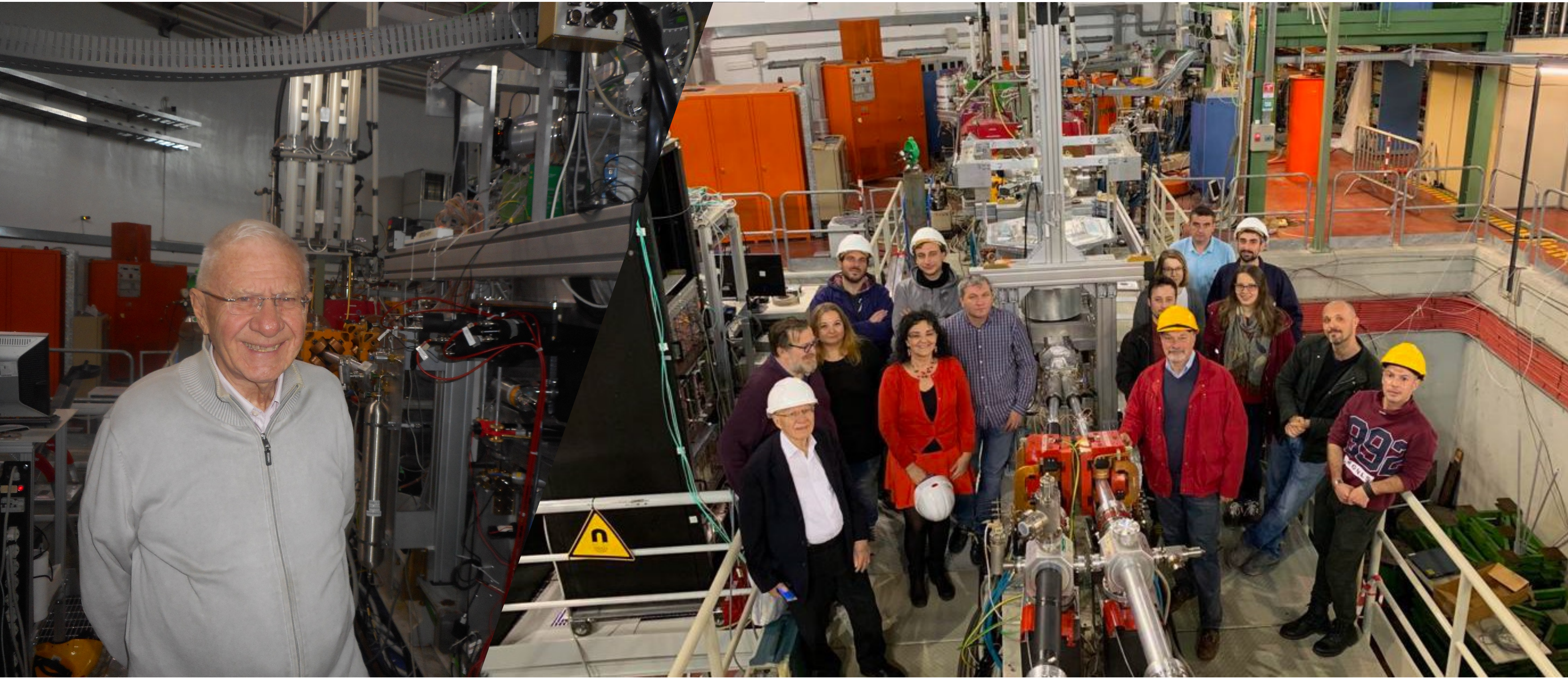
SIDDHARTA-2: Status report

Catalina Curceanu and Francesco Sgaramella
on behalf of the SIDDHARTA-2 collaboration

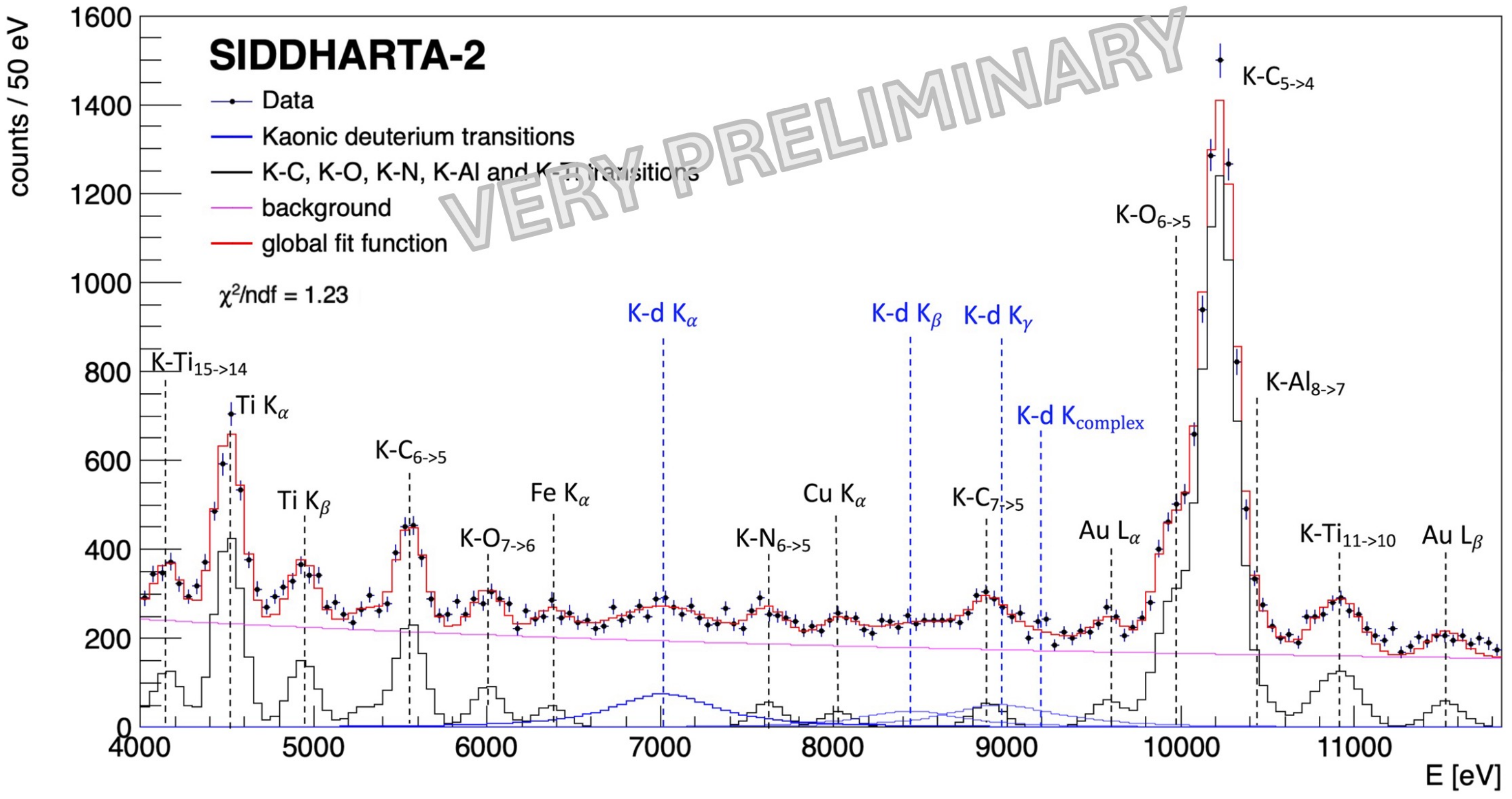
67th Scientific Committee Meeting – 27th May 2024

We dedicated our results to our dear colleague and friend Prof **Carlo Guaraldo** you'll be very much missed!



Kaonic Deuterium: preliminary result

First measurement ever of kaonic deuterium X-ray transitions



$$\varepsilon_{1s} = -816 \pm 53\ (\text{stat}) \pm 2\ (\text{syst})\ \text{eV}$$

$$\Gamma_{1s} = 756 \pm 271\ (\text{stat})\ \text{eV}$$

"The **most important experiment to be carried out in low energy K-meson physics today** is the **definitive determination of the energy level shifts in the K−p and K−d atoms**, because of their direct connection with the physics of $\bar{K}N$ interaction and their complete independence from all other kinds of measurements which bear on this interaction".

R.H. Dalitz (1982)

Contents

- 66th Scientific Committee recommendations and our related actions
- Kaonic Deuterium Run: status and preliminary results
- Updates on HPGe and CdZnTe detectors and preliminary results
- Future plans: EXKALIBUR – first module

66^{th} Scientific Committee recommendations

- The SC endorses the current plan to continue running the DAΦNE/ SIDDHARTA-2 setup, completing a second run by the end of 2023 and a third one before the summer of 2024. Thus, it encourages the SIDDHARTA-2 collaboration to continue decisively with their kaonic deuterium data-taking, with the aim of **collecting 800-900 pb-1 in total**.

- To complete the ongoing evaluation of the usability of the data recorded during **injection time**.

- If the 800-900 pb-1 goal on deuterium is successfully achieved before the end of June, the SC considers it appropriate to still extend Run 3 until the end of June 2024, so that the collaboration can measure light kaonic atoms, partly profiting from the post-calibration run.

- To continue during runs 2 and 3 with the satellite HPGe and CdZnTe detectors, but always minimizing their interference with the Kd data taking.

- Finally, the SC recommends **the submission, before the next SC meeting in May 2024, of a detailed proposal of the first module of the EXCALIBUR proposal**. This should include a calendar for installation, commissioning, and operation, integrated luminosity needs, and details on what parts of the main and satellite detectors could be operative at what times as well as the specific kaonic atoms to be measured.

The Kaonic Deuterium Measurement - Timeline

- **First Kd run** May - July 2023: 164 pb^{-1} integrated luminosity;
- **Second Kd run** October - December 2023: 276 pb^{-1} integrated luminosity;
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2023, 8th Nov
66th Scientific Committee

2023, Oct - Dec
Kaonic deuterium Run2
HPGe and CdZnTe data taking

2023, Dec
Winter stop
Ordinary maintenance of the setup

2024, Feb - Apr
Kaonic deuterium Run3
HPGe and CdZnTe data taking

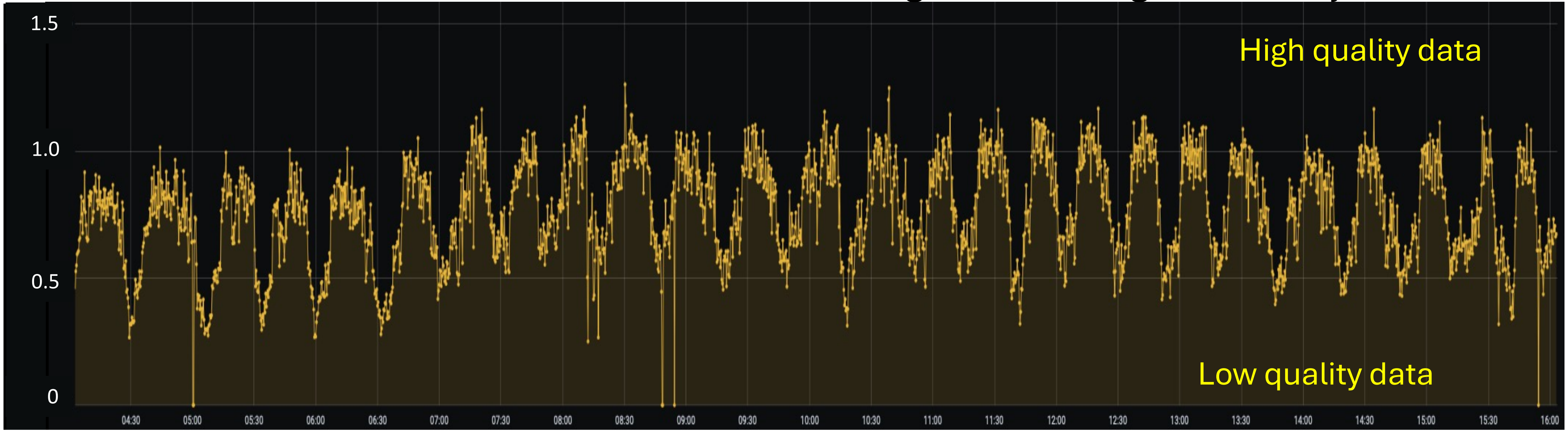
67th Scientific Committee

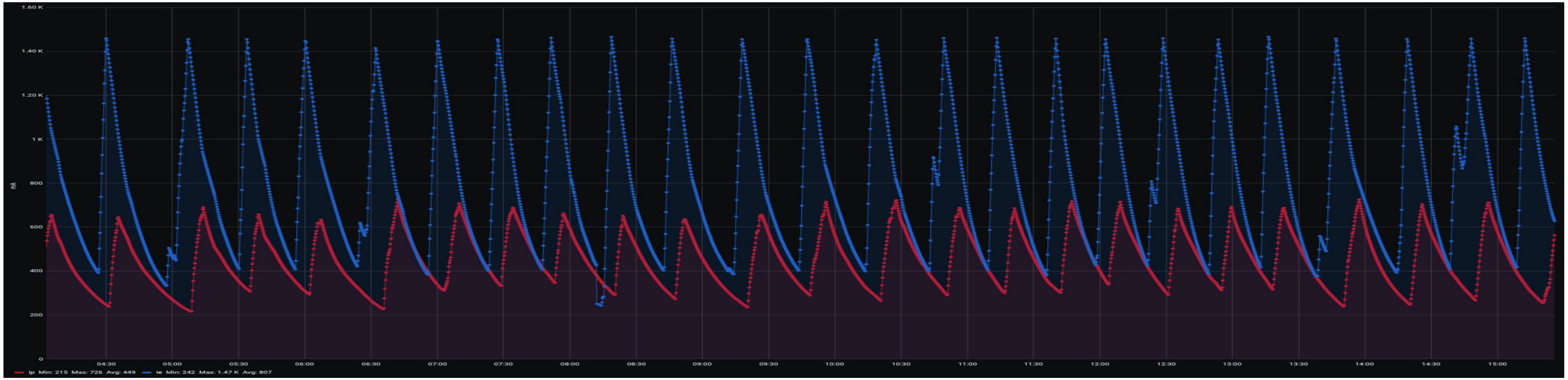
...with the aim of <u>collecting 800-900 pb-1 in total</u> – goal achieved! Thanks to excellent DAΦNE working conditions.

	Luminosity delivered [pb^{-1}]
Run1	196
Run2	344
Run3	435
Total	**975**

Injections data analysis

Kaon/SDD rate used to evaluate the background during the e^-e^+ injections



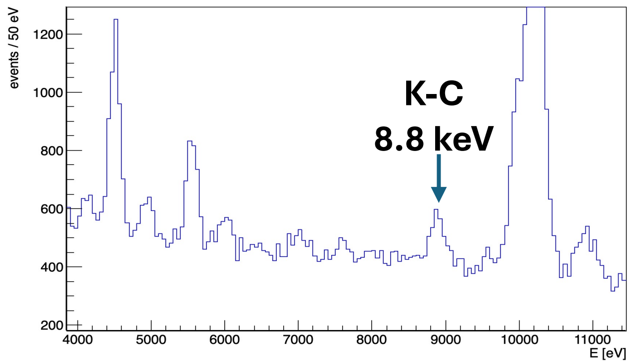


Injection data analysis

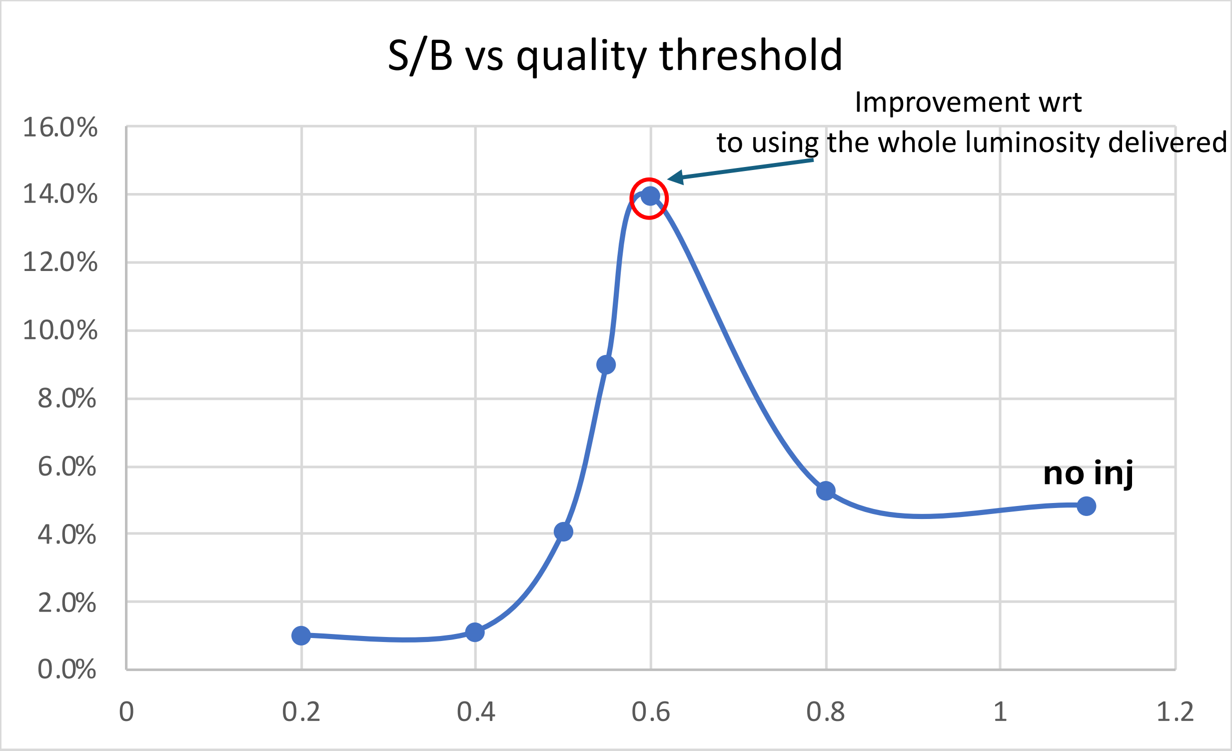
Kaonic deuterium run1 (May – July 2023)

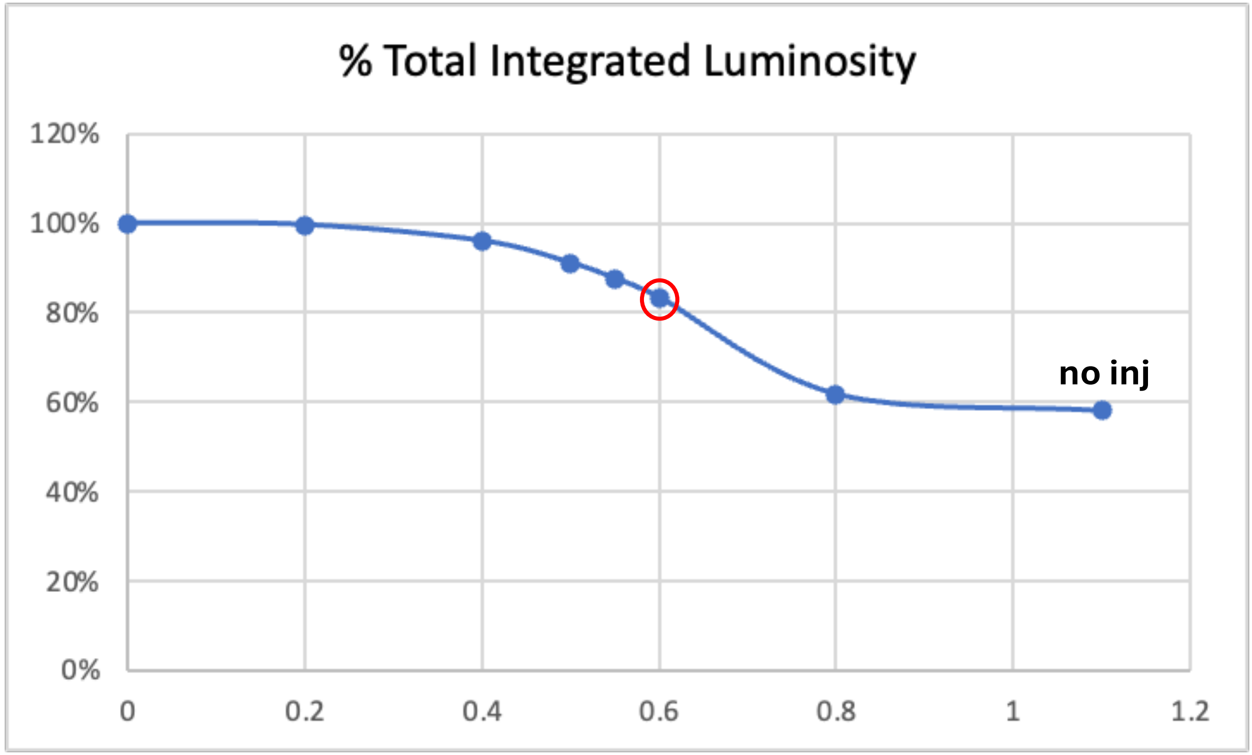
200 pb^{-1} total integrated luminosity

82 pb^{-1} luminosity integrated during injection (40% of the total)



