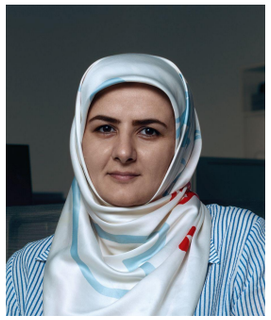
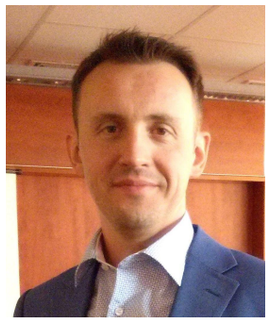
CAMK Annual Report

Masayuki Wada
AstroCeNT, CAMK PAN Group 4
1 Feb. 2024

MEMBERS

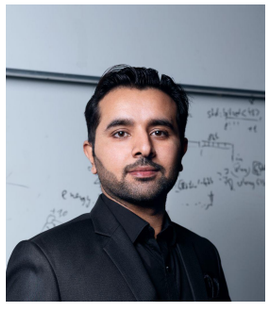


- Azam Zabihi
  - PostDoc working on Medical applications



- Rafał Wojaczyński
  - PostDoc working on low mass dark matter search and neutrino detection
  - Moved to another project in CAMK

- Masato Kimura
  - PostDoc working on low mass dark matter search
  - Moved back to Japan



- Iftikhar Ahmad
  - 4th year PhD student working on SiPM development

- Paul Zakhary
  - 4th year PhD student working on low energy calibration

NEW!!

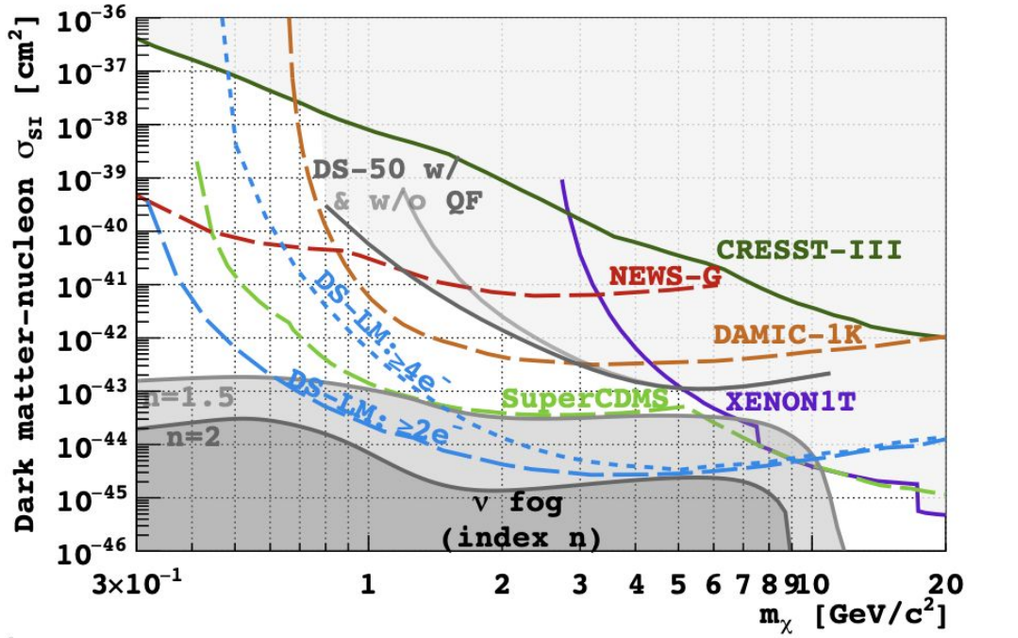
- Andre Cortez
  - PostDoc expert on gas/liquid detector developments

