WELCOME To The WEBINAR

WEDNESDAY 17 NOVEMBER 2021

13h30 CET

Relevant Universe Special Issue:

Women Physicists in Astrophysics, Cosmology and Particle Physics

https://www.mdpi.com/journal/universe/special_issues/WomenAstroCosmo

Guest Editor: Prof. Dr. Norma G. Sanchez

Deadline for manuscript submissions:
31 December 2021

Welcome to the Webinar
Women Physicists in Astrophysics, Cosmology and Particle Physics.

This webinar will highlight the Special Issue devoted to this subject and the results presented in it.

New results and reviews are presented

Dark Matter Sterile Neutrino from Scalar Decays. New Advancements in AdS/CFT (Anti-de Sitter/Conformal Field Theory) in Lower Dimensions. Superconformal Line Defects in Three Dimensions.

Environmental High-Energy Astrophysics in space missions such as LISA, Solar Orbiter and JWST, and its implications for space weather science.

Thus, this webinar offers an updated collection of new results, recent progress and reviews, covering different lines of research of high current interest in these highly active fields.

INTRODUCTION

→ The physical approach to astrophysics, particle physics and cosmology, both in theory and observations, and, in fine, to the understanding of the physics of the Universe, formulation, unifying knowledge, finding the crosscorrelation when possible, in introducing new concepts, mathematical and progresses and opening new avenues of knowledge in the field. ←

→ The aim of this Special Issue is to highlight too the fruitful interplay between these domains. The objective and expected output of this Special Issue is thus double-valued or twofold at least. All fields in modern astrophysics, particle physics and cosmology and their fruitful interplay are included, theory, observations, different methods, models, analytic studies, numerical simulations, as well as high energy astrophysics and black holes in all its mass ranges. ←

→ The aim is to offer opportunity to unify and bring together new research in this discipline performed by women physicists over the world, to promote their research, and provide high visibility to them. ←

→ We expect that this collection will also allow the apprehension of common universal features or properties within, at the same time, a wide range of diversity. ←

→ It is a great pleasure for me to welcome this Webinar and the manuscripts to the associated Special Issue, and I look forward to receiving your manuscripts in this fascinating field. ←

Chair Prof. Norma G. Sanchez **Chair Introduction: Women Physicists in Astrophysics, Cosmology and Particle Physics**	**1:30 – 2:00 pm**
Dr. Lucia A. Popa **Dark Matter Sterile Neutrino from Scalar Decays**	**2:00 – 2:30 pm**
Prof. Yolanda Lozano **New Advancements in AdS/CFT in Lower Dimensions**	**2:30 – 3:00 pm**
Prof. Silvia Penati **Superconformal Line Defects in 3 Dimensions**	**3:00 – 3:30 pm**
Prof. Catia Grimani **Environmental high energy astrophysics in the context of space missions as LISA, Solar Orbiter and JWST, and its implications for space weather science**	**3:30 – 4:00 pm**
Q&A Session & Closing of the Webinar **Chair Prof. Norma G. Sanchez**	**4:00 – 4:10 pm**

→ DARK MATTER FIRMELY EXISTS WITH
A VERY CLEAR MODEL INDEPENDENT STATUS
FROM CMB, LSS and SSS OBSERVATIONS:

→ NO CDM : DARK MATTER IS NOT COLD (nor GeV DM , nor TeV DM…) NO DM WIMPs, NO ANNIHILATING DM (wimps would exist but not as DM). NO SELF-INTERACTING DM (a variation of CDM)

→ DM IS WARM: keV scale mass: O(keV) means between 2 and 9 keV

→ DM is FERMIONIC. DM is a Fermion with mass in the keV scale Therefore, the QUANTUM aspects of DM must be taken into account

→ MANY PARTICLE PHYSICS CANDIDATES: eg keV Sterile Neutrino
→ GRAVITATION IS NEWTONIAN IN GALAXIES and GR in the LSS UNIVERSE. EXTENSION OF GRAVITY at the PLANCK SCALE but NOT at LARGE SCALES.