Study of S/B (K-C 8.8 keV) as function of the **Kaon rate / SDD rate** quality factor





60% of the injection data good for physics (50 pb^{-1} out of 82 pb^{-1})

run1: total "good" integrated luminosity 168 pb^{-1} (84%)

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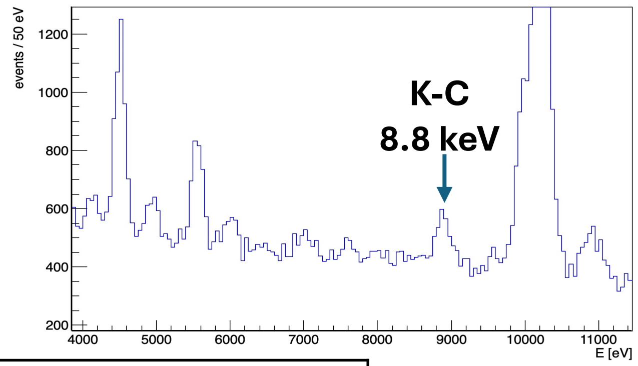

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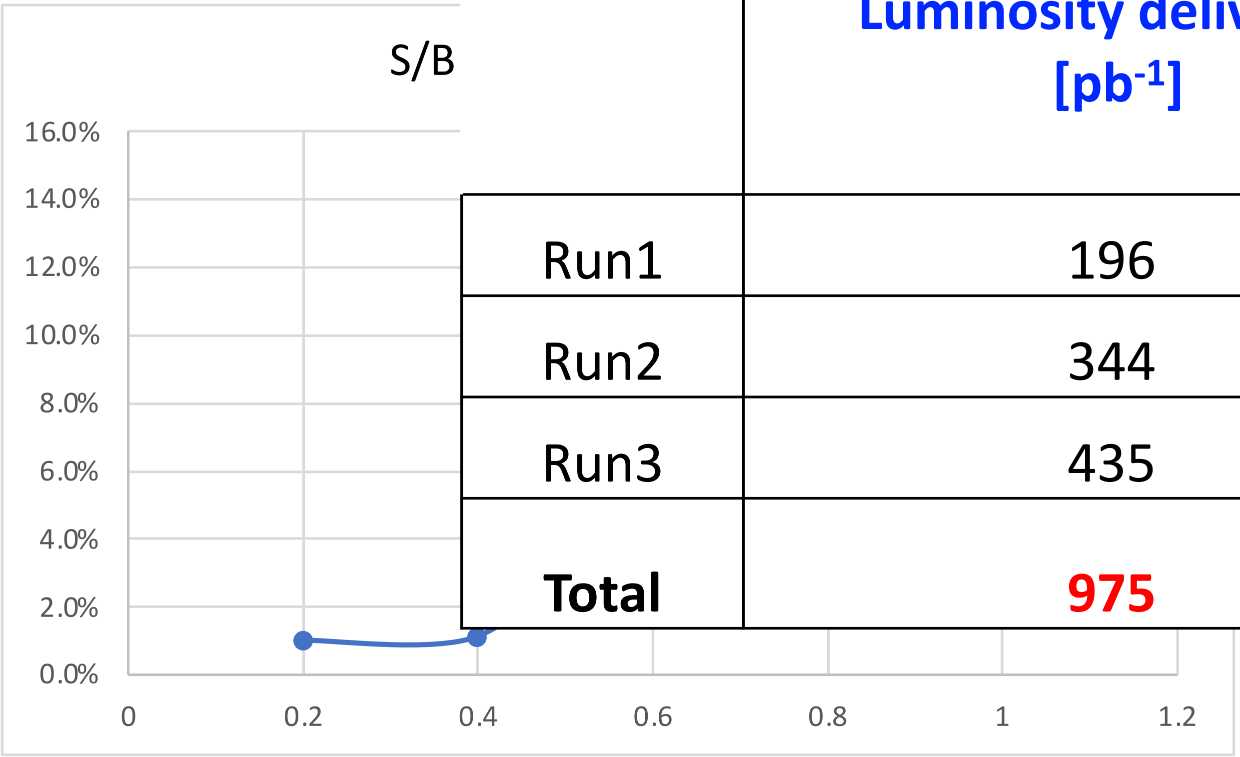
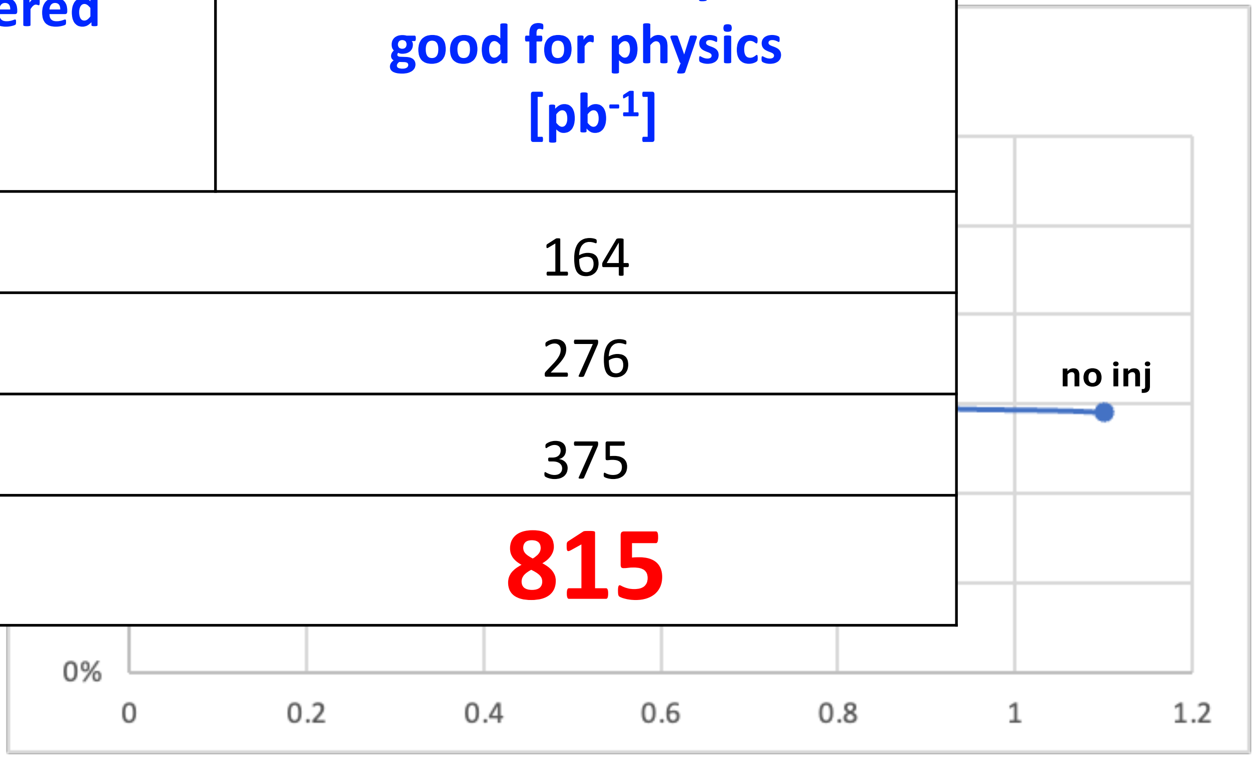


	Luminosity delivered [pb^{-1}]	Luminosity good for physics [pb^{-1}]
Run1	196	164
Run2	344	276
Run3	435	375
Total	**975**	**815**



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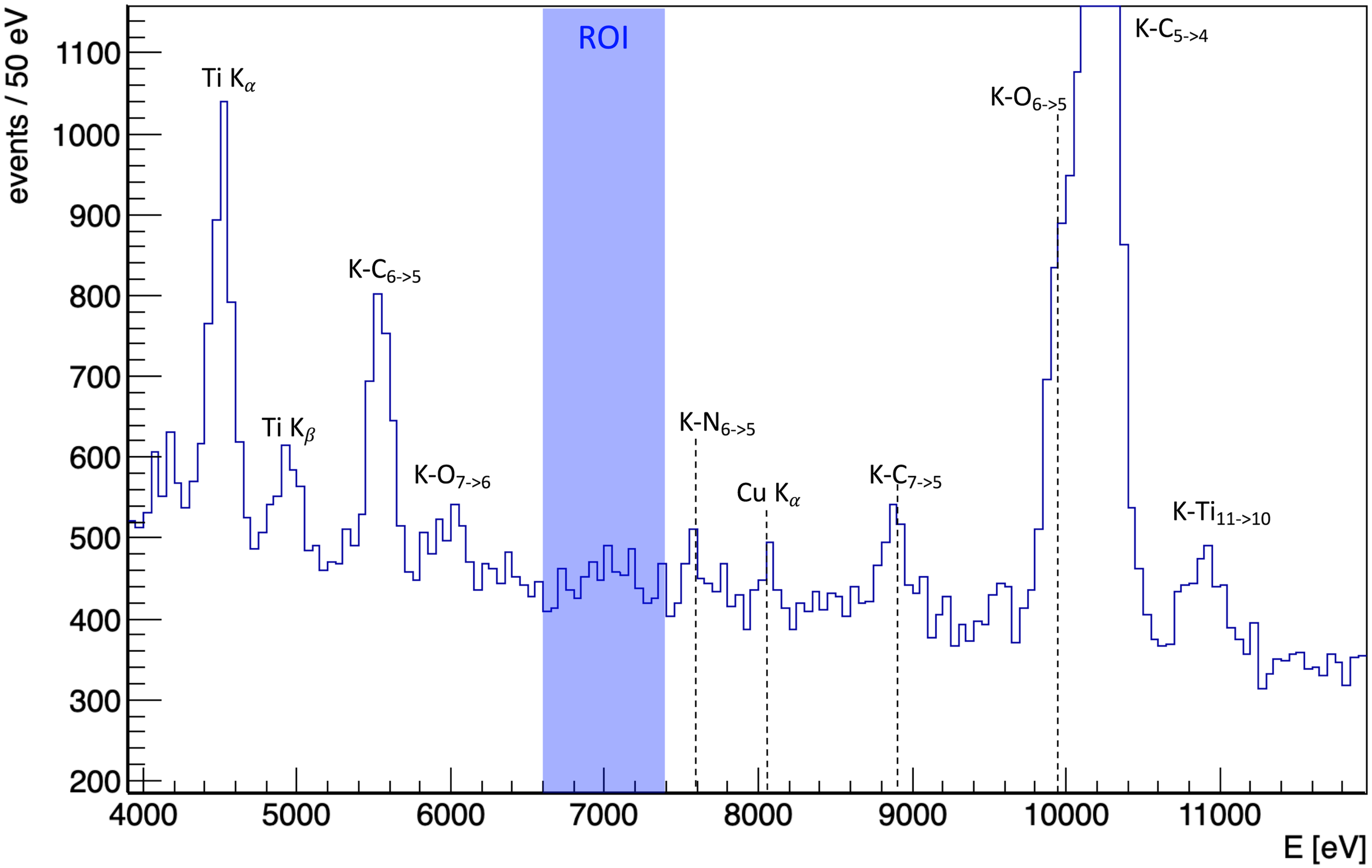
Kaonic Deuterium Run1: data analysis

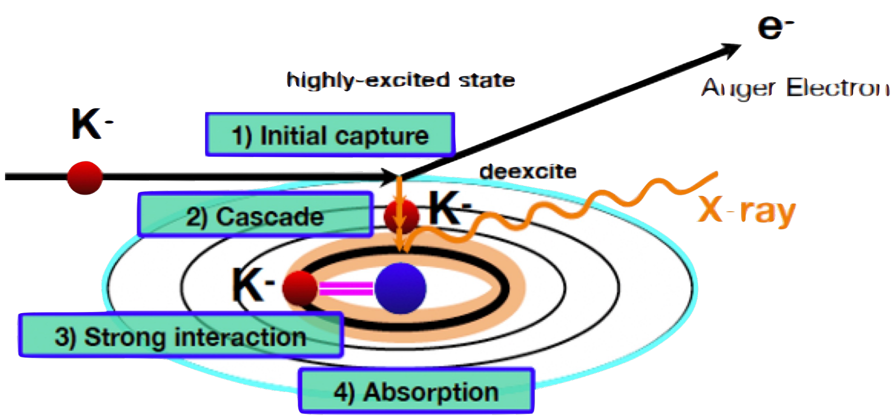
Preliminary energy spectrum after asynchronous (electromagnetic) background rejection

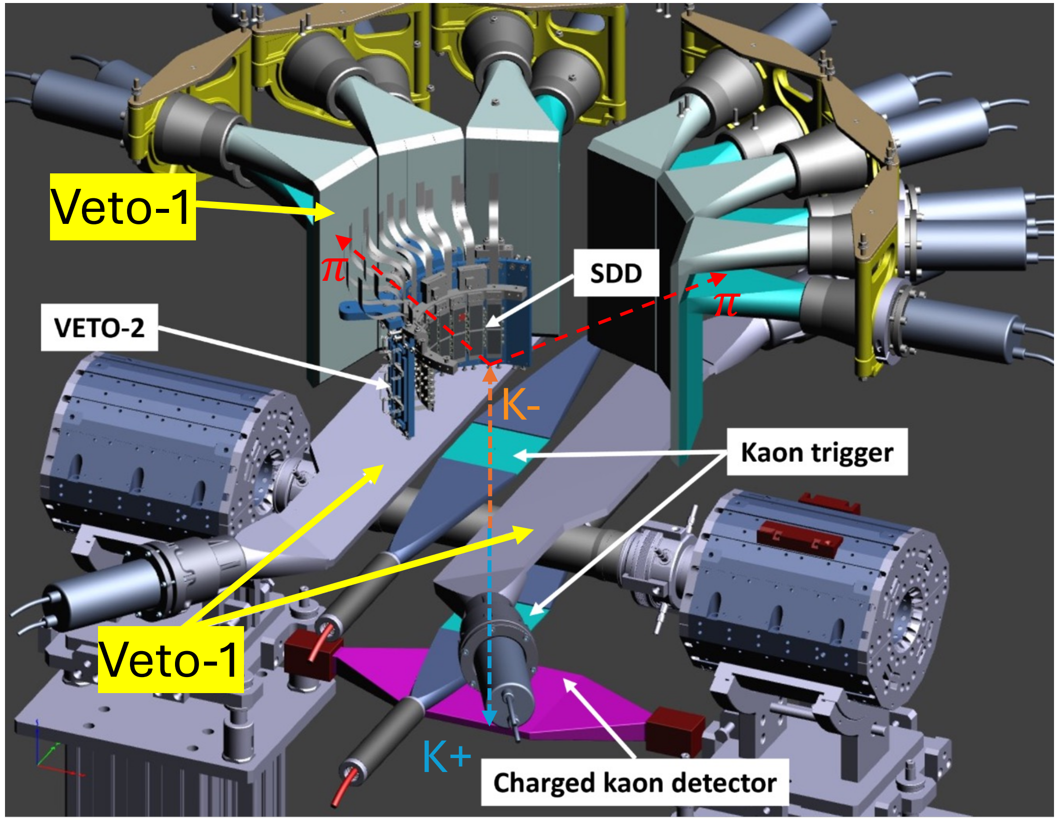


- ✓ Refined calibration
- ✓ Analysis of all veto systems data
  - ➢ Veto-1 system
  - ➢ Veto-2 system
  - ➢ Charged kaon system
- ✓ Hadronic background rejection
- ✓ Preliminary fit of the energy spectrum

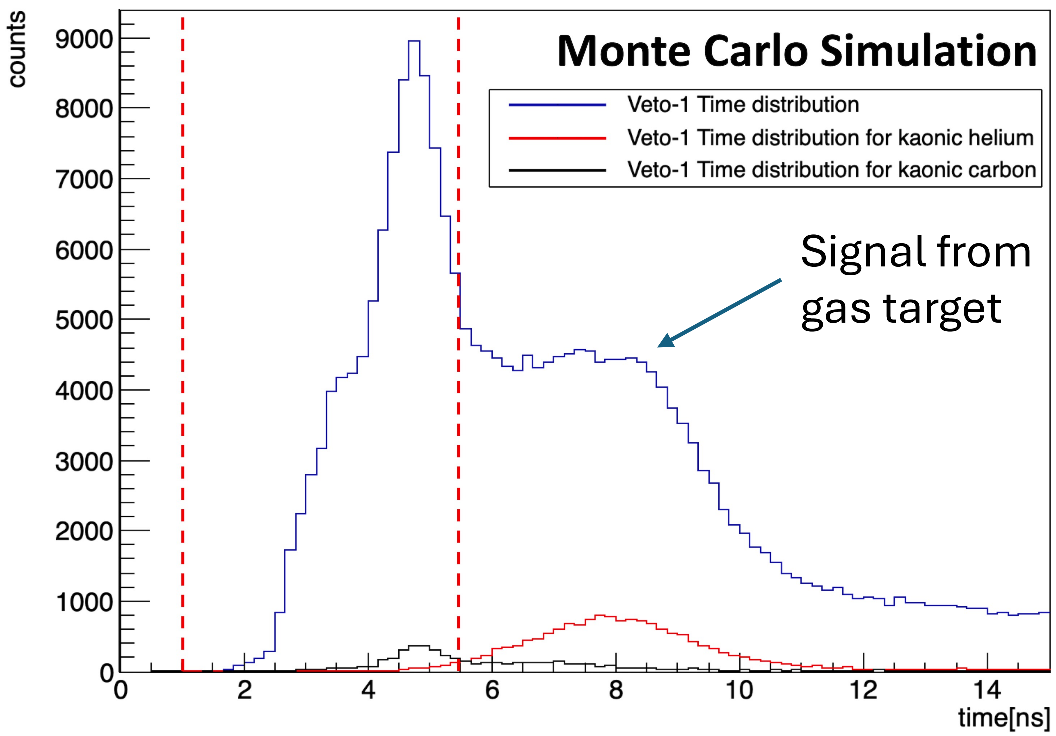
Kaonic Deuterium Run1: veto-1 system analysis

Veto-1 for synchronous background reduction:
measure the arrival time of the charged particles emitted by the kaon-nucleus absorption

