Studies of Cosmic Ray Acceleration in Relativistic Jets

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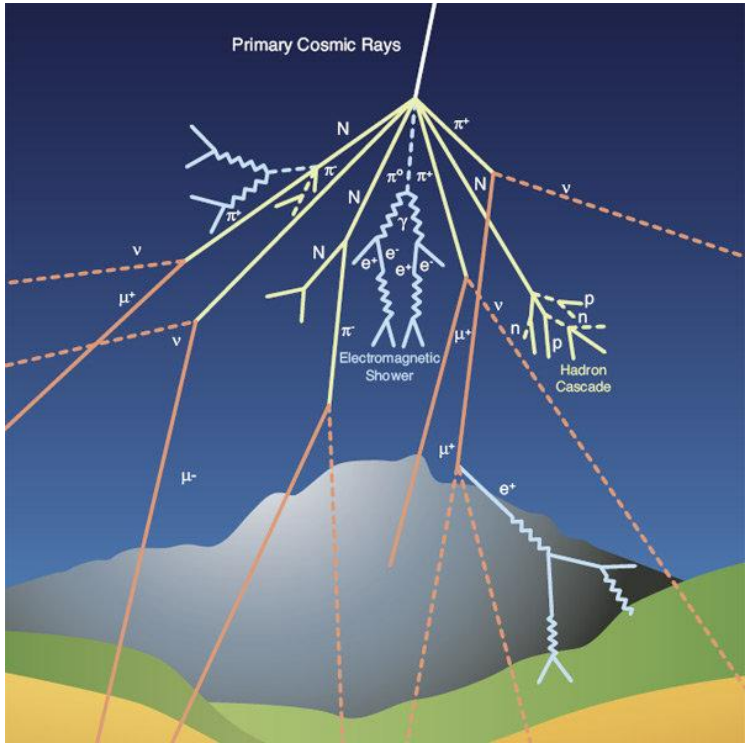
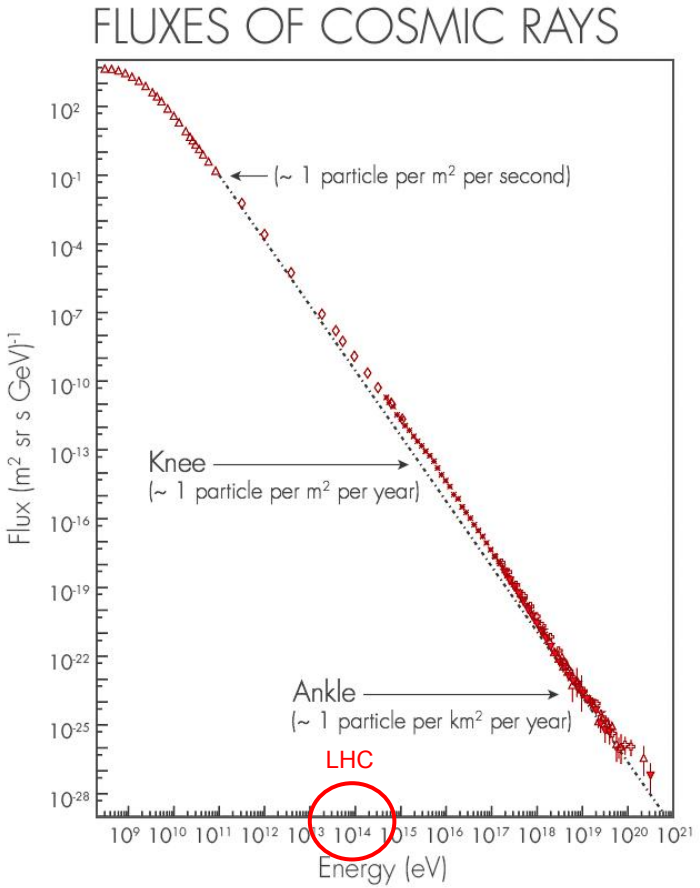
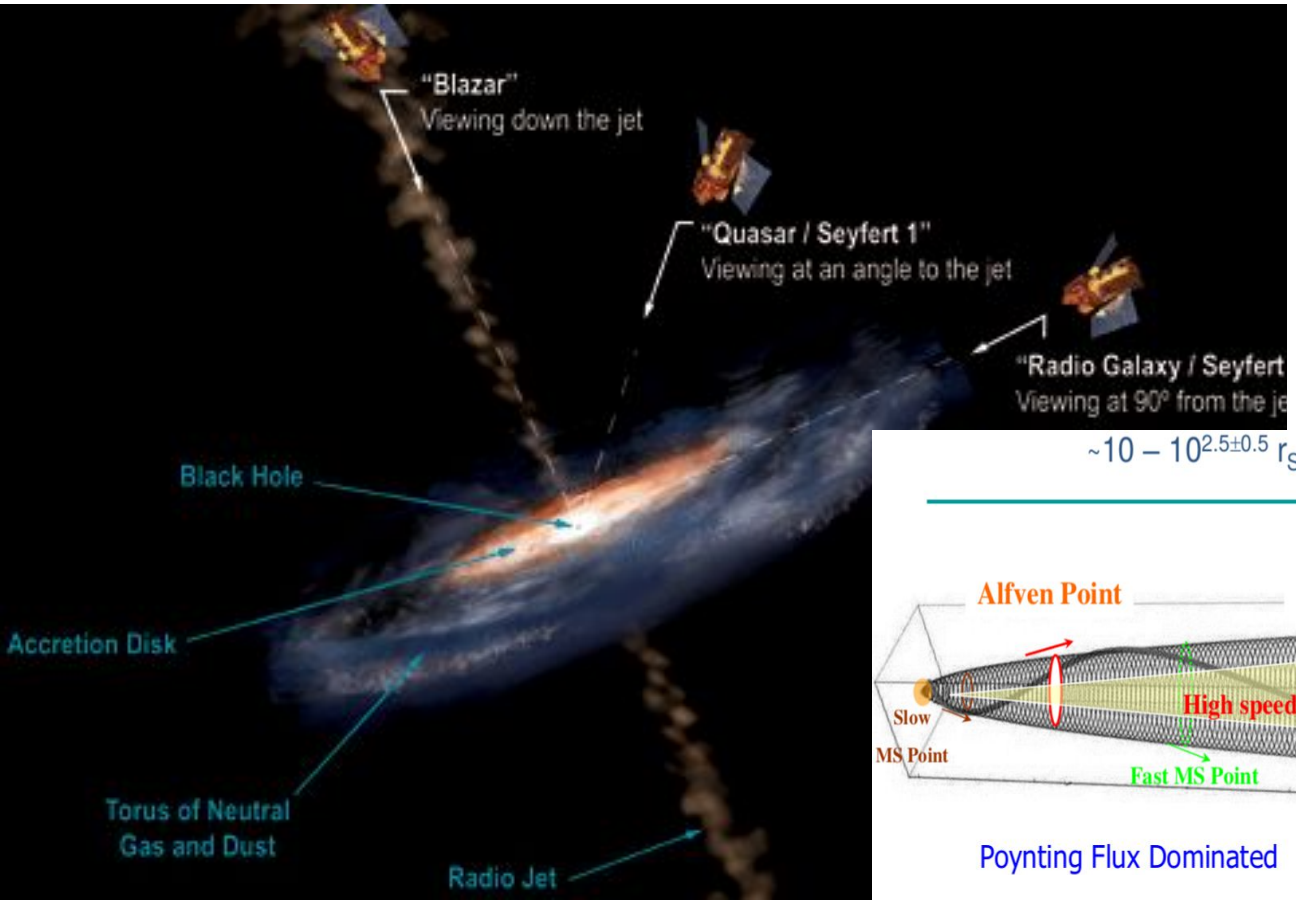
Most energetic relativistic particles (cosmic rays-CRs)

