GSSI Astroparticle Science Fair 2023

The gamma and neutrino contribution from Galaxy Clusters

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Research Directions

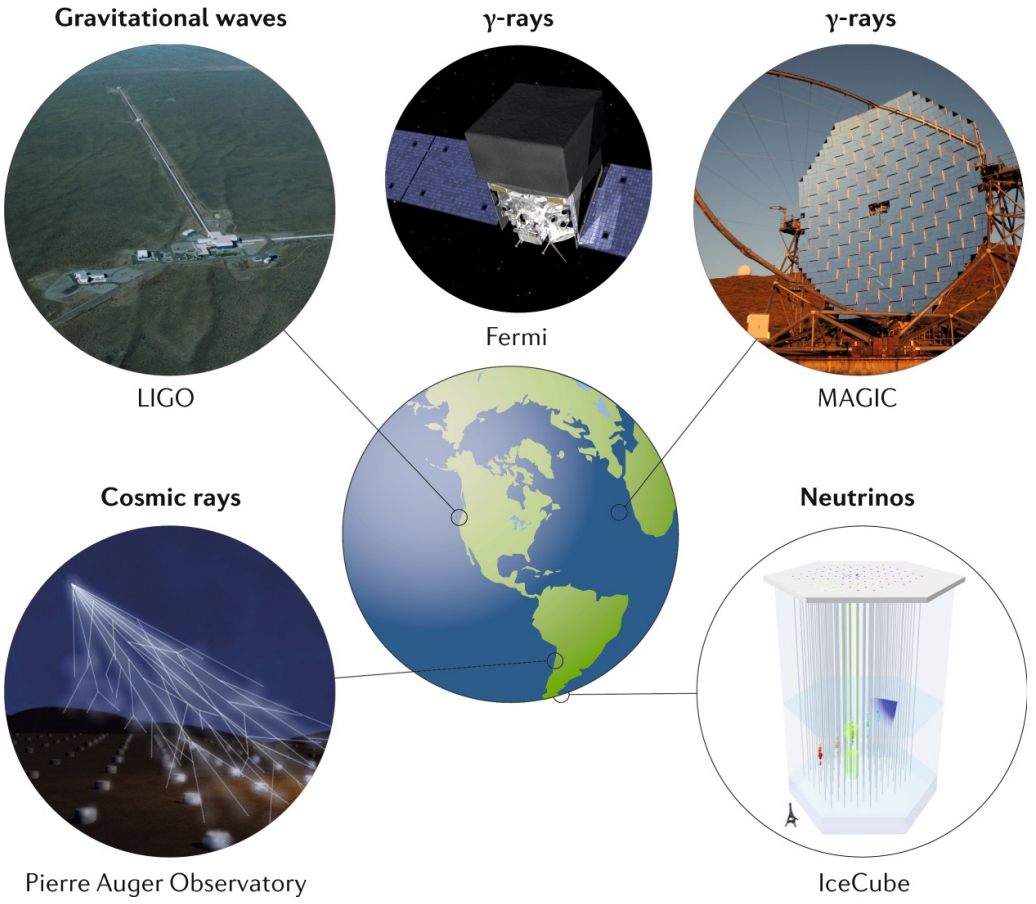
RESEARCH DIRECTIONS

COSMIC RAY PROPAGATION IN AGNS AND CLUSTERS

PRODUCTION OF SECONDARY PARTICLES

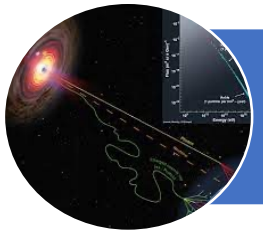
GAMMA-RAYS AND NEUTRINOS

CONSTRAINTS FOR OBSERVATIONS

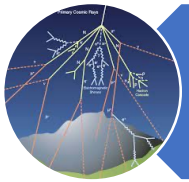


Murase et al 2019

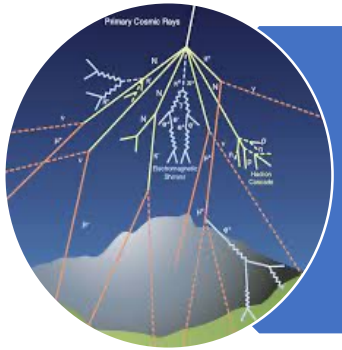
Outline



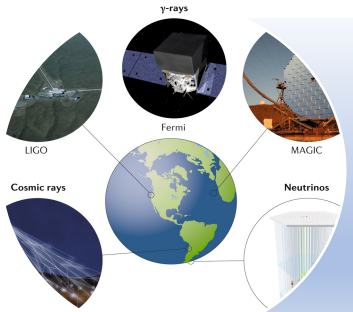
Cosmic-rays and astrophysical environment:
AGNs and Cluster of Galaxy



