Istituto Nazionale Fisica Nucleare - Laboratori Nazionali di Frascati

Fundamental physics with exotic atoms and radiation detectors

25 / 11 /2021

Progresses in Silicon Drift Detectors for high precision kaonic atoms X-ray measurements: from the SIDDHARTA-2 experiment to the future

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On behalf of SIDDHARTA-2 collaboration

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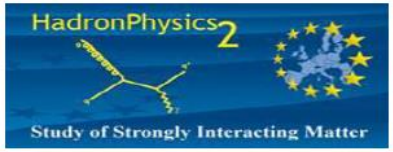
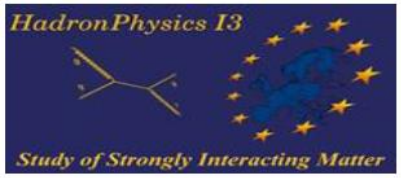
SIDDHARTA – 2

Silicon Drift Detectors for Hadronic Atom Research by Timing Application





FWF Der Wissenschaftsfonds.

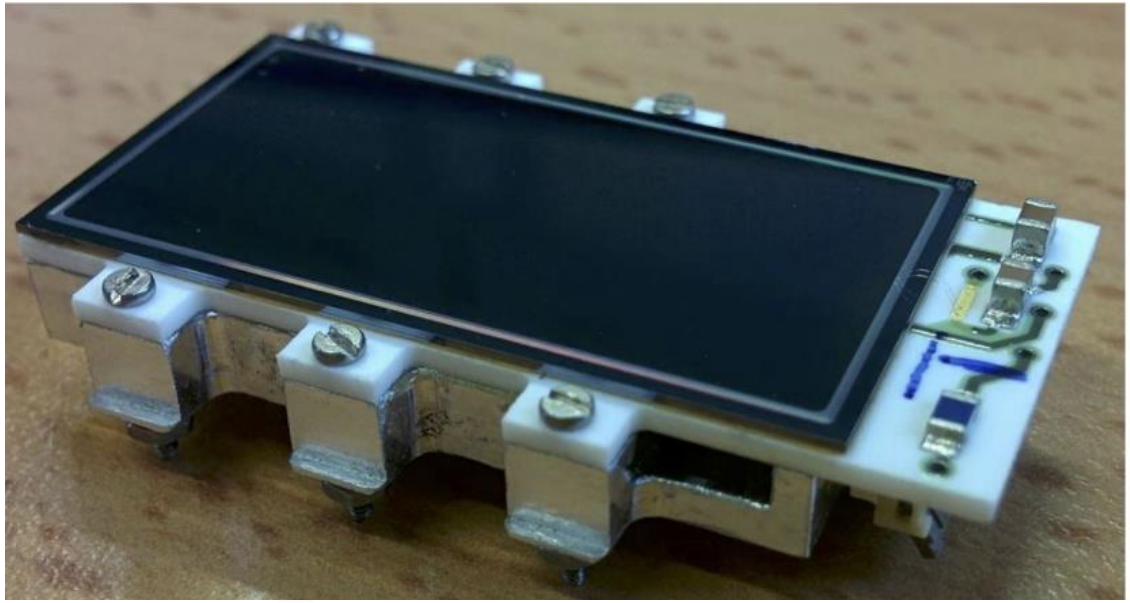
Farnesina
Ministero degli Affari Esteri
e della Cooperazione Internazionale

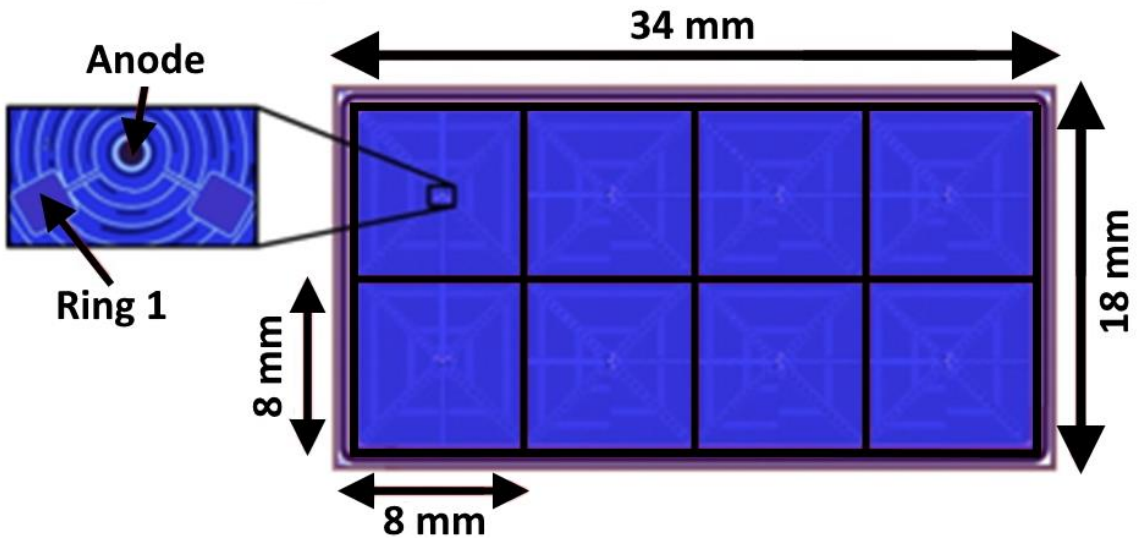
LNF-INFN, Frascati, Italy
SMI-ÖAW, Vienna, Austria
Politecnico di Milano, Italy
IFIN –HH, Bucharest, Romania
TUM, Munich, Germany
RIKEN, Japan
Univ. Tokyo, Japan
Victoria Univ., Canada
Univ. Zagreb, Croatia
Univ. Jagiellonian Krakow, Poland
ELPH, Tohoku University

STRONG-2020

Croatian Science Foundation, research project 8570

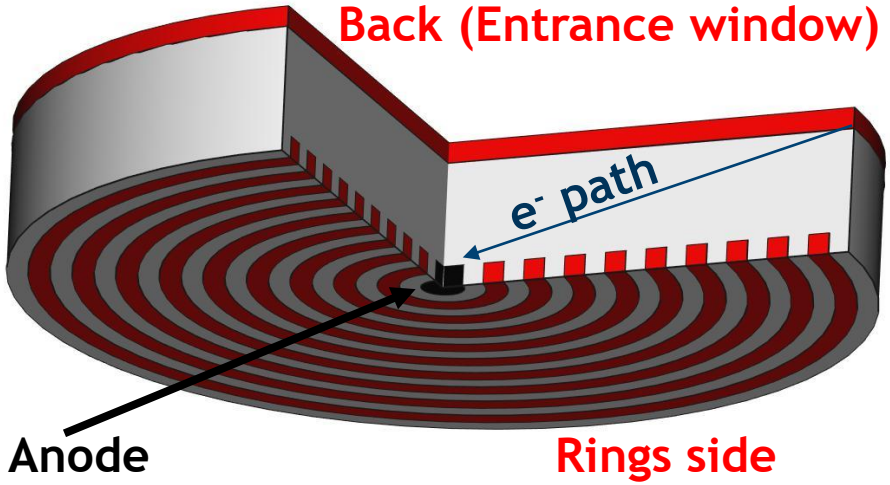
Large area Silicon Drift Detectors (SDDs)

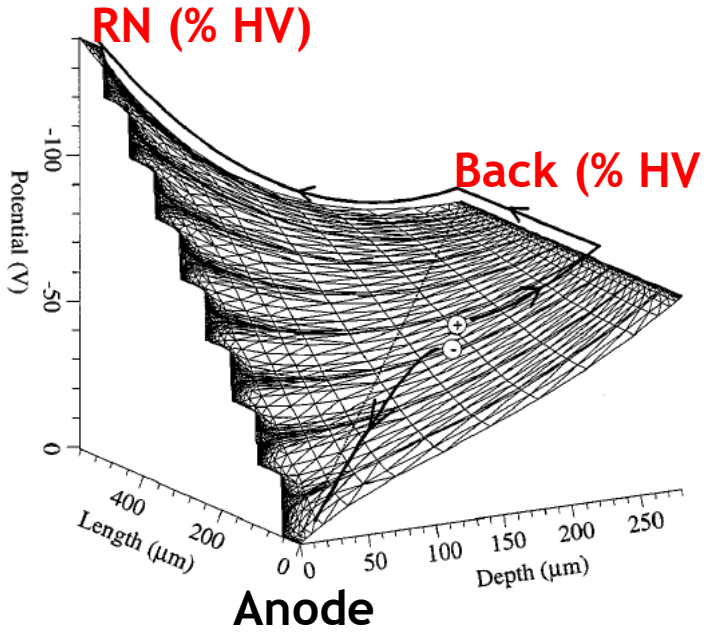




8 SDD units (0.64 cm^2)
total active area of 5.12 cm^2

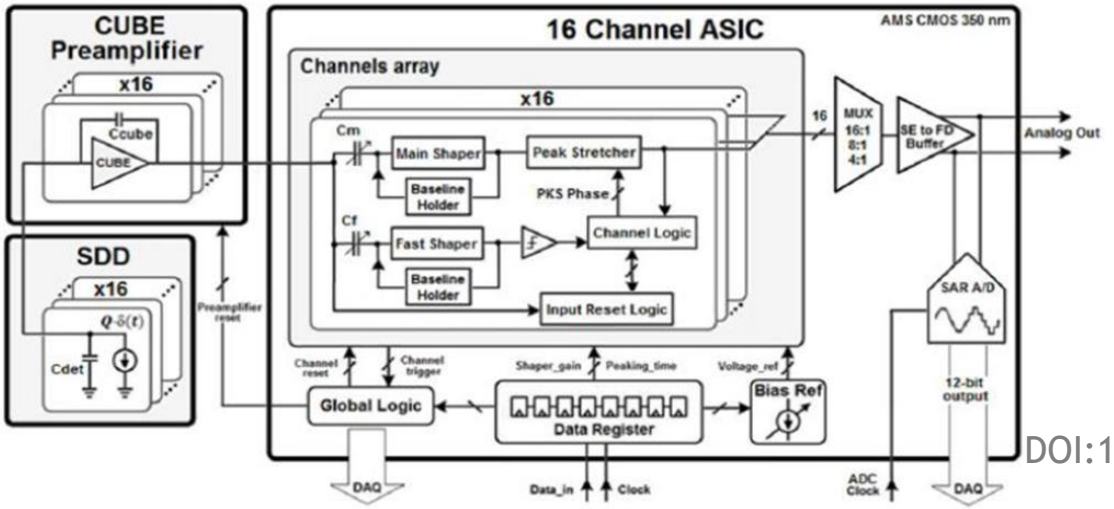
Large area Silicon Drift Detectors (SDDs)





DOI: 10.1109/23.870862

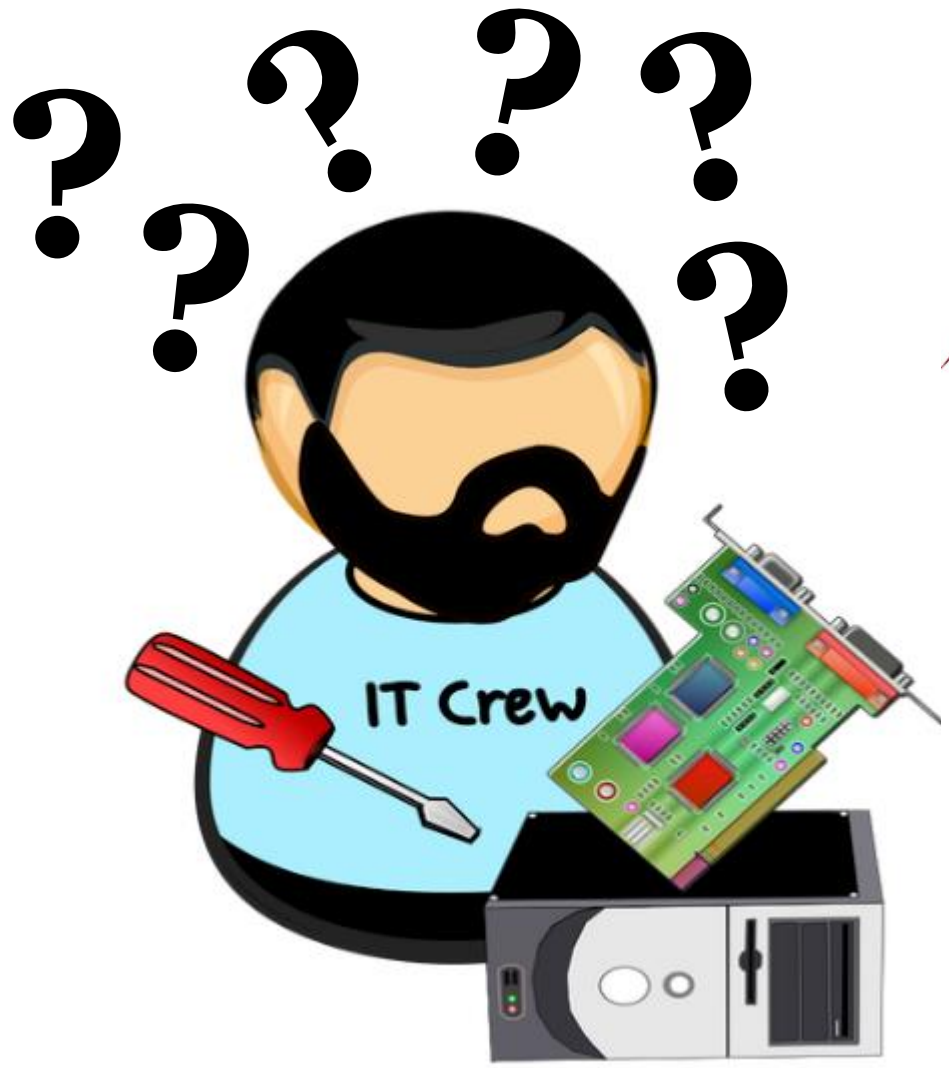
SDDs Front End Electronic (CUBE + SFERA)



