The Astrophysical Journal, 850:71 (19pp), 2017 November 20 https://doi.org/10.3847/1538-4357/aa9219
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A Detailed Study of the Interstellar Protons toward the TeV γ-Ray SNR RX J0852.0–4622 (G266.2–1.2, Vela Jr.): The Third Case of the γ-Ray and ISM Spatial Correspondence

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[1]

Soonyoung Roh

Cosmic-rays : charged and very energetic particles
one of the primary components of high energy particles

Energy Densities in the Local Interstellar Space

Interstellar Component	Energy Density (eV cm^{-3})
Cosmic Microwave Background (CMB)	0.265
Far-infrared radiation from dust	0.31
Starlight ($h\nu$ <13.6 eV)	0.54
Thermal kinematic energy $(3/2)nkT$	0.49
Turbulent kinematic energy $(1/2)\rho v^2$	0.22
Magnetic energy $B^2/8\pi$	0.89
Cosmic-rays	1.39

CRs affect eating and ionization of the interstellar medium (ISM).

However, the **site of galactic cosmic-rays acceleration ($E < 3\times10^{15}$ eV) is still not clear.**

Cosmic-Ray Acceleration in Supernova Remnants

Supernova remnants (SNRs)

-The most likely candidates for the acceleration site below the Knee energy.
-Energy sources satisfactory explain the CR production rate in the Galaxy.

Kinetic Energy Budget:

-Collisionless shock waves are very powerful in the galactic sources satisfying the kinetic energy needed to explain the injection rate of the cosmic-rays.

Required injection rate of CRs (L_{CR}) $$L_{\rm CR} = \frac{V\,\varepsilon_{\rm CR}}{\tau_{\rm esc}} \sim 10^{41}\ {\rm erg\ s^{-1}}$$

Total power of supernova explosion $$P_{\rm SNR} = \frac{E_{\rm SN}}{f_{\rm SN}} \sim 10^{42}\ {\rm erg\ s^{-1}}$$

$E_{SN}=10^{51}$ erg (typical supernova explosion energy)
$f_{SN}=30$ yr (~3 events/century)

$V = \pi R^2 h \sim 4\times10^{66}\ {\rm cm^{-3}}$

$\varepsilon_{\rm CR} = 1.39\ {\rm eV\ cm^{-3}} = 2.2\times10^{-12}\ {\rm erg\ cm^{-3}}$

$\tau_{\rm esc} \sim 3\times10^{6}\ {\rm yr}$

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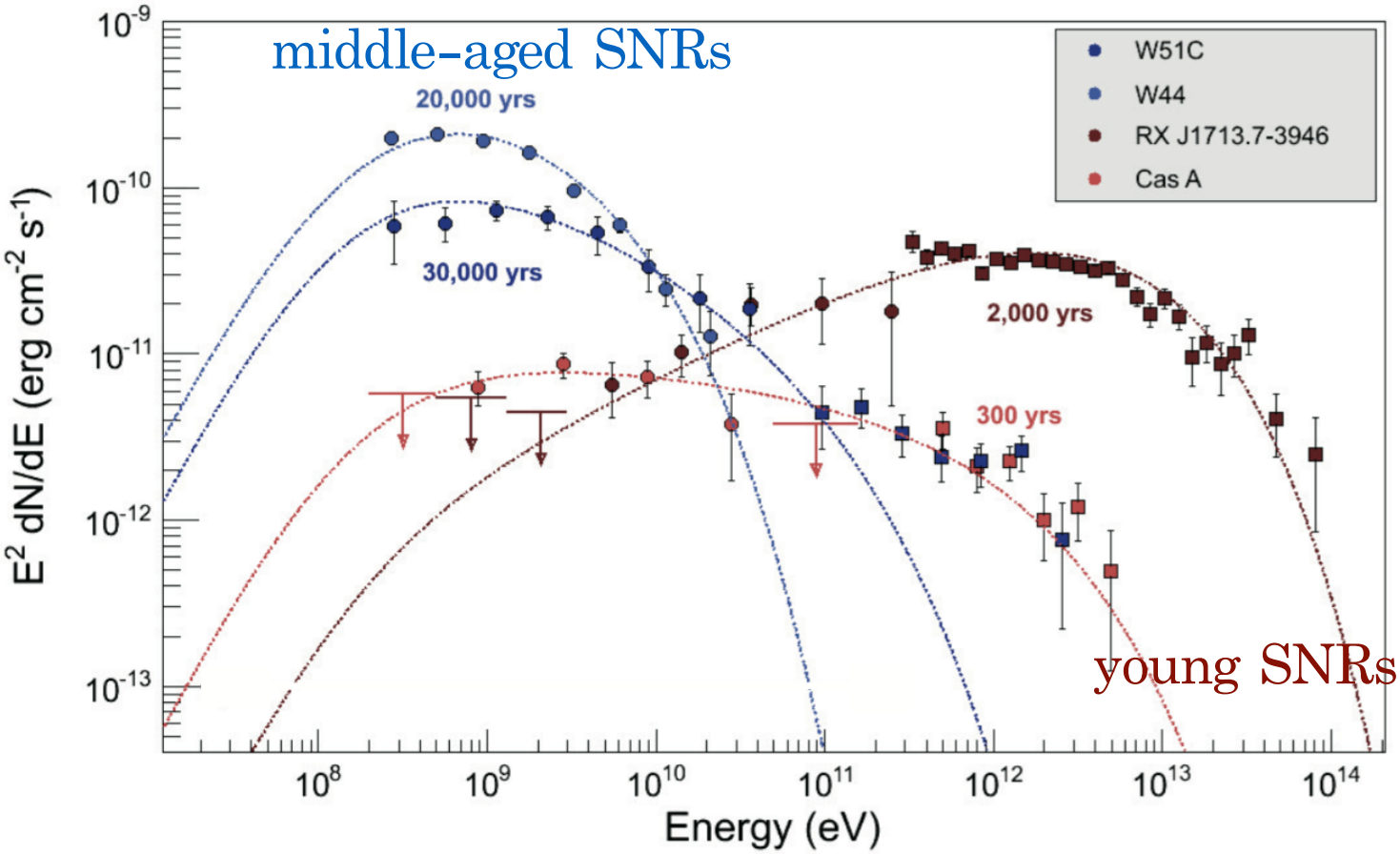
Therefore, if the galactic cosmic-rays are accelerated in SNRs, ~10% of each supernova energy is transferred to cosmic-rays.

Spectral energy distribution of γ-rays toward typical 4 SNRs



Funk, 2012

Filled circles: observed points of GeV
Squared: VHE (> 100 GeV) γ-rays
Each dashed line: expected energy spectrum by the DSA model

In middle-aged SNRs, max energy of expected gamma-ray spectrum: $< 10^{11}$-10^{12}eV

young SNRs: $< 10^{13}$-10^{14}eV

The energy of cosmic-ray protons Ep is ~10 times higher than gamma-ray energy.

Young SNRs are the best target to observe for the understanding efficient acceleration of CR protons.