Propagation and interactions of cosmic rays:
MHD and Monte-Carlo Simulations

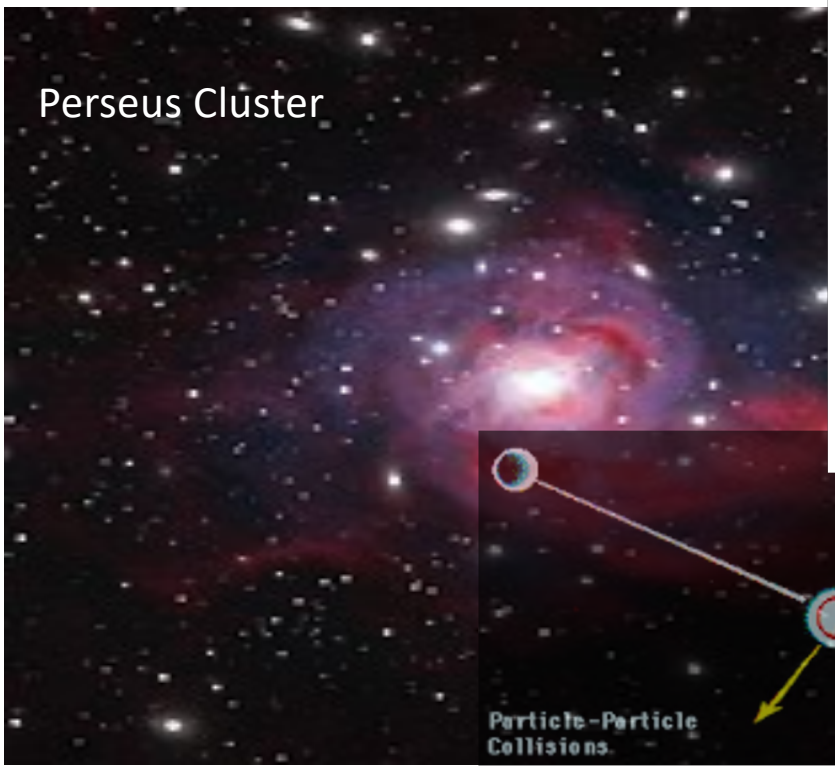


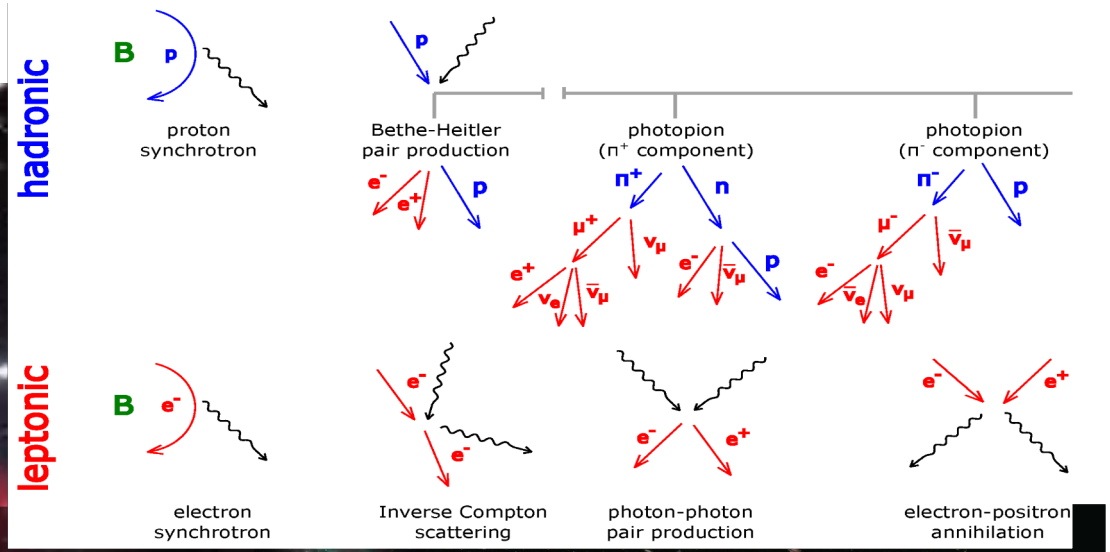
Linking complementary high-energy astrophysical messengers:
Cosmic rays, Neutrino, Gamma rays

