Istituto Nazionale Fisica Nucleare - Laboratori Nazionali di Frascati

Investigating the Universe with exotic atomic and nuclear matter

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Low energy kaon-nuclei interaction at DAΦNE: the SIDDHARTA-2 experiment

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On behalf of the SIDDHARTA-2 collaboration

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Outline

- Kaonic atoms physics at DAΦNE
- New Silicon Drift Detectors (SDDs) technology for precision KD measurements
- SIDDHART(INO) in DAΦNE
- Conclusions

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- Kaonic atoms physics at DAΦNE
- New Silicon Drift Detectors (SDDs) technology for precision KD measurements
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- Conclusions and outlooks

SIDDHARTA (2) Project

Scientific Goal

To perform precise measurements of kaonic atoms X-ray transitions -> unique information about QCD in the non-perturbative regime in the strangeness sector not obtainable otherwise

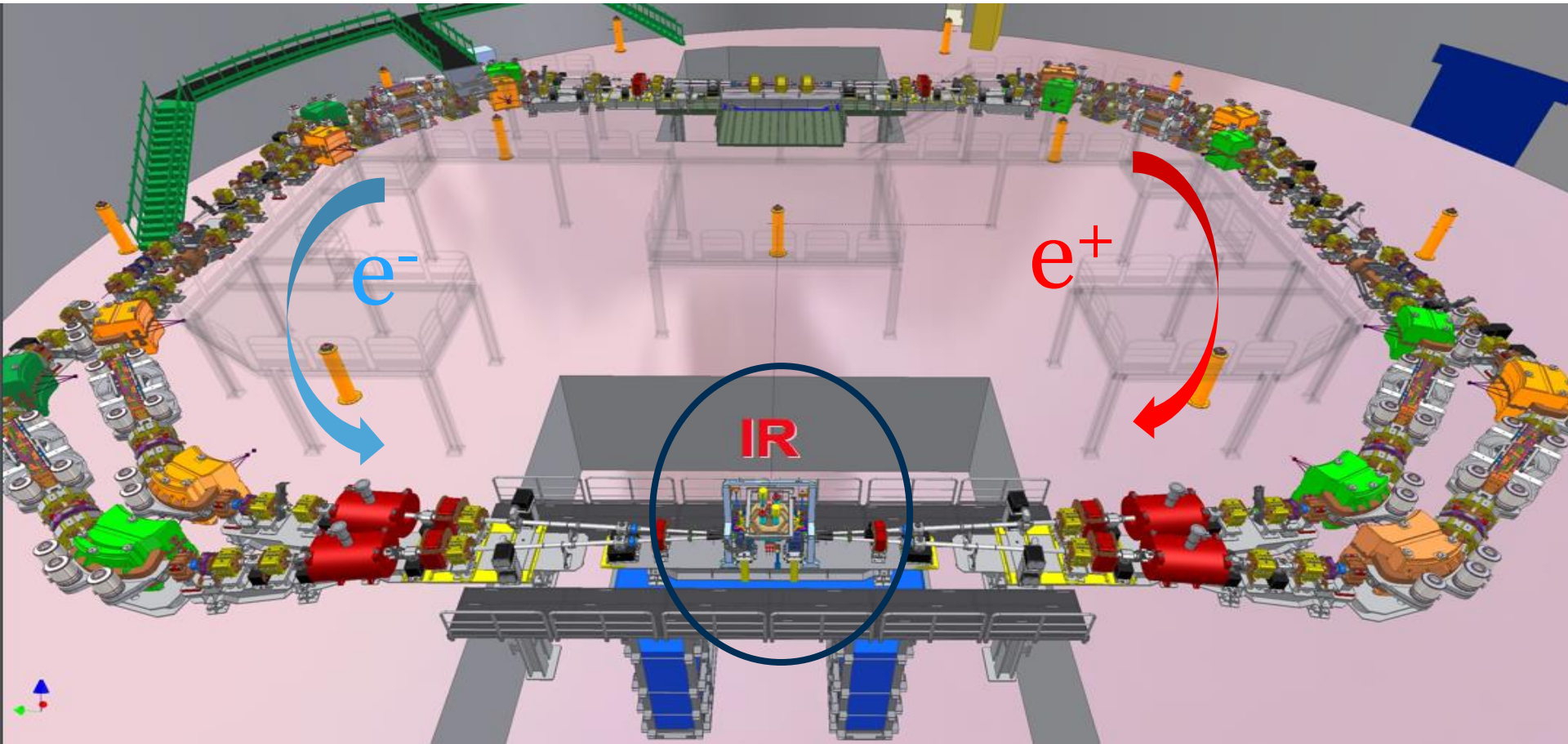
SIDDHARTA 2 aim

to perform the first measurement ever of **kaonic deuterium** X-ray transitions to the ground state (1s-level), such as **to determine its shift and width induced by the presence of the strong interaction.**

The analysis of the combined measurements of kaonic deuterium and kaonic hydrogen (already measured by SIDDHARTA) will allow, **the extraction of the isospin-dependent antikaon-nucleon scattering lengths which are fundamental inputs of low-energy QCD effective theories.**

