Overview and Performance of the SIDDHARTA-2 Apparatus

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Kaonic atoms serve as optimal candidates for studying the low-energy regime of Quantum Chromodynamics (QCD) that includes strangeness [1-3]. There exists a significant difference among theoretical models that describe the low-energy antikaon-nucleon interaction, which highlights the critical role of experimental data to constrain these models. Located at the DAΦNE collider at the INFN-LNF in Italy, the SIDDHARTA-2 (Silicon Drift Detector for Hadronic Atom Research by Timing Application) experimental apparatus is prepared to provide this experimental input [4]. This is achieved through X-ray spectroscopy of light kaonic atoms, with a primary focus on the transition in kaonic deuterium. The experiment employs state-of-the-art large area X-ray detectors, specifically Silicon Drift Detectors [5, 6], coupled with sophisticated background suppression methods, enabling it to conduct the challenging K^--d measurement effectively.
The poster provides an overview of the SIDDHARTA-2 apparatus.

Kaonic atom

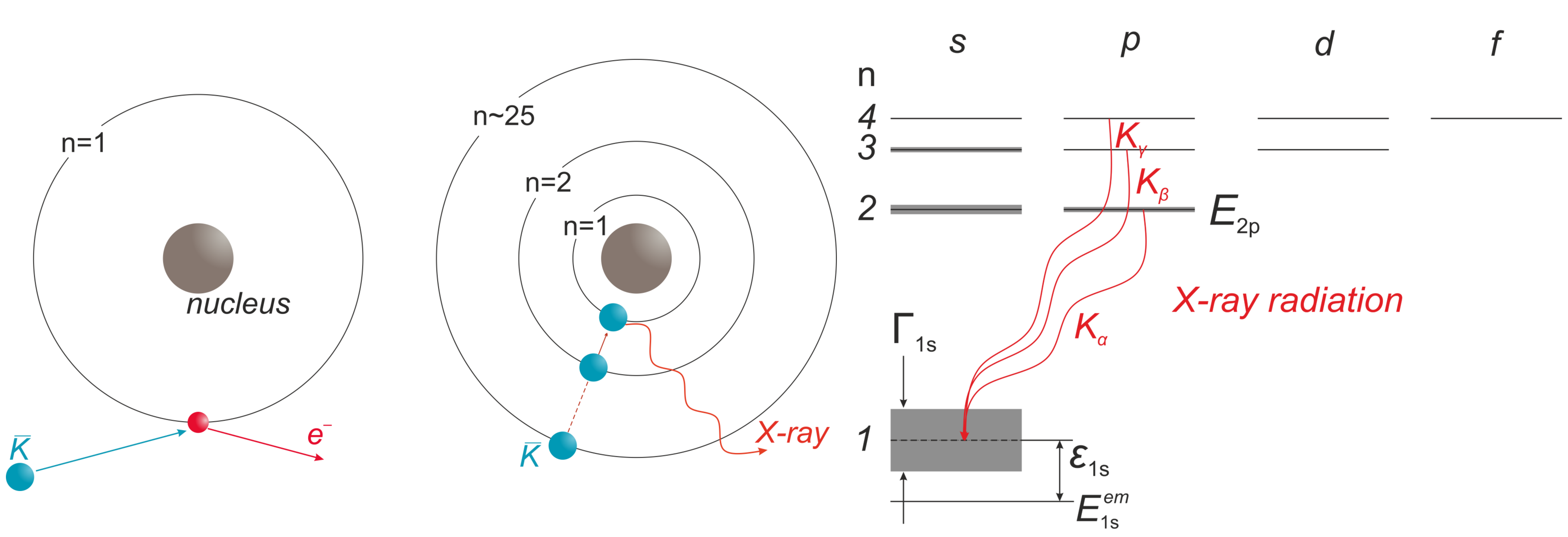

Fig. 1. Left and centre: a kaonic atom is formed when a negative kaon K is captured by a nucleus, replacing an electron in an excited orbit [1-3, 7].
Right: the kaonic atom de-excites to lover states via various cascade processes, emitting radiation in the X-ray domain. When the fundamental, 1s, level is reached, a strong interaction between the kaon and the nucleus takes effect, which induces a shift of the level compared to the pure QED value and its broadening (due to the kaon absorption by the nucleus). The experimentally determined shift (e) and width (G) are related to the s-wave scattering lengths at threshold [3].