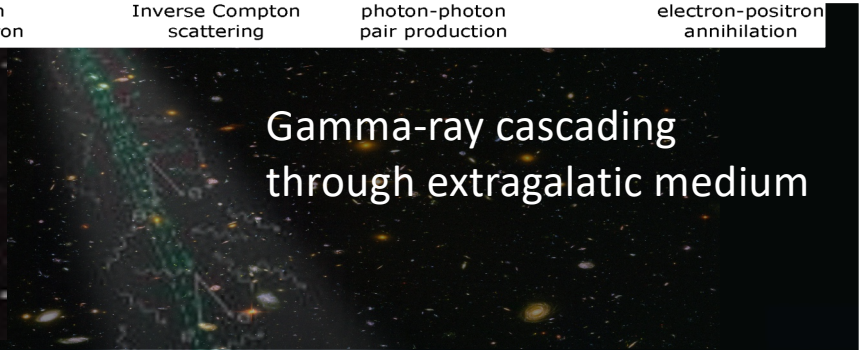


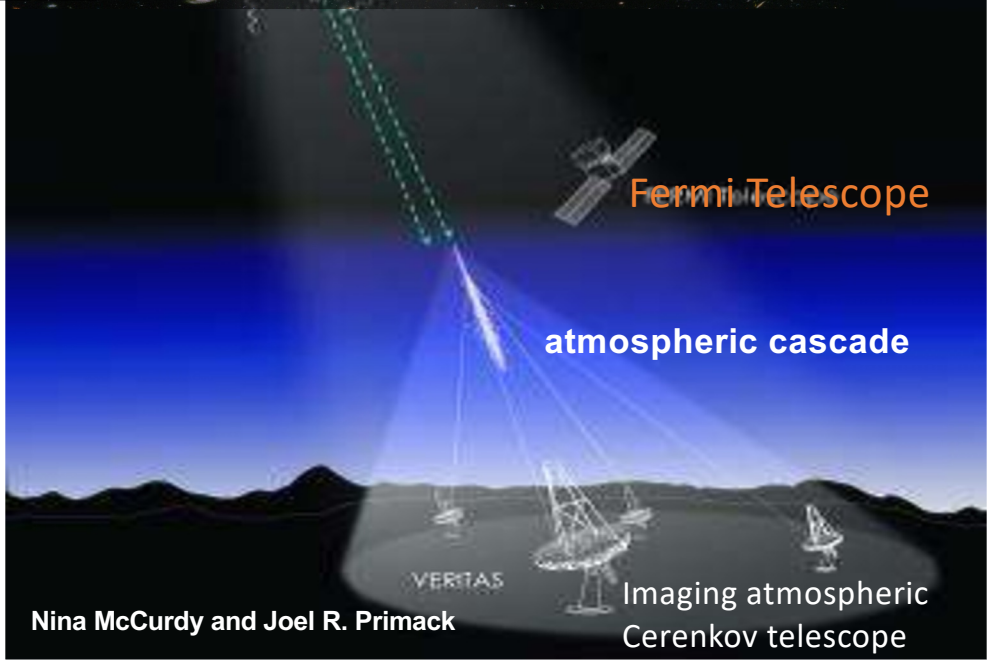
Common Multi-messenger Sources

Schematic Diagram



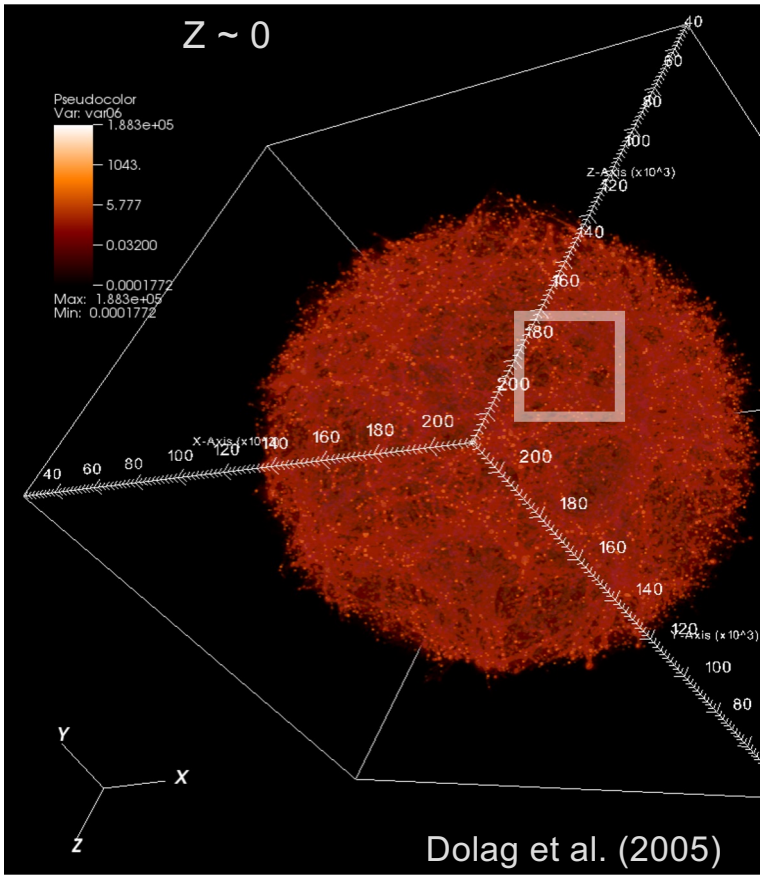




