Unfolding

A toolbox that connects an experiment's observable variables with true physical quantities.

Observed distribution ← R Matrix connect & True distribution

$$n(E) = R\phi(C)$$

THEN

True distribution ← Estimate Inverse R Matrix (M) & Observed distribution

$$\phi(C) = Mn(E)$$

Unfolding

A PyUnfold is used in this work:

https://jrbourbeau.github.io/pyunfold/

We need:

Crab data is used

- Observed distribution to unfold (with uncertainties): `data_observed` , `data_observed_err`
- Detection efficiencies (with uncertainties): `efficiencies` , `efficiencies_err`
- Normalized response matrix (with uncertainties): `response` , `response_err`

MC is used to compute it

To compute the Flux: It is apply to the unfolding output

https://private.hawc-observatory.org/svn/hawc/sandbox/zhampel/Unfolding/PyUnfold/FluxFit.py

Quality cuts

- rec.angleFitStatus==0
- rec.coreFitStatus==0
- rec.zenithAngle<0.785
- rec.nChTot>=800
- rec.nChAvail>0.9*rec.nChTot
- rec.coreFiduScale <= 100
- 0.067*rec.nChAvail<rec.nHitSP20
- rec.nHitSP20<=1.10*rec.nChAvail

Observed distribution

Crab data of 2016 & 2017:

`/data/archive/hawcroot/data/hawc/data/subsets/crab-strip`

Apply G/H separation:

- Sam cuts: /data/scratch/userspace/pretz/scrappy-platypus-dev/optimize-PINCLICompactOptimizer_FHitNNEnergyBinningLogicCFS/cuts-filtered.cuts
- Kelly cuts: /data/scratch/userspace/kmalone/sweets-for-systematics/nominal/cuts/cuts-fhit-variable.txt

Quality cuts:

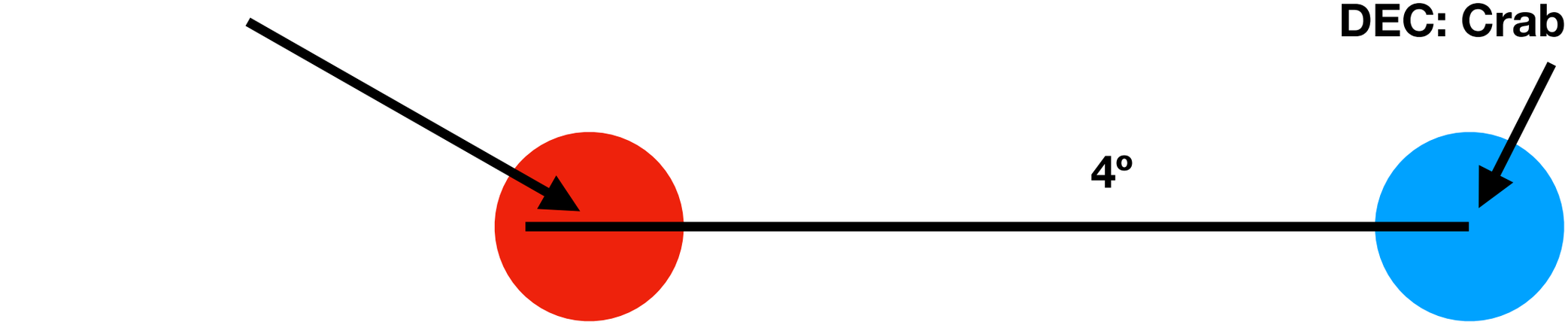
- rec.angleFitStatus==0
- rec.coreFitStatus==0
- rec.zenithAngle<0.785
- rec.nChTot>=800
- rec.nChAvail>0.9*rec.nChTot
- rec.coreFiduScale <= 100
- 0.067*rec.nChAvail<rec.nHitSP20

Observed distribution

Script used: but it was modified to get all events into a radius from a point

http://hawclava.umd.edu/zhampel/hawc/website/UNFOLDING/reco_extractor.php

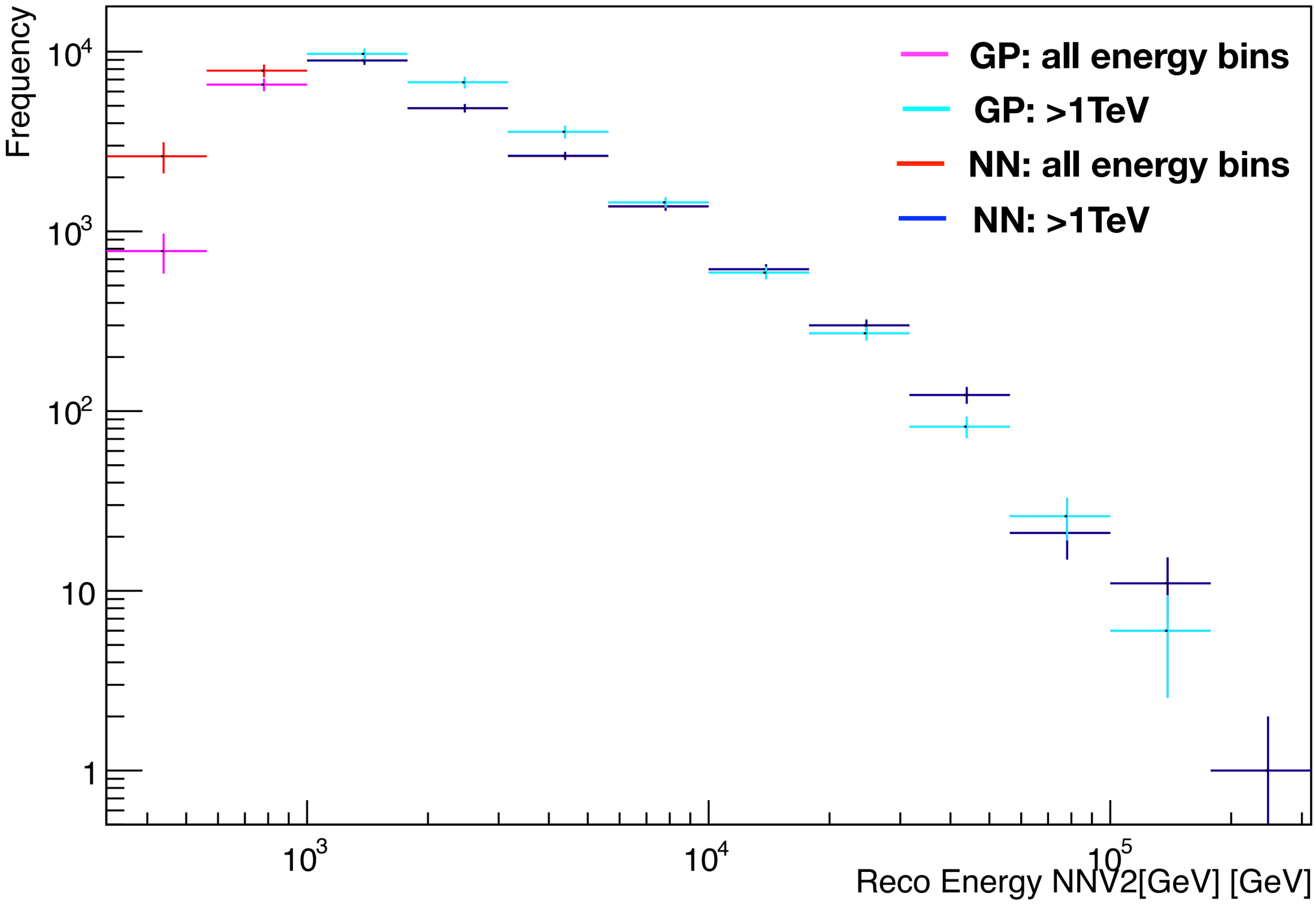
Crab:
RA: 22.0145º
DEC: 83.6332º



Subtraction:

Observed distribution = Signal + Background (0.5º) - Background (0.5º)

Observed distribution



Detector efficiency & response matrix

Script used:

http://hawclava.umd.edu/zhampel/hawc/website/UNFOLDING/detector_response.php

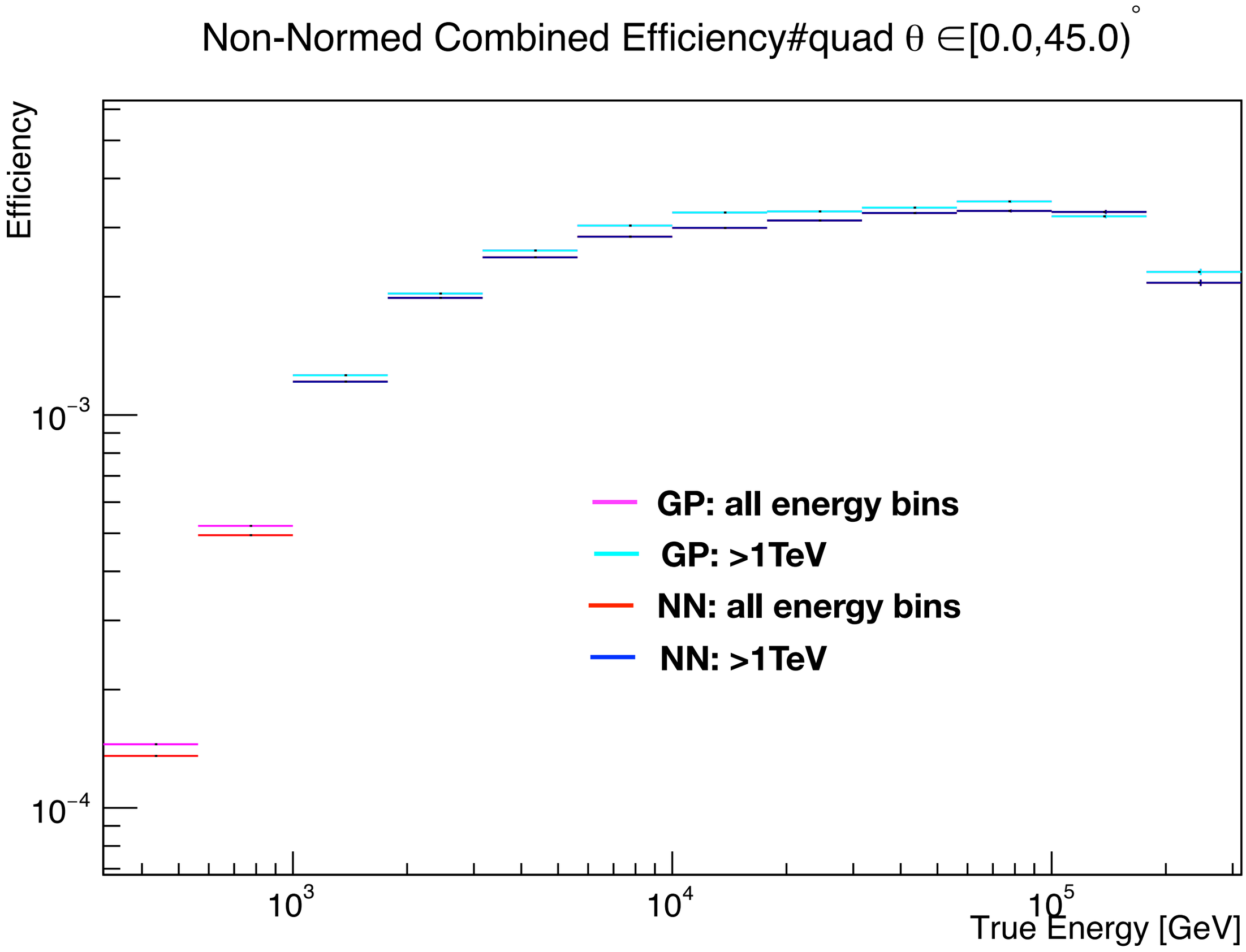
MC take 4:

