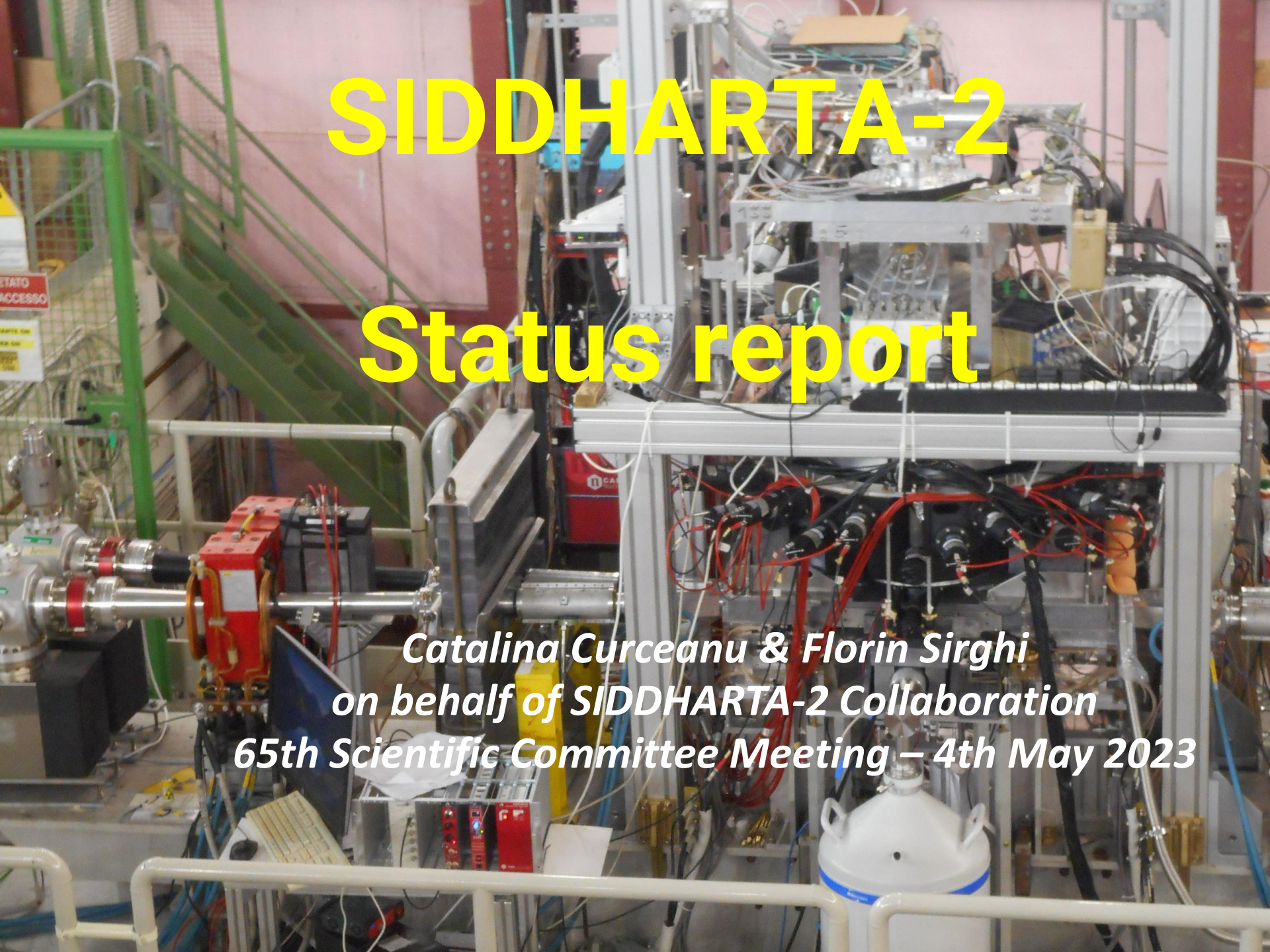


SIDDHARTA-2

Status report

Catalina Curceanu & Florin Sirghi
on behalf of SIDDHARTA-2 Collaboration
65th Scientific Committee Meeting – 4th May 2023

SIDDHARTA-2 Collaboration

Silicon **D**rift **D**etectors for **H**adronic **A**tom
Research 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

HadronPhysics2 Study of Strongly Interacting Matter

INFN LNF
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

STRONG-2020

HadronPhysics I3 Study of Strongly Interacting Matter

HRZZ Croatian Science Foundation

FWF Der Wissenschaftsfonds.

Farnesina
Ministero degli Affari Esteri
e della Cooperazione Internazionale

Before starting:

Huge progress *was achieved since November 2022 Scientific Committee:*

DAΦNE – best working conditions ever (SIDDHARTA-2):

Integrated luminosity: going from 1-2 pb/day to about 8-12 pb/day

Background on SDD detectors:
from 7 (best in SIDDHARTINO) x10^4 X/cm^2 (5-10) keV region to about 2-3!

We are very grateful to DAΦNE team and accelerator division and applaud these achievements which set a solid ground for the kaonic deuterium first measurement ever and other kaonic atoms measurements!

Part of the SIDDHARTA-2 collaboration

Contents

- **Scientific outcome highlights and publications since the last Sci Com (64)**

- **64th SciCom recommendations and preparation for Kd run (+ test measurements)**
  - preparation of SIDDHARTA-2 run: setup optimization, kaonic neon run
  - updates on HPGe and CdZnTe detectors

- **Kaonic Deuterium run plans and requests**

- **Futures plan beyond SIDDHARTA-2 – EXKALIBUR: strange atoms periodic table and fundamental physics at the strangeness frontier**

Publications since last SciCom – Nov. 2022 (>10)

F. Sgaramella et al., Measurements of high-n transitions in intermediate mass kaonic atoms by SIDDHARTA-2 at DAΦNE, Eur.Phys.J.A 59 (2023) 3, 56

D.L. Sirghi et al, New measurements of kaonic helium-4 L-series X-rays yields in gas with the SIDDHARTINO setup, Nucl.Phys.A 1029 (2023) 122567

A. Scordo et al., First Tests of the Full SIDDHARTA-2 Experimental Apparatus with a 4He Gaseous Target, Acta Phys.Polon.A 142 (2022) 3, 373

L. De Paolis et al, Investigating the E2 nuclear resonance effect in kaonic atoms, J.Phys.Conf.Ser. 2446 (2023) 1, 012038

K. Piscicchia et al, A novel approach to the measurement of the hyperon nucleon/s interaction by AMADEUS, EPJ Web Conf. 271 (2022) 07004

L. De Paolis et al., Trigger rejection factor in the first kaonic helium run with the complete SIDDHARTA-2 setup, EPJ Web Conf. 270 (2022) 00028

K. Piscicchia et al., First Simultaneous K−−p →(Σ0/Λ) π0→(Σ0/Λ)π0 Cross Sections Measurements at 98 MeV/c, e-Print: 2210.10342 - submitted Phys. Rev. Lett.

Publications since last SciCom – Nov. 2022

***K. Piscicchia et al*, A novel approach to the measurement of the hyperon nucleon/s interaction by AMADEUS, EPJ Web Conf. 271 (2022) 07004**

***L. De Paolis et al*., Trigger rejection factor in the first kaonic helium run with the complete SIDDHARTA-2 setup, EPJ Web Conf. 270 (2022) 00028**

***A. Khreptak* et al., Studies of the linearity and stability of Silicon Drift Detectors for kaonic atoms X-ray spectroscopy, Acta Phys.Polon.Supp. 15 (2022) 4, 1**

***F. Sgaramella et al,* Kaonic atoms measurements with SIDDHARTA-2, J.Phys.Conf.Ser. 2446 (2023) 1, 012023**

***L. De Paolis et al.,* The SIDDHARTA-2 experiment: preparation for the first kaonic deuterium measurement, PoS ICHEP2022 1003**

***L. Abbene et al.,* New opportunities for kaonic atoms measurements from CdZnTe detectors, e-Print: 2301.12253 [physics.ins-det], accepted for publication in EPJ-ST**

+ 3 articles in preparation

> 10 invited talks in International Workshops and Conferences

Eur. Phys. J. A (2023) 59:56
https://doi.org/10.1140/epja/s10050-023-00976-y

THE EUROPEAN PHYSICAL JOURNAL A

Regular Article - Experimental Physics

Measurements of high-n transitions in intermediate mass kaonic atoms by SIDDHARTA-2 at DAΦNE

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

First measurements ever – QCD and K- multinucleon interaction

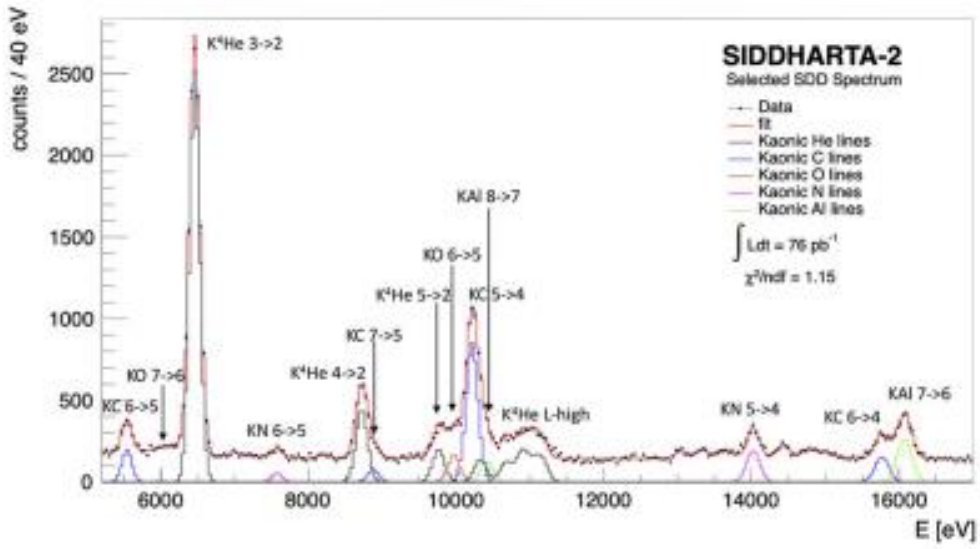


Fig. 6 SDD energy spectrum and fit of SIDDHARTA-2 and SIDDHARTINO summed data after background suppression (see text). The kaonic helium signals are seen as well as the kaonic carbon (KC), oxygen (KO), nitrogen (KN) and aluminium (KAl) peaks

Table 2 Kaonic carbon, oxygen, nitrogen and aluminium transition energies from the fit of the data in Fig. 6

Transition	Energy (eV)
K^-C (6→5)	5541.7 ± 3.1 (stat) ± 2.0 (syst)
K^-C (7→5)	8890.0 ± 13.0 (stat) ± 2.0 (syst)
K^-C (5→4)	10,216.6 ± 1.8 (stat) ± 3.0 (syst)
K^-C (6→4)	15,760.3 ± 4.7 (stat) ± 12.0 (syst)
K^-O (7→6)	6016.0 ± 60.0 (stat) ± 2.0 (syst)
K^-O (6→5)	9968.1 ± 6.9 (stat) ± 2.0 (syst)
K^-N (6→5)	7577.0 ± 17.0 (stat) ± 2.0 (syst)
K^-N (5→4)	14,010.6 ± 8.2 (stat) ± 9.0 (syst)
K^-Al (8→7)	10,441.0 ± 8.5 (stat) ± 3.0 (syst)
K^-Al (7→6)	16,083.4 ± 3.8 (stat) ± 12.0 (syst)

Available online at www.sciencedirect.com
ScienceDirect
Nuclear Physics A 1029 (2023) 122567
www.elsevier.com/locate/nuclphysa

New measurements of kaonic helium-4 L-series X-rays yields in gas with the SIDDHARTINO setup

D.L. Sirghi [a,b,c,*], H. Shi [d], C. Guaraldo [a], F. Sgaramella [a,**], C. Amsler [d], M. Bazzi [a], D. Bosnar [e], A.M. Bragadireanu [c], M. Carminati [f,g], M. Cargnelli [d], A. Clozza [a], G. Deda [f,g], L. De Paolis [a], R. Del Grande [a,h], L. Fabbietti [h], C. Fiorini [f,g], M. Iliescu [a], M. Iwasaki [i], J. Marton [d], M. Miliucci [a], P. Moskal [j], F. Napolitano [a], S. Niedzwiecki [j], H. Ohnishi [k], K. Piscicchia [b,a], Y. Sada [k], A. Scordo [a], M. Silarski [j], F. Sirghi [a,c], M. Skurzok [j], A. Spallone [a], K. Toho [k], M. Tüchler [d,l], O. Vazquez Doce [a], J. Zmeskal [d], C. Yoshida [k], C. Curceanu [a]

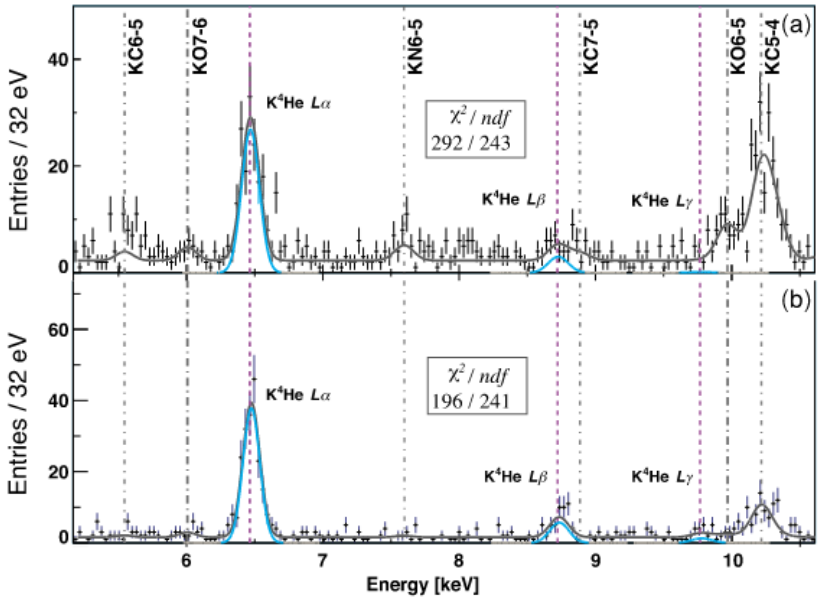
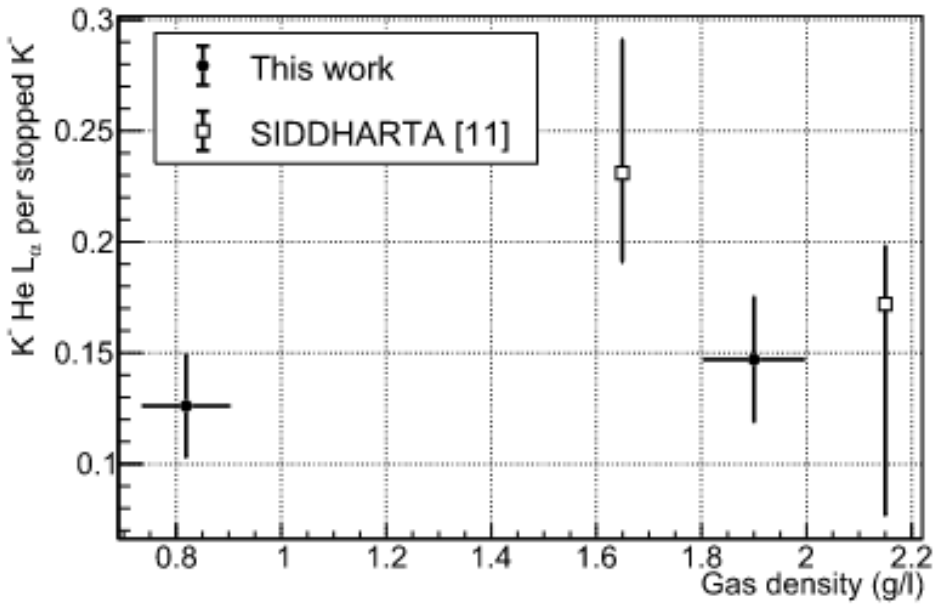


Fig. 2. X-ray kaonic helium-4 spectra measured by SIDDHARTINO for: (a) 0.82 g/l target gas density; (b) 1.90 g/l target gas density. The kaonic helium-4 peaks L_α, L_β and L_γ are shown. Several kaonic atom X-ray lines produced in the Kapton foils are also shown: Kaonic Carbon 6 → 5, Kaonic Oxygen 7 → 6, Kaonic Nitrogen 6 → 5, Kaonic Carbon → 5, Kaonic Oxigen 6 → 5, Kaonic Carbon 5 → 4 transitions. The solid line shows the fit function of the spectrum. The blue line shows the L series L_α, L_β and L_γ kaonic helium-4 components. (For interpretation of the colors in the

First measurements ever – exotic atoms cascade



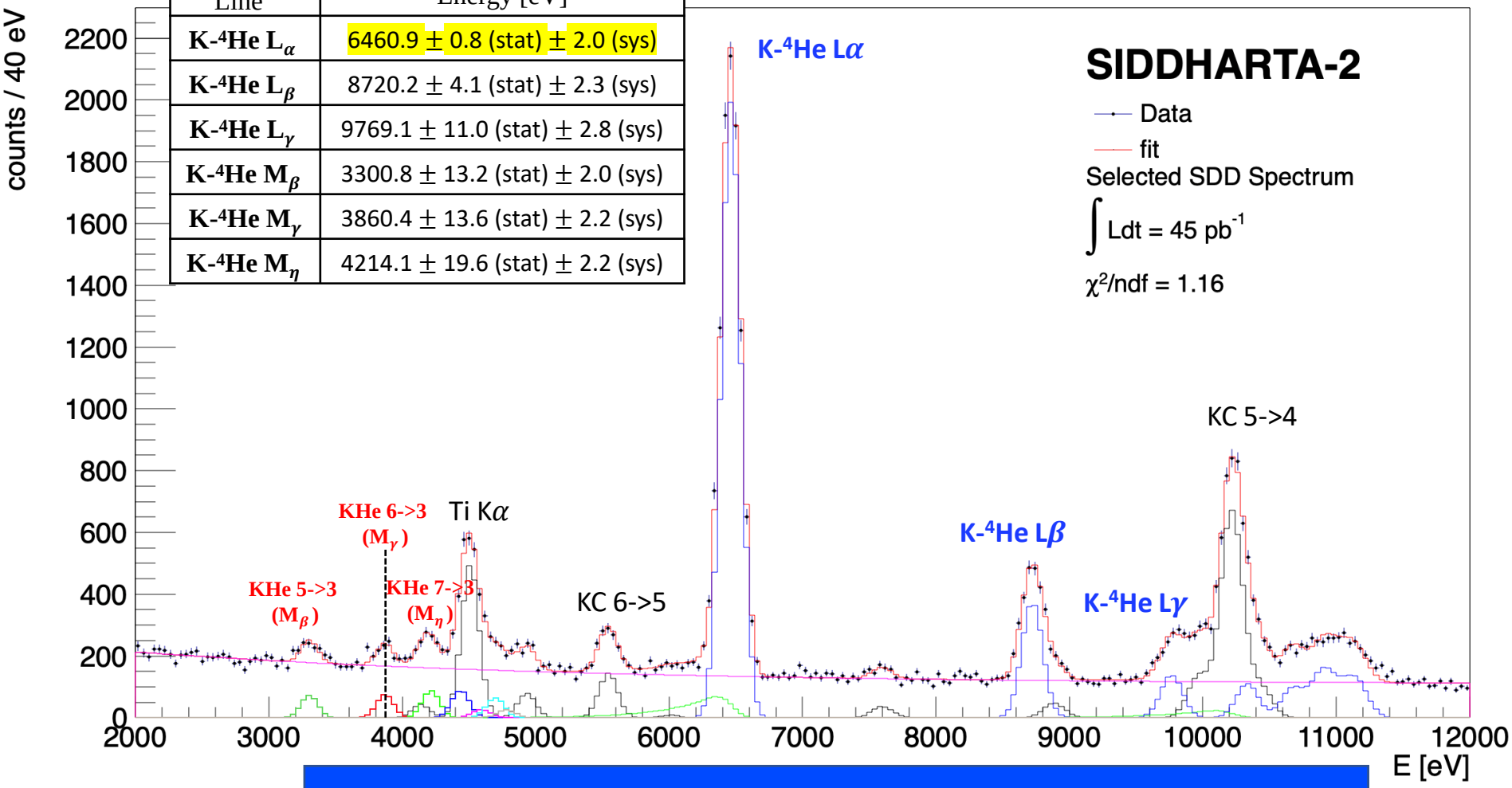
ld of K^- ^{4}He as function of the target density from all gaseous target ARTA [16] (hollow squares).

