Title: Ion-synchrotron emission from reconnecting current sheets in M87

Speakers: Amir Levinson

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Abstract:

It has been proposed recently that Inverse Compton scattering of soft photons by pairs acceleration in reconnecting current sheets that form during MAD states, can be the source of the TeV emission detected in M87. In this talk I'll argue that synchrotron emission by ions accelerated in the current sheet is expected to be the dominant source of the GeV emission observed. The analysis is based on 3D, radiative PIC simulations of magnetic reconnection in pair-ion plasma, under conditions anticipated in M87 during MAD states.

Ion-synchrotron emission from reconnecting current sheets in M87

Hayk Hakobyan, AL, Lorenzo Sironi, Alexander Philippov, Bart Ripperda

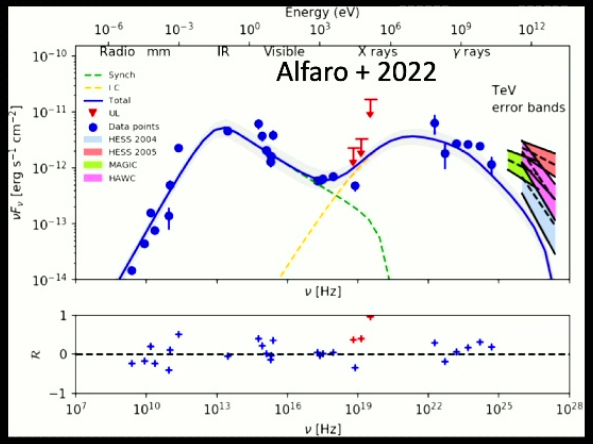
Amir Levinson

Tel Aviv Univ.

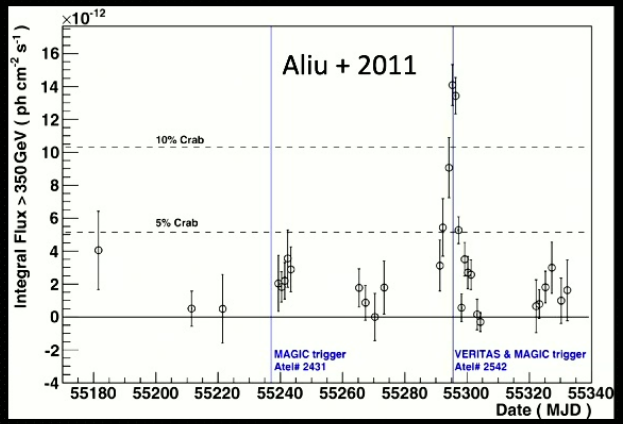
The central theme

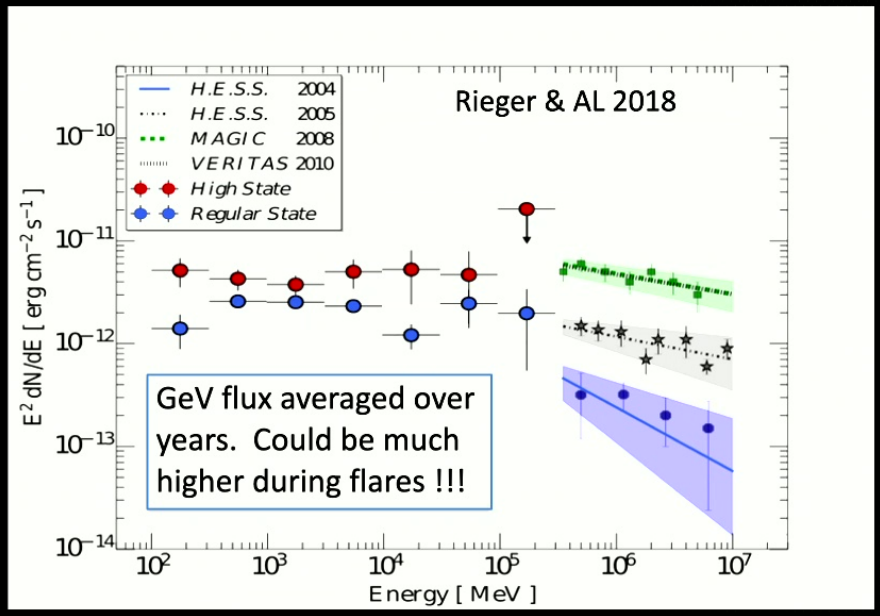
- VHE photons originate from a reconnecting current sheet
- MeV and TeV emissions are produced by pairs
- GeV emission is dominated by ion synchrotron emission

