Dark Matter Search by XENON Detector

2018/10/29

최재진

What is WIMP?

- Weakly Interacting Massive Particles
- Hypothetical Particles
- Candidate of Dark Matter
- Interaction through the Weak Nuclear Force and Gravity
- Non-relativistic Particles

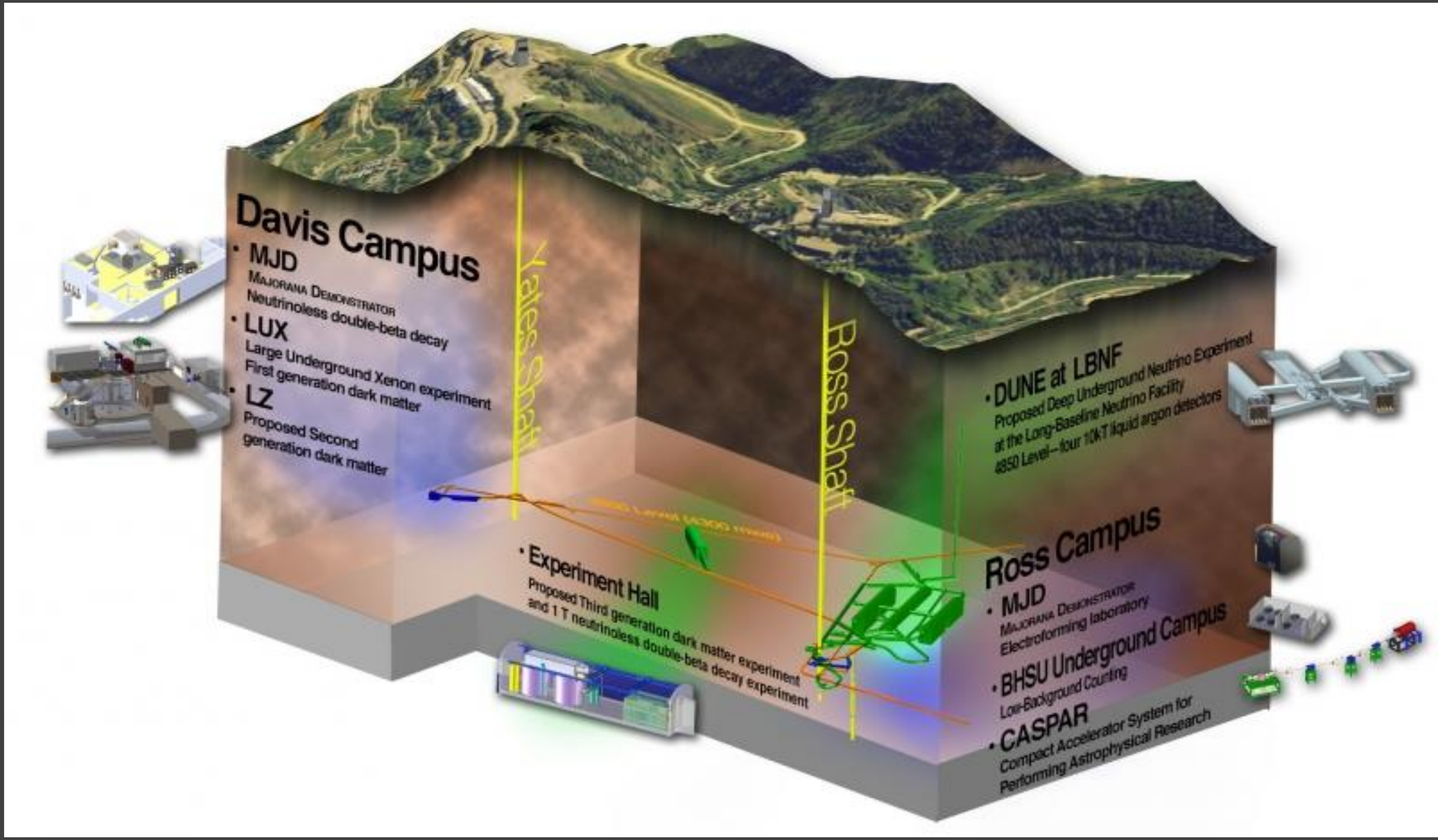
Direct Detection of WIMP

- Detect the elastic scattering of WIMP with nuclei in the detector by measuring the nuclear recoil energy
- Experiment in Underground for reduce background signal (Ex. Muon Flux)