/data/scratch/userspace/pretz/daqsim-reconstruction/output/daqsim-baseline-take4/gamma.xcd

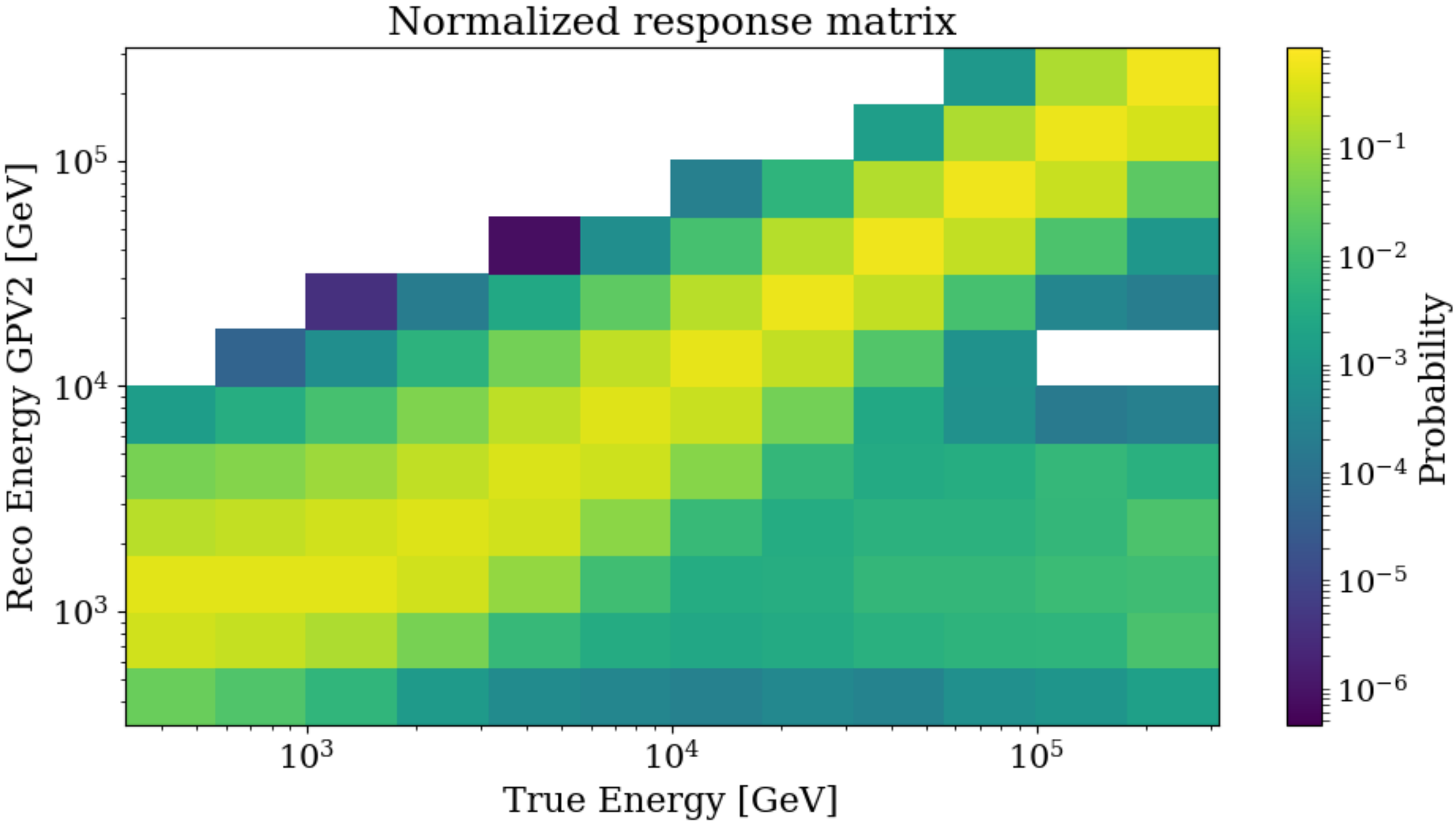
Apply quality cuts & G/H separation:

We use the OneWgt because the efficiency and response matrix are normalized.

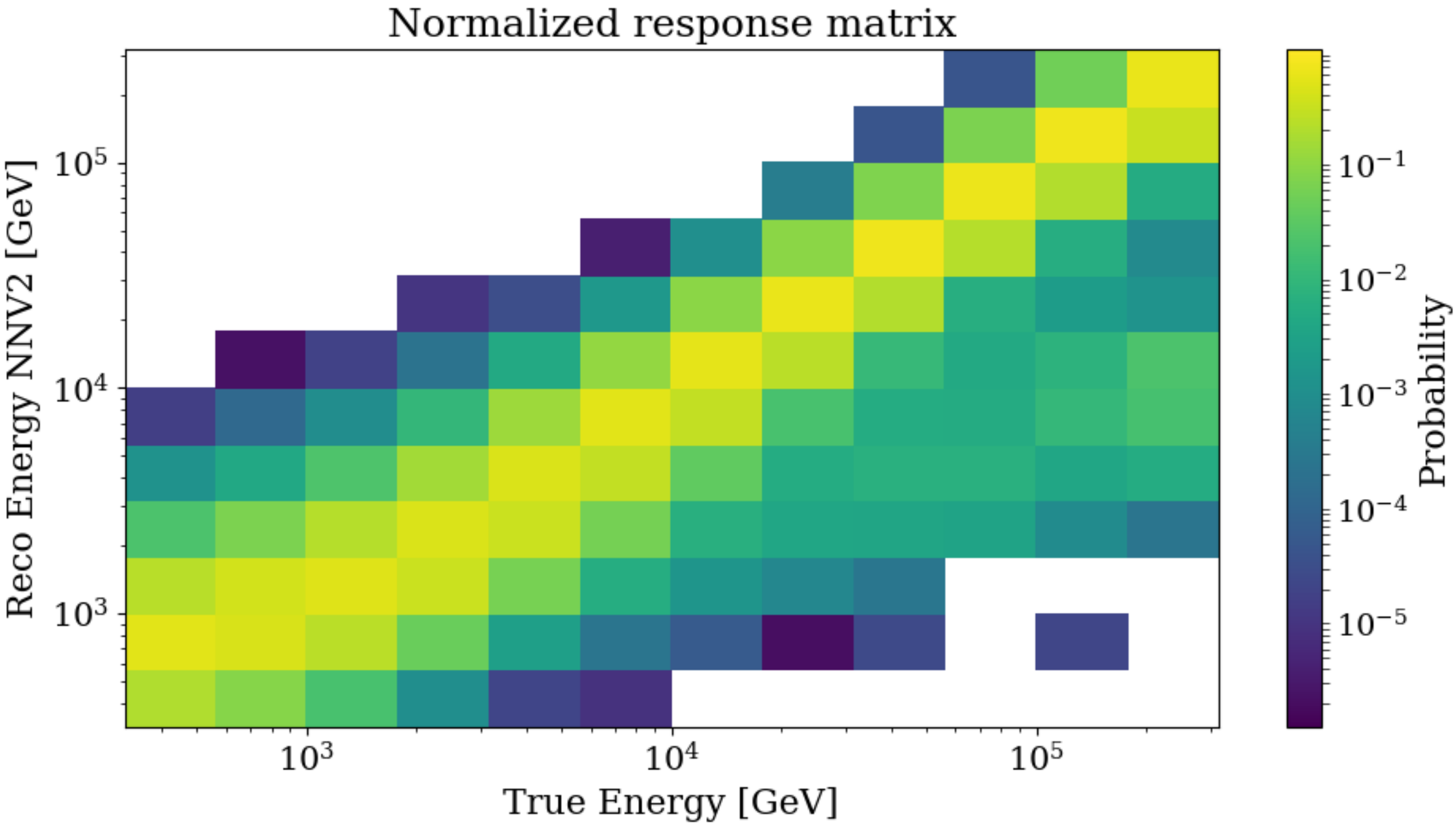
Efficiency:


Non-Normed Combined Efficiency#quad θ ∈[0.0,45.0)°
Efficiency
10^-3
10^-4
10^3
10^4
10^5
True Energy [GeV]
GP: all energy bins
GP: >1TeV
NN: all energy bins
NN: >1TeV

