Unfolding Gammapy

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Settings

- True and Reconstructed Energy Range from 1 TeV to 100 TeV
- Background Spectrum
  - PowerLaw
    (Idx=-2, Amp=10^{-12} cm^{-2} s^{-1} TeV^{-1}, Ref=1 TeV)
- Source Spectrum
  - LogParabola
    (Amp=10^{-12} cm^{-2} s^{-1} TeV^{-1}, Ref=1 TeV, α=2, β=1)
- Unfolding Spectrum
  - PieceWiseNorm · PowerLaw (Idx=0)
    $\rightarrow$ Flat Prior
    - Frozen PowerLaw Parameters: only Fitting Norms

I used the poisson likelihood of the counts:

$$\epsilon = 10^{-8}$$
$$\mathcal{L} = \sum n_{\text{pred}} - n_{\text{true}} \cdot \log_{10}\left(n_{\text{pred}} + \epsilon\right)$$

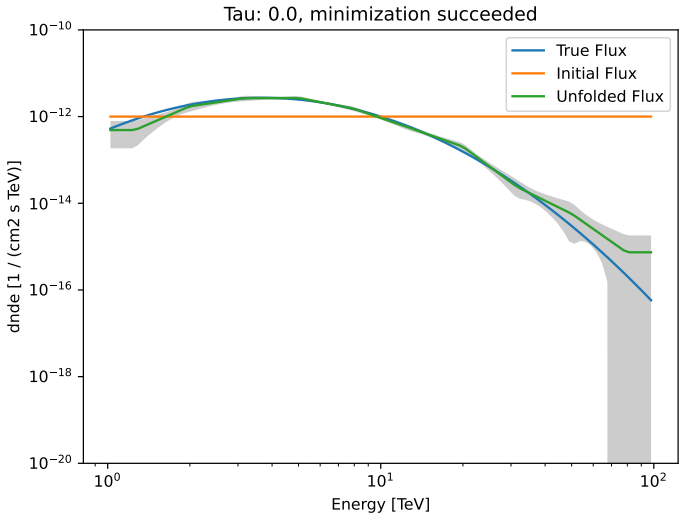
I used the tikhonov regularization (flat 2nd derivative, matrix C) on the norm parameters (f) (they represent the bin heights of the unfolding, hence need to be (2nd derivative)-flat?)

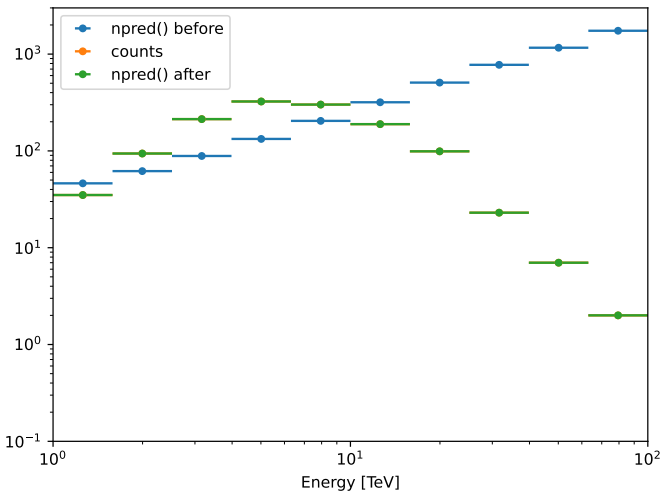
$$\frac{1}{2}(\mathsf{C}f)^{\top}(\tau\mathbb{1})^{-1}(\mathsf{C}f)$$

