STRONG-2020

Annual Meeting 2024

WP26/JRA8: “ASTRA”, Alessandro Scordo (on behalf of J. Zmeskal)

Advanced ultra-fast solid STate detectors for high precision RAdiation spectroscopy : ASTRA

Organization legal name	Short name	Activity leader
Austrian Academy of Sciences, Stefan Meyer Institute, Austria	OEAW	J. Zmeskal
Istituto Materiali per Elettronica e Magnetismo, CNR, Parma, Italy	CNR	A. Zappettini
Jagiellonian University, Krakow, Poland	UJ	P. Moskal
Laboratori Nazionali di Frascati (LNF) – INFN, Italy	INFN	A. Scordo
Politecnico Milano, Dipartimento di Elettronica, Italy	POLIMI	C. Fiorini
University of Zagreb, Croatia	UNIZG	D. Bosnar

The main objective of the ***ASTRA*** project is to develop beyond state-of-art ultra-fast CdZnTe/CdTe radiation detector systems for high-precision measurements of gamma- and X-ray events in a broad energy range, **few keV to MeV**.

JRA8 - project status Nov.2023

Task1: Low energy detector

- ✓ Energy resolution
- ✓ Drift time
- ✓ Cross-talk, charge sharing

Task2: High energy detector

- ✓ Energy resolution
- ✓ Drift time

Missing:

- ➢ temperature dependence: energy resolution and drift time
- ➢ performance test under beam condition

Project Status @ 2023 Annual Report

JRA8 - project status Nov.2023

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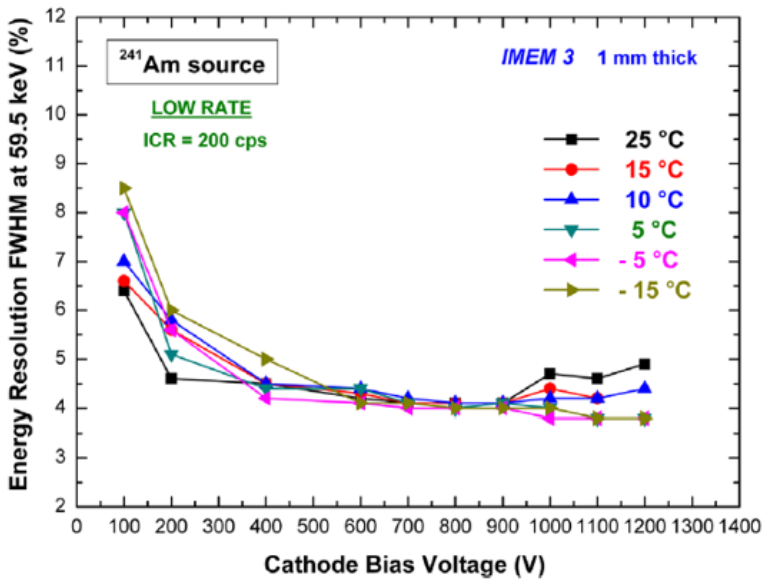
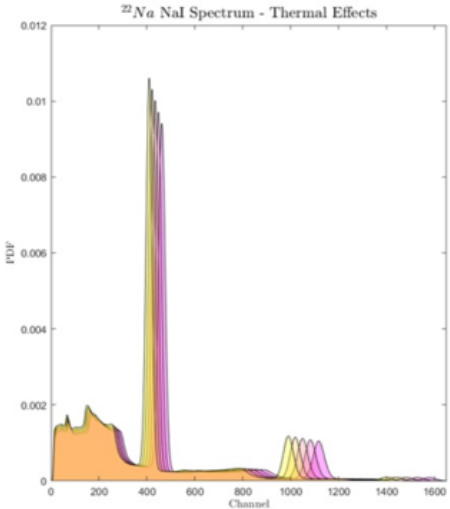
CdZnTe Thermal behaviour

Thermal behaviour has been extensively studied by MC simulations...