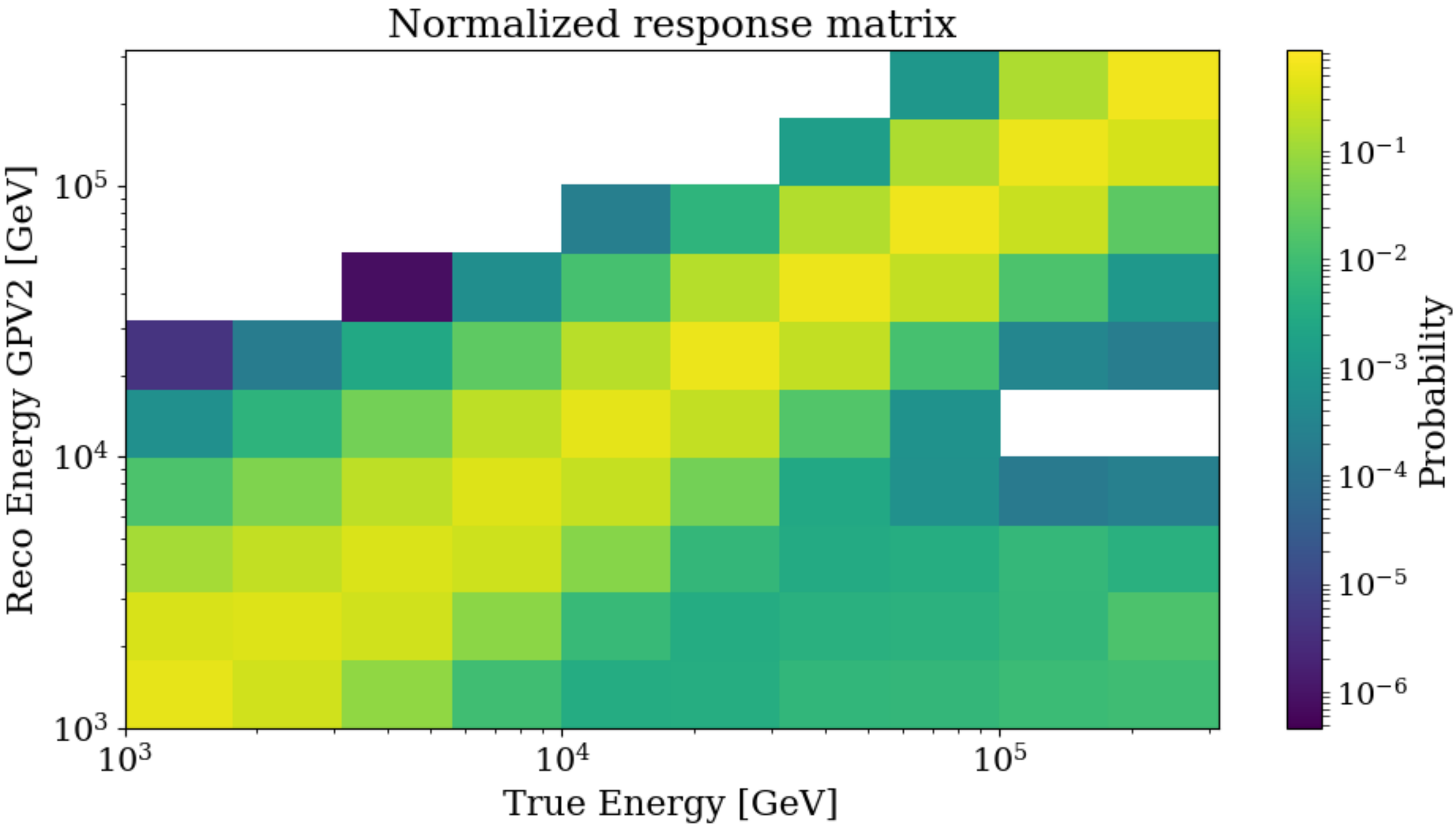
Response Matrix: all & GPEnergyV2 + GP cut



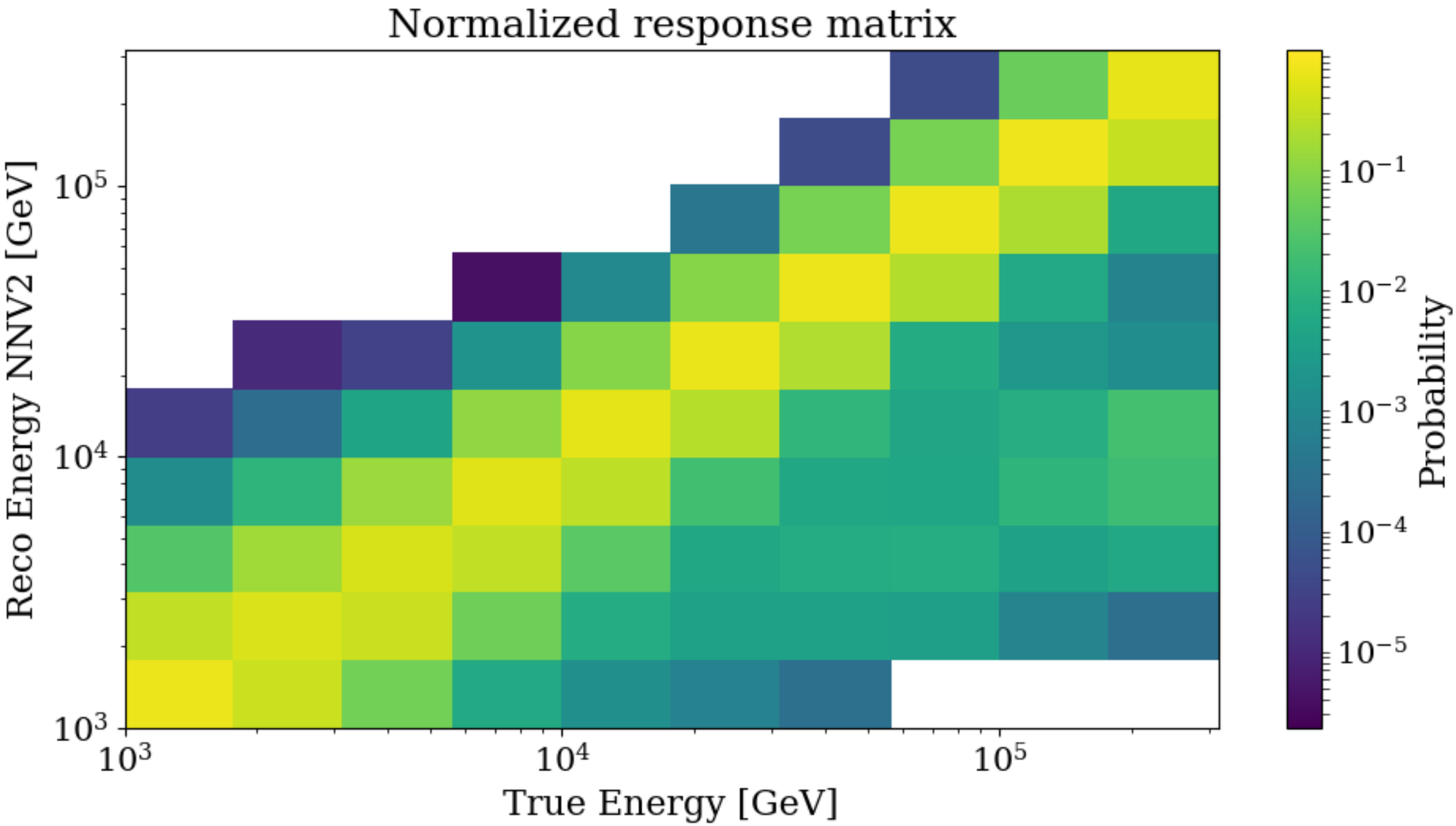
Response Matrix: all & NNEnergyV2 + NN cut



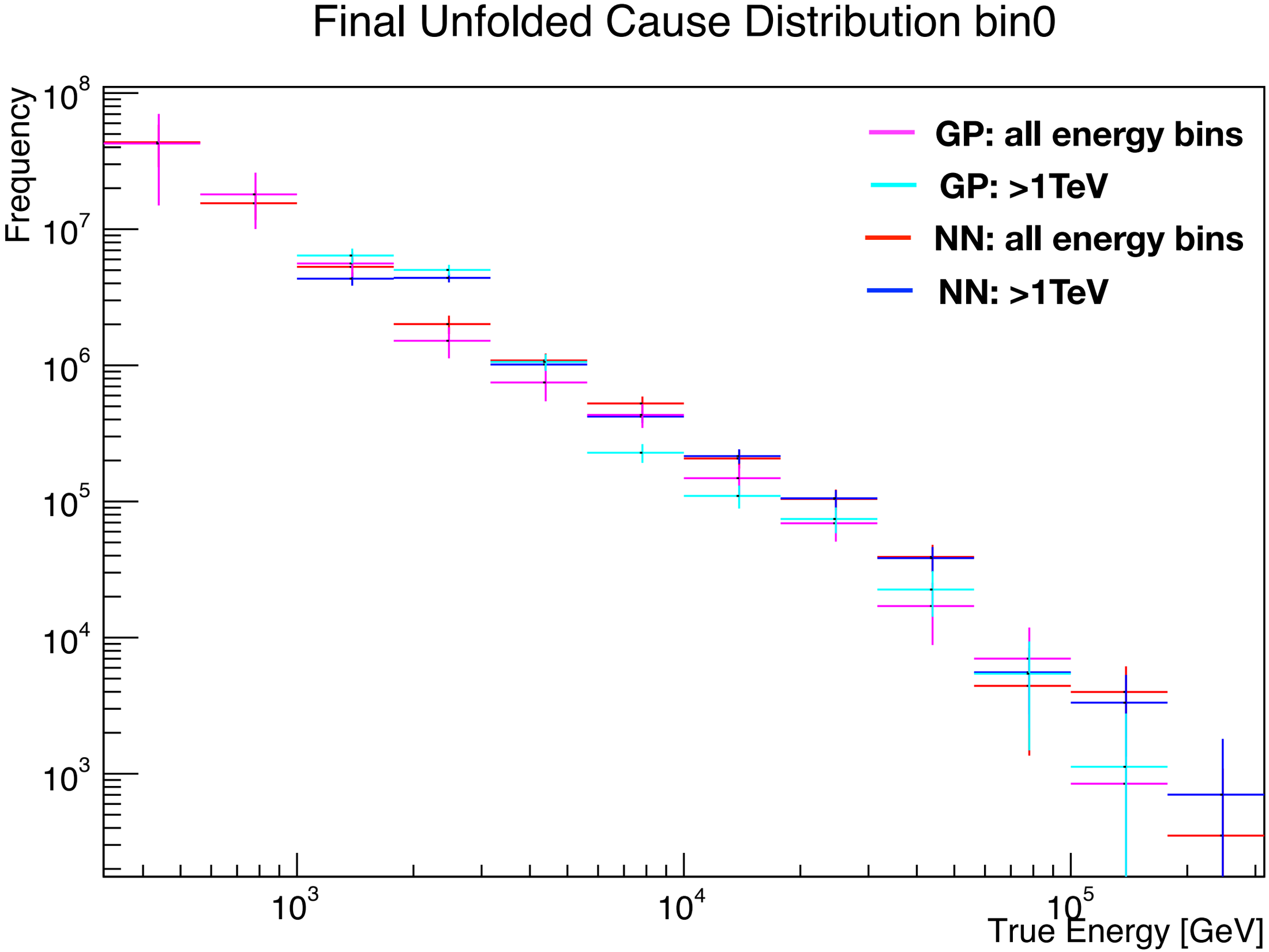
Response Matrix: >1TeV & GPEnergyV2 + GP cut



