KAONNIS

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1 KAONNIS: the scientific program

KAONNIS represents an integrated initiative in the field of experimental low-energy kaon-nucleon/nuclei interaction studies. Under KAONNIS the following activities are performed:

- kaonic atoms measurements by the SIDDHARTA-2 experiment
- studies of kaon-nuclei interactions at low-energies in the framework of the AMADEUS Collaboration
- participation at experiments at J-PARC (Japan) dedicated to strangeness studies
- future kaonic atoms measurements program at the DAΦNE collider

We present in what follows these scientifc lines, together with the 2023 activities and plans for 2024.

The KAONNIS activities are partially financed within the STRONG-2020 European project (grant agreement No. 824093).

2 The SIDDHARTA-2 experiment

The objective of the SIDDHARTA-2 (Silicon Drift Detector for Hadronic Atom Research by Timing Application) experiment is to perform high precision measurements of X-ray transitions in exotic (kaonic) atoms at the DAΦNE collider.

The precise measurement of the shift and width of the 1s level, with respect to the purely electromagnetic calculated values, in kaonic hydrogen and kaonic deuterium, induced by the strong interaction, through the measurement of the X-ray transitions to this level, will allow the first precise experimental determination of the isospin-dependent antikaon-nucleon scattering lengths, fundamental quantities for the understanding of the low-energy QCD in strangeness sector.

The accurate determination of the scattering lengths will place strong constraints on the low-energy K^- N dynamics, which, in turn, constraints the SU(3) description of chiral symmetry breaking in systems containing the strange quark. The implications go from particle and nuclear physics to astrophysics (the equation of state of neutron stars).

The SIDDHARTA collaboration performed the most precise measurement of kaonic hydrogen and the first exploratory study of kaonic deuterium. Moreover, the kaonic helium 4 and 3 transitions to the 2p level were measured, for the first time in gas in He^4 and for the first time ever in He^3. Presently, the SIDDHARTA-2 experiment , is under way, with the aim to measure kaonic deuterium and, as well, other types of kaonic atoms.

2.1 Before SIDDHARTA-2: the SIDDHARTA experiment

In the first decade of this century, SIDDHARTA represented a new phase in the study of kaonic atoms at DAΦNE. The previous DEAR experiment's precision was limited by a signal/background ratio of about 1/70 for the kaonic hydrogen measurement, due to the high machine background. To significantly improve this ratio, an experimental breakthrough was necessary. An accurate study of the background sources at DAΦNE was done. The background includes two main sources:

- *synchronous background*: coming from the K^- interactions in the setup materials and Φ-decay processes; it can be defined as *hadronic background*;
- *asynchronous background*: final products of electromagnetic showers in the machine pipe and in the setup materials, originating from particles lost from primary circulating beams either due to the interaction of particles in the same bunch (Touschek effect) or due to the interaction with the residual gas.

Accurate studies showed that the main background source in DAΦNE is of the second type, which points to the procedure to reduce it. A fast trigger correlated to the kaons entering into the target cut the main part of the asynchronous background. X rays were detected by DEAR using CCDs (Charge-Coupled Devices), which are excellent X-ray detectors, with very good energy resolution (about 140 eV FWHM at 6 keV), but having the drawback of being non-triggerable devices (since the read-out time per device is at the level of 10 s). A new device, which preserves all good features of CCDs (energy resolution, stability and linearity), but additionally is triggerable - i.e. fast (at the level of 1 μs), was implemented. The new detector was a large area Silicon Drift Detector (SDD), specially designed for SIDDHARTA. The development of the new 1cm^2 SDD device, together with its readout electronics and very stable power supplies, was partially performed under the Joint Research Activity JRA10 of the I3 project "Study of strongly interacting matter (HadronPhysics)" within FP6 of the EU.

The trigger in SIDDHARTA was given by a system of scintillators which recognized a kaon entering the target making use of the back-to-back production mechanism of the charged kaons at DAΦNE from Φ decay:

$$\Phi \rightarrow K^+K^- \tag{1}$$

The SIDDHARTA setup contained 144 SDD chips, 1cm^2 each, placed around a cylindrical target, filled with high density cryogenic gaseous hydrogen (deuterium or helium). The target was made of kapton, 75μm thick, reinforced with aluminium grid.

The SIDDHARTA setup was installed on DAΦNE in late summer 2008, and the period till the end of 2008 was used to debug and optimize the setup performances (degrader optimization included). The kaonic atoms measurements were done in 2009 and data analysis followed in the coming years, which produced the most precise measurement of kaonic hydrogen [1] and measurements of kaonic helium 3 [2] and kaonic helium 4 [3], [4]. Kaonic deuterium could not be measured by SIDDHARTA, since signal/background was too small.

2.2 The SIDDHARTA-2 setup

The upgrade from SIDDHARTA to SIDDHARTA-2 is relying on the following essential modifications:

- *Trigger geometry and target density*: By placing the upper kaon-trigger detector in front of the target entrance window the probability that a triggered kaon really enters the gas and is stopped there is improved. Making the detector smaller than the entry area gives away

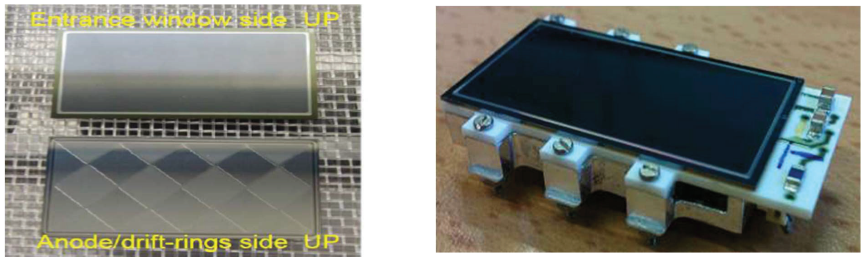

Figure 1: *The new 2 x 4 SIDDHARTA-2 SDD array together with the readout electronics.*

some signal, but suppresses efficiently the kaonic lines from “wall-stops” (kaons entering the gas volume, but passing from the inside of the target to the cylindrical walls). The number ”signal per trigger” goes up, which also reduces the accidental background coming along with every trigger. We will also plan to double the gas density which enhances the gas stops and further reduces the wall-stops.

