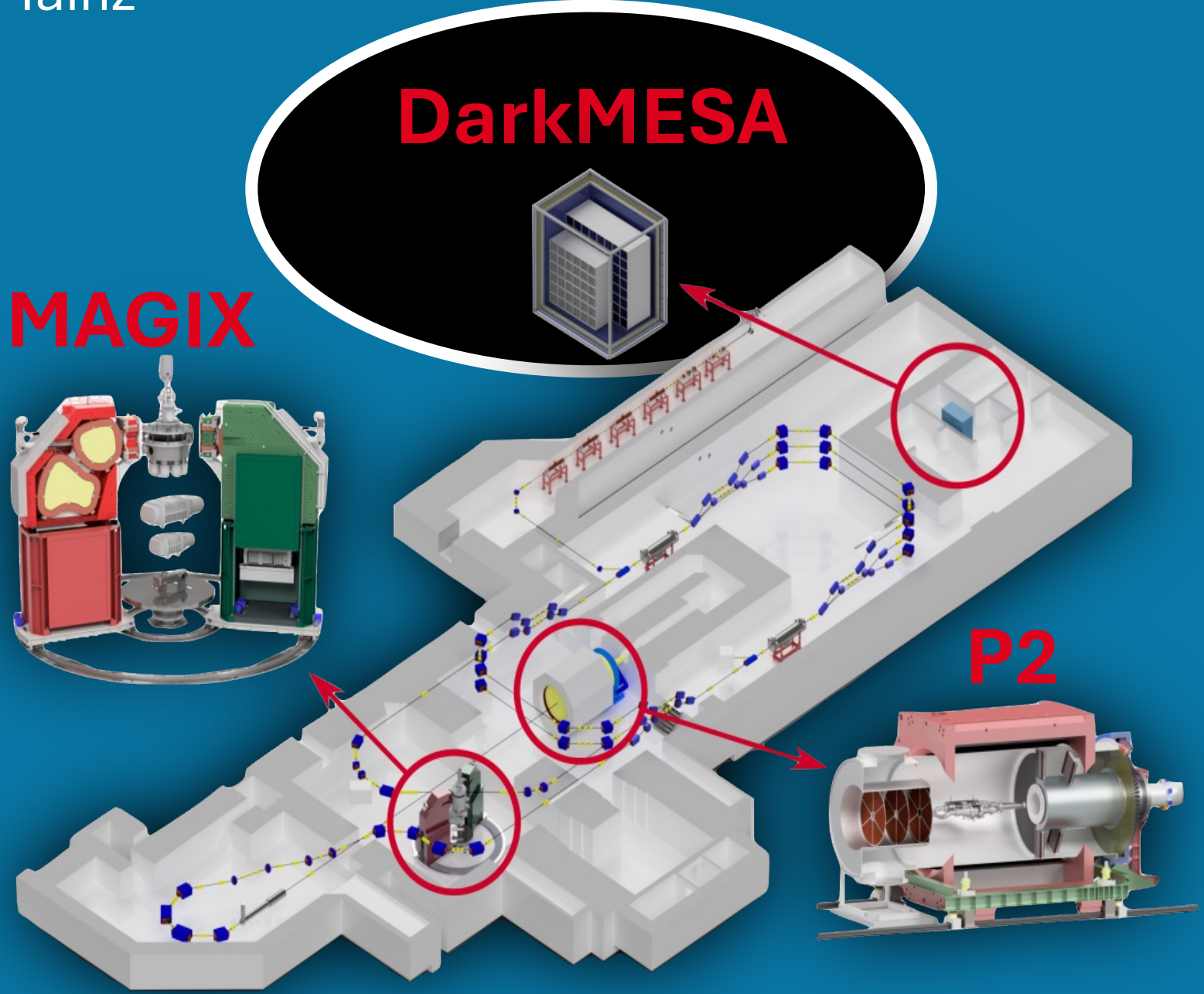


Light Dark Matter Production at MESA

MESA – A New Electron Accelerator in Mainz

Mainz Energy-Recovering Superconducting Accelerator

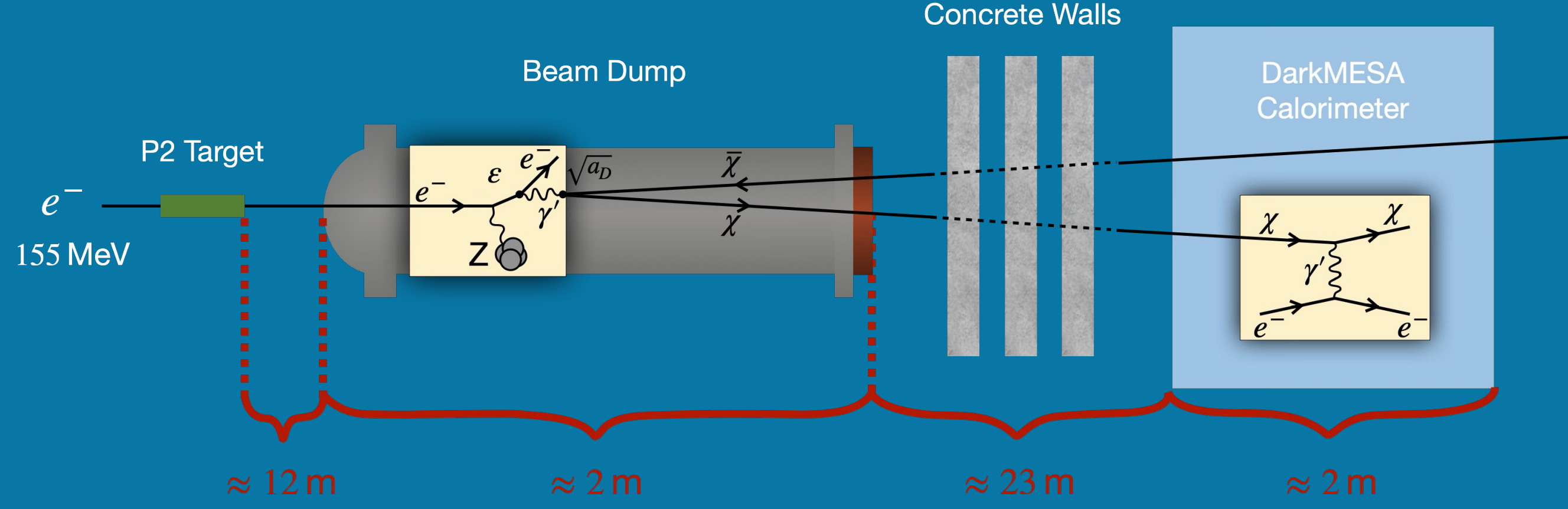
- Currently under construction in Mainz
- First test beam mid 2026
- Experiments:
 - MAGIX
 - P2
 - DarkMESA
- Beam current up to 0.15 mA at 155 MeV for P2 Experiment
- Possibility of the **parasitic beam dump experiment DarkMESA**



[1] Schlimme et al., The MESA physics program, 2024

Physical Motivation

Assumption:
Light dark matter interaction with standard model through (massive) dark photon γ'

