Dark Matter Direct Detection

Cristiano Galbiati Princeton University/LNGS What Next? @LNGS October 16, 2014

Overview

- The DAMA evidence for dark matter
- The low energy frontier
- The high exposure frontier

The Big Questions



The data favor the presence of a modulated behaviour with all the proper features for DM particles in the galactic halo at about 9.2 σ C.L.

DETECTOR SCHEME

- Cylinder : 1.5 m x 1.5 m
- 2 tons LAB scintillator
- 10 8-inch PMTs
- Reflector in inner surface (>95%).
- Expected: 0.22 p.e./ keV
- Shielding: 25cm Pb Portable
- Minimum crystal array: ~50kg (7x8kg)





DM-Ice

Objectives

- Directly test DAMA's observation, definitive probe of longest standing DM claim
- Test assertion that the observed signal is due to dark matter & understand its origin

Key Features

- Nal(TI) target
- only experiment with access to both Northern & Southern Hemispheres

DM-Ice17

Operating continuously since 2011

17 kg of NaI(TI) at 2450m depth at South Pole, analysis ongoing

arXiv:1401.4804

DM-Ice 250 North



Northern Hemisphere Run Definitive testing if signal observed Portable 250 kg Nal(TI) detector Tests the null hypothesis & study possible Astropart.Phys. 35 (2012) 749-754 sources of modulation

Reina Maruyama



500 kg·years

(2 - 4 keV) with 1, 2, and 5 dru background (DAMA has ~1 dru)

DM-Ice 250 South



Deployment at South Pole

Conclusion on current state of affairs

No real smoking gun yet! Axions WIMPs

2 directions (WIMPs)

1. Improve sensitivity at large mass (e.g., liquid noble)

2. Improve sensitivity at small mass (low temperature detectors)

Lessons learnt in the last few years

Phenomenology may be more complex than for the "vanilla" scenarios. Difficulty to get unambiguous results



5 GeV/c^2 50 GeV/c^2

log M





arxiv:1409.4075 MSDM



arxiv:1409.4075 MSDM

The XENON1T Experiment

- Fall 2011. Proposal reviewed by panel in March 2012. Approved by NSF in FY12.
- **Detector:** 1m- drift dual-phase TPC with 3.3 t LXe viewed by 250 3-inch PMTs
- by Summer 15. Complete commissioning/ start science run by late 2015.
- **Science Goal:** 2 x 10⁻⁴⁷ cm² for 50 GeV WIMP with 2 ton x yr data



• Location: LNGS - Hall B. TDR submitted to LNGS in Fall 2010. US groups proposal submitted to the NSF in

Cost: Total capital cost ~20M\$ (including investments made for XENON100). 50% from non-US groups.

Shield: water Cherenkov muon veto. Back goal:100 x lower than XENON100, ~5 x 10⁻² events/(t-d-keV)

Status: In advanced face of construction. Water Tank and Service Building completed. Cryogenic plants and Cryostat installed and commissioning ongoing. Detector installation by Spring 15. Integration with Muon Veto

The DarkSide Program U.S., Italy, France, Poland, Russia, China, Ukraine



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Recent results Oct-2-2014: arxiv:1410.0653 DarkSide-50 search, 1450 kg-day exposure of atmospheric argon = 0.6 t-yr UAr DarkSide-50 is the only dark matter search operating with zero background Third best limit at high masses, best non-Xe limit Science run with underground argon in DarkSide-50 starts in early 2015









Keep zero background, look for direction, and carry on measuring

LNGS still at the center of action