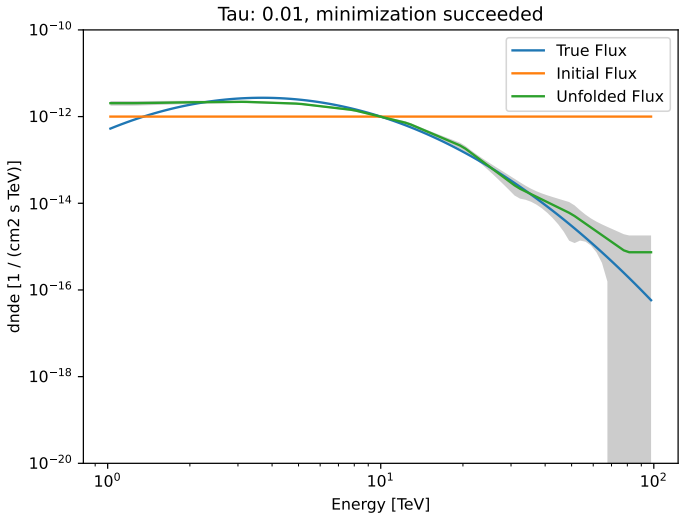
Results

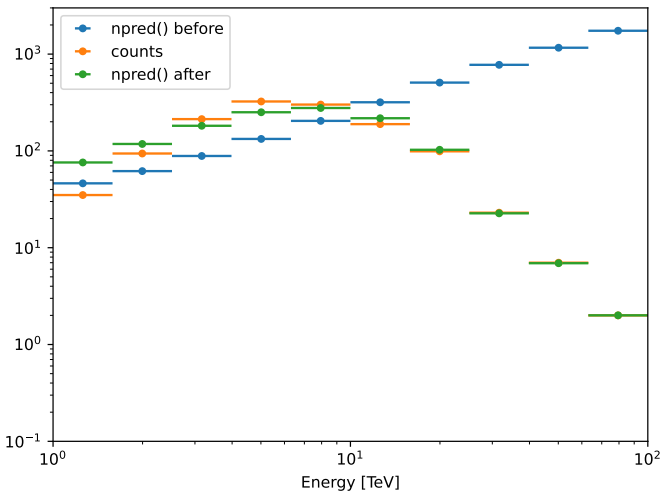
- The following plots show the true spectrum, the start spectrum (i.e. before the unfolding) and the unfolded spectrum.
- Tau=0 means no regularization.
- 10 reconstructed energy bins are used, 80 true energy bins
- Some norms are unfolded to **nan**, which is of course nonsense and makes for really large error bands
- This was not hand-optimized, just some settings ran. If the fit failed (e.g. unfolding **nan**s), the results are still shown.
- Low Sigma/Bias means 0.01, Higher Sigma/Bias means 0.1 for each

