The effect of expansion on high-energy emission from AGN jets

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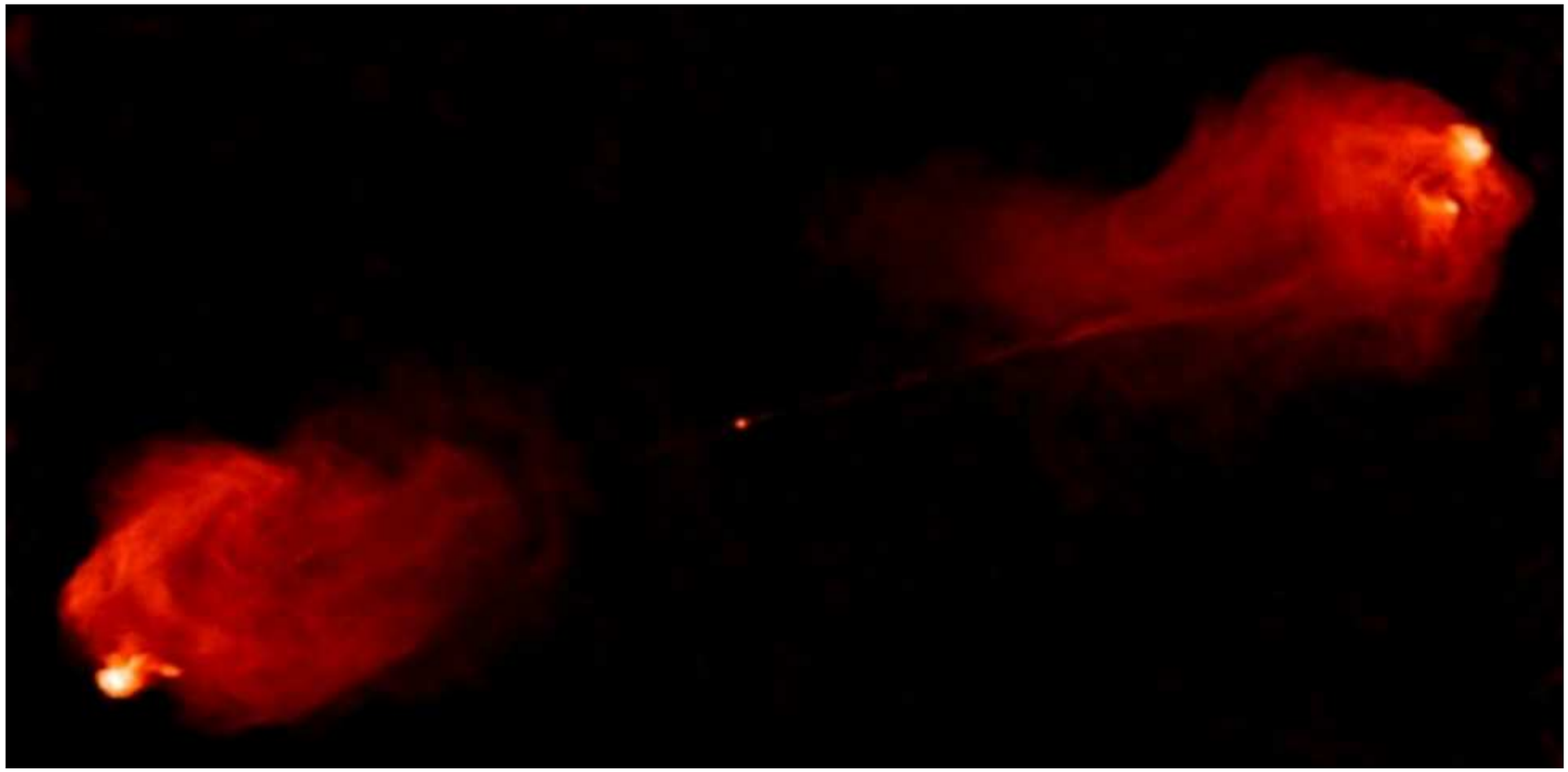
How good is the collimation of jets?

Consider unresolved small-scale emission structures,

not the large-scale appearance!