- *Active shielding*: The scintillators surrounding the target will also be used in prompt anti-coincidence if the spatial correlation of SDD and scintillator hits indicates that it originated from a pion (“charged particle veto”). An anticoincidence covering the SDD time window of about 600 ns (with the exception of the 4 ns of the gas stopping time) will reduce the accidental background. Although the scintillators have low efficiency for gammas, the abundance of secondaries from the electromagnetic showers allows a relevant reduction of accidental (“beam”) background. The upper trigger scintillator has 2 functions, it is also used as an anticoincidence counter: after the kaon and eventual prompt kaon-absorption secondaries pass, it vetos beam background.

- *New SDD detectors*, produced by FBK, having a much better active/total surface ratio (about 85%, with respect to 40% in SIDDHARTA SDDs) (see Fig. 1).

- *Operating SDDs at a lower temperature*: tests indicate that an improvement of the timing resolution by a factor of 1.5 is feasible by more cooling. The signal enhancement by a factor 2 to 3 is due to moving the target cell closer to the IP, by changing its shape, by a better solid angle of the SDDs and by the higher gas density. In such conditions, with an integrated luminosity of 800 pb^{-1} a precision similar to that obtained for kaonic hydrogen is reachable.

In Fig. 2. a drawing of the SIDDHARTA-2 apparatus is shown, where the main components are highlighted.

To perform both conditioning of the machine and tuning of the various components of the SIDDHARTA-2 setup, a reduced version, named SIDDHARTINO , with only 1/6 of the X-ray silicon drift detectors (SDD) was installed in 2019 in the interaction point of the DAΦNE accelerator. Due to the pandemic situation, the SIDDHARTINO run started in January 2021 and lasted until July 2021. During this period, two runs with a target cell filled with ^{4}He gas at about 1.5% and 0.8% of liquid helium density were performed to optimize various setup components, as well as to provide feedback to the machine during its commissioning phase. The choice of ^{4}He was dictated by the high yield of the kaonic helium-4 (3d→2p) transition allowing for very fast tuning. The experimental outcomes of this run already represented the first important physics results of the SIDDHARTA-2 experiment, delivering the most precise measurement of the 2p level shift and width in the gaseous target [5].

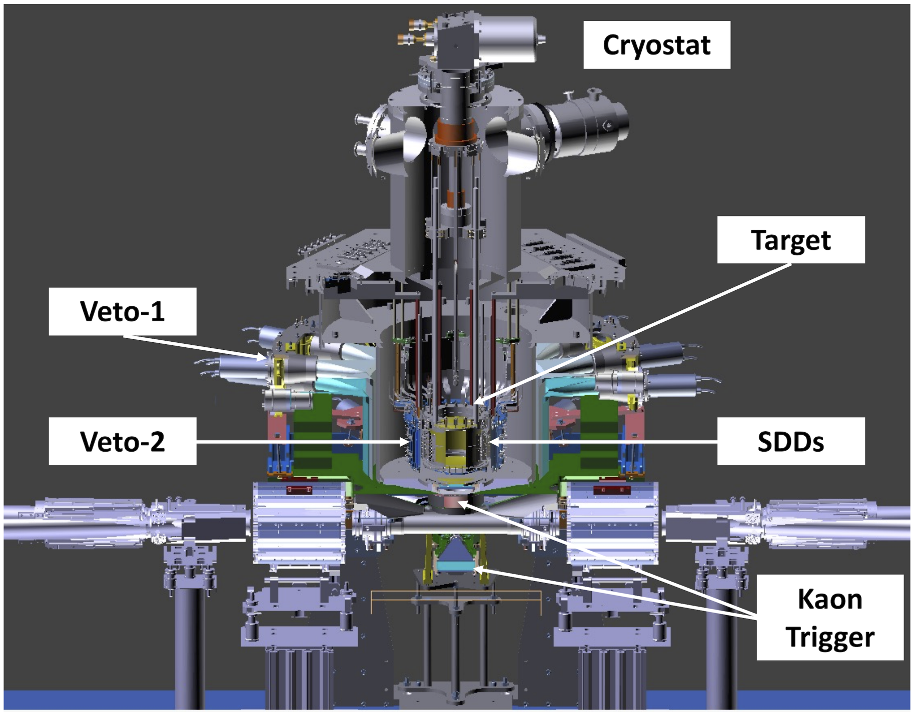

Figure 2: *Schematic view of the SIDDHARTA-2 setup.*

In the second half of 2021, the full SIDDHARTA-2 setup was installed on the DAΦNE interaction region in order to perform the kaonic deuterium measurement. The optimization phase of the collider and of the full setup performance was performed, in dedicated periods, from 2021 to 2023. To optimize the performance of the detectors and of the veto systems, various measurements with helium-4 and neon gas targets were realized in this period. At present, the SIDDHARTA-2 experiment is in data taking for the measurement of kaonic deuterium wich was initiated in spring of 2023, aiming to collect 800 pb^{-1} of data.

