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Semi-analytical model of CR electron transport

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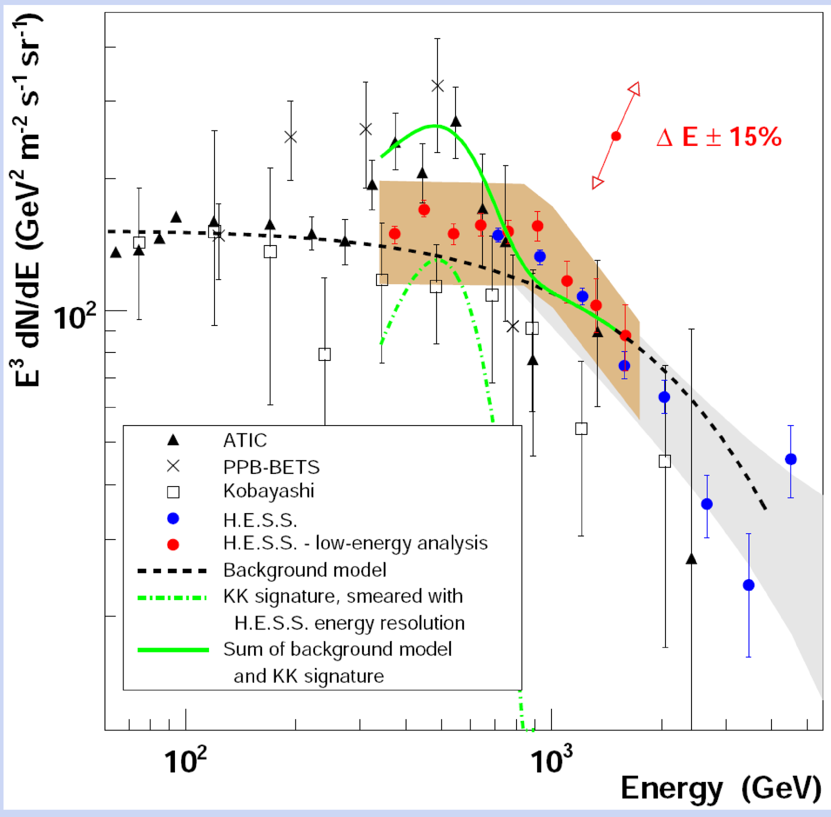
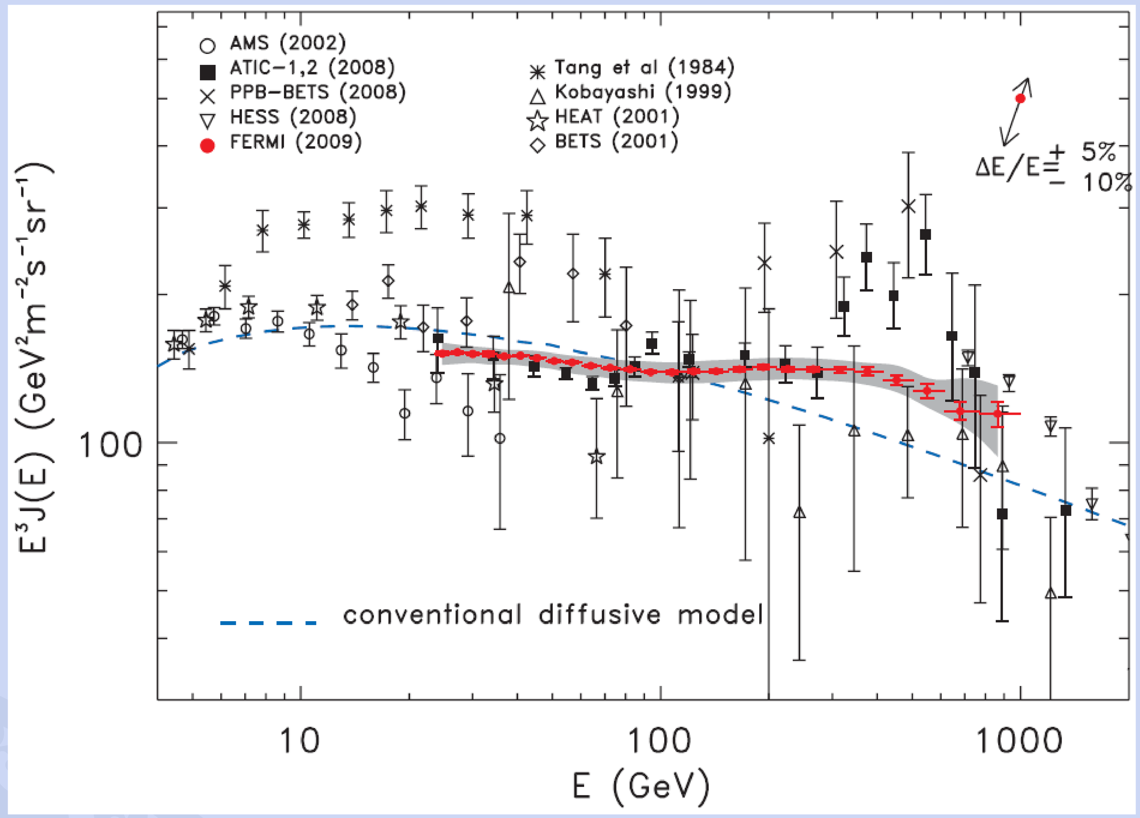