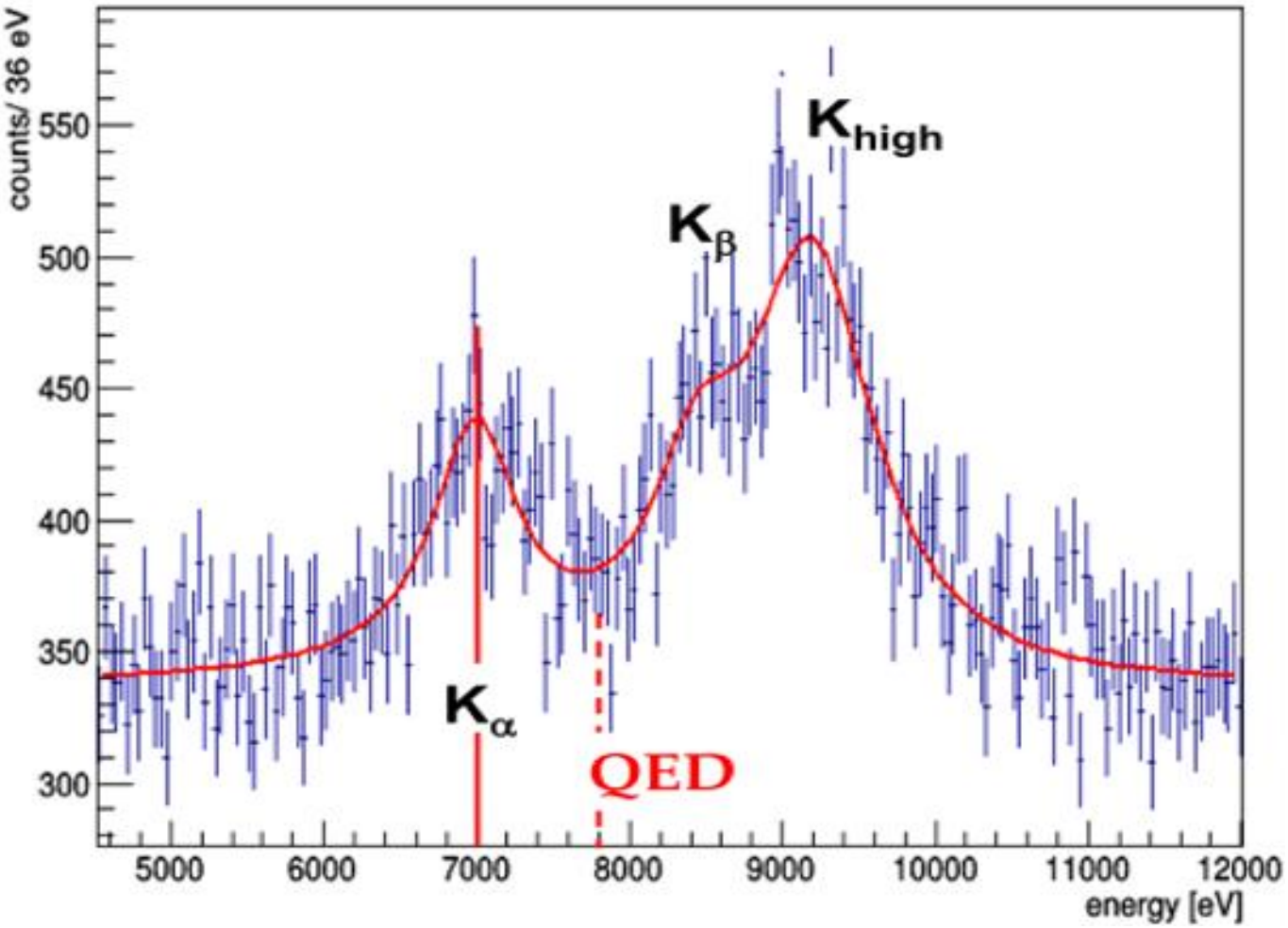
DAΦNE COLLIDER @ LNF

- $\Phi \rightarrow K^- K^+$ (49.1%)
- Monochromatic low-energy K^- used by SIDDHARTA-2
- Electromagnetic (asynchronous) bkg
- Hadronic (syncronous) bkg



MC Kaonic deuterium

KD yield < 0.1 %



$$\int L = 800 pb^{-1}$$

density: 3% (LHD)
detector area: 246 cm^2

$$\varepsilon = -800 \pm \mathbf{30}\ \text{eV}$$
$$\Gamma = 750 \pm \mathbf{75}\ \text{eV}$$

Same precision as SIDDHARTA, which gave the most precise measurement of KH so far

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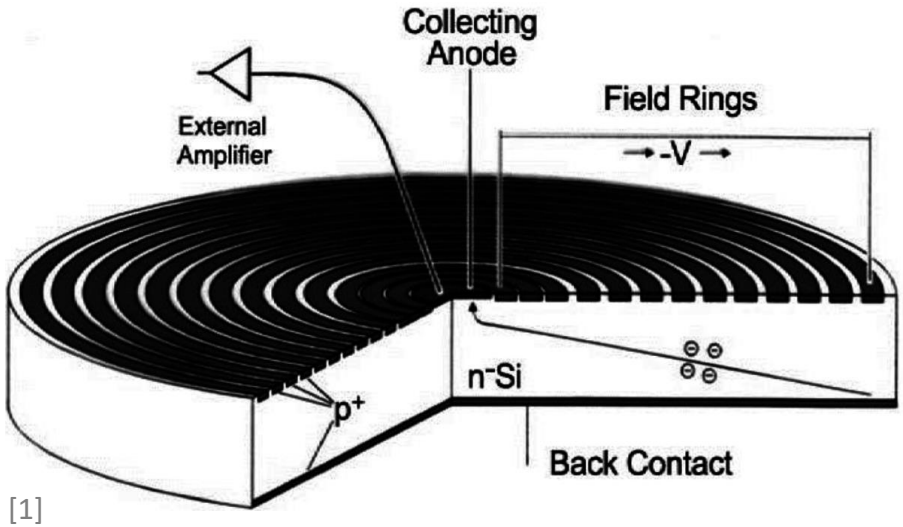
Silicon Drift Detector (SDD)



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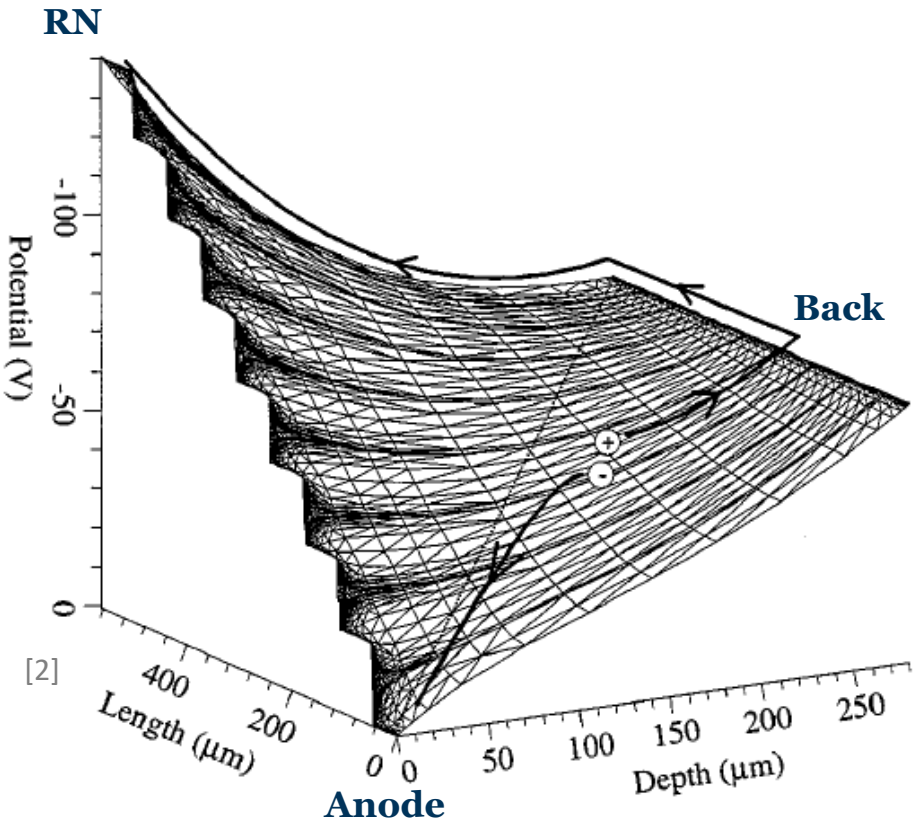
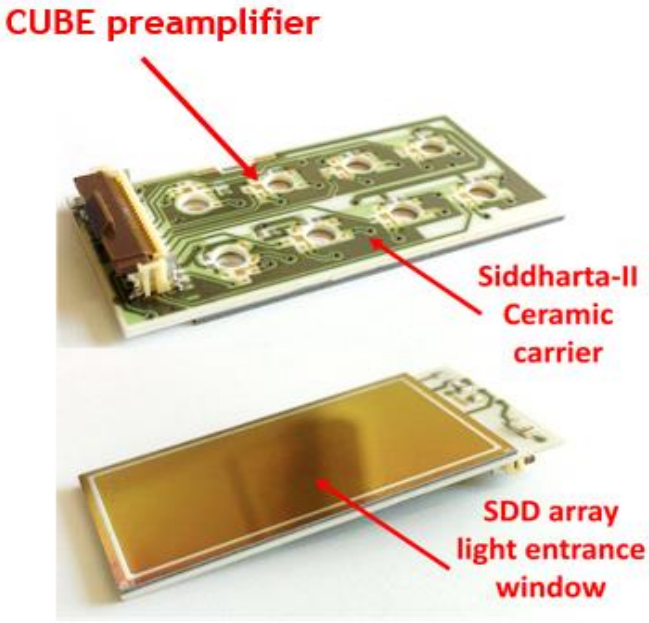