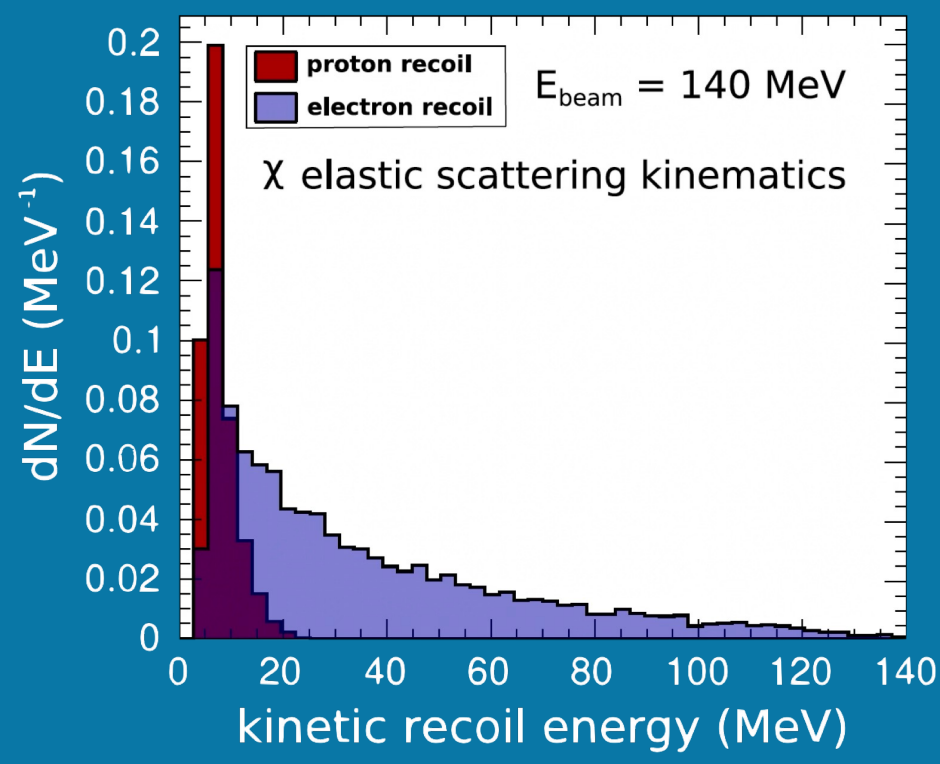
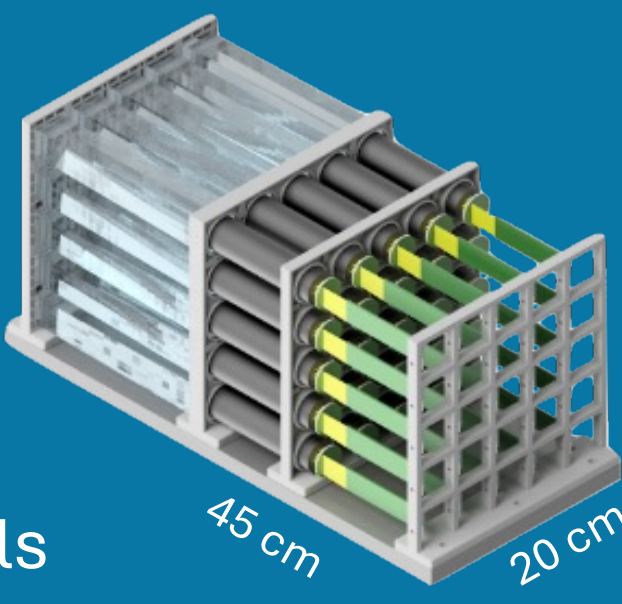


- Generation of γ' through bremsstrahlung like process
- Invisible decay of dark photon in beam dump
- Shielding of SM particles through concrete walls
- DM particle χ cross concrete and air undisturbed
- Fraction of the DM particles scatter off electrons in the DarkMESA detector

