Crab energy spectra predictions in high energy bands

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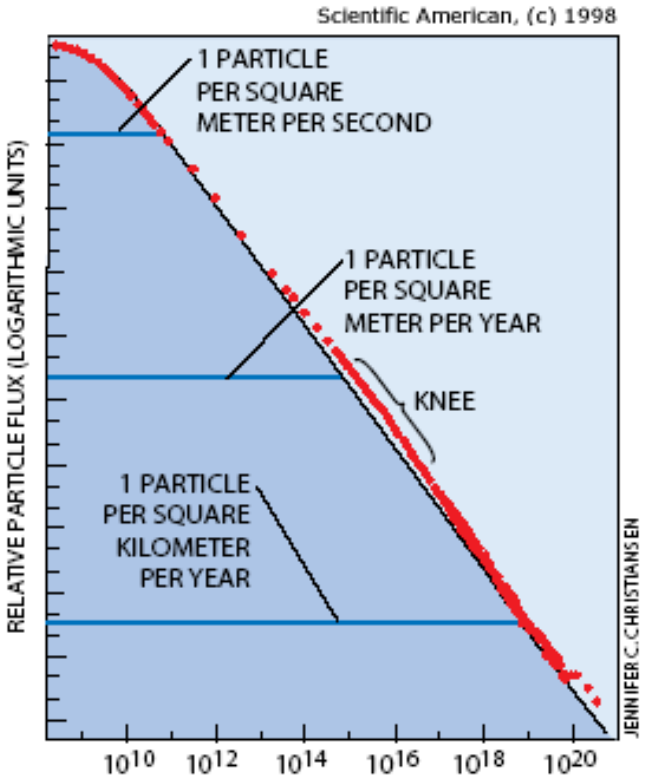
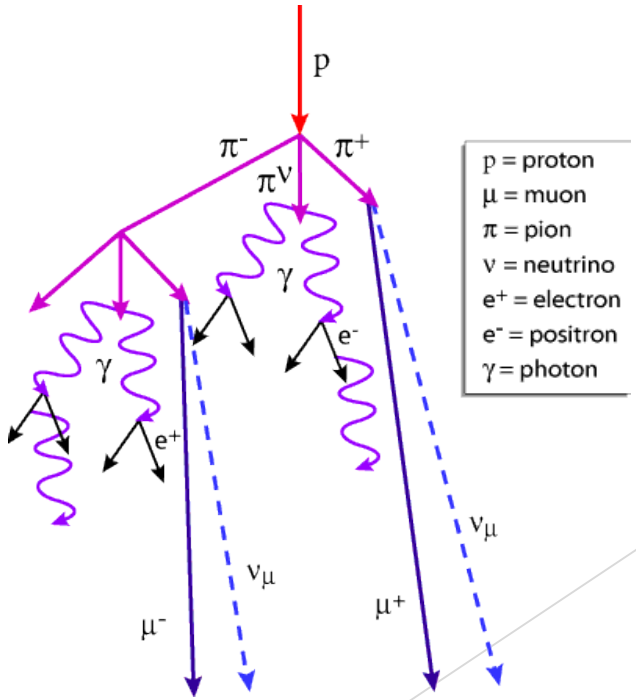
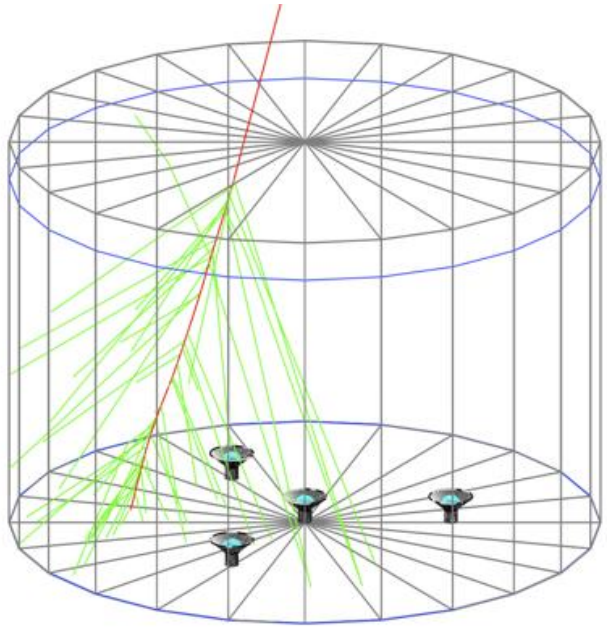
Particle showers

