Experimental Search for Dark Matter

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Part 3: Dark Matter Indirect Detection and at Accelerators

Introduction

Indirect Detection

DM can be detected indirectly:

- By detecting SM particles resulting from DM annihilation (if this channel exists and is not highly suppressed)

$$\chi + \chi \rightarrow SM(+SM)$$

- By detecting SM particles from DM decay (if DM is unstable!)

$$\chi \rightarrow SM(+SM)$$

Note: other processes might exist but are rarely discussed.
An example might be DM excitation by interstellar plasma, DM production in astrophysical jets,..

Indirect Detection

Maximize

$$N = \phi_\chi \cdot A_{off} \cdot t_{exp}$$

DM-induced event rate [$cm^{-2}s^{-1}$]

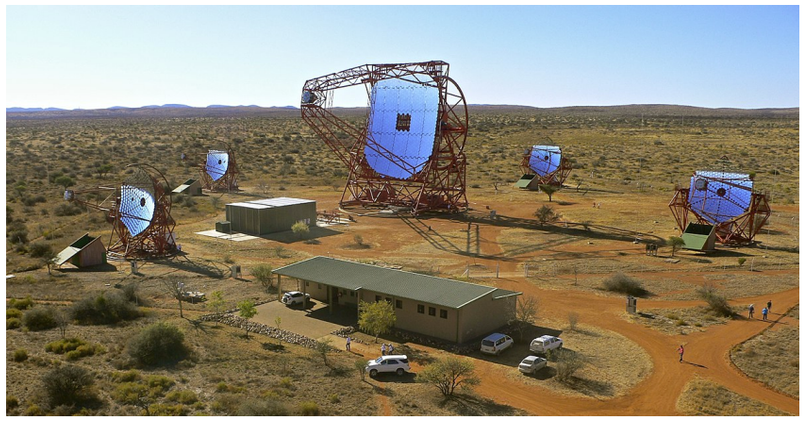
Effective are of the detector(s)

Can vary from m^2 to km^2

exposure time

Can vary from days to years (satellites..)

Example Experiments: Earth-Based



H.E.S.S Telescope

High Energy Stereoscopic System

Gammas up to 100TeV

Location: Namibia (Africa)

MAGIC Telescope

Gammas > 200 GeV

Location: Canary Islands

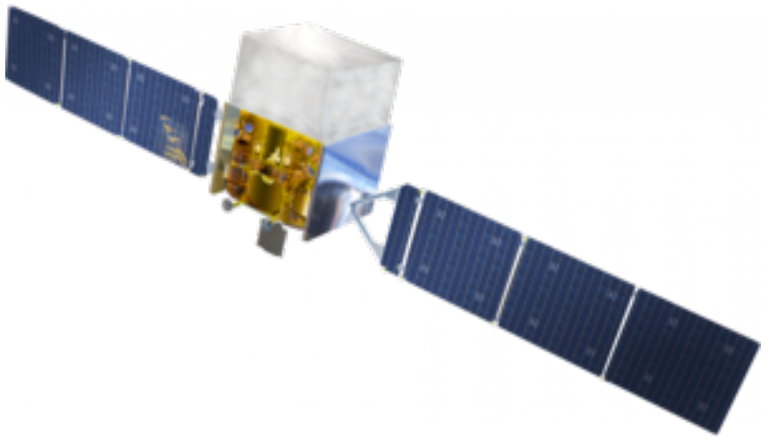
VERITAS Telescope

Very Energetic Radiation Imaging Telescope Array System

Gammas > 10 TeV

Location: Arizona (USA)

Example Experiments: Space-Based



Fermi Gamma-ray Space Telescope

Detectors on-board:

- LAT: gammas up to 300 GeV
- GMB (NaI crystals). Wider accept.