α_D - dark coupling constant
 ϵ - Interaction parameter of DM with SM

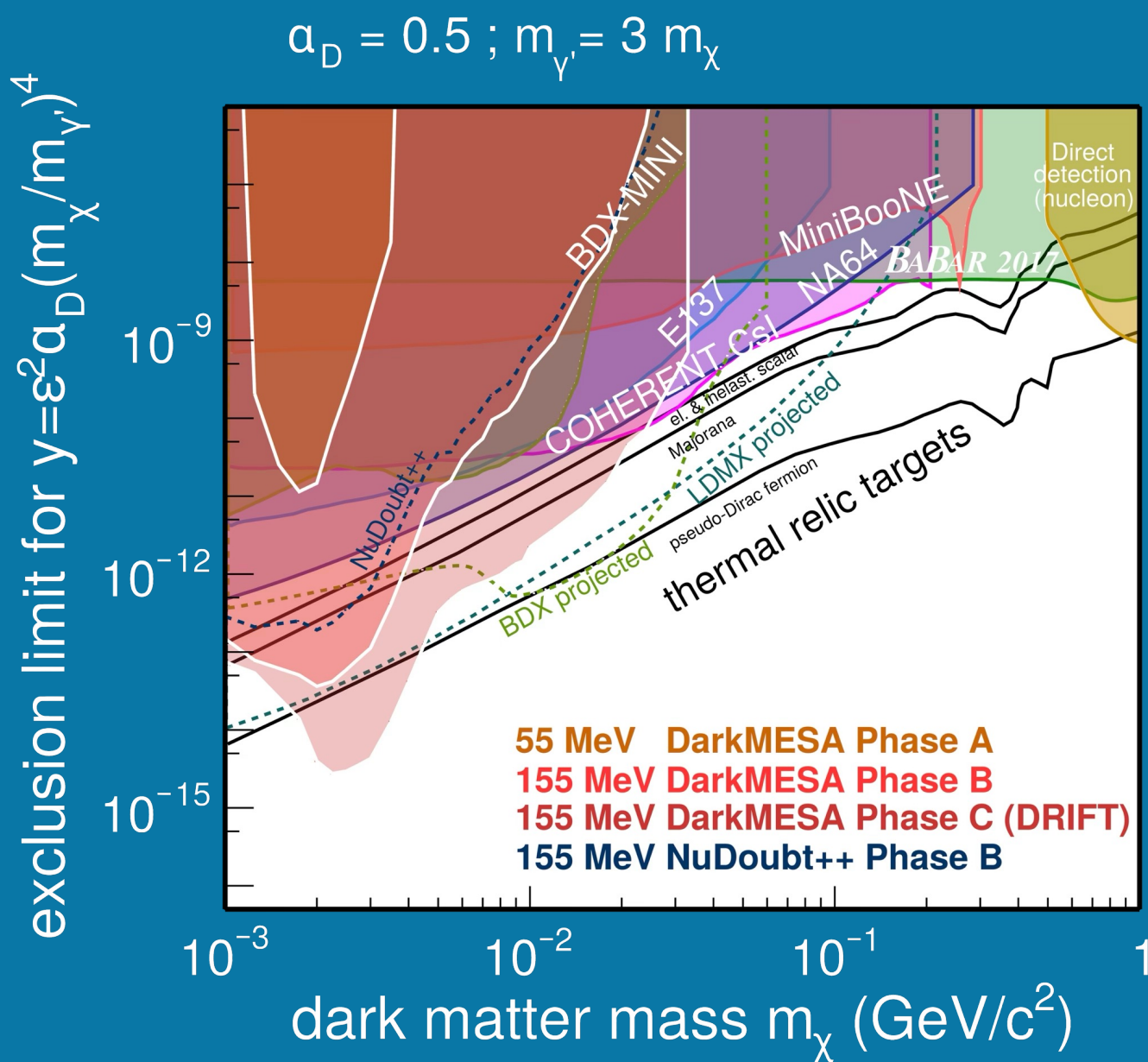
Phase A

- Calorimeter for recoil electrons
- Active volume of 4 dm³
- 5x5 PbF₂ Cherenkov detector crystals
- Readout currently through PMTs
- Veto: two layers of plastic scintillators
- Lead absorber layer in between