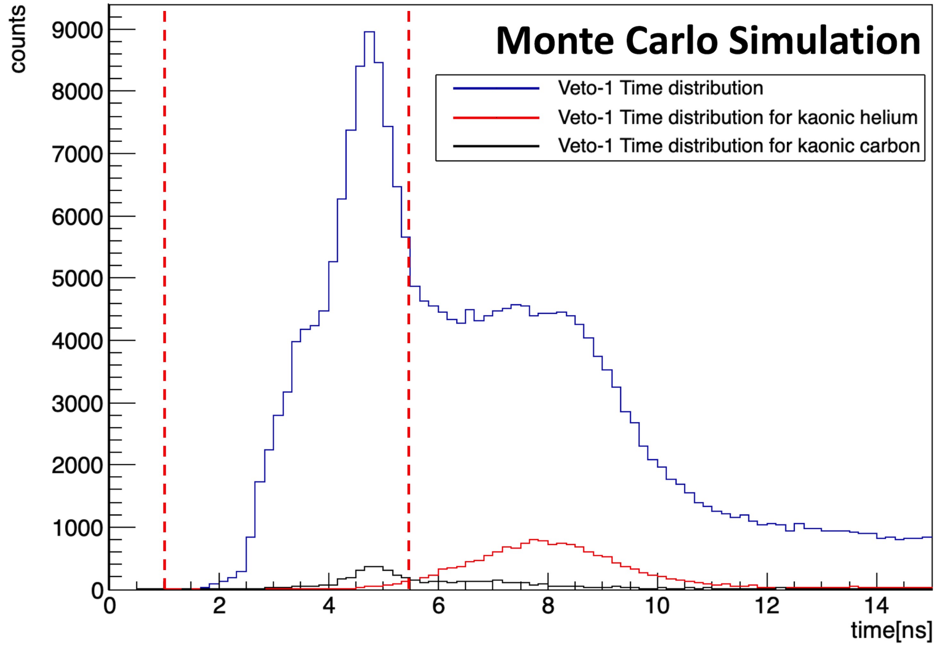


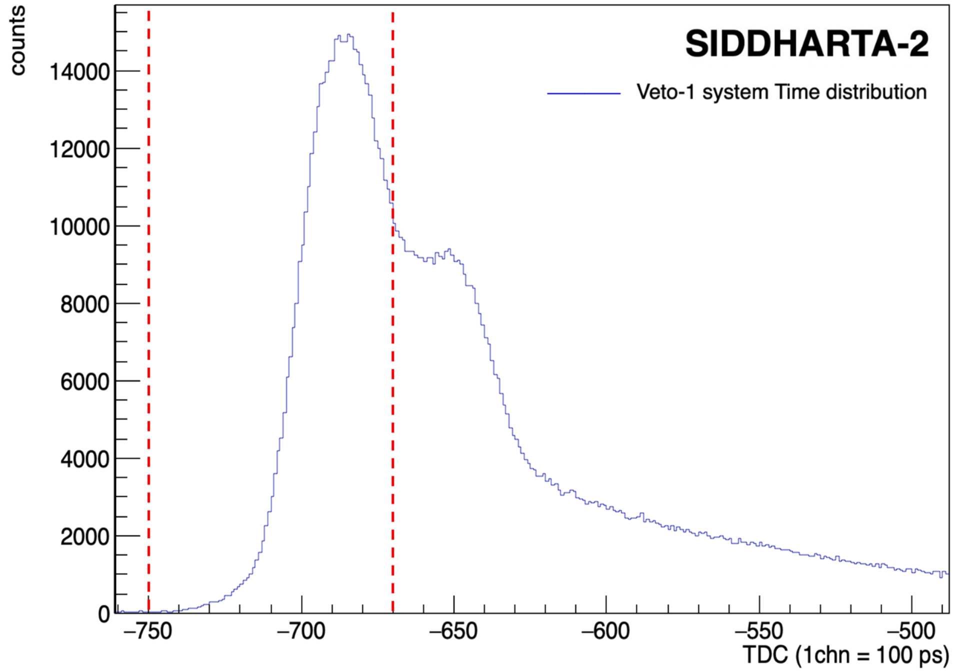


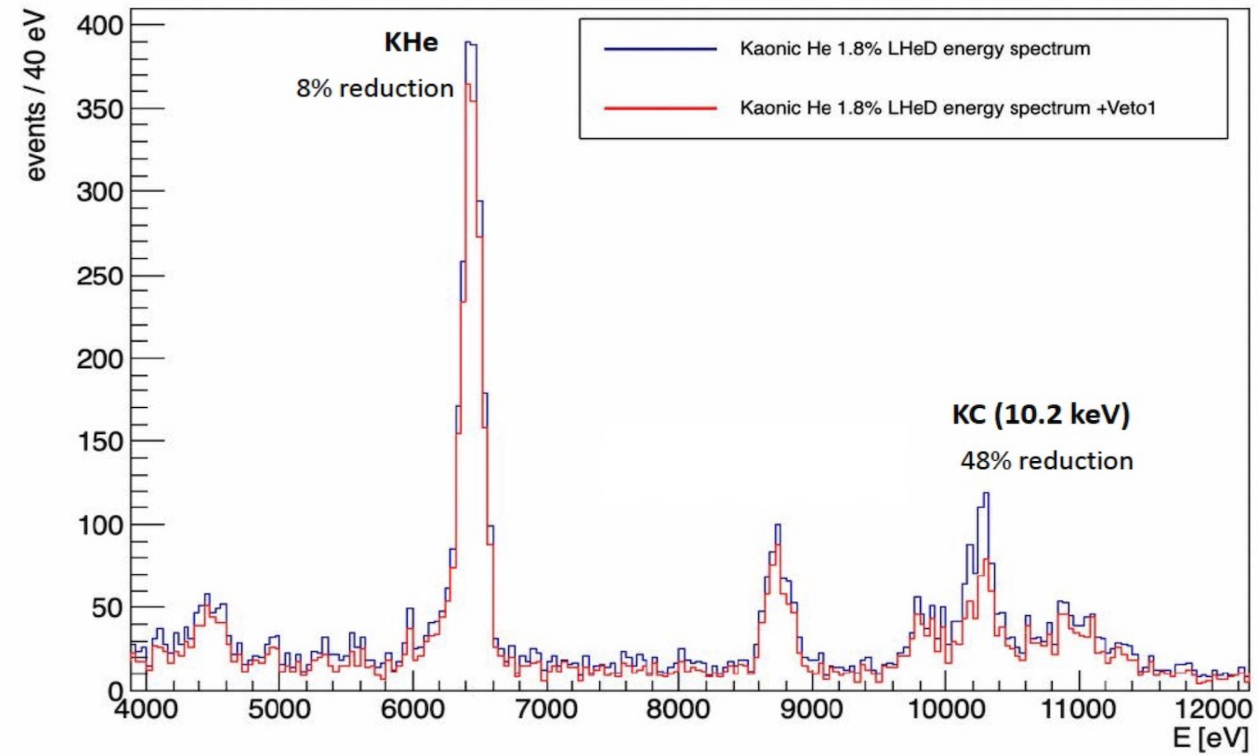
Veto-1: 14 plastic scintillators placed around and below the vacuum chamber



Veto-1 system optimization with kaonic He





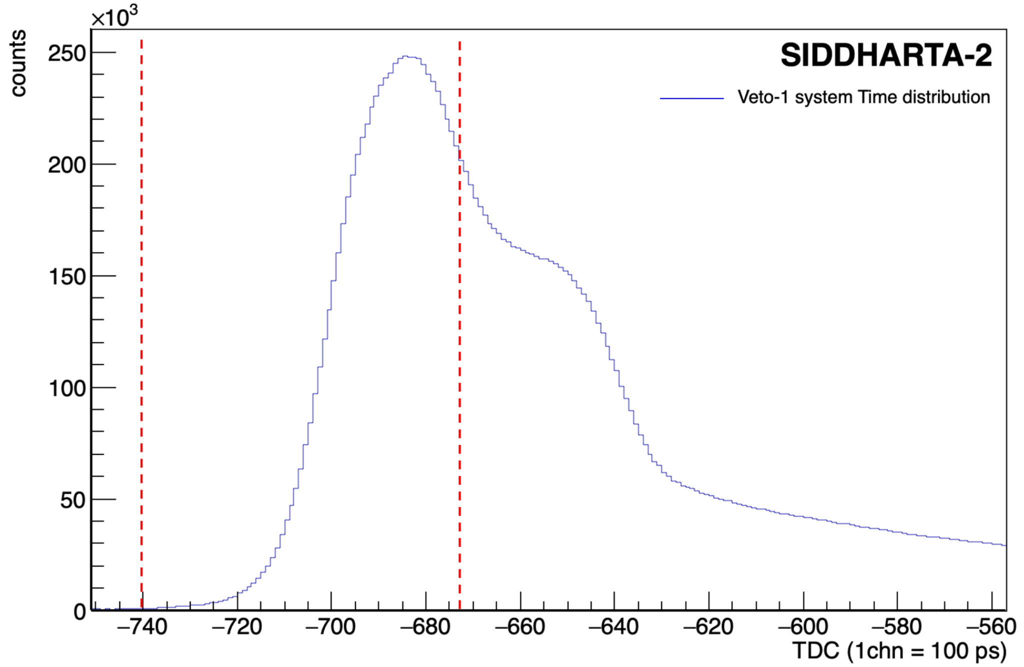


	SIDDHARTA-2 Veto-1 reduction factor	Monte Carlo Veto-1 reduction factor
$K\text{-}^4He\ L_\alpha$	$(8 \pm 1)\%$	4%
$K\text{-}C_{5\to4}$	$(48 \pm 4)\%$	44%

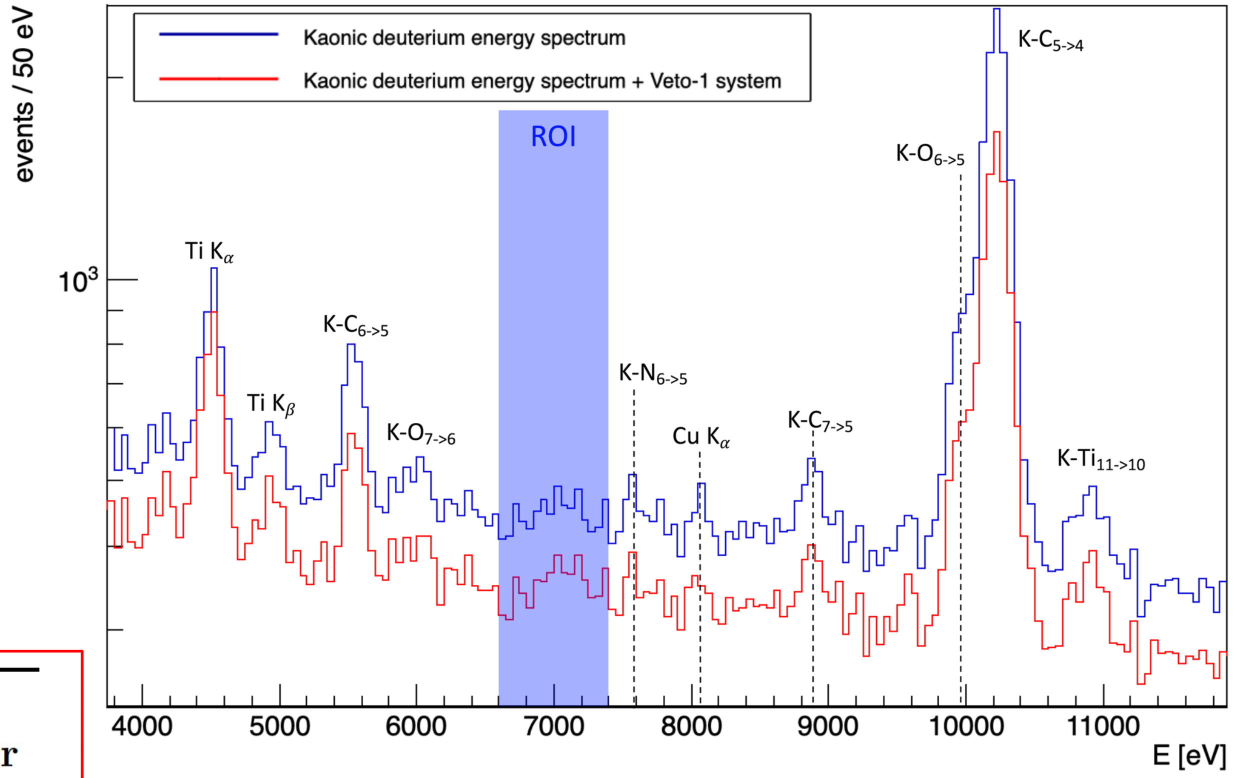
$$\text{reduction factor} = 1 - \frac{\#\text{events(with veto1)}}{\#\text{events}}$$

Kaonic Deuterium Run1: veto-1 system analysis

Veto-1 time distribution and time window used to reduce the background



SDDs X-ray energy spectra with and without the veto-1 (be aware logarithmic scale)



	SIDDHARTA-2 Veto-1 reduction factor	Monte Carlo Veto-1 reduction factor
K-d K_α	$(11 \pm 3)\%$	4%
K-$C_{5\to4}$	$(44 \pm 4)\%$	46%
K-$C_{6\to5}$	$(39 \pm 5)\%$	45%
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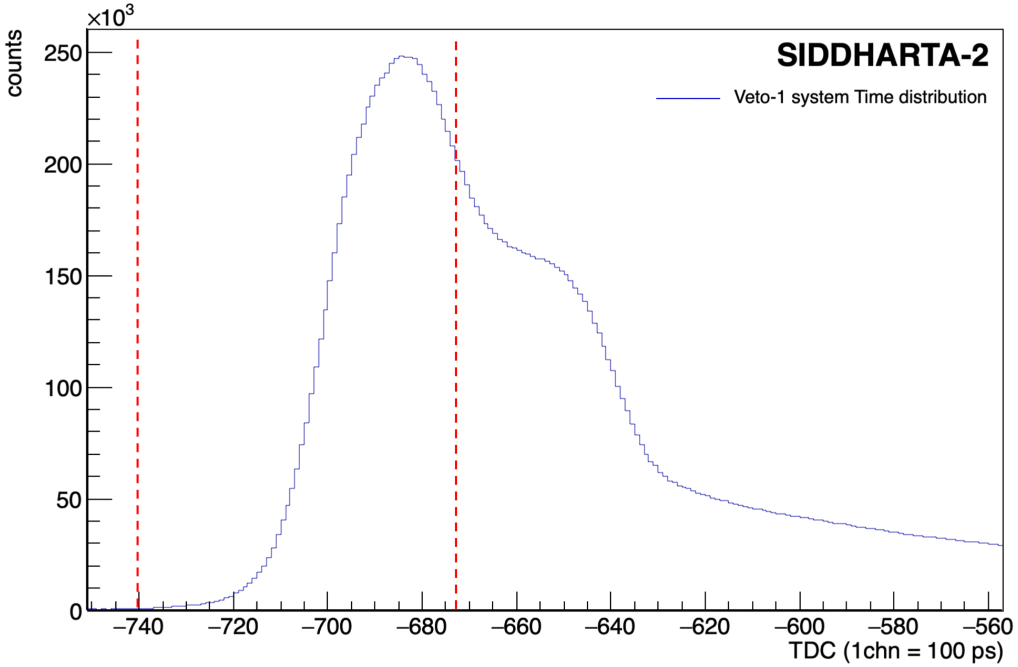

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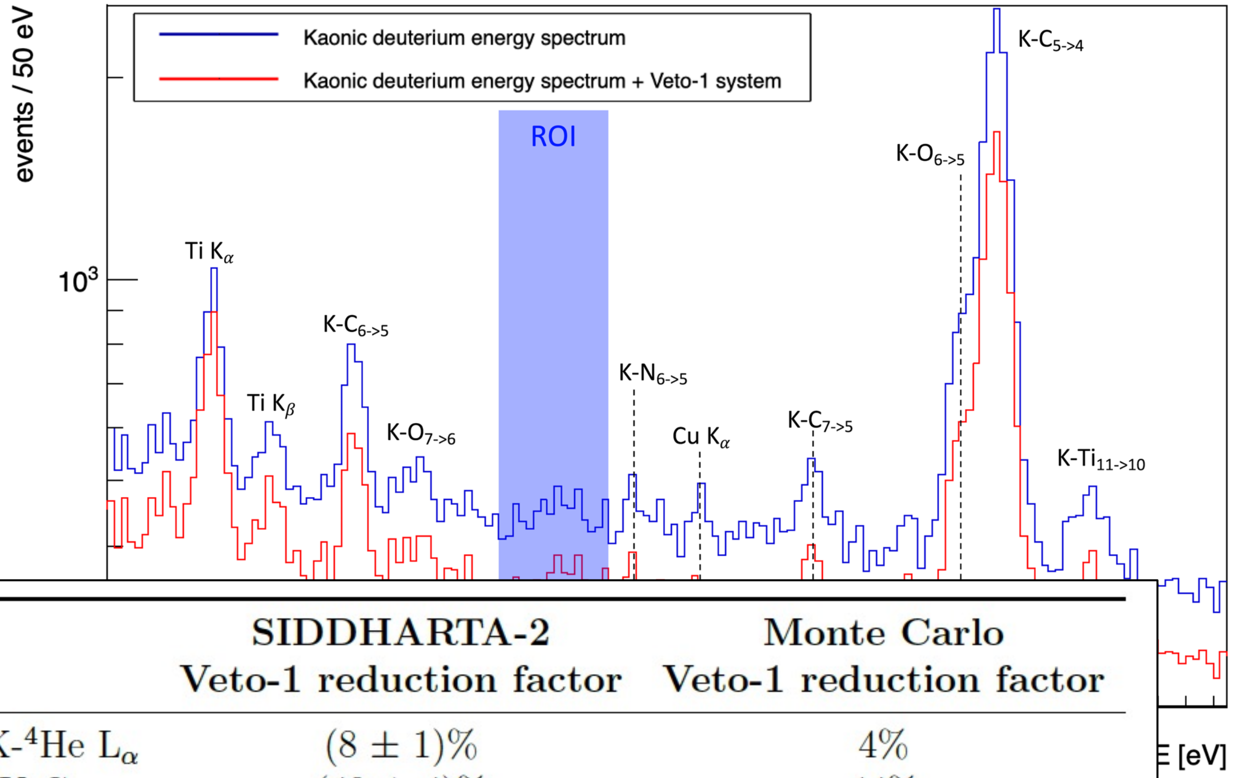

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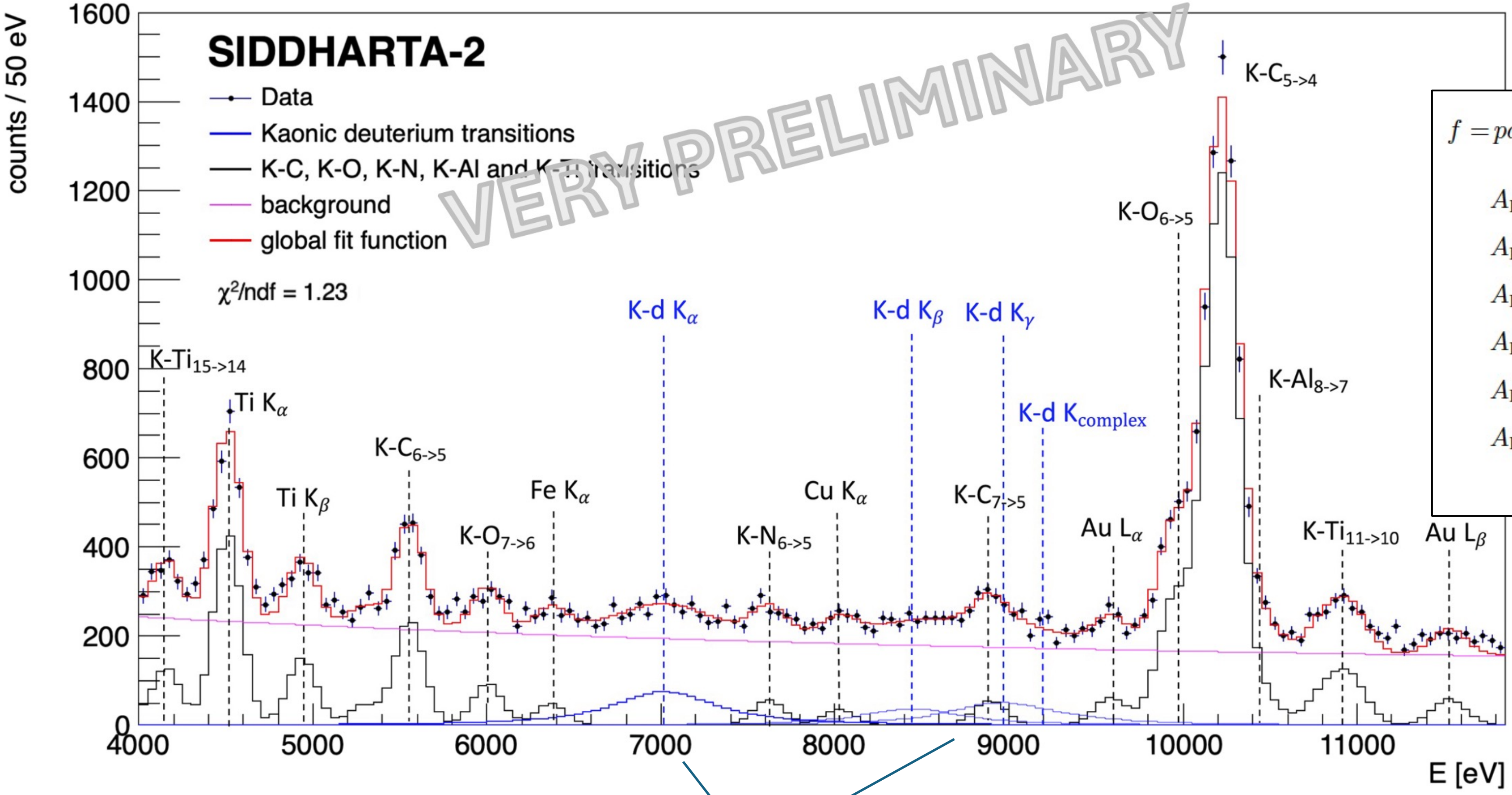
Kaonic Deuterium Run1: preliminary result (F. Sgaramella Ph.D. thesis)

Preliminary fit of the kaonic deuterium energy spectrum



$$f = pol_1(E) + \exp(E) + \sum_i \mathrm{Gauss}(A_{Gi}, E_i, \sigma) + \mathrm{Tail}(A_{Ti}, E_i, \beta, \sigma) +$$
$$A_{Kd_{2\to1}} \cdot \mathrm{Voigt}(E_{2\to1}, \sigma, \Gamma_{1s}) +$$
$$A_{Kd_{4\to1}} \cdot A_{rel_{3\to1}} \cdot \mathrm{Voigt}(E^{e.m.}_{3\to1} + \varepsilon^*_{1s}, \sigma, \Gamma^*_{1s}) +$$
$$A_{Kd_{4\to1}} \cdot \mathrm{Voigt}(E^{e.m.}_{4\to1} + \varepsilon^*_{1s}, \sigma, \Gamma^*_{1s}) +$$
$$A_{Kd_{4\to1}} \cdot A_{rel_{5\to1}} \cdot \mathrm{Voigt}(E^{e.m.}_{5\to1} + \varepsilon^*_{1s}, \sigma, \Gamma^*_{1s}) +$$
$$A_{Kd_{4\to1}} \cdot A_{rel_{6\to1}} \cdot \mathrm{Voigt}(E^{e.m.}_{6\to1} + \varepsilon^*_{1s}, \sigma, \Gamma^*_{1s}) +$$
$$A_{Kd_{4\to1}} \cdot A_{rel_{7\to1}} \cdot \mathrm{Voigt}(E^{e.m.}_{7\to1} + \varepsilon^*_{1s}, \sigma, \Gamma^*_{1s})$$

