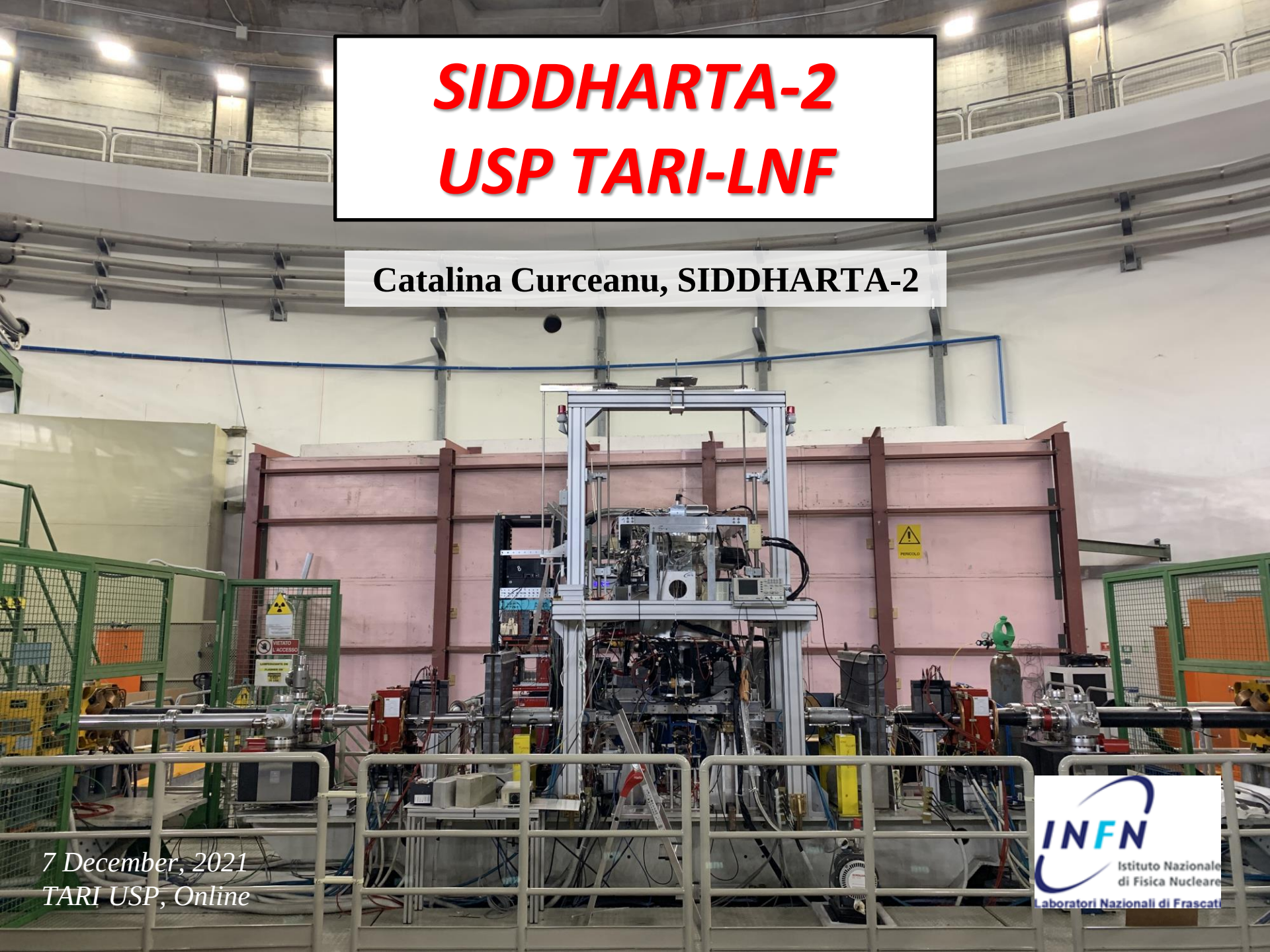
SIDDHARTA-2
USP TARI-LNF

Catalina Curceanu, SIDDHARTA-2



7 December, 2021
TARI USP, Online

SIDDHARTA-2 Collaboration

Silicon Drift Detectors for Hadronic Atom Research by Timing Application

- 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
- IGFAE, Santiago de Compostela, Spain

SIDDHARTA-2 Experiment

OBJECTIVES

Study of strong interaction effects in kaonic atoms

The study of the strong interaction effects was the major motivation for performing experiments with kaonic atoms. The electromagnetic interaction with the nucleus is very well known and the energy levels can be calculated at a precision of eV by solving the Klein-Gordon equation. Even a small deviation from the electromagnetic value allows to get information on the strong interaction between the kaon and the nucleus.

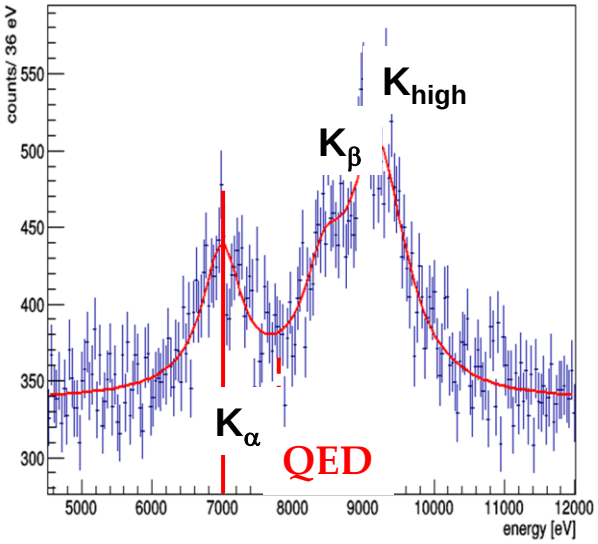
The binding energy of the ground state (K-, p)system is 8,61 KeV, to be compared with the tens of MeV in the low-energy scattering experiments.

Hence, kaonic atoms offer the unique opportunity to study the antikaon-nucleon/nucleus interaction, nearly "at threshold", namely at zero relative energy.

SIDDHARTA-2 Experiment

SIDDHARTA-2 K-d measurement
Monte Carlo simulations

Kaonic deuterium run in
2022 for 800 pb^{-1}
to perform the first measurement of the strong interaction induced
energy shift and width
(similar precision as K$^-$p)



achievable precision:
shift: 30 eV
width: 75 eV

Aim: kaonic atoms measurements; including: SIDDHARTA-2 kaonic deuterium at DAFNE

SIDDHARTA-2 strategy

Phase 1: **Finalized in 2021! (TARI Users: online and some visits (reduced w.r.to planning))**

during the commissioning of DAΦNE

SIDDHARTINO: measurement of K-^{4}He (8 SDD arrays)

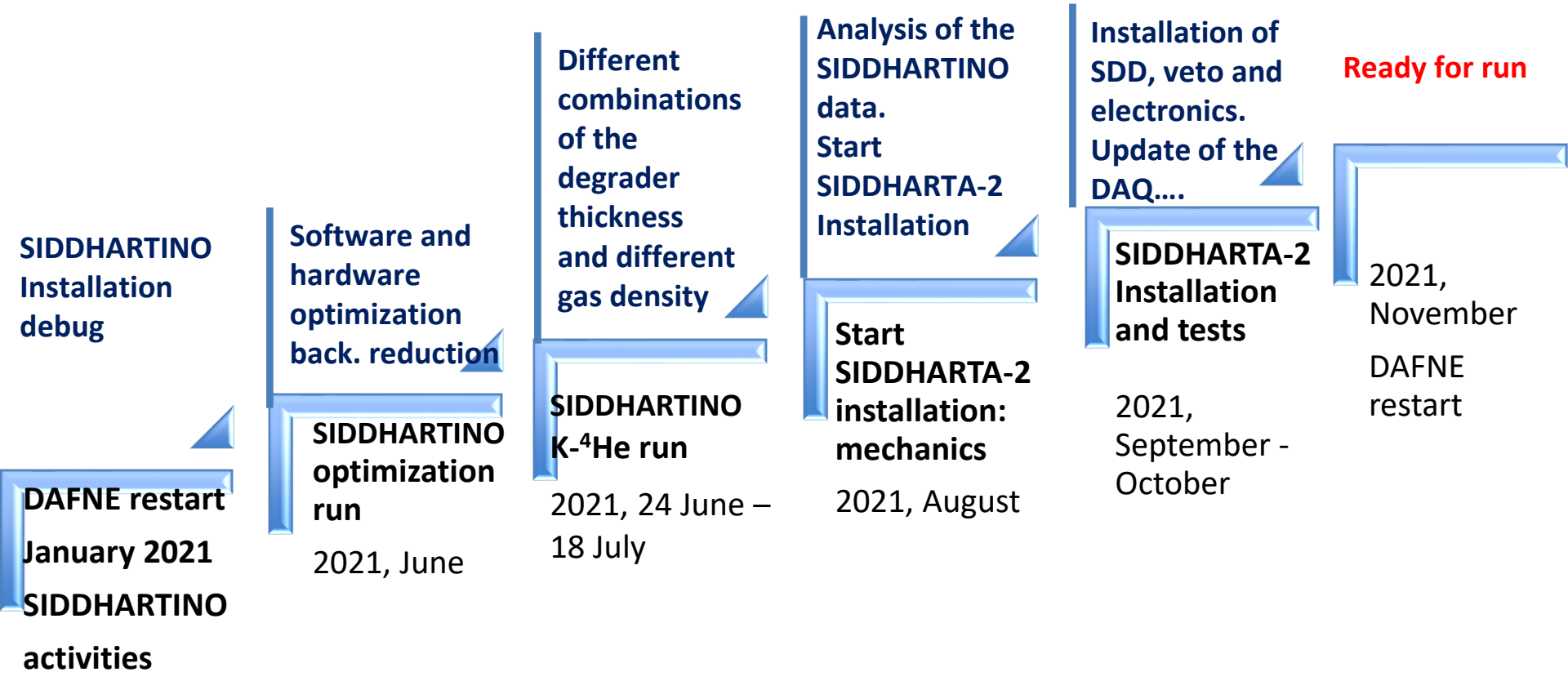
Phase 2: about to start

with DAΦNE operating condition

comparable (S/B) with SIDDHARTA ones

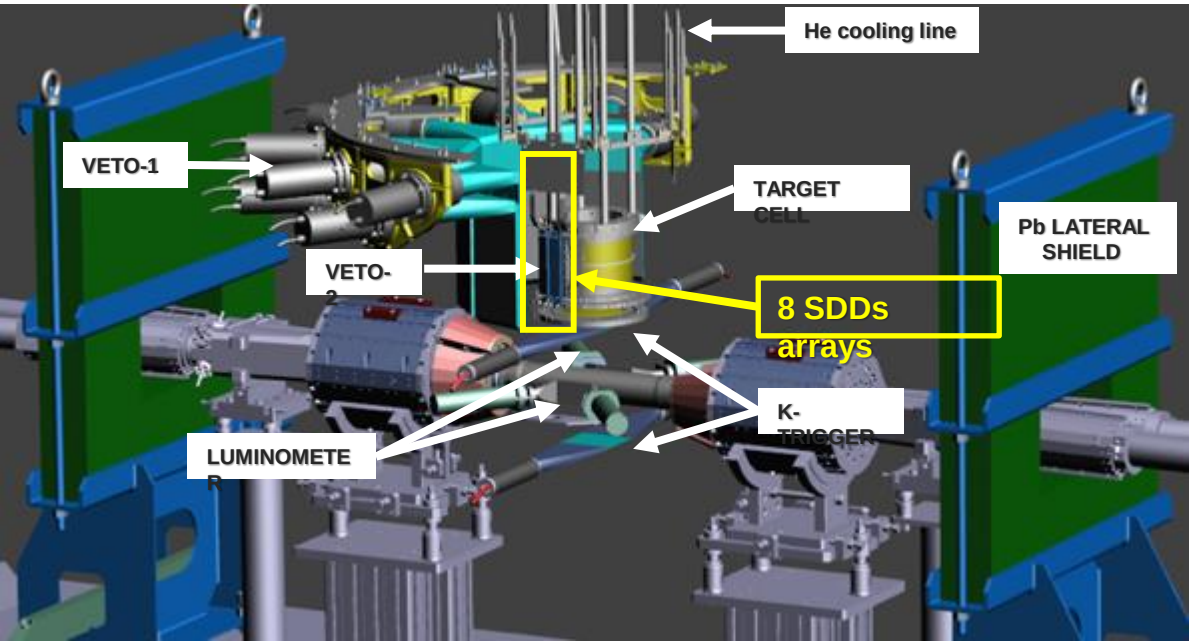
kaonic deuterium **(48 SDD arrays) run for 800 pb^{-1}**