- Thermic excursion in a range between 20°C and 30°C has been studied

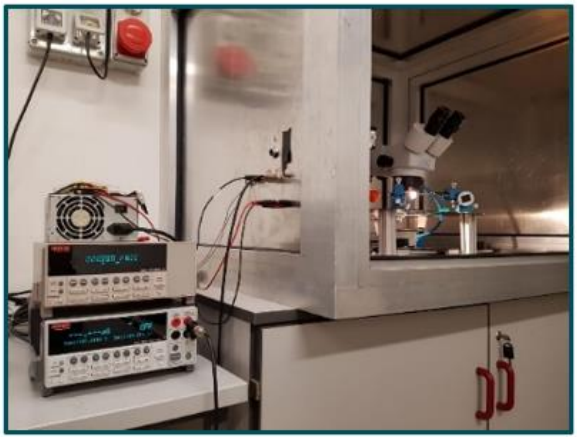


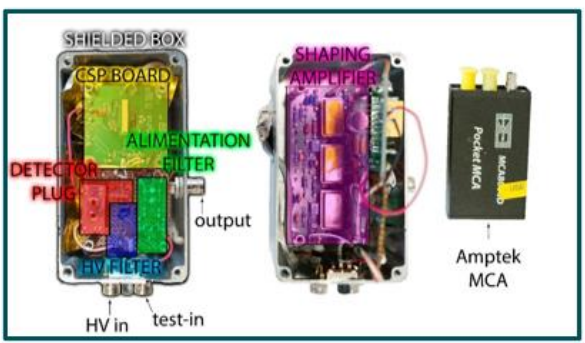


...and with temperature dependent measurements

CdZnTe performances are not strongly T-dependent but are improved by stabilization

CdZnTe Thermal behaviour

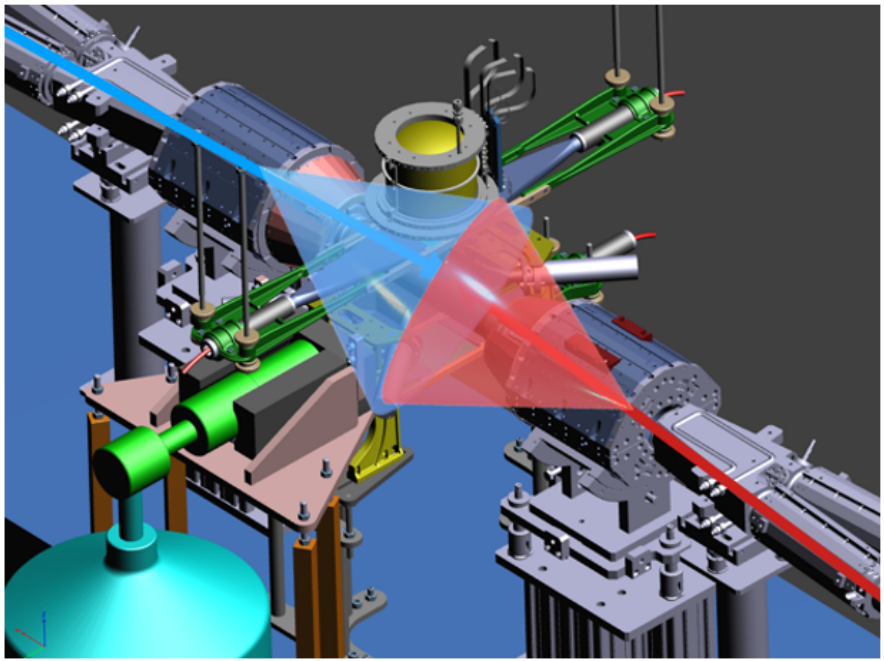




Tests performed at the IMEM-CNR of Parma and University of Palermo

CdZnTe tests in DAFNE

CdZnTe detectors never used in accelerator environments: assessing in-beam behaviour is thus crucial for future applications

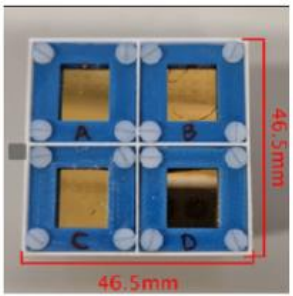


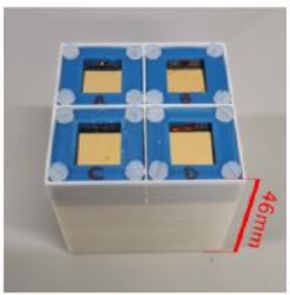
Collisions always come with a huge synchronous background mainly generated in the quadrupoles before the IP

A high flux of e-/e+ (MIPs) arrives on the detectors and need to be rejected

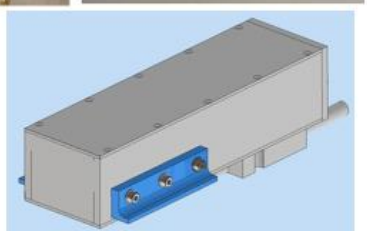
Assessing background rejection capabilities and spectroscopic “in-beam” performances are crucial feasibility tests for future applications

CdZnTe tests in DAFNE





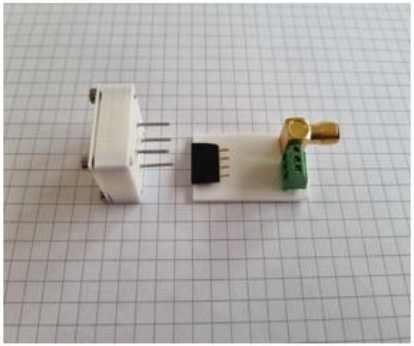
8 (4+4)
1,3x1,5x0,5 cm^3
CZT hemispherical
detectors

