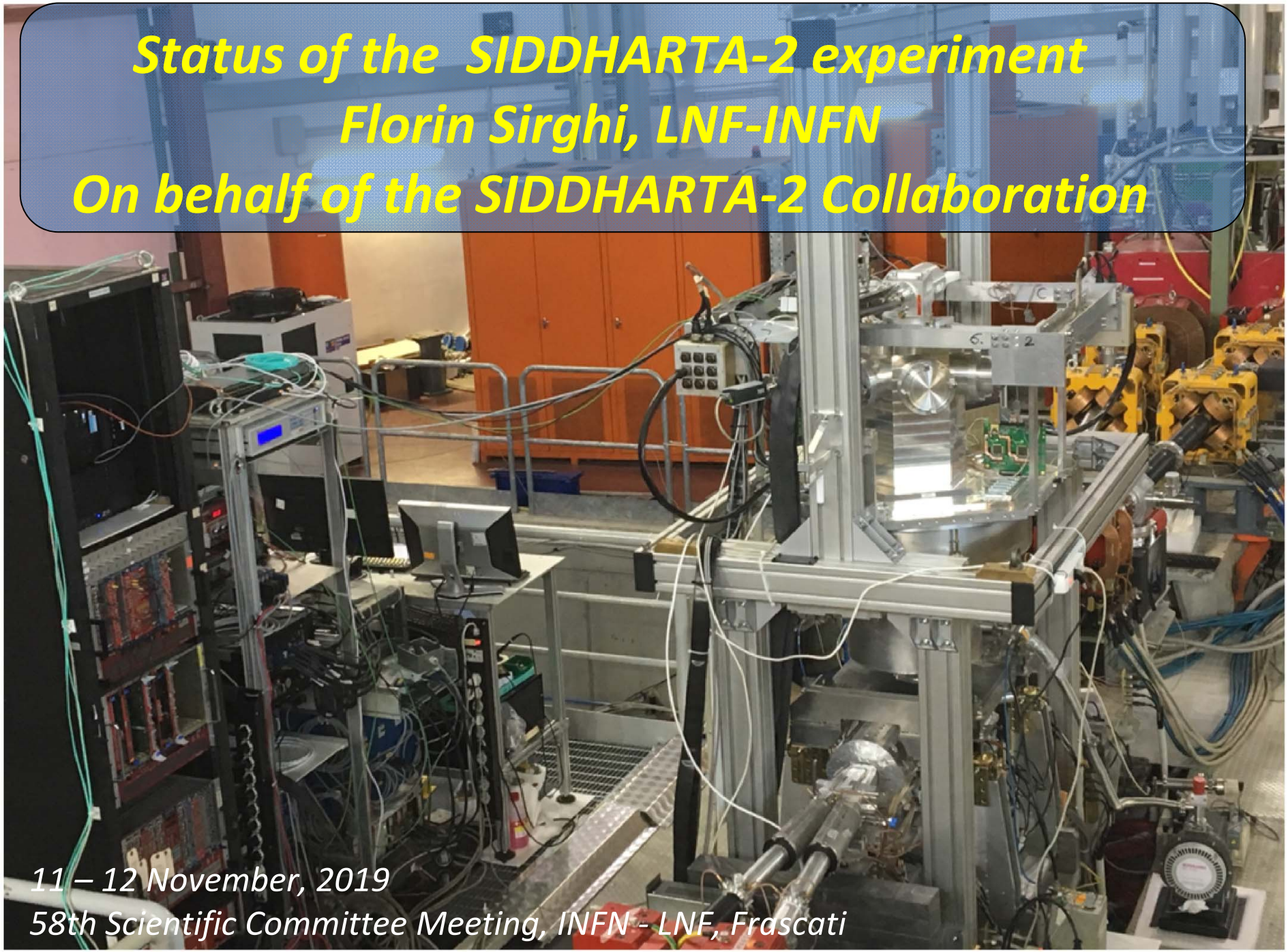
Status of the SIDDHARTA-2 experiment

Florin Sirghi, LNF-INFN
On behalf of the SIDDHARTA-2 Collaboration



11 – 12 November, 2019
58th Scientific Committee Meeting, INFN - LNF, Frascati

SIDDHARTA-2 Collaboration

SIlicon Drift Detector for Hadronic Atom Research by Timing Applications

LNF-INFN, Frascati, Italy
SMI-OAW, Vienna, Austria
Politecnico di Milano, Italy
IFIN-HH, Bucharest, Romania
TUM, Munich, Germany
RIKEN, Japan
University Tokyo, Japan
Victoria University, Canada
University of Zagreb, Croatia
Jagiellonian University, Krakow, Poland
Research Center for Electron Photon science, Japan
Tohoku University, Japan

HadronPhysics2 Study of Strongly Interacting Matter

HadronPhysics I3 Study of Strongly Interacting Matter

FWF Der Wissenschaftsfonds.

Farnesina Ministero degli Affari Esteri e della Cooperazione Internazionale

STRONG-2020

Croatian Science Foundation, research project 8570

CONTENT

1. SIDDHARTINO setup installed on DAΦNE: present status

2. Commissioning of SIDDHARTINO in DAΦNE:

calibration of the SDD detectors
optimizations during the summer shutdown
luminosity monitors crosscheck

3. Strategy and future plans

4. Feasibility tests for future kaonic atoms measurements

SIDDHARTA-2 - present status

We are presently in Phase 1 with SIDDHARTINO:

during the commissioning of DAΦNE we run with the SIDDHARTINO setup aiming to the K-^{4}He measurement (with 8 SDD arrays)

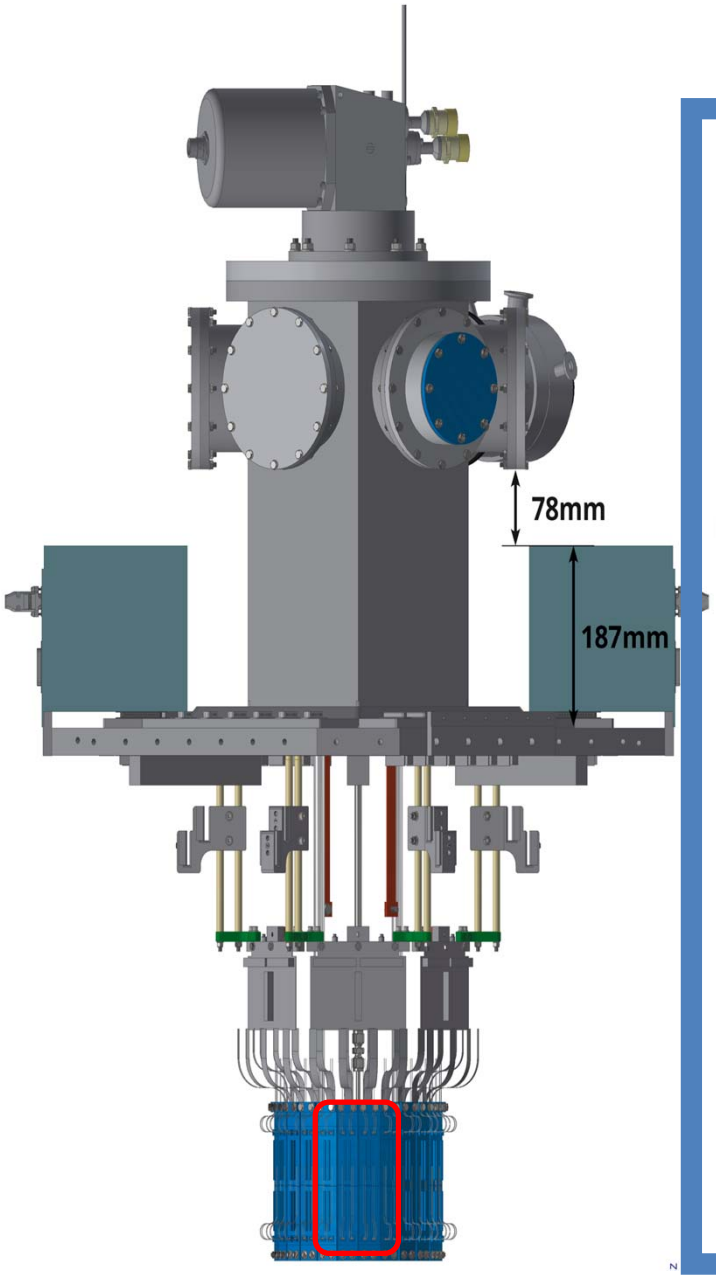
SIDDHARTINO was installed on DAΦNE in April 2019

The summer 2019 shutdown period was used for optimization and debugging

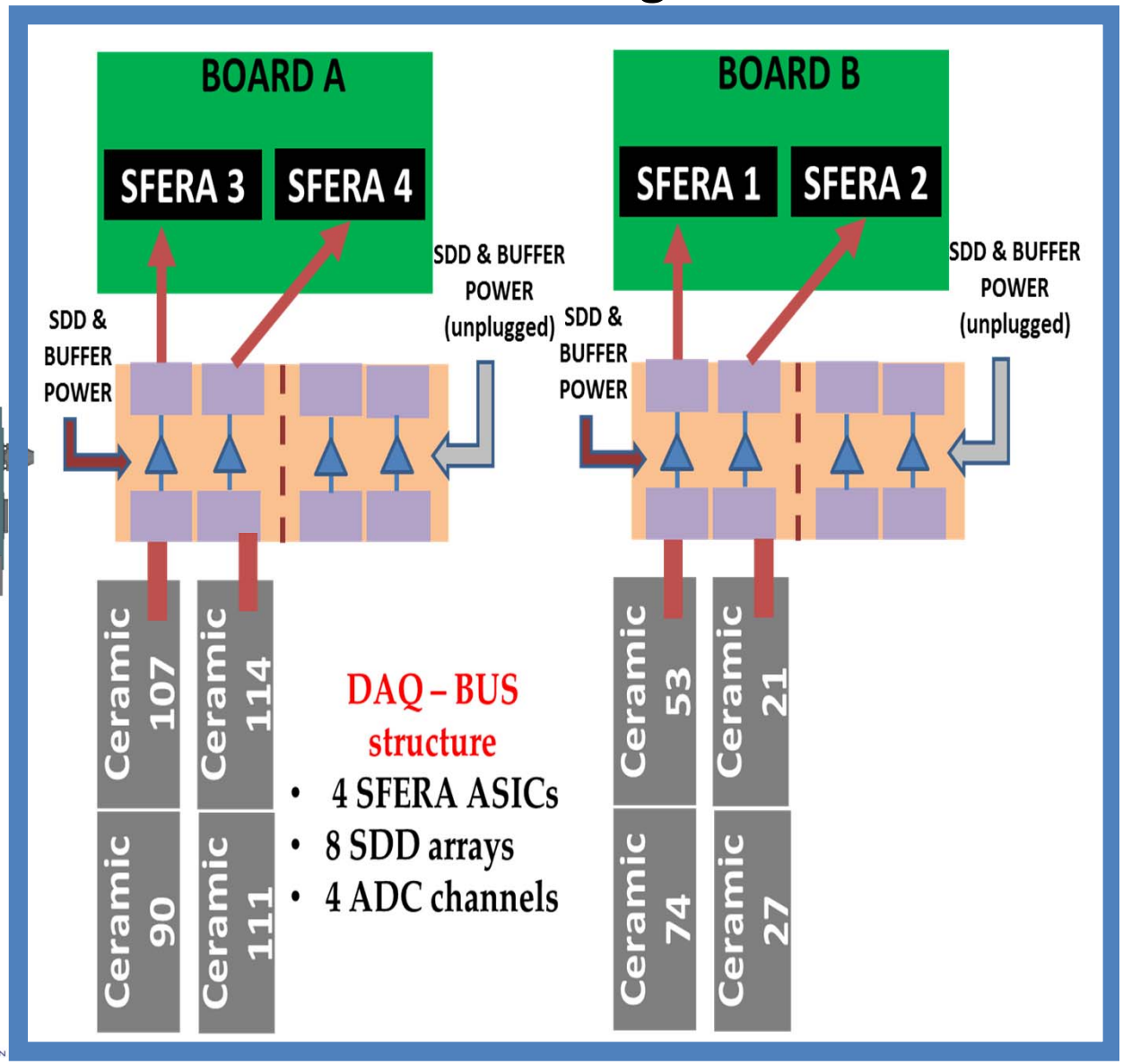
Restart operation with beam in September

(according to the DAΦNE schedule)