- Clea Sunny
  - 2nd year PhD student

DARK MATTER SEARCH

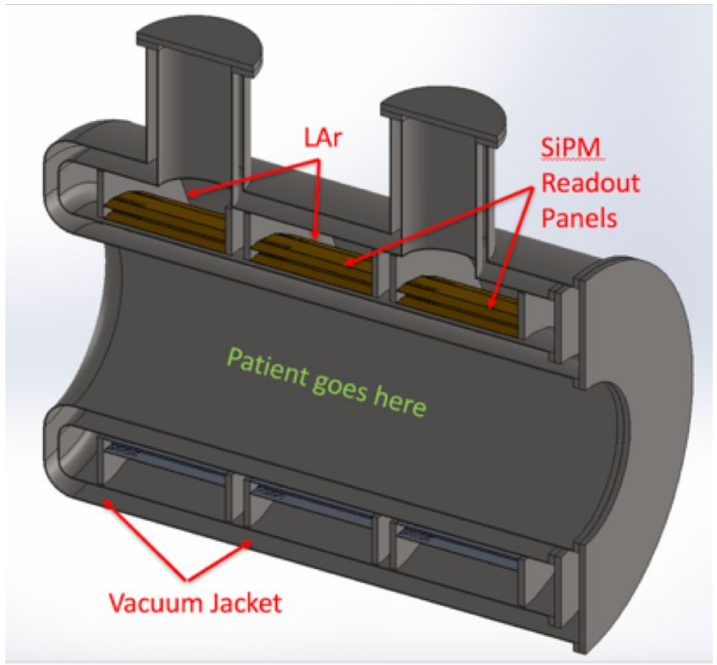
- DarkSide-20k for high mass search
- Argon is a good target also for low-mass dark matter search.
- Need ultra-pure Photo-detectors.
- Potential to search entire available parameter space in 1-10 GeV/c^2 dark matter mass range.

https://arxiv.org/abs/2209.01177



LIQUID ARGON PET SCANNER

- Positron emission tomography (PET) scanner measures physiological function of human body.
- Cutting edge technologies from Physics to the medical application.



Main Goal: Development of ultra-pure SiPM based photo-detectors for physics and medical application.

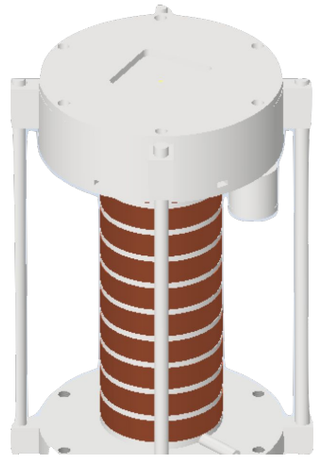
Time Projection Chamber at AstroCeNT

Main characteristics:

- Modular design
  (variable drift region - 1 cm steps)
- Bubbler position defines the gas gap
- Reflective inner walls (improve light collection - teflon)
- Allows to study dedicated optical amplification structures

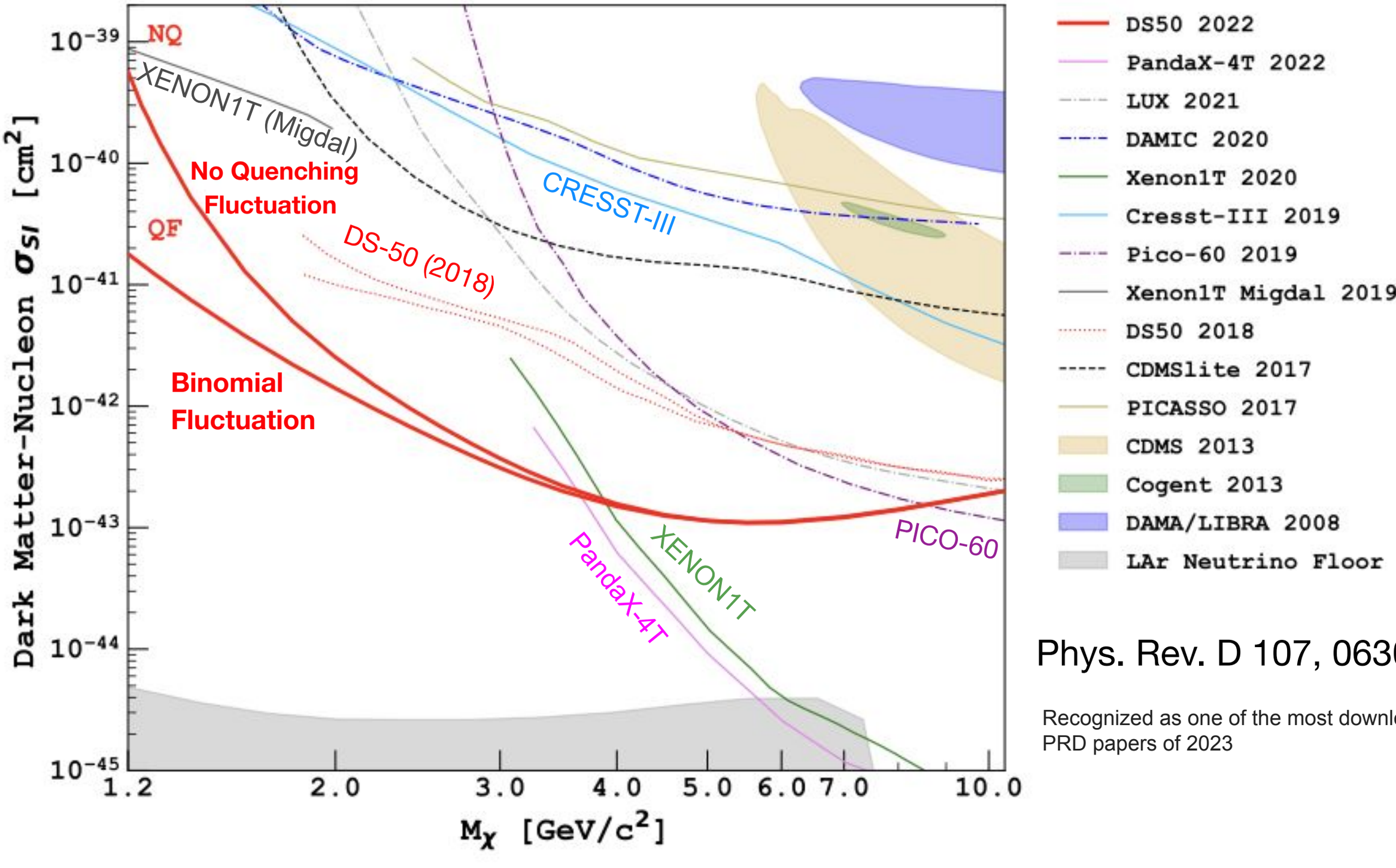
Planned activities:

- Study the influence of impurities in the triplet lifetime constant
- Study of electron extraction efficiency
- Study of delayed (spurious) scintillation events in dual-phase TPCs
- Test new optical amplification structures (MPGD-based)



Dark Matter Search in DarkSide-50

The most stringent limit at M_χ = [1.2, 3.6] GeV/c^2

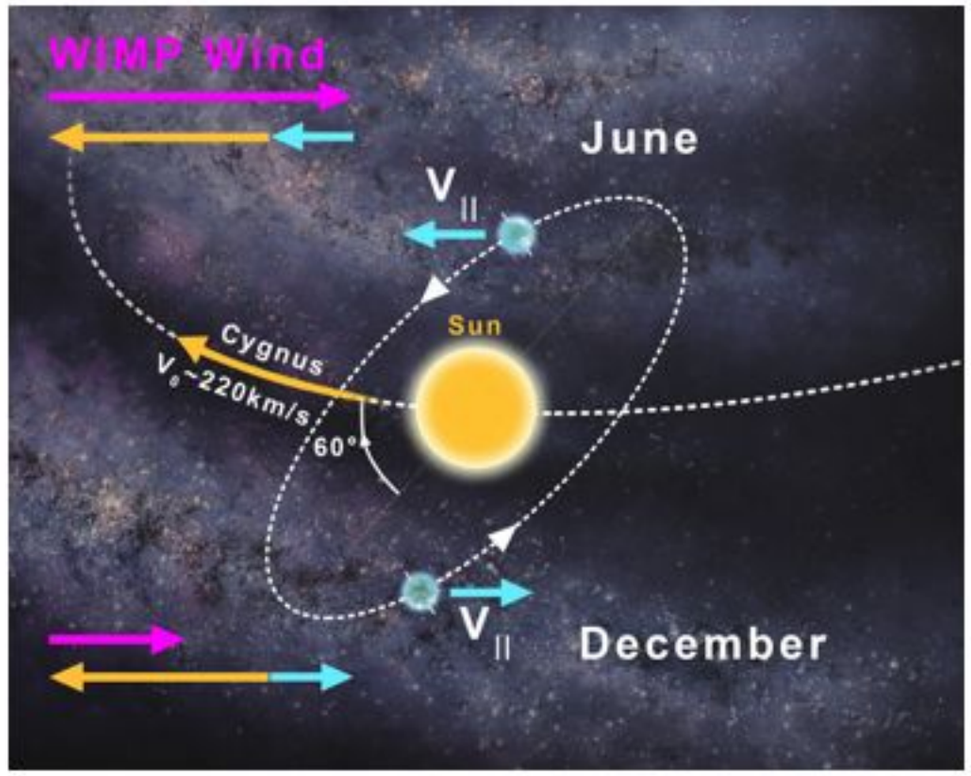


Phys. Rev. D 107, 063001

Recognized as one of the most downloaded PRD papers of 2023

DM ANNUAL MODULATION SEARCH

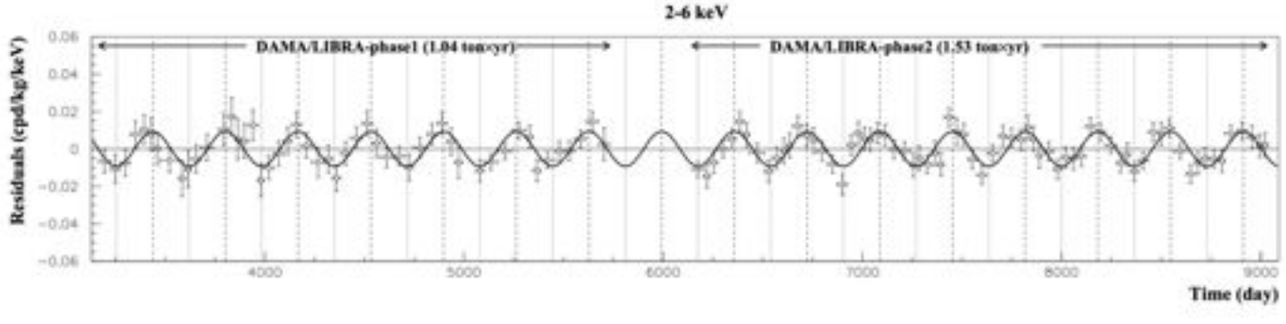
