Non-thermal Radiation in Supernova Remnants

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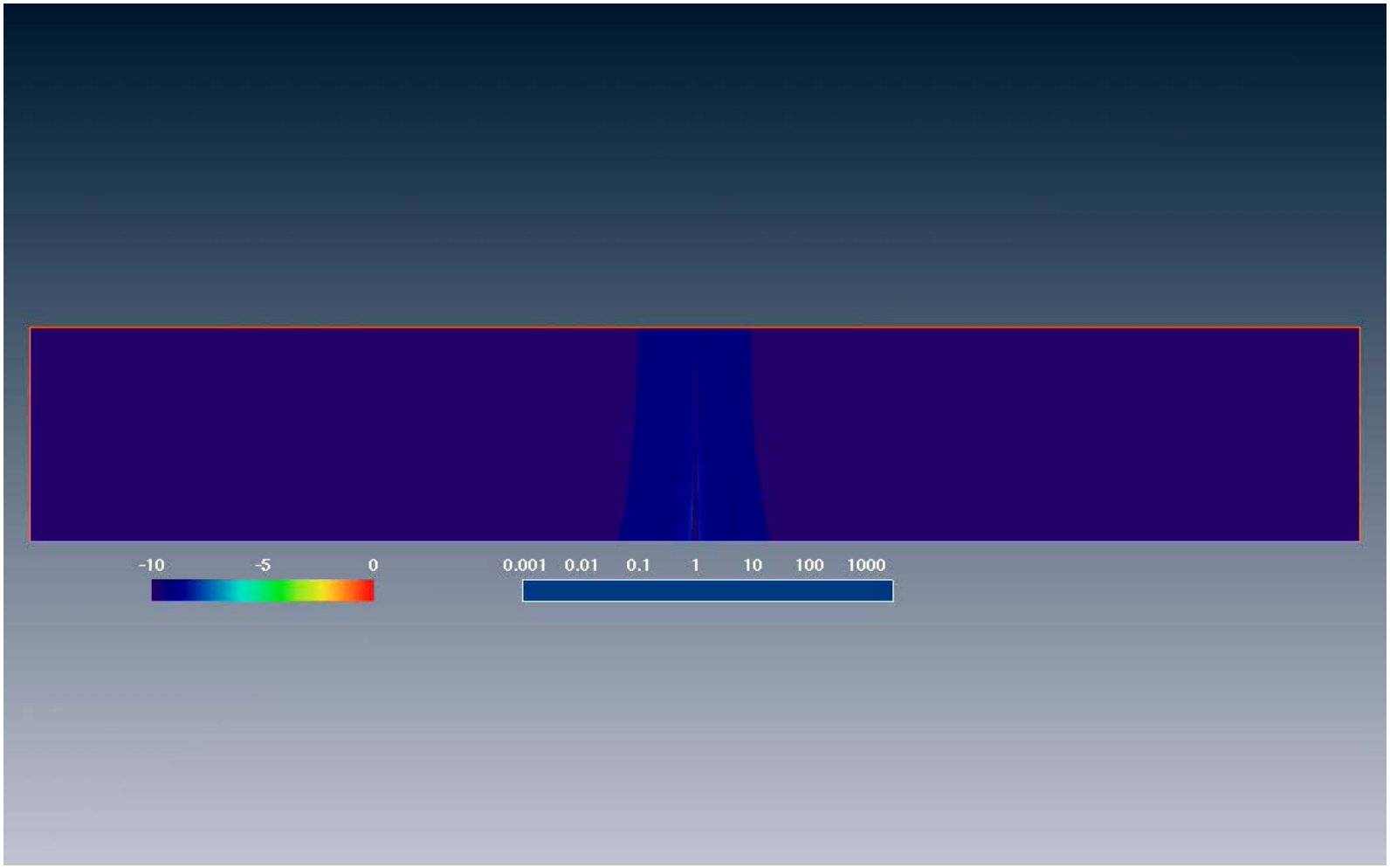
Cosmic Ray Protons in Colliding Wind Binary

