

# Radiation and Polarization from Magnetic Reconnection in Blazars

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## Scientific Goals and Methods

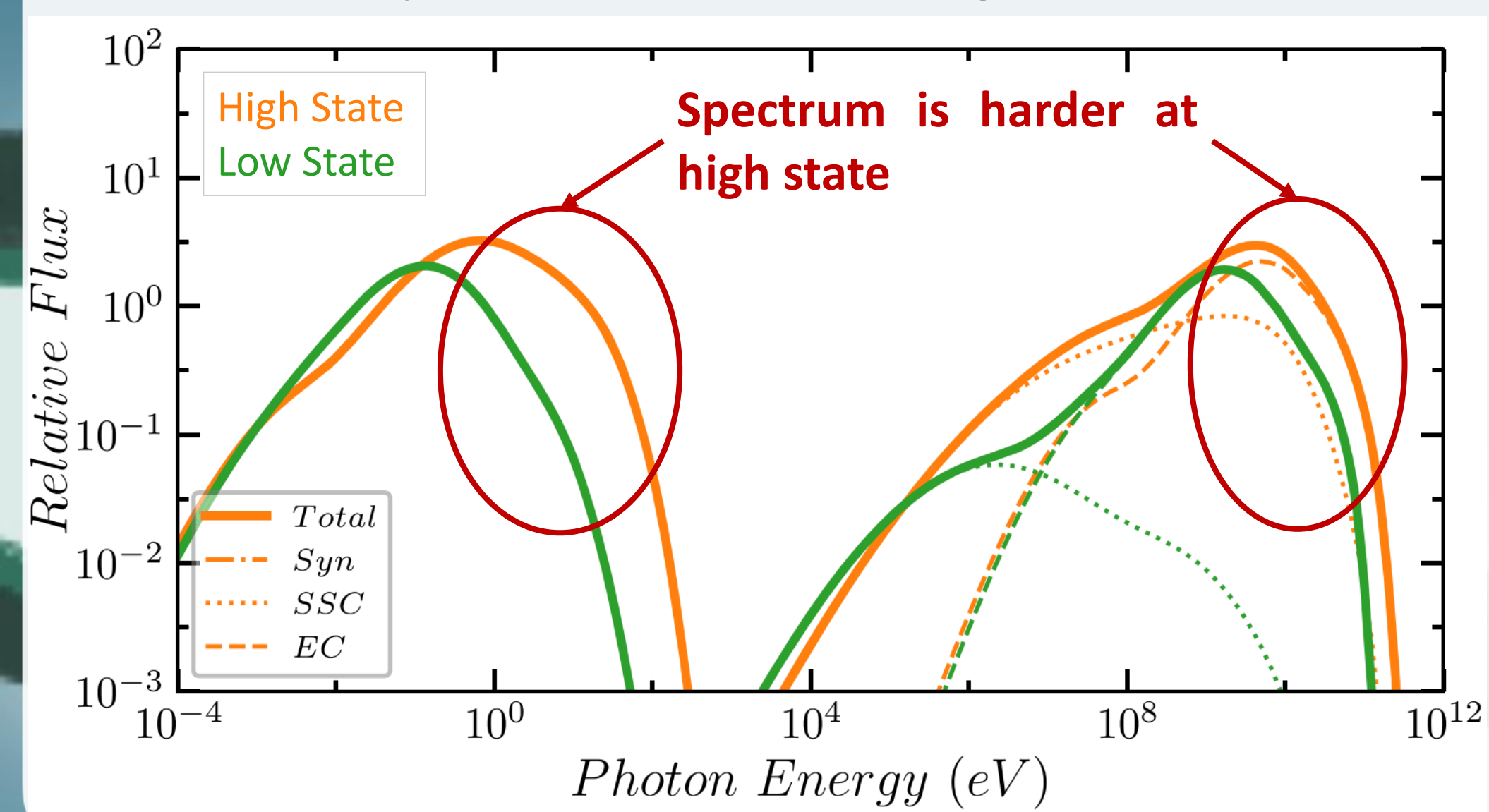
- Blazars exhibit highly variable multi-wavelength emission, implying strong particle acceleration in very localized regions.
- Magnetic reconnection is an efficient particle acceleration mechanism in a magnetized blazar emission region.
- Previous works have not thoroughly explored the multi-wavelength radiation and polarization signatures from reconnection.
- We use coupled particle-in-cell and polarized radiation transfer simulations to study observable patterns under first principles.
- We focus on the dependence of variability on the physical conditions in the blazar emission region.