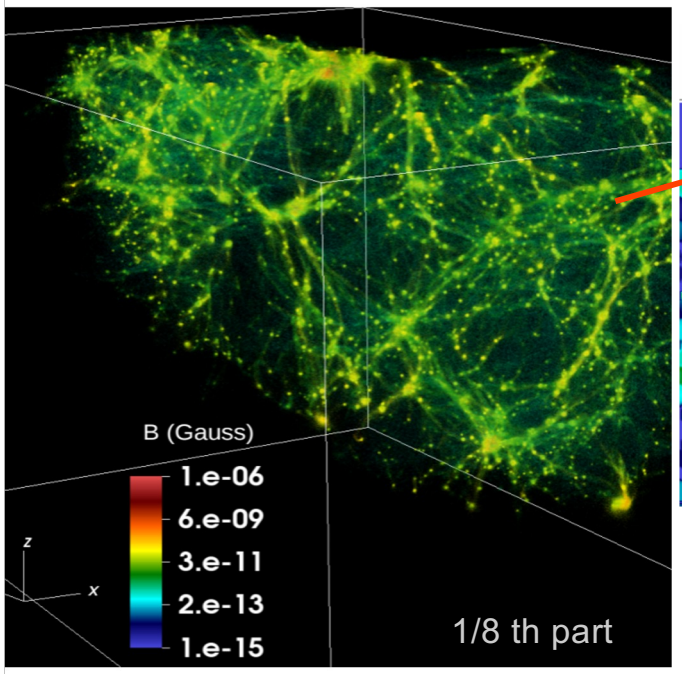


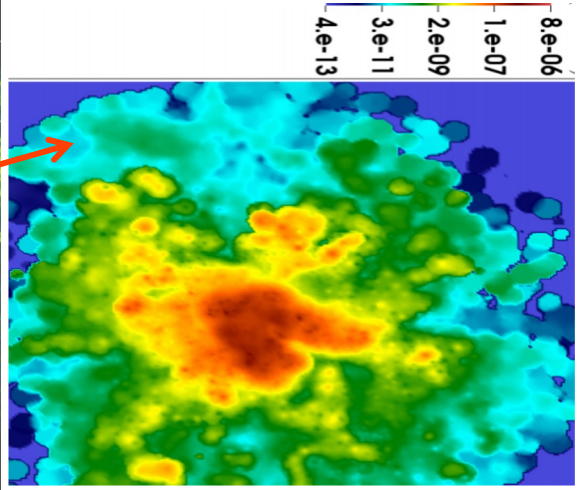
High-energy multi messengers
Emission and Observations