SIDDHARTA-2 Kaonic ^{4}He

M-type transitions analysis finalized - write paper

Run: ID 13 to ID 165; He1.4% LHeD; deg 475+350+600;
old trigger position + trigger moved 2cm boost direction

Line	Energy [eV]
K-^{4}He L_α	6460.9 ± 0.8 (stat) ± 2.0 (sys)
K-^{4}He L_β	8720.2 ± 4.1 (stat) ± 2.3 (sys)
K-^{4}He L_γ	9769.1 ± 11.0 (stat) ± 2.8 (sys)
K-^{4}He M_β	3300.8 ± 13.2 (stat) ± 2.0 (sys)
K-^{4}He M_γ	3860.4 ± 13.6 (stat) ± 2.2 (sys)
K-^{4}He M_η	4214.1 ± 19.6 (stat) ± 2.2 (sys)



First measurements ever – QCD and exotic atoms cascade

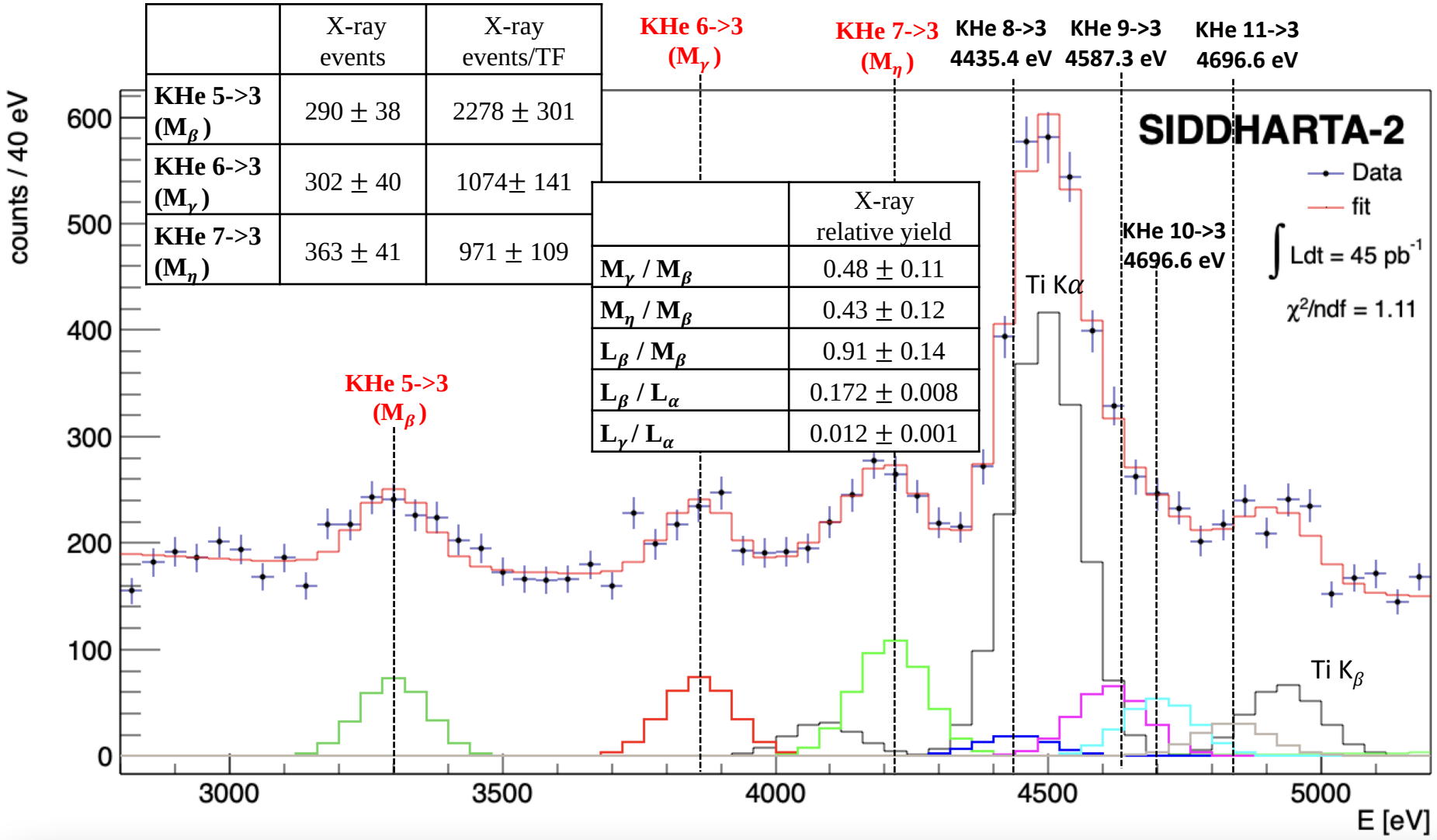
SIDDHARTA-2 Kaonic ^{4}He

M-type transitions analysis finalized - write paper

Run: ID 13 to ID 165; He1.4% LHeD; deg 475+350+600;
old trigger position + trigger moved 2cm boost direction

	X-ray events	X-ray events/TF
KHe 5->3 (M_β)	290 ± 38	2278 ± 301
KHe 6->3 (M_γ)	302 ± 40	1074± 141
KHe 7->3 (M_η)	363 ± 41	971 ± 109

	X-ray relative yield
M_γ / M_β	0.48 ± 0.11
M_η / M_β	0.43 ± 0.12
L_β / M_β	0.91 ± 0.14
L_β / L_α	0.172 ± 0.008
L_γ / L_α	0.012 ± 0.001



Good news about SIDDHARTA folks:

SIF 2022: Migliori Comunicazioni 2022 (best talks award)

Sezione 1: Fisica nucleare e subnucleare
Menzioni
Luca De Paolis: Nuclear resosnance effects in kaonic atoms.

2 Master students with theses in SIDDHARTA:
Francesco Clozza and Francesco Artibani
from La Sapienza University

1 Ph D student from Tokoku Japan: Toho Kairo

and 1 Pd D student from Poli Milano:: Lorenzo Giuseppe Toscano

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64 rd MEETING recommendations

Comments SIDDHARTA-2:

The SC congratulates the collaboration for their precise and surprising new results in K-He, their observation of kaonic atoms from solid targets, for completing the installation of the SIDDHARTA-2 setup and their development of the full apparatus, calibration method, as well as the confirmation of the feasibility of future measurements with HPGe and CdZnTe detectors. The committee also commends the collaboration for its achievements in testing and calibrating the main setup and parasitic detectors as well as for its continuous efforts to conceive additional actions to improve the detector performance and reduce the background.

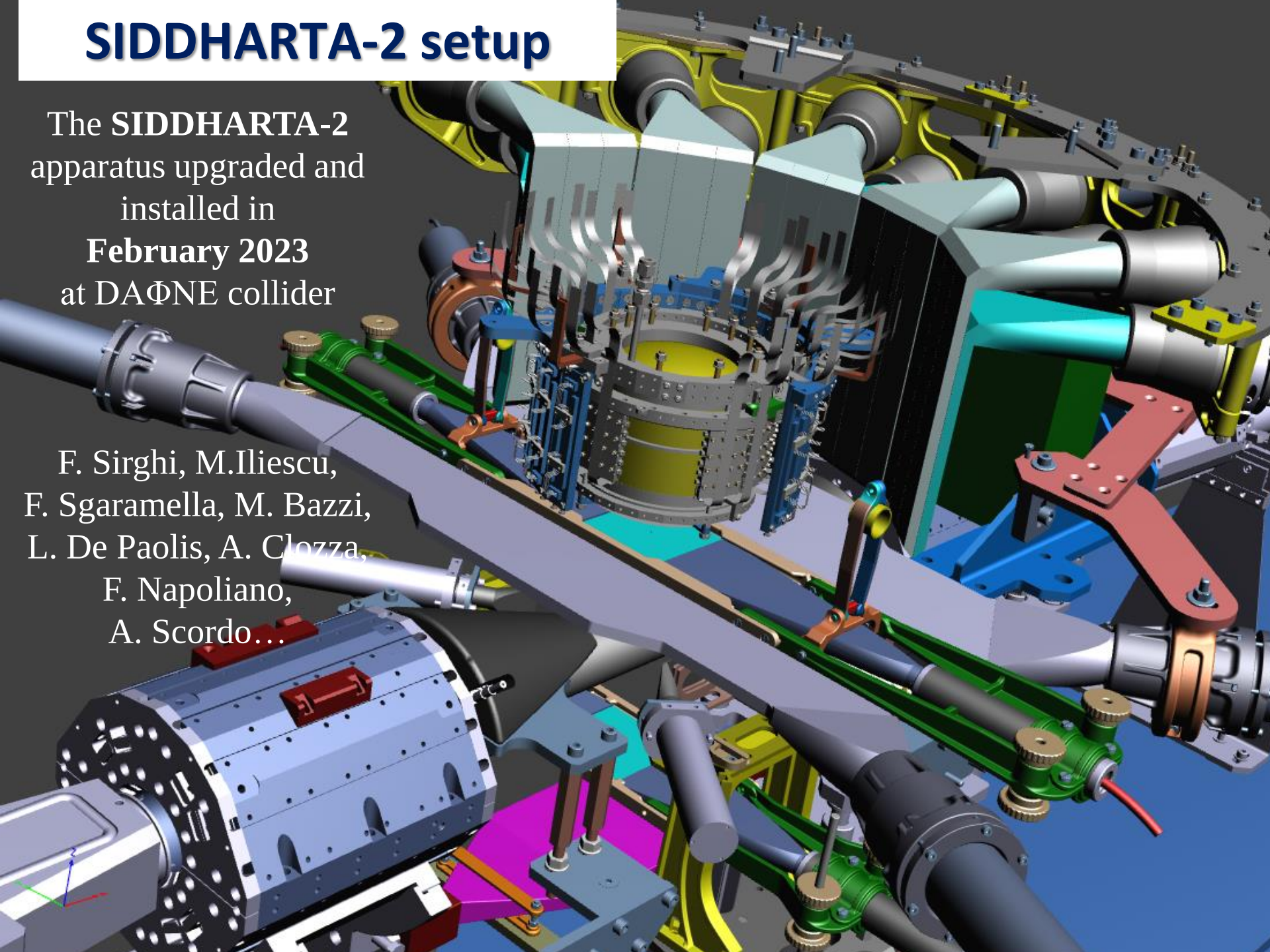
Recommendations SIDDHARTA-2/DAFNE/BTF:

- ***The SC encourages collaboration and coordination with DAΦNE in their mending plan to reduce background and improve the Kaon/SDD ratio.***
- ***To continue their planned optimization activities: shielding reinforcement, veto3 system and installation of new entrance window. These should be completed before the end of February 2023, thus ready for the spring H-deuterium run1.***
- ***To complete the proposed setup tests and installation of the parasitic HPGe and CdZnTe parasitic detectors with the aim of acquiring data during the 2023 runs.***

SIDDHARTA-2 setup

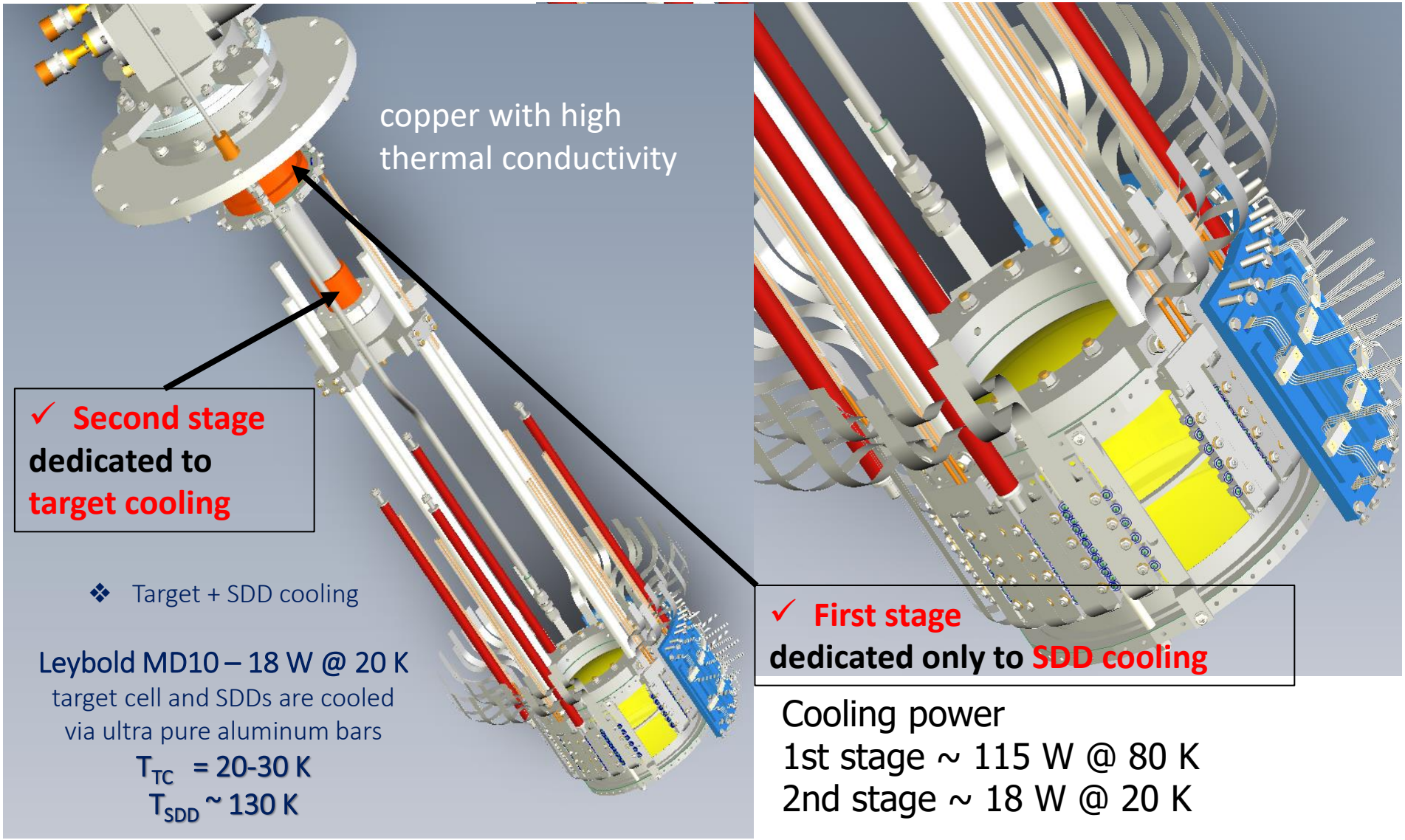
The **SIDDHARTA-2** apparatus upgraded and installed in **February 2023** at DAΦNE collider

F. Sirghi, M.Iliescu, F. Sgaramella, M. Bazzi, L. De Paolis, A. Clozza, F. Napoliano, A. Scordo…



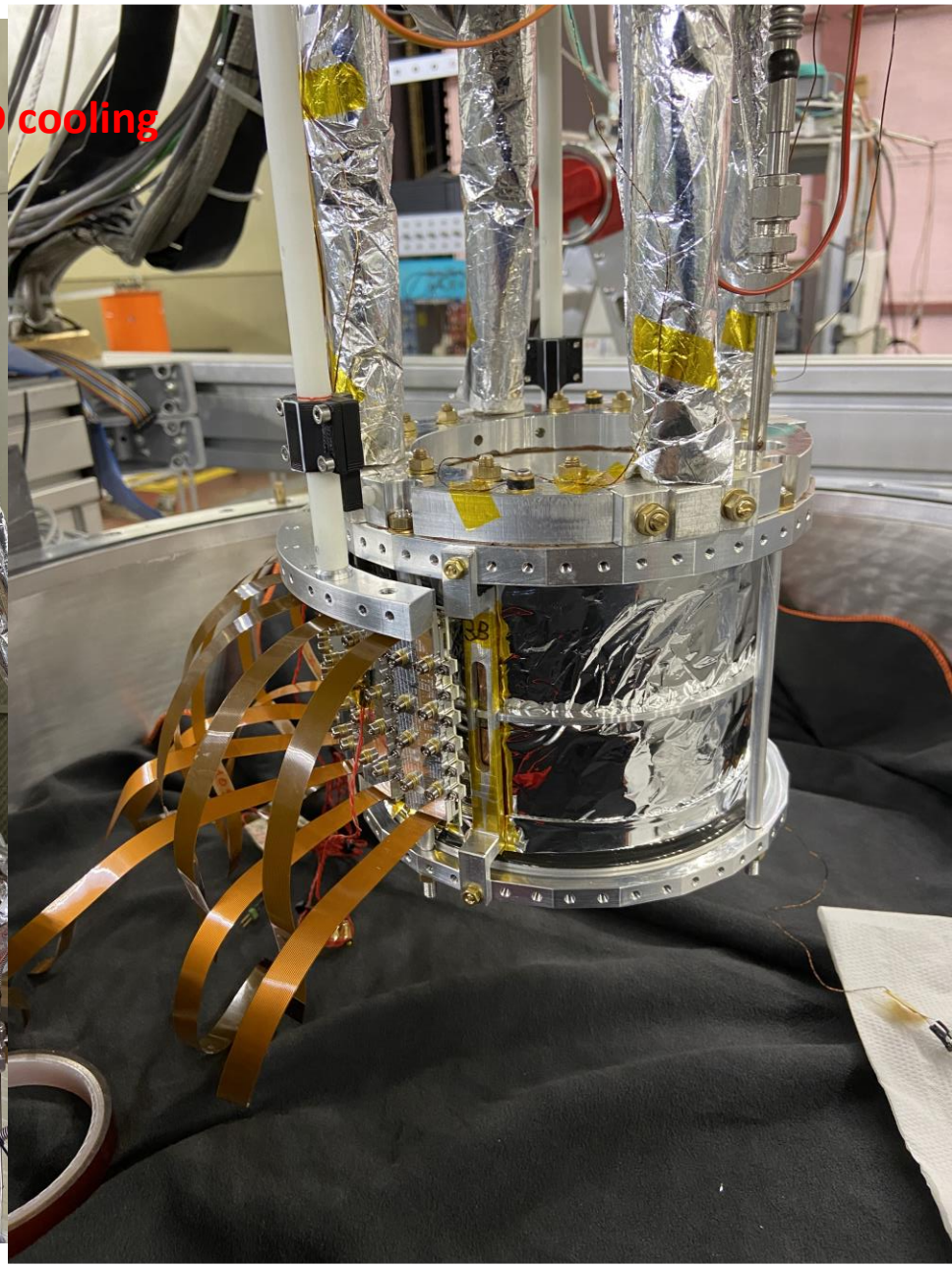
Optimization of SIDDHARTA-2 setup (SMI-Vienna; Zmeskal)

- ✓ new cooling scheme for target and SDD
- ✓ Better control of target parameters (pressure, temperature, density,….)



