Status and perspectives of the POKER detector for Dark Sector searches

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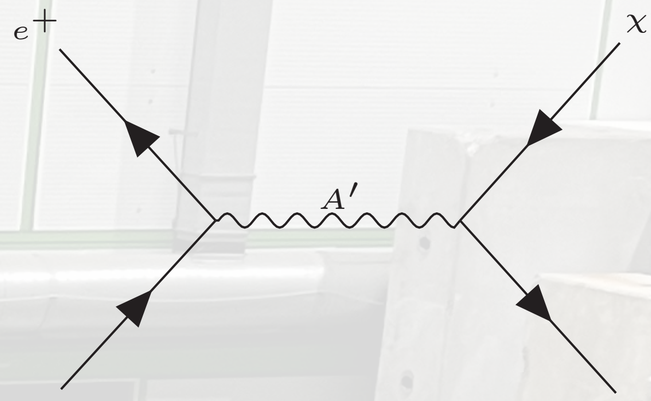
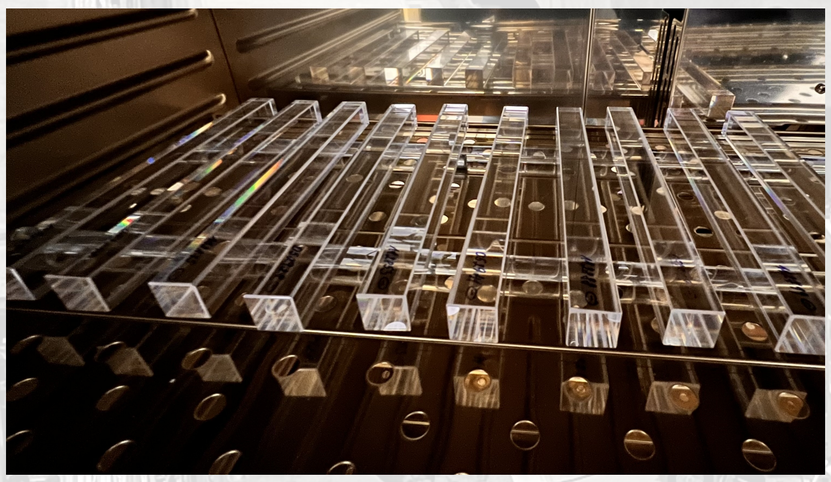
Introduction

The search for Dark Matter is a key question in modern physics.

- The light Dark Matter (LDM) hypothesis suggests particles with mass below a few GeV/c^2 interacting with SM particles via a "dark photon".
- CERN's NA64 experiment uses the SPS beam requiring a 100 GeV electron beam to probe LDM via the missing energy technique [1].
- The POKER project proposes using multi-energy positron beams to detect LDM through resonant annihilation with atomic electrons [2].
- Higher energy resolution is needed due to the annihilation signature, requiring a novel active target (PKR-CAL) made of a 9×9 lead tungstate ($PbWO_4$) crystal matrix with SiPM readout
- The SPS beam has a spill-like structure. Each spill lasts 4.8 seconds. The frequency of the impinging particles is $\approx$ 1 MHz.

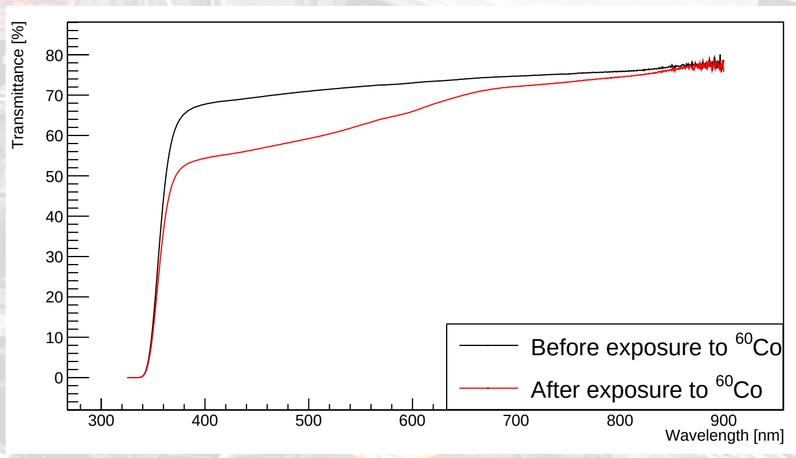




$PbWO_4$ radiation tolerance

PKR-CAL crystals are subjected to a high stochastic rate.

