## The physics of kaonic atoms

# SIDDHARTA

#### WHAT ARE THE KAONIC ATOMS?

The kaonic atoms represent a special case of exotic atoms, in which one of the orbiting electrons was replaced by a different type of negatively charged particle (antiproton, muon, kaon). The kaonic atoms are formed whenever a beam of negatively charged kaons, originating from a particle accelerator (in our case from the DA $\Phi$ NE electron-positron collider, in which  $\phi$ particles decaying to kaons are being created) enters a gaseous target: the kaons lose their kinetic energy via interactions with the matter atoms, up to when they are captured by one of the target atoms replacing an electron and thus forming the kaonic atom. Being the kaon mass about 1000 times bigger than the electron one, the orbit in which the kaon, replacing the electron, is captured is a highly excited one; it follows then a series of de-excitation processes of the kaonic atom. In the last transition (from the level n=2 to n=1, the fundamental level) X rays are generated (photons as the ones of the light, having the energy thousand times higher), which are the ones being measured in SIDDHARTA.



The formation and decay of the kaonic hydrogen

#### WHAT DO WE LEARN?

The negative kaons, differently from the electrons, are not elementary particles, being composed from quarks: a "strange" quark and an "up" antiquark. When inside the kaonic atom the kaon approaches the nuclei – as a consequence of de-excitation processes - it feels not only the electromagnetic interaction (as the electron) but the strong interaction too (acting between quarks). It is thus possible to extract, from the measurements of the X rays generated in the deexcitation processes, information on the strong force acting between the kaon and the nuclei at very low energies, almost at threshold (zero relative kinetic energy between the kaon and the nuclei). In particular, from the study of kaonic hydrogen and deuterium one extracts the strong interaction information between the negative kaon and the proton and neutron. Such information is accessible only by this type of measurements! Further on, this information serves to reveal mysteries of the strong force (the so-called Quantum ChromoDynamics, QCD, the theory describing quarks' behaviour) at very low energies. The strong force is responsible of many of processes in Nature, from the existence of nuclei to stars evolution. While the QCD behaviour at high energies is rather well understood, its low-energy regime is being still investigated in many experiments all around the world. The mere existence of the nucleons (protons and neutrons) is an effect of the lowenergy regime of the strong force; understanding it can contribute to comprehend details about the world around us and about ourselves.

#### HOW SIDDHARTA WORKS?

SIDDHARTA (Silicon Drift Detector for Hadronic Atom Research by Timing Application) is an international Collaboration among 8 Institutes out of 6 countries (Austria, Canada, Italy, Germany, Japan and Romania). It utilize an innovative setup which uses, for the first time in the world, X-ray large area triggerable Silicon Drift Detectors (SDD) with integrated electronics. The SDD detectors were developed in the framework of the collaboration, using European money too (HadronPhysics I3 EU PF6 project) About 200 such detectors, each one with an active array of 1 cm<sup>2</sup>, will be positioned around a cryogenic target filled with hydrogen or deuterium.



The SIDDHARTA apparatus, installed on DA $\Phi$ NE, will take data in 2008. The aim if to perform the best measurement in the world (the most precise one) of the kaonic hydrogen and the first measurement ever of the kaonic deuterium.

In such a way, SIDDHARTA will give a fundamental contribution to the understanding of aspects of strong interaction in the lowenergy regime in systems containing strangeness (strange quark).

### **FALLOUTS**

The SDD detectors for the measure of X rays in SIDDHARTA could be as well used with success for:

- non-destructive analyses of the artistic patrimony;
- analyses in the field of safety;
- analyses in the health sector.



SIDDHARTA on  $DA \Phi NE$