- The Sun moves toward the Cygnus, leading to a boost of the dark matter velocity distribution: "*Dark Matter Wind*"
- The Earth's rotation around the Sun increases the boost around June and decreases around December
  - **Event rate in terrestrial detectors above the energy threshold modulates annually**



(Figure. from J.Phys.G.Nulc.Part.Phys. 47 094002)

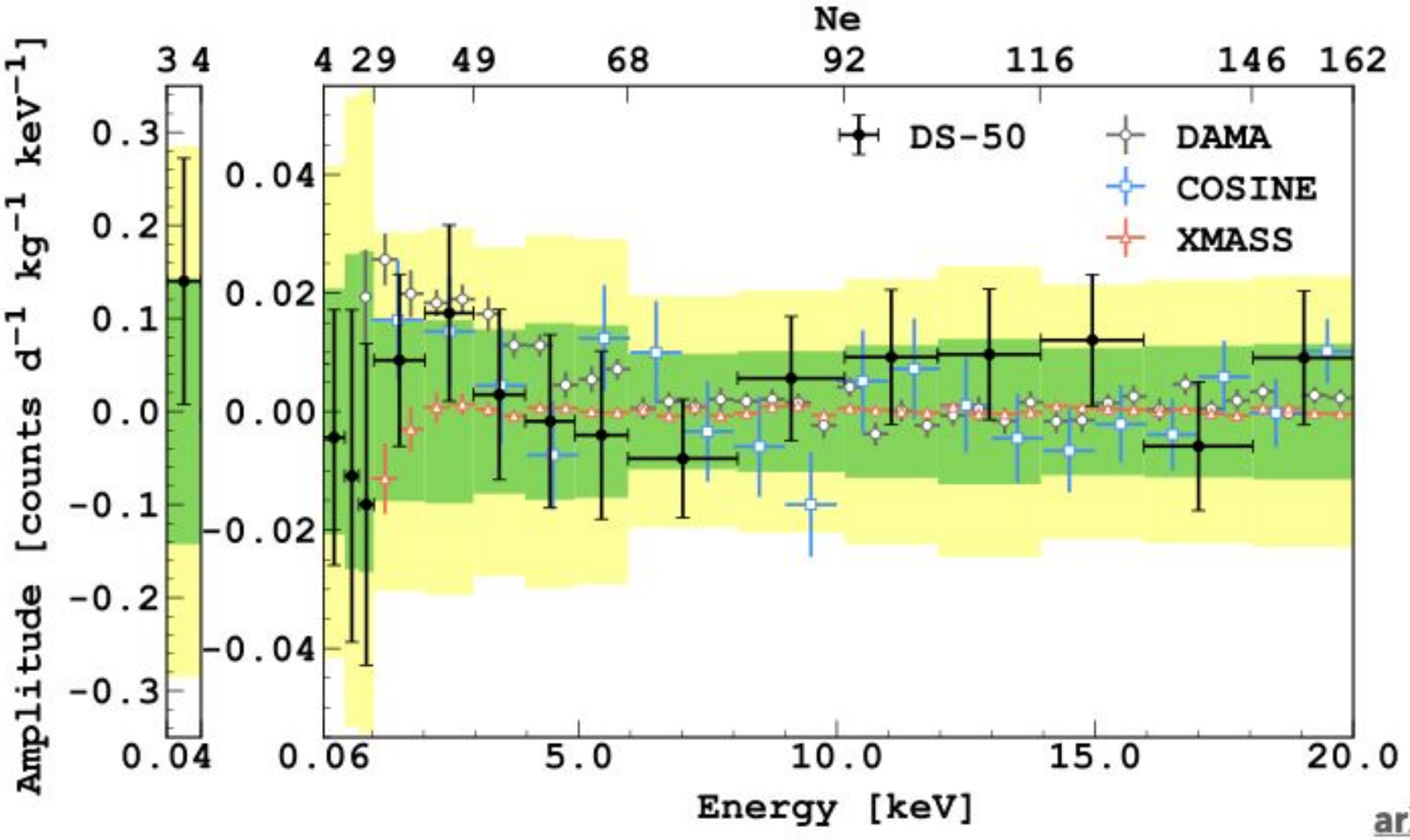
- The DAMA/LIBRA's observation with NaI(Tl) crystal
  - Modulation signature above the energy threshold of 0.75 keV
  - Traditional WIMP model faces challenges from the null-detection in many other experiments