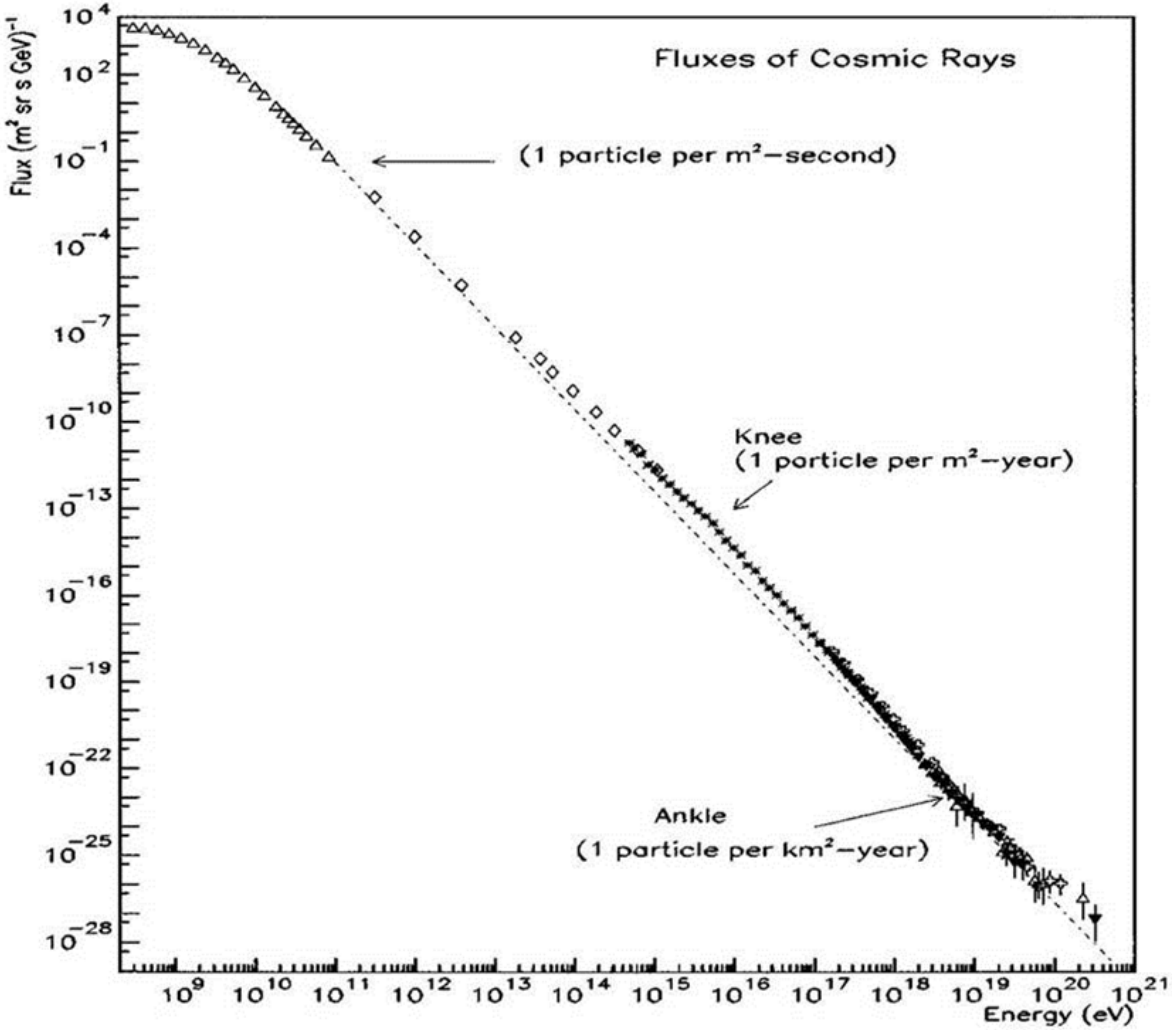


Type Ia Supernovae

- Two Primary Progenitors
  - Colliding WD Binaries
  - WD Accretion
- Explosion Energy
  - One FOE: 10^{51} ergs
- Three Phases of Evolution
  - Free Expansion Phase
  - Sedov-Taylor Phase
  - Radiative Phase