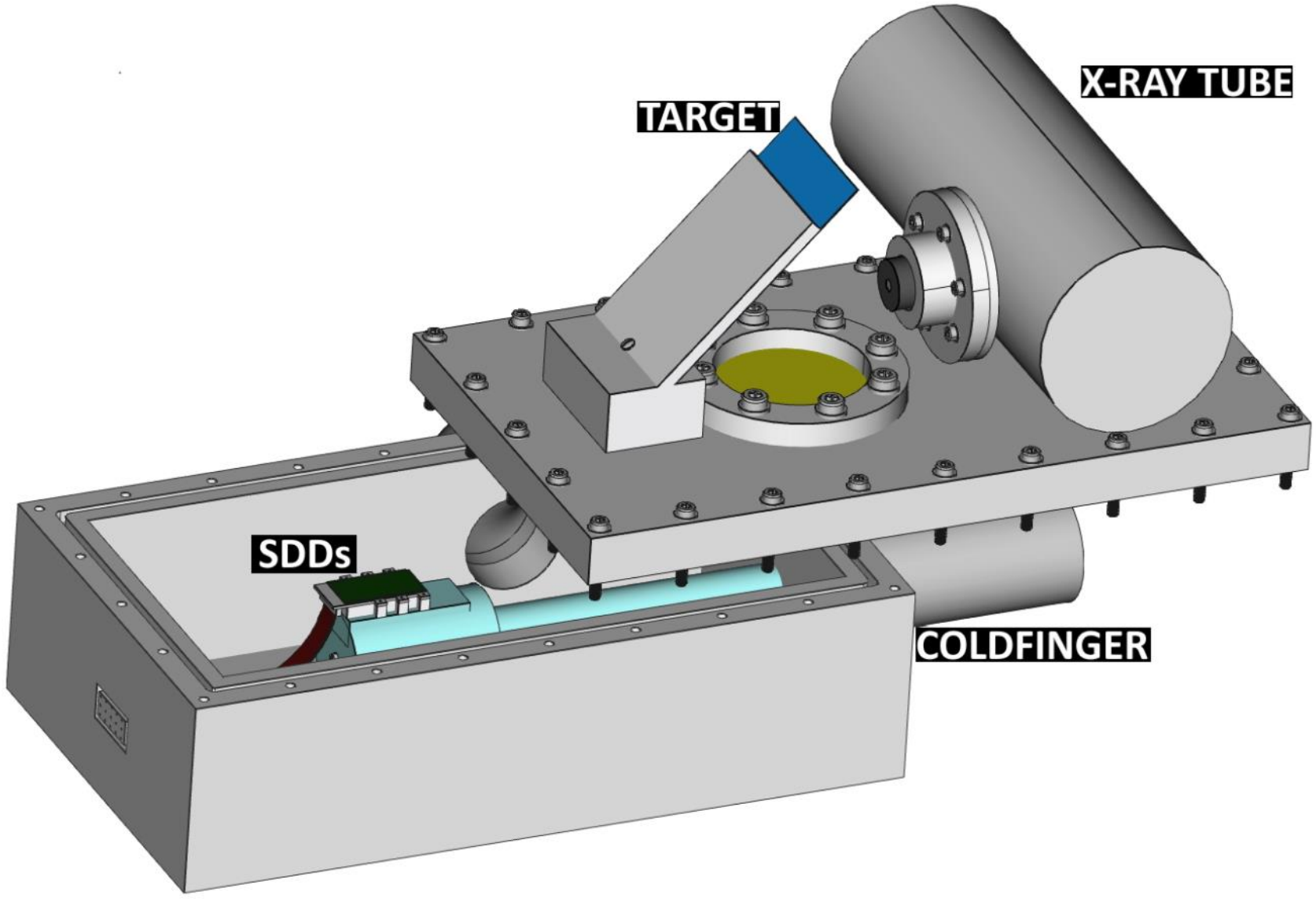
DOI:10.1016/j.nima.2015.08.079

PHASE 1

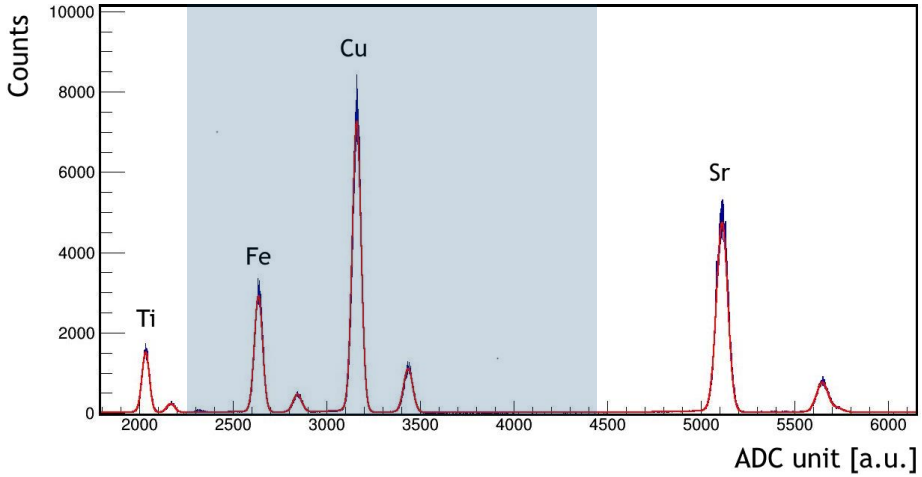
Laboratory SDDs technology optimization



SDDs Energy response optimization

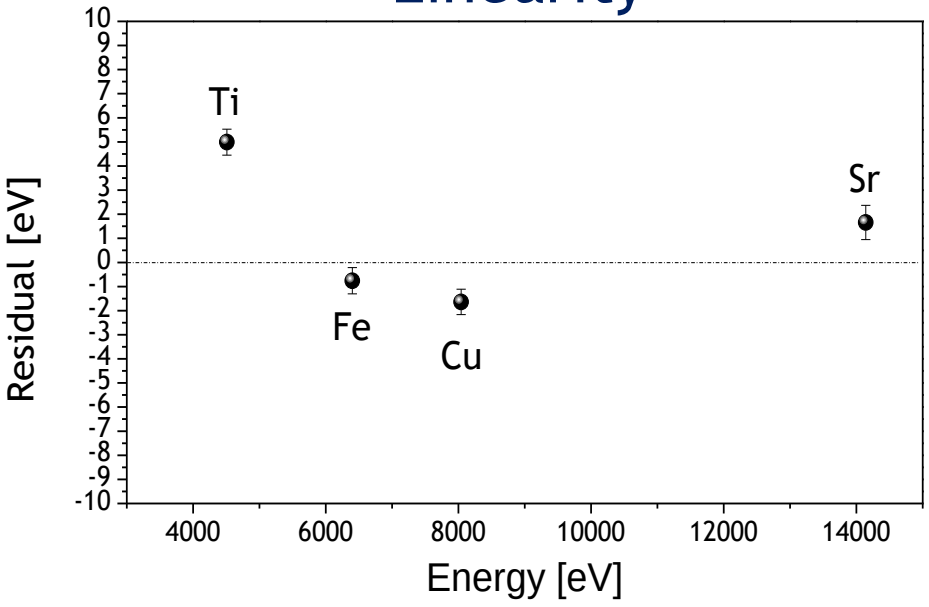


SDDs Energy response optimization

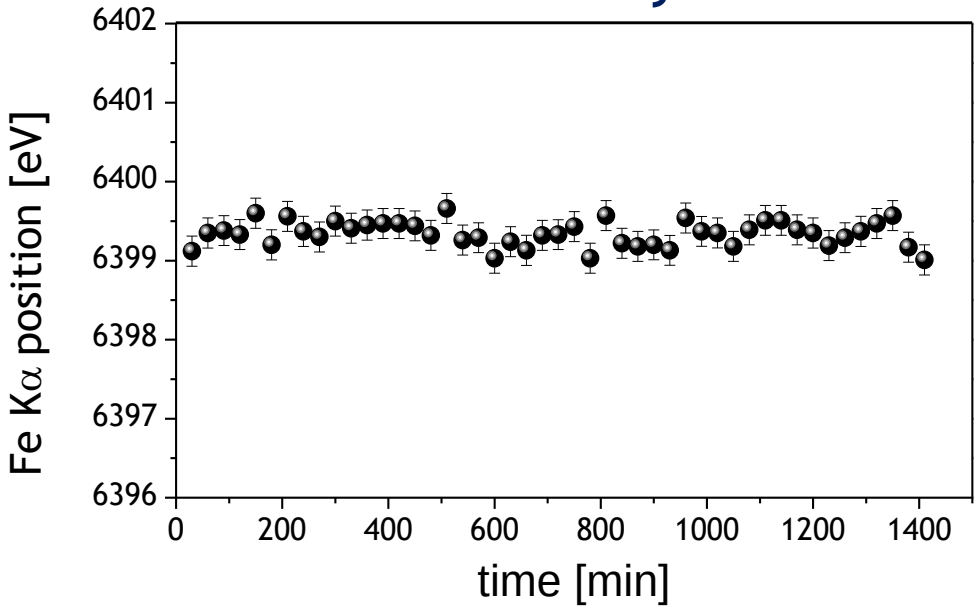


The SDDs system linearity and stability is within few eV ($\Delta E/E < 10^{-3}$)

