Dark matter annihilation into right-handed neutrinos and the galactic center gamma-ray excess

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This slide is based on this paper,
arxiv:1512.02899, by Yi-Lei Tang and Shou-hua Zhu

Introduction to the photon excess from the galactic center

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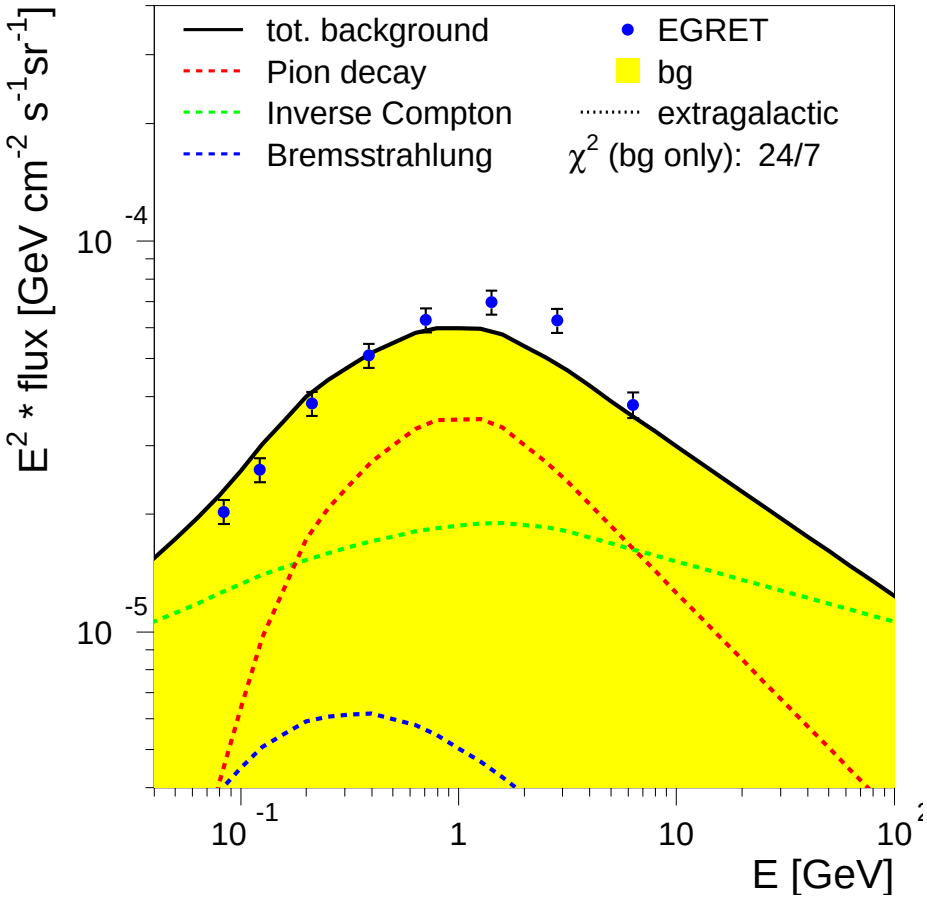

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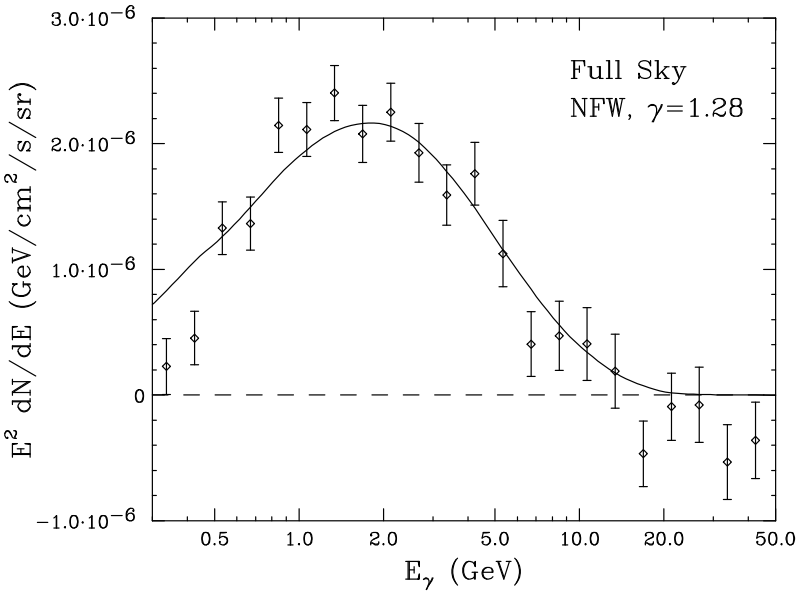