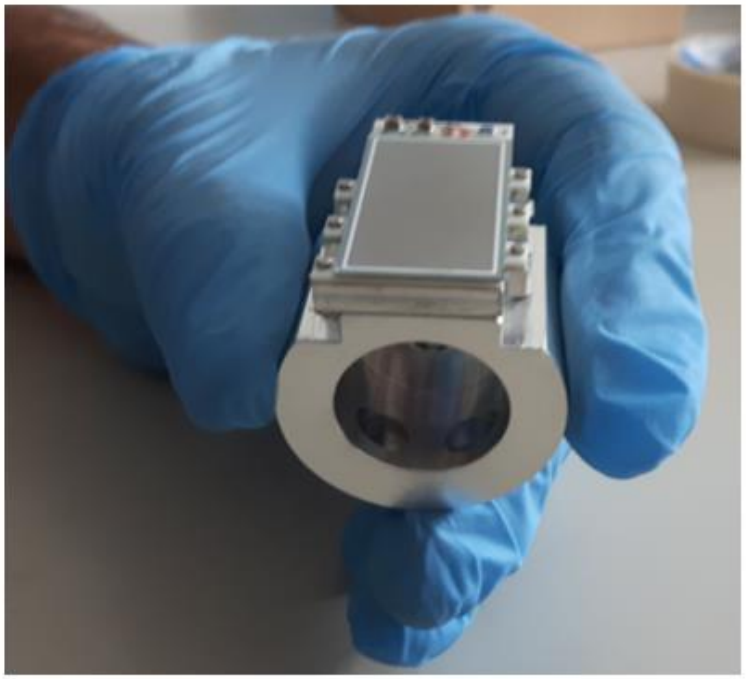
[2]

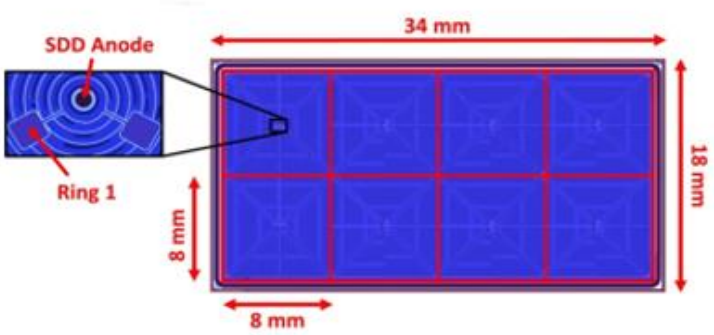
[1] P. Rehak at al, Nucl. Instr. Meth. Phys. Res. A235, (1985)

[2] C. Fiorini et al., IEEE transactions on nuclear science, 47(4) (2000)

New technology SDD



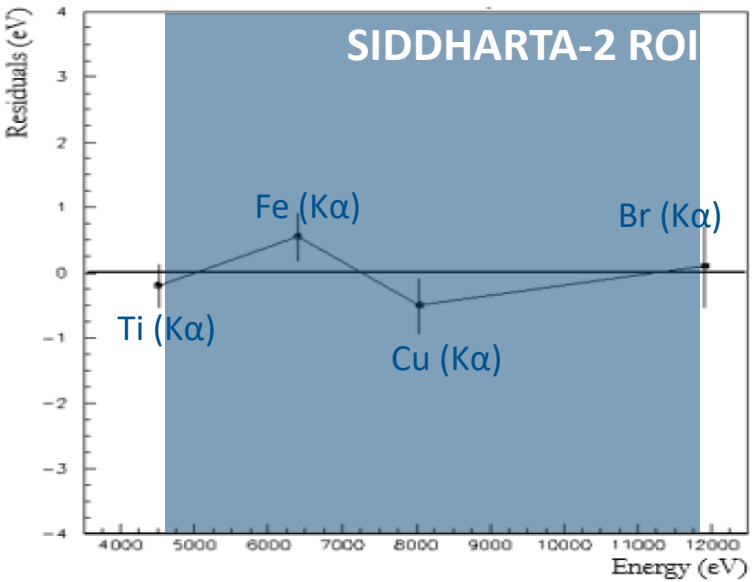




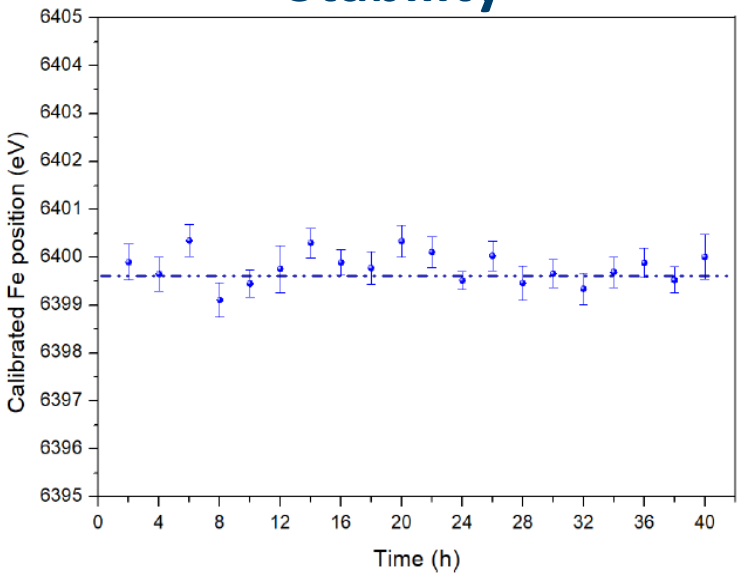
New technology SDD arrays for SIDDHARTA 2
common polarization for all the 8 units