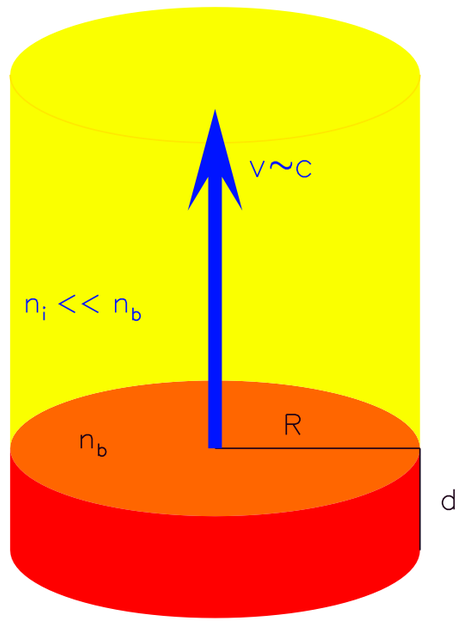


Results of radiation modelling of TeV blazars

Depends on Doppler factor $D_{10} = 10\,D$

- **size of emission zone** $R \ll (10^{15}\ \mathrm{cm})\, D_{10}$
- **plasma density in emission zone** $n_e \gg (10^5\ \mathrm{cm}^{-3})\, L_{\mathrm{peak},44}\, D_{10}^{-6.5}\, B_{\mathrm{G}}^{-1.5}\, E_{\mathrm{keV}}^{-0.5}$
- **energy density in magnetic field is moderate**

- **Individual high-density plasma clouds**
- **Energy reservoir in bulk kinetic energy**
- **One cloud may account for extended high states**
- **How can they remain collimated?**



Expansion changes variability!

We observe $\tau_{\rm var} \simeq 1$ hr variability timescale over $T_{\rm obs} \sim$ days of high state!

Energetically preferred: one or few plasma clouds make the high state!

- **increased light travel time (Compton components)**
  galaxy-frame opening angle $\psi \lesssim \Gamma^{-1}\,(\tau_{\rm var}/T_{\rm obs})$

- **modified particle cooling and escape**
  severe for hadrons and SSC: $\psi \lesssim \Gamma^{-1}\,(\tau_{\rm var}/T_{\rm obs})$

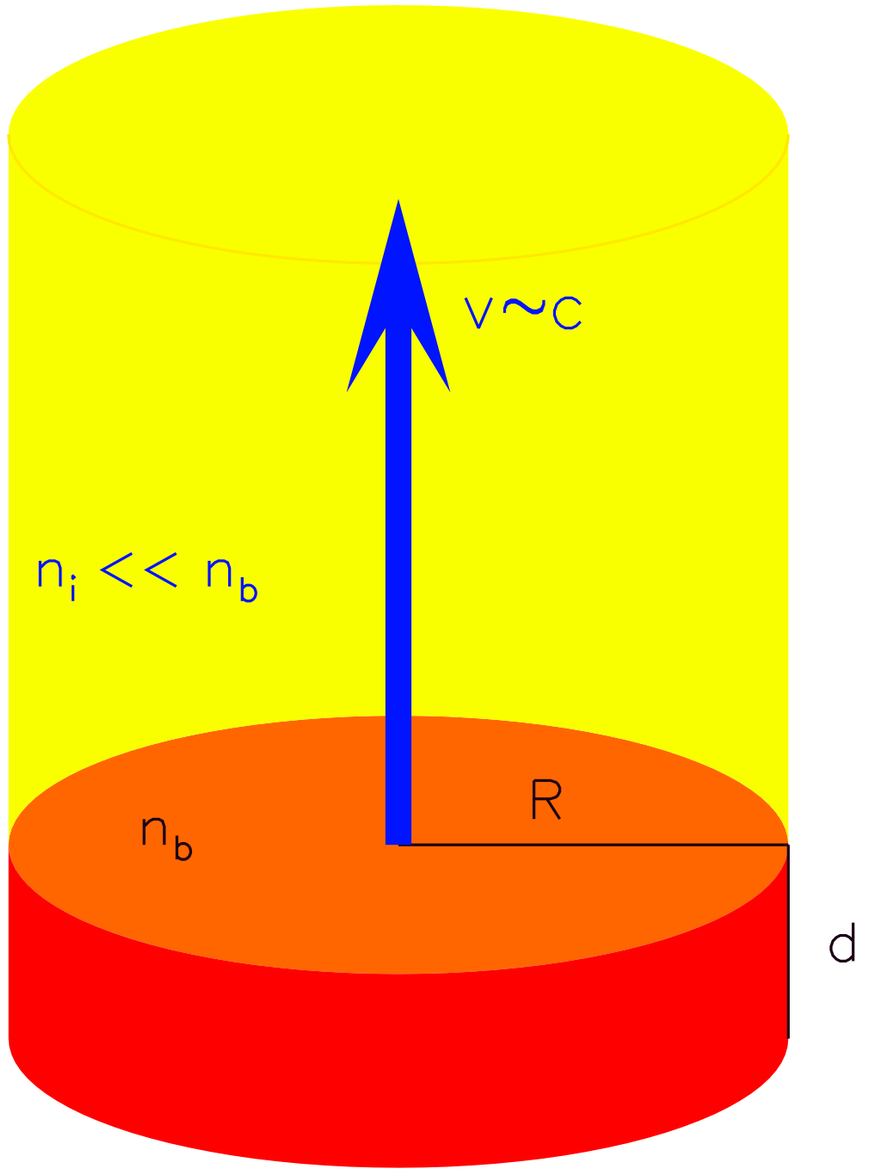
- **differential Lorentz contraction**
  opening angle $\psi \lesssim \Gamma^{-1}\,\sqrt{\tau_{\rm var}/T_{\rm obs}}$