Direct Detection of WIMP

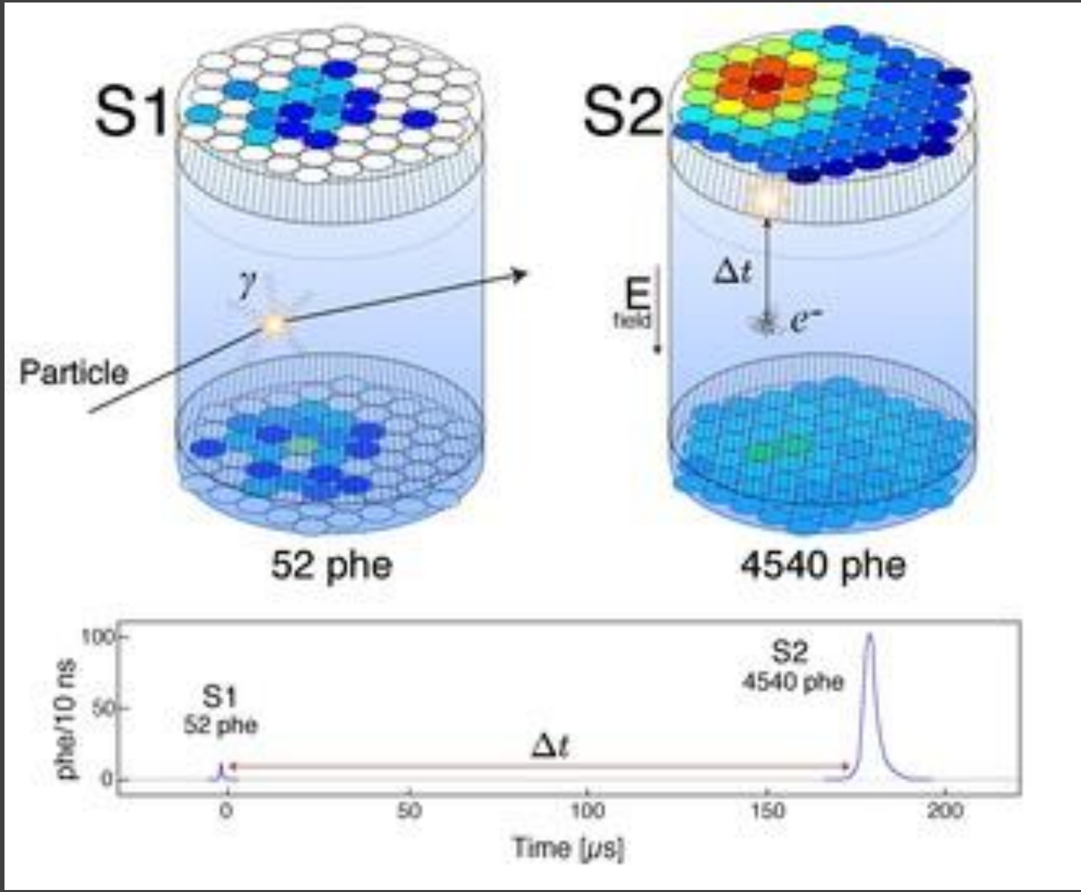
Collaboration	Laboratory	Detector	Published year
LUX	SURF(USA)	Xe	2017
XENON	LNGS(ITALY)	Xe	2017

LUX(Large Underground Xenon experiment)



SURF(Sanford Underground Research Facility)

Detector(Time-Projection Chamber)



Two measurable signal channels

: S1, S2

- S1 : VUV(vacuum ultra violet) photons from scintillation
- S2 : electrons from ionization

-> Drift to the surface of the liquid and into the gas via an applied electric field

-> Producing secondary electroluminescence photons

1. Reconstruction of interaction vertices in 3D dimensions
2. Discrimination between electronic recoils(ER) and nuclear recoils(NR)