Response Matrix: >1TeV & NNEnergyV2 + NN cut

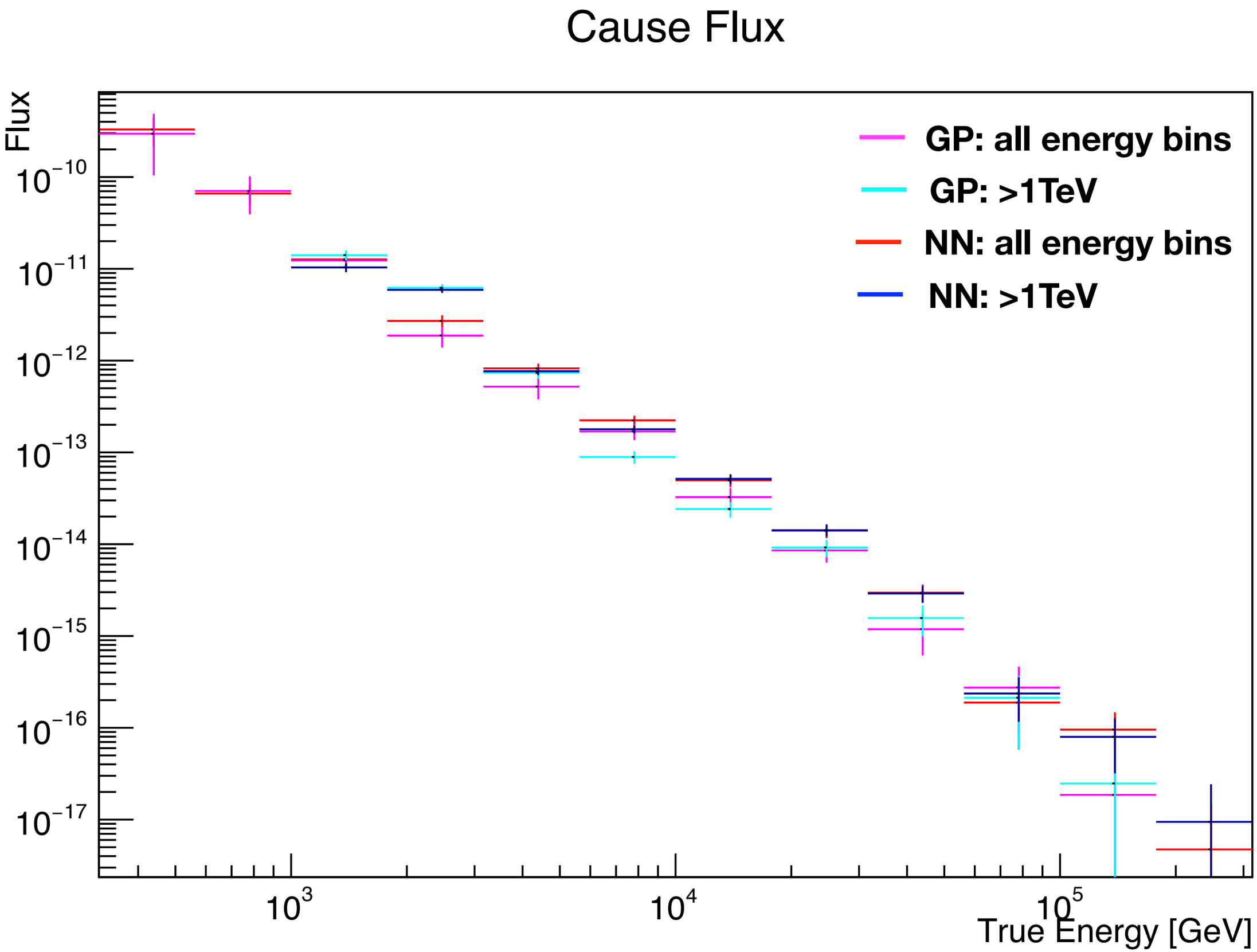


Unfold,


Final Unfolded Cause Distribution bin0
Frequency
10^8
10^7
10^6
10^5
10^4
10^3
10^3
10^4
10^5
True Energy [GeV]
GP: all energy bins
GP: >1TeV
NN: all energy bins
NN: >1TeV

