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Microcalorimetric high-resolution spectroscopy of muonic lithium

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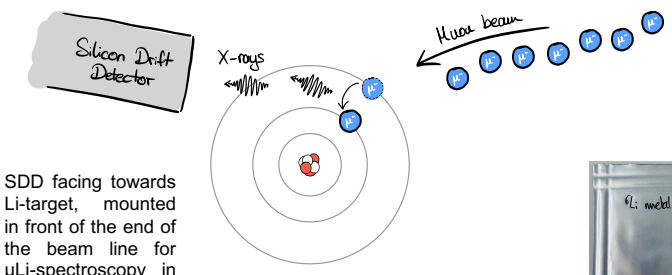
1 Introduction

Precision measurements of absolute charge radii provide important benchmarks and inputs for modern nuclear structure theory using realistic nuclear potentials [1]. In order to overcome the large gap of accurate experimental data for nuclear charge radii in the range of $2 < Z < 11$, we aim at the spectroscopy of muonic atoms using new high-resolution metallic magnetic microcalorimeters (MMC) in an upcoming project at PSI.

2 Muonic Atom X-Ray Spectroscopy

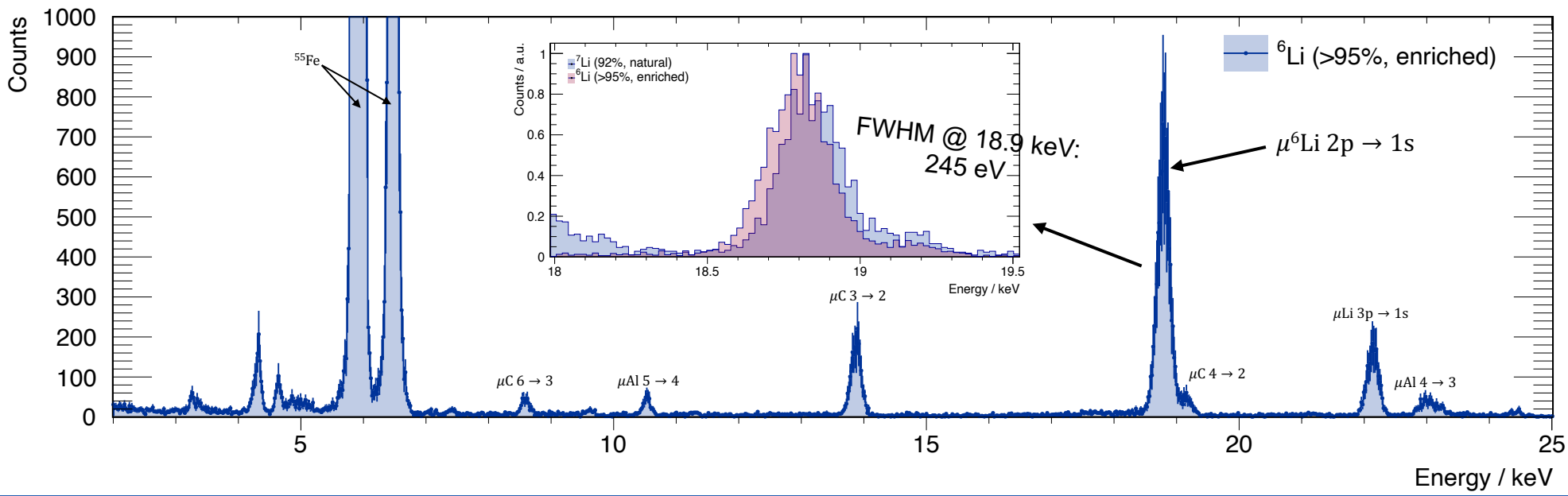
SDD facing towards Li-target, mounted in front of the end of the beam line for μLi-spectroscopy in PiE1 at PSI during the muX beam time in September 2022.



^{6}Li target packed in Al laminate pouch.

