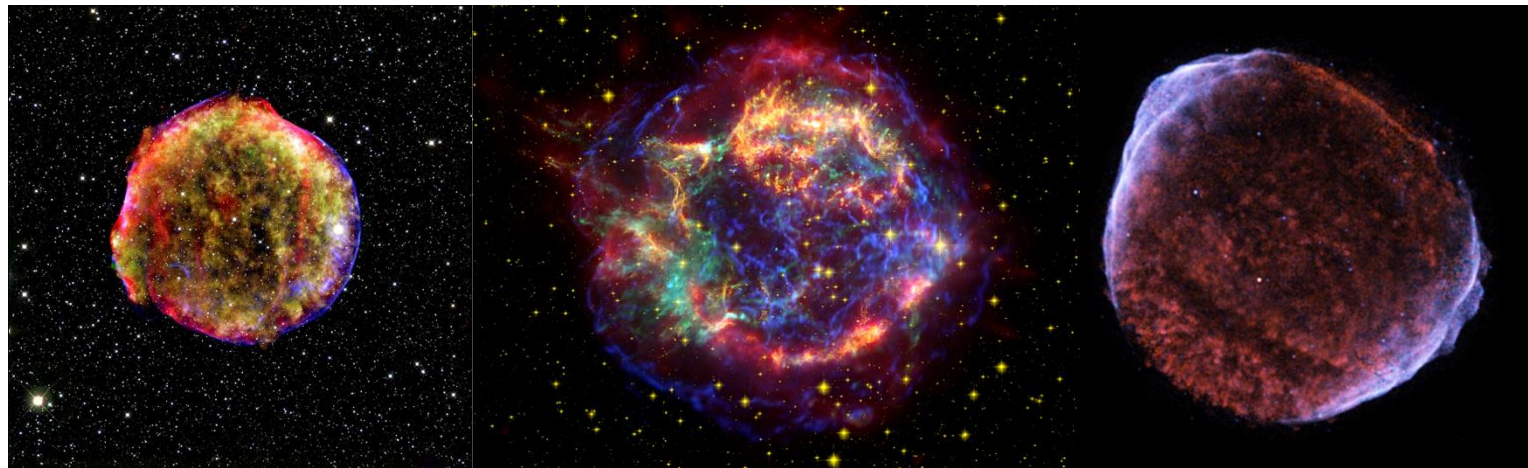


The Impact of the Reverse Shock on Cosmic Ray Spectra in Young SNRs

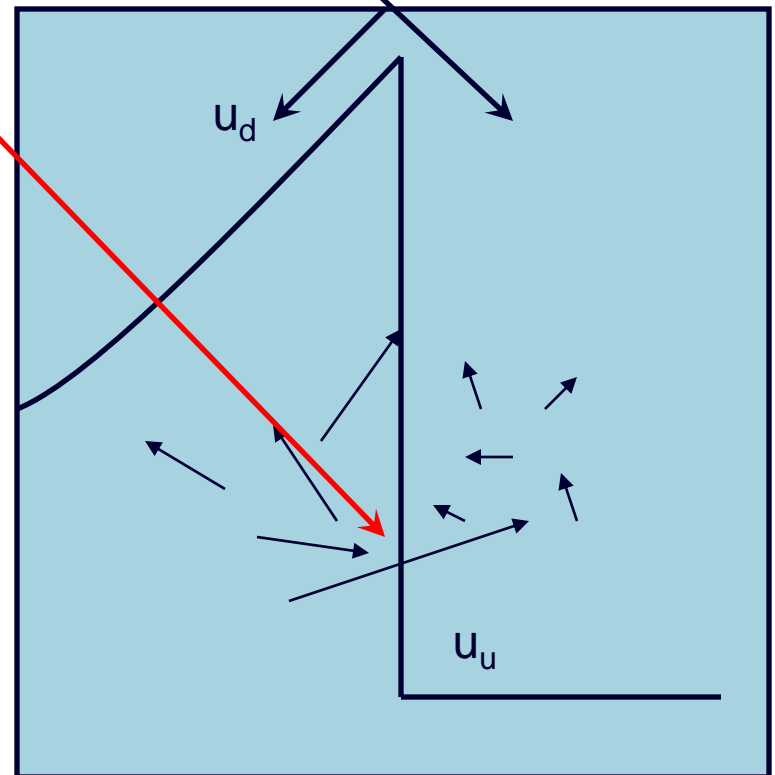
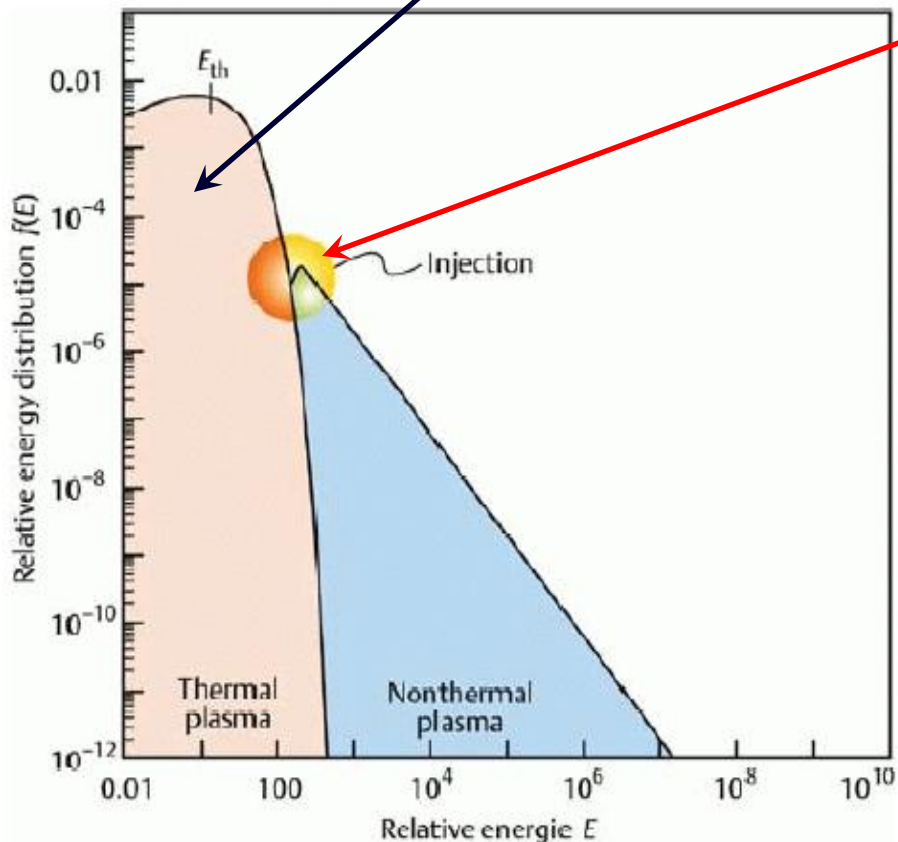


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1. DESY, Zeuthen; 2. U Chicago; 3. U Potsdam

Cosmic Ray Acceleration at Shocks

SNRs shocks heat plasma and set up “converging plasma flows”

Particles from thermal pool can “diffuse through” the shock region



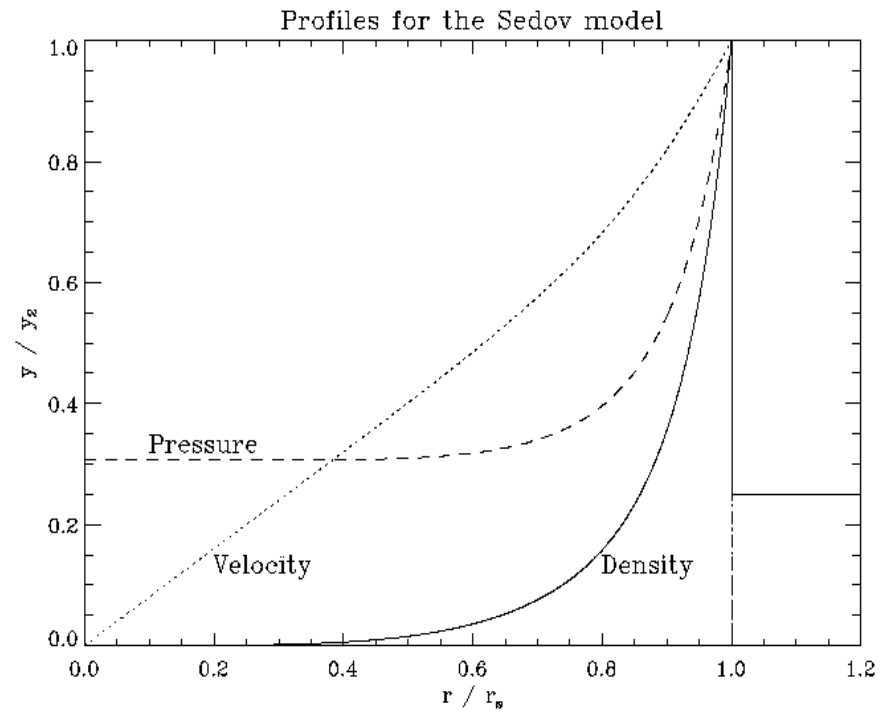
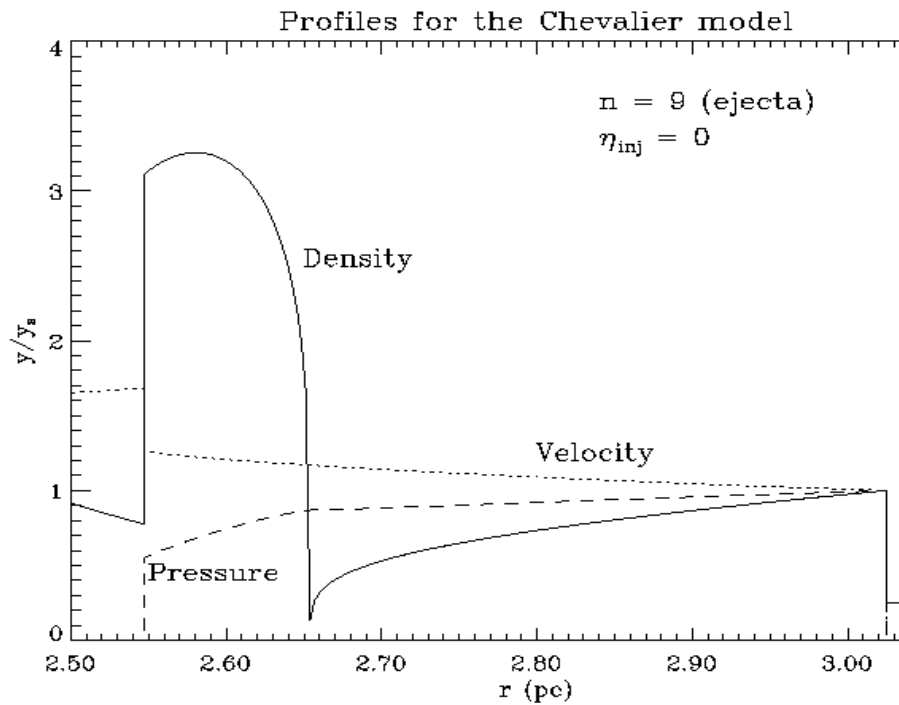
Transport Equation