- This leads to radiation damage which can affect optical properties ($>$ 100 rad/h)
- The radiation tolerance of the crystals was evaluated by exposing them to an intense ^{60}Co source ($\simeq$30 Gy dose)
- The optical transmittance of the crystals was measured before and after the exposure and the damage was evaluated in terms of the parameter $\mathrm{d}_k = \frac{1}{L} \ln \frac{T_{\text{before}}}{T_{\text{after}}}$



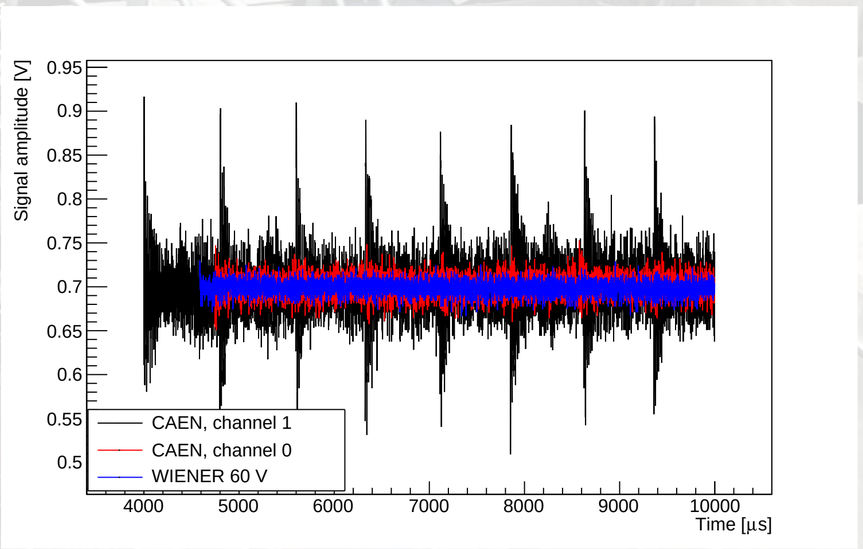
HV supply board

Requested gain fluctuation is $\simeq 1\%$, and since:

$$\frac{\Delta G}{G} \simeq \frac{\Delta V_b}{V_b - V_{break}} \rightarrow \Delta V_b \simeq 10\,\text{mV}$$

The greatest challenge is the response to the SPS beam structure.

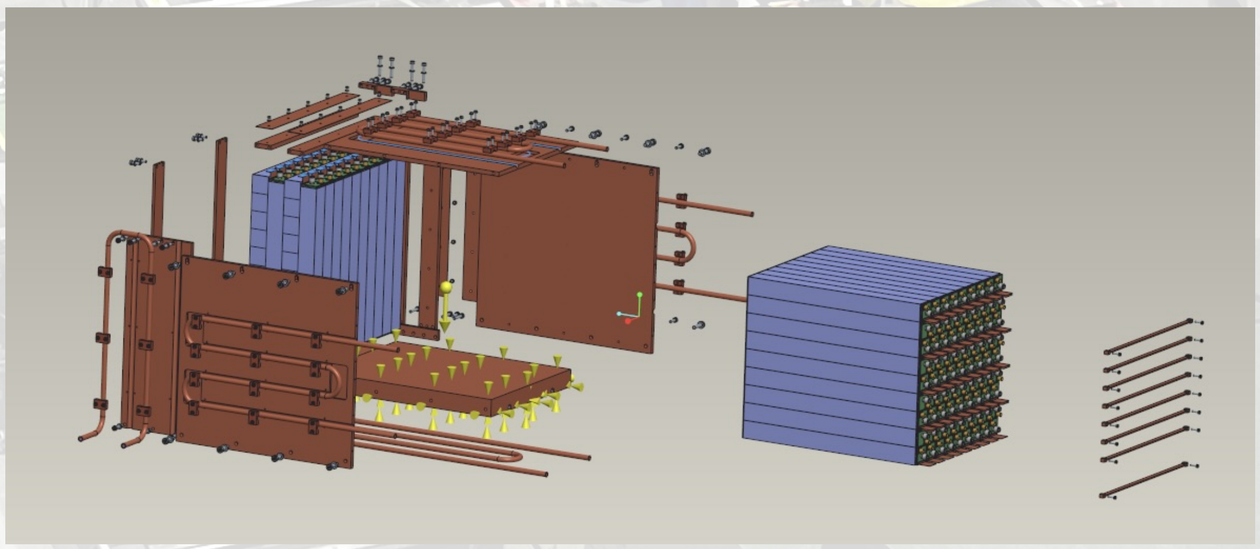
- Boards characterized with a custom laser system that reproduced the SPS spill structure
- We used the thermal noise of a SiPM, coupled to a custom clock system, as a source of stochastic events
- We tested several boards, including CAEN1539A and Wiener OMPV8060
- All characterized boards show an increased bias voltage fluctuation when the system is operated with stochastic laser pulses, possibly because of the HV generator output impedance.



Summary and Outlook

POKER is an ERC-funded project aiming to detect light dark matter using positron beams at the SPS accelerator @CERN.

- The crystals' radiation hardness has been measured, and it is in line with POKER requirements
- The HV supply complies with the requirements
- The PKR-CAL assembly is currently ongoing
- The first run is foreseen for 2025



KEY REFERENCES

[1] Yu. M. Andreev *et al.* (NA64 Collaboration) **Search for Light Dark Matter with NA64 at CERN** - Phys. Rev. Lett. 131, 161801 (2023)

[2] L. Marsicano *et al.* **Novel Way to Search for Light Dark Matter in Lepton Beam-Dump Experiments** - Phys. Rev. Lett. 121, 041802 (2018)

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MORE INFORMATION

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