2.3 More details on 2023 SIDDHARTA-2 activities

2.3.1 First measurement of kaonic helium-4 M-series transitions

SIDDHARTA-2 setup was installed on DAΦNE and optimized by performing kaonic helium transitions measurements to the 2p level, which have a much higher yields than the transitions on the 1s level in kaonic deuterium. The target cell was filled in the period April - May 2022, with helium-4 at the density of 1.37 ± 0.07 g/l (1.1% liquid helium density).

The overall spectrum obtained for the data collected in the period April - May 2022, without selection cut is shown in Fig. 4, where peaks due to the fluorescence of the various materials present in the experimental apparatus. Titanium and copper lines are from setup components inside the vacuum chamber, while the bismuth comes from the alumina ceramic boards behind the SDDs.
The high continuous background contribution prevents to directly observe the kaonic helium signal. In this context, the Kaon Trigger plays a crucial role. Only the events falling in a 5 μs time window in coincidence with a trigger signal are selected, rejecting a substantial fraction of the background. The time window width was tuned to enable the front-end electronics to process and

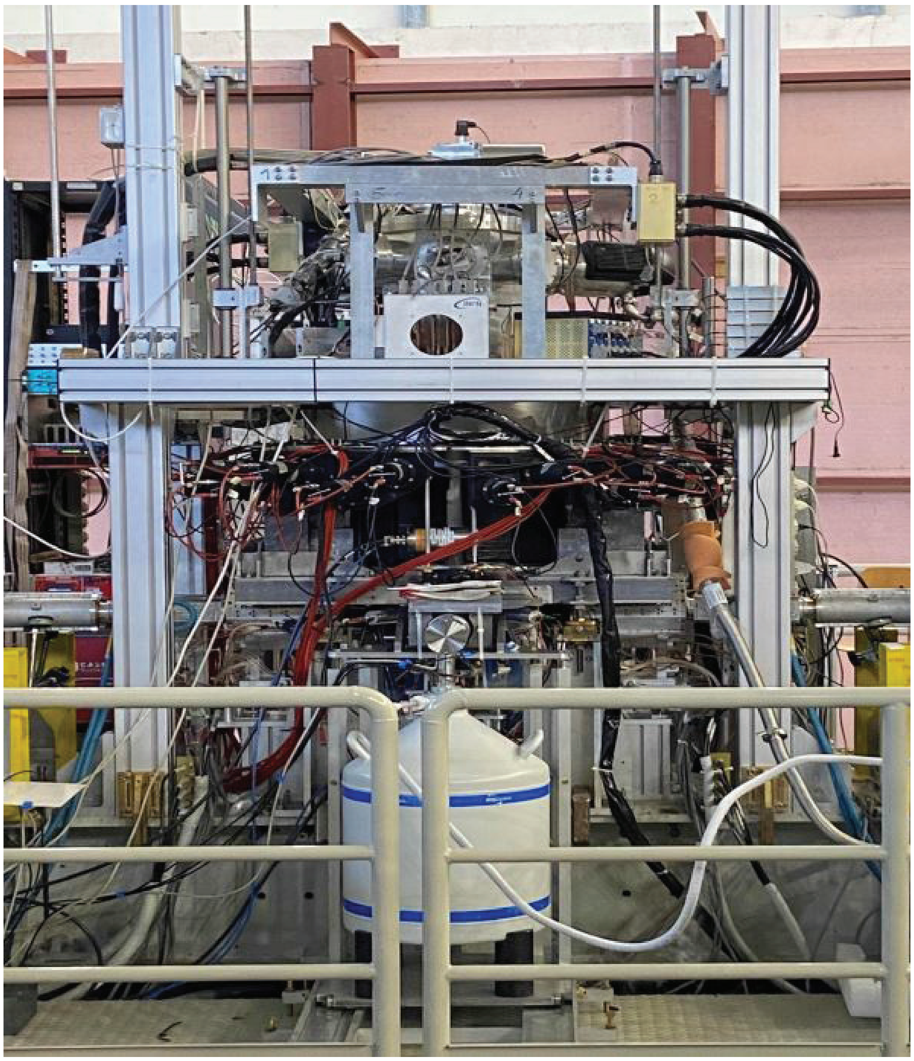

Figure 3: *Photo of SIDDHARTA-2 setup installed in DAΦNE.*

acquire the signals. However, there are cases where MIPs, generated by beam-beam and beam-gas interactions, can produce a trigger signal when they simultaneously pass through the Kaon Trigger scintillators. To distinguish between these MIP-induced triggers and those originating from K^+K^- pairs, a Time of Flight (TOF) analysis is employed. This technique relies on measuring the temporal difference between the trigger signal and the DAΦNE radio-frequency (RF), which serves as a collision reference (Fig. 5 left). In order to enhance the background rejection, the time difference between the Kaon Trigger signal and the time of X-ray detection was evaluated. This time distribution is shown in Fig. 5 right; the main peak within the red dashed lines corresponds to hits on the SDDs in coincidence with the trigger, while the flat distribution is given by uncorrelated events.

