

The origin of cosmic rays

Yago Ascasibar
(Universidad Autónoma de Madrid, Spain)

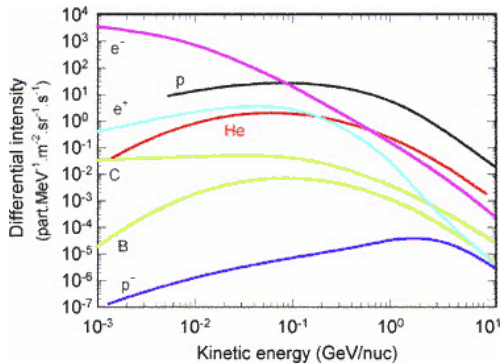
2nd Thai-CTA workshop on Astroparticle Physics
25 August 2021

Outline

- 1 What are cosmic rays?
- 2 Where do they come from?
- 3 Why do we care?

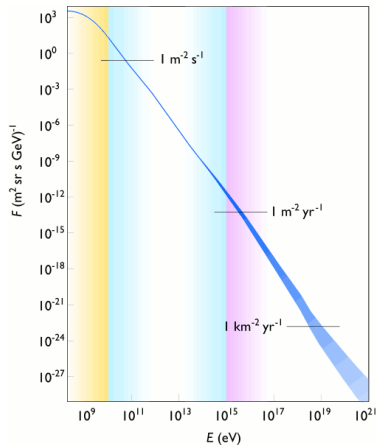
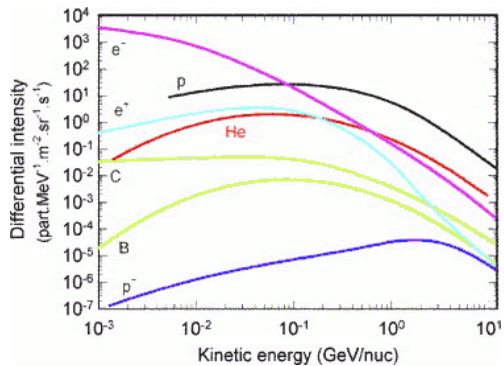
What are cosmic rays?

Composition

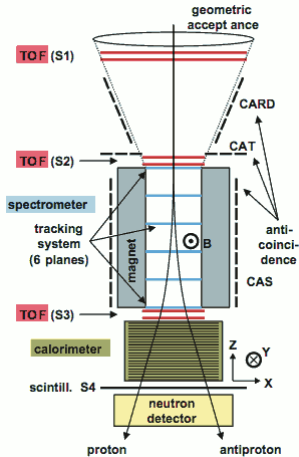


- Protons: 88 %
- Helium: 10 %
- Other nuclei: 1 %
- Electrons: 1 %

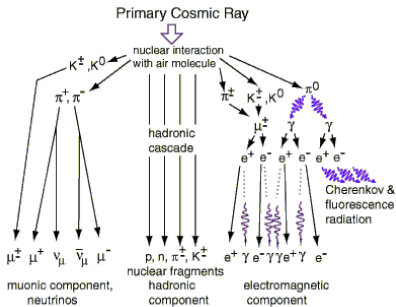
Energy spectrum



Direct measurements



Multi-wavelength emission



Multi-wavelength emission

Hadrons

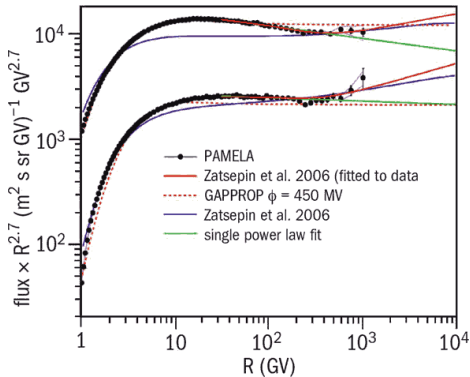
- π^0 decay

Leptons

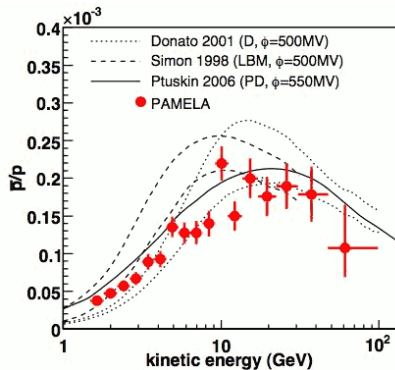
- Inverse Compton Scattering
- Synchrotron
- Bremsstrahlung