ER and NR selection

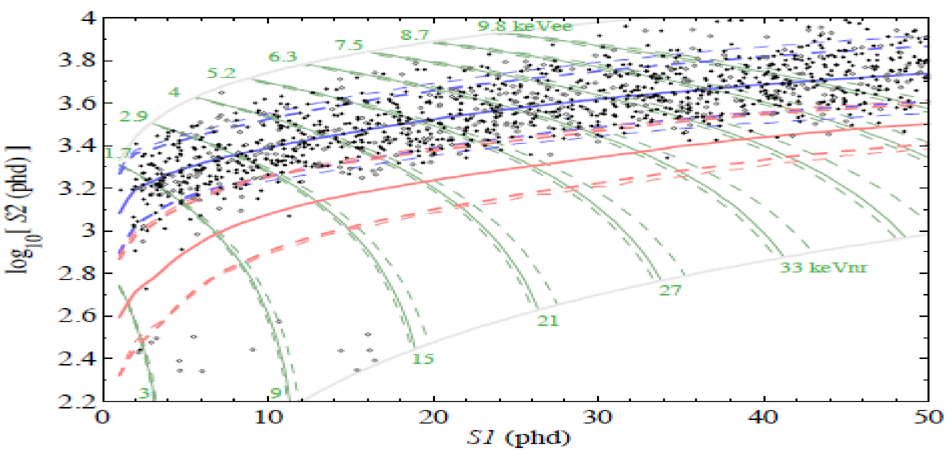


FIG. 1. WS2014–16 data passing all selection criteria. Fiducial events within 1 cm of the radial fiducial volume boundary are indicated as unfilled circles to convey their low WIMP-signal probability relative to background models (in particular the ^{206}Pb wall background). Exposure-weighted average ER and NR bands are indicated in blue and red, respectively (mean, 10%, and 90% contours indicated). Of the 16 models used, the scale of model variation is indicated by showing the extrema boundaries (the upper edge of the highest-S2 model and the lower edge of the lowest-S2 model) as fainter dashed lines for both ER and NR. Gray curves indicate a data selection boundary applied before application of the profile likelihood ratio method. Green curves indicate mean (exposure-weighted) energy contours in the ER interpretation (top labels) and NR interpretation (lower labels), with extrema models dashed.

ER band : BLUE

NR band : RED

Exposure days : 332.0 days

250kg ultra pure liquid Xenon Shielding by water tank(2017)

Background

TABLE I. Predicted background rates in the fiducial volume (0.9–5.3 keV_{ee}) [33]. We show contributions from the γ rays of detector components (including those cosmogenically activated), the time-weighted contribution of activated xenon, ^{222}Rn (best estimate 0.2 mDRUee from ^{222}Rn chain measurements) and ^{85}Kr. The errors shown are both from simulation statistics and those derived from the rate measurements of time-dependent backgrounds. 1 $mDRU_{ee}$ is 10^{-3} events/keV_{ee}/kg/day.

Source	Background rate, $mDRU_{ee}$
γ rays	$1.8 \pm 0.2_{stat} \pm 0.3_{sys}$
^{127}Xe	$0.5 \pm 0.02_{stat} \pm 0.1_{sys}$
^{214}Pb	0.11–0.22 (90% C.L.)
^{85}Kr	$0.13 \pm 0.07_{sys}$
Total predicted	$2.6 \pm 0.2_{stat} \pm 0.4_{sys}$
Total observed	$3.6 \pm 0.3_{stat}$

Predicted background rates(2014)

Upper limit of WIMP nucleus cross section

- Get event rate without background
- Obtain total WIMP rate using standard halo model
- Compare real signal with simulated WIMP signal for each WIMP mass
- Obtain WIMP-nucleus cross section for each WIMP mass

XENON1T Experiment

Laboratori Nazionali del Gran Sasso(LNGS)