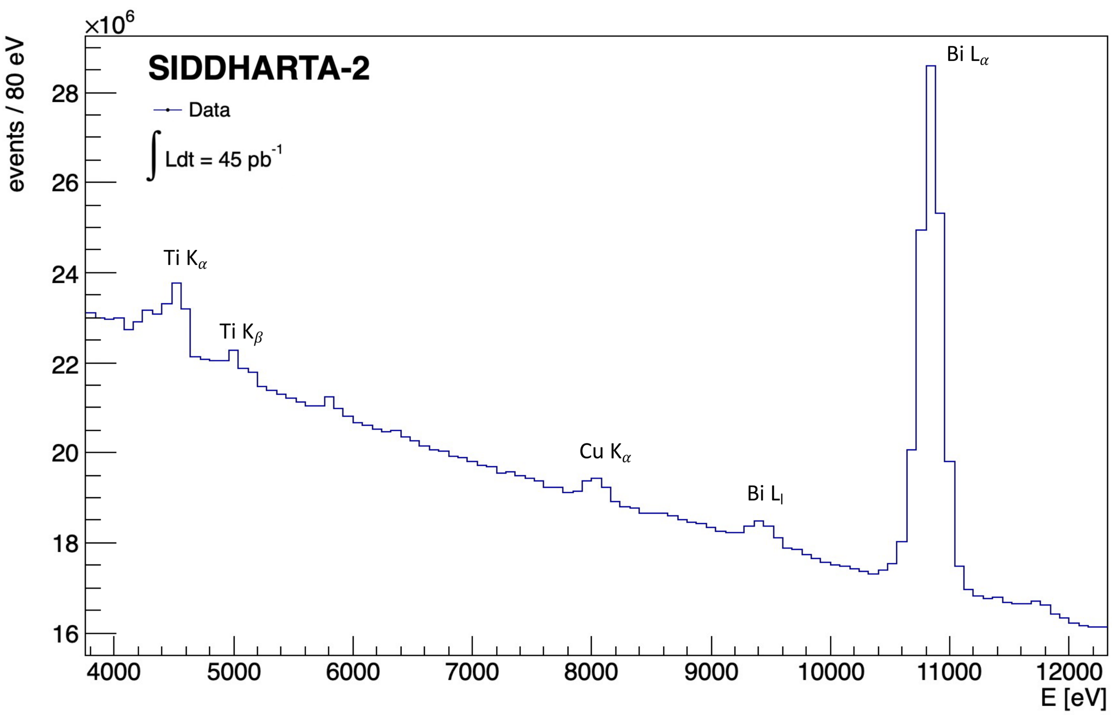

Figure 4: Raw data kaonic helium-4 energy spectrum obtained in the run of April - May 2022.

The combined use of Kaon Trigger and SDDs time information allowed to reduce the background by a factor 10^5 , resulting in the final energy spectrum shown in Fig. 6, where the number of events is drastically reduced and the fluorescence peaks are not visible anymore, except for that from titanium which is present in the top of the target cell and is activated by kaons not stopping in the gas. After the selection procedure, the kaonic helium-4 M-series and L-series lines are clearly visible in the energy regions 3.0 keV - 4.5 keV and 6.4 keV - 12 keV, respectively. Additionally, the X-rays lines corresponding to kaonic carbon, oxygen, nitrogen and aluminium, generated by kaons stopped in the apparatus support frame and in the kapton window of the target cell, are also detected.

Using the gaseous target allowed to observe and measure, for the first time, M-lines in kaonic helium, in particular the M_β, M_γ, and M_δ transitions. Their energies are reported in Table 1. The associated systematic errors were calculated taking into account the linearity and stability of the SDDs, as well as the calibration accuracy [6]. The M_α transition was not observed because,

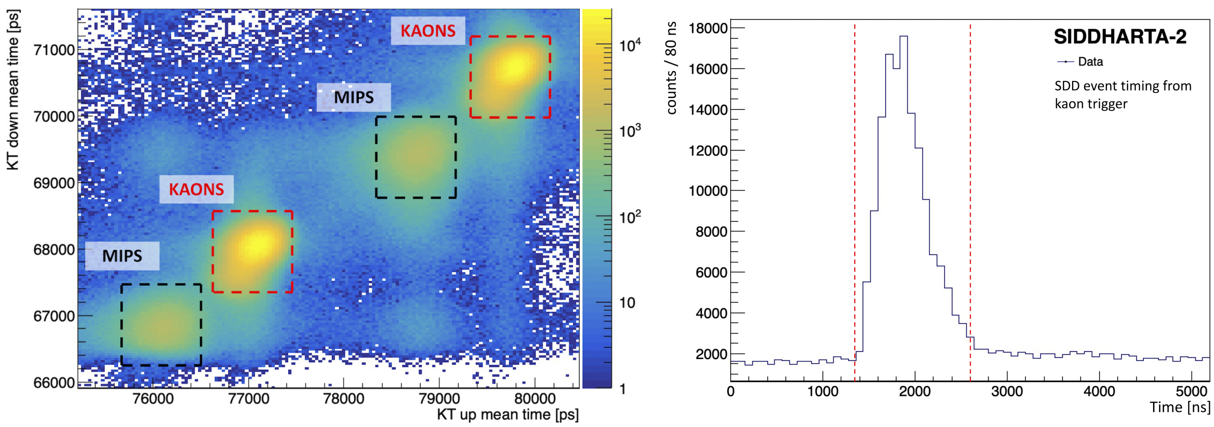

Figure 5: Left: Two-dimensional scatter plot of Kaon Trigger time distributions. The coincidence events related to kaons (high intensity) are clearly distinguishable from MIPs (low intensity). Right: Time difference between the Kaon Trigger signals and X-ray hits on the SDDs. The dashed lines represent the acceptance window.

having an energy lower than 3 keV, it is absorbed by the target cell kapton walls.

Table 1: The measured energies of the kaonic helium-4 L_α, M_β, M_γ, and M_δ transitions (submitted for publication).

