

Search for Dark Matter with Liquid Argon Detector

Theo Hugues

PhD Student at AstroCeNT and APC

ASTROCENT



NICOLAUS COPERNICUS
ASTRONOMICAL CENTER
OF THE POLISH ACADEMY OF SCIENCES



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Annual Modulation and DarkSide-50

Results from other experiments

NaI(Tl) detector

- DAMA/LIBRA: modulation with proper features at 13.7σ CL
- ANAIS112: reject DAMA with $\approx 3\sigma$
- COSINE 100: consistent with both DAMA and the no-modulation case

LXe detector

- XENON100: reject DAMA's modulation in 2-6keV bin
- LUX: 9.2σ tension with the DAMA/LIBRA result
- XMASS: excludes the DAMA/LIBRA allowed region at $\approx 3\sigma$

LAr detector

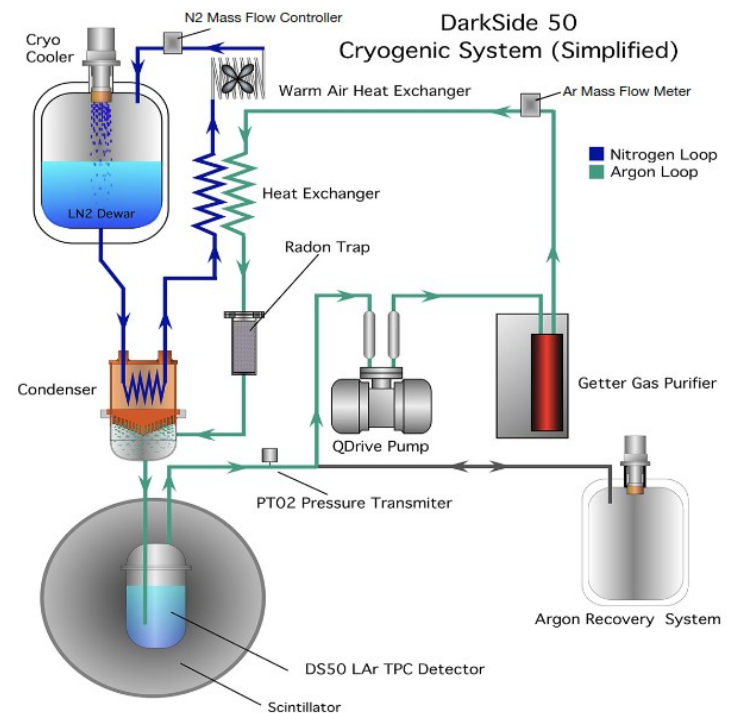
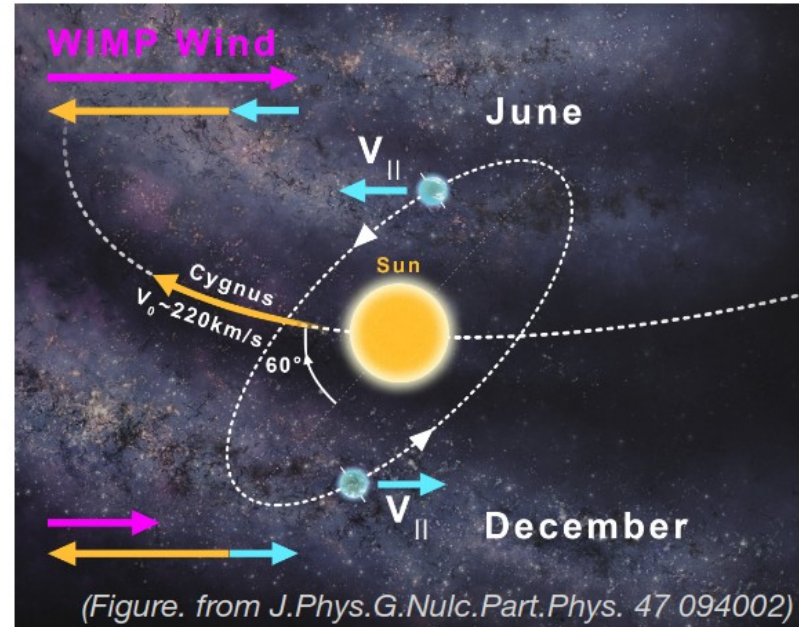
- This talk (arXiv:2307.07249)

Search for dark matter annual modulation with DarkSide-50

DarkSide-50 TPC working principle:

Light collected by top and bottom Photomultiplier Tubes (PMT)

- **S1** (primary scintillation), is produced in LAr due to excitation and recombination after **ionization**
- **S2** (secondary scintillation) produced in the gas phase by **drifted electrons**



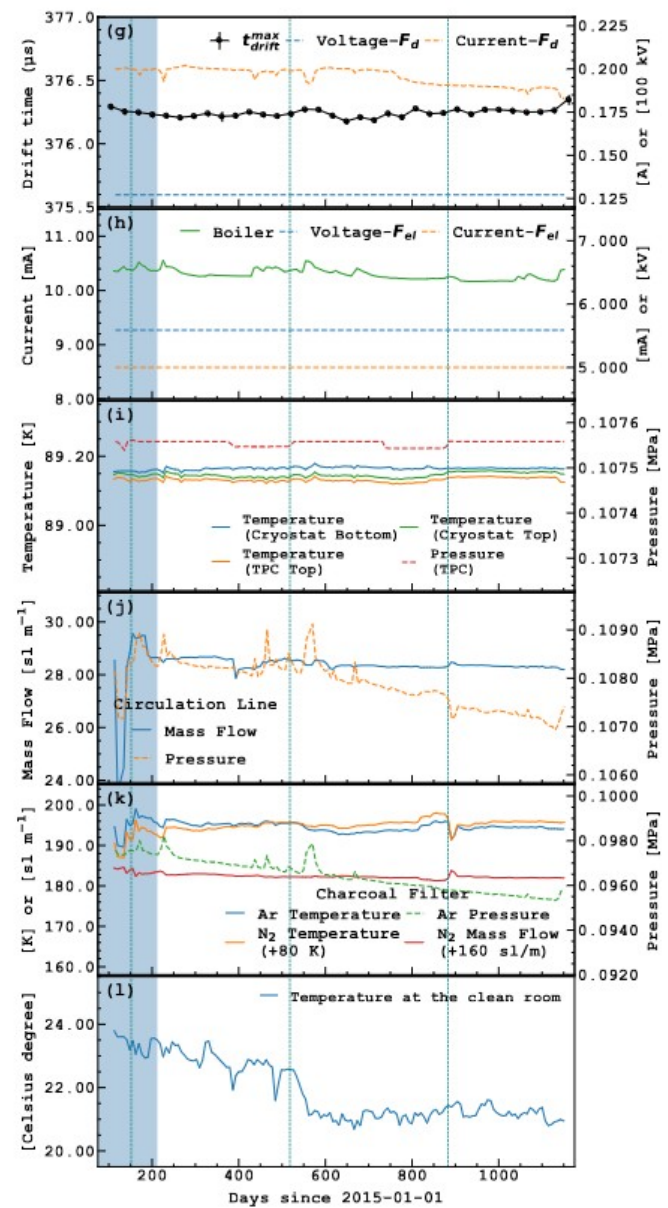
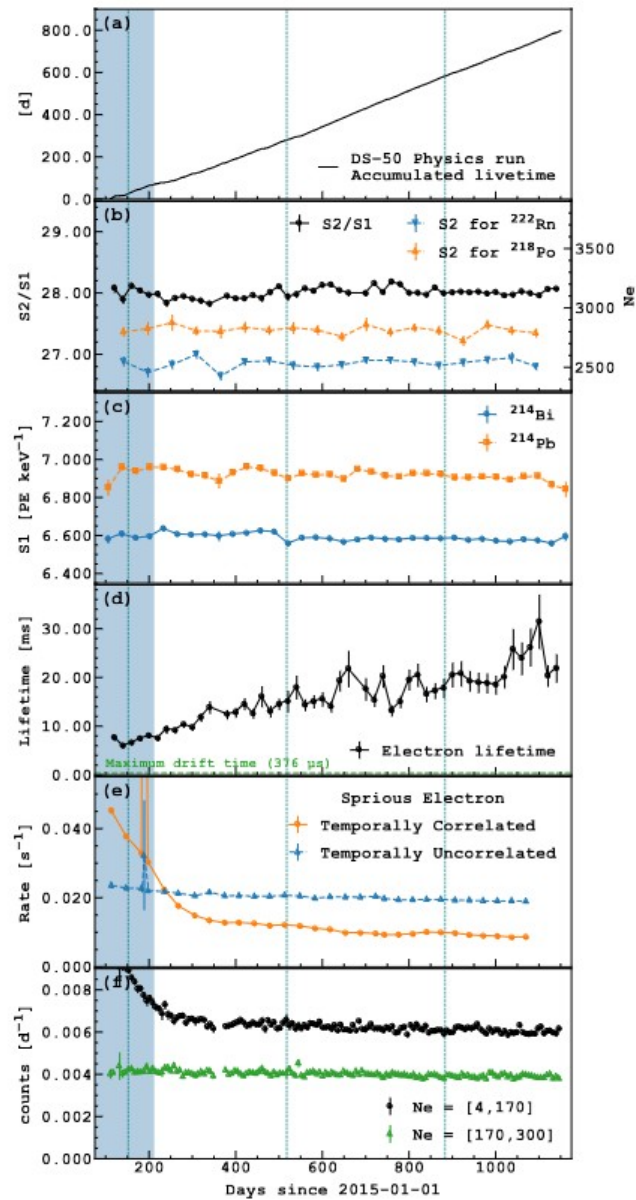
DarkSide-50 Long Term Stability

