

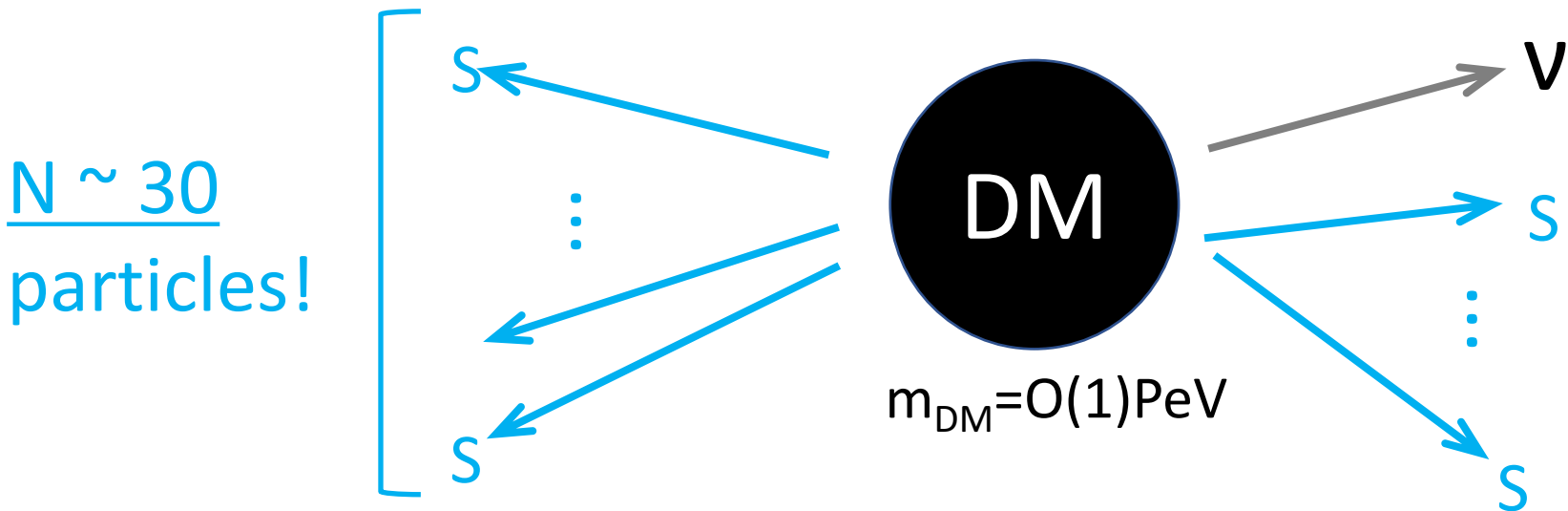
Interpretation of the IceCube TeV-PeV Neutrinos with the Multi-body Decaying Dark Matter

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Interpretation of the IceCube TeV-PeV Neutrinos with the Multi-body Decaying Dark Matter



Outline:

1, Introduction

2, Model

3, Result(s)