Lightcurves for a specific AGN model

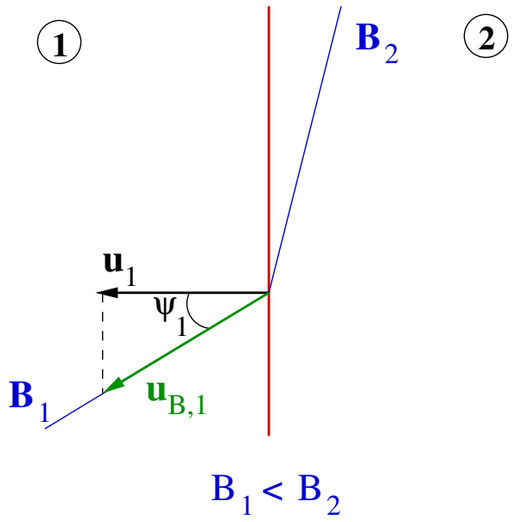
How is bulk kinetic energy transferred into radiation?

What is the physics of collisionless collision fronts?

Do shocks form?

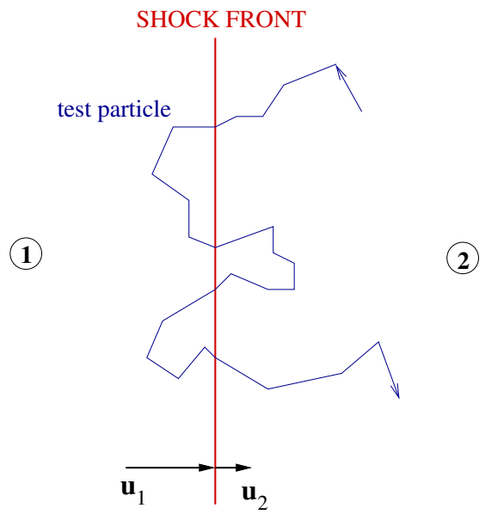


What if a shock forms?



First-order

Fermi acceleration

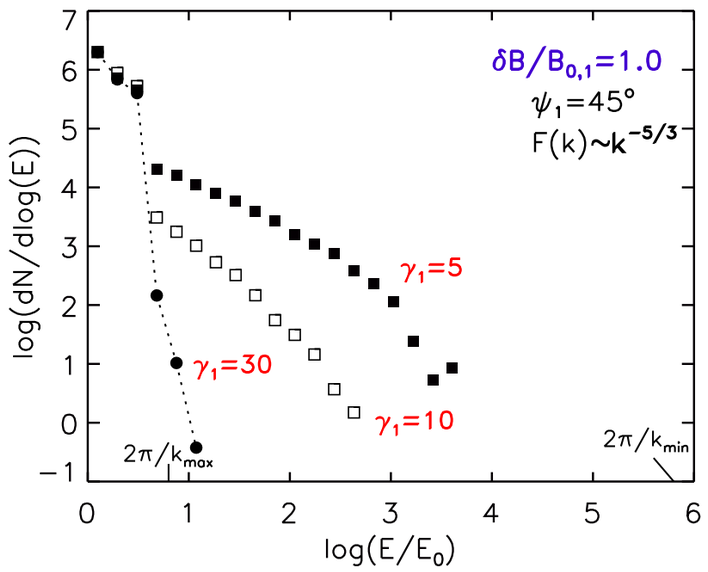


MC simulations (Niemiec et al., see poster)

important: correlations in MF structure

Process is inefficient for high-γ shock!