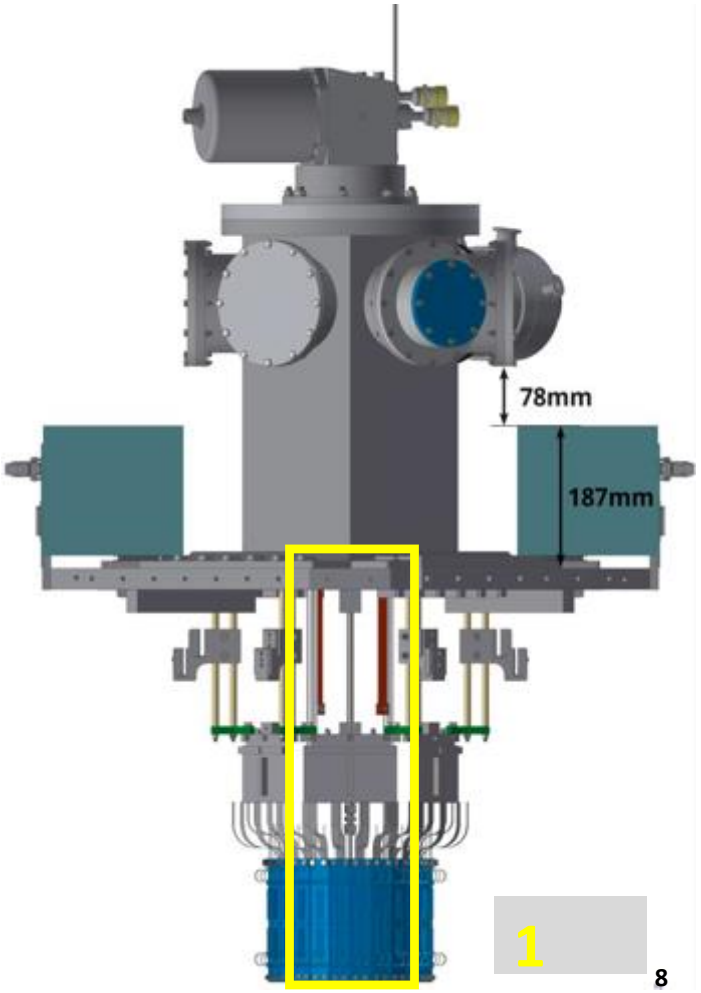
2020 DAFNE was working but March 2020 Lockdown
Activities in laboratory
DAFNE restart: January 2021
Project timeline in 2021



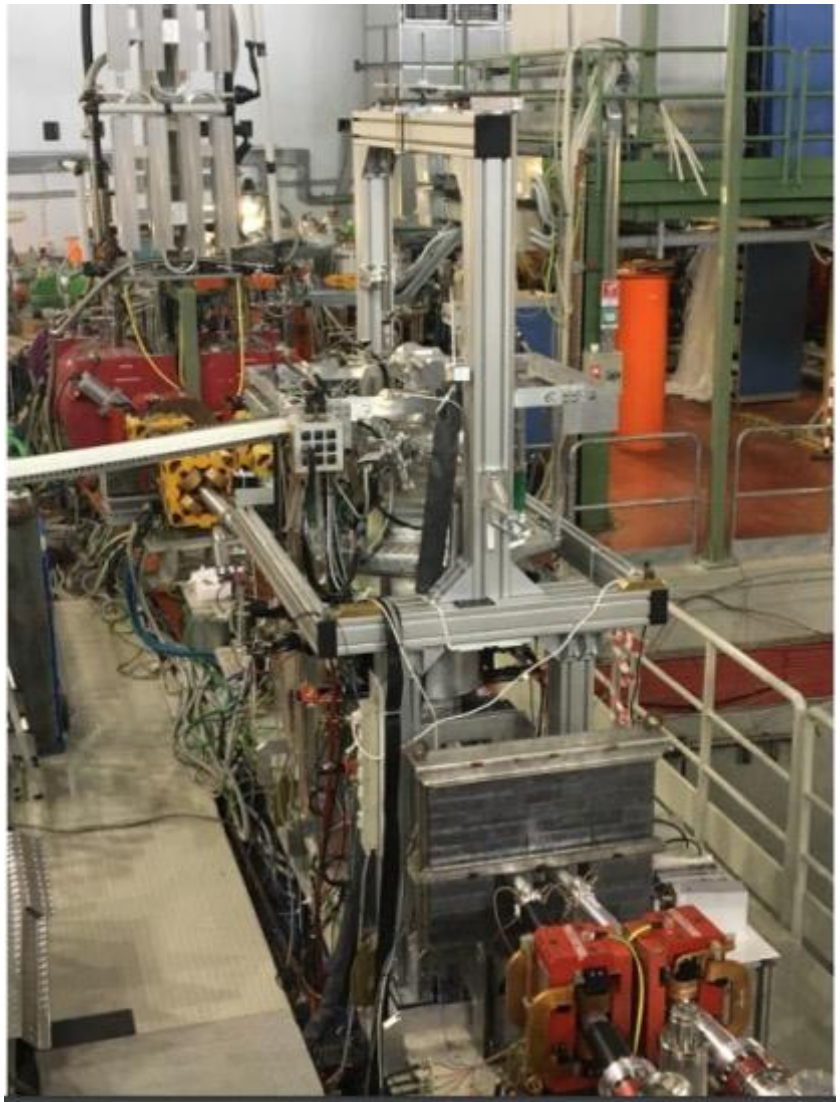
SIDDHARTINO run

Schematic representation of SIDDHARTINO setup





SIDDHARTINO setup (1/6 SDDs)



* Phase 1 with SIDDHARTINO:

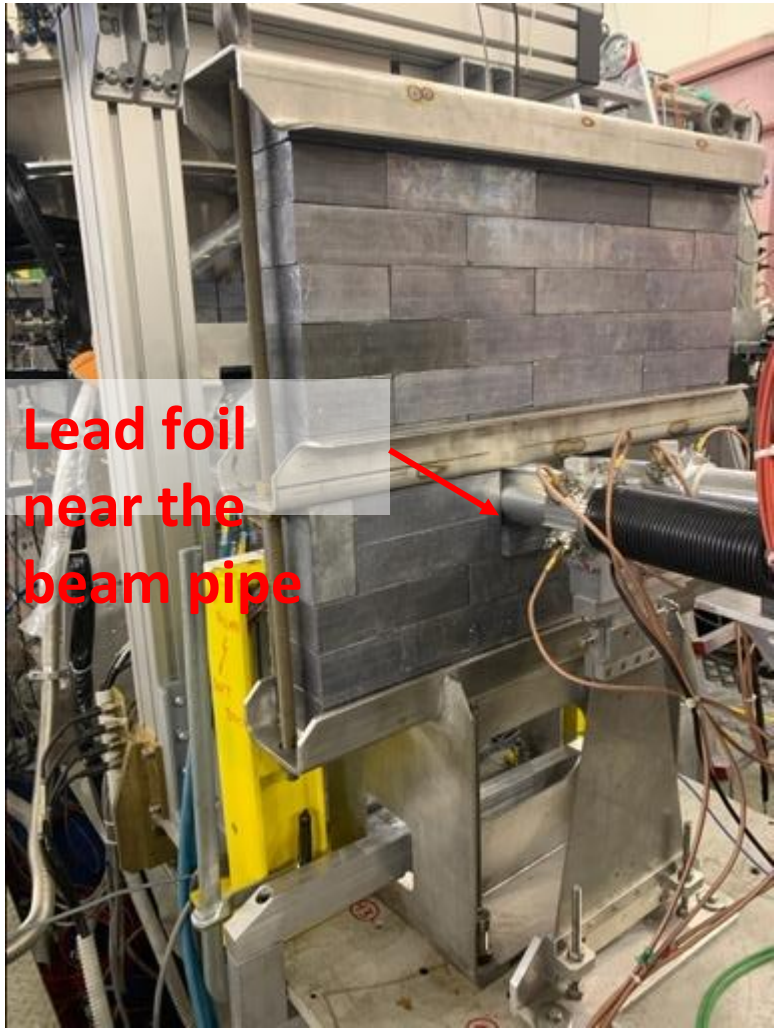
during the commissioning of DAΦNE:

optimization with the SIDDHARTINO setup

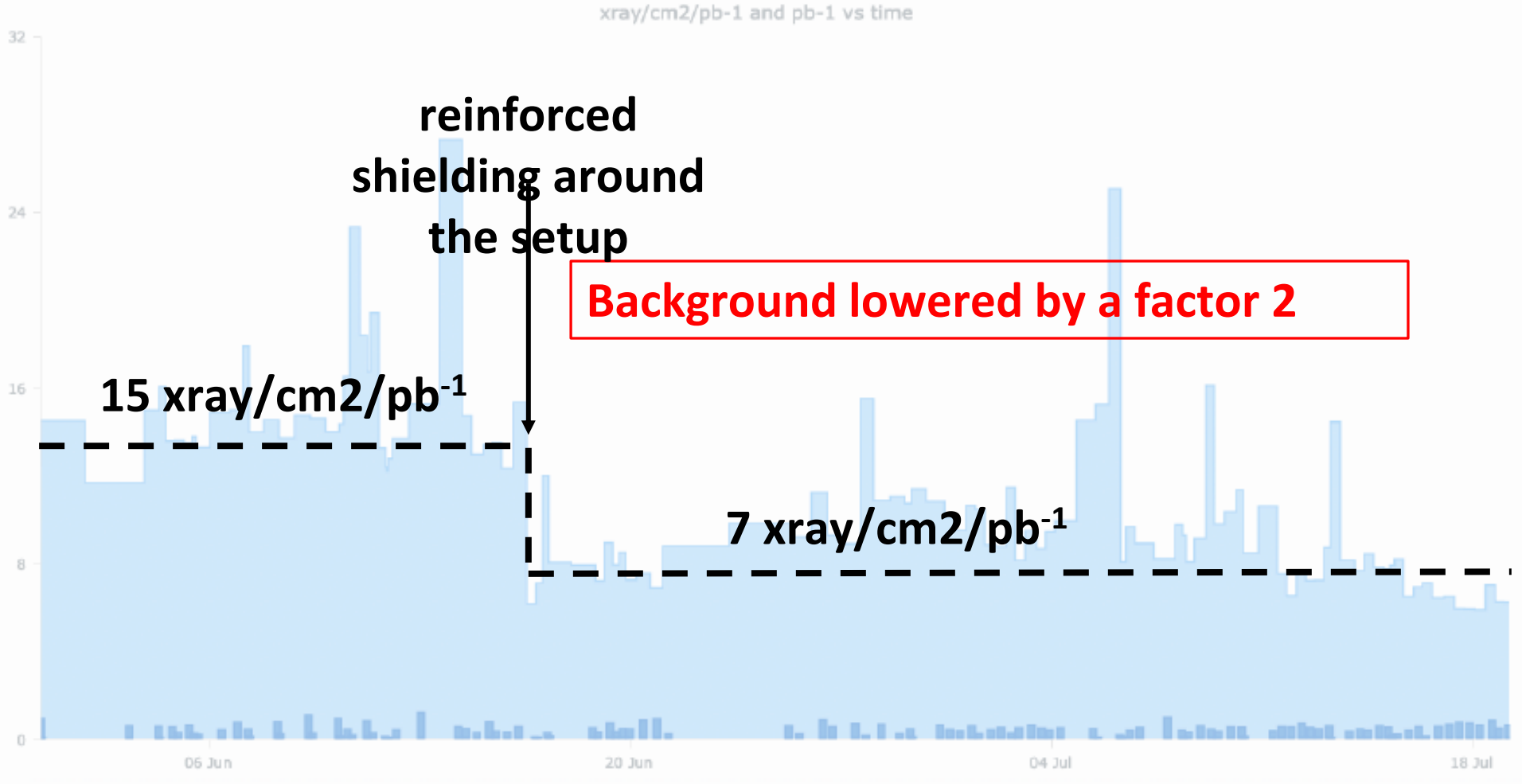
for the K-^{4}He measurement

(with 8 SDD arrays)

Back. reduction: reinforced shielding around the setup



SIDDHARTINO - xray/cm2/pb^{-1}

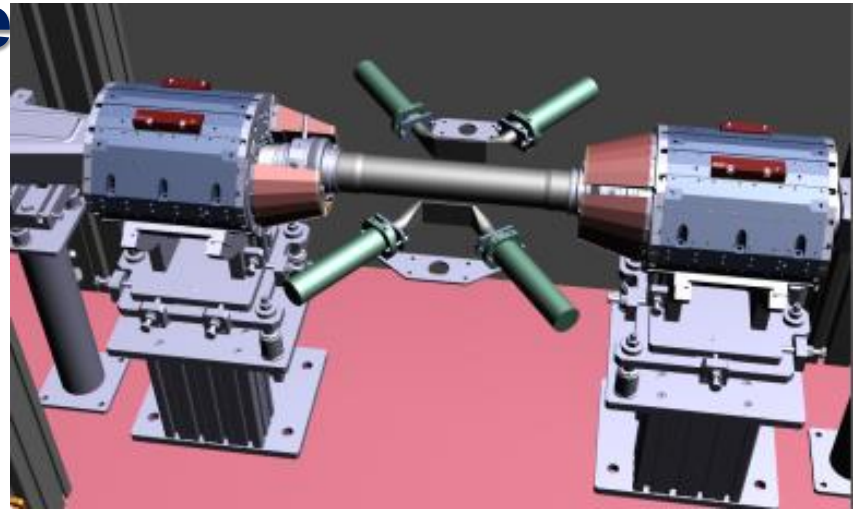


Luminosity measurement to monitor also background (Jagiellonian Univ.)