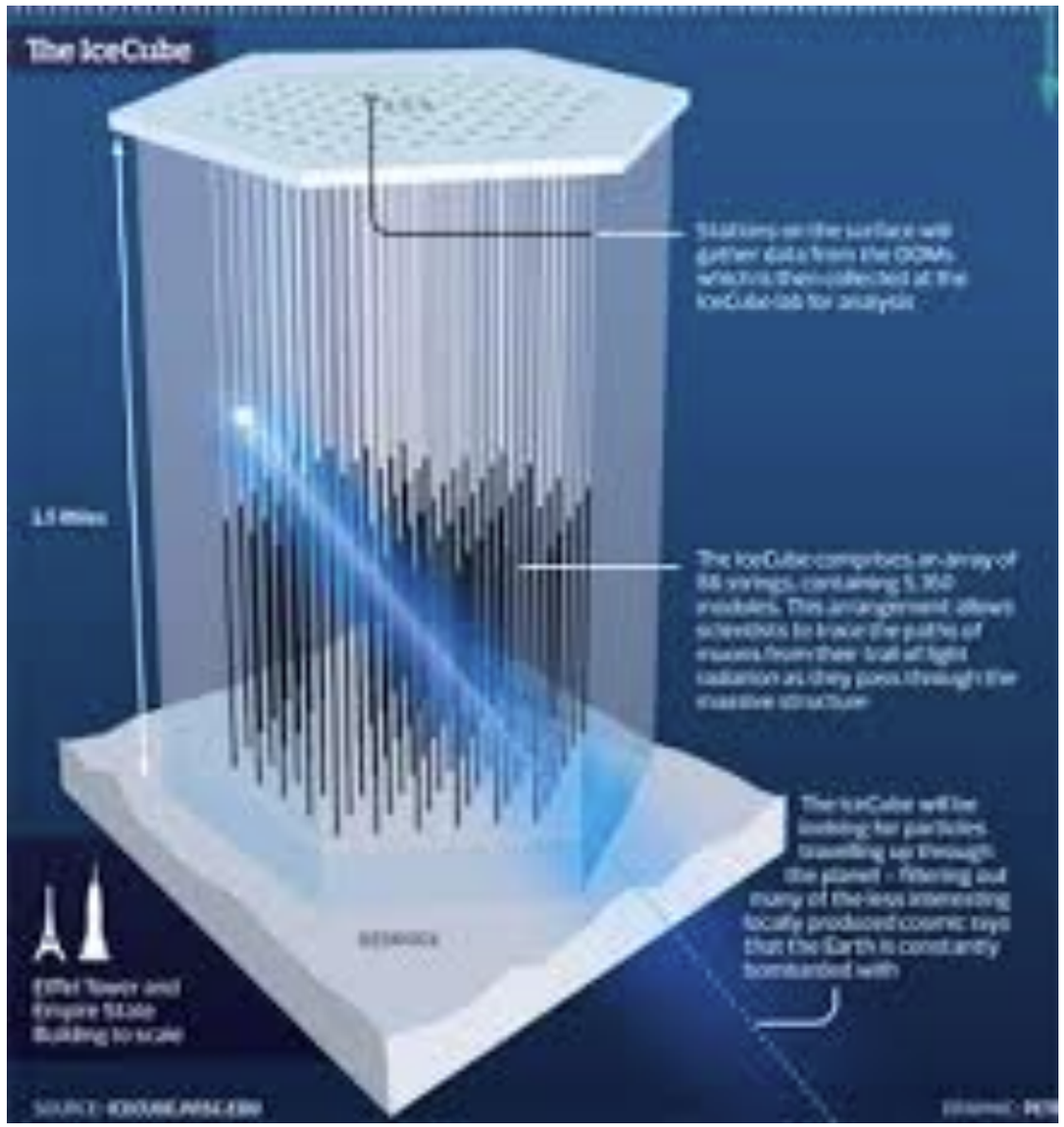
AMS-02

Based on the ISS

<u>Almost a collider detector:</u>

Transition radiation detector
Upper/Lower time of flight counter
Star tracker (determines the orientation of the module in space)
Silicon tracker with magnetic field;
Veto counter for side-entering particles
Ring imaging Cherenkov detector
Electromagnetic calorimeter

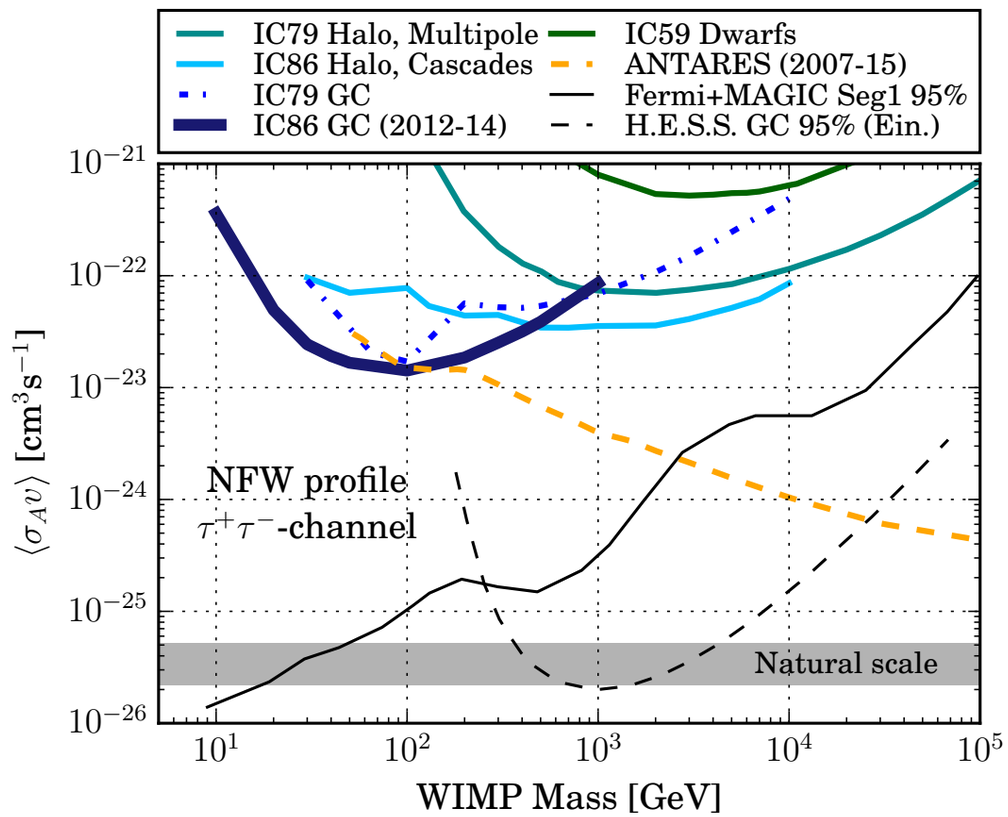
Ice (!) - based: IceCube



Acts like a huge Cherenkov detector using antarctic ice as medium.
Designed for neutrino physics, can be used to investigate certain DM models.

Signal: neutrinos from DM self-annihilation.

Mass range: 10 GeV - 1 TeV



Dark Matter at Accelerators

How much DM can we hope to produce at a collider?

Try the following exercise:

Consider the "standard WIMP case": $m_\chi = 100\ GeV$ $\sigma = G_F^2 \cdot m_\chi^2$

If LHC has a luminosity of the order $\mathcal{L} = 10^{33} cm^{-2} s^{-1}$

Assuming full coverage and efficiency of the detectors, what is the DM rate ?

Consider now a direct detection experiment with $1m^2$ surface, and standard DM galactic velocity.
What is the rate in this case? How does it compare with the collider case?