Stability of all 72 slow control parameters was checked:

- Quantitatively
- Lomb-Scargle periodogram
- Correlation with Data

There is no significantly high coefficient and strong periodicity found for each of energy ranges

The mean number of photoelectrons per ionization electron (g_2 [PE/e-]) the drift field (E_d [V/cm]) are stable within **0.5%** and **0.01%**



Long-term temporal stability of the DarkSide-50 dark matter detector (arXiv:2311.18647)

Search for Annual Modulation

- Four radioactive isotopes decaying in 3 years are taken into account
- Dark Matter Event rate as a function of time is modeled with a cosine signal:

$$f(t) = \underbrace{A_\chi}_{\text{Signal amplitude}} \underbrace{\cos\left(\frac{t-\phi}{T/2\pi}\right)}_{\text{Fixed to 1y}} + \sum_l \frac{A_l}{\tau_l} e^{-t/\tau_l} + \underbrace{C}_{\text{Including long-lived isotope (no constrain)}}$$

- Likelihood fit to the model with 7-d time bin:

$$\mathcal{L} = \prod_{i \in t_{\text{bins}}} \mathcal{P}(n_i | m_i(A_\chi, \phi, C, \Theta)) \times \prod_{\theta_k \in \Theta} \mathcal{G}(\theta_k | \theta_k^0, \Delta\theta_k).$$