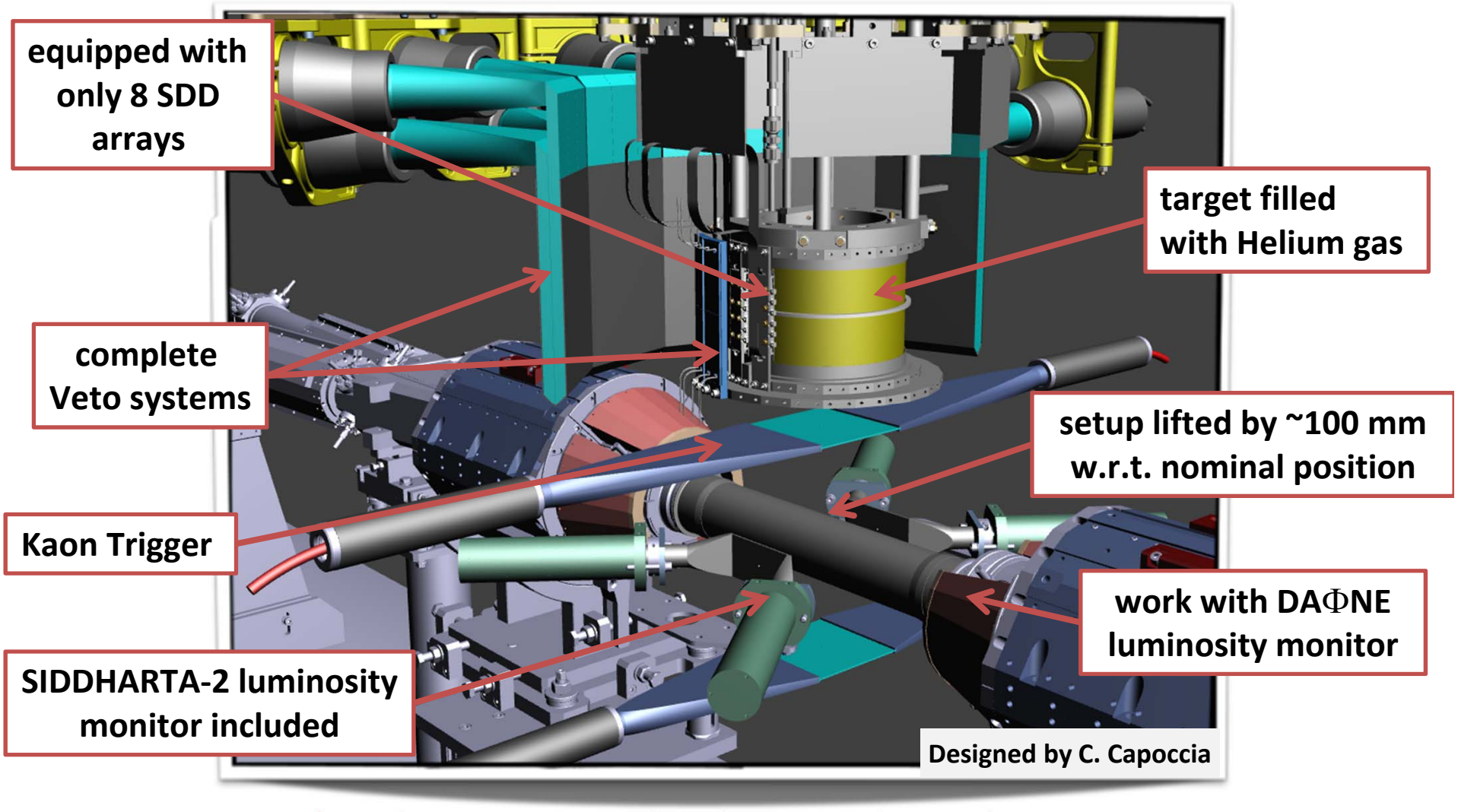
SIDDHARTINO = SIDDHARTA-2 with 8 SDD's



DAQ BUS configuration

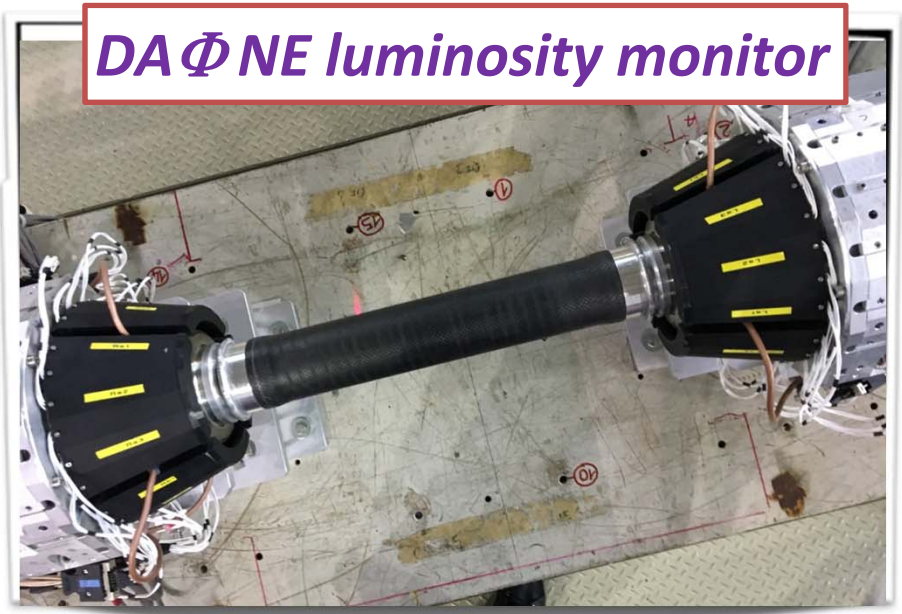


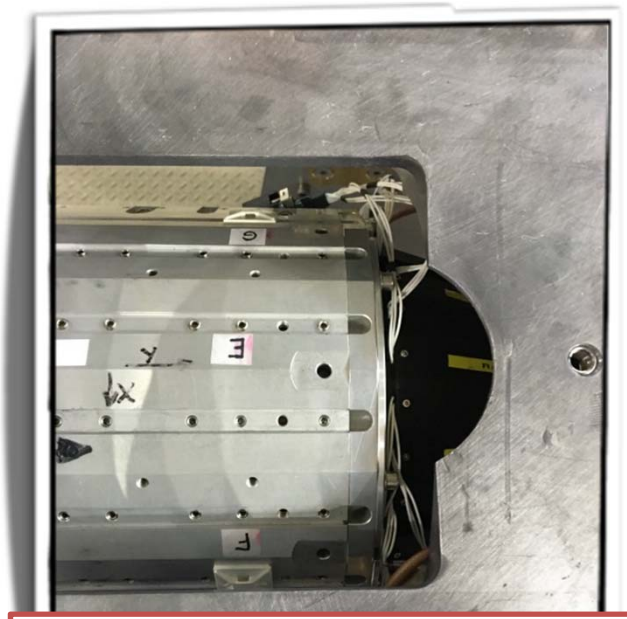
SIDDHARTINO apparatus



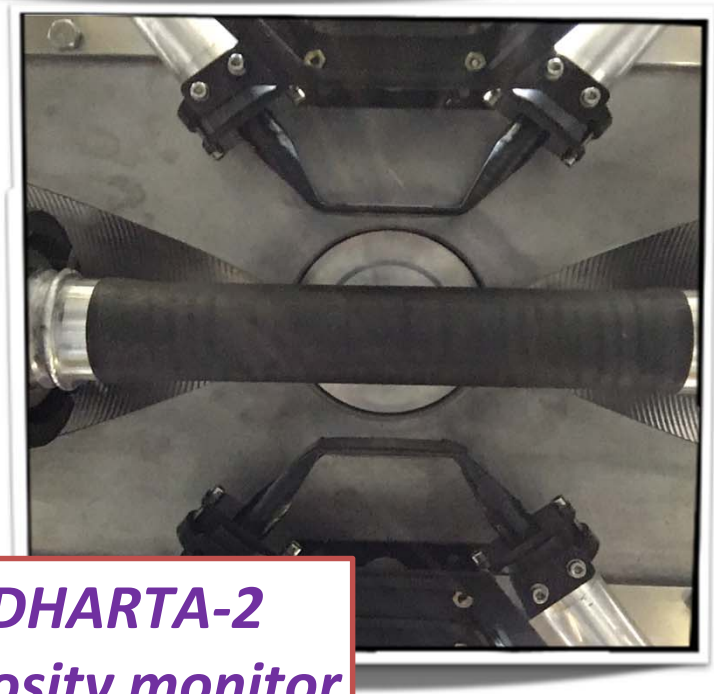
Aim: verify when DAΦNE background conditions are similar to the one in SIDDHARTA 2009