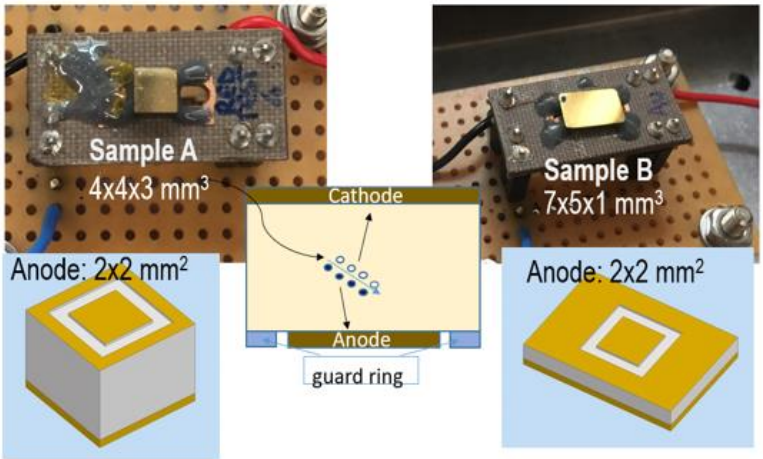


CdZnTe tests in DAFNE

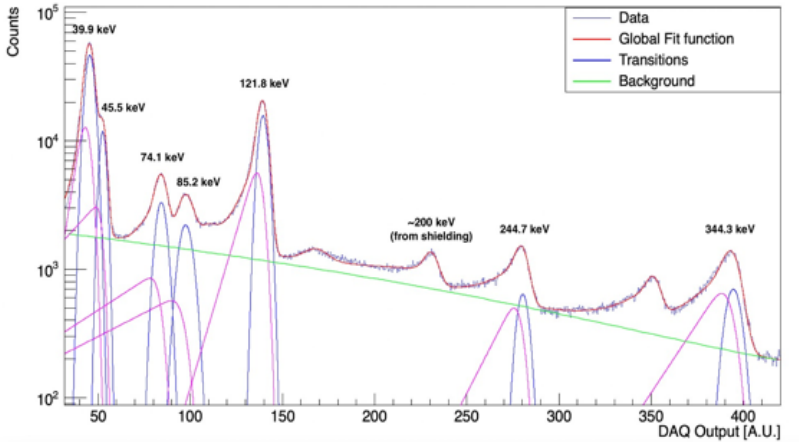
Work in collaboration between

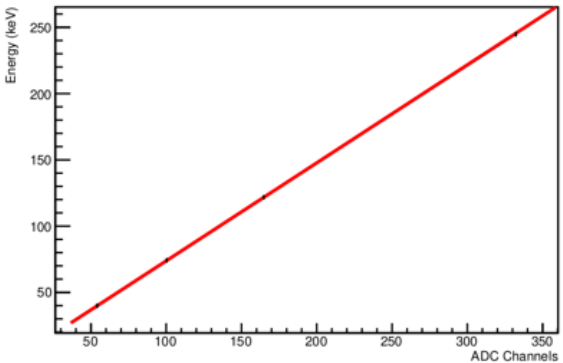
LNF: Setup Assembly and data analysis
IMEM-CNR: Detectors production
UniPa: Front-end and digital electronics
SMI: Mechanical supports and detectors' box