Figure : Tansu Daylan, et.al., arxiv:1402.6703.

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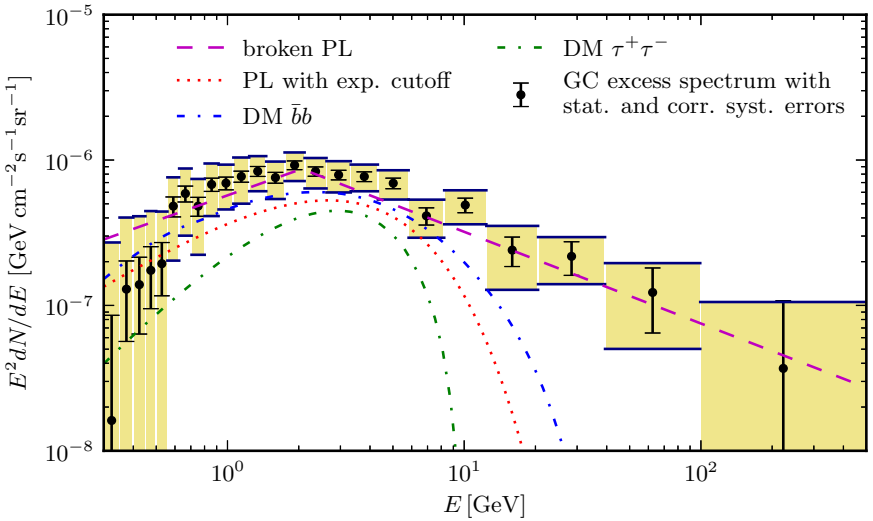

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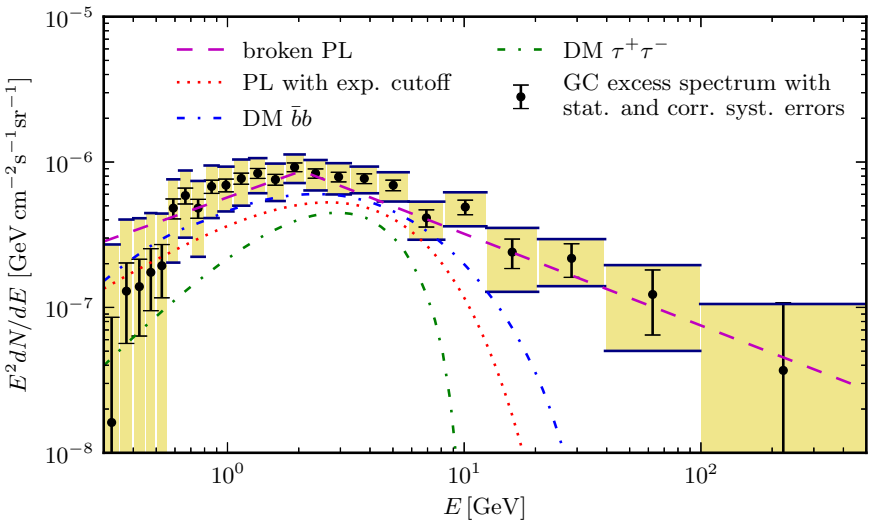

Note that large correlations among the systematic errors of different bins should be considered during the fitting processes.