No relativistic shock acceleration!



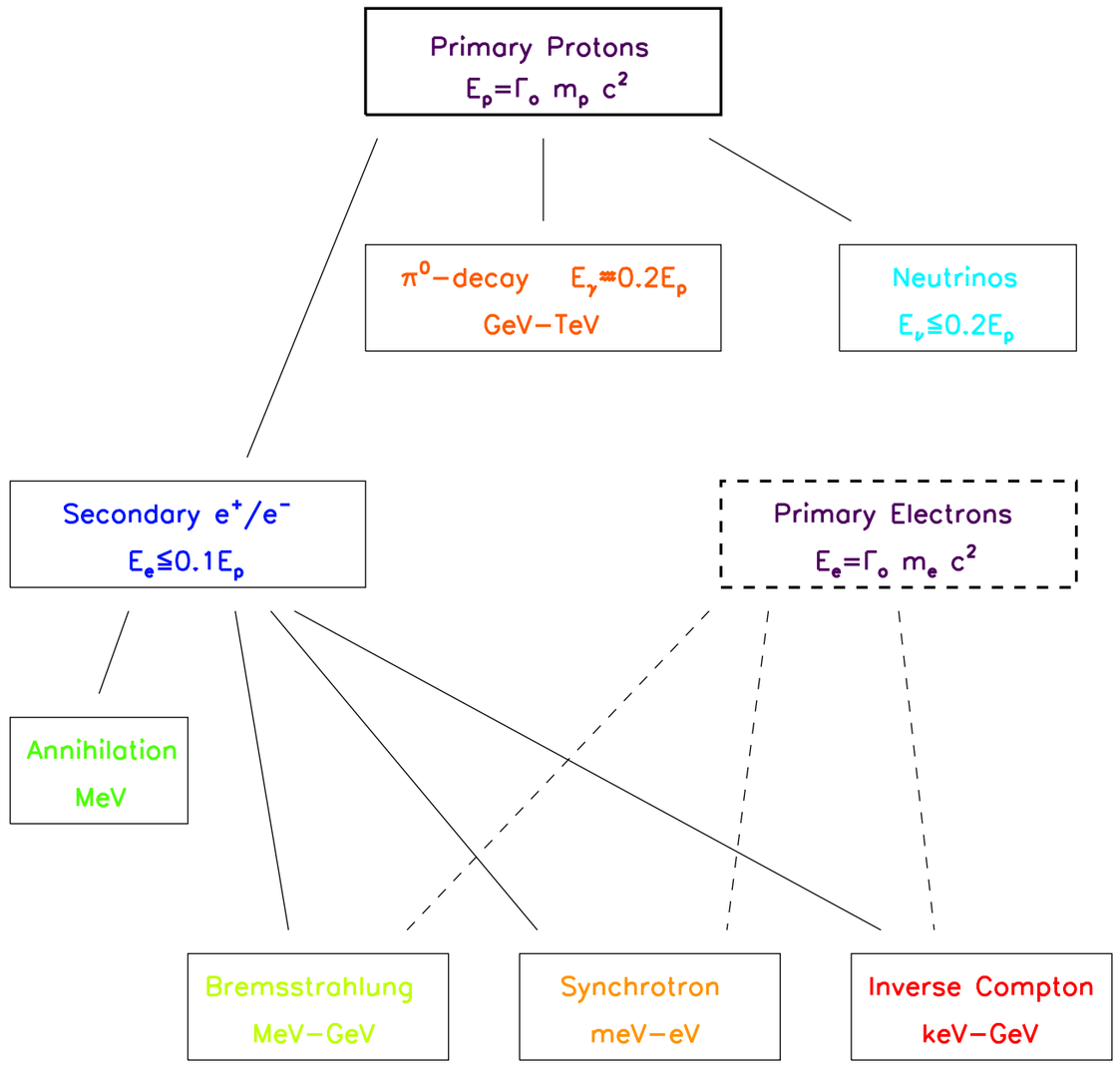
Assume only one crossing (P& S 2000)

High bulk Lorentz factor needed or secondary acceleration.

