Spectral Analysis Comparing Two Different Model

Parameters:

- Index: 2.22
- Amplitude: 1.289e-12 (cm-2 s-1 TeV-1)
- Reference: 1 (TeV)
- Alpha: 1
- Livetime (Duration of exposure of the simulated observation): [25,20,10,8,5,4,2,1] hrs
- Number of observations (no. of simulate spectra using the same set of observation conditions): [40,50,100,125,200,250,500,1000]
- Total Runtime (Total observation time i.e; Livetime* No. of Observations): 1000 hrs
- Energy Range: 30GeV - 100TeV
- Model : [PowerLaw, L=0.01, L=0.1, L=0.2, L=0.3, L=0.5], here L represents the value of lambda for 5 different Exponential Cutoff PowerLaw

Functional Forms:

PowerLaw:

$$\phi(E) = \phi_o.(\frac{E}{E_o})^{-\Gamma}$$

Where,
Index: Γ
Amplitude: ϕ_o (cm-2 s-1 TeV-1)
Reference: E_o (TeV)

Exponential Cutoff PowerLaw:

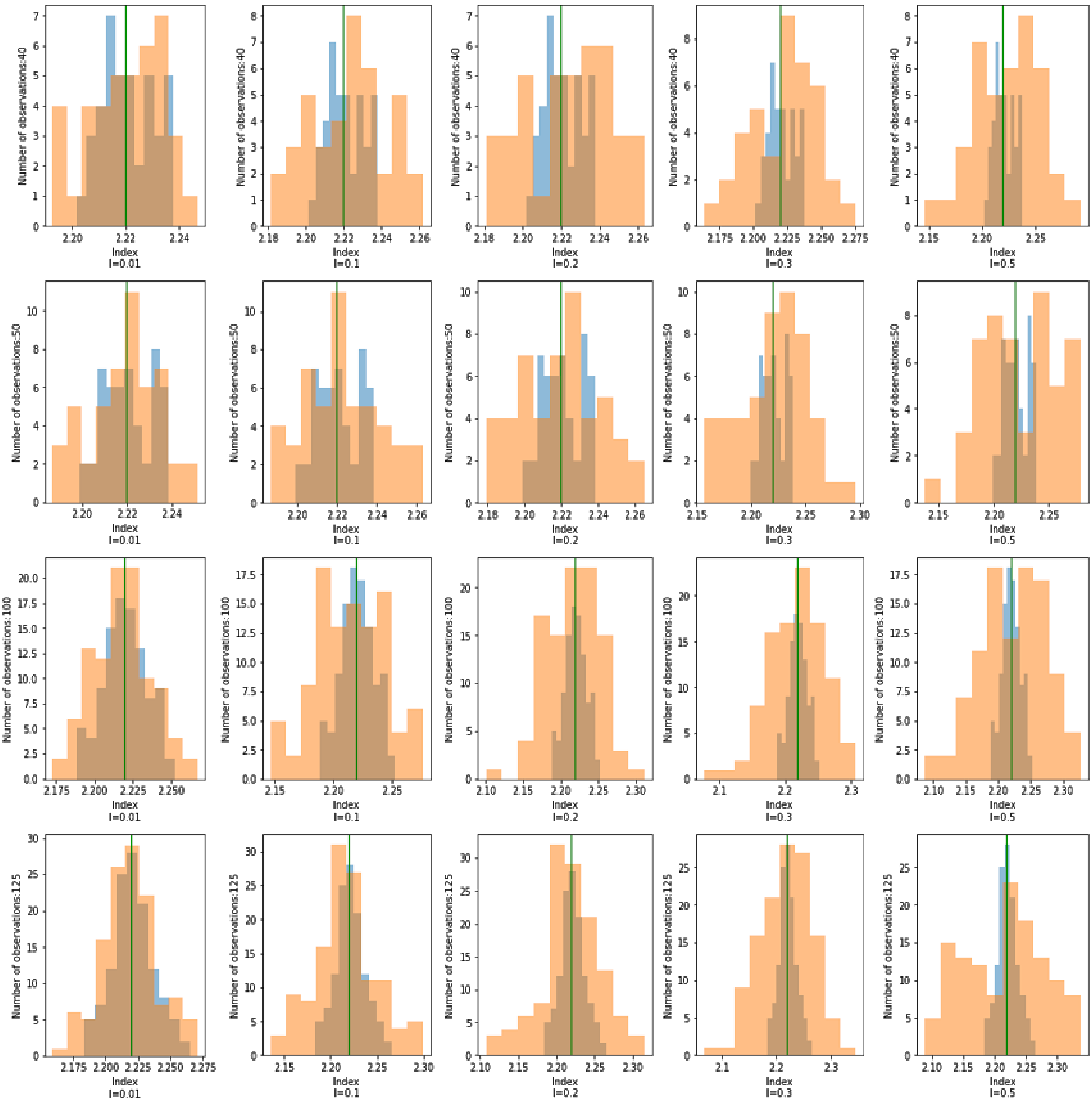
$$\phi(E) = \phi_o.(\frac{E}{E_o})^{-\Gamma}.exp(-(\lambda E)^{\alpha})$$

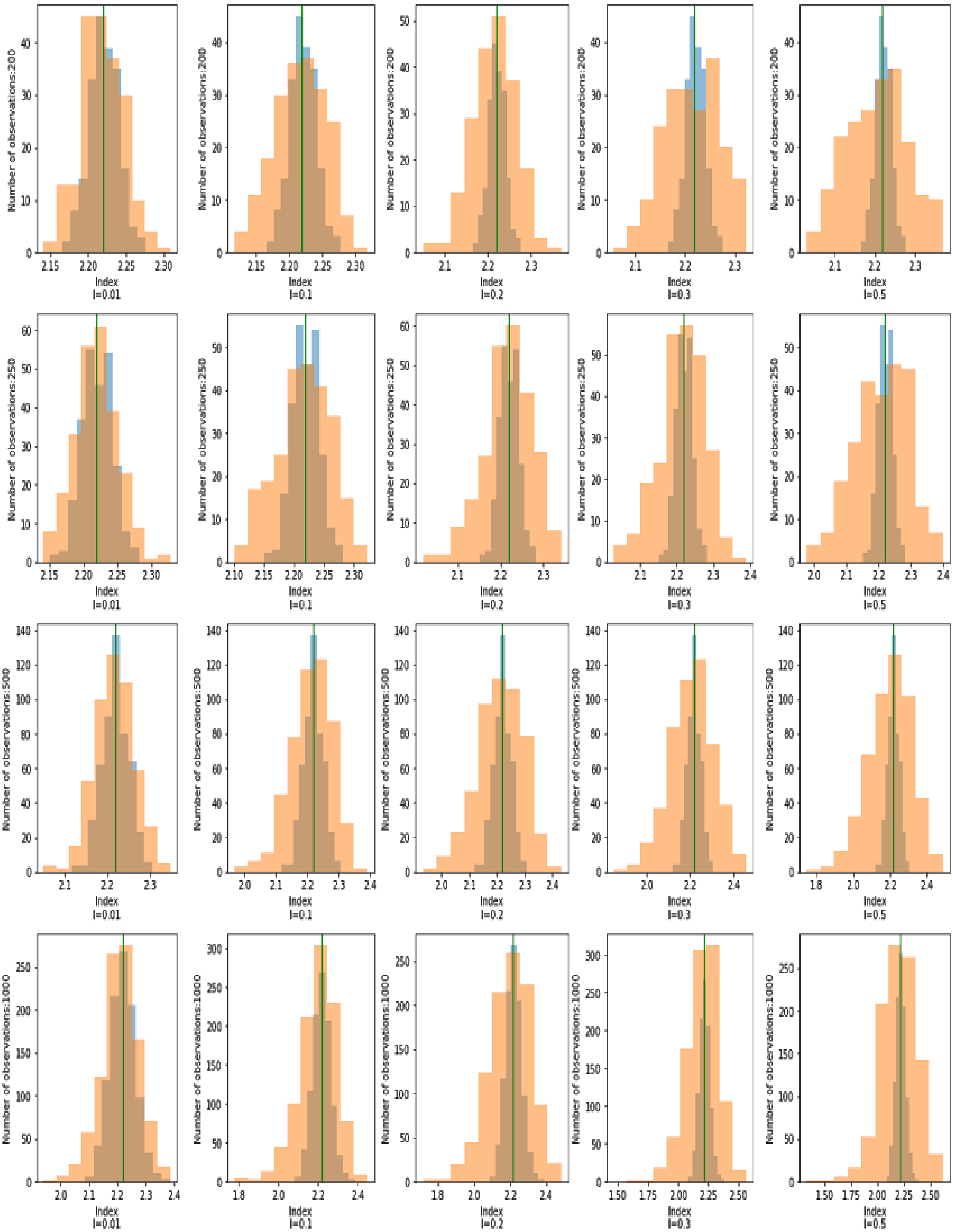
Where,
Index: Γ
Amplitude: ϕ_o (cm-2 s-1 TeV-1)
Reference: E_o (TeV)
Lambda_: λ (TeV-1)
Alpha: α

Comparing PowerLaw with Exponentialcutoff PowerLaw with different Lambda values for the different number of observations:

Here I am comparing histograms for two models mainly **Powerlaw** and **Exponentialcutoff_PowerLaw**. **Horizontally** is the comparison with different values of lambda(cutoff value). **Vertically** is the comparison for different values of n_obs(no. of observations). Comparison has been done for Index and Amplitude values.

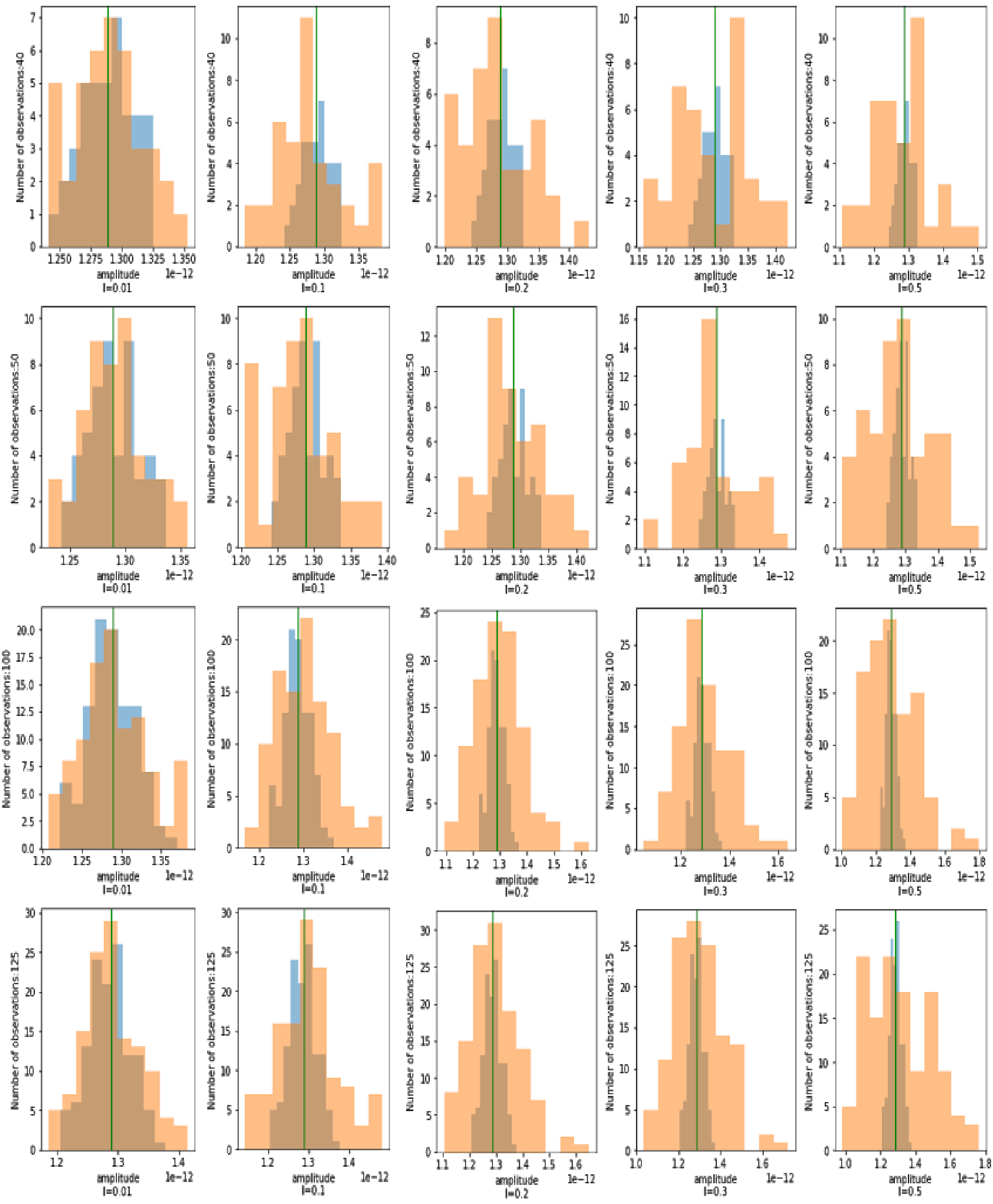
Index:



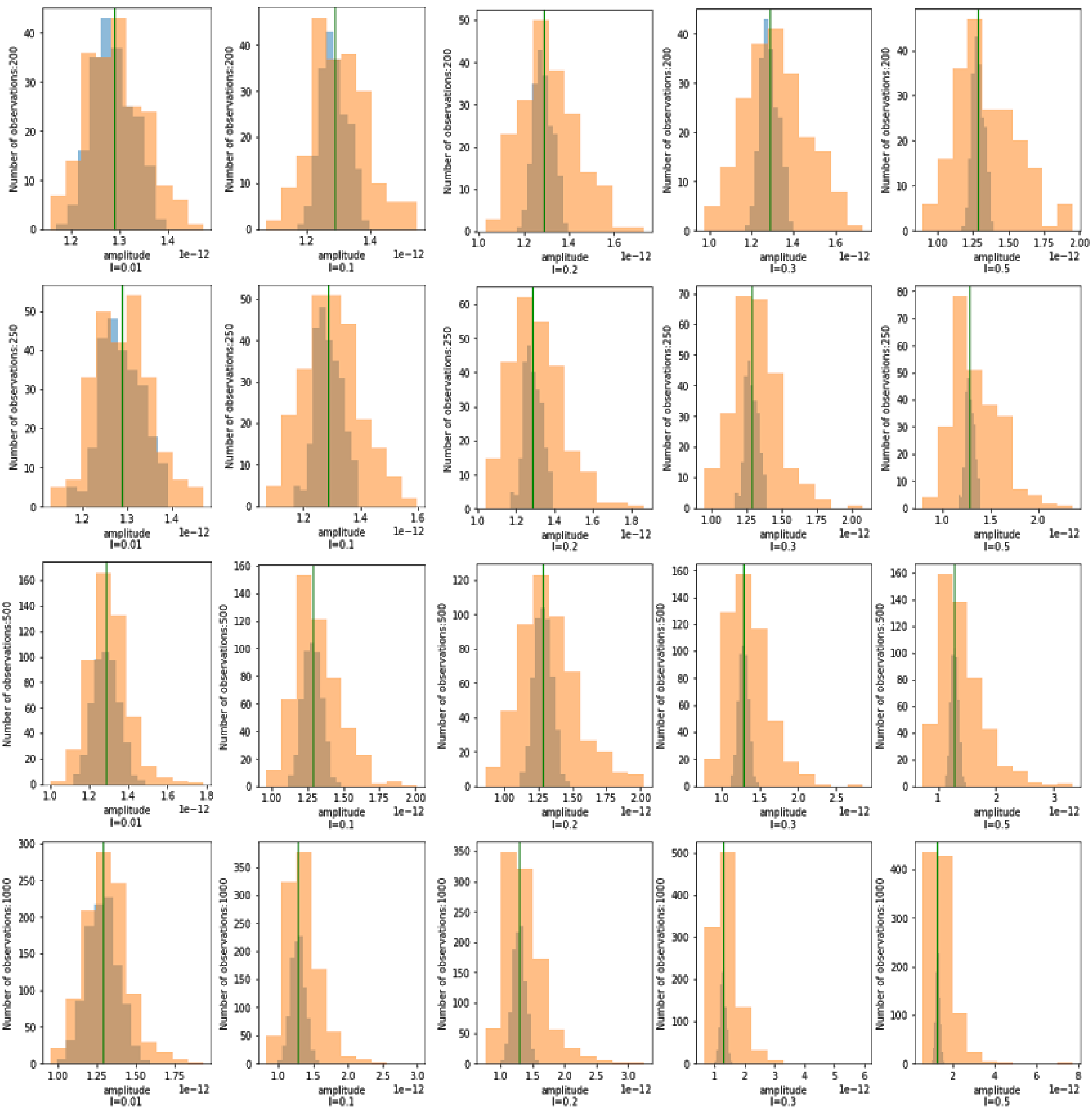


Number of observations:200
Index
l=0.01
l=0.1
l=0.2
l=0.3
l=0.5
Number of observations:250
Number of observations:500
Number of observations:1000

Amplitude:



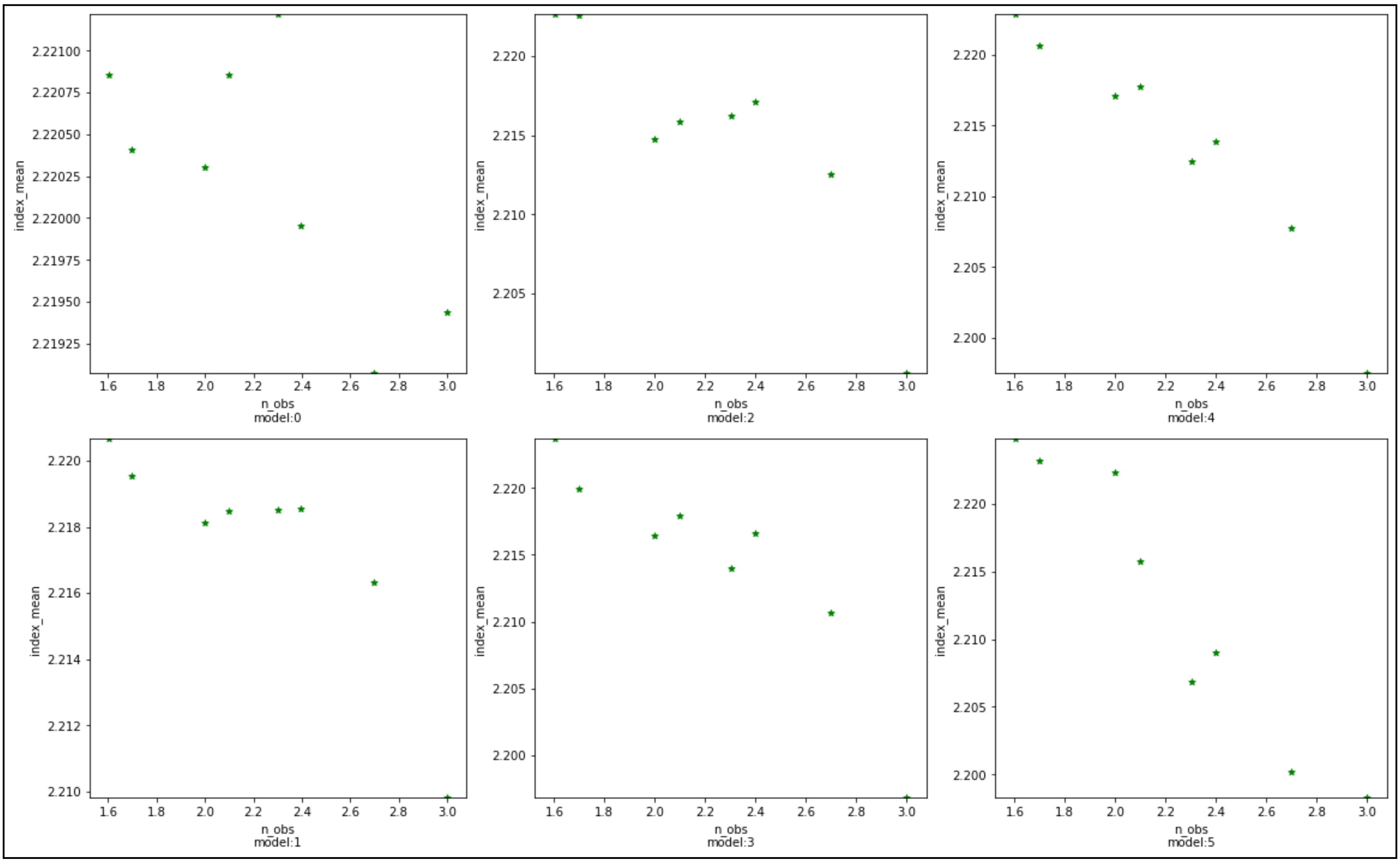
Number of observations:40
Number of observations:50
Number of observations:100
Number of observations:125
amplitude
1e−12
l=0.01
l=0.1
l=0.2
l=0.3
l=0.5

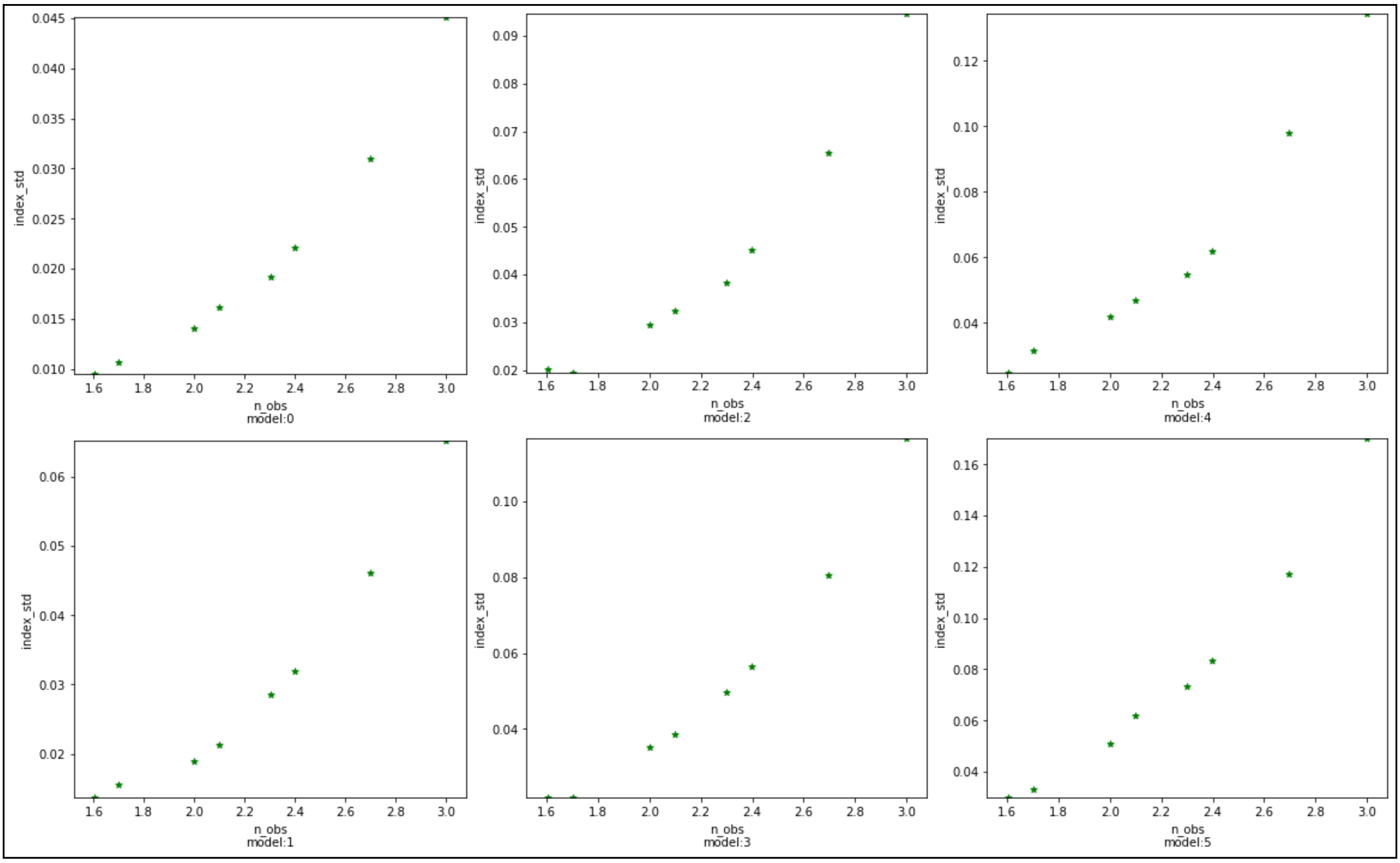


Comparing how Index, Amplitude, Lambda values changes as we change the number of observations for different models:

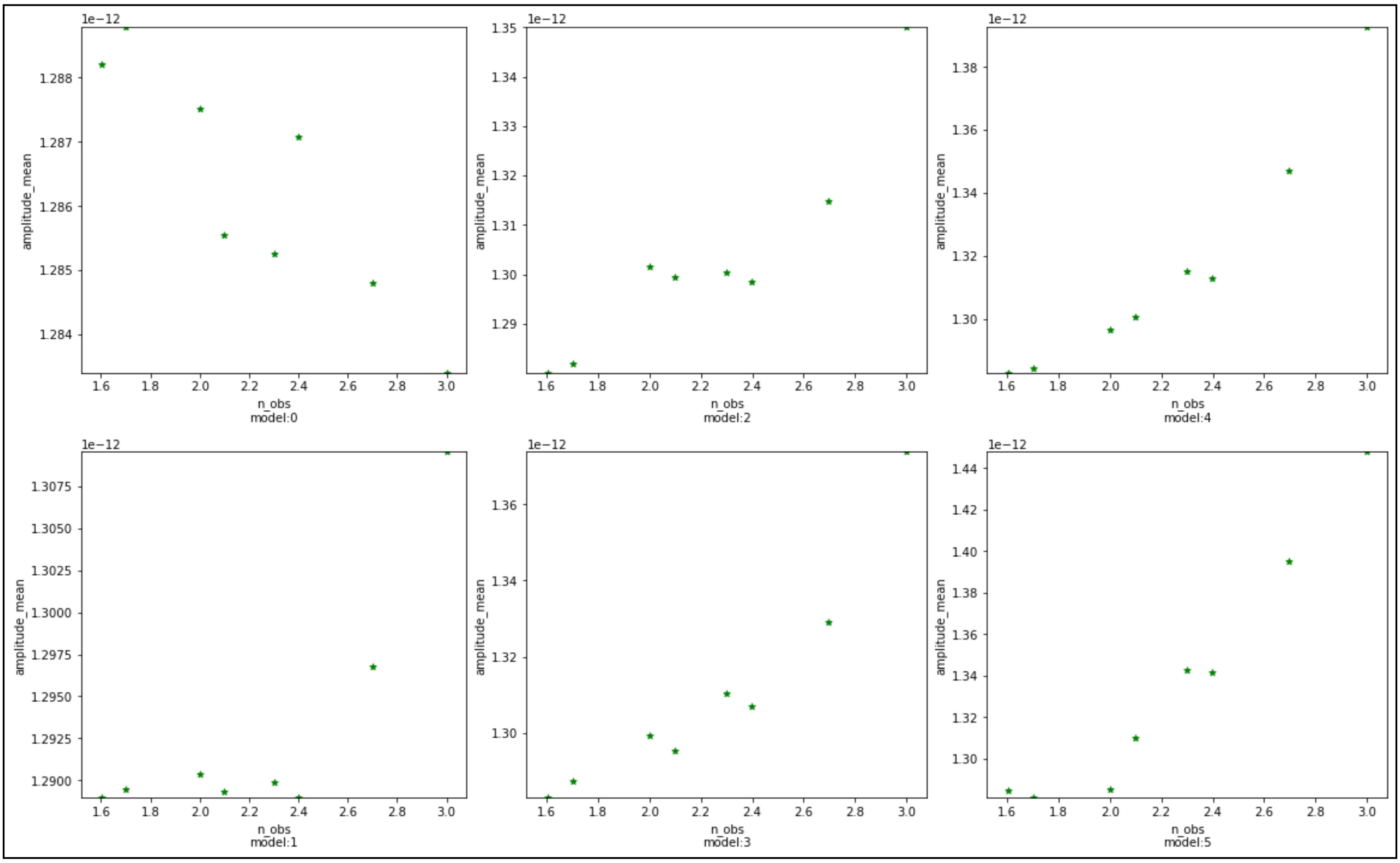
In these plots, we see how the **mean** and **standard deviation** of index, amplitude and lambda change on increasing the number of observations. There are a total of 6 plots for each of 3 parameters, simultaneously also comparing 6 different models with model no. mentioned in their **x-label**.

Index:

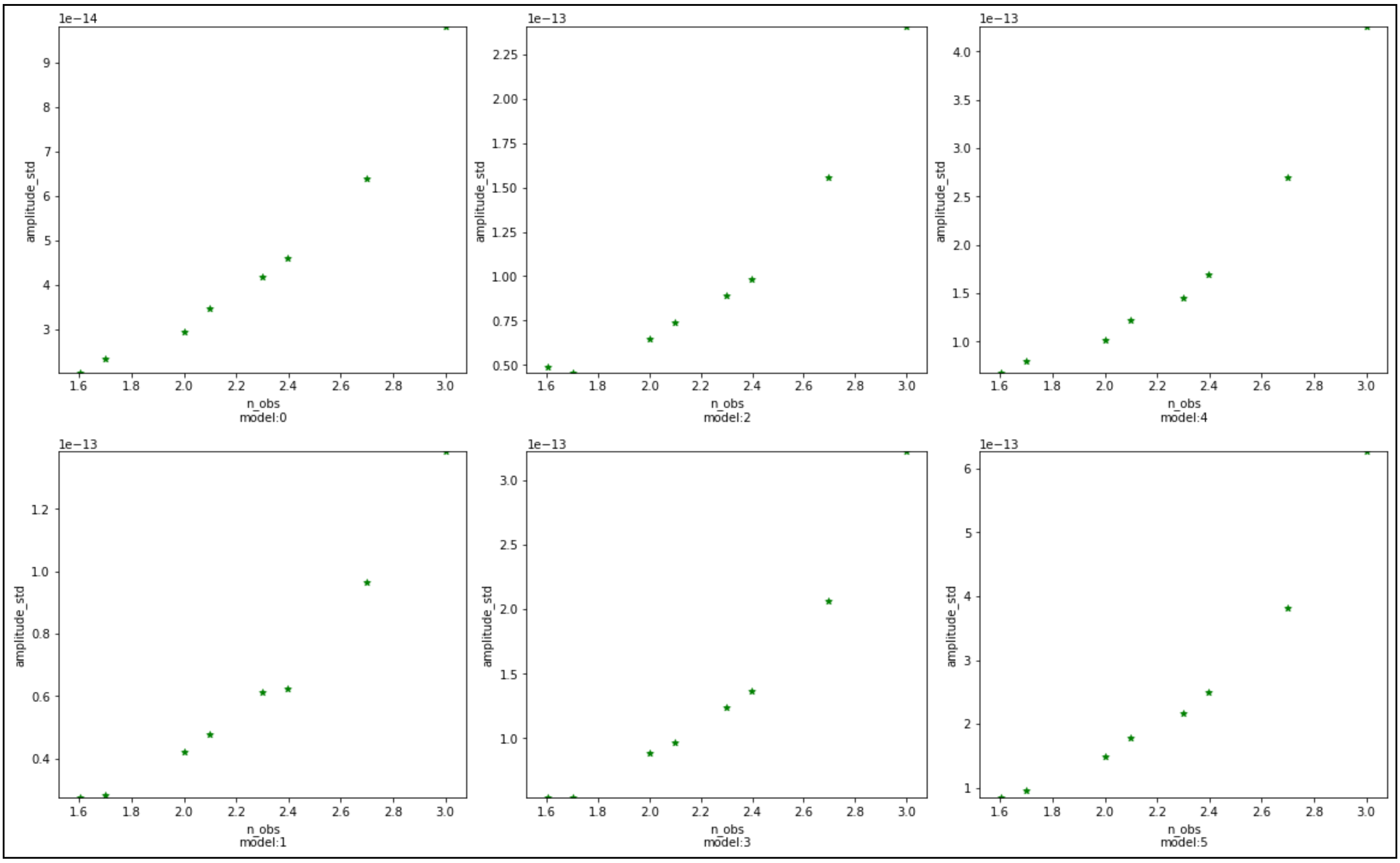

index_mean
n_obs
model:0
model:2
model:4
model:1
model:3
model:5


index_std
n_obs
model:0
model:2
model:4
model:1
model:3
model:5

Amplitude:

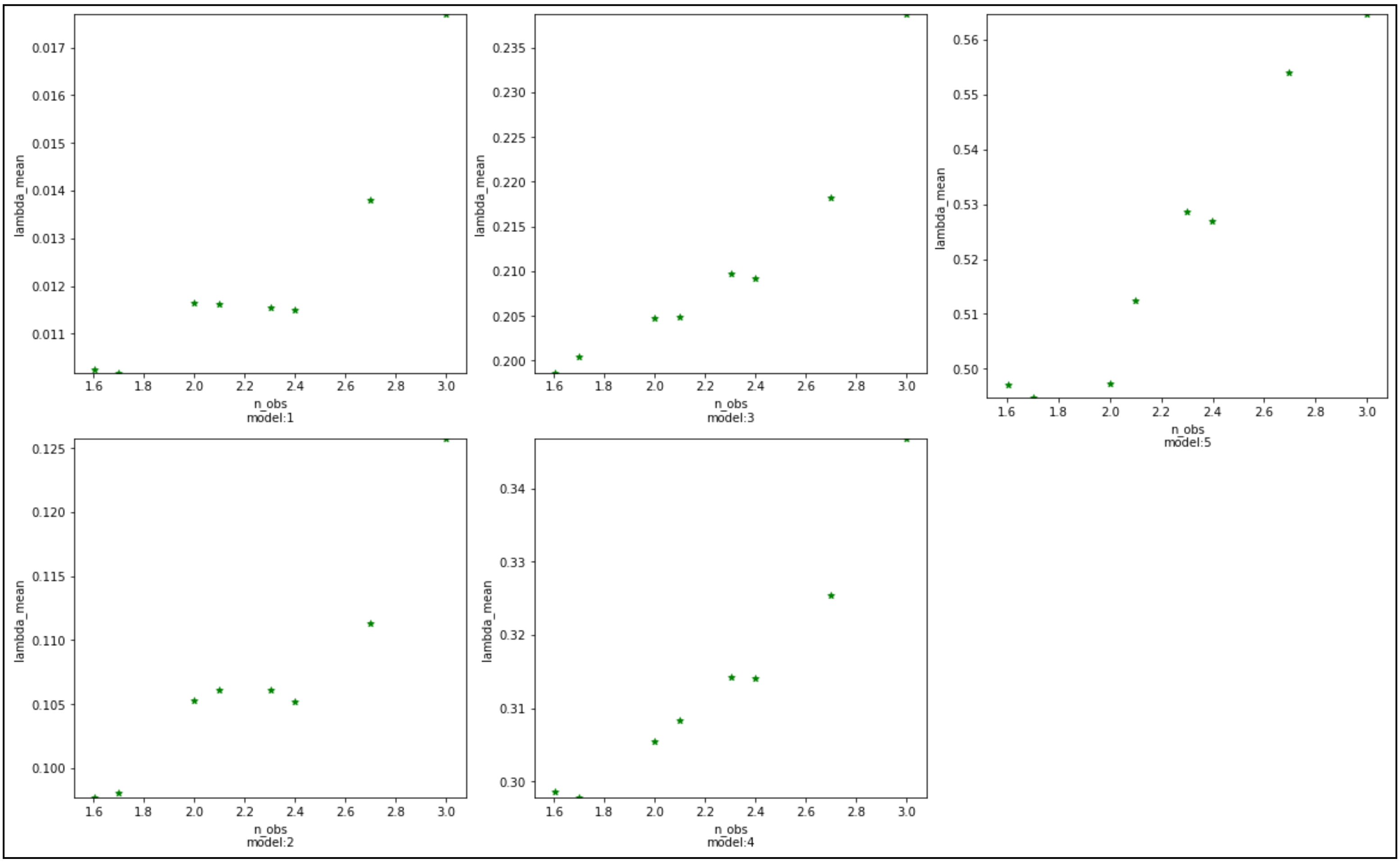


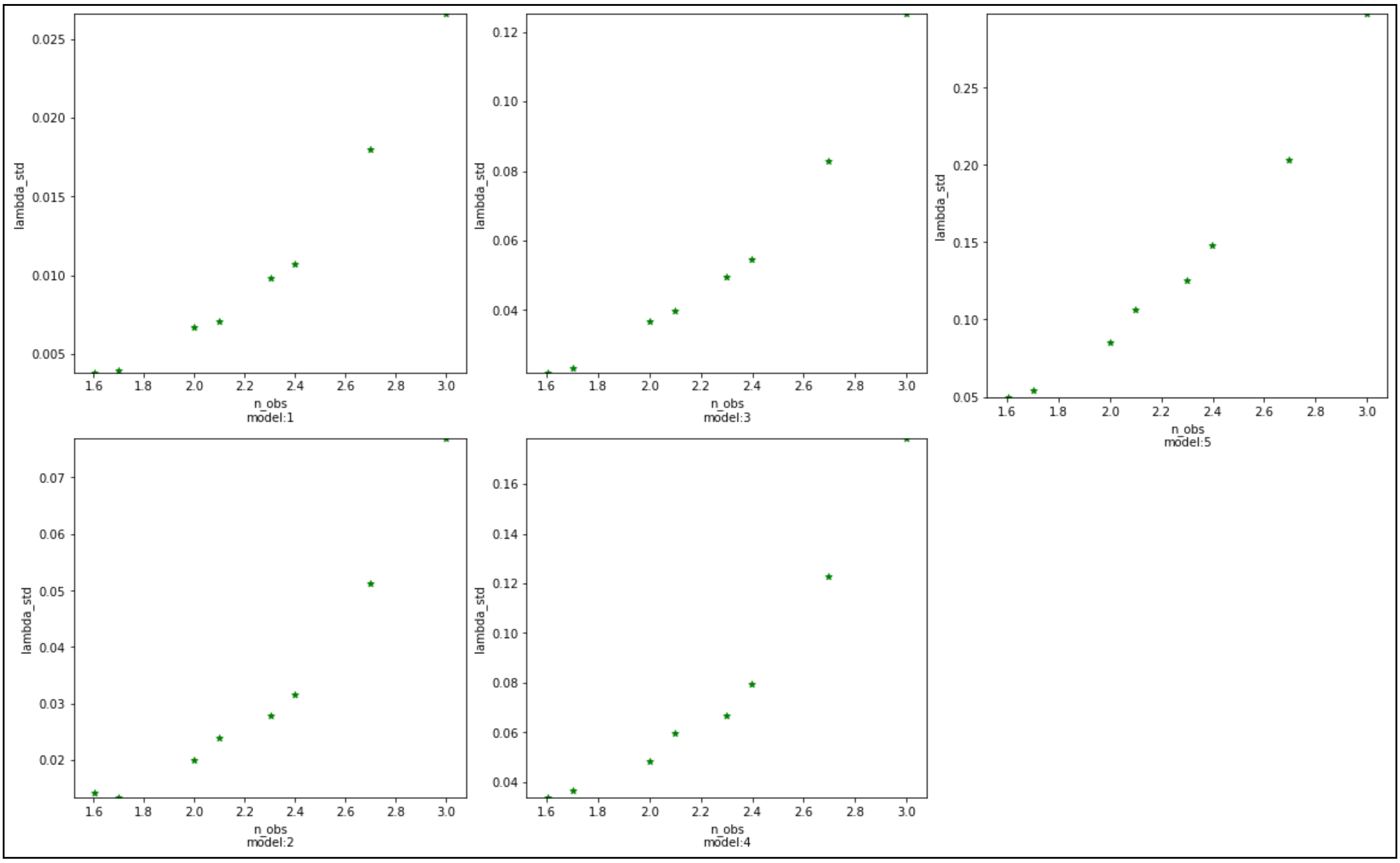
1e−12
amplitude_mean
n_obs
model:0
model:2
model:4
model:1
model:3
model:5



1e−14
1e−13
amplitude_std
n_obs
model:0
model:2
model:4
model:1
model:3
model:5

Lambda:

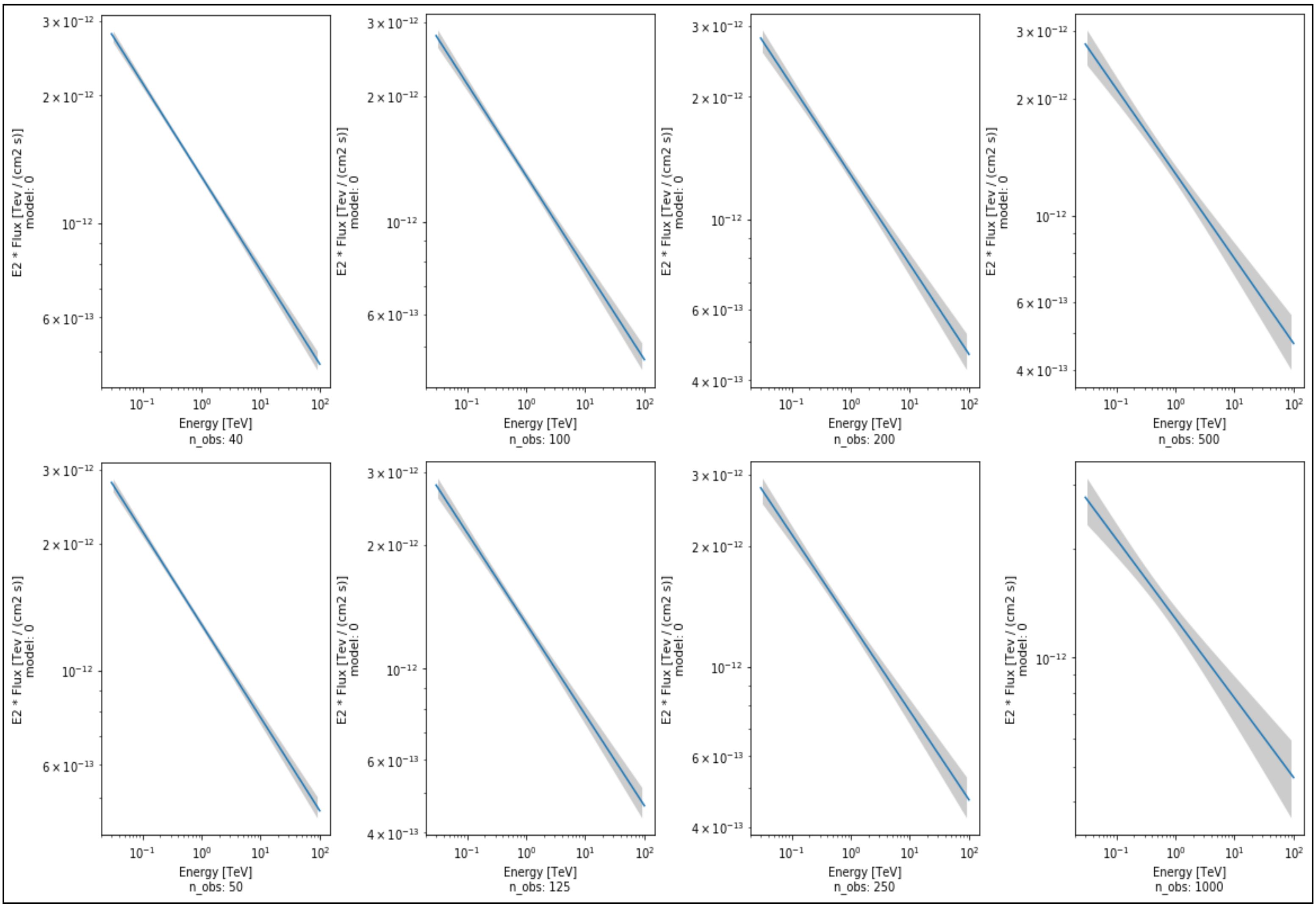

lambda_mean
n_obs
model:1
model:3
model:5
model:2
model:4


lambda_std
n_obs
model:1
model:3
model:5
model:2
model:4

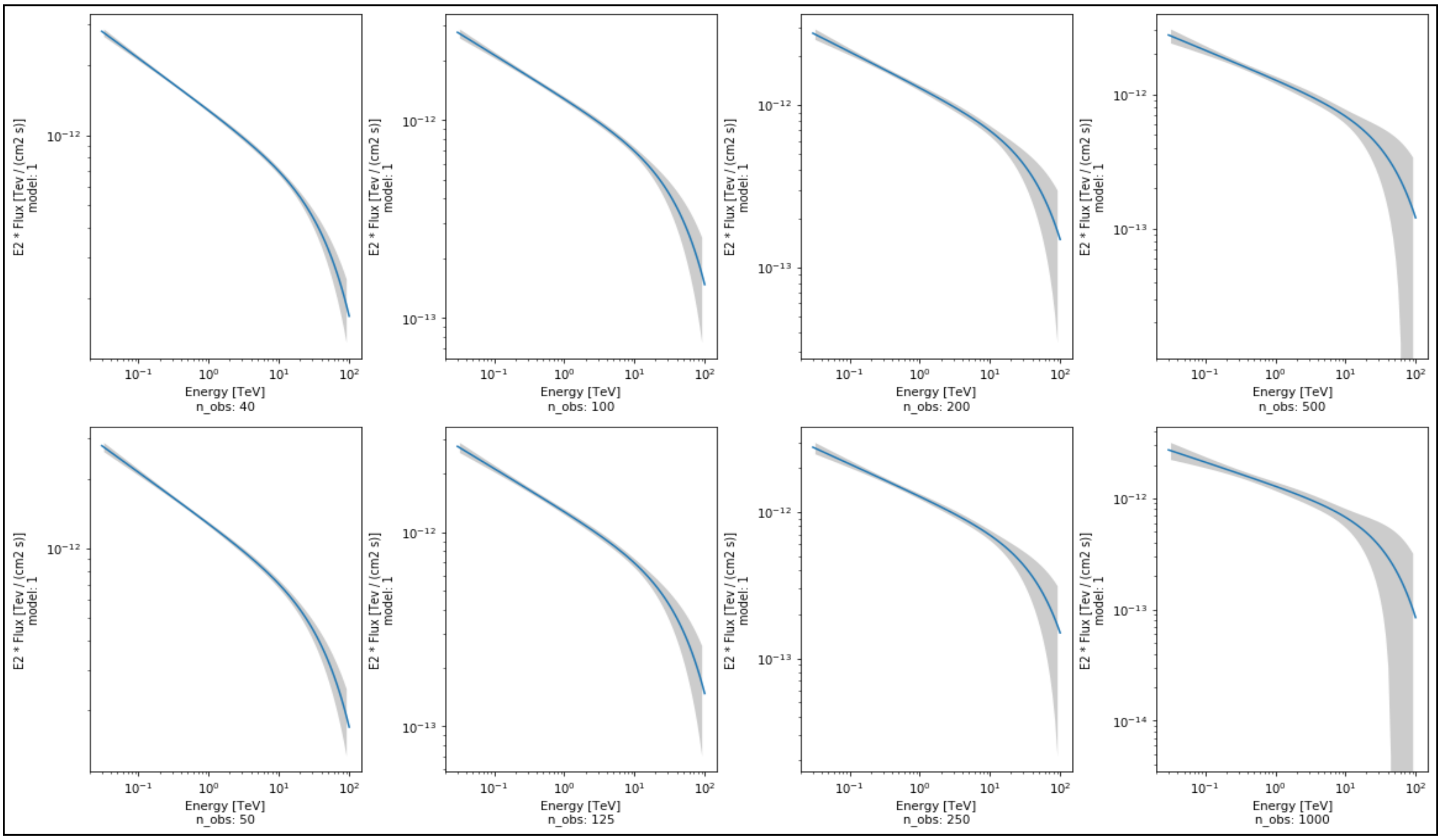
Flux vs Energy Curve with error for different models and number of observations:

Here I have plot 8 plots with the same model parameters but with different no. of observations. In the **x_label**, no. of observation is mentioned and the **y_label** has model no. mentioned in it. These plots compare how for the same model, with different no. of observations the error bar and flux changes. There are 6 models with each including the 8 plots.