3 Preliminary μLi Spectroscopy

First proof of concept-data taken with a silicon drift detector (SDD) during muX beam time 2022:

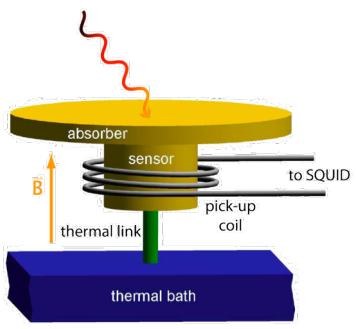


4 Future MMC Spectroscopy

Detection principle:

- X-Ray energy deposited in Au:Er absorber
- Absorber Temperature change readout via SQUID

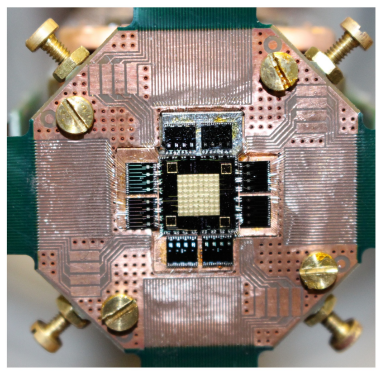
$$\Delta\Phi_{\mathrm{coil}} \propto \frac{\partial M}{\partial T}\Delta T = \frac{\partial M}{\partial T}\cdot\frac{1}{C_{\mathrm{tot}}}E_\gamma$$



Schematic drawing of the MMC working principle. [3]

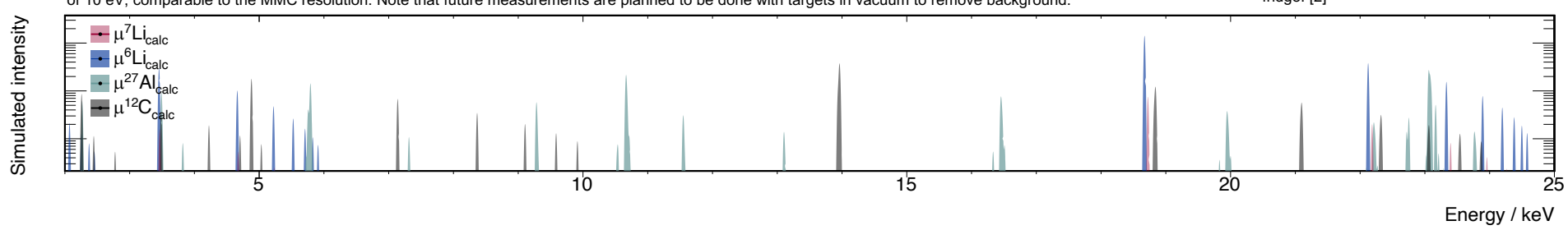
maXs-30 MMC:

- 64-pixel Au:Er absorber array
- Resolution: 9.8 eV @ 60 keV (FWHM) [4]
- Operating temperature: ~ mK



Microfabricated maXs-30 MMC detector array mounted on a cold finger of a dilution fridge. [2]

Calculated spectrum of a μ^{6}Li target according to measured intensities including background from Al, C and and ^{7}Li. The line withs are set to a FWHM of 10 eV, comparable to the MMC resolution. Note that future measurements are planned to be done with targets in vacuum to remove background.



References

1. S. Gandolfi, D. Lonardoni, A. Lovato and M. Piarulli, Atomic Nuclei From Quantum Monte Carlo Calculations With Chiral EFT Interactions, Front. Phys., 2020.
2. Kraft-Bermuth, S., Hengstler, D., Egelhof, P., Enss, C., Fleischmann, A., Keller, M., & Stöhlker, T. (2018). Microcalorimeters for X-Ray Spectroscopy of Highly Charged Ions at Storage Rings. Atoms, 6(4), 59.
3. Schulz, D. P. (2021). Development and characterization of MOCCA, a 4k-pixel molecule camera for the energy-resolved detection of neutral molecule fragments (Doctoral dissertation).
4. Geist, J. (2020). Bestimmung der Isomerenergie von 229Th mit dem hochauflösenden Mikrokalorimeter-Array maXs30 (Doctoral dissertation).