SDD technology optimization

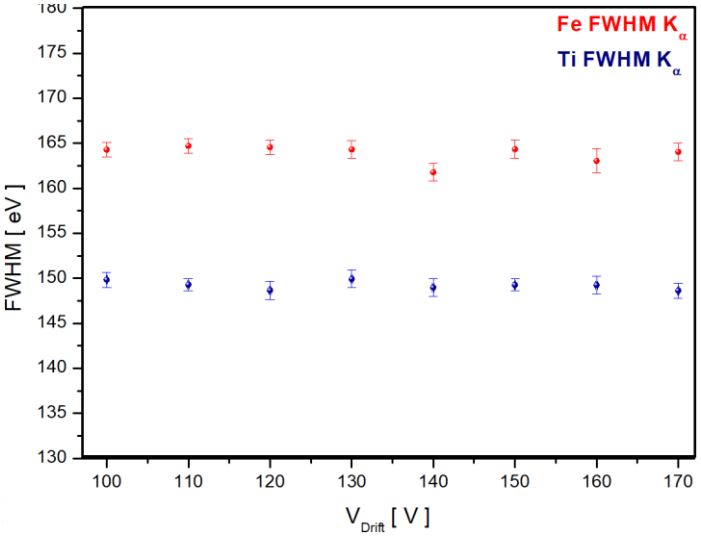
Linearity



Stability

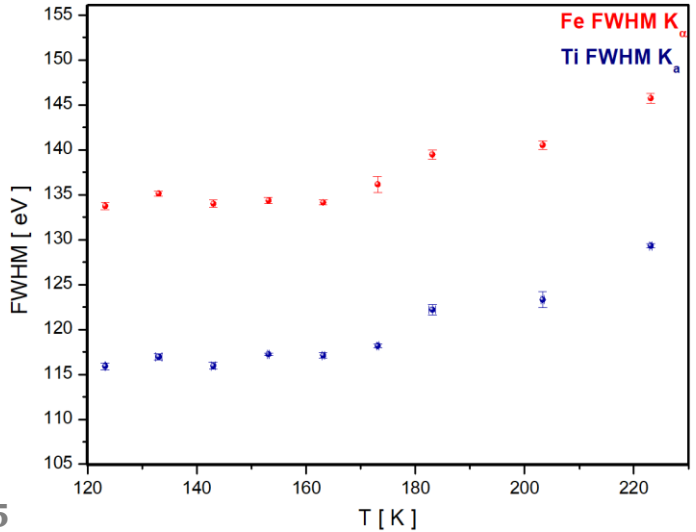


Energy resolution



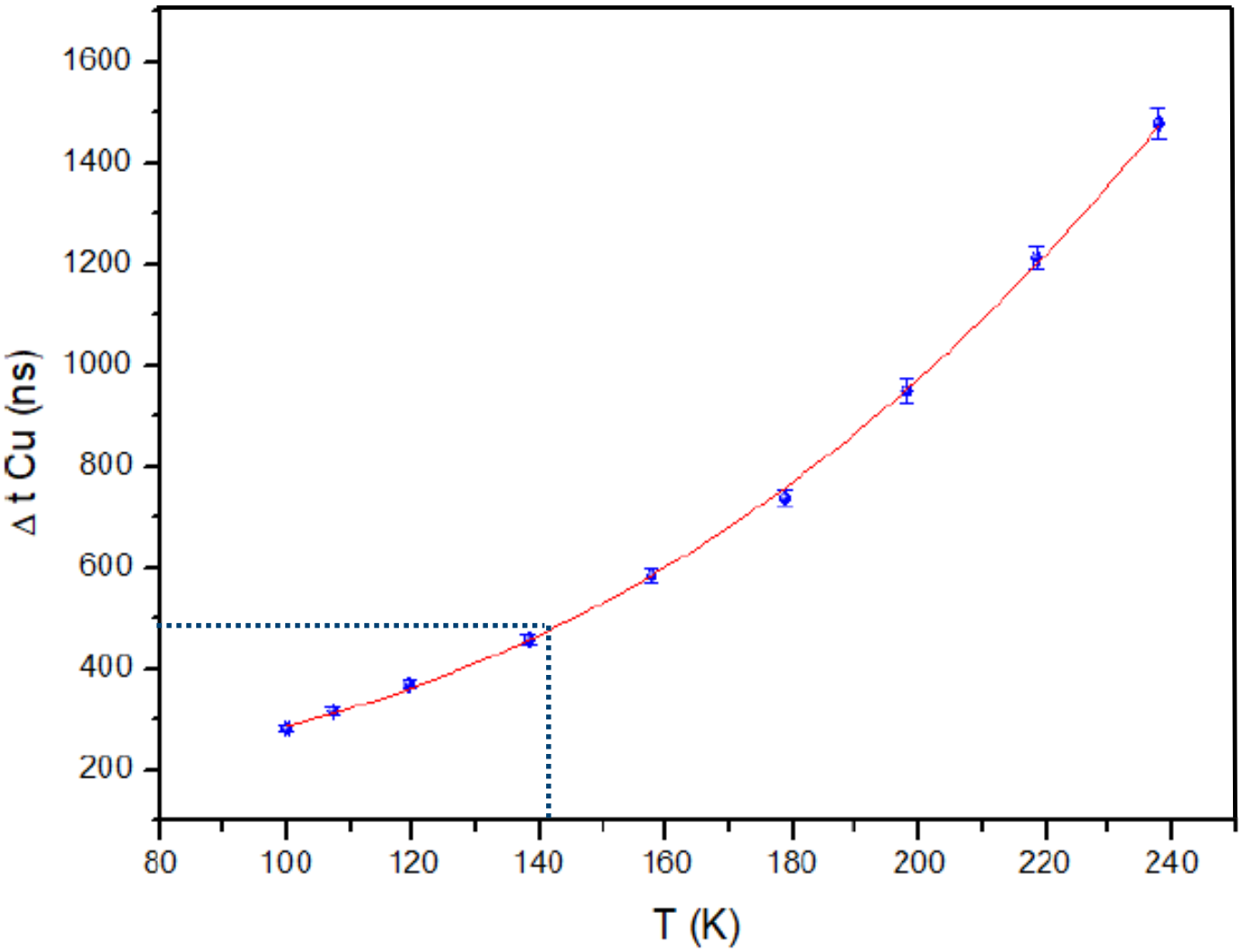
Drift voltage

Temperature



DOI:10.3390/condmat4020045

Drift time (temperature scan)



$$t_{drift} = \frac{d}{\nu_{drift}} = \frac{d}{\mu \cdot E}$$

μ: mobility ~ T^{-n}

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Sharp & Succesfull SIDDHARTINO installation (April 2019)