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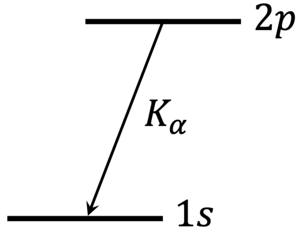
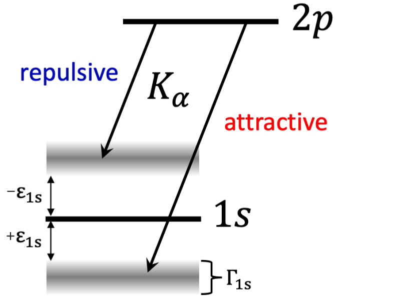
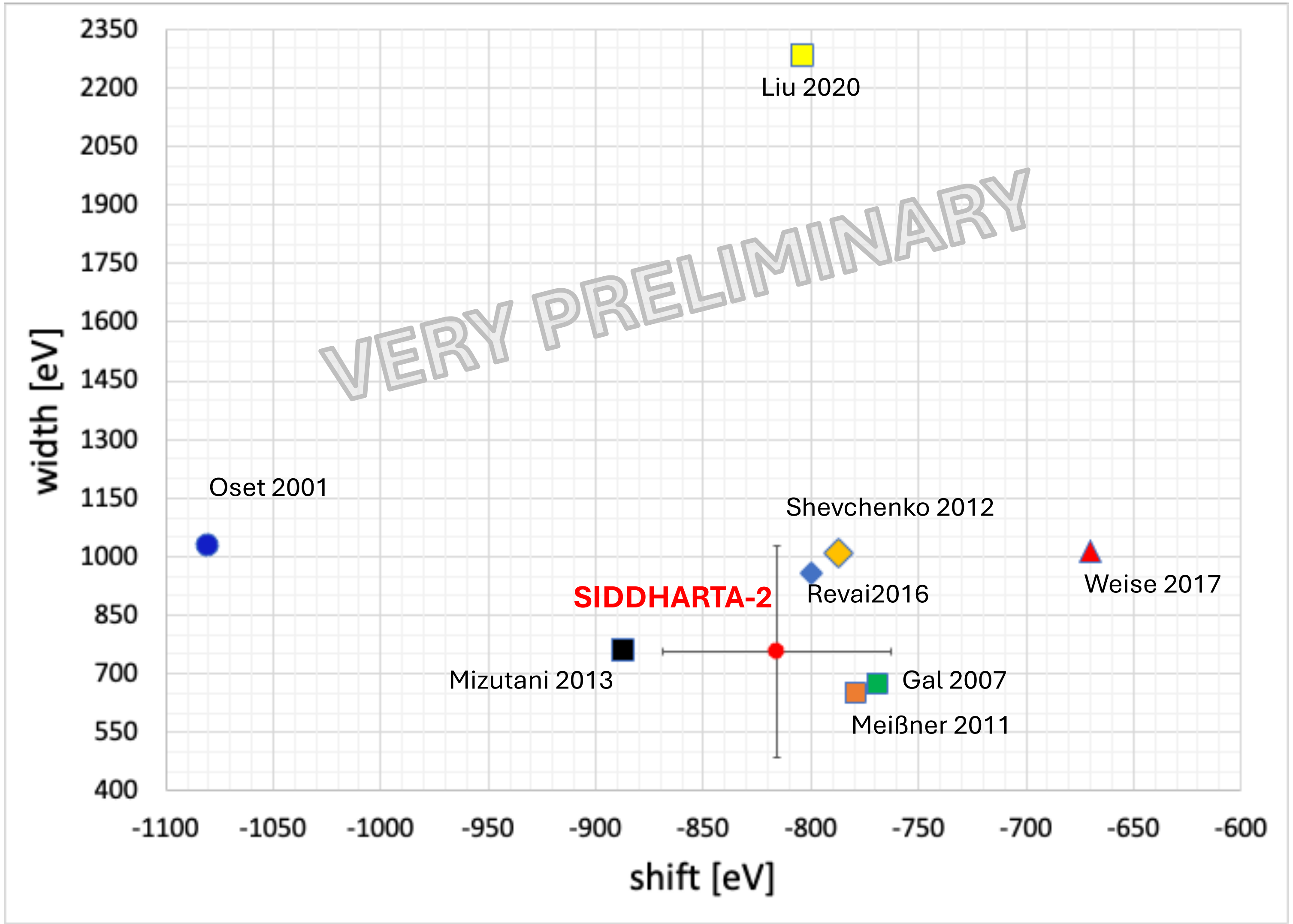
$$\Gamma_{1s} = 756 \pm 271\ (\mathrm{stat})\ \mathrm{eV}$$





Kaonic Deuterium Run1: preliminary result

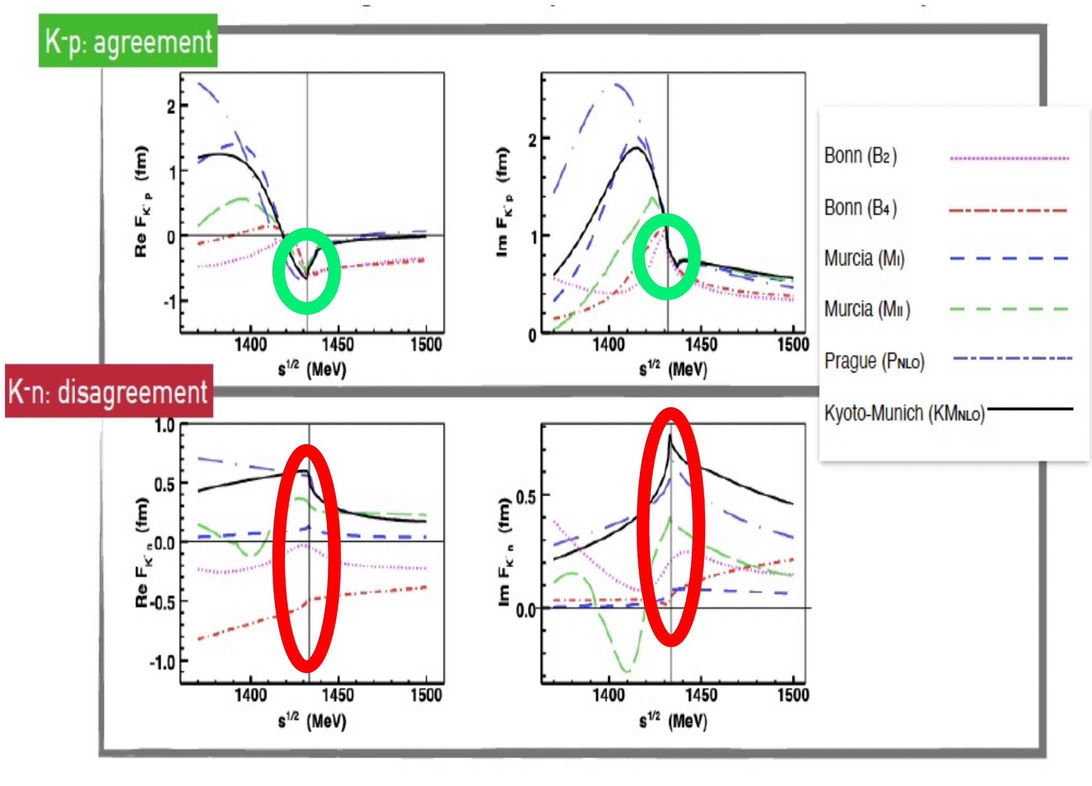
Preliminary comparison between SIDDHARTA-2 Run1 result and the theoretical model



Kaonic Deuterium Run1: preliminary result

first measurement ever of kaonic deuterium X-ray transition to the ground state (1s-level) such as to determine its **shift and width induced by the strong interaction**, providing unique data to determine the **isospin-dependent K-N scattering length**

A New Measurement of Kaonic Hydrogen X-rays
Phys.Lett.B 704 (2011), 113-117
More than 400 citations



A. Cieplý, M. Mai, Ulf-G. Meißner, J. Smejkal, https://arxiv.org/abs/1603.02531v2

ECT* SPICE: Strange hadrons as a Precision tool for strongly InteraCting systEms
13-17 May 2024

K^-d complex scattering length

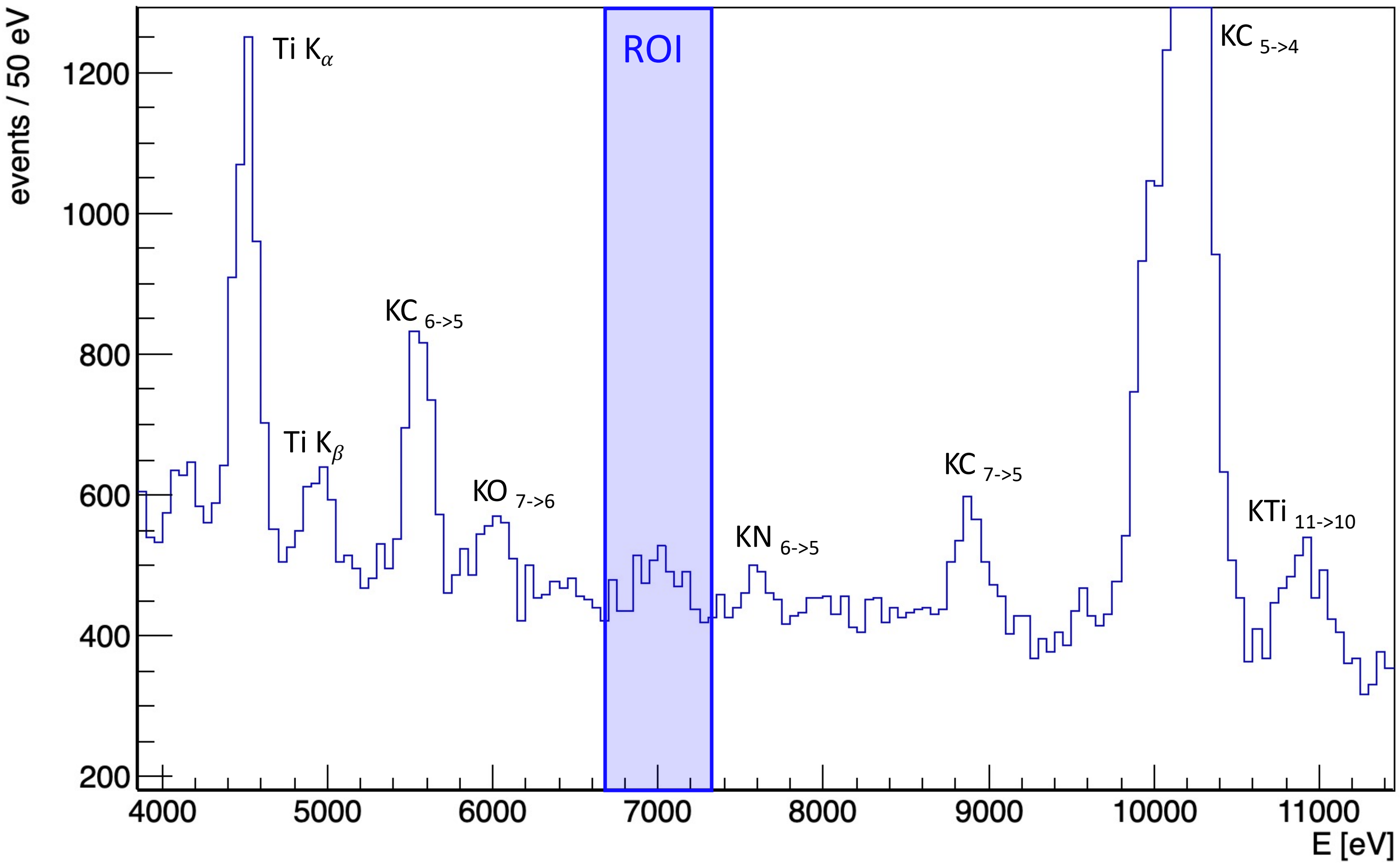
$$\varepsilon_{1s} + \frac{i}{2}\Gamma_{1s} = 2\alpha^3\mu^2 a_{K-d}/\left[1 + 2\alpha\mu(\ln\alpha - 1)a_{K-d}\right]$$

“Summed up Deser” formula

Work in progress in collaboration with Dr. Nina Shevchenko and other theoreticians

Kaonic Deuterium Run2 and Run3: analysis ongoing

Preliminary energy spectrum from run2 + run3 (partial statistics ~300 pb^{-1})



Next Step of the analysis:

- Refined calibration of Run3 data (ongoing)
- Veto-1 analysis (similar to run1 data)
- Define a proper fit function
- Fit of the energy spectrum (full dataset)

The analysis of the full dataset can potentially improve the statistical accuracy by a factor 2

(precision similar to kaonic hydrogen measurement)

66th Scientific Committee recommendations

- The SC endorses the current plan to continue running the DAΦNE/ SIDDHARTA-2 setup, completing a second run by the end of 2023 and a third one before the summer of 2024. Thus, it encourages the SIDDHARTA-2 collaboration to continue decisively with their kaonic deuterium data-taking, with the aim of collecting 800-900 pb-1 in total.

- To complete the ongoing evaluation of the usability of the data recorded during injection time.

- If the 800-900 pb-1 goal on deuterium is successfully achieved before the end of June, the SC considers it appropriate to still extend Run 3 until the end of June 2024, so that the collaboration can measure light kaonic atoms, partly profiting from the post-calibration run.

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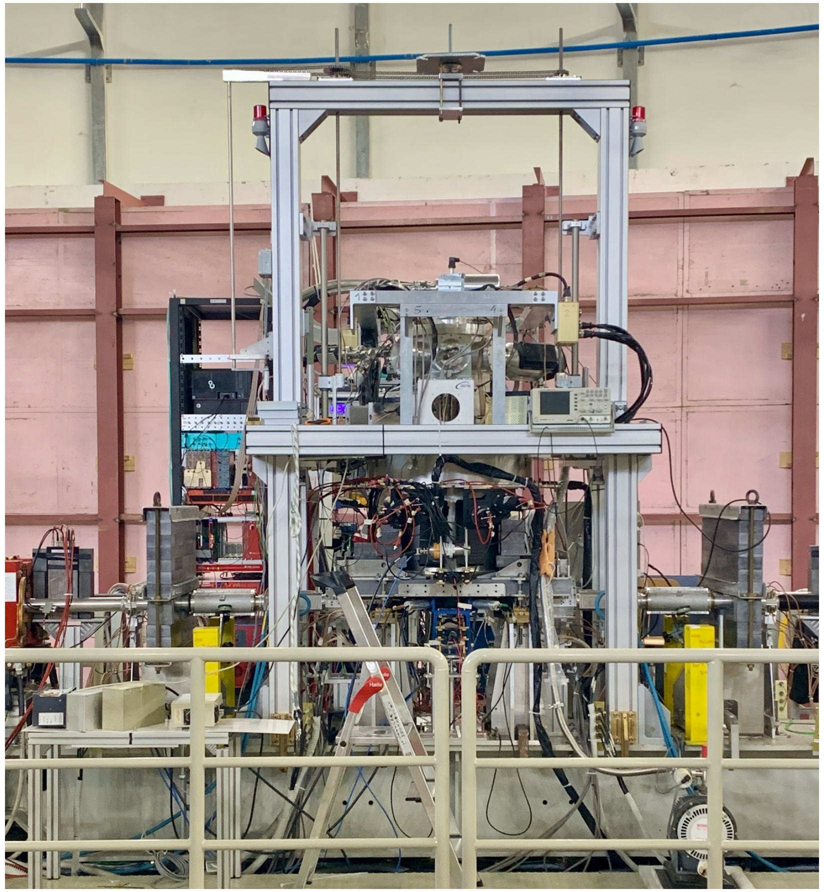
- **Calibration run** with hydrogen 150 pb^{-1};

12th April 2024
End of Kaonic deuterium Run3

15th Apr – 6th May (3 weeks)
Calibration run with kaonic hydrogen

6th -12th May
DAΦNE maintenance: refill of the target cell with deuterium (low density)

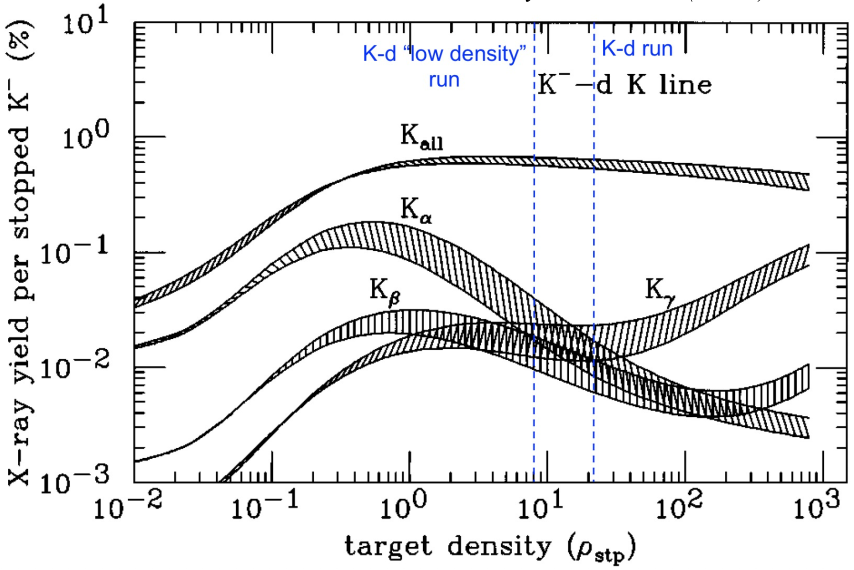


We completed the Kd run3 with a calibration run performed with kaonic hydrogen

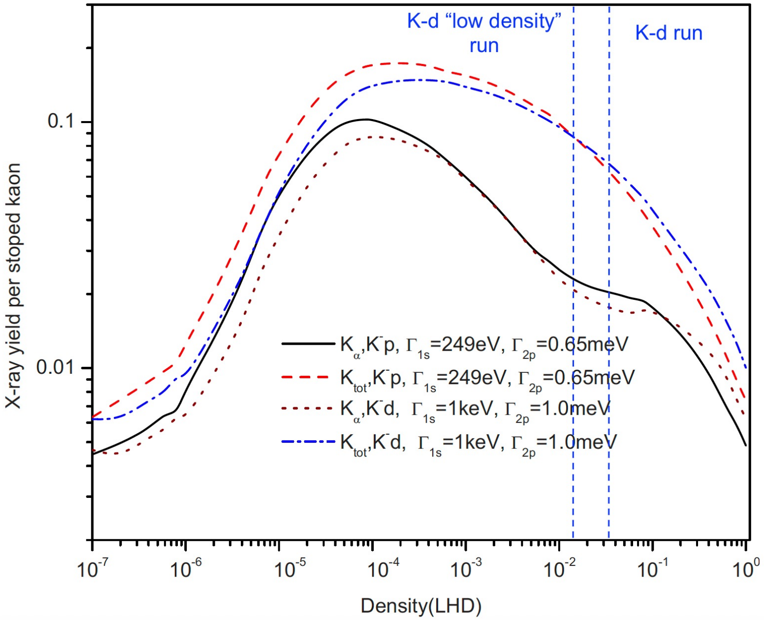
- The kaonic hydrogen run will be used to check the performance of detectors and veto systems
- The results of the kaonic hydrogen analysis will be used to constrain the background for the Kd analysis