Nucleons

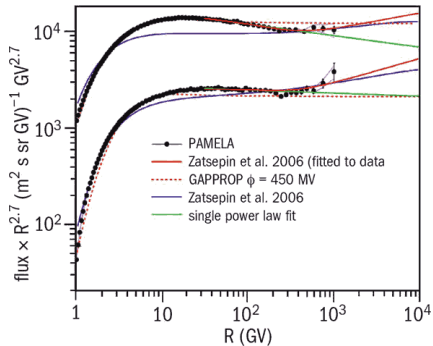


[Adriani et al. \(2011\)](#)

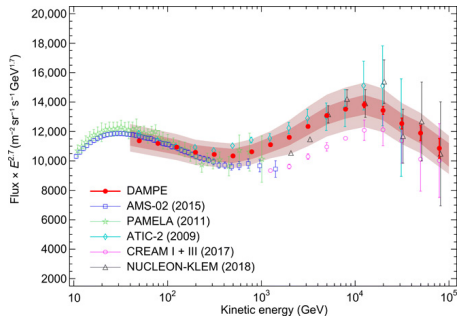


[Adriani et al. \(2009a\)](#)

Nucleons

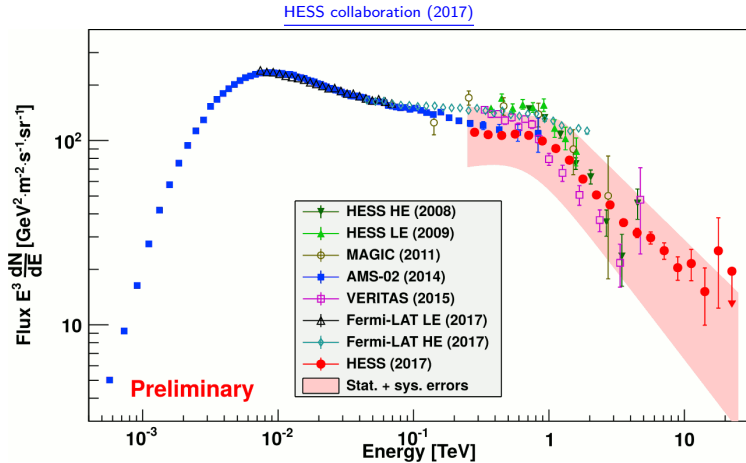


[Adriani et al. \(2011\)](#)

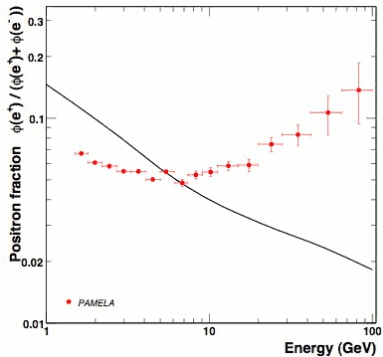


[DAMPE collaboration \(2019\)](#)

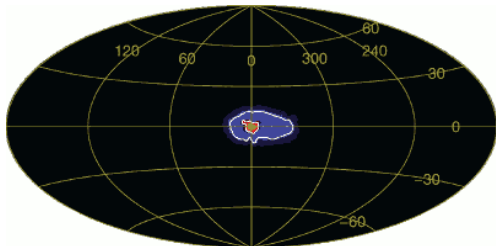
Leptons



Leptons



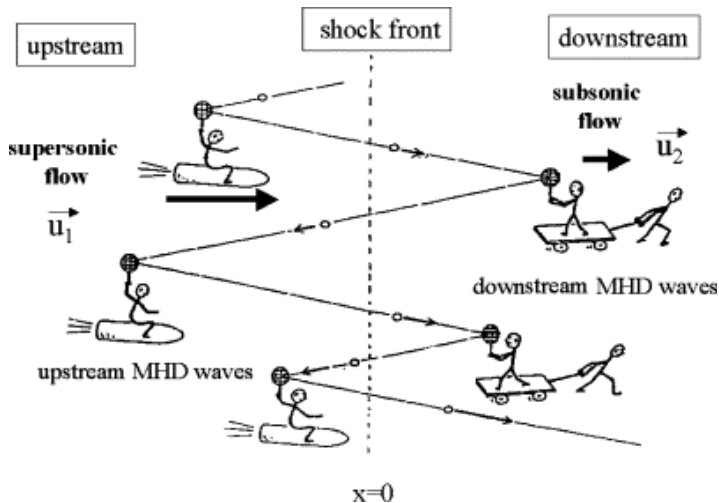
[Adriani et al. \(2009b\)](#)