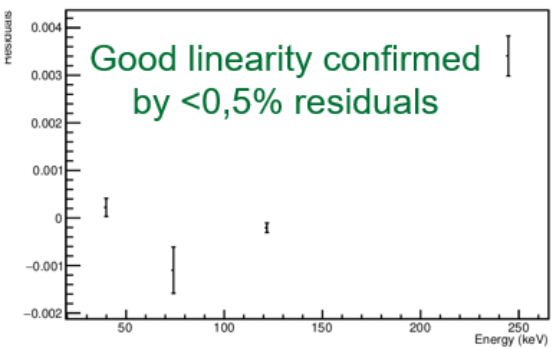


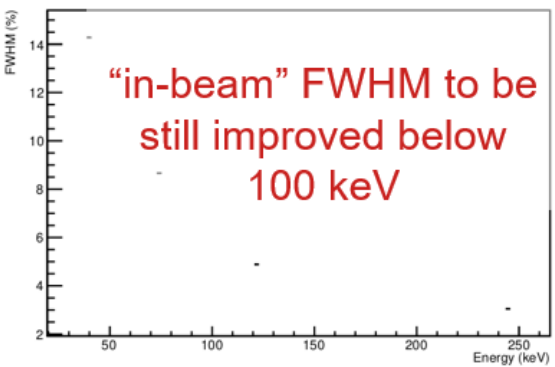


CdZnTe tests in DAFNE

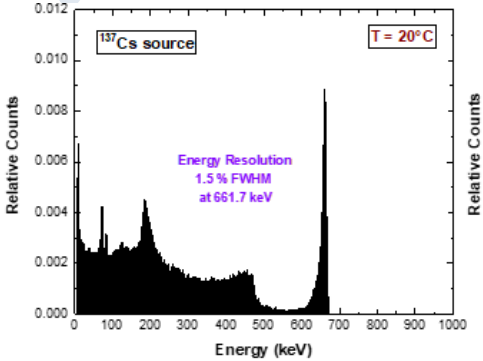


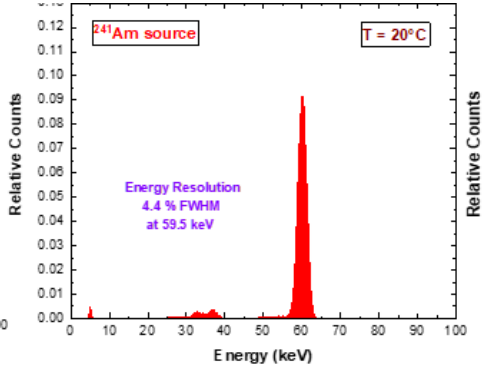


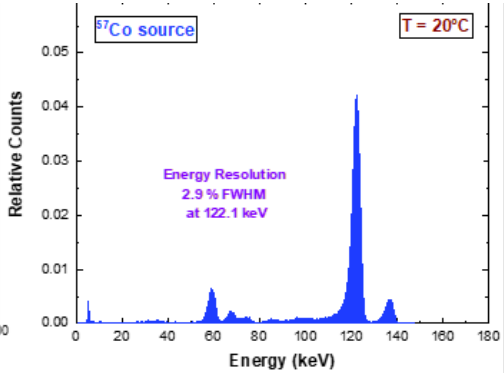


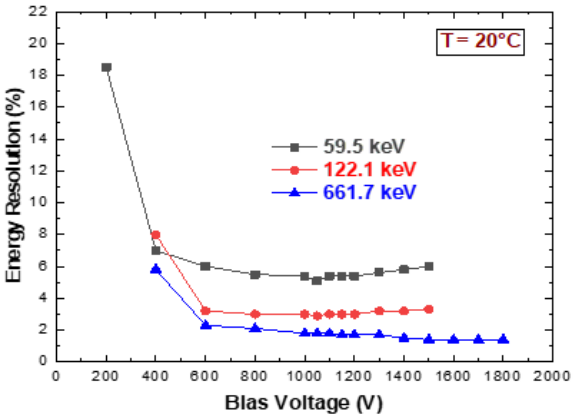


CdZnTe tests in DAFNE

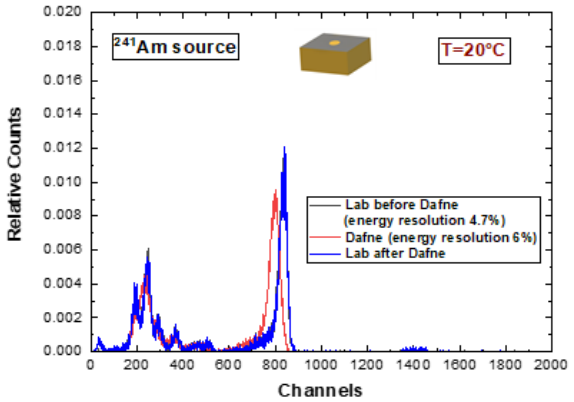




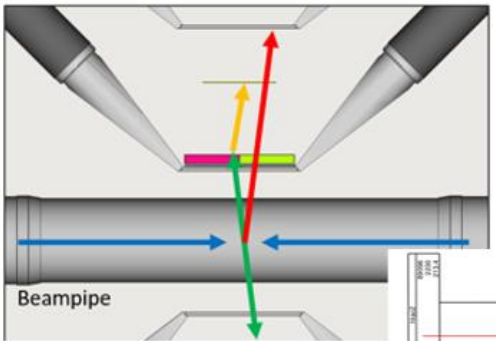


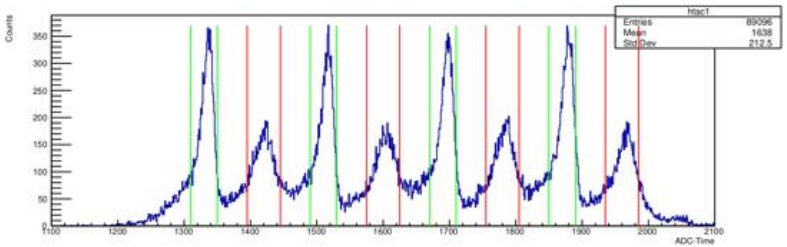


Good news!
No strong evidence of radiation damage on CdZnTe detectors



CdZnTe tests in DAFNE





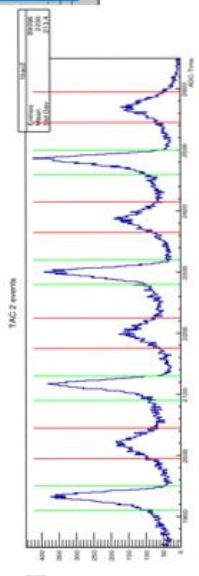
Fast MIPs (e/π)