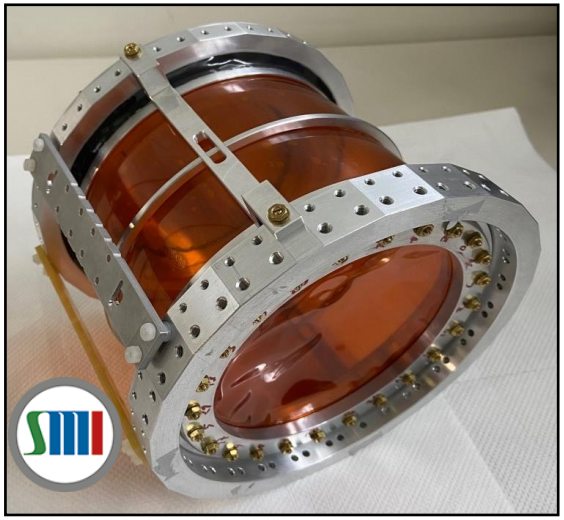
Cooling power
1st stage ~ 115 W @ 80 K
2nd stage ~ 18 W @ 20 K

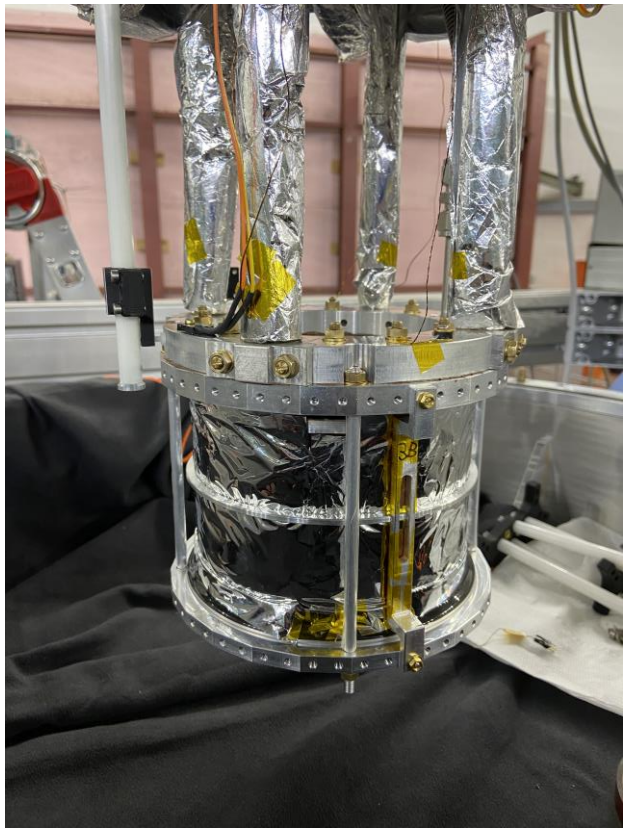
Optimization of SIDDHARTA-2 setup (LNF – Lab)



Optimization of SIDDHARTA-2 setup

✓ **UHMWPE – new entrance windows material**
for target super-strong form of polyethylene, would eliminate both Nitrogen and Oxygen contamination



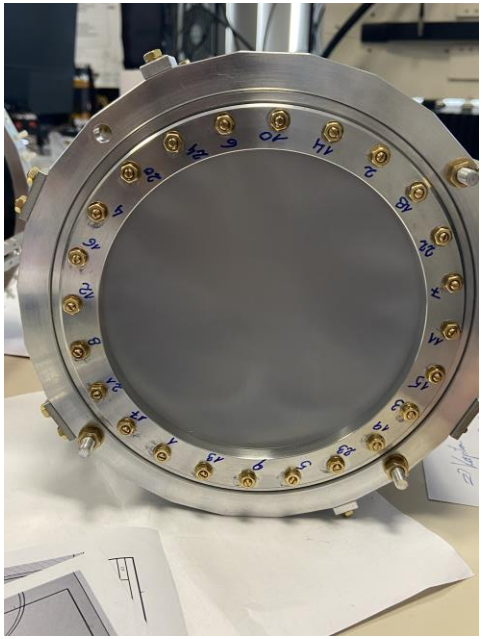


Successful tests done in laboratory in Vienna

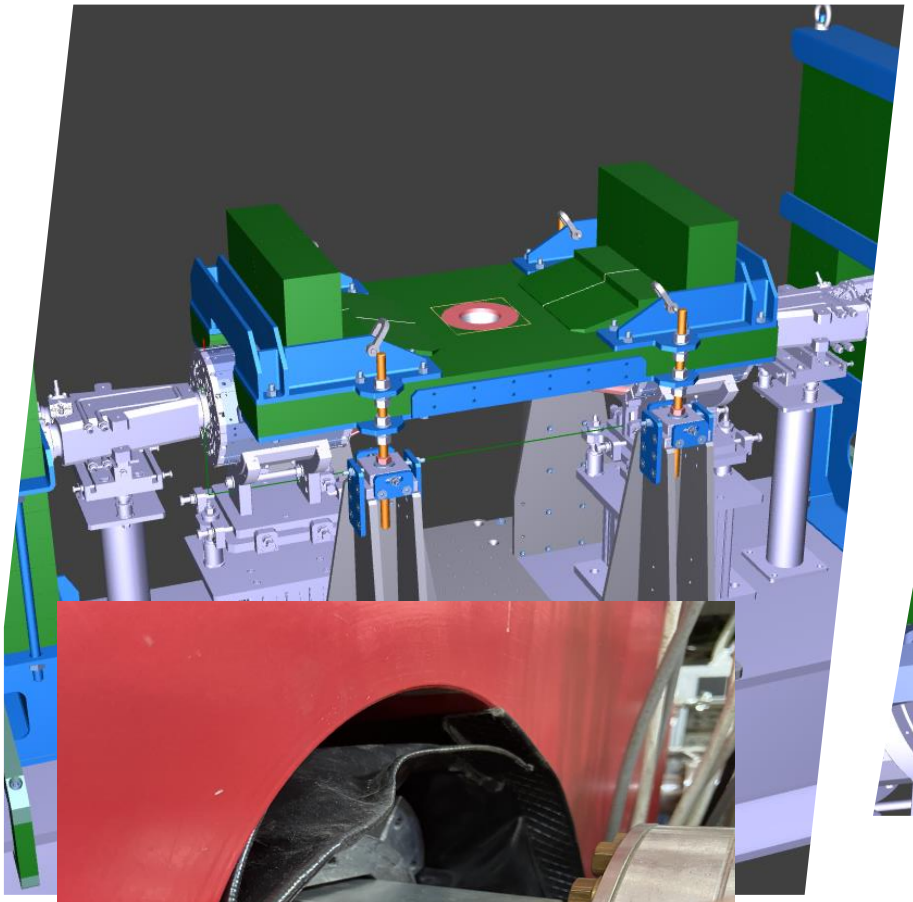
Installation and test in Dafne

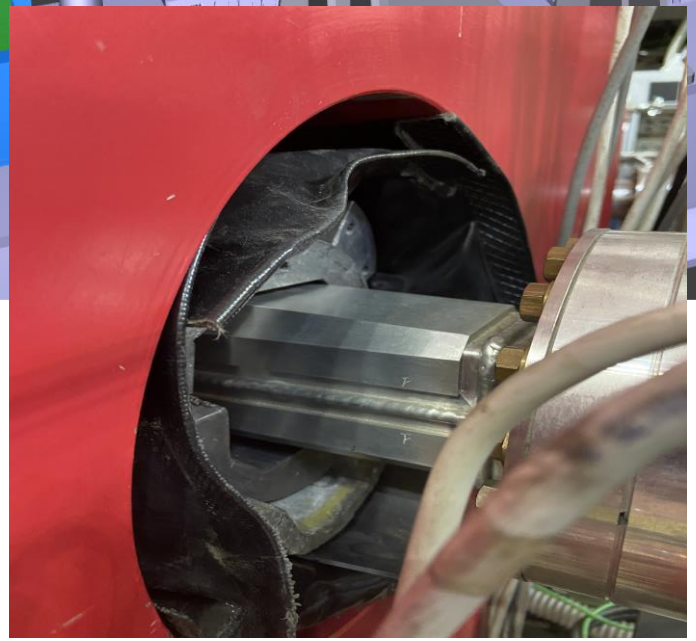
… after two weeks failure in the material composition

Replaced with a back-up Mylar window which works perfectly

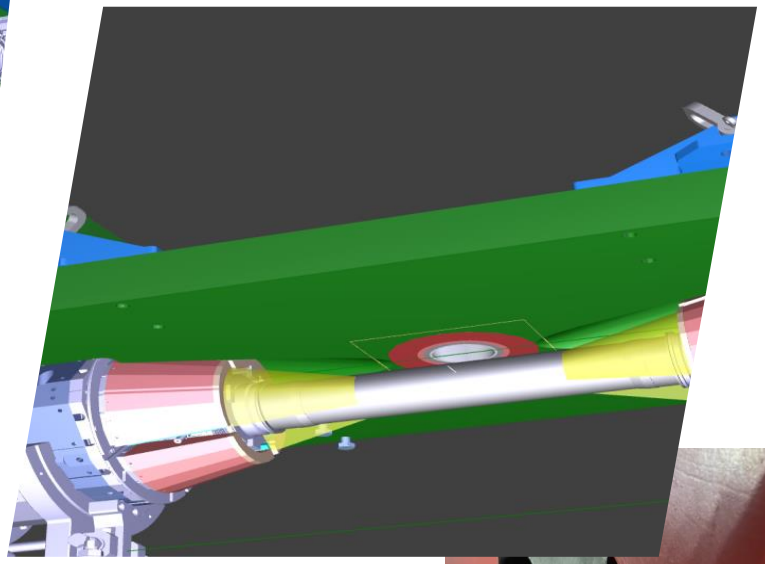


Optimization of SIDDHARTA-2 setup (LNF)

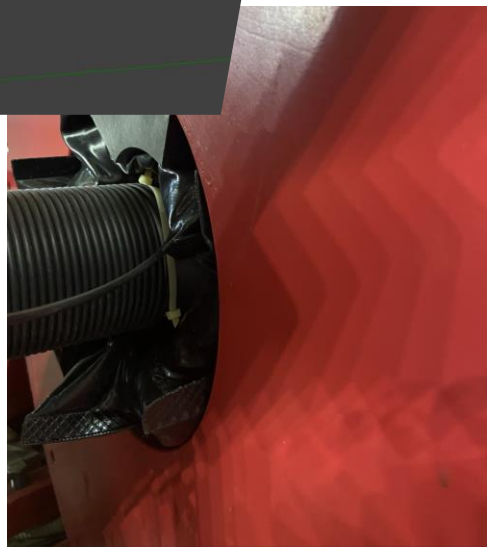




- Improve the lateral shielding around the vacuum chamber
- Redesign the bottom shielding near to interaction point

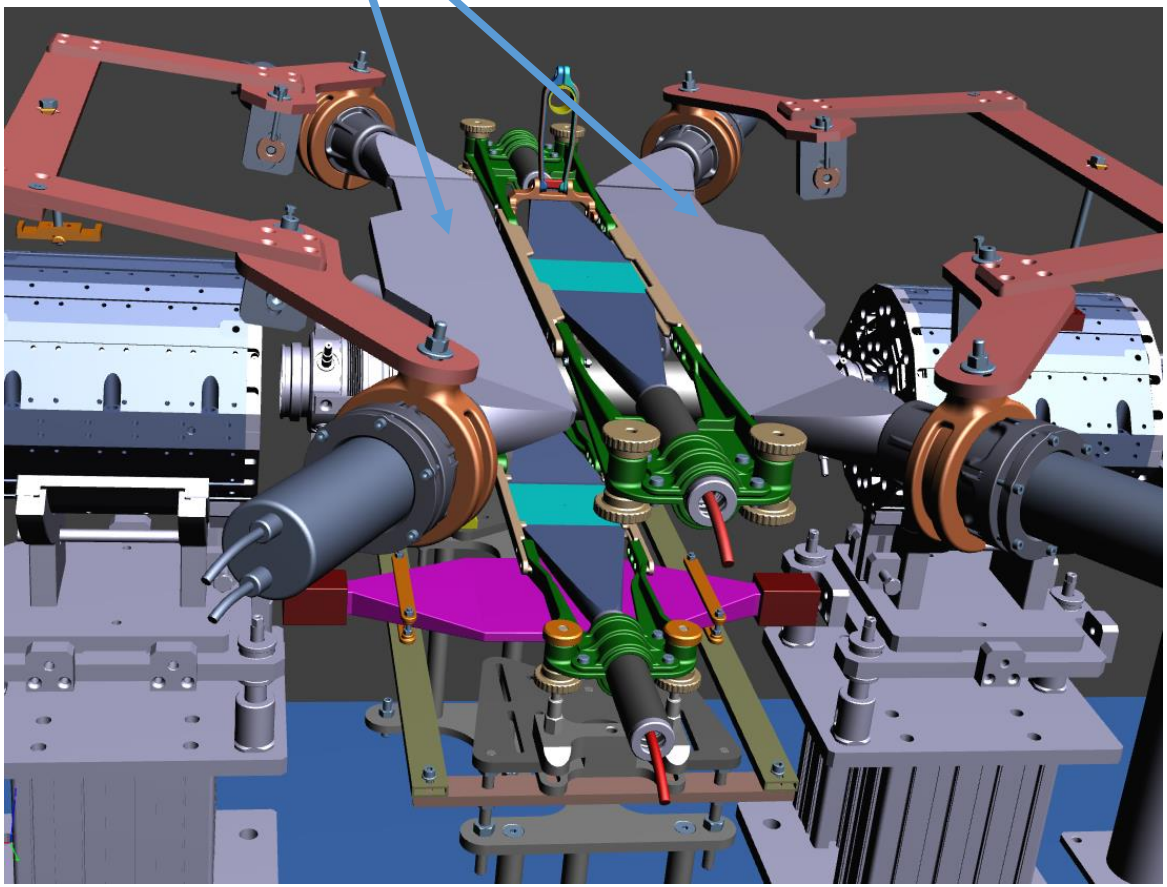


In collaboration with DAΦNE team to fill gaps in compensator magnets



Optimization of SIDDHARTA-2 setup (M.Iliescu, F. Sirghi, F. Sgaramella…)

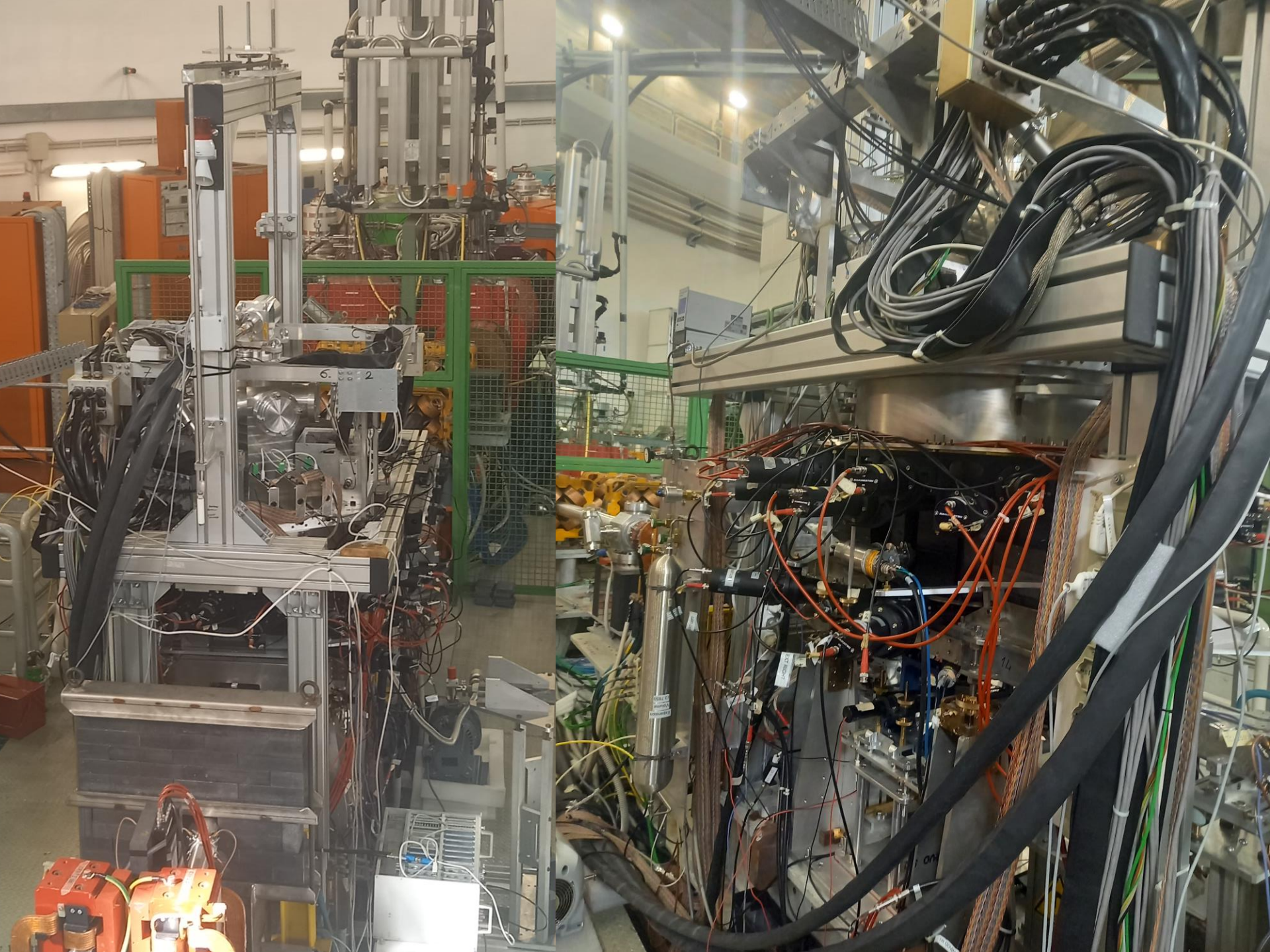
VETO system adds – VETO3



- 2 pairs of scintillator 640 x 130 x 10 mm^3 Scionix EJ-200

- R10533 PMTs Hamamatsu
- light-guides
- Al tube + µMetal (0.1mm)

- reflective and light proof foil
- optical cement

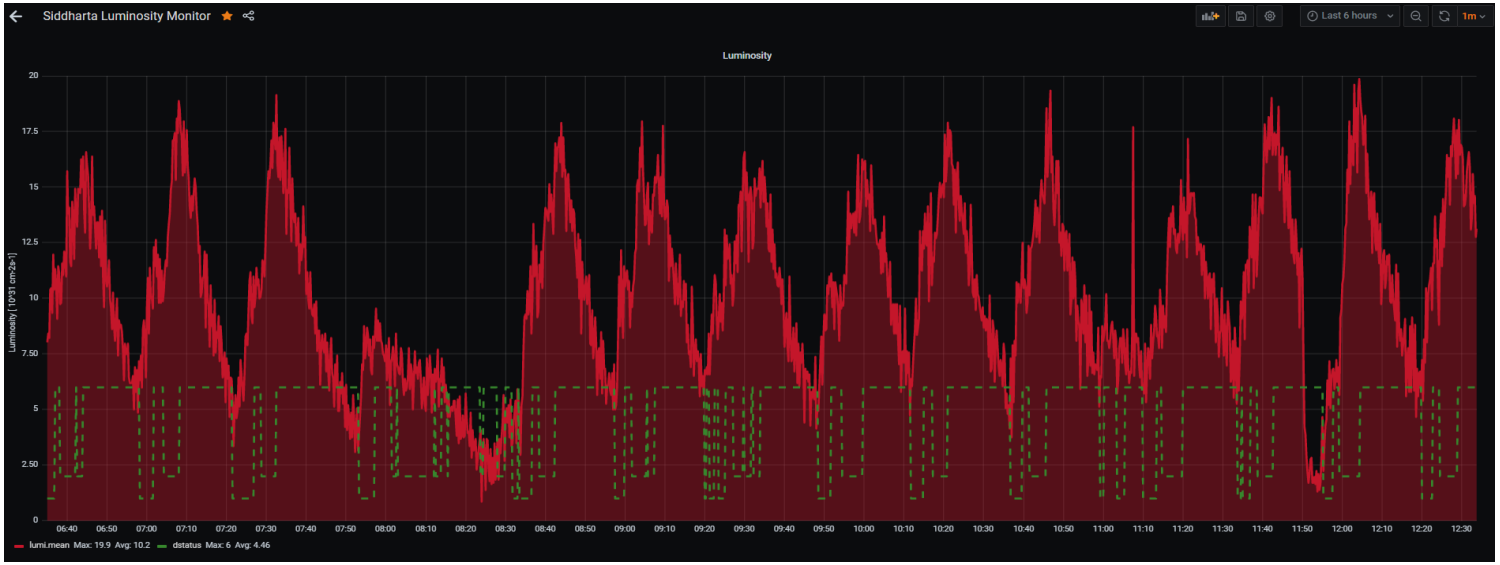


First results of SIDDHARTA-2 run: April 2023

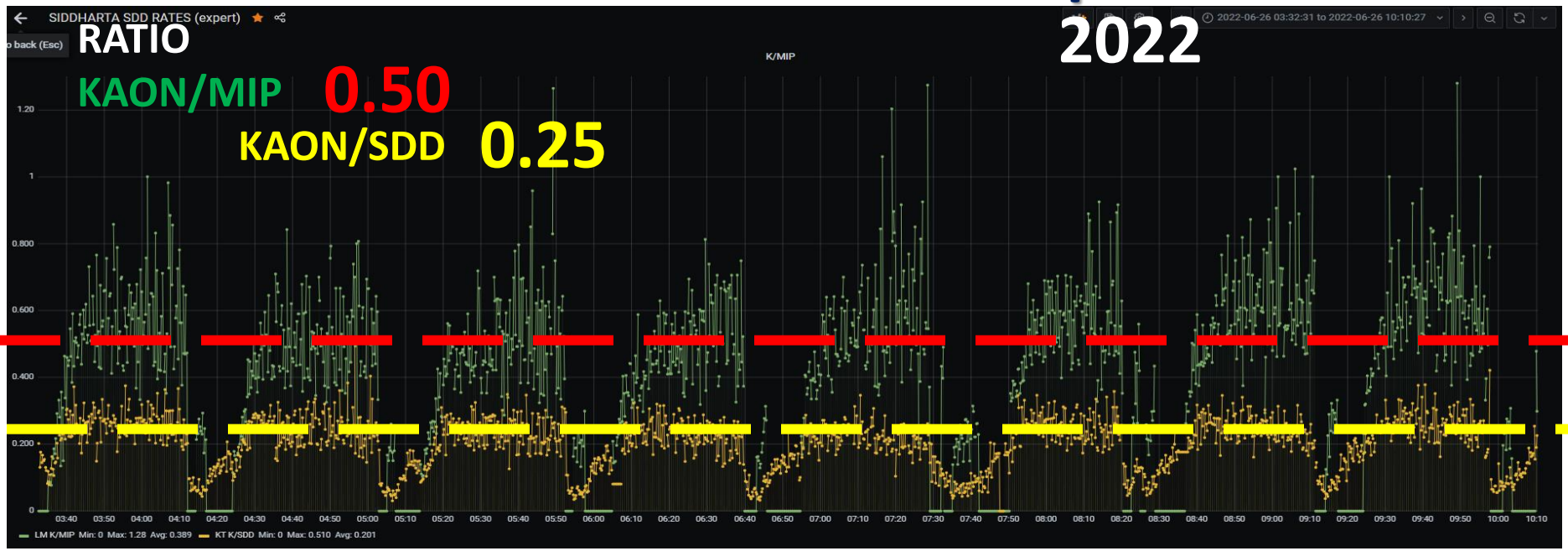
Reduce background and improve KAON/SDD ratio