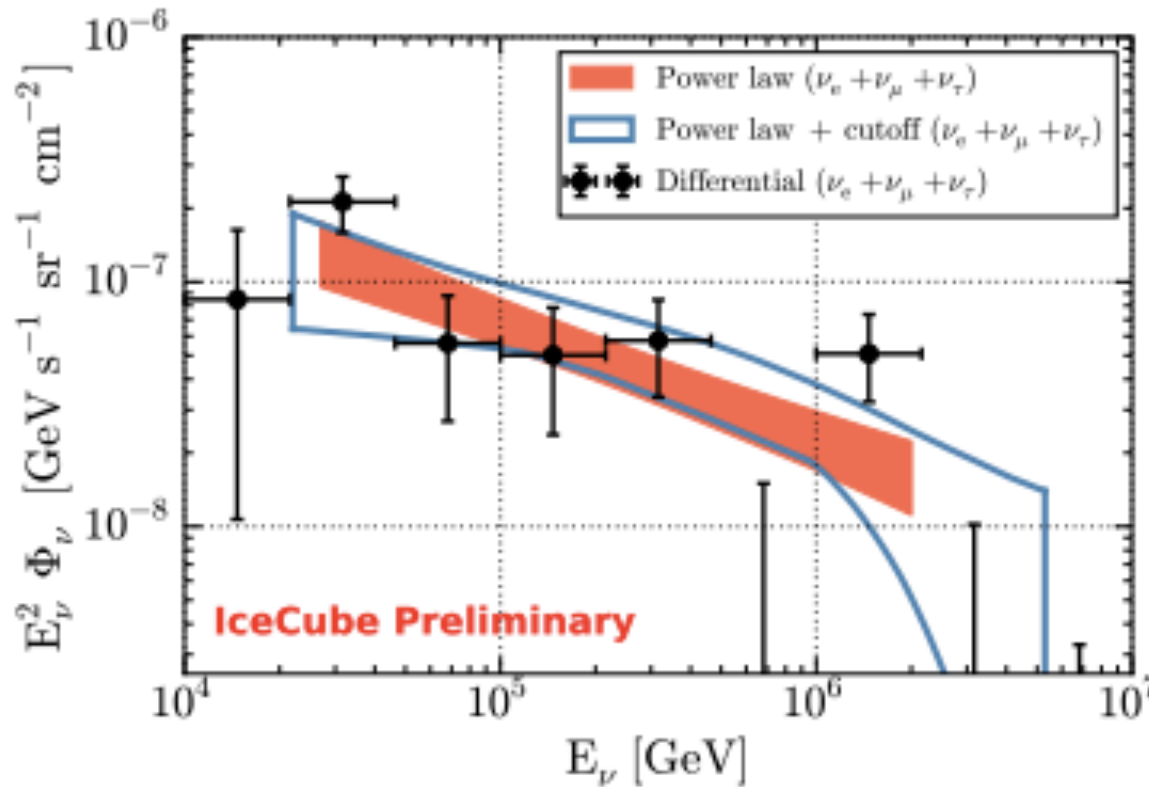
4, Summary

Introduction

What are the motivations for our multi-body decaying DM?

TeV-PeV neutrinos @IceCube

IceCube Collaboration, 1510.05223



$$E_\nu^2 \Phi_\nu \propto E^{-2.3}$$

Origin of the TeV-PeV neutrino

1, astrophysical sources : cosmic ray proton interactions

- $p + p \rightarrow p, p, \pi^0, \pi^+, \pi^- + \dots \rightarrow p + \nu + e^+ + e^-, \gamma, \dots$ $E_p \sim O(10^8)\text{GeV}$

- $p + \gamma \rightarrow p, \pi^0 \text{ or } \pi^+ \text{ or } \pi^- + \dots \rightarrow p + \nu + e^+ + e^- \text{ or } \gamma \dots$ $E_p \sim O(10^6)\text{GeV}$

e.g. GRB, AGN, Star burst galaxies, ...

2, Dark Matter : $DM \rightarrow \nu + \dots$

$$\left\{ \begin{array}{l} \gamma + \dots \\ l^+ + l^- + \dots \rightarrow \text{inverse compton } \gamma + \dots \\ q, \bar{q} + \dots \rightarrow p + \bar{p} + \pi^0 + \pi^+ \pi^- + \dots \\ \qquad \qquad \qquad \rightarrow p + \bar{p} + \nu + e^+ + e^- + \gamma + \dots \end{array} \right.$$