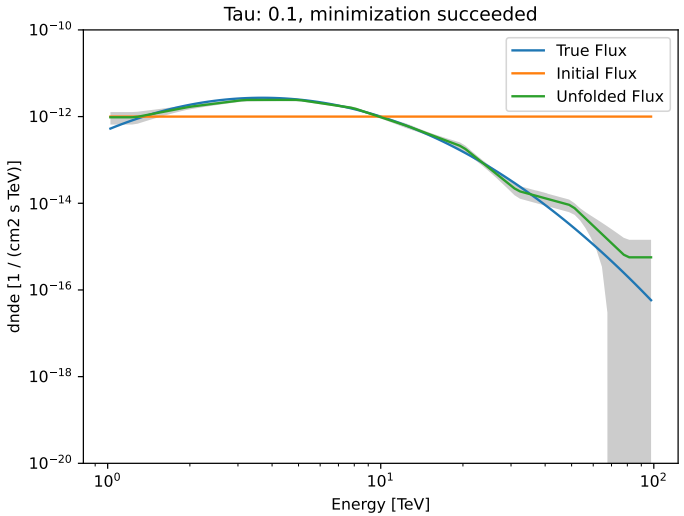
Low Sigma/Bias, 10 Unfolding Bins

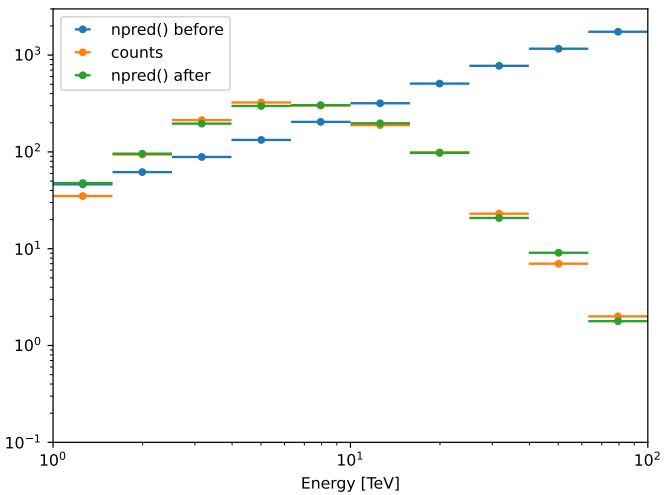

Tau: 0.0, minimization succeeded
True Flux
Initial Flux
Unfolded Flux
dnde [1 / (cm2 s TeV)]
Energy [TeV]

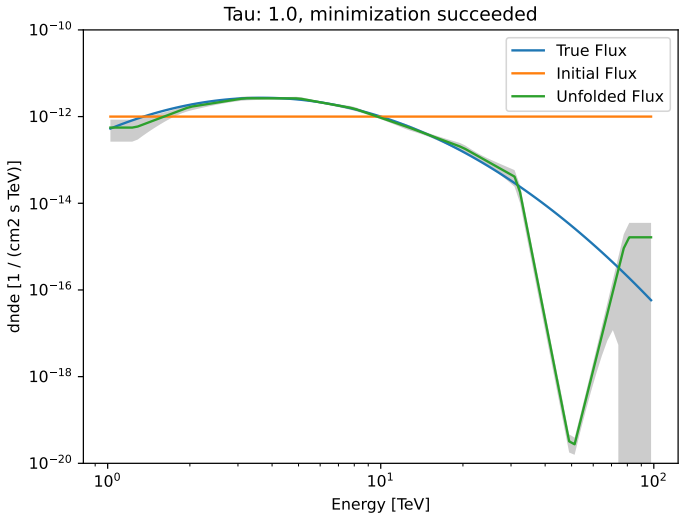

npred() before
counts
npred() after
Energy [TeV]

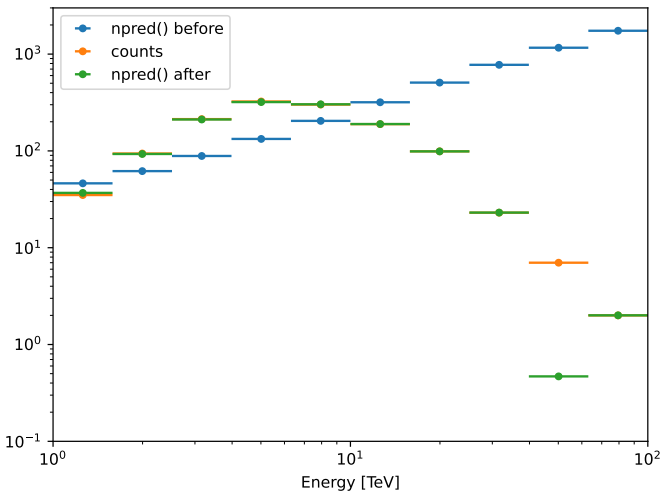

Tau: 0.01, minimization succeeded
True Flux
Initial Flux
Unfolded Flux
dnde [1 / (cm2 s TeV)]
Energy [TeV]