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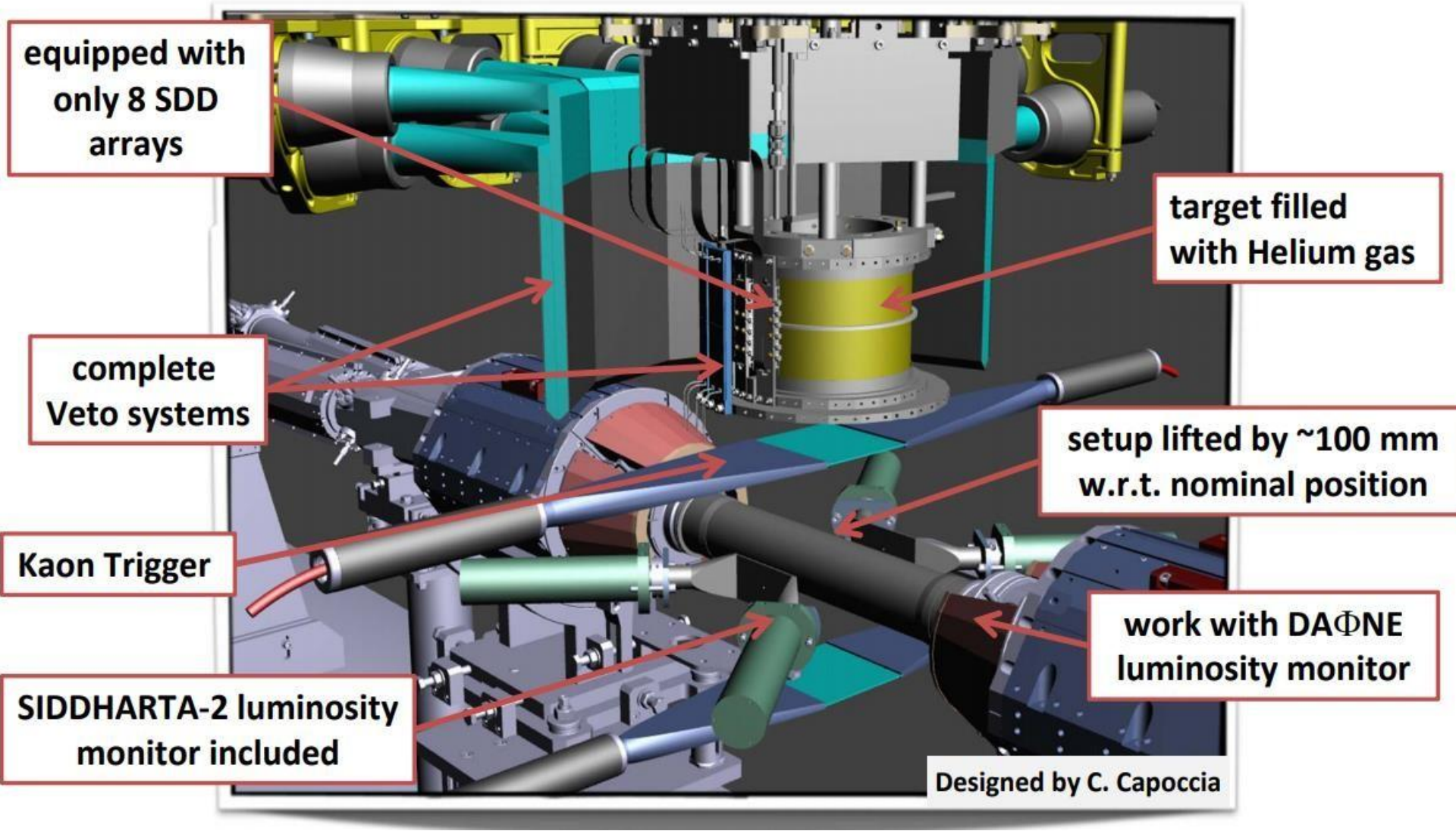
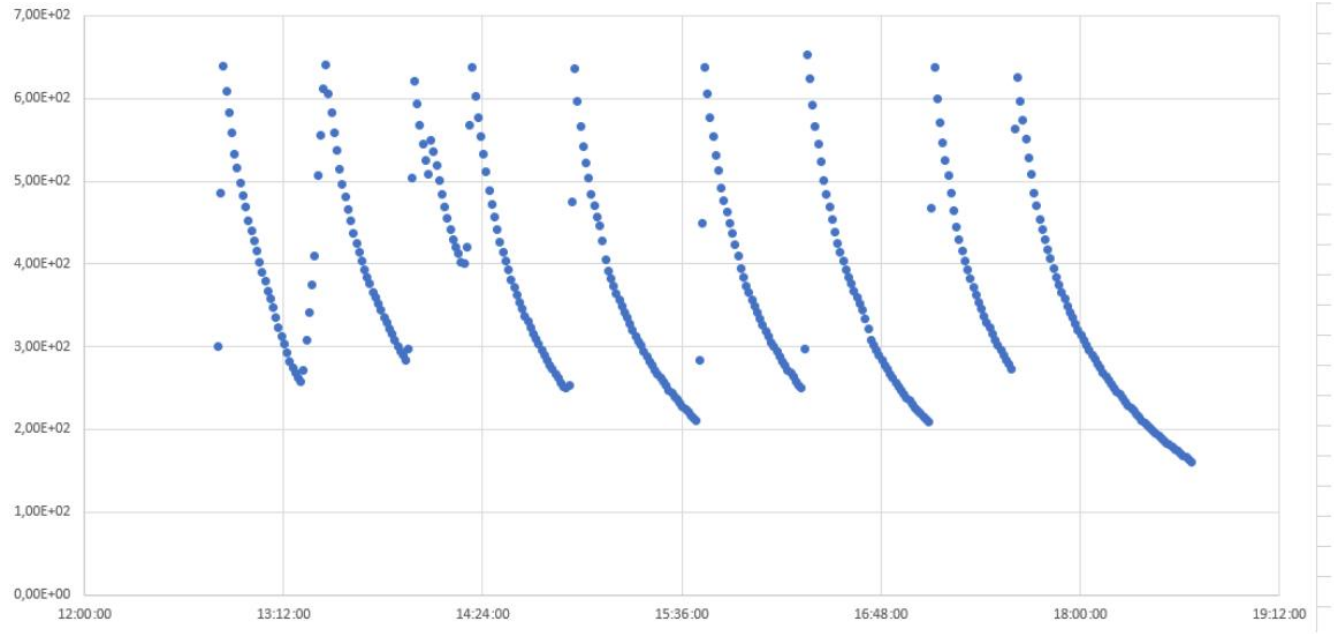
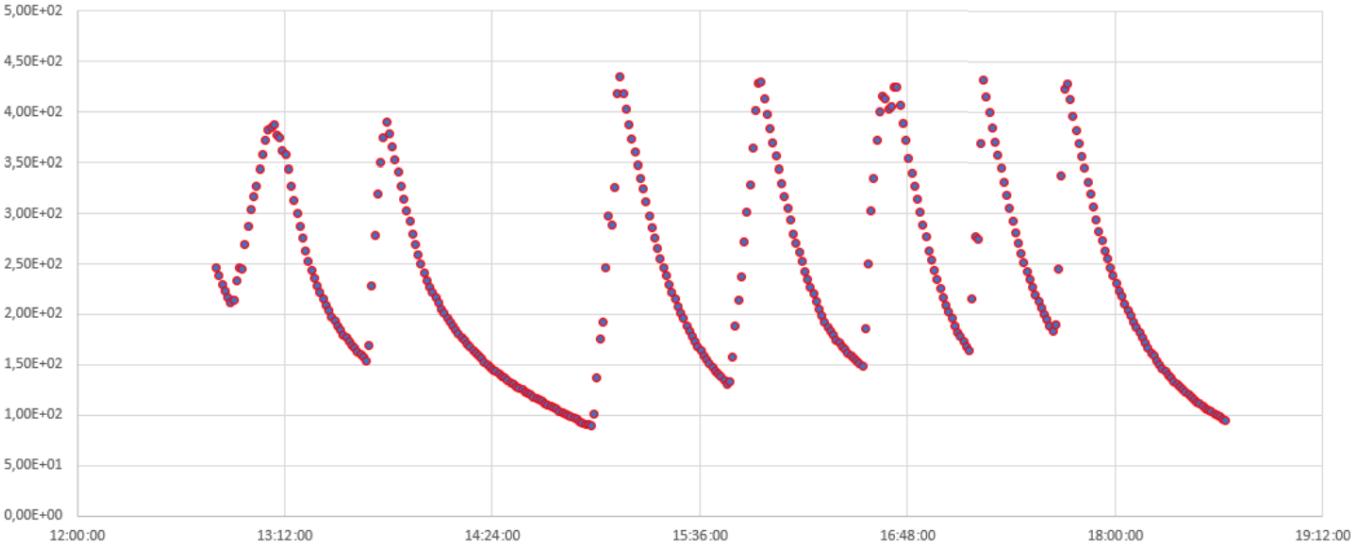
(April 2019)



SDD technology response during DAΦNE BCP



e^- current amplitude (mA)



e^+ current amplitude (mA)