Linearity

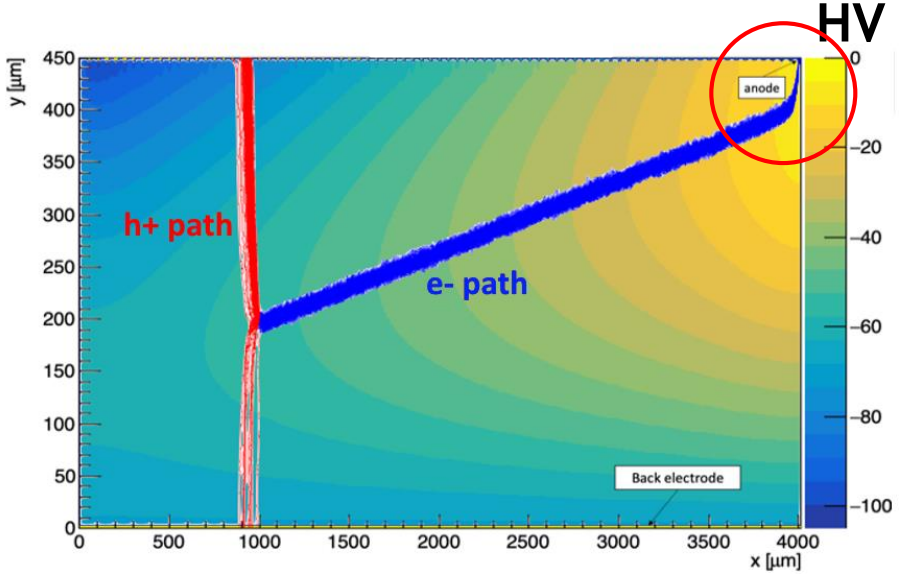


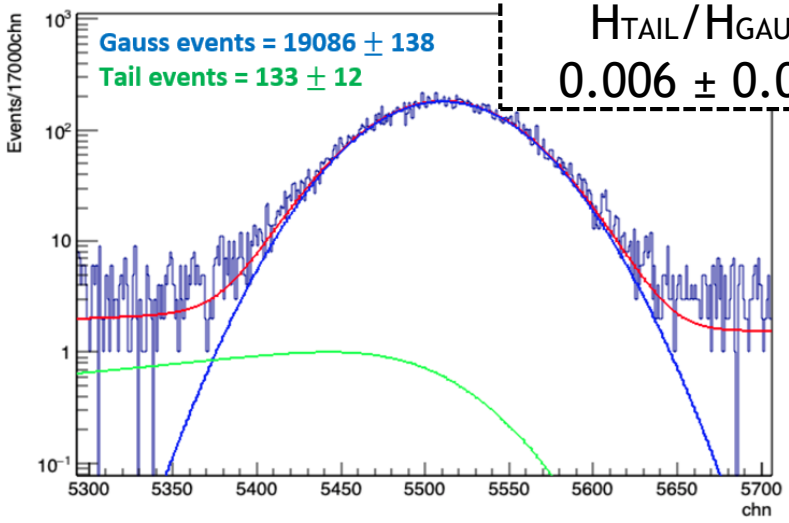
Stability



SDDs Energy response optimization

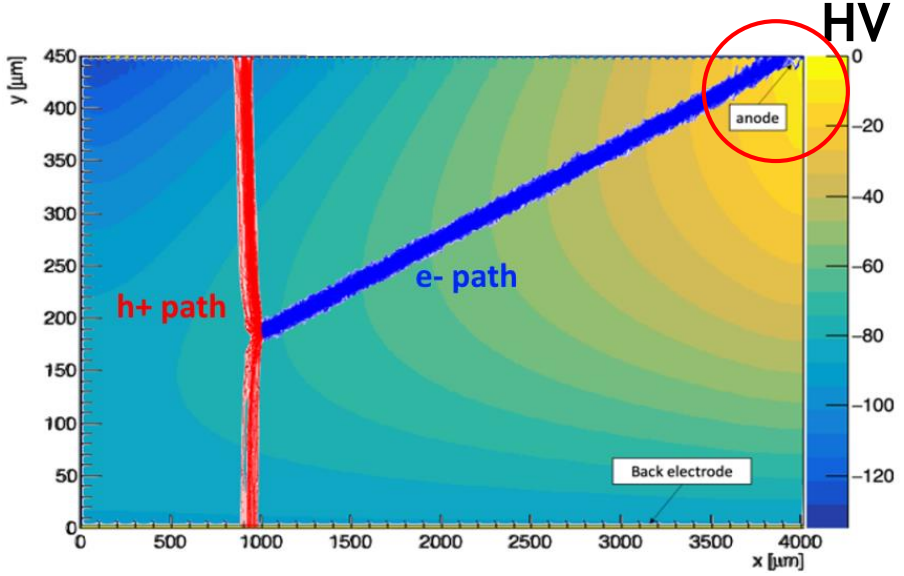
HV = 140 V

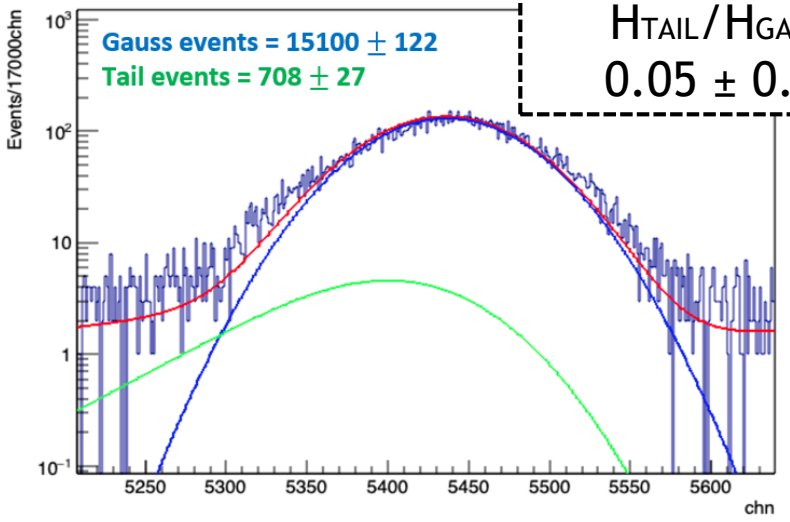




H_{TAIL}/H_{GAUSS}
0.006 ± 0.001

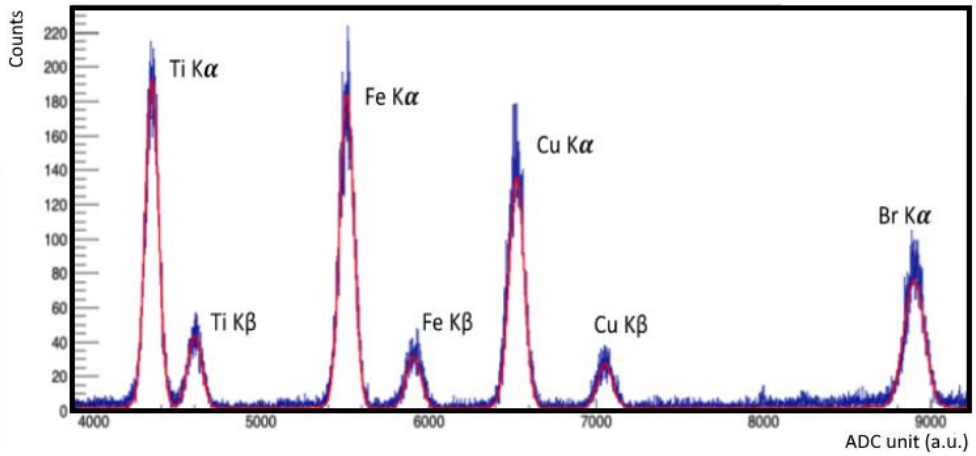
HV = 180 V





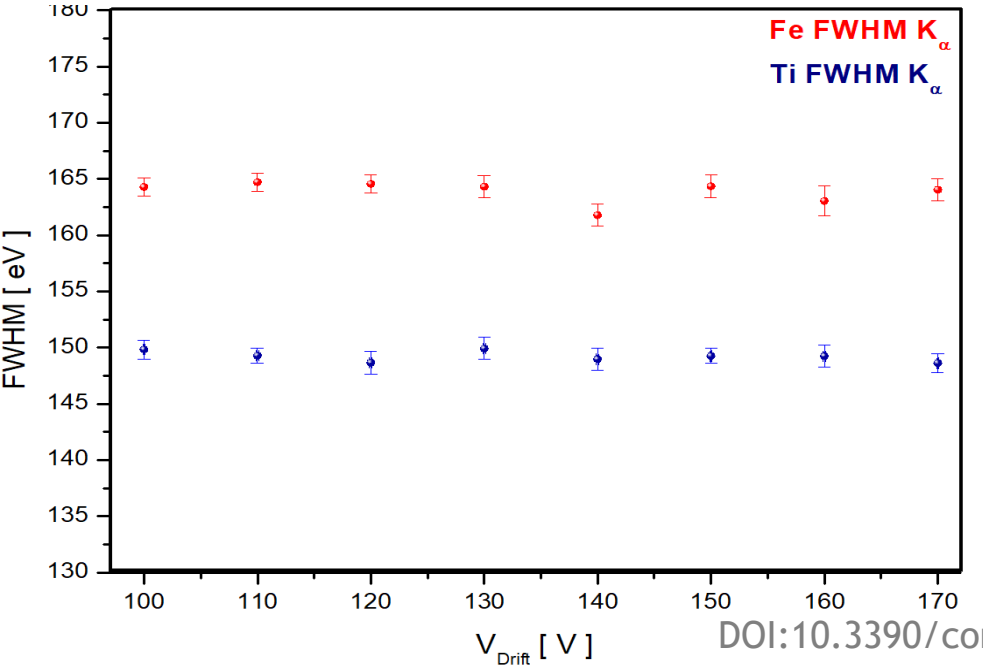
H_{TAIL}/H_{GAUSS}
0.05 ± 0.01

SDDs Energy response optimization

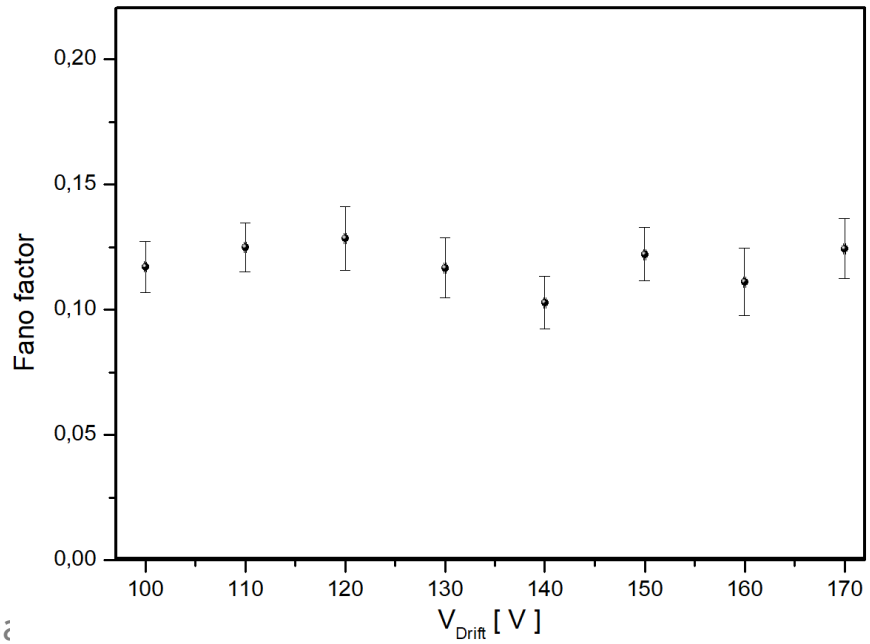


Control of the SDDs energy response (1)
No drawbacks for common polarization

Energy resolution (vs HV)

