

## OBJECTIVES

The ultra-high-energy (UHE;  $E_\gamma \geq 100$  TeV) **gamma-ray** observations by the Cherenkov telescopes provide a very good opportunity to study potential sources of CRs. In our Galaxy, leptonic-pevatrons vs proton-pevatron source classes can be identified using the UHE gamma-ray spectrum. We have investigated two of the LHAASO detected sources **LHAASO J1908+0621** and **LHAASO J2226+6057** where UHE gamma-ray emitting regions are in spatial coincidence with pulsar wind nebula (PWN) objects. These are the salient features of our work:

- One zone, time-dependent leptonic emission model under the radiative and adiabatic cooling.
- Estimation of maximum Lorentz factor for electrons inside PWN.
- Escape-time dependent effects on the model parameters

## MATERIALS & METHODS

We assume a power-law type distribution of electrons inside the PWN and their radiation is calculated by using the NAIMA public code. Further the continuity equation for electron population  $N_e(\gamma, t) \propto \gamma^{-p}$  is

$$\frac{\partial N(\gamma, t)}{\partial t} + \frac{\partial}{\partial \gamma} [\dot{\gamma}(\gamma, t) N(\gamma, t)] + \frac{N(\gamma, t)}{t_{\text{esc}}} - Q(\gamma, t) = 0,$$

where  $\gamma$  is the electron Lorentz factor,  $t_{\text{esc}}$  is escape time and  $Q(\gamma, t)$  is the source term. The second term is the cooling under radiative and adiabatic cooling.

## REFERENCES

- [1] V. Zabalza. naima: a python package. *Proc. of International Cosmic Ray Conference 2015*, page 922, 2015.
- [2] E. van der Swaluw, A. Achterberg, Y. A. Gallant, and G. Tóth. *A&A*, 380:309–317, December 2001.
- [3] Jagdish C. Joshi, Shuta J. Tanaka, Luis Salvador Miranda, and Soebur Razzaque. *arXiv 2205.00521*.