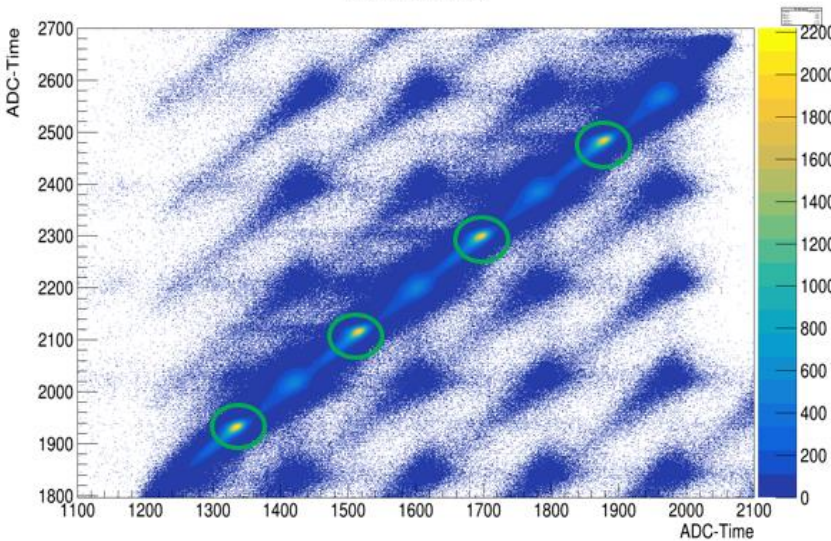
Slow kaons

Kaonic atoms X-rays

ΔT~ 1,4 ns

DAΦNE RF ~ 2,8 ns





CdZnTe tests in DAFNE

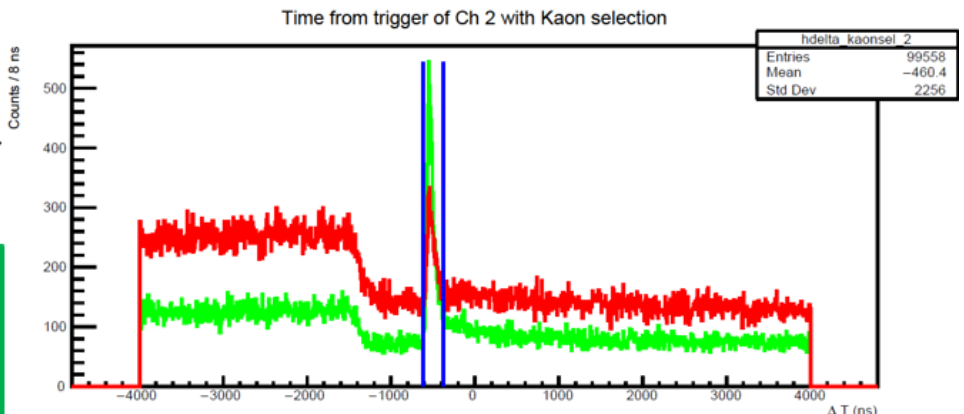
Once a collision occurs, the K- flights through the LM Scintillator and then the target with a very specific timing

The kaonic atom's formation and radiative deexcitation process is order of magnitudes faster than the K- TOF

X-rays fly towards the CZT at speed c with a very specific timing

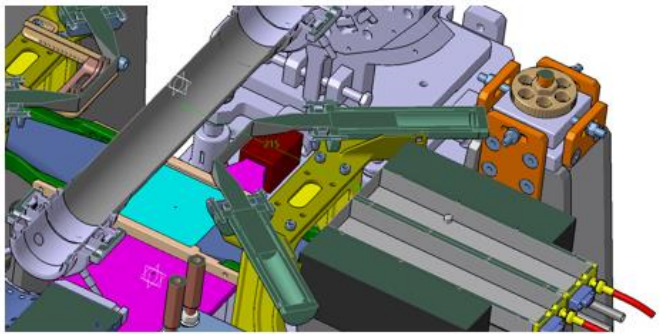
Kaonic atoms's X-rays in the CZT detectors have then a clear time peak wrt to the collision

