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The Dark Side of the Matter

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Introduction

Dark Matter (DM) accounts for about 85% of the total mass budget in the Universe, but the nature of the DM constituents is still hypotetical. Some theories predicts that DM particles can decay or self-annihilate in binary collisions producing high energy photons. MAGIC is a stereoscopic system of two Cherenkov telescopes exploring the gamma-ray sky and DM indirect detection is one of its main fields of research.
The photons (and neutrinos) are not deflected from the magnetic field. In this way we know that signal is come from the source directly. When one photon impacts with atmoshere, it generates an electromagnetic shower. Electrons and positrons can be generated Cherenkov light which can be collected by telescopes.

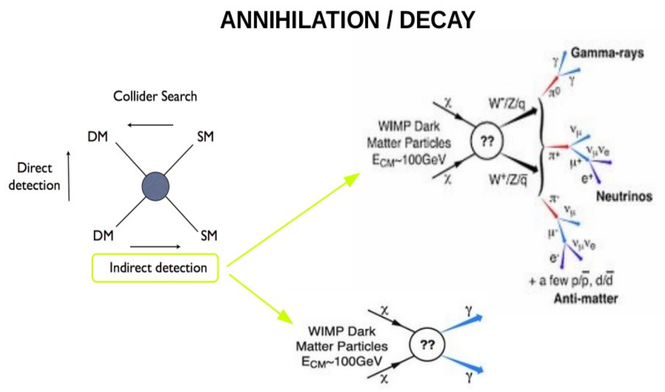


Fig 1: plot of scattering of two DM particles in standard model particles

Globular Cluster source: M15

- M15 is a globular cluster located ~10 Kpc from the Sun
- Its age is around 12 Gyr, stereotype of core-collapsed globular cluster in our Galaxy
- RA = 21h28m58.3s ; DEC =12°10'00.6'' ; situated in the constellation of Pegasus
- Mass ~ $5x10^5 M_\odot$, with a stellar mass density ~ $10^7 M_\odot\ pc^{-3}$ in the core
- M/L ~1.5 $M_\odot/L_\odot$ inside 1' radius
- from theoretical considerations, not expected an intermediate massive black hole in the core

Fig 2: M15 in optical band

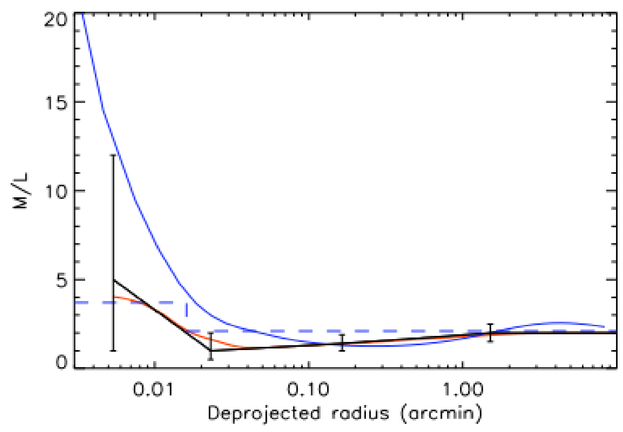


Fig 3: plot of the stellar density in the globular cluster M15

MAGIC Telescopes

- MAGIC is Major Atmospheric Gamma Imaging Cherenkov telescopes
- Consist in two 17 m of diameter Imaging Atmospheric Cherenkov Telescopes
- Extremely fast ~1100 photomultiplayers, fast electronics for the trigger and signal sampling
- Resolution: 0.07°-0.14°; sensitivity: 0.6% Crab units (integral)
- Collected δ–ray with energy range from a few tens of GeV to a few tens of TeV
- Many scientific target: AGN, Fundamental Physics, GRB, Galactic Sources