- Tev photons hit the top layer of our atmosphere and immediately starts to lose energy as it interacts with air molecules, these interactions create particles, which intern interact with the atmosphere to create even more particles, creating a ‘shower’ of sorts, until the average particle energy is around 80 Mev at which point absorption will begin. [4]





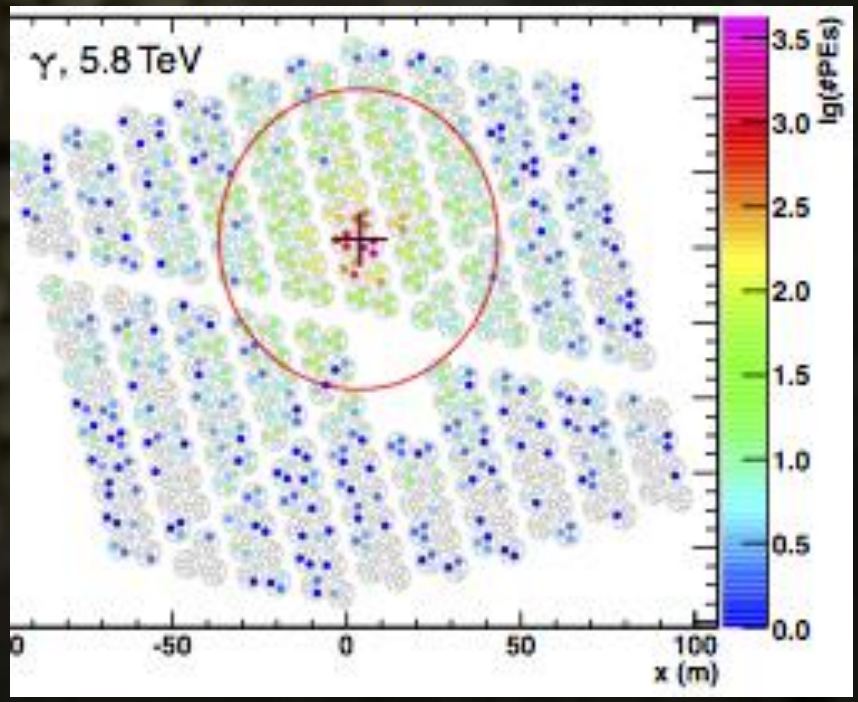
Data collection



- When the particles hit the Cherenkov detector they cause the fluid inside to emit electrons and the resulting energy of each those electrons can be read to determine the energy of the initial particle that started the shower [4]

- Here we can see the result of a shower initiated by a 5.8 Tev particle. The high altitude of the HAWC observatory allows the majority of the shower to interact with the array of Cherenkov detectors, at sea level almost all of the shower would be absorbed by the atmosphere

