Dark Matter Results from XENON100 Data

Yosuke Abe, Jaekeum Lee, Ganesh Tambave

Outline

- Motivation
- Introduction
- Experiment
- Analysis results
- Summary and Conclusion

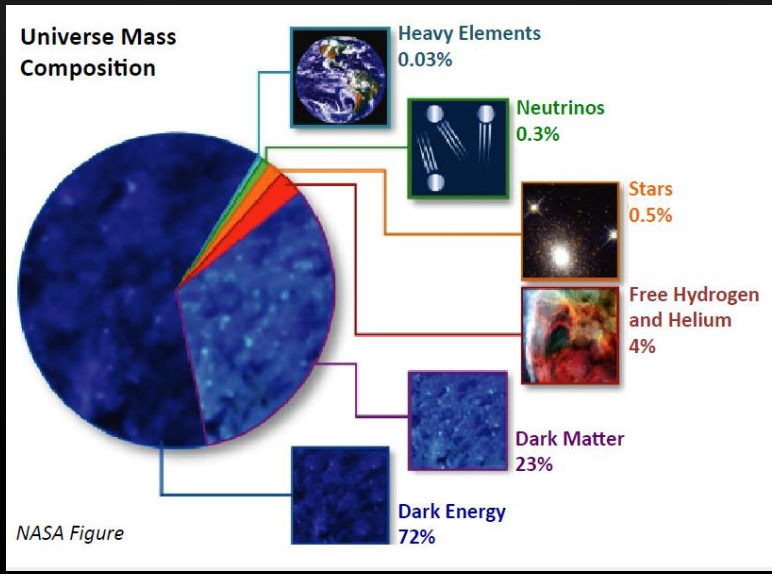


Motivation

- Current research in cosmology centers on resolving these questions:
- What is the nature of dark matter?
- How much dark matter actually exists?
- What is the exact distribution of dark matter in the universe?
- ***Answers to these questions will improve our understanding of the origins, structure and fate of the universe.***

Introduction to Dark Matter

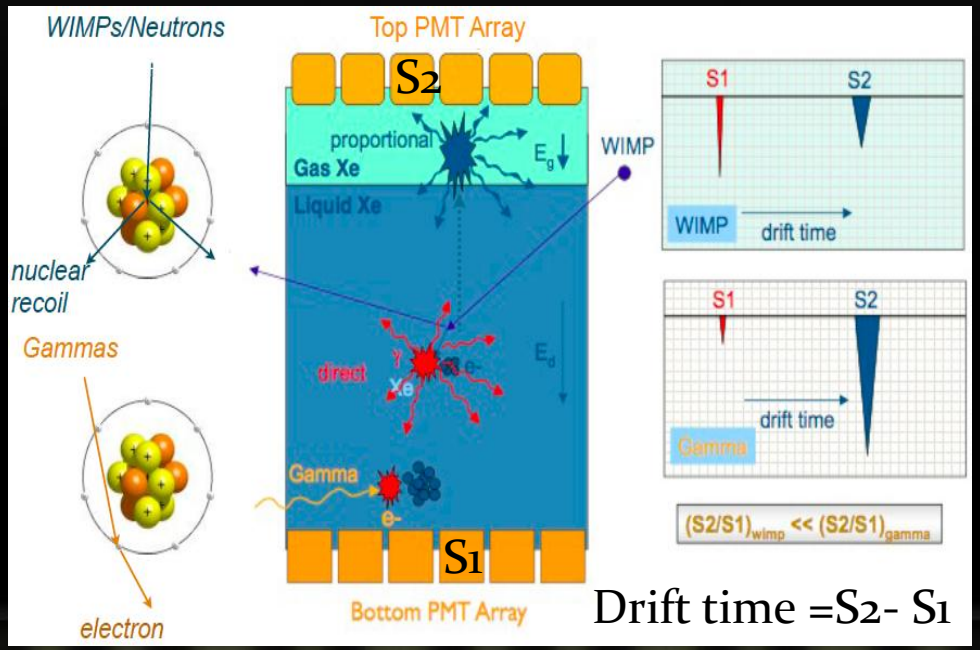
- **“dark matter"** is matter that neither emits nor scatters light or other em radiation
- Thus cannot be detected directly
- But can be detected through their Coherent scattering off target nuclei (e.g. Xe)
- “WIMP” is one of the major constitute of Dark matter.
- The expt. like CDMS, EDELWEISS, XENON100 made an attempt to detect WIMP.