Flux,

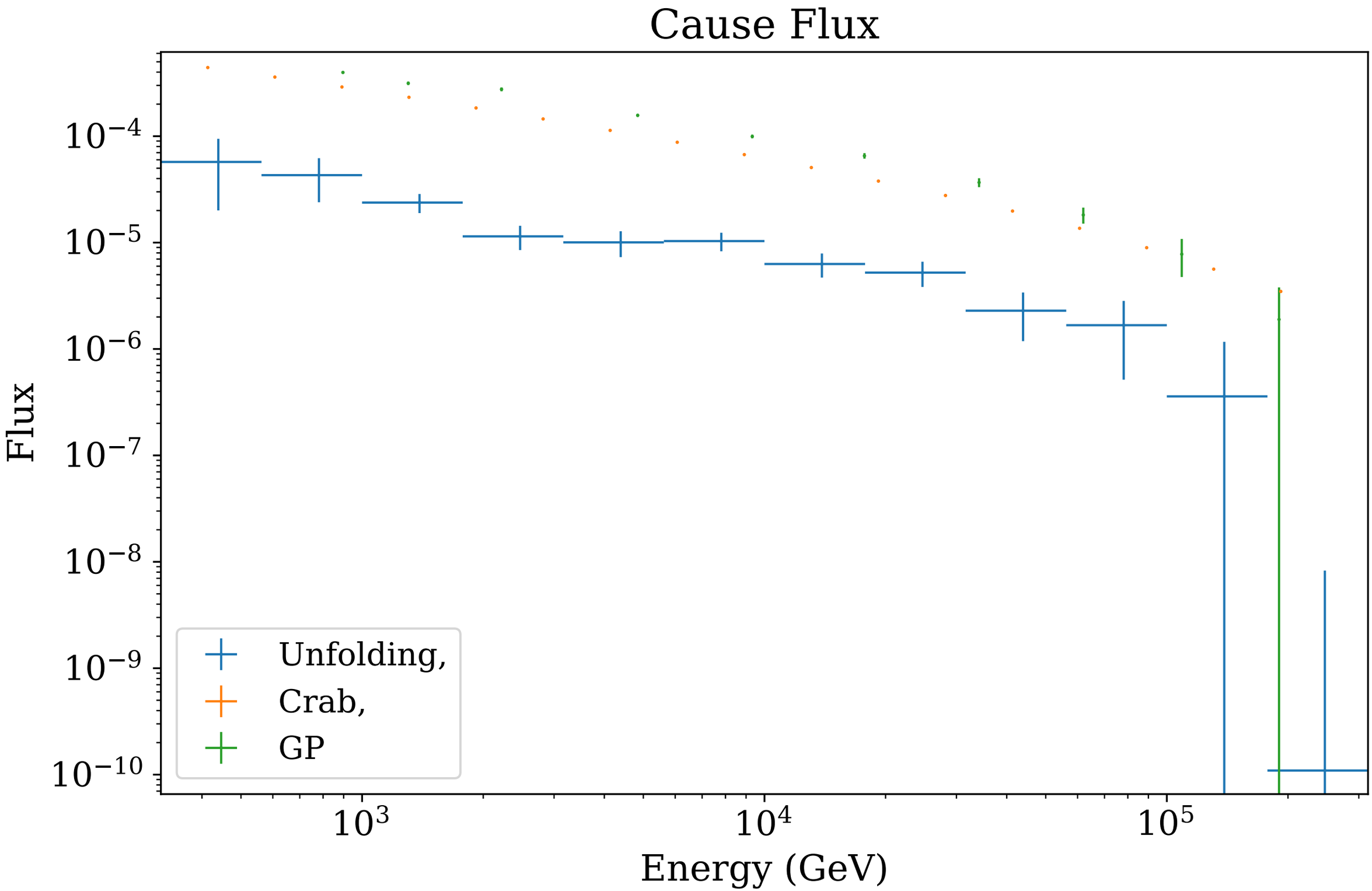
script: FluxFit.py



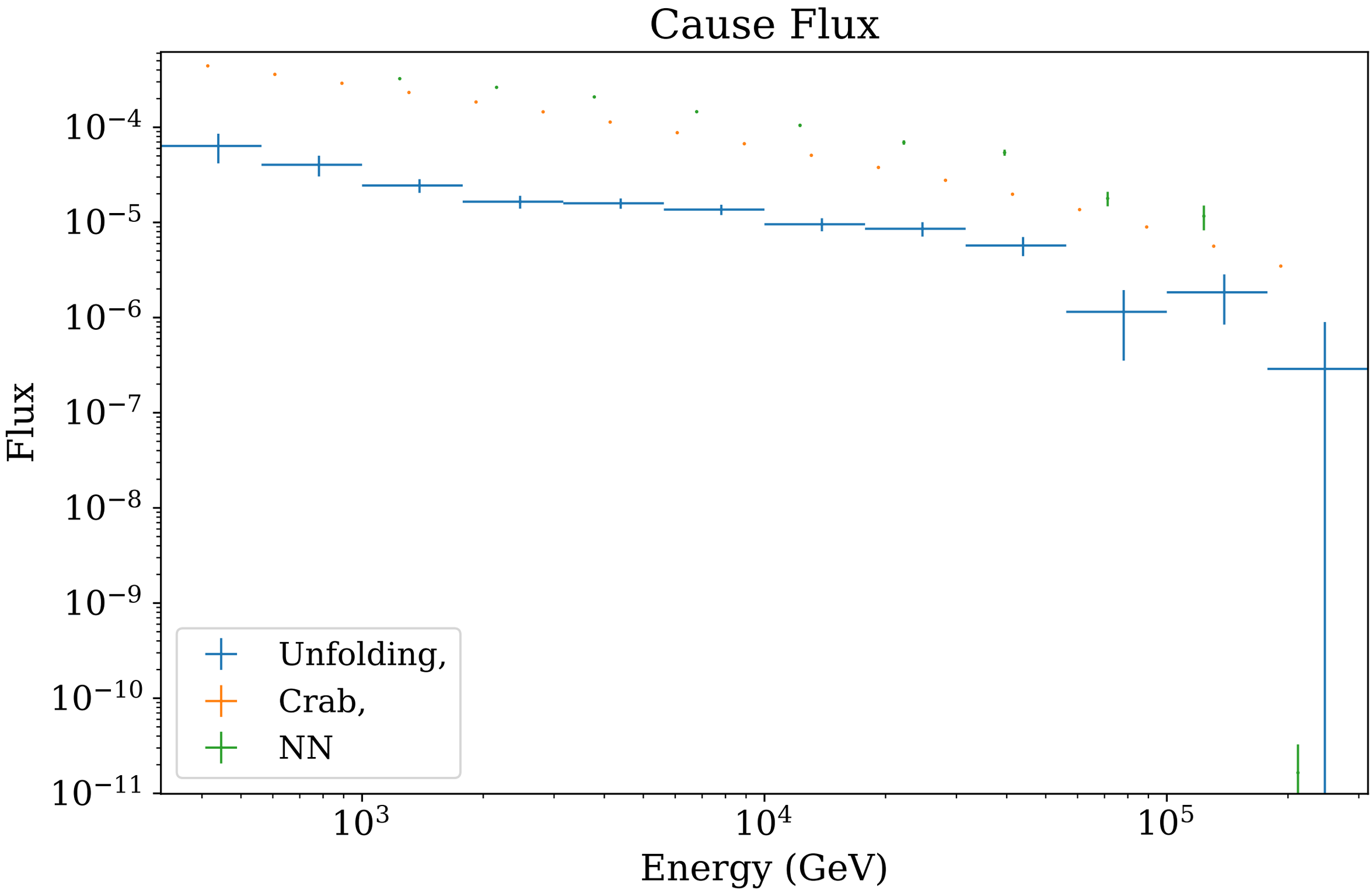
Function fit: $N * E^{Y}$

	N	Y	Chi2 / NDF	Chi2	NDF
NN cut, NN energy all	1.45E-03	-2.561	2.330	23.303	10.000
NN cut NN energy >1TeV	1.07E-03	-2.522	7.735	61.879	8.000
GP cut GP energy all	—	—	—	—	—
GP cut GP energy >1TeV	1.35E-02	-2.850	5.501	44.005	8.000

E^2 flux,

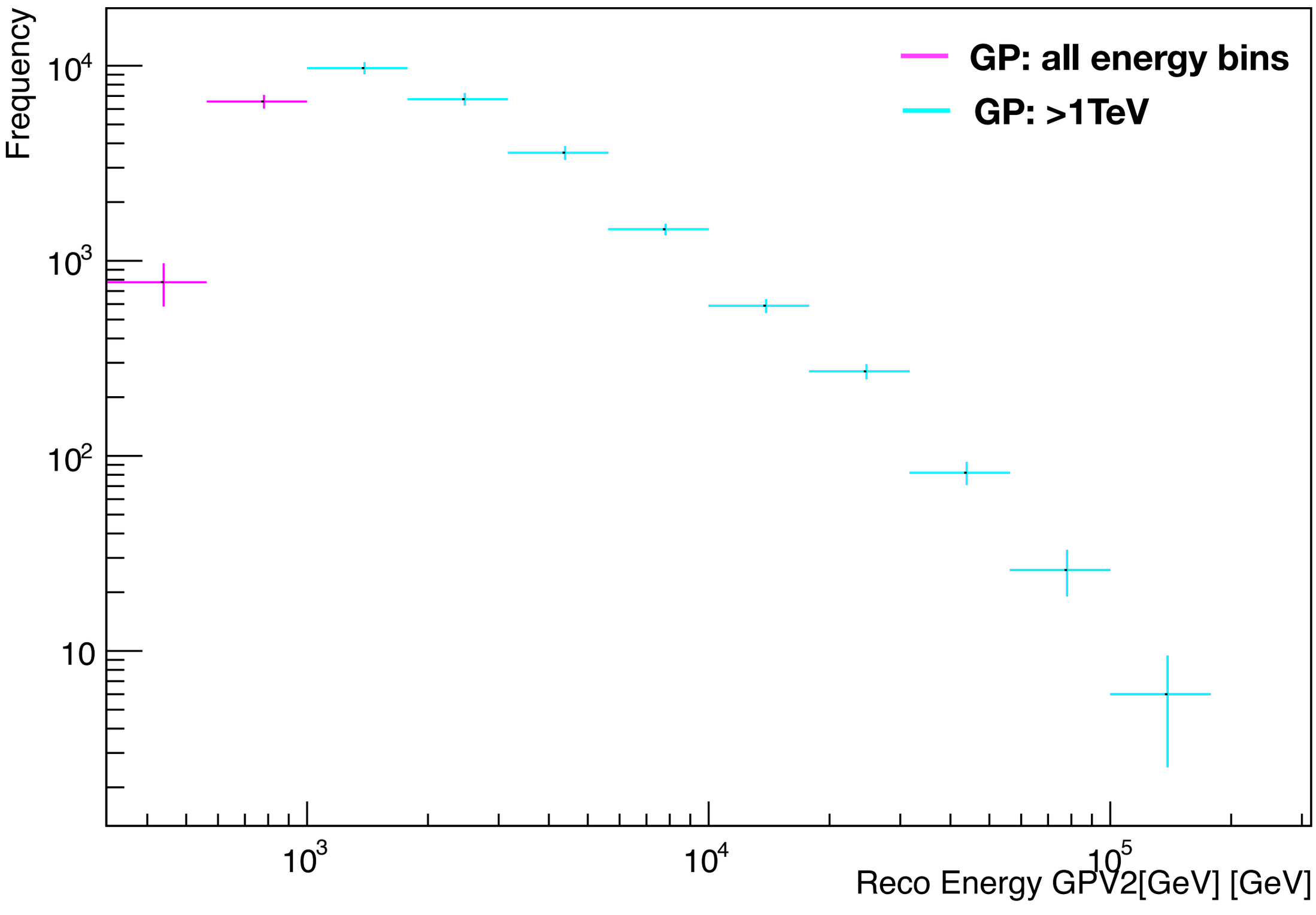

Cause Flux
Flux
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
Unfolding,
Crab,
GP
10^{3}
10^{4}
10^{5}
Energy (GeV)

E^2 flux,

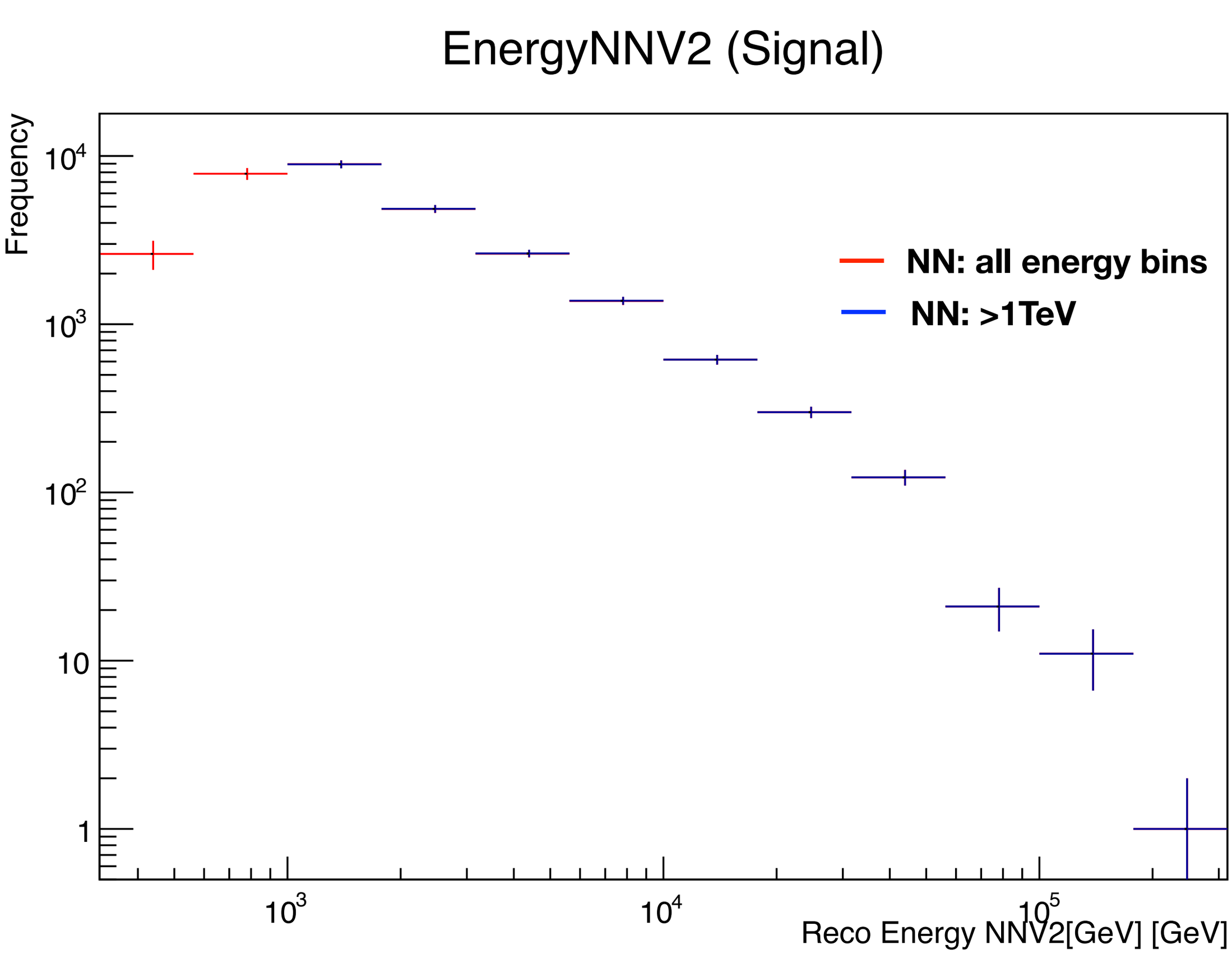

Cause Flux
Flux
Energy (GeV)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{3}
10^{4}
10^{5}
Unfolding,
Crab,
NN