## Take Away Messages

- Reconnection exhibits a harder-when-brighter trend in spectrum.
- Higher-energy bands are more variable in flux and polarization.
- Fast gamma-ray flares result from synchrotron self Compton by dense nonthermal particles at plasmoid merger sites.
- Optical polarization angle swings are correlated to multi-wavelength flares, due to stream of nonthermal particles around the post-merger plasmoid.
- Polarization degree drops during angle swings.
- Flux and polarization are more variable with lower guide field in the reconnection region. Angle swings are only possible with very low guide field strengths.

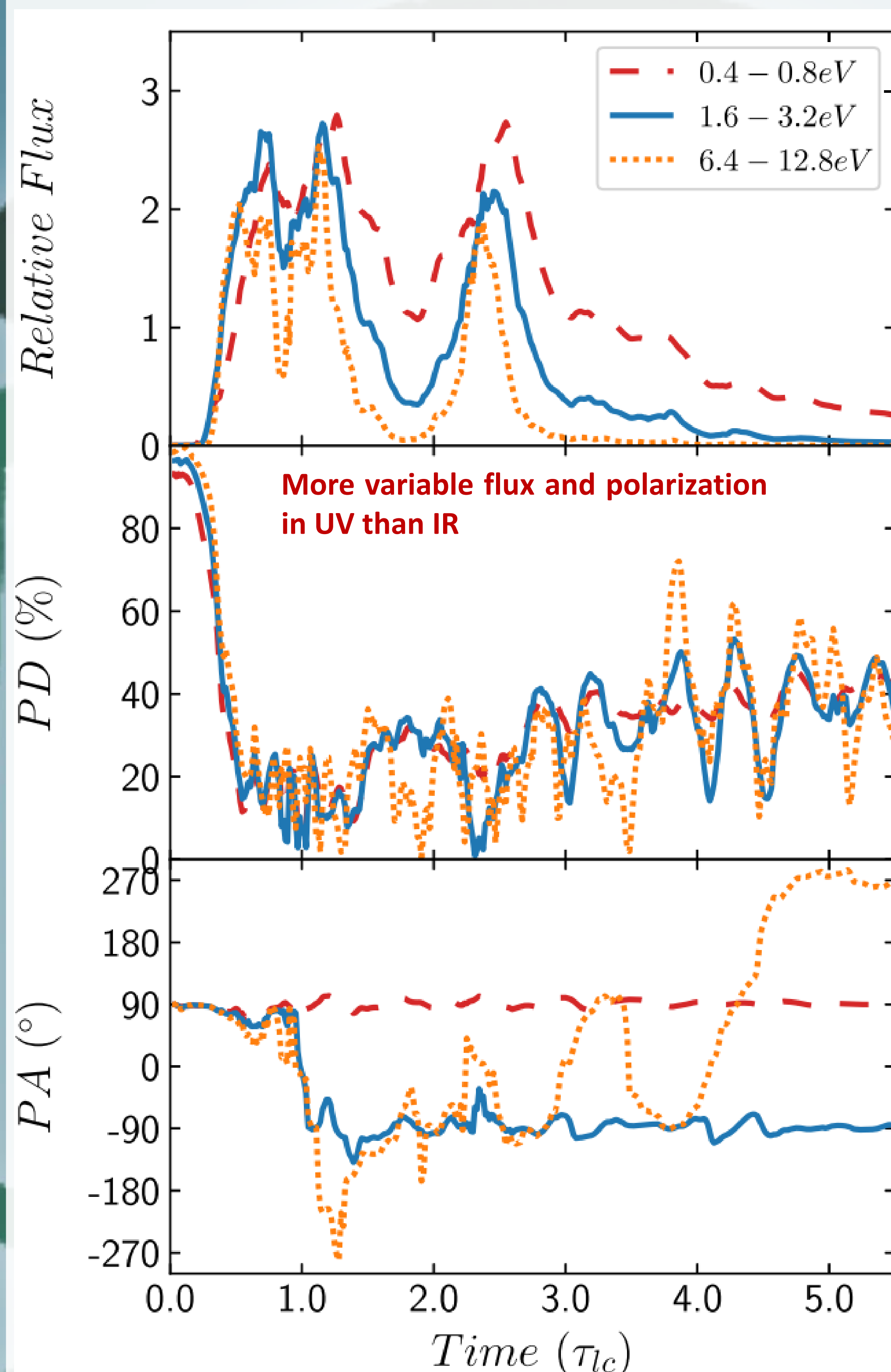
## Harder-When-Brighter Trend

- Particles are accelerated to maximal energy very efficiently, then gradually cool down by radiation. Thus the spectrum is hard at high states.