Cosmological 3D-MHD simulation

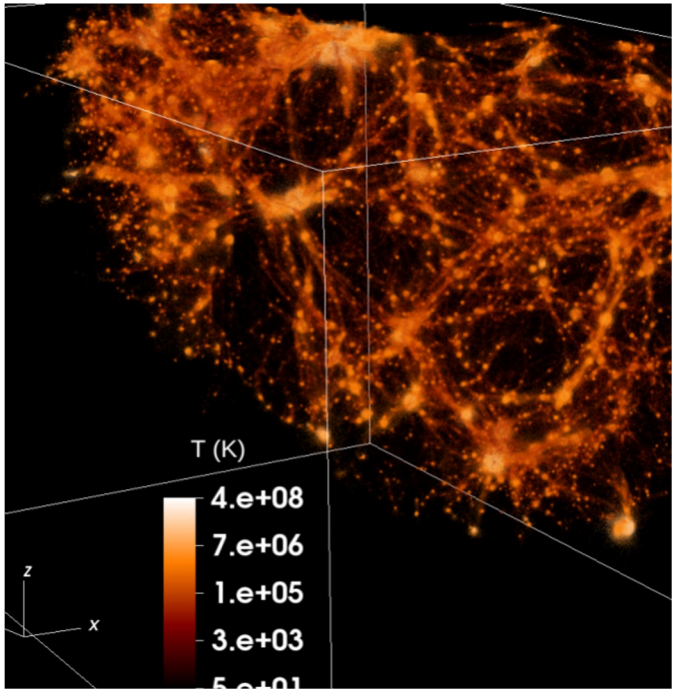


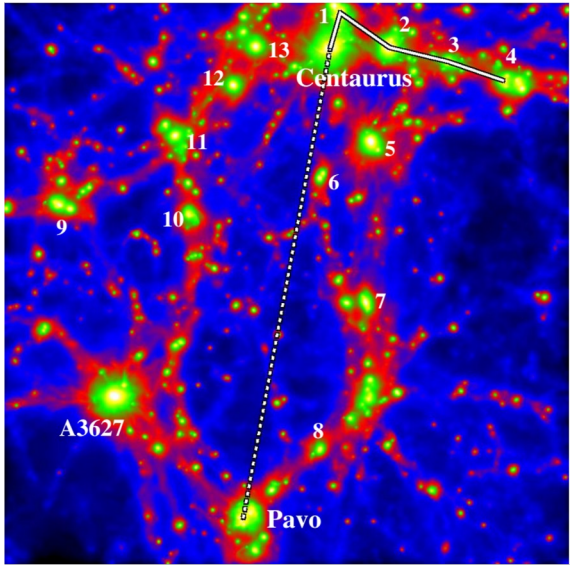
SPH GADGET simulations
(Springel 2005)
Large-scale structure, filaments, and clusters, $Z < 5.0$
seed magnetic field ~ 10^{-12} [G]
Maximum spatial resolution ~ 10 kpc