Axions are ruled out as dark matter

Hot Dark Matter (eV particles or lighter) are ruled out because their free streaming length is too large $\gtrsim$ Mpc and hence galaxies are not formed.

A Bose-Einstein condensate of light scalar particles evades this argument because of the quantum nature of the BE condensate. $r_{Jeans} \sim 5$ kpc implies $m_{axion} \sim 10^{-22}$ eV.

The phase-space density $Q = \rho/\sigma^3$ decreases during structure formation: $Q_{today} < Q_{primordial} \propto m^4$.

Computing $Q_{primordial}$ for a DM BE condensate we derived lower bounds on the DM particle mass m using the data for Q_{today} in dwarf galaxies:

TE: $m \geq 0.155 \text{ MeV} \left(\frac{25}{g_d}\right)^{5/3}$. Out of TE: $m \geq 14 \text{ eV} \left(\frac{25}{g_d}\right)^{5/3}$

Axions with $m \sim 10^{-22}$ eV are ruled out as DM candidates.

D. Boyanovsky, H. J. de Vega, N. G. Sanchez, PRD 77, 043518 (08). H. de Vega, N. Sanchez, arXiv:1401.1214

Many Ongoing WDM Directions of Research :

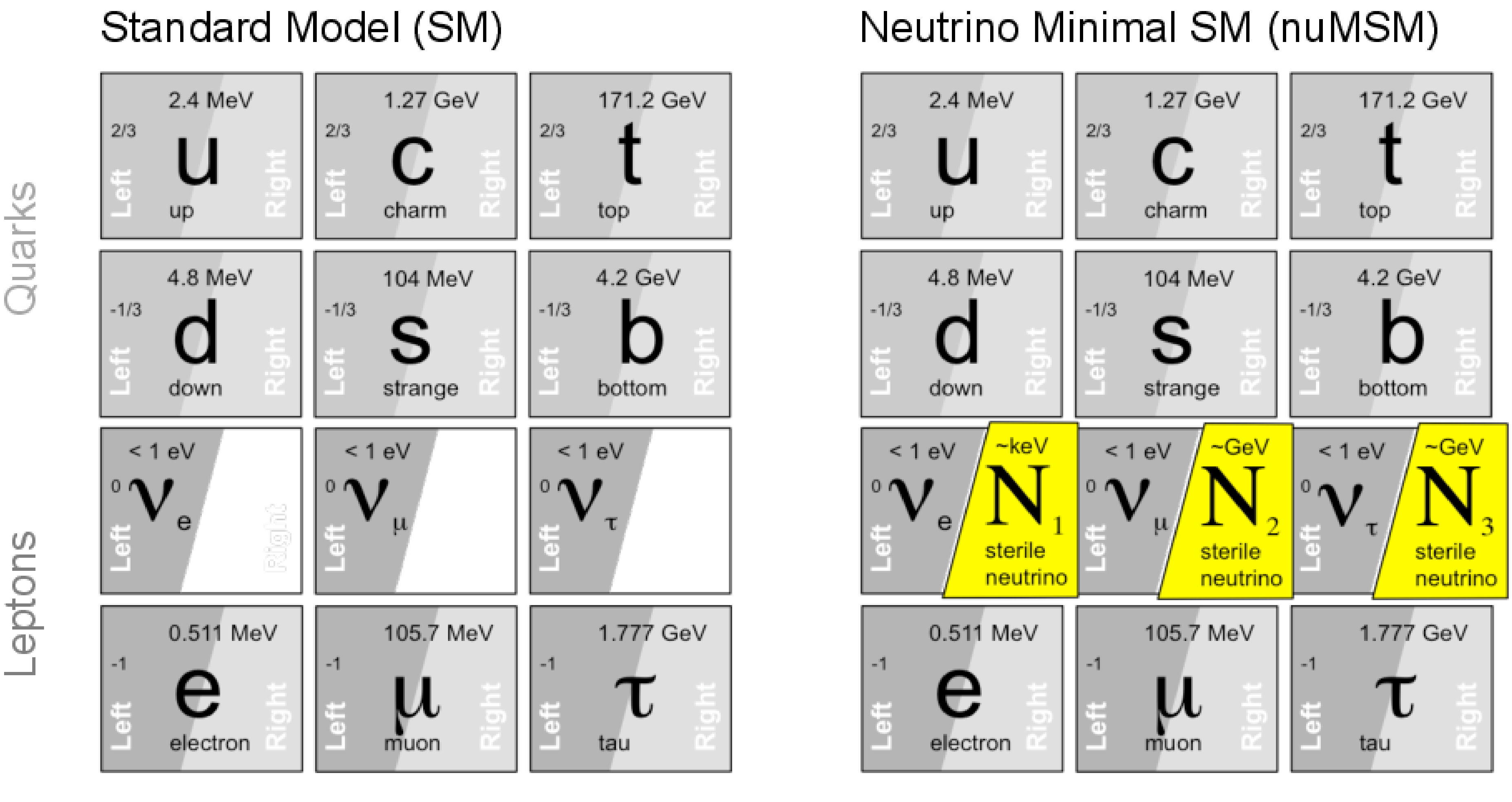
- Particle Models, Sterile neutrinos, Production mechanisms. WDM decay
- Experimental searches.