$$\frac{\partial N}{\partial t} = \nabla(D\nabla N - \vec{v}N) - \frac{\partial}{\partial p} \left((N\dot{p}) - \frac{\nabla\vec{v}}{3} Np \right) + Q$$

- The diffusion coefficient, D , depends on particle momentum and magnetic field
 - Assume *Bohm* diffusion coefficient
 - Assume B profiles of the shocked region scale as *density* $B(r,t) = B_{\text{FS}}\rho(r,t)/\rho_{\text{FS}}(r,t)$
- Magnetic field can be amplified close to the shock region
 - Explore two models:
 - M1: $B_{\text{FS}}(t) = (2\pi\rho_0\xi V_{\text{FS}}(t)^3/c)^{0.5}$ (Caprioli+2009)
 - M2: $B_{\text{FS}} = v\sigma B_{\text{i/csm}}$ (case with constant amp. factor, $v \sim 4.5$)
- There might be Alfvénic drift of scattering centers upstream of the shocks
 - Investigate how much does it affect by setting in the upstream region:

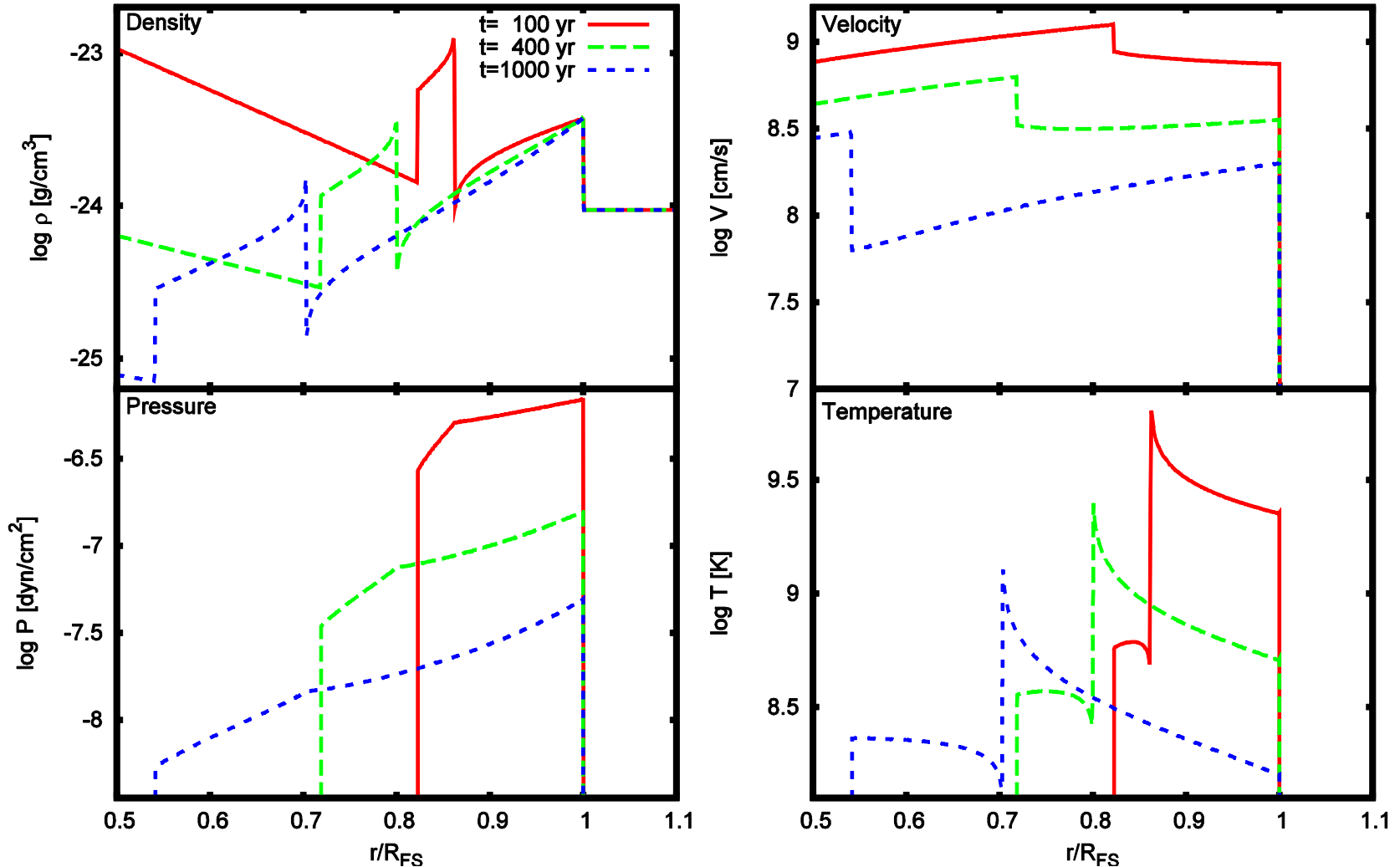
$$v = v_{\text{gas}} + B(r,t)/\sqrt{4\pi\rho}$$

Hydrodynamic Profiles



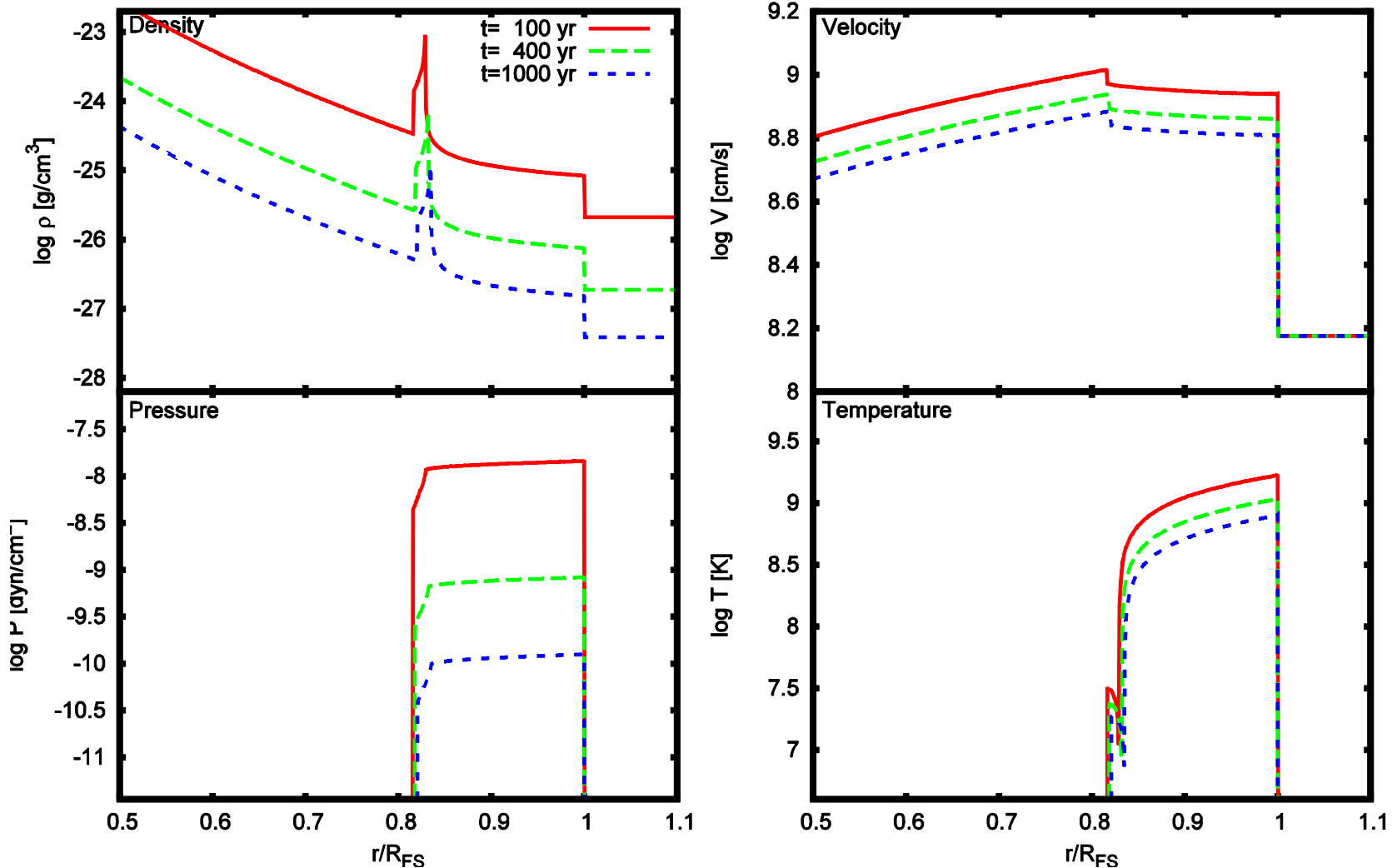
Hydrodynamic Profiles. Type Ia.