$M \sim 10^{14.5} M_{sun}$





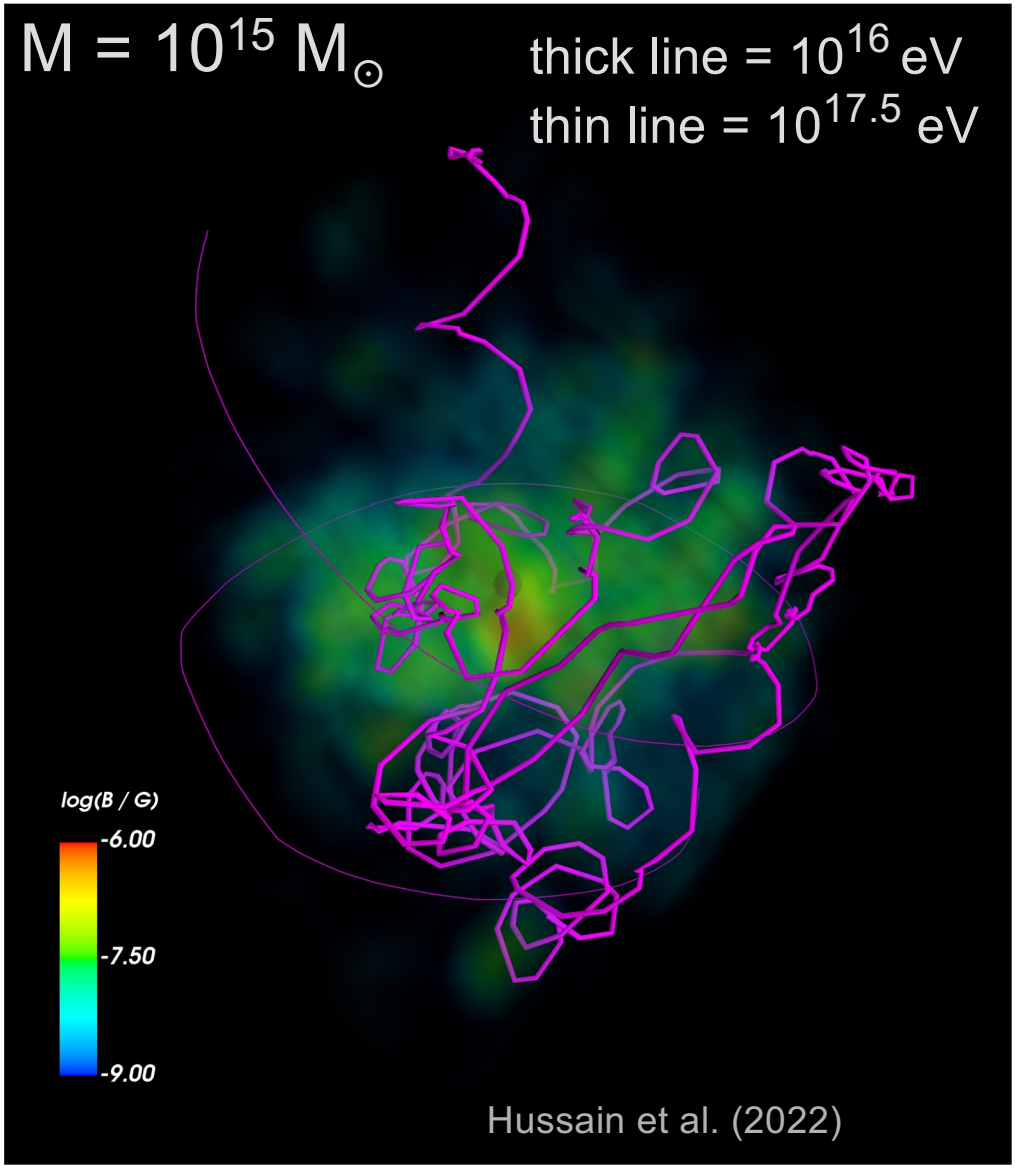
CR trajectories inside a Cluster

