THE UPDATED SIDDHARTA-2 APPARATUS FOR KAONIC DEUTERIUM X-RAY SPECTROSCOPY

Marlene Tüchler*
(on behalf of the SIDDHARTA-2 collaboration)
***Stefan Meyer Institute for Subatomic Physics, Vienna, Austria**

ÖAW AUSTRIAN ACADEMY OF SCIENCES

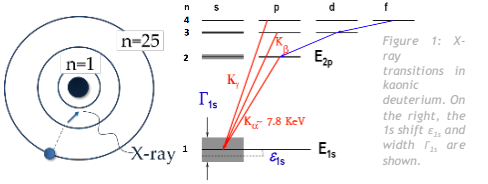

Figure 1: X-ray transitions in kaonic deuterium. On the right, the 1s shift ε_{1s} and width Γ_{1s} are shown.

MOTIVATION

The aim of the SIDDHARTA-2 experiment is to measure the $2p \rightarrow 1s$ transition in kaonic deuterium atoms (Fig. 1) to extract the isospin-dependent $\bar{K}N$ scattering lengths a_0 and a_1 for the first time.

The experimental challenge of this measurement is the low K-d X-ray yield [1], which necessitates an improvement of the S/B ratio of at least a factor of ten compared to the K-p measurement. This can be achieved by the following updates to the experimental apparatus (Fig. 2): a new target cell, the X-ray detection system, and a dedicated veto system.

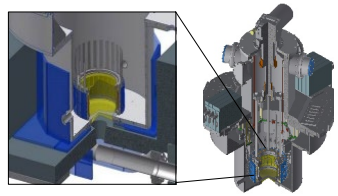

Figure 2: SIDDHARTA-2 apparatus with target cell, detector system, luminosity monitor and cooling system.

THE TARGET CELL

A new, lightweight, gaseous target cell was developed for SIDDHARTA-2. To ensure optimal X-ray transmission to the surrounding SDDs, the sidewalls are made from two layers of Kapton, with a total thickness of ~150 µm (Fig. 3, 4).

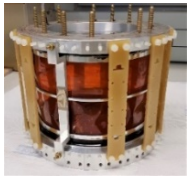

Figure 3: New target cell with Kapton sidewalls.

The working parametres of the gas target are listed in Table 1.

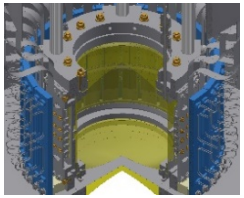

Figure 4: Schematic drawing of target cell with X-ray and Veto-2 detectors.

Working Parametres	
Temperature	30 K
Pressure	0.3 MPa
Density	1.5% LDD

Table 1: Working parametres of the deuterium target.

THE SILICON DRIFT DETECTORS

The SIDDHARTA-2 X-ray detection system consists of 48 arrays of Silicon Drift Detectors (SDDs) with eight channels each (Fig. 5), closely packed around the target cell.
For the K-d measurement, a CUBE preamplifier is implemented on the backside of the ceramic holder directly connected to the anode (Fig. 6). In Fig. 7, a calibration spectrum for one chip is shown with an energy resolution of 145 eV (FWHM) at 6 keV.

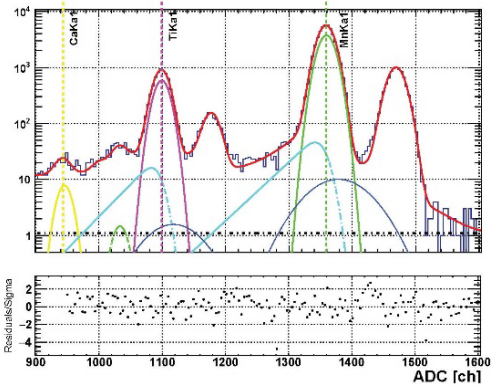

Figure 5: SDD array with eight channels.

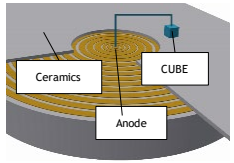

Figure 6: New configuration with CUBE preamplifier.

Figure 7: SDD calibration spectrum with Fe-55 source and Ti foil (145 eV FWHM at 6 keV) with fit residuals at the bottom.

THE VETO SYSTEMS

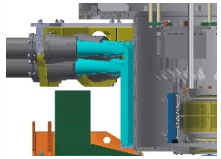

Figure 8: Apparatus with inner (Veto-2) and outer (Veto-1) veto systems.

A two-stage veto system is responsible for the active suppression of synchronous background (Fig. 8).
The outer stage, the Veto-1, suppresses events produced by kaon stops outside of the target gas using timing information (Fig. 9).
The inner stage, the Veto-2 system, rejects hadronic background in the form of MIPs (from the final kaon absorption) passing the SDDs (Fig. 10).

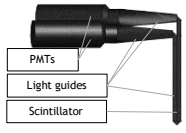

Figure 9: Veto-1 unit with scintillator and light guides, read out by 2 PMTs.

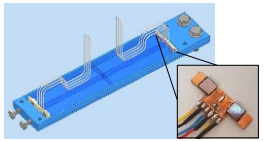

Figure 10: Veto-2 unit with four scintillators, 4 SiPMs and 2 LEDs for calibration.

REFERENCES

[1] Curceanu C. *et al.* (2019), Rev. Mod. Phys **91**, p. 025006.

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INFN LNF Istituto Nazionale di Fisica Nucleare

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