Origin of the TeV-PeV neutrino

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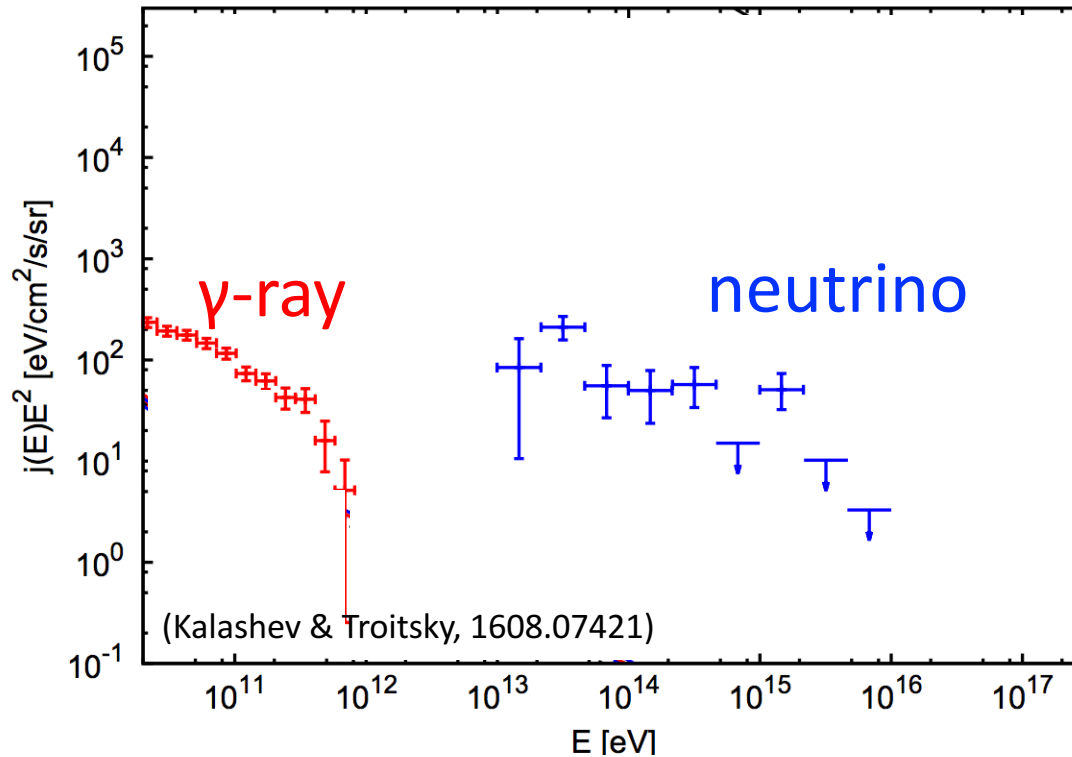
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Neutrinos often associate γ -rays

Problem1 : Isotropic γ -ray Background (IGRB)



$\Phi_\gamma \propto \Phi_\nu \Rightarrow$ higher γ -ray flux than the observed IGRB

Problem2 : substructures

Motivations:

- TeV – PeV neutrinos have been detected
- We do not know the origin of the TeV-PeV neutrino and structures of its spectrum
.....
- high energy neutrino emissions often associates γ -rays which is in conflict with IGRB observations
.....

Can we explain the TeV-PeV neutrino spectrum in consistency with the IGRB observations?

We consider the $N \sim 30$ decaying DM scenario

Model

multi-body decay!

$$\mathcal{L}_{int} = \epsilon \bar{L} l X + \frac{1}{M_*^{3n-1}} \bar{L} l S^{2n}$$

n=15

$$\left[\begin{array}{l} L = \begin{pmatrix} N_0 \\ E^- \end{pmatrix}, \quad l = \begin{pmatrix} \nu \\ e^- \end{pmatrix} \\ S: \text{dark fermion} \end{array} \right. \text{DM}$$

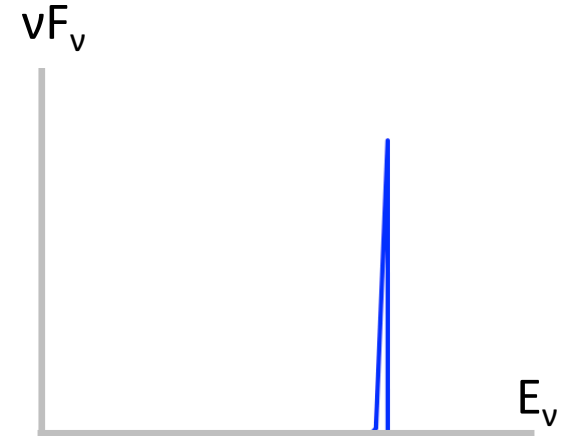
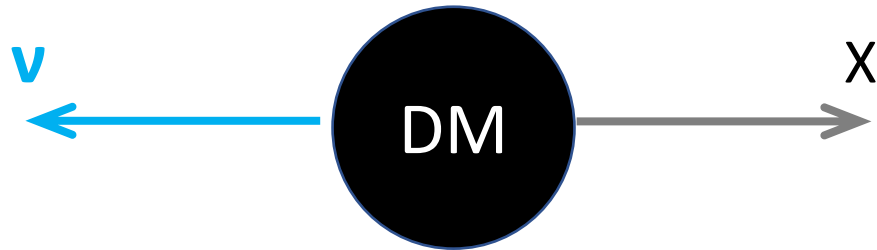
2 branches of decay modes:

- DM \rightarrow X + ν
- DM \rightarrow 2n S + ν

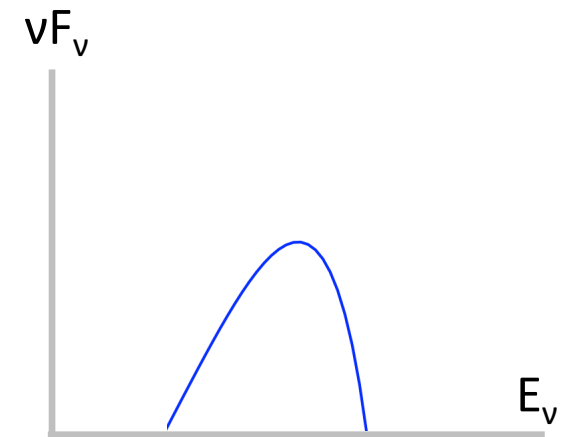
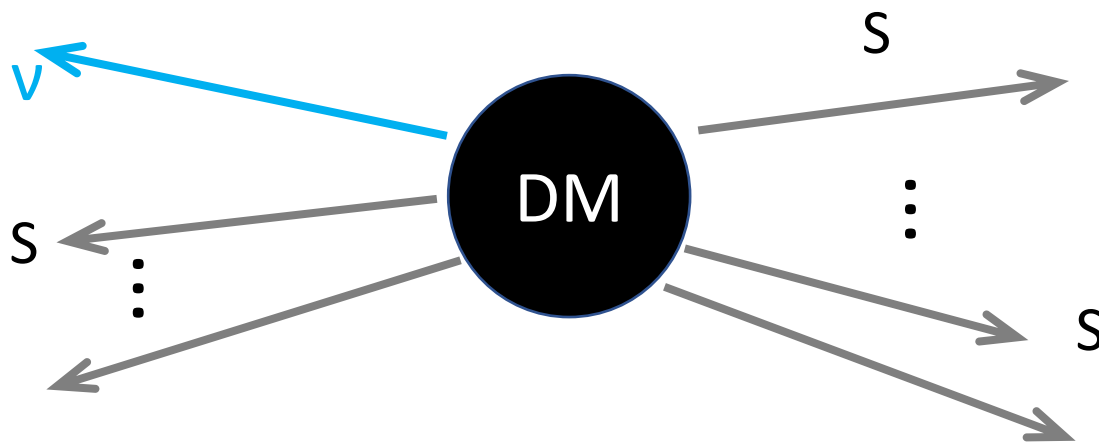
We can predict 2 components in produced neutrino spectrum