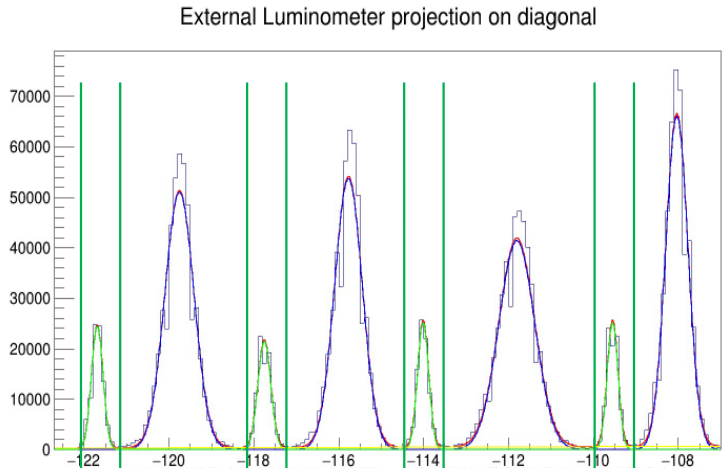
- **Luminosity detector:**

- SIDDHARTA-2 luminomete used for back: kaons/MIPS

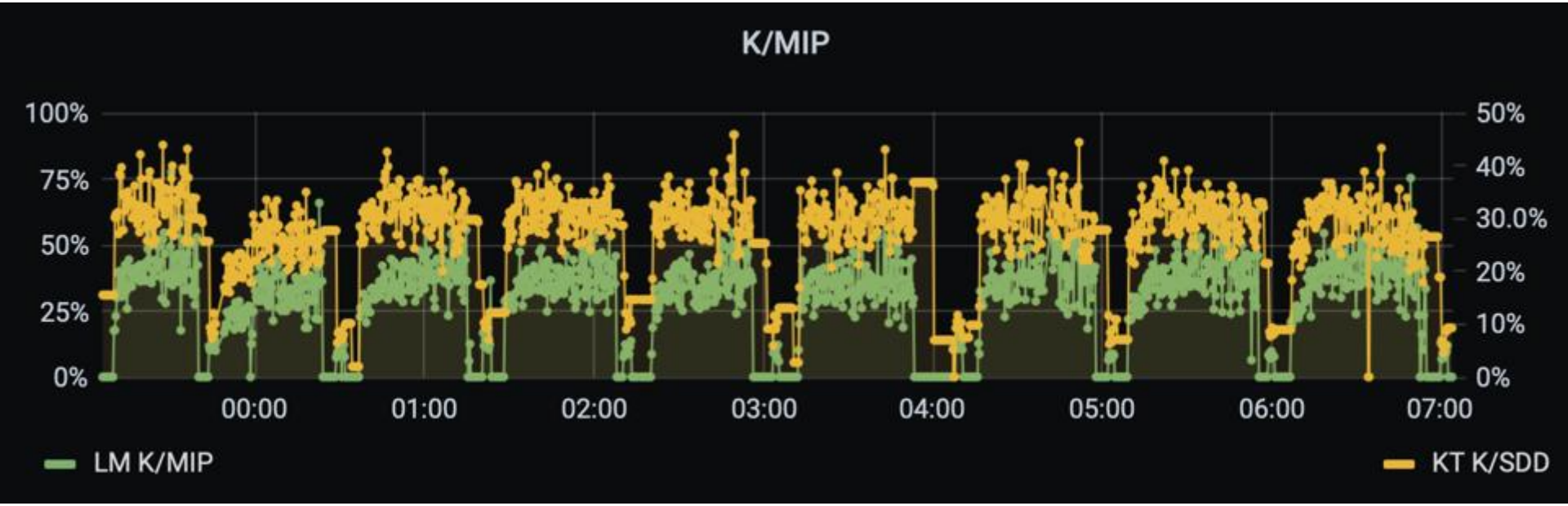
- luminosity delivery



Back to plastic scintillators in coincidence with RF/4 signal



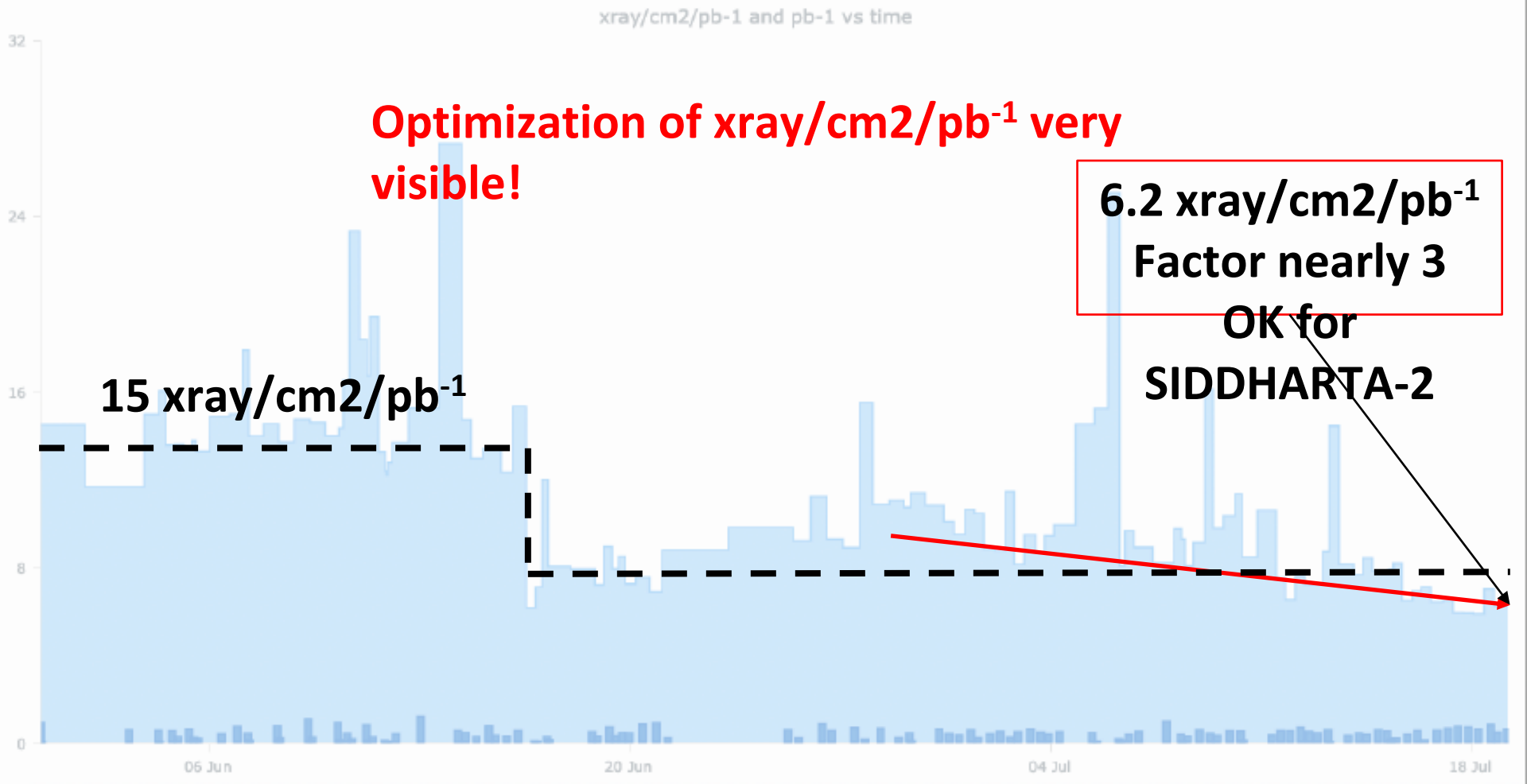
Background levels monitor



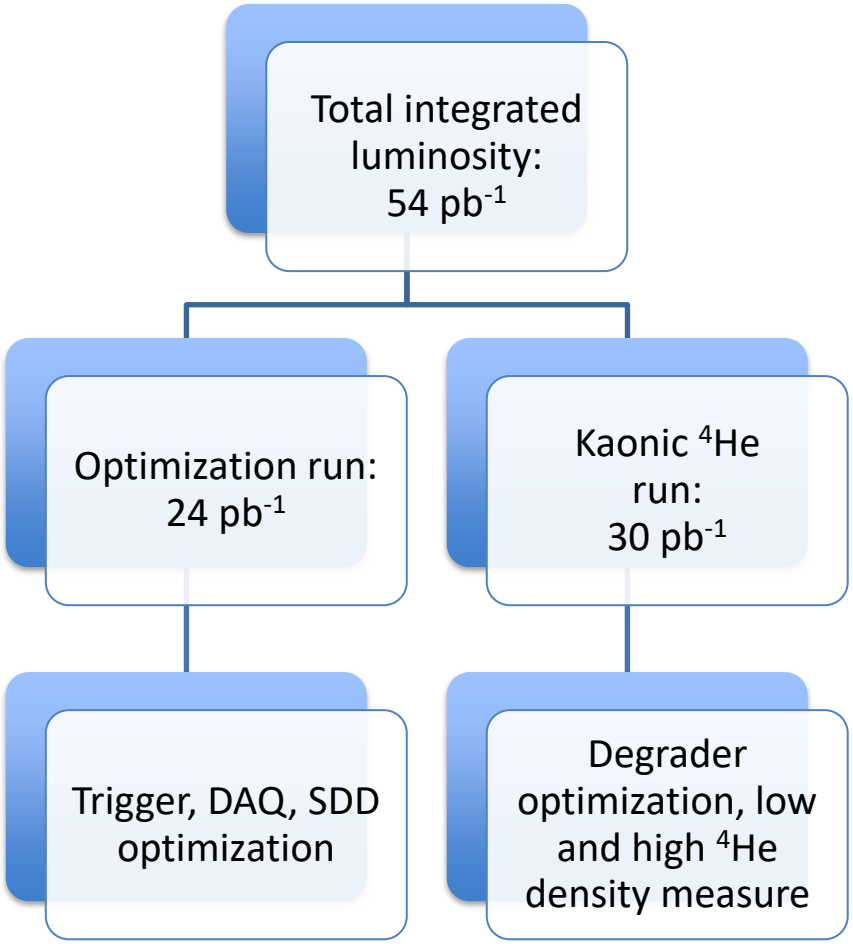
Background levels were monitored online by a counter based on Kaon/Mip rate and a second based on Kaon/SDD rate.

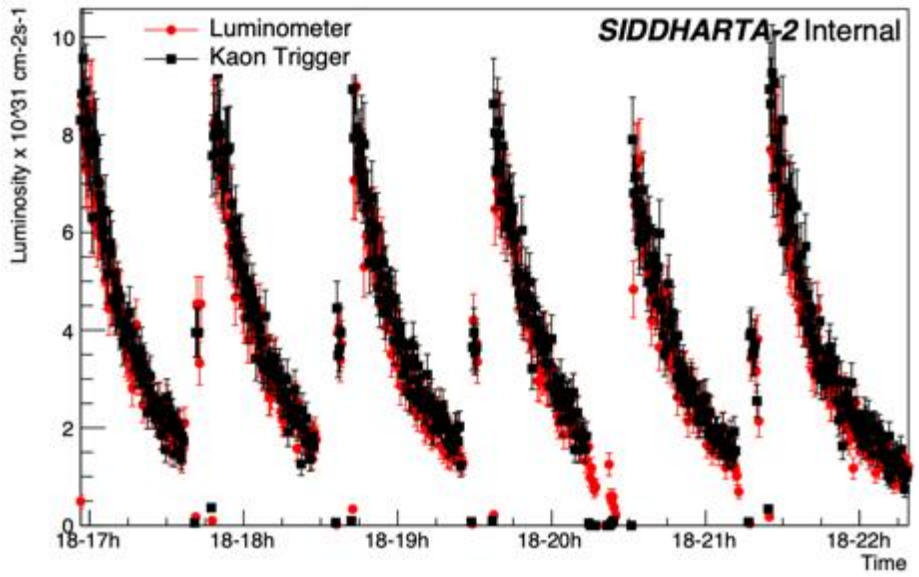
Shared with the DAΦNE staff to optimize the background