For E = 10^{17} eV, B = 10^{-6} G,

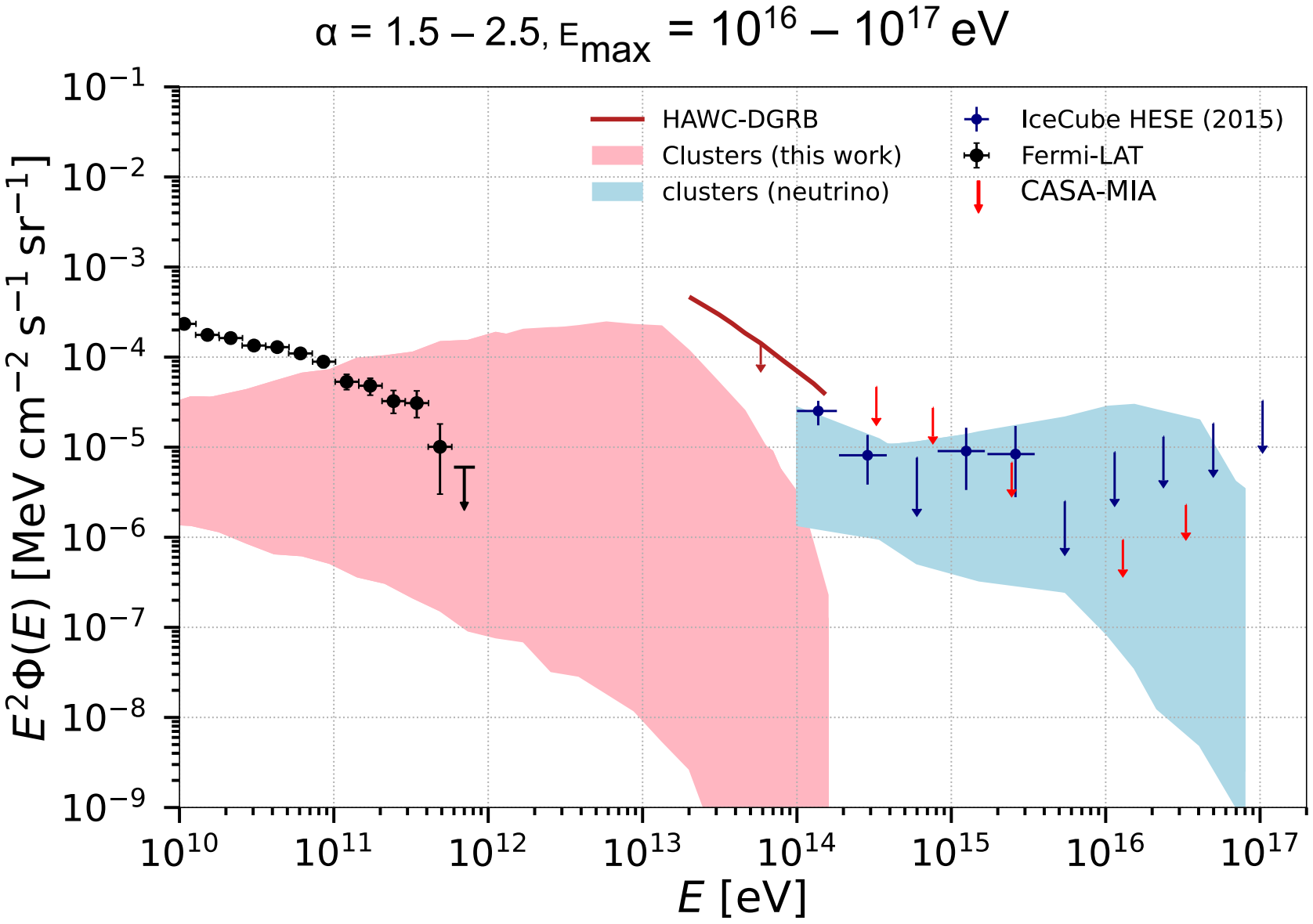
Larmor Radius ~ 1.08(E/10^{15} eV) / Z (B/μG) pc ~ 100 pc