Online monitoring tools for fast feedback

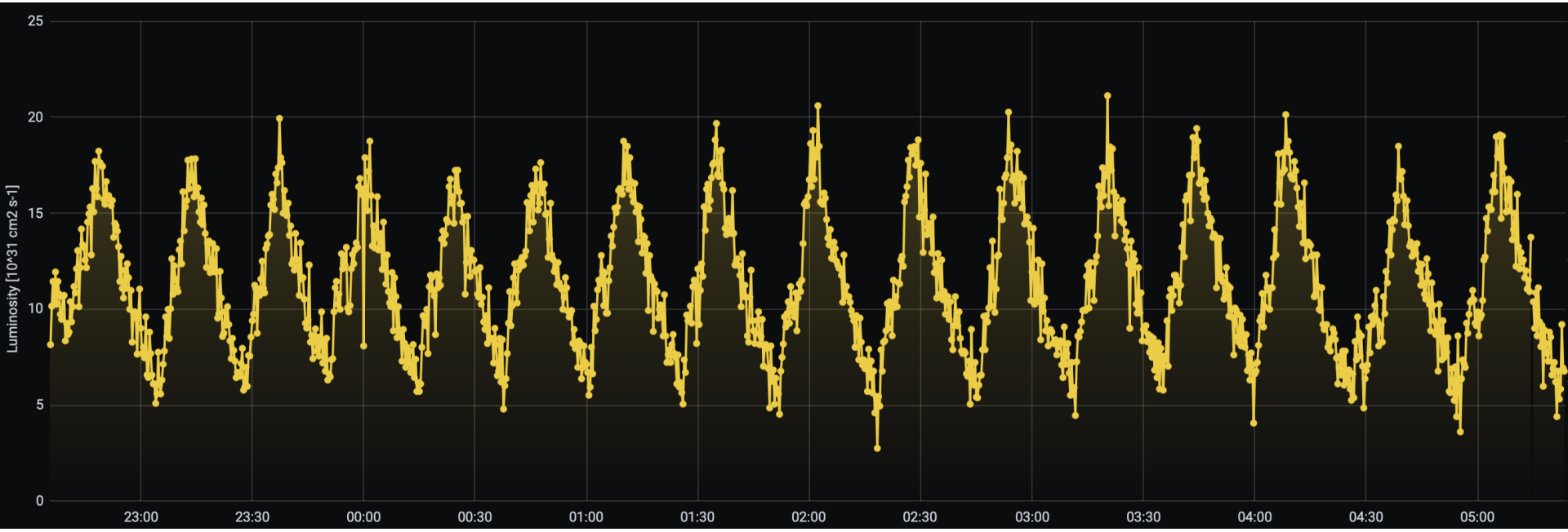
Instantaneous luminosity estimation and fast feedback with Dafne team

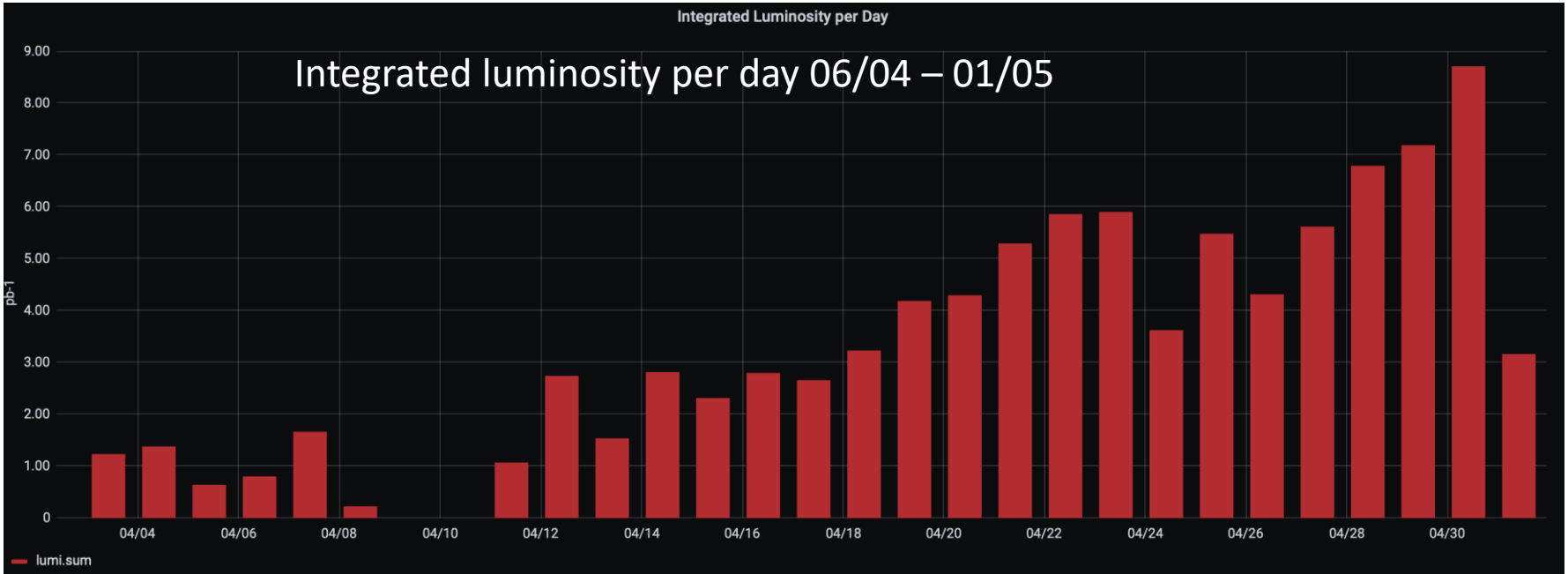


First results of SIDDHARTA-2 run: April 2023



Instantaneous luminosity per day, end april

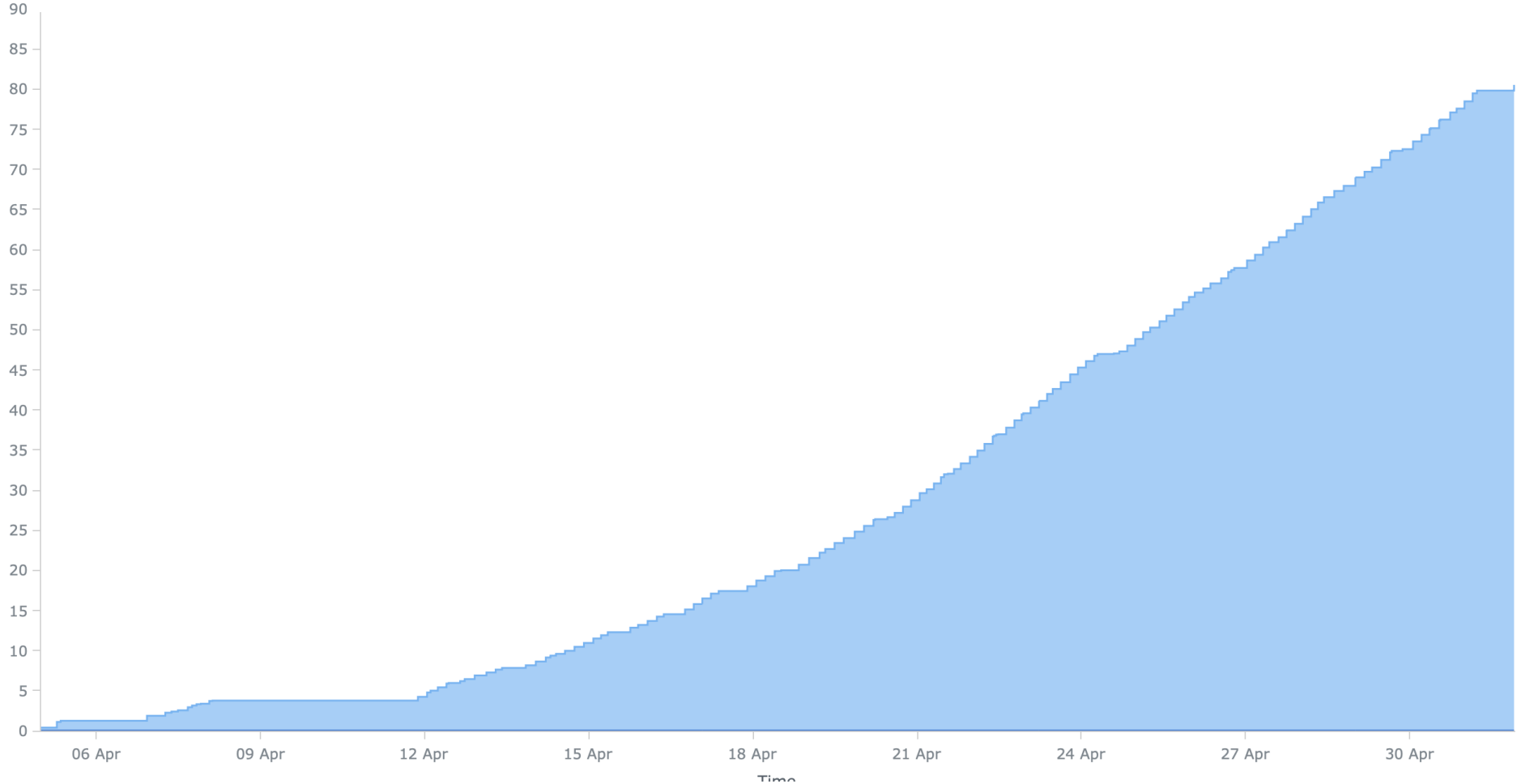




Integrated luminosity over time without injection

06/04 – 01/02: 84 pb

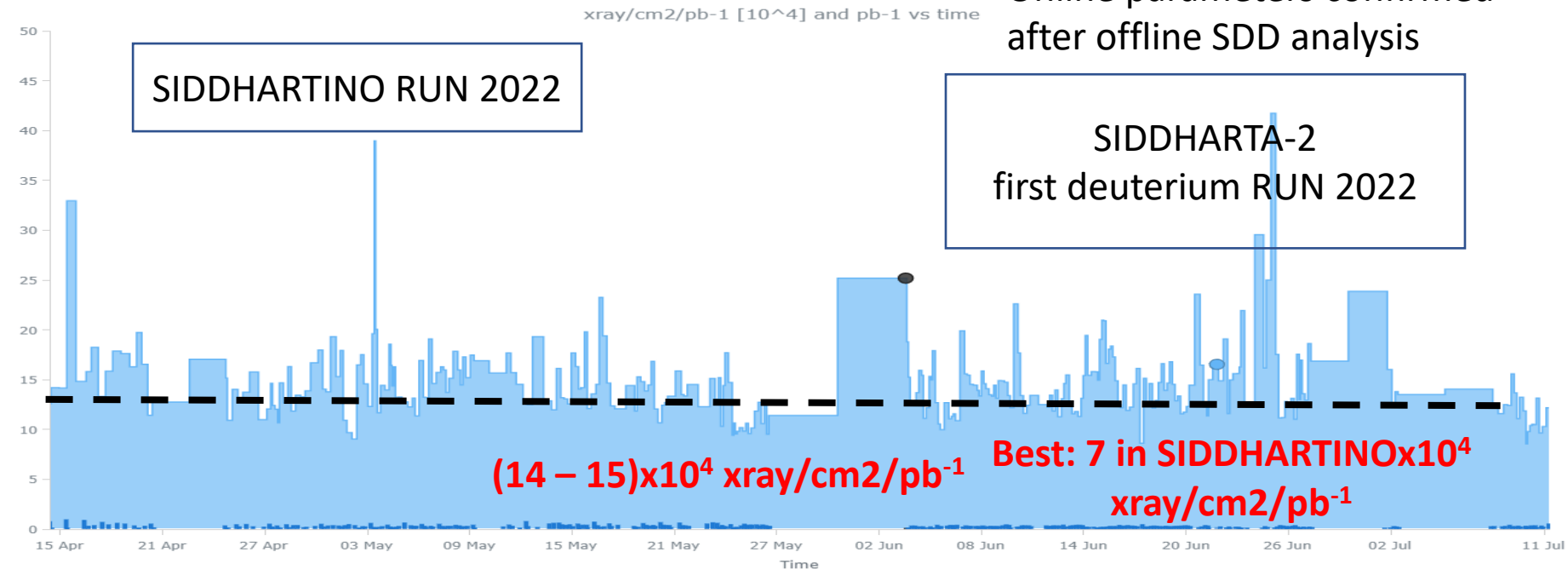
With injection 124 pb; during injection back about 30% higher – we collect the data – need to check quality

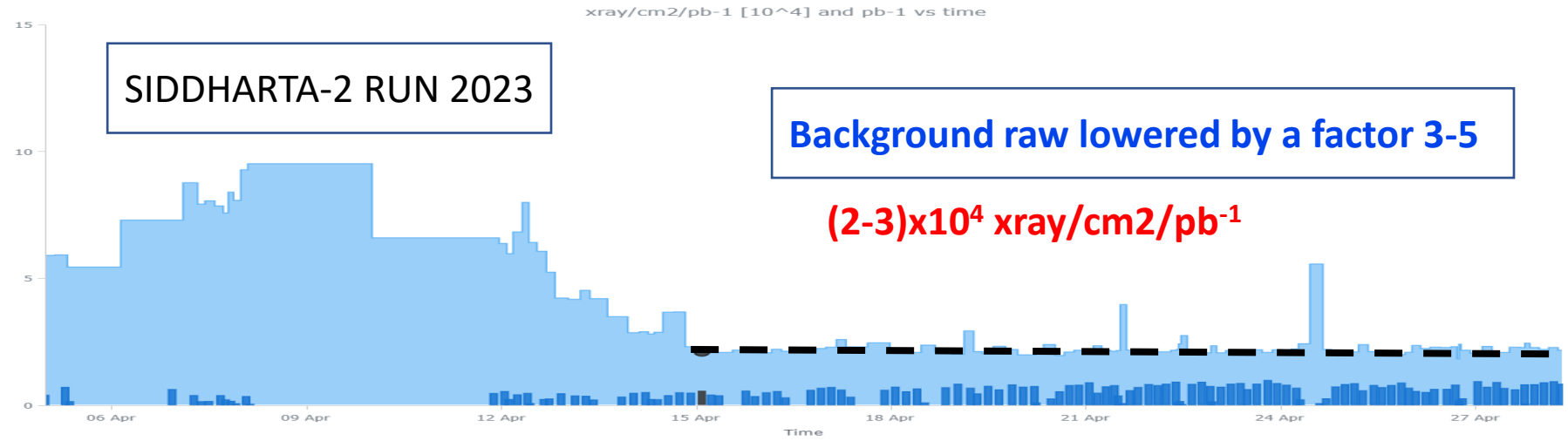


First results of SIDDHARTA-2 run: April 2023

Reduce background and improve KAON/SDD ratio

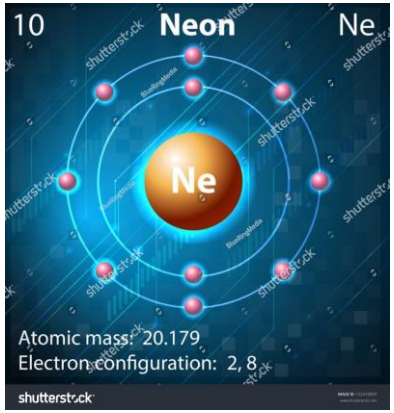
Online parameters confirmed after offline SDD analysis





SIDDHARTA-2 Kaonic Neon
FIRST MEASUREMENT EVER

Calibration technical run

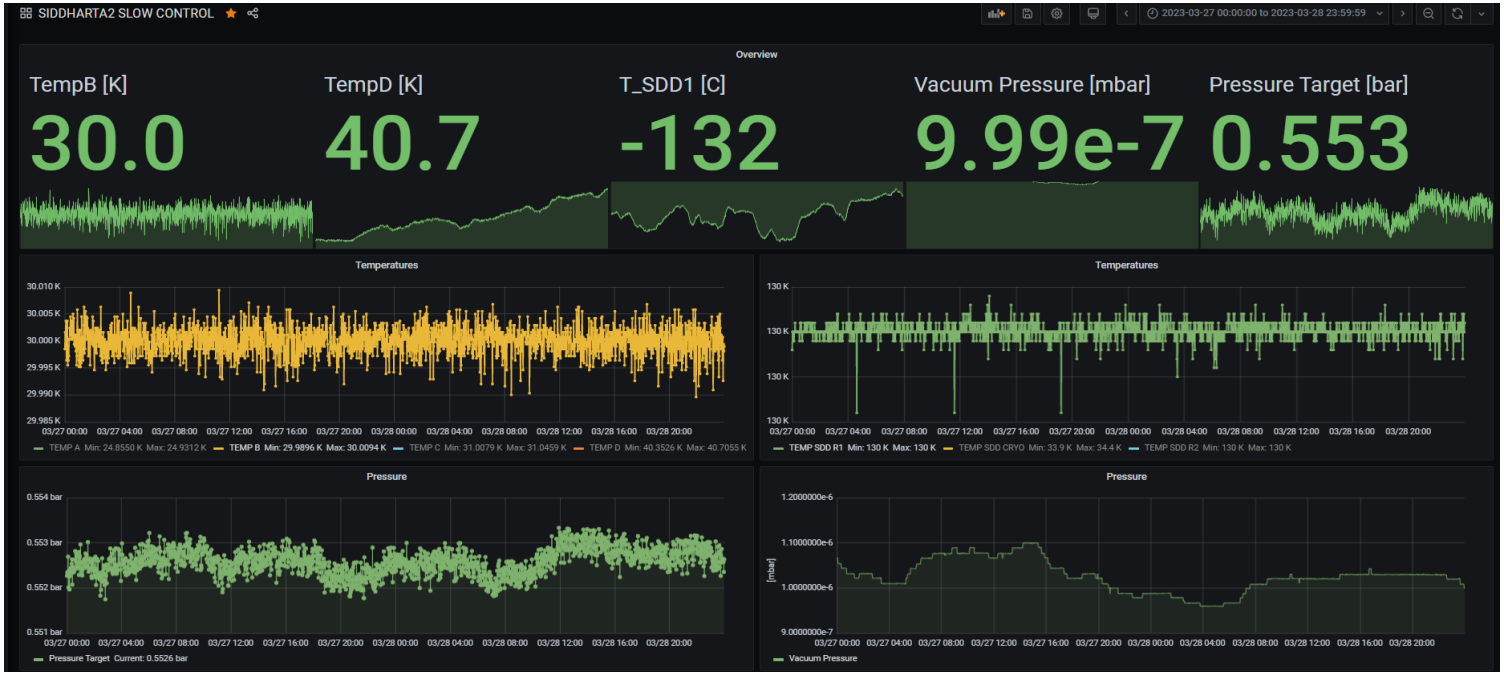


Kaonic Neon transitions energies

kaonic Neon 6-->5 transition = 15.6354 keV

kaonic Neon 7-->6 transition = 9.42765 keV

kaonic Neon 8-->7 transition = 6.11891 keV



High yield gas for fast response

Controlled parameters of target and SDD

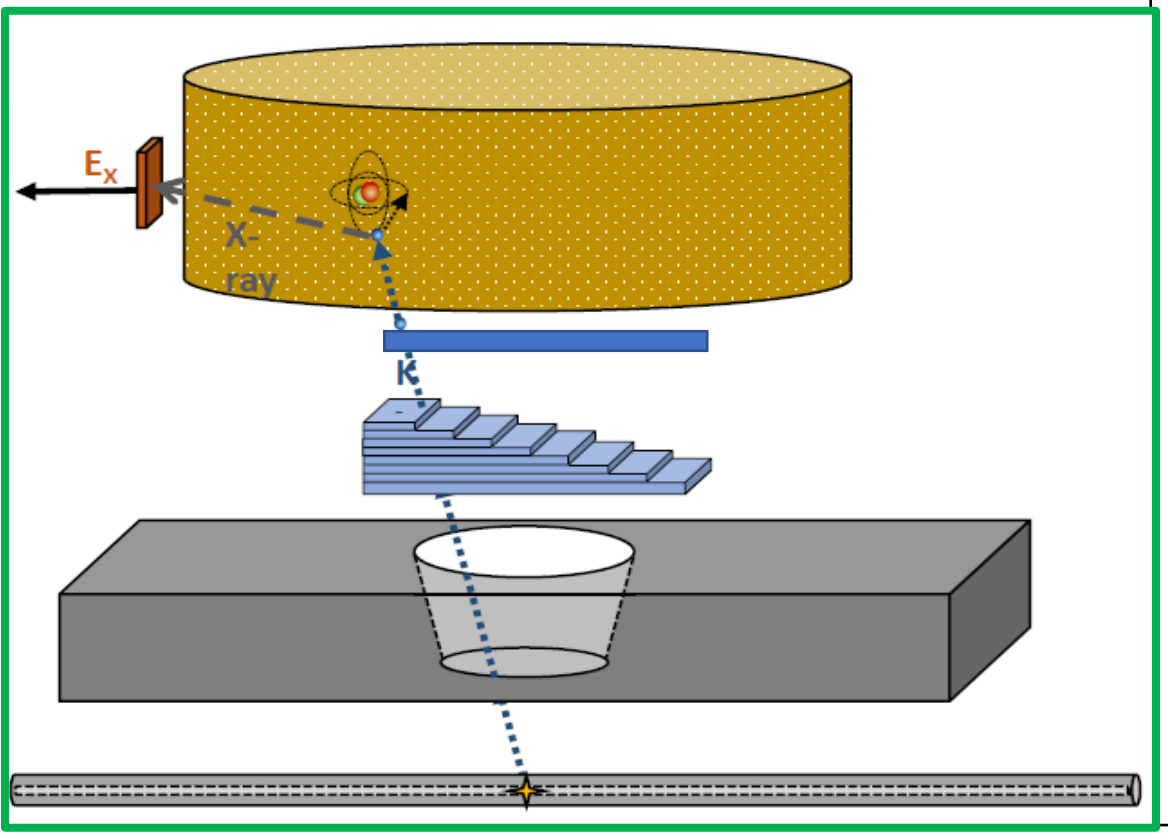
kaonic Neon 9-->8 transition = 4.1951 keV

kaonic Neon 10-->9 transition = 3.00073 keV

kaonic Neon 11-->10 transition = 2.2202 keV

SIDDHARTA-2 Kaonic Neon

Degrader optimization: sensitivity to 100 microns over all material budget (about 4 mm materials of various densities)! – a very delicate and fundamental operation (knowledge of material budget at 2.5 % level)