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$$\chi^2 = \left[\frac{dN}{dE} - \left(\frac{dN}{dE}\right)_{\text{obs}}\right] \cdot \Sigma^{-1} \cdot \left[\frac{dN}{dE} - \left(\frac{dN}{dE}\right)_{\text{obs}}\right]. \qquad (1)$$

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- The data is actually on the homepage of one of the authors, `http://christophweniger.com/?page_id=248`.

Introduction to the WIMP Dark Matter

- Weak Interacting Massive Particles (WIMPs). As the temperature of the universe drops down after the Big Bang, the annihilating dark matter particles finally "freeze-out" when $n_{eq}\langle\sigma v\rangle_{\text{dec}} \approx H$.

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Explaining the Excess from the Galactic Center

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- Sub-dominant inverse Compton scattering to the CMB, bremsstrahlung, synchrotron radiation... (Usually omitted in the hadronic final states).

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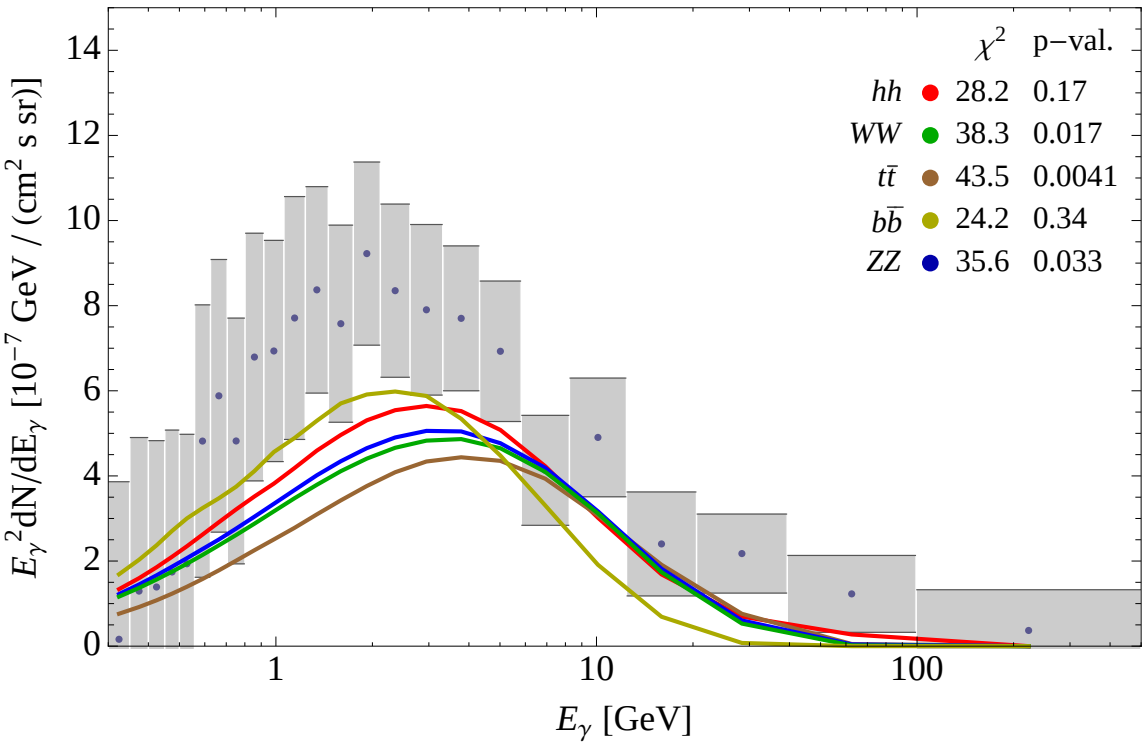