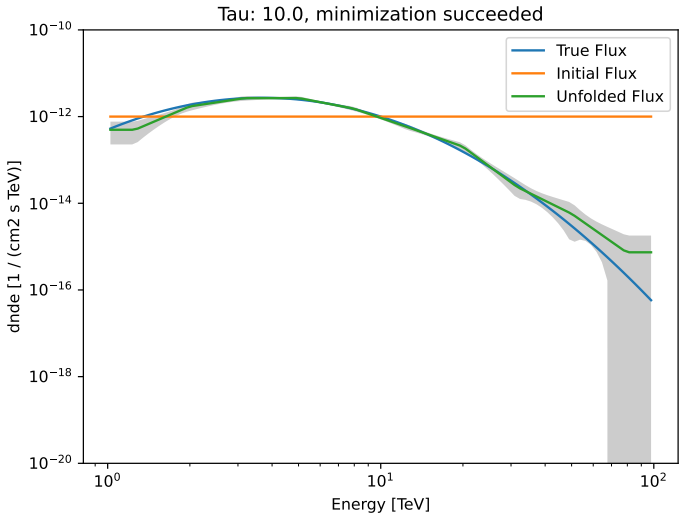

npred() before
counts
npred() after
Energy [TeV]

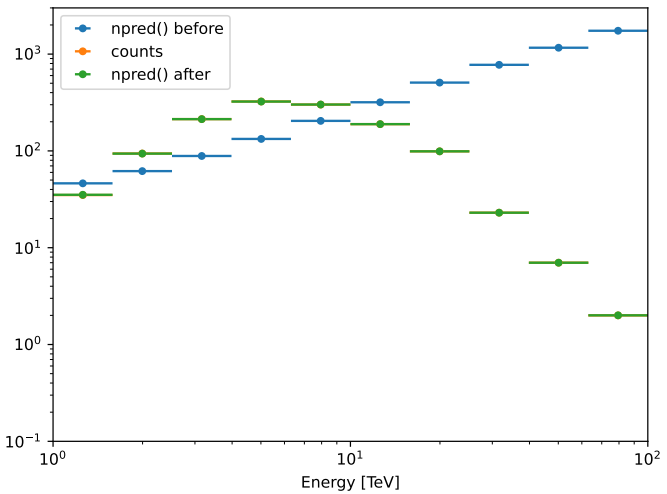

Tau: 0.1, minimization succeeded
True Flux
Initial Flux
Unfolded Flux
dnde [1 / (cm2 s TeV)]
Energy [TeV]


npred() before
counts
npred() after
Energy [TeV]

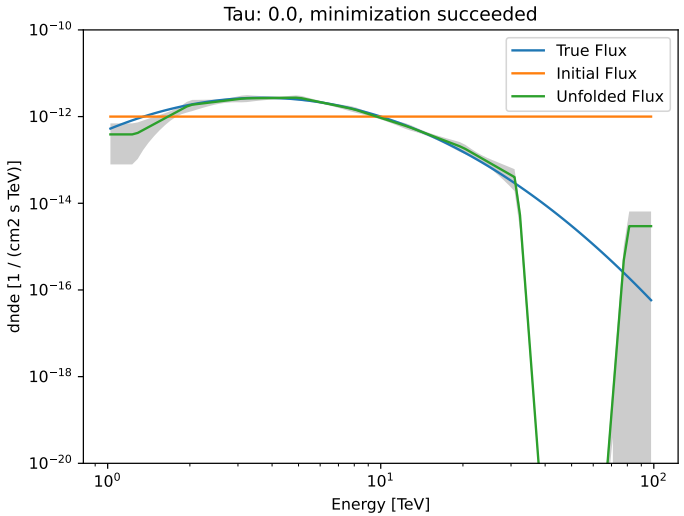

Tau: 1.0, minimization succeeded
True Flux
Initial Flux
Unfolded Flux
dnde [1 / (cm2 s TeV)]
Energy [TeV]