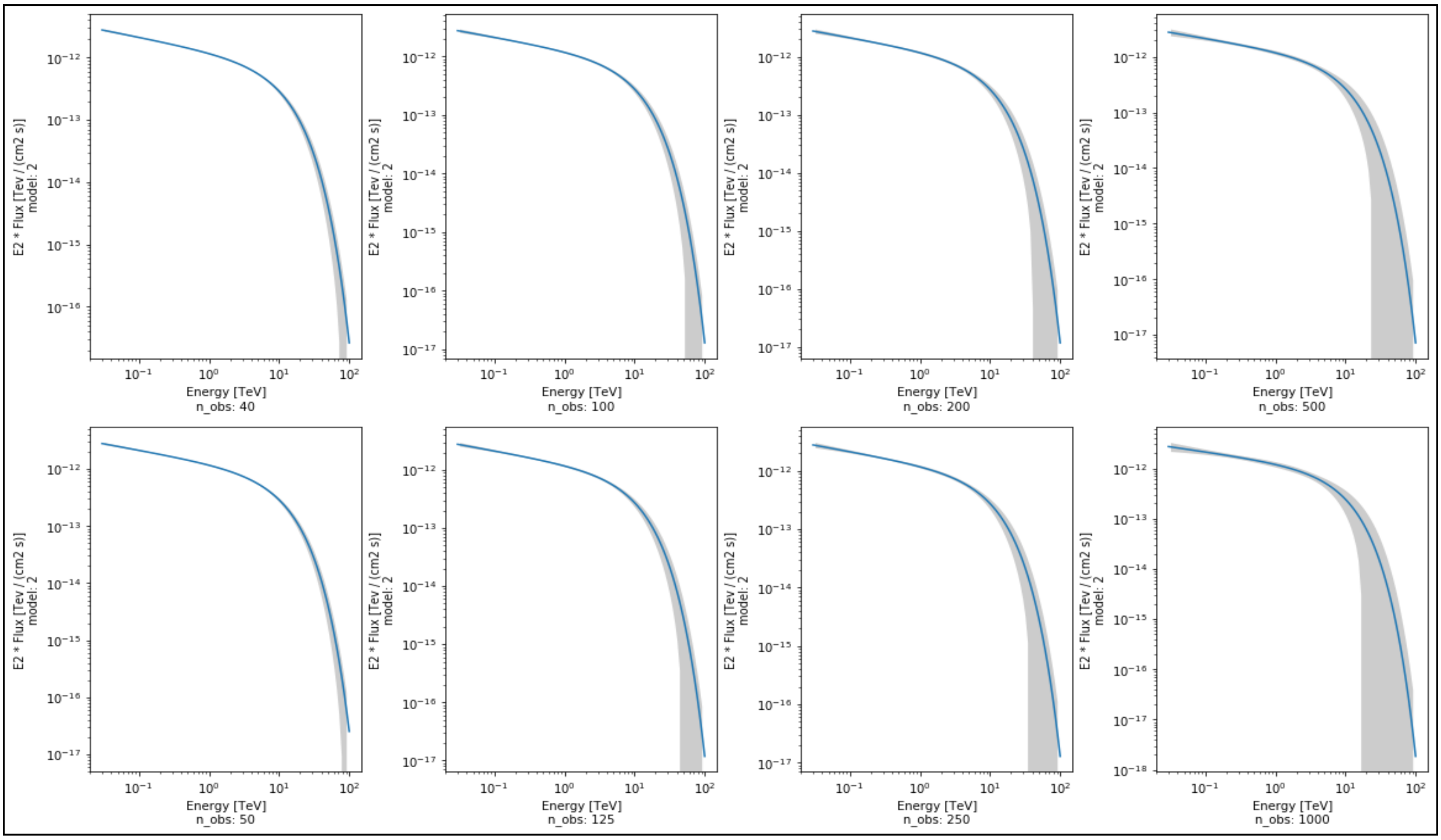
Model: 0



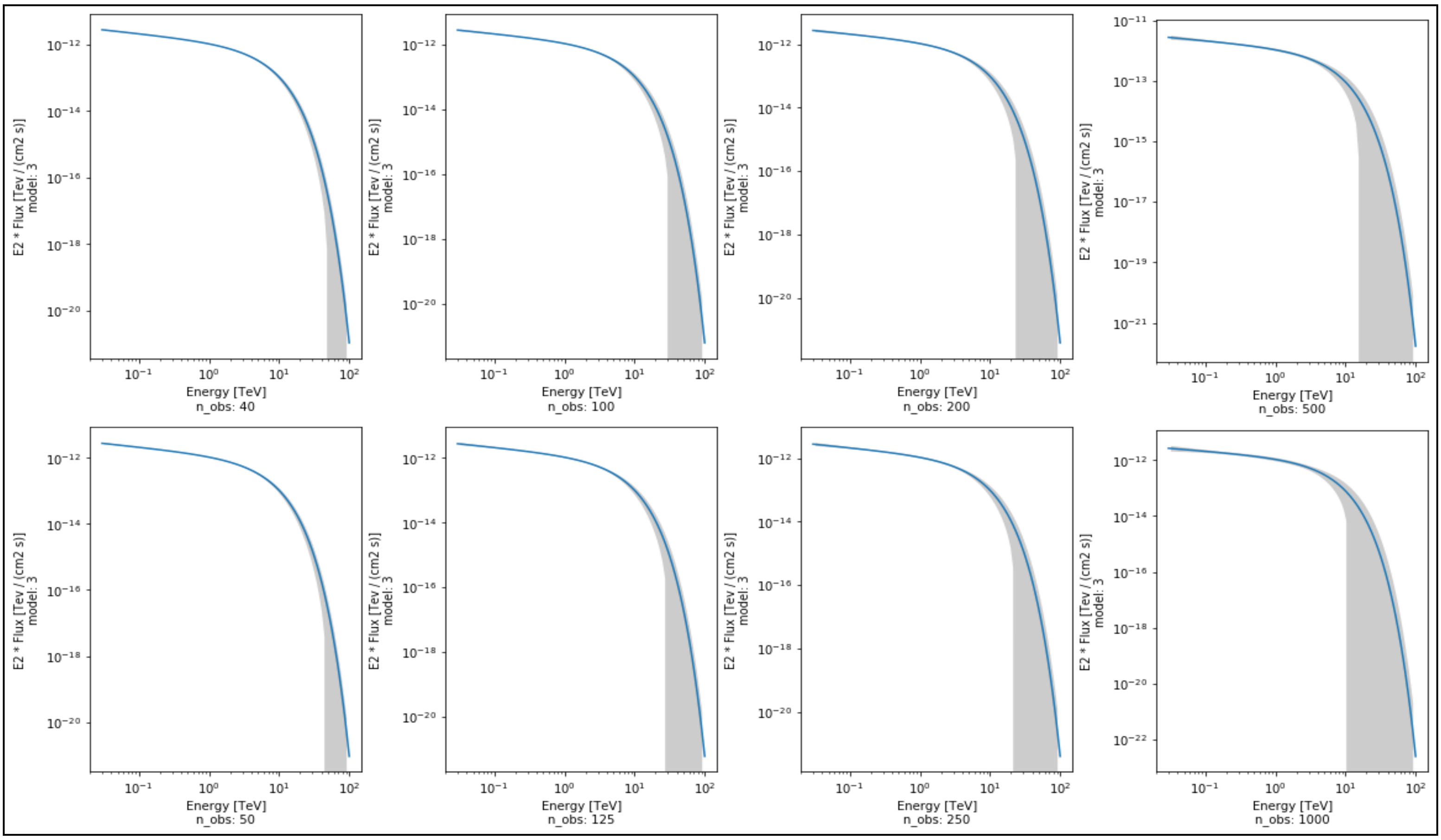
Model: 1



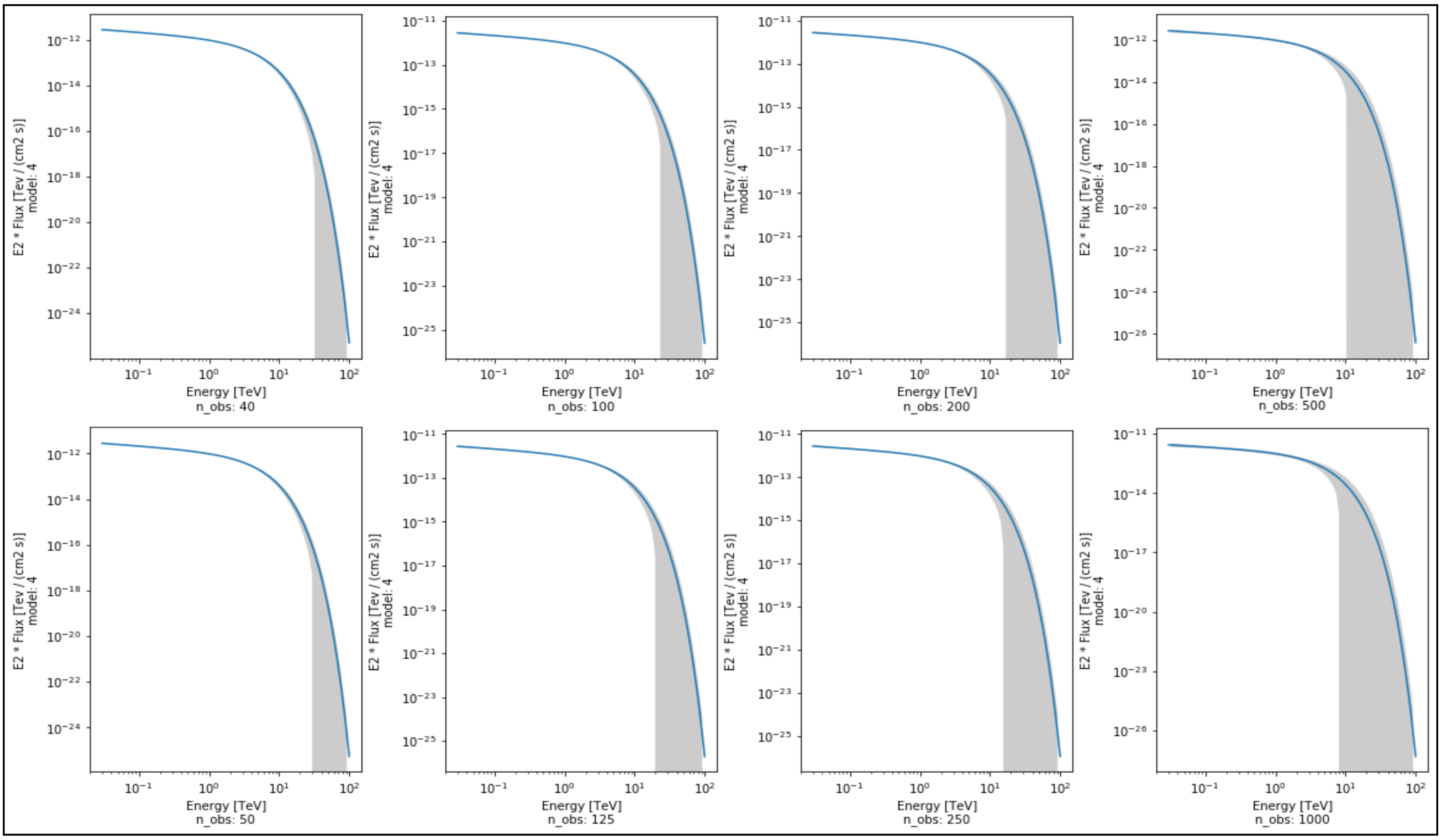
Model: 2



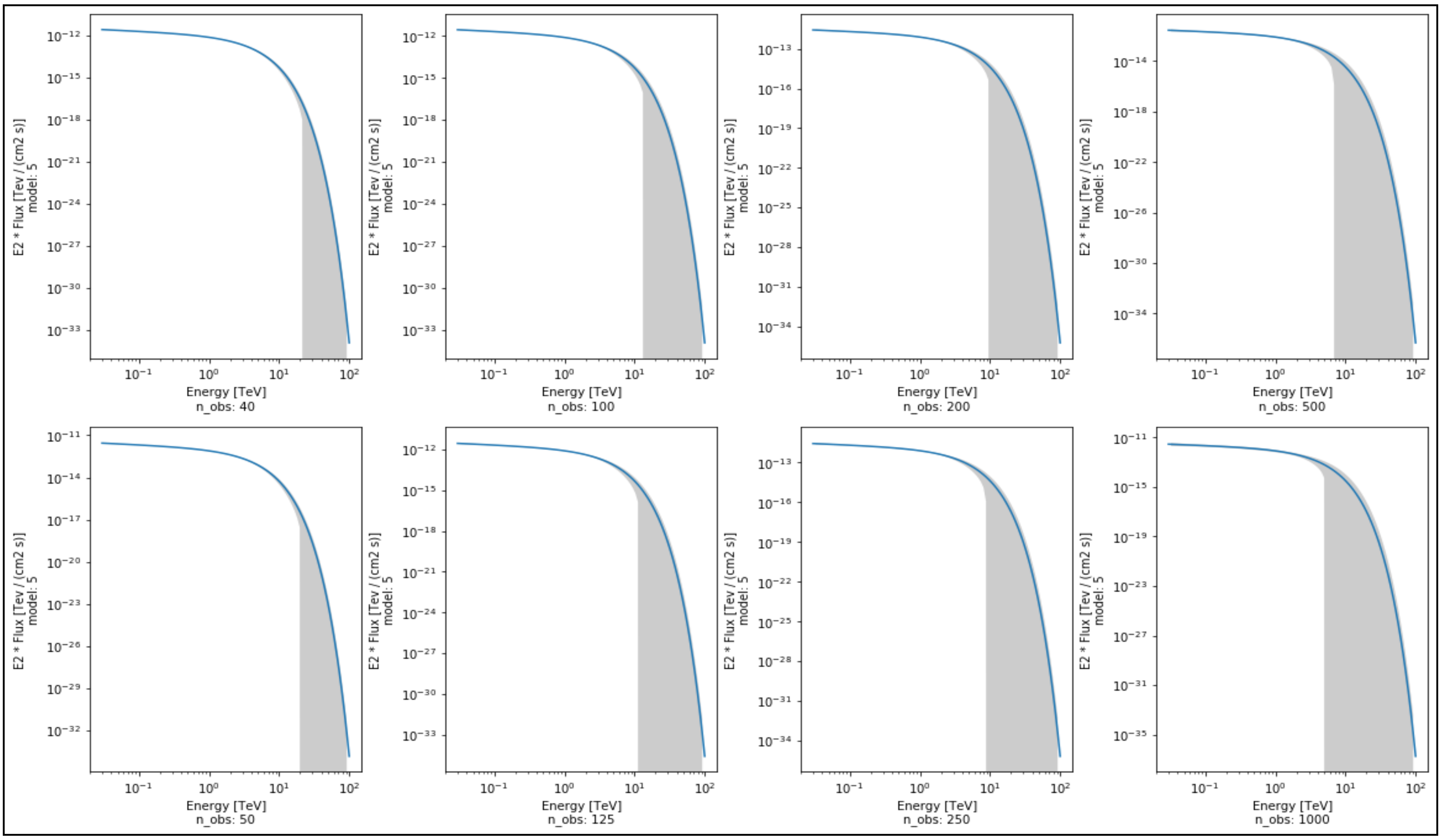
Model: 3



Model: 4

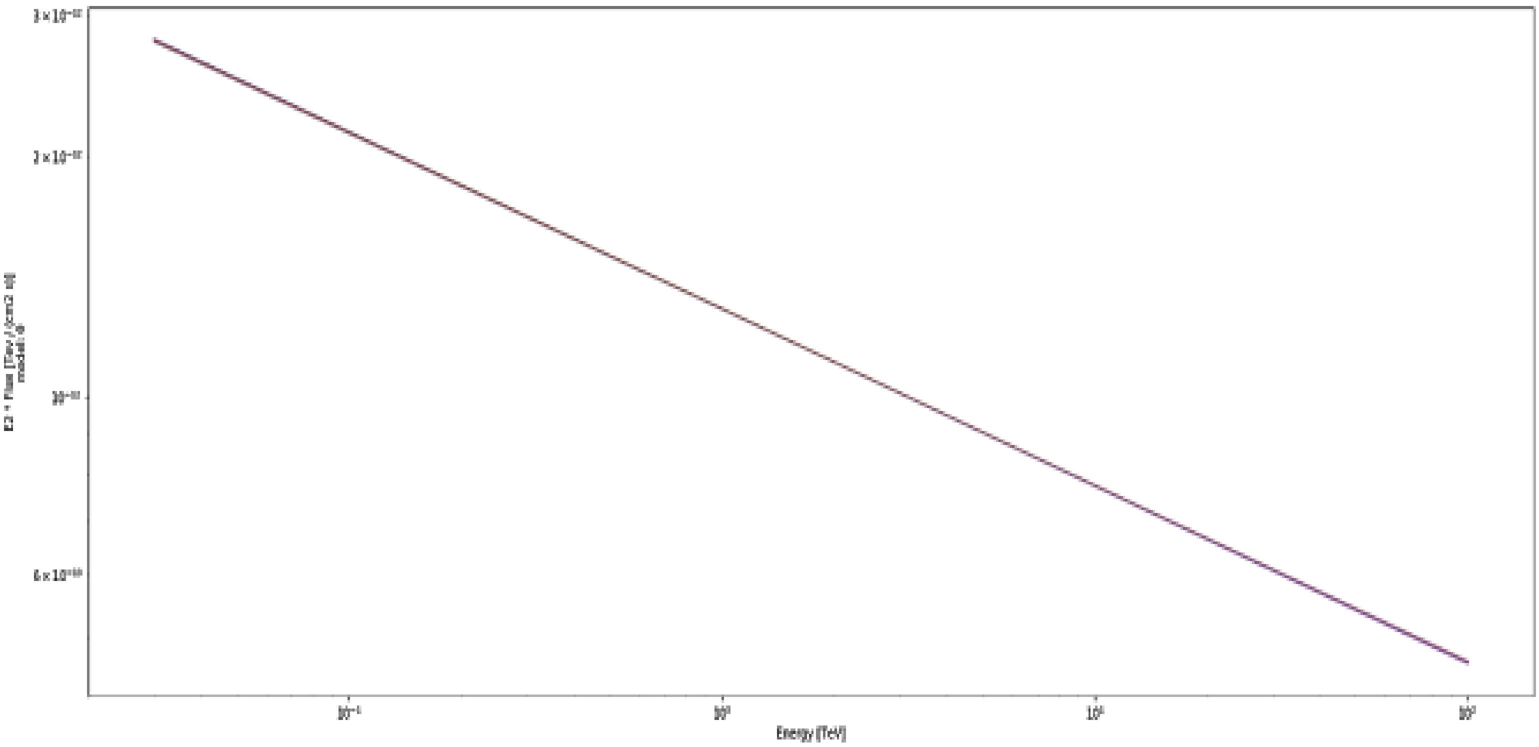


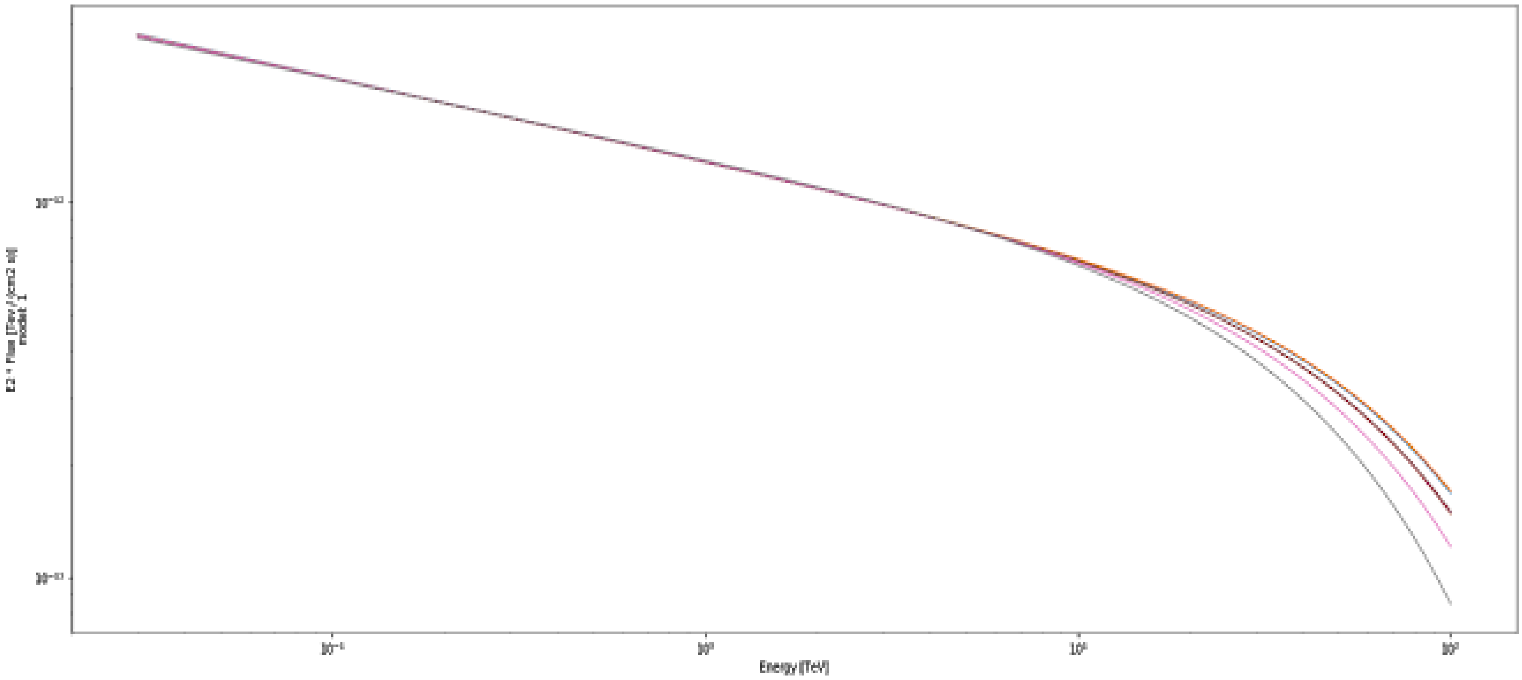
Model: 5

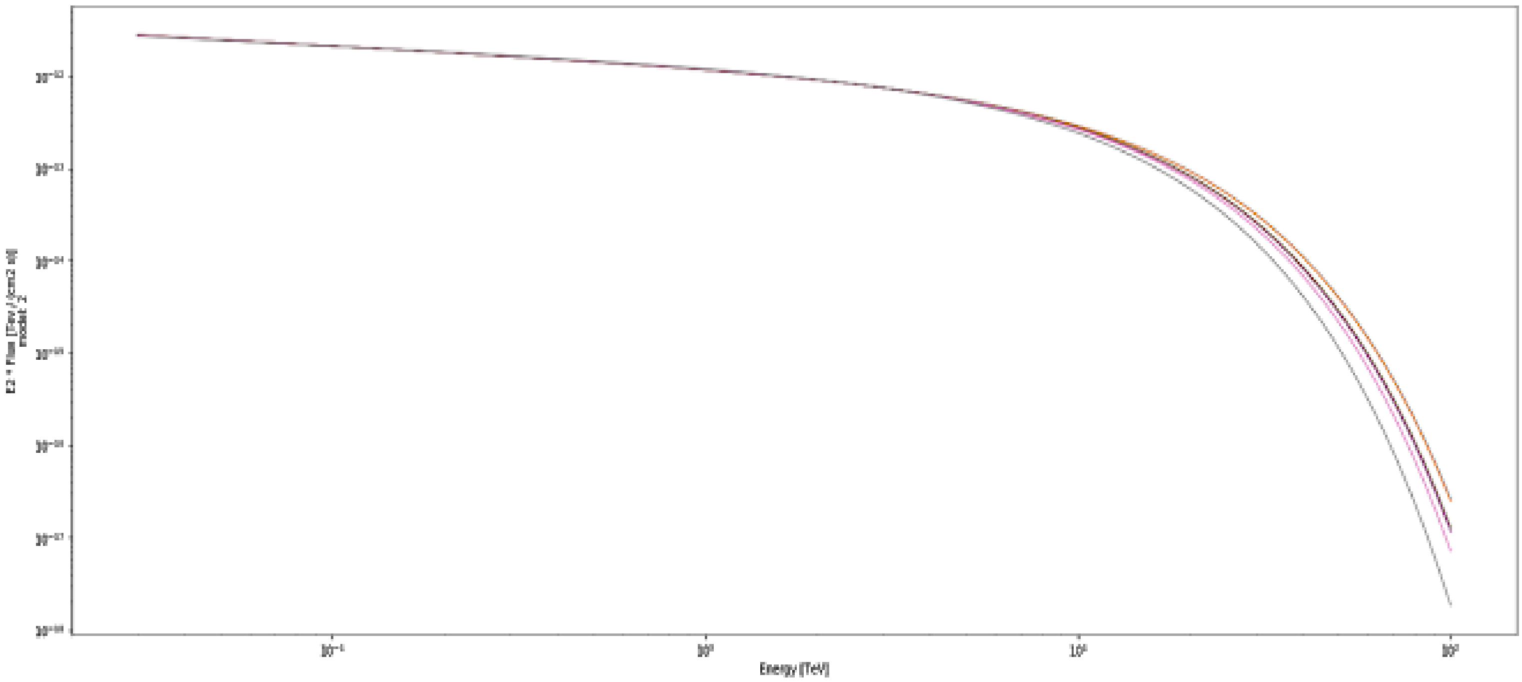


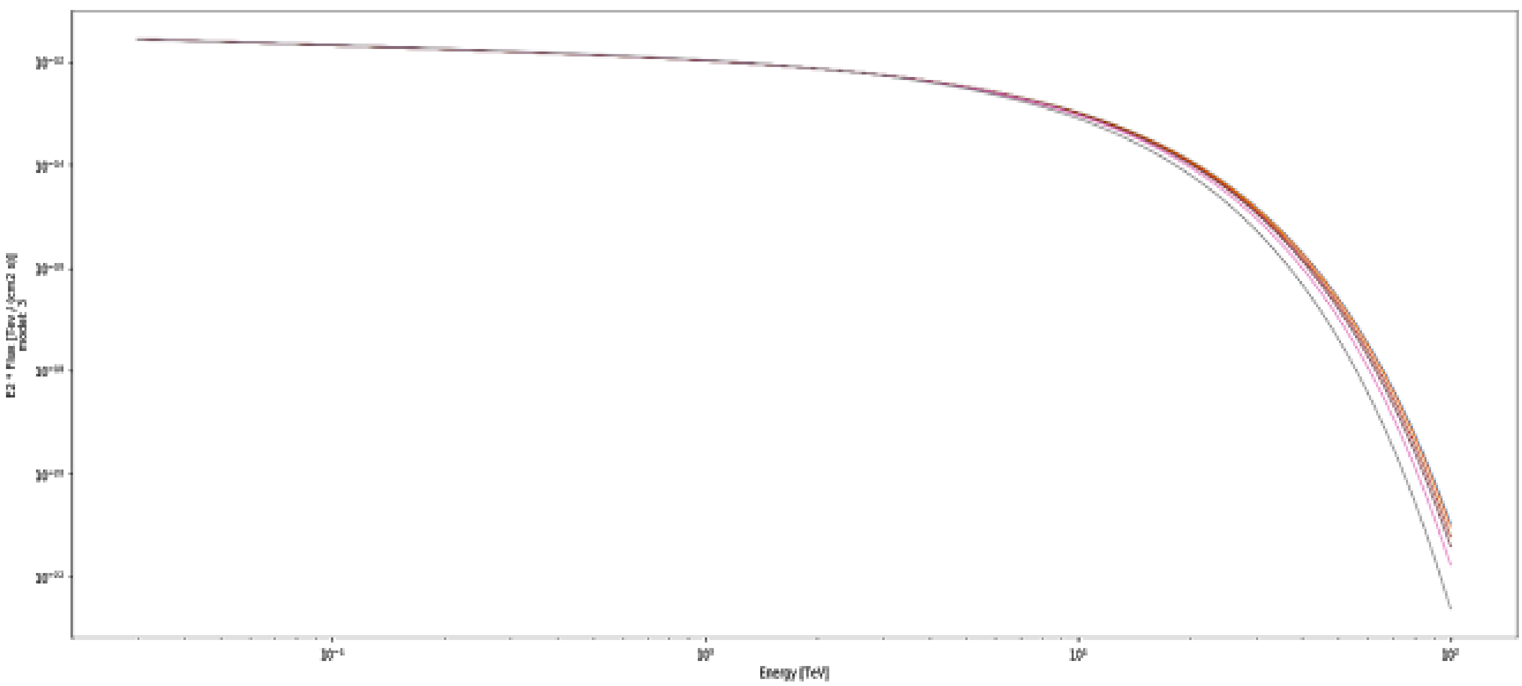
Flux vs Energy curve for different models:

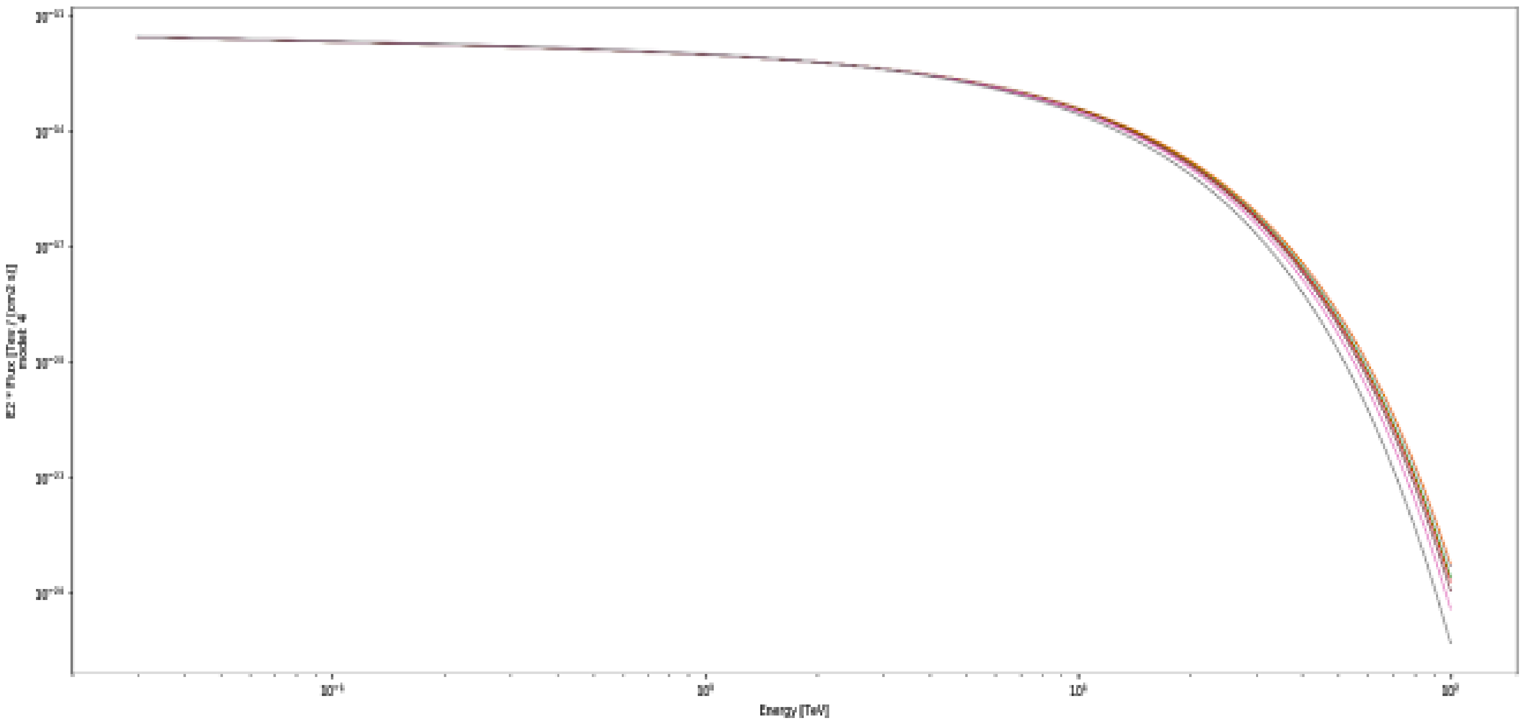
I have plotted 8 different curves with different no. of observation in the same plot to compare the effect of no. of observation on Flux. **Vertically** going there are 6 plots of 6 different models

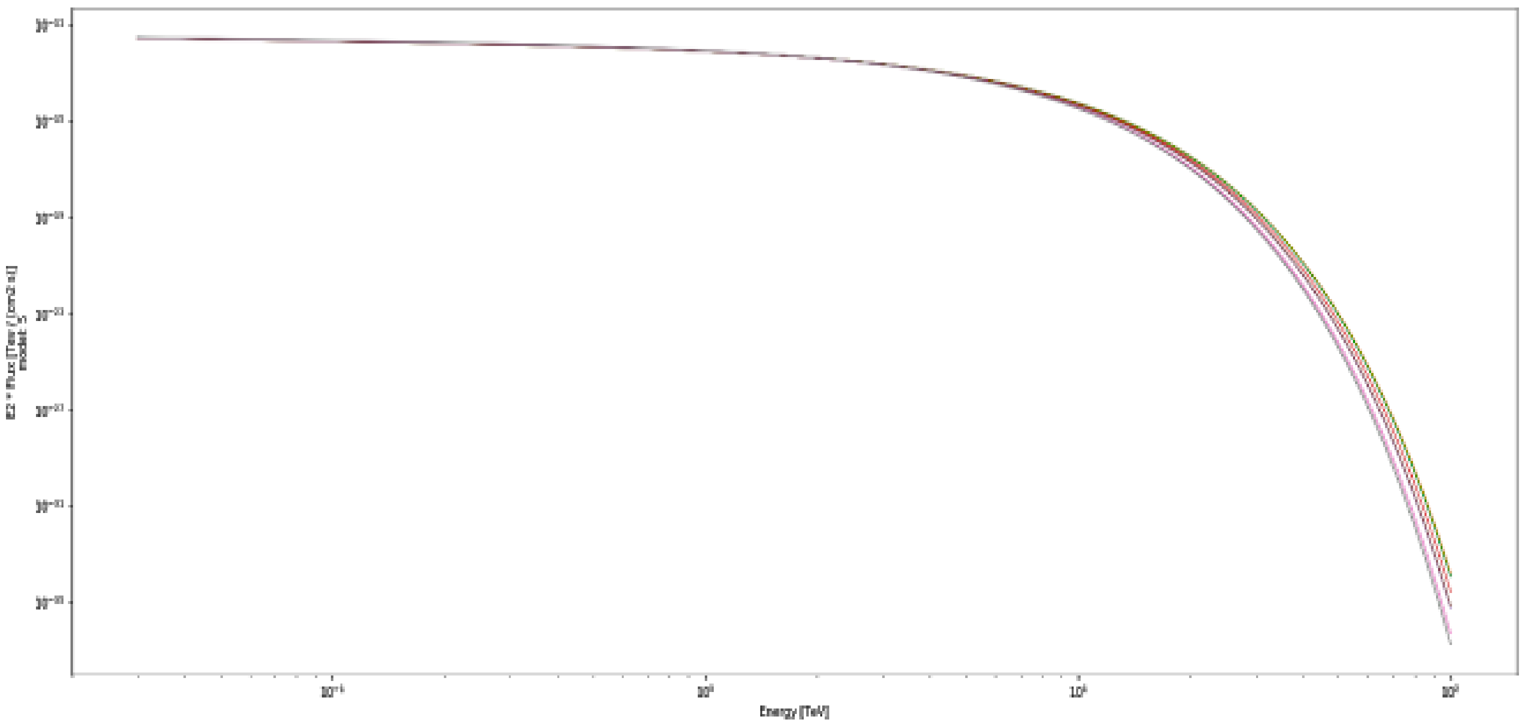



E2 * Flux [TeV / (cm2 s)]
model: 1
Energy [TeV]


E2 * Flux [TeV / (cm2 s)]
model: 2
Energy [TeV]


E2 * Flux [TeV / (cm2 s)]
model: 3
Energy [TeV]