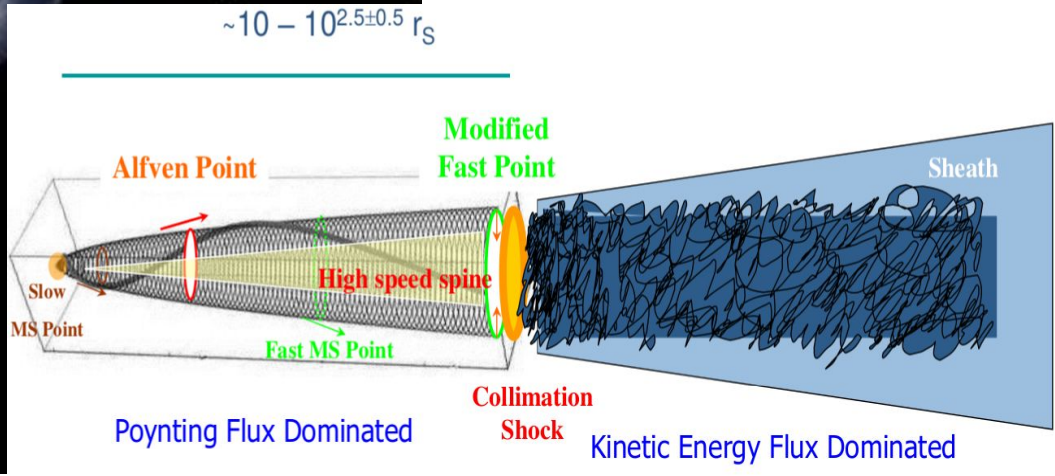




Astrophysical jets

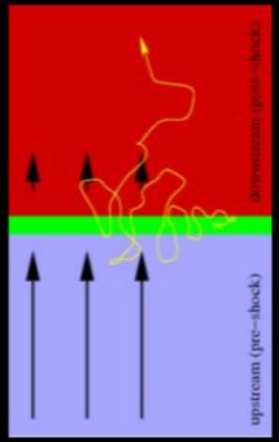


Blandford & Znajek, 1977
Blandford & Payne, 1982



How these particles can be accelerated?

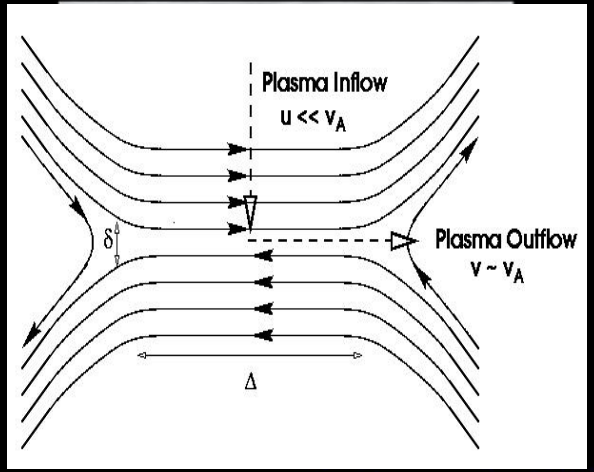
Shock Acceleration



1st-order Fermi (Bell+1978):