DarkMESA Detector design

Exclusion Limits

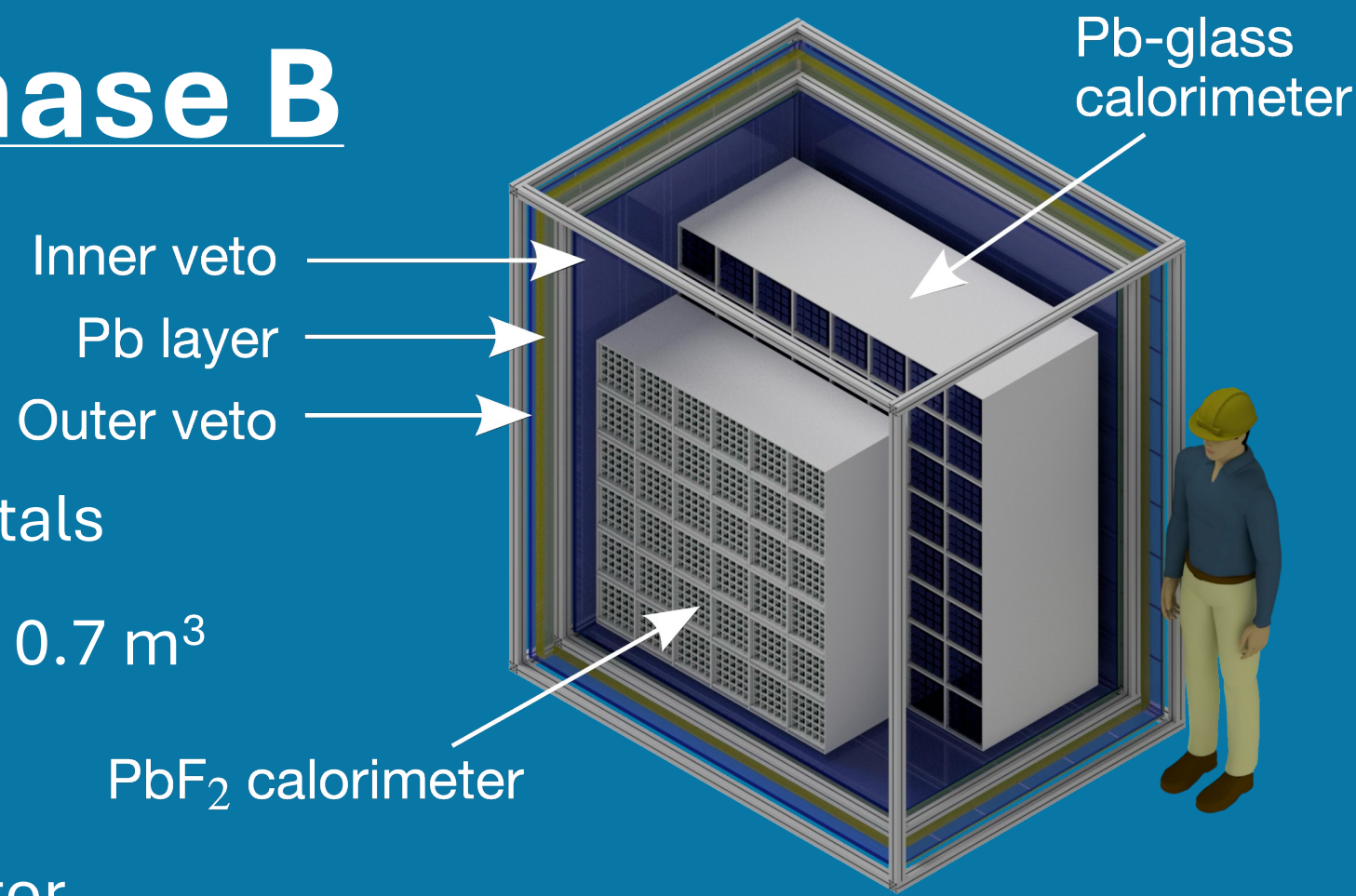


[2] Plura et al., Search for Light Dark Matter with the DarkMESA Experiment, 2024

Phase B

Current plan:

- 30x30 PbF₂ crystals
- 32x32 SF5 lead glass crystals
- Active volume increase to 0.7 m³
- Improvement of Phase A
- Possibly additional detector technologies (Liquid Scintillators, ...)



Phase	Time	EOT
A	2000 h	$6.74 \cdot 10^{21}$
B	6000 h	$2.02 \cdot 10^{22}$
C	6600 h	$2.22 \cdot 10^{22}$

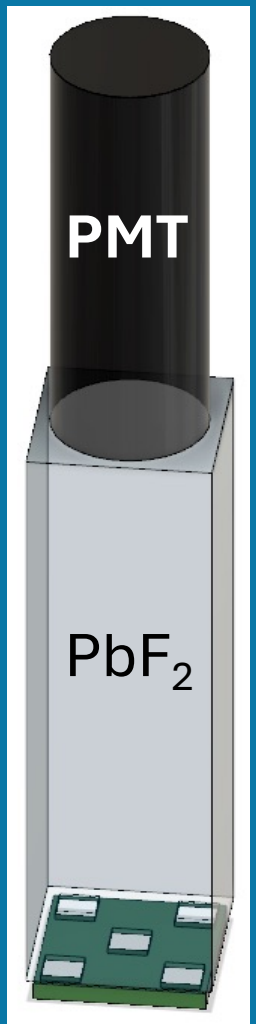
EOT = Number of Electrons on Target

Challenge

- LDM events proposed to be only a few counts per year
- Noise reduction and coincidence important
- Aim: Reducing dark count rate to 1 per 1000 years
- Even double sided PMT still not sufficient