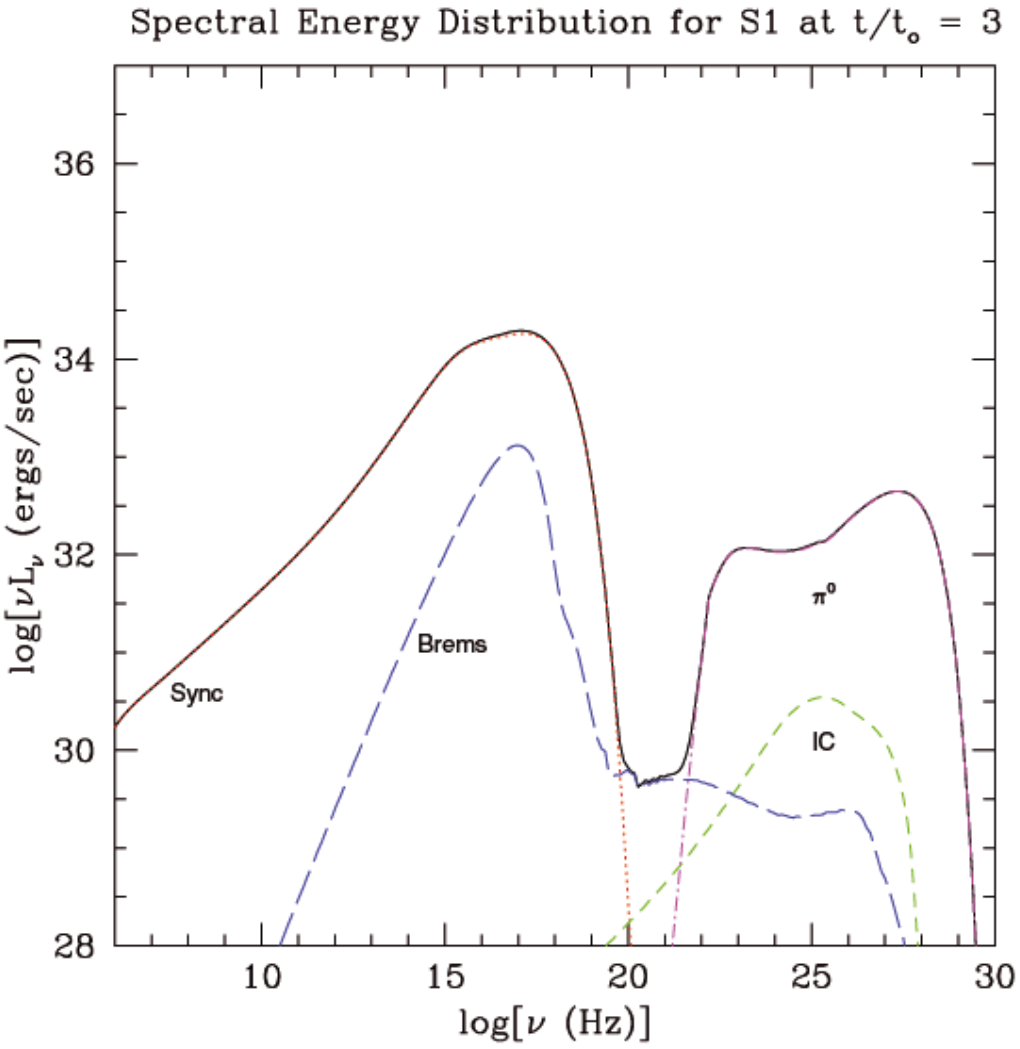
Credit: Zolt Levay (STScI)