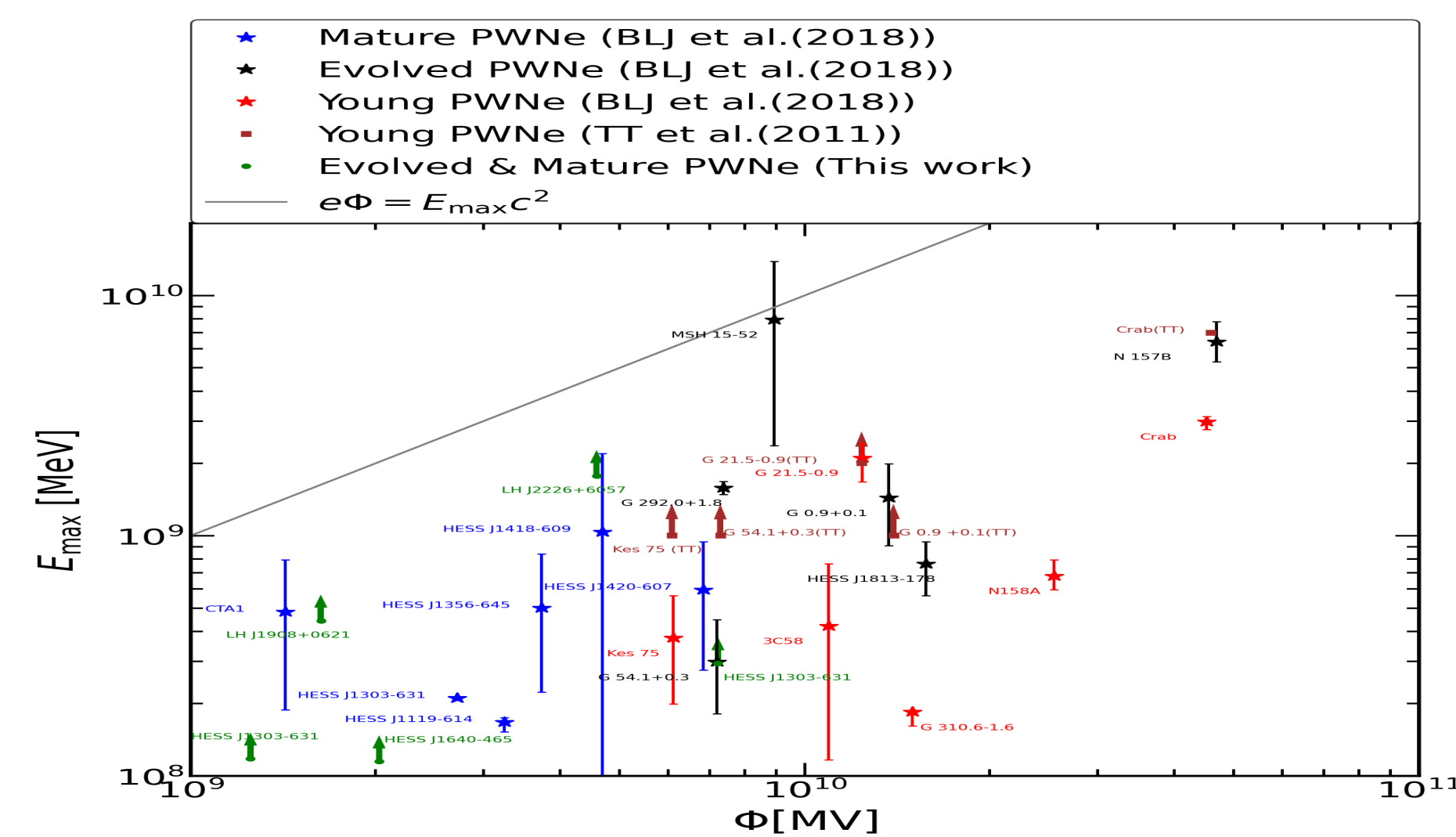
## INTRODUCTION

Recently, the Large High Altitude Air Shower Observatory (LHAASO) reported discovery of 12 UHE gamma-ray sources located in the Galactic plane. We study multiwavelength radiation from these sources by considering a PWN origin. The pulsar wind nebula (PWN) structure is energetically supported by the spin-down luminosity of the central pulsar and its composition is dominated by  $e^\pm$  pair-plasma coupled with the magnetic field, as well as nuclei.

In this work, we consider a semi-analytical formalism for the evolution of the PWN radius in which the reverse-shock effects from the associated supernova-remnants are not included. Further we have tested the effects on the model parameters, if the particle escape are allowed from the PWN region assuming Bohm type ( $D(\gamma) \propto \gamma$ ) and Kolmogorov type  $D(\gamma) \propto \gamma^{1/3}$  diffusion mechanisms.

## MAXIMUM ENERGY: ELECTRONS

The maximum energy of the electrons is scaled with the polar cap potential of the central pulsar.