features of the neutrino spectrum

mode 1: $DM \rightarrow X + \nu$



mode 2: $DM \rightarrow 2n S + \nu$



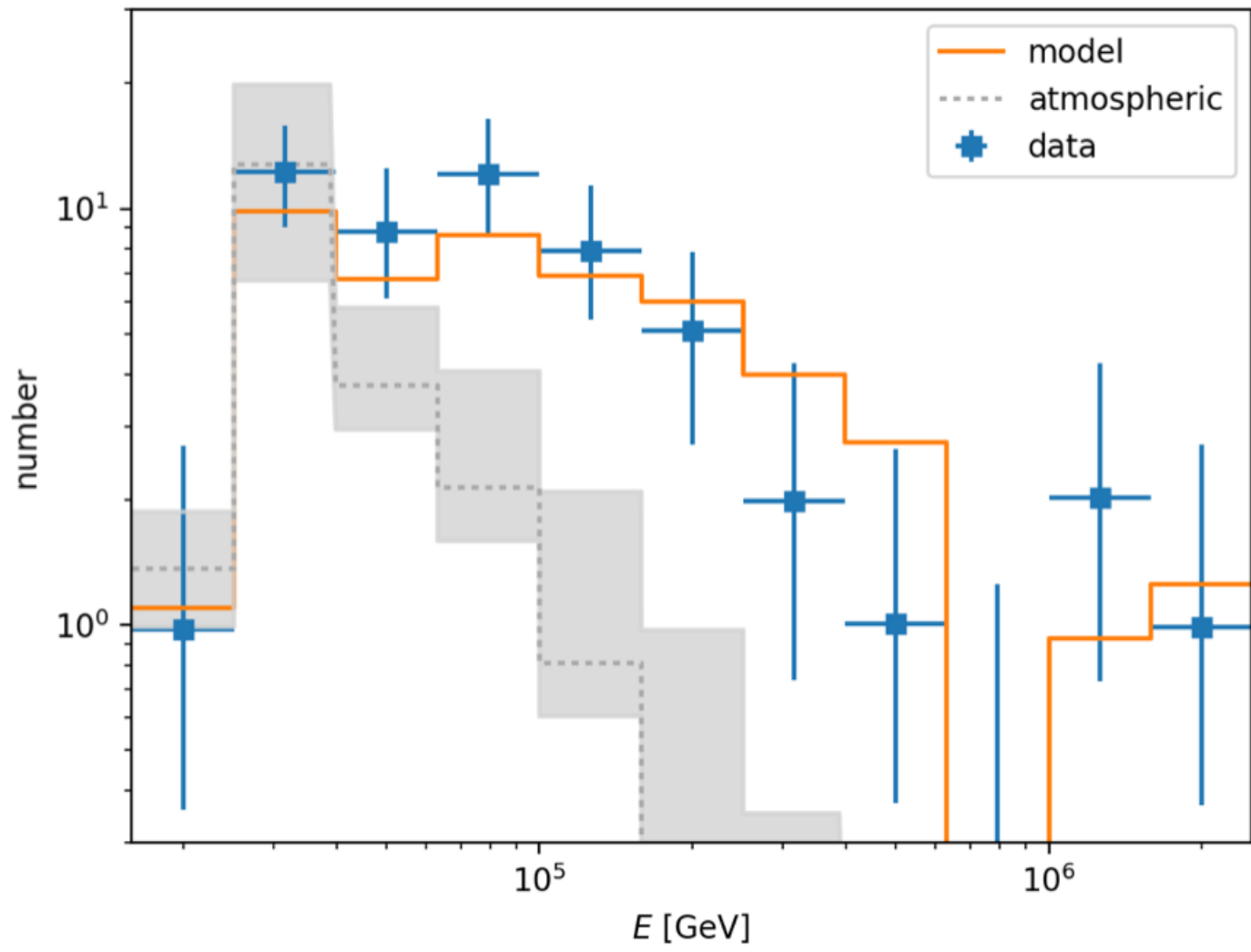
We can predict broad & line-like features in neutrino spectrum