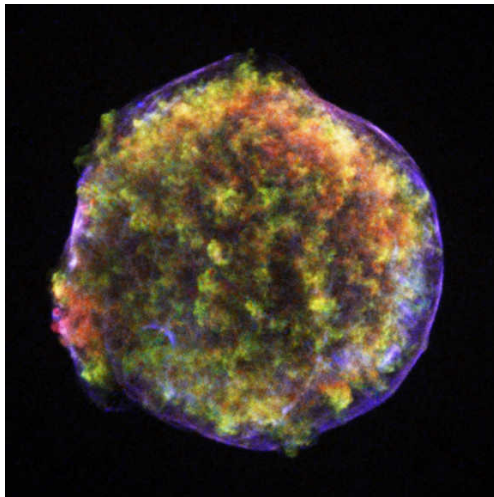
[Weidenspointner et al. \(2008\)](#)

Where do they come from?

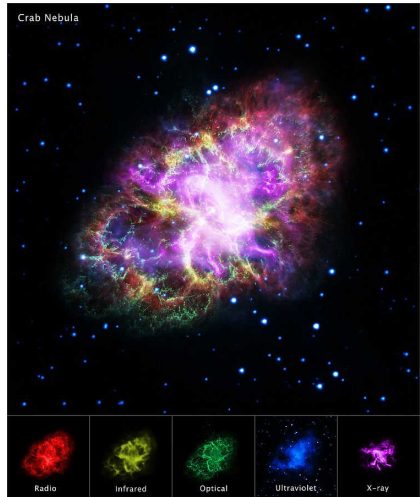
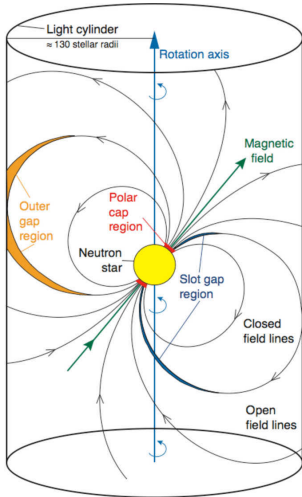
Fermi acceleration mechanism



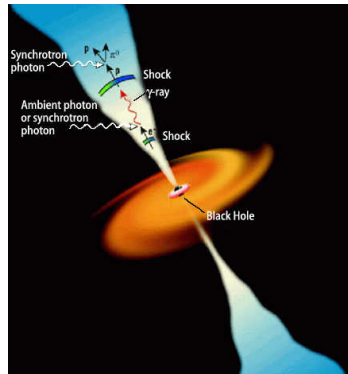
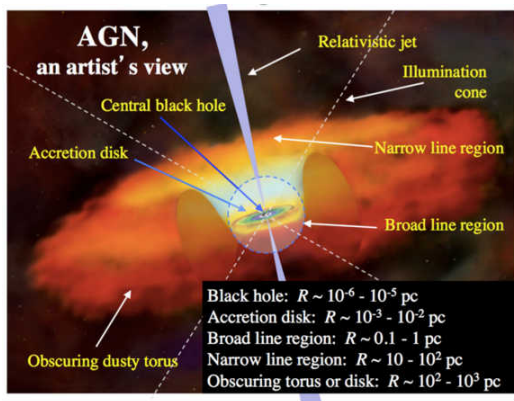
Supernova remnants (SNR)



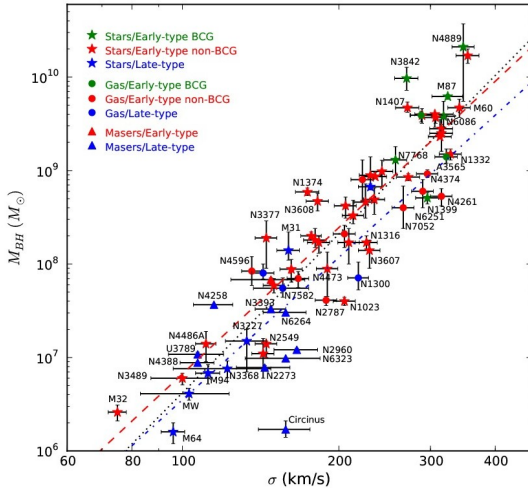
Pulsar Wind Nebulae (PWN)