DAΦNE luminosity monitor

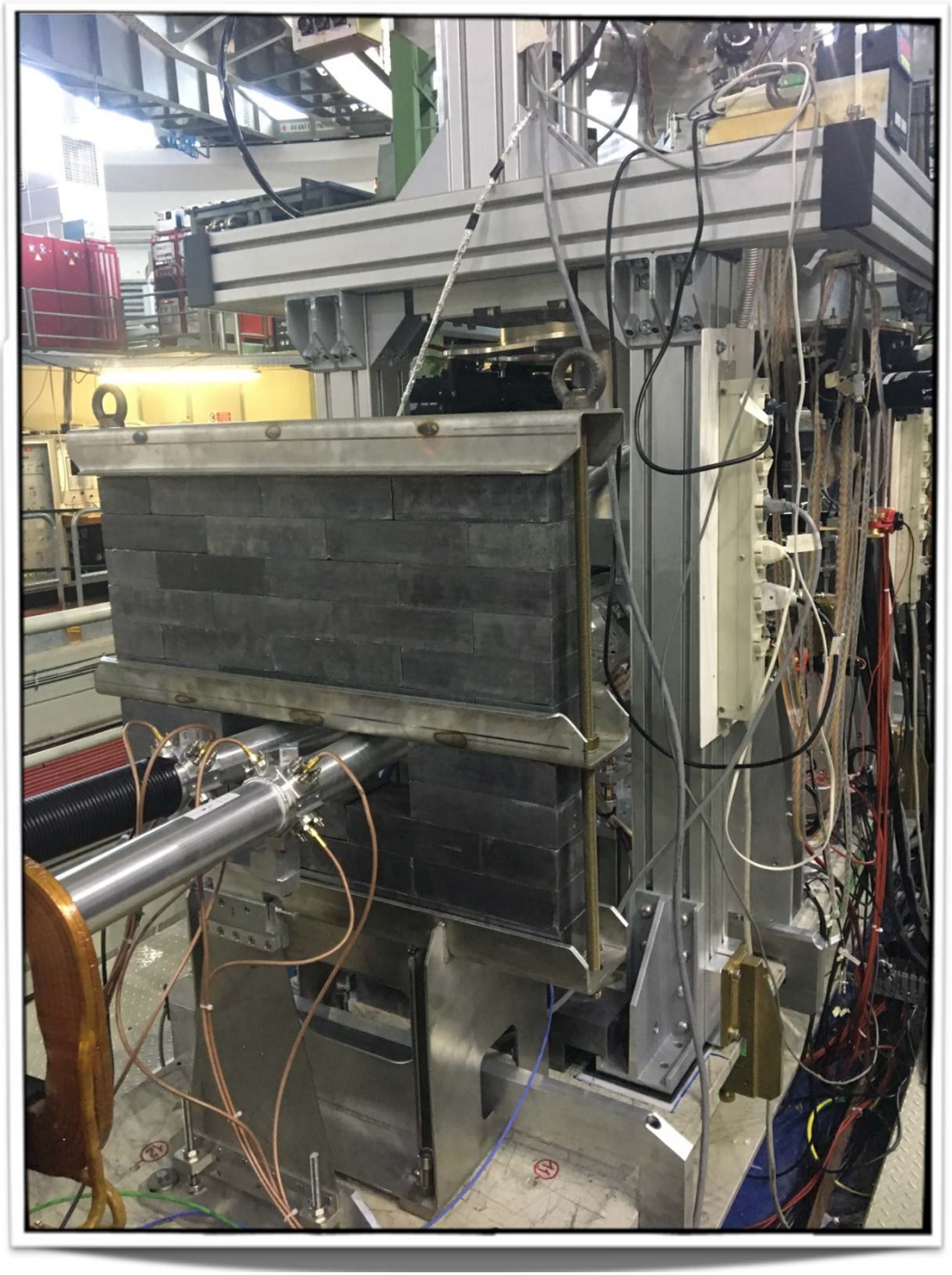




Shielding optimization



SIDDHARTA-2
luminosity monitor



SIDDHARTINO

lateral shielding

completed in summer shutdown period

Commissioning of SDD's in DAΦNE

- ***Test of the first signals in the accelerator environment***

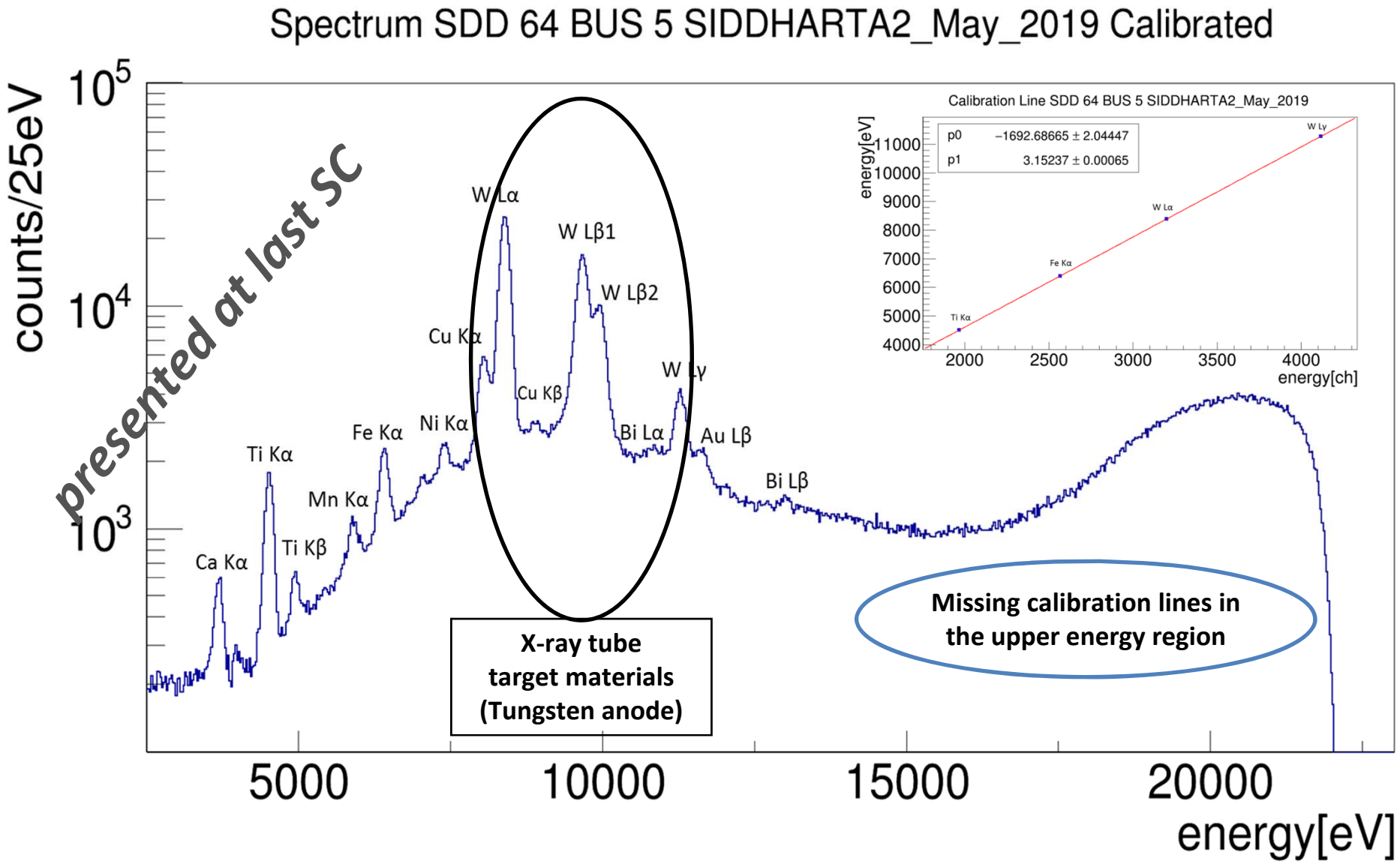
  front-end electronics (SFERA) - SDD coupling
  noise test
  EMI/RFI filters on power lines

- ***Tuning of the power supply parameters***

- ***Calibration with the x-ray tube***

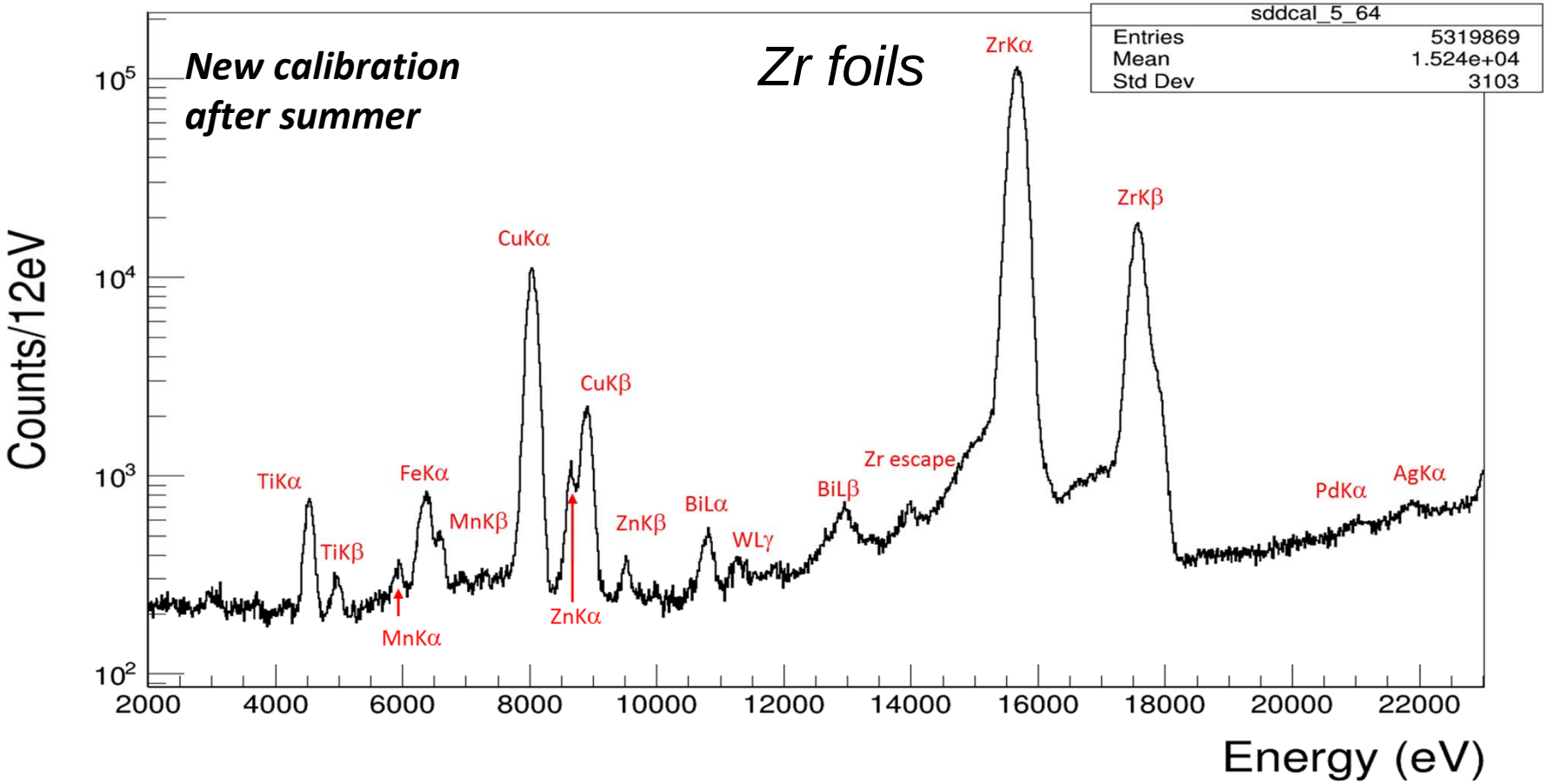
- ***Comparison of data with x-ray tube***

First calibration of SDD's in DAΦNE



Calibration of SDD's in DAΦNE ***autumn 2019***

… more optimization in the summer shutdown period
change calibration materials, filters on x-ray tubes

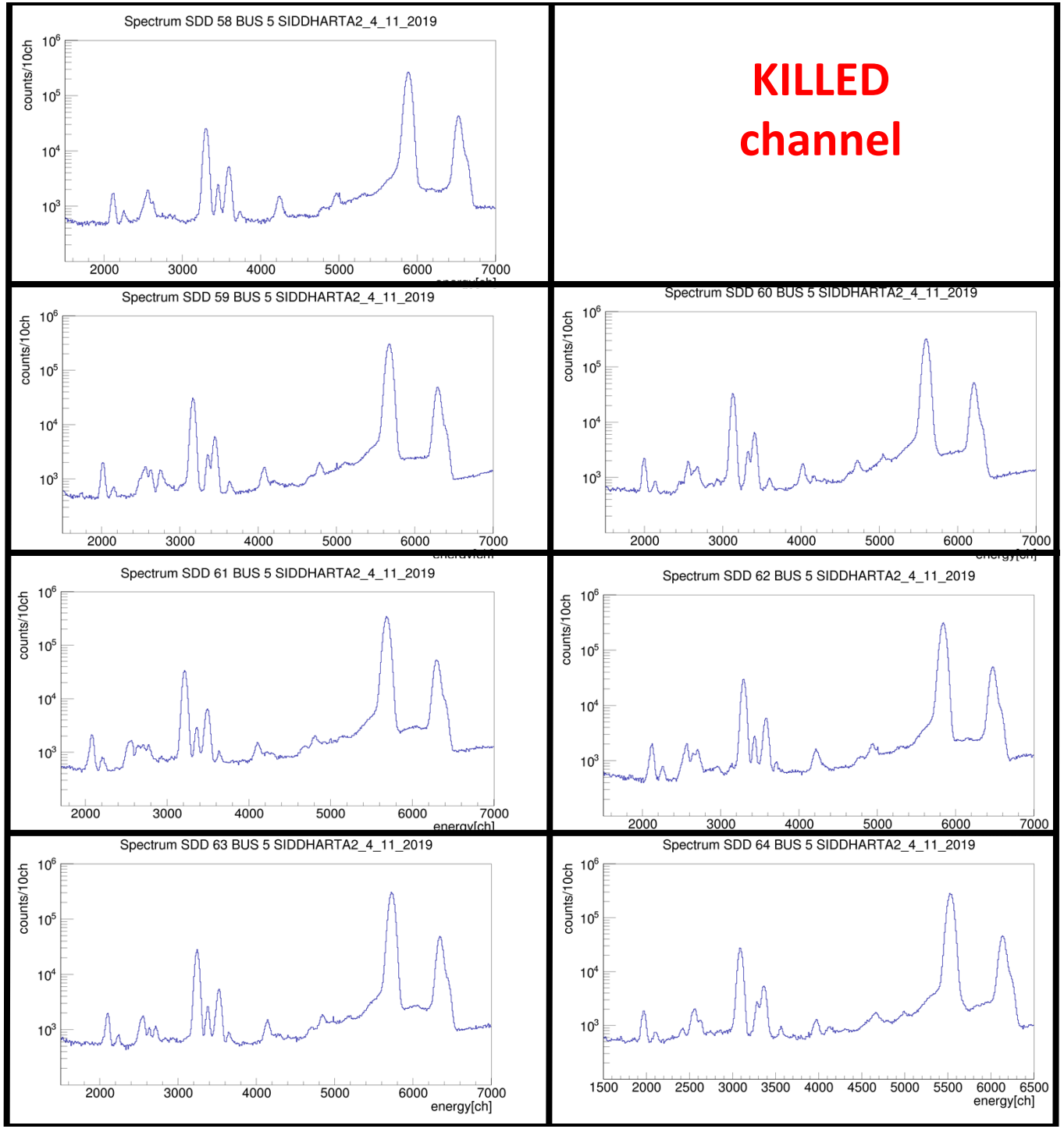


… suppress the activation on the target materials

SDD CERAMIC 53

Check the working Channels

The resolution obtained in DAFNE is compatible with the one from laboratory measurements (FWHM ~190 eV at Cu line)