$\langle \Delta E/E \rangle \sim v_{sh}/c$

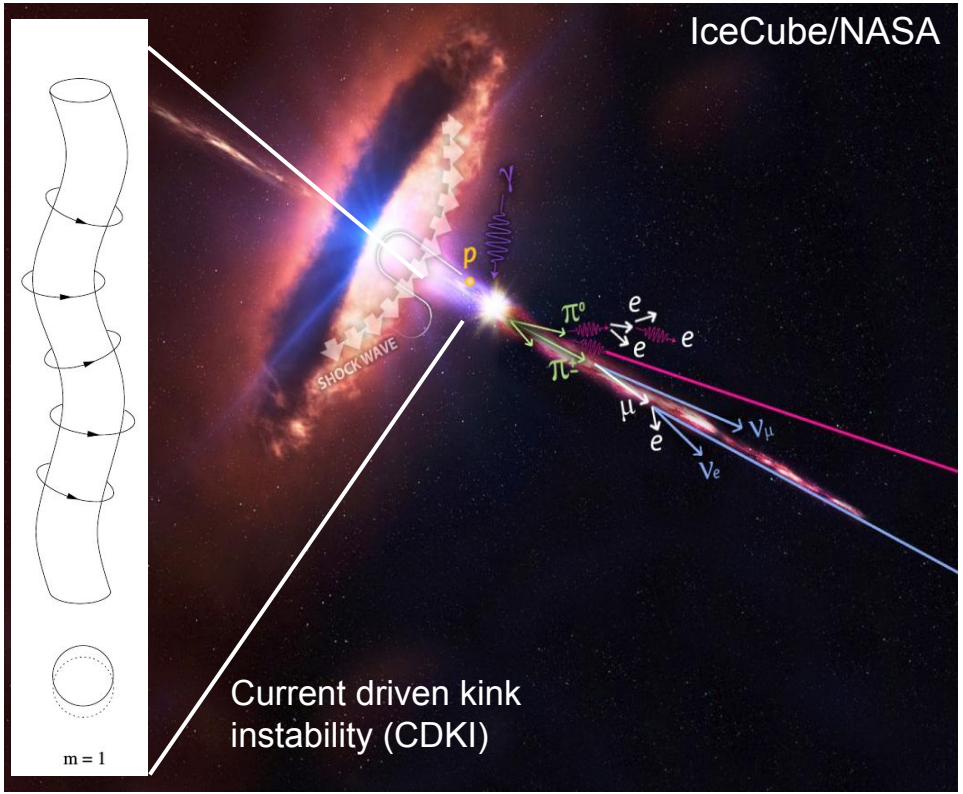
Reconnection Acceleration



1st-order Fermi (de Gouveia Dal Pino & Lazarian 2005):
particles bounce back and forth between 2 converging magnetic flows

$\langle \Delta E/E \rangle \sim v_{rec}/c$

Fast magnetic reconnection in relativistic jets: one possibility



Current driven kink instability

The presence of **instabilities in the jet can drive turbulence** and thus fast magnetic reconnection.

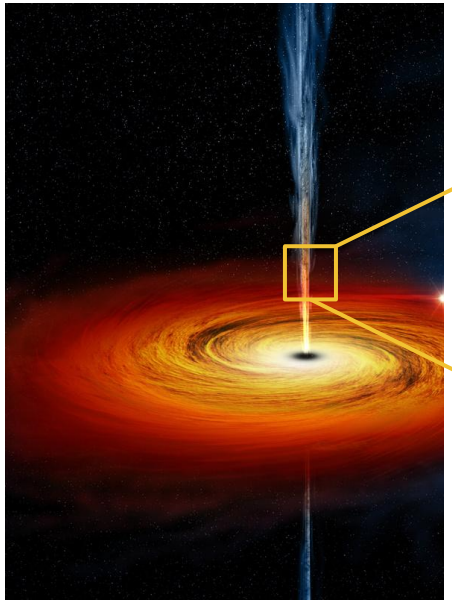
Jets with helical magnetic field structure, can be subject to the **CDKI.**

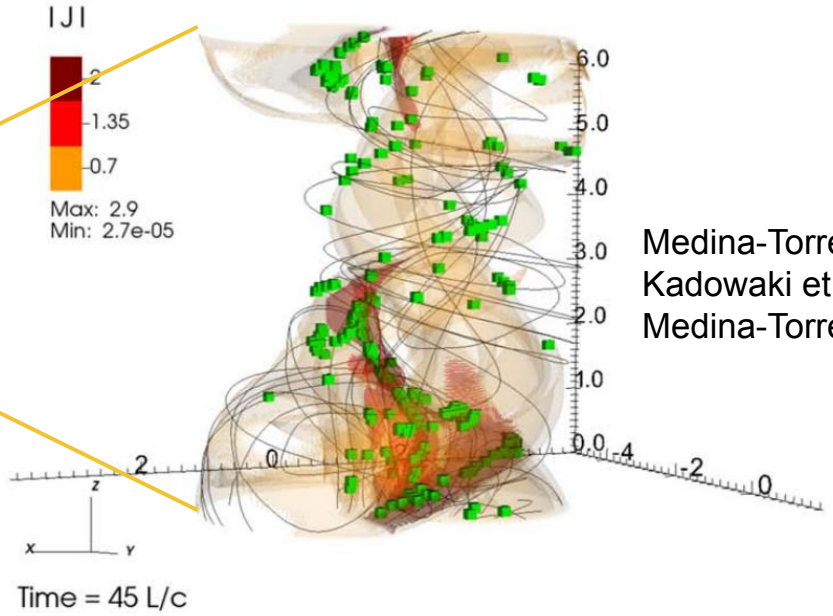
3D SRMHD simulations of Relativistic jets

Helical magnetic field and magnetization parameter $\sigma_0 = B_0^2/\gamma^2\rho h$ ~1