Result

Result1: pure DM

$m_{DM}=4\text{PeV}$

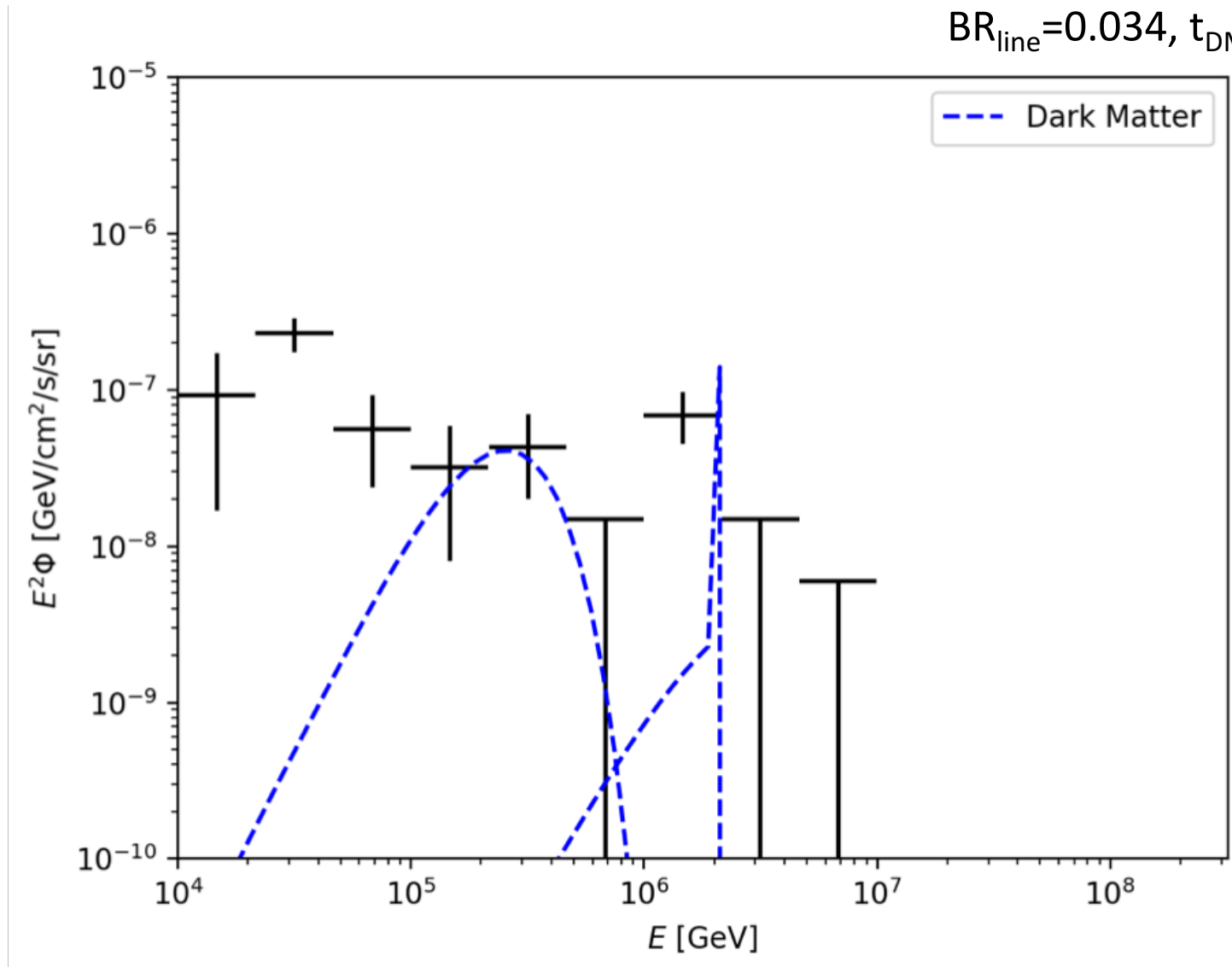
$BR_{line}=0.034, t_{DM}=1.5 \times 10^{27}\text{s}$