Low energy (<10^{17} eV) CRs: Diffusive

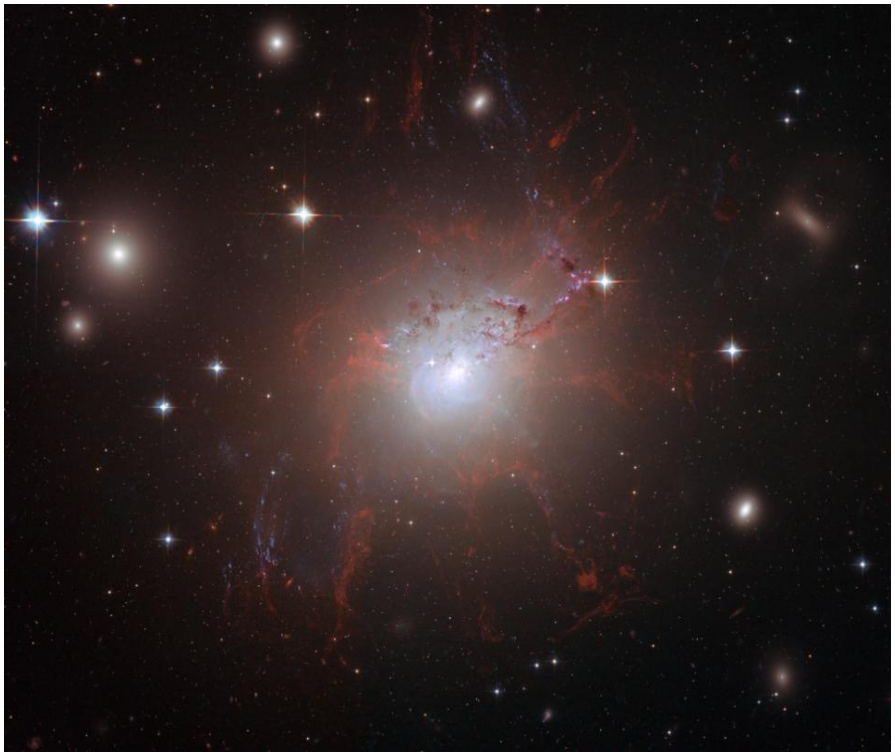
High Energy (> 10^{17} eV) CRs: Ballistic

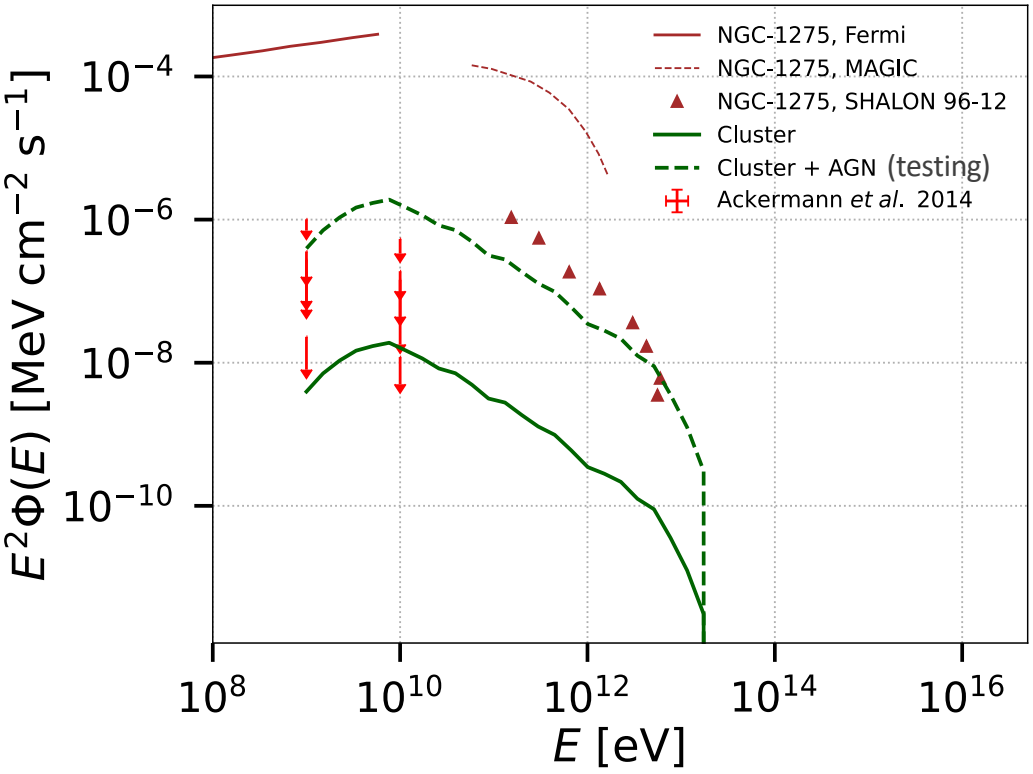


Gamma and neutrino from clusters of galaxies



Perseus-like Cluster





Future Work

Diffuse neutrino and gamma-ray background

Prominent sources: AGNs and Blazars

Contribution from local clusters of galaxies

Perseus cluster: Source of UHECRs and gamma rays

Prominent sources: NGC 1275 radio galaxy and IC 310

Gamma-ray study from clusters can provide the constraints on decaying dark matter

Common Multi-messenger Sources

Thanks