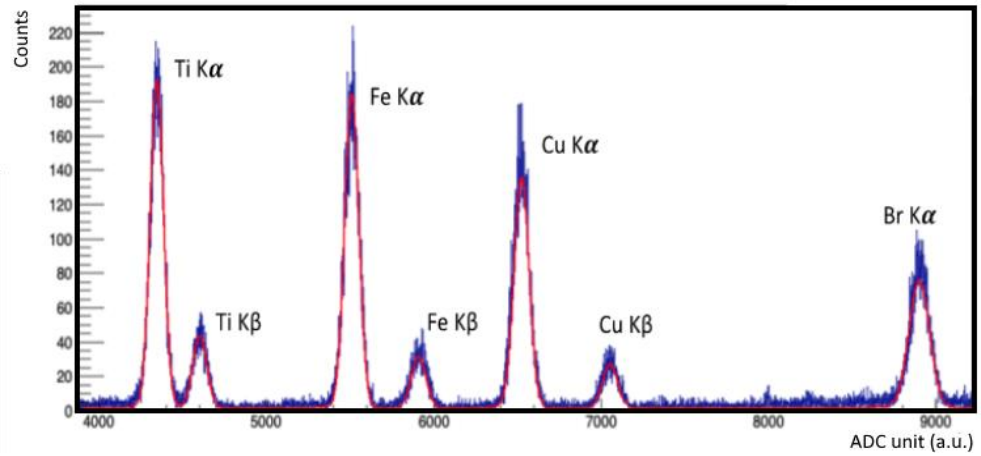


FF = 0.118 ± 0.009



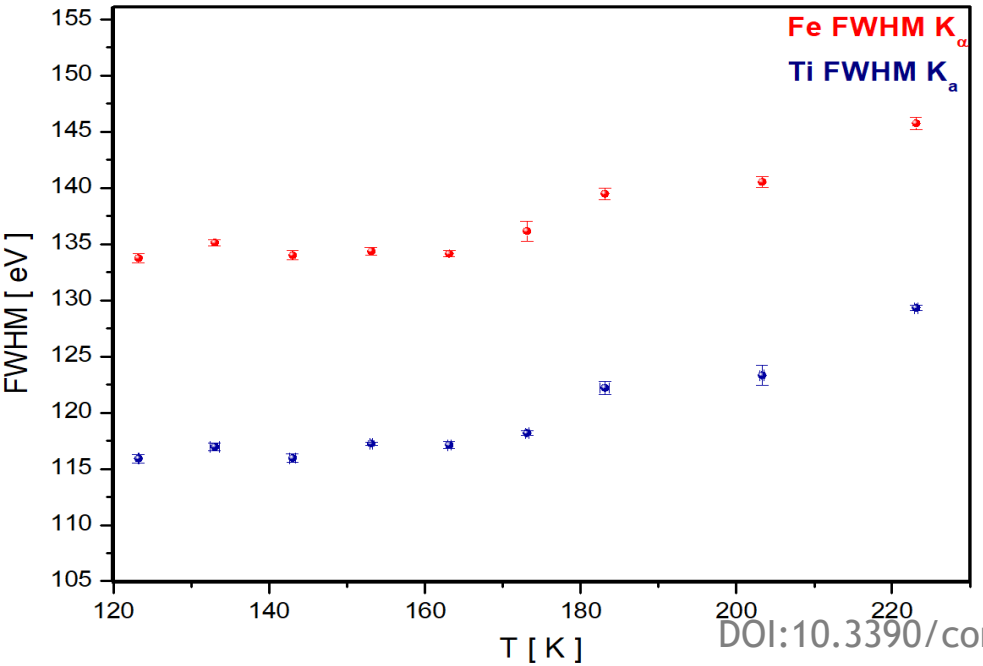
DOI:10.3390/condma

SDDs Energy response optimization

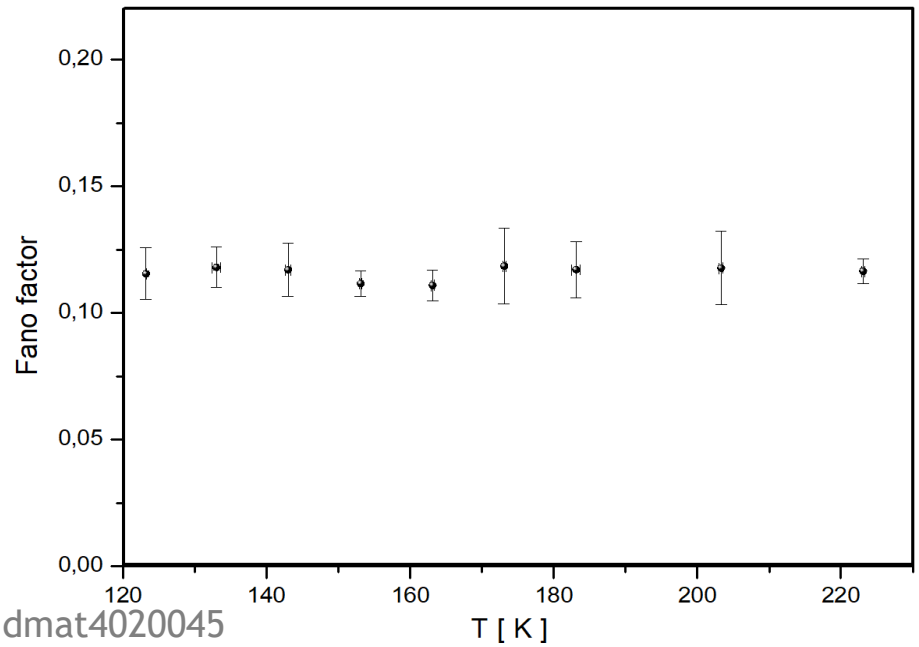


Control of the SDDs energy response (2) Resolution worsening due to leakage current

Energy resolution (vs T)

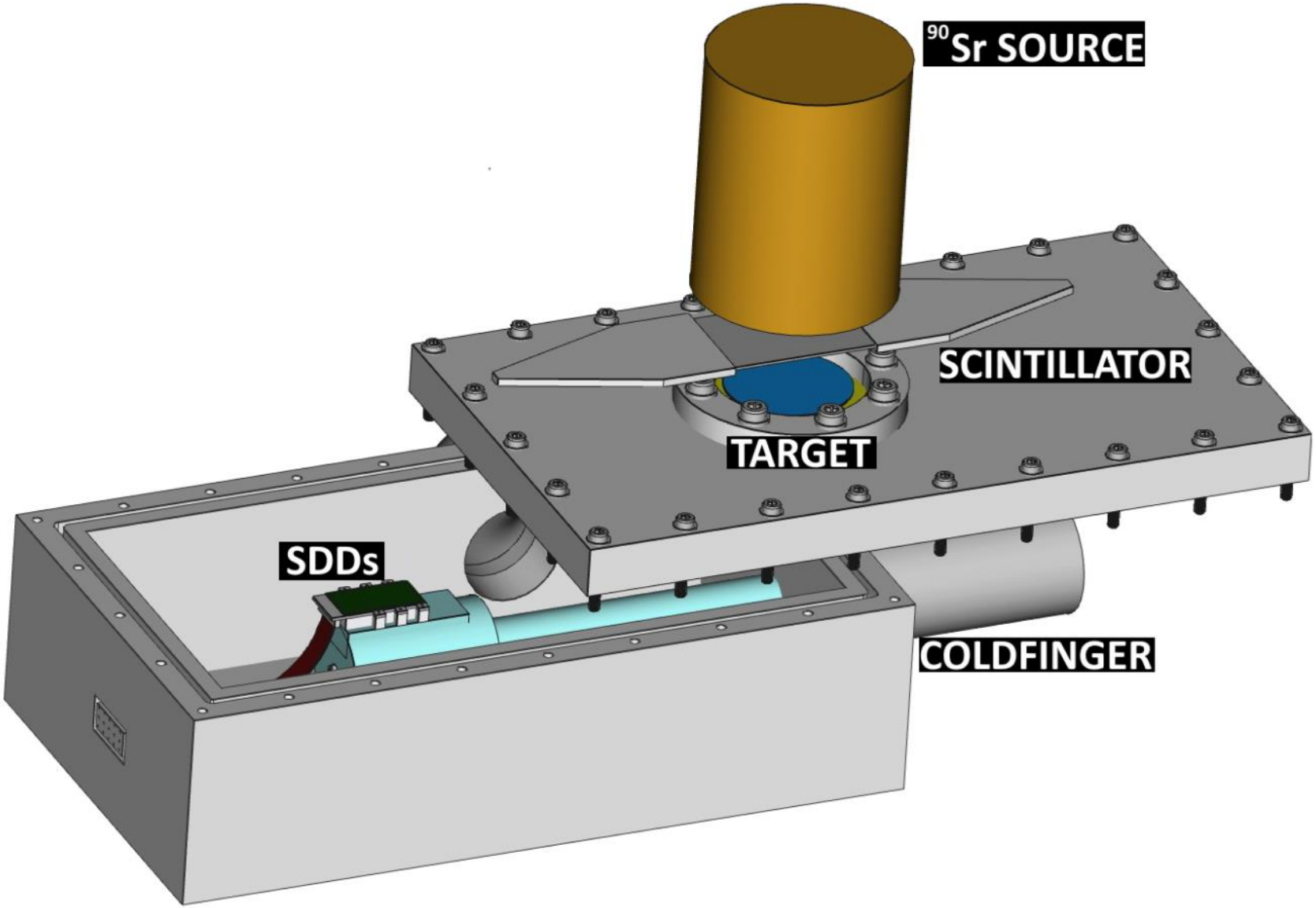


FF = 0.116 ± 0.009

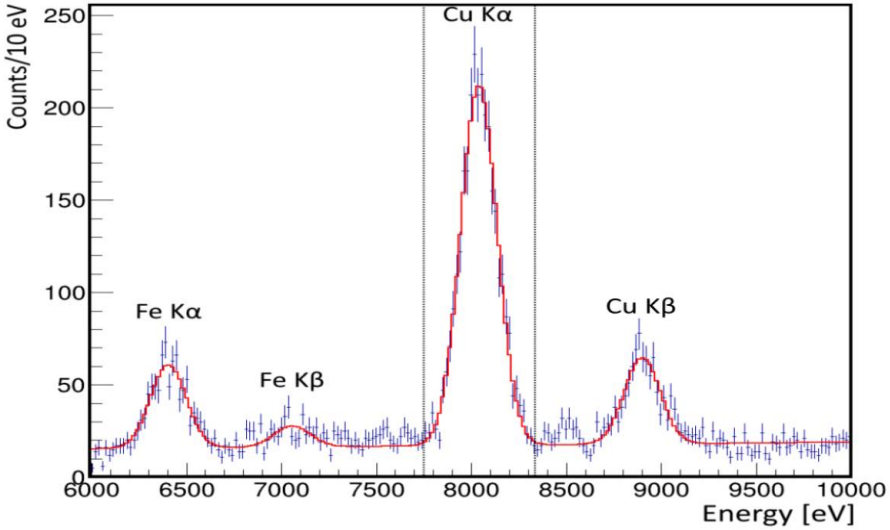


DOI:10.3390/condmat4020045

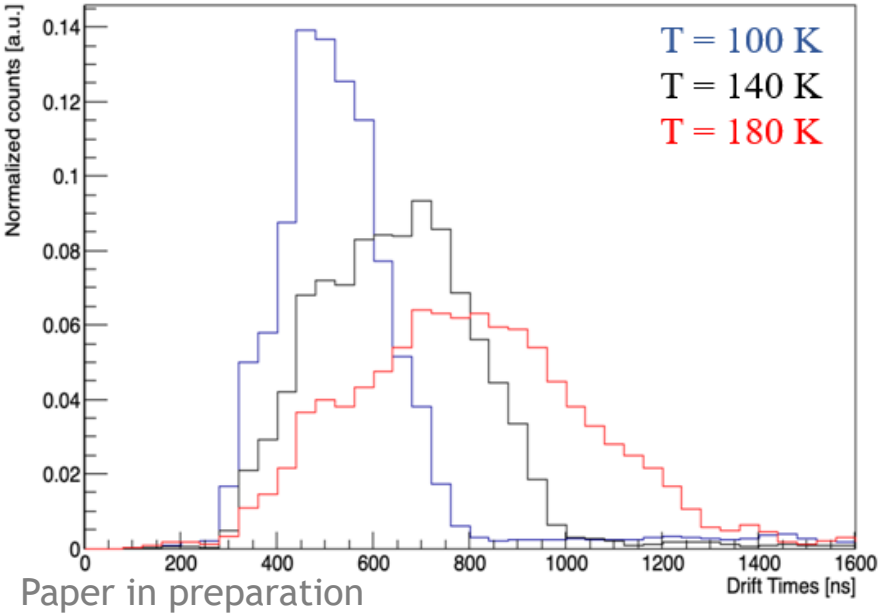
SDDs Timing response optimization

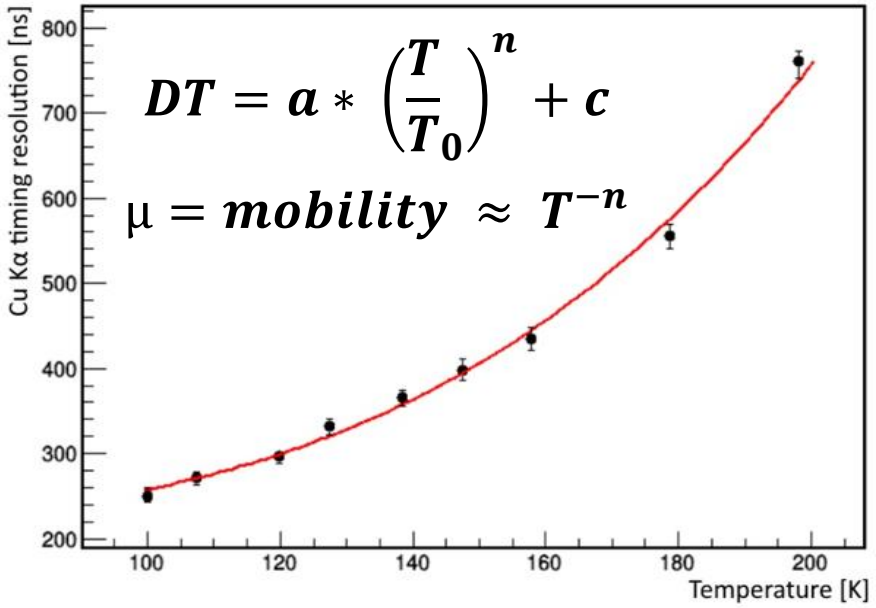


SDDs Timing response optimization



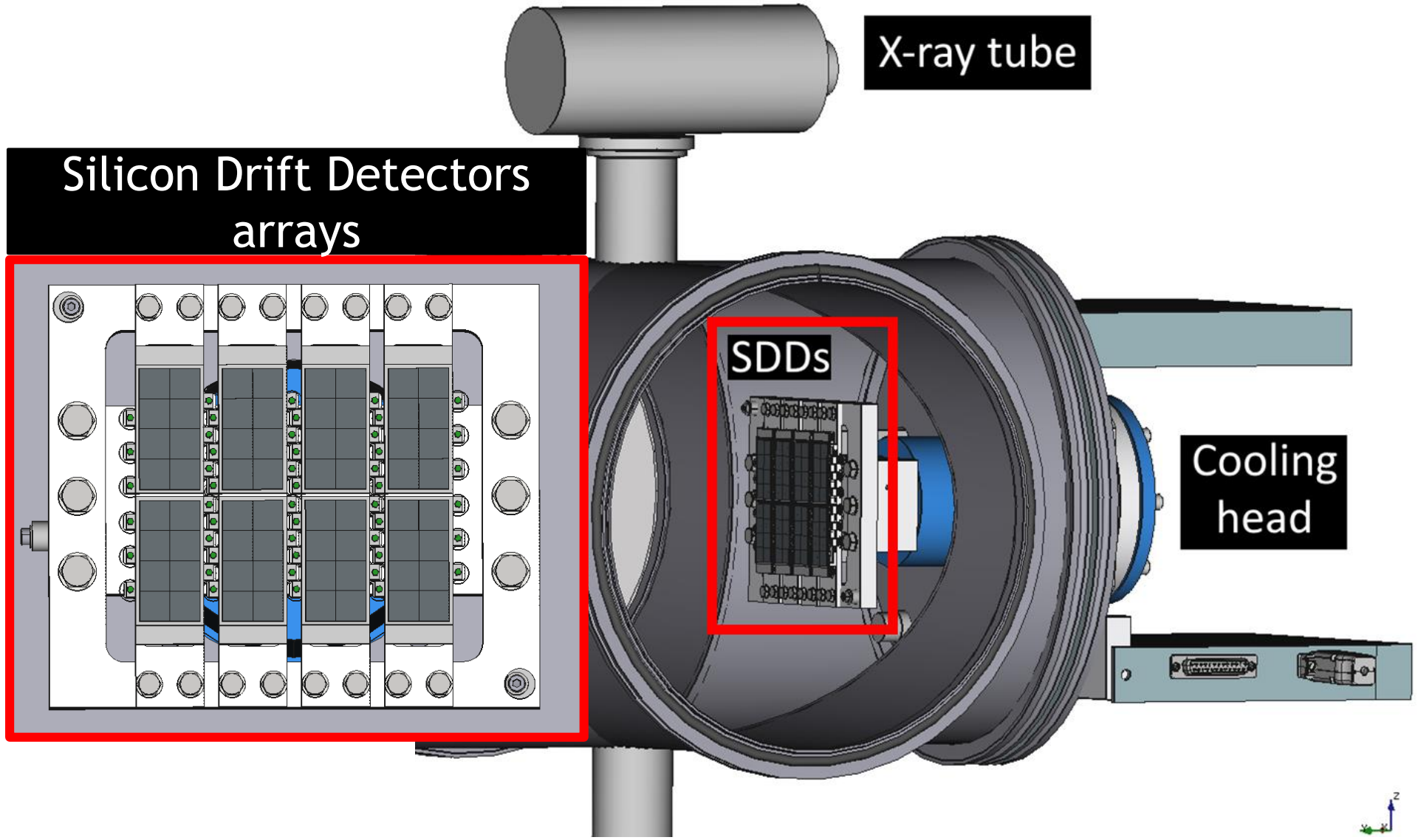
Control of the SDDs timing response Electrons mobility follows a power-law in temperature