Data visualization



deconvolution

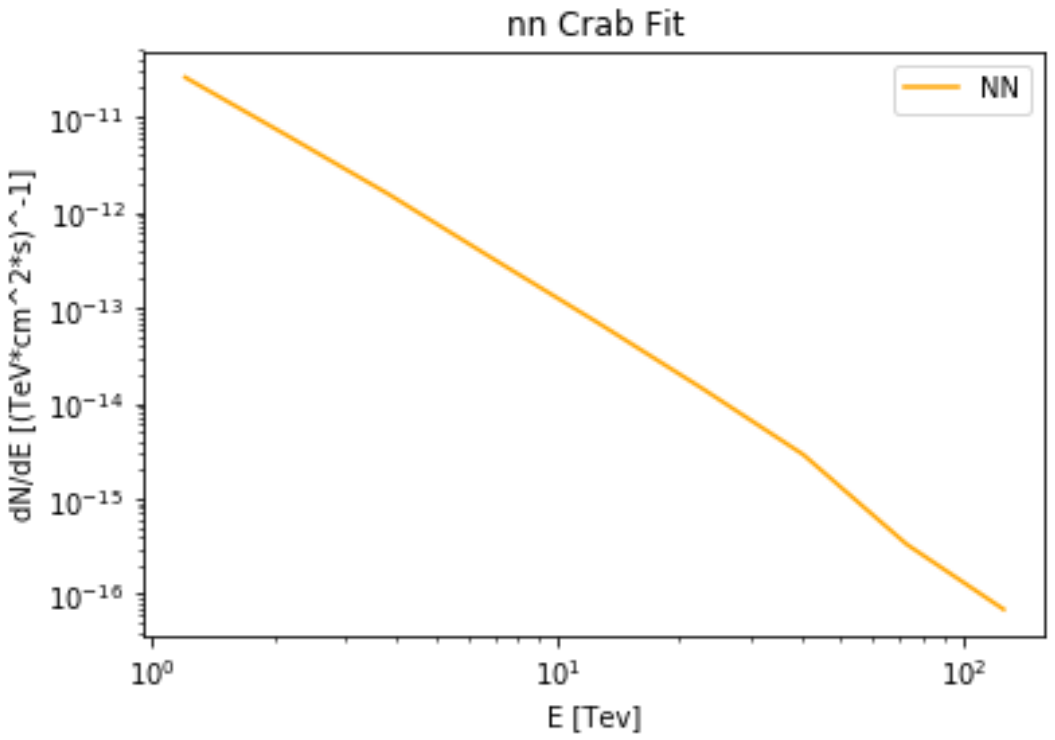
- The method of analysis of the crab spectrum will involve deconvolution. Using monte carlo data, the ratios between true energies and observed energies will be calculated as a function of energy. This will produce a function that can be multiplied by the crab spectrum flux from what is observed to improve its accuracy

The Crab Nebula

- First discovered in 1054 by Chinese astronomers, the crab nebula was only discovered to be a TeV source (relatively) recently in 1989 [2]
- Below 50 TeV in the very high energy band, its considered to be standard candle whose spectrum is well understood, making it a good candidate to test this method of cross check