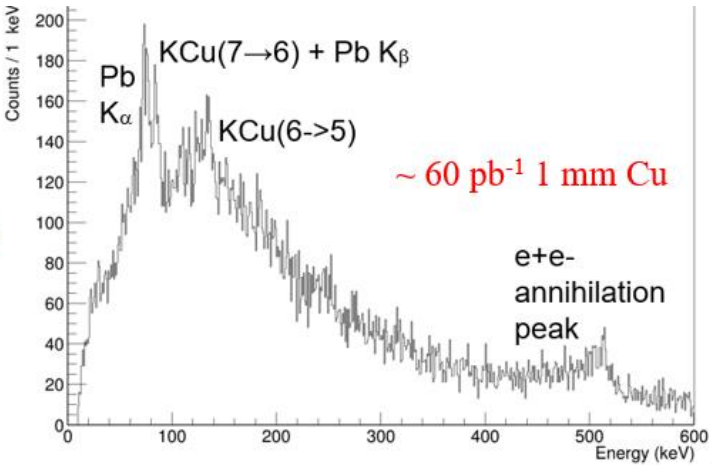
The time difference between the collision and the CZT signal can be used to further clean the final spectrum

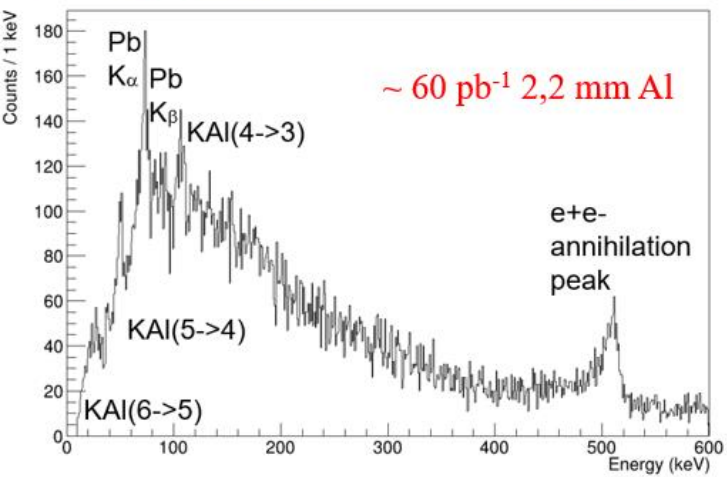


Overall background reduction of the order of 10^5

CdZnTe tests in DAFNE







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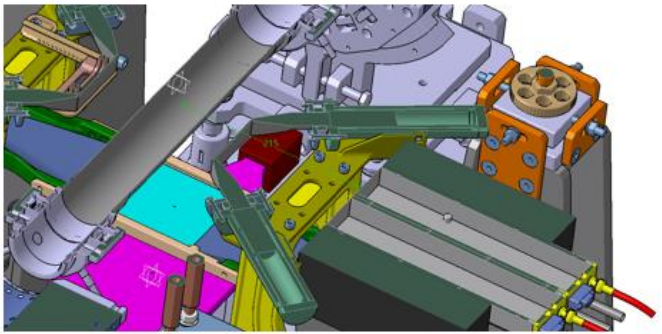

