Cosmic-ray Spectra in the Vicinity of Supernova Remnant W28

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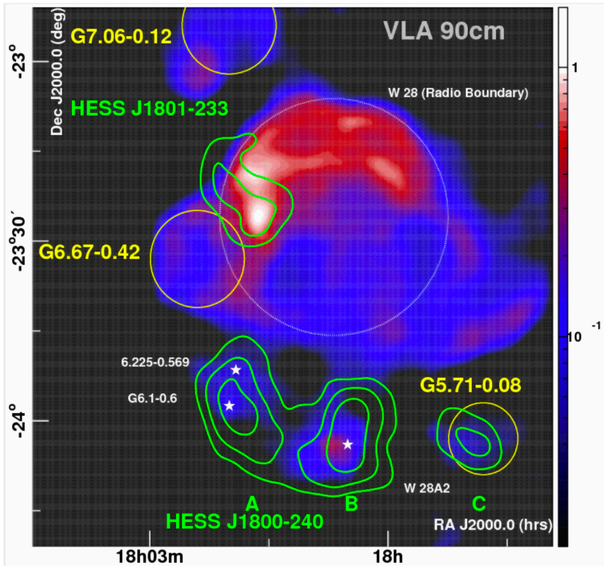
Introduction

Supernova remnants interacting with molecular clouds are ideal laboratories to study the acceleration of particles at shock waves and their transport and interactions in the surrounding interstellar medium.

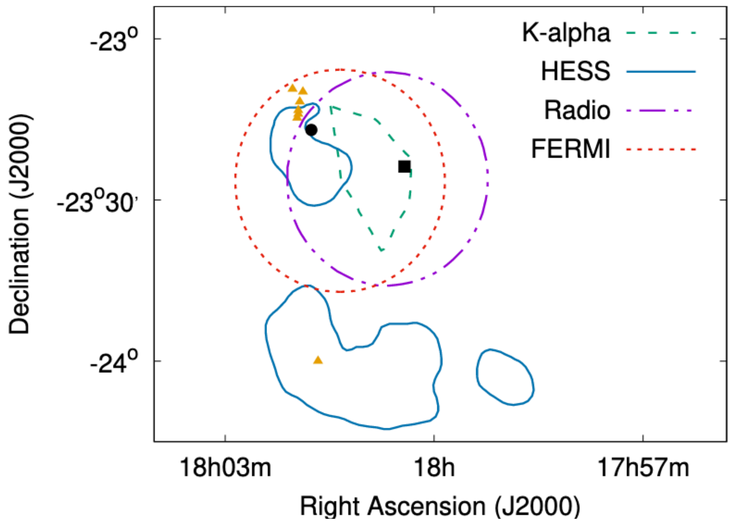
Ionization rate and gamma-ray data could provide constraints on the cosmic-ray spectra at low and high energies.

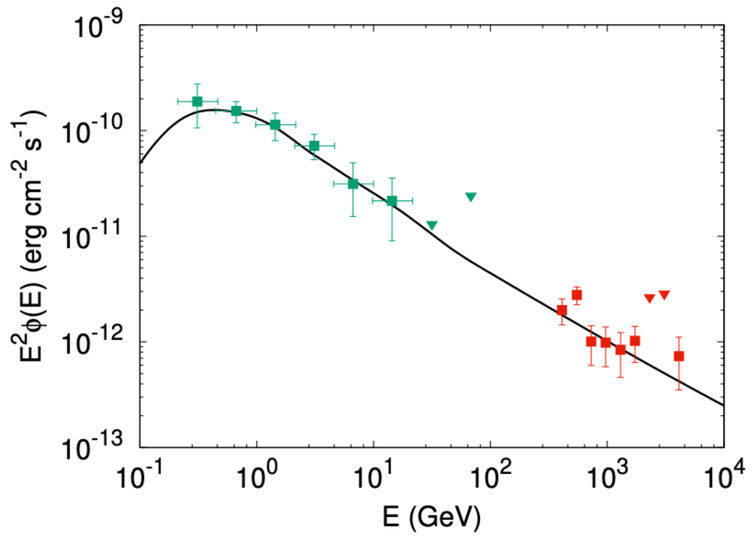
Observations of the W28 region



Constraints from Nonthermal Emission

Measurements of the ionisation rates are also available for line of sights coinciding with the cloud observed in gamma rays.





Cosmic-Ray Spectra

Species	$A_{p,e}$ ($eV^{-1}\,cm^{-3}$)	$\delta_{p,e}$	$T_c^{min} - T_c^{max}$ (MeV)
Proton	3.15×10^{-17}	2.76	26–320
Electron	$\ll 6.4 \times 10^{-19}$	2.7	$\ll$20–130

Discussion

Even though we cannot exclude a contribution to the ionization rate coming from cosmic-ray electrons, we show that a scenario where cosmic-ray protons explain both the gamma-ray flux and the enhanced ionization rate provides the most natural fit to multiwavelength data. This strongly suggests that the intensity of CR protons is enhanced in the region for particle energies in a very broad range covering almost six orders of magnitude: from around 100 MeV up to several tens of TeV.

References

1. Phan et al., 2020, A&A, 635, A40.
2. Aharonian et al. 2008, A&A, 481, 401

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