pure DM: source spectrum

$$m_{\text{DM}} = 4 \text{ PeV}$$

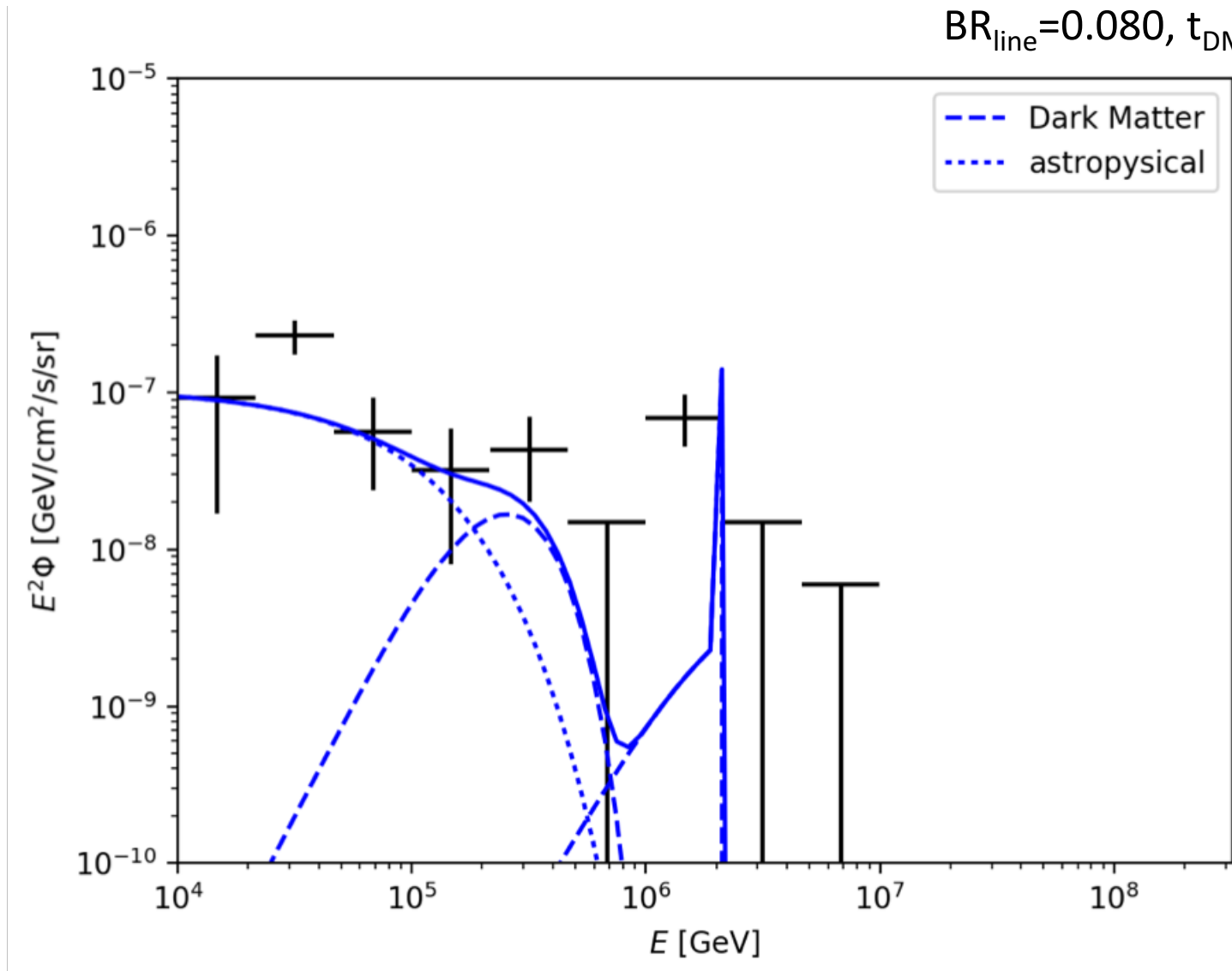
$$\text{BR}_{\text{line}} = 0.034, t_{\text{DM}} = 1.5 \times 10^{27} \text{ s}$$



fill the deficit: hidden accelerator?