Kaonic Deuterium yield puzzle– low density run

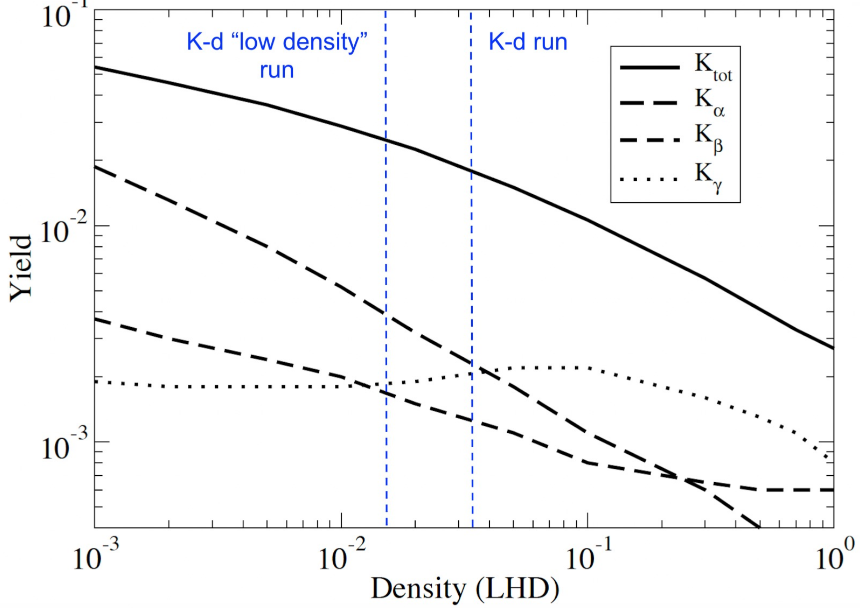
T. Koike, T. Harada, Y. Akaishi, Phys.Rev.C 53 (1996), 79-87



M Raeisi, S. Z. Kalantari, Phys.Rev.A 79, 012510 (2009)



T.S. Jensen, Frascati Phys.Ser. 36 (2004), 349-354



Several cascade model predict **completely different kaonic deuterium X-ray yields** (absolute and relative) and different trends as function of the density

Low density kaonic deuterium measurement

(60% lower compared to the previous run)

Providing unique data to investigate the de-excitation mechanism in kaonic atoms (cascade model)

The combined analysis of the kaonic deuterium measurement performed at 1.4% LDD and the ongoing measurement at 0.8% LDD **can help to disentangle between the various theoretical cascade models**

SIDDHARTA-2 Kd run – Future plan

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- **Calibration run** with hydrogen 150 pb^{-1};
- **Kd low density run** – goal 200 pb^{-1}

We aim to collect 200 pb^{-1} (similar statistics to Kd run1)

12th April 2024
End of Kaonic deuterium Run3

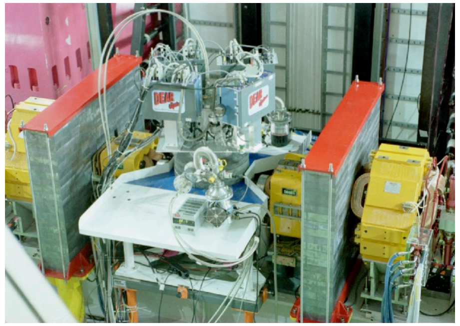
15th Apr – 6th May (3 weeks)
Calibration run with kaonic hydrogen

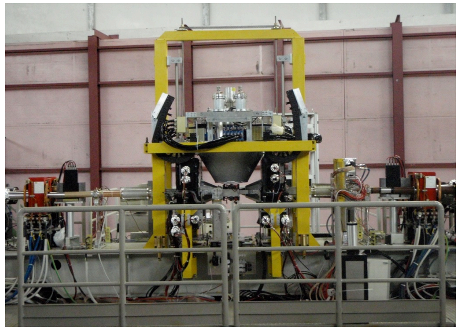
6th -12th May
DAΦNE maintenance: refill of the target cell with deuterium (low density)

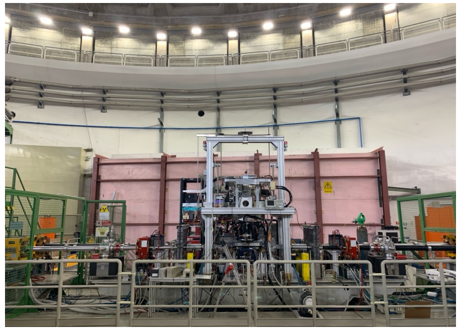
24th May – End of June - first week of July
Kaonic deuterium "low density" run

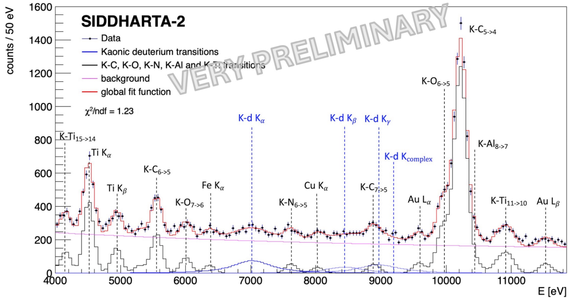
DEAR **SIDDHARTA** **SIDDHARTA-2**

First measurement ever of Kd









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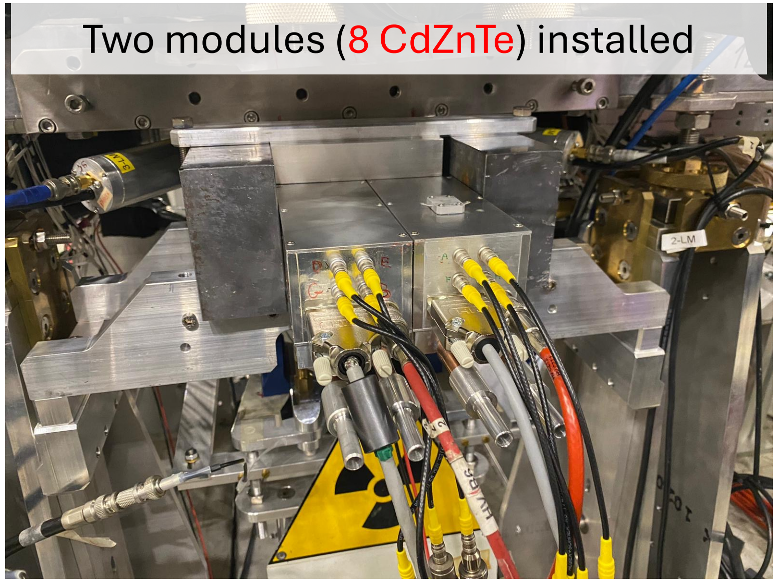
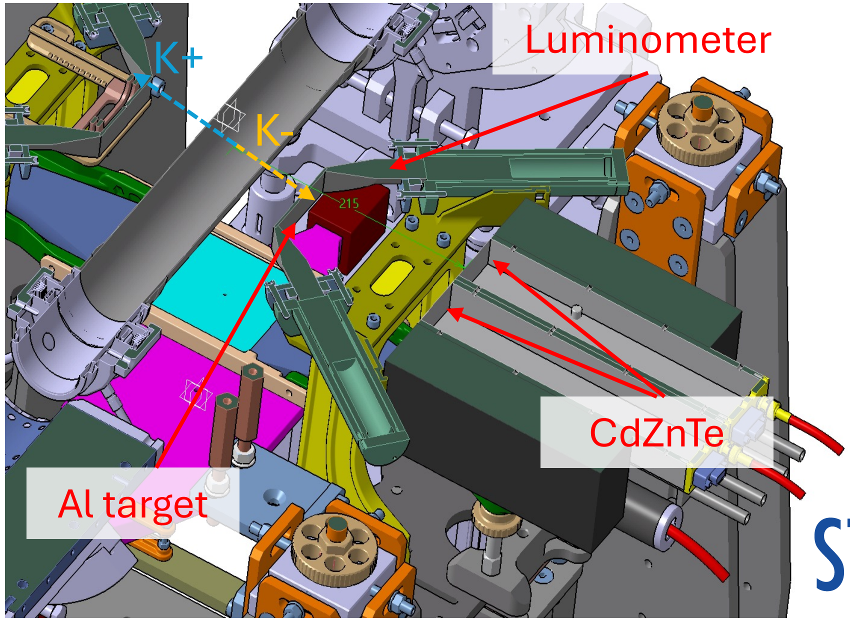
CdZnTe detectors: test run with 8 detectors

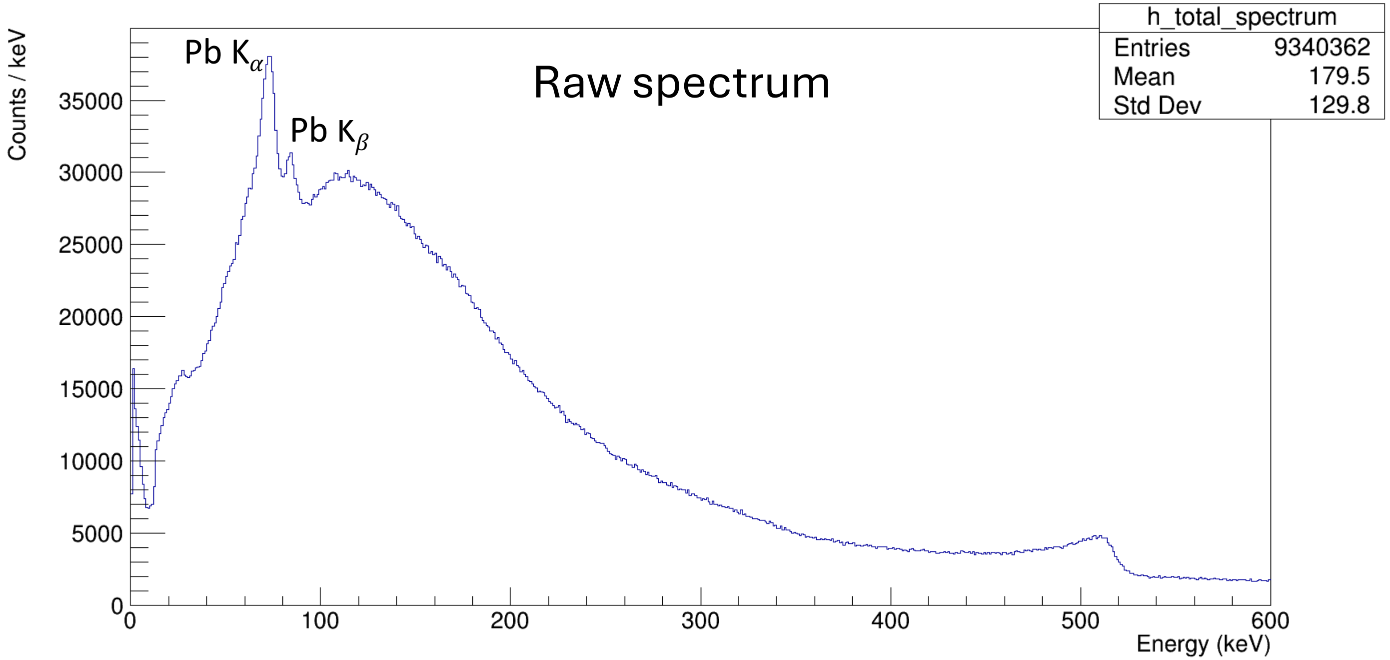




8 cm^2 CdZnTe detectors to perform X-ray spectroscopy of kaonic aluminium in parallel with SIDDHARTA-2 kaonic deuterium run (L. Abbene, A. Buttacavoli, F. Principato, A. Scordo)

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

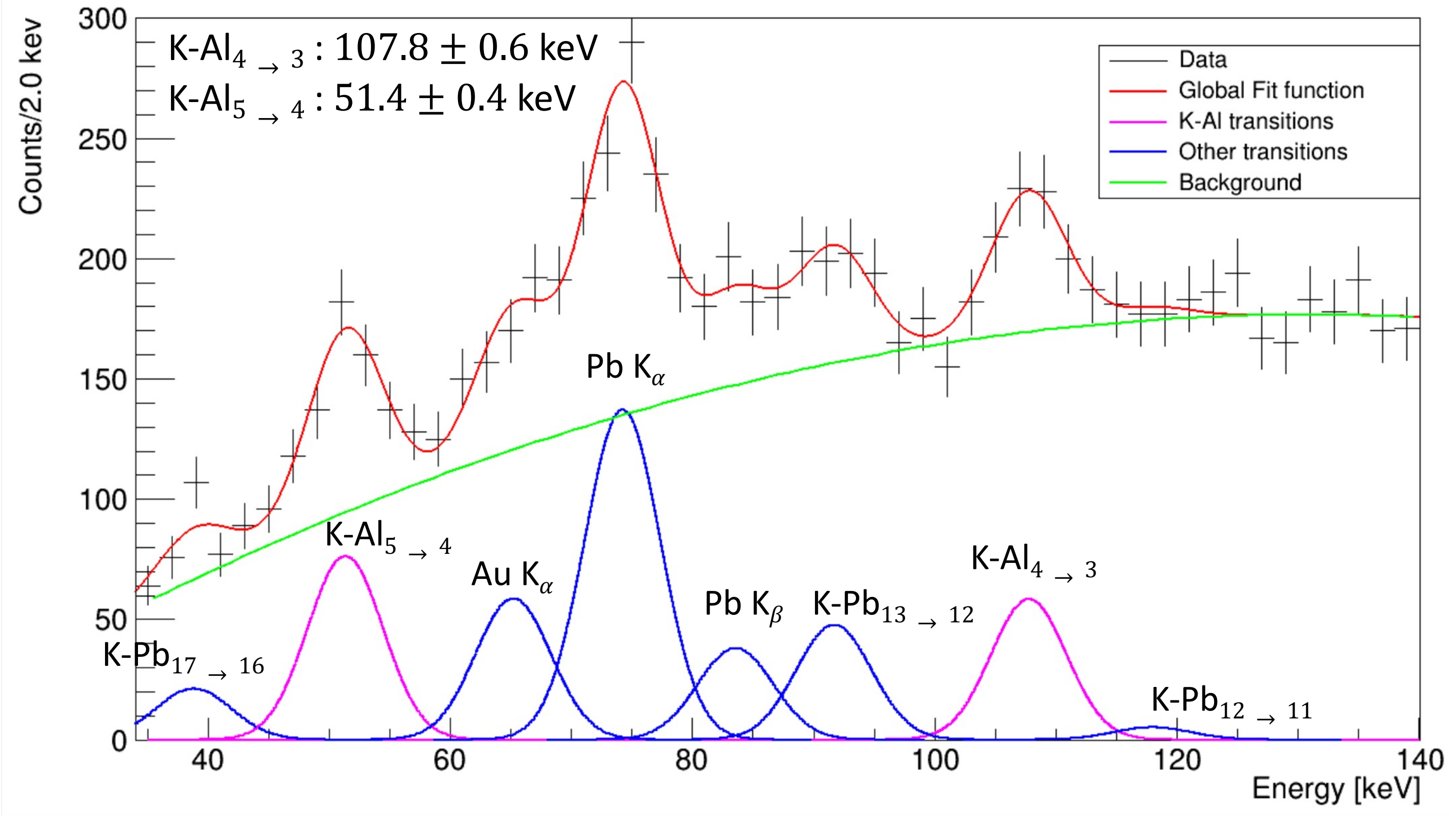
~ 60 pb^{-1} of data with a 2,2 mm Al target



STRONG-2020 · Università degli Studi di Palermo · unipa · imem Istituto dei Materiali per l'Elettronica ed il Magnetismo, Consiglio Nazionale delle Ricerche

CdZnTe detectors: test run with 8 detectors

Preliminary result from the kaonic aluminium analysis (~60 pb^{-1})



An article is in preparation

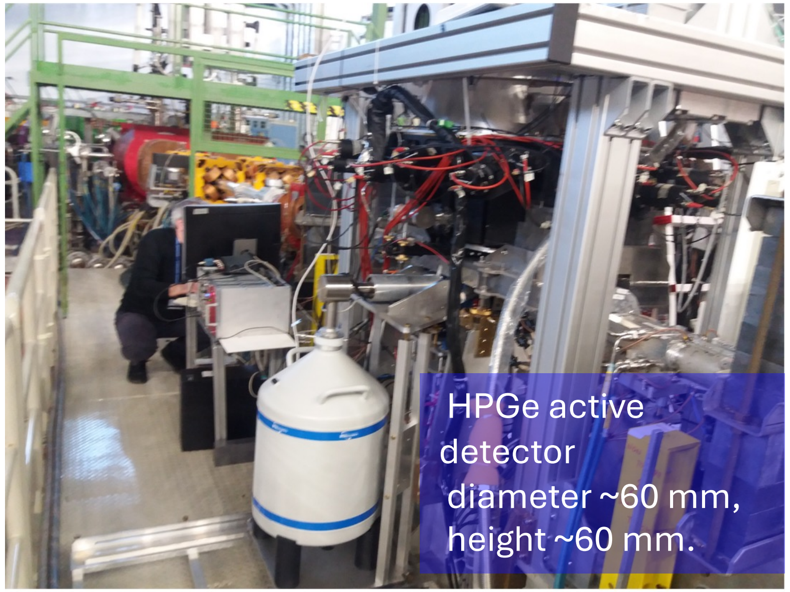
- First kaonic atoms' spectrum measured with CZT detectors
- CZT proved to be the **perfect technology for intermediate mass kaonic atoms**, with very good "in-beam" performances during preliminary tests
- CdZnTe detectors can be easily used in parallel with already existing experiments, requiring very small space and not invasive electronics.

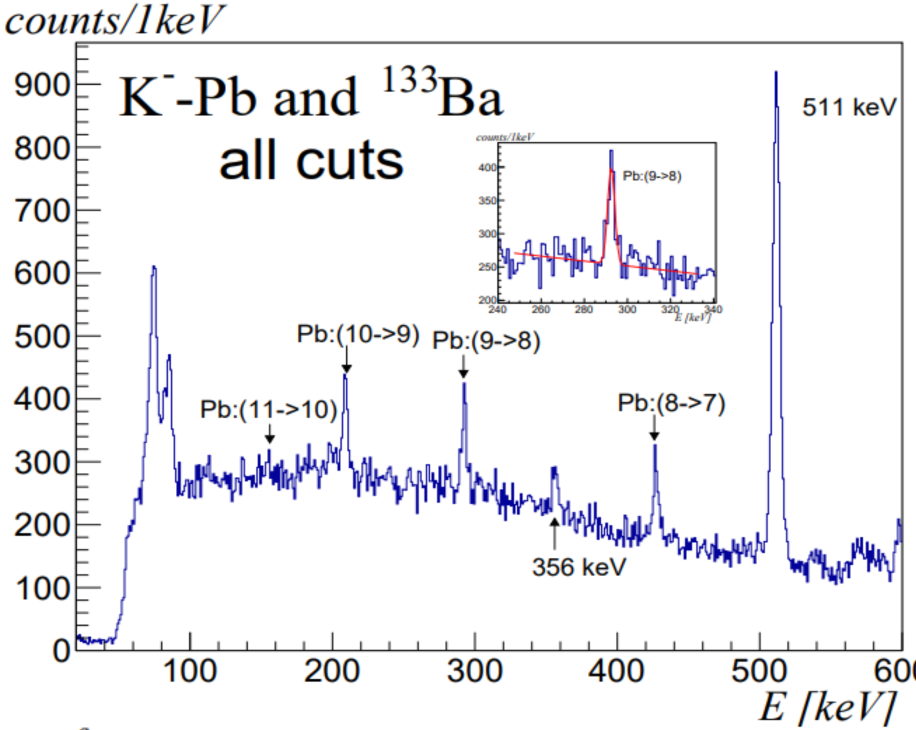
Kaonic Lead Measurement at DAΦNE with HPGe

(Zagreb Uni; Krakow, Jagiellonian Uni – Lumi)

Installed in the antiboost side of the IP to perform the kaonic lead measurement in parallel with the SIDDHARTA-2 kaonic deuterium measurement

Integrated luminosity: 109.38 pb^{-1}: subset of 40 pb^{-1} already analysed





K⁻-Pb transition	Peak position (keV)	Resolution (FWHM) (keV)	Number of events
$10 \rightarrow 9$	208.92 ± 0.17	3.68 ± 0.42	584 ± 30
$9 \rightarrow 8$	292.47 ± 0.17	3.97 ± 0.49	770 ± 65
$8 \rightarrow 7$	427.07 ± 0.24	4.37 ± 0.54	457 ± 45

Article submitted to Nuclear Instruments and Methods A

preprint: arXiv:2405.12942

Publications since last SciCom of November 2023

1) *F. Sgaramella et al.*, **First measurement of kaonic helium-4 M-series transitions**, 2024 **J. Phys. G: Nucl. Part. Phys**. 51 055103

2) *A. Scordo et al.*, **CdZnTe detectors tested at the DAFNE collider for future kaonic atoms measurements**. **Nuclear Instruments and Methods in Physics Research Section A**, Volume 1060, 2024, 169060.

3) *F. Sgaramella et al.*, **Kaonic helium-4 L-series yield measurement at 2.23 g/l density by SIDDHARTA-2 at DAΦNE**, **Acta Phys. Pol. B** 17, 1-A8 (2024)

4) *F. Clozza et al.*, **Characterization of the SIDDHARTA-2 Setup via the Kaonic Helium Measurement**, ***Condensed Matter***. 2024; 9(1):16.

5) *F. Artibani, F. Clozza et al.*, **The Odyssey of Kaonic Atoms Studies at the DAFNE collider: from DEAR to SIDDHARTA-2**. **Acta Phys. Pol. B** 55, 5-A2 (2024)

Publications since last SciCom – November 2023

6) *Wycech, S.; Piscicchia, K.* **On the Importance of Future, Precise, X-ray Measurements in Kaonic Atoms.**, **Condens. Matter** 2024, 9, 4.