+

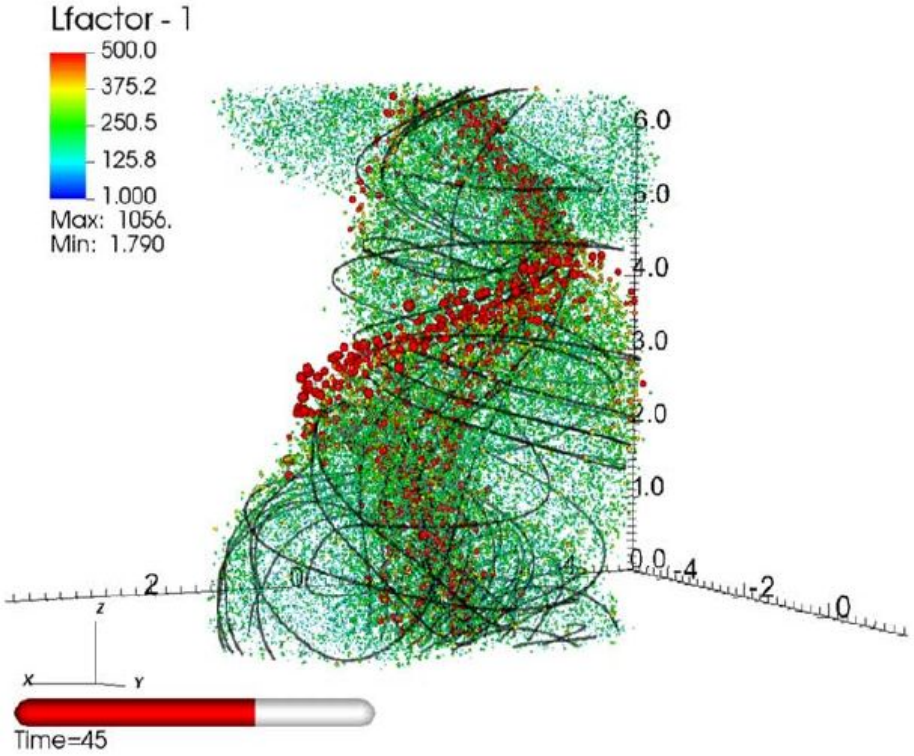
Current drive kink instability

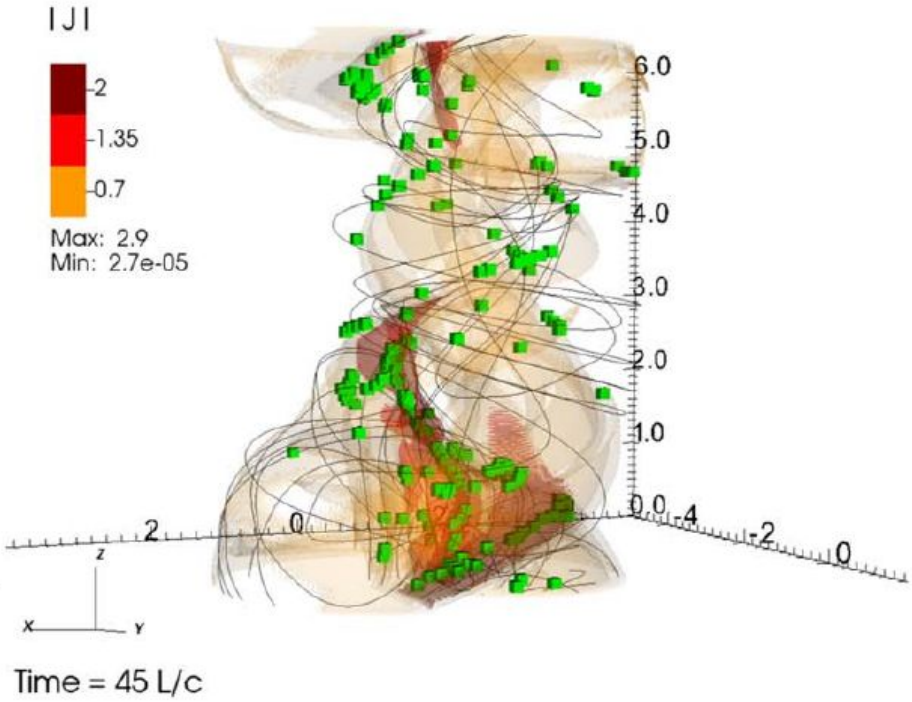




Medina-Torrejon et al. 2021
Kadowaki et al. 2021
Medina-Torrejon et al. 2023

Acceleration by magnetic reconnection **MHD-PIC**