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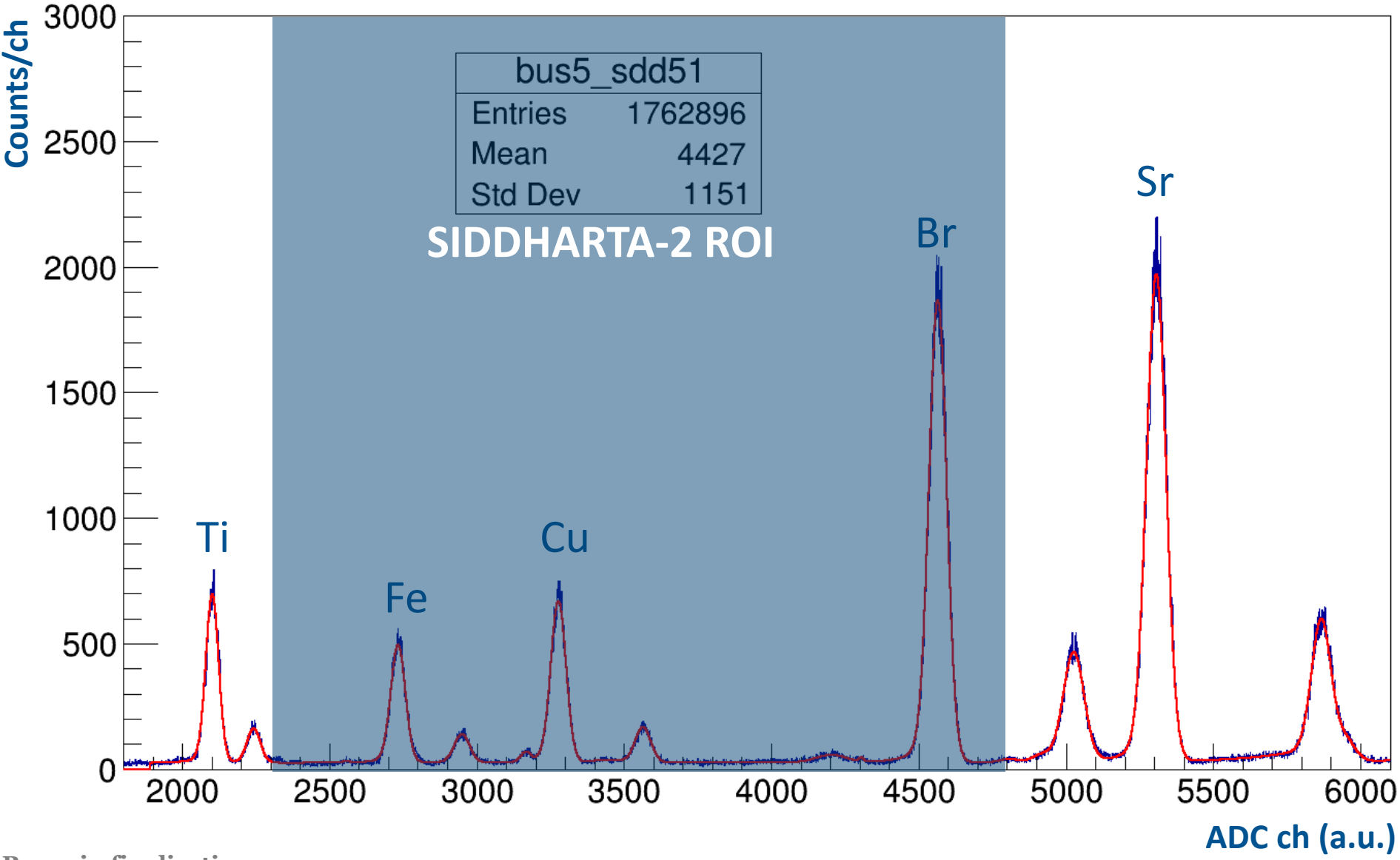
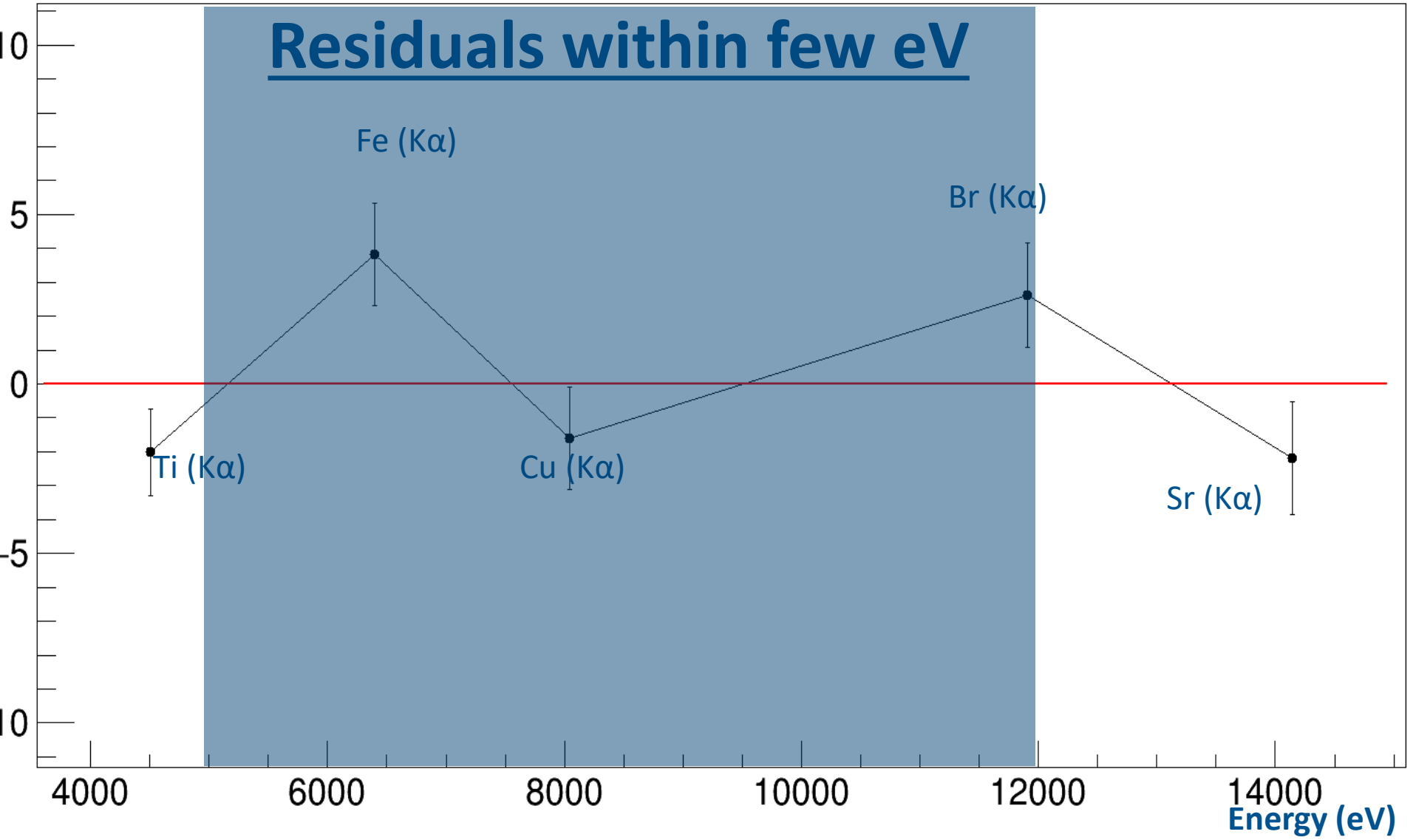