VHE emission from M87



Extreme flares

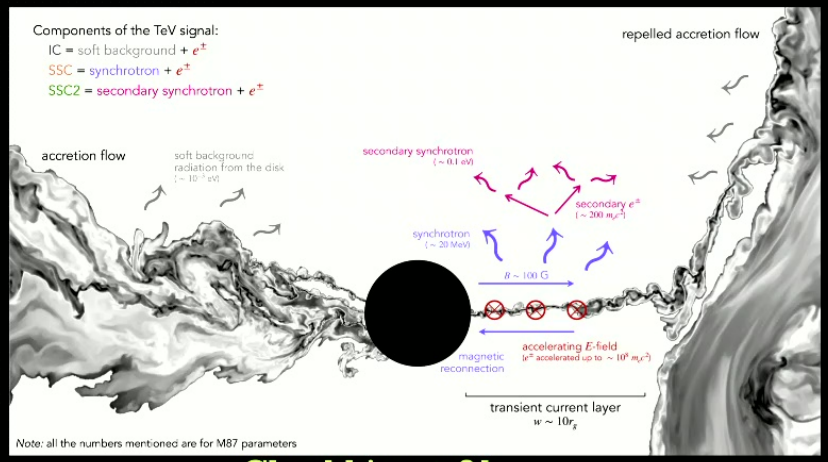




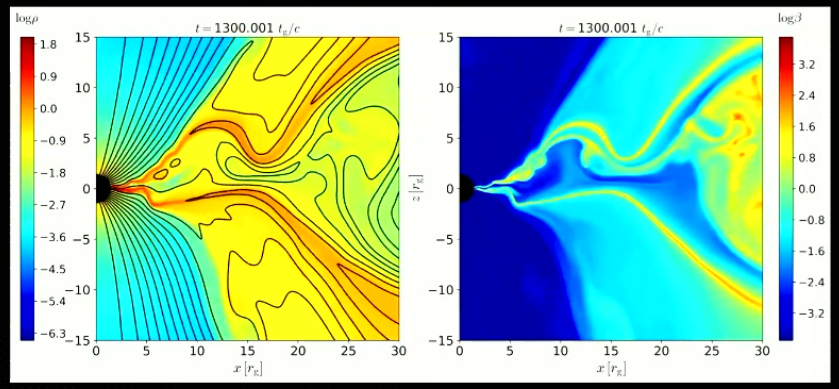
- Rapid TeV flares with durations ~ 1 day. emission from BH vicinity
- GeV Component distinct ?
- Source of VHE emission: spark gaps ? current sheets ?