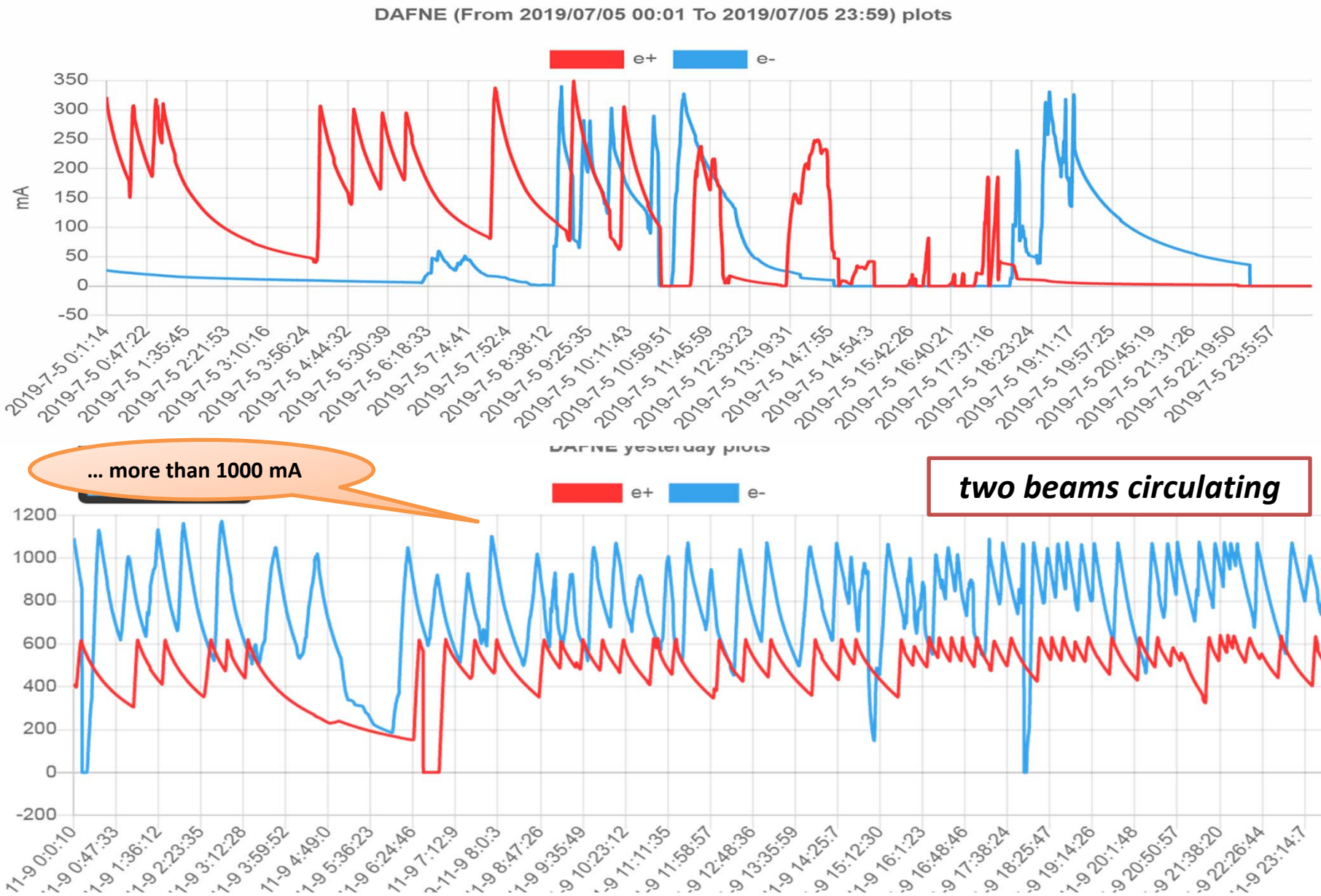


Laboratory results

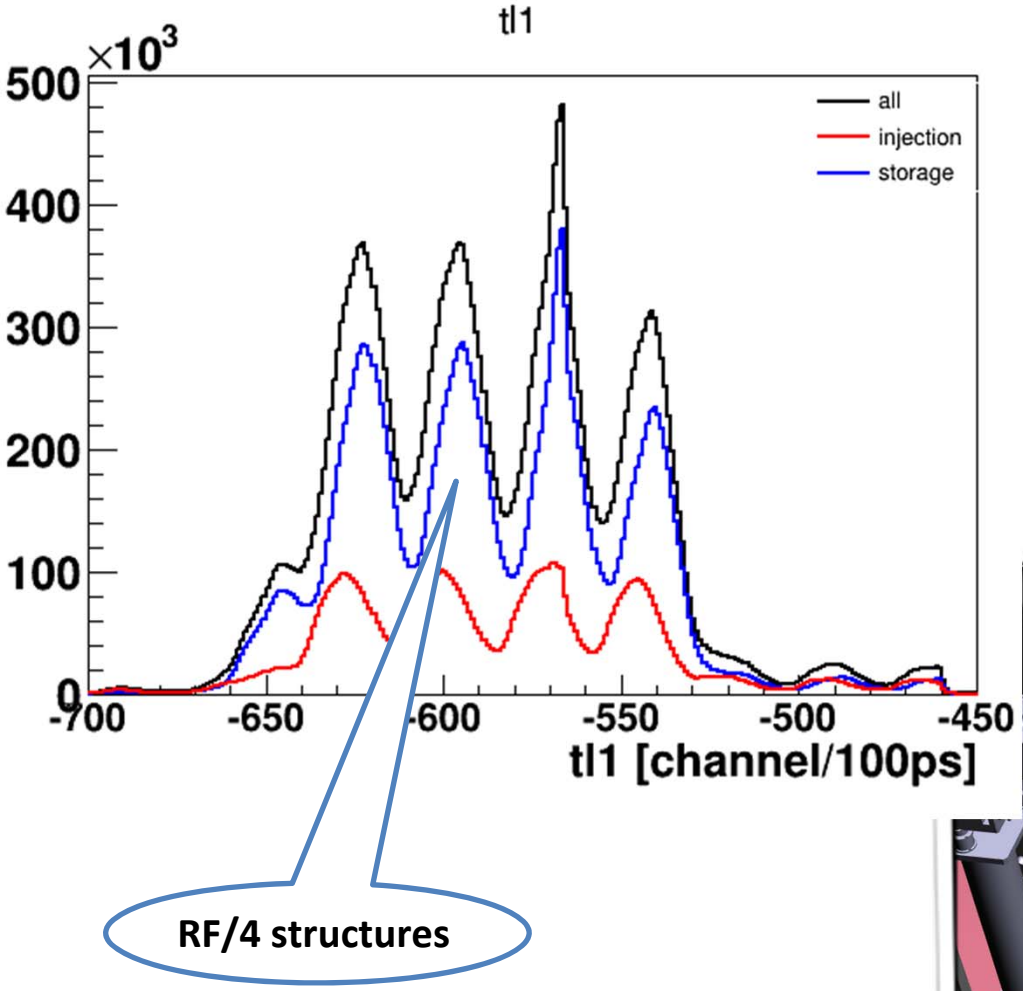
Connector			
I	Silver	II	Not Working
III	Silver	IV	Wood
V	Silver	VI	Wood
VII	High Leakage	VIII	Silver

7/8 channels working

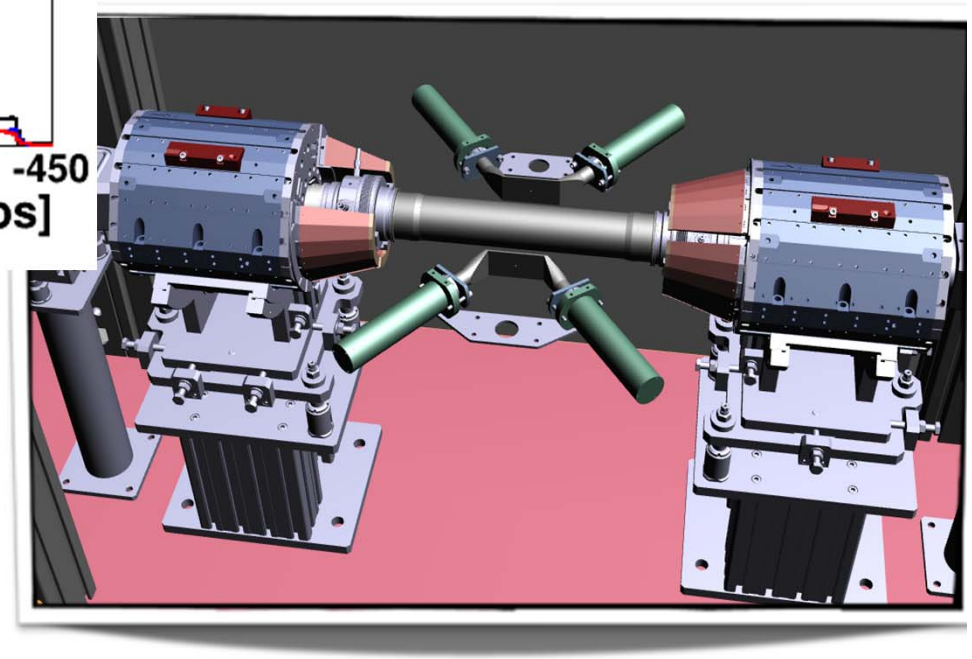
Circulating beam in DAΦNE



SIDDHARTA-2 Luminosity monitor



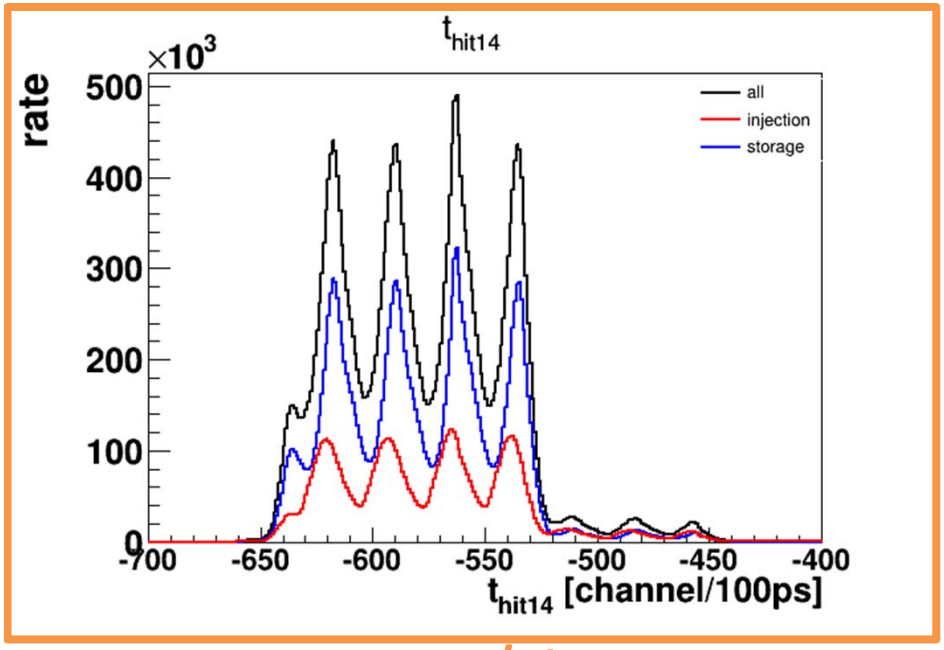
- 2 pairs of scintillator:
  $80x40x2mm^3$ Scionix EJ-200
- R4998 PMTs Hamamatsu
- light-guides
- aluminum tube+μMetal (0.1mm)
- reflective and light proof foil
- optical cement



SIDDHARTA-2 Interaction regions

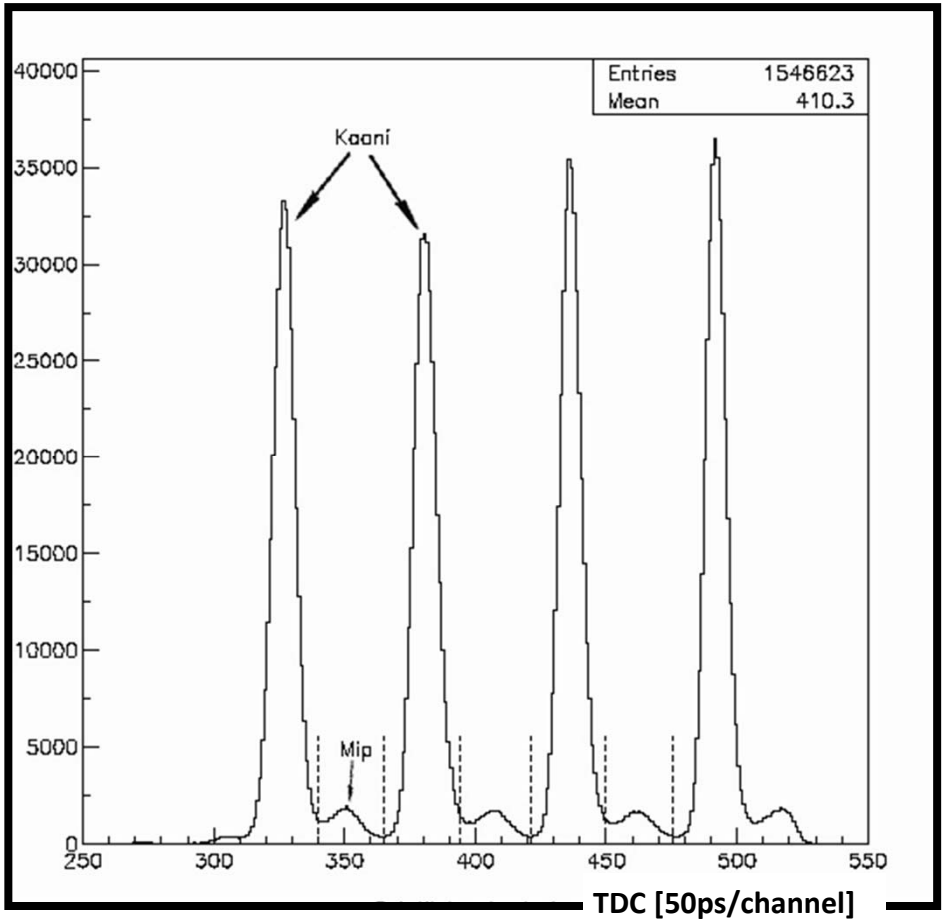
Luminosity ~ 10^{32} cm^{-2} s^{-1}
Expected rate ~ 50-60 Hz