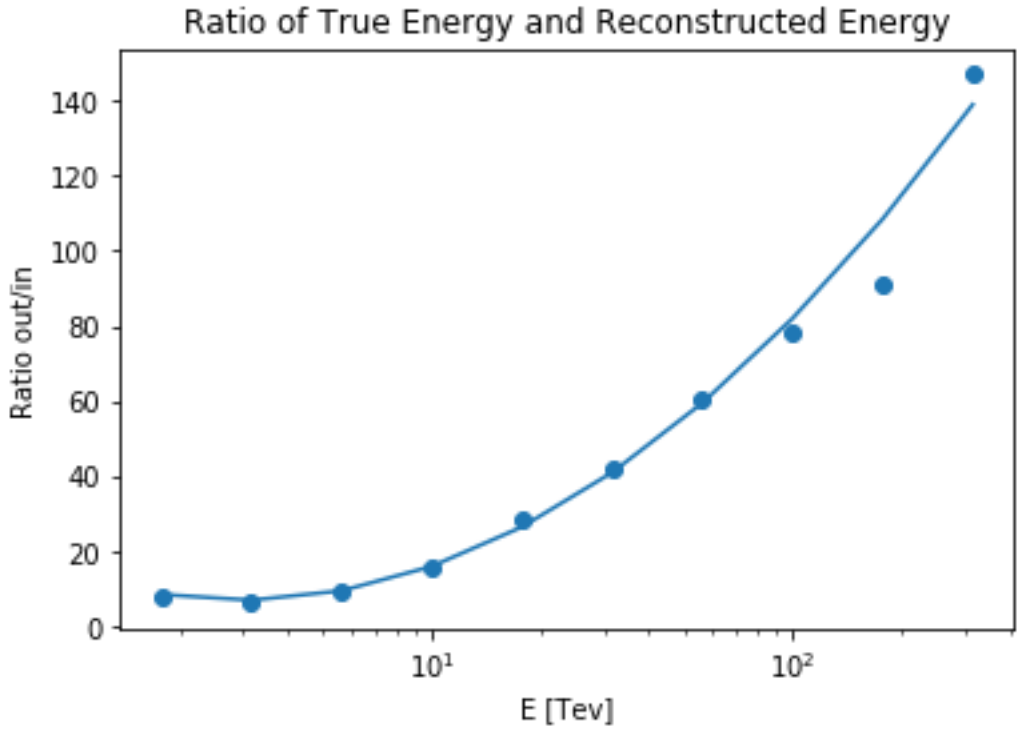
The neural Network crab spectrum

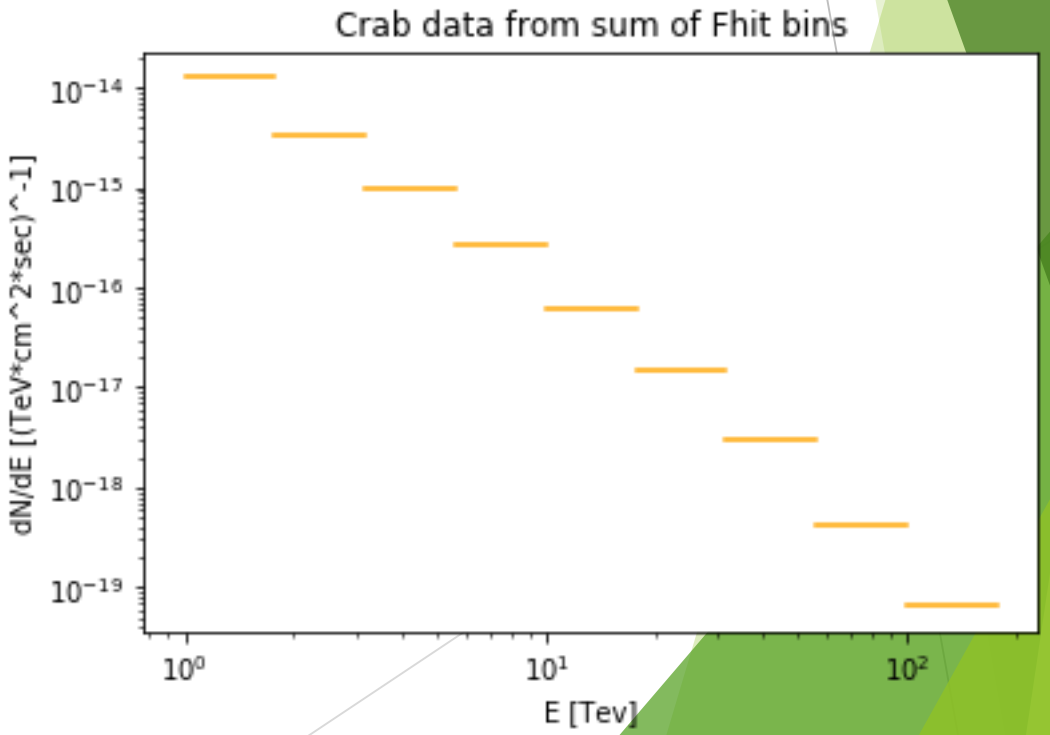
- This is what the deconvolution should approximate to act as a crosscheck that the input data is permuted correctly by the neural network
- A histogram will be constructed from events originating from the crab binned by energy