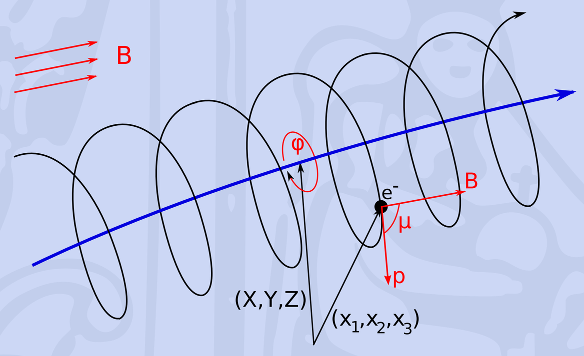
Recent observations of the leptonic component of the cosmic ray spectrum by ATIC, PAMELA and Fermi have shown an excess of both electrons and positrons in the GeV-regime. To connect this measurements to the injection spectra of possible sources (dark matter, pulsars, etc.), a transport model for cosmic ray leptons is needed. With a simple semi-analytical approach we are able to reproduce the basic shape of the spectrum and find a possible explanation for the "Feature".



Starting point: Vlasov equation

$$\frac{\partial f_e}{\partial t} + \frac{\vec{p}}{\gamma m_e}\nabla_x f_e - e\left(\vec{E}(\vec{x},t) + \frac{\vec{v}}{c}\times\vec{B}(\vec{x},t)\right)\nabla_p f_e = S_e(\vec{x},\vec{p},t)$$

Describes the time evolution of a probability density f_e in 6-dim. phase space under the influence of electromagnetic fields with the particle source function $S_e(\vec{x},\vec{p},t)$.