Transition	X-ray name	Energy
3d→2p	L_α	$6461.4 \pm 0.8\,(\text{stat}) \pm 2.0\,(\text{sys})$ eV
5f→3d	M_β	$3300.8 \pm 13.2\,(\text{stat}) \pm 2.0\,(\text{sys})$ eV
6f→3d	M_γ	$3860.4 \pm 13.6\,(\text{stat}) \pm 2.2\,(\text{sys})$ eV
7f→3d	M_δ	$4214.1 \pm 19.6\,(\text{stat}) \pm 2.2\,(\text{sys})$ eV

2.3.2 *A new kaonic helium-4 L_α transition measurement*

The energy shift (ϵ_{2p}) has been extracted for the 2p level in the kaonic helium-4, from the difference between the measured L_α transition energy ($E^{exp}_{3d\to 2p}$), reported in Table 1, and the electromagnetic value ($E^{e.m}_{3d\to 2p}$) calculated by considering vacuum polarization and the recoil effect. The width (Γ_{2p}) was obtained from the Γ parameter of the Lorentzian function used to fit the L_α peak. The measured strong interaction induced shift and width of the 2p level in kaonic helium-4 (submitted for publication) are :

$$\epsilon_{2p} = E^{exp}_{3d\to 2p} - E^{e.m}_{3d\to 2p} = -1.9 \pm 0.8\,(\text{stat}) \pm 2.0\,(\text{sys})\ \text{eV} \quad (2)$$

$$\Gamma_{2p} = 0.01 \pm 1.60\,(\text{stat}) \pm 0.36\,(\text{sys})\ \text{eV} \quad (3)$$

The systematic uncertainty on the shift is related to the accuracy of the SDDs calibration, whereas the one on the width is given by the inaccuracy on the SDDs energy resolution.
The obtained results was improving by a factor of three the statistical precision on the 2p level shift and width obtained in the previous SIDDHARTA-2 measurement [5] making it the most precise measurement in a gas target. It shows that there is no sharp effect of the strong interaction on the 2p level, confirming the past measurements on gaseous kaonic helium-4.

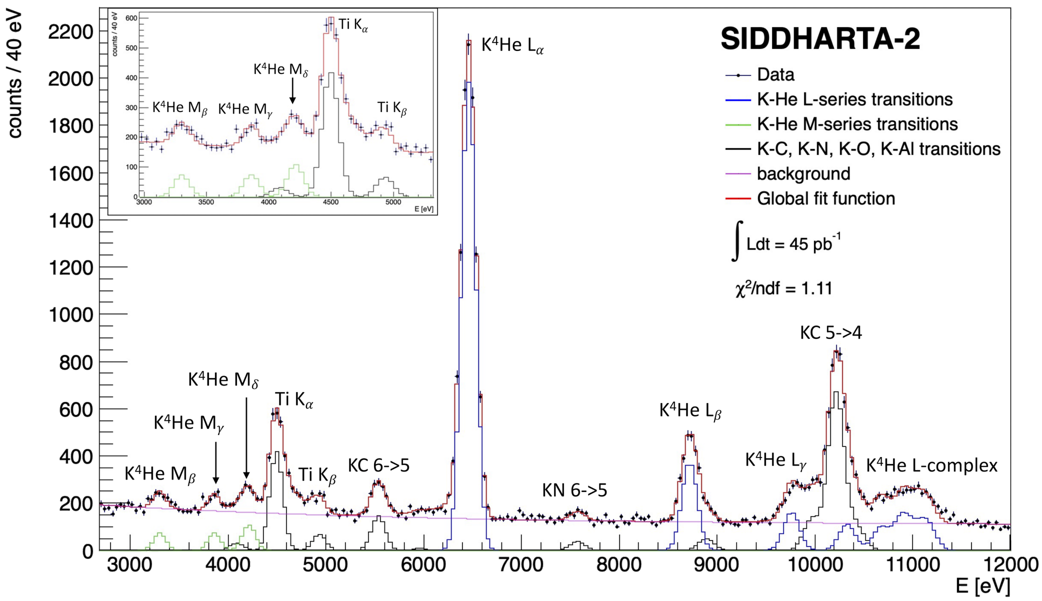

Figure 6: X-ray energy spectrum and fit of the data after the background suppression procedure. The kaonic helium-4 L-series and M-series transitions are indicated (reproduced from the article "First measurement of kaonic helium-4 M-series transitions", submitted for publication).

2.3.3 The L and M-series transitions X-ray yields

In Table 2 are reported the first experimental measurement of the M-series transitions yields, providing new experimental data to optimize the cascade models for kaonic helium and, more generally, kaonic atoms. Furthermore, the measurement of the L_α X-ray yield at the density of 1.37 ± 0.07 g/l establishes a new experimental record and data point that, combined with the measurements performed by SIDDHARTA [7] and SIDDHARTINO [8], will allow to check and improve kaonic atoms cascade models across the density scale (see Fig. 7).

Table 2: The absolute yields of the kaonic helium-4 L_α and M_β transitions and the relative yields of L_β, L_γ, M_γ, and M_δ transitions (submitted for publication).