Computing the ratio

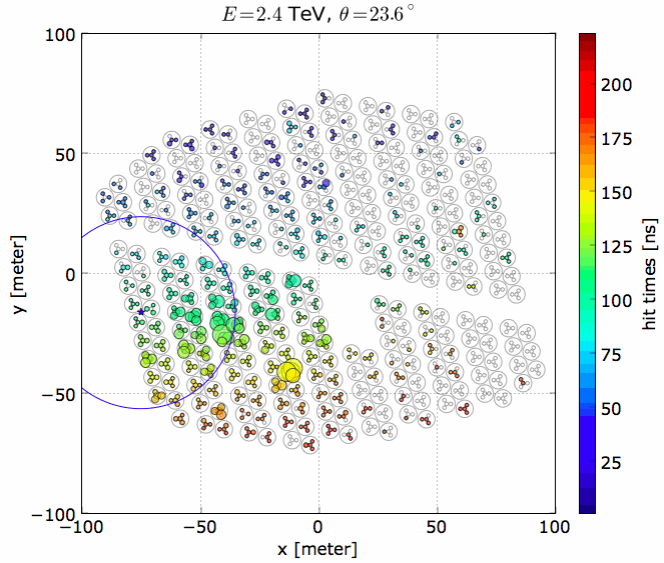
- Needed quantities: True energy, Estimated energy, Event weighting
- Populate a histogram with these energies, one from all the data and one from the same pool with various cuts (fiducial scale, fraction hit, and delangle) with binning scheme from HAWC collaboration [1]
- Since the binning schemes are the same, divide histograms (estimated energy over true energy) to yield a ratio as a function of energy



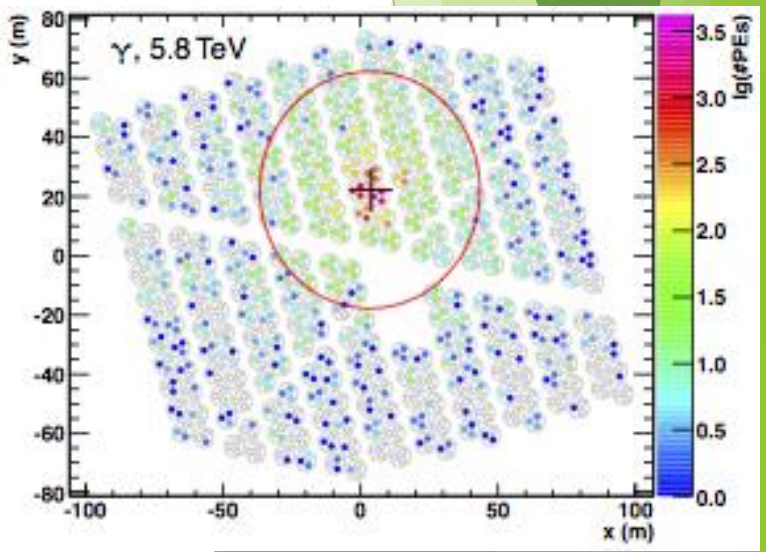


Computing the energy curve

- To compute the flux of the crab spectrum, we'd want to subtract the observed energy by the background in each bin.
- at this point the resolution of this data would entail a 2d binning of the flux in energy and 'Fhit', or roughly the fraction of the event shower that lies within the detector radius.
- Summing each Fhit bin within an energy bin will provide us with a rough dN/dE flux curve.