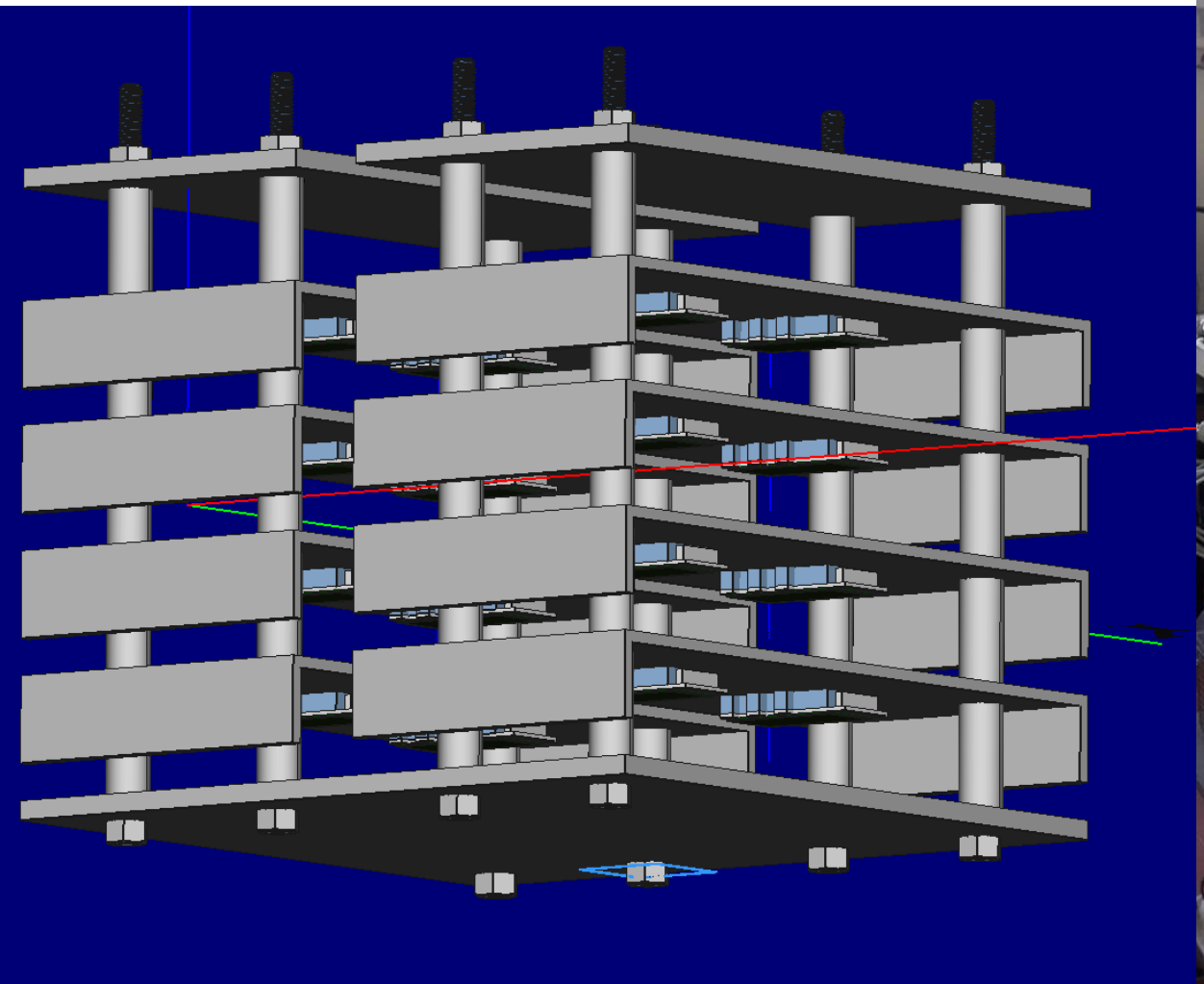
Paper in preparation

SDDs arrays qualification

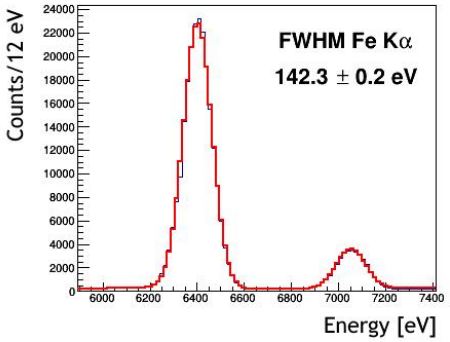


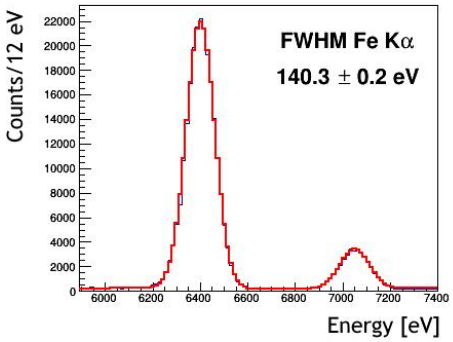
SDDs arrays qualification

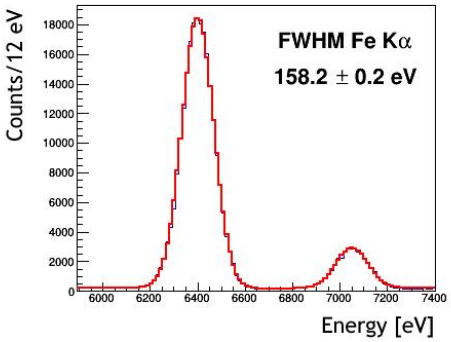
SDDs storage vacuum chamber (2 buses)

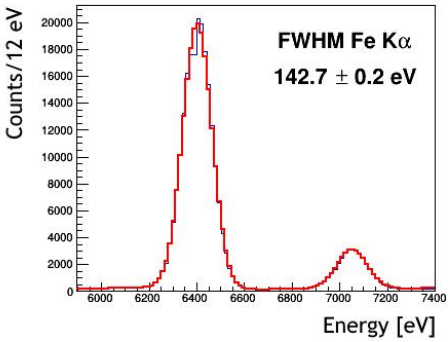


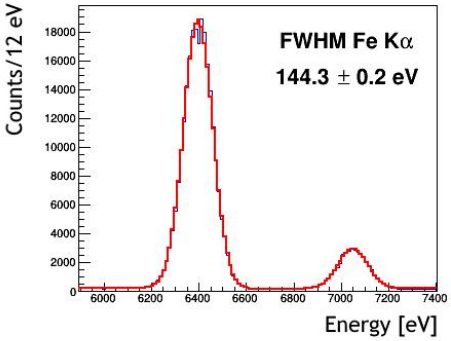
SDDs arrays qualification

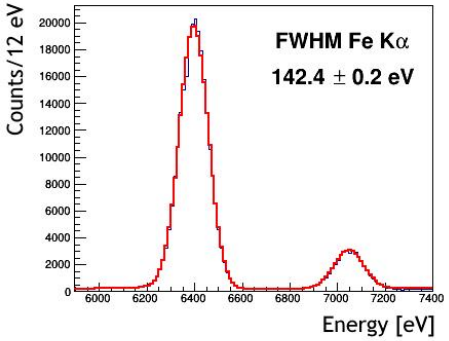


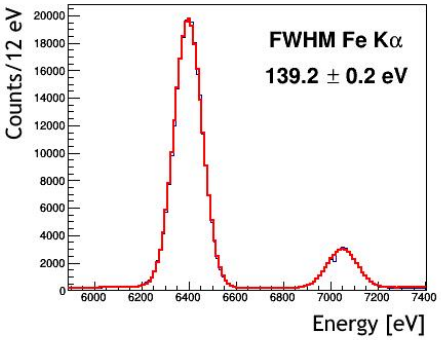


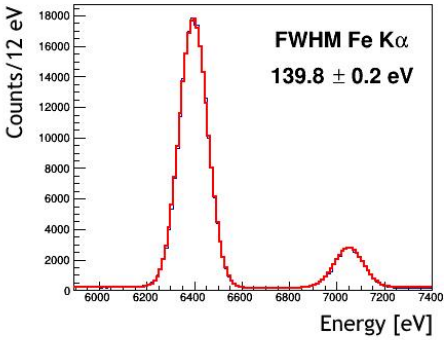








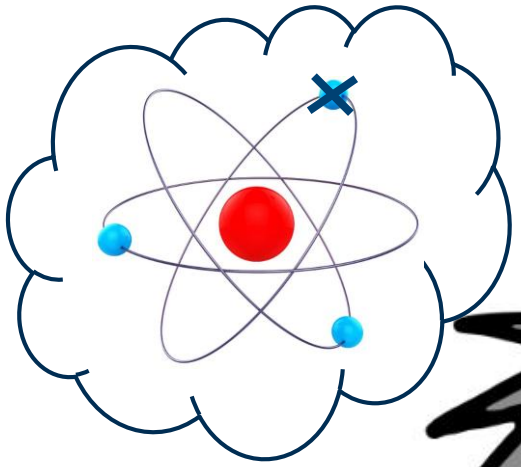


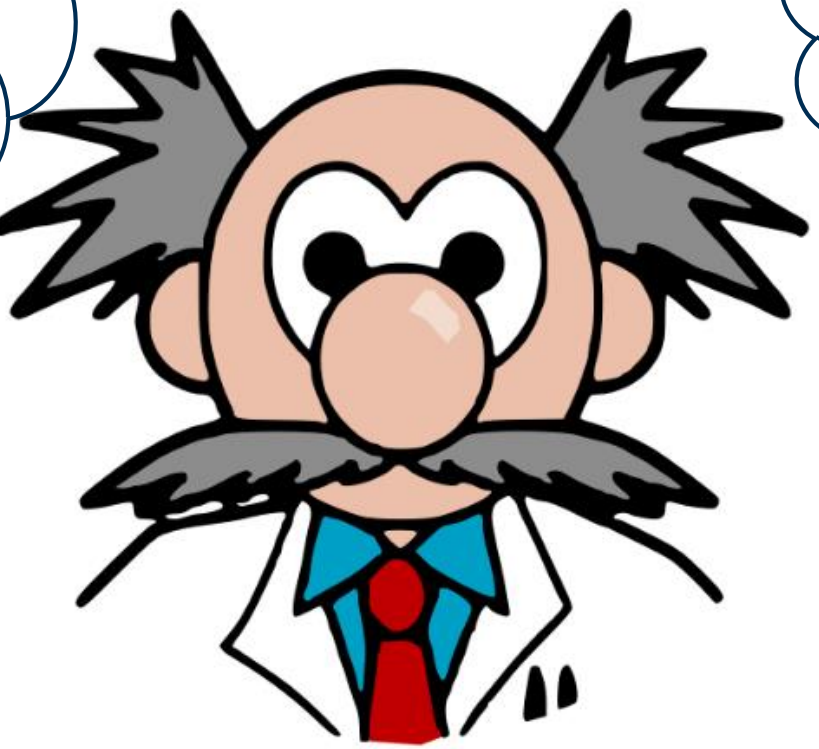


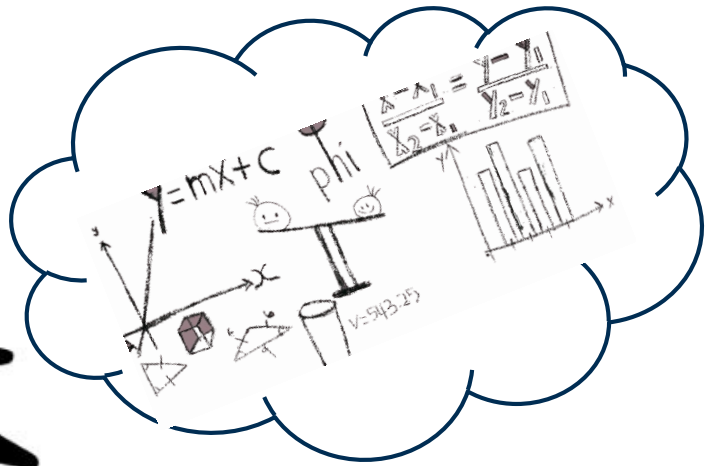
Ready for the installation in the SIDDHARTA-2 experimental apparatus