SIDDHARTA-2 Luminosity monitor



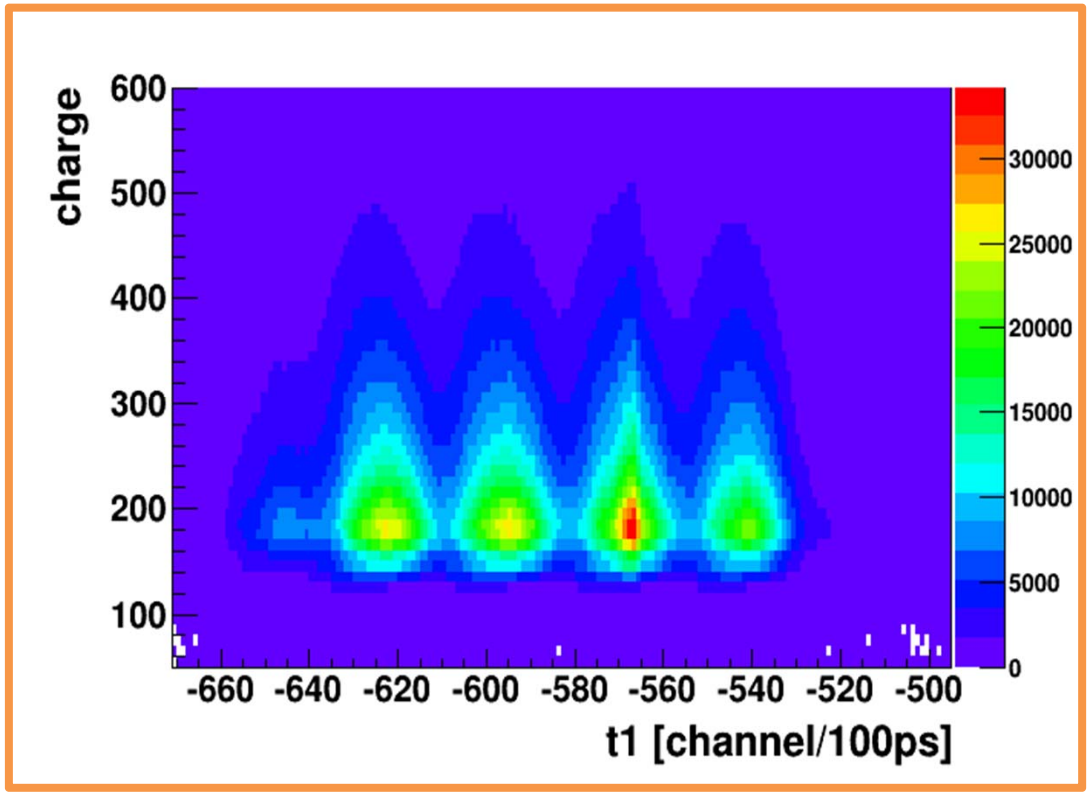
new data

TDC data of the inner scintillator



- ***check of the interaction point stability***
- ***measurement of the crossing angle***

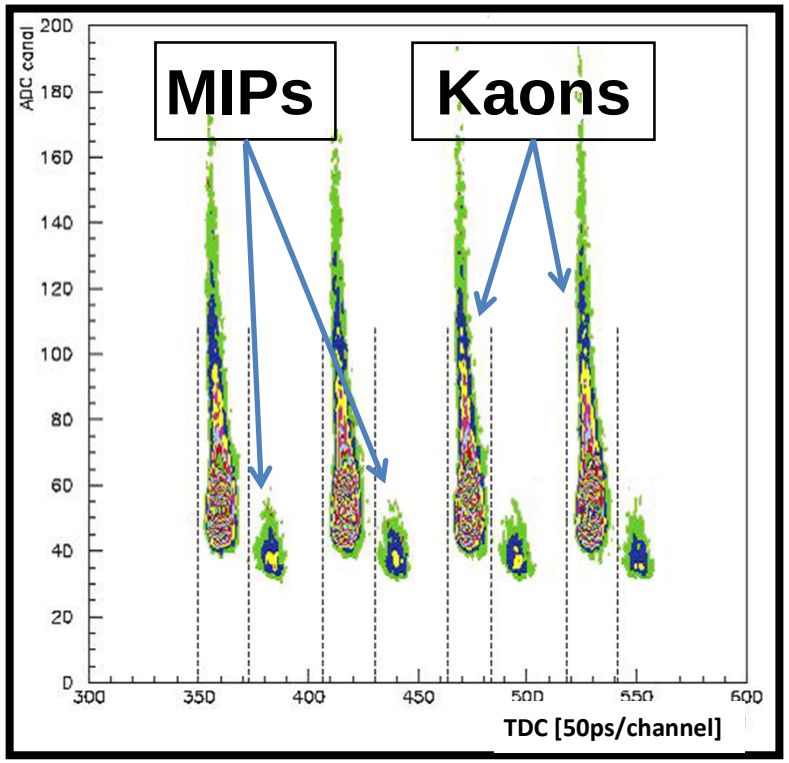
Collision data with a similar system in the past - DEAR kaon Monitor



new data

TDC vs ADC correlation

important tool for machine optimization

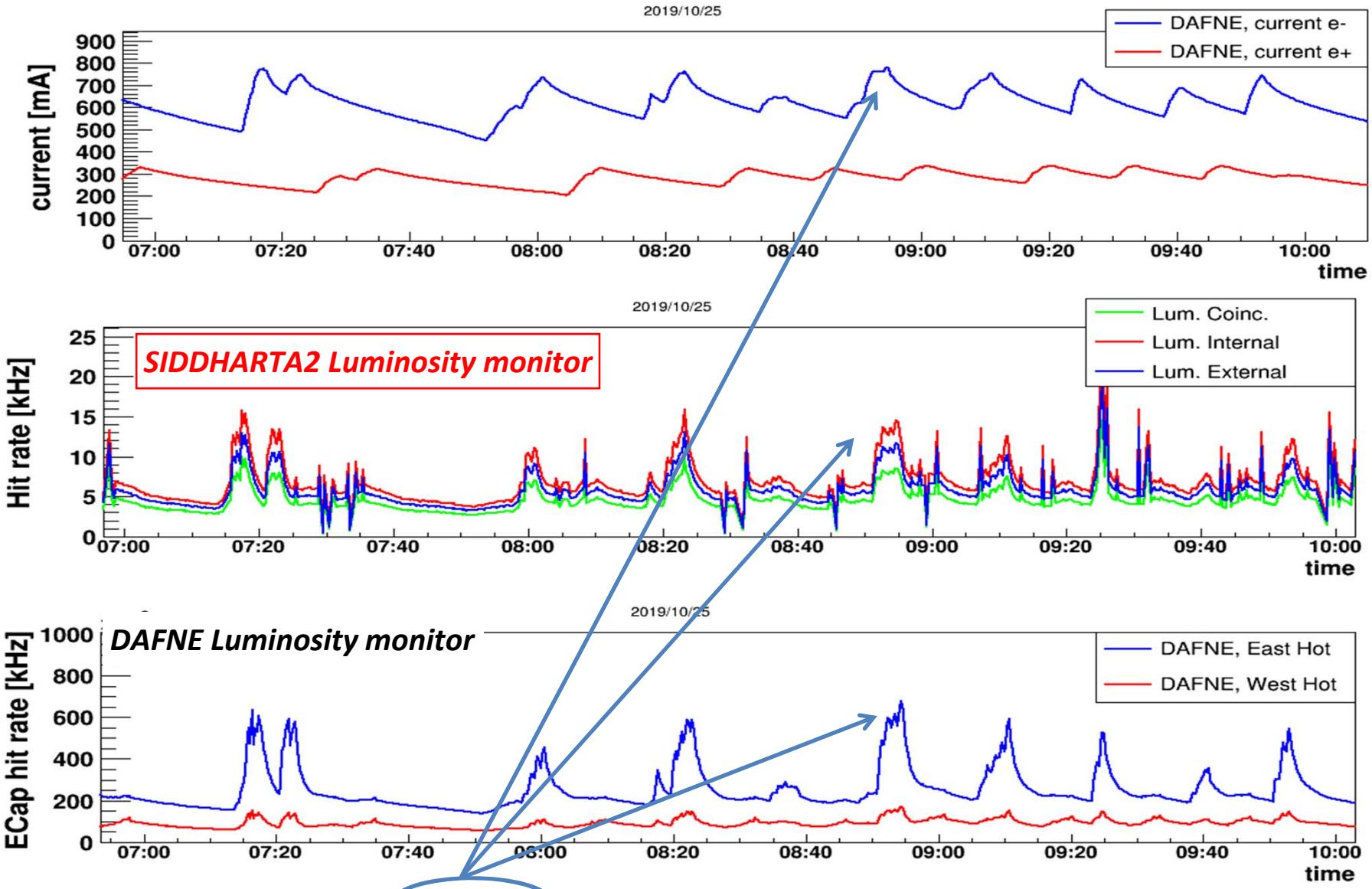


DEAR data

Work to be done after the first collisions:

- **threshold optimization**
- **Kaons/MIPs separation**
- **Background estimation**
- **luminosity estimation**

Luminosity monitors – online and offline crosscheck



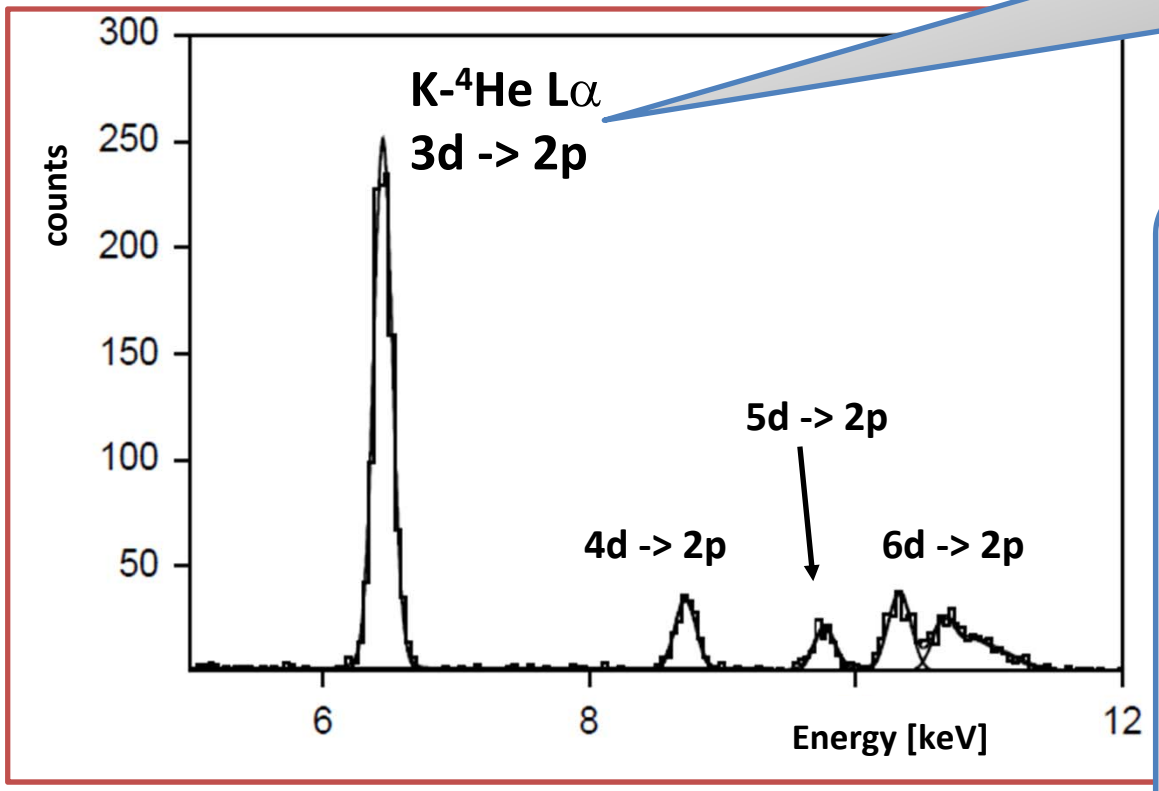
The beam *behavior* is registered by the two independent monitors

important tools for machine optimization

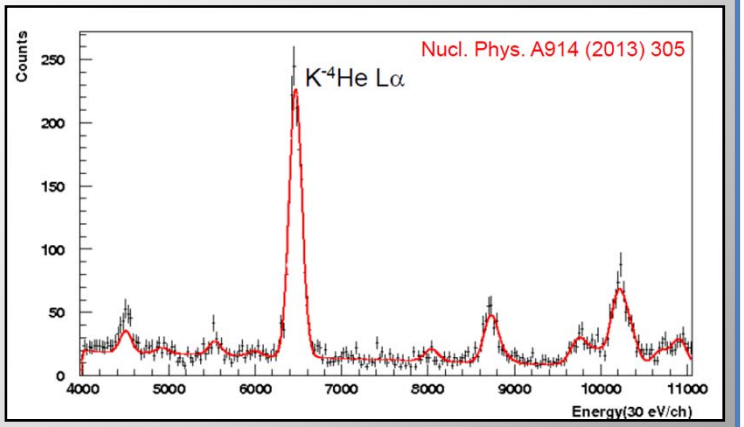
SIDDHARTINO aim – K-^{4}He test measurement

SIDDHARTINO expected spectrum for ~ 50 pb^{-1}
(one week of data taking in SIDDHARTA-like conditions)

About 1000 events in La peak, S/B > 100/1
(ideally should be 300/1)
Position precision :
6.452 +- 0.002 (stat) keV