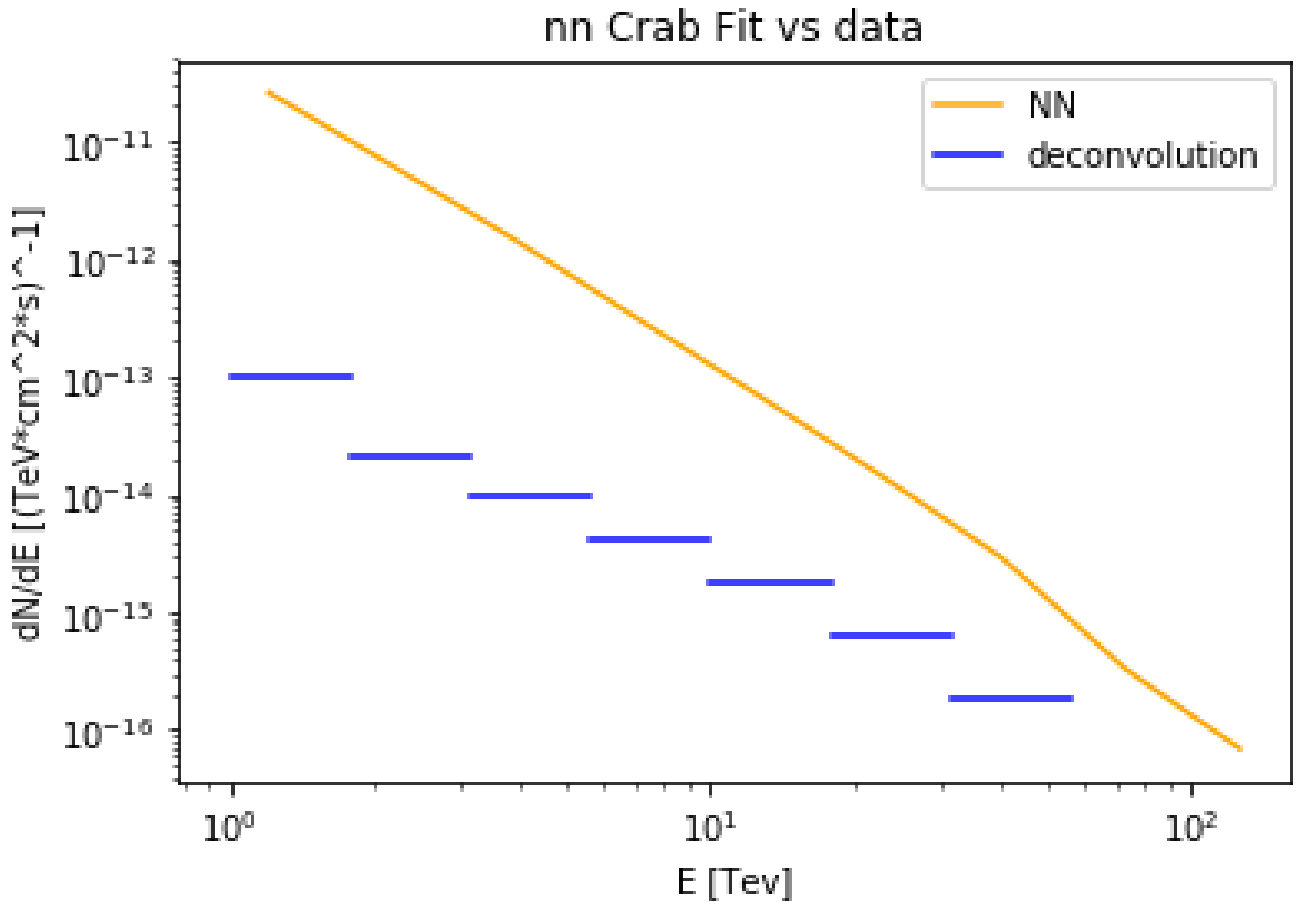


- The event on the left has a lower Fhit than the one on the right, as we can see almost half of the shower lies off the detector, whereas for the right, the core of the event is completely captured by the detector.[4]