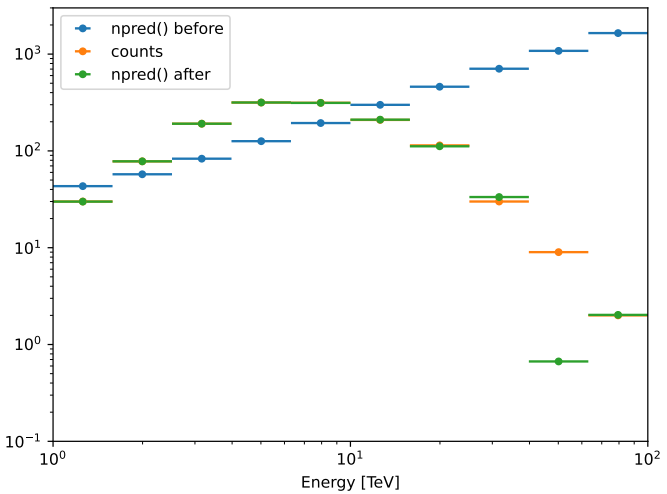

npred() before
counts
npred() after
Energy [TeV]

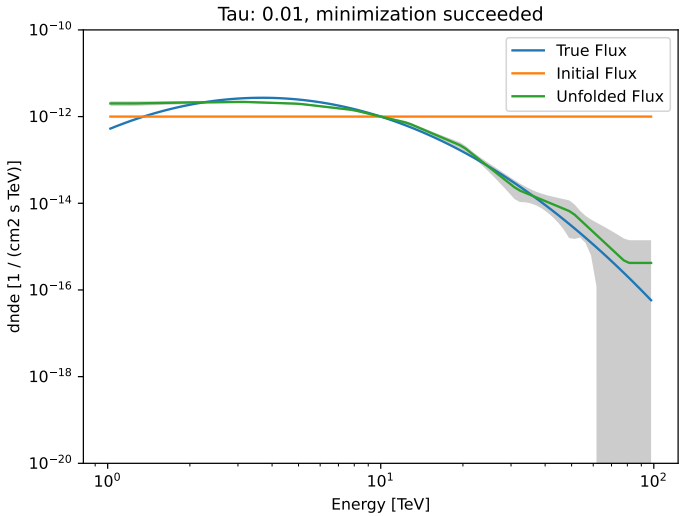

Tau: 10.0, minimization succeeded
True Flux
Initial Flux
Unfolded Flux
dnde [1 / (cm2 s TeV)]
Energy [TeV]

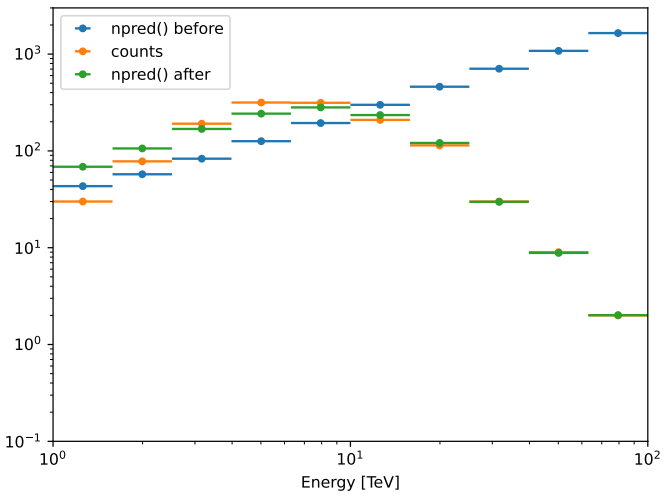

npred() before
counts
npred() after
Energy [TeV]