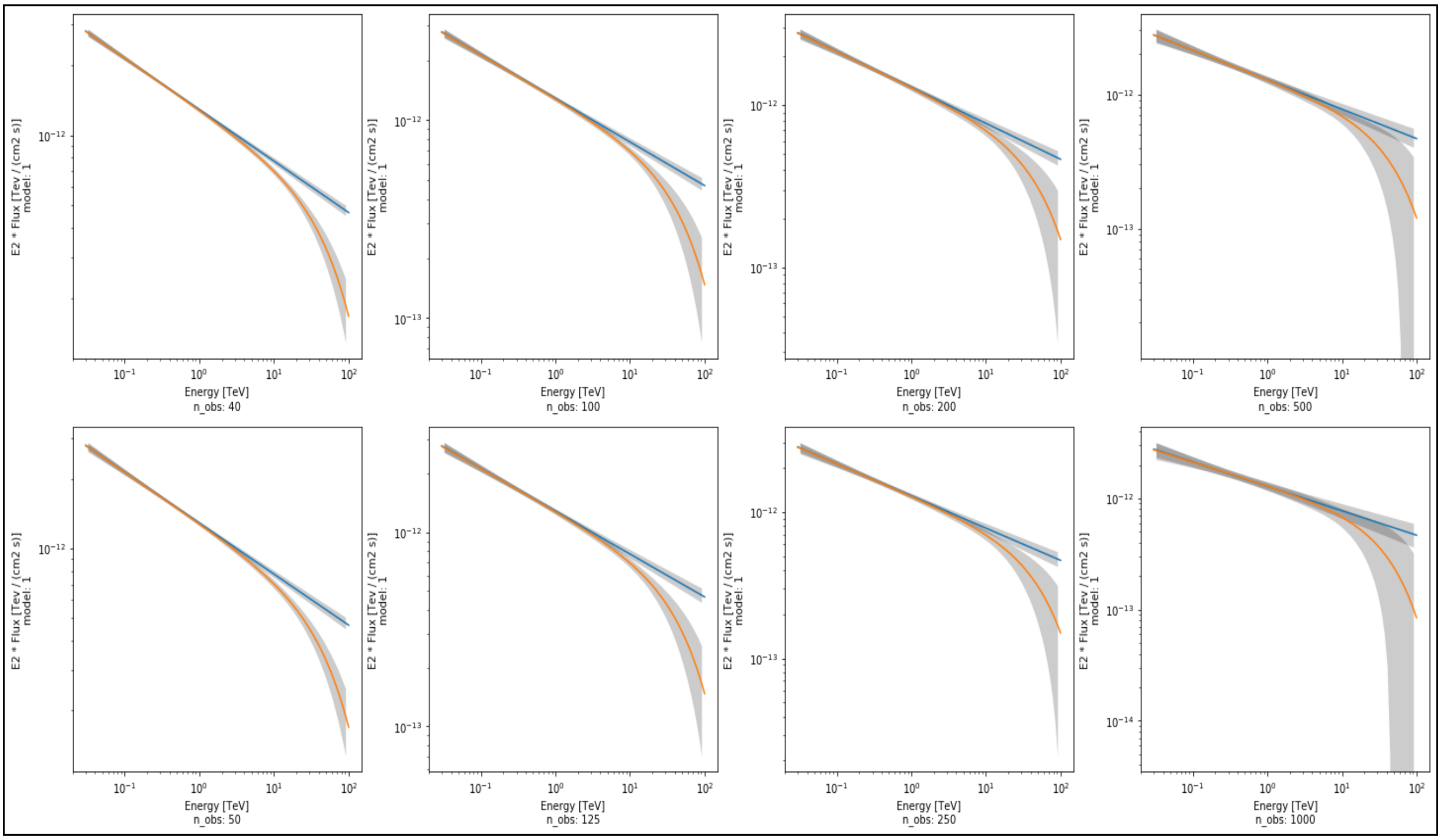




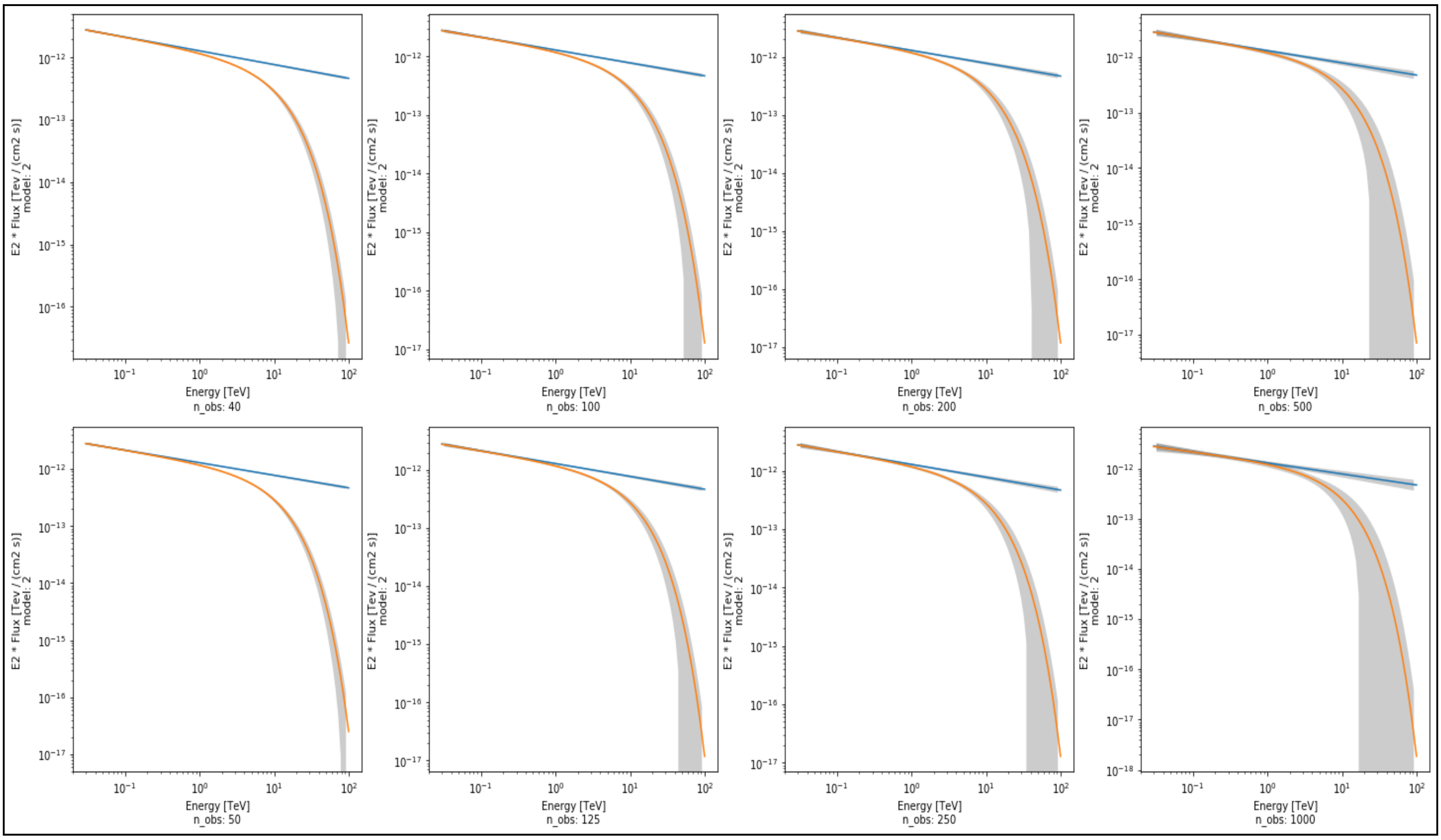
Comparing Flux vs Energy curve of PowerLaw with ExponentialCutoff_PowerLaw for same model:

Here I compare the Flux vs Energy curve for two models **Powerlaw** and **ExponentialCutoff_Powerlaw**. There are 5 parts for this analysis, each part represents a comparison with 5 ExponentialCutoff models with different lambda value. Each part also includes 8 plots giving comparison for 8 different values of no. of observation for the same model. **X_label** contains the no. of observation and **Y_label** has model no.