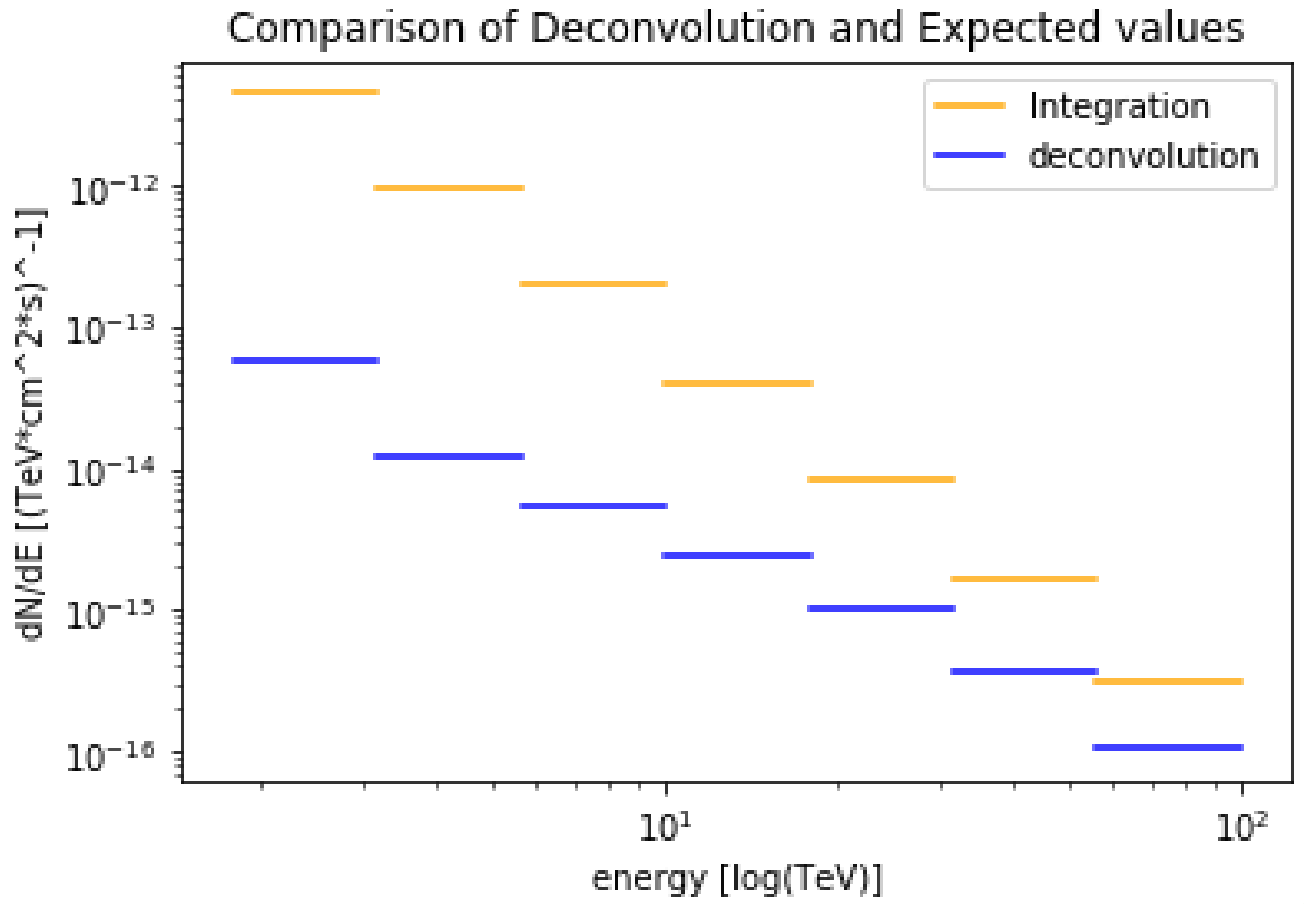
Resultant curve; ratio times energy curve

- These values are not quite consistent
- If this was the result of a simple error in computation the difference between both curves would likely be more homogenous