SIDDHARTA-2 Apparatus

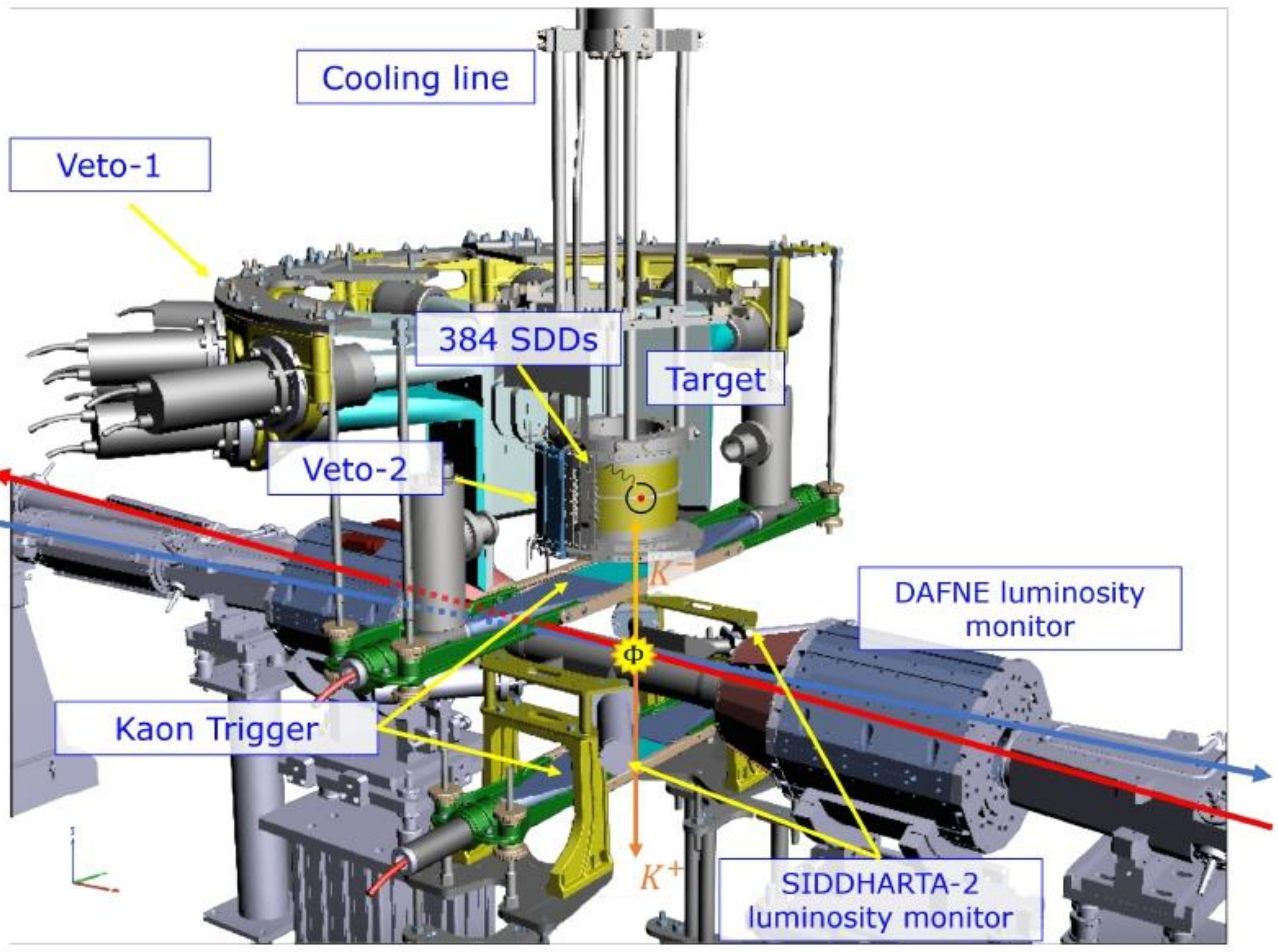

Fig. 2. Illustration of the SIDDHARTA-2 apparatus.