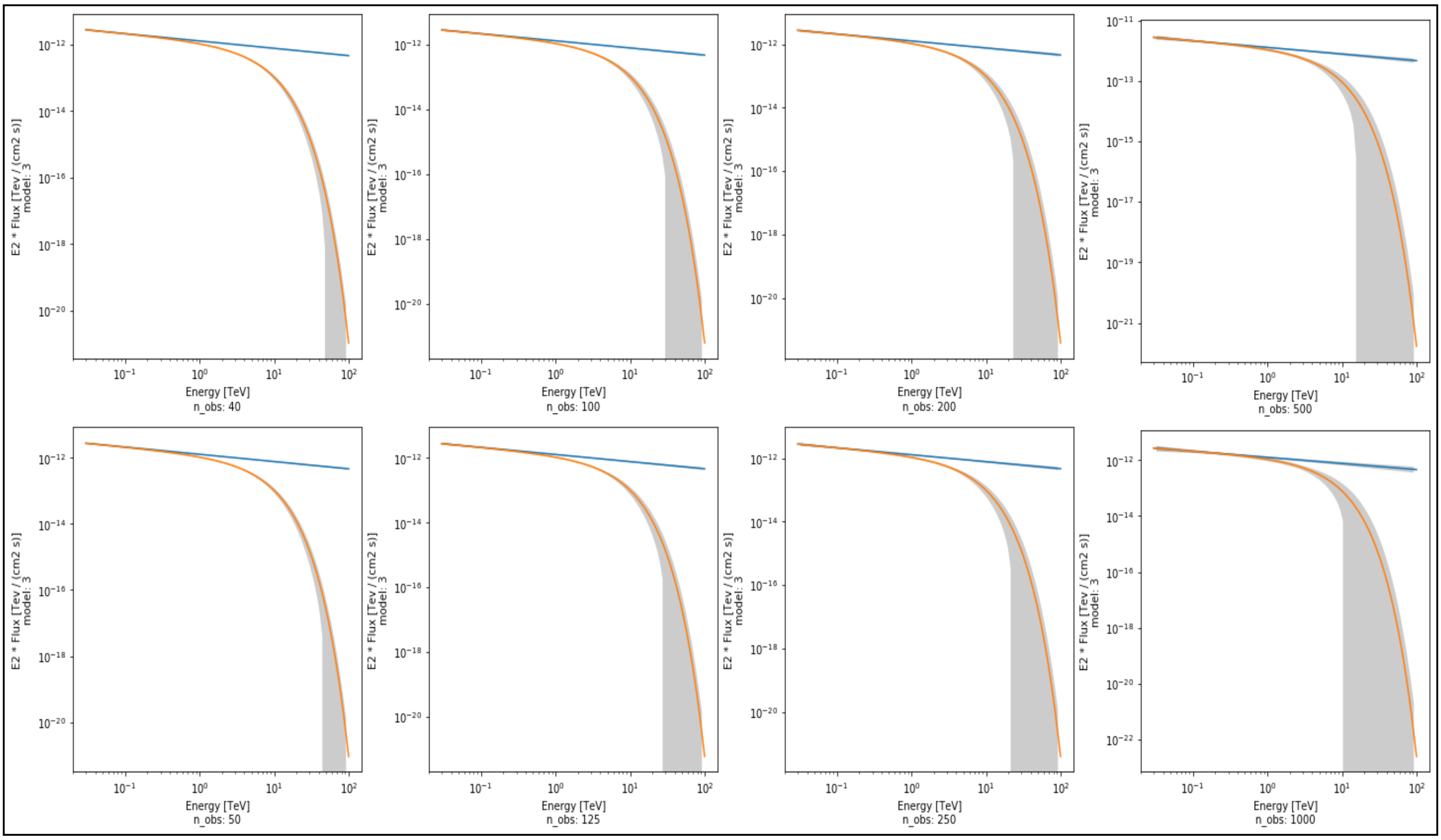
Model: 1



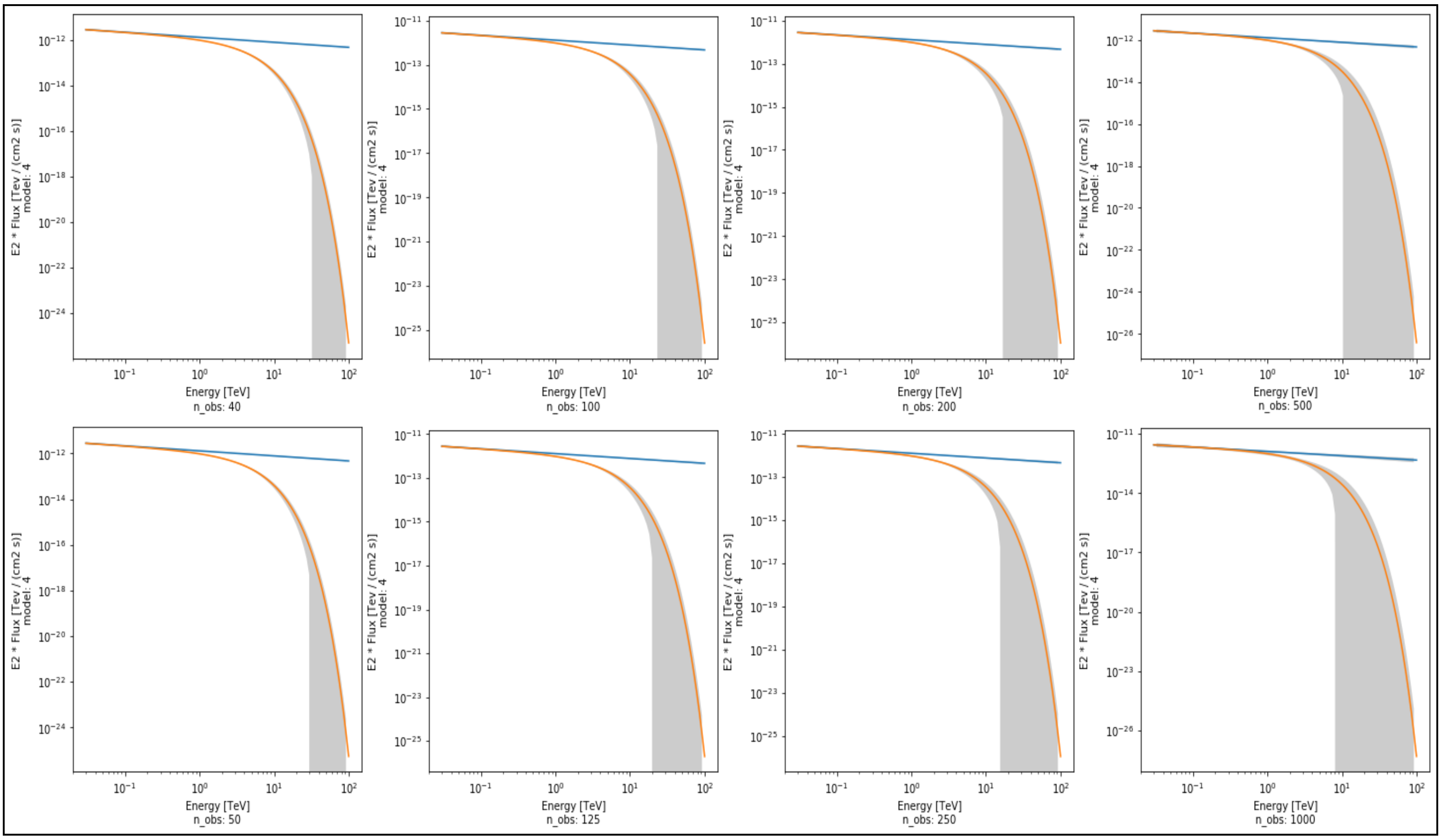
Model: 2



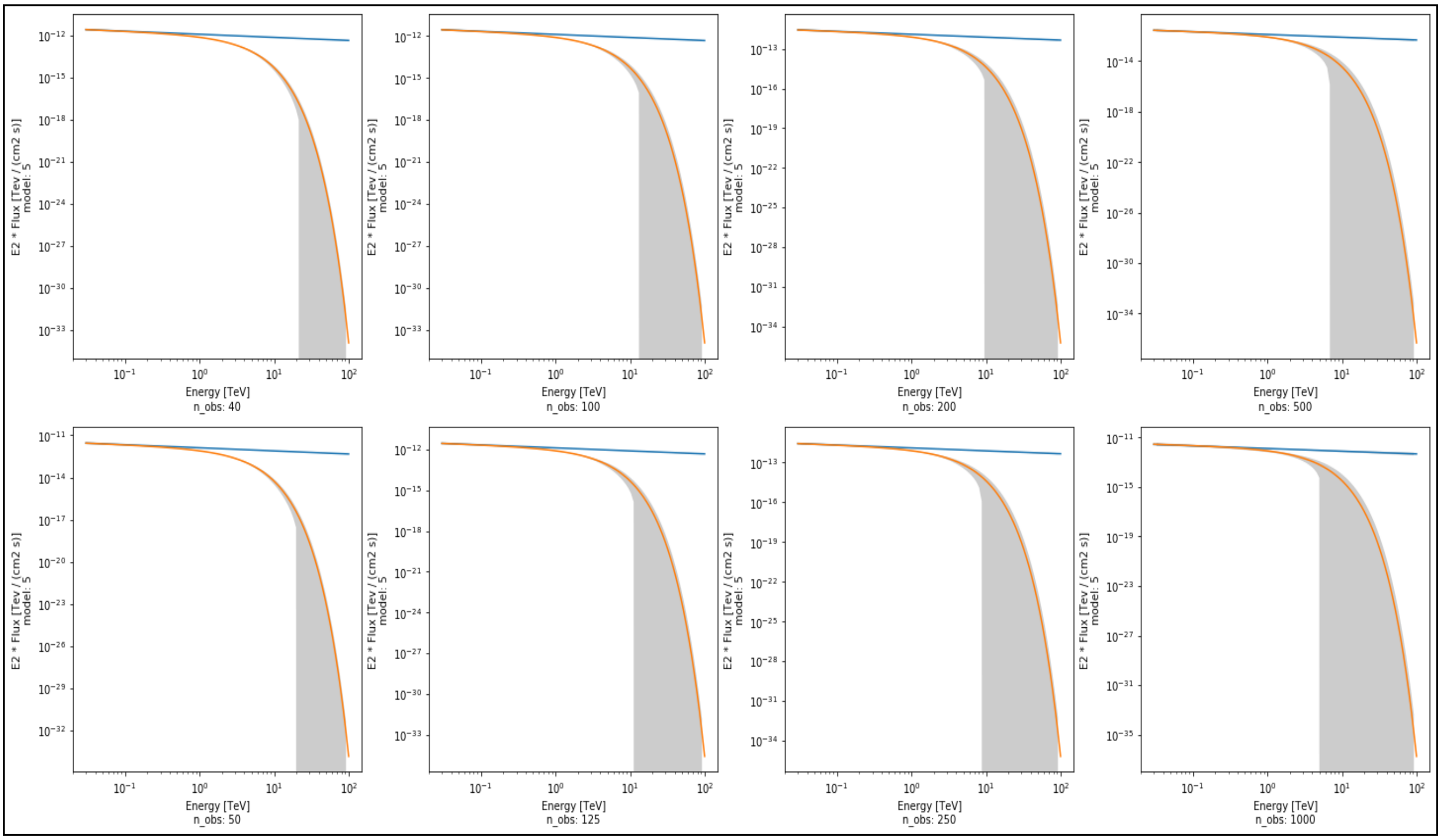
Model: 3



Model: 4



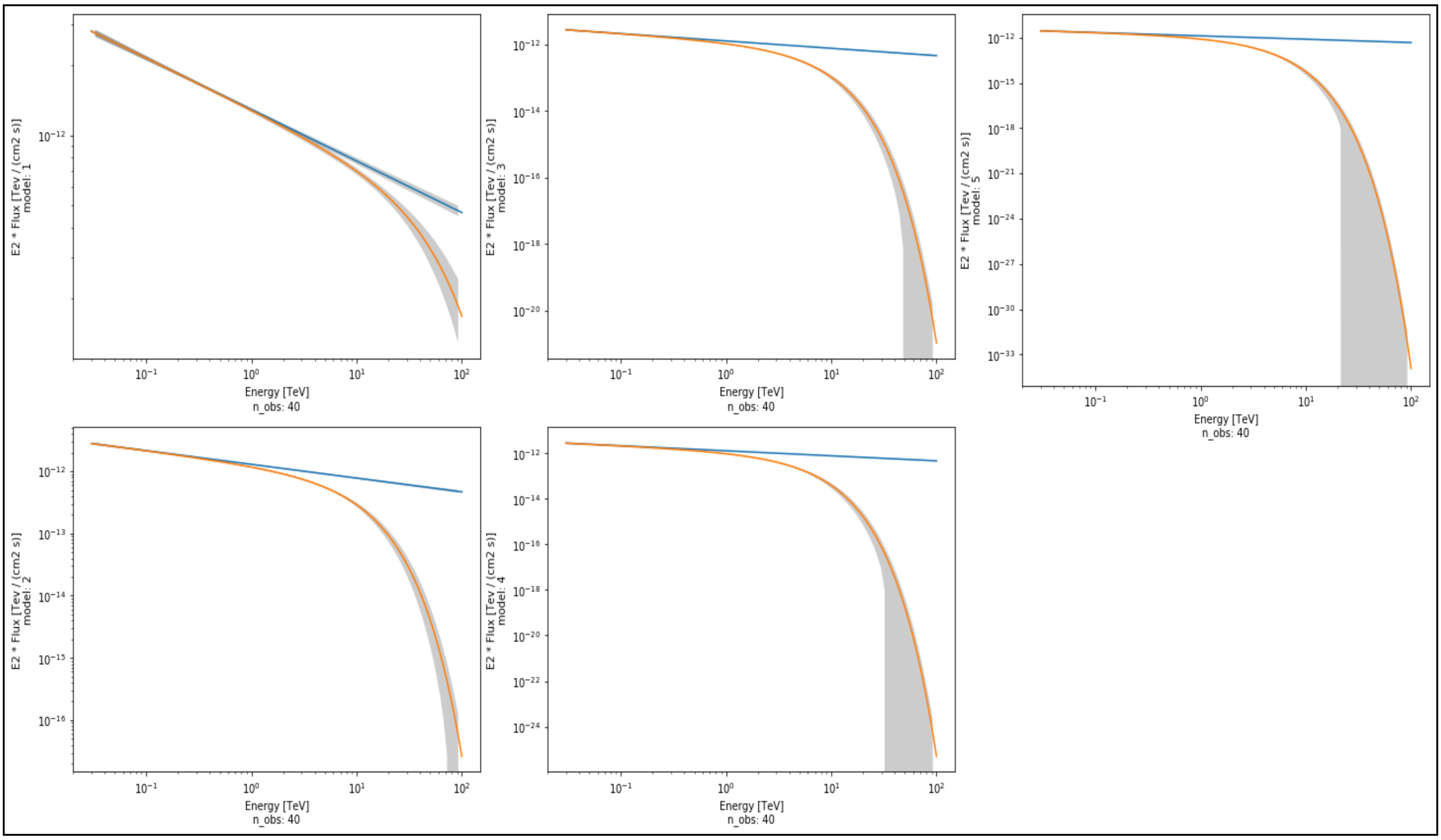
Model: 5



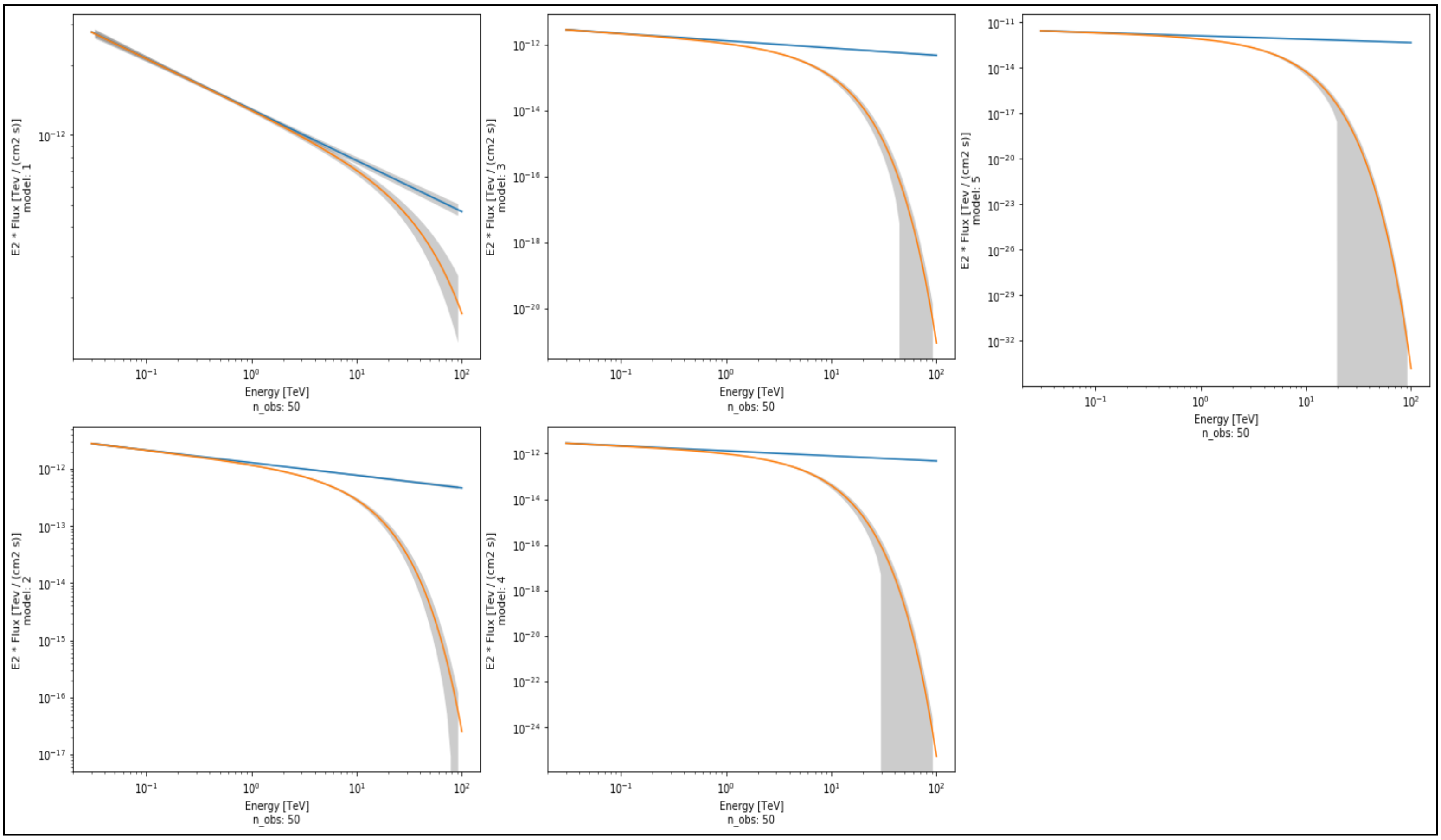
Comparing Flux vs Energy curve of PowerLaw with ExponentialCutoff_PowerLaw for the same no of observations:

Here I compare the Flux vs Energy curve for two models **Powerlaw** and **ExponentialCutoff_Powerlaw**. There are 8 parts for this analysis, each part represents comparison with different values of no. of observation. Each part also includes 5 plots giving comparison for 5 ExponentialCutoff models with different lambda value. **X_label** contains the no. of observation and **Y_label** has model no.