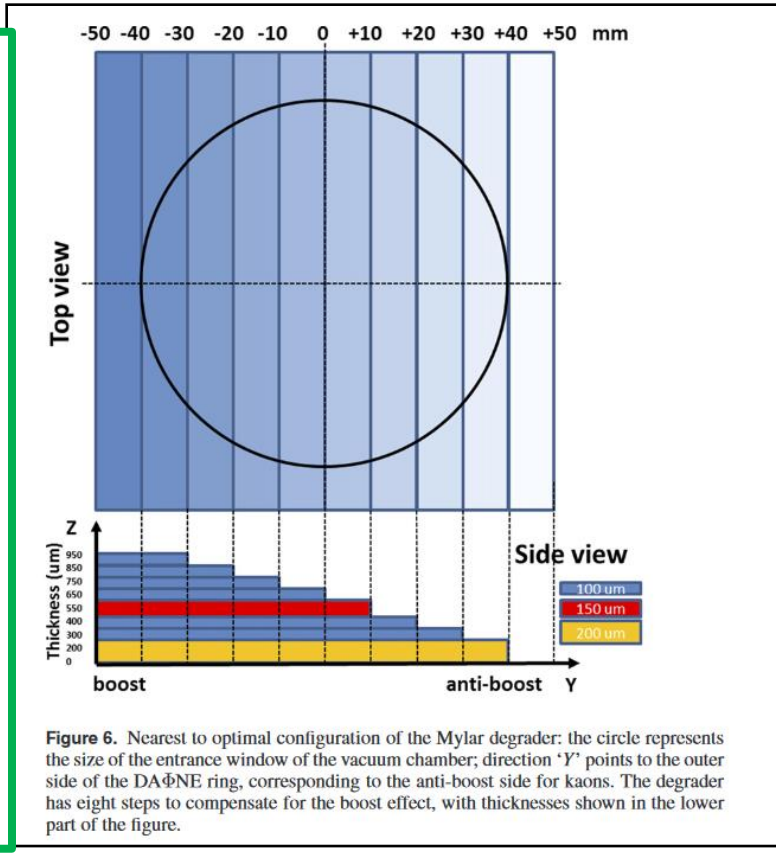
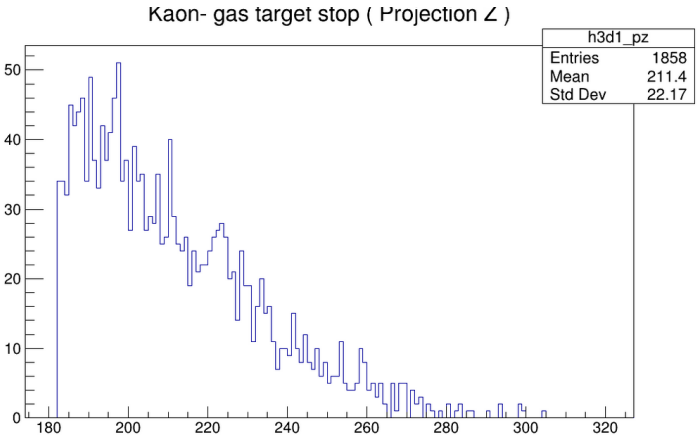


Figure 6. Nearest to optimal configuration of the Mylar degrader: the circle represents the size of the entrance window of the vacuum chamber; direction '*Y*' points to the outer side of the DAΦNE ring, corresponding to the anti-boost side for kaons. The degrader has eight steps to compensate for the boost effect, with thicknesses shown in the lower part of the figure.

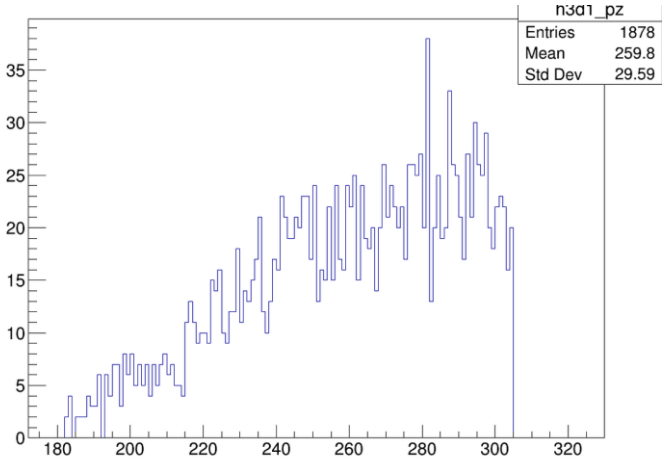
SIDDHARTA-2 Kaonic Neon (D. Sirghi, K. Dulski and M. Iliescu; M. Cargnelli)

Monte Carlo simulation

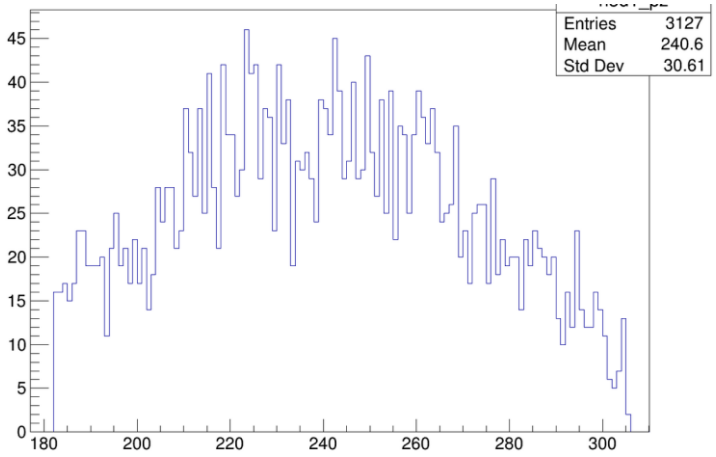
Neon 0.3% LNeD



Degrader : 600 um



Degrader : 350 um

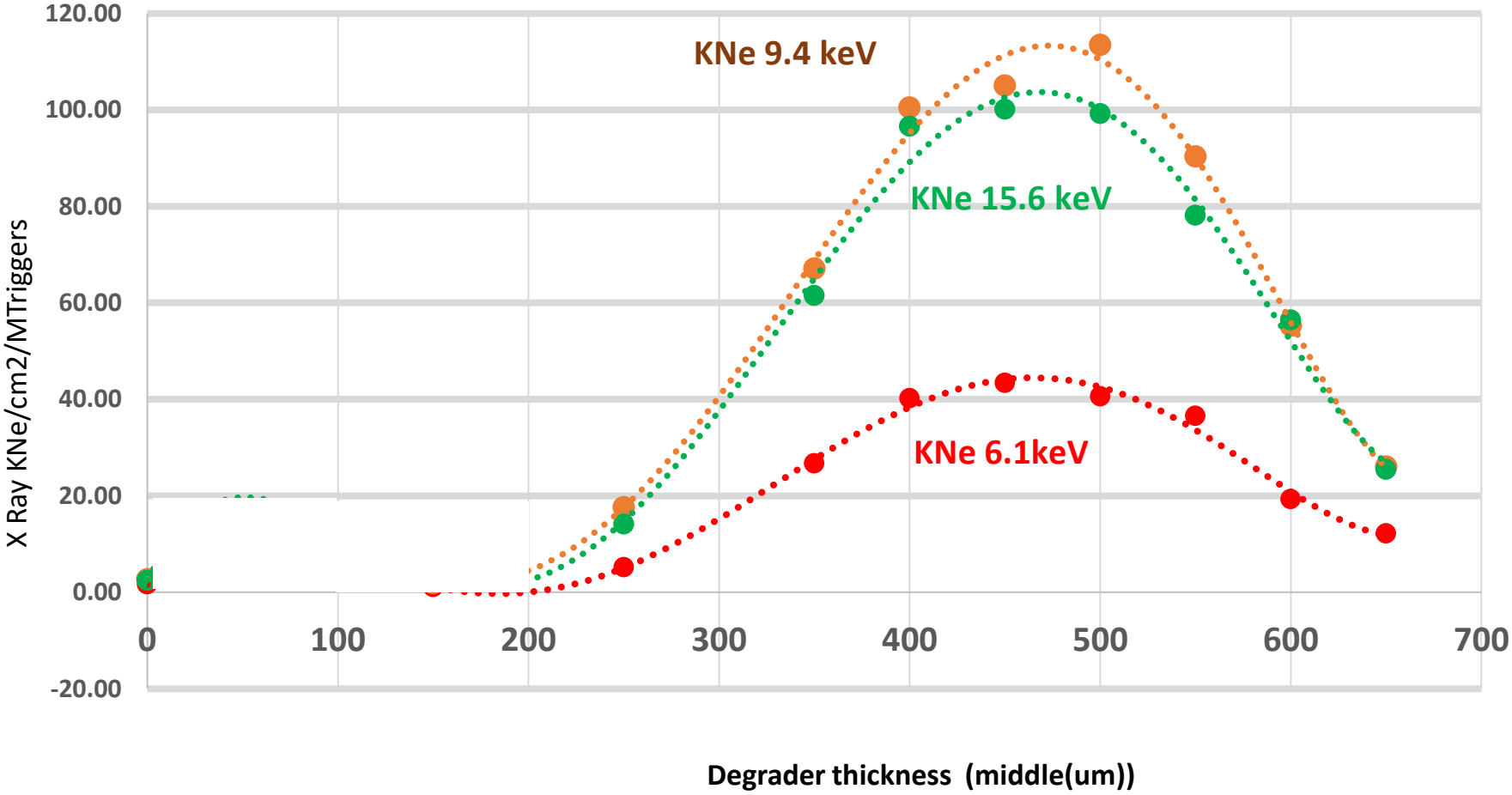


Best Degrader : 450 um

Efficiency of kaon stopped in the target

$$\frac{\text{No of kaons (stopped in the target)}}{\text{No of triggered kaons}} = \textbf{16,64\%}$$

SIDDHARTA-2 Kaonic Neon: Monte Carlo at 0.3% LD (as an example)



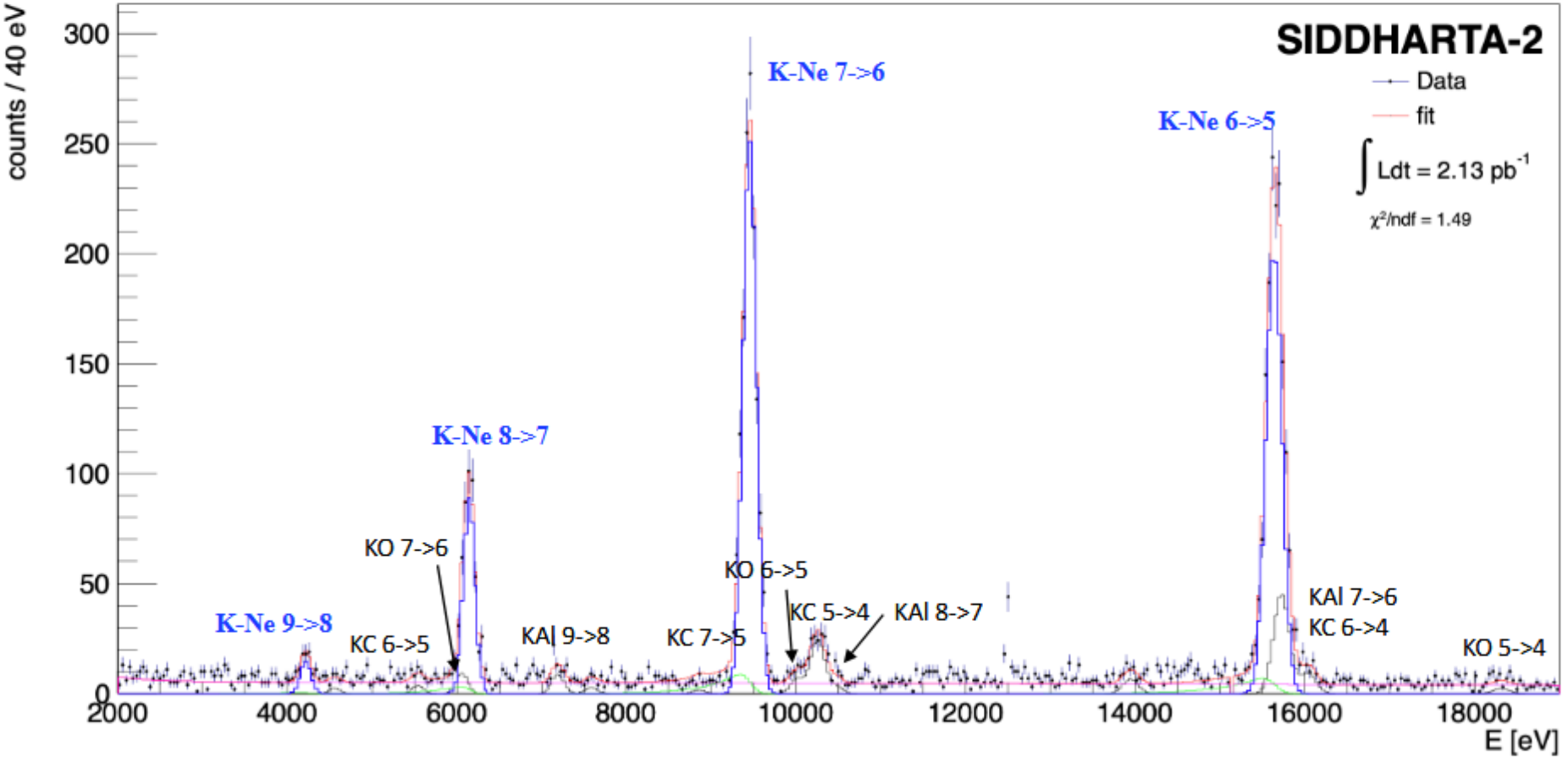
SIDDHARTA-2 Kaonic Neon

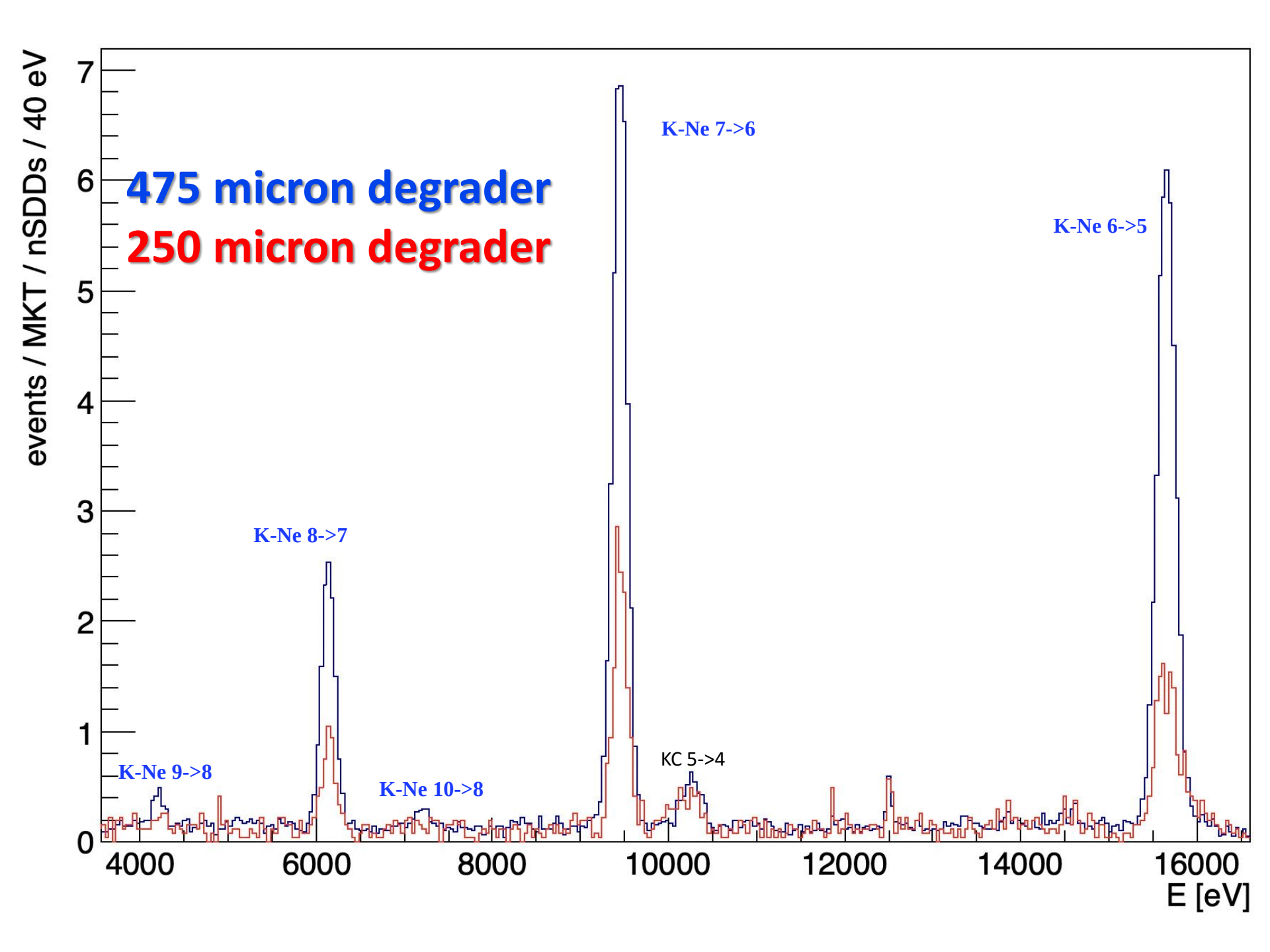
F. Sgaramella, F. Sirghi,
M.Iliescu, D. Sirghi, K. Dulski,
O. Vazuqez Doce

(all)

