GeV

Best-fit value $E_{\rm cut}$: 90.4977375566 GeV
Upper limit for $1/E_{\rm cut}$: 0.0221445377138 1/GeV
Lower limit for $E_{\rm cut}$: 45.1578629875 GeV

3.2.2 IC

Best-fit value1/$E_{\rm cut}$: 0.003454 1/GeV
Parameter error printed by MIGRAD: 0.001583 1/GeV

Best-fit value $E_{\rm cut}$: 289.5193978 GeV
Upper limit for $1/E_{\rm cut}$: 0.00605780329146 1/GeV
Lower limit for $E_{\rm cut}$: 165.076340694 GeV

3.2.3 Pi0

Best-fit value $1/E_{\rm cut}$: 0.0007884 1/GeV
Parameter error printed by MIGRAD: 0.0004543 1/GeV

Best-fit value $E_{\rm cut}$: 1268.39167935 GeV
Upper limit for $1/E_{\rm cut}$: 0.00153565700272 1/GeV
Lower limit for $E_{\rm cut}$: 651.187080335 GeV

4 How I calculate 95 %-confidence lower limit for $E_{\rm cut}$

Assume

$$\ln L(x) = \frac{1}{\sqrt{2\pi\sigma^2}}\, e^{\frac{(x-x_0)^2}{2\sigma^2}},$$

where $x == E_{\rm cut}$ and $x_0 ==$ best-fit $E_{\rm cut}$, $\sigma ==$ parameter error given by MIGRAD.

$$\begin{aligned} 0.05 &= \int_{x_0+k\sigma}^{\infty} \frac{1}{\sqrt{2\pi\sigma^2}}\, e^{\frac{(x-x_0)^2}{\sqrt{2}\sigma^2}}\, dx \\ &= \frac{1}{2}\left[\mathrm{erf}\left(\frac{x-x_0}{2\sigma^2}\right)\right]_{x_0+k\sigma}^{\infty} \qquad (1) \\ &= \frac{1}{2}\left(1-\mathrm{erf}\left(\frac{k}{\sqrt{2}}\right)\right) \\ \rightarrow k &= \sqrt{2}\cdot \mathrm{erf}^{-1}(0.9) = 1.64485 \qquad (2) \end{aligned}$$

The lower limit for $1/E_{\rm cut}$ is

$$x_0 + k\ \sigma. \qquad (3)$$