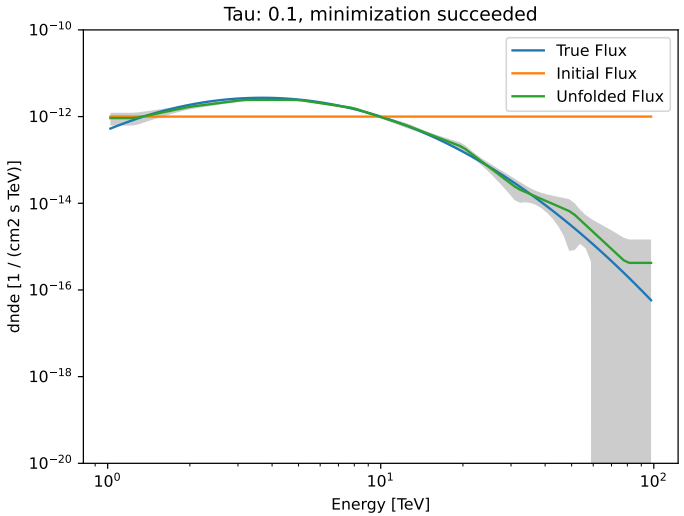
Higher Sigma/Bias, 10 Unfolding Bins

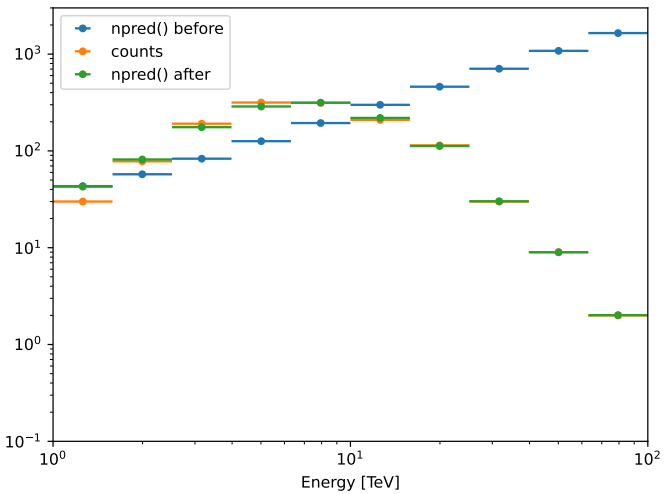

Tau: 0.0, minimization succeeded
True Flux
Initial Flux
Unfolded Flux
dnde [1 / (cm2 s TeV)]
Energy [TeV]

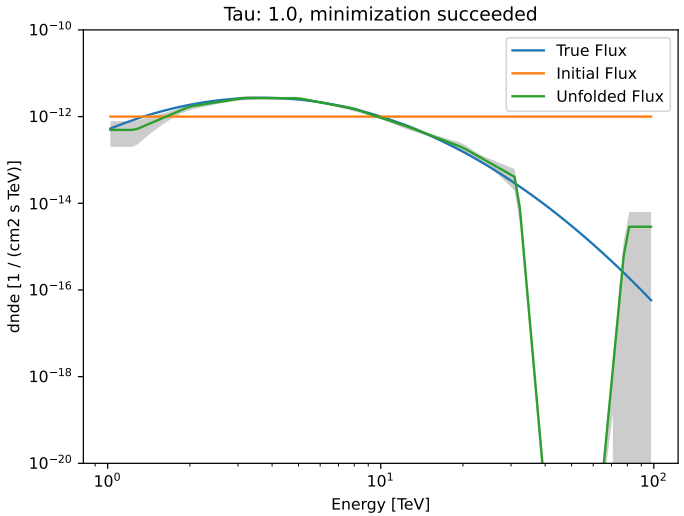

npred() before
counts
npred() after
Energy [TeV]