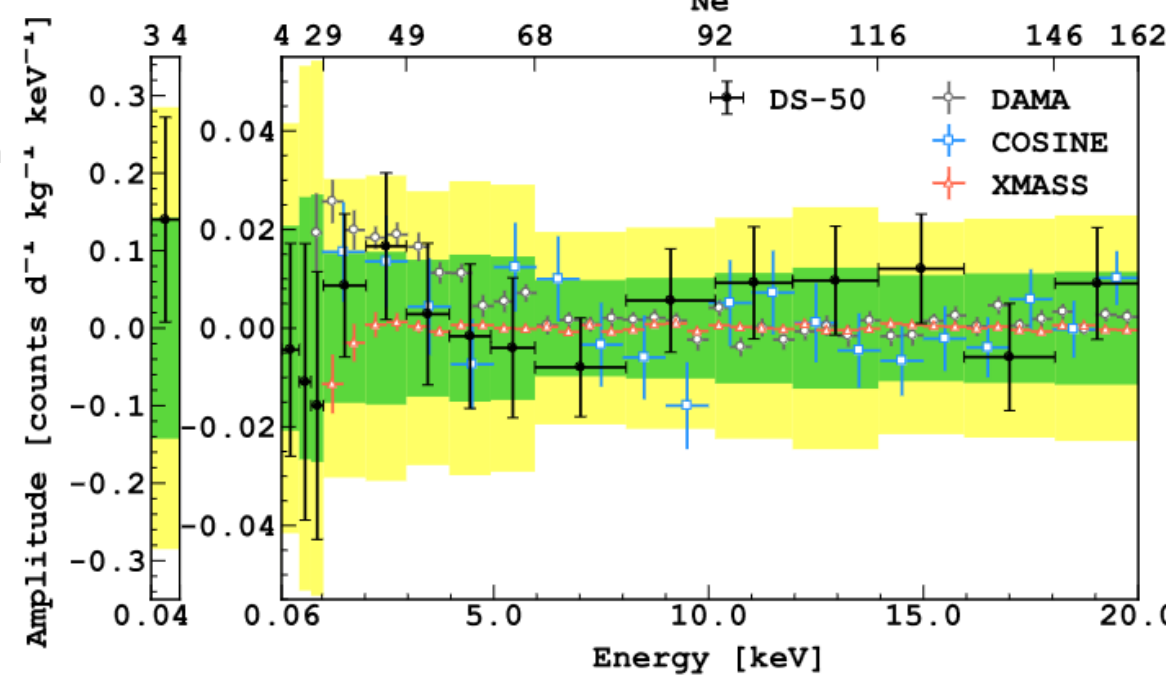
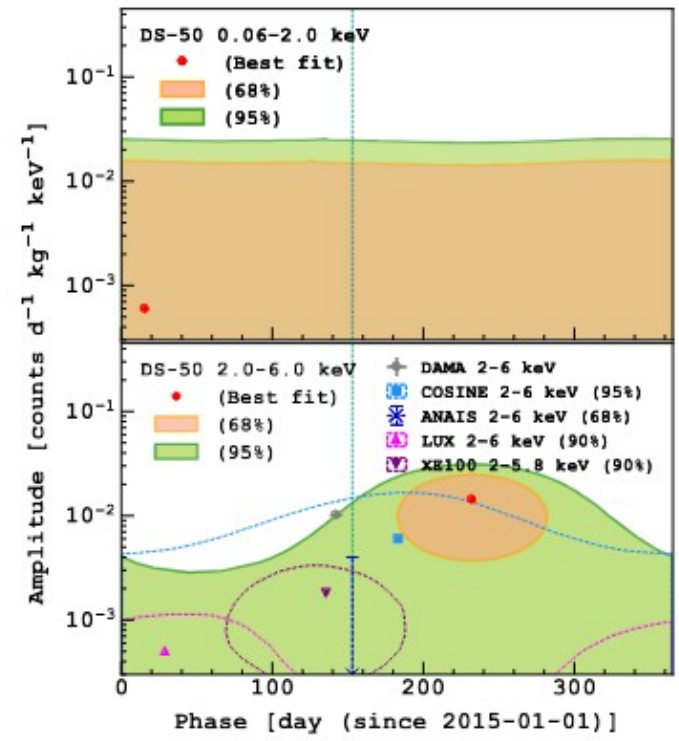
The 1D fit (uppers plots) are **consistent to the background-only model**

- Neither confirm nor reject the DAMA's observation

The 2D simultaneous fit (bottom plot) in both time and energy bins uses:

$$\mathcal{L} = \prod_{i \in t_{\text{bins}}} \prod_{j \in E_{\text{bins}}} \mathcal{P}(n_i^j | m_i^j(A_\chi^j, C^j, \tilde{\Theta})) \times \prod_{\tilde{\theta}_k \in \tilde{\Theta}} \mathcal{G}(\tilde{\theta}_k | \tilde{\theta}_k^0, \Delta\tilde{\theta}_k),$$

- Fixed the phase ϕ (June 2nd) and period T (1-yr)
- Amplitudes of the short-decayed component for each energy bin are correlated