Backslide:

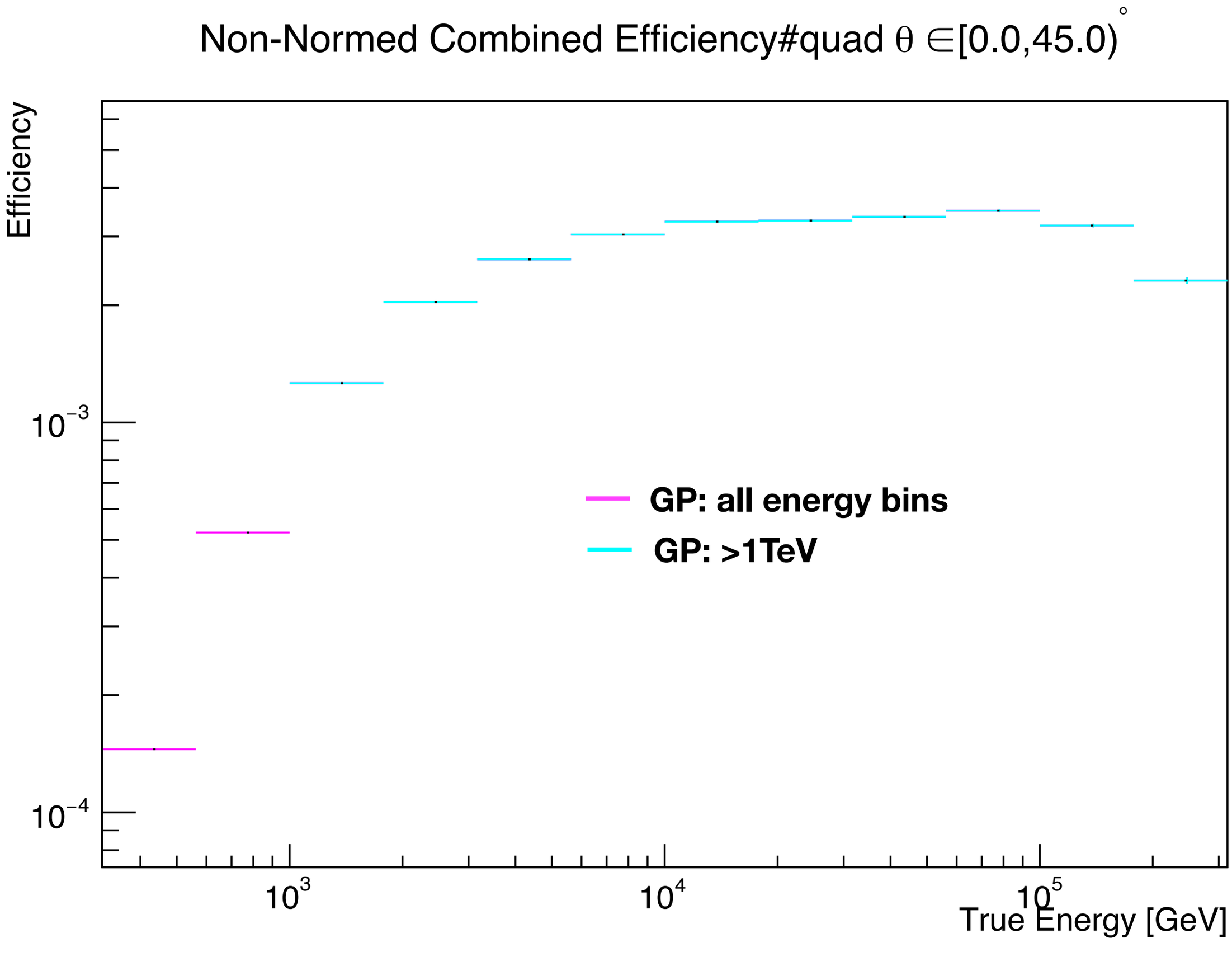
Obs: GPEnergyV2 + GP cuts



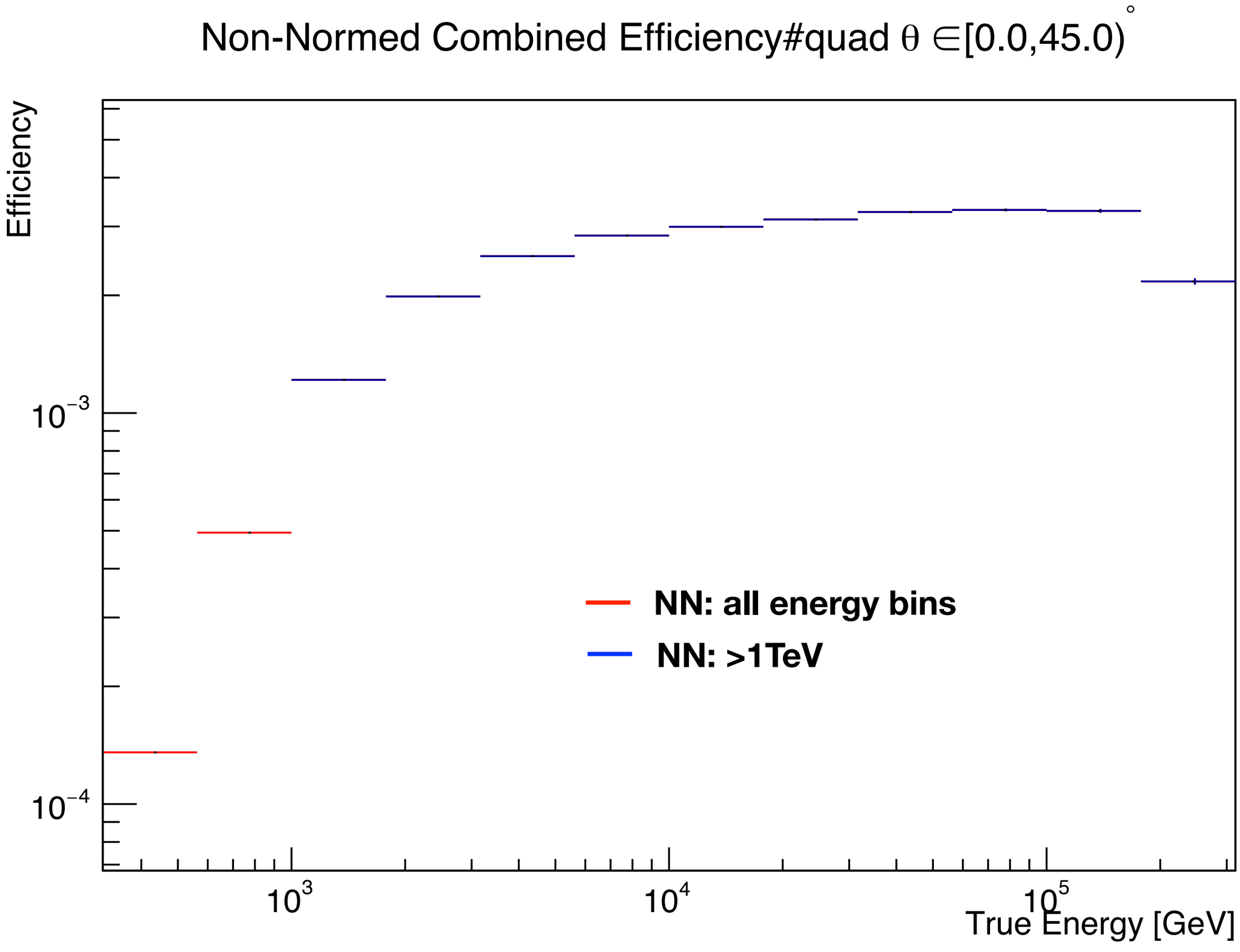
Obs: NNEnergyV2 + NNcuts



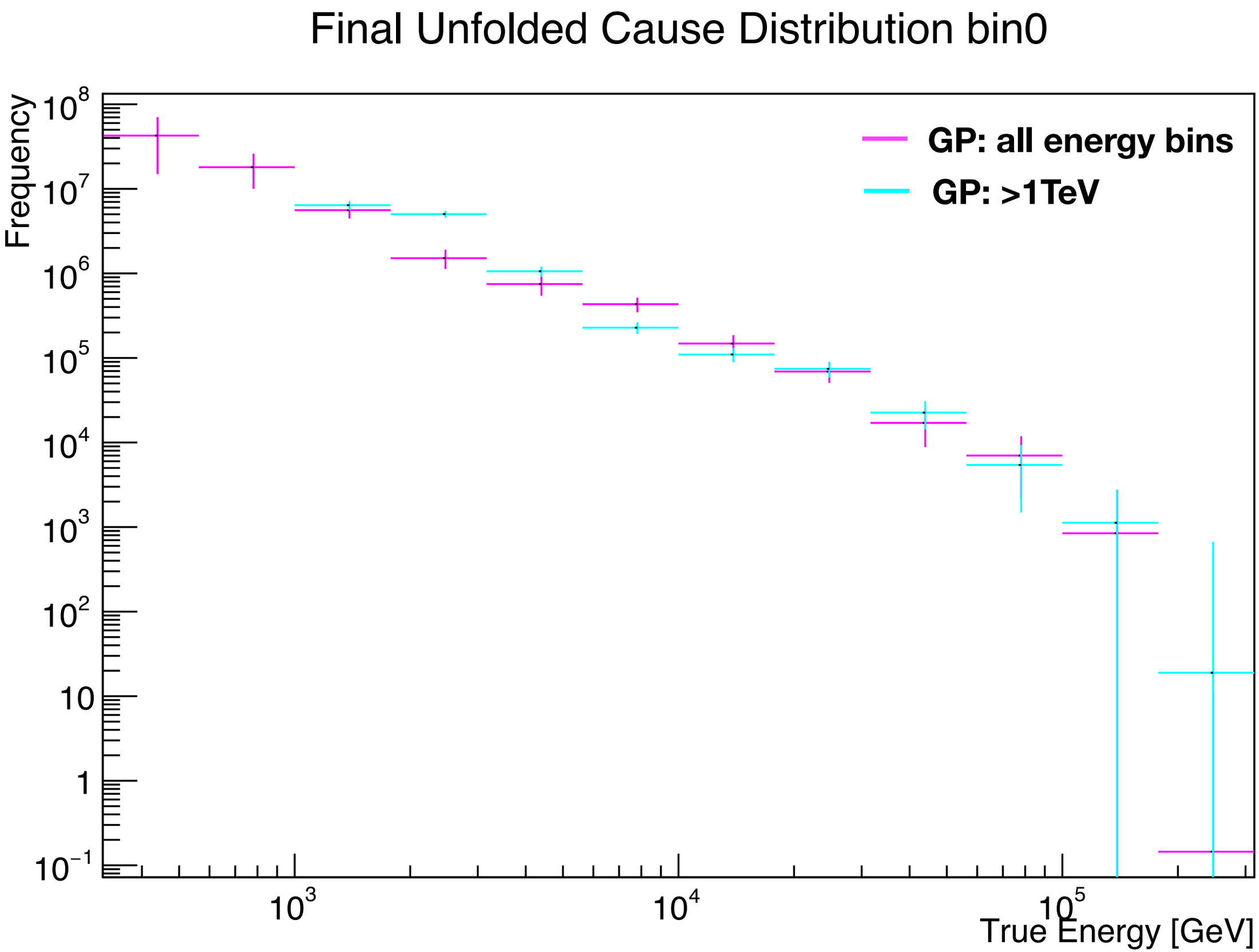
Efficiency: GPEnergyV2 + GP cuts