VHE emission from reconnecting current sheet

Ripperda + 22, Hakobyan + 23



Chashkina + 21

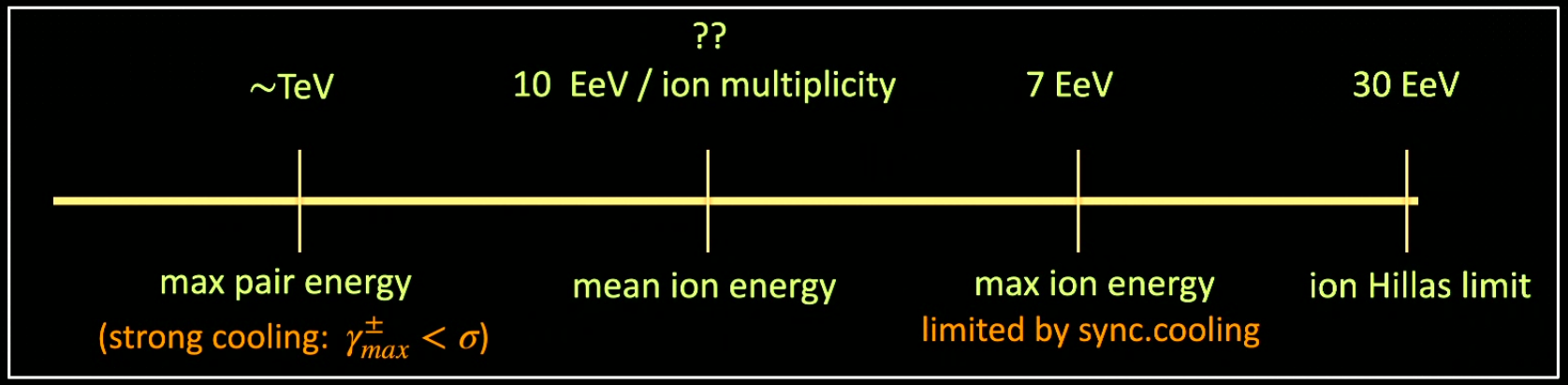


- Flux eruptions during MAD states leads to reconnection
- Pairs and ions accelerate in the reconnecting current sheet
- Emission processes
  - MeV: pair Synchrotron.
  - GeV: ion synchrotron.
  - TeV: IC of disk radiation by pairs

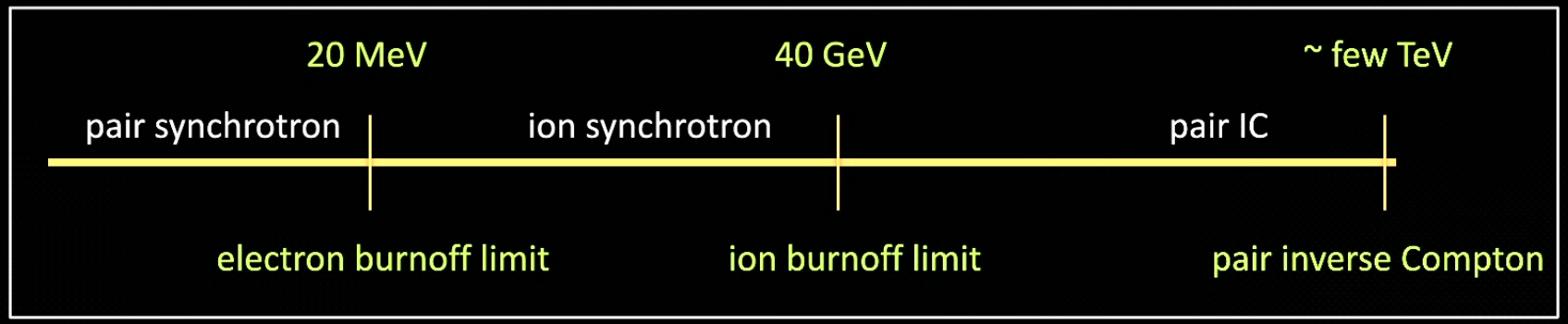
This model requires magnetization $\sigma > 10^6$!