P. Belli, IDM2022



DM-ANNUAL MODULATION SEARCH

- Searched for an event rate modulation in the DarkSide-50 data between 2.0 and 6.0 keVee, where DAMA/LIBRA observed a yearly modulated signal compatible with dark matter.
- For the first time, probed the energy range down to 0.04 keVee, the lowest threshold ever probed in an annual dark-matter modulation search.
- In **all** of the analyzed intervals, **a modulation signal was NOT observed**. The significance of this result is not sufficient to confirm or reject the DAMA/LIBRA observation.



arXiv:2307.07249

Publications and grants

- Publications:
  - "Sensitivity projections for a dual-phase argon TPC optimized for light dark matter searches through the ionization channel" The DarkSide-20k collaboration, P. Agnes *et al.* Phys. Rev. D 107, 112006 (2023).
  - "Search for low-mass dark matter WIMPs with 12 ton-day exposure of DarkSide-50" The DarkSide-50 collaboration, P. Agnes *et al.* Phys. Rev. D 107, 063001 (2023) *World Leading Results!!*
  - "Search for dark matter particle interactions with electron final states with DarkSide-50" The DarkSide-50 collaboration, P. Agnes *et al.* Phys. Rev. Lett. 130, 101002 (2023) *World Leading Results!!*
  - "Search for dark matter-nucleon interactions via Migdal effect with DarkSide-50" The DarkSide-50 collaboration, P. Agnes *et al.* Phys. Rev. Lett. 130, 101001 (2023) *World Leading Results!!*
  - "Measurement of isotopic separation of argon with the prototype of the cryogenic distillation plant Aria for dark matter searches" The DarkSide-20k collaboration, E. Aaron *et al.* Eur. Phys. J. C 83, 453 (2023)
  - "Study on cosmogenic activation above ground for the DarkSide-20k project" The DarkSide-20k collaboration, E. Aaron *et al.* Astropart. Phys. 152, 102878 (2023)
  - "Constraints on directionality effect of nuclear recoils in a liquid argon time projection chamber" The DarkSide-20k collaboration, P. Agnes *et al.* Eur. Phys. J. C 84, 24 (2024)
  - "Search for low mass dark matter in DarkSide-50: the bayesian network approach" The DarkSide-50 collaboration, Agnes, P. *et al.* Eur. Phys. J. C 83, 322 (2023)
  - "Search for dark matter annual modulation with DarkSide-50" The DarkSide-50 collaboration, Agnes, P. *et al.* submitted to a journal *First measurement of this kind in liquid Ar!!*
  - "Long-term temporal stability of the DarkSide-50 dark matter detector" The DarkSide-50 collaboration, Agnes, P. *et al.* submitted to a journal
- Presentations:
  - Particle Astrophysics in Poland (Feb. 2023)
  - TAUP 2023 (Aug. 2023)
  - ACHEP23 (Oct. 2023)
  - IFJ Seminar (Dec. 2023)
- Outreach:
  - MasterClass 3Dpi: the Liquid Argon PET (July 2023)
- Grants:
  - SONATA-BIS 11 (M. Wada, granted 2.8M PLN for 3 years) On going…
  - Nicolaus Copernicus Grant (submitted in Summer 2023, but need to be resubmitted)