- WDM Numerical Simulations: structure formation
- Constraints on WDM m_x, mvs: Analytical, numerical, small scales, velocity dispersions

- WDM Astrophysics & Cosmological: reionization, 21 cm line, prospects for SKA. High z supernova lensing, HST, WDM Star Formation, WDM Galactic BHs

- WDM CMB: WDM decay, CMB Spectrum distortions, ….

Sterile Neutrinos



→ keV Sterile Neutrino Warm Dark Matter ←

→ Sterile neutrinos can decay into an active-like neutrino and a monochromatic X-ray photon with an energy half the mass of the sterile neutrino. Observing the X-ray photon provides a way to observe sterile neutrinos in DM halos.

→ WDM keV sterile neutrinos can be copiously produced in the supernovae cores. SN stringently constrain the neutrino mixing angle squared to be 10^{-9} for m > 100 keV (in order to avoid excessive energy lost) but for smaller masses the SN bound is not so direct. Within the models worked out till now, mixing angles are essentially unconstrained by SN in the keV mass range.

→ Sterile neutrinos are produced out of thermal equilibrium and their production can be non-resonant (in the absence of lepton asymmetries) or resonantly enhanced (if lepton asymmetries are present).

Sterile Neutrinos ν

Rhenium and Tritium beta decay (MARE, KATRIN).
Theoretical analysis: H J de V, O. Moreno, E. Moya de Guerra, M. Ramón Medrano, N. Sánchez,
Nucl. Phys. B866, 177 (2013).

[Other possibility to detect a sterile ν_s: a precise measure of nucleus recoil in tritium beta decay.]

Conclusion: the empty slot of right-handed neutrinos in the Standard Model of particle physics can be filled by keV-scale sterile neutrinos describing the DM.

An appealing mass neutrino hierarchy appears:

- Active neutrino: $\sim$ mili eV
- Light sterile neutrino: $\sim$ eV
- Dark Matter: $\sim$ keV
- Unstable sterile neutrino: $\sim$ MeV....

Sterile neutrino models

- DW: Dodelson-Widrow model (1994) sterile neutrinos produced by non-resonant mixing from active neutrinos.
- Shi-Fuller model (1998) sterile neutrinos produced by resonant mixing from active neutrinos.
- ν-MSM model (1981)-(2006) sterile neutrinos produced by a Yukawa coupling from a real scalar χ.
- DM models must reproduce $\bar{\rho}_{DM}$, galaxy and structure formation and be consistent with particle experiments.

WDM particles in different models behave just as if their masses were different (FD = thermal fermions):

$$\frac{m_{DW}}{\text{keV}} \simeq 2.85 \left(\frac{m_{FD}}{\text{keV}}\right)^{\frac{4}{3}}, \; m_{SF} \simeq 2.55 \; m_{FD}, \; m_{\nu\text{MSM}} \simeq 1.9 \; m_{FD}.$$

H J de Vega, N Sanchez,
Phys. Rev. D85, 043516 and 043517 (2012).