Temporal Evolution



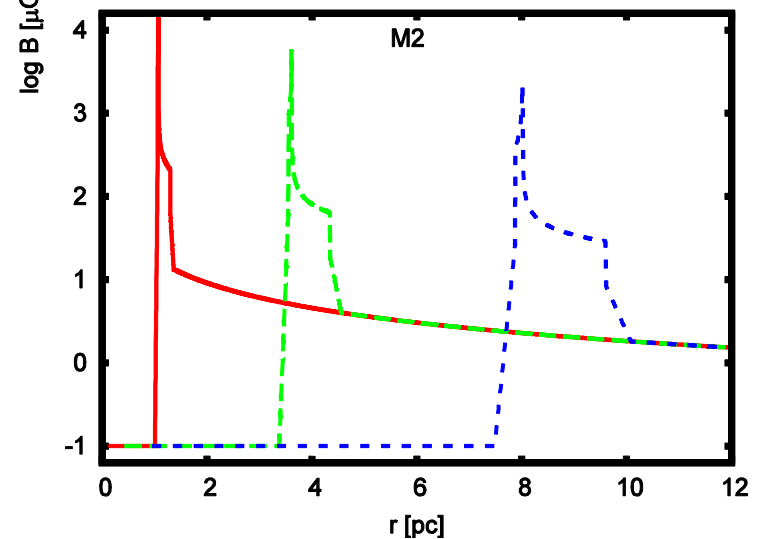
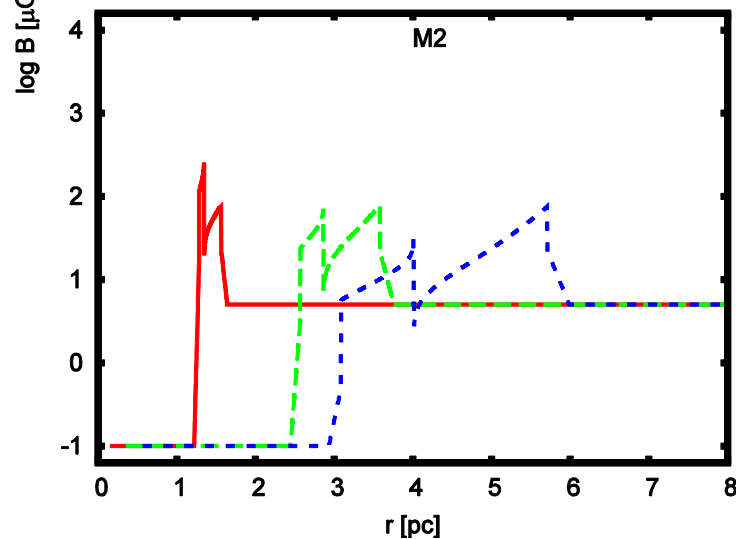
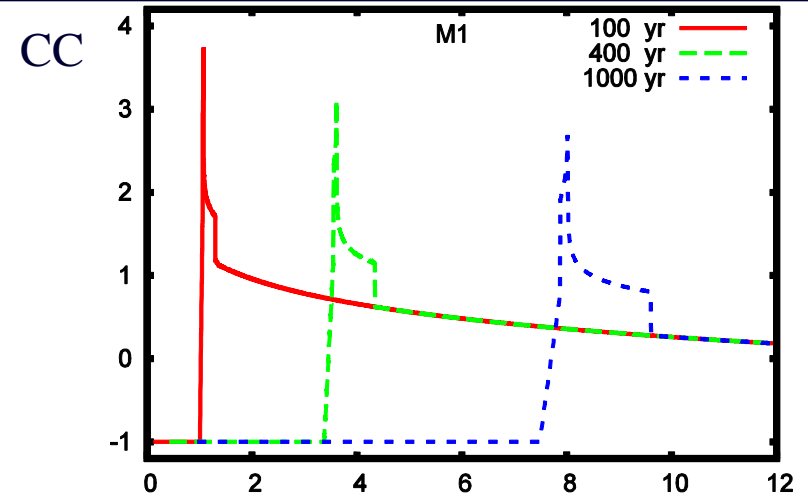
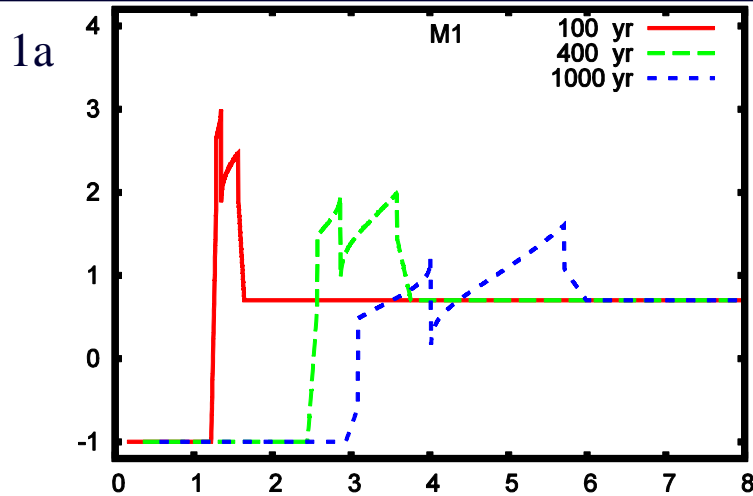
Hydrodynamic Profiles. Core-Col.

Temporal Evolution

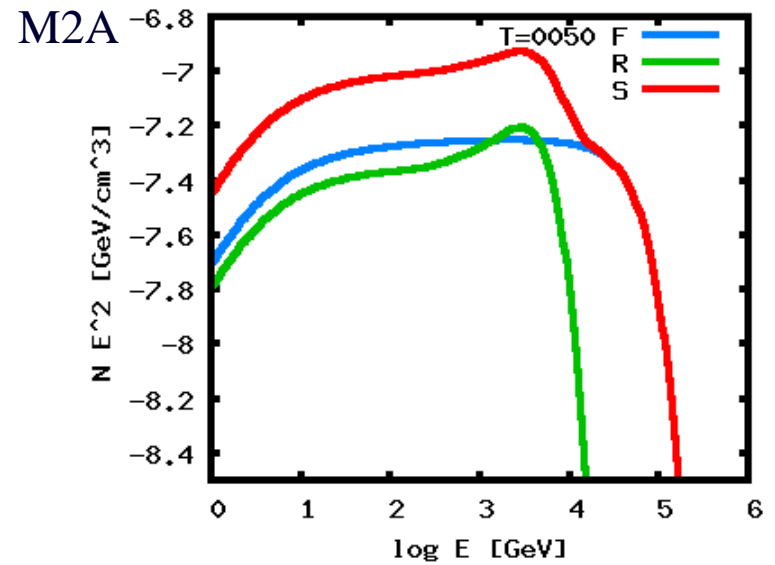
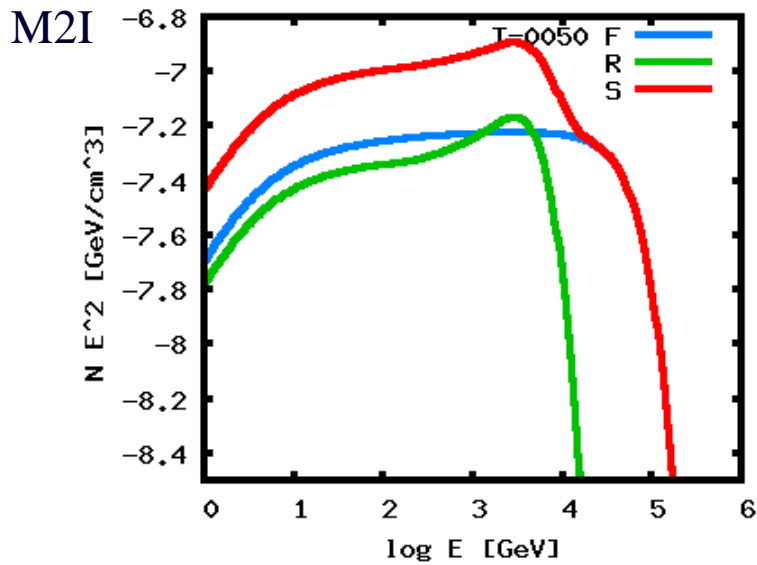
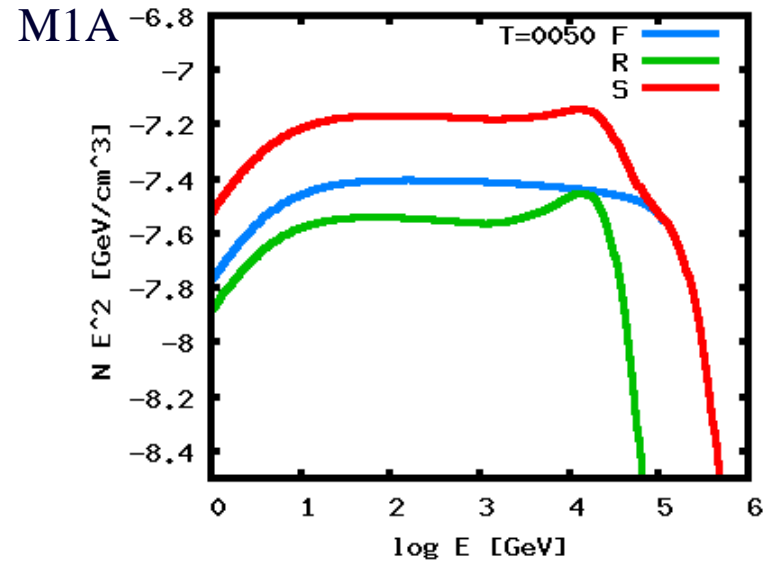
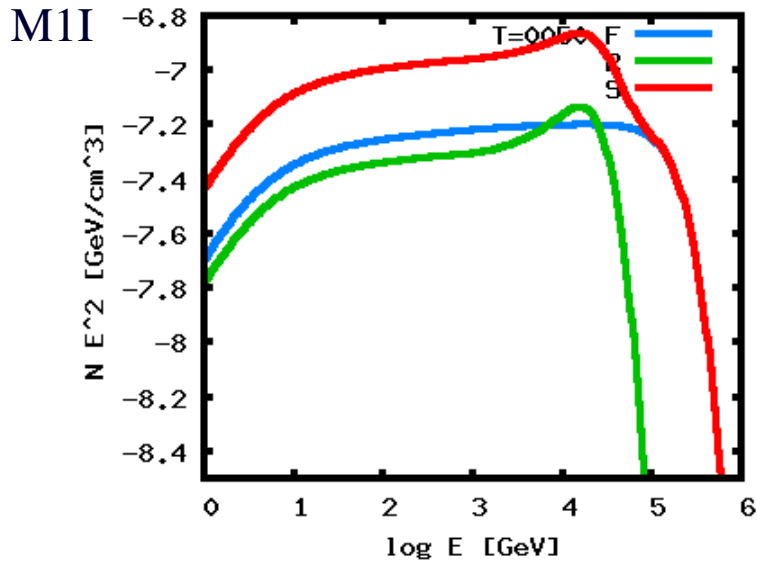


Magnetic Field Profiles.

