Phenomenology of Extreme TeV Bl Lacs

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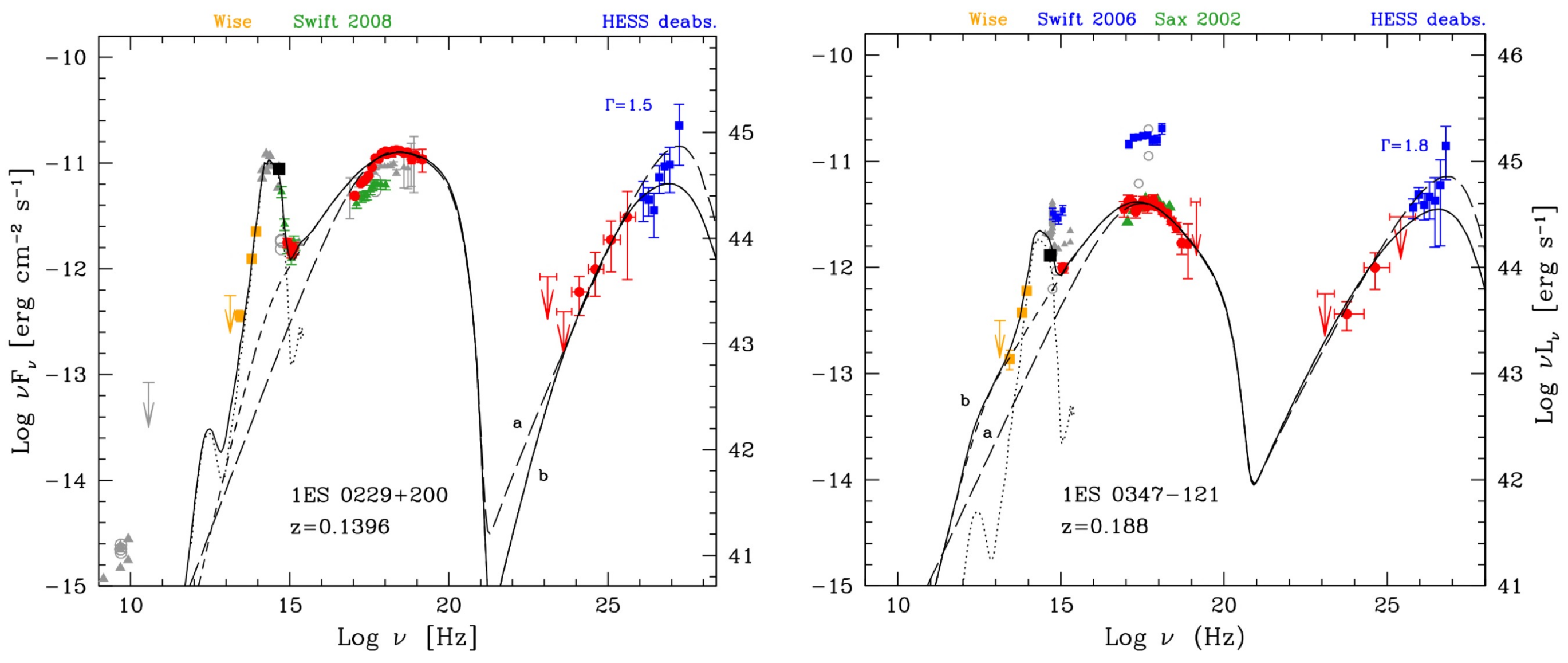
Introduction

Extreme TeV Bl Lacs are a subclass of blazars with peculiar properties:

- First peak in the hard X-ray band
- Second peak beyond 1 TeV
- Hard spectrum in the sub-TeV range
- Stable TeV emission over years