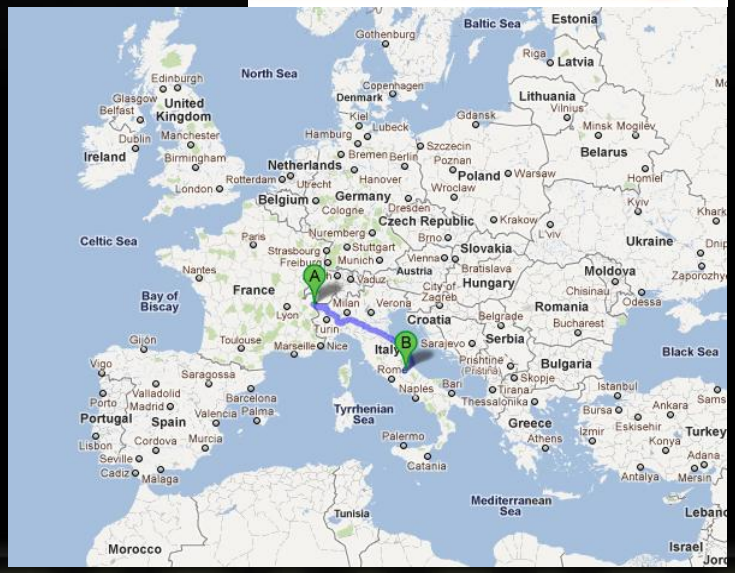


XENON100 two-phase TPC

The simultaneous detection of charge and light signals provides discrimination between

- Expected WIMP-induced Nuclear Recoils (NRs) signal
- Interactions from the electromagnetic background in the form of Electronic Recoils (ERs)
- 3D interaction vertex reconstruction





Scintillation efficiency of NRs

Energy of nuclear recoil (NR)

quenching of scintillation yield for 122 keV γ due to drift field

measured signal in p.e.

$$E_{nr} = \frac{S1}{L_y L_{eff}} \times \frac{S_e}{S_r}$$

light yield for 122 keV in p.e./keV

scintillation efficiency of NR relative to 122 keV γ at zero field

quenching of scintillation yield for NR due to drift field

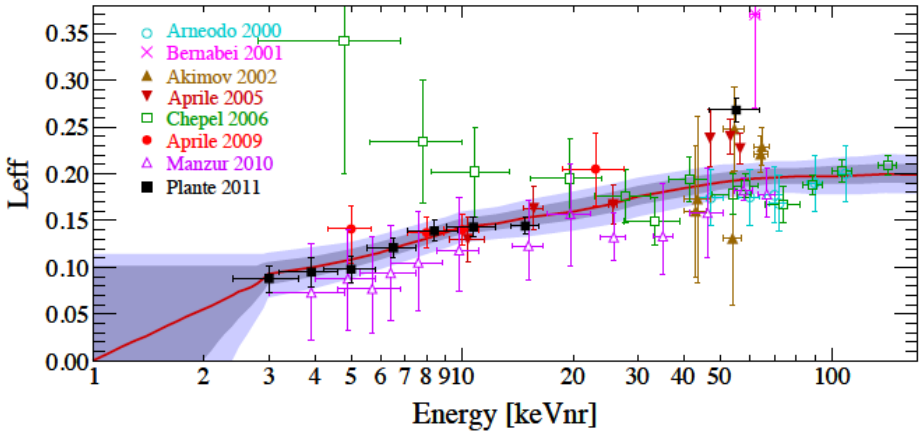


FIG. 1: All direct measurements of $\mathcal{L}_{\rm eff}$ [12, 13] described by a Gaussian distribution to obtain the mean (solid line) and the uncertainty band (1σ and 2σ). Below $3\,{\rm keV_{nr}}$ the trend is logarithmically extrapolated to $\mathcal{L}_{\rm eff} = 0$ at $1\,{\rm keV_{nr}}$.