Density	1.37 ± 0.07 g/l
L_α *yield*	$0.119 \pm 0.002\,(\text{stat})^{+0.006\,(\text{sys})}_{-0.009\,(\text{sys})}$
M_β *yield*	$0.026 \pm 0.003\,(\text{stat})^{+0.010\,(\text{sys})}_{-0.001\,(\text{sys})}$
L_β / L_α	0.172 ± 0.008 (stat)
L_γ / L_α	0.012 ± 0.001 (stat)
M_β / L_α	0.218 ± 0.029 (stat)
M_γ / M_β	0.48 ± 0.11 (stat)
M_δ / M_β	0.43 ± 0.12 (stat)

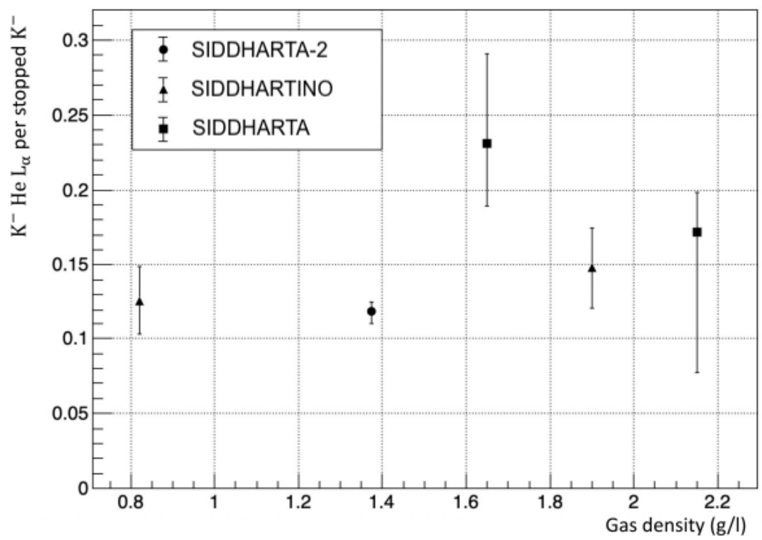

Figure 7: K^- ^{4}He L_α X-ray yield as function of the target density from this work, SIDDHARTINO [8], and SIDDHARTA [7].

2.3.4 *First kaonic neon measurement*

After additional improvements and optimizations of the SIDDHARTA-2 setup, in the periods April - May 2023 and September - October 2023, the first measurement ever of kaonic neon transitions was performed. In Fig. 8, the kaonic neon energy spectrum using 5 pb^{-1}, after having applied the data selection, is shown. The kaonic neon 8→7, 7→6 and 6→5 transitions are clearly visible in the energy region from 6 keV to 16 keV. The Kaonic carbon line 5→4 is also present, due to kaons stopped in the Kapton walls of the target cell. This result represents the first observation of the kaonic neon lines, and their measurement is an important source of data to improve the knowledge about the kaonic neon cascade process. A refined data analysis is ongoing, for a dedicated publication.

2.3.5 *Kaonic deuterium measurement*

The first period of the campaign measurement dedicated to the kaonic deuterium 2p→1s transition, was done from May to July 2023 (Run 1). The kaonic deuterium measurement Run 2 was performed in the period October - December 2023, followed by the Run 3, which started in February 2024 and will last until the summer 2024. A total luminosity of about 500 pb^{-1} (including injections) was collected in Runs 1 and 2. The use of data during injections is presently being evaluated.

2.4 Plan for the SIDDHARTA-2 activities in 2024

The LNF group main activities in SIDDHARTA-2 for 2024 will be the following ones:

- Run 3 kaonic deuterium measurement with the aim to an overall integrated luminosity of 800 pb^{-1}
- refined data analysis using also Machine Learning techniques

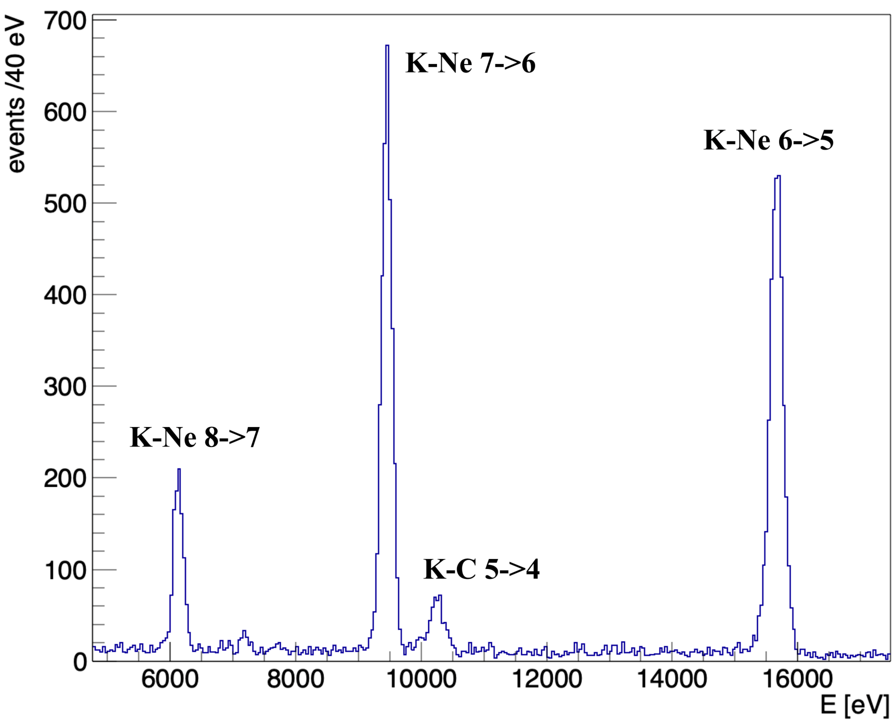

Figure 8: Kaonic neon energy spectrum after background suppression (see text) using 5 pb^{-1} delivered by DAΦNE. The kaonic neon signals are seen together with the kaonic carbon peak.

- test run with a High Purity Germanium detector for testing the feasibility of other kaonic atoms measurements, as kaonic lead.
- test run with CdZnTe detectors, which are ideal for detecting transitions toward both the upper and lower levels of intermediate-mass kaonic atoms, like kaonic carbon and aluminium
- consolidation of the proposal for kaonic atoms measurements beyond SIDDHARTA-2, i.e. EXKALIBUR program

In Fig. 9 we show the kaonic deuterium simulated spectrum and expected results for an integrated luminosity of 800 pb^{-1}.