SIDDHARTINO - xray/cm2/pb^{-1}



SIDDHARTINO data - Integrated Luminosity

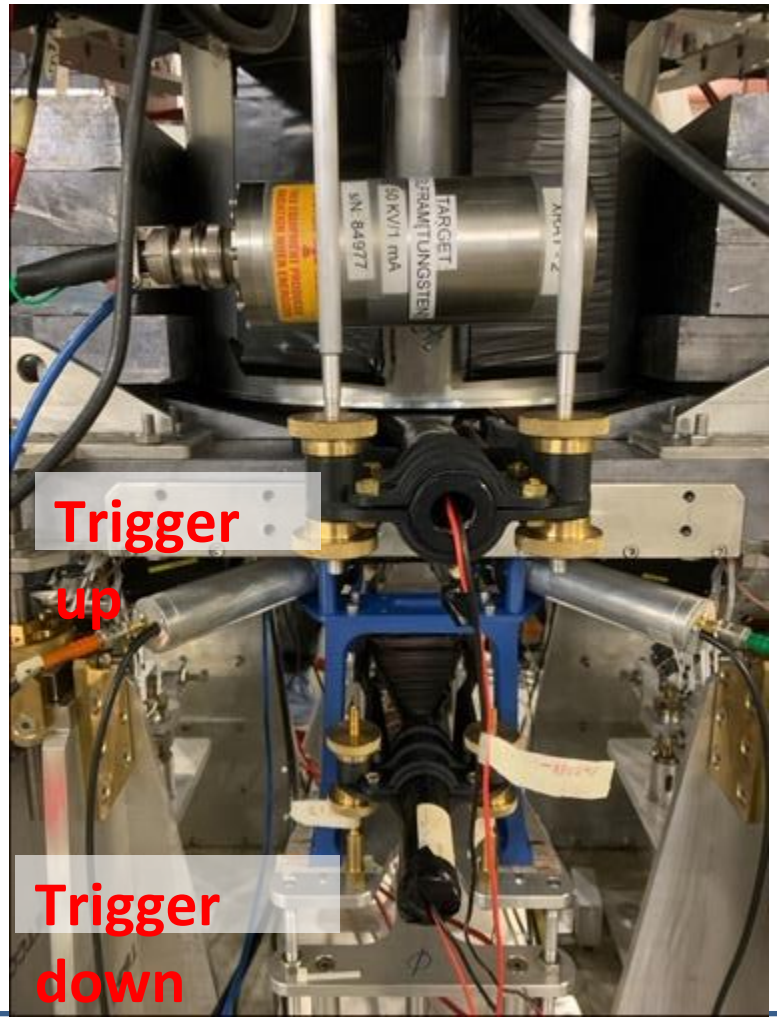


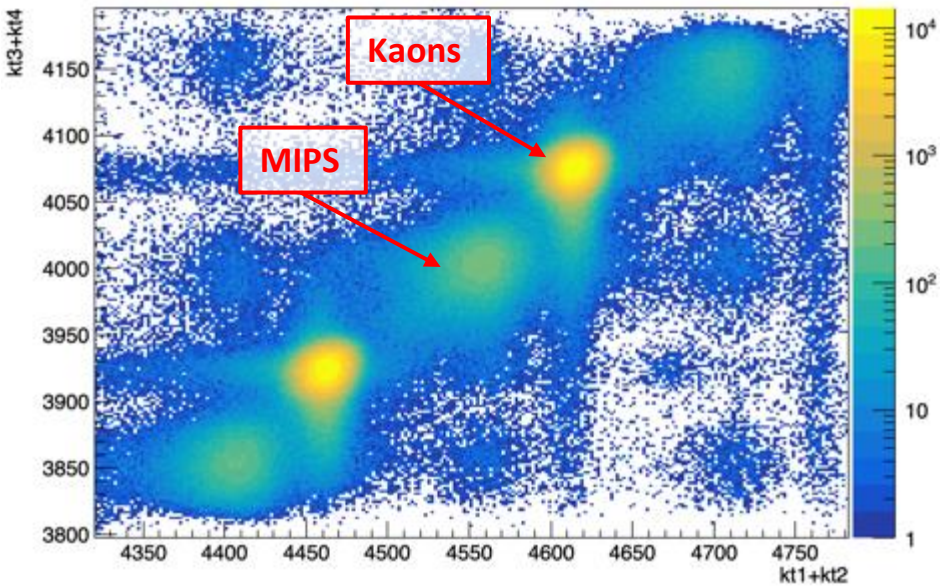


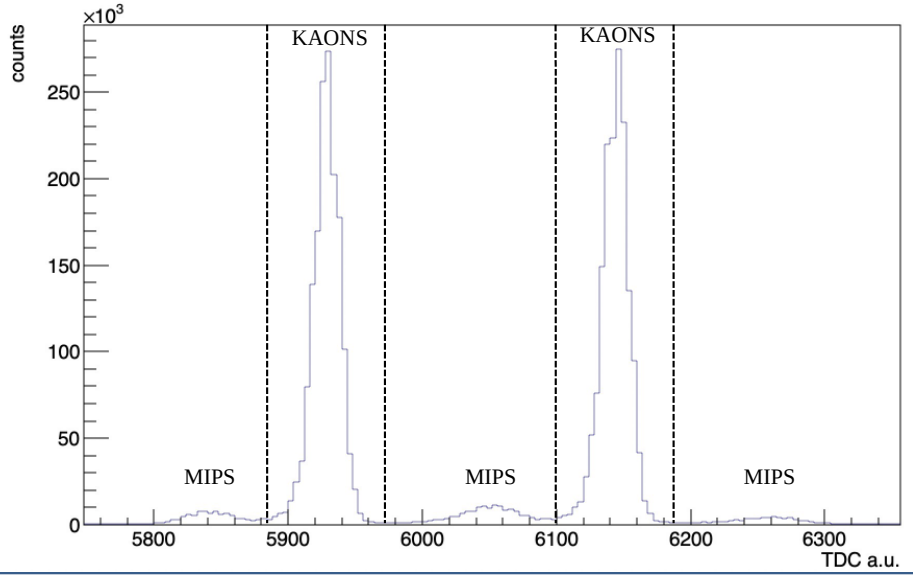
Kaon monitor and Luminometer measure at the end of SIDDHARTINO