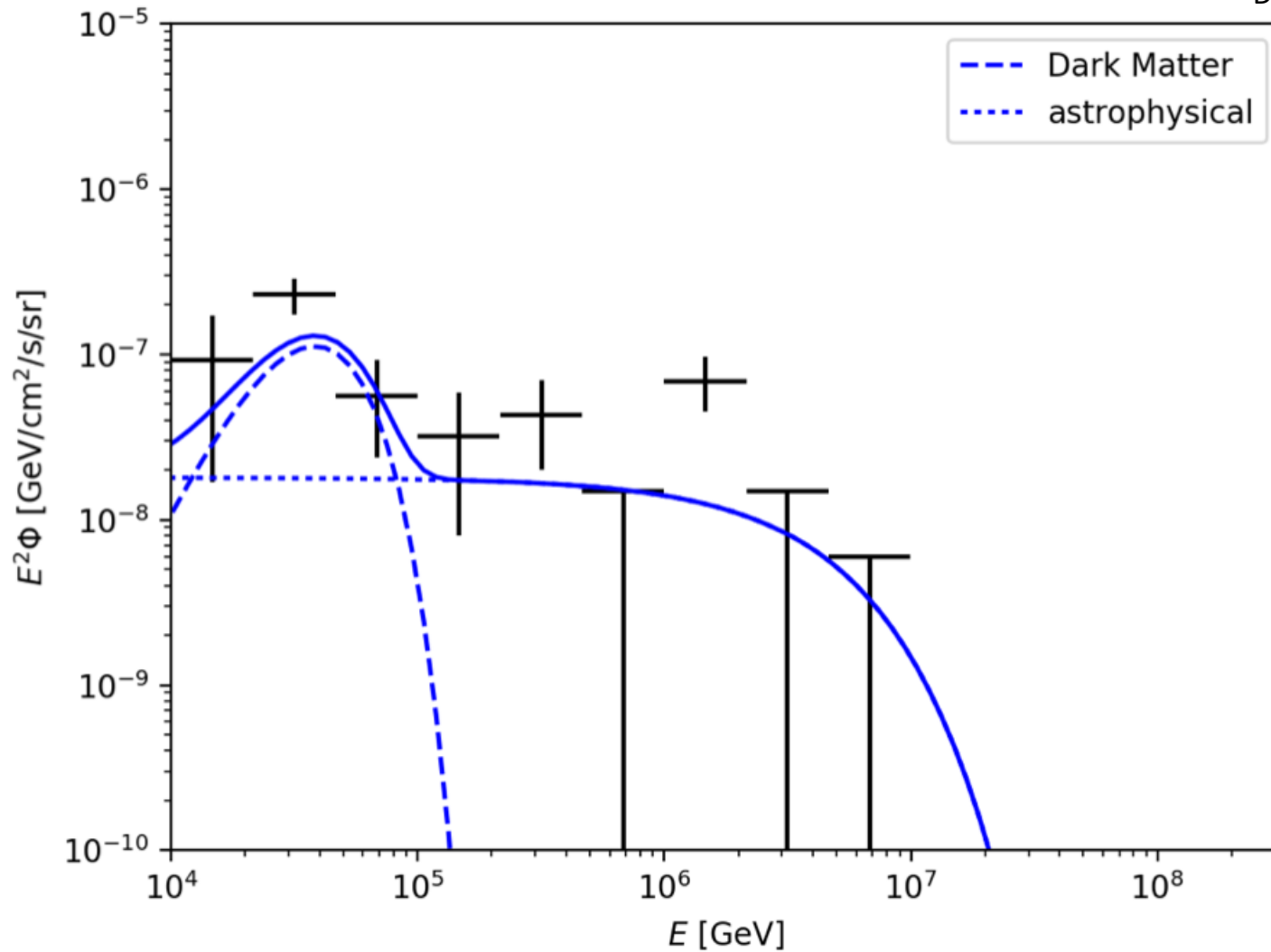
$$m_{\text{DM}} = 4 \text{ PeV}$$

$$\text{BR}_{\text{line}} = 0.080, t_{\text{DM}} = 3.4 \times 10^{27} \text{ s}$$



or the grand unified scenario?

$m_{\text{DM}}=600\text{TeV}$
 $t_{\text{DM}}=2.6 \times 10^{27}\text{s}$



Summary:

Conditions:

- We do not know the origin of the TeV-PeV neutrinos @ IceCube
- We should be careful about the IGRB when we discuss the origin of the neutrino

Choices:

- astrophysical or dark matter (DM)?

Conclusion:

Our $N \sim 30$ body decaying DM scenario can explain the observed spectrum without suffering from IGRB constraint

- 2 (or multi)- component scenario is also possible