Acceptance of all data quality

Energy window for WIMP search: 8.4-44.6 keV_{nr}

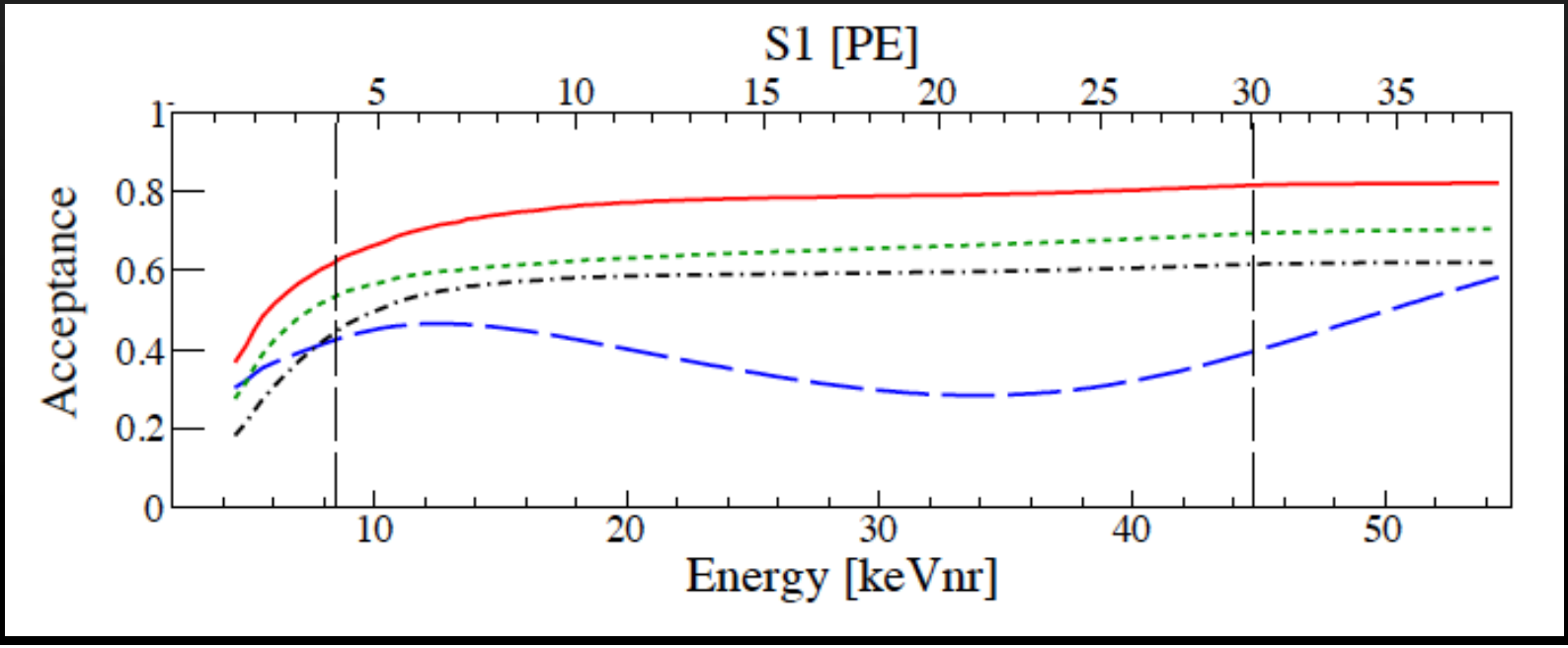
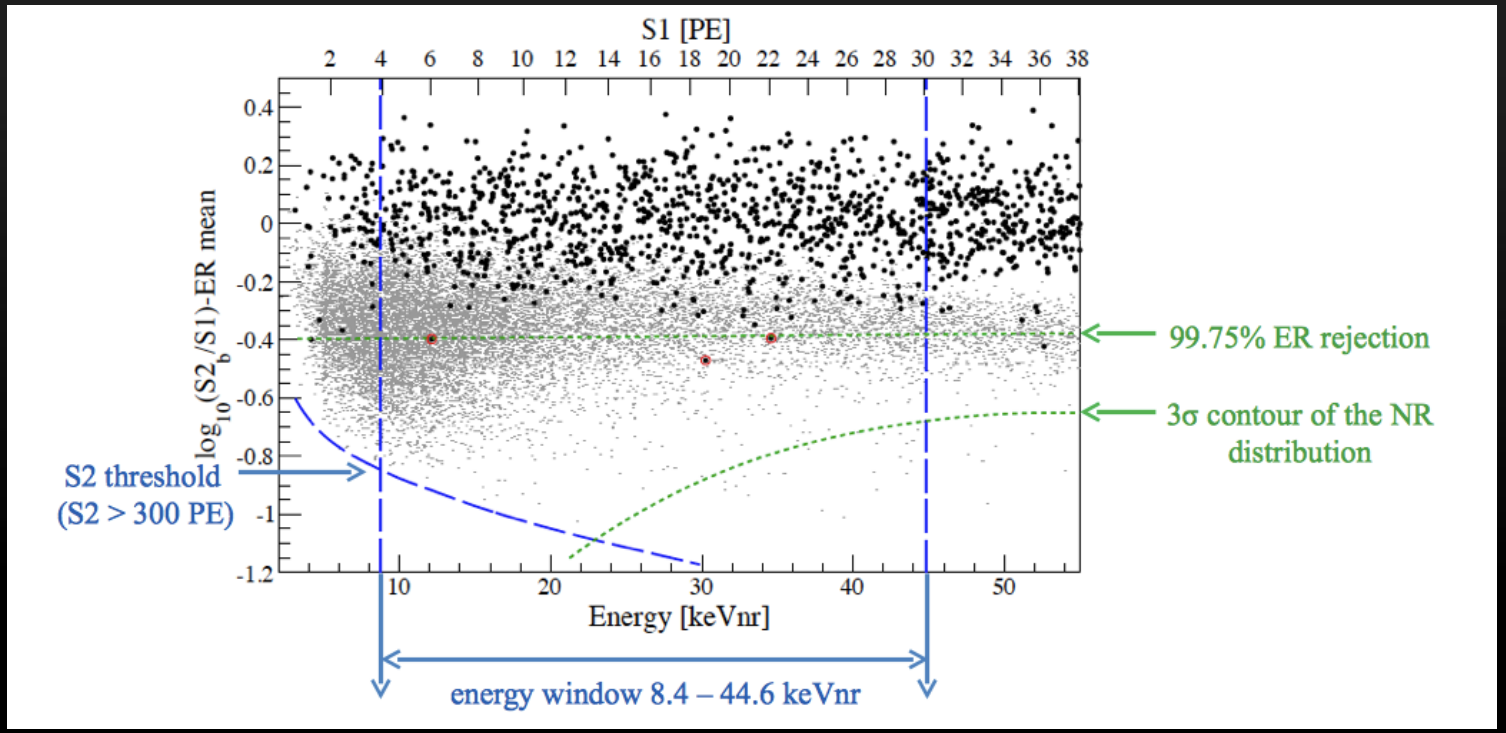