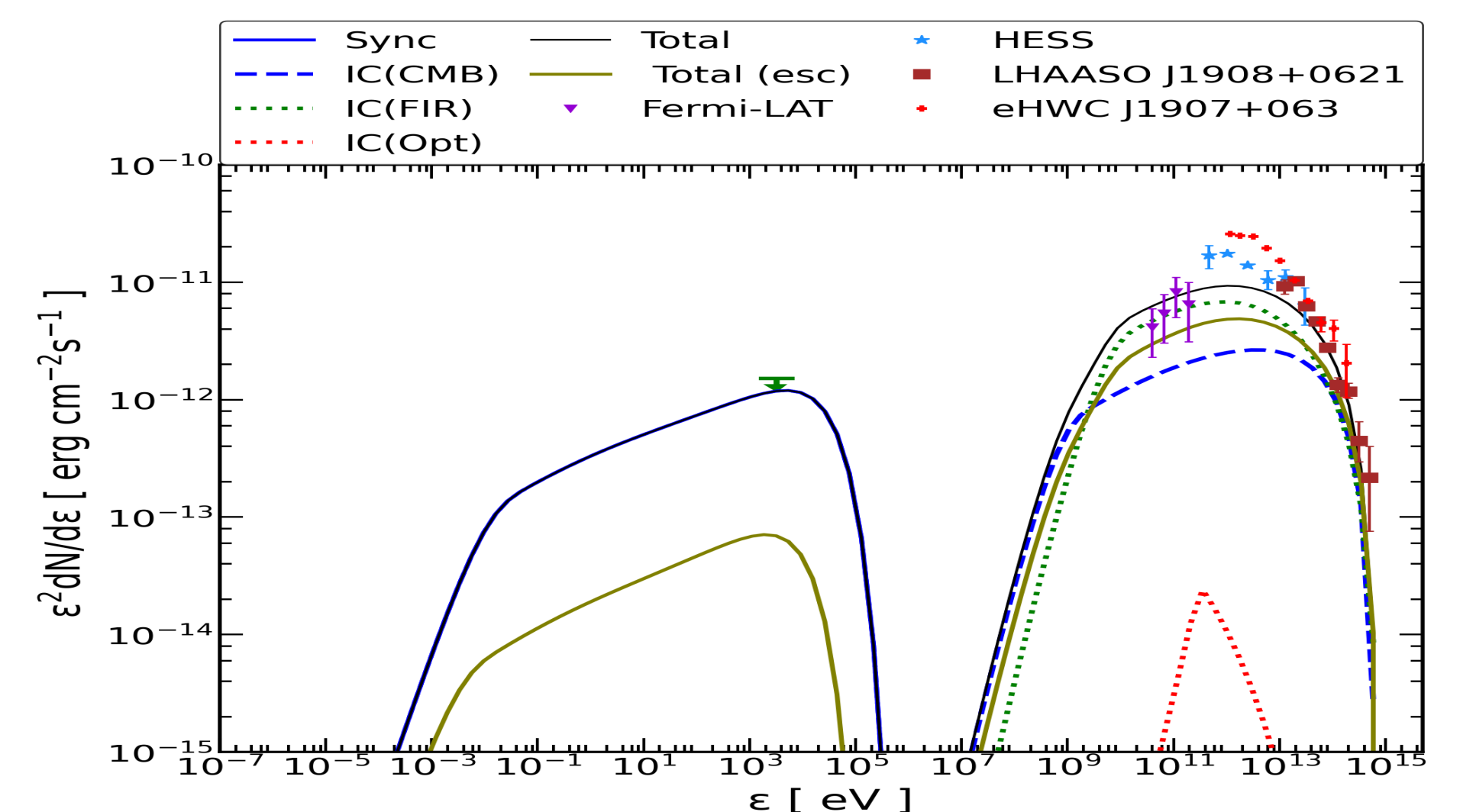
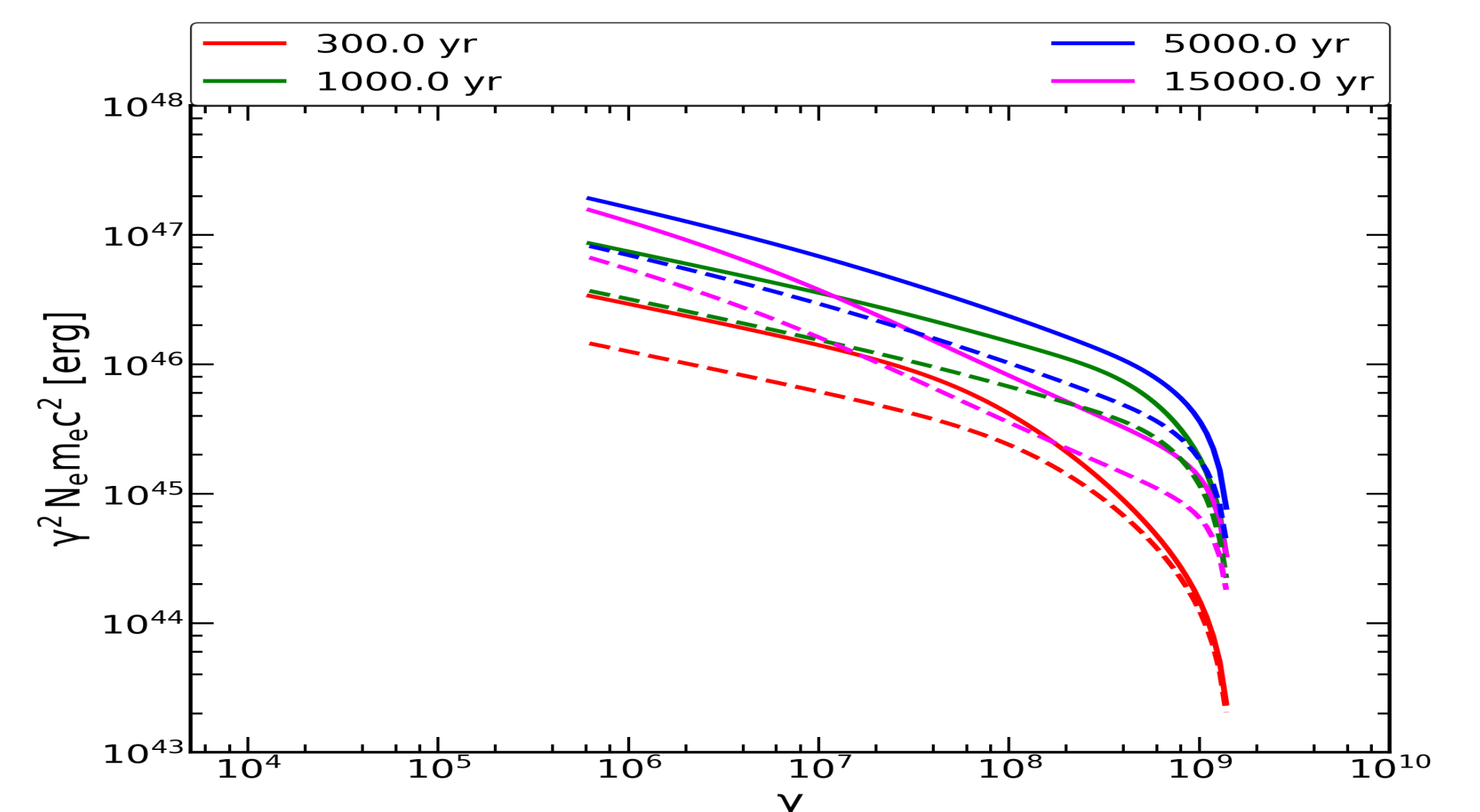