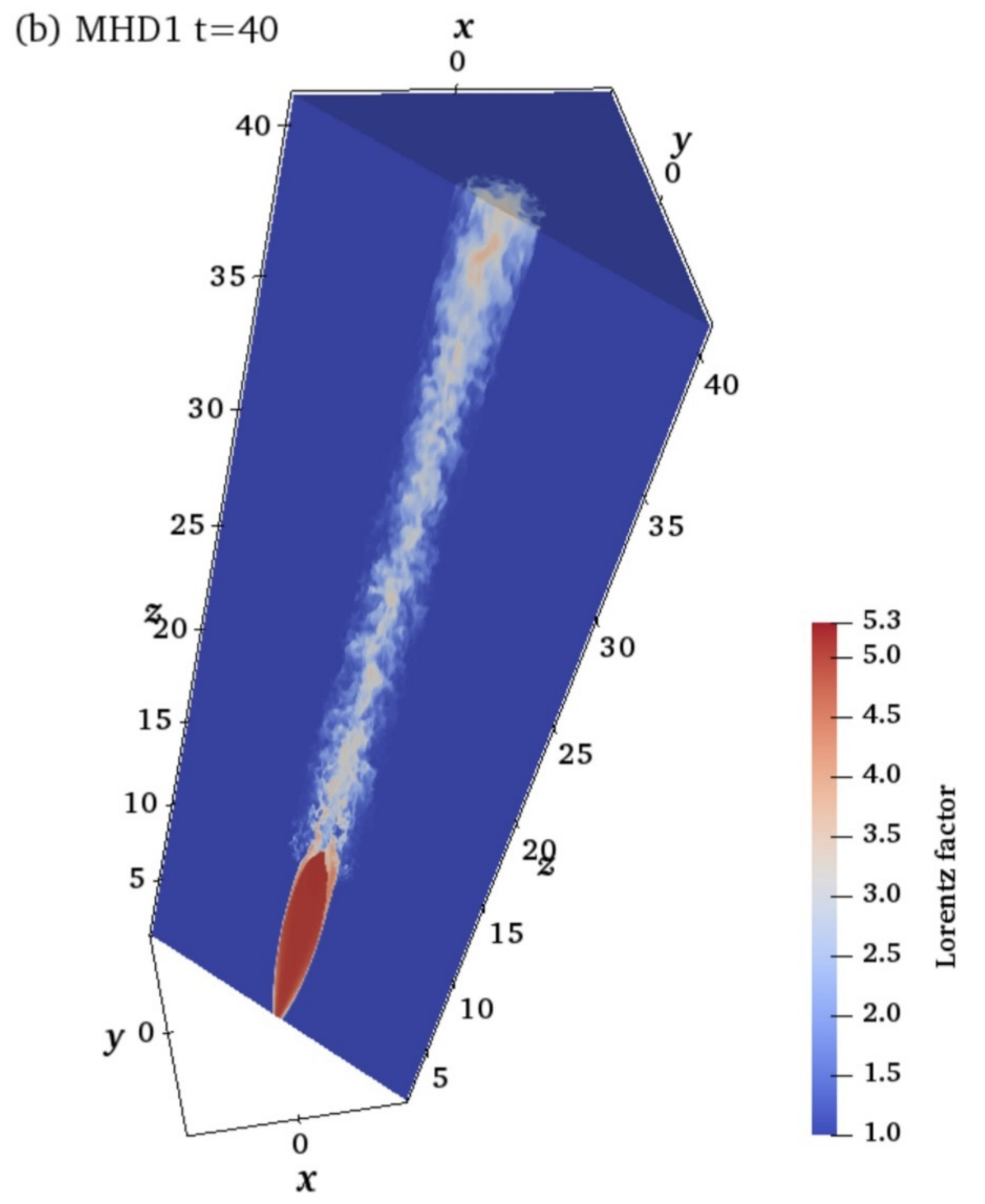
The emission of these sources is in tension with the existing phenomenological models and it is still an open challenge.



Starting point

The hard sub-TeV spectrum requires low magnetization, which in turn favors the developing of turbulence in downstream region. Following MHD simulations we suggest a *double acceleration model*.

- Dynamics
  - recollimation shock
  - turbulence
- Non-thermal particles
  - Diffusive Shock Acceleration
  - Stochastic Acceleration
- Emission
  - One-zone leptonic model
  - Synchrotron Self-Compton



Modeling

When stochastic acceleration is considered, turbulence damping is often neglected. Since magnetization is weak, the system is far from equipartion, so damping is expected to be stronger than turbulence cascading:

$$\frac{t_{\rm dam}}{t_{\rm cas}} \propto \frac{U_e}{U_B}$$

The particle and the turbulence spectra evolves in time:

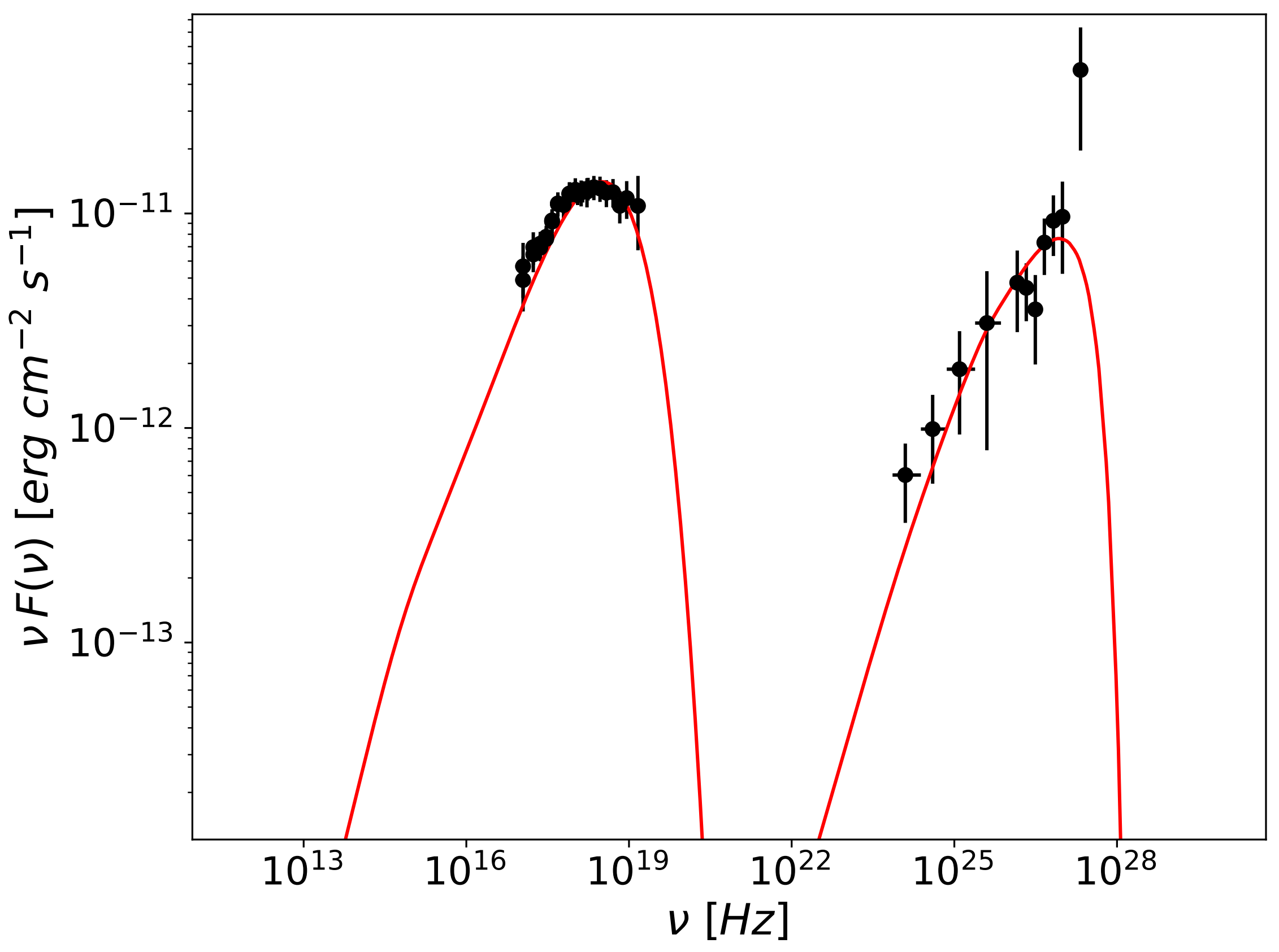
- After the shock, particles are further accelerated by the downstream turbulence and lose energy through synchrotron, inverse Compton and escape
- Turbulence cascades from larger length to smaller and it is damped by electrons

1ES0229+200

Our model depends on five parameters:

- Downstream region radius
- Alfven velocity
- Magnetic field
- Injected electron power
- Injected turbulence power

The model was compared with the data of the prototypical source 1ES0229+200. The realization is consistent with the theoretical constraints.