The SIDDHARTA-2 apparatus is currently installed at the Interaction Region (IR) of the DAΦNE collider [4]. The target consists of a cylindrical cell. The target gas is fluxed inside the cylindrical cell. Outside, 384 Silicon Drift Detectors (SDDs) laterally surround the cylindrical target, for x-ray detection. Outside the cylindrical target and surrounding the SDDs, plastic scintillators read by pairs of Silicon Photo-Multipliers (SiPMs) are placed and used as a veto system for external background identification (VETO-2). The target cell, the SDDs, and the VETO-2 are placed inside a vacuum chamber, which is kept at a pressure below 10^{-5} mbar. Radially, outside the vacuum chamber, a second veto system consisting of 12 plastic scintillators read by pairs of Photo-Multipliers (PMTs) is installed for further external background reduction (VETO-1). Two plastic scintillators read by PMTs are placed one below and one above the DAΦNE Interaction Point (IP) and used to discriminate the back-to-back kaons directed to the SIDDHARTA-2 target, based on the time-of-flight (Kaon Trigger system). A luminometer, consisting of two plastic scintillators read by pairs of photomultipliers, is placed on the horizontal side of the IP.

Target Cell

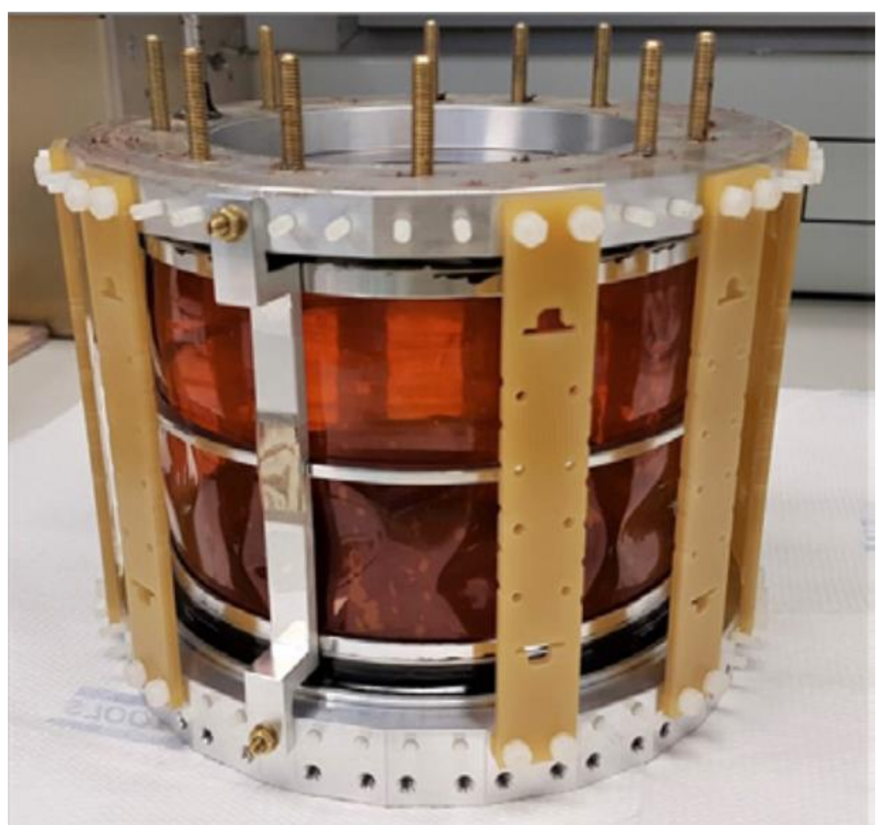

Fig. 3. The lightweight SIDDHARTA-2 target cell. The cylindrical experimental target, measuring 144mm in diameter and 125mm in height, features sidewalls constructed from two layers of 50 μm Kapton foils bonded with epoxy adhesive, resulting in a total thickness of approximately 150μm, ensuring 90% transmission of 8 keV X-rays to the detectors. The cell is filled with the target gas, where kaonic atoms are formed, and operates at a temperature of 30 K.