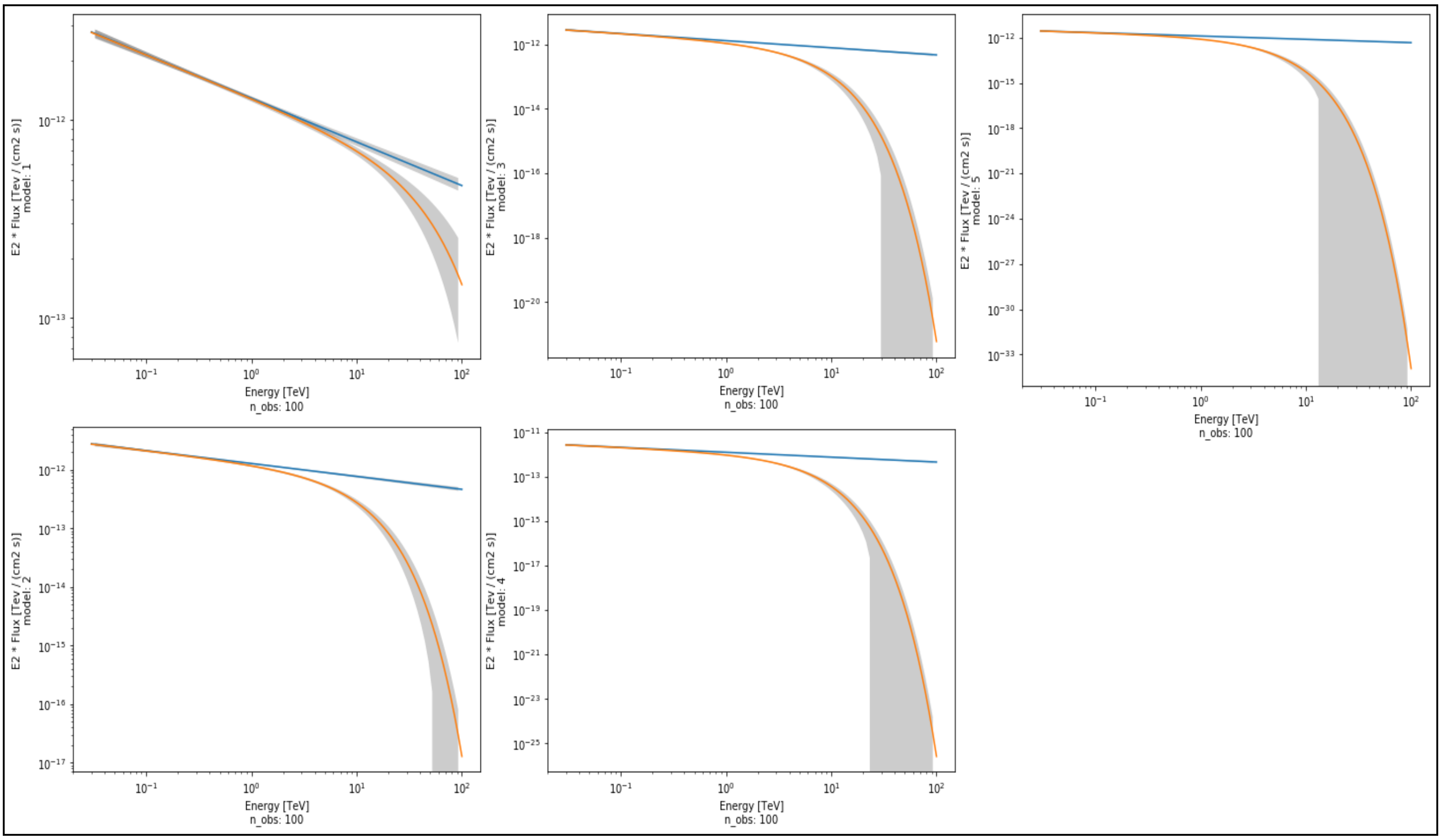
N_obs = 40



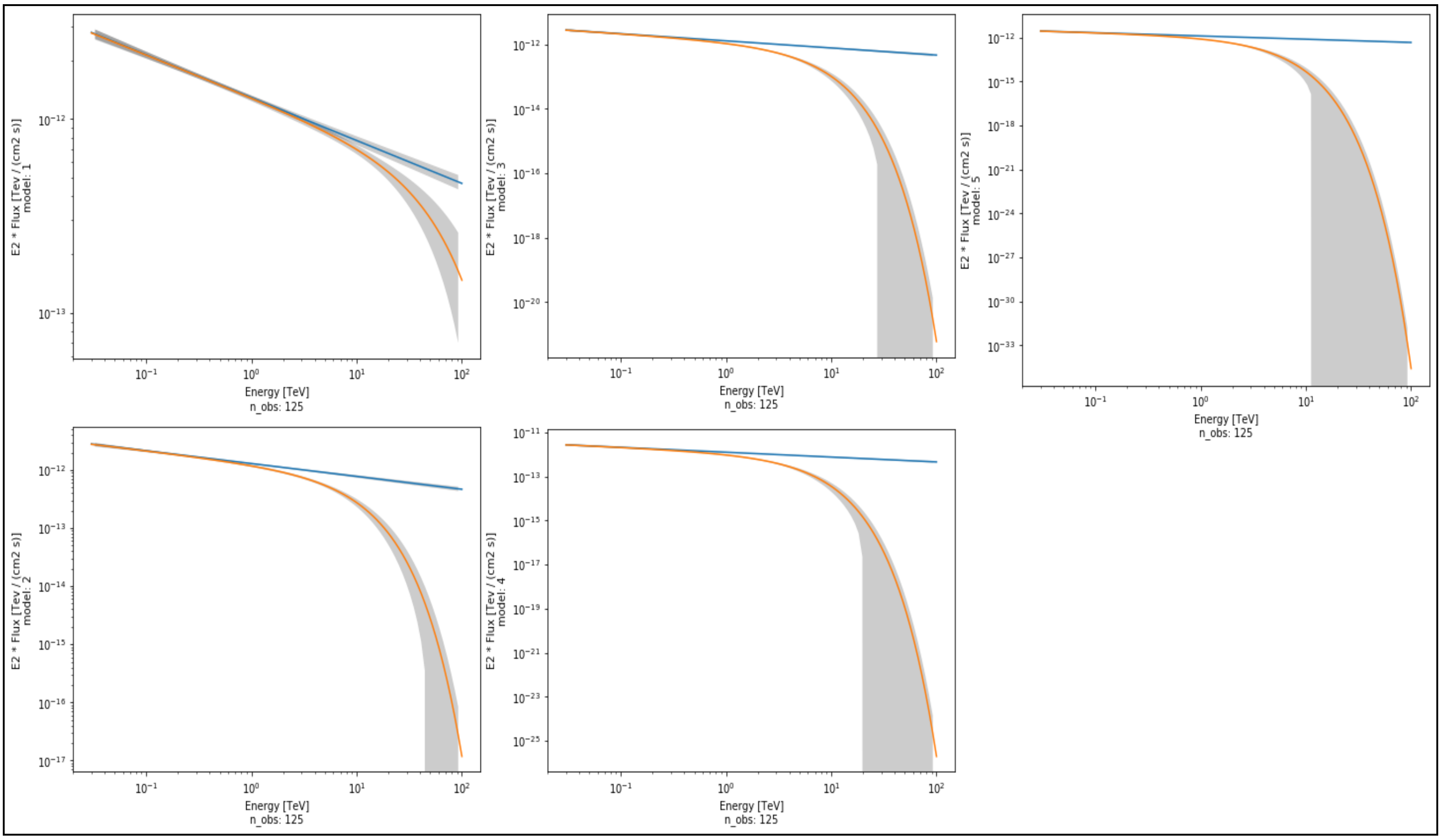
N_obs = 50



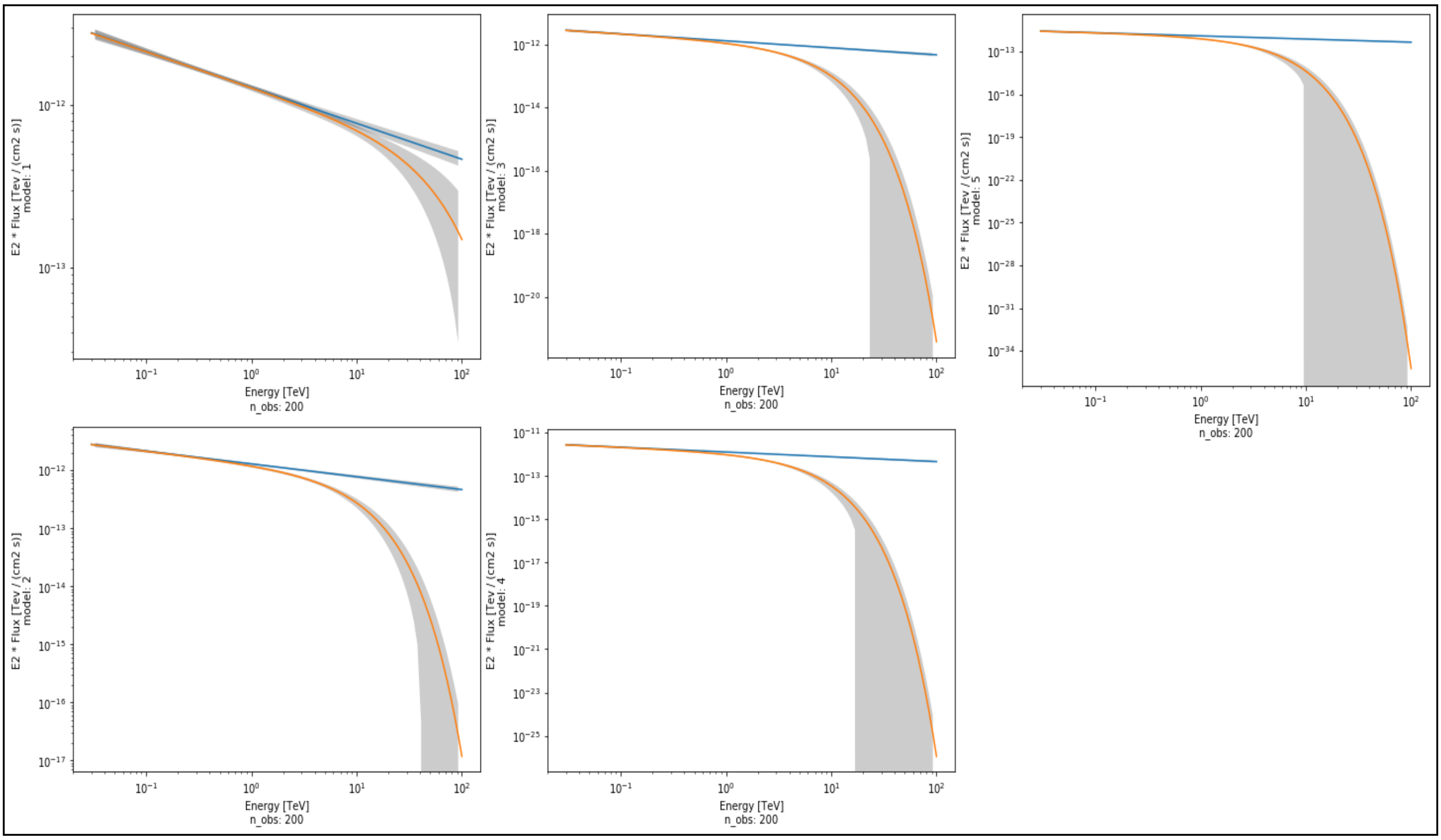
N_obs = 100



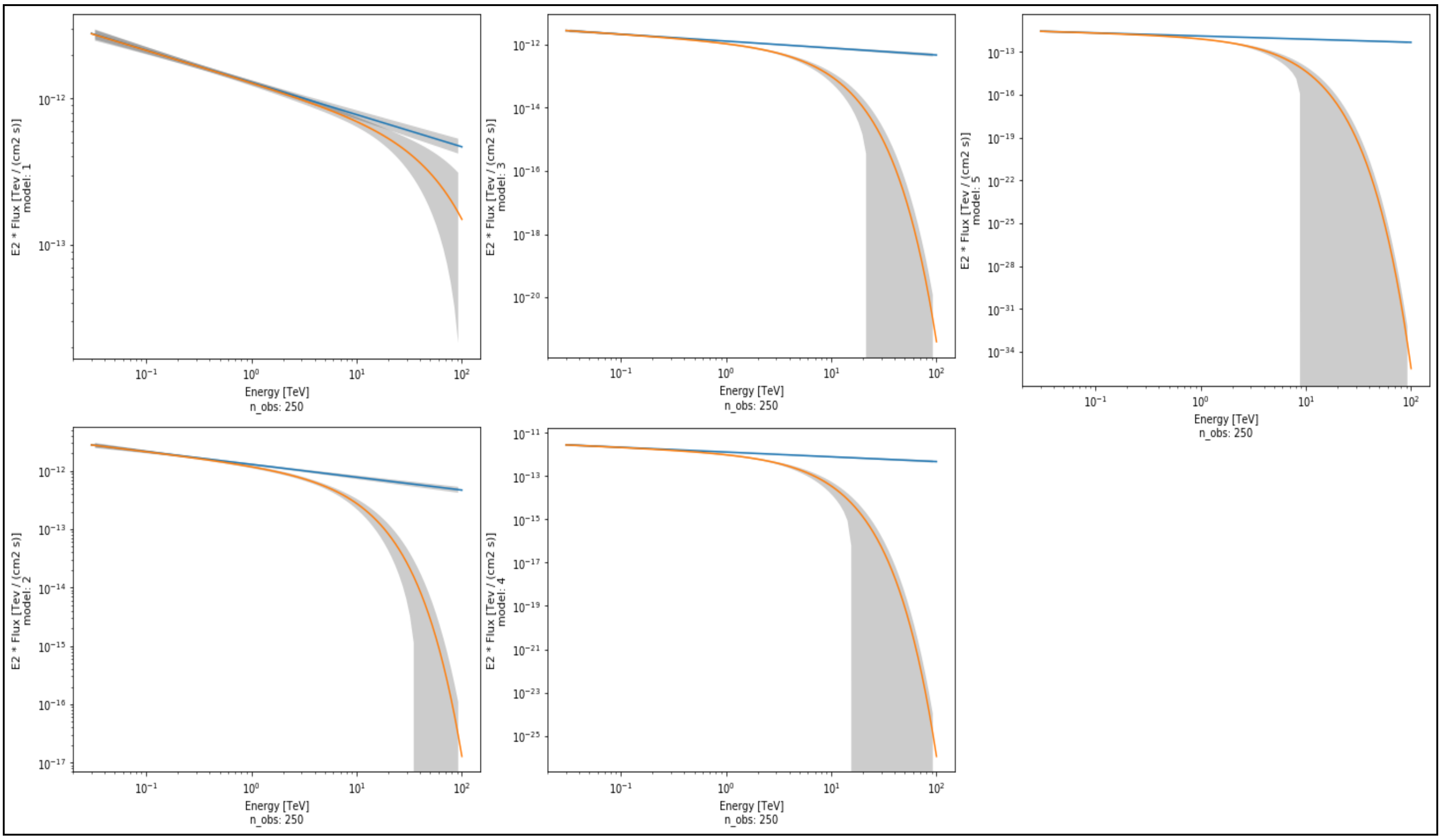
N_obs = 125



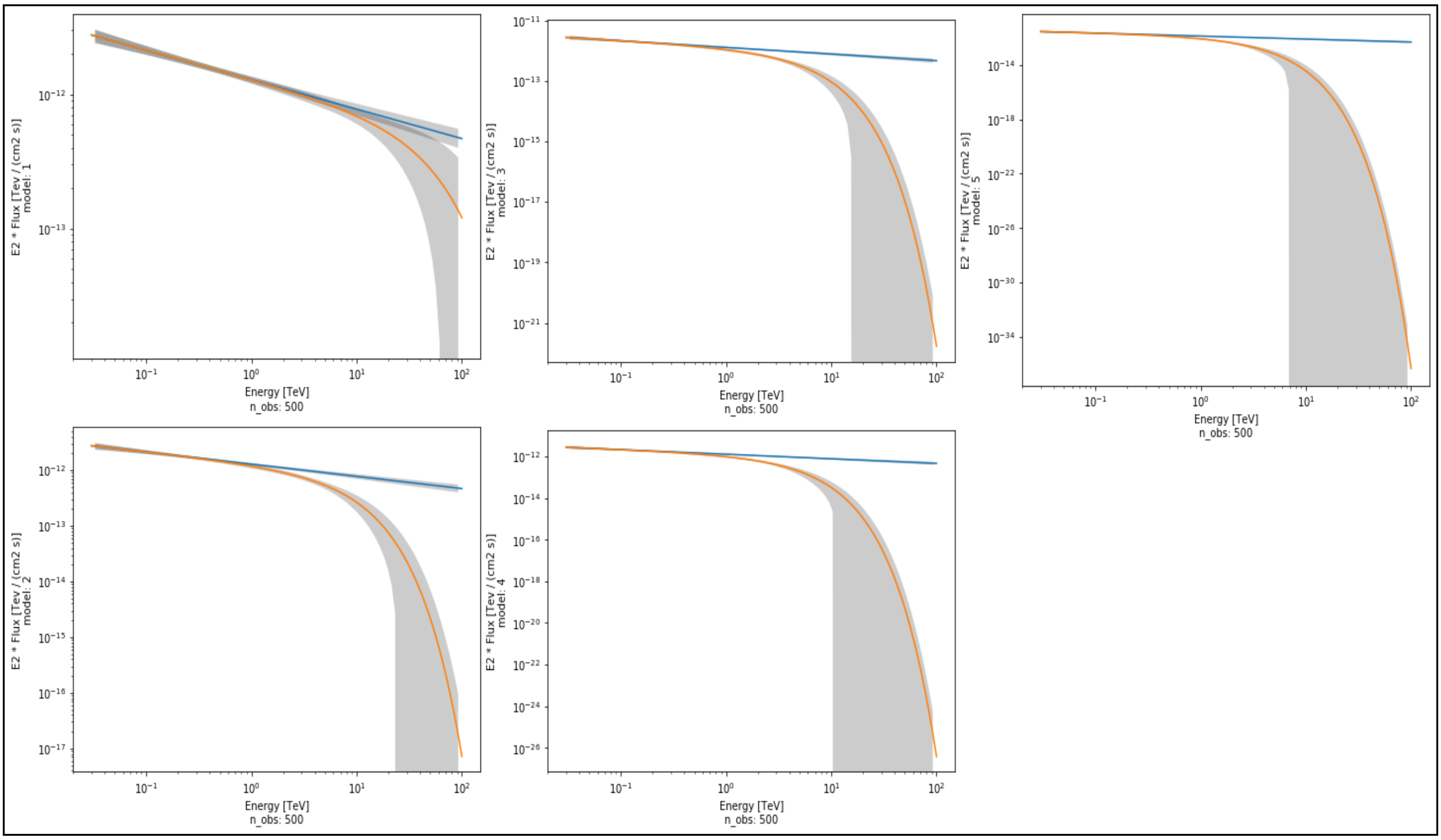
N_obs = 200



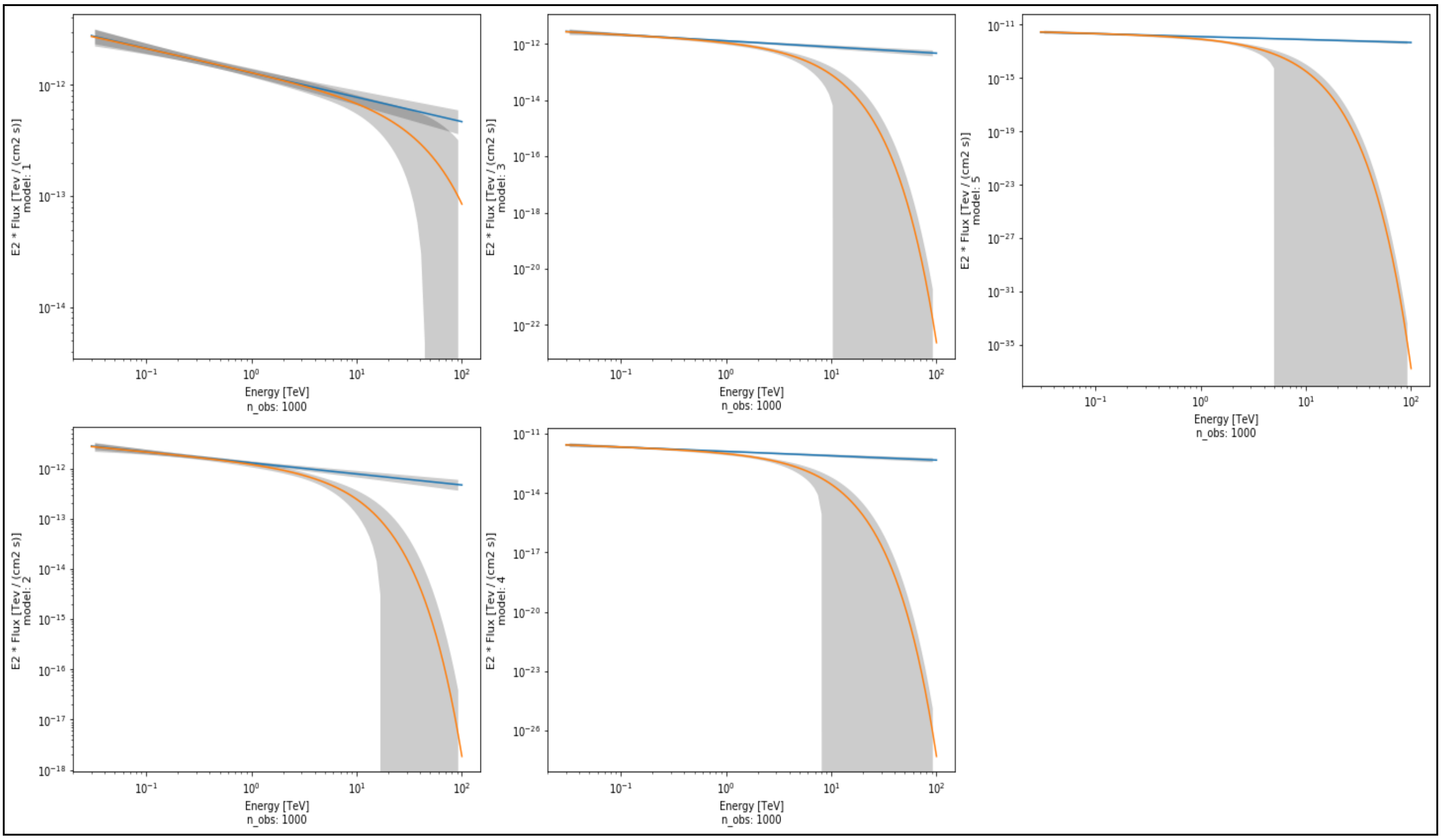
N_obs = 250



N_obs = 500



N_obs = 1000



Conclusions:

There are 6 comparisons above which take different initial parameters into account and help us know which better about them. Here I have taken 8*6 different scenarios. 8 different no. of observation and 6 different models. Initially, I preferred taking 4 more models, i.e; ExponentialCutoff_Powerlaw with lambda values 1,2,3,5. But while taking these models there were errors in simulating events from these models as well as fitting them was also creating large error bars, so these 4 models where discarded. In this analysis talking about no. of observation is same as talking about livetime, one increases the other decreases.

Taking into account the first comparison. As you can see there are 2 simultaneous histograms plotted in the same plot. There are 5 plots horizontally and 8 vertically creating a 5*8 matrix. Horizontally is the increasing no. of model and vertically is increasing no. of observation. The blue curve represents the PowerLaw and Orange represents the ExponentialCutoff_Powerlaw. Increasing the no. of model means, model=0 is simple PowerLaw, model=1 is ExponentialCutoff_powerlaw with L(lambda)=0.01 and so on. This comparison has been done for Index and Amplitude values.

The second Comparison is the plot of Mean and Standard Values against no. of observation. There are a total of 6 plots(5 in case of lambda) signifying 6 models in each case of Index_mean, Index_std, Amplitude_mean, Amplitude_std, Lambda_mean, Lambda_std.

The third comparison includes 6 boxes representing 6 models and each box containing 8 plots of different observations. These are the Flux vs Energy Curve with error bars. These plots tell us how the plot changes when the same model parameters are provided but are simulated for different no. of times. The forth does provide the same comparison without the error bars.

The fifth and sixth comparison are the same plots but changing the comparison window. The fifth one provides comparison when I keep the model same whereas the sixth one provides comparison when I no. of observation same. Both fifth and sixth comparison are Flux vs Energy Curves with error bars and also a simultaneous comparison between models, i.e; PowerLaw and ExponentialCutoff_PowerLaw.

From the above comparisons, we can see that increasing the no. of observations(reducing livetime) increases the Std. Deviation and it also creates the offset in mean value from the provided model parameter value. Comparing model wise when increasing the value lambda at large livetime the mean value tends to coincide with provided value but as the lambda increases, on decreasing livetime we can see the rate at which mean starts to offset also increases. Comparing PowerLaw and ExponentialCutoff_PowerLaw, PowerLaw tends to satisfy more with L=0.01 model, but also all plots overlap over each other no matter the model or no. of observations. Only in case of model when lambda increases its histogram overlaps the PowerLaw ones and expands in x-axis showing how big the std. deviation value is for same no. of observations.