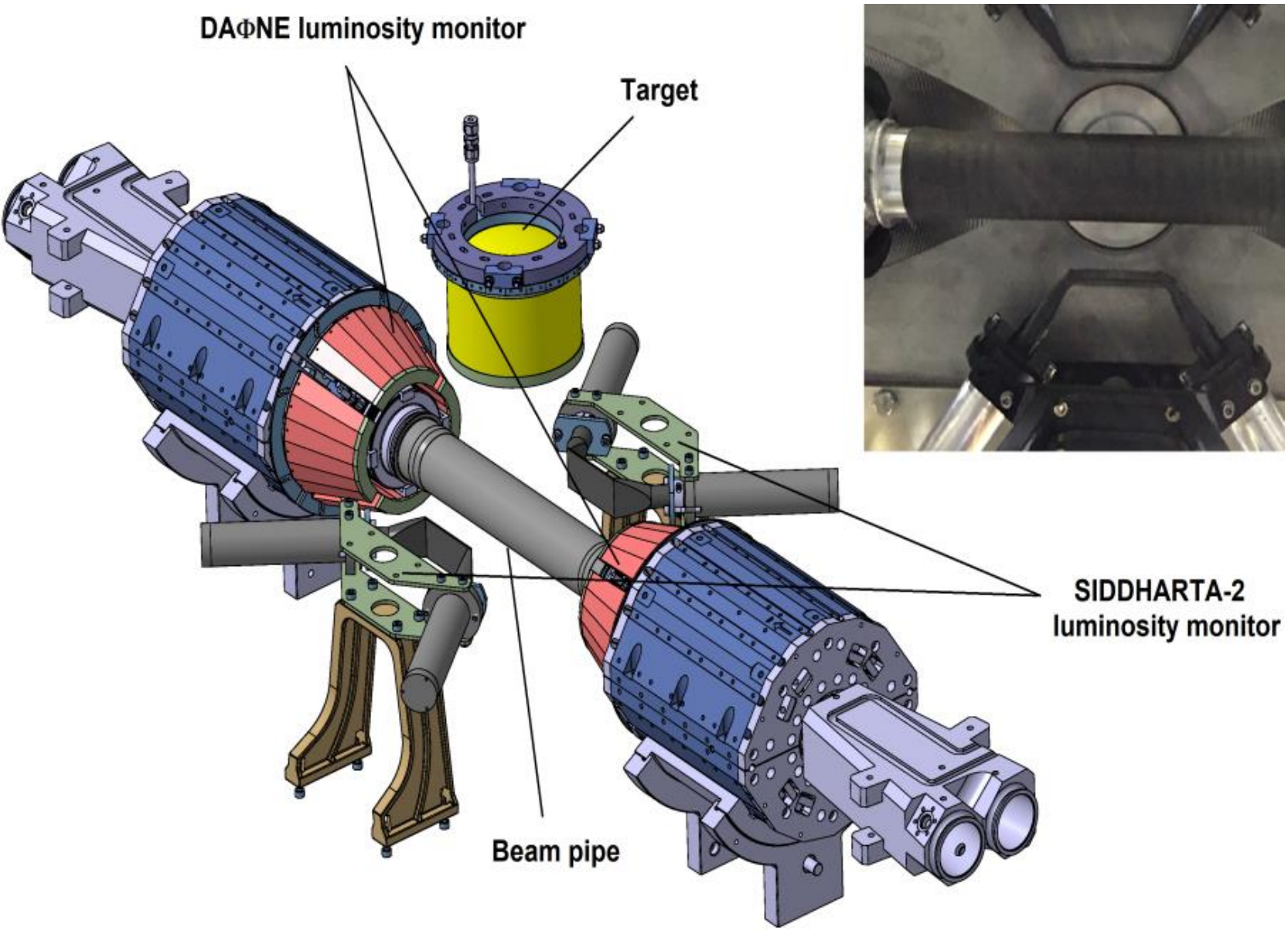
Paper in finalization

SDD technology response during DAΦNE BCP



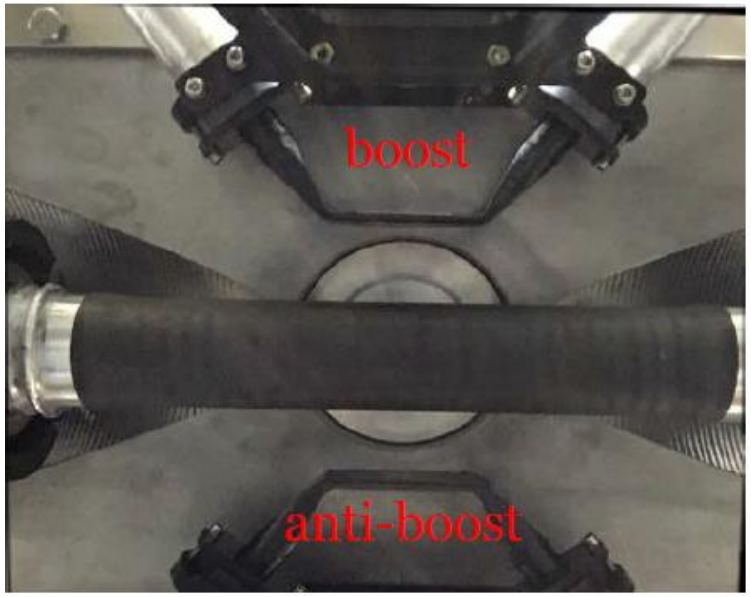
Paper in finalization

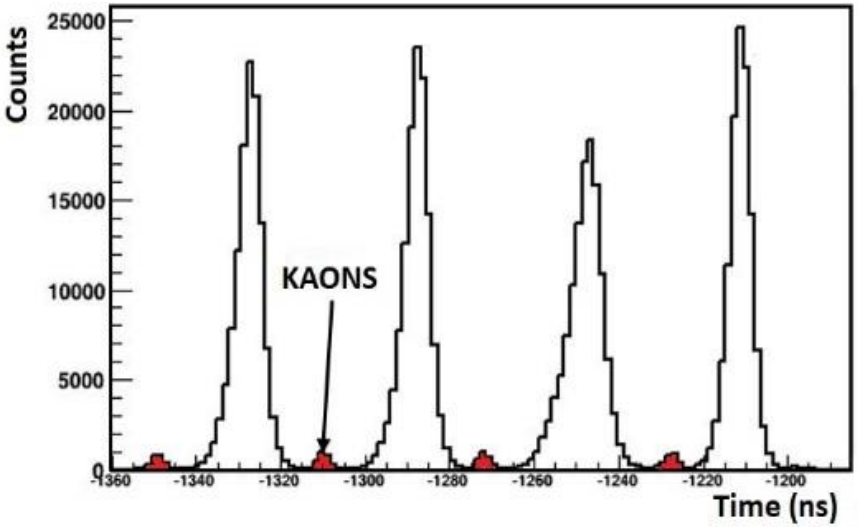
Luminometer

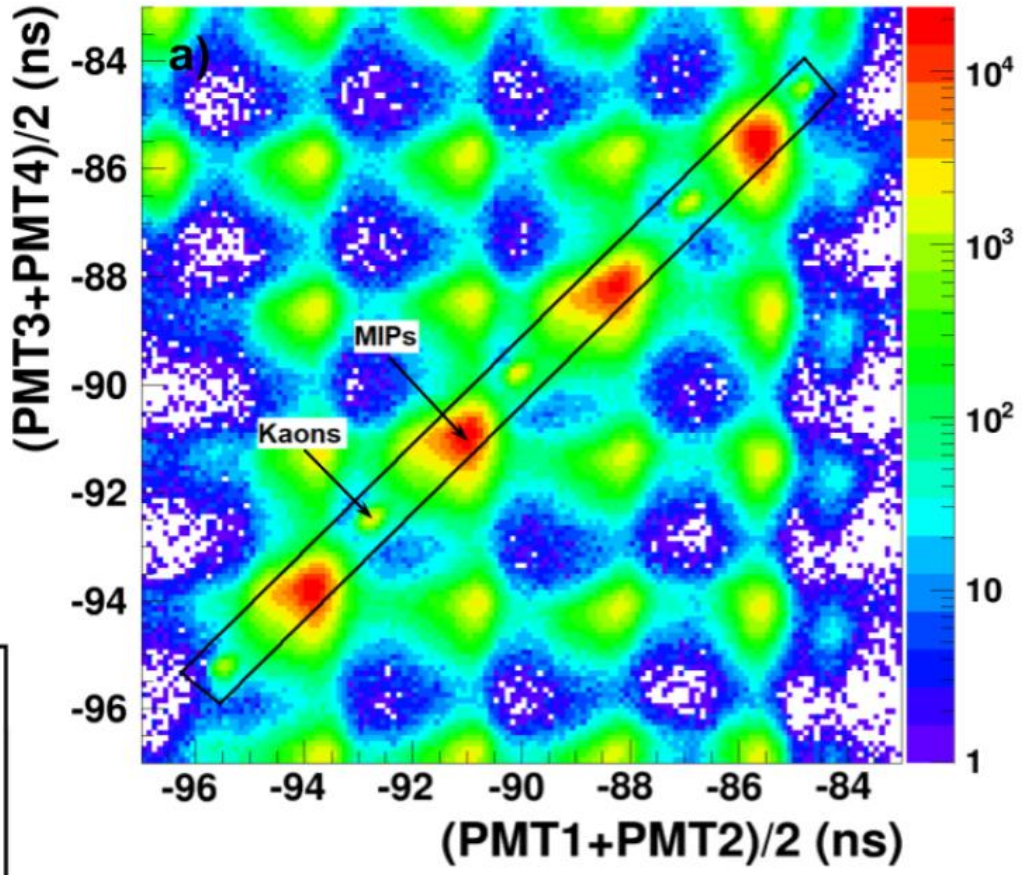


(arXiv: 2008.05472, JINST)

Luminometer



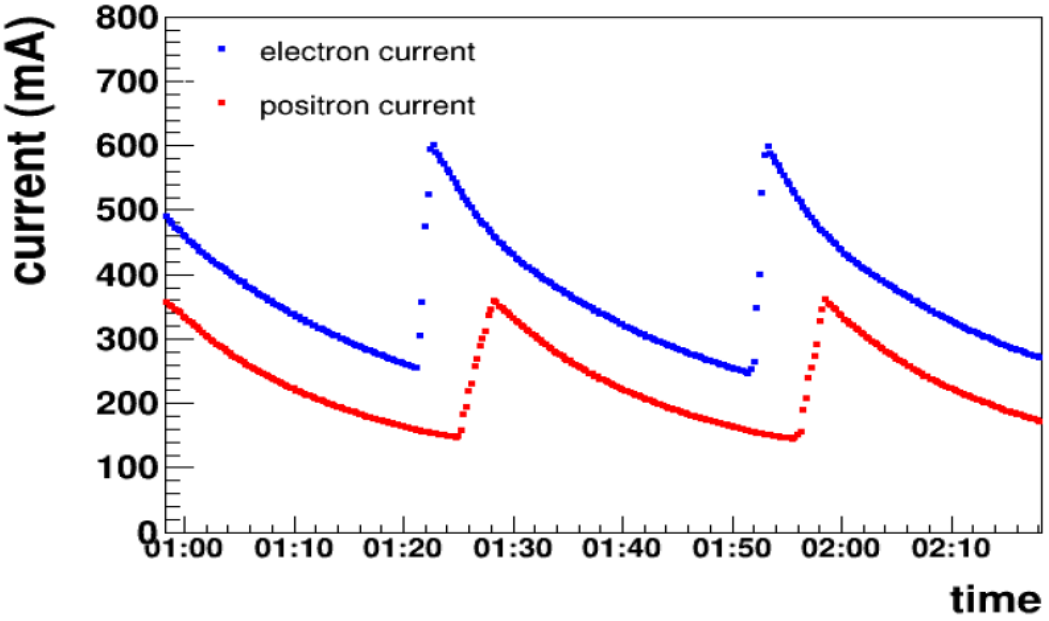


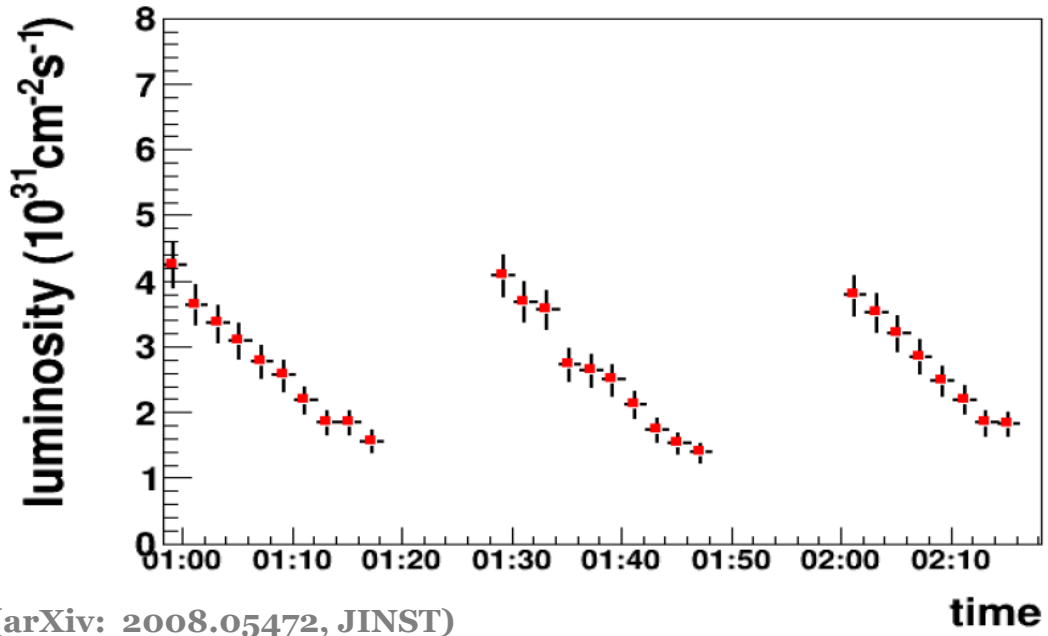


Habemus K!

(arXiv: 2008.05472, JINST)

Luminometer





$L > 10^{31}\ cm^{-2}\ s^{-1}$

(arXiv: 2008.05472, JINST)

Conclusions

- The SIDDHARTA-2 experimental apparatus has been successfully installed in April 2019 and it is taking data during the **DAΦNE Beam Commissioning Phase**;

- The optimization of the new technology of Silicon Drift Detectors reveals very good performances of the system in terms of Linearity, Stability and both Energy - **Timing** Resolution, together with a full control of the system;

- During the DAΦNE Beam Commissioning Phase it has been demonstrated that **performances are not affected by the huge background induced by the collider** (even in the worst condition with respect to the one expected during the final run);

- The Luminometer analysis reports a detectable amount of Kaons even during the first collisions attempts at the DAΦNE collider. **Luminosity > 10^{31} cm^{-2} s^{-1}**.

- Presently, both the SIDDHARTA-2 apparatus and the DAΦNE collider are restarting after the summer shutdown and they are ready for the new **cooperative activity towards the kaonic deuterium run, planned for 2021.**

THANK YOU

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