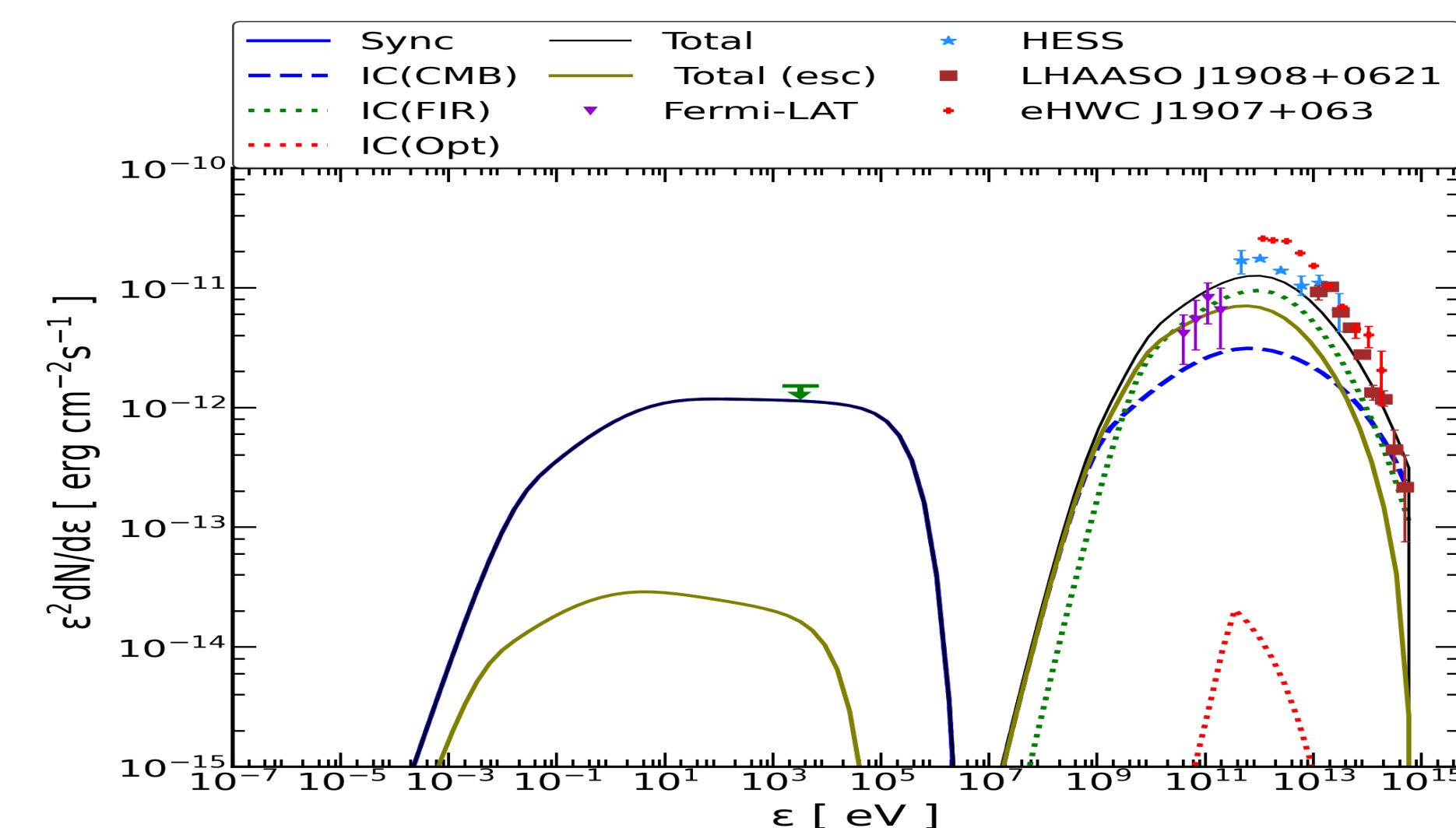