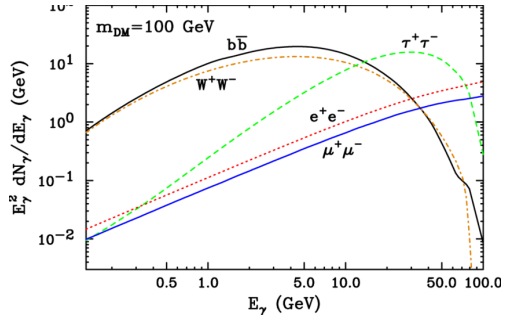
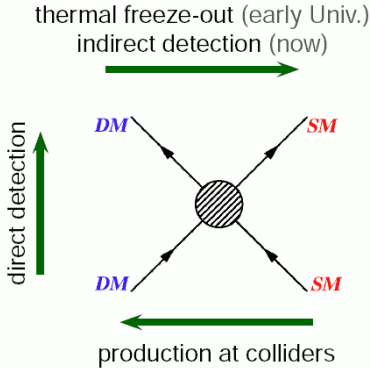
Active Galactic Nuclei (AGN)



Active Galactic Nuclei (AGN)



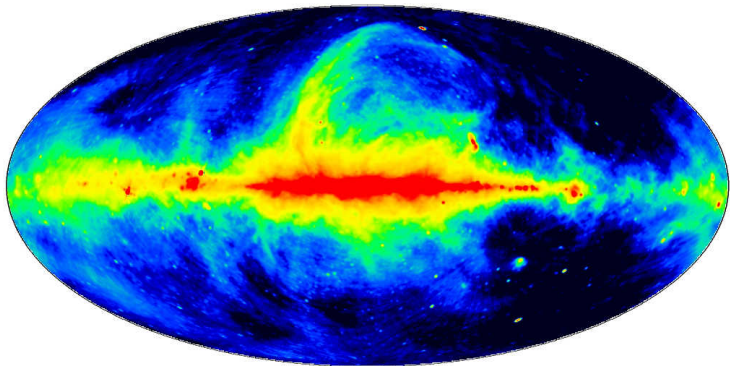
Not-so-dark matter (DM)



Why do we care?