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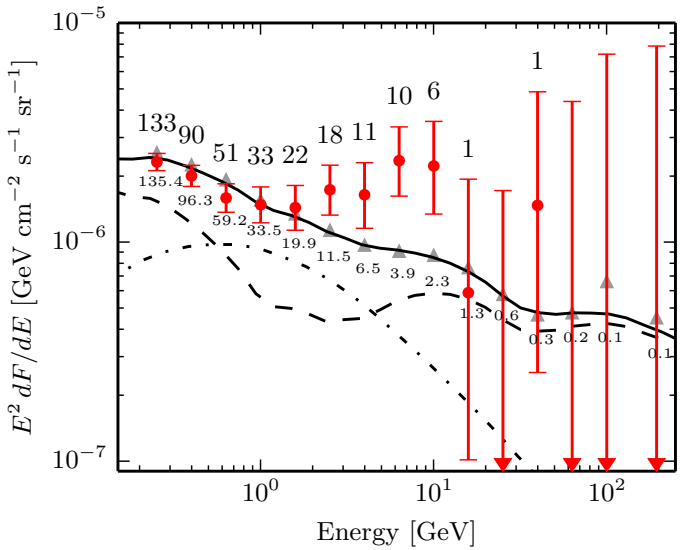
- It should be noted that recently, there seem to be some excesses from two dSphs, Reticulum II (See arxiv:1503.02320) and Tucana III (See arxiv:1511.09252).



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- For linear see-saw or inverse see-saw, y_ν can be as large as 10^{-3}.

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- Build model by ourselves?

γ spectrum from the N's decay

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- Solution: We have used MadGraph to calculate the three-body decay, and input the event file to Pythia8 to do showering, hadronization, and particle decay processes.

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- $\frac{\sum_i Br(N\to\nu_i Z^*)}{\sum_i Br(N\to l_i^{\pm} W^{\mp *})}$ is independent on the specific value of y_i's.

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- $\tau_N \lesssim 10^{-3}$ sec $\ll 1$ sec. It might fly for a distance of 10^5 m, which is far below the radius of the Milky Way.

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- The gamma-ray spectrum by general values of $y_{1,2,3}$ are just linear-combinations of the above two cases.

Numerical Results

The best-fitted points are $m_N = 32.0$ GeV, $m_\chi = 44.2$ GeV, with $\chi^2 = 24.22$ and the best-fitted $\langle \sigma v \rangle = 2.63 \times 10^{-26} \mathrm{cm}^3/\mathrm{s}$ for the $y_1 = y_2 = 0$, $y_3 \neq 0$ case, and $m_N = 27.0$ GeV, $m_\chi = 45.4$ GeV, with $\chi^2 = 23.81$ and the best-fitted $\langle \sigma v \rangle = 3.37 \times 10^{-26} \mathrm{cm}^3/\mathrm{s}$ for the $y_3 = 0$, $y_1^2 + y_2^2 \neq 0$ case.

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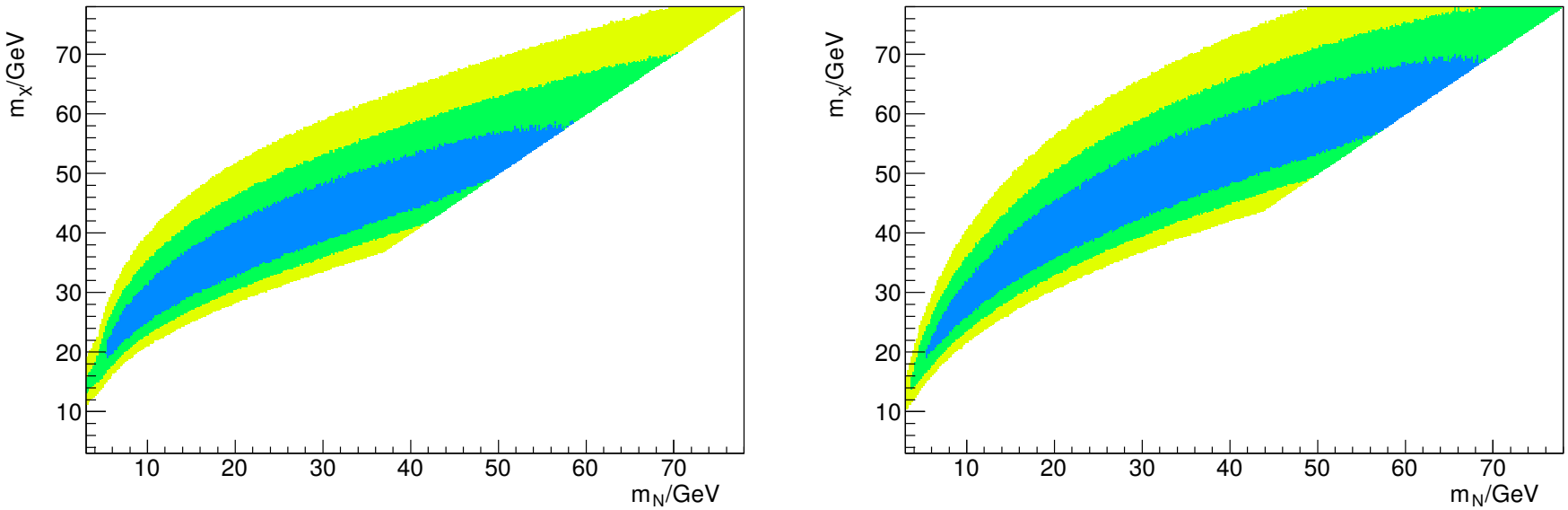