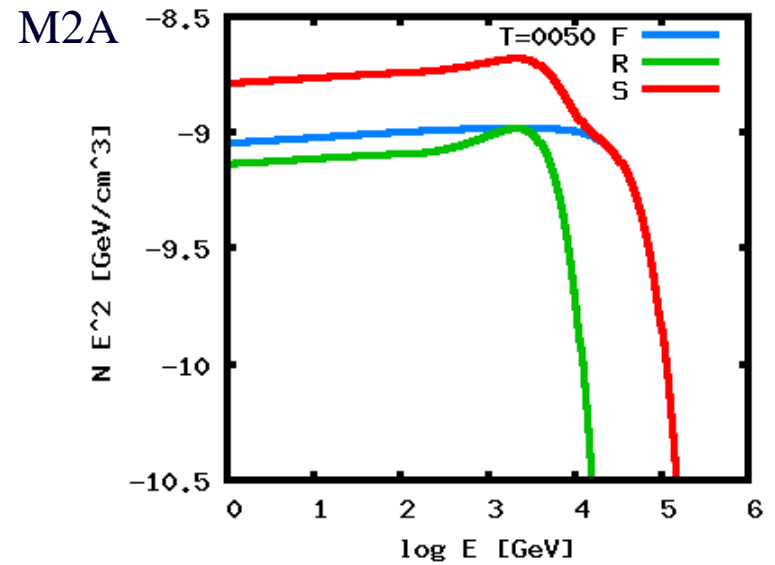
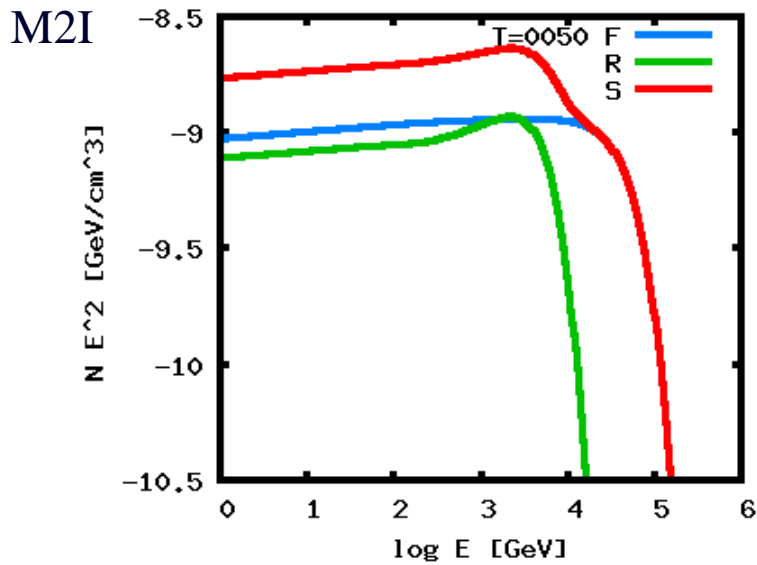
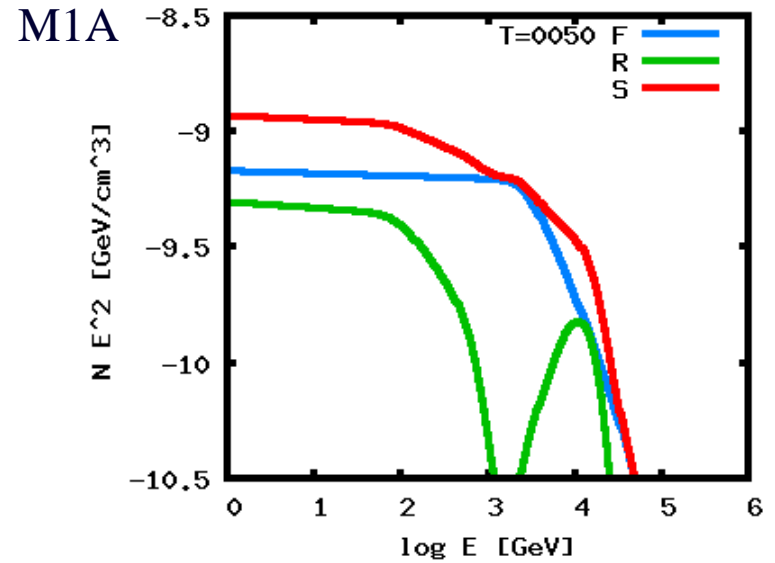
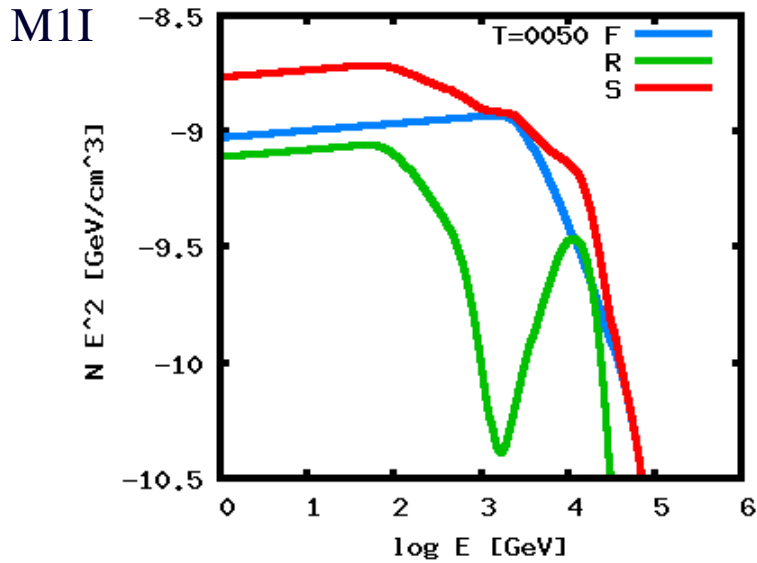
Temporal Evolution