SIDDHARTA 2009 measurement



S/B was 10/1 for the K-^{4}He measurement with ~ 30 pb^{-1}

SIDDHARTA-2 K-d measurement

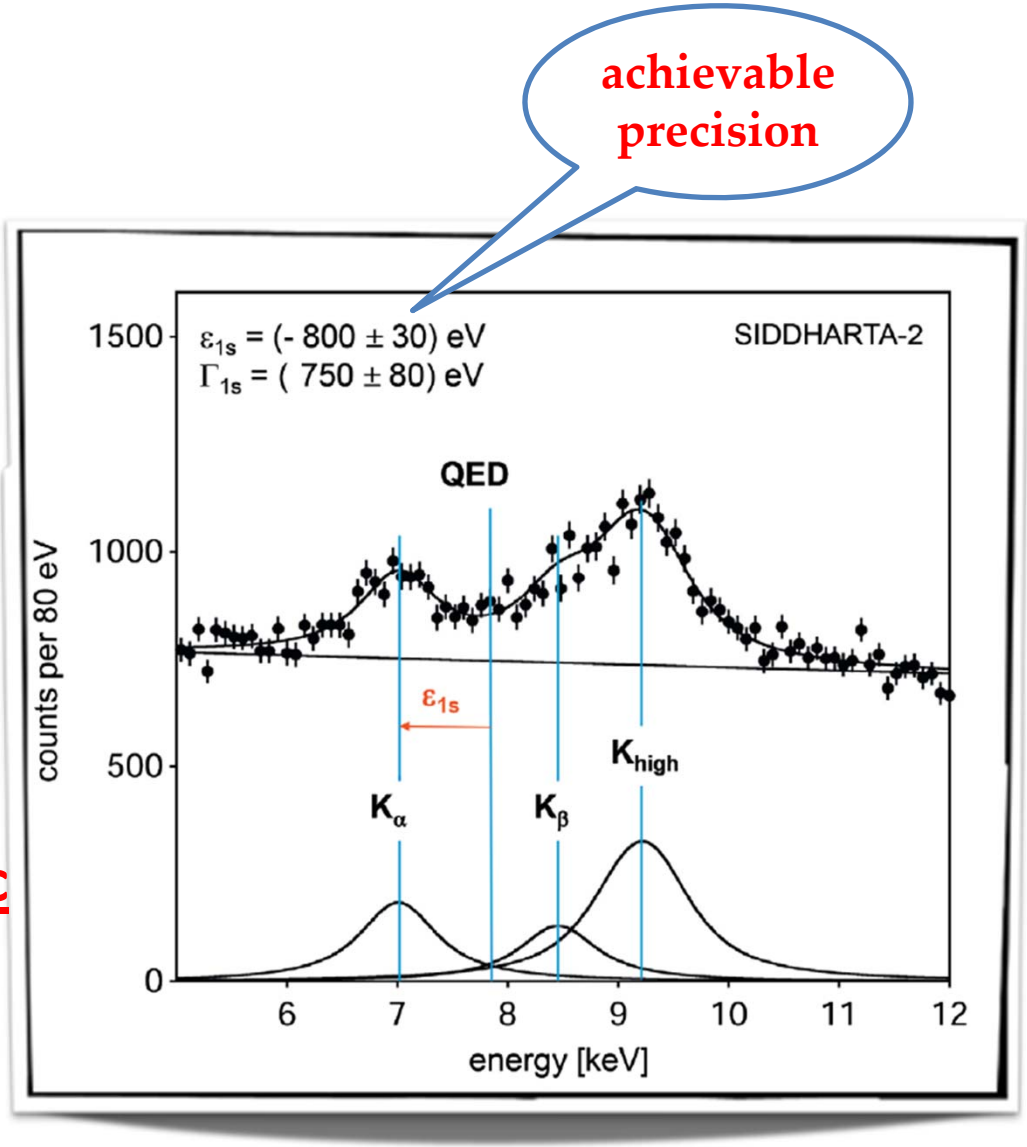
Kaonic deuterium run in

2020/2021

for S/B as 1/3:

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) !



SIDDHARTA-2 strategy and plan

Phase 1
SIDDHARTINO

during the commissioning of DAΦNE:
Run with SIDDHARTINO for optimization of run conditions, verified with the measurement of K-^{4}He (8 SDD arrays) until S/B better than 100/1

Phase 2
SIDDHARTA-2

Kaonic deuterium measurement
(48 SDD arrays) for a run of 800 pb^{-1}

- First run with SIDDHARTA-2 setup as existent (about 300 pb^{-1} integrated);
- Second run with a new veto2 second layer optimized shielding, readout electronics and other optimizations (for other 500 pb^{-1} integrated);

Test runs for other kaonic atoms measurements

Feasibility tests for future measurements

GEKA **proposal**

presented at DAΦNE as Open Accelerator Test Facility, LNF December 17, 2018

Precision measurement of X and gamma-ray transitions in selected Kaonic Atoms with High Purity Germanium detectors

"A Report will be presented at the next SC meeting"

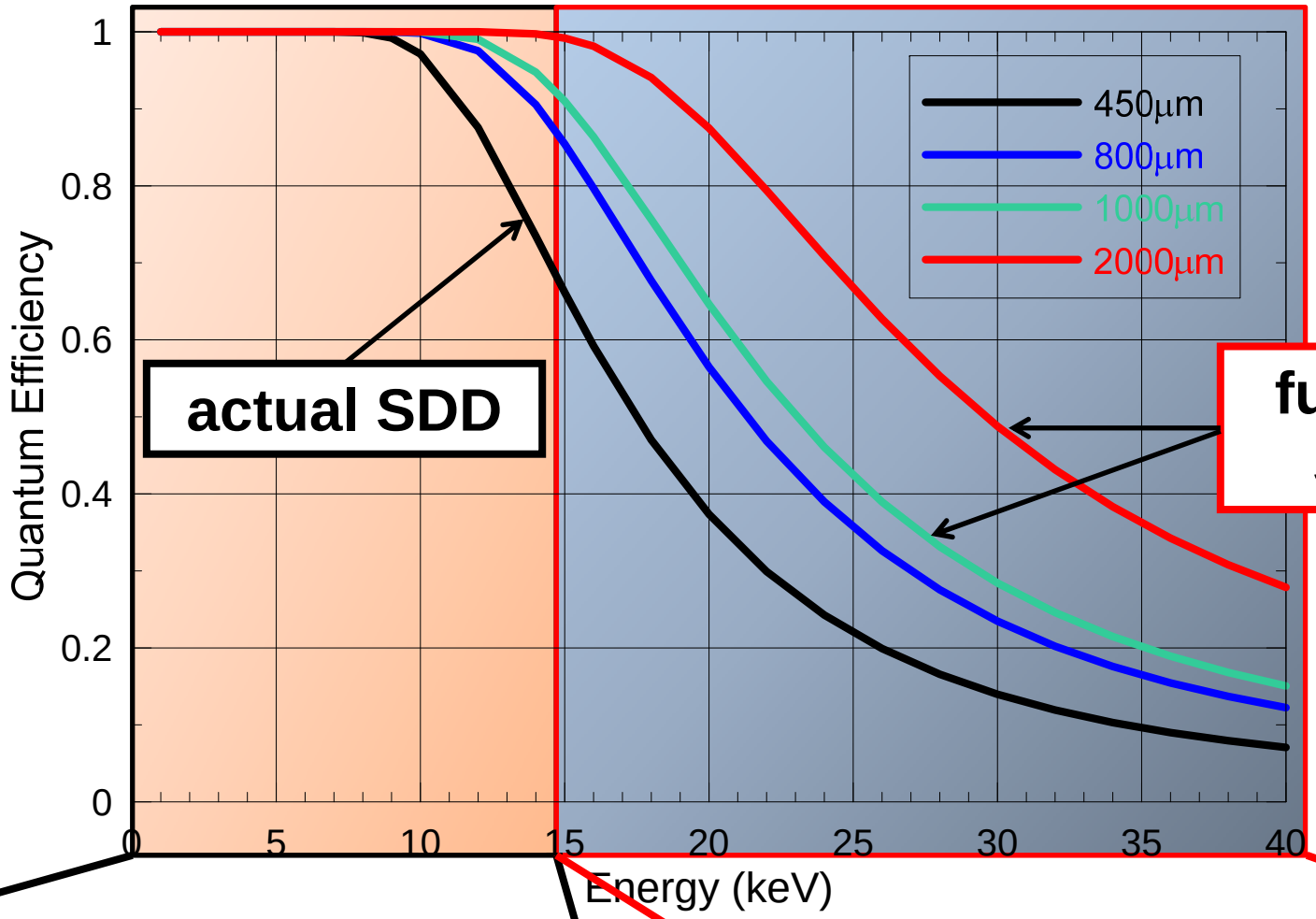
Dedicated talk by prof. Damir Bosnar from Zagreb University

New development of thick (1 - 2 mm) SDD's

for study of other kaonic light atoms

may increase by x2 - x4 the efficiency @30keV

Thicker SDD's for larger efficiency at Energy > 15 keV



present measurements

Kaonic Deuterium → to 1s transitions ~ 7 keV

Kaonic Hydrogen → to 1s transitions ~ 6 keV

future measurements

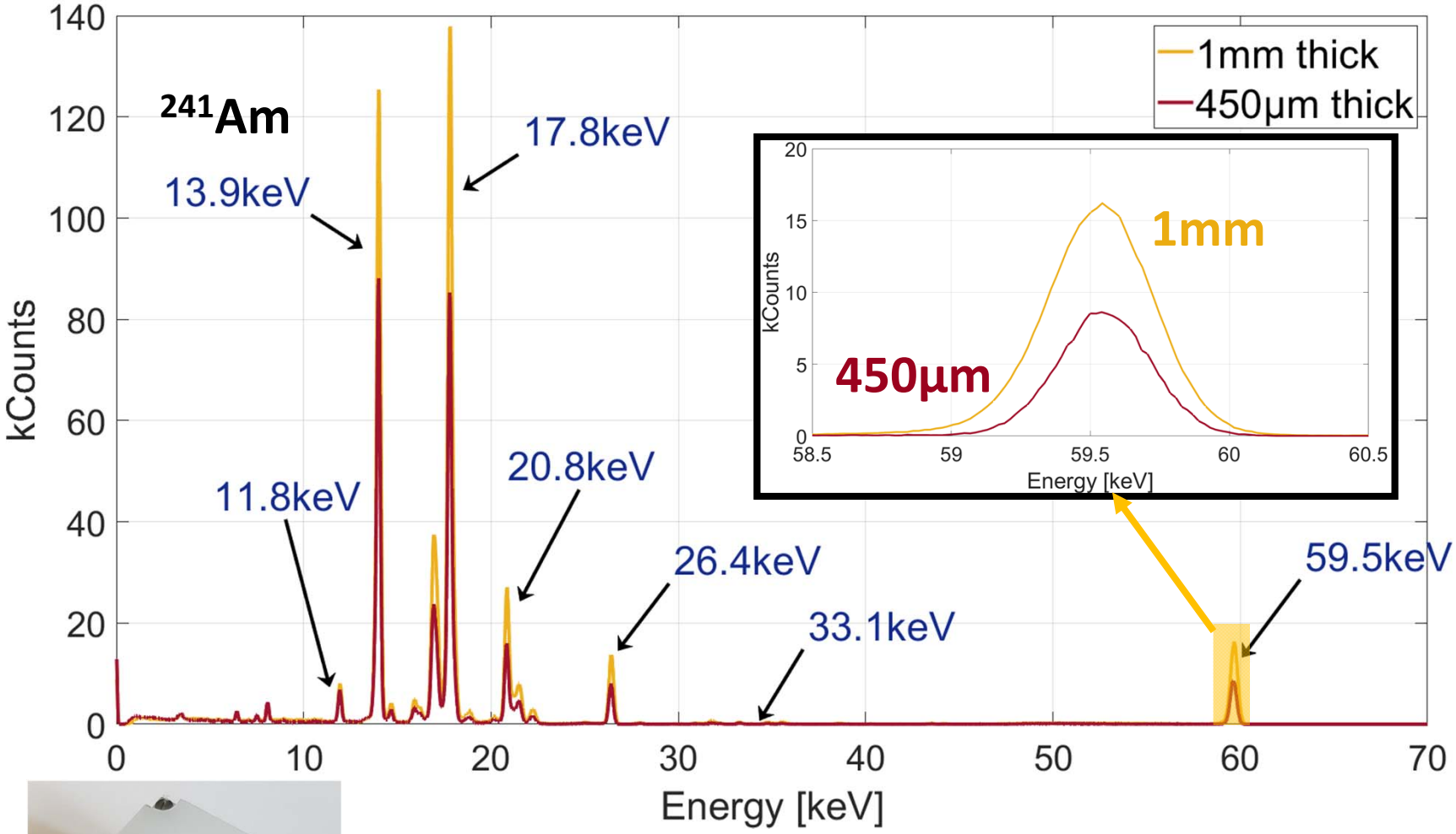
Kaonic ^{8}Be → to 2p transitions ~ 27 keV