Figure : The $\Delta\chi^2$ figures. The blue, green, yellow areas are corresponding to the 1,2 and 3 σ areas respectively. $\langle\sigma v\rangle$ is adjusted in order to acquire the best-fitted result. The left panel indicates the $y_1 = y_2 = 0$, $y_3 \neq 0$ case. The right-panel indicates the $y_3 = 0$, $y_1^2 + y_2^2 \neq 0$ case.

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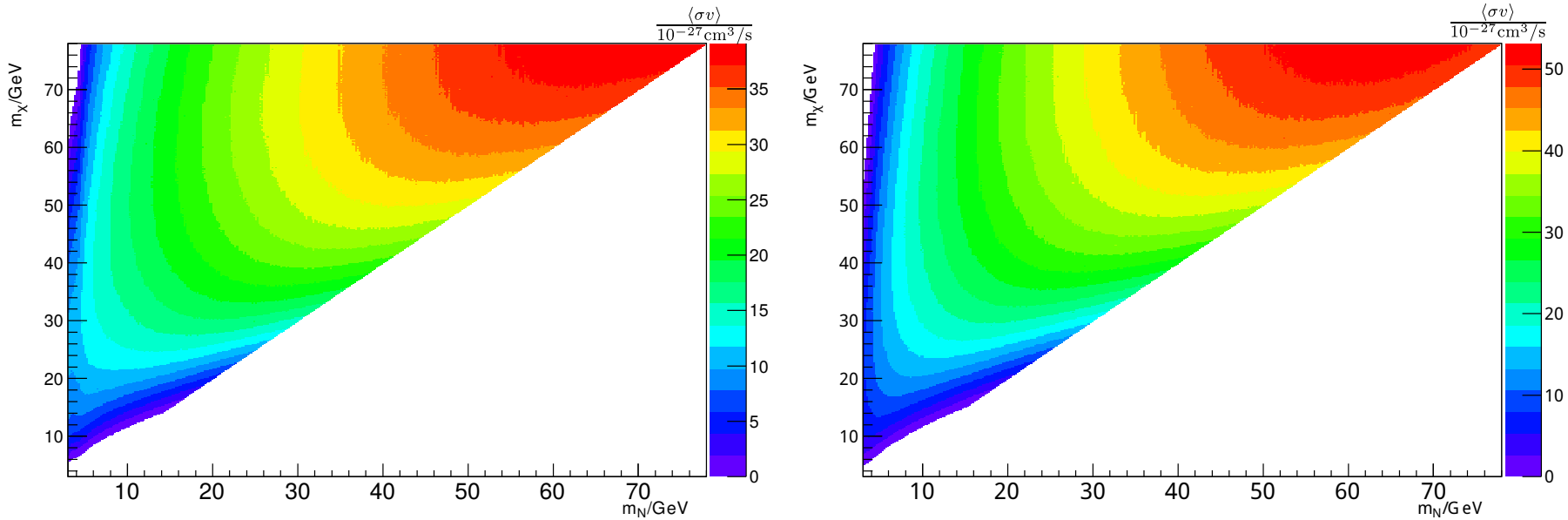