7) *L. De Paolis et al.,* **The measurements of E2 nuclear resonance effects in kaonic atoms at DAΦNE: the KAMEO proposal, EPJ Web Conf**., 291 05003 (2024)

8) *F. Sirghi et al.,* **Kaonic atoms with SIDDHARTA-2 at the DAΦNE Collider, EPJ Web Conf.,** 291 (2024) 01008

9) *F. Sgaramella et al.,* **The SIDDHARTA-2 experiment for high precision kaonic atoms X-ray spectroscopy at DAΦNE**, accepted for publication on **Nuovo Cimento C-** Colloquia and Communications in Physics.

10) *D. Bosnar et al.,* **Kaonic lead feasibility measurement at DAΦNE to solve the charged kaon mass discrepancy,** submitted to **Nuclear Instruments and Methods A** (arXiv:2405.12942)

11) *F. Artibani, F. Clozza et al.*, **Intermediate Mass Kaonic Atoms at DAΦNE. Submitted to Acta Phys. Pol.**

66th Scientific Committee recommendations

- The SC endorses the current plan to continue running the DAΦNE/ SIDDHARTA-2 setup, completing a second run by the end of 2023 and a third one before the summer of 2024. Thus, it encourages the SIDDHARTA-2 collaboration to continue decisively with their kaonic deuterium data-taking, with the aim of collecting 800-900 pb-1 in total.

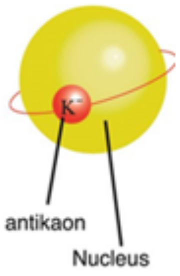
- To complete the ongoing evaluation of the usability of the data recorded during injection time.

- If the 800-900 pb-1 goal on deuterium is successfully achieved before the end of June, the SC considers it appropriate to still extend Run 3 until the end of June 2024, so that the collaboration can measure light kaonic atoms, partly profiting from the post-calibration run.

- To continue during runs 2 and 3 with the satellite HPGe and CdZnTe detectors, but always minimizing their interference with the Kd data taking.

- **Finally, the SC recommends the submission, before the next SC meeting in May 2024, of a detailed proposal of the first module of the EXCALIBUR proposal. This should include a calendar for installation, commissioning, and operation, integrated luminosity needs, and details on what parts of the main and satellite detectors could be operative at what times as well as the specific kaonic atoms to be measured.**

First Module of Kaonic Atoms Measurements within the EXKALIBUR scientific program



20th May 2024

By SIDDHARTA2-/EXKALIBUR Collaboration

EXtensive
Kaonic
Atoms research: from
LIthium and
Beryllium to
URanium

Built up on our world-recognized expertise:

- Kaonic Hydrogen
- Kaonic Nitrogen
- Kaonic Helium
- Kaonic Neon
- Kaonic deuterium
- + more

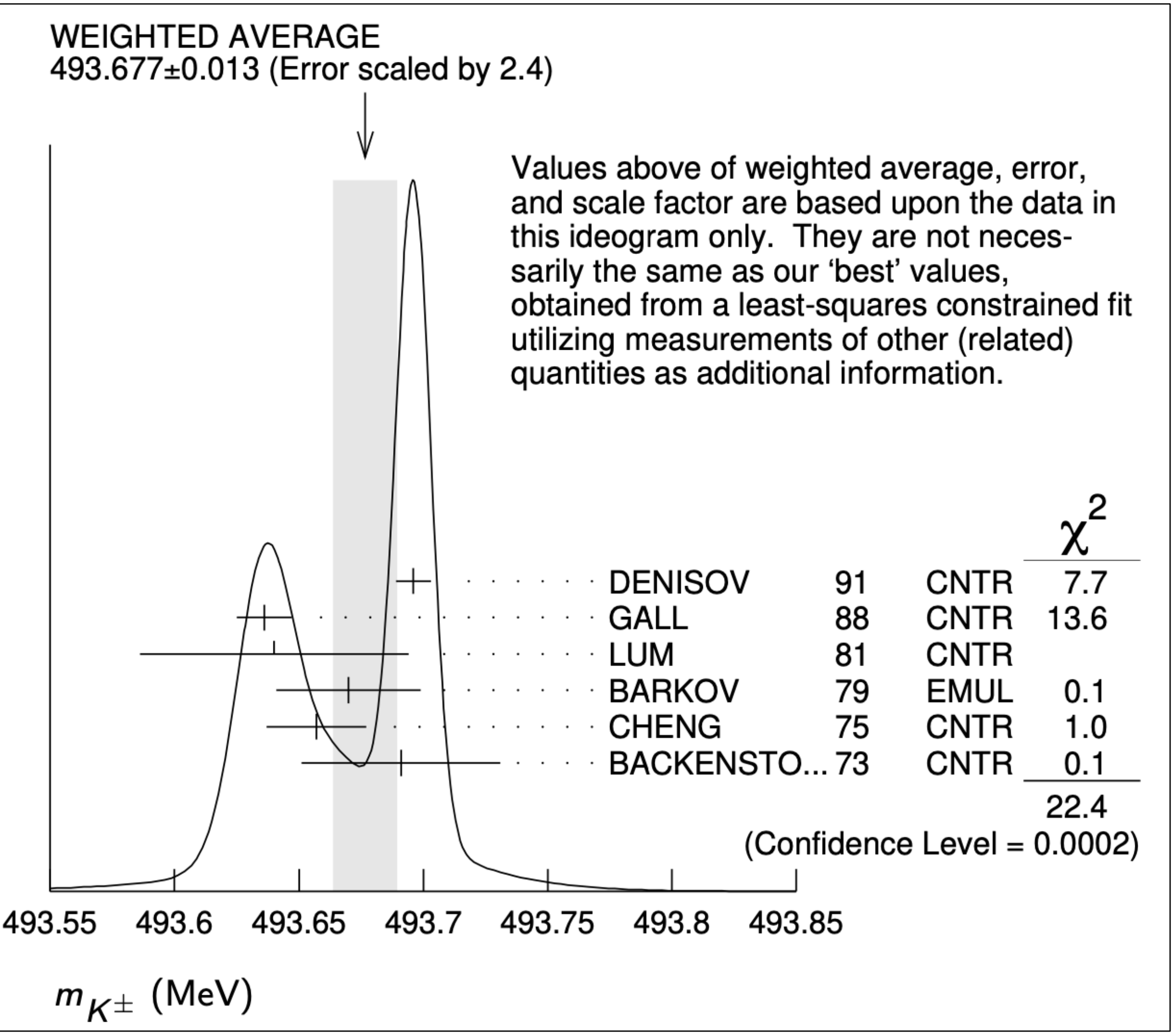
(>60 articles since 2018)

The measurement for the first EXKALIBUR module were selected based on two criteria:
Feasibility with **minimal modifications/addings** of the already existent SIDDHARTA-2 setup and within a reduced timescale

Impact: i.e. the **maximal scientific outcome:**

Kaonic Neon -> kaon mass
Light kaonic atoms (KLi; Be; B)
In parallel intermediate mass kaonic atoms

Kaonic neon for the charged kaon mass

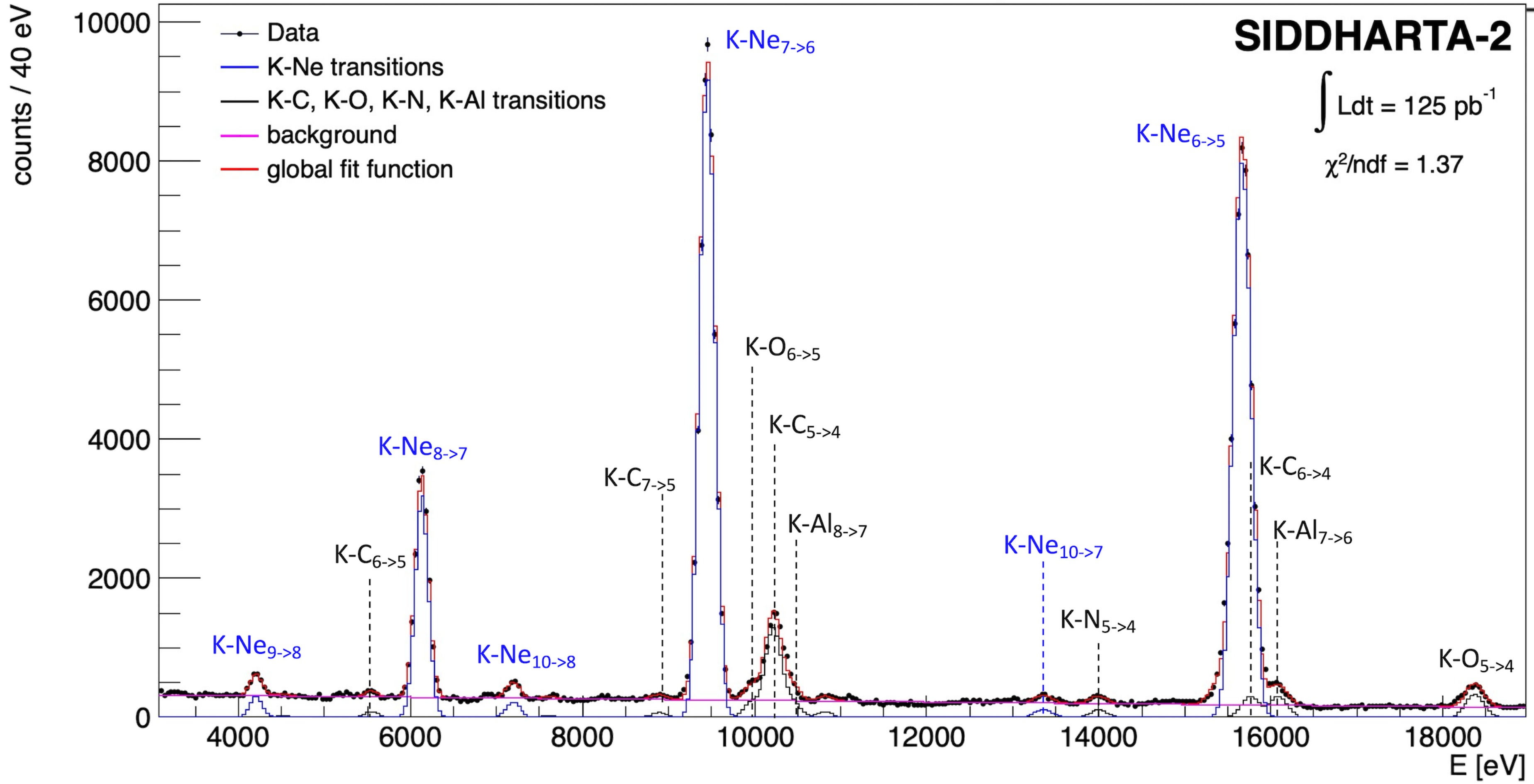


- The first measurement we plan doing is the kaon neon high-n levels transition with precisions below 1 eV, **to extract the charged kaon mass**.

- By using a **gaseous target**, we can resolve the ambiguity in the charged kaon mass de-termination, providing **a new precise value through the measurement of kaonic neon high-n transitions**. Moreover, the measurement also provides **a precision test of QED in atomic systems with strangeness** (Rydberg constant, as example).

Our own Kaonic Neon measurement (2023)

Transition	Energy [eV]
K-Ne ($9 \to 8$)	4206.35 ± 3.75 (stat) ± 2.00 (syst) eV
K-Ne ($8 \to 7$)	6130.86 ± 0.71 **(stat)** ± 1.50 **(syst) eV**
K-Ne ($10 \to 8$)	7191.21 ± 4.91 (stat) ± 2.00 (syst) eV
K-Ne ($7 \to 6$)	9450.08 ± 0.41 **(stat)** ± 1.50 **(syst) eV**
K-Ne ($10 \to 7$)	11428.30 ± 8.37 (stat) ± 3.00 (syst) eV
K-Ne ($6 \to 5$)	15673.30 ± 0.52 **(stat)** ± 9.00 **(syst) eV**



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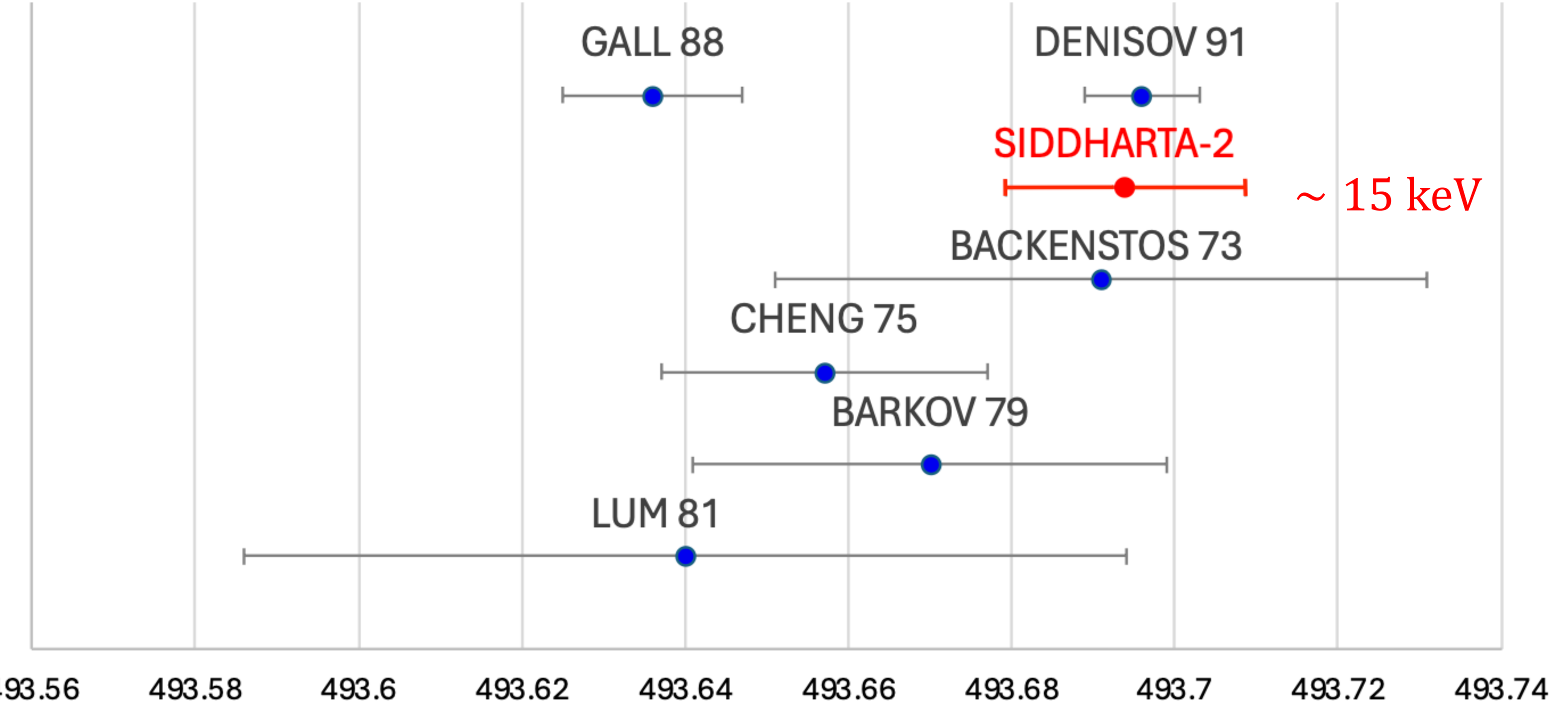