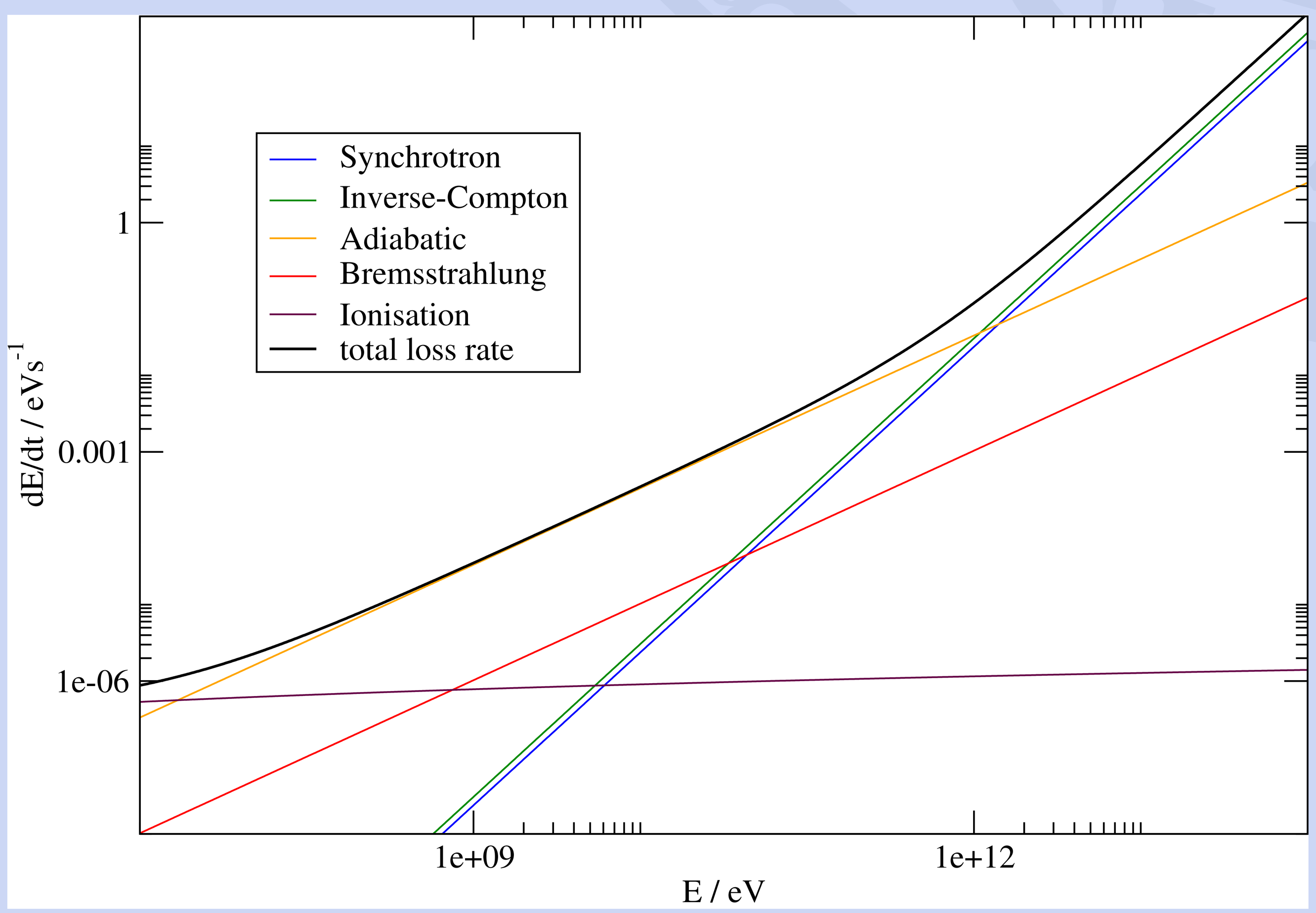


Simplifying assumptions necessary

- Quasilinear transport theory: particle trajectories → guiding centers, transport parameters from turbulence properties
- Diffusion approximation: reduction of momentum dimensions
- Separation in space and momentum

Integration of acceleration and cooling processes + particle escape ⇒ Leaky-Box-Equation:

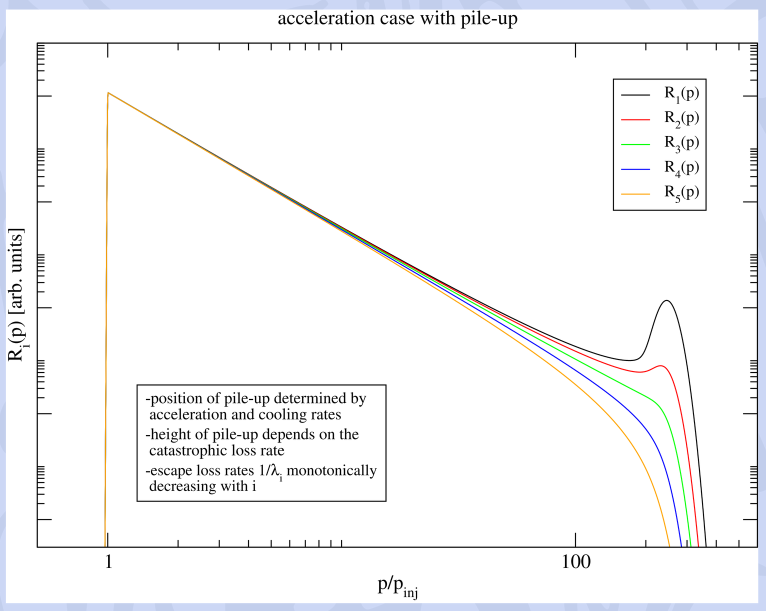
$$\frac{1}{p^2}\frac{\partial}{\partial p}\left(p^2 A_2 \frac{\partial R_i(p)}{\partial p} - p^2 \dot{p} R_i(p)\right) - \lambda_i^2 g(p) R_i(p) = -Q(p)$$

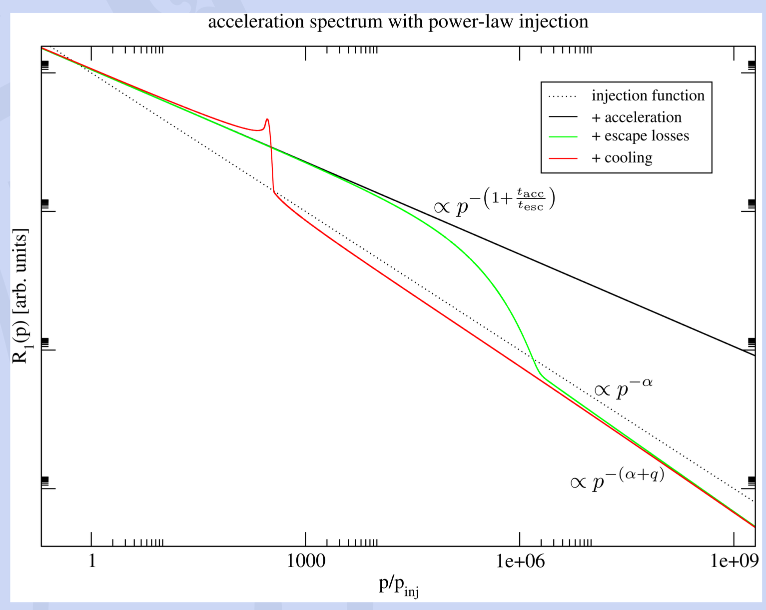


Electrons in the TeV-regime are cooled very efficiently by synchrotron radiation and inverse compton scattering. At lower energies adiabatic deceleration becomes important.