PHASE 2

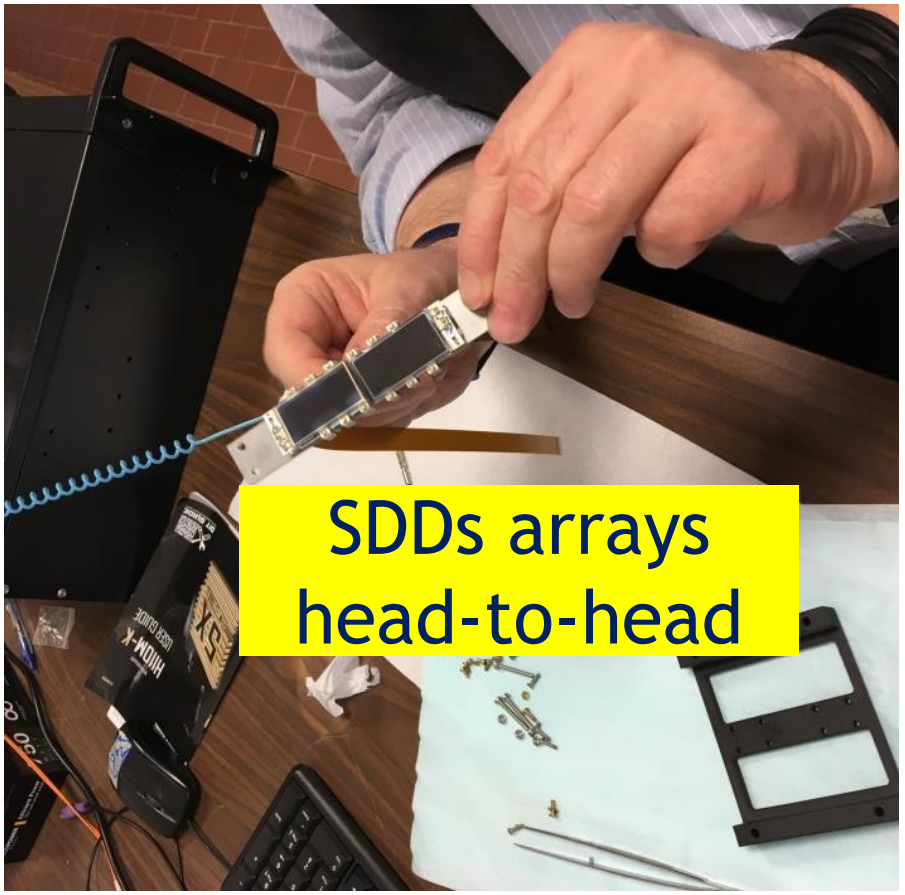
SDDs for high precision kaonic atoms spectroscopy measurements



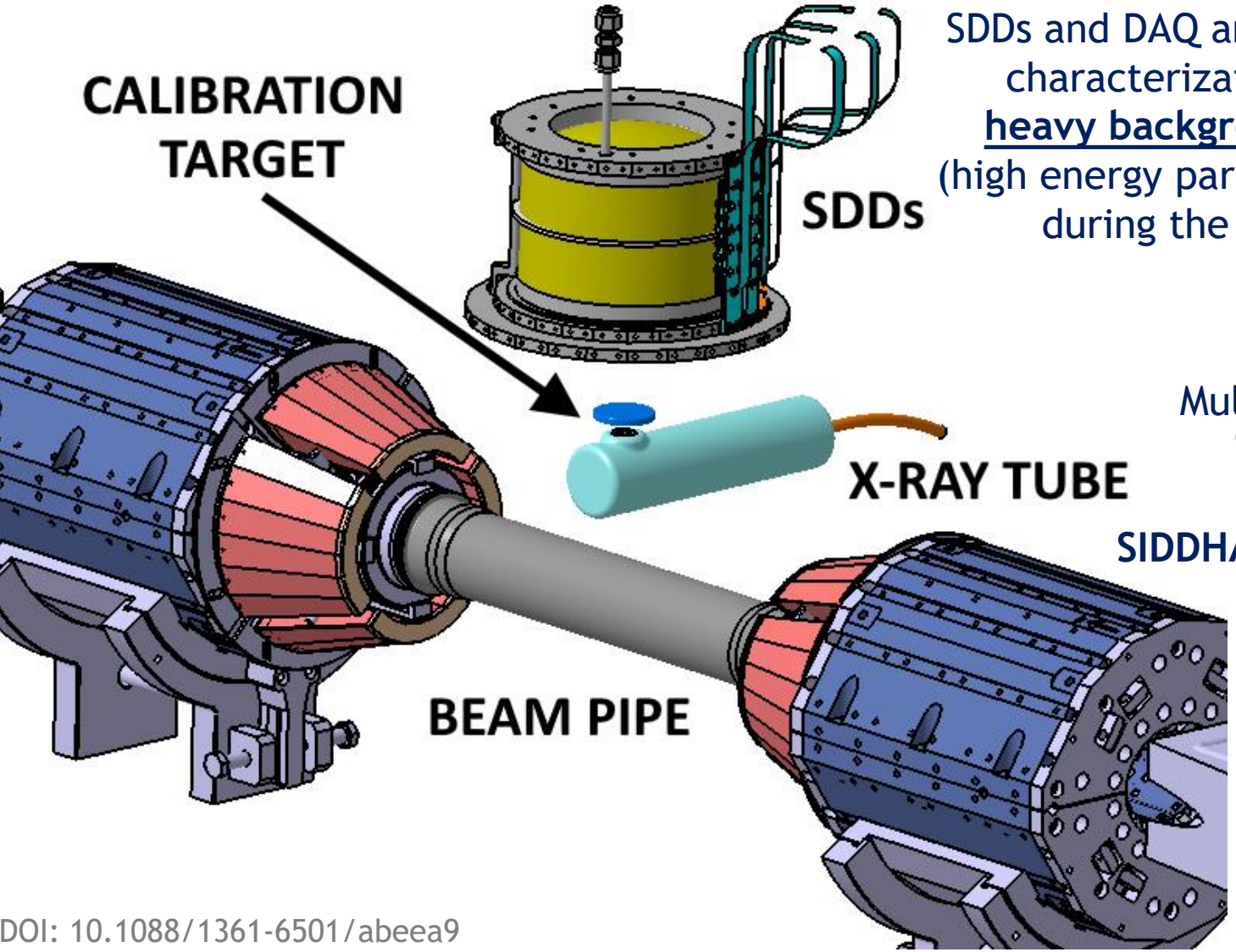




SDDs installation in the SIDDHARTA-2 setup



SDDs test during the beam commissioning



SDDs and DAQ analog/digital chain characterization in machine **heavy background conditions** (high energy particle and radiation) during the DAΦNE B.C.P

Multi-element target **Ti-Fe-Cu-Br-Sr** to include the **SIDDHARTA-2 energy range**

DOI: 10.1088/1361-6501/abeea9

SDDs test during the beam commissioning

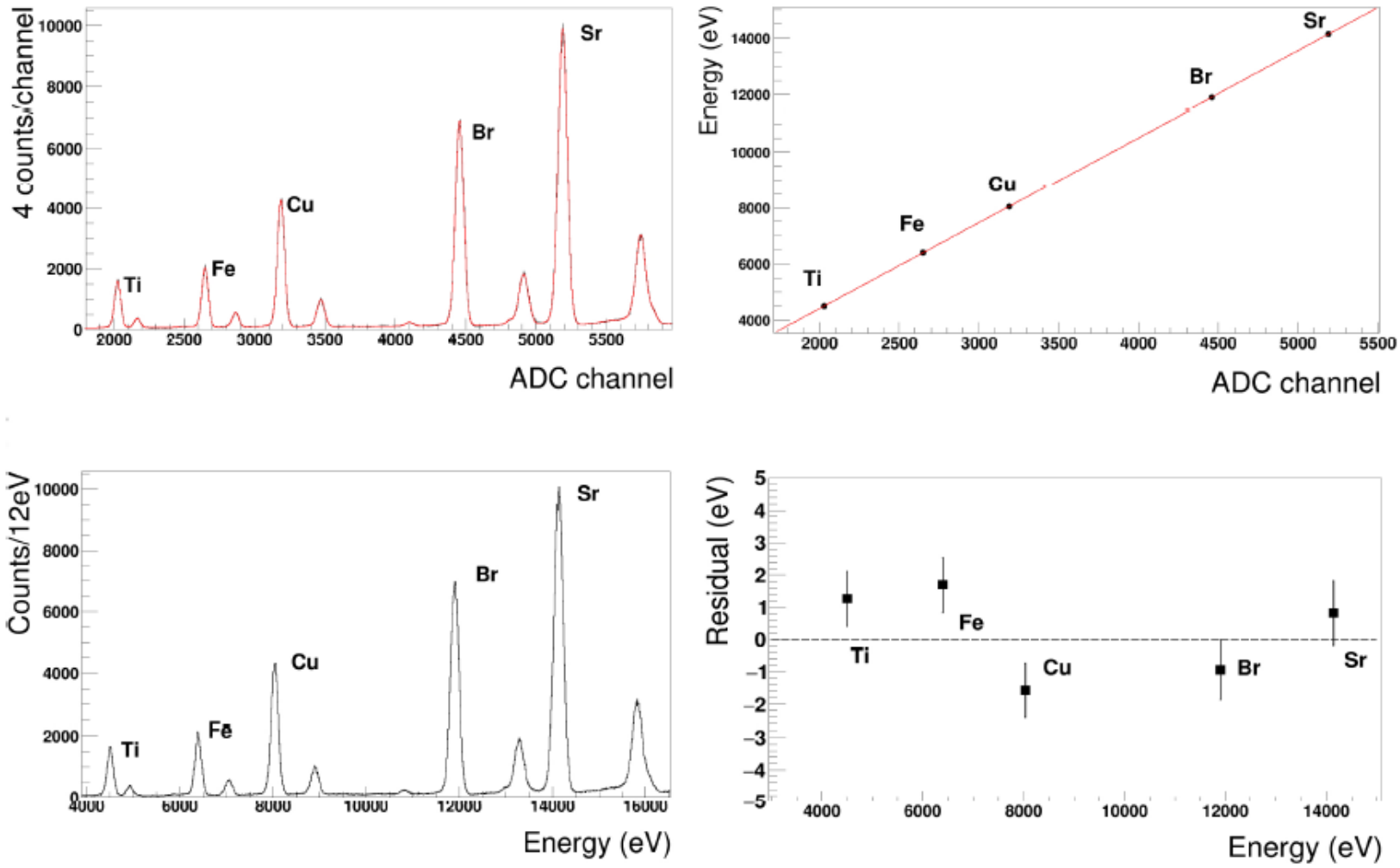


Figure 4: Typical example of a SDDs system unit energy response analysis. Top-left: Fit (red)