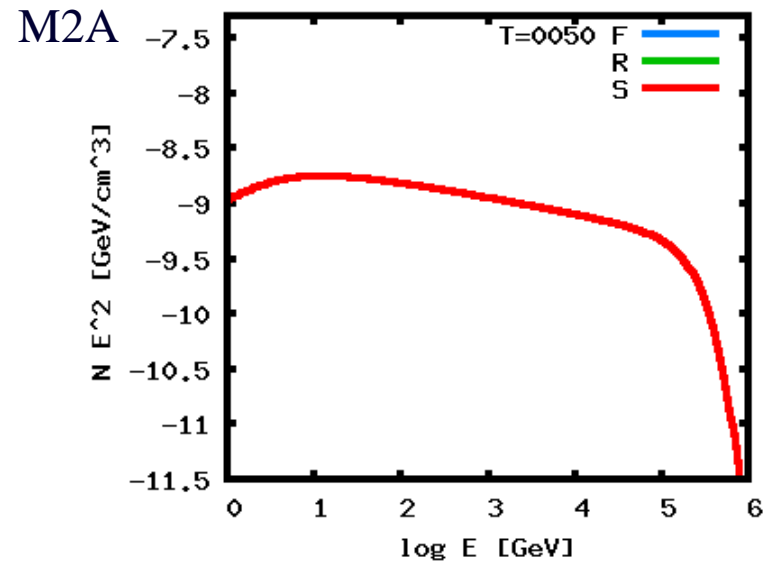
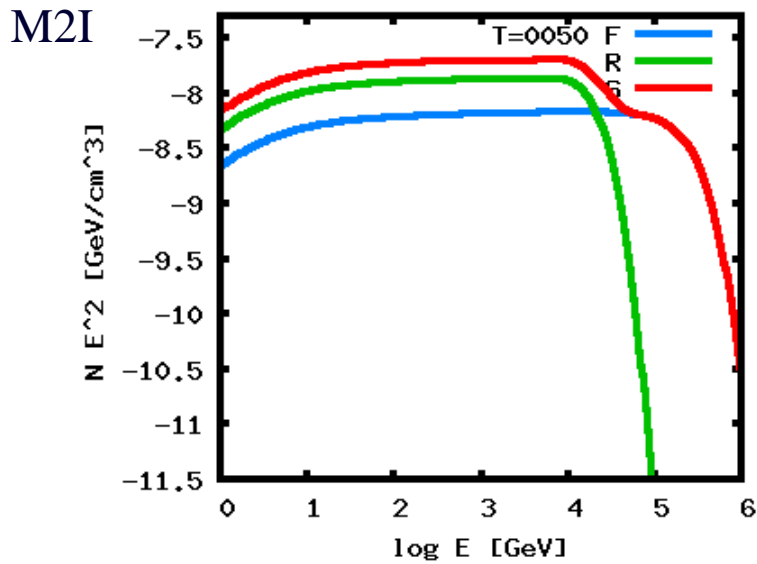
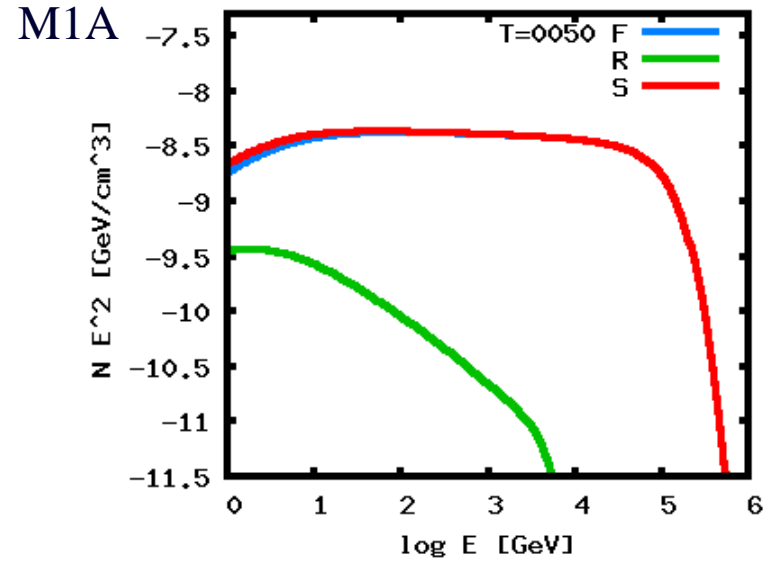
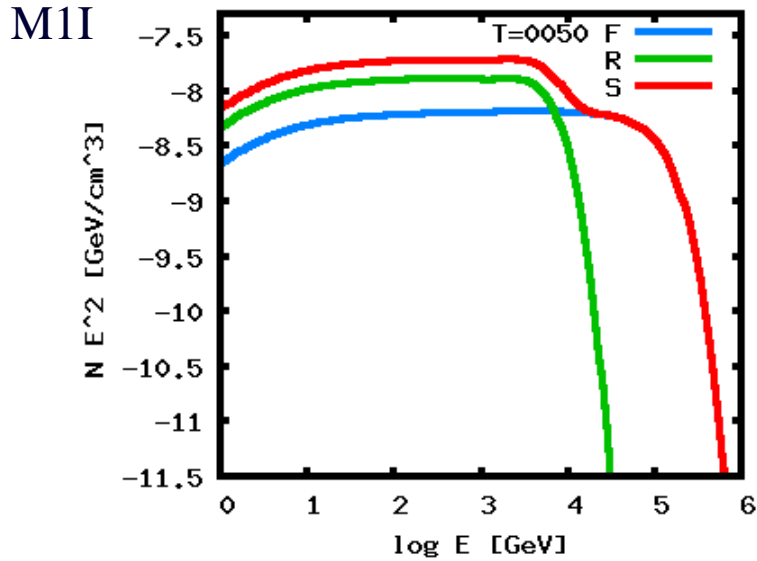
Particle Spectra. Type Ia. Protons.



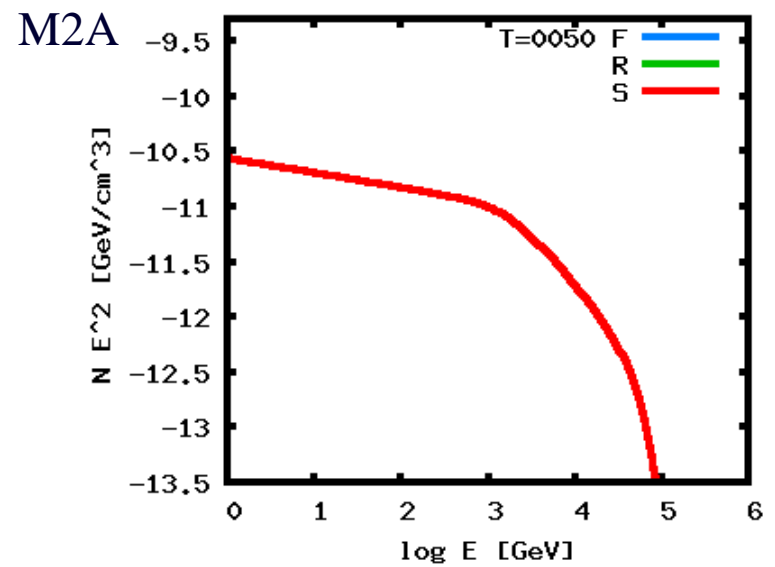
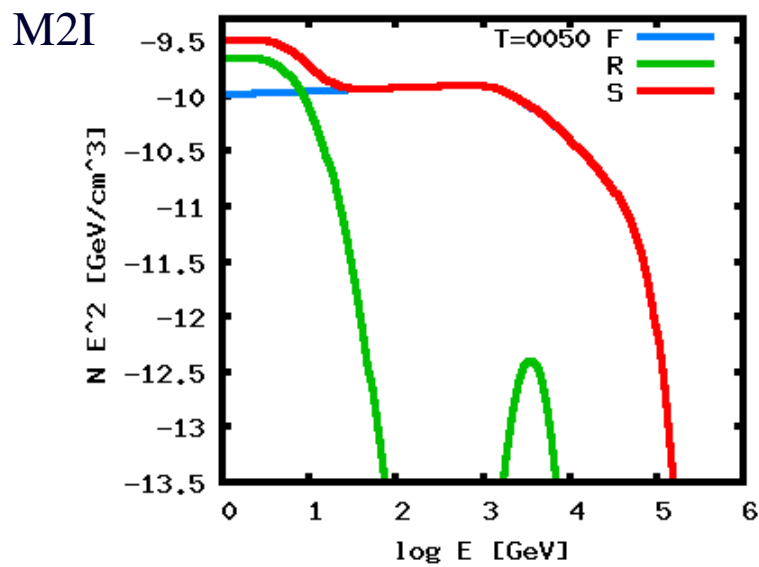
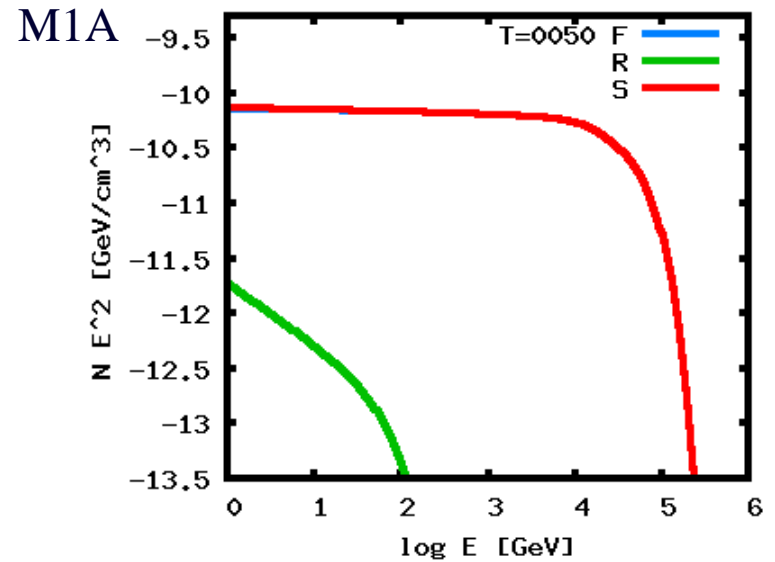
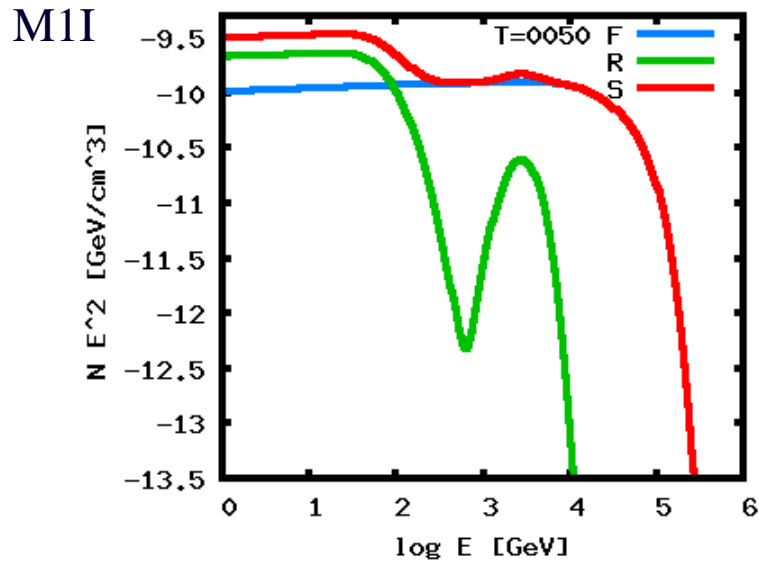
Particle Spectra. Type Ia. Electrons.



Particle Spectra. Core-Col. Protons.