Experimental Setup

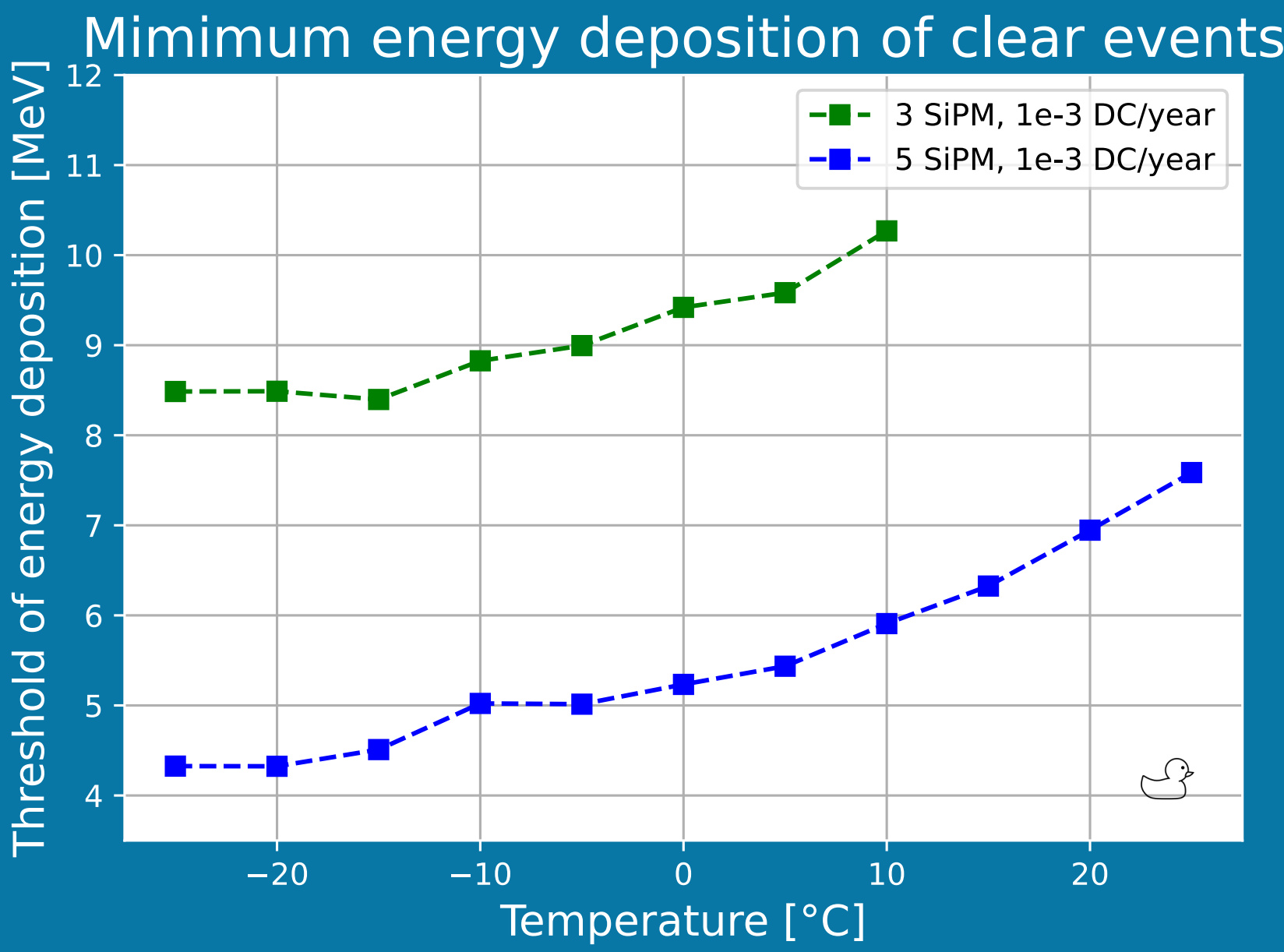
- Idea: PMT (trigger) + 5 SiPMs in coincidence
- SiPM with high dark count rate
- Alcohol cooling for SiPMs
- Dark count measurement with scaler
- Cosmics measurement with digitizer