Galactic Cosmic Rays



Credit: Simon Swordy

Nonthermal Radiation



Credit: Edmon et al. 2011

Simulations

- Edmon, Kang, Jones, & Ma MNRAS 414 (2011) 3521
- Cosmic RAy SHock (CRASH) code
  - 1-D Adaptive Mesh Refinement
  - Bohm Diffusion
  - Shock Frame
  - Active Proton CR Feedback
  - Passive Electron CR
- Aura Radiation Code
  - Assumed $K_{e/p} = 10^{-4}$
  - Assumed 4 Component Galactic Radiation Field: CMB + Dust + Old Red Stars + Young Blue Stars

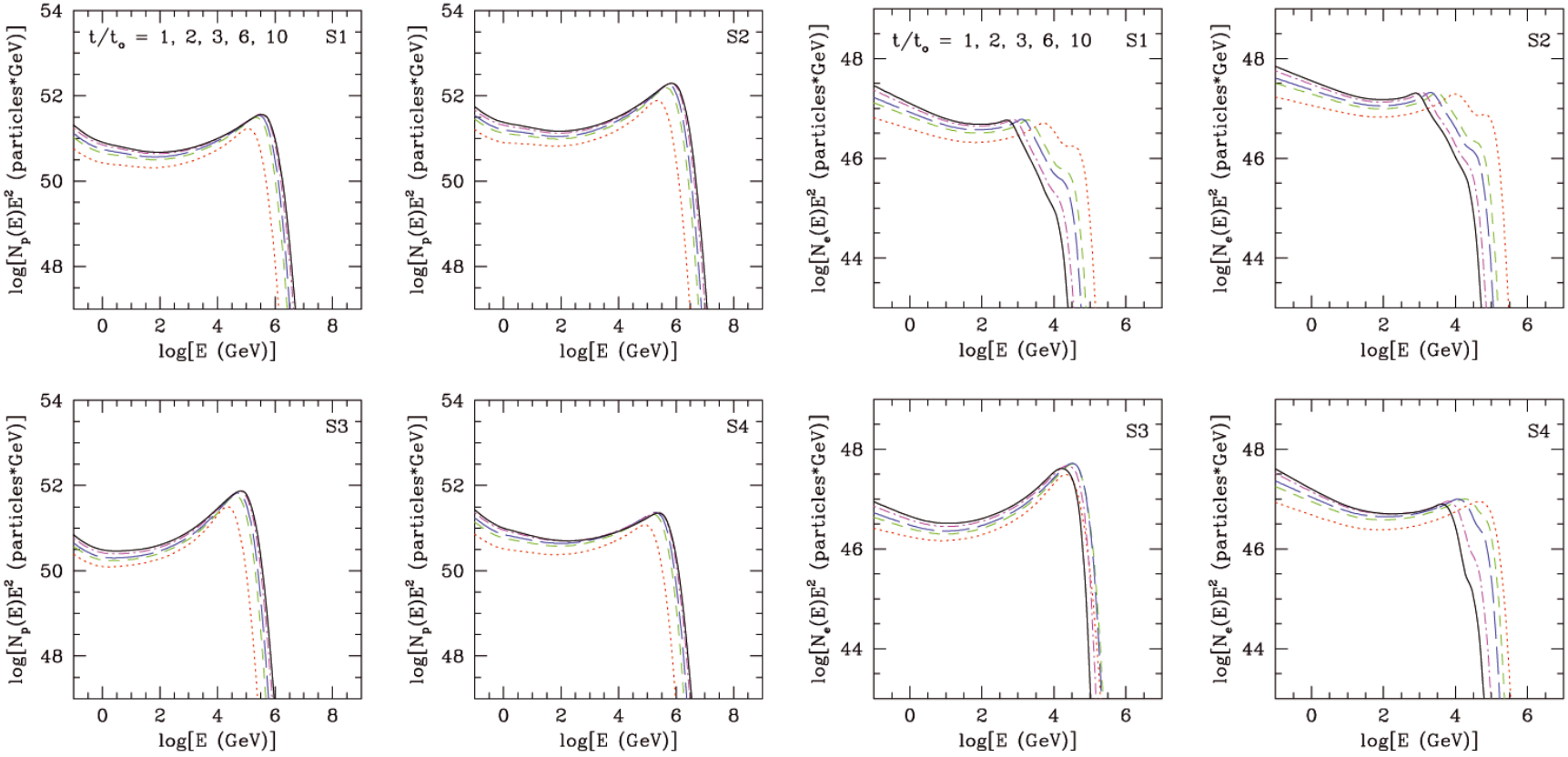
Model	n_{ISM} (cm^{-3})	T_{ISM} (K)	E_o (10^{51} erg)	B_0 (μG)	r_o (pc)	t_o (yr)	u_o (10^4 km s^{-1})
S1	0.3	3×10^4	1	30	3.19	255	1.22
S2	0.3	3×10^4	4	30	3.19	127	2.45
S3	0.3	3×10^4	1	5	3.19	255	1.22
S4	0.003	10^6	1	5	14.8	1182	1.22