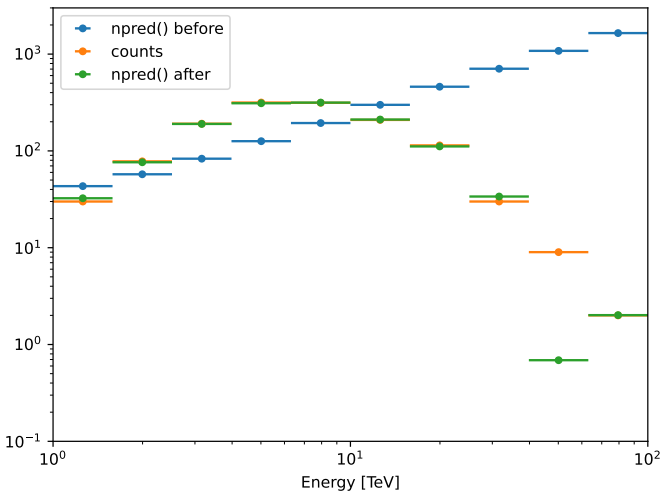

Tau: 0.01, minimization succeeded
True Flux
Initial Flux
Unfolded Flux
dnde [1 / (cm2 s TeV)]
Energy [TeV]

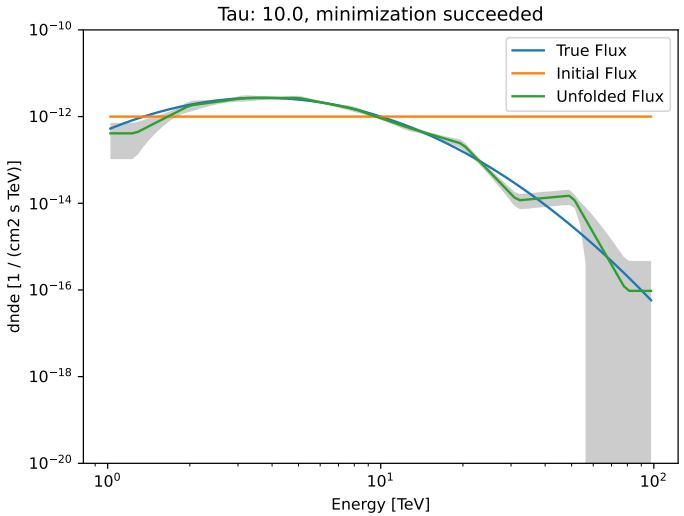

npred() before
counts
npred() after
Energy [TeV]


Tau: 0.1, minimization succeeded
True Flux
Initial Flux
Unfolded Flux
dnde [1 / (cm2 s TeV)]
Energy [TeV]


npred() before
counts
npred() after
Energy [TeV]


Tau: 1.0, minimization succeeded
True Flux
Initial Flux
Unfolded Flux
dnde [1 / (cm2 s TeV)]
Energy [TeV]


npred() before
counts
npred() after
Energy [TeV]


Tau: 10.0, minimization succeeded
True Flux
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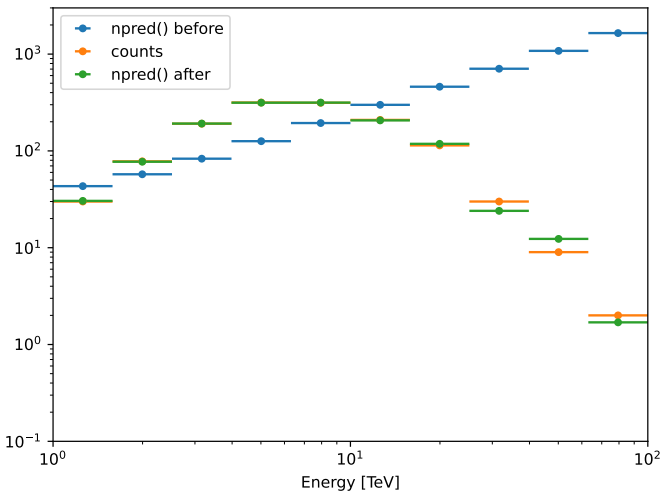
Unfolded Flux
dnde [1 / (cm2 s TeV)]
Energy [TeV]


npred() before
counts
npred() after
Energy [TeV]