12th Vienna Conference on Instrumentation “VCI2010”,
Feb. 15-20, 2010, TU-WIEN, Vienna, Austria

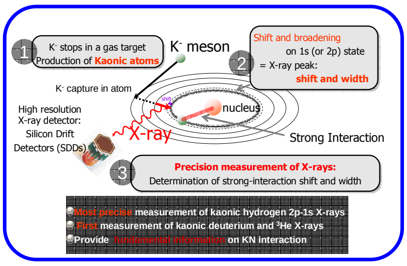
Performance of Silicon-Drift Detectors in kaonic atom X-ray measurements

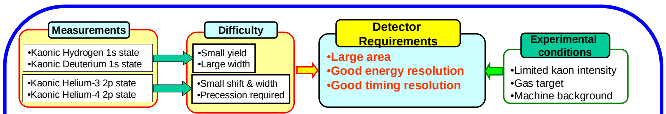
T. Ishiwatari[1] and F. Sirghi[2,3] on behalf of the SIDDARTA collaboration
1. Stefan Meyer Institute, Austrian Academy of Sciences, Vienna, Austria
2. INFN, Laboratori Nazionali di Frascati, Frascati (Roma), Italy
3. IFIN-HH, Magurele, Bucharest, Romania

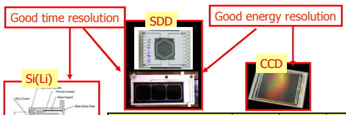
Introduction

For the study of kaonic atom X-ray measurement at the SIDDHARTA experiment, large area silicon drift detector (SDDs) were developed and used in the background condition of the e^+e^- collider machine. Here, the SDD system used in the experiment and the performance of the SDDs were reported.

Principle of the kaonic atom X-ray measurements is shown in the right figure. Due to the strong interaction between the kaon and nucleus, the X-ray energy is shifted and broadened. A precise measurement of the X-ray energy and width provides us an effect of the K^{bar}-N strong-interaction at the low-energy limit.







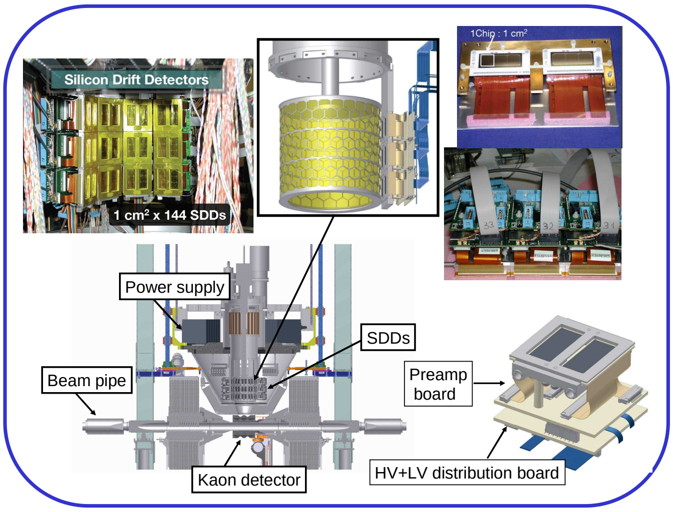
experiment		KpX	DEAR	E570
Detector		Si(Li)	CCD	SDD
Area	[mm^2]	200	724	100
Thickness	[mm]	5	0.03	0.26
ΔE (FWHM)	[eV]	410	170	185
Δt (FWHM)	[ns]	290	None	430

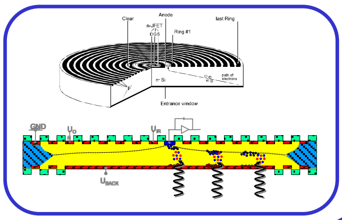
Large area X-ray detectors used in kaonic atom X-ray experiments were listed.

SDDs have good resolution both in energy and timing.

SDD data provide precise determination of X-ray energy with excellent background suppression.

SIDDHARTA experimental setup

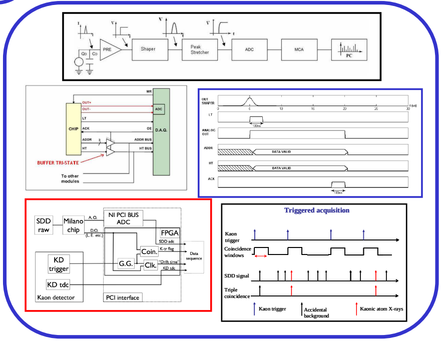




Schematic view of SDD is shown on the left side. Applying the DC voltages in the central anode, last ring, and backplane, photoelectrons produced by X-rays drift to the anode. Due to the small anode size and capacitance, the energy resolution is fine in spite of a large size. The time resolution depends on the size, as well as the SDD temperature.