Figure : The best-fitted $\langle\sigma v\rangle = \langle\sigma v\rangle_{\text{real}}\mathcal{J}$, in the unit of cm^3/s. The left panel indicates the $y_1 = y_2 = 0$, $y_3 \neq 0$ case. The right-panel indicates the $y_3 = 0$, $y_1^2 + y_2^2 \neq 0$ case.

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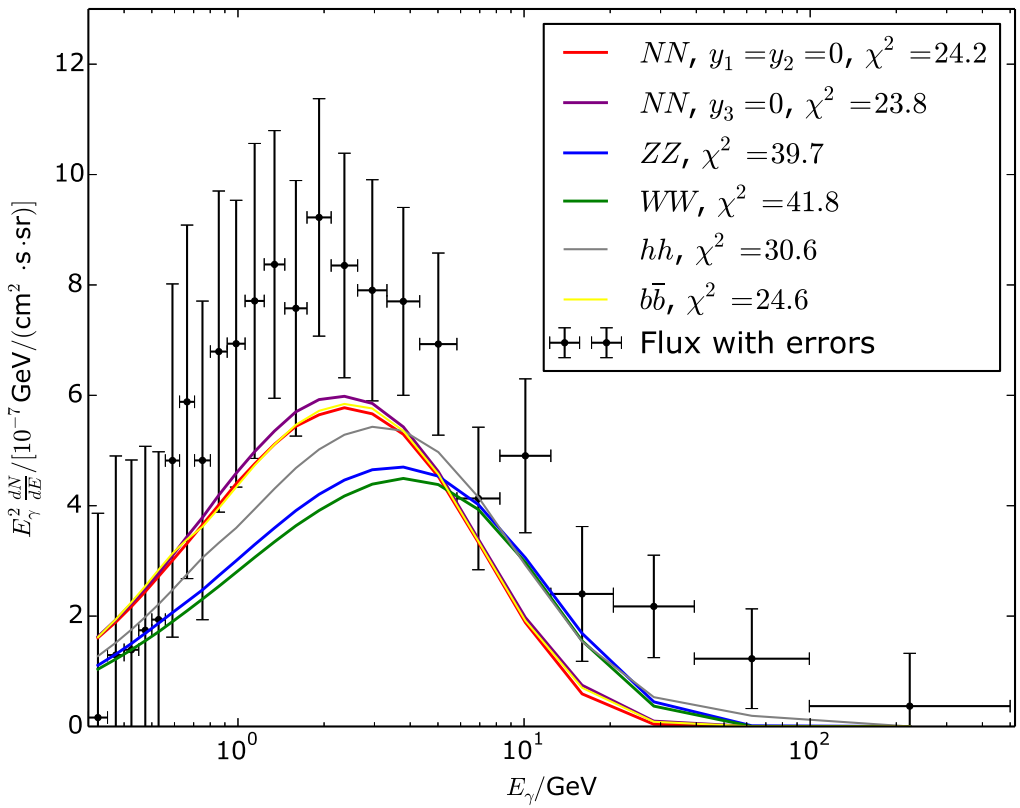

Figure : The best-fitted gamma-ray spectrum together with the observed central values and the errorbars. In the case of $y_1 = y_2 = 0$, $y_3 \neq 0$, $\chi^2 = 24.22$, with the p-value 0.336. In the case of $y_3 = 0$, $y_1^2 + y_2^2 \neq 0$, $\chi^2 = 23.81$, with p-value 0.357.

Future Plan

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- Study the two existing model I have listed before.

Thank You!