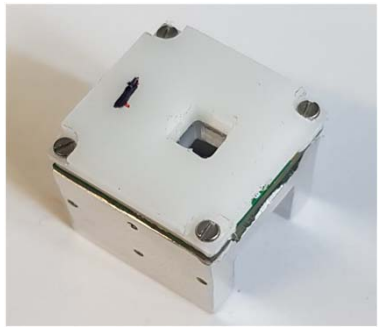
Kaonic ^{6,7}Li → to 2p transitions ~ 15-18 keV

Kaonic ^{10,11}B → to 3d transitions ~ 15 keV

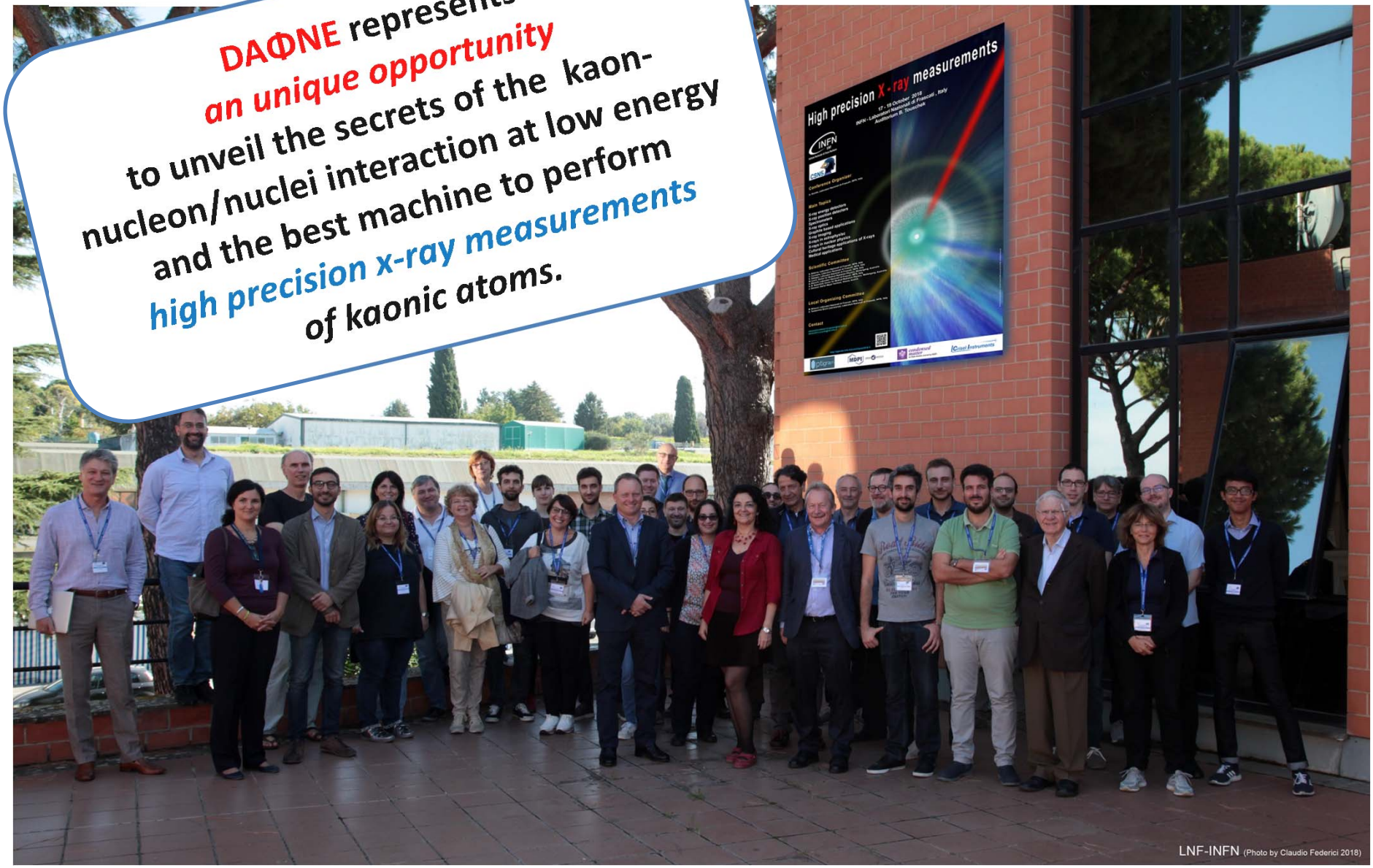
Kaonic ^{10,11}B → to 2p transitions ~ 45 keV

Preliminary tests on 1mm thick SDD

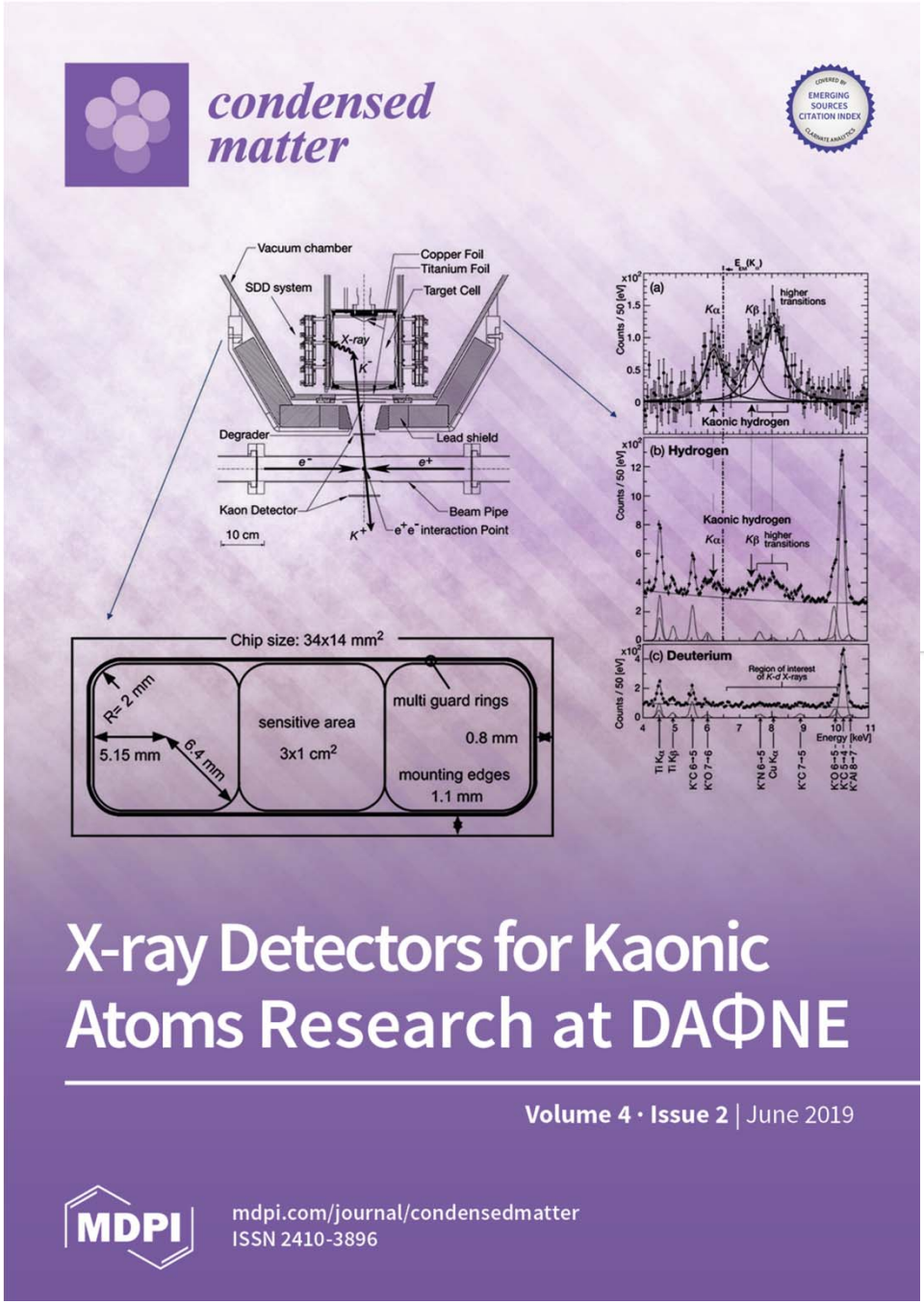




single SDD 5x5mm² square
operation temperature = -40°C
measurement performed at Politecnico di Milano
©1mm SDDs prototypes already produced by FBK Trento



The R&D work and the progress in detector development - dedicated workshop at LNF



***Condensed Matter*, Volume 4, Issue 2 (June 2019)**
https://doi.org/10.3390/condmat4020042
(This article belongs to the Special Issue
High Precision X-Ray Measurements)

condensed matter
MDPI

Article

X-ray Detectors for Kaonic Atoms Research at DAΦNE

Catalina Curceanu [1], Aidin Amirkhani [2], Ata Baniahmad [2], Massimiliano Bazzi [1], Giovanni Bellotti [2], Carolina Berucci [1,†], Damir Bosnar [3], Mario Bragadireanu [4], Michael Cargnelli [5], Alberto Clozza [1], Raffaele Del Grande [1], Carlo Fiorini [2], Francesco Ghio [6], Carlo Guaraldo [1], Mihail Iliescu [1], Masaiko Iwasaki [7], Paolo Levi Sandri [1], Johann Marton [5], Marco Miliucci [1], Pavel Moskal [8], Szymon Niedźwiecki [8], Shinji Okada [7], Dorel Pietreanu [1,4], Kristian Piscicchia [1,9], Alessandro Scordo [1], Hexi Shi [1,‡], Michal Silarski [8], Diana Sirghi [1,4,*], Florin Sirghi [1,4], Magdalena Skurzok [8], Antonio Spallone [1], Hideyuki Tatsuno [10], Oton Vazquez Doce [1,11], Eberhard Widmann [5] and Johann Zmeskal [5]

STRANEX: Recent progress and perspectives in STRANge EXotic atoms studies and related topics

21 - 25 October 2019, ECT Trento, Italy*

The STRANEX workshop was focused on the most recent achievements and open problems in the studies of strange exotic atoms & related topics.

The workshop addressed questions as:

How does QCD behave at very low-energies in systems with strangeness and how strange exotic atoms contribute to its understanding?

What is the nature of Lambda(1405) and how strongly bound are kaonic nuclei?

What is the role of strangeness in neutron stars?

4. Nuclear Physics (CSN3)

From kaonic atoms to strangeness in neutron stars

by Wolfram Weise (ECT* Trento and TU Munich)

Friday 6 Dec 2019, 14:30 → 17:00 Europe/Rome

Aula Leale (LNF)

Description An updated review is presented of the theory of low-energy antikaon and hyperon interactions with nucleons and nuclear systems. Applications include kaonic hydrogen, recent calculations of kaonic deuterium and comparisons with K-p correlation functions from ALICE at LHC. This is followed by a discussion of the possible role played by kaons and hyperons in dense baryonic matter, with special emphasis on constraints provided by the existence of two-solar-mass neutron stars and garvitational wave signals of neutron star mergers.

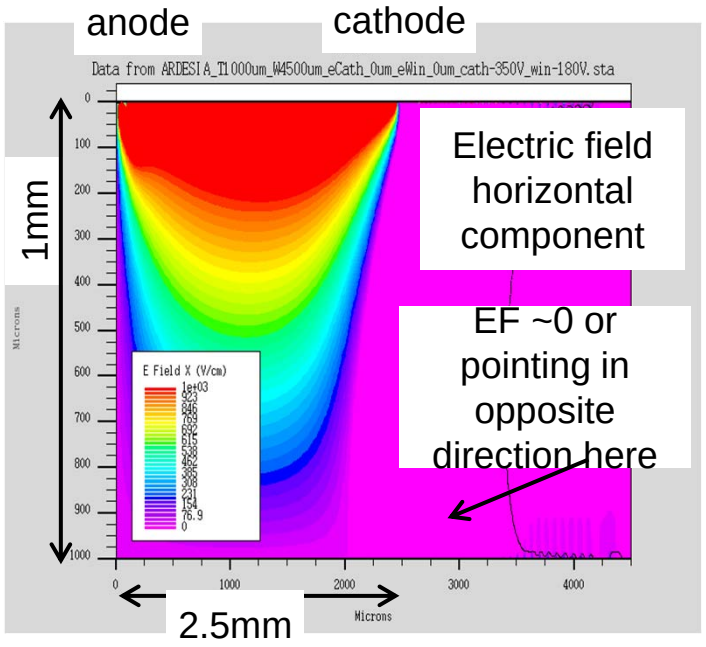

Special thanks to the accelerator,
research and technical divisions,
and in particular to
the DAFNE staff and
to the LNF Director
via
hideki yukawa
Thank you!