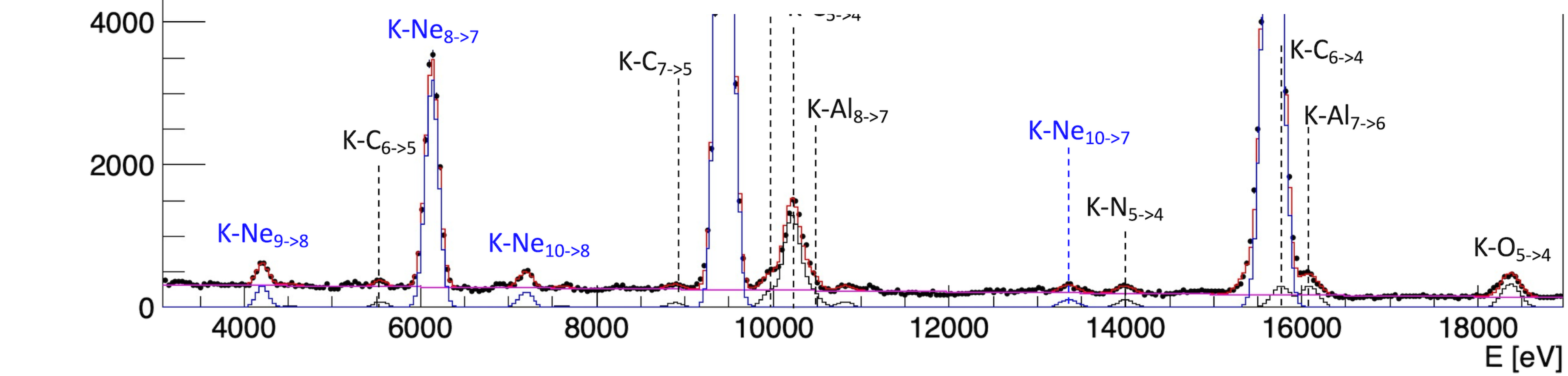

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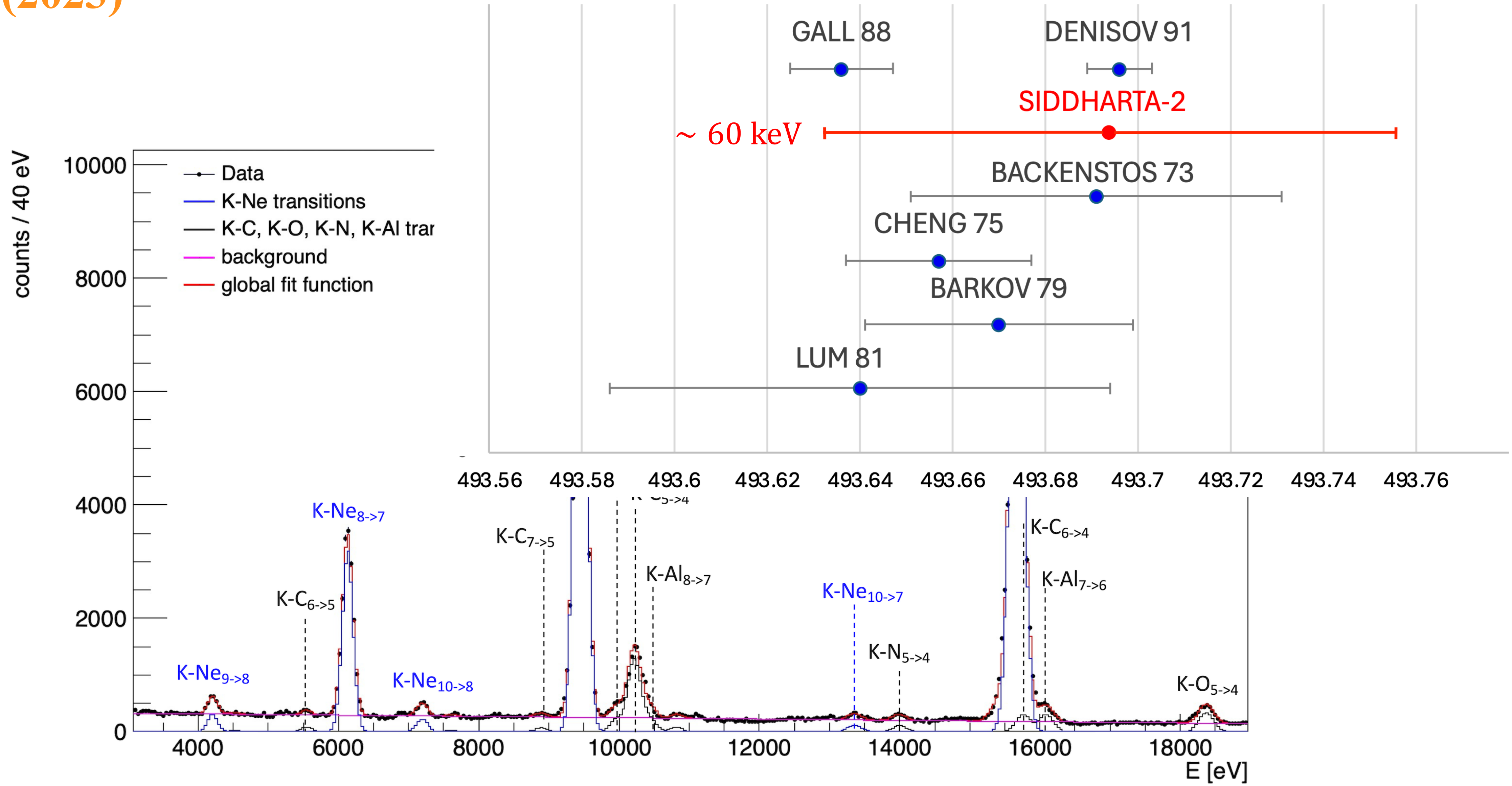
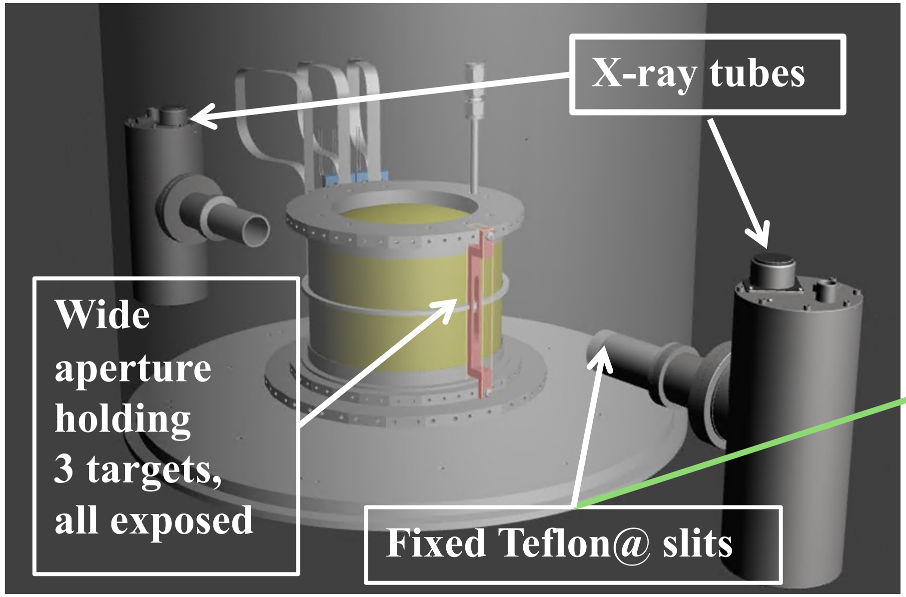
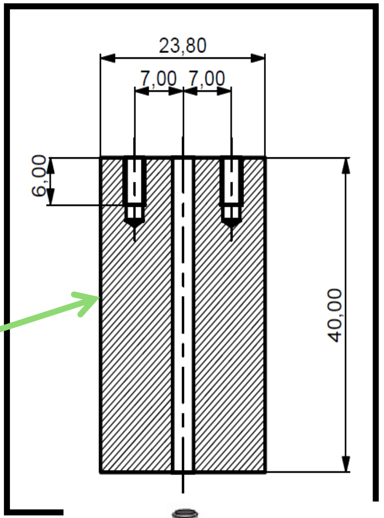
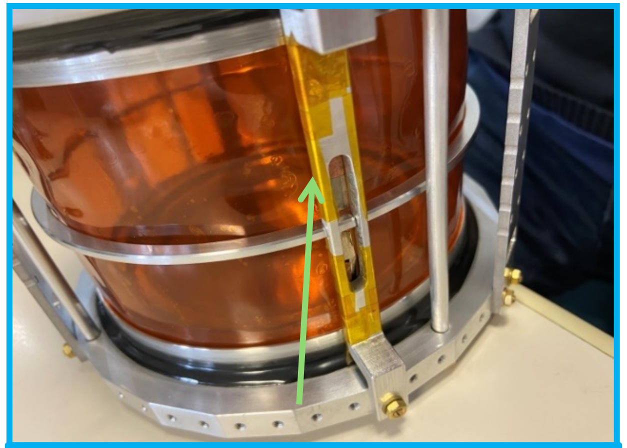


Refined calibration system : 7 (8) movable fluorescent foils



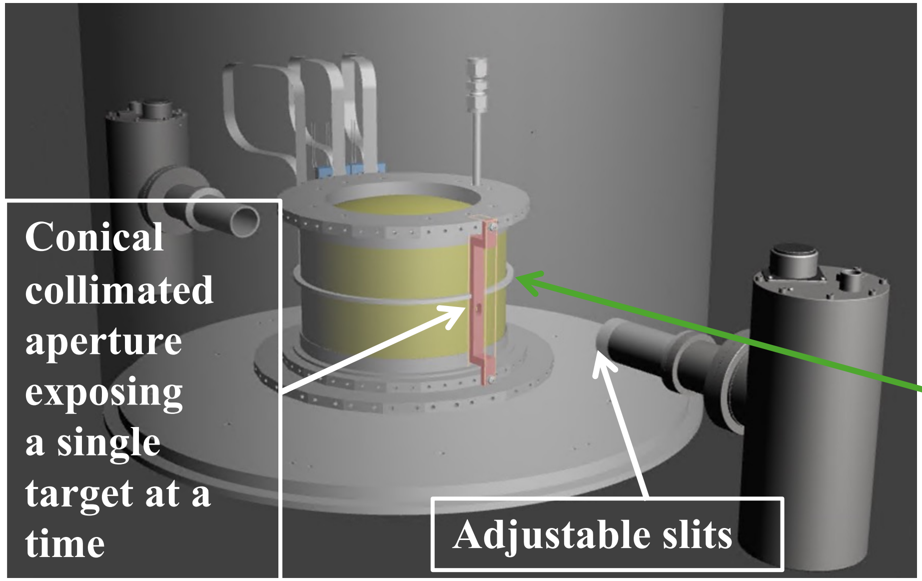


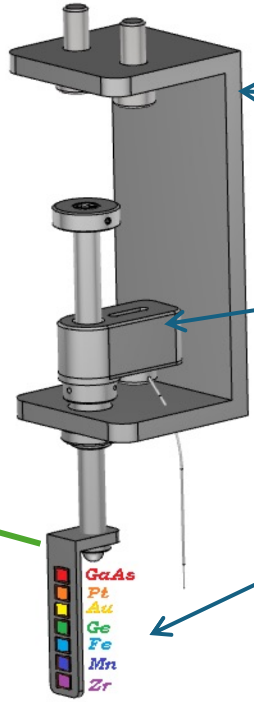
Current calibration system



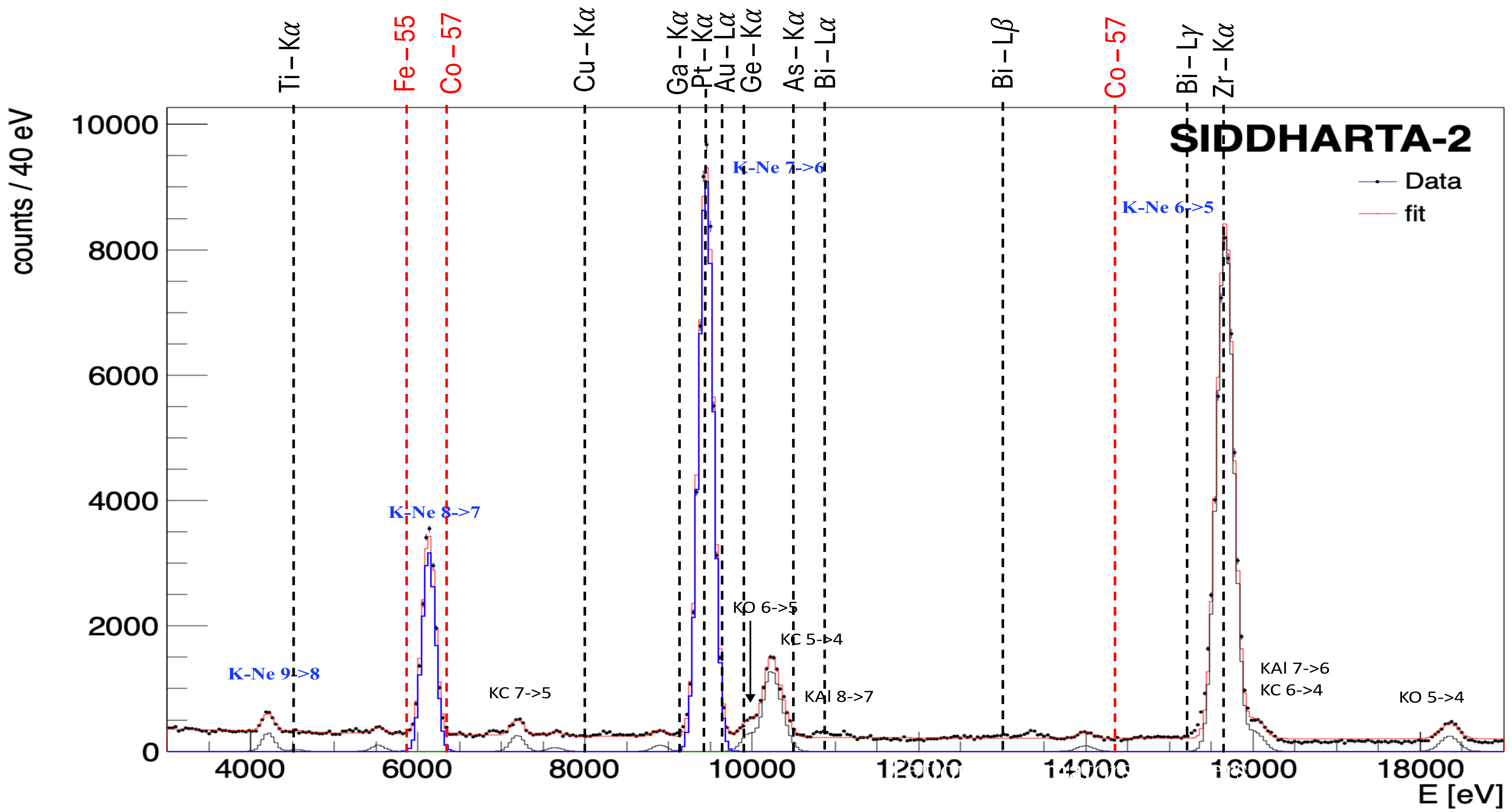
Ti, Cu, Zr calibration foils holder

Upgraded calibration system





New calibration system for a systematic error of 0.2 eV or better

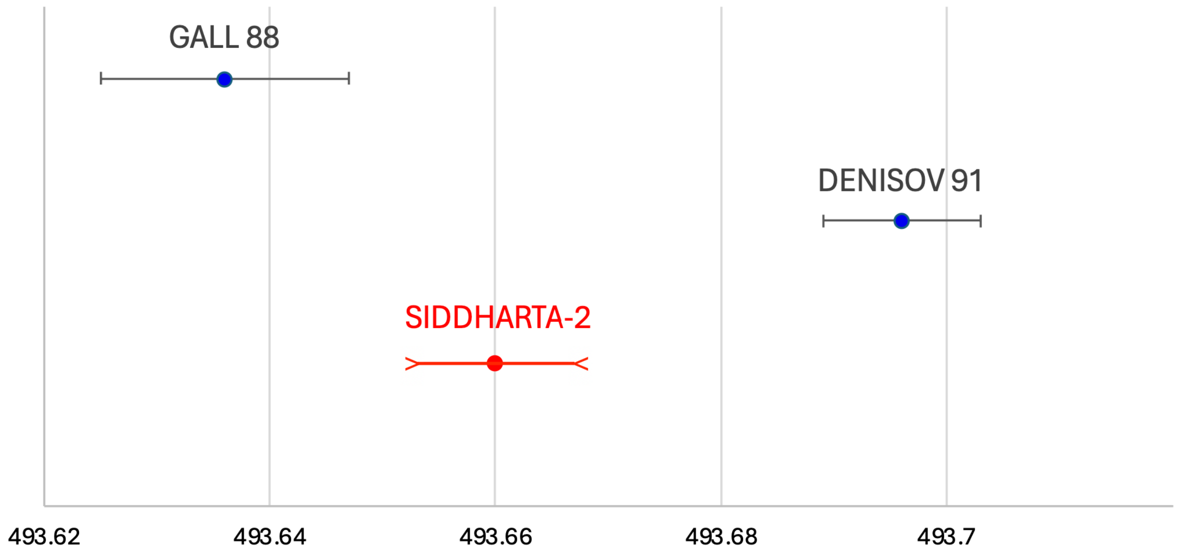


- **Integration of an advanced calibration system for sub-eV precision measurements of X-rays transitions, to achieve a systematic error at the same level of the statistical one.**

- **An integrated luminosity of about 200-300 pb^{-1} to achieve an overall precision on the charged kaon mass below 7 eV (ready from January 2025)**

			Preparation																								Run												
		Month	June				July				August				September				October				November				December				1				2				3				
ID		Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11	12	1
M	**General maintenance of the setup**											x	x												x	x														
M.1-M.5	Maintenance of the setup											x	x												x	x														
KNe	**Kaonic Neon measurement**											x	x												x	x														
KNe.1-KNe.2	Realization of the calibration system and test in lab											x	x												x	x														
KNe.3	Installation and test of SIDDHARTA-2 setup for KNe run in DAFNE											x	x												x	x														
KNe.4	Commissioning and calibration of the experimental apparatus with beam											x	x												x	x														
KNe.5	Data taking: kaonic neon (300 pb^{-1} integrated luminosity)											x	x												x	x														

Colours legend:
- Purple: setup maintenance, upgrade and installation
- Green: test and characterization of the detectors in laboratory
- Orange: commissioning and test with beam at DAΦNE or BTF.
- Yellow: production of the new 1mm SDDs, solid target, front-end electronics and mechanical support frames.
- Blue: data taking.
- X: closure of the lab



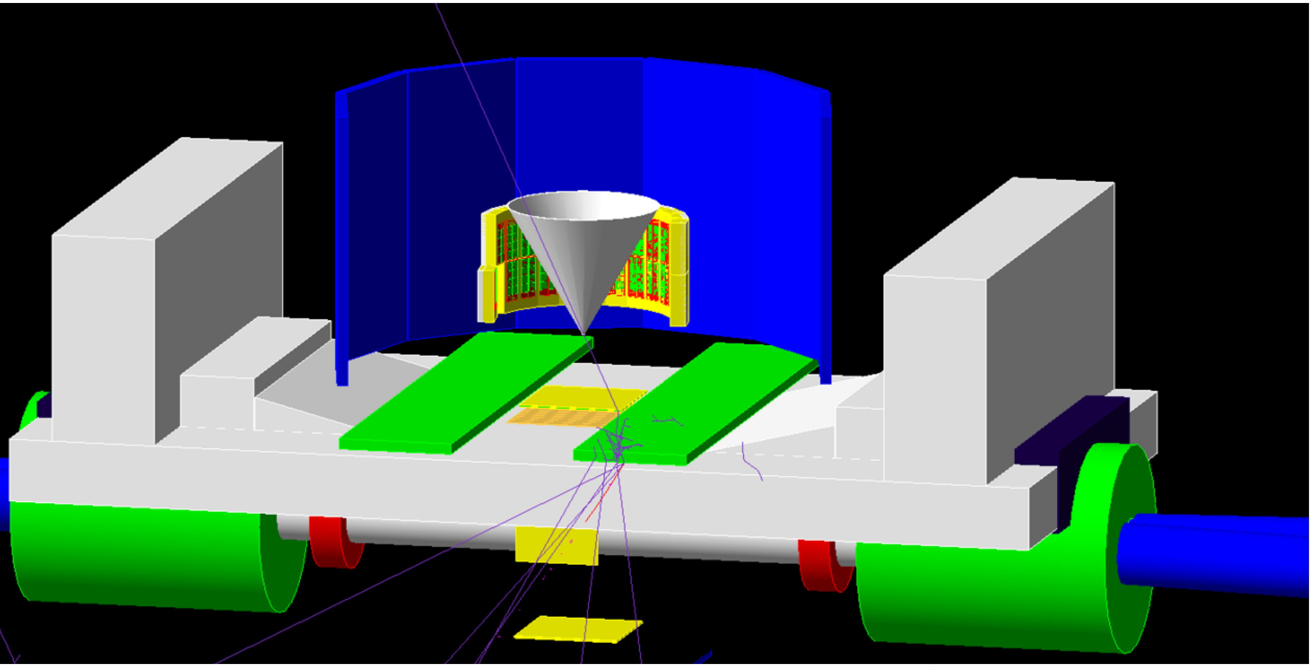
Light Mass (low-Z) Kaonic Atoms

- The second module of measurement are **light mass (Li, Be, B)** kaonic atoms, **to study in detail the strong interaction between kaon and few nucleons (many body).**

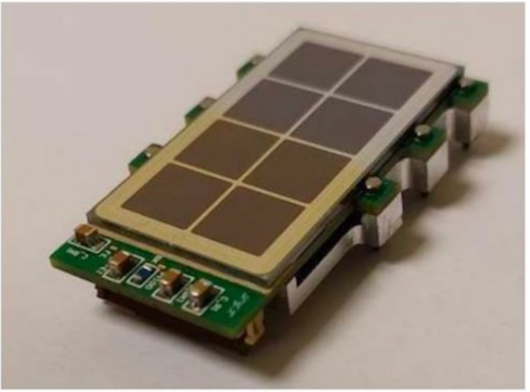
- Now precise measurements for these kaonic atoms of the shifts, widths and yields will result in a **significative improvement on the knowledge of the interactions of kaons in matter**, with a great impact on the **low energy QCD and astrophysics** (equation of state for neutron stars) .

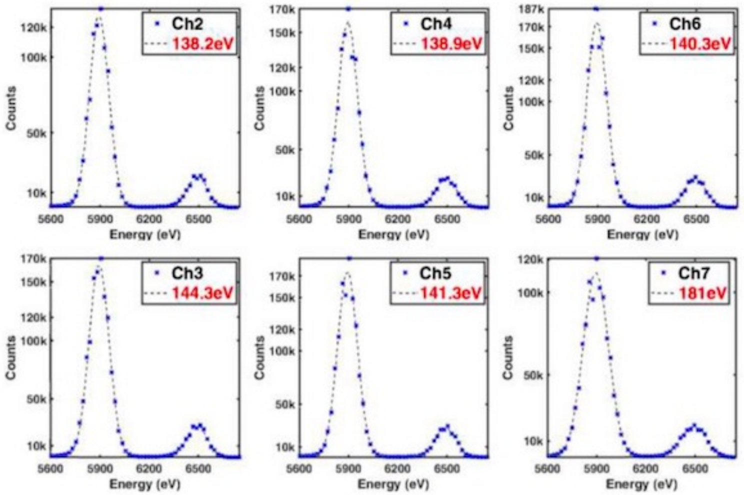
Lithium-6		Lithium-7		Beryllium-9		Boron-10		Boron-11	
Transition	Energy (keV)	Transition	Energy (keV)	Transition	Energy (keV)	Transition	Energy (keV)	Transition	Energy (keV)
$3 \to 2$	**15.085**	**$3 \to 2$**	**15.261**	**$3 \to 2$**	**27.560**	**$4 \to 3$**	**15.156**	**$4 \to 3$**	**15.225**
$4 \to 2$	**20.365**	**$4 \to 2$**	**20.603**	**$4 \to 3$**	**9.646**	**$5 \to 3$**	**22.171**	**$5 \to 3$**	**22.273**
$5 \to 2$	**22.809**	**$5 \to 2$**	**23.075**	**$5 \to 3$**	**14.111**	$5 \to 4$	7.015	$5 \to 4$	7.047
$4 \to 3$	5.280	$4 \to 3$	5.341	$5 \to 4$	4.465	$6 \to 4$	10.826	$6 \to 4$	10.875
$5 \to 3$	7.724	$5 \to 3$	7.814	$6 \to 4$	6.890	$6 \to 5$	3.811	$6 \to 5$	3.828
$5 \to 4$	2.444	$5 \to 4$	2.472	$6 \to 5$	2.425				
$6 \to 4$	3.771	$6 \to 4$	3.815						