Energy scales

particle energy (for B = 100 G)



photon energy



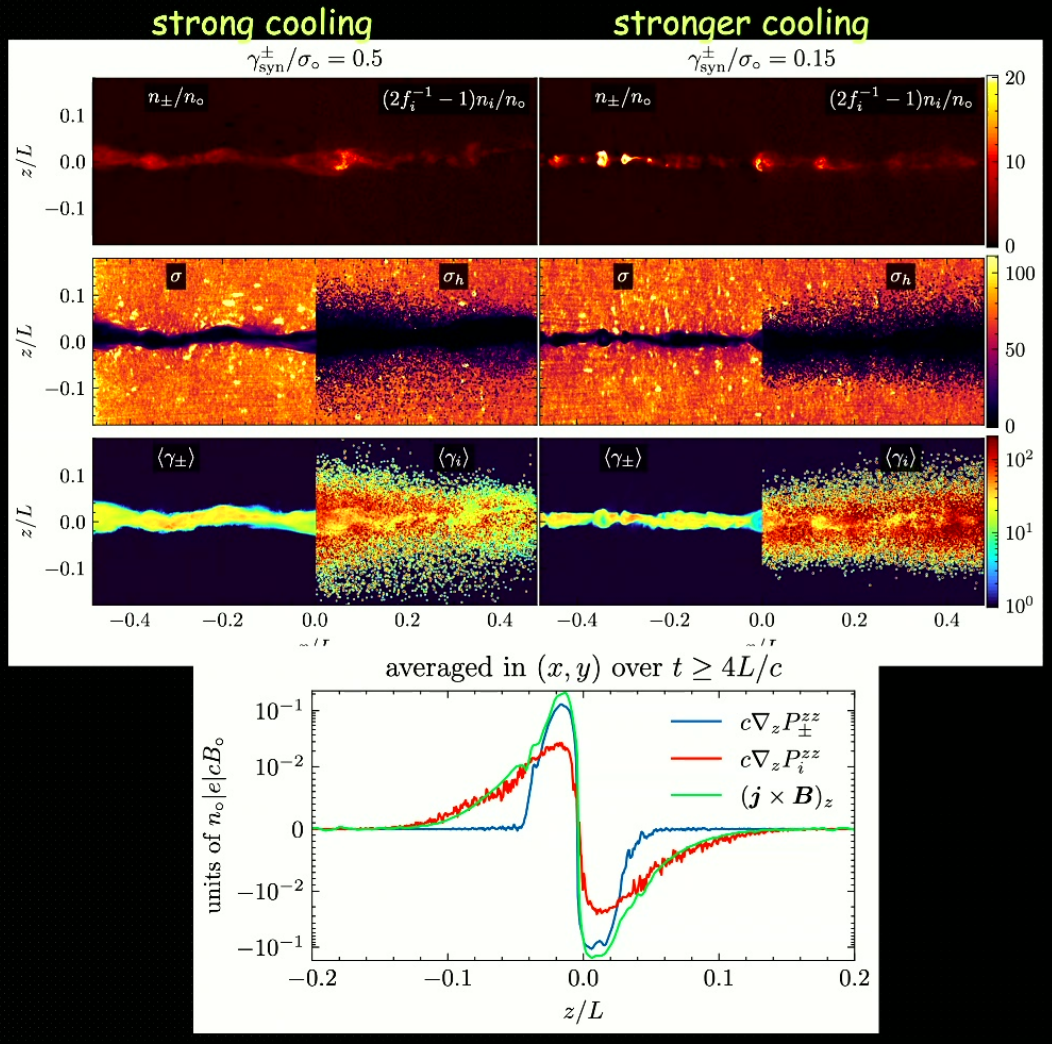
Desired input from simulations

- Ion energy spectrum? (dictates radiative efficiency)
- Energy partition between ions and pairs (relative normalization)

- 3D radiative PIC simulations
- plasma: ion-pair composition
- Cooling: only pairs via drag force
- Emission is computed post-processing

- mass ratio: $m_i/m_e = 5$
- magnetization: $\sigma_0 = 100$
- ion fraction: $f_i = \dfrac{n_i}{n_i + n_+} = 0.05$
- pair cooling: $\gamma_{rad}/\sigma_0 = 0.15,\ 0.5$