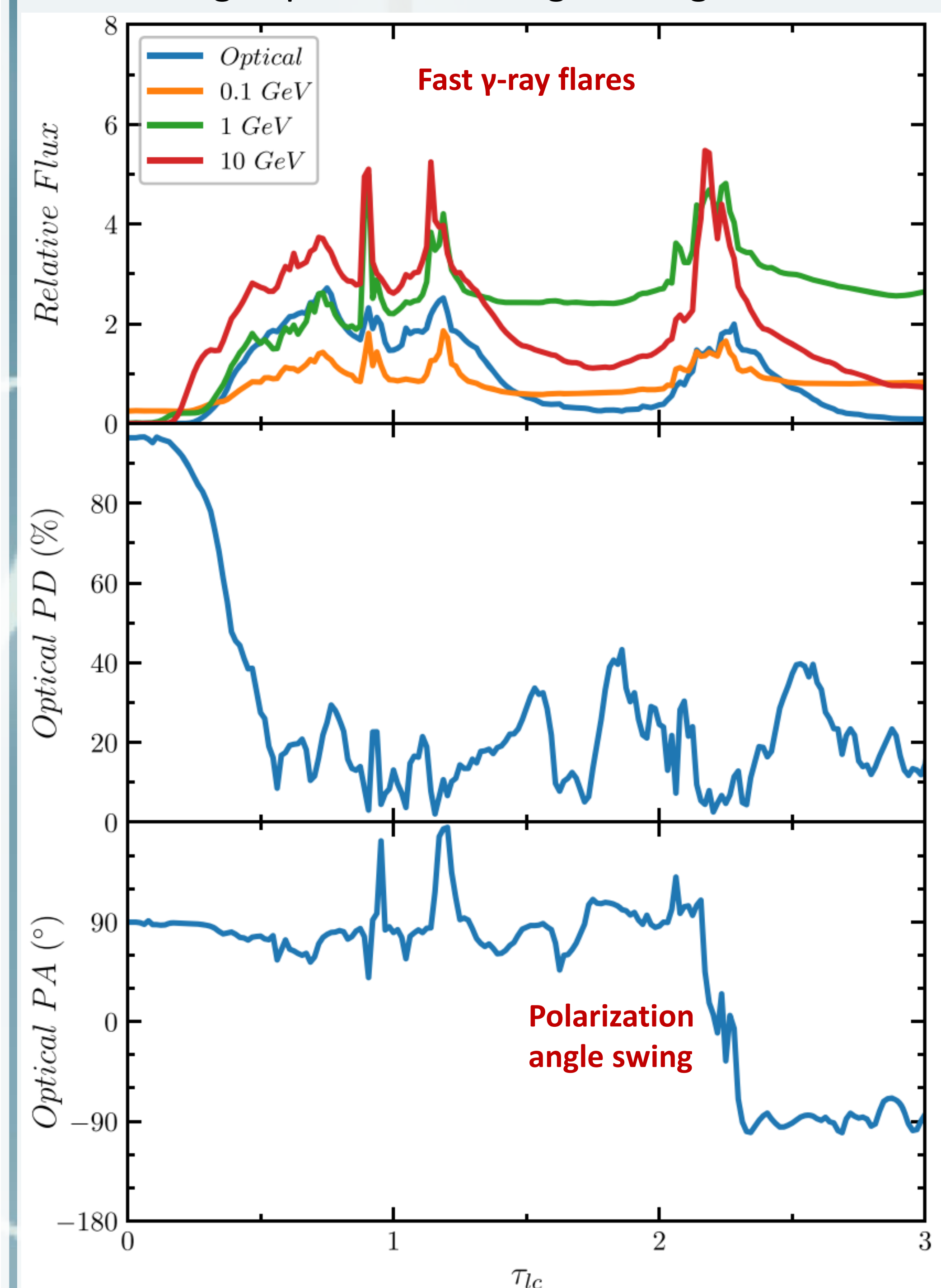
## More Variable at Higher Energies

- Higher-energy particles cool faster.
- Particles beyond the cooling break occupy less regions, resulting in higher polarization degree.
- Those regions are mostly plasmoid mergers, where the acceleration and magnetic evolution are the strongest, leading to stronger variability.