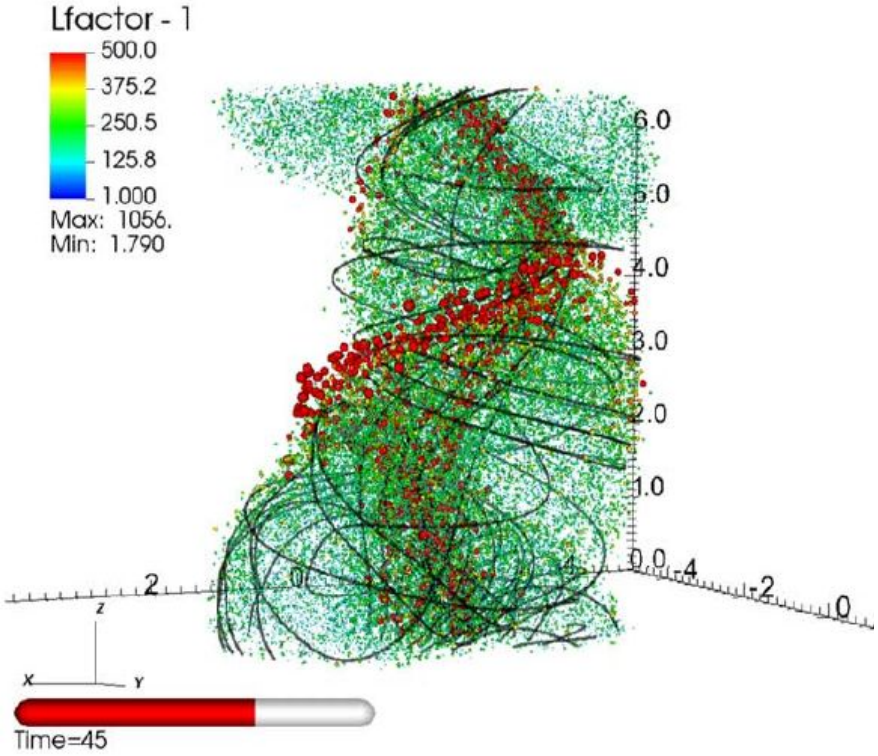




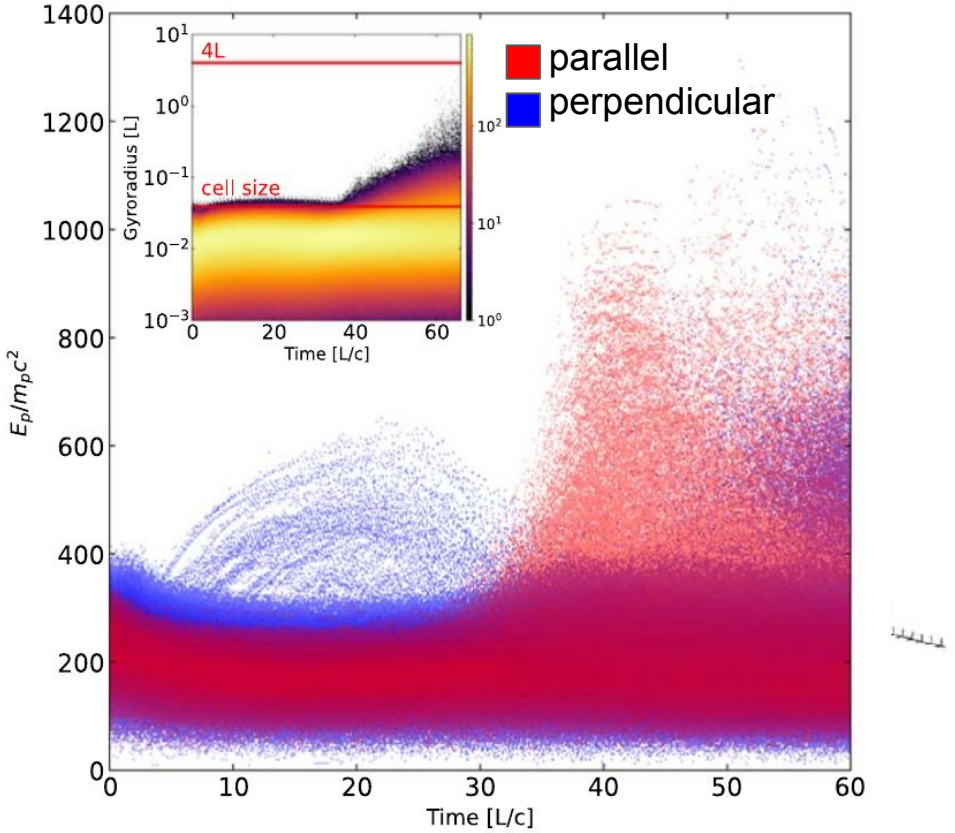
Hadronic model

Medina-Torrejon, de Gouveia Dal Pino, Kowal 2023

Acceleration by magnetic reconnection **MHD-PIC**