How to detect sterile neutrinos?

Sterile neutrinos can be detected in beta decay and in electron capture (EC) when a ν_s with mass in the keV sca is produced instead of an active ν_e.

Beta decay: the electron spectrum is slightly modified at energies around the mass ($\sim$ keV) of the ν_s.

$$^3H_1 \Longrightarrow {}^3He_2 + e^- + \bar{\nu}_e \quad , \quad {}^{187}Re \Longrightarrow {}^{187}Os + e^- + \bar{\nu}_e .$$

The electron energy spectrum is observed.

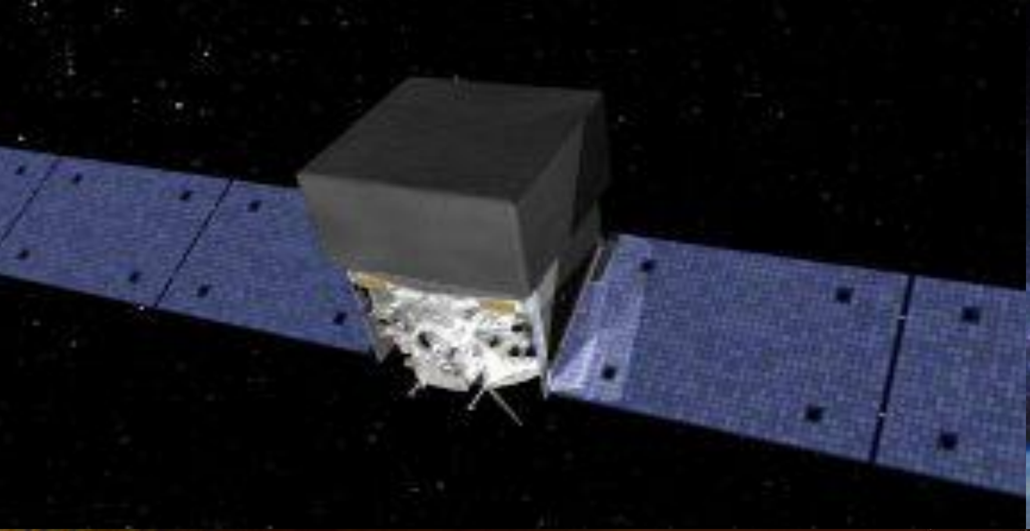
Electron capture: $^{163}Ho + e^- \Longrightarrow {}^{163}Dy^* + \nu_e$

The nonradiative de-excitation of the Dy^* is observed and different for ν_s in the keV range than for active ν_e.

Experiments that may detect sterile neutrinos:

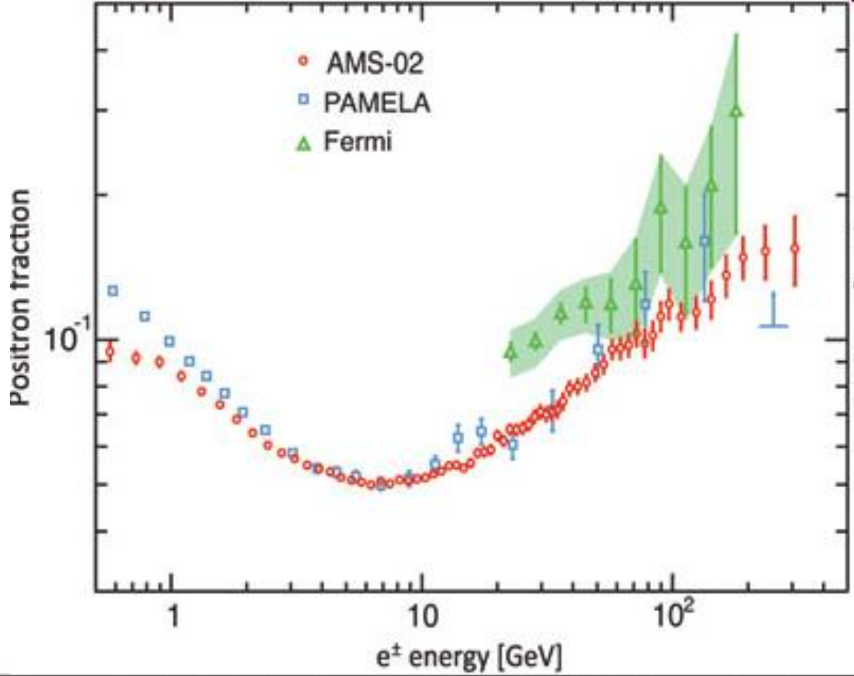
MARE (Milano), KATRIN (Karlsruhe), PTOLEMY (Princeton), ECHo (Heidelberg).