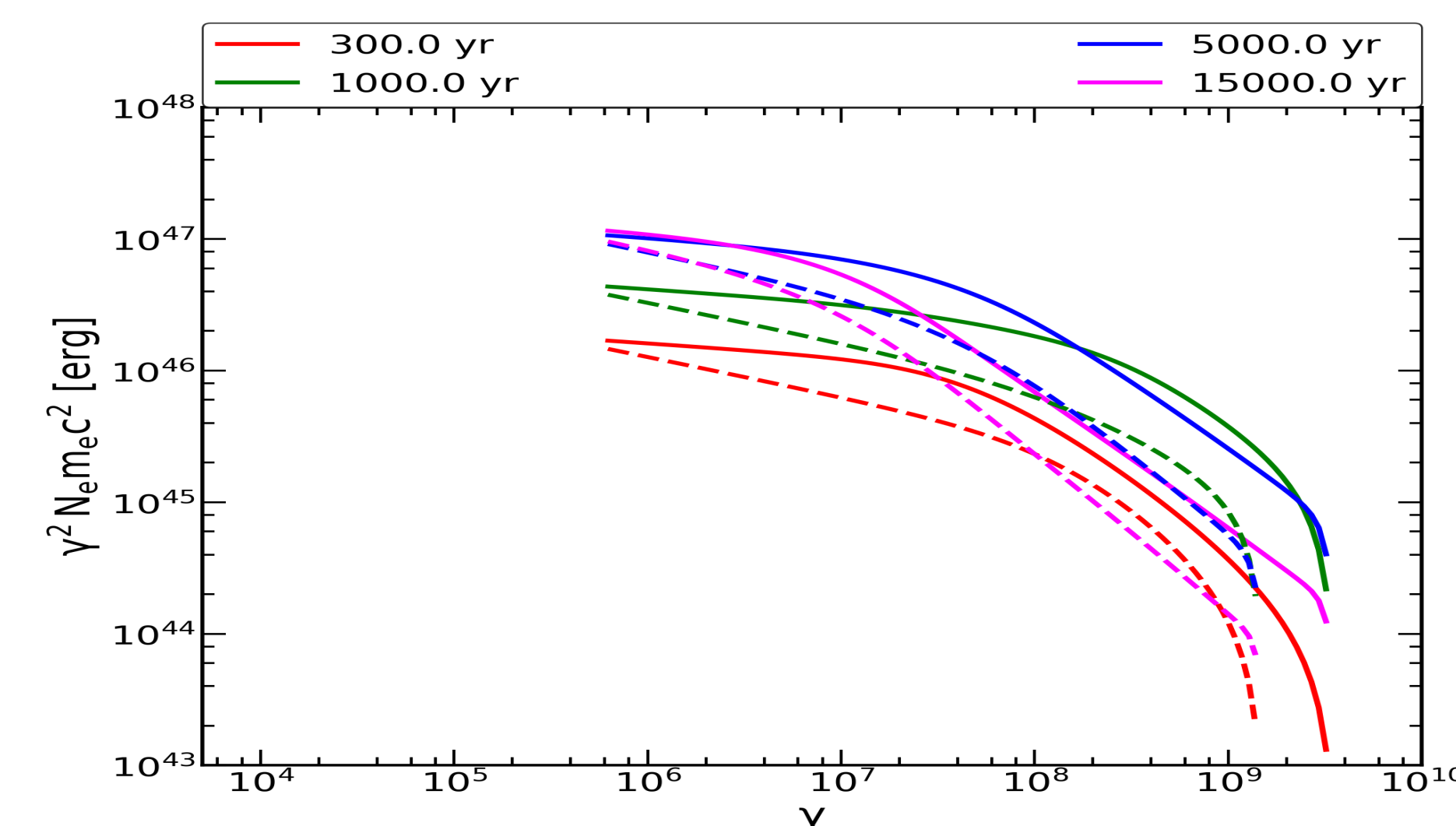
## DIFFUSION COEFFICIENT AND MODEL PARAMETERS