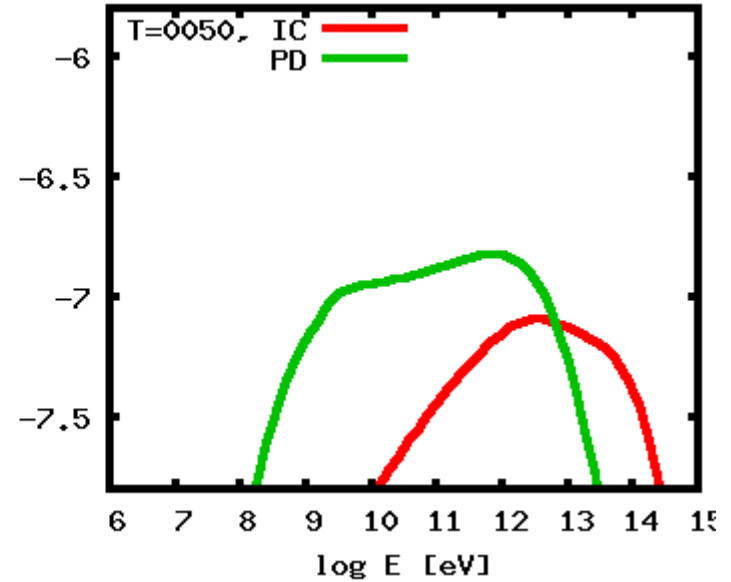
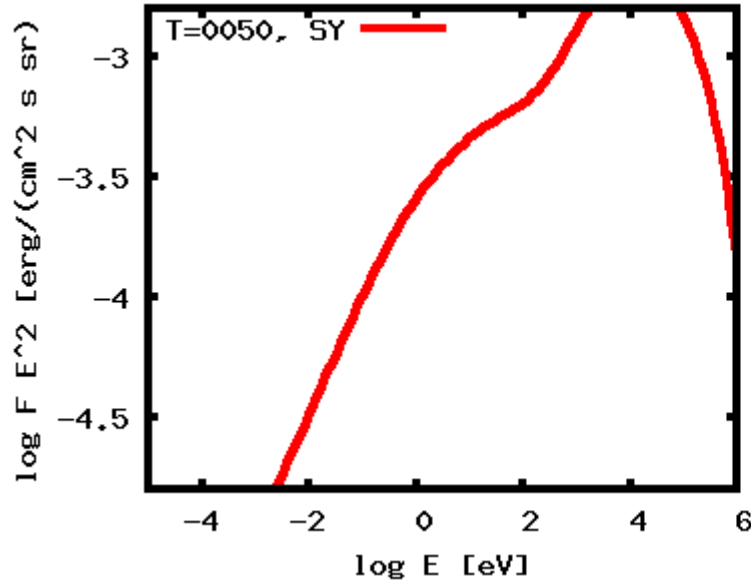


Particle Spectra. Core-Col. Electrons.

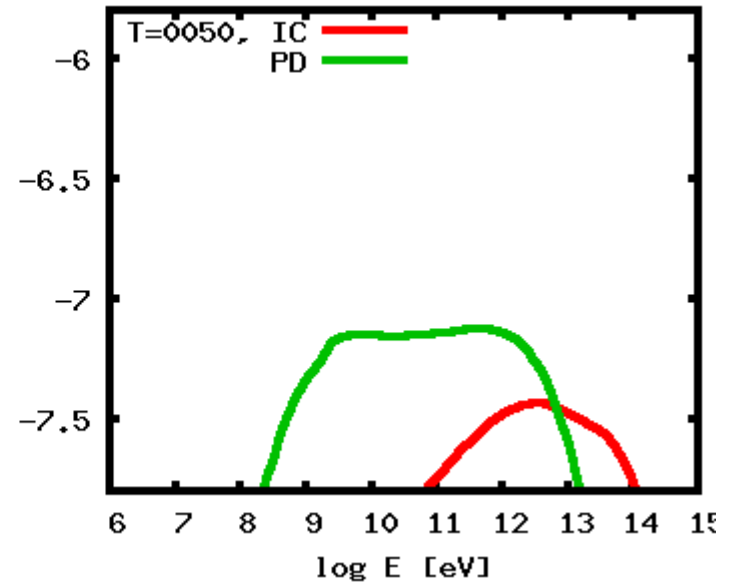
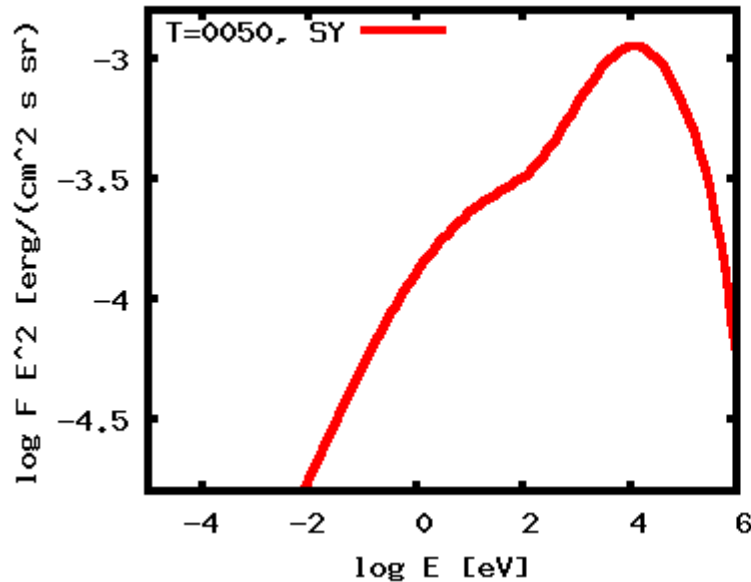


Radiation Spectra. Type Ia. M1.

M1I

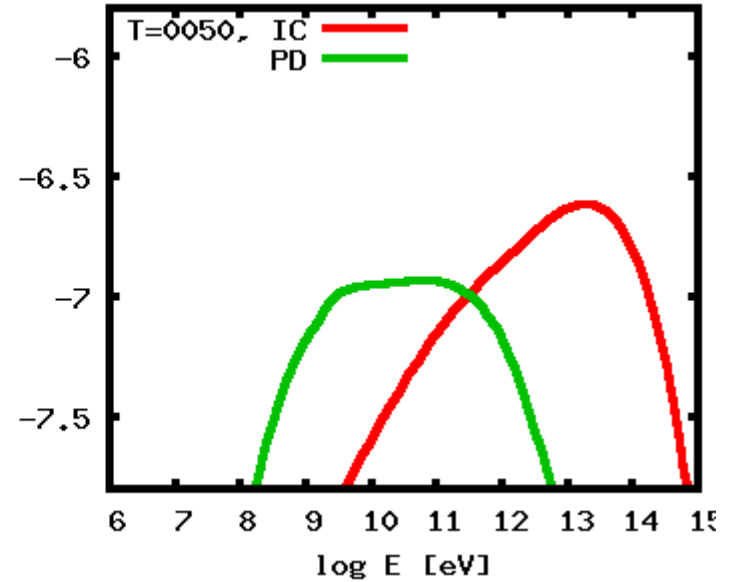
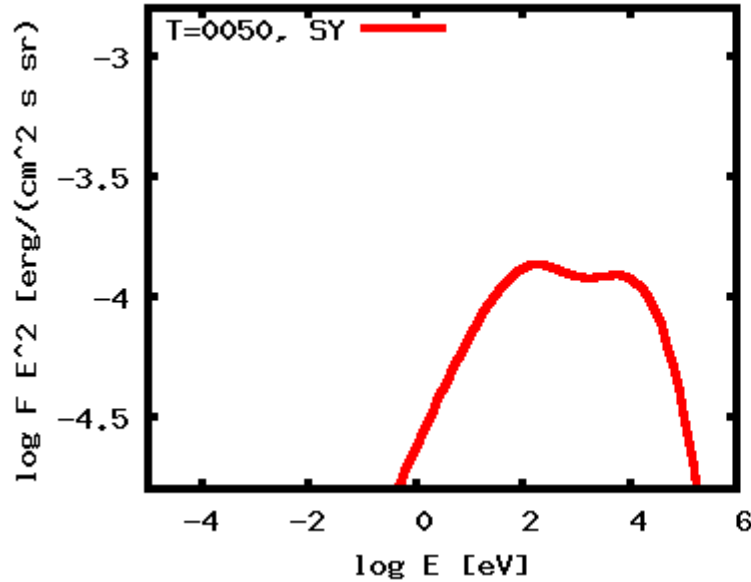


M1A

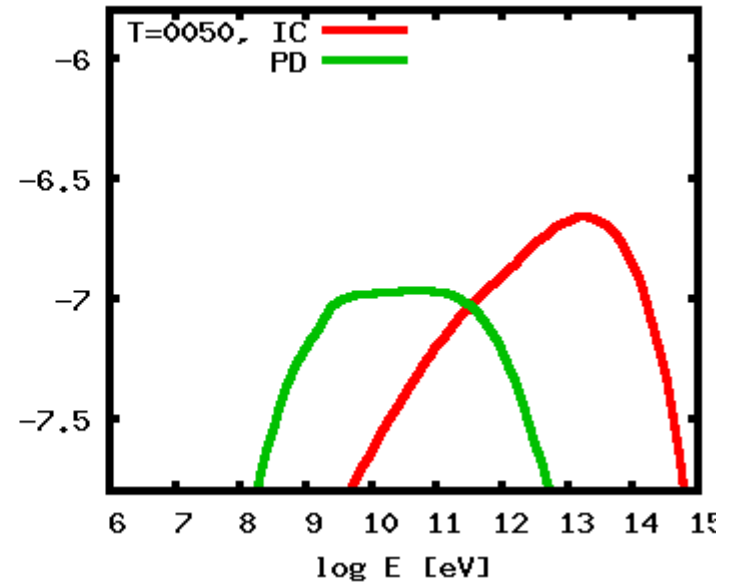
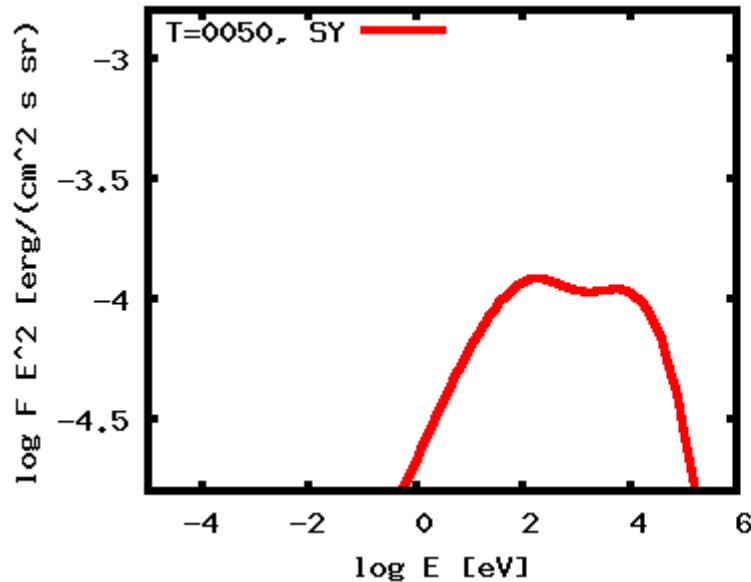


Radiation Spectra. Type Ia. M2.