SIDDHARTINO – Optimization Run

Trigger time window optimization



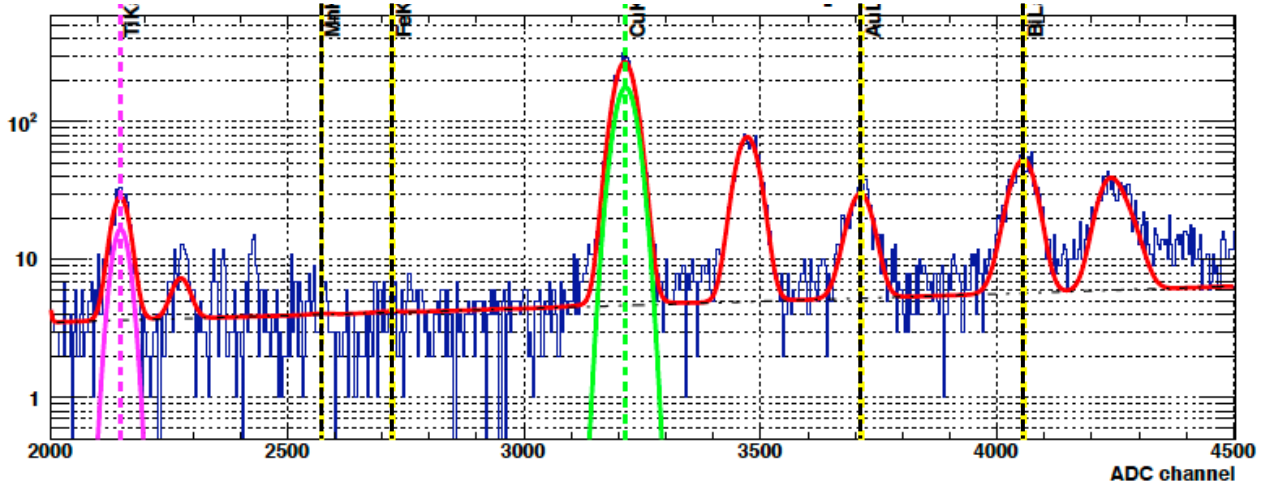




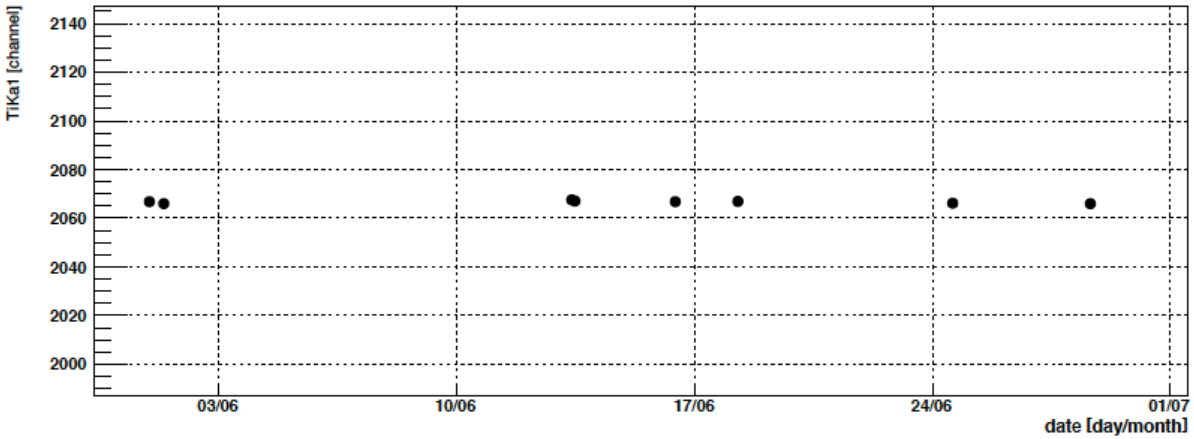
SIDDHARTINO – Optimization Run

SDD calibration and energy response

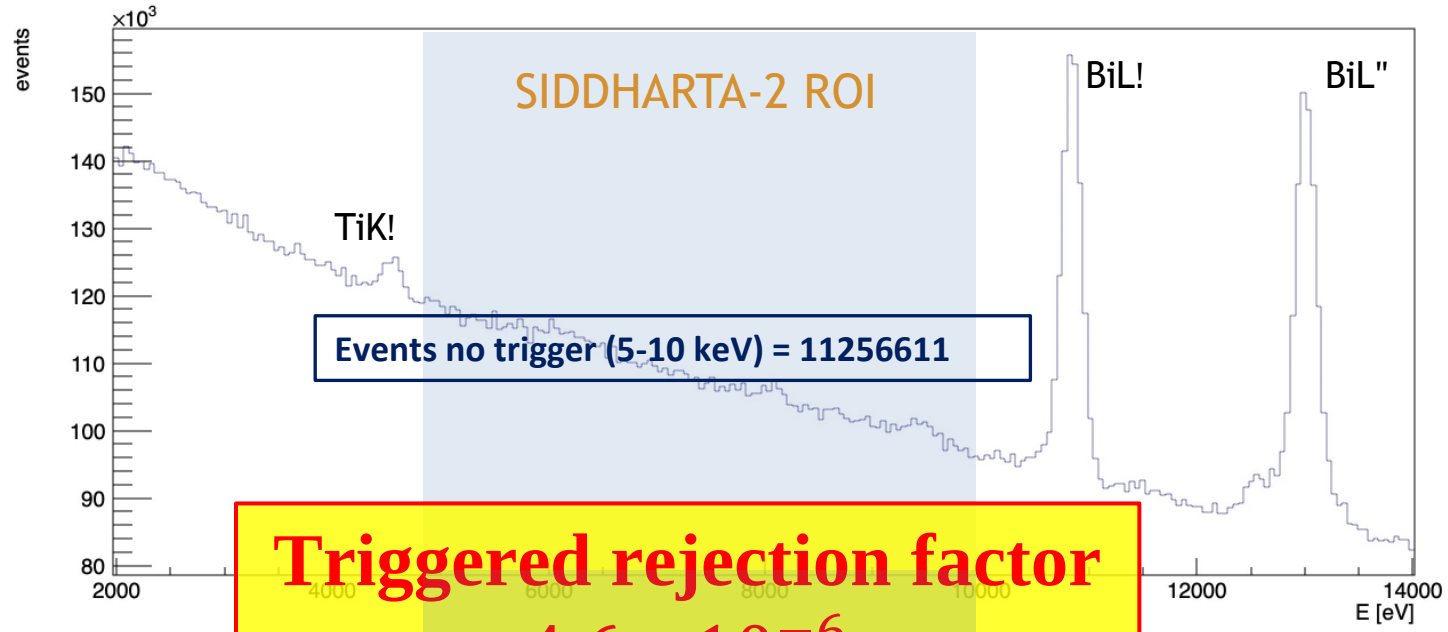
SDD calibration run



SDD Stability

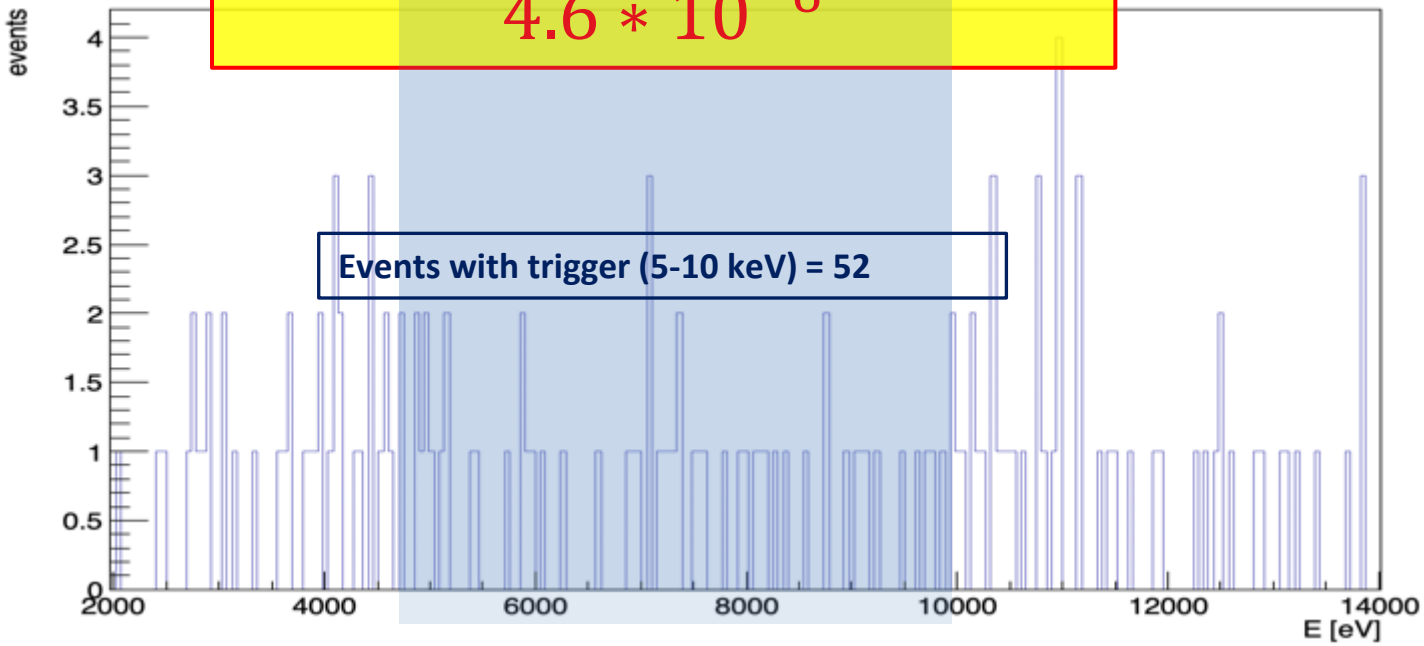


Trigger rejection factor



Triggered rejection factor

$$4.6 * 10^{-6}$$

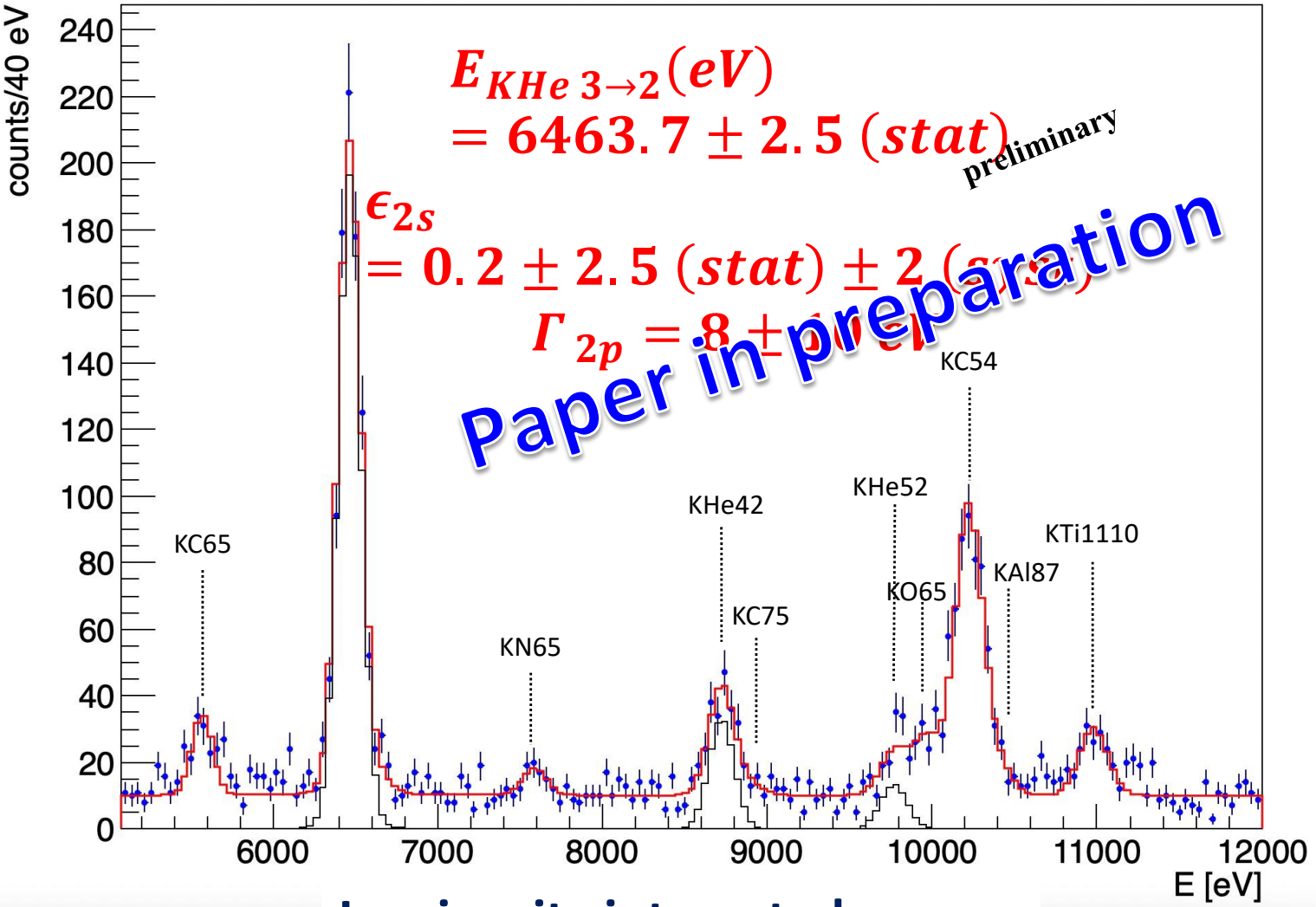


Sum of all SDDs after individual calibration

Sum of all SDDs after trigger cut

SIDDHARTINO - K-^{4}He run

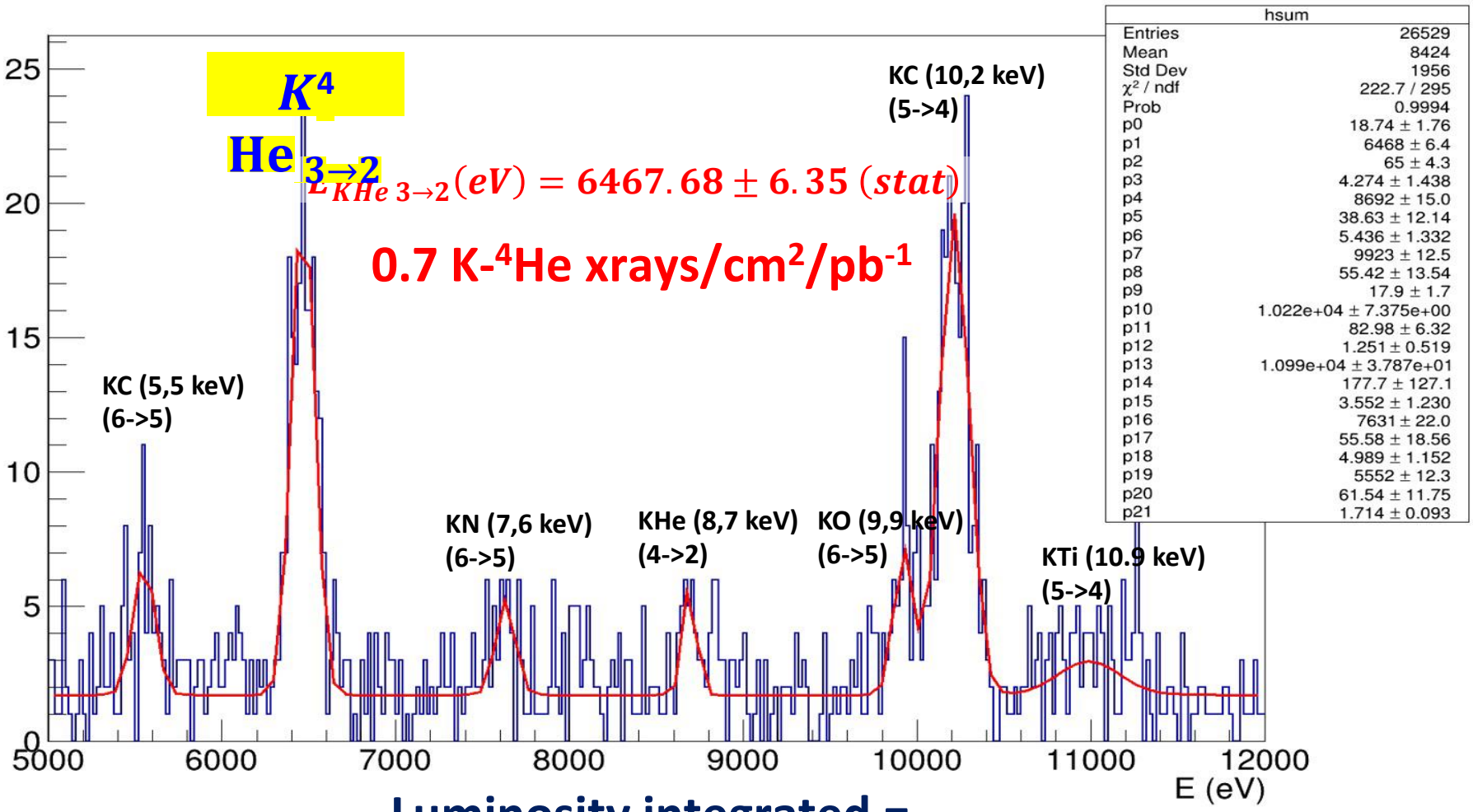
K-^{4}He shift and width:
the most precise measurement in gas!



Luminosity integrated =

SIDDHARTINO - K-^{4}He run

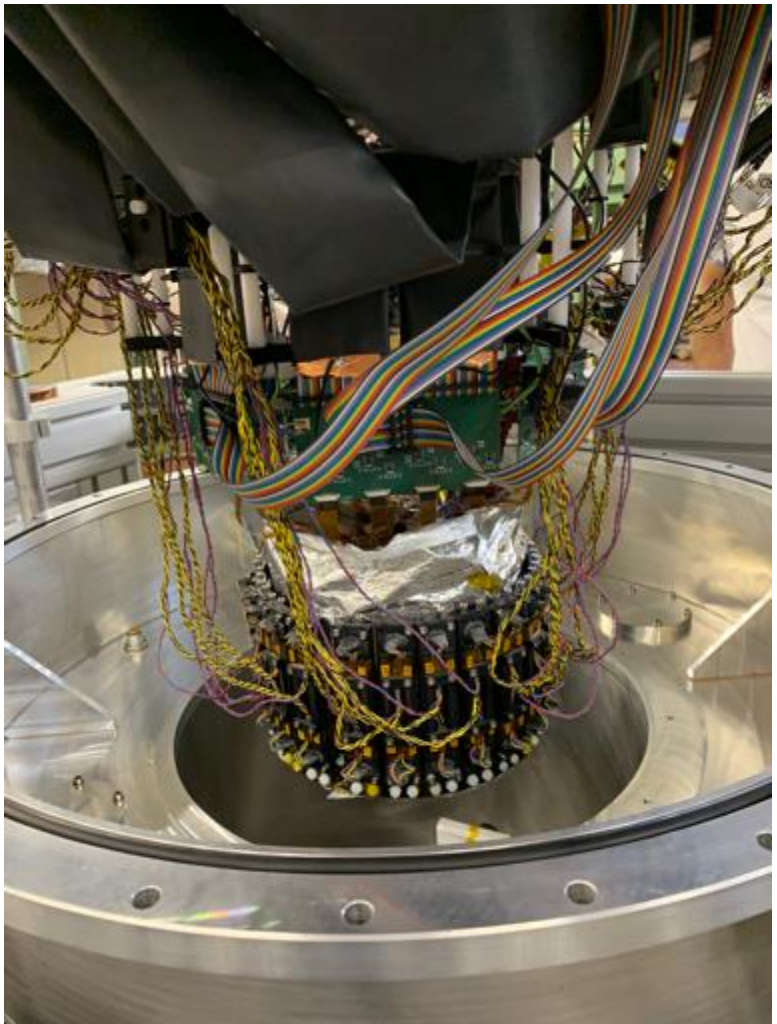
K-^{4}He low density run: 0.75% liquid helium density -> **yields at lowest measured density analyses undergoing -> paper**



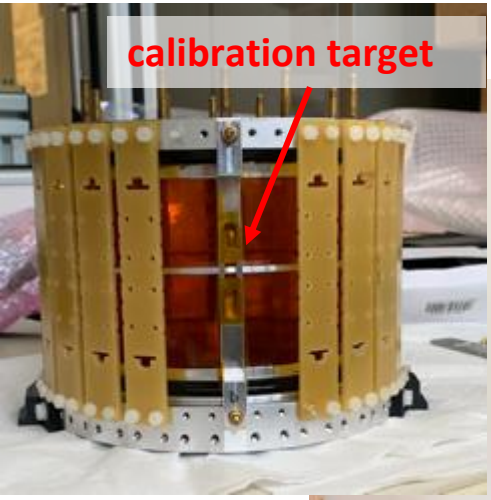
Luminosity integrated =

SUMMER 2021: installation of SIDDHARTA-2

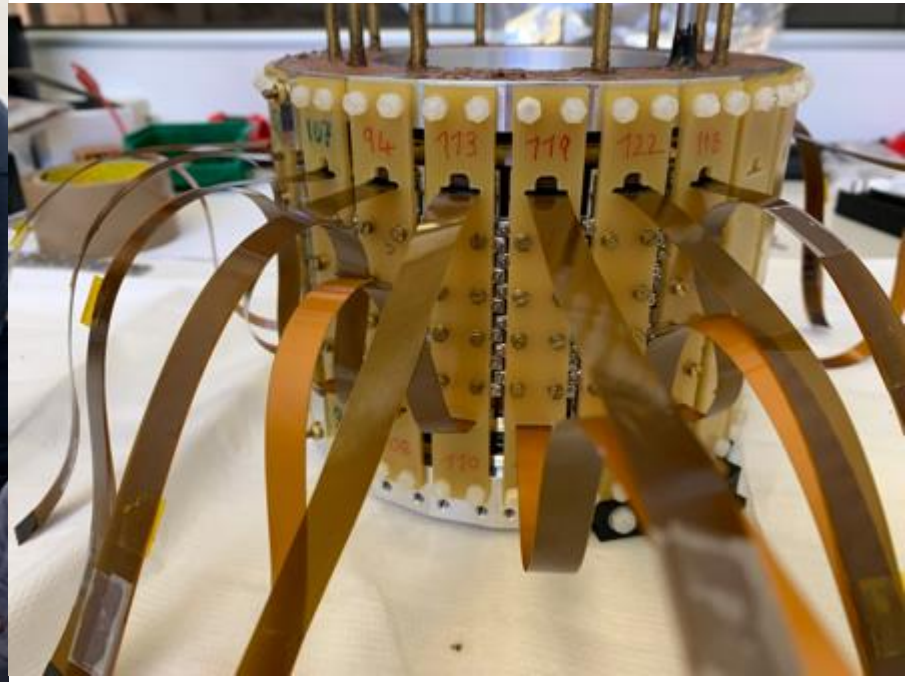
- **SDD detectors installation**
- **Veto-2 installation**
- **Front-end electronic installation**
- **Veto-1 installation**