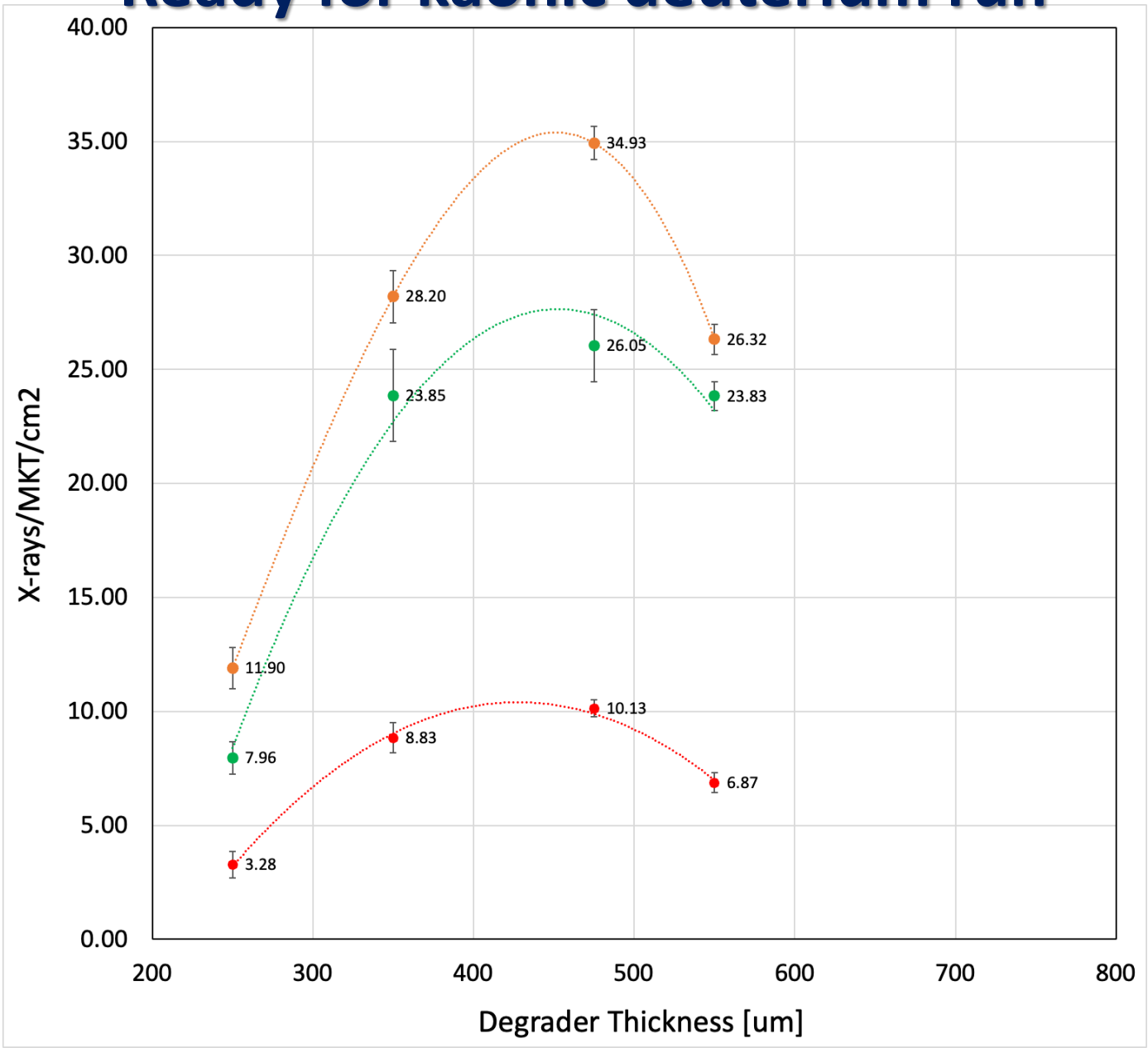
0.3% LNeD; deg 350 28/04 afternoon ; 275 SDDs

This required: SDD energy calibration; apply trigger; drift time….




475 micron degrader
250 micron degrader
K-Ne 7->6
K-Ne 6->5
K-Ne 8->7
K-Ne 9->8
K-Ne 10->8
KC 5->4
events / MKT / nSDDs / 40 eV
E [eV]
0
1
2
3
4
5
6
7
4000
6000
8000
10000
12000
14000
16000

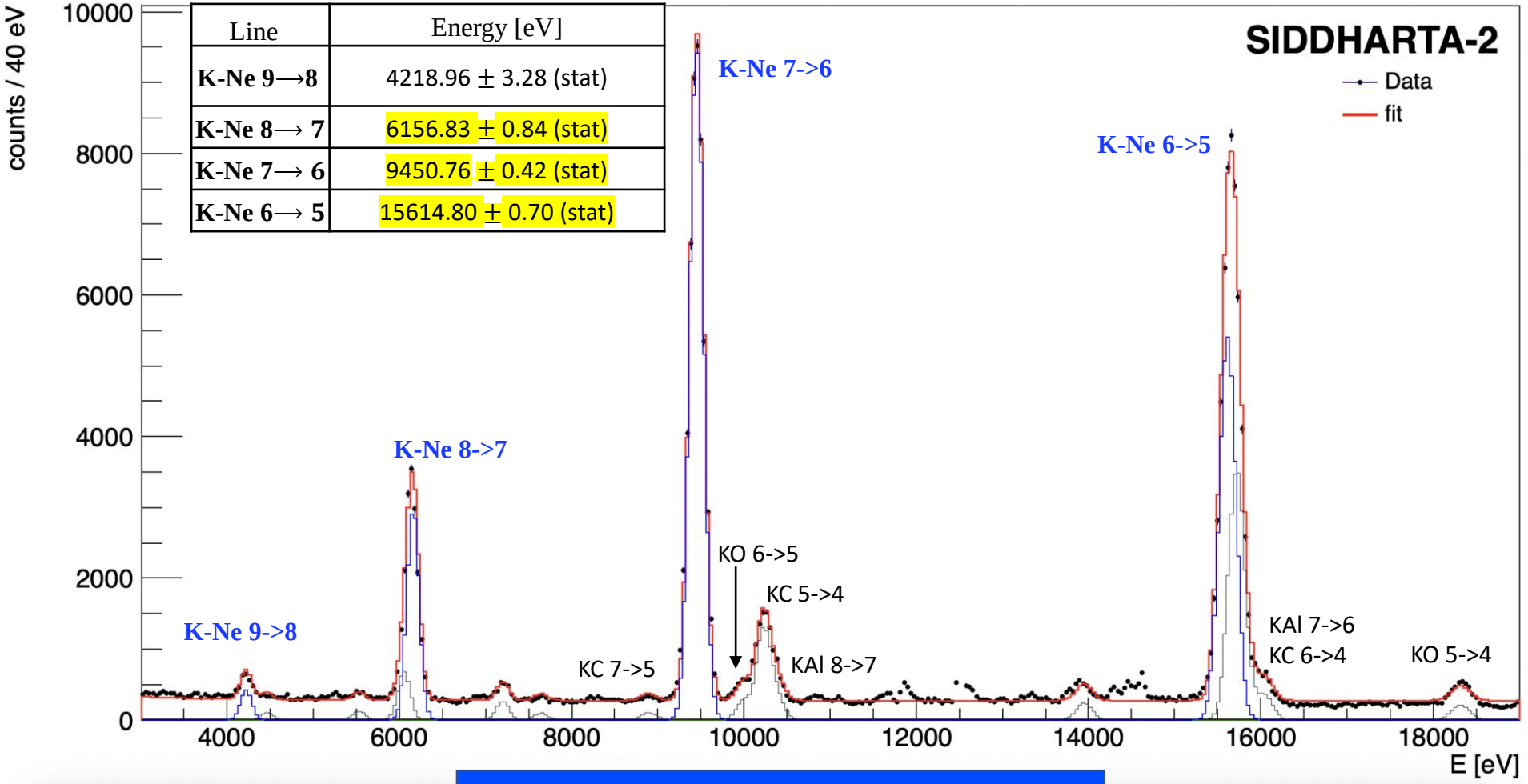
SIDDHARTA-2 Kaonic Neon
Ready for kaonic deuterium run



SIDDHARTA-2 Kaonic Neon – absolute record of precision – 1-2 papers

All degraders; 275 SDDs; L = 124 pb^{-1}

Line	Energy [eV]
K-Ne 9⟶8	4218.96 ± 3.28 (stat)
K-Ne 8⟶ 7	6156.83 ± 0.84 (stat)
K-Ne 7⟶ 6	9450.76 ± 0.42 (stat)
K-Ne 6⟶ 5	15614.80 ± 0.70 (stat)



First measurements ever – QCD and K- multinucleon interaction

Very preliminary – data taken till 1st May!

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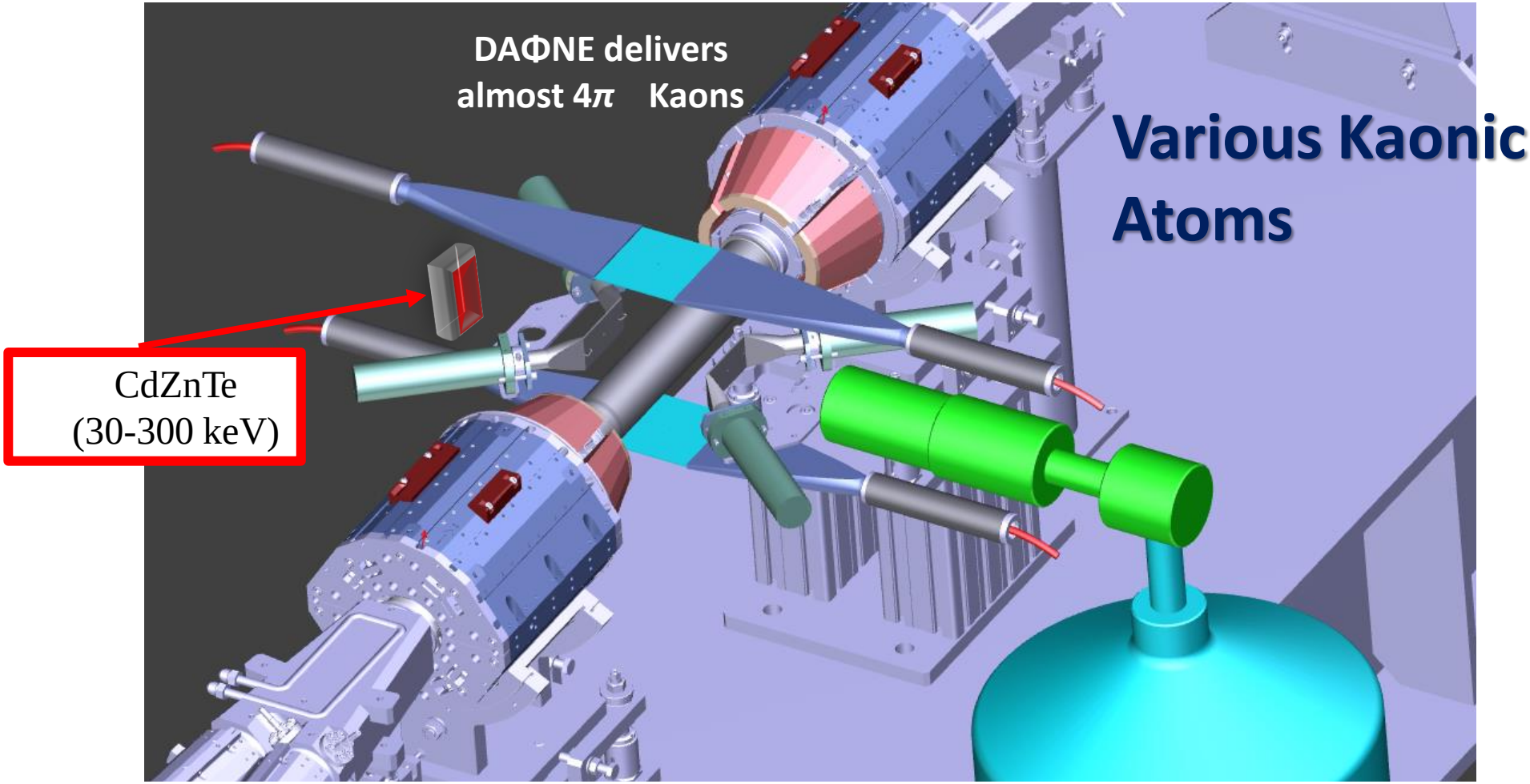
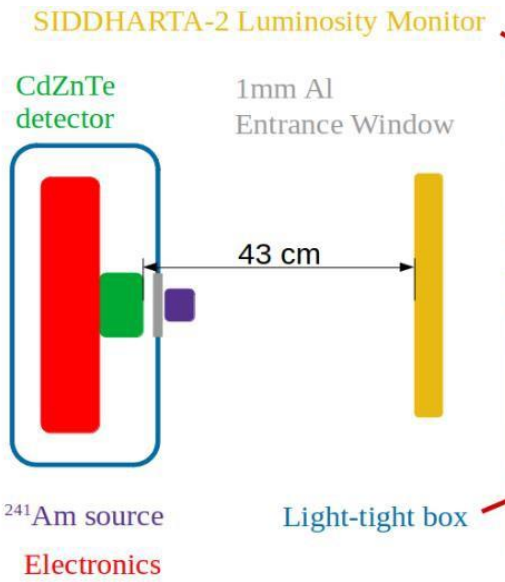
Take advantage of “free space” in DAΦNE
Test measurements HPGe and CdZnTe

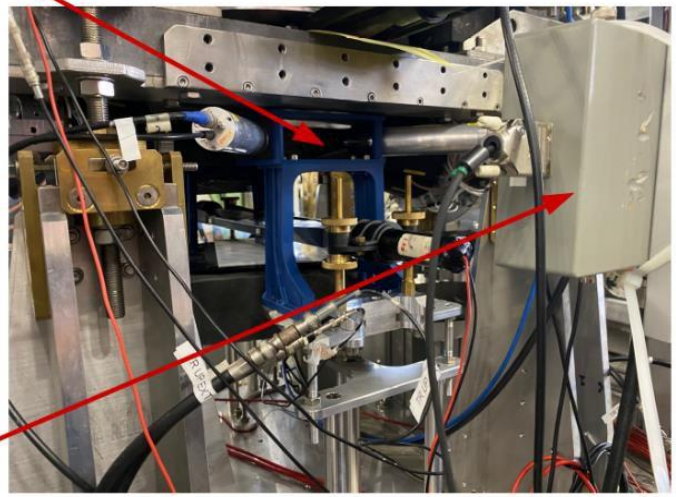


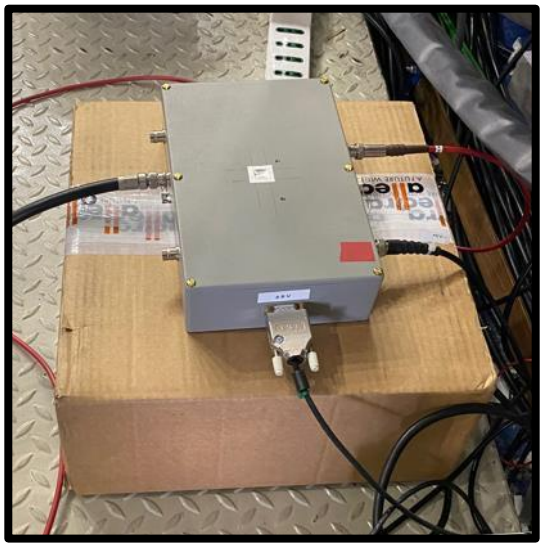
Kaonic Atoms with CdZnTe (A. Scordo)

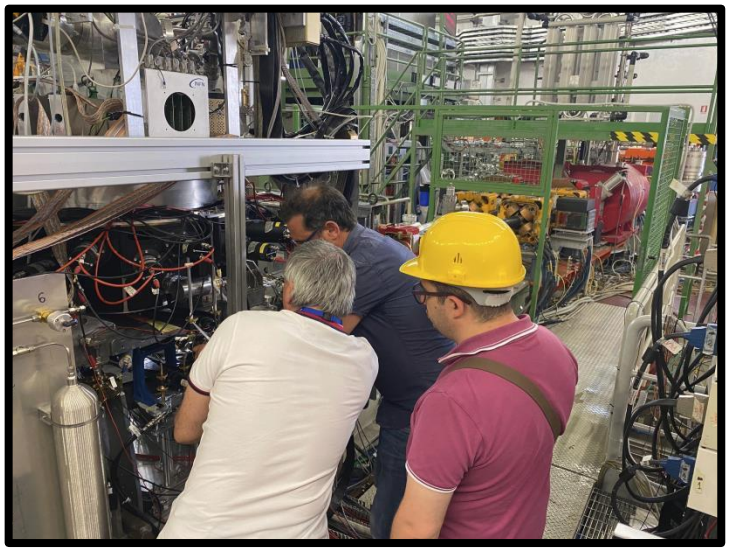
Goal: background and resolution assessment in machine environment (first time)

Detecting surface : 1 cm^2



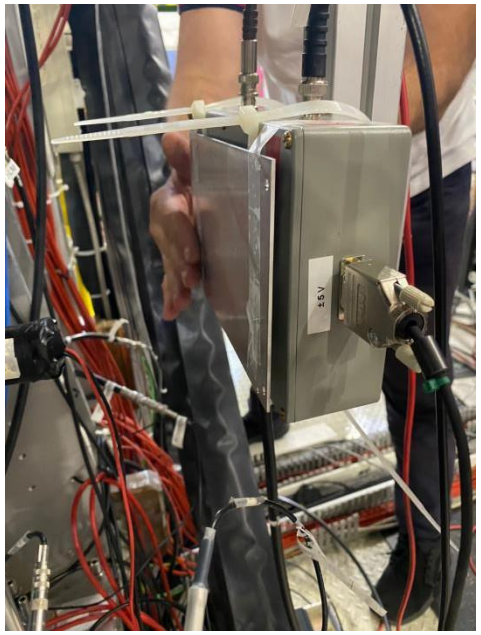




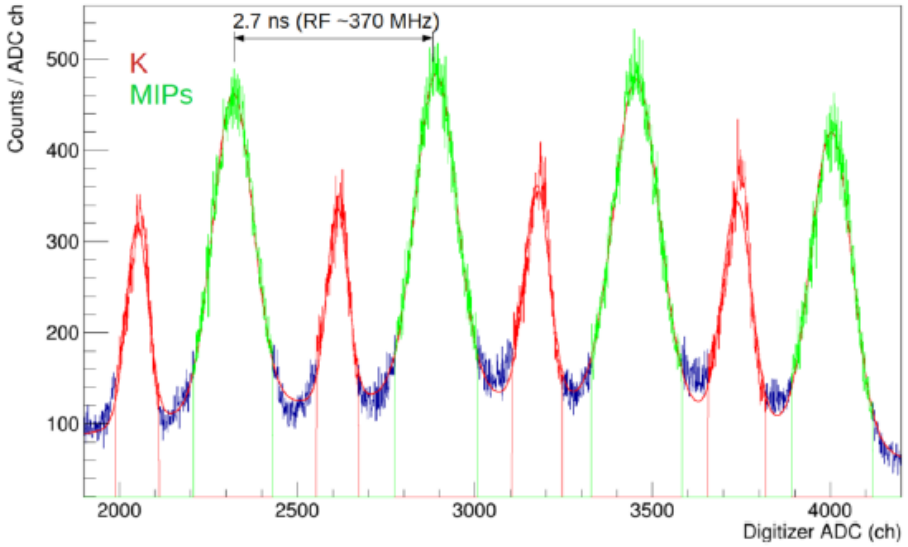


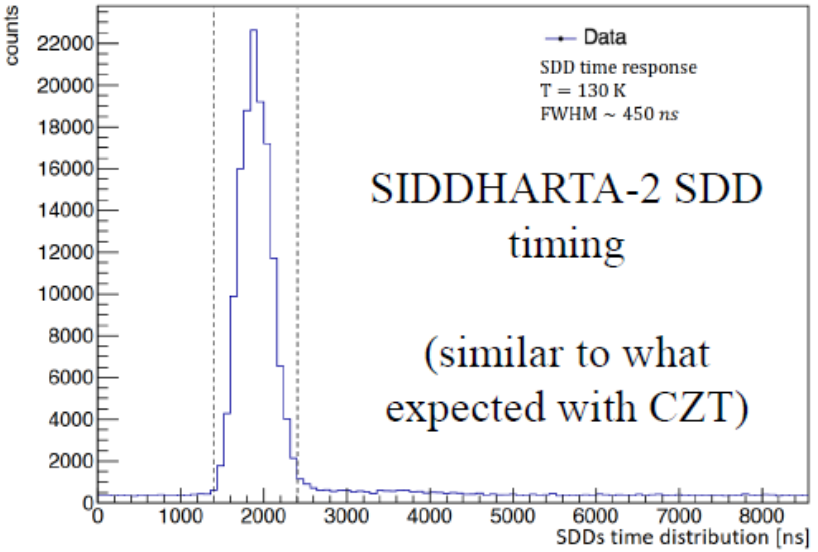
CdZnTe: first tests done @ DAΦNE June 2022

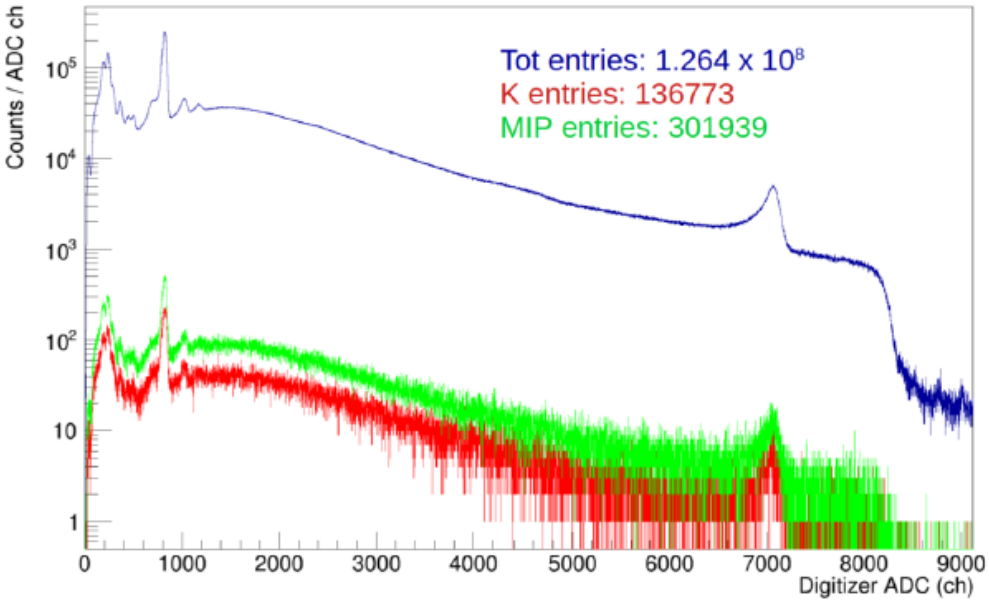
First prototype installed in DAΦNE with the help of Palermo Team



CZT detectors - first tests 2022 @ DAFNE







Request	Events	Rejection factor
No request	1.26×10^8	1
K^-_{TAC}	136359	3×10^2
$K^-_{TAC}, \Delta T < 1\,\mu s$	1096	1.15×10^5
$K^-_{TAC}, \Delta T < 500\,ns$	605	2.08×10^5
$K^-_{TAC}, \Delta T < 300\,ns$	374	3.33×10^5
$K^-_{TAC}, \Delta T < 100\,ns$	124	1.02×10^6

CdZnTe will allow for FWHM< 100 ns timing peak

Rejection factors ~10^6 can be expected

Intermediate-mass kaonic atoms' spectroscopy with CZT detectors: First technical papers

New opportunities for kaonic atoms measurements from CdZnTe detectors

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

Accepted for publication in EPJ_ST

sensors

MDPI

Article

Potentialities of Digital Quasi-Hemispherical CdZnTe Detectors for Hard X-ray Spectroscopy of Kaonic Atoms.