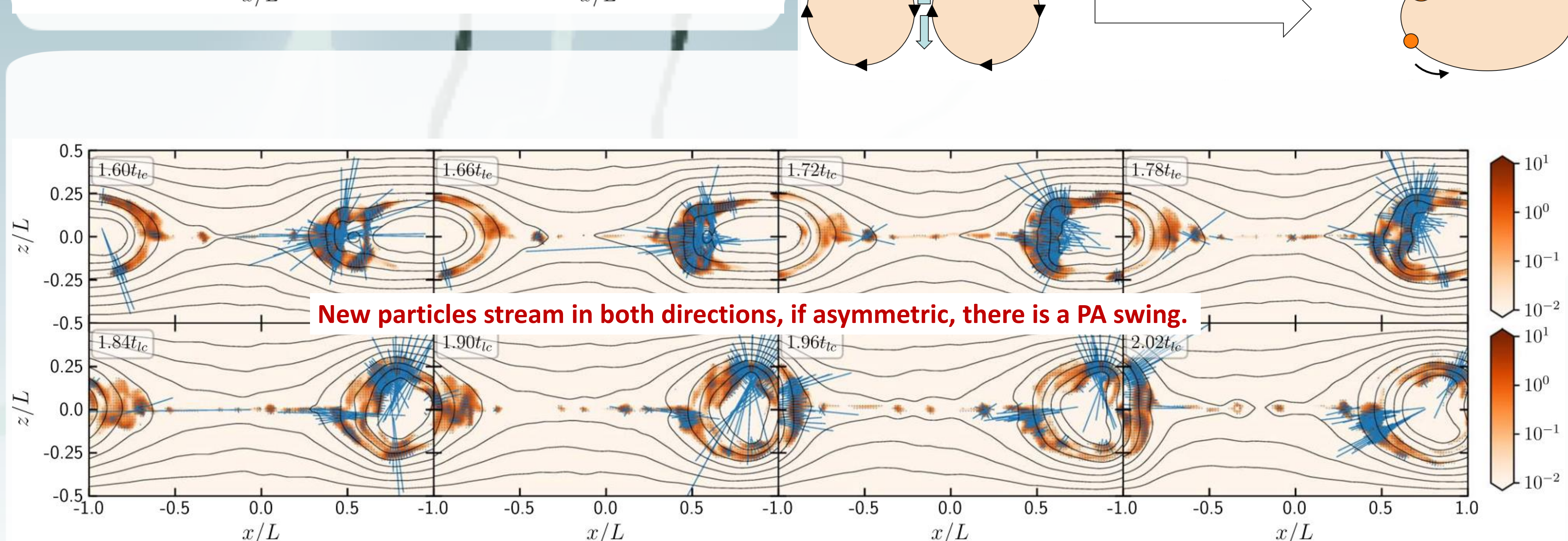
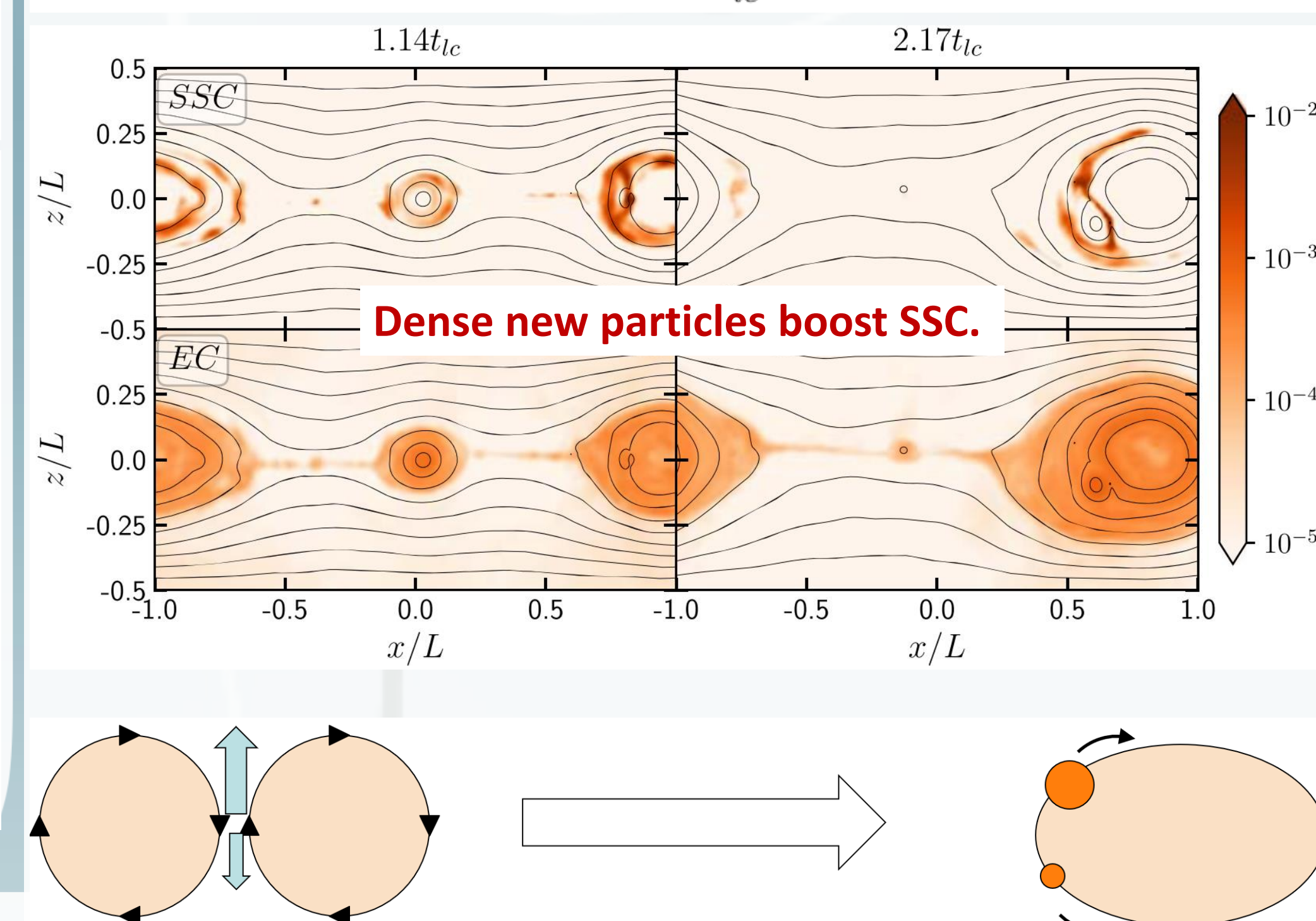
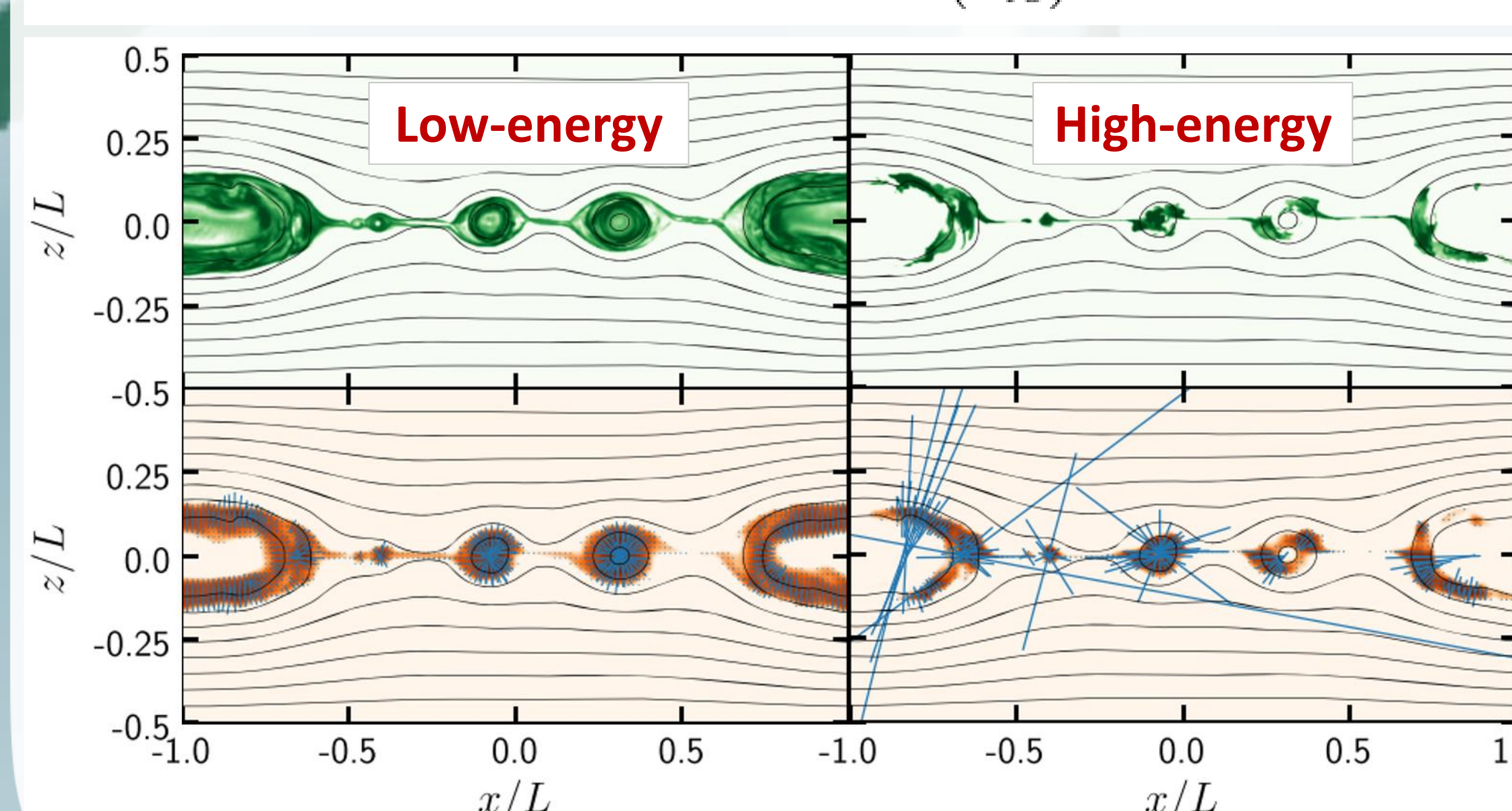
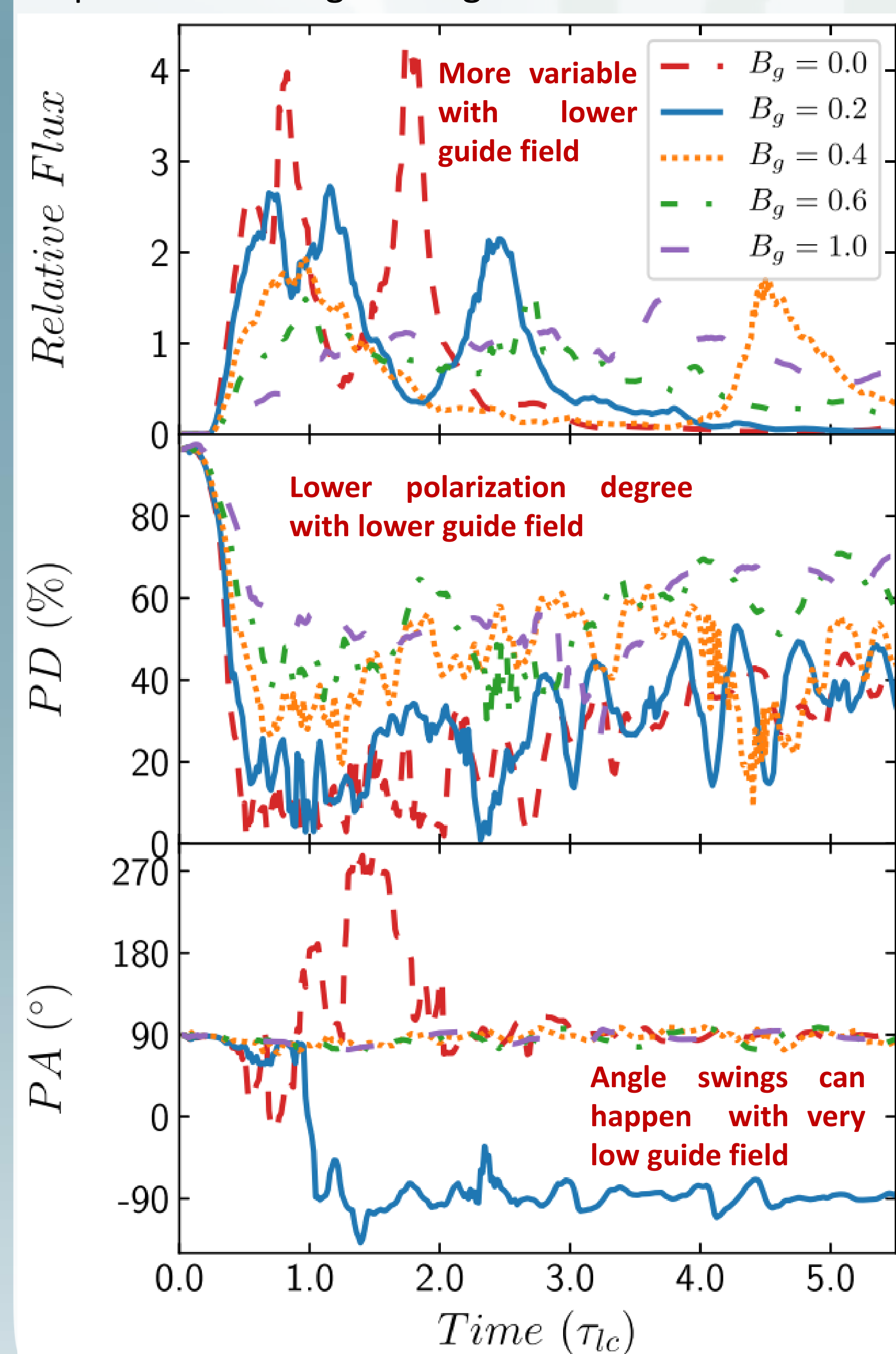
## Fast gamma-ray Flare and Angle Swing

- Plasmoid mergers make secondary reconnection, leading to dense newly accelerated particles.
- High density boosts synchrotron self Compton by  $n^2$ , making gamma-ray flashes.
- New particles may stream along the magnetic field lines enveloping the post-merger plasmoid, resulting in polarization angle swings.



## Variability and Guide Field

- Lower guide field leads to stronger reconnection and more plasmoids.
- More plasmoids imply more disordered magnetic field and more plasmoid mergers.
- Strong plasmoid mergers lead to flares and polarization angle swings.



## References

- Zhang et al., 2018, ApJL 862, L25
- Zhang et al., 2020, ApJ 901, 149
- Zhang et al., 2021, ApJ 912, 129
- Zhang et al., 2022, ApJ 924, 90