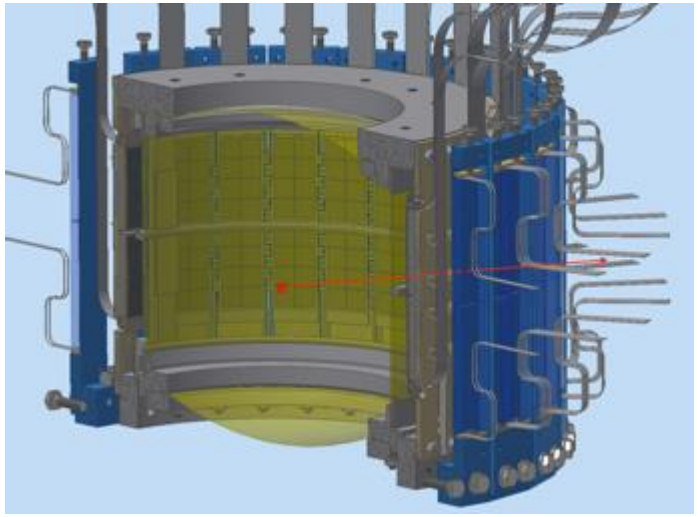
SDD installation

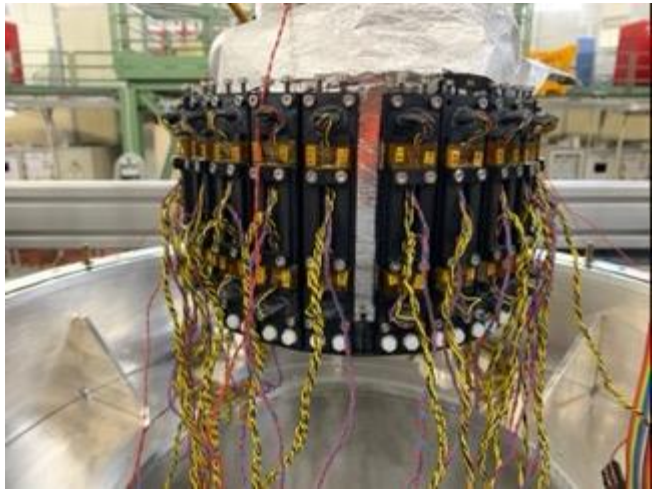


SDD installed around the target

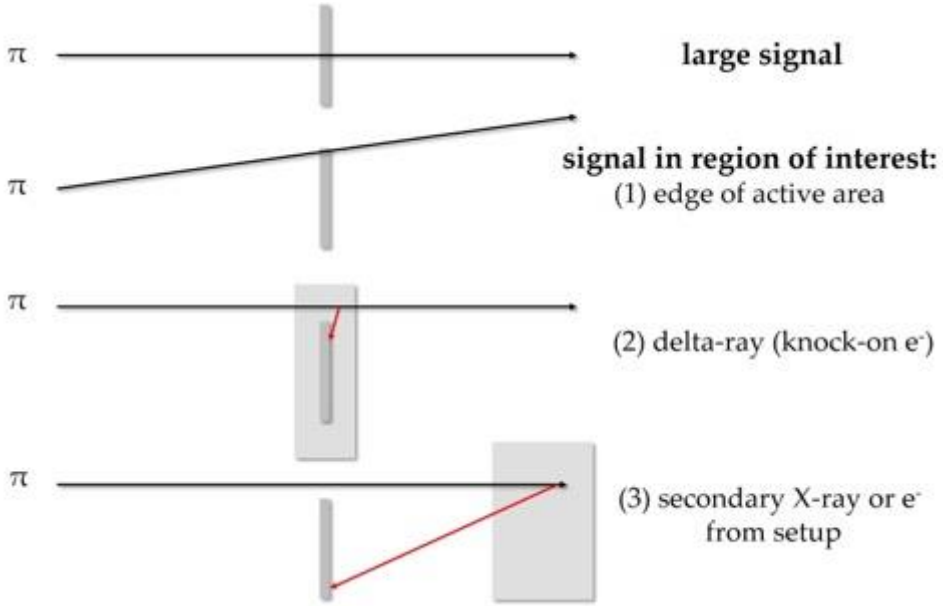


Veto-2 installation (Vienna – SMI)





Working principle of veto-2 system

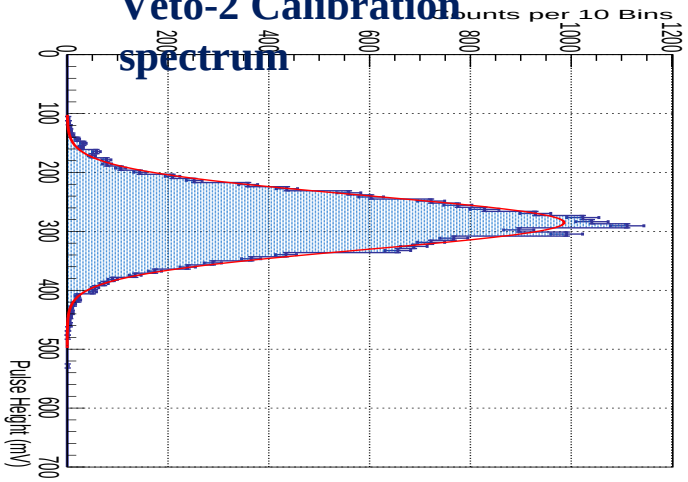


Veto-2 installation

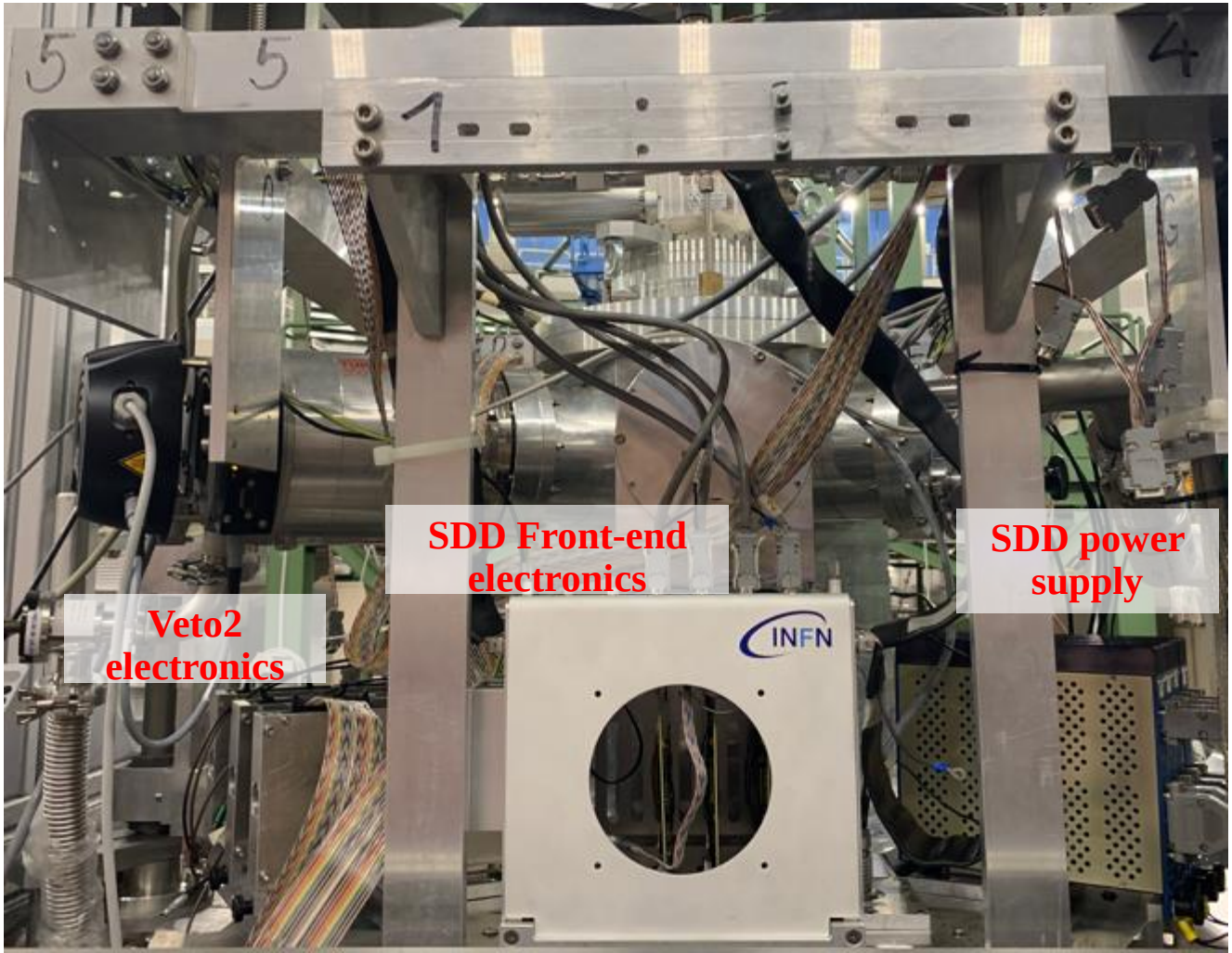
- **The installation of veto 2 has been completed and the correct operation of each unit has been verified**
- **Each veto-2 unit is equipped with an LED that will allow to calibrate and verify the correct functioning of the system with and without beams**

Veto-2 single unit

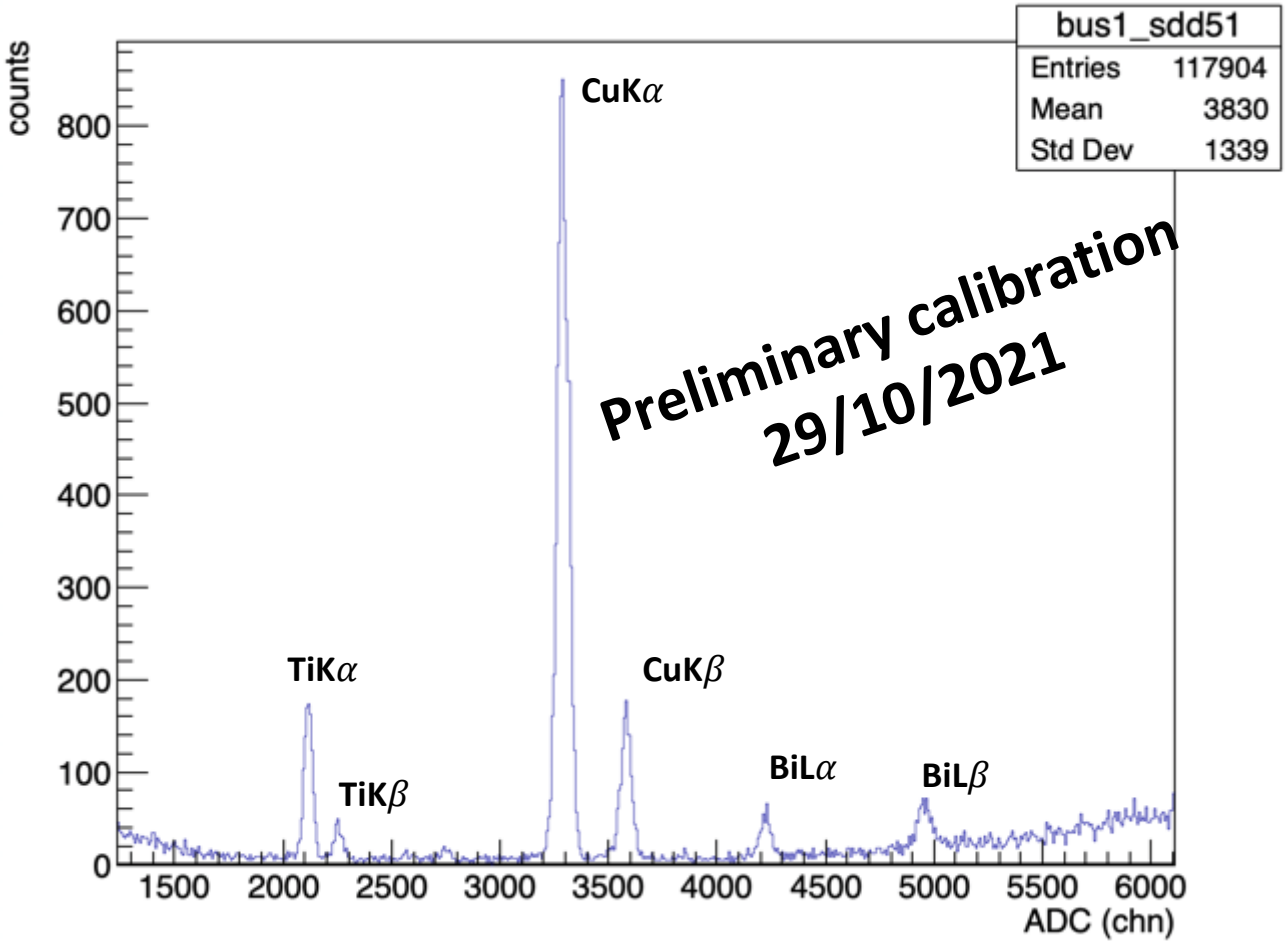
Veto-2 Calibration spectrum



Front-end electronics installation

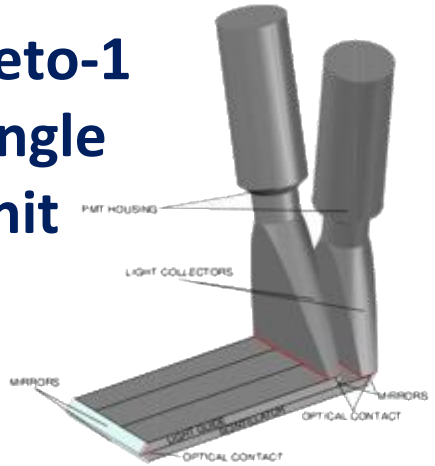


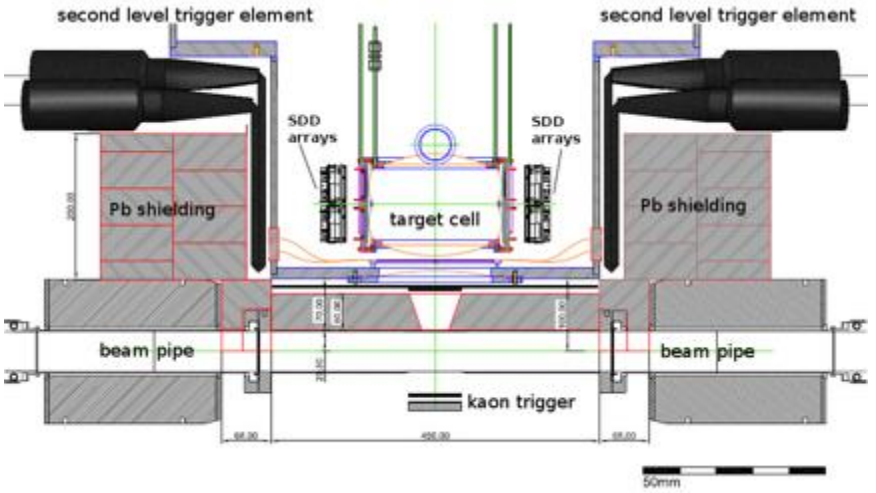
SDD calibration spectrum acquired with SIDDHARTA-2