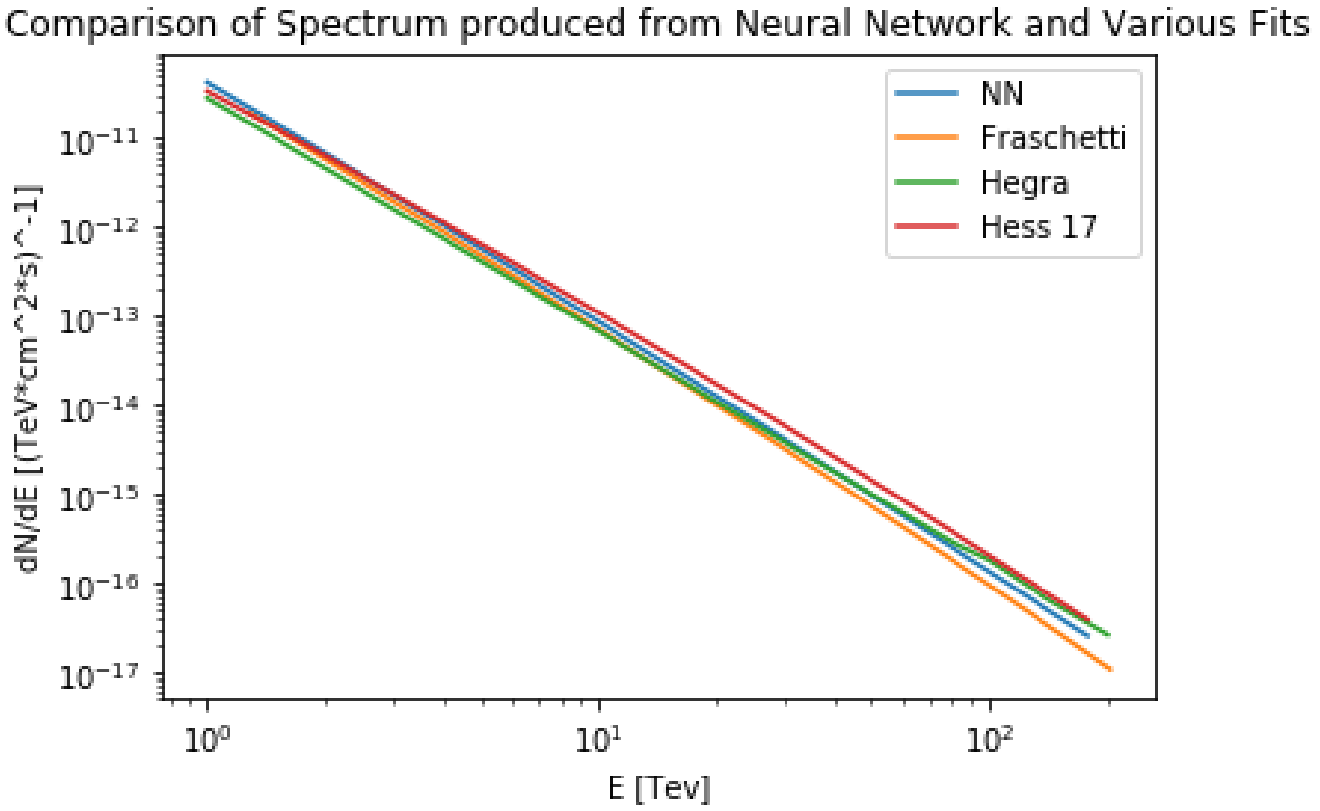
Evaluation; This curve as a crab spectrum prediction and cross check

- The previous curve is not a valid result, what is expected from this deconvolution can be seen if the functional form of the spectrum produced by the neural net is integrated across each bin width



further research

- Here it can be seen that the spectrum produced by the neural network agrees with several spectra produced from other collaborations [4]
- The errors in the deconvolution are likely due to inconsistencies between the data that contributed to it (i.e. the version of the monte carlo). With more time it will be possible to isolate these issues and eliminate them



Comparison to curves from other collaborations [2][3]

references

1. A.U. Abeysekara et al. "OBSERVATION OF THE CRAB NEBULA WITH THE HAWC GAMMA-RAY OBSERVATORY." 1701.01778.Pdf, HAWC Observatory, 17 Jan. 2017, arxiv.org/pdf/1701.01778.pdf

2. Fraschetti, F., and M. Pohl. "Two-Zone Model for the Broadband Crab Nebula Spectrum: Microscopic Interpretation."EPJ Web of Conferences, 2017, doi:10.1051/epjconf/20171360200

3. H.E.S.S. Collaboration, "The Crab Nebula," H.E.S.S. - The High Energy Stereoscopic System, October 1, 2004, accessed April 23, 2019 https://www.mpi-hd.mpg.de/hfm/HESS/pages/home/som/2004/10/

4. "HAWC." HAWC Collaboration, HAWC Observatory, 2011, accessed April 23, 2019 www.hawc-observatory.org/