SiPM board

Noise Reduction SiPM dark count analysis

Result



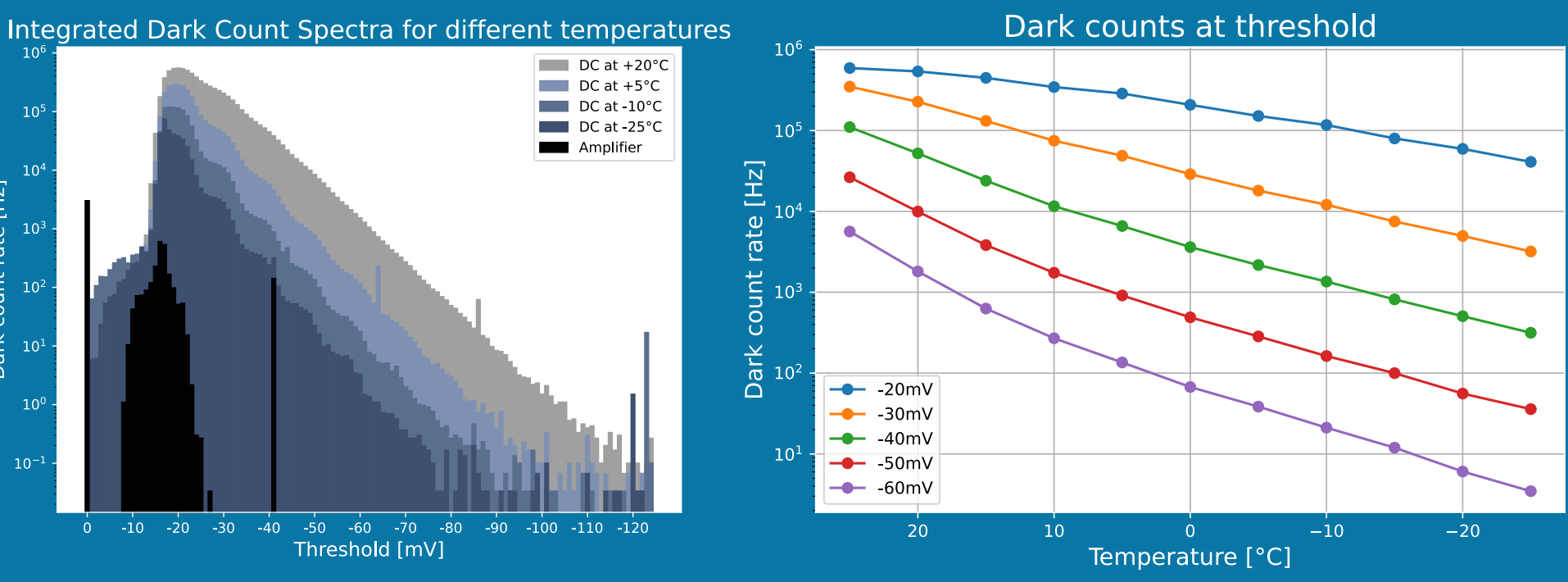
- Cosmic muons for energy calibration
- Measurement of 5 MeV energy deposition possible
- Dark count rate less than 1 per 1000 years

Summary and Outlook

- Dark count rate of SiPMs with coincidence and cooling at extremely low level
- Long-term measurements at -25°C

SiPM Study

- Dark counts of single SiPM at different temperatures
- Dark count rate with amplitude higher than threshold



SiPM Coincidence

- Coincidence rate:

$$f_{DC} = k \cdot \tau^{k-1} \cdot f^k$$

(From [3] V. Bocci, A simple model for multiple coincidence SiPM dark noise, 2024)

- Minimal threshold for 3- and 5-fold SiPM coincidence
- Threshold corresponds to energy deposition in detector