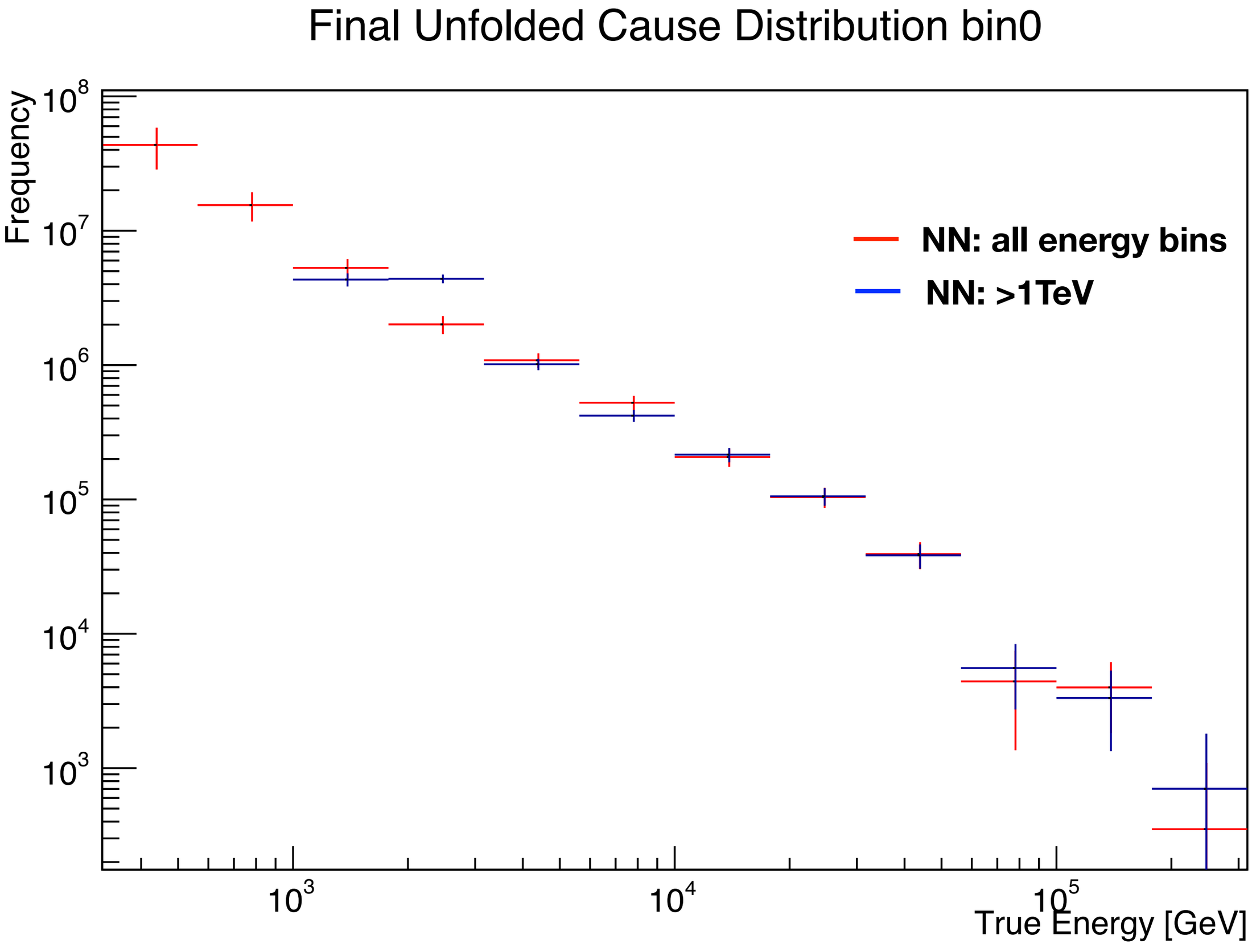
Efficiency: NNEnergyV2 + NN cuts



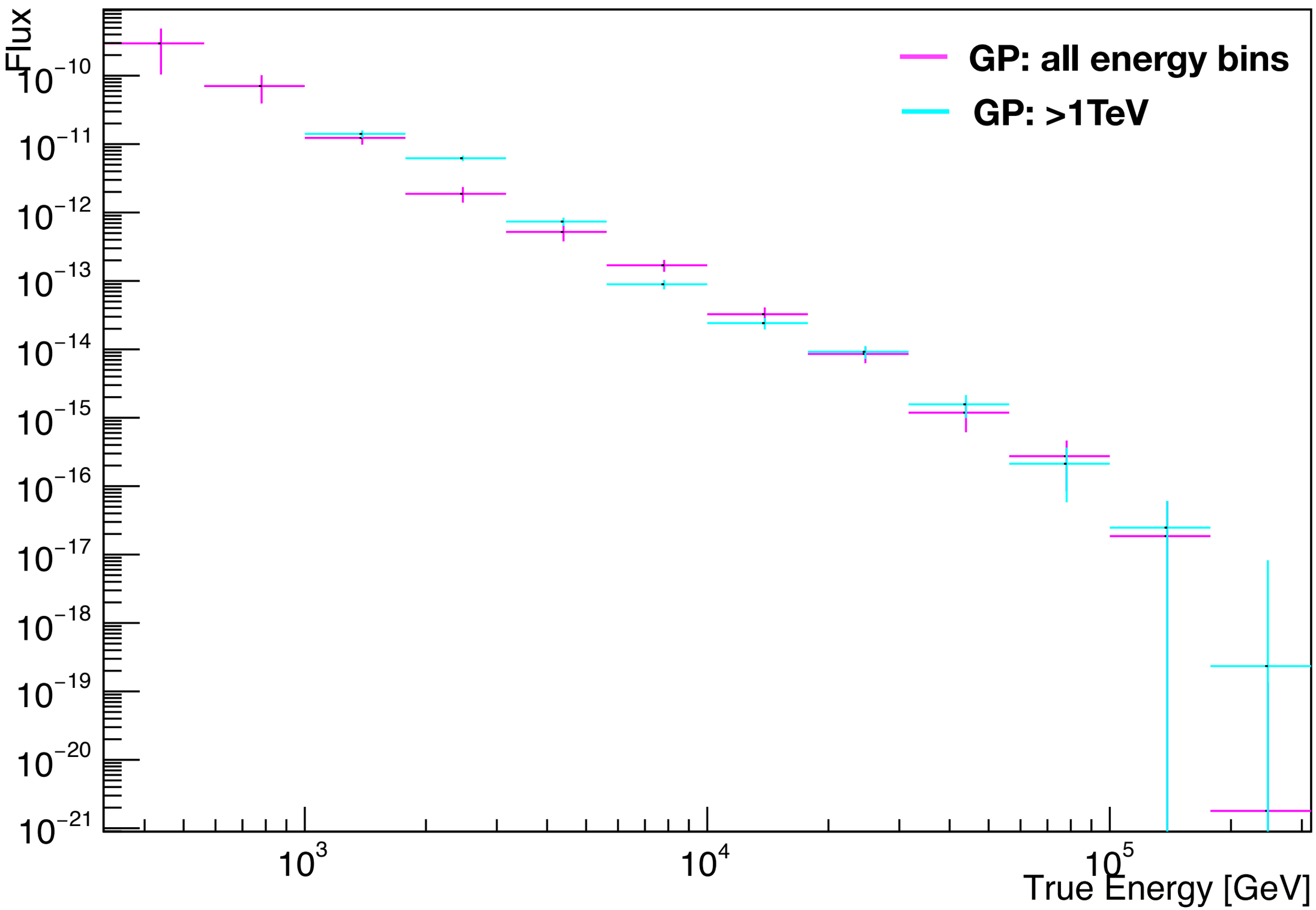
Unfold, GPEnergyV2 + GP cut



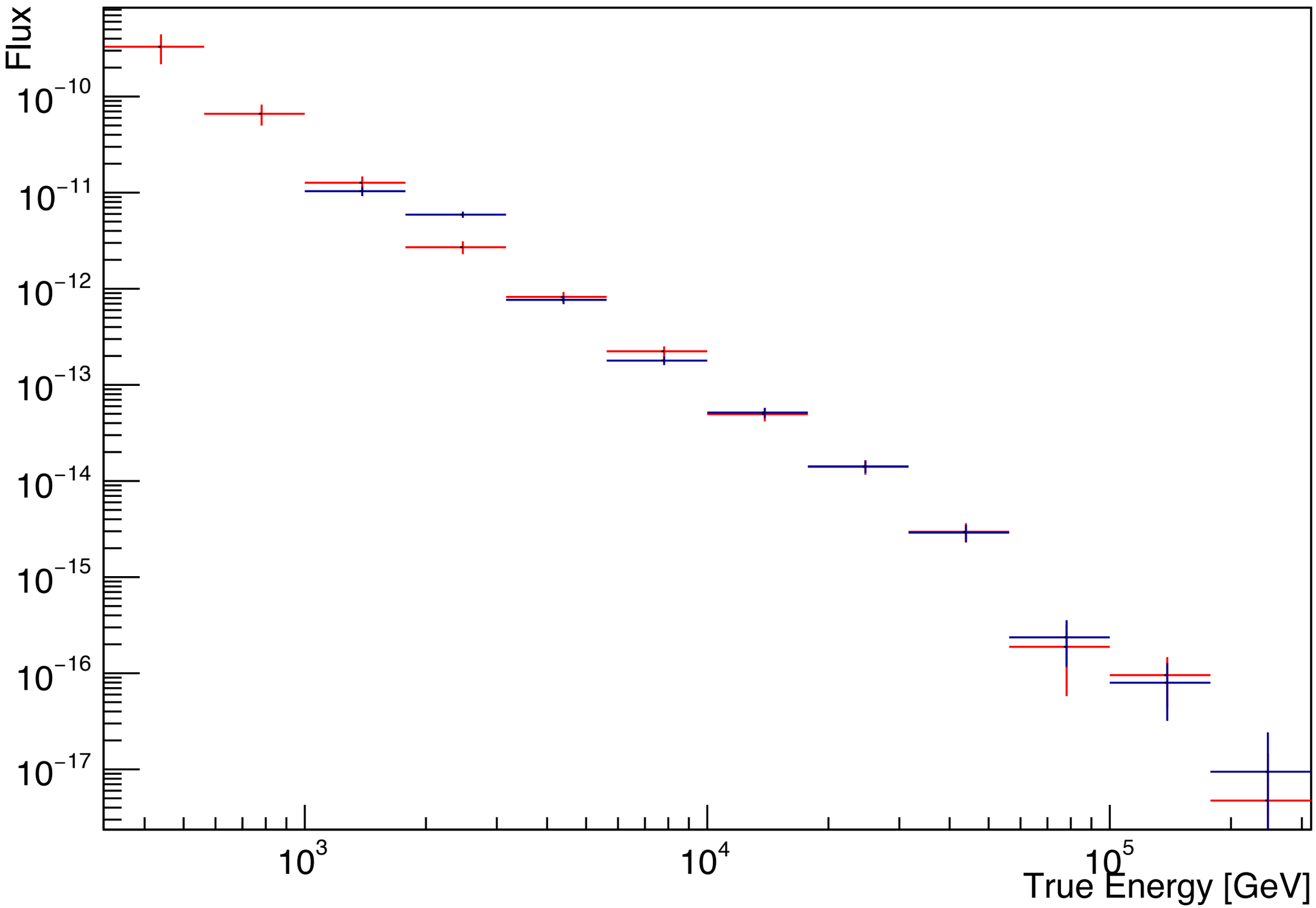
Unfold, NNEnergyV2 + NN cut



Flux, GPEnergyV2 + GP cut script: FluxFit.py