M2I

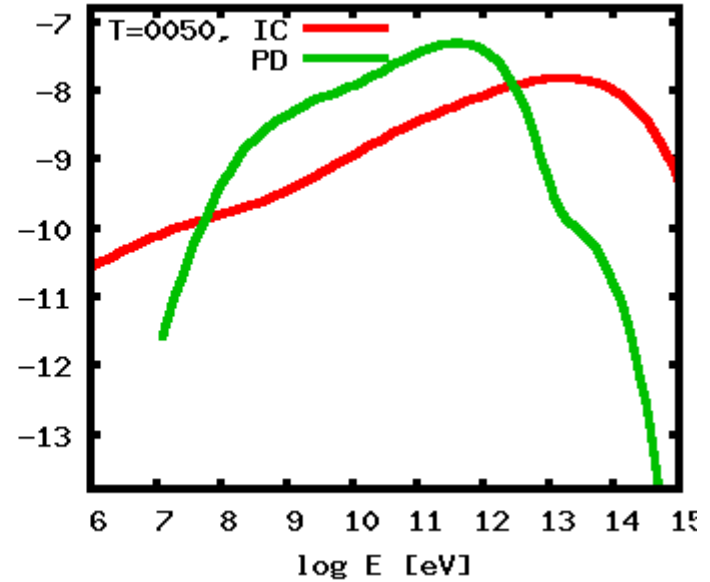
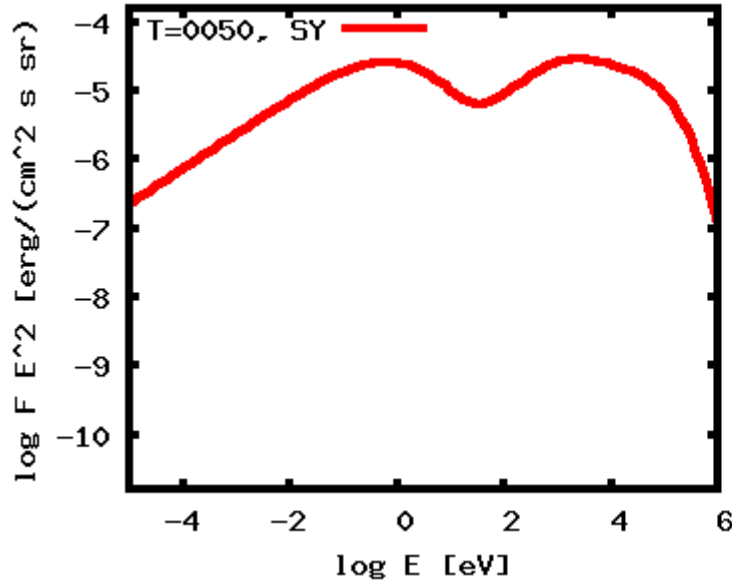


M2A

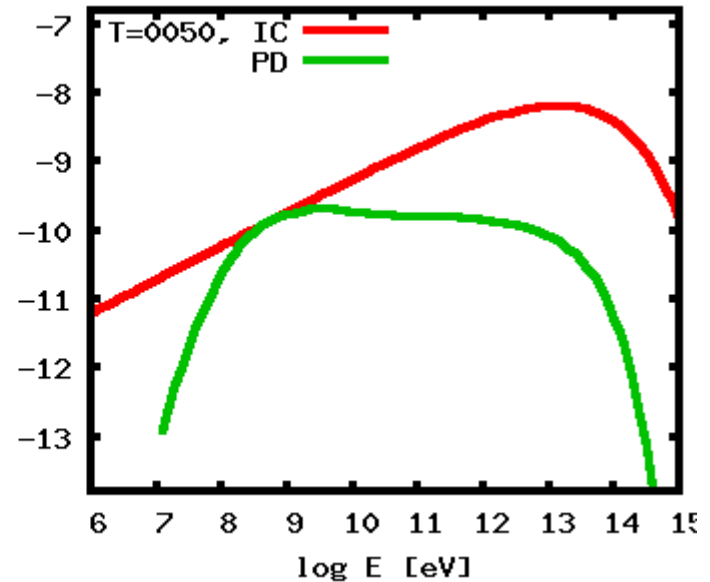
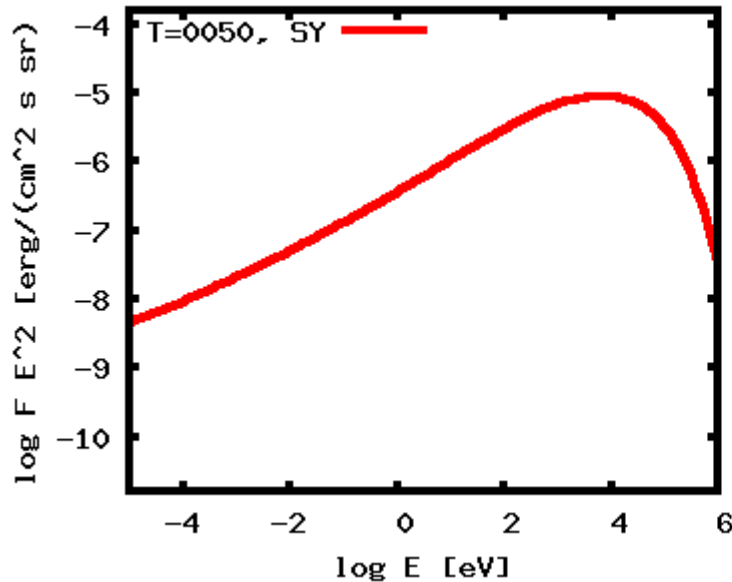


Radiation Spectra. Core-Col. M1.

M1I

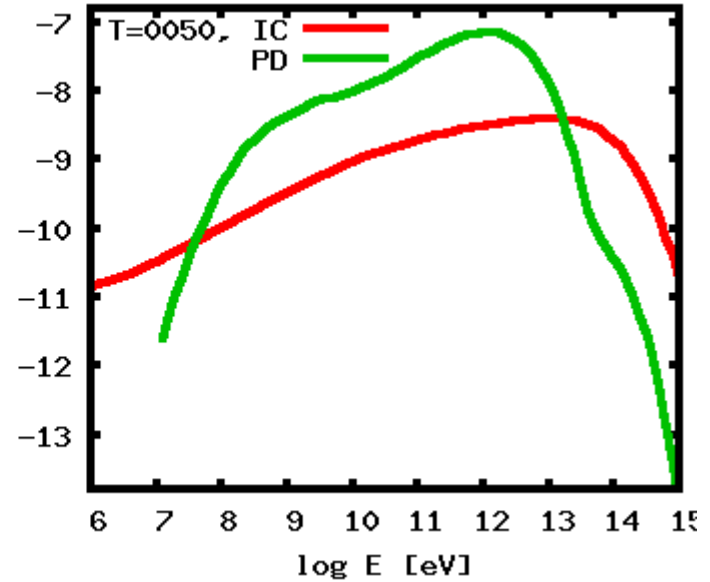
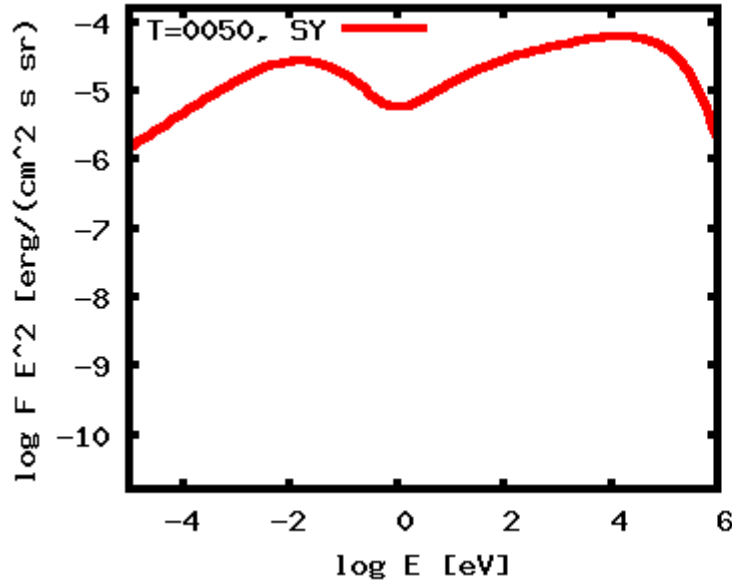


M1A

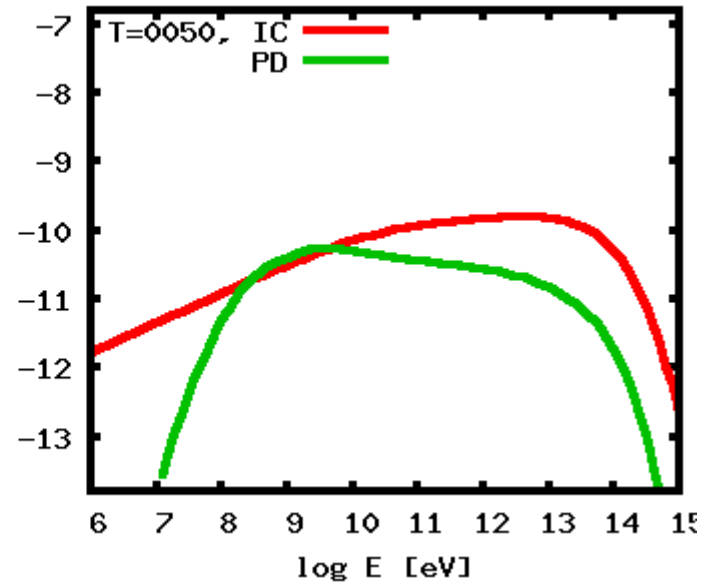
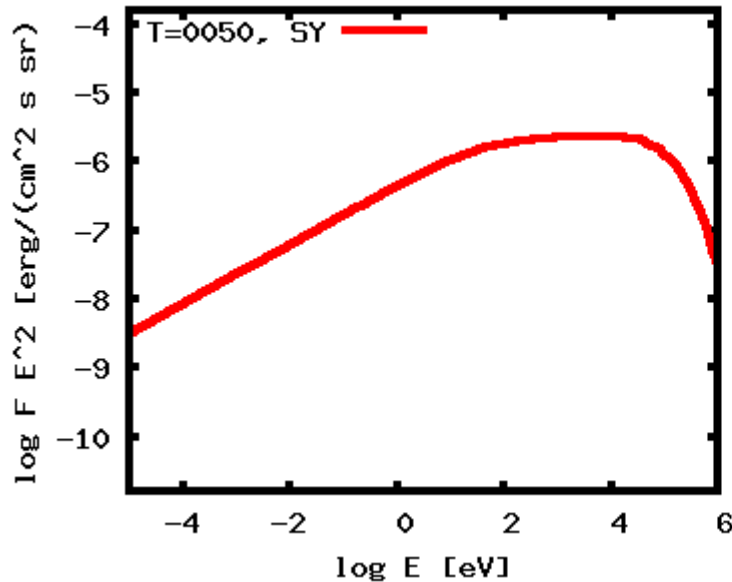


Radiation Spectra. Core-Col. M2.