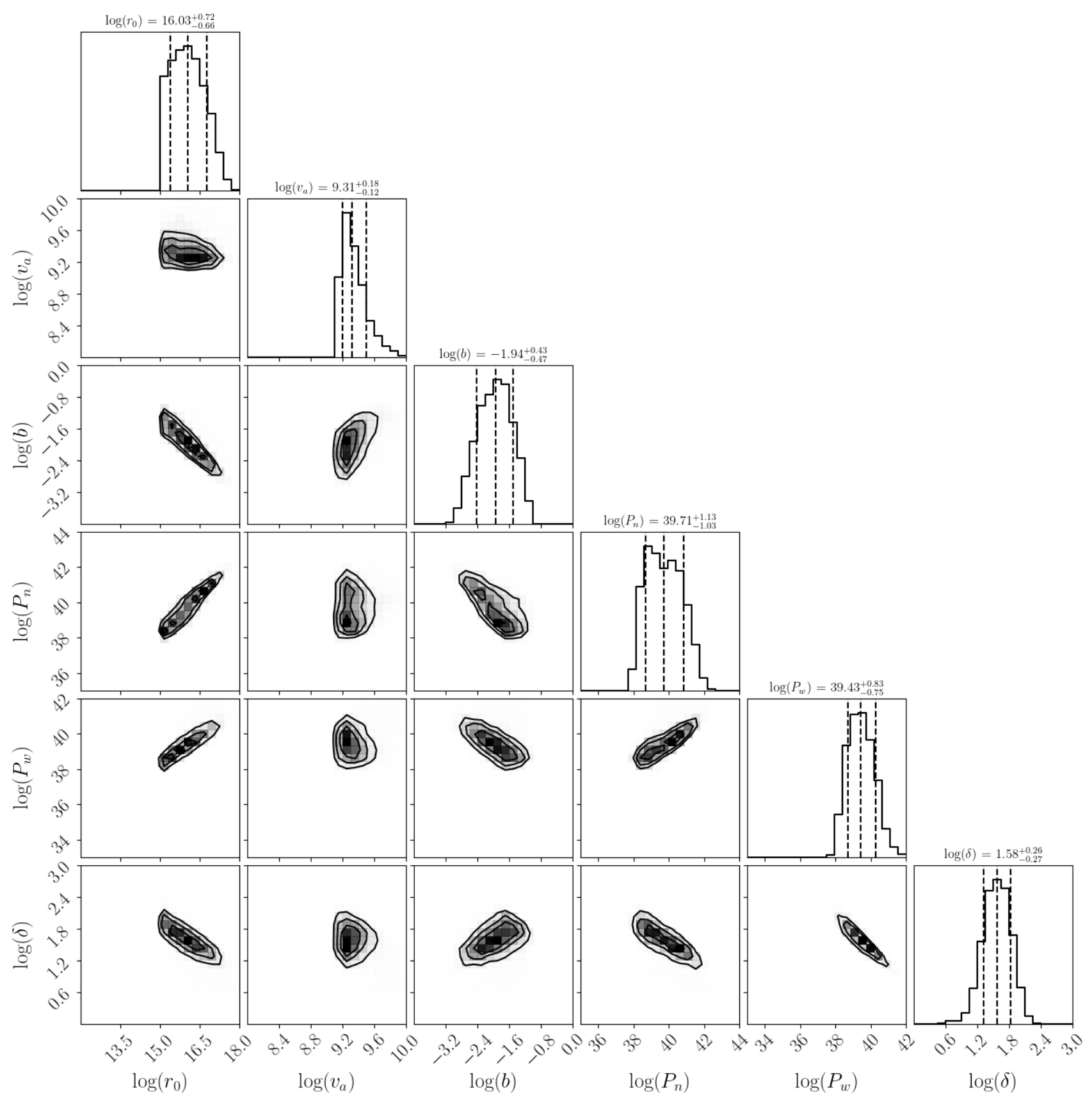


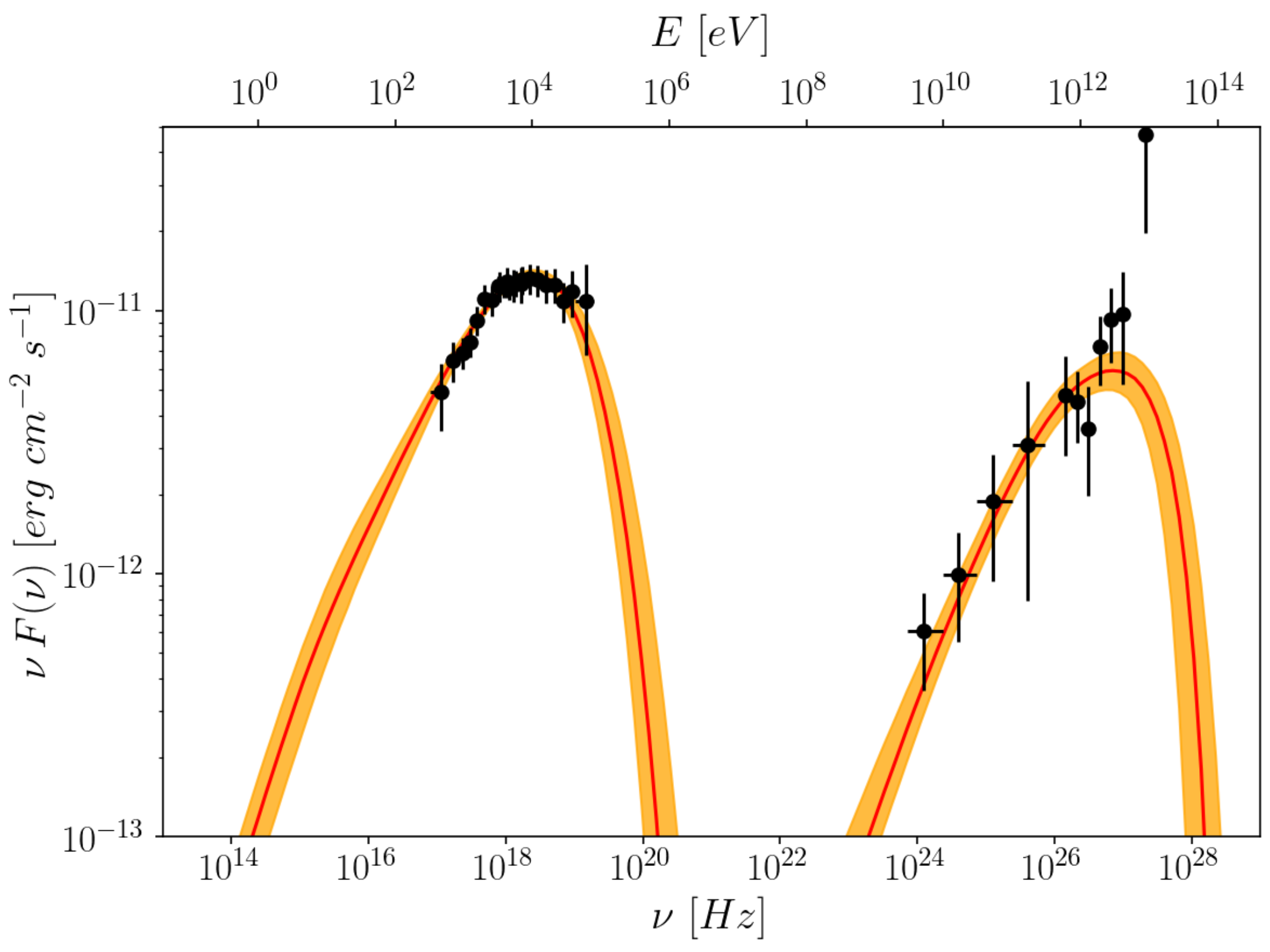
MCMC

Models are usually adjusted on the data by eye. *MCMC sampling* can automatize this procedure, with other advantages:

- Parallel evaluation
- Uncertainties estimation
- Non-diagonal priors

MCMC requires thousands of function evaluations, therefore it requires high-performance computers: we employed *Amazon Web Services.*





What's next?

The current model, based on MHD evidences, presents some limitations:

- No spatial resolution
- Simple shock interpretation

Our next goal is to calculate jet emission starting directly from MHD simulations. We wanted the code to remain fast, while implementing new physics.

- *Stationarity*: post processing analysis
- *Hybrid approach*: non-thermal particles are decoupled from thermal plasma
- *PIC*: at shocks spectra are updated following microphysical simulations

This framework will permit to calculate the spatial emissivity distribution, the polarization and the flux of stable sources.

References

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