Note. the model ISM Alfvén speed, $v_A = 101\,km\,s^{-1}$ for S1, S2; $v_A = 16.8\,km\,s^{-1}$ for S3; $v_A = 168\,km\,s^{-1}$ for S4.

Simulations

Protons

Electrons



Credit: Edmon et al. 2011

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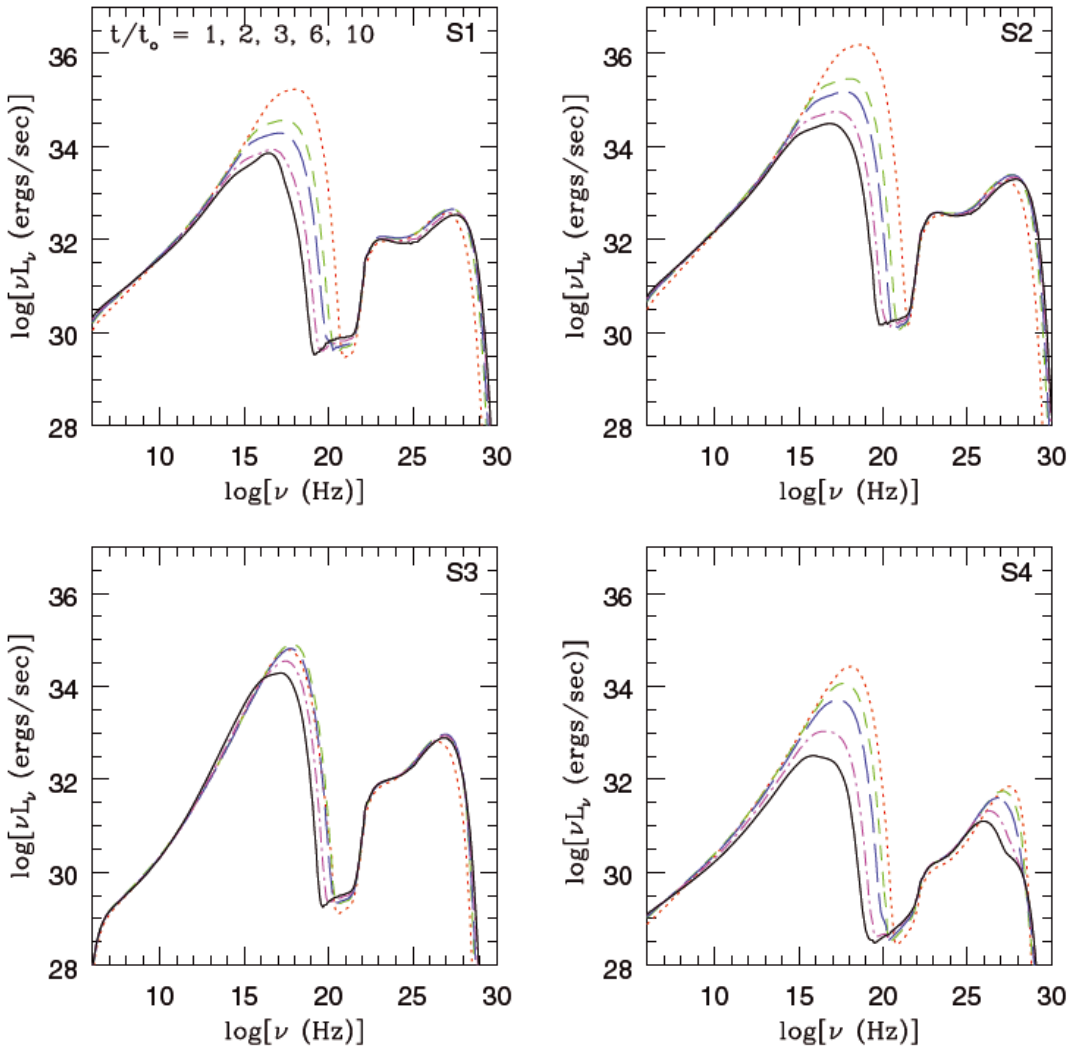
Compare and Contrast