Silicon Drift Detector

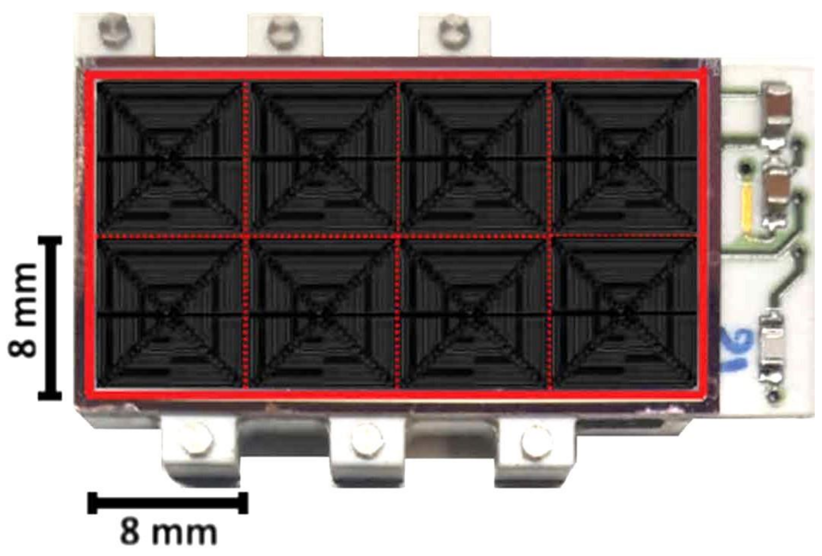

Fig. 4. Picture of the SIDDHARTA-2 silicon drift detectors 2×4 array screwed on the aluminium block. The red rectangle defines the active area of the device (5.12 cm2) given by the eight cells of 0.64 cm2 each.

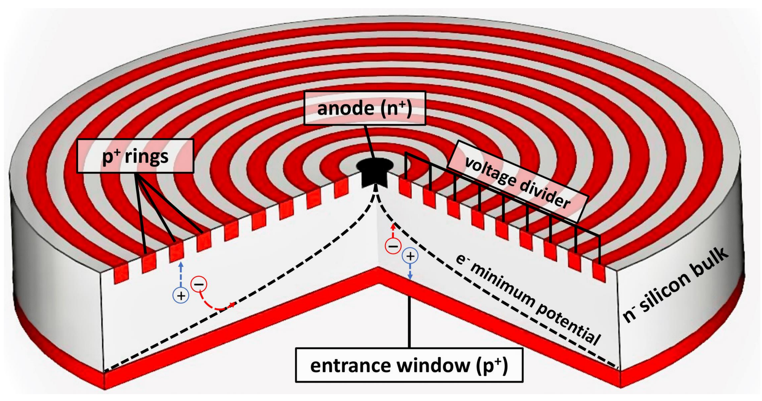

Fig. 5 Cross section of a cylindrical silicon drift detector. The radiation entrance window for the ionizing radiation is the non-structured backside of the device.

[1] C. Curceanu *et al.* *Front. Phys.* **11** (2023) 1240250. [2] C. Curceanu *et al.* *Rev. Mod. Phys.* **91** (2019) 025006. [3] C. Curceanu *et al.*, *Acta Phys. Polon.* **B 51** (2020) 251.
[4] L. De Paolis *et al.* *PoS ICHEP2022* (2022) 1003. [5] M. Miliucci *et al.*, Meas. Sci. Technol. **33** (2022) 095502. [6] M. Miliucci *et al.*, *Condens. Matter* **6** (2021) 47.
[7] M. Miliucci *et al.*, *Il Nuovo Cimento* **44 C** (2021) 152.