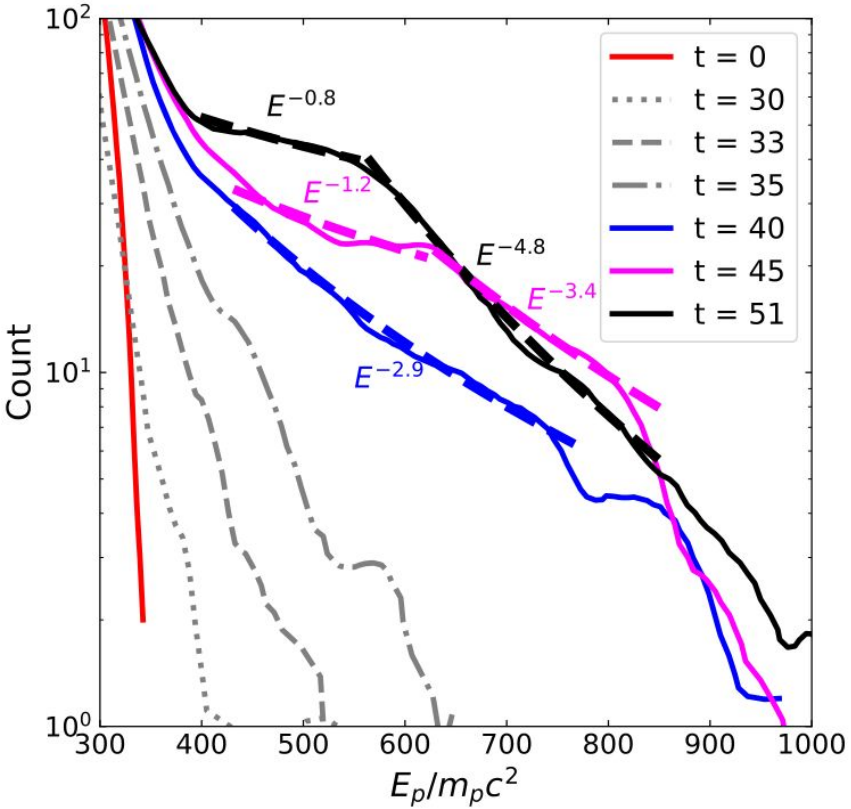


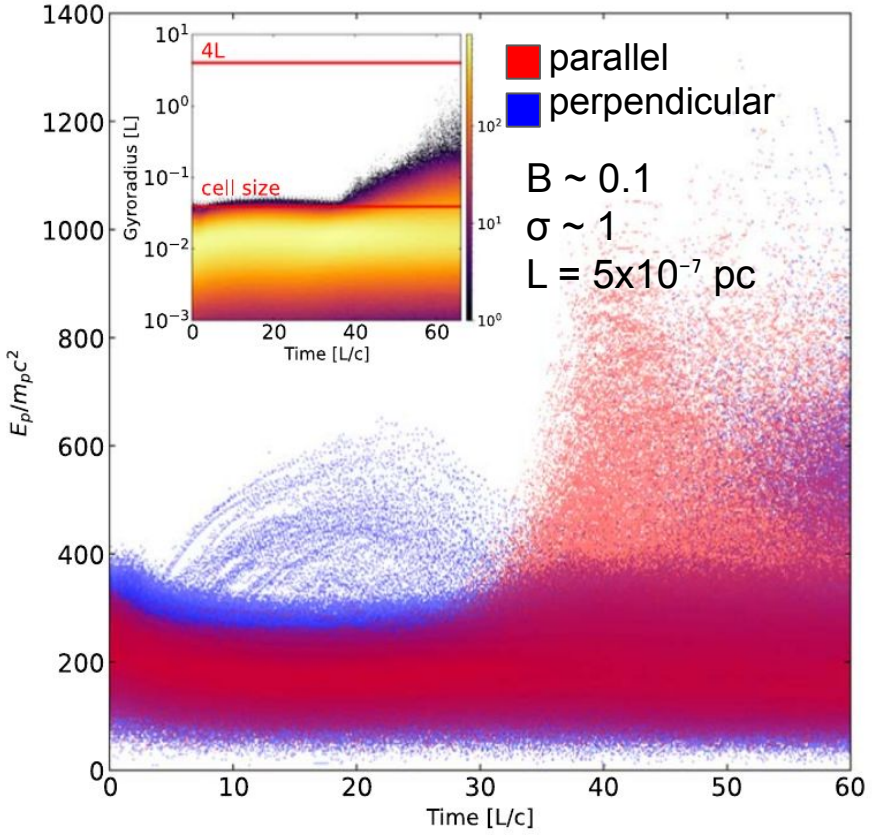
Hadronic model



Medina-Torrejon, de Gouveia Dal Pino, Kowal 2023

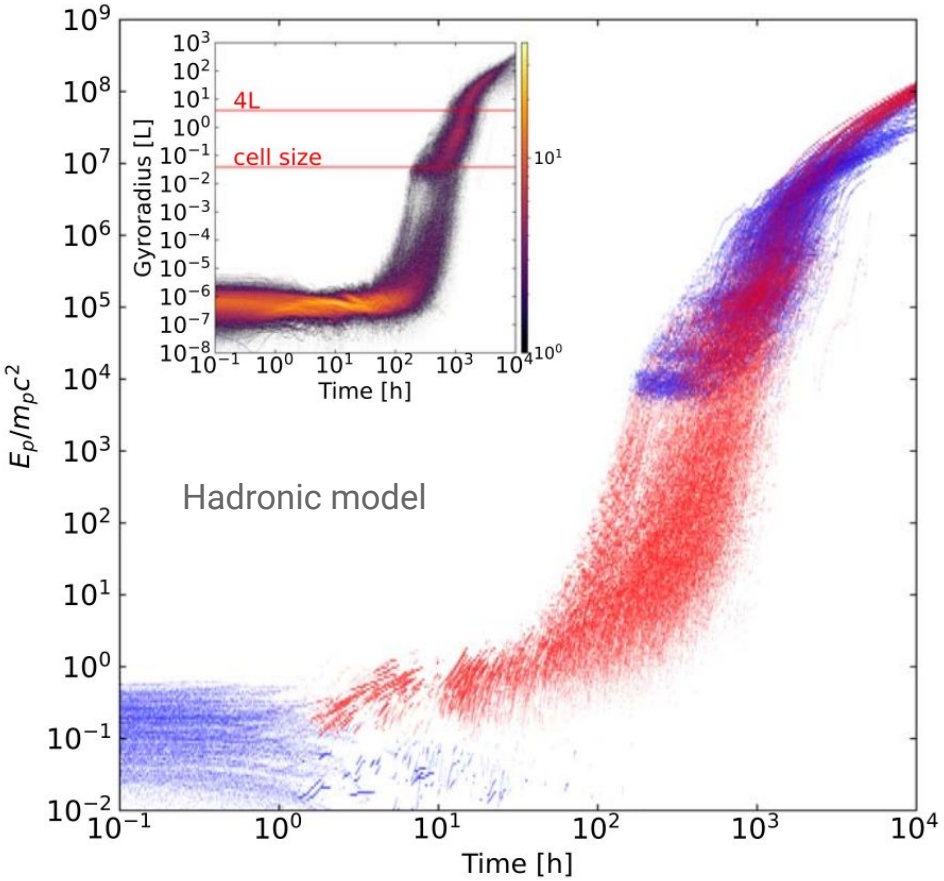
Acceleration by magnetic reconnection **MHD-PIC**