Antonino Buttacavoli[1], Fabio Principato[1], Gaetano Gerardi[1], Manuele Bettelli[2], Andrea Zappettini[2], Alessandro Scordo[3], Catalina Curceanu[3], and Leonardo Abbene[1,*]

[1] Department of Physics and Chemistry (DiFC) - Emilio Segrè, University of Palermo, Viale delle Scienze, Edificio 18, Palermo, 90128, Italy; antonino.buttacavoli@unipa.it (A.B.); fabio.principato@unipa.it (F.P.); donato.cascio@unipa.it (D.C.); giuseppe.raso@unipa.it (G.R.); gaetano.gerardi@unipa.it (G.G.);
[2] IMEM/CNR, Parco Area delle Scienze 37/A, Parma 43100, Italy; manuele.bettelli@imem.cnr.it (M.B.); andrea.zappettini@imem.cnr.it (A.Z.);
[3] INFN-LNF, Istituto Nazionale di Fisica Nucleare-Laboratori Nazionali di Frascati, Frascati, 00044 Roma, Italy
* Correspondence: leonardo.abbene@unipa.it

Received: date; Accepted: date; Published: date

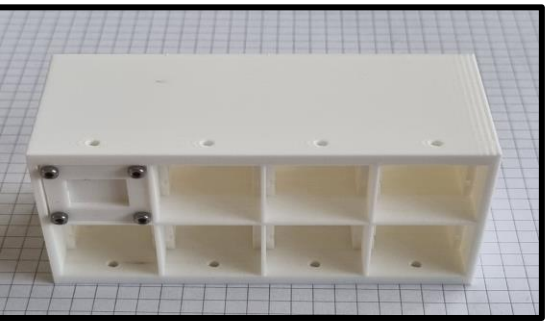
Abstract:

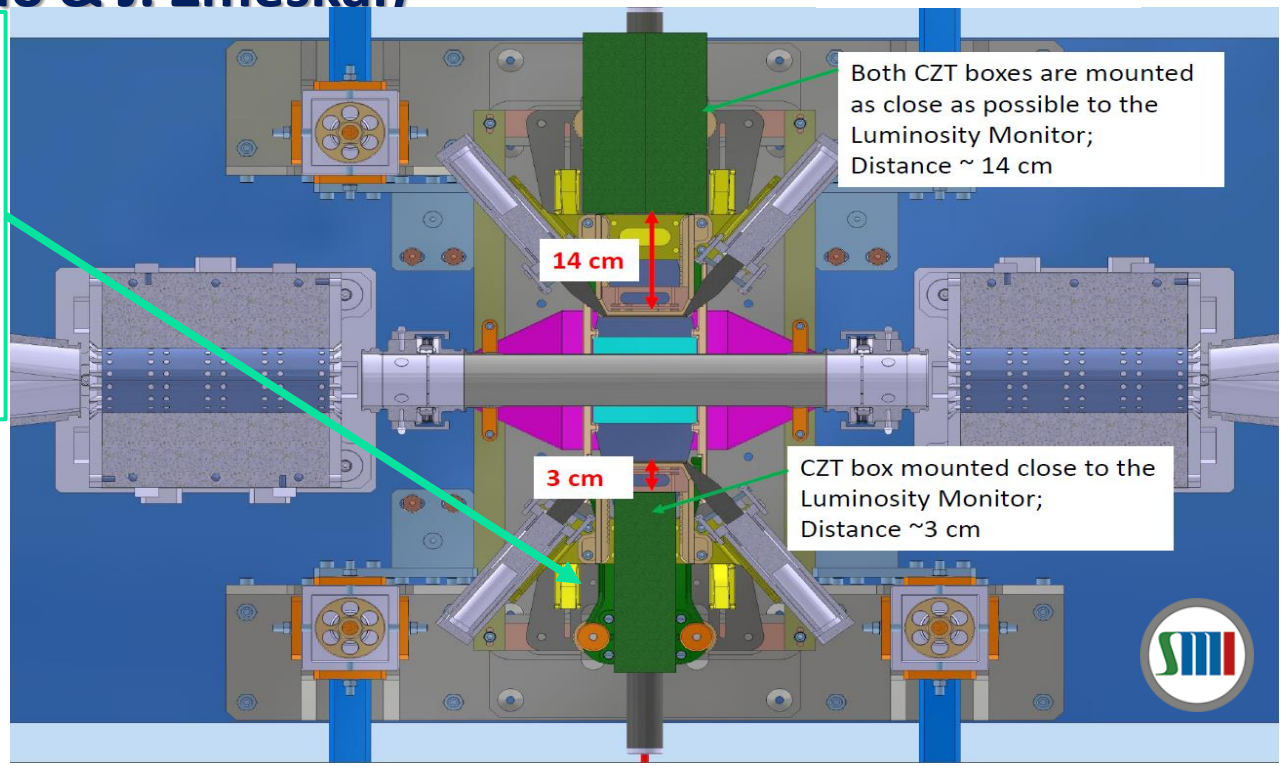
Keywords: CZT detectors; charge sharing; incomplete charge collection; charge sharing correction; semiconductor pixel detectors.

Submitted publication in SENSORS

Intermediate-mass kaonic atoms' spectroscopy with CZT detectors: 2023 - 2024 plans (A. Scordo & J. Zmeskal)

A new test run is foreseen in 2023 (installation at end of May) to measure intermediate mass kaonic atoms' transitions





Improvements:

Detecting surface : 1 cm^2 → ~13 cm^2

Degrader and geometry tuned with GEANT4 MC

Mechanical setup to maintain the alignment with the LM

Participation Palermo (UniPa) and Parma (IMEM-CNR) groups

imem
Istituto dei Materiali per l'Elettronica ed il Magnetismo
Consiglio Nazionale delle Ricerche

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Project timeline – future plan and requests
Fill in deuterium in target: 6-11 May 2023

SIDDHARTA-2 Kd run: run 1 (requested 300 pb^{-1})
run 2 (500 pb^{-1}) with optimized setup

SIDDHARTA-2
setup preparation
till early March'23

Start of the data taking
kaonic deuterium
SIDDHARTA-2 run

Start Run1
SIDDHARTA-2
and
HPGe and CdZnTe
setups test s

From March to July 2023

DAΦNE summer
shutdown

Continue with
Run2
SIDDHARTA-2
Kd
HPGe

as soon as possible!

Autumn 2023

or 2024

SIDDHARTA-2 K-d measurement expected result

Kaonic deuterium run in ***2023/4***

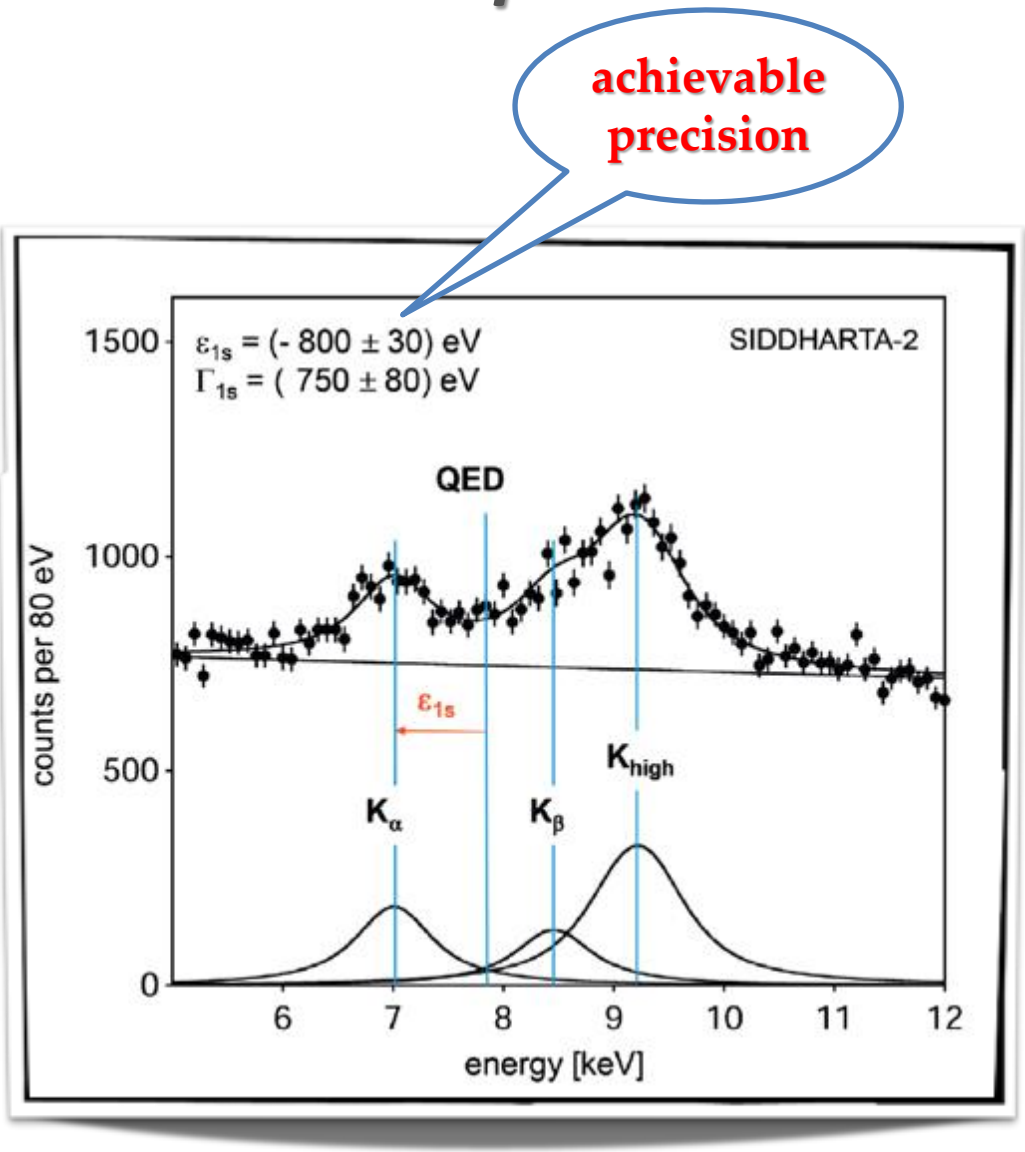
Monte Carlo for an integrated luminosity of ***800 pb^{-1}***

to perform the first measurement of the strong interaction induced energy shift and width of the kaonic deuterium ground state (similar precision as K-p) !

When significative?

Depends on yield (unknown)

Not less than 500 pb $^{-1}$



SIDDHARTA-2 K-d measurement

Paper KH:

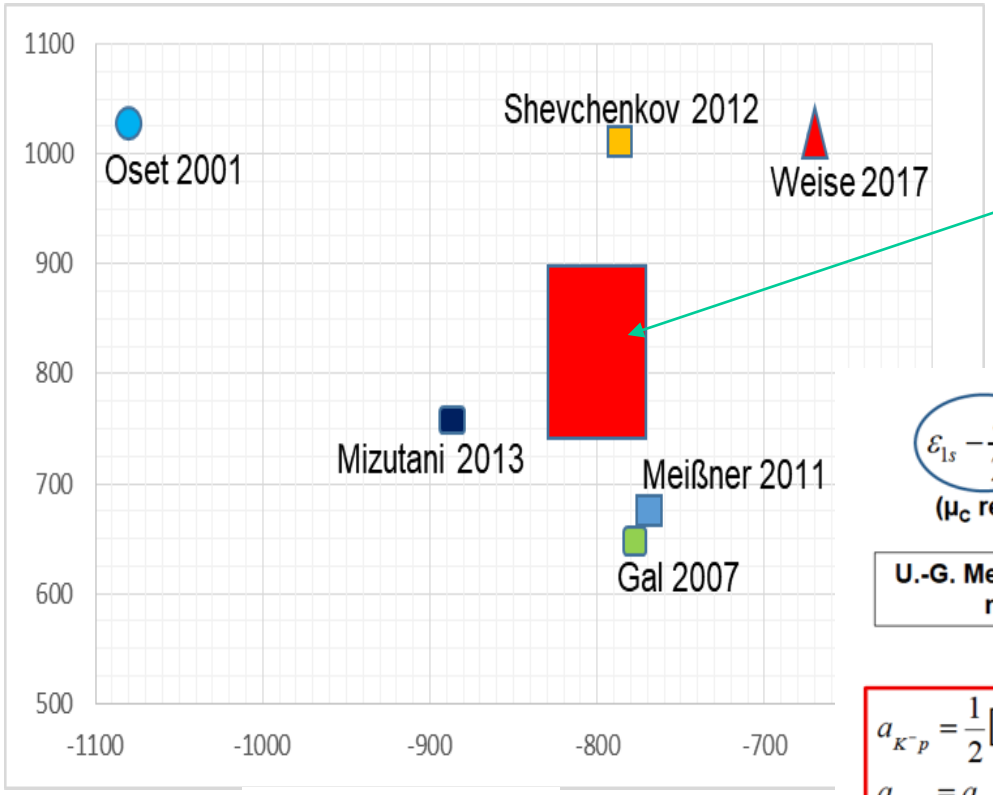
Phys.Lett.B 704 (2011) 113

374 citations

see also:
Liu et al (2020)

$\epsilon^d_{1S} = 803$ eV, $\Gamma^d_{1S} = 2280$ eV.

Measurement



$$\varepsilon_{1s} - \frac{i}{2}\Gamma_{1s} = -2\alpha^3 \mu_c^2 a_{K^-p}(1 - 2\alpha\mu_c(\ln\alpha - 1)a_{K^-p})$$

(μ_c reduced mass of the K^-p system, α fine-structure constant)

U.-G. Meißner, U.Raha, A.Rusetsky, Eur. phys. J. C35 (2004) 349
next-to-leading order, including isospin breaking

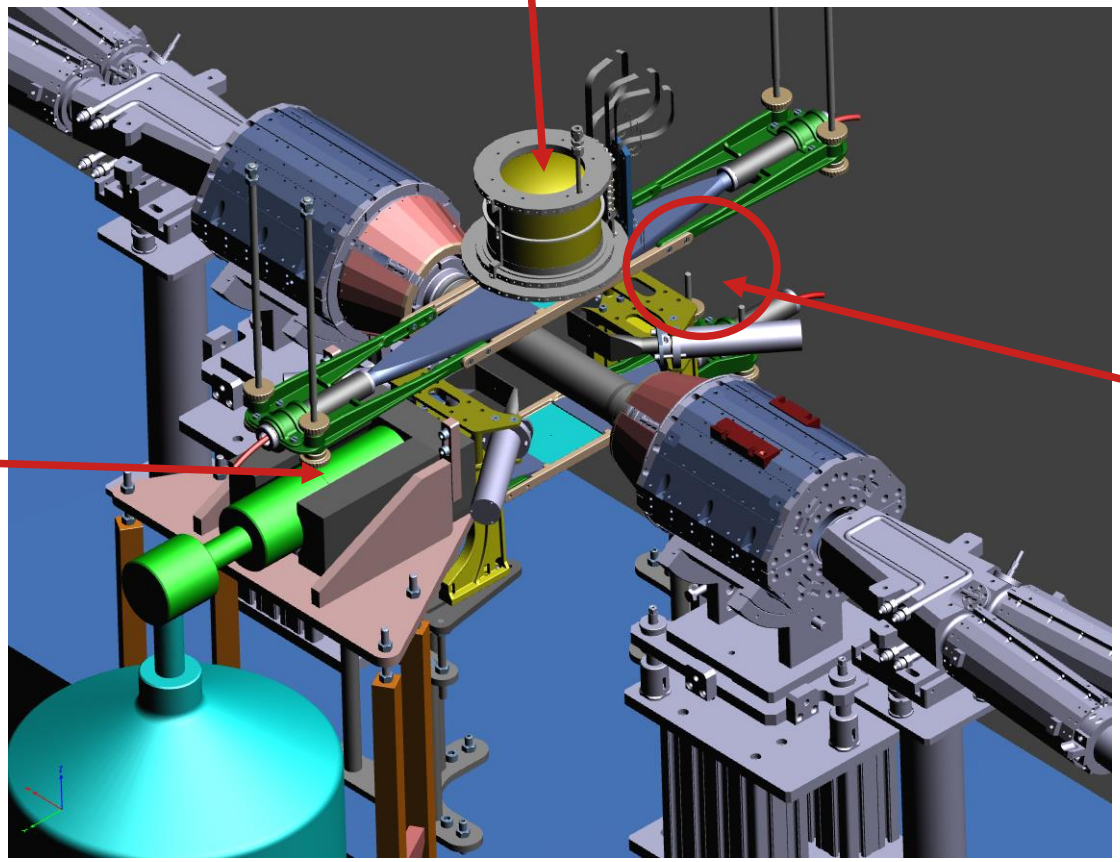
$$a_{K^-p} = \frac{1}{2}[a_0 + a_1]$$
$$a_{K^-n} = a_1$$

$$a_{K^-d} = \frac{k}{2}[a_{K^-p} + a_{K^-n}] + C = \frac{k}{4}[a_0 + 3a_1] + C$$
$$k = \frac{4[m_n + m_K]}{[2m_n + m_K]}$$

High and Intermediate-mass kaonic atoms with HPGe and CZT detectors as test measurements in parallel with SIDDHARTA-2

HPGe
D. Bosnar
(0,1-1 MeV)

Heavy Kaonic Atoms



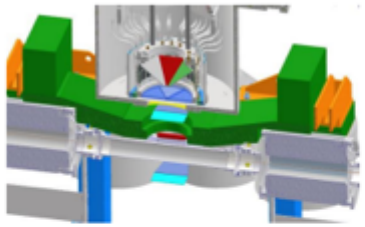
CdZnTe
(30-300 keV)

Intermediate Kaonic Atoms

DAΦNE delivers 4π K^-

We want to exploit this unique beam as much as possible to perform KA measurements

We reiterate the request for an extension of run with solid targets and 1 mm SDDs