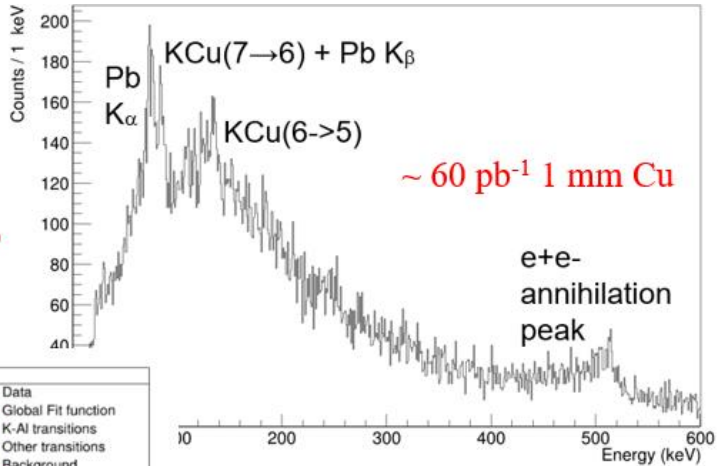

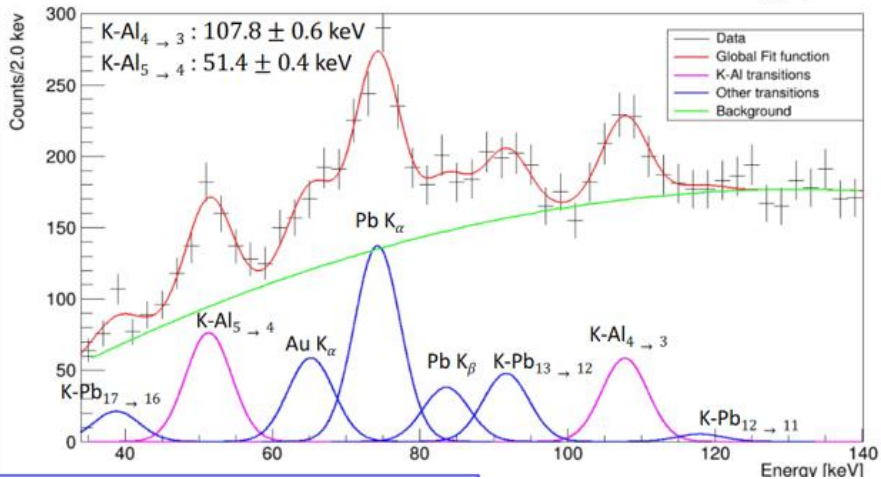

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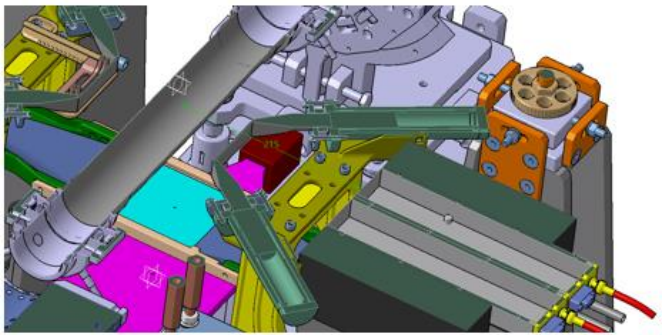

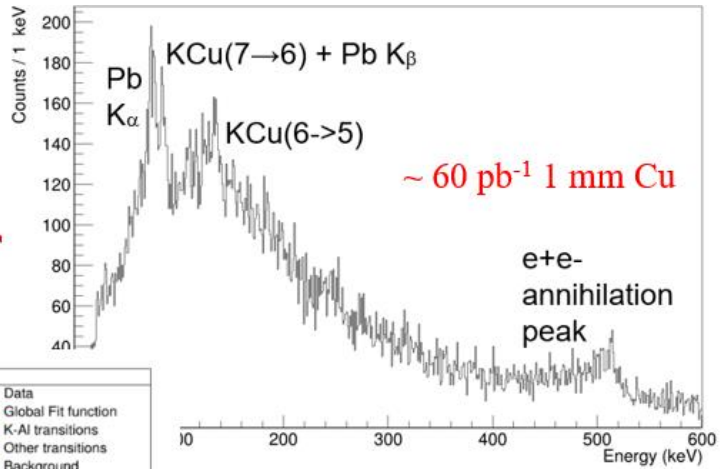

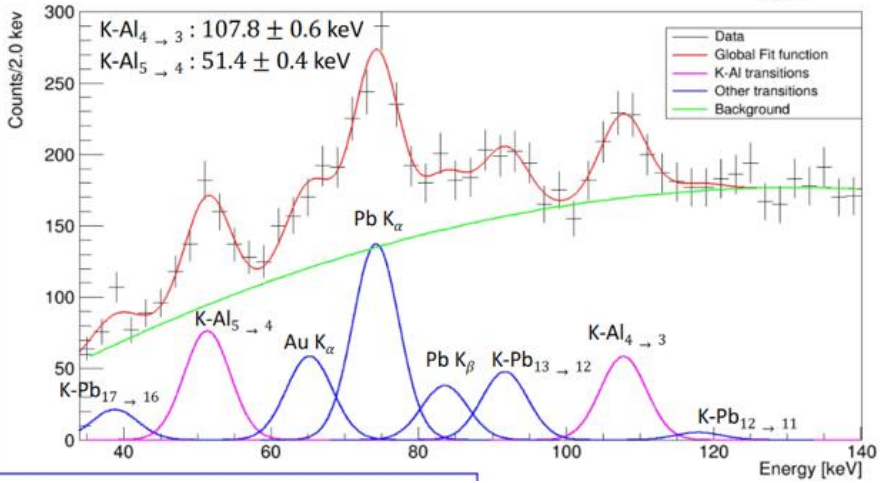

First kaonic atoms' spectra measured with CZT detectors

New perspectives opening

Papers published within JRA8-ASTRA

THE EUROPEAN PHYSICAL JOURNAL SPECIAL TOPICS

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Regular Article

New opportunities for kaonic atoms measurements from CdZnTe detectors

L. Abbene[1], M. Bettelli[2], A. Buttacavoli[3], F. Principato[3], A. Zappettini[2], C. Amsler[4], M. Bazzi[5], D. Bosnar[6], M. Bragadireanu[5], M. Carminati[7,8], A. Clozza[5], G. Deda[5], L. De Paolis[5], R. Del Grande[5,9], L. Fabbietti[9], C. Fiorini[7,8], I. Friščić[6], C. Guaraldo[5], M. Iliescu[5], M. Iwasaki[10], A. Khreptak[11], S. Manti[4], J. Marton[12], M. Miliucci[13], P. Moskal[10,11], F. Napolitano[5], S. Niedźwiecki[10,11], H. Ohnishi[14], K. Piscicchia[5,13], Y. Sada[14], F. Sgaramella[5], H. Shi[9], M. Silarski[10,11], D. L. Sirghi[5,15], F. Sirghi[5,15], M. Skurzok[10,11], A. Spallone[5], K. Toho[14], M. Tüchler[7,16], O. Vazquez Doce[4], C. Yoshida[17], J. Zmeskal[7], A. Scordo[5]✉, and C. Curceanu[5]