Spares

Development of thicker SDDs: design and simulations (1)

Goal: increase the SDD efficiency over 15 keV

➔ *Develop SDDs realized on thicker substrates*
Search for proper wafers:
800µm and 1000µm (100)
Nominal Resistivity > 10 kΩ cm
➔ *Maximum expected depletion voltage:*
~200V (800µm), ~320V (1000µm)

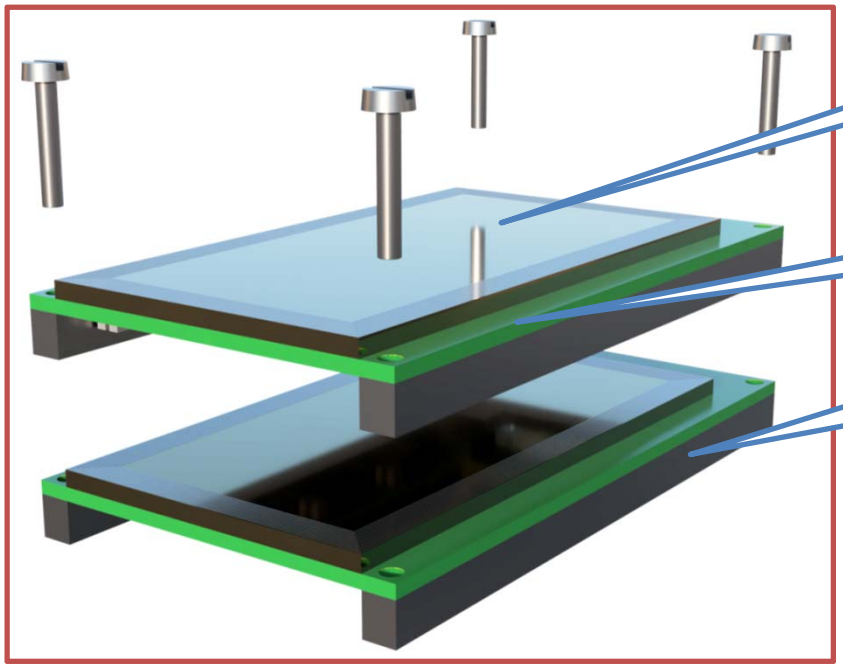


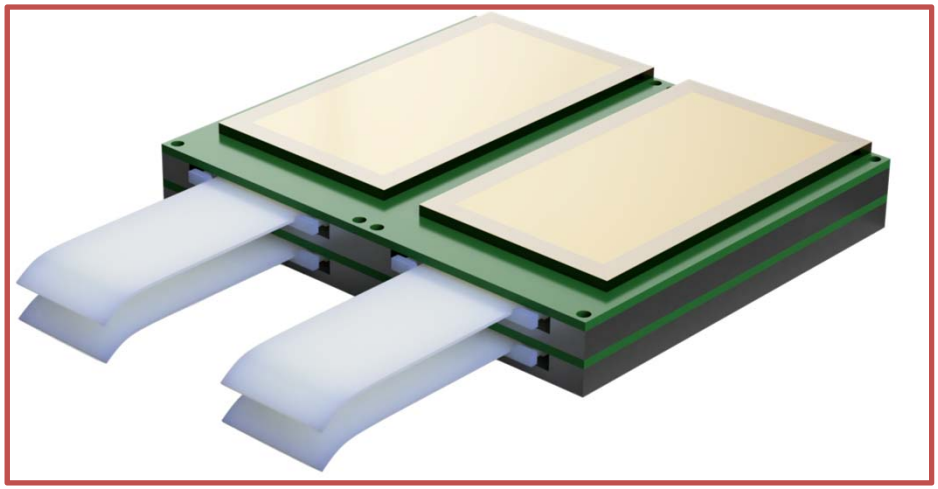
Device simulations for addressing the design

Example: effective collecting area

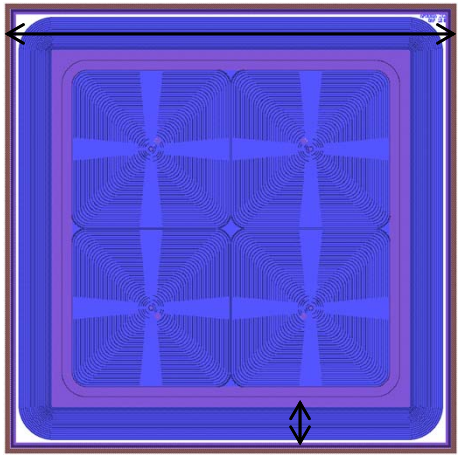
With unchanged design, a border region ~500µm wide becomes inactive for 1mm thick devices
➔ Need to increase by 500µm the dimension of last drift ring and entrance window

Proposal for a new design of SDD detection module





Thick batch design



<u>Concept</u>:
stack of 2 (o more) SDD chips to further increase efficiency

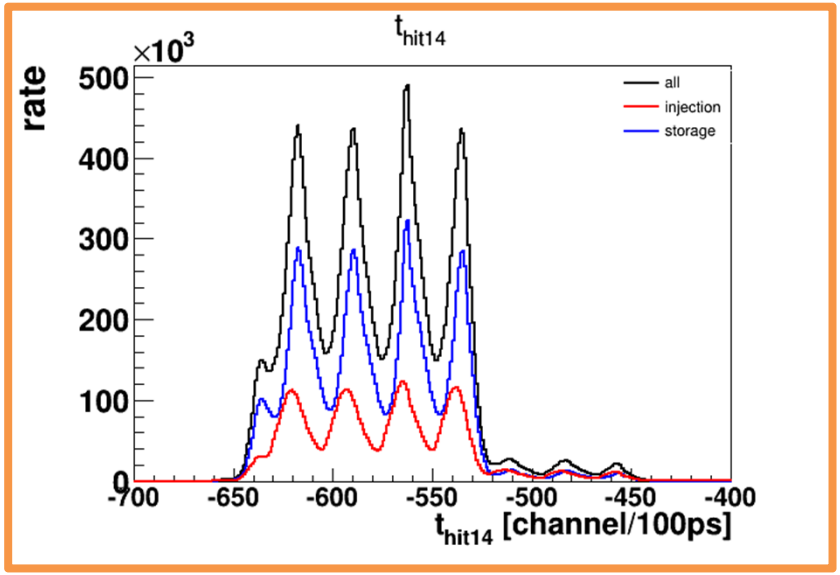
<u>Main challenges</u>:

1) avoid substrate materials between SDD chips

2) cooling efficiency

3) spurious fluorescence's?

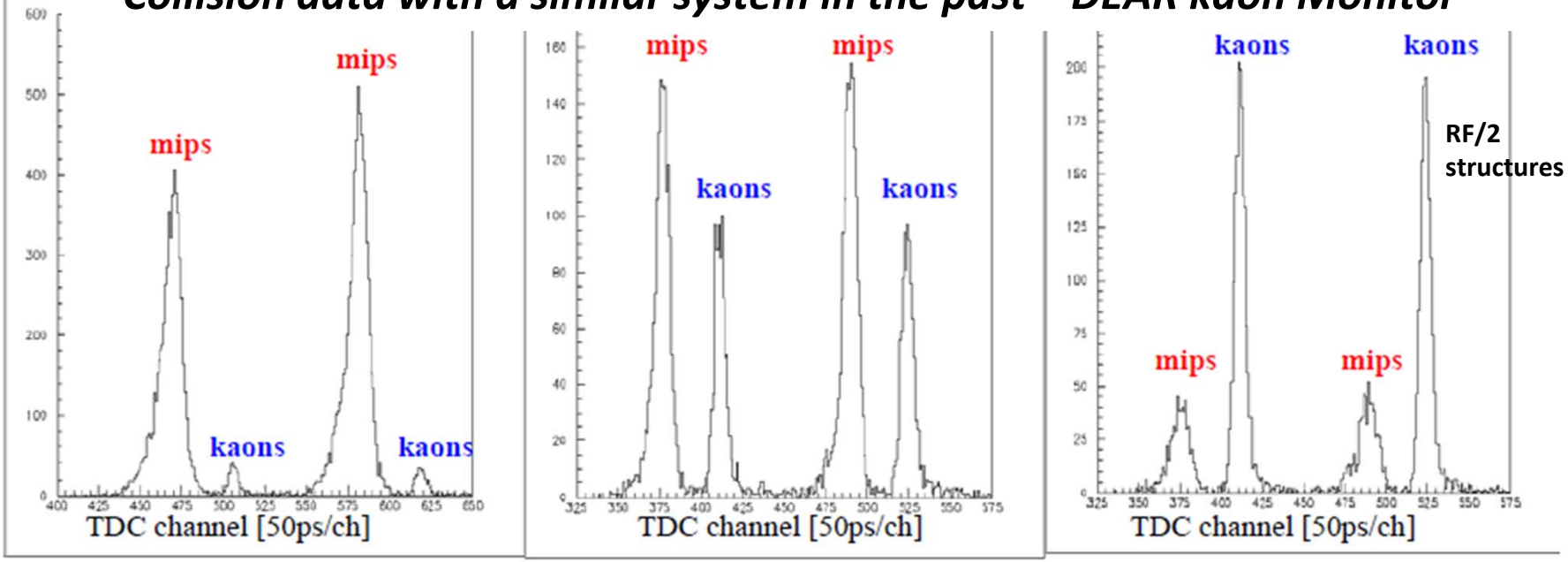
SIDDHARTA-2 Luminosity monitor

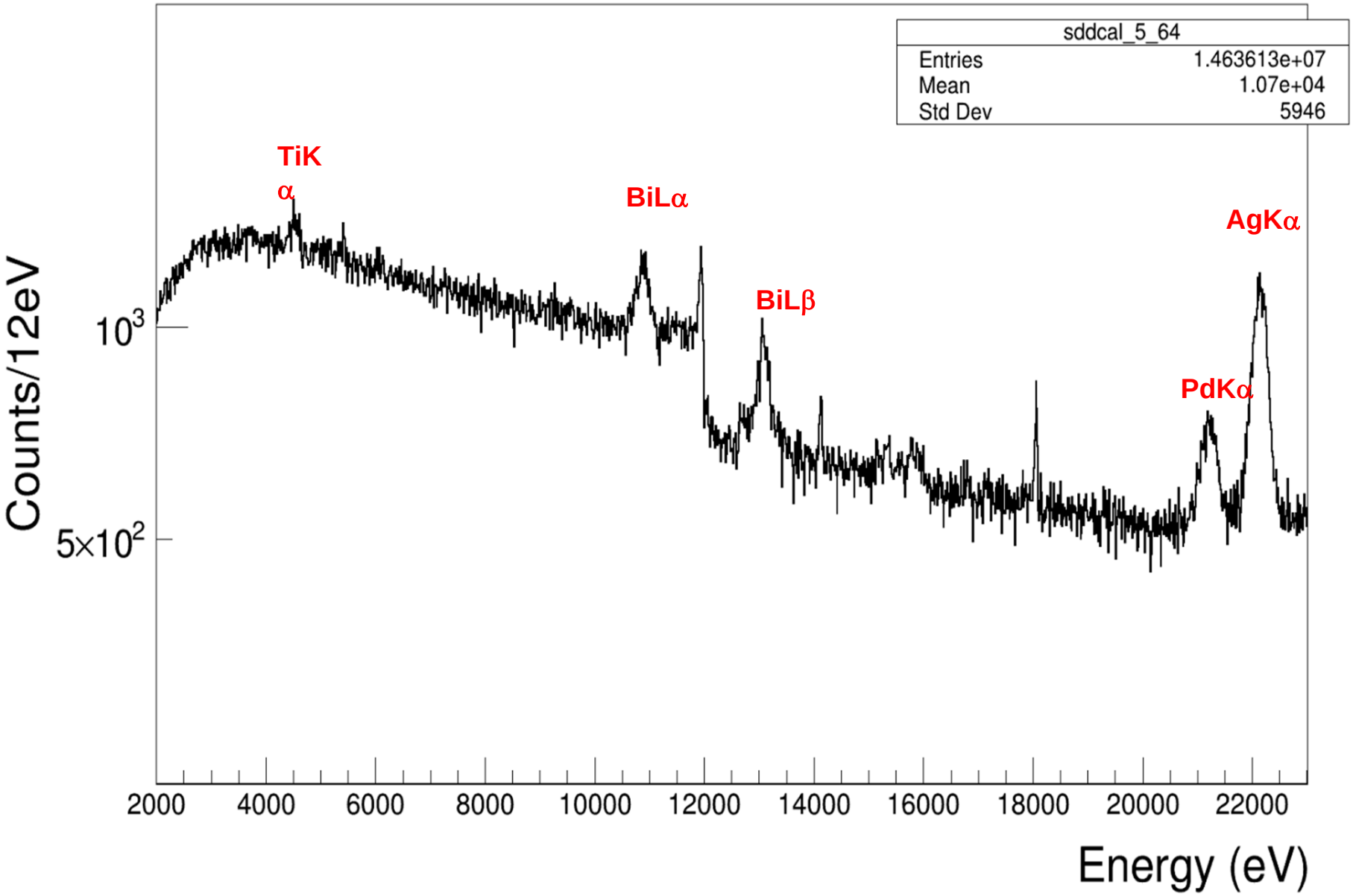


TDC difference between the two pairs of scintillators

- ***check of the interaction point stability***
- ***measurement of the crossing angle***

Collision data with a similar system in the past – DEAR kaon Monitor




sddcal_5_64
Entries 1.463613e+07
Mean 1.07e+04
Std Dev 5946
TiKα
BiLα
BiLβ
PdKα
AgKα
Counts/12eV
10^3
5×10^2
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000
Energy (eV)

Comparison x-ray tube vs beam