DOI: 10.1088/1361-6501/abeea9

SDDs test during the beam commissioning

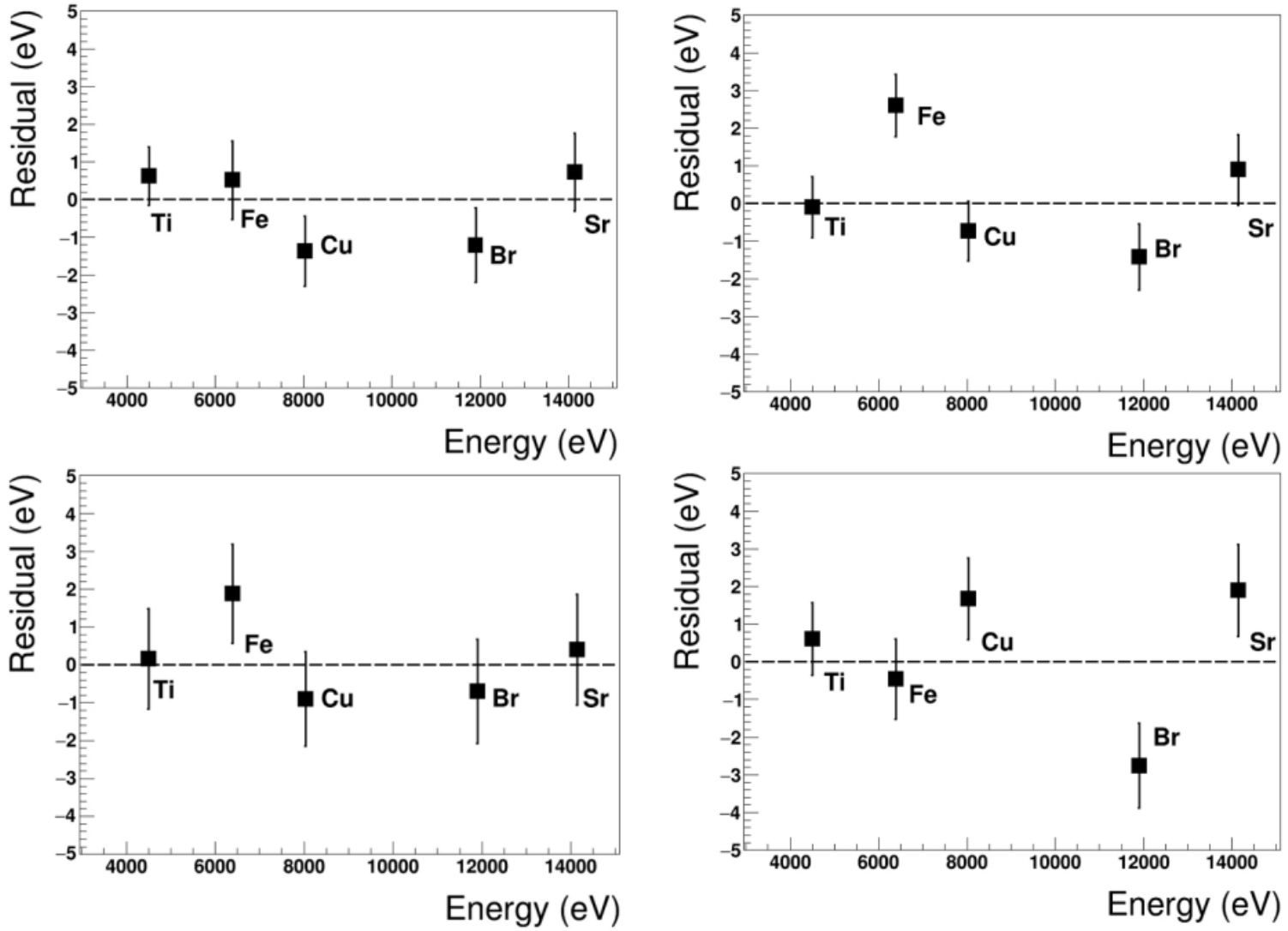
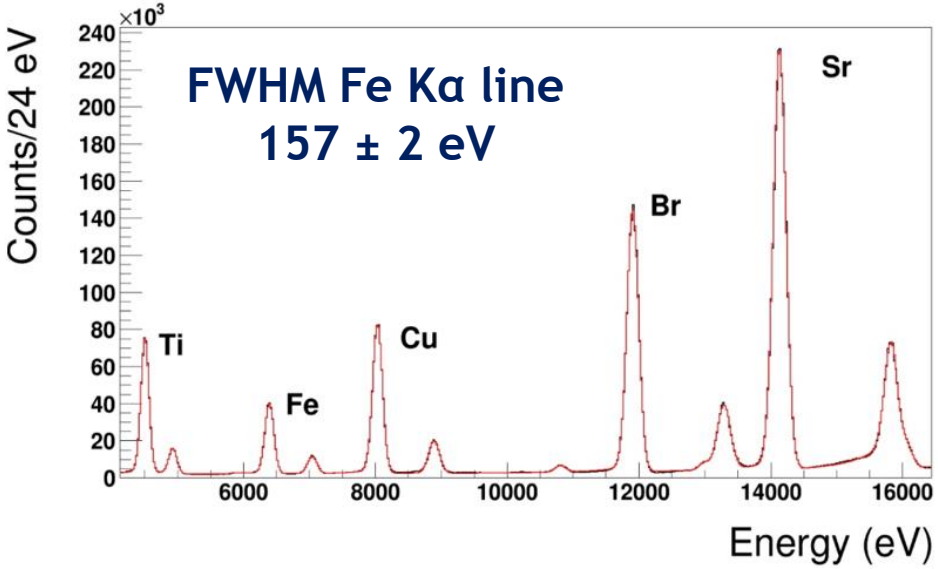
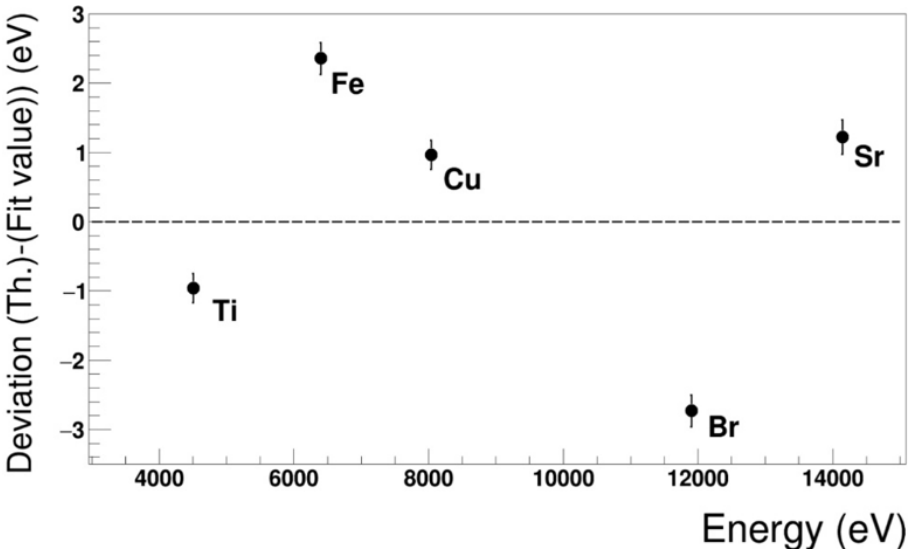


Figure 5. Residuals plots for four different SDDs system units.

DOI: 10.1088/1361-6501/abeea9

SDDs test during the beam commissioning

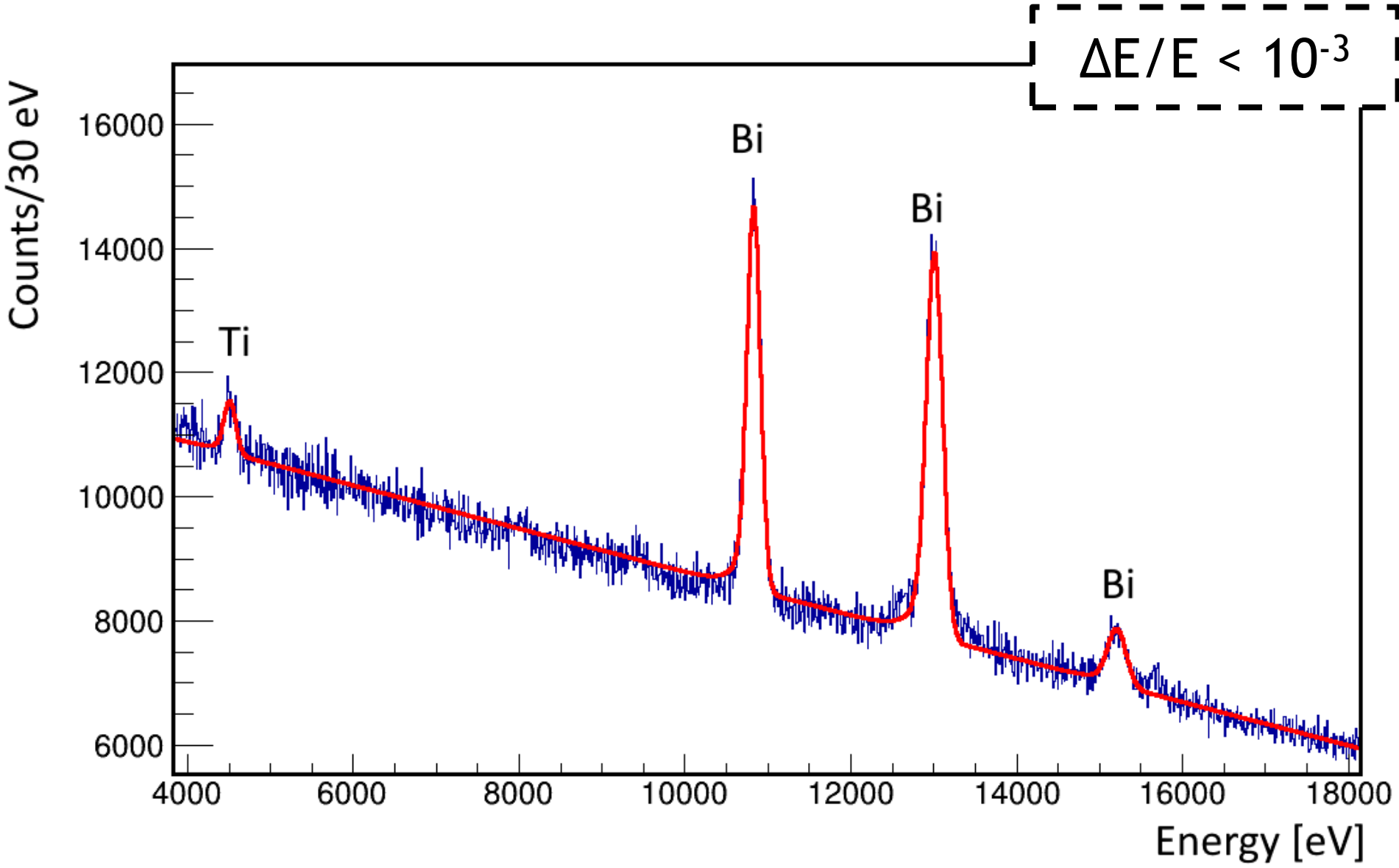




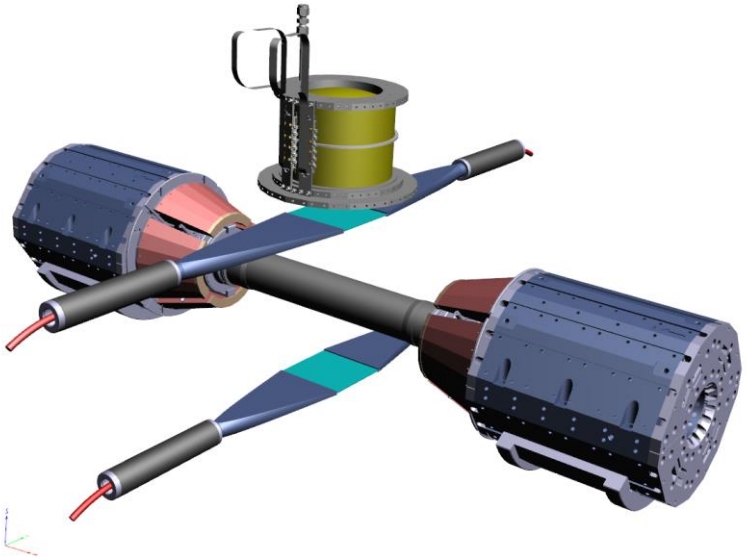
Spectroscopic properties are preserved in the heavy background condition of DAΦNE