Structure of current sheet



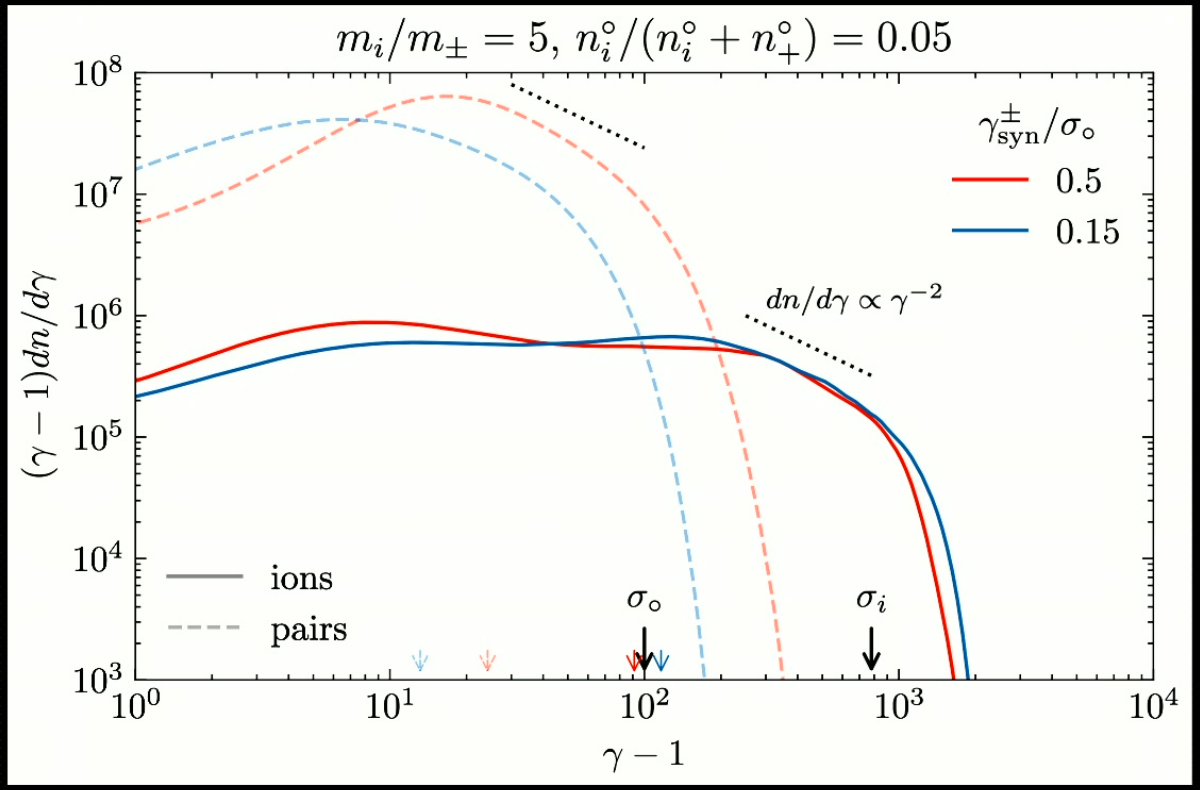
Dissipation power:

$$L_{rec} = v_{rec}\frac{B^2 S}{4\pi} \approx 10^{44}\, B_2^2\, (r/10r_g)^2\ \mathrm{erg/s}$$

- pairs are strongly cooled
- ion feedback important
- pair layer << ion layer (ion Larmor radii >> sizes of pair-dominated plasmoids)