Veto-1 system installation

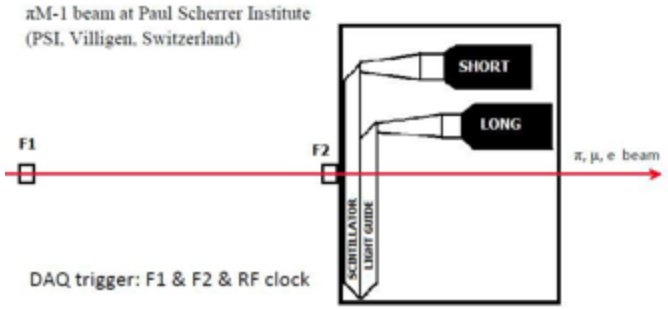
Veto-1 single unit





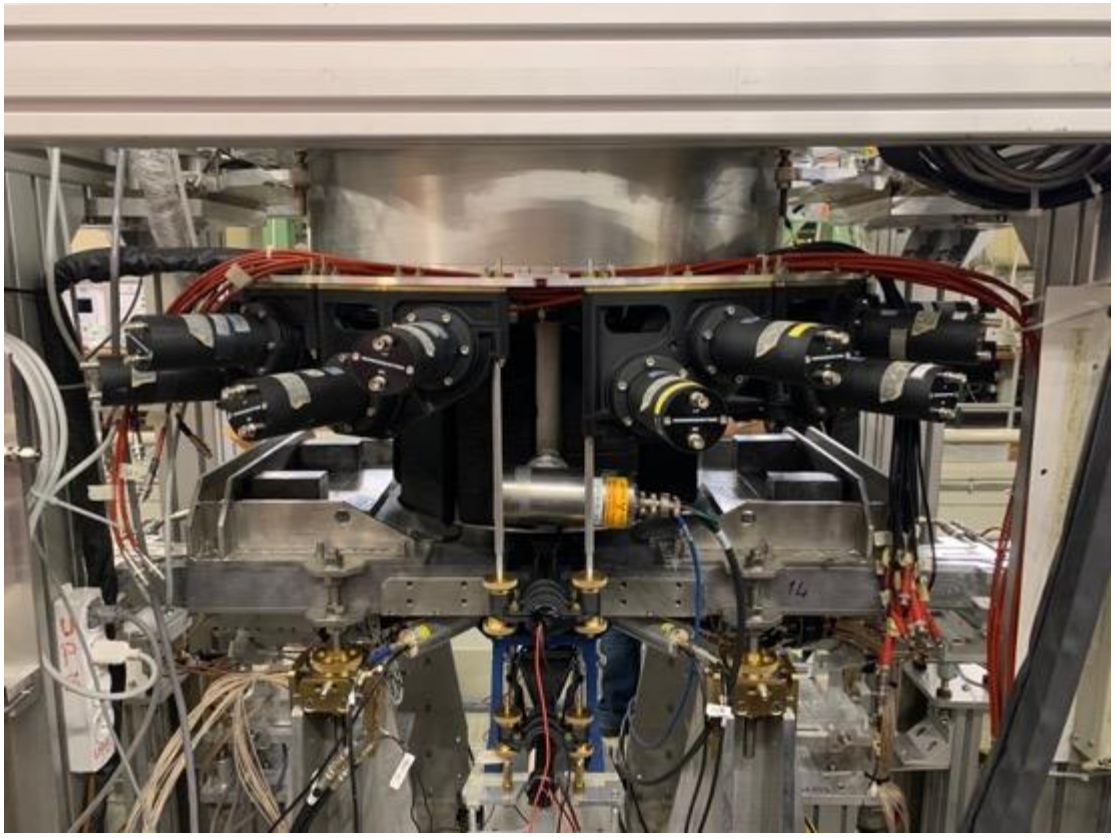
Drawing of the veto-1 elements placed around the vacuum chamber

Working principle of veto-1 system



M. Bazzi et al, 2013 *JINST* 8 T11003

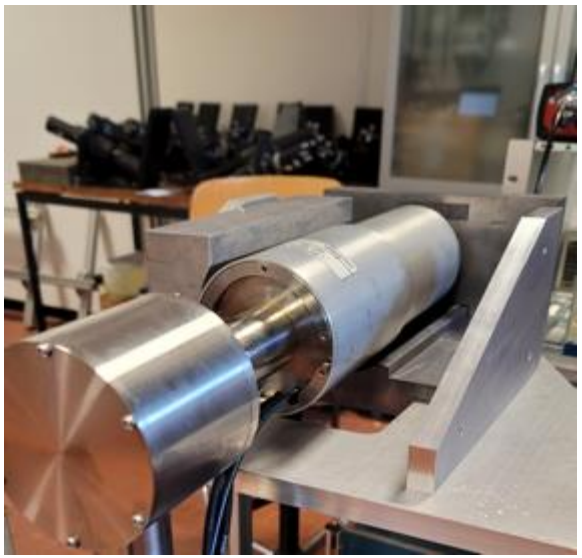
Veto-1 system installation



Veto-1 system installed


SIDDHARTA-2 setup
Ready for Run

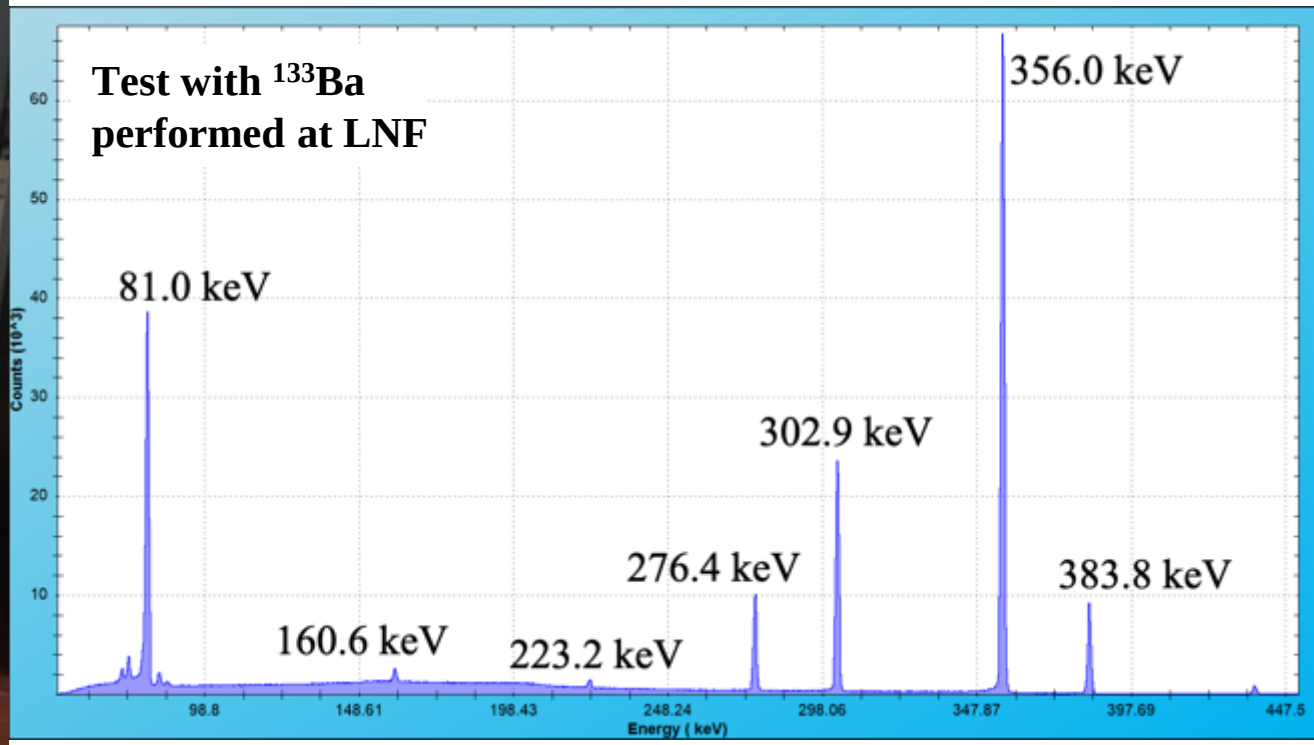
HPGe - feasibility test for the kaonic lead measurement (Zagreb Univ.)



- **HPGe detector available,**
  Funded by University of Zagreb
  Croatian Science Foundation project 8570

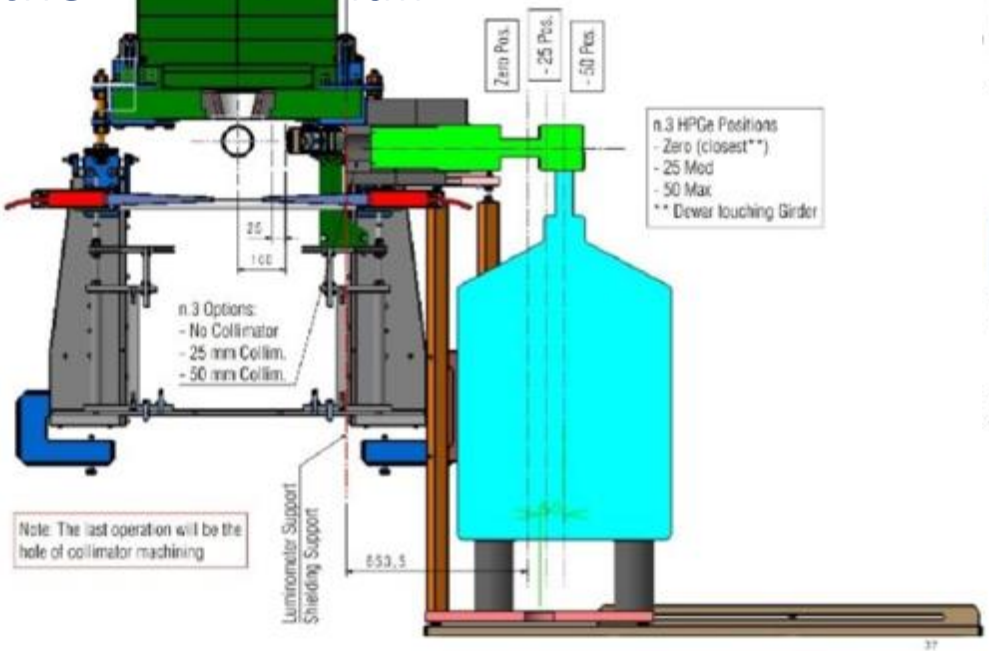
support structure and

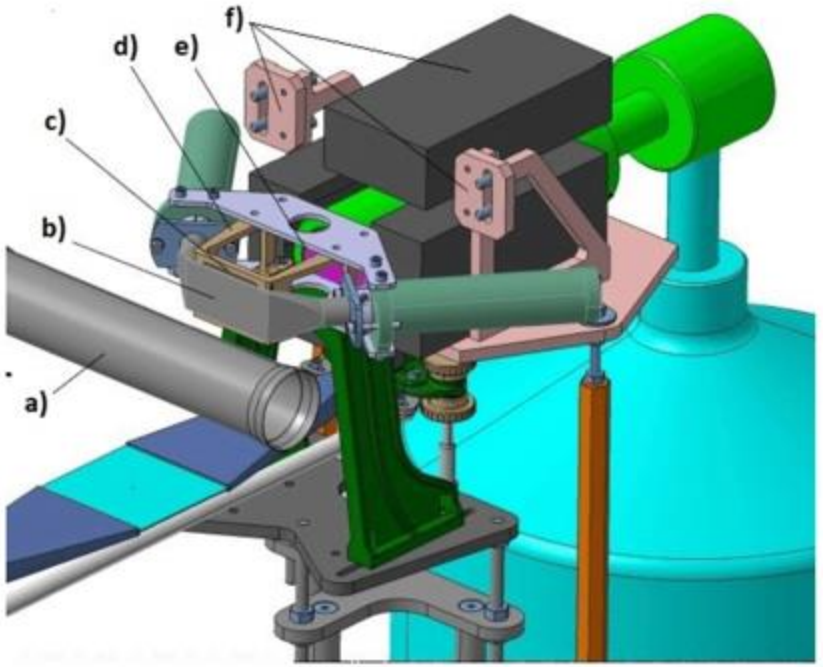
HPGe - feasibility test for the kaonic lead measurement



HPGe - feasibility test for the kaonic lead measurement

schematic representation of the apparatus, that will be installed in the DAΦNE hall





The layout of the HPGe setup: (a) beam pipe, (b) luminometer, (c) target, (d) target holder, (e) active part of the HPGe detector, (f) lead shielding with the holder (figure done by C. Capoccia, LNF).