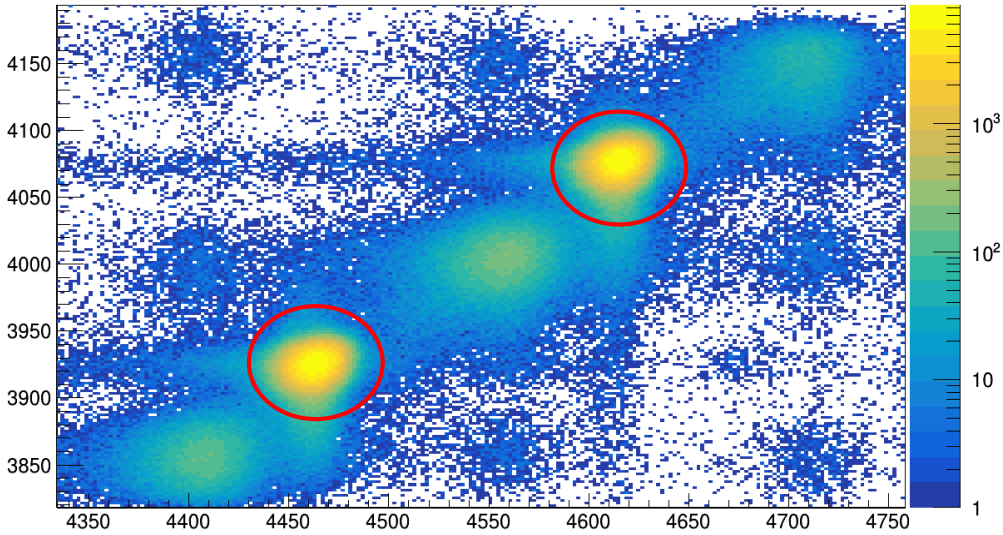
DOI: 10.1088/1361-6501/abeea9

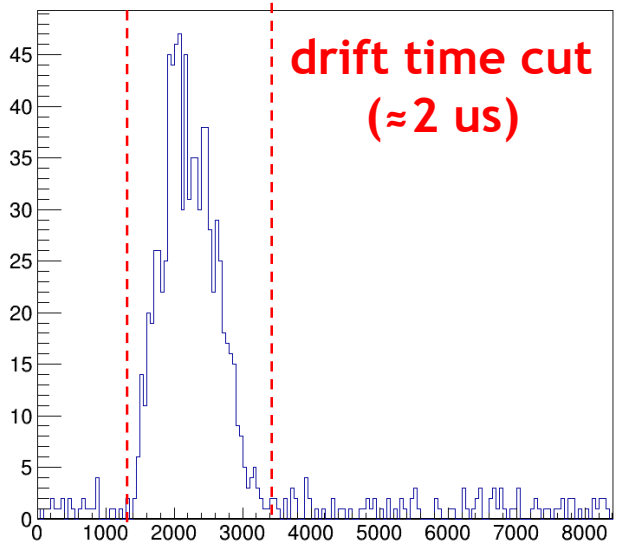
THE SIDDHARTINO RUN



THE SIDDHARTINO RUN

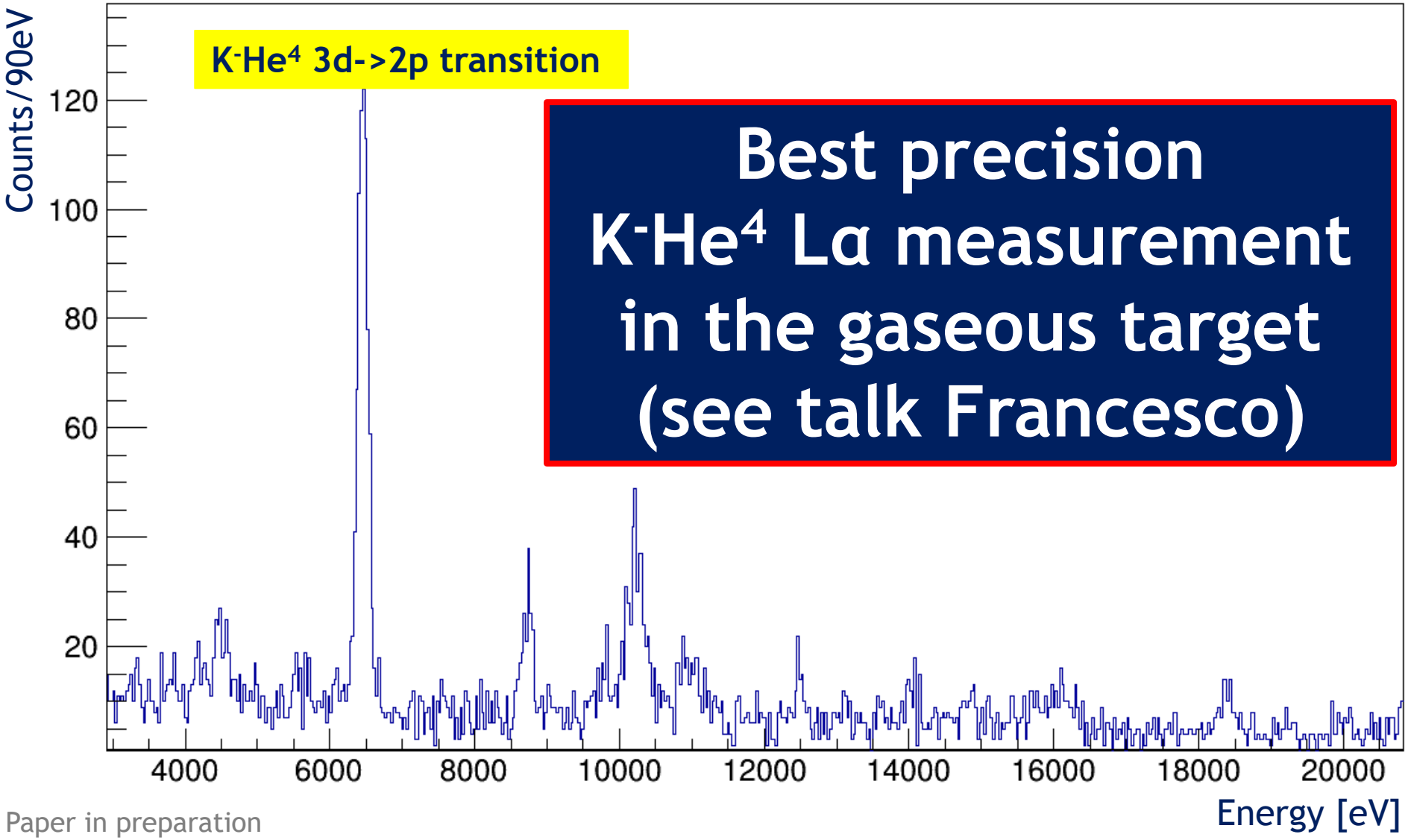






Asyncronous evns rejected: background scales by a factor 10^{-5} - 10^{-6}

THE SIDDHARTINO RUN



Best precision K^-He^4 Lα measurement in the gaseous target (see talk Francesco)

Paper in preparation

PHASE 3

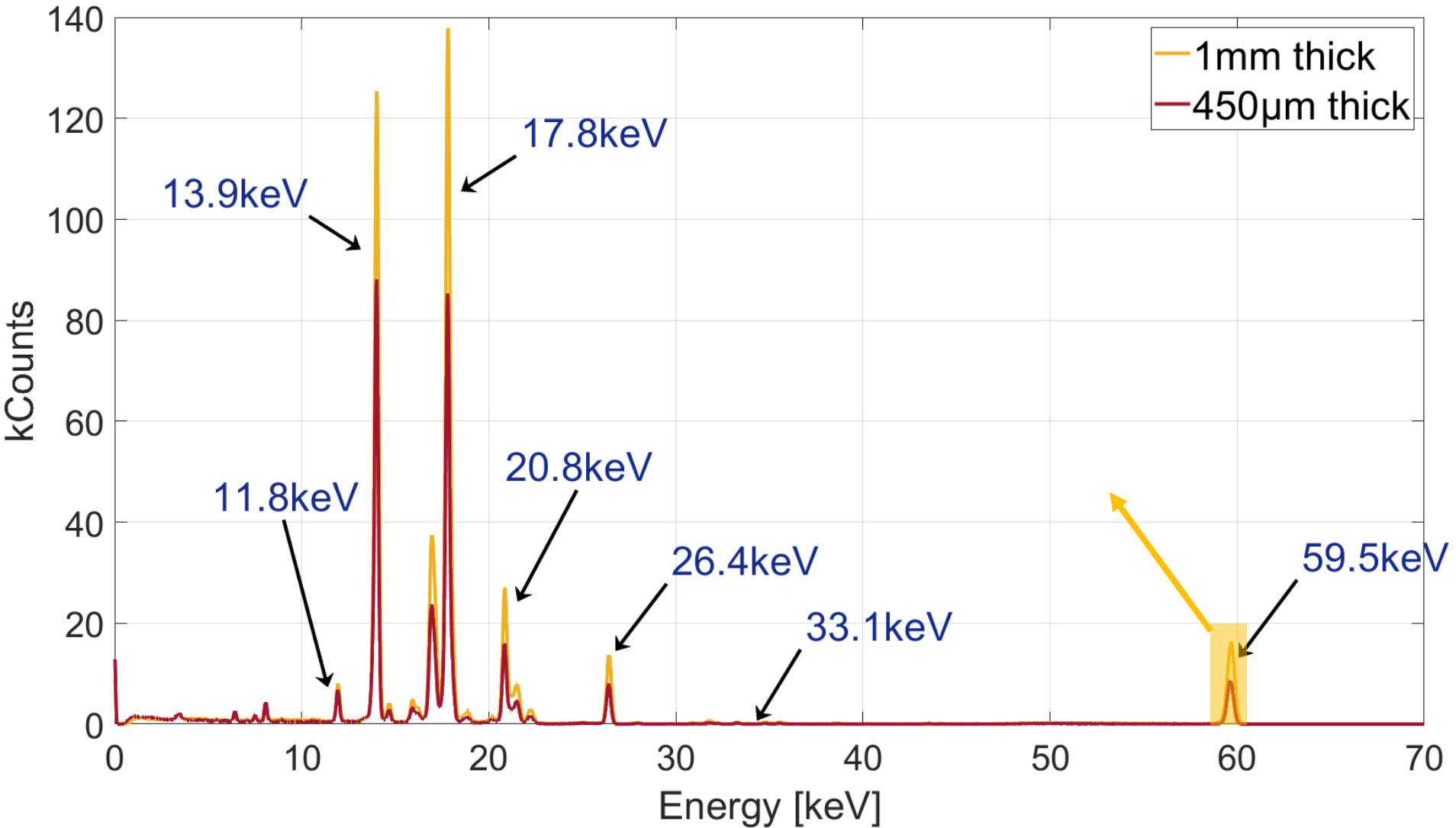
Futures Perspectives

FONDAZIONE BRUNO KESSLER

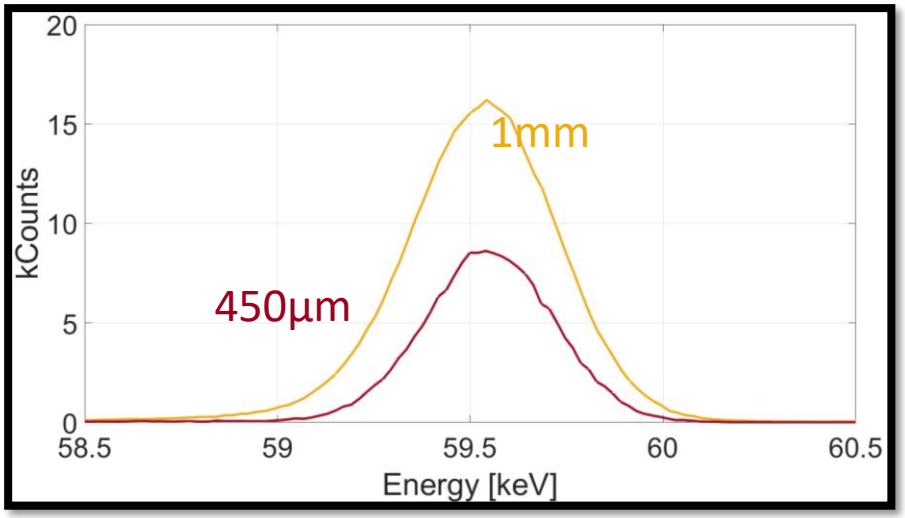
INFN LNF
Istituto Nazionale di Fisica Nucleare

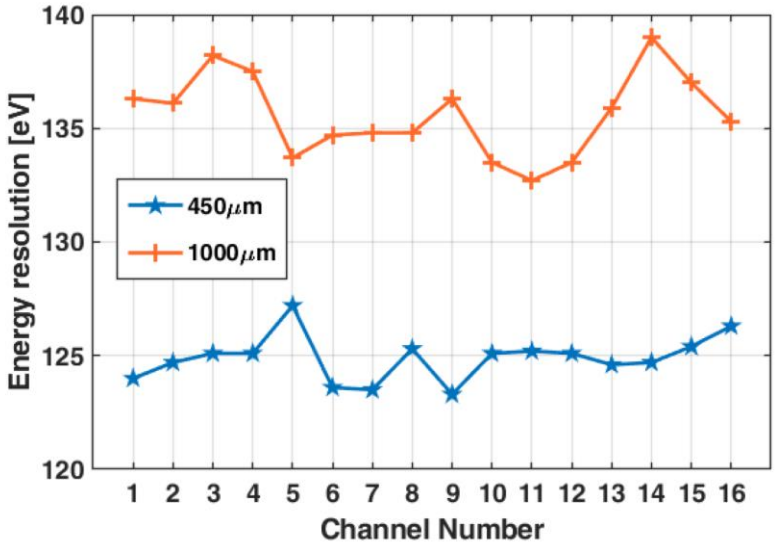
POLITECNICO MILANO 1863

1 mm thick SDDs



1 mm thick SDDs





450um vs 1mm thick: Doubled the efficiency

450um vs 1mm thick: Comparable E_resolution

1 mm thick SDDs

…open to the measurements of kaonic atoms higher energy transitions (tens of keV), to further explore the QCD in the strangeness sector…
(see talk Catalina)

Ad maiora!

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