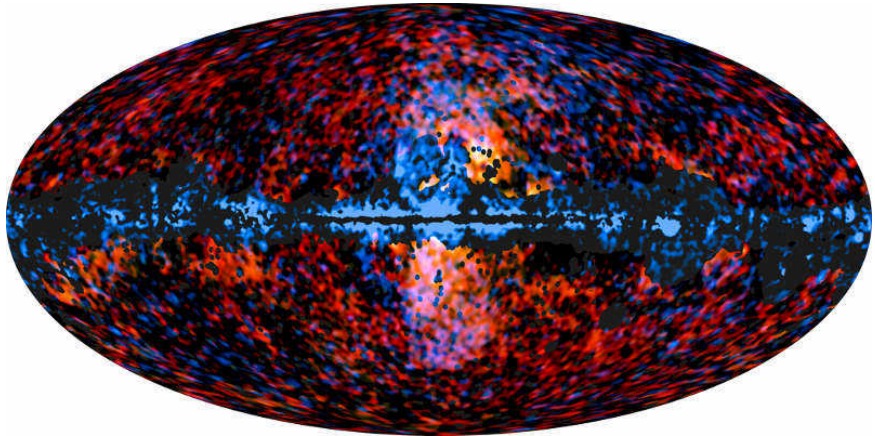
Multi-wavelength emission

408 MHz

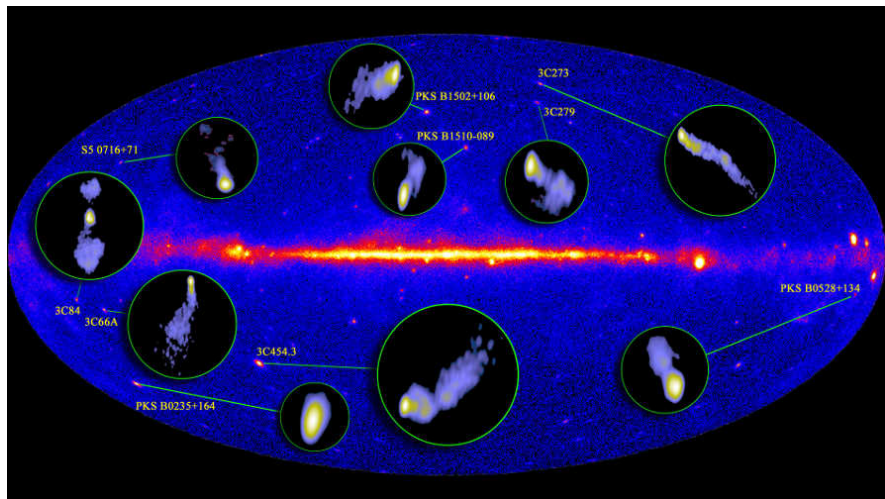


Jodrell-Bank 250-feet + Effelsberg 100-m + Parkes 64-m

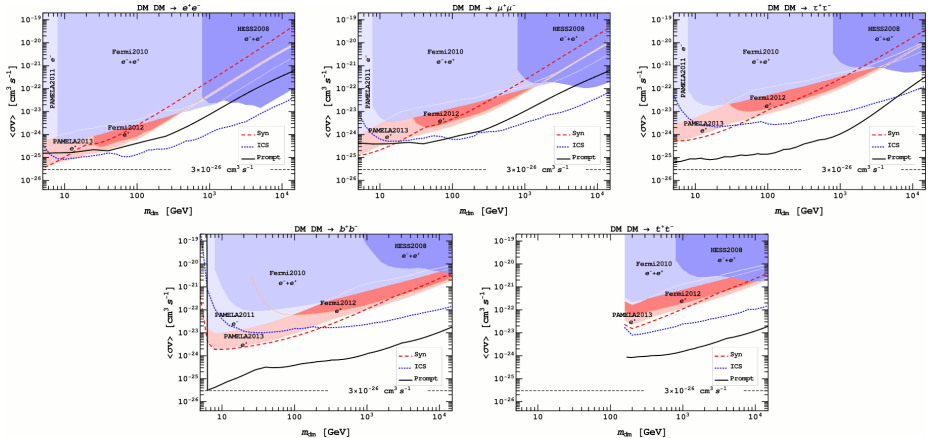
Multi-wavelength emission



Multi-wavelength emission

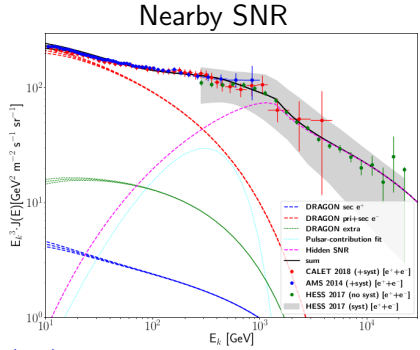
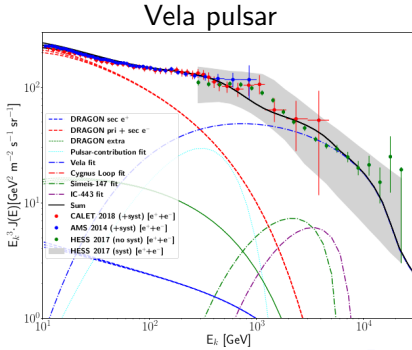


Have we detected dark matter?



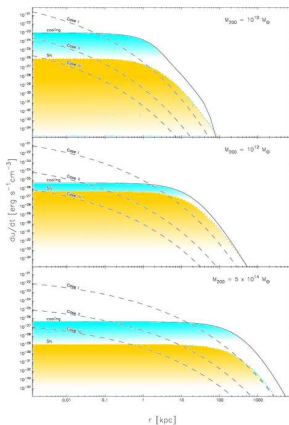
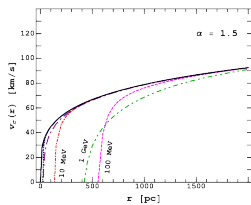
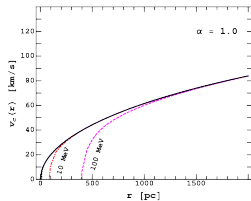
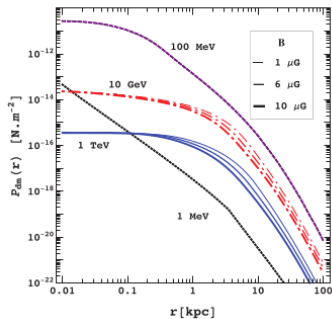
[Wechakama & Ascasibar \(2014\)](#)

Have we detected something else?



[Fornieri et al. \(2020\)](#)

Galaxy formation, evolution and structure



Summary

What are cosmic rays?

- Relativistic particles (nucleons and leptons)

Where do they come from?

- Shock waves and magnetic fields
- Dark matter?

Why do we care?

- Nature of dark matter
- Galaxies
 - observable properties
 - non-thermal pressure
 - heating and ionisation

Thank you!