HPGe detector ready to be install in the DAΦNE hall

Project timeline – future

Plan DAFNE not yet fully defined

However: run through all 2022 (SIDDHARTA-2 and PADME)

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

Installation of SIDDHARTA-2 setup

2021, September - October

Start Run SIDDHARTA-2 and HPGe parasitic test

2021, November

Start of the data taking with ^4He to check the status of the background with respect to SIDDHARTINO run

DAΦNE shutdown for winter holiday

2021, December

Continue the run SIDDHARTA-2

Kd

HPGe

2022, from January through all 2022

Part of the SIDDHARTA-2 collaboration

SIDDHARTA-2 - organization structure

Spokespersons:
Catalina Curceanu (LNF-INFN)
Johann Zmeskal (SMI)

Technical Coordinator:
Florin Sirghi (LNF-INFN)

Contact person DAFNE - SIDDHARTA-2:
Alberto Clozza (LNF-INFN)

DAQ responsible:
Mihai Iliescu (LNF-INFN, SMI and CERN)

Readout electronics:
Massimiliano Bazzi (LNF-INFN)
Carlo Fiorini (Politecnico di Milano)

Slow Control:
Mario Bragadireanu (IFIN-HH)

SDD detector system:
Marco Miliucci (LNF-INFN)

Veto systems and trigger:
Alessandro Scordo (LNF-INFN)
Hexi Shi (SMI)

Luminometer:
Magda Skurzok (Krakow)
Alessandro Scordo (LNF-INFN)

Monte Carlo simulations:
Diana Sirghi (LNF-INFN)
Michael Cargnelli (SMI)

Data analysis group:
Luca De Paolis, Raffaele Del Grande, Alessandro Scordo, Magda Skurzok, Diana Sirghi (SMI), Marlene Tuchler (SMI), Antonio Romero (Spain)

VOXES system:
Alessandro Scordo (LNF-INFN)

Germanium detector system:
Damir Bosnar (Uni. Zagreb)

SMI-Vienna (Austria)

APPLICATION FORM TARI-LNF

1) Group Leader

Family Name	Zmeskal
First Name	Johann
Nationality	Austria
Home Institution	Stefan Meyer Institute for Subatomic Physics
Legal Status of Home Institution Code (1)	RES
Home Institution Country Code (2) AT	Position Code (3) EXP
Mailing Address	Kegelgasse 27, A-1030 Vienna, Austria
Phone (office)	+43 1 51581 4500
Phone (home)	+43 664 612 7206

e-mail johann.zmeskal@oeaw.ac.at

3) Project Title **Studying kaonic deuterium atoms with SIDDHARTA-2**

4) Project Acronym *(max 20 characters)* **SIDDHARTA-2**

5) Access is requested for the following LNF Facility (tick the item chosen):
(x) Particle and Nuclear Physics
( ) Beam test facility

6) Experimental Setup of interest: SIDDHARTA-2 at DAFNE

7) Duration of the Project: 6 months
Starting from January 2022

8) Access Periods Requested under TARI Programme:

Researcher	**Total No. of days**	**No. of visits**
Zmeskal, Johann	20	3
Shi, Hexi	20	2
Tüchler, Marlene	30	3
Sirghi, Diana	40	2
Amsler, Claude	10	2
Widmann, Eberhard	10	2
Marton, Johann	15	2
Cargnelli, Michael	15	2

Contribution of the researchers to the project

There are different important part to be covered during the start-up and commissioning of SIDDHART2. The member of the SMI team will contribute to the following items:

- Participating in beam time shifts and data analysis.
- Working on the improved MC simulation together with LNF staff.
- Implementing of the veto-2 system in the common DAQ together with LNF staff.
- Calibration of the veto-2 system and installation of the complete detector begin of 2022.
- Participating to the final detector assembly in 2022.

Proposal of assignement

Group Leader	Participants	Request (days/trips)	Residuals (days/trips)	New assignement (days/trips)	Available (days/trips)
Johann Zmeskal	**8**	160/18	76/11	65/5	141/16

Jagiellonian Univ. (Poland)

1) Group Leader

Family Name	Skurzok
First Name	Magdalena
Nationality	polish
Home Institution	Jagiellonian University
Legal Status of Home Institution Code [1(1)]	UNI
Home Institution Country Code [(2)]	PL Position Code [(3)] PDOC
Mailing Address	Łojasiewicza 11, 30-348 Kraków
Phone (office)	+48 664 4589
Phone (home)	+48 794 798 868

3) **Project Title** **Investigation of kaonic deuterium atoms with SIDDHARTA-2**

4) **Project Acronym** *(max 20 characters)* KRAKOW@SIDDHARTA-2
(you are not allowed to use acronyms that infringe existing trademarks, registered patents and other similar rights)

5) **Access is requested for the following LNF Facility (tick the item chosen)**:
(X) Particle and Nuclear Physics
( ) Beam test facility

6) **Experimental Setup of interest:** **SIDDHARTA-2**

7) **Duration of the Project:** **8 months**
Starting from 1 January 2021

Researcher	Total No. of Days	No. of visits
Skurzok	80	5
Niedźwiecki	40	3
Silarski	40	3
Khreptak	80	5
Moskal	20	2

	I 2022	II 2022	IV 2022	VI 2022	IX 2022	X 2022	XI 2022
Skurzok	A, B		A,C	A,D		A, D, E	A, D, E
Niedźwiecki		A,B			A,D		A, D, E
Silarski			A,C		A,D	A, D, E	
Khreptak	A,B	A,C	A,C	A,D		A,D,E	
Moskal		A				A, E	

A). Participating in the beam time shifts;

B). Optimization of the data analysis leading to luminosity determination;

C). Optimization and test of the program for the fast online data analysis;

D). Participating in the data analysis leading to kaonic deuterium identification and determination of its properties (shift and width of the 1s state). The analysis includes analysis of:

a) experimental data

b) dedicated Monte Carlo simulations;

E). Taking part in the preparation of articles presenting the obtained results;

Proposal of assignement

Group Leader	Participants	Request (days/trips)	Residuals (days/trips)	New assignement (days/trips)	Available (days/trips)
Magdalena Skurzok	**5**	260/18	51/7	150/8	201/15

Zagbreb Univ. (Croatia)

1) Group Leader

Family Name	Bosnar
First Name	Damir
Nationality	Croatia
Home Institution	Department of Physics, Faculty of Science, Univer. of Zagreb
Legal Status of Home Institution Code [1]	UNI
Home Institution Country Code [2]	HR
Position Code [3]	EXP
Mailing Address	Bijenička 32, 10000 Zagreb
Phone (office)	+0385 1 4605566
Phone (home)	+0385 1 3487406
Fax	+385 1 4680336
e-mail	bosnar@phy.hr

3) **Project Title** _**SIDDHARTA-2 data taking and HPGe test measurements**__

4) **Project Acronym** *(max 20 characters)* __**SIDDHARTA&HPGetest**_____
(you are not allowed to use acronyms that infringe existing trademarks, registered patents and other similar rights)

5) **Access is requested for the following LNF Facility (tick the item chosen)**:

(X) Particle and Nuclear Physics

( ) Beam test facility

6) **Experimental Setup of interest:** __**SIDDHARTA-2**____

7) **Duration of the Project:** _____**8 months**_____

Starting from _____15.01.2022_____

8) **Access Periods Requested under TARI Programme:**

Researcher	**Total No. of Days**	**No. of visits**
Damir Bosnar	**60**	**4**
Mihael Makek	**45**	**4**
Ivana Tucaković	**30**	**3**
Petar Žugec	**30**	**3**

- **contribution of the researchers to the project**

Damir Bosnar will participate in the SIDDHARTA-2 data taking and will have leading role in test measurements with HPGe detector (installation, data taking and data analysis, development of simulations).

Mihael Makek will participate in data taking with SIDDHARTA-2, in data analyses and MCarlo simulations and will participate in the test measurements with HPGe detector (installation and data taking).

Ivana Tucaković will participate in data taking with SIDDHARTA-2 and will participate in test measurements with HPGe detector (data taking and data analysis)

Petar Žugec will participate in data taking with SIDDHARTA-2 and will participate in test measurements with HPGe detector (data taking and development of simulations)

Proposal of assignement

Group Leader	Participants	Request (days/trips)	Residuals (days/trips)	New assignement (days/trips)	Available (days/trips)
Damir Bosnar	**4**	165/14	30/3	100/16	130/19

IFIN - HH (Romania)

1) Group Leader

Family Name Bragadireanu

First Name Alexandru Mario

Nationality Romanian

Home Institution Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH)

Legal Status of Home Institution Code [1] RES

Home Institution Country Code [2] RO Position Code [3] EXP

Mailing Address Reactorului 30, 077125, Magurele, Ilfov, Romania

Phone (office) +40 21 404 23 00 extension 3311

Phone (home) _____

Fax _____

e-mail mario.bragadireanu@nipne.ro

3) **Project Title** **Exotic Atoms Research with SIDDHARTA-2**

4) **Project Acronym** *(max 20 characters)* **EARS-2**
(you are not allowed to use acronyms that infringe existing trademarks, registered patents and other similar rights)

5) **Access is requested for the following LNF Facility (tick the item chosen)**:
(X) Particle and Nuclear Physics
( ) Beam test facility

6) **Experimental Setup of interest:** **SIDDHARTA-2**

7) **Duration of the Project:** **240 days**
Starting from 15.12.2021

8) **Access Periods Requested under TARI Programme:**

Researcher	**Total No. of Days**	**No. of visits**
A.M. Bragadireanu	45	3
P.C. Boboc	15	1
S.A.Ghinescu	15	1

The contribution of the researchers to the project follows the activity described above:

- beam time shifts in 2022 during the SIDDHARTA-2 run;
- analysis of the data collected during the SIDDHARTA-2 run;
- Monte Carlo simulations for the optimization of the degrader;
- calibration and optimization of the new 1mm thick SDDs in laboratory;
- development of a new interface in LabView software for the DCS;
- integration of the new DCS in DAQ and Slow Control systems;

Proposal of assignement

Group Leader	Participants	Request (days/trips)	Residuals (days/trips)	New assignement (days/trips)	Available (days/trips)
Alexandru Mario Bragadireanu	**3**	75/5	15/1	50/2	65/3

Santiago de Compostela (Spain)

1) Group Leader

Family Name _____Romero Vidal_____

First Name _____Antonio_____

Nationality _____Spain_____

Home Institution _ Instituto Galego de Física de Altas Enerxías (IGFAE), Universidade de Santiago de Compostela (USC), Spain _____

Legal Status of Home Institution Code (1) _____UNI_____

Home Institution Country Code (2) ___ES_____Position Code (3) _____EXP_____

Mailing Address _ Facultad de Física – Bloque IV - Campus Vida - Santiago de Compostela _

Phone (office) _____

Phone (home) _____0034677600193_____

Fax _____

e-mail _____antonio.romero@usc.es_____

3) **Project Title** __ **Kaonic Atoms at SIDDHARTA-2**_____

4) **Project Acronym** *(max 20 characters)* _____ IGFAE-Kd _____
(you are not allowed to use acronyms that infringe existing trademarks, registered patents and other similar rights)

5) **Access is requested for the following LNF Facility (tick the item chosen)**:
(X) Particle and Nuclear Physics
( ) Beam test facility

6) **Experimental Setup of interest:** ___ **SIDDHARTA-2 at DAFNE** _____

7) **Duration of the Project:** _____**6 months** _____
Starting from _____15th November 2021_____

8) **Access Periods Requested under TARI Programme:**

Researcher	**Total No. of Days**	**No. of visits**
Romero Vidal, Antonio	**20**	**1**

Contribution of the researchers to the project

- Participation in beam time shifts and data analysis. The requested funding for traveling and stay at Frascati will allow me to perform shift for the data taking of the experiment.
- Improvement of the MC simulation. Some of the parameters of the MC must be tuned in order to improve the data/MC agreement.

Schedule of work

During the proposed TARI period, I will participate in the data taking shifts. In the same time, I shall contribute to the analysis of the data and to the optimization of the Monte Carlo for the SIDDHARTA-2 experiment. Visits in the framework of TARI to LNF-INFN are fundamental for the proposed objectives.

Proposal of assignement

Group Leader	Participants	Request (days/trips)	Residuals (days/trips)	New assignement (days/trips)	Available (days/trips)
Antonio Romero Vidal	1	20/1	10/1	5/0	15/1

Summary of proposal

	Group Leader	Participants	Request (days/trips)	Residuals (days/trips)	New assignement (days/trips)	Available (days/trips)
10	Johann Zmeskal	8	160/18	76/11	65/5	141/16
11	Magdalena Skurzok	5	260/18	51/7	150/8	201/15
12	Laura Fabbietti	2	70/5	10/2	50/1	60/3
13	Damir Bosnar	4	165/14	30/3	100/16	130/19
14	Alexandru Mario Bragadireanu	3	75/5	15/1	50/2	65/3
15	Antonio Romero Vidal	1	20/1	10/1	5/0	15/1
		SIDDHARTA -2	750/61	192/25	420/32	612/57