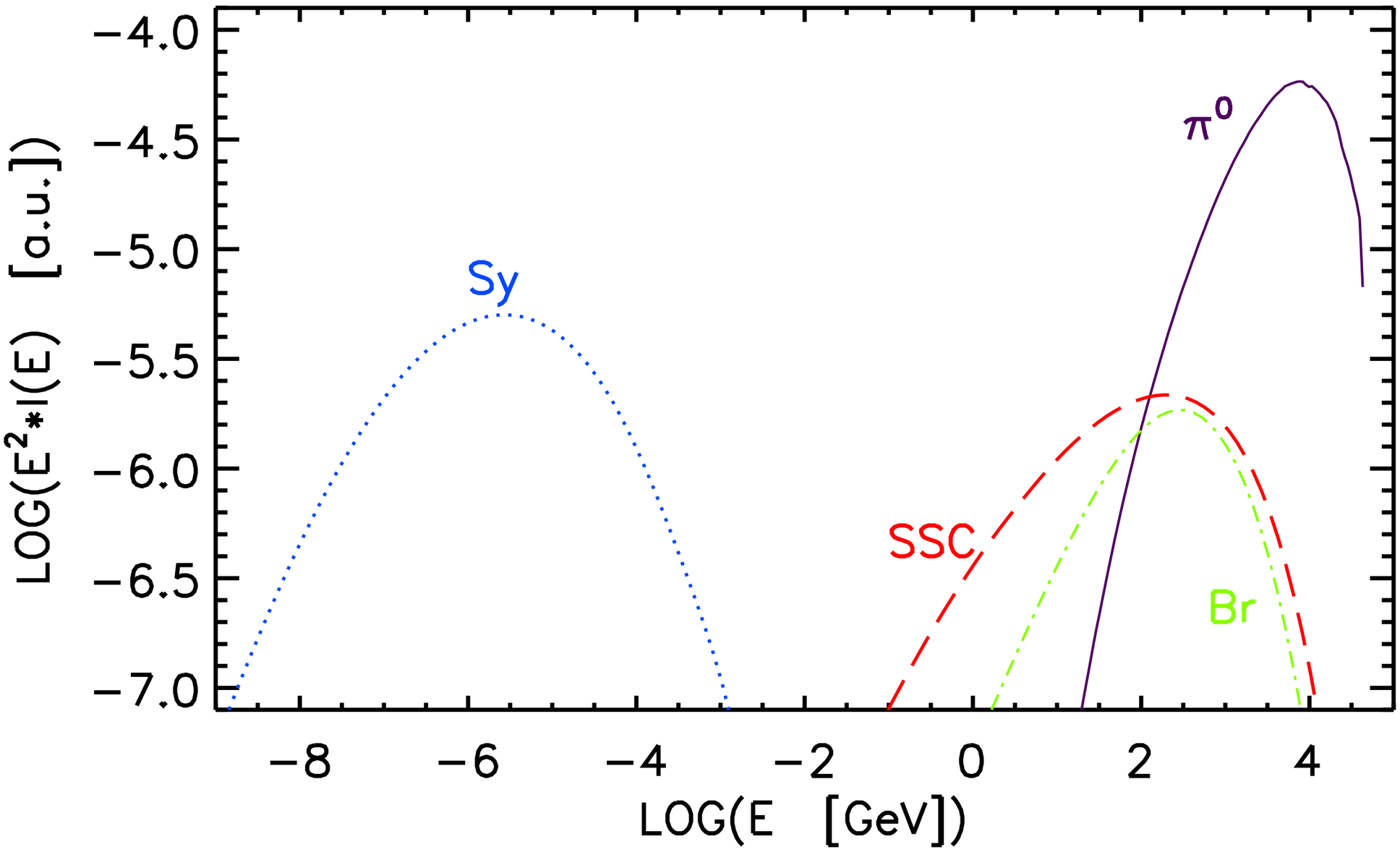
Most energy resides with hadrons.

Hadronic emission important!

Many secondary electrons!