Medina-Torrejon, de Gouveia Dal Pino, Kowal 2023

Acceleration by magnetic reconnection **MHD**



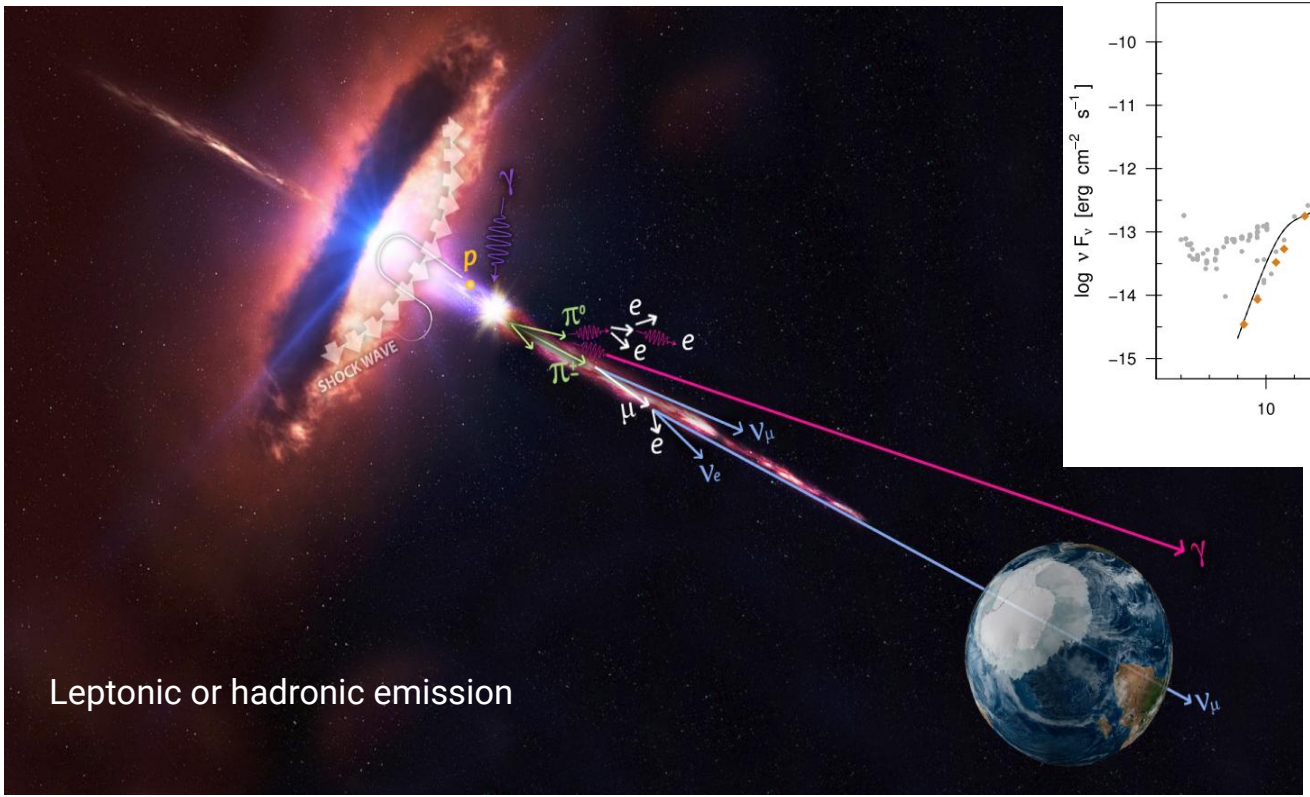
$E_{max} \sim 10^{16}$ eV (B ~ 0.1 G)
$E_{max} \sim 10^{18}$ eV (B ~ 10 G)

B ~ 0.1
σ ~ 1
L = 3.5×10^{-5} pc

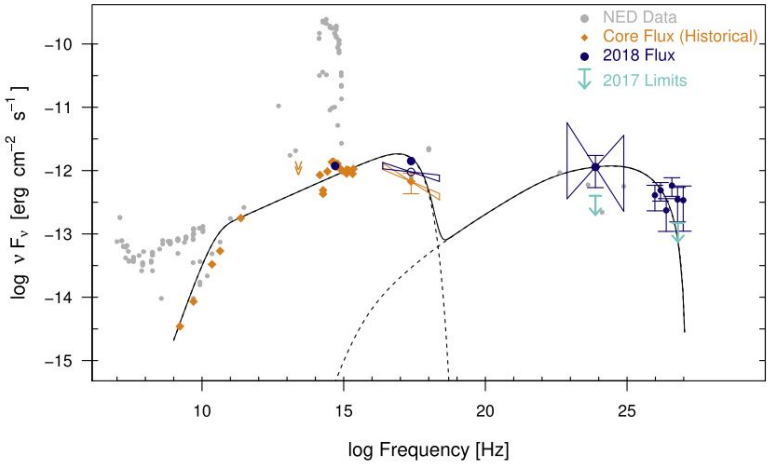
The saturation energy in the e**xponential regime of acceleration due to reconnection** is achieved when the **Larmor radius ~ jet diameter.**

Medina-Torrejon, de Gouveia Dal Pino, Kowal 2023

Spectral Energy Distribution (SED) of AGN sources



Leptonic or hadronic emission

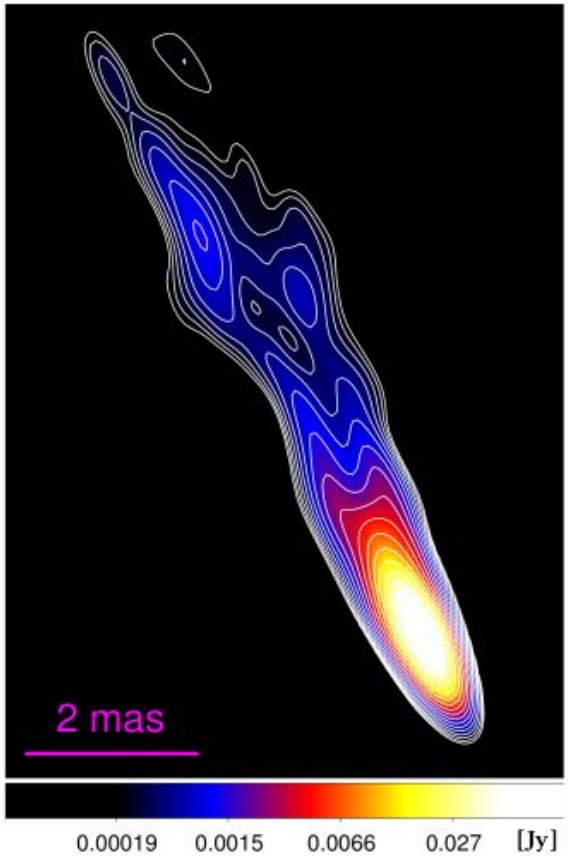


Archer et al. 2020

Choose a source

Radio galaxy 3C 264:

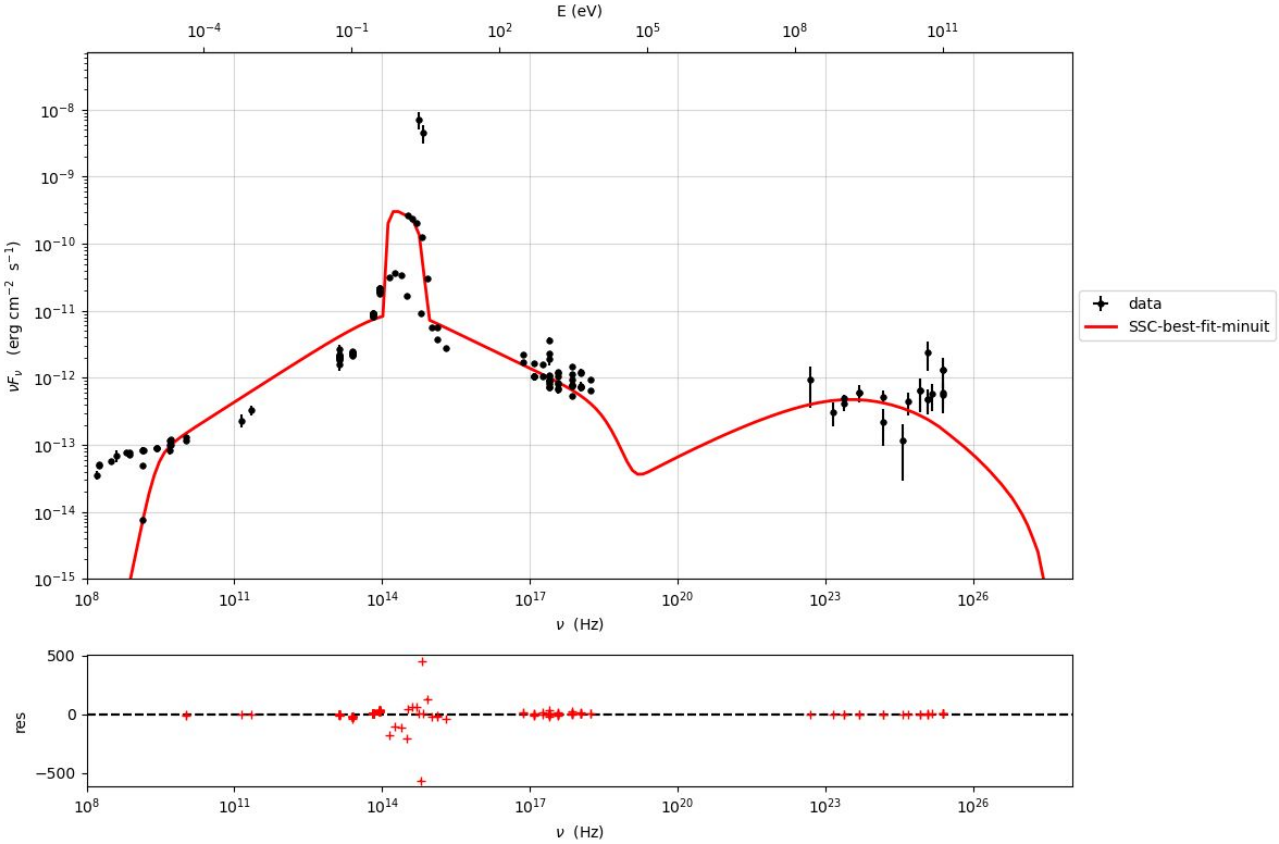
- The source presents a variable VHE flux of the order of some months.
- A nearby Fanaroff-Riley I (FRI) object
- $M\_BH = 4.7 \times 10^8 M\odot$
- $z \sim 0.0217$



Model of 3C264

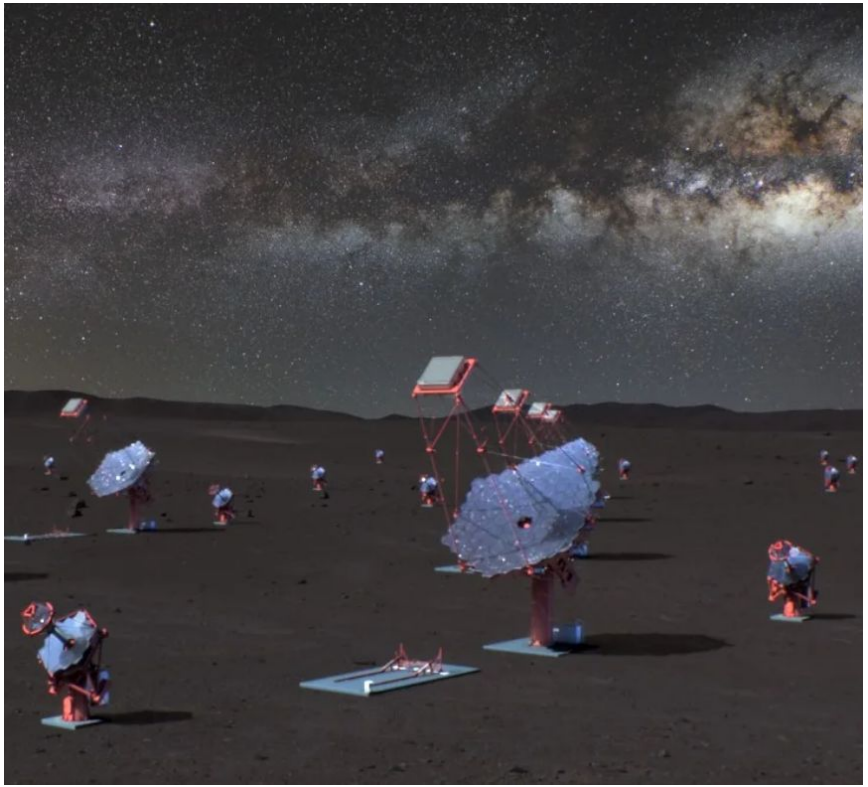
Analysis of the emission energy of different VHE sources, in order to understand the origin of its emission.

JetSet code



Next step

Extent the analisis to study the sensitive detection of the source emission by CTAO.



Acknowledgements