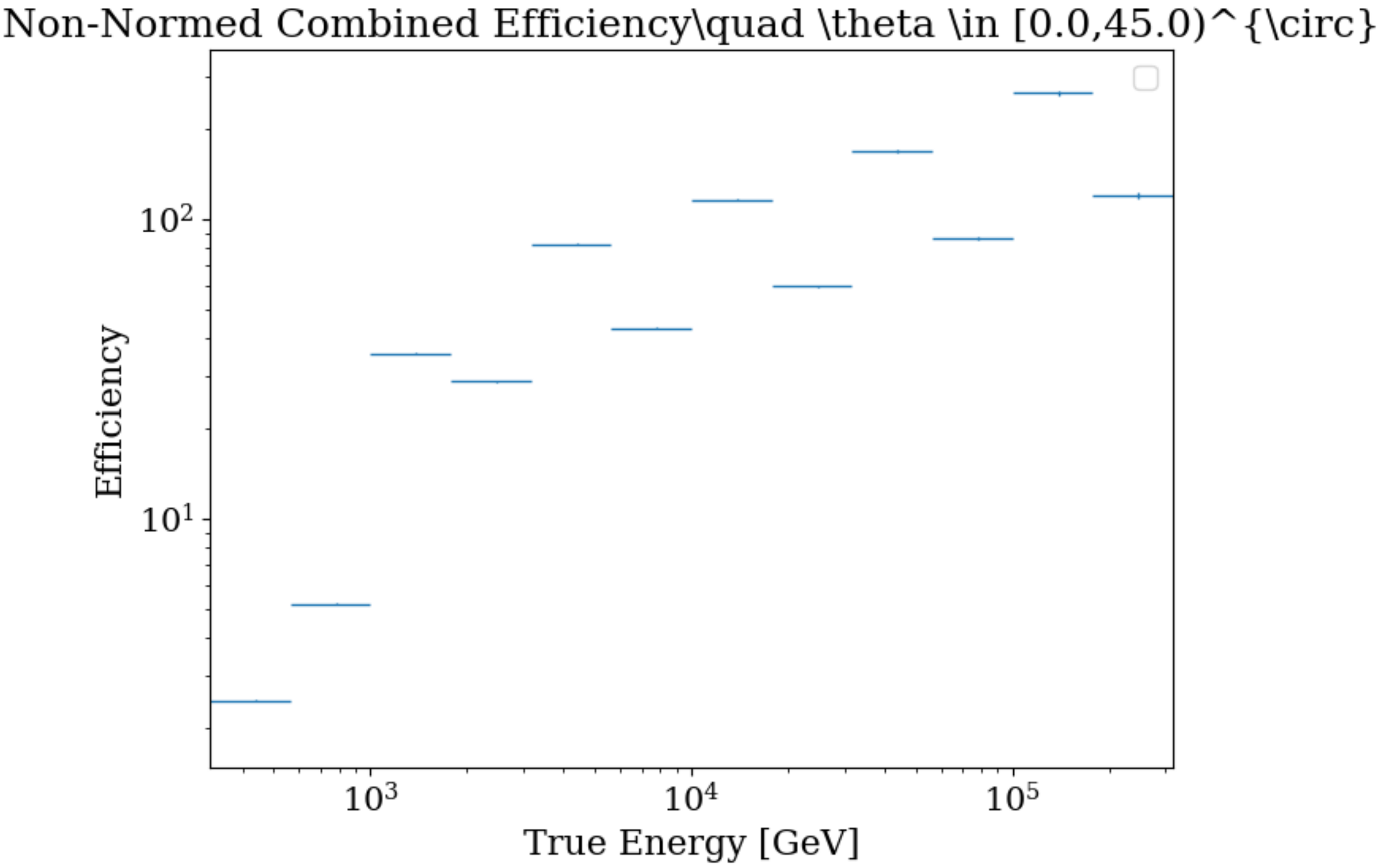


Flux, NNEnergyV2 + NN cut script: FluxFit.py

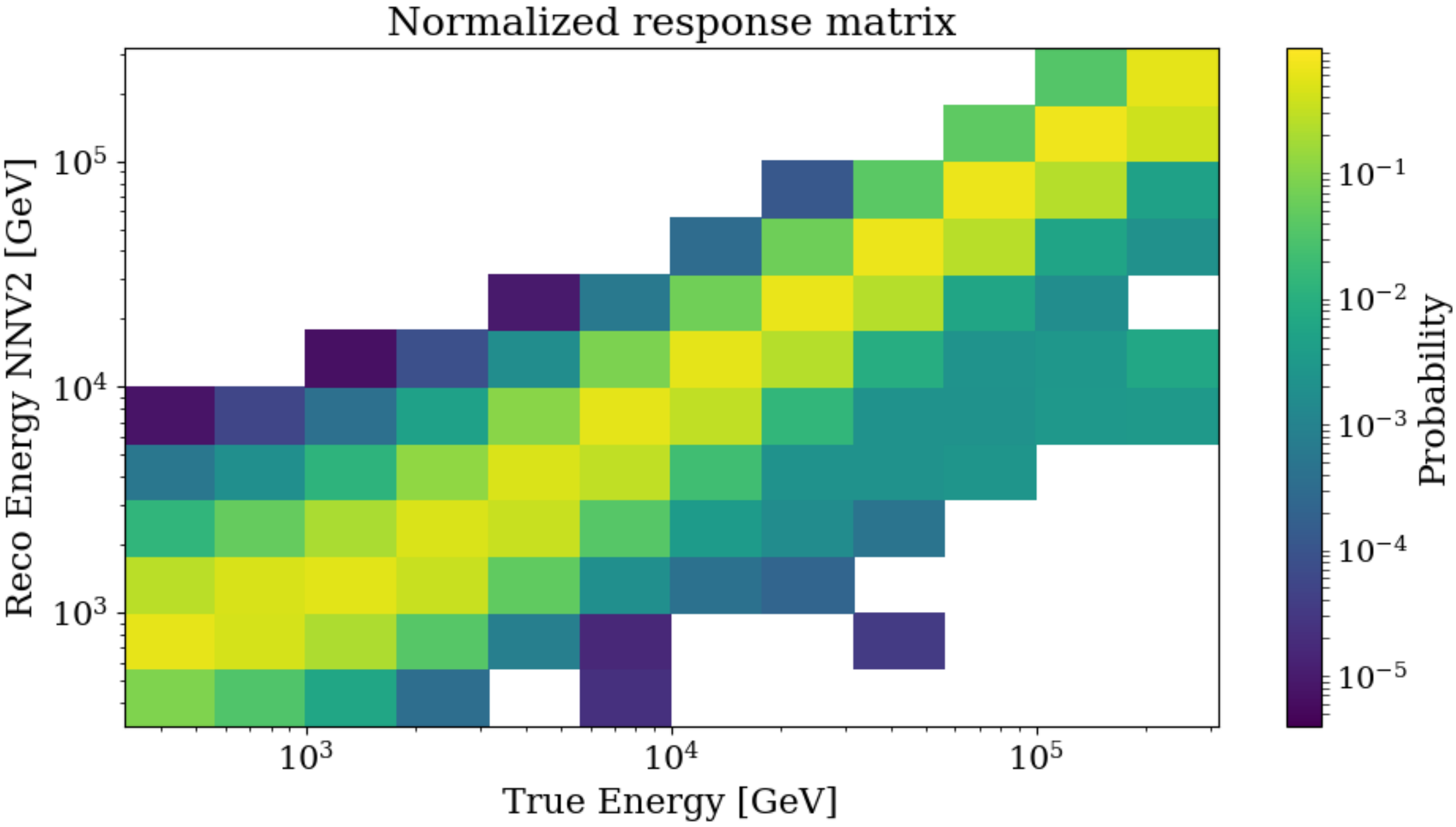


Using TWgt

Efficiency: NNEnergyV2 + NN cuts



Response Matrix:GPEnergyV2 + GP cut



Unfold, NNEnergyV2 + NN cut