Fig 4: MAGIC telescopes located at La Palma

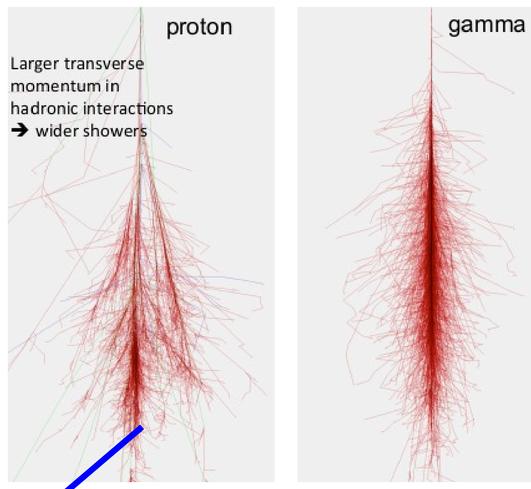


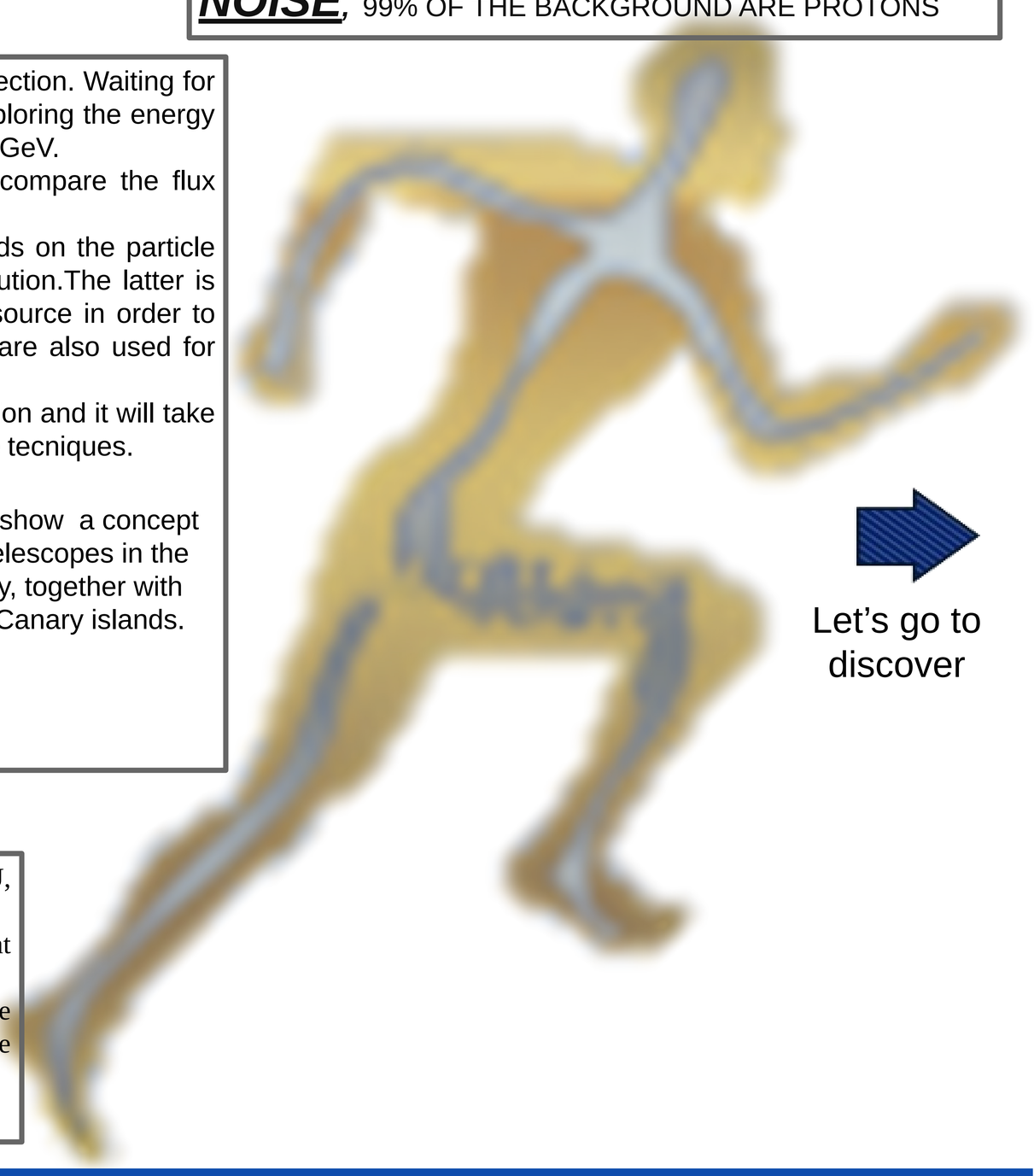
Fig 5: simulation about Hadronic Shower on the left and Electromagnetic Shower on the right

NOISE, 99% OF THE BACKGROUND ARE PROTONS

Research and future objective

The previous anlaysis put an upper limit on the masses of the particles and on their cross section. Waiting for the construction of new telescopes with a lower sensibility, it is possible to extended the exploring the energy range of some tens of GeV. In this way we can find the signal at lower energy around 10, 20 GeV.
It is also important to simulate the expected flux from the source. In this way we can compare the flux measured with the simulated flux obtained from theoretical assumptions on dark matter.
The prompt flux emitted from dark matter particles can be factored into a part that depends on the particle physics model of the dark matter and a part that is determined by the dark matter distribution.The latter is referred to as J-factor. It is important to understand the profile of dark matter inside the source in order to compute the expected flux from Dark Matter. Optical telescopes, satellites or other tools are also used for calculate the J-factor.
The next experiment Cherenkov Telescope Array (CTA) is a new observatory under costruction and it will take the best features of MAGIC and enhance them, from the readout electronics to new software tecniques.

Fig 6: in the picture show a concept design of the CTA telescopes in the northern observatory, together with MAGIC, La Palma, Canary islands.



Let's go to discover

Acknowledgment

Attending this school I could expande my knowledge in different field like machine learning, GPU, SiPM and CCD detector.
I would like to thank Riccardo Paoletti, Giacomo Bonnoli, Stefano Truzzi and Daniel Gubermann that are following me in my PhD journey. If I am here it is because of their support.
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When I will come back in Italy, I would like to put into practice what I learned in this school.