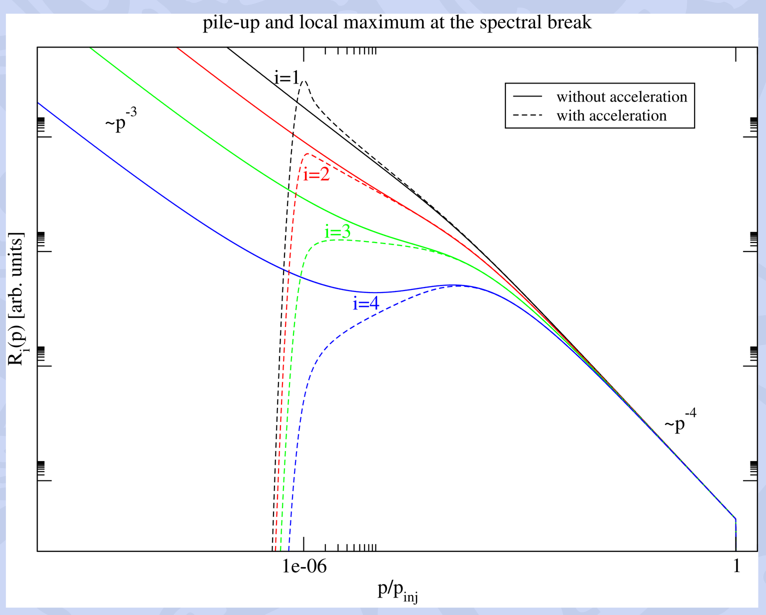
Simulation results

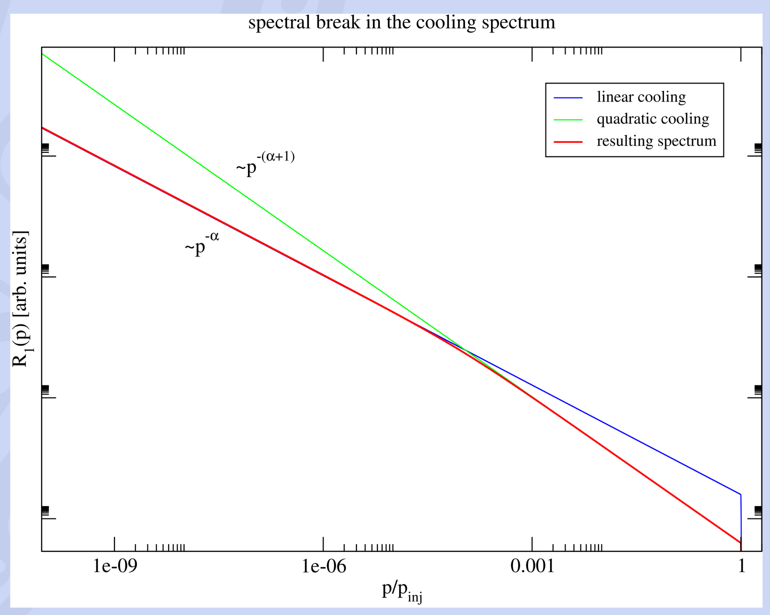
Acceleration spectra for Fermi I/II, cooling and escape losses from monoenergetic and power-law injections.





Cooling spectra with slow (linear) and fast (quadratic) cooling processes + diffusive reacceleration and escape.





Outlook

Drop the simplifications and reduce the complexity by simulating a smaller region - the local bubble.
Short propagation length (~ 100 pc) of high energy electrons due to Synchrotron/IC-losses ⇒ features in GeV-spectrum are signatures of nearby sources. Our neighbourhood was formed by multiple supernovae, which heated up and rarefied the ISM plasma and pumped energy into the EM turbulence. Deformation of the magnetic field lines by the SN-shells, X-rays from cooling gas and UV from B-type stars will be taken into account in the local bubble simulation, while simultaneously dropping assumptions of previous models:

- highly turbulent plasma ⇒ ~~QLT~~
- dynamic, non-isotropic system ⇒ ~~diffusion appr.~~
- inhomogeneous field distributions ⇒ ~~separation~~