3 AMADEUS: 2023

The low-energy kaon-nuclei interaction studies represent the main aim of AMADEUS. The negatively charged kaons from DAΦNE can stop inside the target or interact at low energies, giving birth of a series of processes we plan to study. Among these, a key-role is played by the production of $\Lambda(1405)$ which can decay into: Σ^0 π^0, Σ^+ π^- or Σ^- π^+. We study all these three channels in the same data taking. Another important item is represented by the debated case of the "kaonic nuclear clusters", especially the and K^-pp and K^-ppn ones. We study these channels by measuring their decays to Λp and to Λd. In the same time, many other kaon-nuclei processes are investigated, either for the first time, or in order to obtain more accurate results than those actually reported in literature. Cross sections, branching ratios, rare hyperon decay processes are investigated, taking advantage of the unique kaon-beam quality delivered by DAΦNE.

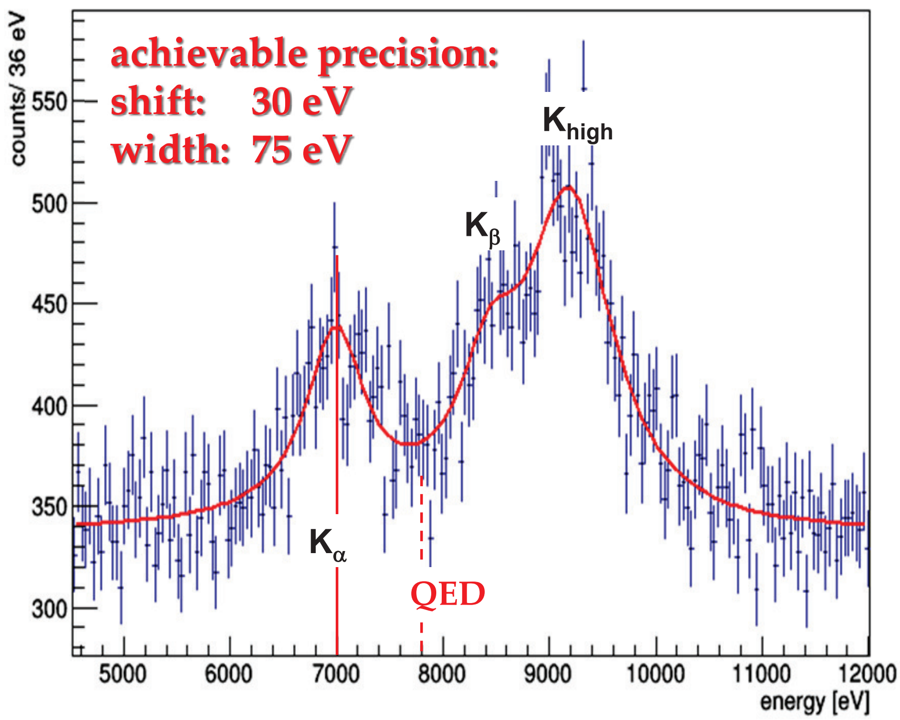

Figure 9: *Monte Carlo simulated kaonic deuterium spectrum for 800 pb^{-1}. sectors.*

In the summer of 2012 a first dedicated target, half cylinder done in pure carbon was realized and installed inside the Drift Chamber of KLOE as a first setup towards the realization of AMADEUS. The target thickness was optimized to have a maximum of stopped kaons (about 24% of the generated ones) without degrading too much the energy of resulting charged particles inside the target material. In the period of data taking a total integrated luminosity of about 90 pb^{-1} was achieved. The ongoing analysis of these data will provide new insights in the low-energy interactions of charged kaons in the nuclear matter.

Activities done in 2023:

- analysis of 2002-2005 KLOE data searching for processes generated by negatively charged kaons interacting at rest or in- fight in the setup materials (wall of the Drift Chamber and gas inside the Drift Chamber); the analyses of the K^- absorption delivering Λd and Λt final states were finalized and results are being prepared for pubblication;
- analysis of Σ^0 π^0;
- analysis of the 2012 Carbon target data;
- Monte Carlo dedicated simulations.
- During 2022 -2023 the highest precision - low-momentum - measurement of the inelastic K^-p $\to (\Sigma^0/\Lambda)\,\pi^0$ cross sections, for a K^- momentum $p_K = (98 \pm 10)$ MeV/c was finalized:
  - $\sigma_{K^-p\to\Sigma^0\pi^0} = 42.8 \pm 1.5(stat.)^{+2.4}_{-2.0}(syst.)$ mb
  - $\sigma_{K^-p\to\Lambda\pi^0} = 31.0 \pm 0.5(stat.)^{+1.2}_{-1.2}(syst.)$ mb.

With respect to previous experiments [9, 10], which extrapolated $\sigma_{K^- p \to \Sigma^0 \pi^0}$ from the measurement of the the $\mathrm{K^-p} \to \Lambda\pi^0$ cross section, assuming isospin symmetry, this is the first direct simultaneous measurement of the cross sections in the isospin $I = 1$, and almost pure $I = 0$ channels. Alongside a comparable range for the kaon momentum (± 10 MeV/c with respect to ± 12.5 MeV/c in Refs. [9, 10]) the present precision achieved in the cross section determination greatly overcomes the other low momentum measurements, providing a key input for the determination of the subthreshold $\bar{\mathrm{K}}\mathrm{N}$ scattering amplitudes and, hence, the determination of the $\Lambda(1405)$ nature, with impact on pending questions in several fields, ranging from nuclear and particle physics, to astrophysics.