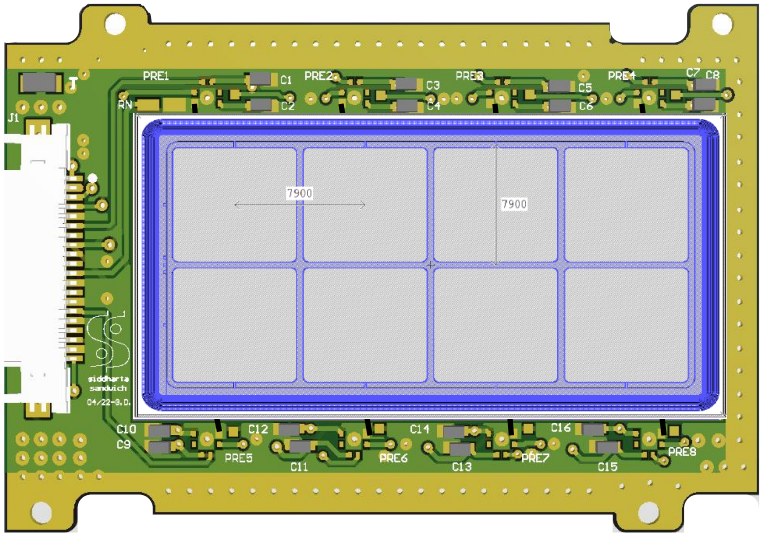
Light Kaonic Atoms Measurements with SIDDHARTA-2 after Kd run

July 2021

The SIDDHARTA-2 Collaboration

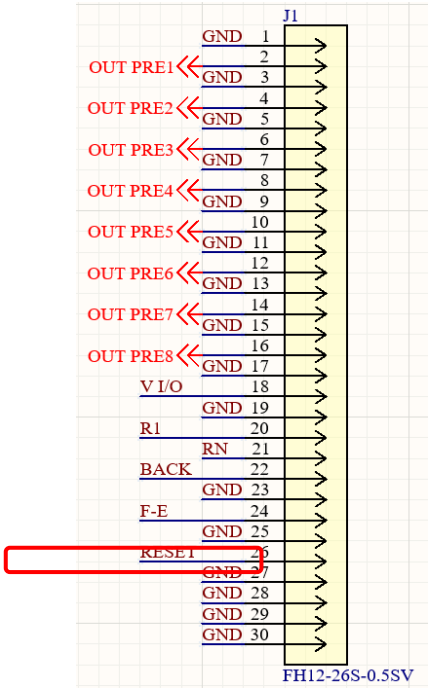
SDD 1mm detector development: financed; production run very successfully concluded at FBK (Poli Milano; M. Bazzi; J. Zmeskal; M. Iliescu, F. Sirghi…)

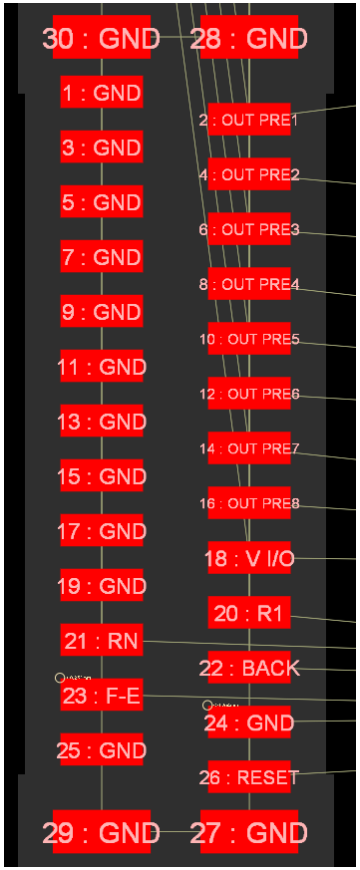
- Thicker detectors are produced by FBK with larger guard rings
- Same active area
- New Focusing electrodes added



New Pin assignment

New

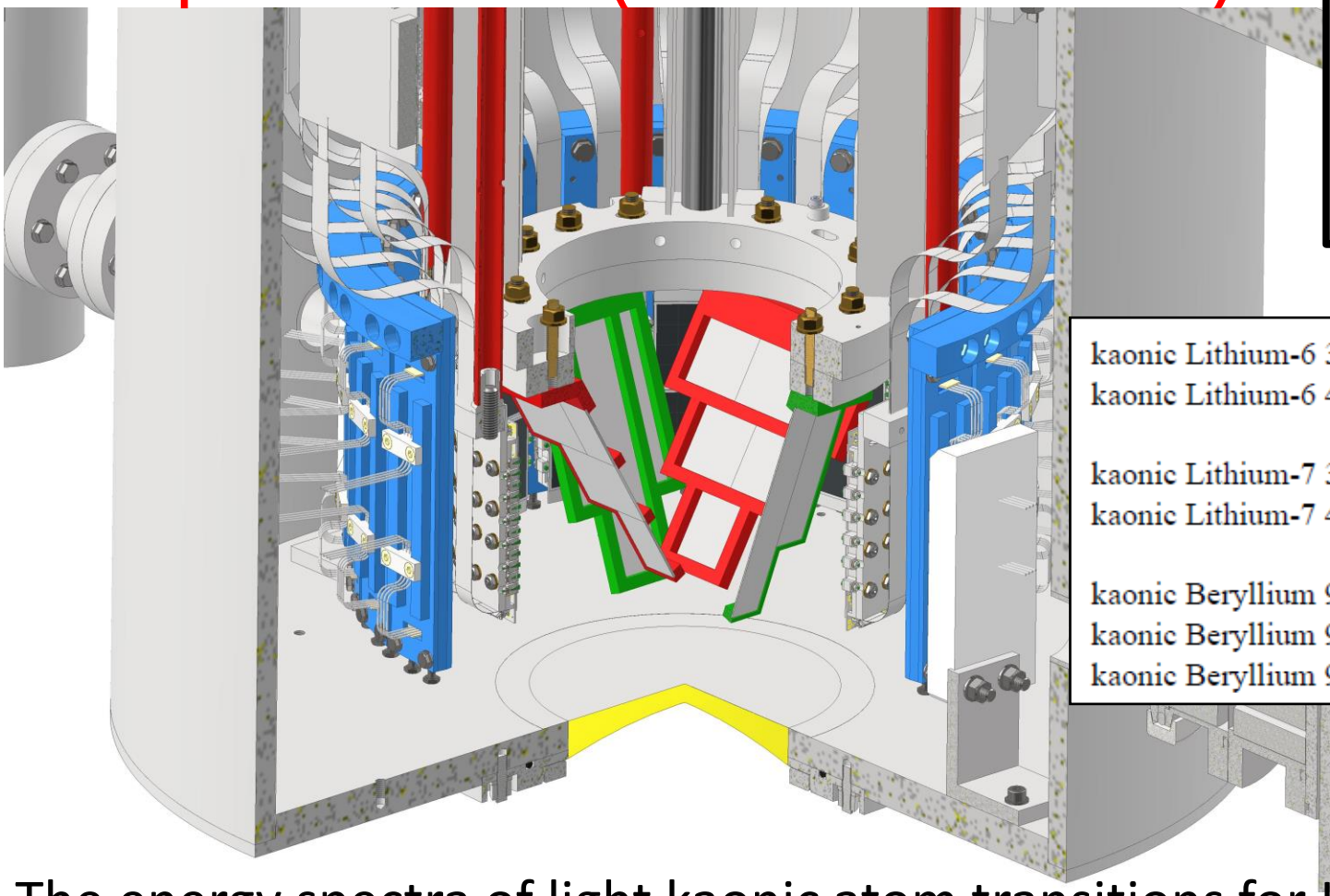


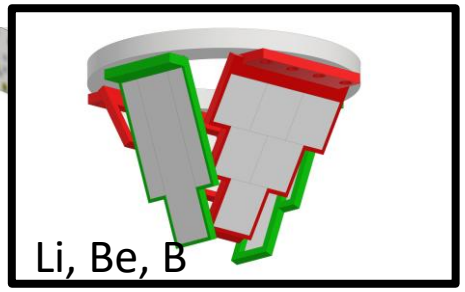


Reset isolated.
Signals between grounds.
Bias grouped together.

FONDAZIONE BRUNO KESSLER
FUTURE BUILT ON KNOWLEDGE
POLITECNICO MILANO 1863
INFN

Use of present SDDs: Solid target system for light kaonic atoms:
e.g. **Li – Be - B financed by INFN Nuclear physics (gr 3) as first step towards Future (see Curceanu talk SC62)**





solid targets

kaonic Lithium-6 3-->2 transition = 15.08 keV
kaonic Lithium-6 4-->3 transition = 5.28 keV

kaonic Lithium-7 3-->2 transition = 15.3 keV
kaonic Lithium-7 4-->3 transition = 5.34 keV

kaonic Beryllium 9 3-->2 transition = 27.56 keV
kaonic Beryllium 9 4-->3 transition = 9.64 keV
kaonic Beryllium 9 5-->4 transition = 4.46 keV

The energy spectra of light kaonic atom transitions for Li, Be and B can achieve a precision below 2-3 eV, for an integrated luminosity of **about 150 pb$^{-1;}$**;

1mm SDDs and target materials financed – construction ongoing

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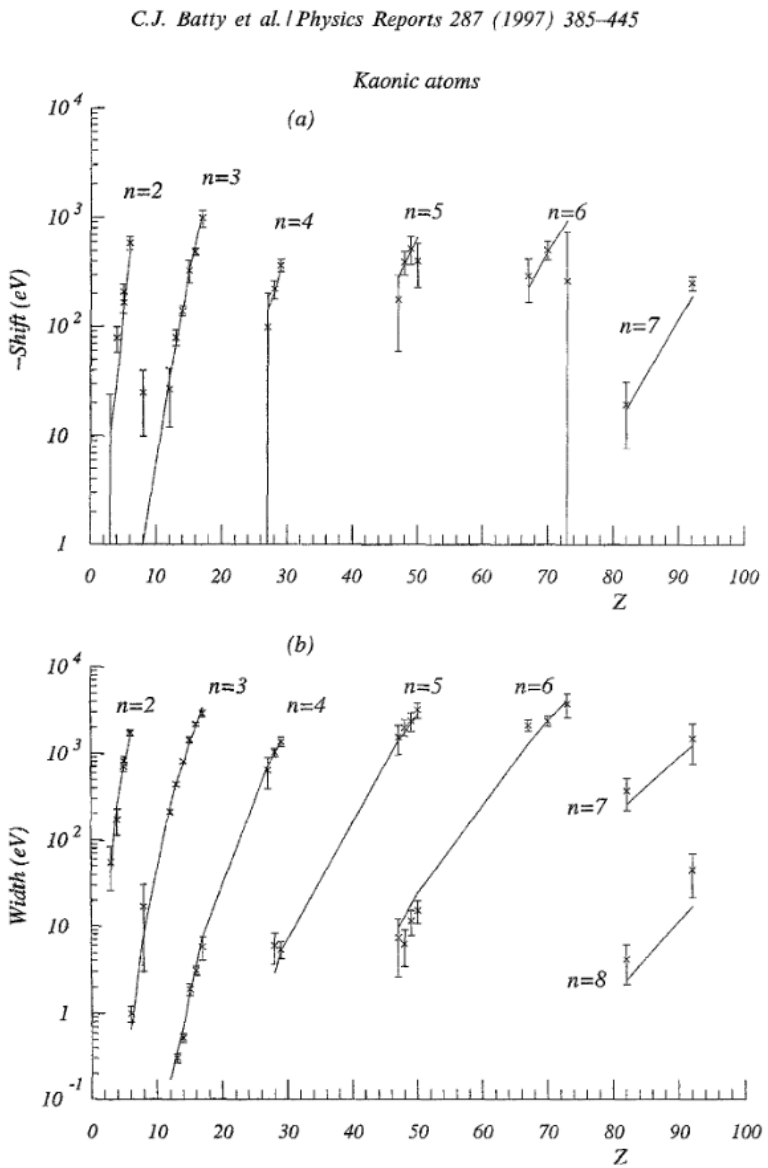
Strangeness precision frontier at DAΦNE: a unique opportunity for measurements of kaonic atoms along the periodic table: **a reference data base in physics with strangeness**

Present status: old and very old measurements with low precisison (some even wrong: kaonic helium puzzle)

We propose to do precision measurements along the periodic table at DAΦNE for:

- Selected light kaonic atoms
- Selected intermediate mass kaonic atoms
- Selected heavy kaonic atoms

charting the periodic table



Future plans beyond SIDDHARTA-2

proposal to perform fundamental physics at the strangeness frontier at DAFNE for a 3-years period (post-SIDDHARTA-2)
- detailed presentation at 62nd LNF Scientific Committee Meeting, November 8, 2021

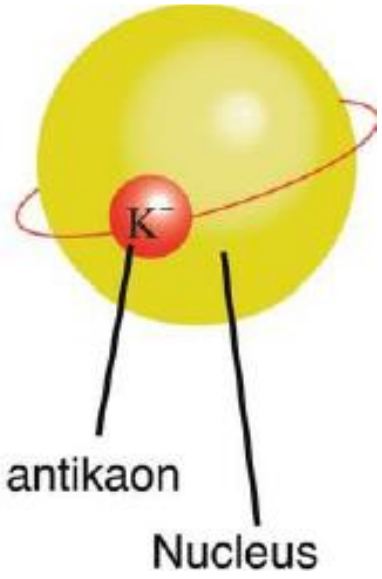
We propose to do precision measurements along the periodic table at DAFNE for:

- **Kaonic Hydrogen: 200 pb^{-1} – with SIDDHARTA-2 setup – to get a precision < 10 eV (KH)**
- **Selected light kaonic atoms (LHKA)**
- **Selected intermediate and heavy kaonic atoms charting the periodic table (IMKA)**
- **Ultra-High precision measurements of Kaonic Atoms (UHKA)**

Dedicated runs with different types of detectors: CZT detectors, HpGe, SDD 1mm, crystal HAPG spectrometer from VOXES project

Fundamental physics at the strangeness frontier at DAΦNE. Outline of a proposal for future measurements, C. Curceanu et al., e-Print: 2104.06076 - article to be submitted for publication

EXtensive
Kaonic
Atoms research: from
LIthium and
Beryllium to
URanium



EXKALIBUR

Kaonic Atoms to Investigate Global Symmetry Breaking Symmetry 12 (2020) 4, 547

Part. and Nuclear physics
QCD @ low-energy limit
Chiral symmetry, Lattice

The modern era of light kaonic atom experiments Rev.Mod.Phys. 91 (2019) 2, 025006

Fundamental physics New Physics

Kaonic atoms

Kaon-nuclei interactions (scattering and nuclear interactions)

On self-gravitating strange dark matter halos around galaxies Phys.Rev.D 102 (2020) 8, 083015

Dark Matter studies

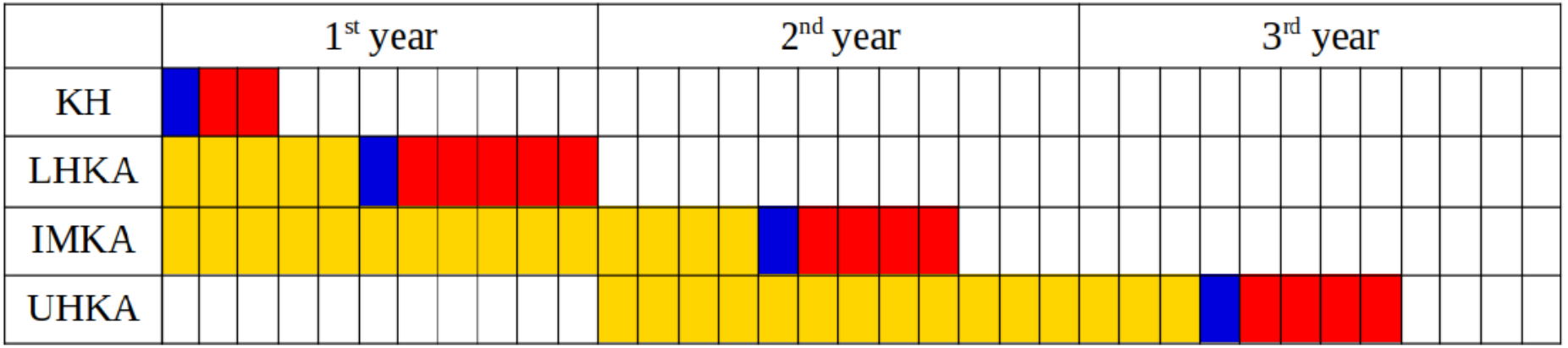
The equation of state of dense matter: Stiff, soft, or both? Astron.Nachr. 340 (2019) 1-3, 189

Astrophysics
EOS Neutron Stars

Future plans EXKALIBUR

Gantt chart

possible implementation of the kaonic atoms measurements



Preparation of the experiment

Installation and commissioning

Data taking

Total integrated Luminosity:

200 + 400 (200) + 400 (200) + 400 pb-1

Very significant physics measurements at the best possible machine

Conclusions

- **The first part of SIDDHARTA-2 2023 run has been concluded successfully: optimization of setup; ready for kaonic deuterium**

- **In particular we: we performed the first ever KNe measurement in gas – optimization of degrader – important scientific output**

- **12 articles were published/submitted since the last Sci Com, 3 are in preparation and > 10 invited talks**

- **We are ready and very motivated to start the SIDDHARTA-2 (first) Kd measurement as soon as possible (in parallel test measurements with HPGe and CdZnTe)**

- **We put forward proposal for solid targets measurements with SIDDHARTA-2 setup for 100-150 pb^{-1} after Kd run - @SC62**

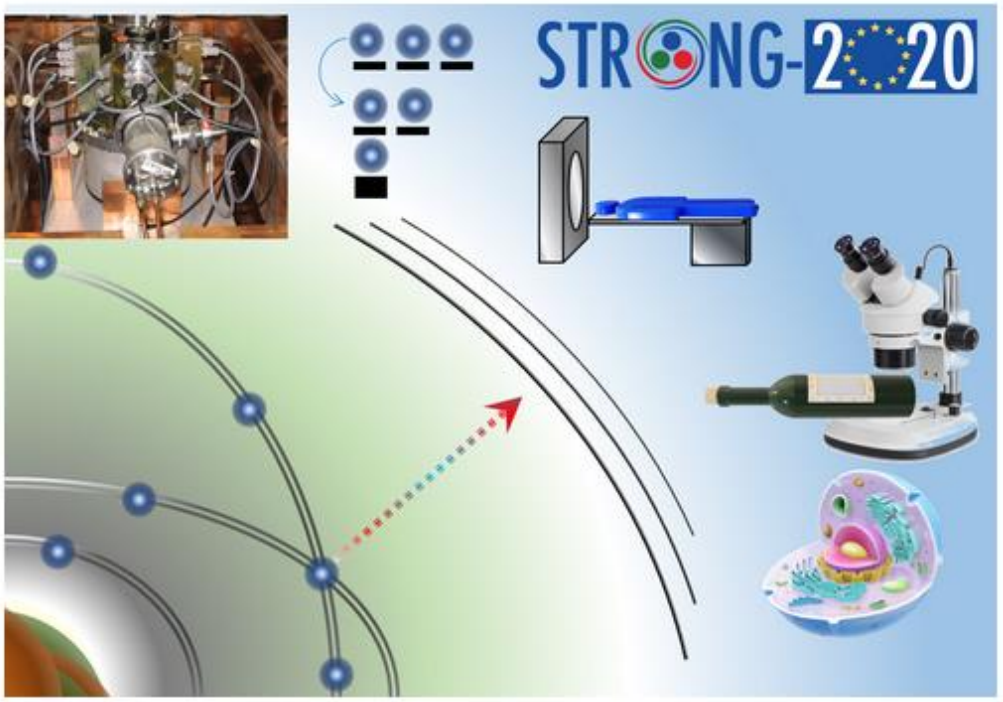
- **We reiterate our (at least) 3 years measurements plans – EXKALIBUR – after SIDDHARTA-2 – strangeness kaonic atoms periodic table**

Applications of radiation detection techniques in fundamental physics, food control, medicine and biology

8–12 May 2023
Laboratori Nazionali di Frascati INFN
Europe/Rome timezone

https://agenda.infn.it/event/33977/

The conference "*Applications of radiation detection techniques in fundamental physics, food control, medicine and biology*" will take place from May 8th to 12th at Laboratori Nazionali di Frascati (LNF - INFN), Italy.



Conference Chairs:

Catalina Curceanu, *Laboratori Nazionali di Frascati, INFN, Italy*
Paweł Moskal, *Jagiellonian University, Center for Theranostics, Poland*
Ewa Stępień, *Jagiellonian University, Center for Theranostics, Poland*

ROCKSTAR: TOWARDS A ROADMAP OF THE CRUCIAL MEASUREMENTS OF KEY OBSERVABLES IN STRANGENESS REACTIONS FOR NEUTRON STARS EQUATION OF STATE

ECT*

09 October 2023 — 13 October 2023

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