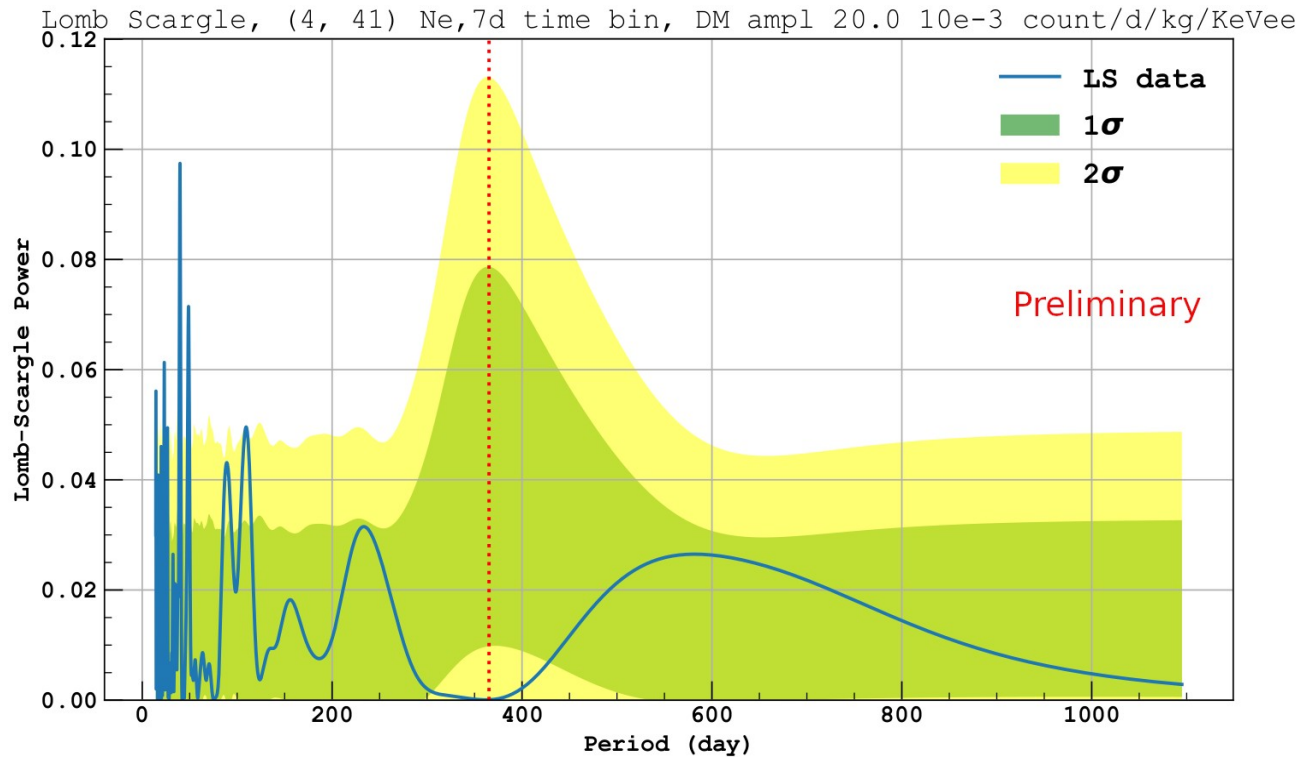
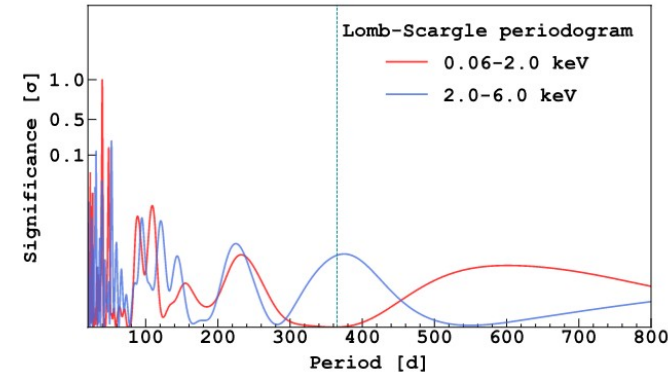
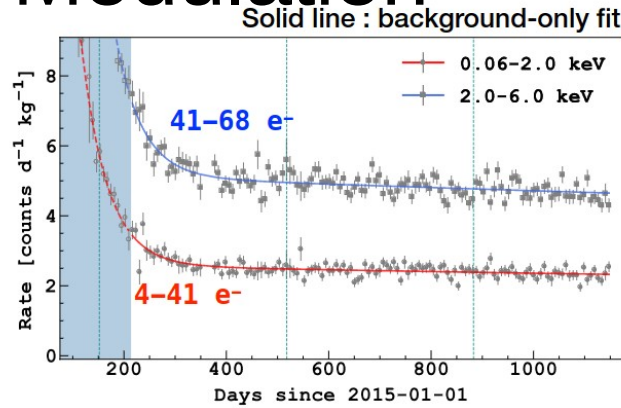
Search for Annual Modulation

Lomb-Scargle algorithm is applied to look for any periodic signal

- **Residuals** of the background-only fit are converted into the frequency space

No significant signal is observed

- Bottom plot shows a Lomb-Scargle periodogram, with Brazilian band corresponding to toy-MC datasets, showing that a median of 1 σ significance for the false alarm probability is obtained with the addition of 0.03 counts/(d kg keV)



Other activities

- DEAP Collaboration meeting, Mexico City
- DarkSide Collaboration meeting, June, LNGS, Italy
- XVIII International Conference on Topics in Astoparticle and Underground Physics (TAUP2023), Vienna
Proceeding under review
- Submitting the thesis manuscript

Thank you for your attention.