3.1 AMADEUS activities in 2024

The main activities of AMADEUS in 2024 will be:

- analyses of data taken with the dedicated carbon target
- Monte Carlo dedicated simulations
- definition of the future strategy for dedicated experiment on DAΦNE and J-PARC.

In the framework of KAONNIS, the collaboration within various J-PARC experiments continued in 2023, and will also be extended in the coming years.

Acknowledgements
The support from LNF Director, Dr. Fabio Bossi and from the DAΦNE, KLOE2 and BTF-LNF teams are gratefully acknowledged.

4 List of Conference Talks by LNF Authors in 2023

1. F. Artibani , Towards new intermediate-mass kaonic atoms measurements with novel CdZnTe X-ray detectors at DAΦNE, ROCKSTAR: Towards a ROadmap of the Crucial measurements of Key observables in Strangeness reactions for neutron sTARs equation of state, 9-13 October 2023, ECT* - Trento, Italy
2. C. Curceanu, SIDDHARTA-2 experiment status at the DAΦNE Collider and future plans 3rd International Workshop on the Extension Project for the J-PARC Hadron Experimental Facility, Japan 14-16 March (online)
3. C. Curceanu, Quantum cats and neutron stars: From exotic atoms studies to Impossible atoms hunting Colloquium, ANU Canberra, Australia, 3rd March 2023
4. C. Curceanu, The new era of kaonic atoms experiments: from SIDDHARTA to EXKALIBUR Applications of radiation detection techniques in fundamental physics, food control, medicine and biology, 8-12 May 2023, LNF-INFN, Frascati, Italy
5. C. Curceanu, Kaonic atoms at the DAΦNE Collider in Italy: a strangeness Odyssey Colloquium, CSSM+CDMPP University of Adelaide, Australia, 2nd August 2023
6. C. Curceanu, Kaonic atoms at the DAΦNE Collider in Italy: a strangeness Odyssey Colloquium, UTAS, University of Tasmania, Australia, 15th August 2023

7. C. Curceanu, Kaonic atoms at the DAΦNE Collider in Italy: a strangeness Odyssey Nuclear Matter at Extreme Densities and High Temperatures September 17-23 2023, Zakopane, Tatra Mountains, Poland

8. C. Curceanu, Low-energy K^--nucleus/nuclei interactions with light nuclei with AMADEUS ROCKSTAR: Towards a ROadmap of the Crucial measurements of Key observables in Strangeness reactions for neutron sTARs equation of state 9-13 October 2023, ECT* - Trento (Italy)

9. C. Curceanu, Future plans at the DAΦNE Collider EXKALIBUR mini-WS: Toward a new era of kaonic nuclei and atoms at DAΦNE and J-PARC RIKEN, Japan, 14th December 2023

10. C. Curceanu, Kaonic atoms at the DAΦNE Collider in Italy: a strangeness Odyssey Colloquium, ELPH, Tohoku University, Sendai (Japan), 20th December 2023

11. L. De Paolis, Kaonic Atoms at the DAΦNE collider beyond SIDDHARTA-2: future perspectives, Meson 2023, 22-27 June 2023, Krakow, Poland

12. L. De Paolis, The KAMEO proposal: Nuclear resonance effects in kaonic atoms, High Precision X-Ray Measurements 2023, 19-23 June 2023, LNF-INFN, Frascati, Italy

13. L. De Paolis, The KAMEO proposal: Nuclear resonance effects in kaonic atoms, Mini-workshop on kaonic atoms and future plans, 18 July 2023, LNF-INFN, Frascati, Italy

14. L. De Paolis, Advanced Kaonic Atom Measurements at the DAΦNE Collider: The SIDDHARTA-2 Experiment and Beyond, XII International Conference of New Frontiers in Physics 2023, 10-23 July 2023, Kolymbari, Crete. Greece

15. L. De Paolis, The KAMEO proposal: investigating the strong kaon-nucleus interaction through the E2 nuclear resonance effect in kaonic atoms, ROCKSTAR: Towards a ROadmap of the Crucial measurements of Key observables in Strangeness reactions for neutron sTARs equation of state, 9-13 October 2023, ECT* - Trento, Italy

16. L. De Paolis, Nuclear resonance effects in kaonic atoms, Applications of radiation detection techniques in fundamental physics, food control, medicine and biology, 8-12 May 2023, LNF-INFN, Frascati, Italy

17. I. Friscic, Data taking with HPGe - status and plans, Mini workshop on kaonic atoms: present status and future plans, 18 July 2023, LNF-INFN, Frascati, Italy

18. A. Khreptak, Calibration of Silicon Drift Detectors for High Precision Spectroscopy in SIDDHARTA-2 Experiment, Applications of radiation detection techniques in fundamental physics, food control, medicine and biology, 8-12 May 2023, LNF-INFN, Frascati, Italy

19. A. Khreptak, Calibration of Silicon Drift Detectors for High Precision Spectroscopy in SIDDHARTA-2 Experiment, High Precision X-ray Measurements 2023, 19-23 June 2023, LNF-INFN, Frascati, Italy

20. A. Khreptak, Calibration of Silicon Drift Detectors for High Precision Spectroscopy in SIDDHARTA-2 Experiment, Symposium on New Trends in Nuclear and Medical Physics. 18-20 October 2023, Kraków , Poland

21. A. Khreptak, Poster: Overview and Performance of the SIDDHARTA-2 Apparatus, Symposium on New Trends in Nuclear and Medical Physics. 18-20 October 2023, Kraków , Poland

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