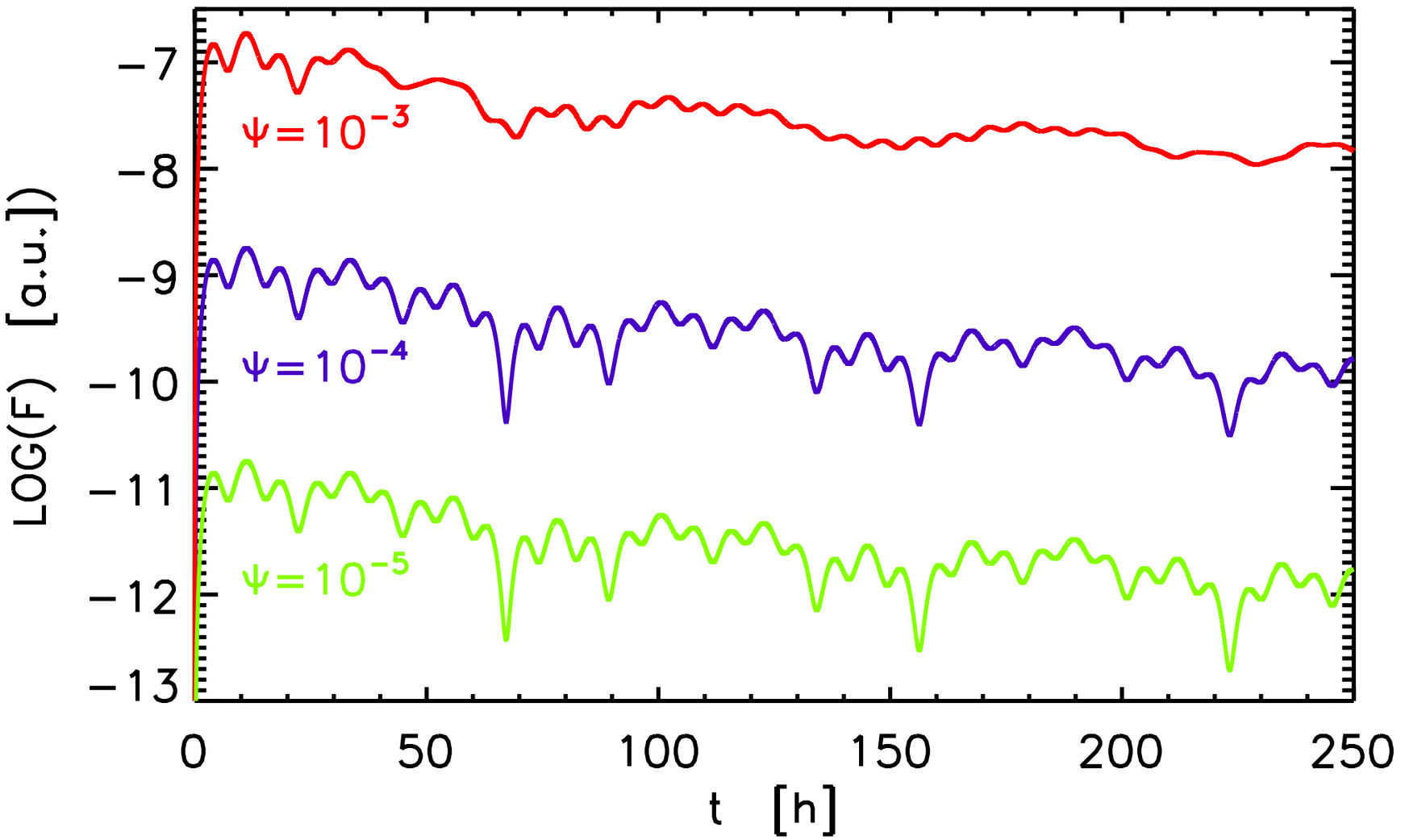


Typical multi-band spectrum without electron acceleration



Example: 100-GeV lightcurves

Three periods: 7.4 h, 22 h, and 74 h



Conclusions

If one emission zone produces many short-lived flares over a few days,

then very good collimation is required!

Important: ratio of variability time and activity time!

- **differential Lorentz contraction independent of model**
- **increased light travel time for leptonic models**
- **modified particle cooling and escape**

GLAST will provide better sampled lightcurves!

Collimation vs. deceleration

Motion through medium at rest

Rapid deceleration!

$$L_{\rm decel} \simeq \psi^{-2/3} \left(\frac{N_{\rm jet}}{\Gamma_0\, n_i}\right)^{1/3}$$

Avoided if $n_{\rm ISM} \propto L^{-2}$