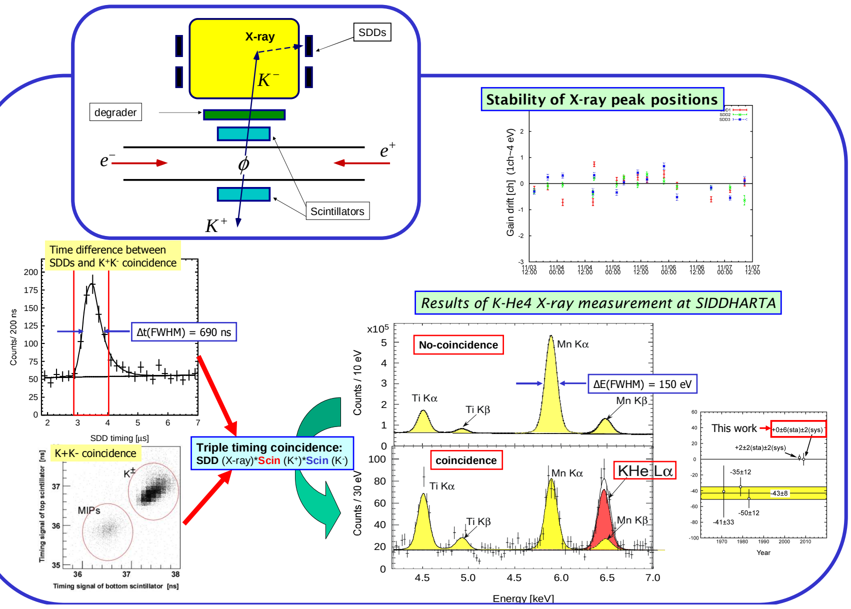
SIDDHARTA experimental setup is shown on the left side. 144 SDDs (1 cm² each a thickness of 450 μm) were installed to view the gas target cell. One chip contains 3 SDDs.

SDD signal was sent to a specially developed signal processing chip. An analog signal from the SDD was amplified and shaped. A DC voltage of a peak stretcher signal was generated as an output signal. Together with the peak stretcher signal, the time difference between the SDD signal and the kaon detector was recorded.



SIDDHARTA data were taken from 2008 to 2009 using gas targets of hydrogen, deuterium, heium-3 and helium-4. Data analysis are ongoing. In January and February 2009, test measurements of kaonic helium-4 X-rays were performed. The K^+K^- pairs produced by ϕ decay were detected by a kaon detector, consisting of two scintillators. Charged kaon pairs were identified by a time-of-flight technique. A correlation of the time difference on the two scintillators is shown. The ratio of kaon coincidences to MIPs during the kaonic helium measurements was about 20:1. The SDDs were cooled to a temperature of 170 K with a stability of ± 0.5 K. Energy data of all the X-ray signals detected by the SDDs were recorded. In addition, time differences between the coincidence signals in the kaon detector and X-ray signals in the SDDs were recorded using a clock with a frequency of 120 MHz, whenever the coincidence signals occurred within a time window of 6 μs. In a typical SDD, gain drift of the X-ray peak positions was found to be within 1 ch (~4 eV). The X-ray energy of the kaonic helium Lα line was determined to be E_{exp} = 6463.6 ± 5.8 eV. The contribution of systematic errors to the kaonic helium X-ray energy was studied. Energy linearity, gain drifts and rate dependence were found to be ± 0.5 eV each. The total systematic error is estimated to be ± 2 eV.

In conclusion, the energy shift of the kaonic helium $3d \rightarrow 2p$ line was measured using the gaseous target in the SIDDHARTA experiment. The resultant shift of 0 eV confirms the result by the E570 group. Prior to the experiment by the E570 group, the average of the three previous results was E =-43±8 eV, while most of the theoretical calculations give E ~ 0 eV. This five-sigma discrepancy between theory and experiment was known as the “kaonic helium puzzle”. A resolution of this longstanding puzzle provided by the E570 group is now firmly established by the present work.



SIDDHARTA Collaboration:

M. Bazzi[1],G. Beer[2],L.Bombelli[3] ,A.M.Bragadireanu[1,4],M.Cargnelli[5] ,G. Corradi[1], C. Curceanu(Petrascu)[1], A.d'Uffizi[1], C. Fiorini[3], T. Frizzi[3], F. Ghio[6], B. Girolami[6],C.Guaraldo[1],R.S.Hayano[7],M.Iliescu[1],T. Ishiwatari[5], M.Iwasaki[8], P.Kienle[5,9], P.Levi Sandri[1],A.Longoni[3],V.Lucherini[1],J.Marton[5],S.Okada[1],D.Pietreanu[1],T.Ponta[4], A.Rizzo[1], A.Romero Vidal[1],A.Scordo[1],H.Shi[7],D.L.Sirghi[1,4], F.Sirghi[1,4],H.Tatsuno[7], A.Tudorache[4],V.Tudorache[4], O.Vazquez Doce[1], E.Widmann[5],J.Zmeskal[5]

1. INFN, Laboratori Nazionali di Frascati, Frascati (Roma), Italy
2.Dep. of Phys. and Astro., Univ. of Victoria, Victoria B.C., Canada
3.Politechno di Milano, Sez. di Elettronica, Milano, Italy
4.IFIN-HH, Magurele, Bucharest, Romania
5.Stefan-Meyer-Institut für subatomare Physik, Vienna, Austria
6.INFN Sez. di Roma I and Inst. Superiore di Sanita, Roma, Italy
7.Univ. of Tokyo, Tokyo, Japan
8.RIKEN, The Inst. of Phys. and Chem. Research, Saitama, Japan
9.Tech. Univ. München, Physik Dep., Garching, Germany

References

[1] M. Bazzi *et al.* (SIDDHARTA Collaboration), Phys. Lett. B681(2009) 310.
[2] C. Fiorini *et al.*, Nucl. Instr. Meth A 568 (2006) 322
[3] T. Ishiwatari *et al.*, Nucl. Instr. Meth. A 581(2007) 326
[4] P. Lechner *et al.*, Nucl. Instr. Meth. A 458 (2001) 281
[5] C. Fiorini *et al.*, Nucl. Instr. Meth A 568 (2006) 322
[6] T. Frizzi, Dr.thesis, Politecnico di Milano (2007)