XENON1T

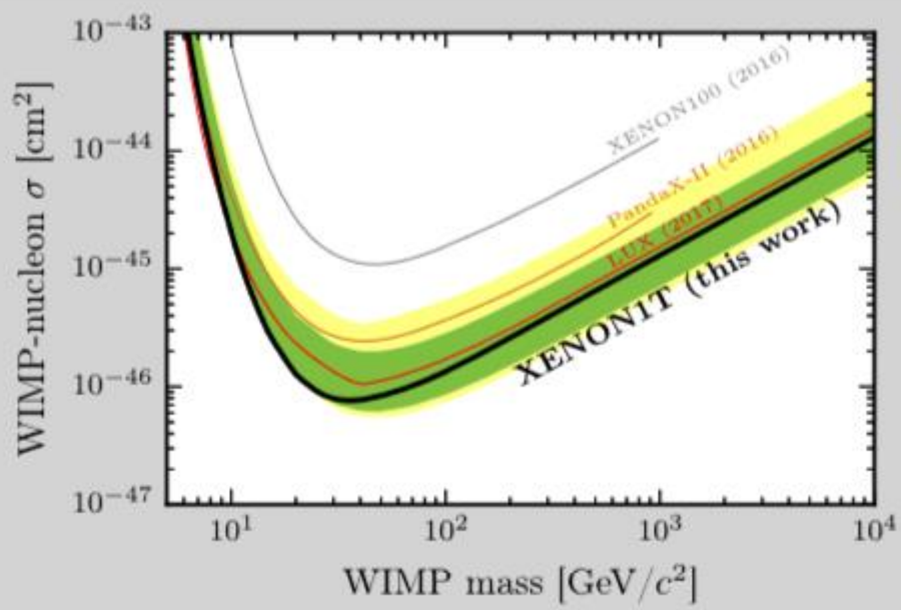
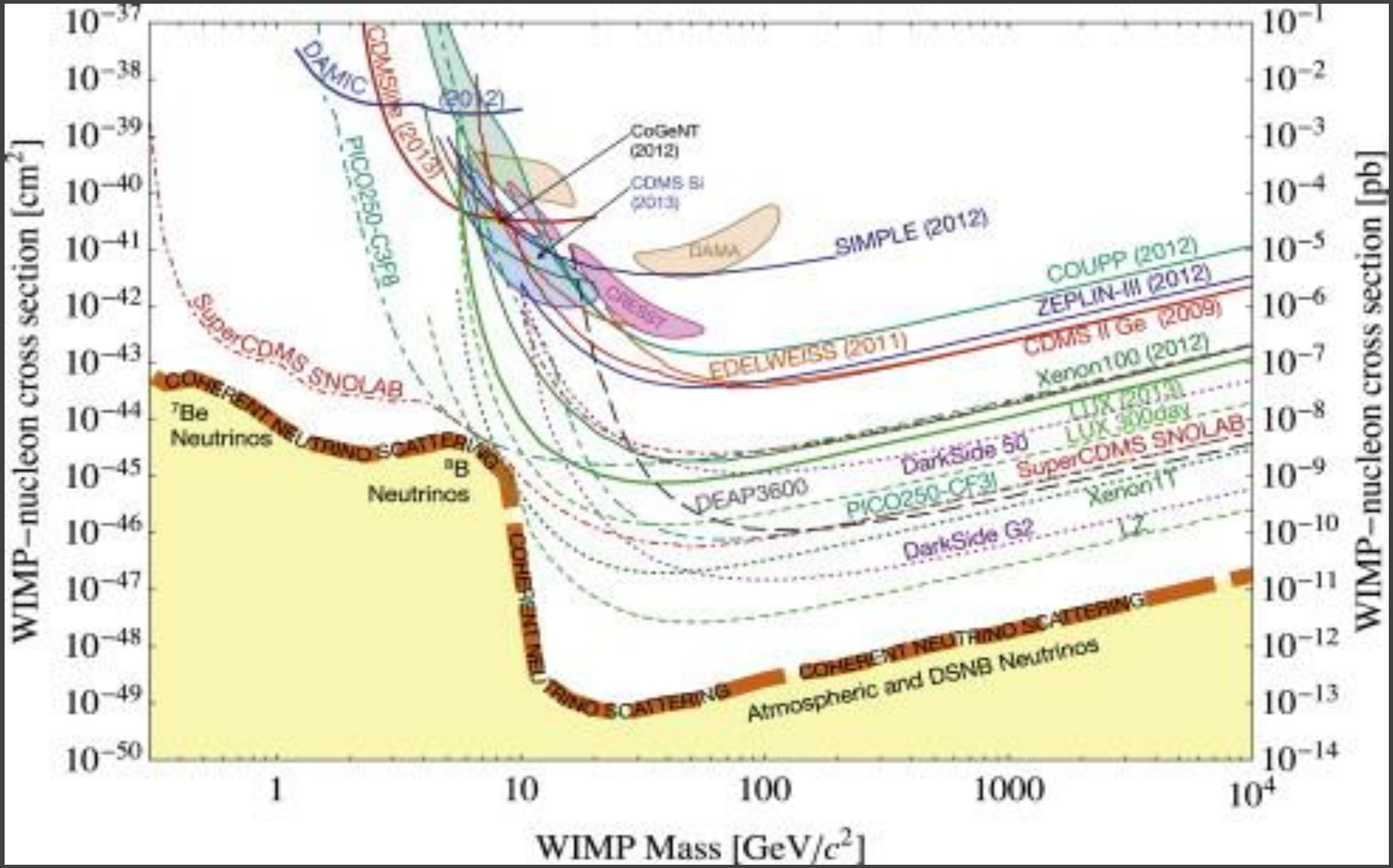


FIG. 4. The spin-independent WIMP-nucleon cross section limits as a function of the WIMP mass at 90% confidence level (black line) for this run of XENON1T. In green and yellow are the 1σ and 2σ sensitivity bands. Results from LUX [27] (the red line), PandaX-II [28] (the brown line), and XENON100 [23] (the gray line) are shown for reference.

- **3200kg liquid Xenon**
- $10^{-46}cm^2$**=**10^{-10}**pb**
- **Minimum cross section is** $7.7 \times 10^{-47}cm^2$ **for** $35 - GeV/c^2$ **WIMPs**

XENON collaboration(2017)

WIMP-nucleon spin independent cross section



REFERENCE

1. LUX Collaboration., Phys. Rev. Lett. 112, 091303 (2014).
2. LUX Collaboration., Phys. Rev. Lett. 112, 091303 (2014).
3. XENON Collaboration., Phys. Rev. Lett. 119, 181301 (2017).