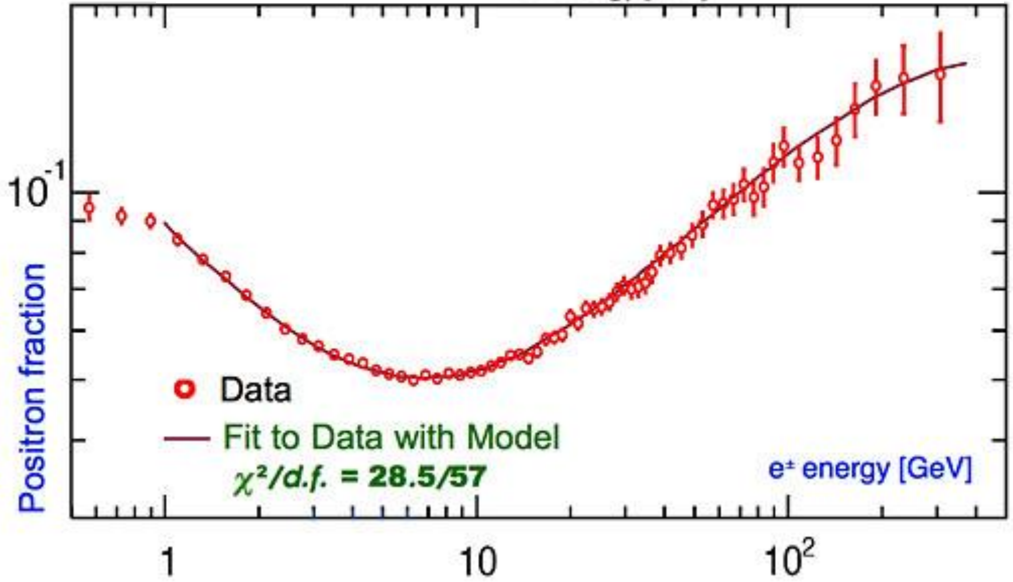
They search the mass of the ordinary neutrino.