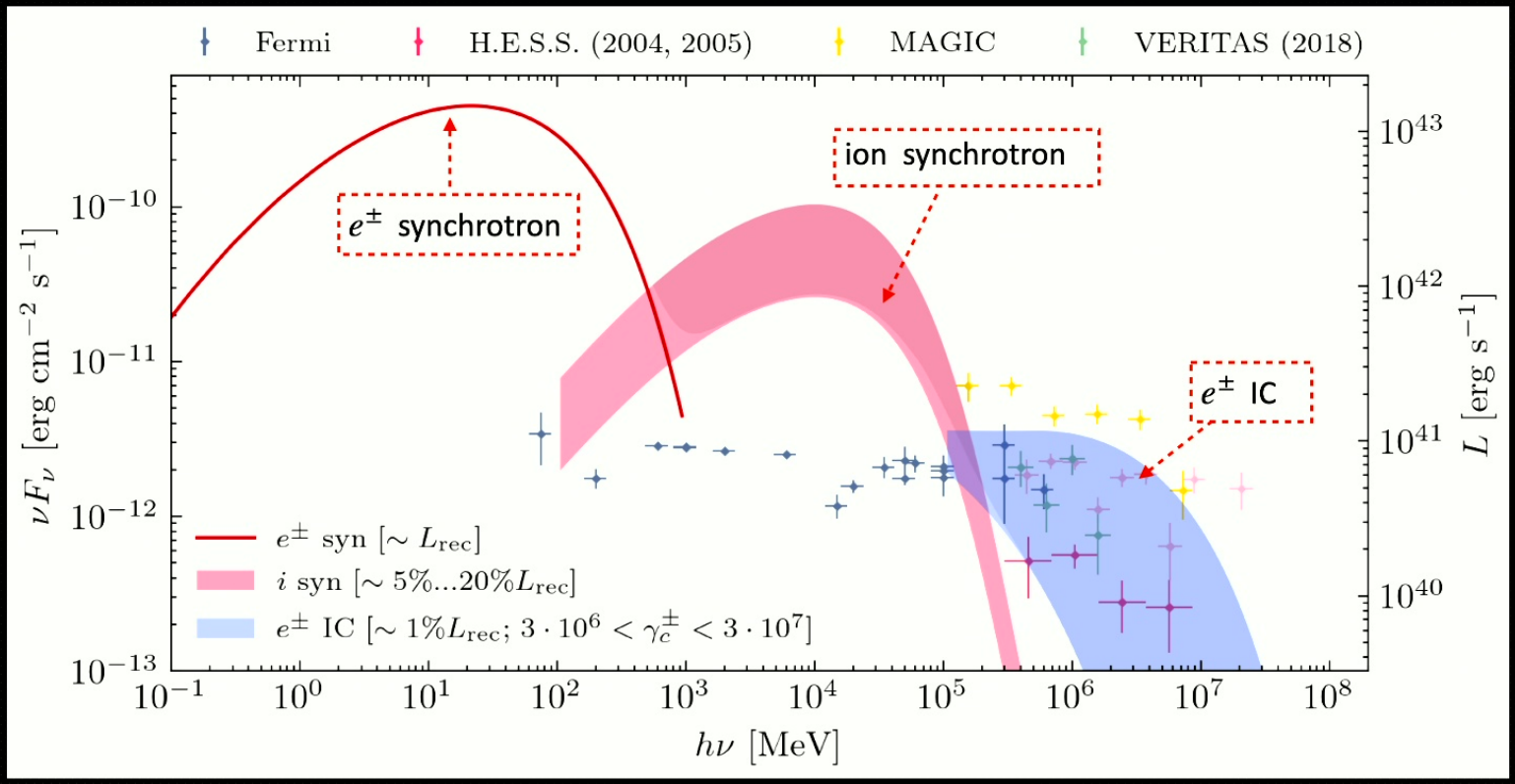
⇒ efficient ion acceleration

Particle spectra



$$\frac{dn_i}{d\gamma_i} = n_i^0 \begin{cases} \gamma_i^{-1}, & 1 \le \gamma_i < \gamma_b^i \\ \gamma_b^i\, \gamma_i^{-2}, & \gamma_b^i \le \gamma_i \le \gamma_{\rm syn}^i \end{cases}$$

Photon spectra for $L_{rec} = 7 \times 10^{43}$ erg/s



Note: Fermi data shown here corresponds to low state