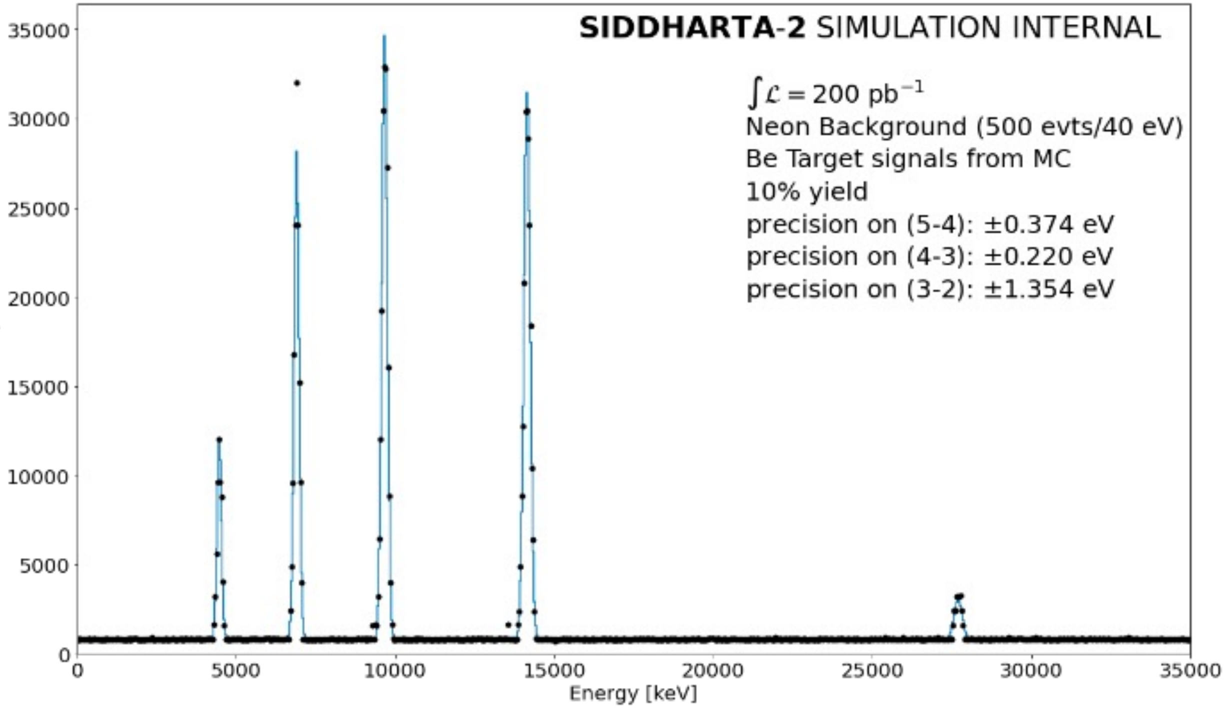
Solid targets replacing the gaseous one
and possible use of 1/2 buses of 1 mm SDDs (>20 keV)



Precision measurements:
Precision below (around) eV







- **Replacement of the gaseous target with a solid one**
- **(Possible) Replacement of one/two SDD buses with 1 mm thick SDDs to also access > 15-20 keV energy X rays**
- **An integrated luminosity of about 200 pb^{-1} to achieve a sub-eV precision on energies of the X-ray transitions**

			Preparation																												Run																					
		Month	June				July				August				September				October				November				December				1				2				3				4				5				6	
ID		Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
M	**General maintenance of the setup**											x	x															x	x																						
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KNe.4	Commissioning and calibration of the experimental apparatus with beam											x	x															x	x																						
KNe.5	Data taking: kaonic neon (300 pb^{-1} integrated luminosity)											x	x															x	x																						
SDD	**Activities for 1mm SDDs modules**											x	x															x	x																						
SDD.1-SDD.2	Installation and test of two 1mm SDDs prototypes in lab and BTF											x	x															x	x																						
SDD.3-SDD.4	1mm SDDs arrays bonding and new front-end electronic production																											x	x																						
SDD.5-SDD.7	Preparation and characterization in lab of one bus of 1 mm SDDs											x	x															x	x																						
SDD.8-SDD.9	Test and characterization of the second bus in lab											x	x															x	x																						
LM	**Light mass solid target measurements**											x	x															x	x																						
LM.1-LM.2	Solid target, vacuum flanges and power supply production											x	x															x	x																						
LM.3-LM.5	Installation of the solid target and one/two buses 1mm SDDs in DAFNE											x	x															x	x																						
LM.6	Commissioning with beam											x	x															x	x																						
LM.7	Kaonic atoms from solid target measurement (200 pb^{-1} Integrated luminosity)											x	x															x	x																						

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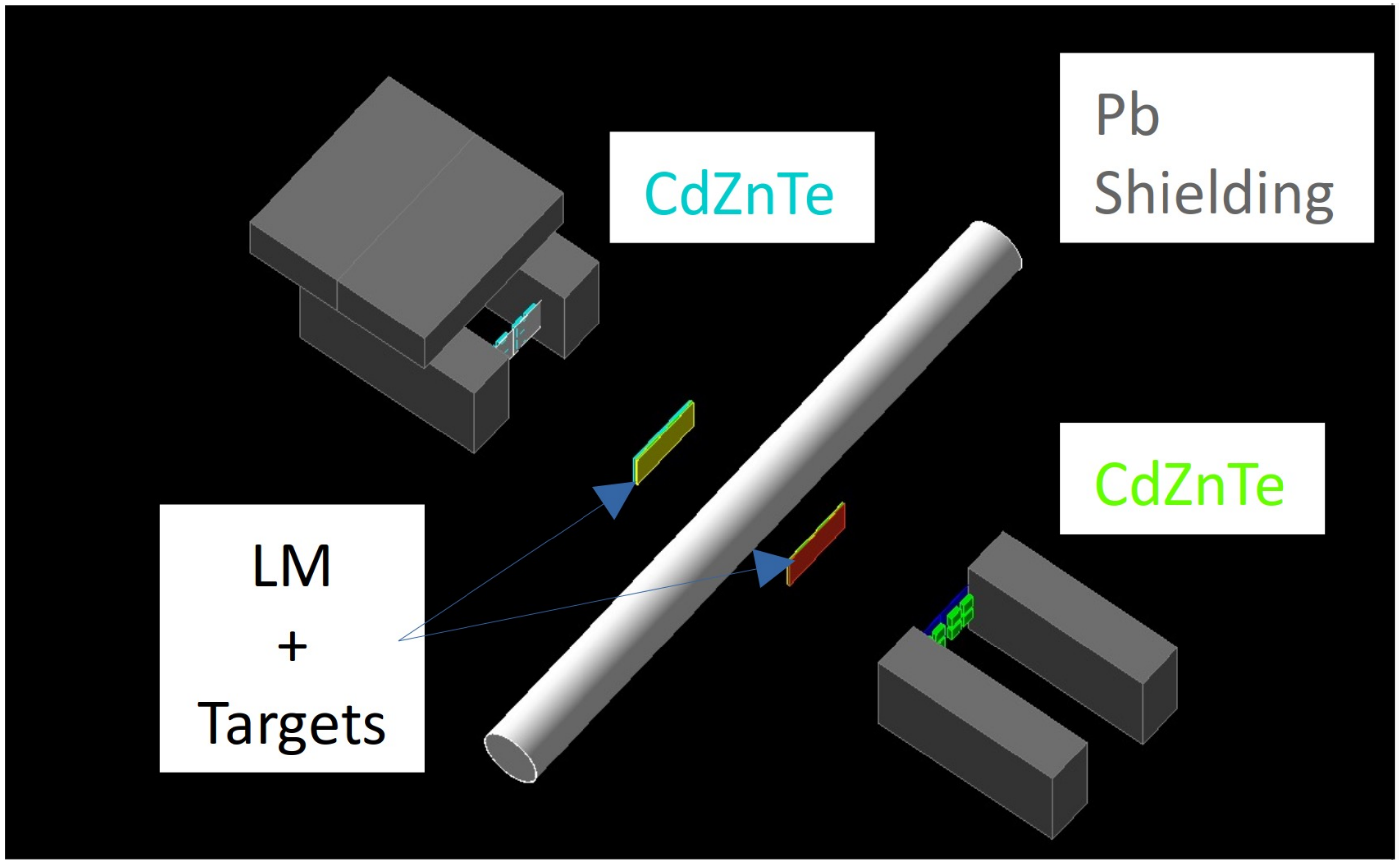
- Blue: data taking.
- X: closure of the lab

As a bonus: intermediate-mass kaonic atoms measurements with CdZnTe setups (same beam)



- **Kaonic Oxygen**: key role in the description of the nuclear-matter density distribution which enters in the formula for the density-dependent optical potentials
- **Kaonic Aluminium**; 3->2 QCD – never measured; 4->3 the inconsistent measurements
  Kaonic Sulphur:

S	4 → 3	−0.550 ± 0.06	2.330 ± 0.200	0.22 ± 0.02	3.10 ± 0.36	[18]
		−0.43 ± 0.12	2.310 ± 0.170	–	–	[21]
		−0.462 ± 0.054	1.96 ± 0.17	0.23 ± 0.03	2.9 ± 0.5	[19]

The setup will work in parallel with the SDD detectors-based ones capitalizing the integrated luminosities provided for those measurements (300 and 200 pb^{-1})

			Preparation																								Run																					
		Month	June				July				August				September				October				November				December				1				2				3				4				5				6	
ID		Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
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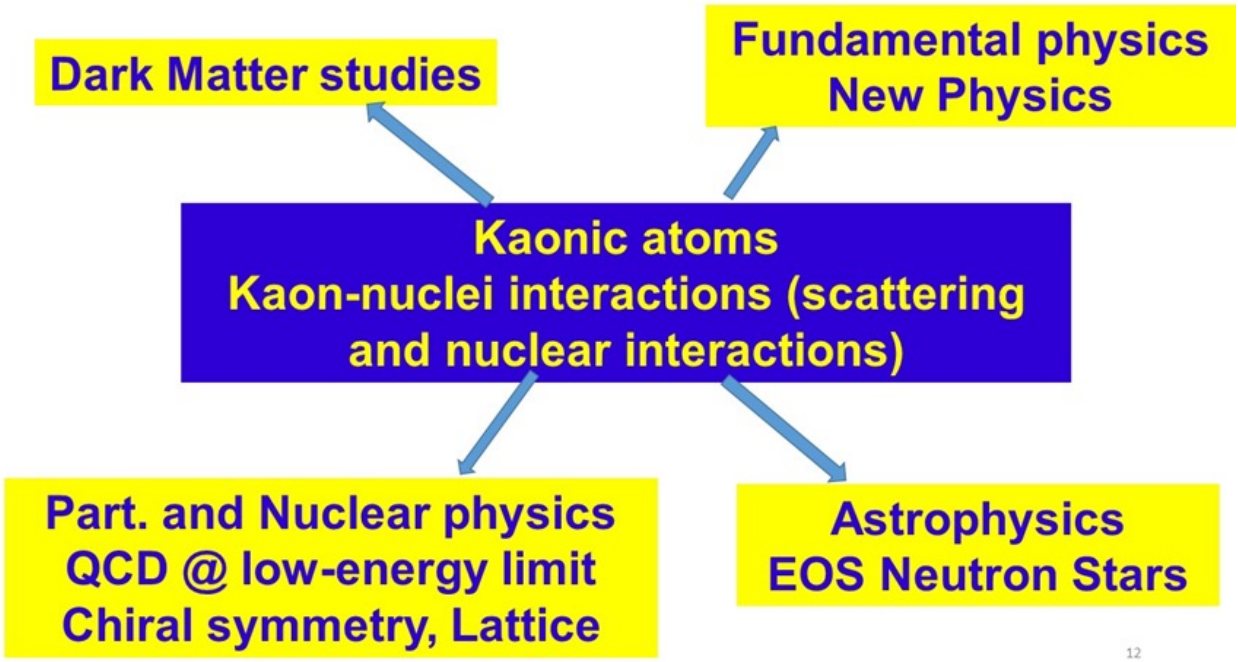
LM.6	Commissioning with beam											x	x												x	x																						
LM.7	Kaonic atoms from solid target measurement (200 pb^{-1} Integrated luminosity)											x	x												x	x																						
	Intermediate mass solid target measurements											x	x												x	x																						
CZT.1-CZT.3	New box, preamplifiers, targets and mechanical supports production											x	x												x	x																						
CZT.4	Test and characterization in lab											x	x												x	x																						
CZT.5	Installation and debug											x	x												x	x																						
CZT.6	Commisisoning with beam											x	x												x	x																						
CZT.7	Data taking: Kaonic Carbon/Oxygen and Sulfur (300 pb^{-1})											x	x												x	x																						
CZT.8	Data taking: Kaonic Aluminum and C/O or S (200 pb^{-1})											x	x												x	x																						

DAΦNE's unique (in the world) capabilities make it the ideal environment for advancing our understanding of strangeness in low-energy systems, with implications ranging from low-energy QCD to astrophysics and cosmology.

Various support letters (already provided to Sci Com) further attest to the significance of these measurements.

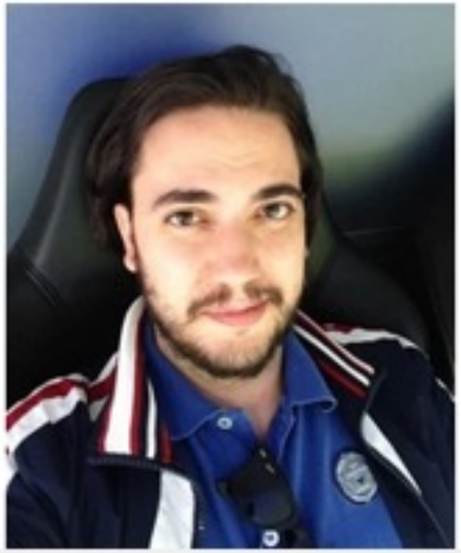


This endeavour presents a unique opportunity <u>We are convinced that this opportunity should not be missed</u>.

The measurements proposed mark the initial phase of a broader program, EXKALIBUR, proposed by a diverse and rich scientific community, which could systematically continue this research for the next years.

Good news about SIDDHARTA folks:

Francesco Sgaramella: best talk at SIF 2023



SOCIETÀ ITALIANA DI FISICA
Italian Physical Society

High-precision kaonic atoms X-ray spectroscopy with the SIDDHARTA-2 experiment at the DAΦNE collider.

Sgaramella F.

Francesco Artibani: won Ph D fellowship in SIDDHARTA-2 at Roma3 University

Francesco Clozza successfully completed Master Thesis at La Sapienza University with a thesis on SIDDHARTA-2: A new measurement of the Kaonic Helium L-lines to characterize the SIDDHARTA-2 apparatus on DAΦNE

Present and future perspectives in Hadron Physics

17–21 Jun 2024
Laboratori Nazionali di Frascati INFN
Europe/Rome timezone

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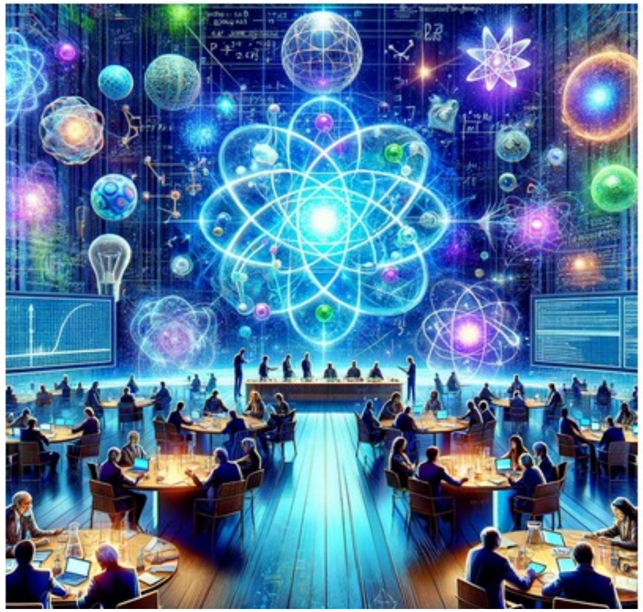
This workshop will be dedicated to the memory of Professor Carlo Guaraldo, from INFN-LNF, Deputy Scientific Coordinator of the STRONG-2020 project, who passed away on 19th May 2024 in Roma.



The Workshop will be held in person fror.. 17 to 19 June 2024, in Frascati (Italy) in the context of the project STRONG-2020 (http://www.strong-2020.eu/).

The objective is to gather a broad Hadron Physics Community, including both young and experienced researchers.

The first day will be dedicated to selected contributions. STRONG-2020 offers an opportunity to cover local and travel expenses for young researchers.

During the second and third days, invited speakers will present their work and perspectives in various areas of Hadron Physics and related fields.

The Workshop will be followed by the STRONG-2020 Annual Meeting organized in Frascati on 20-21 June 2024 and open to a large audience. The Agenda will be

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KAMPAI - KAONIC, ANTIPROTONIC, MUONIC, PIONIC AND "ONIA" EXOTIC ATOMS: INTERCHANGING KNOWLEDGE AND RECENT RESULTS

30 September 2024 — 04 October 2024

Organizers

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Conclusions

- The SIDDHARTA-2 Kd data taking data taking (run1-run2-run3) has been successfully completed, integrating **975/815 pb^{-1} of data**
- We completed the analysis of the usability of the data recorded during injection time
- We performed a preliminary analyses of first Kd Run – **First observation of Kaonic deuterium X-ray transitions to the 1s level – accomplishment of a dream!**
  The analysis of Kd run2 and run3 is ongoing
- We completed the first test run of CZT detectors demonstrating their feasibility to perform kaonic atoms measurement
  We completed and submitted for publication, KPb data acquire with HPGe
- >10 articles were published/submitted since the last Sci Com, 3 are in preparation and > 10 talks in International Workshops and Conferences
- We presented the first module of EXKALIBUR measurements: 300 + 200 pb: ready to start January 2025

SIDDHARTA-2 Collaboration

Silicon **D**rift **D**etectors for **H**adronic **A**tom **R**esearch by **T**iming **A**pplication

- 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
- Univ. of Palermo, Italy
- IMEM-CNR, Parma, Italy

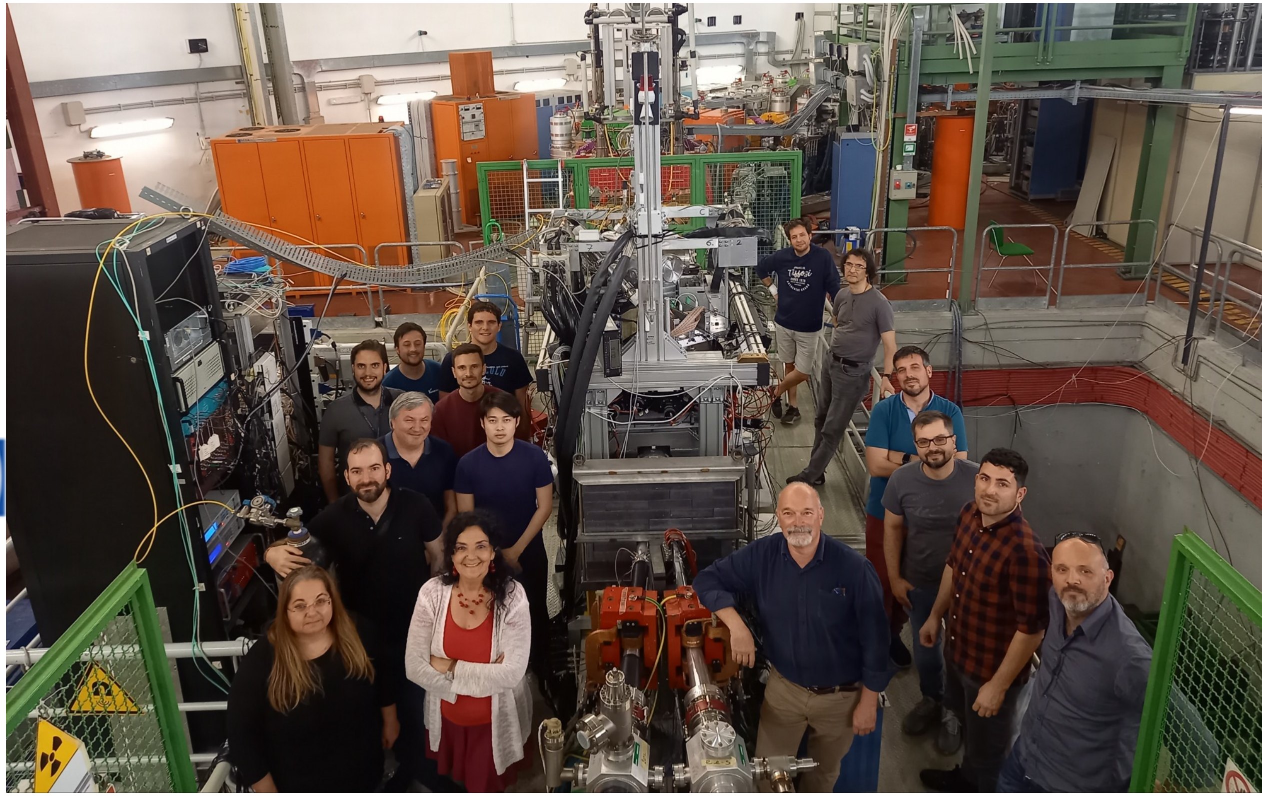
INFN LNF
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

STRONG-2020

HrZZ
Croatian Science Foundation

FWF Der Wissenschaftsfonds.

Farnesina
Ministero degli Affari Esteri e della Cooperazione Internazionale



HadronPhysics I3
Study of Strongly Interacting Matter

HadronPhysics2
Study of Strongly Interacting Matter

Special thanks to the accelerator, research and technical divisions, and in particular to the DAΦNE staff, to Cesidio Capoccia, to the LNF Director, to the Gruppo 3-INFN (Rosario Nania and KAONNIS referees) and to all those who made this possible!

Grazie Carlo!