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CdZnTe detectors tested at the *DAΦNE* collider for future kaonic atoms measurements

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sensors

MDPI

Article

Potentialities of CdZnTe Quasi-Hemispherical Detectors for Hard X-ray Spectroscopy of Kaonic Atoms at the DAΦNE Collider

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Abstract: Kaonic atom X-ray spectroscopy is a consolidated technique i physics of strong kaon-nucleus/nucleon interaction. Several experimen regarding the measurement of soft X-ray emission (<20 keV) from light kao terium, and helium). Currently, there have been new research activities wit SIDDHARTA-2 experiment and EXCALIBUR proposal focusing on perfor measurements of hard X-rays (>20 keV) from intermediate kaonic atoms sulfur). In this context, we investigated cadmium–zinc–telluride (CdZnTe

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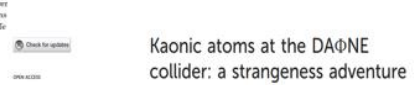

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Kaonic atoms at the DAΦNE collider: a strangeness adventure

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Presentations at conferences and workshops

1) 09-11/05/2022, Talk at the "Quinto Incontro Nazionale di Fisica Nucleare INFN 2022" conference, (LNGS): *"Kaonic atoms beyond SIDDHARTA-2: future measurements and perspectives at the DAFNE collider"*
2) 6-10/06/2022, Talk at the "RAP2022" conference, (online): *"A new life for kaonic atoms at DAΦNE: future measurements and perspectives with advanced X-ray spectroscopy techniques"*
3) 10-15/07/2022, Invited Talk at the "4th Jagiellonian Symposium on Advances in Particle Physics and Medicine" conference, Krakow: *"Kaonic atoms at DAΦNE: where we are and where we go?"*
4) 03-04/10/2022, Talk at the "International workshop on "Hadron physics with kaon beam and related topics" workshop, (online): " *Beyond kaonic deuterium: renewing the kaonic atoms database with future measurements at DAFNE*".
5) 17-21/10/2022, Invited talk at the "EXOTICO: EXOTIc atoms meet nuclear Collisions for a new frontier precision era in low-energy strangeness physics", ECT*, Trento, *"Radiation detectors for future kaonic atoms measurements at DAFNE"*
6) 13/12/2022, Invited seminar at the University of Zagreb, *"Present and future kaonic atoms measurements with new generation radiation detectors"*
7) 16/03/2023, Talk at the "Third International Workshop on the Extension Project for the J-PARC Hadron Experimental Facility (3rd J-PARC HEF-ex WS)", JPARC (online): *"In-beam performances of a CdZnTe detector toward X and Gamma spectroscopy of kaonic atoms at DAFNE and JPARC."*
8) 08/06/2023, Invited Talk at the "Channeling 2023" conference, Riccione (Italy): *"X-ray detectors and measurements at LNF for nuclear and fundamental physics, Quantum Gravity, and agrifood applications"*
9) 18/07/2923, Talk at the " Mini wokshop on kaonic atoms: present status and future plans" workshop, LNF (Italy): *" Data taking with CdZnTe – status and plans"*
10) 28/11/2023, Talk at the Workshop "KASP: Kaonic atoms between QED, QCD and beyond Standard Model physics research", LNF (Italy): *"Kaonic atoms with CdZnTe"*.
11) 04/12/2023 Invited seminar at the Marian Smoluchowski Institute of Physics, Jagiellonian Unversity, Krakow (Poland): *"Kaonic atoms studies at DAFNE: from SIDDHARTA-2 to future perspectives"*
12) "Fourth International Workshop on the Extension Project for the J-PARC Hadron Experimental Facility (HEF-ex 2024)", J-PARC (Tokai): *"Present and future kaonic atoms measurements with new generation radiation detectors"*

Conclusions

JRA8 - project status Nov.2023

Task1: Low energy detector

- ✓ Energy resolution
- ✓ Drift time
- ✓ Cross-talk, charge sharing

Task2: High energy detector

- ✓ Energy resolution
- ✓ Drift time

Missing:

- ➢ temperature dependence: energy resolution and drift time
- ➢ performance test under beam condition

Conclusions

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Task1: Low energy detector

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Task2: High energy detector

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~~[illegible]~~

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Conclusions

JRA8 - project status Nov.2023

Task1: Low energy detector
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- ✓ Drift time
- ✓ Cross-talk, charge sharing

Task2: High energy detector
- ✓ Energy resolution
- ✓ Drift time

[redacted]
- ➢ temperature dependence: energy resolution and drift time
- ➢ performance test under beam condition

ASTRA has been a very successful JRA

All tasks have been fulfilled

New opportunities have been opened for future Hadron Physics projects and experiments