Using  $t_{\text{esc}}^{\text{Bohm}} = 7 \text{ Myr} (B(t)/100 \mu\text{G}) (\gamma/10^6)^{-1} (R_{\text{PWN}}(t)/2 \text{ pc})^2$  and the normalization in case of Kolmogorov type is constrained compared to the average ISM one,  $t_{\text{esc}}^{\text{Kol}} = 5 \text{ kyr} (U/0.001)^{-1} (\gamma/10^6)^{-1/3} (R_{\text{PWN}}(t)/2 \text{ pc})^2$ , where  $U = D_{0,\text{PWN}}/D_{0,\text{ISM}} \approx 10^{-3}$  at 1 GeV.

Parameters	None	Bohm Type	Kolmogorov Type
$\gamma_{\text{min}}$	$6 \times 10^5$	-	-
$\gamma_{\text{max}}$	$1.5 \times 10^9$	$3.5 \times 10^9$	-
$p$	2.3	2.1	-
$\eta_e$	0.15	0.3	0.35
$\eta_B$	$8 \times 10^{-5}$	$3 \times 10^{-4}$	$1.7 \times 10^{-4}$
$\gamma_{\text{max,Sy}}$	$8.8 \times 10^8$	$\sim 10^9$	$\sim 10^9$

## SPECTRAL ENERGY DISTRIBUTION: LHAASO J1908+0621

The electron population/multiwavelength radiation from **LHAASO J1908+0621** (Left Panel: Bohm Type,  $d \sim 3.2$  kpc,  $E_{\gamma,\text{max}} \sim 0.44$  PeV,  $t_{\text{age}} \sim 15$  kyr) and same (Right Panel: Kolmogorov Type).



## CONCLUSIONS AND FUTURE RESEARCH

- Electrons of maximum energy are injected from the central compact object into the PWN.
- The particle escape features are shown here for LHAASO J1908+0621 and similar results are obtained for LHAASO J2226+6057.
- The diffusion mechanism of the particles cannot be established in the current model setup.

The dynamical evolution of the PWN radius are currently under development and it help us to investigate the impact of SN reverse shock on the PWN radius.

## CONTACT INFORMATION

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