Credit: Edmon et al. 2011

Tycho's SNR

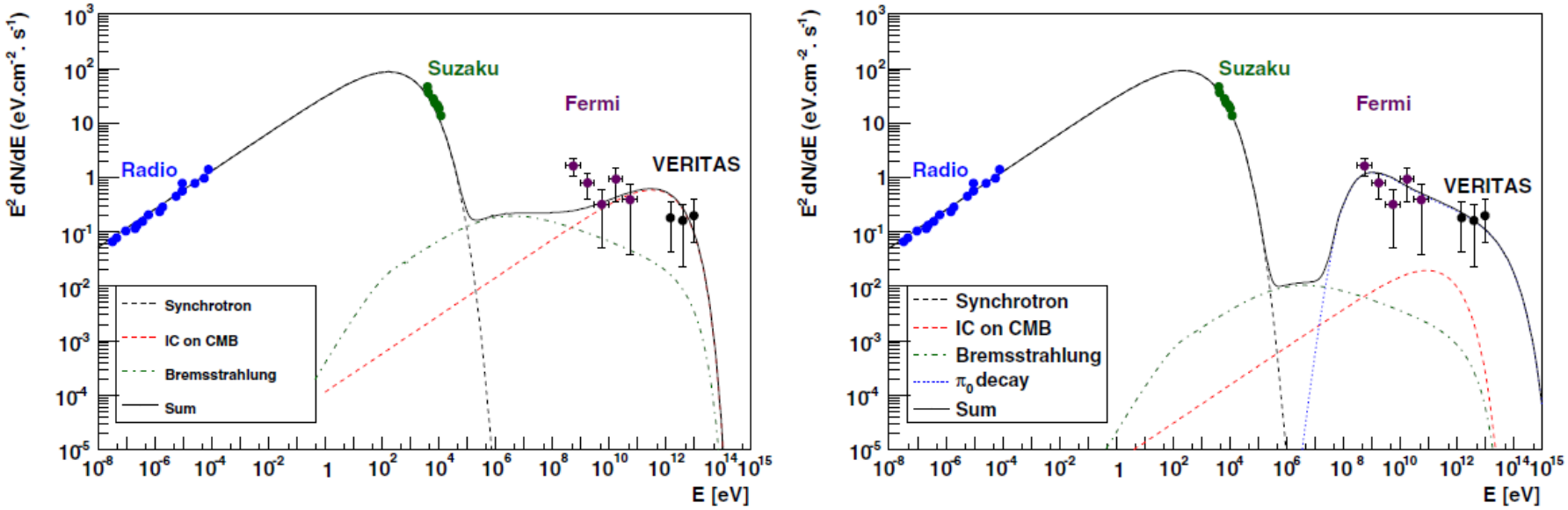


Figure 4. Broadband SED model of Tycho's SNR for the far scenario in leptonic model (left) and hadronic interpretation (right).

Giordano et al. (2012)

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Summary

- Simulations show broad consensus with data
- Data indicates that pions are most likely the cause of the gamma ray spectrum
- Shocks are not as modified as simulation shows though there does appear to be acceleration up to 10^{15} eV for protons