FIG. 2: Acceptance of all data quality cuts used for the analysis for $m_\chi \geq 50$ GeV/c^2 (solid red), $m_\chi = 10$ GeV/c^2 (dotted green), $m_\chi = 7$ GeV/c^2 (dash-dotted black). The optimum interval analysis additionally uses a S2/S1 ER discrimination cut. Its NR acceptance is also shown (dashed blue).

Event distribution using discrimination parameter

Discrimination parameter = Log_{10} (S2/S1)



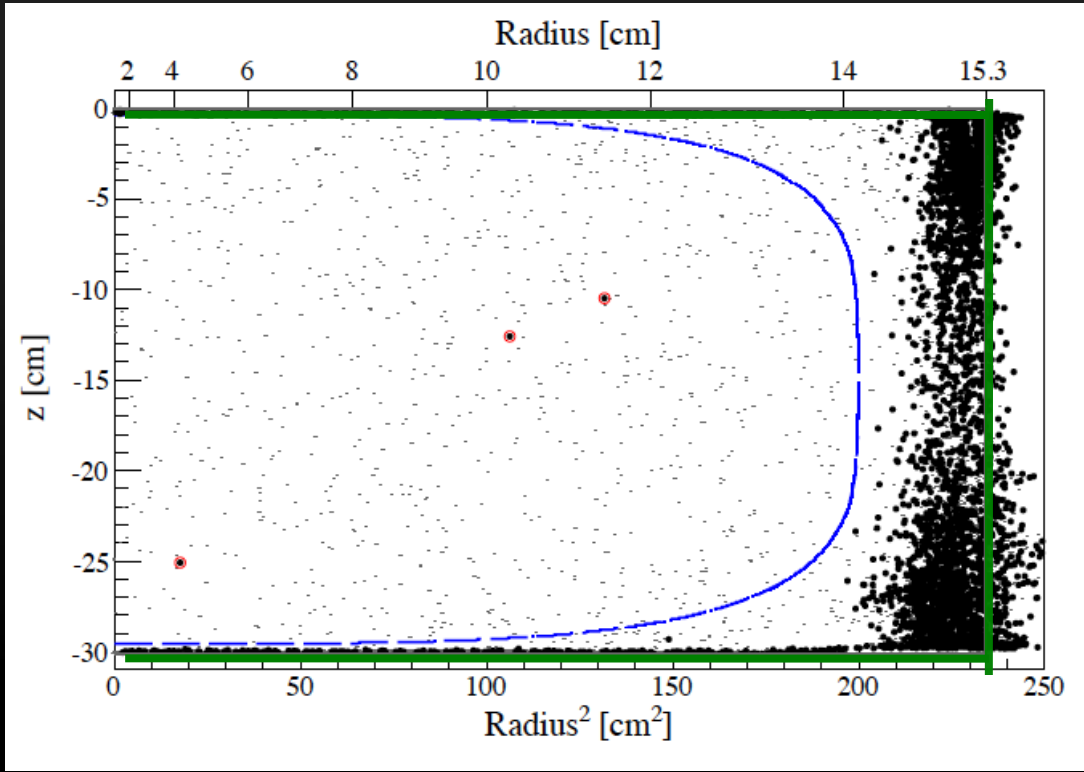
Black dots - observed events

Gray dots - NR band from 241AmBe calibration data

Blue dashed line - WIMP search region, Green line – additional NR and ER cuts

Red circles – WIMP candidate events

Event distribution in TPC



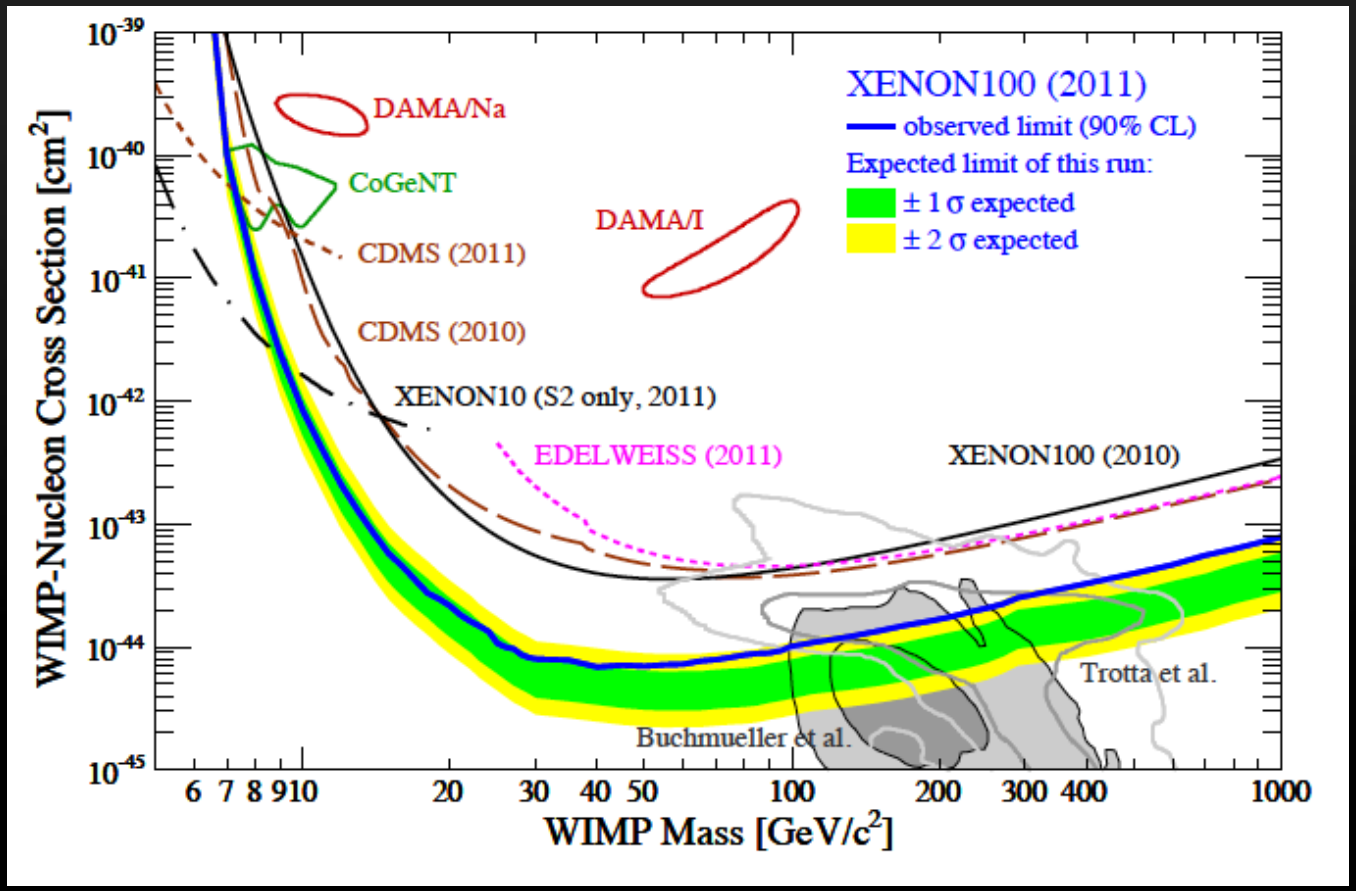
Black dots - events below the 99.75% rejection line in energy window

Blue dashed line - fiducial volume of TPC

Green dashed line - TPC dimensions

Red circles - WIMP candidate events

Spin- independent elastic WIMP-nucleon cross-section vs. WIMP mass



Thick blue line - XENON100 limit @ 90% CL

Yellow/green band - Expected sensitivity

Summary and conclusion

- XENON100 took 100.9 live days of data
- Three candidate events were observed in signal region with expected background of (1.8±0.6) events
- No evidence for dark matter is found
- Leads to the most stringent limit on dark matter interactions today

Thank you all !

Special thanks to FAPPS committee for organizing such a nice school.

Liquid Xenon for Dark Matter

- *scalability:* relatively inexpensive for very large detector (today < $800/kg)
- *Large mass number (A~131):* high rate for SI interactions if NR threshold is low
- *~50% odd isotopes:* SD interactions
- *Excellent Stopping Power:* active volume is shelf-shielding
- *Excellent Scintillator and Ionizer:* highest yield among noble liquids
- *Intrinsically pure:* no long-lived radioactive isotopes; Kr/Xe reduction to ppt level with established methods
- *NR Discrimination:* by simultaneous charge and light measurement

$$R \sim \frac{M_{det}}{M_\chi} \rho \sigma \langle v \rangle$$