ANTIMATTER IN SPACE - AMS on board ISS Alpha Magnet Spectrometer

NASA





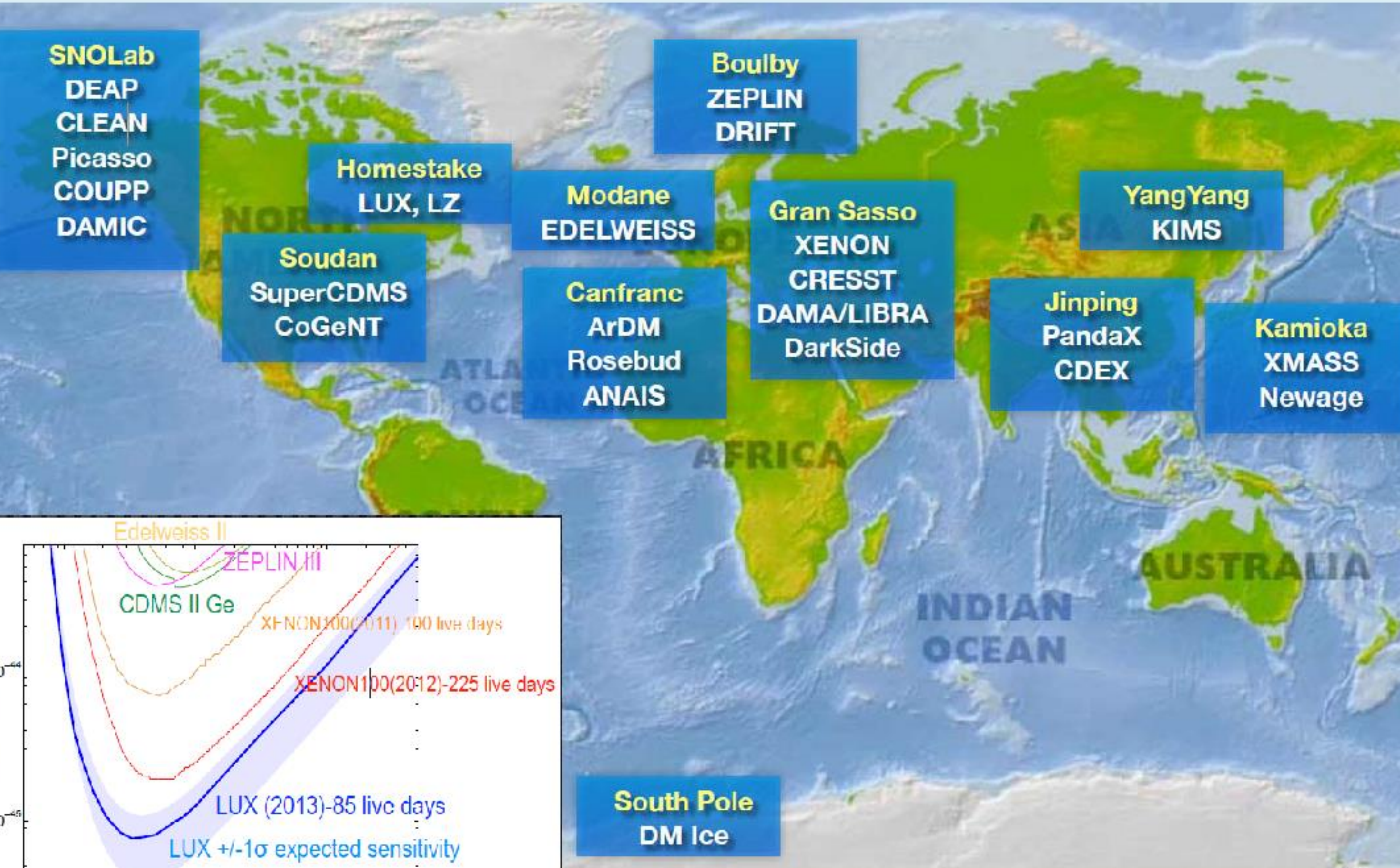
Positron excess in cosmic rays are not related to DM physics but to astrophysical sources and astrophysical mechanisms and can be explained by them

- **Why No Experimental Detection of the DM particle has been reached so far ?**

Because:

- **Most of experimental searches for DM particles are dedicated to CDM: wimps of m > 1 GeV,**
- **While the DM particle mass is in the keV scale .**
- **Moreover, past, present and future reports of signals of such CDM experiments cannot be due to DM because of the same reason.**
- **The inconclusive signals in such experiments should be originated by phenomena of other kinds.**
- **In addition, such signals contradict each other supporting the idea that they are unrelated to any DM detection.**

Dans le monde entier



Constraining the Warm Dark Matter Particle Mass through Ultra-Deep UV Luminosity Functions at high z from the HST Frontier Field

Comparing the predicted and the measured abundance of the faintest galaxies : m_x > ~ O(keV)

The corresponding lower limit for sterile neutrinos depends on the production mechanism: m_sterile >~ 0 (keV).

As a baseline for forthcoming observations from the HST Frontier Field :predictions for the abundance of faint galaxies for different values of m_x ~ 0(keV) valid for high z.

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THANK YOU FOR YOUR

ATTENTION !!