M2I

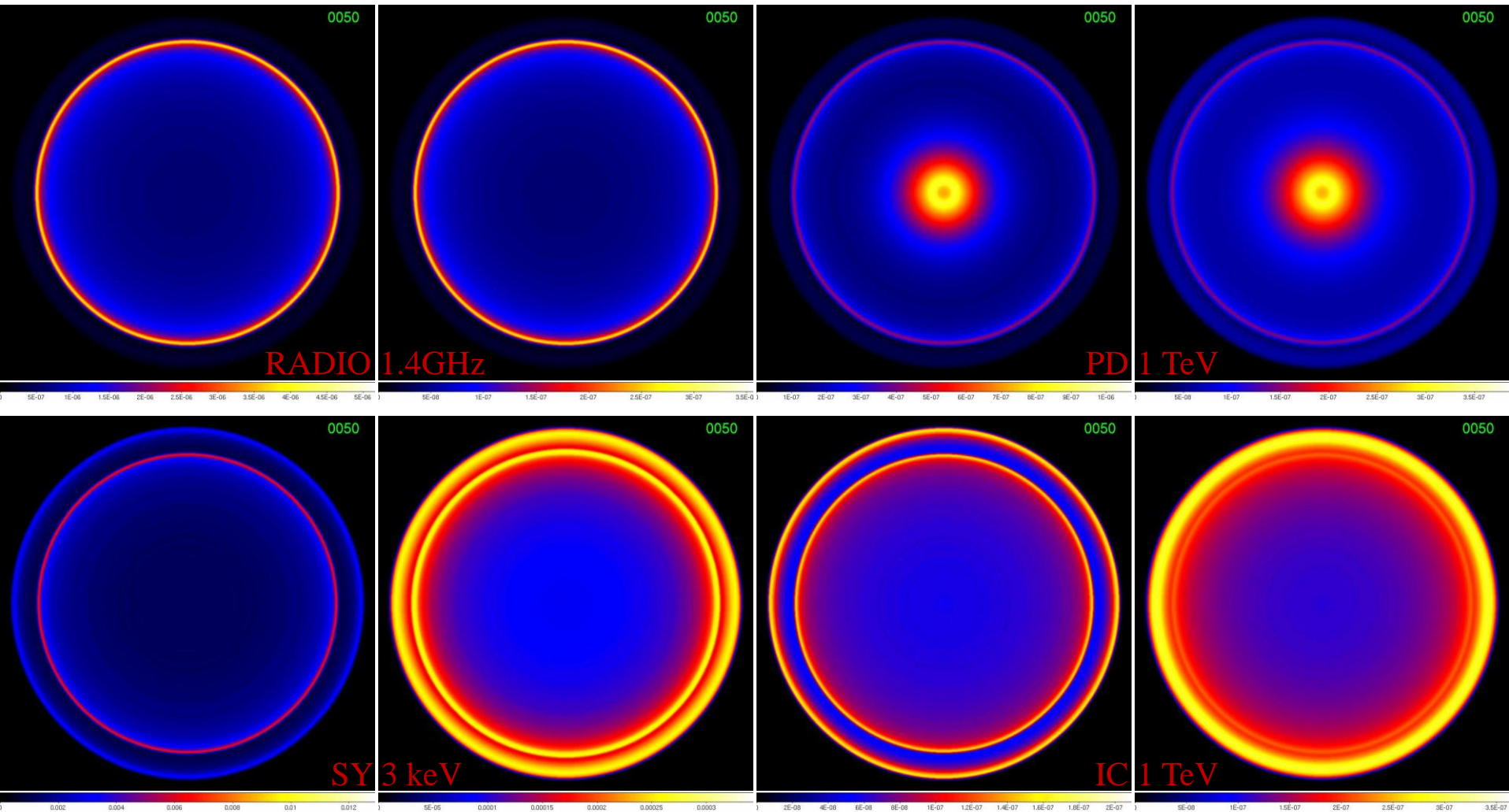


M2A



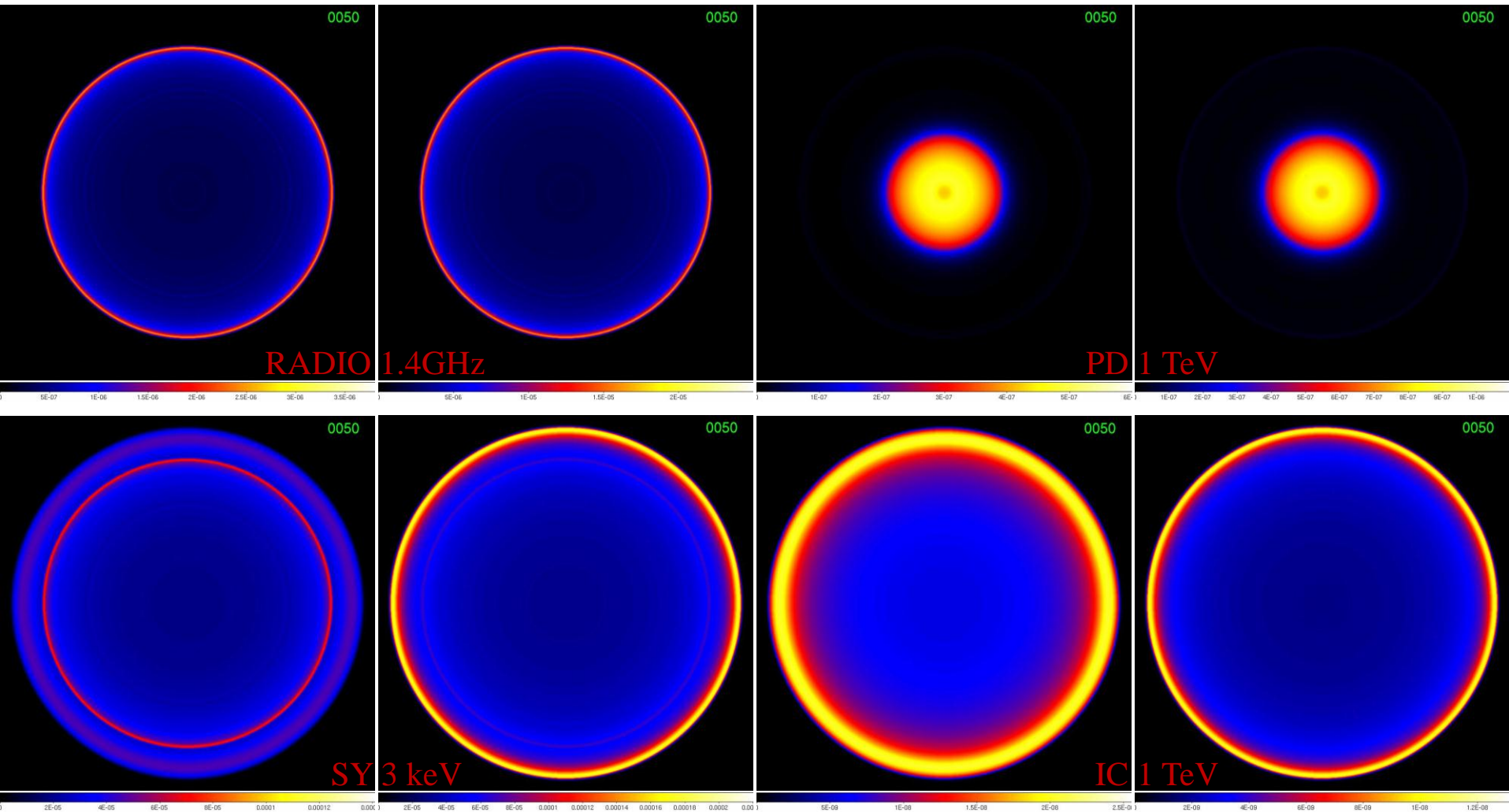
Surface Brightness Maps. Type Ia.

M1 (left) and M2 (right)



Surface Brightness Maps. Core-Col.

M1 (left) and M2 (right)





Conclusions:

- The RS can accelerate particles to high energies.
- The RS contribution changes the total particle and radiation spectra of the SNR.
- The contribution of the RS to the total particle spectra in Type 1a SNRs disappears at early time while it remains visible in CC SNRs through all simulation time.
- The total particle spectra and their radiation in CC SNRs show broken power-law shapes.
- The Alfvénic drift of scattering centers softens the particle spectra produced by the shocks and affects total particles spectra and their emission, however it weakly affects profiles of the SNR surface brightness.
- Radiation fluxes from CC SNR are lower than fluxes of Type 1a SNRs.
- The FS of CC SNRs is much dimmer than the RS (except in IC).

Thank you for attention.
